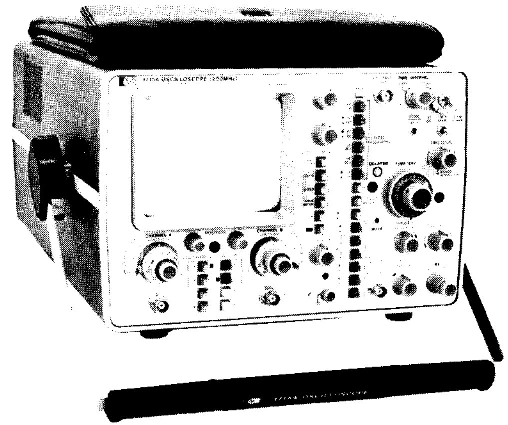
OPERATORS GUIDE

1715A AND 1725A OSCILLOSCOPES



HEWLETT PACKARD

OPERATORS GUIDE

MODELS 1715A AND 1725A OSCILLOSCOPES

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MODELS 1715A AND 1725A OPERATORS GUIDE

OPERATING INSTRUCTIONS

GENERAL INFORMATION.

This Operators Guide will acquaint you with Model 1715A and Model 1725A features, capabilities, accessories, power requirements, and controls. To aid in operating either oscilloscope, initial turn-on and calibration procedures and a performance check are provided. In the Applications Section are detailed explanations showing how you can use the capabilities of the Model 1715A or Model 1725A to best advantage in a variety of electrical measurements. Instrument specifications and general characteristics are listed in tables 1 and 2. Service information is available in a separate service manual.

DESCRIPTION.

Hewlett-Packard Models 1715A and 1725A are general-purpose, wide-band oscilloscopes designed for bench or field service. Model 1715A provides accurate measurements of high frequency signals with 10-mV/div vertical deflection capability over the full 200-MHz bandwidth and 5-mV/div capability up to 150-MHz bandwidth. Model 1725A provides accurate measurements with 10-mV/div vertical deflection capability over its 275-MHz bandwidth. Selectable input impedance of either 50 ohms or 1 megohm permits an impedance selection that best meets measurement applications. Its low shunt capacitance of less than 11 pF reduces phase shift and signal loss in pulse or cw measurements.

Both Models 1715A and 1725A offer the ΔT measurement technique for obtaining accurate measurements of time between any two points on the same or different waveforms. The ΔT measurement technique reduces errors, reduces measurement times, improves repeatability, and eliminates the need for mathematical computations. A built-in digital multimeter (Option 034/035) is available for these oscilloscopes that provides direct readouts in units of time for ΔT measurements. For instruments without the Optional Digital Multimeter, a field kit is available. Order HP Part Number 01715-69501 to receive a complete DMM with all mechanical and electrical hardware required to install it in a Model 1715A or 1725A instrument.

Table 1. Specifications

VERTICAL AMPLIFIERS (2)

BANDWIDTH: (3 dB down from a 6 div reference signal.)

DC-Coupled:

1715A: dc to 200 MHz in both 50-ohm and high impedance input modes 10 mV/div to 5 V/div, to 150 MHz at 5 mV/div.

1725A: dc to 275 MHz in both 50-ohm and high impedance input modes 10 mV/div to 5 V/div.

AC-Coupled: lower limit is approx 10 Hz.

BANDWIDTH LIMIT: limits upper bandwidth to approx 20 MHz.

RISE TIME: <1.75 ns 10 mV/div to 5 V/div, <2.3 ns at 5 mV/div. (calculated by t_r = 0.35/BANDWIDTH in MHz).

DEFLECTION FACTOR

Ranges: 1715A: 5 mV/div to 5 V/div (10 calibrated positions) in 1, 2, 5 sequence, ±2% attenuator accuracy.

1725A: 10 mV/div to 5 V/div (9 calibrated positions) in 1, 2, 5 sequence, ±2% attenuator accuracy.

Vernier: continuously variable between all ranges; extends maximum deflection factor to at least 12.5 V/div. Front panel indicator lights when vernier is not in CAL position.

INPUT RC (selectable)

AC and DC: 1 megohm ±2% shunted by approx 11 pF.

50 Ohm: 50 ohms ±2%; SWR ≤1.3 on 5, 10, 20, and 50 m V ranges and ≤1.15 on all other ranges.

MAXIMUM INPUT

AC and DC: ±250 V (dc + peak ac) 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 40 dB from dc to 5 MHz decreasing to 26 dB at 50 MHz. Common mode signal amplitude equivalent to 12 cm with one vernier adjusted for optimum rejection.

VERTICAL OUTPUT

AMPLITUDE: one division of vertical deflection produces approx 100 mV output (dc to 25 MHz in 1715A; dc to 50 MHz in 1725A).

CASCADED DEFLECTION FACTOR: 1 mV/div with both vertical channels set to 10 mV/div.

CASCADED BANDWIDTH: dc to 5 MHz with bandwidth limit engaged.

SOURCE RESISTANCE: approx 100 ohms.

SOURCE SELECTION: trigger source set to channel A selects channel A output, to channel B selects channel B output.

Table 1. Specifications (Cont'd)

MAIN TIME BASE

SWEEP

Ranges: 10 ns/div to 0.5 s/div (24 ranges) 1, 2, 5 sequence.

Accuracy

Main Sweep Time/Div	Accuracy (0°C to +55°C)	
	X1	X10
10 ns to 50 ns	±3%	±5%
100 ns to 20 ms	±2%	±3%
50 ms to 0.5 s	±3%	±3%

Vernier: continuously variable between all ranges; extends slowest sweep to at least 1.25 s/div. Vernier uncalibrated indicator lights when vernier is not in CAL position.

Magnifier: expands all sweeps by a factor of 10; extends fastest sweep to 1 ns/div.

TRIGGERING

Internal: dc to 100 MHz on signals causing 0.5 division or more vertical deflection, increasing to 1 division of vertical deflection at 300 MHz in all display modes. Triggering on line frequency is also selectable.

External: dc to 100 MHz on signals of 50 mV p-p or more increasing to 100 mV p-p at 300 MHz. Maximum input, ±250 V (dc + peak ac) at 1 kHz or less.

External Input RC: approx 1 megohm shunted by approx 15 pF.

TRIGGER LEVEL and SLOPE

Internal: at any point on the vertical waveform displayed.

External: continuously variable from +1.0 V to —1.0 V on either slope of the trigger signal, +10 V to —10 V in divide by 10 mode (÷10).

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

AC: attenuates signals below approx 10 Hz.

LF Reject: attenuates signals below approx 7 kHz.

HF Reject: attenuates signals above approx 7 kHz.

TRIGGER HOLDOFF: time between sweeps continuously variable, exceeding one full sweep from 10 ns/div to 50 ms/div.

DELAYED TIME BASE

SWEEP

Ranges: 10 ns/div to 20 ms/div (20 ranges) in 1, 2, 5 sequence.

Table 1. Specifications (Cont'd)

Accuracy (0°C to +55°C): same as main time base.
Magnifier (0°C to +55°C): same as main time base.

TRIGGERING

Internal: same as main time base except there is no Line Frequency triggering.

External: dc to 100 MHz on signals of 50 m V p-p or more, increasing to 100 m V p-p at 300 MHz. Maximum input, ±250 V (dc + peak ac) at 1 kHz or less.

External Input RC: approx 1 megohm shunted by approx 15 pF.

TRIGGER LEVEL and SLOPE

Internal: at any point on the vertical waveform displayed when in triggered mode.

External: continuously variable from +1.0 V to —1.0 V on either slope of the trigger signal, +10 V to —10 V in divide by 10 mode (÷10).

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

AC: attenuates signals below approx 10 Hz.

LF Reject: attenuates signals below approx 7 kHz.

HF Reject: attenuates signals above approx 7 kHz.

DELAY TIME RANGE: 0.5 to 10X Main Time/Div settings of 20 ns to 0.5 s (minimum delay 50 ns).

DIFFERENTIAL TIME MEASUREMENT ACCURACY

Main Time Base Setting	Accuracy (+15°C to +35°C)
50 ns/div to 20 ms/div	±(0.5% ±0.1% of full scale)
20 ns/div	±(1% ±0.2% of full scale)
50 ms/div to 0.5 s/div	±3%

DELAY JITTER: <0.005% (1 part in 20 000) of maximum delay in each step.

TIME INTERVAL (Δ TIME MODE)

TIME INTERVAL OUTPUT VOLTAGE: varies from 50 V to 100 mV full scale. Full scale output voltage can be determined by multiplying the number on the TIME/DIV dial by 10 V (e.g., 0.05 s, 0.05 ms, or 0.05 μs per div gives 0.5 V output full-scale).

ACCURACY (1715A or 1725A): measurement accuracy is the Time Interval Accuracy plus the external DVM accuracy.

Table 1. Specifications (Cont'd)

Main Time Base Setting	Accuracy (+20°C to +30°C)
100 ns/div to 20 ms/div	±0.5% of reading ±0.05% of fs
50 ns/div	±0.5% of reading ±0.1% of fs
20 ns/div*	±0.5% of reading ±0.2% of fs
50 ms/div to 0.5 s/div	±3%

*Starting after 60 ns of sweep.

ACCURACY (1715A or 1725A Opt 034/035)	
Main Time Base Setting	**Accuracy (+20°C to +30°C)**
100 ns/div to 20 ms/div	±0.5% of reading ±0.05% of fs
50 ns/div	±0.5% of reading ±0.06% of fs
20 ns/div*	±0.5% of reading ±0.15% of fs
50 ms/div to 0.5 s/div	±3%

*Starting after 60 ns of sweep.

Table 1. Specifications (Cont'd)

STABILITY (0°C to +55°C): short-term 0.005%. Temperature, ±0.03%/°C deviation from calibration temperature range.

X-Y OPERATION

BANDWIDTH

Y-Axis (channel A): same as channel A.

X-Axis (channel B): dc to >1 MHz.

DEFLECTION FACTOR: 5 mV/div to 5 V/div (10 calibrated positions) in 1, 2, 5 sequence.

PHASE DIFFERENCE BETWEEN CHANNELS: <3°, dc to 1 MHz.

INTENSITY MODULATION (Z-AXIS)

+8 V, ≥50 ns width pulse blanks trace of any intensity, usable to 20 MHz for normal intensities. Input R, 1 kΩ ±10%. Maximum input, ±10 V (dc + peak ac).

GENERAL

REAR PANEL OUTPUTS: Vertical Output, main and delayed gates, —0.7 V to +1.3 V capable of supplying approx 3mA.

CALIBRATOR: type, 1 kHz ±15% square wave; 3 V p-p ±1%, <0.1 μs rise time.

Table 2. General Characteristics

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 approx 1 MHz rate with blanking during switching (CHOP); channel A plus channel B (algebraic addition); X-Y (channel A vs channel B).

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

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

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

TRIGGER SOURCE

Selectable from channel A, channel B, or Composite.

Table 2. General Characteristics (Cont'd)

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.

HORIZONTAL DISPLAY MODES

Main, main intensified, delayed, mixed, X-Y, and mag X10. In main intensified, mixed, and delayed modes, selectable delta time with channel A start or channel B start time interval measurements are available.

TRIGGERING MAIN SWEEP

Normal: sweep is triggered by internal or external signal.
Automatic: bright baseline displayed in absence of input signal. Triggering is same as normal above 40 Hz.
Single: in Normal mode, sweep occurs once with same triggering as normal, reset pushbutton arms sweep and lights indicator; in Auto mode, sweep occurs once each time Reset pushbutton is pressed.

DELAYED SWEEP

Starts After Delay: delayed sweep automatically starts at the end of delay period.
Trigger: with delayed trigger level control out of detent (starts after delay) delayed sweep is triggerable at end of delay period.

MAIN INTENSIFIED

DELAYED SWEEP: intensifies that part of main time base to be expanded to full screen in delayed time base mode. Stop control adjusts position of intensified portion of sweep. Rear panel intensity ratio control sets relative intensity of brightened segment.
ΔTIME MODE: intensifies two parts of main time base to be expanded to full screen in delayed time base mode. "START" control positions the first intensified portion of the sweep: "STOP" control positions the second intensified portion of the sweep. Rear panel intensity control sets relative intensity of brightened segments.

TIME INTERVAL (ΔTIME MODE)

FUNCTION: measures time interval between two events on channel A (channel A display); between

Table 2. General Characteristics (Cont'd)

two events on channel B (channel B display); or between two events starting from an event on either channel A or B and ending with an event on either channel A or B (alternate display).

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.

CATHODE-RAY TUBE and CONTROLS

TYPE: post accelerator, approx 20.5 kV accelerating potential, aluminized P31 phosphor.

GRATICULE: 8 x 10 div internal graticule. 0.2 subdivision markings on major horizontal and vertical axes. 1 div = 1 cm. Rear panel adjustment aligns trace with graticule. Internal flood gun graticule illumination.

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

AUTO-FOCUS: automatically maintains beam focus with variations of intensity.

INTENSITY LIMIT: automatically limits beam current to decrease possibility of CRT damage. Circuit response time ensures full writing speed for viewing low duty cycle, fast rise time pulses.

REAR PANEL CONTROLS: astigmatism, pattern, main/delayed intensity ratio, and trace align.

GENERAL

POWER: 100, 120, 220, 240, —10% +5%, 48 to 440 Hz, 110 VA max.

WEIGHT: net, 12.9 kg (28.5 lb); shipping, 17.9 kg (39.5 lb).

OPERATING ENVIRONMENT: temperature, 0°C to +55°C (+32°F to +130°F); humidity, to 95% relative humidity at +40°C (+104°F); 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.

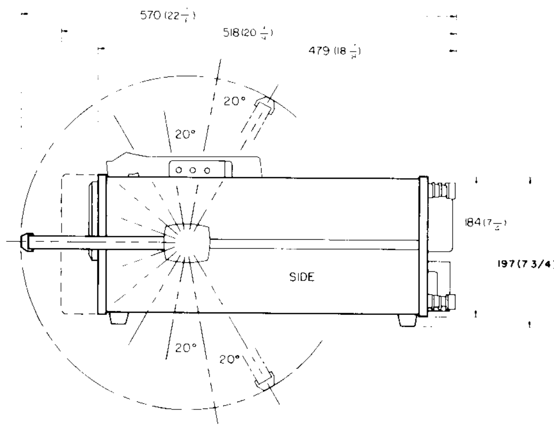
DIMENSIONS: see outline drawing.

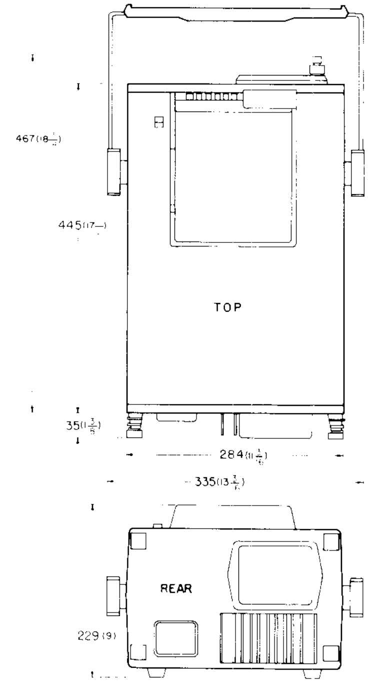
Table 2. General Characteristics (Cont'd)

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).





Both the 1715A and the 1725A contain two vertical preamplifiers for dual-channel operation. Each channel offers a choice of ac, high-Z dc, or 50-ohm input coupling. With the dual-trace feature, displays can be obtained on either channel A or channel B or on both channels. Simultaneous display of two signals is possible in either chopped or alternate mode of display. A+B and A—B modes of operation are also available. In addition, an X-Y mode of operation is provided. In this mode, the instrument becomes an X-Y display with inputs through channel A (Y-axis) and channel B (X-axis). The sensitivity of each axis is controlled by the channel A or channel B attenuator.

Calibrated switch settings on each vertical amplifier provide a deflection factor range from 10 mV/div to 5 V/div in 1, 2, 5 sequence. Vertical verniers permit fine adjustment between calibrated steps and extend the least sensitive deflection factor (5 V/div) to at least 12.5 V/div. The 1715A has one additional range of 5 m V/div with a bandwidth of 150 MHz.

Main horizontal amplifier sweep speed settings from 10 ns/div to 0.5 s/div are available in a 1, 2, 5 sequence. The main sweep speed is calibrated when the SWEEP VERNIER control is set to CAL detent position.

ACCESSORIES FURNISHED.

- One Blue Light Filter, HP Part No. 01740-02701
- One Front-panel Cover, HP Part No. 5040-0516
- One Vinyl Storage Pouch, HP Part No. 1540-0292
- One 7.5-ft Power Cord (See POWER CORD paragraph.)
- Two 10:1 Divider Probes, HP Model 10017A (for Model 1725A only)
- One Attenuator Resistor Kit, HP Part No. 5080-9696
- Two 10:1 Divider Probes, HP Model 10018A (for Model 1715A only)

ACCESSORIES AVAILABLE.

The following accessories are available for the 1715A and 1725A:

- Model 10020A Resistive Divider Probe Kit
- Model 1120A 500 MHZ Active Probe
- Model 10023 Temperature Probe
- Model 1112A Inverter Power Supply
- Model 10491B Rack Mount Adapter*
- Model 1006A and 1007A Test Mobiles
- Model 197B Oscilloscope Camera

*Not compatable with option 034/035

OPTIONS.

The following standard options extend the usefulness of the 1715A and 1725A:

OPTION 001. This option supplies a fixed ac power cord instead of the detachable power cord.

OPTION 003. This option supplies two rear-panel connectors for probe power.

OPTION 011. Replaces standard P31 phosphor CRT (V1) with internal graticule P11 phosphor CRT.

OPTION 034/035. This option provides a built-in digital multimeter that can be used for time interval measurements or as a separate digital multimeter.

OPTION 090. This option deletes the two divider probes normally supplied. You may specify other probes listed that are better suited to your needs.

OPTION 091. This option replaces the standard Model 10018A probes with HP Model 10017A 10:1 Voltage Divider Probes on Model 1715A.

OPTION 092. This option replaces the standard Model 10018A probes with HP Model 10016B 10:1 Voltage Divider Probes on Model 1715A.

OPTION 095: This option replaces the standard Model 10017A probes with HP Model 10014A 10:1 Voltage Divider Probes on Model 1725A.

OPTION 096. This option replaces the standard Model 10017A probes with HP Model 10016B 10:1 Voltage Divider Probes on Model 1725A.

OPTION 101. This option adapts Models 1715A and 1725A for use with an HP Model 1607A Logic State Analyzer to provide both digital and analog analysis.

OPTION 580. This option provides the standard instrument with a special bottom cover to meet Canadian Fire Safety Codes.

PREPARATION FOR USE.

WARNING

Read the Safety Summary at the front of this guide before installing or operating the instrument.

POWER CORD. The power cord required depends on the ac input voltage and the country in which the instrument is to be used. Figure 1 illustrates standard power receptacle (wall outlet) configurations. The number shown above each receptacle drawing specifies the HP Part No. of the power cord equipped with the mating plug for that receptacle. If the appropriate power cord is not included with your instru-

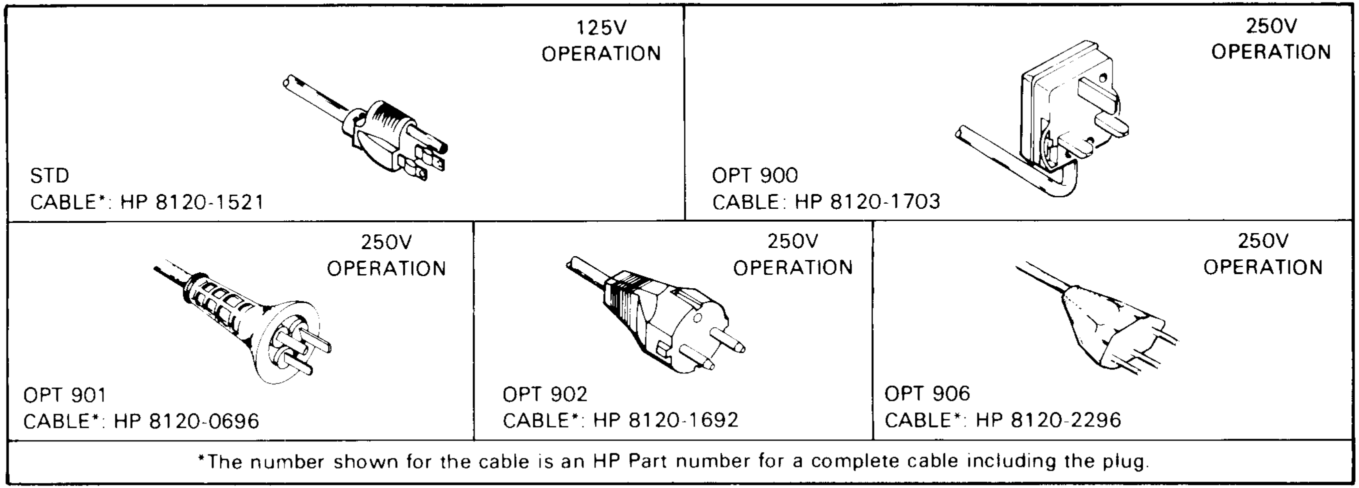


Figure 2-1. Input Power Cable Part Numbers

ment, notify the nearest HP Sales/Service Office and a replacement cord will be provided.

POWER REQUIREMENTS. Model 1715A and 1725A can be operated from any power source supplying 100 V, 120 V, 220 V, or 240 V —10% +5%, single-phase, 48 to 440 Hz. Power dissipation is 110 VA maximum.

CAUTION

Instrument damage may result if the line-voltage selection switch is not set correctly for the input power source.

The instrument is normally set at the factory for 120-volt operation. To operate the instrument from any other ac power source, proceed as follows:

1. Verify that instrument power cable is not connected to any input power source.

2. Move LINE VOLTAGE SELECT switch on rear panel to appropriate position.

3. Replace 1.5-ampere LINE FUSE with 0.8-ampere fuse for 220 or 240 volt operations.

4. Connect proper power cable.

CONTROLS AND CONNECTORS.

Front- and rear-panel illustrations (see figure 21) are located at the rear of this guide on a foldout page for easy reference while reading any part of this guide. The following paragraphs provide functional descriptions of each control and connector. The descriptions have index numbers that are keyed to the panel illustrations. Refer to the Applications Section for information about using this instrument for making measurements.

(1) **INTENSITY.** Controls brightness of display.

(2) **FOCUS.** Control to provide the best focused display.

(3) **MAG X10.** In X10 position, sweep or X-axis in X-Y mode, is magnified 10 times.

(4) **DLY'D.** Selects delayed sweep mode for display.

(5) **MIXED.** Sweep starts with main sensitivity and switches to delayed sensitivity at a point selected by the TIME INTERVAL STOP (18) control.

(6) **MAIN INTEN.** Intensifies delayed sweep portion of main sweep.

(7) **MAIN.** Selects main sweep mode for display.

(8) **X-Y.** 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, and horizontal positioning is adjusted by POSITION and FINE. VERT DISPLAY A (48) and INT. TRIG B (45) must also be selected.

(9) **BEAM FIND.** Returns beam to screen, allowing operator to adjust vertical and horizontal position controls for on-screen display.

10 **Delayed EXT ÷10.** Attenuates external trigger signal by factor of 10; increases external trigger range to ±10 V.

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

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

13 **Delayed LF REJ.** Attenuates delayed trigger signals below 7 kHz.

14 **Delayed HF REJ.** Attenuates delayed trigger signals above 7 kHz.

15 **Delayed slope.** Selects slope of delayed trigger signal that starts sweep.

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

17 **TIME INTERVAL START.** Selects delay time between start of main sweep and start of delayed sweep.

18 **TIME INTERVAL STOP.** Selects the ending point in time-interval measurements. Dial is calibrated in divisions of display for time-interval measurements.

19 **SIGNAL OVERLAY (ΔT = 0).** Screwdriver adjustment for calibrating TIME INTERVAL STOP **18** dial.

20 **Time-Interval Mode Switch:**

a. **ΔT OFF.** Turns off one of the delayed sweep markers, providing normal delayed sweep operation.

b. **CH A START.** Sets first delayed-sweep marker on channel A and second delayed-sweep marker on channel B. This allows time measurement from a reference on channel A to a point on channel B.

c. **CH B START.** Sets first delayed-sweep marker on channel B and second delayed sweep marker on channel A. This allows time measurement from a reference on channel B to a point on channel A.

21 **Delayed TRIG LEVEL.** Selects amplitude point on trigger signal that starts delayed sweep.

22 **RESET.** Resets sweep in single-sweep mode. Reset lamp lights when sweep is armed.

23 **SINGLE.** Selects either single or repetative sweep operation.

(24) **AUTO/NORM.**

a. **AUTO.** Automatic sweep in absence of trigger signal; triggering occurs on trigger signals above 40 Hz.

b. **NORM.** Sweep is triggered only by applying trigger signal.

(25) **Main TIME/DIV.** Controls sweep time in MAIN (7) sweep mode.

(26) **Delayed TIME/DIV.** Selects DLY'D (4) sweep speed and delayed portion in MIXED (5) sweep modes; controls intensified portion of sweep in MAIN INTEN (6) sweep mode.

(27) **UNCAL.** Lights when SWEEP VERNIER (31) is out of CAL detent.

(28) **Main TRIG LEVEL.** Selects amplitude point on trigger signal that starts main sweep.

(29) **TRIGGER HOLDOFF.** Provides control of time between sweeps. With control fully counterclockwise, holdoff time is minimum.

(30) **Horizontal POSITION.** Controls coarse and fine horizontal position of display.

(31) **SWEEP VERNIER.** Provides fine control of sweep time between calibrated positions of main TIME/DIV (25) switch. UNCAL lamp (27) lights when control is out of CAL detent position.

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

(33) **Main slope.** Selects slope of main trigger signal that starts sweep.

(34) **Main HF REJ.** Attenuates main trigger signals above 7 kHz.

(35) **Main LF REJ.** Attenuates main trigger signals below 7 kHz.

NOTE

LINE trigger is selected by engaging both HF REJ (34) and LF REJ (35) pushbuttons simultaneously.

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

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

38 **Main EXT ÷10.** Attenuates external trigger signal by factor of 10; increases external trigger range to ±10 V.

39 ⏚. Chassis ground connection for external equipment.

40 **Power lamp.** Lights when input LINE 41 power switch is on.

41 **LINE/SCALE ILLUM.** Controls brightness of scale illumination; also contains input ac power on-off switch. With control completely counterclockwise in LINE OFF position, ac power is disconnected internally.

42 **CAL 3 V.** Provides 1-kHz, negative square wave of 3 volts ±1%.

43 **Vertical UNCAL light.** Lights when either channel A or channel B vernier 55 is out of CAL detent.

44 **INT TRIG A.** Selects channel A input signal for triggering.

45 **INT TRIG B.** Selects channel B input signal for triggering.

NOTE

Engaging both channel A and channel B INT TRIG pushbuttons 44 and 45 results in composite triggering (COMP) on the displayed signal(s).

46 **BW LIMIT (20 MHz).** Limits vertical amplifier bandwidth to 20 MHz. Useful for noise reduction in normal and cascade operation.

47 **B INVERT.** Control used to invert polarity of channel B signal display.

48 **VERT DISPLAY A.** Selects channel A input signal for display.

49 **VERT DISPLAY B.** Selects channel B input signal for display.

NOTE

Engaging both channel A and channel B vertical display pushbuttons 48 and 49 results in A+B (algebraic addition) display.

50 **ALT.** Displays each channel on alternate sweeps.

51 **CHOP.** Displays each channel by switching between channels at 1 MHz rate.

52 **POSITION A.** Varies vertical position of channel A display.

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

54 **VOLTS/DIV.** Selects vertical deflection factor necessary for calibrated measurements.

55 **Vernier.** Provides continuous adjustment of volts/div between calibrated positions of VOLTS/DIV switch 54.

56 **INPUT.** BNC connector for channel A input signal.

57 **ASTIG.** Adjusts roundness of writing spot.

58 **PATT.** Adjusts for uniform pattern over CRT viewing area.

59 **TRACE ALIGN.** Adjust to align trace with horizontal graticule.

60 **INTEN RATIO.** Adjusts intensity of intensified portion of sweep in MAIN INTEN 6 mode of operation.

61 **Z AXIS.** BNC connector for Z-axis input.

62 **VERTICAL OUTPUT.** BNC connector for vertical amplifier output signal; provides approximately 100 mV/div of vertical display, dc coupled, and source impedance of 100 ohms.

63 **MAIN GATE.** BNC connector for main gate output to external equipment.

64 **DLY'D GATE.** BNC connector for delayed gate output to external equipment.

65 **LINE FUSE.** AC power input fuse.

66 **LINE VOLTAGE SELECT.** Selects 100/120/220/240 Vac operation.

67 **ΔT OUTPUT and GND.** Banana jack connector pair for connecting an external digital multimeter during time-interval measurement. Voltage output is dc proportional to time interval measured.

SWITCH MODE SELECTIONS.

The following paragraphs provide additional information about the use of certain switch modes:

AC VERSUS DC 53. AC coupling removes the dc level from input signals and attenuates signals below 10 Hz.

DC coupling connects input signals directly to the input amplifier. With dc coupling selected, a large dc voltage component in an input signal can offset the input signal outside the trigger level range of the oscilloscope and cause the unit to lose trigger.

AUTO VERSUS NORM (24). In AUTO operation, a baseline will be displayed in the absence of a trigger signal. A trigger of 40 Hz or higher overrides AUTO operation and produces a presentation. Adjustment of main TRIG LEVEL (28) may be necessary for a stable display. If the trigger is less than 40 Hz, NORM operation must be used. A trigger signal is always needed in NORM operation to generate a sweep.

MIXED SWEEP. In MIXED (5) sweep modes of operation, a dual sweep speed display is presented. The main sweep drives the first portion of the display and the delayed sweep completes the display. This mode can also be used when SINGLE (23) sweep is selected.

DELAYED TRIGGERING. When the delayed TRIG LEVEL (21) control is in the detent position (starts after delay mode), the delayed sweep starts immediately after the delay period selected by the TIME INTERVAL START (17) control. When the delayed TRIG LEVEL control (21) is out of detent, the delayed sweep is started by the first trigger signal occurring after the delay period. In this mode, the delay period consists of the time selected by the TIME INTERVAL START (17) control plus the elapsed time until a new trigger signal occurs.

DELAYED SWEEP. After obtaining a sweep, any portion can be expanded up to 1 ns per division with 5% accuracy over center eight major divisions (X10 magnification) or 10 ns per division with 3% accuracy. This permits viewing of critical rise times or signal shapes with high resolution. Because the main and delayed sweeps are independent, the main SWEEP VERNIER (31) may be out of the CAL detent and the delayed sweep will still be calibrated.

REDUCING JITTER. Sweep jitter can be reduced by using the delayed TRIG LEVEL control (21). By rotating the delayed TRIG LEVEL (21) control out of detent, the delayed sweep will start on a new trigger. This reduces the jitter accumulated since start of the main sweep. When the delayed sweep is operated in this mode, the ΔT measurement technique can not be used. The DMM will indicate the position of the TIME INTERVAL STOP dial, but that may not be the same as the time interval shown on the display.

TURN-ON PROCEDURE.

Before turning on the oscilloscope, read and follow the instructions in the safety summary (at the front of this guide) and in the power requirements paragraph. Become familiar with the controls and their functions by reading the controls and connectors section and referring to figure 21 at the back of this operators guide.

To turn on the oscilloscope, perform the following steps:

1. Set INTENSITY (1) fully counterclockwise.
2. Set VERT DISPLAY to ALT (50).
3. Set INT TRIG to A (44).
4. Set vertical vernier controls for channel A and channel B (55) to CAL detent.
5. Set B INVERT switch (47) to out position.
6. Set input coupling (53) for channel A and channel B to GND.
7. Set horizontal POSITION control (30) to midrange.
8. Set main TIME/DIV (25) to 1 mSEC.
9. Set delayed TIME/DIV (26) to OFF.
10. Set main SWEEP VERNIER (31) to CAL detent.
11. Set AUTO/NORM switch (24) to AUTO.
12. Set main INT/EXT trigger switch (37) to INT.
13. Set HORIZ DISPLAY (8) to MAIN.
14. Set LINE/SCALE ILLUM switch (41) to on and allow 5-minute warm-up period.
15. Adjust INTENSITY control (1) for just visible trace.

OPERATORS CALIBRATION.

The following checks and adjustments will ensure that the oscilloscope is operating properly:

TRACE ALIGNMENT. If the oscilloscope is moved from one location to another, the trace alignment coil may need adjustment to align the horizontal trace with the graticule. Proceed as follows:

1. Obtain a display as described in the turn-on procedure.

2. Using channel A POSITION control (52), adjust trace to center horizontal graticule line.

3. Using nonmetallic alignment tool, adjust TRACE ALIGN (59) (on rear panel) for best alignment of trace with horizontal graticule line.

ASTIGMATISM AND FOCUS. Astigmatism and focus controls may need adjustment to obtain the sharpest display. Proceed as follows:

1. Set INTENSITY (1) fully counterclockwise.

2. Set LINE/SCALE ILLUM (41) to the ON position.

3. Set channel A controls as follows:

VOLTS/DIV (54)	.01
Coupling (53)	GND
Vernier (55)	fully cw
VERT DISPLAY (48)	A
INT TRIG (45)	B
HORIZ DISPLAY (8)	X-Y

4. Adjust INTENSITY (1) to observe spot.

5. Adjust FOCUS (2) and ASTIG (57) for best defined spot.

PROBE COMPENSATION. Probe compensation may be required because of variations in total input resistance and capacitance from one oscilloscope to another. Proceed as follows:

1. Obtain a display as described in the turn-on procedure.

2. Connect divider probe cable to channel A INPUT connector (56).

3. Connect probe tip to CAL 3 V terminal (42).

4. Set input coupling (53) to DC.

5. Set channel A VOLTS/DIV (54) for square-wave display with two to three divisions of vertical deflection.

6. Set main TIME/DIV (25) for horizontal display of at least two full square waves.

7. Adjust divider probe compensation for correct display (see figure 2).

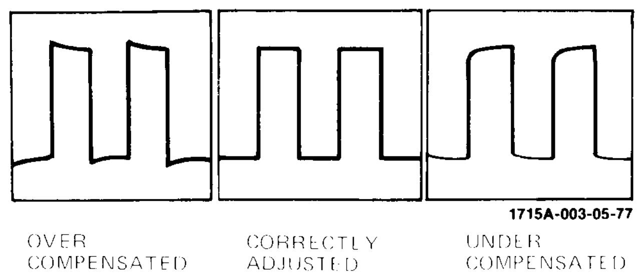


Figure 2. Divider Probe Adjustment Display

SIGNAL OVERLAP: This adjustment compensates for range to range tracking errors in the ΔT measurement system. It calibrates the TIME INTERVAL STOP dial so that the traces are overlaped with dial setting of 0.00. Perform this adjustment for each measurement setup. Proceed as follows:

1. Apply an input signal to channel A or B INPUT (56).

2. Select channel A or B vertical display (48) or (49) and internal trigger (44) or (45).

3. Adjust the appropriate VOLTS/DIV (54) and vernier (55) for a full five-division display of the signal.

4. Select a main TIME/DIV (25) sensitivity that displays at least one full signal cycle.

5. Set delayed TIME/DIV (26) to a sweep speed approximately five times faster than the main TIME/DIV (25) sweep speed.

6. Engage MAIN INTEN pushbutton (6).

7. Set time-interval mode switch (20) to CH A START.

8. Adjust TIME INTERVAL START (17) to place the first intensified marker on a point of interest on the displayed trace. (There may be only one intensified marker visible.)

9. Set TIME INTERVAL STOP dial (18) to 0.00. If using an Option 034 Digital Multimeter or an external multimeter, check for an indication of 0.000 on the LED. (Make certain that Multimeter switch on top cover is in forward position.)

10. Engage DLY'D pushbutton (4) and readjust INTENSITY (1) if necessary.

11. Two intensified portions of waveform are expanded on screen. With an indication of 0.000 on the LED, or 0.00 on the TIME INTERVAL STOP dial (18), the two intensified display segments should be perfectly overlapped. If not, adjust front-panel SIGNAL OVERLAY (19) to overlap the two signal segments displayed.

NOTE

For single channel measurements this adjustment should be made for only one position of the A START/B START switch. For dual channel measurements refer to the ΔT OFFSET adjustment.

ΔT OFFSET: This adjustment inserts a fixed offset into the Two Marker ΔT system that compensates for systematic errors such as unequal length probes. This adjustment is needed only when measurements are being made between the two vertical channels. This adjustment is a function of main sweep speed so it must be performed for each measurement setup. Proceed as follows:

1. Connect both channel A and B probes to a common circuit node that contains a signal that is typical of that to be measured.

2. Select ALT (50) display Mode and adjust Volts/DIV for a useable display.

3. Set main TIME/DIV (25) and delayed TIME/DIV (26) as required for the application.

4. Set TIME INTERVAL STOP (18) to 0.00.

5. Engage MAIN INTEN (6) pushbutton and adjust TIME INTERVAL START (17) to position the marker over a transition of the signal being displayed.

6. Select DLY'D (4) and adjust vertical position controls (52) to overlap the two traces vertically.

7. Switch (20) between A START and B START positions and set the ΔT OFFSET ADJ (RH side panel) so that there is no change in the marker positions as this switch is actuated.

NOTE

A slight misadjustment of the front panel SIGNAL OVERLAP control makes this adjustment some what easier to accomplish.

8. Adjust the front panel SIGNAL OVERLAP (19) for a percise overlap of the two markers.

9. Check that the marker remain overlaped in both A START and B START positions of (20).

OPERATORS PERFORMANCE CHECK.

Oscilloscope operation may be verified without additional test equipment by using the CAL 3 V output as a signal source. These procedures functionally check each display mode and the operation of the front-panel controls. To check specifications, refer to the operating and service manual. The operators checks must be performed in the sequence given. Do not start a procedure in midsequence, because succeeding steps depend on control settings and results of previous steps. If any of the results are unobtainable, refer to the operating and service manual.

1. Set oscilloscope controls as follows:

CHANNEL A	
VOLTS/DIV (54)	.5
Coupling (53)	DC
Vernier (55)	CAL
POSITION (52)	as required
VERT DISPLAY (48)	A
B INVERT (47)	out
TIME BASE	
Horizontal POSITION (30)	as required
SWEEP VERNIER (31)	CAL
HORIZ DISPLAY (7)	MAIN
Main TIME/DIV (25)	0.5 mSEC
Delayed TIME/DIV (26)	.01 μSEC
AUTO/NORM (24)	AUTO
Main INT/EXT (37)	INT
Main slope (33)	+
Delayed slope (15)	+
Main TRIG LEVEL (28)	as required
Delayed TRIG LEVEL (21)	ccw detent
TRIGGER HOLDOFF (29)	ccw
MAG X10 (3)	out
Time Interval Mode Switch (20)	CH A START

2. Set INTENSITY (1), FOCUS (2), and POSITION (52) controls for desired baseline display.

3. Apply CAL 3 V (42) output directly to channel A INPUT (56).

4. Adjust main TRIG LEVEL (28) for a stable display. Observe six positive-going pulses with leading edge of first and sixth pulse on first and eleventh vertical graticule lines respectively (±15%).

5. Set HORIZ DISPLAY for MAIN INTEN (6) operation.

6. Set delayed TIME/DIV (26) to 0.2 mSEC. Observe intensified portion of sweep.

NOTE

Intensified portion should cover 4 to 5 divisions.

7. Adjust TIME INTERVAL START (17) until intensified portion is centered on CRT. You may need to readjust horizontal POSITION slightly.

8. Set HORIZ DISPLAY for DLY'D (4) operation. Observe that intensified portion is expanded to 10 divisions.

9. Set HORIZ DISPLAY for MAIN INTEN (6) operation.

10. Vary TIME INTERVAL START (17). Observe that intensified portion moves smoothly along display.

11. Vary TIME INTERVAL STOP (18). Observe that second intensified portion moves smoothly along display.

12. Press ALT pushbutton (50).

13. Set main TIME/DIV (25) to 5 μsec and delayed TIME/DIV to .5 μsec.

14. Adjust TIME INTERVAL STOP (18). Only marker on channel B should move.

15. Adjust TIME INTERVAL START (17). Both markers should move together.

16. Set time interval mode switch (20) to CH B START.

17. Repeat steps 25 and 26. This time, the TIME INTERVAL STOP (18) will affect the marker on channel A.

OBTAINING BASIC DISPLAYS.

These procedures will help you become familiar with operation of the oscilloscope so that you can obtain commonly used displays. Before performing the procedures, complete the turn-on procedure and adjust the following controls:

Channel A coupling (53)	DC
Channel A VOLTS/DIV (54)	0.05
Main TIME/DIV (25)	0.5 mSEC

NORMAL SWEEP DISPLAY.

1. Connect your divider probe to the channel A INPUT connector (56) and the CAL 3 V terminal (42).

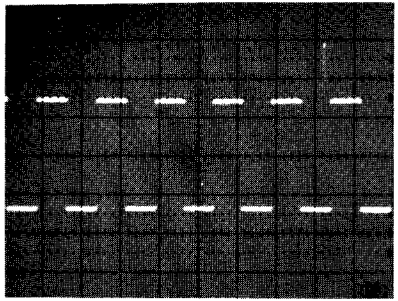
2. Adjust channel A POSITION (52) to align the base of the square wave on the second graticule line from the bottom, and adjust main TRIG LEVEL (28) for a stable display. You will see a square wave with an amplitude of six divisions and four or five positive-going pulses.

MAGNIFIED SWEEP DISPLAY.

1. Follow steps 1 and 2 to obtain a Normal Sweep Display.

2. Adjust horizontal POSITION (30) to place the waveform portion you want to magnify on the CRT center graticule (figure 3a).

3. Press MAG X10 (3) and adjust horizontal FINE (30) for precise placement of the magnified display (figure 3b).



1715A-310-05-77

Figure 3a. Normal Display

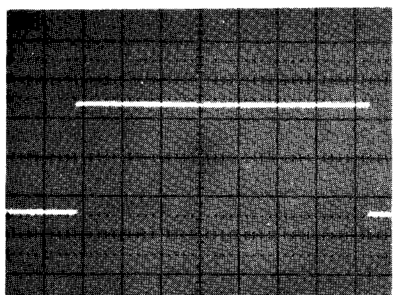


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Figure 3b. Magnified Display

DELAYED SWEEP DISPLAY.

1. Follow steps 1 and 2 to obtain a Normal Sweep Display.

2. Set delayed TIME/DIV ㉖ to .05 mSEC/DIV and observe the portion of the square wave that is intensified. Adjust INTENSITY control ❶ for a comfortable viewing level.

3. Set time-interval mode switch ⑳ to ΔT OFF.

4. Adjust TIME INTERVAL STOP ⑱ until the intensified portion of the trace is over the display segment you wish to investigate. This is demonstrated in figure 4a.

5. Press DLY'D ❹ and note the intensified portion of the trace is now displayed across the entire CRT (figure 4b).

6. You may readjust TIME INTERVAL STOP ⑱ to view other pulses in the pulse train.

For a more complete description of delayed sweep, refer to Time Interval Measurement Applications in this operators guide.

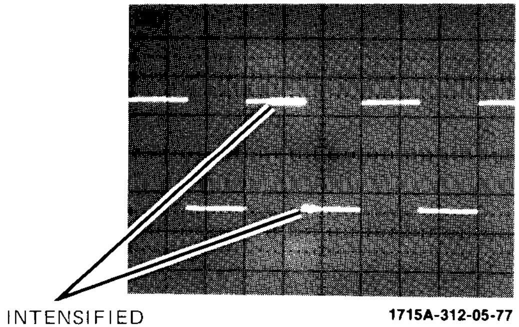

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Figure 4a. Normal Display with Intensified Area

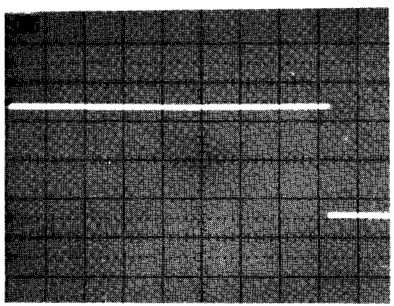

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Figure 4b. Delayed Sweep Display

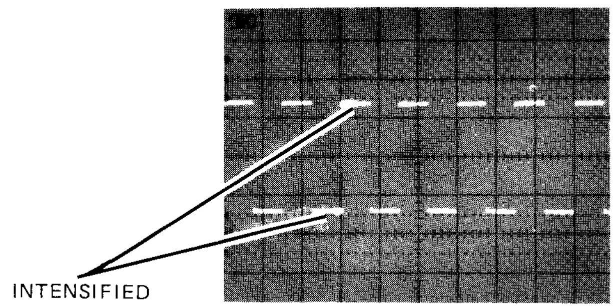
MIXED SWEEP DISPLAY.

1. Follow steps 1 and 2 to obtain a Normal Sweep Display.

2. Press MAIN INTEN (6).

3. Set delayed TIME/DIV switch (26) to .05 mSEC/DIV and note the portion of the square wave that is intensified. Adjust INTENSITY (1) for a comfortable viewing level.

4. Adjust the TIME INTERVAL STOP (18) to place the intensified marker on a portion of the waveform on the CRT (figure 5a).



1715A-314-05-77

Figure 5a. Normal Display with Intensified Area

5. Press MIXED (5) and notice that the first portion of the display is at the main TIME/DIV (25) sweep rate and the second portion of the display is at the delayed TIME/DIV (26) sweep rate (figure 5b). You can vary the transition point from main sweep to delayed sweep by adjusting TIME INTERVAL STOP (18).

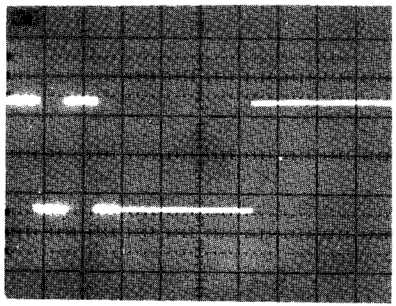


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Figure 5b. Mixed Sweep Display

X-Y DISPLAY.

1. Press X-Y (8), Y (47), and X (48); display INTENSITY (1) may need to be decreased.

2. Apply the vertical (Y-axis) signal to channel A INPUT connector (56) and the horizontal (X-axis) signal to channel B INPUT connector.

3. Adjust channel A and B VOLTS/DIV switches (54) for the desired vertical and horizontal scale factors. Channel A POSITION control (52) adjusts vertical positioning and POSITION control (30) adjusts horizontal positioning.

4. If the display is not visible, press BEAM FIND (9) and adjust channel A and B VOLTS/DIV (54) controls until the display is compressed vertically. Next, center the display with the channel A POSITION (52) and horizontal POSITION (30) controls. Release BEAM FIND (9) and adjust FOCUS (2) for a sharp display.

TIME-INTERVAL MEASUREMENT (ΔT) APPLICATIONS.

Time-interval measurements are made between any two points on the same or different waveforms. In time-interval measurements, both channels of the oscilloscope may be used. Horizontal distance is measured from a reference point on one waveform to another reference point on either the same or a different waveform.

The ΔT measurement technique offered by this instrument reduces errors, reduces measurement time, improves repeatability and eliminates the need for mathematical computations. Controls and indicators dedicated to the ΔT measurement technique are discussed in the following subparagraphs. Applications for the technique follow these discussions.

TIME-INTERVAL MODE SWITCH. Time-interval measurements can be made between any two points on a single trace, from any point beginning on the channel A trace to any point ending on the channel B trace, or from any point beginning on the channel B trace to any point ending on the channel A trace.

The time-interval mode switch simplifies measurement selections. This switch eliminates the need to disconnect input signals and reconnect them to opposing channels whenever exact delayed-sweep measurements are made from an occurrence on one channel to an occurrence on the other channel.

Single-channel Displays. The time-interval mode switch can be set either to CH A START or CH B START during single-channel displays. Regardless of which setting is selected, the Start marker will always appear to the left of the Stop marker on a single trace.

When the time-interval mode switch is set to ΔT OFF, one marker is turned off, and time-interval measurements are made in the conventional manner. With delayed sweep selected, the TIME INTERVAL STOP control is adjusted to place the first point of interest on some reference line on the CRT. The number on the multimeter LED or TIME INTERVAL STOP dial is recorded. Then the TIME INTERVAL STOP control is readjusted to bring the second point of interest to the same reference line on the CRT. Again the number on the multimeter LED or TIME INTERVAL STOP dial is recorded. Finally the number obtained at the first point of interest is subtracted from the number obtained at the second point of interest. The result is the measurement of horizontal separation between the two points. The number, if obtained from the TIME INTERVAL STOP dial, must be multiplied by the setting of main TIME/DIV to determine the time interval measured. The DMM performs this mathematical step for the operator by providing direct readouts of time.

By setting the time-interval mode switch to either CH A START or CH B START position, time-interval measurements can be made between any two signal points using the ΔT mode. In this mode, the two points of interest are overlapped on screen. The multimeter (if used) will indicate the exact time interval between the two points overlapped. If no multimeter is used, the dial of the TIME INTERVAL STOP control will indicate the exact spacing (in graticule divisions) between the two points overlapped.

Dual-channel Displays. When time-interval measurements are made between events on two signal channels, the time-interval mode switch can be used to select the starting point of the measurement, eliminating the need to change probe positions.

To make a measurement from some point on the channel A trace to a point on the channel B trace, the time interval mode switch is set to CH A START. The START marker will appear on the channel A trace and the STOP marker will appear on the channel B trace. When the two points are adjusted to overlap, the multimeter LED or TIME INTERVAL STOP dial will indicate the space between the two markers. Then to make a corresponding measurement from some point on the channel B trace back to some later point on channel A, the time interval mode switch is set to CH B START. The signals and channels are undisturbed. Only the two markers change places. See figure 6.

TIME INTERVAL READOUTS. The TIME INTERVAL STOP dial is calibrated in divisions of main sweep

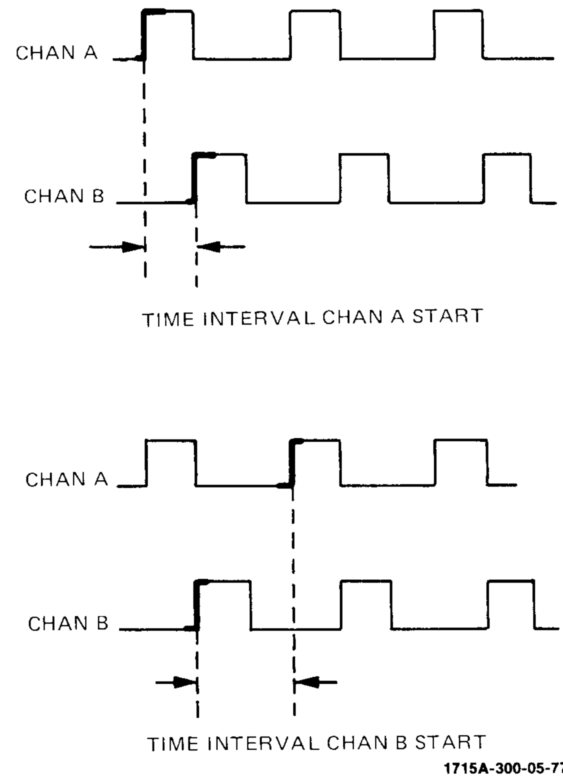

Figure 6. Time Interval Start Selection

as selected on the main TIME/DIV control. To obtain the result of a time-interval measurement, multiply the reading of the TIME INTERVAL STOP dial by the main TIME/DIV setting. Example: with a dial indication of 3.82 and a sweep speed of 5 μsec/div, the measurement is 19.10 μsec. This instrument provides for use of a digital multimeter to simplify time-interval measurements. An optional built-in digital multimeter, Hewlett-Packard Option 034, is available for this instrument. It indicates exact time intervals between the start and stop markers directly in seconds, milliseconds, or microseconds.

The operator can also connect any digital multimeter of his choice to the INTERVAL OUT pair of connectors on the rear panel. To preserve accuracy of the oscilloscope, use a 3-1/2 digit or greater multimeter for digital readout of time intervals.

Models 1715A and 1725A supply an analog dc voltage to the Option 035/035 DMM and to the INTERVAL OUT rear-panel connections. When the time interval mode switch is set to either CH A START or CH B START, the analog voltage is directly proportional to the separation between the TIME INTERVAL START and STOP controls. With the time interval mode switch set to ΔT OFF, the analog voltage is directly proportional to a multiplication of the position of the TIME INTERVAL STOP dial with the setting of the main TIME/DIV control.

USE OF OPTION 034/035 DMM. To use the Optional Digital Multimeter for time-interval measurements, certain multimeter switches must be set properly. The meter POWER must be ON and the front panel DC VOLTS pushbutton must be engaged because the analog voltage is dc.

The two-position switch built into the instrument top cover must be in the forward position to obtain time-interval measurements of displayed waveforms. In the rear-switch position, the analog dc voltage is disconnected from the meter and the multimeter connections at the side of the unit are enabled for normal multimeter measurements.

RISE-TIME MEASUREMENTS. Rise-time measurements are normally made between the 10% and 90% points on a pulse with the vernier adjusted for a full 5-division vertical display. Maximum resolution for this measurement is achieved when the main TIME/DIV sweep speed is set as fast as possible while still being able to accurately position the waveform at the 10% and 90% points. The 10% and 90% points are conveniently marked on the CRT graticule.

To measure signal rise time using the oscilloscope, proceed as follows:

1. Apply the signal to the channel A or B INPUT connector.

2. Select channel A or B VERT DISPLAY and INT TRIG.

3. Set the time interval mode switch to CH A START or CH B START, as applicable.

4. Adjust the appropriate VOLTS/DIV switch and vernier for a full five-division display of the signal.

5. Select a main TIME/DIV sensitivity that places the second occurrence of the transition as far as possible toward the right-hand edge of the CRT.

6. Set the delayed TIME/DIV control to a sweep speed approximately five times faster than the main TIME/DIV setting.

7. Engage MAIN INTEN pushbutton.

8. Adjust TIME INTERVAL START to place the first intensified marker on the 10% portion of the waveform.

9. Adjust TIME INTERVAL STOP to place the second intensified marker on the 90% portion of the waveform.

10. Engage DLY'D pushbutton. Both intensified portions of waveform are expanded on screen.

11. Adjust TIME INTERVAL START to place the 10% point on a convenient vertical graticule line.

12. Adjust TIME INTERVAL STOP to place the 90% point on the same vertical graticule line. (See figure 7.)

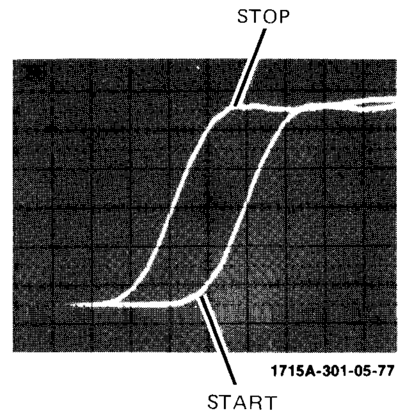

Figure 7. Rise Time Measurement

13. If using Optional Digital Multimeter or an external DMM, read the actual pulse rise time directly from the LED. Refer to the main TIME/DIV setting to determine whether the output is in sec, ms, or μs.

14. If not using a DMM, read the interval between the 10% and 90% points as a measure of CRT divisions on the TIME INTERVAL STOP dial. Multiply the number of divisions by the main TIME/DIV dial setting to determine signal rise time.

PULSE WIDTH AND PULSE PERIOD MEASUREMENTS. Pulse width is normally measured between the 50% amplitude points on the leading and trailing edges of the pulse. Pulse period is measured from the 50% amplitude point of one pulse leading edge to the 50% amplitude point of the next pulse leading edge. The ΔT technique improves the accuracy of pulse width and period measurements by allowing you to overlap the points of interest on a display. To measure pulse width or pulse period, proceed as follows:

1. Apply the signal to the channel A or B INPUT connector.
2. Select channel A or B VERT DISPLAY and INT TRIG.
3. Set the time-interval mode switch to CH A START or CH B START, as applicable.
4. Adjust the VOLTS/DIV switch for a convenient display of pulse amplitude.
5. Select a main TIME/DIV sensitivity that places the second occurrence of the measurement as far as possible toward the right-hand edge of the CRT.
6. Set the delayed TIME/DIV control to a sweep speed approximately five times faster than the main TIME/DIV setting.
7. Engage the MAIN INTEN pushbutton.
8. Adjust TIME INTERVAL START to place the first intensified marker at the beginning of the time interval to be measured.
9. Adjust TIME INTERVAL STOP to place the second intensified marker at the end of the time interval to be measured.
10. Engage DLY'D pushbutton. The beginning and ending segments of the time interval to be measured should both appear on screen.

11. Adjust TIME INTERVAL START to place the 50% point of the first leading edge at the center vertical graticule line.

12. Adjust TIME INTERVAL STOP to overlap the 50% point of the pulse trailing edge (for pulse-width measurements) or 50% point of the next pulse leading edge (for pulse-period measurements) at the center vertical line. (See figure 8 or 9 as applicable.)

13. If using Optional Digital Multimeter or an external DMM, read the actual pulse width or pulse period directly from the LED. Refer to the setting of main TIME/DIV to determine whether the output is in sec, ms, or μs.

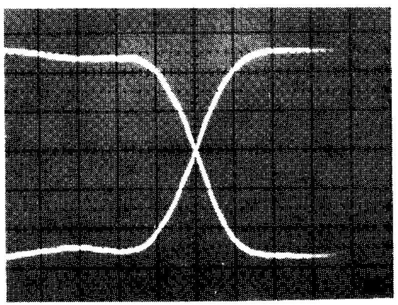

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Figure 8. Pulse-width Measurements

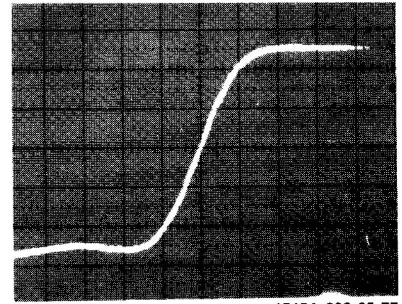

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Figure 9. Pulse-period Measurement

14. If not using a DMM, read the interval measured in divisions from the TIME INTERVAL STOP control. Then multiply the number of divisions by the main TIME/DIV dial setting to determine the actual pulse width or pulse period.

DUTY CYCLE MEASUREMENTS. The duty cycle is expressed as the ratio of pulse width to pulse period (width/period = duty cycle). Duty cycle measurements are important in systems where a pulse must remain within certain limitations to allow for pulse recognition.

The accuracy of duty cycle measurements depends upon the length of the time interval over which the pulse width and period are measured. To increase measurement accuracy for low duty cycle signals, increase the main time base sweep speed when measuring the pulse width. Use the preceeding pulse width and pulse period measurement technique.

SIGNAL FREQUENCY OR PULSE REPETITION RATE. The repetition rate or frequency of a signal is the reciprocal of the period. Use the pulse period measurement application procedure to determine the period of a signal. Then take the reciprocal of the period to determine repetition rate or frequency. Use the following formula:

$$\frac{1}{\text{time (in seconds) of period}}$$

Example: If a period of 0.8 ms is measured, then:

$$\frac{1}{0.8\ \text{ms}} = \frac{1}{8 \times 10^{-4}\ \text{sec}} = 0.125 \times 10^{4}\ \text{Hz} = 1.25\ \text{kHz}$$

PROPAGATION DELAY MEASUREMENTS. By selecting ALT or CHOP mode of operation, ΔT measurements can be made between an event on channel A and an event on channel B. The time interval mode switch on the oscilloscope permits measuring from an event on channel A to an event on channel B, or from an event on channel B to an event on channel A. To measure propagation delay between signals in the two channels, proceed as follows:

1. Apply one signal to channel A and the other signal to channel B INPUT connectors.

2. Select either ALT or CHOP VERT DISPLAY and INT TRIG.

3. Adjust each VOLTS/DIV switch to obtain a usable display on the respective channel.

4. Set the time interval mode switch to select the channel where the measurement will begin. If the measurement will start from a point on channel A, set time interval mode to CH A START. If the measurement will start from a point on channel B, set time interval mode to CH B START.

5. Select a main TIME/DIV sensitivity that places the second occurrence in the measurement as far as possible toward the right-hand edge of the CRT.

6. Set the delayed TIME/DIV control to a sweep speed approximately five times faster than the main TIME/DIV setting.

7. Engage MAIN INTEN pushbutton switch.

8. Adjust TIME INTERVAL START to position the first intensified marker at the beginning of the desired time interval (one channel). See figure 10.

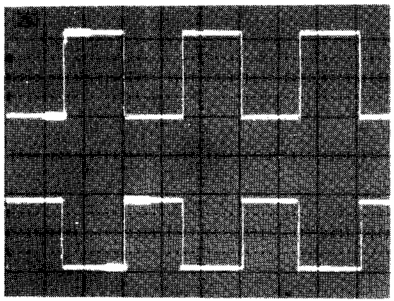

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Figure 10. Adjustment of Start and Stop

9. Adjust TIME INTERVAL STOP to position the second intensified marker at the end of the desired time interval (other channel).

10. Engage DLY'D pushbutton switch. The intensified portions of both waveforms should be present on screen.

11. Adjust TIME INTERVAL START and the associated vertical POSITION control to place the 50% amplitude point of the beginning trace at the center vertical graticule line. See figure 11.

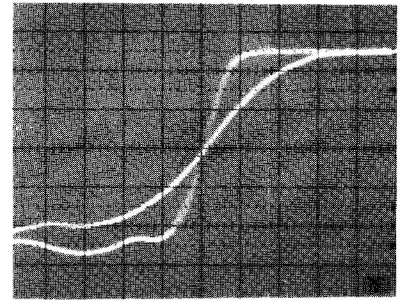

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Figure 11. Propagation Delay Measurement

12. Adjust TIME INTERVAL STOP and the associated vertical POSITION control to superimpose the ending trace on top of the beginning trace.

13. If using Optional Digital Multimeter or an external DMM, read the actual propagation delay directly from the LED. Refer to the setting of main TIME/DIV to determine whether the output is in sec, ms, or μs. When using cables of unequal length, remember to consider the cable delays in this measurement.

14. If not using a DMM, read the divisions and subdivisions of delay directly from the dial of the TIME INTERVAL STOP control. Multiply this number by the main TIME/DIV dial setting. When using cables of unequal length, remember to consider the cable delays in this measurement.

ADJUSTING A DESIRED TIME INTERVAL BETWEEN PULSES. The ΔT feature of the oscilloscope provides ease and accuracy when adjusting for a particular time interval between pulses, such as dual-clock phasing or dual-trigger circuitry. With the ΔT technique, the two signals are applied to the two oscilloscope channels, and the TIME INTERVAL controls are adjusted to indicate the desired time interval between pulses. Then the signal source is adjusted until the two signals are superimposed on the CRT. To make this adjustment, proceed as follows:

1. Apply one signal to channel A and the other signal to channel B INPUT connectors.

2. Select either ALT or CHOP VERT DISPLAY and INT TRIG.

3. Adjust each VOLTS/DIV switch to obtain equal amplitude displays on both channels.

4. Adjust both vertical POSITION controls to center traces on the CRT.

5. Select a main TIME/DIV sensitivity that permits a good view of the entire time interval to be established.

6. Set the delayed TIME/DIV control to a sweep speed approximately five times faster than the main TIME/DIV setting.

7. Set the time interval mode switch to select the channel which has the beginning event, normally the reference pulse or waveform. Set time interval mode to CH A START if the reference signal is on channel A and to CH B START if the reference signal is on channel B.

8. Adjust the TIME INTERVAL STOP control to select the desired time interval between pulses. If using an Optional Digital Multimeter or an external DMM, the LED will indicate the time interval adjusted. If not using a DMM, determine the horizontal scale factor selected on the main TIME/DIV switch and adjust TIME INTERVAL STOP for the number of divisions and subdivisions of display equal to the desired time interval.

9. Engage MAIN INTEN pushbutton switch.

10. Adjust TIME INTERVAL START to position the first intensified marker on the pulse which represents the beginning of the desired time interval.

11. Engage DLY'D pushbutton switch. The intensified portions of both waveforms should appear on screen.

12. Adjust TIME INTERVAL START to place the first pulse (reference pulse) at the center of the CRT.

13. Adjust the source of the signal under test to superimpose the two traces. When the traces are superimposed, the pulses will be separated by the time interval selected.

PULSE JITTER MEASUREMENTS. Jitter is a time uncertainty in a waveform caused by random noise or spurious or periodic signals. The ΔT technique in this oscilloscope makes jitter measurements which are both accurate and very easy. To measure jitter with this instrument, proceed as follows:

1. Apply the signal to channel A or B INPUT connector.

2. Select channel A or B VERT DISPLAY and INT TRIG.

3. Set the time interval mode switch to CH A START or CH B START, as applicable.

4. Adjust the appropriate VOLTS/DIV switch and vernier for a full six-division display of the signal.

5. Adjust main TRIG LEVEL until display is as stable as possible.

6. Select a main TIME/DIV sensitivity that places the next occurrence of the transition as far as possible toward the right-hand edge of the CRT.

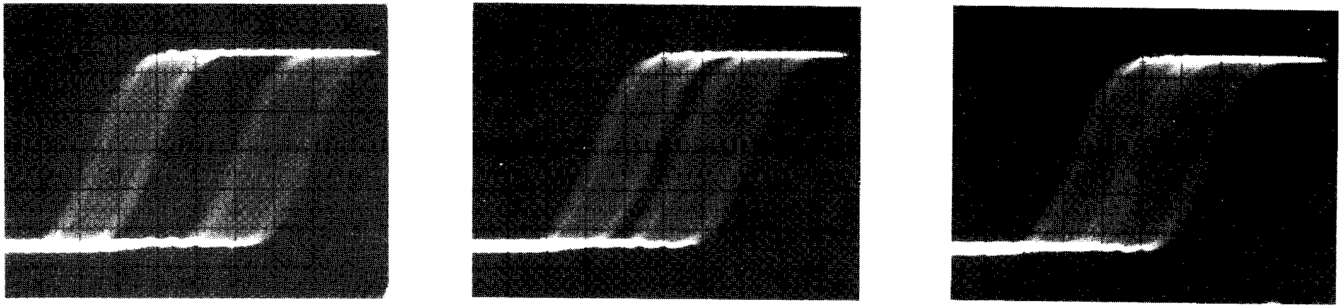
7. Set the delayed TIME/DIV control to a sweep speed approximately five times faster than the main TIME/DIV setting.

8. Engage MAIN INTEN pushbutton switch.

9. Adjust TIME INTERVAL START to place the first intensified marker on the signal leading edge.

10. Set TIME INTERVAL STOP to 0.00.

11. Engage DLY'D pushbutton switch.



A. NO AC TOUCH B. RANDOM PEAKS CONTACT C. CORRECT JITTER DISPLAY-EVEN DENSITY

Figure 12. Jitter Measurement Displays

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12. Adjust TIME INTERVAL START to place the trace at the center of the CRT.

13. Adjust TIME INTERVAL STOP to separate a second trace and then return it to the point where it just contacts the first trace. See figure 12.

14. If using an Optional Digital Multimeter or an external DMM, read the actual pulse jitter from the LED. Refer to the setting of the main TIME/DIV switch to determine whether the value displayed is in sec, ms, or μs.

15. If not using a DMM, read the number of CRT divisions and sub-divisions directly from the display. Multiply this number by the sensitivity selected on main TIME/DIV to determine the exact jitter time duration.

PHASE DIFFERENCE MEASUREMENTS USING TIME DELAY. The phase difference between two signals of the same frequency can be determined up to the frequency limit of the vertical amplifier by using ΔT techniques. Use the following procedure:

1. Apply the reference signal to channel A INPUT.

2. Select channel A VERT DISPLAY and INT TRIG.

3. Select a main TIME/DIV switch sensitivity which provides a display of one complete signal cycle.

4. Adjust the TIME INTERVAL START and TIME INTERVAL STOP controls until the first and second markers are exactly one cycle apart (example: first marker on first leading edge and second marker on second leading edge).

5. Engage the DLY'D pushbutton switch.

6. Readjust the TIME INTERVAL STOP control to overlap both traces on the CRT.

7. If using an Optional Digital Multimeter or an external DMM, record the indication of the LED. If not using a DMM, record the setting of the TIME INERVAL STOP dial. Do not change the main TIME/DIV setting after this step.

8. Engage the MAIN pushbutton switch.

9. Connect the other signal to channel B INPUT.

10. Select either ALT or CHOP VERT DISPLAY.

11. Adjust the TIME INTERVAL STOP control to place the marker on the channel B trace at the same relative position as the marker on the channel A trace (example: both markers on leading edges).

12. Engage the DLY'D pushbutton switch.

13. Readjust the TIME INTERVAL STOP control to overlap both traces on the CRT.

14. If using an Optional Digital Multimeter or an external DMM, record the indication on the LED. If not using a DMM, record the setting of the TIME INTERVAL STOP dial.

15. To determine the phase difference between signals, take the ratio of the numbers recorded in steps 5 and 11 and multiply by 360.

Example: If 5.26 was recorded in step 5 and 3.02 was recorded in step 11, then the phase difference between signals is 3.02/5.26 x 360 = 206 degrees of phase difference.

VOLTAGE MEASUREMENT APPLICATIONS.

Voltage measurements can be made between any point on a waveform and a 0-volt reference (absolute

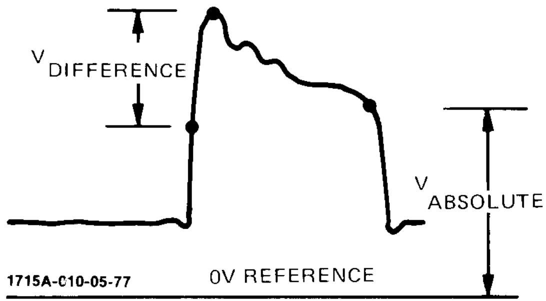


Figure 13. Types of Voltage Measurements

voltage) or between any two points on a waveform (voltage difference). See figure 13.

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:

1. Connect the signal to the channel A or B INPUT connector.

2. Set coupling to DC and adjust main TRIG LEVEL for a stable display.

3. Adjust vertical POSITION, VOLTS/DIV, and main TIME/DIV for a well centered display. Make sure that the associated verniers are in their CAL detents.

4. Set input coupling to GND and AUTO/NORM to AUTO. The trace defines the level of zero volt. If the level is below the signal, the signal is positive. If the level is above the signal, the signal is negative.

5. Adjust the vertical POSITION control to set the trace on a convenient graticule line to establish the 0-volt reference level. Do not move the vertical POSITION control after this step.

6. Return coupling to DC.

7. Measure the distance in divisions between the reference line and any point of interest in the signal.

8. Multiply the number of divisions obtained in step 7 by the VOLTS/DIV setting to determine the signal voltage. Include the attenuation factor if using a probe.

Example: Assume vertical deflection of 7 divisions, waveform above reference line, and VOLTS/DIV setting of 1 (figure 14). Absolute Voltage = 7 x 1 = 7 volts.

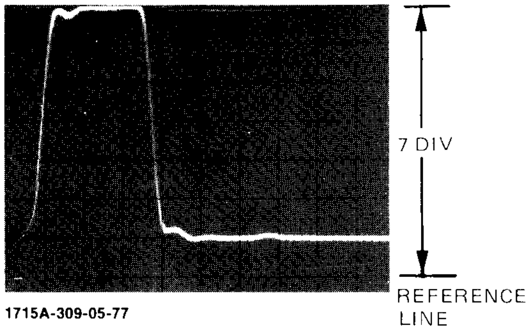


Figure 14. Absolute Voltage Measurements

Waveform is above reference line so voltage is positive.

PEAK-TO-PEAK VOLTAGE MEASUREMENTS. Oscilloscope displays of ac voltages contain amplitude error due to the frequency response of the instrument. With low signal frequencies, there is less error amplitude. With increasing signal frequencies, the amplitude of the error increases. To obtain displays with less than 10% error amplitude, the frequency of the signal being measured must be less than half of 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. The frequency roll off of the instrument must be considered when making voltage measurements with an oscilloscope. To measure the peak-to-peak voltage of an input signal, proceed as follows:

1. Connect the signal to the channel A or B INPUT connector.

2. Set coupling to AC and adjust main TRIG LEVEL for a stable display.

3. Adjust vertical POSITION, VOLTS/DIV, and main TIME/DIV for a well centered display of at least three cycles duration and at least three divisions of amplitude. Make sure that the VOLTS/DIV vernier is in the CAL detent.

4. Using the vertical POSITION control, place the negative peaks of the input signal on a horizontal graticule line near the bottom of the graticule.

5. Using the horizontal POSITION control, place one positive peak of the signal on the center vertical graticule line.

6. Count the number of vertical divisions from the most negative to the most positive portions of

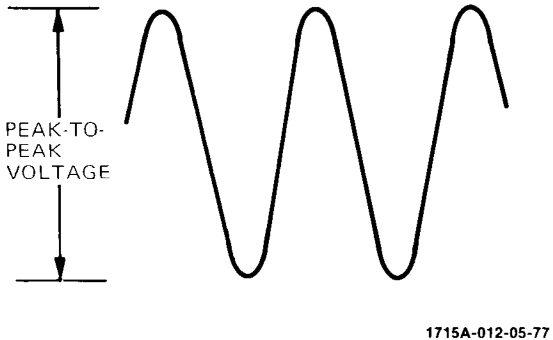


Figure 15. Peak-to-peak Measurement

the waveform (estimate to nearest tenth of division). See figure 15.

7. Multiply the number of divisions noted in step 6 by the setting of the VOLTS/DIV switch. If the signal is derived through a divider probe, multiply the result of this step by the attenuation factor of probe. Remember to consider the amplitude attenuation caused by the frequency roll off of the oscilloscope.

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

1. Connect the signal to the channel A or B INPUT connector.

2. Set coupling to GND and AUTO/NORM to AUTO. The trace level is zero volt.

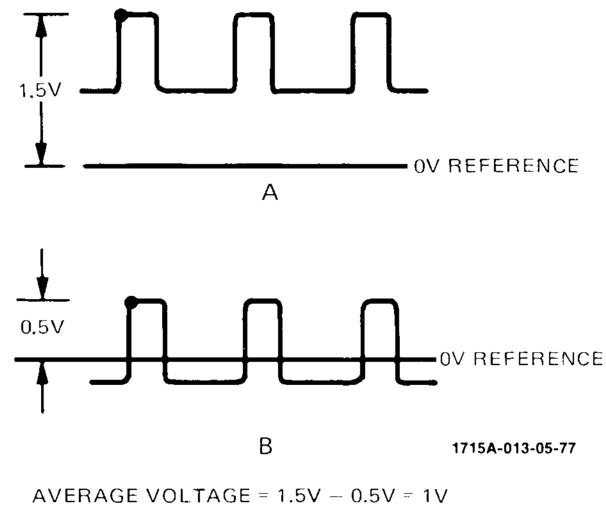


Figure 16. Average Voltage Measured with Oscilloscope

3. Switch coupling to DC and measure the absolute voltage at the point of interest on the waveform. See figure 16A.

4. Switch coupling to AC and measure the absolute voltage to the same point on the waveform. See figure 16B.

5. The difference between the first and second voltage measurements is the average voltage.

AVERAGE AND RMS VOLTAGE MEASUREMENTS USING OPTION 034/035 DMM. The Optional Digital Multimeter is an average-responding meter calibrated in rms. To measure rms voltage using the digital multimeter, proceed as follows:

1. Press the two-position switch in the oscilloscope top cover to the rear position.

2. Set the digital multimeter controls as follows:

POWER	ON
DC/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.

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

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:

1. Apply the reference signal to the channel A INPUT connector, and set VERT DISPLAY and INT TRIG to channel A.

2. Adjust the main TIME/DIV control to display several signal cycles.

3. Adjust the VOLTS/DIV switch and vernier to obtain a display with an exact number of divisions of vertical deflection. Greater accuracy is obtained with greater vertical deflection. Do not readjust the VOLTS/DIV vernier after this step.

4. Calculate the scale factor. Use the following formula:

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

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

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

5. Disconnect the reference signal and connect the signal to be measured.

6. Set the VOLTS/DIV switch for a measurable display amplitude. Do not readjust the VOLTS/DIV vernier.

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

Signal Amplitude = VOLTS/DIV setting multiplied by sf (step 4) multiplied by display amplitude (step 6).

Example: Assume a signal amplitude of 5 divisions, a VOLTS/DIV setting of 2, and a scale factor of 1.3.

Signal amplitude = 5 x 2 x 1.3 = 13 volts

8. You can also calculate the value of an unknown signal as a percentage of a reference signal.

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

Unknown signal amplitude = 6.2 DIV x 12.5% = 77.5% of reference signal amplitude

COMMON-MODE REJECTION. Frequently signals of interest are offset by undesired dc or low frequency 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.

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 the amplitude and frequency of the signals. Very high common-mode amplitudes may not be completely cancelled. Good common-mode rejection should be achieved with common-mode signal amplitudes of up to 12 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 will be the common-mode rejection in the oscilloscope.

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

1. Apply the signal to be measured (with the unwanted component) to the channel A INPUT.

2. Apply the signal similar to unwanted component to the channel B INPUT. See figure 17.

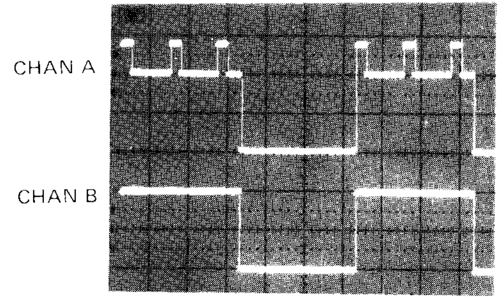


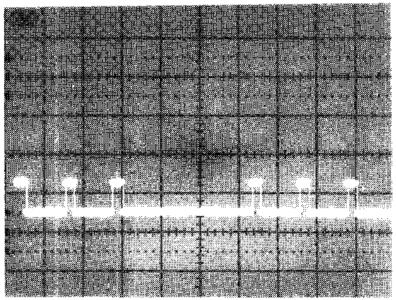
Figure 17. Common-mode Signals

3. Set coupling as required and select the ALT display mode.

4. Adjust the VOLTS/DIV and vernier controls so that the display on channel B is approximately equal to the amplitude of the unwanted component on channel A.

5. Set the oscilloscope controls as follows:

INT TRIG	A
B INVERT	INV
VERT DISPLAY	A+B



A--B

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Figure 18. Resultant Display

6. With either the channel A or B VOLTS/DIV vernier, adjust for minimum deflection in the common-mode signal. The resultant display will either subtract all of the unwanted component or display the desired signal larger than the common-mode signal. See figure 18.

OPTION 101 — LOGIC STATE DISPLAY.

This option allows you to use this oscilloscope with the HP Model 1607A Logic State Analyzer to aid in your analysis of digital systems that depend on sequences of logic states to control their operation. Horizontal, vertical, and Z-axis signals from the Model 1607A convert the oscilloscope into a 16-channel logic state analyzer. You can switch from logical state to electrical analysis by pressing one pushbutton - a real convenience.

To connect the oscilloscope to the Model 1607A, place the oscilloscope on top of the Model 1607A and using three Model 10502A cables, connect the Model 1607A rear-panel outputs: HORIZ, VERT, and Z-AXIS to the corresponding oscilloscope rear-panel inputs.

You may check the oscilloscope operation with the Model 1607A by the following procedure:

NOTE

Clock and data probes don't have to be connected to the Model 1607A for this procedure.

1. Press STATE DSPL on the oscilloscope.

2. Set the Model 1607A controls as follows:

POWER .... OFF
OFF/WORD .... WORD
Sample Mode .... SINGLE

COLUMN BLANKING	fully CCW
Z-AXIS	ON
All other pushbuttons	disengaged

3. Apply power to the oscilloscope and the Model 1607A, and adjust the oscilloscope FOCUS control for the sharpest display. A focused 16-word table of one's and zero's will be displayed. If the table is not displayed, you may have to press the Model 1607A power switch on and off to cause the Model 1607A to start up in a display mode.

NOTE

The following adjustments apply to the Model 1607A.

4. Adjust the HORIZ SIZE control for a six-division wide display and the VERT SIZE control for an eight-division high display. You may have to adjust the HORIZ and VERT POSN controls to center the display.

5. Set BYTE to 3 BIT and notice that the display format changes from four-bit bytes to three-bit bytes.

6. Set LOGIC to NEG and note that all zeros change to ones and all ones change to zeros.

7. Rotate the COLUMN BLANKING control clockwise and observe that the vertical columns are blanked, starting with the most significant bit.

8. Rotate the COLUMN BLANKING control fully clockwise and note that the least significant bit column remains on the CRT.

9. Rotate the COLUMN BLANKING control fully counterclockwise.

10. Set trigger mode to START DSPL and observe that the first word is intensified.

11. Set trigger mode to END DSPL and note that the last word is intensified.

12. Set DELAY ON/OFF to ON. Setting the DELAY thumbwheels from 0 to 15 will move the intensified word on the display. For delays greater than 15, the intensified word will not be displayed.

In the following example, we will show how you can use Option 101 in logic state and electrical analysis to find the location of a fault in digital program flow.

Since a fault in an algorithmic state machine will cause an erroneous state to exist in the program flow, it is desirable to start troubleshooting using program flow. When you find the fault location, you can more easily find the specific cause using conventional time analysis techniques. With Option 101, the oscilloscope and Model 1607A provide logic state and timing analysis displays.

Assume our algorithmic state machine is a 60-second timer that is terminating its count prematurely. By observing the logic state flow with the oscilloscope and Model 1607A, the premature termination point can easily be found. In this example, the malfunction is at count 25 (see figure 19). In this case we triggered on word 20. Notice the timer proceeded normally until word 24, when it reset to zero.

The Model 1607A supplied an external trigger to the oscilloscope, triggering the time display on the word we selected (word 20). A probe was connected from channel A on the oscilloscope to the least significant bit channel on the timer. Another probe was connected from channel B to the reset line on the timer.

Least Significant Bit

BCD "10's" Column	BCD "1's" Column	Word	
0010	0000	20	← TRIGGER WORD
0010	0001	21	
0010	0010	22	
0010	0011	23	
0010	0100	24	
0000	0000	0	← ERROR
0000	0001	1	
0000	0010	2	
0000	0011	3	
0000	0100	4	
0000	0101	5	
0000	0110	6	
0000	0111	7	
0000	1000	8	
0000	1001	9	
0001	0000	10	

1715A-004-05-77

Figure 19. Logic State Display

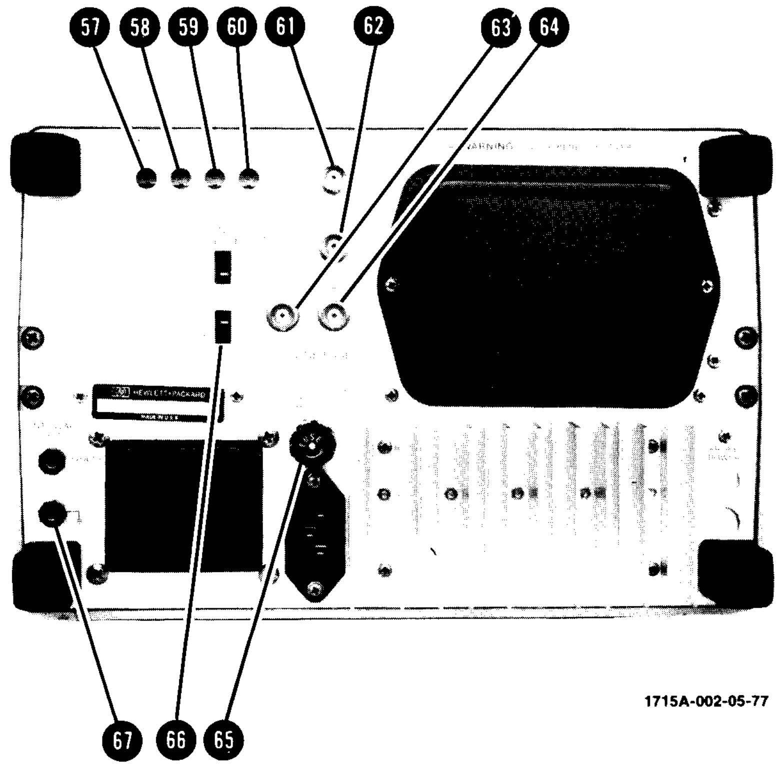
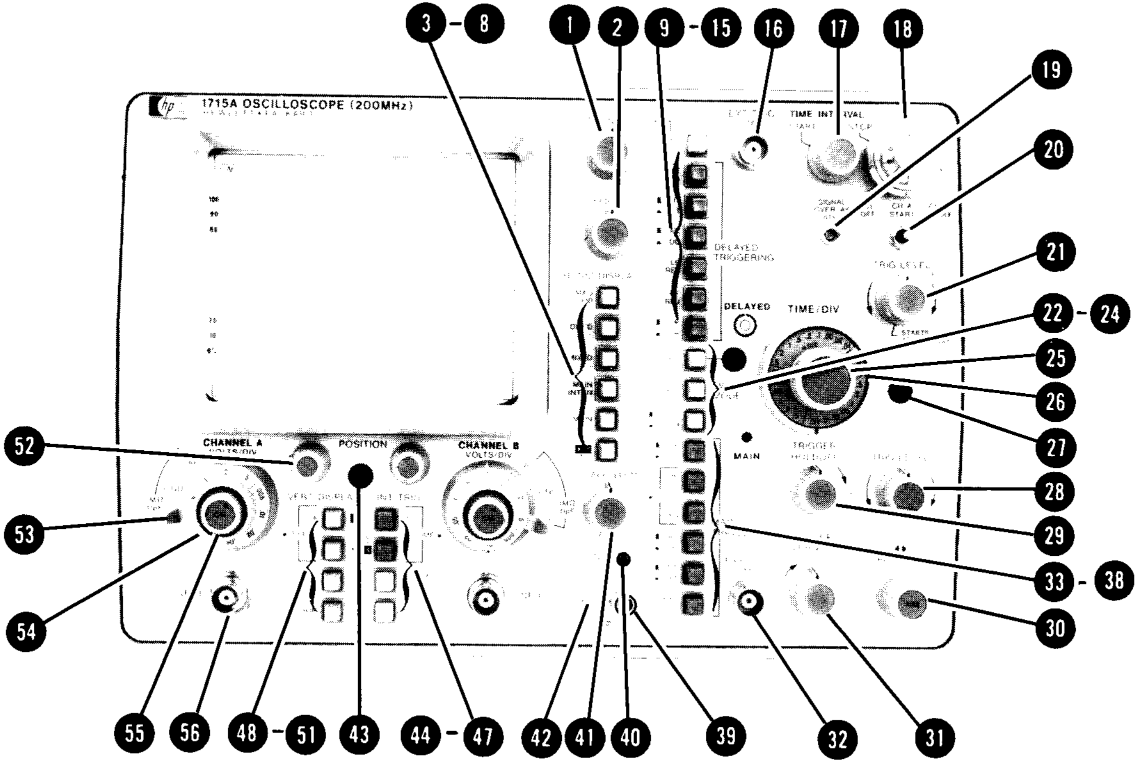


Figure 21. Controls and Connectors



1715A OSCILLOSCOPE (200MHz)
TIME INTERVAL
DELAYED TRIGGERING
DELAYED
TIME/DIV
TRIG LEVEL
MAIN
TRIGGER HOLDOFF
CHANNEL A
VOLTS/DIV
POSITION
CHANNEL B
VOLTS/DIV
3 - 8
1
2
9 - 15
16
17
18
19
20
21
22 - 24
25
26
27
28
29
33 - 38
30
52
53
54
55
56
48 - 51
43
44 - 47
42
41
40
39
32
31

By switching the oscilloscope STATE DSPL push-button to the off position, we obtained a time display starting with word 20 (see figure 20).

You will notice on channel A the pulses are normal until after word 24. The pulse at word 25 started to go high, but was not completed. Instead, the timer reset and started again at zero. Looking at the reset line on channel B, we see a "glitch" at word 25.

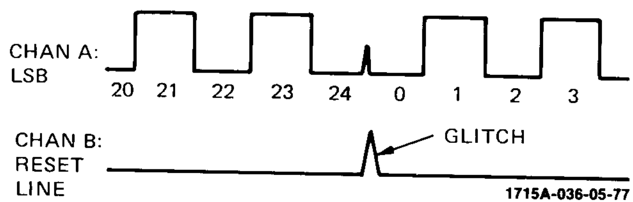


Figure 20. Glitch on Timer Reset Line Causing Timer to Reset Prematurely

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Arranged alphabetically by country

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