Service Scope

USEFUL INFORMATION FOR USERS OF TEKTRONIX INSTRUMENTS

NUMBER 34 PRINTED IN U.S.A OCTOBER, 1965

# INTRODUCTION TO OSCILLOSCOPE DIFFERENTIAL AMPLIFIERS

by
Joseph E. Nelson
Tektronix Product Technical Information Group

*This is the second and concluding half of an article describing oscilloscope differential amplifiers. The first half, which appeared in the August, 1965 issue of SERVICE SCOPE, discussed differential amplifier characteristics such as common mode rejection ratio, voltage range, frequency range, etc. The effect of probes and filters as well as the importance of source impedance was also discussed.*

*This second half of the article presents several applications that either require a differential amplifier or can more effectively be performed with a differential amplifier.*

## Part II
## Applications

### *Differential Measurements*

A differential input measurement is one in which the two inputs to a differential amplifier are connected to two points in a circuit under test and the amplifier displays the difference voltage between the points. In this type of measurement each input of the amplifier acts as a reference for the other and ground connections are only used for safety reasons. (Note: The term "differential input" is synonymous with "floating input".)

One application in which differential input was used to advantage concerned the power source of an electric railroad engine. This was a 3-phase transformer system with a solid-state controller that consisted of strings of silicon-controlled rectifiers. The measurement problem was to examine the individual rectifier switching characteristics and note risetime, ringing, and point of occurrence. The circuit (simplified) is shown in Figure 10.

The voltage across the silicon controlled rectifiers before switching was approximately 250 volts; however, the entire system was several kV off ground. Because of this latter voltage, two P6013 high-voltage X1000 probes connected to a differential amplifier were used. With this arrangement, the amplifier sensitivity was increased to a point where the switching transients could be seen and photographed.

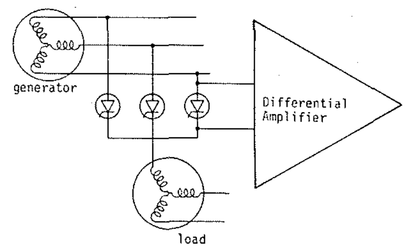



**Figure 10. A differential amplifier connected for a differential input measurement in the power system of an electric train.**

### *Slideback Technique*

*Slideback* can be defined as the technique of applying a dc voltage to one input of a differential amplifier in order to change the vertical position on the crt screen of the signal applied to the other input. For example, if an oscilloscope differential amplifier is set for a vertical sensitivity of 0.01 V/cm (trace on-screen) and a +1 volt dc voltage is applied to input A, the trace will be deflected upward off screen. If a +1 volt dc voltage is now applied to input B, the trace will return on screen. One might say that the signal *slides back* on-screen as a result of the voltage (slide-back voltage) applied to input B. Also, and this is the principle of operation, the dc voltage applied to input B is common-mode with that of input A, and thus, both are rejected by the amplifier.

A measurement problem often encountered is the need to examine a pulse (say 0.01 volt height) that is superimposed on a dc level (say +1 volt), and make the measurement with the oscilloscope's amplifier dc-coupled.

If this composite signal is applied to input A of a differential amplifier and a +1 volt dc voltage (slideback voltage) is applied to input B, the two dc levels are common-mode and thus rejected, and only the pulse remains. In this situation, the vertical sensitivity could be increased to 5 mV/cm where the pulse would have a height of 2 centimeters.

Because the dc level of the composite signal in this example can be any voltage up to the maximum common-mode input voltage specified for the amplifier, the slideback voltage should be adjustable from zero volts up to this maximum common-mode input voltage level. With this source in a separate black box, an arrangement similar to that shown in Fig. 11 can be set up.

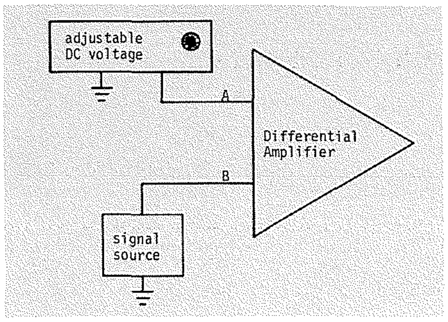



**Figure 11. Circuit connections for the slide-back technique described in the text.**

A second example of slideback technique concerns the detailed examination of small amounts (1 millivolt) of modulation superimposed on a pulse or square wave of +1.0 volt pulse height. If this pulse is applied to input A of a differential amplifier (at 0.2 V/cm) and the "black box" slideback voltage source applied to input B, the pulse displayed on the crt screen can be moved vertically by varying the slideback voltage. If the sensitivity is now increased to 1 mV/cm, the top of the pulse will go off-screen. It can be returned on-screen by adjusting the slideback voltage. Since the sensitivity remained at 1 mV/cm, the sought-for modulation on top of the pulse should occupy one vertical centimeter. (See over-scan limitations later in text).

This example introduces the concept of *effective* crt screen height. A 1 volt pulse was displayed on the crt screen at a sensitivity of 1 mV/cm. Through use of the slideback voltage any portion of the pulse could have been brought on-screen. Since the pulse height was 1 volt and the sensitivity 1 mV/cm, the effective screen height was 1000 cm. The formula for finding the effective screen height is:

$$\frac{\text{Slideback Voltage}}{\text{Vertical Sensitivity}} = \text{Effective screen height}$$

Applying this formula to the Tektronix Type W High-Gain Differential Comparator Plug-In Unit comes out as follows:

$$\frac{\pm 11.000 \text{ V dc}}{.001 \text{ V/cm}} = 11{,}000 \text{ cm maximum}$$

### *Differential Comparator*

Carrying the slideback technique one step further by making the slideback voltage a calibrated supply with a precision dial and building this into the amplifier makes the device a differential comparator. This instrument, sometimes called a slideback voltmeter, can make both ac and dc voltage measurements. The precision of these measurements in terms of a ± percent can be calculated from the differential comparator specifications (attenuator accuracy, comparison voltage accuracy, etc.; see example later in text).

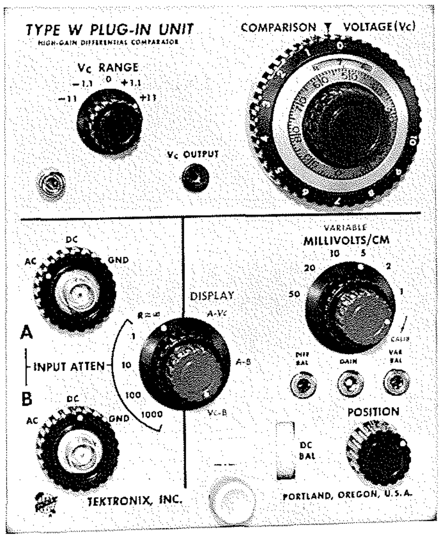



**Figure 12. The Tektronix Type W High-Gain Differential Comparator Plug-In Unit.**

Operation of the differential comparator as a precision voltmeter consists of applying the signal to be measured to input A with the front panel controls set for a comparison measurement. This internally connects the comparison (slideback) voltage (Vc) to input B. Figure 12 shows the front panel of the Type W High-Gain Differential Comparator Plug-In Unit. Note that the Vc range switch not only changes the range but also can change the polarity of the comparison voltage. This allows comparisons with both positive-going and negative-going signals.

In dc voltage measurements the signal-carrying cable is connected to the A input connector with the input attenuator at 1, but with the input coupling switch set to GND. The display switch is set to A-Vc which means a comparison between whatever signal is present at input A and the comparison voltage. The precision dial is set to zero and the position control used to move the trace (free-run) to the center vertical reference graticule line. This zero voltage line is the start and finish point of a measurement. All that remains is to turn the coupling switch of input A to dc, which allows the trace to disappear off-screen; then slide the trace back on-screen to the reference line with the precision dial. The value of the unknown voltage is the reading of the precision dial.

AC voltage measurements that use a-c input coupling have signals that pass through both polarity. To measure peak-to-peak, the comparison voltage dial is adjusted to bring one peak to a graticule reference line and the dial reading is noted. Then the Vc range switch is turned to the opposite polarity and again the precision dial is used to move the peak to the same graticule reference line. The dial reading is noted, and this reading, added to the first dial reading, equals the peak-to-peak voltage.

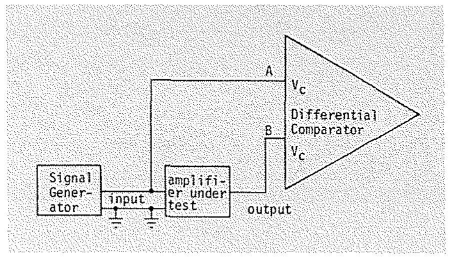



**Figure 13. Test setup to measure amplifier gain.**

An application in which the two inputs to a differential comparator are used to advantage is the gain setting of low-frequency amplifiers. Figure 13 shows a suggested arrangement in which input A of the comparator is used to measure the input signal (A-Vc Display) and then input B of the comparator is used to measure the output (B-Vc Display).

A second application is the measurement of transmitter carrier power. In the following description, correction must be made for carrier frequencies that are above the flat response portion of the amplifier passband. In addition, since this is a voltage measurement, the transmission line should be terminated so as to minimize standing waves. A "Tee" connector is inserted in the output transmission line and used to couple the *input of the differential comparator, through* attenuator probes, to the line center conductor. Figure 14 shows the connections.

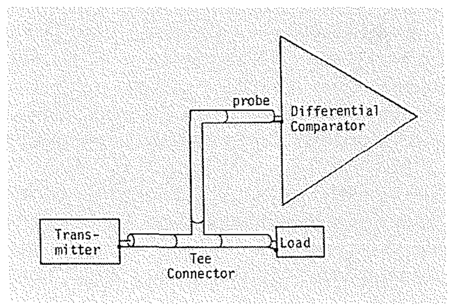



**Figure 14. Test setup to measure transmitter power with a differential comparator.**

The peak-to-peak sine wave carrier is measured with the differential comparator and the results used in the following formula:

$$\frac{\left[\frac{\text{P-P Voltage}}{2} \text{ X } 0.707\right]^2}{\text{Z of System}} = \text{Power}$$

For example, if 200 volts peak-to-peak carrier voltage is measured with a differential comparator and the transmission system is 50 Ω, the power is:

$$\frac{\left[\frac{200}{2} \text{ X } 0.707\right]^2}{50\,\Omega} = \frac{70.7^2}{50\,\Omega} = \frac{4998.5}{50\,\Omega} = 99.97 \text{ W}$$

At low power, as in this example, the signal can be connected directly into the comparator, but at higher power levels attenuator probes must be used and the tolerance of these probes should be included in the power computation.

*Limitations of Differential Comparators*

*Overscan Recovery* is a characteristic of differential comparators that states the time required for the amplifier to recover to within some amount of voltage after a return to the screen. For example, in the discussion of effective screen height, the top of a pulse was brought on-screen by use of the slideback voltage. When the pulse falls and rises again, the rapid change causes peaking and ringing of the pulse leading edge. The overscan recovery specifications state that this ringing will reduce to within 10 millivolts after 300 nanoseconds (W unit). Because of this, measurements should not be made in the first 300 nanoseconds after the leading edge of the pulse reappears on the screen.

*Rate of Rise* is a specification of some differential amplifiers (Tektronix Type Z Differential Comparator Plug-In Unit) that is specified in volts per time. For instance, the maximum rate of rise of the Z unit is 1 volt in 7 nanoseconds. Signals that exceed this rate will cause grid current and subsequent waveform distortion. Similarly, rate of fall of the Z unit is 1 volt in 5 nanoseconds.

Recovery from the conditions caused by pulses that exceed these rates takes an amount of time that is proportional to the pulse amplitude. For example, a 10.0 volt pulse that exceeds the rate of rise specification (say 1.0 volt per 7 nanoseconds) would cause the first 70.0 nanoseconds, measured from the start of the rise, to be unusable.

*Differential Comparator Measurement Accuracy*

The accuracy of a differential comparator measurement depends on several characteristics of the amplifier. These are: comparison voltage (Vc) and linearity accuracy, CMRR, drift, and input attenuator accuracy. In addition to these characteristics which affect *all* measurements, certain other factors must be considered when measuring pulse amplitude. These include: errors due to amplifier recovery, shift in reference level, and input attenuator compensation.

Each of these characteristics, where applicable, can influence the overall accuracy of a measurement. By adding the tolerance figures of each characteristic, a "worst case" figure can be obtained for any particular comparator measurement. For example, the overall accuracy of a dc level measurement of approximately 25 volts (2.5 volts after X10 input attenuation) using a W unit would be:

| | |
|---|---|
| Operator resolution (1 mm at 10 mV/cm) | 0.04 % |
| Vc supply accuracy | 0.15 % |
| Vc readout linearity (0.05% of 11.0 volt range) | 0.22 % |
| CMRR (20,000:1) | 0.005% |
| Reference drift (1 mV) | 0.04 % |
| Input attenuator accuracy | 0.05 % |
| Overall accuracy | 0.505% |

A pulse measurement in which the signal was approximately 25 volts (2.5 volts after X10 input attenuation) with a width of 0.75 microseconds would be:

| | |
|---|---|
| Operator resolution (1 mm at 10 mV/cm) | 0.04 % |
| Vc supply accuracy | 0.15 % |
| Vc readout linearity (0.05% of 11.0 volt range) | 0.22 % |
| CMRR (20,000:1) | 0.005% |
| Reference drift (1 mV) | 0.04 % |
| Input attenuator accuracy | 0.05 % |
| Input attenuator compensation (1% with 20 microseconds time constant) | 1.00 % |
| Recovery offset (10 mV) | 0.40 % |
| Reference level shift (5 mV) | 0.20 % |
| Overall accuracy | 2.105% |

The large influence of the input attenuator compensation (1%) in this example is due to the narrow width of the signal. When this width is increased to 100 microseconds, the overall accuracy figure is 0.958%.

The tolerance figures used to compute the overall figures can be obtained from the instrument instruction manual. The following formulas should be used to convert these figures to percentages where necessary.

$$\text{Vc readout linearity} = \frac{\text{Vc linearity (\%)} \times \text{range in volts}}{\text{Vc}}$$

CMRR error is the reciprocal of the CMRR expressed as a percentage

CMRR error (%) = 1/CMRR

$$\text{Reference drift} = \frac{\text{drift (volts)}}{\text{Vc}} \times 100\%$$

$$\text{Error due to amplifier recovery} = \frac{\text{offset (volts)}}{\text{Vc}} \times 100\%$$

In the above formula, offset refers to the voltage that remains due to overdrive recovery at the time a measurement is made.

$$\text{Error due to reference shift} = \frac{\text{shift (volts)}}{\text{Vc}} \times 100\%$$

*Measuring Potentiometer Conformity*

A differential amplifier combined with a storage oscilloscope and test jig can be used to measure linearity, tracking, and backlash of potentiometers. The test setup is similar for all three measurements and is shown in Figure 15.

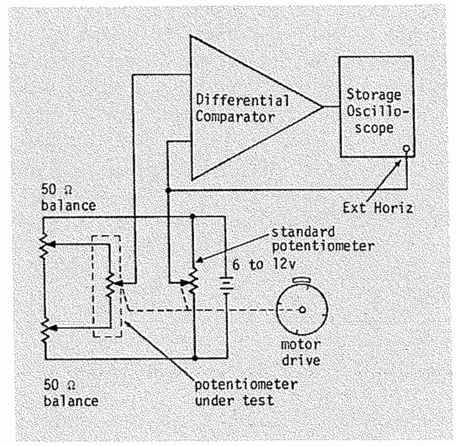



**Figure 15. Test setup to check potentiometers for linearity, tracking, and backlash.**

*Linearity* (independent): This term is defined as the maximum deviation, expressed as a percent of the total applied voltage, of the actual function characteristic from a straight reference line with its slope and position chosen to minimize the maximum deviation over the actual electrical travel, or any specified portion thereof*.

The test for linearity is a comparison between a standard and unknown. A standard potentiometer and the potentiometer to be tested are connected in the test circuit with their shafts mechanically coupled together. Both controls are set at the end of their shaft rotation (zero volts out) and the differential amplifier and the oscilloscope are adjusted to position the start of the trace at the vertical midline. Since the horizontal trace is driven by the voltage from the standard potentiometer, the horizontal amplifier should be adjusted to make the complete rotation of the potentiometers correspond to degrees, i.e., degrees per horizontal centimeter. Thus, deviations in linearity can be described in terms of voltage excess at specific points of shaft rotation. For example, a report on a test could read "20 mV beyond tolerance at 200° from ccw end."

With both potentiometers coupled together and connected to the amplifier, it only remains to determine the sensitivity setting of the amplifier before the actual test is run. This setting depends on the tolerance of the potentiometer under test. For example, ±0.1% linearity would mean that the difference voltage between standard and unknown should not exceed 0.1% of the total voltage applied across the controls. With 10.0 volts as a source voltage, the allowable deviation is ±0.010 volt. With the differential amplifier sensitivity set to 5 mV/cm, the tolerance is ±2 vertical centimeters from the midline.

The test is completed by turning the two controls throughout their range, either by hand or driven by a slow-speed motor. The interpretation of the trace is simply whether it is within the tolerance limits prescribed.

*From: *Wirewound Precision Potentiometers,* an Industry Standard published by the Precision Potentiometer Manufacturers Assn.

At this point the backlash** of the potentiometer can be checked by reversing the rotation of the control shafts and returning them to their starting point. If no backlash is present, the new trace will exactly superimpose over the first. But with backlash, the new trace will be shifted, and the amount of this shift is a measure of the backlash. This same check can be made after the tracking measurement described below:

*Tracking*: This term is defined as the difference at any shaft position between the output ratios of any two commonly actuated similar electrical elements expressed as a percentage of the single total voltage applied to them.

In tracking, the measurement is: how closely do two or more ganged potentiometers have the same output voltage as they are rotated throughout their range? The test setup is the same as that shown in Figure 15. The specification is usually given as: should track within some percentage such as 1.0%. With this specification and 10 volts applied across the potentiometers under test, the difference voltage should not exceed 1% of 10 volts or 0.1 volt. At these figures, the sensitivity of the differential amplifier should be set to 0.05 V/cm. This corresponds to ±2 vertical cm.

Backlash can also be checked as described above under linearity. However, in this case the results are total backlash for both controls.

**Backlash: Defined as the maximum difference in a shaft position that occurs when the shaft is moved to the same acutal output ratio point from opposite directions. This measurement excludes the effect of resolution and contact width.

*About the Author*

Joseph E. Nelson originally trained as a biochemist at Massachusetts Institute of Technology while a member of the U.S. Army. This was concurrent with 6 years as a clinical chemist in army laboratories during World War II.

At the conclusion of World War II, he entered electronics with stress on communications. During the fifties, while with Northrop Aircraft he became associated with standards and measurement techniques. He has published several articles on primary and secondary standards and their relationship to the calibration laboratory.

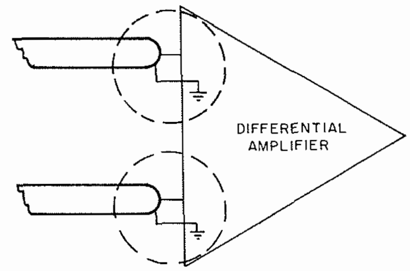
With Tektronix he has served as a technical writer of instruction manuals and currently as an engineering writer of technical application and instructional articles.

Drawing on his original training as a chemist, he is now active in seeking ways to apply electronic instruments such as differential amplifiers to the field of analytical chemistry.

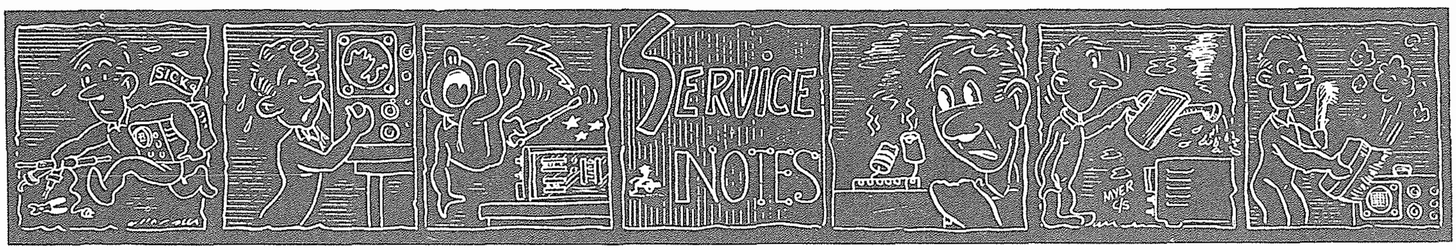
—The Editor

## ERRATA

Figure 9 in Part I of Introduction to Oscilloscope Differential Amplifiers published in the August 1965 issue of Service Scope is incorrectly drawn. The probe shields, in all cases, should be shown grounded to the differential amplifier chassis as follows:




Also in the article, Introduction to Oscilloscope Differential Amplifiers under the heading Probes and Common-Mode Rejection, 2nd paragraph, page 3, the statement, "Tektronix Type 190B Sine-wave Generator at 1 kHz," should read, "General Radio Type 1210C Sine-Wave Generator set to 1 kHz."




## IEEE STANDARD SYMBOLS FOR UNITS

In this issue of SERVICE SCOPE we initiate our use of the IEEE STANDARD SYMBOLS FOR UNITS. Future issues of SERVICE SCOPE will continue to use this standard.

The IEEE publication *IEEE Transactions on ENGINEERING WRITING AND SPEECH*, Volume EWS-8, No. 1, June 1965, presented the Symbols in an article entitled "IEEE Standard Symbols for Units". The Symbols first appeared in the publication "IEEE Standard Symbols for Units, No. 260 (Revision of Part of 51 IRE 21 S1), January 1965".* The Standard Symbols for Units was compiled by the Abbreviations Subcommittee of the IEEE Symbols Committee. It represents four years of careful consideration, thorough discussion and plain hard work by many people. It is consistent with the recommendations of the International Organization for Standardization (ISO) and with the current work of the International Electrotechnical Commission (IEC).

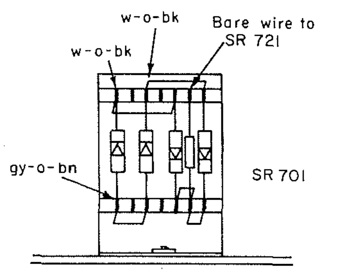
Tektronix, Inc. has decided to follow the lead of the IEEE and adopt the Symbols for Units as a standard for use in our texts, equations, in graphs and diagrams, on the panels and name plates. In so doing, we admit, along with the IEEE, that the Symbols for Units is not perfect. We do believe, however, that the potentialities it offers for better, unambiguous communication are great.

* Reprints are available ($1.00 for IEEE members; $3.00 for nonmembers) from IEEE headquarters, 345 East 47 Street, New York, N.Y. 10017.

## TEKTRONIX PARTS REPLACEMENT KIT 050-0226-00 — ATTENTION U.S. AIR FORCE INSTRUMENT-CALIBRATION AND REPAIR PERSONNEL

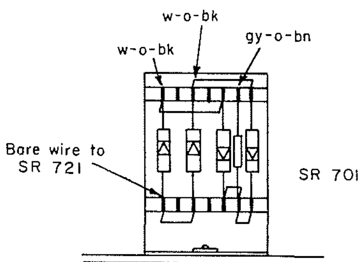
The instruction sheet for parts replacement kit 050-0226-00 contains an error. This kit replaces the selenium rectifier stack SR741 or SR701 in the Type 180A Time-Mark Generator, or SR460 in the Type 315D Oscilloscope with a silicon rectifier bridge. The kit was produced as a special order for the U.S. Air Force.

The error in the instruction sheet is important only when the kit is used to replace SR701 in the +350-V supply of the Type 180A Time-Mark Generator.




TYPE 180A
+350 Supply

Figure 1 (a).




TYPE 180A
+350 Supply

Figure 1 (b).

Figure 1 (a) is a reproduction of the SR701 rectifier diagram as it appears in the instruction sheet. Here the plus (gy-o-bn wire) and minus (bare wire strap) leads are called out incorrectly. With SR701 connected in this manner, the resistor R701 will smoke and burn. Figure 1 (b) shows SR701 connected properly. Notice that the plus and minus leads are connected the reverse of the way shown in Figure 1 (a).

Our thanks to Sgt. Haist of the Portland Air Force Base for calling this error to our attention.

## TYPE 1A1 DUAL-TRACE UNIT—VAR. ATTEN. BAL. CONTROL REPLACEMENT

The following information applies to Type 1A1 Dual-Trace Units with serial numbers below 360.

R130 (Channel 1) and R230 (Channel 2) are the parts list and schematic designations for the potentiometers that serve as the VAR. ATTEN. BAL. controls for Channel 1 and Channel 2 in the Type 1A1 Unit.

Starting with serial number 360, these potentiometers were replaced with a more-serviceable potentiometer (Tektronix part number 311-0459-00). This is the potentiometer you should order when replacing R130 or R230 in units with serial numbers below 360. You should also order an adapter nut (Tektronix part number 220-0420-00) for each replacement potentiometer. The nut used to hold the original potentiometer will not fit the replacement.

## TYPE 555 DUAL-BEAM OSCILLOSCOPE — FAILURE OF INTENSITY CONTROL TO TURN OFF BEAM

The Type 555 Oscilloscope has two INTENSITY controls—one for the Upper Beam and one for the Lower Beam. Inability of one of these controls to turn off its associated beam may be caused by failure of the type 5642 vacuum tube in the INTENSITY control's circuit. Schematic designation of this tube is V822 in the Upper Beam's INTENSITY control circuit or V922 in the Lower Beam's INTENSITY control circuit. Replacement of the defunct 5642 tube will generally clear up the problem.

## TYPE M FOUR-TRACE PLUG-IN UNIT—CHANNELS A, B, C, AND D: CROSS-TALK REDUCED

The addition of four 0.01 μF capacitors (Tektronix part number 283-0050-00) will eliminate high-frequency cross-talk (approximately 0.5% at 20 MHz) in early Type M Four-Trace Units, serial numbers 101-3120.

To add the capacitors, install a #2 solder lug (Tektronix part number 210-0001-00) under the socket-mounting screw nearest pin 2 of each V5323 tube socket. V5323 is a type 7586 vacuum tube and there are four of them—one for each channel—in a Type M Unit. Solder an 0.01 μF capacitor between pin 2 of the tube socket and the newly installed solder lug of each V5323 tube.

Designate the capacitor C5323 and add it to the parts list and schematic of the Type M Unit's Instruction Manual.

Type M Units, serial numbers 3120 and up have this modification installed at the factory.

## TYPE 3A3 DUAL-TRACE DIFFERENTIAL AMPLIFIER — UNSTABLE TRACE AND DC SHIFT

Some Type 3A3 Dual-Trace differential amplifier units within the serial number range 101-969, will sometimes exhibit an unstable trace and evidence of dc shift when the attenuator POSITION control is adjusted. This, when it occurs in Channel 1, is caused by oscillations in transistor Q143 and (or) Q243, and, when it occurs in Channel 2, by oscillations in transistors Q343 and (or) Q443.

The cure is the addition of 4 ferrite cores (Tektronix part number 267-0532-00). Install a ferrite core on the #22 wire strap that runs between the emitter pin and the ceramic strip of each of the four transistors, Q143, Q243, Q343, and Q443. Designate the cores L143, L243, L343, and L443 as shown in Figure 2. Add them to the parts list and to the Channel 1 Input Amplifier and the Channel 2 Input Amplifier schematics in your Type 3A3 Instruction Manual.

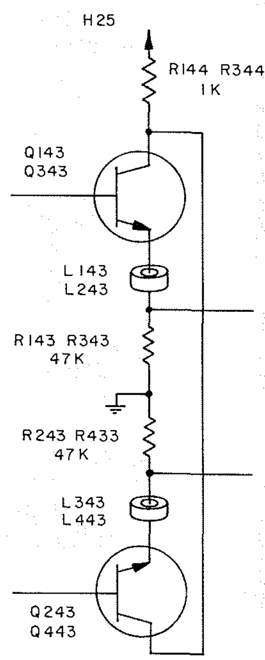



**Figure 2. Partial schematic showing installation of ferrite cores to emittter leads of Q143, Q243, Q343, and Q443 in the Type 3A3 Unit.**

## TYPE 3A74 FOUR-TRACE PLUG-IN UNIT — PROTECTION AGAINST LARGE POSITIVE TRANSIENTS

The addition of a 1 k, ½ W, 10% resistor (Tektronix part number 302-0102-00) in early Type 3A74 Plug-In Units reduces the possibility of a failure of the Channel 1 trigger-amplifier transistor, Q503, caused by a large positive transient at the input connector. The new resistor replaces the wire strap between the collector and ground of the trigger-amplifier transistor Q503.

Designate this new resistor R501 and add it to the parts list and schematic in the Type 3A74 Instruction Manual.

This improvement is applicable to Type 3A74 Units, serial numbers 101-1309. In Units with serial numbers 1310 and up the protection is installed at the factory.

## TYPE 2B67 TIME-BASE UNIT—PROTECTION FOR DIODE D126

A grid-to-plate short in V135 (a 6DJ8 vacuum tube) in the Type 2B67 Time-Base Unit, can cause damage to the diode D126, when the MODE switch is in the NORMAL position.

Changing R137, a 100 Ω ½ W, 10% resistor, to a 220 k, ½ W, 10% resistor (Tektronix part number 302-0224-00) and paralleling it with a 68 pF, 500 V speed-up capacitor (Tektronix part number 281-0549-00) will protect D126 against this damage.

R137 is located between pins 1 and 7 of V135.

Designate the new capacitor C137 and add it to the parts list and schematic in your Type 2B67 Instruction Manual. Note also, in these sections of the Instruction Manual, the changed value for R137.

This information is applicable to Type 2B67 Units with serial numbers below 15380. Instruments with higher serial numbers have the new-value resistor and paralleling capacitor installed at the factory.

# NEW FIELD MODIFICATION KITS

## TYPE 544, TYPE 546, and TYPE 547 OSCILLOSCOPES — VERTICAL-OUTPUT AMPLIFIER PROTECTION

This modification protects the output transistors Q1114 and Q1134 in the Vertical Amplifiers of the above instruments (both conventional and rackmount versions) from excessive collector voltage. The excessive voltage is caused primarily by grid-to-cathode shorts in V707, a type 6080 series-regulator tube, in the +225 V supply.

The protective circuit consists of a new transistor, Q1109, in series with the collector supply of the output-amplifier transistors Q1114 and Q1134. The base of Q1109 is returned to +100 V through a new 105 V zener diode (D1109). Should the +225 V supply go out of regulation, the fixed base voltage of Q1109 limits the output transistors collector voltage to approximately 205 V.

The new transistors and associated circuitry are all mounted on a small sub-chassis. This sub-chassis mounts near the rear of the input Vertical-Amplifier chassis using an existing hole in this chassis.

This modification is applicable to the following instruments:

| TYPE | SN's |
|---|---|
| 544 | 101-374 |
| RM544 | 100-119 |
| 546 | 100-449 |
| RM546 | 100-149 |
| 547 | 100-2343 |
| RM547 | 100-259 |

Order through your local Tektronix Field Office, Field Engineer, Field Representative or Distributor. Specify Tektronix part number 040-0405-00.

## ALTERNATE/CHOPPED COMPATIBILITY REWORK

This modification kit is applicable to Type 531, Type 535, Type 541 and Type 545 Oscilloscopes, sn's 101-20000, that have had Field Modification Kit 040-0403-00 (see SERVICE SCOPE, issue #5, December, 1960) installed; and, Type RM31, Type RM35, Type RM41 and Type RM45, sn's 101-1000, that have had Field Modification Kit 040-0198-00-01 (see SERVICE SCOPE, issue #5, December, 1960) installed.

Installation of the Alternate/Chopped Compatibilty Rework field modification kit gives to these instruments the ability to utilize the Alternate-Trace feature of the Type 1A1 and Type 1A2 Dual-Trace Plug-In Units.

These plug-in units require an alternate-trace sync pulse at pin 8 of the oscilloscope's plug-in interconnecting socket. This pulse is not available in the oscilloscopes listed above.

The Alternate-Trace/Chopped Compatibility Rework field modification kit corrects this situation by replacing the 6J6 tube in the V78 position with a 6DJ8 tube and changing the oscilloscope's Multi-Trace sync and Chopped-Blanking circuitry to conform to that in the Type 531A, Type 535A, Type 541A, Type 545A/B, Type 546, Type 547, etc., oscilloscopes.

To install the 6DJ8 tube it is necessary to enlarge the socket-mounting hole and replace the original socket for the V78 position with a 9-pin type.

Order through your local Tektronix Field Office, Field Engineer, Field Representative or Distributor. Specify Tektronix part number 040-0404-00.

## 12 KV HIGH VOLTAGE

This modification is applicable to the following oscilloscopes:

| TYPE | SN's |
|---|---|
| 541 | 101-20000 |
| RM41 | 101-1000 |
| 541A | 20000-up |
| RM41A | 1001-up |
| 543 | 101-3000 |
| RM43 | 101-1000 |
| 543A | 3001-up |
| RM43A | 1001-up |
| 545 | 101-20000 |
| RM45 | 101-1000 |
| 545A | 20000-up |
| RM45A | 1001-up |
| 581 | 101-3974 |
| 581A | 3975-4999* |
| 585 | 101-5968 |
| 585A | 5969-8999* |
| RM85A | 101-999* |

The modification replaces the original 10-kV high-voltage transformer with a 12-kV transformer, thus increasing the crt accelerating potential to provide greater intensity at fast sweep speeds.

The vertical and horizontal deflection sensitivities of the crt are reduced approximately 15%; a special graticule (supplied with the kit) is used to compensate for this reduction. All front panel and manual references to "CM" should be interpreted as "DIV". For example, read "TIME/CM" as "TIME/DIV".

Order through your local Tektronix Field Office, Field Engineer, Field Representative or Distributor. Specify Tektronix part number 040-0176-00.

*NOTE: This kit can be installed in instruments above these serial numbers provided they have external-graticule crt's. It can also be installed in those instruments above these serial numbers provided *the instrument is first converted to an external-graticule crt.*

The external-graticule crt must be ordered separately as follows:

Crt, external grat. P31 phosphor (T5810-31), Tektronix part number 154-0354-00.

Crt, external grat. P11 phosphor (T5810-11), Tektronix part number 154-0230-00.

Steps 17 through 22 on page 4 of the modification's instruction sheet tell how to remove the internal-graticule crt and install the external-graticule crt replacement.

## TYPE 530 AND TYPE 540 SERIES OSCILLOSCOPES — DC FAN MOTOR

This modification supplies a dc fan motor to enable the following instruments to operate on 50-400 cycle power lines.

| TYPE | SN's |
|---|---|
| 531 | 5001-20000 |
| RM31 | 101-1000 |
| 533 | 101-3000 |
| RM33 | 101-1000 |
| 535 | 5001-20000 |
| RM35 | 101-1000 |
| 541 | 5001-20000 |
| RM41 | 101-1000 |
| 543 | 101-3000 |
| RM43 | 101-1000 |
| 545 | 5001-20000 |
| RM45 | 101-1000 |

Order through your local Tektronix Field Office, Field Engineer, Field Representative or Distributor. Specify Tektronix part number 040-0255-00.

## THE TEKTRONIX TYPE 453 DUAL-TRACE DC-TO-50 MHz PORTABLE OSCILLOSCOPE

Until rather recently, the need for a sophisticated oscilloscope offering DC to 50 MHz bandpass and versatile capabilities was, for the most part, confined to the laboratory. The need today however, for an instrument with these qualities, extends beyond the laboratory into many areas of servicing, research and development. Examples of these areas are: computer installations, radar and guidance systems, telemetry and microwave equipment, commercial aircraft, aerospace work, and defense systems.

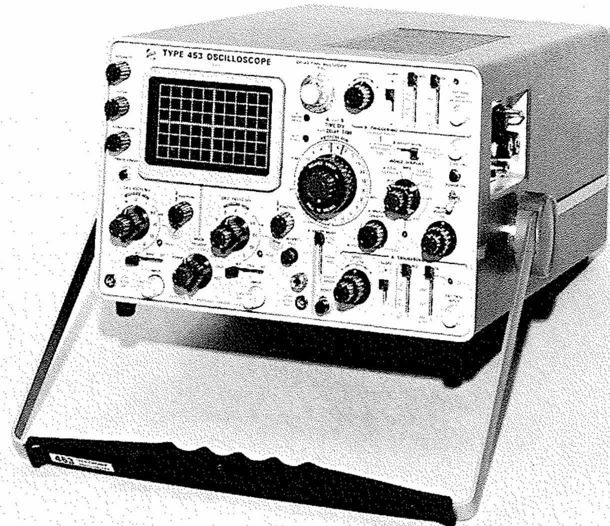
In addition to the capabilities stated above, an instrument designed for use outside the laboratory must be capable of withstanding a wide range of environmental conditions, be ruggedly constructed and compactly contained in a highly portable package. The Type 453 Dual-Trace, DC to 50 MHz Oscilloscope is just such an instrument in just such a package. It provides the highest performance compatible with cost and portability. It possesses rather extended environmental capabilities and delivers information with laboratory accuracy.

The vertical amplifier system of the Type 453 Oscilloscope combines in one oscilloscope many features normally available only in a plug-in type instrument using several different plug-in units. These features amongst others are: (a) high gain, low bandwidth; (b) medium gain, high bandwidth; (c) low gain, high bandwidth; (d) medium gain, medium bandwidth, dc coupled; (e) dual trace, low gain, high bandwidth; and, to a not inconsiderable degree, differential input capability.

Here, briefly, are some of this instrument's characteristics:

1). Dual-Trace Vert.
2). Signal Delay
3). 50 MHz basic Vert. bandwidth
4). 5 mV/div basic Vert. sensitivity
5). 1 mV/div maximum Vert. sensitivity at reduced bandwidth (One Channel only —Ch 1 and Ch 2 cascaded).
6). 5 sec/div minimum sweep rate
7). 10 nsec/div maximum sweep rate (with X10 magnifier).
8). Full bandwidth triggering
9). Normal sweep plus delayed sweep
10). 6 x 10 div* (4.8 x 8 cm) vert. and hor. crt display size
11). 10 kV crt accelerating voltage
12). Only 100 W power consumption
13). 31 lbs weight complete with accessories

The Type 453 maintains its full bandwidth of 50 MHz to a sensitivity of 20 mV/div, and drops to 45 MHz and 40 MHz at 10 mV/div and 5 mV/div respectively.




It presents the usual five vertical display modes of dual-trace instruments—CH 1, CH 2, ALT, CHOP, and ADDED. CH 2 has polarity selection to provide some differential amplifer performance in the ADD Mode. Sampling rate for the CHOP Mode is 0.5 MHz rather than 1 MHz—a relaxation that reduces the loss of brightness due to chopped transient blanking.

Internal triggering may be selected between either the displayed signal or that of a single channel. The latter selection enables stable triggering when observing time related events in either of the dual-trace modes.

The input impedance of 1 megohm paralleled by 20 picofarad is compatible to previous laboratory instruments.

All previous passive probes adjustable to this input capacitance are applicable to the Type 453 Oscilloscope. However, a new 10X probe, the P6010, was designed specifically to provide a smaller tip for use with the increasingly compact equipment that it is anticipated this oscilloscope will service. This new probe's tip is pencil size and free of adjustment.

Capacitance compensation is accomplished at the scope end of the probe. Two of these probes are shipped with each Type 453 Oscilloscope. Bandwidth figures quoted here include the effect of the P6010 probe.

The Type 453 utilizes a four-inch, rectangular-faced crt which features an internal graticule illuminated with edge lighting. The significantly improved display contrast of this crt provides enhanced viewing under high ambient light conditions. In addition, a fine mesh filter, placed in front of the crt, attenuates bothersome external reflections for easier viewing.

The Type 453 will operate on either 115 V or 230 V nominal power-line supplies; and, without the need to make internal wiring changes. Two power cords are shipped with the instrument, one for 115 V line supplies and one for 230 V line supplies. Selection of the correct power cords automatically adapts the instrument's power supply to the available line supply. The oscilloscope power supply automatically operates at either nominal voltage, when the appropriate power cord is inserted. A rear-panel switch permits operation on line voltage above or below nominal: high range—103 to 137 volts or 206 to 274 volts, low range—96 to 127 volts or 192 to 254 volts (when line contains less than 2% total harmonic distortion).

The Type 453 will accept the recently-announced Tektronix Type C30 Camera, thus assuring those whose applications require it the capability of trace photography.

Many will find that in the laboratory (where, incidently, it requires a minimum of bench space) the Type 453 delivers all the oscilloscope capability they require. In addition, it will provide them with an easily transported instrument—remember it weighs only 31 pounds—for servicing equipment or maintenance or research work in the field. This can be a mighty important consideration, particularly for those who must operate on limited budgets.

The Type 453 Dual-Trace DC to 50 MHz Portable Oscilloscope offers many other features not described here. Full appreciation of this advanced example of the state-of-the-art in portable oscilloscopes requires a demonstration of the instrument.

May we suggest you call your Tektronix Field representative or distributor to arrange one. He'll be pleased to accommodate you—no obligation on your part, of course.

* 1 div = 0.8 cm

# Service Scope

USEFUL INFORMATION FOR

USERS OF TEKTRONIX INSTRUMENTS

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon, U.S.A. 97005

BEAVERTON OREG. DEC 3 2 '65 U.S. POSTAGE 05 P.B. METER 336216

Mr. Dave Yule
Department of Transport
Maintenance & Operations Div.
Temporary Building #3
Ottawa, Ontario, Canada 8-61

RETURN REQUESTED