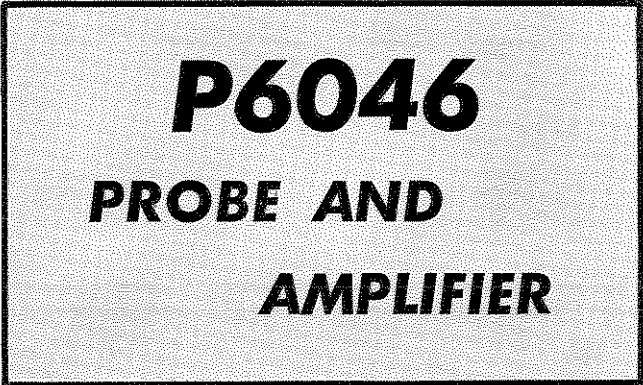


# INSTRUCTION MANUAL



**P6046**  
**PROBE AND**  
**AMPLIFIER**

*Tektronix, Inc.*

S.W. Millikan Way • P. O. Box 500 • Beaverton, Oregon 97005 • Phone 644-0161 • Cables: Tektronix  
070-0756-00



## **WARRANTY**

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial or Model Number with all requests for parts or service.

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# SECTION 1

## CHARACTERISTICS

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

### General Information

The P6046 Differential Probe is an active, dual input probe designed for use with the Tektronix Type 1A5 Differential Amplifier or the "Amplifier For P6046". High common-mode rejection ratios are provided at high frequencies by performing the common-mode rejection within the probe body. Calibrated vertical deflection factors of from 1 mV through 200 mV/division (in 1, 2, 5 sequence) can be selected by switching at the Type 1A5 or at the Amplifier for P6046. These deflection factors can be increased to ten times the indicated amount through use of a calibrated Dual Attenuator Head, which is a standard accessory to the P6046 Probe.

The Probe and Type 1A5 combination has a 45 MHz bandwidth when used with an appropriate oscilloscope. The Probe and Amplifier For P6046 combination has a 100 MHz bandwidth. This provides a 70 MHz overall system bandwidth when the Probe and Amplifier are operated into the single-ended input of any 100 MHz oscilloscope having a vertical deflection factor of 10 mV/division.

The Probe has a 5-V common-mode operating range and a 25-V maximum input which can be extended by a factor of ten through use of the Dual Attenuator Head.

### Characteristics

A summary of the P6046 Differential Probe electrical characteristics, and pertinent mechanical and environmental characteristics are contained in Table 1-1. Specifications pertain to operation with both the Type 1A5 and the Amplifier For P6046, except where noted otherwise.

Fig. 1-2, 1-3, and 1-4 contain graphs of common-mode rejection ratios (CMRR) under different equipment setups at 25°C. MINIMUM refers to the values required to meet specifications. TYPICAL indicates the approximate values which most probes will obtain.

Fig. 1-5 shows how CMRR varies as temperature deviates from 25°C. For example, if the Probe is to be operated at 20°C to test a 50 MHz circuit, the specified CMRR should be multiplied by 0.95 to determine the minimum CMRR value which may be expected.

Fig. 1-6 displays the effect that source impedance has on the gain of the Probe as a function of frequency. It can be applied to differential operation as follows: Relate the upper graph to the display amplitude ÷ input signal when the signal source impedances are matched (up to a 5:1 source impedance ratio); Relate the lower graph to the display amplitude ÷ input amplitude when the signal source impedances are greatly mis-matched.

### Accessories

A number of accessories which extend operating capabilities are supplied with the P6046 Probe and the Amplifier For P6046 as Standard Accessories. These are listed on the last page of the Mechanical Parts List.

An optional accessory which must be used during Probe calibration is listed in the Calibration section. Additional miscellaneous accessories are listed in the Tektronix catalog. All accessories can be purchased through the Tektronix Field Office.

TABLE 1-1  
CHARACTERISTICS

Characteristic	Performance Requirement at 25°C		Supplemental Information
Step Response			
With Type 1A5	Bandwidth	Risetime	
5 to 200 mV/CM	≥ 45 MHz	≤ 7.8 ns	
2 mV/CM and 20 mV/CM—Retained Range	≥ 43 MHz	≤ 8.1 ns	
1 mV/CM and 10 mV/CM—Retained Range	≥ 38 MHz	≤ 9.2 ns	
With Amplifier For P6046	Bandwidth	Risetime	
1 mV/DIV through 200 mV/DIV	≥ 100 MHz	≤ 3.5 ns	Bandwidth in 1 and 2 mV/DIV positions decreases to 90 MHz at 50°C.

**Characteristics—P6046 Probe and Amplifier**

Characteristic	Performance Requirement	Supplemental Information
Ringing, Rounding, Overshoot and Tilt With Type 1A5	$\leq \pm 4\%$ ( $\leq 6\%$ peak to peak) in first 70 ns $\leq \pm 1.5\%$ ( $\leq 2\%$ peak to peak) thereafter	Percent of deviation specification increases by 4% within the first 10 ns at 0°C and +50°C.
With Amplifier For P6046	$\leq \pm 2\%$ ( $\leq 2\%$ peak to peak) after the first 70 ns	
2 to 200 mV/DIV 1 mV/DIV	$\leq \pm 4\%$ ( $\leq 5\%$ peak to peak) in first 70 ns $\leq \pm 5\%$ ( $\leq 6\%$ peak to peak) in first 70 ns	
AC Low Frequency Response Basic (1X)	20 Hz	At 70% Voltage point (−3 dB)
With 10X Dual Attenuator Head	2 Hz	
Deflection Factor Basic (1X)	1 mV/div to 200 mV/div calibrated in 1, 2, 5 steps	1 mV/div through $\geq 500$ mV/div uncalibrated with 1A5
With 10X Dual Attenuator Head	10 mV/div to 2 V/div calibrated in 1, 2, 5 steps	10 mV/div through $\geq 5$ V/div uncalibrated with 1A5
mV/div Accuracy With Type 1A5		Within 2%; function of Type 1A5
1 mV/CM to 20 mV/CM	Within 4%	Function of Probe and Type 1A5
50 mV/CM to 200 mV/CM	Within 4%	Function of Probe and Type 1A5
With Amplifier For P6046	Within 3%	1 mV through 200 mV/DIV
Dual Attenuator Head	Within 2%	Probe and Type 1A5 or Probe and Amplifier For P6046 accuracy must also be considered
Source impedance effect on gain as a function of frequency Basic (1X)		See Fig. 1-6
With 10X Dual Attenuator Head		Typically within 1.5%
Common-Mode Operating Range DC to 10 MHz	$\pm 5$ V (DC + peak AC) from average signal level; not exceeding $\pm 5$ V with respect to ground	
10 MHz to 50 MHz	Decreasing from $\pm 5$ V (DC + peak AC) at 10 MHz to $\pm 2$ V at 50 MHz	
Linear Differential Input Range	$\pm 10$ div	
Common Mode Rejection Ratio, 25°C		Typically 100:1 at 100 MHz when used with Amplifier For P6046.
1 mV through 20 mV/div	See Fig. 1-2	See Fig. 1-5 for temperature effects
50 mV/div through 200 mV/div	See Fig. 1-3	Also pertains to 10 and 20 mV-Retained Range positions of Type 1A5
In combination with 10X Dual Attenuator Head	See Fig. 1-4	
Input Resistance	1 M $\Omega$ $\pm 1\%$	See Fig. 1-7.
Input Capacitance Probe		10 pF or less; see Fig. 1-7.
10X Dual Attenuator Head		3 pF or less
DC Thermal Drift Probe	Equivalent to $\leq 250$ $\mu$ V/°C at Probe head	
Amplifier	$\leq 200$ $\mu$ V/°C	$\leq 450$ $\mu$ V/°C combined drift of Probe and Amplifier

Characteristic	Performance Requirement	Supplemental Information		
Displayed Noise With Type 1A5	200 $\mu$ V tangentially measured	RMS value is approximately $\frac{1}{2}$ of the tangentially measured value. Peak to peak value is approximately 5.1 times RMS.		
	With Amplifier For P6046			
DC Shift Due to Overdrive	1.5% or less of input signal			
Overdrive Recovery Time With Type 1A5	0.15 $\mu$ s or less (to within 10 mV of DC shifted level)	5 V Input		
	With Amplifier For P6046			
Maximum Allowable Input	25 V total DC + Peak AC; 25 V total difference between + and - Input tips	AC or DC-coupled		
Gate Leakage Current	$\leq 0.3$ nA at 25°C	$\leq 2$ nA at 50°C		
Warm-up Time	20 minutes for rated accuracies at 25° C $\pm 5^\circ$ C			
Amplifier For P6046 Operating Voltage	90 to 136 V or 180 to 272 V AC, 48 to 400 Hz	Change power connections for range and voltage within range. See Table 4-3.		
	Temperature			
Non-operating	-40°C to +65°C			
Operating	0°C to +50°C			
Altitude Non-operating	To 50,000 feet	May be tested during Non-operating Temperature tests at -40°C		
	Operating			
Humidity Non-operating	5 cycles MIL-STD-202C, Method 106B, omitting freezing and vibration subcycles.			
Vibration Operating	15 minutes each axis at 0.015 inch. Frequency varied from 10-50-10 c/s in 1-minute cycles with instrument secured to vibration platform. Three minutes each axis at any resonant point or at 50 c/s.			
Shock Non-operating Probe Body	400 g's $\frac{1}{2}$ sine; 6 shocks along transverse axis at $\frac{1}{2}$ ms, 1 ms and 2 ms duration (total of 18 shocks); 3 additional shocks in longitudinal axis at $\frac{1}{2}$ ms, 1 ms and 2 ms (total of 9)			
Amplifier	200 g's, $\frac{1}{2}$ sine, 3 ms or 7 ms duration: 3 shocks each direction along the 3 major axes for a total of 18 shocks			
Transportation Package Vibration	1 hour at 1 g			
Package Drop	30 inches on 1 corner, all edges radiating from that corner and all flat surfaces for a total of 10 drops			
Dimensions (inches)		H	W	L
Probe Body		0.75	1	5
Cable				72
Amplifier		3.6	1.9	5
Power Supply		3.5	2.5	2.6
Power Cable				54

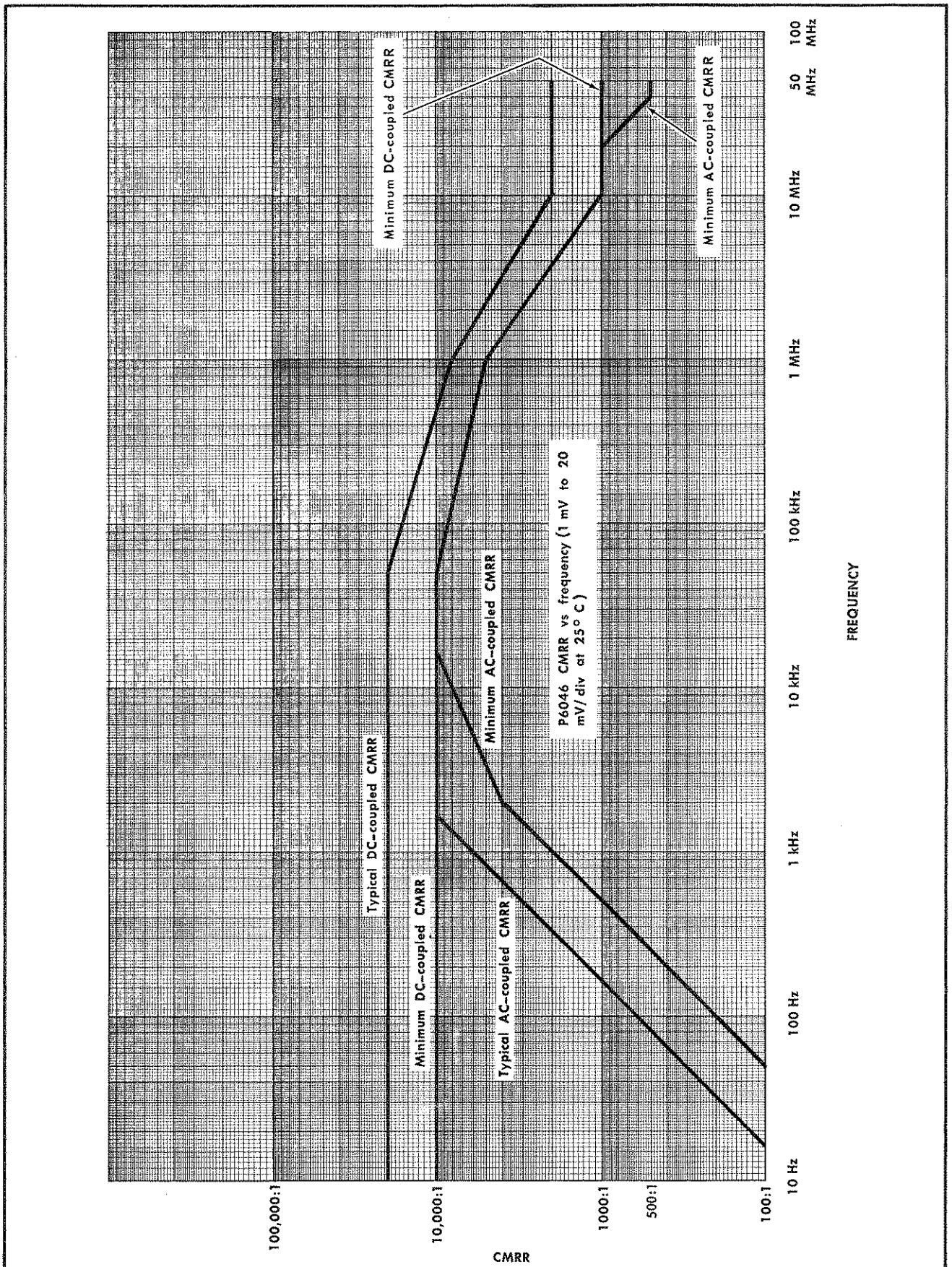


Fig. 1-2. P6046 CMRR versus frequency for 1 mV through 20 mV/division at 25° C.

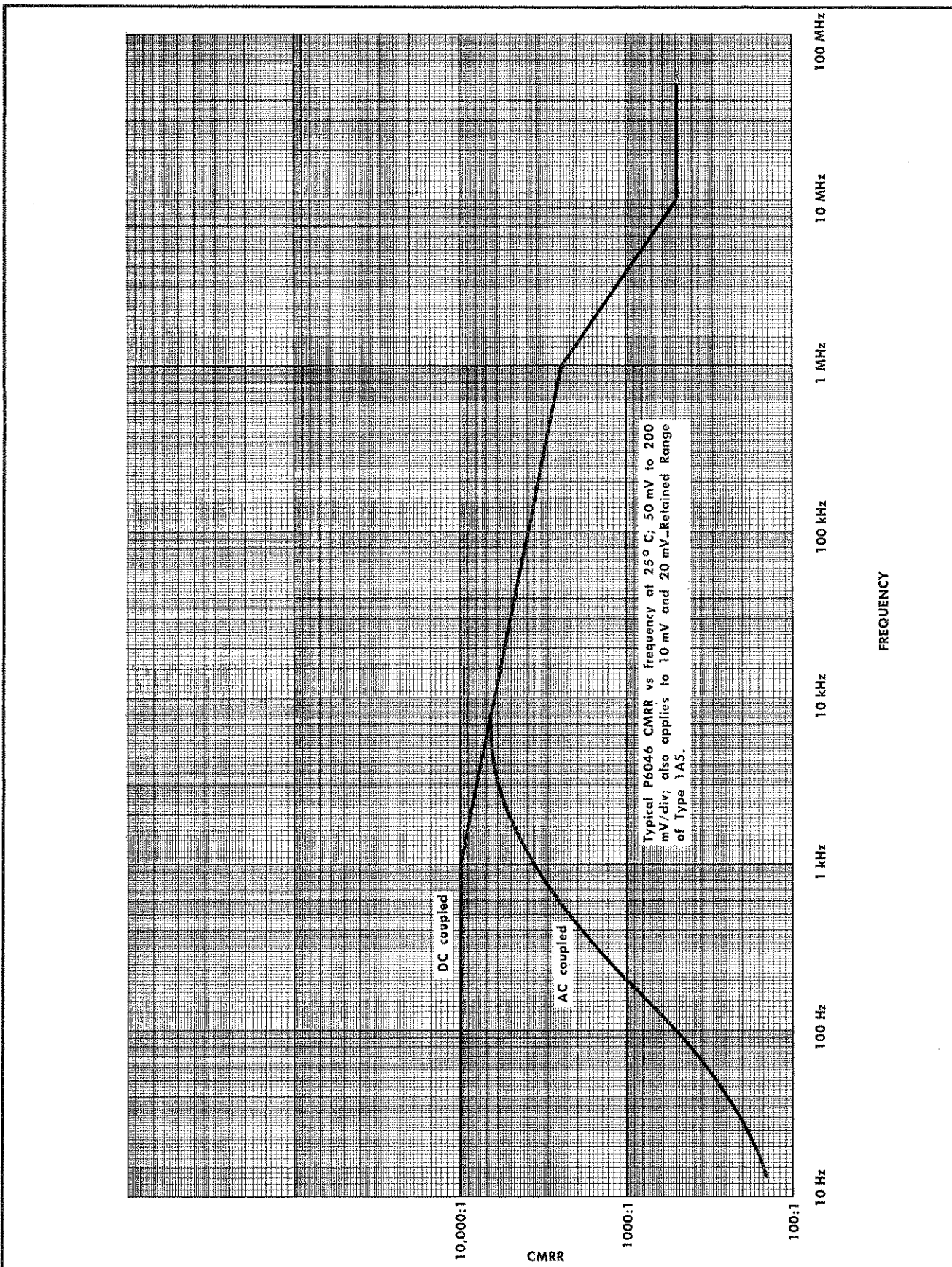


Fig. 1-3. Typical P6046 CMRR versus frequency for 50 mV through 200 mV division at 25° C. Also applies to 10 and 20 mV—Retained Range positions of Type 1A5.

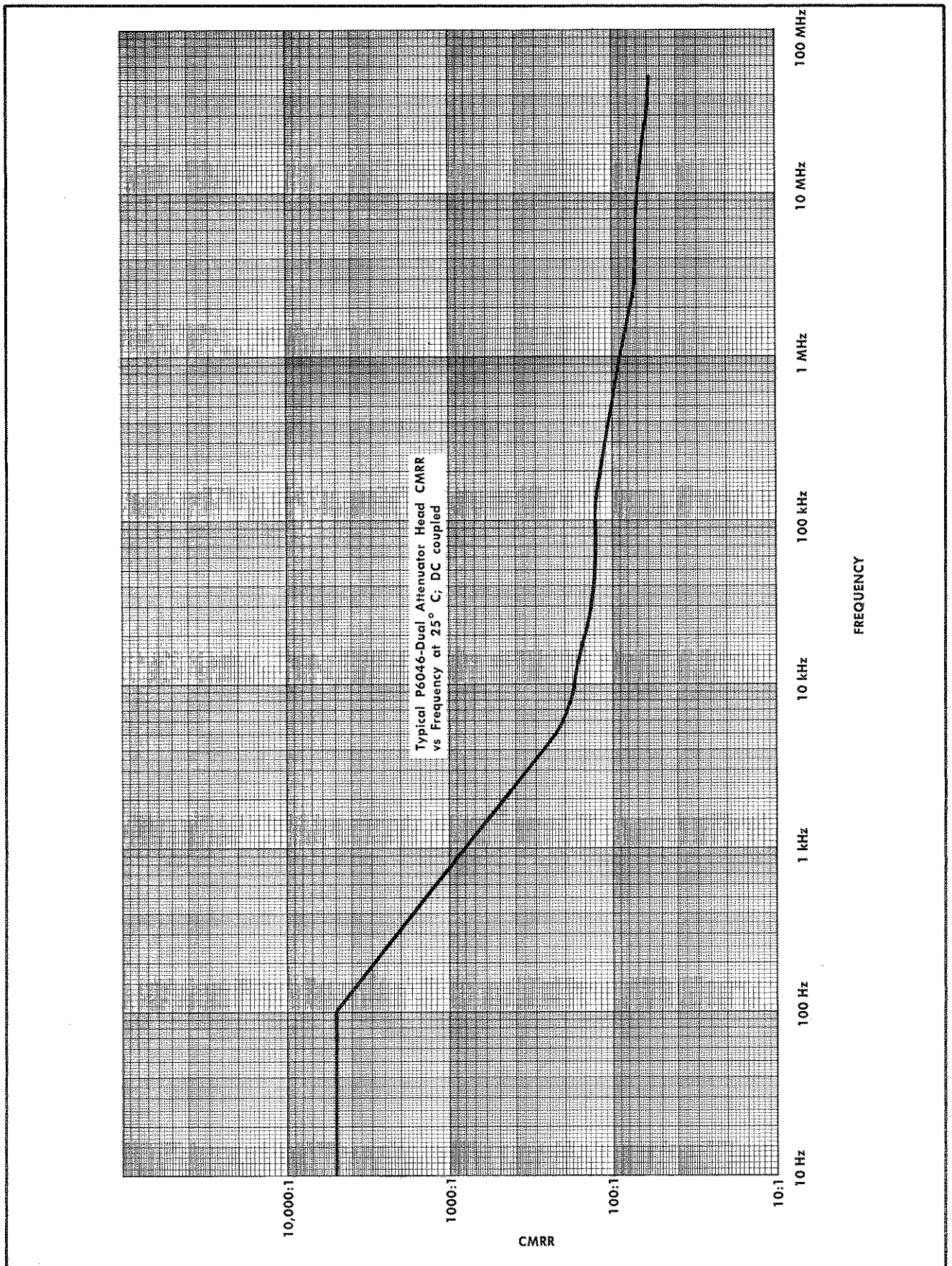


Fig. 1-4. Typical DC-coupled CMRR versus frequency of P6046 Differential Probe with the Dual Attenuator Head Attached; temperature 25° C.



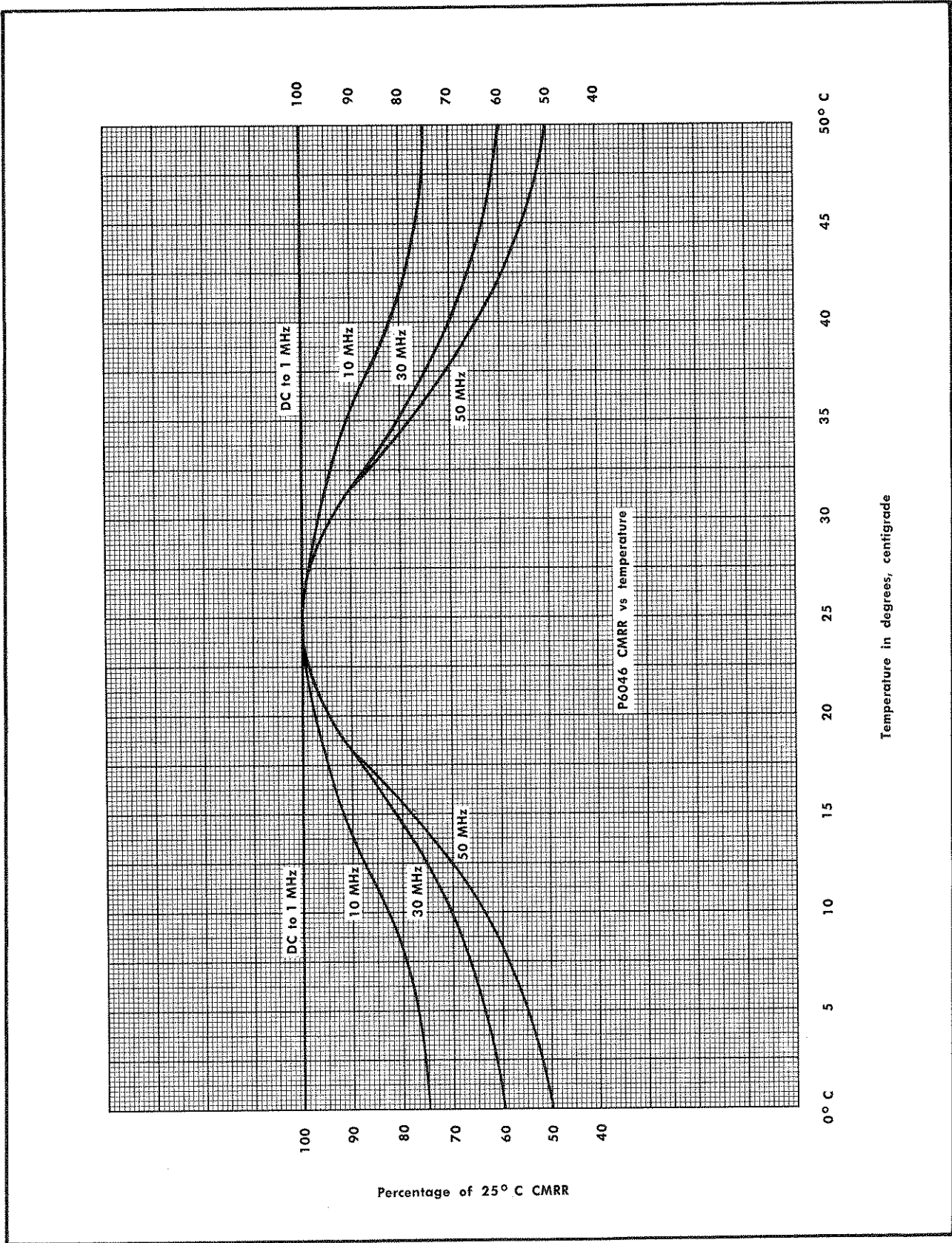


Fig. 1-5. P6046 Probe CMRR variation with temperature; 1 mV through 20 mV/division.

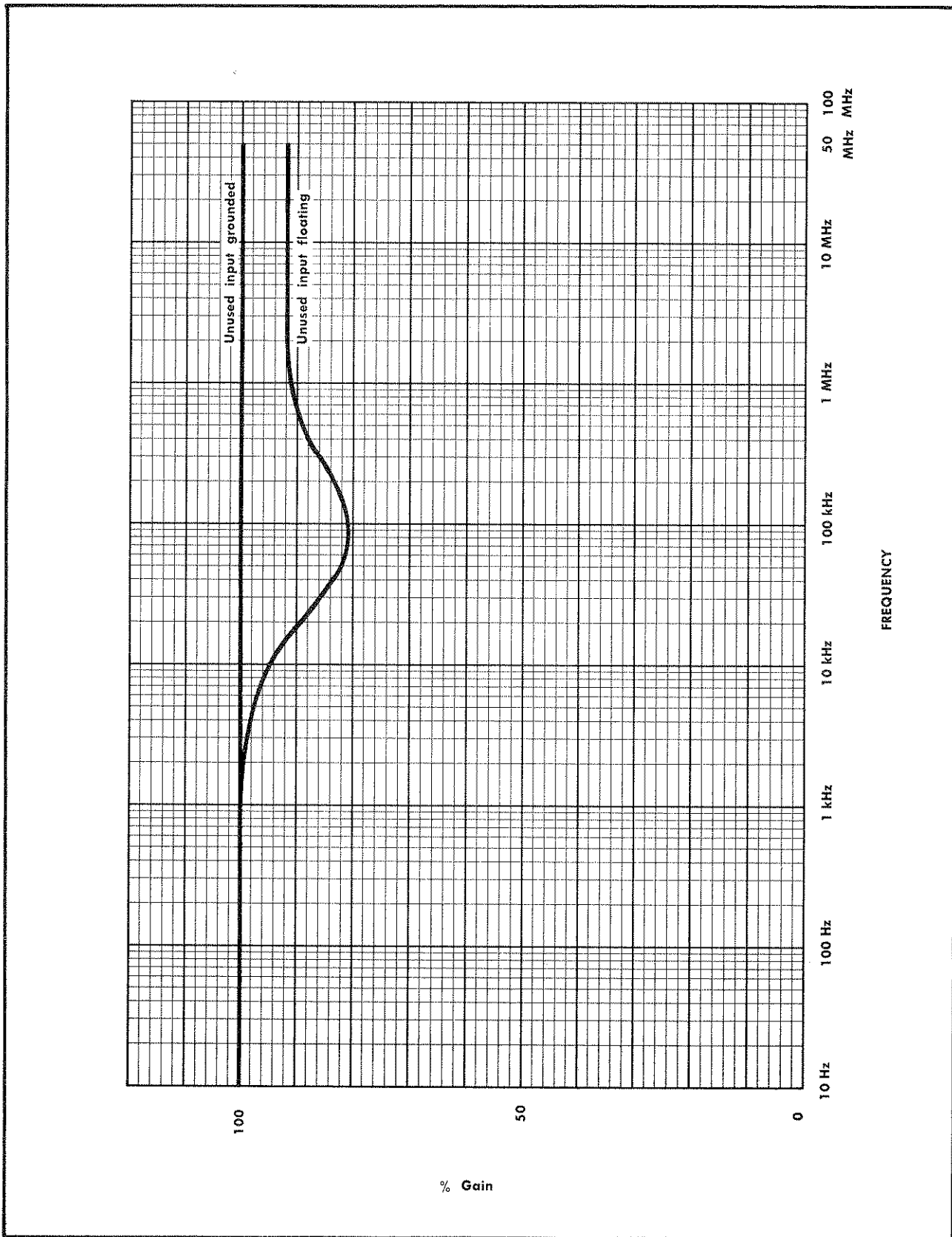


Fig. 1-6. Source impedance effect on gain as a function of frequency.

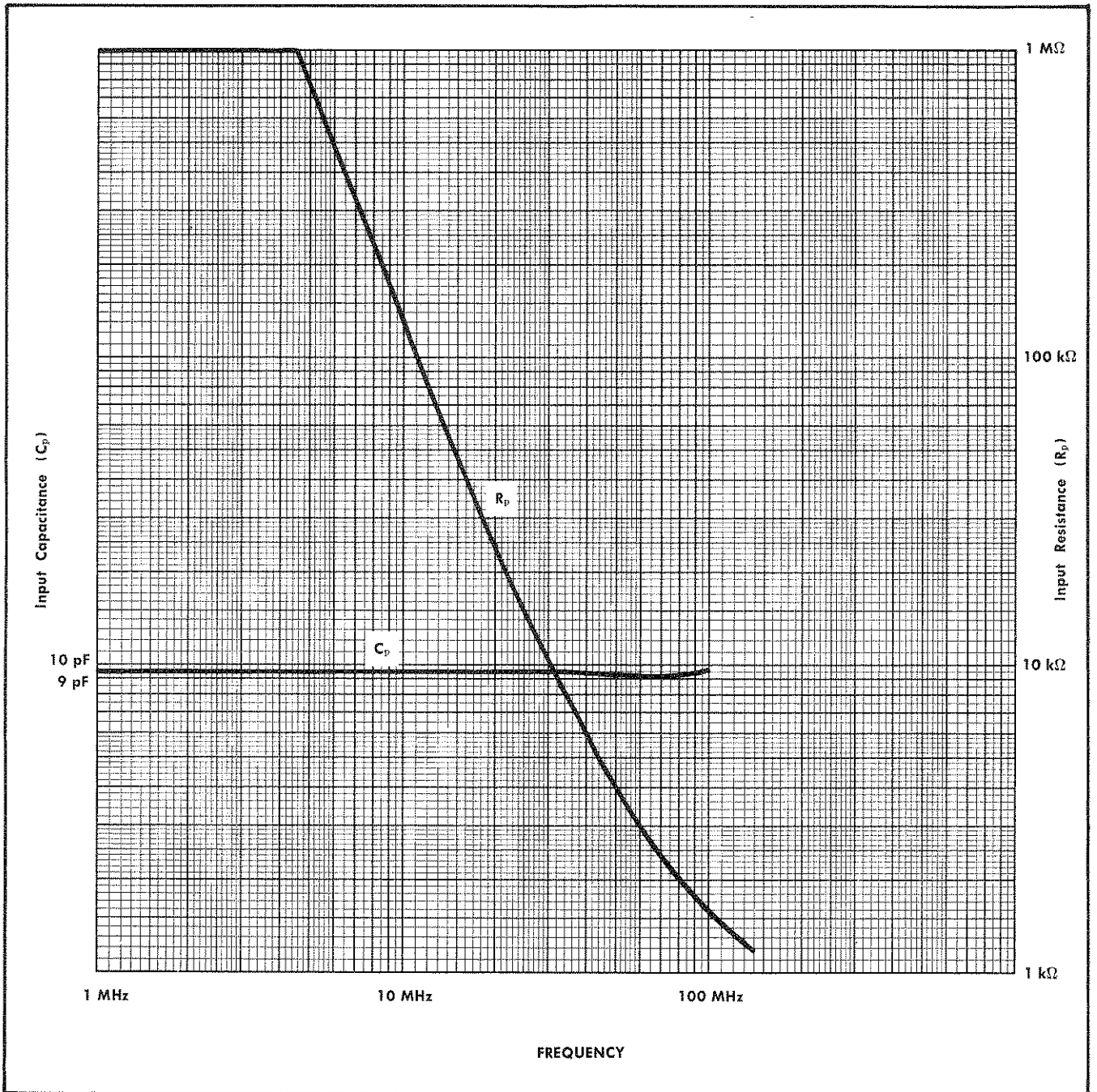


Fig. 1-7. P6046 Input capacitance ( $C_p$ ) and resistance ( $R_p$ ) versus frequency. (Input to positive tip; negative tip grounded).



# SECTION 2

## OPERATING INSTRUCTIONS

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

### CAUTION

Operating the P6046 Differential Probe without a common reference (ground) between it and the unit under test may destroy components in the Probe input circuitry. Connect a ground lead from the probe grounding lug to the equipment to be tested before touching the Probe to the equipment or its test jacks.

### Introduction

The P6046 Differential Probe is essentially a differential amplifier with unity gain. Proper operation of it is dependent upon a basic knowledge of differential principles. A summary of these principles therefore precedes the operating instructions.

### GENERAL DIFFERENTIAL AMPLIFIER INFORMATION

An oscilloscope with a differential amplifier is a device that amplifies and displays a voltage difference which exists at every instant between signals applied to its two input connectors. The following conclusions can be drawn from this definition.

1. If the two signals are in phase and of equal amplitude (hereafter called common mode), the output will be zero.
2. If the two signals are in phase but of different amplitudes, the output will equal the amplitude difference.
3. If the two signals are out of phase and of equal amplitude the output will be the phasor difference between the two signals (sinusoidal signals).
4. If the two signals are out of phase and of different amplitudes, the output signal will be a complex quantity derived from both amplitude and phase differences.

### Common Mode Rejection

The definition of the term "differential amplifier" implies a rejection of equal amplitude, coincident signals. This implication is correct. However, the degree of rejection depends primarily on the symmetry of the amplifier inputs. The amount of difference signal contributed by a particular amplifier at a specific frequency is documented with a mathematical relationship that is called the common-mode rejection ratio (CMRR). This ratio and associated terms are defined as follows:

**Common Mode**—Refers to signals that are identical in both amplitude and time. It is also used to identify the respective parts of two signals that are identical in amplitude and time.

**Common-Mode Rejection Ratio**—A ratio which expresses the efficiency of a device in preventing common-mode signals from affecting its output. A differential amplifier, like all other things, cannot be a perfect device. Some output signal, however small, always occurs in response to common-mode signals applied to the two inputs. In any specific instance, an output resulting from application of common-mode signals can be duplicated by grounding one input and applying a specific size signal to the second input. The comparison of the common-mode signal to the single-ended signal is the Common-Mode Rejection Ratio of the device. See Fig. 2-1.

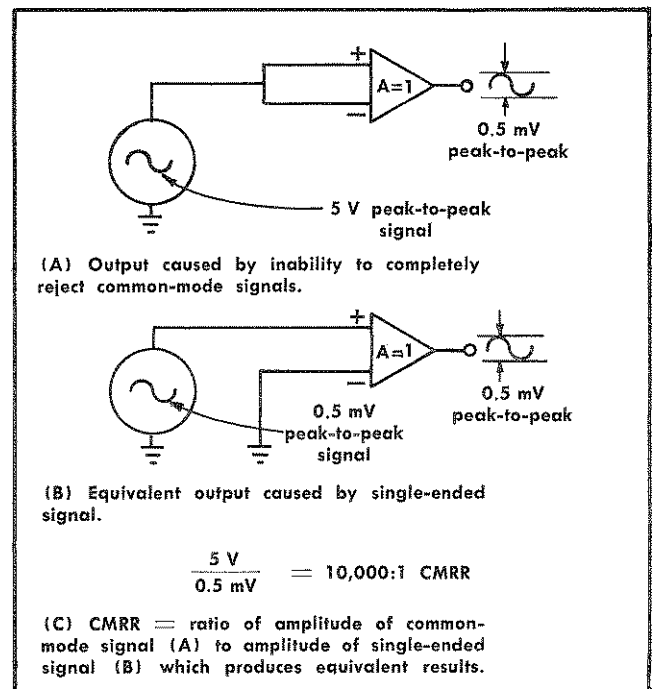


Fig. 2-1. Common-mode rejection ratio.

### NOTE

Since the differential amplifier is part of an oscilloscope, the output signal used to calculate the CMRR is measured from the CRT display and VOLTS/CM switch setting.

## Factors Which Affect CMRR

**Frequency.** Since the common-mode rejection ratio is affected by the gain and phase shift introduced by the two sides of the amplifier, the frequency of the input common-mode signal has a direct bearing on the CMRR. Generally, as the frequency of the input signal increases, the CMRR decreases. (Exception: with AC-coupled inputs the CMRR will become higher as frequency is increased from DC to over 1 kHz).

**Source Impedance.** To obtain optimum CMRR, points being measured must have identical source impedance. The source impedance and the amplifier input impedance form an RC divider which determines the portion of the signal that appears across the amplifier input. Unequal source impedances show up as an apparent decrease in CMRR.

**Signal Transporting Leads.** The input connectors of a differential amplifier are usually remote from the actual signal source. Even with a portable amplifier such as the P6046 Probe, some transporting of the signal is required from the source to connectors which are compatible with the Probe inputs.

Several undesirable effects can be introduced by transporting leads. If they are unshielded, stray pickup will occur. Differences between the stray pickup in the two leads will be accepted by the differential amplifier as signals. The capacitance of unshielded leads is relatively unpredictable and will vary with the lead location. AC signals will be affected by this (especially at high frequencies), and a difference between the source signal and that delivered to the differential amplifier will occur. Unless the introduced difference is equal in both leads, the amplifier will again see a differential signal that is not actually present at the sources. See Fig. 2-2.

The capacitance of shielded cables affects signals, just as it does in unshielded leads. However, the capacitance of shielded cables is known and can be kept relatively equal by matching the two signal cables in every respect. The cables should normally be short to keep their capacitance as low as possible.

Signal transporting cables can also affect the source signal by causing reflections. These reflections can be eliminated by terminating the cables in their characteristic impedance unless prohibitive source-loading would result.

**Attenuators.** Any device (such as capacitors or resistors) connected between the source and the amplifier, unless perfectly matched, will also cause additional differences between the signals at the amplifier. Attenuators therefore normally lower a system's common-mode rejection capabilities. This is illustrated in Fig. 2-3 and its accompanying table.

**Ground Connections.** In addition to providing a common reference for safety reasons, proper ground connections are essential for eliminating signal interference caused by ground loop currents. Ground leads should be as short as possible in all instances. A ground lead should accompany each signal lead to the proximity of the test jack. The shield of the signal's coaxial cable is usually used for this purpose.

Probe input tips very often are accidentally touched to equipment ground during insertion into test jacks. If sufficient difference exists between the differential amplifier reference and reference for the equipment being tested, valuable input components can be destroyed. Proper grounding will also eliminate this problem.

## P6046 DIFFERENTIAL PROBE CONTROLS, CONNECTORS AND ACCESSORIES

The P6046 Probe and accessories are shown in Fig. 2-4. The P6046 Probe has an Amphenol power and signal connector, dual signal input tips, and an AC-DC Input Coupling switch which controls the mode of coupling for both tips. Accessories and their uses are as follows:

1. Dual Attenuator Head—Provides 10× attenuation of signals applied to its inputs. Attaches directly to P6046 Probe tips. Has same tip configuration as the Probe.

2. Swivel Tips—Sleeve-type connectors which fit individually over probe tip input connectors. Not equipped with coaxial ground connectors. They adapt the probe tips to terminals whose spacings are between  $\frac{3}{16}$  and  $1\frac{1}{2}$  inches.

3. Spring Ground Clip—Clips to coaxial ground at probe tip. Equipped with wire-soldering lug.

4. Special Ground Tip—Sleeve-type adapter. Internally short tip to coaxial ground connection. Adapts Probe for single-ended operation. A common ground connection between the Probe and the equipment under test is still required.

5. Test Jacks—Coaxial female connectors, normally installed permanently into or near the equipment being tested. Spacing should conform to the  $\frac{1}{2}$  inch tip spacing. (If the swivel tips are used with the probe, additional spacings are possible. It should be noted that no coaxial ground contact accompanies the swivel tip.) The test jacks can be installed by drilling holes through the selected mounting plate, inserting the threaded end through from the front of the plate, and fastening the test jack in place with a nut and star washer. A soldering lug can be fastened between the nut and the back of the plate to facilitate the making of ground connections.

6. Alligator Clip—Threaded for use with ground leads.

7. Hook Tips—Sleeve-type connectors which fit individually over probe tip input connectors. Facilitates "hanging" the Probe into circuitry.

8. Insulating Tube—Sleeve-type adapter for insulating the tip's coaxial ground. Permits use of tip in close quarters with minimum danger of causing a short circuit.

9. 12-inch Ground Lead—Same as 5-inch, except that it should be used only when the 5-inch will not reach.

10. 5-inch Ground Lead—Equipped with a spring clip on one end intended to snap onto the Probe ground lug; machine screw on the other end for attachment to an alligator clip. It should be connected between the Probe ground lug and the equipment being tested before the Probe is connected to the equipment.

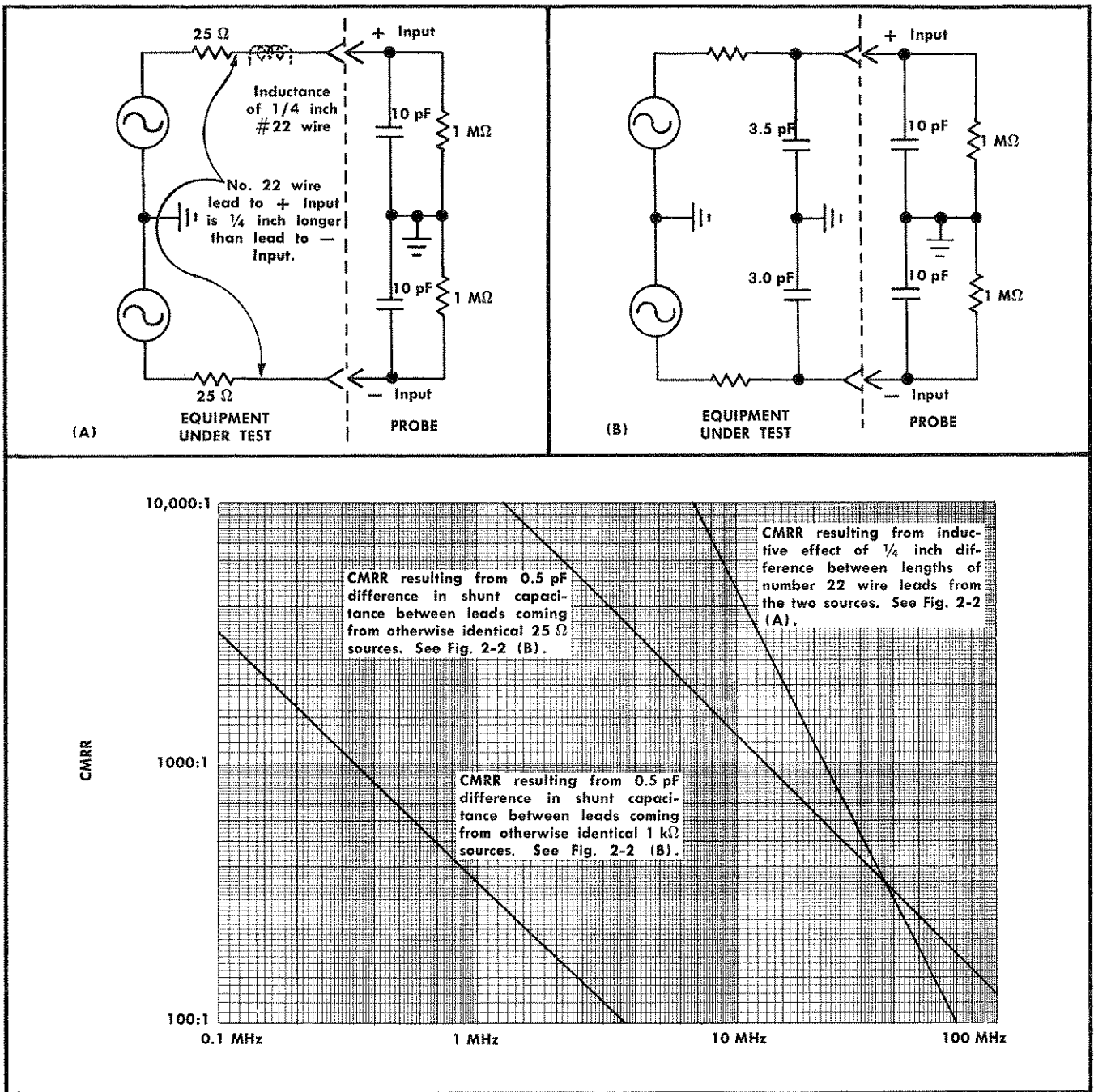


Fig. 2-2. Impedance effects upon apparent CMRR.

### Amplifier For P6046

The Amplifier For P6046 is an optional P6046 Probe accessory consisting of an Amplifier unit and a Power Supply unit. See Fig 2-4. It makes the Probe compatible with any oscilloscope and plug-in combination which has 10 mV/div deflection capability and appropriate bandwidth. Operating it into a less sensitive device (higher mV/div) will provide unreliable results because of overdriving the Probe and Amplifier. Operating it into a more sensitive device can produce some usable results if proper consideration is given to the signal-to-noise ratio.

The Power Supply unit attached to the Amplifier For P6046 must be wired to conform with the source voltage. Three ranges are available in the vicinity of 115 V-AC, and three are available in the vicinity of 230 V-AC. Connection instructions are contained in the Maintenance section.

The Amplifier For P6046 comes equipped with the following accessories:

An 18 inch 50 Ω coaxial cable with which to couple its output to an oscilloscope input connector.

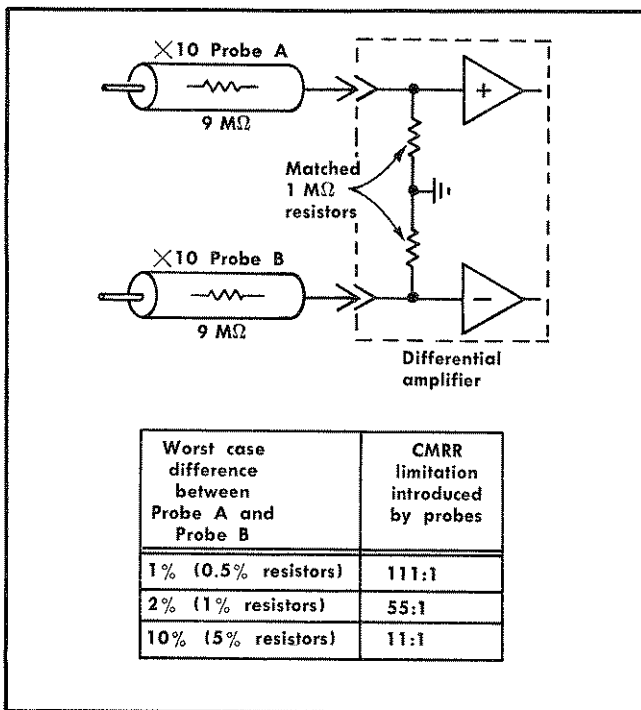


Fig. 2-3. Simplified circuit showing the limitation in CMRR that a difference between attenuator probes can introduce. Differences between probe capacitances add to the effect on AC signals.

A 50 Ω BNC termination with which to terminate the Amplifier output.

A hanger bracket which can be mounted at a convenient location on the side cover of the oscilloscope with which it is used.

### HANDLING THE PROBE

The P6046 Differential Probe is made as rugged as possible without sacrificing performance or portability. However, its sensitive circuitry, small size and mobility make necessary the use of some caution in its handling. Use normal care to avoid severe mechanical shocks to the device, and do not subject the circuitry to voltages in excess of its breakdown values. It is suggested that points to be checked be tested with another device to insure that voltages do not exceed the P6046 Probe capabilities.

### OPERATING PROCEDURE

The P6046 Probe is designed to operate either with a Type 1A5 Differential Amplifier Plug-In Unit or with an Amplifier For P6046 whose output is connected to an oscilloscope having a 10 mV/div vertical sensitivity and an appropriate bandwidth. This procedure covers both situations. It includes setting up the equipment, performing operator adjustments, checking gain through single-ended operation, checking common-mode rejection, observing AC-coupled operation and attenuator operation. Differential operation and external triggering operation information is also included. Pertinent precautions are contained along with techniques to improve operating results.

### Equipment Required

The following equipment is recommended for use in this operating procedure.

Oscilloscope. Tektronix Type 544, 546, 547 or 556. A 580-series Oscilloscope may be used if it is equipped with a Type 81A Plug-In Adapter. (If the Amplifier For P6046 is to be used with the P6046 Probe, any oscilloscope and plug-in combination having a vertical deflection factor of 10 mV/div and an appropriate bandwidth can be substituted.)

Type 1A5 Differential Amplifier Plug-In Unit. (Not required if the Amplifier For P6046 is to be used with the P6046 Probe.)

Amplifier For P6046 and Standard Accessories; Tektronix Part No. 015-0106-00. (Not required if a Type 1A5 Differential Amplifier Plug-In Unit is used.)

P6046 Differential Probe, Dual Attenuator Head, and Standard Accessories.

Probe Tip-to-GR Adapter, Tektronix Part No. 017-0076-00.

GR-to-BNC Male Adapter, Tektronix Part No. 017-0064-00.

50 Ω Termination, Tektronix Part No. 011-0049-00. (Not required if the Type 1A5 is to be used.)

Probe Dual Tip-to-BNC Female Adapter, Tektronix Part No. 067-0562-00.

42 inch Coaxial Cable, Tektronix Part No. 012-0057-01.

GR-to-BNC Male Adapter, Tektronix Part No. 017-0064-00.

### Operator Adjustments

No adjustments at the Probe are associated with routine operation. An attenuator balance adjustment is available at both the Amplifier For P6046 (ATTEN BAL), and the Type 1A5 (PROBE STEP ATTEN BAL) to eliminate trace shifts which might otherwise accompany switching from one deflection factor to another.

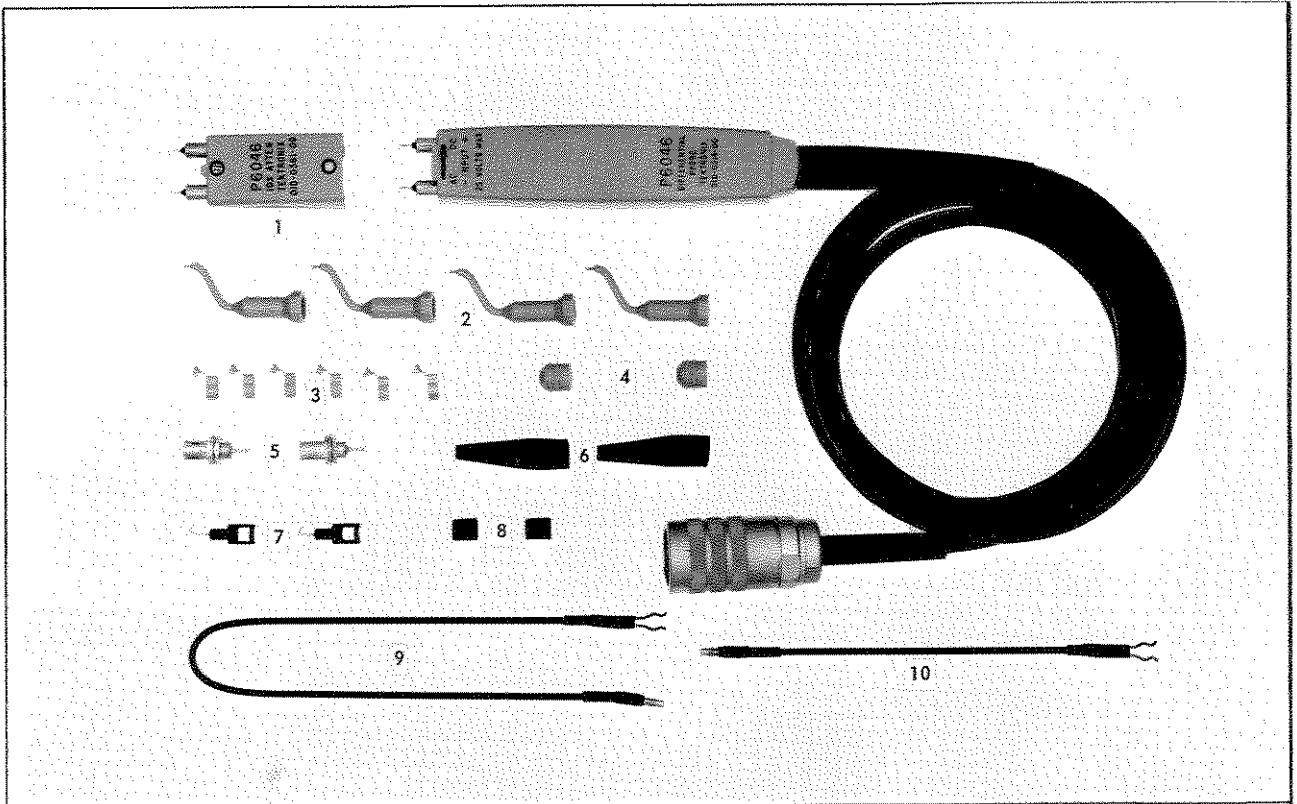
The exposed adjustments in the Dual Attenuator Head have been factory-calibrated to the Probe with which the Head is shipped. No further adjustment should be required unless the Head is used with a different Probe. In that event, the attenuator calibration procedure contained in the Calibration section should be accomplished.

### CAUTION

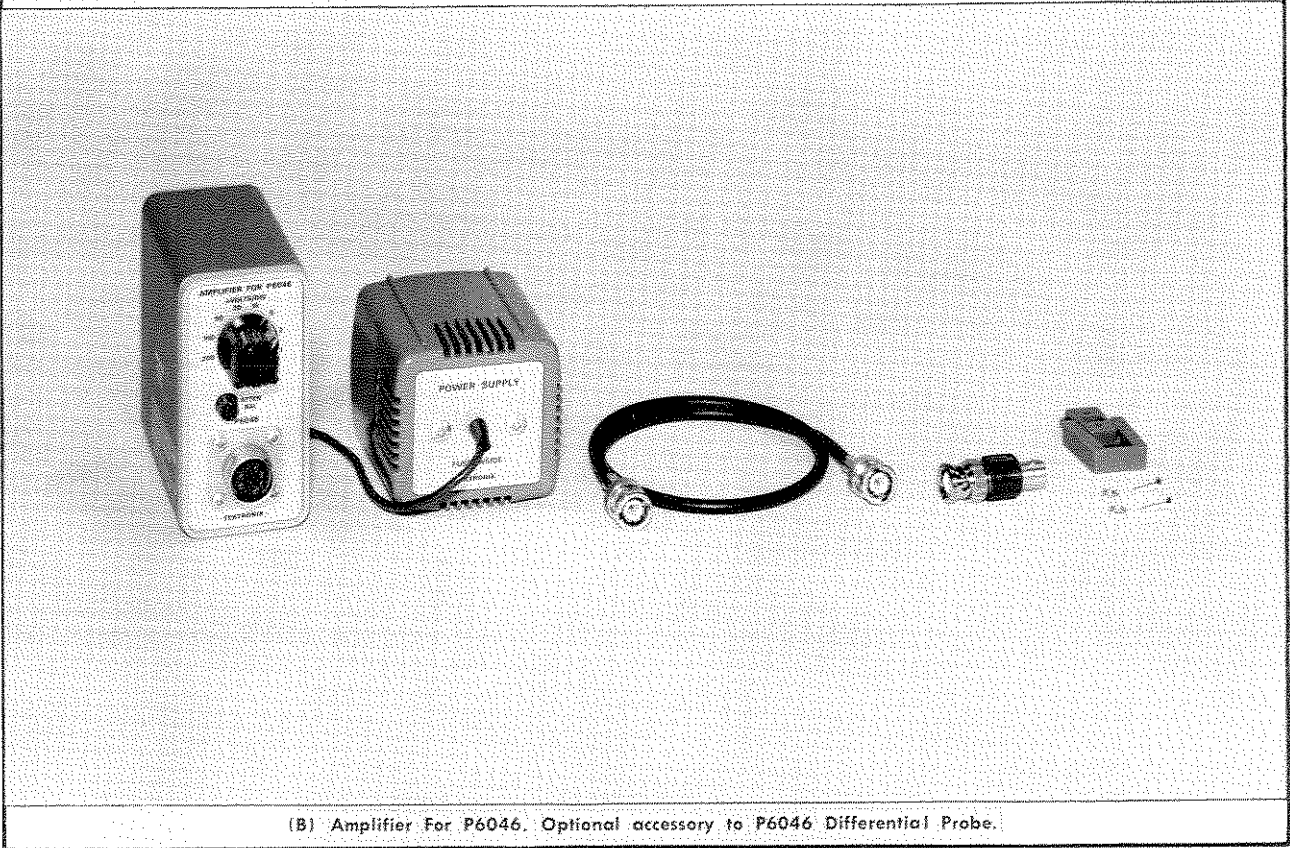
1. A common ground must always exist between the P6046 Probe and any equipment with which it is being used. A ground lug is built into the Probe, and ground leads are supplied as standard accessories for ground purposes.
2. Maximum allowable single-ended input is  $\pm 25$  V DC + peak AC with respect to Probe ground.
3. Maximum allowable difference between voltages at the two tips is 25 V DC + peak AC.

The Type 1A5 controls associated with the P6046 Differential Probe operation are high-lighted in Fig. 2-5. None





(A) P6046 Differential Probe and Standard Accessories.



(B) Amplifier For P6046. Optional accessory to P6046 Differential Probe.

Fig. 2-4. P6046 Differential Probe and Accessories.

## Operating Instructions—P6046 Probe and Amplifier

of the other controls on the Type 1A5 directly affect the Type 1A5 operation while the Probe On lamp is on, although the comparison voltage (V<sub>c</sub>) selected by the POLARITY and AMPLITUDE controls is still available at the MONITOR jack.

### Preliminary Procedure For P6046 Differential Probe-Amplifier For P6046 Operation

a. The Power Supply Unit shipped with the Amplifier For P6046 is wired for 104 to 126 V AC, 50 to 400 Hz operation. Rewire the unit in accordance with table 4-3 (located in the maintenance section) if the unit is to be used with voltages outside this range. Then connect the Power Supply Unit to the voltage source.

b. Connect the P6046 Probe Amphenol connector to the Amplifier For P6046. Connect the output of the Amplifier For P6046 to the vertical input of the oscilloscope. If the oscilloscope has 50 Ω input impedance, the connection may be made directly through the 50 Ω coaxial cable. If the oscilloscope has a high input impedance, the 50 Ω cable must be connected to a 50 Ω termination (Amplifier For P6046 standard accessory) at the oscilloscope input connector.

c. Preset equipment controls as follows:

#### Oscilloscope

Sweep Rate	0.2 ms/div
Triggering	Automatic, Internal
Amplitude Calibrator	Off
Vertical Deflection Factor	10 mV/div (Calibrated)

#### Amplifier For P6046

mVOLTS/DIV	20
------------	----

d. Do not change the calibrated vertical deflection factor at the oscilloscope for the remainder of this procedure. All vertical deflection factor changes must be made at the Amplifier For P6046.

### Preliminary Procedure for P6046 Probe-Type 1A5 Operation

a. Insert the Type 1A5 into an appropriate oscilloscope and preset the controls as follows:

#### Oscilloscope

Sweep Rate	0.2 ms/div
Triggering	Automatic, Internal
Amplitude Calibrator	Off

#### Type 1A5

POSITION	Midrange
VOLTS/CM	20 mV
VARIABLE	CAL

b. Connect the P6046 Differential Probe Amphenol plug to the DIFFERENTIAL PROBE jack on the Type 1A5.

c. Energize the equipment and depress the PUSH ON/OFF button to light the Probe On lamp which is located in the PUSH ON/OFF button assembly.

## NOTE

The Probe On lamp will not light if the VOLTS/CM control is at a lower sensitivity (higher VOLTS/CM) setting than 0.2 V. The Probe is supplied with power whenever it is connected to an energized Type 1A5, regardless of the condition of the Probe On lamp. Only the P6046 Probe inputs to the Type 1A5 are interrupted when the Probe On lamp is out.

### ATTEN BAL (PROBE STEP ATTEN BAL) Adjustment

a. Connect special ground tips to the Probe + and — Input tips. Wait 5 minutes or more for the equipment operating temperature to stabilize.

b. Set the CRT controls for optimum display.

c. Check that the vertical deflection factor is set at 20 mV/div. Using the vertical position control, set the oscilloscope trace to graticule vertical center.

d. Change the vertical deflection factor (at the Amplifier For P6046, if used) to 1 mV/div and adjust the ATTEN BAL (PROBE STEP ATTEN BAL) control as necessary to return the trace to the center of the graticule. Some small amount of drift of the trace vertical position can be expected at 1 mV sensitivity, especially during warmup.

e. Repeat steps c and d until no further adjustment is necessary.

## IMPORTANT

The ATTEN BAL (PROBE STEP ATTEN BAL) adjustment should not be used as a vertical position control. The Vertical POSITION control at the oscilloscope should be used for this purpose. An occasional check of the ATTEN BAL adjustment is recommended.

### Single-Ended Operation—Gain Check

## NOTE

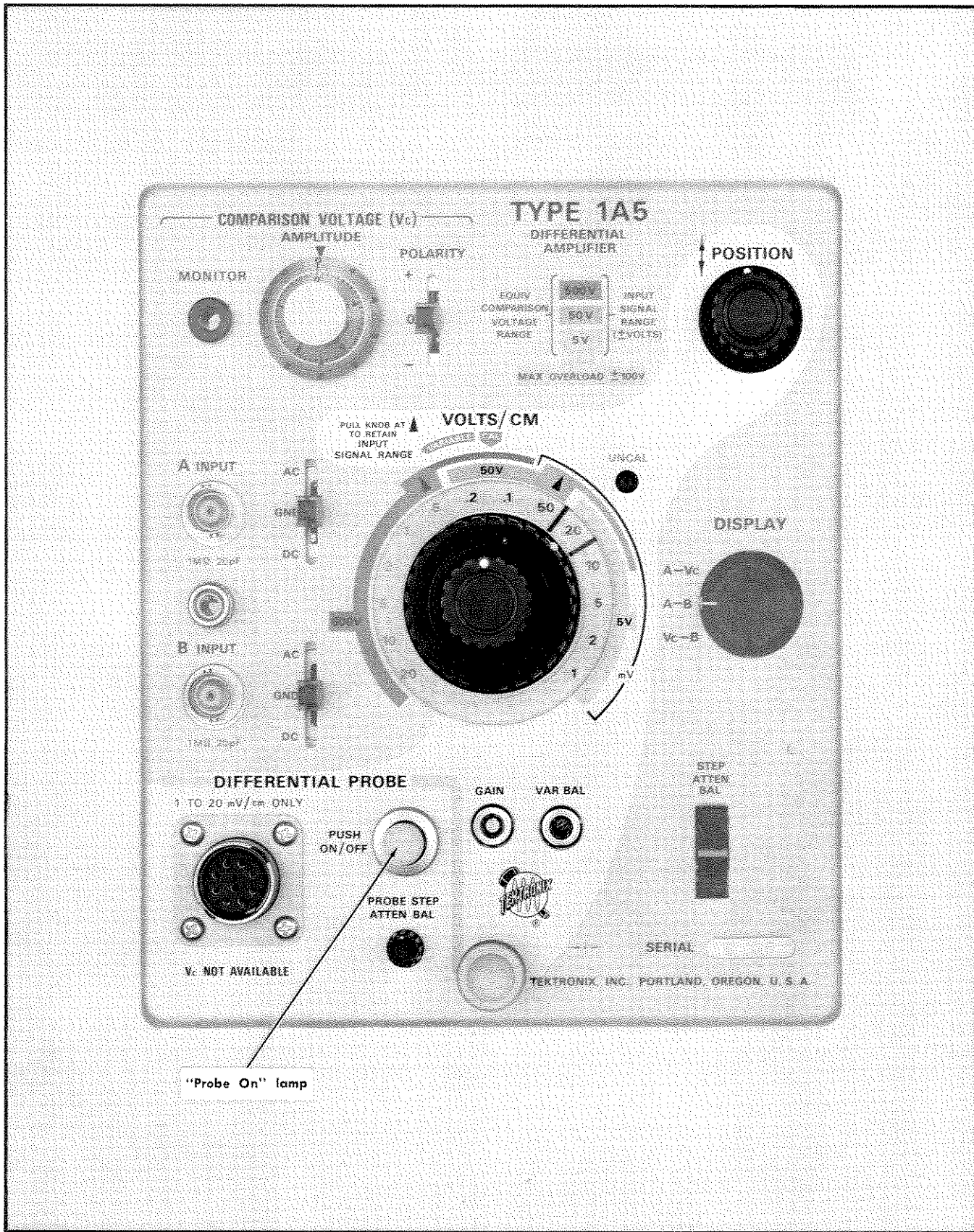
The single-ended linear operation limit of the Probe, with or without the Amplifier For P6046, is + or — 10 divisions of DC + peak AC deflection from 0 reference position. The oscilloscope and vertical plug-in limit must also be considered in determining the limit of the complete system.

## CAUTION

Breakdown voltage is ±25 V, DC + peak AC, and extends to 250 V when the Probe Dual Attenuator Head is installed.

a. Connect a special ground tip (P6046 accessory) to the — Input of the P6046 Probe. Connect a probe tip-to-GR adapter to the Probe + Input tip.

b. The habit of ALWAYS connecting a ground lead before connecting the Probe tips should be developed. Therefore, connect a ground lead and alligator clip (P6046



"Probe On" lamp

Fig. 2-5. Type 1A5 front panel, high-lighting controls directly associated with the P6046 Differential Probe operation.

## Operating Instructions—P6046 Probe and Amplifier

Probe accessories) from the P6046 Probe ground lug to a ground terminal at the oscilloscope.

c. Check that the oscilloscope's amplitude calibrator is off. Set the Probe AC-DC switch to DC. Then connect the Probe tip to the oscilloscope calibrator output jack, via the probe tip-to-GR adapter and the GR-to-BNC male adapter.

### CAUTION

The output from the amplitude calibrator must never exceed 25 V while it is applied to the P6046 Probe.

d. Set the vertical deflection factor and the amplitude calibrator output to the values given in Table 2-1. Set the triggering and position controls to obtain a centered, stable display. Check the display for the specified amplitude at each setting.

### NOTE

Although the gain can be adjusted to obtain exact results, adjustment is not recommended if the gain has been previously set with a standard amplitude calibrator. Most standard amplitude calibrators have a higher accuracy than calibrators which are built into oscilloscopes.

**TABLE 2-1**  
**P6046 GAIN CHECK**

AMPLITUDE CALIBRATOR	Vertical Deflection Factor	Amplitude	Tolerance
5 mV	1 mV	5 cm	See Performance Check
10 mV	2 mV	5 cm	
25 mV	5 mV	5 cm	
.05 V	10 mV	5 cm	
.1 V	20 mV	5 cm	
50 mV	10 mV Retained Range <sup>1</sup>	5 cm	
.1 V	20 mV Retained Range <sup>1</sup>	5 cm	
.2 V	50 mV	4 cm	
.5 V	100 mV (.1 V)	5 cm	
1 V	200 mV (.2 V)	5 cm	

<sup>1</sup>Type 1A5 only; VOLTS/CM knob placed at 50 mV, then pulled out and rotated clockwise.

e. Switch the P6046 AC-DC control to AC. Two effects are obvious. The 0-V DC reference supplied with the calibrator signal is blocked by the coupling capacitor and the waveform shifts down  $2\frac{1}{2}$  divisions to operate above and below the Probe DC reference. The second result is that the time constant introduced by the coupling capacitor causes a tilt in the 1 kHz square wave presentation. Return the Probe switch to DC, and then turn the amplitude calibrator control off.

## Common-Mode Rejection Check

### NOTE

Linear common-mode operation with or without the Amplifier For P6046 can be obtained up to 5 V DC + peak AC, provided that the difference between the two signals does not exceed + or - 10 divisions of vertical deflection.

Linear common-mode operation is extended to 50 V DC + peak AC when the Probe Dual Attenuator Head is installed.

### CAUTION

The applied voltage must never exceed 25 V with respect to Probe ground. The difference between the voltages applied to the two tips of the Probe must never exceed 25 V DC + peak AC. These values increase to 250 V when the Probe Dual Attenuator Head is installed.

a. Disconnect the Probe and adapter from the calibrator. Remove the adapter from the one tip, and the ground tip from the other. Connect the calibrator signal to both tips, using a probe dual tip-to-BNC female adapter and a 42 inch 50  $\Omega$  coaxial cable equipped with BNC-male connectors. Set the amplitude calibrator control to 5 V and the vertical deflection factor to 1 mV. Set the oscilloscope triggering controls to stabilize the presentation, if possible. (The CMRR may be so high that insufficient signal exists to trigger the oscilloscope.) Divide the peak-to-peak value of the presentation into 5 V to determine the CMRR which is in effect. LACK OF IDENTICAL SIGNAL CONNECTIONS TO THE TWO TIPS WILL DECREASE THE APPARENT CMRR. (If the two tips were connected to two separate signals, the common-mode portions would be almost totally rejected, with the difference between the two being processed for display.)

b. Switch the P6046 AC-DC control to AC and again calculate the CMRR. (A slight increase in display amplitude and a change in the shape of the presentation will possibly be noted. Both are caused by the lack of total identity between the matched input coupling capacitors)

c. Turn the oscilloscope amplitude calibrator off and disconnect the Probe and adapter from the calibrator output jack. Remove the adapter from the Probe.

## Attenuator Operation

a. Attach the Dual Attenuator Head to the Probe. Attach a special ground tip to the - Input. Connect the Probe + Input tip to the oscilloscope amplitude calibrator jack, using the probe tip-to-GR adapter and a GR-to-BNC male adapter. Set the vertical deflection factor to 20 mV and the amplitude calibrator to 1 volt. Set the triggering and position controls as necessary to obtain a centered square wave. A 5 cm square wave with sharp corners should be observed, indicating  $\times 10$  attenuation of the amplitude calibrator signal, and proper compensation adjustment. Remove the adapter from the amplitude calibrator output jack.

b. Disconnect the adapter from the + tip and remove the ground tip from the — tip. Attach the probe dual tip-to-BNC adapter to the Dual Attenuator Head. Connect the BNC connector to the amplitude calibrator output jack, using a 42 inch coaxial cable. Set the amplitude calibrator control to 50 volts. Measure the display amplitude and divide it into 50 volts. The quotient is the CMRR of the Attenuator-Probe-Amplifier (or 1A5) combination.

#### CAUTION

Never exceed 250 V DC + peak AC input to either tip of the Dual Attenuator Head. Never exceed 250 V DC + peak AC difference between Attenuator Input tips.

### Additional Operating Hints

#### Differential Amplifier Operation

Connecting the two inputs to separate signals will result in a display of the instantaneous phasor and amplitude differences between the two signals.

#### NOTE

Do not exceed 5 V DC + peak AC common-mode input, or 10 divisions of difference between signals for linear operation. Never exceed 25 V DC + peak AC difference between signals applied to the probe.

### External Triggering

Use of one of the signal sources to provide external triggering will introduce an apparent common-mode difference due to the loading caused by the triggering circuit. External triggering during differential measurements which require a high CMRR should only be used if identical loading is provided to the second signal source, or if a signal-associated source is available which will not affect the signal being observed.

### Differential Comparator Operation

Any adjustable DC voltage source of 5 V or less can be used for differential comparator operation.

The Type 1A5 COMPARISON VOLTAGE makes a 0 to 5 volt DC output available which can be connected to one side of the Probe (DC-coupled) while a signal is connected to the other side. This enables common-mode cancellation of an equivalent DC or instantaneous level of AC, permitting the observation of specific amplitude points on signals up to 5 V DC + peak AC, using a much more sensitive VOLTS/CM setting than would otherwise be possible. Use a comparison voltage of the same amplitude and polarity as that existing at the point being checked. A .001  $\mu$ F capacitor must be close-coupled between the Probe tip and ground to bypass voltages induced in the Vc lead which would otherwise be accepted as signals.

