Service Scope

USEFUL INFORMATION FOR USERS OF TEKTRONIX INSTRUMENTS

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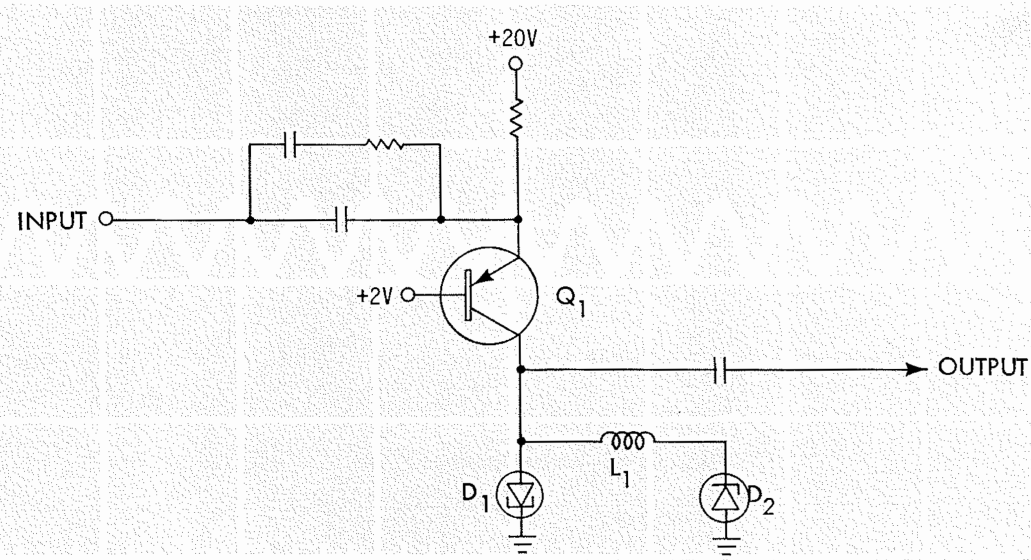


TUNNEL DIODE SWITCHING CIRCUITS AND THE BACK DIODE

By The Marketing Technical Training Department
Tektronix, Inc.

The concepts discussed in this article should lead to a better understanding of tunnel-diode switching circuits. It discusses in particular, the effect of a rather new component on tunnel-diode switching circuits—the back diode.

Several Tektronix sampling instruments incorporate the tunnel diode-back diode concept in their trigger recognition circuitry. Examples of these instruments are: the Type 3T4 Programmable Sampling Unit, Type 3T77 and Type 3T77A Sampling Time Base Plug-In Units, Type 1S1 Sampling Unit, Type 1S2 Reflectometer and Sampling Unit, and Type 5T1A and Type 5T3 Time Base Plug-In Units.

INTRODUCTION

Part I

Tunnel-diode switching circuits are widely used today in a variety of measuring and signal-generating equipment. For example: Tunnel-diode circuits are used for trigger recognition in sampling oscilloscopes, and wide-band conventional oscilloscopes, for gating sweep circuits and for generating fast-rise pulses. Some desirable features of tunnel-diode switching circuits are:

1. Fast switching speed.
2. Maximum obtainable pulse amplitude.
3. High sensitivity to triggering signals over a wide frequency range.
4. Low "idle" power dissipation.

Tunnel-diode circuit elements are combined to fulfill the above needs. One of these elements, the BACK DIODE, is responsible for improved performance in the areas of switching speed, sensitivity, and "idle" power dissipation.

This article is concerned with the theory, function and application of the back diode, in relation to tunnel-diode switching circuits. The first half of this article develops the need for such a device; the second half examines back-diode theory and discusses the function and applications of this unique diode to tunnel-diode switching circuits.

TYPICAL SAMPLING TRIGGER CIRCUIT

A basic sampling trigger circuit is shown in *Figure 1*. Q_1 is used to provide isolation between input and output. The back diode (D_2), tunnel diode (D_1), and inductance (L_1) form a one-shot multivibrator for trigger recognition. Synchronization on input signals is achieved by free-running this multivibrator.

The following discussion will develop this circuit and its related components. The emphasis will be on the function and operation of the back diode as a circuit element.

In order to understand the operation of the back diode, let us consider a few basic circuits. *Figure 2* shows a basic tunnel-diode (TD) switch.

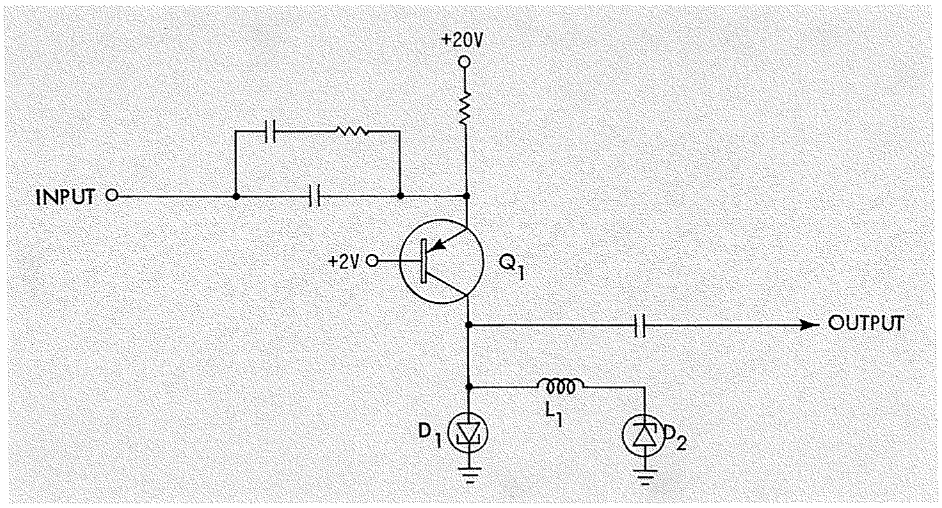


Figure 1 Typical Sampling Trigger Circuit.

BISTABLE OPERATION

A 20-V supply and a resistance, R_1, of 2.5 kΩ biases the TD at 8 mA. The DC load line is the solid line in Figure 2B. If the TD is in the low-voltage state, a 2-mA signal will cause the load line to move up toward the peak current point of the TD (dashed, or AC, load line in Figure 2B). The voltage across the TD increases along the slope of the TD curve at point "a". When the TD current reaches 10 mA (I_p), the voltage drop across the TD jumps almost instantly to the voltage at point "b". When the 2-mA signal is completed, the *load line* returns to its original mA position on the TD curve (point "c"). Notice that the *TD* does not return to the low-voltage state.

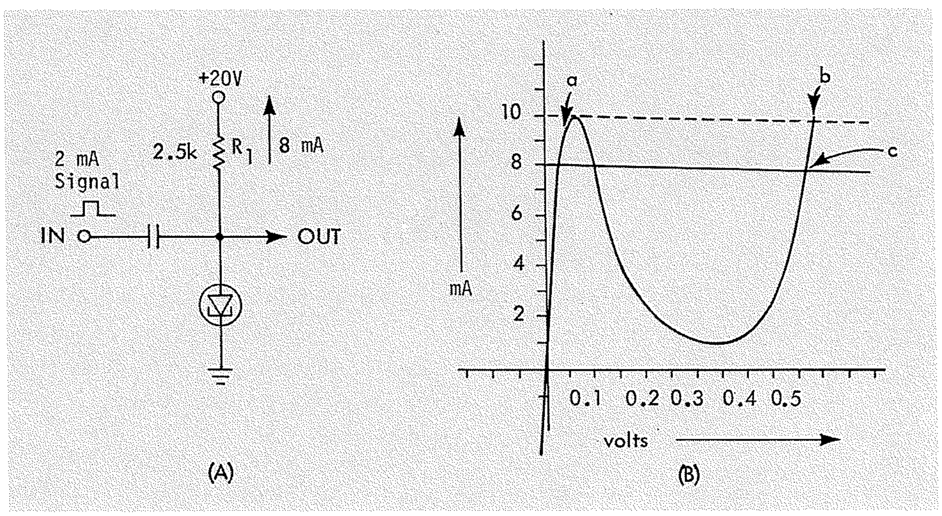


Figure 2 (A) Basic tunnel-diode switch circuit for bi-stable operation.
(B) AC and DC load lines superimposed on a 10-mA curve of the tunnel diode in Figure 2, (A).

MONOSTABLE OPERATION

The TD must return to the low-voltage state to respond to the next trigger signal. One way to insure that the TD always returns to the low-voltage state after a trigger occurs is to use a very small series R and a low voltage source. See *Figure 3*.

The 50-Ω series resistor will drop 0.4 volts at 8 mA. The TD will drop 0.03 volts at 8 mA, therefore the supply voltage will have to be 0.43 volts to put the quiescent point at "a" on the DC load line. The low impedance gives much more slope to the load line. When a 2-mA input signal arrives, the TD will switch to the high-voltage state. When the input signal ends, the load line drops below the switching point at "b" and TD reverts to the low-voltage state. The steep slope of the load line makes

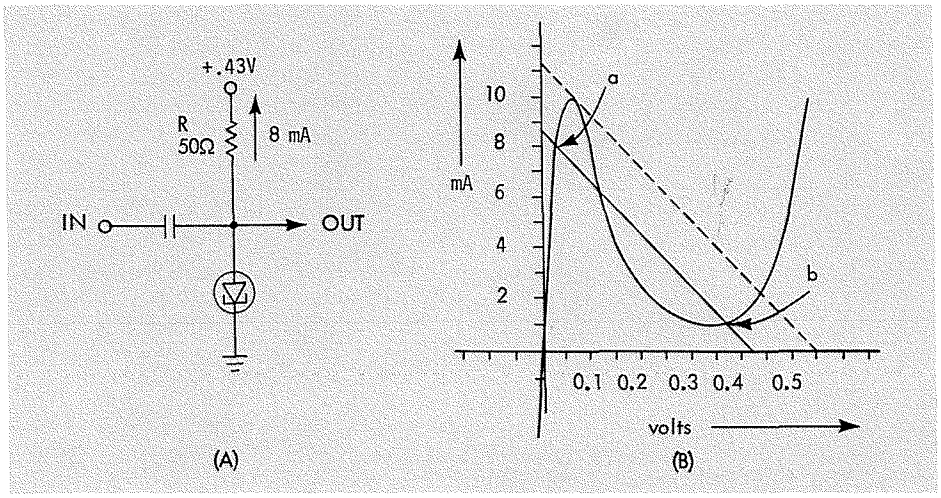


Figure 3 (A) Basic tunnel diode switch for monostable operation.
(B) AC and DC load lines superimposed on a 10-mA curve of the tunnel diode in Figure 3, (A).

the output voltage in Figure 3 less than the output voltage of the circuit in Figure 2. The duration of the output signal is the same as the input signal, resulting in monostable operation.

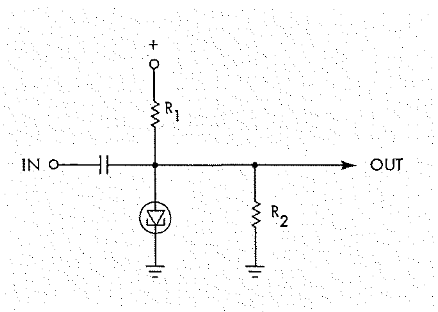


Figure 4

Figure 4 shows another method of obtaining the low impedance load described in the previous paragraph. This circuit has the same characteristics as the circuit in Figure 3 except:

1. A higher source voltage can be used.
2. Some additional current must be provided through R_1 to satisfy the needs of R_2.
3. Some additional signal current is needed to drive the shunt resistance of R_2.

A method of increasing the output voltage and switching speed is shown in *Figure 5A*. The coil provides a very flat load line during switching time (shown as dashed line in Figure 5B) because of the high impedance of the coil at the switching speed of the TD. Note the increase in the voltage excursion. Switching speed is increased because current which would have otherwise passed through R_2 is now available to charge the capacitance of the TD. This circuit is monostable if the load line is steep enough to cross only one positive slope of the TD curve. The slope of the load line depends primarily on the value of R_2. The width of the output pulse is controlled mainly by the L/R time of the circuit, where L is the inductance of L_1 and R is the resistance of R_2 in series with the impedance of the TD. The impedance of the TD in the high-voltage state is different from the impedance of the TD in the low-voltage state.

OSCILLATOR OPERATION

Circuit operation as an oscillator is also possible. *Figure 6* shows the addition of R_3, a bias control. Resistor values are chosen to place the TD near its current peak (low-voltage state) when R_3 is in the center of its range.

If the resistance of R_3 is reduced, more current flows from the —20-V supply and less current flows through the TD—the TD will now be biased at some point below peak current (as indicated by the dashed line paralleling the R_2 25-Ω line in Figure 6 (B). If the resistance of R_3 is increased (reducing the current through R_3), more current will flow through the TD—if this current exceeds 10 mA, the TD will switch to its high-voltage state, along the dashed load line to point "a". If the DC load line produced by R_2 intersects the lower negative resistance portion of the TD curve (point "b", Figure 6), the TD will automatically switch back to its low-voltage state. The effective load line will change from a high impedance (point "a") to a low impedance (point "b"). This change will take place at an L/R rate—when point "b" is reached, the TD will revert to a position on the DC load line, as determined by R_3. If this load line places the TD current above 10 mA, the circuit will oscillate.

CIRCUIT ANALYSIS

The tunnel diode and the resistor, R_2, in Figure 6A can be considered as parallel elements. Let us assume a value of 25 Ω for R_2. *Figure 7* shows a 25-Ω resistance plot superimposed on a 10-mA TD curve. The instantaneous current of each element can be found by drawing a perpendicular line at the voltage point of interest—for instance, at about 80 mV, the TD is close to its peak current state at 10 mA. The current through the resistor, R_2, with an 80-mV drop will be:

$$I = \frac{E}{R} = \frac{80 \times 10^{-3}}{25} = 3.2 \text{ mA.}$$

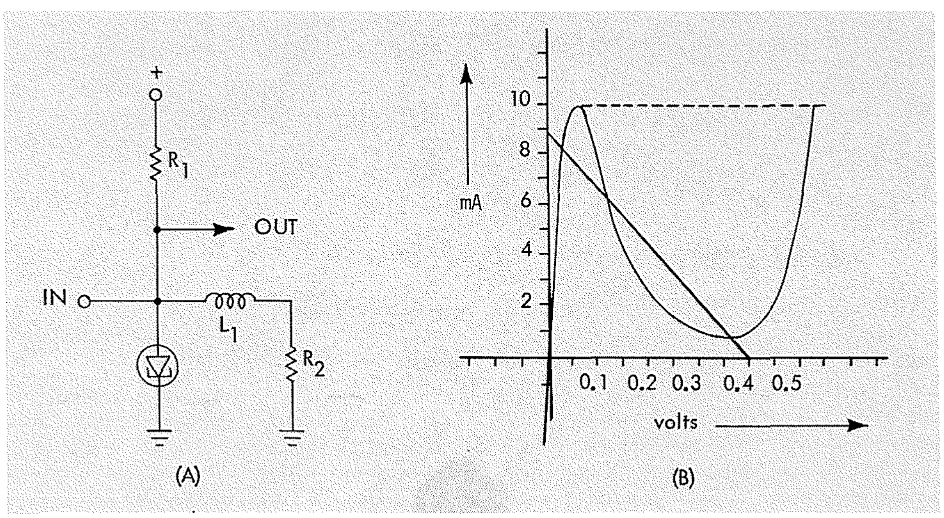


Figure 5 (A) Another version of a monostable tunnel-diode switching circuit. The coil, L_1, helps to increase the output voltage and switching speed.
(B) AC and DC load lines superimposed on a 10-mA curve of the tunnel diode in Figure 5, (A).

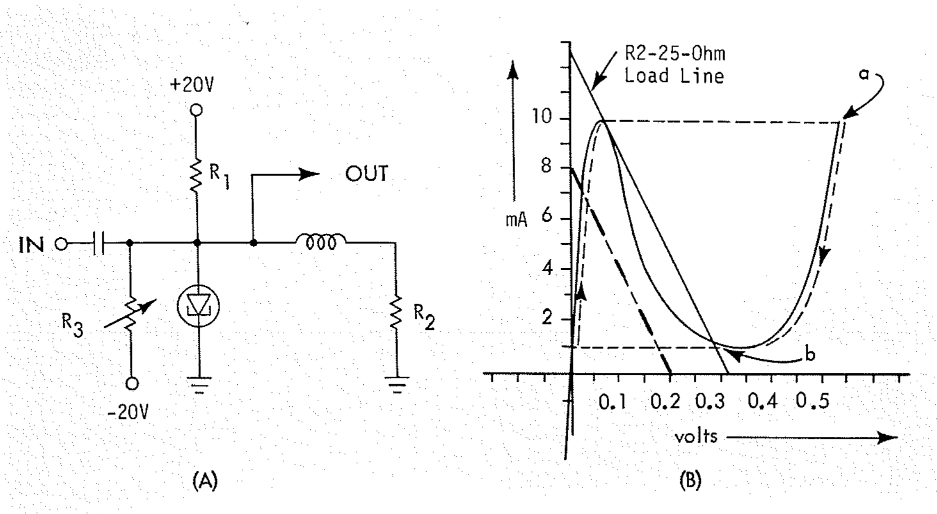


Figure 6 (A) The addition of a variable resistor, R_3, enables the circuit shown in Figure 5, (A), to operate as an oscillator.
(B) AC and DC load lines superimposed on a 10-mA curve of the diode shown in Figure 6, (A).

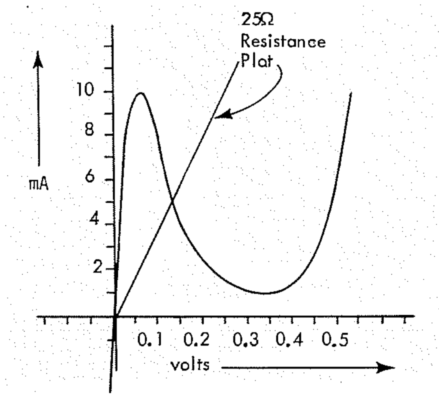


Figure 7 25-Ω resistance plot on a 10-mA tunnel-diode curve.

The +20-V supply must therefore furnish 13.2 mA to the TD-R_2 combination through R_1.

When a small positive-going signal is applied to the circuit in Figure 6, the TD switches to its high-voltage state. Because the coil provides a fairly flat load line (shown by the dashed line in Figure 6B), the output voltage will be a little greater than 0.5 volts. After the L/R time the DC load line will become effective and determine the current distribution through the TD-R_2 combination. The total current supplied to the circuit via the current control resistor, R_1, is about 13.2 mA. As the L/R time constant decays a greater voltage drop will appear across R_2. When this voltage drop reaches ≈300 mV, the current through the 25-Ω resistor will be about 12 mA—as the total current supplied to the circuit is 13.2 mA, only 1.2 mA will be available to the TD. At this current-voltage point the TD will switch back to its low-voltage state. When the circuit is at "idle"—near its current peak, the voltage across the TD-R_2 combination will be about 80 mV, and about 3.2 mA will be "lost" in the resistor, R_2.

The best component available to replace R_2 is a back diode. The back diode is simply a tunnel diode that is usually selected for its reverse conduction characteristics.

Editor's Note: This concludes the first half of this article. The theory, function and application of the back diode to tunnel-diode switching circuits will be taken up in the next (August) issue of SERVICE SCOPE.

MORE ON TEKTRONIX-PRODUCED FILMS

We have experienced a tremendous response to our announcement in the February, 1966, issue of SERVICE SCOPE on the availability of Tektronix-produced films. The requests by our readers for the use of these films have exceeded our wildest expectations and sorely taxed our ability to promptly supply the films.

We are filling all requests on a first-come, first-served basis and earnestly solicit your patience and understanding if we fail to supply the wanted film promptly. All requests from qualified sources will be honored; but, there may be a delay of several weeks in supplying some of the more popular films.

A new Tektronix-produced film is now available to schools or to companies engaged in educational or training programs for their employees. This film like the previously announced ones may be obtained on a free loan basis, or may be purchased. Title of the new film is 'Transresistance". It is a lecture-type film that offers an explanation of the transresistance method of analyzing transistorized circuitry. (An article in the December, 1964, issue of SERVICE SCOPE, "Simplifying Transistor Linear-Amplifier Analysis" discussed transresistance as an aid in troubleshooting or evaluating transistor circuits.) Audiences for this film should have a sound basic knowledge of transistor theory and terminology.

People interested in showing these films should contact their local Tektronix Field Office, Field Engineer, Field Representative, or Distributor.

THE READER'S CORNER

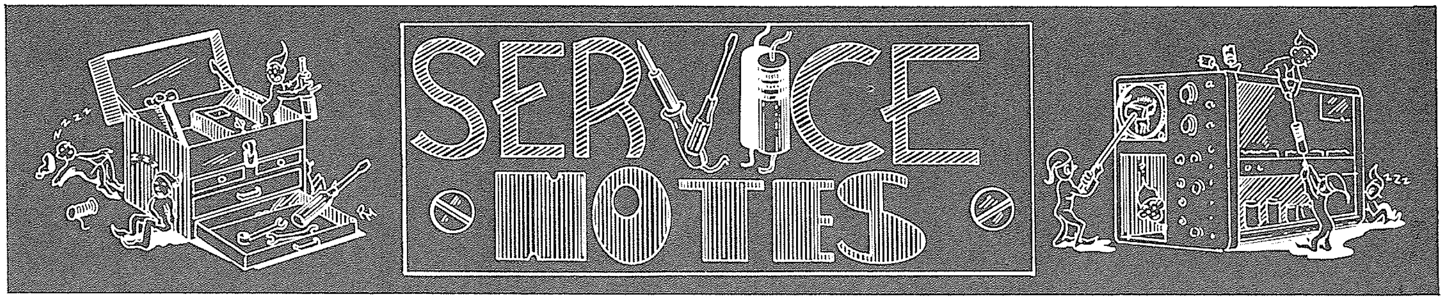
Here are some additional articles, authored by Tektronix personnel, that have appeared in recent issues of trade publications. Listed along with the author's name and the title of the article is the magazine and the month of issue in which the article appeared. Also included is a thumb-nail sketch of the article's content.

Local Tektronix Field Offices, or your Tektronix Field Engineer, Field Representative or Distributor can supply you with reprints of these articles.

"Differential Comparator Extends Measurement Accuracy," by John J. Horn, Design Engineer. Electronic Design, October 25, 1965. A discussion of how a differential comparator can refine oscilloscope voltage-amplitude measurements for either DC or pulse signals.

"Advances in Storage Oscilloscopes," by Donald C. Calnon, Project Engineer. Electronic Industries February, 1966. Discusses state-of-the-art storage tubes and the more versatile oscilloscope they make possible. Some terminology is defined.

"The Sampling Oscilloscope: A Nanosecond Measurement Tool," from information supplied by Tektronix, Inc. The 1965 Test Instrument Reference Issue (A Cahners publication). Tells how the sampling oscilloscope displays high speed phenomena. Explains how it buys sensitivity at the expense of time.



AN INSULATED EXTENDER FOR A PROBE'S RETRACTABLE-HOOK TIP

Here is a "do-it-yourself" project you may want to try. This insulated extender for a probe's retractable-hook tip can be made from an ordinary paper clip and two pieces of insulation or "spaghetti". It makes a handy extension for reaching into those hard-to-get-at places when trouble shooting or checking circuits.

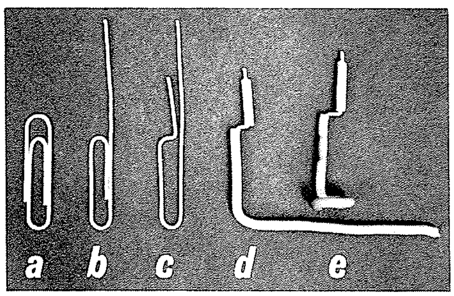


Figure 1. Progressive steps in forming the retractable-hook tip extender.

Figure 1 shows the steps in forming the extender. A. Start with an ordinary paper clip. B. Straighten the outside wire. C. Bend the inside wire to leave a crook. D. Bend the longer wire to form a right angle to the short wire and slip two pieces of insulation over the wire leaving the crook bare. E. With the retractable-hook tip, grip the partially formed extender at the crook and wrap the longer insulated portion around the shaft of the retractable-hook trip to form a one turn coil. *Figure 2* shows a probe with the retractable-hook tip gripping the completed extender.

The extender will offer no problems when used with oscilloscopes having bandpass capabilities of up to 50 MHz. We do not recommend the use of the extender with the Type 580 Series Oscilloscope and the P6008 combination. With this combination, when investigating high frequency signal, the probe ground strap must be kept as short as possible for best results. A probe ground strap in excess of three inches will cause objectionable ringing. An extender and hook tip combination on the probe requires that the probe ground strap be at least 5" inches in length.

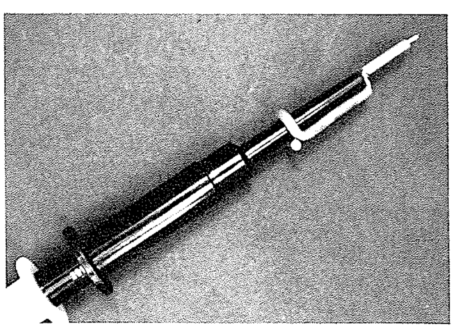


Figure 2. Completed insulated extender in position on a retractable-hook tip.

Our thanks for this idea go to a member of our Instruction Manuals Group, Keith Morrill, who developed the extender and brought it to our attention.

SOLDERING FLUX OR SOLDER RESIST ON ETCHED-CIRCUIT-CARD CONNECTOR TABS

Incompletely removed soldering flux or, more rarely solder resist, can cause poor contact between the connector tabs on etched circuit cards and the connector sockets into which the tabs fit. Soldering flux can be removed with Socal, Fotocal (denatured alcohol), Freon, or Chlorothene. Use a Q-tip to apply the cleaner.

Solder resist which is more tenacious may require a light abrasive, such as a lead pencil eraser, for complete removal. *Use the eraser very lightly.* The connector tabs and connector sockets for Tektronix etched-circuit cards are gold plated to assure a minimum of contact resistance. Care must be taken not to remove this plating.

CRT MESH LIGHT FILTER AND RFI SHIELD—PART NUMBER CORRECTION

In the February, 1966, issue of SERVICE SCOPE we announced a new CRT Mesh Light Filter and RFI Shield. We included a list of oscilloscopes plus the part numbers of the particular filter-shield the instrument would accept.

We have since discovered several errors in that list. Also, we now have a model to fit the Type 321A Oscilloscope.

Here is the corrected list:

TYPE	PART NUMBER
321A	378-0577-00
422	378-0571-00
453	378-0573-00
All Tektronix oscilloscopes with 5" round CRT's	378-0572-00
506, 527, 529, and 561A	378-0575-00
647	378-0574-00

TRANSISTOR FAILURE IN HYBRID CIRCUITS

When an otherwise unexplainable transistor failure occurs in a hybrid circuit, it pays to consider, as a probable cause, an intermittent short in what appears to be a perfectly good vacuum tube. There have been instances where failure of a transistor located in the grid circuit of a vacuum has been traced to intermittent arc-over in the tube. Frame-grid tubes such as the 6DJ8 are particularly prone to this type of failure; but, they are by no means the only offenders. Normally a grid-wire breaking and shorting to the plate will wipe out the tube. There have been some, however, where the short has "healed" itself after passing enough current to destroy an associated transistor.

DUST REMOVAL AND TEKTRONIX INSTRUMENTS

In all Tektronix instruments using forced-air ventilation, the air entering the instrument is filtered. Nevertheless, some dust will eventually penetrate into the interior. This dust should be removed occasionally due to its conductivity under high humid conditions. The best way to clean the interior is to first carefully vacuum all accessible areas. Next blow away the remaining dust with *dry low-pressure* compressed air. Avoid the use of high-velocity air which might damage some of the components. Remove stubborn dirt with a small soft paint brush or a cloth dampened with a mild water-and-detergent solution.

Pay special attention to high-voltage circuits, including parts inside the high-voltage shield. Arcing in this area due to dust or other causes may produce false sweep triggering which in turn will cause an unstable CRT display.

Don't neglect those instruments that do not use forced-air ventilation. Dust will collect in these instruments too. Its presence will have the same effect on these instruments as in the case of forced-air ventilated equipment. The same removal procedure applies to both types of instruments.

Air Filter—The air filter (too often one of the most neglected parts of an instrument) should be visually checked every few weeks and cleaned if dirty. Obviously, more frequent inspection and cleaning will be required for those instruments located in areas with severe environmental conditions.

Older Tektronix instruments use a metal mesh filter. Later instruments use a more recently developed plastic-foam material as the filter element. The following information applies to both types of filter material. To clean the filter, wash it out as you would a plastic sponge (swish metal mesh filters up and down and around). Use a mild warm water-and-detergent solution. Rinse the filter thoroughly and let it dry. Coat the dry filter with fresh "Filter-Kote" or "Handi-Kote". (These products are available from your local Research Products Company, and from some air-conditioner suppliers.) Let the filter dry thoroughly before reinstalling.

The plastic-foam filter is quite a bit more efficient than the older metal-mesh filter. It can be used as a replacement on some of the Tektronix instruments that came equipped with metal-mesh filters. Here is a list of those instruments and the plastic-foam filter kit they will accept.

TYPE	REPLACEMENT KIT NO.
541, 541A, 543A, 545, 545A, 551*, 555*	050-0123-00
175	050-0087-00
1121, 123, 133	050-0148-00

*This replacement kit is for the indicator unit only. Order replacement kit 050-0253-00 for the power supply unit of these instruments.

NEW FIELD MODIFICATION KITS

In the April issue of Service Scope, in this column, we typographically elevated the P510A Probe to the status of a Cathode Follower Probe. A cathode follower it is not! The P510A is a ten times probe that presents an input impedance of 10 megohms paralleled by 14 pF. This probe has not been produced since 1959. It was, in its day, however, a very popular probe and many are still in use, performing very well with the instruments for which they were designed.

The Field Modification Kit 040-0287-01 which was reviewed in this column last issue contains the parts necessary to repair several P510A Probes.

OSCILLOSCOPE CRADLE MOUNT—INCORRECT PART NUMBER

The correct part number for the Oscilloscope Cradle Mount Modification Kit reviewed in this column last issue is 040-0281-00. This is the modification kit that alters the following instruments to fit into a standard 19" relay rack: Type 524AD, 531, 532, 535, 541, 545, and 570, serial numbers 5001 and up; Types 531A, 533, 533A, 535A, 536, 541A, 543, 543A 543B, 544, 545A, 545B, 546, 547, 575, 581, 581A, 585, 585A, and 661, all serial numbers.

TYPE 532 AND TYPE RM32 OSCILLOSCOPES—SILICON RECTIFIERS

This modification replaces the selenium rectifiers in a Type 532 or Type RM32 Oscilloscope with silicon rectifiers. Silicon rectifiers offer greater reliability and longer life. The modification is applicable to Type 532 Oscilloscopes serial numbers 101 through 6921 and Type RM32 Oscilloscopes, serial numbers 101 through 499.

Order through your local Tektronix Field Office, Field Engineer, Field Representative, or Distributor. Specify Tektronix part number 040-0218-00.

MAXIMUM INTENSITY MODIFICATION KIT—FOR LISTED OSCILLOSCOPES

This modification replaces the one megohm INTENSITY potentiometer of the listed oscilloscopes with two two-megohm potentiometers in parallel. One potentiometer serves as the front-panel INTENSITY control. The other serves as the MAXIMUM INTENSITY control and is screw-driver adjusted. With this arrangement, when observing phenomena at slow sweep speeds the MAXIMUM INTENSITY control can be adjusted to provide the best phosphor protection and prevent the CRT phosphor from burn damage. Or, when observing phenomena at the fastest sweep speeds, the MAXIMUM INTENSITY control can be adjusted to provide the best writing rate.

The modification is applicable to the following instruments, all serial numbers:

Type 531	Type 535	Type 543
Type 531A	Type 535A	Type 543A
Type 532	Type 541	Type 545
Type 533	Type 541A	Type 545A
Type 533A		

Order through your local Tektronix Field Office, Field Engineer, Field Representative, or Distributor. Specify Tektronix part number 040-0159-00.

TYPE 551 OSCILLOSCOPE—12-kV HIGH-VOLTAGE TRANSFORMER

This modification replaces the 10-kV High-Voltage transformer with a 12-kV transformer in Type 551 Oscilloscopes, all serial numbers. The increased high voltage offers greater trace intensity at the fastest sweep speeds.

Order through your local Tektronix Field Office, Field Engineer, Field Representative, or Distributor. Specify Tektronix part number 040-0238-00.

BLANK PLUG-IN UNITS

Two modification kits supply the necessary "skeleton" parts (with assembly instructions) to construct blank plug-in units. These units are intended to house circuitry of your own design to provide special-purpose plug-in units.

Modification-kit instruction sheets list pertinent electrical information so that the installed circuitry may be designed to be compatible to the oscilloscope for which the special-purpose plug-in unit is intended.

Special plug-in units may be made to operate in conjunction with a standard Tektronix plug-in unit or with a second special plug-in unit.

Order through your local Tektronix Field Office, Field Engineer, Field Representative, or Distributor.

For Tektronix Oscilloscopes using Letter Series or 1 Series Plug-In Unit, specify Tektronix part number 040-0065-00.

For Tektronix Type 560-Series Oscilloscopes, specify Tektronix part number 040-0245-00.

TEKTRONIX TYPE 1S2 MAKES REFLECTOMETERY EASY

As an analytical technique in the study of high-speed transmission systems and components, TDR (Time Domain Reflectometry) has won wide acceptance. This is particularly true since the advent of the sampling oscilloscope and its fractional nanosecond risetimes.

A new Tektronix oscilloscope plug-in unit, the Type 1S2 Sampling Unit, provides an unusual degree of user convenience for TDR measurements—and does so without sacrificing its sampling capability. The Type 1S2 is designed to operate in Tektronix Type 530, Type 540, Type 550, and Type 580 (with Type 81 Adapter) Series Oscilloscopes.

The essential parts of a TDR system include a fast-flat-top pulse source for launching an incident waveform into a test line. The Type 1S2 contains, within itself, two such pulse sources: (1) a tunnel diode supplying a quarter-volt pulse with a 50-picosecond risetime (giving a TDR system risetime of 140 picoseconds) for observing, with a high degree of resolution, small discontinuities in relatively short 50-ohm systems; and, (2) a one-volt pulse with 50-ohm source impedance and a 1-nanosecond risetime to maximize the signal-to-noise ratio when observing discontinuities in long 50-ohm transmission lines. Either pulse can be fed (via the signal channel containing the sampling-oscilloscope pickoff) into the line under test.

A TDR system discloses, basically, three types of information: (1) the *type* of discontinuity the incident edge encounters as it travels down the line under test, (i.e., whether it meets a new characteristic impedance, or whether it sees a lump of series inductance or shunt capacitance); (2) the *magnitude* of the discontinuity (such as the actual value of shunt capacitance or series inductance); (3) the *location* of a discontinuity with respect to the pulse source and the oscilloscope.

These three types of information can be obtained separately from the Type 1S2. The *type* of discontinuity and its *magnitude* are obtained from the vertical axis of the display. The Type 1S2 offers two sets of scale units on the vertical axis; one calibrated in reflection coefficient "ρ" (rho), and the other in volts per division. A switch provides for scale selection. With the switch in the ρ position, one can read the display of a reflection directly in terms of percent of the incident-pulse amplitude.

By means of an OFFSET control, one can position the display vertically. Also, since the offset voltage itself is available at a front panel jack, slide back measurements of reflection—either in terms of ρ or volts—can be made. The primary function of the OFFSET control, however, is to provide a variable voltage which is essentially added in series to the Type 1S2 input. With this arrangement, when an operator is confronted with a small reflection of interest sitting on a DC voltage, the DC voltage can be cancelled out using the OFFSET control. The signal of interest can thus be examined at a more revealing deflection factor.

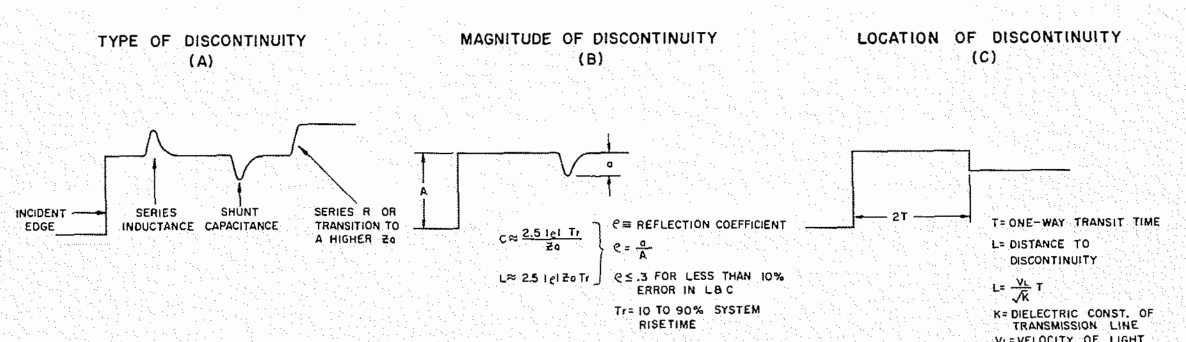
The third type of information, that of the location of a discontinuity is displayed on the horizontal axis of the Type 1S2. This axis also offers two sets of scale units; one calibrated in distance-units per division, the other, in time-units per division. The desired scale is selected via a HORIZONTAL UNITS/DIV front panel control. The actual horizontal units per division changes with the setting of three controls. Therefore a readout indicator is provided to automatically calculate and directly display the actual distance or time units per division.

Separating the processes of locating the discontinuity and analyzing the degree or size of the discontinuity is often desirable. This is very easy to do with a Type 1S2 Unit. When a position range has been selected and the POSITION control set to zero, the leading edge of the incident pulse will be positioned or referenced to the "1" vertical graticule line (graticule lines numbered 0 through 10—left to right), independent of the time-distance settings of the RANGE control. Turning the POSITION control will now cause the leading edge of the incident pulse to go off screen to the left and will bring the aberration, caused by a "down-the-line" discontinuity, to the reference line. With the aberration so positioned, the location of the discontinuity can be determined by multiplying the reading of the POSITION control by the selected range.

When a discontinuity has been thus located, advancing the MAGNIFIER control will expand the display horizontally about the reference line.

With the HORIZONTAL UNITS/DIV switch in the DISTANCE position and the DIELECTRIC control set to the dielectric of the line under test, the location of a discontinuity can be determined directly in meters. DIELECTRIC control positions for air, TFE, and polyethylene lines are provided. The PRESET position of this control provides a relative velocity of propagation from 0.6 to 1. This extends the instrument's distance calibration for use with foam transmission lines, many printed-circuit strip lines and lines with other unusual dielectrics. When a test line is composed of unknown or several different types of dielectrics, it may be more convenient to use the time-scale calibration. The POSITION control will then indicate the round-trip transit time of the incident edge down the test line and back to the oscilloscope.

As a sampling unit, the Type 1S2 offers a flexible high-speed trigger circuit that accepts pulse and sinewave triggering through 5 GHz. However, the low sampling density that occurs in the display at low trigger rates makes trigger rates above 1 kHz desirable. The through-signal channel is then available to provide 90-ps risetime along with vertical deflection factors from 5 mV/div to ½ V/div, and time units from 1 μs/div to 100 ps/div. In either mode of operation—TDR or Sampling—single sweeps are available for photography or storage convenience along with a manual or external scan of the display; most convenient when driving X-Y or Y-T recorders directly from outputs provided at the Type 1S2's front panel.



IDEALIZED WAVEFORMS SHOWING THREE KINDS OF INFORMATION FROM A TDR DISPLAY

Service Scope

USEFUL INFORMATION FOR

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