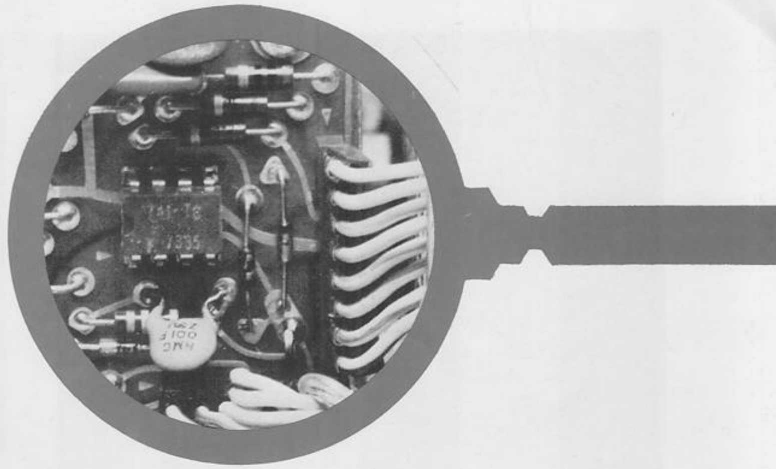
Servicescope

Servicing the 7904 high-efficiency power supply



The high-efficiency power supply, in some form, is used in many TEKTRONIX instruments. While this particular article deals with the 7904, some of the techniques discussed here will be helpful in servicing other instruments using this type of supply.

The high-efficiency supply, a relatively recent innovation in power supply design, provides a considerable savings in volume, weight, and power consumption. Figure 1 shows a simplified block diagram of the supply, which is essentially a dc-to-dc converter. The line voltage is rectified, filtered, and used to power an inverter which runs at approximately 25 kHz. Operating frequency is determined basically by the resonant frequency of a series-LC network placed in series with the primary of the power transformer. The inverter drives the primary of the power transformer, which supplies the desired secondary voltages. These are then rectified, filtered, and regulated for circuit use.

Pre-regulation of the voltage applied to the power transformer is accomplished by controlling the frequency at which the inverter runs. A sample of the secondary voltage is rectified and used to control the frequency of a monostable multivibrator. This multivibrator, in turn, controls the time that either half of the inverter can be triggered, thus controlling inverter frequency. Pre-regulation to about 1% is achieved by this means.

Now let's turn our attention to troubleshooting the instrument.

Look for the clues

Stop, look and listen. You can often save valuable time by noting symptoms that can serve as clues to the section in trouble. For example, the high-efficiency supply has two basic failure modes:

1) The inverter is working in the "burst" mode, as evidenced by a ticking sound occurring about four times a second.

2) The scope is dead, no inverter operation at all, possibly the sign of a blown fuse.

Let's examine these two problems separately.

Problem 1: The inverter is working in the burst mode. The plug-ins have been removed to eliminate them as the source of trouble and the problem still exists.

Procedure: Remove the line plug and set CONTROL ILLUM to OFF and GRAT ILLUM counterclockwise. Remove the instrument side panels and locate the Z-axis board located on the right side of the instrument at the rear.

Using a VOM, take resistance readings at the supply test points located on the Z-axis board. See Figure 2. Contact the +5V lamp supply at the rear wafer of the CONTROL ILLUM switch (red and black lead).

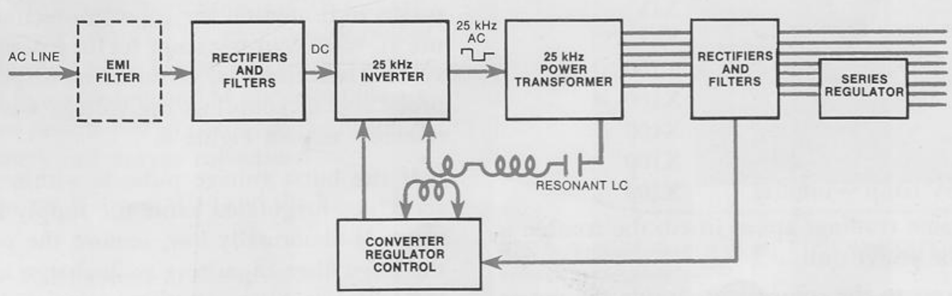


Fig. 1. Simplified block diagram of a typical high-efficiency power supply.

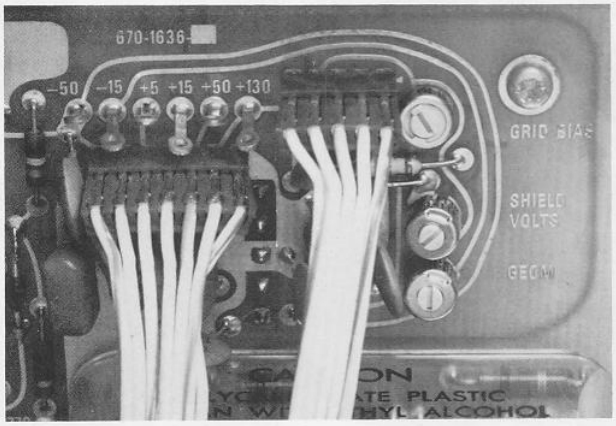


Fig. 2. Power-supply test points on the Z-axis board.

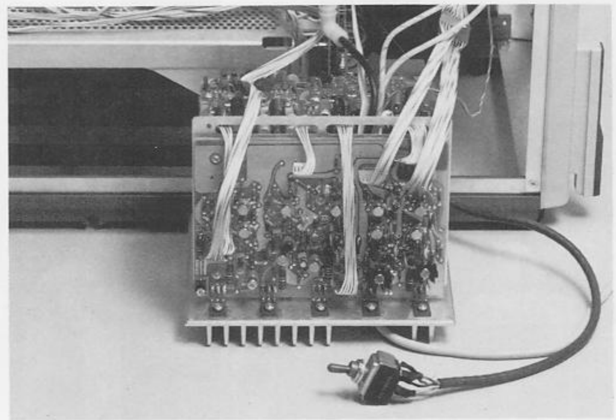


Fig. 3. The high-efficiency supply extended for servicing.

A. Check resistance of the supplies and mainframe.

Supply	Scale
+130V = 6 kΩ	X1k
+50V = 2 kΩ	X1k
+15V = 90 Ω	X100
−15V = 100 Ω	X100
−50V = 250 Ω	X100
+5V lamp = 800 Ω	X100

A low resistance reading usually indicates trouble in the mainframe. Since only troubles in the power supply will be considered in this procedure, continue on to the next step.

To perform the next step it is necessary to remove the power supply unit from the mainframe. This is easily done by removing the four screws holding the power unit to the rear frame of the instrument and then sliding the unit out the rear. Disconnect all connections between the mainframe and the power unit. (The POWER switch can remain mounted in the scope front panel.) When disconnecting the crt anode lead, ground it to the scope frame momentarily to dissipate any stored charge.

B. Check resistance of the mainframe only, taking readings at the same test points on the Z-axis board and CONTROL ILLUM switch.

Supply	Scale
+130V = 6.6 kΩ	X1k
+50V = 2 kΩ	X1k
+15V = 90 Ω	X100
+5V = 65 Ω	X100
−15V = 110 Ω	X100
−50V = 2 kΩ	X100
+5V lamp = infinite	X100

If the mainframe readings are as listed, the trouble is probably in the power unit.

To gain access to the components inside the power unit, remove the nut holding the POWER switch to the front panel and remove the switch and its interconnecting cable through the rear of the instrument. The unit is now completely free of the mainframe, making it easy to remove the power-unit covers.

A note of caution is in order at this point. The primary storage capacitors, C1216 and C1217, remain charged with high voltage dc for several minutes after the line power is disconnected. A neon bulb located on the power supply inverter board flashes when this stored voltage exceeds about 80 volts. Do not remove the power-unit covers while this light is flashing.

After removing the covers the power unit can be positioned as in Figure 3 and the leads connected so the unit can operate. A pair of multi-pin cable extensions (Tektronix Part Nos. 012-0577-00 and 012-0578-00) are available to extend the cables between the low-voltage regulator board and the main interface board on the mainframe 7904 and 7704A.

There are a number of faults that will cause the supply to operate in the burst mode. Let's examine the symptoms and the probable causes individually.

Symptom 1: Burst operation—resistances are normal.

Probable cause: One of the semi-regulated supplies is overloaded.

Procedure: Check the semi-regulated voltages at the points indicated on the capacitor-rectifier board (Figure 4). With your test scope set for a sweep of 10ms/div, vertical sensitivity for an on-screen display using a 10X probe and dc coupling, the voltage waveforms should resemble that of Figure 5.

If the burst voltage pulse is within $\approx 15\%$ of the stated semi-regulated value the supply is probably all right. If abnormally low, remove the power, wait for the large filter capacitors to discharge and then check the tantalum filter capacitors associated with the supply for shorts or leakage.

To speed servicing, you can use a 1.5 kΩ, 2 watt insulated resistor to short the storage capacitors (C1216 and C1217). Do not place a dead short across the capacitors as this can damage them.

Symptom 2: Burst operation—semi-regulated voltage normal.

Probable cause: High-voltage circuit problems or inverter control circuit problems.

Procedure: With the line power off, disconnect the crt anode lead and short it momentarily to ground to bleed off any charge. Disconnect multi-lead cables P1675 (green), and P1704 (yellow), at the Z-axis board.

If the power unit now operates properly, a crt failure or problem in the mainframe high-voltage circuitry is indicated.

If burst operation persists with these cables disconnected, replace U1275 and check the components in the inverter control loop. A good place to start checking is pins 6, 7, 10 and 11 back to T1235 and then pins 8 and 9 back to T1230.

Another point to check is the over-voltage protection circuitry Q1248 and VR1246. If the zener voltage of VR1246 has shifted it can cause erratic operation.

If these circuits are normal, remove the low-voltage regulator chassis and check on the high voltage board for shorted or leaky components.

Problem 2: Now let's consider the conditions which cause either the 2 amp or 4 amp fuse to blow.

Symptom: The scope is inoperative and the 4 amp fuse is blown.

Probable cause: Trouble in the line input circuitry or in the inverter section.

Procedure: Remove the line plug from ac power and discharge storage capacitor, C1216 and C1217, using the 1.5 kΩ, 2 watt resistor. Check diode bridge, CR1215, and the associated line input circuit for a shorted component, then replace the four amp fuse.

If these circuits appear normal, connect the line plug to a variable line source and advance the line voltage from 0 to 20 V ac. Using your test scope check the waveform on each of the storage capacitors (C1216, C1217). The capacitor should have a 60 Hz waveform displaced by some amount of dc as in Figure 6. The dc voltages should be equal in amplitude and of opposite polarity. These waveforms permit you to check the condition of the bridge rectifiers and storage capacitors.

Symptom: The scope is inoperative and the 2 amp fuse is blown.

Probable cause: Malfunction in the inverter.

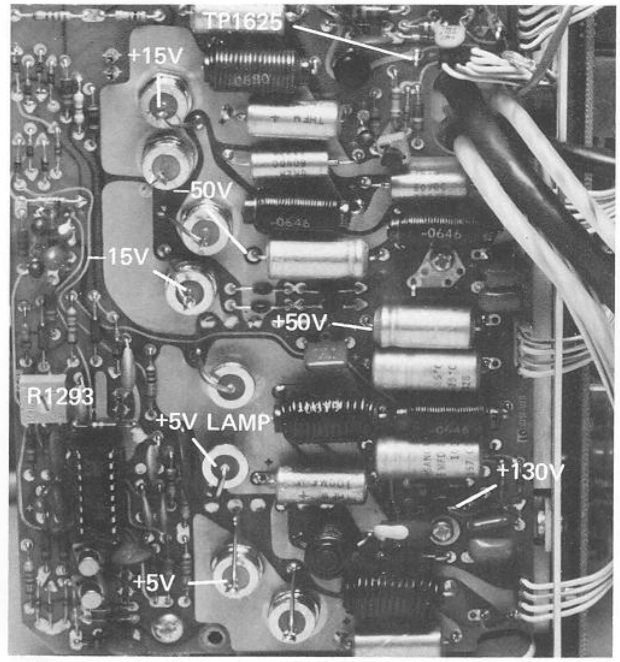


Fig. 4. Partial view of the capacitor-rectifier board showing voltage check points and key components.

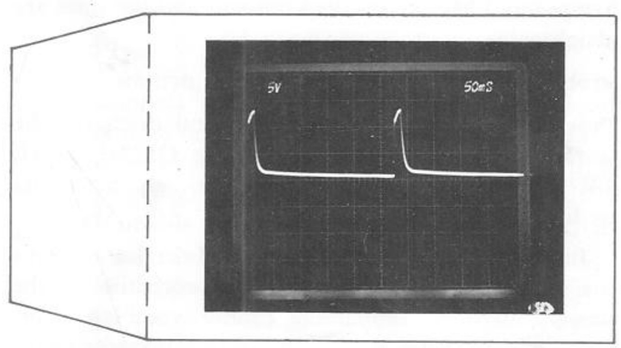


Fig. 5. Typical supply voltage waveform when operating in the "burst" mode.

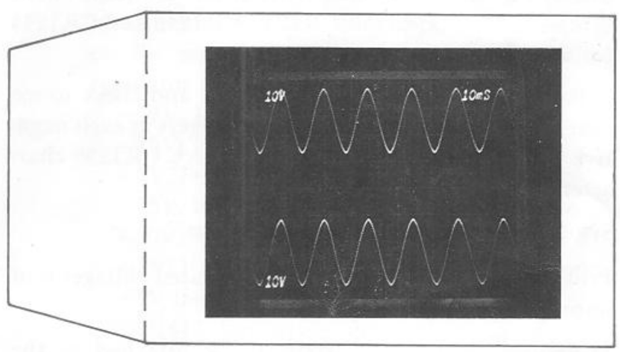


Fig. 6. Typical waveforms on C1216 and C1217 with line voltage set to about 20V.

Procedure: Remove the line plug from the variable line source and manually discharge the storage capacitors as before. Remove the gray cover from the inverter board. Remove Q1234, Q1241, CR1234 and CR1241 from the inverter board (Figure 7) and check their characteristics with a curve tracer or VOM.

Install the checked components in the inverter board and replace the 2 amp fuse. Locate T1230 on the inverter board and note a black wire loop that passes through small toroid T1235. Connect a current probe (TEKTRONIX P6021 with passive termination, or equivalent) to the black lead and set the test scope for an equivalent vertical sensitivity of 1A/div and set the time base for 2 ms/div.

Connect the line plug to the variable line control which should be set at 0V. Slowly increase the line voltage and note a burst waveform of ≈20 kHz occurs at ≈60 V ac (Figure 8). As you continue to increase the line voltage, stable operation should occur at about 85 V ac. Figure 9 shows the normal waveform at 115 V ac. Note that the test scope sweep speed has been increased to 50 μs/div. Analysis of these waveforms should give you a clue to the circuitry in trouble.

Symptom: The inverter does not run and the fuses are alright.

Probable cause: Inverter circuit malfunctions.

Procedure: Remove the line plug and discharge the storage capacitors as before. Remove Q1234, Q1241, CR1234 and CR1241 and check their characteristics with a curve tracer.

Install the checked components and check the circuit for operation as in the preceding procedure. If the power unit is still inoperable, connect your test scope, using a 10X probe, to TP1234 on the inverter board (see Figure 7). Set the variable line control at 20 V ac and check to see that the 60 Hz waveform is approximately dc centered (Figure 10). If not centered, check Q1246, CR1232, CR1240, CR1242, CR1249 and CR1244 for shorts or leakage.

Increase the line voltage to 60 V ac and check to see that the 60 Hz waveform has start triggers at each negative tip. If no start triggers occur, check CR1238 characteristics on the curve tracer.

Symptom: Unstable inverter operation.

Probable cause: One of the semi-regulated voltages is of improper value.

Procedure: With the current probe attached to the black wire loop associated with T1230, adjust the variable line voltage for the most stable waveform. (The 20 kHz waveform should be limited to 5 amps peak-to-peak.)

Referring to Figure 4, check the raw voltages on the capacitor-rectifier board with your VOM. They should be as follows:

Check +15V dc at CR1345 for ≈ +17V dc.
Check −15V dc at CR1347 for ≈ −17V dc.
Check −50V dc at CR1362 for ≈ −54V dc.
Check +50V dc at CR1358 for ≈ +54V dc.
Check + 5V dc at CR1313 for ≈ + 7V dc.
Check +5V dc lamp supply at CR1312 for ≈ +5V dc.
Check +130V dc at CR1323 for ≈ +130V dc.

For stable operation of the inverter control circuitry, +5V lamp, −17V dc and +130V dc must be present on the capacitor-rectifier board and −50V dc must be present on the low-voltage regulator board.

Symptom: Stable inverter operation when the multilead cables P1675 (green) and P1704 (yellow) are removed.

Probable cause: Crt circuit malfunction.

Procedure: Remove the line plug and disconnect P1675 and P1704 from the Z-axis board. Place the VOM on the cables to hold P1675 and P1704 down on the bench so that voltage readings can be taken. Apply power to the setup and set the VOM to the 60 V dc scale. With the positive meter lead on pin 2 and negative lead on pin 3 of P1675 (green) you should read ≈25 V. (Auto focus check.) With the positive lead on pin 4 and negative lead on pin 5 (P1675) you should read ≈35V. (Auto focus check.) Moving to P1704 (yellow), with the positive lead on pin 1 and negative lead on pin 2 you should read ≈35V. (Auto focus check.)

With the positive lead on pin 7 and negative lead on pin 6 of P1704 (yellow) check for ≈25V. (Exercise caution as pin 7 is elevated to 3 kV.) This is a crt grid bias check.

Change the VOM setting to the 60 V ac scale and apply the leads to pins 8 and 9. Check for ≈8V ac. This is a crt filament check.

If the auto focus or bias voltages were low or zero in any of the previous checks, there is the probability of shorted or leaky diodes on the high voltage board. These can be checked using the 100 kΩ scale on the VOM.

If the crt filament voltage was low or zero, remove the high-voltage assembly and check for open runs on the circuit board.

A quick operational and cal check.

After locating and repairing the malfunction, it would be good to make a quick operational and calibration check before installing the power unit back into the mainframe. Here are the points to check and adjust:

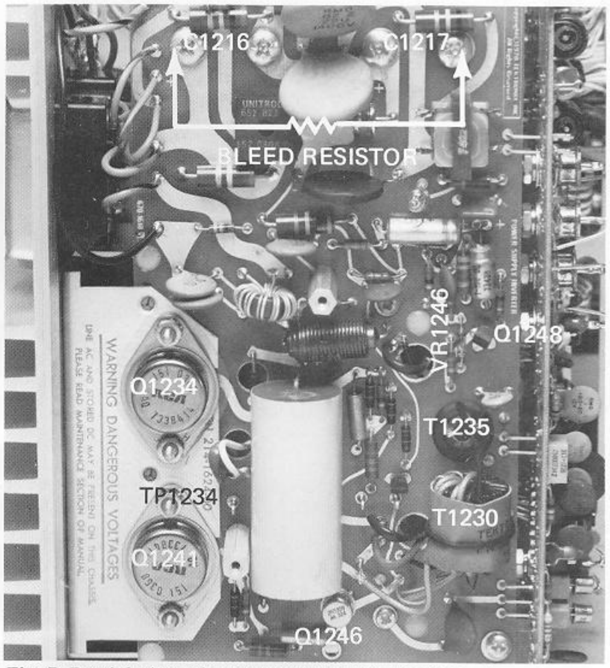


Fig. 7. Partial view of the inverter board showing where to apply bleeder resistor to discharge C1216 and C1217.

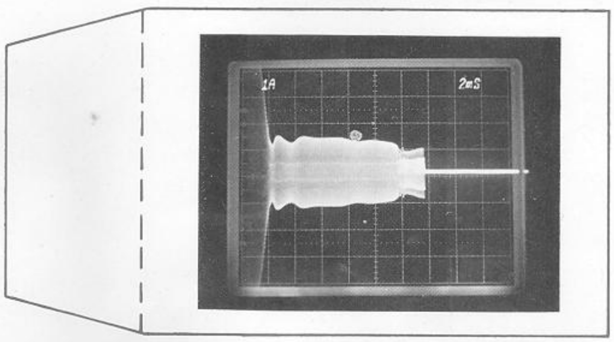


Fig. 8. Current waveform at T1230 showing burst operation at a line voltage of about 60V.

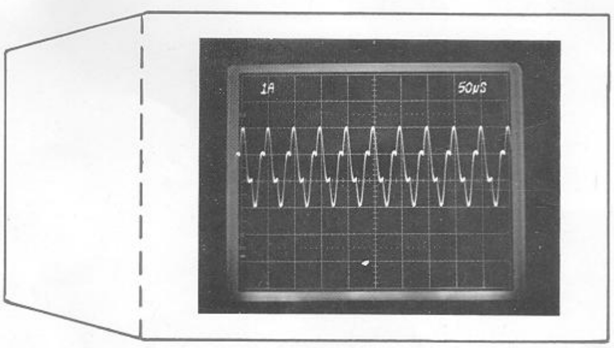


Fig. 9. Current waveform at T1230 for normal inverter operation at a line voltage of 115V.

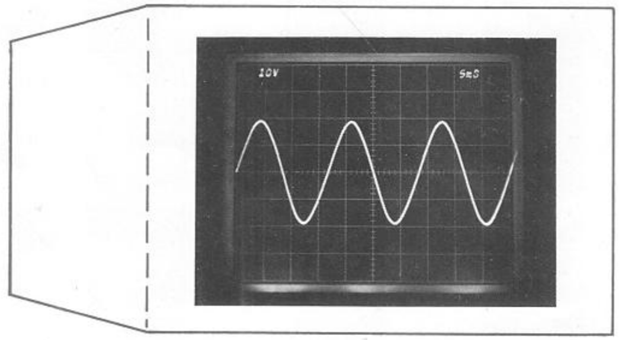


Fig. 10. Waveform at TP1234 on inverter board with line voltage set to about 20V. Waveform should be equally displayed from center-screen.

1) Connect a precision dc voltmeter (0.1% or better) to the −50V sense and ground sense points on the low-voltage regulator board near P1483 (orange). Adjust R1513 (−50V adjust) for −50V, ± 0.1V.
2) Check +50V supply for +50V, ± 0.25V.
3) Check +15V supply for +15V, ± 0.1V.
4) Check +5V supply for +5V, ± 0.05V.
5) Check −15V supply for −15V, ± 0.1V.
6) Check the above supplies for regulation while changing variable line voltage from 90V ac to 132V ac.
7) Connect the voltmeter between TP1625 and ground on the capacitor-rectifier board and turn inverter adjustment (R1293) full ccw to full cw and check for a voltage range of −49V to +132V. If unable to adjust to these voltages, try replacing U1635 and check Q1627, Q1631 and VR1635.
8) With the mainframe CONTROL ILLUM to OFF and GRAT ILLUM full ccw and all plug-ins removed, set the line voltage to 117V ac and set R1293 for +40V.
9) Connect a pair of 1X probes to a vertical amplifier in your test scope suitable for differential measurements. Check the ripple of the supplies on the sense points located on the low-voltage regulator board as follows:
   −50V, less than 2 mV.
   −15V, less than 1 mV.
   +5V, less than 1 mV.
   +15V, less than 1 mV.
   +50V, less than 3 mV.
   +130 V, less than 500 mV at +130V test point.
   +5V lamp, less than 25 mV at pin 4 of P1415 (green).

This completes the troubleshooting and recalibration procedure. Remove the extender cables and other connections, replace the power unit cover and reinstall the power unit in the mainframe.