Notes on the Troubleshooting and Repair of Computer and Video Monitors

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Preface

Author and Copyright

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DISCLAIMER

Working inside a CRT-based computer or video monitor, or television set can be lethal from line-connected and high voltage power supplies as well as CRT implosion. Read and follow ALL of the safety guidelines found in Safety Guidelines for High Voltage and/or Line Powered Equipment and the section "SAFETY", below. If in doubt about your abilities or experience, leave repair and internal adjustments to a professional.

We will not be responsible for damage to equipment, your ego, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury or worse that may result from the use of this material.

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Introduction

Monitors, monitors, and more monitors

In the early days of small computers, a 110 baud teletype with a personal paper tape reader was the 'preferred' input-output device (meaning that this was a great improvement over punched cards and having to deal with the bozos in the computer room. Small here, also meant something that would comfortably fit into a couple of 6 foot electronics racks!)

The earliest personal computers didn't come with a display - you connected them to the family TV. You and your kids shared the single TV and the Flintstones often won out. The Commodore 64 would never have been as successful as it was if an expensive monitor were required rather than an option.

However, as computer performance improved, it quickly became clear that a dedicated display was essential. Even for simple text, a TV can only display 40 characters across the screen with any degree of clarity.

When the IBM PC was introduced, it came with a nice 80x25 green monochrome text display. It was bright, crisp, and stable. Mono graphics (MGA or MDA) was added at 720x350, CGA at a range of resolutions from 160x200 to 640x200 at 2 to 16 colors, and EGA extended this up to a spectacular resolution of 640x350. This was really fine until the introduction of Windows (well, at least once Windows stayed up long enough for you to care).

All of these displays used digital video - TTL signals which coded for a specific discrete number of possible colors and intensities. Both the video adapter and the monitor were limited to 2, 4, 16, or a whopping 64 colors depending on the graphics standard. The video signals were logic bits - 0s and 1s.

With the introduction of the VGA standard, personal computer graphics became 'real'. VGA and its successors - PGA, XGA, and all of the SVGA (non) standards use analog video - each of the R, G, and B signals is a continuous voltage which can represent a continuous range of intensities for each color. In principle, an analog monitor is capable of an unlimited number of possible colors and intensities. (In practice, unavoidable noise and limitations of the CRT restricts the actual number to order of 64-256 distinguishable intensities for each channel.)

Note that analog video was only new to the PC world. TVs and other video equipment, workstations, and image analysis systems had utilized analog signals for many years prior to the PC's 'discovery' of this approach. In all fairness, both the display adapter and monitor are more expensive so it is not surprising that early PCs did not use analog video.

Most of the information in this document applies to color computer video monitors and TV studio monitors as well as the display portions of television sets. Black and white, gray scale, and monochrome monitors use a subset of the circuitry (and generally at lower power levels) in color monitors so much of it applies to these as well.

For most descriptions of symptoms, testing, diagnosis, and repair, an auto-scan PC SVGA monitor is assumed. For a fixed frequency workstation monitor, studio video monitor, or closed circuit TV monitor, only a subset of the possible faults and procedures will apply.

Note: we use the term 'auto-scan' to describe a monitor which accepts a wide (and possibly continuous) range of scan rates. Usually, this refers mostly to the horizontal frequency as the vertical refresh rate is quite flexible on many monitors of all types. Fixed scan or fixed frequency monitors are designed to work with a single scan rate (though a 5% or so variation may actually be accepted). Multi-scan monitors sync at two or more distinct scan rates. While not very common anymore, multi-scan monitors may still be found in some specific applications.

Related Information

See the documentss: Troubleshooting and Repair of Small Switchmode Power Supplies and Troubleshooting and Repair of Television Sets for additional useful pointers. Since a monitor must perform a subset of the functions of a TV, many of the problems and solutions are similar. For power related problems the info on SMPSs may be useful as well. If you are considering purchasing a monitor or have one that you would like to evaluate, see the companion document: Performance Testing of Computer and Video Monitors.

Monitor fundamentals

Note: throughout this document, we use the term 'raster' to refer to the entire extent of the scanned portion of the screen and the terms 'picture', 'image'. or 'display', to refer to the actual presentation content.

Monitors designed for PCs, workstations, and studio video have many characteristics in common. Modern computer monitors share many similarities with TVs but the auto-scan and high scan rate deflection circuitry and more sophisticated power supplies complicates their servicing.

Currently, most inexpensive computer monitors are still based on the Cathode Ray Tube (CRT) as the display device. However, handheld equipment, laptop computers, and the screens inside video projectors now use flat panel technology, mostly Liquid Crystal Displays - LCDs. These are a lot less bulky than CRTs, use less power, and have better geometry - but suffer from certain flaws. As the price of LCD (and other technology) flat screen technology decreases, such monitors will become dominant for desktop computers as well and CRT based monitors will eventually go the way of dinosaurs, core memory, and long playing records that dominated their respective industries for decades but eventually yielded to fundamentally new technology. :)

However, there are still problems with (low cost, at least) LCD monitors. First, the picture quality in terms of gray scale and color is generally inferior to a decent analog monitor. The number of distinct shades of gray or distinct colors is a lot more limited. They are generally not as responsive as CRTs when it comes to real-time video which is becoming increasingly important with multimedia computers. This is partly due to the response of the LCD material itself but also a result of the scan conversion that's needed for non-native resolution formats. Brightness is generally not as good as a decent CRT display. And last but not least, the cost is still somewhat higher due both to the increased complexity of flat panel technology and lower production volumes (though this is certainly increasing dramatically). It is really hard to beat the simplicity of the shadow mask CRT.

The really bad news from the perspective of repair is that they generally cannot be repaired outside of a manufacturer authorized service center and the way they do the repair most likely will be to swap the entire LCD/driver panel, if not the entire monitor. Only repair of the most simple problems like obvious bad connections, a bad cable, a bad backlight lamp, or a failure of the power supply or backlight inverter, can realistically be accomplished without fancy specialized test equipment and facilities. Access to the backlight lamps might substantial disassembly.

Buying a broken LCD monitor to repair may have better odds than the State Lottery, but probably not by much. Where one or more columns or rows or an entire half screen are not displaying properly, I wouldn't consider it unless nearly totally free, hoping for a miracle, and even then it might not be worth it. Loose connectors and solder joints are possible, though not nearly as common as with CRT monitors.

Also a note to those with less than perfect vision: If you tend to view your monitor from less than 10 to 15 inches, you may be disappointed, or at least have a hard time getting used to LCD monitors. The appearance of a CRT display is nearly independent of viewing angle. But for an LCD display, this is not the case. Only the central part of your field of vision will have the proper brightness, contrast, and color rendition. If the curser isn't within this central area, it will be harder to locate than on a CRT. In short, don't just depend on the hype. An LCD with a slightly lower contrast ratio and lower price may have a substantially wider viewing angle and better match to your needs than a top-of-the-line model. Test drive multiple LCD monitors before committing to one!

Nonetheless, a variety of technologies are currently competing for use in the flat panel displays of the future. Among these are advanced LCD, plasma discharge, and field emission displays. Only time will tell which, if any survives to become **the** picture-on-the-wall or notepad display - at reasonable cost.

Projection displays, on the other hand, can take advantage of a novel development in integrated micromachining - the Texas Instruments Inc. Digital Micromirror Device (DMD). This is basically an integrated circuit with a tiltable micromirror for each pixel fabricated on top of a static memory - RAM - cell. DMD technology would permit nearly any size projection display to be produced and would therefore be applicable to HDTV as well as PCs. Since it is a reflective device, the light source can be as bright as needed. This technology is already appearing in commercial high performance computer projectors and is competing for use in totally digital movie theaters to replace the film projector, but to my knowledge is not in any consumer TV sets - yet.

As noted, the plasma panel flat screen display has been around for several years in high-end TVs, typically in the 42 inch diagonal range. But they are very expensive ($5,000 to $15,000 as of Winter, 2003), and their life expectancy may be limited due to the gradual degradation of the active pixel cells - which occurs faster than for a CRT. The physical resolution is also probably still too low to really justify the large screen size for computer displays. However, there is little doubt that this or a similar technology will eventually replace the direct view CRT and 3-tube projection TVs in the mid to large screen sizes in the not too distant future. But to what extent it is used for computer monitors is still unclear.

The remainder of this document concentrates on CRT based computer and video monitors since these still dominate the market and realistically, they are the only type where there is a good chance of repair without access to specialized test equipment and parts. I wouldn't recommend any sort of attempt at repair of flat screen TVs or monitors - no matter what the size - beyond checking for bad connections, dead power supplies, or other obvious problems. The chance of success is vanishingly small and it's very likely that even with great care, damage could occur to the panels or circuitry.

Monitor characteristics

The following describe the capabilities which characterize a display:

1. Resolution - the number of resolvable pixels on each line and the number of scanning lines. Bandwidth of the video source, cable, and monitor video amplifiers as well as CRT focus spot size are all critical. However, maximum resolution on a color CRT is limited by the dot/slot/line pitch of the CRT shadow/slot mask or aperture grille.

2. Refresh rate - the number of complete images 'painted' on the screen each second. Non-interlaced or progressive scanning posts the entire frame during each sweep from top to bottom. Interlaced scanning posts 1/2 of the frame called a field - first the even field and then the odd field. This interleaving reduces the apparent flicker for a given display bandwidth when displaying smooth imagery such as for TV. It is usually not acceptable for computer graphics, however, as thin horizontal lines tend to flicker at 1/2 the vertical scan rate. Refresh rate is the predominant factor that affects the flicker of the display though the persistence of the CRT phosphors are also a consideration. Long persistence phosphors decrease flicker at the expense of smearing when the picture changes or moves. Vertical scan rate is equal to the refresh rate for non-interlaced monitors but is the twice the refresh rate for interlaced monitors (1 frame equals 2 fields). Non-interlaced

vertical refresh rates of 70-75 Hz are considered desirable for computer displays. Television uses 25 or 30 Hz (frame rate) interlaced scanning in most countries.

3. Horizontal scan rate - the frequency at which the electron beam(s) move across the screen. The horizontal scan rate is often the limiting factor in supporting high refresh rate high resolution displays. It is what may cause failure if scan rate speed limits are exceeded due to the component stress levels in high performance deflection systems.

4. Color or monochrome - a color monitor has a CRT with three electron guns each associated with a primary color - red, green, or blue. Nearly all visible colors can be created from a mix of primaries with suitable spectral characteristics using this additive color system.

   A monochrome monitor has a CRT with a single electron gun. However, the actual color of the display may be white, amber, green, or whatever single color is desired as determined by the phosphor of the CRT selected.

5. Digital or analog signal - a digital input can only assume a discrete number of states depending on how many bits are provided. A single bit input can only produce two levels - usually black or white (or amber, green, etc.). Four bit EGA can display up to 16 colors (with a color monitor) or 16 shades of gray (with a monochrome monitor).

   Analog inputs allow for a theoretically unlimited number of possible gray levels or colors. However, the actual storage and digital-to-analog convertors in any display adapter or frame store and/or unavoidable noise and other characteristics of the CRT - and ultimately, limitations in the psychovisual eye-brain system will limit this to a practical maximum of 64-256 discernible levels for a gray scale display or for each color channel.

   However, very high performance digital video sources may have RAMDACs (D/A convertors with video lookup tables) of up to 10 or more bits of intensity resolution. While it is not possible to perceive this many distinct gray levels or colors (per color channel), this does permit more accurate tone scale ('gamma') correction to be applied (via a lookup table in the RAMDAC) to compensate for the unavoidable non-linearity of the CRT phosphor response curve or to match specific photometric requirements.

Types of monitors

Monitors can be classified into three general categories:

1. Studio video monitors - Fixed scanning rate for the TV standards in the country in which they are used. High quality, often high cost, utilitarian case (read: ugly), underscan option. Small closed circuit TV monitors fall into the class. Input is usually composite (i.e., NTSC or PAL) although RGB types are available.

2. Fixed frequency RGB - High resolution, fixed scan rate. High quality, high cost, very stable display. Inputs are analog RGB using either separate BNC connectors or a 13W3 (Sun) connector. These often have multiple sync options. The BNC variety permit multiple monitors to be driven off of the same source by daisychaining. Generally used underscanned for computer workstation (e.g., X-windows) applications so that entire frame buffer is visible. There are also fixed frequency monochrome monitors which may be digital or analog input using a BNC, 13W3, or special connector.

3. Multi-scan or auto-scan - Support multiple resolutions and scan rates or multiple ranges of resolutions and scan rates. The quality and cost of these monitors ranges all over the map. While cost is not a strict measure of picture quality and reliability, there is a strong correlation. Input is most often analog RGB but some older monitors of this type (e.g., Mitsubishi AUM1381) support a variety of digital (TTL) modes as well. A full complement of user controls permits adjustment of brightness, contrast, position, size, etc. to taste. Circuitry in the monitor identifies the video scan rate automatically and sets up the appropriate circuitry. With more sophisticated (and expensive) designs, the monitor automatically sets the appropriate parameters for user preferences from memory as well. The DB15 high density VGA connector is most common though BNCs may be used or may be present as an auxiliary (and better quality) input.

Why auto-scan?

Thank IBM. Since the PC has evolved over a period of 15 years, display adapters have changed and improved a number of times. With an open system, vendors with more vision (and willing to take more risks) than IBM were continuously coming up with improved higher resolution display adapters. With workstations and the Apple MacIntosh, the primary vendor can control most aspects of the hardware and software of the computer system. Not so with PCs. New improved hardware adapters were being introduced regularly which were not following any standards for the high resolution modes (but attempted to be backward compatible with the original VGA as well as EGA and CGA (at least in terms of software).) Vast numbers of programs were written that were designed to directly control the CGA, EGA, and VGA hardware. Adapter cards could be designed to emulate these older modes on a fixed frequency high resolution monitor (and these exist to permit high quality fixed scan rate workstation monitors to be used on PCs) However, these would be (and are) much more expensive than basic display adapters that simply switch scan rates based on mode. Thus, auto-scan monitors evolved to accommodate the multiple resolutions that different programs required.

Note: The generic term 'auto-scan' is used to refer to a monitor which automatically senses the input video scan rate and selects the appropriate horizontal and vertical deflection circuitry and power supply voltages to display this video. Multi-scan monitors, while simpler than true auto-scan monitors, will still have much of the same scan rate detection and selection circuitry. Manufacturers use various buzz words to describe their versions of these monitors including 'multisync', 'autosync','panasync', 'omnisync', as well as 'autoscan' and 'multiscan'.

Ultimately, the fixed scan rate monitor may reappear for PCs. Consider one simple fact: it is becoming cheaper to design and manufacture complex digital processing hardware than to produce the reliable high quality analog and power electronics needed for an auto-scan monitor. This is being done in the specialty market now. Eventually, the development of accelerated chipsets for graphics mode emulation may be forced by the increasing popularity of flat panel displays - which are basically similar to fixed scan rate monitors in terms of their interfacing requirements.

Analog versus digital monitors

There are two aspects of monitor design that can be described in terms of analog or digital characteristics:

1. The video inputs. Early PC monitors, video display terminal monitors, and mono workstation monitors use digital input signals which are usually TTL but some very high resolution monitors may use ECL instead.

2. The monitor control and user interface. Originally, monitors all used knobs - sometimes quite a number of them - to control all functions like brightness, contrast, position, size, linearity, pincushion, convergence, etc. However, as the costs of digital circuitry came down - and the need to remember settings for multiple scan rates and resolutions arose, digital - microprocessor control - became an attractive alternative in terms of design, manufacturing costs, and user convenience. Now, most better quality monitors use digital controls - buttons and menus - for almost all adjustments except possibly brightness and contrast where knobs are still more convenient.

Since monitors with digital signal inputs are almost extinct today except for specialized applications, it is usually safe to assume that 'digital' monitor refers to the user interface and microprocessor control. And, except perhaps for the very cheapest monitors, all now have digital controls.

Interlacing

Whether a monitor runs interlaced or non-interlaced is almost always strictly a function of the video source timing. The vertical sync pulse is offset an amount equal to 1/2 the line time on alternate fields (vertical scans - two fields make up a frame when interlaced scanning is used).

- Generally, a monitor that runs at a given resolution non-interlaced can run interlaced at a resolution with the same number of pixels per line but twice the number of lines vertically at roughly the same horizontal and vertical scan rates and video bandwidth (but half the frame rate).
- Alternatively, it may be possible to increase the resolution in both directions while keeping the horizontal scan rate the same thus permitting a monitor to display the next larger size format. However, in this case, the video bandwidth will increase.

Here are a couple of examples:

- A monitor that will run 640x240 at 60 frames per second non-interlaced will run 640x480 at 30 frames per second interlaced. This would permit a monitor with a horizontal scan rate of 15.7 kHz (NTSC TV compatible) to display VGA resolution images - though they will likely flicker since the 30 Hz is way too low for most graphics.
- A resolution of 1024x768 at 50 frames per second interlaced requires roughly the same horizontal scan rate (about 42 kHz) as 800x600 at 66 frames per second non-interlaced. The flicker may be acceptable in this case being at 50 Hz for the worst case of single horizontal lines as the high 100 Hz vertical scan rate will reduce flicker otherwise.

Whether the image is usable at the higher resolution of course depends on many other factors (in addition to flicker) including the dot pitch of the CRT and video bandwidth of the video card and monitor video amplifiers, as well as cable quality and termination.

Monitor performance

The ultimate perceived quality of your display is influenced by many aspects of the total video source/computer-cable-monitor system. Among them are:

1. Resolution of the video source. For a computer display, this is determined by the number of pixels on each visible scan line and the number of visible scan lines on the entire picture.

2. The pitch of the shadow mask or aperture grille of the CRT. The smallest color element on the face of the CRT is determined by the spacing of the groups of R, G, and B colors phosphors. The actual conversion from dot or line pitch to resolution differs slightly among dot or slot mask and aperture grille CRTs but in general, the finer, the better - and more expensive.

   Typical television CRTs are rather coarse - .75 mm might be a reasonable specification for a 20 inch set. High resolution computer monitors may have dot pitches as small as .22 mm for a similar size screen.

   A rough indication of the maximum possible resolution of the CRT can be found by determining how many complete phosphor dot groups can fit across the visible part of the screen.

   Running at too high a resolution for a given CRT may result in Moire - an interference pattern that will manifest itself as contour lines in smooth bright areas of the picture. However, many factors influence to what extent this may be a problem. See the section: Contour lines on high resolution monitors - Moire.

3. Bandwidth of the video source or display card - use of high performance video amplifiers or digital to analog convertors.

4. Signal quality of the video source or display card - properly designed circuitry with adequate power supply filtering and high quality components.

5. High quality cables with correct termination and of minimal acceptable length without extensions or switch boxes unless designed specifically for high bandwidth video.

6. Sharpness of focus - even if the CRT dot pitch is very fine, a fuzzy scanning beam will result in a poor quality picture.

7. Stability of the monitor electronics - well regulated power supplies and low noise shielded electronics contribute to a rock solid image.

The following are only partly dependent on the monitor's design:

8. Anti-glare treatment of screen and ambient lighting conditions - No matter how good are the monitor's electronics, the display can still be washed out and difficult or tiring to view if there is annoying glare or reflections. The lighting and location are probably more important than how the screen itself is designed to minimize glare.

9. Electromagnetic interference - Proximity to sources of magnetic fields and power line noise can degrade the performance of any monitor, no matter how well shielded it might be.

Performance testing of monitors

WARNING: No monitor is perfect. Running comprehensive tests on your monitor or one you are considering may make you aware of deficiencies you never realized were even possible. You may never be happy with any monitor for the rest of your life!

Note: The intent of these tests is **not** to evaluate or calibrate a monitor for photometric accuracy. Rather they are for functional testing of the monitor's performance.

Obviously, the ideal situation is to be able to perform these sorts of tests before purchase. With a small customer oriented store, this may be possible. However, the best that can be done when ordering by mail is to examine a similar model in a store for gross characteristics and then do a thorough test when your monitor arrives. The following should be evaluated:

- Screen size and general appearance.
- Brightness and screen uniformity, purity and color saturation.
- Stability.
- Convergence.
- Edge geometry.
- Linearity.
- Tilt.
- Size and position control range.
- Ghosting or trailing streaks.
- Sharpness.
- Moire.
- Scan rate switching.
- Acoustic noise.

The companion document: Performance Testing of Computer and Video Monitors provides detailed procedures for the evaluation of each of these criteria.

CAUTION: Since there is no risk free way of evaluating the actual scan rate limits of a monitor, this is not an objective of these tests. It is assumed that the specifications of both the video source/card and the monitor are known and that supported scan rates are not exceeded. Some monitors will operate perfectly happily at well beyond the specified range, will shut down without damage, or will display an error message. Others will simply blow up instantly and require expensive repairs.

Monitor repair

Unlike PC system boards where any disasters are likely to only affect your pocketbook, monitors can be very dangerous. Read, understand, and follow the set of safety guidelines provided later in this document whenever working on TVs, monitors, or other similar high voltage equipment.

If you do go inside, beware: line voltage (on large caps) and high voltage (on CRT) for long after the plug is pulled. There is the added danger of CRT implosion for carelessly dropped tools and often sharp sheetmetal shields which can injure if you should have a reflex reaction upon touching something you should not touch. In inside of a TV or monitor is no place for the careless or naive.

Having said that, a basic knowledge of how a monitor works and what can go wrong can be of great value even if you do not attempt the repair yourself. It will enable you to intelligently deal with the service technician. You will be more likely to be able to recognize if you are being taken for a ride by a dishonest or just plain incompetent repair center. For example, a faulty picture tube CANNOT be the cause of a color monitor only displaying in black-and-white (this is probably a software or compatibility problem). The majority of consumers - and computer professionals - may not know even this simple fact.

This document will provide you with the knowledge to deal with a large percentage of the problems you are likely to encounter with your monitors. It will enable you to diagnose problems and in many cases, correct them as well. With minor exceptions, specific manufacturers and models will not be covered as there are so many variations that such a treatment would require a huge and very detailed text. Rather, the most common problems will be addressed and enough basic principles of operation will be provided to enable you to narrow the problem down and likely determine a course of action for repair. In many cases, you will be able to do what is required for a fraction of the cost that would be charged by a repair center.

Should you still not be able to find a solution, you will have learned a great deal and be able to ask appropriate questions and supply relevant information if you decide to post to sci.electronics.repair. It will also be easier to do further research using a repair text such as the ones listed at the end of this document. In any case, you will have the satisfaction of knowing you did as much as you could before taking it in for professional repair. With your new-found knowledge, you will have the upper hand and will not easily be snowed by a dishonest or incompetent technician.

Most Common Problems

The following probably account for 95% or more of the common monitor ailments:

- Intermittent changes in color, brightness, size, or position - bad connections inside the monitor or at the cable connection to the computer or or video source.
- Ghosts, shadows, or streaks adjacent to vertical edges in the picture - problems with input signal termination including use of cable extensions, excessively long cables, cheap or improperly made video cables, improper daisychaining of monitors, or problems in the video source or monitor circuitry.
- Magnetization of CRT causing color blotches or other color or distortion problems - locate and eliminate sources of magnetic fields if relevant and degauss the CRT.
- Electromagnetic Interference (EMI) - nearby equipment (including and especially other monitors), power lines, or electrical wiring behind walls, may produce electromagnetic fields strong enough to cause noticeable wiggling, rippling, or other effects. Relocate the monitor or offending equipment. Shielding is difficult and expensive.
- Wiring transmitted interference - noisy AC power possibly due to other equipment using electric motors (e.g., vacuum cleaners), lamp dimmers or motor speed controls (shop tools), fluorescent lamps, and other high power devices, may result in a variety of effects. The source is likely local - in your house - but could be several miles away. Symptoms might include bars of noise moving up or down the screen or diagonally. The effects may be barely visible as a couple of jiggling scan lines or be broad bars of salt and pepper noise, snow, or distorted video. Plugging the monitor into another outlet or the use of a line filter may help. If possible, replace or repair the offending device.
- Monitor not locking on one or more video scan ranges - settings of video adapter are incorrect. Use software setup program to set these. This could also be a fault in the video source or monitor dealing with the sync signals.
- Adjustments needed for background brightness or focus - aging CRT reduces brightness. Other components may affect focus. These are often easy internal (or sometimes external) adjustments but some manufacturers have gone to digital setup requiring expensive an adapter (serial cable) to a PC and their own (expensive and/or unavailable) software.
- Dead monitor due to power supply problems - very often the causes are simple such as bad connections, blown fuse or other component.

Repair or replace

If you need to send or take the monitor to a service center, the repair could easily exceed half the cost of a new monitor. Service centers may charge up to $50 or more for providing an initial estimate of repair costs but this will usually be credited toward the total cost of the repair (of course, they may just jack this up to compensate for their bench time). With new monitors going for under $200, the costs of any significant repair are no longer justifiable unless there is something unique about your monitor.

Some places offer attractive flat rates for repairs involving anything but the CRT, yoke, and flyback. Such offers are attractive if the repair center is reputable. However, if by mail, you will be stuck with a tough decision if they find that one of these expensive components is actually bad.

Monitors become obsolete at a somewhat slower rate than most other electronic equipment. Therefore, unless you need the higher resolution and scan rates that newer monitors provide, repairing an older one may make sense as long as the CRT is in good condition (adequate brightness, no burn marks, good focus). However, it may just be a good excuse to upgrade.

If you can do the repairs yourself, the equation changes dramatically as your parts costs will be 1/2 to 1/4 of what a professional will charge and of course your time is free. The educational aspects may also be appealing. You will learn a lot in the process. Thus, it may make sense to repair that old clunker for your 2nd PC (or your 3rd or your 4th or....).

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Monitors 101

Subsystems of a monitor

Please refer to Typical SVGA Monitor Block Diagram while reading the following description.

A computer or video monitor includes the following functional blocks:

1. Low voltage power supply (some may also be part of (2).) Most of the lower voltages used in the monitor may be derived from the horizontal deflection circuits, a separate switchmode power supply (SMPS), or a combination of the two. Rectifier/filter capacitor/regulator from AC line provides the B+ to the SMPS or horizontal deflection system. Auto-scan monitors may have multiple outputs from the low voltage power supply which are selectively switched or enabled depending on the scan rate, or an power supply with programmable output voltage for the deflection system. A common configuration is a pair of SMPSs where one provides all the fixed voltages and the other is programmable based on scan rate.

   Degauss operates off of the line whenever power is turned on (after having been off for a few minutes) to demagnetize the CRT. Better monitors will have a degauss button which activates this circuitry as well since even rotating the monitor on its tilt-swivel base can require degauss.

2. Horizontal deflection. These circuits provide the waveforms needed to sweep the electron beam in the CRT across and back at anywhere from 15 kHz to over 100 kHz depending on scan rate and resolution. The horizontal sync pulse from the sync separator or the horizontal sync input locks the

horizontal deflection to the video signal. Auto-scan monitors have sophisticated circuitry to permit scanning range of horizontal deflection to be automatically varied over a wide range.

3. Vertical deflection. These circuits provide the waveforms needed to sweep the electron beam in the CRT from top to bottom and back at anywhere from 50 - 120 or more times per second. The vertical sync pulse from the sync separator or vertical sync input locks the vertical deflection to the video signal. Auto-scan monitors have additional circuitry to lock to a wide range of vertical scan rates.

4. CRT high voltage 'flyback' power supply (also part of (2).) A modern color CRT requires up to 30 kV for a crisp bright picture. Rather than having a totally separate power supply, most monitors derive the high voltage (as well as many other voltages) from the horizontal deflection using a special transformer called a 'flyback' or 'Line OutPut Transformer (LOPT) for those of you on the other side of the lake. Some high performance monitors use a separate high voltage board or module which is a self contained high frequency inverter.

5. Video amplifiers. These buffer the low level inputs from the computer or video source. On monitors with TTL inputs (MGA, CGA, EGA), a resistor network also combines the intensity and color signals in a kind of poor man's D/A. Analog video amplifiers will usually also include DC restore (black level retention, back porch clamping) circuitry stabilize the black level on AC coupled video systems.

6. Video drivers (RGB). These are almost always located on a little circuit board plugged directly onto the neck of the CRT. They boost the output of the video amplifiers to the hundred volts or so needed to drive the cathodes (usually) of the CRT.

7. Sync processor. This accepts separate, composite, or 'sync-on-green' signals to control the timing of the horizontal and vertical deflection systems. Where input is composite rather than separate H and V syncs (as is used with VGA/SVGA), this circuit extracts the individual sync signals. For workstation monitors which often have the sync combined with the green video signals, it needs to separate this as well. The output of the sync processor is horizontal and vertical sync pulses to control the deflection circuits.

8. System control. Most higher quality monitors use a microcontroller to perform all user interface and control functions from the front panel (and sometimes even from a remote control). So called 'digital monitors' meaning digital controls not digital inputs, use buttons for everything except possibly user brightness and contrast. Settings for horizontal and vertical size and position, pincushion, and color balance for each scan rate may be stored in non-volatile memory. It may communicate with the video card over the serial VESA bus to inform if of its capabilities. The microprocessor also analyzes the input video timing and selects the appropriate scan range and components for the detected resolution. While these circuits rarely fail, if they do, debugging can be quite a treat.

Most problems occur in the horizontal deflection and power supply sections. These run at relatively high power levels and some components run hot. This results in both wear and tear on the components as well as increased likelihood of bad connections developing from repeated thermal cycles. The high voltage section is prone to breakdown and arcing as a result of hairline cracks, humidity, dirt, etc.

The video circuitry is generally quite reliable. However, it seems that even after 15+ years, manufacturers still cannot reliably turn out circuit boards that are free of bad solder connections or that do not develop them with time and use.

For more information on monitor technology

The books listed in the section: Suggested references include additional information on the theory and implementation of the technology of monitors and TV sets.

Philips/Magnavox used to have a very nice on-line introduction to a variety of consumer electronics technologies. Although their site has disappeared - and even people who work for them have no clue - I have now recovered several of the articles including those on TVs, VCRs, camcorders, satellite reception, and connections. See the Introductory Consumer Electronics Technology Series. These as well as most or all of the other articles, as well a glossary and much more, can be also be accessed via the Internet Archive Wayback Machine. Copy and paste the following URL into the search box:

- http://www.magnavox.com/electreference/electreference.html

The earliest (Nov 09, 1996) archive seems to be the most complete.

On-line tech-tips databases

A number of organizations have compiled databases covering thousands of common problems with VCRs, TVs, computer monitors, and other electronic equipment. Most charge for their information but a few, accessible via the Internet, are either free or have a very minimal monthly or per-case fee. In other cases, a limited but still useful subset of the for-fee database is freely available.

A tech-tips database is a collection of problems and solutions accumulated by the organization providing the information or other sources based on actual repair experiences and case histories. Since the identical failures often occur at some point in a large percentage of a given model or product line, checking out a tech-tips database may quickly identify your problem and solution.

In that case, you can greatly simplify your troubleshooting or at least confirm a diagnosis before ordering parts. My only reservation with respect to tech-tips databases in general - this has nothing to do with any one in particular - is that symptoms can sometimes be deceiving and a solution that works in one instance may not apply to your specific problem. Therefore, an understanding of the hows and whys of the equipment along with some good old fashioned testing is highly desirable to minimize the risk of replacing parts that turn out not to be bad.

The other disadvantage - at least from one point of view - is that you do not learn much by just following a procedure developed by others. There is no explanation of how the original diagnosis was determined or what may have caused the failure in the first place. Nor is there likely to be any list of other components that may have been affected by overstress and may fail in the future. Replacing Q701 and C725 may get your equipment going again but this will not help you to repair a different model in the future.

Please see the document: On-Line Tech-Tips Databases for the most up to date compilation of these resources for TVs, VCRs, computer monitors, and other consumer electronic equipment.

Additional monitor technology and repair information

See Sam's Neat, Nifty, and Handy Bookmarks under "Monitor" and "Manuals/Schematics/Repair Guides" for additional links.

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CRT Basics

Note: Most of the information on TV and monitor CRT construction, operation, interference and other problems. has been moved to the document: TV and Monitor CRT (Picture Tube) Information. The following is just a brief introduction with instructions on degaussing.

Color CRTs - shadow masks and aperture grills

All color CRTs utilize a shadow mask or aperture grill a fraction of an inch (1/2" typical) behind the phosphor screen to direct the electron beams for the red, green, and blue video signals to the proper phosphor dots. Since the electron beams for the R, G, and B phosphors originate from slightly different positions (individual electron guns for each) and thus arrive at slightly different angles, only the proper phosphors are excited when the purity is properly adjusted and the necessary magnetic field free region is maintained inside the CRT. Note that purity determines that the correct video signal excites the proper color while convergence determines the geometric alignment of the 3 colors. Both are affected by magnetic fields. Bad purity results in mottled or incorrect colors. Bad convergence results in color fringing at edges of characters or graphics.

The shadow mask consists of a thin steel or InVar (a ferrous alloy) with a fine array of holes - one for each trio of phosphor dots - positioned about 1/2 inch behind the surface of the phosphor screen. With some CRTs, the phosphors are arranged in triangular formations called triads with each of the color dots at the apex of the triangle. With many TVs and some monitors, they are arranged as vertical slots with the phosphors for the 3 colors next to one another.

An aperture grille, used exclusively in Sony Trinitrons (and now their clones as well), replaces the shadow mask with an array of finely tensioned vertical wires. Along with other characteristics of the aperture grille approach, this permits a somewhat higher possible brightness to be achieved and is more immune to other problems like line induced moire and purity changes due to local heating causing distortion of the shadow mask.

However, there are some disadvantages of the aperture grille design:

- Weight - a heavy support structure must be provided for the tensioned wires (like a piano frame).
- Price (proportional to weight).
- Always a cylindrical screen (this may be considered an advantage depending on your preference.
- Visible stabilizing wires which may be objectionable or unacceptable for certain applications. (Definitely on 15" and larger sizes, possibly on smaller ones as well.)

Apparently, there is no known way around the need to keep the fine wires from vibrating or changing position due to mechanical shock in high resolution tubes and thus all Trinitron monitors require 1, 2, or 3 stabilizing wires (depending on tube size) across the screen which can be see as very fine lines on bright images. Some people find these wires to be objectionable and for some critical applications, they may be unacceptable (e.g., medical diagnosis).

Degaussing (demagnetizing) a CRT

Degaussing may be required if there are color purity problems with the display. On rare occasions, there may be geometric distortion caused by magnetic fields as well without color problems. The CRT can get magnetized:

- if the TV or monitor is moved or even just rotated.
- if there has been a lightning strike nearby. A friend of mine had a lightning strike near his house which produced all of the effects of the EMP from a nuclear bomb.
- If a permanent magnet was brought near the screen (e.g., kid's magnet or megawatt stereo speakers).
- If some piece of electrical or electronic equipment with unshielded magnetic fields is in the vicinity of the TV or monitor.

Degaussing should be the first thing attempted whenever color purity problems are detected. As noted below, first try the internal degauss circuits of the TV or monitor by power cycling a few times (on for a minute, off for at least 20 minutes, on for a minute, etc.) If this does not help or does not completely cure the problem, then you can try manually degaussing.

Note: Some monitors have a degauss button, and monitors and TVs that are microprocessor controlled may degauss automatically upon power-on (but may require pulling the plug to do a hard reset) regardless of the amount of off time. However, repeated use of these 'features' in rapid succession may result in overheating of the degauss coil or other components. The 20 minutes off/1 minute on precedure is guaranteed to be safe. (Some others may degauss upon power-on as long as the previous degauss was not done within some predetermined amount of time - they keep track with an internal timer.)

Commercial CRT Degaussers are available from parts distributors like MCM Electronics and consist of a hundred or so turns of magnet wire in a 6-12 inch coil. They include a line cord and momentary switch. You flip on the switch, and bring the coil to within several inches of the screen face. Then you slowly draw the center of the coil toward one edge of the screen and trace the perimeter of the screen face. Then return to the original position of the coil being flat against the center of the screen. Next, slowly decrease the field to zero by backing straight up across the room as you hold the coil. When you are farther than 5 feet away you can release the line switch.

The key word here is ** slow **. Go too fast and you will freeze the instantaneous intensity of the 50/60 Hz AC magnetic field variation into the ferrous components of the CRT and may make the problem worse.

WARNING: Don't attempt to degauss inside or in the back of the set (near the CRT neck. This can demagnetize the relatively weak purity and convergence magnets which may turn a simple repair into a feature length extravaganza!

It looks really cool to do this while the CRT is powered. The kids will love the color effects (but then lock your degaussing coil safely away so they don't try it on every TV and monitor in the house!).

Bulk tape erasers, tape head degaussers, open frame transformers, and the "butt-end" of a weller soldering gun can be used as CRT demagnetizers but it just takes a little longer. (Be careful not to scratch the screen face with anything sharp. For the Weller, the tip needs to be in place to get enough magnetic field.) It is imperative to have the CRT running when using these whimpier approaches, so that you can see where there are still impurities. Never release the power switch until you're 4 or 5 feet away from the screen or you'll have to start over.

I've never known of anything being damaged by excess manual degaussing as long as you don't attempt to degauss *inside* or the back of the monitor - it is possible to demagnetize geometry correction, purity, and static converence magnets in the process! However, I would recommend keeping really powerful bulk tape erasers-turned-degaussers a couple of inches from the CRT.

Another alternative which has been known to work is to place another similar size monitor face-to-face with the suspect monitor (take care not to bump or scratch the screens!) and activate degauss function on the working monitor. While not ideal, this may be enough to also degauss the broken one.

If an AC degaussing coil or substitute is unavailable, I have even done degaussed with a permanent magnet but this is not recommended since it is more likely to make the problem worse than better. However, if the display is unusable as is, then using a small magnet can do no harm. (Don't use a 20 pound speaker or magnetron magnet as you may rip the shadow mask right out of the CRT - well at least distort it beyond repair. What I have in mind is something about as powerful as a refrigerator magnet.)

Keep degaussing fields away from magnetic media. It is a good idea to avoid degaussing in a room with floppies or back-up tapes. When removing media from a room remember to check desk drawers and manuals for stray floppies, too.

It is unlikely that you could actually affect magnetic media but better safe than sorry. Of the devices mentioned above, only a bulk eraser or strong permanent magnet are likely to have any effect - and then only when at extremely close range (direct contact with media container).

All color CRTs include a built-in degaussing coil wrapped around the perimeter of the CRT face. These are activated each time the CRT is powered up cold by a 3 terminal thermistor device or other control circuitry. This is why it is often suggested that color purity problems may go away "in a few days". It isn't a matter of time; it's the number of cold power ups that causes it. It takes about 15 minutes of the power being off for each cool down cycle. These built-in coils with thermal control are never as effective as external coils.

Note that while the monochrome CRTs used in B/W and projection TVs and mono monitors don't have anything inside to get magnetized, the chassis or other cabinet parts of the equipment may still need degaussing. While this isn't likely from normal use or even after being moved or reoriented, a powerful magnet (like that from a large speaker) could leave iron, steel, or other ferrous parts with enough residual magnetism to cause a noticeable problem.

See the document: TV and Monitor CRT (Picture Tube) Information for some additional discussion of degaussing tools, techniques, treatments for severe magnetization from lightning strikes, and cautions.

How often to degauss

Some monitor manufacturers specifically warn about excessive use of degauss, most likely as a result of overstressing components in the degauss circuitry which are designed (cheaply) for only infrequent use. In particular, there is often a thermistor that dissipates significant power for the second or two that the degauss is active. Also, the large coil around the CRT is not rated for continuous operation and may overheat.

If one or two activations of the degauss button do not clear up the color problems, manual degaussing using an external coil may be needed or the monitor may need internal purity/color adjustments. Or, you may have just installed your megawatt stereo speakers next to the monitor!

You should only need to degauss if you see color purity problems on your CRT. Otherwise it is unnecessary. The reasons it only works the first time is that the degauss timing is controlled by a thermistor which heats up and cuts off the current. If you push the button twice in a row, that thermistor is still hot and so little happens.

One word of clarification: In order for the degauss operation to be effective, the AC current in the coil must approach zero before the circuit cuts out. The circuit to accomplish this often involves a thermistor to gradually decrease the current (over a matter of several seconds), and in better monitors, a relay to totally cut off the current after a certain delay. If the current was turned off suddenly, you would likely be left with a more magnetized CRT. There are time delay elements involved which prevent multiple degauss operations in succession. Whether this is by design or accident, it does prevent the degauss coil - which is usually grossly undersized for continuous operation - to cool.

Why are there fine lines across my Trinitron monitor or TV?

These are not a defect - they are a 'feature'.

All Trinitron (or clone) CRTs - tubes that use an aperture grille - require 1, 2, or 3 very fine wires across the screen to stabilize the array of vertical wires in the aperture grille. Without these, the display would be very sensitive to any shock or vibration and result in visible shimmering or rippling. (In fact, even with these stabilizing wires, you can usually see this shimmering if you whack a Trinitron monitor.) The lines you see are the shadows cast by these fine wires.

The number of wires depends on the size of the screen. Below 15" there is usually a single wire; between 15" and 21" there are usually 2 wires; above 21" there may be 3 wires. (Some very small Trinitron CRTs may not need these but they will be present on most of the sizes of interest here.)

Only you can decide if this deficiency is serious enough to avoid the use of a Trinitron based monitor. Some people never get used to the fine lines but many really like the generally high quality of Trinitron based displays and eventually totally ignore them.

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Monitor Placement and Preventive Maintenance

General monitor placement considerations

Proper care of a monitor does not require much. Following the recommendations below will assure long life and minimize repairs:

- Subdued lighting is preferred for best viewing conditions. Avoid direct overhead light falling on the screen or coming from behind the monitor if possible.
- Locate the monitor away from extremes of hot and cold. Avoid damp or dusty locations if possible.

(Right you say, keep dreaming!) This will help keep your PC happy as well.

- Allow adequate ventilation - monitors use a fair amount of power - from 60 watts for a 12 inch monochrome monitor to over 200 W for a 21 inch high resolution color monitor. Heat is one major enemy of electronics.

- Do not put anything on top of the monitor that might block the ventilation grill in the rear or top of the cover. This is the major avenue for the convection needed to cool internal components.

- Do not place two monitors close to one another. The magnetic fields may cause either or both to suffer from wiggling or shimmering images. Likewise, do not place a monitor next to a TV if possible.

- Locate loudspeakers and other sources of magnetic fields at least a couple of feet from the monitor. This will minimize the possibility of color purity or geometry problems. The exception is with respect to good quality shielded multimedia speakers which are designed to avoid magnetic interference problems.

  Other devices which may cause interference include anything with power transformers including audio equipment, AC or DC wall adapters, and laptop power supplies; fluorescent lamps with magnetic ballasts; and motorized or heavy duty appliances.

- Situate monitors away from power lines - even electric wiring behind or on the other side of walls - and heavy equipment which may cause noticeable interference like rippling, wiggling, or swimming of the picture. Shielding is difficult and expensive.

- Make sure all video connections are secure (tighten the thumbscrews) to minimize the possibility of intermittent or noisy colors. Keep the cables as short as possible. Do not add extension cables if at all possible as these almost always result in a reduction in image crispness and introduce ghosting, smearing, and other termination problems. If you must add an extension, use proper high quality cable only long enough to make connections conveniently. Follow the termination recommendations elsewhere in this document.

- Finally, store magnetic media well away from all electronic equipment including and especially monitors and loudspeakers. Heat and magnetic fields will rapidly turn your diskettes and tapes into so much trash. The operation of the monitor depends on magnetic fields for beam deflection. Enough said.

Non-standard monitor mounting considerations

Monitors normally are positioned horizontally or via the limits of their tilt swivel bases out in the open on a table or desktop. However, for use in exhibits or for custom installations, it may be desirable to mount a monitor in a non-standard position and/or inside an enclosure.

(From: Bob Myers (myers@fc.hp.com).)

Your mileage may vary, but (and please take the following for what it is, a very general answer)...

There are basically two potential problems here; one is cooling, and the other is the fact that the monitor has no doubt been set up by the factory assuming standard magnetic conditions, which probably DIDN'T involve the monitor tilting at much of an angle. If you're happy with the image quality when it's installed in the cabinet, that leaves just the first concern. THAT one can be addressed by simply making sure the cabinet provides adequate ventilation (and preferably adding a fan for a bit of forced-air cooling), and making sure that the whole installation isn't going to be exposed to high ambient temperatures. (Most monitors are speced to a 40 deg. C ambient in their normal orientation; adding forced-air cooling will usually let you keep that rating in positions somewhat beyond the normal.) Under no circumstances should you block the cabinet's vents, and - depending on the installation - it may be preferable to remove the rear case parts of the monitor (but NOT the metal covers beneath the plastic skin) in order to improve air circulation.

Your best bet is to simply contact the service/support people of the monitor manufacturer, and get their input on the installation. Failing to get the manufacturer's blessing on something like this most often voids the warranty, and can probably lead to some liability problems. (Note - I'm not a lawyer, and I'm not about to start playing one on the net.)

Preventive maintenance - care and cleaning

Preventive maintenance for a monitor is pretty simple - just keep the case clean and free of obstructions. For CRT monitors, clean the screen with a soft cloth just dampened with water and mild detergent or isopropyl alcohol. This will avoid damage to normal as well as antireflection coated glass. DO NOT use anything so wet that liquid may seep inside of the monitor around the edge of the CRT. You could end up with a very expensive repair bill when the liquid decides to short out the main circuit board lurking just below. Then dry thoroughly. Use the CRT sprays sold in computer stores if you like but again, make sure none can seep inside. If you have not cleaned the screen for quite a while, you will be amazed at the amount of black grime that collects due to the static buildup from the CRT high voltage supply.

There is some dispute as to what cleaners are safe for CRTs with antireflective coatings (not the etched or frosted variety). Water, mild detergent, and isopropyl alcohol should be safe. Definitely avoid the use of anything with abrasives for any type of monitor screen. And some warn against products with ammonia (which may include Windex, Top-Job, and other popular cleaners), as this may damage/remove some types of antireflective coatings. To be doubly sure, test a small spot in a corner of the screen.

In really dusty situations, periodically vacuuming inside the case and the use of contact cleaner for the controls might be a good idea but realistically, you will not do this so don't worry about it.

Note that a drop of oil or other contamination might appear like a defect (hole) in the AR coating. Before getting upset, try cleaning the screen.

For LCD TVs, LCD computer monitors, and laptop displays, the cleaning is particularly critical. The front surface of these facing the viewer is generally not made of glass like those in CRT displays, but rather a plastic layer or film. Thus, any cleaning method that uses harsh chemicals can permanently damage the screen, with or without an anti-reflection coating. Some glass cleaners, acetone (nail polish remover), and other strong solvents can attack the plastic very quickly. By the time you realize there is damage, it may be too late. And, of course, NEVER use anything even mildly abrasive.

A damp cloth with soap or detergent and water is safe, as is generally a damp clost with a solution of 70 percent isopropyl (rubbing) alcohol diluted in the ratio 1:1 with water.

And it is even more essential to avoid allowing any liguid to seep inside along the edges as this can short out the circuitry, especially the high voltage back-light driver,which often located behind the trim at the bottom, and possibly ruin the display entirely, or at least requiring a major repair.

(From: Bob Myers (myers@fc.hp.com).)

Windex is perfectly fine for the OCLI HEA coating or equivalents; OCLI's coating is pretty tough and chemical-resistant stuff. There may be alternative (er..cheaper) coatings in use which could be damaged by various commercial cleaners, (For what it's worth, OCLI also sells their own brand of glass cleaner under the name "TFC", for "Thin Film Cleaner".)

I have cleaned monitors of various brands with both Windex and the OCLI-brand cleaner, with no ill results. But then, I'm usually pretty sure what sort of coating I'm dealing with... :-)

Monitor coatings are always changing; besides the basic "OCLI type" quarter-wave coatings and their conductive versions developed to address E-field issues, just about every tube manufacturer has their own brew or three of antiglare/antistatic coatings. There are also still SOME tubes that aren't really coated at all, but instead are using mechanically or chemically etched faceplates as a cheap "anti-glare" (actually, glare-diffusing) treatment.

In general, look in the user guide/owner's manual and see what your monitor's manufacturer recommends in the way of cleaning supplies.

(From: Tom Watson (tsw@johana.com).)

If you are maintaining a site, consider periodic cleaning of the monitors. Depending on the location, they can accumulate quite a bit of dust. In normal operation there is a electrostatic charge on the face of the crt (larger screens have bigger charges) which act as 'dust magnets'. If the operator smokes (thankfully decreasing), it is even worse. At one site I helped out with, most of the operators smoked, and the screens slowly got covered with a film of both dust and smoke particles. A little bit of glass cleaner applied with reasonable caution and the decree of "adjustments" to make the screen better (these were character monochrome terminals), and lo and behold, "what an improvement!". Yes, even in my dusty house, the TVs get a coating of film/goo which needs to be cleaned, and the picture quality (BayWatch viewers beware) improves quite a bit. Try this on your home TV to see what comes off, then show everyone else. You will be surprised what a little bit of cleaning does.

(From: Bob Myers (myers@fc.hp.com).)

1. Don't block the vents; make sure the monitor has adequate ventilation, and don't operate it more than necessary at high ambient temperatures.

2. If the monitor is used in particularly dusty environments, it's probably a good idea to have a qualified service tech open it up every so often (perhaps once a year, or more often depending on just how dirty it gets) and clean out the dust.

3. The usual sorts of common-sense things - don't subject the monitor to mechanical shock and vibration, clean up spills, etc., promptly, and so forth. And if you're having repeated power-supply problems with your equipment, it may be time to get suspicious of the quality of your AC power (are you getting noise on the line, sags, surges, spikes, brownouts, that sort of thing?).

And most importantly:

4. Turn the monitor OFF when it's not going to be used for an extended period (such as overnight, or if you'll be away from your desk for the afternoon, etc.). Heat is the enemy of all electronic components, and screen-savers do NOTHING in this regard. Many screen-savers don't even do a

particularly good job of going easy on the CRT. With modern power-management software, there's really no reason to be leaving a monitor up and running all the time.

These won't guarantee long life, of course - nothing can do that, as there will always be the possibility of the random component failure. But these are the best that the user can do to make sure the monitor goes as long as it can.

Monitor tuneup?

(From: Bob Myers (myers@fc.hp.com).)

Most manufacturers will quote an MTBF (Mean Time Before Failure) of somewhere in the 30,000 to 60,000 hour range, EXCLUSIVE OF the CRT. The typical CRT, without an extended-life cathode, is usually good for 10,000 to 15,000 hours before it reaches half of its initial brightness. Note that, if you leave your monitor on all the time, a year is just about 8,000 hours.

The only "tuneup" that a monitor should need, exclusive of adjustments needed following replacement of a failed component, would be video amplifier and/or CRT biasing adjustments to compensate for the aging of the tube. These are usually done only if you're using the thing in an application where exact color/brightness matching is important. Regular degaussing of the unit may be needed, of course, but I'm not considering that a "tuneup" or adjustment.

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Monitor Troubleshooting

SAFETY

TVs and computer or video monitors are among the more dangerous of consumer electronic equipment when it comes to servicing. (Microwave ovens are probably the most hazardous due to high voltage at flesh frying and cardiac arresting high power.)

There are two areas which have particularly nasty electrical dangers: the non-isolated line power supply and the CRT high voltage.

Major parts of nearly all modern TVs and many computer monitors are directly connected to the AC line - there is no power transformer to provide the essential barrier for safety and to minimize the risk of equipment damage. In the majority of designs, the live parts of the TV or monitor are limited to the AC input and line filter, degauss circuit, bridge rectifier and main filter capacitor(s), low voltage (B+) regulator (if any), horizontal output transistor and primary side of the flyback (LOPT) transformer, and parts of the startup circuit and standby power supply. The flyback generates most of the other voltages used in the unit and provides an isolation barrier so that the signal circuits are not line connected and safer.

Since a bridge rectifier is generally used in the power supply, both directions of the polarized plug result in dangerous conditions and an isolation transformer really should be used - to protect you, your test equipment, and the TV, from serious damage. Some TVs do not have any isolation barrier whatsoever - the entire chassis is live. These are particularly nasty.

The high voltage to the CRT, while 200 times greater than the line input, is not nearly as dangerous for several reasons. First, it is present in a very limited area of the TV or monitor - from the output of the flyback to the CRT anode via the fat HV wire and suction cup connector. If you don't need to remove the mainboard or replace the flyback or CRT, then leave it alone and it should not bite. Furthermore, while the shock from the HV can be quite painful due to the capacitance of the CRT envelope, it is not nearly as likely to be lethal since the current available from the line connected power supply is much greater.

Of particular note in: Major Parts of Typical SVGA Monitor with Cover Removed are the CRT HV cable and connector, flyback or LOPT, and the horizontal output transistor and its heat sink. With many TVs and some monitors, this may be line-connected and electrically hot. However, this monitor uses a separate switchmode power supply and in any case, there is likely an insulator between the transistor and heat sink.

Safety Guidelines: These guidelines are to protect you from potentially deadly electrical shock hazards as well as the equipment from accidental damage.

Note that the danger to you is not only in your body providing a conducting path, particularly through your heart. Any involuntary muscle contractions caused by a shock, while perhaps harmless in themselves, may cause collateral damage - there are many sharp edges inside this type of equipment as well as other electrically live parts you may contact accidentally.

The purpose of this set of guidelines is not to frighten you but rather to make you aware of the appropriate precautions. Repair of TVs, monitors, microwave ovens, and other consumer and industrial equipment can be both rewarding and economical. Just be sure that it is also safe!

- Don't work alone - in the event of an emergency another person's presence may be essential.
- Always keep one hand in your pocket when anywhere around a powered line-connected or high voltage system.
- Wear rubber bottom shoes or sneakers.
- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or get caught in moving parts.
- Set up your work area away from possible grounds that you may accidentally contact.
- Know your equipment: TVs and monitors may use parts of the metal chassis as ground return yet the chassis may be electrically live with respect to the earth ground of the AC line. Microwave ovens use the chassis as ground return for the high voltage. In addition, do not assume that the chassis is a suitable ground for your test equipment!
- If circuit boards need to be removed from their mountings, put insulating material between the boards and anything they may short to. Hold them in place with string or electrical tape. Prop them up with insulation sticks - plastic or wood.
- If you need to probe, solder, or otherwise touch circuits with power off, discharge (across) large power supply filter capacitors with a 2 W or greater resistor of 100 to 500 ohms/V approximate value (e.g., for a 200 V capacitor, use a 20K to 100K ohm resistor). Monitor while discharging and verify that there is no residual charge with a suitable voltmeter. In a TV or monitor, if you are removing the high voltage connection to the CRT (to replace the flyback transformer for example) first discharge the CRT contact (under the suction cup at the end of the fat HV wire). Use a 1M to

10M ohm 5 W or greater wattage (for its voltage holdoff capability, not power dissipation) resistor on the end of an insulating stick or the probe of a high voltage meter. Discharge to the metal frame which is connected to the outside of the CRT.

- For TVs and monitors in particular, there is the additional danger of CRT implosion - take care not to bang the CRT envelope with your tools. An implosion will scatter shards of glass at high velocity in every direction. There are several tons of force attempting to crush the typical CRT. While implosion is not really likely even with modest abuse, why take chances? However, the CRT neck is relatively thin and fragile and breaking it would be very embarrassing and costly. Always wear eye protection when working around the back side of a CRT.

- Connect/disconnect any test leads with the equipment unpowered and unplugged. Use clip leads or solder temporary wires to reach cramped locations or difficult to access locations.

- If you must probe live, put electrical tape over all but the last 1/16" of the test probes to avoid the possibility of an accidental short which could cause damage to various components. Clip the reference end of the meter or scope to the appropriate ground return so that you need to only probe with one hand.

- Perform as many tests as possible with power off and the equipment unplugged. For example, the semiconductors in the power supply section of a TV or monitor can be tested for short circuits with an ohmmeter.

- Use an isolation transformer if there is any chance of contacting line connected circuits. A Variac(tm) is not an isolation transformer! The use of a GFCI (Ground Fault Circuit Interrupter) protected outlet is a good idea but will not protect you from shock from many points in a line connected TV or monitor, or the high voltage side of a microwave oven, for example. (Note however, that, a GFCI may nuisanse trip at power-on or at other random times due to leakage paths (like your scope probe ground) or the highly capacitive or inductive input characteristics of line powered equipment.) A fuse or circuit breaker is too slow and insensitive to provide any protection for you or in many cases, your equipment. However, these devices may save your scope probe ground wire should you accidentally connect it to a live chassis.

- Don't attempt repair work when you are tired. Not only will you be more careless, but your primary diagnostic tool - deductive reasoning - will not be operating at full capacity.

- Finally, never assume anything without checking it out for yourself! Don't take shortcuts!

Warning about disconnecting CRT neck board

Some manufacturers warn against powering a TV or monitor CRT without the CRT neck board connected. Apparently, without something - anything - to drain the charge resulting from the current flow due to residual gas ions inside the CRT, the shortest path may be through the glass neck of the tube to the yoke or from the pins outside the CRT to whatever is nearby. There aren't many ions in a modern CRT but I suppose a few here, a few there, and eventually they add up to enough to cause a major disaster at least on some CRTs.

This is probably not a problem on small CRTs but for large ones with high high voltages and high deflection angles where the glass of the neck is very thin to allow for maximum deflection sensitivity, the potential does exist for arcing through the glass to the yoke to occur, destroying the CRT.

There is really no way to know which models will self destruct but it should be possible to avoid such a disaster by providing a temporary return path to the DAG ground of the CRT (NOT SIGNAL GROUND!!) via the focus or G2 pins preferably through a high value high voltage rated resistor just in case one of these is shorted.

This probably applies mostly to large direct-view TVs since they use high deflection angle CRTs but it won't hurt to take appropriate precautions with video and computer monitors as well.

Troubleshooting tips

Many problems have simple solutions. Don't immediately assume that your problem is some combination of esoteric complex convoluted failures. For a monitor, it may just be a bad connection or blown fuse. Remember that the problems with the most catastrophic impact on operation like a dead monitor usually have the simplest solutions. The kind of problems we would like to avoid at all costs are the ones that are intermittent or difficult to reproduce: the occasional jitter or a monitor that blows its horizontal output transistor every six months.

If you get stuck, sleep on it. Sometimes, just letting the problem bounce around in your head will lead to a different more successful approach or solution. Don't work when you are really tired - it is both dangerous (especially with respect to monitors) and mostly non-productive (or possibly destructive).

Whenever working on complex equipment, make copious notes and diagrams. You will be eternally grateful when the time comes to reassemble the unit. Most connectors are keyed against incorrect insertion or interchange of cables, but not always. Apparently identical screws may be of differing lengths or have slightly different thread types. Little parts may fit in more than one place or orientation. Etc. Etc.

Pill bottles, film canisters, and plastic ice cube trays come in handy for sorting and storing screws and other small parts after disassembly. This is particularly true if you have repairs on multiple pieces of equipment under way simultaneously.

Select a work area which is wide open, well lighted, and where dropped parts can be located - not on a deep pile shag rug. The best location will also be relatively dust free and allow you to suspend your troubleshooting to eat or sleep or think without having to pile everything into a cardboard box for storage.

Another consideration is ESD - Electro-Static Discharge. Some components (like ICs) in a TV are vulnerable to ESD. There is no need to go overboard but taking reasonable precautions such as getting into the habit of touching a **safe** ground point first.

WARNING: even with an isolation transformer, a live chassis should **not** be considered a safe ground point. When the monitor is unplugged, the shields or other signal ground points should be safe and effective.

A basic set of precision hand tools will be all you need to disassemble a monitor and perform most adjustments. These do not need to be really expensive but poor quality tools are worse than useless and can cause damage. Needed tools include a selection of Philips and straight blade screwdrivers, socket drivers, needlenose pliers, wire cutters, tweezers, and dental picks. For adjustments, a miniature (1/16" blade) screwdriver with a non-metallic tip is desirable both to prevent the presence of metal from altering the electrical properties of the circuit and to minimize the possibility of shorting something from accidental contact with the circuitry. A set of plastic alignment tools will be useful for making adjustments to coils (though you can forgo these until the (rare) need arises.

A low power (e.g., 25 W) fine tip soldering iron and fine rosin core solder will be needed if you should need to disconnect any soldered wires (on purpose or by accident) or replace soldered components. A higher power iron or small soldering gun will be needed for dealing with larger components. Never use acid core solder or the type used for sweating copper pipes!

CAUTION: You can easily turn a simple repair (e.g., bad solder connections) into an expensive mess if you use inappropriate soldering equipment and/or lack the soldering skills to go along with it. If in doubt, find someone else to do the soldering or at least practice, practice, practice, soldering and desoldering on a junk circuit board first! See the document: Troubleshooting and Repair of Consumer Electronic Equipment for additional info on soldering and rework techniques.

For thermal or warmup problems, a can of 'cold spray' or 'circuit chiller' (they are the same) and a heat gun or blow dryer come in handy to identify components whose characteristics may be drifting with temperature. Using the extension tube of the spray can or making a cardboard nozzle for the heat gun can provide very precise control of which components you are affecting.

For info on useful chemicals, adhesives, and lubricants, see "Repair Briefs, an Introduction" as well as other documents available at this site.

Test equipment

Don't start with the electronic test equipment, start with some analytical thinking. Your powers of observation (and a little experience) will make a good start. Your built in senses and that stuff between your ears represents the most important test equipment you have.

However, some test equipment will be needed:

- Multimeter (DMM or VOM) - This is essential for checking of power supply voltages and voltages on the pins of ICs or other components - service literature like the SAMs Photofacts described elsewhere in this document include voltage measurements at nearly every circuit tie point for properly functioning equipment. The multimeter will also be used to check components like transistors, resistors, and capacitors for correct value and for shorts or opens. You do not need a fancy instrument. A basic DMM - as long as it is reliable - will suffice for most troubleshooting. If you want one that will last for many years, go with a Fluke. However, even the mid range DMMs from Radio Shack have proven to be reliable and of acceptable accuracy. For some kinds of measurements - to deduce trends for example - an analog VOM is preferred (though some DMMs have a bar graph scale which almost as good).

- Oscilloscope - While many problems can be dealt with using just a multimeter, a 'scope will be essential as you get more into advanced troubleshooting. Basic requirements are: dual trace, 10-20 MHz minimum vertical bandwidth, delayed sweep desirable but not essential. A good set of proper 10X/1X probes. Higher vertical bandwidth is desirable but most consumer electronics work can be done with a 10 MHz scope. A storage scope or digital scope might be desirable for certain tasks but is by no means essential for basic troubleshooting.

  I would recommend a good used Tektronix (Tek) or Hewlett Packard (HP) scope over a new scope of almost any other brand. You will usually get more scope for your money and these things last almost forever. Until recently, my 'good' scope was the militarized version (AN/USM-281A) of the HP180 lab scope. It has a dual channel 50 MHz vertical plugin and a delayed sweep horizontal plugin. I have seen these going for under $300 from surplus outfits. For a little more money, you can get a Tek 465 or 465B (newer version but similar specifications) 100 Mhz scope ($200 to $600, sometimes cheaper on eBay or elsewhere but there is more risk than buying from a reputable dealer). I have now acquired a Tek 465B and that's what I use mostly these days. The HP-180 is still fine but I couldn't pass up a really good deal. :) The Tek 465/B or other similar model will suffice for all but the most demanding (read: RF or high speed digital) repairs.

- A video signal source - depending on what type of monitor you are repairing, you may need both computer and television signals.

  Computer Monitors - a test PC is useful as a video source. Of course, it will need to support whatever scan rates and video types the monitor is designed to accept. Software programs are available to display purity, convergence, focus, color, and other test patterns. Or create your own test patterns using a program like Windows Paint. See the section: Using a PC as a monitor test pattern generator.

  Studio monitors - a baseband video source like a VCR or camcorder is useful in lieu of a test pattern generator. These will allow you to you to control the program material. In fact, making some test tapes using a camcorder or video camera to record static test patterns will allow you full control of what is being displayed and for how long.

- Color bar/dot/crosshatch signal generator. This is a useful piece of equipment if you are doing a lot of TV or studio monitor repair and need to perform CRT convergence and chroma adjustments. However, there are alternatives that are almost as good: a VHS recording of these test patterns will work for TVs. A PC programmed to output a suitable set of test patterns will be fine for monitors (and TVs if you can set up the video card to produce an NTSC/PAL signal. This can be put through a VCR to generate the RF (Channel 3/4) input to your TV if it does not have direct video inputs (RCA jacks).

  Sophisticated (and expensive) universal test pattern generators are available that will handle any possible monitor scan rate.

Incredibly handy widgets

These are the little gadgets and homemade testers that are useful for many repair situations. Here are just a few of the most basic:

- Series light bulb for current limiting during the testing of TVs, monitors, switching power supplies, audio power amplifiers, etc. I built a dual outlet box with the outlets wired in series so that a lamp can be plugged into one outlet and the device under test into the other. For added versatility, add a regular outlet and 'kill' switch using a quad box instead. The use of a series load will prevent your expensive replacement part like a horizontal output transistor from blowing if there is still some fault in the circuit you have failed to locate.

- A Variac. It doesn't need to be large - a 2 A Variac mounted with a switch, outlet and fuse will suffice for most tasks. However, a 5 amp or larger Variac is desirable. If you will be troubleshooting 220 VAC equipment in the US, there are Variacs that will output 0-240 VAC from a 115 VAC line (just make sure you don't forget that this can easily fry your 115 VAC equipment.) By varying the line voltage, not only can you bring up a newly repaired monitor gradually to make sure there are no problems; you can also evaluate behavior at low and high line voltage. This can greatly aid in troubleshooting power supply problems. Warning: a Variac is not an isolation transformer and does not help with respect to safety. You need an isolation transformer as well.

- Isolation transformer. This is very important for safely working on live chassis equipment. Since nearly all modern monitors utilize line connected switchmode power supply or line connected deflection circuits, it is essential. You can build one from a pair of similar power transformers back-to-back (with their highest rated secondaries connected together. I built mine from a couple of similar old tube type TV power transformers mounted on a board with an outlet box including a fuse. Their high voltage windings were connected together. The unused low voltage windings can be put in series with the primary or output windings to adjust voltage. Alternatively, commercial line isolation transformers suitable for TV troubleshooting are available for less than $100 - well worth every penny.

- Variable isolation transformer. You don't need to buy a fancy combination unit. A Variac can be followed by a normal isolation transformer. (The opposite order also works. There may be some subtle differences in load capacity.).

CAUTION: Keep any large transformer of this type well away from your monitor or TV. The magnetic field it produces may cause the picture to wiggle or the colors to become messed up - and you to think there is an additional problem!

- Degaussing coil. Make or buy. The internal degaussing coil salvaged from a defunct color TV or monitor doubled over to half it original diameter to increase its strength in series with a 200 W light bulb for current limiting will work just fine. Or, buy one from a place like MCM Electronics for about $15-$30 that will be suitable for all but the largest TVs and monitors. Also, see the section: Degaussing (demagnetizing) a CRT.

Safe discharging of capacitors in TVs and video monitors

It is essential - for your safety and to prevent damage to the device under test as well as your test equipment - that large or high voltage capacitors be fully discharged before measurements are made, soldering is attempted, or the circuitry is touched in any way. Some of the large filter capacitors commonly found in line operated equipment store a potentially lethal charge.

This doesn't mean that every one of the 250 capacitors in your TV need to be discharged every time you power off and want to make a measurement. However, the large main filter capacitors and other capacitors in the power supplies should be checked and discharged if any significant voltage is found after powering off (or before any testing - the CRT capacitance in a TV or video monitor, for example, can retain a dangerous or at least painful charge for days or longer!)

The technique I recommend is to use a high wattage resistor of about 100 ohms/V of the working voltage of the capacitor. This will prevent the arc-welding associated with screwdriver discharge but will have a short enough time constant so that the capacitor will drop to a low voltage in at most a few seconds (dependent of course on the RC time constant and its original voltage).

Then check with a voltmeter to be double sure. Better yet, monitor while discharging (not needed for the CRT - discharge is nearly instantaneous even with multi-M ohm resistor).

Obviously, make sure that you are well insulated!

- For the main capacitors in a TV or monitor power supply which might be 400 uF at 200 V, this would mean a 5K, 10W resistor. RC = 2 seconds. 5RC = 10 seconds. A lower wattage resistor can be used since the total energy in not that great. If you want to be more high tech, you can build the capacitor discharge circuit outlined in the companion document: Capacitor Testing, Safe Discharging, and Other Related Information. This provides a visible indication of remaining charge and polarity.

- For the CRT, use a several M ohm resistor good for 30 kV or more (or a string of lower value resistors to obtain this voltage rating). A 1/4 watt job will just arc over! Discharge to the chassis ground connected to the outside of the CRT - NOT SIGNAL GROUND ON THE MAIN BOARD as you may damage sensitive circuitry. The time constant is very short - a ms or so. However, repeat a few times to be sure, then use a shorting clip as these capacitors have a way of recovering a painful charge if left alone - there have been too many stories of painful experiences from charge developing for whatever reasons ready to bite when the HV lead is reconnected.

  Note that if you are touching the little board on the neck of the CRT, you may want to discharge the HV even if you are not disconnecting the fat red wire - the focus and screen (G2) voltages on that board are derived from the CRT HV.

  WARNING: Most common resistors - even 5 W jobs - are rated for only a few hundred volts and are not suitable for the 25 kV or more found in modern TVs and monitors. Alternatives to a long string of regular resistors are a high voltage probe or a known good focus/screen divider network. However, note that the discharge time constant with these may be a few seconds. Also see the section: Additional information on discharging CRTs.

  If you are not going to be removing the CRT anode connection, replacing the flyback, or going near the components on the little board on the neck of the CRT, I would just stay away from the fat red wire and what it is connected to including the focus and screen wires. Repeatedly shoving a screwdriver under the anode cap risks scratching the CRT envelope which is something you really do not want to do.

Again, always double check with a reliable voltmeter!

Reasons to use a resistor and not a screwdriver to discharge capacitors:

1. It will not destroy screwdrivers and capacitor terminals.
2. It will not damage the capacitor (due to the current pulse).
3. It will reduce your spouse's stress level in not having to hear those scary snaps and crackles.

Additional information on discharging CRTs

You may hear that it is only safe to discharge from the Ultor to the Dag. So, what the @#$% are they talking about? :-).

(From: Asimov (mike.ross@juxta.mnet.pubnix.ten).)

'Dag' is short for Aquadag. It is a type of paint made of a graphite pigment which is conductive. It is painted onto the inside and outside of picture tubes to form the 2 plates of a high voltage filter capacitor using the glass in between as dielectric. This capacitor is between .005uF and .01uF in value. This seems like very little capacity but it can store a substantial charge with 25,000 volts applied.

The outside "Dag" is always connected to the circuit chassis ground via a series of springs, clips, and wires around the picture tube. The high voltage or "Ultor" terminal must be discharged to chassis ground before working on the circuit especially with older TV's which didn't use a voltage divider to derive the focus potential or newer TV's with a defective open divider.

(From: Sam)

CAUTION: The Dag coating/springs/clips/etc. may not be the same as signal ground on the mainboard. Discharging to that instead could result in all sorts of expensive blown components. Discharging between the CRT anode cap and Dag should be low risk though it is best to use a HV probe or properly rated high value resistor.

For more details, see the document: TV and Monitor CRT (Picture Tube) Information.

Removing the CRT HV connector

WARNING: Make sure the CRT has been discharged FIRST!

The rubber part is usually not glued down so it can be lifted rather easily. However, there may be some silicone type grease between the rubber boot (that looks like a suction cup) and the CRT glass to seal out dust.

A metal clip with a spring keeping it spread out attaches inside the button.

While there are a variety of types of clips actually used, pushing the connector to one side and/or squeezing it in the appropriate direction (peel up one side of the rubber to inspect) while gently lifting up should free it. Probably :-).

The clip (when removed) and CRT button look sort of like this:

```
                         ||======= HV Cable
                         /\
            Clip       |   |
          (Removed)   _|   |_
                                    (No DAG coating in vicinity of HV connector)
      ____________.-     -.___________
 CRT  ____________|______|___________ Glass
                Metal Button
```

Replacement is done in reverse order!

This isn't rocket science and excessive force should not be needed! :-)

The series light bulb trick

When powering up a monitor (or any other modern electronic devices with expensive power semiconductors) that has had work done on any power circuits, it is desirable to minimize the chance of blowing your newly installed parts should there still be a fault. There are two ways of doing this: use of a Variac to bring up the AC line voltage gradually and the use of a series load to limit current to power semiconductors.

Actually using a series load - a light bulb is just a readily available cheap load - is better than a Variac (well both might be better still) since it will limit current to (hopefully) non-destructive levels.

What you want to do is limit current to the critical parts - usually the horizontal output transistor (HOT). Most of the time you will get away with putting it in series with the AC line. However, sometimes, putting a light bulb directly in the B+ circuit will be needed to provide adequate protection. In that location, it will limit the current to the HOT from the main filter capacitors of line connected power supplies. This may also be required with some switchmode power supplies as they can still supply bursts of full (or excessive) current even if there is a light bulb in series with the AC line.

Actually, an actual power resistor is probably better as its resistance is constant as opposed to a light bulb which will vary by 1:10 from cold to hot. The light bulb, however, provides a nice visual indication of the current drawn by the circuit under test. For example:

- Full brightness: short circuit or extremely heavy load - a fault probably is still present.
- Initially bright but then settles at reduced brightness: filter capacitors charge, then lower current to rest of circuit. This is what is expected when the equipment is operating normally. There could still be a problem with the power circuits but it will probably not result in an immediate catastrophic failure.
- Pulsating: power supply is trying to come up but shutting down due to overcurrent or overvoltage condition. This could be due to a continuing fault or the light bulb may be too small for the equipment.

Note: for a TV or monitor, it may be necessary (and desirable) to unplug the degauss coil as this represents a heavy initial load which may prevent the unit from starting up with the light bulb in the circuit.

The following are suggested starting wattages:

- 40 W bulb for VCR or laptop computer switching power supplies.
- 100 W bulb for small (i.e., B/W or 13 inch color) monitors or TVs.
- 150-200 W bulb for large color monitors or projection TVs.

A 50/100/150 W (or similar) 3-way bulb in an appropriate socket comes in handy for this but mark the switch so that you know which setting is which!

Depending on the power rating of the equipment, these wattages may need to be increased. I have had to go to a 300 W light bulb for some computer monitors. However, start low. If the bulb lights at full brightness, you know there is still a major fault. If it flickers or the TV (or other device) does not quite come fully up, then it should be safe to go to a larger bulb. Resist the temptation to immediately remove the bulb at this point - I have been screwed by doing this. Try a larger one first. The behavior should improve. If it does not, there is still a fault present.

Note that some TVs and monitors simply will not power up at all with any kind of series load - at least not with one small enough (in terms of wattage) to provide any real protection. The microcontroller apparently senses the drop in voltage and shuts the unit down or continuously cycles power. Fortunately, these seem to be the exceptions.

Getting inside a monitor

You will void the warranty - at least in principle. There are usually no warranty seals on a monitor so unless you cause visible damage or mangle the screws or plastic, it is unlikely that this would be detected. You need to decide. A monitor still under warranty should probably be returned for warranty service for any covered problems except those with the most obvious and easy solutions. Another advantage of using warranty service is that should your problem actually be covered by a design change, this will be performed free of charge. And, you cannot generally fix a problem which is due to poor design!

Getting into a monitor is usually quite simple requiring the removal of 2-10 Philips or 1/4" hex head screws - most around the edge of the cabinet or underneath, a couple perhaps in the rear. Disconnect the input and power cables first as it they stay with catch on the rear cover you are detaching. Reconnect whatever is needed for testing after the cover is removed. Set the screws aside and make notes if they are not all of the same length and thread type - putting a too long screw in the wrong place can short out a circuit board or break something else, for example. A screw that is too short may not be secure.

Once all visible screws are out, try to remove the cover. There still may be hidden catches or snaps around the edges or seam or hidden beneath little plastic or rubber cosmetic covers. Sometimes, the tilt-swivel base will need to be removed first. If no snaps or catches are in evidence, the cover may just need a bit of persuasion in the form of a carefully placed screwdriver blade (but be careful not to damage the soft plastic). A 'splitting' tool is actually sold for this purpose.

As you pull the cover straight back (usually) and off, make sure that no other wires are still attached. Often, the main circuit board rests on the bottom of the cover in some slots. Go slow as this circuit board may try to come along with the back. Once the back is off, you may need to prop the circuit board up with a block of wood to prevent stress damage and contact with the work surface.

Most - but not all - monitors can be safely and stably positioned either still on the tilt-swivel base or on the bottom of the frame. However, some will require care as the circuit board will be vulnerable.

Larger monitors are quite heavy and bulky. Get someone to help and take precautions if yours is one of the unstable variety. If need be, the monitor can usually safely be positioned on the CRT face if it is supported by foam or a folded blanket.

Once the cover is off, you will find anywhere from none to a frustratingly large number of sheetmetal (perforated or solid) shields. Depending on which circuit boards need to be accessed, one or more of these shields may need to be removed. Make notes of which screws go where and store in a safe place. However, manufacturers often place holes at strategic locations in order to access adjustments - check for these before going to a lot of unnecessary bother. Note: sheetmetal usually has sharp edges. Take care.

See Major Parts of Typical SVGA Monitor with Cover Removed for what will greet you. This particular sample has a shield only covering the video driver board on the neck of the CRT.

Reassemble in reverse order. Getting the circuit board to slide smoothly into its slots may take a couple of attempts but otherwise there should be no surprises.

Specific considerations before poking around inside a TV or monitor

Both electrical and mechanical dangers lurk:

- Main filter capacitor(s). This is the most dangerous (not the HV as you would expect). Fortunately, these capacitors will normally discharge in a few minutes or less especially if the unit is basically working as the load will normally discharge the capacitors nearly fully as power is turned off. With TVs, the main filter capacitor is nearly always on the mainboard. Monitors are more likely to have a separate power supply module.

However, you should check across this capacitor - usually only one and by far the largest in the unit - with a voltmeter and discharge as suggested in the section: Safe discharging of capacitors in TVs and video monitors if it holds more than a few volts (or wait longer) before touching anything.

Some of these are as large as 1,000 uF charged to 160 V - about 13 w-s or a similar amount of energy as that stored in an electronic flash. This is enough to be potentially lethal under the wrong circumstances.

- High Voltage capacitor formed by the envelope of the CRT. It is connected to the flyback transformer by the fat (usually red) wire at the suction cup (well, it looks like one anyhow) attached to the CRT. This capacitor can hold a charge for quite a while - weeks in the case of an old tube type TV!

  If you want to be doubly sure, discharge this also. However, unless you are going to be removing the HV connector/flyback, it should not bother you.

  The energy stored is about 1 w-s but if you touch it or come near to an exposed terminal, due to the high voltage, you will likely be handed *all* the energy and you *will* feel it. The danger is probably more in the collateral damage when you jump ripping flesh and smashing your head against the ceiling.

  Some people calibrate their jump based on voltage - about 1 inch/V. :-).

  There will be some HV on the back of the circuit board on the neck of the CRT but although you might receive a tingle but accidentally touching the focus or screen (G2) pins, it is not likely to be dangerous.

- CRT implosion risk. Don't hammer on it. However, it is more likely that you will break the neck off the tube since the neck is relatively weak. This will ruin your whole day and the TV or monitor but will likely not result in flying glass everywhere. Just, don't go out of your way to find out.
- Sharp sheet metal and so forth. This is not in itself dangerous but a reflex reaction can send your flesh into it with nasty consequences.

Dusting out the inside of a monitor

The first thing you will notice when you remove the cover is how super dusty everything is. Compliments to the maid. You never dreamed there was that much dust, dirt, and grime, in the entire house or office building!

Use a soft brush (like a new paintbrush) and a vacuum cleaner to carefully remove the built up dust. Blowing off the dust will likely not hurt the unit unless it gets redeposited inside various controls or switches but will be bad for your lungs - and will spread dirt all over the room. Don't turn anything - many critical adjustments masquerade as screws that just beg to be tightened. Resist the impulse for being neat and tidy until you know exactly what you are doing. Be especially careful around the components on the neck of the CRT - picture tube - as some of these are easily shifted in position and control the most dreaded of adjustments - for color purity and convergence. In particular, there will be a series of adjustable ring magnets. It is a good idea to mark their position in any case with some white paint, 'white out', or a Magic Marker so that if they do get moved - or you move them deliberately, you will know where you started.

Troubleshooting a monitor with the mainboard disconnected

There are times when it is desirable to remove the chassis or mainboard and work on it in a convenient location without having to worry about the attachments to the CRT and cabinet circuitry.

My approach is usually to do as much work as possible without removing the main board and not attempt to power it up when disconnected since there are too many unknowns. Professionals will plug the chassis into a piece of equipment which will simulate the critical functions but this is rarely an option for the doit-yourselfer.

Note that if you have a failure of the power supply - blown fuse, startup, etc., then it should be fine to disconnect the CRT since these problems are usually totally unrelated. Tests should be valid.

However, if you really want to do live testing with the main board removed, here are some considerations. There are usually several connections to the CRT and cabinet:

- Deflection yoke - since the horizontal coils are part of the horizontal flyback circuit, there could be problems running without a yoke. This could be anything from it appearing totally dead to an overheating or blown horizontal output transistor. There may be no problems. Vertical and any convergence coils may or may not be problems as well.

- CRT video Driver board - pulling this should not usually affect anything except possibly video output and bias voltages.

- CRT 2nd anode - without the CRT, there will be no capacitor to filter the high voltage and you would certaily want to insulate the HV connector **real** well. I do not know whether there are cases where damage to flyback could result from running in thie manner, however.

- Front panel controls - disconnecting these may result in inability to even turn the unit on, erratic operation, and other unexpected behavior.

- Degauss - you just won't have this function when disconnected. But who cares - you are not going to be looking at the screen anyhow.

- Remote sensor - no remote control but I doubt that the floating signals will cause problems.

- Speakers - there will be no audio but this should not cause damage.

  If you do disconnect everything, make sure to label any connectors whose location or orientation may be ambiguous. Most of the time, these will only fit one way but not always.

Comments on repairing modern computer monitors

(From: Wild Bill (kwag98@tcis.net).)

Without even taking into consideration all of the other features of most late model (15" or larger) monitors, such as the multisync and multi-resolution circuitry, many of these units are very complex. They combine almost every example of present circuit design technology. A vacuum display tube, digital data, HF switching, all types of regulators and sense circuits and linear power devices. Funny too, that the end result is just dots of light.

A good (perhaps the best) first action is to search the USENET newsgroup sci.electronics.repair via an archive like Google Groups for previous postings of questions on the same model with related symptoms and replies. Solder in the replacement part, and BINGO, it's repaired. Rest assured that it's always something simple. Yeah, right. :) Time to check some archive repair sites with tech-tips databases.

Typically, for a dead unit, I get a DMM, pencil and paper....

After a fairly thorough overall inspection, i generally resort to a section-by-section investigation for shorted/open power devices, followed by PN junction checks, then an overall ESR check SxS. In circuit ESR checking will nearly always convince me to replace at least a couple of caps. But if ya don't replace 'em, ya just never know. Hehehe.

By now, I'm at least an hour into this potential research project, if the unit's operation hasn't yet been restored. The next phase is usually determined by whatever i feel like doing next.. i might get a couple of datasheets, try a series lamp technique, or test the major parts.. flyback/IHVT, CRT or yokes. If one of these are faulty, it will help determine the cost effectiveness of proceeding. If it's not my monitor, i contact the owner.

Barring any major parts failure, there are several more options for a direction to proceed in.. making sense of any of the available voltages or waveforms, checking the HV semis for leakage, or as a last (but maybe not final) resort.. making circuit diagrams of specific sections. If there hasn't been any sign of progress by this point, the unit usually finds it's way to a shelf until more inspiration arrives.. that reminds me, when did i place that order?

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Monitor Adjustments

These include both controls accessible to the user (and often not understood) as well as internal adjustments that may need to be touched up due to the aging of components or following a repair.

Note that monitor (software) drivers often have the capability to provide some control of picture size, position, color balance, and other parameters via the video card. There is also third-party software for this purpose. So, before blaming the monitor, make sure your software settings (and monitor user controls) have been reset to their defaults. Then see if the monitor controls and/or the driver adjustments have enough range with the procedures described below. However, where a sudden change in behavior occurred without anything being done in either hardware or software (e.g., a new video card or OS/revision), trying to adjust out such a fault is like putting a Band-Aid on a broken bone. There is likely to be a hardware fault in the monitor which will need to be identified and repaired.

User picture adjustment

For general viewing, subdued lighting is preferred. Avoid backlighting and direct overhead lighting if possible.

Display an image with a variety of colors and the full range of brightness from deep shadows to strong highlights. For PCs, a Windows desktop is generally satisfactory. An outdoor scene on a sunny day is excellent for studio monitors. Alternatively, use a test pattern specially designed for this purpose.

Turn the BRIGHTNESS and CONTRAST controls (or use the buttons) all the way down.

Increase the BRIGHTNESS until a raster is just visible in the darkest (shadow) areas of the picture and then back off until it **just** disappears.

Increase the CONTRAST until the desired intensity of highlights is obtained.

Since BRIGHTNESS and CONTRAST are not always independent, go back and forth until you get the best picture.

On monitors with a color balance adjustment, you may want to set this but unless you are doing photorealistic work, using the manufacturer's defaults will be fine unless you need to match the characteristics of multiple monitors located side-by-side.

Focus adjustment

One of the most common complaints is that the monitor is not as crisp as it used to be - or just not as sharp as expected.

Assuming that the focus has just been gradually getting worse over time, tweaking the internal focus control may be all that is needed.

Some monitors have the focus adjustment accessible through a (possibly unmarked) hole in the side or rear of the case. If there is a single hole, it is almost certainly for overall focus. If there are two holes, one may be the screen (G2 - master brightness) or the two adjustments may be for different aspects of focus (e.g., horizontal and vertical). Just carefully observe what happens when each adjustment is moved a little so that you can return it to its original setting if you turned the wrong one. Use a thin insulated screwdriver - preferably with a plastic blade. As a extra precaution, determine of the screwdriver will mate easily with the adjustment with the monitor **off** (don't turn anything, however).

Where there are two adjustment knobs on the flyback transformer, the top one is generally for focus and the bottom one is for G2.

Most inexpensive monitors have only what is known as static focus - a constant voltage derived from the HV power supply is applied to the focus grid of the CRT. This does not allow for optimal focus across the screen and any setting is just a compromise between central and edge sharpness.

Better monitors will have separate H and V focus controls as well as dynamic focus circuitry which generates focus correction signals that are a function of screen position to compensate for changing distance to electron guns at the edges and corners of the screen. There may be some interaction between the static and dynamic adjustments. If either of these controls has no effect or insufficient range, then there may be a fault in the circuitry for that particular adjustment - a fault with the driver, waveform source, power supply, etc.

The most sophisticated schemes use a microprocessor (or at least digital logic) to specify the waveform for each section of the screen with a map of correction values stored in non-volatile memory. It would be virtually impossible to troubleshoot these systems without detailed service information and an oscilloscope - and even then you might need a custom adapter cable and PC software to adjust values!

Also see the section: About the quality of monitor focus.

If you need to go inside to tweak focus pots:

SAFETY: as long as you do not go near anything else inside the monitor while it is on AND keep one hand in you pocket, you should be able to do this without a shocking experience.

Plug it in, turn it on and let it warm up for a half hour or so. Set your PC (or other video source) to display in the resolution you use most often. First turn the user brightness and contrast fully counterclockwise. Turn brightness up until the raster lines in a totally black area appear, then back a hair until they disappear. Then, turn the contrast control up until you get a fairly bright picture. Fullly clockwise is probably ok. Adjust FOCUS for generally best focus. You will not be able to get it razor sharp all over the screen - start at the center and then try to get the edges and corners as good as you can without messing up the center too much. Double check that the focus is OK at your normal settings of brightness and contrast and at other resolutions that you normally use.

The focus pot is usually located on the flyback transformer or on an auxiliary panel nearby. The focus wire usually comes from the flyback or the general area or from a terminal on a voltage the multiplier module (if used). It is usually a wire by itself going to the little board on the neck of the CRT.

The SCREEN control adjusts background brightness. If the two controls are not marked, you will not do any damage by turning the wrong one - it will be immediately obvious as the brightness will change rather than focus and you can then return it to its original position (or refer to the section on brightness adjustments to optimize its setting).

On a decent monitor, you should be able to make out the individual scanning lines at all resolutions though it will be toughest at the highest scan rates. If they lines are fuzzy, especially in bright areas, then focus may need to be adjusted or there may be an actual fault in the focus circuitry or a defective or just marginal CRT.

Adjusting Monitors with Dual-Focus Flybacks

(From: Andy Cuffe (baltimora@psu.edu).)

I'm sure there is an official procedure, but this always works for me.

First, figure out which control is which. One will appear affect the overall focus. This is the vertical focus control.

The other will mostly affect the width of vertical lines and has the most effect at the left and right edges of the screen. This is the horizontal focus.

Start with both controls near the middle of their range. You need to display something with sharp vertical lines at the edges and sharp horizontal lines in the center (a cross hatch is best).

First, adjust the horizontal focus for the sharpest vertical lines at the edges. Ignore the thickness of the scan lines for now, just make the vertical lines are as thin as possible.

Next, adjust the vertical focus for the thinnest horizontal scan lines in the dead center of the screen. Alternate between the two several times because they interact with each other heavily.

If you don't have any way to display a cross hatch, you can use a computer if it has a TV output, or even the on screen menus of a VCR.

(From: RonKZ650 (RonKZ650@aol.com).)

The old Zeniths with dual focus had a procedure of putting a crosshatch pattern on the screen, adjust one focus for the thinnest vertical line, the other for the thinnest horiz line. This works for me on all dual focus sets. Once you have a crosshatch pattern on the screen it is easy to see which control effects horiz and which effects vertical. From there you have to go back and forth between the two a few times to eventually get both at optimum. I don't like um, but part of the business.

Brightness and color balance adjustment

A monitor which has a picture that is too dark or too bright and cannot be adequately set with the user brightness and contrast controls may need internal adjustment of the SCREEN (the term, screen, here refers to a particular electrode inside the CRT, not really the brightness of the screen you see, though it applies here), MASTER BRIGHTNESS, or BACKGROUND level controls. As components age, including the CRT, the brightness will change, usually decrease. The following procedure will not rejuvenate an old CRT but may get just enough brightness back to provide useful functionality for a few months or longer. If the problem is not with the age of the CRT, then it may return the monitor to full brightness. The assumption here is that there is a picture but the dark areas are totally black and the light areas are not bright enough even with the user brightness control turned all the way up.

Note that circuit problems can also cause similar symptoms. These are particularly likely if the brightness descresed suddenly - CRT emission problems will result in a gradual decrease in brightness over time.

In most cases, the cover will need to be removed. The controls we are looking for may be located in various places. Rarely, there will be access holes on the back or side. However, if there are unmarked holes, then the FOCUS and SCREEN controls are the most likely possibilities.

The controls may be located on the:

- Flyback (LOPT) transformer. Usually there is a master screen control along with a focus control on the flyback transformer.
- A little board on the neck of the CRT. There may be a master screen control. a master brightness control, a master background level control, or individual controls for red, green, and blue background level. Other variations are possible. There may also be individual gain/contrast controls.
- Main video board is less common, but the background level controls may be located here.

Display a black and white picture at the video resolution you consider most important. Select one that has both full blacks and full whites - an nice sunny outdoor scene that has been converted from a color image, for example.

Set the user brightness control to its midpoint and the user contrast control as low as it will go - counterclockwise.

Let the monitor warm up for at least 15 minutes so that components can stabilize.

If there is a MASTER BRIGHTNESS or BACKGROUND level control, use this to make the black areas of the picture just barely disappear. Them, increase it until the raster lines just appear. (They should be a neutral gray. If there is a color tint present, then the individual color background controls will need to be adjusted to obtain a neutral gray.) If there is no such control, use the master screen control on the flyback. If it is unmarked, then try both of the controls on the flyback - one will be the screen control and the other will be focus - the effects will be obvious. If you did touch focus, set it for best overall focus and then get back to the section on focus once you are done here.

If there are individual controls for each color, you may use these but be careful as you will be effecting the color balance. Adjust so that the raster lines in a black area are just visible and dark neutral gray.

If there is a 'service switch' you may prefer to make the adjustment with this in the service position. The raster will collapse to a single horizontal line and the video input will be disabled and forced to black. The BACKGROUND or SCREEN control can then be adjusted as above.

Now for the gain controls. On the little board on the neck of the CRT or on the video or main board there will be controls for R, G, and B DRIVE (also may be called GAIN, or CONTRAST - they are the same). The knobs or slots may even be color coded as to which primary (R,G,B) it affects.

If there are only two then the third color is fixed and if the color balance in the highlights of the picture was ok, then there is nothing more you can do here.

Set the user contrast control as high as it will go - clockwise.

Now adjust each internal color DRIVE control as high as you can without that particular color 'blooming' at very bright vertical edges. Blooming means that the focus deteriorates for that color and you get a big blotch of color trailing off to the right of the edge. You may need to go back and forth among the 3 DRIVE controls since the color that blooms first will limit the amount that you can increase the contrast settings. Set them so that you get the brightest neutral whites possible without any single color blooming.

Note that this is ignoring the effects of any beam current or brightness limiter circuitry. Any recommendations in the service manual should be followed to minimize the chance of excess X-ray emissions as well as to avoid burn-in of the phosphor screen.

Now check out the range of the user controls and adjust the appropriate internal controls where necessary. You may need to touch up the background levels or other settings. Check at the other resolutions and refresh rates that you normally use.

If none of this provides acceptable brightness, then either your CRT is in its twilight years or there is something actually broken in the monitor. If the decrease in brightness has been a gradual process over the course of years, then it is most likely the CRT. As a last resort you can try increasing the filament current to the CRT the way CRT boosters that used to be sold for TVs worked. See the section: Brightening an old CRT.

Optimal procedure for setting brightness/background and screen adjustments

For slight tweaks, the following is not necessary. However, if someone turned all the internal controls, if you are making significant changes that affect G2 (screen), or you are setting up a new or replacement

CRT for the first time, then following the procedure below is desirable to achieve best performance and maximize life of the CRT.

The typical user controls - brightness and contrast can, of course, be set arbitrarily, depending on video content and ambient lighting conditions.

Set the user brightness and contrast controls in the middle for the following adjustments and let the monitor warm up for 20 minutes or so.

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

Now the screen control, that's another matter. It sets the voltage on the second grid of the electron guns, typically between +500 and +1000 V. You will want to use a well-isolated screwdriver for that if it is a naked potentiometer. In the old days there used to be 3 separate potentiometers for 3 G2s, now there is generally only one.

Its purpose is to set the cutoff voltage for the guns, i.e. the voltage between K and G1 at which the beam is just off. The higher you set the VG2, the higher VK - VG1 must be to cut off the beam.

If you set VG2 too low then your picture will be dark. You can compensate for that with the brightness control, which in effect will lower the VKs. A disadvantage is that you will not get optimum sharpness and peak brightness from your picture tube.

If you set VG2 too high then your picture will be bright. You can compensate for that with the brightness control, which in effect will raise the VKs. You might even get retrace lines which can usually not be made to disappear with the brightness control. Another disadvantage is that you will not get optimum LIFETIME from your picture tube. With a too high cutoff voltage the cathode (electron emitting surface) will wear out too soon.

You will need to see the picture tube specifications (or possibly the service manual for the monitor --- sam) in order to find the correct setting for the cutoff voltage. This is measured as VK - VG1 (for each channel RGB) and is typically 130-160 V max. There will be spread between the 3 channels, typically the highest of the 3 measured values will be set against the upper limit.

The usual adjustment procedure is as follows:

- Use any low-level adjustments to set a black picture with all 3 cathode voltages at the specified level (e.g. 130 V) above the VG1 voltage (may be 0 V or 12 V or 20 V ?). (These are typically called RGB brightness, bias, or background level and are often on the little board on the neck of the CRT but not always --- sam).
- Adjust VG2 (screen) until one colour just starts too light up, turn it back down until the screen is just black again. (Occasionally, there are two G2 controls - one on the flyback and another on the CRT neck board or elsewhere. If so, they control are basically in series - leave the one on the flyback alone if the other one has enough range.)
- Now adjust 2 of the 3 low-level black controls until the other 2 colours just light up, and then back to black again.
- Select a white picture and use 2 low-level white (RGB drive or gain, also generally on the neck board --- sam) controls to set the proper colour temperature for white to your own taste.

- Check your black calibration again, may have to iterate a bit.

Position, size, and linearity adjustment

Position and size are usually user controls on computer and video monitors but not on TVs. On monitors with digital controls, they may usually be set for each resolution and (automatically) stored in non-volatile memory so they will be retained when the monitor is turned off. On cheaper monitors, there may be a knobs on the front or back panel and may need to readjusted whenever the scan rate/resolution is changed. Sometimes, there are located internally. There may be separate adjustments for each scan range and may or may not be accessible through holes in the back panel.

There may also be an adjustment called 'horizontal phase' which controls the relative timing of the horizontal sync pulse with respect to retrace. Its effect is subtly different than horizontal position which actually moves the raster. If possible, center the raster and then use H Phase to center the picture.

In monochrome monitors (mostly), position may be set via a pair of rings on the neck of the CRT.

Size can be set to your preference for each scan rate (if they are independent). For computer work, slight underscan is often preferred as all of the frame buffer is visible. However, any slight geometric problems with the raster will be all too visible when compared with the straight sides of the CRT bezel.

Note that resolutions like 640 x 480, 800 x 600, and 1024 x 768 all have a 4:3 aspect ratio. The edge of the image will line up with the bezel on most if not all monitors since CRTs are made to a 4:3 aspect ratio. However, resolutions like 1280 x 1024 and 1600 x 1280 have a 5:4 aspect ratio. With these, in order to get (highly desirable) square pixels, the horizontal size must be adjusted slightly smaller than that required to fill the screen.

For normal viewing of video (television) monitors, raster size should be set so that there is about 10-15 percent overscan all around. This will allow ample margin for power line voltage fluctuations, component aging, and the reduction in raster size that may occur with some VCR special effects (CUE and REV) modes. However, for studio use, underscan is often preferred or at least an option to permit the entire raster to be inspected.

Modern color monitors may not have any horizontal linearity control but you may find this on older models. There may be an internal vertical linearity adjustment. I am not aware of any that have user accessible linearity controls. If there are internal pots or coils, you will need to go back and forth between size and linearity as these adjustments are usually not independent.

Of course, parameters controlling your video card also affect position and size. There is no best approach to reconciling the effects of monitor and video card position adjustments. But, in general, start with the monitor controls centered within their range or use the memory defaults as appropriate. Then, use the video card setup program to optimize the settings. Only if these do not have enough range should you use the monitor controls.

Comments on linearity or lack thereof

(From: Jerry Greenberg (jerryg50@hotmail.com).)

If you can get a grating test generator this would be the proper way to test for non-linearity. Using a camera or device other than that would not be an acceptable reference if you call any engineer from the manufacture. If you mention a grating generator, he will certainly listen.

You would need the service manual for the model to know the specs. Some of these sets can have a non-linearity of up to about 2% near to the edges. Only professional broadcast monitors will be down to the 0.5% and less error factor near to the corners.

On a 27 inch screen 2% can mean an error of can give a visible non-linearity of 0.5 inches. Convergence errors can be as much as 0.25 or 1/4 inch at the corners. Generally they are more accurate than these figures. This is the worse case that is generally accepted on a consumer TV by the manufactures.

I have found that on flat screen consumer TV sets, the linearity sort of gets a bit stretched towards the ends of the scan. This is because of the beam angle. There is compensation for azimuth of beam focus (dynamic focus) and for the scans to a degree that keeps the price of the TV within consumer range.

The screens that are a bit more spherical or rounded will have less of this effect because it is lower in cost to compensate for these errors. A true accurate screen would be one that is spherical following exactly to the beam angle. But, for viewing this would not be very desirable.

Pincushion adjustments

Horizontal pincushion refers to any bowing in or out on the vertical sides of the raster. There is not usually any explicit vertical pincushion adjustment. Adjustment usually uses two controls - amplitude and phase. Pincushion amplitude as its name implies, controls the size of the correction. Pincushion phase affects where on the sides it is applied. Don't expect perfection.

If the controls have no effect, there is probably a fault in the pincushion correction circuitry.

It is best to make these adjustments with a crosshatch or dot test pattern

Geometry adjustment

This refers to imperfections in the shape of the picture not handled by the pincushion and size adjustments. These types of defects include a trapezoidal or keystone shaped raster and jogs or wiggles around the periphery of the raster. Unfortunately, one way these are handled at the factory is to glue little magnets to strategic locations on the CRT and/or rotate little magnets mounted on the yoke frame. Unless you really cannot live with the way it is (assuming there isn't something actually broken), leave these alone! You can end up with worse problems. In any case, carefully mark the position AND orientation of every magnet so that if this happens, you can get back to where you started. If the magnets are on little swivels, some experimenting with them one at a time may result in some improvement. Of course it is best to obtain a service manual and follow its instructions. However, this may not be possible at reasonable cost or at all for many computer monitors.

Why is the convergence on my monitor bad near the edges

Very simple - nothing is quite perfect. Perfect convergence is not even necessarily possible in theory with the set of adjustments available on a typical monitor. It is all a matter of compromises. Consider what you are trying to do: get three electron beams which originate from different electron guns to meet at a single point within a fraction of a mm everywhere on the screen. This while the beams are scanning at an typical effective writing rate of 50,000 mph across the face of a 17" CRT (assumed resolution: 1024x768 at 75 Hz) in a variable magnetic environment manufactured at a price you can afford without a second mortgage!

The specifications for misconvergence have two parts: a center error and a corner error. The acceptable center error is always the smaller of the two - possibly .1-.2 mm. compared to .3-.5 mm in the corners. Very often, you will find that what you are complaining about is well within this specification.

CRT purity and convergence

Purity assures that each of the beams for the 3 primary colors - R, G, B, - red, green, and blue - strikes only the proper phosphor for that color. A totally red scene will appear pure red and so forth. Symptoms of poor purity are blotches of discoloration on the screen. Objects will change shades of color when the move from one part of the screen to another. There may even be excess non-uniformity of pure white or gray images.

Convergence refers to the control of the instantaneous positions of the red, green, and blue spots as they scan across the face of the CRT so that they are as nearly coincident as possible. Symptoms of poor convergence are colored borders on solid objects or visible separate R, G, and B images of fine lines or images,

Note: It is probably best to face the monitor East-West (front-to-back) when performing any purity and convergence adjustments. Since you probably do not know what orientation will eventually be used, this is the best compromise as the earth's magnetic field will be aligned mostly across the CRT. This will minimize the possible rotation of the picture when the unit is moved to its final position but there may be a position shift. Neither of these is that significant so it probably doesn't really matter that much unless you are super fussy. Of course, if you know the final orientation of the monitor use that instead. Or, plan to do the final tilt and position adjustments after the monitor is in position - but this will probably require access to the inside!

First, make sure no sources of strong magnetic fields are in the vicinity of the monitor - loudspeakers, refrigerator magnets, MRI scanners, etc. A nearby lightning strike or EMP from a nuclear explosion can also affect purity so try to avoid these.

Cycle power a couple of times to degauss the CRT (1 minute on, 20 minutes off) - see the section: Degaussing (demagnetizing) a CRT. If the built in degaussing circuits have no effect, use an external manual degaussing coil to be sure that your problems are not simply due to residual magnetism.

Assuming this doesn't help, you will need to set the internal purity and/or convergence adjustments on the CRT.

First, mark the positions of all adjustments - use white paint, 'White out', or a Magic Marker on the ring magnets on the neck of the CRT, the position and tilt of the deflection yoke, and any other controls that you may touch deliberately or by accident.

Note: if your monitor is still of the type with a drawer or panel of knobs for these adjustments, don't even think about doing anything without a service manual and follow it to the letter unless the functions of all the knobs is clearly marked (some manufacturers actually do a pretty good job of this).

CRT purity adjustment

Purity on modern CRTs is usually set by a combination of a set of ring magnets just behind the deflection yoke on the neck of the CRT and the position of the yoke fore-aft. As always, mark the starting position of all the rings and make sure you are adjusting the correct set if rings!

Use the following purity adjustment procedure as a general guide only. Depending on the particular model monitor, your procedure may substitute green for red depending on the arrangement of guns in the CRT. The procedures for dot-mask, slot mask, and Trinitron (aperture grille) CRTs will vary slightly. See you service manual!

Obtain a white raster (sometimes there is a test point that can be grounded to force this). Then, turn down the bias controls for blue and green so that you have a pure red raster. Let the monitor warm up for a minimum of 15 minutes.

Loosen the deflection yoke clamp and move the yoke as far back as it will go,

Adjust the purity magnets to center the red vertical raster on the screen.

Now, move the yoke forward until you have the best overall red purity. Tighten the clamp securely and reinstall the rubber wedges (if your CRT has these) to stabilize the yoke position. Reset the video adjustments you touched to get a red raster.

CRT convergence adjustment

In the good old days when monitors were monitors (and not just a mass produced commodity item) there were literally drawers or panels full of knobs for setting convergence. One could spend hours and still end up with a less than satisfactory picture. As the technology progressed, the number of electronic adjustments went down drastically so that today there are very few if any. However, some high end monitors do have user accessible controls for minor adjustment of static (center) convergence.

Unless you want a lot of frustration, I would recommend not messing with convergence. You could end up a lot worse. I have no idea what is used for convergence on your set but convergence adjustments are never quite independent of one another. You could find an adjustment that fixes the problem you think you have only to discover some other area of the screen is totally screwed. In addition, there are adjustments for geometry and purity and maybe others that you may accidentally move without even knowing it until you have buttoned up the set.

Warning: Accurately mark the original positions - sometimes you will change something that will not have an obvious effect but will be noticeable later on. So it is extremely important to be able to get back to where you started. If only red/green vertical lines are offset, then it is likely that only a single ring needs to be moved - and by just a hair. But, you may accidentally move something else!

If you really cannot live with it, make sure you mark everything very carefully so you can get back to your current state. A service manual is essential!

Convergence is set using a white crosshatch or dot test pattern. For PCs (a similar approach applies to workstations) If you do not have a test pattern generator, use a program like Windows Paint to create a facsimile of a crosshatch pattern and use this for your convergence adjustments. For a studio video monitor, any static scene (from a camcorder or previously recorded tape, for example) with a lot of fine detail will suffice.

Static convergence sets the beams to be coincident in the exact center of the screen. This is done using a set of ring magnets behind the purity magnets on the CRT neck. (Set any user convergence controls to their center position).

Adjust the center set of magnets on the CRT neck to converge blue to green at the center of the screen. Adjust the rear set of magnets to converge red to green at the center of the screen." Your monitor may have a slightly different procedure.

Dynamic convergence adjusts for coincidence at the edges and corners.

On old tube, hybrid, and early solid state monitors, dynamic convergence was accomplished with electronic adjustments of which there may have been a dozen or more that were not independent. With modern monitors, convergence is done with magnet rings on the neck of the CRT, magnets glued to the CRT, and by tilting the deflection yoke. The clamp in conjunction with rubber wedges or set screws assures that the yoke remains in position.

Remove the rubber wedges.

Loosen the deflection yoke clamp just enough so that it can be tilted but will remain in the position you leave it. Rock the yoke up and down to converge the right and left sides of the screen. Rock the yoke from side to side to converge the top and bottom of the screen. The rubber wedges can be used as pivots to minimize the interaction between the two axes but you may need to go back and forth to optimize convergence on all sides. Reinstall the wedges firmly and tape them to the CRT securely. Tighten the yoke clamp enough to prevent accidental movement.

Some monitors may use a plastic frame and set screws instead of just a clamp and rubber wedges but the procedure is similar.

Refer to your service manual. (Is this beginning to sound repetitious?)

For additional comments on convergence adjustments, see the section: Tony's notes on setting convergence on older delta gun CRTs.

Tilted picture

You have just noticed that the picture on your fancy (or cheap) monitor is not quite horizontal - not aligned with the front bezel. Note that often there is some keystoning or other geometric distortion as well where the top and bottom or left and right edges of the picture are not quite parallel - which you may never have noticed until now. Since this may not be correctable (at least, not without a lot of hassle), adjusting tilt may represent a compromise at best between top/bottom or left/right alignment of the picture edges. You may never sleep again knowing that your monitor picture is not perfect! BTW, I can sympathize with your unhappiness. Few things are more annoying than a just noticeable imperfection such as this.

This is probably one reason why older monitors tended not to be able to expand the picture to totally fill the screen - it is easier to overlook imperfect picture geometry if there is black space between the edges of the picture and the bezel!

There are several possible causes for a tilted picture:

1. Monitor orientation. The horizontal component of the earth's magnetic field affects this slightly. Therefore, if you rotate the unit you may be able to correct the tilt. Of course, it will probably want

to face the wall!

2. Other external magnetic fields can sometimes cause a rotation without any other obvious effects - have you changed the monitor's location? Did an MRI scanner move in next door?

3. Need for degaussing. Most of the time, magnetization of the CRT will result in color problems which will be far more obvious than a slight rotation. However, internal or external shields or other metal parts in the monitor could become magnetized resulting a tilt. More extensive treatment than provided by the built-in degaussing coil may be needed. Even, the normal manual degaussing procedure may not be enough to get close enough to all the affected parts.

4. You just became aware of it but nothing has changed. Don't dismiss this offhand. It is amazing how much we ignore unless it is brought to our attention. Are you a perfectionist? Did your friend just visit boasting about his P8-1000 screamer and point the tilt out to you?

5. There is an external tilt control which may be misadjusted. Newer Sony monitors have this (don't know about TVs) - a most wonderful addition. Too bad about the stabilizing wires on Trinitron CRTs. A digital control may have lost its memory accidentally. The circuitry could have a problem.

   For example, on the Sony CPD1730, you press the left arrow button and blue '+' button at the same time. Then adjust the tilt with the red buttons.

6. There is an internal tilt control that is misadjusted or not functioning. The existence of such a control is becoming more common.

7. The deflection yoke on the CRT has gotten rotated or was not oriented correctly at the time of the set's manufacture. Sometimes, the entire yoke is glued in place in addition to being clamped adding another complication.

   If the monitor was recently bumped or handled roughly, the yoke may have been knocked out of position. But in most cases, the amount of abuse required to do this with the yoke firmly clamped and/or glued would have totally destroyed it in the process.

   There is a risk (in addition to the risk of frying yourself on the various voltages present inside an operating monitor) of messing up the convergence or purity when fiddling with the yoke or anything around it since the yoke position on the neck of the tube and its tilt may affect purity and convergence. Tape any rubber wedges under the yoke securely in place as these will maintain the proper position and tilt of the yoke while you are messing with it. (Don't assume the existing tape will hold - the adhesive is probably dry and brittle).

8. The CRT may have rotated slightly with respect to the front bezel. Irrespective of the cause of the tilt, sometimes it is possible to loosen the 4 (typical) CRT mounting screws and correct the tilt by slightly rotating the CRT. This may be easier than rotating the yoke. Just make sure to take proper safety precautions when reaching inside!

Monochrome monitor size, position, and geometry adjustments

These tend to be a lot simpler and less critical than for color monitors or TV sets.

On a monochrome (B/W) monitor you will probably see some of the following adjustments:

1. Position - a pair of rings with tabs on the neck of the CRT. There may be electronic position adjustements as well.
2. Width and height (possibly linearity as well) controls. There may be some interaction between size and linearity - a crosshatch test pattern is best for this. Vertical adjustments are almost always pots while horizontal (if they exist) may be pots and/or coils. Where desired, set sizes for 5-10% overscan to account for line voltage fluctuations and component drift. Confirm aspect ratio with test pattern which includes square boxes.
3. Geometry - some little magnets either on swivels around the yoke or glued to the CRT. If these shifted, the the edges may have gotten messed up - wiggles, dips, concave or convex shapes. There may be a doxen or more each mostly affecting a region around the edge of the raster. However, they will not be totally independent.

Check at extremes of brightness/contrast as there may be some slight changes in size and position due to imperfect HV regulation.

There may be others as well but without a service manual, there is no way of knowing for sure.

Just mark everything carefully before changing - then you will be able to get back where you started.

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Low Voltage Power Supply Problems

Low voltage power supply fundamentals

Monitors require a variety of voltages (at various power levels) to function. The function of the low voltage power supply is to take the AC line input of either 115 VAC 60 Hz (220 to 240 VAC 50 Hz or other AC power in Europe and elsewhere) and produce some of these DC voltages.

- In all cases, the power to the horizontal output transistor (HOT) of the horizontal deflection system (B+) is obtained directly from the low voltage power supply.

  Note: we will often use the term 'B+' to denote the main DC voltage that powers the horizontal deflection system of most monitors.

- In some cases, some other DC voltages are also derived directly from the AC line by rectification, filtering, and possibly regulation.
- With small video monitors which operate at a fixed scan rate (e.g., TV monitors), many or most of the low voltages may be derived from secondary windings on the flyback (LOPT) transformer of the horizontal deflection system.
- The typical SVGA autoscan monitor will use one or more switchmode power supplies (SMPSs) to provide most or all of the low voltages - the flyback isn't used for this purpose. (High voltage is obtained from a flyback type supply or a separate HV module in which case there may be no flyback at all!)

- There are also various (and sometimes convoluted) designs using combinations of any or all of the above.

Typical Switchmode Power Supply for Small SVGA Color Monitor shows the complete schematic for the SMPS from a "I guarantee you never heard of the brand name" monitor.

The AC line input and degauss components are at the upper left, the SMPS chopper, its controller, and feedback opto-isolator are lower left/middle, and the secondaries - some with additional regulation components - occupy the entire right side of this diagram. Even for relatively basic application such as this, the circuitry is quite complex. There are more than a half dozen separate outputs regulated in at least 3 different ways!

For large high performance auto-scan monitors, it becomes even worse as highly stable voltages need to be programmed based on a wide range of scan rates. Several common design approaches are used to generate the required variable regulated B+ voltage:

1. A separate programmable SMPS generates the B+. This is done by selecting its reference voltage or the fraction of the output voltage that is fed back to the regulator.

2. A voltage from the main SMPS is fed through an additional series switchmode or linear regulator that drops it down to the required value.

3. One of several fixed post-regulators is selected based on scan rate.

Technique (2) is used by the power supply is the diagram, above. Can you locate the circuitry? Hint: Look in the upper right hand corner of the schematic.

The need for a variable B+ is one area where a typical PC monitor departs significantly in design compared to a TV or fixed scan rate studio or workstation monitor. Nearly everything is made more complex as a result of this requirement.

Components of the low voltage power supply

All monitor low voltage power supplies will have:

1. A power switch, relay, or triac to enable main power.

2. Various line filter, RFI, and surge suppression components (coupled inductors, LCL filter networks, MOVs, etc.).

3. A set of rectifiers - usually in a bridge or doubler configuration - to turn the AC into DC. Additional small ceramic capacitors are normally placed across the diodes to reduce RF interference. There may be an inrush current limiter in the form of an NTC (Negative Temperature Coefficient) resistor.

4. One or more large filter capacitors to smooth the unregulated DC. This voltage is either around 300 to 320 VDC (doubled from 115 VAC or bridge rectified from 230 VAC) for compatibility with U.S. and foreign power or 150 to 160 VDC bridge rectifier from the 115 VAC line.

   Many monitors permit the input voltage to be either 115 or 230 VAC depending on a switch or jumper, or automatically adapt to these or a range of input voltages - usually 100 to 240 VAC or DC. The latter are termed 'universal' power supplies.

5. A discrete, hybrid, IC, or switchmode regulator to provide B+ to the horizontal deflection.
6. Some means of generating the various other DC voltages required by the monitor's analog and logic circuitry.

Items (1) to (6) may be part of a separate low voltage power supply module or located on the mainboard.

7. Zero or more voltage dividers and/or regulators to produce additional voltages directly from the line power. This relatively rare except for startup circuits. THESE VOLTAGES WILL NOT BE ISOLATED FROM THE AC LINE!
8. A degauss control circuit usually including a thermistor or Posistor (a combination of a heater disk and Positive Temperature Coefficient (PTC) thermistor in a single package). Monitors having manual degauss buttons will include additional circuitry.
9. A startup circuit for booting the horizontal deflection if various voltages to run the monitor are derived from the flyback. This may be an IC, discrete multivibrator, or something else running off a non-isolated voltage or the standby power supply, or it may be derived from the video input. (Mostly small video monitors, not autoscan types.) However, the SMPS itself will have a startup circuit!
10. A standby power supply if the monitor doesn't use a latching power switch. Usually, this is a separate low voltage power supply using a small power transformer for line isolation.

What symptoms are likely the result of a low voltage power supply problem?

There are an almost unlimited number of possibilities but the following probably covers the most likely:

- Monitor is as dead as a concrete block - no picture or raster, no LEDs lit, no sounds of life (like degauss) of any kind.

  Most likely causes: No power at AC outlet or outlet strip, bad or loose line cord, bad power switch, blown fuse due to internal short or overload.

- No picture but unusual sounds like a whine, periodic clicks, tweets, or flubs, and/or possibly flickering or flashing front panel LEDs.

  Most likely causes: Excessive load or short on output of power supply (shutdown or cycling due to overcurrent) or loss of horizontal drive (cycling from overvoltage due to lack of load).

- Unusual aromas, smoke, or six foot flames coming from inside the case.

  Most likely causes: Failed parts in low voltage power supply, deflection, or high voltage sections.

  Actually, while burning smells and even smoke aren't that unusual when parts overheat as a result of a short circuit, actual fire is quite unlikely due to regulatory design requirements for materials and protection devices UNLESS safety systems have been tampered with or the monitor has been operated in an environment where there is lots of flammable dust.

- Jittering, vibrating, or unstable picture.

Most likely causes: External magnetic interference or power line noise, hum in various power supply voltages resulting from dried up main filter capacitor(s) or other capacitors, resistors out of tolerance - all affecting power supply regulation.

- Loss of video, deflection, geometry or size problems, or some or all adjustments have no effect.

  Most likely causes: Failure of one or more power supply voltages, selection circuitry not selecting properly (autoscan monitors), bad connections.

- Monitor doesn't power up immediately.

  Most likely causes: Dried up electrolytic capacitors in power supply or bad connections.

- Interaction of adjustments. For example, turning up the brightness results in a loss of sync or a wavy raster.

  Most likely causes: Poor power supply regulation due to bad capacitor, resistor, regulator, or other component - or bad connections.

Note that the underlying cause may not be in the low voltage power supply itself but may actually be elsewhere - a shorted horizontal output transistor or deflection yoke, for example. This results in either the power supply shutting down, becoming extremely unhappy, blowing a fuse, or just plain dying. Thus, we cannot really limit our investigation to only the power supply! In fact, with so many interconnected systems in a monitor, particularly a high performance SVGA model - it can require the services of a master sleuth Sherlock Holmes type to identify the perpetrator!

However, before you break out the socket wrenches and DMM (or 10 pound hammer!) or call Scotland Yard, double check that:

- your AC outlet is live, the power cord is intact (not chewed by the dog), is firmly seated, and the monitor is switched on.
- that you have a valid video signal, the video cables are securely attached to the proper connectors (e.g., BNCs) and/or there are no bent over pins (e.g., VGA/SVGA HD15 or Mac DB15).
- the monitor isn't being commanded to go into a power savings mode because your computer thinks it is smarter than you!
- you have the front panel switches and controls set properly and the video source selection is correct. Reset it to factory defaults.

If possible, try the monitor with another known good video input that is compatible with its scan rates and signal levels or substitute a known good monitor for the suspect unit. In other words, try to rule out external problems and 'cockpit error'.

Monitor power supply problems

WARNING: Always use an isolation transformer when working on a monitor but this is especially important - for your safety - when dealing with the non-isolated line operated power supply section. Read and follow the safety guidelines presented last month and at my Web site.

The following can cause symptoms of a dead or mostly dead monitor:

1. Shorted Horizontal output transistor (HOT). This will usually blow a fuse or fusable resistor as well if fed directly from the AC line. However, when fed by a SMPS, the result may just be a soft audible whine or periodic tweet or flub possibly accompanied by flashing front panel LEDs. Here, the failure is not in the power supply itself but may result in damage to it or other components especially if it continues to run in this state.

2. Shorted output rectifier diodes can load down the outputs to the point of shutting down or resulting in the same audible symptoms as (1) above.

3. Flyback transformer can have shorted windings or shorts in the focus/screen divider network which load down the output.

   These (primary shorts in particular) may cause the horizontal output transistor to fail as well. This is a common problem with older MacIntosh computers and video terminals. Some secondary faults may not be instantly destructive but result in little or no high voltage and eventual overheating.

4. Some load or even the CRT could be shorted leading similar behavior or blowing fuses or fusable resistors which then result in no power to that circuitry.

5. Failure in horizontal drive chain - horizontal oscillator, driver, or driver transformer. Newer monitors may use an IC for the oscillator and this can fail. Without drive, there will be no deflection and this will either result in no high voltage directly (when it is derived from the horizontal deflection) or cause it to be shut down to prevent CRT screen burn (from a stationary spot or line). When powered by an SMPS, there may be an audible ticking from the SMPS cycling on overvoltage due to lack of load. This is also not a failure of the power supply itself.

6. Failure of an SMPS to start. There can be any number of causes though dried up electrolytic capacitors and open high value startup resistors are high on the list if the chopper transistor is not blown.

7. Cold solder joints or other bad connections - monitors tend to have these as a result of temperature cycling and with all too many - poor manufacturing quality control. It is possible that no parts have been damaged - at least not yet. Resoldering may be all that is needed.

If there is B+ (typically 60 to 150 VDC depending on the scan rate) at the output of the power supply but nothing on the HOT collector, an open fusable resistor, blown fuse, or bad connection, is likely.

If there is voltage on the HOT collector, there is probably a drive problem.

Troubleshooting the switchmode power supply

If the SMPS is a separate module, it may be possible to unplug its output connector and test it for proper operation independently of the monitor circuitry. However, a minimum load may be needed at least on the output that is used for regulation feedback and there could be other interlocks that will complicate your testing.

The most common failures in monitor SMPSs are:

- Main chopper transistor - in a monitor, this is often an expensive power MOSFET.

- Other shorted semiconductors - particularly high speed rectifiers on the secondary side of the high frequency transformer.
- Dried up electrolytic capacitors leading to startup and regulation problems.
- Open high value startup resistors resulting in no initial drive to chopper.
- Bad connections (is this sounding repetitive?).

See the document: Notes on the Troubleshooting and Repair of Small Switchmode Power Supplies for more information.

Common problems

Here are just a few of those that you may come across:

Power button on monitor is flakey

If the on/off (or other button) on the monitor itself behaves erratically then the most likely cause is the obvious - the button or switch is dirty or worn. Believe it or not, this isn't as unusual as you might think On a momentary pushbutton, if you can get at it, some contact cleaner may help. Replacement with a common pushbutton or toggle type switch (as appropriate) available at Radio Shack may be much easier than attempting to locate the original part!

Dead monitor

This means that there is absolutely no evidence of anything happening when the power switch is activated.

The most like causes are:

- Outlet isn't live, power cord is loose or defective. Try something else in the outlet, inspect/replace the power cord.
- Bad power switch. With plug pulled, check for continuity in the on or pressed position.
- Blown fuse or fusable resistor (probably from shorted parts in power supply or elsewhere like the HOT). It usually won't hurt to try a replacement fuse with exactly the same ratings but don't be surprised if it blows.
- Bad power supply (not starting up or just dead), bad connections. However, degauss would likely still operate in this case.

Monitor blows fuse

A blown fuse is a very common type of fault due to poor design very often triggered by power surges due to outages or lightning storms. However, the most likely parts to short are easily tested, usually in-circuit, with an ohmmeter and then easily removed to confirm.

Note that it *may be* useful to replace a fuse the *first* time it blows (though it would be better to do some basic checks for shorted components first as there is a small chance that having a fuse blow the second time could result in additional damage which would further complicate the troubleshooting process). However, if the new one blows, there is a real problem and the only use in feeding the TV fuses will be to keep the fuse manufacturer in business!

Sometimes, a fuse will just die of old age or be zapped by a power surge that caused no damage to the rest of the monitor. However, it must be an EXACT replacement (including slo-blow if that is what was there originally). Else, there could be safety issues (e.g., fire hazard or equipment damage from too large a current rating) or you could be chasing a non-existent problem (e.g., if the new fuse is not slo-blow and is blown by the degauss circuit inrush current but nothing is actually wrong).

If the fuse blows absolutely instantly with no indication that the circuits are functioning (no high pitched horizontal deflection whine (if your dog hides under the couch whenever the monitor is turned on, something is probably working).) then this points to a short somewhere quite near the AC power input. However, if there is indication of life - for a second or two, or longer, and then the fuse blows, the cause is likely an overload on the power supply. See the section: Dead monitor with audible whine, periodic tweet or flub, and low-low voltage since similar causes apply.

For the instantly blown fuse case, the most common places to look would be:

- Degauss Posistor. This is a combination of a heater and PTC thermistor which controls current to the degauss coil upon power-on. These tend to like to turn into short circuits.
- Shorted parts in the AC input line filter caps and MOVs.
- Diode(s) in main bridge.
- Main filter capacitor(s).
- SMPS chopper (usually a MOSFET) if there is a line operated SMPS or HOT (if a deflection derived power supply).

You should be able to eliminate these one by one using a multimeter to check for short circuits/low resistance. It is best to remove at least one side of each component while testing to avoid sneak paths which can fool your meter.

WARNING: Make sure to unplug the monitor and discharge the main filter capacitor(s) before attempting any of the following measuremente!

Unplug the degauss coil as this will show up as a low resistance.

- Measure across the input to the main power rectifiers - the resistance should not be that low (though it may start out at zero and climb as the main filter capacitors charge). A reading of only a few ohms may mean a shorted rectifier or two, a shorted Posistor, or a fried MOV.
- Test the posistor (if present). Trace back from the degauss connector - it will probably be nearby. The posistor is a little cubical component (about 1/2" x 3/4" x 1") with 3 legs. It includes a line operated heater disk (which often shorts out) and a PTC (Positive Temperature Coefficient) thermistor to control current to the degauss coil. The easiest thing to do it so remove the posistor and try power. If the monitor now works, obtain a replacement but in the meantime you just won't have the automatic degauss.

- Remove and test the HOT or chopper with an ohmmeter. A reading of less than 10 ohms between any combination of pins means the device is shorted.

For everything but the HOT or chopper, replacing the bad parts should be all that is needed - these rarely fail due to OTHER parts going bad.

However, if the HOT or chopper tests bad, it is possible (though not always the case) that something downstream is causing an excessive load which caused the part to fail. Therefore, don't put the cover back on just yet!

With the HOT or chopper removed, it should be possible to power the monitor with your series light bulb. Of course, not much will work - surprise, surprise. :-) With the deguass coil unplugged, the light should flash once as the main filter caps charge and then remain dark.

WARNING: Unplug the monitor and discharge the main filter caps after trying this experiment!

Install a new transistor and power the monitor using your series light bulb.

- If the bulb now flashes once and then settles down to a low brightness level, the monitor may be fine. See if there is an indication of deflection and HV - look for the glow of the CRT filaments and turn up the brightness to see if there is any indication of a raster. With the light bulb, not everything will be normal but some life would be a good sign. Even a pulsating light bulb may just mean that the light bulb is too small for the monitor power requirements. It may be safe to try a higher wattage bulb.

- However, if the bulb glows at close to full brightness, there is probably still some fault elsewhere. Don't be tempted to remove the light bulb just yet. There is still something wrong. Continue to search for shorted parts.

  See if you can locate any other large power transistors in metal (TO3) cans or large plastic (TOP3) cases. There may be a separate power transistor that does the low voltage regulation or a separate regulator IC or hybrid. As noted, some monitors have a switchmode power supply that runs off a different transistor than the HOT. There is a chance that one of these may be bad.

  If it is a simple transistor, the same ohmmeter check should be performed.

If none of this proves fruitful, it may be time to try to locate a schematic or a service center.

Internal fuse blew during lightning storm (or elephant hit power pole)

Power surges or nearby lightning strikes can destroy electronic equipment. However, most of the time, damage is minimal or at least easily repaired. With a direct hit, you may not recognize what is left of it!

Ideally, electronic equipment should be unplugged (both AC line and phone line!) during electrical storms if possible. Modern TVs, VCRs, microwave ovens, and even stereo equipment is particularly susceptible to lightning and surge damage because some parts of the circuitry are always alive and therefore have a connection to the AC line. Telephones, modems, and faxes are directly connected to the phone lines. Better designs include filtering and surge suppression components built in. With a near-miss, the only thing that may happen is for the internal fuse to blow or for the microcontroller to go bonkers and just require power cycling. There is no possible protection against a direct strike. However, devices with power switches that totally break the line connection are more robust since it takes much more voltage to jump the gap in the switch than to fry electronic parts. Monitors and TVs may also have their CRTs magnetized due to the electromagnetic fields associated with a lightning strike - similar but on a smaller scale to the EMP of a nuclear detonation.

Was the monitor operating or on standby at the time? If it was switched off using an actual power switch (not a logic pushbutton), then either a component in front of the switch has blown, the surge was enough to jump the gap between the switch contacts, or it was just a coincidence (yeh, right).

If it was operating or on standby or has no actual power switch, then a number of parts could be fried.

Monitors usually have their own internal surge protection devices like MOVs (Metal Oxide Varistors) after the fuse. So it is possible that all that is wrong is that the line fuse has blown. Remove the case (unplug it first!) and start at the line connector. If you find a blown fuse, remove it and measure across the in-board side of fuse holder and the other (should be the neutral) side of the line. The ohmmeter reading should be fairly high - more than 100 ohms in at least one direction. You may need to unplug the degaussing coil to get a reasonable reading as its resistance may be less than 30 ohms. If the reading is really low, there are other problems. If the resistance checks out, replace the fuse and try powering the monitor. There will be three possibilities:

1. It will work fine, problem solved.

2. It will immediately blow the fuse. This means there is at least one component shorted - possibilities include an MOV, line rectifiers, main filter cap, regulator transistor, horizontal output transistor, etc. You will need to check with your ohmmeter for shorted semiconductors. Remove any that are suspect and see of the fuse now survives (use the series light bulb to cut your losses - see the section: The series light bulb trick.

3. It will not work properly or appear dead. This could mean there are open fusable resistors other defective parts in the power supply or elsewhere. In this case further testing will be required and at some point you may need the schematic.

If the reading is very low or the fuse blows again, see the section: Monitor blows fuse.

Fuse replaced (doesn't blow) but monitor is still nearly dead

There may be a click indicating that the power relay is engaging (there could be bad contacts though this isn't that likely) and the degauss is probably working now.

Since the fuse doesn't blow now (you did replace it with one of the same ratings, right?), you need to check for:

- Other blown fuses. Occasionally there are more than one in a monitor.

- Open fusable resistors. These are usually low values (a few ohms or less) and are in big rectangular ceramic power resistor cases or smaller blue or gray colored cylindrical power resistors. They are supposed to protect expensive parts like the HOT but often blow at the same time - or the expensive HOT or SMPS chopper sacrifices itself to save the 25 cent resistor.

If any of these test open, they will need to be replaced with flameproof resistors of the same ratings. However, you can substitute an ordinary resistor for testing purposes ONLY as long as you don't leave the monitor unattended.

If you find one bad part, still check other power components for shorts or opens as more than one part may fail and just replacing that one may cause it to fail again. These include (depending on your monitor): Rectifier diodes, main filter capacitor(s), fuses and fusable resistors, horizontal output transistor, regulator pass or chopper transistor.

Assuming nothing tests faulty so far, clip a voltmeter set on its 500 V or higher scale across the horizontal output transistor and turn the power on. Warning - never measure this point if the horizontal deflection is operating. It is OK now since the monitor is dead. If the voltage here is 60 to 150 V, then there is a problem in the drive to the horizontal output circuit. If it is low or 0, then there are still problems in the power supply.

No picture but indications of power

The screen is blank with no raster at all. There are indications that the power is alive - the status LEDs are lit and you can hear the normal relay clicking sounds when you change video modes. This indicates that some of the low voltages are present but these may be derived from the standby supply.

Assuming there is no deflection and no HV, you either have a low voltage power supply problem, bad startup circuit, or bad horizontal output transistor (HOT)/bad parts in the horizontal deflection.

Check for bad fuses.

(If you have HV as indicated by static electricity on the front of the screen and you hear the high pitched whine of the horizontal deflection when it is turned on, then the following does not apply).

1. Use an ohmmeter to test the HOT for shorts. If it is bad, look for open fusable resistors or other fuses you did not catch.

2. Assuming it is good, measure the voltage on the collector-emitter of the HOT (this is safe if there is no deflection). You should see the B+ of between 60 and 150 V (typical) depending on mode (for a auto-scan monitor).

3. If there is no voltage, you have a low voltage power supply problem and/or you have not found all the bad/open parts. The flyback primary winding may be open as well.

4. If there is voltage and no deflection, you probably have a startup problem - all TVs and most monitors need some kind of circuit to kick start the horizontal deflection until the auxiliary power outputs of the flyback are available. Some designs use a simple multivibrator for this - a couple of transistors. Others power the horizontal oscillator IC from a special line-derived voltage.

   Look for pulses at the HOT base. If there are none, trace back to the driver and oscillator. Most likely: the power for startup is missing.

   Test the transistors if it is that type with an ohmmeter. If one is shorted, you have a problem. The usual way a TV service person would test for startup problems is to inject a signal to the base of the HOT of about 15.75 kHz. If the TV then starts and runs once this signal is removed, the diagnosis is confirmed. This is very risky for monitors and I would not recommend it - you can all too easily blow things up if not careful (including yourself).

If you hear the high pitched whine of the deflection (probably not for workstation or SVGA computer monitors unless you are a bat) and/or feel some static on the scree, confirm that the horizontal deflection and high voltage are working by adjusting the SCREEN control (probably on the flyback). If you can get a raster then your problem is probably in the video (or chroma) circuits, not the deflection or high voltage.

Monitor deflection derived power supply faults

This section applies to studio video monitors, small computer terminals, and most TVs, which derive many of their supply voltages from auxilary windings on the flyback transformer.

The following are common areas of failure:

- Horizontal output transistor (usually a TO3 metal or TOP3 plastic case shorts out. This will usually blow a fuse or fusable resistor as well.
- Horizontal drive chain - horizontal oscillator, driver, or driver transformer. Newer monitors may use an IC for the oscillator and this can fail.
- Startup - There may be some kind of startup circuit which gets the whole thing going until the auxiliary voltages are available. This could be as simple as a multivibrator or transistor regulator to provide initial voltage to the horizontal oscillator chip or circuit.
- Output rectifier diodes can fail shorted and load down the outputs to the point of shutting down.
- Some load could be shorted or a capacitor could be shorted leading to overload and shutdown.
- Flyback transformer can have shorted windings which load down the output. These (primary shorts in particular) may cause the horizontal output transistor to fail as well. Common problem with older MacIntosh computers and video terminals. Some secondary faults may not be instantly destructive but result in little or no high voltage and overheating.
- Cold solder joints or other bad connections - monitors tend to have these as a result of temperature cycling and bad manufacturing. (Is this sounding repetitive yet?)
- Sometimes there is a series regulator after the filter cap and this could be bad as well.

Without a schematic, I would attempt to trace the circuit from the main filter cap or output of the line operated switchmode power supply assuming that has the proper (approx. 60-120 VDC depending on scan range) voltage.

If you can locate the horizontal output transistor, see if there is voltage on its collector, should be the same. If there is, then there is probably a drive problem. If you have an ECG or similar semi cross reference, that will help you identify the ICs and transistors and locate the relevant portions of the circuitry.

If there is no voltage at the horizontal output transistor, then there is probably a blown fuse or bad connection somewhere or a fault in the line operated SMPS if there is one. However, the fuse may have blown due to a fault in the SMPS or horizontal deflection.

Power-on tick-tick-tick or click-click-click but no other action

A variety of problems can result in this or similar behavior. This applies to both monitors using SMPSs and flyback derived power supplies. Possibilities include:

- Lack of horizontal drive. The main regulator is cycling on overvoltage due to very little load.
- Excessive load or faulty power supply cycling on its overcurrent protection circuit. The sound in this case may be more like a tweet-tweet-tweet or flub-flub-flub, however - see the section: Dead monitor with audible whine, periodic tweet or flub, and low-low voltage.
- HV shutdown, or some other system detecting an out of regulation condition. However, in this case, there should be some indication that the deflection and HV is attempting to come up like momentary high pitched deflection whine, static on the screen, etc.
- A dried up main filter capacitor or other filter capacitor in the low voltage power supply that is producing an out-of-regulation condition
- A problem with the microcontroller, relay or its driver, or standby power supply.

If you have a Variac, vary the line voltage and observe the monitor's behavior. It may work fine at one extreme (usually low) or the other. This might give clues as to what is wrong.

Dead monitor with audible whine, periodic tweet or flub, and low-low voltage

A monitor which appears to be dead except for an audible whine or a once a second or so tweet or flub coming from the SMPS usually indicates an overload fault in the power supply itself or a short in one of its load circuits (usually the main B+). In most cases, the voltages (including B+) will be reduced to a fraction of their normal value (and/or be pulsing along with the animal sounds) as a result of the overload. The power (or other) LED may be weak or flashing as well. Flyback derived power supplies are less likely to exhibit these symptoms.

Note: using too small a series light bulb while testing for the size of the monitor may also result in this condition. If you have found and replaced a bad part, it increase the wattage of the light bulb and try again. If the frequency of the cycling decreases - i.e., it stays up longer, it may be safe to remove the light bulb entirely.

Summary of possible causes:

- Shorted rectifiers or capacitors on secondary side of SMPS.
- Other problems in the power supply or its controller like bad caps.
- Shorted HOT.
- Flyback with shorted turns or breakdown in focus/screen divider network.
- Short or excessive load on secondary supplies fed from flyback.
- Short in horizontal yoke windings.
- Bad solder connections.

Note that a whine may be perfectly normal for your monitor if there is no video input - confirm that there is a signal that is compatible with the monitor's scan rate(s) and type of sync (e.g., separate, composite, or sync-on-green).

However, where a confirmed good video input is present, this may indicate an overloaded low voltage switching power supply.

The whine is caused by the switching power supply's chopper frequency dropping down due to the overload. The periodic tweet or flub is caused by the SMPS attempting to come up, sensing the excessive load, and restarting.

Test the B+ input to the flyback.

If it is near zero, test the HOT for shorts and replace if defective, but continue testing with a series light bulb and/or Variac. There may be something causing the HOT to go bad like a shorted flyback or bad damper diode or snubber cap.

If the voltage is not zero but is low (e.g., it should be 120 V but is only 60 V) or fluctuating in time with the tweet or flub, there may be a problem with:

1. The SMPS. Test with a substitute load like a 40 W light bulb or power resistor. If the supply now outputs full voltage, it is probably fine. For a power resistor, select a value such that the load at the expected voltage will be about 1/2 to 2/3 of the nameplate power rating of the monitor.

   One common type of failure are shorted rectifiers in the switching supply or secondary supplies running off the flyback. The HFR854s (one popular type in monitors) or other high speed high efficiency rectifiers in the output side of the switching power supply or flyback seem to like to turn into short circuits. (I had a couple of DOA monitors where this was the problem. so much for quality control!)

   WARNING: Unplug the monitor and discharge the main filter caps before attempting the following tests!

   Use an ohmmeter to check the various diodes in the power supply. The higher power diodes appear commonly as black cylinders about 3/8" long by 1/4 diameter - kind of like 1N400Xs on steroids. The resistance of the diodes in at least one direction should be greater than 50 ohms in-circuit. If you find one that is much less (like 0 or 5 ohms), then it is probably bad. Unsolder and check again - it should test infinite (greater than 1M ohms) in one direction. If it now tests good, there may be something else that is shorted.

   Replacements are available for about $0.25 from places like MCM Electronics.

2. Flyback (LOPT) transformer - shorted windings. See the document: Testing of Flyback (LOPT) Transformers.

3. Deflection yoke - shorted turns in the horizontal or geometry correction windings. See the section: Deflection yoke testing.

4. Excess load on one of the flyback's secondaries. Disconnect all secondary output pins from the flyback if possible and see if your B+ returns to normal.

5. Improper drive to HOT. Inspect with an oscilloscope. The drive should match the horizontal rate of the video input with a high time (at .7 to 1 V or so) typically 75 to 95% of the total line time.

Monitor power cycling on and off

The power light may be flashing or if you are runing with a series light bulb it may be cycling on and off continuously. There may be a chirping or clicking sound from inside the set. (Note: using too small a light bulb for the size of the monitor may also result in this condition.)

If there is a low voltage regulator or separate switching supply, it could be cycling on and off if the horizontal output, flyback, or one of its secondary loads were defective.

These symptoms are slightly different than those discussed in the section: Dead monitor with audible whine, periodic tweet or flub, and low-low voltage in that a picture may actually appear for an instant.

Verify that the main filter capacitor is doing its job. Excessive ripple on the rectified line voltage bus can cause various forms of shutdown behavior. An easy test is to jumper across the capacitor with one of at least equal voltage rating and similar capacitance (make connections with power off!).

Use a Variac, if possible, to bring up the input voltage slowly and see if the monitor works at any point without shutting down. If it does, this could be an indication of X-ray protection circuit kicking in, though this will usually latch and keep the set shut off if excessive HV were detected.

Something could be breaking down like a capacitor or the flyback as the voltage builds up to normal values

Startup problems - nothing happens, click, or tick-tick-tick sound

TVs and and small fixed scan rate monitors (e.g., CCTV or TV monitors, video display terminals) usually incorporate some kind of startup circuit to provide drive to the horizontal output transistor (HOT) until the flyback power supply is running. Yes, TVs and many monitors boot just like computers.

There are two typical kinds of symptoms: power on click but nothing else happens or a tick-tick-tick sound indicating cycling of the low voltage (line regulator) but lack of startup horizontal drive.

Check the voltage on the horizontal output transistor (HOT). If no voltage is present, there may be a blown fuse or open fusable resistor - and probably a shorted HOT.

However, if the voltage is normal (or high) - usually 60-150 V depending on scan rate (for an auto-scan monitor), then there is likely a problem with the startup circuit not providing initial base drive to the HOT.

The startup circuits may take several forms:

1. Discrete multivibrator or other simple transistor circuit to provide base drive to the HOT.
2. IC which is part of deflection chain powered off of a voltage divider or transformer.
3. Other type of circuit which operates off of the line which provides some kind of drive to the HOT.

The startup circuit may operate off of the standby power supply or voltage derived from non-isolated input. Be careful - of course, use an isolation transformer whenever working on TVs and especially for power supply problems.

Note that one common way of verifying that this is a startup problem is to inject a 15 kHz signal directly into the HOT base or driver circuit (just for a second or two). If the TV then starts up and continues to run, you know that it is a startup problem.

Caution: be careful if you do this. The HOT circuit may be line-connected and it is possible to destroy the HOT and related components if this is not done properly. I once managed to kill not only the HOT but the chopper transistor as well while working in this area. An expensive lesson.

I have also seen startup circuits that were designed to fail. Turning the TV on and off multiple times would exceed the power ratings of the components in the startup circuit. Some Zenith models have this 'feature'.

When this situation exists, it could be that the circuit is not providing the proper drive or that due to some other circuit condition, the drive is not always sufficient to get the secondary supplies going to the point that the normal circuits take over.

I would still check for bad connections - prod the circuit board with an insulated stick when the problem reoccurs.

Reduced width picture and/or hum bars in picture

The most likely cause is a dried up main filter capacitor. Once the effective capacitance drops low enough, 120 Hz (or 100 Hz in countries with 50 Hz power) ripple will make its way into the regulated DC supply (assuming full wave rectification).

Another likely cause of similar symptoms is a defective low voltage regulator allowing excessive ripple. The regulator IC could be bad or filter capacitor following the IC could be dried up.

Either of these faults may cause:

1. A pair of wiggles and/or hum bars in the picture which will float up the screen. For NTSC where the power line is 60 Hz but the frame rate is 59.94 Hz, it will take about 8 seconds for each bar to pass a given point on the screen. (On some sets, a half wave recitifier is used resulting in a single wiggle or hum bar).

   For high scan rate computer monitors, the this may result in horizontal hum bars, wiggles, or other distortions that will drift up or down the screen based on the difference frequency between the power line and video refresh rate being supplied by the PC or workstation. A confirmation can be obtained by varying the scan rate and seeing if the rate of drift changes predictably.

2. Possible regulation problems resulting in HV or total shutdown or power cycling on and off.

The best approach to testing the capacitors is to clip a good capacitor of approximately the same uF rating and at least the same voltage rating across the suspect capacitor (with the power off). A capacitor meter can also be used but the capacitor may need to be removed from the circuit.

Once the capacitors have been confirmed to be good, voltage measurements on the regulator should be able to narrow down the problem to a bad IC or other component.

Wiggling or jiggling picture

Depending on the frequency of the instability relative to the scan rate in use, the symptoms may be that the entire picture is vibrating, that ripples are moving up or down the screen, or something else. There may also be variatons in brightness - hum bars - in the picture.

- Very high frequency oscillations will result in multiple waves or scalloped edges on the sides of the raster possibly extending into the picture itself. These patterns may or may not remain stationary.
- Low or power line frequency oscillations will result in the entire raster moving back and forth, vibrating, or 1 or 2 wiggles along the sides of the raster that move up or down the screen. The actual behavior will depend on the relative frequencies of the oscilations and the vertical scan rate.

When the vertical scan rate is set close to the local power line frequency, effects resulting from power line interference or bad filter capacitors will produce 1 or 2 wiggles or bars, and these will remain almost stationary on the screen. Those caused by internal power supply stability problems may or may not do this.

First, eliminate the possibility of external magnetic interference, power line noise, or a video card/computer problem. Try the monitor in another location and on another computer if possible. Or, try another similar monitor in its place.

Once these causes have been ruled out, the most likely ones are:

- Dried up electrolytic capacitors in the power supply.
- A resistor or other component has changed value in the B+ (or other) regulator.

  For example, one very common monitor - the Gateway CS1572FS - uses a 91K, 1W resistor (R331) to set its 180 V B+ output. Invariably with use and age, its resistance increases in value leading to a vibrating raster and eventual failure of other parts.
- Bad connections.

Monitor doesn't power up immediately

The monitor may do nothing, cycle on and off for a while, power up and then shutdown in an endless cycle - or at least for a while. Then it comes on and operates normally until it is turned off.

A couple of possibilities:

1. The main filter capacitor or other filter capacitors in the low voltage power supply is dried up and this can cause all kinds of regulation problems. Other regulating components may be marginal. This may be allowing excessive voltage to reach the output of the power supply and then the X-ray protection circuitry shuts you down.

   Try powering the monitor on a Variac when cold. Bring up the voltage slowly and see if there is some point at which it would stay on. If there is, then a regulation problem is likely. If the picture has serious hum bars in it, check the main filter capacitor(s) first.
2. Bad connections may be preventing the power supply from operating normally until the mainboard or components heat up a bit.

   Inspect the solder side of the mainboard for cracked solder connections. Some gentle poking and prodding with a well insulated stick may reveal the location though a problem that goes away once the unit heats up can be tough to identify!. The use of 'cold spray' may help. Also, clean and reseat internal connectors.

Also see the section: Old monitor requires warmup period.

Old monitor requires warmup period

So, what else is new? In the old days, a TV or monitor was expected to take a few minutes (at least) to warm up. We are all spoiled today. Of course, you usually maintained a full time technician or engineer to fiddle with the convergence adjustments!

If it just takes a while for the picture to become as bright as you like, this is probably just a result of an old tired CRT (see the section: Monitor Monitor life, energy conservation, and laziness and Brightening an old CRT. If, however, nothing happens for a few minutes, then some component needs to be powered for a while before it starts cooperatings. This is probably a dried up capacitor in the power supply since that is drifting with temperature and needs to be located with cold spray or a heat gun.

Adjustment or picture interactions

This describes problems such as turning up the brightness causes a loss of sync or adjusting height also affects width or produces a wavy raster. Or, a bright picture or opening a bright window results in a significant change in picture size or wiggly edges. Or, the monitor simply decides to shut down!

These may be caused by poor regulation in one or more low voltage power supplies or and interaction between the high voltage and low voltage power supplies - possibly a dried up capacitor if it is relatively old, bad connections, or another faulty component. Measure the B+ to the horizontal deflection (to the flyback, not the horizontal output transistor). If it is changing with the problem, then a regulation problem is confirmed. If this voltage is solid, you will need to check the others to see which one is actually changing.

Shorted Components

A failure of the horizontal output transistor or power supply switchmode transistor will blow a fuse or fusable resistor.

Look for blown fuses and test for open fusable resistors in the power circuits. If you find one, then test the HOT and/or switchmode transistor for shorts.

Other possibilities: rectifier diodes or main filter capacitor.

While you are at it, check for bad connections - prod the circuit board with an insulated stick when the problem reoccurs - as these can cause parts to fail.

Monitor turns off after warming up

If you can turn it back on with the s momentary key or power button:

When it shuts off, do you need to push the power button once or twice to get it back on? Also, does anything else about the picture or sound change as it warms up?

1. If once, then the controller is shutting the TV down either as a result of a (thermally induced) fault in the controller or it sensing some other problem. Monitoring the voltage on the relay coil (assuming these is one) could help determine what is happening. The controller thinks it is in

charge.

2. If twice, then the power supply is shutting down as the controller still thinks it is on and you are resetting it. A couple of possibilities here would be low voltage or high voltage regulation error (excessive high voltage is sensed and causes shutdown to prevent dangerous X-ray emission). A partially dried up main filter capacitor could also cause a shutdown but there might be other symptoms like hum bars in the picture just before this happened. Clipping a good capacitor across the suspect (with power off!) would confirm or eliminate this possibility.

If it uses a hard on/off switch, then this may be like pulling the plug and would reset any abnormal condition.

Monitor shuts down with bright picture or when brightness is turned up

This is probably a protection circuit kicking in especially if turning power off or pulling the plug is required to restore operation.

The detection circuit could be in the power supply or horizontal deflection output circuit. It may be defective or the current may be too high for some other reason. A couple of tests can be performed to confirm that it is due to beam current:

- Determine if behavior is similar when adjusting the user brightness control and the screen (G2) pot (on the flyback) or master brightness control. If the monitor quits at about the same brightness level, overcurrent protection is likely.
- Disconnect the filaments to the CRT (unsolder a pin on the CRT socket) and see if it still shuts down under the same conditions. If it is overcurrent protection, shut down should now *not* take place since there is no beam current.

Relays in the Power Circuitry of monitors

What exactly is the purpose of such a relay? Why doesn't the power switch on the monitor just apply power directly instead of through a relay?

On a TV, the usual reason for a relay instead of a knob switch is to permit a remote control to turn power on and off. If your TV does not have a remote, then it is simply the same chassis minus 24 cents worth of circuitry to do the remote function. Isn't marketing wonderful?

On a monitor without any remote control, there can be two likely reasons:

1. Reduce the needed capacity of the on/off switch. High resolution monitors do consume a fair amount of power. A soft touch button may be more elegant or cheaper.
2. Allow for automatic power saving 'green' operation.

When replacing a relay, only unknown is the coil voltage. It is probably somewhere in the 6-12 volt range. You should be able to measure this on the coil terminals in operation. It will be a DC coil.

However, the relay controls the 125 VAC (or 220) which you should treat with respect - it is a lot more dangerous than the 25kV+ on the CRT!

Almost certainly, the relay will have 4 connections - 2 for power and 2 for the coil. If it is not marked then, it should be pretty easy to locate the power connection. One end will go to stuff near the AC line and the other end will go to the rectifier or maybe a fusable resistor or something like that. These will likely be beefier than the coil connections which will go between a transistor and GND or some low voltage, or maybe directly into a big microcontroller chip.

Of course, the best thing would be to get the schematic but with monitors this may not be easy.

Once you are sure of the AC connections - measure across them while it is off and also while it is on. While off, you should get 110-125 VAC. While on and working - 0. While on and not working either 110-125 VAC if the relay is not pulling in or 0 if it is and the problem is elsewhere. We can deal with the latter case if needed later on. Note the even if the relay contacts are not working, the problem could still be in the control circuitry not providing the correct coil voltage/current, though not likely.

It may be expensive and/or difficult to obtain an exact replacement, but these are pretty vanilla flavored as relays go. Any good electronics distributor should be able to supply a suitable electrical replacement though you may need to be creative in mounting it.

What is a posistor?

A posistor is a combination of a PTC (Positive Temperature Coefficient) resistor and another resistor-element to heat it up and keep it hot. Sometimes, these will go by the name posistor or thermistor. The heater is a disk shaped resistor across the power line and the themister is a disk shaped device in series with the degauss coil. They are in clamped together to be in close contact thermally. You can pry off the lid and see for yourself.

The most common failure mode is for the part to short across the line.

Its function is to control degauss, so the only thing you lose when you remove one of these is the degauss function on power-on. When you turn the TV or monitor on, the PTC resistor is cold and low resistance. When heated, it becomes very high resistance and turns off the degauss coil but gradually - the current ramps down to zero rather than being abruptly cut off..

Computer Component Source stocks a wide variety, I believe but it may be cheaper to go direct to the manufacturer if they will sell you one.

Flameproof Resistors

Flameproof Resistor or Fusable Resistor are often designated by the symbol 'FR'. They are basically the same. The designation "Flameproof" means that if they fail due to excessive current, there will be no chance of, well, them going up in flames. :) They will also have a power rating and thus can act as a protective device, though a specific circuit may not depend on a precise fuse rating, rather that the resistor will open with massively excessive current.

You may see these in the switchmode power supplies used in TVs and monitors. They will look like power resistors but will be colored blue or gray, or may be rectangular ceramic blocks. They should only be replaced with flameproof resistors with identical ratings. They serve a very important safety function.

These usually serve as fuses in addition to any other fuses that may be present (and in addition to their function as a resistor, though this isn't always needed). Since your FR has blown, you probably have shorted semiconductors that will need to be replaced as well. I would check all the transistors and diodes in the power supply with an ohmmeter. You may find that the main switch mode transistor has decided to turn into a blob of solder - dead short. Check everything out even if you find one bad part - many components can fail or cause other components to fail if you don't locate them all. Check resistors as well, even if they look ok.

Since they function as fuses, flameproof resistors should not be replaced with higher wattage types unless specifically allowed by the manufacturer. These would not blow at the same level of overload possibly resulting in damage to other parts of the circuitry and increasing the risk of fire.

Then, with a load on the output of the power supply use a Variac to bring up the voltage slowly and observe what happens. At 50 VAC or less, the switcher should kick in and produce some output though correct regulation may not occur until 80 VAC or more. The outputs voltages may even be greater than spec'd with a small load before regulation is correct.

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Deflection Problems

Deflection fundamentals

Note: the following is just a brief introduction. For more detailed deflection system theory of operationo and sample circuits, see the document: TV and Monitor Deflection Systems.

The electron beams in the CRT need to be scanned horizontally and vertically in a very precise manner to produce a raster - and a picture.

For NTSC and PAL, the horizontal scan rates are 15,734 and 15,625 Hz respectively, the vertical scan rates are 60 and 50 Hz (approximately) respectively.

For PCs and workstation monitors, a wide range of scan rates are used.

For example:

```
  Standard      Horizontal, kHz  Vertical, Hz
------------------------------------------------
    MDA               18.43           50
    CGA               15.75           60
    EGA               15.75-21.85     60
    VGA               31.4            60-70
    SVGA (800x600)    35-40           50-75+
    SVGA (1024x768)   43-52+          43-75+
    SVGA (1280x1024)  64-72+          60-75+
    Workstations      64-102+         60-76+
```

Even in high resolution fixed frequency monitors, these high horizontal (in particular) scan rates necessitate some fancy circuit design. All components are running under stressful conditions and it is amazing that failures are not more common.

With auto-scan monitors, the complexity of the circuits increases dramatically to accommodate the wide range of horizontal scan rates. Relays or electronic switches are used to select power supply voltages, tuning components, and to make other alternations in the deflection circuits to handle DOS VGA one minute and Autocad 1280x1024 the next. It comes as no surprise that the most stressful time for a monitor may be when switching scan rates.

Unfortunately, successfully diagnosing problems dealing with the scan switching logic and circuitry is virtually impossible without a schematic.

The deflection yoke includes sets of coils for horizontal and vertical scanning oriented at 90 degrees with respect to each other. Additional coils are needed to correct for pincushion and other geometric defects.

The deflection circuits must be synchronized and phase locked to the incoming video signal.

Therefore, we have the following functions:

1. Sync separator to obtain horizontal and vertical synchronization pulses for monitors with composite video or sync inputs. Input sync detectors and auto polarity switching circuits as needed for separate horizontal and vertical sync inputs.

2. Horizontal oscillator which locks to horizontal sync pulses.

3. Horizontal drive followed by horizontal output which feeds deflection yoke (and flyback for HV and other voltages), Yoke requires a sawtooth current waveform for linear horizontal deflection. Horizontal output in all but the smaller TVs or monitors is a large discrete power transistor, most often an NPN bipolar type.

4. Vertical oscillator which locks to vertical sync pulses. Yoke requires sawtooth waveform for linear vertical deflection.

5. Vertical drive/output which feeds vertical deflection yoke. Newer TVs and monitors use ICs for vertical drive and output.

6. Various additional deflection signals to correct for the imperfections in the geometry of large angle deflection CRTs. These may be fed into the normal deflection coils and/or there may be separate coils mounted on the neck of the CRT.

7. Auto-scan deflection control and selection circuitry (auto-scan monitors only), probably controlled by a microprocessor which stores scan parameters for each scan rate and automatically detects the appropriate settings to use by analyzing the input video. For horizontal deflection, the usual way of size constant regardless of scan rate is to scale the B+ to the HOT with horizontal frequency. Thus, VGA resolution may us 60 V B+ while 1280x1024 at 75 Hz may require 150 V. Various other components may need to be selected based on scan rate. Relays are often used for this selection since they are easy to control and can handle the voltages and currents in the various deflection circuits reliably.

See Symptoms of Some Common Deflection Problems when referring to the specific descriptions below.

Monitor display is off-center

These sorts of problems usually relate to the picture shifting when switching between applications or between DOS and Windows. First, make sure you are using the correct monitor settings and video drivers. Note that a fraction of a mm offset may be normal and you are just too fussy!

If you have a setup program for your video card:

1. Make sure you are running well within the accepted scan rates for each resolution.
2. Toggle sync polarity and see if this makes any difference.
3. Adjust H position or phase and see what this does.

Also make sure your cables are secure. While a bad connection would likely messed things up worse, it won't hurt to check. Assuming none of this helps, your monitor may have a problem though it is not likely to be major (in a relative way). If you still like the monitor, repair may be worth the money.

Gross problems in size or position at certain scan rates

First, make sure you are not specifying incorrect scan rate for your monitor. Check your video card setup and/or monitor selection in Win95/98 as above.

Assuming you are not violating the scan rate specifications but have a picture that is twice the height of the screen and one half the width, for example, this could indicate a failure in the scan rate switching circuitry of an auto-scan monitor. Either the logic is faulty and ordering the wrong selections for power supply voltage and tuning components or the relays or the relevant parts are faulty. This could be due to bad connections as well - quite likely in fact. Also, try to reset the afflicted parameters using the digital controls (if relevant) and confirm that your video card is putting out the correct scan rate - try another monitor or examine the video signals with an oscilloscope.

Try prodding the circuit boards with an insulated stick - this may identify bad connections or unstick a sticky relay.

A schematics will likely be needed to proceed further with these sorts of problems.

Reduced width

Complaints about the picture not filling the screen with computer monitors are common but may not indicate problems (except with your expectations). Older monitors, in particular, often did not allow a full screen display at certain resolutions. There may be underscan modes/switches as well. Keep in mind that advertizing a large diagonal CRT does not necessarily imply that you can fill it!

However, if this problem just happened with no changes to your computer system (video card, scan rates, O/S), then the following are possibilities:

- The B+ to the horizontal output is lower than normal. The way width control functions is that as you increase the horizontal scan rate, the B+ to the HOT must increase to keep the width constant. It could be that yours is low to start with and not tracking scan rate changes either.
- A bad capacitor might also result in reduced width but I would expect non-linearity as well.
- As noted in the section: Gross problems in size or position at certain scan rates, there could be problems in the scan rate switching circuitry selecting incorrect components for certain scan rates.
- There might be a bad (low value or high ESR) decoupling capacitor. Scope the rail after the low-value decoupling R for H-rate stuff. There shouldn't be anything significant. If there is, the ESR of

the decoupling capacitor is too high or its value is too low. Seen it often where it also cooks the decoupling R, because the efficiency of the H-out becomes poor. (gwoods@albany.net (Gary Woods).)

- A more unlikely possibility is a open yoke winding. The horizontal deflection yoke consists of multiple windings in parallel so it is theoretically possible for one or more of these to open up. I don't know what effects the associated detuning of the horizontal output circuit would have in this case.

Can incorrect or missing video damage my monitor?

The short answer is - quite possibly. Don't push your luck.

Mostly, there are problems at scan rates which exceed the monitor's specifications (low or high). However, some poorly designed monitors or just a particular combination of events can blow a monitor with too low a scan rate or an absent or corrupted signal input. There was one case where a very expensive high performance monitor would consistently blow its horizontal deflection circuits when driven by a particular ATI video card. It turned out that during the power-on self test of the ATI BIOS, just the wrong video timing was being generated for a fraction of a second - but that was enough.

As far as scan rate limits, there is no way of knowing - it really all depends on the quality of the design of your monitor. Some will happily run continuously at 25% above specifications. Other will blow out totally at the first excuse.

The specification that is likely to be more critical is the horizontal rate as it probably puts more stress on the components than the vertical rate. I have found that as you approach the upper limits, there is a good chance that the geometric accuracy of the raster near the top of the screen may start to deteriorate due to lock in problems as well. However, it would be foolhardy to depend on this sort of behavior as an indication of going over the edge.

It will be much too late when you find out. If the manual says 75 Hz V and 64 kHz H, stay below **both** of these. If you exceed the safe ratings and the design isn't really good, there is the possibility of blowing components in the horizontal deflection and high voltage sections which will result in expensive repair bills. You will likely get no warning of impending failure. In addition, even if the monitor does not immediately turn into a pile of smoking silicon and plastic, components may be under more stress and running at higher levels of power dissipation. Total failure may be just around the corner. More subtle degradation in performance may occur over time as well.

You won't see the difference anyhow beyond 75 Hz and your programs may run slightly faster at lower refresh rates since the video is not using as much bandwidth (however, the difference here may be very slight or non-existent depending on your board, computer, applications, etc.).

Picture squeezed in then died

You were happily playing 'Doom' when the sides of the picture squeezed in two inches or so when the entire monitor went dead - has remained like this since. There is no activity at all from the tube. Has it died? How much time, effort, and expense to fix?

No, it's not dead, at least it certainly is not the picture tube.

You probably shot the monitor instead of the bad guys!

Is there any indication of light on the screen? Any indication of the horizontal deflection running at all as evidenced by static on the screen?

In any case, there is a problem in the horizontal deflection and you probably have no high voltage as well assuming no light on the screen.

The fact that it squeezed in first indicates that a partial short or other fault may have developed in the horizontal deflection circuits - possibly the deflection yoke or flyback transformer. It could also have been a bad connection letting loose. Once it failed completely, the horizontal output transistor may have bought the farm or blown a fuse.

Horizontal deflection shutting down

Confirm that the horizontal deflection is shutting down along with the high voltage if it is derived from horizontal deflection: listen for the high pitched deflection whine (NTSC/PAL/CGA), test for static on the screen, see if the CRT filaments are lit, turn up the brightness and/or screen control to see if you can get a raster. Some possibilities:

- Power is failing to the horizontal output transistor - this could be due to a low voltage power supply problem, bad connection, etc.
- Base drive to the horizontal output transistor is failing - could be a fault in the horizontal oscillator or bad connection.
- Problem with the flyback transformer or its secondary loads (flyback may provide other power voltages).
- X-ray protection is activating - either due to excess HV or due to a fault in the X-ray protection circuitry.

If the problem comes and goes erratically it sounds like a bad connection, especially if whacking has an effect. If it comes and goes periodically, then a component could be heating up and failing, then cooling, etc.

Horizontal squashed

A very narrow picture may indicate problems with the power supply to the horizontal deflection circuits, incorrect scan rate selection or defective components, faulty deflection yoke, or bad connections.

If the size is erratic and/or gently whacking the monitor makes the width change, bad connections are likely. See the section: Monitor manufacturing quality and cold solder joints.

Confirm that your video card is running at the proper scan rate - particularly that it is not violating the monitor's specifications. An excessive horizontal scan rate is a common cause of a reduced width raster. Try its software setup adjustments as these may have been lost.

Beyond this, a schematic will probably be needed to isolate the fault.

Monitor non-linearity

Most modern monitors are nearly perfect with respect to linearity. There are almost never any user adjustments and there may not even be any internal adjustments. See the section: Position, size, and linearity adjustment.

A sudden change in linearity or a monitor that requires a warmup period before linearity becomes acceptable may have a bad component - probably a capacitor in the horizontal deflection circuits. For the latter, try some cold spray or a heatgun to see if you can locate the bad part.

(From: helio (mmccann@usa.pipeline.com).)

You should likely begin in the area immediately around the HOT, perhaps there might be a high frequency NP (non polarized) electrolytic just starting to go. Some larger monochrome monitors actually have working H-lin adjustment coils (believe it or not) especially if they are older ones. But most are glued/potted down or fixed value. If you locate it (the coil) the problem should be nearby.

Picture squeezed on both left and right side of screen

> "I'm trying to repair a Target DN-1564 monitor with a problem in the horizontal deflection: on both the left and right side of the screen the picture gets squeezed together, regardless of H-width and other settings. I've checked most semiconductors in this part, but I can't find anything wrong there."

This sounds like an S-correction capacitor may have too small a value or failed open. Check the capacitors in the vicinity of the deflection yoke connector and HOT. It could be due to bad connections as well.

S-correction is needed to linearize the horizontal scan (and vertical as well scan but that is a separate circuit). Without S-correction, the scan current would be nearly linear. This would result in greater coverage in a given time near the edges of high deflection angle CRTs. The picture would appear stretched near the edges In this case, the correction appears excessive.

(From: David Henniker (david.henniker@cableinet.co.uk).)

I had a similar problem with a monitor (here in Edinburgh Scotland). The S-correction cap was open-circuit altogether. Other caps in parallel allowed the distorted scan. If it had been a TV there wouldn't have been other caps in parallel and the result would have been no line scan, maybe a vertical line (line collapse) or nothing at all.

Vertical squashed

This means the vertical size is reduced with or without distortion.

Before attacking the circuitry, make sure your vertical scan rate is within the monitor's capabilities and that the user vertical size control is adjusted properly. If there is no distortion, this is likely as many (but not all) circuit problems would result in non-linearity or cutoff of the top or bottom portions of the picture. All you may need to do is change your computer's video settings! Swap the monitor or computer to be sure it is not a problem with the video card.

However, if failure happened suddenly and the vertical is squashed at all scan rates, this is likely a vertical deflection problem - possibly a bad capacitor, bad connection, bad flyback/pumpup diode, or other component. None of these should be very expensive (in a relative sort of way).

If the symptoms change - particularly if they become less severe - as the unit warms up, a dried up electrolytic capacitor is most likely. If they get worse, it could be a bad semiconductor. Freeze spray or a heat gun may be useful in identifying the defective component.

It is often easiest to substitute a good capacitor for each electrolytic in the vertical output circuit. Look for bad connections (particularly to the deflection yoke), then consider replacing the vertical output IC or transistor(s).

A defective deflection yoke is also possible or in rare cases, a bad yoke damping resistor (e.g., 500 ohms, may be mounted on the yoke assembly itself).

Where the entire top half or botton half of the picture is squashed into into the center (i.e., only half the picture shows), a missing power supply voltage, defective vertical output IC, or a component associated with it is likely bad. A bad connection or blown fusable resistor may be the cause of a missing power supply voltage.

The following are NOT possible: CRT or flyback (except possibly where it is the source for a missing power supply voltage but this is more likely just a bad solder connection at a flyback pin). I am just trying to think of really expensive parts that cannot possibly be at fault. :-)

Keystone shaped picture

This means that the size of the picture is not constant from top to bottom (width changes) or left to right (height changes). Note that some slight amount of this is probably just within the manufacturing tolerance of the deflection yoke and factory setup (geometry magnet placement, if any). With a monitor, such defects are more noticeable than with a TV since much of the display is of rectangular boxes - i.e., windows, lines of text, graphics, etc. Furthermore, the monitor is usually run just barely underscanned to maximize the viewing area without cutting anything off. Any deviations from perfection show up in relation to the CRT bezel.

However, a sudden increase may indicate a problem with the deflection yoke.

An open or short in a winding (or any associated components mounted on the yoke assembly) will result in the beam being deflected less strongly on the side where that winding is located. However, with a high scan rate monitor, there may be many individual windings connected in parallel in the yoke so the effect of only one opening up may not be as dramatic as with a TV where there may only be a single pair of windings for the horizontal and another for the vertical.

A simple test of the yoke in this case can be performed by simply swapping the connections to the yoke for the affected direction (i.e., if the width changes from top to bottom, interchange the connections to the vertical windings).

- If the keystone shape remains the same (but of course the picture flips), it is likely the yoke. The bad yoke winding is the one for the other axis (than what you swapped - if you just swapped the vertical, it is the horizontal yoke that has a short or open).
- If the keystone shape flips, it is a circuit problem (see below).

See the section: Deflection yoke testing.

If the monitor has been dropped off a 20 story building, the yoke may have shifted its position on the neck, of the CRT resulting in all sorts of geometry and convergence problems (at the very least).

(From: James Poore (aw133@lafn.org).)

I have seen the 'reverse keystoning' in several monitors and the fix is usually the same. In the horizontal leg of the pincushion transformer are 1 or more electrolytics to ground. The caps have + going to transformer and - to ground. Anyway when they start loosing capacitance and/or become leaky the reverse keystoning effects become more pronounced.

Picture size changing

If the picture area is expanding or contracting without any changes to your video card settings or other software. then there is a problem with the power supplies in the monitor. This would be confirmed if the change is (1) gradual over the course of say, an hour, and/or (2) gently whacking the monitor has some effect indicating bad internal connections. Software problems would not result in either of these characteristics.

Note that if the change is very small - say, less than 1 or 2%, then it may simply be normal for your monitor due to poor design or the use of inferior components - some parts associated with power supply regulation may be changing value as the monitors warms up.

A way to confirm that something is drifting due to thermal problems would be the monitor from another computer and see if the same thing happens. Just powering the monitor by itself (but not in any power saving mode) might also work for this test.

One possible cause could be that the high voltage is drifting gradually due to a faulty component - increasing and making the beam 'stiffer' or vice-versa. If this is the case there might also be a gradual change in brightness as well (decreasing image size -> increase in brightness). Alternatively, the HV may be stable but the power to both H and V deflection is gradually changing.

Excess high voltage can increase the X-ray emissions and any kind of power supply problems may ultimately result in total failure and an expensive repair. Therefore, these symptoms should not be ignored. See the sections on low voltage and high voltage power supply problems.

Monitor will not sync

For SVGA monitors, check that the sync pins in the video connector are not broken or bent. On the VGA HD15 connector, these are pin 13 (H) and 14 (V).

For monitors using BNC cables, first make sure that the cable connections are correct - interchange of H and V sync or G with one of the other video signals (sync-on-gree setups) can result in all kinds of weird sync problems.

There are a wide variety of causes for a monitor that will not display a stable or properly configured image. Among the symptoms are:

- Lack of sync horizontal - drifts smoothly horizontally. Depending on the difference between the video horizontal rate and the free-run frequency of the horizontal oscillator, the picture may be torn left or right (as shown in [Symptoms of Some Common Deflection Problems] or have multiple images superimposed horizontally. The situation where the picture is neatly split horizontally (which is what you might expect) is a special case where the frequencies are virtually the same. The key symptom common to all these is that there IS vertical lock (no blanking bar visible) AND there is no evidence that the deflection is even attempting to lock horizontally.

This may mean that the horizontal sync signal is missing due to a bent, pushed in, or broken connector pin (pin 13) or other bad connection or a fault in the sync processing circuitry.

- Incorrect lock horizontal - torn picture (like a TV with the horizontal hold control misadjusted - if you remember these). This means that the sync signal is reaching the monitor but that it is having problem locking to it. Check the rate specifications - you may be exceeding them.
- Lack of sync vertical - rolls smoothly vertically. This may mean that the vertical sync signal is missing due to a bent, pushed in, or broken connector pin (pin 14) or other bad connection or a fault in the sync processing circuitry.
- Lock not stable vertical - jumps or vibrates vertically. This may be due to scan rate problems or a fault in the vertical sync circuitry of the monitor.
- Multiple or repeated images horizontally or vertically. There may be multiple images side-by-side, on top of each other, or interleaved. Most likely cause is driving the monitor with an incorrect scan rate. However, faulty circuitry could also be to blame.

Additional comments on some of these problems follow in the next few sections.

Horizontal lock lost

A monitor which loses horizontal lock when changing resolutions, momentarily losing the signal, or switching inputs may have a horizontal oscillator that is way out of adjustment or has drifted in frequency due to aging components. Alternatively, you may be running at scan rates that are not supported by your monitor. Check its user manual (yeh, right, like you have it!). Use the setup program that came with your video card to adjust the default scan rates to match the monitor. Not only will it lock better, you are less likely to damage the monitor by feeding it improper scan rates.

Note that the characteristics of this are distinctly different than for total loss of sync. In the latter case, the picture will drift sideways and/or up and down while with an off frequency oscillator, the torn up picture will try at least to remain stationary.

Assuming you are have your video card set up properly - double check anyhow - this could be a capacitor or other similar part. Or, the oscillator frequency may just need to be tweaked (particularly with older monitors). There may be an internal horizontal frequency adjustment - either a pot or a coil - which may need a slight tweak. If a coil, use a plastic alignment tool, not metal to avoid cracking the fragile core. There may be several adjustments for auto-scan monitors - one for each major scan range.

A schematic will be useful to locate the adjustment if any or to identify possible defective parts. If it is a heat related problem try cold spray or a heat gun in an effort localize the offending part.

Insufficient width (without hum bars)

If there are hum bars or wiggles in the picture, see the section: [Reduced width picture and/or hum bars in picture](#).

If both width and height are affected, the cause is likely something common: low, low voltage power supply voltages or excessive high voltage (resulting in a 'stiffer' beam).

(From: Jerry G. (jerryg@total.net).)

Lack of width is usually caused by defective power supply, low horizontal drive to the yoke and flyback, defective circuits in the pincushioning amplifier section, excessive high-voltage caused by defective voltage regulation, and or excessive loading on the secondary side of the flyback.

Loss of horizontal sync (also applies to vertical) after warmup

The problem lies either in the horizontal oscillator or in the sync system. If it really is a problem with sync pulses not reaching the oscillator, the picture will move around horizontally and can be brought to hold momentarily with the hold control. If the picture breaks up into strips, there is a problem in the horizontal oscillator. If there is an accessible hold control try rotating it: if the frequency is too far off, the picture will not settle into place at any adjustment of the hold control. Look around the horizontal oscillator circuit: all of the oscillator parts will be right there, or check on the horizontal oscillator module. If only one resolution on a auto-scan monitor is affected, the there could be a separate oscillator circuit for each range.

(From: Randy Fromme.)

An additional cause of loss of h. sync can be bad filter cap(s) in the 6.3 VDC SMPS output. This 6.3 is dropped and pegged at +5 vdc by a zener diode and powers the 7486 that is a common sync input circuit (allows either polarity sync). Interestingly, it doesn't affect the vertical sync (even though the same 7486 is used for both H & V) because the SMPS itself is synchronised to the horizontal frequency and thus the ripple is at horizontal frequency as well. It's an interesting failure from that standpoint.

Replicated or offset multiple images

Multiple images on the screen horizontally or vertically indicate that the scan rate is way off (by a factor equal to the number of complete pictures.) This could be a fault in the monitor or you could be running way outside of the monitor's specifications. Even slightly exceeding these for the horizontal or vertical may confuse the scan rate selection logic and result in the monitor setting itself with incorrect scan rate settings.

A situation where successive sweeps alternate position slightly resulting in double or triple images may be caused by a incorrect or out of range video timing, a bad component, or improper sync signals.

Check the settings of the video card and any sync termination or selection on the monitor. Beyond this, a schematic will be required.

Part of picture cut off

The following applies if the part of the picture is missing but not otherwise squashed or distorted. For example, 85% is missing but the portion still visible is normal size.

Wow! That's an interesting one, more so than the typical run-of-the-mill "my TV just up and died on me". Or, "my pet orangutan just put a hole in the CRT, what should I do"?

With a monitor, this is more likely than a TV. But the cause is probably not in the monitor (though not impossible). Check that your video parameters are set up correctly (particularly if you have full control of them as with Linux). You may have set the active too short or blanking too long.

If your video is confirmed to be OK (looking at it with an oscilloscope would be best), then with the size of the picture fragment correct but 85% missing, check waveforms going into the vertical output stage. The supply voltage is probably correct since that often determines the size. It almost sounds like the waveform rather than being mostly on (active video) and off for the short blanking period is somehow only on during the last part of the active video thus giving you just the bottom of the picture. If there is a vertical output IC, it may be defective or the blanking input to it may be corrupted. The problem may be as far back as the sync separator. Then again who knows, schematics would be really handy.

Bright or dark bars on edge of picture (horizontal or vertical)

These may be sharp-edged or blurry. The latter could result when a portion of the active video is unblanked during retrace.

- Where the entire picture is present, the problem is one of the video blanking not occurring properly beyond the picture boundary.
- Where part of the picture is cut off with a bright horizontal or vertical line at that point, it is either a video timing problem or a fault in the deflection circuitry preventing the beam from being where it is supposed to scan in enough time.

  You may be seeing part of the active video during retrace or as the beam reverses direction at the start or end of retrace. Horizontal timing problems would produce vertical bars on the right or left edge; vertical timing problems would produce horizontal bars at the top or bottom edge.
- If your video card permits control of video timing parameters, try reducing the relevant active time relative to the blanking period. The relevant software settings might be horizontal position, phase, size, and sync polarity. If this does not work, your video card may be incompatible with the monitor.
- If the problem just happened without any changes to the video source, the monitor may have a problem:
  - Deflection circuits - coil or capacitor, a power supply fault, position or size settings or control, or deflection yoke.
  - Video amplifier or drive (CRT neck board), or blanking circuits - chip decoupling capacitors or filter capacitors in scan derived power supplies. If the bars are significantly colored - not just shades of gray - then a video problem is likely.

An oscilloscope would help greatly in identifying the source of the problem.

Single Vertical Line

CAUTION: To prevent damage to the CRT phosphors, immediately turn down the brightness so the line is just barely visible. If the user controls do not have enough range, you will have to locate and adjust the master brightness or screen/G2 pots.

Since you have high voltage, the horizontal deflection circuits are almost certainly working (unless there is a separate high voltage power supply - almost unheard of in modern TVs but possible in some higher performance monitors).

Check for bad solder connections between the main board and the deflection yoke. Could also be a bad horizontal coil in the yoke, linearity coil, etc. There is not that much to go bad based on these symptoms assuming the high voltage and the horizontal deflection use the same flyback. It is almost certainly not an IC or transistor that is bad.

Single Horizontal Line

CAUTION: To prevent damage to the CRT phosphors, immediately turn down the brightness so the line is just barely visible. If the user controls do not have enough range, you will have to locate and adjust the master brightness or screen/G2 pots.

A single horizontal line means that you have lost vertical deflection. High voltage is most likely fine since there is something on the screen.

This could be due to:

1. Dirty service switch contacts. There is often a small switch on the located inside on the main board or perhaps accessible from the back. This is used during setup to set the color background levels. When flipped to the 'service' position, it kills vertical deflection and video to the CRT. If the switch somehow changed position or got dirty or corroded contacts, you will have this symptom. Flip the switch back and forth a couple of times. If there is some change, then replace, clean, resolder, or even bypass it as appropriate.

2. Bad connection to deflection yoke or other parts in vertical output circuit. Bad connections are common in TVs and monitors. Check around the pins of large components like transformers, power transistors and resistors, or connectors for hairline cracks in the solder. Reseat internal connectors. Check particularly around the connector to the deflection yoke on the CRT.

3. Bad vertical deflection IC or transistor. You will probably need the service manual for this and the following. However, if the vertical deflection is done with an IC, the ECG Semiconductor Master Substitution guide may have its pinout which may be enough to test it with a scope.

4. Other bad parts in vertical deflection circuit though there are not that many parts that would kill the deflection entirely.

5. Loss of power to vertical deflection circuits. Check for blown fusable resistors/fuses and bad connections.

6. Loss of vertical oscillator or vertical drive signals.

The most likely possibilities are in the deflection output stage or bad connections to the yoke. To locate the vertical output circuitry without a service manual, trace back from the deflection yoke connector. The vertical coils will be the ones with the higher resistance if they are not marked.

Intermittent jumping or jittering of picture or other random behavior

This has all the classic symptoms of a loose connection internal to the TV or monitor - probably where the deflection yoke plugs into the main PCB or at the base of the flyback transformer. TVs and monitors are notorious for both poor quality soldering and bad connections near high wattage components which just develop over time from temperature cycling. The problem may happen any time or more when cold or hot.

The following is not very scientific, but it works: Have you tried whacking the monitor when this happened and did it have any effect? If yes, this would be further confirmation of loose connections.

What you need to do is examine the solder connections on the PCBs in the monitor, particularly in the area of the deflection circuits and power supply. Look for hairline cracks between the solder and the component pins - mostly the fat pins of transformers, connectors, and high wattage resistors. Any that are found will need to be reflowed with a medium wattage (like 40W) or temperature controlled soldering iron.

It could also be a component momentarily breaking down in the power supply or deflection circuits.

Another possibility is that there is arcing or corona as a result of humid weather. This could trigger the power supply to shut down perhaps with a squeak, but there would probably be additional symptoms including possibly partial loss of brightness or focus before it shut down. You may also hear a sizzling sound accompanied by noise or snow in the picture, static in the sounds, and/or a smell of ozone.

If your AC power fluctuates, an inexpensive monitor may not be well enough regulated and may pass the fluctuations on as jitter. The video card is unlikely to be the cause of this jitter unless it correlates with computer (software) activity.

Horizontal output transistors keep blowing (or excessively hot)

Unfortunately, these sorts of problems are often difficult to definitively diagnose and repair and will often involve expensive component swapping.

You have just replaced an obviously blown (shorted) horizontal output transistor (HOT) and an hour (or a minute) later the same symptoms appear. Or, you notice that the new HOT is hotter than expected:

Would the next logical step be a new flyback (LOPT)? Not necessarily.

If the monitor performed normally until it died, there are other possible causes. However, it could be the flyback failing under load or when it warms up. I would expect some warning though - like the picture shrinks for a few seconds before the poof.

Other possible causes:

1. Improper drive to horizontal output transistor (HOT). A weak drive might cause the HOT to turn on or (more likely) shut off too slowly (greatly increasing heat dissipation. Check driver and HOT base circuit components. Dried up capacitors, open resistors or chokes, bad connections, or a driver transformer with shorted windings or a loose or broken core can all affect drive waveforms.

2. Excessive voltage on HOT collector - check LV regulator (and line voltage if this is a field repair), if any.

3. Defective safety capacitors or damper diode around HOT. (Though this usually results in instant

destruction with little heating).

4. New transistor not mounted properly to heat sink - probably needs mica washer and heat sink compound.
5. Replacement transistor not correct or inferior cross reference. Sometimes, the horizontal deflection is designed based on the quirks of a particular transistor. Substitutes may not work reliably.
6. CRT shorting internally. If this happens only once in two weeks, it may be diffuclt to track down :-(.

The HOT should not run hot if properly mounted to the heat sink (using heatsink compound). It should not be too hot to touch (CAREFUL - don't touch with power on - it is at over a hundred volts with nasty multihundred volt spikes and line connected - discharge power supply filter caps first after unplugging). If it is scorching hot after a few minutes, then you need to check the other possibilities.

However, it is possible that the deflection circuit is just poorly designed in the first place and it has always run hot (though it is unlikely to have always been scorching hot). There is no way to know for sure without a complete analysis of the circuit - not something that is a realistic possibility. In this case, the addition of a small fan may make a big difference in HOT survival. If you have it mounted on the case blowing on the HOT, add a filter to minimize dust infiltration.

It is also possible that a defective flyback - perhaps one shorted turn - would not cause an immediate failure and only affect the picture slightly. This would be unusual, however. See the section: Testing of flyback (LOPT) transformers.

Note that running the monitor with a series light bulb may allow the HOT to survive long enough for you to gather some of the information needed to identify the bad component.

Horizontal output transistors blowing at random intervals

The HOT may last a few minutes, days, months or years but then blow again.

These are among the hardest problems to locate. It could even be some peculiar combination of user cockpit error - customer abuse - that you will never identify. Yes, this should not happen with a properly designed monitor.

However, a combination of mode switching, loss of sync during bootup, running on the edge of acceptable scan rates, and frequent power cycles, could test the monitor in ways never dreamed of by the designers. It may take only one scan line that is too long to blow the HOT. Newer horizontal processor chips are quite smart about preventing HOT killing signals from reaching the horizontal driver but they may not be perfect.

On the other hand, the cause may be along the lines of those listed in the section: Horizontal output transistors keep blowing (or excessively hot) and just not as obvious - blowing in a few days or weeks instead of a few seconds but in this case, the HOT will likely be running very hot even after only a few minutes.

Another possible cause for random failures of the HOT are bad solder connections in the vicinity of the flyback and HOT (very common due to the large hot high power components) as well as the horizontal driver and even possibly the sync and horizontal oscillator circuits, power supply, or elsewhere.

Steve's comments on HOT replacement

(From: Steve Bell (service@bell-electronics.freeserve.co.uk).)

A HOT can fail on its own, but to save possibly having to change it again, I always check the following:

If there is an electrolytic capacitor in the base circuit, check it with an ESR meter. If you don't have one, change it, they are cheap. Check the tuning capacitor on the HOT collector for low value or open circuit. These are low value and fairly critical, a capacitance meter is ideal. If you don't have one, a crude way to check is to use an analogue meter on x100 ohms and watch the needle kick as the cap charges and compare to another cap same value. Follow the HOT collector to the FBT, then from the FBT to a B+ regulator circuit if used. These often use a T0220 style FET or power transistor, check for shorts. Locate the B+ filter cap on the feed from the regulate to the FBT. Look for bulges and check with ESR meter. These caps are typically 22 - 100 uF, 160 or 200V. Also visibly check the FBT for bulges or splits. The only way to be sure the FBT is OK is to check with a FBT tester/ringer or similar test equipment. Generally FBT's in monitors are quite reliable. This might sound like a lot to do, but when familiar with the circuitry it doesn't take long.

You could of course just change the HOT and all will be OK.

Vertical foldover

The picture is squashed vertically and a part of it may be flipped over and distorted.

This usually indicates a fault in the vertical output circuit. If it uses an IC for this, then the chip could be bad. It could also be a bad capacitor or other component in this circuit. It is probably caused by a fault in the flyback portion of the vertical deflection circuit - a charge pump that generates a high voltage spike to return the beam to the top of the screen.

Test components in the vertical output stage or substitute for good ones.

Jagged or uneven vertical sweep

(From: Matthias Meerwein (Matthias.Meerwein@rt.bosch.de).)

I recently fixed two CRT display devices that both developed a very similar problem: The vertical deflection was severely "jagged" with uneven line spacing and partial vertical foldover. One patient was a nameless el-cheapo 28-inch TV (1988 made), the other one a 14 inch ADI SVGA monitor (1991 vintage).

My first suspicions were bad contacts on the PCB or yoke connectors or isolation / connectivity problems inside the yoke. However, as the picture didn't change with warmup or tapping, those causes could be ruled out. Examining the vertical deflection waveform with the scope showed the problem being a parasitic high frequency oscillation around the vertical output ic. On the TV, the oscillation extended over the entire scan period, while the monitor exhibited the problem only near the vertical current zero cross.

In both cases I found the capacitor of the RC damping network on the amp output to be at fault. Replacing it fixed the problem in both sets. This is not the well-known dried-up-electrolytic problem described in the FAQ. The culprits were mylar caps (.1 and .47 uF) looking completely unsuspicious. They were probably a bit underrated voltage-wise (40 volts) so I replaced them with 100 volts rated ones. The 2.2 ohms resistor in series with the cap was fine in both cases.

Excessive width/pincushioning problems

This would mean that the left and right sides of the picture are 'bowed' and the screen looks something like the diagram below (or the opposite - barrel distortion).

However, the obvious symptoms may just be excess width as the curved sides may be cut off by the CRT bezel.

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This geometry is the natural state of affairs with linear scan waveforms if there were no correction. Normally, a signal from the vertical deflection that looks something like a rectified sinewave is used to modify width based on vertical position. There is usually a control to adjust the magnitude of this signal and also often, its phase. It would seem that this circuit has ceased to function.

If you have the schematics, check them for 'pincushion' adjustments and check signals and voltages. If not, try to find the 'pincushion' magnitude and phase adjustments and look for bad parts or bad connections in in the general area. Even if there are no adjustment pots, there may still be pincushion correction circuitry.

If the pincushion controls have absolutely no effect, then the circuit is faulty. With modern digital setup adjustments, then it is even tougher to diagnose since these control a D/A somewhere linked via a microprocessor.

Pincushion adjustment adds a signal to the horizontal deflection to compensate for the geometry of the CRT/deflection yoke. If you have knobs, then tracing the circuitry may be possible. With luck, you have a bad part that can be identified with an ohmmeter - shorted or open. For example, if the pincushion correction driver transistor is shorted, it will have no effect and the picture will be too wide and distorted as shown above.

However, without a schematic even this will be difficult. If the adjustments are digital this is especially difficult to diagnose since you don't even have any idea of where the circuitry would be located.

Faulty capacitors in the horizontal deflection power supplies often cause a similar set of symptoms.

Uncorrectable pincushion distortion with new monitor

> "I just bought a new Sony 200SX 17" monitor and I just can't get the pin-cushion control to

work right. If I get the outer edges straight then any window an inch or so from the edge will curve like crazy. The only way around this is to shrink my screen size so I'll have 3/4 in or so of black space. This is very irritating since I am not getting the 15.9" viewable size as advertised. Is this normal?"

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The distortion that you describe is called 'inside pincushion'. Normally it can be corrected by a dynamic S-correction circuit. Maybe Sony didn't do a too good job on this, or none at all. It may also be that the correction is optimized for certain horizontal scan frequencies only, as dynamic S-correction is a resonant circuit. You might want to test at another frequency.

(From: markmtf@earthlink.net).)

You may have a monitor that is at the edge of the acceptance tolerance, (which is a defined acceptable variation for cost and production yield reasons). A typical worse case tolerance may be up to 3mm of a deviation from a straight line for the edges. This applies for all monitors and all manufacturers. Of course some companies actually control the variation better than others, (and some just say they do).

For reference; try using the "Recall" function which will set the adjustments to the original factory settings. (This assumes that your video timing matches the preset timing used in the factory). Check the infamous user manual.

Deflection yoke testing

A faulty deflection yoke can affect the geometry (size and shape) of the raster, result in insufficient high voltage and/or other auxiliary power problems, and blow various components in the low voltage power supply or elsewhere.

- A simple test to determine if the yoke is at fault for a major geometry problem (e.g., a keystone shaped picture) is to interchange the connections to the yoke for the axis that is not affected (i.e., the vertical coils if the width is varying from top to bottom). If the raster/picture flips (indicating that you swapped the proper connections) but the shape of the raster remains the same - the geometry is unchanged, the problem is almost certainly in the deflection yoke.
- Where high voltage (and other flyback derived voltages) are reduced and other problems have been ruled out, unplugging the deflection yoke (assuming no interlock) may reveal whether it is likely at fault. If this results in high voltage and a relatively clean deflection waveform or returns the power supply or deflection chip load to something reasonable, a defective yoke is quite possible.

  CAUTION: powering a TV or monitor with a disconnected yoke must be done with care for several reasons:

  - The CRT electron beam(s) will not be deflected. If it turns out that the yoke is the problem, this may result in a very bright spot in the center of the screen (which will turn into a very dark permanent spot quite quickly) :-(. Disconnecting only the winding that is suspect is better. Then, the other direction will still scan resulting in a very bright line instead of a super bright spot. In any case, make sure the brightness is turned all the way down (using the screen/G2 control on the flyback if necessary). Keep an eye on the front of the screen ready to kill power at the first sign of a spot or line. Disconnecting the CRT heater as an added precaution would be even better unless you need to determine if there is a beam.

- Removing the yoke (which is effectively in parallel with the flyback) increases the inductance and the peak flyback voltage on the HOT. In the extreme, this may blow the HOT if run at full line voltage/normal B+. It is better to perform these tests using a Variac at reduced line voltage if possible.
- The deflection system will be detuned since the yoke inductance plays a very significant role in setting the resonance point in most designs. Don't expect to see totally normal behavior with respect to high voltage. However, it should be much better than with the faulty yoke.

- If possible, compare all measurements with a known good identical deflection yoke. Of course, if you have one, swapping is the fastest surest test of all! In many cases, even a not quite identical yoke will be close enough to provide useful information for testing. However, it must be from a similar piece of equipment with similar specifications - size and scan range. Don't expect a color TV yoke to work in a high performance SVGA monitor!

  Note: the substitute yoke doesn't have to be mounted on the CRT which would disturb purity and convergence adjustments but see the caution above about drilling holes in the CRT face plate!

The deflection yoke consists of the horizontal coils and vertical coils (wound on a ferrite core), and mounting structure. Little magnets or rubber/ferrite strips may be glued in strategic locations. DO NOT disturb them! In rare instances, there may be additional coils or other components mounted on the same assembly. The following deals only with the actual deflection coils themselves - the other components (if any) can be tested in a similar manner.

Where the test procedure below requires removal of the yoke, see the section: Removing and replacing the deflection yoke first.

- Horizontal - the horizontal section consists of an even number of windings hooked up in parallel/interleaved with half of the windings on each of the two ferrite core pieces.

  The horizontal windings will be oriented with the coil's axis vertical and mounted on the inside of the yoke (against the CRT neck/funnel). They may be wound with thicker wire than that used for the vertical windings.

  - Resistance check - This may be possible without removing the yoke from the CRT if the terminal block is accessible. Disconnect the individual windings from each other and determine if the resistances are nearly equal. Check for shorts between windings and between the horizontal and vertical windings as well.

    Typical resistance of the intact windings (at the yoke connector assuming no other components): TV or NTSC/PAL monitor - a few ohms (3 ohms typical), SVGA monitor - less than an ohm (.5 ohms typical).

  - Inspection - Look for charring or other evidence of insulation breakdown due to arcing or overheating. For the horizontal windings, this will require removing the yoke from the CRT since little if any of the windings are visible from the outside. However, even then, most of the windings are hidden under layers of wire or behind the ferrite core.
  - Ring test. See the document "Testing of Flyback (LOPT) Transformers". This deals with

flyback transformers but the principles are the same. Disconnecting the windings may help isolate the location of a fault. However, for windings wound on the same core, the inductive coupling will result in a short anywhere on that core reducing the Q.

- Vertical - The vertical section is usually manufactured as a pair of windings wired in parallel (or maybe in series) though for high vertical scan rate monitors, multiple parallel/interleaved windings are also possible.

  The vertical windings will be oriented with the coil's axis horizontal and wound on the outside of the yoke. The wire used for the vertical windings may be thinner than that used for the horizontal windings.

  - Resistance check - This may be possible without removing the yoke from the CRT if the terminal block is accessible. Disconnect the individual windings from each other and determine if the resistances are nearly equal. Check for shorts between windings and between the horizontal and vertical windings as well.

    Typical resistance of the intact windings (at the yoke connector assuming no other components): TV or NTSC/PAL monitor - more than 10 ohms (15 ohms typical), SVGA monitor - at least a few ohms (5 ohms typical).

  - Inspection - Look for charring or other evidence of insulation breakdown due to arcing or overheating. The accessible portions of the vertical windings are mostly visible without removing the yoke from the CRT. However, most of the windings are hidden under layers of wire or behind the ferrite core.

  - Ring test - Since the vertical windings have significant resistance and very low Q, a ring test may be of limited value.

Deflection yoke repair

So you found a big black charred area in/on one of the yoke windings. What can be done? Is it possible to repair it? What about using it for testing to confirm that there are no other problems before ordering a new yoke?

If the damage is minor - only a few wires are involved, it may be possible to separate them from each other and the rest of the winding, thoroughly clean the area, and then insulate the wires with high temperature varnish. Then, check the resistances of each of the parallel/interleaved windings to make sure that you caught all the damage.

Simple plastic electrical tape can probably be used for as insulation for testing purposes - it has worked for me - but would not likely survive very long as a permanent repair due to the possible high temperatures involved. A new yoke will almost certainly be needed.

Testing of flyback (LOPT) transformers

How and why do flyback transformers fail?

Flybacks fail in several ways:

1. Overheating leading to cracks in the plastic and external arcing. These can often be fixed by cleaning and coating with multiple layers of high voltage sealer, corona dope, or even plastic electrical tape (as a temporary repair in a pinch).

2. Cracked or otherwise damaged core will effect the flyback characteristics to the point where it may not work correctly or even blow the horizontal output transistor.

3. Internal shorts in the FOCUS/SCREEN divider network, if present. One sign of this may be arcover of the FOCUS or SCREEN sparkgaps on the PCB on the neck of the CRT.

4. Internal short circuits in the windings.

5. Open windings.

More than one of these may apply in any given case.

First, perform a careful visual inspection with power off. Look for cracks, bulging or melted plastic, and discoloration, Look for bad solder connections at the pins of the flyback as well. If the TV or monitor can be powered safely, check for arcing or corona around the flyback and in its vicinity,

Next, perform ohmmeter tests for obvious short circuits between windings, much reduced winding resistances, and open windings.

For the low voltage windings, service manuals may provide the expected DC resistance (SAMs PhotoFact, for example). Sometimes, this will change enough to be detected - if you have an ohmmeter with a low enough scale. These are usually a fraction of an ohm. It is difficult or impossible to measure the DC resistance of the HV winding since the rectifiers are usually built in. The value is not published either.

Caution: make sure you have the TV or monitor unplugged and confirm that the main filter capacitor is discharged before touching anything! If you are going to remove or touch the CRT HV, focus, or screen wires, discharge the HV first using a well insulated high value resistor (e.g., several M ohms, 5 W) to the CRT ground strap (NOT signal ground. See the section: Safe discharging of capacitors in TVs and video monitors.

Partially short circuited windings (perhaps, just a couple of turns) and sometimes shorts in the focus/screen divider will drastically lower the Q and increase the load the flyback puts on its driving source with no outputs connected. Commercial flyback testers measure the Q by monitoring the decay time of a resonant circuit formed by a capacitor and a winding on the flyback under test after it is excited by a pulse waveform. It is possible to easily construct testers that perform a well. See the companion document "Testing of Flyback (LOPT) Transformers" for further information.

Picture size suddenly becomes larger (or smaller)

You are playing your favorite game (read: addiction) and suddenly, the picture size increases by 20% and the brightness may have changed as well. What part should I replace? I only used my phasers on the #3 setting!

Unfortunately, I do not have a crystal ball. There are a number of parts that could be faulty and no way of know for your monitor and your symptoms which it is. Sorry, you will almost certainly have to have it professionally repaired or replaced.

What it sounds like is happening is that the circuitry that selects internal components depending on scan rate have failed in some way. They could be making an incorrect selection or the power supply could be faulty and applying an incorrect voltage to the horizontal and vertical deflection circuits. The brightness changes since it is not compensated for properly.

Burning up of various size or centering resistors

Check the capacitors that couple the yoke to to ground. If they become reduced in value or develop a high ESR, the current will be diverted to other components with unfortunate and rapid consequences.

Picture shifted horizontally

The first thing to determine is if this is a position or phase problem:

- A fault with horizontal position means that the entire raster is shifted left or right. This is almost certainly a monitor problem. If you turn up the brightness control, the edges of the scan lines will probably be visible on one side.
    - Assuming the position or centering controls do not work at or or have insufficient range, check for a defective centering pot and bad centering diodes and other components in their vicinity. If digitally controlled, you will probably need a schematic to find the cause.
    - If the monitor was dropped, the yoke or other assembly on the CRT neck may have shifted (though there would probably be other symptoms as well).
    - Monochrome monitors have centering rings on the CRT neck which may have be knocked out of adjustment. Color monitors adjust the centering electronically since magnetic rings would mess up the purity and/or convergence.
- A fault with horizontal phase means that the raster is still centered on the screen but the picture itself is shifted (and may have some wrap-around) within the raster. This could be a fault in the monitor or video card or incorrect settings in the software setup for the video card.
    - If this happened while trying out this monitor on a different or modified computer, just after you have done a software upgrade, or just after something strange happened (like your PC's CMOS settings got corrupted - monitor settings are generally not in the CMOS setup but may have been affected at the same time), reset the monitor's controls to their default or middle position and then use the software setup or install program that came with your video card to set scan rates, size, position, and sync polarity.
    - Some monitors have a user accessible horizontal phase control in addition to horizontal position. This adjusts the delay in the sync circuits so check that area of the electronics if the control doesn't work or have enough range.
- There could also be a problem with base drive to the HOT. This may result in position, phase, size, and linearity errors as the scan being initiated too soon or too late.
    - Weak drive to the HOT due to faulty components in the base circuit or driver stage might result in the HOT coming out of saturation early. The picture would be shifted to the right and the HOT might run excessively hot and blow.

WARNING: The case of the HOT has >1,000 V spikes and B+ when off - don't touch with power on or until you confirm no voltage is present after pulling plug.

- If marginal, a drift of position, phase, size, and linearity with warmup is also likely. Check for dried up electrolytic capacitors and use cold spray to isolate other bad components. If the drive becomes too weak, the HOT may blow after after being on for a while.

Horizontal or vertical flipped picture

The picture is flipped left-to-right or is upside-down or both. This cannot happen as a result of a failure. For a CRT-based TV or monitor, it almost certainly means that the wires to the horizontal or vertical deflection yoke have been swapped to enable the picture to appear correct when viewed via a mirror (horizontal only) or if the unit were mounted base-up to a ceiling (both). The remedy is simply to swap the two wires to the relevant deflection yoke(s). There may even be obvious splices to guide you. There is usually a connector with 4 relatively fat wires that go to the deflection yoke on the CRT neck (NOT the PCB attached to the tube base). If you don't have a schematic, trace these on the main PCB back to their origin. The horizontal will originate somewhere in the vicinity of the flyback transformer. It may be possible to disengage the wires from the connector shell and swap them there. If not, cut, splice, and solder. Adjustment of the appropriate centering controls may be needed.

For flat panel displays, it is even more unlikely this would happen as a result of a hardware failure. Most likely, there is a mode setting in the one of the setup menus for the TV or monitor itself. It could also be in the receiver for the TV, or the driver or application software of the PC. If the source is a video projector, the menu setting is likely there, to select between front and rear projection (horizontal) or table or ceiling mount (both). So, don't bother to open up the flat panel TV or monitor. The problem is not there! :)

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High Voltage Power Supply Problems

Identifying HV voltage problems

In addition to the obvious "monitor screen is as black as a coal mine" symptom, problems in the high voltage power supply can result in a variety of brightness, raster geometry, and other picture problems as well as arcing, corona, or other sights, sounds, and smells not normally associated with a properly functioning monitor. This chapter deals with some of these. Other video related problems will be dealt with in the chapter: "Raster, Color, and Video Problems".

High voltage power supply fundamentals

Most, monitors derive the high voltage for the CRT second anode (THE high voltage, focus, and (sometimes) screen (G2) from the horizontal deflection system. This technique was developed quite early in the history of commercial TV and has stuck for a very simple reason - it is very cost effective. A side effect is that if the horizontal deflection fails and threatens to burn a (vertical) line into the CRT phosphors, the high voltage dies as well. Of course, if the vertical deflection dies....

Some auto-scan monitors utilize a separate high voltage supply. One reason for this approach is to decouple the horizontal deflection from the HV in auto-scan monitors thus simplifying the design.

Usually it is a self contained inverter module. It if can be opened, then repair may be possible. With a separate HV supply, there is no need for a HV flyback transformer on the mainboard. Some designs may use a separate HV supply including a flyback which is part of the mainboard but is self contained and independent of the horizontal deflection system.

Most TV and monitor (flyback) high voltage supplies operate as follows:

1. Horizontal output transistor (HOT) turns on during scan. Current increases linearly in primary of flyback transformer since it appears as an inductor. Magnetic field also increases linearly. Note: flyback is constructed with air gap in core. This makes it behave more like an inductor than transformer as far as the primary drive is concerned.

2. HOT shuts off at end of scan. Current decreases rapidly. Magnetic field collapses inductively coupling to secondary and generates HV pulse. Inductance and capacitance of flyback, snubber capacitors, and parasitic capacitance of circuitry and yoke form a resonant circuit. Ideally, voltage waveform across HOT during flyback (retrace) period will be a single half cycle and is clamped by damper diode across HOT to prevent undershoot.

3. Secondary of flyback is either a single large HV winding with HV rectifiers built in (most often) or an intermediate voltage winding and a voltage multiplier (see the section: What is a tripler?). The output will be DC HV pulses.

4. The capacitance of the CRT envelope provides the needed filtering to adequately smooth the HV pulses into a DC voltage. Sometimes there is a separate HV capacitor as well.

5. A high resistance voltage divider provides the several kV focus voltage and sometimes the several hundred volt screen (G2) voltage as well. Often, the adjustments for these voltages are built into the flyback. The focus and screen are generally the top and bottom knobs, respectively. Sometimes they are mounted separately. This or a similar divider may also provide feedback to control high voltage regulation.

What is a tripler?

In some TVs and monitors, the flyback transformer only generates about 6-10 kV AC which is then boosted by a capacitor-diode ladder to the 18-30 kV needed for modern color CRTs. The unit that does this is commonly called a tripler since it multiplies the flyback output by about 3 times. Some TVs use a quadrupler instead. However, many TVs and monitors generate the required HV directly with a winding with the required number of turns inside the flyback transformer.

Triplers use a diode-capacitor ladder to multiply the 6-10 kV AC to 18-30 kV DC. Many triplers are separate units, roughly cubical, and are not repairable. Some triplers are built in to the flyback - it is probably cheaper to manufacture the HV diodes and capacitors than to wind a direct high voltage secondary on the flyback core. In either case, failure requires replacement of the entire unit.

For external multipliers, the terminals are typically marked:

- IN - from flyback (6-10 kV AC).
- OUT - HV to CRT (20-30 kV DC).

- F - focus to CRT (2-8 kV).
- CTL - focus pot (many megohm to ground).
- G, GND, or COM - ground.

Symptoms of tripler failure are: lack of high voltage or insufficient high voltage, arcing at focus protection spark gap, incorrect focus voltage, other arcing, overload of HOT and/or flyback, or focus adjustment affecting brightness (screen) setting or vice-versa. Where there is overloading, if you disconnect the tripler and everything else comes back to life (obviously, there will be no HV or picture), then it is very likely bad.

High voltage shutdown due to X-ray protection circuits

A monitor that runs for a while or starts to come on but then shuts down may have a problem with the X-ray protection circuitry correctly or incorrectly determining that the high voltage (HV) is too great (risking excessive X-ray emission) and shutting everything down.

A side effect of activation of this circuitry is that resetting may require pulling the plug or turning off the real (hard) power switch.

Was there anything else unusual about the picture lately that would indicate an actual problem with the HV? For example, has it suddenly gotten brighter than normal or has the size decreased? If this is the case, then there may be some problem with the HV regulation. If not, the shutdown circuit may be overly sensitive or one of its components may be defective - a bad connection of leaky cap (or zener).

If the horizontal frequency is not correct (probably low) due to a faulty horizontal oscillator or sync circuit or bad horizontal hold control (should one exist!), HV may increase and trigger shutdown. Of course, the picture won't be worth much either! With a multiscan monitor, this could happen if the mode switching is faulty resulting in incorrect component settings for a given scan rate. A symptom might be HV shutdown when switching into scan ranges.

The HV shutdown circuit usually monitors a winding off of the flyback for voltage exceeding some reference and then sets a flip flop shutting the horizontal drive off.

On some Sony models, a HV resistive divider performs this function and these do fail - quite often. The red block is often called a 'HV capacitor' (but is technically the 'HSTAT' unit because it has a control for horizontal static convergence) and is a common cause of immediate or delayed shutdown on certain Sony monitors and TVs. With these failures, the HV doesn't become excessive but the sense voltage rises due to leakage with the voltage divider. See the section: Apple/Sony monitor dies after variable length of time.

Excessive low voltage supply may trigger high voltage shutdown

(From: Ray Chandos (rchandos@ivc.edu).)

Modern television receivers and video monitors are all equipped with a safety circuit to shut down the high voltage feeding the anode of the picture tube if that high voltage becomes excessive. (This is to prevent dangerous x-rays emitted when electrons with too much energy strike the metal shadow mask just inside the TV screen.) Unfortunately, high voltage shutdown problems can be very difficult to diagnose because, once shutdown has occurred, the horizontal pulses used to generate the high voltage are turned off, and with them the high voltage itself.

In many cases I have encountered, the high voltage is not excessive, but the shutdown circuit itself has failed and falsely triggers. A common cause of this is failure of the circuitry that samples the high voltage and feeds a portion back to the input of the shutdown circuit. Typically, a tap from the flyback transformer feeds a diode and a filter capacitor to produce a sample DC voltage proportional to the high voltage. As the high voltage increases, so does this sample. It is usually further reduced by a voltage divider, then sent through a series zener diode to the "horizontal shutdown" input of a video processor chip, so that, if the divided down voltage exceeds the rating of the zener diode, the latter will conduct and trigger the shutdown input, which then latches off the horizontal pulses. Now if the bottom resistor in the voltage divider opens, or increases above its nominal value (common for high value carbon resistors), the sampled voltage will increase, possibly enough to falsely trip the shutdown input. Check it with an ohmmeter.

Incidentally, if you don't have a schematic, you can still attempt to diagnose and repair your shutdown problem. Start with the video processor IC, a huge chip that controls most of the TV functions. Get the pinout from this web site, the ECG semiconductor replacement guide, or data sheet archives on the Internet. Find the horizontal output and horizontal shutdown pins, and attach oscilloscope probes to verify that you have a shutdown problem. If you do, you will see horizontal pulses for a brief instant on power up, but suddenly disappearing as the shutdown input voltage goes up and turns them off. (This is a latching circuit, so the shutdown voltage will normally stay high until the power is turned off.)

Now trace the shutdown signal voltage back through the voltage divider, the filter capacitor, and the diode to the flyback winding. Test out all these parts as you go.

If the shutdown circuitry all seems OK, it may be doing its intended job of detecting and disabling excessively high voltage. Too much high voltage often results when the lower voltage DC supply feeding the high voltage supply circuitry somehow gets too high. This voltage, often around +160 VDC, nowadays comes from the TV's main regulated power supply and is applied to one end of the flyback transformer primary. The other end connects to the collector of the horizontal output (a large, high voltage power transistor on a heat sink), the emitter of which connects to ground. Horizontal drive pulses originating in the video processor circuit drive the base terminal of this transistor, switching it on when the pulses are high and thus supplying current to the flyback transformer primary. The secondary winding, having many more turns, steps up the +160 Volts applied to the primary to 25 - 45 kV, which is rectified, filtered, and applied to the anode of the picture tube. Now if the +160 Volts increases, say to +200 Volts, due to some malfunction in the main power supply regulation, then the secondary voltage will also increase by the same percentage, and trip the high voltage shutdown circuit.

Fortunately, although the high voltage quickly vanishes after shutdown, preventing you from measuring it, the low voltage usually stays on. You can measure it (carefully) from the collector of the horizontal output transistor to ground. Of course, if you lack a schematic, you won't know if this voltage is correct or not, so again trace it back from the flyback transformer primary to the main TV power supply. There you may find a label printed on the printed circuit board telling you the normal voltage. You can also get a clue by looking at the voltage rating of any filter capacitor connected from this voltage line to ground. For example, if the filter capacitor is rated at 200 V and you are measuring 220 V, you know you have a problem. Sometimes the voltage will come from a linear voltage regulator IC whose pinout and output voltage you can look up from the chip number. These linear regulators can short from input to output, raising the output voltage and leading to the shutdown problem.

If the low voltage comes instead from a switching regulated supply and you can't readily determine the normal output voltage, check for a bad filter capacitor on the feedback winding. Most such power supplies put out several regulated voltages, derived from separate windings on the switching supply transformer, then rectified and filtered, for use in various places in the set. Regulation of these voltages is accomplished by sampling the output from a dedicated feedback winding, and then cranking up the transistor switch if that voltage is too low, or cutting back the transistor switch if the voltage is too high. The idea is that, since all of the output voltages come from the same transformer, with the output voltage of each determined by the number of turns on its winding of the transformer, if one voltage (from the feedback winding)is correct, then they all will be correct. Now if the filter capacitor on the feedback winding opens, lowering the sensed DC voltage from that winding, what will the voltage regulator circuit do? Not realizing that the reduced feedback is due to a bad filter capacitor, it simply cranks up the transistor switch to get the voltage back up where it belongs. But that raises all the other output voltages as well, making them higher than they should be, including the one powering the high voltage supply! And that will trip the shutdown circuit.

When replacing filter capacitors, be sure to use good ones rated for 105 (not 85) degrees C, and able to withstand the high frequency pulses they are getting hammered by in these circuits.

Low or no high voltage

Most of these problems are due to faults in the horizontal deflection system - shorted HOT, shorted windings or HV rectifiers in the flyback, defective tripler, or other bad parts on the primary side of the flyback.

In addition, with auto-scan monitors, the incorrect voltage or other component could be selected due to a logic fault or a problem with the selection relay or other circuitry.

However, if you discover an inch layer of filth inside the monitor, the HV could simply be shorting out - clean it first.

In most cases, these sorts of faults will put an excessive load on the horizontal output circuits so there may be excessive heating of the HOT or other components. You may hear an audible arcing or sizzling sound from internal shorts in the flyback or tripler. Either of these may bet hot, crack, bulge, or exhibit visible damage if left on with the fault present.

Many modern monitors do not regulate HV directly but rather set it via control of the low voltage power supply to the HOT (B+), by snubber capacitors across the HOT, and the turns ratio of the flyback. The HV is directly related to the B+ so if this is low, the HV will be low as well. Faulty snubber capacitors will generally do the opposite - increase the HV and the X-ray protection circuits may kick in. However, low HV is also a possibility. The only way the turns ratio of the flyback can change is from a short which will manifest its presence in other ways as well - excessive heating and load on the horizontal output circuits.

While a shorted second anode connection to the CRT is theoretically possible, this is quite unlikely (except, as noted, due to dirt).

Excessive high voltage

Any significant increase in HV should cause the X-ray protection circuits to kick in and either shut down the set or modify the deflection in such a way as to render it harmless.

Symptoms include arcing/sparking of HV, smaller than normal picture, and under certain scenarios, possible excessive brightness.

Causes of the HV being too high are:

1. Excess B+ voltage to the HOT. The likely cause is to a low voltage regulator failure.

2. Open snubber capacitors across the HOT. These are under a lot of stress and are located near hot components so failure is possible.

3. Incorrect excessively long scan drive to HOT caused by failure of horizontal oscillator/sync circuits. However, other things like the HOT will probably blow up first. The picture will definitely be messed up. This is more likely with auto-scan monitors than TVs since what is too long for one scan range may be correct for another and the selection circuitry is confused or broken.

4. Failure of HV regulator. Actual HV regulators are uncommon today but the HV may controlled by a feedback voltage from a divider (focus or screen, or its own) or a secondary winding on the flyback setting the B+ or drive timing. This may result in an underscanned (smaller than normal) picture if only the HV and not the deflection voltages as well are derived from the same supply.

In one example of (4), a arcing of the HV in a Conrac studio monitor resulted in the destruction of the HV switchmode inverter transistor (this used a separate HV supply) and a fusable resistor. The cause was an open HV feedback resistor divider allowing the HV to increase drastically.

Snaps, crackles, and other HV breakdown

Various problems can result in occasional or sustained sparking or arcing sounds from inside the monitor. Note that a static electricity buildup is common on the front of the screen. It is harmless and there iss nothing you can do about it anyhow.

The following may result in occasional or sustained sounds not commonly associated with a properly working TV or monitor. There may or may not be flashes or blanking of the screen at the same time as the audible noise. See the same-named sections that follow for details.

- Arcing, sparking, or corona from CRT HV anode (red wire/suction cup).
- Arcing at CRT sparkgaps.
- Arcing from flyback or vicinity.
- Arcing due to bad connections to or disconnected CRT return.
- Flashovers inside the CRT.

Arcing, sparking, or corona from CRT HV anode (red wire/suction cup)

Symptoms could include a sizzling corona or more likely, an occasional or rapid series of sharp snaps - possibly quite loud and quite visible - from the anode cap on the CRT to the grounded coating on the outside of the CRT or a chassis ground point (or any other conductor nearby). Corona is a high resistance leakage through the air without total breakdown. The snapping is caused by the sudden and nearly complete discharge of the CRT anode capacitance through a low resistance ionized path similar to lightning.

There are two likely causes:

1. Dirt, dust, grime, around and under the suction cup on the CRT are providing a discharge path. This may be more severe in humid weather. Safely discharge the HV and then remove and thoroughly

clean the HV suction cup and the area under it and on the CRT for several inches around the HV connection. Make sure there are no loose wires or other possible places for the HV to discharge to in the vicinity.

2. The high voltage has gone through the roof. Usually, the X-ray protection circuitry should kick in but it can fail. If cleaning does not help, this is a likely possibility. See the sections: High voltage shutdown due to X-ray protection circuits and Excessive high voltage.

Arcing at spark gaps and gas discharge tubes on CRT neck board or elsewhere

These are protective devices intended to breakdown and divert excessive voltage away from the CRT (usually).

This is rarely due to a defective sparkgap or gas discharge tube but rather is a safety mechanism like a fuse designed to protect the internal electrodes of the CRT if the focus or screen voltage should become excessive. The sparkgap breaks down first and prevents internal arcing in the CRT. These sparkgaps may be built into the CRT socket as well.

Arcing at a sparkgap or a glowing or flashing discharge tube may be accompanied by total loss of picture or bad focus, brightness or focus fluctuations, or any of a number of similar symptoms. A common cause is a breakdown inside the focus divider (usually part of the flyback or tripler) but could also be due to excessive uncontrolled high voltage due to a failure of the B+ regulator or HOT snubber capacitor, or (ironically) even a short inside the CRT.

- Spark gaps may be actual two or three pin devices with seemingly no insides, part of the CRT socket, or printed on the circuit board itself.
- Gas discharge tubes look like small neon lamps (e.g., NE2) but could be filled with some other gas mixture to provide a controlled higher breakdown voltage.

Therefore, like a fuse, don't just replace or disable these devices, locate and correct underlying problem. The CRT makes an expensive fuse!

Spark gaps and gas discharge bulbs on CRT neck board or elsewhere

These are protective devices intended to breakdown and divert excessive voltage away from the CRT (usually).

- Spark gaps may be actual two or three pin devices with seemingly no insides or printed on the circuit board itself.
- Gas discharge bulbs look like small neon lamps (e.g., NE2) but could be filled with some other gas mixture to provide a controlled higher breakdown voltage.

Arcing at a spark gap or a flashing or glowing gas discharge tube may indicate excessive high voltage, a short in the focus/screen divider network of the flyback, a short in the CRT, or some other fault resulting in abnormally high voltage on its terminals.

Arcing from flyback or vicinity

Arcing may be visible or audible and result in readily detectable levels of ozone. Note that very slight traces of ozone may not indicate anything significant but if the TV smells like an office copier, there is probably some discharge taking place.

WARNING: It is possible for arcing to develop as a result of excessive high voltage. Symptoms might be a smaller than normal excessively bright picture but this may not be able to be confirmed until the flyback is repaired or replaced. See the section: Excessive high voltage.

- On the HV output, it will probably be a loud snapping sound (due to the capacitance of the CRT) with associated blue/white sparks up to an inch or more in length. If the arc length is short enough, this may turn into a nearly continuous sizzling sound with yellow/orange arc and melting/burning plastic.

- Prior to the HV rectifier, it will likely be a continuous sizzle with orange/yellow/white arc and melting/burning plastic or circuit board material.

- Internal arcing in the flyback may be audible and eventually result in a bulging and/or cracked case (if some other component doesn't fail first as this would take some time to develop).

- A corona discharge without actual sparks or a visible well defined arc is also possible. This may be visible in a totally dark room, possibly more likely when the humidity is high. A thorough cleaning to remove all dust and grime may be all that is needed in this case.

- If the arc is coming from a specific point on the flyback - a crack or pinhole - this may be patched well enough to confirm that the rest of the monitor is operational and a new flyback is worth the money. Otherwise, there is no way of knowing if the arcing may have damaged other circuitry until a replacement flyback - possibly money wasted - arrives.

  To attempt a repair, scrape off any dirt or carbon that is present along the path of the arcing and its vicinity. Then, clean the area thoroughly with alcohol and dry completely. Otherwise, the dirt and carbon will just act as a good conductor and the arcing will continue under your repair! Several layers of plastic electrical tape may be adequate for testing. Multiple coats of high voltage sealer or non-corroding RTV silicone (if it smells like vinegar - acetic acid - as it cures, this may get in and affect the windings) would be better if the objective is an actual repair. A thick layer of Epoxy may be even better and affected less by possible HV corona. Either of these may prove to be a permanent fix although starting the search for a source for a new flyback would not hurt just in case. The arc most likely did damage the insulation internally which may or may not be a problem in the future.

  Also see the section: Dave's complete procedure for repair of an arcing flyback.

- In some cases, the pinhole or crack is an indication of a more serious problem - overheating due to shorted windings in the flyback or excessive secondary load.

- If the arc is from one of the sparkgaps around the CRT, the CRT socket, or the plastic 'alignment base' on the CRT itself, this could also be a flyback problem indicating internal shorts in the focus/screen network.

- If the arcing is inside the CRT, this could indicate a bad CRT or a problem with the flyback focus/screen network and no or inadequate sparkgap protection.

Where repair seems possible, first, clean the areas around the arc thoroughly and then try several layers of plastic electrical tape. If the TV works normally for say, an hour, then there is probably nothing else wrong and you can try for a proper sealing job or hope that tape holds out (put a few more layers on - each is good for about 8-10 kV theoretically).

Once I had a TV where the main problem was a cracked flyback arcing but this took out one of the fusable resistors for the power supply to the *vertical* output so the symptoms included a single horizontal line. Don't ask me to explain - replacing that resistor and the flyback (the flyback tested good, but this was for someone else) fixed the TV.

In another case, a pinhole developed in the flyback casing probably due to poor plastic molding at the time of manufacture. This resulted in a most spectacular case of sparking to a nearby bracket. A few layers of electrical tape was all that was needed to affect a permanent repair.

However, replacement is really the best long term solution both for reliability as well as fire risk.

(From: Bert Christensen (rosewood@interlog.com).)

It may well last a long time. The insulation breakdown was probably in the area of the rectifier section rather than the flyback section. I have repaired several units in the same way but I have generally replaced the flyback before sending back to the customer. I am worried that the repair will not hold and that a fire could start. I have no desire whatsoever to be sued by some fire insurance company.

I am always reminded by the experience that Zenith had with its System 3 chassis a few years ago. They burned and caused many house fires including one in the governor's mansion in Texas. Zenith spent mega bucks on that one. They also spent mega-bucks on their 'safety capacitor' mess a few years before that.

Dave's complete procedure for repair of an arcing flyback

(From: Dave Moore (penguin@datastar.net).

First I clean the afflicted area with Electromotive spray from Autozone. It's for cleaning alternators. On Z-line I remove the focus control and wash with the alternator cleaner and a tooth brush until all dirt and carbon deposits are removed. Then I take an xacto knife and carve out the carbonized hole where the arcing broke through. Then take your soldering iron and close the hole by melting adjacent plastic into it. (clean any solder off your iron with solder-wick first). Then cut some plastic off of some other part off the flyback where it wont be needed and use this to plastic weld (with your iron) a hump of a patch into and over the arc hole. Smooth and seal with iron. Next apply as thick a layer of silicone rubber as you can and let dry overnight.

Arcing due to bad connections to or disconnected CRT return

The Aquadag coating on the outside of the CRT is the negative plate of the HV filter capacitor. If this is not solidly connected to the HV return, you will have your 25 kV+ trying to go where it should not be. There should be a wire solidly attached to the CRT neck board or chassis. Without this, voltage will build up until it is able to take some other path - possibly resulting in damage to sensitive solid state components in the process. Therefore, is is important to rectify the situation.

Warning: If you find this disconnected, don't just attach it anywhere. You may instantly kill ICs or other solid state components. It must be connected to the proper return point on the CRT neck board or chassis.

Flashovers inside the CRT

Due to sharp edges on the electron gun electrodes, impurities, and other manufacturing defects, there can be occasional arcing internal to the CRT. Properly designed HV, deflection, and power supply circuits can deal with these without failing but not all monitors are designed well.

There is nothing you can do about flashovers assuming your HV is not excessive (see the section: Excessive high voltage. If these persist and/or become more frequent, a new CRT or new monitor will be needed.

Ozone smell and/or smoke from monitor

Smoking is just as bad for monitors as for people and usually more quickly terminal (no pun....).

White acrid smoke may indicate a failed electrolytic capacitor in the power supply probably in conjunction with a shorted rectifier. Needless to say, pull the plug at once.

A visual inspection should be able to easily confirm the bad capacitor as it will probably be bulging and have condensed residue nearby. Check the rectifier diodes or bridge rectifier with an ohmmeter. Resistance across any pair of leads should be more than a few ohms in at least one direction. Remove from the circuit to confirm. Both the faulty diode(s) and capacitor should be replaced (though the capacitor may work well enough to test with new diode(s).

If a visual inspection fails to identify the smoking part, you can probably plug the monitor in for a few seconds until the source of the smoke is obvious but be prepared to pull the plug in a real hurry.

If the smell/smoke is coming from the flyback, then it has probably gone belly up. You may be able to see a crack or bulge in the case. While the flyback will definitely need to be replaced, it is likely that nothing else is wrong. However, it might be prudent to use a Variac when performing initial testing with the replacement just in case there is a secondary short circuit or excess HV problem.

X-ray and other EM emission from my TV or monitor?

X-ray radiation is produced when a high velocity electron beam strikes a target containing heavy metals. In a modern TV or monitor, this can only take place at the shadow mask/aperture grille and phosphor screen of the CRT.

For X-rays, the amount of radiation (if any) will be proportional to brightness. The energy (determined by the CRT high voltage, called kVP in the medical imaging field) is not affected. This is one reason many monitors and TVs are designed with brightness limiting circuits.

In any case, there will be virtually no X-ray emissions from the front of the CRT as the glass is greater than an inch thick and probably contains some lead for added shielding. Also see the section: Should I be worried about X-ray exposure while servicing a TV or monitor?.

Electromagnetic radiation (EM) is produced mostly from the deflection yoke and to a lesser extent from some of the other magnetic components like transformers and inductors. Depending on monitor design (some are specifically designed to reduce this), EM emissions can vary quite a bit. Frequencies range from the 50/60 Hz of the power line or vertical scan rate to several hundred kHz in the AM broadcast band. The intensity and spectral distribution will vary depending on horizontal and vertical scan rate.

A totally black screen will reduce X-ray emission to zero. It will not affect EM emissions significantly as most of this comes from the magnetic parts, particularly the deflection yoke.

There is no measurable microwave, IR, or UV radiation.

I refuse to get into the discussion of what, if any, health problems result from low level EM emissions. There is simply not enough data.

Should I be worried about X-ray exposure while servicing a TV or monitor?

The only source of X-rays in a modern TV or monitor is from the CRT. X-rays are generated when a high velocity electron beam strikes a heavy metal target. For anything you are likely to encounter, this can only happen in a vacuum - thus inside the CRT. The higher the voltage, the greater the velocity and potential danger. Really old TVs (prior to around 1975) may still have HV rectifier and regulator tubes - other sources of X-rays. However, modern TVs and monitors implement these functions with solid state components.

The thick front CRT faceplate protects users adequately but there may be some emission from the thinner sides. At 25-30 kV (quite low as X-ray energies go) X-rays will be stopped by almost any metal so what you have to worry about is where there are no shields. In addition, the CRT glass usually contains some lead compounds to block X-ray emissions.

Other than lowering the brightness (or high voltage!), there isn't anything you can do to reduce X-ray emission from the front of the monitor. Any sort of add-on screen (grounded or otherwise) unless it is made of thick leaded glass, will have no significant effect on X-rays. If you are still concerned, sit farther away.

However, realistically, there is very little danger. I would not worry about exposure unless you plan to be sitting for hours on the sides, behind, or under the TV or monitor - with a picture (there will be none if the screen is black).

It is interesting that even those 1.5" Watchman and .5" camcorder viewfinder CRTs have X-ray warning labels even though the high voltage used with these isn't anywhere near high enough to be of any concern!

More on radiation from TVs and monitors

(From: Jerry Greenberg (jerryg50@hotmail.com).)

Your standard TV set or monitor should not exceed about 0.2 mR/Hr of radiation from a distance of 5 cm from any part of the cabinet. Most TV monitor equipment is less than half of this amount.

The CRT has a coating on the inner wall of its glass envelope, and also there is a metal shadow mask or aperture grill in the front. There is also a metal shroud around its parameter.

The type of emission from the CRT is known as soft X-Ray emission. This is because it is low power, and is in the lower X-Ray region.

The X-Ray emission is strongest at the rear of the TV set because there is some opened area where the electron gun is located. But, this is very weak as well. The radiation from a TV or monitor is not being focused to one point, and is also below the threshold level of being dangerous.

The long term effect of the total radiation from normal operating TV equipment is not fully known. However, the effect of X-Ray radiation is accumulative over time if there are no breaks in between the exposures. As for standard focused X-Rays like the ones used in a medical or security facility, these and most of their effects are well known.

As for normal working TV equipment, when used normally, the total radiation is less that what you would get when walking on the street. There are many satellites beaming down signals, radio and TV broadcast stations, communications systems, and then cell phones.

The X-Ray radiation in a TV set is emitted from the effect of the High Voltage drive generating the electron beam. If the High Voltage exceeds the designed safety limit for the CRT, then there is concern that the X-Ray radiation may have some effect on anyone that is in close proximity to the CRT. The amount of by which the high voltage exceeds the design specfifications will determine the total X-Ray emission. Since this emission is not focused into a fine area, its immediate danger is also greatly reduced.

All TV sets by law must have in their design some type of protection to shut the TV down if there is excessive High Voltage, excessive High Voltage current drive, and a number of other safety criterias.

There is also the concern about electromagnetic radiation. In fact all radio frequencies are based on electromagnetic radiation (EMR).

There was a great concern about the low frequency EMR. This would come from the power supply, deflection amplifier stages, and then from the deflection yoke and flyback transformer. There different types of EMR from TV sets.

Concerning TV's and monitors, this radiation worry comes up from time to time. If a woman is pregnant it would be wiser for her to not expose the unborn baby by working close to a terminal or monitor. This nonexposure is a good policy to make sure that everyone is safe rather than suffer any type of damage or health risks.

As for a safety concern for a mother to be, or a small baby, they can be in front of a TV set but at least 5 to 7 feet away. From this distance there should not be any danger at all.

The above is from my personal observations and is very general. I have also read various publications over the years that pertain to this subject.

I have a personal concern about the radiation from TV sets and monitors because I do an extensive amount of service on these. I am also doing a lot of picture tube changes in monitor equipment. I am then exposed for a few hours because I must do the purity and convergence setups of these sets. I have some days where I work 10 to 12 hours doing TV and monitor service work.

If you want a TV monitor that will put out near zero X-Ray radiation, and very low electromagnetic radiation, then go for one of the new LCD flatscreen monitors.

Flyback got wet

You put your can of Coke where????

Who says these FAQs cannot be funny?

Needless to say, unplug the monitor immediately. Inspect around the target area for obviously blown or damaged components. Test fuses and fusable resistors. Remove all traces of liquid - especially sugary or corrosive liquid. Use water first and then alcohol to promote drying. Repair burnt solder connections and circuit board traces. Once the monitor is entirely dried out, power it up - preferably through a series light bulb and/or Variac until you are sure nothing else will let loose. Look, listen, and smell for any unusual behavior. If it now works, then consider yourself lucky. If not, there may be damage to transistors, ICs, or other components.

Another cause of this is using spray cleaner or a too wet rag on the front of the CRT (other parts of the monitor, for that matter). Any liquid which drips inside (all too likely) may short out circuitry on the mainboard with very expensive consequences.

Blooming or breathing problems

There are several symptoms that are basically similar:

- Blooming is defined as an expansion of the raster or horizontal sections of the raster with bright material. For example, switching between dark and light picture causes the size of the picture to expand by 10%. A slight change in size is unavoidable but if it is greater than 1 or 2 percent from a totally black image to a full white one, this is either an indication of a defective monitor or one that is badly designed. The cause is poor low or high voltage regulation.

  Check the B+ to the horizontal deflection. This is usually well regulated. If it is varying in sympathy to the size changes, trace back to determine why the low voltage regulator is not doing its job. The reason for the size change is that the high voltage is dropping and reducing the stiffness of the electron beam.

- Expansion of the raster width in areas of bright imagery is an indication of short term regulation problems. The video drive may be interacting with the other power supplies. Check for ripple - this would be at the vertical scan rate - in the various regulated power supplies. The cause may be a dried up electrolytic capacitor - once you locate the offending voltage, test or substitute capacitors in that supply.

In both these cases, if this just started after some work was done to the monitor, the brightness limiter and/or video drive may simply be set so high that the monitor cannot supply enough current to the high voltage. If the brightness is acceptable with these turned down slightly and still have acceptable brightness, then there may be nothing wrong.

- Breathing is defined as a periodic change in the size of the raster which may be independent of what is displayed or its severity or frequency may be related to the brightness or darkness of the image. This is another type of regulation problem and may be caused by bad electrolytic capacitors or other components in the low voltage power supplies.

  If the monitor uses a switchmode power supply or low voltage regulator separate from the horizontal deflection, first check its output(s) for a variation in voltage at the breathing rate. Test with a light bulb or resistor load to confirm that the problem is here and not the deflection or remainder of the monitor.

- A condition with somewhat similar symptoms is bad focus - fuzzy picture - but only with bright (high beam current) scenes. This could be just a matter of adjusting the focus control but may also indicate sub-optimal filament voltage due to bad connections or components in the filament circuit, or a tired worn CRT. You won't get high beam current without some serious spot blooming (a fat beam because too much cathode area is used) and you will get cathode 'poisoning' after prolonged use.

Visually inspect the neck of the CRT for the normal orange glow of the filaments and check for bad connections and bad parts.

Erratic focus or screen (G2) voltage and/or controls on flyback

Symptoms may include fluctuating focus or brightness. In extreme cases, the result may be a too bright or dark picture or other behavior caused by breakdown in the Focus/Screen(G2) divider network.

Usually, this will require flyback replacement to repair reliably. Sometimes, the section with the controls can be snapped apart and cleaned but this is not common.

First, just try rotating the screen (G2) control back and forth a few times. This may clean up the contacts and eliminate the erratic behavior. Possibly, positioning it a bit to one side of the original location will help. Then, use the individual or other master background/bias adjustments to compensate for the improper brightness.

If pressing in on the erratic control helps to stabilize the setting, you might try adjusting it to the optimal position and then put a dab of hot-melt glue (or Superglue if you can manage not to stick your fingers together) on the shaft to hold it with a little more contact force.

If none of this helps, here is a 'well it's going in the dumpster anyhow' procedure to try:

After discharging the CRT (so you don't get zapped) drill a tiny hole in the plastic cover near the bad control. Be careful you don't damage anything inside - you just want access to the contacts of the controls. Use a hand drill with, say, a 1/16" bit. Don't drill more than about 1/8" deep which should enter the airspace. Then spray some contact cleaner through the hole and work the controls. Wait sufficient time (say, 24 hours) for everything to dry COMPLETELY and see if behavior changes (or it works at all).

This is a 'you have got to be kidding' type of repair so no guarantees :-).

If by some miracle it does work, fill the hole with a drop of RTV or just put a couple of layers of electrical tape over it.

Focus/Screen divider bypass surgery

This is kludge number 41256 but may be the difference between a bit more life and the dumpster.

If the previous extreme measures don't help, then it may be possible to simply substitute a good divider network externally.

Note that if there is evidence of internal breakdown in the divider of the original flyback (hissing, cracks, overheating, bulging case, etc.), this will not work unless you can disconnect it from its HV connection.

There are two issues:

1. Is this a stable situation? Even if you provide an external substitute, the parts inside the flyback may continue to deteriorate eventually resulting in other more total failure of the flyback or worse.

2. If you provide an external focus/screen divider, it must be done is such a manner (including proper mounting and super insulation) such that it cannot be called into question should there be a fire where the monitor is even the slightest bit suspect.

Various size external focus/screen divider networks can be purchased but whether this is truly a cost effective solution is not obvious.

(From: Larry Sabo (sabo@storm.ca).)

I just ordered a 'bleeder resistor' from Data Display Ltd (Canadian sub of CCS) to use as a cure for flybacks with flaky focus/screen pots. It contains focus and screen pots, and costs Cdn$ 16.99, which is a lot less than a complete flyback, that's for sure. I expect it will be compatible with quite a wide range of flybacks.

I have used bleeder resistor assemblies from duff flybacks a couple of times with good success. You connect the HV lead into the HV cap of the original flyback, ground all pins of the sub flyback, and use the focus and screen leads from the sub bleeder assembly in place of the originals.

Looks like hell but works fine. Mounting (and securing) the substitute is a challenge given the limited space available. I only use this approach on what would otherwise be uneconomical to repair, and always advise the owner or customer of the cobbling job. It also enables you to verify whether it is the flyback that needs replacement, versus the CRT.

Decaying or erratic focus or screen (G2) voltages

The following applies to both CRT focus voltage (which should be a few kV) and screen or G2 voltage (which should be several hundred V).

> "The screen voltage will come up to normal after sitting over night, 400 V or so. After approximately 5 minutes or slightly longer, I hear a slight arcing. From that point on, the screen voltage will wander anywhere from 75 V up to maybe 150 V. Adjustment of the screen control on the flyback has only a small effect and is not permanent. Removing the CRT pcb results in the screen voltage returning to normal."

This is very likely a short between electrodes inside the CRT unless there is something on the neck board that is breaking down as a result of some connection to the CRT. The flyback should largely not know the difference with the socket plugged into the CRT. However, on rare occasions, there is contamination within the 'plastic alignment base' on the end of the CRT neck. (It is possible to *carefully* remove the plastic piece and clean the CRT glass/pins. Reinstall the plastic piece if it is still intact or leave it off - just take care in replacing the CRT neck board.)

One possibility is that glue used to hold components down on some circuit boards has deteriorated and turned conductive. Check for tan to brown stuff shorting traces on the CRT neck board. If this is present on the focus or screen traces or wires, it may just be your problem. Scrape off all of the old glue and then clean thoroughly. Repair any damaged traces.

What happens to the HV? A HV breakdown possibly inside the CRT would result in all the voltages being dragged down.

What happens to the picture?

If you connect a charged HV capacitor (guessing a couple hundred volts, a couple microfarads) between G2 and G1 or focus, you **will** know if tapping the neck results in a momentary short! I cannot predict whether this will be a temporary cure or permanent killer. See the section: Rescuing a shorted CRTRescuing a shorted CRT.

Here is another thing to try: put a 100 M ohm or so resistor between SCREEN and the CRT socket. This should not affect the behavior much until the failure occurs. Then, check the voltage on both sides with a high impedance voltmeter (1000 M). If the CRT is arcing, it will be much lower on the CRT side and will probably fluctuate. You can play similar games with focus voltage.

Disconnecting flyback wire(s) from CRT driver board

In some cases, there may be one or more separate wires running to directly to the CRT socket. These are typically for focus which has a relatively high voltage so better insulation is needed but there may be no obvious means of removal should flyback replacement be needed.

One alternative is simply to cut the wire(s) in a location that is well away from any place to short out, solder, and then do a most excellent job of insulating the splice. If there is more than one wire, make sure to label them first if they aren't color coded.

However, you may find that the cap on the CRT socket snaps off using a thin knife blade or screwdriver. The wire may be soldered or just pressed in place in such a way that pulling it out is difficult or impossible without removing the cover. If there is more than one wire, label them before removal unless the locations are clearly marked. Sometimes the color is stamped on the plastic but there may just be a designation like "A" and "B".

(From: Raymond Carlsen (rrcc@u.washington.edu).)

The last one I worked on puzzled me for a few moments. See if you can see a space between the little cup (where the wire enters the socket) and the socket itself. Pry up on the cap with a knife and it should pop right off. The wire is soldered to a pin under it. Don't apply heat for very long... you may melt the socket.

Focus or screen voltage drifts after warmup only when CRT is connected

> "I have a 3-5 yr old monitor that loses screen voltage. I believe that the problem is specific to the CRT or the flyback, either one is a guess I'd rather be sure of prior to ordering a part.
>
> The screen voltage will come up to normal after sitting over night, 400 V or so. After approximately 5 minutes or slightly longer, I hear a slight arcing. From that point on, the screen voltage will wander anywhere from 75 V up to maybe 150 V. Adjustment of the screen control on the flyback has only a small effect and is not permanent. Removing the CRT pcb results in the screen voltage returning to normal.
>
> I cannot find the source of the arcing, as it happens quickly and I have always been on the other side of the set when it happens. I have replaced the crt socket, thinking the spark gap was arcing. I have checked the CRT for G1 and HK shorts on a sencore crt checker, it checks good, but I am aware that since it is an intermittent problem, that the checker probably will not catch it."

This is very likely a short between electrodes inside the CRT unless there is something on the neck board that is breaking down as a result of some connection to the CRT. The flyback should largely not know the difference with the socket plugged into the CRT. However, on rare occasions, there is contamination within the 'plastic alignment base' on the end of the CRT neck. (It is possible to *carefully* remove the plastic piece and clean the CRT glass/pins. Reinstall the plastic piece if it is still intact or leave it off - just take care in replacing the CRT neck board.)

One possibility is that glue used to hold components down on some circuit boards has deteriorated and turned conductive. Check for tan to brown stuff shorting traces on the CRT neck board. If this is present on the focus or screen traces or wires, it may just be your problem. Scrape off all of the old glue and then clean thoroughly. Repair any damaged traces.

What happens to the HV? A HV breakdown possibly inside the CRT would result in all the voltages being dragged down.

What happens to the picture?

If you connect a charged HV capacitor (guessing a couple hundred volts, a couple microfarads) between G2 and G1 or focus, you **will** know if tapping the neck results in a momentary short! I cannot predict whether this will be a temporary cure or permanent killer.

Here is another thing to try: put a 100 M ohm or so resistor between SCREEN (or FOCUS) and the CRT socket. This should not affect the behavior much until the failure occurs. Then, check the voltage on both sides with a high impedance voltmeter (>1000 M). If the CRT is arcing, it will be much lower on the CRT side.

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Raster, Color, and Video Problems

Blank picture, power light on, digital controls (if any) active

Does 'blank picture' means a totally black screen with the brightness and contrast controls having no effect whatsoever? Or, is there is no picture but there is a raster - light on the screen? The direction in which troubleshooting should proceed differ significantly depending the answer.

Verify that you computer has not simply entered power saving mode and blanked the screen or shut off the monitor video and power circuits entirely.

Confirm that the video source is not defective or blank - try another one.

Here are some questions:

1. Is there any light on the screen at any settings of the brightness and contrast controls, and/or when switching channels. Can you see any raster scanning lines?
2. Can you obtain a raster of any kind by adjusting the screen (G2) control (probably on the flyback) or master background or brightness?
3. Looking in the back of the monitor, can you see the glow of the CRT filaments?

4. Do you get that static on the front of the tube that would indicate that there is high voltage?

If the answer to all of these is 'no', then you have a power supply and/or deflection problem. Refer the the section: No picture but indications of power.

Possible causes of no raster:

- No or low high voltage (low voltage, deflection, or high voltage power supply failure).
- Fault with other voltages like G1 or screen (G2) to CRT.
- Filament to CRT not getting powered.
- Drive to CRT bad/shut off as a result of fault elsewhere. For example, failure of the vertical deflection may disable HV or blank the screem to protect the CRT from burn-in due to the very bright horizontal line that would result. With some monitors, it is possible that the X-ray protection circuitry will blank the screen.

Possible causes of no video: problem in video input, video amplifiers, video output, cutoff due to other fault.

It could be as simple as a bad connection - try gently prodding the boards with an insulated stick while watching the screen. Check for loose connectors and reseat all internal connectors.

Brightness control has no effect

The following assumes that the picture is fine but the brightness is fixed - probably at too high a level. However, there could be several interrelated problems if a common supply voltage were missing, for example.

If it is a knob, then it should be varying the control grid (G1) voltages relative to the cathodes (K) of the CRT. This is not likely to be a very complex circuit. If you do not have a schematic, start by tracing from the control, check continuity and solder connections. Check the control itself for proper operation with an ohmmeter. A power supply going to one side of the control (negative probably) may be missing. Tbe control grid voltage will end up on the little board on the neck of the CRT - check there as well for bad solder connections or open resistors.

If brightness is a digital control, then you will need a schematic unless there is an obvious bad connection.

No color - black and white picture

This means absolutely no color - equivalent to a black and white picture. Not even a hint of color.

If you are using a composite video input, troubleshoot the chroma circuitry like you would a TV - see the document: Notes on the Troubleshooting and Repair of Television Sets.

This is an extremely unlikely failure mode for a computer monitor unless you are using a composite video input. It is most likely to a software driver or program problem. Sometimes, the PC will think that the monitor you have connected is not capable of color and certain programs will then display in B/W no matter what. This may be due to an initialization problem - possibly a race condition during the boot process - especially likely if you are using an older video card with a new fast processor.

First, confirm that the source is actually in color - try the monitor on another computer or vice-versa.

Check the settings of any mode switches - in rare cases there is a color/mono switch or button.

Note that to the average person, the obvious question becomes: is my color picture tube bad? The answer is a definitive NO. It is virtually impossible for a defective CRT to cause a total loss of color. A defective CRT can cause a lack of a primary color - R, G, or, B which will mess up the color but is not likely to result in a black and white picture.

One color is too weak or too strong

If the problem is slight and/or has gradually gotten worse, this may just require an adjustment of the color brightness/background/bias and/or color gain/drive controls inside the monitor. See the section: Brightness and color balance adjustment.

Even if it appears as though there is an excess, this may actually be a reduction in one of the primary colors. For example, a magenta tinge is represents a reduction in the strength of the green signal.

- Too high an intensity for one of the color channels will result in a tint of one of the primaries: red, green or blue.
- Too low an intensity for one of the color channels will result in a tint of the complement of one of the primaries: yellow, cyan, or magenta.
- Problems mainly in the shadows or dark areas of the picture usually represent a fault with brightness/bias/background.
- Problems mainly in the highlights or bright areas of the picture usually represent a fault with the gain/drive.

A color that that is now suddenly brighter or darker than normal resulting in incorrect color balance or a tint in the background could be due to a number of causes:

- Bad cable or pin bent on cable connector.
- Bad connections or bad component in video amplifier or on CRT neck board for that color.
- Weak gun in CRT (reduced color).
- Bad video card or incorrect software color map settings.
- For monitors with sync-on-green capability, the monitor may think you are using sync-on-green when in fact you have separate sync. In particular, this may result in a problem with excessive green:

  (From: Bob Myers (myers@fc.hp.com).)

  Some monitors provide a user-selectable setup option for "sync-on-green" vs. separate syncs. Sometimes, this doesn't really change where the sync itself is coming from. In those cases, it's automatically detected but *does* change where the reference level for the video is expected to be. You might try checking this setting, if you have it, and changing it back and forth to check the effect. It's not likely to be the problem in a separate-sync system like a PC, but weirder things have happened and it's easy and cheap to check out.

Psychodelic color

The means colors that are not normal and that adjustment of the user controls is not able to correct it so that all colors of the picture are properly displayed at the same time. For example, you are unable to get any yellows or blues in picture that should have these colors.

- If you are using a composite video input, troubleshoot the chroma circuitry as you would a TV - see the document: Notes on the Troubleshooting and Repair of Television Sets.
- Confirm that the input is not a weird color video - try another software program or video source. We have a draftsperson who always sets up his Windows color scheme in this manner - we keep wishing it is the monitor as **that** could be fixed!
- Verify that this is not a missing color problem - one of the primary R, G, or B, has disappeared. If so, refer to the section: Intermittent, flickering, or missing colors.
- If this is a monitor with BNC connectors and you are using them, make sure you had the video termination switches set correctly (75 ohms if this is the only monitor or the last monitor in a daisychain; HiZ if an intermediate monitor in a daisychain.) A very common cause of unbalanced or blooming colors assuming the monitor itself is good is incorrect settings of the termination.
- A bad connection, bad component, or short circuit in the video circuitry or CRT neck board could also result in strange colors.

Monitor manufacturing quality and cold solder joints

Any intermittent problems with monitors that cause random sudden changes in the picture brightness, color, size, or position are often a result of bad connections. Strategically placed bad connections can also cause parts to blow. For example, a bad connection to the SCR anode in a phase controlled power supply can result in all the current passing through the startup resistor, blowing it as well as other components. I had a TV like this - the real problem was a bad solder joint at a pin on the flyback. Thus, erratic problems, especially where they are power or deflection related, should not be ignored!

Bad solder joints are very common in monitors due both to poor quality manufacturing as well as to deterioration of the solder bond after numerous thermal cycles and components running at high temperature. Without knowing anything about the circuitry, it is usually possible to cure these problems by locating all bad solder connections and cleaning and reseating internal connectors. The term 'cold solder joint' strictly refers to a solder connection that was either not heated enough during manufacturing, was cooled too quickly, or where part pins were moved before the solder had a chance to solidify. A similar situation can develop over time with thermal cycling where parts are not properly fastened and are essentially being held in by the solder alone. Both situations are most common with the pins of large components like transformers, power transistors and power resistors, and large connectors. The pins of the components have a large thermal mass and may not get hot enough during manufacturing. Also, they are relatively massive and may flex the connection due to vibration or thermal expansion and contraction.

These problems are particularly common with TVs and monitors - especially cheaper monitors.

To locate cold solder joints, use a strong light and magnifier and examine the pins of large components for hairline cracks in the solder around the pin. Gently wiggle the component if possible (with the power off). Any detectable movement at the joint indicates a problem. With the power on, gently prod the circuit board and suspect components with an insulated tool to see if the problem can be effected.

When in doubt, resolder any suspicious connections. Some monitors may use double sided circuit boards which do not have plated through holes. In these cases, solder both top and bottom to be sure that the connections are solid. Use a large enough soldering iron to assure that your solder connection is solid. Put a bit of new solder with flux on every connection you touch up even if there was plenty of solder there before. However, remove any obvious excess. Inspect for solder bridges, sliver, splashes, etc. before applying power.

Why can't monitor manufacturers learn to solder properly?

I can think of several potential reasons - all solvable but at higher manufacturing cost.

1. Mass of large component leads (like shields) does not get adequately heated during manufacture leading to latent cold solder joints. While they may look ok, the solder never actually 'wetted' the heavy pins and therefore did not form a good mechanical or electrical bond.

2. Thermal cycles and differential thermal coefficients of circuit boards, traces, and solder. While it is not easy to do anything about the material properties, using plated through-holes or a similar mechanical via would greatly increase the surface area of the joint and prevent the formation of cracks.

3. Vibration. This is also directly related to the single sided circuit boards without plated through-holes to strengthen the joints.

4. Lack of adquate mechanical support (single sided circuit boards without plated through-holes (vias).

I believe that the single most significantimprovement would come about by using plated trhough-holes but this would add to the cost and apparently the consumer is not willing to pay more for better quality and reliability! Some designs have used rivlets - mechanical vias instead of plated ones. While this is good in principle, the execution has often been flawed where cold solder joints resulted between the rivlets and the circuit board traces due to lack of adequate process control.

Monitors, due to their generally higher cost compared to TV sets, should be better constructed but not always.

Intermittent, flickering, or missing colors

This is a catch-all for some of the most common monitor problems. Most of the causes boil down to bad connections of one form or another. However, defective components like bias resistors on the CRT driver board or in the video circuitry could also be at fault.

Note that due to the additive color scheme used in all emissive color displays like CRT or flat panel TV sets and video monitors, a single missing primary color (red, green, or blue) will result in the following appearance (for a white screen):

```
   Missing Color       Appearance
 ------------------------------------------------
```

```
Red              Cyan (blue-green)
Green            Magenta (reddish-purple)
Blue             Yellow
```

This may best be observed with a test pattern a color on-screen display for which you recall the proper colors.

- Does whacking the monitor have any effect? If so, then bad connections are confirmed. If the color(s) come and go suddenly, then it is most likely *not* a CRT problem. The bad connections could be at the VGA cable, video driver board on the neck of the CRT, or elsewhere (see below).
- If the color fades in and out with a delay of about 10-15 seconds, it is probably intermittent power to the CRT filament for that color and probably means a bad CRT since the three filaments are wired in parallel inside the CRT. One of the internal connections has come loose.

  Look in the neck of the CRT to make sure all three filaments are glowing orange. If one is out or goes on and off, toss the monitor. Replacing the CRT is probably not worth it. However, if they all go on and off together (all colors would be fading in and out though perhaps not quite in unison), then bad connections for the CRT filaments on the CRT neck board are indicated.

Possible causes of intermittent or missing colors:

- VGA or other video input cable. Sometimes these develop intermittent problems at the connector to the VGA board. These may be internal to the cable in which case it will need to be replaced or if you are handy and have infinite patience, you can replace just the VGA connector.

  Alternatively, the male pins of the cable may not be making good contact with the female VGA socket. First try contact cleaner. If this does not work, gently squishing the male pins with a pair of needlenose pliers may provide temporary or permanent relief if the pins are a tad too small. However, if you go too far, you can damage or break the pins or cause the female socket to become enlarged and loose fitting for any other monitor you may use.

  If this just happened after reconfiguring your system and reconnecting the monitor or installing a new monitor, check your video connector - you may have bent over or pushed in pins 1, 2, or 3 - the R, G, and B video signals respectively.

  If you find a bent pin, ***carefully*** straighten it with a pair of needlenose pliers. If it is pushed in, try to grab onto it and pull it out - then put a drop of Epoxy or other adhesive at its base (don't get any on the part of the pin that makes contact) to prevent it from being pushed in again.

  There may be cold solder joints on the VGA board itself at the VGA connector. These can be resoldered.

- Printed circuit board on the CRT neck. This is a common location for cold solder joints. Check with a bright light and magnifying glass for hairline cracks around the pins of larger parts. Prod and tap with an insulated tool to see if the problem is effected. Resolder if necessary.
- Cold solder joints elsewhere in monitor usually around the pins of large parts such as transformers, power transistors and resistors, and internal connectors. Inspect with a strong light and magnifier if necessary.
- Internal connectors that need to be cleaned and reseated. Remove, clean with contact cleaner,

burnish, and replace.

- Bad filament connections inside the CRT (gradual fade in and out or one filament not lit). Replace CRT or monitor.

To narrow down the problem:

- Locate the output for the bad color on the video driver board on the neck of the CRT. This will probably read a significantly higher voltage than the corresponding pins for the good colors. A circuit problem is likely - probably on this board but it could be in other parts of the video circuitry.
- Test components on this board for the good and bad color channels. A shorted transistor or open resistor can kill one channel. Swap parts between good and bad colors to confirm.
- Gently pull the CRT neck board off of the CRT and replace it. This will tend to clean the contacts.
- Connect an output of the video circuit/chip that is working (i.e., a color that appears on the screen) to *all* three color drivers on the CRT neck board.
    - If you now get a more-or-less black and white picture (there may be a moderate color tint as the relative intensities of R,G,B may not be balanced), the problem is likely with the circuitry on the mainboard.

      Note: the picture will be the intensity of only one color channel so it will not be quite *normal* in any case.
    - If you still have missing or messed up colors, the problem is on the CRT neck board or with the CRT.

Some commentary on monitor and TV whacking

Anytime that intermittent symptoms are experienced, I recommend gently whacking the patient to determine if mechanical shock or vibration affects the behavior. Here are a couple of responses to this suggestion.

(From Marc Gelfond (71363.1700@CompuServe.COM).)

I just love the bit about "whacking it". It brings to mind an episode from the old Andy Griffith show, where a new fangled piece of electronics gear, was broght into Emmets repair shop. After many long hours of fruitless troubleshooting, out of frustration Emmet gave the thing a whack, and sure enough it fixed the problem.

As we say in the Telephony business, it "CCWT" or Came Clear While Testing. Another saying is that it "CCBFM" Came Clear By F------ Magic!!

(To which Gavin Adams (gaa@hopi.com) comments):

In the video industry we had a saying concerning malfunctioning gear:

> "If it's broke, hit it with a hammer"
> "If that doesn't fix it, paint it and sell it"

My DEC 16" monitor is case in point. Evey once in a while it would lose sync, and smacking it would bring it back (sometimes a few smacks). Recently it gave up the ghost completely, and after the local DEC office gave me a quote of $900 to fix it (Bermuda), I ordered a new Viewsonic 17" for the same price.

I ripped the guts out of the DEC beast, painted it with a marble finish, put plants in it, and sold it! :>

Ghosts, shadows, or streaks in picture adjacent to vertical edges

Complaints about these kinds of problems are very common especially as the screen resolution and necessary video bandwidth keeps increasing. Most are due to cable and video termination deficiencies and not actual monitor defects.

The video signals for red, green, and blue (or just a single signal for monochrome) are sent over cables which are generally 75 ohm transmission lines. These are coaxial cables that may be combined inside a single sheath for VGA, SVGA, MACs, and many workstations but may be separate coaxes with BNC (or other) connectors for other video applications.

Without going into transmission line theory, suffice it to say that to obtain good quality video, the following conditions must be met:

- A good quality of cable must be used. This means one in which the characteristic impedance is close to the optimum 75 ohms, one which has low losses, and one which has good shielding. For installations using BNC connectors, a good quality of 100% shielded RG59U is often used. The BNC connectors must be properly installed or they will contribute to mismatch problems.
- Where multiple monitors are to be connected to a single video source, all wiring is done in a daisy chain fashion. The only taps permitted are the minimum necessary to connect each monitor to the chain. This usually means a BNC-T connector or a pair of connectors on the monitor for each video signal. T connections with cable must be avoided. (BNC cables only - SVGA monitors cannot be daisy chained without additional hardware.)
- Only the last monitor in the chain should be terminated in 75 ohms. All of the others must be set to Hi-Z. Monitors with BNC connectors will usually have one switch or a switch for each color to select termination.

Monitors for PCs, MACs, and many workstations usually have built in termination and do not offer the choice of Hi-Z. This means that without a video distribution amplifier, it is not possible to connect multiple monitors of this type to a single video source with any expectation of a good quality display.

Even adding a short extension cable or using an A-B monitor select box may result in unacceptable image degradation especially at higher scan rates.

Failure to follow these rules will result in video ringing, ghosts, shadows, and other unsightly blemishes in the picture. It is often not possible to control all aspects of the video setup. The cable is often a part of the monitor and cannot easily be substituted for a better one. The monitor may not have properly designed circuitry such that it degrades the video regardless of the cable and display board quality. The display card itself may not have proper drivers or source termination.

Ironically, the better the video card, the more likely that there will be visible problems due to termination. This is due to the very high bandwidth and associated signal edge rates.

Some examples of common termination problems:

- Overly bright picture with trails following vertical edges, perhaps with periodic ringing. This is due to a missing termination. Check if the monitor is set for Hi-Z instead of 75 ohms. If there is no switch, then the termination may be faulty or the monitor may need an external resistor. For BNC connectors, plug-on terminations are available.

- Bright ghost images adjacent to vertical lines. This may indicate that the terminating resistor is greater than the impedance of the cable. You may be using Ethernet Thinnet cable by accident which is RG58 with an impedance of 50 ohms.

- Dark picture and ghost images adjacent to vertical lines. This may indicate that the terminating resistor is too low - multiple monitors on a chain all set for 75 ohms instead of just the last one. Or, an improper type of cable such as audio patch cord.

- Fuzzy vertical edges. This may indicate a poor quality cable or a run which is just too long. For high resolutions such as 1280x1024, the maximum cable length may be as short as 25 feet or less for poor quality cable. Better cable or fiber-optic repeaters may be necessary.

- Other similar problems - check cables for defective or improperly installed connectors. This is especially applicable to cables with BNC or UHF type connectors which require a kind of artistic talent to assembly properly and consistently. Throw out those extension cables and switch boxes!

If only 1 or 2 colors (of the R, G, and B) are effected, then look for improper switch settings or bad connections (bad cable connectors are really common) on the problem color cables.

General streaks or lines to the right of bright or dark areas

The problem is that on a white background the various objects leave a shadow to their right. Not a duplicate image but more like horizontal dark streaks on the white background. Also it seems that high intensity colors display very bright but low intensity colors are overly dark (almost black). The contrast and brightness adjustments may make no difference.

This could be a number of things but they are all in the video amplifier and probably not the CRT driver board though this is possible. Dried up filter capacitors could result in video dependent ripple on the power supply lines. Bad coupling capacitors could result in similar symptoms but probably for only one color, not all of them.

Since all colors are effected, look for something common like a bad power supply. With a scope, this would probably be rather easy even without schematics. If the brightness and contrast controls do nothing, this would suggest some fault in their general area or the IC or transistors they control in the video amps - and that this is not a CRT problem. Locate the video amp IC if it uses one and locate a pinout - this should be enough to determine which signals are faulty.

First, do check carefully for bad connections and other obvious failures.

This could also be a symptom of a bad CRT but this would be unusual with a not-ancient monitor (and not if the brightness and contrast controls have no effect).

Washed out picture

If you can obtain a full intensity raster by varying the brightness or screen control, then your problem is most likely in the video amplifiers or power for the video amplifiers.

If, however, the screen control varies the brightness but will not get a bright raster, you probably have problems either with the HV power supply or the filament supply for the CRT - is there the normal bright orange glow at the base of the CRT? If it is dim or very reddish, there may be a marginal connection or bad component in the filament circuitry.

Retrace lines in picture

During the time the electron beam is returning from right to left at the end of a line and bottom to top (over the course of multiple lines), it is supposed to be result in no visible light on the screen. However, a number of faults can result in visible retrace lines.

The appearance will likely be a general reduction in contrast from the visible horizontal retrace on every scan line and two dozen or so diagonal lines lines (lower left to upper right) resulting from the vertical retrace.

The retrace lines may be either white or gray (possibly with a slight color tint due to unequal settings of the color adjustments) or a primary color - red, green, or blue. Anything in between is also possible but less likely.

White/gray retrace lines

Where all colors are involved - the lines are essentially white or gray (or with a slight tint due to slight unequal settings of the color adjustments), look for something common like an incorrectly adjusted screen (G2) or master brightness/background/bias control or a problem in one of these circuits, a defective power supply or a problem in the blanking circuitry:

- Screen (G2) or master brightness/background/bias control - mark setting and then see if a slight adjustment removes the retrace lines. See the chapter: "Monitor Adjustments". Of course, if this happened suddenly, the problem is not due to a misadjusted control though a dirty pot is possible - turn it back and forth - this might clean it and restore normal operation.

- Power supply or connection to CRT neck board - insufficient voltage will result in the CRT never totally blanking. Check (usually scan derived) power supply components (from flyback).

- General power supply - check B+ for correct value and ripple. A main power supply fault might result in these symptoms (and usually many others).

- Blanking circuit - this may be a part of the video/chroma chip or separate. Check waveforms to determine if the blanking pulses are making it to the video output.

Red, green, or blue retrace lines

Where only one color is showing, suspect an incorrectly adjusted individual background/bias control or bad part on the CRT neck board for that color.

- Individual brightness/background/bias control(s) - mark setting of pot for the problem color and then see if a slight adjustment removes the retrace lines. See the chapter: "Monitor Adjustments".

Of course, if this happened suddenly, the problem is not due to a misadjusted control though a dirty pot is possible - turn it back and forth - this might clean it and restore normal operation.

- Component or connection on CRT neck board - insufficient voltage to or incorrect biasing of the video driver for this color can result in the CRT never totally blanking. Compare voltages and signals, and swap components between good and bad channels to confirm.
- Blanking circuit - this may be a part of the video/chroma chip or separate. Check and compare waveforms of good and bad colors to determine if the blanking pulses are making it to the video output.

There is a slight possibility that a bad CRT may result in visible retrace lines. To eliminate this possibility:

- Disconnect the filament - all evidence of a picture, raster, and retrace lines should disappear once the filaments/cathodes have cooled (15 seconds or so. If there are still visible retrace lines, the CRT is suffering from cold or field emission from someplace (may not even be the cathode).
- Turn down the screen (G2) control on the flyback (usually). If one color remains no matter how you set the control, again there is some kind of weird emission from the CRT. However, if white/gray retrace lines remain, the problem may be in the screen supply.

See the section: Bad CRT causing retrace lines.

Bad CRT causing retrace lines

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The TV which I bought last started developing retrace lines after a month or so of use. I took it back to the lab for warranty (special deal) and had it examined by the real experts. They found that even with the filament supply disconnected and VG2 at 0V the screen would still light up. They could even see that the electrons weren't even coming from the cathode. That was with only the picture tube in a test rig. So in this case the obvious conclusion had to be that the tube was bad, and it was replaced (32" 16:9 SF, very $$). It had something to do with processing problems during manufacturing of the electron guns.

So even if this was a rare case, it *can* happen that retrace lines are due to a bad picture tube. It's more usual to suspect the VG2 (screen voltage) or a defect somewhere in the RGB video path.

Red, green, or blue full on - fog over picture

This could be a heater-cathode (H-K) short in the CRT, a failure of a component in the chroma circuits or video output (driver board), or bad connections there or elsewhere.

Don't panic - heater-cathode shorts in CRTs can often be worked around.

Note: before proceeding, it is a good idea to make sure that the screen is degaussed - else you could be attempting to track down problems with the wrong color!

Some simple tests can confirm or rule out other possibilities.

- Compare the voltages for the video drive signals to the CRT on the little board on the neck of the CRT with the CRT both connected and unplugged. A schematic will help greatly in locating these signals.

- If there is a significant difference especially on the bad color, then the CRT is a likely candidate. Try tapping the neck of the CRT GENTLY (with it plugged in and while viewing a picture) to see if it is an intermittent problem.
- If there is no significant difference, you may have a bad driver or a problem in the chroma circuits.

- Look for bad connection/cold solder joints, probably on the little board on the neck of the CRT. Use an insulated stick to gently prod the board and its components in an effort to induce/cure the problem. Look carefully for hairline cracks around the component leads.
- You can swap components between two colors and/or test with an ohmmeter on that driver board to determine what is bad. The nice thing about color monitors and TVs is that there three copies of each of these components. Swapping and/or comparisons between these is an excellent diagnostic technique.
- Another simple test: Disconnect the cathode for the full-on color from its drive. If it is still full-on, there is probably an H-K short in the CRT since the only way to get each color on the screen is via the cathode connection to the CRT neck board. If it is removed and there is still that color, the current must be taking another path inside the CRT.
- Alternatively, interchange the outputs of the bad color with a good one by jumpering on the video driver board (on the CRT neck). If the bad color changes, then the problem is in the circuitry and not the CRT.

  Here is the procedure in more detail (example for red full on):

  (From: J. K. Emerine (jkemerine@aol.com).)

  To identify if the fault is in the crt or a control problem try this (WITH SET OFF):

  On the CRT board, lift the output end of the green cathode final resistor. Do the same with the offending red cathode's resistor. Use short insulated jumpers to 'swap' drive signals - drive the red cathode with the green drive and the green cathode with red drive. (Note that if this problem only occurs after a warmup period, color at turn on will be - well - wierd, but it is just a test.)

  - If the symptom returns = 'goes red' the CRT is shorting. (See the section: Providing isolation for a CRT H-K short. --- Sam.)
  - If instead the symptom becomes 'goes green' then the red drive leg has the fault and the CRT is probably good. (In this case, there may be bad connections or a bad component on the CRT drive board or further back in the chroma circuitry. --- sam)

Totally white screen (probably with retrace lines)

There may or may not be any indication of a picture. This may be a problem in the high voltage power supply (SCREEN, G2), loss of power or a fault in the video output drivers, other video amp problems, or a bad (shorted) CRT.

Is focus still reasonably sharp? If not, try adjusting it (usually on the flyback or a separate little panel). If changing focus affects brightness significantly, there is a short between the two supplies - either in the HV power supply or CRT. See the section: Bad focus and adjustment changes brightness. In this case, changing SCREEN (G2, also on the flyback) may also affect focus or may not do anything.

Try adjusting SCREEN. If it has no affect, a problem in its power supply from the flyback is possible. If you have a high impedance voltmeter (not just a DMM, the resistance of the voltage divider supplying SCREEN is hundreds of M ohms), check it while changing the SCREEN control. If it does not change, you have found a definite problem.

Assuming that adjusting FOCUS and SCREEN result in normal behavior and do not strongly interact, the problem is likely in the video circuitry or output drivers.

Check the power to the CRT video output drivers on the little board on the neck of the CRT. If this failed, all three video outputs will be full on. If you have a scope, look at the video outputs - they should be varying between over 100 V and a low value. If they are missing or very low all the time, there is a problem further back in the video chain.

See the other sections relating to brightness and high voltage problems as well.

Shorts in a CRT

Occasionally, small conductive flakes or whiskers present since the day of manufacture manage to make their way into a location where they short out adjacent elements in the CRT electron guns. Symptoms may be intermittent or only show up when the TV or monitor is cold or warm or in-between. Some possible locations are listed below:

- Heater to cathode (H-K). The cathode for the affected gun will be pulled to the heater (filament) bias voltage - most often 0 V (signal ground). In this case, one color will be full on with retrace lines. Where the heater is biased at some other voltage, other symptoms are possible like reduced brightness and/or contrast for that color. This is probably the most common location for a short to occur.

- Cathode to control grid (K-G1). Since the G1 electrodes for all the guns are connected together, this will affect not only the color of the guilty cathode but the others as well. The result may be a very bright overloaded *negative* picture with little, none, or messed up colors.

- Control grid to screen (G1-G2). Depending on circuitry can result in any degree of washed out or dark picture.

- Screen to focus (G2-F). Screen (G2) and focus voltage will be the same and the controls on the flyback will interact. Result will be a fuzzy white raster with retrace lines and little or very low contrast picture. Symptoms will be similar to those of a flyback with breakdown in the focus/screen divider network.

- Focus to high voltage (F-HV). High voltage will be pulled down - probably arcing at the focus spark gaps/other protective devices. Line fuse and/or HOT may blow. A high impedance short may only result in increased focus voltage but this is probably unusual.

- Other locations between electron gun elements as feed wires.

Except for the high voltage to other places, the short may actually be located in the CRT *socket* or even on the CRT neck board, probably in the spark gap(s) for the problem pins. Remove the socket and test between the suspect pins on the CRT itself. If the CRT itself is fine, the spark gaps should be inspected and cleaned/repaired and/or components replaced. At this point, the cause may still be present - a short inside the flyback for example resulting in excessive voltage on one or more pins.

Assuming this is not the case, replacing the CRT may be the best solution but there are a variety of 'techniques' that can often be used to salvage a monitor that would otherwise end up in the dump since replacing a CRT is rarely cost effective:

1. Isolation - this will usually work for H-K shorts as long as only one gun is involved. However, with high video bandwidth monitors, there may be some smearing of the affected color due to the added capacitance of the transformer and filaments now connected to its video signal.

2. Blowing out the short with a capacitor - depending on what is causing the short, this may be successful but will require some experimentation.

3. Placing the CRT (TV or monitor) face down on a soft blanket and *gently* tapping the neck to dislodge the contamination. Depending on the location of the short, one side or the other might be better as well. Sometimes, this can be done in-place while watching the picture.

A combination of (2) and (3) may be required for intermittent shorts which don't appear until under power. See the sections below for additional details. However, for shorts involving the focus and high voltage elements, even a sharp edge can result in arcing even if there is no actual short. There is no remedy for these types of faults.

Providing isolation for a CRT H-K short

This procedure will substitute a winding of your own for the one that is built in to the flyback to isolate the shorted filament from the ground or voltage reference. Note that if you have a schematic and can determine where to disconnect the ground or voltage reference connection to the filament winding, try that instead.

The flyback is the thing with the fat red wire coming out of it (and perhaps a couple of others going to the CRT board or it is near this component if your set has a separate tripler) and may have a couple of controls for focus and screen. It should have some exposed parts with a ferrite core about 1/2-3/4" diameter.

The filament of the CRT is the internal heater for each gun - it is what glows orange when the set is on. What has happened is that a part of the fine wire of the bad color's filament (assuming this is indeed your problem) has shorted to the cathode - the part that actually emits the electrons. Normally, the heater circuit is grounded or tied to a reference voltage so when it shorts to the cathode, the cathode voltage level is pulled to ground or this reference.

You will need some well insulated wire, fairly thick (say #18-22). Find a spot on the flyback where you can stick this around the core. Wrap two turns around the core and solder to the CRT filament pins after cutting the connections to the original filament source (scribe the traces on the board to break them). Make sure you do not accidentally disconnect anything else.

This winding should cause the filaments to glow at about the same brightness as before but now isolated from ground. If they are too dim, put another turn on the flyback to boost the voltage as low filament temperature will result in reduced emission, blooming, and possible damage to the cathodes after awhile. (Don't go overboard as you may blow the filament totally if you put too many turns on the core - you then toss the monitor.)

Route the wires so that there is no chance of them getting near the high voltage or any sharp metal edges etc. Your picture quality may be a tad lower than it was before because of the added stray capacitance of the filament wiring being attached to the the (formerly bad) video signal, but hey, something is better than nothing.

Rescuing a shorted CRT

If the short is filament-cathode (H-K), you don't want to use the following approach since you may blow out the filament in the process. If this is the case, you may be able to float the filament and live with the short (see the section on: "Red, green, or blue full on - fog over picture".

Shorts in the CRT that are between directly accessible electrodes can be dealt with in a more direct way than for H-K shorts. At this point you have nothing to loose. A shorted CRT is not terribly useful.

If the short is between two directly accessible electrodes like cathode-grid, then as a last resort, you might try zapping it with a charged capacitor.

Unplug the CRT socket!

Start with a relatively small capacitor - say a few uF at a couple hundred volts. Check to see if the short is blown after each zap - few may be needed. Increase the capacitance if you feel lucky but have had little success with the small capacitor.

If the fault is intermittent, you will, of course, need to catch the CRT with the socket disconnected and the short still present. Try some gentle tapping if necessary. If you do this with the charged capacitor across the suspect electrode, you **will** know when the short occurs!

Also see the section: High voltage to focus short.

High voltage to focus short

Symptoms would be (with the unit powered and high voltage present):

- With the CRT neck board plugged into the CRT, the focus spark gap is likely arcing.
- With the socket unplugged, putting anything connected to ground (or any other circuitry) near the focus pin would result in a juicy spark or arc. WARNING: Removing the CRT socket and powering the unit may destroy the CRT on some models. See the section: Warning about disconnecting CRT neck board.

If the CRT is gassy or up to air, forget it - it might make a decent fish tank :-). In this case, there would be visible arcing INSIDE the CRT probably not confined to a single location.

However, if there is just a metal whisker between the F and HV, that might be able to be cleared by careful tapping or a charged capacitor. You may even be able to see it if you were to remove the yoke - the gap is pretty large, about 1-2 mm - the last gap between electrodes before the start of the internal (Dag) coating.

See the section: Rescuing a shorted CRT.

Note that other damage may have been done as

Other components including the flyback, HOT, and parts on the CRT neck board and beyond, may have been damaged as a result of the short. Zapping the CRT may be just the beginning of what is required to repair it all.

Dark picture

A monitor with a picture that is too dark may have a fault or the CRT may just be near the end of its useful life.

First, confirm that your video source - computer, camera, etc. - is producing a proper signal.

Is the brightness at all erratic? Does whacking the monitor have any effect? If so, then you may have bad connections on the CRT driver card or elsewhere. If the brightness tends to fade in and out over a 10 to 20 second period, a bad filament connection is likely. Check for the normal orange glow of the filaments in the neck of the CRT. There should be 3 orange glows. If they are excessively reddish, very dim, or fade in and out, you have located a problem. See the section: Picture fades in and out.

Common causes of brightness problems:

1. Dirty CRT faceplate or safety glass. Don't laugh. It sounds obvious, but have you tried cleaning the screen with suitable screen cleaner? It is amazing how dirty screens can get after a few years - especially around smokers!

   (From: A. R. Duell (ard12@eng.cam.ac.uk).)

   > "I once spent a morning battling with a DEC VT105 terminal with a very dim and washed out picture, and only after checking everything on the video board did I wipe over the screen. That cured it. It's amazing how dirty screens can get after a few years use."
   >
   > Wipe gently with a slightly dampened cloth - not soaking or you may end up with real problems when the water drips down inside and hits the electronics!

2. Old CRT. The brightness of the CRT deteriorates with filament on-time. It doesn't matter much what you are doing or if you use a screen saver.

   An indication of a weak CRT would be that turning up the SCREEN (G2) or master brightness control only results in a not terribly bright gray raster before the retrace lines show up. There may be indications of poor focus and silvery highlights as well. A CRT brightener may help. See the sections: Brightening a old CRT and Monitor life, energy conservation, and laziness.

3. Bad component in filament circuit or bad connection reducing filament voltage. This should be easy to check - there are only a few parts involved. If it is erratic, bad connections are likely.

4. Brightness control faulty - bad pot, bad connections, or problem with its power supply. Depending on specific problem, control may or may not have any effect. If digitally adjusted, there could be a problem with the logic or control chip. If the button or menu item has no effect at all, then a logic or

control problem is likely.

5. Improperly set SCREEN (G2) voltage (usually on flyback) or faulty divider network. See the section: Brightness and color balance adjustment.
6. Improperly set video bias (background) levels or fault in video drive circuitry. See the sections starting with: "Optimal procedure for setting brightness/background and screen adjustments".
7. Fault in video amplifiers. With all three color affected equally, this would most likely be a power supply problem. A video amplifier problem is likely if turning up the SCREEN (G2) or master brightness control results in a very bright raster before the retrace lines appear. Cheack signals out of the video/chroma IC.
8. Fault in beam or brightness limiter. Many TVs and monitors measure the beam current (possibly indirectly) and limit the maximum to a safe value. The purpose of this may be to protect the CRT phosphors, and/or to assure that the power supply does not go out of regulation, and/or to limit X-ray emission. If this circuit screws up, a dark picture may result. Checking the signals and voltages at the CRT socket should determine if this is the problem.
9. High voltage is low. However, this would likely result in other symptoms as well with focus, size, and geometry.

Brightening an old CRT

If performing adjustments of the internal background and/or screen controls still results in a dark picture even after a long warmup period (and the controls are having an effect - they are not faulty), the CRT may simply be near the end of its useful life. In the old days of TVs with short lived CRTs, the CRT brightener was a common item (sold in every corner drugstore, it seemed!).

First confirm that the filaments are running at the correct voltage - there could be a marginal connection or bad resistor or capacitor in the filament power supply. Since this is usually derived from the flyback, it may not be possible to measure the (pulsed high frequency) voltage with a DMM but a service manual will probably have a waveform or other test. A visual examination is not a bad way to determine if the filaments are hot enough. They should be a fairly bright orange to yellow color. A dim red or almost dark filament is probably not getting its quota of electrons. It is not be the CRT since all three filaments are wired in parallel and for all three to be defective is very unlikely.

If possible, confirm that the video output levels are correct. For cathode driven CRTs, too high a bias voltage will result in a darker than normal picture.

CRT brighteners are available from parts suppliers like MCM Electronics. Some of these are designed as isolation transformers as well to deal with heater-to-cathode shorts.

You can try a making a brightener. Caution: this may shorten the life of the CRT - possibly quite dramatically (like it will blow in a couple of seconds or minutes). However, if the monitor or TV is otherwise destined for the scrap heap, it is worth a try.

The approach is simple: you are going to increase the voltage to the filaments of the electron guns making them run hotter. Hopefully, just hotter enough to increase the brightness without blowing them out.

Voltage for the CRT filament is usually obtained from a couple of turns on the flyback transformer.

Adding an extra turn will increase the voltage and thus the current making the filaments run hotter. This will also shorten the CRT life - perhaps rather drastically. However, if the monitor was headed for the dumpster anyhow, you have nothing to lose. You can just add a turn to an existing winding or make your own separate filament winding as outlined in the section: Providing isolation for a CRT H-K short.

In some monitors, there is a separate filament supply on the mainboard - this should be obvious once you trace the filament wires from the video driver board). In this case, it still may be possible to increase this output or substitute another supply but a schematic will be required.

There are also commercial CRT rejuvenators that supposedly zap the cathodes of the electron guns. A TV or monitor service center may be able to provide this service, though it is, at best, a short term fix.

Color balance changes across screen from left to right

The characteristics are that a solid white screen will tend to be blue tinted on one side and red tinted on the other. This is usually a subtle effect and may be unavoidable with some designs.

There are several possibilities:

1. Purity - this means the beams are landing on the wrong phosphor dots. This is what would be affected by moving from one location to another or even rotating the TV on its base without degaussing. If the problem just appeared, degaussing may be needed.

   What do you have near the TV or monitor? Loudspeakers or other devices which generate magnetic fields can easily cause all sorts of color purity problems. Relocate the offending device(s) or the TV or monitor and then degauss it.

   See the section: Degaussing (demagnetizing) a CRT.

   If the problem still persists, purity adjustment may be needed. However, this isn't likely to have changed so look for other causes before tackling these adjustments.

2. Unequal electron gun to shadowmask/screen distance - the electron beams for the red and blue video travel slightly different distances on the left and right sides of the screen so their intensity (due to focus not being optimal and other factors) in each case may differ slightly affecting color balance.

3. Doming - This would only happen in very bright areas and causes the shadow mask to expand and distort. (Doming should not be a problem with Trinitron CRTs which use tensioned wires in their aperture grill.) This would also not really affect left-right color balance in particular.

I don't really know how much of a problem (2) is in practice or whether some manufacturers compensate for it.

Bleeding highlights

On very bright areas of the picture, one or more colors may bleed to the right resulting in a trail of those colors. The difference between this problem and the section: Trailing lines in one or more colors is that in this case, only highlights are affected.

One cause of this is that the color gain, contrast, or intensity controls (whatever they are called on your monitor) are set too high. See the section on: "Brightness and color balance adjustment". Check the settings of any brightness limiter controls as well.

Trailing lines in one or more colors

Assuming this is not a form of ghosting resulting from cabling and/or use of switchboxes, etc, then it could be any of the following:

- Poor decoupling in the power supplies for the video drive circuits - probably on the CRT neck board. Check for bad (low uF or high ESR) filter capacitors (electrolytic mostly) on this board or the power supplies feeding it.

- Insufficient CRT filament voltage. This could be a result of bad connections or a bad component in the filament power supply (probably from the flyback). Check to see if the filaments are glowing bright orange and check the voltage if possible (though this can be tricky since it is often fed from a winding on the flyback and is a pulse waveform, not DC or a sinusoid. The service manual will probably have info and waveforms.

- Bad CRT (more likely if only one color is affected). A weak electron gun can result in this behavior. Swap it with one that work properly. If the same color is still bad, that CRT gun is weak. The CRT will need rejuvenation or need to be replaced (more likely, the entire monitor will be tossed into the dumpster).

Purity problems with bright pictures

Setting the brightness excessively high may result in enough heating of the shadow mask to distort it. IF severe enough, the positions of the holes will shift enough to result in visible purity problems. This is less of a problem with tubes using an InVar shadow/slot mask. It should also be less of a problem for Trinitron aperture grille CRTs.

The only solution is to reduce the brightness.

Why does the intensity appear so non-uniform in bright areas?

Actually, the intensity variation is likely to be even worse than you might think - possibly as much as 2:1 from the center to the corners. In most cases you do not notice it. With large deflection angle tubes, fewer electrons make it to phosphor dots near the edge of the screen. It is simple geometry.

(From: Bob Myers (myers@fc.hp.com).)

It is extremely difficult for any CRT display to maintain perfect brightness and color uniformity across the entire image. Just the geometry of the thing - the change distance from the gun to the screen as the beam is scanned, the changing spot size and shape, etc. - makes this nearly impossible, and there can also be variations in the phosphor screen, the thickness of the faceplate, etc.. Typical brightness-uniformity specs are that the brightness won't drop to less than 70% or so of the center value (usually the brightest spot on the screen).

On color tubes, the lack of perfect brightness uniformity is aggravated by the lack of perfect COLOR uniformity and purity. What appear to be "dark spots" on a solid gray image may actually be beam mislanding (color purity) problems, which may to some degree be remedied by degaussing the monitor.

Again, *some* variation is normal; if you think you're seeing too much, you can try degaussing the thing and seeing if that helps. If it doesn't, then the question is whether or not the product meets its published specs, and that 's something you'll have to discuss with the manufacturer or distributor.

Brightness changes from left-to-right across screen

Slight variations in brightness across the face of the CRT are not unusual. In fact, if you used a photometer to actually measure the brightness, you might be amazed at the actual variance even with the best monitor or TV - you just don't notice it. However, a major variation - usually a decay from left to right but could be the other way indicate a component failure. Of course, make sure the face of the screen is clean!

- A fault in the power supplies to the video amplifier and/or video output circuits. Most likely, an electrolytic capacitor has dried up and is not adequately filtering the power derived from the flyback which then has ripple at the horizontal scan rate and thus locked to the screen. The voltage decays from left-to-right between horizontal flyback pulses.

  The most likely location for these capacitors is in the vicinity of the flyback transformer on the mainboard or on the CRT neck board. Check the capacitors with capacitor tester or ESR meter and/or take a look at the power right at the video amplifier and video output drivers.

- Horizontal linearity is bad - this may actually be a horizontal geometry problem and not a brightness problem.

  See if objects on left side of the screen are stretched compared to those on the right (or vice-versa). If they are, the problem is in the horizontal deflection circuits - possibly a bad (or in the case of a multiscan monitor, correctly selected) S correction capacitor or linearity coil.

- Inoperative degauss circuit, monitor moved or rotated without degaussing, or magnetic field from some other device (like a permanent magnet) is affecting CRT - slight amounts of magnetization may reduce brightness (by moving the beams into the black space between phosphor dots) before affecting color purity (where the beams land on the wrong phosphor dots).

  See if the degauss button, if present, does anything. Try deguassing manually. See the section: Degaussing (demagnetizing) a CRT.

Picture fades in and out

If the picture faded away on the order of 10-20 seconds (and if it comes back, also comes up to full brightness in same time frame - possibly with the persuasion of some careful whacking) AND with NO other significant changes such as size, focus, etc., then take a look in the back of the tube for the filaments to be lit - the orange glow near the CRT socket. If the glow is coming and going as well, then you probably have a bad solder connection on the circuit board on the neck of the CRT. Look for fine cracks around pins on that board. Try prodding it with an insulating stick to see if the picture comes back. Resolder if necessary. It is probably not a bad CRT as the filaments are usually wired in parallel and all would not go bad at the same time.

However, if only a single color fades in and out, then a bad connection inside the CRT is a distinct possibility - look for only one of the filament's glow to be coming and going. This is probably not worth fixing since it will require CRT replacement.

If the picture faded away with other symptoms, then there is probably a fault in the video amplifier/output one of its power supplies - still probably a loose connection if you are able to get it back by whacking.

Occasional brightness flashes

These may last only a fraction of a scan line or much much longer.

Make sure it is not the video source - try another one.

This could mean an intermittent fault in a variety of places including the video circuitry and SCREEN power supply:

- Brightness circuitry - SCREEN, master background or its power supply. Could be in or around flyback or focus/screen divider. Could perhaps be in the CRT, but probably less likely.
- Video amp before or at chroma demodulator (if composite input) - since after this point, you would most likely get colored flashes since only one of the RGB signals would likely be effected. However, a bad power connection to the video circuitry could cause all the colors to be affected.

If you still get flashes, it should be quite easy to monitor either the video outputs or SCREEN supply (with a HV divider on your scope) for noise. Then trace back to power or noise source.

Occasional static, lines, spots, or other unsightly blemishes

First, confirm that these are not video source - PC - related. Try the monitor on another computer. This may be a problem with the hardware or driver (software) for the video card, the O/S, or memory or bus speed.

If it is not computer related, then it could be arcing, corona, bad connections, or some electronic component breaking down. See the appropriate sections for these problems.

Note that problems in absolutely fixed locations or with an extent related to pixel sizes in the video card are nearly always computer/video card related and not due to a faulty monitor.

Flickering monitor

First, make sure your scan rate is set high enough (but not beyond the capabilities of the monitor). A scan rate less than 60 Hz is likely to result in annoying flicker especially at high brightness levels.

See if the flickering correlates with any processor or disk activity indicating a software driver or video card problem.

Assuming neither of these applies and you are not doing your work by candlelight, a flickering image is probably due to an intermittent arc or short, probably in the high voltage section near or at the flyback transformer. However, it is also possible that it is due to a simple bad connection elsewhere.

So the first thing to do will be to remove the cover and without touching anything, carefully examine for any obvious signs of bad connections, arcing, or burned areas. In particular look for:

- hairline cracks around the pins of large components like power transistors, power resistors, transformers, and connectors.

- any discoloration, cracking, other unusual signs on the flyback. The flyback also provides, via a high resistance divider network, the several kV for focus and several hundred V for the G2 (screen) CRT electrode. These are the voltages that may be intermittently changing and resulting in flicker.

Now, with the monitor powered in a darkened room with a normal picture (use the highest resolution at which your monitor will work as this should put the most stress on it, maybe).

- Look for any arcing or corona around the area of the flyback or the neck of the CRT first, then just anywhere.

- Use a well insulated stick (wood or plastic) to gently prod the circuits board, components, wires, etc. to see if you can induce the problem.

There will probably be a pair of adjustments on the flyback itself. One of these is FOCUS and the other is SCREEN - essentially a master brightness.

- Now, with one hand in your back pocket, try turning each of these a fraction of a turn in each direction. Don't worry, you cannot hurt anything by doing this. The FOCUS should only change the sharpness of the picture. The SCREEN should only change the brightness. In both cases, this should be a smooth effect. Sometimes, these controls will simply get dirty and cause the problems you have seen. In this case, just moving them back and forth may clean them. If one affects the other - if turning focus alters brightness or vice-versa, there is a short between the focus and screen voltages, probably inside the flyback but it could be elsewhere.

It is likely that all of the above tests will come out negative as you may have an intermittent short internal to the flyback which can only be fixed by replacement. However, eliminate the easy fixes first.

Excessive brightness and/or washed out picture

There are a number of possibilities including incorrect screen (G2) or bias (G1) voltages, or a problem in the video or blanking circuitry. Any of these could be the result of bad connections as well. A short in the CRT can also result in these symptoms.

- Excessive brightness/washed out picture is often an indication of a problem with the screen (G2) supply to the CRT. May be a bad capacitor or resistor divider often in the flyback transformer assembly or on the board on the neck of the CRT.

- If the excessive brightness just developed over time, then a simple adjustment of the screen or background brightness controls may keep it (and you) happy for a long time.

  When good, a typical value would be in the 200 to 600 VDC at the CRT. The screen (it may also be called master brightness, bias, or background) control should vary this voltage. However, it may be difficult to measure as the resistors in the voltage divider network may be quite large - hundreds of M ohms. If your unit has an external screen control (less likely these days) and it has no effect, trace out the circuitry in the immediate vicinity and check the resistors and potentiometer for opens, look for bad connections, etc. If it is built into the flyback transformer and is sealed, the entire flyback will need to be replaced unless the actual problem turns out to be a bad connection or bad component external to the flyback.

- Where the brightness control has no effect, suspect a missing bias supply to the G1 (control grid) electrodes of the CRT. This is usually derived from the flyback with a simple rectifier/filter capacitor power supply. Parts may have failed (though not likely the flyback itself). Adjusting the user brightness control should vary this voltage over a typical range of 0 to -50 V with respect to signal ground.

- It could also be a problem with biasing of the video output transistors. There may individual controls for background brightness on the little board on the neck of the CRT. However, we are looking for a common problem since all colors are wrong in the same way. This is likely to be a missing voltage from a secondary supply from the flyback.

- A short between electrodes inside the CRT can result in brightness problems. It may be possible to check this with an ohmmeter with the power off and the CRT socket removed. Test between G1, G2, and F where all colors are affected though a short between F and G2 will result in the focus control changing brightness and vice-versa - a classic symptom.

  However, in some cases, it only shows up when operating and one must deduce the presense and location of the short from its affect on voltages and bias levels.

  See the section: Rescuing a shorted CRT and other related topics.

First, check for bad connections/cold solder joints by gently prodding with an insulating stick. Check voltages and bias levels.

Focus problems

Slight deterioration in focus can be corrected by adjusting the focus control usually located on the flyback transformer. Sometimes, this is accessible externally but usually not. On monochrome monitors, the focus control, if any, may be located on the main board.

Don't expect to have perfect focus everywhere on the screen. Usually there will be some degradation in the corners. A compromise can generally be struck between perfect focus in the center and acceptable focus in the corners.

If the adjustments have no effect, then there is probably a fault in the focus power supply.

For most color TVs and monitors, the correct focus voltage will be in the 4 to 8 kVDC range so you will need a meter that can go that high or some big resistors to extend its range or a HV probe. You must use a high impedance meter as the current availability from the focus power supply is very low.

The pots in the flyback are sometimes accessible by removing their cover, which may snap on. However, a typical focus circuit will have a large value resistor potted inside the flyback (like 200 Megohms).

Try to measure the focus in-circuit. If the value you read is very low (assuming your meter has a high enough impedance not to load the circuit appreciably), then disconnect the wire (from the PCB on the neck of the CRT or wherever) and measure again and observe any change in picture.

- If still low, then almost certainly there is a problem with the pot or the flyback. See if you can open it enough to measure and/or disconnect the pot. If the problem is inside the potted part of the flyback, the only alternative is a new flyback or an external divider if you are so inclined. However, once the focus network goes bad inside the flyback, there is an increased chance other parts will fail at some point in the future.

- If the voltages check out with the CRT disconnected, there is a chance of a bad CRT or of a shorted component on the PCB on the neck of the CRT. Look for shorted capacitors or burnt or damaged traces.

  Measure the voltage on the focus pin of the CRT. WARNING: If there is an internal short, you could have the full 25kV+ at this location! If you get a reading, this would be an indication of an internal short in the CRT. See the section "Shorts in a CRT".

Bad focus (fuzzy picture)

Focus voltage on the CRT is usually in the range of 2-8 kV DC and should be controllable over a fairly wide range by the focus pot - usually located on the flyback or a little panel in its vicinity:

- If adjusting the pot results in a position of acceptable focus, you may be done. It is not unusual for the focus setting to drift a over time.
- If the setting is already as good as possible but not really good enough, the CRT may be tired. Alternatively, the filament voltage may be too low. Check for bad connections in the filament circuit.
- If the optimal setting is out of range of the focus pot, the problem is likely leakage in the focus divider in the flyback or one of the components on the CRT neck board.

Also see the sections: Focus adjustment and Focus drifts with warmup.

The focus wire usually comes from the flyback or if the general area or from a terminal on a voltage multiplier module in some cases. It is usually a wire by itself going to the little board on the neck of the CRT.

If a sparkgap (a little 2 terminal device with a 1/8" gap in the middle) is arcing with power on, then the resistive divider has shorted inside the flyback, focus board, or HV multiplier - whatever you TV has - and the this unit will need to be replaced. Ditto if the SCREEN control affects focus and/or vice-versa.

Using a suitable high voltage meter (range at least 10 kVDC, 1000 M ohm or greater input impedance), you should be able to measure it connected and disconnected. The ground return will be the outside coating of the CRT which may or may not be the same as the metal chassis parts. If the voltage is very low (less than 2 kV) and the pot has little effect:

- When measured right off of the source disconnected from the CRT neck board, then the problem is probably in the focus network in the flyback (or wherever it originates). Sometimes these can be disassembled and cleaned or repaired but usually requires replacement of the entire flyback or voltage multiplier. Note: you may need to add a HV (10 kV) capacitor between the focus wire and DAG ground to provide filtering so you get a DC level for your meter.
- When measured with the focus wire attached to the CRT neck board with the CRT connected but reasonable with the CRT unplugged, there is probably a short between the focus and another electrode inside the CRT. See the section: Rescuing a shorted CRT.
- When measured with the focus wire attached to the CRT neck board with the CRT unplugged, there is likely a component on the CRT neck board that is leaky or breaking down. Also, check for decayed (tan or brown) glue which may turn leaky with age.

Focus drift with warmup

This could be due to a problem with the focus voltage power supply, components on the CRT neck board, or a tired worn CRT.

Focus is controlled by a voltage of 2-8 kV DC usually derived from the flyback transformer and includes some resistors and capacitors. One of these could be changing value as it warms up. (assuming nothing else changes significantly as the unit warms up - e.g., the brightness does not decrease.)

Focus voltage is derived from a subset of the high voltage winding on the flyback using a resistive voltage divider which includes the focus pot. These are extremely high value resistors - 200 M ohm is common - and so leakage of any kind can reduce or increase the focus voltage. All other things being OK - i.e., the picture is otherwise fine - I would suspect this type of failure rather than the CRT.

The connection to the CRT is usually a separate wire running from the flyback or its neighborhood to the CRT neck board. Look for components in this general area. Use cold spray or a heat gun to isolate the one that is drifting. If you have access to a high voltage meter, you should be able to see the voltage change as the TV or monitor warms up - and when you cool the faulty part. If it is in the flyback, then sometimes the part with the adjustments clips off and can be repaired or cleaned. Most often, you will need to replace the flyback as a unit.

- If the optimal adjustment point of the focus control doesn't change that much but the best focus is simply not as good as it should be, the CRT is probably the problem. However, if the optimal point produces acceptable focus but it changes (and possibly moves off of one end of the adjustment knob range) as the unit warms up, the flyback or one of the components on the CRT neck board are likely drifting.

- If you have a high voltage meter, you can measure the focus voltage to determine if it is being changed by the focus pot and if it is in the ball park (2-8 kV typical). Sometimes, the part of the flyback with the focus pot can be snapped off and cleaned or parts replaced but usually you need to replace the whole unit. There may a capacitor or two on the PCB on the neck of the CRT that could have increased leakage as well thus reducing the focus voltage.

- To determine if the CRT is the problem, for sharp focus after the unit has warmed up. Power-off for an hour or so and carefully pull the CRT neck board off of the CRT. Then, power up the unit. Let it run long enough such that there would have been a detectable focus drift. Now, power-down, plug the CRT neck board back in, and power-up. Watch the image as it appears on the screen:

    - If the focus starts out fuzzy and sharpens up as the image appears and gradually becomes sharper as the CRT warms up the CRT is likely tired.

      The only catch here is that plugging the CRT neck board into the CRT results in an additional load on the flyback due to the picture beam current which heats it more as well. Thus, if the problem takes a few minutes to appear, keep the brightness turned down except to check the appearance of the picture from time to time.

      You can set the focus control for optimum when warmed up and just turn the monitor on in advance of when you will be needing it or add a user focus adjustment by drilling a hole in the plastic case for an *insulated* screwdriver or flyback focus knob extender :-). The CRT may continue to function for quite a while so this is not impending doom.

- If the focus is relatively stable as the image appears and increases in brightness *and* is about as sharp as it would be with the monitor warmed up, the problem is most likely in the flyback. However, also check for bad components or decayed (tan or brown) glue on the CRT neck board. A drifting flyback will need to be replaced as it will probably get worse and fail completely. Clean the surface of the circuit board and CRT socket in the vicinity of the focus and screen terminals and traces. Contamination or just dirt and grime can easily cause problems especially on humid days since the resistance of these circuits is extremely high (100s of M ohms).
- If the focus is relatively stable as the image appears and increases in brightness *and* is similar to what it would be with the monitor cold, you have a very strange situation where some load on the high voltage power supply, perhaps, is causing a thermal problem. This would be rare.

About the quality of monitor focus

Question: I have 2 identical monitors. One is razor sharp from edge to edge. The other is blurred at the corners- not from convergence problems, but just plain out of focus. In this monitor, the focus adjustment on the flyback can improve the focus at the edges, but then the center of the screen becomes worse..My question is : Is this a problem in the electronics and presumably a fixable flaw or is it caused by variance in the picture tube itself and not correctable ? Or is it some other issue?

(From: Bob Myers (myers@fc.hp.com).)

The adjustment on the flyback sets the "static" focus voltage, which is a DC voltage applied to the focus electrode in the CRT. However, a single fixed focus voltage will not give you the best focus across the whole CRT screen, for the simple reason that the distance from the gun to the screen is different at the screen center than it is in the corners. (The beam SHAPE is basically different in the corners, too, since the beam strikes the screen at an angle there, but that's another story.) To compensate for this, most monitors include at least some form of "dynamic" focus, which varies the focus voltage as the image is scanned. The controls for the dynamic focus adjustment will be located elsewhere in the monitor, and will probably have at LEAST three adjustments which may to some degree interact with one another. Your best bet, short of having a service tech adjust it for you, would be to get the service manual for the unit in question.

It is also possible that the dynamic focus circuitry has failed, leaving only the static focus adjust.

As always, DO NOT attempt any servicing of a CRT display unless you are familiar with the correct procedures for SAFELY working on high-voltage equipment. The voltages in even the smallest CRT monitor can be lethal.

Bad focus and adjustment changes brightness

This is the classic symptom of a short between the focus and screen supplies - probably in focus/screen divider which is part of the flyback or tripler. However, it could also be in the CRT. If you have a high voltage meter, measuring the focus voltage will show that (1) it is low and (2) it is affected by the SCREEN control Similarly, the SCREEN voltage will be affected by the FOCUS control (which is what is changing the brightness.

To determine if the problem is in the CRT, measure the FOCUS and SCREEN voltage with a high voltage meter. If they are identical pull the plug on the CRT. If they are now their normal values, then a shorted CRT is a distinct possibility - see the section: Rescuing a shorted CRT.

Charlie's comments on focus problems

(From: Charles Godard (cgodard@iamerica.net).)

Most true focus problems that I have encountered (when the IHVT is ok) are related to leaks or resistance on the focus output. The diming of the screen when the focus pot is adjusted leads me to think in terms of a leaky socket. I'd remove the ground from the crt socket to the tube dag and see if it sparks. If so there may be a leak in the socket to ground. It could also be leaking to another pin, such as the screen grid. A rhetorical question: What happens to the screen voltage when the focus pot is adjusted?

I have seen sockets that had no arching or other telltale signs, leak through the plastic housing to ground out the focus voltage.

Look closely at the screen. If the blurring is in the form of small circles, then you have an open or hi-resistance focus electrode inside the tube. The circles may vary in visibility with brightness.

If you still haven't found the problem, try to confirm that this is truly a focus problem. Remove the crt socket and observe the hi-voltage. If it climbs more than about 1k, say all the way up to 25kv, then you may have a beam current problem rather than a focus problem. In that case re-check all crt board voltages. WARNING: Removing the CRT socket and powering the unit may destroy the CRT on some models. See the section: Warning about disconnecting CRT neck board.

If you have done all of the above and removing the socket makes no change in the hi-voltage, then try to determine why the hi-voltage is low.

Watch the screen as the brightness, contrast, or screen control are adjusted. See if you can observe any signs of blooming. When the IHVT doesn't provide enough current to satisfy the demands of the tube for current, the the picture tends to appear to expand like a balloon. i.e., bloom. This can be caused by not enough drive to the IHVT. Carefully monitor the b+ to the horizontal drive stages to see that is is stable and correct.

Purple blob - or worse

Have you tried demagnetizing it? Try powering it off for a half hour, then on. Repeat a couple of times. This should activate the internal degausser. See the section: Degaussing (demagnetizing) a CRT.

Is there any chance that someone waved a magnet hear the tube? Remove it and/or move any items like monster speakers away from the set.

Was your kid experimenting with nuclear explosives - an EMP would magnetize the CRT. Nearby lightning strikes may have a similar effect.

If demagnetizing does not help, then it is possible that something shifted on the CRT - there are a variety of little magnets that are stuck on at the time of manufacture to adjust purity. There are also service adjustments but it is unlikely (though not impossible) that these would have shifted suddenly. This may be a task for a service shop but you can try your hand at it if you get the service manual - don't attempt purity adjustments without one.

If the monitor was dropped, then it is even possible that the internal shadow mask of the CRT has become distorted and you now have a seventy-five pound boat anchor. :(If the discoloration is slight, some carefully placed 'refrigerator' magnets around the periphery of the tube might help. See the section: Magnet fix for purity problems - if duct tape works, use it!

It is even possible that this is a 'feature' complements of the manufacturer. If certain components like transformers are of inferior design and/or are located too close to the CRT, they could have an effect on purity. Even if you did not notice the problem when the monitor was new, it might always have been marginal and now a discoloration is visible due to slight changes or movement of components over time.

Color rings - bullseye pattern

This probably means the degaussing circuitry is terminating suddenly instead of gradually as it should. The most likely cause is a bad solder connection to the degauss thermistor or posistor or something feeding it.

You can confirm this by manually degaussing the screen with the TV or monitor turned on. If the problem disappears, the above diagnosis is probably valid. Check for bad solder connections in the vicinity of the degauss components and AC line input.

Magnet fix for purity problems - if duct tape works, use it!

The approach below will work for slight discoloration that cannot be eliminated through degaussing. However, performing the standard purity adjustments would be the preferred solution. On the other hand, the magnets may be quick and easy. And, where CRT has suffered internal distortion or dislocation of the shadowmask, adjustments may not be enough.

In any case, first, relocate those megablaster loudspeakers and that MRI scanner with the superconducting magnets.

The addition of some moderate strength magnets carefully placed to reduce or eliminate purity problems due to a distorted or dislocated shadowmask may be enough to make the monitor usable - though it will probably not be perfect. The type of magnets you want are sold as 'refrigerator magnets' and the like for sticking up notes on steel surfaces. These will be made of ferrite material (without any steel) and will be disks or rectangles. Experiment with placement using masking tape to hold them in place temporarily. Degauss periodically to evaluate the status of your efforts. Then, make the 'repair' permanent using duct tape or silicone sealer or other household adhesive.

Depending on the severity of the purity problem, you may need quite a few magnets! However, don't get carried away and use BIG speaker or magnetron magnets - you will make the problems worse.

Also note that unless the magnets are placed near the front of the CRT, very significant geometric distortion of the picture will occur - which may be a cure worse than the disease.

WARNING: Don't get carried away while positioning the magnets - you will be near some pretty nasty voltages!

(From: Mr. Caldwell (jcaldwel@iquest.net).)

I ended up with the old 'stuck on a desert island trick':

I duck taped 2 Radio Shack magnets on the case, in such a way as to pull the beam back.!!!!

A $2 solution to a $200 problem. My friend is happy as heck.

RCA sells magnets to correct corner convergence, they are shaped like chevrons and you stick them in the 'right' spot on the rear of the CRT.

(From: Tom Sedlemyer (wesvid@gte.net).)

First set purity as best you can.

Obtain some pieces of refrigerator door magnet strips from an appliance repair shop (they usually have some lying around).

Cut the strips into 1 inch pieces. Place a strip as on the bell of the picture tube as close to the yoke as possible and in line with the corner that has the purity error. Rotate the magnet until you correct the purity error and tape it in place. Multiple magnet strips can be used and you may experiment with the size of the strips for best effect. It is very important that the strips are positioned close to the yoke or the effect will not hold. The only drawback to this method is some very slight distortion of the geometry of the raster, but it beats hell out of paying for a new CRT.

Color monitor only displays one color

I assume that now you have no other colors at all - no picture and no raster. Let us say it is red - R.

It is probably not the CRT. Do you have a scope? Check for the R, G, and B video signals at the CRT. You will probably find no signals for the defective colors.

This is almost certainly a chroma circuit problem as any failure of the CRT or a video driver would cause it to lose a single color - the other two would be ok. Therefore, it is probably NOT the CRT or a driver on the little board on the neck of the CRT.

Try turning up the SCREEN control to see if you can get a G and B raster just to confirm that the CRT is ok.

Locate the video drive from the mainboard for the good and a bad color. Interchange them and see if the problem moves. If so, then there is a video signal problem. If not, it is on the little CRT board.

It could be a defective chroma IC or something else in the chroma decoder.

Disappearing Red (or other color)

Problem: I have been given an old colour TV. The reception is good, but very often, when the contrast and brightness of the TV image is low (e.g. when a night scene is shown), the red colour slowly disappears, leaving behind the green and blue image and many red lines.

The remaining red retrace are the giveaway that this is most likely not a CRT problem.

(If there were no red lines, it could be the filament for the red gun of the CRT going on and off due to a bad connection inside the CRT - bad news.)

How is a black and white picture? (Turn down the color control).

If B/W picture is good, then the problem is somewhere back in the chroma decoder circuitry.

Check the video input to the CRT video driver board and signals on that board. If B/W picture is also bad, then you can compare red and green signals to determine where they are becoming different. The red lines in your description sounds like the red video output circuit is drifting and messing up the background level, blanking, screen, or other setting. Could be a capacitor or other component.

Interference resulting in jiggling or wiggling

Note: similar symptoms can be the result of a monitor defect or running the monitor at scan rate beyonds its capabilities. However, magnetic interference from electrical wiring, other equipment is very common and sometimes overlooked when looking for a complex, expensive, and obscure explanation for a misbehaving monitor (or TV).

Also, if your outlet is not grounded, I have heard of similar symptoms under certain conditions. Grounding IS essential for safety should a short circuit fault develop in the PC as well as to get the most benefit from a surge suppressor so now is a good time to upgrade!

Interference from electrical wiring

If the wiring of normal outlets is done correctly even without a safety ground, the currents should be balanced and you will not experience a problem. However, many circuits, particularly those involving setups like 3-way switches or switched outlets and wiring in older buildings can have unbalanced currents when active. If your monitors are close enough to the wiring, there can be interference which will take the form of a flickering or pulsating display.

Other than recommending moving the monitors, there is no easy solution. They can be shielded with Mu Metal but that is expensive. Or you could run all displays at a 60 Hz vertical rate (or 50 Hz depending on where you live). However, this is inconvenient and will never be quite perfect.

If you have flexibility during construction or renovation, there are ways to minimize the chance of unexpected behavior later:

Think of it this way: If the sum of the currents in the cable are zero, there will be no magnetic field to worry about. This will be the case for normal 110 VAC branch circuits.

Some sources for magnetic interference:

- Three (or more) way circuits - lamps or fixtures controlled from more than one location which use a 'traveler'. In this case, a single energized wire runs between switches and/or the switches and the load.
- Circuits which do not have their return in the same cable. For example, ceiling fixtures controlled from a wall switch but where the Hot comes from another location. Or, a string of baseboard heaters fed from opposite ends.
- Circuits which share a Neutral but where one or more of the Hots are not in the same cable. This is more likely to be found in old construction using knob-and-tube wiring where circuits were just

connected in the most convenient way.

- Loops in Neutral and Ground conductors. The way circuits are supposed to be wired (U.S.A. at least) is nearly always in a star sort of configuration where the Neutral and Ground conductors never connect at the ends of the 'star'. However, due to poor wiring practices, it is quite possible for Neutrals to be connected to other Neutrals or Grounds to be connected to other Grounds or for them to be cross connected at various locations - all without any other symptoms. This can even happen between buildings. See the section: Interference from cross-connected buildings. However, the likelihood of this sort of fault isn't that great.

First confirm that the problem is due to inside wiring - shut off all power to the building (if possible) or at least switch off each circuit in turn to see if the problem disappears (run the monitor from a UPS or a remote outlet).

- If the symptoms persist, check for external sources of interference (although there could still be a Ground-Neutral loop formed by the connection between G and N at the service panel or to other buildings. In this case, the effect would likely be strongest near the service panel.). See the section: Interference from power lines.

- If the symptoms are gone, try to narrow down the circuit or circuits that are responsible by switching each one on individually.

In all cases, running the Hots and Neutrals for the circuit in the same cable (or at least in close proximity) will avoid this problem as the total current will sum to zero.

Realistically, you would have to be very unlucky to have a noticeable problem in residential wiring except near the service panel or high power appliances like baseboard heaters, equipment with large motors or transformers, etc.

Interference from power lines

Power lines (any size from local distribution to large intercontinental transmission lines) nearby can result in noticeable effects to monitors as a result of the magnetic fields surrounding the individual wires - similar to that from unbalanced inside wiring (see the section: Interference from electrical wiring. TVs may not be affected, at least not as much, since they will be running at a vertical rate almost the same as the power line frequency).

The severity of the effects will vary depending on the load distribution on the three (probably) phases, distance, orientation with respect to the monitor, etc. Moving the monitor as far from the offending power lines as possible, experimenting with its orientation, and seeing if you can live with a vertical scan rate equal to the power line frequency, are the only realistic options other than constructing an expensive mu-metal box for it. Check out MuShield specifically under "Monitor Enclosures" if you're curious. Less EMF, Inc. sells Mu-metal foil by the foot but what they have listed is rather thin - I don't know how well it would work for monitor CRT shielding.

Interference from cross-connected buildings

Here is a rare case where the neighbor was really at fault (in a historical sort of way).

(From: Tuyen Tran (ttran@ziplink.net).)

Get this: my house and my neighbor's house were grounded together, so we connected to the power company's neutral in two places. The way I understand it, this caused a ground loop between our two panels. My neighbors used to own this place. When they built a small house next door, instead of digging a separate well, they just ran a 3/4 inch copper pipe between my water tank and their new place. (This place used to be a dairy farm, so it had plenty of water capacity.) When they installed their panel, the electrician of course bonded their water pipes to the panel, which then connected our two grounds together. When they sold the place, they put in their own well, but nobody bother to cut the original pipe linking the two houses together. It's been like this for at least 40 years; I'm the third owner!

So I took a pipe cutter to the thing, and no more interference.

Interference from other equipment

Any type of equipment which uses or generates strong magnetic fields can interfere with a monitor. Other computer monitors or TVs, equipment with power transformers, and electric motors will cause a pulsating or flickering display. Loudspeakers or other equipment with static magnetic fields will cause color purity and/or geometric distortion problems which degauss will not cure.

The easiest way to confirm that interference is your problem is to move the monitor or suspect equipment to a different location. The only real solution is to separate the monitor and interfering device.

Note that with scan rates that are not even near the power line frequency any more, a variety of symptoms are possible including shimmering, wiggling, undulating (how many more adjectives can you come up with?). The rate of the movement will be related to the difference between the monitor scan rate and the frequency of interference.

My monitor is possessed!

Problems are that all graphics applications fade to black, lose their color on parts of the screen, and there are strange pincushion problems on the right side of the monitor? This all came up suddenly, with no apparent changes your my part.

You tried changing video drivers, modes, cleaning connections on cables and video card, even pulled the card and cleaned the edge connector.

After cleaning up, things seemed to work (still had pincushion problem), but next time it was powered on, same weird problems.

Voodoo might be required but more down-to-earth causes are likely:

Are you sure nothing changed in the building (like you installed a medical MRI unit with a 2T magnet in the same room)?

All monitors have a built in degauss circuit which operates when power is turned on after being off for at least 15 minutes or so. This could have failed - it is switching off suddenly instead of ramping down as it should - and is making the problem worse or you could have a power supply failure inside the monitor.

Gradual variations in color or brightness on the screen or over time are almost always monitor problems, not video card, software, or cables.

It won't hurt to try manual degauss with the monitor powered, see below. If this clears it up - possibly until you turn the power off and on again, then it may be the internal degauss circuitry.

Shimmering image due to vibrations

If your monitor uses a Trinitron or clone CRT, then this may be normal. Even with the 1-3 unsightly stabilizing wires running across the screen, the vertical aperture grille wires in a Trinitron type CRT can wiggle as a result of mechanical shocks or vibration. Any movement results in momentary changes in color purity, color balance, brightness. Gently tap on the side of the monitor and you may see the same effect.

Wiring transmitted interference

The power that comes from the wall outlet is supposed to be a nice sinusoid at 60 Hz (in the U.S.) and it probably is coming out of the power plant. However, equipment using electric motors (e.g., vacuum cleaners), fluorescent lamps, lamp dimmers or motor speed controls (shop tools), and other high power devices, may result in a variety of effects.

While monitors normally include some line filtering, the noise immunity varies. Therefore, if the waveform is distorted enough, some effects may show up even on a high quality monitor.

Symptoms might include bars of noise or distortion moving slowly or rapidly up or down the screen or diagonally. This noise may be barely visible as a couple of jiggling scan lines or be broad bars of salt and pepper noise, snow, or distorted video.

The source is probably local - in your house and probably on the same branch circuit - but could also be several miles away.

- One way to determine if the problem is likely to be related to AC power is to switch your vertical scan rate to match the power line frequency: 60 Hz in the U.S., 50 Hz in most European countries, etc. If the pattern of noise or distortion is now stationary (or at most slowly drifting up or down the screen), the interference is likely power line related:

  - A single bar would indicate interference at the power line frequency.

  - A pair of bars would indicate interference at twice the power line frequency.

  Either of these are possible.

- Try to locate the problem device by turning off all suspect equipment to see if the problem disappears.

- The best solution is to replace or repair the offending device. In the case of a light dimmer, for example, models are available that do a better job of suppressing interference than the typical $3 home center special. Appliances are supposed to include adequate noise suppression but this is not always the case.

  If the source is in the next county, this option presents some significant difficulties :-).

- Plugging the monitor into another outlet may isolate it from the offending device enough to eliminate or greatly reduce the interference.

- The use of a line filter may help. A surge suppressor is NOT a line filter.
- Similar symptoms could also be produced by a defective power supply in the monitor or other fault. The surest way of eliminating this possibility is to try the monitor at another location.

Jittering or flickering due to problems with AC power

If you have eliminated other possibilities such as electromagnetic interference from nearby equipment or electric wiring or a faulty video card or cable - or software - then noisy or fluctuating AC power may be a possibility. However, modern monitors usually have well regulated power supplies so this is less common than it used to be. Then again, your monitor may just be overly sensitive. It is also possible that some fault in its power supply regulator has resulted in it becoming more sensitive to minor power line fluctuations that are unavoidable.

One way to determine if the problem is likely to be related to AC power is to run the monitor on clean power in the same location on the same computer. For example, running it on an Uninterruptible Power Source (UPS) with the line cord pulled from the wall socket would be an excellent test. The output of the UPS's inverter should be free of any power line noise. If the monitor's image has now settled down:

1. Large appliances like air conditioners, refrigerator, or washing machines on the same circuit might cause significant power dips and spikes as they cycle.

   Plugging a table lamp into the same outlet may permit you to see any obvious fluctuations in power. What else is on the same circuit? Depending on how your house or apartment is wired, the same feed from the service panel may be supplying power to widely separated areas.

2. For some unfathomable reason, your monitor may just be more sensitive to something about the power from the circuit in that room. There may be nothing actually wrong, just different. While unlikely, a light dimmer on the same circuit could be producing line-conducted interference.

   If you have a multimeter, you could at least compare the voltages between the location where it has problems and the one where it is happy. Perhaps, the monitor is sensitive to being on a slightly different voltage. This might only be a problem if some circuitry in the monitor is marginal in some respect to begin with, however.

3. There could be a bad connection somewhere on the circuit. If your house has Aluminum wiring, this is a definite possibility.

   Try a table lamp since its brightness should fluctuate as well. This should be checked out by a competent electrician as it represents a real fire hazard.

An electrician may be able to pinpoint the cause but many do not have the training or experience to deal with problems of this sort. Certainly, if you find any power line fluctuations not accounted for by major appliances, on the same circuit this should be checked by an electrician.

My monitor has the shakes

You turn on your monitor and 5-10 seconds later, the display is shaking or vibrating for a second or so. It used to only occur when first turned on, but now, the problem occurs 3 times in 30 seconds. Of course, many variations on this general theme are possible.

Some possibilities:

1. Defective degauss circuit - this would normally cause a shaking or vibration when you first turn it on but you normally do not notice it since the CRT is not warmed up. The degauss circuit may have developed a mind of its own.

2. Other defective circuitry in monitor - power supply regulation, deflection, or bad internal connections.

3. External interference - did you change anything or move your setup recently? See the sections on: "Interference from other equipment", "Interference from electrical wiring", and "Interference from power lines".

4. Defective video cable (unlikely). Wiggle the VGA cable to be see if you can induce the problem.

5. Loose trim magnets of other magnetic components on or near deflection yoke. This is somewhat rare but if the adhesive comes apart, the magnetic fields from the deflection current can cause the parts to vibrate which will result in a jitter or movement of the picture. There may even be audible crackling or snapping sounds associated with this vibration.

Fred's comments on monitor interference problems

(From: Fred Noble) Fred_Noble@msn.com).)

Monitors are very susceptible to electromagnetic fields. If any of the following is "yes" it may point to an 'electrical' cause of the Monitor problem.

- Do you have a ceiling fan in the same room turned on?
- Do you have a wireless telephone in the room?
- Do you get similar effects on your TV?
- Are you near a large transformer, substation, or high voltage overhead wires?
- Is your computer located close to the meter on the other side of the wall?
- Do you have speakers next to the monitor? Are they shielded?
- Do you have a phone or other device with a magnet in it near the monitor?
- Is the cabling routed too near a printer cable?
- Do you have a surge/power strip or UPS near your monitor?

Reposition the monitor or move it to a different location. Also make sure that you are turning the monitor on first and then the system to ensure that the video card is properly recognizing the monitor.

Check cable connections (make sure no other cables are crossing the monitor cable. If you have an extension on the monitor output cable then remove it as well.

Try swapping out the monitor to verify if it really is the monitor or take your monitor to another system and see how it responds there.

If you are plugging the monitor into a surge strip, remove it from there and plug the monitor directly in the wall outlet.

Discussion:

There might be an ambient RFI/EMI electrical or magnetic field present around your computer location. Some of the electrical field or the conducted RFI/EMI electrical "noise" causes are considered here.

Rough summary of excessive magnetic & electric fields:

- Cause: Electrical wiring errors.

  Electrical wiring errors such as inappropriate or non-NEC code neutral to ground bonds in the facility (not at the common bus in the mains), and other non-NEC Code wiring that results in the HOT wire fields not being OFFSET by the neutral wire fields.

  Incorrect wiring will be aggravated (and will be noticed first) on a circuit where there is an Air Conditioner, copier, laser printer.

  Correction: This is an electrical problem that has resulted in a *net current* flowing in the facility and is also a shock hazard.

  Don't use devices that dump current onto the neutral line, and have an electrician correct the wiring to NEC code.

- Cause: Magnetic flux linkages.

  It is normal for transformers to use magnetic flux linkages (to couple primary to the secondary).

  Correction: Keep transformer based equipment away from sensitive equipment.

  There are other corrective measures here that can be discussed on the design level and on the application level.

  If the transformer is used to power a "noisy" load (high harmonics) perhaps a good harmonic filter can be used between the transformer and the load (example a good UL 1283 noise filter or Surge suppressor with UL 1283 filter).

- Cause: Motors also use magnetic flux linkages in normal usage.

  Correction: Keep large, active, motors away from sensitive equipment (and try to keep them on a different circuit if possible).

  The use of a good harmonic filter on that circuit will help reduce the harmonics (for example, a good surge suppressor with a UL 1283 RFI/EMI filter, or a Line Conditioner).

- Cause: UPSs, especially when on inverter (during brownout or blackout) create magnetic & electric fields.

  Correction: Keep them away from sensitive loads, and advise manufacturer of problems encountered with the UPS.

  The UPS may have a faulty inverter circuit or part, or may be in need of a re-design.

Loss of color after warmup

If there is a general loss of picture but there is light on the screen if the brightness is turned all the way up, then this is a video input, video amplifier, RGB driver, or power supply problem.

If it recovers after being off for a while, then you need to try a cold spray in the video/controller to identify the component that is failing. Take appropriate safety precautions while working in there!

If it stays broken, then most likely some component in the video circuitry, controller, or its power supply as failed. There is a good chance that it is a bad colder connection - the trick is to locate it!

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Miscellaneous Problems

Contour lines on high resolution monitors - Moire

These fall into the category of wavey lines, contour lines, or light and dark bands even in areas of constant brightness. (Some people may refer to this phenomenon as "focus or Newton's rings".) These may be almost as fine as the dot pitch on the CRT or 1 or 2 cm or larger and changing across the screen. If they are more or less fixed on the screen and stable, then they are not likely to be outside interference or internal power supply problems. (However, if the patterns are locked to the image, then there could be a problem with the video board.)

One cause of these lines is moire (interference or beat patterns) between the raster or pixels and the dot structure of the CRT. Ironically, the better the focus on the tube, the worse this is likely to be. If the individual pixels do not cover enough phosphor dots, then the actual color and brightness displayed won't match what the video card is generating and this will depend on the actual location of the pixel relative to the phosphor dots. Trinitrons, which do not have a vertical dot structure should be immune to interference of this sort from the raster lines (but not from the horizontal pixel structure). Slot mask CRTs (not that common on monitors) also have fewer problems with vertical moire.

You can test for moire by slowly adjusting the picture size. If it is moire, you should see the pattern change in location and spatial frequency as slight changes are made to size. Changes to position will move the patterns along with the picture without altering their character and structure significantly (though fine detail will change).

If they are due to the raster line structure - your focus is too good - the patterns will remain essentially fixed in position on the face of the CRT for horizontal size and position adjustments - the patterns will remain fixed under the changing image.

How to eliminate it? If moire is your problem, then there may be no easy answer. For a given resolution and size, it will either be a problem or not. You can try changing size and resolution - moire is a function of geometry. Ironically, I have a monitor which is nicer in this respect at 1024x768 interlaced than at 800x600 non-interlaced.

Some monitors have a 'Moire Reduction Mode' switch, control, or mode. This may or may not be of help. One way to do this is - you guessed it - is to reduce the sharpness of the beam spot and make the picture fuzzier! Another approach adds a high frequency dither to the beam spot position which may result in a headache! You might find these cures to be worse than the disease.

Another cause of similar problems is bad video cable termination creating reflections and ghosting which under certain conditions can be so severe as to mimic Moire effects. This is unlikely to occur in all colors with a VGA display since the termination is internal to the monitor and individual resistors are used for each color (RGB).

I think it is ironic that some people will end up returning otherwise superb monitors because of moire - when in many cases this is an indication of most excellent focus - something many people strive for! You can always get rid of it - the converse is not necessarily true!

Moire and shadow mask dot pitch

(From: Bob Myers (myers@fc.hp.com).)

The density of the holes in the shadow mask set an upper limit on the resolution supported by that monitor. Lower resolutions work just fine; there is no need to have the logical pixels in the image line up with the physical holes in the mask (nor is there any mechanism to make this happen), and so you can think of this as the "larger pixels" of the lower-res image simply covering more than one hole or slot in the mask.

As the effective size of the pixels in the image approach the spacing of the mask holes, individual pixels are no longer guaranteed to cover enough phosphor dots on the screen to ensure that they are constant color or constant luminance, but an image will still be displayed which ON AVERAGE (over a reasonably large area) looks OK. Actually, the specified "top end" format ("resolution") for most monitors usually is at or slightly beyond this point - the effective pixel size is somewhat UNDER the dot pitch.

Sources of external interference that can affect the monitor display

The following list is just some of the ways your picture can get screwed up through no fault of the monitor. It's sort of amazing they work as well as they do! Most of these are discussed in greater detail in subsequent sections.

Static/DC magnetic fields:

- Unshielded/inadequately shielded multimedia speakers
- Stereo loudspeakers
- MRI scanner next door.

Transient magnetic fields:

- Kid's (or adults) playing with magnets
- Electro-Magnetic Pulse (EMP) from nearby lightning strike or nuclear blast
- Changing monitor location or orientation without degaussing.
- Shift in Earth's magnetic field every 10-20K years. :)

AC magnetic fields (usually at power line frequency):

- AC or DC wall adapters/transformers
- Fluorescent lamps (magnetic ballast)
- Laser printer and other peripherals
- TV, VCR, DVD, or other A/V equipment

- Additional computer monitor(s) too close
- Large appliances including furnace, A/C, fridge, microwave

- Wiring in walls (unbalanced load/shared Neutral)
- Wiring in electrical service panel
- Outside wiring and power distribution equipment

Radio Frequency Interference:

- High power radio transmitter nearby (broadcast, military, amateur)

Power Line Transmitted Interference:

- Lighting on dimmers (incandescent/halogen lamps/fixtures)
- Motor speed controls (ceiling fans)
- Fluorescent lamps (all types)
- Vacuum cleaners/shop equipment/other brush type motors
- Equipment using switchmode power supplies
- Heavy industry down the street

Interference affecting video signal:

- Lack of earth/safety ground (line filter ineffective)
- Ground loop caused by PC and monitor plugged into different circuits
- Cross connected buildings resulting in ground loop

Interference between monitor and VCR or TV

> "I've got a desktop computer with a VGA monitor above it. To the left of it (a few inches away), I have a VCR with a Commodore composite monitor above it (1084 model). I don't have Cable TV or anything special, just a simple antenna connected to the VCR to pick up the two local TV stations.
>
> The reception is pretty good with the computer off, but the problem arises when I turn the computer on. The VCR is already plugged into a different outlet than the computer. Since I am into video production, I need this setup as it is laid out (close together).
>
> So, how can I shield the VCR from the interference from the computer? Can I do something with the antenna to make the signal stronger, or can I place some kind of material between the VCR and computer?"

Your PC is a serious RF emitter. Areas of leakage include the case as well as the possibly the monitor and cable. Turn off the monitor and/or unplug the video cable to see if it is the latter.

You PC's case may not have adequate shielding. Better cases have grounding fingers and proper RF shielding throughout - that is one reason they are more expensive. This may be an option.

The VCR may be picking up the interference internally or via its antenna.

There may be some options but you first need to determine where the interference is coming from and where it is being picked up.

Cable installed upside-down - now monitor does not sync correctly

> "I have an old vga monitor that I screwed up. I plugged it into the vga card upside down. Now I know that seems impossible, but believe me, it isn't.
>
> Now the vertical is fine, but the horizontal is all screwy. (is that a word? screwy?) It's about 8" wide and can't be adjusted to normal size.
>
> The result is a very, um, interesting image. Is it possible that I did some minor damage like blowing a cap, diode, or horizontal transistor?"

I'll give you 100:1 odds that you bent the H sync pin and it is now bent over and not inserted in its hole. Remove the connector, and examine the pins - if this is the case, take a pair of needlenose pliers and **very carefully** straighten it out. If it was pushed in, grab hold and pull it out to the same length of the other pins and if necessary, put a drop of adhesive at its base to prevent it from being pushed in again. If it breaks off or is unreachable, you will need to replace the connector (unless the shell comes apart which is usually impossible or at least not easy on newer monitors).

Isolated spots on display

These could be a problem with the video source - bad pixels in the video card's frame buffer or bad spots on a camcorder's CCD, for example. Or, they could be dirt or dead phosphor areas in the CRT. Except for problems with the on-screen character generator, it is unlikely that the monitor's circuitry would be generating isolated spots.

You can easily distinguish between video problems and CRT problems - missing pixels due to the video source will move on the screen as you change raster position. CRT defects will remain stationary relative to the screen and will generally be much more sharply delineated as well.

There is a specification for the number and size of acceptable CRT blemishes so you may have to whine a bit to convince the vendor to provide a replacement monitor under warranty.

Power saving problems

Modern monitors are usually designed to permit software to control various levels of power saving ('green') features from blanking the screen to totally shutting down. Problems can occur if the software to control these features is not compatible with the monitor or not set up correctly or is attempting to control a monitor that lacks power saving modes or is defective or incompatible.

A monitor that behaves normally under most conditions but emits a high pitched whine when the computer attempts to direct it into power saving mode is probably not understanding the commands or does not have the appropriate power saving features. It probably behaves about the same as if there is no video signal - which indeed may be the case as far as it is concerned.

Many monitors not receiving proper sync signals are perfectly happy driving everyone in the office insane with that high pitched whine. Others will blow up eventually.

Recommendation: Don't use power saving until you have the proper software and you know what your monitor supports. Of course, your monitor could be defective and your current software is actually fine. Check your user manuals to determine compatibility and setup parameters. Also see the sections: Monitor life, energy conservation, and laziness and Implications of power saving modes.

Monitor drift?

Problem: I have a 17" monitor that has an image that EVER SO SLIGHTLY drifts to the left (and stops) after a long day's work (heat, I suppose). Also, the vertical height shrinks a little bit. Is this at all normal/acceptable?

How much is 'ever so slightly'? There are a fair number of components whose values could alter the position/size of a monitor image. I do not find it at all surprising that there should be a small shift due to heat. It really depends on many factors including the basic design, quality of components, ventilation/cooling, etc. Of course, it is possible to have a monitor that has a component that is worse with respect to temperature. Could also be related to line voltage depending on the regulation of your monitor's power supplies.

In general, my feeling is that if it is not objectionable (a 1/2" shift would be objectionable) AND it's severity is not changing with time, you can ignore it.

Many monitors do this. TVs do this but you are not aware of it since they are already 5-10% overscanned for just this reason, as well as compensating for component aging and line voltage fluctuations.

A can of cold spray or a heat gun will be useful to track down the bad component but it could be a frustrating search.

Monitor shuts down or goes blank at certain scan rates

It could be the monitor's components have drifted and are now marginal at your one or more of your scan rates. However, first check with an oscilloscope if possible to confirm that your horizontal and vertical timing are indeed as expected.

Some video cards modify horizontal and vertical frequency as part of their software size adjustment in their Setup program. For example, with ATI cards, even though the general resolution option in the DOS Install program may be 800x600 at 75 Hz, adjusting the horizontal size can actually vary the horizontal frequency over a greater than 10% range. A similar variation is possible with the vertical rate.

Does just the picture go away or does power die to the monitor? If you can see the neck of the CRT, the filaments glow orange when it is operating. Does this glow disappear indicating that the deflection/HV is shutting down?

There could be a number of possibilities - no way of knowing if it will be easy or inexpensive to repair without testing. It could be power supply, HV supply, X-ray protection, etc.

Monitor flickers when disk accessed

This is almost certainly a software problem. First, try moving the monitor away from the PC as far as the cable will stretch. If it still occurs, then it is probably not the monitor. Could have to do with power saving (just a guess) or some other incompatibility. Nothing the PC does should affect the monitor in any way once the refresh rate is set.

Buzzing monitor

Do you actually mean buzz - low frequency as in 50 - 120 Hz? Or, do you really mean high pitched whine. If the latter, see the section: High pitched whine or squeal from monitor with no other symptoms.

- If it is from inside the monitor - make sure it is not your multimedia speakers or sound card picking up interference - it is in the deflection (probably vertical) or power supply. Either of these can vary in severity with picture content due to the differing current requirements based on brightness. It could be a power supply transformer, deflection yoke, or other magnetic component. Even ferrite beads have been caught buzzing when no one was looking. :-) Any of these parts could vibrate if not anchored securely or as they loosen up with age.

  Some hot-melt glue, RTV silicone, or even a strategically wedged toothpick may help. A new part may or may not quiet it down - the replacement could be worse! For yoke noise, see the section: Reducing/eliminating yoke noise.

- There is a slight possibility that the AC power in your home or office has some harmonic content - the waveform is not sinusoidal. This might be the case if you try to run on the same circuit as an active dimmer or something else with thyristor control. Proximity to heavy industry could also cause this.

  Relocating the offending device to another branch circuit may help. You could also try a line conditioner (not just surge suppressor) which includes filtering. Else, petition to have that paper manufacturer move out of the neighborhood :-).

- Sometimes, it is simply a design or manufacturing defect and the only alternative is a replacement - possibly a different brand. It may be more difficult to quiet down a buzz than a high pitched whine.

- Some monitorss are simply poorly designed. You cannot infer the severity of this annoyance from any specifications available to the consumer. It is strictly a design (e.g. cost) issue. The size of the monitor is not a strong indicator of the severity of the problem but there will be some relationship as the power levels are higher for larger units. The best you can do is audition various monitors very carefully to find one that you are satisfied with.

- One those rare monitors that have a cooling fan, its bearings may be worn or in need of cleaning and lubrication, or a blade may be hitting something.

High pitched whine or squeal from monitor with no other symptoms

Sometimes this is continuous. In other cases, it comes and goes almost as though there is an intelligence at work attempting to drive you crazy. All the more so since a technician may not even be able to hear what you are complaining about if their hearing is not as sharp at high frequencies as yours. Even high resolution computer monitors running at high horizontal scan rates (beyond human hearing) can have these problems due to the switching power supplies as well as subharmonics of the horizontal scan rate exciting mechanical resonances in the magnetic components or even a portion of the sheetmetal used for shielding if in close proximity to a magnetic component.

If it is a new monitor and you think the sounds will drive you insane, returning it for a refund or replacement may be best alternative. However, you may get used to it in time.

Note: if the whine only occurs when the monitor is unplugged from the computer or the computer is turned off, this is probably normal. Without valid sync signals the monitor defaults to a horizontal rate which is within the audible range (less than 20 kHz). Any vibrating components will be readily heard. It is usually not a sign of impending failure.

In most cases, this sound, while annoying, does not indicate an impending failure (at least not to the monitor - perhaps to your mental health) or signify anything about the expected reliability of the unit though this is not always the case. Intermittent or poor connections in the deflection or power supply subsystems can also result in similar sounds. However, it is more likely that some part is just vibrating in response to a high frequency electric current.

There are several parts inside the monitor that can potentially make this noise - the horizontal flyback transformer and to a lesser extent, the deflection yoke and associated geometry correction coils would be my first candidates. In addition, transformers or chokes in the switching power supply if this is distinct from the horizontal deflection circuitry.

You have several options before resorting to a 12 pound hammer:

- Confirm that the horizontal scan rate being used by the video card is well within the range supported by the monitor. If it isn't, change it to be a one that is - in addition to possible whining, this is stressful on the deflection and power supply and may result in an expensive repair in a very short time. Even if the scan rate is supposed to be fine, changing it slightly (e.g., 5 percent) might help just because it shifts the deflection frequency away from a mechanical resonance. However, this may not be a long term solution.

- As much as you would like to dunk the monitor in sound deadening insulation, this should be avoided as it will interfere with with proper cooling. However, the interior of the computer desk/cabinet can be lined with a non-flammable sound absorbing material, perhaps acoustic ceiling tiles. Hopefully, not a lot of sound energy is coming from the front of the monitor.

- Move the monitor out of a corner if that is where it is located - the corner will focus sound energy into the room.

- Anything soft like carpeting, drapes, etc. will do a good job of absorbing sound energy in this band. Here is your justification for purchasing those antique Persian rugs you always wanted for your computer room :-).

If you are desperate and want to check the inside of the monitor:

- Using appropriate safety precautions, you can try prodding the various suspect parts (flyback, deflection yoke, other transformers, ferrite beads) with an insulated tool such as a dry wooden stick. Listen through a cardboard tube to try to localizing the source. If the sounds changes, you know what part to go after. Sometimes a replacement flyback will cure the problem unless it is a design flaw. You do not want to replace the yoke as convergence and other adjustments would need to be performed. Other transformers can be replaced.

- Sometimes, tightening some mounting screws or wedging a toothpick between the core and the mounting or coils will help. Coating the offending part with sealer suitable for electronic equipment may quiet it down but too much may lead to overheating. A dab of hot-melt glue or RTV silicone may help. Even replacement is no guarantee as the new part may be worse. For yoke noise, see the section: Reducing/eliminating yoke noise.

- A few monitors have internal cooling fans. The whine may be due to worn or dry bearings. If this is the case, the fan must be serviced as it is not likely doing it job and damage due to excessive temperatures may eventually be the result.

Note that the pitch of the whine - the frequency - may not even be audible to a technician assigned to address your complaint. The cutoff frequency for our hearing drops as we get older. Someone over 40 (men more so than women), you may not be able to hear the whine at all (at least you can look forward to silence in the future!). So, even sending the monitor back for repair may be hopeless if the technician cannot hear what you are complaining about and you are not there to insist they get a second opinion!

Monitor whines in power saving (standby) mode

(From: Bob Myers (myers@fc.hp.com).)

In standby, the monitor is not being supplied with horizontal sync, and so the horizontal deflection circuits are free-running. (If they're still powered up in a given monitor design when in standby mode, that is; there are no standards governing what actually gets shut down in the various power-saving states.) It's likely that in this case, the horizontal is free-running at a frequency which is audible, and you're hearing a whine from a vibrating transformer core (for example, the flyback). This will NOT have anything to do with the timing used when the monitor is on and running normally, so it's no surprise that changing the refresh rate didn't affect this.

You can either have a technician try to track down the offending component and try to keep it from making the noise (usually by adding some "goop" to prevent or at least reduce the audible effects of the vibration), or you might try (if your system permits it) using one of the other power-management states instead of standby. Removing BOTH the horizontal and vertical sync signals places the monitor in the "off" condition (I'm assuming compliance to the VESA DPMS standard throughout this discussion), in which just about everything should be shut down. However, since this will remove the heater supply from the CRT as well, it WILL take longer to recover from the off state.

Reducing/eliminating yoke noise

(From: Terry DeWick (dewickt@esper.com).)

Carefully look under vertical core next to plastic liner, on top and bottom is a plate called the astigmatism shunt, it has come loose. Work RTV, epoxy, or service cement onto it to glue it down and noise should quit.

(From: TVman (tvman@newwave.net).)

I have fixed a total of 27 of these sets with noisy yokes by removing the yokes and using motor armature spray sealant.

If you carefully mark the EXACT position of everything (yoke, purity magnets), and slide the yoke off the CRT, then once the yoke has been sealed with motor armature spray sealant and has dried thoroughly, put the yoke back EXACTLY where it was, there should be no problems.

The only thing I have had to do was set the purity on one set, but it was off a little to begin with.

Monitor was rained on

Was the monitor plugged in when the leak started? Any piece of equipment with remote power-on capability has some portions live at all times when plugged in and so there may have been damage due to short circuits etc. Substantial damage could have already been done.

Otherwise, you may just need to give it more time to dry out. I have had devices with keypads getting wet that required more than a week but then were fine. There are all kinds of places for water to be trapped and take a long time to evaporate.

If the monitor got wet while unplugged or it has a mechanical (hard) on/off switch, then give it a lot of time to dry out completely. Assuming all visible water is drained, a week represents a minimum safe time to wait. Don't rush it.

Generally, some moisture will not do any permanent damage unless the unit was on in which case you will simply have to troubleshoot it the old-fashioned way - one problem at a time.

You may be tempted to use a hair drier or heat gun to speed the process along. But, be extra careful not to do damage to the equipment. Slightly melted laptop keyboard is an example of a bit of overkill. As far as I know, this was due to a short exposure to a properly functioning blow drier. The owner swears that the blow drier is not overheating and that she hasn't been able to set her hair on fire. I can just imagine what would have happened with a real heat gun. They just don't make those keys the way they used to! :)

Monitor was dropped

If your work area is maintained like that of Nedrie in the movie "Jurassic Park", you might not even notice if one of your monitors fell off the table! This is no way to treat a monitor.

However, mishaps do happen.

Assuming it survived mostly intact - the CRT didn't implode, you could still have a variety of problems. Immediately unplug the monitor!

If you take it in for service, the estimate you get may make the national debt look like pocket change in comparison. Attempting to repair anything that has been dropped is a very uncertain challenge - and since time is money for a professional, spending an unknown amount of time on a single repair is very risky. There is no harm is getting an estimate (though many shops charge for just agreeing that what you are holding was once a monitor, or was it a fish tank?)

This doesn't mean you should not tackle it yourself. There may be nothing wrong or very minor problems that can easily be remedied. The following are likely possibilities:

1. Cracked circuit boards. These can be repaired since monitors usually have fairly wide open single or two sided boards.
2. Broken circuit components. These will need to be replaced.
3. Broken solder connections particularly to large heavy components on single sided boards. Reflow the solder. If the trace is cracked or lifted, repair as in (1).
4. Broken mounting brackets. These are usually made of cheap plastic and often don't survive very well. Be creative. Obtaining an exact replacement is probably not worth the trouble and expense.

5. Components knocked out of line on the CRT envelope or neck - deflection yoke, purity magnets, convergence magnets and coils, geometry correction magnets. These will need to be reattached and/or realigned. Some CRTs use little magnets glued to the funnel portion of the CRT envelope. If any of these have come loose, it could be quite a treat to figure out where they went and in what orientation.

6. Internal damage to the CRT - popped or distorted shadow mask, misaligned electron guns. Unfortunately, you will probably have no way of identifying these since you cannot see inside the CRT. They will not be apparent until all other faults have been remedied and the TV set is completely realigned. At that point, extremely severe purity or convergence problems that do not respond to the normal adjustment procedure would be one indication of internal damage. Give the TV a nice funeral.

If you still want to tackle a restoration:

As noted, unplug the monitor even if it looks fine. Until you do a thorough internal inspection, there is no telling what may have been knocked out of whack or broken. Electrical parts may be shorting due to a broken circuit board or one that has just popped free. Don't be tempted to apply power even if there are no obvious signs of damage - turning it on may blow something due to a shorting circuit board.

Then, inspect the exterior for cracking, chipping, or dents. In addition to identifying cosmetic problems, this will help to locate possible areas to check for internal damage once the covers are removed.

(At this point, most people will assume there is no interior damage and plug the set back in and turn it on. My recommendation is to resist this temptation since as noted, this could result in further damage making the repair more expensive if there are circuit problems. However, if the unit was on at the time of the "incident" or you are really determined to get to the conclusion and would just throw the thing in the trash if it doesn't work or blows up, go for it! But, if you're the more cautious type, continue with the systematic diagnosis and repair procedure that follows.)

Next, remove the cover. Confirm that the main filter capacitors are fully discharged before touching anything. Check for mechanical problems like a bent or deformed brackets, cracked plastic parts, and anything that may have shifted position or jumped from its mountings. Inspect for loose parts or pieces of parts - save them all as some critical magnets, for example, are just glued to the CRT and may have popped off.

Carefully straighten any bent metal parts. Replace parts that were knocked loose, glue and possibly reinforce cracked or broken plastic. Plastics, in particular, are troublesome because most glues - even plastic cement - do not work very well. Using a splint (medical term) or sistering (construction term) to reinforce a broken plastic part is often a good idea. Use multiple layers of Duco Cement or clear windshield sealer and screws (sheetmetal or machine screws may be best depending on the thickness and type of plastic). Wood glue and Epoxy do not work well on plastic. Some brands of superglue, PVC pipe cement, or plastic hobby cement may work depending on the type of plastic.

Inspect for any broken electronic components - these will need to be replaced. Check for blown fuses - the initial impact may have shorted something momentarily which then blew a fuse.

There is always a risk that the initial impact has already fried electronic parts as a result of a momentary short or from broken circuit traces and there will still be problems even after repairing the visible damage and/or replacing the broken components. This is most likely if the monitor was actually on but some modern monitors have circuitry that is energized at all times. (If power is controlled by a tiny tiny pushbutton this is the case.)

Examine the circuit boards for any visible breaks or cracks. These will be especially likely at the corners where the stress may have been greatest. If you find **any** cracks, no matter how small in the circuit board, you will need to carefully inspect to determine if any circuit traces run across these cracks. If they do, then there are certainly breaks in the circuitry which will need to be repaired. Circuit boards in consumer equipment are almost never more than two layers so repair is possible but if any substantial number of traces are broken, it will take time and patience. Do not just run over them with solder as this will not last. Use a fine tipped low wattage soldering iron and run #22-26 gauge insulated wires between convenient endpoints - these don't need to be directly on either side of the break. Double check each connection after soldering for correct wiring and that there are no shorts before proceeding to the next.

If the circuit board is beyond hope or you do not feel you would be able to repair it in finite time, replacements may be available but their cost is likely to be more than the equipment is worth. Locating a junk unit of the same model to cannibalize for parts may be a more realistic option.

Degauss the monitor as any impact may magnetize the CRT. Power cycling may work but a manual degaussing is best.

Once all visible damage has been repaired and broken parts have been replaced, power it up and see what happens. Be prepared to pull the plug if there are serious problems (billowing smoke or fireworks would qualify).

Perform any purity, convergence, or other realignment as needed.

Then proceed to address any remaining problems one at a time.

Really cleaning a monitor inside and out

(From: Dr. Ludwig Steininger (drsteininger@t-online.de).)

Often I get defective monitors, which are more than 5 years old, and have been run in offices for 8 to 10 hours/day. So, their case and pcbs usually are very dirty and dusty.

What do I do (it's no joke!): After removing the case I carefully put them in a bath (on a flexible layer) and let them have a intensive shower of pure cold water (for 1 to 2 minutes). Additionally, the case is cleaned with soap or a detergent containing liquid (being careful, not to spill to much of it onto the PCBs). After rinsing with fresh clear water, dust and other kinds of dirt are removed and the monitors look new again. Then I allow all drops of water to run off. This can effectively be supported by turning the monitor on another side from time to time (duration: approximately 1 hour). Before turning on AC again, I let the wet monitor dry in ambient air for about 2 days (in the sunshine this can be finished in 1 day only).

This procedure has been applied for many monitors. I've never had any bad experiences (it's very important to wait, until the pcbs are really dry!). Considering this experience, I just can't imagine, that it might not be possible, to "save" a TV set or computer monitor, which has been drowned or some liquid has been spilled, and AC has been plugged off ASAP (although I've never had such a case). I think, that in such a case, it's important to have a rapid shower in order to prevent corrosion and deposits.

By the way: I know a German company, which uses water from cleaning PCBs of computer hardware for cleaning them after being contaminated by smoke from a fire.

So, in case of spillage, one has nothing to loose. Just try to shower your monitor or TV set!

Setup menus will not go away or hieroglyphics on screen

Both these problems could be caused by a faulty microcontroller or its associated circuitry. However, bad connections in the vicinity of the controller logic could also be at fault.

Unless you see something obvious, you will need schematics.

Setup Adjustments Lost

Many modern monitors have RAM, somewhat like the CMOS SETUP memory in your PC, that store all factory adjustments. When power is lost, there is power surge, lightning strike nearby, nuclear detonation or EMP, it may have put bad information into the ram and thrown it out of adjustment. There is a way to get into the service mode (depress and hold a secret button down and turn set on, special combination of buttons on the remote, etc.) and then use the remote to reinitialize and adjust the problems out.

HOWEVER, IF YOU DON'T KNOW WHAT YOU DOING YOU COULD GIVE YOURSELF WORSE PROBLEMS. YOU COULD EVEN BLOW THINGS OUT WITH SOME MONITORS!

The service manual will be essential to have any chance of successfully reinitializing everything without causing damage due to incorrect settings.

If it's not an adjustment problem you probably have a bad part - somewhere.

If you do manage to get into the setup menu and are willing to take the risk without service information, try not to make any unnecessary changes and document every change you make!!! That way you can go back if you do anything wrong (hopefully).

Monitor doesn't work after being in storage

So the monitor you carefully stuffed in a corner of the garage is now totally dead. You swear it was working perfectly a year ago and just have to get that state-of-the-art Commodore 64 up and running!

Assuming there was absolutely no action when you turned it on, this has all the classic symptoms of a bad connection. These could be cold/cracked solder joints at large components like transformers, power resistors, or connectors and connectors that need to be cleaned or reseated. By 'no action' I mean not even a tweet, bleep, or crackle from anything.

To narrow it down further, if careful prodding of the circuit board(s) and various large components with a well insulated stick does not induce the set to come on, even momentarily, check the following:

1. Locate the horizontal output transistor. It will be in a TO3 metal (most likely on an older set) or TOP3 plastic package on a heat sink. With the set unplugged, confirm that there is no voltage across C to E and then measure between them with an ohmmeter. In at least one direction it should be fairly high - 1K or more. This confirms that the HOT is probably good.

   (There is also a slight chance that there is a low voltage regulator in addition to the horizontal output, so don't get them confused. The horizontal output transistor will be near the flyback transformer and yoke connector.)

2. Trace back from the HOT collector to the flyback and through the flyback to the B+ feed from the power supply. Clip a voltmeter between this point and the HOT emitter. Make sure the leads are well insulated and can't accidentally short to anything. (This test can be performed across C to E of the HOT but if the horizontal deflection were to start up unexpectadly, the meter could be damaged by the high voltage pulses on the HOT collector. But if you can't find the B+ source, it may be worth the risk.) Plug it in and turn it on.

    - If the problem is in the low voltage (line) power supply, there will be no substantial voltage across C-E.

      You should be able to trace from the power line forward to find the bad part though a schematic will help greatly.

    - If the problem is in the startup circuit or horizontal oscillator/driver, then there will be something on the order of 100 to 160 V across C-E.

      In this case, a schematic may be essential.

Note: don't assume that the metal parts of the chassis are ground - they may be floating at some line or B+ potential. Also, the HOT emitter may not be connected directly to ground.

Cheap monitors with multiple intermittent problems

If the monitor is a non-name or the company has since gone belly up (no surprise, right?) you may have a monitor with one of those circuit boards best described as bad solder joints held together with a little copper. In this case, prodding with an insulated stick and the use of a few select 4 letter words may get it going. The circuit boards may be double sided with what were called 'rivlets' for vias. The rivlets were relatively massive - literally little copper rivets - and they were not adequately heated or tinned during assembly so there were bucketloads of cold solder joints that show up during middle age. I repaired one of these by literally resoldering top and bottom of every one of the darn things with a high wattage iron. Or, the soldering just may be plain, well, horrible. Carefully going over every connection is the only solution. Sometimes, removing the solder from suspect joints, cleaning both the component lead and trace, and then resoldering will be needed if corrosion has set in.

Monitor has burning smell

Assuming there are no other symptoms:

If this appears after extended operation - an hour or more - it may just be a build up of dust, dirt, and grime over the years. After understanding the safety info, some careful vacuuming inside may help. Just don't be tempted to turn any screws or adjustments!

Dust is attracted to the high voltage section in particular - even the front faceplate of the CRT collects a lot and should be wiped with a damp cloth from time to time.

If the symptoms develop quickly - in a few minutes or less, then there could still be a dust problem - a power resistor may be heating a wad of it but other possibilities need to be considered.

If not dust, then probably in the power supply but realize that TVs don't have a nice metal case labeled 'power supply'. It is just a bunch of stuff scattered around the main board. Without identifying the part that is heating, a diagnosis is tough especially if the set really does work fine otherwise. However, if a series regulator were faulty and putting out too much voltage, the set could appear to work properly but in fact have excessive power dissipation in certain components. If cleaning the dust does not solve the problem, you will probably need a schematic to identify the correct voltages.

Static discharge noise and picture tube quality

This question came up with respect to a large screen TV but may apply to large screen monitors as well.

> "I bought a 29" TV a couple of weeks ago and I have noticed that after being switched on for > about 15/20 minutes, whenever the picture changes from a "light" scene to a darker scene, the set makes a crackling noise. It sounds as though there has been a build-up of static and it is being discharged. I have never noticed this in a TV before and I was wondering if this is normal and acceptable behaviour for a large-screen TV?"

It probably is normal. Whether it is acceptable is a personal matter. In some geographic areas no countermeasures are taken at all...

When the scene changes from bright to dark, the beam current is reduced to practically zero. As a result, the high voltage rises. (The high voltage supply has a relatively high internal impedance.) The high voltage is connected to the inside layer of the picture tube. A voltage change on the inside will also cause a voltage change on uncovered parts of the outside, especially on the part of the picture tube that is hidden under the deflection coils. This causes little sparks between the picture tube surface and the inside of the deflection coils and this is accompanied by a crackling sound.

On the better picture tubes, a dark "anti-crackle coating" is painted on the picture tube near the deflection coil. This is a very high impedance coating, dark black, much darker than the usual aquadag coating over the rest of the picture tube. You should be able to see the difference.

If, on the other hand, the outside of the picture tube near the deflection coil is not coated then you have a problem. Then you will hear strong crackling also at switch-on and switch-off. Normally you shouldn't see such a 'cheap' picture tube on the European market...

The area of the picture tube around the anode connector is also not coated, for obvious reasons. Normally that should not cause any significant sound. Same goes for the front of the screen and neither should the anode cable crackle.

In a dark room you should be able to see from the tiny blue flashes where the sound comes from. This is perhaps best observed at switch-on and switch-off (with a black picture on the screen). Try and keep the back cover mounted !

Loudspeakers and monitors

Loudspeakers incorporate powerful magnets - the larger the speaker, the larger the magnet. However, anyone who goes ballistic when the mention is made of a loudspeaker near a TV or monitor, should take their Valium.

The fringe fields outside the speaker box will not be that great. They may affect the picture perhaps to the point of requiring degauss. The normal degauss activated at power-on will usually clear up any color purity problems (assuming the loudspeakers have been moved away). At worst, manual degauss will be needed. The CRT will not be damaged. The maximum field - inaccessible at the voice coil - is quite strong. However, even for non-shielded loudspeakers, the magnetic field decays rapidly with distance especially since the core structure is designed to concentrate as much of the field as possible in the gap where the voice coil travels.

Speakers specifically designed for use with multimedia computers have (or should have) specially shielded magnet structures or an additional magnet with its field set up to cancel the main magnet's fringe field which will minimize these effects. Nonetheless, if you see any indication of discoloration, move them to a greater distance.

However, keeping unshielded (e.g., megawatt stereo) speakers away from CRTs is a good idea.

Now, you really should keep your superconducting magnetic resonance imager magnet at least in the next room.....

Should I replace all the electrolytic capacitors if I find a bad one?

When a bad capacitor is found in a monitor, the question of course arises as to the likelihood of other capacitors going bad in short order. It might be worth checking (other) caps in the power supply or hot (temperature) areas but you could spend you whole life replacing **all** the electrolytics in your older equipment!

Black powder being generated inside monitor?

You have just noticed a black powder spontaneously appearing from inside your computer monitor. What is it? The monitor seems happy as a clam.

Well, it is probably just air-born dust that is collecting there due to the air flow in your area and high voltage static fields. The monitor is acting like an electrostatic dust precipitator. If there were really black powder being generated inside, I would expect you would smell something really really bad and the monitor would not continue to be happy.

Sweet little old ladies and TVs from attic

The following story is specifically for a TV but the same applies to any electronic servicing. Always confirm the customer's complaints first!!

Then verify that everything else works or you will never know if your efforts have affected something unrelated.

(Original request from rogerj@apex.com):

> "A sweet little old lady has duped me into repairing her old G.E. 13" color TV. Wanted me fix bad volume pot..... "oh it has such a good picture"... she says.
>
> Stupidly w/o even turning it on, (big mistake) I begin to open the set. After 15-20 min. of travail, I discover that a previous "repairman" has glued the case shut!

> Now w/ set open, I turn it on and this picture is LOUSY. Bad color, and very poor convergence. But I don't know if I'm to blame for banging it around trying to open it up. Also, no hor. or vert. hold. (fixed that w/a few caps) This things probably been sitting around for a few years."

Well, you certainly did not kill the caps. Anything that sits for a few years - probably in a damp unheated attic - is suspect.

Did you find the adjustments on the yoke assembly tight? If so, you probably did not move anything very much either. She may remember the good picture it produced before being stuffed away in the attic.

> "Anyway after going through all the adjustments, the convergence at the sides is still bad and the horizontal size is a tad insufficient (w/no adjustment available)"

Could be that the convergence (including pincushion) circuits are still faulty - not just misadjusted.

Other things that can effect horizontal size while still giving you a complete picture:

1. Voltage to horizontal output transistor low. Is there a voltage regulator in your set? The one I have has none. I assume your line voltage is ok.

2. Increased resistance or inductance of the yoke windings. For all you know, the yoke may have been replaced with the wrong part.

3. Yoke improperly positioned on tube neck.

4. Excessive high Voltage. This is usually not adjustable.

I bet the thing hasn't worked properly in 10 years.

Disposing of dead monitors (CRTs and charged HV capacitors)

I don't know what the law says, but for safety, here is my recommendation:

Treat the CRT with respect - the implosion hazard should not be minimized. A large CRT will have over 10 tons of air pressure attempting to crush it. Wear eye protection whenever dealing with the CRT. Handle the CRT by the front - not the neck or thin funnel shaped envelope. Don't just toss it in the garbage - it is a significant hazard. The vacuum can be safely released (Let out? Sucked in? What does one do with an unwanted vacuum?) without spectacular effects by breaking the glass seal in the center of the CRT socket (may be hidden by the indexing plastic of the socket). Cover the entire CRT with a heavy blanket when doing this for additional protection. Once the vacuum is gone, it is just a big glass bottle though there may be some moderately hazardous materials in the phosphor coatings and of course, the glass and shadow mask will have many sharp edges if it is broken.

In addition, there could be a nice surprise awaiting anyone disconnecting the high voltage wire - that CRT capacitance can hold a charge for quite a while. Since it is being scrapped, a screwdriver under the suction cap HV connector should suffice.

The main power supply filter caps should have discharged on their own after any reasonable length of time (measured in terms of minutes, not days or years).

Of course around here, TVs and monitors (well, wishful thinking as I have yet to see a decent monitor on the curb) are just tossed intact which is fortunate for scavengers like me who would not be happy at all with pre-safed equipment of this type!

Apple/Sony monitor dies after variable length of time

The following discussion relates to failures of the X-ray protection tap on a Sony part affectionately known as the 'big red cap' or the HSTAT block in some Sony manufactured monitors.

> "This is a (Apple) Sony 13" monitor, 4 years old. After being turned on for 30 minutes, the display goes completely blank and the front LED goes off. If the power is shut off for 10 minutes or so, it will come back on for another 15 minutes or so, then go blank again, etc. The +120v and +65v from the power module is still present when it blanks out, but no other voltages (+12, +960, etc) are present on the main circuit board. I've been told it might be the HV capacitor is bad; would like to hear a 2nd or 3rd opinion before buying a new capacitor."

That is the same diagnosis a friend of mine got for her monitor with that identical problem. Replacing the capacitor did fix the problem.

That 'big red capacitor' is a Sony part which includes some kind of low voltage sense connection as well. It is used to shut the monitor or TV down should the HV increase resulting in increased risk of X-ray generation. Unfortunately, the resistors inside often go bad causing the unit to shut off erroneously. The guy at the place where she got it repaired said that the capacitor is one of the most common problems with those monitors. $70 for the part + $50 for labor, ouch!

These used to be only available from Sony. Why can't Sony design monitors like everyone else? Sure, I know, theirs are better (well, except for the unsightly stabilizing wires on Trinitrons!). Now, however, less expensive replacements can be had at places like Computer Component Source.

For testing, it may be possible to disconnect the sense output. With shutdown disabled, the monitor should continue to run BUT WITH NO X-RAY PROTECTION. Therefore, this should only be used for testing - a replacement will be required.

Note: On some models, the sense wires need to be connected during startup or else it will never come on.

CAUTION: On some models (like the Sony CPD1302), the sense signal may be used for actual HV regulation. Thus, if the sense wire is disconnected, (or the divider inside the Hstat block fails open) there is no feedback and it is possible for the high voltage (and probably B+) to increase until the HOT (and possible other components) blow.

(From: Duke Beattie (beattie@wsu.edu).)

The low voltage connection of the 'big red cap' is part of the "X-ray protection" circuit. If the high voltage to the crt goes to high it is supposed to shut down the whole thing. Unfortunately the sensor inside goes bad and puts out the wrong voltage and that shuts down the world. The part is available at "Computer Component Source" for about $30, it is a "M041" (Sony/Apple part number" These things go out with great regularity. So if your Apple monitor shuts down this is probably the culprit.

(From: A.R. Duell (ard12@eng.cam.ac.uk).)

On some of the older Trinitrons (certainly on the 13" Trinitron monitor I have), the HSTAT pot is connected as a potential divider on the EHT supply. The slider of the pot is connected to the static convergence electrode, but a tap on the lower end of the pot goes to the protection circuit. Something like this:

```
            Static Conv Electrode
                  o
                  |
                  V
    EHT---------/\/\/\-------\/\/\---+---\/\/\-----+
                                     |              |
                                     o             _|_
                              Protection           ///
```

If the EHT rises too high, then the voltage at the protection point also rises, and a shutdown signal is sent to the scan processor.

All those resistors are encapsulated in the HSTAT block which has an EHT input from the flyback, a Coaxial EHT output (EHT and Hstat electrode) to the CRT, an earth wire, and a 2 core cable (earth and Protection) that goes to the scan board.

Unfortunately, if those resistors change in value, then the protection circuit may operate even at the normal EHT voltage. And as they're all potted in one block, you have to change the complete unit.

(From: Neil brown (nbrown@whispa.co.nz).)

When your monitor works do you see faint diagonal white line on it?

If so the cutoff need adjusting and it will cause the symptoms you describe exactly, If it doesn't come on after a "rest" then yes it may be a bad cap but I have realigned a lot more than I have replaced HV caps!

Also on the adjustment board there is a resister that goes and pushes the cutoff up high, from memory it is a 1 M resister and it drifts up high.

More on the Apple/Sony 'big red capacitor thing'

(From Terry L. Wright (terryl@wolfenet.com).)

The big red thing has been called a capacitor, a voltage tripler and a diode assembly not to mention other less polite names. It is in fact at the root of the failure in this monitor but does not necessarily need to be replaced. You will find a low voltage shielded wire comes from the red block. It goes to a four lead jack and plug which connects to the main board. The two pins that the shielded cable goes to are marked ground and Href, short for high voltage reference. If these two pins are shorted together the unit will no longer shut off by itself.

Why does this work? Because the red block contains a voltage divider, the output of which tells the main board if the 25 Kilovolt supply to the crt goes too high. When the red block ages the relative values of the internal resistors changes and the block output increases. The main board interprets this as excessive high voltage and shuts the horizontal output down to protect the circuit and ostensibly to protect from Xrays. By shorting the output you can force the main board to assume that the voltage is not too high. Note that you have also disabled any protection that the circuit may have provided from Xrays or high voltages. Personally I do not care about this as I have never seen this monitor fail in any way to cause excessive second anode voltage.

Editor's note: failure (open) of a snubber capacitor across the HOT is one failure that can result in excess high voltage. Thus, I would consider this a temporary 'for testing' solution unless you add some other mechanism for detecting excess high voltage. First confirm with a high voltage probe that the monitor isn't shutting down properly - due to excess high voltage! In addition, the original problem may get worse and eventually affect the convergence and other functions of the Hstat unit. --- sam

(From: David J. Pittella (ddc_pitt@ix.netcom.com).)

I spent 8 years working for a very large Apple authorized service provider.

The original 13" Model MO-401 (not the MO401LL/B) actually had a bad run of these high voltage capacitors. Apple did have a warranty extension on specific date ranges of these parts, I would doubt this is still in effect ... but you could check.

The 'big red' high voltage capacitor is Apple P/N 910-0058, it is mounted to the bottom of the chassis on this display. This part connects between the flyback and the anode connector on the CRT, there is also small grey cable from this device to the "D" (main) board.

The "C" board (on the neck of the crt) is notorious for cold solder joints on the CRT connector. I would always resolder these whenever I worked on this display.

CTX monitor intermittent or blows fuse

Initial symptoms are erratic startup or shutdown sensitive to temperature or vibration. Eventually, the monitor will go totally dead if the original problems are not dealt with.

Look for a vertically mounted daughterboard. This board contains an IC UT3842 which is the pulse width modulator IC for the switcher supply. ECG makes a replacement although I don't have the number handy. Make sure you check associated parts on this card for damage, as this circuit usually fries pretty well.

The entire cause of these problems is generally bad solder joints on the back side of that daughter board. Unsolder it from the main board, and fix those first. Where a connector is used (P104) resolder this as well. Then replace Q101, the 18 V zener next to it (ZD101), and the .39 ohm resistor if necessary. Note: The zener is for protection only. Therefore its exact voltage rating is not critical - anything over about 6 V will work.

(From: Keith Scott (kscott@news.HiWAAY.net).)

Exactly! Every 14 or 15" CTX I've worked on had the MOSFET, zener and the low ohm resistor toasted. BTW, they use the low ohm resistor as a fuse to keep them catching on fire when the other stuff shorts out.

(From the editor).

Once the fuse blows, several parts have gone belly-up and will need to be replaced in addition to the soldering of the daughter board.

(From: Bill Rothanburg (william.rothanburg@worldnet.att.net).)

Replacing the fuse will not fix the monitor. The odds are rather overwhelming that you have been bit by the infamous CTX 'daughter board with bad solder joint' flaw. If you have the ability to handle a soldering iron, order the repair kit from CCS (1-800-356-1227). This will contain all of the parts and instructions on fixing this problem. IMPORTANT!!! Remove the daughter board, resolder all of the joints on the connector, and reinstall the daughter board.

CCS sells a kit for $13.99, includes 2SK955, 1N5248 18V zener, .39 R, and fuse. #07-1512 800 356-1227 They also warn of solder breaks on plug of daughter board. The service manual is available from CTX for $15, 800 888-2120 (compared to $50 from CCS!!).

Gateway Crystalscan and MAG monitor problems

The following applies to several Gateway monitors including the CS1572FS (very common) and CS1776LE, as well as similar models from MAG (who is the actual manufacturer of these Gateway monitors).

> "I have a Gateway CS1572 FS monitor. Recently, a high pitched whine accompanied by faint dark lines scrolling from top to bottom appeared. Initially the problem disappeared after a warm-up period, but now it is constant. Can anyone give me info on: solving similar problem, or a source for schematics on this type of monitor. Gateway wants me to send it to MAG, but that sounds like big $$$."

Other related symptoms: Wiggling raster, possibly only at higher scan rates.

R331 is a common failure in the power supplies of Gateway CS1572 monitors. Apparently, a number of other models also use this design, and got the same batch of bad resistors :-).

It is supposed to be 91K. 1 W but gradually increases in value until regulation is compromised. While it is marked 1%, hand selecting a 5% metal film resistor that is within tolerance will work fine and even this may not be needed as the voltage adjustment pot is in series with R331. Therefore, if you have the adjustment procedure, a 1% resistor is unnecessary in any case. Then, adjust the B+ to the value marked.

Note: It is probably a good idea to replace R331 for these symptoms even if it tests good. In some cases, it would appear that these resistors fail at full voltage but not when tested with a multimeter.

If symptoms persist, check ZD302 (12.2 V?).

While you are in there, check for bad solder connections or damage to R302 and Q105 (swivel base hits these).

Allergies from monitors?

Aside from eye, back, or finger strain, there may be two possible sources of actual chemical/gaseous emissions:

1. The materials used in some of the electronic components as well as the plastics of the case can outgas - possibly for quite some time after manufacture. This is made worse due to the heat inside.
2. Ozone production. This is caused by electrical discharges - corona - from various high voltage terminals. Ozone really shouldn't be a problem with a monitor in good condition but it is possible. And, as a monitor ages and collects all sorts of dirt and dust, it is more likely.

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Items of Interest

Web sites with monitor specifications

Of the half dozen or so Web sites that I used to have for extensive monitor information, only Monitorworld has survived as far as I can tell: They still have the important specifications for a wide variety of monitors indexed by manuracturer and model:

- Monitor World

I am only recommending this site for the information on monitor specifications, not necessarily for other products or services since I haven't evaulated them. Note that since this data comes from undetermined sources, it isn't always to be accurate. Sorry for the lack of additions Web sites but believe it or not, I am not usually informed when any particular company goes belly-up or their Marketing department decides that fluff is more important than substance and they pull the plug on the pages with useful information. :(

How do multiscan monitors determine and store the scan parameters?

With modern SVGA multiscan monitors, once a particular resolution and scan rate is set up, there is rarely a need to readjust size, position, and other parameters. How is this accomplished?

(From: Bob Myers (myers@fc.hp.com).)

It's different for different designs, of course, but in general today's 'digitally controlled' monitors recognize various timing modes by counting the horizontal and vertical sync pulses to determine the line scan and vertical refresh rates. Any input within a certain tolerance of a recognized pair of frequencies here is assumed to be that timing, and a set of stored numbers corresponding to that timing are then read from a memory and used to set up the adjustments. In most of these monitors, the various adjustable parameters - size, centering, etc., - are controlled by voltages coming from a set of D/A converters, so the stored information is basically just a table of numbers that get sent to the D/As when that timing is recognized.

The number of both factory and user presets available varies from product to product, of course, but there's usually somewhere between 8-15 of each. The exact number is going to depend on how much memory is available, and how many different parameters need to be controlled for each recognized timing.

Unless the output of the graphics controller is an exact match for the timing used at the factory when the preset information was generated, there may still be slight errors, for obvious reasons. Fortunately, the widespread acceptance of timing standards (such as those produced by VESA) are reducing the severity of this problem.

Monitor reliability with SVGA

There are parts in the monitor which may get hotter with SVGA but if it is designed for SVGA resolution, there should be no problem (assuming you are not running in an excessively hot room or with the ventilation holes covered).

A good quality auto-scan monitor should not mind switching screen resolutions frequently (though doing it every few seconds continuously may stretch this a bit).

Newer auto-scan monitors should also be smart enough not to blow up if you feed then a scan rate which exceeds their capabilities. However, there are a lot of poorly designed monitors out there.

If it is supposed to run SVGA, use it at SVGA. If it blows up, switch to a different brand. There are a lot of crappy monitors being sold on their own and bundled with PCs.

How high a refresh rate should I use?

It is the vertical refresh rate that impacts display appearance. The visual effect of too low a vertical scan rate is excessive flicker.

Up to a point, higher is better. Everyone agrees that appearance improves up to at least 70-75 Hz (vertical) non-interlaced but beyond this point is a hotly debated issue (and a topic for a never ending discussion on your favorite Internet newsgroup). The use of interlaced scanning can reduce apparent flicker for a given scan rate for typical gray scale or color images but may result in annoying flickering or jumping of fine horizontal lines in graphics and text displays.

In any case, you must not exceed the maximum scan rate specs of your monitor. See the section: Web sites with monitor specifications if in doubt. Also, very high refresh rates may result in decreased graphics performance particularly with DRAM based video cards due to bus contention between the PC memory accesses and the video readout to the RAMDAC.

And, a horizontal scan rate below the specified limits may blow the HOT instantly.

For the discussion below, the key words are "well designed". There are a lot of mediocre monitors out there!

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The dissipation in the deflection coils rises sharply with the horizontal scan frequency. The horizontal scan frequency is of course higher at higher resolution and higher vertical refresh rates. But the monitor will have been designed to handle that, unless you don't permit adequate ventilation. Component failure occurs often during mode-switching, not due to keeping the monitor in one mode or another.

It is a popular myth that a (well-designed) monitor could be damaged by connecting it to a signal source with frequencies that are out of range. These will be (should be) automatically blocked by the sync circuitry and you will simply not get a stable picture. There will be no damage, and if there would be (most likely from a too LOW line frequency) then it would be done immediately. No need to rush setting things right.

So my advice would be to go ahead, use whatever resolution you like. The acceleration of the wear will be insignificant, you'll probably want a better monitor long before it is technically worn out. If you want to be kind to your monitor, then keep the contrast below maximum, use a black-screen screen saver and keep the dust and smoke and moisture and grease away.

Number of colors and monitor type

> "I have a CTX CVP-5468 that will not do more than 16 colors in windows. It is being driven by an Orchid Kelvin 64 VLB board, but had the same problem with an ATI card. When using it in linux under x-windows the same thing and more than vga and it goes blurry and very pixelated."

It is really not possible for this to be a monitor problem as the signals are analog - continuous - the monitor displays whatever it is given and does not even know the color depth except to the extent that cards are often set up via software to use different scan rates for different color depths (bits/pixel) often due to hardware memory/bandwidth limitations.

For the ATI in particular, I know that you can use ATI's DOS Install program to set it up for each resolution and mode - try this. I bet your monitor is fine.

Various video standards

Here is a link:

- Standards for analog component video

Monitors, humans, and flicker

(From: Bob Myers (myers@fc.hp.com).)

The flicker-fusion frequency for emissive displays such as CRTs cannot be given as a single number applicable to all people, all displays, and all ambient conditions. It is dependent on the particular individual, the size and brightness of the display (and the characteristics of the phosphor, if a CRT), the viewing distance, and the ambient lighting conditions.

For a typical color CRT computer monitor, at typical brightness levels and viewing distances, the image will appear "flicker free" to 90% of the population by the time the refresh rate has reached the upper 70 Hz range; into the low 80 Hz range, and you cover 95% of the population. Given the statistics, there are probably a few people who could still see flicker by the time you got above 90 Hz, but there sure aren't many of 'em.

The effects of the screen refresh rate on perceived motion have more to do with the relationship between that rate and the ORIGINAL sampling rate (i.e., ~60 Hz for standard video), and higher refresh rates are definitely NOT always better in this regard. Depends on the artifact in question.

Is fluorescent lighting a significant source of flicker?

(From: Bob Myers (myers@fc.hp.com).)

Actually, this is a myth. Ambient light flicker is at best a second-order effect in determining perceived flicker levels, and then only through modulating the display's contrast ratio. (Ambient light flicker isn't even considered in the flicker calculations of the various ergonomic standards, although the ambient light *level* is a concern.)

The notion that fluorescent lamps flicker and that this somehow produces a "beat" with the screen refresh is simple to disprove. First, if this were so, 75 Hz screen refresh would appear WORSE than 60 Hz, since it's farther removed from the line rate. In reality, the reverse is true - and if you REALLY want to maximize perceived flicker, turn OFF all the lights. The display will then appear to flicker MUCH worse, as one determining factor in flicker is the APPARENT brightness of the screen (how bright the screen is in relation to its surroundings). Lastly, people don't realize that fluorescents DON'T flicker at the line rate; being essentially plasma displays wherein the plasma emissions exicte a phosphor, these tubes flicker at TWICE the line rate - too high to be perceived. Fluorescents show a flickering appearance when they're failing, but that's a different kettle of fish altogether.

(Also note that a large percentage of fluorescent lighting these days uses electronic rather than magnetic ballasts. Most of these do not suffer from significant power line flicker (100/120 Hz) flicker as they are driven at 10s of kHz by what are essentially switching power supplies. Any variation in intensity is at too high a frequency to matter. This is true of most compact fluorescent lamps, many cheap fixtures, as well as large (newer) office installations or retrofits. --- sam)

Interlaced vs. non-interlaced monitors

The difference between interlaced and non-interlaced displays is in the video timing. Nearly all monitors can handle either. Monitors are specified as non-interlaced because for a given screen resolution and vertical refresh rate, this is the tougher (higher) horizontal (H) scan rate and it is desirable to minimize flicker in a graphical display (Fine horizontal lines will tend to flicker on an interlaced display). The H scan rate is double the interlaced H scan rate since all scan lines rather than just the even or odd lines are being displayed for every vertical scan.

Digital versus analog controls on monitors and picture quality

> "Could someone tell me if there's a noticeable difference in picture quality between analog and digital monitors? Is digital worth the extra money?"

There is no inherent reason for a digital monitor to have a better picture but as a practical matter, I would expect this to be the case in the vast majority of monitors - especially models from the same manufacturer. The digital monitors will be the ones that the designers concentrate on. Digital controls (both those you can access and those used only during setup at the time of manufacturing or servicing) permit more flexibility in setting parameters and automated more consistent adjustments on the assembly line (at least this is possible in principle).

For the average not terribly fussy PC user, the major difference is in the convenience of not having to adjust size and position whenever the scan rate changes. In my opinion, while the price difference between monitors having analog or digital controls but with the same screen size, resolution, and scan range specifications may seem excessive, the added convenience of digital controls and scan rate parameter memory makes the added cost well worthwhile.

Should I be concerned about very frequent scan rate switching

This question arises in a PC software development environment where the programmer needs to go back and forth between a Windows display and a DOS debugger, for example.

Obviously, without knowing the precise design of your monitor, there can be no definitive answer. It is true that some older monitors blew up if you looked at them the wrong way. Newer monitors from well known manufacturers like Nokia, NEC, and many others are designed with a moderate amount of scan switching in mind. However this is stressful for the monitor's power supply and deflection circuitry. I would suggest that you use a dedicated mono monitor for debugging if you really are switching multiple times per minute. If you cannot afford the space, you can probably assume that if the first few days of this kind of treatment have not induced a failure, the monitor is robust enough to withstand it indefinitely. If you really are switching many times per minute 8 hours or more a day, then what may wear out are the internal relays (the clicks you hear are from these). You are still talking about years, however. They are rated in 100s of thousands or millions of operations when used within their ratings.

Or, just go for the peace of mind of an extended warranty or service contract.

What is monitor video bandwidth and why is it important?

(From: Bob Myers (myers@fc.hp.com).)

Video bandwidth is an indication of the frequency range over which the monitor's video amplifiers are capable of doing their job, which is to translate the video signal at the monitor inputs (about 0.7 volt, peak-to- peak) to something like 35-40V peak-to-peak at the CRT cathodes. Higher bandwidths ARE better, UP TO A POINT.

The bandwidth required is NOT given by multiplying the numbers in the format (what most call the "resolution") by the refresh rate; even allowing for the required blanking time, what THAT gives you is the pixel rate or "pixel clock". As the fastest thing that happens in a video signal is one dot on followed by one dot off, the fastest FUNDAMENTAL frequency in the video signal is half the pixel clock. Normally, you might think you'd want to cover some of the harmonis to "sharpen up" the pixel edge, but that's actually less important than you might think (in part due to the fact that the CRT screen itself, being made up of discrete dots of color, already has the effect of "sharpening up" the image AND limiting how sharp it's going to get, anyway).

There's also the problem of "bandwidth" not being measured or speced consistently by all manufacturers, making it difficult to compare one product to another. Some simply give a "max. video rate supported" number, which is about as useless a spec as one can imagine. (It's just telling you the pixel rate of the fastest timing supported - but says nothing about the image quality at that timing!) Still, a claimed bandwidth of about 2/3 to 3/4 of the fastest pixel rate to be used should indicate adequate performance - beyond that, you need to compare products with the good ol' Mark I eyeball. Using this rule of thumb, a monitor intended for use at 1280 x 1024, 75 Hz (a 135 MHz pixel rate) needs a speced amp bandwidth of around 100 MHz. (But just to show how far you can trust this particular number, I know of a product which does a very nice job of displaying 1600 x 1200 at 75 Hz - slightly more than a 200 MHz pixel rate - but which has a video amp bandwidth of only about 100 MHz, if measured per certain definitions!)

I find the rise and fall time of a full-scale (white to black or black to white) video signal, as measured at the cathode, to be a much better spec, and here would look for something not slower than 2/3 of the pixel period for the timing of interest. But these numbers are rarely quoted in consumer-oriented spec sheets, and even these take some care in applying.

Why a good monitor may produce a fuzzy picture

The ultimate sharpness of the picture on your monitor depends on many factors including but not limited to:

1. Focus of the electron beam spot(s) at the face of the CRT.

Affected by: quality of the CRT and its supporting circuitry and adjustment of focus control(s).

2. Convergence of the RGB electron beams at each point on the face of the CRT.

   Affected by: quality of the CRT, deflection components, and how carefully the convergence adjustments were done during manufacture (or repair). In many cases, it is this last item that is most critical. Bad quality control during final setup can ruin a monitor manufacturer's reputation - and has.

3. Moire reduction (if any or if enabled) reduces the effective sharpness of the electron beam either through actual defocusing or a high frequency dither. IMO, the net effect is almost always bad.

   Affected by: enabling and magnitude of moire reduction.

Items (1) through (3) are somewhat independent (though not entirely) of scan rate. The newest high-end monitors have a fairly comprehensive set of digital (on-screen) adjustments for these but may still not produce acceptable results for every monitor.

4. Bandwidth of the video amplifiers in the monitor - essentially how quickly the intensity can be altered by the video signal.

   Affected by: design of video amplifier circuitry and circuit board layout. This used to be much more of an art than it is today. Integrated circuits have replaced many of the discrete components used in the past resulting in simple designs with clean circuit board layouts.

5. Bandwidth of the digital to analog converter (D/A, DAC, or RAMDAC) of the video card.

   Affected by: DAC or RAMDAC chip used, supporting circuitry, and video card board layout. As with (3), these are largely cookbook designs these days.

6. Dispersion in the video cable - how smeared out the video signal becomes traveling through the cable.

   Affected by: quality and length of video cable. Since cables often come attached to the monitor nowadays, you don't have much control of this. Just don't add problems such as switchboxes.

7. Reflections from any impedance discontinuities in the cable - video card DAC, video card connector, monitor connector, monitor video amplifier input, monitor termination. All of these will introduce just a bit of mismatch - or perhaps much more - which will add up to either barely detectable fuzziness or totally unacceptable ghosting or ringing at vertical edges.

   Affected by: connectors and circuit board layouts of both video card and monitor input as well as any additional connectors or a switchbox.

Items (4) through (7) are heavily dependent on scan rate since higher scan rates translate into higher video bandwidth. Any degradation of the edges of the video signal - transitions from black to white, for example - will be much more visible at the higher scan rates - they will be spread out resulting in pronounced blurring, ghosting, or ringing.

Thus, it is critical to use the highest quality components wherever possible. While you don't have control over what is on your video card and inside your monitor, selecting a high quality video card and monitor should help. If you have the option to use a BNC cable (at least your monitor has BNC jacks on the back), try out a high quality BNC cable - you may be pleasantly surprised at the improvement in edge definition and overall sharpness.

Ghosts - card or monitor?

(From: Bob Myers (myers@fc.hp.com).)

This isn't as simple as it may appear. 'Ghosts' are caused by reflections of the video signal edges, caused by impedance mismatches between the driver (graphics card), the video cable, and the monitor video inputs. Add in the problems caused by the video connectors, and you wind up having to say that this is really (most often) a system problem, and all the parts get some of the blame.

With that said, the practical answer is that you should avoid using anything other than a single, reasonably-good-quality video cable, with decent connectors, between your PC and monitor, this being the part that you have the most control over. The more breaks in the cable - adding extension cables, switchboxes, etc. - the more chances you have for a mismatch in the line. BNC connectors (or the new VESA EVC connector) are MUCH better in this regard than the 15-pin D "VGA" connector (although if you're getting good results with the D connector, don't worry about it). Also, do NOT make the mistake of using anything other than 75 ohm coax for your video cables. Just to mention one common mistake, LAN cable is *50* ohms, so it's NOT going to work here!

If you've done all you can with the cable, the next place to go is the monitor itself; there's probably something wrong with the video input termination. By the way, a simple way to confirm that what you're seeing IS a ghosting (reflections) sort of problem is to use a DIFFERENT LENGTH of the video cable. Since the ghost is the result of a reflection going from the monitor back to the PC and then back up the line, the length of the cable affects where the ghost appears relative the edge which caused it. Inserting a longer cable moves the ghost out (to the right), while a shorter one will move it closer in (to the left). If you change cable lengths and the ghost doesn't move, you most likely have a problem within the monitor itself, past the video inputs.

BTW, longer cables may also make the ghost less distinct, due to the increased attenuation of the signal by the cable. Unfortunately, the longer cable also means more attenuation of the video signals that you WANT, in addition

Extension cables and monitor ghosting

(From: Bob Myers (myers@fc.hp.com).)

With an extension cable, there is the chance that this ghost is being caused by an impedance mismatch AT THE CONNECTOR OF THE EXTENSION; unless the cable is completely the wrong impedance, it is unlikely that the cable itself (meaning the actual "wire") is the culprit. But any break in the cable (connectors, switchboxes, etc.) is a chance for a mismatch.

But before blaming the cable, there's another possibility to check out. One commone source of ghosting is a poor termination of the line at the monitor itself and at the graphics card driving it. It can look worse with an extension simply due to the extra cable length moving the "ghost" farther away from the image causing it. (The ghost is, after all, just a reflected signal that went back DOWN the cable, got reflected again at the controller, and sent back up to the monitor. Added cable length makes this round trip longer, and moves the ghost farther to the right of the original edge in the displayed image.) If this is the case, the you will also see the ghost without the extension - it'll simply be much closer to the original edge that it's "ghosting". In that case, a better extension cable can actually make the appearance of the ghost worse - a lower-loss cable means that more of the reflection will get through back to the monitor!

If it is being caused by the extension cable, you may get better results by using BNC connections instead of the D-sub at the point where the cables mate. The D-sub is a pretty poor connector in terms of providing the proper impedance. Using a pair of 15D-to-5-BNCs back to back may give better results.

Driving multiple monitors from a single PC

Where BNC monitors are involved and daisychaining is acceptable, additional circuitry is generally not required for reasonable distances. BNC cables for R, G, B, and possibly H and V sync, are run from the source to each monitor in turn with only the last one being terminated in 75 ohms (the others MUST be Hi-Z).

Some newer BNC monitors do not have a Hi-Z option for termination so daisychaining is not even an option with these.

Attempting to drive multiple monitors in a star configuration without buffering the signals will generally result in poor results - reduced brightness and contrast (by 1/n where n is the number of monitors) and ghosting and other signal degradation. However, nothing will blow up so for 2 monitors it may be worth trying.

In either of these cases, what is needed is a distribution buffer amplifier.

Using a PC as a monitor test pattern generator

Almost any PC with at least a medium performance SVGA video card can be programmed for a wide range of resolution options, dot clocks, horizontal and vertical sync timing, and sync polarity. Some can be programmed to generate composite sync and sync-on-green as well.

DOS/Windows/Win95 will suffice for most PC applications using drivers supplied by the video card manufacturer but for complete flexibility, run under Linux - take a look at the Xfree86 documentation for more details.

Test patterns can be created with any graphics applications and then saved for rapid recall.

Of course, for different output levels and impedances you will need some extra electronics. A normal SVGA card only produces R,G,B video and H and V sync signals compatible with doubly terminated 75 ohm cables. As noted, some will generate composite sync and/or sync-on-green. See the "Sync-on-Green FAQ" for more information on how to do this if your card is not capable of it. For NTSC/PAL video generation, additional hardware will be needed. See the section: Displaying computer video on a TV.

Monitor testing programs

There are a variety of PC compatible software programs for testing of SVGA computer monitors. These display various test patterns and color charts which are appropriate for the procedures discussed in this document.

Here are a few pointers:

- The monitor test program "NTest" is very often recommended on the comp.sys.ibm.pc.hardware.video Newsgroup. This was originally available from Nokia but since Nokia sold their monitor division to Viewsonic, it has disappeared so here is a copy. I'll be happy to link to the Viewsonic site if they replace it.

  - Nokia Ntest Monitor Test.

- ComputerCraft provides a shareware program for testing monitors and video cards. I have not tested it but as they say: "If you are aware of the dangers, Monitors 1.01 is a powerful tool." See the document: Performance Testing of Computer and Video Monitors, specifically the section: "WARNING and DISCLAIMER" for some of these. This shareware program can also test video cards for characteristics and graphic modes.

  - Monitors 1.01.

  (From: Mark E. Nikl (markn3@infoave.net).)

  In the download section of the Web site, there is a file called monitors. It will give you all the test patterns and setups for gray scales, HV regulation, tell you about you video card and much more. I just ran across it the other day. You can even set up the pincushion and lots more.

- SONERA Technologies markets a set of programs called "DisplayMate" available for DOS and Windows/Win95. This is supposed to guide you through the monitor testing and setup process with a series of test pattern 'slides'. I have not tried it so I cannot comment on its utility.

  A demo version with a few test patterns, more information on their products, and some video tech tips, and some test patterns are available at:

  - Display Mate Home Page and Demo.
  - Test Patterns.

- PassMark has a product that appears to have a fairly comprehensive set of features including 25 test patterns, display of monitor and video adapter information, and support for multiple resolutions, color depths, and display types. It can be downloaded for free with a 15 day evaluation, then costs $15:

  - PassMark MonitorTest.

Using a TV tuner card in a PC

These ISA, EISA, or PCI cards put TV programs or other NTSC/PAL source material into a window on your PC's monitor screen. The question has come up as to whether this will damage the monitor in the long term.

I would not think that there should be any problems unless you tend to turn the brightness up much higher than normally used for computer activities. If anything, the constantly changing picture will be better than a stationary window. However, moving it to different locations every so often will not hurt.

Similar comments apply to other types of image and video captures as well.

IMHO, I still think it is silly to use an expensive PC and monitor to watch TV.

What is color temperature and what does it affect?

Some monitors have the capability of selecting or adjusting for the 'color temperature' of the display. NEC AcuColor on the 4/5/6FG series of monitors is one example.

The terminology refers to the spectral output of an ideal black body source at that actual physical temperature. It essentially sets the appearance of a white screen. For example, a color temperature of 9300K will appear blue-white while 6300K will appear yellow-white.

It only affects the relative balance of R,G,B and has nothing to do with refresh rates or anything performance related. Unless you are doing work where the exact colors matter or are using multiple monitors where the colors need to match, use whichever setting ismore pleasing

What is this goop around some electrolytic capacitors and other components?

That goop is probably glue and generally harmless - it is there to hold down the components aganst vibration. I have heard of it sometimes decomposing and shorting stuff out but I doubt you have that problem.

Therefore, unless you find a bad cap in the focus or related circuit, we are still looking at a flyback problem.

What does the flyback (LOPT) transformer do?

The typical flyback or Line OutPut Transformer (LOPT) consists of two parts:

1. A special transformer which in conjunction with the horizontal output transistor/deflection circuits boosts the B+ (120 V typical for a TV) of the low voltage power supply to the 20 to 30 kV for the CRT as well as provide various secondary lower voltages for other circuits.

   A HV rectifier turns the high voltage pulses into DC and the CRT capacitance smooths it. The HV may be developed from a single winding with many many turns of wire or a lower voltage winding and a diode-capacitor voltage multiplier.

   The various secondary voltages power the logic, tuner, video signal, vertical deflection circuits, and CRT filaments. In fact, with many TV designs, the only power not derived from the flyback is for the keep-alive circuitry needed to maintain channel memory and provide startup drive to the horizontal deflection/high voltage system.

2. A voltage divider that provides the focus and screen supplies. The pots are in this divider network - and these things fail resulting poor focus, uncontrolled brightness, or fluctuating focus and/or brightness. A total short could also result in failure of other components like the horizontal output transistor. In some monitors, the focus and screen divider and/or controls are external to the flyback and susceptible to dust and problems particularly on humid days. The resistance of these circuits is so high that dirt or other contamination can easily provide a bypass path to ground especially when slightly damp.

Tony's notes on setting convergence on older delta gun CRTs

(From: ard12@eng.cam.ac.uk (A.R. Duell))

The older delta-gun tubes (3 guns in a triangle, not in a line) can give **excellent** pictures, with very good convergence, provided:

1. You've set those 20-or-so presets correctly - a right pain as they interact to some extent.
2. The CRT is set up in the final position - this type of tube is more sensitive to external fields than the PIL type.

Both my delta-gun sets (a B&O 3200 chassis and a Barco CDCT2/51) have very clearly set out and labeled convergence panels, and you don't need a service manual to do them. The instructions in the Barco manual are something like:

"Apply crosshatch, and adjust the controls on the convergence board in the numbered order to converge the picture. The diagrams by each control show the effect".

Here's a very quick guide to delta gun convergence where the settings are done using various adjustments on the neck of the CRT (if you don't have a service manual but do know what each control does, and where they all are - otherwise, follow the instructions in the service manual --- sam):

1. Apply a white crosshatch or dot pattern to the set. Don't try and converge on anything else - you'll go insane. It's useful to be able to switch between those 2 patterns.
2. Before you start, set the height, width, linearity, pincushion, etc. They will interact with the convergence. Also check PSU voltages, and the EHT voltage if it's adjustable. That's where you do need a service manual, I guess.
3. Turn off the blue gun using the A1 switch, and use the red and green static radial controls to get a yellow croshatch in the middle of the screen. These controls may be electrical presets, or may be movable magnets on the radial convergence yoke (the Y-shaped think behind the deflection yoke).
4. Turn on the blue gun and use the 2 blue static controls (radial and lateral) to align the blue and yellow crosshatches at the center of the screen. Some manufacturers recommend turning off the green gun when doing this, and aligning red with blue (using *only* the blue controls, of course), but I prefer to align blue with yellow, as it gives a check on the overall convergence of the tube.
5. Turn off the blue gun again. Now the fun starts - dynamic convergence. The first adjustments align the red and green crosshatches near the edges - I normally do the top and bottom first. There will be 2 controls for this, either a top and a bottom, or a shift and a linearity. The second type is a *pain* to do, as it's not uncommon for it to affect the static convergence.
6. Getting the red and green verticals aligned near the edges is a smilar process.
7. You now have (hopefully) a yellow crosshatch over the entire screen.
8. Now to align the blue. This is a lot worse, although the principle is the same. Turn on the blue gun again, and check the static (center) convergence
9. To align the blue lines with the yellow ones, you'll find not only shift controls, but also slope controls. Use the shift controls to align the centers of the lines and the slope controls to get the endpoints right. These interact to some extent. You'll need to fiddle with the controls for a bit to work out what they do, even if you have the manual.

The convergence over the entire screen should now be good....

A word of warning here... The purity is set by ring magnets on almost all colour CRTs, but on PIL tubes, there are other ring magnets as well - like static convergence. Make sure you know what you are adjusting.

Jerry's comments on convergence and other advanced CRT adjustments

(From: Jerry G. (jerryg@total.net).)

Convergence alignment is not something you can do yourself unless you have the proper calibration instruments and skills. It takes lots of experience and time. There are published specs for most of the good monitors. Most of the time they are as follows:

There is the 'A area', 'B area', and 'C area'. On a 15 inch monitor the A area would be a diameter of about 4 inches. The B area would be about 7.5 inches. The C area would be the outside areas including the corners. These numbers are approximate. There are actually standard specs for these areas. They are expressed in percentage of screen viewing area. Therefore the inches would vary with the CRT size.

The higher the price (quality) of the monitor CRT, yoke, and scanning control circuits, the tighter the convergence can be aligned by the technician. For the A area on a good monitor, the maximum error should not exceed 0.1 mm. For the B area it should not exceed more than about 0.25 mm. And for the C area, it can be allowed up to about 0.3 mm. Most of the monitors that I have repaired, seen, and used did not meet these specs unless they were rather expensive. With these specs there would not be any real visible misconvergence unless you put your nose very close to the screen... A lot of the ones in the medium price range they were about 0.15 mm error in the A area, about 0.4 in the B and greater than in the C area. This also annoys me because I am very critical.

If one has the skills and test gear he or she can do a better job on most monitors. It is a question of the time involved. To see the convergence errors a grating or crosshatch pattern is used. A full raster color generator is required for the purity adjustments as well. This is necessary to align the landing points of the CRT guns. The exact center reference and purity adjustments are done with the ring magnets on the CRT neck. The yoke position angle adjustments are also done for the side and top-bottom skewing as well. Everything interacts!

The corners are done with various sorts of slip or edge magnets. As for corner convergence skewing, button magnets are used. The color purity will be effected as you go, and must be also corrected. These adjustments interact on one another, and the processes continues until the convergence and purity are good at the same time...!

I don't recommend the amateur or hobbiest, or even the do-it-yourselfer to attempt this alignment procedure. The test gear would exceed the cost of a really good monitor anyways...!!! And without the proper skills required, he or she would only make it worse anyways...

As for purity specs, the color change from any corner to any corner must not exceed an error of more than 200 degrees Kelvin. The error in the B area should not exceed 300 degrees kelvin. This applies to a white raster. Most of the monitors I see don't get better than about 300 degrees Kelvin. And some are even 1000 out! The purity errors are best checked with a full Red raster using 100 % saturation. Then the other color vector angles are checked with cyan, and then magenta. The color temperature stability should be the same in all aspects.

A color spectrometer should be used to judge this error factor. As far as the eye is concerned, it will see a purity error of more than about 500 degrees Kelvin if the person knows what to look for...

When changing the CRT, this alignment must be done completely. Most shops do not even employ people who are skilled to a proper alignment, or don't even own the instruments to do it right, and the poor customer get back a monitor that is not in specs...!

Use of surge suppressors and line filters

Should you always use a surge suppressor outlet strip or line circuit? Sure, it shouldn't hurt. Just don't depend on these to provide protection under all circumstances. Some are better than others and the marketing blurb is at best of little help in making an informed selection. Product literature - unless it is backed up by testing from a reputable lab - is usually pretty useless and often confusing.

Line filters can also be useful if power in you area is noisy or prone to spikes or dips.

However, keep in mind that most well designed electronic equipment already includes both surge suppressors like MOVs as well as L-C line filters. More is not necessarily better but may move the point of failure to a readily accessible outlet strip rather than the innards of your equipment if damage occurs.

Very effective protection is possible through the use of a UPS (Uninterruptible Power Supply) which always runs the equipment off its battery from the internal inverter (not all do). This provides very effective isolation power line problems as the battery acts as a huge capacitor. If something is damaged, it will likely be the UPS and not your expensive equipment. Another option is to use a constant voltage transformer (SOLA) which provides voltage regulation, line conditioning, and isolation from power spikes and surges.

It is still best to unplug everything if the air raid sirens go off or you see an elephant wearing thick glasses running through the neighborhood (or an impending lightning storm).

GFCI tripping with monitor (or other high tech equipment)

Ground Fault Circuit Interrupters (GFCIs) are very important for minimizing shock hazards in kitchens, bathrooms, outdoors and other potentially wet areas. They are now generally required by the NEC Code in these locations. However, what the GFCI detects to protect people - an imbalance in the currents in the Hot and Neutral wires caused possibly by someone touching a live conductor - may exist safely by design in 3 wire grounded electronic equipment and result in false tripping of the GFCI. The reason is that there are usually small capacitors between all three wire - Hot, Neutral, and Ground in the RFI line filters of computer monitors, PCs, and printers. At power-on and even while operating, there may be enough leakage current through the capacitors between Hot and Ground in particular to trip the GFCI. Even for ungrounded 2 wire devices, the power-on surge into inductive or capacitive loads like switching power supplies may falsely trip the GFCI. This is more likely to happen with multiple devices plugged into the same GFCI protected outlet especially if they are controlled by a common power switch.

Therefore, I do not recommend the use of a GFCI for computer equipment as long as all 3 wire devices are connected to properly grounded circuits. The safety ground provides all the protection that is needed.

Monitors on foreign power

Using a monitor on a different voltage or frequency is usually not a serious problem.

Your PC and monitor should be fine requiring at most a transformer (not just an adapter for heating appliances, however) to convert the voltage. They both use switching power supplies which don't care about the line frequency.

Some power supplies are universal - they automatically adapt to the voltage they are fed without requiring even a transformer but don't assume this - check you user manual or contact the manufacturer(s) to determine if jumpers or switches need to be changed. You could blow up the PC or monitor by attempting to run it on 220 VAC when set of 115 VAC. If you are lucky, only a fuse will blow but don't count on it.

For non-switching power supply devices like printers and wall adapters that use line power transformers, in addition to matching the voltage (or setting jumpers or switches), running on a lower line frequency may be a problem. There is a slight chance that the power transformer will overheat on 50 Hz if designed for 60 Hz. (The other way around should be fine.) It is best to check the nameplate - it should tell you. If it does not, then best to contact the manufacturer.

Lifespans of Monitors

(From: Bob Myers (myers@fc.hp.com).)

Most manufacturers will quote an MTBF (Mean Time Before Failure) of somewhere in the 30,000 to 60,000 hour range, EXCLUSIVE OF the CRT. The typical CRT, without an extended-life cathode, is usually good for 10,000 to 15,000 hours before it reaches half of its initial brightness. Note that, if you leave your monitor on all the time, a year is just about 8,000 hours.

The only "tuneup" that a monitor should need, exclusive of adjustments needed following replacement of a failed component, would be video amplifier and/or CRT biasing adjustments to compensate for the aging of the tube. These are usually done only if you're using the thing in an application where exact color/brightness matching is important. Regular degaussing of the unit may be needed, of course, but I'm not considering that a "tuneup" or adjustment.

How do monitors know when to enter power saving modes?

(Portions from Bob Myers (myers@fc.hp.com).)

If the monitor complies with the VESA DPMS (Display Power Management Signalling) standard, it will go into power saving modes when either horizontal or vertical sync is disabled. Different combinations of the sync signals indicate different levels of power management, distinguished by how much the power is reduced and the expected recovery time. The greater the power savings, the greater the recovery time is expected to be. For instance, one thing that may distinguish the greater power savings states is turning off the CRT filament, something that you don't recover from in just a second or two.

You can tell which power saving mode is active by how long the monitor takes to come back to life:

1. Video blanking - image will appear instantly when any key is pressed since this is just a logic level inhibiting the video drivers.
2. Full shutdown - a warmup period of around 15 seconds will be needed for the image to reappear since the filaments of the CRT need to warmup.

Monitor life, energy conservation, and laziness

A common misconception about the care and feeding of computer monitors is that they should be left on all the time. While there are some advantages to this, there are many more disadvantages:

1. CRT Life: The life of a monitor is determined by the life of the CRT. The CRT is by far the most expensive single part and it is usually not worth repairing a monitor in which the CRT requires replacement. The brightness half-life of a CRT is usually about 10-15K hours of on time independent of what is being displayed on the screen. 10K hours is only a little more than a year. By not turning the monitor off at night, you are reducing the life of the monitor by a factor of 2-3. Screen savers do not make any substantial difference especially with modern displays using X-Windows or MS Windows where the screen layout is not fixed. With video display terminals, the text always came up in the same position and eventually burned impressions into the screen phosphor. With modern CRTs, the filaments can be left to minimize the time needed for a picture to appear since this doesn't affect CRT life very much.

2. Component life: The heat generated inside a monitor tends to dry out parts like electrolytic capacitors thus shortening their life. These effects are particularly severe at night during the summer when the air conditioning may be off but it is still a consideration year around.

3. Safety: While electronic equipment designed and manufactured in accordance with the National Electrical Codes is very safe, there is always a small risk of catastrophic failure resulting in a fire. With no one around, even with sprinklers and smoke alarms, such an failure could be much more disasterous.

4. Energy use: While modern monitors use a lot less energy than their older cousins, the aggregate energy usage is not something to be ignored. A typical monitor uses between 60 and 200 Watts. Thus at a $.10 per kWH electric rate such a monitor will cost between $48 and $160 a year for electricity. During the night, 1/2 to 2/3 of this is wasted for every monitor that is left on. If air conditioning is on during the night, then there is the additional energy usage needed to remove this heat as well - probably about half the cost of the electricity to run the monitor.

The popular rationalization for what is most often just laziness is that power-on is a stressful time for any electronic device and reducing the number of power cycles will prolong the life of the monitor. With a properly designed monitor, this is rarely an issue. Can you recall the last time a monitor blew up when it was turned on? The other argument, which has more basis in reality is that the thermal cycling resulting from turning a monitor on and off will shorten its life. It is true that such thermal stress can contribute to various kinds of failures due to bad solder connections. However, these can be easily repaired and do not effect the monitor's heart - the CRT. You wouldn't leave your TV on 24 hours a day, would you? Full power saving where virtually everything including the CRT filaments is turned off is really best but the delay before a picture appears may be 20 seconds or more.

Also see the section: Thermal cycling and component life.

Most of the newest ('green') monitors have energy conserving capabilities but it is necessary for the software to trigger these power reduction or power down modes. However, many monitor still in use lack these features. And not all workstations or PCs are set up to support them. If you have such a monitor and computer to support it, by all means set up the necessary power off/power down timers.

However, using the power saving modes of a 'green' PC with an older monitor can potentially cause damage since some of the modes disable the sync signals. A 'green' monitor which can detect a blank screen and and use this as a trigger can easily be used with a screen saver which can be set to display a blank screen - on any PC or workstation.

Even if the monitor does not support power saving modes, a blank screen or dark picture will reduce stress on the CRT and power supply. Electronic components will run cooler and last longer.

Please make it a habit to turn your monitors off at night. This will extend the life of the monitor (and your investment) and is good for the environment as well. For workstations, there are good reasons to leave the system unit on all the time. However, the monitor should be turned off using its power switch. For PCs, my recommendation is that the entire unit be turned off at night since the boot process is very quick and PCs are generally not required to be accessible over a network 24 hours a day.

Thernal cycling and component life

(From: Bob Myers (myers@fc.hp.com).)

In a CRT monitor, the shortest-lived component BY FAR is the CRT itself, and it ages (more properly, the cathode is aging) as long as the heater is on and the tube is under bias. Most monitors don't get around to turning the heater down or off until they enter the DPMS "suspend" or "off" modes. (And no, screen-savers do NOT help here - the tube is still on and the cathode is aging.)

Other factors - simply having the circuits hot and powered up in general means that they're aging. Clearly, they're NOT aging when they're off. This needs to be balanced against the thermal-cycling sort of stresses that you mention which happen during power cycling, and this is why I recommend shutting off only when you're going to be away for an extended period, such as overnight. This is, of course, most important for those components which have clear heat-related aging, but most do to some extent. Esp. vulnerable are things like electrolytic caps, for obvious reasons.

The bottom line is that nothing is ever going to last forever, and trying to maximize the life of the product is an exercise in making tradeoffs between various aging/failure mechanisms.

Minimum and maximum lifespan of monitors

(From: Bob Myers (myers@fc.hp.com).)

There's no way to set a "minimum" or "maximum" life, as there's quite a variation from unit to unit. Some small percentage will fail right out of the box ("infant mortality") while others will run happily for years. We normally speak of a mean, or average, life expectancy, as in "MTBF" ("mean time before failure"). In a CRT display, the CRT itself is usually the limiting factor in this, and in THAT specific case we usually speak of "mean time to half-bright" instead, since it's rare for a CRT to simply die once it's past its early operating life. (Excluding such things as mechanical damage and so forth, of course.) Mean-time-to-half-bright is just what it says: how long, on average, can you operate the tube before the brightness drops to half its initial level for a given set of operating conditions. (Brightness is ALWAYS slowing decreasing throughout the tube's life, due to the aging of the cathode and the phosphor.) For most tubes with standard cathodes, this will be in the neighborhood of 10K-15K hours (a little over a year to not quite two years of continuous operation).

Implications of power saving modes

(From: Bob Myers (myers@fc.hp.com).)

Energy Star and similar power-saving certifications generally don't specify what is done inside the monitor to achieve the power reduction, just the maximum power dissipation in the "reduced power" state(s). Still, most designs WILL either reduce the voltage to the filament, or shut it off completely, depending on the degree of power reduction needed for a given state.

Thermal stresses would be damaging to the heater and cathode if they happened significantly more often than the daily power-down (you DO turn you monitor off for the night, don't you?). The way to use these features properly is to NOT set up the system to enter the more reduced states ("suspend" and "off") until a reasonably long period has passed with no action. Use the "standby" state for the first level, the one you enter after a few minutes (10?) of inactivity, and don't go beyond that unless the system is inactive long enough to suggest thay you're going to be away for a while. But make sure that the system WILL get to the deepest level of power reduction supported - with the monitor as close to full off as you can get - when you're going to be away for a really long while, like overnight. Turning the monitor off overnight is the best thing you can do for it.

And no, I don't think these monitors will be that much more difficult to service, just because they've got power management. This is usually a fairly simple addition to the power supply, and doesn't really affect the complexity of the rest of the unit. But modern monitors DO tend to be more complicated anyway - what with digital controls, on-screen displays, etc. - and so are somewhat more difficult to repair. It just doesn't really have much to do with the power-saving bits.

Methods to prevent screen burn-in on fixed format monitors

When TVs or monitors are used to display the same pattern day in and day out, screen burn is likely to result. This may happen with TVs used extensively for video games and text display terminals - both situations where the format of the screen is relatively fixed. It is not likely with TVs under normal usage or monitors used with windowing systems (e.g., Win95, X-windows) where the display changes from time-to-time.

With TVs, your only options are to reduce the brightness or get the kids (you?) to participate in less mind numbing activities.

For monitors, here are three approaches (they can obviously be used together).

- Blank or dim the screen or use a screen saver when not in use (won't prolong CRT life but will reduce possibility of burn-in).

- Only set the brightness and contrast as high as needed for comfortable viewing. Subdued ambient illumination will allow these to be greatly reduced (and save energy as well!).

- Randomize the display. On a text entry terminal, for example, the system could be set up to vary the position of the text on the screen by a small amount - a random number of pixels horizontally and scan lines vertically less than the character size. This could be done every time it is switched on or periodically. Of course, unless you are the designer or programmer, this option probably isn't very viable!

There will always be some degradation of the phosphor even during normal use. With changing scenes, it will simply result in a long term darkening of the screen and reduction in maximum brightness (independent of the reduced mission from the electron guns). This effect is likely very slight but my advice is to keep contrast (peak whites) only as high as you need and turn the brightness down when not using the monitor for a few minutes. Also see the section: Monitor life, energy conservation, and laziness.

Monitors, heat, and cooling fans

Electronic equipment in general most often really likes to be kept cool. Up to a point, cooler is better. However, to save a few cents and to avoid complaints about noise, few monitors come equipped with internal cooling fans even though these could substantially reduce the internal temperature and may prolong a trouble free life.

Without a fan, there are still (possibly) simple steps that can be taken to keep the monitor happy:

- Keep the ambient temperature low. There is no need for the humans to freeze, but if you are uncomfortably warm, so is your monitor.
- Run the monitor at the minimum brightness for your needs. It is better for the monitor and energy conservation use lower ambient illumination and lower brightness. Stress on both the CRT and power supply components is reduced and the monitor will run cooler.
- When idle, use a screen blanker (or screen saver that displays a dark picture) or take advantage of any power saving modes that may be supported. As above, this will reduce stresses on the monitor's components and save energy as well. Of course, turn all the monitors off at night. See the section: Monitor life, energy conservation, and laziness.
- Make sure the monitor's ventilation holes are not covered or blocked in any way. There should be several inches of clearance on all sides, top, and bottom. Make sure dust doesn't collect - suck it out with a portable vacuum cleaner.

However, even if you follow these recommendations (or have no control over some aspects of your monitor's environment and operation), some monitors run excessively hot.

While I don't know of any controlled studies on this topic, anecdotal evidence suggests a substantial benefit to forced air cooling for some monitors.

It doesn't take much - even a CPU style 1.5 inch fan will make a noticeable difference in nearly total silence.

The best place to mount such a fan is probably on the plastic case in the vicinity of the high power components - power supply or horizontal deflection. Provide a hole and grill to match the fan. Orienting it to blow outward may be better for general cooling. However, it will be easier to cool specific parts if the fan blows in and with a filter, this will also reduce dust infiltration.

Power can be tapped from any convenient source which provides a voltage that is compatible with the fan. For example, a 12 VDC fan can run on anything from 8 V (or somewhat less) to 15 V or so with a corresponding variation in speed. The current used by such a fan is generally negligible so it shouldn't be a problem to find a source with enough excess capacity.

If you really want to be slick, add a circuit to adjust fan speed based on scan mode (higher scan modes->higher air flow) and/or temperature.

Why are prices of video monitors so high compared to similarly sized TVs?

> "How come I can buy a 32" Sony Trinitron TV set for $800, but when it comes to buying a monitor for my PC, $1400 only gets me a no-name 20" tube?

Why can't a giant like Sony produce a PC monitor anywhere close in cost to an equivalently sized TV set?"

Well, the bottom line is that there isn't much in common between a TV and computer monitor when one gets down to the details. The basic principles of raster scan display apply to both and that is about it! Monitors would already be much more expensive if it weren't for the additional fact that many more TVs are manufactured and sold than monitors - which drives down their prices still further:

(Some of this from: Mike Stewart (mstewart@whale.st.usm.edu).)

There are several significant factors being overlooked here:

1. Economy of scale. There are still *many* more TV sets being sold than computer monitors. Manufacturers order TV chipsets in much larger quantities. This drives down the price.

2. Resolution. NTSC TV signals aren't even VGA resolution. Try getting that 32" Sony Trinitron XBR to give you 1280x1024. A computer monitor has a CRT with a resolution about 2 to 3 times that of a TV of similar size in both horizontal and vertical directions. The beam is also more sharply focused.

3. Refresh rates. NTSC TV signals come at one refresh rate, period. You either watch broadcast NTSC at 59.94Hz (interlaced), or you don't watch it at all. No nice, clean 72Hz NI display on there. (NOTE: This only refers to the 99+% of TV playback equipment that contains no line- doubling circuitry. That's fair, as you'll pay a good bit more for a non-interlaced, line-doubled NTSC picture than the previous poster was complaining about, anyway.)

   Therefore, a auto-scan monitor needs more sophisticated deflection and power supply circuitry. It must run at much higher scan rates and this complicates the circuitry as well.

4. Geometry. The precision of a good computer monitor is much greater then any TV. The sides will be parallel and square. Adjustments are provided to eliminate pincushion, keystone, and trapazoid distortions.

5. Stability. The image on a high quality computer monitor is rock solid and does not shift position or change size as components warm up, or the power line voltage fluctuates, etc.

(From: Bob Myers (myers@fc.hp.com).)

The basic reason for the cost difference between CRTs for computer and TV is that they are NOT the same product AT ALL.

They do not share ANY major component. The glass is different (for one thing, computer tubes are still almost ALL 90 deg. deflection; TV glass is for 110-114 deg. deflection). The electron guns are different (different spot size vs. brightness tradeoff). The shadow masks are different (computer displays use a much finer dot pitch than the same size TV tube). Even the phosphors used are sometimes different. They are aimed at different markets, with different requirements, and so are completely separate designs. They most often are not even produced on the same production line.

Beyond the CRT, every other major part of the display design is different, mostly owing to the difference in horizontal rates required (~15.7 kHz for TV, vs. 30-85 kHz and often MUCH higher for computer displays) and the need for multifrequency operation in the computer market, combined with the need to hold to much tighter geometry, convergence, etc. specs at these higher rates.

In short, the only thing that's the same between a TV set and a computer monitor is that they're both boxes which make pictures on a glass screen. Sort of like the Queen Elizabeth II and the Exxon Valdez - yes, they're both big metal things that float in the ocean, but there's not really all THAT much in common between the two designs.

Why is the resolution of a computer monitor so much better than a TV

Of course, computer displays may run at resolutions of 1280 x 1024 or more. These are not limited by minor considerations such as channel bandwidth, and to a lesser extent, cost. These are separate issues from why a computer monitor display is so much better even when the number of scan lines is the same - as with NTSC versus basic VGA (640 x 480).

1. NTSC (525/30) is fundamentally limited by the bandwidth and color encoding of the composite video signal. This is the most significant factor limiting any possible display on a TV via the RF/cable/antenna, or composite or NTSC (direct A/V) inputs to perhaps half of VGA resolution horizontally.

   PAL (625/25) more closely matches an 800x600 SVGA format but still suffers from similar limitations in horizontal resolution.

2. Monitors are designed to provide sharp focus at the expense of brightness. TVs don't have great focus but produce brighter display. This limits both horizontal and vertical resolution.

3. Monitor CRTs are designed with much finer dot/line pitch in the shadow/slot mask or aperture grill - often better than 2:1 smaller than similar size TVs.

4. TVs use interlaced scanning. Jitter in the vertical also affects perceived display quality.

Where a TV/monitor has direct RGB inputs, the limitation is primarily due to (2) to (4) though they may not have the same high bandwidth circuitry as a more costly computer monitor.

There are other factors but these are the most important.

Combined TV and computer monitor

> "This is a 27" VGA monitor which should also be able to be used as an NTSC television monitor. Can anybody comment on it?"

IMO, I think the entire idea of a combined TV/computer monitor is silly especially when the likely cost premium is taken into account. Watching the boob tube will tie up your entire PC. The optimal size for TV and computer use is not the same nor are the requirements in terms of scan rate, resolution, brightness, and sharpness. Thus, the design will be inherently more expensive and include more compromises.

So, I will probably be proved wrong by record sales of these things...

Problems with designing a combination TV and computer monitor

(From: Bob Myers (myers@fc.hp.com).)

It's possible, and has been done (for instance, Toshiba has one product and offerings from other companies are available or are on the way). But such designs ARE compromises, and won't give the best performance possible in either application.

There is a fundamental difference between CRTs designed for TV use, and those used in computer monitors. It's a brightness/resolution tradeoff - TV tubes are run about 3X or so the brightness of a typical computer monitor, but sacrifice the ability to use small spot sizes and fine dot pitches to do this. You don't see very many color tubes running at 100 - 150 fL brightness and still using an 0.28 mm pitch!

So, what about truly digital monitors?

The following issue is distinct from that of flat-panel technology which of course is rapidly replacing the CRT in computer monitors.

> "I am really interested in this Digital Revolution (DVD, HD-TV) but what about PC monitors? Wouldn't it be great to have a monitor that was also compatible with HD-TV? I want to buy a new 17" or 19" but I don't want to invest in CRT (analog technology), when will Digital PC Monitors be coming out?"

(From: Bob Myers (myers@fc.hp.com).)

Being compatible with HDTV just means having the right front end to interpret the signals, just as using NTSC video on a current computer monitor requires a decoder. I seriously doubt that we'll see computer displays which are DIRECTLY capable of handling the HDTV data stream.

Having said that, there is ALREADY a standard for a digital display interface, which was approved by VESA last year. The new "Plug & Display" interface standard supports BOTH digital and analog video outputs on a single standard connector, enabling monitors with either sort of interface to be easily supported. (The host uses ID information from the monitor - already a standard feature of most CRT displays - to decide which interface to use and how to configure it for a given monitor.) There are already products on the market (a few) or in development using the new interface.

Having said THAT, don't count the CRT monitor out just yet; it'll probably be with us for some time yet, and there's little reason to use a digital interface for a CRT-based display (since, under the new standard, you're going to have BOTH flavors of interface available anyway). Actually, there is very little inherent advantage for MOST display technologies in the interface itself being "digital" (even LCDs are "analog" at the pixel level); the problems most non-CRT displays have today with "analog" video have to do with getting a good TIMING reference with which to sample the video, NOT with whether that video is encoded in digital or analog form.

About sync polarity options

Many video cards provide polarity options for each scan mode. Why?

Probably to be compatible with older monitors. Most modern monitors are auto polarity detecting so the settings should not matter.

(Note that some of the digital PC video standard did have specific sync polarity specifications.)

Some software programs that directly access the video card may even be changing sync polarity - for apparently no reason - without you being aware of it.

Your video card determines the maximum video rate you can generate. The monitor has to be able to lock to it. So, if you cannot setup higher than some specified rate (i.e., the options do not exist in your menu), it is a function of the video card and drivers. If you can set it but the monitor displays garbage or nothing at all, it is a limitation of the monitor. The sync polarity rarely makes any difference and if it does, the effects will be obvious - picture shifted left/right/up/down on screen - or just won't sync at all.

If you experience problems of this type, experimenting with the sync polarity may be instructive.

If you do not know what your monitor wants and you have the option, set both horizontal and vertical sync polarities to be negative as this is nearly always acceptable (for studio video and VGA/SVGA monitors).

(From: Bob Myers (myers@fc.hp.com).)

This was used in older systems to identify certain display modes, but in general modern monitors accept either polarity equally well. Recent display timing standards have all been written specifying positive-polarity sync (the sync pulse is at logical "1" rather than "0"), but the use of negative polarity usually won't do anything except possibly cause the image to be off-center by the width of the sync pulse.

VESA Display Data Channel standard

(From: Bob Myers (myers@fc.hp.com).)

This defined several protocols for digital communications between a host system and its display. DDC provides 3 different modes:

```
DDC1 - A unidirectional (display to host only) serial communications system
        which provides basic display ID and feature support information
        (including supported timings, display size, colorimetry and gamma,
        etc.) to the host.  This uses pin 12 on the 15-pin "VGA" connector as
        a data line.


DDC2B - Adds clock (pin 15) and return (pin 11, I think - I'm at home, and
        don't have the standard with me) to enable at least ID information to
        be obtained via an I2C interface.  I2C is a bidirectional interface,
        but display control via DDC2B is not defined at this time.


DDC2AB - Full ID and control of the monitor via ACCESS.bus.  As ACCESS.bus is
        basically a command and protocol definition on top of the I2C
        hardware interface, this uses the same lines as DDC2B.
```

DDC was the first and only definition of the 15-pin D-subminiature video output connector which VESA has provided. No further definitions on this connector will be made, as VESA is instead concentrating on the new Enhanced Video Connector standard which is due out later this year. This will define a completely new connector which will include support for DDC and separate syncs as in the 15-pin D-sub, and will also include support for audio I/O, video input, and the USB and P1394 serial interfaces.

Identifying connections on unknown or cut monitor cables

Obviously, this is best done with a schematic. However, since such a luxury may not be possible, how can you go about figuring out where all the wires go? Easy answer - very carefully.

For the following, I assume a VGA/SVGA monitor. You need to identify the grounds, video signals, H and V sync, and monitor sense lines. The procedure is described with respec to a cut cable but if you are trying to identify an unknown connector type on the monitor, the same comments apply to the wiring **inside** the monitor.

First identify the grounds. Use an ohmmeter between each wire and the shell of the video connector on the monitor. Resistance will be less than an ohm for the ground wires. These will often be colored black. The shields of the RGB coaxes will also be connected to ground.

The high bandwidth video signals will always use individual coaxial cables. These may even be color coded red, green, and blue. If not, you can determine which is which later on. If there are only three such coaxes, they are the video signals. If there are four, the extra one may be the H sync. If there are five, the extra two may be the H and V syncs. Testing between these wires and ground with an ohmmeter should measure 75 ohms for the video terminations.

Display a lively screen on your PC at a resolution you know the monitor should support (remember, trying to drive a monitor of unknown scan rate specifications beyond its ratings is like playing Russian Roulette.) When in doubt, VGA (640x480, 31.4 kHz H, 60 Hz V) should be safe.

Turn up the brightness and contrast on the monitor. If you are lucky, even without any sync, there will be a visible raster. Set it to be just visible. If there is none, then it should appear once there is valid sync.

You will need to bring out wires from the video connector on your PC.

Connect the ground of your video card to the ground wires you already identified on the monitor cable.

Attach a wire in series with a 200-500 ohm resistor to H sync (pin 13) on the VGA connector.

Momentarily touch the end of this wire to each of the remaining unidentified wires (including the coaxes if you have 4 or 5 of these and it is not obvious which are the video signals) on the monitor. When you find the H sync input, the raster should lock in and probably brighten up. If the monitor was originally whining due to lack of sync, it should quiet down.

Once you have located H sync, you can remove the resistor and connect the wire up directly.

Now, attach the video signals. It is likely that you will now have a picture but it will be rolling on the screen. Some monitors, however, will not unblank until they receive both valid H and V sync. Use your resistor with the V sync output of the video card (Pin 14) on the remaining unidentified wires. Once you find the V sync input, the display should lock in solid.

The only remaining unknowns are the monitor sense lines. For older monitors - those without the ACCESS.bus interface, you can just wire up the sense lines to the appropriate levels (Color: ID0 (Pin 11) to ground, ID1 (Pin 12) NC).

See the document "Pinouts for various connectors in Real Life(tm)" for detailed hookup information". Replacement VGA connectors are readily available.

Also see the section: Replacing the cable on an HP D1182A monitor for some hints and helpful 'hassle savers(tm)'.

Replacing monitor cables or connectors

Many intermittent or erratic loss of color or loss of sync problems are due to a bad cable - more specifically, bad connections usually between the male pins and the wires. Or, perhaps, one or more pins were accidentally broken off as a result of the connector being forced in the wrong way around.

Unfortunately, it is all too likely - particularly with newer monitors - that the shell is molded on and impossible to non-destructively remove to access the connector for wire repair or pin replacement.

You have several options:

- For name brand monitors, entire replacement cables may be available. These will be pricey ($25 to $50 typical) but are by far the easiest solution.
- The connector itself can be replaced. Places like MCM Electronics stock VGA (HD15) male connectors and pins. These may be either solder or crimp type (both can actually be soldered if you work at it). It takes a steady hand, bright light, and patience to solder the fine wires to the tiny pins. A crimp tool is probably not worth the investment for a single repair.
- If you can locate a dead monitor with a good VGA cable still attached, it is possible to cut and splice the wires away from the connector. Use an ohmmeter to identify which signal pin connects to which color coded wire on each cable and then solder and tape the individual wires. It won't be pretty but should work reasonable well.

Replacing the cable on an HP D1182A monitor

(From: Marion D. Kitchens (jkitchen@erols.com).)

By following the procedure in the section: Identifying connections on unknown or cut monitor cables, I was able to get a D-15 correctly connected on the ends of an HP D1182A monitor's video cable. This was a monitor that came to me with the D-15 missing. The only remaining unknown is the brown wire but the monitor seems to work fine without it (however, see below).

```
 Cable Wire  Internal Pin #   Function   Resistance  D-15 Pin     Notes
--------------------------------------------------------------------------------
 White Coax      5,4          Red Video      75         1,6    shield is 6
 Black Coax      3,1         Green Video     75         2,7    shield is 7
 Red Coax        7,6          Blue Video     75         3,8    shield is 8
 Red              8             Gnd           0          10   red & blue are
 Blue             9           V. sync        1K          14     twisted pair
 Yellow          10             Gnd           0          10   yellow & clear are
 Clear           11           H. Sync       500          13     twisted pair
 Brown           12             ID0??     Infinite     11??    Works OK w/o
```

Internal pin numbers refer to a 12 pin, in-line connector inside the monitor. It is mounted on a circuit board (model XC-1429U printed on board) that is mounted on the neck of the CTR. There are 12 pins, but one is blank -- nothing connected. I have called that one pin # 2 for reference, and the pin furthermost away I called pin #12. Double numbers mean the first is connected to the coax center conductor, and the second is the coax shield.

The double numbered pins under D-15 above mean connect the center conductor of the coax to the first pin number, and the coax shield to the second pin number. All the coax shields should measure zero Ohms to ground, and all the center conductors should measure about 75 Ohms to ground. Ground is the outer shield of the video cable, which is connected to the D-15 connector shell when doing the wiring job.

Pins 5 & 10 are also listed as ground connections on the D-15 connector. I suspect these are for the H. sync & V. sync, but do not know that for a fact. I connected what I believe to be both ground returns (per the twisted pairs show above) to pin 10.

The currently unconnected brown wire does have a signal of some sort on it. At least when trying to find the H. sync and V. sync wires, I got screen reactions if I connected it to some pins on the D-15 connector. Since it was the only "left over" wire when I got H. sync & V. sync correct, I suspect it to be the ID0 wire. Yes? No? Maybe? Nothing seems to happen when I connect it to D-15 pin #11. The monitor SEEMS to be OK without the brown wire connected to anything (but the color balance is a bit off, green and blue OK, but red is a pale pink). An Ohmmeter connected between ground and the brown wire "acts like" it is charging a capacitor -- resistance starts low and increases with time to several 10's of Meg. Is that a clue?

As an aid in finding the correct wiring connections I make a special floppy. It is a bootable floppy for use in the A: drive. Boot the computer from that floppy. First format a system floppy for the A: drive. Then copy the ANSI.SYS file from your C:\DOS\ files to the floppy. Next write a CONGIF.SYS file to the floppy, containing one line --- DEVICE=A:\ANSI.SYS Now write three batch files to the floppy, one for each color.

```
RED.BAT file
  PROMPT  $p$g$e[41m
  CLS


GREEN.BAT
  PROMPT  $p$g$e[42m
  CLS


BLUE.BAT
  PROMPT  $p$g$e[44m
  CLS
```

In trying to find the H. sync and V. sync, I found it most helpful to use the following procedure.

1. Connect all of the ground wires, and one of the coax center conductors (any one at random) to D-15 pin #1.
2. Boot the computer from the above floppy. Watch the drive light to determine when the boot process is completed. Hit RETURN twice to get past the new time and date that it asks for.
3. Turn on the monitor, and type RED to run the red batch file.
4. Now follow the procedure in the section: Identifying connections on unknown or cut monitor cables to find the H & V sync wires. When you have them correct you should see a colored screen (it might be red, green, or blue) and two "A:>" prompts on screen. Make sure the brightness control is set for maximum brightness, and that contrast is high.
5. Once you have a readable screen, find the correct coax to produce a red screen when connected to D-15 pin #1. Then type GREEN to run the green batch file, and find the correct coax to produce a green screen. The remaining coax is, of course, the blue video. But verify that anyway by typing BLUE to run the blue batch file.
6. Now you should be able to get red, green, and blue screens buy running the respective batch files.

To aid in the trial and error process of finding all the correct wiring, I made a small (3 by 4 inch) PCB with 15 connection points and a large grounding point, and mounted a D-15 connector on one edge. The 15 copper traces were wired to the D-15 connector so that pin numbers 1 through 15 followed a simple series across one edge of the PCB. The 15 traces were about 1/4 by 1 inch to make life easy. I even soldered 220 Ohm resistors to pin numbers 13 & 14 on the board to make that easy too. With this "aid" I used a video extension cable to bring my working point to the front of the test bench, and had plenty of working room for all those trial and error connections. Yes, I do like 'hassle savers(tm)'!

How can I determine monitor specifications or whether it supports SVGA?

There is no easy way to tell by just examining the monitor visually. Even those with only a 9 pin rather than a 15 pin connector are sometimes SVGA (e.g., Mitsubishi AUM1381 and NEC Multisync II which will do 800x600 at 56 Hz V non-interlaced and 1024x768 interlaced at 43 Hz V).

You cannot even safety test scan rates on all monitors - some (mostly older ones) will blow up or be damaged by being driven with incorrect video.

For a monitor that you already have, looking it up in a monitor database is really the only way to be sure of its capabilities (well, pretty sure - these listings are not always correct!). See the section: Web sites with monitor specifications for on-line resources. If this doesn't help, you try posting the information you have (model number, FCC code, etc.) to the newsgroups: comp.sys.ibm.pc.hardware.video and sci.electronics.repair. Where none of this is production, here are some quickie tests:

1. Check the video connector. If it has a high density (VGA) 15 pin connector then there is a greater likelihood of SVGA but not always.

2. Check the manufacturing date on the back. If it has a manufacturing date of 1991 or later, the likelihood of it supporting SVGA is higher as demand for VGA-only monitors was rapidly declining by this point.

3. Check the dot pitch on the CRT by examining the screen with a magnifier. If it is really coarse, the monitor probably cannot do anything beyond VGA.

4. Become familier with the major manufacturers and models so that you will recognize the common SVGA models.

5. Check the databases listed in the section: Web sites with monitor specifications.

While not conclusive, positive results on the first 3 of these tests definitely increases the likelihood that it supports at least some SVGA modes. Of course, if you recognize a model number, you have dramatically increased your odds of success - assuming it works!

From: Adrian Kwong (a.kwong@ieee.ca).)

Most new monitors employ frequency protection. The symptom that you will typically see is, a complete lack of video. Most monitors with multicolored power LED's, usually change color to indicate an error. Some monitors like Nokia's, will flash the screen on and off (black and white) to indicate that the over-frequency protection circuits have been activated.

I have blown a few monitors by setting the video resolutions either too high, or setting the vertical refresh to something that puts the horizontal frequency waaay above the rated specifications.

I actually have no idea how some of these monitors actually received a UL or CSA approval stamp, as I have seen some of these monitors catch on fire. Most of the 'blow outs', were just capacitors that exploded and about a room full of smoke fills the vicinity.

All of the monitors that I blew up, were really old monitors with no frequency protection.

Is CRT replacement worth it?

The sad fact is that even if you can obtain a new CRT you won't have the proper set up for getting proper alignment and convergence. They generally use various permanent magnet glued to the perimeter of the yoke to set the geometry of the raster. It takes a special factory jig to do this step or really great persistence and patience. However, if you have the time and will resist punching a hole in the new CRT before you finish, by all means.

Also, consider the cost of a new CRT may be more than half the cost of the monitor when it was new.

Replacing a monochrome CRT is a snap in comparison.

A better (or at least less stressful) approach is to locate a monitor that died due to a circuit problem and salvage the CRT including the yoke and all the other magical magnets and coils.

(From: Andy Cuffe (baltimora@psu.edu).)

I have found that most 15" monitors use compatible CRTs. I just put the CRT from an old Gateway2000 with analog controls into a nice 2 year old monitor. As long as the yokes and CRT sockets are similar it should work fine. Don't try to swap the yokes or you will never get it converged.

An informal history of X-ray protection

(The following is from: Marty).

Most of the old tube type color TV sets used a shunt HV regulator tube, usually a 6BK4. If it failed, or some component in the HV circuit failed, the high voltage, normally 25 kV, could go up to 35kV or more, causing some X-Ray leakage from the CRT. In the early 70s when news of this radiation scare was first announced, there was a public outcry to immediately fix the problem. The Feds hastily imposed a requirement on manufacturers of TV sets to somehow render a TV set "unwatchable" if the HV exceeded rated limits.

The manufacturers first response was to follow the letter of the law and the first "HEW" circuit simply blanked the video when the HV exceeded a setpoint to make the set "unwatchable".

It was quickly noticed that the HV was not turned off with this circuit and the CRT still could emit some radiation. Many TV sets with this feature were left on so the consumer could listen to the sound, so the feds tightened the requirement.

By this time new TV sets were all solid state and some manufacturers experimented with HV shutdown circuits, but most of these circuits were poorly designed and not reliable.

Zenith thought they had the answer by regulating the HV with a bank of 5 capacitors across the horizontal output transistor to "hold down" the HV to 25kV. If one capacitor opened, the HV would only rise about 2kV, not a dangerous situation. This wasn't good enough for the feds.

The "fix" that Zenith finally came out with, was a "4 legged capacitor. Two legs were the emitter return for the horizontal output transistor, & two legs were the HV holddown capacitor (the equivalent value of the bank of 5 caps). This "fix" was accepted by HEW and millions of TVs were produced. It worked so well, that other manufacturers soon followed the lead (Magnavox, GE, etc.).

Then the worst happened! The 4 legged monsters started failing in a large numbers. Not opening completely & not shorting out. They sometimes allowed the HV to skyrocket to over 50kV. Some of them even cut the necks off of the CRTs.

Zenith issued a recall on those models with the problem (more than one entire model year). After several "improved" versions of the capacitor, the problem was fixed but that recall almost bankrupted the company. Other companies had failures too, but usually not as dramatic as Zenith's.

Magnavox used the HV holddown capacitor, both single & 4 leg version in several 70s era TV sets and is a good candidate for fireworks as well.

Turning a TV (or monitor) into an oscilloscope?

This question comes up so often and it does sound like a neat project to give a defunct TV a second life. Don't expect to end up with a Tek 465 on the cheap when you are done. However, it could be a fun learning experience.

CAUTION: See the safety recommendations below.

You will be severely limited in the performance of such a scope. TVs and monitors are designed to operate at a very narrow range of horizontal scan rates and the high voltage is usually derived from the horizontal deflection. So, you would need to retain the original deflection system for this purpose at least.

1. You will need to disconnect the defection yoke from the horizontal and vertical deflection circuits of the TV or monitor without killing the HV. (also, doing all this without killing yourself as well). Depending on the design, this may be as simple as unplugging the yoke connector. More than likely, you will need to substitute a load for the horizontal deflection coil. A coil from another sacrificial similar TV or monitor would probably suffice.

Warning: at this point you have a really bright spot in the middle of the screen which will turn to a really black spot if the brightness is not turned way down really really quickly.

2. For the horizontal, you need a ramped current source. You are driving a non-ideal inductor (the deflection coil) so it has both inductance and resistance. Thus the waveform is a trapezoid - a voltage ramp (for the resistive part) superimposed on a voltage step (for the inductive part). This should not be too difficult. Don't expect to be able to achieve really fast sweep. Even running at normal TV rates is non-trivial.

3. Similarly, for the vertical you need to drive with a voltage (your signal) controlled current source. However, if you just screwing around, then the linearity etc. for the vertical may not be that important. In this case, one way is to put a current sensing resistor in series with the deflection coil and use this in a power op amp type of feedback arrangement. (You could do this for (2) as well.

4. There is a good chance that the original brightness control will work as an intensity adjustment. However, with some TVs and monitors, this depends on receiving a valid video signal. You may

need to improvise. If you do want to control the intensity from a signal source, you should be able to tap into the drive signals going to the little board on the neck of the CRT.

5. Don't expect high bandwidth, uniform response, or any of the other things you take for granted with a decent scope. That takes work. However, as a fun project, this certainly qualifies. Interchanging the functions of the horizontal and vertical deflection yoke (and rotating it 90 degrees) may provide a better match of horizontal and vertical bandwidth to your intended applications or experiments.
6. With a color TV or monitor, these experiments could be quite interesting and educational but there may be color fringing effects since you are not compensating for certain aspects of dynamic convergence at all.
7. SAFETY: Once you disconnect the deflection yoke from the TV or monitor's circuits, move the original circuits out of the way and put a barrier between between you and the rest of the TV or monitor. All you will need are connections to the deflection yoke on the CRT (unless you want to do intensity modulation in which case you will need to drive the video output(s) to the CRT cathodes. I would recommend against doing this if your unit is one of those with a totally 'live' chassis as there would be additional safety hazards and circuit complications).

(From: Lance Edmonds (lanceedmonds@xtra.co.nz).

Some years ago ELEKTOR and Electronics Australia magazines published articles on a design for this. Dick Smith Electronics in both NZ & Australia used to sell the kit.

Max Bandwidth was a startling 10 or 15Khz. Enough for elementary audio servicing.

Those magazines also published designs for delayed sweep & trigger modules as additions to any basic 'scope. Plus, a storage scope design, logic analyzer design, and a Dual trace emulator design.

Enough to keep the average hobbist/experimenter happy for quite a while (g).

(From: Dale H. Cook (dhcook@rev.net).)

Every few months someone will pop up with this question. A TV would not make a very good scope. Bandwidth would be limited and the amount of work needed to build the horizontal and vertical amplifiers, sweep and triggering circuits and so on wouldn't be worth the effort. You'd need even more work to add modern features such as delayed triggering and variable hold-off. Don't even think about multiple channels and the advantages they offer. In a time when I see used Tek 465s offered for $200 it certainly doesn't pay to try to convert a TV. If you are just looking for a challenging electronic project I can think of several that have a far better chance of yielding something useful. Now, if you were starting with an antique set that used an electrostatic CRT you might do a bit better, but a 1937 Dumont will set you back about $3,000.00 or so - a little too much of an investment.

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

I've worked on the vector monitors that were used on some of the 1970's minicomputers. These are essentially X-Y displays (not raster scanned), and would make audio-bandwidth 'scopes if given a timebase. I would guess at a bandwidth of the order of 100kHz.

Some of them (DEC, certainly, maybe Tektronix) were electromagnetically deflected like a TV. However, there are a couple of things to be aware of. Firstly, the output amplifier, which drives the yoke at constant current, is pretty complex. Secondly, the yoke is specially made - the 2 sets of coils are pretty similar (unlike those in a TV), and the inductance is critical.

So, while I'll keep these monitors running, I'd not want to have to covert a TV into one :-).

(From: David Katz (DAVEkATZ@prodigy.net).)

If by chance what you want is an X-Y display for audio, not a (more typical) X-T, it's easy. Just put a resistor in series with each yoke (about 100 ohms, 5 W) and drive them with a stereo amp.

(From: Steve Roberts (osteven@akrobiz.com).)

Your best hope might be to get a older generation heart monitor from a hospital, these have a professional X-Y display module to begin with, and are surprisingly easy to hack, mine was $10 at the local surplus shop. The ultra long persistence phosphor is a pain/blessing depending on what you are doing.

For a description of what one person did, see: Dan's Home-Built O-Scope Page.

(From: Alan (revidyks@rocketmail.com).)

Apparently it's pretty hard to produce a decent scope.

It is, however, pretty easy to use the CRT as something like a scope, which I did recently with the built-in green screen monitor of a thing called a Kapro 2X. It was being thrown away, so I said I'd take it and have a look inside before throwing it away.

I wondered what if it was possible to drive the CRT from a source other than the computer video circuitry, so I did some tests, worked out how and by what voltage the deflectors were driven, (about 1v, 0.3A measured as an AC voltage).

Once I'd worked out that this was about the same as the output from a small stereo amp, I removed the horizontal signal from the CRT and hooked one channel of my stereo across the horizontal deflector , left the vertical deflector hooked up to it's (60Hz?, 30Hz?) signal, and switched it on. The results look pretty good, I get a full-screen moving trace of the sound wave. One other thing that I did was make the beam intensity constant by turning a knob marked 'B-SUB' a bit, this would have flooded the screen with 'white' ordinarily, but was perfect for me as I could now remove the computer motherboard all together.

I also tried connecting the left and right channels across the horizontal and vertical deflectors respectively (first disconnecting them from their normal inputs), which produced some really cool looking lissijous (sp?) figure type things, that change and throb with the music- each CD seemed to have distinctive characteristics. Maybe I'll try two different pieces of music across the axes, could be interesting...

I'd love to try throwing some different signals of different frequencies and shapes across the axes too, especially in combination a with musical one. The 'best' results so far, have been from music with a strong bass, simple beat (cymbals with a bass drum look great), and not too many layers of guitars, vocals, etc. (too many sounds and it's an uninteresting mess...)

If you want more information or have any advice on or experience with this sort of thing, mail me...

If you're thinking of trying any of this, remember (in case you don't know) that TVs/Monitors can be REALLY dangerous even when switched off and unplugged. See the section: SAFETY.

Displaying a video signal as a picture on an oscilloscope

I am not sure why anyone would really want to do this other than as an experiment - it would be interesting one.

If a composite video signal is the input, you will need a sync separator. For VGA, the sync signals are already available.

You will have to construct a vertical deflection voltage ramp generator which can be locked to your vertical sync signal.

The horizontal timebase of the scope will be fine for the horizontal deflection and should easily lock to your horizontal sync pulse or (if the scope has a TV trigger mode) directly to the video signal.

A video amplifier will be needed if your Z axis does not have an internal amplifier (you need .7 V p-p to be full brightness range.) Unless you provide automatic gain control, this will need to include offset (brightness) and gain (contrast) adjustments. Even if there is an internal amplifier, it may not have the required bandwidth for the video signal.

However, the overall brightness may be disappointing - a scope is not designed for overall high brightness. The beam focus will not be as good as that on a little TV either.

Could a monitor be modified for 3D (stereo) display?

The whole idea of stereo 3-D vision to put the left and right views to the appropriate eyeball. There are two common ways of doing this:

1. Use different colors for the two views with color filters in from of each eye to separate the views. This is what were often used for the really bad (content wise) sci-fi movies of the '50s.
2. Display alternate views on the same monitor screen but use LCD shutter glasses to allow each eye to only see the appropriate view. This requires increasing the refresh rate to avoid unacceptable flicker.

The first approach can be used with any TV and a pair of monochrome video cameras. Of course, true color cannot be used since pure colored images are needed to separate the stereo views.

Alternating views with synchronized LCD glasses is a possibility but and has been used commercially but requires special hardware to synchronize to the computer's video card. Best results are obtained with refresh rates of at least 120 Hz permitting 60 full left-right frames per second. If you try to this with a regular TV or CGA monitor, the resulting refresh rate would be 30 Hz with a 50% duty cycle which is likely to be useful only as a short experiment - else your viewers will likely develop splitting headaches.

Should I use a VGA to BNC cable if my monitor has BNC connectors?

(The following assumes a normal video card with a mini-DB15 VGA/SVGA connector - if yours has BNC connectors, the improvement may be even greater.)

The answer is an unqualified maybe. In principle, the BNC cable should have higher bandwidth and better transmission line characteristics (impedance, termination) and result in sharper crisper images with less ghosting, ringing, and other artifacts. However, this will only likely be significant at higher refresh rates (1024x768 at 75 Hz and beyond) and depending on your monitor and video card, you may see no change - or it may even get worse. It is best to purchase a good quality VGA to 5-BNC cable with a return privilage and try it. I suggest a 5-BNC cable even if you only need 3 or 4 connectors so that it will be compatible with any monitor or video card you might have in the future. Cost should be in the $25 to $70 range.

Potential advantages of using the BNC connector inputs on your monitor with a good quality cable are:

- higher video bandwidth -> sharper display.
- proper connectors (at one end, at least) and correct termination implies less ghosting and ringing.

For a good monitor with a high quality video card, the difference can be dramatic - as is the case with my ATI GPT and NEC 5FG.

(From Bob Myers (myers@fc.hp.com).)

However, one should also note that connecting via BNCs generally disables monitor "plug 'n' play" features, since these are based on ID information conveyed on dedicated pins (using the VESA DDC & EDID standards) on the 15-pin "VGA" connector.

As of last year, a new connector standard - the VESA Enhanced Video Connector, or EVC - has been released, which will provide both greatly improved video signal performance AND support for DDC and a number of other features.

Most current monitors comply with the VESA Display Data Channel (DDC) standard which provides a path and protocol for getting some basic ID information (model, manufacturer, supported timings, chromaticites, etc.) back from the monitor. Under that standard, the following new signals have been added to the DB-15 connector:

```
Pin 9:  +5 VDC from host
Pin 12: Serial data
Pin 15: Data clock
```

Pin 10 (the old sync return pin) now does double duty as the return/reference for DDC. The DDC system uses the I2C spec for one level of implementation, although a base level is also provided in which the data is clocked back from the display by the vertical sync pulse.

The old 4-line ID scheme using pins 4, 11, 12, & 15 is obsolete. I can't think of too many hosts, or ANY monitors, still using it.

Additional information on the EVC standard is available from the VESA Web Site.

And one manufacturer's way around the preceeding:

(From: Russ Smith (smith@ur-guh.com).)

The Nanao F2-21 I'm using is connected via 5 split-out BNCs on its end; on the OTHER end is the standard VGA connector - that connector plugs into not the video card, but a little "black box" which performs the plug-n-play identification. That little widget plugs into the PnP-compatible video card (Matrox Millenium).

Thus, even though BNCs are used at the monitor end and the monitor itself can't communicate anything useful, the information is none-the-less communicated.

A hack that works.

Building a 5 BNC cable

This is straightforward, if time consuming and tedious.

The five coaxial cables (75 ohm, RG59 typical) are wired as shown in the table. The corresponding VGA connector pin numbers are in ().

```
     Coax Center         Coax Shield
  --------------------------------------
    Red Video  (1)      Red Return (6)
    Green Video  (2)    Green Return (7)
    Blue Video  (3)     Blue Return (8)
    H Sync (13)         Ground (5,10)
    V Sync (14)         Ground (5,10)
```

Tie pin 11 (ID0) to Ground to indicate a color monitor. Leave pin 12 (ID1) open.

Make sure that the lengths of the cables are fairly well matched - to within a couple of inches - to assure that the 3 color channels line up precisely. (One foot of cable is about 1.5 to 2 ns of delay which is significant for a 10 ns dot clock!).

Also note (see the other sections on BNC cables) that you will lose your Plug and Play capabilities without the direct control connections to the monitor (or for monitors without these featuers).

That's it!

You will wish that your fingers were about 10 times smaller than they are, however. :-)

Using a workstation monitor on a PC

These are nearly always fixed frequency monitors with a scan rate that is not compatible with typical SVGA cards.

They may have a special connector like a 13W3 or 3, 4, or 5 BNC connectors. Some have a non-standard connector.

While these normally use standard analog video signal levels, you have a couple of problems out of the starting gate:

1. The fixed scanning frequencies of most of these monitors are not directly compatible with typical SVGA standards. Many high end boards like the ATI ProTurbo can scan at 1280x1024 probably at an appropriate refresh (horizontal is going to be the critical one) rate. Also, boards that allow software adjustment of size (like the ATI) are in effect changing scan rates as well so that gives another degree or two of freedom.

   However, many typical video cards do not provide this degree of flexibility.

2. The monitor needs sync-on-green (3 BNC connectors), composite H and V sync (4 BNC connectors and 13W3) or at least a VGA to BNC adapter cable (5 BNC connectors). Your VGA card normally

puts out separate syncs.

Many video cards have a software mode (probably accessible in the setup program) to enable composite sync output so for these at least there is no problem with a 4 BNC monitor.

You can build a circuit to generate the required video for a 3 BNC monitor if you are so inclined. See the "Sync on Green FAQ" for detailed information and schematics.

3. What you do for booting since the default will be VGA (at least for DOS/Windows. If you only use your PC at one fixed high resolution, than this may not be that much of a problem..

There are specialized boards that will emulate standard VGA/SVGA modes using a fixed frequency monitor. For more information, see the document: Notes on Approaches to using Fixed Frequency or Non-Standard Monitors on PCs.

Tweaking the deflection rate of a fixed frequency or non-standard monitor

Pulling a fixed frequency monitor by more than a few percent will likely be a problem. I know this is not the answer you were looking for but getting a new inexpensive video card may be a better solution.

Other types of monitors - XGA for example - may be variable or multiple frequency but incompatible with VGA/SVGA. Some adjustment may be possible but how far you can go will depend on many factors.

If not, you are looking for an adjustment called horizontal oscillator, horizontal frequency, or horizontal hold. If you do tweak, mark everything beforehand just in case you need to get back to the original settings.

There is a slight risk of damage, particularly when lowering the horizontal rate as this increases peak current to the horizontal output transistor. This may result in immediate failure or more stress on components resulting in failure down the road. I have no idea with your monitor.

An alternative that may be possible is to use the setup or install program that came with your video card to decrease horizontal size and then adjust vertical size if needed. This would best be done while monitoring with a scope or multiscan monitor. A byproduct of software adjustments to size will often be a change in the scan rate of a few percent which may completely cover what you need. The reason this may work is that these adjustments vary the length of the H and V video back-porch which affect the total scan time.

I know I can do this with my ATI cards.

Also see the document: Approaches to Using Fixed Frequency or Non-Standard Monitors on PCs which includes a specific modification to permit an IBM9517 XGA monitor to be used at VGA/SVGA scan rates.

Displaying TV on a computer monitor

My general recommendation is that if you have the space, buy an inexpensive TV - the quality in the end may in fact be better. And, it will be usable without tying up your expensive monitor and (maybe) PC.

Some older monitors like the Mitsubishi AUM1381 and Emerson CGA (which also has a speaker) include a composite NTSC input jack requiring only a baseband video source like a VCR. These do produce a very nice picture. However, most newer auto-scan VGA/SVGA monitors do not go to low enough horizontal scan rates. To display NTSC or PAL on these requires a scan convertor (likely to be very expensive) or at least a scan doubler (less expensive but not as good).

For the case of older monitors with digital (TTL) inputs, see the section: Modifying a CGA (or EGA) monitor for NTSC or PAL input.

You can also buy video input cards complete with tuners ('PCTV') which will put TV into a window and allow you to idle away the time you are supposed to be working while watching 'Mork and Mindy'.

While various convertors are advertized to use a computer monitor with video from a VCR or other source, keep in mind that if it sounds too good to be true, it probably is like the claim of a $200 box for this:

OK, let me get this straight - this card/box will enable a 31.4 kHz horizontal scan rate monitor (VGA) be used as a TV - yes or no? It thus includes a video A/D, full screen frame buffer, D/A, and all the other tuner stuff for under $200? I don't think so. A scan doubler - which is a subset of the above - will not result in a high quality picture since it will display pairs of lines interleaved or leave alternate lines blanked reducing brightness. Or does the impressive advertisement leave out the key requirement that the monitor sync at the NTSC horizontal scan rate of 15.734 kHz (most newer monitor do not)? Or is it a board that plugs into a PC and indeed does use the resources of the PC including the VGA card and bus?

In any case, get a written money back satisfaction guarantee.

Modifying a CGA (or EGA) monitor for NTSC or PAL input

These are often high quality monitors and would make nice TV displays - especially as there are many no doubt gathering dust on their way to the dumpster!

However, these are digital (TTL) monitors with respect to the video inputs and proper linear video amplifiers may not even be present. Therefore, you may need to implement both the NTSC or PAL decoding as well as boosting the signal levels to the hundred volts or so needed to drive the CRT.

The scan rate of CGA is the same as NTSC so deflection is not a problem.

For PAL (625/50) instead of NTSC, the vertical rate will need to be reduced to 50 Hz but this should not be a problem. The horizontal scan rate is close enough (15.625 kHz).

Similar comments apply to EGA monitors that have a compatible scan rate. EGA represents a range of scan rates between 15.75 kHz and 21.85 kHz so this should not be a problem.

Picture instability of computer monitor used to watch videos

Assuming you have one of those older computer monitors that syncs to TV scan rates (NTSC/PAL/SECAM/whatever) or have found some other way to adapt your monitor to TV signals, you may find that when attempting to use it with a VCR, there is a bending or jittering at the top of the picture.

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

The problem is with the timebase instability of modern VCRs. At the end of each frame there is a phase jump of up to +/- 20 microseconds in the H-sync. The line PLL in a computer monitor is way too slow to follow this jump. The line PLL in a television is switched to a fast mode to follow it just fast enough. This has never been a requirement for computer monitors. You may need a timebase corrector. You may be unable to afford it. Some VCRs have one built in. All Laserdisc players have built-in TBC. Video-CD and DVD don't need it.

Driving multiple non-daisy-chained monitors from one video source

It is not possible to just connect monitors in parallel. The terminating resistors (75 ohms) of each monitor will also be in parallel reducing signal strength and resulting in various problems with cable termination including ghosting, ringing, etc.

A simple circuit to implement a video splitter is shown at:

- Anatekcorp Articles Page.

This is just a set of emitter following buffer amplifiers and should suffice for many applications. Various companies including Elantec, Analog Devices, Maxim, and others have video amplifier chips as well but the basic approach may be adequate for your needs.

Displaying computer video on a TV

Assuming this means NTSC:

1. You need to convert RGB to NTSC - there are single chips for this. Try Sony, Philips, Motorola, and others. These will combine the R, G, B, H sync, and V sync into a single composite video signal using a minimum of additional components.

2. You need to match the scan rate to NTSC - 15.734 kHz horizontal. Even basic VGA is twice this - 31.4 kHz. If your video card can be programmed to put out interlaced NTSC rate video then this is easy. If not, it is more difficult. If you want to use anything higher res than VGA, it is a very non-trivial problem requiring the construction of a scan convertor which includes a video A/D, full frame store, interpolator/readout timing, video D/A. Unless you are an experienced digital/analog designer, you really do not want to tackle any of this.

For the special case of VGA->NTSC, you may be able to get away with just storing a single scan line since the horizontal frequency is (almost) exactly twice the NTSC horizontal of 15.734 kHz. A double buffer where one buffer is storing while the other is reading out at approximately half the VGA pixel rate should work. With appropriate timing, even lines become the even field for NTSC and odd lines become the odd field (I may have this backwards). It is still not a trivial undertaking. Also, keep in mind that the quality you will get on NTSC will be poorer than the VGA due to fundamental NTSC bandwidth limitations. Also, flicker for line graphics will be significant due to the interlacing at 30 Hz. Even this is a non-trivial undertaking.

The requirements for PAL are very similar. For 625 lines systems, the 800x600 is the format that most closely matches the TV resolution.

You can also buy little boxes to do this. Quality is general not great as you are seriously limited by NTSC/PAL and the VCR. Except for presentations on existing TV rate equipment, it is probably not worth the effort. This is totally useless for any serious computer applications.

For professional presentations, modern video projectors are available that use high resolution LCD panels and real-time scan conversion. However, they are still relatively expensive).

HDTV as computer monitor - Can it be worth it?

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Some info:

- HDTV at 1080 lines interlaced uses a line frequency of 33.75 kHz.
- Line-doubled PAL runs at 31.25 kHz, line-doubled NTSC at 31.47 kHz.
- Philips has made VGA televisions capable of 31, 35 and/or 38 kHz.

Now what sort of computer performance does that buy you?

- 31 kHz: 640x480 NI @ 60 Hz
- 35 kHz: 800x600 NI @ 56 Hz
- 38 kHz: 800x600 NI @ 60 Hz

In other words: nothing to write home about compared to today's computer monitors. My 17A goes up to 95 kHz. TVs are good enough to be used as presentation displays - to be watched from a distance. They will also make excellent game displays. But you don't want to use them for word processing. Just because it is sold as an HDTV display does not mean that the sharpness will be that much better. Certainly not as good as that of a computer monitor.

HDTV monitors will never have only composite inputs, because composite=CVBS is used only for PAL/Secam/NTSC. Most likely it will have YPbPr inputs (Y,B-Y,R-Y), which is inconvenient with a computer that delivers only RGB. If you are lucky it will have a VGA input or a Golden Scart (a Thomson standard for RGB HDTV signals).

Hold on to your 17" computer monitor...

What is Kell factor with respect to interlaced displays?

(From Bob Myers (myers@fc.hp.com).)

The Kell factor - which has to do with the fact that we're often undersampling an image from the standpoint of the Gospel According to St. Nyquist - IS a factor in the reduction of vertical resolution, but interlacing plays a part as well. This comes from at least two factors:

1. The monitor or receiver usually cannot precisely interleave the two fields.

2. More importantly, there are steps taken to reduce the interline flicker which reduce the effective vertical resolution. This includes running the line width of the display somewhat larger than would otherwise be the case, and in interlaced cameras, discharging the entire screen (including the lines from the "other" field) after every field scanned.

Interlace is particularly troublesome on moving images, where you will often perceive momentarily "missing" details. There was a LOT of discussion regarding the gory details of interlacing in the recent HDTV debates within SMPTE and other groups.

Weird phenomenon of the month

Talk about unusual. This was posted to sci.electronics:

> "Something VERY strange is happening, and I cant explain it.
>
> There is a "ghost" on my TV screen of the text appearing on my computer screen. They are NOT hooked together in any manner. They are about 4-5 feet apart. Although, the antenna cable runs within a foot of my computer. I am wondering what causes this to happen. I have experienced interference, but this is more like a wireless second monitor. I can turn off my monitor, and look over at the TV. The text on the TV is scrolling up every 9 seconds. (like when the v-hold isn't adjusted.) Any Ideas?"

This is probably caused by RFI - radio frequency interference - from a CGA or PC TV card being picked up on the TV's cable or antenna. Only CGA has a scan rate that is nearly the same as NTSC. Any other PC video scan rate would result in a torn up or rolling picture.

(From: Bobby Richardson (boreal@vance.net).)

That is indeed RFI, and during the heyday of CGA was called 'Really Free Intelligence' in military intelligence circles because, with a highly directional, well-tuned antenna, intel ops could read the target's monitor just like looking over their shoulder.

Big Al's rules of thumb on monitor repair

1. Use an isolation transformer. A variac can be helpful too. A cheap isolation transformer can be constructed by wiring two identical transformers of adequate power capability back-to-back. (Here is a use for those old boat anchors you can't bear to part with).

2. If it's just the power supply or flyback switching transistors that have failed, then the repair is probably easy enough and quick enough to be worthwhile. Blown power transistors are trivial to locate in the circuit and quite easy to find replacements for. In many cases I've found that the monitor would have lived a much longer life if only the transistor mounting screws had been tightened properly by the manufacturer. Make sure you use appropriate replacements and the proper heat sink parts and heat sink compound.

3. If it's the flyback transformer, then judgement should be made based on the cost and availability of the replacement part. Also, on the risk of there being additional problems beyond that of the bad flyback. Who get's to eat the cost of the part in the event you don't succeed and give up? However, determining that the flyback is indeed at fault may prove challenging without a flyback tester. Sometimes there will be obvious damage such as burnt marks, cracked plastic, or other signs of overheating. If you have the correct resistance measurements, then for the primary you may be able to detect shorted windings. You can also construct the brute force flyback tester at the end of the document.

4. If it's the CRT then make the project "someone else's problem" and give the monitor to someone else to use as a parts carcass. My life is much happier since I learned there is no disgrace in making this choice.

5. There is another common failure category which is a result of people who are too lazy to turn off the power switch at night. The constant heat causes the electrolytic capacitors to dry out and become intermittent. I often replace all of the smallest electrolytics in the power supply section

especially when I know the switching transistor is good. If after a couple of hours of labor and a dozen caps I still don't have it running, I give up on these too.

6. Be realistic with yourself about the value of a used working monitor. CGA's EGA's and monochrome Hercules monitors rarely fetch more than $25 at a swap meet.

7. Don't sell a used monitor to a friend unless you want to continue repairing the thing until you're old and grey.

8. Don't put a scope on the collector of the supply or flyback transistors, unless you have a special X100 high voltage / high frequency scope probe.

Tic-Toc Tips

(From: Andy Laberge (tic-toc@wolfenet.com))

1. When you go to discharge the anode of a picture tube make sure you hook up your ground first or you may get an unexpected surprise. I have.

2. Picture tubes will hold their charge for a long time. In fact I have been bitten from a tube that was removed from a TV, discharged and allowed to sit for six months. Treat all picture tubes as though they were fully charged.

3. There is a practical reason for using an isolation transformer for troubleshooting monitors besides the safety issue. The primary side of the power supply is isolated from ground and if you start probing it with a grounded scope you will short out components that were perfectly good until then. It will cost you more time in trouble shooting and more money.

4. When looking for real small cracks in a monitor board try to use a strong indirect light to keep the glare and reflections to a minimum. You can loose a crack in the glare. Cracks also hide underneath the solder mask (the green stuff). I have scrapped away the solder mask and there pretty as you please is that little beggar. Next you want to fix it; scrap more solder mask off the trace about 1/2" on both sides of the crack. Brighten the copper using an ink eraser (it has abrasive grit in it). Tin the exposed copper very well and then solder on a piece of bare tinned buss wire. This is sort of an acquired art. Cut the bus wire about 6" long. Next bend the wire at 90 degrees at the 5" mark you now have an L that is 1" on the bottom and 5" on the stem. Hold the stem and solder the bottom to the PCB on top of your excessively soldered crack. Now just clip the stem off. You should now have a crack that is bridged by a soldered on wire which will give your cracked board the added strength that it needs. If there are near-by traces you should also check these for possible hairline cracks or the starts of some. On boards with high trace density this method may not be possible; in that case use small gauge (#30) Kynar covered wirewrap wire and solder it to the associated trace pads on opposite sides of the crack.

5. Some connections won't take the solder very easily. In that case remove all the old solder with either wick or a solder sucker. Pre-tin the connector until it excepts the solder readily and then solder the connector and it's pad. If you don't do this you will end up with a cold solder joint underneath your new solder.

6. If you are a person that is for some reason or other always moving or unplugging your monitor; go out and buy yourself an extension for your monitor signal plug. Hook the monitor signal plug to the

extender and then use the male end of the extension plug as your signal plug. If you bend one of these pins it will be a lot cheaper then having to buy a signal plug for your monitor if you can find one.

7. In some VGA monitors you may have video smearing with dark letters on a light background. This maybe caused from some low value electrolytics (usually around 1 uf) that have gone bad in the video driver circuits. Usually you can check these in circuit with an oscilloscope or out of circuit with a capacitance checker.

8. Other filament problems might be low voltage caused from a leaky filter capacitor in the filament circuit. The capacitor will dropped the filament voltage down. A resistor can increase in value causing the filament current to drop off. Both of these problems can give you a faded picture look. A filter capacitor that has opened up will give you a bright picture full of noise and that is hard to trace especially if you are looking for it in the video.

9. Homemade degaussing coils can be made using three degaussing coils (out of junked monitors) in series that way you do not need a ballast load and it acts more like the heavy duty degaussering coils. They still get warm though.

10. When checking a focus control the main thing to look for here is that the best focus is not on one end of the control. If it is then your focus control block is bad or falling out of tolerance.

11. High voltage regulation circuits can give you some weird problems. One particular monitor would shut down when it went from high white screen to a black screen. High voltage will elevate when the screen is darker and sometimes exceed the high voltage safety limit activating the shut down circuit.

12. Changing CRT's is more of an art that gets better with practice. Some color CRT's line right up with a new tube and some take over four hours experimenting with results that still do not fall within specs.

13. Capacitors in the primary of the SMPS may go bad and cause the shape of the switching pulse to be distorted; the SMPS becomes inefficient and causing over heating and lower voltage. Change the capacitors if they look bad; shrinking of the vinyl casing or leakage underneath (looks like a leaky battery in a radio). Capacitors with 105 degree temperature ratings are recommended in power supplies instead of 85 degree types because of the self generated heat. Everything in the power supply is a suspect of failure. SMPS transformers can even fail although it is rare. Some produce a high audio frequency whine at times due to material oscillations and load conditions.

14. Metal film resistors can cause weird shut down and start up problems. These are usually found in the power supply over current sense circuits. These resistors check good cold but fail after applying heat to them. When cool they would seem to run all day but if heat is applied they fail faster. The value of these resistors would fall between 100k and 500k usually.

15. A good flyback source: Component Technology 1-800-878-0540

Monitor service and how to get some

A typical monitor warranty is something like: 2 years parts, 1 year parts and labor (i.e. you have to pay for labor the last year of your warranty). What should you do when you are totally unsatisfied with warranty service or when your monitor blows up 1 day after the warranty expires.

(From material provided by a former head service guy for a major computer sales/service company.)

The behind the scenes secrets to get what you want are to do one or a multiple of the following:

1. Call the "Service" (it appears they really aren't) Department of the company you procured the monitor from, and kindly ask to speak with the Service Manager. If they ask for your name, they will most likely pass it on, as well as your service history... The manager will be "not at his desk". They will ask to take a message... say something like "I would like to discuss a service contract" (free money) or "I would like to speak to him about your firm's good service" (appeal to his ego). These are positive things they like. They person on the phone will get your # and you will hear back within maybe an hour or so. Reason: Service people like myself live in a very, VERY negative world... in the back of our minds we like to hear good and hide from the every day bad. He will call back thinking good and when you get him, you can either beat him up, or butter him up... depending on your personality or style. The later is best. The nicer you are to someone, the more they will do for you... treat him like you've known him for years... talk to him on a one on one type style... tell him what has happened in a very calm, relaxed mood... sit back and relax... imagine yourself as Jack Nicolson.(?) Talk as long as you can... joke, talk about golf, whatever... The longer you are on the phone with him, the more likely he is to do something.

2. Hardball! Tell'em you are going to call the Attorney General and get this monitor covered under the Lemon law in your state if they don't get it fixed NOW! They will have to give you a new monitor if the machine has to be fixed under warranty more than 3-times in a 1-year period.

3. Call the manufacturer. Tell them your monitor is bad and that the company that sold you the monitor has sent it to for service multiple times and that you must have it fixed because it monitors a dialysis machine for a 5-month old baby with liver cancer and a broken leg or something like that... Pull their strings. Kindly let them know you aren't pleased with the monitor and you would like to send it in personally... (yes! you can do this!) The key acronyms are RMA# or RA# or MRA#.... they all refer to Return Merchandise Authorization number in some form.

4. (This one is from sam) Threaten to plaster their miserable product name all over the Internet. Note that I do not believe one should actually do this - posting whiney messages to a bunch of newsgroups is largely non-productive and may leave you open to legal repercussions. But, the threat will need to be taken increasing seriously as the importance of Internet as an international medium expands exponentially.

When you send it the monitor, the RMA# has to be on the box. Call the manufacturer at their 800 number. Ask for Customer Service. Tell them the story (kindly) and say that you would like to get an RMA#. This is a type of laundry ticket # they give you to track the monitor's progress... and they report directly to you when you call the RMA department to check on it's status. If they won't do this for an individual person, ask for an address of an Authorized Repair Depot. You will have to call the repair depot and get an RMA#.

Let them know you would like to deal with them directly. I would use tip (3) as a last resort, (just before I call the Attorney General).

I would also be careful of the game they may be playing: let the warranty on labor run over so we can get some money.

Shipping damage 1: why monitors are like basketballs

(From: Stephen Swann (swann@panix.com).)

Monitors are more prone to shipping damage than most other computer components, and it doesn't help that they typically pass through several people's hands (several stages of shipping) before they get to you: factory -> distribution center -> vendor -> you.

And from what I've seen first hand of shipping practices (I put in a couple of months working in a distribution warehouse during college), you can safely assume that each stage of shipping is roughly the equivalent of your monitor being dropped down a flight of stairs.

You wouldn't *believe* the abuse that UPS and FedEx can subject packages to. In fact, putting a *FRAGILE* sign on the side of the box is about the equivalent of writing "KICK ME" on it. I remember receiving packages marked "FRAGILE" where the (originally cubical) cardboard boxes had been smashed into shapeless cardboard "bags", and it took us 20 minutes to figure out what the contents of the box had originally been. ("What are all these shards?" "I think it was some kind of vase" "No, it was some kind of lamp." "Where's the bulb socket, then?" "How about this squashed piece of aluminum?" "Yeah, you're right, but where's the cord then?" etc). :-) Shipping guys would think nothing of dropping "fragile" boxes from waist-high onto a concrete floor - safe in the knowledge that the package had passed through so many hands that the damage could never possibly be traced back to them. "Blameless is Guiltless" should be the motto of these folks.

Basically, what I'm saying is that if 1 monitor in 3 arrives arrives in workable condition, you should be surprised that even that one monitor survived.

Shipping damage 2: why monitors are like hammers (as in throw)

(From: Steve Cunningham (swc@tamu.edu).)

Yes folks! As a training exercise for the 2002 Summer games, Bill Baxter (not his real name), a union thug from United Parcel will attempt to beat the steroid enhanced monitor-throw record of 55 1/4 feet set by Udo Schrank of the former East Germany.

But seriously folks--UPS and I just "go round 'n' round!" Over the past two years, they have broken about one third of the monitors shipped to us, even those packed in the original polystyrene foam. One monitor had the case shattered, and the tube neck sheared off--even though the monitor was packed securely in the original box and foam. The stock response from UPS is that "it probably wasn't packed securely," or some such drivel, while ignoring the obvious--they are careless with fragile merchandise.

The latest outrage was when I was taking a short nap in my house (I work out of my house), and a very loud crashing sound startled me awake. My wife said that it sounded as if someone was crashing through the front door. Turns out that the UPS dude dropped a $2000.00 70 pound 20" Ikegami monitor from waist level to the ground, hitting the front door in the process. After cooling off, I carefully inspected the monitor, and, amazingly, it wasn't destroyed (I have witnessed monitor boxes dropped from the airplane to the ground).

To add to the outrage, when I was ready to return the repaired monitor, the local UPS manager made me purchase a new box, and have foam injected into it, at a cost to the customer of about 50 bucks, before they would consider shipping it (the old box was dented, but no worse for wear). In a remarkable bit of restraint (if I don't say so myself), I calmly walked out of the UPS office (after waiting in line 30 minutes), and used a remailing company in the area to ship it via UPS at an additional fee. The customer received the monitor a few days later, and yes, it was broken. All of this despite being packed with several inches of hard foam, and in a new, sturdy, 27" Uhaul TV box. The package arrived at the customer's place of business upside down, despite up arrows.

I realize that they are a discount shipper, but, they are not paid to merely ship packages. They are paid to ship them in one piece. If they can't do that, I think that they should get out of the business and quit running an insurance scam. I can't return repaired monitors to people with the screws missing, saying, "it's because I'm a discount servicer." There is a minimum level of quality that is acceptable. Sometimes the lowest price is not the best value. As in all things human, let the buyer beware! Hopefully someone will find this useful to that end. We won't be using UPS anymore.

Shipping damage 3: why small monitors are like footballs

(From: Captain Mocha (CaptainMocha@Electra.com).)

I used to work for UPS, I loaded the trucks.

It's amazing you get anything in one piece when shipping with UPS. There are so so so so many packages that need to be loaded in those trucks in just three hours per work shift. The floor managers would encourage us to get the trucks loaded in 'any way possible'.

We used to treat the small packages as 'footballs' and try to throw them through box "goals" from the other end of the truck. We also did 'punt kicking' etc.

So get your facts straight!! It's not 'Hammer Throwing', it's football! =)

(From: Michael Schuster (schuster@panix.com).)

A friend used to work in Manhattan, NYC and during lunch hour he often passed the large camera/electronics retailer, 47th Street Photo, just as the UPS truck was unloading.

It was common for this to be accomplished by having the driver stand in the truck, and KICK the boxes to the ground one by one. So you see, it isn't a hammer throw... It's football (or soccer) that they're modeled after.

Shipping damage 4: so maybe if monitors were packed and shipped like eggs

> "After receiving my third crunched monitor this week, I've about had it with these "Brown Shirted Box Stompers-in-the-mist!" You would think that a well packed 14" clone monitor would survive a 30 mile journey while in their very incapable hands. Actually, I should apologize to Jane Goodall, or whoever that Gorilla babe was--her objects of study would probably be much more care with monitor boxes than the knuckle-walkers at UPS. I have been thinking of doing my own study as to what deceleration it takes to do the damage to a monitor that they have done. My guess is that they must have to drop the thing on concrete from 5 to 7 feet high! I've seen high impact cases shattered, tube necks sheared off, board cracked in half--sheesh, where do they get these guys? From a zoo? Sure, they reimburse the owner, but I lose the repair fee. Does anyone know if can make a loss claim also?"

(From: David Rouse (david.rouse@engineers.com).)

Actually they are probably only being normally clumsy. It probably is the packaging of the monitor that is causing the failures. A monitor is a fragile thing. It only takes about 50 g's of acceleration to kill one. This translates into about a 3-4 inch drop onto a hard surface. The packaging is supposed to protect it by spreading the shock pulse out over a longer time period. Alas, though, all styrofoam (or whatever is being used for cushioning) is not created equal. The maker was most likely trying to save a couple of pennies and use something a little too rigid. The wrong material can provide too little cushioning and in some cases even amplify the shock transmitted to the product under the right(or wrong) circumstances. FYI Trinitron tubes have really bad shock characteristics.

Cleaning plastic monitor cases

For surface contamination like grease or tobacco smoke, a variety of household cleaners will work including Fantastik, Windex, 409, etc. - some better than others depending on the type of coating. Verify that whatever you use is safe for the plastic by trying it out on an inconspicuous location first.

For ozone or heat damage which penetrates deeply into the plastic, painting may be the only a solution. Test on a non-visible section to see how deeply the discoloration has penetrated. For modest discoloration, I have had some success with water and scouring powder containing bleach.

CAUTION: Test any cleaning agent or solvent on an inconspicuous area of the monitor first to be sure it doesn't damage it.

Secret menus

> "I've seen some tantalizing references to the SECRET menu for adjusting VisionMaster Pro 17 monitor secret menu.
>
> Could someone kindly point me to some details so that I can access and properly use this covert functionality?"

(From: Scot Miller (scot@cts.com).)

Shut the power off, then switch it back on while simultaneously holding down the 'menu', '-', and '+' buttons. Then the 'menu' button works normally but will bring up the secret menu.

Reliability and performance of refurbished or remanufactured monitors

> "Considering a 21-inch monitor and have seen a number of resellers beginning to carry refurbished monitors. Under most circumstances I would walk right past anything refurbished for the shiny new model, but at the price of new 21 inchers, well... Monitor would be used primarily in Windows and for playing Quake. Locally I'm seeing prices of $1100.00 to $1300.00 with a 2 year warranty for 1st & 2nd tier products. Feedback, anyone?"

Assuming you can fully test drive it and/or get a money back no questions asked warranty, then they are worth considering. The most critical issue is the condition of the CRT make sure it is bright, sharp, and has no screen burn. If the CRT is in good condition, then there is no reason to think that the rest of the monitor will fall apart or go up in smoke. Note: Test from a power off for at least an hour condition. Once an old CRT warms up, it may appear to be better than it actually is. See the document: Performance

Testing of Computer and Video Monitors for additional evaluation criteria but be warned that no monitor is perfect - some 'defects' you find may be inherent in the design or simply due to normal variations in manufacturing quality control.

The two terms 'refurbished' and 'remanufactured' may be mean the same thing. However, it would probably be worth trying to get a clarification in writing of exactly what was done to the monitor. Depending on the integrity of the reseller, these terms could mean anything from 'well, we turned it on and it didn't blow up' to 'unit was completely overhauled and restored to new specifications replacing parts where necessary'.

Ron's notes on video signal quality problems

From: pinecone@pacbell.net (Ron)

Here are some possible causes for ghosting, smearing, etc.:

1. A poor quality video cable.
2. A video extension cable (making the cable longer always makes things worse).
3. Running the video card and/or monitor too close to their maximum bandwidths.
4. Impedance mismatch between the video card and the monitor. Most cards, monitors, and cables are 75 ohms, but 50 ohm parts exist.
5. Bad video card. I've seen many video cards with this problem, and a manufacturer recently admitted to me that one revision of their board has a grounding defect that causes...ghosting.
6. Bad monitor. I think this is unlikely. Usually poor monitors produce muddy images that hide ghosting, if indeed there is any.

Monitor quality control

(From: Bob Myers (myers@fc.hp.com).)

The bottom line is that I've been involved with the design, manufacture, specification, and purchase of CRT displays for longer than I care to admit, and I can tell you one thing with absolute certainty: it is IMPOSSIBLE to maintain visibly perfect geometry, linearity, etc., on the things over a production run. You can spend hours and hours getting a given unit to look pretty darn good, but even that is iffy - it depends to much on the limitations built into that particular CRT and yoke. And even if you CAN get that unit 'perfect', this ISN'T something that you can do in normal production - not unless you find customers willing to pay SIGNIFICANTLY higher costs for the products. Despite claims to the contrary here, that has NOT been the desire expressed by the market.

(From: Gary Flynn (gary@habanero.jmu.edu).)

Many years ago I did TV repair and there were LOTS of adjustments available. I haven't cracked open a TV or monitor lately but your statement about CRT and yoke limitations jogged my memory. Are most monitors today "rack and stack" or are there internal factory adjustments? Having just ordered a 17" Trinitron based monitor and having confidence in my old TV abilities makes me want to explore :-)

(From: Sam.)

No, you will not find many of these sorts of twiddles in modern monitors. Most purity, convergence, and geometry adjustments are via strategically placed magnets glued to the CRT, the orientation of multiple magnetized rings, the position and tilt of the deflection yoke, etc. You really do not want to mess with these unless you have no choice and lots of time.

Many modern monitors control the picture adjustments via hidden menus and digital controls.

The 'good old days' are gone forever... :-) :-(.

Is Big Brother watching over your shoulder?

> "Does anyone out there know how the Timex/Microsoft watch is programmed by holding the watch in front of a VGA monitor. There must me some sort of sensor on the watch that picks up some sort of pattern on the screen retrace of the monitor...."

(From: Len Turnbow (quartlow@netcom.com).)

I know nothing about the Timex/Microsoft VGA optical communications protocol. But, sometime when you have nothing better to do, you might connect a phototransistor to a biasing source and thence to your oscilloscope. Aim phototransistor at your computer monitor and check out all the weird patterns produced as a result of various screen displays.

Before long, you will note that the leftmost edge of your scope display represents information present near the top of your screen. If you have your trigger properly set, you will also note that the whole contents of the screen are presented (top to bottom) on your scope (left to right).

With a blank white raster, you will be able to move your hand in front of the screen and see the result on your scope a la flying spot scanner. But I digress.

Armed with a borrowed copy of the Microsoft interface software and your phototransistor, you could probably reverse engineer the protocol.

Or ask someone at Microsoft.com :-). What would be the fun in that, though?

(From: David Fries (dfries@mail.win.org).)

I don't know why it would be referred to as 'the Timex/Microsoft watch', when it just includes windows software. It really should be referred to as the Timex Datalink watch. Microsoft wouldn't know anything about the protocol as it is a Timex product (and patent I believe).

I maintain the Linux software to interface with the Timex Datalink watches, model 70, 150, 150s, and Ironman. See: Datalink Library for the Ironman Watch. I can say something of the physical layer communication and that in the past I have decoded the ironman protocol by using a photocell (as opposed to a phototransistor) connected to the sound card input of another computer. A photocell varies resistance with the amount of light it receives, perfect for plugging into a sound card mic in without any other components.

There are two variations, the 150, 150s, and Ironman both send two bytes per screen refresh. There are up to nine lines lit at the top of the screen and 9 lines at the bottom. Each line is a solid white or off. The first line of each set is always on, and used as a start bit, the rest are data bits. The protocol partitions the data into packets with check bytes at the end of each packet followed by a few completely black screens before the next packet. That is why it looks like it flickers, stops, flickers, stops, etc. The screen is set to 60Hz, two bytes per refresh or 120 bytes a second, not exactly speedy by any means and that doesn't include the built in pauses.

The model 70 is similar, but only fills the top nine lines giving it an even slower transfer rate of one byte per refresh or 60 bytes per second.

The protocol makes the monitor into a serial output device because the watch doesn't pay any attention to where the lines are, only the overall brightness of the screen.

Lament of the lack of adjustment pots on the newest monitors

In 'the good old days' before digital controls and service menus, one could spend a substantial fraction of one's life tweaking monitor adjustments. The newest monitors (and TVs) are nearly totally controlled by settings stored in EEPROM. The service adjustments may only be accessible via a port connection to a PC running a special manufacturer specific setup program.

This is the wave of the future and we are stuck with it for better or worse. In all fairness, digital adjustments are less costly to manufacture and permit much more automation in the factory setup of screen geometry, color, and so forth. However, not making the setup software available for a reasonable licensing fee is a serious problem which will result in lost opportunities for smaller independent repair shops.

(From: CiaraTom (ciaratom@aol.com).)

The point is that each manufacturer has written a program for his monitor to tweak things that we used to do with a screwdriver. It is model specific, not generic, and often requires an interface (special cable, with or without circuitry in between) sometimes connecting to your parallel port, sometimes to the serial.

Goldstar does this with a special proprietary software and special cable; Viewsonic has (that cost me $220 - try to recoup that from a repair) and it is so user unfriendly that you don't even know what to do with it.

Analog versus digital LCD flat screen monitors

(From: Bob Myers (myers@fc.hp.com).)

This refers to the interface to the monitor, with "analog" generally meaning that it can plug directly into the same video connector as your typical CRT monitor. Digital-input monitors have in the past required special interface cards, but there are new standards for digital video outputs (such as the VESA "Plug & Display" connector family). The displays themselves (the inner workings aren't REALLY "inherently digital" either - although the interface to the panel itself usually is - but they ARE fixed-format devices, which brings along its own set of problems.

Digital interfaces, assuming you DON'T need a special interface card in the PC, will be less expensive than analog interfaces and will offer better performance. The performance increase doesn't come so much from having the information provided in "digital" form, but rather from having accurate timing information available. The biggest headache in designing an analog interface for these monitors is trying to generate the correct clock for sampling the incoming video. It's usually been done by multiplying the horizontal sync rate up to the proper frequency, but that is hard to do with REALLY good stability, and the phase relationship between the H. sync signal and the video isn't all that reliable. This makes for an unstable display, with what looks like considerable noise (especially when you have lots of single-pixel details).

Why is there a growth on my monitor cable?

(From: David Kessner (davidk@peakaudio.com).)

Well, it is a ferrite sleeve or bead. There's a thing called a ferrite bead which is a simple doughnut, sleeve, or bead that a wire goes through. Electrically this is similar to an inductor. There are other, larger, types that are made to clamp on to cables.

The practical effect of a ferrite bead (FB) is that it causes a resistance at high frequencies, but almost no resistance at low frequencies. Most FB's are rated at XXX ohms at YYY MHz. Small ones are typically about 25 ohms at 100 MHz, with the resistance increasing with frequency.

Usually, FB's are used to filter out high frequency noise. In a cable, if you provide a high frequency resistance then you will have less high frequency current as well. This means less high frequency signals or noise on the line. This makes the FCC happy, since you won't be emitting as much EMI/RFI.

When you see FB's on cables, it is usually put there as a quick fix. Someone will design a device and it'll fail FCC testing. Through trial and error, they will find that putting a FB on the cable will make it pass. So they put one on and ship it that way. Well designed cards either have FB's on the PCB, or they do something else to reduce the EMI/RFI emitted.

There are other uses for FB's, but this is the general use of them when cables are concerned.

(From: Douglas W. Jones (jones@pyrite.cs.uiowa.edu).)

The thing is a ferrite core. It is used to control EMI/RFI interference. They're sometimes called filter blocks, because they're a block of ferrite used as a filter, but sometimes people just call the thing "a ferrite".

You can buy after-market filter blocks from ParaCon; these just clip onto the outside of a cable. They're listed in the DigiKey catalog under the name "ferrites" on the catalog page, but they're indexed under "filter blocks".

What do they do? Two things. First, if you've got a wire coming out of your electronic whatsit, that wire can act as a transmitting antenna for any RF oscillator within the whatsit. So, the cable between your computer and your video monitor might end up transmitting not only a base-band video signal at somewhere near 10 Mhz, but it could also transmit your CPU clock signal and other annoying signals generated within your computer's box.

To keep the cable from transmitting a video signal, we use coaxial cable with a decent shield. To keep the cable as a whole from transmitting the CPU clock and other higher frequency signals, we put a ferrite core around the cable. This acts as a low-pass filter preventing common-mode signals from getting through while allowing balanced signals (properly sent over the coaxial cable) to get to the video monitor.

The second possibility to worry about is the cable acting as a receiver. This is particularly troublesome when there is a ground loop. For example, my computer and video monitor both have grounded line cords that are plugged into the wall. The computer cable to the video monitor also has a ground path, through the shield, so there's a loop, from wall outlet to computer to video monitor to wall outlet. This loop acts as a loop antenna, and it can pick up signals from around 100 Khz to 1 Mhz quite well, depending on the geometry of the loop. These could cause real problems if they were confused with logic signals inside the computer.

The standard advice to electrical engineers is: Avoid ground loops. When this advice fails, the fallback position is, break the loop with a filter. That's what the filter block does!

- Back to Monitor Repair FAQ Table of Contents.

Service Information

Advanced monitor troubleshooting

If the solutions to your problems have not been covered in this document, you still have some options other than surrendering your monitor to the local service center or the dumpster.

Also see the related document: Troubleshooting of Consumer Electronic Equipment.

Manufacturer's service literature: Service manuals may be available for for your monitor. Once you have exhausted other obvious possibilities, the cost may be well worth it. Depending on the type of equipment, these can range in price from $10-150 or more. Some are more useful than others. However, not all include the schematics so if you are hoping to repair an electronic problem try to check before buying.

Inside cover of the equipment: TVs often have some kind of circuit diagram pasted inside the back cover. In the old days, this was a complete schematic. Now, if one exists at all for a monitor, it just shows part numbers and location for key components - still very useful.

SAMs Photofacts: These have been published for over 45 years but have never been common for monitors. There are a few for some early PC monitors but for anything modern, forget it.

Whatever the ultimate outcome, you will have learned a great deal. Have fun - don't think of this as a chore. Electronic troubleshooting represents a detective's challenge of the type hat Sherlock Holmes could not have resisted. You at least have the advantage that the electronics do not lie or attempt to deceive you (though you may beg to differ at times). So, what are you waiting for?

Additional information

For general information on PC video cards and monitors, see the FAQ of the USENET newsgroup: comp.sys.ibm.pc.hardware.video. This document has a wealth of data on nearly everything you could possibly want to know about video for the PC world.

The FAQ is available via ftp and the WWW:

To ftp a text-only version of this FAQ, and/or the chipset list:

- Compressed Video FAQ

- Compressed Video Chipset List

The FAQ has received news.answers approval, so it should be archived at rtfm.mit.edu and all mirrors, as well as in news.answers and comp.answers.

Contributions, questions and corrections always welcome and appreciated.

The USENET newsgroup: sci.electronics.repair

Where you have a specific question on a particular monitor (or other equipment), posting the make and model and a concise description of the problem and what you have already attempted, may result in suggestions from both professionals and others like yourself who have had experience with your monitor.

See the document: Troubleshooting of Consumer Electronic Equipment for many additional on-line resources to aid in monitor servicing.

Suggested references

There don't seem to be that many readily available books on monitor repair. Here are a couple:

- Troubleshooting and Repairing Computer Monitors
  Stephen Bigelow
  McGraw Hill, 1995
  Hardcover, 304 pages
  ISDN 0-07-005408-8

  Some of the topics are

  - CRT alignment and degaussing
  - State-of-the-art plasma displays
  - Specifications and architectures of monochromw, CGA, EGA, VGA, and SVGA
  - Linear, switching, and high voltage powersupplies
  - Logic and drivers supporting both CRT and LCD monitors
  - Graphics standards
  - Sample schematics

  However, a couple of people have commented that the document you are reading is more useful and better organized than this book :-). I cannot comment as I have not seen it. So, try to check it out before purchasing or make sure you can return it if not satisfied.

- Computer Monitor Troubleshooting and Repair
  Joe Desposito and Kevin Garabedian
  Howard W Sams and Co, 1997
  ISBN: 0-7906-1100-7

  Lots of diagrams and photos, schematics, and examples of problems and how they are solved. This is a good basic book.

Also, since monitors share much in common with color TVs, books on their repair would also be applicable for many problems - and may be more readily available from your local public library.

There don't seem to be nearly as many TV repair books for modern solid state TVs as I recall for old tube sets. Here are is one suggestion which you may find (or its predecessor) at your local public library (621.384 if you library is numbered that way) or a technical book store. MCM Electronics has this as well.

- Troubleshooting and Repairing Solid State TVs
  Homer L. Davidson
  2nd Edition, 1992
  TAB Books, Inc.
  Blue Ridge Summit, PA 17214

(From: Skip (skipperm@mtc2.mid.tec.sc.us))

I recently attended a monitor repair course put on by Philips electronics. They have a technical training manual which can probably be ordered without signing up for the course:

- Hi-Res Computer Display Systems
  Part # ST1496-1093LE/KGPGC
  Philips Service Co.
  P.O. Box 555, Jefferson City, TN 37760
  Phone: 423-475-0044

  This book does an excellent job of explaining how these monitors work. Most is about Philips monitors but the material is applicable to most manufacturers. This course and reading this text has help me a lot with my monitor repair efforts.

The following doesn't specifically deal with monitors but may be of interest as well:

- Video Demystified: A Handbook for the Digital Engineer
  Keith Jack
  Brooktree Corporation, 1993
  ISBN 1-8787-0709-4

FCC ID Numbers of monitors

Only a few manufacturers actually produce the vast majority of computer and video monitors. For example, Radio Shack, Magnavox, and Emerson do not make their own monitors (I can tell you are not really surprised!). All those house-brand monitors that come bundled with mail order or 'Mike and Joe's Computerama' PCs are not actually put together in someone's garage! Well, not that many, at least :-).

How do you determine the actual manufacturer? For most types of consumer electronic equipment, there is something called an 'FCC ID' or 'FCC number'. Any type of equipment that may produce RF interference or be affected by this is required to be registered with the FCC. This number can be used to identify the actual manufacturer of the equipment.

A cross reference and other links can be found at:

- S.E.R. FAQ FCC ID Links

Parts information

I have found one of the most useful single sources for general information on semiconductors to be the ECG Semiconductors Master Replacement Guide, about $6 from your local Philips distributor. STK, NTE, and others have similar manuals. The ECG manual will enable you to look up U.S., foreign, and manufacturer 'house' numbers and identify device type, pinout, and other information. Note that I am not necessarily recommending using ECG (or other generic) replacements if the original replacements are (1) readily available and (2) reasonably priced. However, the cross reference can save countless hours searching through databooks or contacting the manufacturers. Even if you have a wall of databooks, this source is invaluable. A couple of caveats: (1) ECG crosses have been known to be incorrect - the specifications of the ECG replacement part were inferior to the original. (2) Don't assume that the specifications provided for the ECG part are identical to the original - they may be better in some ways. Thus, using the ECG to determine the specifications of the parts in your junk bin can be risky.

Other cross reference guides are available from the parts source listed below.

Monitor schematics and manuals

In some cases, these may be available from the manufacturer and even reasonably priced (much less than other sources). For example, a manual for a typical CTX monitor is only $15 from CTX but around $50 elsewhere. However, more often than not, this will not be the case.

See the manuals list in the document: Troubleshooting of Consumer Electronic Equipment.

Information sources on the Internet

Many manufacturers are now providing extensive information via the World Wide Web. The answer to you question may be a mouse click away. Perform a net search or just try to guess the manufacturer's home page address. The most obvious is often correct. It will usually be of the form "http://www.xxx.com" where xxx is the manufacturers' name, abbreviation, or acronym. For example, Hewlett Packard is hp, Sun Microsystems is sun, Western Digital Corp. is wdc. NEC is, you guessed it, nec. It is amazing what is appearing freely accessible via the WWW. For example, monitor manufacturers often have complete information including detailed specifications for all current and older products. Electronic parts manufacturers often have detailed datasheets for their product offerings.

Don't expect to find complete schematics (at least none of the models I checked went into this depth) but there will be specifications, setup and adjustment instructions, and, depending on model, some troubleshooting information, disassembly instructions and exploded views, etc.

Interchangeability of components

The question often arises: If I cannot obtain an exact replacement or if I have a monitor, TV, or other equipment carcass gathering dust, can I substitute a part that is not a precise match? Sometimes, this is simply desired to confirm a diagnosis and avoid the risk of ordering an expensive replacement and/or having to wait until it arrives.

For safety related items, the answer is generally NO - an exact replacement part is needed to maintain the specifications within acceptable limits with respect to line isolation, X-ray protection and to minimize fire hazards. Typical parts of this type include flameproof resistors, some types of capacitors, and specific parts dealing with CRT high voltage regulation. However, during testing, it is usually acceptable to substitute electrically equivalent parts on a temporary basis. For example, an ordinary 1 ohm resistor can be substituted for an open 1 ohm flameproof resistor to determine if there are other problems in the horizontal deflection circuits before placing an order - as long as you don't get lazy and neglect to install the proper type before buttoning up the monitor or TV.

For other components, whether a not quite identical substitute will work reliably or at all depends on many factors. Some deflection circuits are so carefully matched to a specific horizontal output transistor that no substitute will be reliable.

Here are some guidelines:

1. Fuses - exact same current rating and at least equal voltage rating. I have often soldered a normal 3AG size fuse onto a smaller blown 20 mm long fuse as a substitute.

2. Resistors, capacitors, inductors, diodes, switches, potentiometers, LEDs, and other common parts - except for those specifically marked as safety-critical - substitution as long as the replacement part fits and specifications should be fine. It is best to use the same type - metal film resistor, for example. But for testing, even this is not a hard and fast rule and a carbon resistor should work just fine.

3. Rectifiers - many are of these are high efficiency and/or fast recovery types. Replacements should have at equal or better PRV, Imax, and Tr specifications.

4. Posistors - many of these are similar. Unfortunately, the markings on the devices are generally pretty useless in determining their ratings. Note, however, that the prices for replacement posistors may be quite reasonable from the original manufacturer so it may not make sense to take the risk of using an unknown part.

   (From: Stefan Huebner (Stefan.Huebner@rookie.antar.com).)

   In most cases you can use a standard 3-terminal-device, the resistance of the temperature dependent resistors in it are nearly identical. Here is a list of possible replacement devices:

   380000-01, 24340521, 2199-603-1201, 163-024A, 163-035A, CO2200-N66, C8ROH, QX265P05503, 32112026, 4822-A1-11240148, 02199-003-120, 15-08-001A, 5391560067, F400001.

5. Transistors and thyristors (except HOTs and SMPS choppers) - substitutes will generally work as long as their specifications meet or exceed those of the original. For testing, it is usually OK to use types that do not quite meet all of these as long as the breakdown voltage and maximum current specifications are not exceeded. However, performance may not be quite as good. For power types, make sure to use a heatsink.

6. Horizontal output (or SMPS) transistors - exact replacement is generally best but except for very high performance monitors, generic HOTs that have specifications that are at least as good will work in many cases. Make sure the replacement transistor has an internal damper diode if the original had one. For testing with a series light bulb, even a transistor that doesn't quite meet specifications should work well enough (and not blow up) to enable you to determine what else may be faulty. The most critical parameters are Vceo/Vcbo, Ic, and Hfe which should all be at least equal to the original transistor. I have often used by favorite BU208D as a temporary substitute for other HOTs in TVs and SMPS (chopper) transistors. However, for high performance monitors, a BU2508D type is a better choice. Make sure you use a heatsink (with insulating washer if

applicable) and thermal grease in any case - even if you have to hang the assembly with a cable-tie to make it fit.

However, using an HOT with much better specs may actually result in early failure due to excessive heating from insufficient and/or suboptimal base drive. See the document: TV and Monitor Deflection Systems for more info.

Also see the section: Replacement power transistors while testing.

7. Deflection yokes - in the old days, particularly for TVs, all of these were quite similar. It was common to just swap with one that fit physically and at most need to adjust or change a width coil. With high performance auto-scan monitors, this is no longer the case. Sometimes it will work but other times the power supply won't even be able to come up as a result of the impedance mismatch due different coils and pole piece configurations. In addition, there may be other geometry correction coils associated with the yoke that could differ substantially.

   However, if you are really determined, see the section: Swapping of deflection yokes.

8. CRTs - aside from the issues of physical size and mounting, many factors need to be considered. These include deflection angle, neck diameter, base pinout, focus and screen voltage requirements, purity and convergence magnets, etc. Color CRT replacement from scratch (not using a CRT and yoke/convergence/purity assembly from another monitor) is rarely worth the effort in any case. But, trying to substitute a different CRT is really asking for frustration.

   For monochrome CRTs, there is less variation and this may be worth a try.

The following are usually custom parts and substitution of something from your junk box is unlikely to be successful even for testing: flyback (LOPT) and SMPS transformers, interstage coils or transformers, microcontrollers, and other custom programmed chips.

Substituting mainboards and other modules from identical models is, of course, possible but some realignment may be needed. Even a monitor from the same manufacturer that is not quite identical may use the same subsystems, perhaps depopulated or jumpered differently.

Horizontal output transistor pinouts

You will nearly always find one of two types of horizontal output transistors in TVs and monitors:

- Metal can - TO3 package:

```
        / _ \          View from bottom (pin side)
       /  O  \
      / o   o \
     (  B   E  )       B = Base, E = Emitter, C = Collector
      \       /
        \ o / C        The metal case is the Collector.
```

- Plastic tab - TO3Pn (n = several suffixes) package:

```
       _____
      /     \
     |   o   |        View from front (label side)
     |       |
```

```
       |        |        B = Base, E = Emitter, C = Collector
       |________|
         | | |           If there is an exposed metal tab, this is the
         | | |            Collector as well.
         B C E
```

Some other transistor types use the same pinout (TO66 for metal can, TO218 and TO220 for plastic tab) but not all. However, for horizontal output transistors, these pinouts should be valid.

Note that those with a built in damper diode may read around 50 ohms between B and E (near 0 on the diode test range) - this is normal as long as the resistance is not really low like under 10 ohms.

How do you locate the HOT

Well, it is usually the LARGEST transistor in the set near the LARGEST transformer in the set (flyback - the thing with the FAT red wire connecting to the picture tube) on the LARGEST heat sink in the set.

Got that? :-)

Or, in the good old days - oops - but that was before computer monitors...

(From: Don Wall (d.wall@nunet.neu.edu).)

Sure, it's usually the largest tube in the set, has a top cap, runs very hot, and is often a 6BQ6G or some such. (tongue firmly in cheek) Actually, back in the days of yore, the Horizontal Output Tube was frequently referred to as the HOT; guess some things don't change!

Replacement power transistors while testing

During testing of horizontal deflection circuits or switchmode power supplies, particularly where the original failure resulted in the death of the HOT or chopper, overstress on replacement transistors is always a possibility if all defective components have not be identified.

Therefore, using a part with better specifications may save you in the long run by reducing the number of expensive blown parts. Once all other problems have been located and repaired, the proper part can be installed.

However, this is not always going to work. In a TV and especially a high performance monitor, the HOT may be closely matched to the drive and output components of the deflection circuits. Putting in one with higher Vce, I, or P specifications may result in overheating and failure due to lower Hfe.

Where possible, a series load like a light bulb can be used limit the maximum current to the device and will allow you to power the equipment while checking for other faults. Some designs, unfortunately, will not start up under these conditions. In such cases, substituting a 'better' device may be the best choice for testing.

(From: Glenn Allen (glenn@manawatu.gen.nz).)

I been repairing SMPS of all types but when I started on those using MOSFETs I was blowning a few of them when replaced because something else was faulty.

Ever since I have been using a BUZ355 on a heat sink I haven't blown it. It is rated at 800 V, 6 A, and 220 W. it is a TO218 case bigger than a T0220. It seems the higher ratings allows you to do repair where as a something like a 2SK1117 or MTP6N60 will just blow.

Testing of replacement HOTs

The following is useful both to confirm that a substitute replacement HOT is suitable and that no other circuit problems are still present. However, single scan line anomalies (particularly when changing channels and/or where reception is poor with a TV or when switching scan rates and/or when no or incorrect sync is present with a monitor) resulting in excessive voltage across the HOT and instant failure are still possible and will not result in an HOT running excessively hot.

(From: Raymond Carlsen (rrcc@u.washington.edu).)

After installing a replacement HOT in a TV set or monitor, I like to check the temperature for awhile to make sure the substitute is a good match and that there are no other problems such as a weak H drive signal. The input current is just not a good enough indicator. I have been using a WCF (well calibrated finger) for years. For me, the rule of thumb, quite literally, is: if you can not hold your finger on it, it's running too hot, and will probably fail prematurely. Touching the case of the transistor or heat sink is tricky....

Metal case transistors will be connected to the collector and have a healthy pulse (>1,200 V peak!) and even with plastic case tab transistors, the tab will be at this potential. It is best to do this only after the power is off and the B+ has discharged. In addition, the HOT may be hot enough to burn you.

A better method is the use of an indoor/outdoor thermometer. I bought one recently from Radio Shack for about $15 (63-1009). It has a plastic 'probe' on the end of a 10' cable as the outdoor sensor. With a large alligator clip, I just clamp the sensor to the heat sink near the transistor and set up the digital display near the TV set to monitor the temperature. The last TV I used it on was a 27" Sanyo that had a shorted H. output and an open B+ resistor. Replacement parts brought the set back to life and the flyback pulse looked OK, but the transistor was getting hot within 5 minutes... up to 130 degrees before I shut it down and started looking for the cause. I found a 1 uF 160 volt cap in the driver circuit that was open. After replacing the cap, I fired up the set again and monitored the heat sink as before. This time, the temperature slowly rose to about 115 degrees and stayed there. I ran the set all day and noticed little variation in the measurement. Test equipment doesn't have to cost a fortune.

Removing and replacing the deflection yoke

Should you need to remove the deflection yoke on a color CRT, some basic considerations are advised both to minimize the needed purity and convergence adjustments after replacement as well as to prevent an unfortunate accident.

The position and orientation of the yoke (including pitch and yaw) and magnet assembly (purity and static convergence rings, if used) are critical. Use paint or White-Out(tm) to put a stripe across all of the magnet rings so you will know their exact positions should they accidentally shift later. If there are rubber wedges between the yoke and the funnel of the tube, assure that they are secure. Tape them to be doubly sure as adhesive on old tape dries up with age and heat and becomes useless. This will avoid the need for unecessary dynamic convergence adjustments after reassembly.

The neck is the most fragile part of the CRT so do not apply any serious side-ways force and take care not to bend any of the pins when removing and replacing the CRT socket.

The yoke and purity/static convergence assemblies will be clamped and possibly glued as well. However, the adhesive will probably be easily accessible - big globs of stuff like hot melt glue and/or RTV silicone. Carefully free the adhesive from the glass neck of the CRT. Loosen the clamps and gently wiggle the magnets and yoke off the neck. They may appear stuck from age and heat but should yield with gently persuasion.

Once the yoke is replaced, some fine adjustments of the picture rotation, purity, and static and dynamic convergence may be needed but hopefully with your most excellent diagrams, these will be minimal.

Similar comments apply for monochrome CRTs but there are far fewer issues as the yoke is positioned firmly against the funnel of the CRT and rotation and centering are usually the only adjustments. However, there may be magnets located on swivels or glued to strategic locations on the CRT envelope to correct for geometric distortion.

Swapping of deflection yokes

This should work with identical TVs or monitors. Your mileage will vary if you are attempting a swap between monitors with similar specifications. Chances of success for monitors with widely different screen sizes or scan rate specifications is close to zero.

One indication of compatibility problems would be major differences in resistance readings for the corresponding yoke windings, CRT HV and other bias levels, etc.

Before you do the transplant, see the section: Removing and replacing the deflection yoke for procedures and precautions to minimize problems in realignment.

Make a precise diagram of everything you do.

Keep the purity/static convergence magnet assembly with the original CRT if possible and install it in the same or as nearly the same position as possible when you replace it.

Once you are sure of the connections, power it up carefully - there is no assurance that your yokes are compatible. A yoke with a much lower resistance or inductance than the original may overstress components in the power supply.

You will then need to go through all the adjustments starting with purity and convergence.

Swapping of non-identical CRTs

Given the problems of just replacing a CRT with an identical new one, it isn't surprising that attempting to substitute a CRT which is not the same type will result in difficulties - to say the least. Obviously, the closer in size, scan rate (for monitors), and deflection angle, the more likely the chances of success. Where the alternative is to junk the TV or monitor, it may be worth a shot - and you may get lucky!

It may be best to transfer as much as possible with the CRT - yoke and purity and convergence magnets. The connectors to the yoke may need to be changed but this may be the least of your problems. Difference in yoke impedance and other characteristics may result in anything from incorrect size to a truly spectacular melt-down! The latter is much more likely with SVGA monitors compared to similar size/deflection angle TVs.

Where the neck size is the same, the yoke can be moved from one CRT to the other but you will have to do a complete purity and convergence set up and even then you may have uncorrectable convergence errors. See the section: Swapping of deflection yokes.

(From: J. G. Simpson (ccjgs@cse.bris.ac.uk).)

Monitors are generally designed by choosing a CRT, then the EHT, then designing a yoke to scan the CRT, then designing a driver circuit to drive the yoke.

In a CRT test lab it's common to have variable supplies for EHT and other voltages, a small selection of yokes, and variable amplitude drive circuits.

EHT affects scan sensitivity, brightness, spot size. You can't get high brightness and small spot size on a large monitor with 3 kV of EHT. Virtually every variable has some effect on convergence. Spot size is important, in as much as you want most of it on the phosphor and not the shadow mask.

Provided the neck size is the same you can swap tubes in yokes but don't expect it to work very well. Different tube manufacturers may use radically different gun structures. A given yoke and its driver may give underscan or overscan and it's pretty well certain that convergence will be way off.

The military spends a small fortune on trying to get the drop into the yoke and it flies with no adjustment or convergence CRT. For the rest of us swapping a CRT is a pain in the butt.

Decayed glue in electronic equipment

Larger components like electrolytic capacitors are often secured to the circuit board with some sort of adhesive. Originally, it is white and inert. However, with heat and age, some types decay to a brown, conductive and/or corrosive material which can cause all sorts of problems including the creation of high leakage paths or dead shorts and eating away at nearby wiring traces.

The bottom line: Most of the time, this stuff serves no essential purpose anyhow and should be removed. A non-corrosive RTV or hot-melt glue can be used in its place if structural support is needed.

Repair parts sources

For general electronic components like resistors and capacitors, most electronics distributors will have a sufficient variety at reasonable cost. Even Radio Shack can be considered in a pinch.

However, for modern electronic equipment repairs, places like Digikey, Allied, and Newark do not have the a variety of Japanese semiconductors like ICs and transistors or any components like flyback transformers or degauss Posistors.

See the document: Major Service Parts Suppliers for some companies that I have used in the past and others that have been recommended. Also see the documents: Troubleshooting of Consumer Electronic Equipment and Electronics Mail Order List (this one is quite dated though) for additional parts sources.

Sources for adapters and cables

Office and computer supply companies like Inmac and Global may have some very common types like VGA switch boxes and extension cables - of unknown quality.

However, there are companies specializing in cables for computers, video, and communications. For example:

- Black Box Corporation. Check out their on-line catalog and other information.

Monitor replacement cables

Here is a company that used to supply replacement cables for a wide variety of computer monitors.

- Interface 2 Ltd (UK) (formerlay A+G Computerware Limited)

I don't know if they still have any standard products though. A custom made cable might cost more than a dozen new monitors. :)

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-- end V3.22 --