Service Scope

USEFUL INFORMATION FOR USERS OF TEKTRONIX INSTRUMENTS

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TELEVISION AND SINE-SQUARED TESTING

by Joseph E. Nelson
Tektronix Product Information Department

Electronic people, other than those engaged in television work, should also find this article of interest. Where there is a necessity for good resolution of phase characteristics, the sine-squared testing technique offers great potential in the evaluation of broad-band amplifier performance.

Editor's note — The major North American television networks now transmit a sine-squared signal for network-testing purposes. Test methods employing this signal easily detect small abnormalities in the linear-transmission performance of television links. Abnormalities that, although they greatly affect the quality of the television picture, are difficult to evaluate using conventional steady-state methods of signal testing.

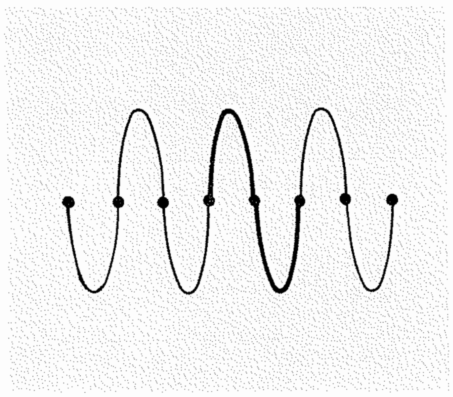


Figure 1. Sine wave with a single cycle indicated by the heavier line.

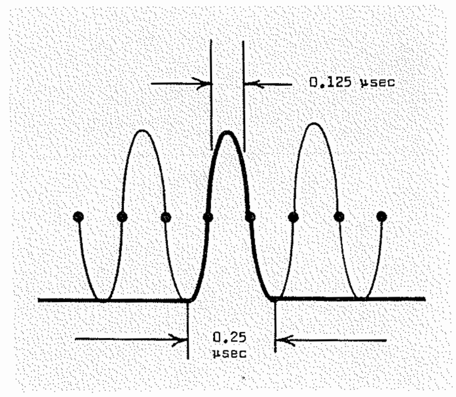


Figure 2. The single cycle of Figure 1 with the base line moved to the bottom.

When a television camera scans a vertical white line against a black background, the camera output resembles a sine-squared pulse. This pulse contains frequency components that extend toward the upper bandwidth of the TV system. For faithful reproduction of a televised picture, the entire TV system should be capable of passing this pulse without undue distortion or change in width or shape.

Since the reproduced condition of this pulse depends on the quality of the TV system, i.e., transient response, envelope and phase delay, it became apparent that a synthetically generated pulse of this type would make an ideal test signal. Thus the sine-squared pulse was born.

To make this type of test more complete, a low-frequency signal, the $\sin^2$ bar, was joined with the $\sin^2$ pulse to form a composite signal that can test the entire frequency spectrum of a TV system.

This composite signal, now available from commercial sine-squared generators, can be used in a number of ways. The test signal can be coupled directly into a camera, link amplifier, or transmitter, and the output examined on an oscilloscope. Or, during non-viewing hours of a TV network, the composite signal can be transmitted on each horizontal line of the camera scan, received at network affiliate stations, and examined for distortion. An additional method, used by all major networks, is to transmit the composite test signal during regular viewing hours but only include it in a single horizontal line during the vertical blanking period. With this latter method, the condition of the entire system can be constantly monitored throughout the transmission period. Since the test signal occurs on a single line during vertical blanking, an oscilloscope capable of displaying this line is necessary. The Tektronix Special-Model Type 527 or Special-Model Type RM527 TV Monitor can be used for this purpose.

$\sin^2$ Pulse and Bar

One can perhaps best visualize the shape of the $\sin^2$ pulse by thinking of a sine wave with the base line moved to the bottom (see Figure 1 and 2). The pulse width of the test pulse is made to be one-half of the period of one cycle of the upper cutoff frequency of the TV system. Thus the pulse width when used with a 4 megacycle system is 0.125 microsecond. This time (0.125 μsec) is designated by a capital T. A $\sin^2$ pulse with a width of 0.125 μsec is 6 db down at 4 megacycles and contains practically zero energy at 8 megacycles. For routine tests a $\sin^2$ pulse with a width of 2T (0.250 μsec) can be used. A $\sin^2$ T pulse is shown in Figure 3.

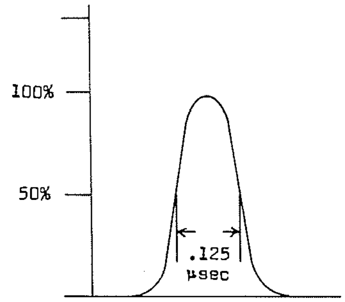


Figure 3. $\sin^2$ T pulse.

The $\sin^2$ bar, also called a white window, is a combination of a square-wave and a $\sin^2$ pulse. The risetime and falltime is the same as an integrated $\sin^2$ pulse while the flat-top is similar to a square-wave. Pulse width of the bar signal is 25 microseconds which is 0.4 H. (H is the time-length of one horizontal line, 63.5 μsec). The bar signal is shown in Figure 4.

The composite test signal, with typical time spacings is shown in Fig. 5.

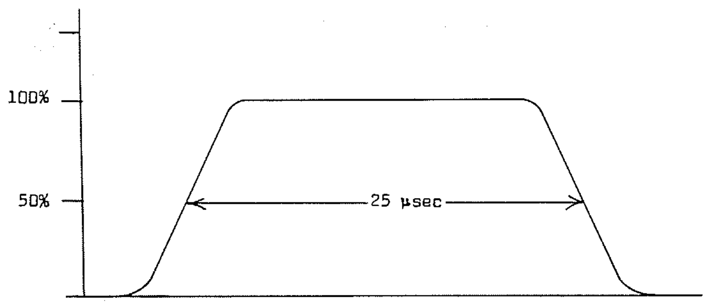


Figure 4. $\sin^2$ bar, a combination of a $\sin^2$ pulse and a square wave.

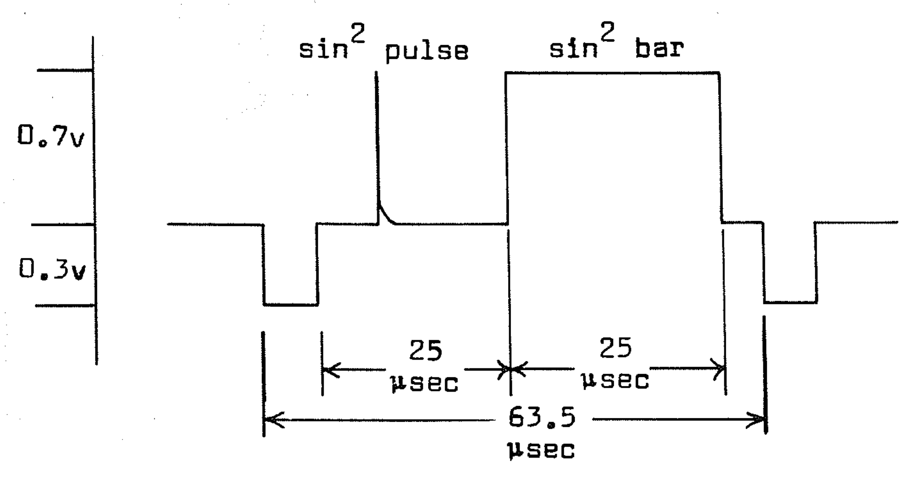


Figure 5. Composite test signal with typical time spacings.

The Oscilloscope and $\sin^2$

The type of oscilloscope needed to examine the sine-square signal depends on the type of transmission. For example, within the studio, where a sine-square generator supplies the test signal continuously a triggered oscilloscope such as the Tektronix Type 524 with adjustable time-base can be used. However, when the test signal is present only on a single line of each frame, some method of selecting and examining this line must be used. The line selector feature of the Tektronix Special-Model Type 527 or Type RM527 allows the operator to select and examine any line within the television frame. Briefly, the line selector uses the principle of a delayed trigger. A trigger circuit phantastron is started by the vertical sync pulse of the received signal. The phantastron is mixed with each horizontal sync pulse of the signal and presented to a comparator. The voltage on the opposite side of the comparator can be adjusted to make the comparator switch on any one of the field horizontal sync pulses. The output of the comparator is a trigger pulse that starts the sweep in the oscilloscope.

When a single line that contains the $\sin^2$ pulse and bar is selected, the Type 527 sweep is set to 0.125 H/CM, and since the bar signal is 0.4H, it will occupy 3.2 horizontal centimeters. After the bar signal has been examined, the sweep control is switched to 0.005 H/CM and the $\sin^2$ pulse examined in detail.

Typical $\sin^2$ Response to Distortion

The change in shape and size of the composite $\sin^2$ test signal is a direct indication of the kind of distortion a system produces. Here are several examples of these changes.

1. Low-frequency distortion. This type of distortion has its greatest effect on the $\sin^2$ bar while little change is seen in the $\sin^2$ pulse. Depending on the time-constant of the circuit involved, the bar will show: undershoot, overshoot, or horizontal tilt. For example, a short time-constant undershoot is a leading-edge roll-off, as shown in Figure 6-a; while a long time-constant overshoot is a negative tilt (drop in amplitude from leading to trailing edge), as shown in Figure 6-b.

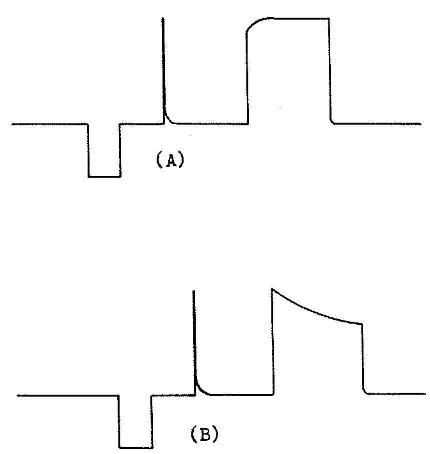


Figure 6. $\sin^2$ test signal showing: (a) short time constant undershoot, (b) long time constant overshoot.

2. Frequency Response irregularities. When the frequency response is not flat across the bandwidth of the system, we get dips and bumps. These dips and bumps on the test signal are actually ringing that is related to the frequency

Figure 7. Sin^2 test signal with dips and bumps caused by frequency response irregularities.

Figure 8. Sin^2 pulse showing a leading and a trailing reflection or echo.

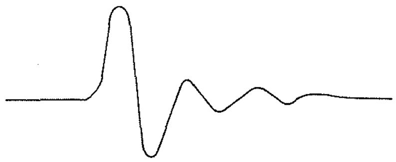


Figure 9. Sin^2 pulse showing distortion caused by high frequency roll off: reduced height, increased width, and decaying ringing.

irregularity (Figure 7). Once again the change in the test signal depends on the frequency.

3. Reflections. Since the sin^2 test signal can be transmitted (during the vertical blanking interval), the nature of reflections caused by multi-path signals can be measured. (See Figure 8.)

4. High-frequency roll-off (Figure 9). The most significant change caused by reduced bandwidth is the amplitude of the sin^2 pulse. And with this reduced amplitude, the pulse width increases since the area of the pulse represents a dc component that remains constant. From the appearance of the pulse, you can estimate the shape of the roll-off curve. For example, a slow roll-off produces a large reduction in amplitude with little, if any, ringing; while a rapid roll-off (almost a cutoff) affects the amplitude less, but does show considerable ringing.

CAPTURING POWER-LINE TRANSIENTS

by Ron Bell
Tektronix Field Engineer

Power-equipment engineers frequently find it necessary to measure transients on sixty-cycle power lines. The need arises, for example, when working with solid-state power-control equipment. Large voltage transients, introduced through the power line, can cause equipment malfunction or even semi-conductor failures. Circuit-breaker testing, where the sudden closure or opening of a circuit marks the beginning of a test, is another situation requiring transient measurements. In these circumstances, it is common for the engineer to display the transient on an oscilloscope; photographing the results for analysis.

But it is not always easy to photograph the transients.

The power-line waveform with simulated transients, shown in Figure 1, will serve to explain the operating problems. Notice first that transient A exceeds the peak line voltage; whereas transient B does not. Notice also that transient A is a positive-going impulse and transient B is negative going.

Photographing transient A would be relatively easy. The oscilloscope triggering circuits could be adjusted to initiate a sweep (1) during a positive-going slope and (2) when the instantaneous voltage exceeds the peak-line voltage. If, however, the transient occurred later in the cycle, the instantaneous transient voltage would not exceed the instantaneous power-line voltage. As a result, condition (2) would prevent sweep triggering. Adjusting the trigger circuits for a lower triggering level would result in power-line waveform triggering.

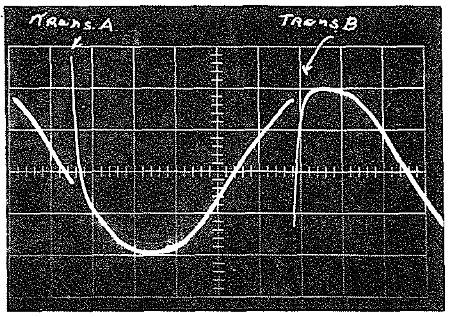


Figure 1. Power-line waveform with simulated transients.

To differentiate between transient voltages and the power-line waveform, the sixty-cycle component can be rejected from the trigger circuits. This is accomplished by operating in the AC LF-REJECT mode. In this mode, the triggering circuits respond to the transients as though they started at zero volts, regardless of when they occur during the power-line cycle.

Using the AC LF REJECT mode, transient B could be photographed by adjusting the trigger circuits for triggering during a negative slope. Obviously, it is rare that the polarity of a transient is known beforehand. In short, for any one setting of the triggering controls, we can display either transient A or B, but not both. If transients of both polarities are to be displayed, it is necessary that the triggering circuits respond to both concurrently.

This article describes a modification to permit triggering on plus and minus slopes concurrently. The circuit information applies specifically to the 530A-, 540A- and 550-series oscilloscopes. In general the circuit modification can be applied to other instruments (except those with solid-state triggering circuits) with only minor changes.

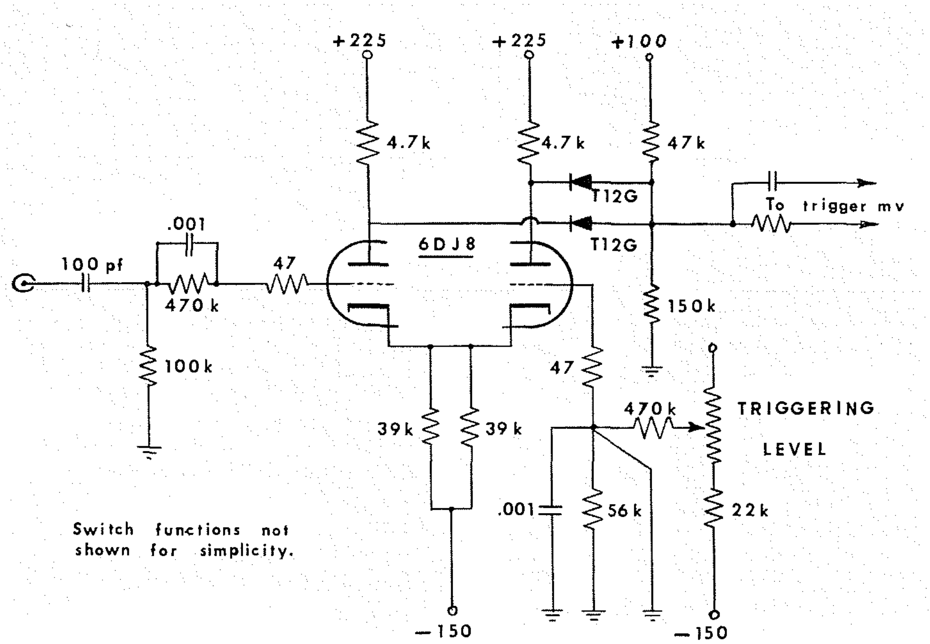


Figure 2. Modified Trigger-Amplifier Circuit of a Type 530 or Type 540 Series Oscilloscope.

The modified-circuit diagram is shown in Figure 2. Notice that the only additional parts required are two T-12G diodes, a 150 k resistor and a 47 k resistor. Notice also that the 47 pf capacitor normally connected across the plate-load resistor of the left-hand triode has been removed and that the grid of the right-hand triode is grounded.

Circuit operation is almost self-explanatory. The two T12G diodes are normally back-biased between the center-tap of the voltage divider and the quiescent triode plate voltages. The sixty-cycle power-line waveform (and, of course, the transient) is connected to the input connector.

The time constant of the 100 pf coupling capacitor and the 100 K input resistor is short enough to effectively block the sixty-cycle component; while at the same time, allowing fast-changing transient voltages to pass through to the input grid. The two triodes are operating as a paraphase inverter. If the input transient is positive-going, it will cause the left-hand plate voltage to go down. Similarly, if the input transient is negative-going, it will cause the right-hand plate to go down.

A negative-going voltage on either triode plate will cause the associated diode to go into conduction. When one of the diodes conducts, a negative-going voltage appears at the common-anode point. This negative-going voltage is coupled to the trigger multivibrator which, in turn, triggers the time-base generator.

Trigger sensitivity of the modified circuit is less than normal. Unmodified, the triggering circuit will respond to 0.1 volts or less. This circuit requires approximately 1.5 volts. For simplicity, the right-hand triode grid is grounded. Because of imbalance in the triodes and tolerance in the plate-load resistors, it is unlikely that the plate voltages will be equal. To avoid the possibility of no-signal diode conduction, the diode anode voltages are lower than necessary. This means the triggering voltage must overcome this back-bias before triggering can occur. This should not be a handicap, however, since ample triggering voltages are usually available in power-line testing.

Near-normal sensitivities can be realized by replacing the 150 k resistor in the divider with a 220 k resistor. It will be necessary to check the plate voltages for imbalance. Removing the ground from the right-hand triode grid will permit using the TRIGGERING LEVEL control to achieve perfect balance. Of course, the operator must be careful not to disturb this control once adjusted.

To adjust the circuits for correct operation, set the front-panel controls as follows:

TIME/CM	2 μsec
5X MAGNIFIER	Off
STABILITY	Preset
TRIGGERING LEVEL	0
VOLTS/CM	1
CALIBRATOR	5
TRIGGERING MODE	AC LF-REJECT
TRIGGER SLOPE	+ Int.

Connect the Calibrator output to the plug-in input. Starting with the Trig. Level Centering Control turned fully clockwise, turn it counter-clockwise for a display

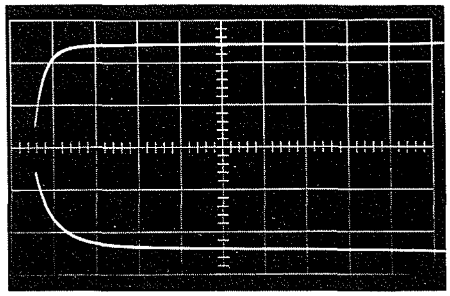
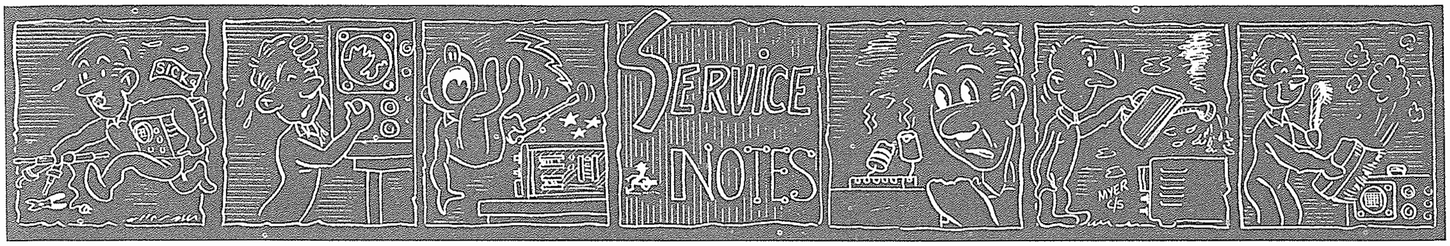


Figure 3. Initial display during adjustment procedure. The vertical deflection factor is 1 volt/cm. The sweep rate is 2 μsec/cm.

similar to Figure 3. Next, reduce the vertical deflection with the Volts/CM controls until either the upper or lower trace disappears. Turn the Trig. Level Centering Control CCW to restore the display. Continue to reduce the vertical deflection while adjusting the Trigger Level Centering Control until the two traces are separated by 1 cm or less.

To verify your adjustments, connect the calibrator output to the External Trigger Input connector. Set the Trigger Slope Switch to + Ext. You should be able to obtain displays similar to Figure 3 over a range of input voltages from 2 to 10 volts.

Details on how this modification might be installed in an oscilloscope are left to the inventiveness of the reader. Certainly, consideration should be given to how frequently it might be used. In those situations where this mode of operation would be used often, a permanent switch function would seem most convenient. On the other hand, for occasional "one-shot" applications, it might be simpler to "tack-in" the components as needed. On those instruments having an operator's manual compartment in the right-hand side panel, one shouldn't overlook the possibility of mounting a chassis directly underneath the compartment for easy access through the trapdoor.



CERAMIC STRIP BREAKAGE TRACED TO EXCESS SOLDER

The newer high-density (tightly-notched) ceramic strips will sometimes break if the notches are over-filled with solder. The shrinking of the solder as it cools can cause stresses severe enough to crack the strip. The shrinking solder tries to pull the two ends of the strip together.

One should take care when soldering these strips to use just enough solder to cover the wires. The resulting connection will be just as electrically sound as when the notch is filled.

The use of Enthoven *silver-bearing* solder (instead of Divco), coupled with the use of solder in judicious amounts reduces the hazard of breakage to a minimum. Enthoven solder possesses a higher "creep-rate", i.e., it relaxes more quickly after hardening. Both Enthoven and Divco solder tend to cold-flow and relieve the tension, the Enthoven immediately, the Divco more slowly. Enthoven solder is identified by a star-shaped rosin core; Divco has a round core.

A recent change in the material used in the manufacture of our high-density ceramic strips should further alleviate this breakage problem. This new material offers increased flexural strength, tensile strength and compressive strength. It also has a lower thermal expansion which helps in thermal shock. An empirical test which we developed for checking thermal shock, consists of excessive loading of silver or solder in the notches. Under these test conditions, the new porcelain material displays a pronounced superiority over the old material.

NEW NE-23 NEONS VERSUS THE OLDER NE-2 NEONS

From time to time a problem arises within an instrument because a NE-2 neon refuses to immediately ionize upon application of voltage. Previously, all neons exhibited a touchiness about environmental conditions — sensitivity to temperature changes, light, radiation, etc. A new neon, the NE-23, offers a good solution to this problem. A tiny dot of radioactive material, added to the glass envelope during manufacture, guarantees the immediate ionization of the neon gas.

Modifications now in progress will change, wherever possible, the neons in instruments manufactured by Tektronix, Inc. to the new NE-23's. For the present, certain circuits will continue to use NE-2's for a specified voltage drop. As selected NE-23's become available for these circuits they will replace the NE-2 neons.

BLADE-TYPE ALIGNMENT TOOL IMPROVEMENT

Our thanks to Bob Nagler, Field Mainland, USAF with the PME Lab. in Ramstein AB, Germany, who offers this suggestion:

"When using blade-type alignment tools it is often difficult to position the blade to fit the slot since the blade cannot be seen from the top. To remedy this trouble, modify the tool as follows: Scribe a line across the top of the handle of the blade-type tool to indicate the position of the blade. The scribed line may be filled with paint to give better visibility."

We tried Sgt. Holland's suggestion (see Figure 1) and liked the result.

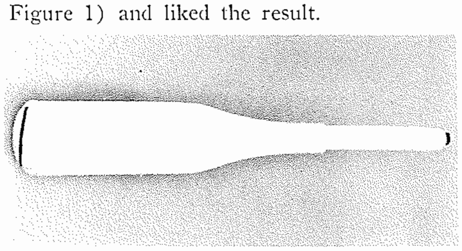


Figure 1. Scribed line on handle indicates position of blade.

TYPE 2B67 TIME-BASE UNIT—COMPROMISE SETTING OF STABILITY CONTROL CRITICAL

With the MODE control of the Type 2B67 Time Base Unit in the SINGLE SWEEP position, current drawn through R126 (a 220 k resistor) can cause the setting of the STABILITY control to become quite critical.

R126 functions to keep Q124 (a 2N2043 transistor) turned off when the sweep is "armed" and the READY light on (ready to be triggered). It may pull the plate of V135A (½ of a 6DJ8 tube) enough positive while in this condition to shift the triggerable range of the multivibrator considerably. In a typical instrument, the STABILITY control may offer a compromise setting (for operation in both NORM and SINGLE SWEEP modes) with a range of only about 0.5 volt.

The 220-k value of R126 was selected to prevent Q124 from turning itself on with collector-base leakage which, according to the manufacturer's spec sheet, can be 500 μamp at 71°C. However, experience in the field with this instrument indicates a much smaller typical value of leakage—so much so that most of the current from R126 simply goes to upset the sweep-gating multivibrator's hysteresis range.

Check the quiescent (READY) value of plate voltage at pin 1 of V135A. If plate voltage changes by more than about 5 volts as the MODE control is moved from NORM to SINGLE SWEEP, try changing R126 to a value between 470 k and 1 M. This will usually help considerably in making the compromise setting of the STABILITY control easier to find and more stable.

Our thanks to Bob Nagler, Field Maintenance Representative of the Toronto Field Office of Tektronix Canada, Ltd. for pointing up this problem and offering a solution.

TYPE 6R1 AND TYPE 6R1A DIGITAL UNIT CAUTION

Ben Franklin, or somebody, once said, "A word to the wise is sufficient". The word this time is: Always turn off the power when removing or replacing circuit cards in the Type 6R1 or Type 6R1A Digital Unit of a Type 567 Digital Readout Oscilloscope.

Failure to do so may cause destruction of some transistors and other components both in the replacement and other circuit cards of the Digital Unit.

Plugging a circuit card into the Digital Unit with the power on can cause the 2B67 Time Base Unit in the SINGLE voltage-carrying contacts in the connector to introduce voltage to the board's circuit (or circuits) a momentary instant before other contacts in the connector mate to establish a return-voltage path.

When this occurs, the momentary delay may cause a surge of power or generate a transient that exceeds the dissipation capabilities of certain transistors or other components in the Digital Unit's plug-in circuit cards.

TYPE 580 SERIES OSCILLOSCOPES—DIRECT CONNECTION TO CRT VERTICAL PLATES

Several circuit changes plus the construction of a balun will allow direct connection of signals to the vertical deflection plates of the crt in Type 580 Series Oscilloscopes. Input impedance is about 50 ohms (47½ ohms actual) and sensitivity is about 5 volts per centimeter depending on the crt. Risetime is essentially that of the crt deflection structure—about 1 nanosecond. Low-frequency cutoff L/R-risetime constant varies with signal amplitude from about 20 microseconds a centimeter step amplitude, to about 30 microseconds at ½ centimeter amplitude.

Returning the oscilloscope to normal operation will require rewiring the vertical output system to the original circuit.

Figure 2 shows the new vertical output circuit. Figure 3 shows the input connector, cables, balun and 107 ohm resistors. The cable from the input connector, through the balun and to the one deflection plate and the cable from the input connector to the other deflection plate *must be the same length, and as short as possible* (for minimum cable loss).

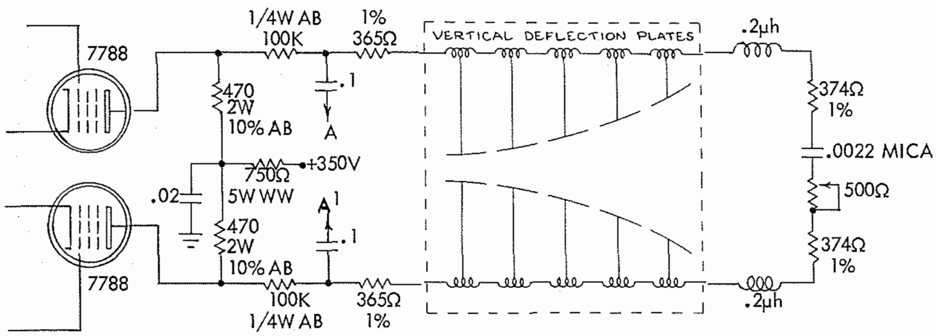


Figure 2. Type 580 Series Oscilloscope — Vertical-output circuit for direct connection to crt vertical plates.

To construct the balun, first construct the transition by severing one of the pieces of 93 Ω cable at mid-point and reconnecting the severed pieces as shown in the "Transition detail" of Figure 3. Next, place the transition within the 101 ferrite core and pass each end of the cable through the core four times as shown in Figure 3. Each pass of the cable through the core constitutes a turn and each side of the transition is considered ½ a turn.

Parts required:

Qty.	Item	Tektronix Part No.
1	500 Ω pot.	311-056
1	0.0022 μfd Mica cap.	283-530
2	374 Ω, 1%, ½ w, Prec. res.	323-152
2	365 Ω, 1%, ⅛ w, Prec. res.	321-151
2	0.1 μf, Cer. Cap.	283-008
2	0.2 μf fixed coil	108-008
2	100 k, ¼ w, comp. res.	316-104
2	470 Ω, 2 w, comp. res.	305-471
1	750 Ω, 5 w, WW, res.	308-067
1	0.02 μf, Cer. cap.	283-004
1	GR connector	none
1	Ferrite core, 101	276-519
2	107 Ω, comp. res.	
2	pc's. 93 Ω cable of equal length	none

The 500 Ω pot installed in this modification takes the place of R1293 in the normal circuitry. Consult the "Adjust Vertical System High-Frequency Compensations" section of your Type 580 Series instruction manual for instructions on the function of this pot.

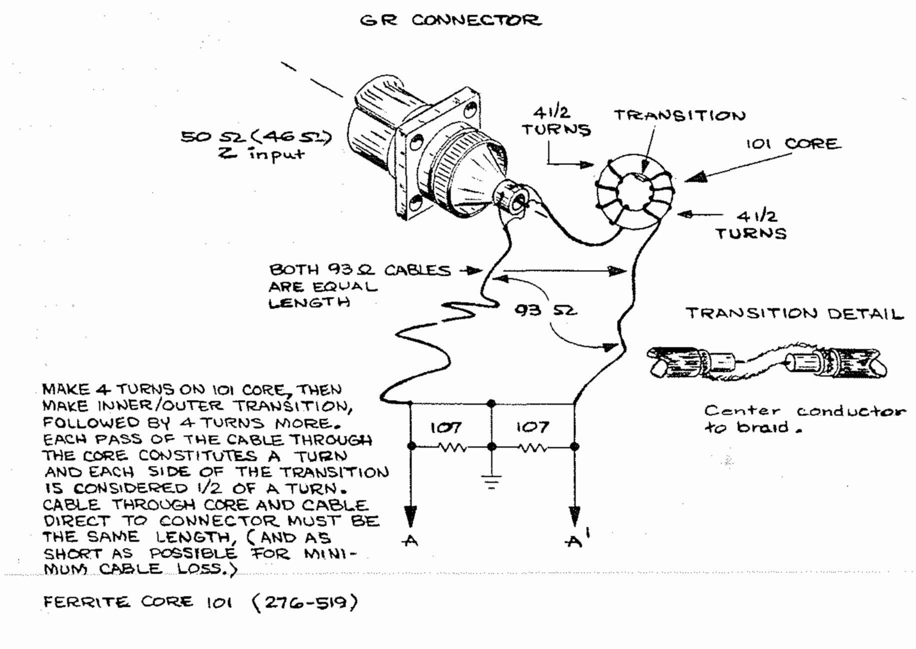
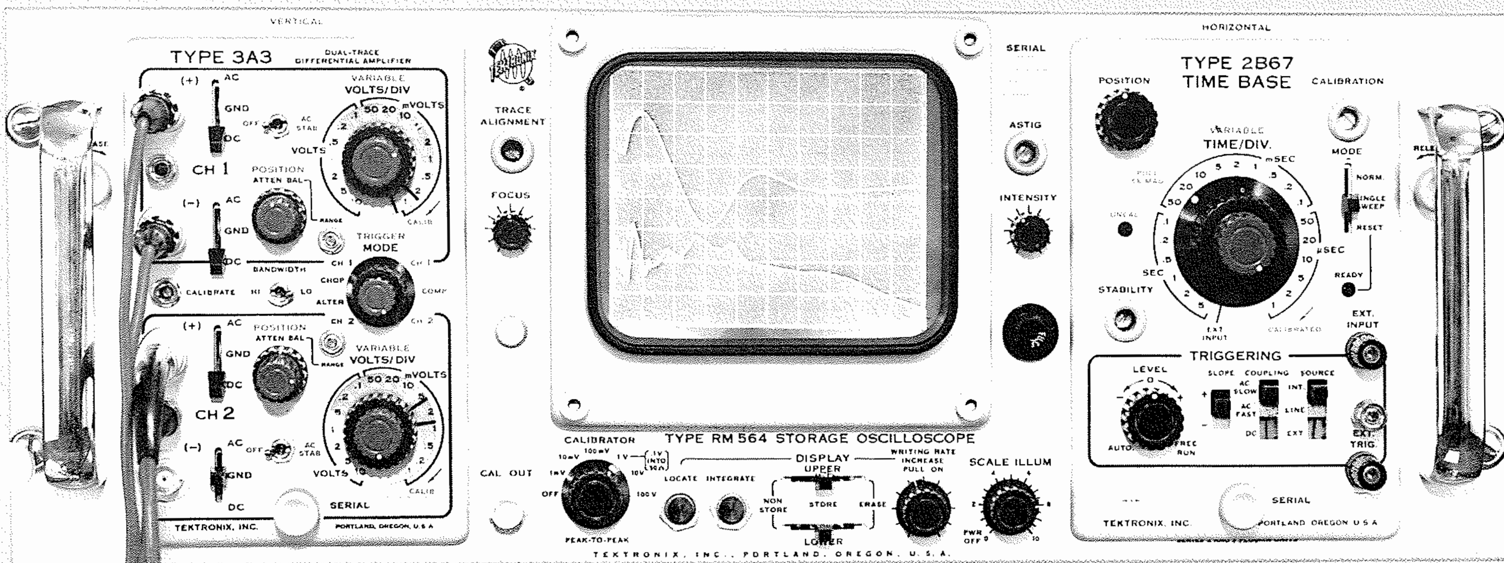


Figure 3. Connector detail for direct connection to crt vertical plates — Type 580 Series Oscilloscope.

PRESENTING THE TEKTRONIX

TYPE RM564

RACK-MOUNT STORAGE OSCILLOSCOPE



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