SECTION 1
GENERAL INFORMATION

1-1. INTRODUCTION

This service manual contains information on installing, testing, adjusting, and servicing the Hewlett-Packard Model 54501A Digitizing Oscilloscope. This section of the manual includes instrument identification, description, options, accessories, specifications and other basic information.

A microfiche part number is listed under the manual part number on the title page of this manual. This number may be used to order 4 X 6-inch microfiche transparencies of the manual. Each microfiche contains up to 96 photo-duplicates of the manual pages. The microfiche package also contains the latest Manual Changes supplement as well as pertinent Service Notes.

1-2. INSTRUMENTS COVERED BY MANUAL

On the rear panel of the instrument is a serial number plate. The serial number is in the form: 0000A00000. It is composed of two parts; the first four digits and the letter are the serial prefix and the last five digits are the suffix. The prefix is the same for all identical instruments and changes only when a change has been made to the instrument. The suffix however, is assigned sequentially and is different for each instrument. The contents of this manual apply to instruments with the serial number prefix(es) listed under SERIAL NUMBERS on the title page.

An instrument manufactured after the printing of this manual may have a serial number prefix different than those listed on the title page. This unlisted serial number prefix indicates the instrument is different from those described in this manual. The manual for this instrument is accompanied by a yellow Manual Changes supplement. This supplement contains the necessary "change information" that explains how to adapt the manual to the newer instrument.

In addition to change information, the supplement may contain information for correcting errors in the manual. To keep this manual as accurate as possible, periodically request the latest Manual Change supplement for the instrument manual. The supplement for this manual is identified with the manual part number and print date, both of which appear on the manual title page. Complimentary copies of the supplement are available from Hewlett-Packard.

For information concerning a serial prefix number not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

1-3. INSTRUMENT DESCRIPTION

The HP 54501A Digitizing Oscilloscope is a general-purpose, 100 MHz bandwidth oscilloscope. The HP 54501A has four input channels, two of which have limited input attenuation. Channels 2 and 3 are limited to an attenuation factor of 10 and optimized for digital signals. Full programmability has been incorporated into the HP 54501A and may be used in a broad range of HP-IB applications, from high-speed ATE to device characterization in a research and developement environment. The HP 54501A Digitizing Oscilloscope. features powerful triggering, easy waveform storage, automatic measurements and instant hardcopy ouput.

1-4. ACCESSORIES SUPPLIED

The following accessories are supplied with the HP 54501A Digitizing Oscilloscope:

Two **HP 10432A Miniature Passive Probes.**

One miniature probe to BNC male adapter.

One 2.3 metre (7.5 feet) **power cord.** See section 2 for available power cords.

One **Operating and Programming Manual Set.**

One **Service Manual.**

1-5. ACCESSORIES AVAILABLE

The following accessories are available for use with the HP 54501A:

Soft Carrying Case. *HP Part Number 1540-1066.*

HP Model 1008A Option 006 Testmobile.

Transit Case. HP Part Number 9211-1645.

1-6. OPTIONS AVAILABLE

Option 908 - HP Rackmount Kit. *HP Part Number 5061-6175.*

Option 910 - Additional Service Manual and Operating and Programming Manual Set.

Option 090 - Deletion of probe accessories.

1-6. SPECIFICATIONS

Table 1-1 is the list of specifications and characteristics for the HP 54501A Digitizing Oscilloscope. The specifications are the performance standards or limits for which the oscilloscope is tested.

1-7. OPERATING CHARACTERISTICS

Table 1-2 is a list of the operating characteristics of the HP 54501A Digitizing Oscilloscope. The operating characteristics are a summary of performance capabilities of the HP 54501A.

1-8. GENERAL CHARACTERISTICS

Table 1-3 is general characteristics of the HP 54501A Digitizing Oscilloscope. The general characteristics are useful environmental operating conditions, shipping weights, and instrument dimensions.

1-9. RECOMMENDED TEST EQUIPMENT

Table 1-4 is a list of the test equipment required to test performance, make adjustments, and troubleshoot the HP 54501A Digitizing Oscilloscope. The table indicates the critical specification of the test equipment and for which procedure the equipment is necessary. Equipment other than the recommended model may be used if it satisfies the critical specification listed in table 1-4.

Table 1-1. HP 54501A Specifications and Characteristics

SPECIFICATIONS

BANDWIDTH:

dc-coupled

Repetitive: dc to 100 MHz (-3 dB)

Single Shot: dc to 1 MHz

(Based on 10 points per period of input signal.)

ac-coupled

Repetitive: 10 Hz to 100 MHz (-3dB)

Single Shot: 10 Hz to 1 MHz

(Based on 10 points per period of input signal.)

RISETIME: 3.5 ns

(Calculated from: Risetime = 0.35/Bandwidth.)

NUMBER OF CHANNELS: 4 (2+2)

Channels 2 and 3 are limited attenuator inputs, optimized for digital signals.

SIMULTANEOUS CHANNELS: 2+2

Channels 1 or 2 simultaneous with 3 or 4. With more than two channels, the other channels are acquired alternately in pairs.

VERTICAL SENSITIVITY

Maximum: 5 mV/div

Minimum: 5 V/div

VERTICAL GAIN ACCURACY (dc): ±1.5%

MAX INPUT VOLTAGE: ±250 V DC + peak ac (<10KHz)

OFFSET ACCURACY:

±2% of offset + 0.2 X (V/div) + .075 div/Δ°C from calibration temperature.

(For 5 mV/div range, ±2% of offset + 0.4 X (V/div) + + 0.15 div/$^\circ$C from calibration temperature.)

VOLTAGE MEASUREMENT ACCURACY (single channel)

Single Cursor: Gain Accuracy + offset + A/D resolution

Dual Cursor: Gain Accuracy + 2X A/D resolution

TIME BASE RANGE

Minimum: 2 ns/div

Maximum: 5 s/div

TIME BASE ACCURACY: 0.005%

DELTY t ACCURACY:

+-2% of (t/div) +- .005% of Delta t +- 1 ns

Delta t accuracy for dual-cursor, single-channel measurement, or for channel-to-channel measurement after visual time null calibration has been done.

TRIGGER SENSITIVITY

5 mv/div:

dc-20 MHz	0.1 X full-scale
20 MHz-100 MHz	0.25 X full-scale

All other:

dc-20 MHz	0.05 X full-scale
20 MHz-100 MHz	0.125 X full-scale

CHARACTERISTICS

VERTICAL RESOLUTION:

±0.4% - 8-bit A/D

(Since expansion is used for 5 mV/div range, A/D resolution is 7 bits [0.8%] in that range.)

±0.1% - 10 bits via HP-IB

(with averaging)

MAXIMUM SAMPLE RATE: 10 Msa/s

MEMORY DEPTH:

501 points (display)

1024 points (via HP-IB)

(For single-shot via HP-IB, maximum memory depth is 501 points. For 2 ns/div time base range, memory depth is 200 points. For 5 ns/div time base range, maximum memory depth via HP-IB is 501 points.)

INPUT RC (nominal): 1 MΩ, 16 pF

INPUT COUPLING: ac, dc

OFFSET RANGE:

Sensitivity Range	-	Available Offset
5 - 50 mV/div		±2V
0.1 - 1 V/div		±20V
1 - 5 V/div		±200V

DYNAMIC RANGE: ±16 divisions from center

Operating range for dc + peak AC input.

CHANNEL-TO-CHANNEL ISOLATION:

(with channels at equal sensitivity)

40 dB dc to 20 MHz

30 dB 20 MHz to 100 MHz

MAXIMUM TIME BASE RESOLUTION: 100 ps

DELAY RANGE (post trigger):

Time Base Setting	-	Available Delay
50 ms- 5 s		40 X (s/div)
100μs - 20 ms		1 s
2ns - 50 μs		-10,000 X (s/div)

DELAY RANGE (pretrigger):

Time Base Setting	Delay
10 μs - 5 s	-40 X (s/div)
20 ns - 5 μs	-200 μs
2 ns - 10 ns	-10,000 X (s/div)

TRIGGER PULSE WIDTH (minimum): 7 ns

TRIGGER LEVEL RANGE: ±6 div from center

Specifications valid for temperature range ± 10° C calibration temperature with 8 averages selected and channel(s) in sensitivity range 1, 2, or 5.

Table 1-2. HP 54501A Operating Characteristics

VERTICAL

Deflection factors: Channels 1 and 4: With single screen selected, attenuation factors are adjustable from 5 mV/div to 5 V/div in a 1-2-5 sequence with the knob. Finer adjustments may be made using direct keypad entry or the knob with the FINE key selected.

Channels 2 and 3: With single-screen mode selected, attenuation factors are adjustable from 100 mV/div to 500 mV/div in a 1-2-5 sequence with the knob. Finer adjustments may be made using direct keypad entry or the knob with the FINE key selected.

Probe attenuation factors: Values from 0.9 to 1K may be entered to scale the oscilloscope for external probes or attenuators attached to the channel inputs. When probe tip calibration is performed, this value is calculated automatically.

Bandwidth limit (HF Reject): May be selected for each individual input to provide a low-pass filter with a -3 dB point at approximately 20 MHz for both triggering and signal display.

ECL/TTL Presets: vertical deflection factor, offset, and trigger level may be preset independently on each channel for ECL and TTL levels.

HORIZONTAL

Dual time base windowing: Allows user to zoom in on user-defined portion of the waveform using cursors that are displayed on the top half of the screen. An expanded time base is displayed on the lower half of the screen. The window time base may be set to provide as much as a 20:1 expansion ratio.

Waveform measurements are performed on the dual time base window information when windowing is turned on.

Delay between channels: difference in delay between channels may be nulled out to compensate for differences in input cables or probe length. Use the *time null cal* found in the Utility menu.

Reference location: The reference point may be located at the left edge, center, or right edge of the display. For zero delay, the reference point is the trigger point. For non-zero delay, the reference point is equal to the trigger point plus the delay time.

TRIGGER MODES

Edge trigger: Positive or negative edge may be selected for trigger on any of the four channel inputs.

Pattern trigger: A pattern may be specified using all four of the inputs. Each of the inputs may be specified as a *high, low,* or *don't care* with respect to the level setting in the edge trigger menu. Trigger may be selected to occur on the last edge to enter the specified pattern or the first edge to exit the specified pattern.

Time-qualified pattern trigger: A trigger will occur on the first edge to exit a pattern, only if it meets the specified time criteria. The available time-qualified modes are:
pattern present less than [time] pattern present greater than [time] range-pattern present greater than [time1] and less than [time2]
The time [time] settings are adjustable from 20 ns to 160 ms (±/-3% ±2 ns). The time filter recovery time is less than or equal to 12 ns. In the PATTERN PRESENT LESS THAN [TIME] mode, the pattern must be present greater than 7 ns for the trigger to respond.

Glitch trigger: Use PATTERN PRESENT LESS THAN [TIME] with [time] selected such that is just under the pulse width of the signal you are analyzing. The minimum capturable glitch width is 7 ns.

State trigger: A pattern is specified on any three of the four inputs with the fourth input used as a clock. A trigger will occur on the rising or falling edge of the input specified as the clock. A trigger will occur on the rising or falling edge of the input specified as the clock when the pattern is present or not present. Setup time for the pattern with respect to the clock is less than or equal to 10 ns; hold time is zero.

Table 1-2. HP 54501A Operating Characteristics (continued)

TRIGGER MODES (continued)

DELAYED TRIGGER:

Event-delayed mode: The trigger may be qualified by an edge, pattern, time-qualified pattern or state. The delay may be specified as a number of occurrences of a rising or falling edge of the input specified as the clock when the pattern is present or not present. The trigger is an occurrence of a rising or falling edge of any of the four inputs. The occurrence values may be set from 1 to 16,000,000. The maximum edge- counting rate is 100 MHz.

Time-delayed mode: The trigger may be qualifed by an edge, pattern, time-qualified pattern or state. The delay is selectable from 30 ns to 160 ms. The trigger is an occurrence of a rising or falling edge of any of the four inputs. The number of occurrences may be set from 1 to 16,000,000. The maximum edge counting rate is 100 MHz.

TV TRIGGER

60 Hz / 525 lines: Source may be selected to be any of the four inputs. Trigger level is adjustable for the selected source. Polarity is selected for positive or negative synchronizing pulses. A trigger occurs on the selected line and field of a 2/1 interlaced composite video signal. Line numbering is 1 to 263 for field 1 and 1 to 262 for field 2. This TV trigger mode is compatible with broadcast standard M.

50 Hz / 625 lines: Same as 60 Hz / 525 lines, except numbering is 1 to 313 for field 1 and 314 to 625 for field 2. This TV trigger mode is compatible with braodcast standards: B,C,D,G,H,I,K,K1,L and N.

User-defined mode: Source may be selected to be any one of the four inputs. Trigger level is adjustable for the selected source. The trigger is qualified with a high or low pulse that meets a selectable time range. The trigger is an occurrence of a rising or falling edge of the source after the qualifying pulse. The time settings for the qualifier are selectable from 20 ns to 160 ms. The trigger occurrence value is selectable from 1 to 16,000,000.

NOTE: All TV trigger modes require a clamped video signal for stable triggering. Use the HP 1133A TV/Video Sync Pod to provide clamped video output that can be used with the HP 54501A's TV triggering capabilities.

Holdoff: Holdoff is adjustable in 20 ns steps from 40 ns to 320 ms. A separate holdoff setting is available for each trigger mode except DELAYED TRIGGER, which is fixed to 40 ns.

Waveform Math

Two independent functions are provided for waveform math. The operators are +, -, X, VS, INVERT and ONLY. The vertical channels on any of the waveform memories may be used as operands for the waveform math. Sensitivity and offset for these functions may be adjusted independently.

Waveform Save

Four non-volatile memories and two volatile pixel memories are provided. Waveform memories store single-valued waveforms, such as an averaged waveform. If an envelope waveform is stored to a memory waveform, it will automatically be stored with the upper waveform in one waveform memory and the lower waveform in another. Pixel memories store an entire screen of waveform data. They are very useful for storing multiple, overlapping waveforms and infinite persistence waveforms.

DISPLAY

Data display resolution: 451 points horizontally by 256 points vertically.

Number of screens: 1,2, or 4 screens can be selected. This allows the overlapping of channels or memories for comparison, or viewing them on up to 4 data display areas.

Display Modes

Minimum persistence: One waveform data value is displayed in each horizontal position of the display. The waveform is updated as the new data is acquired for a particular horizontal position.

Table 1-2. HP 54501A Operating Characteristics (continued)

Display Modes (continued)

Variable persistence: The time that each data point is retained on the display may by varied from 200 ms to 10 seconds, or it may be displayed infinitely.

Averaging: The number of averages, (n) may be specified in powers of 2, up to 2048. On each acquisition, 1/n times the new data is added to (n-1)/n of the previous value at each time coordinate. Averaging operates continuously, except for the HP-IB DIGITIZE command, for which averaging terminates at a user-specified number of averages.

Envelope: Provides a display of the running maximum and minimum voltage levels at each horizontal position of a repetative waveform.

Graticules: The user may select full grid, axes, frame, or no graticule.

Connect-the-dots: Provides a continuous display, connecting the sample points with straight lines. Connect-the-dots is operative for modes in which a single valued waveform can be connected, including AVERAGE, ENVELOPE, and MINIMUM PERSISTENCE modes.

Scroll mode: The HP 54501A automatically selects scroll mode at time-per-division settings from 200 ms/div to 5 s/div if the scope is in AUTO mode, or if the scope is in TRIGGERED mode with the delay at the left edge of the display set is greater than or equal to 0. Scroll mode updates each data point on the displayed waveform as the data is acquired.

DELTA V / DELTA t Markers: dual voltage markers and dual time markers are provided. Voltage markers may be independently assigned to channels, memories, or functions.

AUTOMATIC PARAMETRIC MEASUREMENTS

Automatic Pulse Parameter Measurements: The HP 54501A performs 16 automatic pulse parameter measurements from the front panel and additional measurements via HP-IB including ALL, OVERSHOOT, and PRESHOOT. The standard measurements are performed with 10%, 50%, and 90% voltage thresholds, as defined by IEEE Standard 194-1977, "IEEE Standard Pulse Terms and Definitions".

User-definable Measurement Thresholds: The HP 54501A lets you set your own thresholds for automatic measurements. Both the upper and the lower thresholds may be set from 0% to 100% as long as the upper threshold value is greater than or equal to the lower threshold. The mid threshold is always equal to the mid-value between the upper and lower threshold.

Continuous measurements: may be turned on or off. With continuous measurements off, the voltage and time markers are placed on the waveform to indicate where the measurement is taken.

Measurement Statistics: The maximum, minimum, average, and most recent of continuously updated measurements are calculated and displayed. Any three measurements may be selected.

Measurement Limit Test: Maximum and minimum limits may be set for three of the automatic measurements. These continuously updated measurements are compared to the maximum and minimum limits. If the measurements are found to be outside the defined limits, the acquisition is stopped and the waveform can be stored to a memory or the screen can be sent to a printer. In addition, an HP-IB Service Request can be generated, so a controller can be flagged to request the waveform and the measurement information via HP-IB.

SETUP AIDS

Autoscale: Pressing the Autoscale button automatically adjusts the vertical and horizontal deflection factors as well as the trigger level for a display appropriate to the signals applied to the inputs. The Autoscale feature requires a signal with a duty cycle greater than 0.5% and a frequency greater than 50 Hz.

Table 1-2. HP 54501A Operating Characteristics

SETUP AIDS (continued)

Save/Recall: Four front-panel setups (1-4) may be saved in non-volatile memory.

Recall Clear: Resets the HP 54501A to its factory default settings.

Recall 0: If Autoscale, ECL, or TTL preset, or RECALL SETUP are inadvertently selected, RECALL 0 restores the memory to its last state prior to selection.

Show: Displays instrument status, including volts/div, offset, and trigger condition.

HARDCOPY: The CRT display, including menus and measurement results, can be transferred directly to an HP-IB graphics printer, including the HP 2225A ThinkJet® or compatible printers.

HP-IB PROGRAMMABILTITY

Full Programmability: The HP 54501A provides full programmablity. Instrument settings and operating modes, including automatic

measurements, may be remotely programmed via HP-IB (IEEE 488). HP-IB programming complies with IEEE 488.2-1988 "Standard Codes, Formats, Protocols, and Common Commands".

Data Acquisition and Transfer Rate: A 500-point data record can be acquired and transferred to a computer at a rate of approximately 10 times per second, as tested with an HP 9000, Series 200 Controller. The acquired data was type normal, completion criteria 100% with the oscilloscope at a time/div setting of 5 μ s/div.

Data Transfer Rates: Approximately 120 Kbytes/s.

Probe Compensation Output: An approximately 1.5 MHz signal is provided for probe compensation. A probe-to-BNC adapter is used to connect the probe to the rear panel Probe Compensation BNC output. During calibration, this output is used to provide other calibration signals.

DC Calibrator Output: This output is used for vertical calibration of the HP 54501A.

Table 1-3. HP 54501A General Characteristics

Environmental Conditions

Temperature
Operating: 0° C to + 55° C.
Non-operating: -40° C to 70° C.

Humidity
Operating: up to 95% relative humidity (non-condensing) at 40° C.
Non-operating: up to 90% relative humidity at 65° C.

Altitude

Operating: up to 4600 meters (15 000 ft).
Non-operating: up to 15 300 meters (50 000 ft).

Vibration

Operating: Random vibration 5-500 Hz, 10 minutes per axis, 0.3 G(rms).
Non-operating: Random vibration 5-500 Hz, 10 minutes per axis, 2.41 G(rms).
Resonant search: 5 to 500 Hz swept sine, 1 octave/minute sweep rate, (0.75g), 5 minute resonant dwell @ 4 resonances per axis.

Power Requirements

Voltage: 115/230 Vac,-25% to +15%, 48-66 Hz.
Power: 350 VA maximum.

Weight

Net: approximately 10 kg (22 lb).
Shipping: approximately 20 kg (44 lb).

Dimensions

Refer to outline drawings below.

NOTES

1. Dimensions are for general information only. If dimensions are required for building special enclosures, contact your HP field engineer.
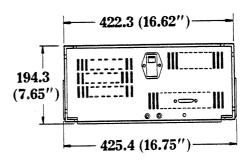
2. Dimensions are in millimetres and (inches).

439.4 (17.3″)
362.5 (14.3″)
355.6 (14.0″)

422.3 (16.62″)
194.3 (7.65″)
425.4 (16.75″)

Table 1-4. Recommended Test Equipment

REQUIRED	CRITICAL SPECIFICATIONS	RECOMMENDED	USE*
DMM	5 1/2 digit resolution	HP 3478A	A, T
OSCILLOSCOPE	100 MHz BW high-z input w/10:1 probe	HP 54501A	A
PULSE GENERATOR	<70 ps risetime	Tektronix 284	A
POWER SUPPLY	30 mV to 30 V 0.025% accuracy	HP 6114A	P
SIGNAL GENERATOR	100 MHz .003% accuracy	HP 8656B	P
SQUARE-WAVE GENERATOR	100 Hz to 1 kHz 300 mV p-p to 5 V p-p	HP 8116A	A
POWER METER	100 MHz frequency range .02 dB accuracy	HP 436A	P
POWER SENSOR	HP 436A compatibility	HP 8482A	P
BNC TEE	(m) to (f) (f)	HP 1250-0781	P
50 OHM TERMINATION	Accuracy: ±1%	HP 10100C	A, P
TYPE N (m) CABLE	24 inches (m) to (m)	HP 11500B	A, P
TYPE N (f) BNC ADAPTER	N (f) to BNC (f)	HP 1250-1474	P
BNC 50 OHM ADAPTER	BNC (f) to dual banana plug (m)	HP 1251-2277	A, P
BNC CABLE	48 inches	HP 10503A	A, P
EXTENDER CABLE	no substitute	HP 54503-61604	A
RESISTOR	2 ohms, 25 Watts	HP 0811-1390	T
* P=Performance Tests A=Adjustments T=Troubleshooting			