Horizontal output transistor problems

By Homer L. Davidson

Horizontal output transistors (HOTs) and surrounding components have probably made more money for TV technicians than any other components. The horizontal circuits were the major cause of failure back in the days of tube chassis. When the solid-state chassis was introduced, replacement of the horizontal output transistor was an everyday occurrence in most service centers. Today there are fewer breakdowns, because of improved TV chassis reliability, but more problems still occur in the horizontal and high-voltage circuits than in any other area of the TV set.

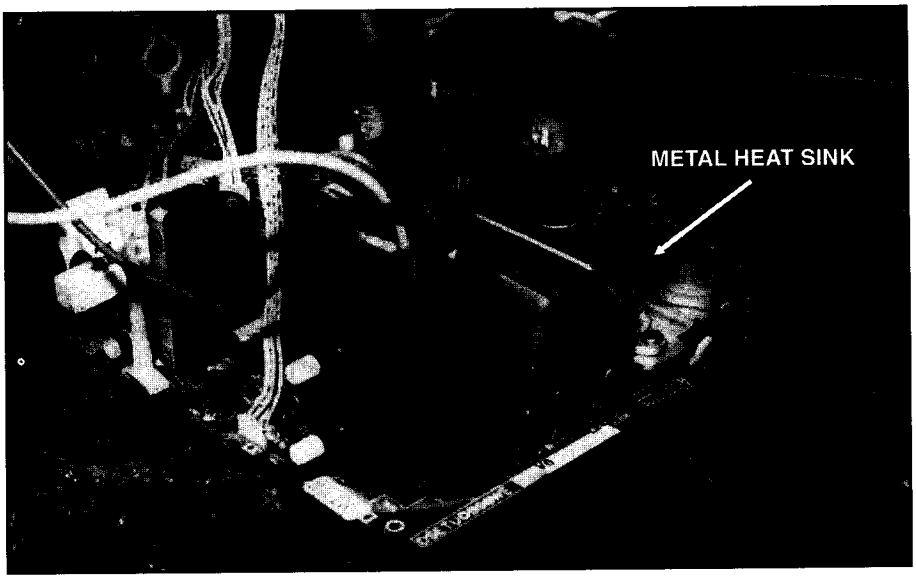

Figure 1. The horizontal output transistor is usually located on a metal heat sink.

Some typical HOT problems

A leaky horizontal output transistor may blow the fuse and cause chassis shutdown (Figure 1). A leaky damper diode may cause the same symptoms. An intermittent output transistor or surrounding components may produce that TV tough dog symptom. An open output transistor or circuits may produce a dead chassis.

A frequent cause of failure in early flybacks or horizontal output transformers was arcing over and firing between windings. Repeated damage to the HOT might be caused by a leaky, arcing flyback and overloaded secondary circuits.

Innovations in horizontal circuits

More recent sets feature an integrated high-voltage transformer (IHVT) with internal HV diodes. These diodes may arc over, destroying the transformer and horizontal output transistor.

Other recent innovations are the many

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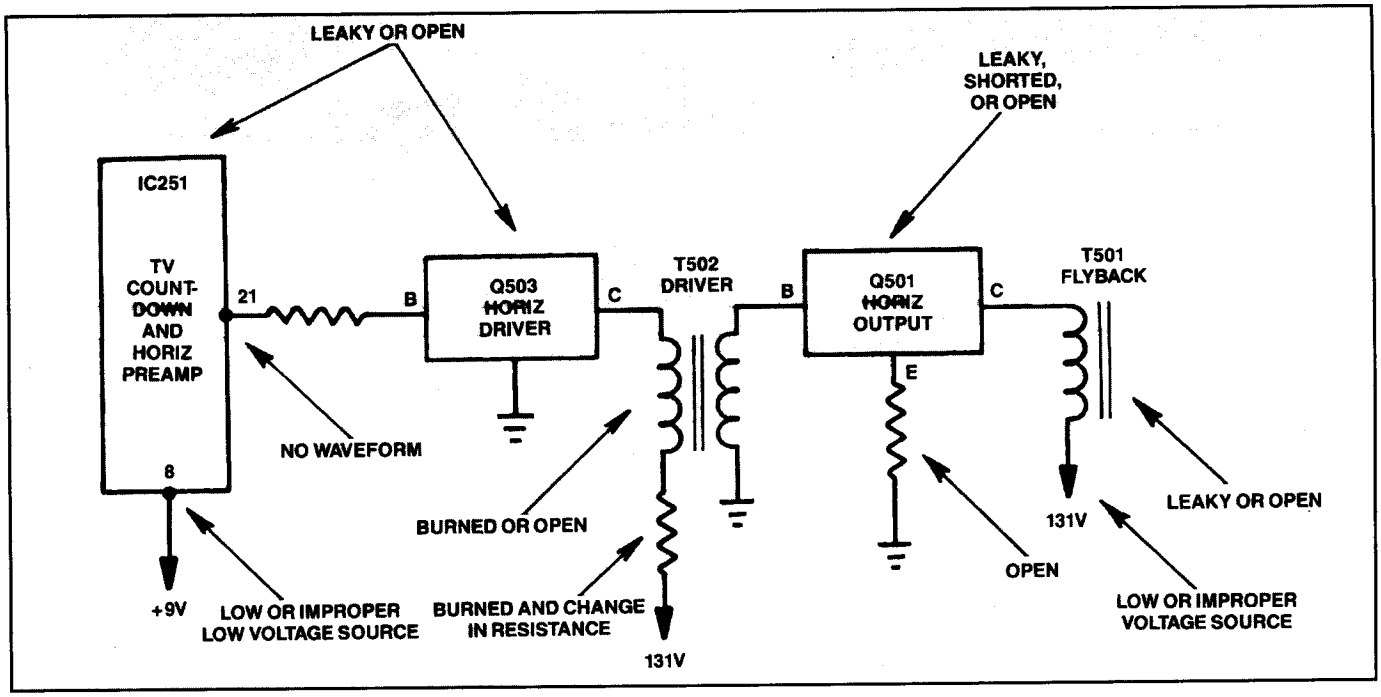

Figure 2. A basic horizontal output circuit with possible defective components.

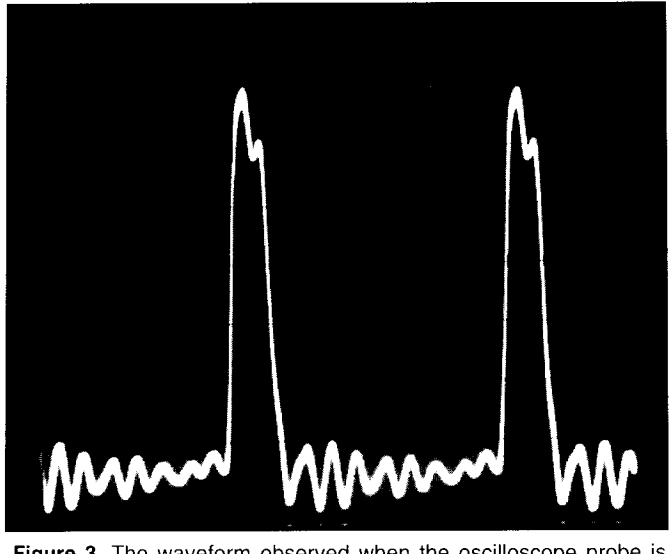

Figure 3. The waveform observed when the oscilloscope probe is placed near the flyback.

Figure 4. The horizontal output transistor (Q4401) is mounted on a separate "hot" heat sink in this 1993 RCA chassis.

circuits that derive their supply voltages from additional windings on the secondary of the flyback. These scan-derived voltage sources produce supply voltages for other circuits in the TV chassis.

In TV sets that feature scan-derived sources, after the transformer starts up, the derived voltage is fed to the horizontal oscillator or countdown circuits.

Although the introduction of scan-derived voltage supplies solved many problems for manufacturers (for example, elimination of the power transformer) it introduces additional complexity for service centers. To cope with this complexity, different service techniques were tried and mastered to repair the present-day horizontal output circuits.

Defective safety capacitors are another cause of failure in the horizontal transistor output circuits: they may cause excessive high voltage arcover and HV shutdown. A shorted or leaky safety or hold-down capacitor may blow the B+ and ac line fuses (Figure 2). An arcing deflection yoke or internal shorted windings may inhibit horizontal sweep.

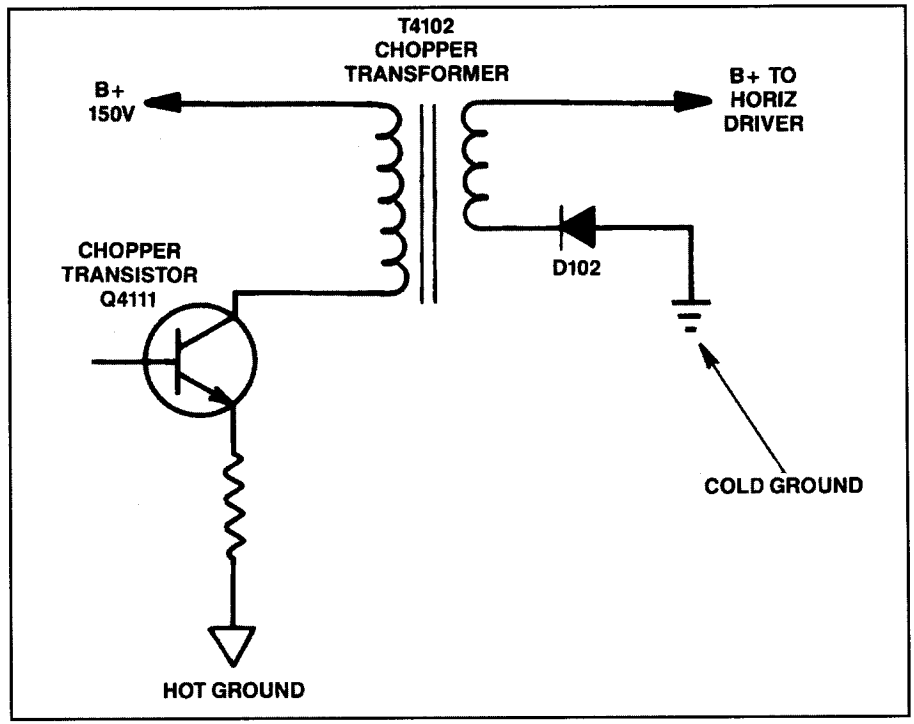

Figure 5. The primary of transformer T4012 contains the hot ground in a low voltage chopper circuit, while the secondary winding is tied to cold ground.

Checking horizontal circuits

The horizontal output circuits can be quickly checked using scope waveforms, and voltage, diode, resistance and signal injection tests. A quick waveform test, performed by placing the scope probe next to the flyback, will indicate if horizontal sweep is present (Figure 3). A check of the voltage on the B+ fuse or isolation resistor to the primary winding of the horizontal output transformer will determine if the collector supply voltage is correct.

Voltage and diode tests upon the collector (body) of the horizontal output transistor may indicate a leaky, open, or overloaded transistor. Of course, some of these statements may be a little fuzzy at this point. I will explain it later in this article.

A semiconductor junction test from the collector terminal to chassis ground may indicate a leaky transistor or damper diode. A low resistance measurement, with reversed test leads, may indicate a leaky transistor or diode. In some cases, the output transistor may be open and you are only measuring the resistance of the damper diode.

An open horizontal output transistor can cause the technician fits and produce a few gray hairs, since it's usually located behind a metal heat sink or chassis. Then too, the secondary winding of the driver transformer returns the base terminal to chassis ground, producing test problems.

Horizontal waveform tests

Oscilloscope tests are the most accu-

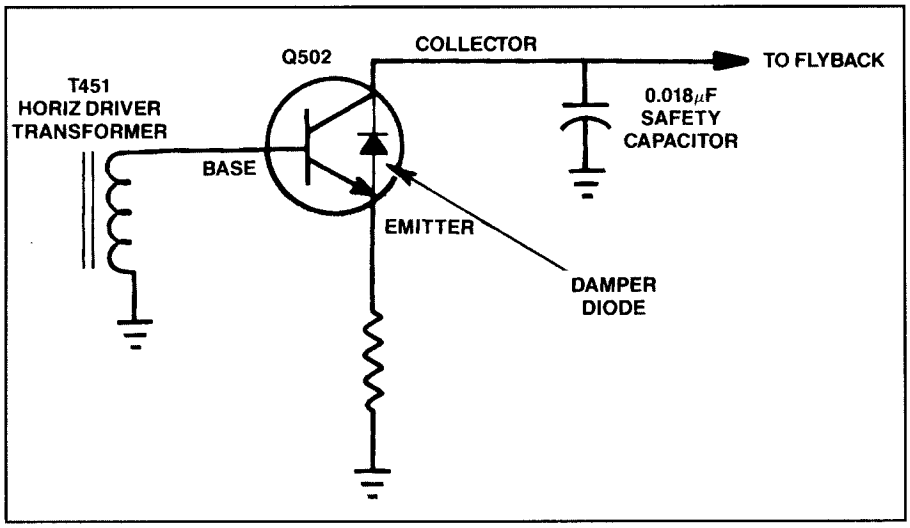

Figure 6. Look for the damper diode inside the case along with the HOT in the latest TV chassis.

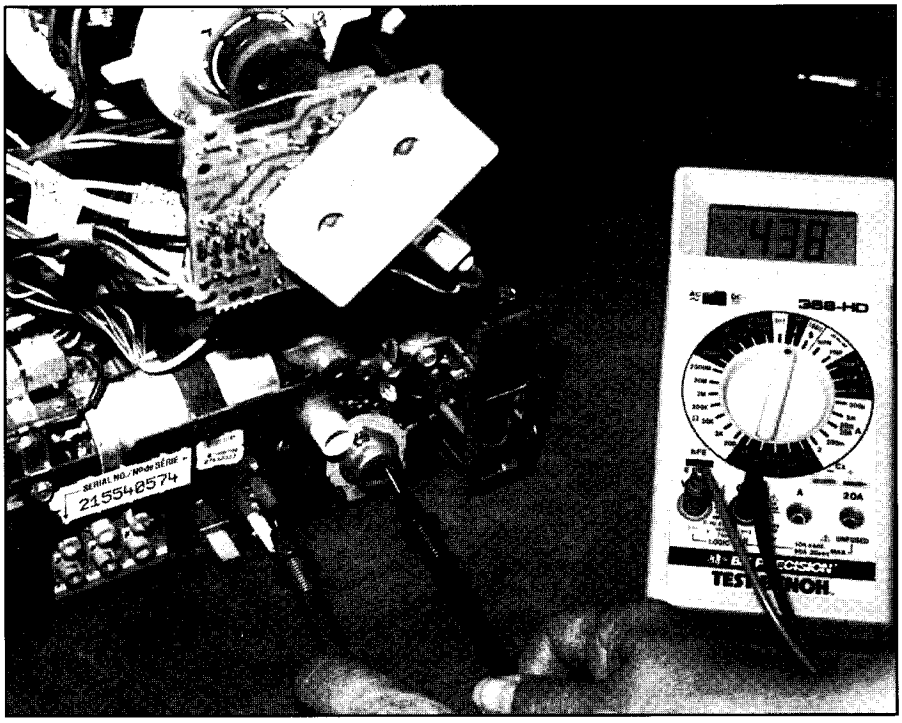

Figure 7. Check the resistance of the output transistor and damper diode for leakage to chassis ground.

rate and least damaging to your test instruments. A quick waveform check made by placing the scope probe next to the flyback may indicate a correct or improper horizontal sweep. Low waveform amplitude, or absence of a waveform may be caused by a defective flyback, insufficient drive voltage, a leaky output transistor, or an abnormal low-voltage supply source.

Next, a horizontal sweep test at the horizontal oscillator or countdown IC circuit, drive transistor, and the base of the horizontal output transistor, may turn up a defective component. Measure the voltage at the collector terminal of the HOT only if you observe no sweep waveform at the flyback. I will explain later.

Signal injection tests

If the set is totally inoperative, determine if the chassis is shut down because of a defective horizontal component, or if shutdown was due to excessive high voltage. High voltage shutdown can be determined with a variable isolation ac transformer. Connect the set to the transformer and gradually increase the ac voltage. If the set operates at reduced voltage, but then fails as you increase the ac voltage toward 120Vac, most likely the problem is high-voltage shutdown.

If this test confirms chassis shutdown, inject a signal from a waveform generator at the base of the horizontal output transistor. If this injected signal results in horizontal sweep, check voltages and waveform at the driver transistor, oscillator or countdown IC. Voltage measurements within the drive circuits may uncover the defective component.

If injection of a signal at the base of the HOT doesn't produce horizontal sweep, suspect improper voltages, a defective output transistor, or a defective flyback. Overloaded circuits in the secondary derived output transformer windings may prevent horizontal sweep. If the yoke assembly is defective, it may be loading down the output circuits. In order to determine if this is the case, disconnect the red yoke lead and see if sweep occurs. If so, the yoke assembly is the problem.

Hot chassis—cold chassis

Many of the new TV sets have separate "hot" chassis and "cold" chassis. The "hot" chassis is necessary in sets that employ a full-wave bridge rectifier. The common point of the bridge output cannot be connected to ground, or some components would be shorted out and destroyed. The hot chassis may include the horizontal output transistor (Figure 4).

In some sets, the output of the bridge rectifier is applied to, or part of, a switched mode power supply (SMPS) or a variable interval pulse regulator (VIPUR) power supply. The heat sink of the horizontal output transistor, chopper, SMPS and VIPUR transistors may operate upon a hot heat sink, away from the regular PCB chassis. The regular PCB or metal chassis may be referred to as the cold chassis.

If you take a voltage measurement from a horizontal output transistor mounted on a hot chassis with respect to chassis ground, it will not be accurate or the same voltage on the schematic. All voltage measurements made on components mounted on the hot chassis should use the heat sink as the negative or ground terminal. The hot ground symbol is a standard ground outline. All components on the hot chassis are returned to it (Figure 5). Use the hot heat sink as the common

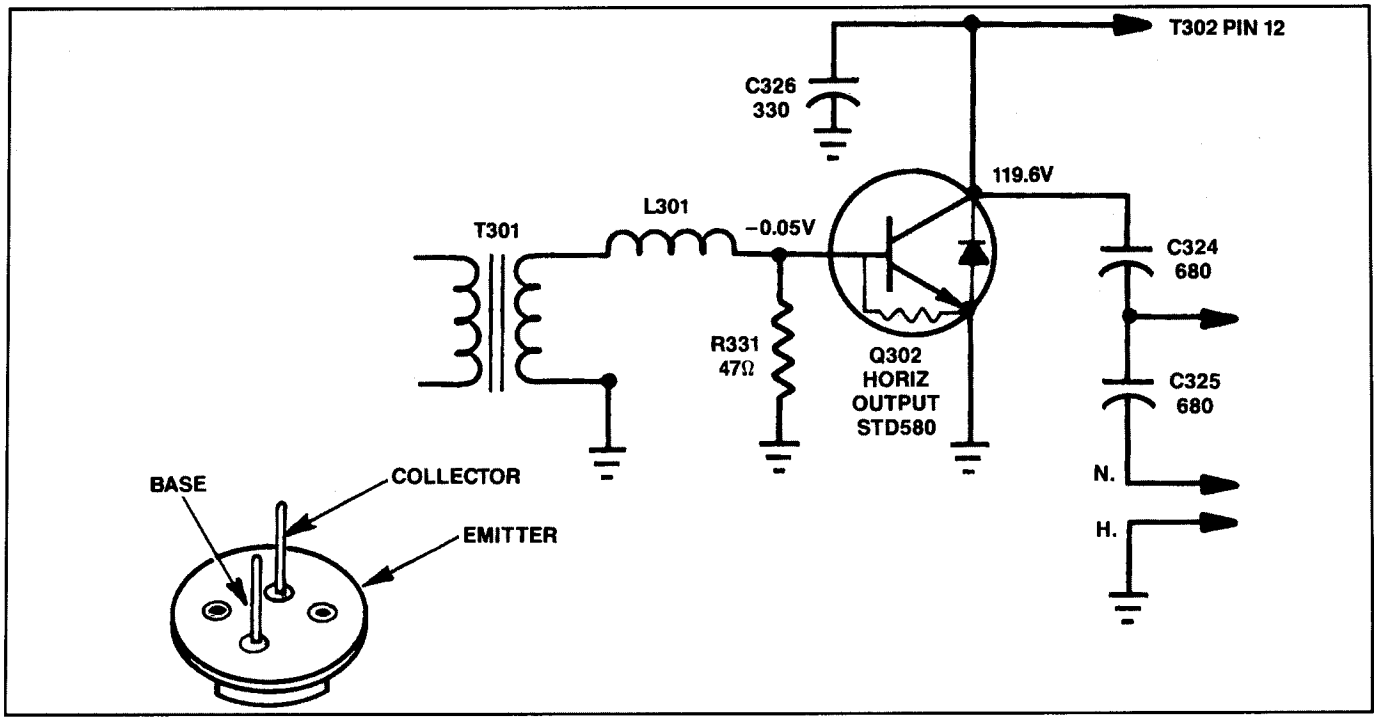

Figure 8. The STD580 output transistor found in the horizontal circuits of a Sanyo 91C550A portable with correct base connections.

hot ground when taking voltage and resistance measurements.

Different horizontal output transistors

In the earliest solid-state TV sets, the damper diode was connected to the collector terminal of the HOT, next to the safety capacitor. Later, the damper diode was mounted within the same case with output transistor.

If you suspect a leaky horizontal output transistor, take diode and resistance tests at its terminals. Examine the schematic diagram to determine if the damper diode is inside the output transistor case, before making tests or replacing the HOT. Simply check the transistor number within the semiconductor replacement manual to determine if the damper diode is inside (Figure 6). In some TV chassis, you may see a flat plastic horizontal output transistor mounted upon the large heat sink.

STD580 horizontal output transistor

In several of my books and magazine articles, I have stated that you should connect the meter probe to the case (metal body) of the horizontal output transistor to check for a short or leaky transistor to chassis ground.

A fellow technician from Maryland wrote that this statement was misleading; that the HOT case is not always connected internally to the HOT collector. He referred to several Sears and Sanyo TV chassis that he had serviced, in which the metal case of the horizontal output transistor was the emitter terminal instead of the collector terminal.

This was news to me. I have never seen a HOT connected in that manner in all my years of servicing TV sets, so I checked with local and Sears TV service techs. They had never seen one either. Most had not heard of such a thing. The collector terminal was always insulated from the heat sink and the metal body was definitely the collector terminal. Since I was born in Missouri, he had to show me, and after several years, he did.

Michael B. Danish of Mike's Repair Service of Aberdeen Proving Grounds, MD, tried to get information on the STD580 output transistor. He contacted Sears, Sanyo and Sanken without any results. As you know, Sanyo manufactures several TV chassis for Sears. The STD580 transistor was manufactured by Sanken. Of course, this output transistor is not listed in any semiconductor replacement manuals.

After about four years of trying to get the required information on the STD580 transistor, he hit paydirt courtesy of Sams Photofact. He received a photocopy of a Sanyo model 91C55UA schematic with pinout information. Q302, a STD580 horizontal output transistor shows the emitter terminal as the metal body and the two terminal pins are collector and base terminals (Figure 8).

I tip my hat to Michael Danish for his persistence and determination in the matter of the metal emitter terminal. From now on, I shall write that the resistance test from the collector terminal of the horizontal output transistor to chassis ground will indicate a leaky transistor or damper diode. I will no longer assume that the metal case is the collector terminal.

Voltage test of the horizontal output transistor

Most TV manufacturers and Sams Photofacts warn against measuring the voltage on the collector terminal of the horizontal output transistor. The high signal voltages can quickly damage almost any meter.

In fact, we had a DMM that was damaged when accidentally touched to the collector terminal or any place near the flyback and yoke circuits. The fuse would blow and parts within the tester were destroyed. This turned out to be costly each time it was sent in for repair. That meter is now collecting dust upon a shelf.

In the past year, I have heard from several beginning technicians, and even a few more experienced technicians, who

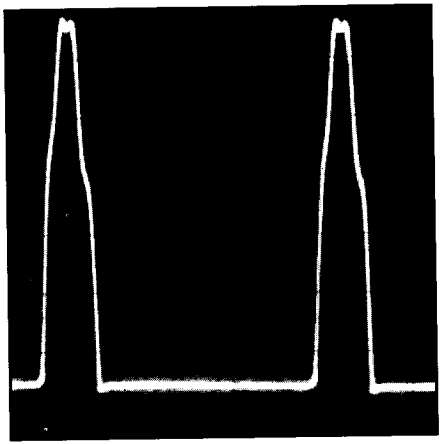

Figure 9. Use the oscilloscope to observe the horizontal output waveform at the collector terminal of the HOT.

have experienced meter damage by taking voltage measurements upon the metal body of the horizontal output transistor.

Do not take any voltage measurements upon the collector output terminal if the output circuits are functioning. Instead, use an oscilloscope to observe waveforms at this terminal (Figure 9).

In preparing material for many of my service articles and books, I have used the Beckman Tech 310 DMM and safely measured the horizontal output transistor collector terminal. That meter is still working fine. But not every DMM will take this measurement without damage. Play it safe; take a scope waveform.

If observations using an oscilloscope show that there is no waveform on the horizontal output transistor, measure the collector voltage with a DMM. A low voltage measurement may indicate a leaky output transistor or damper, improper drive voltage, or overloaded horizontal circuits. Higher than normal voltage may indicate an open output transistor, or emitter resistor, if there is an emitter resistor in the circuit. In the horizontal output circuits in some imported sets, a small resistor is found in the emitter circuit.

And never use a meter to measure the high voltage at the anode terminal of the picture tube either. You will receive a nasty shock, and the meter will be damaged beyond repair. Always use a high voltage probe meter to measure the picture tube anode voltage, preferably one that measures up to 40KVdc. A high voltage probe connected to a VTVM does a fine job. Be sure to connect the meter ground cable to the TV chassis.

Quasar TP2020DW portable TV horizontal tests

A Quasar TV set was brought into the shop. The symptoms were no raster, no picture, no sound. Both the line fuses (F001) and B+ fuse (F002) were open. Since both fuses were blown, I suspected a defective low-voltage regulator circuit or horizontal output transistor. A quick leakage test from collector terminal to common ground (0.13Ω) indicated a leaky horizontal output transistor or damper diode (Figure 10).

I removed the output transistor and tested it out of circuit. This test confirmed that it was leaky. This transistor was a flat plastic three-leg part mounted on a heat sink ahead of the flyback. I replaced the leaky output transistor with an ECG2302 replacement.

I connected the DMM as monitor at TP91 (the same point electrically as pin 14 of the low-voltage regulator source). This 131V source supplies collector voltage for the horizontal output transistor (Q551) and driver transistor (Q501).

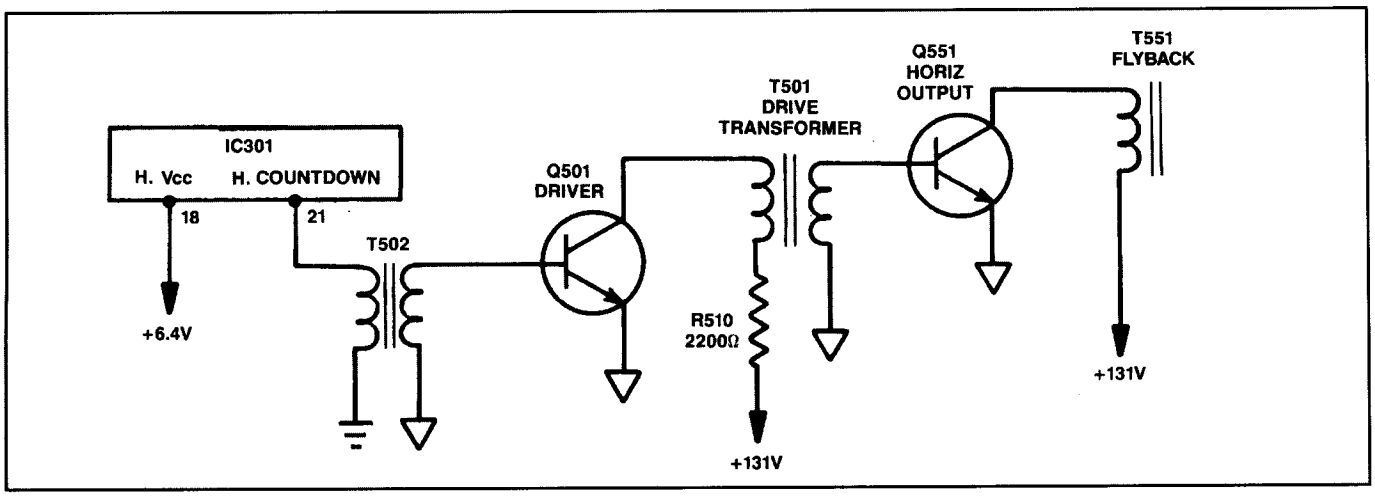

Figure 10. Horizontal circuits of the Quasar TP2020DW TV chassis.

Some further tests

After replacing Q551 and both fuses, I slowly raised the variable isolation transformer voltage to about 65Vac. The voltage at the regulator was extremely low, and the horizontal output transistor was getting warm. I connected the oscilloscope probe to the collector terminal of the driver transistor and pin 21 of countdown IC, IC301. There was no signal at that point. I turned off the set and disconnected the ac plug then turned to the TV schematic diagram for further study.

At first I suspected that IC301 was open or leaky. But other possible causes of this symptom occurred to me. The voltage applied to IC301 might not be correct. Or a component connected to the countdown IC terminals might be defective, loading it down.

Examination of the schematic indicated that the voltage source for IC301 (terminal 18) was supplied by a dc source originating from a transformer other than the flyback. I was in luck. If this voltage was supplied from the flyback, troubleshooting would have required more time.

Checking the supply voltage

To prevent damage to the new output transistor during further troubleshooting, I removed fuse F002, supplying voltage to regulator IC801 and Q551. I could have removed horizontal output Q551, but this was a lot easier and faster. Slowly I raised the line voltage and checked IC301 supply source at pin 18. The voltage remained at zero, even when the line voltage reached 100Vac. Either IC301 was leaky or the supply voltage, specified at 6.4Vdc, was incorrect.

I decided to check the supply voltage circuits. Using Sams Photofacts grid trace location guide I located the vicinity of regulator diode D507. After pulling back a few wires I saw that the 6V regulator showed signs of having been overheated. Replacing the overheated R503 and the leaky D507 restored the 6.4V source (Figure 11).

I replaced the fuse and slowly increased the output voltage of the isolation transformer. Sound and raster returned. I was lucky that the low-voltage regulator had not been damaged as well.

If I had jumped to the conclusion that IC301 was defective when I was evaluating the possible causes of the symptoms, I would have done a lot of desoldering and soldering on IC301 for nothing.

Servicing means proper procedures and constant learning

With this article I have tried to show how to make quick and correct tests in servicing the horizontal output circuits. I also wanted to point out that we can learn from other technicians. Constant learning can help keep one on the right track. ■

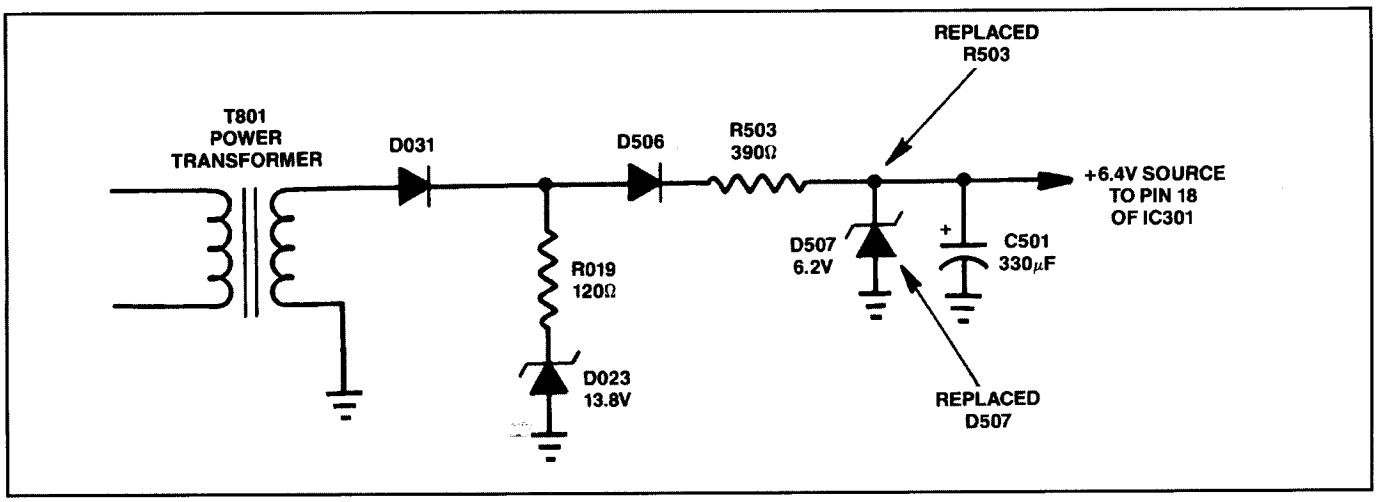

Figure 11. D507 was leaky and R503 was burned in this power supply. Consequent absence of dc source voltage (6.4V) to IC301 caused the no raster-no sound symptom.