Service Scope

USEFUL INFORMATION FOR USERS OF TEKTRONIX INSTRUMENTS

NUMBER 27 PRINTED IN U.S.A AUGUST 1964

THE CATHODE FOLLOWER

Because both its input-grid capacitance and its output-impedance are small, the cathode-follower circuit lends itself to many uses in electronics. This article discusses these and other useful characteristics of cathode-follower circuits.

Part I

The cathode follower is a circuit related to the familiar plate-loaded amplifier. In the plate-loaded amplifier the load resistance R_L is connected in the plate lead to the tube. But in the cathode follower, shown in Fig. 1, the load resistance R_k is connected in the cathode lead to the tube. Useful characteristics of the cathode follower include these:

1. The grid-input capacitance is small.

2. And the internal output impedance is small.

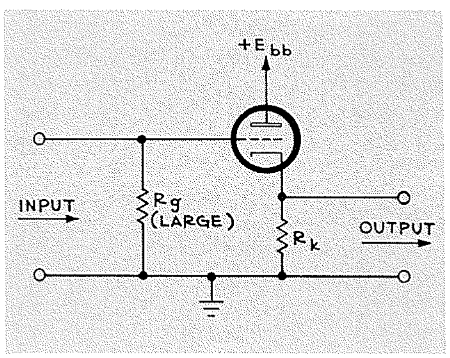


Fig. 1 — Basic cathode-follower circuit. Here the load resistor R_k is connected in the cathode circuit, rather than in the plate circuit as in the plate-loaded amplifier.

In this article we shall take up these and other cathode-follower characteristics in more detail. But first, let's consider some cases where we can take advantage of the two characteristics we have mentioned above.

Need for a device having a small input capacitance. Suppose we apply an input signal to a device whose input capacitance is C_{in}. And suppose that the source of the signal voltage has an internal output impedance (resistance) R_o (see Fig. 2). For simplicity, assume that C_{in} and R_o are the only impedances present in the source or in the circuit connected to the source. Then the time constant of the source-and-input circuit will be R_oC_{in}.

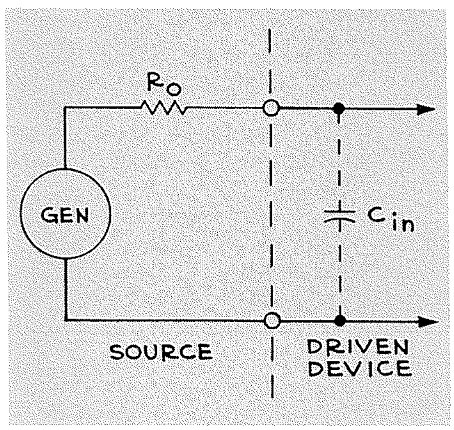


Fig. 2 — Here a signal source has an internal impedance R_o. The source drives a circuit whose input capacitance is C_{in}. If the time constant R_oC_{in} of this arrangement is small, then the risetime of the combination is short. One way to keep the time constant small is to make C_{in} very small. Then the risetime is short even if R_o is relatively large.

If we can keep the input capacitance C_{in} very small, then the time constant R_oC_{in} will be small — even though R_o might be quite large. And consequently the risetime of the R_oC_{in} circuit will be short.

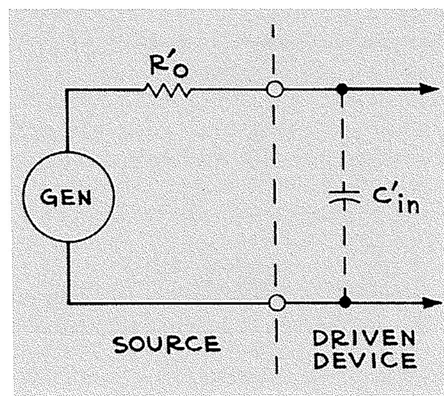


Fig. 3 — Here a second signal source whose internal impedance is R'_o drives a circuit whose input capacitance is C'_{in}. One way to keep the time constant $R'_oC'_{in}$ short is to make R'_o very small. Then the risetime is short even if C'_{in} is relatively large.

The input capacitance C_{in} of a cathode follower is small, for reasons that will be explained later. Consequently the cathode follower has the advantage that we can connect the cathode-follower input circuit to a signal source without greatly lengthening the risetime of the source itself.

Need for a device having a small internal output impedance. Suppose a signal source has an output impedance (resistance) R'_o that is very small. Imagine that we use this signal source to apply a signal voltage to another device whose input capacitance is C'_{in} (See Fig. 3). For simplicity, assume that C'_{in} and R'_o are the only impedance present in the source or in the circuit connected to the source. Then the time constant of the source-and-input circuit will be $R'_oC'_{in}$.

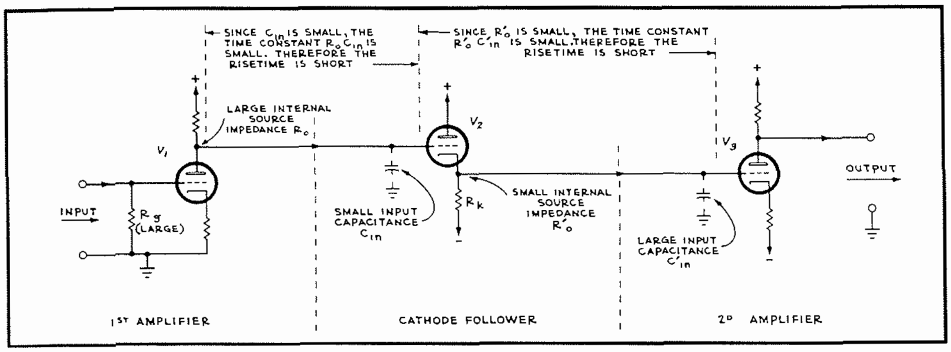


Fig. 4 — Here we want to apply a signal from the plate circuit of V_1 (representing a relatively large impedance R_o) to the grid circuit of V_3 (representing a relatively large capacitance C'_{in}). If we couple the plate of V_1 directly to the grid of V_3, the corresponding coupling-circuit time constant is a large value $R_oC'_{in}$. But if we insert the cathode follower V_2 as shown, we now have two coupling-circuit time constants in cascade. The first time constant is R_oC_{in}, where C_{in} is the very small input capacitance to the cathode-follower; thus, as indicated in Fig. 2, this first time constant is relatively small. The second time constant is $R'_oC'_{in}$, where R'_o is the very small output impedance of the cathode follower; thus, as indicated in Fig. 3, this second time constant is relatively small. By inserting the cathode follower we thus break up a large time constant $R_oC'_{in}$ into two much smaller time constants R_oC_{in} and $R'_oC'_{in}$. In this way we use the cathode follower to improve the coupling-circuit risetime.

If we can keep the source impedance R'_o very small, then the time constant $R'_oC'_{in}$ will be small — even though C'_{in} might be quite large. And consequently the risetime of the $R'_oC'_{in}$ circuit will be short.

The internal output impedance of a cathode follower is small, for reasons that will be explained later. Consequently the cathode follower has the advantage that we can use the cathode follower to drive a device that has appreciable input capacitance while still achieving a short risetime. As an example, we might use a cathode follower to drive a coaxial transmission line — where the capacitive effect of the line is appreciable — and still preserve a short-risetime characteristic.

Figure 4 shows an application that utilizes the advantages of both the small input capacitance and the small output impedance of the cathode follower. We desire to couple a rapidly changing signal from the plate of V_1 to the grid of V_3. In Fig. 4, we apply the output signal from the plate of V_1 to the grid of the cathode follower V_2. The internal source impedance of the amplifier stage that includes V_1 is ordinarily rather large. But the input capacitance of the cathode follower V_2 is small, so that we end up with only a short risetime T_{R1} associated with the circuit that couples the plate of V_1 to the grid of V_2. Now, the input capacitance of the amplifier stage that includes V_3 is ordinarily rather large. But we drive the grid of V_3 from the low-impedance output circuit of the cathode follower V_2. Thus we end up with only a short risetime T_{R2} associated with the circuit that couples the output of V_2 to the grid of V_3. The effective risetime of the cathode-follower coupling system between V_1 and V_3 will, by the equation $T_R = (T_{R1}^2 + T_{R2}^2)^{1/2}$, be shorter than the sum of the two individual risetimes T_{R1} and T_{R2}.

We see, then, that we can often shorten the risetime of an interstage-coupling system by inserting a cathode follower between one stage and the next.

Polarity of output signal from a cathode follower. Let us now consider some factors that tell us how a cathode follower actually operates.

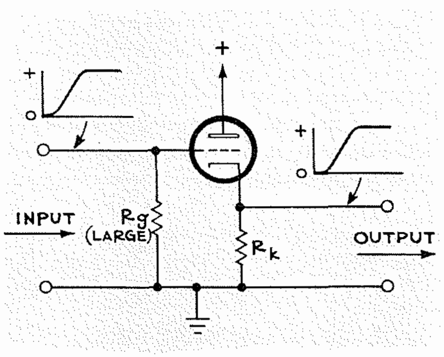


Fig. 5 — Illustrating that the polarity of the cathode-follower output-signal voltage is the same as that of the input-signal voltage — in contrast to the polarity reversal that occurs in the plate-loaded amplifier.

If we apply to the cathode-follower circuit of Fig. 5 a grid-input signal that makes the grid more positive, the cathode-to-plate electron flow will increase. Therefore the voltage drop across the cathode resistor R_k will increase, so that the voltage at the cathode of the tube will be farther removed from the potential of the grounded negative terminal of the power supply. That is, the voltage at the cathode output terminal of the cathode-follower stage will become more positive. Thus, in contrast to the action in the plate-loaded amplifier, *the polarity of the output signal from the cathode follower is the same as the polarity of the input signal:*

Output impedance. The internal output impedance of a cathode-follower stage is comparatively small (usually from less than 100 ohms to perhaps 200 or 300 ohms). This range of values represents impedances that are considerably smaller than the typical output impedances we would expect from plate-loaded amplifiers (from a few hundred to several thousand ohms).

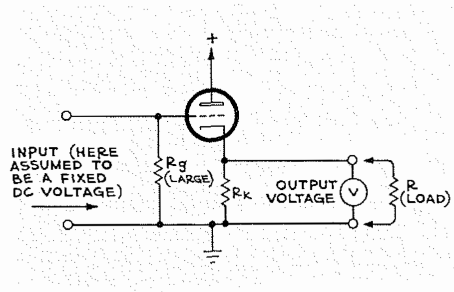


Fig. 6 — Illustrating that the internal output impedance of a cathode follower is small. A given cathode current makes the voltmeter V show a certain dc output voltage (the IR voltage drop across R_k). If we connect the external load R, we thereby reduce the total resistance in the cathode output circuit. Thus we might at first expect the voltmeter to show a sharply reduced output-circuit IR voltage drop. But this voltage drop is also the negative dc grid-to-cathode bias voltage — so that the tube allows a greater cathode current to flow. Therefore the new output voltage is the IR voltage drop produced by a larger current in a smaller total resistance. As a result, this new output voltage isn't much less than the original voltmeter reading. The fact that the output voltage changes only a little when we connect the load R shows that the internal source impedance of the cathode follower is small.

To see why the internal output impedance of a cathode follower is small, suppose we connect an external load resistor R across the output terminals of the cathode follower as shown in Fig. 6. Let the input grid-to-ground voltage be held constant. When we connect the external load resistor R, we effectively reduce the resistance in the cathode circuit. Suppose first that cathode current remains constant. Then the voltage drop across the cathode resistance decreases. Therefore, the grid-to-cathode voltage becomes less negative. But this actually allows more cathode current to flow. Thus the voltage drop across the paralleled cathode resistor and external load resistor tends to increase again to almost its original value. In effect, then, *the voltage across the output terminals doesn't depend greatly upon the amount of external load resistance we connect to these terminals.* This statement is equivalent to saying that a cathode follower is a source that has a small internal impedance.

The actual internal source impedance of a cathode-follower stage is not simply the value of the cathode resistor R_k. Instead, it consists of a parallel combination of R_k shunted by the internal impedance of the tube. We can see that this statement applies if we look at Fig. 7. Note that the power supply represents a short circuit to signal variations. Thus the signal output impedance of the cathode-follower stage, looking back into the output terminals, is made up of the tube impedance in parallel with the cathode resistor R_k.

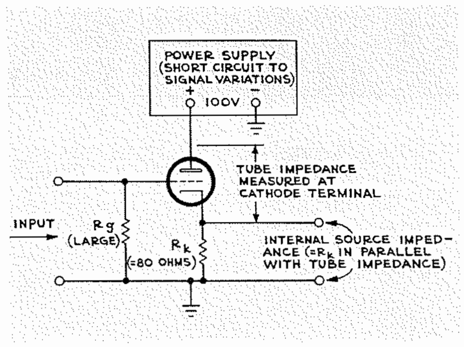


Fig. 7 — The internal source impedance of a cathode-follower stage includes the cathode resistor R_k. But for a varying signal, the cathode-to-plate dynamic impedance of the tube is connected (through the power supply) in parallel with R_k. This tube impedance is roughly $1/g_m$, and is therefore often quite low. For example, if the tube has the characteristic curve of Fig. 8, its cathode-to-plate impedance is about 80 ohms. With such a tube, the cathode-follower stage of Fig. 7 would have an internal source impedance of only about 40 ohms.

The impedance of the tube itself, at its cathode terminal, can be shown to be approximately $1/g_m$ (where g_m is the mutual conductance of the tube in mhos). But the value of g_m of a given tube depends upon the operating point at which the tube works. Suppose, for example, that we use a tube whose plate current-grid voltage characteristics is that shown in Fig. 8. For this particular tube, the operating point is that shown as point A in Fig. 8 when the tube is used as indicated in Fig. 7. The slope of the tangent line to the characteristic curve at the operating point A shows that g_m is 12,500 micromhos (= 0.0125 mho). Then the impedance of the tube, at its cathode terminal, is approximately 1/0.0125 = 80 ohms. Since the cathode resistor is also 80 ohms, the effective internal impedance of the cathode-follower stage of Fig. 7 is about 40 ohms.

Voltage Gain. In a plate-coupled amplifier stage, the varying output signal voltage may well be several times the varying input signal voltage. That is, a plate-coupled amplifier stage may have a voltage gain of several times.

But the voltage gain of the cathode follower cannot be as great as unity. In other words, the varying output signal voltage cannot be as great as the varying input signal voltage. This result springs from the fact that the cathode electron flow for a given plate voltage is controlled essentially by the grid-to-cathode voltage. Suppose, for example, that an input grid-to-ground signal-voltage change of +2 volts *could* change the electron flow sufficiently to vary the cathode-to-ground voltage by +2 volts (corresponding to a voltage gain of unity). But this change would involve no net change in grid-to-cathode voltage; therefore there would be no net change in electron flow — an absurdity. Thus the voltage gain of the cathode follower cannot be as great as unity.

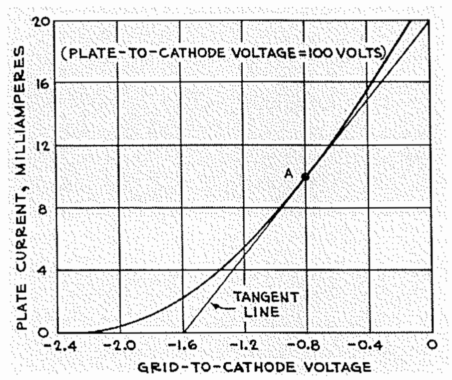


Fig. 8 — Assume that this curve represents the plate current-grid voltage characteristics of the tube in Fig. 7. Then we can use this curve to find the approximate internal impedance of the tube itself, measured at the cathode pin. First note that the 80-ohm cathode resistor R_k in Fig. 7 establishes the tube operating point as point A in Fig. 8. (To check this, observe that a current of 10 milliamperes in 80 ohms produces an 0.8-volt drop — the grid-to-cathode bias corresponding to point A). Next, to find the mutual conductance of the tube at operating point A, we draw a straight tangent line to the curve at point A. We see that the tangent line intercepts a base interval corresponding to 1.6 volts and a vertical interval corresponding to 20 milliamperes (0.02 ampere). Thus, at operating point A, the mutual conductance g_m is 0.02/1.6 = 0.0125 mho. Since the tube internal impedance at the cathode pin is approximately $1/g_m$, the tube whose characteristic curve is shown in Fig. 8 has an internal source impedance of about 1/0.0125 = 80 ohms.

Clearly, then the cathode follower is not useful directly in providing voltage gain. But as we have seen, the cathode follower can be very useful in improving the risetime characteristics of circuits that actually do produce voltage gain.

The voltage gain of a cathode-follower stage depends both upon the characteristics of the tube and upon the value of the cathode resistor R_k. When R_k is equal to the internal output impedance of the tube itself (approximately $1/g_m$, where g_m is in mhos), the gain of the stage is approximately one-half. Thus, with values shown in Fig. 7, we realize an output of about one-half volt for each volt of input grid-to-ground signal. If we use greater values of R_k, we can make the gain of the stage appreciably greater. We can make the voltage gain reach values between 0.9 and 0.99 by using large values of R_k.

Since the output signal from a cathode follower has the same polarity as the input signal, and since the output signal can be made almost as large as the input signal, we can consider that the output signal approximately duplicates the input signal. Hence the name *cathode follower.*

Part 2 of this article will appear in the October, 1964 issue of Service Scope.

The material for this article was taken from the book "Typical Oscilloscope Circuitry", published by Tektronix, Inc. The complete text is available from your Tektronix Field Engineer or Representative.

SOLDERING OF TEKTRONIX ETCHED CIRCUIT BOARDS

An Explanation and Technique
by Verne McAdams
Tektronix Manufacturing Staff Engineer

Soldering is an alloying process between two metals. In its molten state, solder chemically dissolves some of the metal with which it comes into contact. However, the metals to be soldered, are, more often than not, covered with a thin film of oxide that the solder cannot dissolve. A flux must be used to remove this oxide film from the area to be soldered. The solder used in most electronic work contains this flux as a center core which has a lower melting point than solder itself. The flux in its molten state cleans the metal and holds the oxides suspended in solution. The molten solder can then make contact with the cleaned metal and the solvent action of solder on metal can take place.

The soldering process then is the following:

1. The cored flux melts first and removes the oxide film on the metal to be soldered.
2. The solder melts, floating the lighter flux and the impurities suspended in it to the surface.
3. The solder dissolves some of the metal in the connection.
4. The solder cools and fuses with the metal.

To do a proper soldering job the following must be done:

1. The connection itself must become hot enough for the rosin to melt and clean the metal.
2. The cored solder must be applied directly to the heated connection so that the flux, which melts at a lower temperature than the solder, will melt first and clean the connection by the time the solder has melted. (If the solder is applied to the soldering-iron tip, the flux, being lighter, will float on top of the solder. It will be unable to reach the connection and clean it.)
3. A good easy flow of heat from the soldering-iron tip to the connection must be obtained by a clean, well-tinned soldering-iron tip. A thin film of molten solder will transfer heat rapidly.

In soldering techniques for etched circuit boards, the basic principles for soldering prevail. We are now interested in the difference in the soldering of etched circuit boards and normal soldering.

The first consideration of soldering to etched circuit boards is the limitations of the substrate of the boards. The Tektronix etched circuit boards have a substrate of fiber-glass epoxy, which has a temperature limitation of 530° F for not more than 5 minutes. Hotter temperatures reduce the time in inverse relationship; the hotter the temperature, the less time the boards will stand it before damage. (As an indication of damage, white flakes will first appear in the surface of the board. These white flakes indicate a decomposition of the fiber-glass epoxy substrate).

A second consideration is the soldering-iron-tip temperature, which is determined by the type of soldering iron and soldering-iron tip used. The wattage of the soldering iron and the configuration of the soldering-iron tip combined with the speed of soldering will determine the ultimate tip temperature as well as the working-tip temperature. Since we are here primarily concerned with the working tip temperature, the soldering iron and tip should be chosen so that the working tip temperature will at no time exceed the limitations of heat set forth above.

A third consideration in soldering of etched circuit boards is the type of solder used. The best type for use on the Tektronix etched circuit boards is a "eutectic"-type cored-wire solder of size #20 AWG, composed of 63% tin and 37% lead (as designated in FED. SPECS. QQ-S-571c as Sn63) with a central core of activated rosin flux (Divco X-25, or equivalent).

The fourth consideration is the technique of repair — repair in this case consisting of replacement of components. The Tektronix etched circuit boards consist of straight-through connections (no crimped connections) gold plated to facilitate soldering. Carelessness in reheating the solder connections for the removal and replacement of components is the only difficulty to be guarded against here. Caution must be taken not to overheat the substrate and this can best be accomplished with deft hands and by small applications of heat. If the removal or replacement is not accomplished in the first few seconds of heat application, avoid transferring too much heat to the substrate by *going to another connection or waiting a few minutes before reheating the connection.* Giving the connection these few minutes to cool will allow the heat to dissipate and help to avoid overheating the substrate. Heat dissipates quite slowly from some of the smaller connections and too long an application of the soldering iron will result in the overheating of the substrate.

Repair on the older phenolic-copper laminate boards is similar to that on the newer gold-plated fiber-glass epoxy boards with a cautionary remark that the problems of heat limitation applies even more so on the *older* boards. Their ultimate heat limitation is much lower than that of the newer boards and the copper laminate is glued to the board instead of being bonded to the substrate as in the case in the fiber-glass epoxy boards.

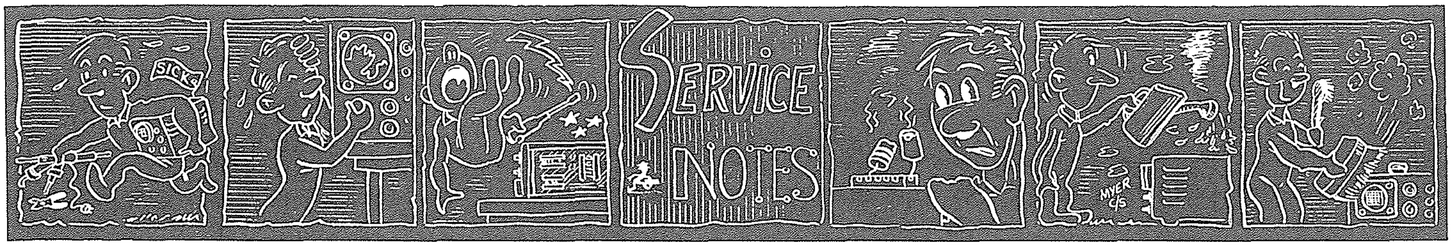
Some things to be considered in order to obtain a low working-tip temperature are:

1. At slow soldering speeds, a 25-watt iron and a ⅛" tip.
2. At medium soldering speeds, a 40-watt iron and a 3/16" tip.
3. At fast soldering speeds, a 50- or 60-watt iron and a ¼" tip.

A recommendation for soldering tips is that they be made of copper and have a chisel or bevel shape.

There are two areas on an etched circuit board which might require different soldering techniques. One is the large copper area used as a common connection in contrast to the smaller spot connections. The larger areas will absorb heat much more rapidly than the smaller spot connection. This may necessitate a hotter iron and a larger tip for these areas than the smaller spot connections.

With these cautions and recommendations in mind you should encounter no trouble when soldering Tektronix etched circuit boards.



TYPE 551 OSCILLOSCOPES — CRT REPLACEMENT

The Type 551 (T57) crt (cathode ray tube), original equipment in Type 551 Oscilloscopes, s/n's 101 to 2031, has been discontinued. An improved crt, T5511, is offered as a replacement. This new crt is designed for use with a Horizontal Beam Registration control — an adjustment that allows you to compensate for stray fields to make the starting times of both beams coincide. For Type 551's with serial numbers below 2032 you will need to install a parts modification kit (Tektronix Part Number 050-026) in order to use the new T5511 crt. We will supply the modification kit at *no charge*. Please note that the T551 (T57) crt can no longer be supplied!

Although Type 551 Oscilloscopes before serial number 216 have a Horizontal Beam Registration control, the parts replacement modification kit 050-026 *must be installed*.

When necessary to order a replacement for your T551 (T57) crt, please order Parts Replacement Mod Kit 050-026 *plus* the T5511 crt with desired phosphor. See below:

Old crt	Tektronix Part No.	New crt	Tektronix Part No.
T551(T57)-P1	154-186	T5511-P1	154-186
T551(T57)-P2	154-160	T5511-P2	154-160
T551(T57)-P5	154-210	T5511-P5	154-210
T551(T57)-P7	154-189	T5511-P7	154-189
T551(T57)-P11	154-143	T5511-P11	154-143

TYPE E PLUG-IN UNIT — HIGH FREQUENCY OSCILLATION

The Type E Plug-In Unit, when used in a Type 547 Oscilloscope, tends to oscillate at about 200 Mc. You can overcome this tendency by adding one ferrite bead (Tektronix Part Number 276-532) on each signal output lead at pins 1 and 3 of the interconnecting plug. This Service Note applies to Type E instruments with serial numbers below 6490. Instruments with higher serial numbers have the ferrite beads installed at the factory.

TYPE 21A AND TYPE 22A TIME BASE UNITS — TRIGGER IMPROVEMENT

A recent production modification greatly improves triggering stability of the Type 21A and Type 22A Time Base Units. It also makes adjustment of TD BIAS and LOCKOUT LEVEL less critical. The modification is quite simple and can be installed in Type 21A's with serial numbers below 8398 and Type 22A's with serial numbers below 8400.

The modification consists of changing D40, a Type BD-1 diode in the Time Base trigger circuit, to a Type TD-2 diode (Tektronix Part Number 152-081) and R126, a 100 k, ½ w, 10% resistor in the Lockout multivibrator circuit, to a 47 k, ½ w, 10% resistor (Tektronix Part Number 302-473). Changing this resistor brings the nominal setting of the LOCKOUT LEVEL control to the center range of its adjustment.

After the modification, the TD BIAS and LOCKOUT LEVEL controls are set according to instructions in the Type 555 Instruction manual. The benefits of the modification are that one setting gives reliability of trigger and equal response to both sine waves and pulses.

TYPE 564 AND TYPE RM564 OSCILLOSCOPES — SOME PRECAUTIONARY MEASURES

Here are some precautionary measures which, if observed, will prolong the useful life of the storage screen in the Type 564 and Type RM564 Oscilloscopes.

First and foremost, take great care in the degree of writing-gun intensity you use. High writing-beam current can cause permanent damage to the storage target. Always use the minimum beam intensity required to produce a clear well-defined display. Special care should be taken during warm up or when using slow rates or sampling displays.

Use caution when storing fast-changing portions of a waveform. Beam current could then be too great on the slow-changing portions of the waveform.

Avoid repeated use of the same area of the screen for storing displays. Distributing the use will allow the storage target to "age" uniformly and will prolong the effective life of the storage tube.

Turn the intensity control to minimum when changing plug-in units. An undeflected spot on the crt screen can burn the storage target even at normal intensity.

Do not leave a display on the crt screen (either writing or stored) when the display is not needed.

Do not leave the DISPLAY switches at STORE when the storage mode is not needed.

"Negative images" (dark waveform images that appear as a darker background light level when the DISPLAY switch is at STORE) result from writing or storing a waveform in one position on the screen for a relatively long period of time. Negative images will usually disappear in a short time, but may cause a temporary decrease in writing speed of the affected areas.

"Bright burns" (bright waveform images that will not erase completely) are caused by excessive intensity of the writing-gun beam. Severe burns may remain indefinitely; a mild case which may only show when the writing speed enhancement circuit is used (Type 564, s/n 2000 and up, or RM-564), will slowly fade to normal over a period of a few days normal use.

"Dark burns" (spots or lines on the screen that will neither write nor store) result from destructive burning of the storage target by the writing-gun beam. Replacement of the storage tube will be required if dark burns impair operation of the instrument.

TEKTRONIX CIRCUIT COMPUTER — AN ADDITIONAL USE

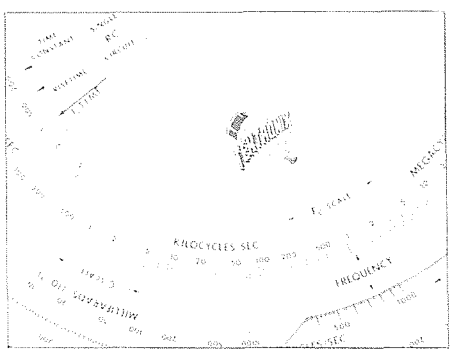


Figure 1. Shows location of new F_c TIME arrow on the top deck of the Tektronix Circuit Computer.

In this column of the June, 1964, issue of Service Scope, we describe the Tektronix Circuit Computer (Part Number 003-023), a circular slide-rule type of device.

Since then, Nelson R. Drew, K3RGH, of 906 7th Street in Laurel, Maryland, has written us telling about an additional use for this computer. By the addition of another "Time" arrow to the top deck of the computer you can read time as a reciprocal of frequency — in other words, solve the equation $T = \frac{1}{f}$.

You determine the location of the new arrow by positioning the top deck of the computer so that the 1-megacycle marker of the F_c scale is aligned with the FREQUENCY marker on the middle deck. Then, reading through the top-deck cut out, locate the 1-microsecond marker on the middle deck. Then, on the top deck opposite this 1-microsecond marker, scribe a short radial line to form the new "Time" arrow. Label this new arrow "F_c TIME". See Figure 1. Your computer will now solve the equation $T = \frac{1}{f}$. Example: Set F_c Scale to 5 megacycles; read 200 nanoseconds (through the top-deck cut out) opposite the new "F_c Time" arrow.

Our hearty thanks to Mr. Drew for his suggestion of a new use for the circuit computer.

THIN-BLADE, SINGLE-PINCHER PROBE TIP — INDEXING FOR PINCHER-TIP ORIENTATION

Indexing the barrel back near the finger flange identifies orientation of the pincher-tip hook (see Service Scope, issue 24, February, 1964) and so simplifies the probe removal when the tip is buried in a maze of wires. Red nail polish or lacquer shows up well on the plastic, see Figure 2.

H. I. Wilson of 40 Hillside Road, Beacon, New York, sent in this suggestion. Thank you, Mr. Wilson, for sharing your idea with our readers.

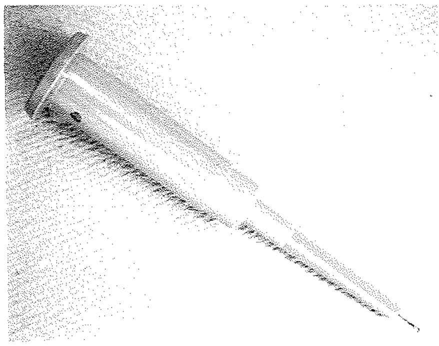


Figure 2. Adding a dot of red lacquer identifies orientation of pincher-tip hook.

PLUG-IN EXTENSION 013-055 — SUPPORT FOR EXTENSION

Here's another do-it-yourself project. Figure 3 shows a support that fits into the plug-in compartment of a Type 530, Type 540, Type 550 or Type 580 Series Oscilloscope. When using a Plug-In Extension (Tektronix Part Number 013-055), this support holds and aligns the outboard end of the extension so that a plug-in can be quickly and easily changed or installed. We made the one shown here (see Figure 3) from a one-inch thick piece of pine board.

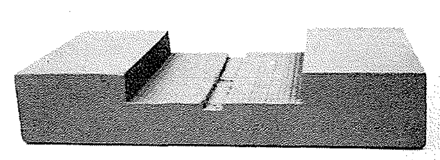


Figure 3. An easily-made support for the Tektronix Plug-In Extension (013-055).

The width of the support is 3 inches and the length is 5½ inches. The cut out portion of the support measures 2 7/16 inches wide by 7/16 of an inch deep. The narrow groove in the bottom of the cutout is 3/16 of an inch wide and 1/16 inch deep.

The support should fit snugly in the oscilloscope plug-in compartment and the plug-in extension should be a press fit into the cutout section of the support so that support and extension will stay in place when exchanging plug-ins.

Our thanks for this suggestion go to Mr. Ed Davis of Raytheon, HASCO, Ft. Bliss, Texas.

NEW FIELD MODIFICATION KITS

TYPE 131 CURRENT AMPLIFIER — UHF CONNECTOR

This modification supplies a special replacement UHF connector that will more perfectly fit a wider tolerance range of Type 131 housings. It helps to overcome and prevent the problem of the connector working loose.

Order through your local Tektronix Engineer, Field Office or Representative. Specify Tektronix Part Number 040-373.

TYPE 561 AND TYPE 561A OSCILLOSCOPES — POWER SUPPLY IMPROVEMENTS

This modification installs a means for accurately adjusting power supply voltages. It adds potentiometers to the divider network in the comparator circuits of the —12.2, +125, and +300-volt supplies. Installation involves the drilling of two holes and mounting a potentiometer assembly on the rear of the horizontal plug-in housing and changing several components in the —12.2, +125 and +300-volt supplies. A 10-Ω fuse resistor is added to limit surge currents and protect the +300-volt supply.

The modification is applicable to Type 561 Oscilloscopes, s/n's 101 through 5000; and Type 561A Oscilloscopes, s/n's 5001 through 6634. Order through your local Tektronix Field Engineer, Field Office or Representative. Specify Tektronix Part Number 040-347.

TYPE 502 OSCILLOSCOPE — INTENSITY BALANCE CONTROL

This modification moves the Intensity Balance control to the front panel. It allows a more precise control of trace brightness — a useful feature in dual-trace photography.

A new front panel overlay makes room for the new control and supplies graduated markings for all five crt controls. Order through your local Tektronix Field Engineer, Field Office or Representative. Specify Tektronix Part Number 040-350.

TYPE 527 AND TYPE RM527 WAVEFORM MONITORS — VERTICAL AMPLIFIER AND TRIGGER IMPROVEMENT

Installation of this modification brings four improvements to the Type 527 and Type RM527 instruments.

1. It improves triggering at low-level input signals by changing V24 (a 6EW6 tube in the Trigger amplifier) to a 6EJ7 tube. This 6EJ7 tube gives increased trigger gain.

2. It ac couples the Internal Sync amplifier tube (V14) to isolate the Internal Snyc signal from the DC Restorer feedback loop. This minimizes trace disappearance and distortion that may occur at low-level input signals.

3. It adds diodes between the grid and cathodes of V444 and V544 and from the cathode of V413 to ground. This gives warm up protection for the Vertical Amplifier tubes by limiting the positive grid-to-cathode potentials and eliminates the possibility of waveform distortion from damaged tubes.

4. It changes the time constant of the Gate Multi (V595). This minimizes Vertical DC-Restorer shift in the presence of color burst so that video will not occur during restoration time.

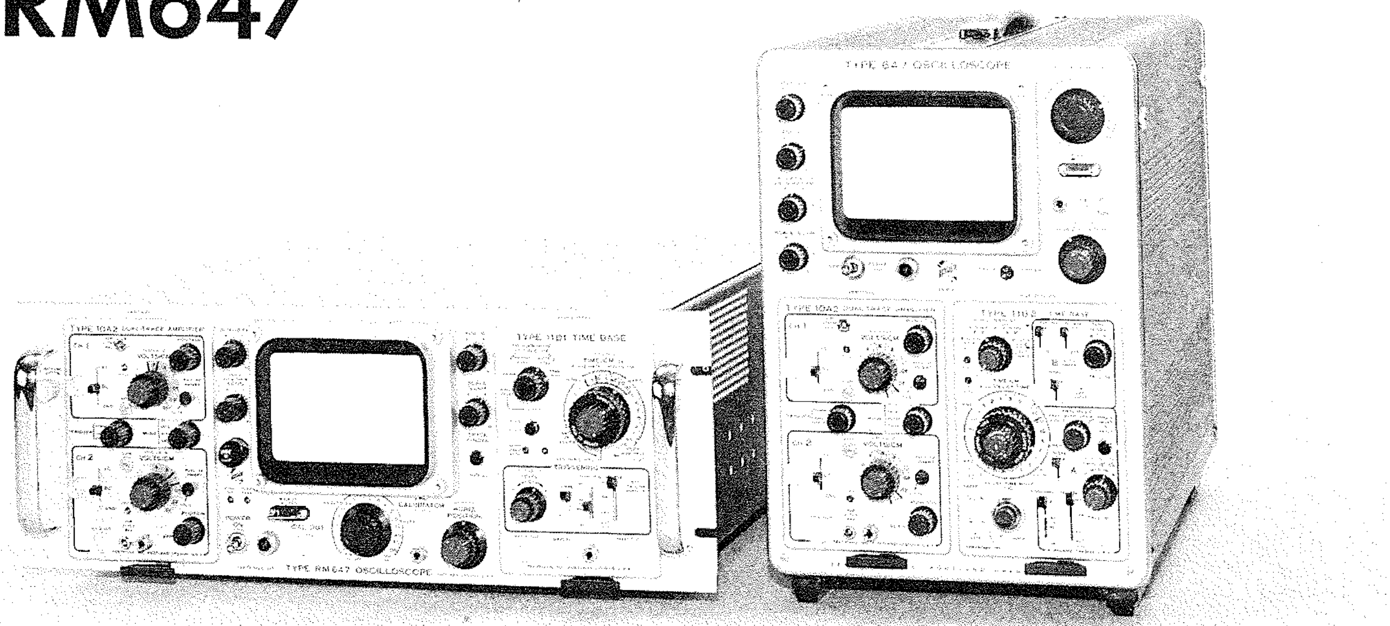
The modification applies to Type 527's s/n's 151 through 744 and Type RM527's*, s/n's 151 through 1189. Order through your local Tektronix Field Engineer, Field Office or Representative. Specify Tektronix Part Number 040-362.

*A few instruments in the following serial number ranges were modified at the factory: Type 527, s/n's 645 to 744; Type RM527, s/n's 730 to 1189. Consult your Tektronix Field Engineer or Representative before ordering if your instruments fall in these serial number ranges.

DC-TO-50 MC, 10 MV/CM

NEW SOLID STATE OSCILLOSCOPES

TYPE 647
RM647



COMPACT HIGH-PERFORMANCE INSTRUMENTS CAPABLE OF ACCURATE MEASUREMENTS IN SEVERE ENVIRONMENTS (−30°C TO +65°C).

EVEN GREATER ACCURACY PLUS AN EXTRA MARGIN OF DEPENDABILITY IN NORMAL ENVIRONMENTS (0°C TO +40°C).

The Type 647 And Type RM647 Offer These "Most Wanted" Features In A Ruggedized Oscilloscope:

DC-To-50 MC Dual-Trace Capability

Choice Of Horizontal Plug-Ins:

Calibrated Sweep Delay, Or

Wide-Range Magnification

Bright 6 x 10 cm No-Parallax Displays

Low Power Requirements

Ease Of Maintenance

All In A Compact Easily-Handled Package.

For more information contact the distributor in your country.

Service Scope

USEFUL INFORMATION FOR

USERS OF TEKTRONIX INSTRUMENTS