

INSTRUCTION MANUAL

Serial Number _____

7CT1N CURVE TRACER

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Fig. 1-1. 7CT1N Curve Tracer.

SECTION 1

OPERATING INSTRUCTIONS

Introduction

This section of the manual gives a general description of the 7CT1N, installation instructions, a functional description of the front-panel controls and connectors, a basic operation procedure, application notes and the instrument characteristics.

GENERAL DESCRIPTION

The 7CT1N is a curve tracer plug-in unit for the 7000-Series Oscilloscope System (see Fig. 1-1). It is to be used to make quick checks of the operation of small-signal semiconductor devices, particularly transistors and FET's. It features a variable collector or drain voltage supply with a maximum peak voltage of at least 240 volts and a base or gate step generator which produces calibrated current of voltage steps. The ranges of step amplitudes available are from $1\ \mu\text{A}/\text{step}$ to $1\ \text{mA}/\text{step}$ for current steps, and from $1\ \text{mV}/\text{step}$ to $1\ \text{V}/\text{step}$ for voltage steps. The maximum power which can be supplied to a device is limited to about 0.5 watt. In addition, the unit has a vertical display amplifier for measuring collector or drain currents from about 5 nA to 160 mA and a horizontal display amplifier for measuring collector-emitter or drain-source voltages ranging from about 0.2 V to 200 V.

INSTALLATION

The 7CT1N is calibrated and ready for use upon arrival. It can be operated in either a vertical or horizontal plug-in compartment in any of the 7000-Series Oscilloscope mainframes. It is suggested that the plug-in be installed in a center compartment.

To install, align the upper and lower tracks of the 7CT1N with the guides of the desired plug-in compartment in the mainframe and slide it in until its front panel is flush with the mainframe front panel. To remove, pull the release latch (labeled 7CT1N) to disengage the 7CT1N from the mainframe and pull the instrument out.

To operate the 7CT1N, its horizontal or vertical output must be connected to another plug-in in the oscilloscope system, through the EXT HORIZ OR VERT OUT cable. If the 7CT1N is in a vertical compartment, connect the cable to a plug-in in a horizontal compartment; if the 7CT1N is in a horizontal compartment, connect the cable to a plug-in in

a vertical compartment. The plug-in to which the cable is connected should have an external input with a deflection factor of 100 mV/division. At the time of printing of this manual, all the 7000-Series amplifier plug-ins and all the time-base plug-ins except the delaying time bases meet this qualification (see Table 1-1). The deflection factor of the external input to some of the time bases must be set using a variable control.

Also, after the 7CT1N has been installed, set the PLUG-IN COMPARTMENT pushbutton according to the location of the 7CT1N in the mainframe. The pushbutton must be out if the plug-in is in a horizontal compartment, and in if the plug-in is in a vertical compartment. See the beginning of the Familiarization Procedure for other initial control settings for the 7CT1N and oscilloscope system.

Table 1-1

7000-Series Plug-Ins Which Can Be Used with the 7CT1N

Amplifiers	Time Bases
7A11	7B50
7A12	7B52
7A13	7B53N
7A15	7B70
7A16	
7A18	
7A22	

CONTROLS AND CONNECTORS

This is a description of the function and operation of the front-panel controls and connectors. More information is given under Basic Operation.

PLUG-IN COMPARTMENT Pushbutton	Determines the output of the EXT HORIZ OR VERT OUT cable, according to the location of the 7CT1N in the mainframe.
POSITION	Positions the display vertically or horizontally depending on the setting of the PLUG-IN COMPARTMENT pushbutton.

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COLLECTOR/DRAIN VOLTS Varies the collector-drain supply output voltage within the range set by the .5 V - 2 V and X10 pushbuttons.

.5 V - 2 V and X10 Pushbuttons Selects the horizontal deflection factor and the range of the collector-drain supply output. Table 1-2 shows the deflection factors and voltage ranges for the various states of the pushbuttons.

TABLE 1-2

**Collector-Drain Supply Output Ranges
and
Horizontal Deflection Factors**

X10 Pushbutton	.5 V - 2 V Pushbutton	Collector-Drain Supply Range	Horizontal Deflection Factor
Out	Out	0 V to 7.5 V	0.5 V/Div
Out	In	0 V to 30 V	2 V/Div
In	Out	0 V to 75 V	5 V/Div
In	In	0 V to 300 V	20 V/Div

VERTICAL Selects the vertical deflection factor. The range of the switch is from 10 μ A/division to 20 mA/division in a 1-2-5 sequence, with the \div 1000 pushbutton in; and from 10 nA/division to 20 μ A/division in a 1-2-5 sequence with the pushbutton out.

\div 1000 When out, the sensitivity of the vertical display amplifier is increased 1000 times for making leakage current measurements. Also, when out, the collector-drain supply is changed from a sweeping output to a DC (non-looping) output.

STEP AMPL Selects the step amplitude of the base-gate step generator output. When the XSTR-FET pushbutton is out, the step amplitude range is from 1 μ A/step to 1 mA/step in a 1-2-5 sequence; when the pushbutton is in, the step amplitude range is from 1 mV/step to 1 V/step in a 1-2-5 sequence.

STEP Continuously variable control which determines the number of steps in the base-gate step generator output. The number of steps ranges from 0 to at least 10 steps.

STEP OFFSET When pulled out, the control provides continuously variable offset of the base-gate step generator output from at least 5 steps of opposing offset (control fully counterclockwise) to at least 5 steps of aiding offset (control fully clockwise). When the control is pushed in, zero offset is obtained.

NPN, N CH - PNP, P CH Pushbutton

Selects the polarity of the collector-drain supply output and the base-gate step generator output. When the pushbutton is out, the collector-drain supply output is positive and the base-gate step generator steps are either positive-going for current steps or negative-going for voltage steps. When the pushbutton is in, the collector-drain supply output is negative and the base-gate step generator steps are negative-going for current steps and positive-going for voltage steps. The XSTR-FET pushbutton determines whether the base-gate step generator output is current or voltage steps. The NPN, N CH-PNP, P CH pushbutton also determines the position of the display. When the pushbutton is out, the zero position of the display is located in the lower left corner of the display unit CRT; when in, the zero position is in the upper right corner of the CRT. The positioning accuracy is within 0.3 division and may be used to the check calibration accuracy of the system.

XSTR-FET Pushbutton

Selects whether the base-gate step generator output is current steps or voltage steps. When the pushbutton is out, the base-gate step generator output is current steps in the same direction as the collector-drain supply output; when the pushbutton is in, the output is voltage steps in the opposite direction to the collector-drain supply output. This pushbutton also selects which

device testing jacks the collector-drain supply output and the base-gate step generator output are connected to (see Table 1-3).

TABLE 1-3

Connection of Collector-Drain Supply Output and Base-Gate Step Generator Output to Device Testing Jacks

B or D	C or G	XSTR-FET
Step Generator	Collector-Drain Supply	Out
Collector-Drain Supply	Step Generator	In

WARNING Light Light flashes when a dangerous voltage is present at the device testing jacks.

Device Testing Jacks Three binding posts on the front of the unit permit connection of devices to be tested to the curve tracer unit. The collector-drain supply output and the base-gate step generator output are connected either to the B or D (base or drain) or C or G (collector or gate) binding post, depending on the state of the XSTR-FET pushbutton (see Table 1-3). The E or S (emitter or source) binding post is always connected to ground.

EXT HORIZ OR VERT OUT Cable Connects the horizontal or vertical signal (depending on the setting of the PLUG-IN COMPARTMENT pushbutton) to another plug-in in the oscilloscope for display on the CRT.

BASIC OPERATION

Familiarization Procedure

This procedure will familiarize the user with the operation of the 7CT1N, and show how to obtain the basic characteristic curves for a diode, bipolar transistor and field effect transistor (FET). Applications are given at the end of this section. This procedure may also be used as an operational check. For a performance check of the instrument, see Section 3.

1. Install the 7CT1N in the mainframe as described in the beginning of this section. Turn on the oscilloscope system and set the mainframe, and time base or amplifier controls as follows:

Mainframe

Horizontal and Vertical Mode Set for location of 7CT1N and for location of plug-in 7CT1N is connected to.

Amplifier

Polarity +Up
Coupling DC
Volts/Div .1

Time Base

Display Mode (7B50 or 7B70) Amplifier
Time/Div or DI'y
Time (7B52 or 7B53N) Ampl
Trigger Source Ext
Triggering Coupling DC

DIODE CHECK

2. Set the 7CT1N controls as follows:

POSITION	Centered
COLLECTOR/DRAIN	
VOLTS	Fully counterclockwise
X10	Pushbutton out
.5 V - 2 V	Pushbutton out
VERTICAL	1 mA/Div
÷ 1000	Pushbutton in
STEP AMPL	No effect for diode check
STEP	No effect for diode check
STEP OFFSET	No effect for diode check
NPN, N CH - PNP,	
P CH	Pushbutton out
XSTR-FET	Pushbutton out

3. Position the spot to the lower left corner of the CRT graticule using the 7CT1N POSITION control and the position control of the plug-in which the EXT HORIZ OR VERT OUT cable is connected to.



Occasionally, a single spot may be displayed on the CRT. In such cases, avoid high spot intensity to prevent burning the CRT phosphor. This precaution is especially important when using a storage oscilloscope.

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Press the **NPN, N CH—PNP, P CH** pushbutton. Check that the spot moves from the lower left corner of the CRT graticule to the upper right corner. If the mainframe display amplifiers are properly adjusted, the position of the spot should be within 0.3 division of the upper right corner of the CRT graticule. If the spot position is not correct, adjust the Volts/Div Variable (amplifier) or Variable (time base) until the spot deflection is correct between the two settings of the **NPN, N CH—PNP, P CH** pushbutton. Release the **NPN, N CH—PNP, P CH** pushbutton.

4. Connect a silicon diode between the C or G (anode) and E or S (cathode) binding posts of the 7CT1N. The transistor-FET adapter supplied with the 7CT1N may be used for this purpose.

5. Turn the **COLLECTOR/DRAIN VOLTS** control clockwise and obtain a display of the forward current versus voltage characteristic of the diode (see Fig. 1-2A).

6. Press the **NPN, N CH—PNP, P CH** pushbutton. The polarity of the collector-drain supply output voltage is now negative, providing a display of the reverse current versus voltage characteristic of the diode.

7. Turn the **COLLECTOR/DRAIN VOLTS** control fully counterclockwise and set the **.5 V - 2 V** and **X10** pushbuttons for a new collector-drain supply range and horizontal deflection factor (see Table 1-2).



*Always turn the **COLLECTOR/DRAIN VOLTS** control counterclockwise before changing the collector-drain supply range, to avoid damage to the device under test.*

Set the **VERTICAL** switch to $10\mu\text{A}/\text{Div}$ and turn the **COLLECTOR/DRAIN VOLTS** control clockwise until the reverse voltage breakdown of the diode is obtained. If the device does not break down within the display window of the CRT, select a higher collector-drain supply range.

Note that when the collector-drain voltage is above about 50 V, the **WARNING** light flashes.



A flashing warning light indicates that a potentially hazardous voltage is present on the device testing terminals.

TRANSISTOR CHECK

8. Set the 7CT1N controls as follows:

POSITION	Centered
COLLECTOR/DRAIN VOLTS	Fully counterclockwise
X10	Pushbutton out
.5 V - 2 V	Pushbutton in
VERTICAL	1 mA/DIV
÷ 1000	Pushbutton in
STEP AMPL	1 $\mu\text{A}/\text{STEP}$
STEP	Fully clockwise
STEP OFFSET	Pull-switch in
NPN, N CH - PNP	
P CH	Pushbutton out
XSTR-FET	Pushbutton out

9. Position the spot to the lower left corner of the CRT graticule.

10. Connect the transistor-FET adapter, which is supplied with the 7CT1N, to the device testing jacks. Install an NPN transistor (with the following suggested characteristics: β of 50 to 100, BV_{CE0} at least 30 V, I_{Cmax} at least 20 mA) in one of the test sockets.

11. Turn the **COLLECTOR/DRAIN VOLTS** control clockwise until a trace of about 5 divisions ($V_{CE} = 10\text{ V}$) is obtained. Turn the **STEP AMPL** switch clockwise until a family of curves similar to that shown in Fig. 1-2B is obtained. This set of curves is a display of the I_C vs. V_{CE} for a transistor operated in a common-emitter configuration. With the **XSTR-FET** pushbutton out, the step generator output is current steps. The setting of the **STEP AMPL** switch indicates the increment of current added to each step (or the step amplitude).

12. Turn the **VERTICAL** switch throughout its range and note the change in vertical deflection factor.

13. Turn the **STEP** control fully counterclockwise. Note that the number of steps decreases to zero. With the **STEP** control fully counterclockwise, the base current of the transistor is essentially zero. (For a true open base condition, disconnect the base lead from the test socket.)

14. Release the $\div 1000$ pushbutton and note that the collector-drain supply output becomes a DC voltage (a spot) rather than a sweeping voltage (a trace). Turn the **VERTICAL** switch clockwise to obtain a measurable display of leakage current (in this case I_{CE0}). The vertical deflection factor with the $\div 1000$ pushbutton out is the setting of the **VERTICAL** switch divided by 1000. Before

measuring leakage current, remove the transistor from the test socket and vertically position the spot to the bottom horizontal graticule line (top line for PNP transistor). Repositioning of the spot compensates for leakage current in the transistor-FET adapter and 7CT1N. (As is mentioned in part 13, the best measurement of I_{CEO} is obtained when the base lead is disconnected from the test socket).

FIELD EFFECT TRANSISTOR CHECK

15. Set the 7CT1N controls as follows:

POSITION	Centered
COLLECTOR/DRAIN VOLTS	Fully counterclockwise
X 10	Pushbutton out
.5 V - 2 V	Pushbutton in
VERTICAL	1 mA/DIV
÷ 1000	Pushbutton in
STEP AMPL	1 mV/STEP
STEP	Fully clockwise
STEP OFFSET	Pull-Switch in
NPN, N CH - PNP, P CH	Pushbutton out
XSTR-FET	Pushbutton in

16. Position the spot to the lower left corner of the CRT graticule.

17. Install an N channel FET in one of the test sockets. The lead configuration of most FET's should match the sockets on the transistor-FET adapter. Information on the side of the adapter indicates which terminals of the socket the leads of the FET should be connected to.

18. Turn the COLLECTOR/DRAIN VOLTS control and the STEP AMPL switch clockwise until a family of curves similar to those shown in Fig. 1-2C is obtained. (The VERTICAL switch may have to be reset to obtain this display.) This set of curves is a display of I_C vs. V_{DS} for an FET operated in the depletion region. With the XSTR-FET pushbutton in, the step generator output is voltage steps. The setting of the STEP AMPL switch indicates the increment of voltage added to each step (or the step amplitude). Turn the STEPS control fully counterclockwise. The step generator output is now zero volts and the curve displayed on the CRT is the zero gate-voltage curve.

19. Turn the STEP control clockwise and pull the STEP OFFSET control out. Turn the STEP OFFSET control fully clockwise and note that the curves are offset further into the depletion region of the device toward pinch-off. Turn the control fully counterclockwise and note that the family of curves is offset into the enhancement region of the device. When an FET is operated in its enhancement region, the $1\text{ k}\Omega$ output impedance of the step generator

protects the device by causing the voltage steps to be compressed as gate current increases. Push in the STEP OFFSET control to obtain the zero offset condition.

Device Adapters

A transistor-FET device testing adapter (Tektronix Part No. 013-0128-00) for TO-5 and TO-18 type cases is supplied as a standard accessory with the 7CT1N. A number of other adapters, which may be used with the 7CT1N, are available from Tektronix. Table 1-4 lists the adapters available at the time of printing of this manual and their uses.

TABLE 1-4

Test Fixture Adapters Which May Be Used With the 7CT1N

Tektronix Part Number	Case Type
013-0072-00	Diodes with axial leads
013-0069-00	Devices with long leads
013-0070-01	TO-3 and TO-66
013-0074-00	Transistors with stud leads
013-0110-00	Diodes with stud leads; DO-4/DO-5
013-0112-00	TO-36

APPLICATIONS

The following section describes how to use the 7CT1N to make some common checks and measurements of diodes, transistors and FET's. These checks may range from checking if a device is operating or not (go, no-go) to checking manufacturer-specified parameters. Before reading this section, it is suggested that a user go through the preceding Familiarization Procedure to acquaint himself with the 7CT1N.

Diodes

General. Most signal, Zener and tunnel diodes can be tested with the 7CT1N. The maximum I_F which can be measured is about 160 mA and the maximum V_R is about 200 V. Care should be taken when testing diodes which are sensitive to current, especially tunnel diodes.

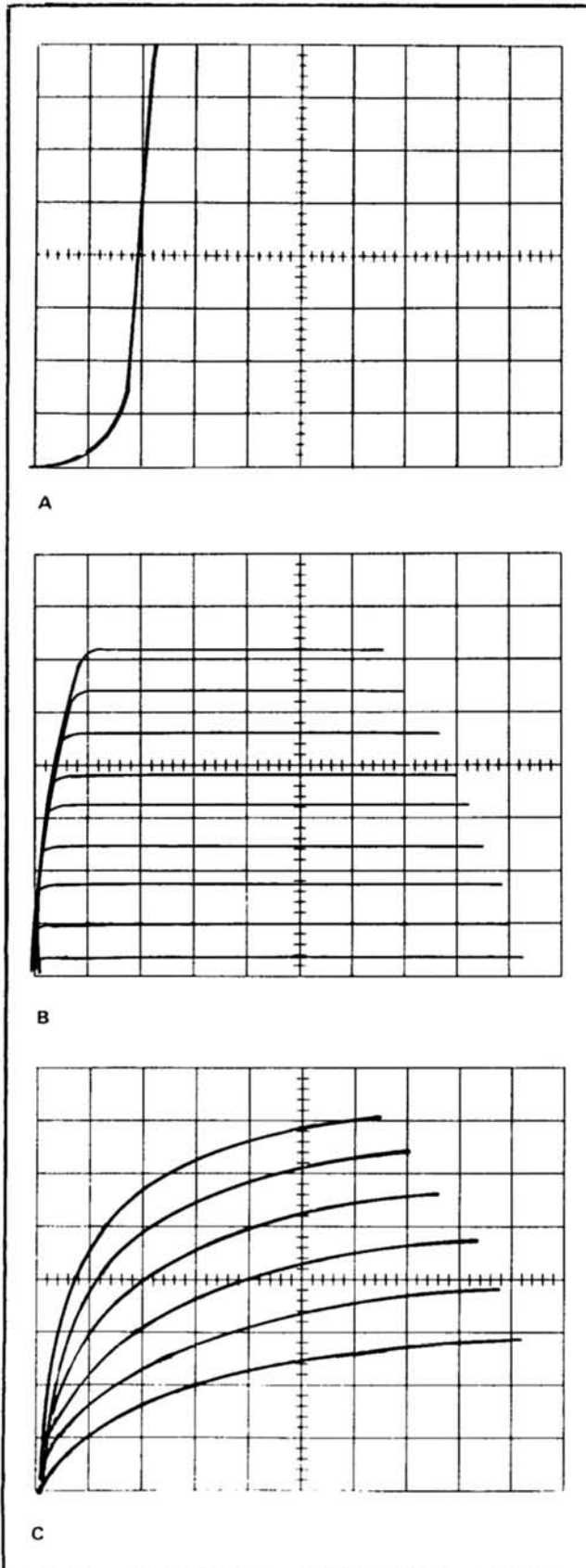


Fig. 1-2. Characteristic curves: (A) Diode; (B) Bipolar transistor; (C) Field effect transistor.

Controls Settings. Set the 7CT1N controls initially as follows:

POSITION	Centered
COLLECTOR/DRAIN VOLTS	Fully counterclockwise
X10	Pushbutton out
.5 V - 2 V	Pushbutton out
VERTICAL	As desired
÷ 1000	Pushbutton in
STEP AMPL	No effect for Diode Check
STEP	No effect for Diode Check
STEP OFFSET	No effect for Diode Check
NPN, N CH - PNP	
P CH	Pushbutton out
XSTR-FET	Pushbutton out

Installation. Connect the diode to the device testing jacks as shown in Fig. 1-3. The device may be connected either directly to the jacks or through the transistor-FET adapter included with the 7CT1N. Special diode adapters are also available from Tektronix (see Table 1-4).

Checks and Measurements. Use the following instructions to make checks and measurements of a diode once the controls have been set and the diode has been installed as described previously.

Go, No-Go Turn the COLLECTOR/DRAIN VOLTS control clockwise to obtain a display of the forward conduction characteristic of the diode. Fig. 1-3 shows typical displays for a rectifier type diode and a tunnel diode.

I_F and V_F Turn the COLLECTOR/DRAIN VOLTS control clockwise to obtain a display of the forward conduction characteristic of the diode. Measure the turn-on voltage on the horizontal axis of the CRT graticule and measure the forward current on the vertical axis. Measure the peak and valley currents and voltages of a tunnel diode in the same manner.

I_R (leakage) and V_R or V_Z Press the NPN, N CH - PNP, P CH pushbutton. Turn the COLLECTOR/DRAIN VOLTS control clockwise until Zener or avalanche breakdown voltage is obtained. If breakdown is not obtained, select a higher collector-drain supply output voltage. Measure V_R or V_Z on the hori-

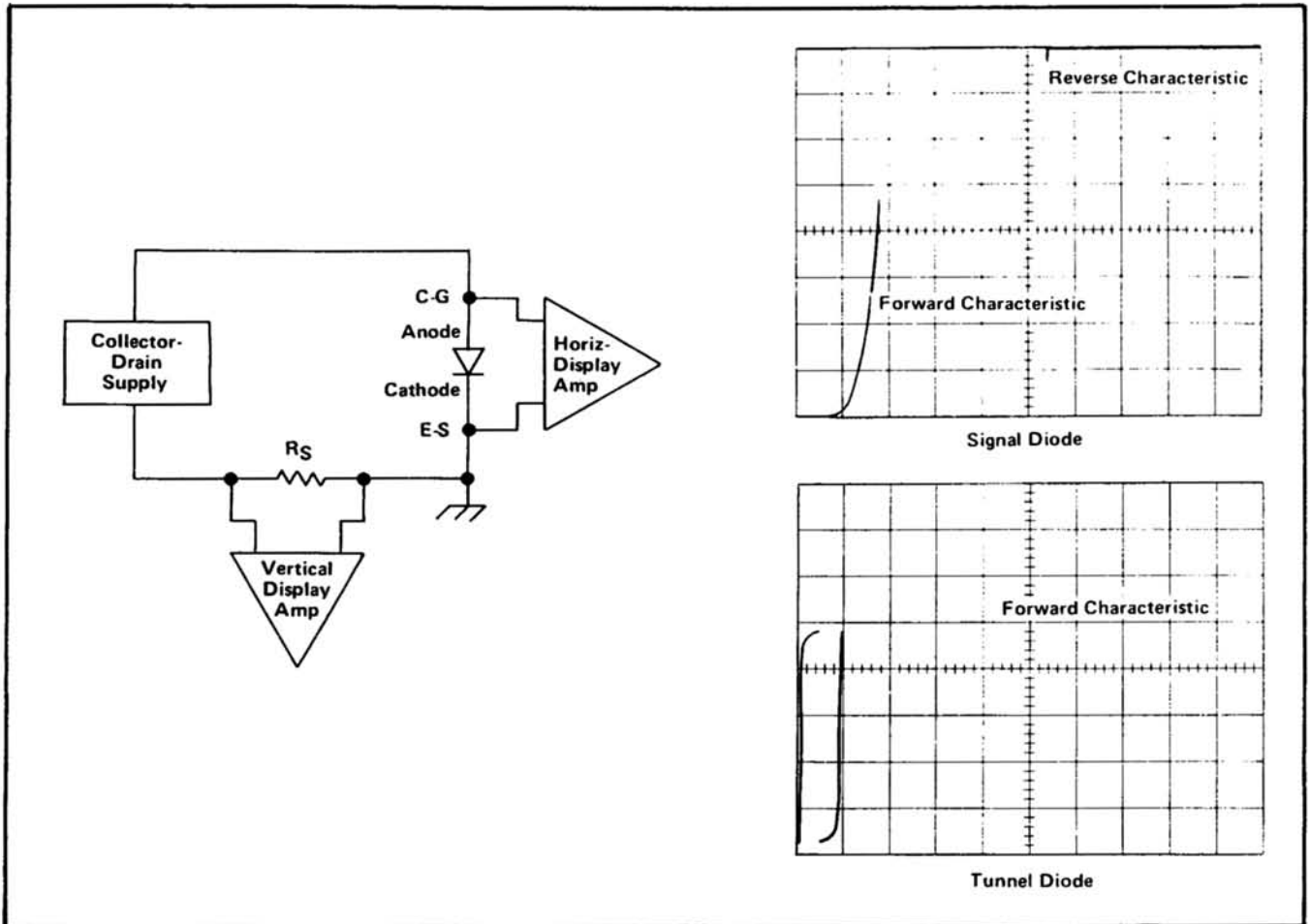


Fig. 1-3. Simplified diagram showing the connection of a diode to the 7CT1N and some typical displays.

zontal axis. Release the $\div 1000$ pushbutton to measure leakage current. With the $\div 1000$ pushbutton out, divide the VERTICAL switch setting by 1000 to obtain the vertical deflection factor. Before measuring leakage current, momentarily disconnect the diode from the test socket and vertically position the spot to the zero current line (normally the top horizontal graticule line).

X10
.5 V - 2 V
VERTICAL
 $\div 1000$
STEP AMPL
STEP
STEP OFFSET
NPN, N CH - PNP,
P CH

XSTR-FET

Pushbutton out
Pushbutton in
As desired
Pushbutton in
 $1 \mu\text{A}/\text{DIV}$
Fully clockwise
Pull-Switch in

Pushbutton out
(NPN Devices)
Pushbutton in (PNP Devices)
Pushbutton out

Bipolar Transistors

General. All bipolar transistors can be tested with the 7CT1N. The maximum I_C which can be measured is 160 mA.

Controls Settings. Set the 7CT1N controls initially as follows:

POSITION	Centered
COLLECTOR/DRAIN	
VOLTS	Fully counterclockwise

Installation. Connect the transistor to the device testing jacks through the transistor-FET adapter which is included with the 7CT1N. This adapter accepts TO-5 and TO-18 type cases. For devices which do not match this adapter, connect the leads to the jacks as shown in Fig. 1-4.

Checks and Measurements. Use the following instructions to make checks and measurements of a transistor once the controls have been set and the diode has been installed as described previously.

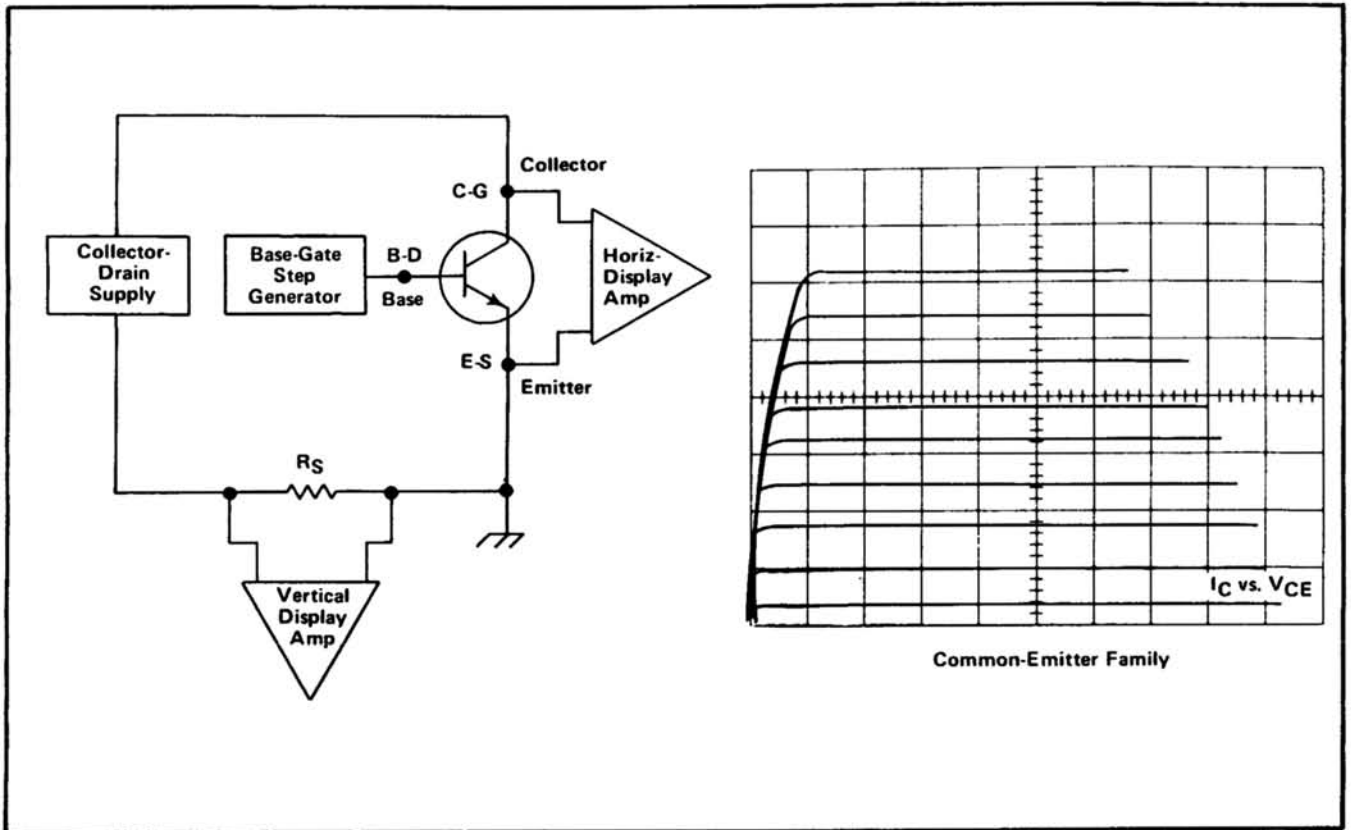


Fig. 1-4. Simplified diagram showing the connection of a bipolar transistor to the 7CT1N and a typical display.

Go, No-Go

Turn the COLLECTOR/DRAIN VOLTS control clockwise to obtain a horizontal trace of about 5 divisions. Turn the STEP AMPL switch clockwise until a display similar to that shown in Fig. 1-4 is obtained.

measurement. Multiply this distance by the β /division previously calculated to determine β .

β (small-signal)

The small-signal short-circuit forward current transfer ratio (emitter grounded), β or h_{fe} , is $\Delta I_C / \Delta I_B$. To measure β , obtain a display of I_C vs. V_{CE} as described for the go, no-go check. Set the STEP AMPL switch and VERTICAL switch for the I_C at which β is specified. I_C is measured on the vertical axis. The VERTICAL switch sets the deflection factor. When the desired display is obtained, calculate a value for β /division by dividing the VERTICAL switch setting by the setting of the STEP AMPL switch. Next, measure the vertical distance between two curves in the vicinity of the I_C at which β is specified. Offset may be used to position the curves for more convenient

V_{CE} (Sat.)

Obtain a display of I_C vs. V_{CE} as described for the go, no-go check. Release the .5 V - 2 V pushbutton and adjust the COLLECTOR/DRAIN VOLTS control for a display of the saturation region of the curves. The saturation region is usually defined as the non-linear or "knee" region of a curve.

V_{BE} (Sat.)

Obtain a display of V_{CE} (Sat.) and measure the base voltage on the device, using a probe from a vertical unit in the oscilloscope system.

I_{CEO} and BV_{CEO}

Disconnect the base lead from the test socket. Turn the COLLECTOR/DRAIN VOLTS control clockwise until the transistor breaks down. If breakdown does not occur, select a higher collector-drain supply range. Collector-emitter breakdown volt-

age with the base open is measured on the horizontal axis. Collector-emitter leakage current with the base open is measured on the vertical axis. To make this measurement, release the $\div 1000$ pushbutton and adjust the COLLECTOR/DRAIN VOLTS control for the V_{CE} at which the leakage current is specified. Before measuring I_{CEO} momentarily disconnect the transistor from the test socket and position the spot to the zero current line (the bottom horizontal graticule line for NPN transistors, and the top horizontal graticule line for PNP transistors).

I_{CES} and BV_{CES}

Collector-emitter leakage current and collector-emitter breakdown voltage (base shorted to emitter) are measured the same as I_{CEO} and BV_{CEO} , except that the base lead of the device is shorted to the emitter lead.

I_{CER} and BV_{CER}

Collector-emitter leakage current and collector-emitter breakdown voltage (with a specified resistance between the base terminal and the emitter terminal) are measured the same as I_{CES} and BV_{CES} , except that a specified resistance is connected between the base lead and the emitter lead.

α (small-signal)

The small-signal short-circuit forward current transfer ratio (base grounded), h_{fb} , cannot be measured conveniently with the 7CT1N. It can, however, be calculated from β with the following equation: $\alpha = \beta / (1 + \beta)$.

I_{CBO} and BV_{CBO}

Collector-base leakage current and collector-base breakdown voltage (emitter open) is measured the same as I_{CEO} and BV_{CEO} , except that the base lead is connected to the E or S terminal, and the emitter lead is left open (or connected to the B or D terminal).

I_{EBO} and BV_{EBO}

Emitter-base leakage current and emitter-base breakdown voltage (collector open) are measured the same as I_{CEO} and BV_{CEO} , except that the emitter lead is connected

to the C or G terminal, the base lead is connected to the E or S terminal, and the collector lead is left open (or connected to the B or D terminal).

Field Effect Transistors

General. All Field Effect Transistors including junction FET's and MOS-FET's can be tested with the 7CT1N.

Control Settings. Set the 7CT1N controls initially as follows:

POSITION	Centered
COLLECTOR/DRAIN VOLTS X10	Fully counterclockwise
.5 V - 2 V	Pushbutton out
VERTICAL $\div 1000$	Pushbutton in
STEP AMPL STEP	As desired
STEP OFFSET	Pushbutton in
NPN, N CH - PNP, P CH	1 mV/STEP
	Fully clockwise
	Pull-Switch in
	Pushbutton out (N channel)
	Pushbutton in (P channel)
XSTR-FET	Pushbutton in

Installation. Connect the FET to the device testing jacks through the transistor-FET adapter which is included with the 7CT1N. This adapter is wired to accept devices with gate-drain-source configurations. If the adapter can not be conveniently used, connect the leads directly to the device testing jacks as shown in Fig. 1-5.

Checks and Measurements. Use the following instructions to make checks and measurements of an FET once the controls have been set and the FET has been installed as previously described.

Go, No-Go Turn the COLLECTOR/DRAIN VOLTS control clockwise to obtain a horizontal trace of about 5 divisions. Turn the STEP AMPL switch clockwise until a display similar to that shown in Fig. 1-5 is obtained.

g_m (small-signal) The small-signal transconductance (source grounded) is $\Delta I_D / \Delta V_{GS}$. To measure g_m , obtain a display of I_D vs. V_{DS} as is described for the go, no-go check. Set the STEP AMPL switch and VERTICAL switch for the I_D at which g_m is specified. I_D is measured on the vertical axis. The VERTICAL switch sets the deflection factor. When the desired display is

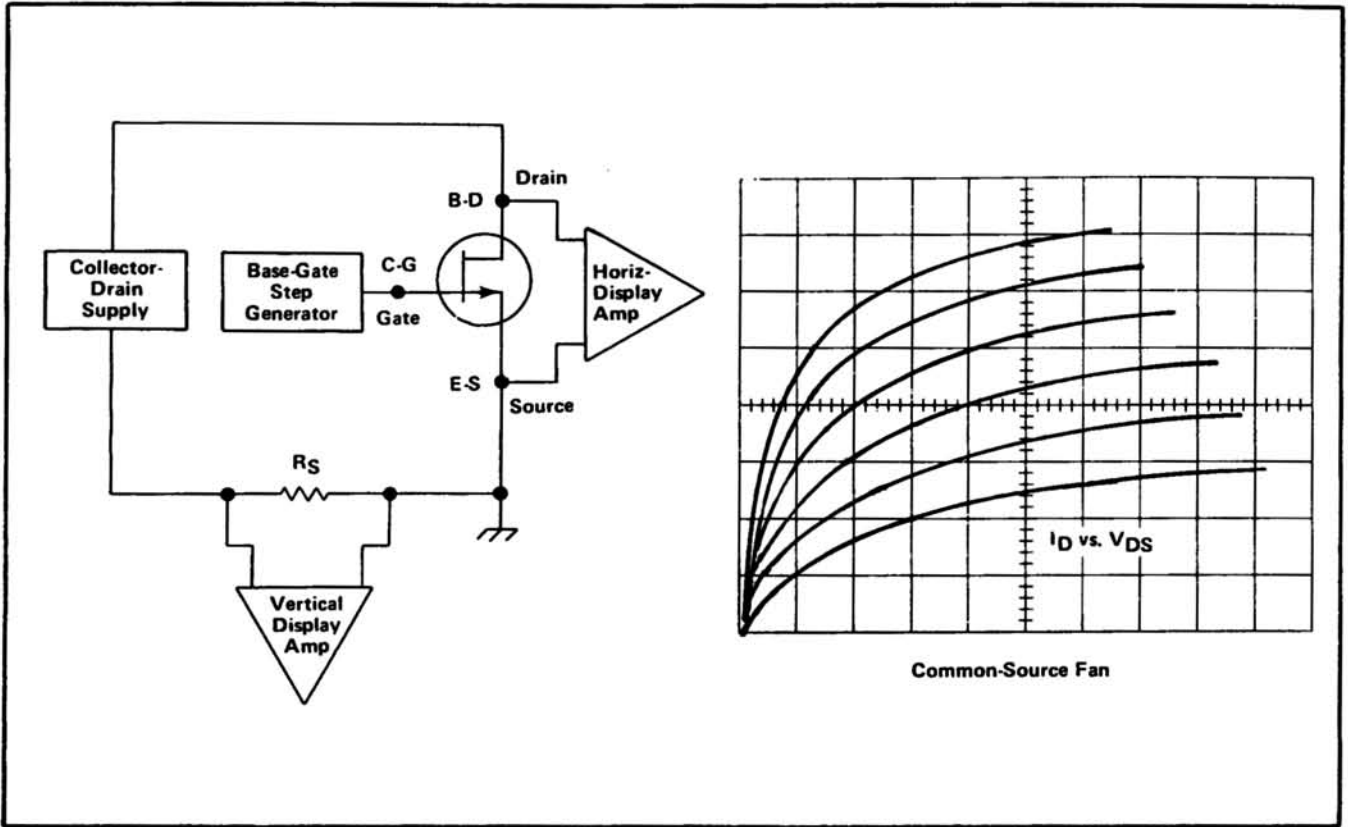


Fig. 1-5. Simplified diagram showing the connection of an FET to the 7CT1N and a typical display.

obtained, calculate a value of g_m /division by dividing the VERTICAL switch setting by the setting of the STEP AMPL switch. Next measure the vertical distance between two curves in the vicinity of the I_D at which g_m is specified. Offset may be used to position the curves for convenient measurement. Multiply this distance by the g_m /division previously calculated to determine g_m .

I_{DSS}

Obtain a display of I_D vs. V_{DS} as described for the go, no-go check. Turn the STEPS control fully counterclockwise. Drain-source current with zero V_{GS} is the current level of the single curve measured above the knee.

Pinch-Off Voltage (V_p)

Obtain the display of I_D vs. V_{DS} as described for the go, no-go check. Pinch-off voltage is measured by increasing the gate-source depletion voltage, using the STEP AMPL switch and the STEPS control, until the specified pinch-off current is

obtained. V_p is then the gate-source voltage required to reach pinch-off current. Multiply the number of steps required to reach pinch-off current by the setting of the STEP AMPL switch to obtain a value for V_p . For a more accurate measurement of V_p , use the STEP OFFSET control. Since the STEP OFFSET control is not calibrated, some reference point must be established on the CRT graticule. For example, the level of the 10th step could be marked on the CRT graticule before the STEP OFFSET control is pulled out.

BV_{GSS}

Install the device in the test socket with the gate lead connected to the E or S jack and the source and drain leads shorted together and connected to the B or D jack. Turn the COLLECTOR/DRAIN VOLTS control clockwise until the gate-source breakdown voltage is obtained. This measurement should not be made on insulated gate devices.

SPECIFICATION

This specification lists the electrical performance limits and physical requirements of the 7CT1N. A procedure for checking the electrical performance limits is given in the Performance Check/Adjust section.

Collector-Drain Supply

Polarity: + or —.

Voltage Ranges: (No Load)

0 V to 7.5 V.

0 V to 30 V.

0 V to 75 V.

0 V to 300 V.

Maximum Voltage Limit: Within 20%

Peak Current: (Short Circuit)

240 mA in 7.5 V range.

60 mA in 30 V range.

24 mA in 75 V range.

6 mA in 300 V range.

Peak Current Limit: Within 30%

Base-Gate Step Generator

Step Polarity: Positive-going or negative-going

Number of Steps: From 0 to at least 10.

Step Accuracy:

Absolute: (Eighth step) within 5%.

Incremental: Within 3%

Zero Step Level: Within 0.3 step.

Step Offset:

Aiding: At least 5 steps (or 13 V total step generator output for voltage steps).

Opposing: At least 5 steps.

Display Amplifiers

Vertical:

Ranges: Normal and Leakage.

Accuracy: Within 5% + 0.2 nA/V.

Horizontal Accuracy: Within 5%.

Positioning Accuracy: Within 3% using NPN, N CH - PNP, P CH pushbutton.

General

Temperature:

Operating: 0° C to +50° C.

Storage: -40° C to +70° C.

Altitude:

Operating: To 15,000 feet.

Storage: To 50,000 feet.

Vibration Range: To 0.015 inch total displacement at 50 Hz.

Shock Range: 30 g's, 1/2 sine, 11 ms duration.

Transportation: Qualified under National Safe Transit Committee Test Procedure 1A, Category II.

Standard Accessories:

1 Instruction Manual 070-1247-00

1 Transistor, FET Adapter, TO-5 and TO-18.

SUPPLEMENTARY INFORMATION

This section lists additional information about the 7CT1N which may be useful in using or maintaining the instrument.

Collector-Drain Supply

Modes: Normal sweeping output or DC output (for leakage current measurements).

Sweep Waveform: Triangular.

Sweep Frequency: ≈ 110 Hz.

Peak Power: ≈ 0.5 watt. Limited by internal series resistors. Reduced in higher sensitivity positions of VERTICAL switch.

Warning Light: Flashes when collector-drain supply is set above about 50 volts open circuit to indicate a dangerous voltage at the device testing terminals.

Base-Gate Step Generator

Modes: Current steps for testing bipolar transistors, and voltage steps for testing field effect transistors.

Step Rate: 1 step per cycle of the collector-drain supply.

Ranges:

Current Mode: $1 \mu\text{A}/\text{step}$ to $1 \text{ mA}/\text{step}$ in a 1-2-5 sequence.

Voltage Mode: $1 \text{ mV}/\text{step}$ to $1 \text{ V}/\text{step}$ in a 1-2-5 sequence.

Limits—Current Mode:

Maximum Current:

With Aiding Offset: 15 times the STEP AMPL switch setting.

With Opposing Offset: 5 times the STEP AMPL switch setting.

Maximum Voltage:

With Aiding Offset: $\pm 13 \text{ V}$.

With Opposing Offset: $\pm 15 \text{ V}$.

Limits—Voltage Mode:

Maximum Voltage:

With Aiding Offset: 15 times the STEP AMPL switch setting or $\pm 13 \text{ V}$, whichever is less.

With Opposing Offset: 5 times STEP AMPL switch setting.

Maximum Current: Limited by output impedance of $1 \text{ k}\Omega$ (aiding or opposing offset).

Display Amplifiers

Vertical Ranges:

Normal: $10 \mu\text{A}/\text{divisions}$ to $20 \text{ mA}/\text{division}$ in 1-2-5 sequence.

Leakage: $10 \text{ nA}/\text{division}$ to $20 \mu\text{A}/\text{division}$ in 1-2-5 sequence.

Horizontal Ranges: $.5 \text{ V}/\text{division}$, $2 \text{ V}/\text{division}$, $5 \text{ V}/\text{division}$ and $20 \text{ V}/\text{division}$ through plug-in with $100 \text{ mV}/\text{division}$ deflection factor.

SECTION 2

CIRCUIT DESCRIPTION

BLOCK DIAGRAM DESCRIPTION

The 7CT1N is divided into a stimulus section which provides voltages and currents for application to the device under test, and a measurement section which measures the effects of the stimulus. The stimulus section consists of the collector-drain supply (see Fig. 2-1) and the base gate step generator. The measurement section consists of the vertical and horizontal display amplifiers.

The collector-drain supply produces a voltage which is connected to the collector of a bipolar transistor, the drain of an FET, or either lead of a diode. This voltage can be either a sweeping voltage or a DC voltage. The sweeping voltage has a triangular waveshape.

The base-gate step generator produces current steps for application to the base of a bipolar transistor or voltage

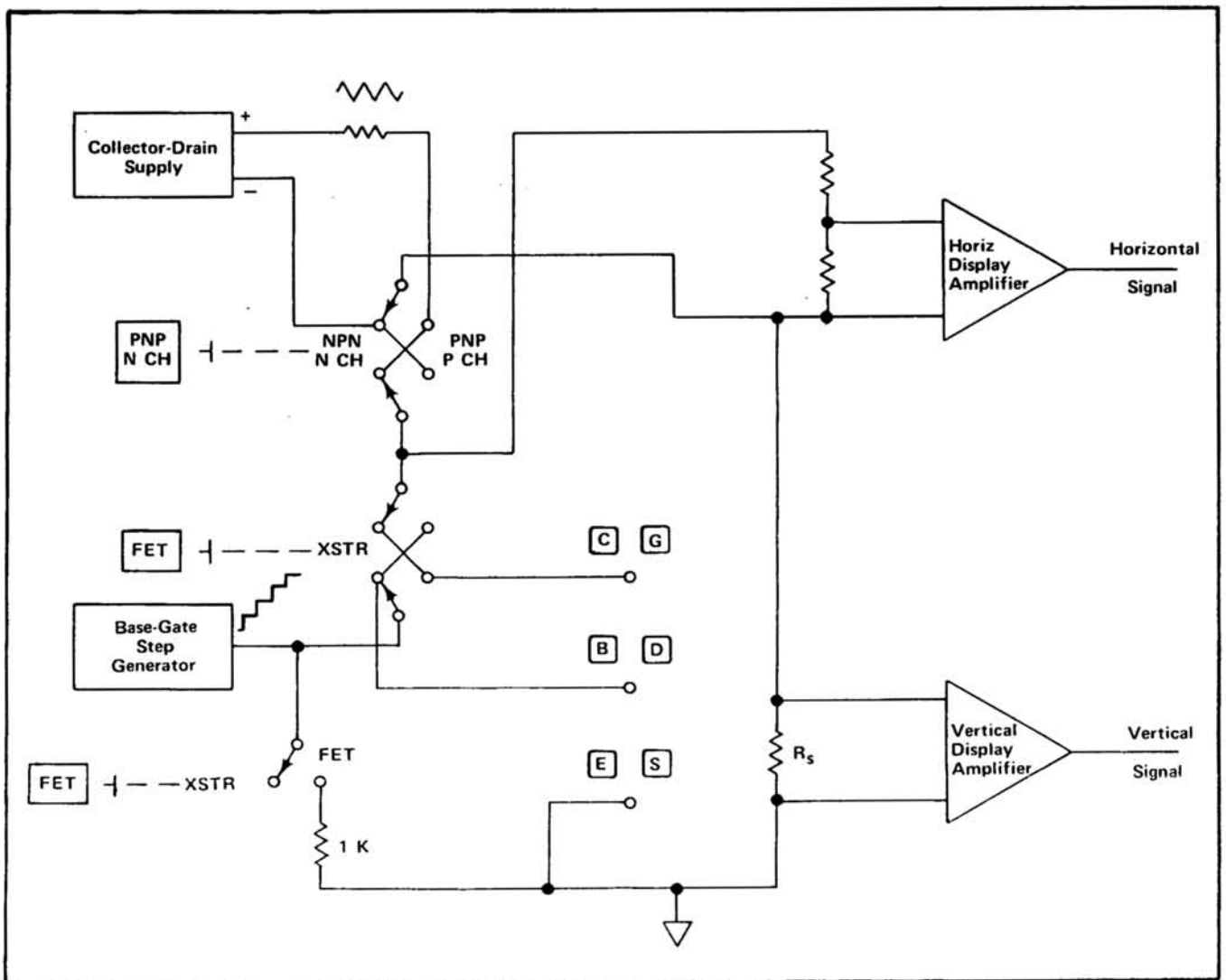


Fig. 2-1. Simplified block diagram of the 7CT1N.

Circuit Description—7CT1N

steps for application to the gate of an FET. The steps occur at a rate of one step per cycle of the collector-drain supply.

The vertical display amplifier measures current for display on the vertical axis of the CRT. A resistor in the return path to the collector-drain supply is used to sense current.

The horizontal display amplifier measures voltage for display on the horizontal axis of the CRT. The voltage measured is V_{CE} for a bipolar transistor, V_{DS} for an FET or an anode-cathode voltage for a diode.

CIRCUIT DESCRIPTION

Collector-Drain Supply

The sweep generator (see the Block Diagram in the diagrams section) produces a triangular waveform which is the basis for the collector-drain supply output. The signal is generated at a rate of about 55 Hz with a peak-to-peak amplitude of about 10 V. To produce the triangular waveform (see the circuit diagram), C11 is charged and discharged with constant current conducted through R11. Q2 and Q4 form a Schmitt trigger circuit which determines when C11 is charged and discharged.

The sweep generator output is transmitted through variable attenuator R20, the COLLECTOR/DRAIN VOLTS control, to the sweep amplifier. The sweep amplifier amplifies the triangular waveform about five times.

From the sweep amplifier, the triangular waveform is transmitted through collector supply transformer T39. T39 has four taps which determine the four ranges of the collector-drain supply. CR52 full-wave rectifies the output of the transformer secondary, producing the collector-drain sweep output. The sweep output is thus a positive or negative triangular waveform produced at twice the rate of the unrectified waveform, or 110 Hz.

The collector-drain supply voltage is applied to the device under test through S70C, controlled by the PNP, P CH pushbutton, and S75B, controlled by the FET pushbutton. The path of collector or drain current (see the Block Diagram) is from one side of the rectifier, through the device under test, through the current sensing resistor, and back to the other side of the rectifier. S70C determines the polarity of the collector-drain supply sweep applied to the device under test, and thus the direction of current through the device under test.

R56 and R57 are series limiting resistors which limit the power dissipated by the device under test. The VERTICAL switch determines when these resistors are in the circuit.

C52 and C53, or C54 are connected between the two outputs of the collector-drain supply rectifier when the ÷ 1000 pushbutton is released. These capacitors filter the collector-drain sweep voltage, producing a DC voltage.

Q208 performs two functions; it turns off the collector-drain supply when the 7CT1N is installed in the oscilloscope system, but not in use, and it helps limit beam intensity when the collector-drain supply voltage is low. A6, connected to the emitter of Q204, is a common. A16 and B7 are logic lines which indicate whether the plug-in is in use or not. When the plug-in is not being used, A16 and B7 are either both high or both low. In this case, Q208 is off and Q210 and Q212 are on, holding the output of the sweep generator at ground.

When the plug-in is in use, the logic levels on A16 and B7 are opposite one another, and Q208 is on. In this case, the amount of current conducted by Q208 controls the beam intensity. As current increases through Q208, the beam intensity decreases. The voltage across C214, which is controlled by the negative portion of the sweep amplifier output, determines the amount of current Q208 conducts. As the collector-drain supply voltage decreases, the voltage across C214 decreases. This causes the current conducted by R214 to decrease, which increases the current through Q208 and reduces the beam intensity.

The voltage across C214 controls the WARNING HIGH VOLTAGE light. When the voltage across C214 gets higher than 5 V or 24 V, depending on the position of S45C, multivibrator Q226 and Q228 is allowed to free run causing the warning light to flash. 5 V and 25 V across C214 correspond to about 50 V at the output of the collector-drain supply.

Base-Gate Step Generator

The zero crossing detector produces a positive-going pulse each time the output of the sweep generator crosses 0 volts. When the sweep generator output crosses 0 volts going positive, Q82 is turned on and Q84 is turned off, causing a positive pulse to be transmitted through CR86 to the base of Q92. When the output crosses zero going negative, Q84 turns on, Q82 turns off and a positive pulse is transmitted through CR88 to the base of Q92.

The step generator produces a DC voltage which increases by one increment (or step) each time the zero crossing detector produces a positive pulse. The output of the step generator is, thus, a positive-going staircase. The staircase voltage increases until it reaches a level set by the STEP control. At this time, the step generator output returns to 0 volts and a new staircase begins.

C114 is charged in increments to produce the step generator output voltage. Quiescently, C96 is charged to about 5 volts as set by R90, the V/STEP CAL adjustment. When a positive-going pulse from the zero crossing detector is applied to the base of Q92, its collector goes to ground, causing a negative-going pulse to be conducted through CR97. This negative pulse causes C114 to be charged by an amount proportional to the initial charge on C96. R90 thus determines the step amplitude at the step generator output. When C96 has discharged, CR97 turns off, holding the charge on C114 constant.

C114 will continue to charge in this manner until the step generator output voltage becomes high enough to turn on Q104. R100, the STEP control, determines the voltage required to turn on Q104. When Q104 turns on, Q108 turns on, which turns on Q114. With Q114 on, C114 is discharged. When Q108 turns on, Q92 is also turned on, keeping C96 discharged until the step generator output returns to 0 volts.

The offset circuit allows the DC level of the step generator staircase to be shifted either positive (aiding) or negative (opposing). R120, the STEP OFFSET control, controls the output voltage of the offset circuit.

The step amplifier amplifies the step generator output 1.5 times and converts the voltage steps into current steps. Q132 and Q136 form an emitter-coupled amplifier. The output of this amplifier is at the collector of Q132. Q142 and Q148 conduct constant current. Q144 and Q146 conduct varying current as determined by the collector of Q132. To obtain positive current steps (current steps conducted into the device under test), the base of Q136 is grounded and positive-going voltage steps from the step generator are applied to the base of Q132. The resulting negative-going voltage steps at the collector of Q132 cause the current conducted by Q144 and Q146 to increase in step increments. Since Q142 and Q148 conduct constant current, the additional current conducted by Q144 and Q146 is conducted into the device under test.

To obtain negative-going current steps (current steps conducted out of the device under test), the base of Q132 is grounded and the step generator output is applied to the base of Q136. In this case, the voltage steps at the collector of Q132 are positive-going, causing the current conducted by Q144 and Q146 to be reduced in step increments. Since Q142 and Q148 are still conducting constant current, current will have to be conducted out of the device under test to make up for the reduced current conducted by Q144 and Q146.

When voltage steps are desired, R169 is switched into the circuit. The current produced by the step amplifier is then conducted through R169 to produce voltage steps. The accuracy of the voltage steps is dependent on the amount of current R169 conducts. If the voltage steps are

applied to the gate of an FET being operated in its enhancement region, the steps will be compressed due to the gate current conducted by the device. This voltage limiting protects the gate from excessive current in such cases.

R139, the 1-5 μA BAL adjustment sets the current conducted by emitter-coupled amplifier Q132 and Q136. It thus sets the overall balance of the step amplifier. R158, R155, and R152 (the 10-50 μA , 100-500 μA , and 1 mA BAL adjustment, respectively) set the balance of the step amplifier for their respective positions of the STEP AMPL switch. These four controls are adjusted for zero current when no steps are being generated.

Display Amplifiers

The vertical display amplifier measures the current supplied to the device by the collector-drain supply, by measuring the voltage across a current sensing resistor in the return path to the supply. The size of the current sensing resistor is changed to obtain the decade ranges of the vertical deflection factor. The size of the feedback resistor across the vertical amplifier determines the 1-2-5 multiplier of the vertical deflection factor. When the $\div 1000$ push-button is released, a different set of current sensing resistors is used to increase the sensitivity of the vertical amplifier and allow leakage currents to be measured. R194, the VERT AMP BAL adjustment, adjusts the balance of U194 so that there is no DC shift in the output when the VERTICAL AMPERES/DIV switch position is changed. U232 is an amplifier which provides a voltage gain of 2.

The horizontal display amplifier measures the output voltage of the collector-drain supply, which is essentially the voltage between the C-G and E-S jacks, when the XSTR-FET pushbutton is out, and the B-D and E-S jacks, when the pushbutton is in. Since the current sensing resistors are in series with the device under test (see Fig. 2-1), the voltage measured by the horizontal display amplifier is not exactly the voltage across the device under test. This error is only significant for the 0.5 V/div horizontal deflection factor. In this case, divider R171-R172 compensates for the error introduced by the current sensing resistor.

The 7CT1N transmits the output of one display amplifier to the mainframe through push-pull amplifier Q252 and Q262, and the output of the other amplifier through the EXT HORIZ OR VERT OUT cable. From this cable the signal is transmitted to the mainframe through an amplifier in another plug-in in the oscilloscope system. The position of VERT pushbutton S230 determines which signal is transmitted through the EXT HORIZ OR VERT OUT cable. If the 7CT1N is in a vertical compartment, the VERT pushbutton is pressed and the horizontal signal is transmitted through the EXT HORIZ OR VERT OUT cable; if the 7CT1N is in a horizontal compartment, the VERT pushbutton is left out and the vertical signal is transmitted through the cable.

SECTION 3

PERFORMANCE CHECK / ADJUSTMENT PROCEDURE

GENERAL

Introduction

This section contains a procedure for checking the performance capabilities of the 7CT1N and, when necessary, for making internal adjustments to bring the instrument performance within specified limits. The basic operation procedure in Section 1 verifies instrument operation, but does not check its performance to specified limits.

Services Available

Tektronix, Inc. provides complete instrument repair and calibration at local Field Service Centers and at the Factory Service Center. Contact your local Tektronix Field Office or representative for further information.

TEST EQUIPMENT REQUIRED

General

The following test equipment and accessories, or the equivalent, are required for complete calibration of the 7CT1N. Specifications given for the test equipment are the minimum necessary for accurate calibration. Therefore, some of the specifications listed here may be less rigorous than the performance capabilities of the test equipment. All test equipment is assumed to be operating within the listed specifications.

Special Calibration Fixtures

Special Tektronix calibration fixtures are used in this procedure only where they facilitate instrument calibration. These special calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

Calibration Equipment Alternatives

If other test equipment is substituted, control settings or calibration setups may need altering to meet the requirements of the equipment used. Detailed operating instruc-

tions for the test equipment are not given in this procedure. Refer to the instruction manual for the test equipment if more information is needed.

Test Equipment

1. 7000-Series Oscilloscope System, including a mainframe, one vertical amplifier and one time-base. The measurement accuracies of the vertical amplifier and time-base must be within 3%.

2. Voltage Source. A voltage source with DC voltages (or pulse amplitudes) of 500 mV, 5 V, 20 V, 50 V and 100 V, accuracy within 1%. A Tektronix Standard Amplitude Calibrator is suggested (Tektronix Part No. 067-0502-01).

3. The following precision resistors checked to within 1/2% accuracy, 100 Ω , 1 k Ω , 10 k Ω , 20 k Ω , 50 k Ω , 100 k Ω , 200 k Ω , 2 M Ω and 20 M Ω (all 1/8 watt or greater).

Accessories

1. Patch cords (2). 12 to 18 inches long with standard banana plug connectors. (Tektronix Part No. 012-0031-00 or 012-0039-00.)

2. Connector adapter. BNC male-to-dual binding post (Tektronix Part No. 103-0035-00).

3. Plug-in extender (optional). Tektronix Part No. 067-0616-00. Used for adjustments only.

NOTE

The display amplifiers in the oscilloscope mainframe should be calibrated before performing this procedure.

TABLE 3-1
Check/Adjust Procedure Index and Record

Step	Title	Adjustments	Page
1	Check Horizontal Display Amplifier		3-2
2	Check/Adjust Vertical Display Amplifier	R194	3-3
3	Check Collector-Drain Supply		3-4
4	Check/Adjust Base-Gate Step Generator	R139, R152, R155, R158, R100	3-5

Performance Check/Adjustment Procedure—7CT1N

Preliminary Procedure

1. Install the 7CT1N and amplifier plug-ins in the 7000-series oscilloscope system.

a. (Performance Check Only)—Install the 7CT1N in the Right plug-in compartment and the amplifier plug-in in the A compartment.

b. (Performance Check and/or Adjustment)—Remove the left dust cover from the 7CT1N and install the plug-in in the Right plug-in compartment through a plug-in extender. Install the amplifier plug-in in the A compartment. If a plug-in extender is not available, install the 7CT1N in the Left compartment and remove the left dust cover from the mainframe. The plug-in extender is required for rack-mounted oscilloscope systems.

2. Connect the oscilloscope system and Standard Amplitude Calibrator to a suitable power source and turn on the instruments. Allow 5 minutes warmup before starting the procedure.

NOTE

The performance of this instrument can be checked at any ambient temperature within the 0°C to +50°C range. If adjustments are to be made, the ambient temperature should be 25°C ±5°C, for best overall accuracy.

1. Check Horizontal Display Amplifier

a. Set the 7CT1N, oscilloscope system and standard amplitude calibrator controls as follows:

7CT1N	
PLUG-IN COMPARTMENT POSITION	VERT Centered
COLLECTOR/DRAIN VOLTS	Fully counterclockwise
X10	Pushbutton out
.5 V-2 V	Pushbutton out
VERTICAL	20 mA/DIV
÷1000	Pushbutton in
STEP AMPL	1 mA/STEP

STEP	Fully counterclockwise
STEP OFFSET	Pull-switch in
NPN, N CH -	
PNP, P CH	Pushbutton out
XSTR-FET	Pushbutton out

Oscilloscope System

Vertical Mode	Location of 7CT1N
Horizontal Mode	A
Amplifier	
Position	Centered
Polarity	+Up
Coupling	DC
Volts/Div	.1 (Cal)

Standard Amplitude Calibrator

Mode	Square Wave
Amplitude	5 Volts

CAUTION

Occasionally while using this procedure, a single spot will be displayed on the CRT. In such cases, avoid high spot intensity to prevent burning the CRT phosphor. This precaution is especially important when using a storage oscilloscope.

b. Connect the 7CT1N EXT HORIZ OR VERT OUT cable to an input to the amplifier plug-in. Connect the square wave output of the Standard Amplitude Calibrator to the C or G jack on the 7CT1N and the ground to the E or S jack. It is suggested that a BNC male to dual binding post adapter and two patch cords with banana plug connectors be used.

c. Position the display so that both spots are visible on the CRT graticule.

d. CHECK FOR—Horizontal separation of spots as shown in Table 3-2 ±0.5 division (±0.25 division for the 20 V/div deflection factor) for all the settings of the .5 V-2 V and X10 pushbuttons. Note that for the 0.5 V/div, 2 V/div and 5 V/div deflection factors, the 7CT1N loads the Standard Amplitude Calibrator, causing the spot separation to be reduced 0.2 division.

TABLE 3-2

Check Horizontal Display Amplifier Accuracy

X10 Pushbutton	.5 V-2 V Pushbutton	Horizontal Deflection Factor	Standard Amplitude Calibrator	Horizontal Separation
Out	Out	.5 V/Div	5 V	9.8 divisions
Out	In	2 V/Div	20 V	9.8 divisions
In	Out	5 V/Div	50 V	9.8 divisions
In	In	20 V/Div	100 V	5.0 divisions

e. Calibrate the CRT horizontal deflection for 5 V over the center 8 divisions. This is done by setting the Standard Amplitude Calibrator for 5 V and the 7CT1N horizontal deflection factor for 0.5 V/division. Then release the amplifier volts/div variable control and adjust it for a spot separation of 7.8 divisions.

f. Disconnect the Standard Amplitude Calibrator from the 7CT1N.

2. Check/Adjust Vertical Display Amplifier

a. Set the 7CT1N and Oscilloscope System controls as follows:

STEP OFFSET	Pull-switch in
NPN, N CH-	
PNP, P CH	Pushbutton out
XSTR-FET	Pushbutton out

Oscilloscope System

Vertical Mode	Location of 7CT1N
Horizontal Mode	A
Amplifier	
Position	Centered
Polarity	+Up
Coupling	DC
Volts/Div	.1 (Cal)

7CT1N

PLUG-IN COMPARTMENT	VERT
POSITION	Centered
COLLECTOR/ DRAIN VOLTS	Fully counterclockwise
X10	Pushbutton out
.5 V-2 V	Pushbutton out
VERTICAL	50 μ A/DIV
\div 1000	Pushbutton in
STEP AMPL	1 mA/STEP
STEP	Fully counterclockwise

b. Center the spot on the CRT both horizontally and vertically.

c. Switch the VERTICAL switch back and forth between the 50 μ A/DIV and 100 μ A/DIV positions.

d. ADJUST—R194, the VERT AMPL BAL adjustment (see Fig. 3-1), for no vertical shift in spot between the two positions of the VERTICAL switch.

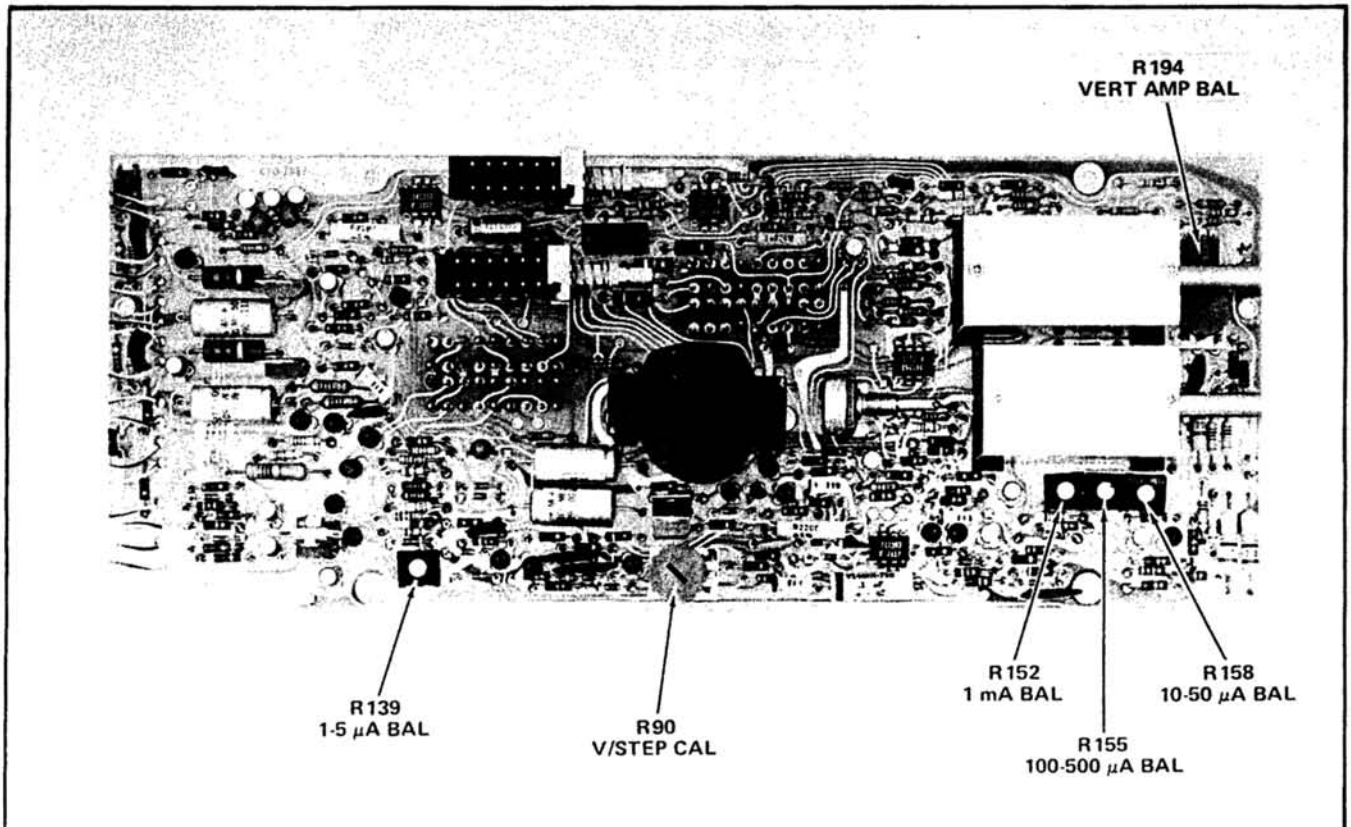


Fig. 3-1. Location of internal adjustments for the 7CT1N.

Performance Check/Adjustment Procedure—7CT1N

e. Turn the COLLECTOR/DRAIN VOLTS control fully clockwise and set the VERTICAL switch to one of the positions shown in Table 3-3. Connect the resistor shown in the table for that switch position between the C or G and the E or S jacks. Position the left end of the trace at the intersection of the second vertical graticule line on the left of the CRT and the second horizontal graticule line from the bottom of the CRT.

TABLE 3-3
Check Vertical Display Amplifier Accuracy

VERTICAL	÷1000	Resistor Value
10 mA/DIV	In	100 Ω
1 mA/DIV	In	1 kΩ
100 μA/DIV	In	10 kΩ
50 μA/DIV	In	20 kΩ
20 μA/DIV	In	50 kΩ
10 μA/DIV	In	100 kΩ
10 μA/DIV	Out	100 kΩ
5 μA/DIV	Out	200 kΩ
500 nA/DIV	Out	2 MΩ
50 nA/DIV	Out	20 MΩ

f. CHECK FOR—Trace slope, 5 divisions ±0.25 division ±1 nA, for 8 divisions (5 volts) of horizontal movement. The top of the trace should intersect the second vertical graticule line from the right and the third horizontal graticule line from the top.

g. Repeat parts e and f for all the non-leakage (÷1000 pushbutton in) positions of the VERTICAL switch.

h. Release the ÷1000 pushbutton and repeat parts e and f for all the leakage positions of the VERTICAL switch. When measuring leakage current, a spot is displayed, rather than a trace. The COLLECTOR/DRAIN VOLTS control must, therefore, be turned counterclockwise until the spot can be positioned onto the intersection of the second vertical and horizontal graticule lines from the left and bottom, respectively. Once the position of the spot has been established, the COLLECTOR/DRAIN VOLTS can be turned clockwise to obtain the current at 5 volts. The spot may be shaped like an X. In such cases, make measurements from the top right of the display.

i. Remove the resistor connected to the device testing jacks.

3. Check Collector-Drain Supply

a. Set the 7CT1N and Oscilloscope System controls as follows:

	7CT1N
POSITION	Centered
COLLECTOR/ DRAIN VOLTS	Fully counterclockwise
X10	Pushbutton out
.5 V-2 V	Pushbutton out
VERTICAL	20 mA/DIV
÷1000	Pushbutton in
STEP AMPL	1 mA/STEP
STEP	Fully counterclockwise
STEP OFFSET	Pull-switch in
NPN, N CH-	
PNP, P CH	Pushbutton out
XSTR-FET	Pushbutton out

Oscilloscope System

Vertical Mode	Location of 7CT1N
Horizontal Mode	A
Amplifier	
Position	Centered
Polarity	+Up
Coupling	DC
Volts/Div	.1 (Cal)

b. Position the spot to the first vertical graticule line on the left. Turn the COLLECTOR/DRAIN VOLTS control clockwise to obtain a trace 10 divisions long, then release the amplifier volts/div variable control and adjust it to reduce the trace length to 5 divisions. (Reposition the left end of the trace to the left of the CRT graticule.) Turn the COLLECTOR/DRAIN VOLTS control fully clockwise.

c. CHECK FOR—Trace length of 7.5 divisions ±1.5 divisions (±20%).

(The display may be offset up to 30 nA vertically when the ÷1000 pushbutton is released. The vertical position control can be used to reposition the trace.)

d. Set the .5 V-2 V and X10 pushbuttons for the other 3 collector-drain supply ranges and repeat part c for each range.

e. Reset the following 7CT1N controls as follows:

COLLECTOR/ DRAIN VOLTS	Fully Counterclockwise
.5 V-2 V	Pushbutton Out
X10	Pushbutton Out

f. Connect a short between the C or G and the E or S jacks. Position the spot to the center of the bottom horizontal graticule line. Turn the COLLECTOR/DRAIN VOLTS control clockwise to obtain a vertical trace of 8 divisions.

g. CHECK FOR—Trace tilt less than 0.2 division horizontally, over total length of trace.

h. Vertically position the top of the trace to the bottom horizontal graticule line and turn the COLLECTOR/DRAIN VOLTS control fully clockwise.

i. CHECK FOR—End of trace on the center horizontal graticule line ± 3.6 divisions ($\pm 30\%$).

j. Set the .5 V-2 V and X10 pushbuttons and the VERTICAL switch as shown in Table 3-4 for the other 3 collector-drain supply ranges. Repeat parts i for each range.

TABLE 3-4

Check Collector-Drain Supply Peak Current

X10 Pushbutton	.5 V-2 V Pushbutton	VERTICAL Switch
Out	In	5 mA/DIV
In	Out	2 mA/DIV
In	In	.5 mA/DIV

k. Turn the COLLECTOR/DRAIN VOLTS control fully counterclockwise, remove the short and reposition the spot to the lower left corner of the CRT graticule. (Reset the amplifier variable control to its calibrated position.) Press the NPN, N CH-PNP, P CH pushbutton.

l. CHECK FOR—Spot moving to the top right corner of the CRT graticule within 0.3 division vertically and horizontally. (The display amplifiers in the oscilloscope mainframe must be properly adjusted to perform this check.)

m. Turn the COLLECTOR/DRAIN VOLTS control fully clockwise.

n. CHECK FOR—Trace extending right to left, indicating that the polarity of the collector-drain supply voltage has been switched to negative.

4. Check/Adjust Base-Gate Step Generator

a. Disconnect the EXT HORIZ OR VERT OUT cable from the amplifier plug-in, remove the amplifier from its horizontal location and install it in the vertical compartment not being used by the 7CT1N. Install the time base plug-in in a horizontal compartment. Set the 7CT1N and Oscilloscope System controls as follows:

7CT1N

PLUG-IN COMPARTMENT POSITION	VERT Fully Clockwise
COLLECTOR/DRAIN VOLTS X10	Fully Counterclockwise Pushbutton Out
.5 V-2 V	Pushbutton Out
VERTICAL $\div 1000$	20 mA/DIV Pushbutton In
STEP AMPL STEPS	5 mV/STEP Fully counterclockwise
STEP OFFSET	Pull-switch In
NPN, N CH-PNP, P CH	Pushbutton In
XSTR-FET	Pushbutton In

Oscilloscope System

Vertical Mode	Chop
Horizontal Mode	Location of Time-Base
Trigger Source	Location of Amplifier
Amplifier Position	Centered
Polarity	+Up
Coupling	Gnd
Volts/Div	5 mV (Cal)
Time Base Display Mode (7B50 or 7B70)	Time Base
Position	Centered
Triggering	Norm, +Slope, Int
Time/Div	5 ms (Cal, X1 Mag)

b. Connect a cable between the C or G jack of the 7CT1N and the external input to the amplifier plug-in.

c. Vertically position the trace to the center horizontal graticule line and release the ground pushbutton on the amplifier.

d. CHECK FOR—Vertical shift in the trace within ± 0.3 division. If noise makes this check difficult, a probe or coaxial cable can be used in place of the patch cord.

e. ADJUST—R139, the 1-5 μA BAL adjustment (see Fig. 3-1), to move the trace to the center horizontal graticule line.

f. Press the ground pushbutton on the amplifier and repeat parts c through e for the other adjustments in Table 3-5. Note that the 7CT1N STEP AMPL switch and the amplifier volts/div switch will have to be changed for each adjustment.

TABLE 3-5
Adjust Zero Step Level

STEP AMPL	Volts/Div	Adjustment
50 mV/STEP	50 mV/Div	R 158 (10-50 μ A BAL)
.5 V/STEP	0.5 V/Div	R 155 (100-500 μ A BAL)
1 V/STEP	1 V/Div	R 152 (1 mA BAL)

g. Turn the 7CT1N STEP control fully clockwise. Trigger the display and position the zero step to the bottom horizontal graticule line.

h. CHECK FOR—Eighth step on the top horizontal graticule line ± 0.4 division (one step per vertical division).

i. ADJUST—R90, the V/STEP CAL adjustment (see Fig. 3-1), so that the eighth step is on the top horizontal graticule line.

j. Set the amplifier volts/div switch to .2 volt/div.

k. CHECK FOR—Step increments of 5 divisions ± 0.15 division for the first three steps. (Additional steps can be checked by using the STEP OFFSET control.)

l. Set the 7CT1N STEP AMPL and amplifier volts/div switch as shown in Table 3-6. For each setting of the STEP AMPL switch, position the zero step on the bottom horizontal graticule line.

m. CHECK FOR—Eighth step on the top horizontal graticule line ± 0.4 division for each setting on the STEP AMPL switch in Table 3-6. Noise received through the unshielded patch cord may cause measurement difficulty for the lower voltage steps. In such cases, replace the patch cord with a shielded cable.

TABLE 3-6
Check Step Amplitude Accuracy

STEP AMPL	Volts/Div
1 mV/STEP	1 mV/Div
2 mV/STEP	2 mV/Div
5 mV/STEP	5 mV/Div
10 mV/STEP	10 mV/Div
20 mV/STEP	20 mV/Div
50 mV/STEP	50 mV/Div
.1 V/STEP	0.1 V/Div
.2 V/STEP	0.2 V/Div
.5 V/STEP	0.5 V/Div

n. Set the 7CT1N STEP AMPL switch to 0.5 volt/step and the amplifier volts/div switch to 1 volt. Vertically center the zero step on the CRT graticule. Pull the 7CT1N STEP OFFSET pull-switch and turn it throughout its range.

o. CHECK FOR—At least 2.5 divisions of offset both above and below the center horizontal graticule line.

p. CHECK FOR—At least 10 steps in the display. (Use STEP OFFSET control to position display to bottom of graticule.)

q. Push in the 7CT1N STEP OFFSET pull-switch and release the NPN, N CH-PNP, P CH pushbutton.

r. CHECK FOR—Negative-going steps (the Oscilloscope System may have to be retriggered).

s. Disconnect the 7CT1N from the input to the amplifier.

This completes the 7CT1N Check/Adjust procedure.

SECTION 4

DIAGRAMS AND PARTS LISTS

Change information, if any, affecting this section will be found at the rear of the manual.

General

The following section contains a complete electrical and mechanical parts lists, a block diagram, a schematic diagram, typical waveforms and a circuit board picture with the electrical components labeled by circuit number.

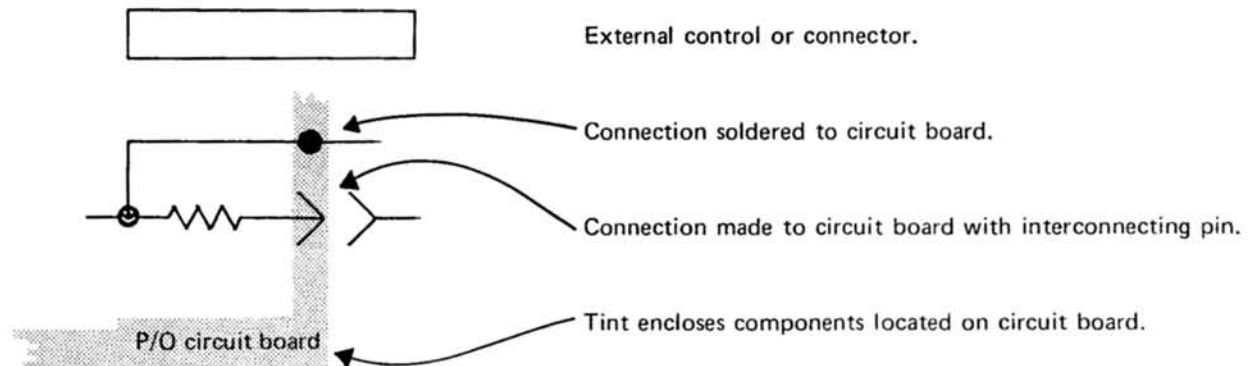
Diagram Symbols

Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors =	Values one or greater are in picofarads (pF). Values less than one are in microfarads (μ F).
Resistors =	Ohms (Ω)

Symbols used on the diagrams are based on USA Standard Y32.2-1967.

The following special symbols are used on the diagrams:



ELECTRICAL PARTS LIST

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

ABBREVIATIONS AND REFERENCE DESIGNATORS

A	Assembly, separable or repairable	FL	Filter	PTM	paper or plastic, tubular molded
AT	Attenuator, fixed or variable	H	Heat dissipating device (heat sink, etc.)	R	Resistor, fixed or variable
B	Motor	HR	Heater	RT	Thermistor
BT	Battery	J	Connector, stationary portion	S	Switch
C	Capacitor, fixed or variable	K	Relay	T	Transformer
Cer	Ceramic	L	Inductor, fixed or variable	TP	Test point
CR	Diode, signal or rectifier	LR	Inductor/resistor combination	U	Assembly, inseparable or non-repairable
CRT	cathode-ray tube	M	Meter	V	Electron tube
DL	Delay line	Q	Transistor or silicon-controlled rectifier	Var	Variable
DS	Indicating device (lamp)	P	Connector, movable portion	VR	Voltage regulator (zener diode, etc.)
Elect.	Electrolytic	PMC	Paper, metal cased	WW	wire-wound
EMC	electrolytic, metal cased	PT	paper, tubular	Y	Crystal
EMT	electrolytic, metal tubular				
F	Fuse				

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
ASSEMBLY				
A1	670-1933-00			MAIN Circuit Board Assembly
CAPACITORS				
C11	285-0683-00			0.022 μ F, PTM, 100 V, 5%
C16	290-0530-00			68 μ F, Elect., 6 V, 20%
C26	281-0525-00			470 pF, Cer, 500 V, 20%
C30	290-0215-00			100 μ F, Elect., 25 V
C32	290-0215-00			100 μ F, Elect., 25 V
C52	290-0480-00			0.5 μ F, Elect., 200 V
C53	290-0480-00			0.5 μ F, Elect., 200 V
C54	290-0528-00			15 μ F, Elect., 50 V, 20%
C84	283-0003-00			0.01 μ F, Cer, 150 V, +80%-20%
C86	283-0092-00			0.03 μ F, Cer, 200 V, +80%-20%
C88	283-0092-00			0.03 μ F, Cer, 200 V, +80%-20%
C94	283-0023-00			0.1 μ F, Cer, 10 V, +80%-20%
C96	285-0683-00			0.022 μ F, PTM, 100 V, 5%
C108	281-0525-00			470 pF, Cer, 500 V, 20%
C111	283-0092-00			0.03 μ F, Cer, 200 V, +80%-20%
C113	281-0518-00			47 pF, Cer, 500 V, 20%
C114	285-0703-00			0.1 μ F, PTM, 100 V, 5%
C179	283-0203-00			0.47 μ F, Cer, 50 V, 20%
C197	283-0203-00			0.47 μ F, Cer, 50 V, 20%
C214	290-0522-00			1 μ F, Elect., 50 V, 20%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)				
C227	290-0530-00			68 μ F, Elect., 6 V, 20%
C229	290-0530-00			68 μ F, Elect., 6 V, 20%
C248	283-0003-00			0.01 μ F, Cer, 150 V, +80%-20%
C252	281-0525-00			470 pF, Cer, 500 V, 20%
C266	283-0003-00			0.01 μ F, Cer, 150 V, +80%-20%
C274	283-0004-00			0.02 μ F, Cer, 150 V
C275	290-0117-00			50 μ F, Elect., 50 V
C279	283-0010-00			0.05 μ F, Cer, 50 V
C281	283-0010-00			0.05 μ F, Cer, 50 V
C284	283-0004-00			0.02 μ F, Cer, 150 V
C285	290-0117-00			50 μ F, Elect., 50 V
SCD, DIODES				
CR1	152-0141-02			Silicon, replaceable by 1N4152
CR12	152-0141-02			Silicon, replaceable by 1N4152
CR28	152-0141-02			Silicon, replaceable by 1N4152
CR52	152-0488-00			Silicon, rectifier bridge, 1.5 A
CR80	152-0141-02			Silicon, replaceable by 1N4152
CR81	152-0141-02			Silicon, replaceable by 1N4152
CR86	152-0141-02			Silicon, replaceable by 1N4152
CR88	152-0141-02			Silicon, replaceable by 1N4152
CR96	152-0141-02			Silicon, replaceable by 1N4152
CR97	152-0141-02			Silicon, replaceable by 1N4152
CR105	152-0141-02			Silicon, replaceable by 1N4152
CR111	152-0141-02			Silicon, replaceable by 1N4152
CR131	152-0141-02			Silicon, replaceable by 1N4152
CR132	152-0141-02			Silicon, replaceable by 1N4152
CR138	152-0141-02			Silicon, replaceable by 1N4152
CR191	152-0246-00			Silicon, replaceable by CD12676 or FD3375
CR192	152-0246-00			Silicon, replaceable by CD12676 or FD3375
CR201	152-0141-02			Silicon, replaceable by 1N4152
CR202	152-0141-02			Silicon, replaceable by 1N4152
CR214	152-0107-00			Silicon, replaceable by TI60 or 1N647
CR224	152-0141-02			Silicon, replaceable by 1N4152
VR142	152-0243-00			Zener, replaceable by 1N965B, 0.4 W, 15 V, 5%
VR143	152-0243-00			Zener, replaceable by 1N965B, 0.4 W, 15 V, 5%
BULBS				
DS150	150-0048-01			Incandescent, #683, selected
DS170	150-0048-01			Incandescent, #683, selected
DS228	150-0048-01			Incandescent, #683, selected

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
TRANSISTORS				
Q2	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q4	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q8	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q22	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q24	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q26	151-0347-00			Silicon, NPN, replaceable by 2N5551
Q28	151-0347-00			Silicon, NPN, replaceable by 2N5551
Q30	151-0365-00			Silicon, NPN, replaceable by D42C8
Q32	151-0364-00			Silicon, PNP, replaceable by D43C8
Q70A, B	151-1054-00			Silicon, FET, replaceable by FD1644, dual
Q82	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q84	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q92	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q104	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q108	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q114	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q124	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q126	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q132	151-0254-00			Silicon, NPN, replaceable by 2N5308
Q136	151-0254-00			Silicon, NPN, replaceable by 2N5308
Q138	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q142	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q144	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q146	151-0364-00			Silicon, PNP, replaceable by D43C8
Q148	151-0365-00			Silicon, NPN, replaceable by D42C8
Q204	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q208	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q210	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q212	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q224	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q226	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q228	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q252	151-0192-00			Silicon, NPN, selected from MPS6521
Q262	151-0192-00			Silicon, NPN, selected from MPS6521
Q274	151-0365-00			Silicon, NPN, replaceable by D42C8
Q276	151-0302-00			Silicon, NPN, replaceable by 2N222A
Q284	151-0364-00			Silicon, PNP, replaceable by D43C8
Q286	151-0342-00			Silicon, PNP, replaceable by 2N4249
RESISTORS				
R1	315-0303-00			30 k Ω , 1/4 W, 5%
R2	315-0623-00			62 k Ω , 1/4 W, 5%
R3	315-0912-00			9.1 k Ω , 1/4 W, 5%
R6	315-0391-00			390 Ω , 1/4 W, 5%
R7	315-0822-00			8.2 k Ω , 1/4 W, 5%
R8	315-0391-00			390 Ω , 1/4 W, 5%
R9	315-0303-00			30 k Ω , 1/4 W, 5%
R11	321-0481-00			1 M Ω , 1/8 W, 1%
R12	315-0103-00			10 k Ω , 1/4 W, 5%
R20	311-1220-00			20 k Ω , Var

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
RESISTORS (cont)				
R21	315-0512-00			5.1 k Ω , 1/4 W, 5%
R22	315-0512-00			5.1 k Ω , 1/4 W, 5%
R23	316-0222-00			2.2 k Ω , 1/4 W, 10%
R24	316-0562-00			5.6 k Ω , 1/4 W, 10%
R25	315-0471-00			470 Ω , 1/4 W, 5%
R26	315-0303-00			30 k Ω , 1/4 W, 5%
R28	316-0102-00			1 k Ω , 1/4 W, 10%
R30	315-0241-00			240 Ω , 1/4 W, 5%
R32	315-0241-00			240 Ω , 1/4 W, 5%
R33	316-0473-00			47 k Ω , 1/4 W, 10%
R39	316-0270-00			27 Ω , 1/4 W, 10%
R41	301-0393-00			39 k Ω , 1/2 W, 5%
R42	301-0222-00			2.2 k Ω , 1/2 W, 5%
R43	301-0241-00			240 Ω , 1/2 W, 5%
R44	307-0023-00			4.7 Ω , 1/2 W, 10%
R56	315-0912-00			9.1 k Ω , 1/4 W, 5%
R57	316-0222-00			2.2 k Ω , 1/4 W, 10%
R61	321-1330-02			27.1 k Ω , 1/8 W, 1/2%
R62	321-0386-00			102 k Ω , 1/8 W, 1%
R63	322-0684-09			1.024 M Ω , 1/4 W, 1/2%
R64	321-0432-00			309 k Ω , 1/8 W, 1%
R68	315-0434-00			430 k Ω , 1/4 W, 5%
R69	321-0272-00			6.65 k Ω , 1/8 W, 1%
R71	321-0360-00			54.9 k Ω , 1/8 W, 1%
R72	321-0355-00			48.7 k Ω , 1/8 W, 1%
R74	321-0360-00			54.9 k Ω , 1/8 W, 1%
R75	321-0355-00			48.7 k Ω , 1/8 W, 1%
R76	321-0358-00			52.3 k Ω , 1/8 W, 1%
R77	321-0358-00			52.3 k Ω , 1/8 W, 1%
R81	316-0562-00			5.6 k Ω , 1/4 W, 10%
R82	316-0222-00			2.2 k Ω , 1/4 W, 10%
R83	315-0243-00			24 k Ω , 1/4 W, 5%
R84	316-0222-00			2.2 k Ω , 1/4 W, 10%
R86	315-0103-00			10 k Ω , 1/4 W, 5%
R88	315-0103-00			10 k Ω , 1/4 W, 5%
R90	311-1154-00			1 k Ω , Var
R91	316-0332-00	B010100	B010199	3.3 k Ω , 1/4 W, 10%
R91	315-0202-00	B010200		2 k Ω , 1/4 W, 5%
R92	316-0102-00			1 k Ω , 1/4 W, 10%
R94	316-0101-00			100 Ω , 1/4 W, 10%
R100	311-1220-00			20 k Ω , Var
R101	321-0374-00			76.8 k Ω , 1/8 W, 1%
R102	321-0319-00			20.5 k Ω , 1/8 W, 1%
R104	315-0103-00			10 k Ω , 1/4 W, 5%
R105	315-0243-00			24 k Ω , 1/4 W, 5%
R107	316-0562-00			5.6 k Ω , 1/4 W, 10%
R108	316-0222-00			2.2 k Ω , 1/4 W, 10%
R109	316-0104-00			100 k Ω , 1/4 W, 10%
R111	316-0473-00			47 k Ω , 1/4 W, 10%
R112	316-0335-00			3.3 M Ω , 1/4 W, 10%
R114	321-0289-00			10 k Ω , 1/8 W, 1%
R116	321-0272-00			6.65 k Ω , 1/8 W, 1%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
RESISTORS (cont)				
R120	311-1310-00			20 k Ω , Var
R121	315-0103-00			10 k Ω , 1/4 W, 5%
R122	315-0203-00			20 k Ω , 1/4 W, 5%
R123	315-0103-00			10 k Ω , 1/4 W, 5%
R124	315-0223-00			22 k Ω , 1/4 W, 5%
R125	315-0563-00			56 k Ω , 1/4 W, 5%
R126	315-0363-00			36 k Ω , 1/4 W, 5%
R127	315-0203-00			20 k Ω , 1/4 W, 5%
R132	321-0285-00			9.09 k Ω , 1/8 W, 1%
R133	321-0273-00			6.81 k Ω , 1/8 W, 1%
R136	315-0103-00			10 k Ω , 1/4 W, 5%
R137	321-0273-00			6.81 k Ω , 1/8 W, 1%
R138	321-0255-00			4.42 k Ω , 1/8 W, 1%
R139	311-1223-00			250 Ω , Var
R141	321-0291-00			10.5 k Ω , 1/8 W, 1%
R142	321-0264-00			5.49 k Ω , 1/8 W, 1%
R151	323-0192-00			976 Ω , 1/2 W, 1%
R152	311-1221-00			50 Ω , Var
R154	323-0192-00			976 Ω , 1/2 W, 1%
R155	311-1221-00			50 Ω , Var
R157	321-0288-00			9.76 k Ω , 1/8 W, 1%
R158	311-1224-00			500 Ω , Var
R159	321-0645-00			100 k Ω , 1/8 W, 1/2%
R161	323-0193-01			1 k Ω , 1/2 W, 1/2%
R163	323-0193-01			1 k Ω , 1/2 W, 1/2%
R165	321-0289-01			10 k Ω , 1/8 W, 1/2%
R167	321-0645-00			100 k Ω , 1/8 W, 1/2%
R169	321-0193-00			1 k Ω , 1/8 W, 1%
R171	321-0387-00			105 k Ω , 1/8 W, 1%
R172	321-0442-00			392 k Ω , 1/8 W, 1%
R173	321-0360-00			54.9 k Ω , 1/8 W, 1%
R174	315-0621-00			620 Ω , 1/4 W, 5%
R176	321-0264-00			5.49 k Ω , 1/8 W, 1%
R177	315-0620-00			62 Ω , 1/4 W, 5%
R179	321-0164-00			499 Ω , 1/8 W, 1%
R181	321-0005-00			11 Ω , 1/8 W, 1%
R182	321-0005-00			11 Ω , 1/8 W, 1%
R183	321-0750-06			55.5 Ω , 1/8 W, 1/4%
R184	321-0749-06			450 Ω , 1/8 W, 1/4%
R187	321-0068-03			49.9 Ω , 1/8 W, 1/4%
R193	321-0765-01			969 Ω , 1/8 W, 1/2%
R194	311-1153-00			5 k Ω , Var
R195	321-0285-00			9.09 k Ω , 1/8 W, 1%
R196	321-0276-00			7.32 k Ω , 1/8 W, 1%
R197	321-0207-00			1.4 k Ω , 1/8 W, 1%
R201	315-0302-00			3 k Ω , 1/4 W, 5%
R202	315-0243-00			24 k Ω , 1/4 W, 5%
R203	315-0472-00			4.7 k Ω , 1/4 W, 5%
R204	315-0203-00			20 k Ω , 1/4 W, 5%
R207	315-0152-00			1.5 k Ω , 1/4 W, 5%

ELECTRICAL PARTS LIST (cont)

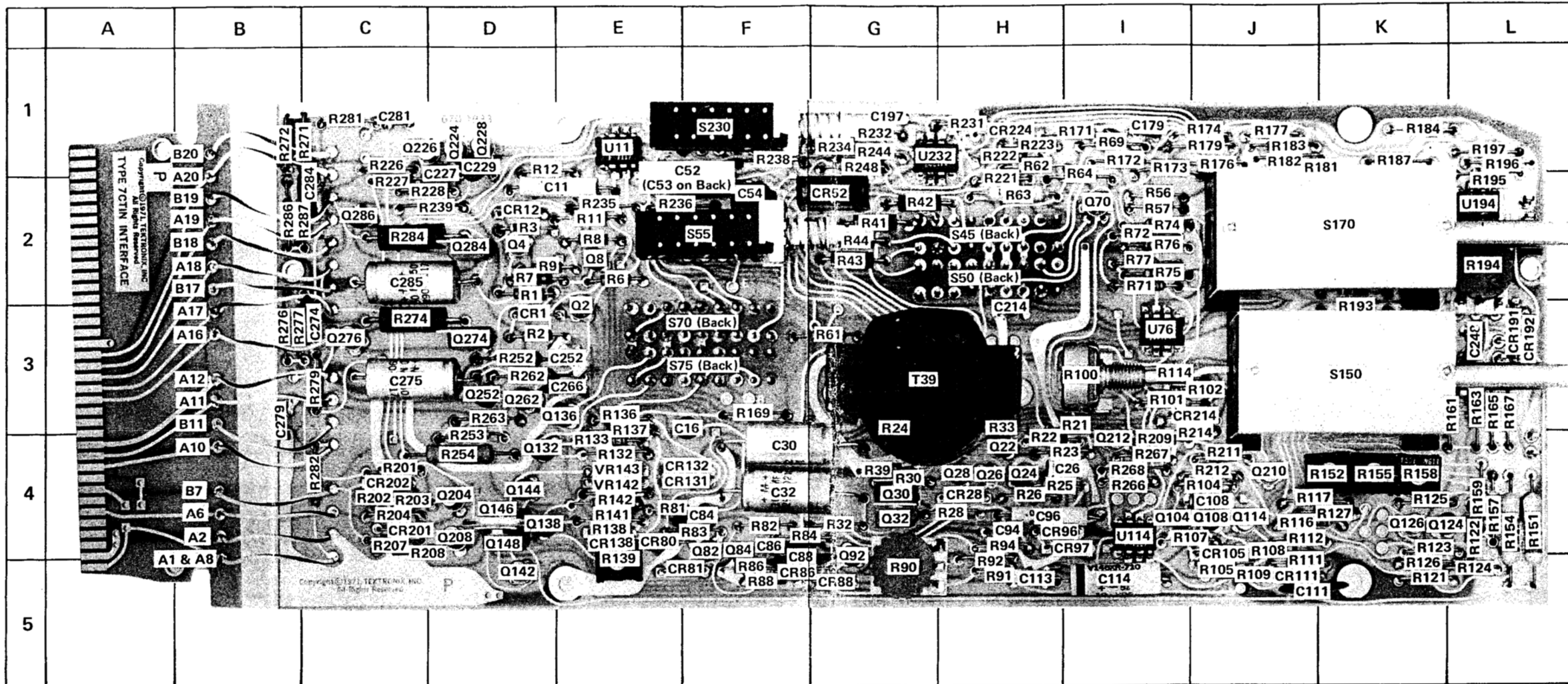
Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R208	316-0102-00			1 k Ω , 1/4 W, 10%
R209	315-0753-00			75 k Ω , 1/4 W, 5%
R211	315-0132-00			1.3 k Ω , 1/4 W, 5%
R212	315-0273-00			27 k Ω , 1/4 W, 5%
R214	315-0184-00			180 k Ω , 1/4 W, 5%
R221	316-0473-00			47 k Ω , 1/4 W, 10%
R222	315-0154-00			150 k Ω , 1/4 W, 5%
R223	315-0563-00			56 k Ω , 1/4 W, 5%
R226	316-0473-00			47 k Ω , 1/4 W, 10%
R227	316-0222-00			2.2 k Ω , 1/4 W, 10%
R228	316-0473-00			47 k Ω , 1/4 W, 10%
R231	321-0638-00			7.96 k Ω , 1/8 W, 1%
R232	321-0307-00			15.4 k Ω , 1/8 W, 1%
R234	321-0765-01			969 Ω , 1/8 W, 1/2%
R235	321-0405-00			162 k Ω , 1/8 W, 1%
R236	321-0420-00			232 k Ω , 1/8 W, 1%
R238	321-0720-01			60.0 k Ω , 1/8 W, 1/2%
R239	321-0308-00			15.8 k Ω , 1/8 W, 1%
R244	321-0765-01			969 Ω , 1/8 W, 1/2%
R248	321-0720-01			60.0 k Ω , 1/8 W, 1/2%
R252	322-0603-00			2.51 k Ω , 1/4 W, 1%
R253	321-0090-00			84.5 k Ω , 1/8 W, 1%
R254	323-0188-00			887 Ω , 1/2 W, 1%
R262	322-0603-00			2.51 k Ω , 1/4 W, 1%
R263	321-0089-00			82.5 Ω , 1/8 W, 1%
R265	311-1220-00			20 k Ω , Var
R266	315-0303-00			30 k Ω , 1/4 W, 5%
R267	315-0302-00			3 k Ω , 1/4 W, 5%
R268	321-0354-00			47.5 k Ω , 1/8 W, 1%
R271	315-0510-00			51 Ω , 1/4 W, 5%
R272	315-0510-00			51 Ω , 1/4 W, 5%
R274	304-0181-00			180 Ω , 1 W, 10%
R276	321-0267-00			5.9 k Ω , 1/8 W, 1%
R277	321-0289-00			10 k Ω , 1/8 W, 1%
R279	315-0100-00			10 Ω , 1/4 W, 5%
R281	315-0100-00			10 Ω , 1/4 W, 5%
R282	315-0470-00			47 Ω , 1/4 W, 5%
R284	304-0181-00			180 Ω , 1 W, 10%
R286	321-0267-00			5.9 k Ω , 1/8 W, 1%
R287	321-0289-00			10 k Ω , 1/8 W, 1%
SWITCHES				
S45				2 V
S50	260-1356-00			Pushbutton, X 10
S55	260-1209-00			Push-push, \div 1000
S70				PNP, P CH
S75	260-1356-00			Pushbutton, FET
S120 ¹				PULL ON
S150	105-0308-00			Cam, STEP AMPL
S170	105-0307-00			Cam, VERTICAL AMPERES/DIV
S230	260-1209-00			Pushbutton, VERT/HORIZ

¹Furnished as a unit with R120.

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
TRANSFORMER				
T39	120-0756-00			Collector Sweep
INTEGRATED CIRCUITS				
U11	156-0067-00			Operational amplifier, replaceable by UA741C
U76	156-0067-00			Operational amplifier, replaceable by UA741C
U114	156-0067-00			Operational amplifier, replaceable by UA741C
U194	156-0200-00			Single operational amplifier, replaceable by N5556V
U232	156-0067-00			Operational amplifier, replaceable by UA741C

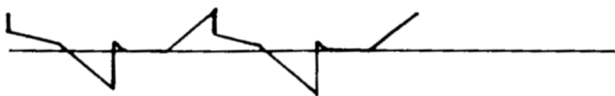
MAIN CIRCUIT BOARD LOCATION GRID



CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC
C11	E2	C274	C3	CR1	D3	Q2	E3	Q204	D4	R1	D2	R57	I2	R104	J4	R151	L4	R194	L2
C16	F3	C275	C3	CR12	D2	Q4	D2	Q208	D4	R2	D3	R61	G3	R105	J5	R152	K4	R195	L2
C26	I4	C279	B3	CR28	H4	Q8	E2	Q210	J4	R3	D2	R62	H1	R107	J4	R154	L4	R196	L1
C30	F4	C281	C1	CR52	G2	Q22	H4	Q212	I4	R6	E2	R63	H2	R108	J4	R155	K4	R197	L1
C32	F4	C284	C2	CR80	E4	Q24	H4	Q224	D1	R7	D2	R64	I2	R109	J5	R157	L4	R201	C4
C52	F2	C285	C2	CR81	F5	Q26	H4	Q226	C1	R8	E2	R69	I1	R111	J5	R158	K4	R202	C4
C53	F2			CR86	F5	Q28	H4	Q228	D1	R9	D2	R71	I2	R112	J4	R159	L4	R203	C4
C54	F2			CR88	G5	Q30	G4	Q252	D3	R11	E2	R72	I2	R114	I3	R161	L3	R204	C4
C84	F4			CR96	H4	Q32	G4	Q262	D3	R12	D2	R74	I2	R116	J4	R163	L3	R207	C4
C86	F4			CR97	I4	Q70A,B	I2	Q274	D3	R21	I3	R75	I2	R117	J4	R165	L3	R208	C4
C88	F5			CR105	J4	Q82	F4	Q276	C3	R22	H4	R76	I2	R121	K5	R167	L3	R209	I4
C94	H4			CR111	J5	Q84	F4	Q284	D2	R23	H4	R77	I2	R122	L4	R169	F3	R211	J4
C96	H4			CR131	F4	Q92	G4	Q286	C2	R24	G3	R81	E4	R123	K4	R171	I1	R212	J4
C108	J4			CR132	F4	Q104	I4			R25	H4	R82	F4	R124	L5	R172	I1	R214	J3
C111	J5			CR138	E4	Q108	J4			R26	H4	R83	F4	R125	K4	R173	I1	R221	H2
C113	H5			CR191	L3	Q114	J4			R28	H4	R84	F4	R126	K5	R174	J1	R222	H1
C114	I5			CR192	L3	Q124	L4			R30	G4	R86	F5	R127	K4	R176	J1	R223	H1
C179	I1			CR201	C4	Q126	K4			R32	G4	R88	F5	R132	E4	R177	J1	R226	C1
C197	G1			CR202	C4	Q132	D4			R33	H3	R90	G5	R133	E4	R179	J1	R227	C2
C214	H3			CR214	J3	Q136	E3			R39	G4	R91	H5	R136	E3	R181	J1	R228	D2
C227	D2			CR224	H1	Q138	D4			R41	G2	R92	H5	R137	E3	R182	J1	R231	H1
C229	D1			VR142	E4	Q142	D5			R42	G2	R94	H4	R138	E4	R183	J1	R232	G1
C248	L3			VR143	E4	Q144	D4			R43	G2	R100	I3	R139	E4	R184	K1	R234	G1
C252	E3					Q146	D4			R44	G2	R101	I3	R141	E4	R187	K1	R235	E2
C266	E3					Q148	D4			R56	I2	R102	J3	R142	E4	R193	K3	R236	E2

7CT1N

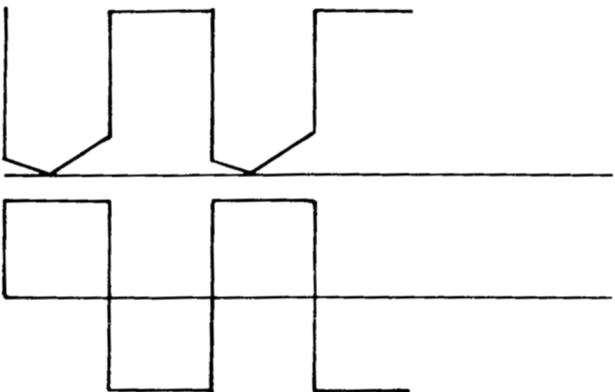
Base
of Q4



Emitter
of Q4



Junction
of
R8 and R9



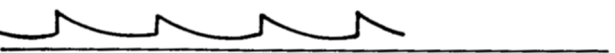
Pin 6
of U11



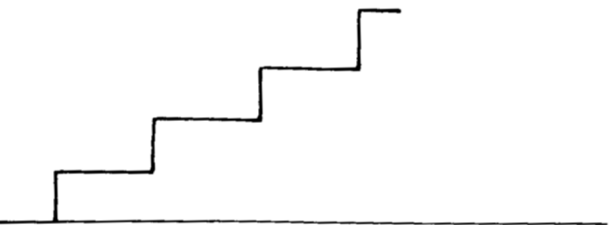
Base
of Q92



Junction
of C96
and CR97



Pin 6
of U114



MECHANICAL PARTS LIST

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

ABBREVIATIONS

BHB	binding head brass	h	height or high	OHB	oval head brass
BHS	binding head steel	hex.	hexagonal	OHS	oval head steel
CRT	cathode-ray tube	HHB	hex head brass	PHB	pan head brass
csk	countersunk	HHS	hex head steel	PHS	pan head steel
DE	double end	HSB	hex socket brass	RHS	round head steel
FHB	flat head brass	HSS	hex socket steel	SE	single end
FHS	flat head steel	ID	inside diameter	THB	truss head brass
Fil HB	fillister head brass	lg	length or long	THS	truss head steel
Fil HS	fillister head steel	OD	outside diameter	w	wide or width

FIGURE 1 EXPLODED

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
1-1	337-1064-04			2	SHIELD, electrical, side
-2	366-0494-00			1	KNOB, charcoal--STEP
	-----			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-3	366-1376-00			1	KNOB, charcoal--STEP AMPL
	-----			-	knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-4	366-1382-00			1	KNOB, gray--RELEASE TO $\frac{1}{1000}$
	-----			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-5	366-1375-00			1	KNOB, charcoal--VERTICAL
	-----			-	knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-6	366-0494-00			1	KNOB, charcoal--POSTITION
	-----			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-7	366-0494-00			1	KNOB, charcoal--COLLECTOR/DRAIN VOLTS
	-----			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-8	366-0494-02			1	KNOB, charcoal--STEP OFFSET
	-----			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-9	366-1058-38			1	KNOB, latch
	-----			-	mounting hardware: (not included w/knob)
-10	214-1095-00			1	PIN, spring, split
-11	105-0076-00			1	RELEASE BAR, latch
-12	214-1280-00			1	SPRING, helical compression
-13	214-1054-00			1	SPRING, latch detent
-14	105-0075-00			1	BODY, latch, plastic
-15	366-1257-95			1	PUSHBUTTON--VERT
-16	366-1257-88			1	PUSHBUTTON--2 V
-17	366-1257-87			1	PUSHBUTTON--X 10
-18	366-1257-76			1	PUSHBUTTON--PNP Pch (-)
-19	366-1257-86			1	PUSHBUTTON--FET
-20	426-0681-00			5	FRAME, pushbutton

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q t y	Description				
				1	2	3	4	5
-21	195-0095-00		1	LEAD, test, BNC				
-22	348-0301-00		1	GROMMET, plastic, 0.312 ID x 0.43 inch OD				
-23	343-0144-00		1	CLAMP, cable, plastic, 0.125 inch diameter				
	- - - - -		-	mounting hardware: (not included w/clamp)				
-24	211-0121-00		1	SCREW, sems, 4-40 x 0.438 inch, PHB				
-25	129-0064-00		3	POST, binding				
	- - - - -		-	mounting hardware for each: (not included w/post)				
-26	210-0457-00		1	NUT, keps, 6-32 x 0.312 inch				
-27	358-0181-00		1	BUSHING, plastic				
-28	358-0029-00		2	BUSHING, 0.375-32 x 0.50 inch				
	- - - - -		-	mounting hardware for each: (not included w/bushing)				
-29	210-0590-00		1	NUT, hex., 0.375-32 x 0.438 inch				
-30	210-0978-00		1	WASHER, flat, 0.375 ID x 0.50 inch OD				
-31	210-0012-00		1	WASHER, lock, internal, 0.384 ID x 0.50 inch OD				
-32	- - - - -		2	RESISTOR, variable (R20 & R265 see electrical list)				
	- - - - -		-	mounting hardware for each: (not included w/resistor)				
-33	210-0583-00		1	NUT, hex., 0.25-32 x 0.312 inch				
-34	210-0940-00		1	WASHER, flat, 0.25 ID x 0.375 inch OD				
-35	- - - - -		1	RESISTOR, variable (R120, S120 see electrical list)				
	- - - - -		-	mounting hardware: (not included w/resistor)				
-36	210-0583-00		1	NUT, hex., 0.25-32 x 0.312 inch				
-37	210-0940-00		1	WASHER, flat, 0.25 ID x 0.375 inch OD				
-38	333-1553-00		1	PANEL, front				
-39	348-0235-00		2	SHIELDING GASKET				
-40	200-0935-00		3	COVER, lampholder				
-41	331-0262-00		2	DIFFUSOR, light				
-42	378-0635-00		2	LENS, indicator light				
-43	378-0602-02		1	LENS, indicator light				
-44	352-0157-01		1	LAMPHOLDER				
-45	352-0157-00		2	LAMPHOLDER				
-46	386-1447-62		1	SUBPANEL, front				
	- - - - -		-	mounting hardware: (not included w/subpanel)				
-47	213-0192-00		4	SCREW, thread forming, 6-32 x 0.50 inch, Fil HS				
-48	384-1059-00		3	SHAFT, extension, 7 inches long				
-49	384-1061-00		2	SHAFT, extension, 4.375 inches long				
-50	384-0496-00		1	SHAFT, extension, 4.85 inches long				

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q					Description	
		Eff	Disc	f	y	1	2	3		4
1-51	376-0051-00			1						1 COUPLING, flexible
	---			-						coupling includes:
	213-0022-00			4						4 SETSCREW, 4-40 x 0.188 inch, HSS
	376-0049-00			1						1 COUPLING, plastic
	354-0251-00			2						2 RING, coupling
-52	384-1125-00			1						1 SHAFT, pushbutton
-53	103-0161-00			1						1 ADAPTER, pushbutton to coupler
-54	386-1402-00			1						1 PANEL, rear
	---			-						mounting hardware: (not included w/panel)
-55	213-0192-00			4						4 SCREW, thread forming, 6-32 x 0.50 inch, Fil HS
-56	388-2485-00			1						1 CIRCUIT BOARD--INTERFACE
-57	---			1						1 CIRCUIT BOARD ASSEMBLY--MAIN (A1 see electrical list)
	---			-						circuit board assembly includes:
	388-2486-00			1						1 CIRCUIT BOARD
-58	131-0604-00			22						22 CONTACT, electrical, cam switch
-59	136-0252-04			93						93 SOCKET, pin connector
-60	214-0579-00			6						6 PIN, test point
-61	260-1209-00			1						1 SWITCH, push--VERT/HORIZ (S230)
-62	260-1209-00			1						1 SWITCH, push-- $\frac{1}{2}$ 1000 (S55)
-63	361-0383-00			4						4 SPACER, switch, gray
-64	260-1356-00			1						1 SWITCH, push--X 10 (S50) 2 V (S45)
-65	260-1356-00			1						1 SWITCH, push--PNP PCH - (S70) FET (S75)
-66	361-0385-00			8						8 SPACER, switch, green
-67	376-0029-00			1						1 COUPLING, shaft
	---			-						coupling includes:
	213-0075-00			2						2 SETSCREW, 4-40 x 0.094 inch, HSS
-68	---			1						1 RESISTOR, variable (R100 see electrical list)
-69	211-0008-00			1						1 SCREW, 4-40 x 0.25 inch, PHS
-70	210-1061-00			1						1 WASHER, flat, 0.203 ID x 0.625 inch OD
-71	210-0586-00			1						1 NUT, keps, 4-40 x 0.25 inch
	105-0307-00			1						1 ACTUATOR ASSEMBLY, cam switch--VERTICAL (s170)
	---			-						actuator assembly includes:
-72	200-1193-00			1						1 COVER, cam switch
	---			-						mounting hardware: (not included w/cover)
-73	211-0022-00			2						2 SCREW, 2-56 x 0.188 inch, RHS
-74	210-0001-00			2						2 WASHER, lock, internal, 0.092 ID x 0.18 inch OD
-75	210-0405-00			2						2 NUT, hex., 2-56 x 0.188 inch
-76	354-0219-00			1						1 RING, retaining
-77	401-0057-00			1						1 BEARING, front, w/bushing
-78	214-1127-00			1						1 ROLLER, detent
-79	214-1139-00 ¹			-						SPRING, flat, gold
	214-1139-02 ¹			-						SPRING, flat, green
	214-1139-03 ¹			-						SPRING, flat, red
-80	401-0056-00			1						1 BEARING, rear
-81	105-0306-00			1						1 DRUM ASSEMBLY
-82	210-0406-00			4						4 NUT, hex., 4-40 x 0.188 inch
	---			-						mounting hardware: (not included w/actuator assembly)
	211-0116-00			3						3 SCREW, sems, 4-40 x 0.312 inch, PHB

¹Replace only with part bearing the same color code as the original part in your instrument.

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	1 2 3 4 5	Description
		Eff	Disc			
1-	105-0308-00			1		ACTUATOR ASSEMBLY, cam switch--STEP AMPL (S150)
-83	200-1010-00			1		actuator assembly COVER, cam switch mounting hardware: (not included w/cover)
-84	211-0022-00			2		SCREW, 2-56 x 0.188 inch, RHS
-85	210-0001-00			2		WASHER, lock, internal, 0.092 ID x 0.18 inch OD
-86	210-0405-00			2		NUT, hex., 2-56 x 0.188 inch
	354-0219-00			1		RING, retaining
-87	401-0057-00			1		BEARING, front, w/bushing
-88	214-1127-00			1		ROLLER, detent
-89	214-1139-00 ¹			-		SPRING, flat, gold
	214-1139-02 ¹			-		SPRING, flat, green
	214-1139-03 ¹			-		SPRING, flat, red
-90	401-0056-00			1		BEARING, rear
-91	105-0305-00			1		DRUM ASSEMBLY
-92	210-0406-00			4		NUT, hex., 4-40 x 0.188 inch mounting hardware: (not included w/actuator assembly)
-93	211-0116-00			4		SCREW, sems, 4-40 x 0.312 inch, PHB mounting hardware: (not included w/circuit board assembly)
-94	213-0146-00			4		SCREW, thread forming, 6-20 x 0.312 inch, PHS
-95	426-0499-14			1		FRAME SECTION, bottom
-96	426-0505-14			1		FRAME SECTION, top
-97	175-0826-00			ft		WIRE, electrical, 3 wire ribbon, 14 inches long
-98	175-0828-00			ft		WIRE, electrical, 5 wire ribbon, 4 inches long
-99	361-0326-00			1		SPACER, sleeve
-100	214-1061-00			1		SPRING, flat, sliding ground

CARTON ASSEMBLY
(Part No. 065-0125-00)

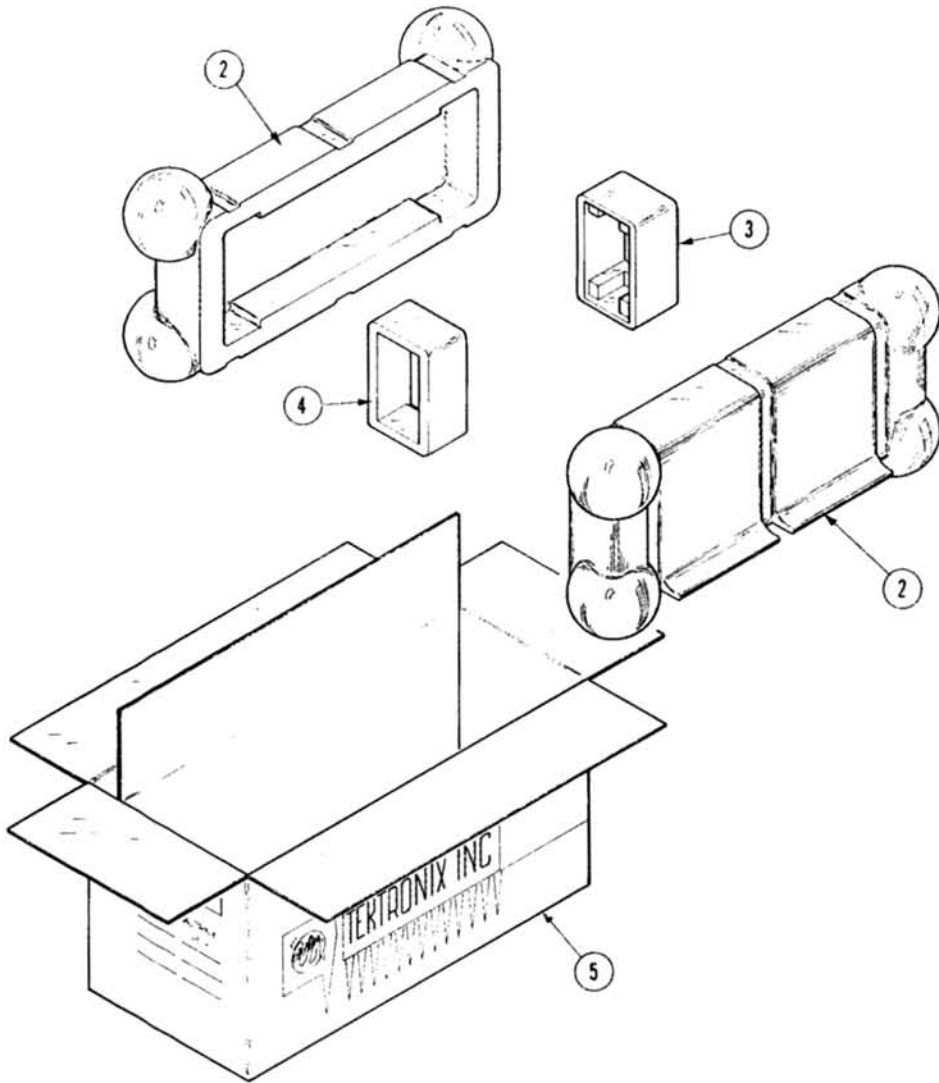


Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	1	2	3	4	5	Description
		Eff	Disc							
2-	065-0125-00			1						CARTON ASSEMBLY
	-----			-						carton assembly includes:
-2	004-0241-00			2						CASE HALF
-3	004-0242-00			1						END CAP, rear
-4	004-0243-00			1						END CAP, front
-5	004-0748-00			1						CARTON

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

**TEKTRONIX®**committed to
technical excellence**MANUAL CHANGE INFORMATION**PRODUCT 7CT1N
EFF SN B050000-upCHANGE REFERENCE M21,683
DATE 4-3-74**CHANGE:****DESCRIPTION**

ELECTRICAL PARTS LIST AND SCHEMATIC CHANGE

CHANGE TO:

A1 670-1933-01 MAIN Circuit Board Assembly

ADD:

C12 283-0003-00 0.01 μ F, Cer, 150 V, +80%-20%C112 283-0003-00 0.01 μ F, Cer, 150 V, +80%-20%C212 283-0003-00 0.01 μ F, Cer, 150 V, +80%-20%

(C12, C112, C212 are added across pins 4 and 7 of U11, U114 and U194
respectively on the Main circuit board.)