Service Scope

USEFUL INFORMATION FOR USERS OF TEKTRONIX INSTRUMENTS

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TUNNEL DIODE SWITCHING CIRCUITS AND THE BACK DIODE

By The Marketing Technical Training Department
Tektronix, Inc.

PART II

This is the concluding half of an article intended to give the reader a better understanding of tunnel-diode switching circuits. The first half of the article appeared in the June, 1966 Service Scope. It reviewed the several methods of tunnel-diode circuit operation and, in a circuit analysis, developed the need for a device, such as the back diode, in these circuits. This half of the article discusses the theory of the back diode and the application of this rather new device to tunnel-diode circuits.

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GAC

BACK DIODE

In order to avoid the waste power in R_2, during "idle" time of the circuit, the ideal component to replace R_2 would be a 200-mV zener diode (see Figure 8). Normally when the TD is biased on the first positive slope, there would be essentially no current supplied to the zener. The steep slope of the zener that extends between the peak and valley current points of the TD would cause very positive switching back to the low-voltage state. Unfortunately, 200-mV zeners are not available.

A more practical solution is the use of a back diode[1].

The back diode is simply a tunnel diode that is usually chosen for its reverse conduction characteristics. If the peak current is small compared to the operating

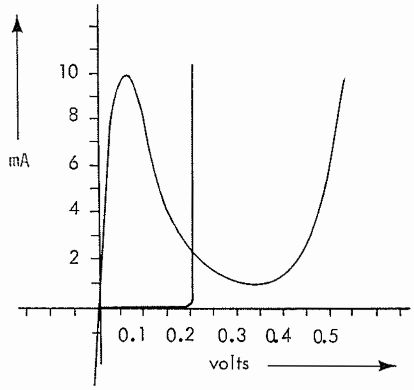
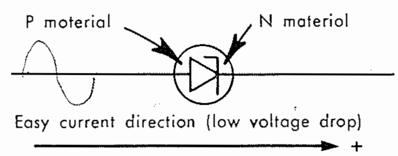


Figure 8 Curve of a hypothetical 200-mA zener diode superimposed on a 10-mA tunnel-diode curve.

current, the peak current can be ignored. The BD-4 back diode has a peak current of from 50 μA to 100 μA (see Figure 9A). When a 200-mA peak to peak sinewave is applied to the BD-4, the E-I characteristics of the back diode are represented by the curve in Figure 9B. Notice that the negative resistance characteristic cannot be seen.

[1]The back diode is a tunnel diode whose reverse characteristics are being used. Just as there are many symbols for tunnel diodes, many symbols have been used for back diodes. In order to avoid confusion, the symbol shown below has been chosen to represent a "backward" diode in this article.



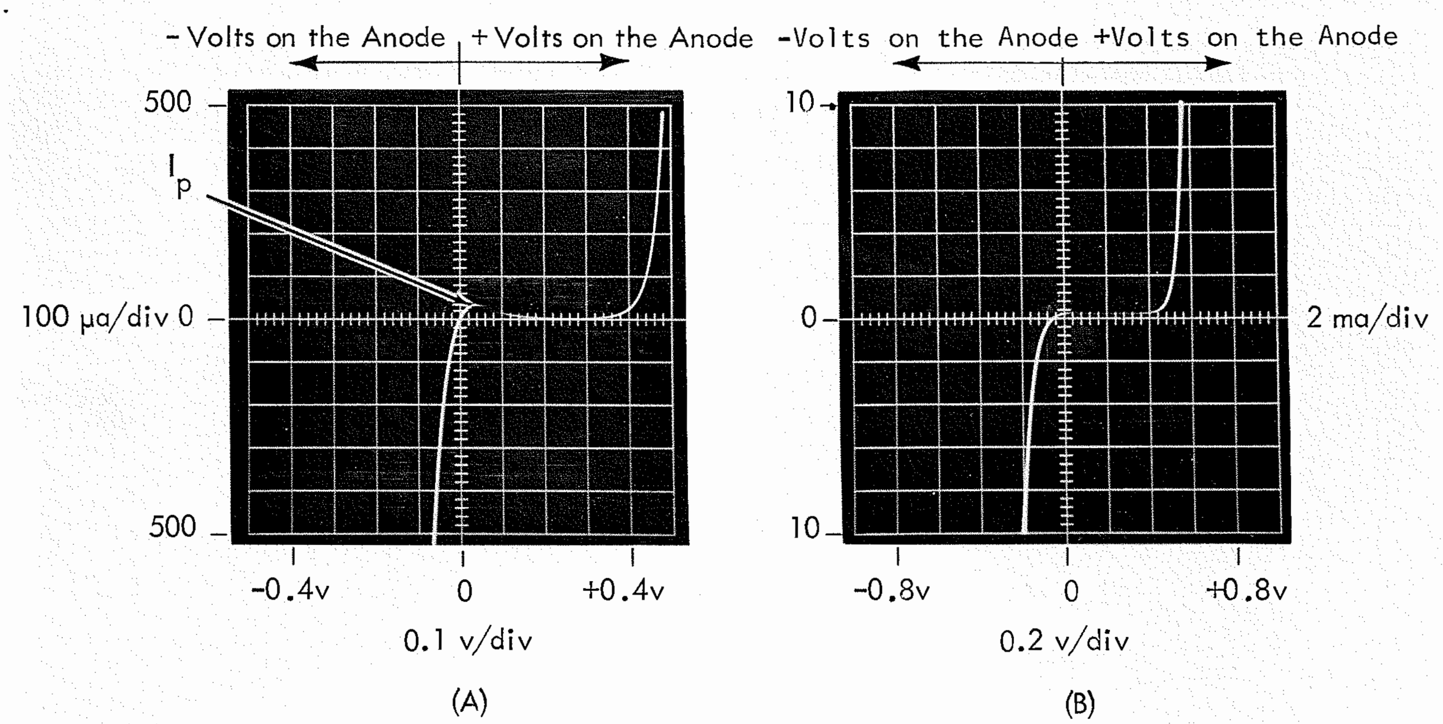


Figure 9 (A) Waveform photo showing peak current of a BD-4 back diode.
(B) Waveform of a BD-4 back diode with a 20-mA sinewave applied.

Since the back diode is operated in the reverse direction, the conduction curve in Figure 9B must also be reversed to give a proper picture of the conduction characteristics of the device. See Figure 10. Notice this appears like a regular diode with a low-voltage zener region and an extremely low forward voltage drop. Any TD can be used as a back diode, although the high forward-current tunnel diodes will have a less desirable "reverse" characteristic.

Figure 11A shows curves of a tunnel diode type TD253B and a back diode type BD-4 superimposed. These curves were taken on a Tektronix Type 575 Curve Tracer with the vertical deflection factor set to 1 mA/div and the horizontal set to 0.1 volts/div.

In Figure 11B, if the TD bias resistor, R_3, is adjusted so that the tunnel diode is biased at some current below I_p, the TD circuit is in a triggerable mode. The new DC load line, using the back diode as a load for the TD, is shown in Figure 12. The curve of the load line is the inverse of the impedance of the back diode. The AC load line is still the flat line (dashed) produced by the coil. At the time the peak current on the tunnel diode is reached, the current in the back diode is approximately 1 mA. This compares to 3.2 mA of "lost" current when using the 25-Ω resistor. As more current flows in the back diode, the non-linear impedance decreases substantially. The back diode must conduct about 10 mA when switching the TD to the low-voltage state. At this point (10 mA) the impedance of the BD-4 is about 2 Ω. This low impedance will cause a very positive "back to low-voltage state" switching of the tunnel diode. The non-linear impedance of the BD-4 offers the following advantages over a resistor:

1. The high impedance at low current insures that the triggering point of the TD does not depend on the rate of rise of the trigger signal because the L is essentially disconnected.
2. The very low impedance at high current will insure that the TD always returns to its low-voltage state after a trigger.

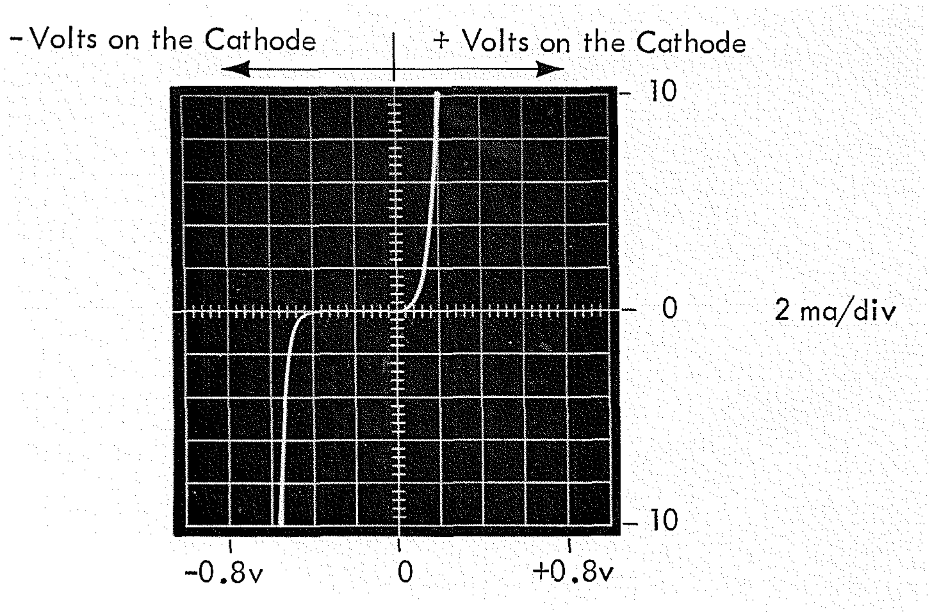


Figure 10 Conduction curve in Figure 9, (B) reversed to give a proper picture of conduction characteristics.

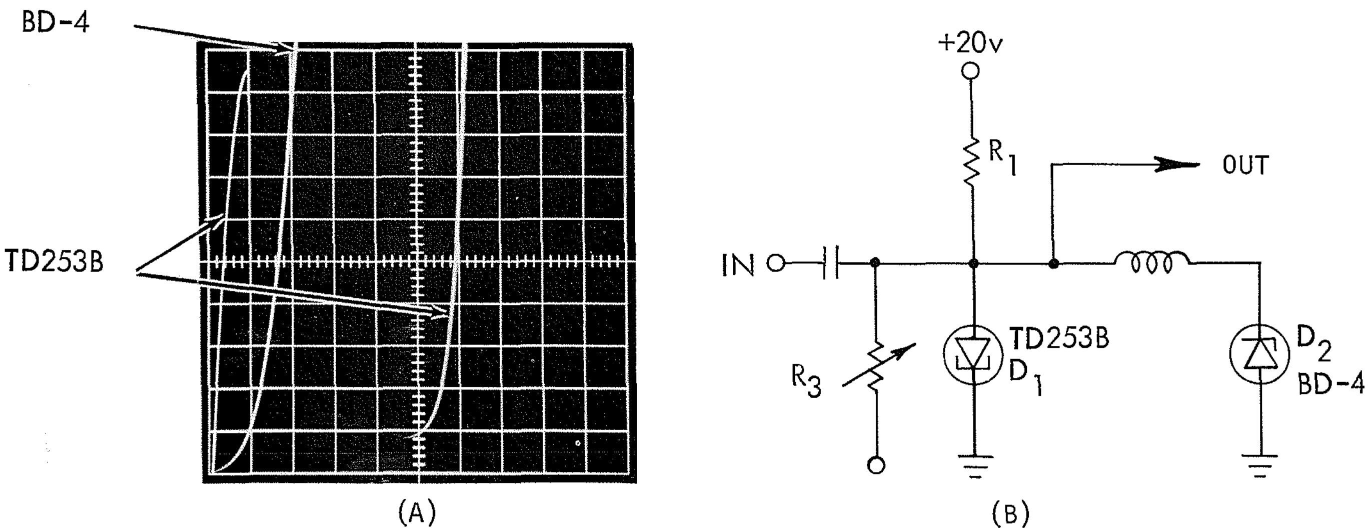


Figure 11 (A) Curves of a TD253B tunnel diode and a BD-4 back diode superimposed.
(B) Same circuit as in Figure 6, (A) except here a back diode, D_2, is the load for the tunnel diode.

3. The static power requirements are less.

The BD-4 also aids in operation of the circuit as a count-down unit. It has been noted that the circuit in Figure 11B will oscillate if the TD is biased above the peak current point. Current switching will take place between the TD and the back diode. The frequency can be influenced by changing bias on the TD. If the circuit has a free-running frequency of 49 MHz and a 200-MHz signal is applied, the TD multivibrator circuit will synchronize with some sub-multiple of 200 MHz—in this case 50 MHz. In any case, the output frequency will be some sub-multiple of the input frequency when the input frequency is significantly higher than the circuit free-running frequency.

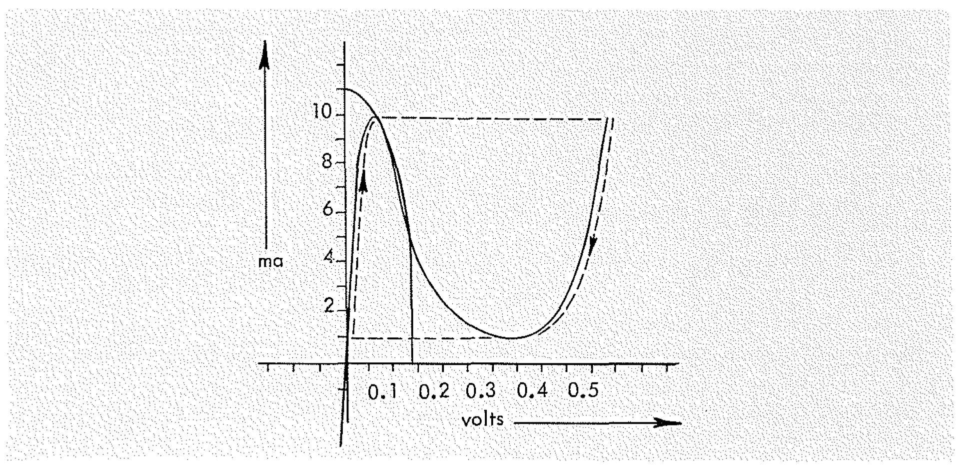


Figure 12 AC and DC load lines of tunnel diode in Figure 11 (B) superimposed on a 10-ma tunnel-diode curve.

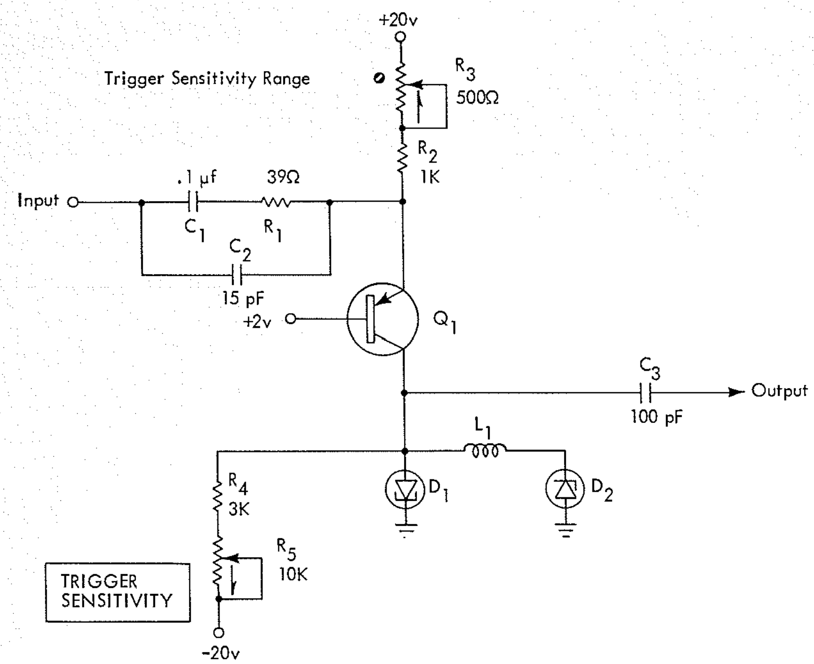


Figure 13 A few refinements to the circuit in Figure 11 (B) are included in the circuit shown here. See text for explanation.

A few refinements to the circuit in Figure 11B are included in the circuit in Figure 13. The transistor is a fast PNP device which isolates the voltage excursion of the TD circuit from the input signal. Static current in the transistor is adjusted by R_3 to compensate for circuit values and peak current differences of TD's. Normally, R_3 is adjusted for a free-running TD circuit when R_5 is at the center of its range. When R_5 is set in the center of its range, the circuit operating conditions are as follows:

1. Current from the —20 V supply to D_1 anode is $\frac{E}{R} = \frac{20\text{ V}}{8\text{ k}\Omega} = 2.5\text{ mA}$.
2. D_1 must be biased at peak current which is 10 mA.
3. D_2 will have a reverse current of ≈ 1 mA.
4. Current in Q_1 must equal R_4, R_5 current plus D_1 current plus D_2 current which total 13.5 mA.
5. Voltage drop across R_2, R_3 is +20 V minus emitter voltage of +2 V (base voltage) plus ≈ 0.6 V (base-emitter drop) which equals 20 — 2.6 or 17.4 volts.
6. Required total resistance of R_2, R_3 is $\frac{E}{I} = \frac{17.4\text{ V}}{13.5\text{ mA}} = 1.29\text{ k}\Omega$.
7. Current requirements are satisfied when R_3 is adjusted for 290 Ω.

The input signal is AC coupled by C_1 and C_2. If the input frequency is sufficiently high, the impedance of C_1 can be ignored and input impedance is R_1 in series with the transistor emitter resistance; 39 Ω + 11 Ω = 50 Ω. The small capacitor, C_2, provides additional high-frequency coupling of the input signal to compensate for the increase in emitter resistance at higher frequencies, thus the input impedance is held fairly constant throughout the circuit operating range. Since the input impedance is a predictable 50 Ω, the signal current can be found by $I = \frac{E\text{ signal}}{R\text{ input}}$. For a 10-mV signal, I becomes $\frac{10\text{ mV}}{50\ \Omega}$ or 0.2 mA. An increase in current is required to switch D_1 so the circuit responds to positive signals only.

When triggered operation is desired, R_5 is set ccw of center (less than 5 kΩ). More current is furnished to the transistor collector by R_4, R_5 — perhaps 2.7 mA. The additional 0.2 mA through R_4, R_5 subtracts from the current in the TD. The TD is biased at 0.2 mA below peak current or 9.8 mA. A positive 10 mV signal will cause an increase of current in Q_1 of 0.2 mA and the TD will switch. The TRIGGER SENSITIVITY control is usually adjusted so that the current requirements of D_1 are compatible with the input signal.

When synchronized operation is desired, D_1 is made to free-run by reducing the shunt current through R_4, R_5. (R_5 is adjusted for greater than 5 kΩ.) D_1 current increases to greater than peak current and D_1, D_2 and L_1 act as an oscillator. The oscillating frequency is influenced by the additional current through D_1, D_2 and L_1 when the resistance of R_5 is increased. As current increases, frequency decreases because even though the time constant remains the same, a longer time is required to switch the *additional* current from D_1 to D_2.

Let us assume the TD has just switched to the high state. Current through D_2 increases exponentially as fast as L_1 and the impedances of D_1 and D_2 will allow. As the current in D_2 increases, current in D_1 will decrease proportionally until D_1 switches to the low-voltage state. At this time, the current in D_1 will increase as current in D_2 decreases until D_1 peak current is reached and switching occurs again.

When a high-frequency signal is applied at the circuit input, each positive peak will cause a small increase of current in Q_1. If D_1 is almost ready to switch when a current increase occurs in Q_1, the switching of D_1 and the positive peak of the input signal occur coincidently. (The increase in Q_1 current will cause D_1 to switch.) When the free-running frequency of D_1 D_2, and L_1 is such that one of several input signals always causes D_1 to switch, the TD multivibrator circuit will be in synchronization with the input signal. Since the TRIGGER SENSITIVITY setting influences the free-running frequency of the circuit, it can be adjusted to achieve optimum synchronization.

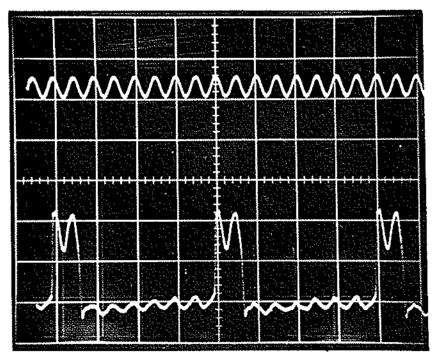


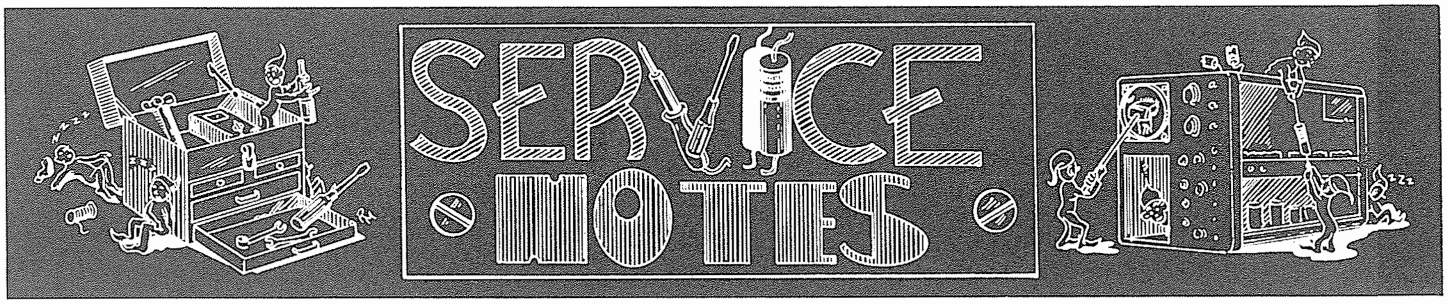
Figure 14 Waveform photo showing a 200-MHz input signal on the upper trace and the synchronized switching of the TD circuit on the lower trace.

The photo in Figure 14 shows the 200-MHz input signal on the upper trace and the synchronized switching of the TD circuit on the lower trace.

The obvious advantages of this type of trigger circuit are:

1. The circuit is *very* sensitive to small input signals.
2. The circuit can be made to oscillate and produce a trigger in the absence of an input signal.
3. In synchronous operation, high-frequency input signals can be converted to a more useable frequency.
4. The TD circuit operates at low power levels so radiation interference is correspondingly low.

In the interest of simplicity the influence of the usual hold-off circuitry has been deliberately ignored. By adjusting circuit values in Figure 13, current in Q_1 has been increased to include TD bias current normally supplied by the hold-off circuitry.



TYPE 580/580A SERIES OSCILLOSCOPES WITH TYPE 82 DUAL-TRACE PLUG-IN UNITS—A SYSTEMATIC STEP-BY-STEP PROCEDURE FOR MAKING GAIN ADJUSTMENTS

A Type 580/580A Series Oscilloscope in combination with a Type 82 Dual-Trace Plug-In Unit has eight gain adjustments which must be adjusted in the proper sequence to realize optimum vertical-amplifier performance. These eight gain adjustments —five potentiometers and three solder-in resistors—are necessary to compensate for the effects of parameter variations of transistors and tubes. Before we outline a systematic step-by-step procedure by which these adjustments are made, we should point out that the three solder-in resistors are selected during the initial factory calibration of the Type 82 and Type 580 Series Oscilloscope—*they will very seldom require changing*. However, to make a complete story, the selection procedure for each of the three solder-in resistors has been included in the adjustment procedure. The adjustment procedure was written with the Type 581A and Type 585A Oscilloscopes in mind. Certain notes have been added to make the procedure equally useful for the Type 581 and Type 585 Instruments.

The step-by-step gain adjustment procedure which follows is intended to delete one step in the Calibration section of the Instruction Manuals for the Type 580 Series Oscilloscopes and to replace one step. The steps deleted and replaced will depend upon whether the calibration procedure you are following is for a Type 581, Type 585, Type 581A, or Type 585A Oscilloscope. If your Instruction Manual is for a:

Type 581, delete step 15, page 6-8; replace step 16, page 6-9.

Type 585, delete step 15, page 6-9; replace step 16, page 6-10.

Type 581A, delete step 11, page 6-6; replace step 14, page 6-6.

Type 585A, delete step 11, page 6-6; replace step 14, page 6-7.

The Type 580 Series Indicator (Oscilloscope) deflection factor (Volts/cm) must first be verified before using the indicator for plug-in calibration.

Adjustment of the Type 580 Series Indicator Gain:

1. Install a Type 84† Plug-In Test Unit in the Type 580 Series Indicator.

   NOTE: If a Type 84 Plug-In Test Unit is not available, a Type 82 Dual-Trace Plug-In Unit can be used to provide the push-pull signal required—see Step 4-c. A second *calibrated* scope is the instrument you would choose to verify that the Type 82 Plug-In was delivering 100 millivolts peak-to-peak to the input of the indicator.

2. Set the Type 84 DISPLAY SELECTOR to CAL (2 cm), ALT. SYNC and free run the sweep.

3. Rotate the Type 580 Series Indicator Vert. Gain Adj. full clockwise (R1015).

4. Check the gain limits:
   a. If the deflection is less than 2.3 cm, the 6DJ8's on the upper vertical chassis and/or the 7788 CRT driver tubes may need replacements. (Type 581 & 585 used a single 7699 CRT driver tube.)

   NOTE: Typical voltage gains for each of the three sections of the vertical amplifier will be useful in determining if tubes should be replaced for insufficient gain. Typical gains are:

Delay Line Driver section (lower vertical chassis)	X3 gain
Vertical Output section (upper vertical chassis)	X5 gain
CRT driver chassis	X4 gain

   b. If the CRT deflection is greater than 2.5 cm, add a 2W 180-Ω resistor (R1016)* between the Vert. Gain Adj. pot (R1015) and the cathode bus wire. (R1016 replaces a wire strap.) Until Type 585A, sn 10870, R1016 was usually 0 Ω (wire strap) and not listed in the manual. If GE 6DJ8's are used in the vertical amplifier, gain may be excessive—requiring use and selection of R1016. R1016 can have any value between 0 Ω and 200 Ω.

   c. Vary the line voltage from 105—125 V AC. With marginal tubes, the CRT display will shift vertically about 1.8 mm and the peak-to-peak deflection will change about 2 mm (10%). With new tubes, line voltage variation will cause virtually no vertical shift or gain change. Return the line voltage to 117 V AC.

   NOTE: With a 2-cm display and change of line voltage from 105—125 V AC, vertical trace shift of 0.5 cm and a peak-to-peak deflection change of nearly 1.0 cm can be expected on a Type 585 which has not been modified by installation of kit 040-0303-00 (Vertical DC Filament Supply Modification Kit).

   Type 585A should not produce 1.0 cm of CRT deflection when 100 mV of peak-to-peak signal is *differentially* applied to the indicator between pins 9 and 11 of the Amphenol connector. A Type 82 or 86 Plug-In Unit develops a differential (push-pull) signal at these pins.

Adjustment of the Type 82 Gain:

Remove the Type 84 Plug-In Test Unit from the indicator and install the Type 82; allow 10 to 15 minutes warm-up time. Perform all manual checks and adjustments pertaining to gas, microphonics, position range, and grid current before starting the gain adjustments.

NOTE: Prior to sn 3000, the Gain Bal. Adj. pot was in Channel B instead of Channel A and designated R277. For these early Type 82's, Steps 1-5 should be performed in Channel B; Step 7 should be performed in Channel A.

1. Set Channel A and B VOLTS/CM to 0.1, VARIABLE VOLTS/CM clockwise and MODE switch to A only.

2. Apply 0.2 V from the Type 585A calibrator (±3%) to the A Channel input.

3. a. Vary the line voltage from 105—125 V AC. If the change in CRT deflection is 5—10% greater than the change noted in Step 4 c of the Type 585A adjustment section, replace the three output 6DJ8's in the Type 82. 6DJ8's with low transconductance will reduce the gain of the Type 82 output amplifier as much as 10%.

b. Mechanically center the front panel X1 GAIN ADJ. control. Rotate the Gain Bal. Adj. (R177), located on the circuit board assembly near Channel A Attenuator switch. If the range is not approximately ±3 mm (nominal 2-cm CRT deflection), select and install a new value of R550.* Typical range of R550 is 10 Ω to 68 Ω.

c. Change the 0.2-V calibrator signal to Channel B, MODE switch to B only (front panel X1 GAIN ADJ. is still mechanically centered), and select R262* for approximately 2-cm CRT deflection. Reducing the value of R262 will increase the CRT deflection; typical range of R262 is 390 Ω to 1.5 kΩ. (R262 is in parallel with R267 and, if present, is located on the circuit board assembly near B attenuator switch.)

4. a. Adjust the X1 GAIN ADJ. for exactly 2 cm of CRT deflection.

   b. Change the 0.2-V calibrator signal to Channel A, MODE switch to A only and adjust the Gain Bal. Adj. for exactly 2-cm CRT deflection.

5. With the calibrator signal still applied to Channel A, change the GAIN switch to X10 and the calibrator signal to 20 mV.

6. Adjust the X10 Gain Adj. (R356) for exactly 2-cm deflection.

7. Turn MODE switch to Channel B only, change the calibrator signal to Channel B and adjust the X10 Gain Adj. (R456) for exactly 2-cm deflection.

† The Type 84 designation for the Plug-In Test unit for the Type 580 Series Oscilloscopes has been changed to a Tektronix part number — 067-0523-00. This part number, rather than the Type 84 designation, should be used in ordering or referring to the Type 580 Series Oscilloscopes Plug-In Test Unit.

* The resistors identified by an asterisk are the three solder-in resistors that along with five potentiometers comprise the eight gain adjustments with which this procedure is concerned.

TRANSISTOR TESTING WITH THE TYPE 575 TRANSISTOR-CURVE TRACER AS AN AID TO TROUBLESHOOTING

Usually when a transistor fails one junction becomes shorted or open. Quick checks for opens or shorts can be made on suspect transistors by using a Type 575 Transistor-Curve Tracer to determine whether a typical family of curves can be produced. Nearly every transistor can stand a collector voltage of about 2 volts without danger of breakdown; and, base current drive of up to 100 microamperes will almost never exceed dissipation limits with only 2 volts on the collector. So, by limiting the collector voltage and the base drive on the Type 575, you can quickly and safely make non-destructive tests to determine if the transistor is functioning properly. To do this you need only to know whether the transistor is an NPN or PNP type, which leads go to the emitter, the base and the collector, and how to set up the Type 575. (Pages 2-5 and 2-6 in the Operating Instructions section of the Type 575's Instruction Manual contain information on how to set up the Type 575 to display a family of curves.)

The Beta of most transistors is usually between 10 and 200. Therefore, a vertical mA/division setting of about 20 times the amount of base current per step will usually produce a display of a typical-looking family of curves on the CRT of the Type 575. Putting it in terms of front-panel controls for the Type 575, the CURRENT OR VOLTAGE PER DIVISION switch (located in the Vertical block) should be set to a value on the COLLECTOR mA range, that is 20 times the value of the mA PER STEP setting of the STEP SELECTOR switch (located in the Base Step Generator block).

From an instrument troubleshooting standpoint, the Type 575 is a valuable tool. Transistor characteristics can be easily matched for use in push-pull solid state amplifiers. Verification of tunnel diode, zener diode, and signal diode characteristics is a relatively simple task. For maintenance activities, it proves to be quite a time saver.

NEW FIELD MODIFICATION KITS

TYPE 316 AND TYPE 317 OSCILLOSCOPES—DC FAN MODIFICATION

Installation of this modification enables the Type 316 and Type 317 Oscilloscopes to operate from a 50-to-400-cycle power source. The kit supplies a DC fan assembly and the necessary hardware and components along with step-by-step instructions for easy installation.

Order through your local Tektronix Field Office, Field Engineer, Field Representative, or Distributor. Specify Tektronix part number 040-0228-00.

TYPE 316 AND TYPE 317 OSCILLOSCOPES—SILICON RECTIFIERS

This modification replaces the selenium rectifiers originally used in the power supplies of the Type 316 and Type 317 Oscilloscopes with silicon rectifiers. The new rectifiers offer more reliability and longer life than selenium rectifiers.

Order through your local Tektronix Field Office, Field Engineer, Field Representative, or Distributor. Specify Tektronix part number 040-0212-00.

TYPE 422 OSCILLOSCOPE—PORTABLE-TO-RACKMOUNT CONVERSION

This modification is applicable to Type 422 Oscilloscopes, AC powered only. It is not applicable to Type 422 instruments with AC/DC Battery Power Supply.

The modification supplies an R422 Rackmount Assembly for rackmounting the Type 422 Oscilloscope. This assembly has two oscilloscope compartments. With this arrangement, two Type 422 Oscilloscopes can be mounted side-by-side in the same relay rack. Or, one Type 422 may be rackmounted in either the right or left compartment, leaving the remaining compartment to be used for storage of accessories or other equipment. A convenient pulldown door is provided for the storage compartment.

The kit also includes two Rackmount Rear Support brackets with instructions for their installation. These brackets are required when two Type 422's are rackmounted side-by-side. When properly installed the two Rackmount Rear Support brackets enable the Type 422's to withstand an environmental shock or vibration as described in the Characteristic section of the Type R422 Instruction Manual (page 1-3). If only one instrument is rackmounted, support to the storage compartment side of the assembly is not required.

The assembled R422 Rackmount Assembly may be installed in any standard 19-inch open or closed relay rack.

The slide-out tracks used on the Type 422 consist of two assemblies, one for the right side and one for the left side. Each assembly consists of three sections. The stationary section attaches to the rack, the chassis section attaches to the surrounding instrument frame, and the intermediate section fits between the other two sections. This allows the instrument to be pulled forward and extend out of the rack.

Order through your local Tektronix Field Office, Field Engineer, Field Representative, or Distributor. Specify Tektronix part number 040-0419-00.

TEKTRONIX TECHNICAL PUBLICATIONS

A considerable number of varied forms of Technical Publications have been produced by Tektronix during the past few years. The main purpose of these publications is to educate the customer in techniques unique to Tektronix, and thus, enable him to apply our products more usefully. They also provide a fuller explanation of certain procedures and technical information mentioned all too briefly in some Instruction Manuals.

Much of the need for such a range of publications has been reduced because of the considerable improvements to, and expansion of material in many Tektronix Instruction Manuals.

PROGRAMMED INSTRUCTION

The use of Programmed Instruction is becoming quite widespread throughout the United States and many overseas countries. The Product Technical Information Department at Tektronix produces a range of such books. These are designed to be used as self-teaching devices to complete the training (of an individual who has some electronic background) in the theory of operation of Tektronix circuits.

At the present time eight programmed volumes are available and four more will be added to the range shortly. Two further volumes are available published in conventional text-book form.

Details are as follows:

Semiconductor Series	Order Part Number
Volume 1 Basic Theory	062-0053-00
Volume 2 Diode Devices	062-0112-00
Volume 3 Transistors	062-0067-00
Volume 4 Circuit Analysis 1	062-0216-00
Volume 5* Circuit Analysis 2	062-0217-00
Volume 6** Reference for Vol's 1 and 3	062-0422-00
Volume 7** Reference for Vol's 4 and 5	062-0432-00

Analysis of Passive Networks	Order Part Number
Volume 1 DC Equivalent Circuits	062-0605-00
Volume 2 AC Theory	062-0606-00
Volume 3 Integrators	062-0607-00
Volume 4 Differentiators	062-0608-00
Volume 5* Circuit Application	062-0609-00

Time Domain Reflectometry	Order Part Number
Volume 1*	062-0703-00
Volume 2*	062-0704-00

* Not presently available. To be added to the range in the near future.

** Available in conventional textbook form only.

The publication "Junction Functions" (061-0662-00) is no longer available. It has been superseded by Programmed Instruction.

In addition to these books several other specialized booklets are currently available. These are prepared in conventional text form and in the main cover specific applications or techniques:

Sampling Notes—First published in 1962. Describes basic repetitive sampling techniques (N, 3S76, 4S1, etc). 061-0557-00.

Storage to Picoseconds, a Survey of the Art—Reprint of magazine article, August, 1963. Comparison of sampling and conventional oscilloscope techniques. 061-0991-00.

Spectrum Analyzer Notes—A basic approach to the use of analyzers. 062-0433-00.

Strain Gage Measurement Concepts—A new booklet, published in 1966, describing basic techniques, circuits and applications to oscilloscope displays. 062-0710-00.

Some Transistor Measurements Using the Type 575—Describes exact use of instrument with varied types of semiconductors, 1959. 070-0192-00.

Typical Oscilloscope Circuitry—A 300 page book analyzing basic Tektronix circuits in use up to 1964. 070-0253-00.

Magnetic Ink Character Recognition—Published in 1962, this booklet describes the oscilloscope displays derived from Magnetic Ink readers. 070-0283-00.

Rackmounting Instructions—1964, information concerning the installation of the majority of Tektronix instruments in standard 19" (48.5 cm) racks. 070-0440-00.

Operational Amplifiers and Their Applications—1965, detailed techniques and uses. 070-0526-00.

Oscilloscopes at Work No. 1—Measurement of High Current Forward-Reverse Recovery Times in Signal Diodes—Technique utilizes Tektronix sampling system. A2271.

Oscilloscopes at Work No. 2—Measurement of Shock Imparted During Drop Test—Using a storage oscilloscope. A2270.

Oscilloscopes at Work No. 3—Monitor of Cortical Impedance During Periodically Increased Stimulation—Using 564/2A63/2B67 and 160 series generators. A2277.

Getting Acquainted with Spectrum Analyzers—A basic approach to analysis, reprinted from articles appearing in Service Scopes No.'s 31 and 32, April and June, 1965. A2273-1.

Fundamentals of Selecting and Using Oscilloscopes—A booklet designed to provide abridged details of the entire Tektronix product range and how to select an instrument for a particular application. X2146-7.

Some currently available booklets relate to Tektronix Instruments no longer in our product range. These will be of interest to customers who possess the instrument types concerned. Supplies of the booklets are rather limited.

Some Basic Circuits Used in Tektronix Instruments—Published in 1960, details of then current circuits—known as FIP-1. 061-0139-00.

Measuring the Angular Velocity and Acceleration Characteristics of Rotating Machines—1959, refers in the main to techniques involving the Rotan Angular Transducer—now discontinued. 061-0151-00.

567/3S76/3T77/6R1 Data Flow Diagram—1963, interconnections and signal paths diagram using the 6R1—not the 6R1A. 061-0938-00.

Using Your Oscilloscope Type 535/45—1958, not "A or B" series. FIP-1. 070-0185-00.

A Primer of Waveforms and Their Oscilloscope Displays—1960, basic waveform analysis, simple circuit discussion—FIP-7851. Refers to obsolete instruments and publications but still a good training guide. 070-0190-00.

Using Your Oscilloscope Type 535A/545A—1959. 070-0239-00.

Maintenance and Calibration of Type 545A Oscilloscope—070-0282-00.

For price and availability details concerning all the above described publications and any other Technical Publication originated by Tektronix, please contact the Tektronix Field Office, Distributor or Representative in your area or write to:

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Service Scope

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