SLOT TECH
MAGAZINE

Presents:

TechFest 10

Name: ______________________

UNDERSTANDING
DIODES AND TRANSISTORS

Do you remember when you first started working on slots? Remember when you didn't even know what a transistor was, let alone how to test one to see if it was good or bad? Now that you've been working on power supplies and monitors for a while, you probably can't recall a time when you didn't know how to test transistors and obtain substitute components.

If you can call to mind the difficulty of those early days, you'll understand why I occasionally take a step back and take a look at some of the fundamentals of troubleshooting. Of these basic skills and procedures, none is more important than the ability to test transistors. If you are already familiar with transistors, this discussion will probably be a complete bore. Consider yourself fortunate to possess such a vital skill and move on in the magazine. I'll catch you next month.

Still here? That's good because you just gotta learn how to test transistors. It's really the whole basis for troubleshooting monitors, power supplies, drivers for diverter coils and a host of other things electronic.

The basic philosophy is simple. Since many circuit faults are caused by transistor failure, we don't always have to know exactly how the circuit works in order to repair it. All we have to do is test the transistors in the circuit and replace the ones that are bad. Since transistors all test the same (with a few exceptions) once you've mastered the test you can fix just about anything!

Diodes

We use the "diode test" function of the meter to test both transistors and diodes. Let's take a quick look at diodes first.

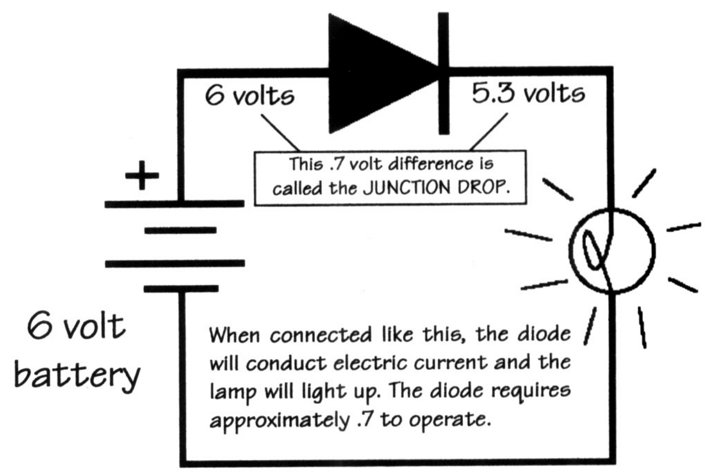
The diode is the simplest semiconductor that we have. The schematic symbol looks like an arrow with a bar at one end. The arrow symbol makes a lot of sense since a diode is a one way gate for the flow of electric current. It's kind of like the turnstile at a supermarket or amusement park where people are allowed to move through the gate in one direction only. A diode has just two component leads. They're called the "anode" and the "cathode."

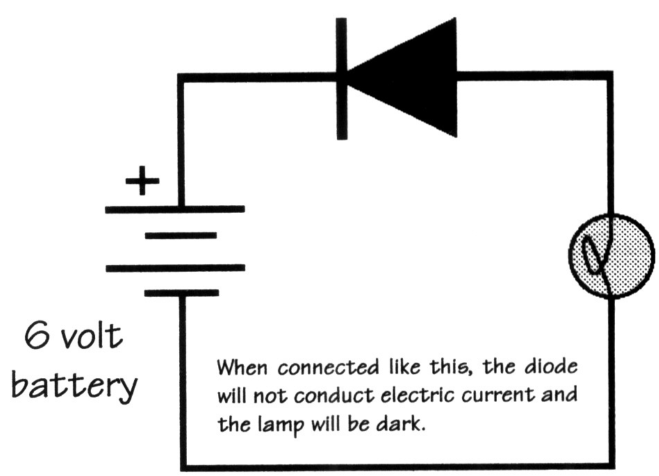
It's interesting to note how the diode actually works inside. Just about all of the diodes we use in games are made of an element called silicon. In its pure form, silicon is an insulator. It cannot pass any electric current through itself. During the manufacturing process, small quantities of impurities called dopants are added to the silicon. The addition of the dopants causes a change in the structure of the silicon atoms.

When phosphorus is added to the silicon crystal, extra electrons are added to the silicon. This gives the silicon a net negative charge, with some free electrons scooting around inside the crystal. We call this type N silicon; N for negative.

When boron is added to the silicon, it develops a net positive charge. We call this type P silicon. We can think of type P silicon as having atoms with "holes" in the electron shell, just waiting for an electron to fall into it. In fact, we call these atoms in the type P silicon "holes."

The diode is made from a single chip of silicon. One half of the chip is type P silicon; the other half is type N silicon. Where the two types of silicon come together, we





A diode is like a one-way gate for electric current.

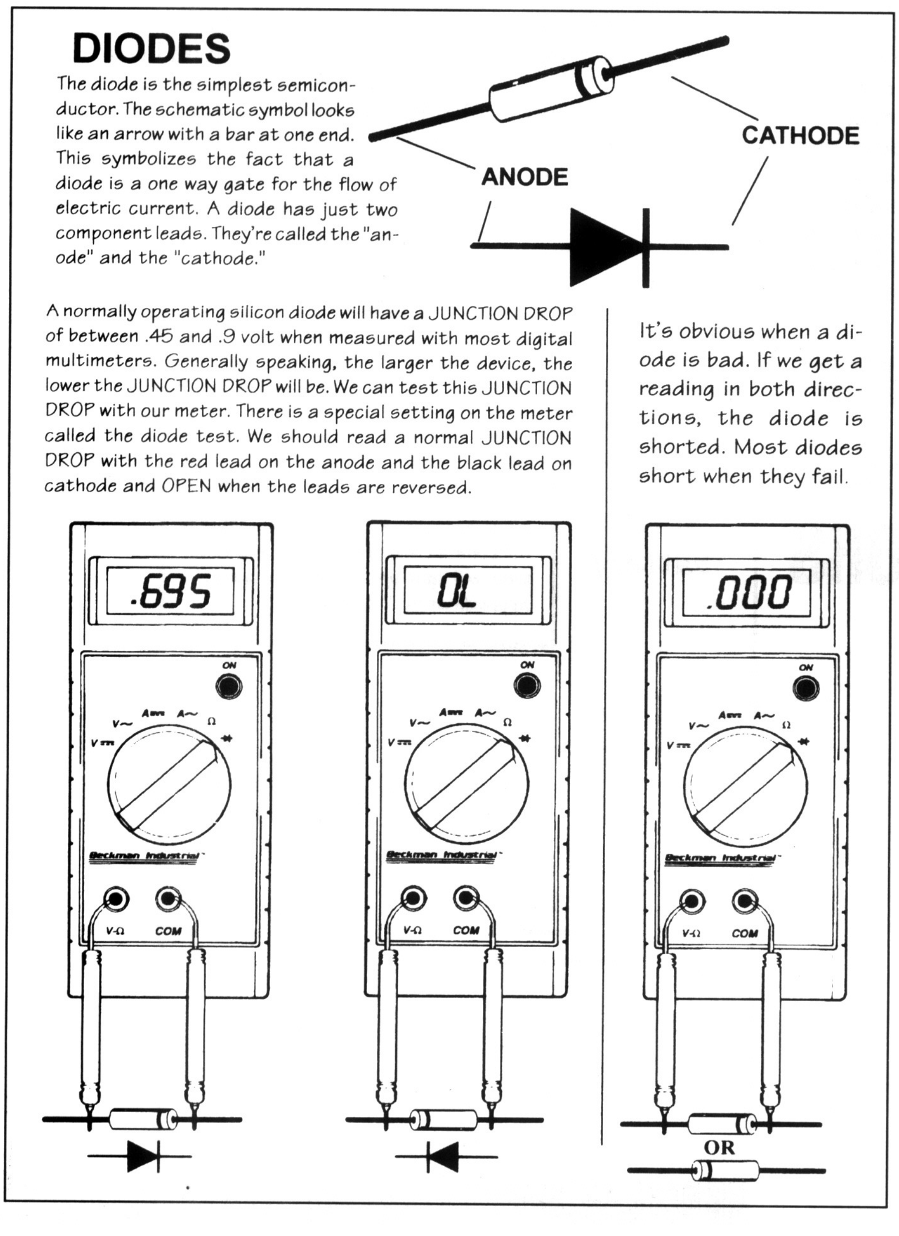
have something called the PN junction. The PN junction acts as a kind of barrier to prevent the free electrons in the type N silicon from reaching the holes in the type P silicon. When we test diodes and transistors, we will actually use the meter to test this PN junction. Your ability to test this PN junction will enable you to repair more electronic equipment than any other single test you will perform!

It takes a certain amount of voltage to push aside the PN junction and allow current to flow through the diode. It takes an average of .7 volt to break down the PN junction and allow current to flow.

Let's hook up this diode and see how it works. The anode is connected to the positive side of the battery. The cathode is connected to the negative side of the battery through the lamp. The electrons are repelled by the negative side of the battery toward the junction and the holes are repelled by the positive side of the battery toward the junction. Where they meet at the junction, the electrons fall into the holes. This pushes the PN junction aside and current flows through the diode.

If the battery is reversed, the holes and electrons are attracted to opposite ends leaving pure silicon as an insulator between them. The silicon insulator prevents current from flowing through the diode. This is why it is called a semiconductor. Sometimes it conducts; sometimes it doesn't.

It takes around .7 volt to break the barrier at the PN junction. This .7 volt is used up inside the diode as the energy required to push the current across the PN junction. We call this .7 volt the "JUNCTION DROP."



A normally operating silicon diode will have a JUNCTION DROP of between .45 and .9 volt when measured with most digital multimeters. Most engineers and technicians use the average of .7 volt when discussing the JUNCTION DROP. Generally speaking, the larger the device, the lower the JUNCTION DROP will be. We can test this JUNCTION DROP with our meter. There is a special setting on the meter called the diode test. When we use the diode test, we are actually measuring the voltage required to get through the PN junction. What we should see is a normal JUNCTION DROP with the red lead on the anode and the black lead on cathode (diode conducting) and OPEN when the leads are reversed.

This means that the diode is doing its job as a one way gate for current. When we read a normal JUNCTION DROP it means that current is flowing through the diode. When we read OPEN, the diode is blocking the current.

It's obvious when a diode is bad. If we get a reading in both directions, the diode is shorted. In fact, most diodes short when they fail. I'd say that 99 out of 100 diode failures are short circuits. If the meter shows OPEN in both directions, the diode is open.

You can usually tell if a diode is good or bad, even when testing diodes in-circuit. Needless to say, if you test a diode in-circuit and it appears to be bad, you should test it again after removing it from the circuit just to be sure.

Diode Specifications

A diode is rated by voltage and current. The voltage rating of a diode is the maximum amount of voltage that the diode can block without breaking down. The voltage rating is listed as PRV (peak reverse voltage) or PIV (peak inverse voltage.)

The current rating is the maximum amount of current that the diode can safely pass without getting too hot. Believe it or not, we use the letter "I" to represent current. Huh??? Early experimenters thought of current as "intensity," so the letter designation "I" has remained with us. Io means output current.

When substituting diodes, you can always use a diode with a higher voltage and/or current rating. Remember, the voltage rating of a diode has nothing to do with the voltage the diode is "putting out." It is simply a rating of the maximum voltage that the diode can block. You can replace a 50 volt, 1 amp diode with a 400 volt, 1 amp diode. You could also use a 50 volt, 3 amp diode or even a 400 volt, 3 amp diode as a replacement.

Transistors

Transistors come in a lot of different shapes and sizes. The packages we commonly see in games are TO-3, TO-220, TO-218 and TO-92. There are two general types of transistors: NPN and PNP. Both are named for the way they are made. They're kind of like a sandwich with type N and type P silicon. The schematic symbol for the two types of transistors is basically the same. Notice that the arrow points away to designate an NPN transistor while the arrowhead points toward the center of the schematic symbol for PNP.

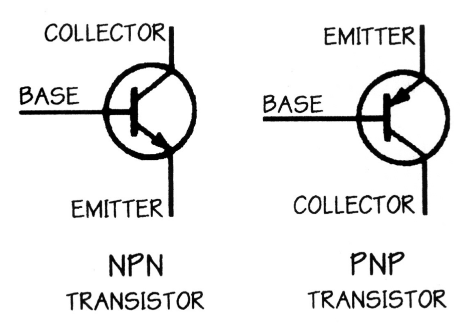
Since we're talking a lot about P's and N's here, chances are pretty good we're talking about a PN junction somewhere. In fact, each transistor has two junctions. The NPN transistor is made of a single chip of silicon that has one area made of type N material, a thinner region made of type P silicon and another N region on the other side. The PNP transistor has N silicon in the middle, surrounded by P silicon.

A transistor has three leads and each lead has a name. They are the emitter, base, and collector. There are two PN junctions in the transistor that we have to test. One is between the base and the emitter. The other is between the base and collector. It is the same test we used for the diode but we'll check two junctions instead of just one.

TESTING TRANSISTORS

Regardless of what type of package they're in, transistors will pretty much all test the same way. You'll need a digital multimeter with a "diode" test.

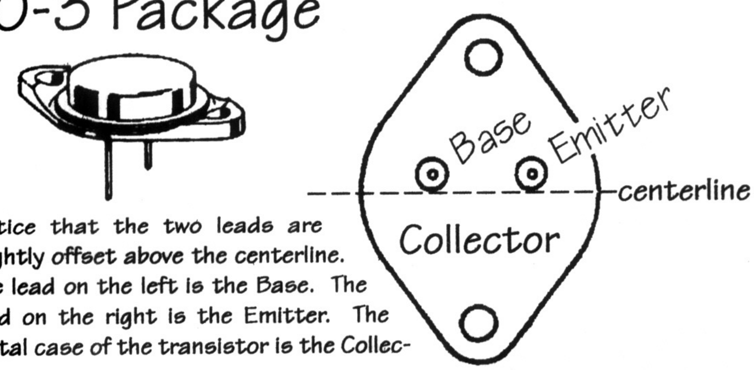
1. Set your meter to the diode test.
2. Connect the red meter lead to the base of the transistor. Connect the black meter lead to the emitter. A good NPN transistor will read a JUNCTION DROP voltage of between .45v and .9v. A good PNP transistor will read OPEN.
3. Leave the red meter lead on the base and move the black lead to the collector. The reading should be the same as in step 2.
4. Reverse the meter leads in your hands and repeat the test. This time, connect the black meter lead to the base of the transistor. Connect the red meter lead to the emitter. A good PNP transistor will read a JUNCTION DROP voltage of between .45v and .9v. A good NPN transistor will read OPEN.
5. Leave the black meter lead on the base and move the red lead to the collector. The reading should be the same as in step 4.
6. Place one meter lead on the collector, the other on the emitter. The meter should read OPEN. Reverse your meter leads. The meter should read OPEN. This is the same for both NPN and PNP transistors.



The schematic symbols are almost identical. If the arrowhead points out, it's an NPN transistor. If the arrow points in, it's a PNP transistor.

If the transistor fails any of these tests, it is bad. If you read a short circuit anywhere, the transistor is bad. As with the diode, you may attempt to test transistors in-circuit. However, transistors will often

TO-3 Package



Notice that the two leads are slightly offset above the centerline. The lead on the left is the Base. The lead on the right is the Emitter. The metal case of the transistor is the Collector.

I_C	V_{CEO}	DEVICE TYPE NPN	DEVICE TYPE PNP	h_{FE} MIN/MAX
15	60	2N3055	MJ2955	20/70
		2N6576		2k/20k
		2N5881		20/100
	80	2N5882	2N5880	20/100
	90	2N6577		2k/20k
	120	MJ15015	MJ15016	20/70
		2N6578		2k/20k
	140	MJ15001	MJ15002	25/150
	200	2N6249		10/50
	275	2N6250		8/50
	300	2N6546		6/30
20	40	2N6257		15/75
	60	2N3772		15/60
		2N6282	2N6285	750/18k
	75	2N5039		20/100
	80	2N5303	2N5745	15/60
		2N6283	2N6286	750/18k
	90	2N5038		20/100
	100	2N6284	2N6287	750/18k
	140	MJ15003	MJ15004	25/150
	200	MJ13330		8/40

TRANSISTOR SPECIFICATIONS

I_C
Collector Current
This is the maximum current (measured in amperes) that can be controlled by the transistor.

V_{CEO} or BV_{CEO}
Collector-to-Emitter Voltage
This is the maximum voltage that the transistor can handle as measured between the collector and the emitter when the base lead is open (not connected.)

h_{FE}
Current Gain or "Beta"
This is an indication of the transistor's ability to amplify an incoming signal. The higher the gain, the less current it takes to drive the transistor. For example, a transistor with a gain factor of 100 will require just 1/100 amp of base current for 1 amp of collector current.

not test properly in-circuit and must be unsoldered and removed from the circuit for proper testing. Don't agonize over whether or not the transistor is bad when testing in-circuit. It only takes 30 seconds to remove the transistor and another 30 to test it properly. Just do it!

Transistor Specifications and Replacements

Transistors are rated much the same as diodes; maximum current and maximum voltage.

I_C- Collector Current - This is the maximum current (measured in amperes) that can be controlled by the transistor. Naturally, large transistors can handle more current that small transistors, just as thick wire can handle more current than thin wire. The largest size transistor we commonly use in games is the TO-3 package, which can handle up to 40 amps of current.

V_{CEO} or BV_{CEO} - Collector-to-Emitter Voltage - This is the maximum voltage that the transistor can handle as measured between the collector and the emitter when the base lead is open (not connected.) This is when the transistor is completely turned off and must block the current from flowing between the collector and emitter of the transistor. Although there are other voltage ratings for transistors, this is generally the only one that's important to us.

h_{FE} - Current Gain or "Beta" - This is an indication of the transistor's ability to amplify an incoming signal. The higher the gain, the less current it takes to drive the transistor. For example, a transistor with a gain factor of 100 will require just 1/100 amp of base current for 1 amp of collector current.

We can lump most transistors into three general categories. Low gain transistors have a gain of up to 250. Medium gain transistors have a gain of 250-750. High gain transistors are those with a gain factor of more than 750. Admittedly, these figures are somewhat arbitrary.

Substituting transistors is just like substituting diodes. You can make the substitution as long as the replacement transistor is the same polarity (NPN or PNP) and has the same or higher voltage rating and current rating.

However, you should try to match the gain rating of the transistor as best you can. Substitute only low gain transistors for low gain transistors, mediums for mediums and highs for highs. This is not actually too difficult. As long as you're in the ballpark you should be okay.

Naturally, if you can obtain an exact replacement you should do so. Most cities have at least one electronic component retailer who carries a series of universal replacement components that can be used as substitutes. These companies publish an extensive cross-reference catalog that will allow you to make substitutions as quickly as locating a word in the dictionary. You simply look up the original part number of the component you want to replace and the index will tell you which substitute to use.

A cross-reference is also available online from NTE. http://www.nteinc.com/. You can download their cross-reference database as well, making it possible for you to cross-reference components without having to be on-line.

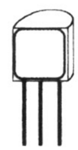
TRANSISTOR SUBSTITUTION GUIDELINES

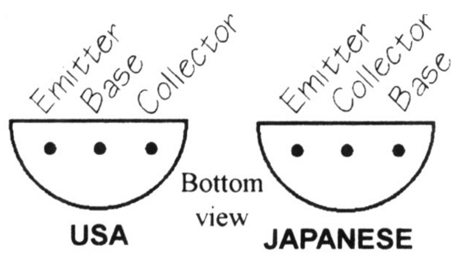
It's as easy as 1-2-3!

1. I_C Use the same or higher.
2. V_{CEO} Use the same or higher
3. h_{FE} Try to match as closely as possible

TO-92 Package

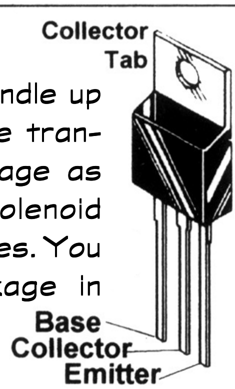
This is the smallest transistor that you commonly will find in monitors, power supplies and other circuits (other than SMDs or surface-mount devices). It is often called a "signal transistor" as it can handle only 1 amp of current.





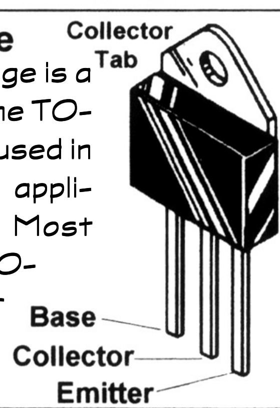
TO-220 Package

This package can handle up to 10 amps. We use transistors in this package as lamp matrix and solenoid drivers in slot machines. You also see this package in power supplies.



TO-218 Package

The TO-218 package is a larger version of the TO-220 package. It's used in many of the same applications as well. Most monitors use a TO-218 package for the horizontal output transistor.



How Monitors Work

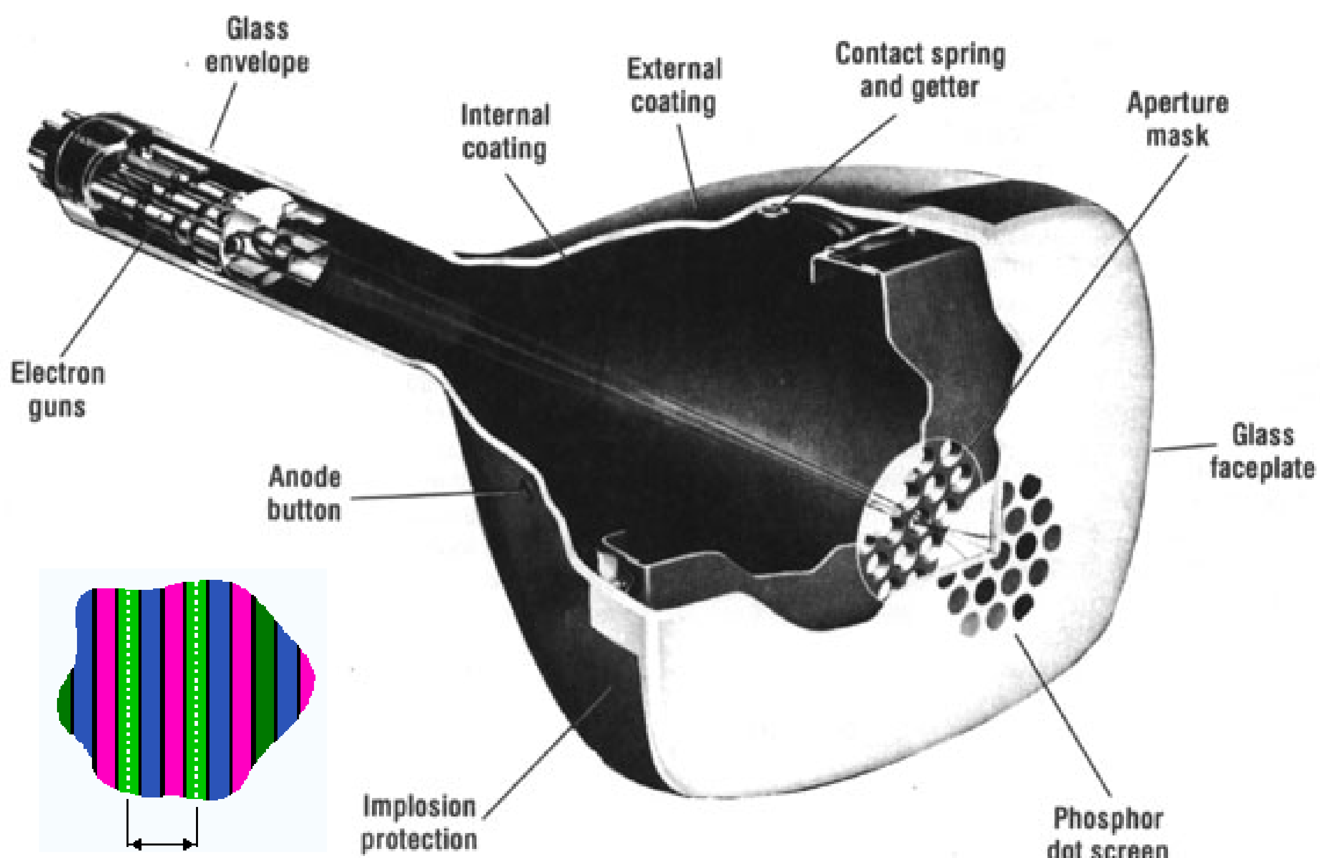
Video gaming machines are more popular than ever. Not the least of our responsibilities is video monitor repair. When you have hundreds of machines running twenty-four hours a day, three hundred, sixty-five days a year, monitor repair quickly becomes a priority.

Video monitors (also known as "raster scan" monitors) are easy to troubleshoot and to repair. Once we have a basic understanding of how monitors work, the vast majority of monitor problems can be isolated and repaired in well under an hour.

We can get a good idea of how the monitor works by looking at the picture tube. In the neck of the picture tube, there's a device called the "electron gun assembly." The electron gun does exactly what its name implies. It shoots out a stream of electrons. Electrons are the tiny, sub-atomic particles that surround the nucleus of an atom. The electron gun assembly actually consists of three, individual electron guns. There is a separate gun for each of the three primary colors: Red, green and blue.

In order to get an electron gun to emit the electrons, the "cathode" of the electron gun must be heated red-hot. The cathode is actually the source of electrons in the picture tube. In fact, the technical term for a picture tube is "cathode ray tube" or "CRT." When you see the reddish-orange glow in the neck of the picture tube, you're looking at the heater doing its job. To keep the heater from burning up, all the oxygen is removed from the picture tube. In fact, all gas is removed from the CRT during manufacturing. A picture tube is a "vacuum tube."

Coating the inside of the glass screen of the CRT is a substance called "phosphor." There are actually three different types of phosphor. The three different types of phosphor are laid down in alternating vertical stripes across the face of the picture tube.When struck by an electron from the electron gun, each one glows a different color. Each electron gun is precisely aligned so that its electrons strike only one color phosphor, hence the guns are referred to as the "red gun" the "green gun" and the "blue gun." By combining red, green and blue in different proportions, we can create any color we want. For example, red and blue create violet when combined. Adding red and green makes yellow! Blue and green mix to create a kind



The "pitch" of the CRT

of turquoise color called "cyan." When all three colors are added together, we get white. Conventional televisions and computer monitors work in exactly the same way.

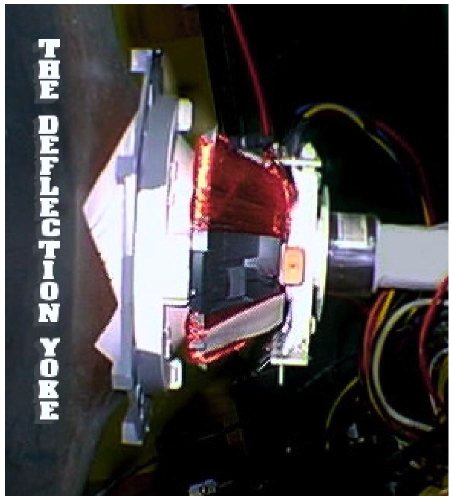
Note that the electrons do not pass through the glass front of the picture tube (glass is an insulator and will not allow the electrons to pass through) but bounce off and back into the picture tube. In doing this, the electrons have traded their "kinetic energy" (the energy of a moving object) for the light energy that we can see with our eyes.

Because the electron gun is securely fitted in the neck of the picture tube, Its aim is fixed at the center of the face of the CRT. We need a way to move the electron beam or our picture will be limited to a just a single bright spot in the center of the screen! To move the electron beam(s) on the phosphor-covered screen of the CRT, we use an electromagnet assembly called the "yoke."

The yoke is made of two pairs of coils of wire. When current is passed through the coils they create a magnetic field that "deflect" the electron beam(s) causing the spot to move on the screen of the picture tube.

One pair of coils is used to move the beam to the left and right. They are called the "horizontal deflection coils." The other pair of coils move the beam up and down. They are the "vertical deflection coils." By working together, the spot can be moved all over the front of the picture tube.

Let's see how the raster scan monitor creates the images on the front of the picture tube. When the electron gun is first turned on, the electron beam starts in the upper left corner of the CRT. The horizontal deflection coils (and the horizontal deflection circuitry of the monitor that drives them) cause the beam to move from the left edge of the monitor to the right edge. This draws a line across the top of the screen, called a



"Raster line." When the beam gets to the right edge of the CRT, it is turned off and quickly returned to the left edge again. This is called the "horizontal retrace." While the horizontal deflection circuit of the monitor is making the beam move from left to right and back again, the vertical deflection circuit is driving the vertical deflection coils in the yoke, dragging the beam down from the top. When the horizontal retrace is completed, the beam ends up in a slightly lower position than before. The next horizontal line will be drawn just slightly below the first one. The process is repeated until somewhere around 250 individual, horizontal lines have been drawn.

It's important to note that the lines are drawn only from left to right. During the horizontal retrace time, all three electron guns are turned off. There is a circuit in the monitor called the "blanking" circuit that turns off all three electron guns during the retrace. This is important because if the guns were allowed to turn on during the horizontal retrace (as the magnetic field of the yoke resets to start the beams on the left side of the screen) we would see a thin, diagonal line sandwiched between raster lines.

At this point, the electron beams are down in the lower right corner of the CRT. They have drawn one screen full of raster lines. A single pass of the beams from the upper left-hand corner at the top of the screen to the lower right-hand corner on the bottom is called a "field."

After drawing a field, the beams must now return to their starting point at the upper left corner of the CRT. This is called the "vertical retrace." But we cannot allow the beams to draw a line as they return from the bottom to the top of the screen. Remember the blanking circuit? The same circuit that is used to turn off the electron guns during the horizontal retrace is now used to turn off the guns during the vertical retrace as well. In fact, the blanking circuit is probably most important during the vertical retrace as we'll see below.

Once the beams are returned to the upper left corner of the CRT, they are turned back on and the process is repeated, 60 times a second. Note that the horizontal deflection circuit has to make the beam travel back and forth across the screen some 250 times before the vertical deflection circuit completes a single trip from the top to the bottom. Consequently, the frequency at which the horizontal deflection circuit operates is much higher than the frequency of the vertical circuit. The horizontal deflection circuit operates at approximately 15,750 hertz (cycles per second) while the frequency of the vertical deflection circuit is 60 hertz.

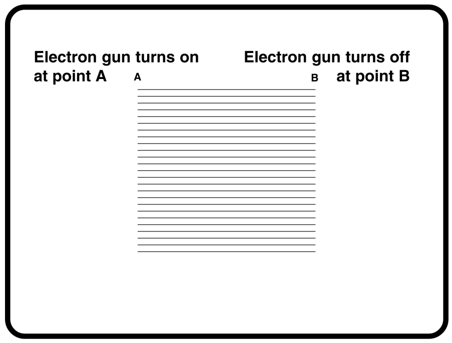
Because the horizontal deflection circuit is operating so much faster than the vertical deflection circuit, an interesting but hidden phenomenon occurs during the vertical retrace. As the magnetic field in the vertical deflection coils reverses polarity (to begin each field at the top of the CRT) the quickly scanning horizontal deflection circuit actually makes the beam move back and forth a dozen or so times before the beams reach the top of the screen. Turning up the brightness will often reveal these hidden "vertical retrace lines" that zig-zag their way across the screen. This is actually the path the beams take as they make their way from the bottom of the screen back to the top. Naturally, these lines are normally hidden from view. They are concealed by the blanking circuit as it is activated during the vertical retrace. Remember the blanking circuit turns off all three electron guns during the retrace time. If you see these vertical retrace lines, you may have a problem with the blanking circuit.

Now we have a way to fill the entire screen with "raster," but we still do not have any kind of image. At this point, all we can make is a solid field of white, gray or colored raster. How can we make the images appear on the face of the CRT? It's easy! All we have to do is turn the electron guns on and off at the right times! When an electron gun is turned on, its electrons hit the colored phosphor and we see that color on the screen. When the electron guns are off, the screen appears black.

A group of three signals are sent from the computer in the game to the circuits in the monitor that control the three electron guns. These signals are called the "video" signals and the circuits in the monitor that control the electron guns are called the "video amplifiers." By controlling the amounts of red, green and blue on the screen we can make any picture we want. This is known as the RGB system.

The three electron guns are driven by the three video amplifier circuits. When the computer wants something to appear red, it sends a signal to the red amplifier. If the computer wants something to appear blue, it signals the blue amplifier, and so on. The higher the voltage, the brighter the color will be. Typically, the color will begin to appear on the screen when the video input signal is at 1 volt and the gun will be fully turned on at around 4 volts.

Other colors are made from combinations of the three primary color. For example, to make the color yellow, the same signal is sent to both the red and green amplifiers. Because the phosphor stripes are so close together, our eyes and brain combine the colors and we see yellow!



Let's draw something on the front of the screen. For example, suppose we want the monitor to display a red box in the center of the CRT. As the horizontal section of the monitor is "sweeping" across the screen from left to right, and the vertical section is "sweeping" down, the red electron gun remains turned off until it reaches point A. The gun is then turned on and kept on until the horizontal deflection circuit brings the electron beam to point B. At point B, the electron gun is turned off again. It stays off until it reaches the right edge of the screen, retraces back to the left edge of the screen and returns to the point just below point A (the next "raster line" down). The electron gun is then turned on again, and a second line drawn just below the first, ending just below point B. The process is repeated until the entire box has been drawn. Although the box has been drawn with individual horizontal lines, the lines are so close together that we see it as a solid red box.

In order for the monitor to display the images properly, it has to be "synchronized" with the computer that is generating the video signal. Without synchronization, the box that we just looked at would be completely scrambled. It would appear something like a pay TV channel on cable television. In fact, the most common method used to scramble a pay TV channel is a scheme called "sync supression" where the synchronization signal is removed from the channel and you pay to get it back. What you're doing is buying the sync!

In addition to the three video signals for red, green and blue, the computer also generates two "sync" signals. There is a "horizontal sync" signal that comes at the end of each line. The horizontal sync signal tells the monitor to stop drawing the horizontal line and quickly retrace to the left side of the CRT to begin the next line.

The "vertical sync" signal that occurs when the beam is down in the lower right corner. The vertical sync signal tells the monitor to start the vertical retrace sequence, turning the electron gun off and returning it to the top of the CRT.

The sync signals have a separate input to the monitor. In some cases, there is a separate connection for both the vertical and horizontal sync. sometimes, the vertical and horizontal sync signals are combined

Vertical sync prevents the picture from rolling as shown here.

at the computer to form something called "composite sync."

Computers may produce either one of two types of sync signals. The vertical and horizontal sync signals may be "positive sync" or "negative sync" Positive sync starts at around +5 volts, and pulses briefly down to 0 volts and back to +5 volts. Negative sync does just the opposite. It's normally at 0 volts, pulsing briefly to +5 volts and back in order to synchronize the monitor.

Both sync systems are equally effective. The designer of the game's hardware simply chooses one system or the other. In order to make their monitors compatible with any computer system, most monitor manufacturers have designed their monitors to accept both positive and negative sync inputs. In some monitors, the negative sync is connected to the monitor through a separate connector. Some monitors use a switch to select either positive or negative sync, others are designed to accept either sync polarity at a single connector; automatically detecting its polarity.

A monitor with bad horizontal sync

The best way to understand sync is to see what happens to a monitor without sync. If a monitor loses vertical sync, the picture will roll from top to bottom or from bottom to top EXACTLY AS IF YOU NEED TO ADJUST THE VERTICAL HOLD (also known as "vertical frequency") CONTROL. Naturally, if you see a rolling picture you will try adjusting the vertical hold control. If you can get the picture to slow down but it never locks in place, you have a problem with vertical sync.

Loss of horizontal sync can be a bit more difficult to recognize until you know what to look for. If the horizontal sync is just barely out of wack, the picture may be seen as shifting from left to right or vice-versa. Generally, the picture will be completely scrambled (worse than a scrambled pay TV channel) with little segments of diagonal lines all over the screen. Nothing will be recognizable on the screen. Again, try adjusting the frequency control (this time the "horizontal frequency" or "horizontal hold" control) to see if you can lock the picture in place. If not, you most likely have a problem with horizontal sync.

So, the picture is actually made from electron beams that are scanning across the screen from top to bottom, being controlled by the three video signals and two sync signals that come from the computer. Although we now have a way to control the electron beams, we still have another problem to overcome before our monitor will work properly. Remember when we looked at the beam of electrons as they left the electron gun and struck the glass front of the picture tube? The electrons struck the phosphor coating the inside of the glass, and bounced back into the picture tube. But what happens to the electrons now? An electron is a real, honest-to-goodness physical particle of matter, so it cannot just disappear! If we leave the electrons alone, however, our monitor will not work. If left to themselves, the electrons will form a negatively charged cloud inside the bell of the CRT. This negatively charged cloud will repel the beam of negatively charged electrons as they try to get from the electron gun to the front of the picture tube, preventing them from reaching the phosphor and producing an image.

The flyback transformer

This problem is solved by a part of the monitor called the "high voltage unit." The high voltage unit is also known as the "flyback transformer." All monitors and television sets have a high voltage unit. When they say "high voltage," they are not kidding! The high voltage unit in video gaming monitors can produce +20,000 volts DC or more!

The inside of the bell of the picture tube is covered with a metallic coating that conducts electricity. It's called "aquadag." On the top of the picture tube is a small metal plug called the "second anode" of the picture tube. The second anode is connected to the aquadag that coats the inside of the CRT, and the high voltage is connected to the second anode.

Now, an electron that has struck the front of the CRT and bounced off is immediately attracted to the positively charged aquadag and literally sucked out of the second anode by the high voltage. The high voltage is essential to the operation of the monitor. If you lose the high voltage power supply in a monitor, you will not see anything on the screen!

Part 2 of "How Monitors Work" will appear in next month's issue (May, 2001) of Slot Tech Magazine

How Monitors Work - Part II The Seven Sections

A monitor can be broken down into seven basic sections. Armed with a general understanding of how these sections work, we can often observe the symptoms of a bad monitor and have a pretty good idea which sections are operating properly and which are not. Once we have the problem isolated down to a single section, troubleshooting is often a simple matter of testing the parts in that section with a meter.

MONITOR SECTIONS
1. Power supply
2. Video
3. Blanking
4. Sync
5. Vertical deflection
6. Horizontal deflection
7. High voltage

There is also a very close relationship between the horizontal section and the high voltage. In fact, the horizontal section is actually used to create the high voltage! Can you hear the high frequency "squeal" that comes from a standard resolution tevelision monitor as it is operating? Some people can, others cannot. That high frequency squeal is the sound of the high voltage unit in operation, as it is being driven by the 15,750 hertz horizontal deflection circuit. If you can hear the squeal of the high voltage, the high voltage unit must be working properly. If the high voltage is okay, the horizontal section must also be working properly, since the horizontal section is used to create the high voltage! If the high voltage and horizontal sections are working normally, chances are extremely good that the power supply circuit is good as well! So just by listening to the monitor as we turn it on, we can verify that three of the seven sections of the monitor are probably working okay. Note that this only applies to standard resolution monitors, not the high resolution monitors used in today's video slots. The operating frequency of a VGA resolution monitor is 31.5 kHz, too high a frequency for us to be able to hear.

Let's take a look at some common monitor problems and see if we can determine the source of the problem just by looking at the symptom.

Where is the problem as shown in figure 1? It's certainly not a high voltage problem! Generally speaking, if you see any brightness at all on the screen, your high voltage is probably okay!

Figure 1. Loss of vertical deflection causes just a horizontal line to appear on the screen.

It's not a horizontal problem either. We can see a horizontal line on the screen, so the horizontal deflection section must be making the beam sweep left and right. Besides that, the fact that we have any kind of display at all means that the high voltage is working and if the high voltage is working, the horizontal section must be working too! Of course, if the horizontal section is working, the power supply is working as well!

Can the video circuit be the cause of this problem? No way! In order to draw a line on the screen, the electron guns must be turning on. If you were seeing this symptom on an actual monitor connected to a game, you would see colors in the horizontal line as well.

It can't be a sync problem because the picture is not rolling or shifting. In fact, we don't really have a picture at all, just a horizontal line across the screen!

We know it's not a blanking problem because a blanking failure will reveal the zig-zag, vertical retrace lines and that's not our problem here.

Notice the curves and distortion on this monitor? This is almost always caused by bad electrolytic capacitors in the deflection circuits. It is also possible (although not likely) that this can be caused by a low-voltage condition in the monitor's B+ power supply

That only leaves the vertical deflection section as the possible cause of the symptom! You see, it’s pretty logical once you know how the monitor works.

What if you are missing a color? Perhaps you have a video poker game and the blue background has become black. Naturally, this cannot be a problem in the power supply, blanking, sync, vertical deflection, horizontal deflection or high voltage. A missing color has to be a video problem. In fact, it has to be a problem in the blue video amplifier or the blue gun in the CRT itself.

So by a logical process of elimination, we have not only eliminated six out of seven sections as being the possible cause of our missing color problem, we have eliminated two-thirds of the remaining circuits as well. Neat, huh?

This monitor displays just white raster with diagonal, "vertical retrace" lines. This might be a problem in the "blanking" circuit.

What if you get to a monitor whose symptom is a screen filled with raster and vertical retrace lines but you do not see any images? Assuming that a good video signal is getting to the monitor from the computer, the problem is likely to be in the blanking section of the monitor! All of the other sections in the monitor must be working to produce raster.

What can cause the raster to shrink in both the horizontal and the vertical direction? Is there any section of the monitor that is common to both the horizontal and the vertical sections? How about the power supply? This symptom is typical of a “low voltage” power supply problem. There is enough voltage from the power supply to allow the monitor to function, but just barely!

The point is this:

ONCE YOU HAVE DETERMINED WHICH SECTION IS BAD, TURN THE MONITOR OFF AND USE YOUR METER TO CHECK ALL OF THE COMPONENTS IN THAT SECTION!

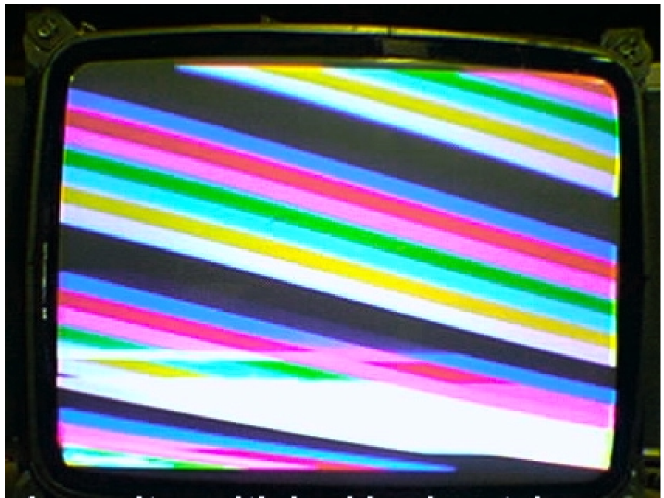
Start with the semiconductors first. The diodes and transistors are the most suspect to failure because they are the active components in the circuits. They are switching on and off, or otherwise controlling the current in the circuits.

Con't on page 27

Monitors - Con't

Capacitor failure is a common problem in monitors that are a couple of years old. Bad caps often cause distortion in the picture. Curved sides and squished pictures are generally caused by bad capacitors. The best procedure here is to replace any suspected capacitors (suspect all electrolytic capacitors that are two or three years old) with new ones. Testing capacitors is not always a good way to go here as hand-held capacitor meters will often give bogus results if you don't know what to look for.

Resistors are the next thing to check. Although they are passive devices, they do generate heat as they work. This heat can cause resistors to fail. When resistors fail, they will open circuit or increase markedly in resistance. Resistors will not short circuit.


A monitor with bad horizontal sync

By determining the section of the monitor that is bad, and then using a meter to test the parts, we do not have to know exactly how the circuits operate to be able to fix them. It's also a lot safer to troubleshoot a circuit with the power off than with the power on!

Of course, we will be taking a detailed look at each of the seven monitor sections in future issues of Slot Tech Magazine.

Slot Tech Feature Article

Unlock the Mystery of Monitor Troubleshooting

B+ is the Key

Of all the tests and measurements you can possibly name, none is more important to the art of monitor repair than measuring the B+ power supply.

If you have a monitor with a blank screen, your problem might be in the B+ power supply. If your monitor takes a long time to come on and has a dim picture, you may have a bad B+ power supply. If your monitor has a picture that's doing the hula, you almost certainly have a bad power supply. If your monitor comes on for just a fraction of a second and shuts itself down, you probably have (you guessed it) a B+ power supply problem.

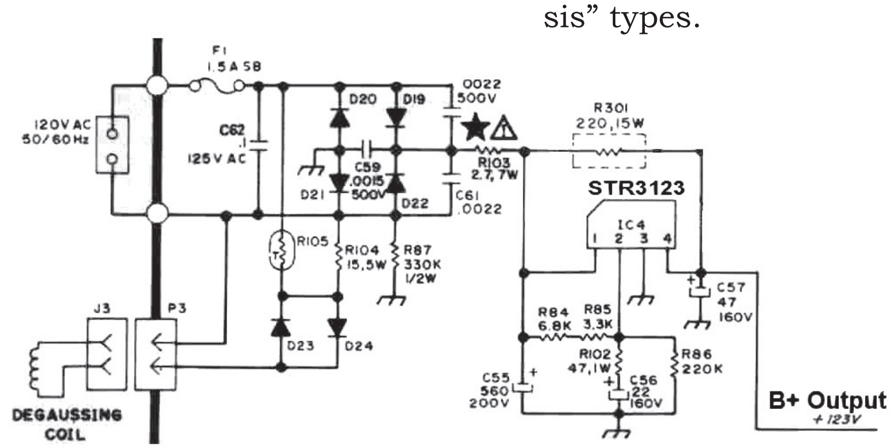
Most monitors, regardless of manufacturer, have one main power supply of between +88 to +136 volts DC. This is the power supply that directly provides the operating current for the high-current circuits in the monitor. Specifically, this power supply, known as the B+, provides the operating current for the two deflection circuits and the high voltage unit. These are the highest current circuits in the monitor, accounting for more than 80% of all the power consumed by the monitor. REMEMBER THIS FACT, as it will explain a lot about monitor troubleshooting, as you'll read later.

The term "B+" is actually a throwback to the old radio days when all radios were battery-operated, vacuum tube sets. They required three types of batteries for operation. A low voltage "A" battery provided power for the tube heater filaments, a high voltage "B" battery provided positive voltage for the vacuum tube's "plate" supply while a moderately rated "C" battery provided a negative voltage for the vacuum tube's "bias" supply. When power supplies replaced batteries, we held on to the term "B+" as an indicator that this is the main power supply for the set (radio or television.)

What's Normal?

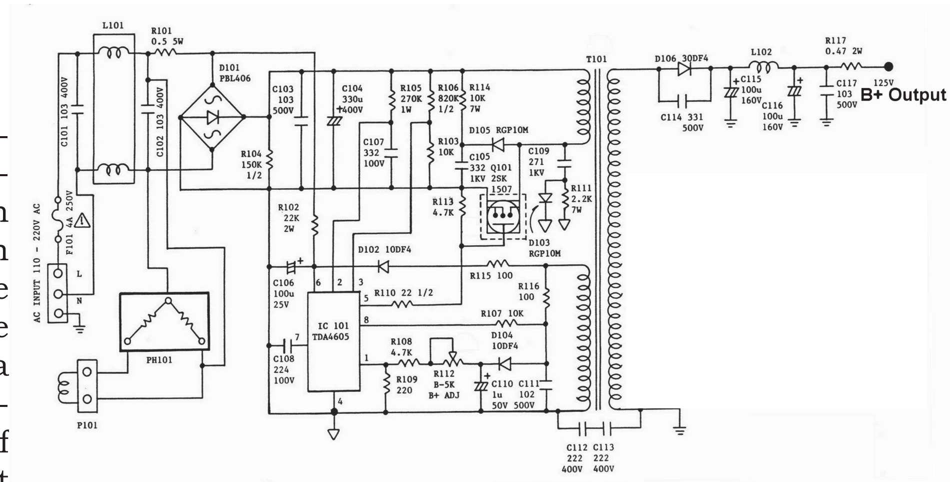
One of the keys to successful troubleshooting is to know what's normal. The best way to learn this is to measure the B+ voltage every time you work on a monitor. This may seem like a waste of time when you have a problem like a missing color or vertical collapse (which couldn't possibly be caused by B+ problems) but it serves to reinforce both the methods of obtaining the measurement and the meaning of what is a normal voltage for the B+.

As mentioned earlier, normal B+ voltages are typically between +88 to +136 volts DC. This will vary between manufacturers and models. Also, there are two types of power supplies we now see in monitors. The majority of monitors now on site use a "linear" or "conventional" power supply. Modern designed monitors use a "switched mode" power supply or "SMPS." You can easily recognize a monitor with an SMPS by the yellow, ferrite-core power transformer mounted on the PC board. Monitors with linear power supplies typically are transformerless, "hot-chassis" types.



Typical Linear Power Supply Using an Integrated Circuit Voltage Regulator

Where to Measure the B+



Typical Switched Mode Power Supply (SMPS)

A schematic diagram is awfully important when working on monitors. Although there are similarities between monitor designs, no two are exactly the same. Having the schematic diagram helps a lot because the B+ is generally labeled at the output of the power supply. Even if it doesn't say "B+" it will generally be labeled with the voltage.

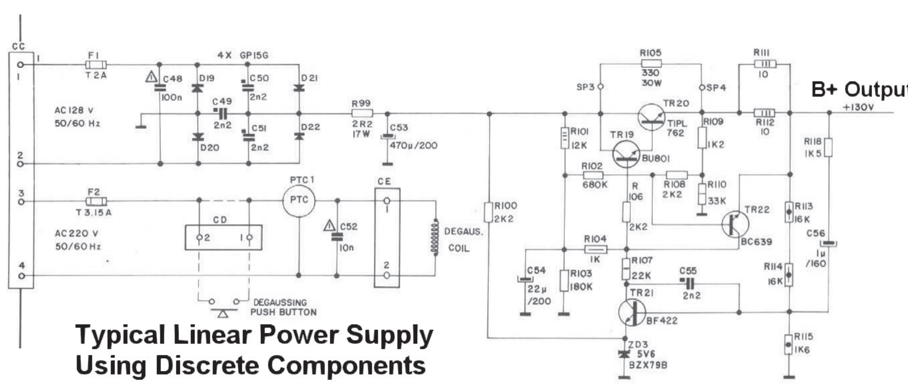
If you don't have a schematic, here's how to locate and measure the B+ in just about anything:

SMPS - Find the yellow power transformer. The output windings (the secondary windings) will be connected to diodes and electrolytic capacitors. Just follow the traces on the bottom of the printed circuit board. These are the output rectifiers and filter capacitors of the power supply. In most monitors, the value of the filter capacitor will be around 200 microfarads at 160 VDC. This may vary somewhat. The voltage across this capacitor is the B+ voltage you want to measure.

But it is inconvenient (not to mention potentially dangerous) to measure the voltage here on the bottom of the PCB, with the board propped up and the power turned on. Instead, with the power turned off, follow the trace from the positive lead of the output filter capacitor as it makes its way across the bottom of the PCB connecting all of the components and circuits that require B+ power. Find a component lead connected directly to this B+ trace, where it will be convenient to measure the B+ FROM THE TOP of the PCB. Now flip the chassis back over into its normal operating position and apply power. Connect your digital multimeter's black lead to the chassis of the monitor and the red meter lead to the convenient test point you just ascertained. Use your DMM to measure the DC volts. That's your B+ voltage.

Linear Power Supply - Not quite as standard as the SMPS, there are a couple of ways to locate the B+ test point in a monitor with a linear power supply.

The quick way is to look for a large, ceramic, wire-wound resistor with a value of 150 to 330 ohms at 15 to 25 watts. It will often be mounted on the side of the chassis, affixed by a mounting bracket to the heatsink.



Typical Linear Power Supply Using Discrete Components

This is a "shunt" resistor that helps carry some of the current so the voltage regulator doesn't have to work so hard, lowering the voltage regulator's operating temperature. This is an excellent place to check the B+ power supply. One side of the resistor is connected to the input of the voltage regulator; the other is connected to the output of the B+ voltage regulator. Simply connect your black meter lead to the chassis and with the power applied to the monitor, use the red meter lead to probe first one side of the resistor, then the other. The side with the least voltage on it is the B+ output.

If there is no shunt resistor, look for the voltage regulator itself. If this is an IC voltage regulator, it will often carry a part number like "STR3123" or "STR30130." The last three digits indicate the output voltage of the regulator; thus you would expect to measure +130 volts at the output pin of the device. If you do not have a schematic that indicates which pin is the output pin, simply check them all. With the power turned on and the black meter lead connected to the monitor chassis, carefully probe each pin of the regulator. One will be B+ output. KNOWING WHAT'S NORMAL, only one pin makes sense as the output pin.

WARNING: There is an EXTREME danger of slipping with your meter probe when making this measurement. If you aren't 100% certain you can make this "power-on" measurement without slipping and letting the smoke out of a bunch of components, it's better to connect your meter probe with the power turned off using a clip lead then apply power and take the reading off the meter.

Another, "power-off" way to locate the output pin of the voltage regulator IC is to set your meter to the continuity beeper or lowest resistance scale, connect one meter lead (either one) to the collector of the horizontal output transistor and probe each pin of the voltage regulator with the other meter lead. The meter will beep or show an ohm or two when you hit the output pin. Of course, this only locates the output pin of the voltage regulator. In order to measure the B+, you must connect your meter, apply power and make the measurement.

If you're working on an older monitor that uses discrete components (individual transistors, diodes and resistors) instead of an integrated circuit voltage regulator, the trick with the big shunt resistor often applies as well. If you do not see the shunt resistor, the B+ can usually be found at the emitter of the series-pass regulator transistor. This transistor will always be the largest one in the regulator circuit. Typically it's in a TO-3 package.

In Next month's Slot Tech Magazine: Associating B+ readings with specific monitor failures . . . How to pinpoint your troubleshooting based on B+ measurements.

Unlock the Mystery of Monitor Troubleshooting - B+ is the Key Part II

Okay . . . Now that you've located a suit able test point for measuring the B+ power supply voltage, you're ready to make the test. Set your meter to read DC volts, connect the black meter lead to ground and connect the red meter lead to the B+ test point. With the power turned on, you should typically measure something between +88 Volts DC and +136 Volts DC. The voltage will vary somewhat between models and manufacturers but it is generally in this range.

What Does It Mean?

Being able to interpret the B+ reading is the key to troubleshooting monitors. For example, one of the most common of all monitor symptoms is "blank screen." This can be caused by a number of completely different failures in altogether different circuits. However, the B+ measurement will point you in the correct direction.

It's important to note that the two types of power supplies we find in monitors will differ in the symptoms of their failures and/or in their response to the failure of other monitor circuits. As you work on a monitor, be certain to relate your B+ measurement to the proper type of power supply, Linear or SMPS, as outlined in last month's column, part one of this discussion.

In a monitor with a linear power supply, a normal B+ measurement tells you two things. The first is pretty obvious. If the output of the B+ power supply is normal, the power supply is working properly (duh). Whatever it is that's causing the problem in your monitor, it's not the B+ power supply.

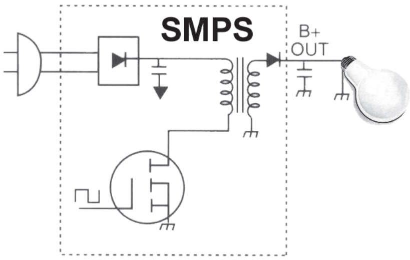
The other bit of information you can infer from a normal B+ reading is that the horizontal deflection circuit is working properly. The horizontal deflection circuit is responsible for the vast majority of the power consumed by the monitor. This is because the horizontal deflection circuit not only makes the beam move right and left across the widest part of the CRT but also drives the high voltage unit. The high voltage unit presents the highest load in the monitor because it powers the CRT itself as well as providing low voltage power supplies for the vertical deflection circuit and the video and sync amplifiers. In other words, just about everything else in the monitor is actually powered or driven by the horizontal deflection circuit!

If the horizontal deflection circuit is not operating, you lose the load and the output voltage of the B+ power supply will rise to around +160 to +170 VDC. Therefore, if the B+ is normal, you KNOW that the horizontal deflection circuit is working properly. In fact, if the B+ power supply is normal, you can infer that your high voltage (eht) is working properly as well, even though you haven't made any direct measurements at the second anode of the CRT.

In a monitor with an SMPS, a normal B+ measurement also tells you that the power supply is working properly but you cannot always make the same assumption regarding the horizontal deflection circuit. It really depends on the design of the power supply. While most power supplies will exhibit a higher than normal output voltage with a loss of load, some continue to operate normally regardless of load (or lack thereof).

Likewise, in an SMPS, a higher than normal B+ reading doesn't necessarily indicate a failure in the horizontal deflection circuit. You may have a problem with the power supply itself.

There is a quick way you can



Use a 25 watt incandescent lamp as a dummy load

determine if the power supply is working properly. You can use a “dummy load.” Connect an ordinary, household 40-watt incandescent lamp between the B+ output and ground. This will load the power supply. If the output of the power supply now measures normal, your horizontal deflection circuit is inoperative. If the output of the power supply still measures too high, your power supply is bad.

So what might be wrong if the B+ voltage is still too high, even with the dummy load? In most SMPS designs, there is a reference voltage that is derived from a “sense” winding on the power transformer. It usually consists of a simple circuit with a single diode and a small filter capacitor. The capacitor is often in the range of one to one hundred microfarads. When the filter capacitor in this circuit fails, the reference voltage drops. This causes the integrated circuit in the SMPS to increase the pulse width to the MOSFET, boosting up the output voltage to a level that is much higher than normal. In fact, this is just about the only failure that can cause the output of an SMPS to go too high. Naturally, this trips the x-ray protection circuit and causes a high-voltage shutdown in order to prevent excessive radiation.

A higher than normal B+ reading for a linear power supply can likewise be caused by an inoperative horizontal deflection circuit or a power supply fault. You can use the dummy load here as well. If the power supply reads normally with the dummy load connected, the power supply is working properly (again, “duh”).

There is another clue that you can use to determine where the problem is in an “over-voltage” condition like this. Listen carefully to the monitor as you turn it on. If you hear a momentary squeal and/or the crackling sound of the static electricity generated by the monitor’s high voltage charge on the CRT, the horizontal deflection circuit is functioning properly (even if it’s just for a moment) and your power supply is at fault.

In this case, the problem is most likely in the voltage regulator itself (either an IC voltage regulator or a regulator circuit made from discrete components) or a faulty bypass capacitor. In the case of the latter, look for an electrolytic capacitor with a value of 22 to 100 microfarads at 160 volts, connected between the B+ output of the voltage regulator and ground. A typical value here is 47 microfarads.

If a linear B+ power supply reads low, the problem likely lies in the power supply itself. The voltage regulator is probably bad or the main filter capacitor has failed. Regulator failure is hundreds of times more likely than capacitor failure in this regard. However, some linear power supplies have an over-current protection (OCP) design that shuts down the voltage regulator circuit if the load becomes excessive. This commonly occurs when the high voltage unit (a.k.a. flyback transformer) or horizontal output transistor fails. To verify, power up the monitor with the horizontal output transistor removed. If the B+ pops back up (in fact, it will rise to about +160 to +170 volts DC) then you most likely have a shorted flyback and/ or horizontal output transistor. You can verify that the power supply is working properly with the dummy load as before.

All switched-mode power supplies have an OCP circuit that shuts down the power supply if the load becomes excessive. As with the linear power supply, this commonly occurs when the flyback transformer or horizontal output transistor fails. When the B+ measures low or is pulsating at two or three times per second, this is likely the cause. Listen carefully to the power supply. If you hear it "ticking" you have a short somewhere in the horizontal deflection circuit and the problem is not in the power supply itself.

Again, you can remove the horizontal output transistor and use the dummy load to verify that the power supply is good. If the power supply output still measures too low, try changing the electrolytic capacitors. It is not likely that the primary filter capacitor will be bad but any other capacitor is a likely suspect. Always use the highest quality replacement capacitors you can in an SMPS circuit. Use low ESR, 105 degree caps if possible and you will greatly extend the longevity of the monitor.

Complete loss of B+ in a linear power supply is likely to be accompanied by a blown fuse. If this is the case, suspect a shorted horizontal output transistor or other component(s) in the horizontal deflection circuit. It is also possible that you have a shorted bridge rectifier in the power supply itself, though this is far less likely.

Staying with the linear power supply, complete loss of B+ with an intact fuse is definitely a power supply failure. Look for an open resistor with a value of 1.2 to 2.7 ohms. It will likely be a ceramic, wirewound resistor of 5 to 10 watts.

Complete loss of B+ in an SMPS is not likely to be accompanied by a blown fuse. If it is, suspect a bad FET switching transistor or a shorted bridge rectifier in the power supply itself. Some SMPS designs use an IC driver module instead of the FET. Naturally, you would suspect this if the fuse is open.

If the fuse is good but the output of the power supply is zero volts and the horizontal deflection circuit is not shorted anywhere, you have a power supply failure. The most likely culprit here is a bad PWM integrated circuit or one or more of those pesky electrolytic capacitors again. The best technique here is a quick substitution of the suspected components.

Slot Tech's Prayer

The tech manager is my shepherd
I shall not want.
He maketh me to lie down and bolt games.
He leadeth me to broken monitors.
He restoreth my lack of parts.
Ye though I walk through the valley of down games,
I will fear no hopper jams,
For my bag is with me,
my screwdrivers and sockets they comfort me.
Thou preparest a list of zero meters in the
presence of my co-workers.
You fill my bag with parts.
My hoppers overflow.
Surely coin-in jams and bill validator failure
will follow me all the days that I work.
And I will work in the casino of my choice forever.

Amen

VIDEO

The word "video" is a common one in Modern English. It is used as a noun to describe a television segment ("Let's look at the video") or a videocassette ("There's nothing on TV. Let's rent a video") or an MTV feature (Madonna's new video) but in the world of electronics, "video" is an adjective, used to describe a specific type of electronic signal: the video signal.

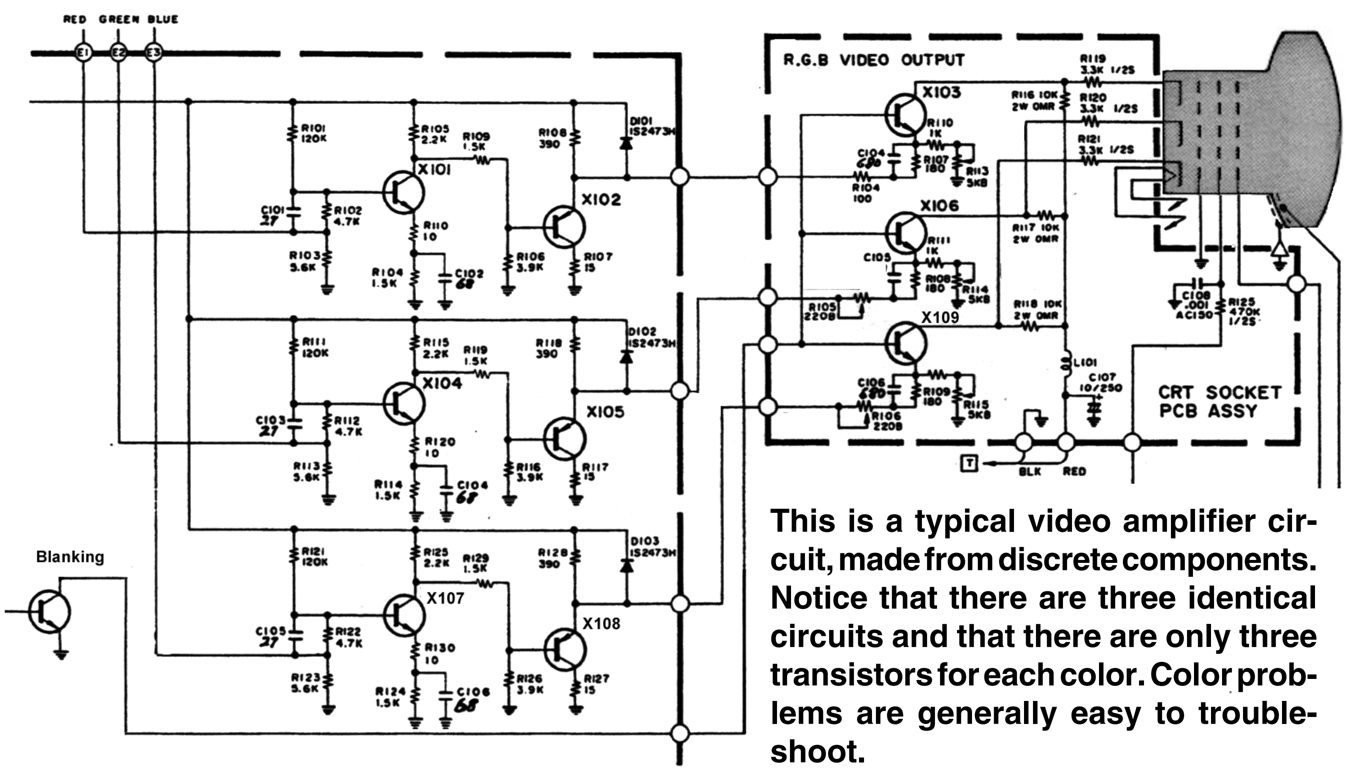
In a video gaming machine such as a video poker, video slot machine or Keno, the CPU board and its associated circuitry create three outputs that contain image information. They are known as the red, green and blue video outputs. Red, green and blue are the three primary colors of light. By combining red, green and blue in various combinations, we can make any color we want. For example, red and blue combine to make magenta. Green and blue combine to create a color known as cyan, a sort of turquoise color. Red and green combine to create yellow. Of course, all three primary colors combine to create white.

These three video signals are simply changing voltages. The video signals control the video amplifiers in the monitor, which, in turn, regulate how much red, green, and blue will show on the screen. Higher voltages at the monitor's video input connector will make a color very bright while lower voltages will produce correspondingly dimmer colors.

For example, if the game's PCB wants something to appear bright red on the screen (say, the red heart on a playing card) it would put out around .7 volts to the red video output. This output is connected via the wiring harness and its associated connectors to the red video input of the monitor (duh!). This turns on the red gun in the monitor all the way, creating a bright red color on the CRT.

If the CPU wants something to appear red but not quite so bright, it might put out only .5 volt. .2 volt would create a dim red color. Naturally, zero volts is totally off.

If the CPU wants the color magenta to appear, it will send a voltage out both the red and blue video outputs simultaneously. You get the idea. Flesh tones and all other colors are displayed in precisely the same way. Your television



This is a typical video amplifier circuit, made from discrete components. Notice that there are three identical circuits and that there are only three transistors for each color. Color problems are generally easy to troubleshoot.

set at home works the same way as well.

But the video signals that come from the game's CPU aren't powerful enough to drive the electron guns in the CRT directly. They have to be amplified by the three (you guessed it) "video amplifiers" in the monitor and so we (finally) come to the subject of this month's presentation on gaming monitors – The video amplifiers.

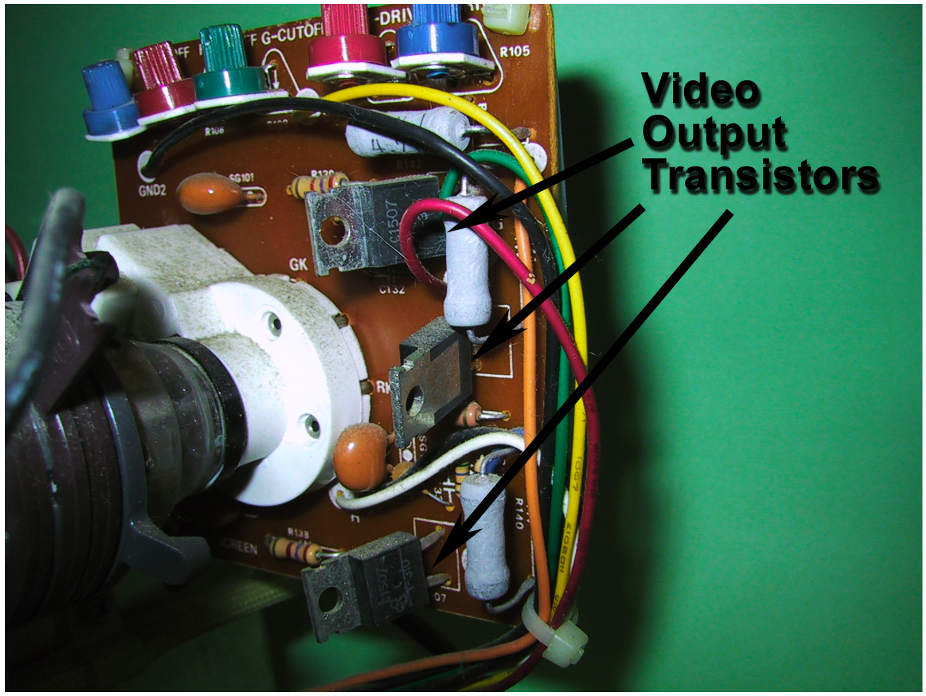
The Video Amplifiers

There are three identical video amplifiers in a color monitor. The video amplifiers take the low-level video signals that come from the game's PCB, amplify them and send them to the video output stage. It is the video output circuitry that controls the electron guns in the CRT itself.

Let's take a look at some examples of video amplifier circuits, starting with an early design using all discrete components. There are three transistors in each of the three video amplifiers. The three video amplifier sections are identical, so we'll just look at one of them. Let's look at the red amplifier.

The video input is coupled to the base of the first video amplifier transistor, X101. The output of X101 is passed through a 1.5k resistor (R109) to the base of the second video amplifier, X102. X101 and X102 are located on the main printed circuit board assembly. This is the large printed circuit board that sits on the chassis below the picture tube.

After being amplified by X102, the red video signal is passed through a connector and a wire (colored red for convenience in trouble-shooting) to



the red video output transistor, X103 on the "CRT SOCKET PCB." Color monitors have a small printed circuit board, mounted on the end of the neck of the picture tube. On this board are mounted 5 or 6 small potentiometers (the color adjustments) and the three "video output" transistors. There is one video output transistor for each color: red, green, and blue. Most (almost all) monitors use a neck board for the video output transistors and the adjustment potentiometers.

The red video output transistor is connected to the red electron gun through a 3.3k ohm resistor (R119). Of course, the red electron gun is not really red at all. It is called the "red gun" because the electrons it shoots will only strike the red phosphor coating the inside of the picture tube. The three video amplifier circuits that drive the red, green, and blue electron guns are identical, the only difference being the final aiming point of the electron guns they control.

We can use this to our advantage when we troubleshoot a monitor that has color problems. If we suspect that one of the video amplifiers is bad, we can compare its operation to that of the two video amplifiers that are working properly. For example, suppose your game is missing one of the three colors. Say you're missing the red in your video poker. At first glance, everything appears normal. The colored background is there (It's blue, remember?) and you see the cards but something isn't quite right. One thing you notice is that instead of being red, the hearts and diamonds are black. And, isn't the paytable supposed to have a red background? That's black as well. Less obvious is the fact that all of the normally white words and numbers are now that cyan color mentioned previously.

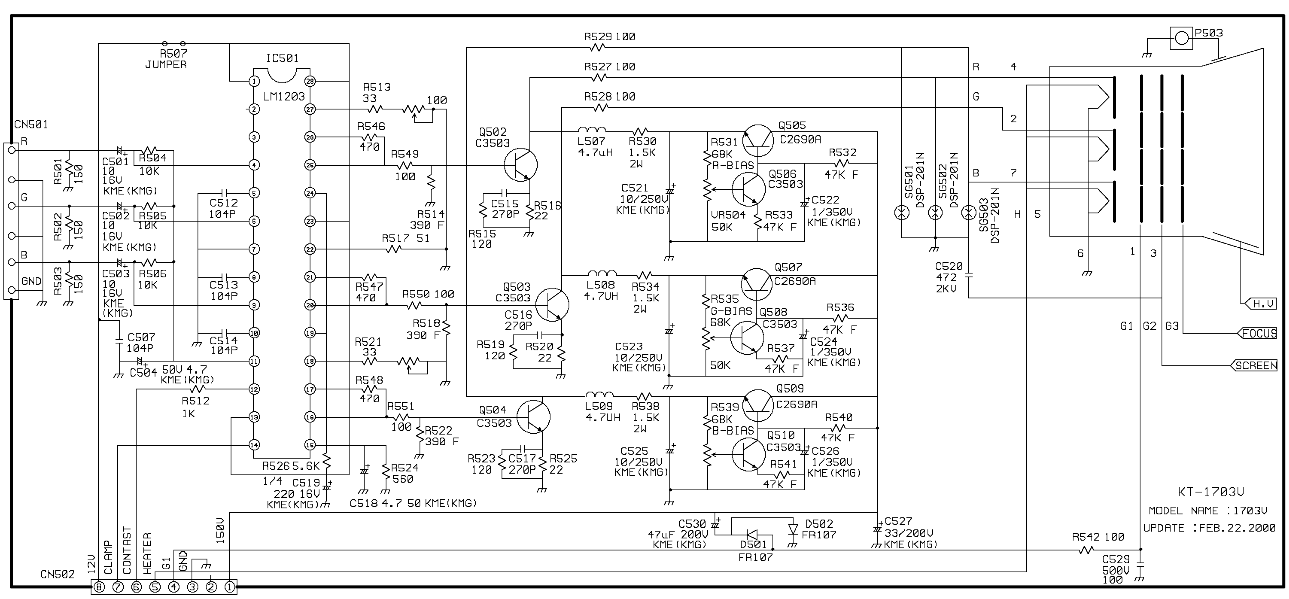
It's now pretty obvious that we're missing red but we don't really know if the problem is in the monitor or not. A problem with the game's computer may be keeping the red video signal from being generated (not too likely) or the connection between the computer and the monitor may be bad (entirely possible, especially where the monitor connectors slam together at the back of the chassis). There is an easy way to determine if the problem lies with the monitor or elsewhere: Swaptronics! In gaming, it's usually the fastest way to narrow down a problem like this.

Let's get back to our "no red video" problem. Now that we have narrowed it down to the monitor (and even to the red video amplifier section of the monitor) all we have to do is TURN THE MONITOR OFF and test all of the transistors in the red video section. There are only three. Chances are very good that one of them will be bad. If you are missing a color as we are in this example, suspect the input transistor (first video amplifier). If you are working on a game whose symptom is a screen that is filled with a very bright raster (often accompanied by vertical retrace lines) of just one color, go right to the neck board and test the video output transistor associated with that color. Chances are really good that it will have an emitter to collector short, keeping the electron gun fully turned on. If you don't have a schematic and you don't want to trace the colored wire that leads from the second video amplifier on the main PCB to the video output transistor on the neck board to determine which transistor controls the color you're interested in, just test all three. They're easy to get to. It's usually faster to go ahead and test all three even when you do have a schematic. If the video output transistor tests good, test the other two transistors in the video amplifier.

Next Generation Video Amplifiers

Jump ahead about fifteen years and witness the change in video amplifier design with the development of the video amplifier IC. The LM1203 video amplifier is one of the most common video amplifier chips in the world today. Just about everybody that has a computer monitor on their desk has one of these ICs inside it. The LM1203 works in the same way as the video amplifier circuit we looked at previously in that it takes the low-level video signal from the CPU board (or video graphics board) and boosts it up so that it can drive the video output transistors that, in turn, drive the cathodes of the CRT. It has some advantages in that it can operate at a faster speed. The LM1203 has a higher bandwidth than the video amplifier circuit we just looked at. Interestingly, the use of the IC doesn't really reduce the complexity of the circuit. As you can see, there are still three transistors for each color, in addition to the IC itself.

Troubleshooting this circuit is still possible, even without using an oscilloscope and armed only with the ability to test discrete components. As before, there are three identical circuits in addition to the LM1203. As previously outlined, you can still test and compare the three circuits. If you can't find any bad components in the bad color's circuitry, try replacing the IC. Be aware that, contrary to what might seem logical, you cannot assume that any problem with the LM1203 will necessarily affect all three colors simultaneously. It is entirely possible that a problem with just one color, red, green or blue, could be caused by a defective integrated circuit video amplifier. That having been said, the LM1203 is a rugged workhorse and is not a common failure item in most monitors that incorporate it into their design.



Low Voltage Equals High Brightness

Understanding the Relationship Between Cathode Voltage and Electron Gun Emission

When does not enough become too much? There are a couple of interesting monitor failures that will cause all three electron guns in a picture tube to operate wide-open, blasting out billions of high-energy electrons and causing an uncontrollibly bright white screen with clearly visible vertical retrace lines.

When it comes to the cathodes of the electron gun, low voltage translates into big emission. That's right . . . The lower the voltage at the cathode of the electron gun, the brighter the screen will be.

At first glance, this seems like just the opposite of the way you would expect the electron gun to operate. I mean, generally speaking, you squirt some juice into an output device and it does something. The more juice you squirt into the device, the more you get out of it. The higher the voltage on a lamp, the brighter it burns. The higher the current through a coil, the stronger the magnetic field. Greater output power from an audio amplifier translates into louder sound coming from the speakers.

But in the electron gun of a picture tube, the emission of each gun is modulated by changing the voltage at the cathode and here, grounding the cathode will cause the output to go to 100%. Try it sometime. Ground the cathode of the red, green or blue gun at the CRT socket. You will see the screen come on full red, green or blue depending on which of the three cathodes are grounded.

By the way, this is a quick and easy way to test the electron gun in a CRT. When you are missing a color, your problem could be in either the chassis or the CRT. To quickly determine which one, try grounding the cathodes of the cathodes one at a time. You should see a bright screen with vertical retrace lines. If you don't, the electron gun in the CRT is at fault. This saves a lot of time.

But what can cause all three guns to come on full blast? Well, a couple of things can cause this. A simple test or two will quickly pinpoint which one.

One cause is loss of the voltage to the video output stages on the neck PCB. This voltage is generally derived from a tap on the primary winding of the flyback transformer in the high voltage unit. The output is rectified and filtered to provide a power supply of around +175 to +190 volts DC depending on the make and model of the monitor. In some monitors, the video output stage is powered by the B+.

If this power supply is missing, either through a bad component or broken conductor, the voltage at the cathodes drops to zero and all three electron guns come on full blast. I know it seems weird that a missing power supply would cause too much output but this is the case with the electron guns.

If you suspect this is your problem, measure the voltage at the collectors of all three video output transistors with no input signal. If you find the voltage to be low or non-existent, you MAY have located your problem. I say "may" because there is another possibility here.

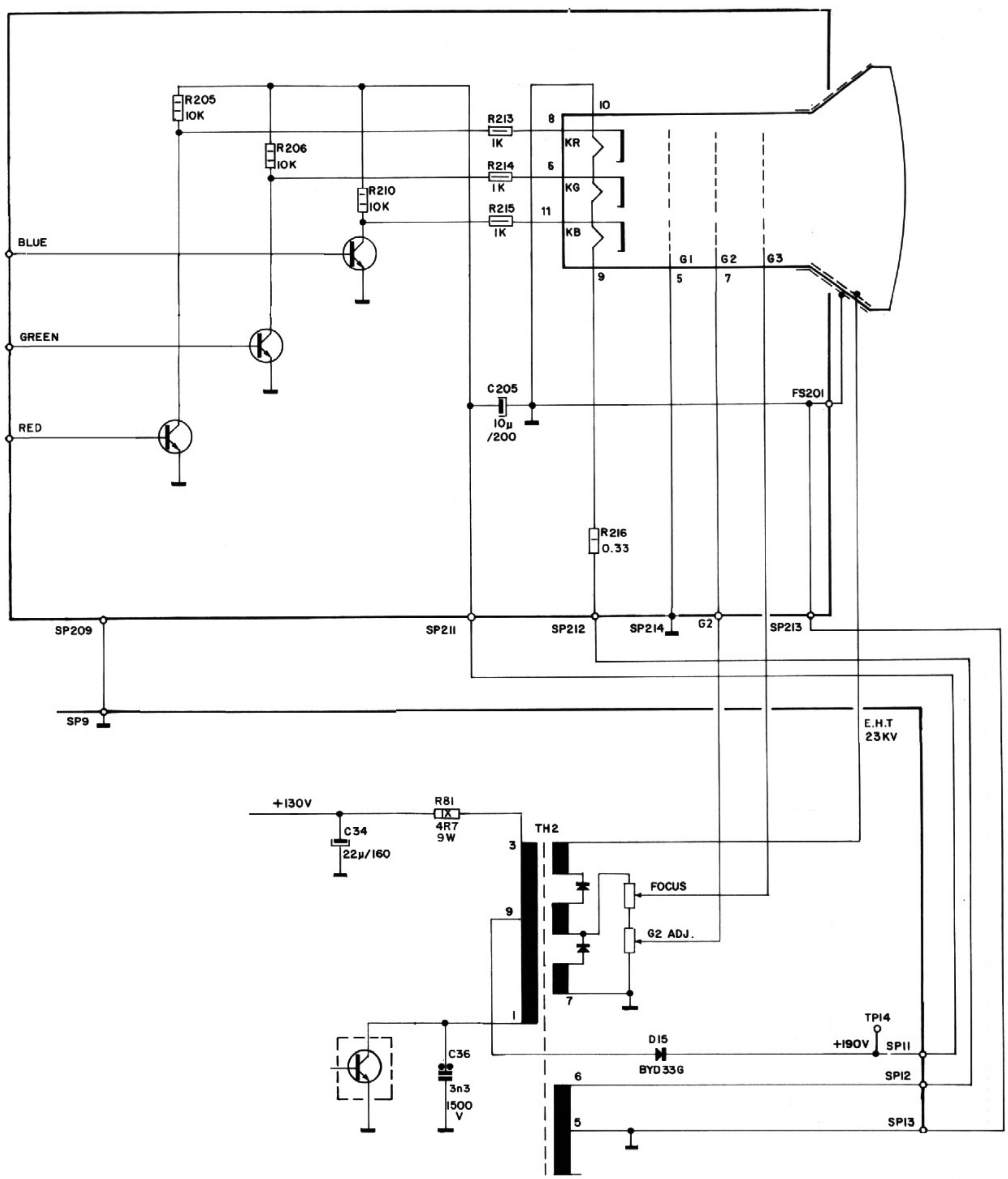
The three video output transistors are driven by the video amplifiers as we saw in last month's Slot Tech Magazine. In a modern monitor, an integrated circuit handles the job of amplifying all three color signals and passes the amplified signal to the output stages.

The outputs of the video amplifier IC typically drive the bases of the output transistors directly. They are DC or Direct Coupled amplifiers. What that means is that if the IC fails in such a way that it puts out too much DC voltage, it will turn on all three video output transistors. In fact, the transistors will be "saturated" or turned on as hard as they can be. When you measure the voltage at the collectors, it will be very low because the collectors are now connected more-or-less to ground through just 200 ohms or so of resistance.

There are a couple of ways to determine where your problem lies. One is to use a meter to measure the power supply voltage of the video output stages. In other words, after you've checked the collector voltage and found it to be very low, more your meter lead to the other side of the collector resistor and measure the voltage there. It's always easy to locate these resistors on any monitor because they are three identical resistors and typically two watts. One side of all three resistors will be tied together and connected to the video output power supply. That's where you measure the voltage. If the voltage is low there as well, you have a problem with your video output power supply.

On the other hand, if the power supply is good but the voltage is low when measured at all three video output collectors, your outputs are probably being over-driven by a bad IC. An easy check is to touch the collector resistors. If they are really hot, you've narrowed down your problem.

-Slot Tech Magazine



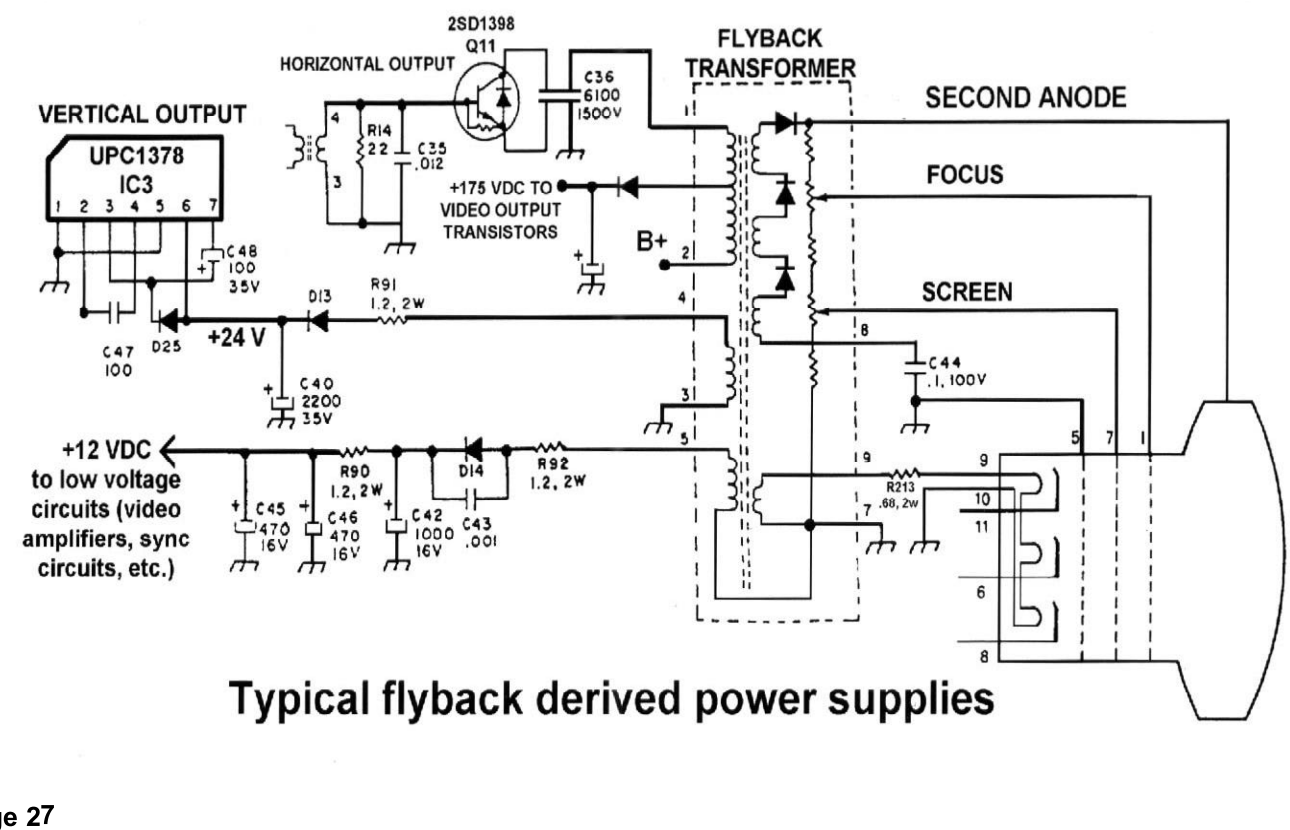
Flyback Derived Power Supplies

At the heart of a monitor's high voltage unit is the "flyback transformer." Like all transformers, the flyback consists of many turns of copper wire wound around a core. Instead of the heavy, laminated iron core that is used in an isolation transformer, the flyback transformer uses a lightweight material called "ferrite." Ferrite is a type of iron impregnated, ceramic material. We can get away with this lighter core material because the flyback transformer operates at a much higher frequency than the 60 hertz operation of the isolation transformer. The flyback transformer in the high voltage unit is driven at approximately 15,750 hertz. That's more that 260 times faster!

Like many transformers, the flyback has more than one winding. The primary winding (the input winding) is used to drive the transformer. This primary winding is also "tapped" at one point to obtain approximately 175 volts. This high frequency, AC output is then rectified with a diode and filtered with an electrolytic capacitor to obtain a +175 VDC power supply. This supply is used to drive the video output transistors on the neck board, which in turn control the electron guns in the CRT.

There are some really high voltage output windings on the flyback transformer. One is the "screen voltage." The screen voltage comes from a high voltage winding on the flyback and is rectified within the EHT unit by a special diode. You cannot see this diode as it is sealed with the flyback in epoxy plastic. The screen voltage is adjustable (generally around +200 VDC - +900 VDC) by a high voltage potentiometer unit that is usually built-in to the EHT unit itself.

Another high voltage output is the "focus" voltage. Like the screen voltage, it is derived from a flyback high voltage winding and diode combination. The focus voltage is also adjustable.



Typical flyback derived power supplies

The highest voltage output of all is the "second anode" or "EHT." This can be as high as 25,000 volts or more and is created through a series of secondary windings and diodes within the high voltage unit. The EHT output is connected through a heavily insulated wire to the second anode of the picture tube.

Low Voltage Power Supplies

Although failure in the high-voltage output windings are a common cause of flyback destruction, there are some low voltage outputs that, while not common failures in and of themselves, are often involved in other monitor failures.

For example, the cathodes in the electron gun assembly in the CRT must be heated. The orange glow you can see in the neck of the picture tube is the "heaters" at work. The heaters are powered by a low voltage winding on the flyback transformer. Just a few turns of wire are all it takes to get enough voltage. The CRT heaters are designed to work on 6.3 VAC.

There are one or two other low voltage windings on the flyback transformer that are rectified and filtered to create low voltage, DC power supplies. These power supplies are generally used by low voltage transistor circuits such as the video amplifiers, the sync amplifiers and the blanking circuits. They are often used to drive the vertical deflection output circuitry as well.

A good example of this is shown in the schematic diagram. In this monitor, the flyback transformer creates two, separate, low voltage power supplies. One is a +12 volt DC power supply that provides power to the video amplifier IC and most of the discrete transistor circuits. The other is a +24 volt DC power supply that powers the vertical output integrated circuit.

Notice the resistors in series with the output side of the power supplies? In the CRT heater circuit, it's R213 (.68 ohm, 2 watts.) In the +12 volt power supply there are two, series resistors. Follow the output of the flyback transformer from pin 5 to the first of the two resistors, R92. After passing through R92, the current is then "rectified" (changed from AC into DC) by diode D14 and "filtered" by capacitor C42. This DC is then passed (in series) through another resistor, R90. The value is the same for both, 1.2 ohms, 2 watts.

The +24 volt DC power supply is much the same. In this case, the flyback output is at pin 4. The AC output of the flyback transformer passes through resistor R91 first before being rectified by diode D13 and filtered by C40 to create +24 volts DC. From there you can see that the output of power supply connects to pin 6, the power input pin of IC3.

So what's the point of these resistors? It's simple, really. The low voltage power supplies are created from just a few turns of wire wound around the ferrite core of the flyback transformer. One turn of wire (or even a fraction of a turn, really) will create a substantial difference in the output voltage. In order to insure sufficient output voltage, there's always a little more on the secondary winding than will actually be needed. A series resistor is added to drop the voltage down to what it should be.

Additionally, the series resistor serves two other functions. One is as an inrush current limiter that protects the diode. The other is that the series resistor serves as a sort of fuse in that if the low-voltage load short-circuits (such as a shorted vertical output device) the resistor will open circuit rather than place an excessive load on the flyback. In fact, some manufacturers use a fusible resistor here specifically for that purpose.

IMPORTANT SERVICE TIP: It is common for these resistors to fail; not just in the example given above but in all types of monitors. When resistors fail, they "open-circuit," cutting off the power to the circuits they're supposed to be driving. It's something that novice technicians often overlook but it's actually one of those simple failures that are a snap to diagnose once you know what to look for.

ANOTHER IMPORTANT SERVICE TIP: Sometimes these resistors fail on their own and all you need to do to fix the monitor is to replace the resistor. However, an open resistor may be indicative of a shorted or otherwise faulty component somewhere else in the circuit. Logical deduction will often lead you right to a shorted component. Any component (other than a resistor) that's connected to the open resistor on one end and ground on the other is a candidate and should be checked out.

You can easily check for a short circuit by setting your meter to the lowest resistance range, grounding the black meter lead and probing the output side of the power supply with the red lead. A short circuit will be obvious. Naturally, if there's more than one component on the supply line that might cause the short, you must isolate the faulty part. There are usually only one or two components that might be shorted so I generally unsolder and remove the suspected components one at a time and re-check for the short as above. When the short goes away, I know I've found and removed the bad part. Alternatively, some technicians will "clip & lift" an IC pin or unsolder a component leg to isolate the short.

High Voltage Unit Failures

Well, regardless of how the EHT unit works, the important thing for the service tech is "how does it fail?" Fortunately, that's simple. It usually burns up or melts! You will often see the plastic bulging or melted. You also may see the shell of the unit cracked and/or burned.

A bad EHT unit will often take out the horizontal output transistor as well. If you replace a bad horizontal output transistor and the monitor still doesn't work, you may have a bad EHT unit (regardless of wether or not you can see any apparent signs of failure by examining the unit.)

Troubleshooting shortcut to finding a bad EHT unit . . . After replacing a bad horizontal output transistor, listen carefully for the sound of the high voltage coming on when you first fire up the monitor to test it. If you do not immediately hear the high pitched squeal of the high voltage unit or the crackling, static buildup on the picture tube, turn the monitor off at once and touch the horizontal output transistor with your finger. If it's at all hot, the high voltage unit is probably bad. If you turn the monitor off right away, you probably will not damage the transistor.

HK Shorts

Heater-to-Cathode Short? Put a Long in it!

Each of the three electron guns in the electron gun assembly uses a heated cathode as a source of electrons. The heater is the element that you see glowing when you look at the neck of a picture tube. The heater must fit closely inside the metal cathode but it must not touch it. If the heater shorts to the cathode, the gun will be stuck "ON" and the screen will appear a super bright color (red, green or blue depending on which of the three guns is affected) with vertical retrace lines visible throughout the screen. Vertical retrace lines appear as diagonal lines that run from lower left to upper right across the screen.

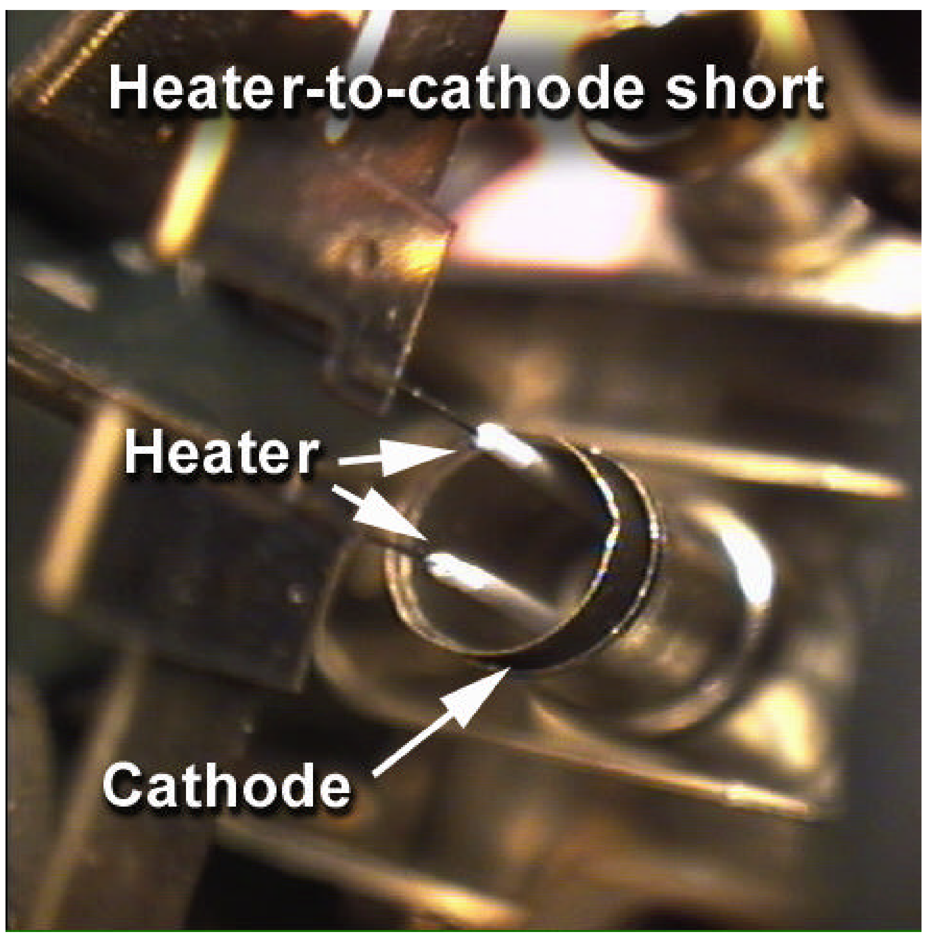
If you believe you might have a heater-to-cathode short, try unsoldering and removing the associated video output transistor from the neck board of the monitor. Fire up the monitor with the transistor removed. If you still have a brightly colored screen with vertical retrace lines, there's a good chance the CRT has a heater-to-cathode short.

You should be able to verify this with an ohmeter. With the neck board removed from the CRT, you should have an infinite resistance between heater and cathode of the picture tube. Although there are many different types of CRTs, you will often find the red cathode at pin 8, the green cathode at pin 6, and the blue cathode at pin 11. Pins 9 and 10 are for the heater.

Fixing the Symptom, Not the Cause

In the past, I had always concentrated on repairing the CRT itself; blowing away the short with a burst of current from a capacitive discharge. The real point is that we need to remove the unwanted ground connection to the cathode. We don't necessarily have to remove the heater-to-cathode connection, as long as neither the heater nor the cathode are grounded.

With that in mind, let's look at four different ways to get around the fact that we have a shorted CRT, without having to replace the CRT itself. Two of these methods use a transformer to isolate the heater connection from ground, the other two require only a slight modification of the high voltage unit



and heater connections.

Remember that the problem lies in the fact that one side of the flyback transformer winding is connected to ground and, naturally, one side of the CRT heater is as well. However, this is only done for the sake of convenience of wiring. It saves one wire (the return path) between the main printed circuit board and the neck board. It is not necessary (electronically speaking) to have one side of the CRT heater grounded. If we can break this ground connection, the heater will no longer be grounded and the defective electron gun will no longer be activated due to the HK short.

Start by locating the two heater pins on the neck board. These are often pins 9 and 10. Likewise, the two pins are often labeled "H" for heater or "F" for filament. One of the pins will be grounded. This should be pretty obvious just by looking at the neck board. One of the two heater pins will be connected to a large expanse of PCB conductor (the "trace"). If you cannot determine which pin is grounded by observation or by referring to the schematic diagram, you can use an ohmeter or continuity tester to determine the grounded heater pin. Just put one meter lead on the metal frame of the monitor and touch the other meter lead to each of the two heater pins one the neck board in turn. One pin will indicate continuity, the other will not.

NOTE: You must remove the neck board from the CRT in order to make this test. The CRT heater has a very low resistance (maybe an ohm or two when cold) and, as such, the ground connection will seem to appear on BOTH pins if the neck board is installed on the CRT itself.

Once you've located the heater ground, your next step is to isolate the pin from ground. Typically, this means using a razor knife or "MotoTool" (a hand-held, high speed grinder) to cut away the copper foil of the printed circuit board that connects ground to the heater pin. For goodness sake, be careful here. Try not to butcher the printed circuit board and don't stab yourself with the razor knife as you're slicing through the foil. You don't have to cut much, just create a thin gap to break the ground connection.

Next, you'll have to do the same thing at the high-voltage unit (A.K.A. flyback transformer) where you'll find the other ground connection. This may be a bit trickier as the ground connection here is often a fairly massive island of copper foil. Again, use a razor knife or grinder to isolate the ground connection from the CRT heater winding of the flyback transformer.

NOTE: Many monitors use a high-voltage unit with a common ground pin for both the high voltage winding and the heater winding. Unfortunately, this modification WILL NOT WORK on any monitor with a common ground for the CRT heater winding and ANY OTHER WINDING. If this is your situation, you'll have to use one of the other "transformer-based" solutions described below.

With the ground connections isolated at both the flyback transformer and the heater connections on the neck board, all that's left to do is to add a single wire between the two isolated points, completing the CRT heater circuit. You now have a complete circuit that powers the CRT heater WITHOUT a connection to ground. Since the heater is no longer grounded, the heater-to-cathode short no longer has any effect on the electron gun and you're back to business as usual (not to mention the fact that you've just saved to boss a bunch of money by not having to purchase a new CRT or entire replacement monitor!)

Isolation by Transformer

If you're working on a monitor with a heater-to-cathode short in the CRT but the high-voltage unit has a common ground between the secondary windings, you cannot isolate the CRT ground by simply cutting the ground traces. To do so would also break the return path for

the other windings as well.

In this case, we need to find another way to isolate the CRT heater from ground. When you talk about "isolation" one component comes to mind: the transformer. Most technicians are familiar with the "isolation transformer." This is a safety transformer often used to provide the AC power to a monitor, especially one under test on the bench. In this case, the isolation transformer is used to break the neutral/ground connection of the AC power, allowing us to connect an oscilloscope the normally "hot" primary side of the monitor's switched-mode power supply (SMPS) without vaporizing the ground lead of the 'scope probe. The isolation transformer also allows us the ground the SMPS ground to the "Earth ground" without blowing up the monitor's power supply.

But we cannot use an ordinary isolation transformer here. The CRT heater is driven by a winding on the flyback transformer in the high voltage unit (See Slot Tech Magazine, January, 2002, page 29). The flyback operates at 15,750 hz on a standard resolution monitor, 31 kHz in a VGA monitor. A normal isolation transformer is designed to operate at 60 Hz. Its heavy, iron core prohibits its use at higher frequencies.

However, a special CRT heater isolation transformer is available at most good electronics shops or thorough mail order from the major electronics parts houses. It's generally referred to as a "CRT heater isolation transformer" or something to that effect. The unit has a male and female socket at either end and plugs right in between the CRT and the CRT socket. A CRT booster or CRT brightener will also isolate the CRT heater.

Also, there is another way to isolate the CRT heaters using a small 6.3 volt transformer from Radio Shack.

1. Disconnect the wire that leads from the main board to the heater connection on the neck board.

2. Isolate the grounded CRT heater connection on the

neck board as described above.

3. Connect the primary winding to the AC input of the monitor (after the fuse, just in case!)

4. Connect the secondary winding of the transformer to the CRT heater pins on the neck board.

The CRT heater will now be powered by the 6.3 volt output of the transformer instead of the winding on the flyback transformer. Since the output winding of the transformer is, by its very nature, isolated, the heater is no longer grounded and the heater-to-cathode short doesn't make any difference. This cures the symptom (the bright screen) without actually curing the problem, the heater-to-cathode short!

The Trickiest of All

Okay . . . If you're still with me, here is the trickiest trick of them all. In fact, this is really the best way to solve this problem. The other stuff was presented more for its educational value than anything else.

Start by isolating the two heater pins on the neck board as you did before, by cutting the PCB traces with a razor knife or Moto-tool. Now this is where the procedure departs from our previous discussion. Next, unsolder and remove the wire that connects the ungrounded side of the CRT heater to the flyback transformer.

An alternative method to the whole slice and dice thingy is to unsolder and remove the CRT socket from the neck PCB (leave the focus wire in place). Enlarge the two holes for the heater pins by drilling them out and replace and resolder the CRT socket (all except the two heater pins, of course). You won't be soldering the CRT socket pins to the PCB anymore. Later, you'll be soldering wires directly to the two pins. Make the holes substantially larger in order to give you room for the wire and room to work with the soldering iron. The heater is now totally isolated from everything else.

Roll Your Own

I guess "wind your own" is really more accurate as what you're about to do is wind your own secondary winding on the exposed ferrite core of the flyback transformer. This is not nearly as involved as it sounds because you're only taking two or three turns around the core. Just grab eighteen inches of insulated wire. You can salvage a bit from an old wire harness. Number sixteen wire works fine. There will only be about an amp of current flowing so wire size isn't critical. Pass the wire through the gap between the body of the flyback and the ferrite core and wrap it around the core twice as shown in figure 2. When wrapped as shown, you actually have two and one-half turns.

Why am I being picky about a measly half turn? Well, you'll be amazed at how much voltage is generated by the little secondary winding you've just created. More about that in a moment but for now, solder the two ends of the wire to the two, isolated CRT heater pins.

You now have a complete circuit that powers the CRT heater WITHOUT a connection to ground. Since the heater is no longer grounded, the heater-to-cathode short no longer has any effect on the electron gun and you're back to business.

Power up the monitor and see if it works properly now. If it does, you've fixed the problem and you're ready to experiment with the next phase of this fun little project in resurrecting an otherwise completely useless CRT.

CRT Brighter

There's another little side benefit to this new flyback secondary you've just created. Since the number of turns of wire determines the output voltage of winding, you can increase the CRT heater voltage by adding an extra half or full turn of wire around the core. This trick is really a poor man's CRT rejuvenator/brighter. When you have an really old CRT that's on its last legs with poor emission from all three guns, boosting the heater voltage will increase the electron emission, restoring acceptable brightness in most cases.

Actually you can try this on any monitor without having to isolate the heater (as long as you don't have a heater-to-cathode short, of course) or create a dedicated secondary winding. Simply disconnect one end of the CRT heater wire that connects between the main PCB and the neck board.

Next, Pass this wire around the flyback core (making one-half to one full turn around the core) and reconnect it to where it was. Fire up the monitor and see what you have. You'll see one of two things: Either the picture will be noticeably brighter or it will noticeably dimmer. You see, that extra loop you just added around the flyback is really a one-volt secondary winding. You are connecting this in series with the existing CRT heater winding in the flyback transformer.

But if the two windings are sources connected in series wouldn't that automatically add the voltages? Not if the "phases" of the two windings are 180 degrees apart. Phase is to AC what polarity is DC. If two AC sources in series are out of phase, one winding subtracts from the other one. If the two are in phase, they add together.

Editor's note: The best way to restore a dim CRT is with THIS gizmo, the CR7000.

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If your picture (and the CRT heater) is dimmer than it was before you started, disconnect the wire and wrap it around the core in the opposite direction. That will reverse the phase and you'll be in business.

You can experiment with this and see what works best in each monitor. Naturally, this is only a last ditch effort to extend the life of an otherwise unusable CRT. Boosting the CRT heater voltage of a good CRT will reduce its life expectancy.

Blanking

There is a great deal of timing going on in the operation of a monitor. There are specific times when specific things are happening. One of these is the retrace time. For example, the electron beams begin at the left edge of the CRT. When the electron beams reach the far right edge of the screen, it is time to initiate the horizontal retrace. The horizontal retrace quickly brings the beams back to the left edge of the screen.

However, we don't want to draw a line on the screen during the horizontal retrace. If we did, we would see a diagonal white line between the two parallel lines of raster. This would cause the image to look all washed out. To prevent this, there is a circuit in the monitor called the blanking circuit. The purpose of the blanking circuit is to turn off all three electron guns during the retrace time. When the blanking circuit is on, the electron guns are turned off.

Because the horizontal deflection circuit is operating so much faster than the vertical deflection circuit, an interesting but hidden phenomenon occurs during the vertical retrace. As the magnetic field in the vertical deflection coils reverses polarity (to begin each field at the top of the CRT) the quickly scanning horizontal deflection circuit actually makes the beam move back and forth a dozen or so times before the beams reach the top of the screen. Turning up the brightness will often reveal these hidden "vertical retrace lines" that zigzag their way across the screen. This is actually the path the beams take as they make their way from the bottom of the screen back to the top. These lines are normally hidden from view; they are concealed by the blanking circuit as it is activated during the vertical retrace. Remember the blanking circuit turns off all three electron guns during the retrace time. If you see these vertical retrace lines, you may have a problem with the blanking circuit.

Blanking failure causes white, vertical retrace lines to appear on the screen.

Let's take a look at a couple of examples of blanking circuits. These are two different approaches used to accomplish the same task.

Turn Off the Outputs

This technique kills the video output transistors by removing their base bias. Check out the video output transistors, X103, X106 and X109. Notice that all three of the base leads are tied together. Follow this connection and it leads to the collector of X304, the blanking transistor. This is an NPN transistor with a grounded emitter. It is a classic "ground switch" configuration.

The blanking transistor is turned on during both the vertical retrace and the horizontal retrace. In other words, when the beam is at the right edge of the screen, the blanking transistor is turned on just before the retrace begins, and remains turned on until the magnetic field in the yoke has reset to the left edge of the screen at which time the blanking transistor is turned off. Likewise, when the beam is at the bottom edge of the screen, the blanking transistor is turned on just before the retrace begins, and remains turned on until the magnetic field in the yoke has reset to the top edge of the screen at which time the blanking transistor is turned off.

So here's the deal: The video output transistors are NPN transistors. In order for an NPN transistor to turn on, the base has to be .7 volt higher (more positive) than the emitter. Our little ground switch, the blanking transistor, drags all three of the base leads to ground which, as we all know, is zero volts. This simultaneously turns off all three video output transistors and their associated electron guns thus accomplishing the blanking procedure. Pretty cool, huh?

Kill the Inputs

Another technique is to attenuate the video inputs. In this case, transistors Q1, Q2 and Q3 are the video input transistors. Technically speaking, these transistors are not acting as video amplifiers. They are impedance matching transistors that convert the high impedance input used in video games to the low impedance input of the video amplifier IC.

The output of this first stage comes off the emitter of the transistor and is passed through a 150 ohm resistor and a 10 microfarad capacitor to the input of the video amplifier IC.

Okay, try to follow me here. See the three diodes, D5, D6 and D7? The anodes of these diodes are

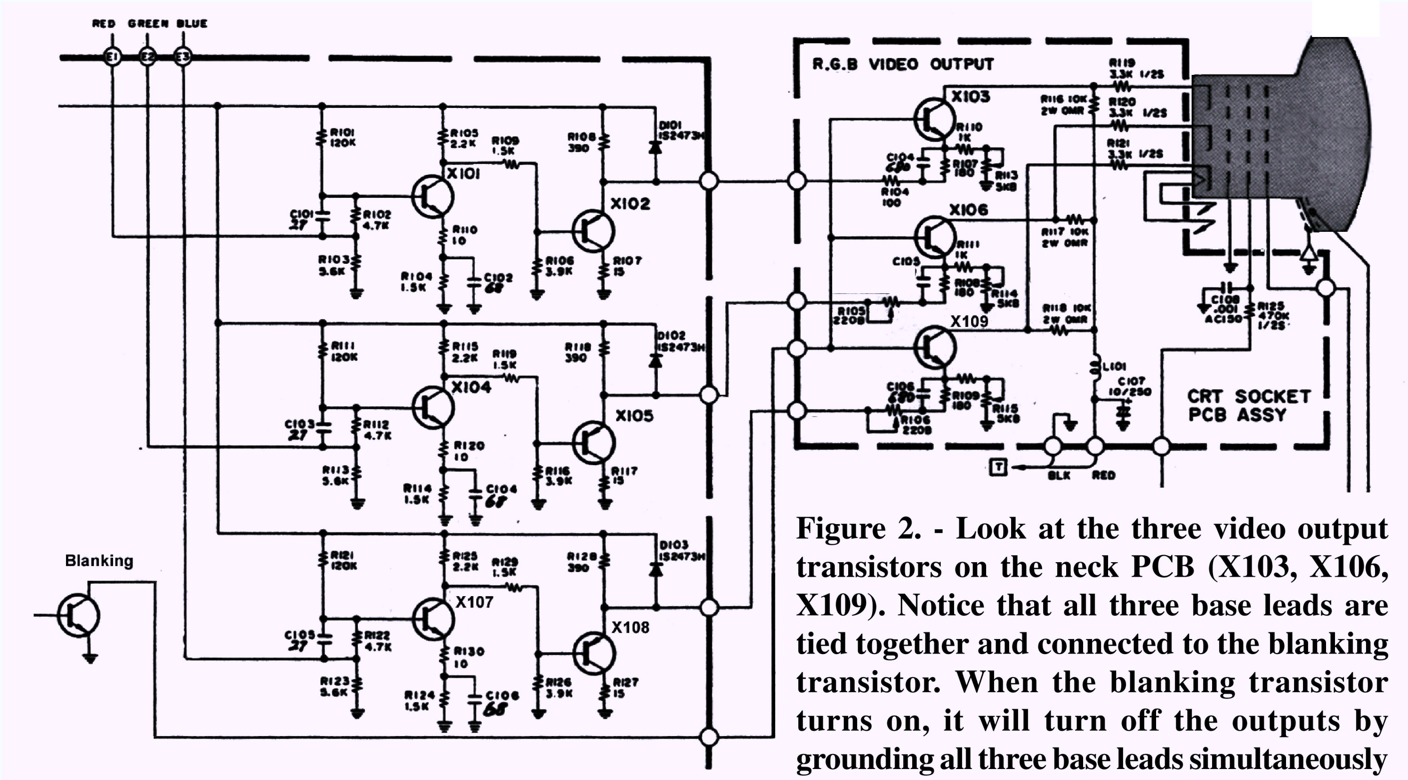
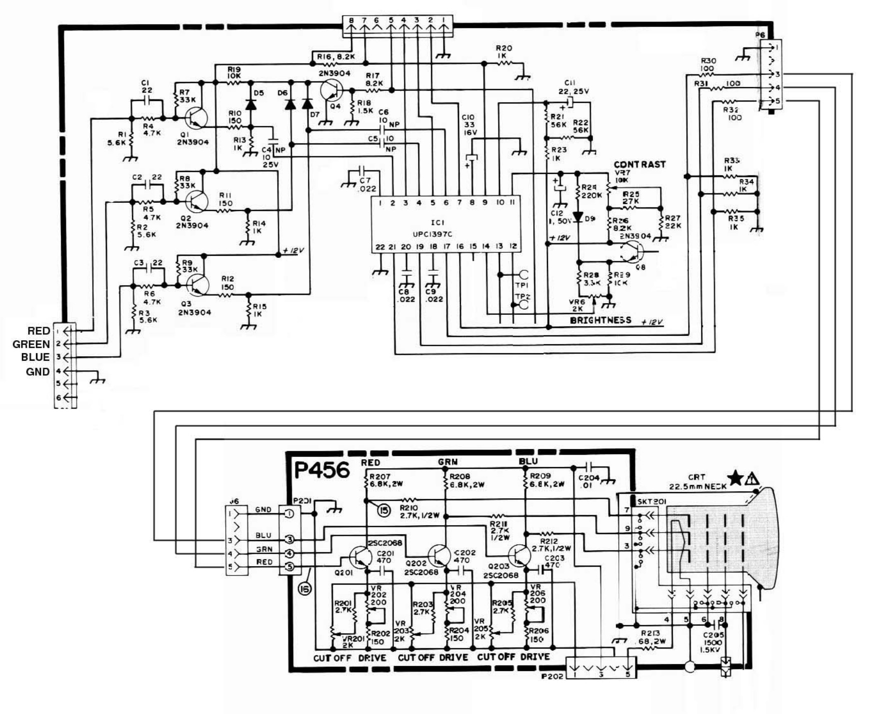


Figure 2. - Look at the three video output transistors on the neck PCB (X103, X106, X109). Notice that all three base leads are tied together and connected to the blanking transistor. When the blanking transistor turns on, it will turn off the outputs by grounding all three base leads simultaneously

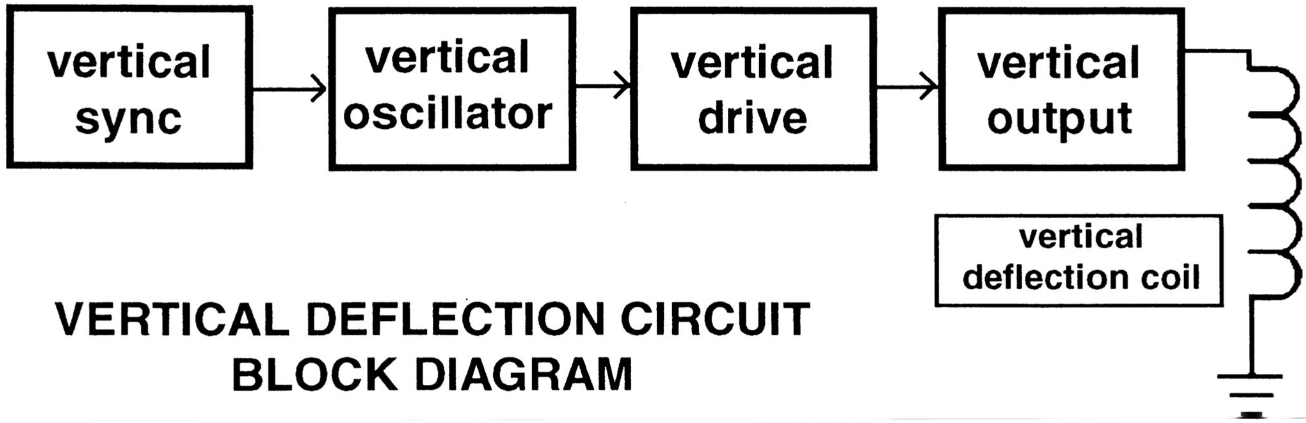
each connected to the red, green and blue video signals, just after the impedance matching transistors but BEFORE the inputs of the video amplifier IC. Notice that the cathodes of all three of these diodes are tied together and connected to . . . could it be . . .? Our old friend the ground switch! There it is, Q4.

As previously described, Q4 is activated during retrace. When the transistor is turned on, the video signals are shunted through the diodes, to ground. This clamps the video to a level of around .7 volt. The IC is looking for something close to a volt before you'll see any appreciable electron gun emission so clamping the video at .7 volt effectively accomplishes blanking.

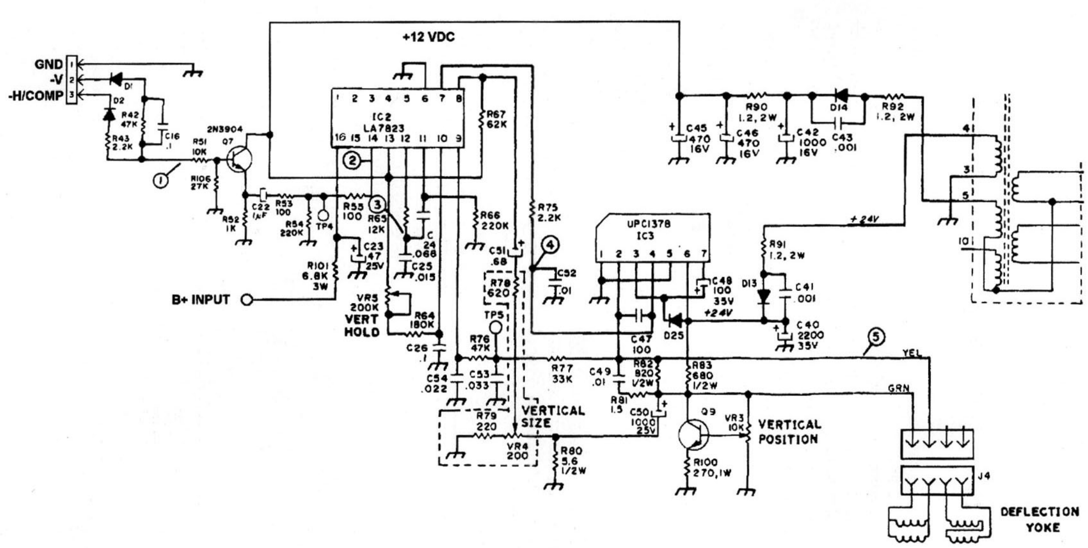
The blanking circuit will differ between monitor designs. The common thread here is that regardless of how it is accomplished, blanking must somehow control all the video circuits simultaneously. If the blanking transistor is not labeled on the schematic diagram, what you are looking for is some commonality between the three video circuits whether it is at the input or at the output.



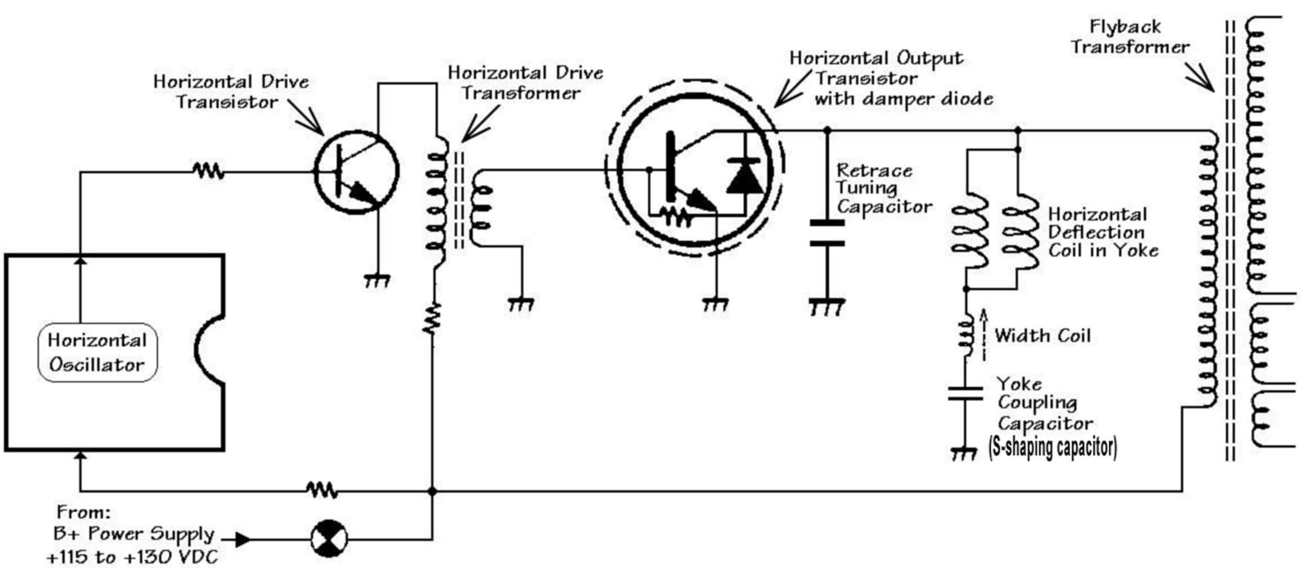
In this video circuit, the output transistors remain unmolested by the blanking transistor. Can you figure out how blanking is accomplished in this circuit? This time, it's the video inputs that are shut down. Q4 is energized during the retrace time, shunting the video signals to ground before they reach IC1, the video amplifier chip.



VERTICAL DEFLECTION CIRCUIT BLOCK DIAGRAM



Typical Vertical Deflection Circuit



Typical Horizontal Deflection Circuit

Slot Tech Magazine's Quick Fixes for Gaming Monitors

TATUNG
(Bally Gamemaker)

Dead Unit (Fuse OK)

Check the following. For capacitors, it is suggested that you replace them (as opposed to simply testing them) as I'll bet that they have a high ESR

C106	100uF@25v	PWM chip reference feed cap. Most common culprit
ZD620	7v Zener Diode	
Q603	2SC4542 (BU508)	Horiz output transistor
Q101	2SK1507	Power supply FET

Horizontal Width Won't Adjust

C19 4.7@50v NON-POLARIZED (High temp +105C) located next to flyback Xfmr

Vertical Problems

C704 & 705	100uF@35v	Lack of Vertical Scan
C714	104pF@100v	Coarse Lines at Top 2'' of Picture
IC701	LA7837 I.C.	Vertical Collapse (Flatline)

CERONIX 1492/2092 (IGT PE+)

Dead Unit or High Voltage Present but no Picture

295	160v Zener Diode	Power supply makes a chirping noise
218	LA7851 I.C.	Vertical output chip. You hear high voltage "fsst" but monitor shuts down again.
268	IRF831 FET	This usually blows the 3A fuse if it goes short circuit
292	1.2 ohm res	Measure carefully. If its above 1.8ohm, the FET will not trigger
130	7812 Regulator	Measure for 12v at the M gain (brightness) control. (HV but no picture)
104	PN2222 xsistor	(HV but no picture)
63/65	PN2222/MPSA64	These control the CRT beam limiter circuit. (HV but no picture)

Color Overdriven on CRT (Overcast)

91(B,G or R)	2SA1370 transistor	These go short causing either a Blue, Red or Green overcast on picture
83(B,G or R)	2SC3467 transistor	These go short causing either a Blue, Red or Green overcast on picture

Color Missing

PRA(x3)	Ceronix Part	The NE222 surface chip will go causing loss of color for that channel

KORTEK KT1703 (IGT Gameking & I Game)

These babies are still relatively new in the field but if you have one that looks like the CRT is on its way out (dull lifeless picture without definition) then get out the soldering iron and your capacitor box and change **ALL** of the following capacitors. There are still a lot of caps on this monitor board but this little family does nasty things. You'll be amazed at the results!

C403	1uf@50v
C407	0.47uF@50v
C408	4.7@50v
C425	1uf@250v
C501	1uF@400
C108	47uF@50v
C126	100uF@35
C128	470uF@25v

Copy this guide and paste it to the wall of the shop!

Olson's Repair Log

By Olson Jake

Here is a collection of miscellaneous symptoms and solutions, mostly on monitors.

Princeton Monitor EO900
Problem: Green power led is on. No screen or picture
Solution:
Replace
C821-47uf@160v
C906-220@16v
C438-100uf@200v
C437-470uf@25v
C445-100uf@25v

Princeton monitor EO50
Problem: No power. No green LED. Screen dark.
Solution:
Replace
C445-100uf@25v
C438-100uf@200v
C304-220uf@25v
Q408-High speed switch transistor, ECG 2388

Princeton monitor EO90
Problem: Power green LED on. Screen dark. No raster. No high voltage Sencore PR 570 - Current power reading about 10 & up to 21.
Solution:
Replace
C945-470uf@25v. This capacitor dead short.

Princeton monitor EO90
Problem: No green power LED, screen dark, no raster, no high voltage Sencore PR570 - Current power reading 0
Solution:
Replace
C945-470uf@25v
C758-10uf@100v
(both dead short)

Princeton monitor EO90
Problem: Green power LED on, no raster or picture Sencore PR570 - Current power reading, no -12 volt to deflection circuit
Solution:
Replace
C951 and C952, causing no -12 volt, both caps should be dead short

Kristel monitor 48CM
Problem: Vertical off frequency - won't lock in
Solution:
Check vertical output @ pin 6 of IC801. If missing, change it. Shorted IC causes vertical to roll.

Kristel monitor 48CM
Problem: DEAD, No picture, no sound, screen dark.
Solution:
Hooked power to Sencore PR570 and current/power indicator fluctuating numbers back and forth, which indicated the horizontal section was shorted. Checked horizontal output transistor with DMM and showed shorted, everything that connected to it was OK.

Kristel monitor 48CM
Problem: Screen keeps shutting down, power reset and screen will return.
Solution:
Replace
C513 - 100uf@25v,
C514 - 100uf@25v,
C616 - 100uf@25v,
check C522 - 47uf@160v for short, also check IC602, 12 volt regulator replace if shorted.

Kristel monitor 48CM
Problem: Monitor comes on for a moment, and then shuts off. No reading on Sencore PR570 when power applied.
Solution:
Replace
C513 - 100uf@25v
C616 - 100uf@25v.
Both found dead short.

Kristel monitor 48CM
Problem: Monitor DEAD, no picture, no raster, no high voltage.
Solution:
Replace
C513 - 100uf@25v
C514 - 100uf@25v
C616 - 100uf@25v
C803 - 220uf@25v
C522 - 47uf@160v
IC 602 (12volt regulator)
Check C522 capacitor, and IC 602 before replacing.

Wells Gardner color 15" model 17K3004
Problem: Has narrow screen.
Solution:
Replace
C726 and C727 - 10uf@50v

Atronic (green) button board
Problem: No LED on comparitor / not accepting coins
Solution: Transistor (T2) on green button board shorted, transistor manufacturer number BC338 cross into ECG 123AP. Replacing the transistor will clear the problem.

Bally Gamemaker - Bartop power supply
Problem: No power to monitor.
Solution: Check caps C7, C8, C9, C10 and usually C12 and C13 are shorted. Also, replace PC1 optoisolator IC (ECG 3041) on the power control board, replace C101-100uf@25v, and C103 - 4.7uf@50v. Checking and replacing these capacitors and ICs will clear the no DC power problem.

Bally Game 5500 Power Supply
Problem: No -12 volt or missing power out
Solution:
check IC1 for open, and SCR1
Replace
C8 — 220uf@25v
C16 — 2200uf@10v
C22 — 1500uf@10v
C15 — 1500uf@10v
C12 — 1500uf@10v
C13 — 1500uf@10v
C18 — 330uf@16v
C14 — 1000uf@16v
C19 — 330uf@16v

All these capacitors are rated at 105 degree temperature. In the same power supply, a large blue capacitor rated at 22000uf@50v should be changed out every three years. Should there be a power supply failure, check this cap. First, disconnect the 500 ohm resistor and then check. When replaced, filter capacitor, 2200uf@50v, C3 (220uf@25v) needs to be replaced also.

Kristel Monitor 48CM
Problem: Monitor dead
Solution: Power PR570 (Sencore) was used to analyze this problem. When power was applied with this machine, the power and current indicator showed only 24 when it should be reading around about 40 and above. This 24 indicates that there is current flowing through but not enough to light the screen.

Further test indicated 88volt is present at cathode of D508. Looking at the schematic and checking voltage at pin 1 of IC201, found 12volt missing. That led to the 12-volt regulator being open. The regulator IC 502 checks good when tested with DMM and comparing reading with good known one, both had the same reading. Replacing with a good regulator brought the 12 volts and the screen back. This indicates that when the reading is taken it checks good but when power is applied, the regulator breaks down, causing no 12 volts and no raster.

Kristel monitor 48CM
Problem: Vertical off frequency — won't lock in
Solution: Check vertical output at pin 6 of IC 801, if missing change it. Shorted chip cause vertical to roll.

Kristel monitor 48CM
Problem: Vertical collapse or horizontal white line across the screen.
Solution: Check IC 801 for cold solder (crack around the solder pins). This will cause the white line across the screen or check for shorted vertical IC.

Bally Gamemaker — Bartop — Power supply
Problem: No raster on monitor. All LEDs lit on processor board. Reset LED is also lit.
Solution:
Replace
C101—100uf@50v,
C103 — 4.7uf@50v,
IC1 replaced witb ECG 7096
PC1 replaced with ECG 3041.

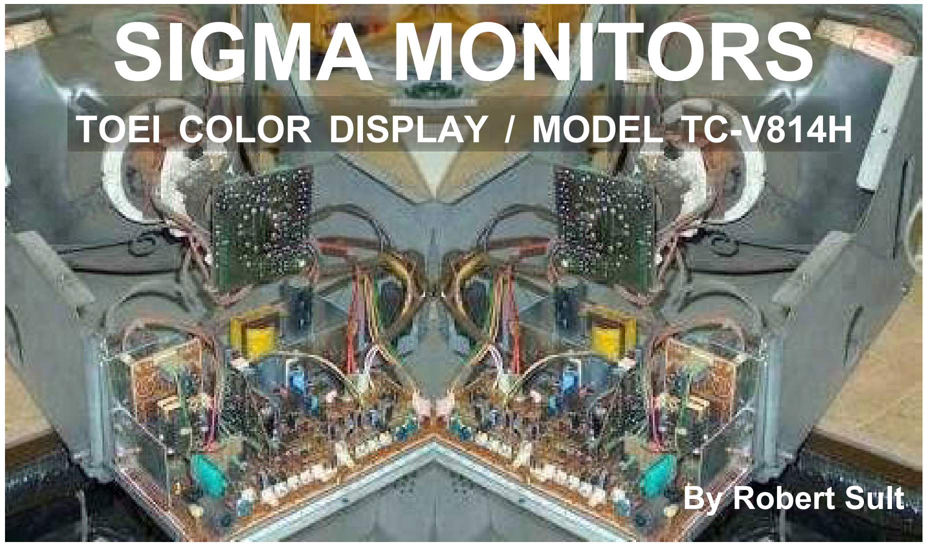
R3 will burn or open if C101 is shorted. Resistor should be 47 ohm 1/4 watt 5% tolerance.

- Olson Jake
ojake@slot-techs.com

Slot Tech Quick Fixes

SIGMA MONITORS

TOEI COLOR DISPLAY / MODEL TC-V814H



By Robert Sult

One of the easiest Monitors to repair is the TOEI Monitors. Over the past 4 Years, I have repaired over 125 of the TOEI Monitors.

COMMON PROBLEMS:

Vertical problems
Vertical distortion
Pincushion distortion
Line in center of screen
Black lines
Vertical roll

For about 85% of all problems, doing a complete capacitor job (replacing all electrolytic capacitors)should fix the problem. There are only 32 capacitors. When you figure the low cost of an electrolytic capacitor, it's just best to replace them all at one time. If not, you will find that you just fixed a monitor and in a week or two you will be working on the same monitor for a different problem. You might have saved time if you had just done the complete cap job.

I could describe a problem and direct you to the correct area (e.g. Dark on left side of screen - replace C28 or hourglass (pincushion) problem replace C601 - C602 - C604) but if you did a complete cap job, you do not really need to know that.

The following list of electrolytic capacitors has been recommended for the board in the TOEI Monitor:

CAPACITORS	PRESENT VALUE	UPGRADE VALUE
C7	100 uF @ 10 v	100 uF @ 25v
C8	47 uF @ 16 v	47 uF @ 25 v
C14	100 uF @ 16 v	100 uF @ 25 v
C15	10 uF @25 v	10 uF @ 35 v
C23	100 uF @ 16 v	100 uF @ 25 v
C27	470 uF @ 16 v	470 uF @ 25 v
C44	1000 uF @ 25 v	1000 uF @ 35 v
C49	100 uF @ 35 v	100 uF @ 50 v
C59	47 uF @ 100 v	47 uF @ 160 v
C71	100 uF @ 35 v	100 uF @ 50 v
C43	47 uF @ 35 v	47 uF @ 35 v
C11	10 uF @ 50 v	10 uF @ 50 v
C6	10 uF @ 50 v	10 uF @ 50 v
C2	10 uF @ 50 v	10 uF @ 50 v
C68	22 uF @ 25 v	22 uF @ 25 v
C17	1 uF @ 50 v	1 uF @ 50 v
C40	100 uF 50 v	100 uF @ 50 v
C50	1000 uF @ 35 v	1000 uF @ 35 v
	220 uF @ 35 v	220 uF @ 35 v
C28	10 uF @ 50 v	10 uF @ 50 v
C206	22 uF @ 200 v	22 uF @ 200 v
C204	100 uF @ 16 v	100 uF @ 16 v

For Problems with horizontal distortion, streaks, or tearing and other horizontal sweep problems, change the following caps:

CAPACITORS	PRESENT VALUE	UPGRADE VALUE
C301	220 uF @ 25 v	220 uF @ 35 v
C305	220 uF @ 25 v	220 uF @ 35 v
C302	33 uF @ 16 v	33 uF @ 25 v
C303	1 uF @ 50 v	1 uF @ 50 v
C308	1 uF @ 50 v	1 uF @ 50 V
C309	10 uF @ 16 v	10 uF @ 25 v

For problems in the area of pincushion distortion (hourglass shaped raster) or vertical sweep distortion, change the following capacitors:

CAPACITORS	PRESENT VALUE	UPGRADE VALUE
C601	22 uF @ 16 v B/P	22 uF @ 25 V B/P
C602	22 uF @ 16 v B/P	22 uF @ 25 v B/P
C603	4.7 uF @ 50 v B/P	4.7 uF @ 50 v B/P
C604	47 uF @ 25 v B/P	47 uF @ 35 v B/P

Other Problems That I Have Seen

BLACK OUT - Fuse Blown

BLACK OUT - Q23 Shorted (2SC2749)
Cross Ref: ECG 2308 - NPN High-Speed Switch - Series Pass

BLACK OUT W/High Pitch sound
Q18 Shorted (2SD1455)
Cross Ref: ECG 2302 - NPN horizontal output transistor with damper diode

Also have seen, flyback cracked - shorting (SPARKING) to the case.

One thing you might want to look for: I had a Sigma monitor come in, BLACK OUT

Found F1 fuse blown
Found Q23 shorted

After replacing them, the monitor would come up but it had a strange sound.
Found IC 2 - Cold Solder joint on all three legs.

Editor's Note: On the following four pages, you will find Robert's monitor repair log. Please keep in mind that this is a raw log and was intended only as a reminder of what had failed, the symptom and what had been replaced. This means that in some cases, the components that were changed may not have been the actual cause of the problem.

- Robert Sult
result1@result1.net

Bally Game Maker

Horiz line	part was LA7850 Replaced 182 & 183
Vert Roll & Horz Problems	Replaced 937 (K PRA Video Amplifier / par #CPR 0510)

Ceronix 1490

Black Out	Replaced 206 (C5184 / par #CPI 1403)
	Now Chirping - Replaced 207 (100 uF @ 25v / par #CPC 1102)
Bright White on left	Replaced 085 (MC7812-CT / par #CPI1407)
Black Out	Replaced 183 (150 uF @ 250 v / par #CPC 1105) &
	207 (100 uF @ 25v / par #CPC 1102)
Vert Roll and Distort.	Replaced 214 (PAR H Vert Cont. par #CPR 0503)&
	140 (.01 uF @ 100v -/ par #CPC 1031)
Flashing White Screen	Replaced 227 (Flyback Transformer - / par #CPT 1500)
No Picture	Replaced 125 (220 uF @ 35v / par #CPC 1103)
	207 (100 uF @ 25v / par #CPC 1102)
Vert Roll	Replaced 145 (PRA H Vert Control / par #CPR0503)
Vert Roll	Replaced 145 (PRA H Vert Control / par #CPR0503)
Black Out	Replaced 228 (1N5954B 160v Z-Diode / par #CPD 1256)
Vert Roll and distort.	Replaced 145 (PRA H Vert Control / par #CPR 0503) &
	98 (10 uF @ 25 v / par #CPC 1101)
	146 (1000 uF @ 35v / par #CPC 1104)
Vert & Horz problems	Replaced 183 (150 uF @ 250v / par #CPC 1105) top of cap blown off
Vert Roll (FAST)	Replaced 145 (PRA H Vert Control / par #CPR 0503)
182 Cap bubbled up	Replaced 182 (150 uF 250 v / par #CPC 1105)
Bright on one side	Replaced 215 (150 uF @ 250v / par #CPC 1105)
Bright White Screen	Replaced 227 (Flyback transformer / par #CPT 1500)
Black out	Replaced 125 (220 uF @ 35 v / par #CPC 1103) &
	126 (LA7830 Vert Deflection / par #CPI 1401)
Black Out	Replaced 227 (Flyback transformer / par #CPT 1500)
Black Out	Found Flyback Cracked - Replaced 227 (Flyback transformer / par #CPT 1500)
Black Out	Bad Flyback Replaced 227 (Flyback transformer / par #CPT 1500)
top corner black	Replaced 215 (150 uF @ 250v / par #CPC 1105)
Vert Black Lines	Replaced 125 (220 uF @ 35 v / par #CPC 1103)
Black out - Chirping	Replaced 208 (.1 uF @ 50 v / par #CPC 1039)
On power up, 1 quick chirp	Replaced 193 (1N4937 / par #CPD 1253)
Black Out & High Pitch sound	Replaced 215 (150 uF @ 250 v / par #CPC 1105)
Black on left side	Found cap 182 (150 uF @ 250v / par #CPC 1105) loose - - Fixed
Vert Roll	Replaced 145 (PRA H Vert Control / par #CPR 0503)
Black Out - Fast Chirp	Replaced 207 (100uF @ 25 v / par #CPC 1102)
fading out - Black on screen	Ripple and fold over Replaced 183 (150 uF @ 250 v / par #CPC 1105)
Left side Black	Replaced 215 (150 uF @ 250 v / par #CPC 1105)
Bad Screen	Replaced 183 (150 uF @ 250 v / par #CPC 1105)
NO Green	Replaced 36G (2SC3467 Video NPN / par #CPQ1308)
Vert Distortion	Replaced cap 129A (cap 10 uF @ 50 v / par #CPC 1101)
Black on one side	Replaced 183 (150 uF @ 250 v / par #CPC1105
Vert Roll	Replaced 145 (PRA H Vert Control / par #CPR 0503) Found Q18 shorted
Black on one side	Replaced 286 (100 uF @ 25 v / par #CPC 1102)
Black Out- CHIRPING	Replaced 215 (150 uF 2 250 v / par #CPC 1105 Flyback cracked
Black 3/4 of screen	Replaced 214 (PRA H Vert Control / par #CPR 0503)
Black Out	Replaced 182 (150 uF @ 250 v / par #CPC 1105)
	Replaced 317 (150 uF @ 250 v / par #CPT 1105)
Black on one side - fold over	Replaced 183 (150 uF 250 v / par #CPC 1105)
Bad Picture	Replaced 183 (150 uF @ 250 v /par #CPC 1105)
	182 (150 uf @ 250 v / par #CPC 1105)
	Replaced 215 (150 uF 250 v / par #CPC 1105)
Bad Picture	Replaced 183 - top ready to blow off
bad picture	Replaced 183 (150 uF @ 250 v par #CPC 1105)
	almost looks like a bad PRA H 182 (150 uF 250 v / par #CPC 1105)
Black Out fast chirp	Now Slow Chirp Replaced 208 (.33 uF @ 50 v / par #CPC 1041)
	Replaced 286 (100 uF @ 25 v / par #CPC 1102)
Black 6.3 volts on 127v line	Replaced 148 (LA7850) Replaced 207
	Replaced Flyback & Replaced 63 & 65
No Picture	Replaced 182- 183- 215
Vert & Horz Distortion	Found Leg broke off & Liquid coming out
	Replaced 182- 183 & 215 Replaced 186
Vert Fold over	Picture comes in slow now - left side fast
	Replaced 215 Replaced shorted Z-Diode 295
No Green & No Blue	Replaced 126
Black out	Replaced PRA H Replaced 191 & 192
Black out	Replaced Blown Fuse 183 Replaced shorted Trans, Mt4n45 195
	Replaced 228 Z-Diode
Vert Roll no Sync	Replaced 99 98 & 105 Replaced bad cap 257
High Voltage OK Bad Picture	Replaced 182 - 183 & 215
Red colored screen	Replaced 286
White Flicking Screen	Replaced 280 (C5184)
Black Out	Replaced 81G
black out	Replaced 80 - 81 - 82 - 158 - 152
power up/ monitor shout down	Replaced Flyback Replaced 83 B
bad picture/ bad Vert	Replaced 83R - 83B
Vert roll	Replaced c59 - c8 - c14 - c44 - c - c15
black out	Replaced 192
retrace lines at top	Replaced PRA J
ok for a few min. then black	Replaced 191

Ceronix 1492

Black Out	Replaced 192 (LA7830 Vert. Output / par #CPI 1401) & 191 (220uF @ 35V / par #CPC 1103)
Black Out	Replaced 191 (220 uF @35v / par #CPC 1103) & 286 (100 uF @ 25v / par #CPC 1102)
Black Out	Replaced 192 (LA7830 Vert. Output / par #CPI 1401) & 191 (220 uF @ 35v / par #CPC 1103)
Black Out - Chirping	Replaced 191 (220 uF @ 35v / par #CPC 1103) & 192 (LA7830 Vert. Output / par #CPI 1401)
Black Out	Replaced 191 (220 uF @ 35v / par #CPC 1103) and 286 (100 uF @ 25v / par #CPC 1102)
Black Out	Replaced 286 (100 uF @ 25v / par #CPC 1102)
Vert Problems	Replaced 214 (PRA H Vert contorl / par #CPR0503)
Vert Roll - Jumping	Replaced 191 (Cap 220 uF @ 35v / par #CPC 1103)
Vert Roll - No Red	Replaced 191 (220 uF @ 35v / par #CPC 1103) Started Chirping fast - Replaced 286 (100 uF @ 25v / par #CPC1102)
Vert - Jitters	Replaced 214 (PRA H Vert Control / par #CPR0503) & 191 (220 uF @35v / par #CPC 1103)
Black Out Chirping fast	Replaced 286 (100 uF @ 25v / par #CPC 1102)
Jumping No Vert Hold	Replaced 191 (220 uF @ 35v / par #CPC 1103)
Too much blue	Replaced 90B (FDH 400 - .1a, 200v Diode - / par #CRD 1250) & 91B (2SA1370E - / par #CRQ 1309)
Black Out Chirping	Replaced 192 (LA7830 Vert Output / par #CPI 1401) & 191 (220 uF @ 35V / par #CPC 1103)
Black Out	Replaced 286 (100 uF @ 25v / par #1102) & 191 (220 uF @ 35v / par #CPC 1103)
Horz Size too narrow	Replaced 121 (.047 uF @ 50v - / par #CPC 1036)
Picture Jumping	Replaced 191(220 uF @ 35v / par #CPC 1103)
Black Out Chirping	Replaced 191(220 uF @ 35v - / par #CPC 1103) & 192 (LA7830 Vert Output - / part# CPI1401)
Black out - Chirping	Replaced 191(220 uF @ 35v - par #CPC 1103) & 192 (LA7830 Vert Output - / part #CPI 1401)
Vert Roll	Replaced 214 (PRA H vert control / par #CPR0503)
Picture shrinking (Vert Size)	Replaced 214 (PRA H Vert Control / Par #CPR 0503) Now Rolling & Jumping Replaced 215 (1000uF @ 35V- / par #CPC1104)
Black Out Chirping Fast	Replaced 286 (100 uF @ 25v - / par #CPC 1102)
Vert Size Prob - Vert Roll	Replaced 191(220 uF @ 35v / par #CPC 1103) and 214 (PRA H Vert Control / par #CPR 0503)
No Picture - No 127V	Replaced 280 (C5184 Custom P. S. IC / par #CPI 1403)
No Picture - Chirping	Replaced 191 (220 uF @ 35v / par #CPC 1103)
Red over white cards	Replaced 83G (2SC3467F / par #CPQ1308)
Vert Roll	Found Shorted Diode (Add On Mod) Replaced Diode
Vert Problems	Replaced 214 (PRA H Vert. Control / par #CPI 1407)
Black Out vert roll	Replaced 214 (PRA H Vert Control / par #CPR 0503)
Black Out	Found Flyback cracked - Replaced 297 (Flyback transformer / par #CPT 1500)
Horz Distortion	Replaced 215 (1000 uF @ 35 v / par #CPC 1104)-
Black Out - Chirping	Replaced 191 (220 uF @ 35 v / par #CPC 1103) & 192 (LA7830 Vert Output / par #CPI 1401)
Black Out Chirping	Found Fly Back Cracked - Replaced 297 (Flyback transformer / par #CPT 1500)
Screen came up then faded out	Replaced 63 (PN2222A / par #CPQ1303) & 65 (MPSA64 / par #CPQ1302)
NO GREEN	Replaced 81G (Green Video Amplifier / par #CPR0500)
Vert Problems - Jumping	Replaced 214 (PRA H Vert Control / par #CPR 0503)
Black out - Chirping	Found Flyback sparking on case Replaced 297 (Flyback transformer / par #CPT 1500)
Vert Roll	Replaced 214 (PRA H Vert output / par #CPR 0503)
Black Out fast Chirping	Replaced 286 (100uF @ 25 v / par #CPC 1102)
Vert Fold Over	Replaced 183 (.33 uF @ 50 v / par #CPC 1041)
Black on right side	Replaced 317 (150 uF @ 250 v / par #CPT 1105)
Black Out	Replaced 191(220 uF @ 35 v / par #CPC 1103)
Black Out Fast Chirp	Replaced 286 (100 uF @ 25 v / part CPC 1102)
Slow chirp	Replaced 191 (220 uF @ 35 v / par #CPC 1103) & 192 (LA7830 Vert Output / par #CPI 1401)
Black Out - Chirping	Replaced 192 (LA7830 Vert Output / par #CPI 1401)
Vert Roll	Replaced 214 (PRA H Vert Control par #CPR 0503)
Video Jumping	Replaced 214 (PRA H Vert Control / par #CPI 1401) & 191(220 uF @ 35 v / par #CPC 1103)
Black Out - Chirping	Replaced 191 (220 uF @ 35 v / par #CPC 1103) & 192 (LA7830 Vert Output / par #CPI 1401)
NO Green	Replaced 83G (2SC3467F / par #CPQ 1308)
Black Out Chirping	Replaced 286 (100 uF @ 25v / par #CPC 1102)
slow chirping	Replaced 280 (C5184 Custom P.S. IC / par #CPI 1403) NOW Vert problems Replaced 214 (PRA H Vert Control / par #CPR 0503)
Black Bars - Distortion	Replaced 178 (1K ohn / par #CPR 0009) & 183 (.33 uF @ 50 v / par #CPC 1041) - and 146 (LM324 Quad Op amp / par #CPI 1405)
Black Out - Chirping	Replaced 191 (220 uF @ 35 v / par #CPC 1103) - 192 (LA7830 Vert Output / par #CPI 1401) & 256 (150 uF @ 250 v / par #CPC 1105
NO RED	Replaced 83R (2SC3467 / par #CPQ 1309)

Vert Roll	Replaced 214 (PRA H Vert Control / par #CPR 0503)
Black Out	Replaced 286 (100 uF @ 25 v / par #CPC 1102)
Black Out	Replaced 191 (220 uF @ 35 v / par #CPC 1103)
Vert Problems	Replaced 214 (PRA H Vert Control / par #CPR 0503)
Black Out	Replaced 191(220 uF @ 35 v / par #CPC 1103)
Vert Problems - Jumping	Replaced 214 (PRA H Vert Control / par #CPR 0503)
Vert Roll	Replaced 214 (PRA H Vert Control / par #CPR 0503)
Vert Size problem	Replaced 214 (PRA H Vert Control / par #CPR 0503)
Black Out - Fast Chirp	Replaced 288 (330 uF @ 100 v / par #CPC 1002)
Horz center problems	Replaced 230 (1 uF @ 50 v / art # CPC 1100) & 233 (1 uF @ 50 v / par #CPC 1100)
Vert Jump	Replaced 214 (PRA H Vert Control / par #CPR 0503)
Fast Chirp	Replaced 286 (100 uF @ 25v / par #CPC 1102)
Vert Jumping	Replaced 214 (PRA H Vert Control / par #CPI 0503)
Black Out Chirping	Replaced 192 (LA7830 Vert Output / par #CPI 1401)
Black Out	Replaced 286 (100 uF @ 25v / par #CPC 1102) - Now chirping Replaced 192 (LA7830 Vert output t/ par #CPI 1401)
Black Out	Replaced 286 (100 uF 25 v / par #CPC 1102) 127v@ 7.2v
Black Out - Chirping	Replaced 125 (10 uF @ 25 v / par #CPC 1101)
Vert Jumping	Replaced 215 (PRA H Vert Control / par #CPR 0503) Replaced 207 (100 uF @ 25v / par #CPC 1102)
NO GREEN	Replaced 112 (Flyback Transformer / par #CPT 1500)
Vert Roll	Replaced 4 (74LS04 / par #CPI 1410)
Black Out- Chirping	Found 182 cap - top ready to blow off
Red - comes and goes	Replaced 280 (C5184 Custom P.S. IC / par #CPI 1403)
Black Out	Replaced 286 (100 uF @ 25 v / par #CPC 1102) 191 (220 uF @ 35 v / par #CPC 1103) Replaced 83R (2SC3467F / par #CPQ 1308)
No Red	Replaced 286 (100 uF @ 25 v / par #CPC 1102)
Black Out	Replaced 286 (100 uF @ 25 v / par #CPC 1102) Replaced 286 (100 uF @ 25 v / par #CPC 1102)
Fast Chirp	Replaced C59 - C44 - C14
NO Green	Replaced 286 (100 uF 25 v / par #1102)
fast chirp	Now slow chirp Replaced 192 (LA7830 Vert Output / par #CPI 1401)
Vert Roll	Replaced 286 (100 uF @ 25 v / par #CPC 1102)
black out Fast Chirp	Now Vert Roll Replaced 214 (PRA H Vert Control / par #CPR 0503) Replaced 214 (PRA H Vert Control / par #CPR 0503)
Vert. Roll	Replaced Broken V size pot (500 ohm black pot / par #CPR 0413) Found Q18 shorted
Black Out	Replaced 286 (200 uF @ 25 V / par #CPC 1102)
Black Out No Chirp	Replaced 286 (100 uF @ 25 v / par #CPI 1401) (Power outage)
Black Out - fast chirp	now slow chirp (Power outage) Replaced 191 (220 uF @ 35 v / par #CPC 1103) & 192 (LA7830 Vert Output / par #CPI 1401)
Black Out fast chirp	Now slow chirp Replaced 191 (220 uf @ 35 v / par #CPC 1103) & 192 (LA7830 Vert Output / par #CPI 1401)
Black out fast chirp	Found Crack in Flyback (Replaced Flyback) Replaced 230 & 233
Black out	Replaced 91B PRA
1/4 x 1/2 Blue line	Replaced 183 - cap look like ready to BLOW
Black out & Fast Chirp	Now Slow Chirp
Black out	Replaced 145 PRA H
No Blue Now have Vert Roll	Replaced 214 PRA H
Power Up No Picture	Replaced Flyback Replaced 214 PRA H
Vert Roll	Replaced 286
Black out Chirping	Replaced 286 - power up OK
Black out	Replaced 183
Black out	Replaced PRA H
Black out	Replaced shorted Z-Diode 295 Replaced shorted NTE2398 268
Power up & shut down	Replaced C5184 280 Replaced 82B
No Color Green	Replaced 37R 37G 38R
Vert Roll	Replaced 183 (Cap Bad)
Horz center problem	Replaced 230 & 233 10uF @ 50v cap Replaced 182 - 183 & 215
Retrace lines	Replaced 286
Chirping then would come on	Now Vert Roll - Replaced PRA H Replaced PRA H
Horz Size	Replaced 165 Replaced C601 C602 C603 & C604
Black out chirping FAST	Now Retrace lines at top of screen Replaced 191 Replaced PRA H
Vert Jitter	Replaced Pot on remote control board Replaced 183
Horz position will not adjust	Replaced 230 & 233 Replaced 83B (C3467)
No Blue	Replaced 317 (Cap 100 uF 250v) Now Fast Chirp
NO Green	Replaced 83G (C3467)
Bad Picture Bad Focus	Replaced 192
Black out chirping	Replaced 280
Black out 7.5 v on 127 v line	Replaced 191 192 & 286
Black out	Replaced 233, 230 & 191 Replaced 192
Retrace lines	Replaced 191, 230 & 233 change 191 & 192
Vert Roll	Replaced PRA H
Black out then retrace lines	Replaced 191, 230 & 233 Replaced 191, 230 & 233 Replaced 191, 230 & 233
retrace lines	Replaced 191, 192
retrace lines	Replaced 286
black out	Replaced 83G
bright green	Replaced 286
no green - Some Vert jitters	Replaced cap on PRA H board Replaced 233 & 230 adjusted and Replaced PRA H board

unable to adjust picture Horz	Replaced 230 & 233
short Vert	Replaced 230 & 233
Can't adjust picture horiz	Replaced 286
black out	Replaced c71- c603- c601- c602- c604
no blue	Replaced remote board Replaced 215 - 183 - 182 - 125
	Replaced PRA H
bad picture	Replaced 146 - 144 - 125 no red - no blue Replaced Q23
Vert roll retrace lines	Replaced 191
no green	Replaced 83G 191 - 230 - 233 Replaced PRA h
retrace lines	Replaced 83r
Vert roll	Replaced PRA h
no red	Replaced PRA h
Vert roll retrace lines	Replaced 191 Replaced 192 Replaced 83R
black out - chirping	Replaced C610 - C615
no blue	Replaced 191
black out / 30v on 127v retrace lines at top -	
	Replaced 191 found neck board loose
black out slow chirp	Replaced PRA h
too much red	Replaced 122
no blue	Replaced 257
no blue	Replaced 126- also 125 178
black out	Replaced 125 207
black out then Vert roll	Replaced PRA h Replaced Flyback
Vert roll retrace lines	Replaced 191 Replaced PRA h
Vert roll Vert static	Replaced 215
retrace lines	Replaced 191 - 230 - 233 Replaced 83G
no green / too much red	Replaced PRA h
short picture - Vert roll some retrace lines -	
	Replaced 191 - 230 - 233 Replaced 1258 - 162
black out chirping then too much green -	
	found green PRA b board cracked Replaced PRA b
Black out - after a while it will start to chirp	
	Replaced 286 (Cap 100 uF 25 v) Replaced 83G (C3467)
power up, High pitch sound- Black out 295 shorted -	
	Replaced 245 Fuse Blown Replaced Replaced 286
	Replaced 601 - 602 - 603 - 604
24V on 127V line Powered up - Looked OK but after 2 min Black Out and strange Chirping Sound.	
	Replaced 286 (100uF 25 V cap)
	Now Slow Chirp Replaced 192 (La7830) Replaced 280
Ceronix 2793	
Blue retrace lines	Replaced 945 (MPS2907 / par #CPQ 1301) &
	951 (2SA1370AE / par #CPQ 1309)
Wells Gardner 3001	
Vert collapse	Replaced 286
Mini Bertha	
Black Out	Replaced 191(220 uF @ 35 v par #CPC 1103)
	192 (LA7830 Vert Output / par #CPI 1401)
	286 (cap 100 uF @ 25 v / par #CPC 1102)
Sigma TOEI	
Black Out	Replaced Q18 (D1455) Replaced - 286 (100 uF @ 25 v / par #CPC 1102)
Black Out	Replaced C40 - C51 - C50
Black Out	Replaced caps C50 - C51 - C40 - C28
	Powered up 2 picture @ bottom of screen -
	Did A Complete cap job & cap update - .
Black Out	Replaced Q23
Dark on left side	Replaced C40 - C28 - C50
Vert line in center	Found 182 - top of cap ready to blow off
Vert Roll	Replaced 308 (1 uF @ 50 v) 313 301 (220 uF @ 35 v) 302 (33 uF @ 25 v)
Picture OK High Pitch Sound	Replaced C59 C8 C44 C27 & C15 Replaced Flyback
Black out	Replaced Shorted Q23
Black Lines	Replaced 2SC945 also Caps - C7 (100 uF @ 25 v) C8 (47 uF @ 25 v)
Black Out	Replaced shorted Q23 Replaced 191 & some other old caps
black out high pitched sound	Good picture now just high pitch sound found cold solder joint on c59
	Replaced 192 board ok, Replaced CRT
hour glass picture	Replaced PRA h
black out	cap up date Replaced PRA h Replaced 601 - 602 - 604 - 603
Black Out	Replaced Fuse & Q23 (C2749)
power up, high pitched sound	Replaced caps checked ok
Vert Too Short	Replaced Q202 Total Cap Update
Black Out - High pitch Sound	Replaced Q18
Hour Glass Picture	Replaced C601 - C602 - C603 - C604
Black Out	Blown Fuse - Replaced Fuse & Q23 (C2749)
1 Inch of picture at top	Replaced 286 - Now Slow Chirp
Vert Size problem	Replaced 192 (LA7830 Vert Output / par #CPI 1401)

And finally . . .
Sigma monitor - Black out - found blown fuse
Found out Flyback was cracked and it was shorting to case,
where I was holding it.

Thought long and hard about just being a floor tech.
GIVE UP THE BENCH WORK....
I'm still here !!! On The Bench............. **- Robert Sult**

X-Ray Protection

Would it surprise you to learn that almost every home in America has at least one X-ray machine? Your casino has hundreds or thousands of them.

Okay, maybe I'm stretching it a bit but in fact, monitors are really just an inch away from being X-ray machines. The high voltage in a monitor's CRT, combined with its electron gun, create x-rays as a by-product of their normal operation. For this reason, the glass in a CRT has a high concentration of lead. You probably know that the glass screen of a CRT is pretty darned thick. While the thickness of the glass does serve to strengthen the CRT against breakage, that is not the only reason for its thickness. The leaded glass in a CRT serves as an X-ray shield. It functions in the same way as the lead apron that your dentist uses to protect your internal organs when he takes a dental x-ray.

Almost all monitors include a circuit known as an "X-ray protector" or "high voltage shut-down." The purpose of this circuit is to shut down the EHT if it becomes excessively high in voltage. In a nutshell, it does this by killing the horizontal oscillator circuit. This prevents the monitor from emitting excessive X-rays.

The symptom of a monitor that has gone into X-ray protection mode is that you will hear the monitor fire-up momentarily but it will immediately shut down. That is to say, you will hear the crackling sound of the static electricity buildup on the CRT (if you're in a quiet shop, that is. You likely will not hear it on

An NE2 Neon lamp will verify that the monitor has entered X-ray protection mode. If you hold the lamp against the ferrite core of the flyback transformer, upon initial power-up it will blink once, showing you that the EHT has come up but shut down immediately.

the floor) but the EHT shuts down and, of course, the monitor never warms up.

An NE2 Neon lamp will verify this condition. If you hold the lamp against the ferrite core of the flyback transformer, upon initial power-up it will blink once, showing you that

Instead of connecting to the second anode, the X-ray protection circuit looks at a separate secondary winding on the flyback transformer (Figure 1). This is not a step-up winding like the EHT wind-

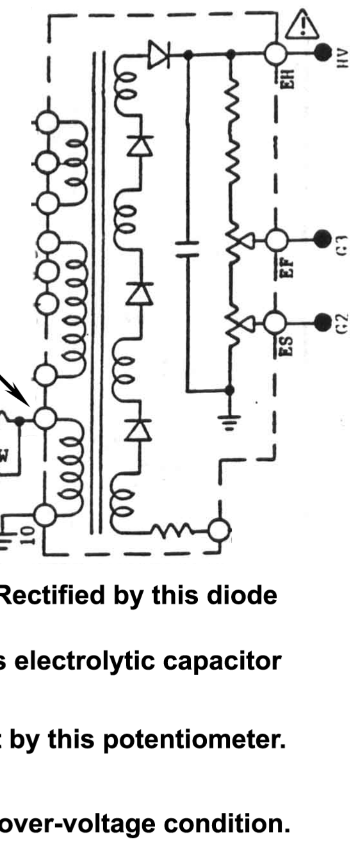
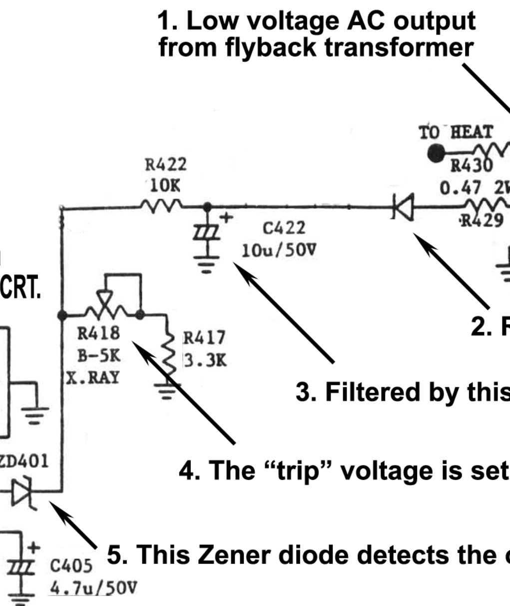
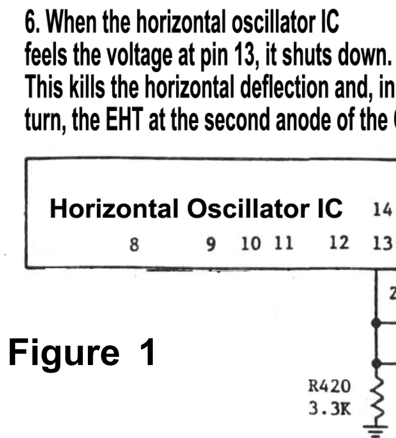




Figure 1

the EHT has come up but shut down immediately.

How it Works

In order for the X-ray protector to work, it has to know what the voltage is at the second anode of the CRT. Right away, we're in trouble here because the second anode voltage is tens of thousands of volts. In most color monitors, it's around one kilovolt for each diagonal inch of the CRT. This type of high voltage doesn't mix well with the semiconductors and other low voltage components on the monitor PCB. There has to be another way to determine the voltage at the second anode without actually touching it.

ing. This is a low voltage, step-down winding. The voltage varies between monitors but typically, it's 6 to 10 volts AC. Since this winding is on the same transformer core as the EHT winding, its voltage will be directly proportional to the EHT. In other words, if the EHT voltage rises, so does the voltage at this winding. If the EHT falls, so does the low voltage AC output. By sampling the voltage at this winding, we can deduce the EHT without touching it directly.

But the output of the step-down winding needs to be tamed a bit before we measure it. At this point, it's alternating current. Pull out your back issues of Slot Tech Magazine (October 2001) if you need a refresher on transformers and why the output of a transformer is AC. Not only is it alternating current, it's AC at the horizontal frequency of 15 kHz or 31kHz or whatever frequency your monitor is using, depending on its resolution.

The fix is simple, of course. We can turn it into DC with a diode and then filter it with an electrolytic capacitor. Looks like a power supply, doesn't it? Smells like a power supply too but it's not. This DC voltage isn't going to power anything at all. This DC voltage is directly proportional to the DC voltage at the second anode. Just to plug in some typical (and easy) numbers, when the second anode is 20 kV, the DC voltage is at this point is 10 VDC. The ratio is

2000:1.

Now what? Using this proportional DC voltage, something has to detect whether or not the voltage is normal (everything's working ok - no X-ray threat detected) or if the DC voltage is too high (Warning! Danger, Will Robinson!). There is one component that suits this function perfectly: The Zener diode (Slot Tech Magazine, August 2001).

As long as everything is working perfectly, the voltage at the cathode of the Zener diode is less than the nominal Zener voltage. Let's continue to use 10 volts as an example. The Zener diode is a 1N4742 diode, rated at 12 volts. Remember, the Zener diode will not conduct until we exceed the Zener voltage so as long as the cathode voltage is 10 volts, the Zener diode will not conduct.

If the EHT rises due to some type of monitor fault (more on this later) the low-voltage will follow suit and will rise to the point where it will exceed the Zener voltage. For the sake of discussion, let's say 13 volts (representing, of course, 26 kV at the second anode - high enough to cause the emission of soft X-rays). Now the Zener diode will conduct. It will drop 12 volts and give us 1 volt at the anode.

Okay. Now we're on our way. We have created a circuit where an over-voltage condition at the second anode of the CRT gives us a 1 volt signal at the anode of the Zener diode. Now what? Well, check it out . . . The "one volt when bad" signal is connected to the horizontal oscillator IC. As you recall, this is where the horizontal deflection is born (see Slot Tech Magazine, December 2002) - the horizontal deflection that drives the flyback transformer in the high voltage unit. By killing the horizontal oscillator, you kill the EHT, hence you kill the X-ray hazard. Sweet.

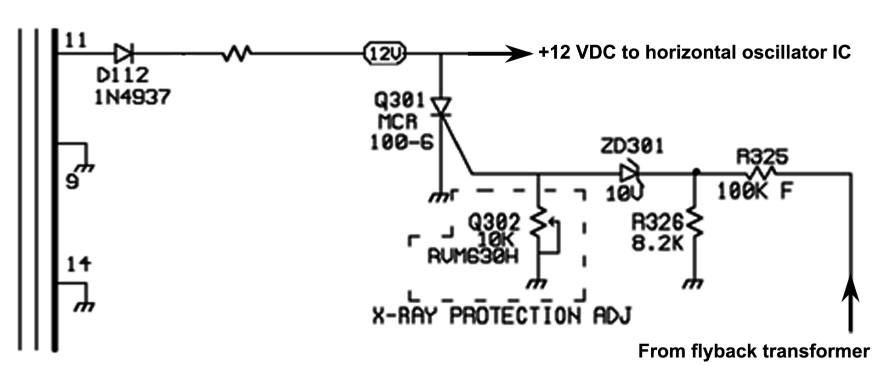
In another X-ray protection scheme, the signal from the anode of the Zener diode is used to gate an SCR (see Slot Tech Magazine, May 2001) which, in turn, drags down the +12 VDC power supply buss to ground. Since the horizontal IC needs this +12 VDC to operate, the oscillator is killed. The SCR latches the protection condition until the fault is rectified and power is reapplied. This is how Kortek does it in their KT-1703NA.

What is the Cause?

That's all well and good. Protection is a good thing. But what can cause the monitor's X-ray protector to kick in? What type of failure can cause the monitor's CRT to become an X-ray generator? Generally speaking, there are just two things that activate the X-ray protector, one of which is much more common than the other.

The most common cause of this problem is a power supply voltage that is unacceptably high. When the B+ power supply voltage rises, naturally all of the voltages in the monitor rise as well including the EHT at the second anode of the CRT. This is what causes excessive X-radiation.

In most SMPS designs, there is a reference voltage that is derived from a "sense" winding on the power transformer. It usually consists of a simple



In another X-ray protection scheme, the signal from the anode of the Zener diode is used to gate an SCR which, in turn, drags down the +12 VDC power supply buss to ground.

circuit with a single diode and a small filter capacitor. The capacitor is often in the range of one to one hundred microfarads. When the filter capacitor in this circuit fails, the reference voltage drops. This causes the integrated circuit in the SMPS to increase the pulse width to the MOSFET, boosting up the output voltage to a level that is much higher than normal. Naturally, this trips the X-ray protection circuit and causes a high-voltage shutdown in order to prevent excessive radiation.

In the November 2002 issue we looked at a similar result (over-voltage) caused by a bad optical coupler. Kortek had received a bad batch of the opto-isolators. The nature of the failure was that the transfer rate was bad and that fooled the SMPS into thinking that the B+ output voltage was too low. The PWM controller IC responded by raising the B+ voltage. As the B+ rose, the current in deflection circuits increased, resulting in a picture that was "overscanned." The edges of the raster extended beyond the edges of the CRT. The picture appeared "overscanned" in all dimensions. As the entire picture became intermittently larger, this symptom was referred to as "blooming" as the raster seemed to bloom outwards from the center of the CRT. Eventually, the B+ would rise to the point that the X-ray protection kicked in, causing the monitor to black out completely.

Another failure that can trip the X-ray protector may be in the bypass capacitor that removes spikes from the horizontal output circuit (Slot Tech Magazine, October 2002).

The noise generated by the horizontal output transistor (and the rest of the horizontal output circuit in a monitor) takes the form of huge voltage spikes that can easily reach +160 volts or more. Since the horizontal output stage of a monitor is directly powered by the B+, these voltage spikes will travel along with the B+ to other circuits and can really mess up the monitor!

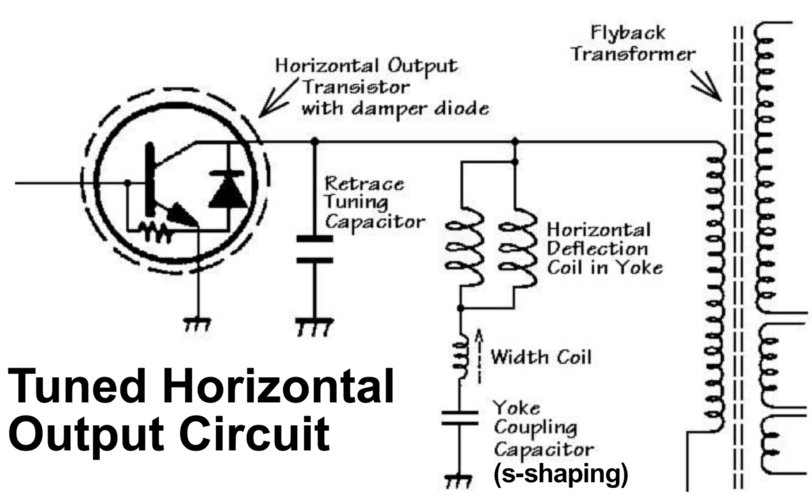
The bypass capacitor filters out the voltage spikes to prevent them from affecting the rest of the monitor circuits. It absorbs the spikes, passing them to ground.

When this capacitor fails, the voltage spikes are delivered, full force, to the rest of the monitor circuits, including the X-ray protector. In this case, the voltage spike exceeds the Zener voltage, tripping the X-ray protector and shutting down the monitor, even though there was no real threat of X-rays. Just a little something extra, thrown in there to make life a challenge for inexperienced technicians.

LC Circuits

If you are still having problems with high EHT tripping the X-ray protector, you might have one of the hardest of all problems to diagnose in a monitor; you might have a de-tuned horizontal output circuit.

The horizontal output circuit is a tuned circuit. It consists



Tuned Horizontal Output Circuit

of five basic parts: The retrace tuning capacitor, the pair of horizontal coils in the deflection yoke, the width coil, the yoke coupling (also known a the "S shaping") capacitor and the flyback transformer in the integrated high voltage transformer (IHVT) which is also known as the high voltage unit. The operation of the horizontal output circuit was covered in December 2002. What wasn't covered is an admittedly rare condition when one of these components doesn't fail completely but rather shifts its value or "quality" somehow.

You see, the horizontal output circuit is a tricky little devil. Because it's a tuned circuit, it's designed to operate most efficiently at a specific frequency. For example, in a VGA resolution monitor, the horizontal frequency is around 31.5 kHz. The coils in the deflection yoke and the retrace tuning capacitor(s) form what's known as an LC "tank." A tank is a capacitor in parallel with a coil. The electronic abbreviation for coil the letter "L." C means capacitor, of course.

In a tank circuit, the inductance of the coil and the capacitance of the capacitor are chosen carefully by the design engineer to resonate at exactly the horizontal frequency. If either of the values changes (due to age or some type of failure), the naturally resonate frequency of the tank changes.

There is another LC circuit at work here as well. It's the width coil in series with the S shaping capacitor. In this case, it's also designed to work at a specific frequency but it doesn't resonate. In a series LC circuit, the inductive reactance of the coil (a coil is also known as an "inductor") is canceled out by the capacitive reactance of the capacitor. That's right! In a perfectly tuned series LC circuit where the capacitive and inductive reactance are equal, the two components actually cancel each other out and, electronically speaking, disappear! When the value of either component changes, the subtractive difference of the two values will change as well. They will either cancel out more of each other's inductance (creating a lower total impedance) or not cancel enough of each other's inductance, causing the total impedance to rise.

Even the smallest change in value can create a big change in the total impedance of a series LC circuit or the resonate frequency of a tank. However, regardless of any change in the tank or the LC series circuit, the horizontal output circuit is still being driven by the normal, proper frequency. This frequency is determined by the horizontal oscillator and the sync signal that comes from the game PCB, both of which are, presumably, still operating normally.

This can cause all kinds of problems, including a substantial rise in EHT voltage even though the B+ power supply is perfectly normal! In this case, the cause might be a drop in value of one or more retrace tuning capacitor(s). They're easy to find because they're in parallel with the horizontal output transistor. There may be two, three or even four of these in parallel here. This is where you have to be careful because the value, which is usually expressed in picofarads (3900 to 5600 is typical), can vary quite a bit depending on the size of the CRT and the operating frequency of the horizontal deflection circuit. Two chassis that look otherwise identical can have a wide range of different values here.

Use a good capacitance meter to ferret out a drop in capacitance or try replacing them. Since it's such a rare failure, you're likely to have a junk chassis with these components still on it.

- Slot Tech Magazine

March 1998 • 16-003918

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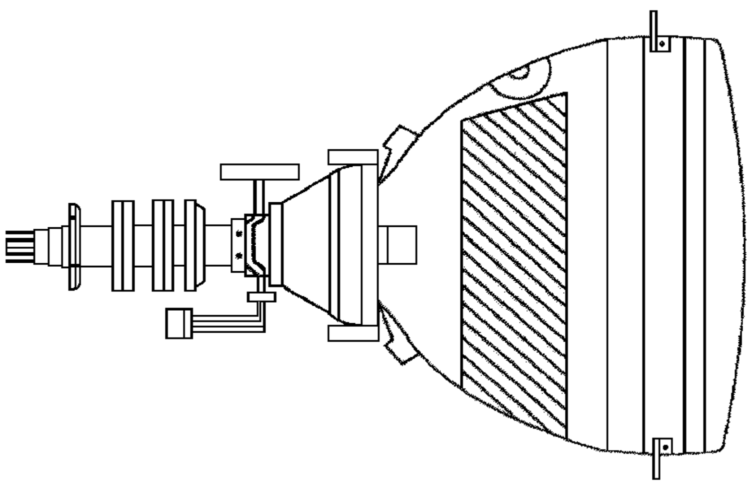

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Contents

Notes

Chapter 1. Safety Precautions

⚠ WARNINGS

Circuit Modifications

❑ **FOR CONTINUED PROTECTION,** make no changes to the circuit unless authorized in writing by the manufacturer.

❑ **DESIGN ALTERATIONS** void the manufacturer's warranty. Such alterations also relieve the manufacturer of responsibility for resulting personal injury or property damage.

❑ **"REPLACEMENT" COMPONENTS.** Many monitor parts have special, safety related characteristics. These characteristics are seldom evident from visual inspection. "Replacement" components rated for higher voltage, wattage, current, etc. *don't offer the same protection*. For continued safety, replace safety critical components only with manufacturer recommended parts.

Using the Monitor

❑ **WARNINGS ON THE MONITOR**. Follow warnings and instructions marked on the product.

❑ **PLACEMENT.** Never place the monitor on an unstable surface. If the product falls, it may become seriously damaged. It may also injure the user.

Servicing the Monitor

❑ **SAFETY PROCEDURES.** Before performing service work, thoroughly familiarize yourself with monitor safety procedures.

❑ **HV TESTING.** Never check high voltage by drawing an arc. Use a high voltage meter or a high voltage probe with a digital voltage meter.

❑ **DAMAGE FROM ARCING.** If severe arcing occurs, remove the AC power immediately. Determine the cause by visual inspection: *Incorrect installation, cracked or melted HV harness, poor soldering, broken wires, etc.*

❑ **TUBE REPLACEMENT.** The monitor tube incorporates x-radiation and implosion protection. To assure continued safety, replace the tube with the same type or a recommended substitute.

❑ **LEAD DRESS.** When the monitor requires service, observe the original lead dress. Take extra precautions to assure correct lead dress in the high voltage circuit area. If a short circuit occurs, then replace components that show evidence of overheating. Always use original components.

❑ **ANODE BUTTON.** Turn off the power switch before making the connection to the anode button.

❑ **X-RADIATION.** Operation of this color monitor under normal conditions won't exceed the 0.5 mR/h iso-exposure rate. Be sure that the anode voltage and other tube voltages are adjusted to recommended values.

❑ **SHOCK HAZARD.** Before handling the tube, remove its residual charge. Do this by shorting the tube's anode button to the external conductive coating. The anode button is on the tube funnel.

❑ **TUBE HANDLING.** Never handle the tube by its neck, deflection yoke or other neck components. If suspending the tube from the mounting lugs, use a minimum of two lugs. Never suspend the tube from one lug. Protect the screen when placing the tube facedown: Rest the tube face on a cushion kept free from abrasive substances or parts.

Chapter 2. Monitor Adjustments

Required Tools

- Miniature flatblade screwdriver
- Assorted jumper cables
- External degaussing coil
- Digital multimeter
- Test bezel (fixture model, if possible)
- CRT diagnostic software (Kristel 3.5” diskette)
- Color analyzer (Recommended: Minolta CA-100)
- Plastic hex wrench
- 10µF, 50V capacitor
- IBM PC compatible
- Hi-pot tester
- Crosshatch generator

NOTICE

Unless otherwise specified, “factory spec” means the final adjustment made by the operator in the factory. This adjustment approximates the standard display characteristics.

Adjustment Conditions

Specified Signals

Standard VGA mode of 480 lines. RGB video signals are identical.

Warmup Time

Apply the recommended AC power to the monitor. Monitor warmup requires 15 minutes (minimum).

Direction

The CRT faces east.

Ambient Lighting Environment

400 to 600 lux.

Ambient Temperature

25°C (77°F).

Video Mode

640 X 480 lines.

Variable Resistor (VR) Adjustments

Adjust SCREEN Control (on the FBT)

a) Input 31kHz (480 lines) timing with a crosshatch pattern.
b) On the flyback transformer, adjust the SCREEN control so that you can view screen images.
c) Adjust the FOCUS control to the best possible setting.

B+ Adjustment VR501

a) Connect the positive lead of a multimeter to D508 cathode.
b) Connect the negative lead to chassis ground.
c) Adjust VR501 to obtain an 88V reading.

NOTICE

These adjustments require a video signal from a crosshatch generator. Your gaming device can also generate suitable video patterns. A third option is to use an IBM compatible computer as a crosshatch generator. Kristel supplies pattern generation software for IBM compatible PCs.

Remote (Front Panel) Variable Resistors

VR Name	VR #	VR Name	VR #
Brightness	VR902*	Horizontal Width	VR307
Contrast	VR207†	Vertical Center	VR302
Horizontal Phase	VR604	Vertical Size	VR309

*Not used on auto bias neck boards.
†On auto bias neck boards, number changes to VR201.

Vertical Linearity Adjustment VR310

a) Input 31kHz (480 lines) timing with a crosshatch pattern.
b) Adjust VR310 to obtain the best vertical linearity. Allow no more than 3.0mm maximum misadjustment.

Vertical Size Adjustment VR309 (Remote)

a) Input 31kHz (480 lines) timing with a crosshatch pattern.
b) Adjust remote pot VR309 to obtain a suitable vertical size. VR309 is on the front panel.

Horizontal Width Adjustment VR307 (Remote)

a) Input 31kHz (480 lines) timing with a crosshatch pattern.
b) Adjust remote VR307 and VR501 to obtain a suitable horizontal size. VR307 is on the front panel. During VR501 adjustment, monitor the CRT heater voltage. Maintain the voltage between 5.9 and no more than 6.5VDC.

Horizontal Raster Centering Adjustment VR604 (Remote)

a) Input 31kHz (480 lines) timing with a crosshatch pattern.
b) Horizontally center the raster by adjusting potentiometer VR604. VR604 (also known as H-PHASE) is on the front panel.

Pincushion Adjustment VR304

a) Input 31kHz (480 lines) timing with a crosshatch pattern.
b) Adjust VR301 and VR304 to minimize pincushion distortion.

FOCUS Adjustment (on the FBT)

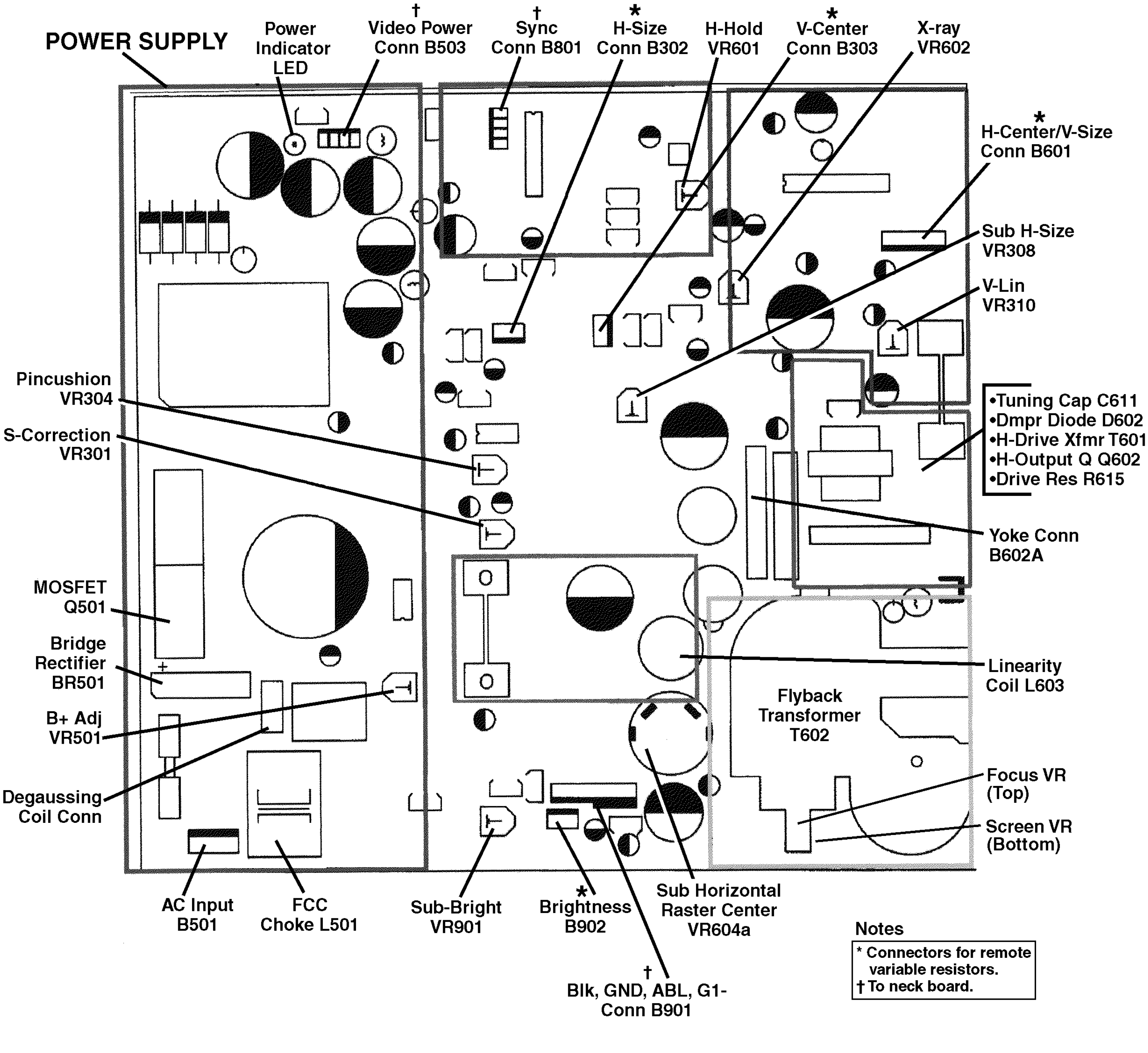
a) Display any character all over the screen.
b) Set VR207 (CONTRAST) to maximum. VR207 is on the front panel.

PC Board Variable Resistors

VR Name	VR #	VR Name	VR #
Blue Bias	VR206	Red Bias	VR204
Blue Gain	VR203	Red Gain	VR202
B+ Adjustment	VR501	S-Correction	VR301
Focus	FBT*	Screen	FBT*
Green Bias	VR205	Sub-Brightness	VR901
Horizontal Hold	VR601	Sub H-Size	VR308
Sub H-Center	VR604a†	Vertical Linearity	VR310
Pincushion	VR304	X-ray Protect	VR602

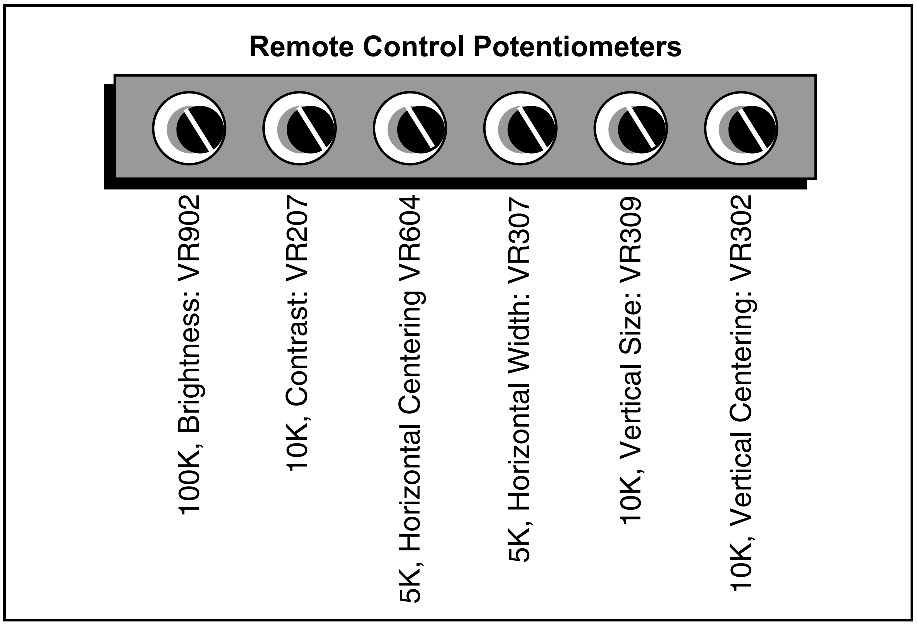
*No number. Located on flyback transformer.
†VR604a may appear as "VR604" on the main PCB silkscreen.

Components & Controls: Main PCB, Kristel Chassis 1428-30K



NOTICE

Monitors with the auto bias neck don't include Brightness Control Connector B902. On these monitors, B901 is a larger connector.



c) Set VR902 (BRIGHTNESS) to the cutoff position. VR902 is on the front panel.
d) On the flyback transformer, adjust the FOCUS variable resistor for best resolution.

Horizontal Oscillator Frequency VR601

a) Input 31kHz (480 lines) timing with a crosshatch pattern.
b) Use a 10μf, 50V capacitor for this step. Connect the capacitor's "+" lead to the Neck Board horizontal sync input. (You'll find this input on connector B201.) Connect the "–" capacitor lead to ground.
c) Adjust VR601 until the sync/blanking bar is as vertically stable as possible.
d) Remove the capacitor.

X-ray Protection Setting VR602

a) Input 31kHz (480 lines) timing with a crosshatch pattern.
b) Connect the positive lead of a multimeter to ZD601+.
c) Connect the negative multimeter lead to chassis ground.
d) Adjust VR602 to obtain a 3.5 to 5.4V reading.

Vertical Raster Centering Adjustment VR302 (Remote)

a) Input 31kHz (480 lines) timing with a crosshatch pattern.
b) Adjust VR302 to center the raster. VR302 is on the front panel.

Purity, Convergence and Setup

The following procedures have been performed at the factory and should require no further attention. After servicing the monitor, determine whether any of these procedures need to be performed. Note: Purity and convergence adjustments interact.

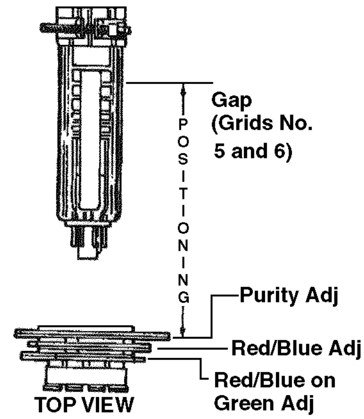
Degaussing
The monitor is equipped with an automatic degaussing circuit. However sometimes, the CRT shadow mask becomes excessively magnetized. In that case, degauss the CRT and all surrounding metal parts with an external degaussing coil. Don't switch the coil off while the raster shows any effect from the coil.

Color Purity Adjustment

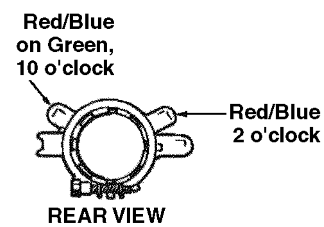
a) For best results, make the purity adjustment at the final monitor location. If you intend to move the monitor: Adjust purity with the monitor facing west or east.
b) Operate the monitor for 15 minutes.
c) On a picture tube with a 22.5mm neck diameter: Set the ring assembly on the CRT neck. Place the center line of the purity ring pair over the gap between grids 5 and 6.
d) Display the magenta color pattern.
e) Make certain that magnetic ring pairs are in their correct starting position. The correct starting position varies among ring manufacturers. You must determine the correct starting position, also known as the zero correction position. Figure 1 shows a ring assembly. Each ring of the purity ring pair has two handles, one long and one short. With some ring assemblies, the starting position involves aligning the long handles of each ring. On other assemblies, the starting position involves aligning one long and one short handle. Try one of these orientations.
f) Rotate the two rings together, as a pair. Don't change their orientation with respect to each other.
g) If this rotation causes no change in the purity, then it's the starting position. If the purity changes, then return to Step e, and try the other orientation.
h) Adjust the purity magnets so that the picture is uniformly magenta in color.
i) Turn the two overlapping handles in opposite directions, until they are at the same angle: 9 o'clock and 3 o'clock respectively. (See Figure 1 of the diagrams entitled *Purity & Convergence Adjustments.*)

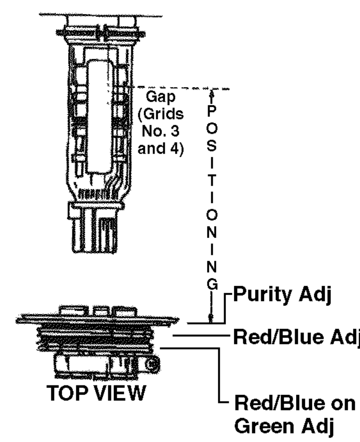
Static Convergence Adjustment
After this procedure, convergence will be best in the center of the screen. To reduce screen-edge misconvergence, you must perform a dynamic convergence procedure.

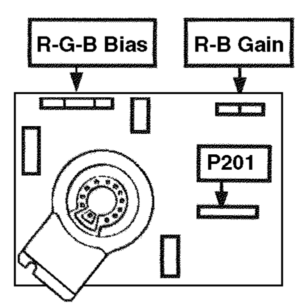
a) See Figures 2 and 3 of the diagrams entitled *Purity & Convergence Adjustments*. Display the magenta crosshatch pattern.
b) **Vertical, R/B Static Convergence:** Open the two handles of the four-pole magnets. Continue opening until the red and blue *vertical* lines unite.
c) **Horizontal R/B Static Convergence:** Open the two handles. Rotate them at a constant angle, until the red and blue *horizontal* lines unite.
d) If the vertical line deviates, open the two handles at the deviation position. Change the angle between handles slightly.
e) Display the crosshatch pattern.



Purity and Convergence Rings, Showing Starting Position







VIDEO NECK BOARD

Purity & Convergence Adjustments

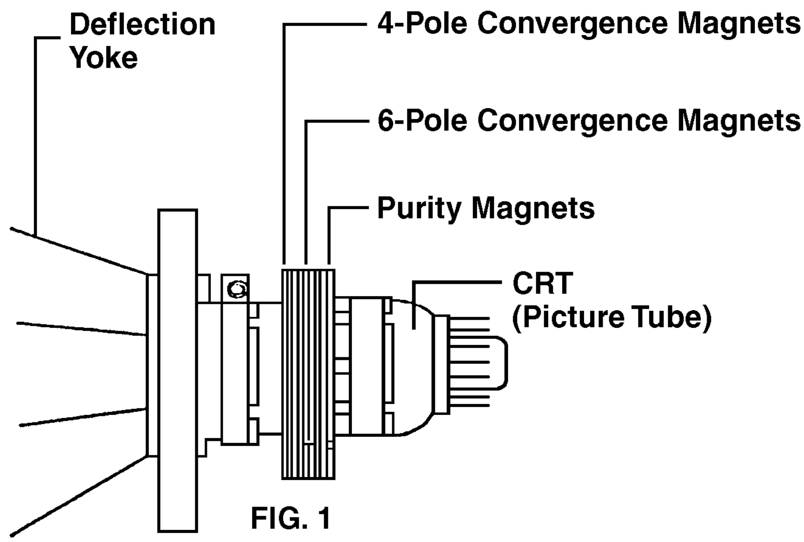


FIG. 1

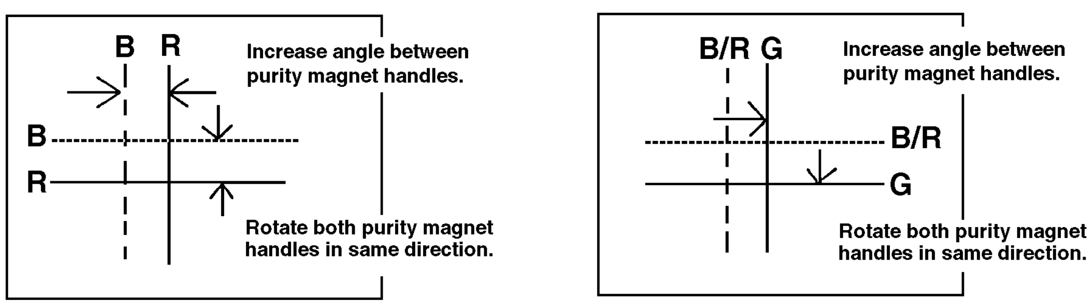


FIG. 2

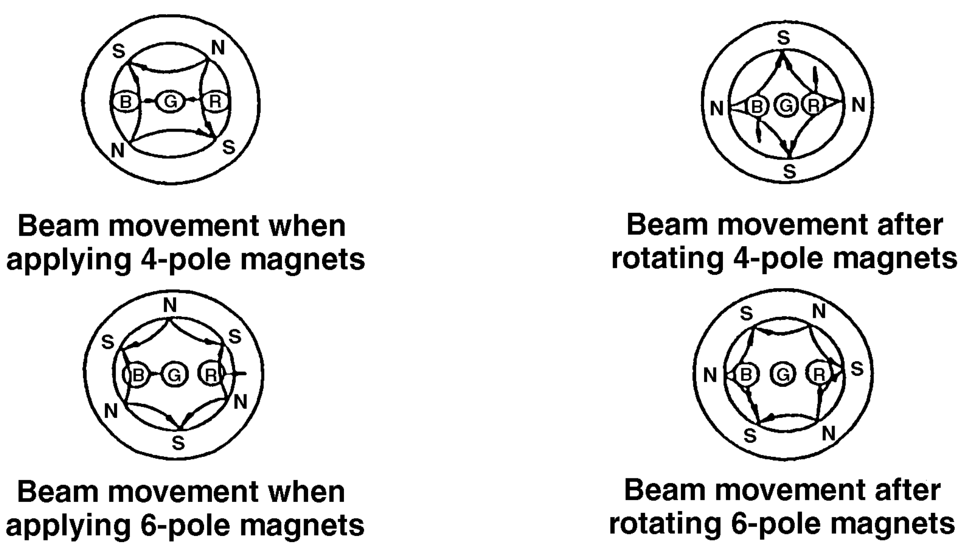


FIG. 3

f) **Vertical, RB/G Static Convergence:** Open the two, six-pole handles. Continue opening until the red and blue *vertical* lines unite with the green line.
g) **Horizontal, RB/G Static Convergence:** Rotate the two handles at a constant angle. Continue the rotation until the red and blue *horizontal* lines unite with the green.
h) If the vertical lines deviate, change the angle between handles.

Dynamic Convergence

To reduce screen-edge misconvergence, you must perform a dynamic convergence procedure. Dynamic convergence is a factory procedure which involves repositioning the yoke and magnetic yoke wedges. The details are beyond the scope of this manual.

Background White Balance Adjustment

a) Set all BIAS variable resistors (VR204, VR205, VR206) to maximum. Allow the raster to disappear.
b) Display the black pattern. (Disable all video signals.)
c) Adjust the SCREEN variable resistor. This is on the flyback transformer. As soon as the raster appears, note which color (red, green or blue) appears first.
d) Adjust the BIAS variable resistors of the other two colors to achieve a gray raster.
e) Adjust gray raster brightness with the SCREEN variable resistor. At maximum brightness, the gray raster must be no brighter than 1 Ft-L.

White Balance Adjustment VR902 (Remote)

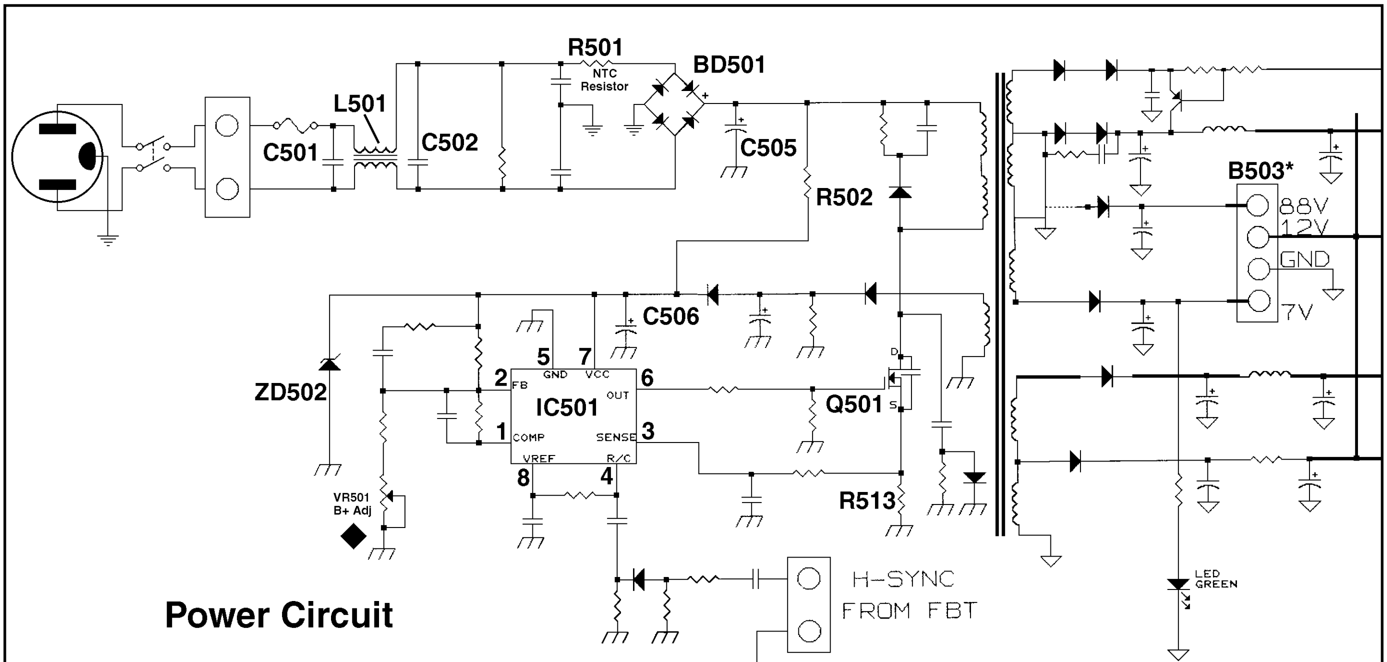
a) Display the center block pattern.
b) Set remote BRIGHTNESS variable resistor VR902 to minimum. VR902 is on the front panel.
c) Use the color analyzer photometer for measurements in this step. Adjust remote Contrast variable resistor VR207 so that brightness measures 35 Ft-L.
d) Balance RGB according to color analyzer readings.

Notes

Chapter 3. General Theory of Operation

Power Circuit

The power circuit includes the line filter, input rectifier circuit, startup circuit, current-mode control and over-voltage protector *(OVP)* circuit. The diagram *Power Circuit* highlights key circuit components. (Complete circuit diagrams appear in the back of this manual.)



Power Circuit

Line Filter Circuit

Components C501, C502 and L501 comprise the line filter circuit. This line filter reduces EMI noise conducted from the monitor into the power line.

Input Rectifier Circuit

The input rectifier circuit is comprised of BD501 and C505. BD501 and C505 form a full-wave rectifier and hum filter. R501 reduces surge current while the power supply is on.

Startup Circuit

Resistor R502 provides startup currrent for IC501. IC501 is the pulse-width moldulator *(PWM)* and switching regulator chip. Inside IC501 is an under-voltage lockout circuit. This circuit's turn-on and turn-off thresholds are both 16VDC. To start up, C506 must charge to 16VDC with a current of 0.3mA to 0.5mA. This current depends on the IC501 startup current characteristics and R502 resistor value.

Current Mode Operation

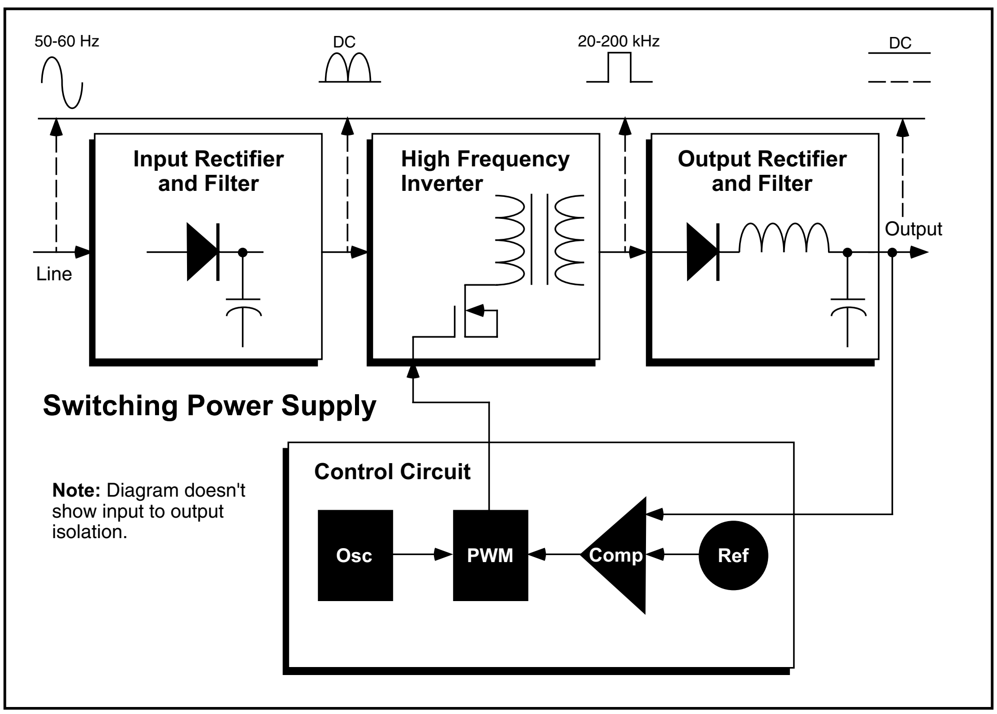
Charging capacitors cause the IC501, pin 7 Vcc voltage to rise above 16 volts. When the pin 7 voltage exceeds 16V, IC501 outputs a square wave at pin 6. This variable width square wave drives the gate of power MOSFET Q501. Source resistor R513 measures current flowing through Q501, and converts it to a voltage. The circuit feeds this “sense” voltage back to IC501, pin 3. Responding to the voltage, IC501 modulates current pulse widths to limit output power. Pin 2 and pin 1 connect to an error amplifier section. IC501 detects the output voltage while the line voltage and load current change.

OVP Circuit

Zener diode ZD502 is the OVP (over-voltage protection) circuit. If an over-voltage condition exists, ZD502 shuts down IC501.

Switching Power Supply

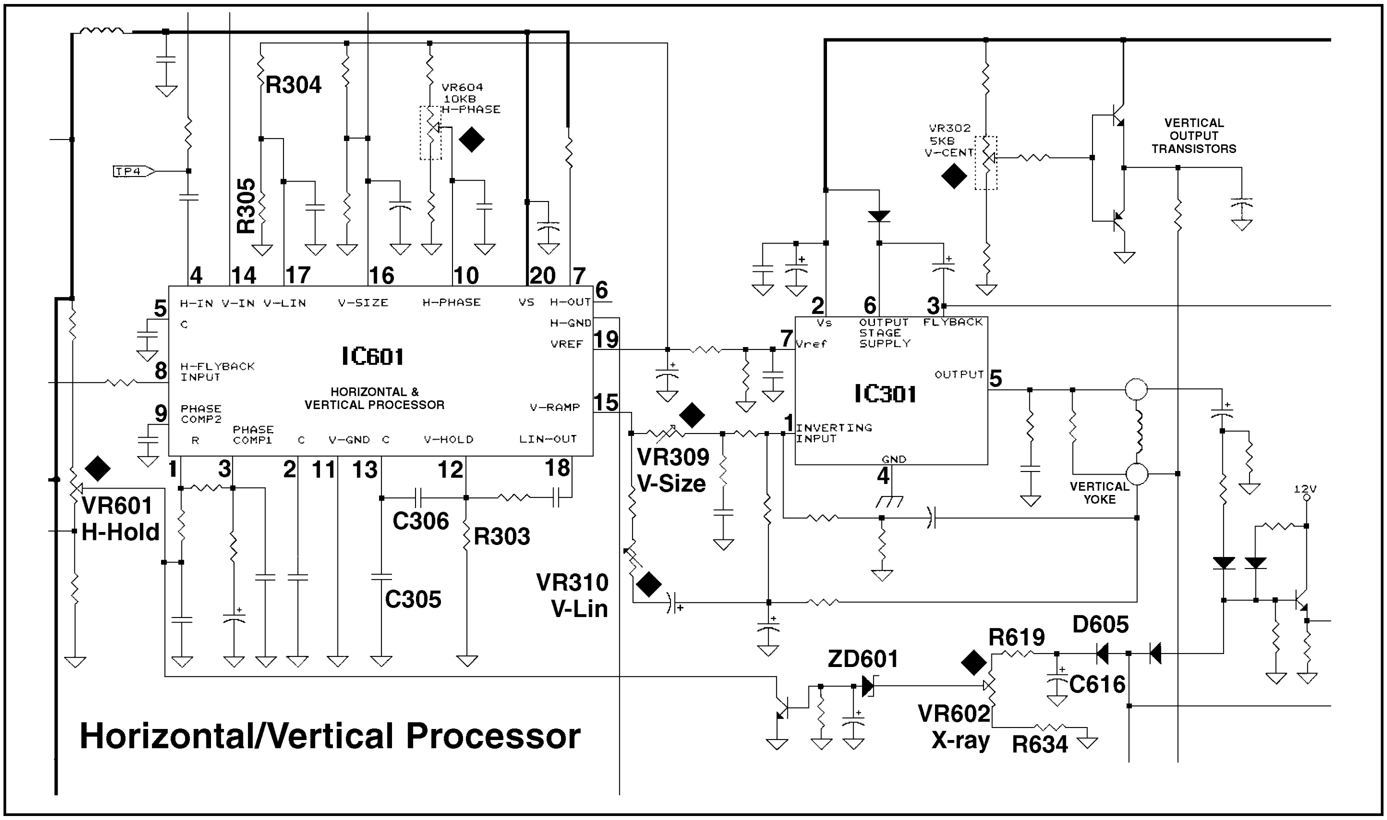
A switching power supply is a relatively complex circuit. See the block diagram. The left block rectifies and filters the 60 Hz AC input line voltage. The heart of the supply is the high frequency inverter in the middle block. The inverter chops the rectified line at a high frequency, between 20 and



200 kHz. The inverter transformer reduces the line voltage to the correct output level. Next, the output (right) block rectifies and low-pass filters the inverter voltage. Notice the control circuit that runs across the bottom of the block diagram. This circuit regulates the output voltage, and closes the loop from output to inverter.

Synchronous Processor

IC801 circuit (WT8041), is a synchronous signal processor of multiple video formats. IC801 can perform several functions, such as... Horizontal and



Horizontal/Vertical Processor

vertical frequency discrimination, display mode selection and synchronous pulse polarity detection.

Pins 15 and pin 16 function as a clock generating circuit. Output pin 4 is active high, while pin 5 is active low, fixed polarity. These pins maintain the same pulse width as the original horizontal and vertical sync signals have. Pin 7 functions as an active low frequency discriminator. Pin 9 and 14 function as an output mode selector. These pins control the vertical size, horizontal phase and horizontal oscillator frequency for every display mode.

Horizontal/Vertical Processor

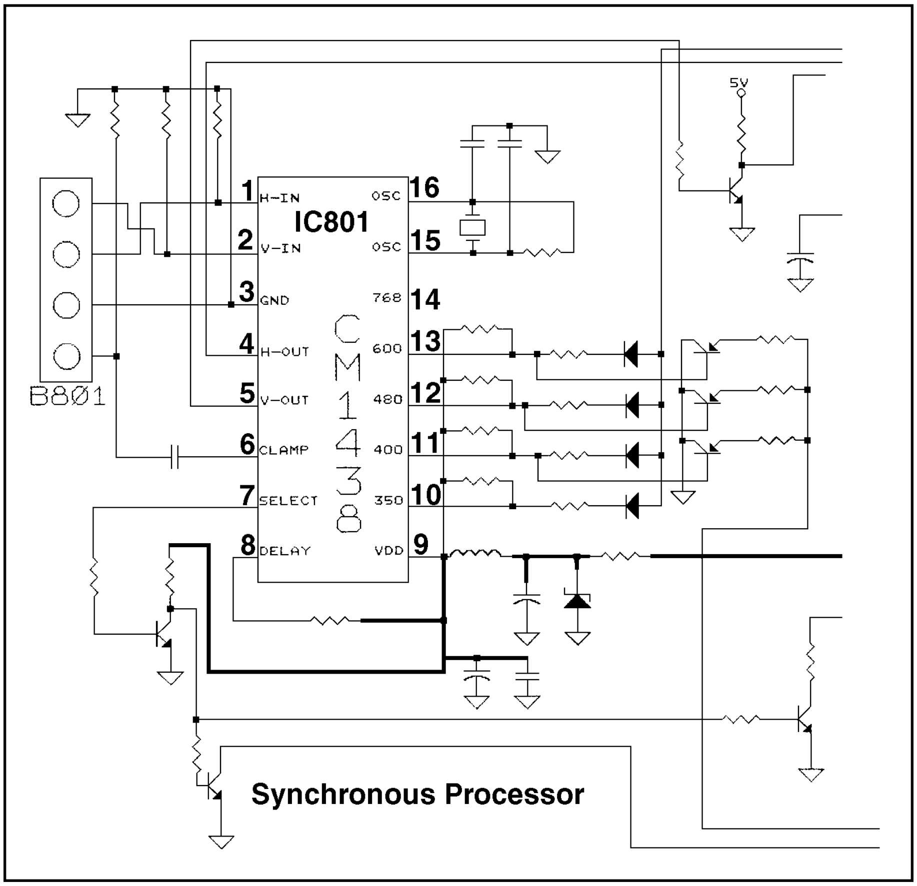
See the drawing entitled *Horizontal/Vertical Processor.* IC601 is a combination horizontal and vertical processor. Vertical sync enters pin 14 of IC601. Components C306, R303 and C305 determine the oscillation frequency. A buffered generator inside the IC outputs a sawtooth signal at pin 15 (“V-Ramp”).

Then the signal enters the linearity control circuit via R304 and R305. VR310 adjusts the vertical linearity. VR309 adjusts vertical size. IC801 provides proper signals for pin correction through R806, R807, R808, R809, Q805, Q806 and Q807. The circuit maintains vertical size within ± 5 mm of these specs...

- 48 cm Monitors: 270 mm
- 41 cm Monitors: 220 mm
- 34 cm Monitors: 180mm

Abbreviations in This Manual

Adj	Adjustment
AFC	Automatic Frequency Control
C	Capacitor or Celsius
CCW	Counterclockwise
CD	Candella
Conn	Connector
CRT	Cathode Ray Tube (picture tube)
CW	Clockwise
D	Diode
F	Farenheit or Fuse
FBT	Flyback Transformer
Freq	Frequency
FT-L	Foot-Lamberts
H	Horizontal (sometimes “Horiz”)
H-DY	Horizontal Deflection Yoke
IC	Integrated Circuit
K	Kelvin
kHz	Kilohertz
L	Coil
LED	Light Emitting Diode
mA	Milliamperes
Max	Maximum
µF	Microfarads (may appear as “uF”)
mm	Millimeter
MPCD	Minimum Pereceptible Color Difference
NTC	Negative Temperature Coefficient (Thermistor)
Osc	Oscillator
OVP	Over-Voltage Protector
PTC	Positive Temperature Coefficient (Thermistor)
PLL	Phase-Locked Loop
PWM	Pulse width modulation
Q	Transistor
QC	Quality Control
R	Resistor
RGB	Red-Green-Blue
SG	Spark Gap
Sync	Synchronization
T	Transformer
TP	Test Point
uF	Microfarads (more properly “µF”)
V	Vertical (sometimes “Vert”); also Volts
VAC	Volts Alternating Current
VDC	Volts Direct Current
VGA	Video Graphics Array
Vpp	Volts Peak-to-Peak
VR	Variable resistor (pot)
X	Transistor
ZD	Zener Diode



Horizontal Oscillator Circuit

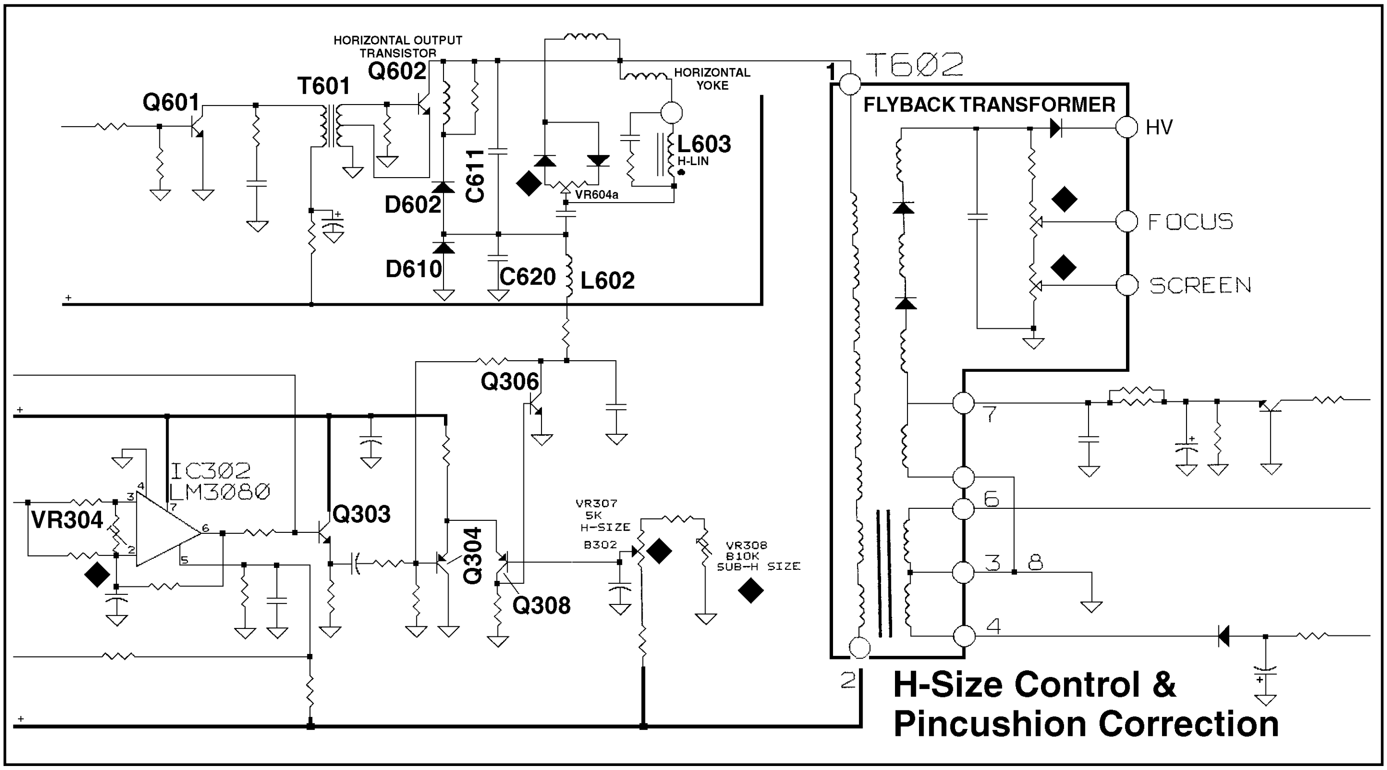
See the drawing entitled *Synchronous Processor.* Part of IC601 is a horizontal deflection processor. It contains the oscillator, AFC, phase shifter and pulse duty setting. The horizontal sync signal departs from the sync processing circuit and arrives at IC 601, pin 4.

VR604 is an external, horizontal phase control. VR601 is an internal, horizontal frequency control. VR602 is the x-ray protector. The flyback pulse occurs at flyback transformer T602, pin 6. D605 and C616 rectify the flyback pulse, producing 26VDC at the positive terminal of C616.

Under normal conditions, ZD601 measures open. You can adjust VR602 to obtain 5.4VDC at the ZD601 cathode. Under abnormal conditions, the voltage increases, creating a current through bleeder resistors R634, VR602 and R619. This current turns on ZD601. Next, the current flows to IC601, pin 1 to operate the x-ray protector circuit. The x-ray protector disables the oscillator. Finally, pin 12 of IC601 maintains the low HV state.

Horizontal Deflection Circuit

See the drawing entitled *H-Size Control and Pincushion Correction.* The horizontal deflection circuit includes the horizontal driver and horizontal output circuit. The positive horizontal pulse at IC601, pin 6 excites driver transistor Q601. Q601 sends a current spike through transformer T601. This spike then saturates output transistor Q602. When Q602 conducts, it allows



H-Size Control & Pincushion Correction

horizontal deflection current to flow. The current also passes through the flyback transformer *(FBT),* producing high voltage. L603 is a linearity coil, which enables “S” wave correction.

Horizontal Size and Side Pincushion Circuit

See the drawing entitled *H-Size Control and Pincushion Correction.* VR304 is the pincushion correction gain control. The monitor compensates for side pincushion distortion by altering the horizontal deflection voltage. Picture width control also involves dynamically changing this voltage.

IC302 generates the side pincushion compensation signal, a parabolic waveform. After exiting this dual integrated circuit, the waveform enters the base of Q303. Transistors Q304, Q306 and Q308 amplify the horizontal width control voltage and parabolic wave.

A diode modulator superimposes the compensation voltage over the horizontal source voltage. The modulator circuit includes these components: C620, L602, C611, D602, D610 and the horizontal yoke. The compensation signal controls the source voltage of the horizontal deflection circuit.

Standard Neck Board Video Circuit

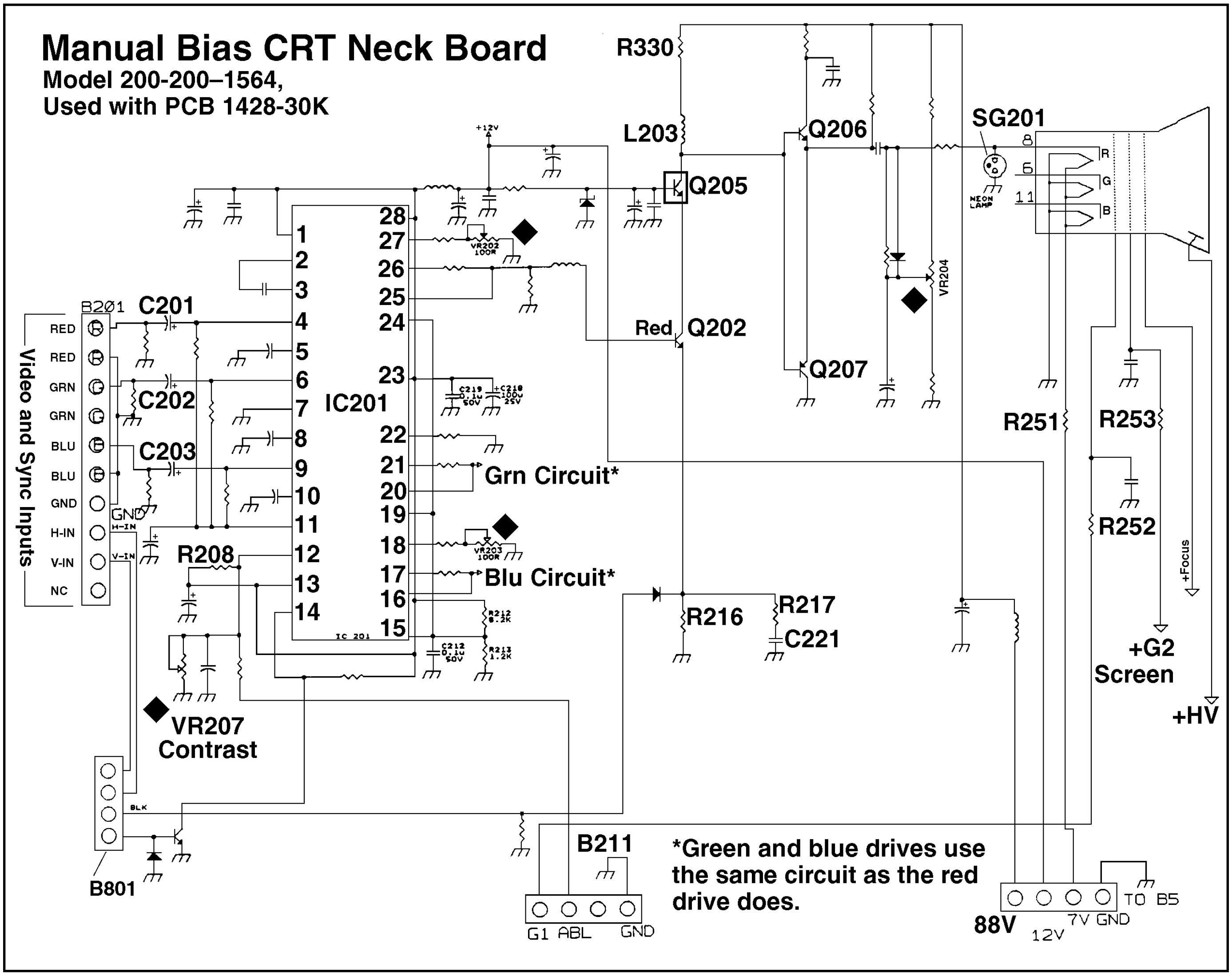
Kristel monitors include either a manual bias or an auto bias neck board. Both neck boards include the standard video circuit. The auto bias board adds circuitry that adjusts gain and bias automatically. Since the standard circuit is part of both neck boards, we’ll describe it here. See the *Auto Bias Theory* chapter for a discussion of auto bias technology.

NOTICE

CRT and yoke model or characteristics may vary. Certain neck board components are subject to change according to CRT model and deflection yoke charactertistics. These components include the following...

- **C611:** 0.0039µF/2kV to 0.0068/2kV (Tuning capacitor, H-output section)
- **R208:** About 560Ω
- **R230:**1.5K/5W
- **R233:** 1.5K/5W
- **R234:** 1.5K/5W
- **R251:** 1.5Ω/2W to 10Ω/2W (Filament heater/6.2V)
- **R315:** 0.68Ω/1W to 1Ω/1W (V-Size)
- **R615:** 100Ω/2W to 250Ω/2W (Driver resistor for horizontal retrace)

200-series resistors above appear on both the manual bias and auto bias neck boards.



The standard neck board video circuit includes two major parts. One is the analog video processing circuit and the other is the video amplifier circuit. See the drawing entitled *CRT Neck Board.*

Analog video processor IC201 includes a gain control and DC restoration circuit. RGB video signals enter IC201 inputs through coupling capacitors C201, C202 and C203. VIDEO GAIN control VR201 normally limits the RGB output voltage at IC201 to between 3.5 and 4.0 VDC. This voltage changes according to the 0.7Vpp input level. The input level depends upon the DC voltage from CONTRAST potentiometer VR207. This DC voltage appears at IC201, pin 12.

A cascode circuit amplifies each RGB signal. The cascode design eliminates Miller Effect-related distortion at the high resolution display. The cascode stage for each color consists of two transistors... For the red drive, Q202 and Q205. For the green drive, Q203 and Q208. And for the blue drive, Q204 and Q211. Collector and emitter resistors set each cascode channel's gain. *(Red resistors:* R230/R216; *green resistors:* R233/R221; *blue resistors:*

R236/R227.) Coils L203, L204 and L205 are series peaking inductors. Components R217, C221, R222, C222, R228 and C223 form emitter peaking circuits.

The output amplifier circuit stage for each color consists of two transistors... For the red drive, Q206 and Q207. For the green drive, Q209 and Q210. And for the blue drive, Q212 and Q213. Each output stage amplifies one color video signal to 40Vpp.

Spark gaps SG201, SG202, SG203, and resistors R252 and R253 are arc protection components. They protect electrical components during a CRT arc condition.

Video Output Circuit Parts

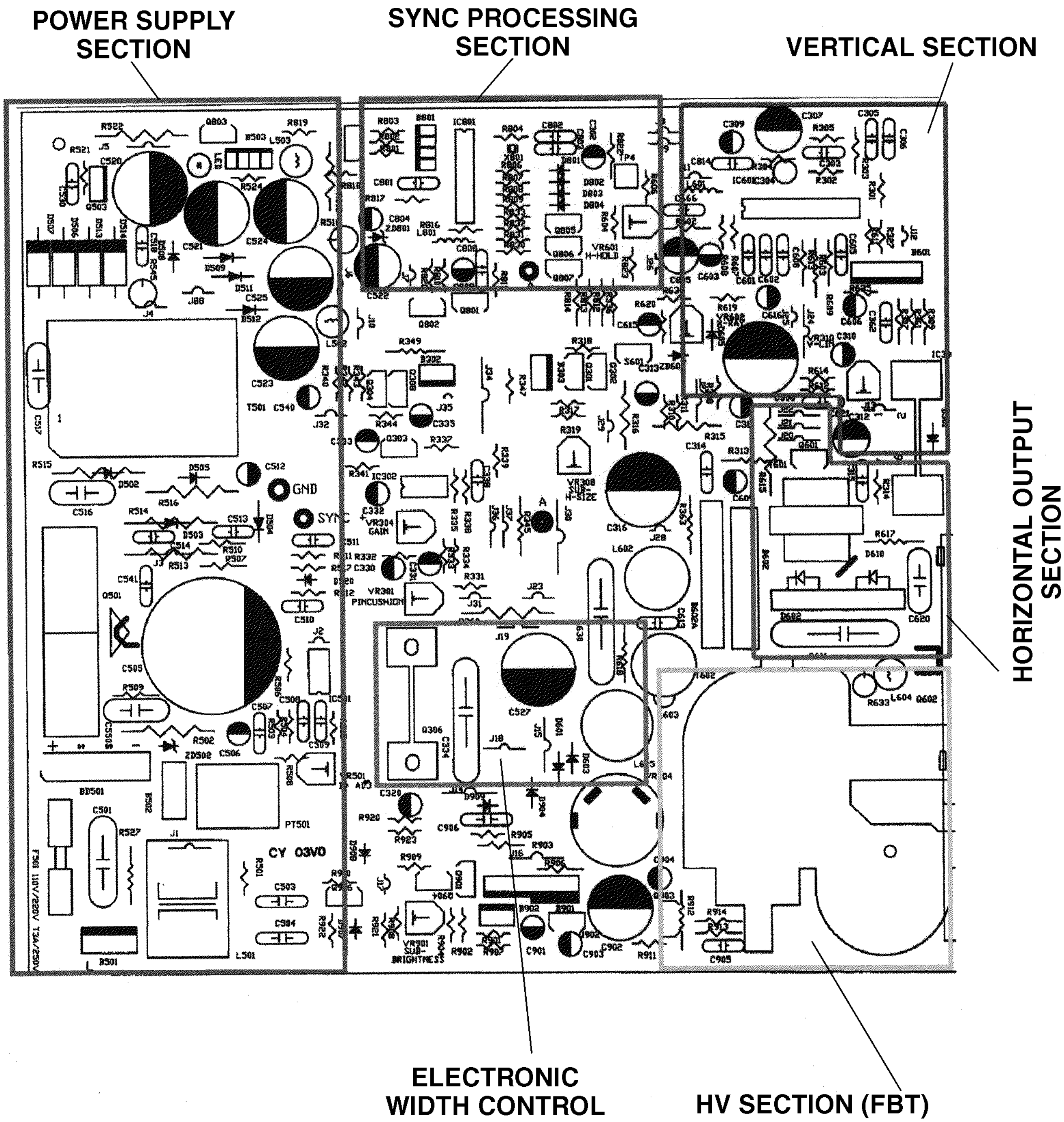
Circuit	Pre-Drive	Outputs	Spark Gap
Red	Q202 Q205	Q206 Q207	SG201
Green	Q203 Q208	Q209 Q210	SG202
Blue	Q204 Q211	Q212 Q213	SG203

Auto Bias Neck Board Video Circuit

This chapter describes standard Kristel neck board circuitry. Instead of the standard neck board, some Kristel monitors substitute the new auto bias neck board. The new board automates several video functions that require manual adjustment on the standard neck board. Other board features remain identical to their counterparts in the standard board. The block diagram later in this chapter includes auto bias as well as standard neck board functions. See the *Auto Bias Theory* chapter for a discussion of auto bias technology.

Before servicing your monitor, check to see which neck board it has. You can recognize the standard neck board by its three bias and two drive gain pots. Also, the board is rectangular, and its three large load resistors are are widely separated. The auto bias board includes the two drive gain pots, but has no bias controls. Although this board is also rectangular, it has one missing corner. The auto bias board's three load resistors are parallel to one another. They mount fairly close together, in one corner of the board.

Main PCB, Kristel Chassis 1428-30K

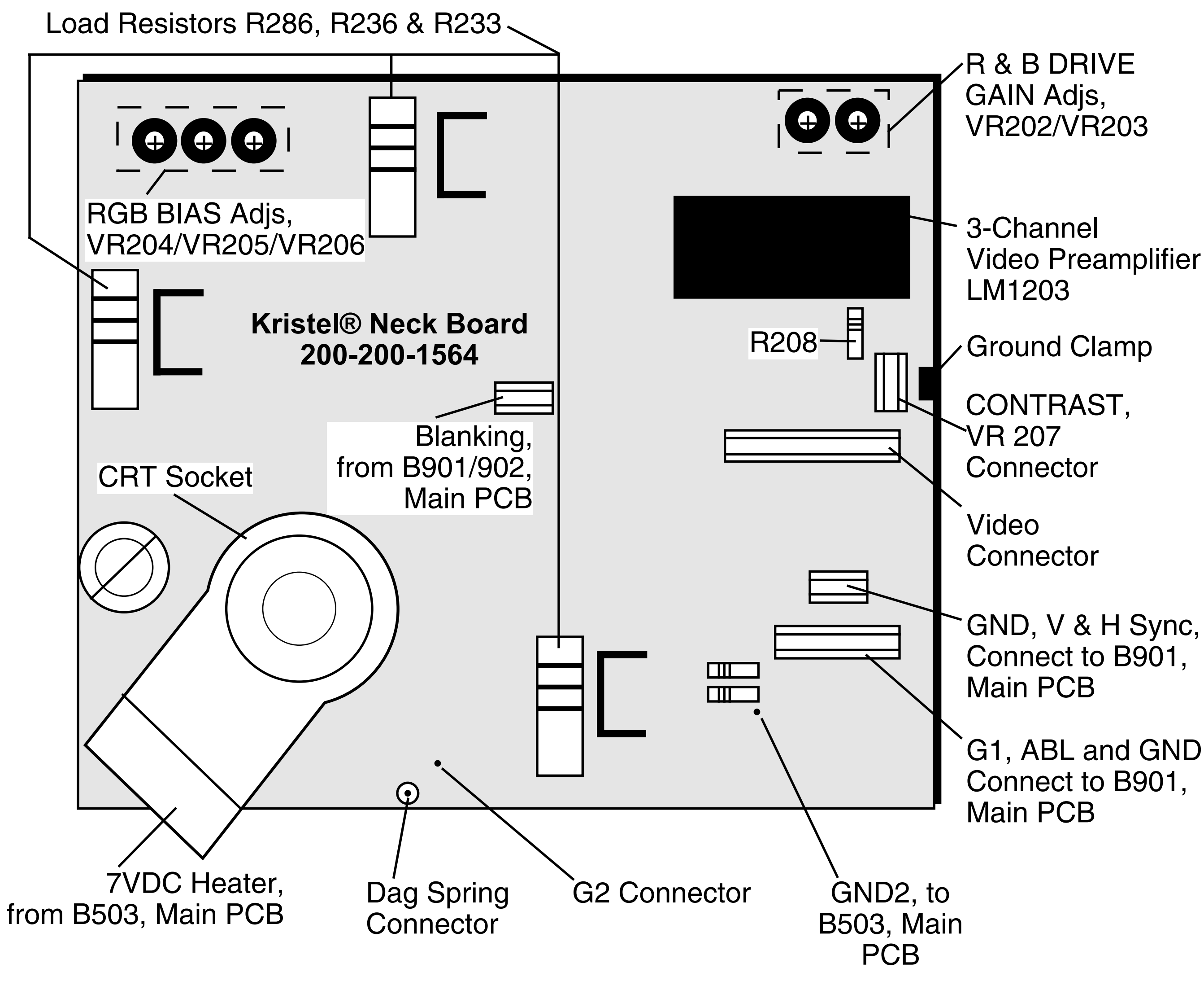


Part Numbers Indicate Monitor Section

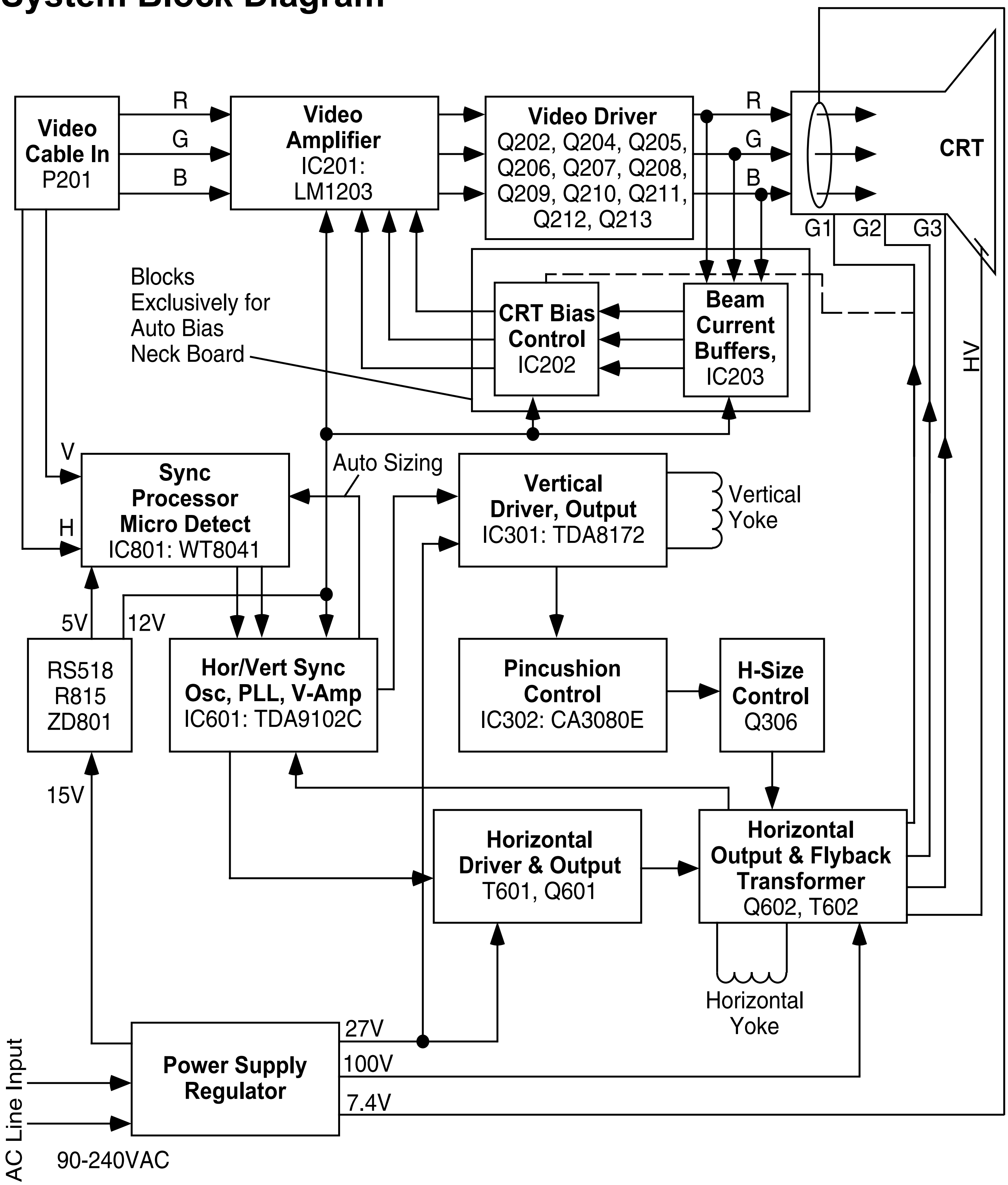
Part No. Series	Monitor Section	Part No. Series	Monitor Section
200*	Video (Neck Board)	600	Horizontal
300	Electronic Width Control;	800	Sync Processing
	Vertical	900	High Voltage
500	Power Supply		

*For example: R223, D201, IC201, Q205, etc.

Manual Bias Neck Board 200-200-1684
(without Auto Bias Circuit)



System Block Diagram



Chapter 4. Auto Bias Circuit Theory

What is Auto Bias Technology?

This chapter will help you to understand auto bias technology. Auto bias technology is a new innovation in video amplifier circuits. The auto bias system involves added video amplifier circuitry on the neck board. A neck board with the auto bias circuit automates several video adjustments. The main monitor board is compatible with either manual bias or auto bias neck boards. Except for the added auto bias sections, the two neck boards are quite similar. Before servicing your monitor, check to see which kind of neck board it has.

Auto Bias Advantages

The auto bias system maintains a constant and correct black level (cutoff level) on the CRT screen. The system also eliminates the need for manually adjusting the bias of individual video amplifiers. Auto bias has the advantage of greatly simplifying setup. Moreover, auto bias maintains bias conditions though the life of the CRT, despite aging. auto bias also eliminates the need for color bias potentiometers and a brightness control.

Overview of Operation

Auto bias works by sending a DC correction voltage to each video amplifier. The correction voltage is a response to cathode current changes resulting from a fixed step in G1 voltage. During a setup and sampling period after vertical retrace, a fixed step is applied to the G1 grid. Meanwhile the circuit holds the three cathodes steady. When bias conditions are correct, the voltage step results in a small step in cathode current for each gun. This step produces a faint horizontal line at the top of the screen. You can view the line if you set the vertical size low enough.

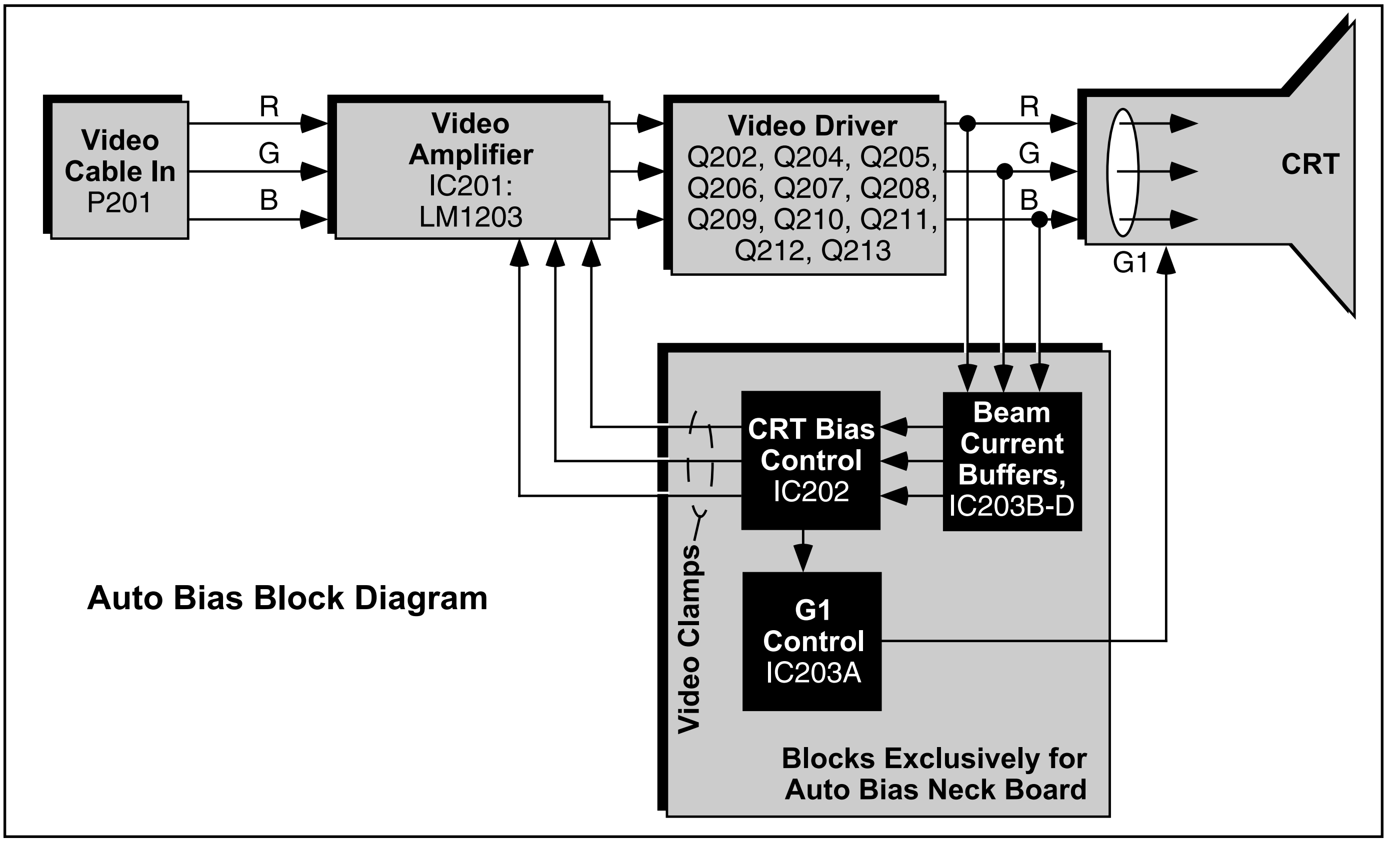
Operation Description

Video System

The video system consists of three-channel video processor IC201 and

Video Output Circuit Parts

Circuit	Pre-Drive	Outputs	Spark Gap
Red	Q202 Q205	Q206 Q207	SG201
Green	Q203 Q208	Q209 Q210	SG202
Blue	Q204 Q211	Q212 Q213	SG203



three video output stages. (Q202, Q205, Q206 and Q207 comprise the red video output stage.) The Automatic Biasing System adds Bias Control Processor IC202, plus beam current buffers IC203B through D, G1 control circuit IC203A, and clamping circuits.

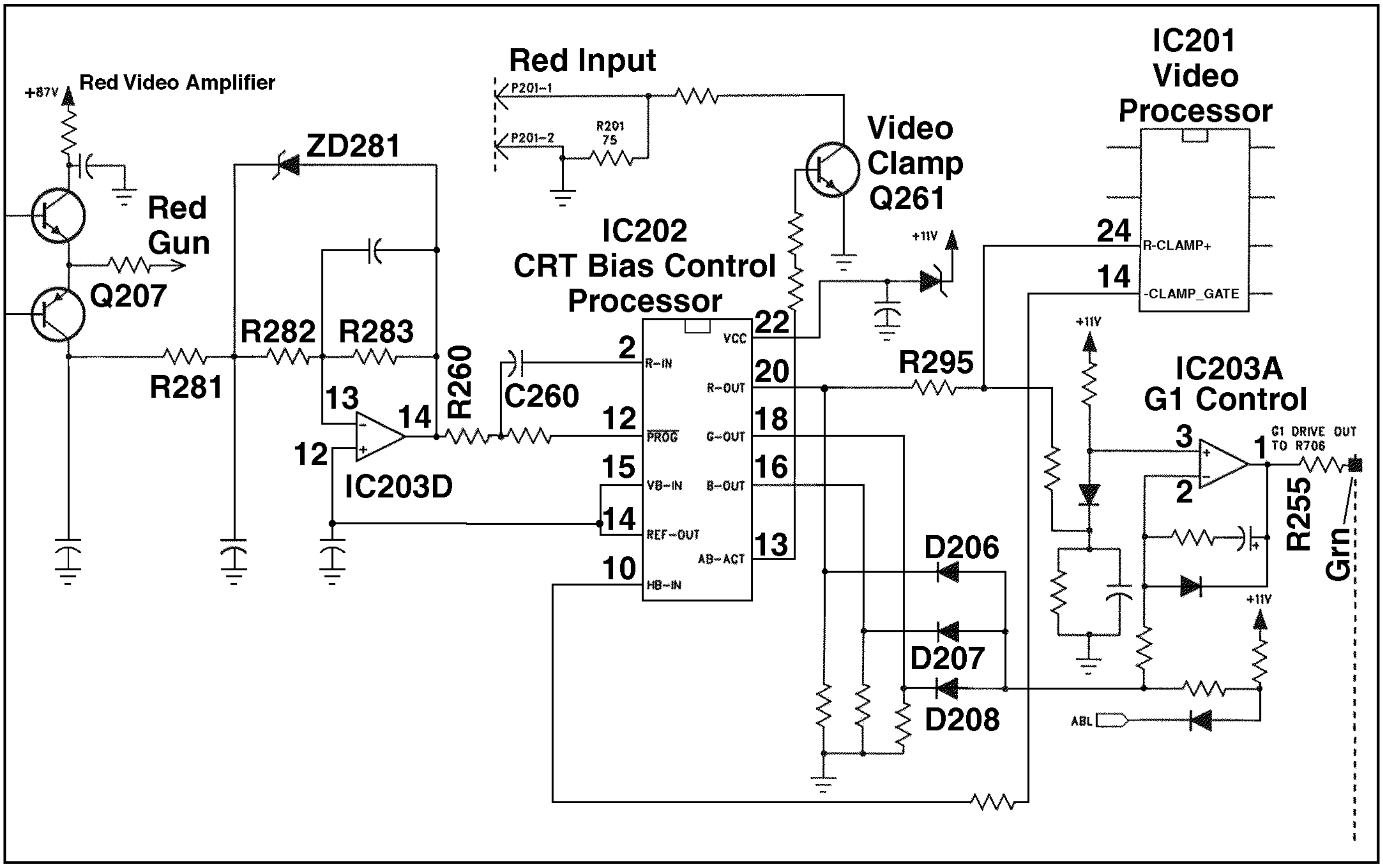
IC201 contains three video preamplifiers with DC-controlled gain and DC clamping. IC202 contains timing circuits, sample-and-hold circuits, and buffers.

The three video channels are identical. This manual only describes the red channel in detail. R201 terminates the red video input signal. The circuit delivers this red signal to the input of video processor IC201. The signal enters the IC at pin 4, through R274 and AC coupling capacitor C201. Pin 11 supplies a DC bias level for the video input signal through R204.

IC201 increases the 0.7Vpp nominal video input level to about 2.7Vpp at pin 25. The amplified signal drives the base of Q202. The DC level on pin 12, the contrast control input, determines the amount of gain. In fact, this DC level controls the gain of all three video channels simultaneously.

Q202 and Q205 operate as a cascode video output amplifier, with a gain of about 15. The video swing at Q205's collector is about 40Vpp. Q206 and Q207 operate as a buffer, driving the red CRT cathode through R242.

The horizontal retrace signal drives Q201. Q101 then supplies a negative-going clamping pulse to IC201, pin 14. This provides DC restoration for the



video signal by forcing the output of the video processor, IC201 pin 25, to the same DC voltage as on pin 24.

Beam Current Buffers

The red cathode beam current flows through Q207's collector and enters IC203 through R281 and R282. IC203D is an inverting amplifier. It converts beam current swings to voltage swings at pin 14. An increase in beam current results in a decrease in the voltage at pin 14.

ZD281 limits the voltage swing during high beam current conditions. These voltage swings enter Bias Control Processor IC202, pin 2 through R260 and C260.

Bias Control Processor

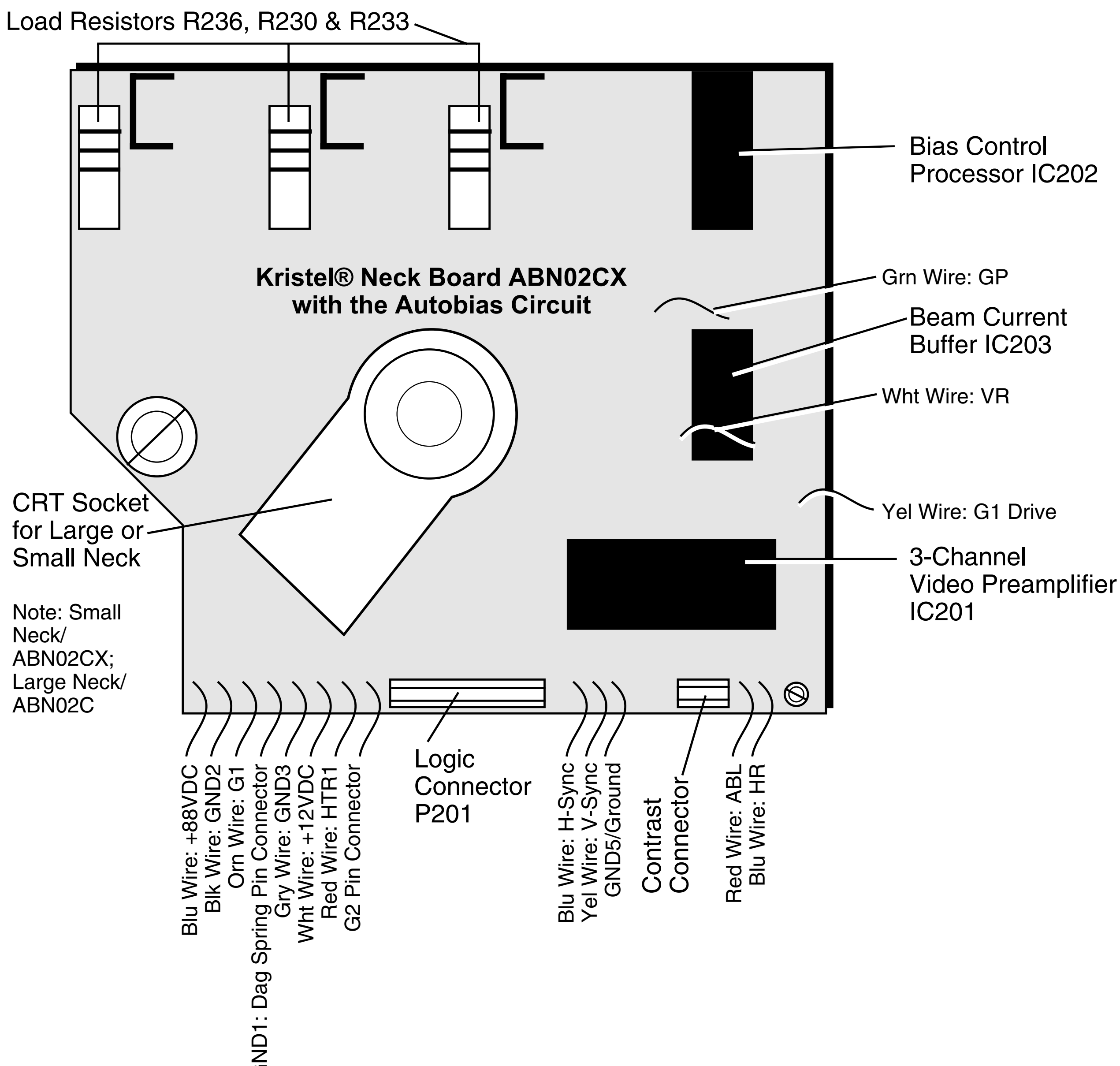
Bias Control Processor IC202 reads timing information from vertical and horizontal retrace signals. (Vertical: pin 8; horizontal: pin 10.) IC202 uses this timing information to control the bias control cycle. The bias control cycle begins a few lines after vertical retrace is completed. Pin 13 goes high during the entire cycle. This turns Q261 on, forcing the video input to ground during the bias control cycle.

The bias control cycle consists of two periods: *setup* and *sense.* During the setup period, pin 11 (GP-OUT) goes low. This low results in a positive-going 12V pulse (Grid Pulse) at the collector of Q904. C906 couples this pulse to the first grid of the CRT. (Q904 and C906 are on the main circuit board.)

Beam current responds by increasing slightly. During this period, the Bias Control Processor resets its internal sample-and-hold circuits. Meanwhile, you can see a faint horizontal line at the top of the screen.

The sensing period begins when the setup period ends. During the sensing period, pin 11 (GP-OUT) returns high. Meanwhile, pin 12 (PROG) goes low. The low causes a small, negative-going pulse (Program Pulse) to appear across R260. IC202 compares this pulse to the swing at IC203, pin 14. (The pin 14 swing resulted from the change in beam current from the Grid Pulse.)

Auto Bias Video Neck Board ABN02CX



The IC202 comparison operation produces a difference potential. The internal sample-and-hold block at pin 20 amplifies and maintains the difference. The voltage at pin 20 then enters IC201, pin 24 through R295. This voltage controls the DC output level of the video processor and red cathode. The cathode voltage maintains a constant beam current level during the Grid Pulse.

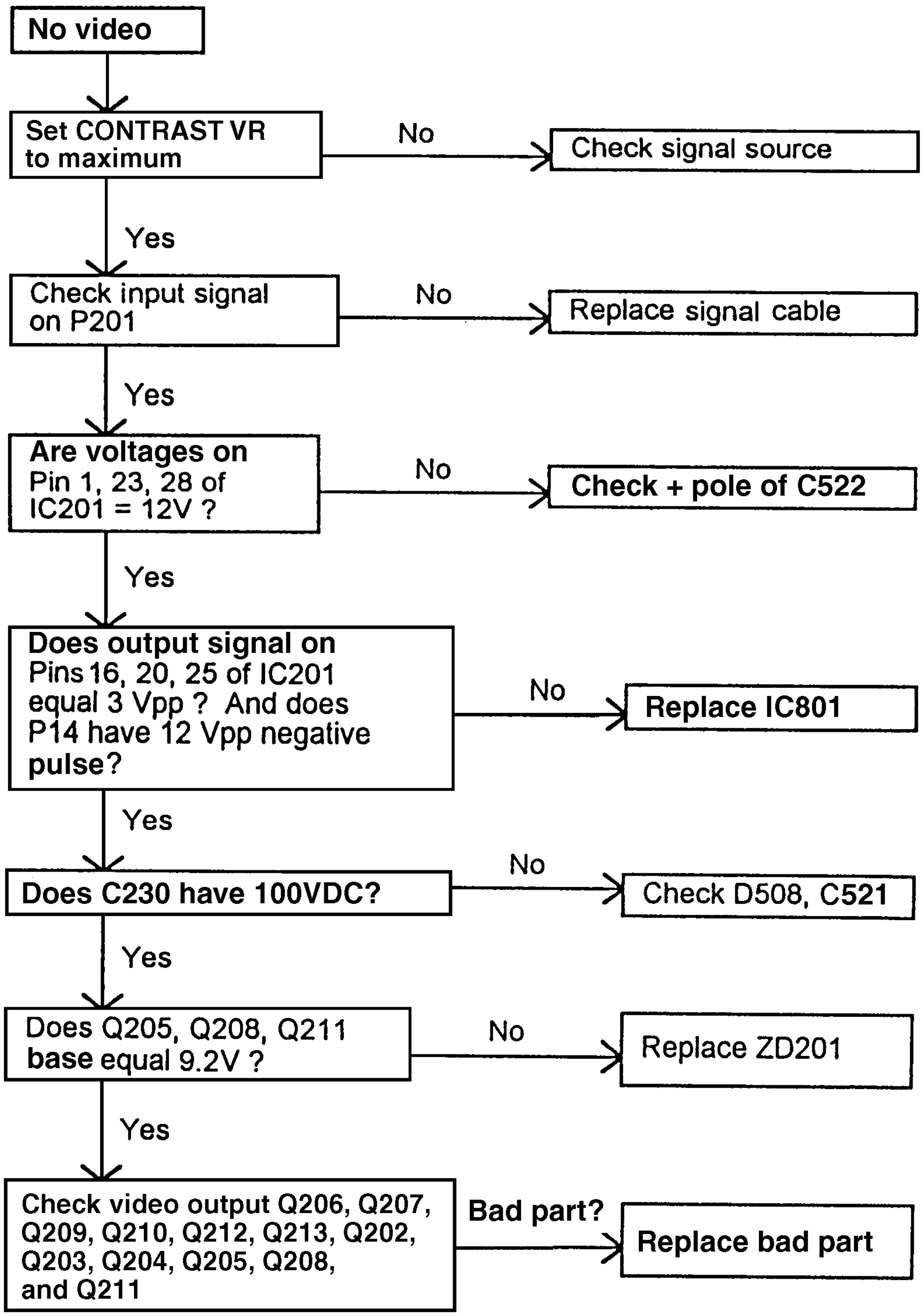
G1 Control
IC203A is a high-gain, slow-responding, inverting amplifer. Each of the three colors has a separate bias-control voltage. The lowest of these voltages feeds through one of three diodes: D206, D207 or D208. IC203A then applies a control voltage (G1 DRIVE OUT) through R255. The control voltage arrives at the base of brightness control circuit Q901. (Q901 is on the main circuit board.) Responding, Q901 adjusts the G1 average DC level. This adjustment impacts the video output stage with the highest cutoff voltage. There, the adjustment maintains a constant operating. This stage has the widest operating range of the three video amplifiers.

You can indirectly set the G1 voltage by adjusting the Screen (G2) control. The factory sets the Screen control so that G1 measures approximately -50VDC. The Automatic Biasing System then adjusts the G1 and cathode voltages. These automatic adjustments maintain optimum cutoff conditions throughout the life of the CRT.

Notes

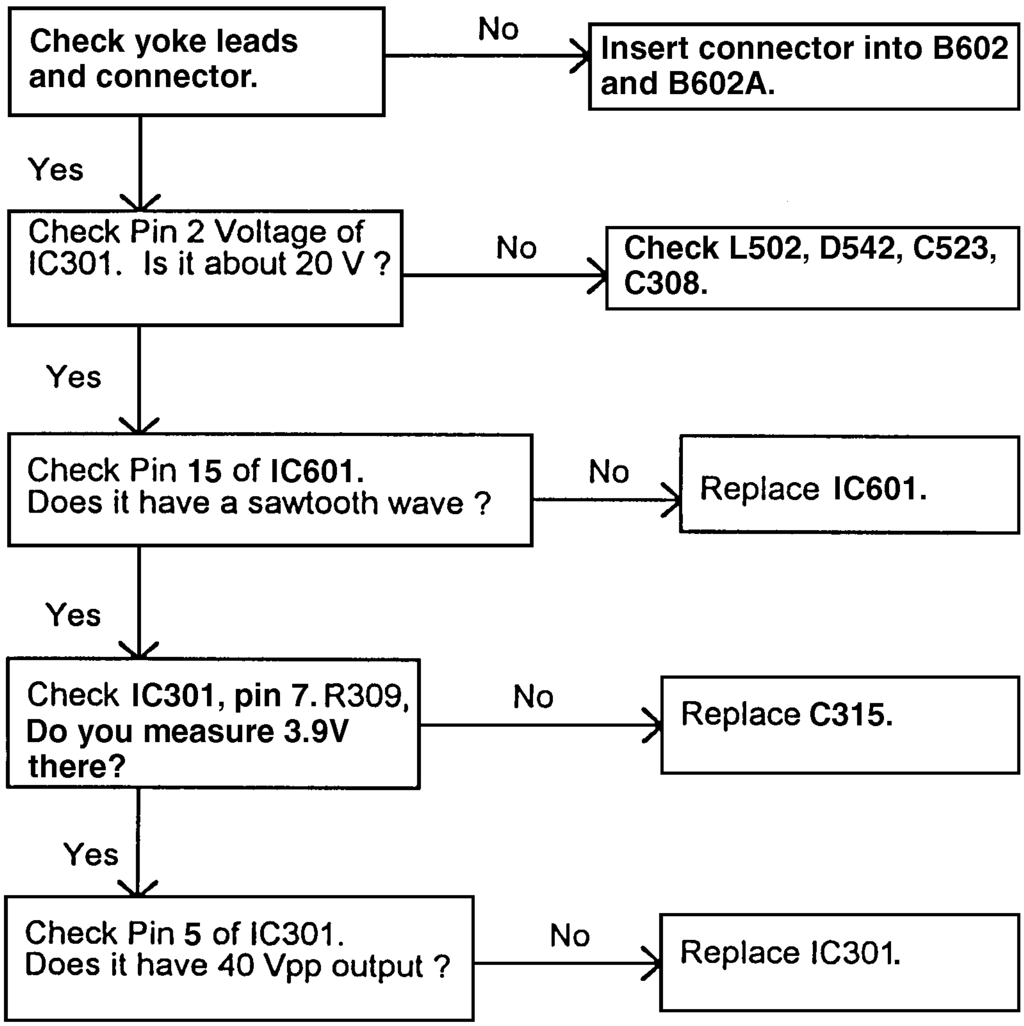
Chapter 5. Troubleshooting Flow Charts

- **No Video**



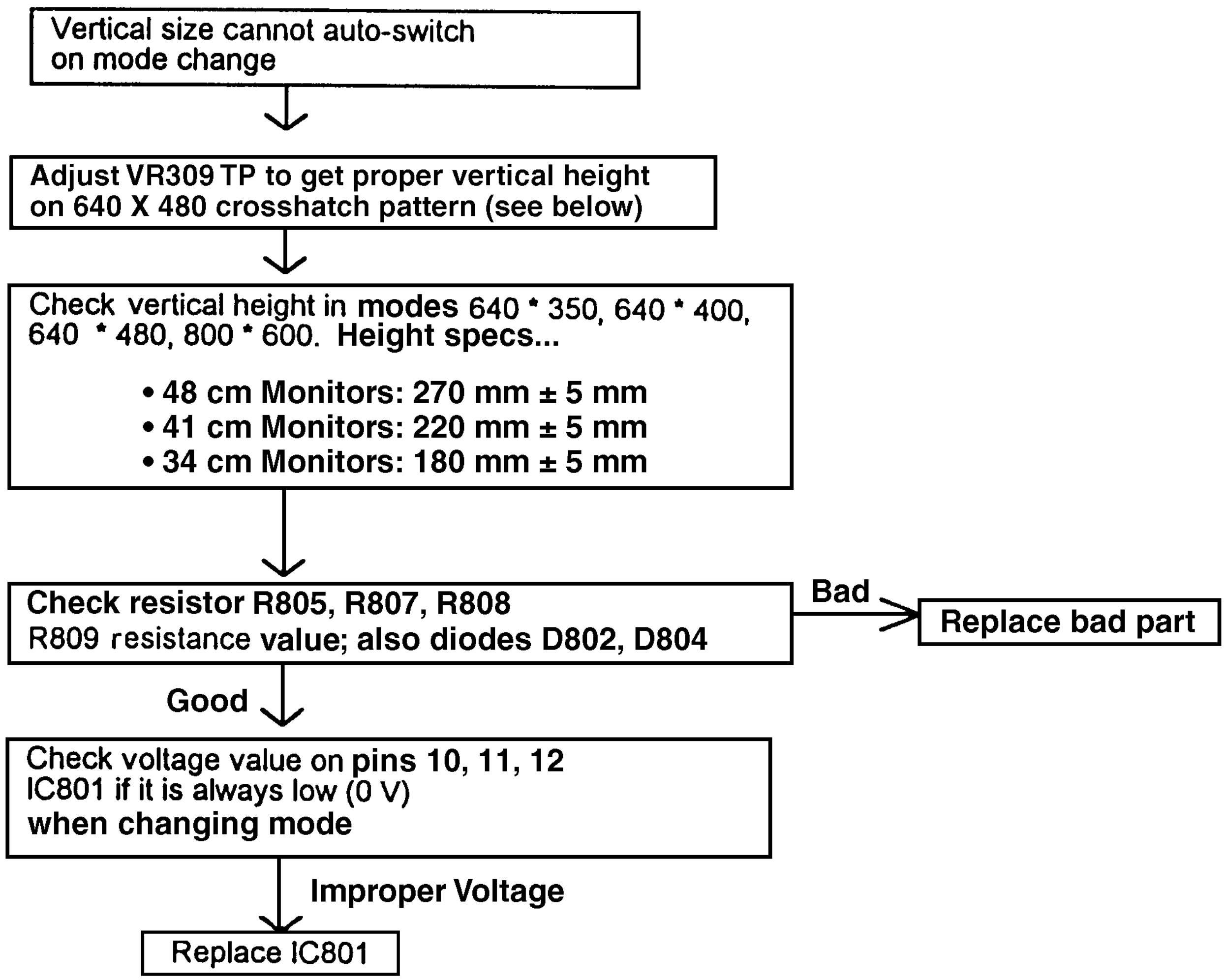
Troubleshooting Flow Charts

• Single, Horizontal Line Appears on Screen



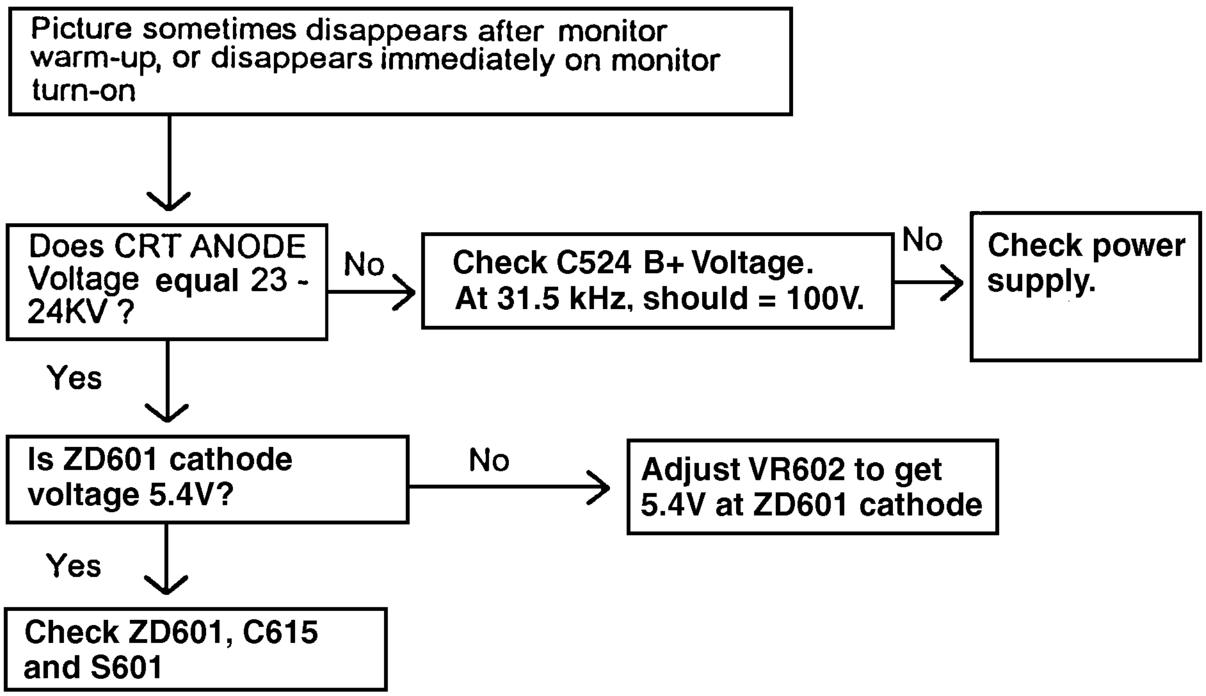
Troubleshooting Flow Charts

- **Improper Vertical Size When Mode Changes**



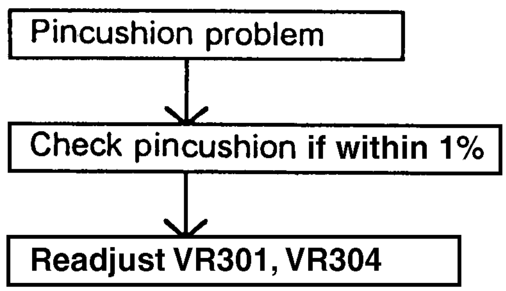
Troubleshooting Flow Charts

- **Picture Suddenly Disappears**

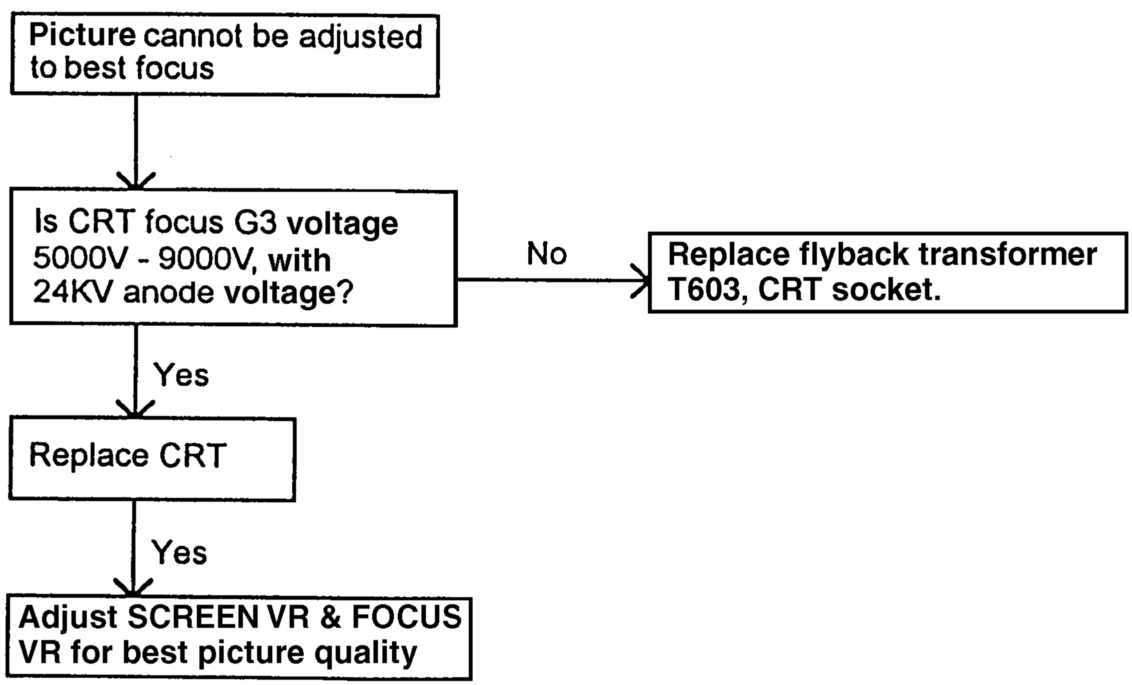


Troubleshooting Flow Charts

• Pincushion Problems

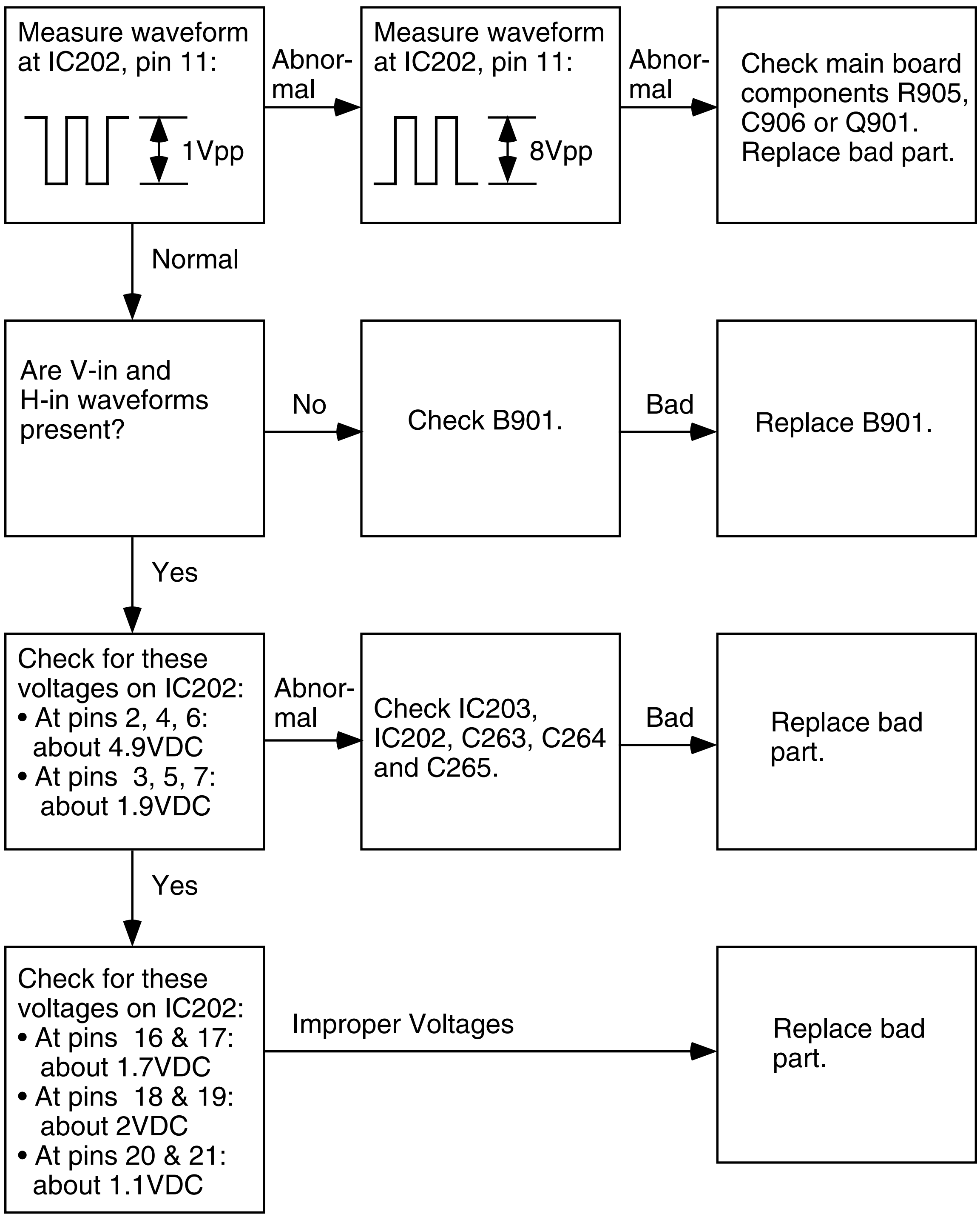


• Fuzzy Pictures



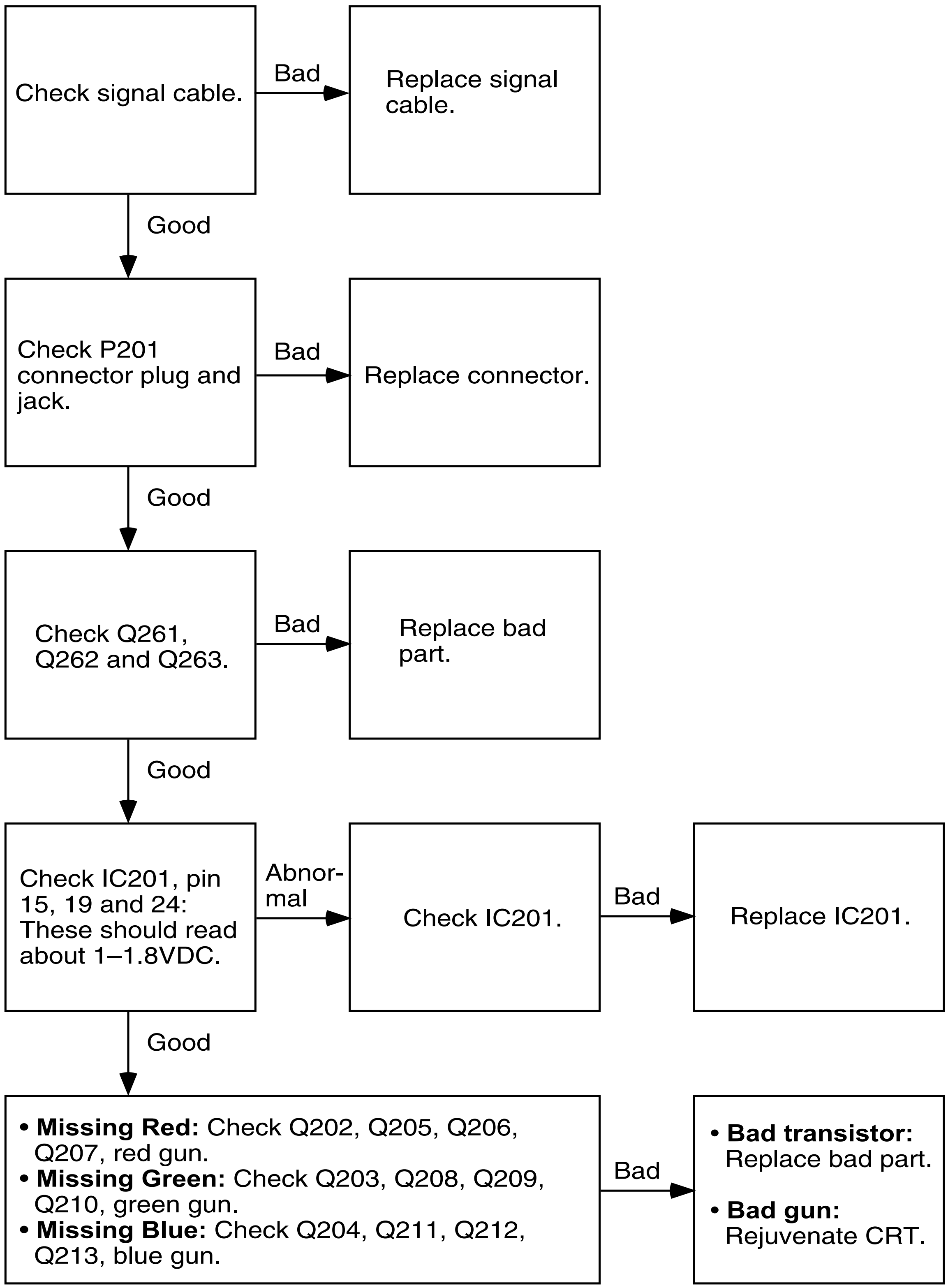
Troubleshooting Flow Charts

- **Auto Bias Neck: No Response to G1 Adjustment**



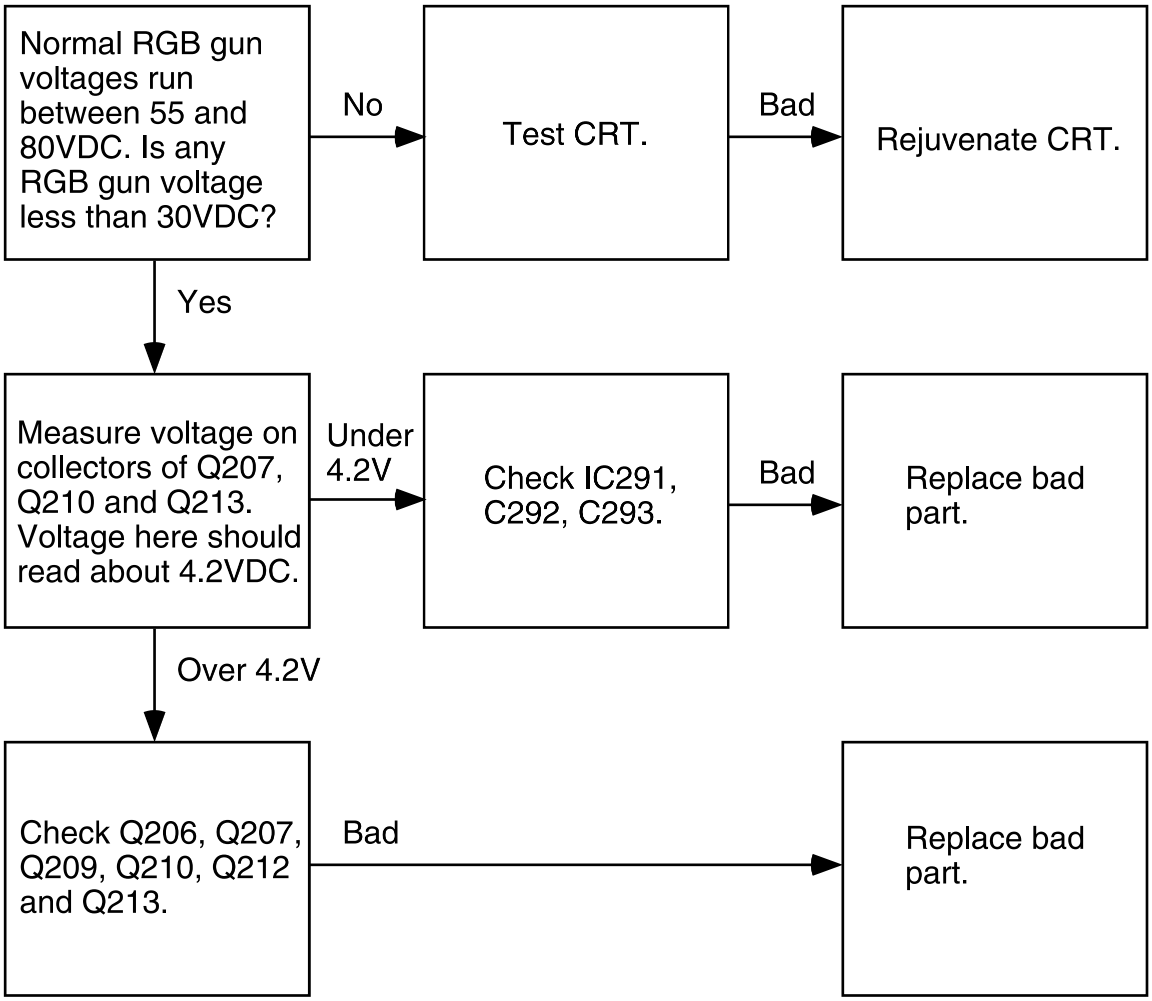
Troubleshooting Flow Charts

• Auto Bias Neck: Missing Color



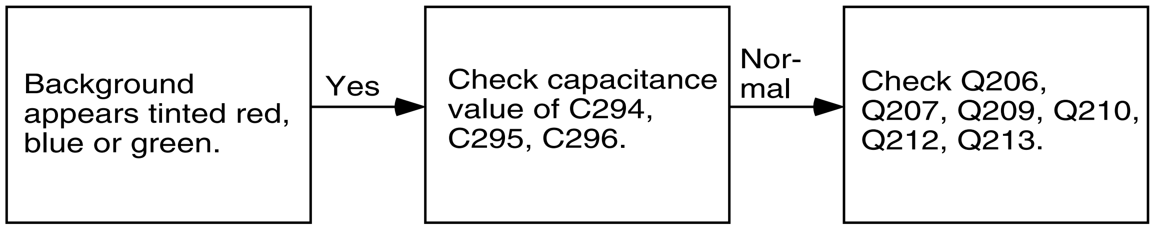
Troubleshooting Flow Charts

- **Auto Bias Neck: Low Cutoff Voltage of an RGB Gun**

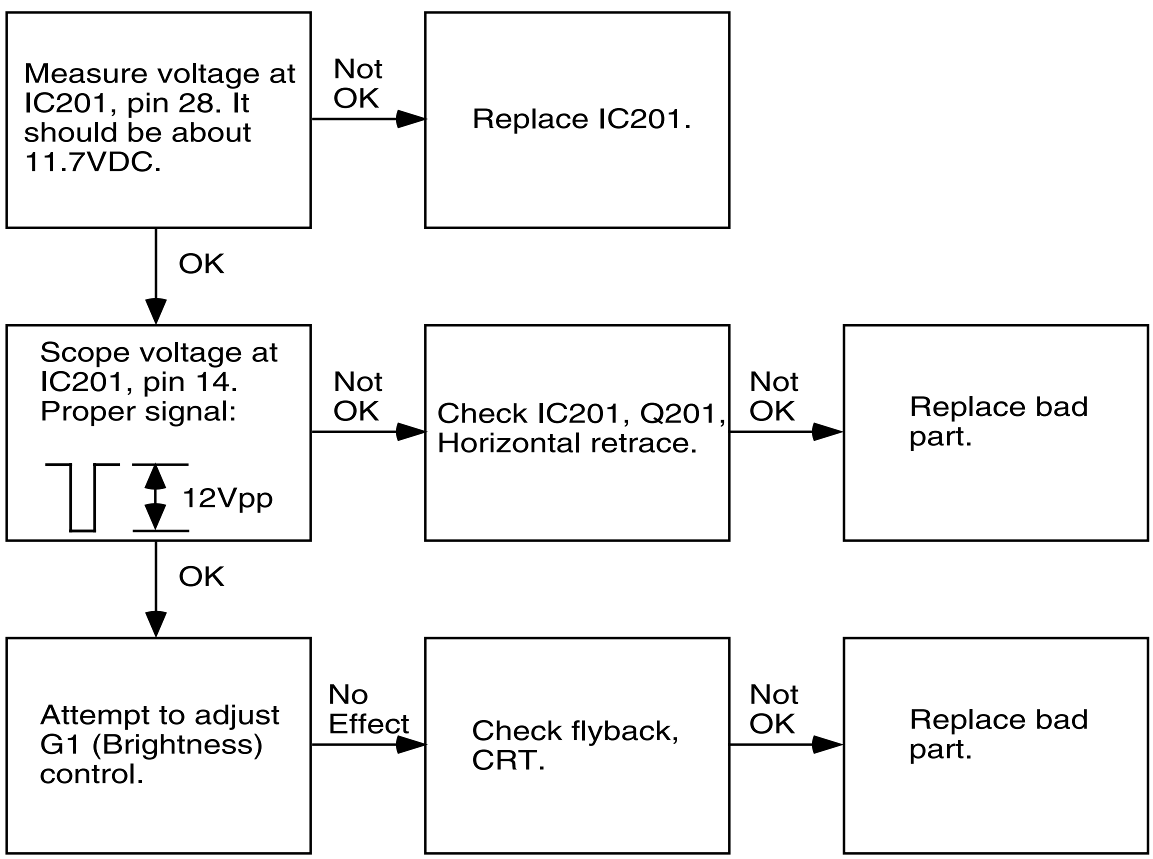


Troubleshooting Flow Charts

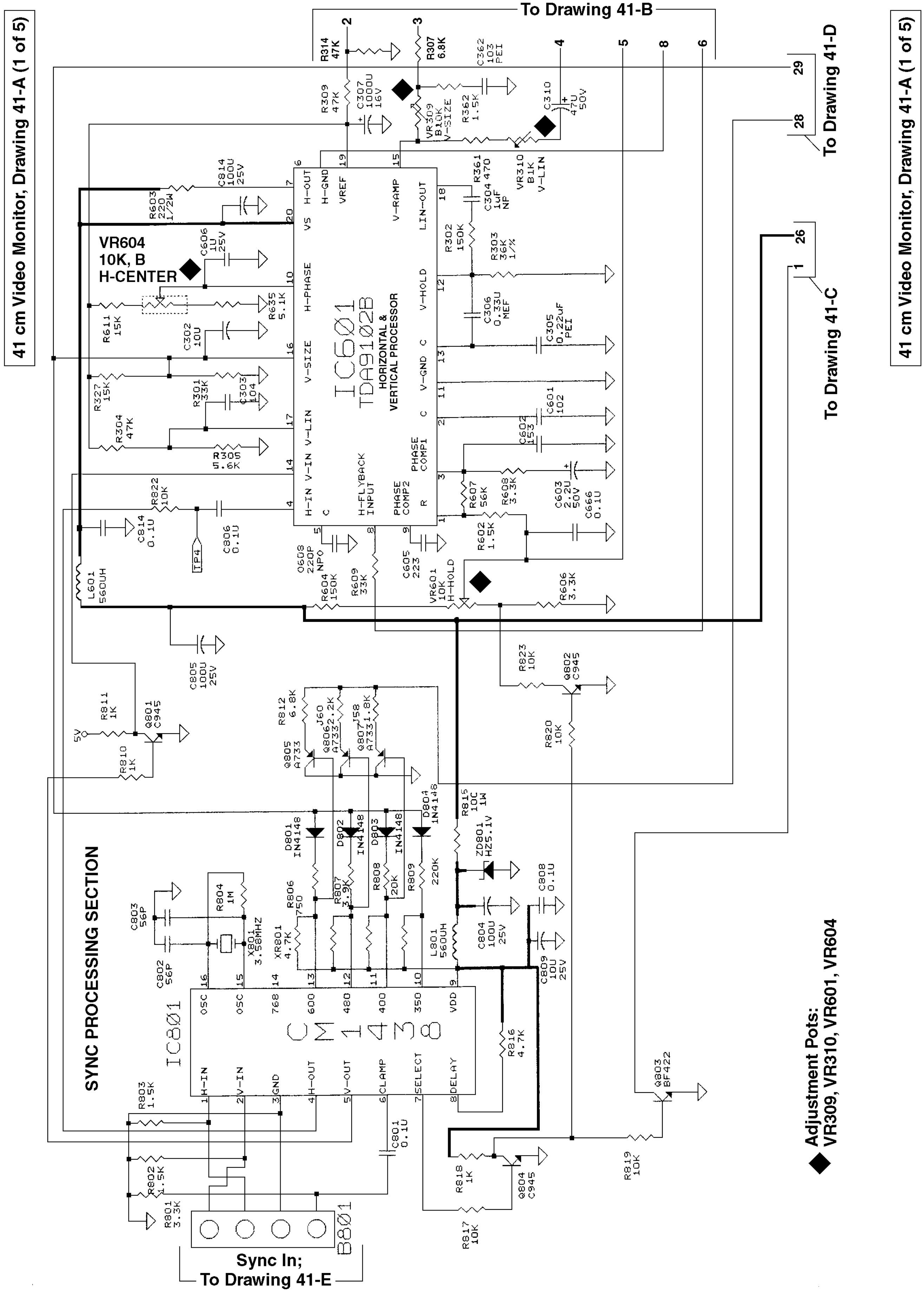
• Auto Bias Neck: Improper Colors



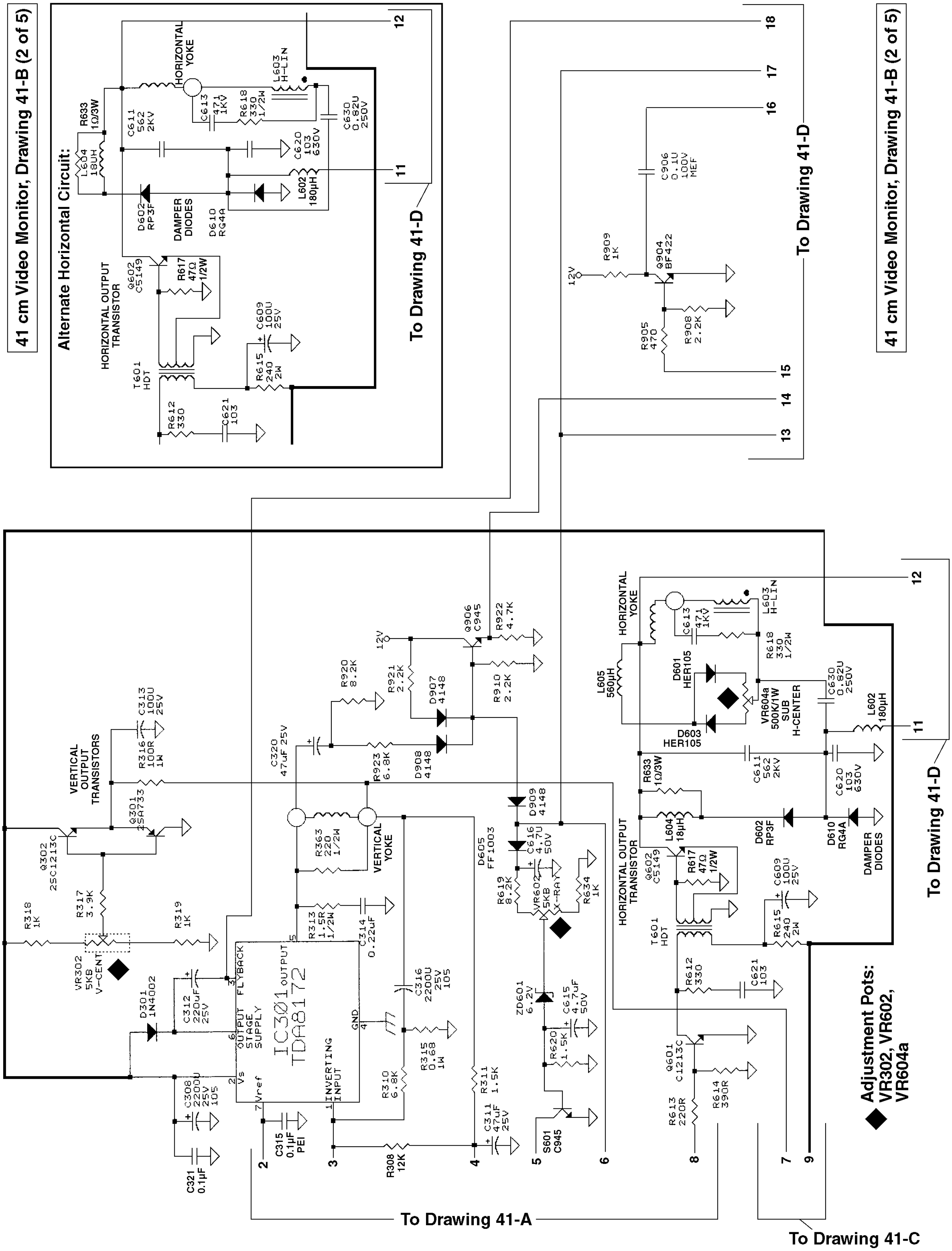
• Auto Bias Neck: No Video



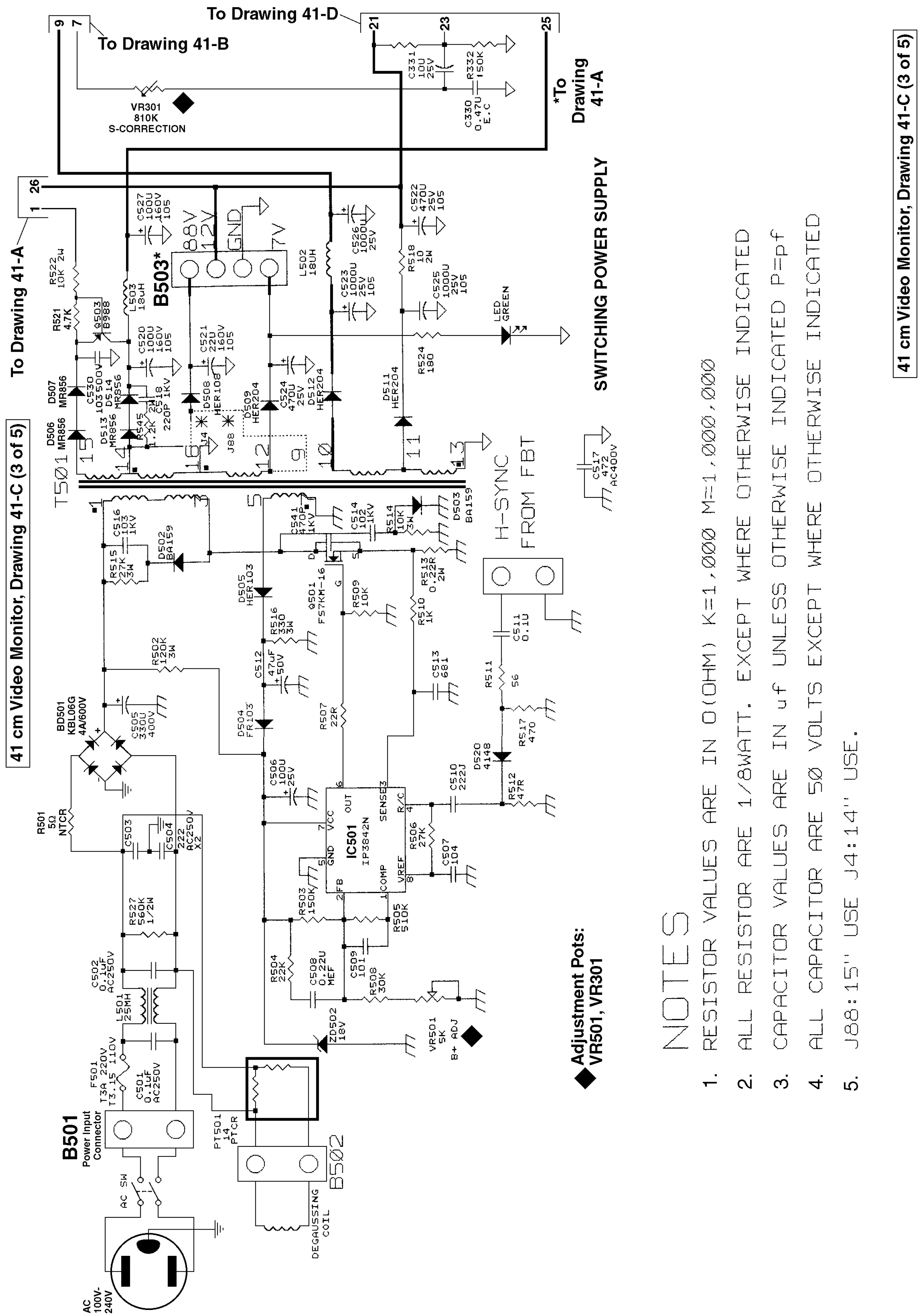
41 cm Monitor Schematic, Drawing 41-A



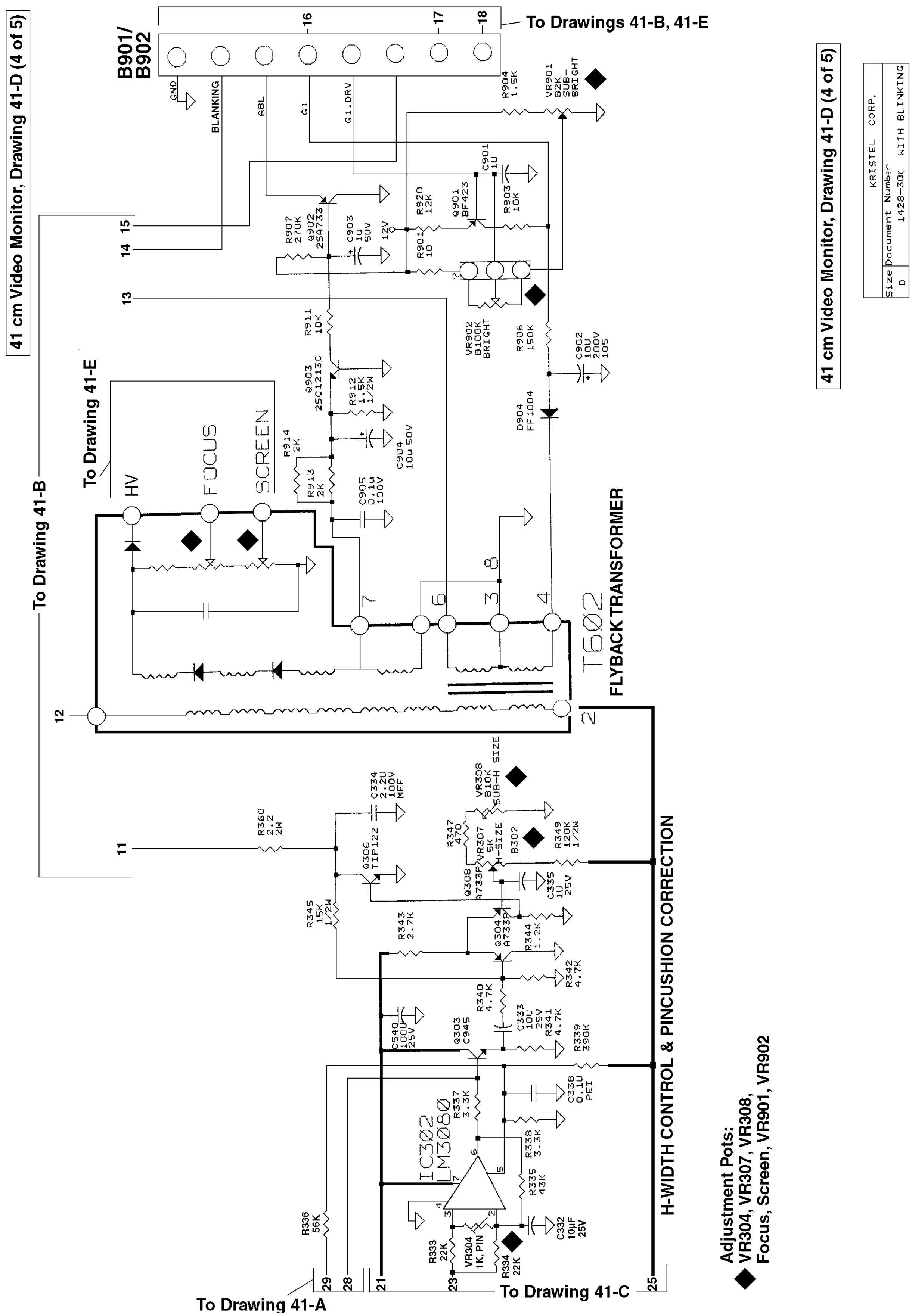
41 cm Monitor Schematic, Drawing 41-B



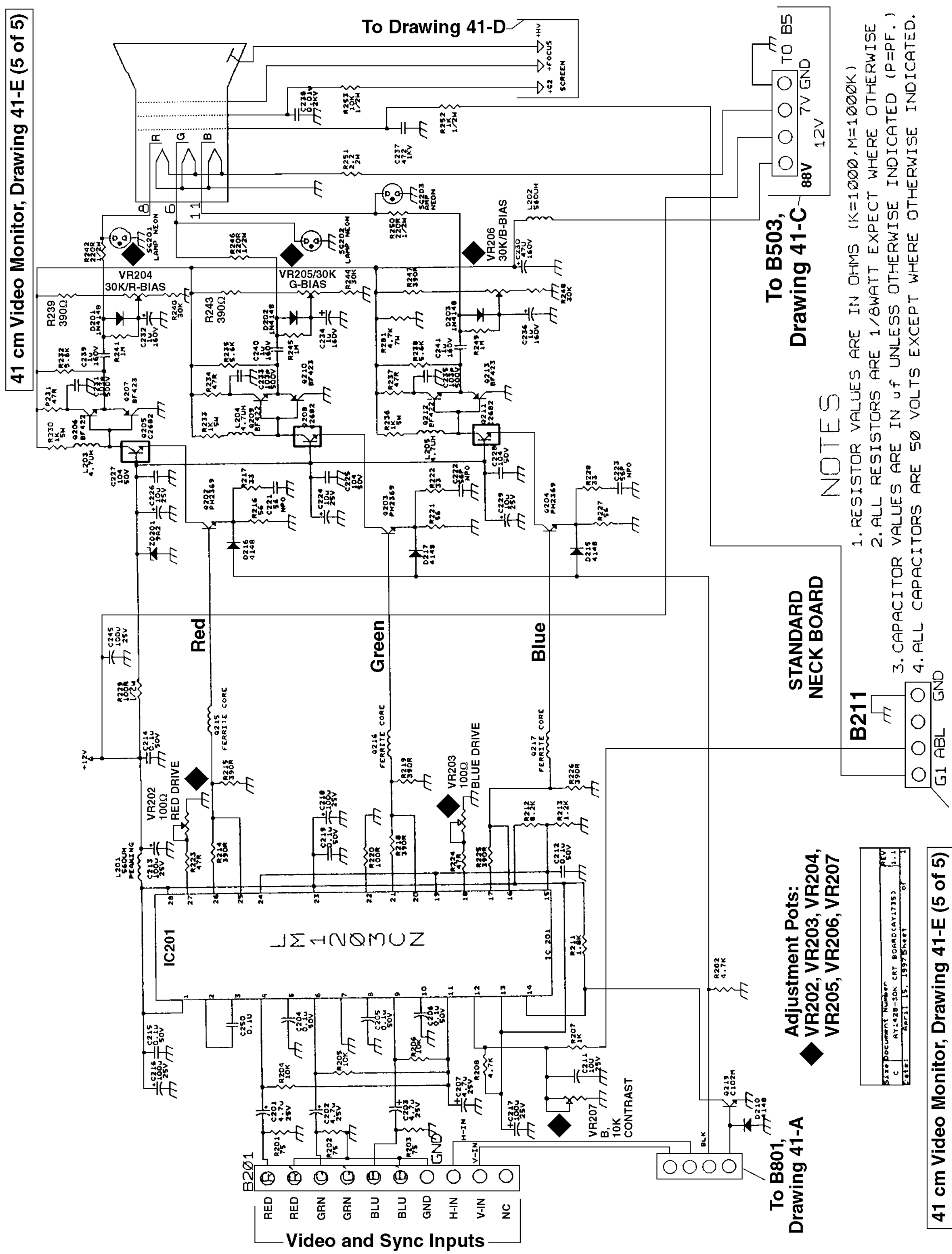
41 cm Monitor Schematic, Drawing 41-C



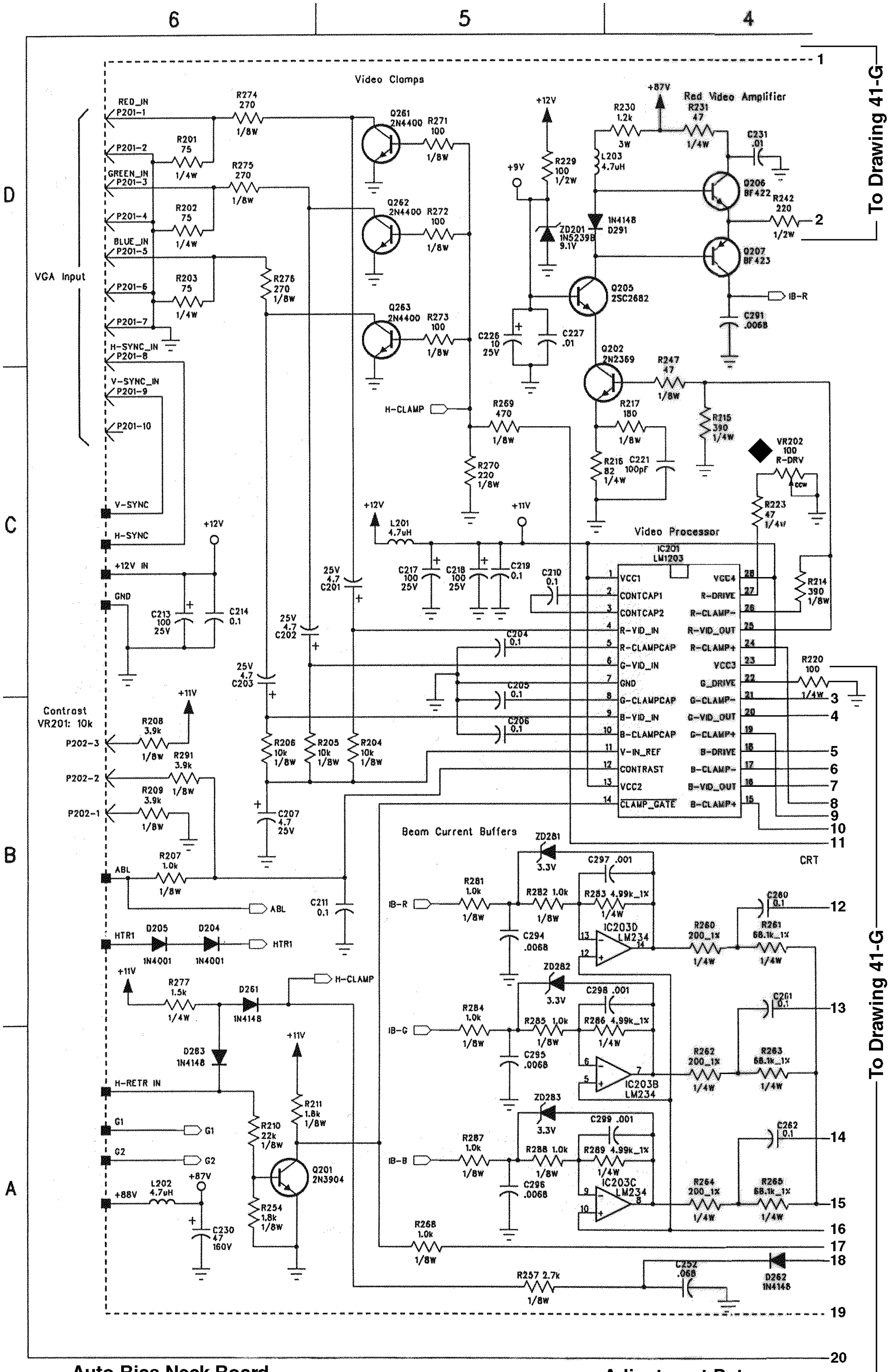
41 cm Monitor Schematic, Drawing 41-D



41 cm Monitor Schematic, Drawing 41-E



41 cm Monitor Schematic, Drawing AB-1

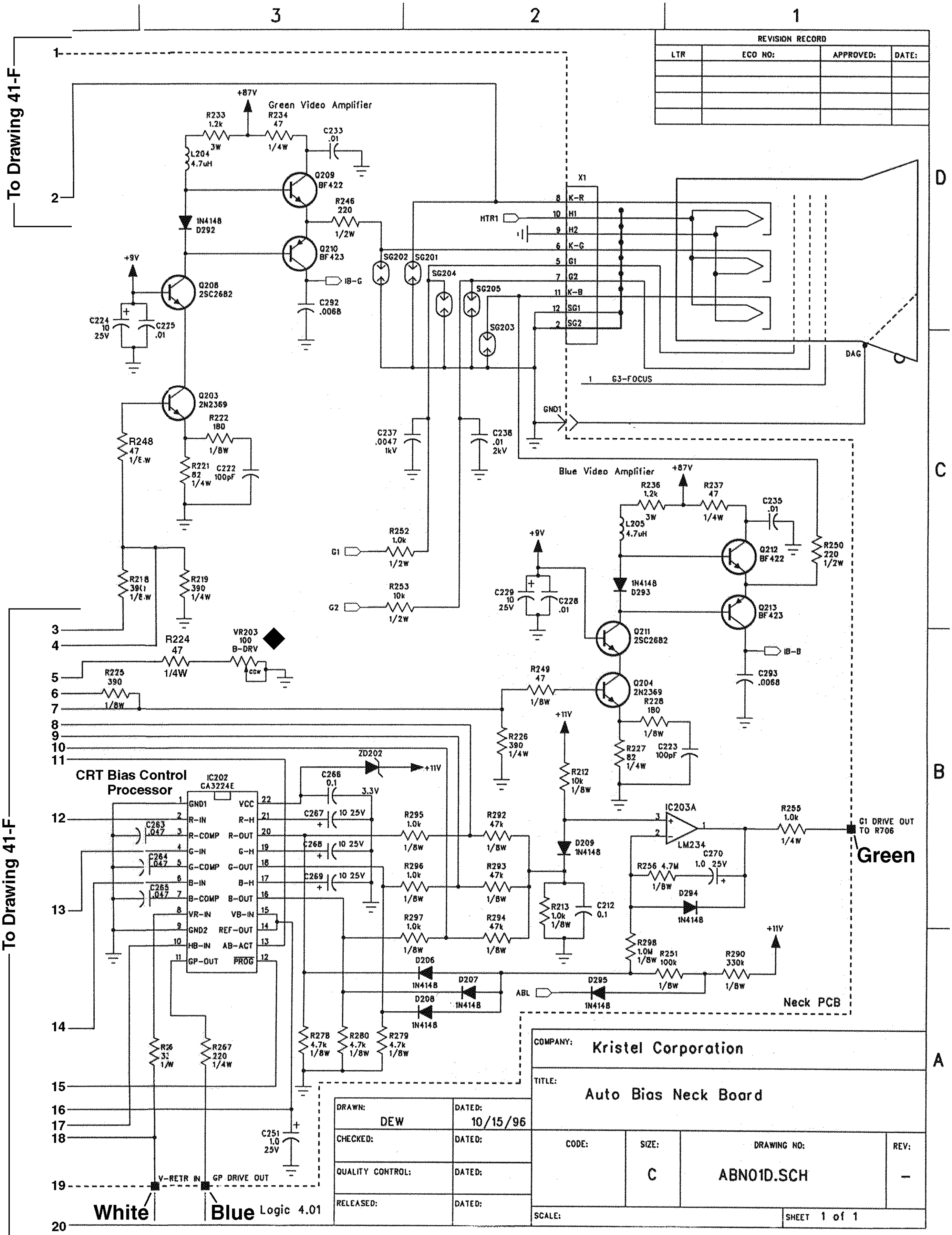


Auto Bias Neck Board

41 cm Video Monitor, Drawing AB-1 (1 of 2)

◆ **Adjustment Pots: VR202**

41 cm Monitor Schematic, Drawing AB-2



Auto Bias Neck Board

41 cm Video Monitor, Drawing AB-2 (2 of 2)

◆ Adjustment Pots: VR203

"On behalf of Table Mountain Casino I just wanted to express our thanks to you and your team. I couldn't have asked for anything better."

Brian Rankin - Slot Technical Manager

On-Site Slot Tech Training

Customized Classes Available

Randy Fromm's Casino School is a practical, no-nonsense look at how gaming machines work and how to repair them when they don't. **No previous knowledge of electronics is required** to get the most out of the school. The Casino School is geared for those who want to learn how to fix gaming devices without having to learn complex electronic theory or purchase expensive test equipment.

Be prepared for six hours of accelerated learning each day. Class begins at 9:00 am sharp each day and continues until 4:00 pm. The Casino School provides each student with reference materials and troubleshooting guides that will be valuable aids for repairing equipment on location and in the shop.

Students learn how to work with:

THE DIGITAL MULTIMETER

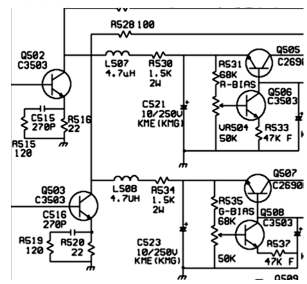
This relatively inexpensive piece of test equipment is easy to operate. Casino School students learn to use the digital multimeter to perform tests and measurements that will pinpoint the cause of a failure down to a single component.

ELECTRONIC COMPONENTS

The individual components used in games are introduced. Parts such as resistors, capacitors, diodes, potentiometers and transistors are covered individually. Students learn how the components work and how to test them using the meter.

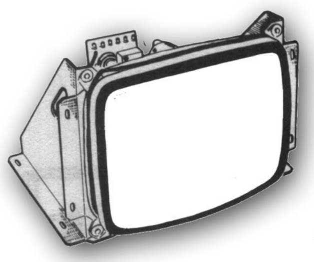
SCHEMATIC DIAGRAMS

Schematic diagrams are the "blueprints" for electronics. Learning to read schematics is easy once you know how the parts work!



POWER SUPPLIES

Power supply failure is a common complaint in many different types of systems.. Power supply failures are discussed during the class, along with shortcuts for troubleshooting and repairing them.



MONITOR REPAIR

The monitors used in video slots are designed for quick, easy, and safe repair. Students will learn the theory of operation of all types of monitors and how to repair monitors down to the component level. Of course, monitor safety will also be discussed.

You do not have to send your slot techs to Las Vegas or Atlantic City for training. The Casino School brings the training to you. Contact Randy Fromm's Casino School today to reserve a date for your tech school

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