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tech tips

# Analyzing the RCA TX81/82 Horizontal Output Stage

The horizontal output stage found in the RCA or GE TX81 or TX82 chassis differs from conventional TV horizontal output stages. While the TVA92 TV Video Analyzer's Horizontal Out put Load and Dynamic Tests can analyze the TX81/82 horizontal output stage, minor changes in the lead connections and test interpretations are required. This Tech Tip briefly describes the operation of the TX81/82 horizontal output stage and explains how to use and interpret the TVA92's Horizontal Output Load and Dynamic Tests.

## The TX81/82 Horizontal Output Stage

The horizontal output stage of most televisions includes six basic components (as shown in Fig. 1a): primary of the flyback, damper diode, retrace capacitor, output transistor, yoke, and yoke series capacitor. A conventional output stage applies a regulated B+ voltage from the power supply to the flyback primary. The other side of the primary winding connects to the collector of the horizontal output transistor.

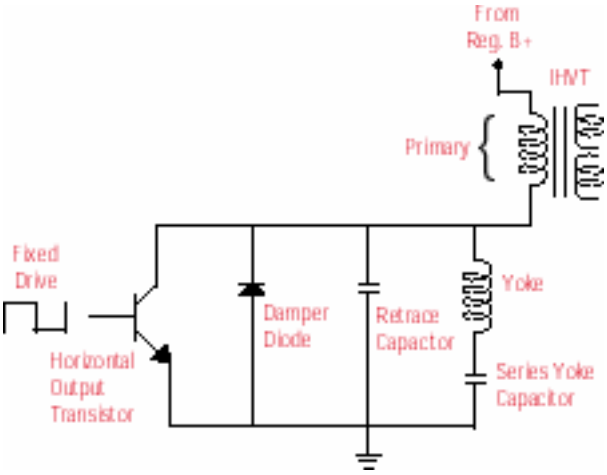


*Fig. 1a: Conventional horizontal output stage found in most television chassis.*

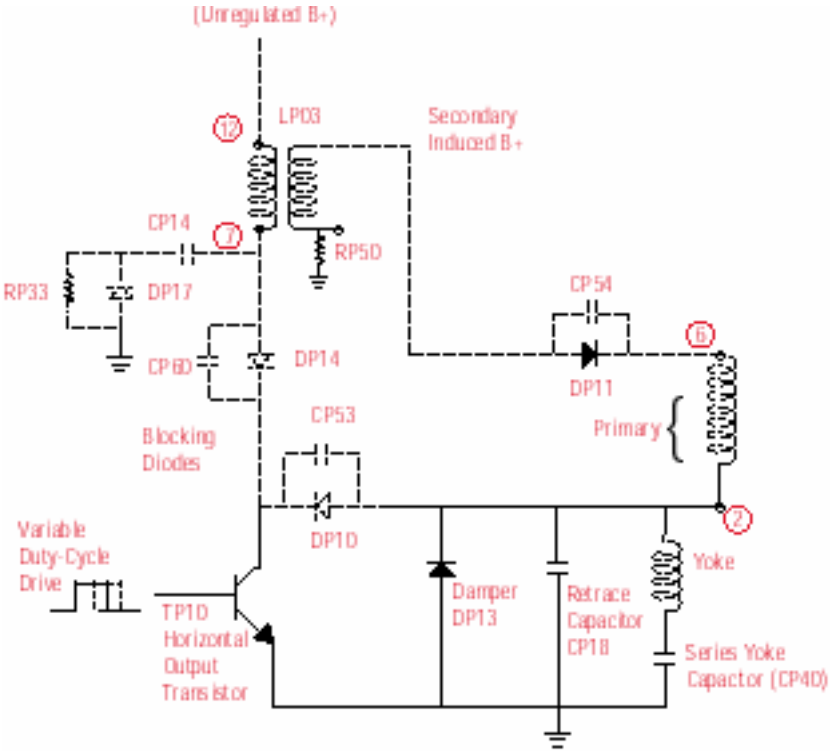


*Fig. 1b: The non-conventional horizontal output stage found in the RCA or GE TX81/82 television chassis.*

During normal operation, the horizontal output transistor is switched on by base drive producing an increasing primary current and magnetic field. When the transistor is turned off, the flyback's magnetic field collapses, charging the retrace capacitor. When fully collapsed, the retrace capacitor discharges, producing current in the flyback primary resulting in a magnetic field. With the retrace capacitor discharged, the flyback's magnetic field collapses and biases on the damper diode to complete the horizontal cycle. For a detailed explanation of the operation of a conventional horizontal output stage, See Sencore Tech Tip #207, "Understanding The TV Horizontal Output Stage."

The horizontal output stage found in the TX81 and TX82 chassis contains the same components found in a conventional TV output stage. See the simplified schematic of the TX81 and TX82 horizontal output stage shown in Fig. 1b. The primary of the flyback transformer (LP04) is located between pins 2 and 6. The flyback damper is DP13, retrace capacitor is CP18, horizontal output transistor is TP10, and the yoke series capacitor is CP40.

In addition to these basic components, the TX81 and TX82 horizontal output stage contains a B+ transformer (LP03) and its damping components (CP14, DP17). It further includes blocking diodes and capacitors (DP14, CP60, DP10, CP53). The B+ transformer (LP03) produces B+ to energize the flyback transformer. Its damping components produce alternating currents in the primary, and damp inductive voltages and energy returning into the primary. The blocking components isolate alternating currents in the primary of LP03 and the flyback primary.

The TX81 and TX82 chassis differs from the conventional output stage in the manner that B+ voltage is produced and input to the flyback transformer. The B+ voltage to the primary of the flyback at pin 6 is produced inductively by the secondary of transformer LP03. When current flows in the primary of LP03, voltage is developed in the secondary which biases on DP11 applying a positive voltage to the flyback primary at pin 6.

The secondary voltage produced by LP03 is determined by how much current flows in the primary. The raw DC voltage from the power supply is applied to pin 12 of LP03. The path for LP03 primary current is through blocking diode DP14 and through the horizontal output transistor. When the horizontal output transistor is driven on by base drive, current flows and produces an inductively rising current in the primary of LP03.

The design of the TX81 and TX82 chassis is such that the base drive to the horizontal output transistor is varied in duty cycle or conduction time for each horizontal cycle. A shortened conduction time permits a lower level of current build-up in the primary of LP03 reducing the secondary B+ voltage applied to the flyback. A lengthened conduction time permits more current buildup in the primary of LP03 increasing the secondary B+ voltage applied to the flyback primary.

The level of secondary induced B+ voltage controls the flyback's primary current. By increasing the B+ voltage, the flyback pulse increases, resulting in an increase in yoke current (increase deflection width) and flyback secondary voltages, including the CRT high voltage. A decrease in induced B+ voltage reduces deflection and high voltage. By varying the conduction time of the horizontal output transistor, the deflection and high voltage can be regulated.

## Understanding The TX81/82 Horizontal Output Stage

Let's take a look at the transformer action and currents during one horizontal cycle of the TX81/82 horizontal output stage. Figure 2a-d shows the action occurring at four distinct times during one horizontal cycle starting with the horizontal output transistor turning on.

When the H.O.T. turns on, current flows through DP14 and the primary of LP03 (Fig. 2a). Voltage induced into the secondary of LP03 produces a positive potential biasing on DP11 and applies the positive potential to pin 6 of the flyback. The positive potential biases on DP10 producing a path for flyback primary current. Current flows through the H.O.T. - DP10 through the flyback primary and DP11. The buildup of current in the primary is determined by how long the horizontal output transistor conducts.

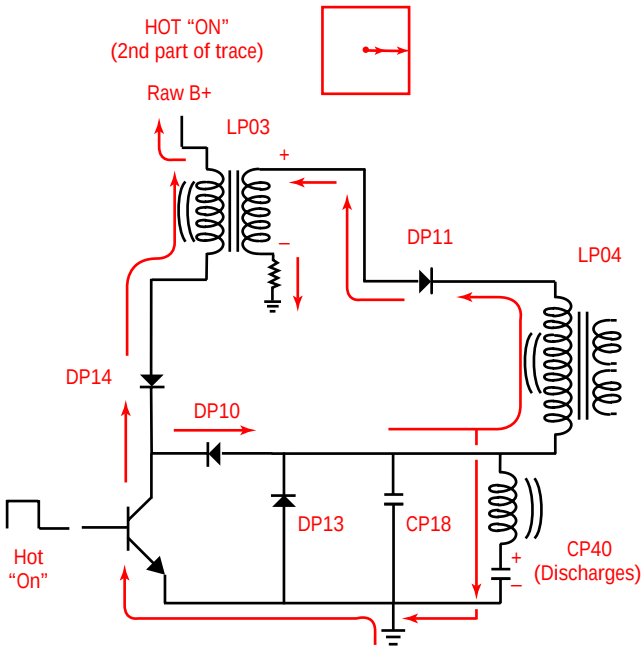


*Fig. 2a*

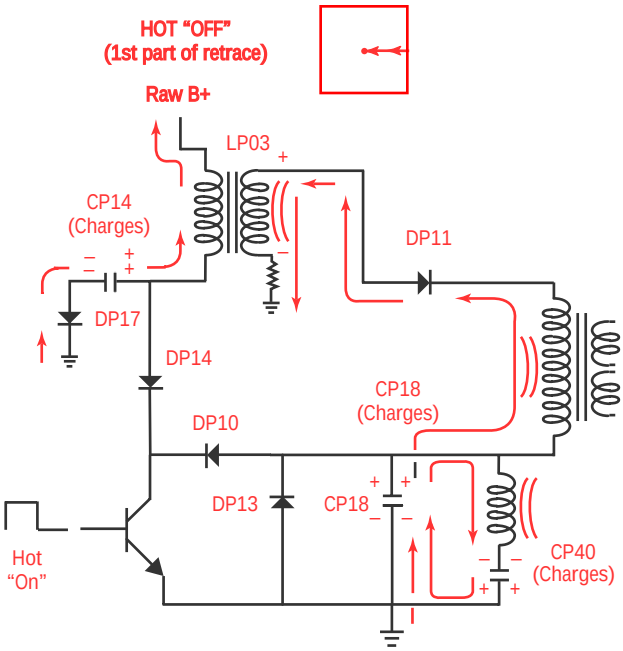


*Fig. 2b*

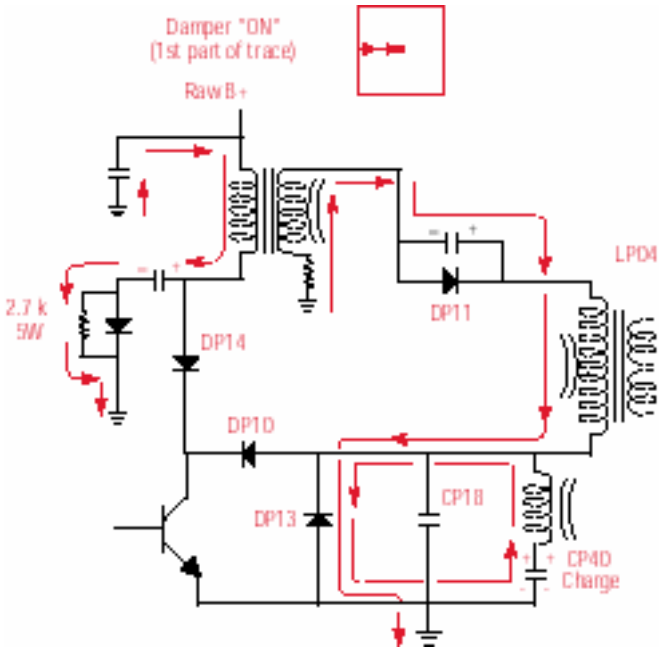


Fig. 2c

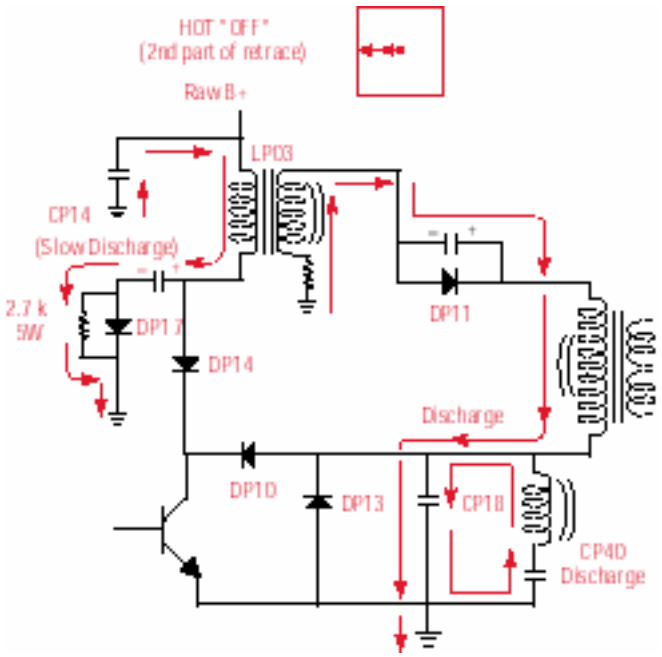


Fig. 2d

***Fig. 2: Circuit action and resulting currents during the four portions of one horizontal cycle.***

At the start of this cycle, the yoke series capacitor has a full charge. The horizontal output transistor and DP10 provide a discharge current path producing yoke current and an expanding magnetic field which pulls the electron beam from the center of the CRT to the right side. This is the second part of tracing one horizontal scan line on the CRT.

Retrace consists of two parts (Fig. 2b and 2c) and begins when the horizontal output transistor is turned off. During the first part of retrace, the magnetic fields in the flyback, yoke, and LP03 collapse, inducing voltage into their respective primary windings. The induced voltage in the flyback primary produces current, quickly charging up retrace capacitor C18 as shown in Fig. 2b. The charging capacitor produces a fast rising voltage which biases on DP10. A scope connected to the collector of the output transistor shows the fast rising voltage as the rising edge of the flyback pulse (see Fig. 3).

The induced voltage developed in the primary of the LP03 produces current, charging capacitor CP14 through DP17. The rate of field collapse and charging are in step with the flyback, so the transformer action is compatible. Blocking diode DP14 remains reversed biased, separating the currents in the flyback primary and LP03 primary.

During the first part of retrace, the yoke's magnetic field quickly collapses, charging up the yoke series capacitor as shown. This moves the CRT electron beam quickly from the right back to the center of the CRT.

During the second part of retrace, the charge on retrace capacitor C18 begins to discharge quickly, producing a rising current and expanding magnetic field in the flyback primary (see Fig. 2c). The discharging capacitor C18 produces the falling portion of the flyback pulse waveform seen at the collector of the horizontal output transistor. As the voltage falls, DP10 is reversed biased and DP14 is forward biased by the charge retained by capacitor CP14. This prevents the falling edge of the flyback pulse waveform at the collector from decreasing to zero volts. The voltage falls to a level slightly higher than the raw B+ voltage as shown in Fig. 3.

During the second part of retrace, the yoke current suddenly increases as the yoke series capacitor discharges. This quickly moves the CRT's electron beam from the center to the left side of the CRT.

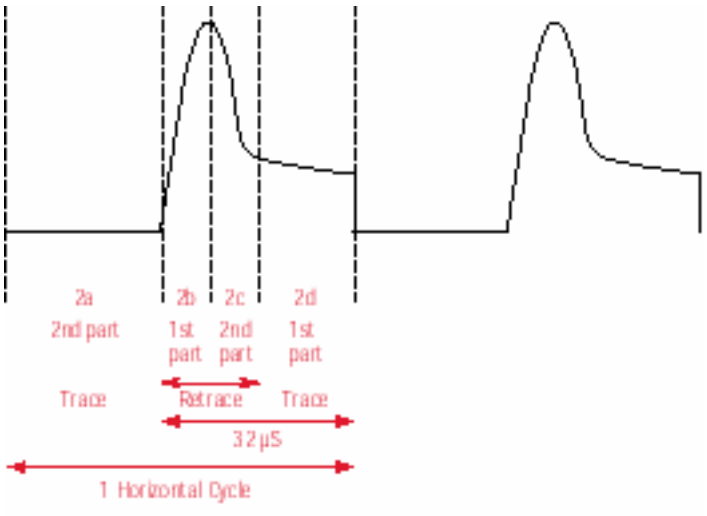


***Fig. 3: Collector waveform produced at the horizontal output transistor during the horizontal cycle.***

During the last part of the horizontal cycle, the magnetic fields of the flyback and yoke collapse. The voltage induces into the flyback primary forward biases damper diode DP13 into conduction and current flows as shown in Fig. 2d.

## Performing The TVA92 Horizontal Output Load Test

You can use the Horizontal Output Load Test of the Sencore TVA92 TV Video Analyzer to detect and isolate severe problems in the TX81/82 horizontal output stage without needing to apply AC power to the TV chassis. This is especially important for quickly diagnosing defects or preparing repair estimates on these chassis.

To fully detect and isolate problems, it is recommended that you perform two separate Horizontal Output Load tests. For the first test, connect the orange Load test clip to pin 6 of the flyback. This connection applies B+ directly to the flyback transformer at pin 6 as you recall LP03 does during normal operation. Connect the yellow test clip to the collector of the HOT and the black clip to horizontal circuit ground as you would for Load Tests on conventional TV horizontal outputs. The first recommended Load Test lets you produce flyback primary circuit currents only, so you can closely analyze and detect problems in the flyback circuitry and flyback secondaries.

For the second Horizontal Output Load Test, make sure capacitor CP31 is discharged by placing a 1k resistor momentarily across its terminals. Then connect the orange test lead clip to pin 12 of LP03. This second Horizontal Output Load Test energizes the B+ transformer LP03 in the same manner as the circuit normally does. This lets you duplicate the normal circuit operation and detect problems in the LP03 primary circuits or blocking diodes.

The Load Test "mA" readout indicates if excessive current is demanded by problems in the horizontal output stage or defects in the secondary circuits of the flyback. The normal or "GOOD" mA range of the TVA92 is 5 to 80 mA on conventional horizontal output stages. The Load Test mA readouts on the TX81 and TX82 chassis conform with those of conventional horizontal output stages and should be within this range.

Typically the mA readings during the first recommended Load Test of the TX81/82 chassis range from 50 to 70 mA. Typical mA readouts during the second Horizontal Output Load Test range from 15 to 35 mA. Milliamp (mA) readouts of approximately 250 mA indicate a likely DC short from the orange lead connection to ground. A DC short is indicated when the reading remains near 250 mA when the yellow load test lead is momentarily disconnected. Load Test mA readouts exceeding 80 mA indicate a circuit condition that is demanding excessive power supply current.

The operation of the TX81,82 horizontal output stage produces a waveform at the collector of the HOT that differs from conventional horizontal output stages (refer to Fig. 3). The waveform consists of a fast rise and fall in voltage as a normal flyback pulse plus a stair step on the falling edge that corresponds with the conduction of the damper diode. The addition of the stair step on the falling edge of the flyback pulse extends the duration or time of the flyback pulse (typically 11.3 - 13 uS) to approximately 32 uS.

When performing either of the two recommended Horizontal Output Load Tests on the TX81/82, the Load Test's uS readout should indicate approximately "32 uS". While the TVA92 says "Bad", this is normal for the TX81/82 chassis. Normal uS readings for the TX81/82 range from 30 to 34 uS. Readings outside of this range or readings that fluctuate outside the range indicate a timing or loading problem in the horizontal output stage.

While the waveform at the collector in the TX81/82 chassis differs from a normal collector waveform, a conventional flyback pulse waveform is developed at pin 2 of the flyback during either of the recommended Horizontal Output Load Tests. To more accurately determine the retrace timing of the flyback primary and primary components, connect an oscilloscope to pin 2 and horizontal ground. Manually measure the flyback pulse duration. It should measure between 11.3 and 13 uS. Readings outside of the range indicate a timing or flyback loading problem.

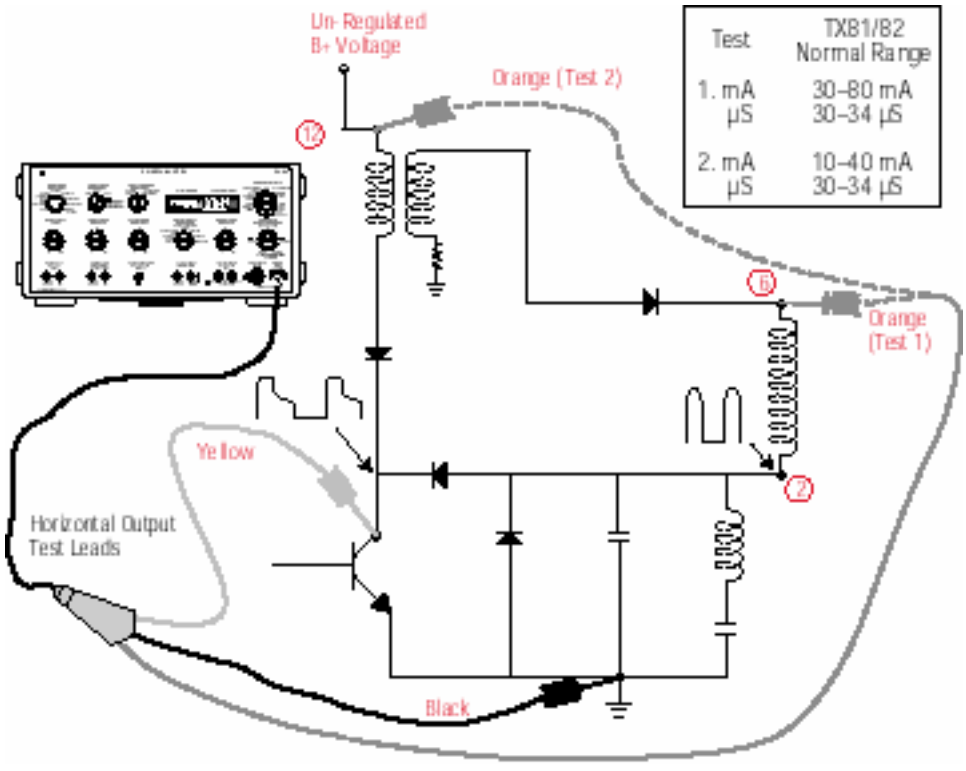


***Fig. 4: Use the Load Test to isolate severe loading or timing problems in the TX81/82 horizontal output stage.***

**Isolating Horizontal Defects With The TVA92 Horizontal Output Load Test**

Serious horizontal problems detected during the Horizontal Output Load Test can be further isolated with the Load Test. The Load Test duplicates the circuit operation independent o fhe TV power supply and horizontal drive circuits permitting problems to be isolated that otherwise would be extremely difficult to find.

Two troubleshooting methods or a combination of each can be used. One effective troubleshooting method is to open the secondaries one by one and note changes in the mA and uS Load Test readouts. A second effective method is to use conventional voltage and waveform measurements to isolate suspect circuits.

To isolate defects, disconnect flyback secondaries one at a time and check for significant decreases in the Load Test mA readout and corrections to the uS timing readout. If opening a secondary causes a large reduction in the mA readout and/or returns the uS timing to a TX81/82 normal range (30-34 uS), a defect on that secondary is indicated. Typical problems such as shorted secondary rectifier diode, leaky filter capacitor, or secondary circuit short can be quickly isolated in this manner. If a high current draw and abnormal timing remains after all the secondaries are open, a problem exists in the flyback or flyback primary components in the horizontal output stage.

Another method of isolating defects is to use voltage and waveform measurements. The TVA92 energizes the horizontal output stage at a fraction of normal. Typically the level of voltages produced during the Load Test is approximately 1/10 of normal. Measure the flyback derived secondary voltages. Each voltage should be the same % less than its normal output with little peak-to-peak ripple. An output reduced considerable below the normal reduction % or with excessive peak-to-peak voltage indicates a likely defect with that output or load circuits.

**Using The TVA92 Substitute HOT & Drive To Analyze The TX81/82**

The control circuitry and shutdown circuit loops of the TX81/82 chassis cause many troubleshooting challenges. Most defects kill or alter the flyback secondary voltages and don't permit voltage/waveform measurements and schematic comparisons. The TVA92 Horizontal Output Sub & Drive can be used to test the horizontal output stage, flyback, and flyback secondary voltages to full potential permitting conventional measurements to isolate defects.

One design characteristic of the TVA92's Horizontal Output Sub & Drive is especially suited for use on the TX81/82 chassis. The Horizontal Output Device Sub & Drive control of the TVA92 increases the conduction time (duty-cycle) of the TVA92's subbing transistor through a range of approximately 10 to 35 uS. This is ideal for duplicating the variable duty cycle drive found at the base of the TX81/82 horizontal output transistor. When using the TVA92's Horizontal Output Sub & Drive, this characteristic permits a slow increase in flyback currents and resulting flyback secondary voltages. It also lets you duplicate the normal drive duty cycle for testing and isolating flyback secondary supply problems or secondary circuit problems.

Before using the TVA92 Sub & Drive, perform the Horizontal Output Load Test to detect and isolate severe timing and/or loading problems. Do not attempt to use the Sub & Drive when severe problems exist in the horizontal output stage ad the TVA92 subbing transistor maybe damaged. To prevent damage or interaction between the chassis and the TVA92, unsolder the transistor and remove it from the TV chassis.

To use the TVA92 Sub & Drive, disconnect the Load Test lead from the chassis and connect the black and red Dynamic Test lead clips to the chassis. With no AC power to the TV chassis, connect the red test lead clip to the circuit point corresponding to the collector of the horizontal output transistor. Connect the black test lead clip to the horizontal circuit ground. Leave the blue test lead clip disconnected so it does not alter the horizontal drive and driver stage operation while using the TVA92 Sub & Drive.

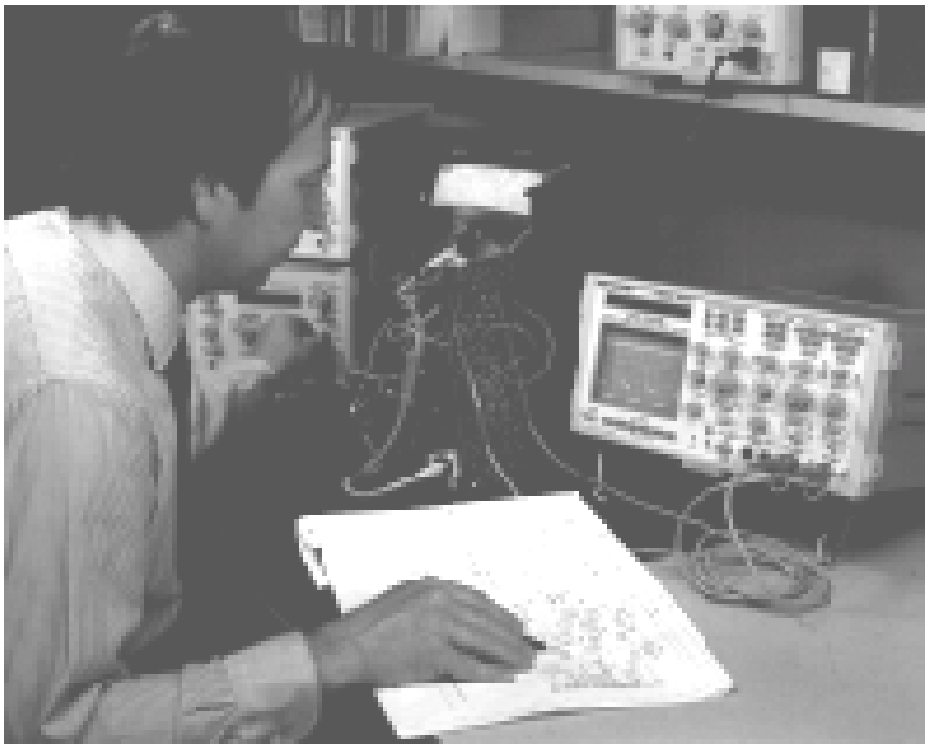

***Fig. 5: Use the TVA92 Sub & Drive to power the high voltage and flyback derived supplies to power the chassis. Isolate defects with conventional voltage and waveform analyzing.***

Start with the TVA92 Horizontal Output Device Sub & Drive control set to "OFF". Apply 120 VAC to the chassis. Select the "DCV" position of the Dynamic Tests and confirm that the raw DCV to the collector of the horizontal output transistor is approximately 150 to 155 volts. Little or no DCV indicates a problem with the raw DC power supply that needs to be corrected before using the Output Device Sub & Drive.

If the raw DC voltage is present, hook the positive probe of the Sencore Waveform Analyzer (SC3100 "AUTO TRACKER") to the B+ regulated output test point at filter capacitor CP17. Connect the ground lead to circuit ground. Increase the Horizontal Output Device Sub & Drive control while monitoring the voltage at the B+ test point and the TVA92 Dynamic Test's "Device Sub Current" readout. A Device Sub Current reading exceeding 1 amp indicates a leakage or component breakdown problem. If a problem is noted, decrease the Sub & Drive control.

If the Device Sub Current reading is not excessive as you begin to increase the Device Sub & Drive control, you may continue to increase the Device Sub & Drive control. As you increase the control, the duty cycle increases to gradually develop more flyback current and higher output voltages. Continue to increase the Sub & Drive control so that the B+ voltage measured by the SC3100 or a DC meter is just below normal or approximately 100 VDC. At this level, the output stage should be producing near normal high voltage and flyback derived power supply voltages.

Once you have fully energized the flyback to normal operating voltages, you can troubleshoot many of the TX81/82 circuits with voltage and waveform measurements. Start by checking the flyback derived power supply voltages and peak-to-peak voltage on each for defects. The supplies should be close to their normal output voltages with peak-to-peak voltage less than 1 volt. Abnormal DC voltage or excessive peak-to-peak voltages indicate a secondary supply or circuit problem.

If all the flyback derived supplies are near normal, press the TV "Power" button to turn on the horizontal drive and drive control circuitry. Use the SC3100 to check for horizontal drive at the circuit point corresponding to the horizontal output transistor base. No drive indicates a problem with the horizontal drive or control stages. Use conventional voltage and waveform measurements here to isolate suspect circuits and components.

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SENCORE
3200 Sencore Drive, Sioux Falls, SD 57107



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