

# Troubleshooting Monitor Problems

*Many common monitor problems are easily fixed if you know what you're looking for, but it's important to keep safety in mind when dealing with high-voltage devices, and to recognise when it's better to let the experts take over.*

By David Stott

**D**espite the fact that monitors are fairly robust when compared with the internal logic circuitry of personal computers, display monitors can have a considerably higher failure rate.

There are two major reasons for this: firstly, the circuitry in monitors operates at a much higher voltage than that in the PC, and secondly, while PCs are digital circuitry, which either works or doesn't, monitors are mostly analogue circuitry which can gradually drift off and give inferior performance.

Most of the logic circuitry inside a PC operates at around 5 volts, and such a low voltage induces virtually no stress on the circuitry. However, monitor circuitry can operate at voltages up to 10,000 volts for monochrome displays, and anything up to around 25,000 volts for colour displays. Such high voltages impose considerable stress on the components and may cause them to drift in value, and this will cause corresponding drifting and non-linearity in the displayed image.

Furthermore, digital logic gates are either on or off, with essentially no in-between states, whereas the analogue circuitry of a CRT monitor can take any voltage in a continuously varying range, and this gives a lot more scope for things to go wrong.

In this article, I will discuss the basic principles of operation of display monitors, discuss the faults and maladjustments which can arise, and describe how to fix them. It is also worth considering using a monitor test utility - see below.

**Important: Lethal voltages exist in a monitor long after it has been turned off and disconnected from the electricity supply. Do not touch anything inside the case unless you know exactly what you are doing.**

## ***CRT Principles***

The primary component in a display monitor is the display tube or cathode ray tube (CRT). This fan-shaped glass tube contains a vacuum through which electrons may travel. At the rear end of the CRT is a (usually nickel) cylindrical cathode, or electron gun, which is heated by a small 6.3 V heater in order to "boil off" electrons - this is the principle of thermionic emission.

Electrons, being negatively charged, are attracted to the positively charged anode at the other end of the tube, and accelerate, in a stream, to strike the phosphor coating on the inside of the glass face of the tube. When the electron beam hits the phosphor, the phosphor emits light; this light can be green, orange, pale blue or white, depending on the type of phosphor, and the glow might persist for some time or fade quickly.

The anode has a very high positive voltage applied - typically tens of thousands of volts - and it can be easily identified by the large rubber cap over its connector behind the tube face, and the thick rubber insulation on its wiring.

Left to its own devices, the electron stream will simply strike a single point in the centre of the tube face. However,

because a magnetic field exerts a force on charged particles we can apply a magnetic field around the electron beam, and "bend" the stream to strike any spot on the face of the tube.

The magnetic field is supplied by two sets of electromagnets mounted on a yoke and wrapped around the neck of the tube; one set deflects the beam horizontally while the other bends the beam in the vertical axis. On many CRTs you may also find a set of coils behind the deflection yoke which is used to focus the electron beam.

By applying a sawtooth waveform to the horizontal deflection coils we can cause the electron beam to repeatedly move slowly from left to right across the screen and then quickly "fly back" to the left hand side again. Likewise, by applying a lower frequency sawtooth to the vertical deflection coils, we can cause the beam to slowly move down the screen and quickly return to the top.

Incidentally, the high frequency used for the horizontal scan is ideal for driving a transformer (called a flyback transformer) which steps it up to the high voltage required for the CRT anode. You can find the flyback transformer by following the thick insulated wire back from the anode - but keep your fingers clear!

In the case of a computer monitor (as opposed to a television screen), the electron beam is normally turned off, and is turned on when we want to illuminate a particular spot on the screen. This is known as modulation. By doing this under the control of a character generator as part of an

adapter card we can display text on the screen or, by writing directly into video memory, we can create graphics.

The electron beam is modulated only during the horizontal forward scans, and is turned off during both the horizontal and vertical retrace intervals. But this introduces another complication: somehow the information coming from the graphics adapter must be synchronised to the sweeps of the electron beam (or vice versa, which is actually the case).

This is achieved by the generation, by the graphics adapter, of horizontal and vertical sync pulses, each of which triggers the retrace and positions the electron beam at the left or top of the screen. Some video cards provide separate horizontal and vertical sync signals, others combine them into a composite sync signal, while a few (like CGA) have a composite video output in which the syncs and video are all combined into a single signal (usually for use with domestic television sets or television monitors rather than computer monitors).

### Colour

Colour makes life more complicated still. In the monochrome monitor there is a single electron gun, and the face of the tube is completely painted with phosphor, so that, to create an image, we simply have to aim the electron beam at the desired points and turn it on.

Some early colour monitors used a single electron gun and special phos-

phors which changed colour depending upon the energy of the electron beam, in turn controlled by the anode voltage or a grid. These were not very successful as the range of colours which could be produced was limited.

Modern displays use a more complicated arrangement of three electron guns and three different kinds of phosphor spots on the screen, corresponding to the colours red, green and blue. A special grid called a shadow mask ensures that the red gun can hit only red dots, the green gun can hit only green and so on (at least in vastly simplified theory).

Because all three electron beams are deflected by the same coils, they scan across the screen "in step", and are subject to the same deflections. If all three beams strike an adjacent group of red, green and blue dots, the result will be an area on the screen which looks white. If just the green and blue guns are on at full strength, the result will be a cyan pixel. Other colours can be created by varying the intensity of the electron beams to achieve colour mixing.

This is the difference between TTL/RGB monitors and analogue monitors. With the former, the CGA and EGA adapters, for example, have four output signals only (excepting sync): red, green, blue, and intensity (which brightens the current colour). Each signal is either on or off, so that the combination of R, G and B will allow us to generate eight different colours only, and the addition of an intensity signal allows 16 colours.

An analogue monitor, on the other hand, can cope with a continuously varying voltage on each colour input, allowing infinite subtlety in colour mixing. To be precise, a digital computer can never generate a perfectly variable analogue voltage (it must vary in steps under the control of a digital-to-analogue converter), but, in practice, the 256,256 colours available from a VGA provide close to pure analogue video quality.

### Monitor Faults

In general, monitor faults are best left to hardware technicians with special tools and test equipment - particularly in view of the risks of working with high-voltage circuitry. However, certain kinds of maladjustments can be easily rectified in the field with only a trimming tool and screwdriver, and do not really warrant the expense of a technician call-out.

#### Test Patterns

Figure 1 shows a correctly adjusted test pattern, while the figures which follow are idealised representations of various kinds of video faults. Note that the faults are exaggerated to help you identify them more easily; generally any true faults on a monitor are likely to be much more subtle in appearance. Pick the pattern which most closely matches your system, and follow the directions below.

You can easily generate your own test pattern by creating a simple bit-map using, say, the Windows Paint

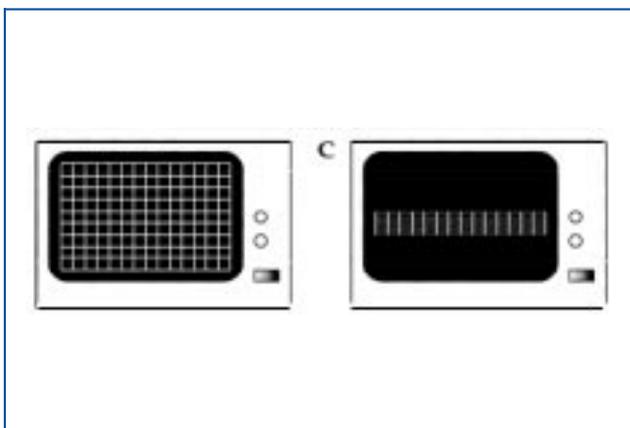


Figure 1 - One of these test patterns is correctly adjusted.

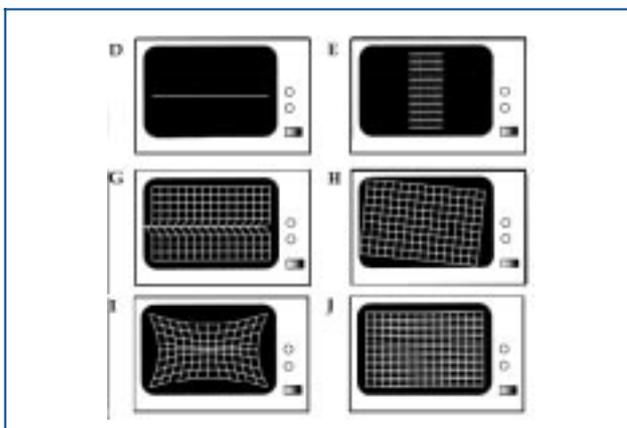


Figure 2 - Common monitor faults.

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program. Use the Fill Tool to flood the background with black and then use the Line Tool to draw a grid of white lines; hold down the shift key to snap the lines to the standard vertical and horizontal grid. Once created, you can display the .BMP file full-screen using the View Bitmap option which is under View on the main menu.

### Safety

The high-voltage circuitry inside a monitor can pose a serious health hazard. When working on exposed high-voltage circuitry make sure that you are well insulated from ground. Keep one hand in your pocket at all times, to minimise the risk of current flow through the chest cavity, and make all adjustments with an insulated trimming tool. If you are in any doubt about the safety of any adjustment or procedure then stop immediately and seek expert assistance.

### Simple Adjustments

On most monitors, some of the controls are easily accessible - perhaps they project through the rear of the cover, as is often the case with horizontal and vertical hold - whereas others are more difficult to get at.

You may have to push a trimming tool through a hole in the cover and feel for the notch in the potentiometer, or you may have to remove the cover entirely and work on exposed circuitry in order to get access to the potentiometers. In such cases, take heed of the safety rules above, use a long plastic

trimming tool and keep fingers well away from high-voltage circuitry.

Controls accessible through the cover are generally labelled on the outside. Internal potentiometers are usually labelled as part of the silk-screening on the printed circuit board, but occasionally they are simply labelled with their component number - RV57 or whatever. This is of no use without a service manual: you can attempt to make adjustments on a trial and error basis if you are desperate enough, but experience shows this is often unsuccessful.

Before you start it is worth bearing in mind that CRT-based monitors only reach their best performance after a warm-up period. Some of the energy from the beam that produces the image on the screen is converted to heat and the heat causes the CRT to change shape slightly. This is enough to change the screen performance, including focus, colour purity and geometry. After 20 to 30 minutes the temperature will reach working levels and, at that point, you will be able to make a proper judgement of the quality of the monitor.

### Common Faults

Figures 2 and 3 show a variety of common monitor faults. Most of these can be corrected by making the appropriate adjustments using the controls provided.

- A Screen completely black (not shown). Check the following things:
  - That the monitor is plugged into

power (at both ends) and switched on (at both ends).

- That the signal cable is connected to the graphics adapter (and especially not a Token Ring card).
  - That the user hasn't simply turned down the brightness overnight, or that a screensaver utility has not cut the video.
  - Turn the brightness right up and look for the screen to go grey and the appearance of the retrace lines. If they are there, then the problem lies either in the input circuitry of the monitor, the video cable or the circuitry of the graphics adapter.
  - If turning up the brightness has no effect, yet the power indicator on the front of the monitor is glowing, then it's most likely that a fault in the monitor circuitry has caused the power supply circuitry to "crowbar" or shut itself off internally. Send out for repair.
- B Screen grey (green, amber) when brightness increased (not shown). In this case the monitor is displaying the raster pattern correctly, so the power supply, high voltage and both horizontal and vertical circuitry are working okay. Check the cabling to the graphics adapter. If that is okay, then the fault must be in the video input or sync circuitry: send out for repair.
- C Image is squashed vertically. Identify the "vertical size" adjustment potentiometer and use it to

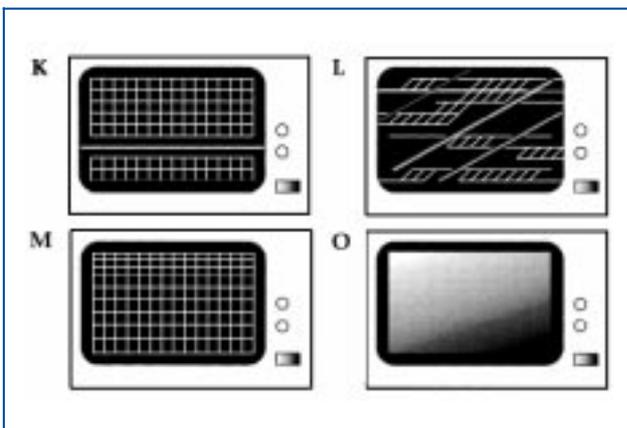


Figure 3 - Common monitor faults.

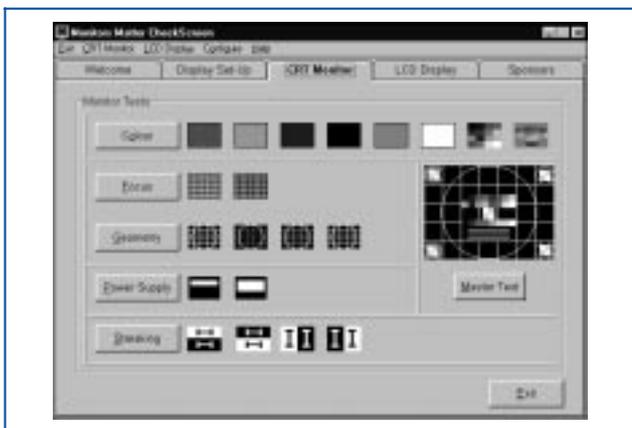


Figure 4 - CheckScreen.

attempt to restore the image to full size. If you are unable to restore the vertical output to full strength, send out for repair. After adjusting vertical size, check vertical linearity.

**D** Image is reduced to a single horizontal line.  
In this case, the vertical output has gone entirely, and it is unlikely that adjusting the "vertical size" will have any effect. Send out for repair.

**E** Image is squashed horizontally.  
Identify the "horizontal size" adjustment potentiometer and use it to attempt to restore the image to full size. If you are unable to restore the horizontal output to full strength, send out for repair. After adjusting horizontal size, check horizontal linearity.

**F** Image is reduced to a single vertical line (not shown).  
As for case D above, this means that horizontal output has gone entirely, and you should send the monitor out for repair.

**G** Image is "tearing" horizontally.  
Generally, this is caused by degradation of the filter capacitors in the monitor power supply. As they break down, they generate noise and cause this problem. Adjustment of the "horizontal sync" control might provide some relief, but it may only give a temporary solution and the problem may recur later; if it does, send the monitor out for repair.

**H** Image is twisted to one side.  
This is caused by the yoke carrying the deflection coils having come free from the tube (it's usually glued in place) and shifting around. On colour monitors, it may be accompanied by colour shifts. The fix is to restore the yoke to the correct position and (in the case of a colour monitor) reconverge the guns, but I wouldn't recommend this job for anyone who is not confident around high-voltage circuitry, for safety reasons. It's also time-consuming. I'd send this one out for repair.

**I** Pincushion distortion.  
Generally speaking, this is caused either by power brown-outs, and is usually quite short-lived, or by problems in the power supply. Send out for repair.

**J** Retrace lines visible.  
Adjustment of the brightness and contrast controls will usually fix this problem. However, if it persists and no combination of these controls will give satisfactory results, then locate the "black level" potentiometer, which is probably set too high, and adjust it accordingly.

**K** Picture rolls vertically.  
The monitor is failing to "lock on" to the vertical sync signal from the graphics adapter. The fact that horizontal sync is okay suggests the graphics card is probably okay, so adjust the "vertical hold" control. If unable to achieve sync, substitute another monitor in order to check the card; if that's okay, send the original monitor out for repair. If the substitute monitor exhibits the same fault, then check the video cable for continuity on the sync lines and, if that's okay, suspect a fault in the graphics card.

**L** Picture "tears" and rolls horizontally.  
Try adjusting the "horizontal hold" and, if necessary, "vertical hold". If these have no effect, proceed as for K above, suspecting the horizontal sync signal.

**M** Test pattern square size varies top to bottom.  
Otherwise known as vertical non-linearity. Locate and adjust the "vertical linearity" potentiometer until all squares are the same size.

**N** Horizontal non-linearity (not shown).  
This looks just the same as vertical non-linearity, only sideways. Locate and adjust the "horizontal linearity" control.

**O** Colour changes across or down screen.  
If a screen changes colour - particu-

larly from top to bottom - one prime suspect is a stray magnetic field from the PC underneath the monitor, particularly the power supply area. Try moving the monitor or inserting a sheet of steel underneath it. If this does not fix the problem, then it could be a convergence problem: send out for repair.

### Monitor Test Program

Whilst our basic bitmap test pattern can be used to diagnose the most common and simple monitor faults, you may find that you need something more sophisticated to help you correct things like colour balance or image focus.

CheckScreen version 1.1 (see Figure 4) is a freeware utility that can be used to test monitors or LCD flat panel displays. The program can be downloaded from [www.csf.org.uk](http://www.csf.org.uk), and runs under Windows 95, 98 and NT. CheckScreen provides a series of test screens to help you adjust your monitor to get the most from it.

### Conclusion

The monitor is the major PC component least likely to become obsolete and require upgrading. Looked after properly there is no reason why a monitor of decent quality can't be used for five to 10 years, long after other system components, such as processors, hard disks, etc, have been replaced by more up-to-date versions. Therefore it is well worth performing some diagnostic tests and adjustments periodically to make sure your monitors stay in tip-top shape.



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