INSTRUCTION MANUAL

P6045
PROBE

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Abbreviations and symbols used in this manual are based on, or taken directly from, IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

SECTION 1
CHARACTERISTICS

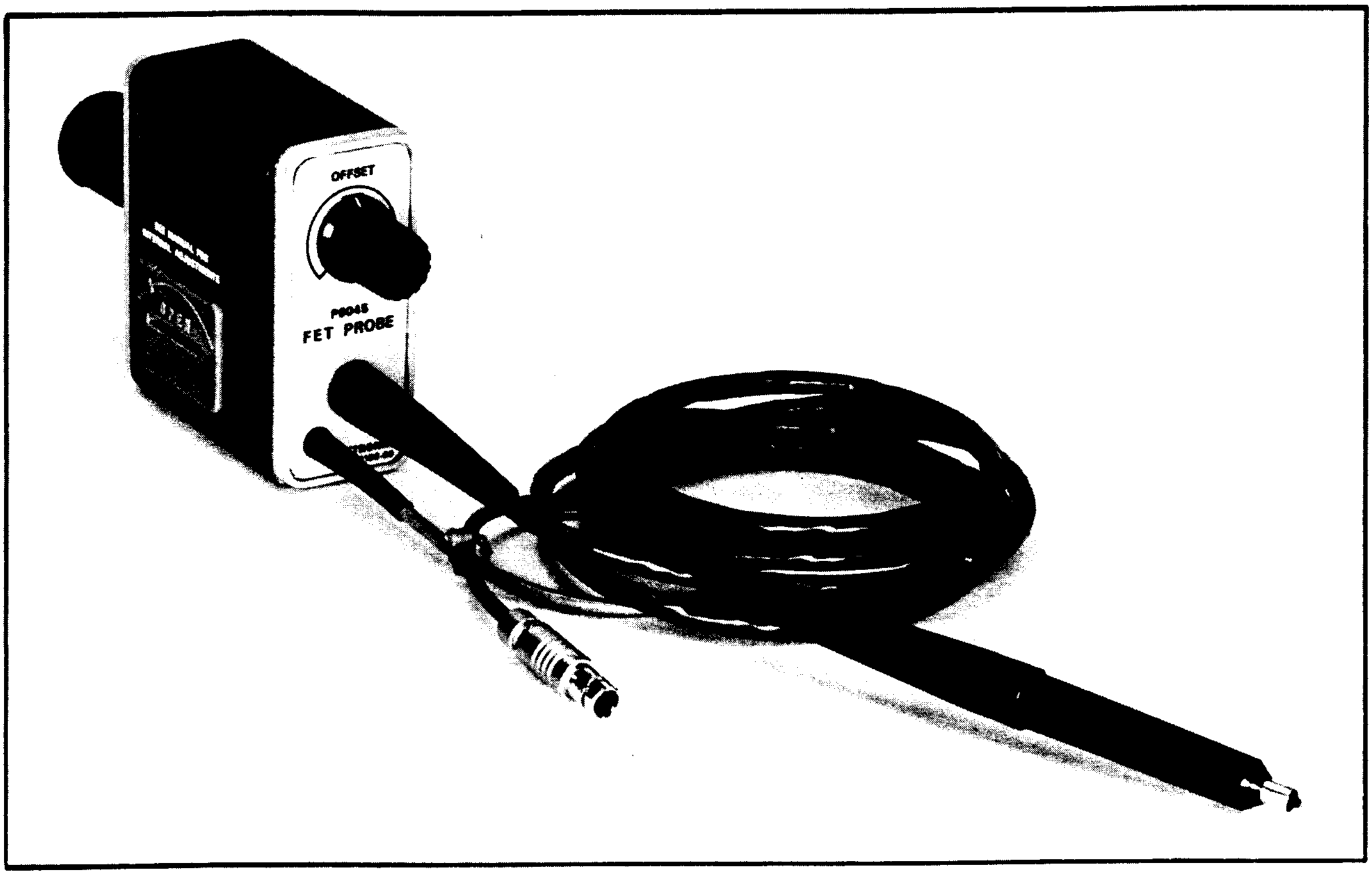


Fig. 1-1. The P6045 FET Probe.

General Information

The Tektronix P6045 Probe is a high gain-bandwidth low-capacitance 1× probe designed for use with oscilloscope systems having either high-impedance inputs or 50-ohm inputs. The probe itself has a high input impedance achieved by means of a field-effect transistor built into the probe tip, followed by amplifier and DC offset circuits. Overall bandwidth is from DC to approximately 230 megahertz.

Operation of the P6045 requires the use of a separate power source. Correct operating voltages for the P6045 are provided by the Tektronix 015-0073-00 Accessory Power Supply unit.

Electrical Characteristics

The characteristics given in Table 1-1 apply over an ambient temperature range from 0° C to +50° C, after the probe has been calibrated at +25° C ±5° C. Warm-up time is 5 minutes. Under these conditions, the P6045 Probe will meet or exceed the requirements given in the Performance Requirement column of the table. Performance of the probe is checked to these requirements in the Performance Check and Calibration section of this manual.

The Supplemental Information column of Table 1-1 provides additional information about the probe and describes certain conditions that pertain to the performance requirements. Any characteristics given in the Supplemental Information column are not requirements in themselves and are not necessarily checked in the performance check procedure.

TABLE 1-1

ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
Bandwidth		DC to 230 MHz or more (3 dB down), calculated from risetime.
Risetime	1.5 ns or less.	Measured with a fast-rise square wave centered about zero volts with maximum excursions $\leq \pm 200$ mV.
Rounding, overshoot and ringing	+ and — 3% or less for probe alone when used with an 80-MHz high input impedance oscilloscope; + and — 4% or less for probe alone when used with a 500-MHz (or greater) oscilloscope.	Typically 5% or less for probe with 10× or or 100× attenuator.
Gain	Adjustable to ×1.0	
Gain range		Approximately ×0.9 to ×1.1.
Dynamic range	+500 mV to —500 mV at probe amplifier output.	
Compression at limits of dynamic range	10% or less.	Measured with a 20-mV signal at +500 mV and —500 mV.
Offset range	+1 V to —1 V.	
DC drift with temperature change of probe head		Adjustable to $\leq$0.5 mV/°C.
Noise	400 μV or less over bandwidth of DC to 8 MHz; 1.5 mV or less over bandwidth of DC to 230 MHz.	Using 015-0073-00 Accessory Power Supply; oscilloscope noise excluded; measured with 50-ohm source resistance.
Input RC characteristics		Approximately 10 megohms paralleled by approximately 4 pF (with probe only). See Figs. 1-2 and 1-3 for other input characteristics.
Signal delay time		Approximately 11.7 ns from probe tip to probe amplifier output.
Output impedance with LOAD switch at INT position		Approximately 50 ohms.
Output load required with LOAD switch at EXT position.		50 ohms.
Maximum input overload voltage Probe only		±100 VDC surge for 1 minute maximum.
Probe with 10× or 100× attenuator		±100 V, DC plus peak AC.
Maximum input voltage of probe with coupling capacitor.		±200 V, DC plus peak AC.
Probe power requirements		+12.5 V (±5%) at approximately 50 mA and —12.5 V (±5%) at approximately 100 mA.

MECHANICAL CHARACTERISTICS

Characteristic	Description
Approximate Dimensions	
Probe head	
Length	4 7/8 inches
Maximum diameter	7/16 inch
Probe cable	
Length	6 feet
Power cable	
Length	12 inches
Amplifier box	
Height	2 7/8 inches
Width	1 1/4 inches
Depth	2 3/4 inches, body only; 5 inches including connector and knob.
Construction	
Probe head	
Circuit board	Epoxy laminate
Enclosure	Black polyvinyl plastic
Tip	Standard miniature tip (3/16-inch diameter ground contact)
Amplifier box	
Body	Gray cast aluminum ends; epoxy laminate circuit board
Front panel	Anodized aluminum alloy
Enclosure	Blue vinyl-coated aluminum alloy; plastic snap-in adjustment cover
Output connector	Locking-type BNC
Power connector	Keyed 3-terminal male snap-lock type with grounded shield

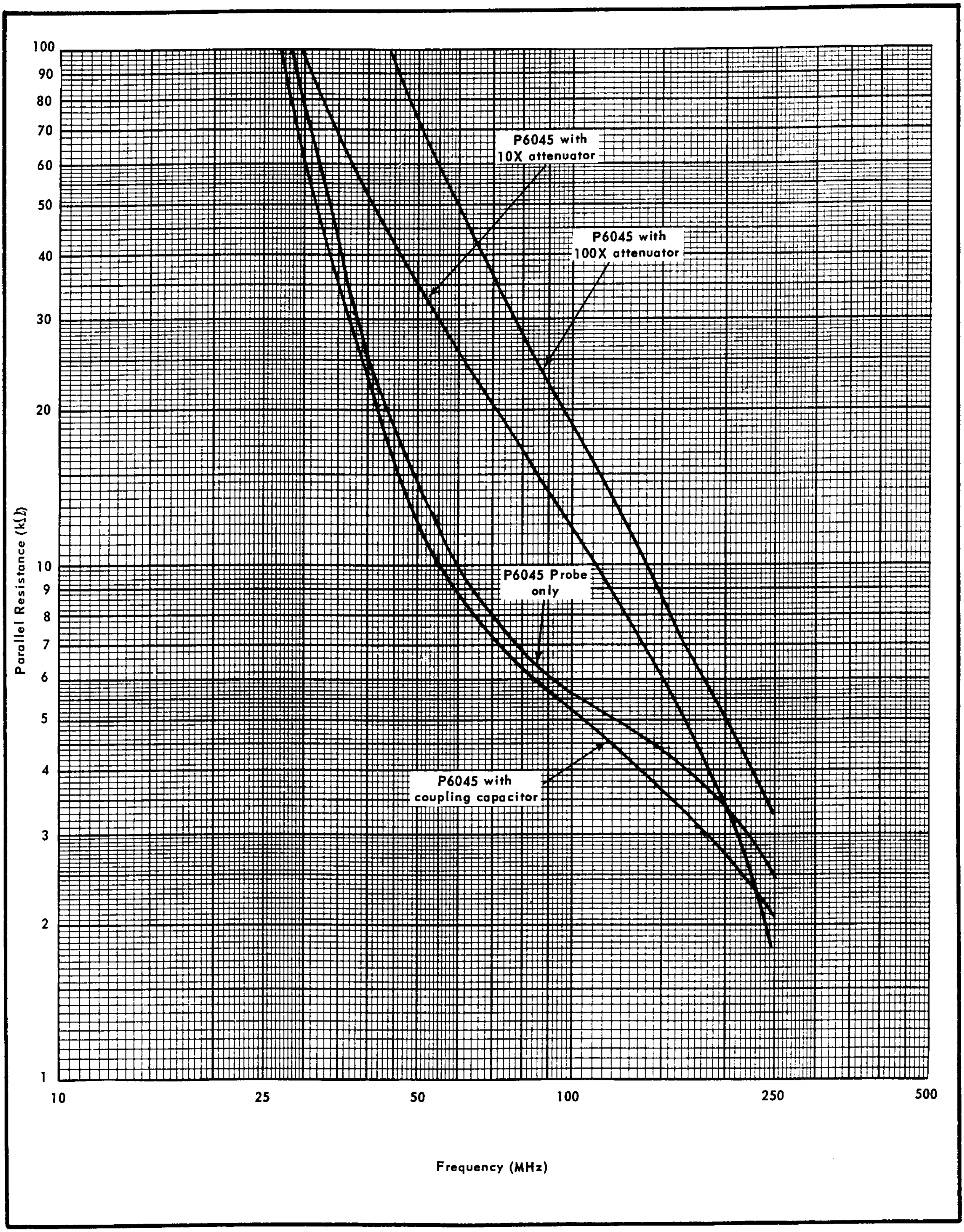


Fig. 1-2. Typical parallel input resistance versus frequency curves of the P6045 Probe.

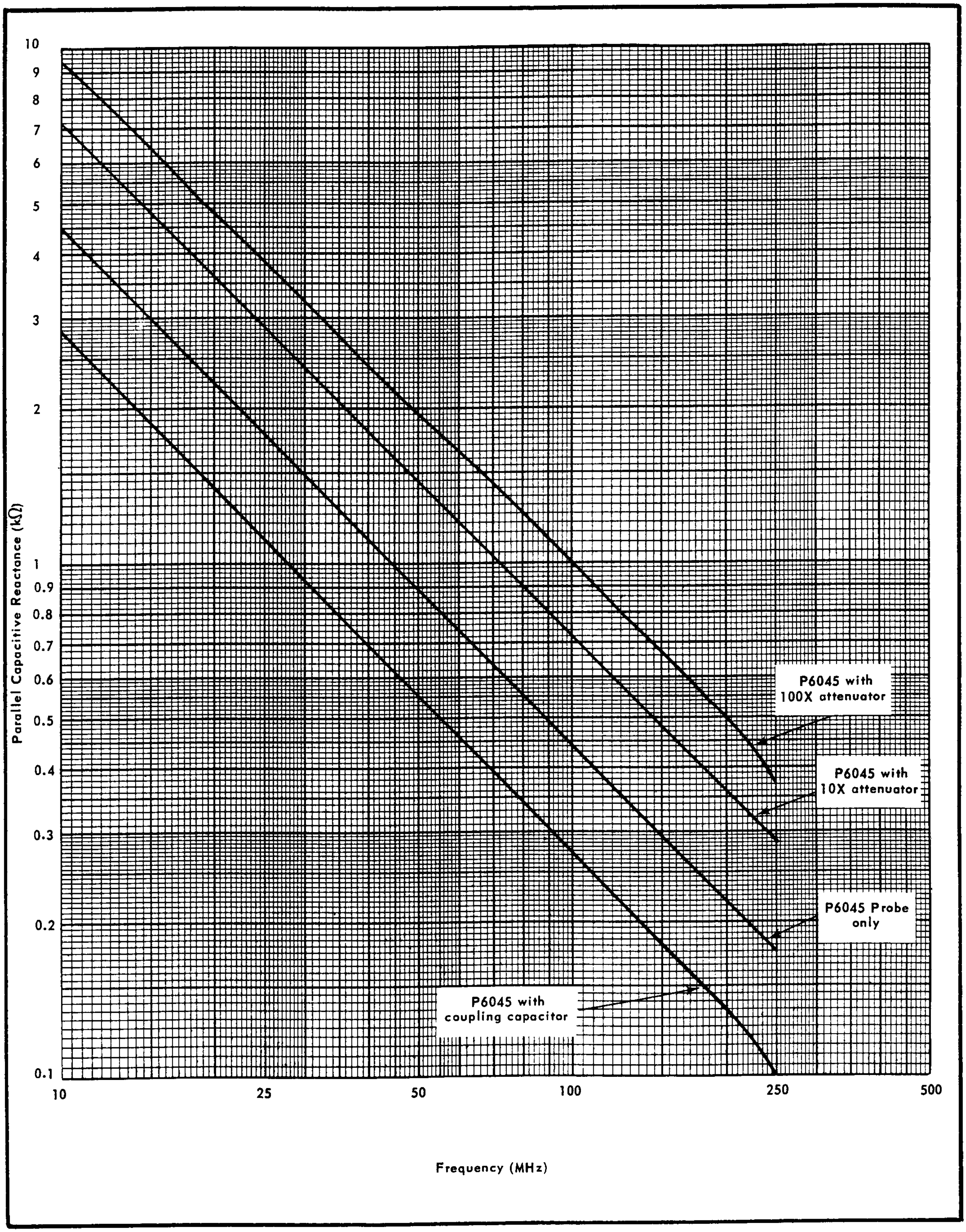


Fig. 1-3. Typical input capacitive reactance versus frequency curves of the P6045 Probe.

SECTION 2

OPERATING INSTRUCTIONS

Introduction

The P6045 Probe is designed to work into either a high-impedance oscilloscope or a 50-ohm system such as the input to a 50-ohm sampling unit. An internal 50-ohm load that can be switched into or out of the circuit eliminates the need for an external 50-ohm termination when used with a high-impedance system. The DC to 230-MHz bandwidth of the probe and its linear response at a gain of ×1 make it suitable for nearly any system that requires accurate low-voltage measurements without loading the signal source.

Due to wide variations in input impedance, frequency response and transient response between the various systems with which the P6045 can be operated, the high-frequency response of the probe must be checked whenever the probe is transferred from one instrument type to another. Failure to adjust the P6045 to the system with which it is to be used may cause measurement error at high frequencies. It is recommended that the Tektronix 015-0088-00 Probe Pulser or an equivalent fast-rise ($\leq$1 ns) square-wave generator be used to check the response of the probe.

This section of the manual describes the use of the P6045 Probe with different measurement system and the adjustments that are required when transferring the probe from one system to another. Information is also given to aid in making accurate voltage measurements with the probe.

Handling

The P6045 Probe has been designed to be as rugged as possible, consistent with good high-frequency response and miniature size. However, as with all precision devices, the probe and cable should be handled as carefully as possible to avoid damage. Special care should be taken that the cable not be crushed or pulled very hard. The probe tip should also be treated especially carefully. Use caution when inserting the probe tip into attenuators or other jacks to make sure that the tip is aligned with the receptacle. Avoid dropping the probe head, as some of the most sensitive circuitry of the probe is in the head. When not in use, protect the probe tip from damage by covering it with one of the small plastic probe-tip covers.

Controls and Connectors

Fig. 2-1 shows the controls and connectors on the P6045 Probe and describes the function of each.

Installation

When received, the P6045 is ready to be used with a high-impedance oscilloscope system. The gain of the probe is calibrated at the factory on a high-impedance oscilloscope to within 1% of ×1 with less than + and −3% aberrations in the response to a step transient. Due to normal differences in oscilloscope input characteristics, however, the high-frequency response of the probe should be checked on the system with which it is to be used before any accurate high frequency voltage measurements are made.

If the probe is to be operated with a 50-ohm system, the high-frequency compensation adjustments should be optimized as described in the Performance Check and Calibration section of this manual.

To set up the probe for operation with either a high-impedance system or a 50-ohm system, use the following procedure:

1. Turn the locking sleeve on the output connector of the probe amplifier box (see Fig. 2-1) counterclockwise several turns.

2. Install the probe output connector on the BNC input connector of the oscilloscope (or other system).

3. Turn the locking sleeve clockwise until it is tight.

4. Connect the probe power input connector to a probe power source such as the Tektronix 015-0073-00 Accessory Power Supply unit. Press the two connectors together lightly and rotate one with respect to the other until the key of one section engages with the slot of the other section and the three terminals are aligned with their receptacles; then press the connectors firmly together until they snap tight.

CAUTION

If the connectors are not correctly aligned, the terminals can be damaged by forcing the connectors together.

NOTE

If the probe power is obtained from an oscilloscope Probe Power output, be sure that the output is compatible with the P6045. Required voltages for this probe are +12.5 volts ±5% at about 50 mA and −12.5 volts ±5% at about 100 mA, referenced to ground. Some Tektronix instruments that have Probe Power connectors provide voltages that would damage the P6045 (e.g., +100 volts); however the power connectors on these instruments are not compatible with the power input connector on the P6045. There is, therefore, little chance of making the wrong connection unless a deliberate attempt is made to adapt one connector type to the other.

5. Remove the adjustment window cover (see Fig. 4-1) and set the LOAD switch (see Fig. 2-1) to correspond to the system being used. For a 50-ohm system, set the switch to EXT; for a high-impedance system, set the switch to INT.

6. Allow at least 5 minutes warm up before making any adjustments in the probe.

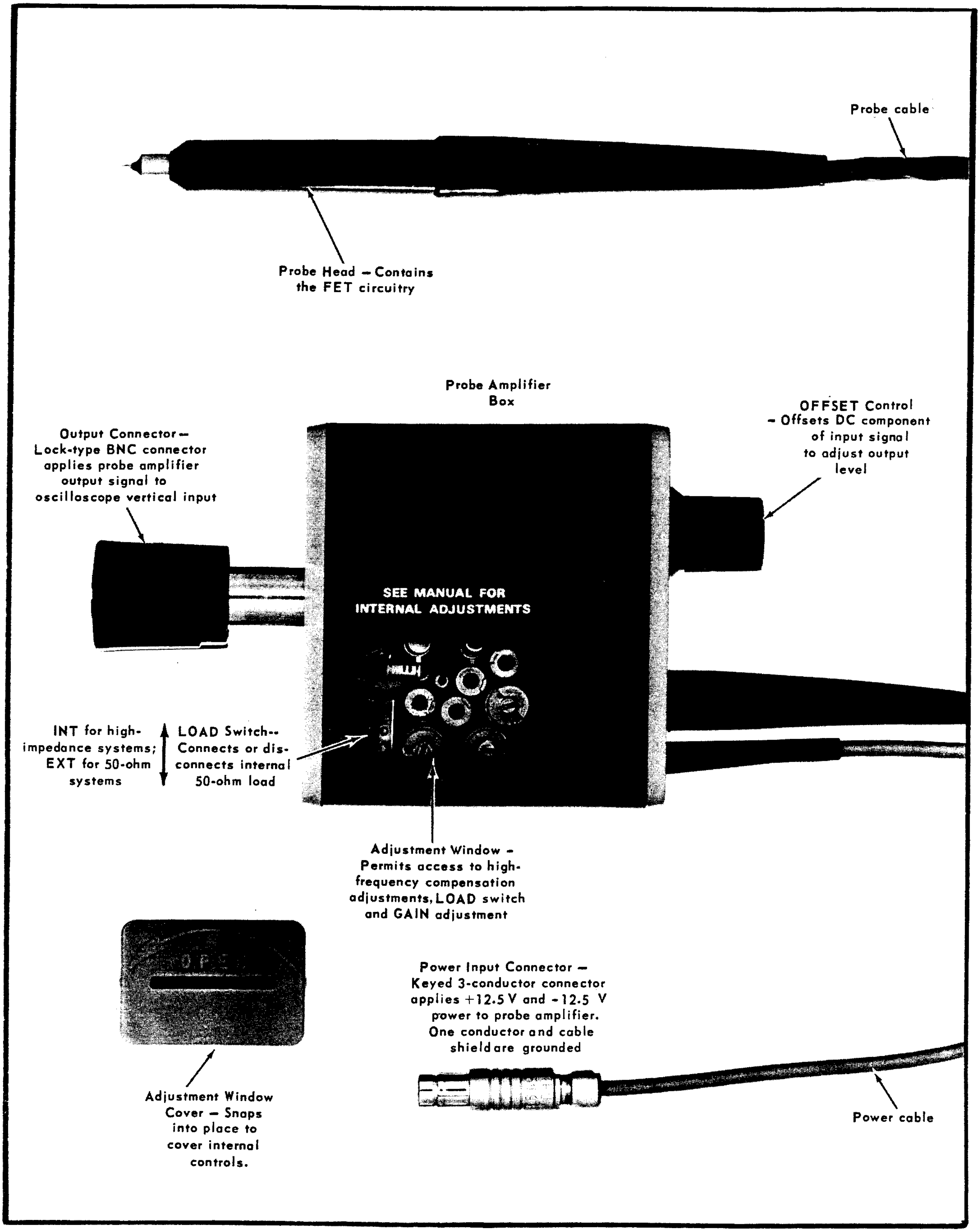


Fig. 2-1. Sections of the P6045 Probe and functions of controls and connectors.

7. Set the oscilloscope for a free-running trace with a sweep rate of 0.2 ms/cm (to start) and a vertical sensitivity of 100 mV/cm. If the oscilloscope does not have a sweep rate as slow as 0.2 ms/cm, set it for the slowest sweep rate available.

8. Connect the P6045 Probe tip to a signal source providing a 250-mV to 400-mV fast-rise ($\leq$1 ns) square-wave at a repetition rate of 1 MHz or less. A convenient source for this signal is a Tektronix 015-0088-00 Probe Pulser driven by an oscilloscope calibrator or other suitable source providing a +100-volt square-wave and current up to 10 mA. (Adjust the pulser bias as described under High-Frequency Adjustments in the Performance Check and Calibration section of this manual.)

9. Trigger the oscilloscope display and center the pulse display about zero volts as described in the performance check procedure.

10. Observe the displayed pulse rise and the top of the pulse immediately following the rise. Check for rolloff, ringing or aberrations not exceeding + and — 3% (see Fig. 2-2A) for a high-impedance system or not exceeding + and — 4% (see Fig. 2-2B) for a 50-ohm system.

11. If the displayed pulse characteristics are within the given tolerance, the probe is properly compensated and ready to be used with the system to which it is connected. If not, the high-frequency compensation controls must be readjusted as given in the Performance Check and Calibration section.

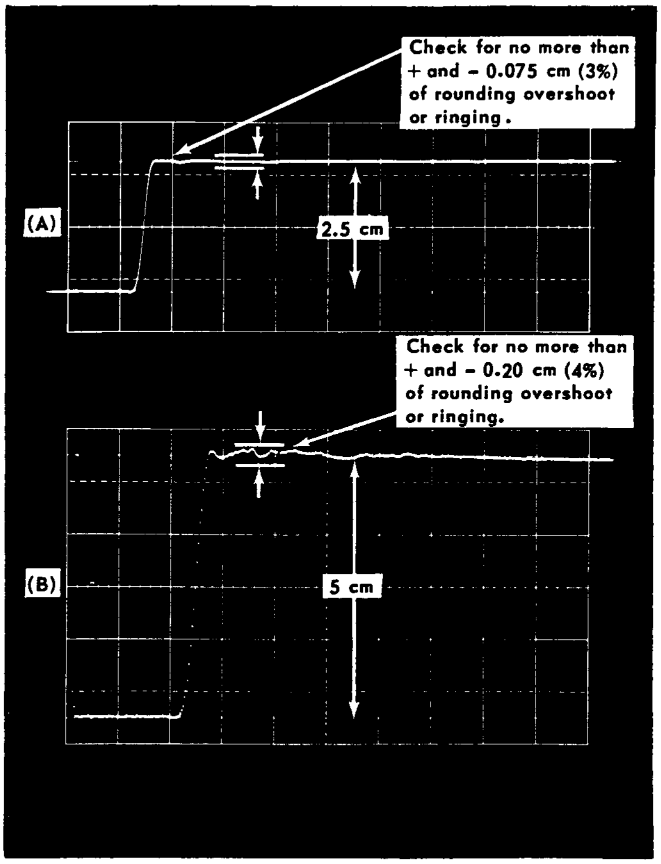


Fig. 2-2. Transient response check of the P6045 Probe (A) When used with a high-impedance system; (B) When used with a 50-ohm sampling system.

12. Re-install the adjustment window cover after checking and/or adjusting the high-frequency compensation.

Operational Adjustments

Whenever transferring the P6045 Probe from one oscilloscope system to another:

(1) Be sure to set the LOAD switch to the correct position to correspond to the impedance of the system with which it is to be used as described under Installation (above). If the LOAD switch is left in the INT position when the probe is connected to a 50-ohm system, the probe load will be 25 ohms and the gain will be approximately 0.5 and uncalibrated. If the switch is left in the EXT position when the probe is connected to a high-impedance system, the output amplitude from the probe will be very high and will also be uncalibrated.

(2) Check the transient response of the probe as described under Installation. If necessary, readjust the response as described in the Performance Check and Calibration section.

The gain of the P6045 Probe is adjusted during the calibration procedure and should not require readjustment during normal operation. If the vertical gain of the display is incorrect, check and adjust the gain of the vertical channel of the system as well as the gain of the P6045. If the GAIN adjustment of the P6045 is changed, the high-frequency compensation of the amplifier should also be checked.

Input Signal Requirements and Limits

Maximum voltages that may be applied to the probe or its attenuator or coupling capacitor tips without damage are given in Table 1-1 of the Characteristics section. However, since the dynamic range at the output of the P6045 Probe is $\pm$0.5 volt and the offset capability at the probe tip is $\pm$1 volt, any signal in excess of 1.0 volt peak to peak and/or offset by more than $\pm$1 volt cannot be placed within the dynamic range of the probe output circuit, and therefore cannot be displayed normally on the CRT screen (see Fig. 2-3).

The most linear response of the probe and the best transient response occur at the center of the dynamic range of the probe output amplifier (after the signal has been offset, if required). Signal compression is $\leq$10% at the limits of $\pm$0.5 volt at the output, and the signal becomes clipped when the probe is overdriven.

The P6045 Probe OFFSET control cannot be used as a slideback control to observe small portions of a large signal (larger than 2 volts peak). The reason for this is the poor recovery time of the probe after it has been saturated by a large signal. This recovery time is typically 500 μs and may cause erroneous readings for the duration of the recovery period. For input signals of 2 volts peak or less, measurements within 5% accuracy may be made typically after 50 ns. However, for rated performance, the input signals should be limited as previously described and shown in Fig. 2-3.

Use of Coupling Capacitor and Attenuators. A probe-tip coupling capacitor and probe-tip attenuators with 10×

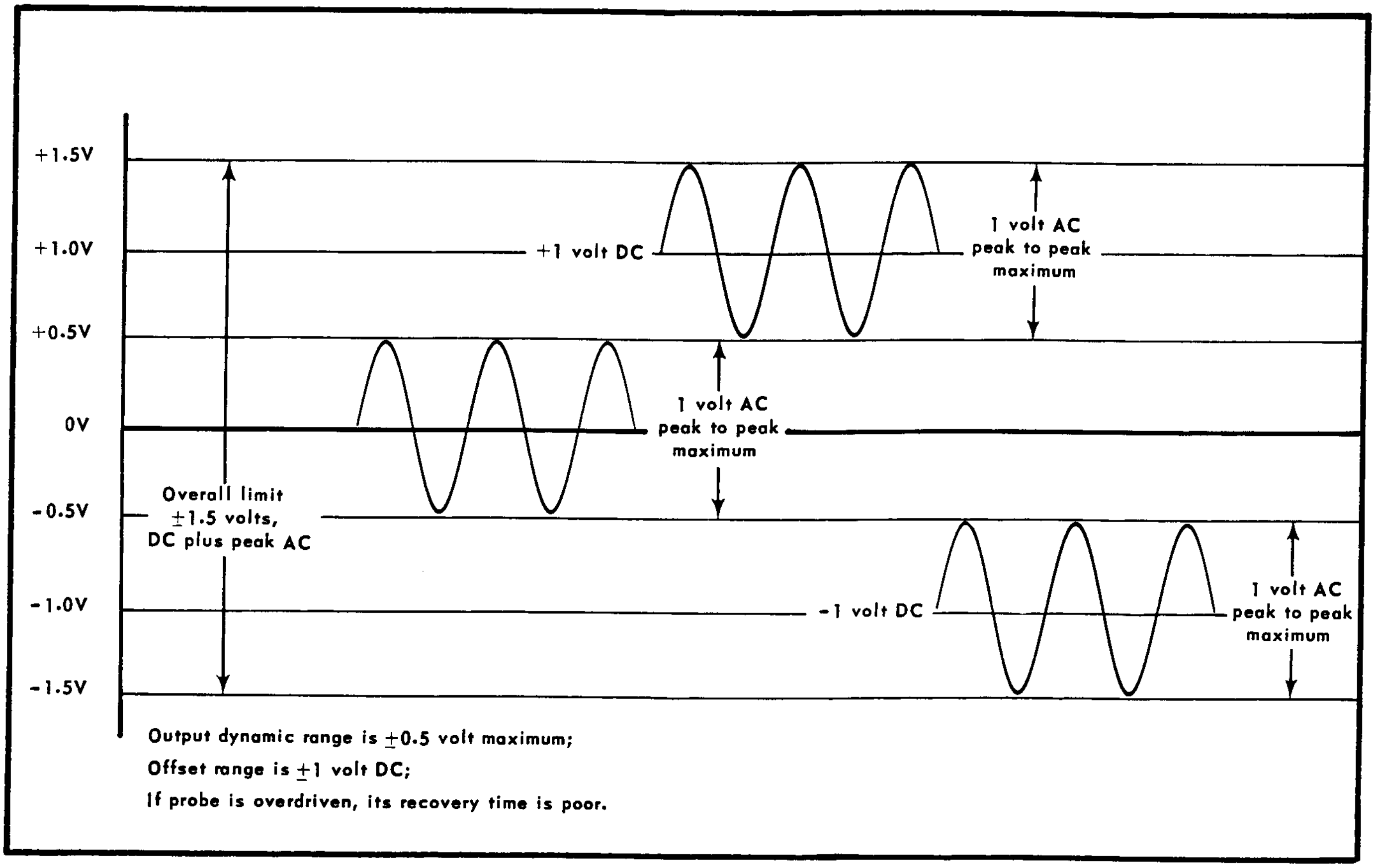


Fig. 2-3. Dynamic range of the P6045 amplifier and limits of the P6045 DC offset voltage. For the two cases shown with DC offset, the P6045 OFFSET control must be adjusted to match the DC component of the signal so that the amplifier is operating in its linear range.

and 100× attenuation factors are supplied with the P6045 Probe. If the input signal amplitude exceeds 1 volt peak to peak, or if it exceeds ±1.5 volts DC plus peak AC (see Fig. 2-3), it should be applied to the probe tip through one of the attenuators or the coupling capacitor, or a combination of the two depending on the signal characteristics.

The coupling capacitor blocks the DC component of the input signal and passes only the AC signal. The low-frequency 3-dB down point of the coupling capacitor is approximately 16 Hz. The attenuators attenuate both the AC and DC components of the input signal by the indicated attenuation factor. When using both the coupling capacitor and one of the attenuators on the probe tip, connect the coupling capacitor closest to the signal source.

For the various probe-tip coupling combinations, the input signal may have AC and/or DC components up to the limits given in Table 2-1 and still provide accurate displays on the oscilloscope CRT screen.

No advantage is gained by stacking the 10× attenuators to obtain 1000× attenuation, since the maximum input voltage for either attenuator is ±100 volts, whether stacked or not. Thus no increase in usable signal amplitude is gained.

Use of DC Offset. The purpose of the P6045 Probe offset capability is to permit the input signal to be positioned to the center of the dynamic range of the probe amplifier, so that best transient response is obtained. The easiest way to accomplish this is to disconnect the P6045 from the oscilloscope input (or set the Input Coupling switch to Gnd) and adjust the Vertical Position control of the DC coupled oscilloscope to center the trace on the CRT screen. From that time on, use the P6045 OFFSET control to vertically position the display to the center of the CRT screen for viewing. Do not readjust the oscilloscope Vertical Position control after it has been set to zero.

TABLE 2-1

	Peak to Peak maximum	DC plus Peak AC maximum
P6045 Alone	1 volt	±1.5 volts
With Coupling Capacitor	1 volt	±200 volts DC with 1 volt AC
With 10× Atten	10 volts	±15 volts
With 10× Atten and Coupling Capacitor	10 volts	±185 volts DC with 15 volts AC or ±200 volts DC with 1 volt AC
With 100× Atten	100 volts	±100 volts (breakdown limited)
With 100× Atten and Coupling Capacitor	100 volts	±100 volts DC with 100 volts AC or ±200 volts with 1 volt AC

If the input signal is applied through one of the attenuators, the apparent offset capability is increased by the attenuation factor, since both the AC and DC components of the signal are attenuated.

Voltage Measurements

When making voltage measurements from an oscilloscope display, the actual voltage at the signal source is equal to the amount of vertical deflection on the CRT screen times the deflection factor indicated by Volts/Cm switch. If an attenuator is used, the amplitude thus measured from the display should be multiplied by the attenuation factor.

The gain of the P6045 Probe is within 1% of ×1 with less than + and − 3% aberrations in its response to a step transient. With the 10× or 100× attenuator, the voltage accuracy is within 3% and aberrations in the response to a step transient are within approximately + and − 5%.

Tolerance of a voltage measurement made with a P6045 Probe and read from the CRT display is equal to the tolerance of the display by itself (perhaps ±3%) plus the 1% tolerance of the probe (or 3% tolerance with an attenuator). These are the tolerance *limits* of voltage error, but with the actual error in the display is probably much less than the sum of the tolerance limits.

Input R and X_C Changes With Frequency

The parallel input resistance and capacitive reactance versus frequency curves of the P6045 Probe are given in Figs. 1-2 and 1-3. These show the changes in input resistance and reactance that occur at high frequencies. Signal source loading can be obtained from these curves by using the two curves together. For example, when measuring a signal containing 100-MHz information, the probe appears to the signal source as a 5-kilohm resistance with 0.44 kilohms of capacitive reactance in parallel. The probe input reactance is therefore essentially that of the 4 pF input capacitance. Note that the ratio R/X_C is greater than 10 for all frequencies shown in Figs. 1-2 and 1-3. This ratio is often called the Quality Factor and is represented by the symbol Q.

Also when connecting the probe into a circuit with high source impedance, keep in mind that the capacitive reactance introduced by the probe tip into the circuit may cause a phase shift of the source signal. When connecting into a tuned circuit, the probe input resistance as read from Fig. 1-2 will somewhat reduce the Q of the circuit.

Signal Connections

All signal connections should be made directly to the tip of the probe or to the attenuator or coupling capacitor attached to the probe tip. Always establish a ground connection between the probe ground terminal and signal ground. If the signal source originates from an instrument (such as a pulse or time-mark generator) that has a coaxial output connector, use a probe-tip adapter (Tektronix Part No. 013-0084-00 for BNC; 017-0076-00 for GR) for connecting the probe tip to the signal source. This provides a coaxial environment for the signal and eliminates noise and other external EMI[1] signals. A 50-ohm feed-through termination is available for use with BNC connectors that must be terminated for proper operation.

Ground connections should always be made near the probe tip connection. When connecting the probe directly into a circuit, ground the probe ground terminal by means of one of the clips or connections supplied with the P6045 (see Fig. 2-4.) The bayonet tip is convenient for this purpose if a ground plane is adjacent to the signal source. If no ground plane is in line with the bayonet tip, use the clip-on lead and fasten it to a ground connection that is close to the signal source. Ground leads should always be as short as possible. If a long ground lead is used or if the distance from the signal source to the ground connection is too great, ground-loop currents may occur and cause distortion of high-frequency signals. If no ground at all is used, the ground connection to the probe tip is made through the probe cable from the amplifier and is very long. In this case, distortion may occur at relatively low frequencies.

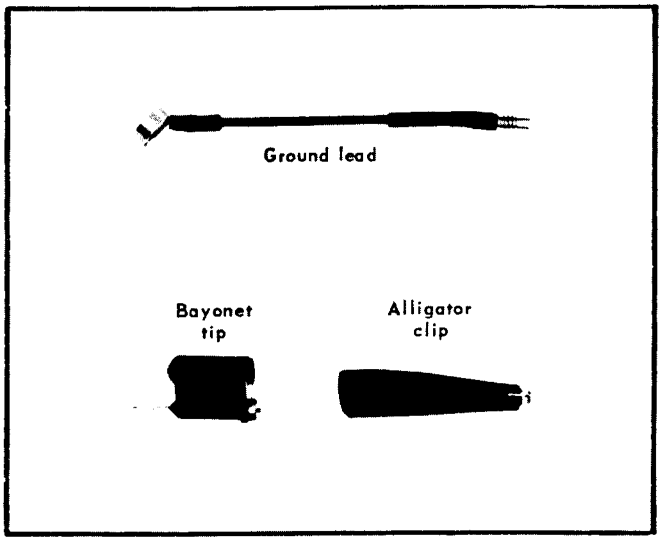


Fig. 2-4. Connections supplied for connecting the probe cable ground to signal ground.

P6045 Probe With a 50-ohm System

Since the output of the P6045 is designed to drive a 50-ohm load (with the LOAD switch set to EXT), it can also be operated at the end of a terminated 50-ohm coaxial cable or serve as an input to a 50-ohm switching system. Fig. 2-5 shows an example of a signal-switching system that uses three P6045 Probes as the signal inputs. Only one input signal is applied to the oscilloscope at one time, as selected by the relays.

Noise vs Bandwidth Characteristics

The noise characteristics of the P6045 Probe, as observed in an oscilloscope CRT display, depend on the bandwidth of the oscilloscope being used. In the calibration procedure,

[1]Electromagnetic Interference.

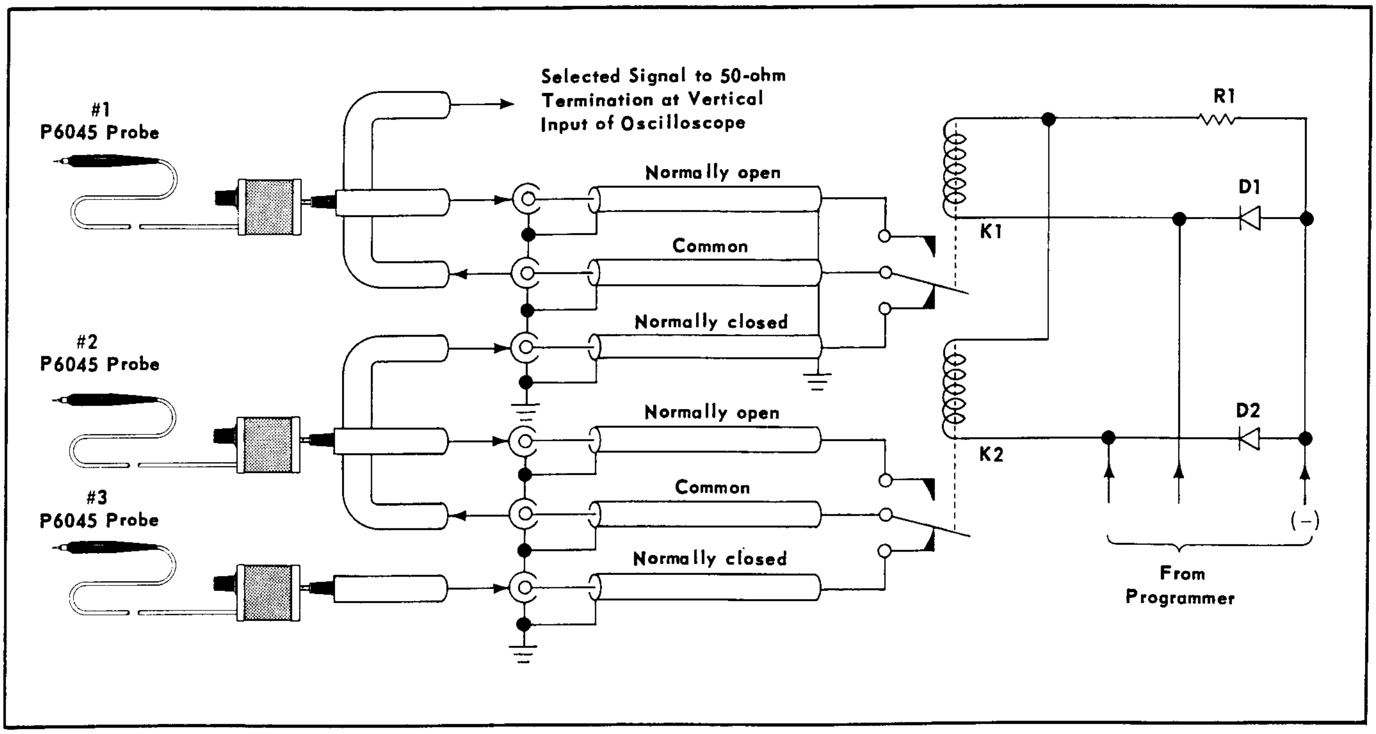


Fig. 2-5. Example of 50-ohm coaxial signal-switching system utilizing P6045 probe inputs. When neither relay is actuated, the signal from probe No. 3 is applied to the oscilloscope input.

TABLE 2-2

Maximum Display Noise Contribution of P6045 with Various Oscilloscope Systems

Oscilloscope/Plug-in Combination	Bandwidth with P6045 at Given Sensitivity	Nominal Trace Width of System with P6045	P6045 Noise Determined from Trace Width[2]
Type 547/1A7 (Differential)	DC to 500 kHz	12.5 mm at 200 μV/cm	250 μV
Type 547/W (Differential comparator)	DC to 8 MHz	4.4 mm at 1 mV/cm	400 μV
Type 547/1A1 (Dual-Trace)	DC to 28 MHz	2.2 mm at 5 mV/cm	750 μV
Type 581A/82 (Dual-Trace)	DC to 80 MHz	1 mm at 10 mV/cm	1 mV
Type 547/1S1 (Sampling)	DC to 230 MHz	9 mm at 2 mV/cm	1.5 mV

[2]**Probe noise voltage (E) is determined as follows:**

$$E_{probe} = \sqrt{(E_{oscilloscope + probe})^2 - (E_{oscilloscope})^2}$$

where E_{probe} is the P6045 noise voltage determined from the trace width, $E_{oscilloscope}$ is the noise voltage observed as trace width on the CRT screen without the probe, and $E_{oscilloscope + probe}$ is the noise voltage observed as trace width on the CRT screen with the probe connected to the oscilloscope vertical input.

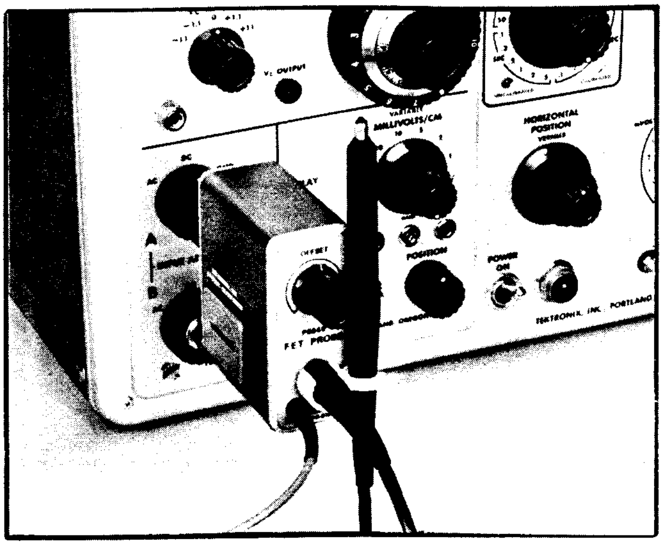


Fig. 2-6. Use of Probe Holder.

the P6045 is checked for $\leq$400 μV of noise on an 8-MHz oscilloscope and for $\leq$1.5 mV of noise on a sampling oscilloscope. Maximum noise characteristics that may be expected on these and some other typical oscilloscope systems are given in Table 2-2. The amount of noise contributed by the probe is considered to be only the increase in trace width as determined by the equation given under the table.

Probe Holder

The probe holder supplied with the P6045 provides a convenient means of keeping the probe available but out of the way when it is not in use. Place the wide half of the probe holder around the probe cable near the amplifier box and slide it onto the tapered section of the cable connected to the amplifier. Then whenever the probe is not being used, the head can be placed in the holder as shown in Fig. 2-6.

SECTION 3
CIRCUIT DESCRIPTION

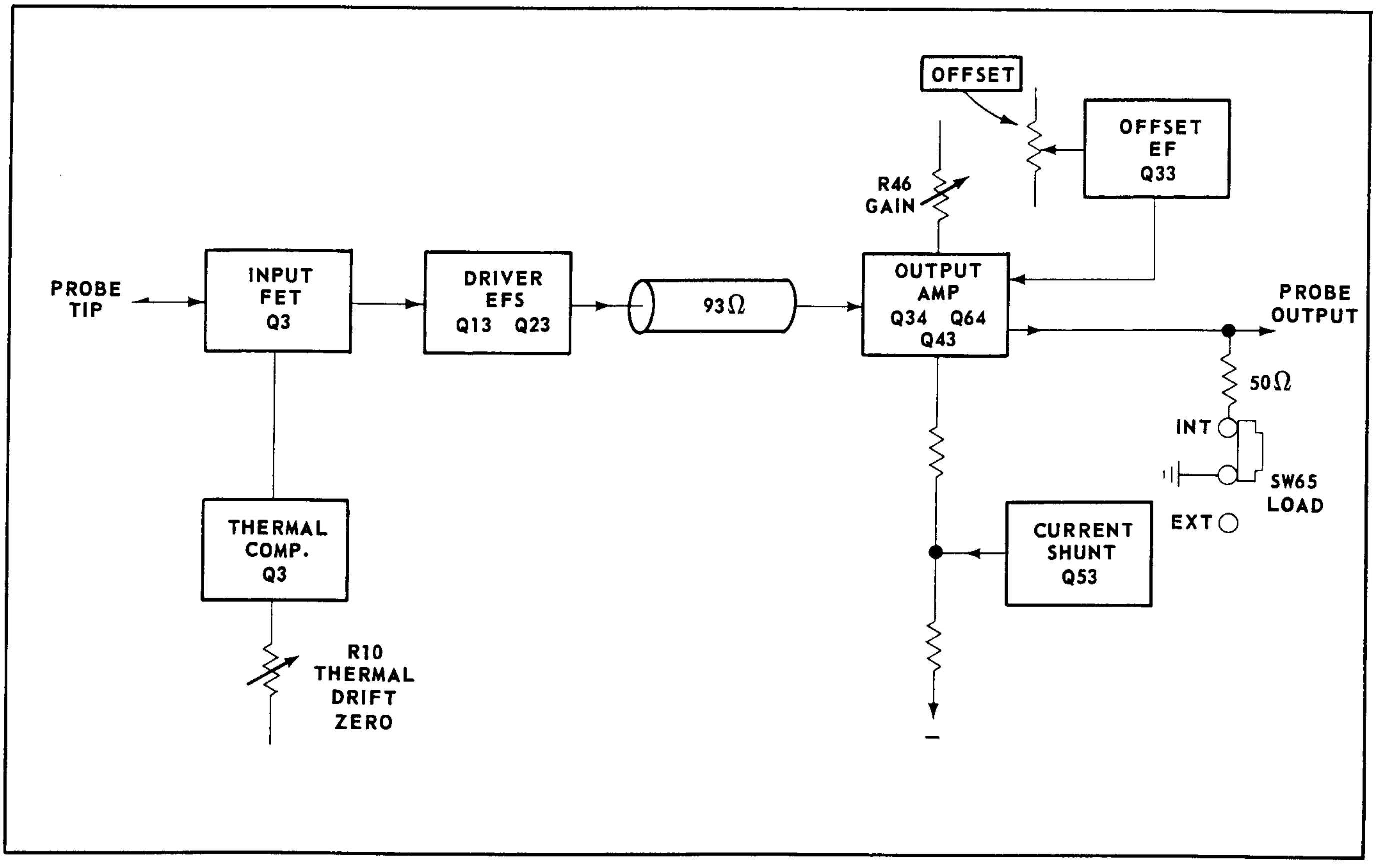


Fig. 3-1. Block diagram of the P6045 circuit.

Introduction

The circuit of the P6045 Probe consists of two sections—the probe head and the compensating amplifier. The probe cable between the two sections is made up of four conductors and a 93-ohm coaxial cable. The coaxial cable is used for signal transmission and the remaining leads provide operating voltages for the transistors in the probe head. A shielded 3-conductor power cable supplies power to the probe amplifier.

Refer to the block diagram in Fig. 3-1 and to the circuit diagram at the rear of this manual during the following discussion of the probe circuitry.

Probe Head

The input circuitry and field-effect transistor Q3 present a high-impedance input to the signal source connected to the probe tip. DC input resistance at the probe tip is approximately 10 megohms, set primarily by R2. Input capacitance is approximately 4 pF. RC network R1-C1 is a protective circuit designed to protect the field-effect transistor from overload voltages.

Drain voltage for Q3 is obtained through the probe cable from the +12-volt supply. Emitter followers Q13 and Q23 provide a low-impedance output from the probe head to drive the 93-ohm line in the probe cable. Q23 is set to operate at is optimum power point by R20-C20 in its collector circuit. The signal at the emitter of Q23 is applied through the probe cable and R30-C30 to the emitter of Q34 in the amplifier.

Since all of the transistors in the probe head are at essentially the same temperature, the circuit is designed so that the transistors provide temperature compensation for each other. The temperature coefficients of Q13 and Q23 are opposite to those of Q3 and Q8; therefore the coefficients counteract each other. Since the temperature coefficient of the field-effect transistor depends on its drain current, R10 THERMAL DRIFT ZERO is set to adjust current through Q8 and Q3 so that the overall temperature coefficient of the probe head is zero.

Amplifier

Signal current from Q23 in the probe head is applied to the emitter of Q34 and passes through this transistor, producing a voltage change across divider R41-R42 and thus at the base of Q43. The voltage signal is inverted and amplified by Q43 and re-inverted and amplified again by output transistor Q64. The overall gain of the probe is adjusted to ×1 by the GAIN control, R46, which controls the resistance in the emitter circuit of Q43.

Transistor Q53 provides a current shunt in the collector circuit of Q43 and the emitter circuit of Q64 to keep current constant through R58 so that signal-current changes in these transistor do not affect the —12.5-volt supply.

Load resistor R66, together with R67, sets the operating point of Q64 at its constant-power point when a 50-ohm load is present at the output. Resistor R69 serves as a 50-ohm load for the probe output circuit when LOAD switch SW65 is set to the INT position. This load is for use with oscilloscopes that have high-impedance input circuits. When the probe is to be used with a 50-ohm system, SW65 is set to the EXT position, disconnecting R69. The 50-ohm impedance of the system being driven by the P6045 then provides the required 50-ohm output load.

The DC level at the output of the amplifier is set primarily by the voltage at the base of Q43, which in turn is determined by current through Q34 and Q23. Current through these transistors and through load resistors R41 and R42 is set by the voltage difference betwen the bases of Q23 and Q34 and is proportional to the difference between their emitter voltages (the voltage drop across R30). The voltage at the emitter of Q23 is set by the DC level at the input to the probe, and the voltage level at the emitter of Q34 is set by OFFSET control R35. If the voltage at the probe input moves up or down while the OFFSET control remains at one setting, the emitter voltage of Q23 moves up or down an equal amount, causing a proportional current change through Q34. The resulting voltage change at the base of Q43 thus moves the amplifier output voltage in the same direction as the change at the probe input. If, on the other hand, the voltage at the probe input remains constant while the OFFSET control setting is changed, the emitter voltage of Q23 remains constant and the current change through Q34 is proportional to the voltage change applied by the OFFSET control through Q33 to the base of Q34. The resulting voltage change at the base of Q43 then moves the amplifier output voltage in the same direction as the OFFSET control voltage change. To set the DC level at the amplifier output to zero volts so that the input signal is in the center of the dynamic range of the probe amplifier, the OFFSET control is adjusted to match the offset of the input signal so that the current through Q34 and the voltage at the base of Q43 is the same as it is when no signal is applied and the OFFSET control is at midrange. This permits any signal ($\leq$1 volt, peak to peak) with a center DC level from +1 volt to —1 volt at the probe input to operate in the linear region of the amplifier and to be DC coupled to an oscilloscope.

High-frequency response through the probe circuitry is peaked up by LR40 and the compensating networks in the emitter circuits of Q43 and Q64 to make up for the lower gain of the transistors at high frequencies.

Attenuator Heads and Coupling Capacitor

The 10× and 100× attenuator heads which plug onto the probe tip contain resistors and capacitors that have been selected to provide the desired attenuation ratio without changing the frequency response characteristics of the probe. The 10-megohm input DC resistance of the probe remains the same regardless of the attenuator used. The input capacitance is approximately 2.3 pF with the 10× attenuator and approximately 1.8 pF with the 100× attenuator.

The coupling capacitor plugs onto the probe tip or onto the attenuators to provide AC coupling of the input signal. The low-frequency 3-dB point of the probe, when the coupling capacitor is used is approximately 16 Hz.

SECTION 4
MAINTENANCE

Introduction

This section of the manual presents preventive and corrective maintenance information for servicing and repairing the P6045. If trouble occurs in the probe, corrective maintenance should be performed immediately to avoid additional damage and to restore the probe to proper operation.

PREVENTIVE MAINTENANCE

Preventive maintenance consists of cleaning, visual inspection and recalibration. The severity of the environment in which the probe is used will determine the frequency of maintenance required.

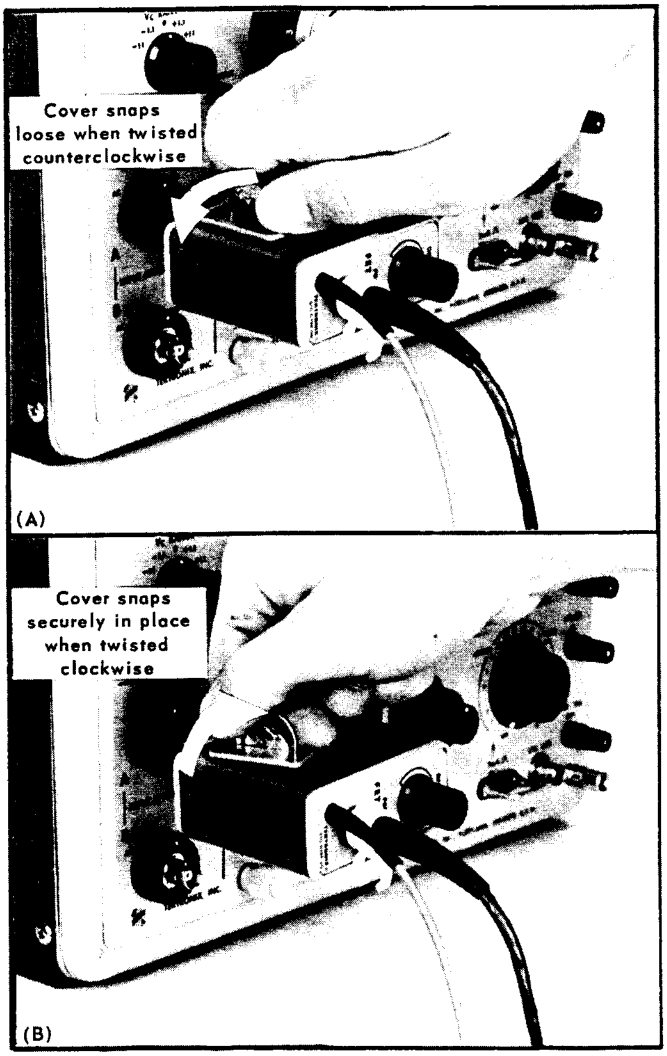


Fig. 4-1. Adjustment window cover removal and installation.

Adjustment Window Cover Removal

The cover for the adjustment window in the probe amplifier box can be easily removed for access to the probe LOAD switch and to the high-frequency compensation controls to be adjusted when the probe is transferred from one instrument type to another.

To remove the adjustment window cover, insert a large coin such as a quarter or nickel into the slot in the cover and twist it in a counter-clockwise direction while holding the probe amplifier box securely (see Fig. 4-1A). The window cover will snap loose and can be easily removed. To replace the window cover, reverse the removal procedure (see Fig. 4-1B). The window cover will snap firmly into place.

For normal operation of the probe, the cover should be left in place in the amplifier box window.

Amplifier Cover Removal

In order to gain access to all the circuitry in the probe amplifier box for calibration or troubleshooting, it is necessary to remove the wrap-around cover from the box. The probe power should be disconnected from the probe for this operation. To remove the cover, unscrew and remove the two Phillips-head screws from the rear (output) end of the box and partially separate the rear section from the cover (see Fig. 4-2). Disconnect the coaxial cable from the connector on the circuit board in the amplifier box and the three sections of the box can be completely separated.

For the operation or troubleshooting with the amplifier cover removed, the front section of the amplifier box should be reconnected to the rear section by means of the two

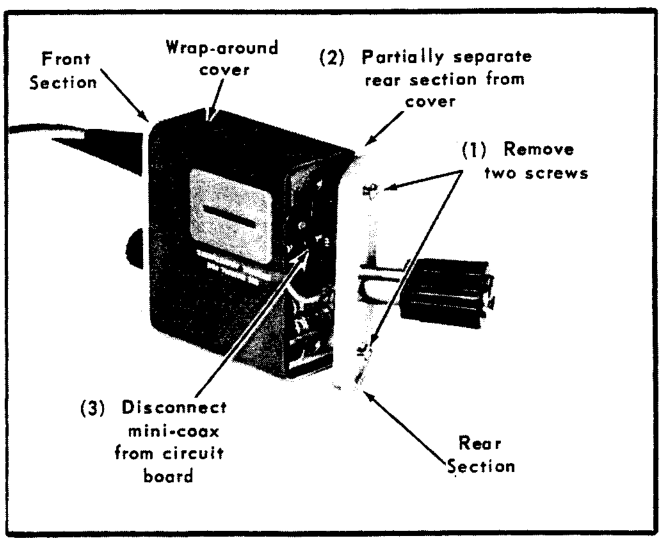


Fig. 4-2. Disassembly of the probe amplifier box.

screws. The coaxial cable must also be reconnected to the circuit board. For normal operation of the probe, the cover should be left on the amplifier box to keep out dust and stray radiation.

Removal of Probe Head Barrel

To gain access to the components mounted on the circuit board in the probe head, the barrel of the probe head may be removed by turning it counterclockwise as viewed from the probe tip (see Fig. 4-3).

CAUTION

Always disconnect the probe power before removing the probe head barrel.

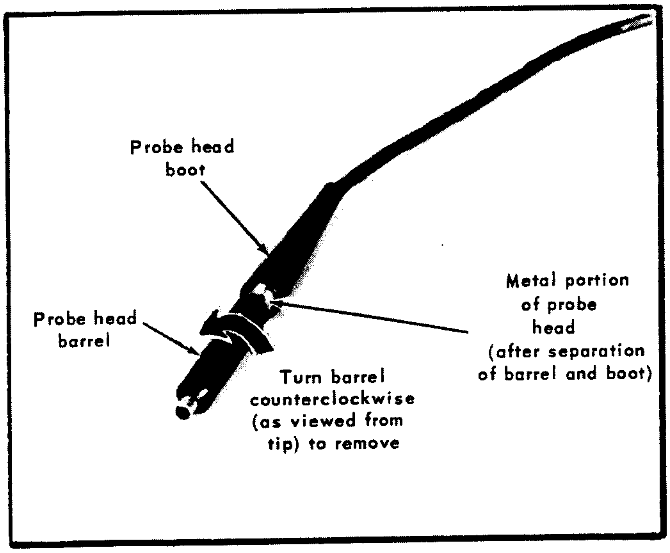


Fig. 4-3. Removal of the probe head barrel.

If the boot of the probe head tends to unscrew more easily than the barrel, it will be necessary to unscrew the boot completely, then hold on to the metal portion of the probe head while unscrewing the barrel. The probe head boot can then be screwed back on. For normal operation, the barrel must be left on the probe head to protect the circuitry, to keep out dust and stray radiation, and to provide a coaxial ground path to the probe tip.

Cleaning

The P6045 Probe should be cleaned as often as operating conditions require. Loose dust accumulated on the outside may be removed by wiping with a dry soft cloth. If any dirt remains, it can be removed with a cloth dampened in a solution of mild detergent and water.

Normally, the interior of the instrument will not require cleaning unless the cover has been left off for an extended period of time. Any cleaning on the inside of either probe section should be done with a cotton-tipped applicator dampened with a solution of mild detergent in water. After cleaning the interior, allow it to dry thoroughly before applying power to the probe.

CAUTION

Do not clean any plastic materials with organic cleaning solvents such as benzene or acetone. These compounds may damage the plastics.

Visual Inspection

The P6045 should be inspected occasionally for possible defects such as damaged parts. The procedures for correcting most visible defects are obvious, but particular care should be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument. Therefore, it is important that the cause of the overheating be found and corrected to prevent a recurrence of the damage.

Transistor Checks

The transistors in the P6045 should not be checked during periodic servicing of the instrument. The best determination of performance is the actual operation of the component in the circuit. However, if a circuit malfunction occurs, the transistors should be checked as a part of the troubleshooting procedure.

Recalibration

To assure the correct and accurate operation of the P6045 Probe, it should be checked after each 1000 hours of operation and recalibrated if necessary. A complete recalibration should be performed at least every six month, even if the probe is used only intermittently. Minor troubles that may not be apparent during normal use may be detected during the calibration procedure.

TROUBLESHOOTING

The following information is provided to aid in locating and correcting trouble in the P6045 Probe. Information found in the Circuit Description, Performance Check and Calibration procedure and on the circuit diagram may also be helpful when attempting to troubleshoot the instrument.

Troubleshooting Aids

Diagram. The circuit diagram of the P6045 Probe is given at the rear of this manual. Circuit numbers and electrical values of the components are shown on the diagram. Portions of the circuitry that are mounted on circuit boards are outlined in dashed lines.

Circuit Board Illustrations. All of the electrical components in the P6045 Probe are mounted on circuit boards. To aid in locating components and identifying supply leads on the circuit boards, Fig. 4-5 shows the physical locations of all components mounted on the boards and the color code of the connecting wires. The square-pin terminals used for connecting to the circuit board in the probe amplifier box provide convenient test points for troubleshooting. Test points can also be located where the components are soldered to the boards.

Preliminary Troubleshooting Procedure

The following general procedure is suggested for isolation of a malfunction in the probe circuitry.

Check Associated Equipment. If apparent trouble occurs in the P6045, first disconnect the probe from the oscilloscope input and check that the oscilloscope is operating properly without the probe. Also check that the voltages from the probe power supply are correct with the probe connected to the supply. The +12.5-volt and −12.5-volt supplies can be located as described in the Performance Check and Calibration procedure after removal of the cover from the probe amplifier box. Check that the power cable ground lead is not open.

Check Voltages and Waveforms. If the associated equipment appears to be operating normally, check through the circuitry for the correct operating voltages and waveforms as given on the schematic diagram. A 200 mV fast-rise square wave ($\leq$1 MHz) is applied to the probe tip through an appropriate connection such as a coaxial cable and clip-lead adapter (see Fig. 4-4) to obtain waveforms through the probe.

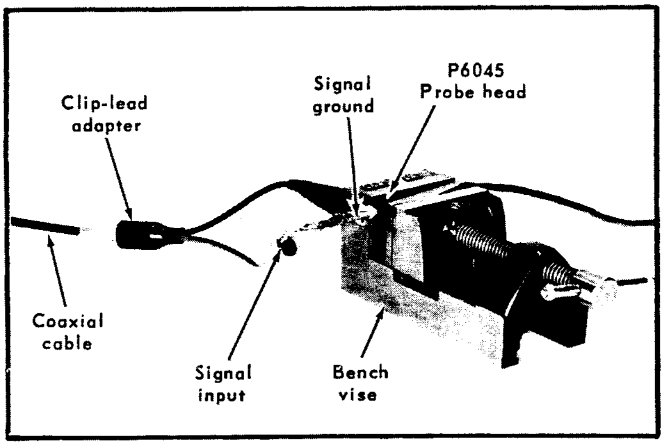


Fig. 4-4. Suggested connections for applying an input signal to the P6045 for troubleshooting.

CAUTION

Use care when attaching to the probe tip, as it is fragile without the support of the barrel. Clamp the probe head so that it cannot move around.

Check Circuit Calibration. If the preceding voltage and waveform checks indicate improper operation of a particular part of the circuitry, check the calibration of that circuit according to the procedure given in the Performance Check and Calibration section of this manual. Improper setting of a calibration adjustment can often cause the incorrect operation of a circuit, and thus of subsequent circuits.

Amplifier Circuit Troubleshooting

Visual Inspection. If the trouble has been isolated to the amplifier unit, check for damaged parts or broken connections. A visual inspection can sometimes indicate the source of trouble.

Check Semiconductors. Most circuit failures result from the failure of a transistor or diode due to normal aging and use. The recommended method of checking transistors in the amplifier unit is by direct substitution, since static parameter testers do not indicate the circuit performance of the component. NPN or PNP transistor junctions can be tested for open or shorted conditions by treating the base-collector and base-emitter junctions as separate diode junctions and measuring the resistance between terminals. A resistance scale that has an internal voltage source between 800 mV and 3 volts should be used. The resistance should measure very high in one direction and very low in the other direction.

CAUTION

An ohmmeter scale that has a source voltage outside of the indicated range (800 mV to 3 volts) will probably give an incorrect reading and may damage the component.

A dynamic parameter tester, such as a Tektronix Type 575 Oscilloscope, may also be useful for checking transistors, signal diodes or zener diodes that are suspected of being defective. The components will have to be disconnected from the circuit for testing. Be sure to return the transistors and diodes to their original positions if they are found to be operating correctly.

Check Passive Components. A passive component such as a resistor or capacitor in the amplifier unit can be checked with an appropriate meter after unsoldering one end of the component to eliminate the effect of the surrounding circuitry.

Probe Head Troubleshooting

Visual Inspection. If the trouble has been isolated to the probe head, inspect the circuit components with a low-power binocular microscope (approximately 10 power to 20 power). Check for broken solder connections and broken components. In particular, examine the small black resistors for cracks near the end caps. Examine the resistor and capacitor in the probe tip and the connections to these components. Do not apply any pressure to the components on the probe head circuit board, as many of them are very fragile.

Check Semiconductors. Do not disconnect any semiconductors from the probe head circuit board to check them. The condition of transistors and diodes can be determined by checking voltages as given on the schematic and by checking resistances in the circuit with power disconnected. The source-gate junction of the field-effect transistor (Q3) is checked by the gate leakage current check in the calibration procedure.

Check Passive Components. Do not unsolder any components to check them. Continuity and resistance values can be measured approximately with the components in the circuit.

CORRECTIVE MAINTENANCE

Corrective maintenance generally consists of component replacement and instrument repair. The following paragraphs provide information that may be helpful if parts have to be replaced in the P6045.

Replacement Parts

Replacements for all electrical and mechanical parts used in the P6045 Probe can be obtained through your local Tektronix field office or representative. Some of the standard electronic components can be obtained more quickly, however, by purchasing them locally. Before ordering or purchasing any replacement parts, refer to the Parts List in this manual for the required characteristics and correct description.

In addition to the standard electronic components, many special parts and components are used in the P6045. These parts are manufactured by or for Tektronix or are selected to meet specific requirements. Each of the special electrical components is indicated by an asterisk preceding the part number in the Parts List. In addition, most of the mechanical parts used in the probe are manufactured by Tektronix and are not available from other sources. Order all special parts directly from your Tektronix field office or representative.

When ordering parts from Tektronix, always include the following information:

1. The instrument type (P6045 Probe).

2. A complete description of the part as given in the Parts List. (For an electrical part, also give the circuit number of the component, such as Q8.)

Circuit Boards. The circuit boards in the P6045 can be ordered either with or without circuit components wired in place. The Tektronix part numbers of the boards are given in the Parts List. To obtain a replacement board with the components soldered in place, be sure to order the replacement board assembly. (The socket-mounted transistors in the amplifier section are not included in the assembly number.) In any case where component troubles occur in the probe head, it is strongly recommended that a complete new probe new probe head and cable assembly be ordered. Be sure to specify a probe head and cable assembly connected as a unit when you order.

Attenuators and Coupling Capacitor. Repair of the attenuator heads or coupling capacitor should not be attempted. The entire assembly should be replaced if defective. Part numbers are given in the Standard Accessories list in the Parts List.

Amplifier Circuit Board Repair

Soldering. The components mounted on the circuit board in the amplifier box can be replaced using normal circuit board soldering techniques. Keep the following points in mind when soldering to the circuit board:

1. Use a pencil-type soldering iron with a power rating of from 15 to 50 watts.

2. Apply heat from the soldering iron quickly to the junction between the component and the circuit board.

3. Heat-shunt the lead of the component by means of a pair of long-nosed pliers.

4. Avoid excessive heating of the junction with the circuit board, as this could separate the circuit board wiring from the laminate.

5. Use electronic grade 60-40 tin-lead solder.

6. Clip off any excess lead length extending beyond the circuit board and clean off any residual flux with a flux-removing solvent. Be careful that the solvent does not remove any printing from the circuit board.

Transistor Replacement. Since each transistor has its own individual operating characteristics, a transistor should not be replaced unless it is actually defective. Any replacement transistor should be of the original or equivalent type and should be mounted in the same manner as the original transistor. Bend the leads to fit the socket correctly and cut the leads to a length of approximately 1/4 inch (6 mm). Since transistor lead wiring is no longer consistently arranged as to collector-base-emitter, the lead configuration of the replacement transistor must be known. All of the transistor sockets in the P6045 are wired for the standard collector-base-emitter configuration. If the leads of the replacement transistor are not arranged in this sequence, they must be bent into this configuration before being installed. After any transistor has been replaced, the calibration of the probe must be checked.

Board Replacement. If the circuit board in the amplifier box is damaged and cannot be repaired, replace the board as follows:

1. Disassemble the amplifer box as described previously.

2. Disconnect all wiring connections from the circuit board.

3. Unscrew the two screws that fasten the board to the lugs attached to the chassis. The board may then be removed.

When installing the replacement board, use the wiring color code given in Fig. 4-5 to connect the wires to the square-in connectors on the board.

Probe Head Circuit Board Repair

Soldering. All of the miniature components in the probe head are soldered onto the circuit board. It is recommended that the probe be returned to one of the Tektronix field maintenance centers for repair if a malfunction is known to exist in the probe head. Alternatives to returning the probe are replacement of the probe head circuit board and cable assembly or replacement of only the probe head circuit board assembly as described below.

If, however, it is decided that repair of the circuitry in the probe head is to be attempted, the customer is advised to use great care and a minimum of heat when soldering to the circuit board. The following equipment should be available before attempting to do any work on the circuit board: A low-power binocular microscope as described under Troubleshooting; a 15-watt pencil-tip soldering iron; a pair of tweezers; some small-diameter solder such as Tektronix part no. 251-0514-00 and a small bench vise or clamp for holding the probe head. After doing any soldering in the probe head, check carefully with the microscope to make sure that no solder drops are shorting between conductors on the board.

Board Assembly Replacement. Though it is strongly recommended that the probe be taken to a Tektronix field maintenance center for repair of the probe head, the entire head and cable assembly can be replaced by disconnecting the probe cable from the amplifier box as described below under Probe Cable Replacement. If only the circuit board assembly is to be replaced, it can be disconnected from the probe cable also as described under Probe Cable Replacement. The replacement circuit board assembly includes the metal portion of the probe head. Before reconnecting the probe cable to the circuit board, the cable should be cut back slightly and any melted insulation should be removed.

If an attempt is to be made to replace only the bare probe head circuit board, be sure to have extra components available in addition to the special equipment described above under Soldering. Some of the small components will probably be broken during the removal and remounting procedure. Care must be taken to align the circuit board properly when soldering it to the metal portion of the probe head and to position it so that the tip will extend approximately 1½ mm from the end of the probe barrel when the barrel is completely tight.

Replacement of Q3 or R1-C1. If it is necessary to replace either the field-effect transistor or the input resistor and/or capacitor, use the circuit board soldering techniques given under Amplifier Circuit Board Repair.

1. For removing the FET or other component from the probe head circuit board, cut off the leads adjacent to the body of the defective component and unsolder each lead individually. Do not overheat the pads where the leads connect to the circuit board, as this will separate the pads from the board .

2. Before installing the new component, open each hole in the circuit board by inserting a toothpick into the hole from the reverse side of the board while quickly touching the soldering iron to the solder in the hole.

3. Bend the leads of the replacement component into the proper shape with needle-nose pliers before inserting the leads into the holes.

4. After soldering the leads, clip off the excess lead length on the reverse side of the board as close as possible to the circuit board.

Probe Cable Replacement

The probe cable is specially designed and manufactured for high-frequency operation as part of the P6045 Probe. If trouble occurs in the cable, it is recommended that the probe be returned to one of Tektronix field maintenance centers for replacement of the cable.

If, however, it is decided not to take the probe to the maintenance center, the probe cable may be replaced as follows:

1. Remove the probe amplifier cover as described previously.

2. Unsolder the grounded end of capacitors C9 and C25 (see Fig. 4-5) and bend the capacitors upward from the board.

3. Disconnect the probe cable connections from the circuit board in the amplifier box.

4. Remove the nut holding the cable clamp in the amplifier box.

5. Unscrew the boot from the amplifier box and remove the cable.

6. Remove the barrel and the boot from the probe head.

7. Unsolder the voltage leads and coaxial cable from the circuit board in the probe head.

Install the replacement cable by reversing the removal procedure. When connecting the replacement cable, refer to the wiring color code shown in Fig. 4-5.

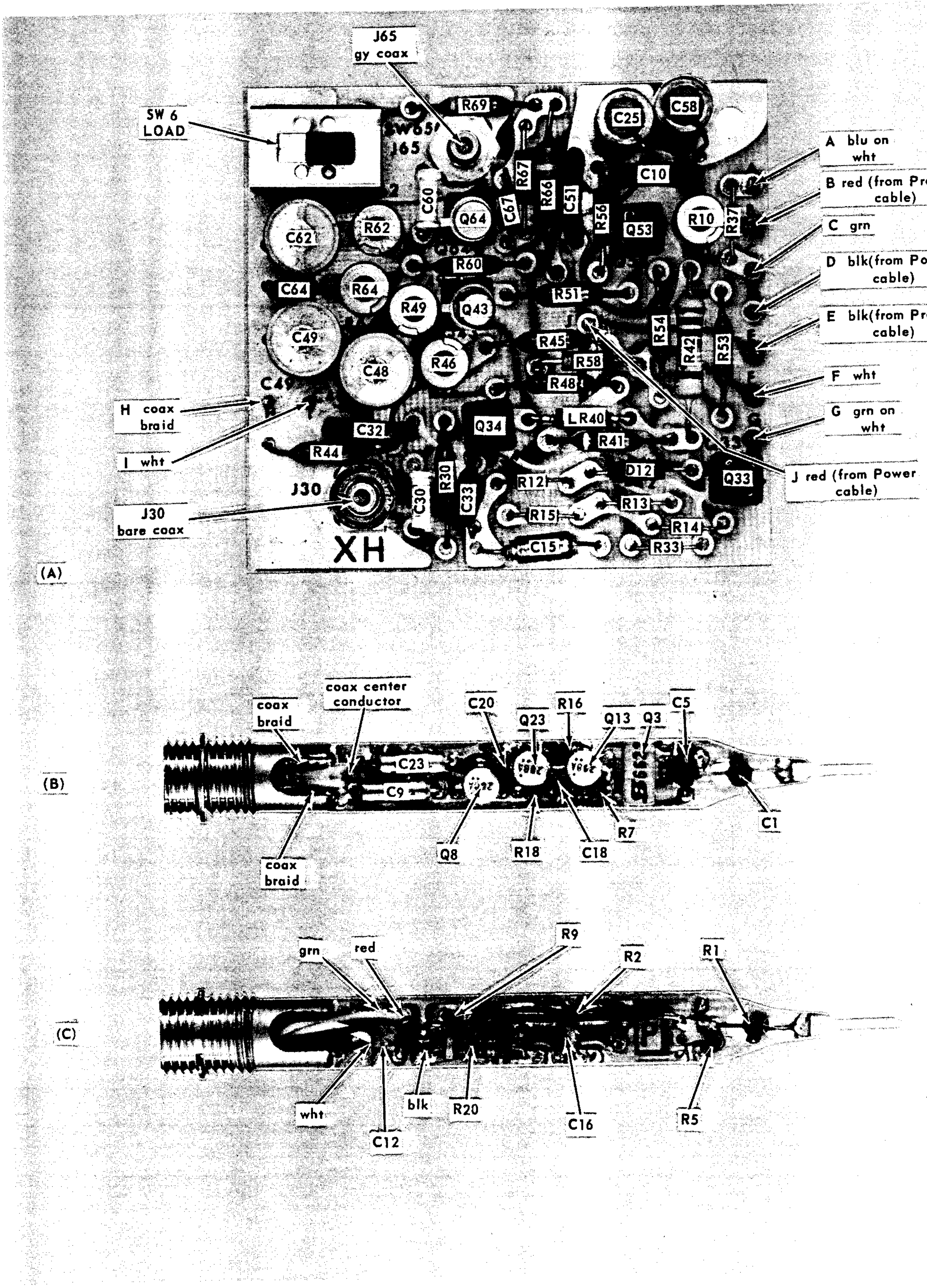


Fig. 4-5. Locations of components mounted on circuit boards and color code of wiring connections. (A) Circuit board in probe amplifier box; (B) and (C) two sides of circuit board in probe head.

SECTION 5
PERFORMANCE CHECK AND CALIBRATION

General Information

Performance and/or calibration of the P6045 FET Probe should be checked after each 1000 hours of operation and at least once every 6 months to assure that the instrument is operating correctly and accurately. Recalibration of the probe may be performed periodically as part of a regular preventive maintenance schedule or may be done whenever the need is indicated by a performance check. In addition to the periodic recalibration, portions of the circuitry may require recalibration if components have been replaced or other electrical repairs have been made in the probe.

The procedure given in this section is a combined verification and adjustment procedure that permits the probe to be checked to the performance requirements given in the Characteristics section and to be adjusted for best performance.

The step by step instructions of the procedure furnish an orderly approach to the isolation of possible malfunctions and thus serve as an aid in troubleshooting and repairing the probe. Any maintenance that is known to be needed should be performed before strating the procedure. If any trouble becomes apparent during the performance check or calibration, this should also be corrected and the procedure started over. Repair and servicing information is given in the Maintenance section of this manual.

EQUIPMENT REQUIRED

The following (or equivalent) items of equipment are required for a complete calibration of the P6045 Probe. The recommended equipment is illustrated in Fig. 5-1. If substitute equipment is used, it must equal or exceed the given requirements in order to check or calibrate the P6045 to the given accuracy.

1. High-frequency test oscilloscope, Tektronix Type 581A. Minimum alternate requirements: Vertical bandwidth (with plug-in unit) from DC to 80 MHz or more; sweep rates from 0.5 μs/cm to 10 ns/cm (magnified); voltage and timing accuracy of display within 3% of indicated values; within 5% when magnified.

2. High-frequency vertical plug-in unit, Tektronix Type 82. Minimum alternate requirements: Compatible with high-frequency test oscilloscope; vertical bandwidth (with oscilloscope) from DC to 80 MHz or more; vertical deflection factor of 0.1 V/cm at the specified bandwidth. A single vertical input channel is used.

3. Test oscilloscope, Tektronix Type 547. Minimum alternate requirements: Compatible with differential comparator plug-in unit and sampling plug-in unit; vertical bandwidth (with non-sampling plug-in unit) from DC to 8 MHz or more; sweep rate of 2 ms/cm: voltage and timing accuracy of display within 3% of indicated values; calibrator square-wave output with amplitudes of 20 mV and 100 volts at approximately 1-kHz frequency; external horizontal input for sampling sweep.

4. Differential comparator plug-in unit, Tektronix Type W. Minimum alternate requirements: Compatible with the test oscilloscope (item 3); vertical bandwidth from DC to 8 MHz at 1 mV/cm; vertical deflection factors from 1 mV/cm to 200 mVcm; differential inputs; internal comparison voltage variable from zero to ±1 volt; trace noise of 185 μV or less.

5. Sampling plug-in unit, Tektronix Type 1S1. Minimum alternate requirements: Compatible with the test oscilloscope (item 3); risetime of 350 ps or less; equivalent sweep rates from 0.5 μs/cm to 0.1 ns/cm; timing accuracy within 3% of indicated value; vertical deflection factor of 100 mV/cm; input impedance of 50 ohms; display noise of 1 mV or less.

6. Square-wave generator, Tektronix Type 106. Minimum alternate requirements: Output amplitude of 300 mV into 50 Ω; output repetition rate of 100 Hz; risetime of 100 μs or less.

7. Time-mark generator, Tektronix Type 184. Minimum alternate requirements: Sine-wave marker output of 2 ns; timing accuracy within 0.5% of indicated value; output amplitude at least 1 volt into 50 ohms.

8. Standard amplitude calibrator, Tektronix 067-0502-00. Minimum alternate requirements: Square-wave output amplitude of 0.1 V; DC output amplitudes of +1 V and −1 V.

9. Power supply for P6045 probe, Tektronix 015-0073-00 Accessory Power Supply. Minimum alternate requirements: Voltage outputs of +12.5 volts ±0.625 volt at approximately 50 mA and −12.5 volts ±0.625 volt at approximately 100 mA, with ground reference.

10. Probe pulser unit, Tektronix 015-0088-00. Minimum alternate requirements: 260 mV or greater square-wave output at frequency of 1 MHz or less; risetime of 0.5 ns or less; aberrations on pulse top 2% or less; probe-tip adapter output connector.

11. Temperature-control and measurement system (not shown). Minimum requirements: Capable of varying and accurately measuring the probe head temperature over the range from +25°C to +50°C (+77°F to +122°F) electrically insulated from the probe head which is heated and cooled after removing the enclosing barrel. This system may be a refined device consisting of two accurately controlled

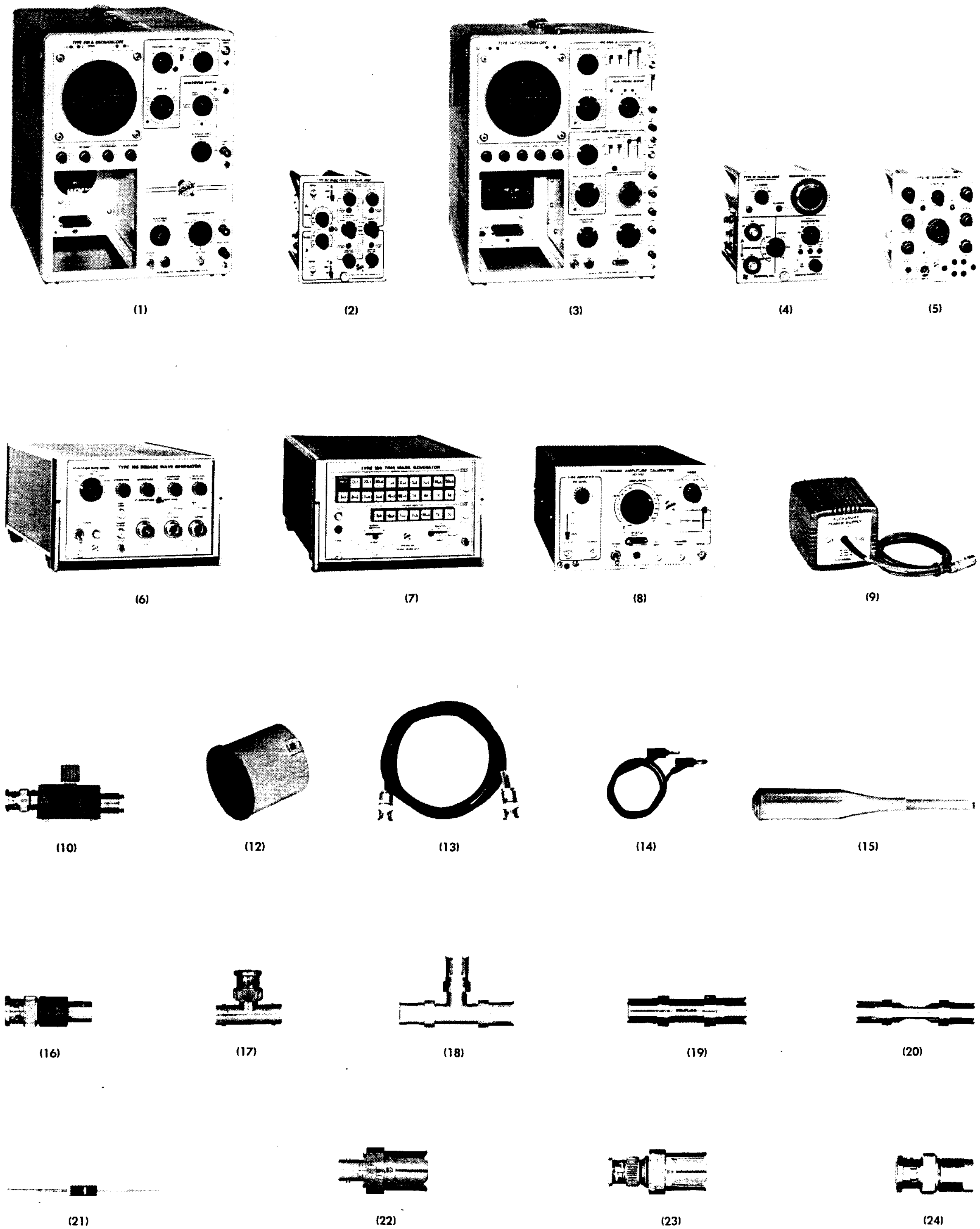


Fig. 5-1. Recommended calibration equipment.

temperature chambers or may be a combination of simpler devices for warming, cooling and monitoring the probe head temperature. For example, an accurately calibrated thermometer attached to the probe head may be used for monitoring the temperature, a hair dryer may be used for warming, and a fan may be used for cooling.

12. Viewing hood, Tektronix Part No. 016-0001-00, or polarized viewer, Tektronix Part No. 016-0053-00, for use with the high-frequency test oscilloscope.

13. Two 42-inch coaxial cables with BNC connectors, Tektronix Part No. 012-0057-01. Characteristic impedance approximately 50 ohms.

14. 18-inch patch cord with banana plugs on both ends, Tektronix Part No. 012-0031-00.

15. Plastic screwdriver-type adjustment tool with 1½-inch shaft length, Tektronix Part No. 003-0000-00.

16. 50-ohm termination with BNC connectors, Tektronix Part No. 011-0049-00.

17. BNC T connector, Tektronix Part No. 103-0030-00.

18. GR T connector, Tektronix Part No. 017-0069-00.

19. GR coupling capacitor (4700 pF), Tektronix Part No. 017-0028-00.

20. GR insertion unit, Tektronix Part No. 017-0030-00.

21. Resistor, 10 MΩ ±10%, ¼ W, Tektronix Part No. 316-0106-00. Solder resistor into insertion unit, in series with the signal path.

22. Two BNC jack to GR connector adapters, Tektronix Part No. 017-0063-00.

23. BNC plug to GR connector adapter, Tektronix Part No. 017-0064-00.

24. BNC to probe tip adapter, Tektronix Part No. 012-0084-00.

25. Connector adapters as required for adapting between instruments with different connector types.

INDEX AND RECORD

The following outline is provided to serve as a verification and/or calibration record. It may be reproduced for that purpose or as a guide for calibrators who are familiar with the procedure.

Calibration Date ____________ **Engineer** ____________

Cal. Record No. ____________________

A supply of calibration tags (Tektronix part no. 334-1082-00) is provided with the P6045 Probe to record the following information: The type of oscilloscope (or other system) to which the probe is calibrated, the serial number of the oscilloscope and the date of calibration. Whenever the P6045 is recalibrated, one of these tags should be filled out and placed on the back side of the probe amplifier box or over the previous calibration tag.

☐ 1. Adjust Thermal Drift Zero R10
DC drift of ≤0.5 mV/°C from +25° C to +50° C.

☐ 2. Adjust Gain R46
Input-to-output gain within 1% of ×1 (unity).

☐ 3. Check Dynamic Range
DC plus peak AC amplitude of at least +500 mV to —500 mV at probe output;
≤10% compression at limits of dynamic range.

☐ 4. Check Offset Range
DC offset capability of at least +1 volt to —1 volt.

☐ 5. Check Probe Noise at 8 MHz.
Probe noise of ≤400 μV, determined from trace width.

☐ 6. Check Gate Leakage Current
FET gate leakage current of ≤0.5 nA.

High-Frequency Adjustments

☐ 7. Check/Adjust 80-MHz System Response.
7A. Adjust High-Frequency Compensation
≤ + and — 3% rounding, overshoot or ringing.

Adjustment sequence:

(1A)	Preset C49, C48 and C62	Maximum front-corner rolloff on displayed pulse. Fig. 5-10B.
(1B)	Preset R64, R49 and R62	Fully counterclockwise.
(2)	Adjust R64	Optimum response; control should be near center of adjustment range. Fig. 5-10C.
(3)	Adjust R49 then C49	Readjust alternately for optimum response. Fig. 5-10D.
(4)	Adjust C48	Optimum response. Fig. 5-10E.
(5)	Adjust C62 then R62	Readjust alternately for fastest rise; may be slightly overpeaked. Fig. 5-10F.
(6)	Repeat steps (4) and (5)	Optimum response; do not overpeak. Fig. 5-10G.
(7)	Recheck step (3)	Optimum response.
(8)	Recheck step (4)	
(9)	Recheck step (5)	

Recheck for ≤3% rounding, ringing or overshoot.

7B. Check Risetime
≤1.5 ns risetime, calculated from system risetime.

7C. Check Flatness
≤2% deviation from flat top on a 100-Hz square wave.

☐ 8. Check/Adjust 50-Ohm Sampling System Response
8A. Adjust High-Frequency Compensation
≤ + and — 4% rounding, overshoot or ringing.

Ⓐ

Adjustment sequence:

(1)	Set LOAD switch to EXT; do not preset compensation controls.	System should previously have been compensated on 80-MHz system.
(2)	Repeat 7A step (3)	Fig. 5-10D
(3)	Repeat 7A step (4)	Fig. 5-10E
(4)	Repeat 7A step (5)	Fig. 5-10F
(5)	Repeat 7A step (6)	Fig. 5-14D

Recheck for $\leq$4% rounding, overshoot or ringing.

8B. Check Risetime
$\leq$1.5 ns risetime.

☐ 9. Check Probe Noise at 230 MHz
Probe noise of $\leq$1.5 mV, determined from trace width.

CHECK AND CALIBRATION PROCEDURE

The following procedure is arranged in a sequence that permits calibration of the P6045 with a minimum of adjustment interaction. When using the procedure for checking performance only, do all of the procedure except those sub-steps that specifically require the adjustment of calibration controls. Each adjustment step provides a check of the particular characteristic before the adjustment is made.

When performing a complete recalibration of the probe, best overall performance will be obtained if each adjustment is made to the exact setting, even if the observed performance is within the allowable tolerance. To make only the control adjustments without completely checking performance of the probe, do only the Adjust steps. The symbol ⬮ is provided to help locate those steps. Any during the omitted steps must be noted and performed if necessary. If any adjustment steps are done individually or out of sequence, subsequent steps may also need to be checked, since some adjustments affect the calibration of others. Do not preset any internal calibration adjustments unless they are known to be significantly out of adjustment. In this case, set the particular controls to midrange.

To identify the two test oscilloscopes used in this procedure, the 80-MHz oscilloscope with its plug-in unit (items 1 and 2) will be referred to as the HF test oscilloscope and the lower-frequency test oscilloscope with its plug-in units (items 3 and 4 or 5) will be referred to as the differential test oscilloscope or the sampling oscilloscope, depending on whether the differential plug-in unit or the sampling plug-in unit is used.

Equipment used in the following procedure is that listed under Equipment Required. If substitute equipment is used, connections and control settings may need to be modified to correspond to the characteristics of the equipment.

PRELIMINARY PROCEDURE

1. Install the high-frequency plug-in unit in the high-frequency test oscilloscope.

2. Install the differential amplifier plug-in unit in the lower-frequency test oscilloscope.

3.[1] Remove the cover from the amplifier section of the probe, then reconnect the front and rear sections of the amplifier box. This procedure is illustrated in the Maintenance section.

NOTE

All of the procedure except step 1 (Thermal Drift Zero Adjustment) can be performed by removing the adjustment window cover instead of the amplifier cover. See the Maintenance section for removal of the adjustment window cover.

4. Install the P6045 Probe amplifier box on the Channel A input connector of the differential amplifier unit.

5. Carefully remove the enclosing barrel from the head of the probe as described in the Maintenance section. (This step may be omitted for a performance check procedure.)

6. Connect the P6045 Probe power cable to the probe power supply unit.

7. Set LOAD switch SW65 in the P6045 Probe amplifier box to the INT position (see Fig. 5-3A). This provides an internal 50-ohm load for the probe output.

8. Connect the test instruments and the probe power supply to the power line.

9. Turn on the test instruments and allow them to warm up for specified warm-up period.

10. By means of the temperature-control system, adjust the temperature of the P6045 probe head to +25° C (+77° F). Keep the probe head at this temperature for at least 2 minutes. If the probe barrel was not removed in step 5, keep the probe head at +25° C for at least 5 minutes.

11. Check the DC balance of the two test oscilloscopes after the warm-up period.

12. Set the instrument controls as given following Fig. 5-2.

[1]**Omit this step if only a performance check is being done.**

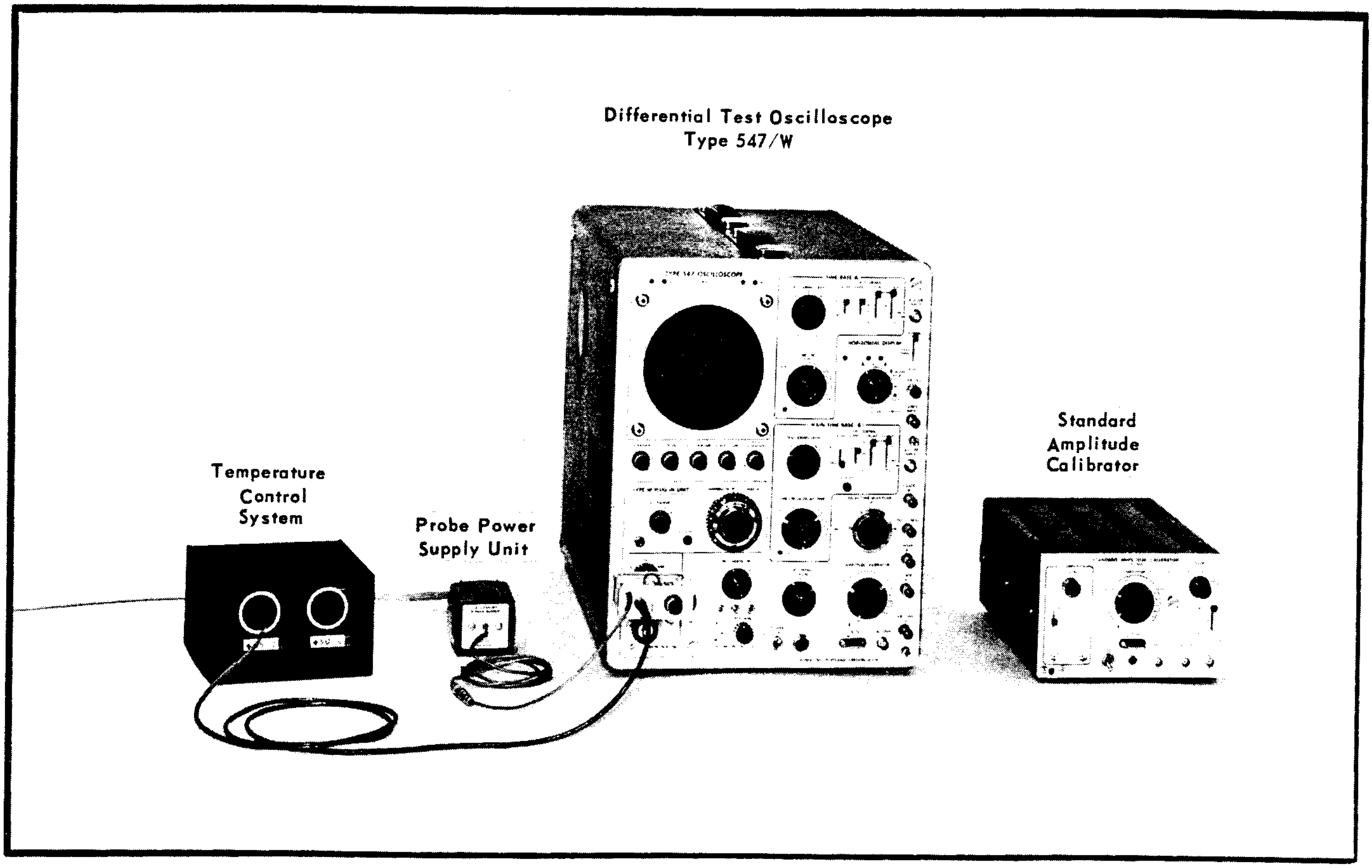


Fig. 5-2. Initial test equipment setup.

Control Settings

Differential Test Oscilloscope	
Horizontal Display	A
Sweep Magnifier	Off
Triggering	Auto + AC Norm
Triggering Level	Clockwise
Time/Cm	.2 ms
Variable Time/Cm	Calibrated
Vertical Display	A—Vc
Vc Range	0
Comparison Voltage	5.000
Input Atten	1
Millivolts/Cm	10
Variable Millivolts/Cm	Calib
Position	Centered
Channel A Input Coupling	Gnd
Channel B Input Coupling	Gnd

1. Adjust Thermal Drift Zero R10 ⓿

Requirement—DC drift of $\leq$0.5 mV per °C from +25° C to +50° C.

a. Adjust the differential oscilloscope Intensity control for a trace of normal brightness and position the start of the trace to the left edge of the CRT graticule with the Horizontal Position control.

b. Position the trace to the center horizontal line of the differential test oscilloscope CRT screen with the vertical unit Position control.

c. Check that the temperature of the probe head is +25° C.

d. Set the differential unit Input Coupling switch to DC.

e. With the P6045 OFFSET control (located on the probe amplifier box), reposition the trace to the center horizontal line of the graticule.

f. Increase the temperature of the probe tip to +50° C (+122° F) by means of the temperature-control system. Maintain the +50° C temperature of the probe tip for at least 2 minutes (or for at least 5 minutes if the probe barrel was not removed).

g. Set the differential unit Input Coupling switch to Gnd.

h. Check that the CRT trace is at the center horizontal line of the graticule. Readjust the differential unit Position control if necessary.

i. Set the Channel A Input Coupling switch to DC.

j. Check—Test oscilloscope trace that is within 1.25 cm of the center horizontal line of the graticule (see Fig. 5-3B). This represents a DC drift of no more than 0.5 mV per °C over the temperature range from +25° C to +50° C.

k. Note the exact amount of shift caused by the thermal change if the shift exceeded 1.25 cm.

l. Adjust—R10 Thermal Drift Zero (see Fig. 5-3A) to move the trace position approximately 6 times as far as

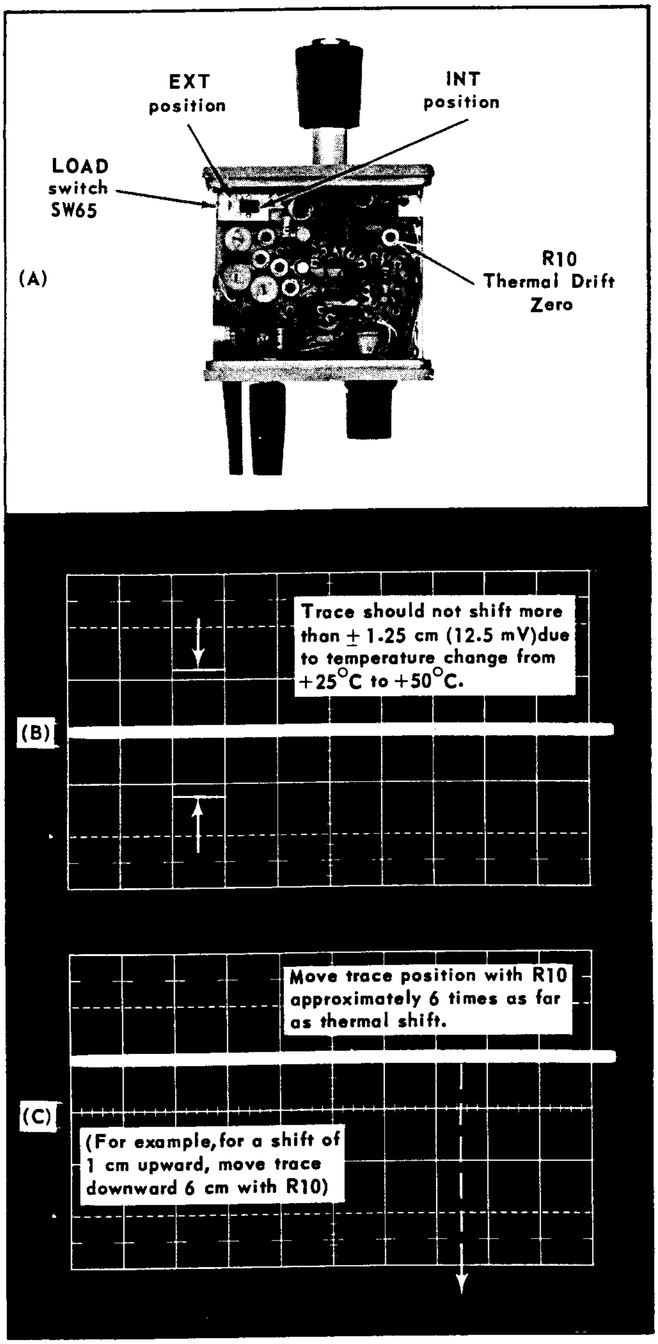


Fig. 5-3. (A) Location of LOAD switch and R10 Thermal Drift Zero adjustment; (B) Differential oscilloscope display for checking Thermal Drift Zero; (C) Typical display for adjusting R10.

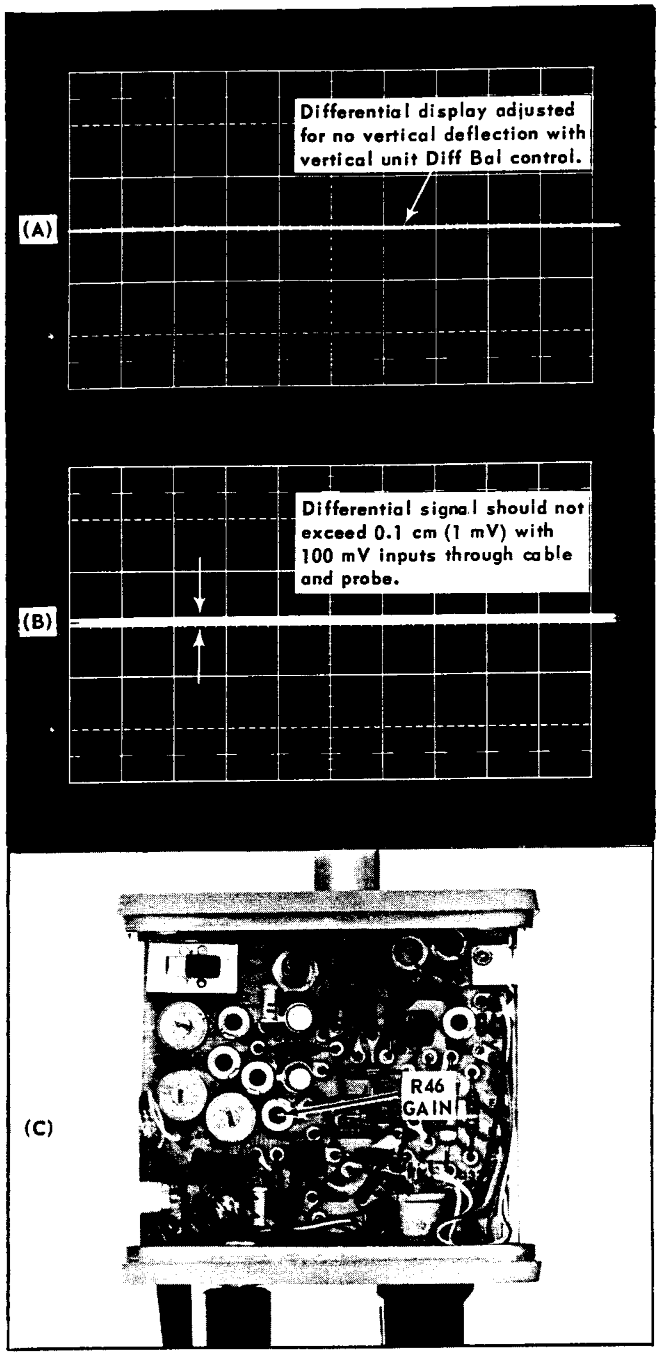


Fig. 5-4. (A) Typical differential oscilloscope display for setting differential balance; (B) Display for checking P6045 Gain adjustment; (C) Location of R46 (Gain) control.

the shift noted in step k, and in the opposite direction from that shift. For example, if the trace shifted upward 1 cm, R10 should be adjusted to move the trace downward by 6 cm (see Fig. 5-3C). (This would be most easily accomplished by moving the trace with the P6045 OFFSET control to the top graticule line, then adjusting R10 to move the trace downward the required 6 cm).

m. If R10 required adjustment in the previous step, cool the probe head to +25° C, then repeat steps e through l. This procedure may need to be repeated once or twice if R10 was initially very far out of adjustment.

n. Temporarily disconnect the probe power cable from the power supply unit.

o. Replace the probe barrel on the probe head and tighten it securely by hand.

p. Reconnect the probe power cable to the power supply unit.

2. Adjust Gain R46 ⓿

Requirement—Input-to-output gain within 1% of ×1 (unity).

a. Temporarily remove the P6045 amplifier box from the input of the differential test oscilloscope.

b. Set the differential oscilloscope vertical unit Display switch to A—B.

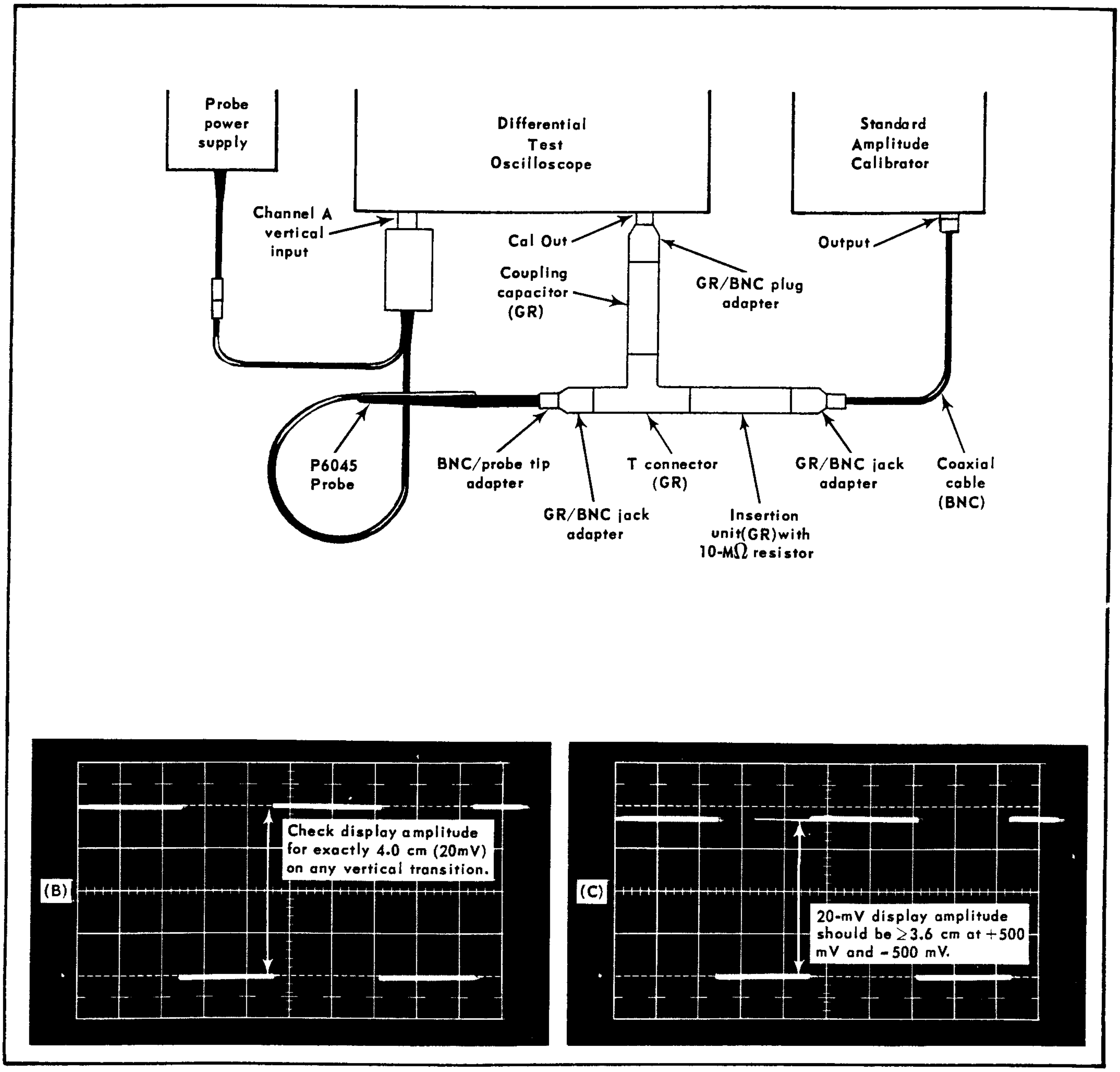


Fig. 5-5. (A) Connections for checking signal compression at ±500 mV DC offset; (B) Typical differential oscilloscope display for checking display amplitude, prior to checking P6045 dynamic range; (C) Typical display of 20 mV signal at +500 mV or —500 mV offset.

c. Set the standard amplitude calibrator for a 0.1 V square-wave output.

d. Install a T connector on the output of the standard amplitude calibrator and connect coaxial cables from the T connector to the Channel A and Channel B inputs of the differential oscilloscope.

e. Set the Channel B Input Coupling switch to DC.

f. Adjust the differential unit Diff Bal control if necessary for zero signal amplitude on the CRT screen (Fig. 5-4A).

g. Remove the coaxial cable from the Channel A input of the oscilloscope and from the T connector.

h. Install the BNC to probe-tip adapter on the T connector from which the cable was just removed.

i. Install the P6045 Probe amplifier box on the Channel A Input connector of the differential oscilloscope.

j. Insert the probe tip into the probe-tip adapter on the standard amplitude calibrator output.

k. Adjust the P6045 OFFSET control to position the trace to the center horizontal line of the oscilloscope screen.

l. Check—Test oscilloscope trace that has no more than 0.1 cm (1 mV) of signal amplitude (see Fig. 5-4B). This indicates an input-to-output gain of the probe within 1% of ×1 (unity).

m. Adjust R46 Gain (see Fig. 5-4C) for zero deflection if the display is not correct.

n. Remove the probe tip from the probe-tip adapter.

3. Check Dynamic Range

Requirement—DC plus peak AC amplitude of at least +500 mV to —500 mV at probe output; $\leq$10% compression at limits of dynamic range.

a. Set the differential test oscilloscope vertical Display switch to A—Vc and the Millivolts/Cm switch to 5.

b. Disconnect the T connector, the probe-tip adapter and the coaxial cable from the standard amplitude calibrator and the differential test oscilloscope Channel B input.

c. Set the test oscilloscope calibrator for a 20-mV square-wave output.

d. Connect the P6045 Probe tip to the calibrator signal and to the standard amplitude calibrator output as shown in Fig. 5-5A.

e. Set the differential unit Channel A Input Coupling switch to Gnd.

f. Position the oscilloscope trace to the center horizontal graticule line with the differential unit Position control.

g. Temporarily set the standard amplitude calibrator for a zero-volt output (Off).

h. Set the differential unit Channel A Input Selector switch to DC.

i. With the P6045 OFFSET control, center the oscilloscope display on the CRT screen.

j. Trigger the CRT display.

k. Check that the vertical deflection of the displayed signal is exactly 4.0 cm on any vertical segment of the waveform (see Fig. 5-5B). If necessary, adjust the differential unit Variable Millivolts/Cm control and/or Millivolts/Cm switch to obtain exactly 4.0 cm of deflection (20 mV). The horizontal portions of the waveform may have some slope due to the coupling capacitor.

l. Set the standard amplitude calibrator for a +DC voltage output and set the output amplitude to 1 Volt. This offsets the signal to the probe tip by +500 mV ±5%.

m. Set the differential unit Vc Range switch to +1.1.

n. Center the CRT display with the P6045 OFFSET control.

o. Check—Test oscilloscope display of the calibrator waveform with 3.6 cm or more of vertical deflection (see Fig. 5-5C). This represents signal compression of no more than 10% at +500 mV.

p. Set the standard amplitude calibrator for a —DC output of 1 volt.

q. Set the differential unit Vc Range switch to —1.1.

r. Center the display with the P6045 OFFSET control.

s. Check—Test oscilloscope display of the calibrator waveform with 3.6 cm or more of vertical deflection (see Fig. 5-5C). This represents no more than 10% compression at —500 mV.

t. Reset the differential unit Vc Range switch to 0.

u. Disconnect the probe tip from the probe-tip adapter and disassemble the signal connections used in this step.

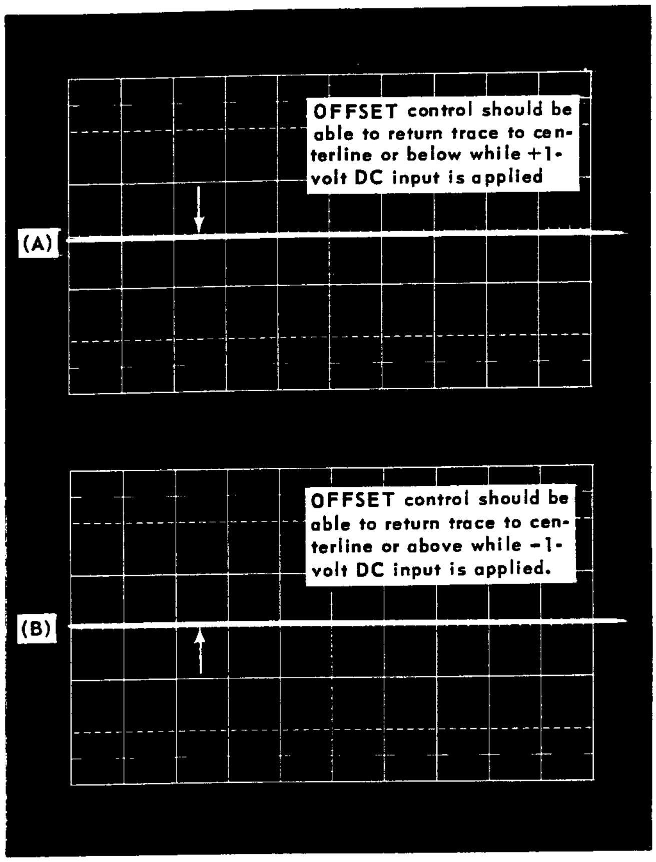


Fig. 5-6. Typical differential test oscilloscope displays for checking the P6045 OFFSET control range.

4. Check DC Offset Range

Requirement—DC offset capability of at least +1 volt to —1 volt.

a. Install the probe-tip adapter directly on the output of the standard amplitude calibrator.

b. Insert the tip of the P6045 into the probe-tip adapter.

c. Set the standard amplitude calibrator for a +DC output of 1 volt.

d. Set the differential unit Channel A Input Coupling switch to Gnd and the Millivolts/Cm switch to 10.

e. With the differential unit Position control, reposition the CRT trace to the center horizontal line of the graticule.

f. Set the Channel A Input Coupling switch to DC.

g. Turn the P6045 OFFSET control counterclockwise and observe the test oscilloscope screen.

h. Check—OFFSET control range that permits the CRT trace to be repositioned to the center horizontal graticule line (or below it). See Fig. 5-6A.

i. Set the standard amplitude calibrator for a —DC output of 1 volt.

j. Turn the P6045 OFFSET control clockwise and observe the test oscilloscope screen.

k. Check—OFFSET control range that permits the CRT trace to be repositioned to the center horizontal graticule line (or above it). See Fig. 5-6B.

l. Remove the P6045 probe tip from the probe-tip adapter.

m. Remove the probe-tip adapter from the standard amplitude calibrator output.

5. Check Probe Noise at 8 MHz

Requirement—Probe noise $\leq$400 μV, determined from trace width.

a. Connect the BNC to probe-tip adapter to a 50-ohm termination (not connected to any instrument).

b. Insert the P6045 probe tip into the adapter to ground the probe tip through 50 ohms.

c. Set the differential unit Millivolts/Cm switch to 1 and the Channel A Input Coupling switch to AC.

d. Set the P6045 OFFSET control to midrange.

e. Position the oscilloscope trace to the center horizontal graticule line with the differential unit Position control.

f. Check—Test oscilloscope display with no more than 0.44 cm (440 μV) of trace width (see Fig. 5-7A). This represents P6045 Probe noise of 400 μV or less at the bandwidth of the oscilloscope (8 MHz at 1 mV/Cm), determined as described in Table 2-2.

6. Check Gate Leakage Current

Requirement—FET gate leakage current of $\leq$0.5 nA.

a. Set the differential unit Millivolts/Cm switch to 5 and the Input Coupling switch to DC.

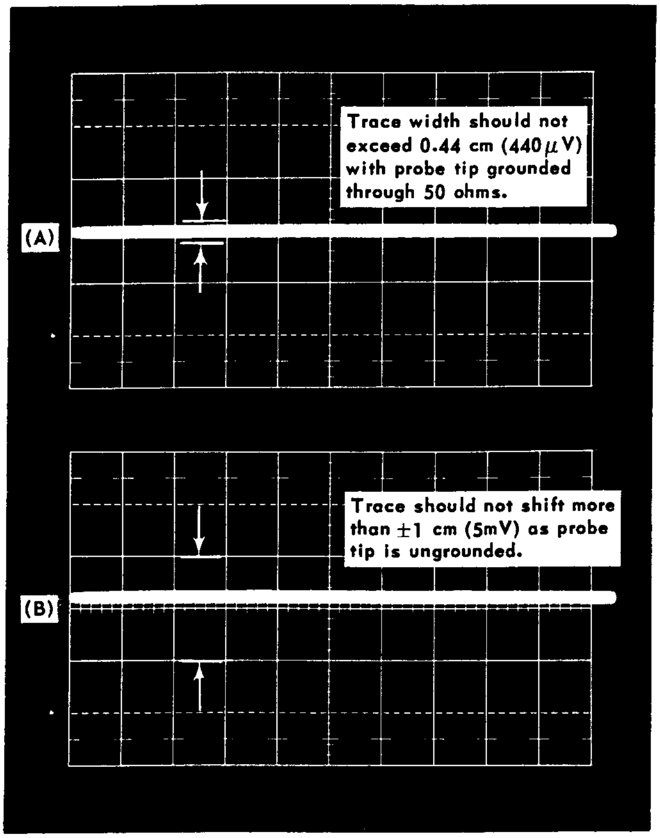


Fig. 5-7. (A) Typical differential oscilloscope display obtained when checking display noise at 8 MHz; (B) Display for checking FET gate leakage current.

b. Position the test oscilloscope trace to the center horizontal line with the P6045 OFFSET control.

c. Disconnect the probe-tip adapter from the 50-ohm termination. (Leave the probe tip in the adapter.)

d. Check—Differential oscilloscope display with no more than $\pm$1 cm (5 mV) of vertical shift of the trace (see Fig. 5-7B). This indicates a gate leakage current of $\leq$0.5 nA in the FET circuit.

e. Remove the probe from the probe-tip adapter.

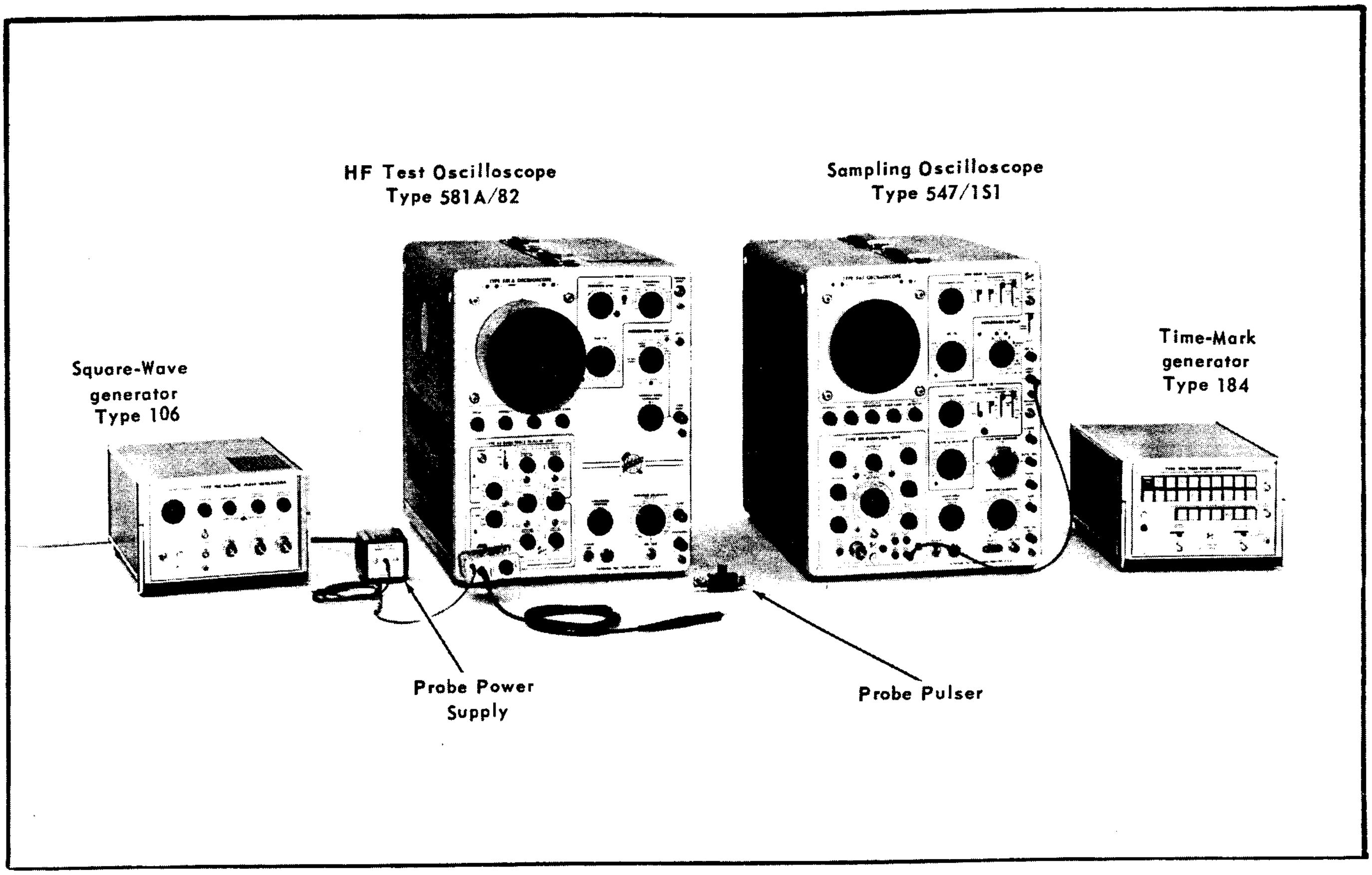


Fig. 5-8. Initial test equipment setup for steps 7 through 9.

High-Frequency Adjustments

Preliminary Setup

a. Remove the P6045 amplifier box from the input connector of the differential oscilloscope and install it on the Channel B input of the HF oscilloscope.

b. Turn off the differential test oscilloscope, remove the differential plug-in unit and install the sampling unit in the oscilloscope.

c. Connect a patch cord from the sampling unit Horiz Output connector to the external Horiz Input of the test oscilloscope.

d. Set the instrument controls as given following Fig. 5-8.

e. Turn on the sampling test oscilloscope and allow it to warm up for about 1 minute.

f. Position the trace onto the CRT screen with the oscilloscope Horizontal Position control and the sampling unit DC offset control.

g. Adjust the oscilloscope Ext Horiz Input Var 10-1 control to produce approximately 10.5 cm of trace length on the CRT screen. (If a trace length of 10.5 cm cannot be obtained with the Horizontal Display switch at Ext ×10, set the switch to Ext ×1 and adjust the Var 10-1 control for a 10.5-cm trace length.)

h. Adjust the sampling unit Samples/Cm control for a continuous trace.

i. Install the viewing hood or polarized viewer on the graticule bezel of the HF test oscilloscope.

Control Settings

HF Test Oscilloscope

Horizontal Display	Internal Sweep
5× Magnifier	Off
Triggering Source	Int AC
Trigger Slope	+
Stability	Clockwise
Triggering Level	Clockwise
Time/Cm	.2 ms
Variable Time/Cm	Calibrated
Channel A V/Cm	.1
Channel B V/Cm	.1
Mode	B Only
Gain	×1
Channels A and B	
Variable Volts/Cm	Cal
Polarity	Norm
Input Coupling	DC

Sampling Oscilloscope

Horizontal Display	Ext ×10
Var 10-1	Clockwise
Crt Cathode Selector	Chopped Blanking
Millivolts/Cm	100
Variable Millivolts/Cm	Cal
Vert Position	Centered
DC Offset	Midrange

Time/Cm	5 ns
Time Position Range	Locked to Time/Cm
Smoothing	Clockwise (Norm)
Samples/Cm	Centered
Trigger Sensitivity	Clockwise
Recovery Time	Counterclockwise
Trigger Source	Int +
Display Mode	Normal
Manual Scan	Any Position
Variable Time/Cm	Cal
Time Position	Clockwise
Time Position Fine	Centered

7. Check/Adjust 80-MHz System Probe Response

Requirements—≤ + and − 3% rounding, overshoot or ringing; ≤1.5 ns risetime, calculated from system risetime (4.65 ns); ≤2% deviation from flat top on a 100-Hz square wave.

NOTE

If the probe is to be used with a 50-ohm sampling system, perform steps 7 and 8, excluding step 7B. If the probe is to be used with an 80 MHz to 300 MHz high-impedance system and if it is not necessary to have an accurate check of the probe risetime, perform only step 7. If step 8 is performed, a readjustment of the transient response will be required for use with the 80-300 MHz system.

7A. Adjust High-Frequency Compensation ❶

(1). Install the probe pulser on the Calibrator Output connector of the HF test oscilloscope or the sampling oscilloscope.

(2). With the pulser bias control knob turned fully counterclockwise, set the amplitude calibrator for a 100-volt square-wave output.

(3). Insert the P6045 probe tip into the pulser output.

(4). With the P6045 OFFSET control position the free-running display of the feed-through calibrator waveform near the bottom of the CRT graticule (see Fig. 5-9A).

(5). Observe the HF test oscilloscope display while turning the probe pulser bias control slowly clockwise until the pulse amplitude suddenly increases to approximately 3 cm (see Fig. 5-9B). Leave the pulser bias control at this setting for the following high-frequency compensation checks and adjustments.

(6). Set the HF oscilloscope Time/Cm switch to 0.5 μs.

(7). Trigger the test oscilloscope display.

(8). Adjust the Variable Volts/Cm control to obtain 2.5 cm of vertical deflection on the pulse rise (see Fig. 5-9C). It may be necessary to increase the oscilloscope intensity.

(9). Temporarily set the test oscilloscope Channel B Input Coupling switch to Gnd.

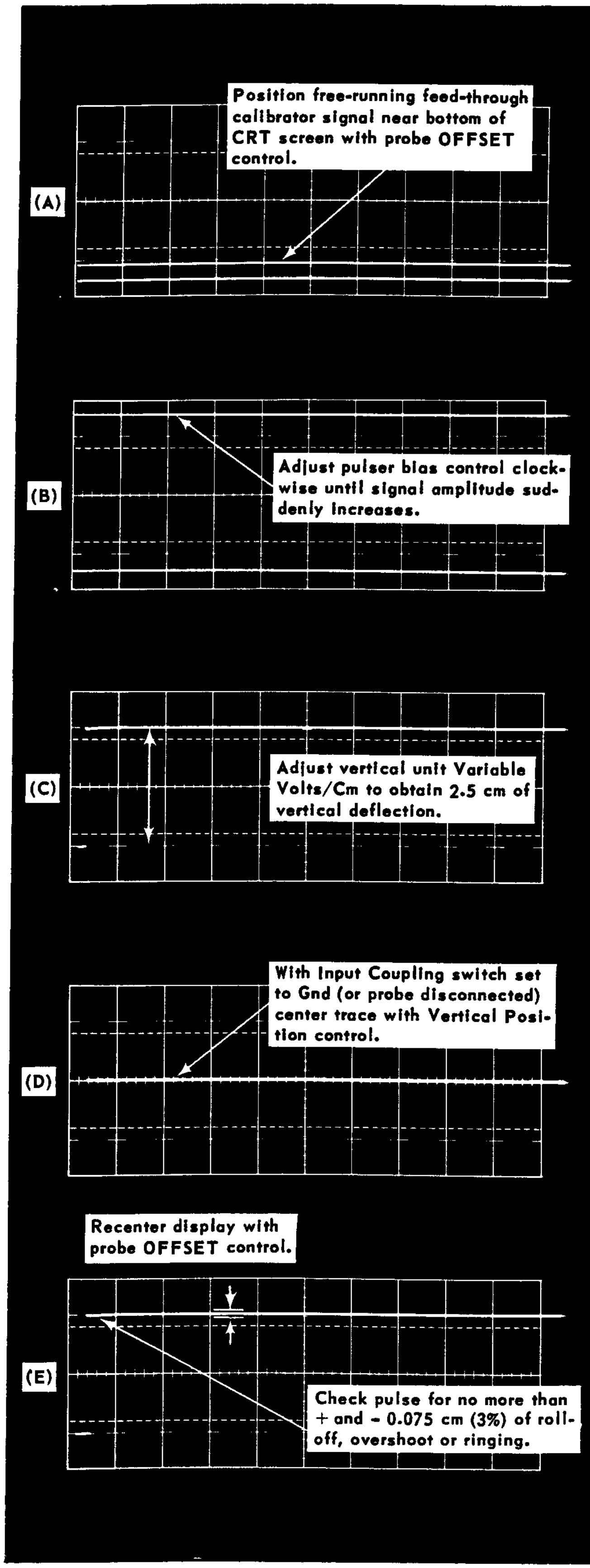


Fig. 5-9. Typical HF test oscilloscope displays for checking high-frequency response of the P6045.

(10). Decrease the oscilloscope intensity, free run the trace and check that the trace level is at the center horizontal graticule line. If not, move the trace to that position with the Channel B Position control (see Fig. 5-9D).

(11). Set the Input Coupling switch to DC, increase the oscilloscope intensity and retrigger the display on the pulse rise.

(12). Adjust the probe OFFSET control to center the pulse rise vertically on the CRT screen (see Fig. 5-9E).

(13). Check—Test oscilloscope display of the pulse with no more than 0.075 cm (3%) of rounding, overshoot or ringing following the pulse rise (see Fig. 5-9D).

(14). If there is more than the specified amount of aberrations on the pulse top, the entire group of high-frequency compensation controls must be readjusted. The sequence of the adjustments is very important and must be performed as given in the following steps.

(15). Refer to Fig. 5-10A and preset the high-frequency controls as follows:

(a). Set the test oscilloscope sweep rate to 0.1 μs/Cm and adjust C49, C48 and C62 for maximum rolloff of the front corner of the pulse (see Fig. 5-10B).

(b). Preset R64, R49 and R62 fully counterclockwise.

(16). Set the test oscilloscope sweep rate to 0.5 μs/Cm.

(17). Adjust R64 for the best possible appearance of the pulse corner (see Fig. 5-10C). R64 should be near the center of its adjustment range. If not, the remainder of the adjustments may not be adjusted correctly.

(18). Set the test oscilloscope sweep rate to 0.1 μs/Cm.

(19). Adjust R49, then C49 for best appearance of the front corner and top of the pulse. Readjust these two controls alternately until the appearance of the corner is satisfactory (see Fig. 5-10D).

(20). Adjust C48 for best appearance of the pulse corner (see Fig. 5-10E).

(21). Set the test oscilloscope sweep rate to 0.05 μs/Cm.

(22). Adjust C62, then R62 for fastest rise of the pulse corner. Readjust these two controls alternately to obtain the fastest possible rise on the pulse (see Fig. 5-10F). There may be a slight spike at the front corner.

(23). Set the test oscilloscope Time/Cm switch to 0.1 μs and turn on the 5× Magnifier.

(24). At this sweep rate, repeat the adjustments given in steps (20) and (22) to obtain a waveform similar to that shown in Fig. 5-10G.

(25). Turn off the 5× Magnifier.

(26). Recheck steps (19) through (22) to optimize the waveshape, but do not overpeak the front corner in step (22). This completes the adjustment procedure.

(27). Set the sweep rate to 0.5 μs/Cm.

(28). Check—Test oscilloscope display of the pulse with no more than + and — 0.075 cm (3%) of rounding, overshoot or ringing following the pulse rise (see Fig. 5-9E).

(29). If there is still more than the specified amount of aberrations on the pulse, repeat the entire adjustment procedure, starting with step (15). Do not try to improve the response by readjusting just two or three of the controls.

7B. Check Risetime

Omit this step if the risetime check with the sampling system (step 8B) is going to be performed.

(1). Set the HF test oscilloscope sweep rate to 0.05 μs/Cm and turn on the 5× Magnifier.

(2). Position the pulse rise on the CRT screen with the test oscilloscope Horizontal Position control. The vertical unit Variable Volts/Cm control should be set to produce 2.5 cm of vertical deflection (see Fig. 5-11A).

(3). Position the pulse rise on the CRT graticule as shown in Fig. 5-11B to check risetime.

(4). Check—Test oscilloscope display of the pulse rise with a system risetime of 4.65 ns (0.465 cm) or less (see Fig. 5-11B), indicating a probe risetime of 1.5 ns or less. This probe risetime determination is based on the following assumptions:

The HF test oscilloscope risetime (with plug-in unit) is exactly 4.38 ns; the probe pulser risetime is exactly 0.50 ns and the following relation holds for this system:

$$Tr_{probe} = \sqrt{(Tr_{display})^2 - (Tr_{oscilloscope})^2 - (Tr_{pulser})^2}$$

where Tr is risetime.

NOTE

Since the CRT display probably cannot be read to the accuracy required here and since most of the values assumed for risetimes of other components of the system are probably not correct for the system being used, this measurement should be considered only an approximation. The check is included here only to detect any gross error in the probe risetime. To obtain a valid measurement of risetime, an oscilloscope with a risetime of 1 ns or less must be used.

(5). Disconnect the P6045 probe tip from the pulser. Leave the pulser connected to the calibrator output.

7C. Check Flatness

(1). Set the HF test oscilloscope Time/Cm switch to 5 ms and the vertical unit Variable Volts/Cm control to the Calib position. Turn off the 5× Magnifier.

(2). Install a 50-ohm termination on the fast-rise + output of the square-wave generator (Type 106) by means of a GR/BNC adapter.

(3). Install the BNC to probe-tip adapter on the termination.

(4). Insert the P6045 probe tip into the probe-tip adapter.

(5). Set the square-wave generator for a 100-Hz output signal.

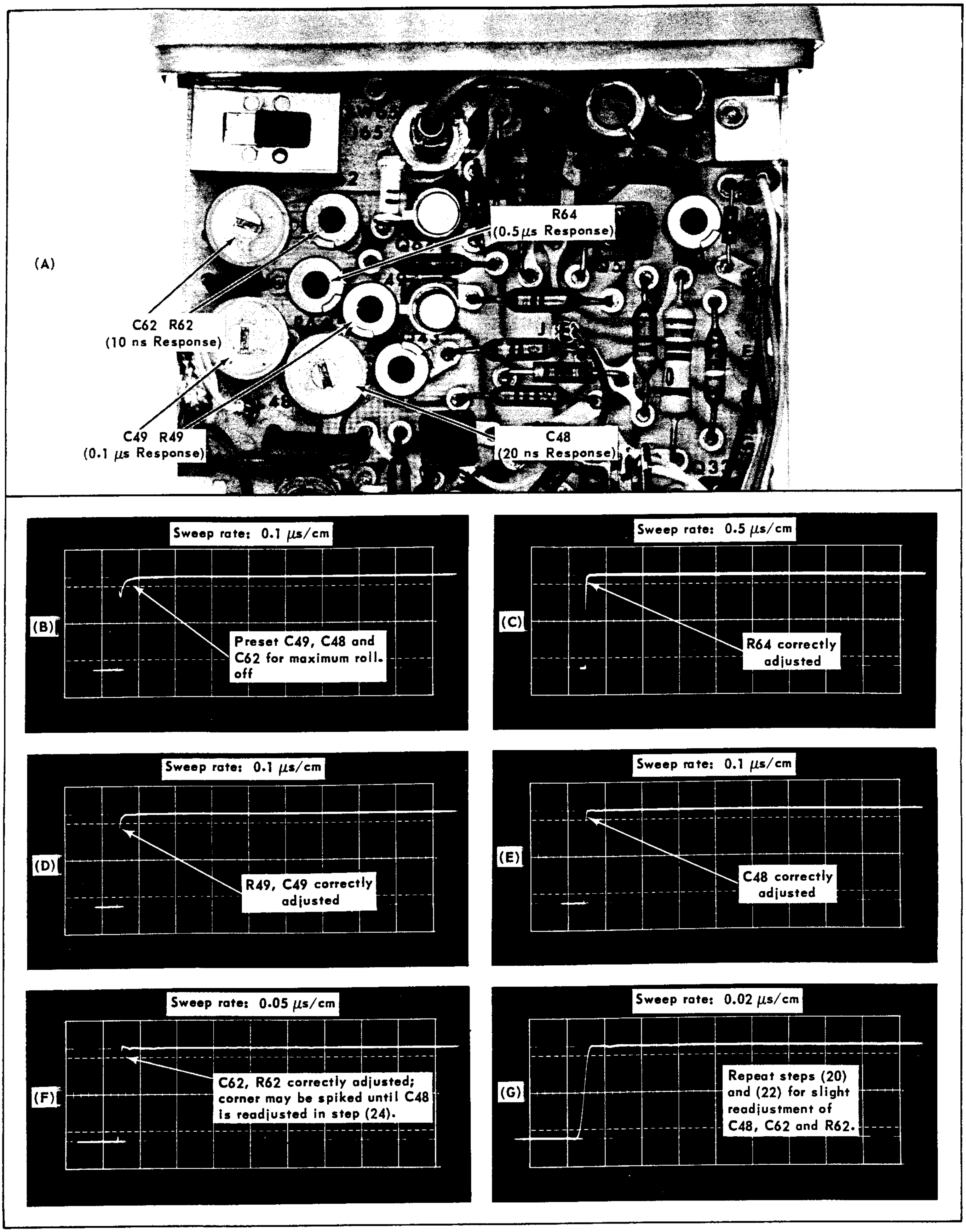


Fig. 5-10. (A) Location of high-frequency compensation adjustments; (B) through (G) Typical displays for adjusting compensation (see text).

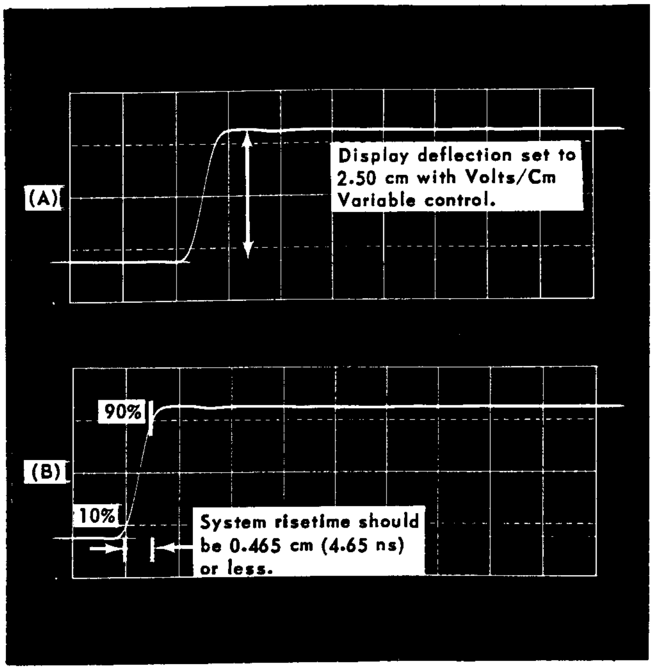


Fig. 5-11. Typical HF test oscilloscope displays for checking system risetime.

(6). Adjust the output amplitude of the square-wave generator to produce 3 cm of vertical deflection on the CRT screen (see Fig. 5-12A).

(7). Set the HF test oscilloscope Channel B Input Coupling switch to Gnd and free run the trace.

(8). Check that the CRT trace is at the center horizontal line of the graticule. Readjust the Channel B Position control if necessary (see Fig. 5-12B).

(9). Set the Channel B Input Coupling switch to DC and retrigger the trace.

(10). Adjust the probe OFFSET control to center the display vertically on the CRT screen.

(11). Check—HF test oscilloscope display of the 100-kHz square-wave pulse with no more than 0.06 cm (2%) of deviation from a flat response on the pulse top (see Fig. 5-12C).

(12). Remove the probe from the probe-tip adapter and disconnect the adapters and termination from the output of the square-wave generator.

8. Check/Adjust 50-Ohm System Response

Requirements—≤ + and — 4% rounding, overshoot or ringing; ≤1.5 ns risetime, calculated from system risetime (1.62 ns).

8A. Adjust High-Frequency Compensation ⓿

(1). Remove the P6045 Probe amplifier box from the Input connector of the HF oscilloscope and install it on the sampling unit input by means of a BNC/GR adapter.

(2). Set the P6045 LOAD switch to the EXT position (see Fig. 5-13).

(3). Insert the probe tip into the pulser on the calibrator output. (If the pulser bias control was not changed from its previous setting, it should not require readjustment).

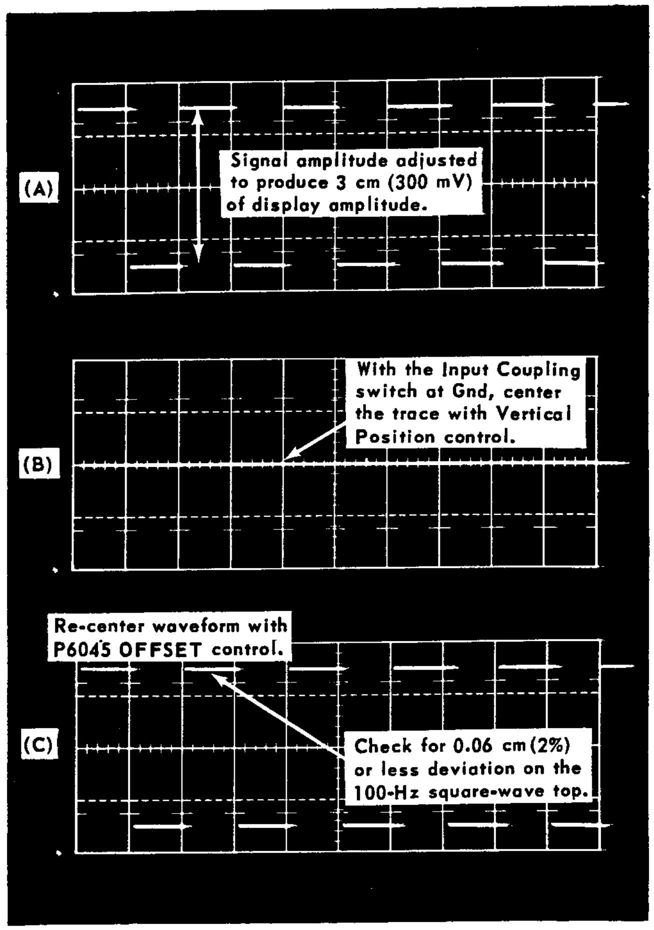


Fig. 5-12. Typical HF test oscilloscope displays for checking flatness with a 100-Hz square-wave.

(4). Trigger the sampling oscilloscope display. The oscilloscope Intensity control may need to be readjusted to observe the triggered display.

(5). With the sampling oscilloscope DC Offset and Time Position controls, position the pulse rise onto the CRT screen.

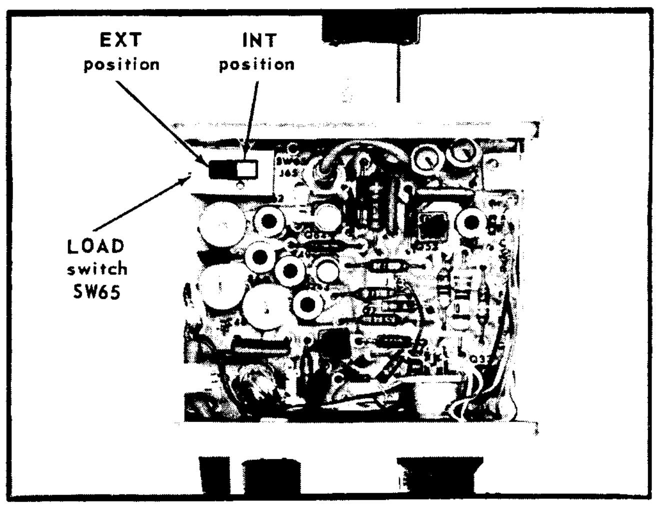


Fig. 5-13. Location of LOAD switch in the probe amplifier box. Set the switch to the EXT position for operation with the 50-ohm sampling system.

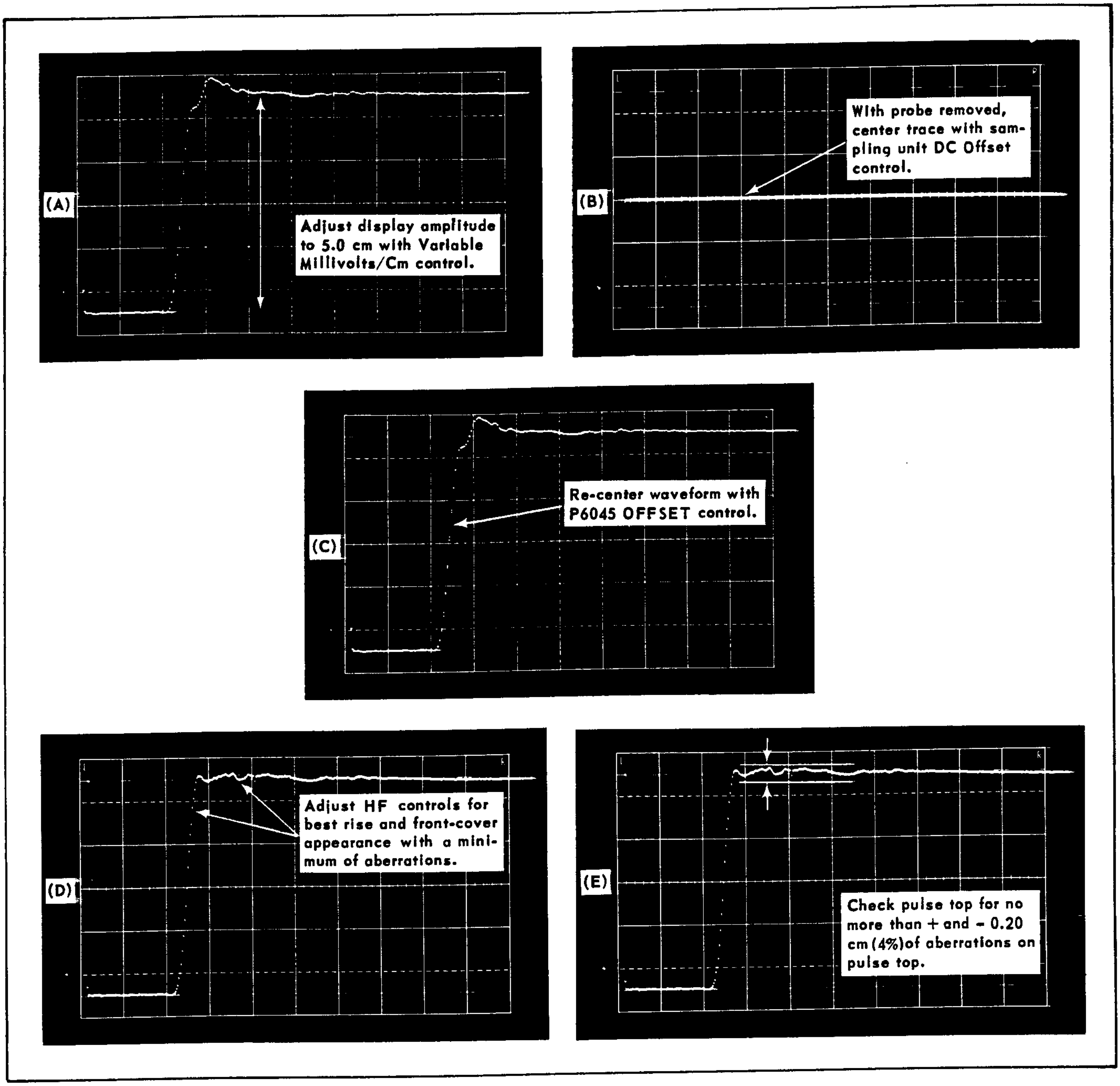


Fig. 5-14. Typical sampling oscilloscope displays for checking or adjusting high-frequency compensation on the 50-ohm system.

(6). Adjust the sampling unit Variable Millivolts/Cm control to obtain 5 cm of vertical deflection on the pulse rise (see Fig. 5-14A). There will probably be some aberrations on the pulse corner if transient response was adjusted on the 80-MHz system, due to the different response of the probe into the two oscilloscope systems.

(7). Temporarily disconnect the P6045 Probe from the sampling unit input and set the unit for a free-running trace.

(8). Check the DC level of the trace. Adjust the sampling unit DC Offset control if necessary to position the trace at the center horizontal graticule line (see Fig. 5-14B).

(9). Reconnect the probe to the sampling unit input.

(10). Trigger the sampling oscilloscope display and adjust the probe OFFSET control to recenter the pulse vertically on the CRT screen (see Fig. 5-14C).

(11). Adjust—High frequency compensation adjustments as described in steps 7A(18) through 7A(24) to obtain a pulse display similar to that shown in Fig. 5-14D.

NOTE

This partial readjustment of the high-frequency adjustments in normal when transferring the probe from a high-impedance system to a 50-ohm sampling system.

(12). Set the sampling unit sweep rate to 0.5 μs/Cm.

(13). Check—Sampling oscilloscope display of the pulse with no more than + and — 0.20 cm (4%) of rounding, overshoot or ringing following the top of the pulse rise (see Fig. 5-14E).

8B. Check Risetime

(1). Set the sampling unit Time/Cm switch to 0.5 ns.

(2). With the Time Position control, center the pulse rise on the CRT screen.

(3). Temporarily disconnect the P6045 amplifier box from the sampling unit input.

(4). Connect the HF time-mark output through a 50-ohm termination (or a 2X attenuator), a coaxial cable and a BNC/GR adapter to the sampling oscilloscope vertical input. Set the time-mark generator for a 2-ns sine-wave output signal.

(5). Trigger the sampling unit and check the CRT display for exactly 1 cycle per 4 cm of horizontal deflection over the center 8 cm of the graticule (see Fig. 5-15A). Adjust the sampling oscilloscope Horiz Input Var 10-1 control if the display is not correct.

(6). Disconnect the time-mark signal from the adapter at the sampling oscilloscope vertical input.

(7). Free run the sampling oscilloscope trigger and recenter the trace with the sampling unit DC Offset control.

(8). Re-install the P6045 amplifier box on the adapter. The probe tip should still be connected to the pulser.

(9). Position the pulse rise on the sampling oscilloscope CRT screen as shown in Fig. 5-15B with the probe OFFSET control and the sampling unit Time Position control. Do not change the setting of the sampling unit DC offset or Position controls.

(10). Check—Sampling oscilloscope display of the pulse rise with a system risetime of 1.62 ns (3.24 cm) or less, indicating a probe risetime of 1.5 ns or less. The equation given in step 7B is assumed to apply here, the pulser risetime is assumed to be exactly 0.50 ns and the sampling system risetime is assumed to be 0.35 ns.

(11). Disconnect the probe tip from the pulser.

9. Check Probe Noise at 230 MHz

Requirement—Probe noise of ≤ 1.5 mV, determined from trace width.

a. Temporarily disconnect the P6045 Probe from the sampling unit input.

b. Set the sampling unit Millivolts/Cm switch to 2, the Millivolts/Cm Variable control to the Cal position and the Trigger Source switch to Free Run.

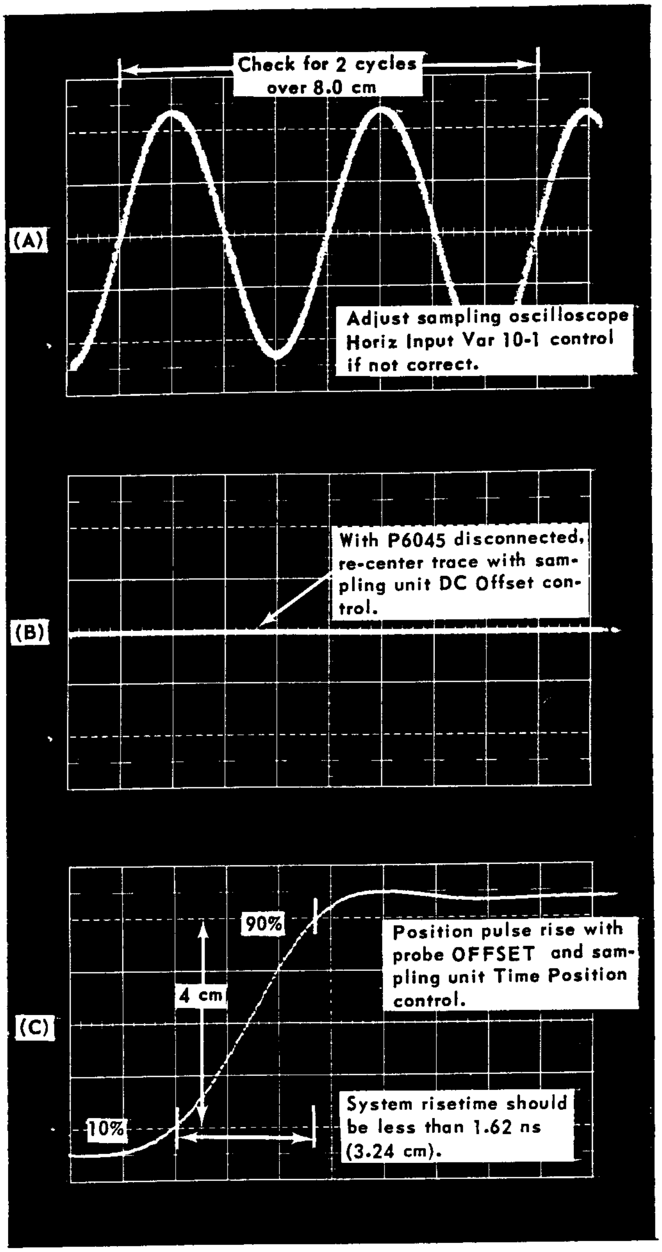


Fig. 5-15. Typical sampling oscilloscope displays for checking risetime: (A) Preliminary timing check; (B) Setting input level to zero; (C) Check of system risetime.

c. Position the trace to the center horizontal graticule line with the sampling unit DC Offset control.

d. Set the sampling unit Time Position control to a point on the time window that has a minimum of inherent system aberrations.

e. Install the P6045 on the sampling unit input again.

f. Connect the BNC to probe-tip adapter to a 50-ohm termination (not connected to any instrument).

g. Insert the P6045 probe tip into the adapter to ground the probe tip through 50 ohms.

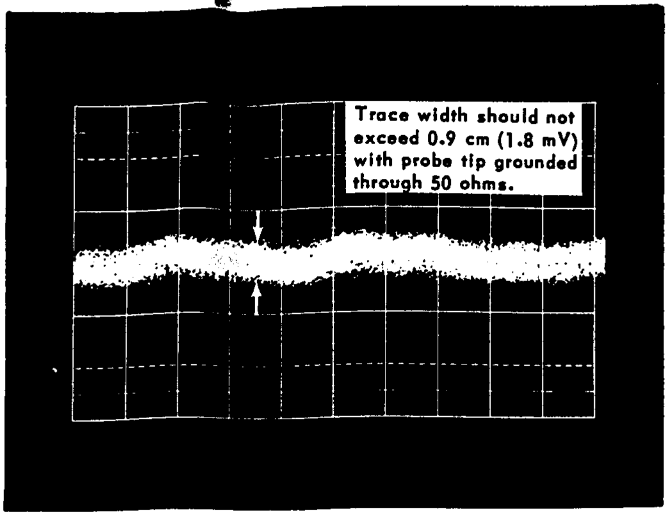


Fig. 5-16. Typical sampling oscilloscope display for checking noise at 230 MHz. (In sampling displays, the trace width is considered to contain 90% of the displayed dots.)

h. With the P6045 OFFSET control, center the trace on the CRT screen.

i. Check—Sampling oscilloscope display with no more than 0.90 cm (1.8 mV) of trace width (see Fig. 5-16). This represents P6045 Probe noise of 1.5 mV or less at the full bandwidth of the probe (230 MHz), determined as described in Table 2-2. Discount any trace aberrations that are inherent in the sampling system.

If the probe is to be used with the 50-ohm sampling system, this completes the performance check and calibration procedure. If the probe is to be used with an 80-MHz system, return the probe to the input of the HF test oscilloscope, set the internal LOAD switch to INT and perform steps 7A(7) through 7A(12) and 7A(18) through 7A(24). These steps merely readjust the compensation adjustments that were reset for the sampling system. When these readjustments have been made, the procedure is completed and the test instruments and equipment can be disconnected.

SECTION 6

PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description					S/N Range

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description					S/N Range
C1	283-0141-00	200 pF	Cer		600 V	10%	
C5	283-0138-00	1.5 pF	Cer		200 V	10%	
C9	290-0308-00	1 μF	Elect.		35 V		
C10	283-0059-00	1 μF	Cer		25 V	+80%—20%	
C12	283-0139-00	150 pF	Cer		50 V		
C15	290-0276-00	0.68 μF	Elect.		35 V	10%	
C16	283-0139-00	150 pF	Cer		50 V		
C18	283-0139-00	150 pF	Cer		50 V		
C20	283-0139-00	150 pF	Cer		50 V		
C23	290-0308-00	1 μF	Elect.		35 V		
C25	290-0272-00	47 pF	Elect.		50 V		
C30	281-0610-00	2.2 pF	Cer		200 V	±0.1 pF	
C32	283-0059-00	1 μF	Cer		25 V	+80%—20%	
C33	283-0067-00	0.001 μF	Cer		200 V	10%	
C48	281-0093-00	5.5-18 pF	Cer	Var			
C49	281-0093-00	5.5-18 pF	Cer	Var			
C51	283-0059-00	1 μF	Cer		25 V	+80%—20%	
C58	290-0272-00	47 pF	Elect.		50 V		
C60	281-0613-00	10 pF	Cer		200 V	10%	
C62	281-0092-00	9-35 pF	Cer	Var			
C64	283-0076-00	27 pF	Cer		500 V	10%	
C67	283-0067-00	0.001 μF	Cer		200 V	10%	

Diode

Ckt. No.	Tektronix Part No.	Description	S/N Range
D12	152-0127-00	Zener 1N755A 0.4 W, 7.5 V, 5%	

Connectors

Ckt. No.	Tektronix Part No.	Description	S/N Range
J30	131-0391-00	Coaxial, 50 Ω male	
P30	131-0155-00	Coaxial, 50 Ω	
J60	131-0440-00	Plug, 3 contact, male	
J65	131-0391-00	Coaxial, 50 Ω male	
P65	131-0155-00	Coaxial, 50 Ω	

Inductor

Ckt. No.	Tektronix Part No.	Description	S/N Range
LR40	*108-0411-00	0.2 mH (wound on a 27 Ω, ¼ W, 5% resistor)	

Transistors

Ckt. No.	Tektronix Part No.	Description		S/N Range
Q3	*151-1001-00	Silicon	Field Effect Tek Spec	
Q8	151-0206-00	Silicon	2SC288A	
Q13	151-0206-00	Silicon	2CS288A	
Q23	151-0206-00	Silicon	2CS288A	
Q33	151-0188-00	Silicon	2N3906	
Q34	151-0123-00	Germanium	2N976	
Q43	151-0202-00	Silicon	2N4261	
Q53	*151-0195-00	Silicon	Replaceable by MPS 6515	
Q64	*151-0109-00	Silicon	Selected from 2N918	

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R1	307-0100-00	120 kΩ	1/10 W			
R2	319-0040-00	9.9 MΩ	¼ W		Prec	2%
R5	307-0117-00	2 kΩ	1/10 W			
R7	307-0119-00	1 kΩ	1/10 W			
R9	307-0119-00	1 kΩ	1/10 W			
R10	311-0609-00	2 kΩ		Var		
R12	317-0122-00	1.2 kΩ	⅛ W			5%
R13	317-0392-00	3.9 kΩ	⅛ W			5%
R14	317-0152-00	1.5 kΩ	⅛ W			5%
R15	317-0300-00	30 Ω	⅛ W			5%
R16	307-0118-00	500 Ω	1/10 W			
R18	307-0117-00	2 kΩ	1/10 W			
R20	315-0471-00	470 Ω	¼ W			5%
R30	321-0087-00	78.7 Ω	⅛ W		Prec	1%
R33	317-0242-00	2.4 kΩ	⅛ W			5%
R34	315-0511-00	510 Ω	¼ W			5%
R35	311-0091-00	1 kΩ		Var		
R37	317-0242-00	2.4 kΩ	⅛ W			5%
R41	321-0189-00	909 Ω	⅛ W		Prec	1%
R42	322-0147-00	332 Ω	¼ W		Prec	1%
R44	321-0182-00	768 Ω	⅛ W		Prec	1%
R45	321-0207-00	1.4 kΩ	⅛ W		Prec	1%
R46	311-0609-00	2 kΩ		Var		
R48	321-0150-00	357 Ω	⅛ W		Prec	1%
R49	311-0633-00	5 kΩ		Var		
R51	321-0108-00	130 Ω	⅛ W		Prec	1%
R53	321-0231-00	2.49 kΩ	⅛ W		Prec	1%
R54	321-0186-00	845 Ω	⅛ W		Prec	1%
R56	315-0221-00	220 Ω	¼ W			5%
R58	315-0430-00	43 Ω	¼ W			5%

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R60	321-0069-00	51.1 Ω	1/8 W		Prec	1%	
R62	311-0643-00	50 Ω		Var			
R64	311-0633-00	5 kΩ		Var			
R66	322-0173-00	619 Ω	1/4 W		Prec	1%	
R67	315-0151-00	150 Ω	1/4 W			5%	
R69	321-0068-00	49.9 Ω	1/8 W		Prec	1%	

Switch

	Unwired	Wired	
SW65	260-0723-00		Slide

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
 Detail Part of Assembly and/or Component
 mounting hardware for Detail Part
  Parts of Detail Part
  mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specified.

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

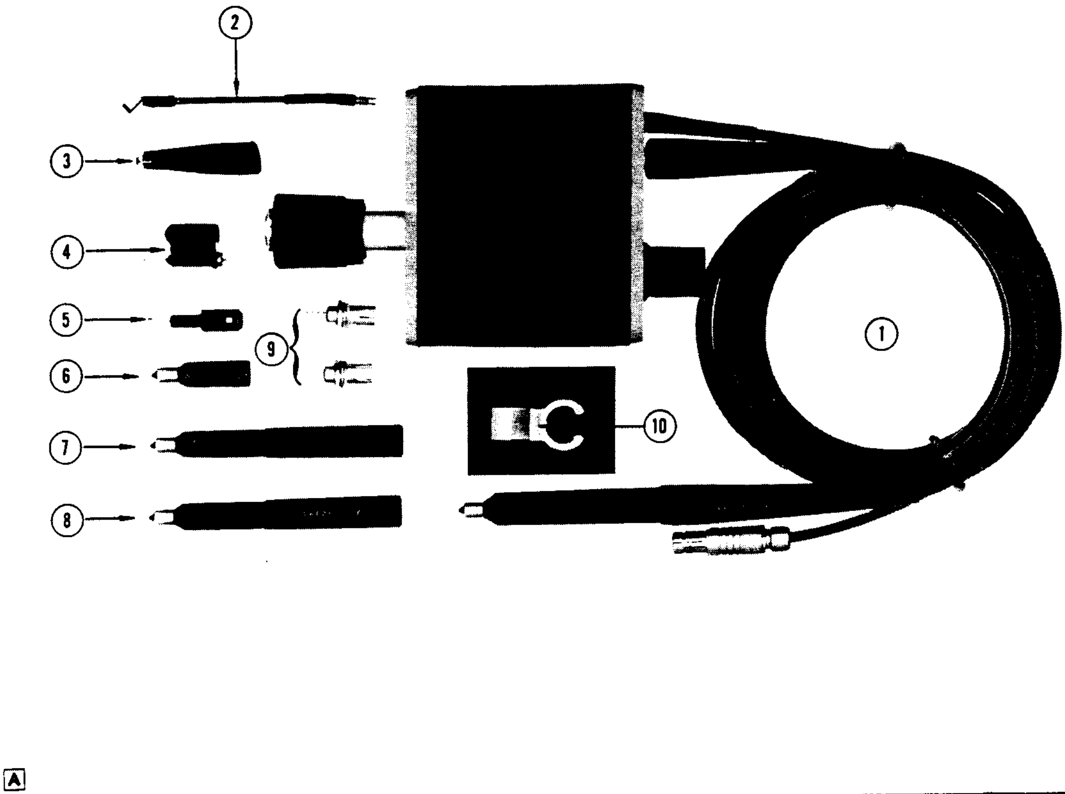
If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.
⦶	Screwdriver adjustment.
▭	Control, adjustment or connector.

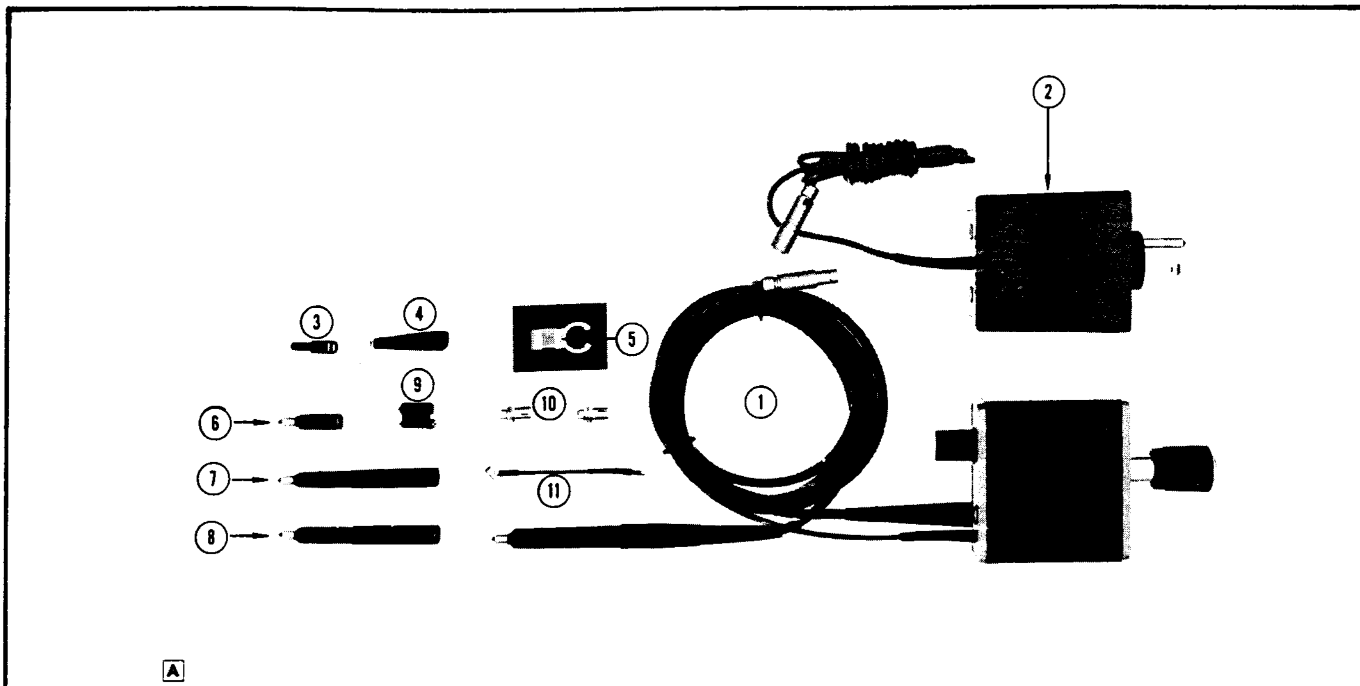
Ⓐ

PROBE PACKAGE and STANDARD ACCESSORIES



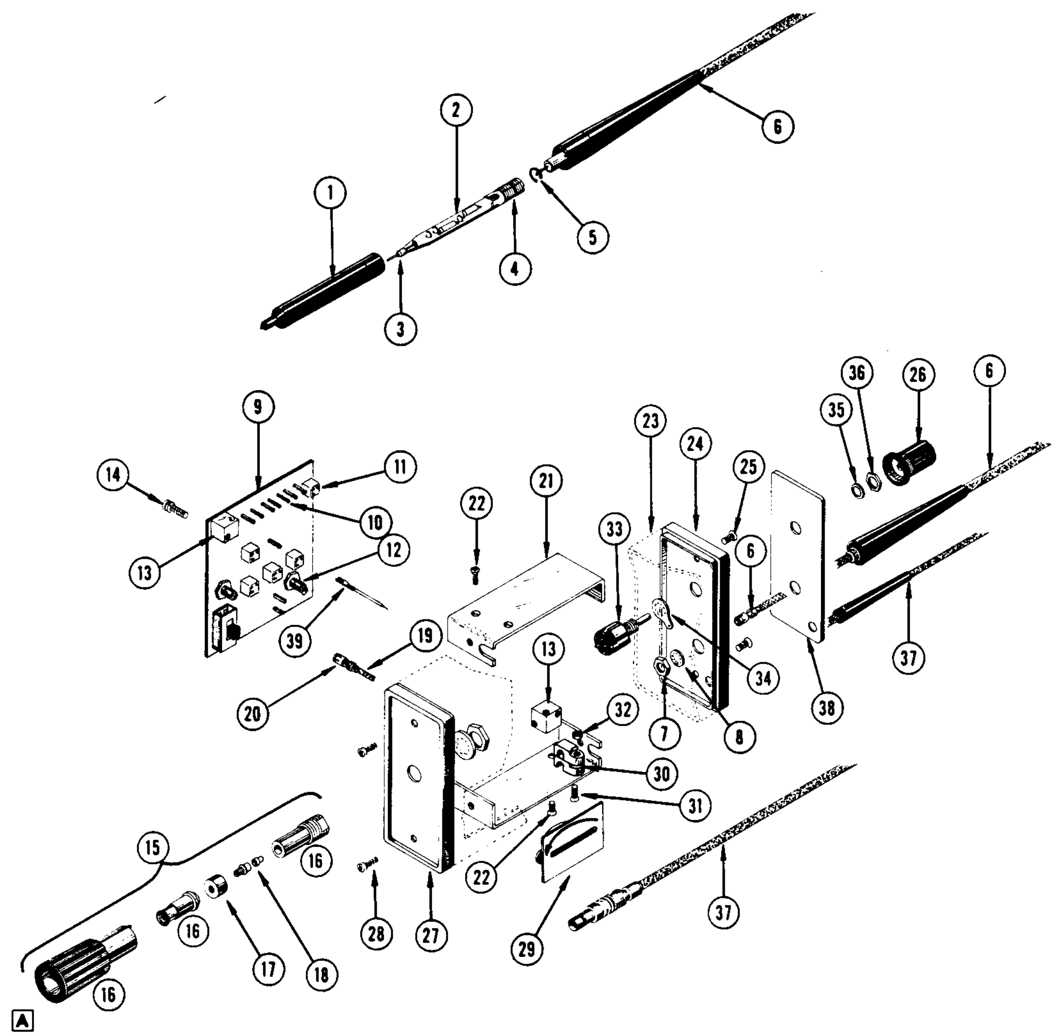
Ref. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
PROBE PACKAGE					
1-10	010-0204-00			1	PROBE PACKAGE, P6045
	- - - - - -			-	package includes:
PROBE ONLY					
1	010-0198-00				PROBE, P6045
STANDARD ACCESSORIES					
2	175-0249-00			1	CABLE, ground assembly
3	344-0046-00			1	CLIP, probe
4	013-0085-00			1	ADAPTER, bayonet ground
5	206-0114-00			1	TIP, probe, hook
6	010-0360-00			1	CAPACITOR, coupling
7	010-0358-00			1	HEAD, attenuation, 100X
8	010-0357-00			1	HEAD, attenuation, 10X
9	131-0258-00			2	CONNECTOR, test point
10	352-0090-00			1	HOLDER, probe
	016-0090-00			1	CASE, carrying (not shown)
	334-1082-00			7	TAG, calibration (not shown)
	070-0597-00			2	MANUAL, instruction (not shown)

PROBE PACKAGE and STANDARD ACCESSORIES *(cont)*



Ref. No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
PROBE PACKAGE					
1-11	010-0205-00			1	PROBE PACKAGE, P6045
	- - - - - -			-	package includes:
PROBE ONLY					
1	010-0198-00			1	PROBE, P6045
STANDARD ACCESSORIES					
2	015-0073-00			1	ACCESSORY POWER SUPPLY, probe
3	206-0114-00			1	TIP, probe, hook
4	344-0046-00			1	CLIP, probe
5	352-0090-00			1	HOLDER, probe
6	010-0360-00			1	CAPACITOR, coupling
7	010-0358-00			1	HEAD, attenuation, 100X
8	010-0357-00			1	HEAD, attenuation, 10X
9	013-0085-00			1	ADAPTER, bayonet ground
10	131-0258-00			2	CONNECTOR, test point
11	175-0249-00			1	CABLE, ground assembly
	016-0090-00			1	CASE, carrying (not shown)
	334-1082-00			7	TAG, calibration (not shown)
	070-0597-00			-	MANUAL, instruction (not shown)

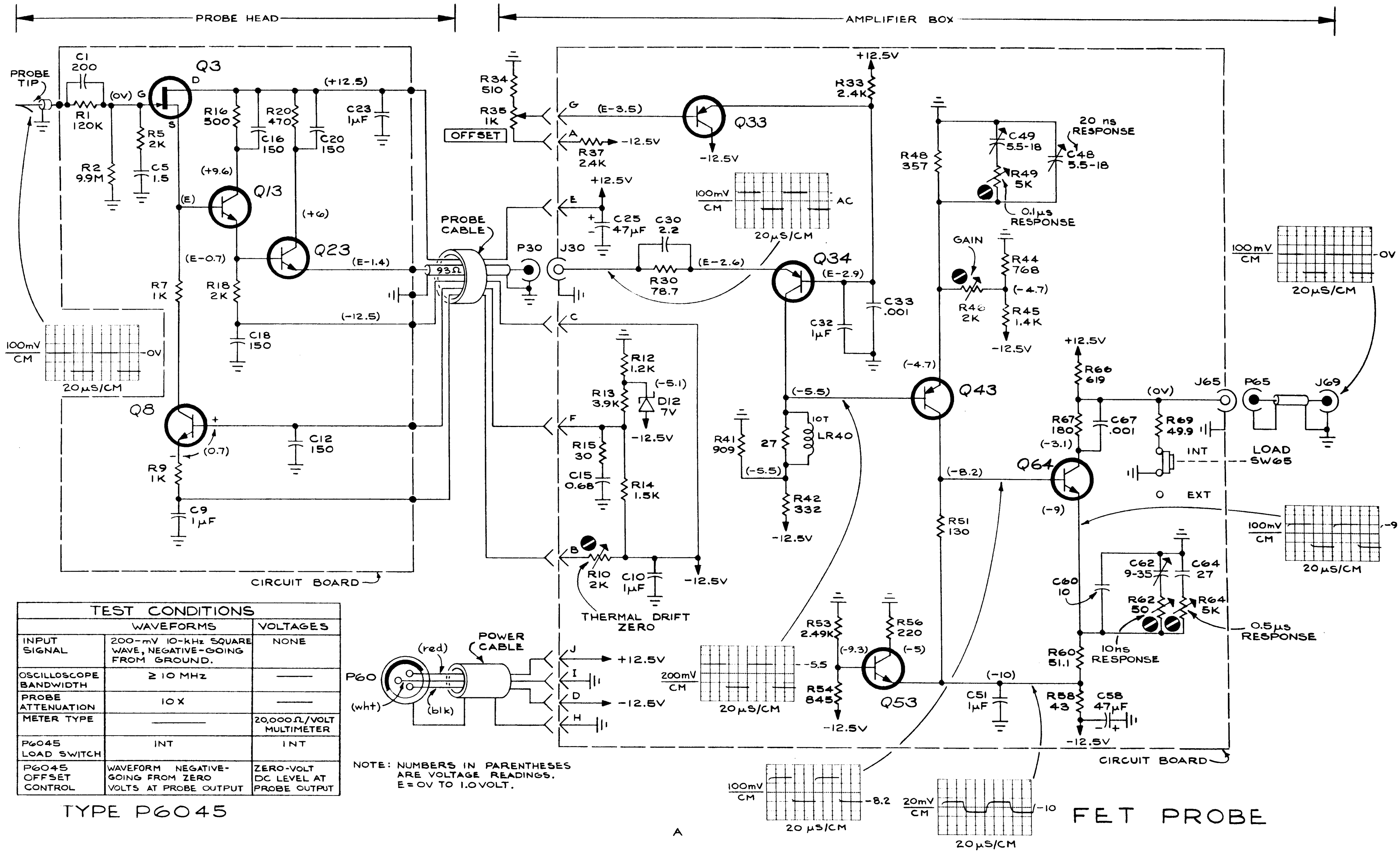
P6045 REPLACEABLE PARTS



Ref. No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
	010-0198-00			1	P6045 PROBE
	- - - - - - -			-	probe includes:
1	204-0270-00			1	BODY, probe
	175-0400-01			1	ASSEMBLY, cable, special purpose elect. (w/board)
	- - - - - - -			-	assembly includes:
2	670-0501-00			1	ASSEMBLY, circuit board
	- - - - - - -			-	assembly includes:
	388-0748-00			1	BOARD, circuit, unwired
3	206-0139-01			1	TIP, probe
4	103-0060-00			1	ADAPTER, probe to cable nipple
5	354-0292-00			1	RING, retaining, crescent shape
6	175-0400-00			1	ASSEMBLY, cable, 6 feet long, R.F.
	- - - - - - -			-	assembly includes:
	131-0371-00			4	CONNECTOR, single contact
	- - - - -			-	mounting hardware: (not included w/assembly)

P6045 REPLACEABLE PARTS *(cont)*

Ref. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
7	210-0580-00			1	NUT, hex., 3/8-24 x 5/16 inch
8	210-0048-00			1	LOCKWASHER, internal, 5/16 ID x 0.425 inch OD
9	670-0122-00			1	ASSEMBLY, circuit board
	- - - - - -			-	assembly includes:
	388-0754-00			1	BOARD, circuit, unwired
	- - - - - -			-	board includes:
10	214-0506-00			10	PIN, connector, straight
11	136-0220-00			5	SOCKET, 3 pin transistor
12	131-0391-00			2	CONNECTOR, coaxial, 50 Ω, male
13	220-0455-00			2	NUT, block
	- - - - - -			-	mounting hardware for each: (not included w/block)
14	211-0116-00			1	SCREW, 4-40 x 5/16 inch, w/washer
15	131-0464-00			1	ASSEMBLY, CONNECTOR, BNC
	- - - - - -			-	assembly includes:
16	131-0319-00			1	CONNECTOR, BNC locking
17	103-0062-00			1	ADAPTER, connector
18	131-0208-00			1	CONNECTOR, cable
19	175-0284-00			ft.	CABLE, coaxial, 50 Ω (3 3/4 inch)
20	131-0155-00			1	CONNECTOR, coaxial, minature, 50 Ω
21	407-0267-00			2	BRACKET, spacing, 2.4 x 0.83 x 0.50 inch
	- - - - - -			-	mounting hardware for each: (not included w/bracket)
22	211-0101-00			1	SCREW, 4-40 x 1/4 inch, 100° csk, FHS
23	380-0107-00			1	HOUSING, amplifier, wrap-around
24	426-0310-01			1	SUB-PANEL, front
	- - - - - -			-	mounting hardware: (not included w/sub-panel)
25	211-0105-00			2	SCREW, 4-40 x 3/16 inch, 100° csk, FHS
26	366-0225-00			1	KNOB, charcoal
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
27	426-0310-02			1	PANEL, rear
	- - - - - -			-	mounting hardware: (not included w/panel)
28	211-0065-00			2	SCREW, 4-40 x 3/16 inch, PHS
29	200-0701-00			1	COVER, access, adjust, molded
30	343-0132-00			2	CLAMP, cable, w/holding slot
	- - - - - -			-	mounting hardware: (not included w/clamps)
31	211-0115-00			1	SCREW, machine, 2-56 x 1/2 inch, OHS
32	210-0405-00			1	NUT, hex., 2-56 x 3/16 inch
33	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
34	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
35	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
36	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
37	175-0402-00			1	CABLE ASSEMBLY
	- - - - - -			-	assembly includes:
	131-0371-00			4	CONNECTOR, single contact
38	333-0952-00			1	PANEL, front
39	131-0371-00			2	CONNECTOR, single contact



TEST CONDITIONS		
	WAVEFORMS	VOLTAGES
INPUT SIGNAL	200-mV 10-kHz SQUARE WAVE, NEGATIVE-GOING FROM GROUND.	NONE
OSCILLOSCOPE BANDWIDTH	≥ 10 MHz	———
PROBE ATTENUATION	10 X	———
METER TYPE	———	20,000 Ω/VOLT MULTIMETER
P6045 LOAD SWITCH	INT	INT
P6045 OFFSET CONTROL	WAVEFORM NEGATIVE-GOING FROM ZERO VOLTS AT PROBE OUTPUT	ZERO-VOLT DC LEVEL AT PROBE OUTPUT

NOTE: NUMBERS IN PARENTHESES ARE VOLTAGE READINGS. E = 0V TO 1.0 VOLT.

TYPE P6045

A

FET PROBE

MANUAL CHANGE

Change all references to the power supply voltages from +12.5 V ±5% and -12.5 V ±5% to +12 V ±1% and -12 V ±1%.

PARTS LIST CHANGES

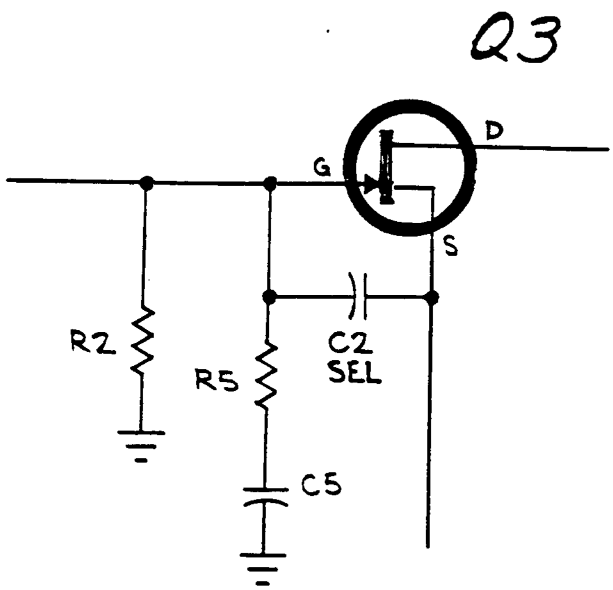
Change To:

R20	315-0431-00	430Ω	1/4w		5%
R66	322-0178-00	698Ω	1/4w	prec	1%

PARTS LIST CHANGES

ADD:

C2	Selected	length of #27 wire (175-0643-00)



PARTIAL FET PROBE

TEXT CORRECTION

The following step should be added to the Operation Instructions after "Use of Coupling Capacitor and Attenuators":

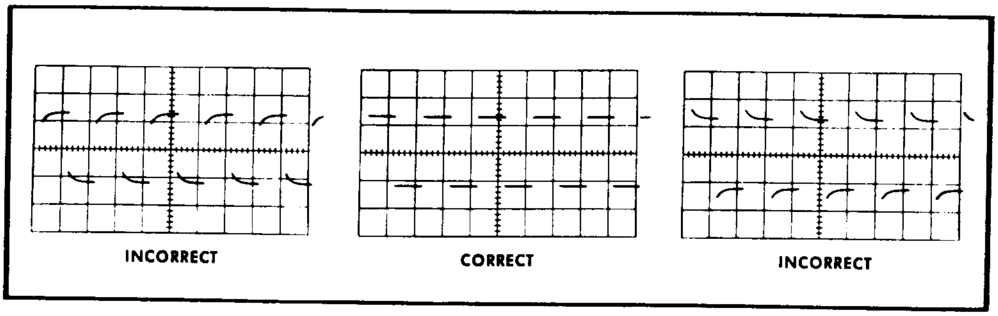
Attenuator Compensation. Each of the attenuators contains a variable capacitor to match the time constant of the attenuator to the time constant of the probe input. The following procedure should be used to compensate the attenuator.

1. Set the oscilloscope calibrator for an output of suitable amplitude.

2. Touch the probe tip to the calibrator output connector.

3. Set the sweep rate to display several cycles of the output signal.

4. Through the hole in the attenuator, rotate the variable capacitor with a small non-conducting screwdriver to obtain a flat-top presentation of the calibrator output signal. See the figure below.



Attenuator Compensation

Type P6045

TEXT CORRECTIONS

CHANGE TO:

Section 5 Performance Check and Calibration

Page 5-12, Column 1

Step (15a) should read:

Set the test oscilloscope sweep rate to 0.1 µs/cm and adjust C48, C49, C60 and C62 for maximum rolloff of the front corner of the pulse (see Fig. 5-10B).

Step (22) should read:

Adjust C60, C62, then R62 for the fastest rise of the pulse corner. Readjust these controls alternately to obtain ......

PARTS LIST CORRECTIONS

CHANGE TO:

C60	281-0123-00	5-25 pF	var		
C64	281-0528-00	82 pF	±8.2 pF	500V	cer

TYPE P6045

TEXT CORRECTION

Section 1 Characteristics

Page 1-2 ELECTRICAL CHARACTERISTICS

CHANGE: Input RC Characteristics, Supplemental Information to read:

Approximately 10 megohms paralleled by $\leq$5.5 pF (with probe only). See Figs. 1-2 and 1-3 for other input characteristics.

TYPE P6045

PARTS LIST CORRECTION

CHANGE TO:

C5	283-0066-00	2.5 pF	200 V	±20%
R5	317-0512-00	5.1 kΩ	1/8 W	±5%

M13,076/1067