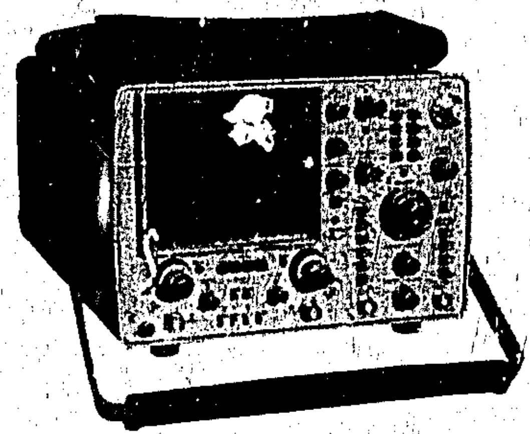
OPERATORS GUIDE

1745A OSCILLOSCOPE



HEWLETT PACKARD

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability of the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT.

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

USE CAUTION WHEN EXPOSING OR HANDLING THE CRT.

Breakage of the Cathode-ray Tube (CRT) causes a high-velocity scattering of glass fragments (implosion). To prevent CRT implosion, avoid rough handling or jarring of the instrument. Handling of the CRT shall be done only by qualified maintenance personnel using approved safety mask and gloves.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification of the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS.

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

> **Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.**

OPERATORS GUIDE

MODEL 1745A
OSCILLOSCOPE

Manual Part Number 01745-90902
Microfiche Part Number 01745-90802

PRINTED: DECEMBER 1982

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

The cathode-ray tube (CRT) in the instrument and any replacement CRT purchased from HP are also warranted against electrical failure for a period of one year from the date of shipment from Colorado Springs. BROKEN TUBES AND TUBES WITH PHOSPHOR OR MESH BURNS, HOWEVER, ARE NOT INCLUDED UNDER THIS WARRANTY.

For warranty service or repair, this product must be returned to a service facility designated by HP. However, warranty service for products installed by HP and certain other products designated by HP will be performed at Buyer's facility only upon HP's prior agreement and Buyer shall pay HP's round trip travel expenses.

For products returned to HP for warranty service, Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer. Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

LIST OF TABLES

LIST OF ILLUSTRATIONS

SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. The HP Model 1745A is a dual-channel, 100-MHz, delayed sweep oscilloscope designed for general-purpose bench or field use. The 1745A Operator's Guide contains the following information:

Section I. General Information: describes the instruments documented by this manual. It also provides a basic description of the oscilloscope which includes accessories and specifications.

Section II. Installation: provides information about initial inspection, preparation for use, and storage and shipment.

Section III. Operation: provides detailed operating information for the instrument, including operator's checks and maintenance.

1-3. One copy of the 1745A Operator's Guide is supplied with each instrument. Additional copies may be ordered separately through your nearest Hewlett-Packard Sales office. The part number for the complete Operator's Guide is listed on the title page of this manual.

1-4. Also listed on the title page is the part number for a microfiche version of the complete Operator's Guide. The microfiches are 100×150 mm (4×6 in.) microfilm transparencies of the manual. Each microfiche contains up to 96 photo duplicates of manual pages. The microfiche package also includes the latest Manual Change supplement.

1-5. SPECIFICATIONS.

1-6. Specifications and supplemental characteristics of the 1745A Oscilloscope are listed in table 1-1. This instrument will meet the electrical characteristics listed following complete calibration as given in the Adjustments section of the manual. These electrical characteristics apply over the ambient temperature range of 0 to 55°C except as otherwise noted.

1-7. SAFETY CONSIDERATIONS.

WARNING

To prevent personal injury, observe all safety precautions and warnings stated on the instrument and in the manual.

1-8. The 1745A and related documentation must be reviewed for familiarization with safety markings and instructions before operation. Refer to the Safety Considerations page found at the beginning of this manual for a summary of general safety information. Safety precautions for installation and operation are found in appropriate locations throughout the Operator's Guide. These precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in the manual violates safety standards of design, manufacture, and intended use of this instrument. Hewlett-Packard assumes no liability for failure to comply with these requirements.

1-9. DESCRIPTION.

1-10. The Model 1745A is a dual-channel, 100-MHz, delayed-sweep oscilloscope. The dual-channel dc to 100 MHz vertical deflection system has 12 calibrated deflection factors from 5 mV/div to 20 V/div. A maximum sensitivity of 1 mV/div to 40 MHz is provided on both channels by means of a 5× vertical magnification. Selectable input impedance of either 50 ohms or 1 megohm permits impedance selection that best meets measurement applications.

1-11. The horizontal deflection system has calibrated sweep rates from 2 s/div to 0.05 μs/div and delayed sweep rates from 20 ms/div to 0.05 μs/div. A 10× magnifier expands all sweeps by a factor of 10 and extends the fastest sweep speed to 5 ns/div. In alternate or chop modes, a trigger-view control will display three signals: channel A, channel B, and the trigger signal. This allows correlation of time between the trigger signal and the channel A and channel B signals. In trigger-view operation, center screen represents the trigger threshold point and allows the operator to see the triggering level location. With the A vs B control, an X-Y mode of operation is possible; channel A input (Y-axis) is plotted versus channel B input (X-axis). The CRT screen has 10 by 10 major divisions on an internal graticule.

1-12. OPTIONS.

1-13. Standard options are modifications installed on HP instruments at the factory and are available on request. The following options extend the usefulness of the 1745A:

OPTION 001: Supplies a fixed ac power cord in place of the normal detachable power cord.

OPTION 005: Adds the necessary controls and circuitry to enable the oscilloscope to be triggered internally from a television composite video signal applied to channel A or B. The main time base triggers on a field reference pulse, and the delayed time base triggers on a line reference pulse for displaying selected TV lines.

OPTION 034/035: Adds 3-1/2 digit, five-function, autoranging digital multimeter installed on top of the oscilloscope. The multimeter can also be used for time interval measurements. The option 034 is calibrated for 60-Hz line operation and the option 035 is calibrated for 50-Hz line operation. This option is covered by a separate Operating and Service manual. Installation information may be obtained from the nearest Hewlett-Packard Field Service Office.

OPTION 090: This option omits the two Model 10041A divider probes normally supplied as accessories.

OPTION 091: Replaces two Model 10041A (2 metre) 10:1 divider probes with two Model 10042A (3 metre) 10:1 divider probes.

OPTION 092: Replaces two Model 10041A (2 metre) 10:1 divider probes with two Model 10040A (1 metre) 10:1 divider probes.

OPTION 096: Replaces two Model 10041A (2 metre) 10:1 divider probes with two Model 10006D (1.8 metre) 10:1 divider probes.

OPTION 112: This option adds Model 1112A Inverter Power Supply, a portable power source for the oscilloscope.

OPTION 534/535: Option 534 is a combination of Options 005 and 034. Option 535 is a combination of Options 005 and 035.

OPTION 580: Provides a special bottom cover to meet Canadian Fire Safety Codes.

OPTION 9XX: These options are special cord options. The connector configurations are shown in Section II of this manual.

1-14. ACCESSORIES SUPPLIED.

1-15. Included with the instrument are:

One 2.3 m (7.5 ft) power cord
One front-panel cover, HP Part No. 5040-0516
One Accessory Storage Pouch, HP Part No. 1540-0292
Two 10:1 Divider Probes, HP Model 10041A

1-16. The power cable and line fuse are selected at the factory according to the voltages available in the country of destination. For the part numbers of the available power cords, refer to AC Power Cable paragraph in Section II.

Table 1-1. Specifications

VERTICAL DISPLAY MODES
Channel A; channel B; channels A and B displayed alternately on successive sweeps (ALT); channels A and B displayed by switching between channels at an approximate 250 kHz rate with blanking during switching (CHOP); channel A plus channel B (algebraic addition); and trigger view.

VERTICAL AMPLIFIERS (2)
Bandwidth and Rise Time at all deflection factors from 0°C to +55°C.

BANDWIDTH: 3 dB down from 6 div reference signal.

DC-Coupled: dc to 100 MHz in both 50Ω and 1 MΩ input modes.

AC-Coupled: approx 10 Hz to 100 MHz.

BANDWIDTH LIMIT: limits upper bandwidth to approx 20 MHz.

RISE TIME: ≤3.5 ns, measured from 10% to 90% points of a 5 div input step.

DEFLECTION FACTOR

Ranges: 5 mV/div to 20 V/div (12 calibrated positions) in 1, 2, 5 sequence, accurate within 3%.

Vernier: continuously variable between all ranges, extends maximum deflection factor to at least 50 V/div. UNCAL light indicates when vernier is not in the CAL position.

POLARITY: channel B may be inverted, front panel pushbutton.

DELAY LINE: input signals are delayed sufficiently to view leading edge of input pulse without advanced trigger.

INPUT COUPLING: selectable AC or DC, 50Ω (dc), or ground. Ground position disconnects input connector and grounds amplifier input.

INPUT RC (selectable)

AC or DC: 1 MΩ ±2% shunted by approx 20 pF.

50 Ohm: 50Ω ±3%.

Table 1-1. Specifications (Cont'd)

MAXIMUM INPUT
AC or DC: 250 V (dc + peak ac) or 500 V p-p at 1 kHz or less.
50 Ohm: 5 V rms.
A+B OPERATION
Amplifier: bandwidth and deflection factors are unchanged; channel B may be inverted for A–B operation.
Differential (A–B) Common Mode: CMR is at least 20 dB from dc to 20 MHz. Common mode signal amplitude equivalent to 8 divisions with one vernier adjusted for optimum rejection.

VERTICAL MAGNIFICATION (X5)

BANDWIDTH: 3 dB down from 6 div reference signal.
DC-Coupled: dc to approx 40 MHz.
AC-Coupled: approx 10 Hz to 40 MHz.
RISE TIME: ≤9 ns (measured from 10% to 90% points of 5 div input step).
DEFLECTION FACTOR: increases sensitivity of the 5 mV and 10 mV/div deflection factor settings by a factor of 5 with a maximum sensitivity of 1 mV on channels A and B.

TRIGGER SOURCE

Selectable from channel A, channel B, composite, or line frequency.

CHANNEL A: all display modes triggered by channel A signal.
CHANNEL B: all display modes triggered by channel B signal.
COMPOSITE: all display modes triggered by displayed signal except in Chop, which is triggered from channel A.
LINE FREQUENCY: power line frequency.

TRIGGER VIEW

Displays internal or external trigger signal. In Alternate or Chop mode, channel A, channel B, and the trigger signals are displayed. In channel A or B mode, Trigger View overrides that channel. Internal trigger signal amplitude approximates vertical signal amplitude. Ext trigger signal deflection factor is approx 100 mV/div or 1 V/div in EXT ÷10. Trigger point is approx center screen. With identically timed signals to a vertical input and the Ext trigger input, trigger signal delay is ≤3.5 ns.

HORIZONTAL DISPLAY MODES

Main, Main Intensified, Delayed, Mag X10, and A vs. B.

Table 1-1. Specifications (Cont'd)

MAIN AND DELAYED TIME BASES

RANGES

Main: 50 ns/div to 2 s/div (24 ranges) in 1, 2, 5 sequence.

Delayed: 50 ns/div to 20 ms/div (18 ranges) in 1, 2, 5 sequence.

Accuracy:

Sweep Time/Div	*Accuracy		Temp Range
	X1	X10	
50 ns to 20 ms	±3% ±2% ±3%	±4% ±3% ±4%	0°C to +15°C +15°C to +35°C +35°C to +55°C

*Add 1% for 50 ms to 2 s ranges.

MAIN SWEEP VERNIER: continuously variable between all ranges, extends slowest sweep to at least 5 s/div. UNCAL light indicates when vernier is not in CAL position.

MAGNIFIER (X10): expands all sweeps by a factor of 10, extends fastest sweep to 5 ns/div.

CALIBRATED SWEEP DELAY

DELAY TIME RANGE: 0.5 to 10X Main Time/Div settings of 100 ns to 2 s (minimum delay 150 ns).

DIFFERENTIAL TIME MEASUREMENT ACCURACY– Helidial Readout:

Main Time Base Setting	*Accuracy (+15°C to +35°C)
100 ns/div to 20 ms/div	±(0.5% + 0.1% of full scale)
50 ms/div to 2 s/div	±(1% + 0.1% of full scale)

*Add 1% for temperatures from 0°C to +15°C and +35°C to +55°C.

DELAY JITTER: <0.002% (1 part in 50 000) of maximum delay in each step from +15°C to +35°C; <0.005% (1 part in 20 000) from 0°C to +15°C and +35°C to +55°C.

TRIGGERING

MAIN SWEEP

Normal: Sweep is triggered by internal or external signal.

Table 1-1. Specifications (Cont'd)

Automatic: bright baseline displayed in absence of input signal. Triggering is same as Normal above 40 Hz.

Single: sweep occurs once with same triggering as Normal; reset pushbutton arms sweep and lights indicator.

DELAYED SWEEP (SWEEP AFTER DELAY)

Auto: delayed sweep automatically starts at end of delay.

Trig: delayed sweep is armed and triggerable at end of delay period.

INTERNAL: dc to 25 MHz on signals causing 0.3 divisions or more vertical deflection, increasing to 1 division of vertical deflection at 100 MHz in all display modes (required signal level is increased by 2 when in Chop mode and by 5 when ×5 vertical magnifier is used). Line frequency triggering is selectable (main sweep only).

EXTERNAL: dc to 50 MHz on signals of 50 mV p-p or more increasing to 100 mV p-p at 100 MHz (required signal level is increased by 2 when in Chop mode).

EXTERNAL INPUT RC: approx 1 MΩ shunted by approx 20 pF.

MAXIMUM EXTERNAL INPUT: 250 V (dc + peak ac) or 500 V p-p ac at 1 kHz or less.

LEVEL and SLOPE

Internal: at any point on the positive or negative slope of the displayed waveform.

External: continuously variable from +1 V to −1 V on either slope of the trigger signal, +10 V to −V in divide by 10 mode (÷10).

COUPLING: AC, DC, Main LF REJ, or Main HF REJ.

AC: attenuates signals below approx 20 Hz.

LF Reject (Main Sweep): attenuates signals below approx 4 kHz.

HF Reject (Main Sweep): attenuates signals above approx 4 kHz.

TRIGGER HOLDOFF (Main Sweep): increases sweep holdoff time in all ranges.

MAIN INTENSIFIED

DELAYED SWEEP: intensifies that part of main time base to be expanded to full screen in delayed time base mode.

CALIBRATED MIXED TIME BASE

Dual time base in which the main time base drives the first portion of sweep and the delayed time base completes the sweep at the faster delayed sweep. Also operates in single sweep mode. Accuracy, add 2% to main time base accuracy.

Table 1-1. Specifications (Cont'd)

A vs. B OPERATION

BANDWIDTH

Channel A (Y-axis): same as channel A.

Channel B (X-axis): dc to 5 MHz.

DEFLECTION FACTOR: 5 mV/div to 20 V/div (12 calibrated positions) in 1, 2, 5 sequence.

PHASE DIFFERENCE: <3°, dc to 100 kHz.

CATHODE-RAY TUBE AND CONTROLS

TYPE: Hewlett-Packard, 15.6 cm (6.15 in.) rectangular CRT, post accelerator, approx 21 kV accelerating potential, aluminized P31 phosphor.

GRATICULE: 10 X 10 div internal, non-parallax graticule with 0.2 subdivision marking on major horizontal and vertical axes and markings for rise time measurements. Internal floodgun graticule illumination.

BEAM FINDER: returns trace to CRT screen r ;ardless of setting of horizontal, vertical, or intensity controls.

Z-AXIS INTPUT (INTENSITY MODULATION): +4 V, ≥50 ns width pulse blanks trace of any intensity, usable to ≤10 MHz for normal intensity. Input R, 1 kΩ ± 10%. Maximum input ±20 V (dc + peak ac), ≤1 kHz.

REAR PANEL CONTROLS: astigmatism and trace align.

GENERAL

REAR PANEL OUTPUTS: main and delayed gates, 0.8 V to >2.5 V capable of supplying approx 5 mA.

AMPLITUDE CALIBRATOR (0°C to +55°C)

Output Voltage	1 V p-p into ≥1 MΩ 0.1 V p-p into 50 Ω	±1%
Rise Time	≤0.1 μs	
Frequency	approx 1.4 kHz	

POWER: 100, 120, 220, 240 Vac, ±10%; 48 to 440 Hz; 100 VA max.

WEIGHT: net, 13 kg (28.6 lb); shipping, 15.7 kg (34.6 lb).

OPERATING ENVIRONMENT

Temperature: 0°C to +55°C.

Humidity: to 95% relative humidity at +40°C.

Altitude: to 4600 m (15 000) ft).

Vibration: vibrated in three planes for 15 min. each with 0.254 mm (0.010 in.) excursion, 10 to 55 Hz.

DIMENSIONS: see outline drawing.

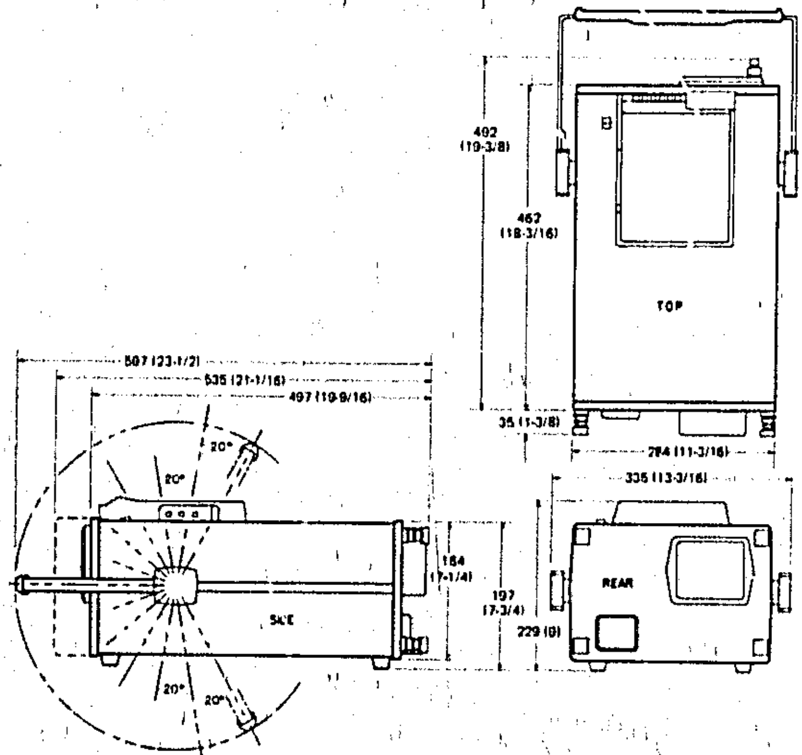
Table 1-1. Specifications (Cont'd)

MODEL 1745A WITH OPTION 034/035 INSTALLED

NOTES:

1. DIMENSIONS ARE FOR GENERAL INFORMATION ONLY. IF DIMENSIONS ARE REQUIRED FOR BUILDING SPECIAL ENCLOSURES, CONTACT YOUR HP FIELD ENGINEER.

2. DIMENSIONS ARE IN MILLIMETRES AND (INCHES).



SECTION II

INSTALLATION

2-1. INTRODUCTION.

2-2. This section provides installation instructions for the Model 1745A Oscilloscope. Also included is information pertinent to initial inspection, preparation for use, storage, and shipment.

2-2. INITIAL INSPECTION.

WARNING

To avoid electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers and panels).

Inspect the shipping container for damage. If the shipping container or cushioning is damaged, it should be kept until the contents of the shipment have been checked mechanically and electrically. Procedures for checking electrical performance are given in the Operator's Checks in Section III. If the contents are incomplete, if there is mechanical damage or defect, or if the instrument does not pass the electrical performance test, notify the nearest Hewlett-Packard Sales and Service office. If the shipping container is damaged, or the cushioning materials show signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carrier's inspection.

2-3. PREPARATION FOR USE.

2-4. **POWER REQUIREMENTS.** The Model 1745A requires a power source of 100, 120, or 240 Vac +5/−10%; 48- to 44-Hz single phase. Power consumption is 100 VA maximum.

WARNING

This is a Safety Class I product (provided with a protective earth terminal). An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

WARNING

If this instrument is to be energized via an autotransformer for voltage reduction, make sure the common terminal is connected to the earthed pole of the power source.

2-5. LINE VOLTAGE AND FUSE SELECTION.

WARNING

For protection against fire hazard, the line fuse should be replaced with 250 V, slow-blow fuses with the correct current rating.

CAUTION

BEFORE CONNECTING THIS INSTRUMENT TO LINE (Mains) voltage, be sure the line voltage switches are set correctly and that the proper fuse is installed.

If the line fuse burns out, do not replace it until the cause for the failure has been determined and repaired by a qualified service person only. Replacing this fuse in a damaged instrument can cause additional damage.

The line voltage switch settings and line fuse are selected at the factory according to the line (Mains) voltage available in the country of destination. To operate the instrument from any other power source proceed as follows:

a. Disconnect power source.

b. Stand instrument on rear panel legs. Through opening in bottom co.er, position LINE voltage select switches for desired Vac input. (Figure 2-1 shows switches set for 120 Vac operation.)

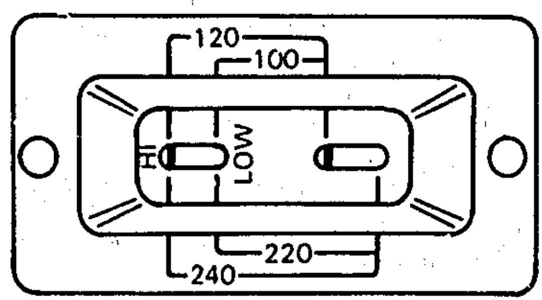


Figure 2-1. Line Voltage Selection Switches

c. Select and install proper line fuse. Fuse current ratings are printed near the fuse on the instrument rear panel and are listed with HP part numbers in table 2-1.

d. Reconnect power cord.

2-6. AC POWER CABLE.

WARNING

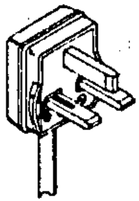
BEFORE CONNECTING THIS INSTRUMENT, the protective earth terminal of the instrument must be connected to the protective Conductor of the line (Mains) power cord. The Mains plug must be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet does not provide an instrument ground.

This instrument is equipped with a three-wire power cable. When connected to an appropriate power receptacle this cable grounds the instrument cabinet. The type of power cable plug shipped with each instrument depends on the country of destination. Figure 2-2 shows the part numbers (and associated Option numbers) for the power cable and plug configurations available.

Table 2-1. Line Fuse Part Numbers

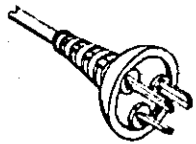
Line Voltage	Fuse Rating	HP Part Number
100/120 Vac	250 V, 1 A Slow blow	2110-0007
220/240 Vac	250 V, 500 mA Slow blow	2110-0202

Option 900 — United Kingdom 250 V



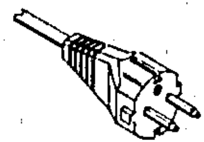
Plug: BS 1363A
HP 8120-1703

Option 901 — Australia/New Zealand 250 V



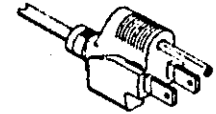
Plug: NZSS 198/AS C112
HP 8120-0696

Option 902 — European Continent 250 V



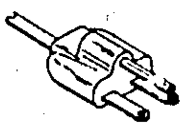
Plug: CEE7-VII
HP 8120-1692

Option 903 — USA/Canada 125 V



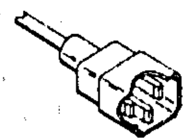
Plug: NEMA 5-15P
HP 8120-1521

Option 904 — USA/Canada 250 V



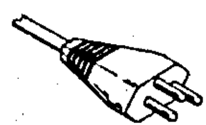
Plug: NEMA 6-15P
HP 8120-0698

Option 905 — Systems 250 V



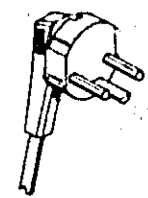
Plug: CEE 22-VI
HP 8120-2191

Option 906 — Switzerland



Plug: SEV 1011.1959-24507
HP 8120-2296

Option 912 — Denmark 220 V



Plug: DHCR 107
HP 8120-2956

NOTE: The number listed for the plug is the industry identifier for the plug only. The HP part number specifies a complete power cordset.

Figure 2-2. Power Cable and Mains Plug Part Numbers

OPERATION

SECTION III

OPERATION

3-1. INTRODUCTION.

3-2. This operating section explains the function of controls, indicators, and connectors on the 1745A. It describes typical operating modes in a measurement system and includes operator's checks and applications.

3-3. PANEL FEATURES.

3-4. The front- and rear panel photograph (figure 3-23) is located at the rear of this guide on a foldout page for easy reference while reading any part of this guide. The following paragraphs describe each control and connector. The descriptions have index numbers that are keyed to the illustration.

(1) **LINE.** Switch turns instrument power on and off.

(2) **LINE INDICATOR.** Indicator lights when instrument power is on.

(3) **BEAM FIND.** Returns display to viewing area relative to its off-screen position.

(4) **SCALE ILLUM.** Adjusts CRT background illumination for good contrast between background and the graticule. Useful to illuminate graticule when viewing in dark area, photographing (if camera has no light source), or prefogging film.

(5) **FOCUS.** Adjusts the writing beam for the sharpest trace. Always keep this display focused to prevent damaging the CRT internally.

(6) **BEAM INTENSITY.** Controls brightness of the CRT display.

(7) & (8) **POSITION.** Coarse (7) and FINE (8) adjustments position display horizontally.

(9) **Reset Lamp.** When lit, indicates trigger circuit is armed. Lamp goes off at end of sweep and remains off until trigger circuit is again armed by pressing RESET (10).

(10) **RESET.** Momentary pushbutton that arms trigger circuit in single-sweep mode. After RESET (10), sweep can be triggered by internal or external trigger signal or by rotating TRIGGER LEVEL control (19) through zero.

(11) **AUTO/NORM.**

AUTO sweep mode (pushbutton out). Free-running sweep provides bright display in absence of a trigger signal. Trigger signal input (internal or external) of 40 Hz or more overrides AUTO operation and sweep triggering is same as in NORM mode.

NORM sweep mode (pushbutton in) requires internal or external signal to generate sweep and must be used if input frequency is less than 40 Hz.

(12) **SINGLE.** Sweep occurs once with same triggering as in NORM. After each sweep, trigger circuit must be manually RESET (10).

(13) **MAG X10.** Magnifies horizontal display 10 times, and expands the fastest sweep time to 5 ns/div.

(14) **DLYD.** Selects delayed sweep mode of display.

(15) **DELAY.** The DELAY control provides a variable delay time from 0.5 to 10X the MAIN TIME/DIV settings of 100 ns to 2 s.

(16) **MIXED.** Selects main and delayed sweeps for the horizontal display. The first portion of the sweep is at the main sweep rate, and the second portion of the sweep (starting point chosen by DELAY (15)) is at the delayed-sweep rate.

(17) **MAIN.** Selects main sweep of display.

(18) **A VS B.** Selects an X-Y mode of operation with channel A input (Y-axis) plotted versus channel B input (X-axis). Vertical positioning is adjusted by channel A POSN (33), and horizontal positioning is adjusted by POSITION (7) and FINE (8).

(19) & (20) **TRIGGER LEVEL.** Selects the voltage level on the input trigger signal where the sweep is triggered. With external trigger signals, the trigger level is continuously variable from +1 V to −1 V on either slope of the input trigger

signal; +10 V to -10 V in EXT ÷ 10 27 or 33 mode. With internal trigger signals, the trigger level selects any point on the vertical waveform displayed.

21 **SWEEP AFTER DELAY AUTO/TRIG.** Selects the method of starting the delayed-sweep when in main intensified, delayed, or mixed mode operation. In AUTO, delayed sweep starts immediately after the delay interval, which is the product of the DELAY 15 dial setting (div) and the main TIME/DIV 22 setting. In TRIG, the delayed-trigger circuit is armed after the delay interval and delayed sweep must be triggered by either an internal or external trigger signal

22 **MAIN TIME/DIV.** Inner knob controls main sweep rate. Rate indicated by numbers displayed in knob skirt opening.

23 **DLY'D TIME/DIV.** The outer rotating section selects the delayed-sweep rate, which is indicated by the marker on the outer knob. Sweep accuracy is the same as with MAIN TIME/DIV. An interlock is incorporated so the delayed sweep is always faster than the main sweep. When rotated out of the off position in the MAIN mode 17, a portion of the main sweep is intensified indicating the length and delay position of the delayed sweep with respect to the main sweep.

24 **⎍/⎍.** Two position switch that selects slope of event that triggers delayed sweep when in TRIG'D 21 mode.

25 **Delayed AC/DC.** Selects delayed sweep trigger coupling.

26 **Delayed INT/EXT.** Selects internal or external delayed sweep triggering.

27 **Delayed EXT ÷ 10.** Attenuates external trigger signal by factor of 10.

28 **Delayed EXT TRIG INPUT.** BNC connector for delayed external trigger signal.

29 **TRIGGER HOLDOFF.** Increases time between sweeps and aids triggering on complex displays such as digital words.

30 **TIME/DIV VERNIER.** Provides continuous adjustment of main TIME/DIV between calibrated positions, extending slowest sweep to 5 s/div.

(31) **UNCAL.** Lights when TIME/DIV VERNIER (30) is out of CAL detent position; indicates that sweep is not calibrated.

(32) **Main EXT TRIG INPUT.** BNC connector for main external trigger signal.

(33) **Main EXT ÷ 10.** Attenuates external trigger signal by factor of 10.

(34) **Main INT/EXT.** Selects internal or external main sweep triggering.

(35) **Main AC/DC.** Selects main sweep trigger coupling.

(36) **HF REJ.** Attenuates internal or external trigger signals above approx 4 kHz. This is useful to condition low-frequency signals for best synchronization by eliminating unwanted high-frequency signals such as RF.

(37) **LF REJ.** Attenuates internal or external trigger signal below approx 4 kHz. This is useful to condition high-frequency signals for best synchronization by eliminating unwanted low-frequency signals such as power line interference.

(36) & (37) **LINE.** Selecting both LF REJ (37) and HF REJ (36) removes all internal and external trigger signals and applies input ac power frequency for triggering.

(38) _|‾/‾|_. Two position switch that selects slope of internal or external trigger signal used to start main sweep.

(39) **CH B INVT.** Inverts polarity of channel B signal. In A+B (58) & (55) mode, pressing CH B INVT (39) results in A minus B display.

(40) **BW LIMIT.** Reduces bandwidth of channel A and channel B to approx 20 MHz.

(41) **MAG X5.** Magnifies vertical presentation five times, and increases maximum sensitivity to 1 mV/div. Bandwidth is decreased to 40 MHz. Recommended on 5 mV/div and 10 mV/div ranges only.

(42) **TRIG VIEW.** Displays the selected internal or external trigger signal at a fixed sensitivity of approximately 100 mV/div or 1 V/div with EXT ÷ 10 (33). TRIGGER LEVEL (19) positions the display vertically. Center screen indicates the trigger threshold level with respect to the trigger signal. If ALT (53) or CHOP (56) is selected, three signals are displayed: channel A, the selected trigger signal (at center screen), and channel B.

(43) **Ground Post ⏚.** Convenient chassis ground connector. Useful to ensure common ground with equipment under test.

(44) **CAL 1 V.** Provides 1-V peak-to-peak (within 1%) square wave voltage signal recurring at approximate rate of 1.4 kHz (100 mV peak-to-peak when terminated in 50Ω).

NOTE

In the following descriptions for controls (45) through (50), only channel A control and connectors are discussed. Channel B controls and connectors are identical in function.

(45) **INPUT.** BNC connector to apply signals to channel A amplifier. Impedance and coupling are selectable by (47).

(46) **POSN.** Varies vertical position of channel A display.

(47) **Coupling.** Selects capacitive (AC), direct (DC), or 50-ohm coupling of input signal. GND position disconnects input signal and grounds input to vertical preamplifier.

(48) **Vernier.** Provides continuous control of deflection factor between calibrated VOLTS/DIV ranges. Vernier range is at least 2.5 to 1.

(49) **VOLTS/DIV.** Selects vertical deflection factor in 1, 2, 5 sequence from 0.005 V/div to 20 V/div, accurate within 3% with vernier (48) in CAL position.

(50) **UNCAL.** Lights when vernier control is out of detent position to indicate VOLTS/DIV (49) is uncalibrated.

(51) **TRIGGER A.** Selects sample of channel A signal as trigger signal when INT/EXT (33) is in INT.

(52) **TRIGGER B.** When in INT (34), sample of channel B signal is selected as trigger signal.

(51) & (52) **COMP.** Engaging both trigger A (51) and trigger B (52) selects composite trigger. When display mode is set to channel A, channel B, ALT, or A+B, sweep is triggered by displayed signal. In CHOP, sweep is triggered by channel A signal only.

(53) **ALT.** Channel A and B signals are displayed alternately on consecutive sweeps.

(54) **Channel A.** Displays channel A input signal.

(55) **Channel B.** Displays channel B input signal.

(54) & (55) **A+B.** Pressing both channel A (54) and channel B (55) displays the algebraic sum of channel A and channel B input signals. If channel B display is inverted (press CH B INVT (39)), A minus B display results.

(56) **CHOP.** Channel A and B signals are displayed simultaneously by switching between channels at 250 kHz rate.

(57) **Z-AXIS INPUT.** BNC connector for intensity modulation of CRT display. +4-volt, >50-ns width pulse blanks trace of any intensity. Do not apply more than ±20 V (dc + peak ac), ≤1 kHz.

(58) **TRACE ALIGN.** Screwdriver adjustment to align horizontal trace with graticule.

(59) **ASTIGMATISM.** Screwdriver adjustment used in conjunction with FOCUS (5) to achieve clean, sharp spot or trace. Adjustment is easier with stationary spot.

(60) **MAIN GATE OUTPUT.** Provides rectangular output of approx +2.5 V coincident with main sweep.

(61) **DLY'D GATE OUTPUT.** Provides rectangular output of approx +2.5 V coincident with delayed sweep.

(62) **FUSE.** 1A 250 V slow-blow for 100-V or 120-V operation 0.5A 250 V slow-blow for 220-V or 240-V operation.

(63) **LINE INPUT.** Connector for ac power cord.

3-5. OPERATOR'S CHECKS.

3-6. The checks that follow allow the operator to make quick evaluation of the instrument's main functions prior to use.

CAUTION

Before connecting power to the 1745A, make sure the low-voltage supply line select switches are set to correspond to the line voltage of the available ac power line. Refer to Section II for proper switch settings.

3-7. INITIAL TURN-ON PROCEDURE. To place the 1745A into operation and avoid CRT damage, accomplish the following steps in the sequence listed:

a. Set BEAM INTENSITY (6) fully counterclockwise.

b. Set vertical DISPLAY to ALT (53).

c. Set internal TRIGGER to A (51).

d. Set vertical verniers (48) for channel A and channel B to CAL detent.

e. Set CH B INV switch (39) to out position.

f. Set vertical coupling control (47) for channel A and channel B to GND.

g. Set vertical POSN controls (46) to midrange.

h. Set horizontal POSN control (7) to midrange.

i. Set main TIME/DIV control (22) to 1 mSEC.

j. Set delayed TIME/DIV control (23) to OFF.

k. Set TIME/DIV VERNIER (30) to CAL detent.

l. Set AUTO/NORM switch (11) to AUTO.

m. Set main INT/EXT trigger switch (33) to INT.

n. Set LINE switch (1) to ON position and allow 15-minute warmup.

o. Adjust BEAM INTENSITY (6) for barely visible trace.

3-8. TRACE ALIGNMENT. The trace align adjustment compensates for external magnetic fields that may affect alignment of the horizontal trace with respect to the graticule. When the instrument is moved to a new location, trace alignment should be checked and adjusted if necessary. To align the trace horizontally proceed as follows:

a. Obtain trace as described in initial turn-on procedure.

b. Using channel A POSN control (46), set trace to center horizontal graticule line.

c. Using nonmetallic alignment tool, adjust TRACE ALIGN (58) (rear panel) for best alignment of trace with horizontal graticule line.

3-9. FOCUS AND ASTIGMATISM ADJUSTMENTS. To adjust focus and astigmatism, proceed as follows:

a. Obtain trace as described in initial turn-on procedure.

b. Set BEAM INTENSITY control 6 fully counterclockwise.

c. Select A vs B 18 horizontal mode of operation.

d. Adjust BEAM INTENSITY 6 to observe spot.

e. Position spot near center of CRT using vertical POSN 46 and horizontal POSITION 7 controls.

f. Adjust FOCUS 5 (front panel) and ASTIGMATISM control 59 (rear panel) for best defined spot.

3-10. PROBE COMPENSATION. To adjust a divider probe that has a compensation adjustment, proceed as follows:

a. Obtain trace as described in initial turn-on procedure.

b. Connect divider probe to channel A INPUT connector 45.

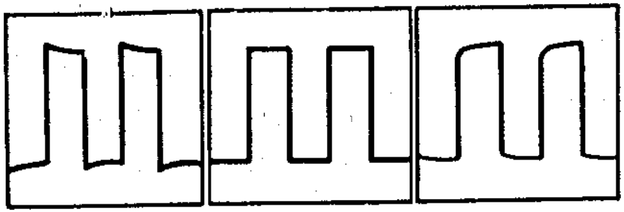
c. Connect divider probe tip to CAL 1 V terminal 43.

d. Set channel A input coupling 47 to DC.

e. Set channel A VOLTS/DIV control 49 for square-wave display with two to three divisions of vertical deflection.

f. Set main TIME/DIV control 22 for horizontal display of at least two full square waves (0.2 mSEC range).

g. Adjust divider probe compensation for correct display (figure 3-1).



OVER COMPENSATED | CORRECTLY ADJUSTED | UNDER COMPENSATED

Figure 3-1. Divider Probe Adjustment Display

3-11. VERTICAL ACCURACY CHECK. To check vertical accuracy, proceed as follows:

a. Accomplish initial turn-on procedure.

b. Connect CAL 1 V (44) output to channel A INPUT connector (45) using BNC to banana plug adapter and test lead with alligator clips.

c. Set channel A VOLTS/DIV control (49) to 0.2 V range.

d. Set main TIME/DIV control (22) to 0.2 mSEC range.

e. Square-wave amplitude of displayed waveform should be five major divisions (±4%).

3-12. SWEEP TIME ACCURACY. To check horizontal sweep accuracy, proceed as follows:

a. Accomplish initial turn-on procedure.

b. Connect time-mark generator to channel A INPUT connector (45).

c. Set main TIME/DIV (22) to 0.5 μSEC position.

d. Set time-mark generator for 0.5 μs markers.

e. Using horizontal POSITION controls (7) and (8), set one marker on far left graticule line.

f. Markers should line up (approximately) with each vertical graticule line across CRT.

g. Marker on far right-hand side of CRT should be within 0.2 major division of last vertical graticule line.

3-13. OPERATING INSTRUCTIONS.

3-14. The following procedures provide additional information concerning operation of the instrument.

3-15. AUTO VERSUS NORM (11). In AUTO operation, there will always be a recurring sweep (baseline trace), except under triggering conditions. A trigger of 40 Hz or higher overrides AUTO operation and a stable presentation is displayed. Adjustment of main TRIGGER LEVEL (19) may be necessary for a stable display. If the trigger signal is 40 Hz or less, NORM operation must be used. A trigger signal is always needed in NORM operation to generate a sweep.

3-16. SWEEP AFTER DELAY (21). In AUTO mode, delayed sweep starts immediately after the delay interval which is the product of the DELAY dial (15) setting and the main TIME/DIV (22) setting. In TRIG mode, the delayed trigger circuit is armed after the delay interval and delayed sweep must be triggered internally or externally by a trigger signal.

3-17. OBTAINING BASIC DISPLAYS. These procedures will aid the operator in becoming more familiar with the instrument. Before performing the procedures, complete the initial turn-on procedure. In addition, set the 1746A front-panel controls as follows:

Coupling (CH A) 47 .... DC
VOLTS/DIV (Ch A) 49 .... 0.02
Main TIME/DIV 22 .... 0.5 mSEC

3-18. NORMAL SWEEP DISPLAY.

a. Connect CAL 1 V terminal 44 to channel A INPUT connector 45 using 10:1 divider probe supplied.

b. Adjust channel A POSN 46 to align base of square-wave display on second horizontal graticule line from bottom. Adjust main TRIGGER LEVEL 19 for stable display.

c. Observe square-wave display with amplitude of five divisions and approximately seven positive-going pulses.

3-19. MAGNIFIED SWEEP DISPLAY.

a. Obtain normal sweep display.

b. Adjust horizontal POSITION 7 to place portion of waveform to be magnified on center graticule of CRT (figure 3-2a).

c. Engage MAG X10 switch 13.

d. Adjust fine horizontal POSITION 8 for precise placement of magnified display (figure 3-2b).

3-20. DELAYED SWEEP DISPLAY.

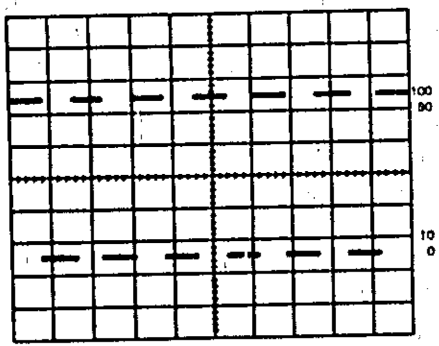
a. Obtain normal sweep display.

b. Adjust delayed TIME/DIV 23 for 50 μSEC, and observe intensified portion of square wave. Set BEAM INTENSITY 6 control to a comfortable viewing level.

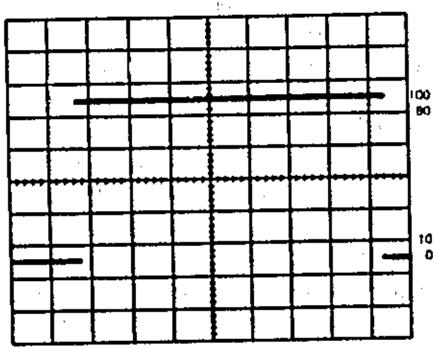
c. Set SWEEP AFTER DELAY 21 to AUTO and turn DELAY dial 15 clockwise until intensified portion of trace is over trace area to be investigated (figure 3-3a).

d. Engage DLY'D switch 18 and note intensified portion of trace is now displayed across entire CRT (figure 3-3b).

e. DELAY dial 15 control may be adjusted to view other pulses in the pulse train.

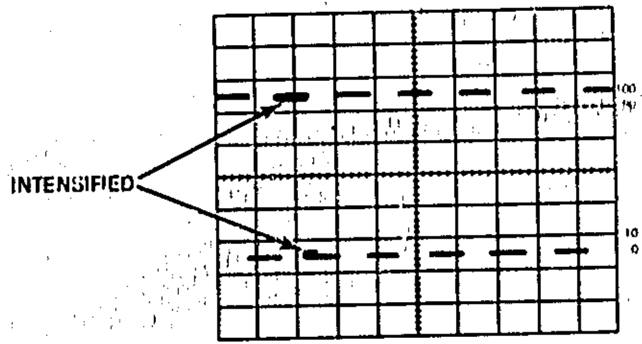


a. Normal Display

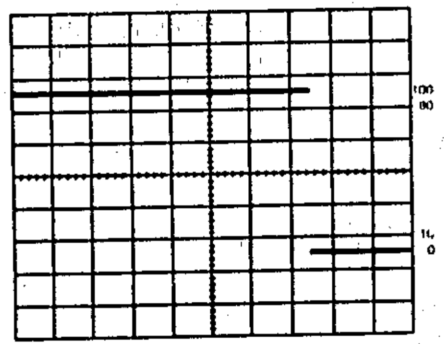


b. Magnified Display

Figure 3-2. Magnified Sweep



a. Normal Display with Intensified Area



b. Delayed Sweep Display

Figure 3-3. Delayed Sweep

3-21. MIXED SWEEP DISPLAY.

a. Obtain normal sweep display.

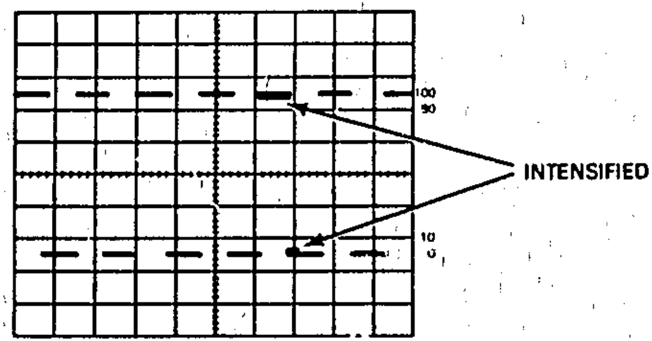
b. Adjust delayed TIME/DIV (23) for 50 μSEC and note intensified portion of square wave. Set BEAM INTENSITY (6) to comfortable viewing level.

c. Turn DELAY dial (15) clockwise until part of waveform in second half of CRT is intensified (figure 3-4a).

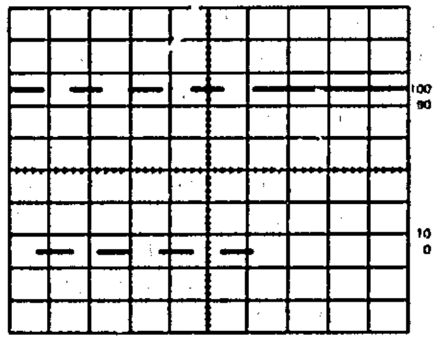
d. Engage MIXED (16) and observe that first portion of the display is at main TIME/DIV (22) sweep rate and second portion is at delayed TIME/DIV (23) sweep rate (figure 3-4b). The transition point from main sweep to delayed sweep can be varied by adjusting DELAY dial (15).

3-22. A VS B DISPLAY.

a. Engage A vs B (18). BEAM INTENSITY (6) may need to be decreased. Apply vertical (Y-axis) signal to channel A INPUT (45) connector and horizontal (X-axis) signal to channel B INPUT connector. Channel A POSN (46) adjusts vertical positioning; POSITION (7) adjust horizontal positioning. Adjust channel A and B VOLTS/DIV (49) controls as required.



a. Normal Display with Intensified Area



b. Mixed Sweep Display

Figure 3-4. Mixed Sweep

b. If display is not visible, press BEAM FIND (3) and adjust channel A and B VOLT/DIV controls until display is compressed vertically. Center compressed display with POSN (36) and POSITION (7) controls. Release BEAM FIND, and adjust FOCUS (5) for a sharp display.

3-23. SINGLE SWEEP OPERATION. Single sweep mode is often used to photograph single occurrence events. To use this mode, proceed as follows:

a. Select SINGLE (12) sweep mode.

b. Set AUTO/NORM to NORM (11).

c. Set all trigger processing controls to desired settings; for example, INT/EXT (34), slope (38), and TRIGGER LEVEL (19).

d. Depress RESET (10) pushbutton; the red RESET (9) lamp will light.

3-24. The sweep circuitry is now armed; as soon as a trigger signal is received that meets the preset requirements (slope, coupling, level, etc.), the time base will generate one sweep. As soon as the sweep ends, the RESET (9) lamp will extinguish and the time base must be reset again.

3-25. SINGLE SWEEP USING TRIGGER VIEW. To use the trigger view feature in single sweep, perform the following steps:

a. Engage TRIG VIEW (42). This turns off both vertical channels; however, trigger view circuitry will not be activated until a certain transition occurs at the end of the sweep.

b. To activate trigger view, press RESET (10) and rotate TRIGGER LEVEL (19) from one extreme to the other or engage AUTO (11) and press RESET, then disengage AUTO.

3-26. After one sweep has been manually generated, the necessary transition will have occurred and trigger view mode will operate in a normal manner.

3-27. TIME MEASUREMENT APPLICATIONS.

3-28. TIME DURATION. Time duration measurements are made between two points on the same or different waveforms (figure 3-5). Alternate should be selected for displaying high frequency signals and chop for low frequency signals. Channel A or B trigger must be selected when using alternate or chop. For fast, single-shot or low repetition rate signals, use the A + B display mode.

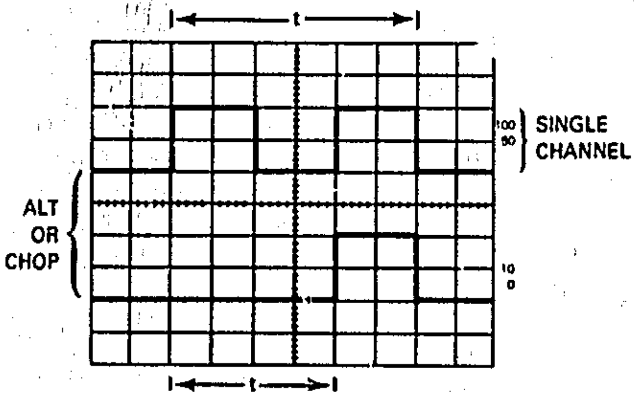


Figure 3-5. Time Duration Measurement

3-29. The following procedures illustrate period and repetition rate or frequency measurements. Pulse width and time difference measurements are very similar. Pulse width is the time duration of the pulse measured between the 50% amplitude point on the leading edge to the 50% amplitude point on the trailing edge of the waveform. On waveforms with variable transitions, measure pulse width from the start of the leading edge to the start of the trailing edge. If these points are not well defined, use the 10% rise and fall points. In time difference measurements, both channels of the oscilloscope are used and the horizontal distance measured is from the start of a reference waveform to the start of the waveform being compared to the reference.

3-30. Period Measurements.

a. Apply signal to the channel A INPUT connector (45), and select Channel A DISPLAY (53) and TRIGGER A (51).

b. Adjust VOLTS/DIV (49) for six to seven divisions of display, if possible, and set the MAIN TIME/DIV (22) to the fastest sweep speed that will display at least one cycle within the 10 available divisions on the CRT.

c. Using the vertical POSN (46) and the horizontal POSITION (7), center the display.

d. Measure the horizontal distance for one cycle in divisions. The TIME/DIV VERNIER (30) should be in CAL detent.

e. Multiply the horizontal distance in step d times the MAIN TIME/DIV setting. If using the MAG × 10 switch (13) divide the product by 10.

Use the following formula:

Period = Horizontal Distance For One Cycle in Div (Step d) × MAIN TIME/DIV Setting (Step b) ÷ Magnifier

Example: Assume one cycle of the waveform occurs in four divisions, the MAIN TIME/DIV setting is 0.2 mSEC, and the MAG × 10 switch is off (figure 3-6).

Substituting in the formula:

Period = 4 Div × 0.2 ms/Div = 0.8 ms

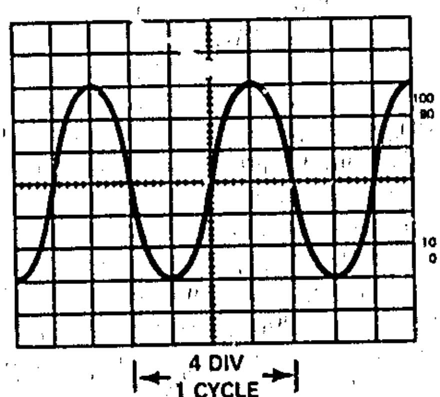


Figure 3-6. Period Measurement

3-31. Repetition Rate or Frequency Measurements.

a. The repetition rate or frequency of a waveform is the reciprocal of the period.

b. Use the procedure for period measurements to calculate the period of your signal and take the reciprocal to determine the repetition rate or frequency.

Example: Using the period from the previous example of 0.8 ms, take the reciprocal to find the repetition rate or frequency.

$$\text{Repetition Rate or Fvequency} = \frac{1}{\text{Period}} = \frac{1\text{ cycle}}{0.8\text{ ms}}$$

$$= \frac{1\text{ cycle}}{8 \times 10^{4}\text{ s}} = 0.125 \times 10^{4}\ \frac{\text{cycle}}{\text{s}} = 1.25\text{ kHz}$$

3-32. RISE TIME MEASUREMENTS. Rise time measurements are made between the 10% and 90% points of the waveform transition. Rise time is measured on the leading edge of the waveform and fall time is measured on the trailing edge of the waveform. The Model 1745A CRT has 10% and 90% points conveniently marked by dotted lines for both a five- and a ten-division reference. The dots are also spaced identically to the minor division markings on the major axis to assist in interpolation.

a. Apply the pulse to the channel A INPUT connector (45), and select Channel A DISPLAY (54) and TRIGGER A (51).

b. Adjust VOLTS/DIV (49) and vernier (48) for five or ten divisions of amplitude and the MAIN TIME/DIV (22) to display enough pulse top and baseline for measurement. Spread the 10% and 90% points as far apart as possible.

c. Turn horizontal POSITION (7) until the 10% point on the waveform intersects a 10% marking and a vertical graticule line. The display should be centered in the viewing area.

d. Count the number of divisions until the pulse rise crosses the 90% markings. The TIME/DIV VERNIER (30) should be in CAL detent.

e. Multiply the number of divisions in step d times the MAIN TIME/DIV setting. This is the rise time (t_r). If using the MAG × 10 switch, divide the product by 10.

Example: Assume the number of divisions between the 10% and 90% points is four and the MAIN TIME/DIV setting is 2 μSEC (figure 3-7).

$t_r = 4 \times 2\ \mu s = 8\ \mu s$

If using the oscilloscope to measure a rise time near the Model 1745A rise time (≤3.5 ns), error correction may be required. For accurate results, error correction should be used when the pulse rise time is four times the oscilloscope rise time or faster.

Use the following formula:

$$t_r\,(\text{pulse}) = \sqrt{t_r^2\,(\text{observed}) - t_r^2\,(\text{oscilloscope})}$$

Example: Assume the 10% to 90% observed rise time is 7.5 ns and the oscilloscope rise time is 3.5 ns.

Substituting in the formula:

$$t_r\,(\text{pulse}) = \sqrt{7.5^2 - 3.5^2} = 6.6\ \text{ns}$$

3-33. DELAYED SWEEP. For many time-interval measurements, delayed sweep will provide increased accuracy and resolution. In this guide three procedures are discussed using delayed sweep: magnification of a portion of a complex waveform for closer investigation, measuring the time interval between two pulses, and measuring pulse jitter. The first procedure is discussed in the section: Operating Instructions. The remaining two procedures are explained in the following paragraphs.

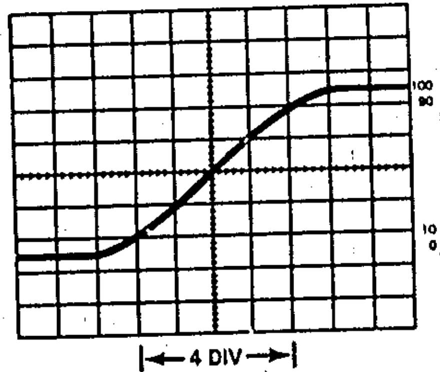


Figure 3-7. Rise Time Measurement

3-34. Delayed Sweep Time Interval Measurements. The delayed sweep mode can be used to increase the accuracy of your timing measurements. The following measurement determines the time interval between two pulses displayed on the same trace. The procedure may also be used to measure the time interval between pulses from two different channels or to make time duration measurements on a single pulse. To demonstrate the increase in accuracy, a measurement will first be made using only the main time base, and then the delayed time base will be used to make the same measurement.

a. Apply signal to the channel A INPUT connector, and select channel A DISPLAY (53) and TRIGGER A (51).

b. Set input coupling as desired, and adjust VOLTS/DIV (49) for approximately four divisions of amplitude.

c. Select INT main trigger (33), and MAIN sweep (17).

d. Adjust the MAIN TIME/DIV (22) to display six to eight divisions between pulses, and adjust main TRIGGER LEVEL (19) for a stable display.

e. Using horizontal POSITION (7), place the 50% point of the first pulse on a convenient graticule line and count the number of divisions to the 50% point of the second pulse (figure 3-8).

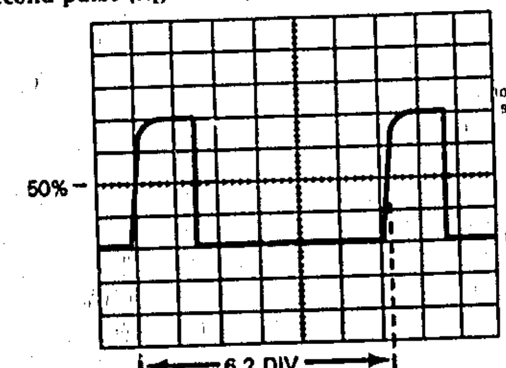


Figure 3-8. Time Interval Measurement Using Main Time Base

f. To calculate the time interval (t), use the following formula:

t = (Divisions between pulses × MAIN TIME/DIV)

Example: Assume 6.2 divisions between pulses, and a MAIN TIME/DIV setting of 0.5 mSEC.

Substituting in the formula:

t = (6.2 DIV × 0.5 ms/DIV) = 3.1 ms

3-35. Now use delayed sweep to make the same measurement.

a. Perform steps a through d of the previous procedure and select SWEEP AFTER DELAY AUTO (21).

b. Set DLY'D TIME/DIV (23) as required, and turn the DELAY (15) dial to place the intensified portion on the first pulse (figure 3-9a).

c. Select DLY'D sweep (18) and adjust the DELAY dial (15) so the 50% amplitude point of the first pulse is on the center vertical graticule line (figure 3-9b). Note the DELAY dial reading.

d. Rotate the DELAY dial clockwise until the second pulse is positioned on the same point of the center vertical graticule line (figure 3-9c). Verify this is the correct pulse by returning to MAIN sweep (17) and observing the intensified portion. Again note the DELAY dial reading.

e. To calculate the time interval (t), use the following formula:

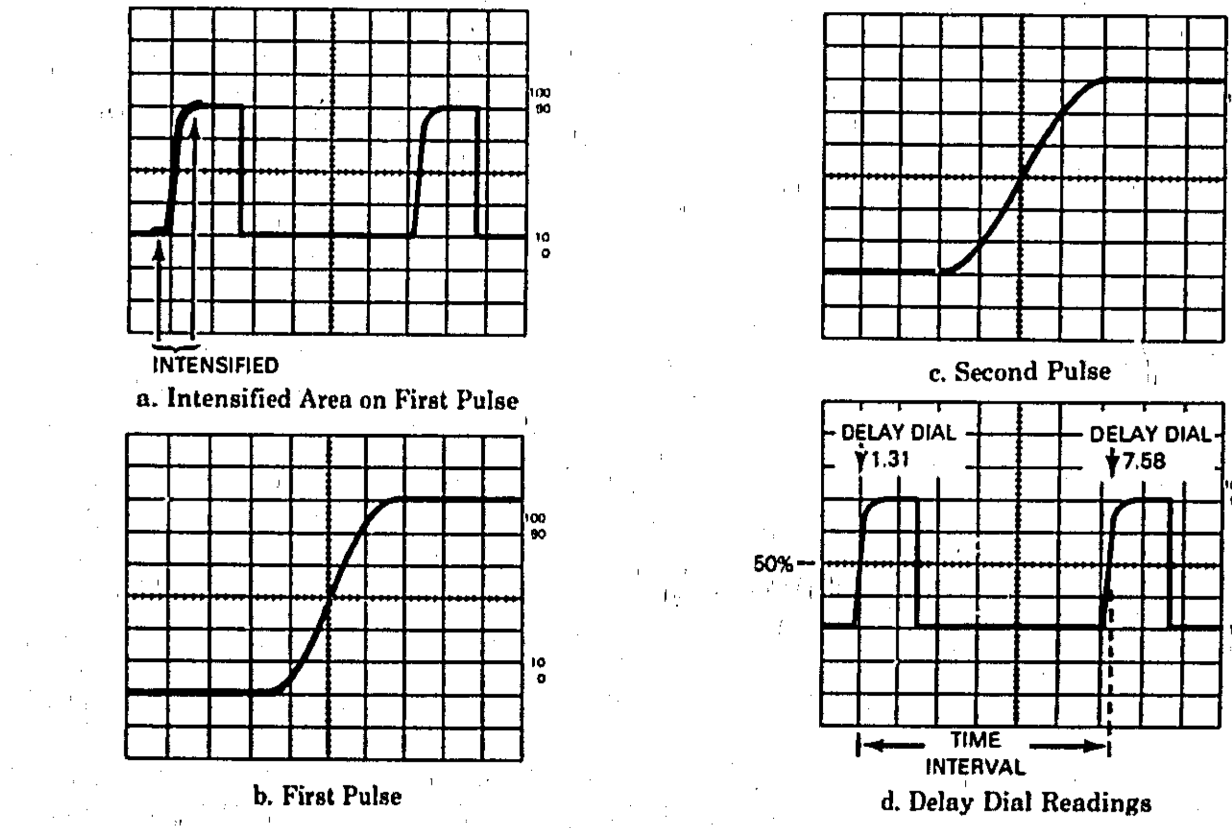
t = Second DELAY reading – First DELAY reading

× MAIN TIME/DIV

Example: Assume the first DELAY dial reading is 1.31 and the second DELAY dial reading is 7.58 with MAIN TIME/DIV set to 0.5 ms and DLY'D TIME/DIV set to 0.05 ms (figure 3-9d).

Substituting in the formula:

t = (7.58 – 1.31) × 0.5 ms/DIV = 3.14 ms.



a. Intensified Area on First Pulse

b. First Pulse

c. Second Pulse

d. Delay Dial Readings

Figure 3-9. Time Interval Measurement Using Delayed Time Base

3-36. Pulse Jitter Measurements. Jitter is a time uncertainty in the waveform caused by random joise, or spurious or periodic signals. To measure jitter use the following procedure.

a. Apply signal to the channel A INPUT connector (45), and select channel A DISPLAY (50) and TRIGGER A (51).

b. Adjust VOLTS/DIV (49) for five or more divisions of vertical deflection, and set MAIN TIME/DIV (22) to show the complete waveform.

c. Adjust main TRIGGER LEVEL (19) until the display is a stable as possible.

d. Set DLY'D TIME/DIV (23) as required, and turn the DELAY dial (15) to place the intensified display on the portion of the pulse showing jitter. The TIME/DIV VERNIER (30) should be in the CAL detent position.

e. Select the DLY'D (13) mode and SWEEP AFTER DELAY AUTO (21). The horizontal movement of the pulse is the pulse jitter. There is some inherent jitter in any delayed sweep time base and should be included in the measurement (jitter in Model 1745A 1:50,000, which is insignificant in most measurements). Using horizontal POSITION (7), place the leading edge of the pulse on the center vertical graticule line. With vertical POSN (46) control center the display.

f. Measure the horizontal displacement on the center horizontal graticule line as shown in figure 3-10. This displacement times the DLY'D TIME/DIV setting equals the pulse jitter in time.

Example: Assume the DLY'D TIME/DIV setting is 0.1 mSEC and the horizontal displacement is 0.4 DIV (figure 3-10).

Pulse Jitter = 0.4 DIV × 0.1 ms/DIV = 0.04 ms.

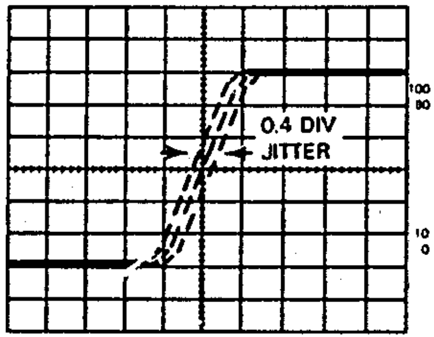


Figure 3-10. Pulse Jitter Measurement

3-37. Eliminating Jitter. Jitter can be eliminated from the display by using the SWEEP AFTER DELAY TRIG control 21. In this mode, the delayed sweep is triggered on the jittering pulse after the delay interval. So by triggering the delayed sweep after the delay period, the effect of jitter on the display is eliminated, and pulse parameters can be measured. Remember, in this mode the DELAY 15 dial is uncalibrated (figure 3-11).

3-38. Viewing Pulses With Variable Time Durations. When the time duration between the end of one pulse and the start of another pulse is variable, use the SWEEP AFTER DELAY TRIG control 21 and the DELAY 15 dial to arm the delayed-trigger circuit after the last known pulse. The delayed sweep will now be triggered by the pulse with variable time duration and its parameters can be measured (figure 3-12).

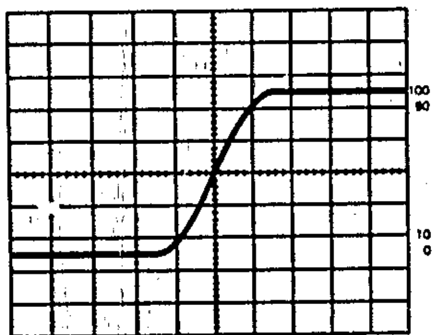


Figure 3-11. Pulse Jitter Eliminated

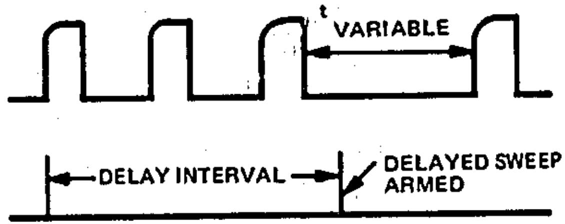


Figure 3-12. Pulse With Variable Time Duration

3-39. MEASURING PHASE DIFFERENCE BY TIME DELAY. The phase difference between two signals of the same frequency can be determined up to the frequency limitation of the vertical amplifier. Use the following procedure:

a. Select ALT 53, TRIGGER A 51, and main trigger positive slope 38.

b. Apply the input signal to the channel A INPUT connector and the output signal to the channel B INPUT connector. The cables or probes used must either have the same electrical length or the delay differences must be accounted for to prevent measurement error.

c. Select AC input coupling (47) for both channels, and adjust channels A and B VOLTS/DIV and vernier controls for an equal amplitude on both channels.

d. Adjust the MAIN TIME/DIV (22) and TIME/DIV VERNIER (30) controls so a complete cycle for each waveform is displayed within 10 horizontal divisions.

e. Using the vertical POSN controls (46) center both waveforms vertically.

f. Readjust TIME/DIV VERNIER for one complete cycle of the inut signal in an exact number of major divisions. Six or eight divisions is suggested, which would equal 60°/Div and 45°/Div respectively. Obtain additional resolution by using the MAG × 10 switch. In this case, six divisions would equal 6°/Div and eight divisions would equal 4.5°/Div.

g. Count the number of major plus minor divisions between the reference signal and the output signal at the point where they both cross the center horizontal graticule line. Convert divisions to degrees and this is the phase difference.

Example: Assume one cycle of the input signal occurs in six divisions and there are three minor divisions between the input and output waveforms (figure 3-13).

Since one major division equals 60°, one minor division equals 12°. Phase Difference = 3 × 12 = 36°; the output lags the input by 36°.

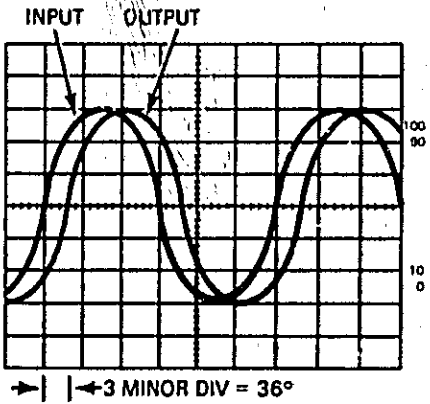


Figure 3-13. Phase Difference Measurement

3-40. VOLTAGE MEASUREMENT APPLICATIONS.

3-41. Voltage measurements can be made between any point on a waveform and a 0-volt reference (absolute voltage) or between any two points on a waveform (voltage difference) (figure 3-14).

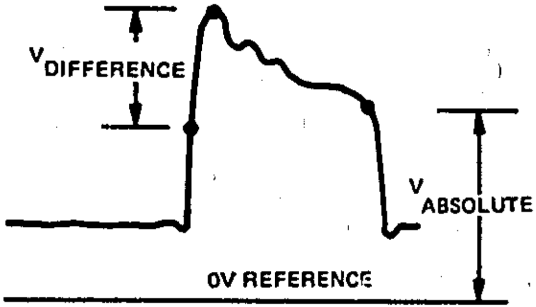


Figure 3-14. Types of Voltage Measurements

3-42. DC AND ABSOLUTE VOLTAGE MEASUREMENTS. The following procedure can be used to make absolute voltage measurements with respect to a 0-volt reference, and to determine the dc component of an input signal.

a. Connect signal to channel A or B INPUT connector (45).

b. Set coupling (41) to DC and adjust main TRIGGER LEVEL (19) for stable display.

c. Adjust vertical POSN (46), VOLTS/DIV (49), and main TIME/DIV (22) for well centered display. Make sure that associated verniers (48) and (30) are in their CAL detent positions.

d. Set input coupling (47) to GND and AUTO/NORM (11) to AUTO. Trace defines level of zero volt. If level is below signal, signal is positive. If level is above signal, signal is negative.

e. Adjust vertical POSN control (46) to set trace on convenient graticule line to establish 0-volt reference level. Do not move vertical POSN control (46) after this step.

f. Return coupling (47) to DC.

g. Measure distance in divisions between reference line and any point of interest on signal.

h. Multiply number of divisions obtained in step g by VOLTS/DIV (49) setting to determine signal voltage. Include attenuation factor if using probe.

Example: Assume vertical deflection of 8 divisions, waveform above reference line, and VOLTS/DIV setting of 0.2 (figure 3-15). Absolute Voltage = $8 \times 0.2 =$ 1.6 volts. Waveform is above reference line so voltage is positive.

3-43. PEAK-TO-PEAK VOLTAGE MEASUREMENTS. Displays of ac voltages contain amplitude errors due to frequency response of the instrument. With increasing signal frequencies, the amplitude of the errors increases.

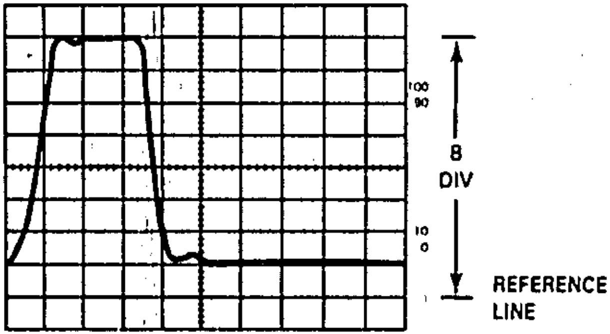


Figure 3-15. Absolute Voltage Measurements

To obtain displays with less than 10% amplitude error the frequency of the signal being measured must be less than half the specified bandwidth of the oscilloscope. A frequency equal to the specified bandwidth of the oscilloscope will display a voltage amplitude on the CRT that is 3 dB down from the actual amplitude of the applied signal. Frequency rolloff of the instrument must be considered when making voltage measurements with an oscilloscope. To measure peak-to-peak voltage of an input signal, proceed as follows:

a. Connect signal to channel A or B INPUT connector or (45).

b. Set coupling (47) to AC and adjust main TRIGGER LEVEL (19) for stable display.

c. Adjust vertical POSN (46), VOLTS/DIV (49), and main TIME/DIV (22) for well centered display of at least three cycles duration and at least three divisions of amplitude. Make sure that VOLTS/DIV vernier [illegible] is in CAL detent position.

d. Using vertical POSN control (46), place negative peaks of input signal on horizontal graticule line near bottom of CRT.

e. Using horizontal POSITION control (7), place one positive peak of signal on center vertical graticule line.

f. Count number of vertical divisions from most negative to most positive portions of waveform (estimate to nearest tenth of division) (see figure 3-16).

g. Multiply number of divisions noted in step f by setting of VOLTS/DIV switch (49). If signal is derived through divider probe, multiply result of this step by attenuation factor of probe. Remember to consider amplitude attenuation caused by frequency roll off of oscilloscope.

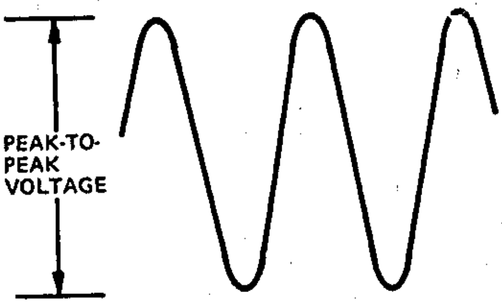


Figure 3-16. Peak-to-Peak Measurement

3-44. AVERAGE VOLTAGE MEASUREMENTS USING OSCILLOSCOPE. To measure average voltage using the oscilloscope alone, proceed as follows:

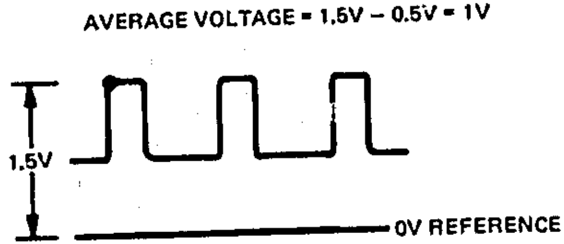
a. Connect signal to channel A or B INPUT connector (45).

b. Set coupling (47) to GND and AUTO/NORM (11) to AUTO. Trace level is zero volt.

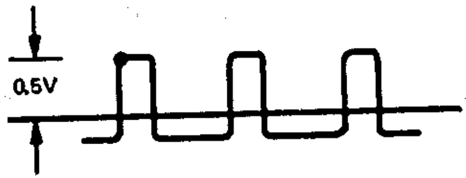
c. Switch coupling (47) to DC and measure absolute voltage at point of interest on waveform (figure 3-17a).

d. Switch coupling (47) to AC and measure absolute voltage to same point on waveform (figure 3-17b).

e. Difference between first and second voltage measurements is average voltage.



a. DC Reference



b. AC Reference

Figure 3-17. Average Voltage Measured with Oscilloscope

3-45. AVERAGE AND RMS VOLTAGE MEASUREMENTS USING OPTION 034 DMM. The Option 034 DMM is an average-responding meter calibrated in rms. To measure rms voltage using the DMM, proceed as follows:

a. Set two-position switch on 1745A top cover to rear position.

b. Set DMM controls as follows:

POWER	ON
AC/AC (~)	~ (IN)
VOLTS (V)	(IN)
AUTO HOLD	AUTO (OUT)
AMPS (A) AND KΩ	(OUT)

CAUTION

Do not connect the leads to any ac voltages greater than 707 V rms.

c. Connect test leads from VΩ (HI) and COM (LOW) on DMM to signal under test. Digital Multimeter will automatically select best meter range for measurement and display rms voltage with maximum resolution. To measure average voltage, set DC/AC for dc voltage (out).

3-46. AMPLITUDE COMPARISON MEASUREMENTS. When measuring the amplitude of a signal, it may be helpful to obtain a deflection factor not calibrated on the VOLTS/DIV switch. This can be done by using a signal of known amplitude (reference signal) and adjusting the VOLTS/DIV vernier to obtain the desired deflection factor. Amplitude comparison measurements may be desirable when calibrating an instrument. By using this method, the accuracy of your measurement depends upon the reference signal accuracy. To make measurements by amplitude comparison, proceed as follows:

a. Apply reference signal to channel A INPUT connector (45), and set DISPLAY and internal TRIGGER (51) to A.

b. Adjust main TIME/DIV (22) to display several signal cycles.

c. Adjust VOLTS/DIV (49) and vernier (48) to obtain display with exact number of divisions of vertical deflection. Greater accuracy is obtained with greater vertical deflection. Do not readjust vernier (48) after this step.

d. Calculate scale factor (sf) by the following formula:

$$sf = \frac{\text{Reference signal amplitude (volts)}}{\text{Display amplitude in DIV}}$$

Example: Assume reference signal amplitude of 40 volts, VOLTS/DIV setting of 5, and display amplitude of six divisions.

$$sf = \frac{40}{6 \times 5} = 1.3$$

e. Disconnect reference signal and connect signal to be measured.

f. Set VOLTS/DIV (49) for measurable display amplitude. Do not readjust vernier (48).

g. Use following formula to calculate amplitude of signal being measured:

Signal Amplitude - VOLTS/DIV setting multiplied by sf (step d) multiplied by display amplitude (step f).

Example: Assume signal amplitude of 5 divisions, VOLTS/DIV setting of 2 and scale factor of 1.3. Signal amplitude = 5 × 2 × 1.3 = 13 volts.

h. You can also calculate value of unknown signal as percentage of reference signal.

Example: Assume reference signal has display amplitude of eight divisions. In this case, each division is equal to 12.5% of total reference signal amplitude. If unknown signal is applied and it has amplitude of 6.2 divisions, then amplitude of unknown signal is:

Unknown signal amplitude = 6.2 DIV × 12.5% = 77.5% of reference signal amplitude.

3-47. COMMON-MODE REJECTION. Frequently, signals of interest are offset by undesired dc or low frequency voltage ac components that prevent use of vertical ranges sensitive enough to make good measurements. Often a signal similar to the unwanted component can be connected to the opposite channel, inverted, and added algebraically to the signal of interest to cancel the unwanted component.

3-48. True dc components can usually be eliminated by selecting ac input coupling. The ability of an oscilloscope to cancel ac common-mode signals varies with amplitude and frequency of the signals. Very high common-mode amplitudes may not be completely cancelled. Good common-mode rejections should be achieved with common-mode signal amplitudes of up to two screen diameters (16 CRT divisions). With high-frequency common-mode signals, minor components may be impossible to eliminate from the display. The lower the frequency of the common-mode signal, the better the common-mode rejection of the oscilloscope.

3-49. To use the common-mode rejection technique, proceed as follows:

a. Apply signal to be measured (with unwanted component) to channel A INPUT (45).

b. Apply signal similar to unwanted component to channel B INPUT (45) (figure 3-18).

c. Set coupling as required and select ALT (53) DISPLAY mode.

d. Adjust VOLTS/DIV (49) and vernier (48) so that display on channel B is approximately equal in amplitude to unwanted component on channel A.

e. Set the oscilloscope controls as follows:

TRIGGER	A (51)
CH B INPUT	INVT (39)
DISPLAY	A+V (54) and (55)

f. With either channel A or B VOLTS/DIV vernier (48), adjust for minimum deflection in common-mode signal. The resultant display will either subtract all of unwanted component or display desired signal larger than common-mode signal (figure 3-19).

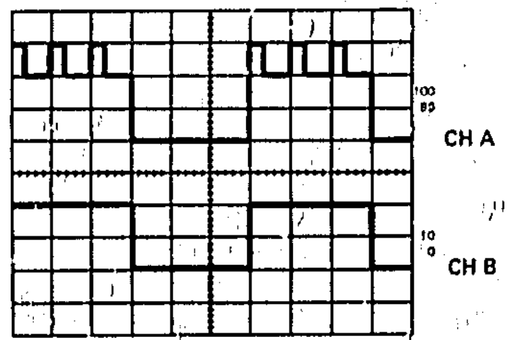


Figure 3-18. Common-Mode Signals

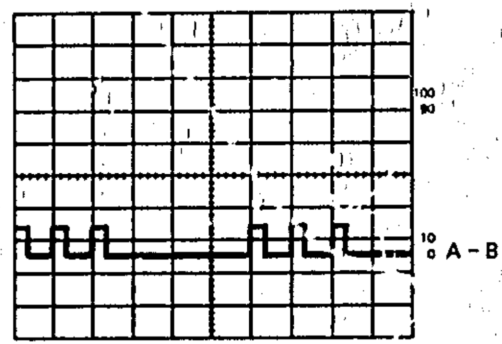


Figure 3-19. Resultant Display

3-50. A vs B PHASE MEASUREMENTS.

3-51. The A vs B mode will allow you to measure the phase differences between two signals of the same frequency up to 100 kHz. The channel A input signal provides deflection along the Y-axis, and the channel B input signal provides deflection along the X-axis. The phase difference can be measured from the resulting lissajous pattern using the following procedure.

a. Connect one signal to the channel A and the other to the channel B INPUT connector (45).

b. Select A vs B (18) and adjust the channel A VOLTS/DIV (49) control for six to seven divisions of vertical deflection (Y-axis) and the channel B VOLTS/DIV control for eight to nine divisions of horizontal deflection (X-axis).

c. Using the channel A POSN (46) control for vertical positioning and the horizontal POSITION (7) control for horizontal positioning, center the display on the CRT.

d. Measure distances A and B as shown in figure 3-20a. A is the distance intersected by the trace on the center horizontal graticule line, and B is the total horizontal deflection of the trace.

e. The sine of the phase angle between the two signals is A/B. Figures 3-20b, 3-20c, and 3-20d show signals in phase, 90° out of phase, and 180° out of phase respectively. If the trace is rotating, the signals are not at the same frequency.

Example: In figure 3-20a, A equals six divisions and B equals eight divisions. Distance C is equal to distance D. The sine of the phase difference (θ) is A/B, which is 0.75.

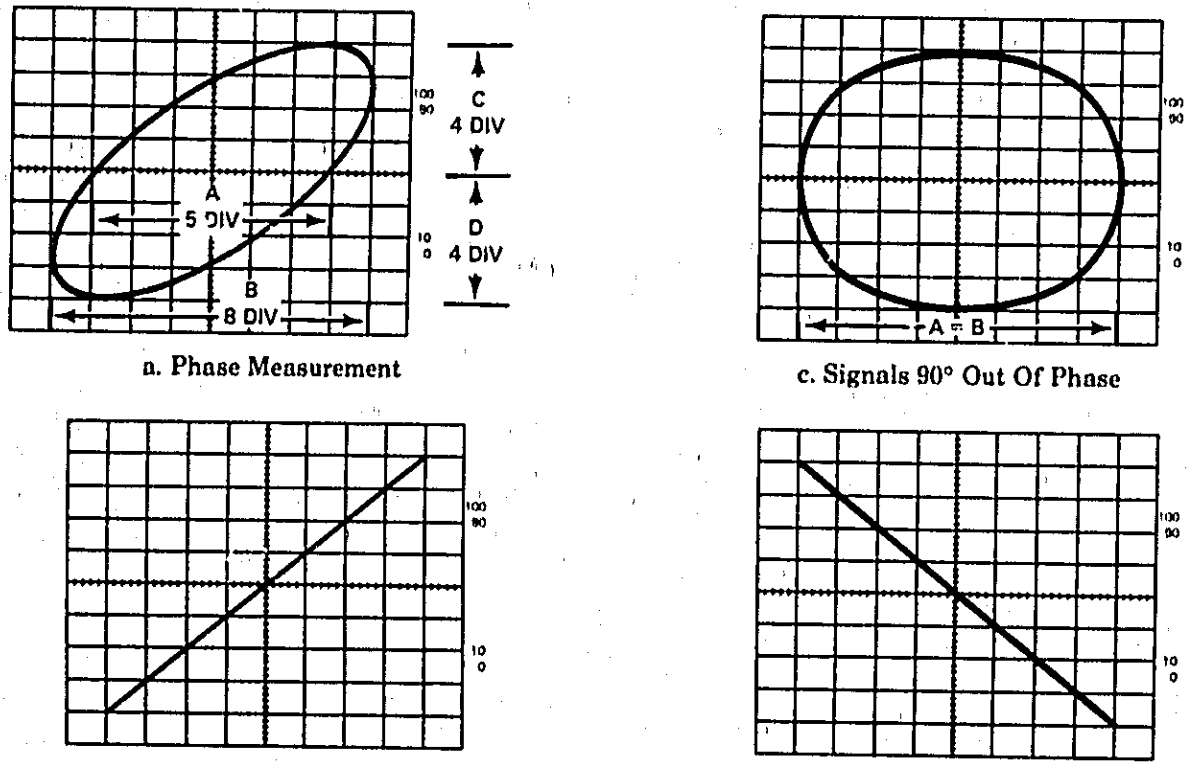
Therefore:

Phase Angle (θ) = arc sine of 0.75 = 48.6°.

3-52. TRIGGERING.

3-53. **TRIGGER VIEW.** The TRIG VIEW (42) control replaces the channel A or B trace with the trigger signal if channel A or B is selected as the display mode. In the ALT or CHOP display mode, three signals are displayed: channel A, the selected trigger signal, and channel B. In TRIG VIEW, the center horizontal graticule line represents the trigger threshold level with respect to the trigger signal (figure 3-21).

3-54. It is frequently helpful to observe the trigger signal being applied to the external trigger input. When you use trigger view in conjunction with CHOP or ALT,



a. Phase Measurement

b. Signals In Phase

c. Signals 90° Out Of Phase

d. Signals 180° Out Of Phase

Figure 3-20. A vs B Phase Measurement

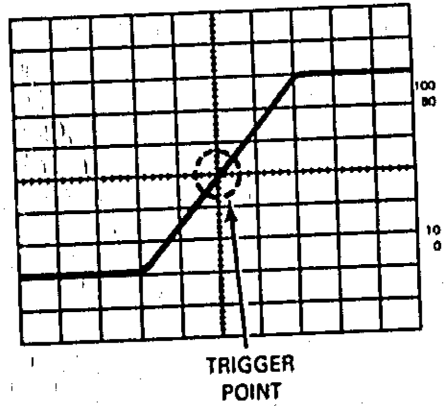


Figure 3-21. Trigger Point Location

both vertical channels plus the external trigger signal can be viewed simultaneously. This is useful in setting triggering and observing time correlation between the external trigger signal and the channel A and B signals. The deflection factor is approximately 100 mV/div.

Example: To determine the triggering level location using trigger view:

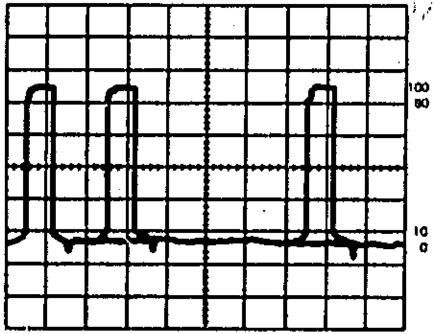
a. Connect the trigger signal to the main EXT TRIGGER (32) input connector, and select main EXT TRIGGER (34).

b. Select TRIG VIEW (42); the trigger signal will be displayed near center screen. The point where the trigger signal crosses the center horizontal graticule is the trigger point.

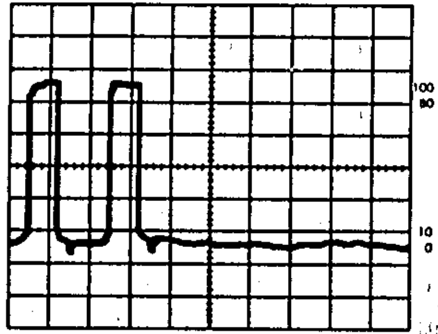
3-55. By adjusting the TRIGGER LEVEL (19) control you can move the trigger level location. The center horizontal graticule indicates the trigger point. When you use the ⎍ position of the ⎍/⎍ switch (38), the trigger circuit triggers on the positive-going portion of the trigger signal; In ⎍ it triggers on the negative-going portion of the trigger signal.

3-56. ELIMINATING MULTIPLE TRIGGERING ON COMPLEX WAVEFORMS. Figure 3-22a shows an example of multiple triggering. To have a stable display, the period between sweeps must match the period of the waveform being displayed. In the example, the first sweep displays three bits of a four-bit word. The next sweep displays the remaining bit in the word. So on consecutive sweeps we see different portions of the same word causing the instability in figure 3-22a.

3-57. To eliminate the instability, the TRIGGER HOLDOFF control (29) can be adjusted to vary the time between the end of one sweep and the beginning of the next. This is the holdoff period. In the example, if you increase the holdoff period long enough, the trigger from the fourth bit is held off, which eliminates the additional sweep that caused the display instability (figure 3-22b).

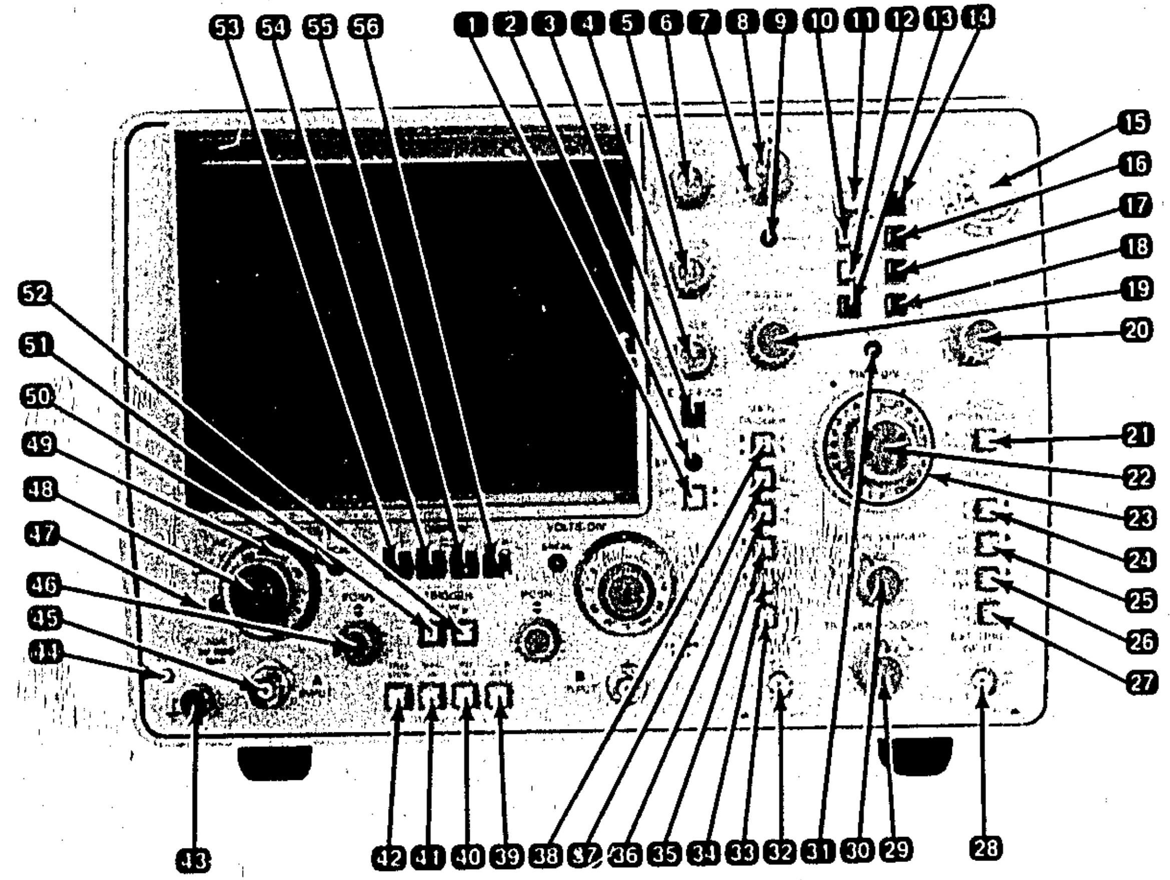


a. Multiple Triggering
With Display Instability



b. Multiple Triggering Eliminated With
Trigger Holdoff Control

Figure 3-22. Eliminating Multiple Triggering



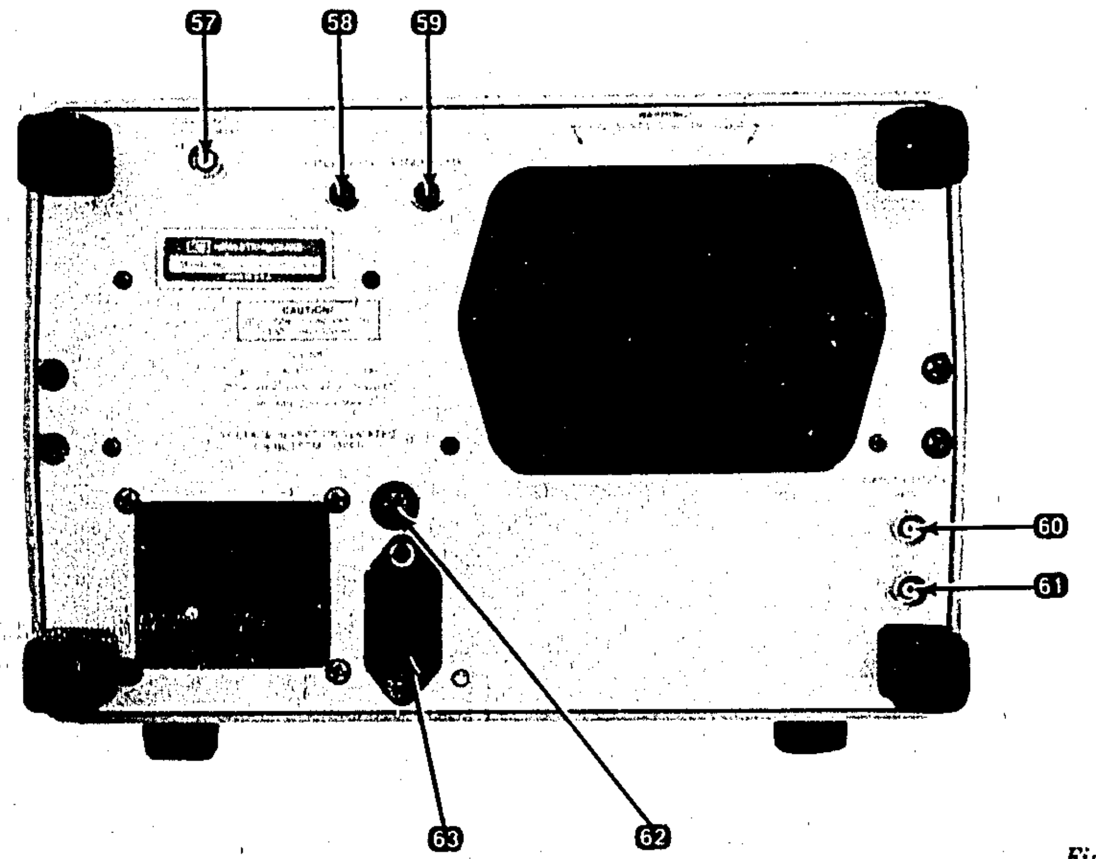


Figure 3-23.
Controls and Connectors