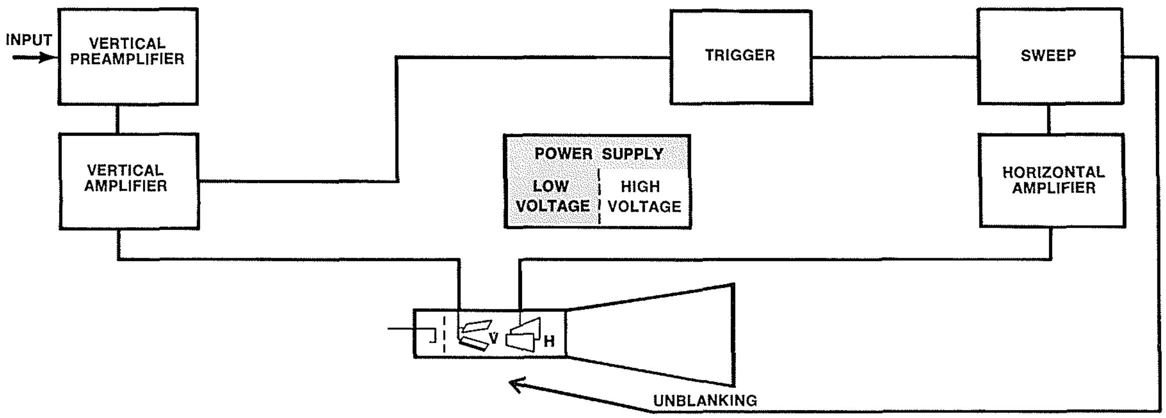
SERVICE SCOPE



TROUBLESHOOTING THE POWER SUPPLY

By Charles Phillips
Product Service Technician
Factory Service Center

This second article in a series discusses troubleshooting techniques for Tektronix power supplies. The February TEKSCOPE discusses localizing problems to a major block of an oscilloscope.

The power supply is the most fundamental block of an oscilloscope. The performance of the instrument is only as good as the condition of the power supply. The following information will assist in checking and obtaining the optimum performance from Tektronix power supplies.

For effective troubleshooting, examine the simple possibilities before proceeding with extensive troubleshooting. The following list provides a logical sequence to follow while troubleshooting:

1. Check control settings.
2. Check associated equipment.
3. Thorough visual check.
4. Check instrument calibration.
5. Isolate trouble to block.
6. Check voltages and waveforms.
7. Check individual components.

Incorrect operation of all circuits usually indicates trouble in the power supply. Check first for correct voltage of the individual supplies. However, a defective component elsewhere in the instrument can appear as a power-supply trouble and may also affect the operation of other circuits. A short circuit in any regulated supply may cause the output level of all supplies in the instrument to drop to zero until the short is removed. If the output level of all the supplies is incorrect, check that the Line Voltage Selector Assembly is set for the correct line voltage and regulating range.

Most Tektronix manuals list the tolerances of the power supplies. If a power-supply voltage is within the listed tolerance, the supply can be assumed to be working correctly. If outside the tolerance, the supply may be misadjusted or operating incorrectly. When testing for shorts or overloads, remove the loads from the output filter. Check the resistance of each to segregate which load is causing the short or overload. Next, look in the defective circuit for connections from the power supply directly to ground. Diodes and potentiometers are a good place to start.

CHECKING POWER SUPPLY REGULATION

Connect the oscilloscope under test to a variable auto-transformer. Turn off the sweep and calibrator, and monitor the individual supplies with a 1X probe, AC-coupled to the test oscilloscope. Begin with the reference supply since other supplies are related to this reference. Adjust the variable auto-transformer to the point where the supply goes completely out of regulation, noted by a large increase in ripple. Next, increase the line voltage to the point where the supply pulls into complete regulation, and note the voltage. This point is the low-line regulation voltage (low-line regulation is checked in this manner because of the regulator tube characteristic of holding gain when heated). Next, increase the line voltage to the point where the supply starts to go out of regulation. This point is the high-line regulation voltage. Fig 1 illustrates the various line conditions normally encountered.

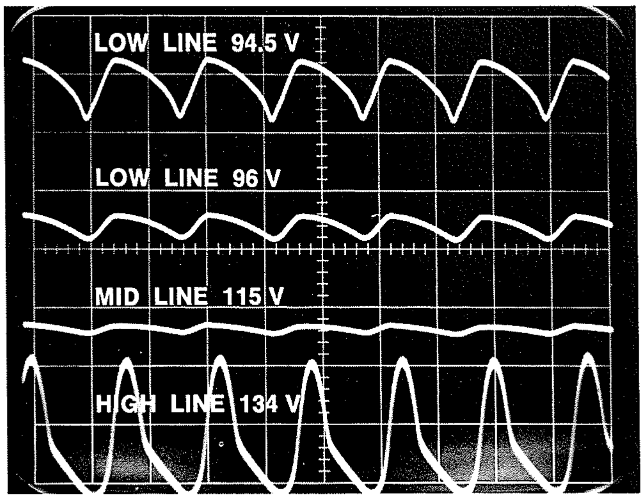


Fig 1. Regulation indications of a typical tube-type power supply.

POWER SUPPLY NOISE

A power supply voltage with noise or microphonics can often be located by rapping softly with a finger. The finger acts as a convenient, reasonably uniform reference when checking for noise. It is often helpful to turn the oscilloscope upside down or on its side and then recheck. This will usually show up loose connections.

RESISTANCE MEASUREMENTS

In tube type instruments (where stacking of supplies is common) the supply resistance will start at ≈2-3 kΩ in the reference supply and increase with each supply. Note—if a supply reads low (500 Ω or so) reverse your meter leads. Some voltage supplies employ a diode at the output and the low reading may be the resistance of the diode. If there is any doubt, consult the instrument manual and check the circuit schematic.

The same technique works with solid-state supplies, although the resistance values are lower. Solid-state power supplies, because of their lower impedance qualities, have supply resistances as low as 25-50 Ω.

Silicon diodes can usually be checked in the circuit and typically read ≈2 kΩ in one direction. When a power supply diode fails it usually will be either a dead short or open. If an in-circuit check leaves doubt as to the condition of a supply, lift one end of the diode to be sure of the reading. Most silicon power supply diodes read ≈2 kΩ or ≈2 MΩ, depending on direction of current flow.

DIFFERENCES IN TRANSISTOR SUPPLIES

Solid-state supplies are more and more common in present day electronic equipment. The following points summarize the major differences between vacuum tube and solid-state supplies:

1. Lower output impedance. As a result, solid-state supplies have lower output ripple—usually on the order of 2 mV.
2. Resistance of supplies is typically lower but checking is the same due to stacking of supplies.
3. Supplies may be checked for shorts immediately after power is applied (no time delay relays).

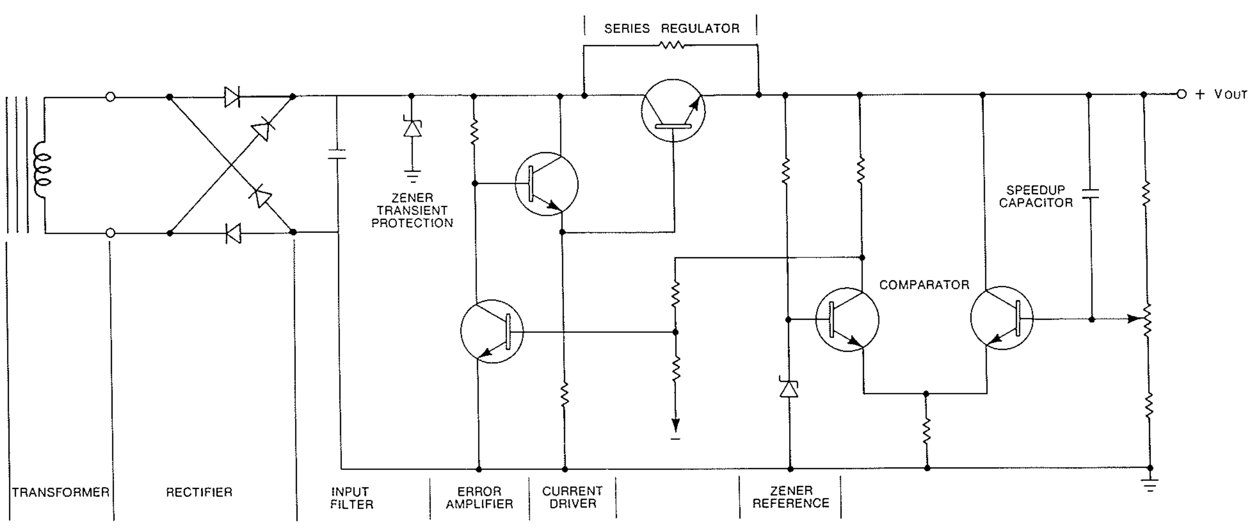


Fig 2. Simplified schematic of solid-state power supply.

4. Less problems with regulators because of less heat dissipation.
5. Varying line voltage does not provide as much information on regulation in a solid-state supply. Use a hair dryer to heat the power supplies, then cool with an aerosol circuit coolant to determine if a supply is faulty. This technique simulates the ambient conditions the supplies encounter over a longer period (2 or 3 hours) than the auto-transformer test. Often this check will indicate a heat sensitive device early and eliminate the need to recalibrate portions of the instrument twice.

COMMON POWER SUPPLY PROBLEMS

1. Fuse blows when power is applied—shorted diode in bridge.
2. Fuse blows when time delay relay closes—overloaded output.
3. Excessive ripple—divide by 10 for approximate solidstate values.
   (a) 50 mV to 1.5 V—comparator, speedup capacitor
   (b) 1.5 V to 8 V—output filter
   (c) 8 V or more—input filter
4. Off tolerance—leakage speedup capacitor (lift one end, change both output voltage setting resistors).
5. Poor regulation:
   at 117 V line—weak compartor
   at 105 V line—weak regulator
6. Noisy output—noisy comparator or regulator, noisy output voltage setting divider, noisy tube or poor connection.

NOTE

Power transformers, manufactured in our plant, are warranted for the life of the instrument. If the power transformer is defective, contact your local Tektronix field engineer for a warranty replacement. Be certain to replace only with a direct replacement Tektronix transformer.

IMPROVED BNC ATTENUATORS

A significant improvement in performance has been incorporated into a new series of BNC attenuators and terminations available from Tektronix. The new design features improved VSWR, greater bandwidth, increased reliability, and extended power ratings (see chart below).

SPECIFICATIONS	OLD	NEW
Power Rating	1 watt	2 watts
VSWR — 250 MHz	(1.1 - 100 MHz)	1.1
VSWR — 500 MHz		1.2
Attenuation Ratio	+ 2% - DC	+ 2% - DC
	+ 3% - 100 MHz	+ 3% - 500 MHz

These new accessories are shorter in length and lower in cost and are available in the following configurations: 50-Ω feedthrough terminations (white); 50-Ω 2X attenuator (red); 50-Ω 2.5X attenuator (white); 50-Ω 5X attenuator (green); and 50-Ω 10X attenuator (brown). In addition, a 5 watt 50-Ω feedthrough termination (black) is available.

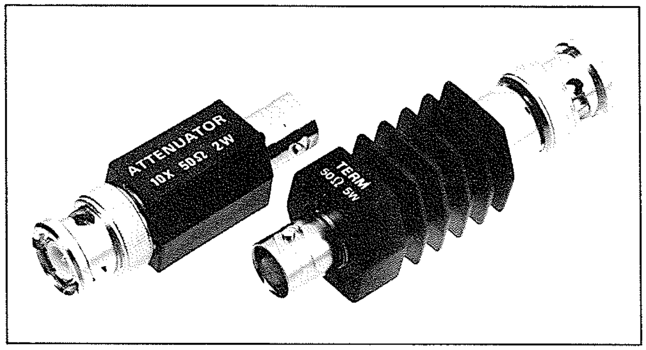


Fig 3. New two-watt attenuator and five-watt termination.

TEKTRONIX WIRING COLOR CODE

All insulated wire and cable used in the Tektronix instruments is color-coded to facilitate circuit tracing. Signal carrying leads are identified with one or two colored stripes. Voltage supply leads are identified with three stripes to indicate the approximate voltage using the EIA resistor color code. (See fig 4). A white background color indicates a positive voltage and a tan background indicates a negative voltage. Note—older Tektronix instruments may use a black background to indicate a negative voltage. The widest color stripe identifies the first color of the code.

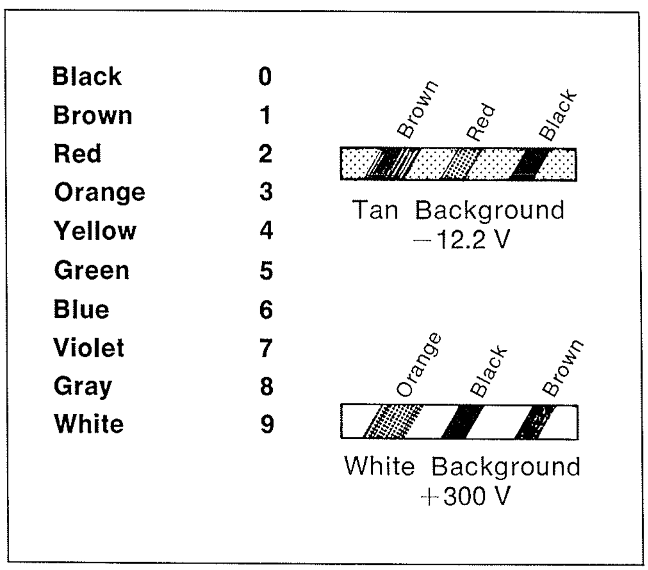


Fig 4. Tektronix color-coded insulated wire.

SERVICE SCOPE

SERVICING THE 7704 HIGH-EFFICIENCY POWER SUPPLY

By Charles Phillips
Product Service Technician, Factory Service Center

This is the first in a series of articles on servicing the 7000-Series oscilloscopes. The 7704 serves as the basis for these articles since it contains most of the new circuitry, components and construction techniques we will be discussing. It is not our intent to discuss the general techniques used in troubleshooting oscilloscope circuitry as these were covered extensively in the February 1969 to February 1970 issues of TEKSCOPE. Copies of these articles are available through your field engineer.

Proper operation of the regulated low-voltage supplies is essential for the rest of the scope circuitry to function properly, so let's look at this section first.

The high-efficiency power supply used in the 7704 is a new concept in power supply design that results in appreciable savings in volume, weight and power consumption. It is called "high efficiency" because its efficiency is about 70% as compared to 45% for conventional supplies. The line-to-DC converter/regulator contains most of the unconventional circuitry so our discussion will deal primarily with this portion.

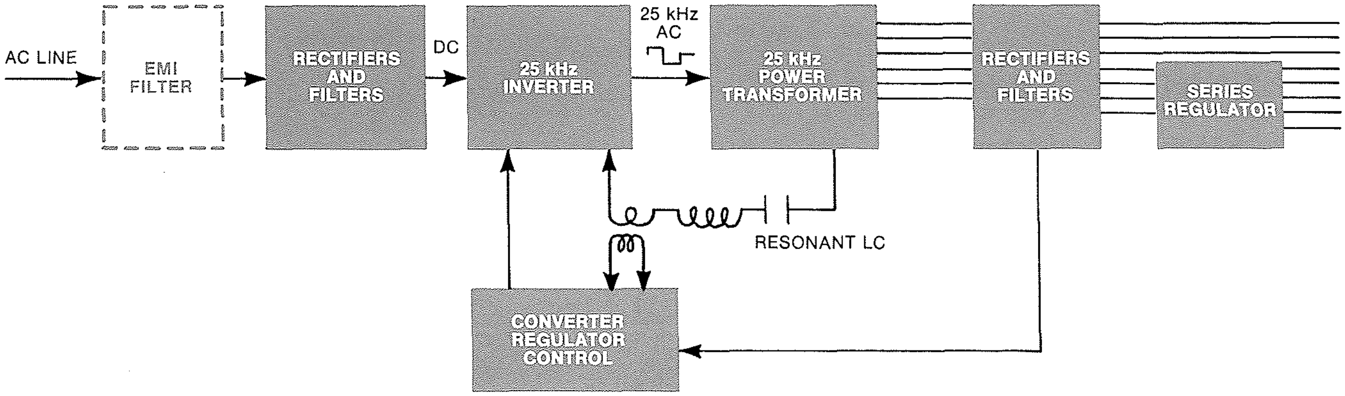
First, let's briefly review the theory of operation. The high-efficiency power supply is essentially a DC-to-DC converter. The line voltage is rectified, filtered and used to power an inverter which runs at approximately 25 kHz. The frequency at which the inverter runs is determined basically by the 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 supplying 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 the inverter frequency. Circuit parameters are such that the multivibrator, and hence the inverter, always runs below the resonant frequency of the LC network. Remembering that the resonant LC network is in series with the primary of the power transformer, we can see that as the inverter frequency changes, the impedance of the LC network changes. The resultant change in voltage dropped across the LC network keeps the voltage applied to the primary constant. Pre-regulation to about 1% is achieved by this means.

Now, let's turn our attention to troubleshooting the supply. Assume you have made the usual preliminary checks; you have power to the instrument, the line selector on the rear of the instrument is in the correct position for the applied line voltage and the line voltage is within specified limits. The plug-ins have been removed to eliminate the possibility of their causing the power supply to malfunction.

With the instrument power off, check the two fuses located in the line selector cover on the rear of the instrument. If the line fuse, F800, is open the problem is probably in the line input circuitry. If the inverter fuse, F810, is open the inverter circuitry is probably faulty. In either case it will be necessary to remove the supply from the mainframe to make further checks. This is easily done by removing the four screws on the rear panel that secure the power unit, then sliding the unit out the rear of the instrument.

Before removing the power-unit cover, check to see that the neon bulb on the left side of the power unit has stopped flashing. The primary storage capacitors C813 and C814



Simplified block diagram of high-efficiency low-voltage power supply.

remain charged with high voltage DC for several minutes after the power line is disconnected. When this voltage exceeds about 80 volts the neon bulb flashes. While servicing the power unit, the discharge time of the storage capacitors can be speeded up by temporarily disabling the inverter stop circuit. Pulling Q864 before turning off the scope power will allow the inverter to keep running for a short time, thus draining most of the charge from the capacitors. A voltmeter reading between test points 810 and 811 on the line input board will indicate the charge remaining on the storage capacitors. Allow at least one minute for the current-limiting thermistors to cool before turning on the power again if you use this fast-discharge technique. Do not attempt to discharge the capacitors by shorting directly across them as this will damage them.

With the power-unit cover removed, orient the supply with the rectifier board on top, the line input board on the left and the inverter board on the right. This will make it convenient to get to all the test points as we go along.

LINE INPUT BOARD

First let's check the line input board. It's fairly easy to tell if this circuit is working. The neon bulb previously mentioned will start flashing when power is applied. On some units it assumes a steady glow, on others it continues to flash. The voltage reading on test points 810 and 811 should be approximately 300 volts DC depending upon the line voltage. Be careful not to ground any point in this circuit except test-point ground or chassis.

Typical troubles in this circuit causing the line fuse to open are shorted diodes on the bridge, CR810, or a shorted capacitor C810, C811, C813 or C814.

INVERTER BOARD

Next in line is the inverter circuit. The problems most common to this circuit are open fuse F810, shorted transistors Q825 or Q835, or shorted diodes CR825, CR835, CR828 or CR838. An open inverter fuse usually indicates trouble in the inverter.

Before working in this circuit, unplug the power cord and give the storage capacitors time to discharge. Remove the line selector cover containing the line and inverter fuses. We're now ready to make some resistance checks on the inverter board.

With your ohmmeter set to the x1 kΩ scale, take a reading between test points 826 and 836. The reading should be several megohms in one direction and $\approx$ 1.5 kΩ with the test leads reversed. Check between test points 836 and 820. You should get a high and low reading as before. This checks the transistors and important diodes in the inverter stage. If you get a low reading in both directions on either of these tests, remove the transistor from the side having the low reading in both directions. A set of readings between the appropriate test points will show whether it is the diode or the transistor that is defective. Diodes CR826 and CR836 are not checked by the above procedure but will not prevent the inverter from running even if shorted. Once you achieve a high resistance on both sides of the inverter, it will probably operate when you apply the proper power to it. However, before applying power, a quick check should be made on rectifier board test point 860 to ground. The resistance should be $\approx$ 2 kΩ or 40 kΩ depending on the polarity of the meter leads.

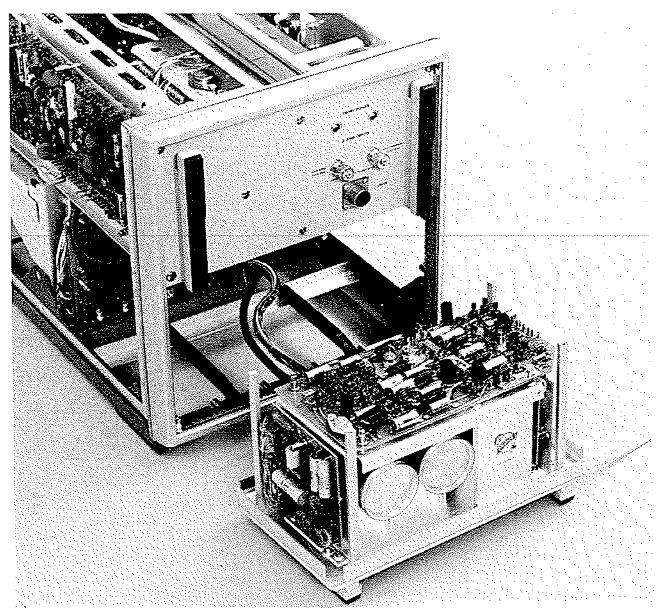
You can now prepare to apply power to the instrument. Install the line selector cover. Remove Q860 to disable the pre-regulator circuit. Connect your test scope between test point 836 and ground on the inverter board. Vertical sensitivity should be 50 V/div DC at the probe tip, the trace centered and the sweep speed set to 10 μs/div. Connect a voltmeter between the +75 V test point and ground on the rectifier board. Plug the scope into an autotransformer and with the line voltage set at zero volts, turn the instrument on. Slowly advance the line voltage while watching the test scope. If the trace moves up or down, the inverter still has problems. If the trace holds steady, the inverter should start as the line voltage approaches 80 volts. A square wave of approximately 25 kHz and 200 volts will appear on the test scope. Do not advance the line voltage any further. The +75 volt supply should not be allowed to exceed 75 volts to prevent blowing the inverter fuse.

RECTIFIER BOARD

You are now ready to check the pre-regulator circuitry. Turn off the scope and return the line voltage to zero volts. Replace Q860 in its socket. Slowly advance the line voltage while monitoring the +75 volt supply. If the +75 volts holds steady, you can advance the line voltage to a normal setting. If the voltage is not stable or if the signal being monitored on test point 836 on the inverter board is erratic in frequency, the pre-regulator is not working properly. The quickest method of troubleshooting this circuit is to check the associated transistors with a curve tracer or ohmmeter. The waveforms shown on the facing page are typical for a properly operating supply.

MECHANICAL CONSIDERATIONS

Most of the components in the power supply are readily accessible from the top of the printed circuit boards. However, when it is necessary to remove a soldered-in component, we suggest you remove the circuit board from the assembly and unsolder the component from the back side of the board. The line input board and the rectifier board are readily



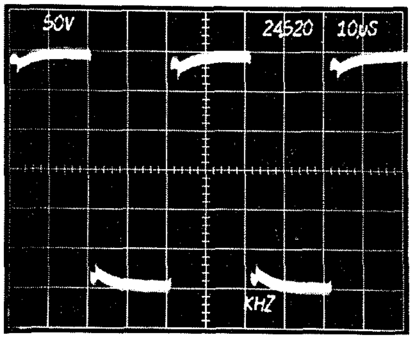
Low-voltage supply removed for easy servicing. Line input board is on the left side, rectifier board on top, and just the edge of the inverter board is visible at the right.

removed by loosening two or three screws. The inverter board is somewhat more difficult to remove; the manual gives the proper procedure.

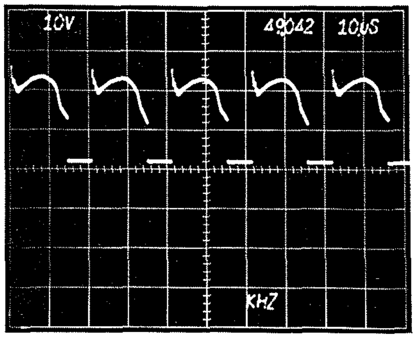
Care should be exercised when replacing Q825 or Q835 located on the ceramic heat sink on the inverter board. The mounting studs are soldered into the printed circuit board and may be broken loose by applying excessive torque.

When placing the power unit back into the mainframe take care to properly dress the power unit cables between the power unit and the logic board. Lowering the swing-down gate on the right side of the instrument will let you guide the cables into place.

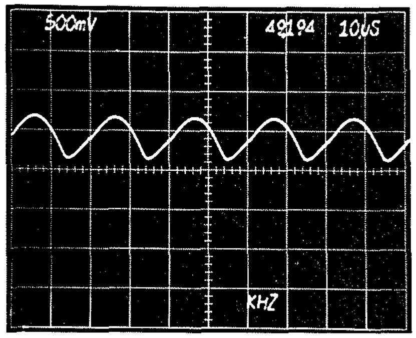
In the next issue of TEKSCOPE we will discuss the 7704 high voltage power supply.



Typical waveform at TP836 for properly operating supply. Mid-screen is 0 Volts.



Waveform at TP860. Note frequency is twice that at TP836.



Waveform at TP859. Frequency increased slightly due to line voltage change.

INSTRUMENTS FOR SALE

561A, $500. 3T77, $500. 3S76, $850. Harold Dove, 837 Uvalda St., Aurora, Colo. 80010. (303) 343-2906.

3-514D, 514AD, 524AD, 502, 541, 543A, 180A. 2 ea. 160A, 161, 163, 162. Jim Kennedy, Technitrol, Inc., 3825 Whitaker Ave., Phila., Pa. 19124. (215) 426-9105.

575, $900. Hans Frank, Dynaco, Phila., Pa. (215) CE 2-8000.

502A, 202-1. Ron Calvanio or Dr. Denton, Mass. Gen'l. Hospital, Dept. of Anesthesia, Fruit St., White Bldg., Boston, Mass. 02114. (617) 726-3851, 726-2034.

2 ea. 513D, 517. Dr. Frederic Davidson, E.E. Dept., Johns Hopkins Univ., Baltimore, Md. 21218. (301) 366-3300, Ext. 249.

515A. G. Katzen, 243 W. Main St., Cary, Ill. 60013. (312) 639-4768.

601, $925. Dr. William Spickler, Cox Heart Institute, 3525 Southern Blvd., Kettering, Ohio 45429.

514D, $250 or trade for 3 in. model. Arthur Pfalzer, Hoover Electric, Hangar 2, Port Columbus Airport, Columbus, Ohio 43219. (614) 235-9634.

561A, 3A6, 3B4. Package price, $1250. Pierre Cathou, MIT Branch, P.O. Box 104, Cambridge, Mass. 02139. (617) 868-5782.

53G, $100. 53/54B, $85. Dan McKenna. (517) 725-7211.

2-453. Dave Ballstadt, Optical Digital Systems, 1175 E. Highway 36, St. Paul, Minn. 55109. (612) 484-8589.

513D. Lou Chall, 2834 Serange Place, Costa Mesa, Calif. 92626. (714) 545-6536.

549, 1A1, 202-2, $2800 complete. J. C. Davis, Republic Nat'l Bank, Sunset Plaza, Pueblo, Colo. 81004.

611. Dr. Les Wanninger, General Mills, Inc., 9000 Plymouth Ave., N., Golden Valley, Minn. 55427. (612) 540-3444.

561A, 3A6, 3B3. Excellent condition. $1000. Might accept 321 or 321A as part payment. (213) 792-4962.

323, $850. C30AP, New, $450. Harold Moss. (213) 398-1205.

536, 53/54K, 53/54T, $800. S54, $300. Geo. Schneider, Profexray Div., Litton Medical Products, 1601 Beverly Blvd., Los Angeles, Calif. 90026. (213) 626-6861.

511AD, $300. Carl Powell, 3906 Jackson Hwy. Sheffield, Ala. 35660. (205) 383-3330.

13-RM561A/2A60/2B67 never used. Attractive discount. J. Wieland, 16950 Encino Hills Dr., Encino, Calif. 91316.

316, $600. I. R. Compton, Comptronics, 3220 — 16th West, Seattle, Wash. 98119. (206) 284-4842.

2B67, $175. 63 Plug-In, $100. Roger Kloepfer. (517) 487-6111, Ext. 392.

514A. Geo. Butcher, Electronics Marine, P.O. Box 1194, Newport Beach, Calif. 92663. (714) 673-1470.

1L20. George Bates, Dynair Elect., 6360 Federal Blvd., San Diego, Calif. 92114. (714) 582-9211.

611, $2000. Dr. A. Sanderson, Harvard Univ., Electronics Design Center, 40 Oxford St., Cambridge, Mass. 02138. (617) 495-4472.

P6046 Probe, Amplifier, P.S., $600. Bob Waters, Jr., ARCT, Inc., P.O. Box 11381, Greensboro, N.C. (919) 292-7450.

503 w/Grid. Wm. Gelb, Gelb Printing & Lithographing Co., 6609 Walton St., Detroit, Mich. 48210. (313) 361-4848.

555 complete. Scope Cart. Fred Samuel, Ch. Engr., WXTV, Ch. 41, 641 Main St., Paterson, N.J. 07503. (201) 345-0041.

547, 422, 453, 502, Plug-Ins, Cal. Fixtures. Manzano Laboratories, Inc., 146 Quincy Ave., N.E., Albuquerque, N.M. 87108. (505) 265-7511.

514AD, $260. J. Barsoomian, 31 Porter St., Watertown, Mass. 02172. (617) 924-6475.

2-531A/CA, $895. 2-531/CA, $695. 53/54C, $150. 2A63, $125. J. Boyd, Tally Corp., 8301 180th South, Kent, Wash. 98031. (206) 251-5500, Ext. 6787.

545B, 1A1, 1A7. Scientific Industries, 150 Herricks Rd., Mineola, N.Y. (516) 746-5200.

547, 1A4, 1A2, 202-2, as package or individually. Phil DiVita, Data Display Systems, Inc., 139 Terwood Rd., Willow Grove, Pa. 19090. (215) 659-6900.

105, $100. Charles Yelverton, Jones County Jr. College, Ellisville, Miss. 39437. (601) 764-3667.

516, $1020. 564B/121N, $876. 3A6, $440, 3B3, $544. 545B, $1360. 1A1, $520, 1A6, $236. 201-1, $116. 201-2, $124. 202-2, $124. Larry Glassman, 5584 Benton Woods Dr., N.E., Atlanta, Ga. 30342. (404) 255-5432.

531A, CA, 202 Mod. A, $500 package. Tom Eckols, Dow Jones Co., Dallas, Texas. (214) ME 1-7250.

INSTRUMENTS WANTED

453. W. Pfeiffer, 1332 E. Portland, Springfield, Mo. 65804. (417) 869-0249.

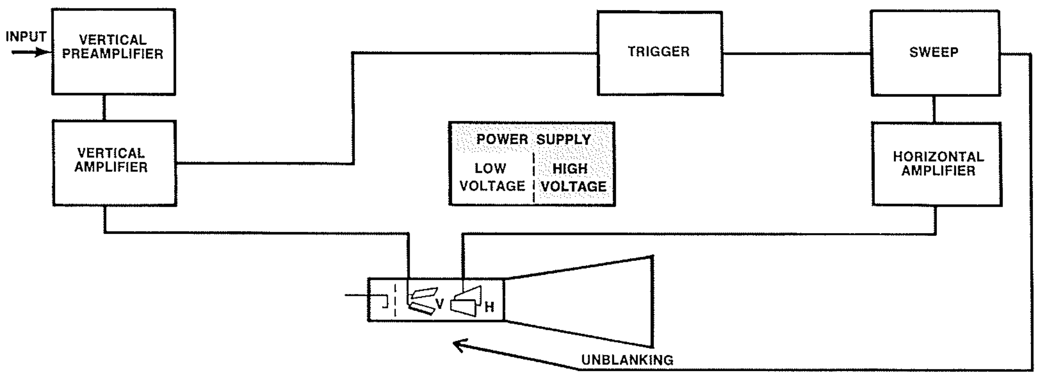
519. John Barth, Barth Corp., 7777 Wall St., Cleveland, Ohio 44125. (216) 524-5136.

503. A. Ruben, Medical Sales & Service, 270 E. Hamilton St., Allentown, Pa. 18103. (215) 437-2526.

R561A or B, with or without Plug-Ins. Dr. Paul Coleman, Univ. of Rochester Medical Cntr., Anatomy Dept., Rochester, N.Y. 14620. (716) 275-2581.

A-2444

SERVICE SCOPE



TROUBLESHOOTING THE HIGH-VOLTAGE SUPPLY

By Charles Phillips
Product Service Technician
Factory Service Center

This third article in the series discusses troubleshooting techniques for Tektronix high-voltage power supplies. The two previous articles available are: "Troubleshooting Your Oscilloscope", February TEKSCOPE: "Troubleshooting the Power Supply", April TEKSCOPE.

The high-voltage supply is fundamental to oscilloscope/CRT performance. Cathode-ray tubes require DC operating voltages much higher than those provided by conventional power supplies. To eliminate large vacuum tubes, bulky and dangerous capacitors and heavily insulated transformer windings, most Tektronix high-voltage power supplies use voltage multipliers to generate high voltages with a considerable savings in cost and space.

By using a frequency of approximately 60 kHz instead of 60 Hz, the required filter capacitor values are reduced by a factor of 1000. Thus, small and relatively inexpensive disc capacitors (0.02 - 0.03 μF) can be used instead of expensive 20-μF capacitors. A class C oscillator usually develops the 40-60 kHz voltage that supplies the primary winding of the high-voltage transformer.

Satisfactory regulation is achieved in most high-voltage supplies by controlling the amplitude of the high-frequency oscillator output. It is important to remember that CRT circuits are very low-current circuits and, as a result, are susceptible to leakage paths.

TYPICAL HIGH-VOLTAGE PROBLEMS

High-voltage power supply problems are usually indicated by one of the following CRT symptoms:

1. No intensity on CRT display.
2. Full intensity on CRT display.
3. No control over intensity and/or focus of CRT display.
4. Incorrect vertical and horizontal calibration.

The control-grid supply is normally 100 V more negative than the cathode supply. If these two supplies for some reason decrease their bias, the high-voltage supply can draw sufficient current to drive it out of regulation. The intensity control varies the bias of the CRT.

Most Tektronix cathode-ray tubes will cut off when the grid is approximately 65 V more negative than the cathode. If the tube is weak, you can never get down below the cutoff point of the tube.

Modern general-purpose oscilloscopes may have either a transistorized solid-state high-voltage supply (e.g., septupler) or the more common vacuum tube trippler high-voltage supply. Some of the more common troubleshooting symptoms are listed below.

1. Inability to turn off the intensity is often caused by a weak rectifier diode in the control-grid supply. If vacuum tube high-voltage rectifiers are used, check visually for filament glow. All the filaments in a properly functioning supply will glow with approximately the same intensity. A bright glow usually indicates a weak tube.

   A control grid to cathode short in the CRT will exhibit similar symptoms. To check for the latter, remove the socket from the CRT and note if the CRT bias changes. If the bias changes, then the loading is caused by the CRT load. The CRT filament supply should also be checked to insure that the problem is not caused by leakage in the filament transformer.

2. No brightness with normal intensity control settings, but slight intensity as the control is moved further counter clockwise, usually indicates a weak rectifier diode in the cathode supply. Similar symptoms will be present if no unblanking is being received from the time-base generator, or in the case of a very gassy CRT. A gradual increase or decrease in intensity are symptoms of weak rectifier diodes in either the control grid or cathode supplies. Note: Grid and cathode vacuum rectifier diodes should be replaced at the same time to prevent differential aging problems.

3. No high voltage is commonly caused by loading (one or more of the secondary supplies is causing the oscillator to not run). To pin point the problem, break the feedback loop by removing the error amplifier stage. In most high-voltage supplies this step will cause the oscillator to free run at a frequency slightly higher than normal. If the oscillator still does not free run, then the problem is probably due to loading of the transformer by one of the secondary loads. By lifting the anode of the rectifiers in the secondary supplies, these stages may be eliminated. (Only the most positive anode need be disconnected in the high-voltage anode supply.) If the oscillator now oscillates, it is only necessary to put back the supplies one at a time to find which one is causing the loading. For example, if this procedure led to a problem in the grid supply, then the next step would be to check for resistance measurements from the intensity control to ground. A good idea is to remove the CRT socket to see whether this has any effect on the circuit symptoms. It is possible for a short in the CRT or extremely gassy tube to load one of the other supplies sufficiently to affect proper oscillator action.

   Typical resistance value in the grid circuit is 4 - 5 MΩ to ground. This holds true for almost any spot that you measure in the circuit. If the components check out properly, it is quite probable that the problem is in the high-voltage transformer and that one of the windings has a leakage path to the core.

Problems in the high-voltage anode supply sometimes show up as insufficient high voltage. Check the output filter capacitors and the anode coupling capacitors. Weak high-voltage rectifiers will also indicate insufficient high voltage. A poor connection at the CRT anode connector can show up as jitter in the sweep or poor regulation. Note: All solder joints on high-voltage chasses should have smooth surfaces. Any protrusions may cause high-voltage arcing, particularly at high altitutdes.

Some of the more recent Tektronix oscilloscopes have a control called the CRT bias control. This adjustment is sometimes used as a maximum intensity control to allow the user to protect his CRT. When the instrument is adjusted in this manner and the intensity is limited, dimness problems may occur at the faster sweep speeds. If there is a brightness problem with a cathode-ray tube, check to be sure that the CRT-grid bias is properly set.

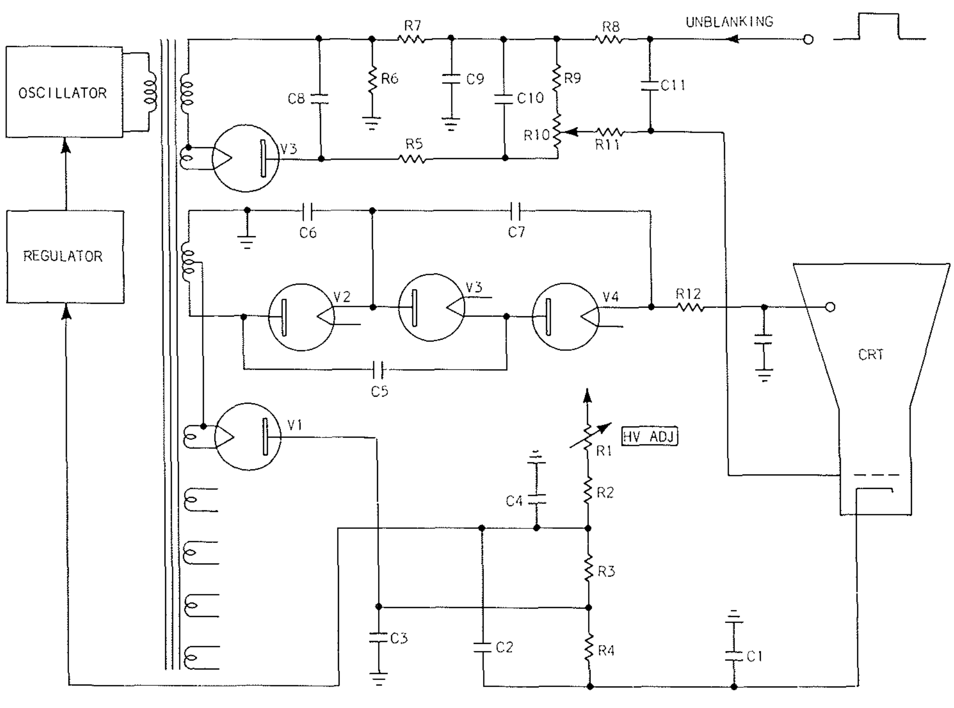


Fig 1. Simplified Schematic of Typical High Voltage Power Supply.

Intensity modulation (blank spots or uneven trace intensity) is often caused by heater-to-cathode leakage in the oscillator, the neons in the CRT-grid circuit, or leaky coupling capacitors in the unblanking circuitry. These symptoms are often seen when high-voltage tubular capacitors have been replaced with disc capacitors. The frequency is usually about 10 kHz or less (related to oscillator frequency) and the problem is present at any sweep speed.

CRT CONSIDERATIONS

Gassy CRT's may be identified by their "double-peaking" characteristic. When the CRT is cold, there are normally two very pronounced spots where the CRT turns on. As the intensity control is advanced CW, the trace comes on (usually dimly), decreases in intensity and then increases somewhat normally to the CW extreme. Once a tube begins to display this characteristic, a self-destructive process has begun and it is only a matter of time until the tube must be changed. Gassy CRT's also often exhibit poor focus and brightness characteristics, and static charge phenomenon. Static charge problems typically may be caused by dirt and if this characteristic is noted, the CRT face and cover should be thoroughly cleaned.

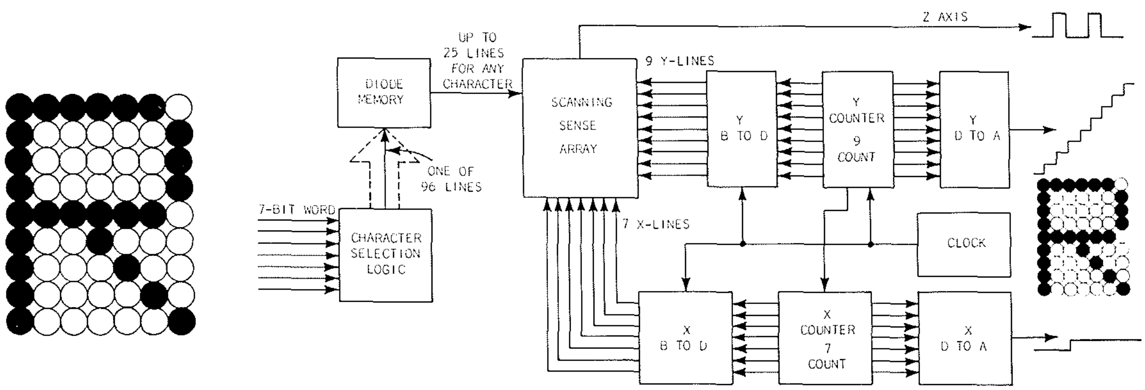
A problem similar to static charge is sometimes caused by the CRT-gun support rods becoming charged. This rod charge may sometimes be eliminated by deflecting the electron beam completly off-screen horizontally, turning the intensity full CW and varying the position control rapidly from the upper extreme to the lower extreme. After a few moments, the rod charge should be dissipated.

NEW CONCEPTS BOOKS

Four new concepts books are now available from your Tektronix Field Engineer. The new titles are: "Digital Concepts"; "Oscilloscope Trigger Circuits"; "Spectrum Analyzer Circuits"; and "Television Systems Measurements".

"Digital Concepts" discusses the binary number system, Boolean algebra, nand gates, nor gates, flipflops, implementing logic functions, implementing logic circuits using integrated circuits, counting circuits, counter readout circuits; "Spectrum Analyzer Circuits"—components and subassemblies, filters, amplifiers, mixers, oscillator and RF attenuators; "Oscilloscope Trigger Circuits"—trigger circuits, input triggering signals, pulse generators, delaying and delayed sweeps and triggered delayed sweep; "Television Systems"—cameras, television tape recorders, telecine, signal switching, transmitter, video distribution system, components of video waveform, measurements requirements, analysis of video transients, color -bar waveform analysis, multiburst test waveform and picture-waveform analysis.

Information Display Concepts will be of special value to those interested in the Tektronix Information Display instruments discussed in this issue of TEKSCOPE. Material covered includes local computer peripherals, time sharing, programming, digital data transmission, computer display terminals, terminal output devices, digital-to-analog and analog-to-digital converters and vector and character generators, characteristics and specifications of direct-view bistable storage tubes and display-unit circuit design considerations.



Dot Character Generator

A character is generated by stepping the beam through 63 positions that make up a 7 x 9 dot character rectangle. When a character line is activated the appropriate diodes in the diode memory conduct. When the inputs from the X and Y B-to-D converters coincide with this information, a pulse turns on the Z axis. X and Y D-to-A converters output the appropriate voltage to step through the 7 x 9 dot matrix.

SERVICE SCOPE

SERVICING THE 7704 CRT CIRCUIT

By Charles Phillips, Product Service Technician
Factory Service Center

This is the second in a series of articles on servicing the 7000-Series Oscilloscopes. The March TEKSCOPE discussed servicing of the high-efficiency low-voltage power supply in the 7704.

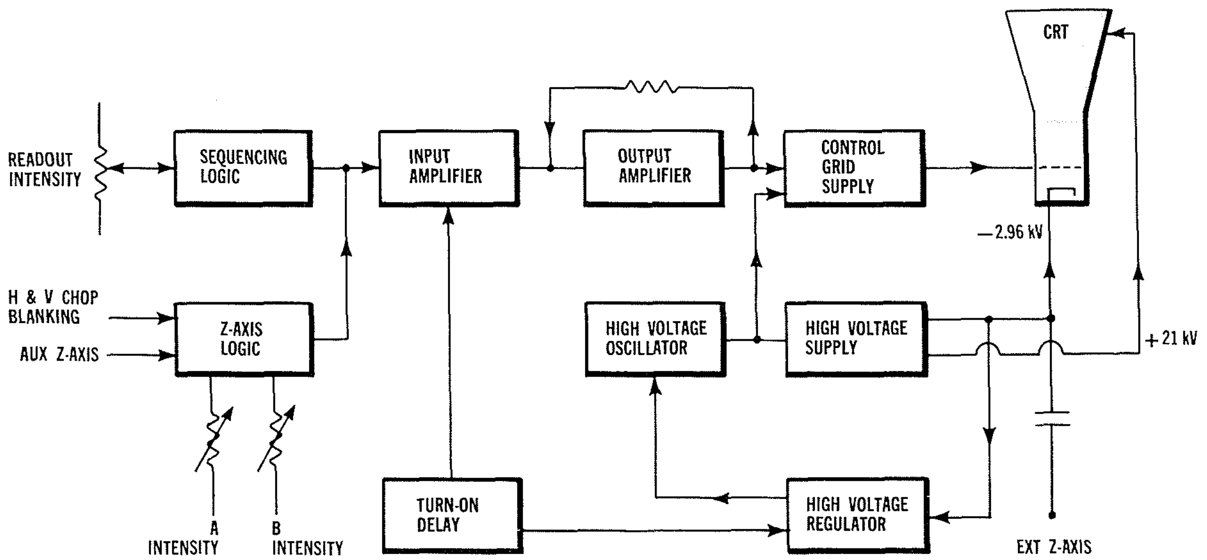
The CRT circuit in today's advanced oscilloscopes performs the same basic functions as in early day instruments. It produces the high-voltage potentials to accelerate the electron beam and provides control circuits to turn the beam on and off and to set the intensity level.

While the basic functions have not changed, the complexity of the functions has. As bandwidth and sweep rates have increased, so have accelerating potentials and the speed with which the beam must be turned on or unblanked. Multiple signals now often control the beam. Main and delayed-sweep unblanking, horizontal and vertical chopped blanking, CRT readout, and external Z-axis modulation must all be accommodated. Logic circuitry and a Z-axis amplifier provide a convenient means of processing these varied signals for control of the beam in the 7000 Series.

With the increase in complexity of the CRT circuitry arises the need for a systematic approach to servicing this portion of the circuitry. Several clues as to the probable location of a problem are available to us from the front panel. For example, there are three intensity controls on the 7704 front panel, A Intensity, B Intensity and Readout. The A and B Intensity controls are activated when plug-ins are inserted into the respective horizontal compartments. The readout is activated when a plug-in is inserted in any of the four plug-in compartments. Intensity levels set by the A and B Intensity controls pass through the Z-axis logic circuitry to the Z-axis amplifier, while the intensity level set by the Readout control goes through the sequencing logic to the Z-axis amplifier. This gives us a quick check to determine whether the problem exists in the Z-axis logic or elsewhere in the CRT circuitry.

Let's assume you have a plug-in in the A Horizontal compartment, the A Horizontal mode button depressed and the A Intensity and the Readout controls set to mid-range. You are experiencing intensity problems. Here are some symptoms and the probable causes:

1. No trace and no readout—
   a) Trace and readout off-screen—Pulling the beam finder control should bring the readout and trace on-screen.
   b) Readout locked up—Pull the readout board. If this clears the problem, U1210 on the readout board is a likely suspect.
   c) Defective Z-axis amplifier—If you have a spare Z-axis board, try replacing the entire board. If not, try replacing Q704, Q706 or Q718.



Block diagram of the 7704 CRT circuit. Note separate logic paths for readout intensity and A and B intensity.

d) Blown fuse F921—Replace the fuse located on the low-voltage regulator board. Corona discharge may cause the fuse to blow. Defective components in the high-voltage oscillator and rectifier assembly can also blow the fuse.

e) Defective CRT—See discussion on troubleshooting the —2960-volt supply. An open CRT heater or defective CRT socket can also be at fault.

2. A spot only, whose intensity is controlled by the Readout intensity control—Defective readout. Pull the readout board or replace U1210 on the readout board.

3. Readout only—

   a) Trace off-screen—Pulling the beam-finder control should bring the trace on-screen.

   b) Defective plug-in—Replace the plug-in. If plug-in is a time base, check to see that the controls are set to generate a trace.

   c) Defective Z-axis logic—Replace U170 Z-axis logic IC.

4. Bright trace and readout but no intensity control.

   a) Defective CRT.

   b) Defective Z-axis logic or Z-axis amplifier.

   c) Defective high-voltage circuitry.

5. Normal trace but no readout—

   a) Defective readout board.

   b) Defective plug-in unit.

TROUBLESHOOTING THE —2960-VOLT SUPPLY

Now let's take a closer look at some of the problems noted. First, that of no trace and no readout. We have determined that the trace is not off-screen and have pulled the readout board to eliminate it as a contributing factor. The next step is to check the —2960-volt cathode supply. This is available at a test point located in the high voltage assembly on the top right side near the rear of the instrument. A note of caution. Turn off the scope before applying or removing the meter lead to or from this test point. Corona discharge may damage some of the solid state components. If you have no voltage on this point, turn off the scope and disconnect the cable running from the CRT anode to the left side of the high voltage assembly. Lowering the swingdown chassis on the right side of the instrument gives you ready access to the anode cable connector. Touch the CRT anode lead to ground to remove the electrostatic charge on the CRT. After you have discharged the anode lead, turn the scope on. If the —2960-volt supply comes up, you have a bad CRT. If the supply still fails to come up, turn off the scope and remove the CRT base socket. This will remove any loading on the supply due to shorted elements in the CRT.

If you still do not have —2960 volts, check Q712, Q752, Q756 and Q758 on the Z-axis board. The oscillator transistors Q764 and Q766 can also be defective. If none of these units are at fault, you will need to get into the high-voltage assembly to troubleshoot further.

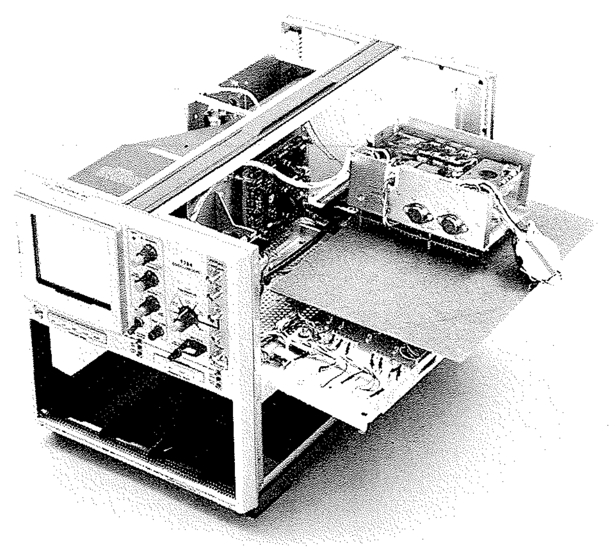
The simplest method to accomplish this is to lower the swing-down chassis on the right side of the instrument. Place a piece of cardboard or a tablet on the chassis as an insulator on which to lay the high-voltage assembly. The assembly is removed by removing the seven screws holding the upper half of the back panel and the two screws holding the front of the assembly. Work the assembly around so you can lay it on the insulating material on the swing-down chassis. The brown and red leads from the trace rotation coil on some early instruments are too short to permit laying the assembly down. Just remove the Z-axis board, unplug the leads and dress them out of the way. They need not be connected to troubleshoot the supply. Reinstall the Z-axis board. Next, remove the plastic cover from the supply and locate the white-green wire running from the encapsulated assembly to the high-voltage transformer. Unsolder this lead and again check the —2960-volt supply. If it comes up, you have trouble in the encapsulated assembly and you will have to replace the entire assembly. If it is not at fault, leave the white-green wire unsoldered. This allows you to pick up the rest of the circuitry involved with the high-voltage transformer and the components around that area.

Another condition that would prevent the high-voltage oscillator from running is a shorted or leaky diode in the high-voltage secondary. We can check CR771 and CR772 by lifting their anode lead and taking a voltage reading. The anode of CR771 should read about —30 V and the anode of CR772 about —3 kV. We cannot lift CR781 to check it as this would remove the feedback to the regulator circuit. The best procedure is to replace it or substitute CR772 temporarily to determine if CR781 is defective.

Other possible causes of high voltage failure are the high-voltage transformer and filter capacitor in the secondary circuitry.

INTERMITTENT OR NOISY HIGH VOLTAGE

Another problem you may experience is an intermittent —2960-volt supply, flashes on the screen, or noisy Z-axis modulation. Principal source of this problem is the thick-film assembly containing resistors R740 through R744. On later schematics these are numbered R740A through E. The assembly is located in the high-voltage plastic housing and can be reached by lifting the circuitry from the housing.



High voltage supply removed for servicing. Insulating board between supply and swing-down gate allows unit to be operated while open for troubleshooting.

The elastic bands holding the thick-film card to the assembly are usually the culprit. The tails of the bands protruding through the circuit board sometimes come in contact with the high-voltage diodes causing a corona discharge. Clipping off these tails may cure the condition. Corona discharge also sometimes occurs between the elastic bands and the thick-film resistors. If removing the bands clears the problem, you can leave them off. If the problem is still present, replace the thick-film card. The leads to the thick film should be unsoldered at the circuit point rather than at the thick film as the card is coated with an insulating material.

NO INTENSITY CONTROL

When you have a bright trace and no control of the intensity, the first thought is to suspect the CRT. Shorted elements in the CRT will cause this. However, problems in the Z-axis amplifier can also give the same symptom. If Q724 or Q734 is defective, you will have no intensity control. A defective Q708 will cause the trace to be bright when the scope is first turned on then dim after several seconds to normal intensity.

Q732, the remaining transistor in the Z-axis amplifier, has no effect at slow or medium sweep rates. However, if you have modulation on the trace at faster sweep rates, suspect Q732. Incidentally, it's not readily apparent how to remove the heat sink from this transistor. The heat sink is in two sections; just unscrew the top from the bottom.

This covers most of the problems you may experience with the high-voltage section of the 7704. High-voltage circuitry in other 7000-Series instruments with readout is similar and can be serviced using the same techniques.

INSTRUMENTS FOR SALE

130LC Meter, $190. 115, $695. 514D, $350. S. King, 725 Little Silver Point Rd., Silvermere, Little Silver, N.J. (201) 741-3891.

3T2, 3S2, S3, 3 ft. cable ext., All $2250. R. Wagner, Wesleyan Univ., Physics Dept., Middletown, Conn. 06457. (203) 347-9411, Ext. 865.

535A with CA Plug-In. d b Electronic Enterprises, 13526 Pyramid Dr., Dallas, Texas 75234. (214) 241-2888.

535A with H Plug-In, $1000. 545A, $1250. G Plug-In, $125. Geo. Maxwell, Rescuair Corp., 9030 Owensmouth Ave., Canoga Park, Calif. 91304. (213) 882-6161.

556. Ron Seldon, Digital Development Corp., 7514 Clairemont Mesa Blvd., San Diego, Calif. 92111 (714) 278-1630.

454, Mod 163D. New condition. Palmer Agnew, 314 Front St., Owego, N.Y. 13827. (607) 687-2406.

Three new Mod 130 LC Meters. Bob Rust, (213) 889-1010, Ext. 1081.

545, CA, $550. J. R. Shapiro, 5 Lynn Dr., Englewood Cliffs, N.J. 07632 (201) 568-9287.

454, RM15, 130, 134, P6022. Three months old. Mr. Puzzuti, Aries Technology, 3475 Victor St., Santa Clara, Calif. (408) 248-9685.

Two 3A3's. B. Murray, Picker Electronics, 601 S. Bowen St., Longmont, Col. (303) 776-6190.

453, $1600. 555 w/2 D's, $1600. 585 w/81 Adapter, D Plug-In, $1500. Ed Franchuk, 1203 Opal Ave., Anaheim, Calif. 92805. (714) 546-0431.

Q Unit, $350. Never used. Vern Iverson, Possis Machine Corp., 825 Rhode Island Ave., S., Minneapolis, Mn. 55426. (612) 545-1471.

310. Norman Orr, Radio Specialists Co., 2450 W. 2nd Ave., Denver, Col. 80223. (303) 744-3461.

Two 422's. $1000 each. David Young, Interdata, Inc., 2 Crescent Pl., Oceanport, N.J. 07757. (201) 229-4040, Ext. 396.

531A, 1A2, N, L, $950. Michael Muegge, 100 Foerster St., San Francisco, Calif. 94112. (415) 931-8000, Ext. 522 or (415) 585-1625.

504, $400. 551, $1000. CA, $125. H, $125. Vince Murray, Audio Devices, 100 Research Dr., Glenbrook, Conn. (203) 324-6761.

561A/3A6/3B3 w/Probes, $1525. James Gamble, 21917 Grant Avenue, Torrance, Calif. 90503. (213) 542-2680.

453 Mod 127C, $1850. 191, $350. E. Paulaitis, 19 W. 380 Lake St., Addison, Ill. 60101. (312) 543-9260 or E. Lauer, (312) 259-6300.

453. Mike Logue, Heidelex Corp., Stuart Rd., Alpha Ind'l Park, Chemsford, Mass. 01824. (617) 256-3921.

545, $700. D, $60. K, $50. B, $45. L, $90. Time Mark Gen, 180-S2, $95. Frank Aamodt, Golden West Airlines, 4200 Campus Dr., Newport Beach, Calif. (714) 546-6570.

531, 53B, $400. Gene Mirro, P.O. Box 274, Hightstown, N.J. 08520 (609) 799-1495 after 6:00.

Two K's, $80 each. 80 w/Prb. & Atten., $80. Mr. Jordan, 1125 Greengate Rd., Fredericksburg, Va. (202) 337-7600, Ext. 711.

Will trade RM17 for 503. T. W. Moore, Mt. Holyoke College, South Hadley, Mass. 01075. (413) 536-4000.

661 w/5T3, 4S1, 51A and two P6032's. Will trade for 454. John Riccitelli or N. Bicknell, The Foxboro Co., Foxboro, Mass. (617) 543-8750.

Six 2A60's, unused. 25% discount. Harold Childers. (713) 771-5821.

512. J. C. Leifer, 328 Cree Dr., Forest Heights, Md. (301) 839-1548 or (703) 560-5000, Ext. 2773.

Sale or trade 1A1, 53/54 K, 110 Pulse Generator. Lawrence Kahn, Gamma Electronic Research Co., 6042 Rockrose Dr., Newark, Calif. 94560. Call evenings & weekends. (415) 797-2595.

317, $665. John Nicholas, Buckeye Cablevision, Inc., 1122 N. Byrne Rd., Toledo, Ohio 43607. (419) 531-5121.

575 Mod 122C, $1000. Jerry Setliff, Nuclearay, Inc., P.O. Box 9320, N.W. Station, Austin, Texas 78757. (512) 836-1120.

503, C-27. Dr. Farhang Soroosh, 1126 E. 2nd St., Casper, Wyoming 82601. (307) 234-2613.

541A, CA, $1000. Frank Cosenza, Tridair Industries, Fastener Div., 3000 W. Lomita Blvd., Torrance, Calif. 90505. (213) 530-2220.

661/4S1/5T3 and Access. Mr. Mawson, Scientific Measurement Systems, 351 New Albany Road, Moorestown, N.J. 08057. (609) 234-0200.

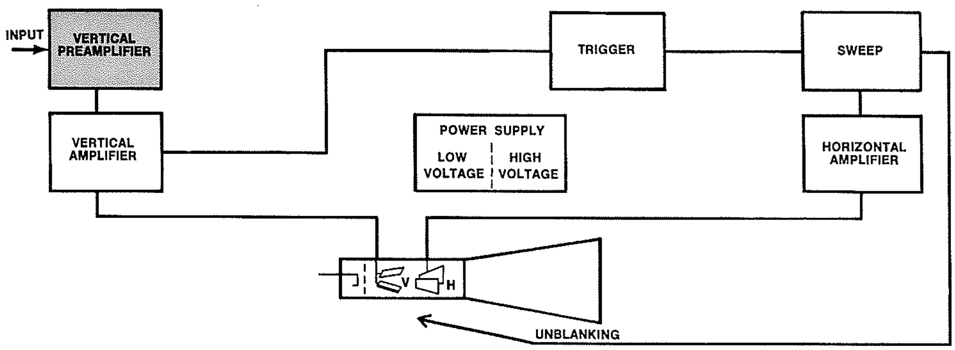
Will trade N for M Plug-In, Four P6010 Probes. Lloyd Hanson, Tri-State College, Engineering-Business Adm., Angola, Ind. 46703.

INSTRUMENTS WANTED

561A, 564, 201-2. 565, 205-1. 1L20. Lawrence Kahn, Gamma Electronic Research Co., 6042 Rockrose Dr., Newark, Calif. 94560. Call evenings & weekends. (415) 797-2595.

564B and Engine Analyzer Accessories, including 2B67, 3A74, all accessory components. As package or separately. Henry Kovar, 11823 Porter Dr., R.R. #4, Osseo, Mn. 55369.

SERVICE SCOPE



TROUBLESHOOTING PREAMPLIFIERS

By Charles Phillips
Product Service Technician
Factory Service Center

This sixth article in a series discusses troubleshooting techniques in the preamplifiers of Tektronix instruments. For copies of the preceding five TEKSCOPE articles, please contact your local field engineer.

Substituting vertical preamplifier plug-in units is an excellent means of checking performance to the vertical amplifier input. Once a problem is isolated to a specific plug-in unit, plug-in circuit boards may isolate the problem even further. Once a problem has been traced to a specific block, a close visual check may pinpoint the problem. Often, burned components or loose leads can be spotted that shorten the troubleshooting job. Substituting the tubes or transistors offers a quick means of checking a suspected stage. **Always** return the original component to its place if the problem remains.

In the case of a plug-in, be certain the plug-in is seated properly and that there is no open connection. Plug-ins that use interlocks are particularly susceptible to this type of problem. Place the input selector to the DC position and turn off X10 amplifiers if they are available.

When troubleshooting a new instrument, take some time to familiarize yourself with the block diagram. Spending a few minutes with the instrument manual can give valuable insight into the particular problem.

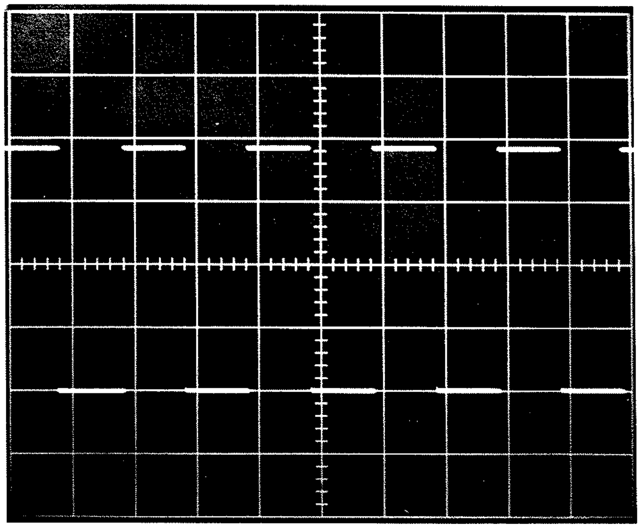
When no spot is seen, use the trace finder or the position indicator to see which direction the spot is deflected. Use the position controls to see whether the display may be centered. Should the indicator lights show that the trace is deflected off screen, invert the display. If the display goes off screen in the other direction, the problem is before the invert switch.

For problems after the invert switch, use a shorting strap, and starting with the output stages of the preamplifier, work stage by stage towards the input amplifier. The stage is working normally when the signal short causes a trace near the vertical center line of the CRT. A defective stage is indicated by the short not centering the trace on the CRT.

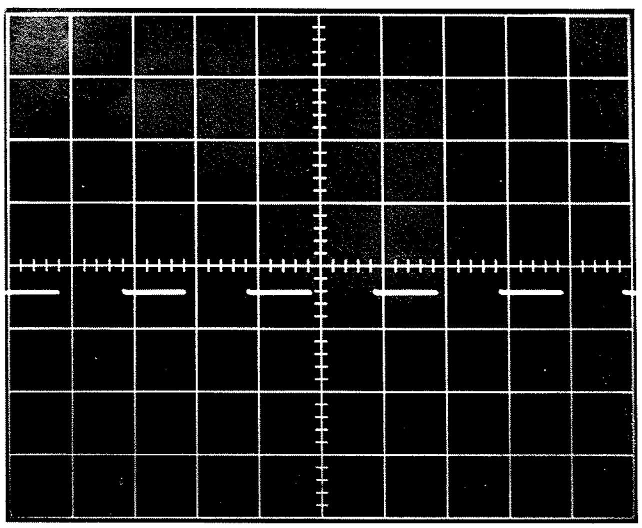
If the amplifier is well-balanced, the position control will be close to midrange when the trace is centered. If a problem exists, switch the output stages to obtain balance near the potentiometer midrange point.

Select output tubes or transistors so that the trace may be positioned off screen in both directions.

Set the calibrator to a convenient figure such as 1 V. Adjust the vertical sensitivity to 0.2 V/div and select a single channel mode. Position controls and the attenuator balance should be adjusted midrange. In some cases, it is convenient to turn the variable gain counterclockwise to lessen the effect of the attenuator balance control.



Attenuator error with 4 div of deflection (2½% per mm).



Attenuator error with 10 div of deflection (1% per mm). Centerline reference.

Good balance is particularly important in multi-trace instruments. For example, good balance is indicated by both traces of a dual trace being within a centimeter of center screen. It's often wise to switch tubes or transistors until A is the upper trace and B is the lower trace (when all controls are centered). In general, when tubes are replaced by raw tubes, be certain to operate the instrument overnight and rebalance.

A technique that may be used to optimize attenuator accuracy is to apply 10 centimeters of CRT deflection and use the oscilloscope as a null detector. This method is particularly valuable on oscilloscopes with limited vertical scan. By using the center line as a reference, DC couple a signal 10 times the attenuator setting on the straight-thru attenuator position.

For example, at 50 mV/div, apply a 500-mV signal to the input. Position the trace so the upper portion of the waveform is aligned with a convenient vertical reference. Check each attenuator position for deviation always keeping the ratio of signal to attenuator 10:1. Under these conditions, each mm of CRT display is equal to 1% error. This method provides much greater resolution since CRT characteristics (geometry, compression, expansion, edge defocusing, etc.) do not enter into the measurement accuracy. After the attenuator ratios are checked for proper values, then gain can be set.

Problem: Microphonic noise that appears when switches and controls are moved. A simple consistent method of checking microphonics is to rap the instrument at the top of the front panel firmly with the palm of your hand.

Solution: Tubes are the most common offenders. Replace as required. If a control or switch is noisy, spray a good contact cleaner directly on the contacts. For noisy potentiometers, use a hypodermic needle and insert one drop on the shaft, contact, and seams. Do not remove the potentiometer covers. In the case of intermittent problems, rotate the instrument in 90° increments and make the above microphonic check on each axis.

Problem: Grid current gain error on DC measurements. If grid current causes a 4-cm signal reference to shift 2 mm, the error is 5%. Check by selecting a reference line on the most sensitive attenuator position. Terminate the input with a 50-Ω termination and keep within 2-mm maximum trace shift.

Solution: Replace input tube to correct this problem.

Problem: Input cap leakage causes the trace to go off screen when operating in the AC mode with a DC voltage applied. For example, at 5-mV sensitivity when checking power supply ripple, 50 mV of leakage will cause the display to be positioned off screen. To check for cap leakage, go to the AC position and center the trace at 50 mV/div sensitivity. Apply ≃500 V to the input and see how far the trace moves.

Solution: The capacitor should be replaced if trace shift exceeds 50 mV.

Problem: Input capacitance range incorrect. It is important that all attenuator ranges have an equal RC so the probe doesn't have to be re-adjusted as the volts/div is changed. When calibrating—if you have dual channels, you want both channels to match.

Solution: Physical arrangement of the input coupling cap can alter the capacitance range of the adjustment if needed. If a capacitance normalizer isn't available, one channel input C can be set to midrange and a 10X probe used to compensate the other dividers.

Problem: Position balance and range. If amp is balanced, the position control will be close to midrange when trace is centered and this will allow the position control to move the trace off screen in either direction.

Solution: Switch output stages to get proper balance.

Problem: Spike on front end of fast rise pulse that cannot be adjusted out. (Cathode interface.) Because DC filaments are used in nearly all plug-ins, varying line voltage does not change the pulse leading edge as it does in an oscilloscope amplifier.

Solution: Replace output amplifier tubes or plate load resistors.

Problem: Tilt on chopped waveshape exceeds 1 mm.

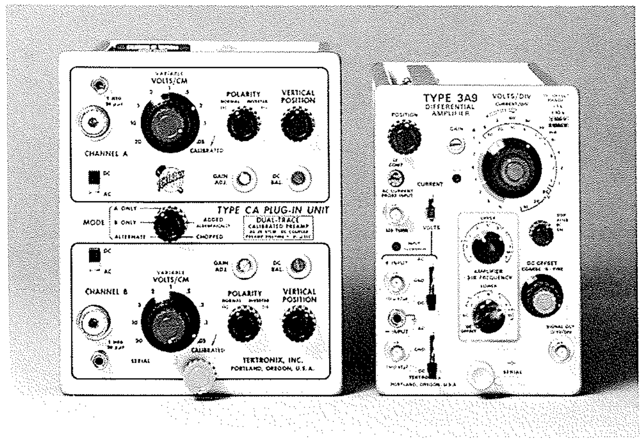
Solution: Select balance amplifier tubes (or transistors) for minimum tilt. Check for leakage in one or more of the switching diodes.

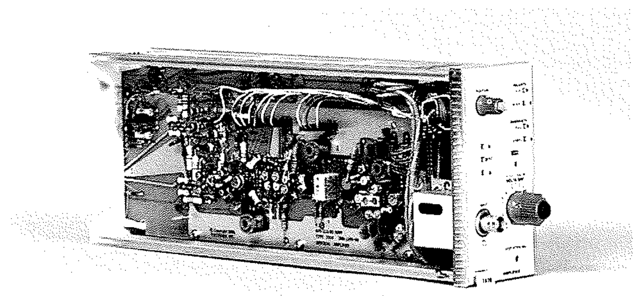
Problem: Interactive trace display, trace is displaced as other trace is positioned across it.

Solution: Check for leaky diodes in switching circuit.

Problem: Bandpass of each channel of a multi-trace unit does not match.

Solution: Select input cathode followers or switch for match.





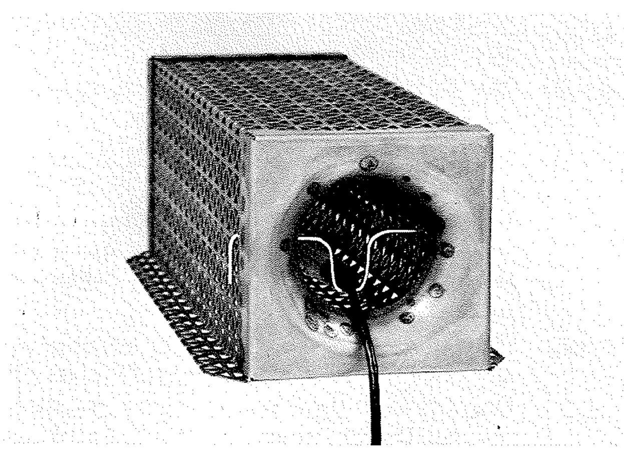
Tektronix plug-in preamplifiers are manufactured in several different configurations. Upper—Letter-Series and 560-Series Plug-Ins. Lower—New 7000-Series Plug-In.

SOLDERING IRON SAFETY TIP

Here's a convenient tip to prevent light weight pencil soldering irons from continually falling on the floor. The small 15-watt irons now commonly in use for circuit board work often fall from their holders when their cord is brushed.

Take a 6-inch piece of 14 or 16 gauge wire and place a U-shaped bend in the center of the wire. A little experimenting will quickly find the optimum wire shape to securely hold the iron in place. Adjust the wire so the iron must be lifted to be removed from its holder. Attach the wire to the holder with two right angle bends at the extremes of the wire.

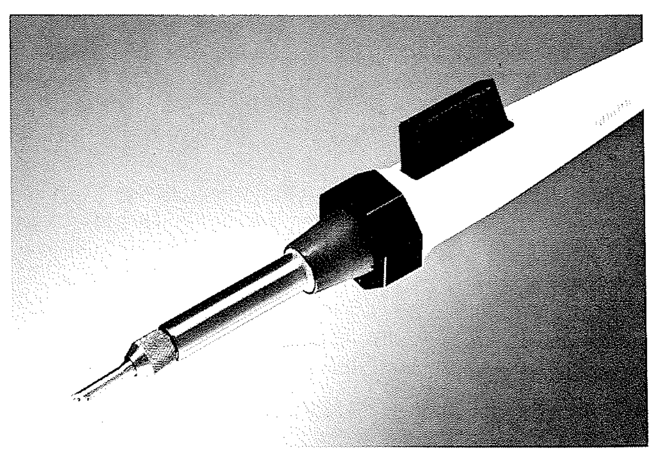
The same technique will also work for the larger 25 and 40 watt irons.



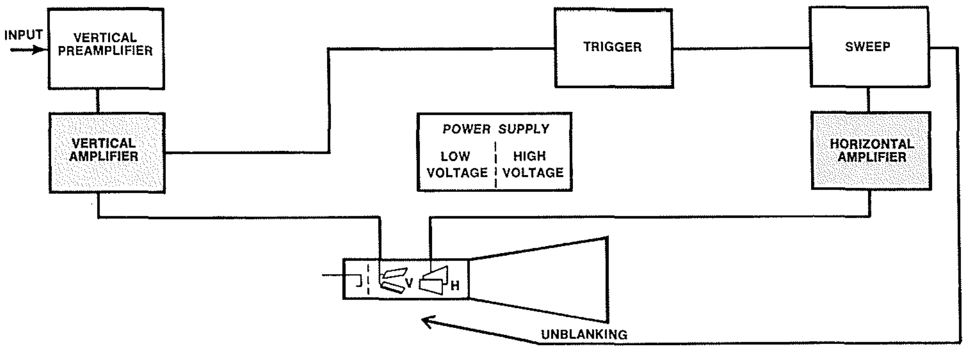
NEW SOLDERING IRON DESIGN

New soldering irons are currently available that are particularly convenient for your circuit board work. The model shown utilizes a built-in solder remover and makes use of special tips with holes in them. The solder is drawn into the tip as the bulb is depressed, thus simplifying the repair job.

An additional advantage of this design is that when removing components from printed circuit boards the hole in the tip provides a convenient method of straightening the ends of the wire. Thus, the component can be removed neatly and cleanly with minimum interference with the board.



SERVICE SCOPE



TROUBLESHOOTING THE AMPLIFIERS

By Charles Phillips
Product Service Technician, Factory Service Center
Contribution by Dave Colbert

This fifth article in a series discusses troubleshooting techniques in the vertical and horizontal amplifier circuits of Tektronix instruments. For copies of the preceding four TEKSCOPE articles, please contact your local Tektronix Field Engineer.

For effective troubleshooting, examine the simple possibilities before proceeding with extensive troubleshooting. The following list provides a logical sequence to follow while troubleshooting both the horizontal and vertical amplifier circuitry:

1. Observe CRT display characteristics.
2. Check control settings.
3. Isolate trouble to block.
4. Thorough visual check.
5. Check voltages and waveform.
6. Check individual components.

Note: **Always** return the original component to its place if the problem remains.

GENERAL

Neon indicator lights and trace finders usually provide sufficient information to indicate which side of the vertical or horizontal amplifier is causing the trouble, or whether both sides are. If the trace-finder button brings the trace back on the screen, then by varying the position control we can observe whether we have position control on both sides. If we have position to one side only, this will tell us that we have an unbalance in one of the amplifiers. If we have no position, then it could be a defective stage completely.

If a vertical or horizontal amplifier is badly out of balance, a clip lead can be used to short the collectors of the output transistors (or plates of output tubes) to ensure that the spot is centered. (The deflection plates themselves may be shorted to verify the true electrical center of the instrument.) The shorting strap is then moved to the base (or grid) of the output stage and the amount of difference in the spot position noted. The position difference indicates the amount and direction of unbalance in the output stage. By applying this technique, stage by stage back to the input, the amount of unbalance may be determined. Switch the input transistors of the output amplifier when the unbalance is over 0.5 centimeter. A defective stage is indicated by the shorting strap not centering the trace on the CRT. It's a good idea to switch transistors around to obtain an unbalance less than that figure. This will ensure a well balanced vertical system and minimize compression or expansion.

The Type 576 Curve Tracer presents a convenient way to locate difficult problems in push-pull or complementary circuitry. The AC Collector Mode is ideal for comparing the impedance of various circuit points against similar impedance points. Any substantial difference in displays indicates a probable incorrect circuit impedance for the test point. Use sufficient voltage to turn on nearby junctions for maximum insight into the test circuit. Open and shorted diodes are easily found this way as well as much more difficult conditions, including in-circuit leakage problems. Be certain that the power is OFF on the scope under test.

This approach is useful whenever suspected stages may be compared against a known good stage. The technique is particularly valuable when troubleshooting feedback circuitry. By setting the initial display to approximately a 45° positive slope, meaningful comparisons can be quickly made.

A convenient method of determining which component in a string is noisy is to use a differential comparator unit. Usually, if such a problem is observed single-ended, it is difficult to localize the faulty resistor. By monitoring the problem differentially and bucking out the voltage, the noisy component is quickly and easily located. The same technique will often work to a lesser degree with add algebraic or ordinary differential amplifiers.

HORIZONTAL AMPLIFIERS

The horizontal amplifier develops a push-pull version of the input ramp from the time-base generator. These simultaneous positive and negative going ramp voltages are then applied to the right and left horizontal deflection plates, respectively, causing the CRT spot to move across the screen. Thus, equal increments of distance represent equal increments of time, and the sweep can be calibrated.

Many horizontal amplifiers include magnifier circuitry that decreases the amount of negative feedback and increases the gain accordingly. Such magnifiers are usually X5 or X10 and effectively increase the sweep rate by that amount. Most oscilloscopes also provide an external input to the horizontal amplifier. In this position, the internally generated sawtooth is disconnected and an external signal may be connected to the external horizontal input terminal. Often a compensated 10X attenuator is used with the external horizontal circuitry to provide a wider range of signal inputs.

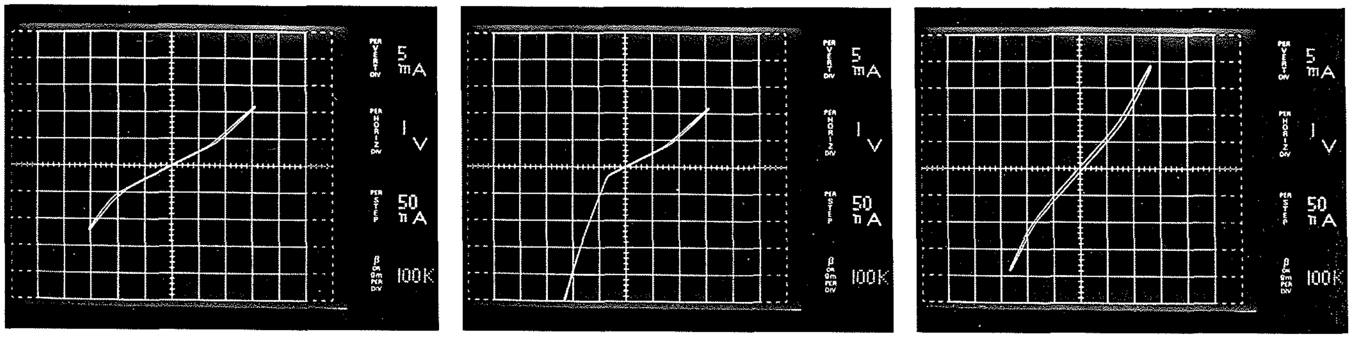
When the oscilloscope has a second sweep, this may be used to check for normal operation. A calibrator signal to the external horizontal input checks the operation of a portion of the horizontal amplifier. If the instrument has a plug-in horizontal, removing the plug-in unit should automatically center the spot. This is of additional assistance with oscilloscopes using deflection blanking. Deflection blanking positions the spot offscreen, except during sweep time, and no spot can be seen by overriding the intensity control.

Switching to the external input disconnects the sweep and is a means of determining whether a problem is associated with the horizontal amplifier. At the same time, it can indicate the condition of the unblanking circuitry.

VERTICAL AMPLIFIERS

The vertical amplifier develops a push-pull version of the input signal from the vertical preamplifier. These simultaneous positive and negative going amplified signal voltages are then applied to the upper and lower vertical deflection plates, deflecting the CRT spot as it traverses the screen. Thus, an accurate amplified reproduction of the original signal is displayed on the CRT. In addition, many oscilloscopes provide a vertical signal output which allows the amplified signal to drive other devices.

No stage where distributed amplifiers are used should contribute more than 2-mm unbalance. In addition, tubes should be switched so the total unbalance of the distributed amplifiers does not exceed 2 mm. Never mix different brands of distributed amplifier tubes. If a distributed amplifier tube fails and a replacement is needed, the trigger pickoff tube makes an excellent aged replacement. The trigger pickoff tube may then be replaced with a different brand.



Comparing similar impedance points can often locate troubles when other techniques fail. In-circuit impedance checks: Left, normal operation of the emitter circuit side of a paraphrase amplifier; Center, opposite side of the same paraphrase amplifier with open emitter; Right, shorted emitter.

TYPICAL HORIZONTAL PROBLEMS

Problem: Sweep shortening at fast sweep speeds. Nonlinearity and sometimes sweep compression to the right.

Solution: This problem is typically caused by an open collector (or plate) load to one of the stages. An open decoupling resistor will also cause this problem.

Problem: Compression or expansion of the sweep as it is positioned from one side to the other.

Solution: This problem is typically caused by the diode network between the bases (or grids) of the amplifier. Check for leaky diodes.

Problem: Horizontal shift exceeds 1 cm as line voltage is varied from 105-125 V.

Solution: Change tubes or transistors.

Problem: Horizontal sweep control center position is shifted and control is nonlinear.

Solution: Check for an open circuit in the center tapped plate load resistors of the output amplifier.

Problem: Nonlinear sweep.

Solution: Gassy HF capacitance driver tube. A faulty input CF tube may also cause a similar problem.

Problem: Insufficient HF timing range and gain or position effect.

Solution: Check the horizontal output amplifier for weak tubes.

Problem: Position range off-centered.

Solution: Check the input compensated divider of the input CF.

TYPICAL VERTICAL PROBLEMS

Problem: Unbalance greater than 0.5 cm.

Solution: Switch tubes to bring within 0.5 cm of electrical center. **NOTE—TURN OFF POWER WHEN SWITCHING INPUT TUBES.**

Problem: No internal triggering capability.

Solution: Open plate load inductance of trigger pickoff amplifiers.

Problem: Bump in display 0.25 μs from beginning.

Solution: Check for open or defective termination network.

Problem: DC shift.

Solution: Check to be sure that the plate load resistor is correct for the brand of tubes being used. (Resistor value varies with tube manufacturer other than original.) If the problem still remains, check the filter capacitors.

Problem: Cathode-Interface—front end of pulse varies as line voltage is varied from 105-125 V.

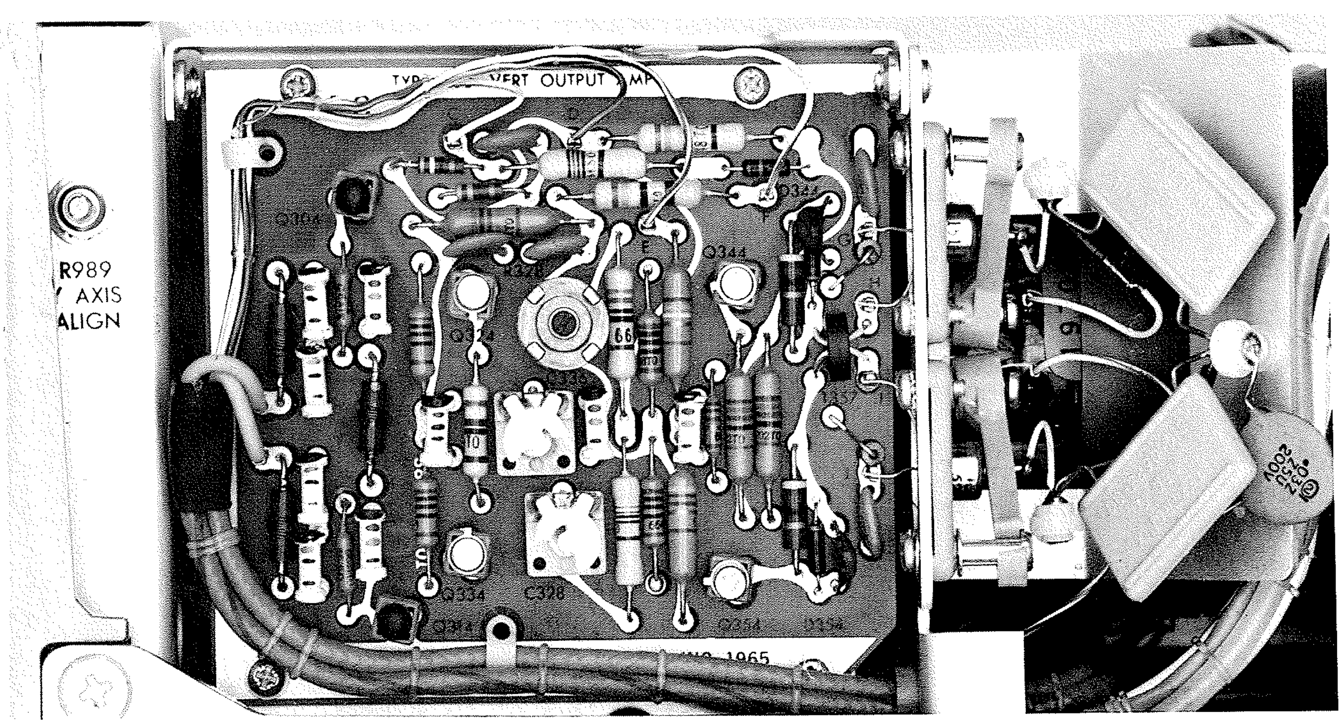
Solution: Replace input tubes. If problem still remains, retube the distributed amplifier.

Problem: Overshoot and ringing.

Solution: Check collector load resistor for out-of-tolerance components. If problems remains, check gain potentiometers. Non-Tektronix made gain pots may not have the right amount of inductance.

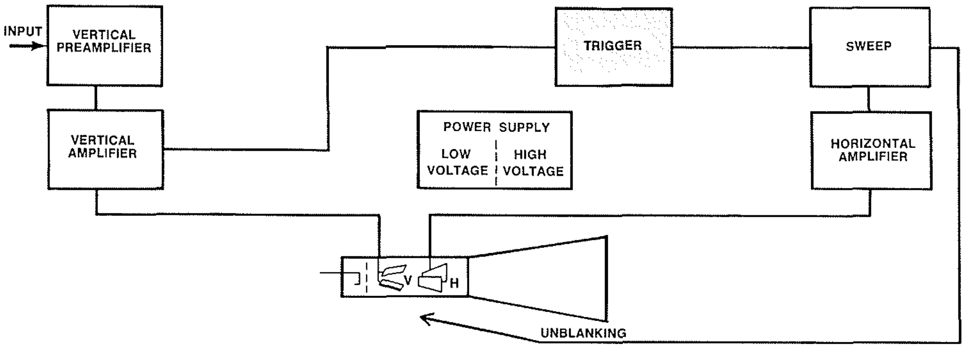
Problem: Compression.

Solution: Check diodes in base circuits for a shorted diode.



Type 422 Vertical Amplifier circuit board. Note that transistor sockets are used where possible for servicing convenience.

SERVICE SCOPE



TROUBLESHOOTING THE TRIGGER CIRCUITS

By Charles Phillips

Product Service Technician, Factory Service Center

This fourth article in a series discusses troubleshooting techniques in the trigger circuits of Tektronix instruments. For copies of the preceding three TEKSCOPE articles, please contact your local field engineer.

For effective troubleshooting, examine the simple possibilities before proceeding with extensive troubleshooting. The following list provides a logical sequence to follow while troubleshooting trigger circuitry:

1. Observe CRT display characteristics.
2. Check control settings.
3. Isolate trouble to block.
4. Thorough visual check.
5. Check voltages and waveform.
6. Check individual components.

Tektronix trigger circuits are designed to respond to a wide variety of input signals. Since many of these input signals are unsuitable as sweep-initiating triggers, signals are first applied to a trigger circuit where they are converted to pulses of uniform amplitude and shape. Thus, regardless of the input signal configuration, it is possible to start the sweep with a pulse that has constant amplitude and risetime. The trigger circuitry allows the operator to start the sweep on either slope of the waveform, select any voltage level on the rising or falling slope of that waveform, and filter out selected frequencies of the input signal for greater ease and repeatability in triggering.

The triggering of the general purpose oscilloscope may be broken down into five basic parts: (1) vertical amplifier trigger pickoff circuitry, (2) input coupling circuitry, (3) input amplifier, (4) trigger pulse generator, and (5) automatic triggering circuitry.

The trigger pickoff circuitry acts as a buffer to keep trigger circuitry from changing the operation of the vertical amplifier, yet pass the amplified vertical signal to the trigger circuit with minimum distortion. Input coupling circuitry allows selection or rejection of various frequency components of the triigger signal. The input amplifier provides gain to assure the trigger pulse generator of sufficient input for proper circuit operation. The automatic triggering circuitry used in older Tektronix instruments eliminated control of coupling and level and provided a baseline in absence of signal at a 50-hertz rate. The automatic triggering used in the more recent Tektronix instruments provides all normal trigger functions as well as a bright baseline in the absence of a trigger signal.

Although trigger circuits vary in their complexity and sophistication, the essentials are the same in all instruments. Nearly all Tektronix trigger circuits use a Schmitt Multivibrator for the trigger pulse generator. Most trigger circuits incorporate a trigger sensitivity control to permit adjustment of the minimum size signal to which the circuit can respond. Fig 1 illustrates simplified block diagrams for vacuum-tube circuits and solid-state circuits. Individual trigger circuits vary but all circuits make use of some of the basic functions listed below.

CONTROLS AND ADJUSTMENTS

Front-panel controls used in conjunction with the internal controls are typically:

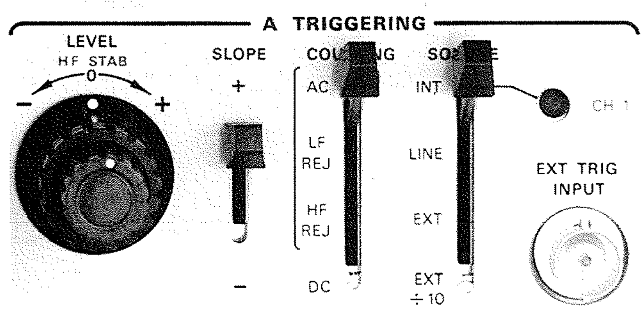
1. SLOPE (+, −)
2. COUPLING (AC, AC LF REJ, AC HF REJ, DC)
3. SOURCE (INTERNAL, EXTERNAL, LINE and PLUG-IN or CH 1)
4. TRIGGER LEVEL
5. MODE (NORM, AUTO, SINGLE SWEEP)
6. STABILITY

The basic internal adjustments of a modern oscilloscope are the following:

1. Trigger level centering adjust—controls trigger circuit symmetry to enable all coupling modes to work properly with the slope switch.
2. Internal trigger DC level adjust—allows the center of the LEVEL control to be set exactly to 0 volts in the DC mode.
3. Trigger sensitivity—controls the minimum signal response—minimum sensitivity limited by noise.

When troubleshooting trigger problems, a few simple steps can often determine which stage of the trigger is at fault. Checking operation of trigger circuit in different sources, modes, slopes, and coupling positions will often isolate a problem. Observing the effect of the stability and level controls gives additional information. In checking trigger circuits, always be sure that sufficient signal is being applied to obtain a large observable deflection. (≃1 cm)

Varying the trigger SOURCE switch between INTERNAL and EXTERNAL triggering checks the trigger pickoff circuitry. Comparing operation in different trigger modes can usually localize a problem to a specific trigger stage (e.g., noting a difference in operation of the trigger circuit in AUTO or NORM may suggest the faulty stage).



Typical Oscilloscope Triggering Controls

Once the problem has been traced to a specific block, a close visual check may pinpoint the problem. Substituting tubes or transistors offers a quick means of checking a suspected stage. Always return the original component to its place if the problem remains.

When troubleshooting a new trigger circuit, take some time to familiarize yourself with the block diagram and schematics. Spending a few minutes with the instrument manual can give valuable insight into the particular problem.

TRIGGER OPERATION

A simple, convenient general method to check proper trigger circuit operation is to apply a calibrator signal to the oscilloscope. Using the INTERNAL trigger source, adjust the controls and vertically center at least 1 cm of calibrator signal on the CRT display. Set the triggering LEVEL control to zero and place the coupling control in the AC LF REJECT position (called AC-FAST on some oscilloscopes). This is

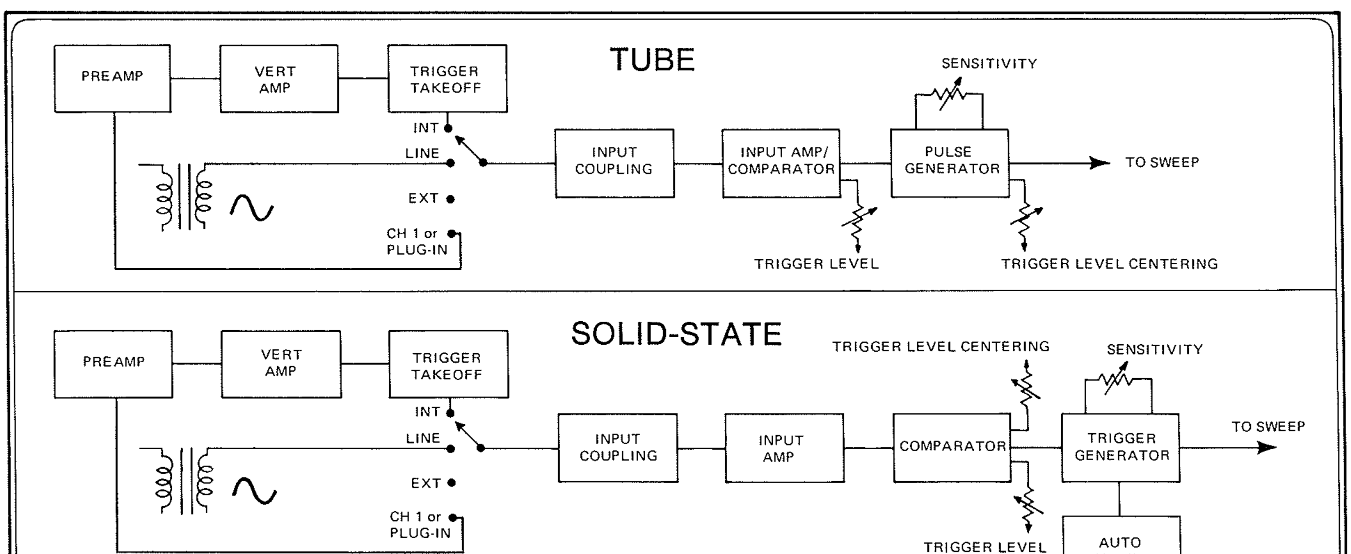


Fig 1. Typical block diagrams for tube and solid-state trigger circuits.

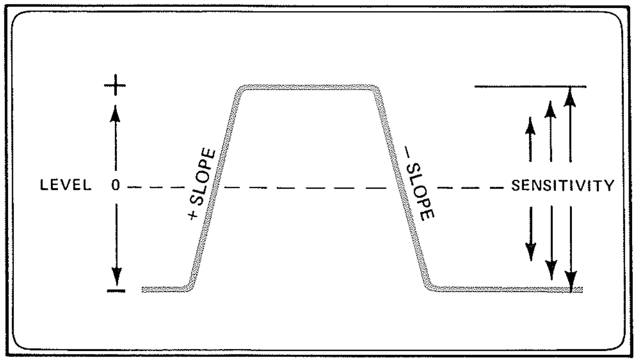


Fig 2. The sensitivity adjust determines the minimum circuit response (in mV). The trigger level centering assures proper slope and level operation in all coupling modes.

typically the most difficult position in which to make trigger adjustments. If the circuit functions properly in this position, you can be assured that the circuitry is good. Set the sweep speed for the appropriate speed to observe 5-10 cycles of the square wave signal. Preset the trigger sensitivity (if there is one) to midrange. Note: If the instrument has a STABILITY control, adjust the control until the trace free runs and then backoff the adjustment 10-15°.

Adjust the trigger level centering for proper switching as the slope switch is switched from + to −. Decrease the signal amplitude slowly, continually adjusting the trigger level centering control, until switching occurs while changing POLARITY. If a problem develops, try changing the tubes or transistors in the comparator and the trigger generator or pulse generator stages. Continue this procedure until the signal amplitude is decreased to 4 or 5 mm.

Next, apply the signal to the external input source and adjust the trigger sensitivity until the scope triggers on + and − SLOPE with 200 mV of input signal. Check to be certain that the scope will not trigger on either polarity at 100 mV. Caution: Do not adjust the trigger sensitivity to be overly sensitive or the oscilloscope may respond to noise pulses. In addition, tube circuits normally age in such a manner that the circuit becomes more sensitive with age. Once the trigger sensitivity is properly set, then the triggering level centering may be more finely adjusted.

Next, select the AC (sometimes called AC-SLOW) position of the COUPLING switch and note whether polarity remains correct. (A problem here usually indicates the large coupling capacitor is defective.) With 0.5 cm of signal, place he COUPLING switch in DC and adjust the internal trig DC adjust for a stable display. Note: Because of signal attenuation in the DC position, approximately twice as much signal is required as in the AC position. In the DC-coupled mode, any movement of the front panel POSITION control will act as a change in DC level and interfere with circuit adjustments. Once a stable display is obtained, check for proper circuit operation in both positions of the POLARITY switch.

TRIGGER PROBLEMS IN TRANSISTOR CIRCUITS

Troubles in the auto-multi block are indicated when triggering with a signal is normal, but there is either no trace or a blinking trace in the automatic mode. This usually indicates a defective or leaky transistor. If a free-running trace is present with signal input conditions, disable the auto-multi block to confirm proper operation of the NORM mode.

A problem in the trigger generator is usually indicated by NO triggering capability. The most common problems in the trigger generator are TD's and transistors. The TD, as well as the transistors, may be checked using a Tektronix Type 575 or 576 Curve Tracer. Defective gating diodes in the Trigger Generator show up as an inability to trigger on one slope. If the problem appears to be a free-running display with no trigger capability in either slope (AUTO mode), the bifilar transformer should be checked. If trigger operation is erratic in HF SYNC, suspect a slow-switching TD.

Comparator stage problems are usually indicated by insufficient range of the variable controls. If this condition arises, change the transistors to determine if the problem is devices or circuitry. If switching of devices unbalances the circuit in the opposite direction, replace the device(s) as they are unbalanced.

TRIGGER PROBLEMS IN TUBE CIRCUITS

If the trigger input stage has a vacuum-tube input, a leaky stage will show up as drift in adjustment. Leakage may be easily checked by monitoring the input to the trigger amplifier/comparator from the triggering level circuit and then switching the SOURCE from INT to EXT. A shift of more than 200 mV indicates excessive leakage.

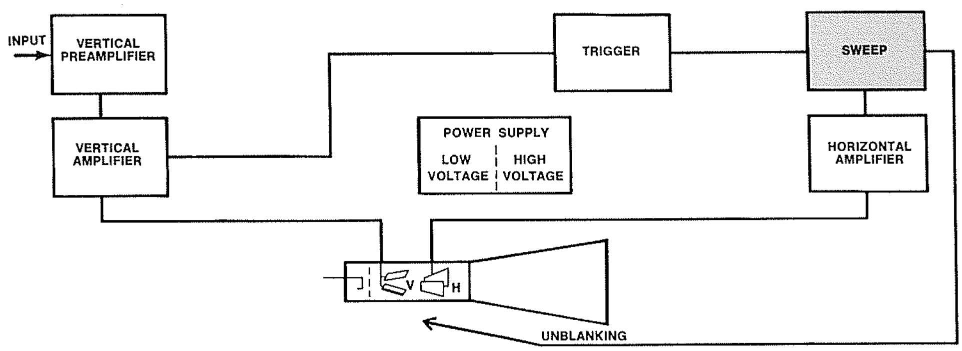
If triggering is erratic near 0 on the trigger level, but control is okay at other points, suspect a defective trigger LEVEL control. If erratic triggering on small signals is noted in INT, the internal trigger pickoff path should be checked for excessive noise.

No trace without input in the AUTO mode (other triggering normal) indicates a weak Pulse Generator tube. If the problem is a bright trace without input the STABILITY and PRESET should be checked for proper operation and adjustment.

NOTE: If possible, use aged tubes or allow tubes to age-in several hours before final realignment for most stable adjustment.

NEXT: Troubleshooting the Sweep

SERVICE SCOPE



TROUBLESHOOTING THE SWEEP CIRCUITS

By Charles Phillips
Product Service Technician, Factory Service Center

This fifth article in a series discusses troubleshooting techniques in the sweep circuits of Tektronix instruments. For copies of the preceding four TEKSCOPE articles, please contact your local field engineer.

Tektronix sweep circuits are designed to develop a linear sawtooth voltage over a wide range of sweep times. Linear sawtooth voltages ensure that the waveform passes through a given number of volts during each unit of time. The sawtooth rate of rise (or fall) is set by the normally calibrated TIME/DIV control. This sawtooth voltage is then processed in the horizontal amplifier and applied to the plates of the CRT, resulting in the horizontal deflection of the electron beam.

As a result, the cathode-ray beam is swept horizontally to the right through a given number of graticule divisions during each unit of time—the sweep rate being controlled by the TIME/DIV control. In this manner, a baseline is produced that is proportional to discrete amounts of time (determined by the TIME/DIV control). By measuring the distance between two different horizontal points on the CRT display a time difference reading may be easily made.

Delaying sweep oscilloscopes are quite common and provide two separate complete sweep systems. The first, or delaying sweep, provides a delayed sweep trigger just prior to the moment when the signal of interest occurs. Generally, a 10-turn multiplier dial used with the TIME/DIV control provides a continuously variable sweep trigger and initiates the delayed sweep at the desired time. Delaying sweep oscilloscopes provide both increased measurement resolution and accuracy.

Modern time-base generators generally consist of five main circuits: a sweep gating multivibrator, a Miller runup (or rundown circuits (sawtooth generator and disconnect diode), holdoff circuitry, sweep lockout circuitry, and automatic sweep generator circuitry. In addition, the sweep circuit provides the unblanking signal to the CRT and often a sawtooth and/or gate output on the instrument panel.

Sweep generators make use of operational amplifier techniques to obtain their required linearity. As a result, if circuit problems appear, they are sometimes difficult to troubleshoot because of the feedback loops involved. Usually the feedback loop must be broken in order to localize the circuit problem.

When troubleshooting an oscilloscope sweep circuit, examine the simple possibilities before proceeding with extensive troubleshooting. The following list provides a logical sequence to follow while troubleshooting sweep circuitry.

1. Observe CRT display characteristics.
2. Check control settings.
3. Isolate trouble to block.

4. Thorough visual check.
5. Check voltages and waveform.
6. Check individual components.

When troubleshooting sweep circuits, free run the sweep to be certain that the trigger circuitry is not inhibiting sweep operation. Gate and sawtooth output connectors provide a quick check of circuit operation and may provide a clue to the problem. If no outputs are observed, check to be certain that trigger inputs are gating the sweep gate circuits.

Holdoff and feedback operation may be checked by monitoring the cathode of the holdoff circuit. Check to see if the cathode of the holdoff cathode follower follows the action of the sweep length control. A similar check is to vary the stability control while monitoring the lockout multivibrator cathode. These two blocks comprise most of the feedback path and if their cathode follower action is inoperative, the problem is quickly localized.

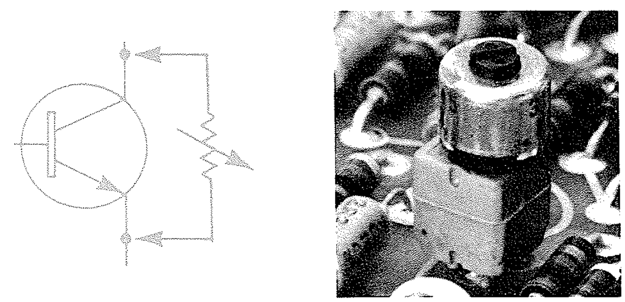
TECHNIQUES

A Tektronix Type 575 or Type 576 is very useful to check tunnel diodes in the circuit (in most cases). If there is any doubt of device performance, one end may be lifted. Connect test leads directly across the TD. Set the vertical sensitivity on the 576 to cover the sensitivity of the diode under test and the horizontal to .1 V/div. (Typical TD's have a horizontal switching voltage of $\simeq \frac{1}{2}$ volt.) The waveform is not exactly like an out-of-circuit check, but in most cases, it indicates whether the TD is working properly. This procedure prevents mechanical strain or excessive heat from being applied to the TD. The photos below show an in-circuit and out-of-circuit check being made on the same TD. Interaction caused between the test leads and the circuit will sometimes produce a cluttered trace, but switching can nearly always be detected.

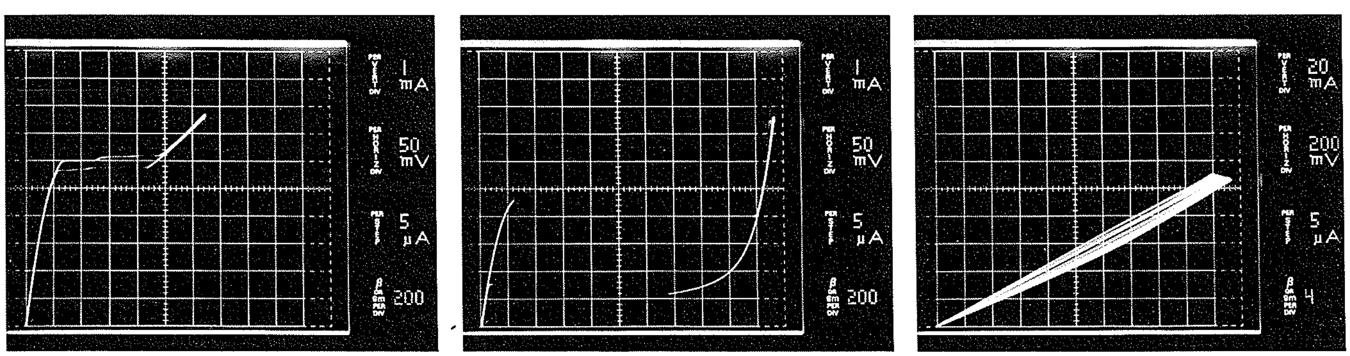
Noisy resistors can also be checked dynamically (with power off on instrument under test) on a Tektronix Type 576. Connect test leads from the sockets on the 576 to the resistor under test. Use the emitter test lead for the low point of the resistor under test and the collector lead for the high point. With the collector sweep in "+" polarity, dial in the proper amount of voltage. (If you don't know how much voltage to use—turn the instrument on and check the voltage drop across the resistor with a meter first.) Next, set the horizontal and vertical switches on the 576 to display the waveform on screen. Noisy resistors will show as an intermittent or broken line. The photo below shows a defective resistor that appeared normal with an ohmic check.

Often it is necessary to start the sweep gating multivibrator manually. If the sweep does not run, ground the collector of the sweep gating multivibrator (e.g. Q504 in a Type 453) and monitor the collector of the sawtooth sweep rundown circuit. This should cause the sweep to rundown and let you troubleshoot in a normal manner.

Breaking the feedback loop is often helpful in large operational amplifiers. One technique that can be used is to pull the transistor from the reset emitter follower and ground the emitter terminal (e.g. Q543 in a Type 453). A sweep should occur each time the point is grounded. Or remove the reset multivibrator (e.g. Q585 in a Type 453) and apply an external positive DC voltage at the collector terminal to "brute force" the sweep to run. (The Type 576 is again convenient for this application.) Often a 10-kΩ minipot connected as shown will work nicely and will plug right into the transistor socket. This is a convenient method since the internal voltage from the collector supply may be used as the voltage source.



A minipot connected into a transistor socket as shown is a convenient way to "brute force" the sweep.



Series of waveforms illustrating the use of the Type 576 Curve Tracer as a versatile troubleshooting tool. Left: In-circuit TD check. Center: out-of-circuit TD check. Right: Noisy resistor.

Another technique is useful when timing delaying sweep oscilloscopes. The horizontal display is set for A delayed by B with A sweep free running. Start with the fastest B sweep where A can be run 100 times faster than B. This will make each cm equal to 0.1%. Set the delay time multiplier to 8.95. This will move the 9th marker to center screen for 0% tolerance.

Each cm to the left of center screen now equals —.1% error and each cm to the right equals +.1% error. Start with time marks of the same speed as the B sweep. If the 9th marker shows up on screen, the error can be read directly + or — from how far it is from center screen. Decrease sweep speeds (A and B) by 1 switch setting until each range of the delayed sweep is checked. When two markers show up on screen, it is time to switch the time-mark source to the next lower decade to match the B-sweep TIME/CM setting. If the pulse is off-screen, use the delay time multiplier to position the pulse on screen and read the number of minor divisions that it takes. Each minor division is equal to 0.1%.

TYPICAL SWEEP TROUBLES (TUBE)

1. Sweep shortens at faster sweep speeds.
   Check: The sawtooth output cathode follower may be loading the circuit. Remove the sawtooth cathode follower and note whether the problem disappears. If the trouble is not in this stage, then check the output stage of the horizontal amplifier.

2. Sweep non-linear at the left side of the CRT.

   Check: Faulty holdoff circuit operation may be causing the problem. Check holdoff cathode follower for gassy tube or improper circuit operation.

3. Sweep shortens on right side of the CRT when sweep is triggered.

   Check: An open diode in the positive trigger clipper circuit may inhibit positive clipping of the sweep gate input and cause premature rundown of the sweep.

4. Sweep tends to free run at different sweep speeds when triggered at other speeds.

   Check: Preset stability is misadjusted or lockout multivibrator circuit operation is weak.

5. Sweep will not run by itself, but will start when shock excited (i.e., rotating the TIME/CM switch).

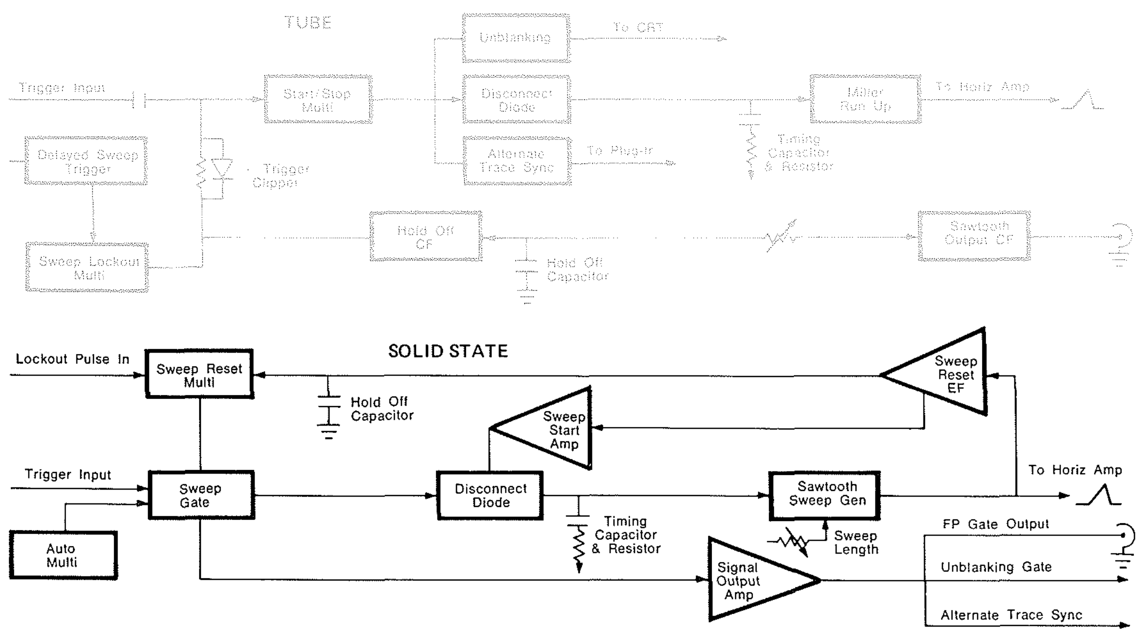
   Check: Start-stop multivibrator circuit failure will show these characteristics. Check the tube and circuitry. Off-tolerance precision (1%) resistors in this circuit will sometimes cause this problem.

6. Sweep non-linear or inaccurate at slow sweep speeds. (In extreme cases, spot may stop part way through the sweep.)

   Check: Disconnect diodes should be tested. Check for proper operation by starting the sweep, and then removing the disconnect diode and see if problem clears itself. The sweep will run for one sweep and stop. Replace diode and repeat procedure if necessary to get a better look. If this procedure clears up the problem, the disconnect diode is faulty (leaky or gassy).

7. Sweep non-linear at some TIME/CM settings; normal operation at others.

   Check: Miller runup circuit may be leaky. Check for gassy Miller tube.



8. Sweep timing off at several of the slower sweep speeds (below 1 ms/div).

   Check: Suspect precision timing resistors. Many older oscilloscopes used brown A-P resistors on the sweep timing switches. These resistors changed value with age and should all be changed.

9. Delayed sweep operation, normal; delaying sweep operation, normal but cannot obtain triggered delayed sweep when using both sweeps.

   Check: Suspect weak or defective delayed sweep trigger amplifier.

10. Sweep timing accuracy long in the .1, .2, and .5 ms/div range.

    Check: Unsolder one end of the small padder capacitor in parallel with the .001 μF timing capacitor located on the A sweep timing switch and monitor timing. If timing is improved, remove the small capacitor.

11. Erratic starting of sweep.

    Check: Noisy resistor in sweep start-stop circuit or poor connection of high voltage anode lead can cause this problem.

12. Erratic sweep operation, sweep start is not erratic.

    Check: Noisy or heater cathode leakage in disconnect diode may cause this problem.

TYPICAL SWEEP TROUBLES (TRANSISTOR)

The operation of transistorized sweep circuitry is generally similar to the tube type circuitry. Some additional specific checks that may be useful are:

1. Sweep inoperative.

   Check: Check the sweep gate transistor and the sweep TD. If these operate properly, then check the fixed divider at the input of the sweep reset multivibrator for proper value.

2. Sweep inoperative.

   Check: If normal troubleshooting doesn't produce a trace (see techniques), check the sweep length circuit. A diode failure or bad switch contact in the sweep length circuit may cause an inoperative sweep.

3. Sweep timing error at different sweep speeds.

   Check: Gallium-arsenide diodes used in the sweep disconnect circuit may be defective. Replace if necessary.

4. Sweep jitter.

   Check: Gallium-arsenide diodes used in the sweep disconnect circuit may be defective. Replace if necessary.

USED INSTRUMENTS FOR SALE

1—Type 526, SN 1544. Price: $1295. Contact: Donald K. McConnell. General Electrodynamics Corp., 4430 Forest Lane, Garland, Texas 75040. Telephone: (214) 276-1161.

1—Type 514D. Excellent condition. Price: $400. Contact: Dr. William Carr, Southern Methodist University, Dallas, Texas 75222. Telephone: (214) 363-5611, extension 2221.

1—Type 524AD/202-1, SN 7750. Two years old. Price: $1000. Contact: Dave Sanders or Charlie Henry, American Microwave & Communications, 203 Stephenson Avenue, Iron Mountain, Michigan 49801. Telephone: (906) 774-2923.

1—Type 422. New. Price: $1,250. Contact: Ellsworth M. Cochran, 7805 Laurel Ave., Cincinnati, Ohio 45243.

1—Type 514D, SN 1348. Excellent condition. Price: $250. Contact: Robert Bartell, RD 2, P.O. Box 31, Kingston, New York 12401. Telephone: (914) 331-9019.

1—Type 545 with D plug-in unit. Price: $1,100. Contact: Dr. J. McConn, Cornell University, Division of Biological Sciences, Savage Hall, Ithaca, New York 14850. Telephone: (607) 275-4809.

1—Type 535A. 1—Type 545A. Several plug-ins for 530/540 Series. 1—Type 515A. 1—Type 575. Contact: Harry Posner, Pacific Certified Electric. Telephone: (213) 225-1584.

1—Type 3A72, SN 4690. Price: $200. 1—Type 53A. Price: $35. Contact: Mr. Myhre, Mission Engineering, Inc., Hiawatha, Iowa 52233. Telephone: (319) 393-2253.

1—Type 310A Contact: Don Pagan, Varian Data Machines, Irvine, California. Telephone: (714) 833-2400.

1—Type 310A, SN 014771. Price: Best offer. Telephone: (415) 326-6200 Extension 2619.

1—Type 551,, SN 3247. Excellent condition. Price: $1350. Contact: Wayne Hunter, Exact Electronics, Hillsboro, Oregon 97123 Telephone: (503) 648-6661.

1—Type 551, SN 002812. 1—Type CA, SN 027013. 2—Type B, SN 011852 and SN 018247. Will sell as a unit for $700. Contact: Jim Rogers, Pacific Assemblers, 4500 Campus Dr., Suite 524, Newport Beach, California 92660. Telephone: (714) 540-0030.

1—Type 454 with cart. Approximately one year old. Perfect condition. Price: $2500. Contact: Robert Crawford, 124 West 86th St., New York, New York 10024. Telephone: (212) 787-6715.

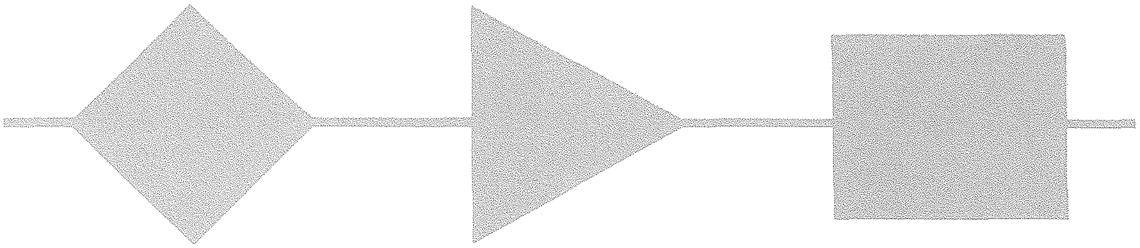
1—Type 321, SN 003443. Has batteries. Price: $400. Contact: Evans Wheeler, 539 South Raymond Ave., Pasadena, California 91101. Telephone (213) 449-5650.

1—Type 533A, SN 4859 with Type B Plug-In, SN 19959. Excellent condition. Used 100 hours. Price: $675. Contact: Henes Manufacturing Co., 4301 East Madison St., Phoenix, Arizona 85034.

Sampling dual-trace and time-base plug-ins for 560 series. 1—Type 3S76, SN 408. 1—Type 3T77, SN 437. 2—Type P6032. All like new condition. Purchase date 4/31/62. Contact: Burr-Brown Research Corp., Tucson, Arizona 85706. Telephone: (602) 294-1431.

A-2412 Printed in U.S.A. 9/69 SKD

SERVICE SCOPE



Troubleshooting Sampling Systems

By Charles Phillips
Product Service Technician, Factory Service Center

Confidence and knowledge enable a service technician to complete his services with best results. Confidence in servicing sampling scopes is sometimes prevented by unnecessary awe of subnanosecond region instrumentation. With normal preparation, you will find much of your knowledge and experience with real-time scopes is of direct value when working on these "fast" scopes.

This article will discuss adjustments and troubleshooting in vertical systems with particular emphasis on the *Sampling Loop*. All Tektronix Sampling Oscilloscopes* use an error or difference detecting technique. Since they use this technique, you will find a similarity in the various sampling systems. These similarities allow us to work in this article with a "composite sampling scope" and make some generalized statements about samplers. These generalizations should not be used in place of specific information included in your instrument's instruction manual. That manual's calibration section should be your source of specific adjustment information. Your Tektronix Field Engineer can aid you further with your individual requirements.

A display visible on screen is the most valuable aid available to you. Here are a few ideas on getting that trace.

*N unit exception.

> *Sampling Notes* and *Sampling Oscilloscope Circuits* by John Mulvey are two publications available from your Tektronix Field Engineer that are valuable sources of sampling facts.

We should start with the output of the vertical system. Output circuitry is straightforward. It amplifies the output of the *Sampling Loop* to drive the vertical deflection system. It can be isolated from the Sampling Loop by sliding the NORM/INVERT switch to its center. This blocks the input to the output circuits and will allow you to localize the off-screen problem to the "loop" or the "output".

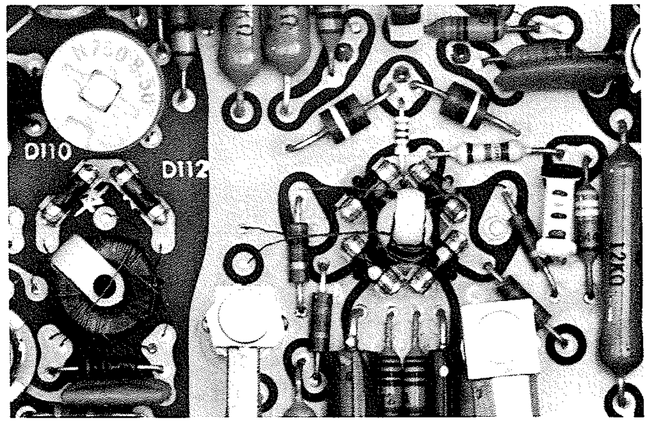
After you have the "output" functioning, set the NORM/INVERT switch to NORM. If no trace is on screen, you should suspect the loop. Try the following:

1. Apply a 25-kHz squarewave of approximately 300 mV to the input. Use 200-mV/div sensitivity.
2. Free run or trigger the time base and use about 10 dots per division, zero the offset (use meter at output jack) and the *Position* control should bring the display on screen. If the position control does not do the job, center it at about 12 o'clock.
3. If step 2 does not produce a display, vary each of the internal adjustments in the "loop" and sampling gating pulse generator full range, one at a time, remembering the original settings. If an adjustment does not reveal a display, return it to its original setting and proceed to the next one. If any adjustment brings the display on screen, attempt to achieve a correct response by using your manual. If all adjustments fail, leave them in their original position and proceed to the troubleshooting information.

SOME INFORMATION ON ADJUSTMENTS

The section of the sampling system that is located within the *Sampling Loop* has the most effect on waveform, risetime, aberrations, and vertical trace position. The adjustments we will discuss often interact and may appear to have the same function. This interaction and similarity of results on screen should be explored to get the "feel" of the system. This "feel" cannot be derived from any written material.

No harm will result if you try extreme range combinations of the adjustments. By this exploration of extreme settings, you rapidly build confidence by gaining knowledge and experience.



Here's where most of the fast action occurs. A four-diode bridge makes the sub-nanosecond voltage sample. The two-diode memory gate accepts processed sample and holds the information for CRT vertical deflection.

Memory

Memory Balance—Purpose: To adjust for no trace shift when "smoothing" (front panel) is operated. Effect: See purpose.

Memory Gating Pulse Width—Purpose: To allow memory to respond to the full input signal. Effect: Will cause "rounded corners" of signal at one extreme (gain <1) or oscillation (gain >1).

Amplifier

Loop Gain—Purpose: To adjust for maximum signal to the memory. Effect: Will cause "rounded corners" of signal at one extreme or oscillation at the other. May also be located in the memory.

Dot Response—Purpose: A front panel adjustment to maintain a loop gain of 1 after internal adjustments have been set. Effect: Similar to loop gain (very evident when using a random sampling system).

Smoothing—Purpose: A front panel control for minimizing noise. Effect: Similar to loop gain, but usually its effect varies from unity gain to less than 0.5 gain.

Sampling Gate

Sampling Gate Volts—Purpose: To set voltage across gate diodes, normally about 2 volts for proper display risetime and dynamic range. Effect: Risetime is changed as adjustment is made.

Sampling Gate Balance—Purpose: To neutralize trace shift as mV/div switch is rotated. Effect: See purpose.

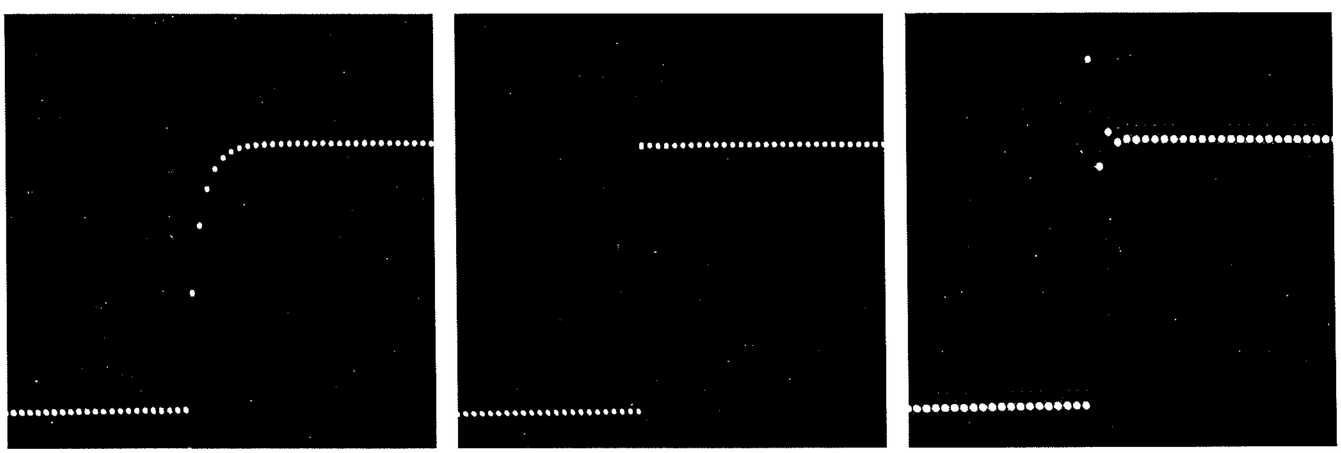
Blowby Compensation—Purpose: To neutralize capacitance in the sampling gate. Effect: Will change aberrations in the 2-μs interval after risetime.

Strobe Pulse Generator

Snap-off Current—Purpose: Adjusts strobe pulse for best resulting display risetime. Effect: Has the most significant control over risetime.

Avalanche—Purpose: To drive the sampling strobe source with minimum noise and jitter. Effect: In addition to noise and jitter effect, there are some risetime effects.

All the adjustments in the loop and strobe generator will have some loop gain effects. It is usually worthwhile to recheck for unity gain using your manual information after completing adjustments.



The sampling gate is unable to fully charge the amplifier input capacity with one sample. Feedback after the gate completes the charging process. Adjustments in the "Loop" produce (1) less than full charge (gain <1) (2) full charge (gain $= 1$) (3) more than full charge (gain >1).

SOME SOLUTIONS

Problem: Dot transient response difference between plus and minus signals.

Check: If more than 10% difference, sampling gate should be replaced.

Problem: Baseline shift with change of trigger frequency.

Check: Set front panel controls for a free-running trace at 2 mV/div (or highest sensitivity). Change time/div through entire range. Trace shift should be less than 2 divisions. If more, the sampling gate diodes should be interchanged. Replace diodes if necessary.

Problem: Memory slash (vertical elongation of dot at low trigger rates).

Check: Trigger sweep at 10 Hz; if slash is more than 0.6 divisions, interchange memory diodes or replace them. Other sources of slash are tubes and FET's.

Problem: Noise, microphonics, level changes, gain changes.

Check: Sampling gate diodes seated with proper clip tension. Grounds solidly made, soldered properly and mechanically tight. Input connectors tight. Input 50-Ω resistors should not be discolored and should be within ±1 Ω. Nuvisor socket should have sufficient tension in tab slots for good grounds.

Problem: Display tilt.

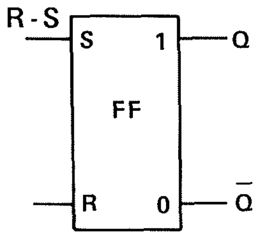
Check: If problem is most noticeable at about 1 MHz, the sampling gate is most suspect. Try blowby adjustment, then gate diodes. If interaction between both channels is noticeable, especially at certain positions on screen, check output amplifier tubes and channel switching diodes.

BREAKING THE LOOP

The feedback in the Sampling Loop can be disabled to further localize problems. Isolation of the memory can be easily accomplished by lifting one end of the memory gating diodes. Some instruments use built-in clips for resistor insertion for isolation. If this provision is made, see your instruction manual.

The sampling gate may be isolated by disconnecting the center arm of the sampling gate balance. This will allow you to check for proper voltages around the gate circuits. You may wish to remove the diodes to check for proper bridge voltage before replacing the gate diodes.

CORRECTION



Input		Output	
R	S	Q	$\bar{Q}$
LO	LO	No change	
LO	HI	HI	LO
HI	LO	LO	HI
HI	HI	Undefined	

Frankly, our truth tables are a pack of lies! In the December Issue, the article "A Basic Logic Review" had a mistake in the R-S Flip-Flop Truth Table. A corrected table is shown above. Our thanks to our readers for notifying us and our apologies for not detecting it.

The Editor

INSTRUMENTS FOR SALE

1—Type 511AD. In operating condition. Contact: Bruce Blevins, Box 2012, Socorro, New Mexico 87801. Telephone: (505) 835-5555.

1—Type 514AD. Good condition. Will accept reasonable offer. Contact: M. R. Sparks, 104 Ward Street, Oxford, North Carolina 27565.

7—Type 535A/CA. 1—Type 543B. Other 530/40 Series with plug-ins. Contact: Mr. Posner, Pacific Engineering Company. Telephone: (213) 225-6191.

1—Type 547, SN 11965. 1—Type 1A1, SN 24603. Both brand new. Contact: Mr. G. Schneider, Space Electronics, 40 Cottontail Lane, Irvington, New York 10533. Telephone: (914) 591-8681 or 8774.

1—Type 1A1, SN 016111. 1—Type 1A2, SN 006740. 1—Type 516, SN 004789. Contact: Bob Smith, Interactive Data Systems, P. O. Box A-O, Irvine, California 92664. Telephone: (714) 549-3329.

1—Type 516. Just calibrated and in excellent condition. Price: $600. Contact: Heinz Frederick, Data Products Corp., 6219 De Soto Street, Woodland Hills, California 91364. Telephone: (213) 887-8219.

1—Type 581, SN 966. 1—Type 82, SN 7944. 1—Type C-40, SN 10639. Reconditioned by Tektronix one and one half years ago. Lot Price: $1900. Contact: Ken Marich, Stanford Medical Center, Room 230, Stanford, California 94304. Telephone: (415) 321-2300 Ext. 6071.

1—Type 546/1A1. Good condition, small amount of use. Price: $1900. Contact: Don R. Green, Ferson Optics, P. O. Box 629, Ocean Springs, Mississippi 39564.

1—Type 575 Mod 122C and 1—Type 202-2. Used approximately 30 hours. Price: $1000. Contact: Mrs. Wainwright, I-Tel Corp., 10504 Wheatley Street, Kensington, Maryland 20795. Telephone: (301) 946-1800.

1—Type 545, SN 15990. 1—Type CA, SN 9652. Price: $1250. Contact: Les, 575 South Barrington, Apt. 202, Los Angeles, California 90049. Telephone: (213) 472-0882.

1—Type 541, SN 693. Best offer. Contact: Mr. Greg Jigamian, Hanson Hawk, Inc., 20327 Nordhoff St., Chatsworth, California 91311. Telephone: (213) 882-9600.

4—Type RM503, SN 001848; SN 001651; 00905; and SN 001866. Price: $450 each. Contact: Stuart Ex, 14827 Cohasset, Van Nuys, California 91405. Telephone: (213) 786-7672 or 873-7672.

INSTRUMENTS WANTED

1—Type 2B67 Time Base. Contact: F. O. Wiseman, T. B. Woods & Sons Co., Chambersburg, Pennsylvania 17201. Telephone: (717) 264-7161.

Printed in U.S.A. 3/70 A-2423

SERVICE SCOPE

TROUBLESHOOTING SAMPLING SYSTEMS PART II

By Charles Phillips

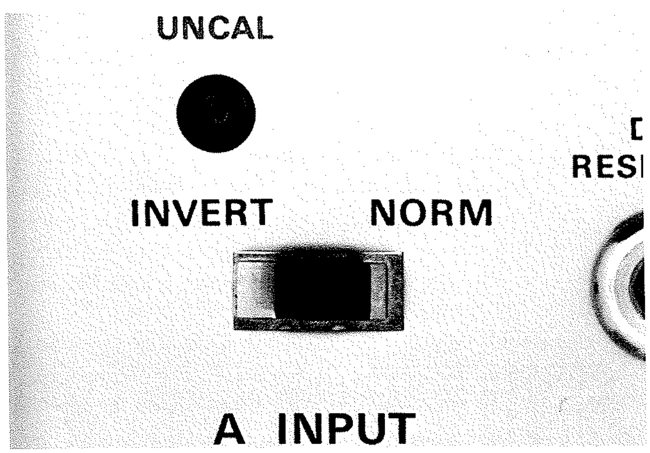
Product Service Technician, Factory Service Center

In the last issue, we covered the vertical circuitry of a "composite" Tektronix Sampling Oscilloscope. This issue discusses troubleshooting the typical horizontal system of that scope.

A spot or trace on screen is very useful in analyzing and finding problems in any scope. To eliminate the effects of most vertical problems, slip the NORM/INVERT switch to its center. A trace or spot will be centered vertically except when the vertical output circuits are defective. Use the horizontal position control to verify that the horizontal deflection amplifier is functioning.

In the absence of a trace, rotate the trigger sensitivity control. If no time base appears, switch to a manual scan mode. In manual scan, a variable DC voltage is substituted for the staircase equivalent time base. The manual scan should plot a horizontal line.

After you have established that the horizontal amplifier and staircase circuitry are operating, set the NORM/INVERT switch to NORM. Now let's proceed to the trigger circuitry. Regenerated trigger pulses should appear at the front panel trigger output connector or at the input to the fast ramp stage if the trigger circuit is operative. Use the trigger sensitivity control over its full range until trigger waveforms appear.



Slide switches of this type "break before make". This allows the troubleshooter to select a mid-range break position that opens the input to the output amplifier.

We now proceed to the fast ramp and comparator. With the regenerated trigger operational, a timing ramp of short duration should be generated. At the input to the comparator, a slewing ramp waveform should appear on a test scope. This slewing waveform verifies operation of the fast ramp and comparator. When the staircase is not functioning, the manual scan may be substituted for the staircase to analyze the fast ramp and comparator.

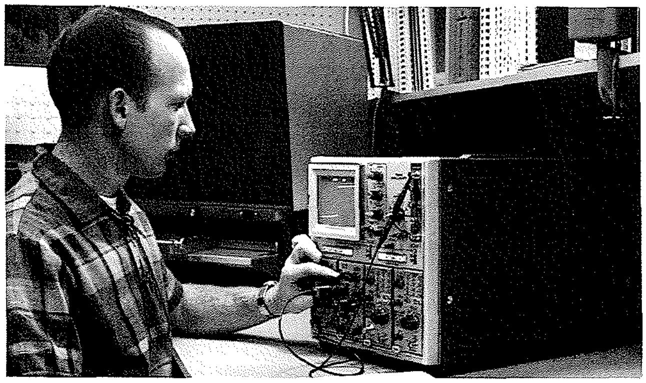
GENERAL TROUBLESHOOTING TECHNIQUES

The techniques used in troubleshooting sampling circuits are generally the same as for any other circuit. You should know the function of front panel controls and how the circuits work. In any malfunctioning circuit, transistors and tunnel diodes are the most suspect components. Here are some of the techniques that we have found helpful in locating defective components.

If you have a unit that is intermittent or drifts, routine checks may reveal no problem. Use a small, portable hair dryer to apply heat to the area where a problem is suspected. Then cool that area with spray-type, circuit cooler. The quick change in temperature will normally cause a defective component to malfunction severely. In many cases, the component will open or short. Locating the defective part should then be easy.

Elusive intermittents are often nailed by using circuit cooler and a hair dryer.

Some tunnel diode troubles are hard to detect. For example, the sampling system may operate, but the operation is not "normal". Triggering insensitivity, display jitter, balky time base operation all may be caused by a sluggish tunnel diode. A Tektronix 576 or 575 Curve Tracer is a very valuable instrument for identifying marginal tunnel diodes and transistors. A sluggish tunnel diode develops excessive voltage before switching. A slower "turn on" voltage than normal results. A good tunnel diode will switch at about 100 mV. A sluggish tunnel diode can develop 200 mV or more before switching.

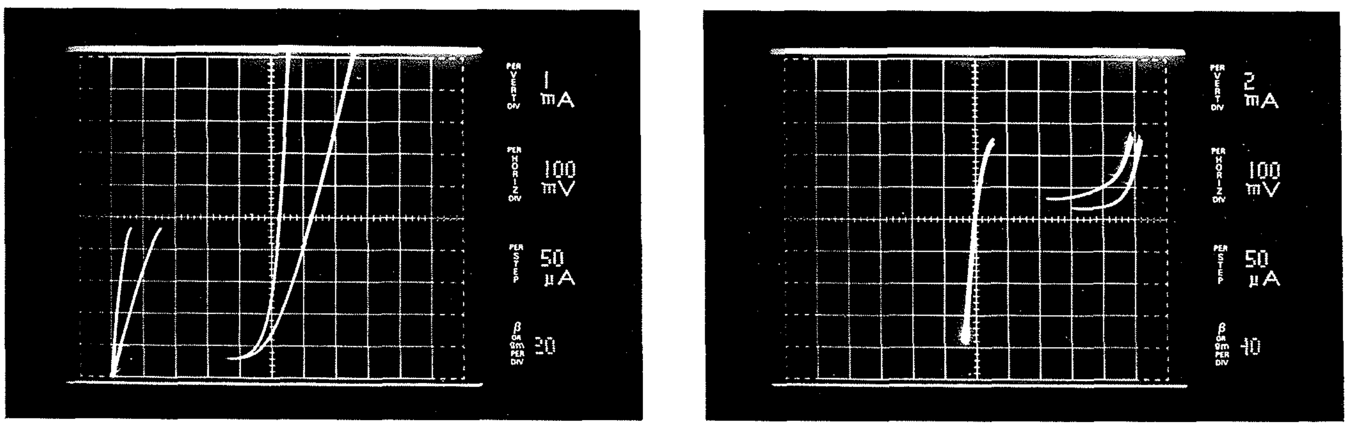


Chuck Phillips uses the 7504 Oscilloscope Sawtooth to verify correct TD performance.

Other methods of testing tunnel diodes are helpful where no curve tracer is available. The sawtooth output from a scope may be used to drive the tunnel diode to determine its switching point.

The sawtooth on a 7000-Series scope is a handy tunnel diode test signal. 10 mA or less TD's may be checked by placing them across a probe from ground lead to tip. The tip is then touched to the sawtooth output. The resulting display will show the voltage across the TD in the vertical axis. Each horizontal division will represent approximately one milliampere. A good 4.7 mA device will switch between the fourth and fifth horizontal division and develop about 500 mV. Caution: Some other scope sawtooth outputs are not current limited; a limiting resistor must be used.

Go, No/Go tests may be made with the multimeter. With power on, an in circuit voltage measurement across a tunnel diode should read 200 to 600 millivolts. A reading of 0 volts or substantially greater than 600 millivolts is a good indication of a shorted or open tunnel diode.



Marginal Tunnel Diodes are quickly detected with Tektronix 576 Curve Tracer. In the left photo, the "good" TD switches at 4.7 mA and 60 mV. The "poor" unit develops 160 mV before switching at 4.7 mA. The right photo shows "acceptable" waveforms made with the AC position of the 576. The AC Mode is a full sinewave sweep mode useful in making quick diode checks. It eliminates the need to observe diode polarities. (Photos are double exposed.)

PROBLEMS & CHECKS

Horizontal Amplifier

Problem: Position control will not move trace or positioning range is not normal.

Check: A. Sweep centering adjustment for proper centering.
B. Output stage for unbalance.

Problem: Display compression or expansion.

Check: A. Output stage.

Staircase Generator

Problem: Sweep starts at a different point on screen than it does in the manual scan position.

Check: A. Staircase DC level adjustment.
B. Output stage tube, nuvistor, or transistor.

Problem: No single sweep operation when in the single sweep mode.

Check: A. Tunnel diode stage in staircase circuitry.

Fast Ramp

Problem: Sweep nonlinearity at beginning of trace.

Check: A. For proper adjustment of the comparator.
B. Comparator tunnel diode.

Problem: Slashing between dots or other indications of improper blanking or unblanking.

Check: A. Transistors in the staircase inverter circuit.

Problem: Time base calibration changes with different values of trigger sensitivity.

Check: A. Transistor at input of the fast ramp where the regenerated trigger signal is applied.

Problem: Center of time base is nonlinear.

Check: A. Nuvistor or transistor in sweep calibration adjustment stage.

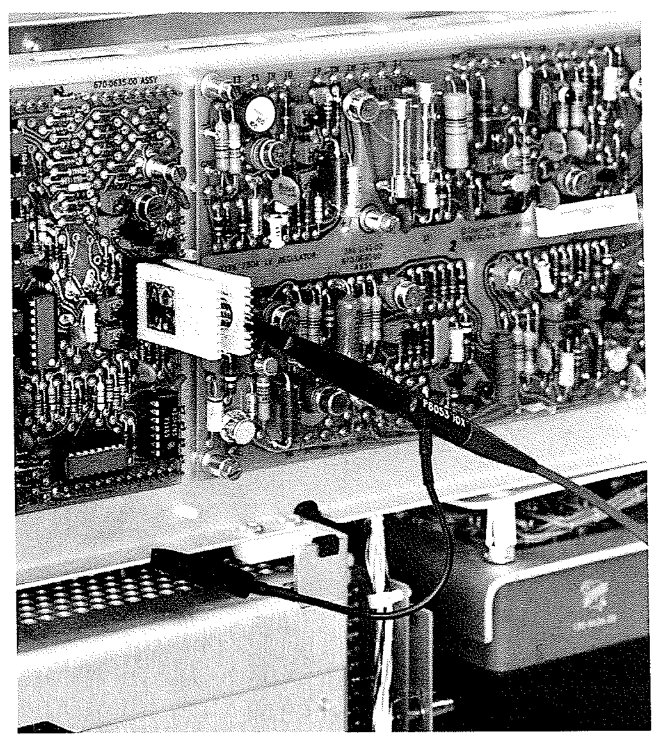
USEFUL IC TOOLS

Integrated circuits are showing up everywhere. Here are several handy IC handling tools available through your *local suppliers.*

The first item is particularly useful in removing TO5 case devices. This tool, manufactured by The Ephrata Tool Co., has tips that grip the TO5 case securely for pulling out of sockets or boards. This tool also has a handy set up for trimming TO5 leads neatly and easily.

Integrated Circuit Test Clip manufactured by AP Incorporated snaps over a 16 pin line like a clothes pin. It provides accessible test points and can help you pull suspect IC out of sockets and boards. Two sizes are available: 0.3 inch #923700 and 0.5 inch #923702.

Trimming individual leads on integrated circuits and transistors is a nuisance. This Ephrata cutter does the job with less effort.



Dual in-line integrated circuits often lack convenient probe test points. The AP, Inc. test clip simplifies the probing job.

SERVICE SCOPE

TROUBLESHOOTING THE 453

By Charles Phillips
Product Service Technician, Factory Service Center

The 453 Oscilloscope has become the most widely used instrument in field servicing. It's also a popular lab item. This popularity makes it likely that you will work on one some day soon. When that day comes and a 453 turns up on your bench needing service, normal scope troubleshooting procedures and the manual are sufficient to locate the source of trouble. All of us develop extra problem solving techniques when we work regularly on a particular series of instruments. We come to recognize and look for troubles we have seen before. I would like to share a few experiences and ideas related to the 453, particularly those with serial numbers above 20,000.

TIME BASE

When time base troubles are suspected, the first thing to do is eliminate possible front panel problems. Remember, all four levers up in the A Sweep control area will produce a time base functioning scope. Then push the TRACE FINDER button to reveal a trace. If no trace appears, we must then positively eliminate the horizontal amplifier as the trouble area. To do this, set the Horizontal Display to EXT. HORIZ. Use the Trace Finder and Horizontal Position controls; you should have a spot that can be moved freely across the CRT.

O.K., we have established the trouble is in Time Base A (A Sweep).

Time base generators consist of a gate generator and an integrating circuit. There are a number of auxiliary circuits tied into the complete time base package. Since everything in this package is dc coupled, chasing voltages around a defective sweep circuit can be confusing. Something more is needed to reveal the component at fault and simplify your task. Here are a few techniques that I have found. They get answers quickly.

When a time base generator malfunctions, almost always we have four conditions. That is, the beam is at the left side of the CRT, on or off; or it is on the right side, on or off. If the beam or spot is hung up at the left side, try grounding Test Point 504 (collector of Q504). This should force the integration circuits into running once. You may find it helpful to use a sweep time slower than 0.1 second per division to give you time to see a sweep more readily. If you have problems getting a spot on screen, rotate focus to extreme CW position and use maximum intensity. Defocusing will eliminate any possibility of phosphor burn.

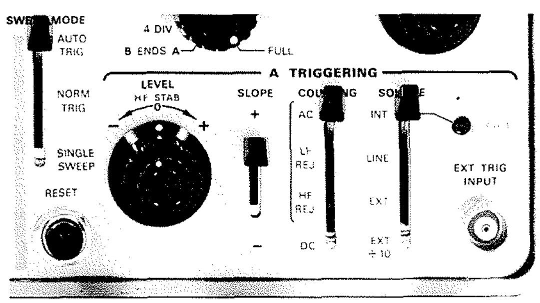
If grounding Test Point 504 starts the time base, the spot will hang up on the right after one sweep until the ground is removed. This is a positive indication that D533, Q533 and Q531 are O.K. If the trace brightened when TP 504 was grounded, Q524 and Q514 are also functioning properly.

The most suspect components are D505, Q585 or Q504. With the sweep forced over to the right, a full rundown condition exists at collector of Q531. The voltage at the collector (Pin AA is a convenient test point) should be about 0. This will be coupled through Q543 and D555 the base of Q575 (use Pin N as a handy test point).

The voltage at the base of Q575 should be about 0, and now you should test or substitute D505, Q585 and Q504. Preferably a curve tracer should be used for tests.

When the spot is hung up at the right side of the screen, the integrator circuit has run down, but has not been reset, Q514, Q543 and Q575 are suspect.

There are occasions when you will find a bright spot at the start of an otherwise normal sweep. There is no unblanking and Q544 should be checked. This is not an obvious effect from the schematic.



All levers up—A quick way to get a sweep on the 453.

If after the above checks, no active devices are found faulty, I have found that it is usually best to verify the values of precision resistors used in transistor base circuits.

B Time Base (sweep) is very similar to A Time Base. Troubleshooting procedures based on forcing the integrator into action can also be used. Just ground Test Point 704 and proceed as in Sweep A.

POWER SUPPLY

Power supply failures in the 453 can be easy to find. Here are some problems and cures.

Problem: Fuse blowing.

Check: Bridge rectifier diodes with ohmeter. Typically, forward readings will be about 2 kilohms, reverse readings should be high.

Problem: Wrong voltages.

Check: If the bridges are O.K., perhaps an overload condition exists somewhere and the protection amplifiers, built in each supply, are *saving* the supply components from destruction. If the base-emitter voltages on a protection amplifier transistor is high, you have a positive indication that an excess load exists. See the tables for typical voltages and resistance under normal conditions.

Problem: High ripple voltages on regulated supplies.

Check: Bridge output filter capacitor may be open.

Problem: Ripple voltages in excess of specifications, but still relatively low.

Check: Filter capacitor at output of each regulated supply. It may be open.

Problem: Wrong output voltage, (voltage emitter/base of protection amplifier within limits).

Check: Protection amplifier transistor for defect. If supply works properly without this transistor, the transistor is bad, replace it.

Problem: Voltages are regulated but somewhat out of tolerance.

Check: Precision resistance values.

Problem: +12 volt supply output low.

Check: Remove Q970 from CRT high voltage supply. The bridge in the +12 volt supply is the source of unregulated dc for the CRT high voltage supply.

CRT HV SUPPLY

Most scopes use a dc to dc converter to produce CRT voltages. An oscillator is used to convert a low dc level to RF. The RF is stepped up through a transformer, rectified and filtered. A sample of the resulting high dc voltage is fed back to control the oscillator voltage. This feedback is necessary to regulate the whole system.

Problem: No significant voltage at TP −1950 V.

Check: Oscillator may be overloaded, pull lead of Pin L on Z Axis Board. This kills the feedback and the oscillator may work, producing higher than normal CRT voltages.

Problem: Oscillator not working after lead to Pin L is removed.

Check: Remove CRT socket. If oscillator functions, the CRT has a problem.

Problem: Oscillator still does not work with Pin L disconnected.

Check: Lift one end of each high voltage rectifier D952, D940, V952, and V962. This "unloads" the secondary and the oscillator will probably start operating. Test semiconductor high voltage diodes D940, D952, and vacuum tube rectifiers (V952, V962) by replacing one at a time. If this does not work, the H.V. filter capacitors should be checked.

The innovative technician can often build upon the manual and other routine maintenance information. The only thing required is imagination and experience.

POWER SUPPLY

TYPICAL PROTECTION AMPLIFIER BASE-EMITTER VOLTAGES

SUPPLY	ACROSS	NORMAL VOLTAGE
−12 V	R1129	0.175 V
+12 V	R1159	0.125 V
+75 V	R1187 & R1188	0.375 V
+150 V	- -	- -

TYPICAL NORMAL RESISTANCES

SUPPLY	TEST POINT	RESISTANCE*
−12 V	H	80 Ω
+12 V	D	70 Ω
+75 V	B	1 kΩ
+150 V Unreg.	F1204	2.6 kΩ

*Negative lead of meter to ground

TEST POINTS

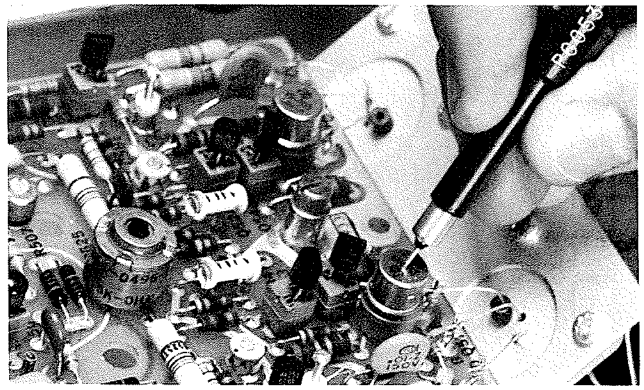
Where can you hang that scope probe or touch that meter lead? This question is a regular part of servicing. You will find very useful test points built into many recent Tektronix instruments. There are even more "test points" where you find metal case transistors.

Did you know that most metal case transistors have their case tied to collector? It makes for better thermal characteristics and it also allows secure mounting of the chip inside the can. You can use the case as a test point, you can touch a probe, but you probably won't be able to clip on to most cases. The "test point" is also labeled by Q number, making it easy to locate.

Square pin connectors on our printed circuit boards are clearly identified by letters and numbers. These connectors and attached leads make excellent test points. Individual instrument manuals contain schematics and detailed board photographs. These aid in pinpointing the connector location, electrically and physically.

Resistors and other components are purposely mounted with sufficient lead-to-board clearance to attach most probe tips.

Some caution is advised when clipping on to some of the sub-miniature resistors used today; they can break with rough handling.



Metal case transistors have easy to reach collector test points—the case itself.

INSTRUMENTS FOR SALE

LC130, 317, 503, 515, 516, several 530/540 Scopes with Plug-ins. Henry Posner, Pacific Combustion Engineering Co., 5272 E. Valley Blvd., Los Angeles, California 90032. (213) 255-6191.

524AD, $450. Larry Lawrence, Lawrence Engineering, Inc., 11965 Beach Blvd., Jacksonville, Florida 32216.

3A72, $200. Mr. Myhre, Mission Engineering, Inc., Hiawatha, Iowa 52233. (319) 393-2253.

565, 3A3, 3C66. Mr. H. Everett, c/o Dr. C. P. Bailey, St. Barnabas Hospital, 183rd Street & 3rd Avenue, Bronx, New York 10457.

127. Pat McCusker, Comsat Labs, P.O. Box 115, Clarksburg, Maryland 20734. (301) 428-4401.

531/53B, 310, 512. Fred Muessigmann, Watson Instruments, Inc., 446 Lancaster Pike, Malvern, Pa. 19335. (215) 647-3777.

547, 1A1. George Schneider, Space Electronics, Inc., 40 Cottontail Lane, Irvington, New York 10533. (914) 519-8681.

535/B, $600. Dr. J. Toole, 27 Sheldon Street, Wilkes Barre, Pennsylvania 18703.

551 with P/S. Plug-ins, D, G, Q. Scope-Mobile® Cart, 500/53A. $1800 or offer. Joe Laub, Unitek Corp., Monrovia, California. (213) 358-0123.

3T77. Les Jacobson, Allen Avionics, 255 E. 2nd Street, Mineola, New York 11501. (516) PI 7-5450.

556, 1A4, 1A5, all $4178. Howard Davis, Silton, 16222 S. Maple Avenue, Gardena, California 90247. (213) 770-0985.

514D. Robert Powers, Stellar Industries, Inc., 10 Graham Rd., W., Ithaca, New York 14850. (607) 273-9333.

181, $100. Dan Wirtz, McGraw-Edison Co., Franksville, Wisconsin. (414) 835-2921.

3—2A63. Make offer. Jack von der Heide, Optron, 50 Fitch Street, New Haven, Conn. (203) 389-5384.

530 Series Scope/1A7A/160 Series/360/1121. Sigmund Hoverson, Physics Department, Texas A & M University, College Station, Texas 77843. (713) 845-5455.

567 Readout Scope, $405/6R1A, $1800/3S1, $900/3T77A, $495/114 Pulse Generators, $288/P6032 Probes, $67.50. John Mattson, Laminar Corp., 222 Plato Blvd., St. Paul, Minnesota 55107. (612) 222-8411.

310A, $600. Mr. Yeomans, Mergenthaller Linotype, 300 Luckie Street, Atlanta, Georgia 30313. (404) 525-7448.

502, $300. John Breickner, Fifth Dimension, Inc., Route 206 Center, Princeton, N.J. (609) 924-5990.

517. Will swap for 15 MHz Scope. Bob Schafer, Midwest Research Institute, 425 Volker Blvd., Kansas City, Mo. 64110. (816) 561-0202, Ext. 374.

63 Plug-in Differential Amplifier, $100. 2B67 Time Base, $200. Roger Kloepfer, (517) 487-6111, Ext. 392.

410 Physiological Monitor. Rudy Kranys, Medrad, Inc., 4084 Mt. Royal Blvd., Allison Park, Pa. 15101. (412) 961-0393.

535A, $700. D Plug-in, $110, A Plug-in, $60. Summers, Simplec Mfg. Company, Inc., 8710 Empress Row, Dallas, Texas 75247. (214) 637-5470.

454, $2500. C-31 w/Pack & Roll Back and 560 Series Adapter, $400. Virgil A. Wiest or Marty Bos, Automix Keyboards, Inc., 13256 Northrup Way, Bellevue, Wash. 98004. (206) 747-6960, Ext. 21.

INSTRUMENTS WANTED

310A, 321A with probes. Mr. C. H. Wexler, Engineering Department, Phoenix Steel Corporation, Claymont, Delaware 19703 (302) 798-1411.

531 with M Plug-in. Stanley Kneppar, Technical Concepts, Inc., 580 Jefferson Rd., Rochester, N.Y. 14623 (716) 271-7953.

3A6. Jack von der Heide, Optron, 50 Fitch Street, New Haven, Conn. (203) 389-5384.

515, 516, or 524. Phil Hester, 546 Evergreen Dr., Corpus Christi, Texas 78412.

3B3 Time Base. Roger Kloepfer, (517) 487-6111, Ext. 392.

Printed in U.S.A. A-2432

SERVICE SCOPE

SERVICING THE 7000-SERIES LOGIC AND READOUT

by Charles Phillips,
Factory Service Technician

This is the concluding article on servicing the 7000-Series oscilloscopes. Other articles in this series appeared in the March and May issues of TEKSCOPE.

The one word that best describes the 7000-Series oscilloscopes is versatility. The key to this versatility is the logic circuitry which develops control signals for circuits in the plug-ins and the mainframe. The CRT readout also plays a key role in extending this versatility to encompass measurement areas formerly outside the scope domain. Digital multimeter and counter applications are now conveniently handled by Tektronix oscilloscopes using the CRT readout.

This article discusses servicing the logic and readout circuitry. Since the instrument instruction manuals include detailed operation of these circuits, we will limit this discussion to a brief summary of their operation and then discuss troubleshooting techniques and typical problems.

The Logic Circuit

The logic circuit is comprised of seven integrated circuits, seven transistors and a handful of components all located on one circuit board. The logic board is mounted on the rear of the main interface circuit board.

The basic functions of the logic circuits are to:

1. Provide command signals to the Vertical Channel Switch, Horizontal Channel Switch and Trigger Selection Circuit.
2. Provide CHOP and ALTERNATE drive signals to dual trace amplifiers.
3. Provide sweep inhibit signals for either the A or B Time-Base Plug-ins.
4. Provide logic for steering of Z-axis signals from:
   a. Time-base plug-in blanking circuits.
   b. A and B intensity controls.
   c. External Z-axis inputs.
   d. Vertical and horizontal chopped blanking circuits.
   e. Z-axis commands from the readout circuit.

All of the logic inputs and outputs are binary signals except for the Z-axis logic. The external Z-axis input, the intensity control inputs and the Z-axis logic output are analog signals. Inputs to the logic circuits come from the Vertical and Horizontal Mode Switches and the plug-in units. In addition, the Z-axis logic receives inputs from the sequencing logic in the readout, the intensity controls and the external Z-axis input.

The logic circuit outputs go to the Vertical Channel Switch, the Horizontal Channel Switch, the Trigger Selection Switch, the plug-ins and the Z-axis amplifier.

Mainframe Interface Switches

We should briefly discuss the function of the vertical, horizontal and trigger selector switches. Each is a separate etched circuit board mounted on the main interface board.

The Vertical Channel Switch determines which input signal drives the delay-line driver. The Horizontal Channel Switch determines which input signal drives the horizontal amplifier, and the Trigger Selector Switch determines which trigger signal is connected to the A and B Time-Base units. It also provides the drive signal for the Vertical Signal Amplifier whose output is the Vertical Signal Out.

A block diagram of the switches with their respective inputs and outputs is shown in Fig. 1.

Pictured on pages 13 and 14 are the switching sequences of the horizontal and vertical channels for several modes of operation.

The Vertical Mode Switch selects one of two different binary signals to be the Vertical Mode Command. In CHOP operation the Vertical Chop signal (1 MHz) is the command signal. When the Vertical Mode Switch is in ALT, the output of the Vertical Binary is the command signal. In this mode the command signal changes state at the end of each sweep (with Horizontal ALT) or at the same time the Display B Command switches (with Horizontal CHOP).

Notice that with the Vertical Mode Switch in ALT (Fig. 2 a and b) that the left vertical is slaved to B sweep and the right vertical to A sweep. This is with the time bases operated in INDEPENDENT mode. If the delayed sweep is used, the switching sequences are changed to that shown in Fig. 3 a and b.

The switching sequences for dual trace plug-in operation are shown in Fig. 4 and 5. The plug-in CHOP command (500 KHz) is always present regardless of the mainframe operating mode selected. It is directed only to the vertical plug-in compartments.

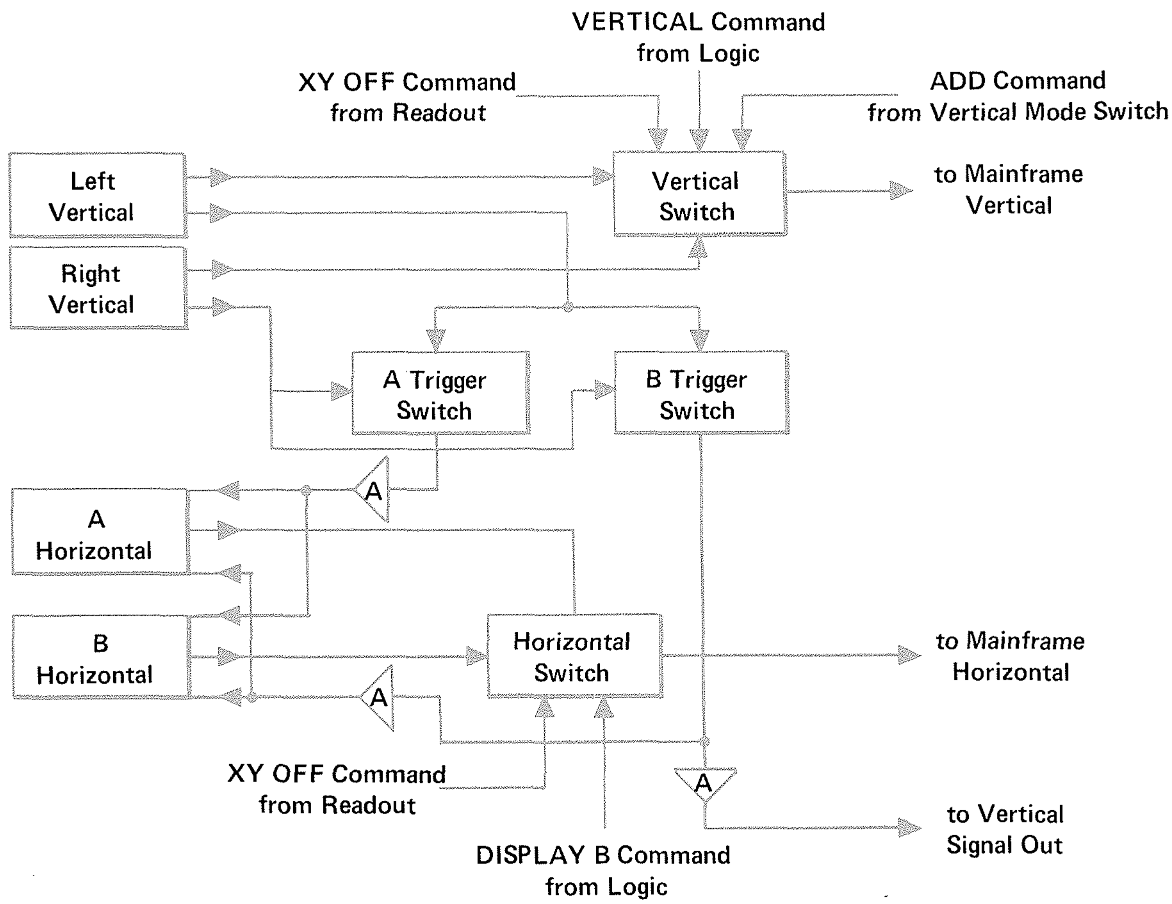


Fig. 1 Vertical, Horizontal and Trigger switching block diagram.

The plug-in ALT command is connected to all four plug-in compartments. It switches states at the end of each sweep for LEFT or RIGHT Vertical operation in the mainframe. In Vertical Mode ALT the plug-in binary counts down by 2 so that the plug-in ALT is operating at half the rate of the mainframe Vertical ALT. Notice that in Fig. 4a and Fig. 5a and b that left vertical is slaved to B sweep and right vertical to A sweep. When the Horizontal Mode is ALT or CHOP, the Vertical Mode is LEFT or RIGHT, and a dual trace plug-in is operated in ALT, Channel 1 is slaved to B sweep and Channel 2 to A sweep.

Troubleshooting the Logic Circuit

There are twenty display modes possible using the Vertical Mode and Horizontal Mode switches on the front panel. In addition, there are several other modes available using the mode switches on the vertical and horizontal plug-ins. Since it is beyond the scope of this article to present the logic signals for each of these modes, we have elected to list the logic output levels available at the test points on the logic board and describe what these levels accomplish. Also listed are the operating malfunctions that would occur should a given active component fail in the logic circuit.

Most of the problems experienced in the logic circuitry are caused by temperature-sensitive components. A can of spray coolant can be very helpful in locating this type of problem.

Following is a list of the logic outputs showing the output level and the function performed. The command signals from the logic circuit are typically small. In most cases the high level is about +1.0 volt and the low level about -0.5 volt. You will need to remove the low-voltage power supply from the scope mainframe to reach the test points on the logic board.

TP 196 Vertical Mode Command – A high level displays the right vertical channel.

TP 137 Plug-in Chop Command – A high level displays channel 2 in dual trace plug-ins.

TP 190 Plug-in Alternate Command – A high level displays channel 2 in dual trace plug-ins and is locked (slaved) to the A horizontal time base when the horizontal mode is in ALT or CHOP.

TP 164 Display B Command – A high level displays the B horizontal time base.

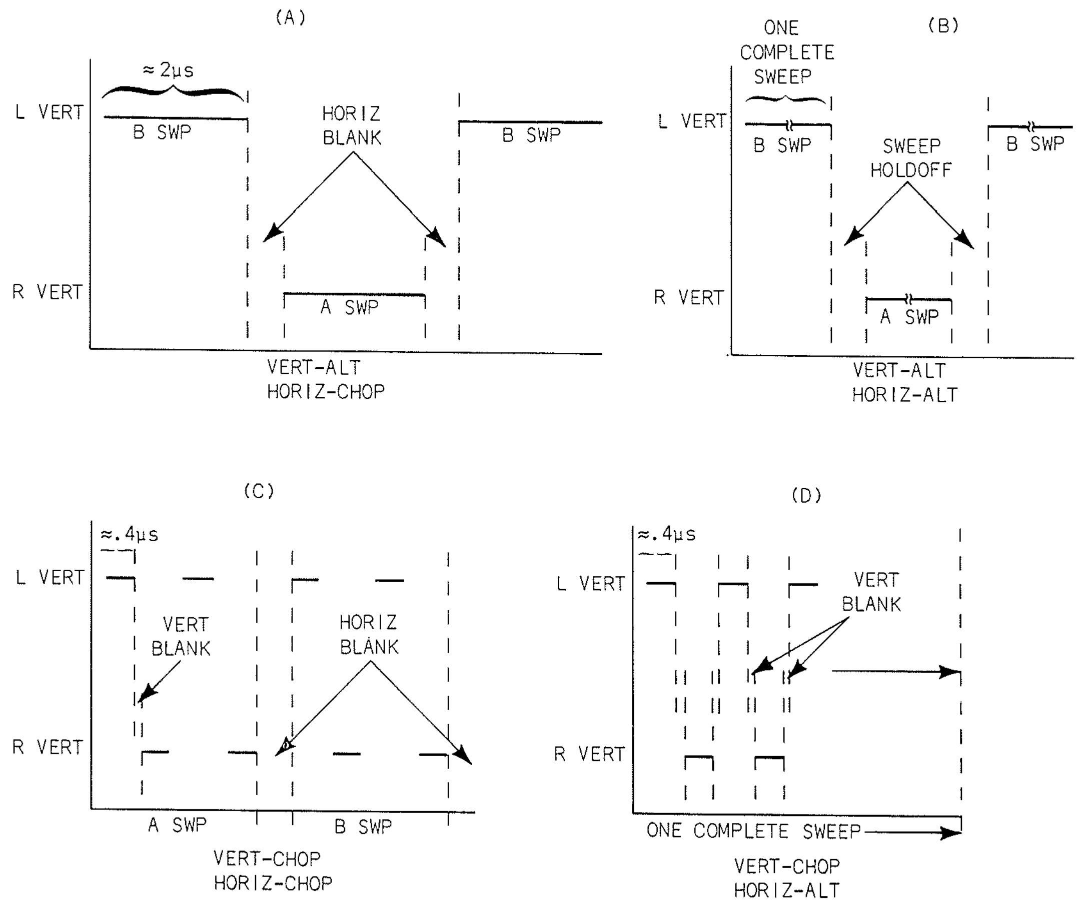


Fig. 2 Switching sequence of two single trace amplifiers with two time base units operated in the INDEPENDENT mode.

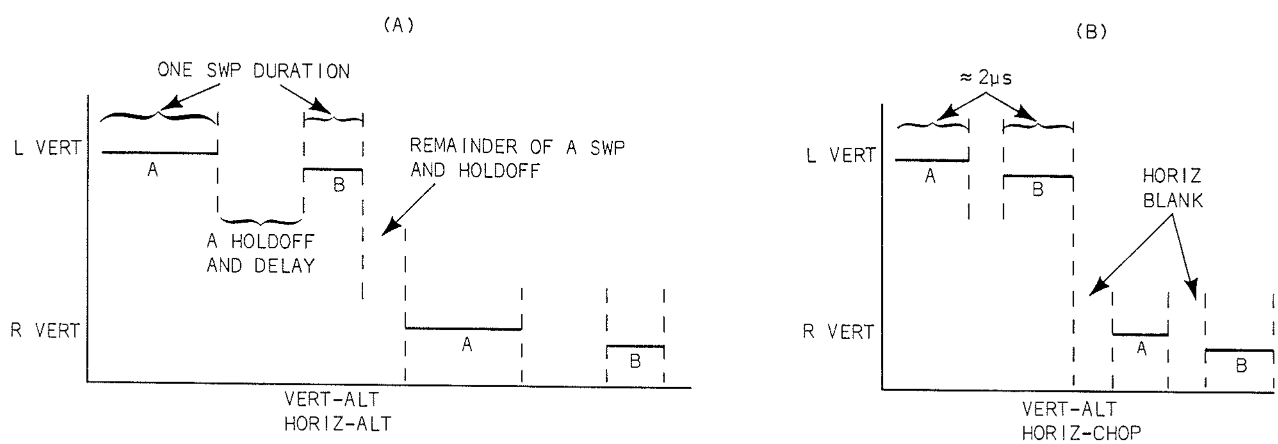


Fig. 3 Switching sequence of two single trace amplifiers with two time base units operated in the DELAYED SWEEP mode.

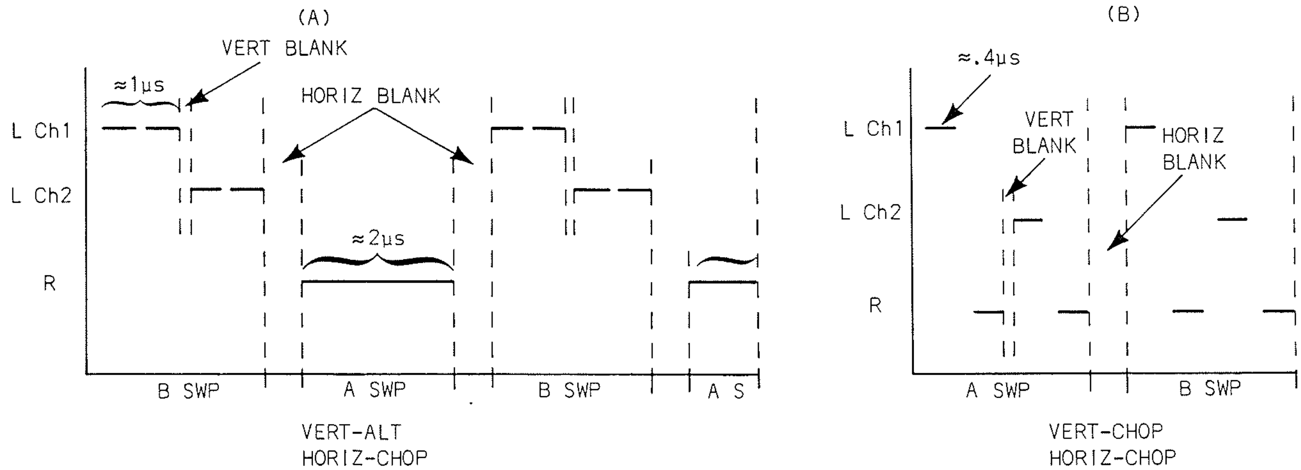


Fig. 4 Switching sequence of one dual trace amplifier operated in CHOP mode with one single trace amplifier and two time base units.

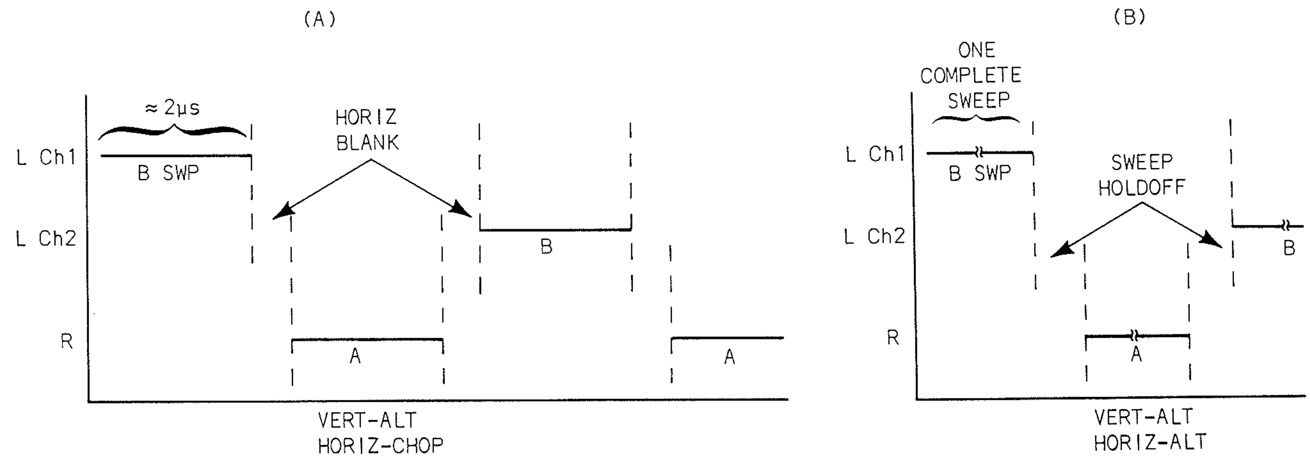


Fig. 5 Switching sequence of one dual trace amplifier operated in ALT mode with one single trace amplifier and two time base units.

TP 167 A Sweep Inhibit – A high level prevents A sweep from running during the time B sweep is displayed.

TP 168 B Sweep Inhibit – A high level prevents B sweep from running during the time A sweep is displayed.

Z Axis Signal – Provides the drive to the Z axis amplifier for the A and B intensity controls. Blanking signals for the vertical, horizontal and readout, and intensity limit control for the 6 slower sweep rates. The output will be about +6 volts with A & B intensity counter-clockwise and the readout turned off.

Following is a list of operating malfunctions and the logic component failure most likely to cause the malfunction.

1. No vertical chopped mode
   No horizontal chopped mode
   No plug-in chopped mode
   Check U120
2. No trace intensity
   Check U130, U170, Q146.
3. No vertical alternate mode
   No horizontal alternate mode
   No plug-in alternate mode
   Check U160, Q168.
4. No horizontal alternate mode
   No horizontal chopped mode
   No horizontal "B" mode
   Check U150
5. No slaving when operating vertical mode in alternate and horizontal in chopped or alternate.
   Check Q182

6. No delayed mode control when operating vertical and horizontal in alternate. The right vertical is displayed with A sweep and the left vertical with B sweep. B sweep is delayed.
   Check Q162
7. No vertical alternate mode
   No plug-in alternate mode
   Check U180
8. No plug-in alternate mode
   Check U190
9. No slaving when vertical mode is in LEFT or RIGHT and plug-in is in alternate.
   Check Q192
10. No vertical alternate, chopped or right mode.
    Check Q194
11. Right vertical mode only. Other vertical modes don't work or foul up readout display.
    Check Q196

THE READOUT SYSTEM

The readout system in the 7000 Series employs an electronic character generating circuit which time shares the CRT with the normal scope function. The characters are formed by a series of X and Y analog currents developed by character generating integrated circuits. Analog data generated in the plug-in determines which characters will be displayed. You must have a plug-in installed in the mainframe for a readout to be displayed.

The character generating circuitry is located on the readout etched circuit board mounted on the right side of the instrument. This board is easily removed and, since it is interchangeable from instrument to instrument, you can speedily confirm that the board is defective by substituting a known good one. A defective readout board can cause the normal scope functions to malfunction. This is true even though the readout is turned off by the front panel intensity control. Removing the readout board will confirm whether the problem is in the readout or elsewhere in the scope circuitry.

A defective plug-in can, in turn, cause the readout to function improperly. This can be quickly checked by substituting another plug-in. The time bases will readout properly in the vertical plug-in compartments and the amplifier plug-ins in the horizontal compartments in a properly operating instrument.

Now let's look at some typical problems that may occur in the readout circuitry. As in the logic circuit, the cause of the problem is often a temperature-sensitive device and a can of spray coolant is of help in troubleshooting.

The readout can be divided into three main sections: the sequencing logic, data collection, and the character generators and output processors. Here are the typical problems relating to these sections, and their probable causes:

The Sequencing Logic

1. No readout
2. No trace
3. No readout and the readout intensity control varies trace intensity.
   Check U1210
4. No readout, trace intensity normal
   Check U1226

NOTE: Troubles in the sequencing logic usually affect the complete display.

Data Collection

1. Mixed up information or no information on one channel of the readout display.
2. Typically the IDENTIFY function will be misspelled when displayed.
3. Interchanging the two suspected IC's will generally cause the problem to go to a different channel (usually a vertical channel).
   Check U1130 and U1170.
4. Symptoms similar to those above but there will be more missing letters or wrong spelling of words.
   Check U1166 and U1186.
5. Improper number of zeros in the displayed word. Typically there is a ten times error such as 1 ms instead of 10 ms.
   Check U1190.

Character Generators and Output

1. One or more characters missing from a word.
   Check U1251 through U1255.

NOTE: Each of five IC's makes ten different characters. If one is suspected, you can trade with another to verify the problem. However, each IC should be put back in its correct location to permit selection of the proper characters.

2. All of the characters smeared or positioned incorrectly on the CRT.
3. Trace displayed vertically or horizontally and no readout.
   Check U1270.
4. Characters overlapping or not spaced properly on the CRT.
   Check U1260.

These are the readout problems encountered most frequently by the factory service center. The instrument instruction manual contains a more detailed troubleshooting procedure should you experience problems not covered here.

SERVICE SCOPE

TROUBLESHOOTING TEKTRONIX HIGH FREQUENCY SPECTRUM ANALYZERS

By Darrell Brink
Product Service Technician, Factory Service Center

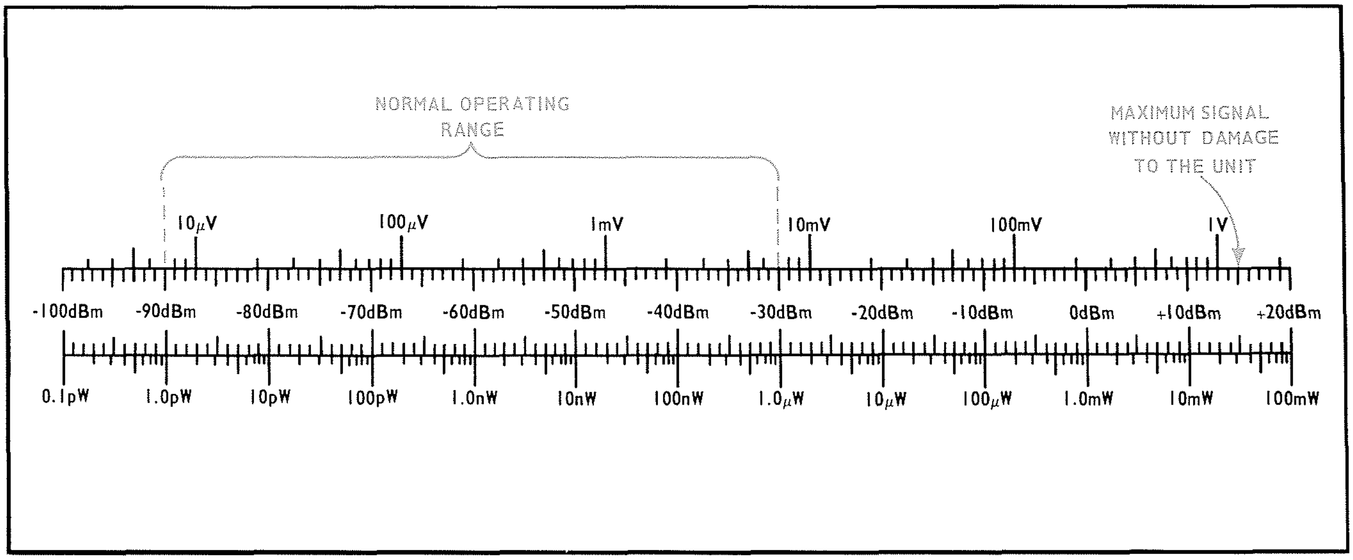
Familiarity with the function of one Tektronix Swept IF Spectrum Analyzer is familiarity with all. All use similar tunable RF oscillators and swept IF systems. The user sees an operational difference in the range covered by the RF center frequency control. The service technician will see a difference in configuration (plug-in form or a complete, self-contained unit) plus differences in RF oscillator circuitry.

The "honeycomb", containing most of the sweeper and IF circuitry, is a conspicuous feature. This method of construction provides excellent shielding between stages and simplifies troubleshooting since it can be replaced to isolate a problem.

A certain amount of troubleshooting can be done using a minimum of equipment. The noise generated internally by the analyzer and the 1 MHz markers available at the phase-lock jack on the front panel can be used as signal sources. However, a test oscilloscope, a time-mark generator such as Tek's 184 or new 2901 and a signal generator capable of 200 MHz with variable attenuation will help considerably. Higher frequency generators will be required if sensitivity or dial tracking is to be checked.

As with oscilloscopes, analyzer problems can often be isolated to a particular section by observing the pattern on the CRT. To insure seeing any signals or noise that may be present, it's usually best to start troubleshooting with the front panel controls set for wide dispersion, maximum gain, and minimum IF attenuation. With plug-in analyzers, be sure the oscilloscope SAWTOOTH OUT is connected to the analyzer SWEEP INPUT—this is often overlooked by the operator. The time base should be set to "free run" at 5 ms/div or slower. A note of caution is in order before applying a signal to the analyzer RF input. *Care should be taken not to exceed the maximum power limits of the input.* For linear operation no greater than —30 dBm should be applied. Signals greater than +15 dBm may damage the unit. See chart below.

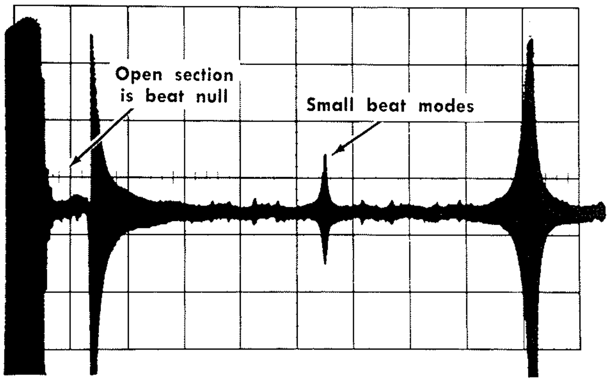
The most common problems encountered in these analyzers are defective mixers and oscillators. Let's take a look at these and other areas that may cause difficulty.



Volts-dBm-Watts conversion chart for 50 Ω impedance.

RF OSCILLATOR SECTION

RF oscillator operation can be checked by applying a known signal to the analyzer and tuning the oscillator to it, or by turning on the PHASE LOCK and checking for beat notes as the oscillator is tuned through its range. Assuming that the phase lock is working, beat notes should be seen across the entire oscillator range as shown below. An *RF oscillator failure* will usually result in the loss of beat notes and signal across all or part of the bands.



Typical display showing presence of phase lock beats, as the RF center frequency control is rotated.

The 1L20 and 491 utilize more than one RF oscillator to cover their respective range. If you suspect oscillator problems, switch to a range which uses a different oscillator. If the problem still exists, the difficulty probably is elsewhere in the analyzer.

An *open oscillator filament* in early vintage plug-in analyzers will remove the +75 volts feeding the 10 volt power supplies, causing them to be very low. In this case, a dead oscillator causes other symptoms such as complete loss of gain and possibly horizontal or vertical positioning problems. Later model 1L20's (above s/n 1150) have zener diodes across the filaments to prolong their life. These diodes also prevent the 10 volt supplies from dropping due to an open filament.

Another type of RF oscillator failure, particularly in the band C oscillator in the 491, is a phenomenon known as *"squegging"*. Squegging occurs when the oscillator breaks into another mode of oscillation and extra sidebands appear or the main signal "breaks up". A low-frequency sinewave several volts in amplitude, e.g., 30 kHz and 10 volts peak-to-peak will appear on the band C oscillator B+ lead (orange wire).

Squegging generally will not occur throughout the band, but only at one or two points. Phase lock beat notes will usually appear distorted and very noisy when squegging occurs. The only cure is to replace the oscillator. Should this be necessary, and if you are not properly equipped to do a total realignment of the RF section, we recommend the complete RF assembly or the complete unit be returned to Tektronix for repair.

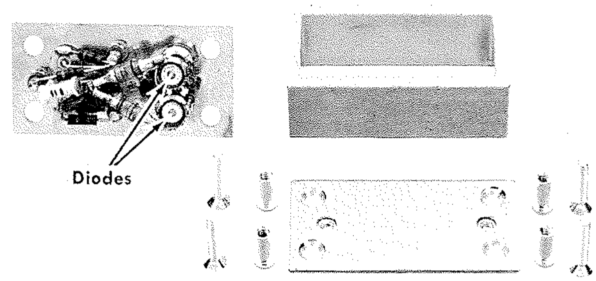
MIXER SECTION

Excessive power inadvertently applied to the analyzer input causes most mixer failures. The presentation on the screen will depend somewhat on the band being viewed. For example, *if the mixer fails in band B* of the 1L20 or 491, you may see a signal on screen (shorted or open diodes still pass signals), however, sensitivity will be down. Varying the mixer peaking knob will have little or no effect on the signal amplitude, and noise amplitude or "grass" will appear normal.

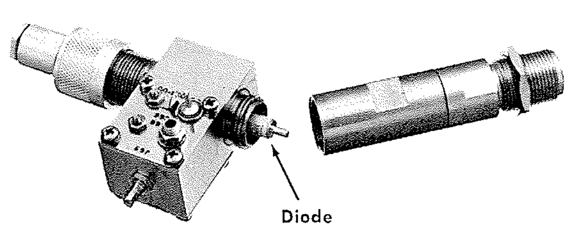
Mixer diode failure in band A of these units typically results in large, spurious signals appearing on screen at about 37.5 MHz, and they cannot be tuned out with the internal mixer adjustments. The mixer peaking control has no effect, as it is out of the circuit when band A is selected.

Mixer diode failure is best confirmed by replacement of the diode. The usual practice of checking diodes with an ohmmeter should not be used, as the current supplied by the ohmmeter may damage the device. Care should also be exercised when replacing the diodes. If soldered in, be sure to "heat sink" them with pliers to prevent damage.

To replace the mixer diode in band B of the 1L20/491 or in the 1L30, remove the mixer from the instrument and carefully unscrew the barrel from the body using a wrench and a vise. Then remove the diode with a pair of pliers. When installing the new diode, be careful not to break the fingers on the contacts in the mixer. Often it requires some force to push the diode into the contact.



(A) Band A mixer assembly. Replace diodes with a matched pair.



(B) Band B mixer assembly. Unscrew the 1 dB pad to replace diode.

Mixer assemblies for bands A and B of the 1L20.

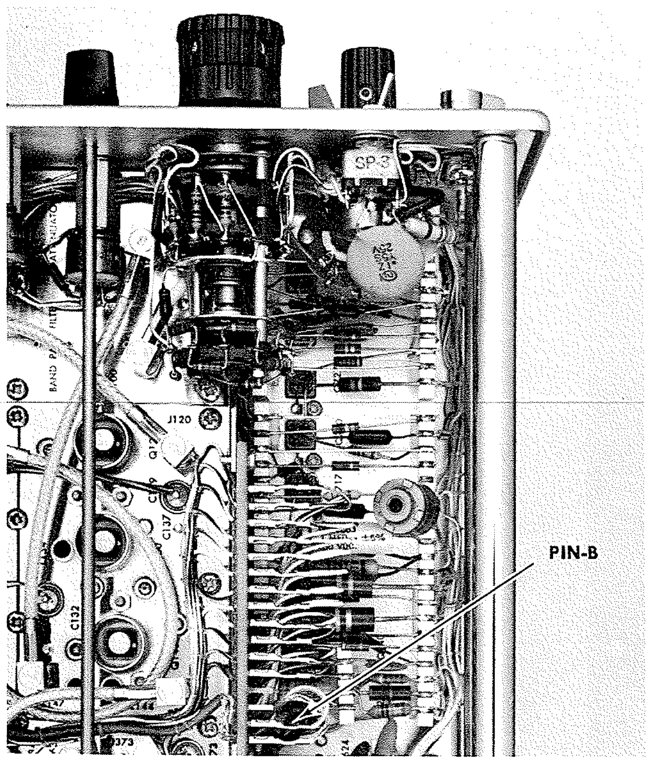
IF SECTION

Although not as common as "front end" problems, the IF section sometimes causes trouble.

Loss of gain can generally be traced to the IF system. When the gain is turned up and little or no noise is seen on screen, the trouble can be in either the honeycomb or the output stages. The output of the honeycomb can be checked with an oscilloscope for noise of about 1 volt peak-to-peak when the GAIN control is fully clockwise. *Absence of noise* could mean the 70 MHz crystal oscillator in the narrow band IF section of the honeycomb has quit. If that is the case, a slight adjustment of the oscillator coil, L444, should cause the noise to suddenly appear. A defective transistor in the wide band amplifier, narrow band amplifier, or resolution sections of the honeycomb will cause a loss of noise also.

Sufficient noise out of the honeycomb, but none on screen in a plug-in analyzer, could mean a defective recorder output transistor Q650, output amplifier V620, or detector diodes D660 and D661. In a 491, check amplifiers Q620, Q630, Q631, and the detector diodes D640 and D641. A failure of Q640 or Q641 will usually shift the trace off screen.

When *noise is present on screen but no signal*, most likely the sweeper is not running or the signal is being lost prior to the honeycomb. A quick way to check sweeper operation is to look at the waveform on pin M of the square pin connector strip of the honeycomb. The signal should appear as a large nonlinear sawtooth. Your manual shows the typical waveform. Normal sweeper operation at this point would indicate that the signal is being lost in the mixer, filters, or cables between the analyzer input and the wide band mixer transistor, Q140.



Output of "honeycomb" can be checked on pin B of the square pin connector. Other key test points are on this same connector.

When working in these circuits, you will find a BNC-to-Sealectro adapter cable very useful as you can insert a 200 MHz signal from a generator at any point up to the input of the honeycomb to help isolate the trouble. Generally, mixers will have a loss of 15 to 20 dB; filters, cables and switches, virtually no loss.

If the sweeper is defective, the analyzer display may appear as either *no signal, extreme nonlinearity of frequency markers, or a short sweep*. The waveform observed on pin M may be a badly distorted sawtooth, a squarewave, or just a DC voltage, depending upon the problem.

Since the sweeper has two feedback loops, troubleshooting can be difficult. However, there are several checks that can be made to isolate the trouble. Set the dispersion range switch to kHz and see if normal operation can be obtained. This eliminates the MHz discriminator diodes. If the symptoms are still present, return the range switch to MHz and check the DC voltage on pin P of the honeycomb. It should be adjustable to about —0.8 V DC with the IF CF (amplitude comparator) range pot (R290) if the amplitude regulating loop is operating. If it cannot be adjusted, continue on to the next check as something else may be causing the loop to lock up.

Next, check the DC voltage on pin M of the honeycomb. If it's within the range of about +14 to +55 volts, the discriminator loop is probably operating, and the trouble probably is a defective sweeper transistor, Q310, or output amplifier, Q340-Q350. However, other active components in the sweeper circuitry can also be suspect. Abnormal voltage readings on pin M usually indicate a problem in the discriminator loop. Grounding the discriminator output (pins N and O) will establish a reference for checking operation of the loop. Checking voltages at several points around the loop should disclose which stage is at fault. For example, the collector of Q260 should go to about +6 V under this condition.

PHASE LOCK SECTION

Phase lock beat notes are produced on the screen when the RF oscillator signal is beat against the internal 1 MHz reference oscillator signal. If the RF oscillator is working, loss of the beat notes can be caused by the 1 MHz crystal oscillator not running. Adjusting the oscillator coil, accessible through a hole in the phase lock chassis, may cause the oscillator to start.

Improper avalanche adjustment can also cause loss of beat notes, low amplitude beat notes, or excessive noise. Check your manual for the proper adjustment procedure.

The trace shifting off screen when the LOCK CHECK button is depressed can be caused by a defective lock check switch, or a leaky capacitor across the switch.