HEWLETT PACKARD

SERVICE MANUAL

HP 54503A
Digitizing Oscilloscope

SERIAL NUMBERS

This manual applies directly to instruments prefixed with serial number:

2929A

For Additional Information about serial numbers see INSTRUMENTS COVERED BY THIS MANUAL in Section 1.

Manual Part No. 54503-90903
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Performance Specifications

The following are performance specifications for the HP 54503A Digitizing Oscilloscope.

Vertical

Bandwidth(-3dB, dc coupled)
Repetitive:[1] dc to 500 MHz
Single-shot: dc to 2 MHz (based on 10 points per period of input signal)

Rise time:[2] 700 ps

Input R (selectable): 1 MΩ ±1% or 50 Ω ±1%

Maximum Input Voltage[3]
1 MΩ: ±250 V [dc + peak ac(< 10 kHz)]
50 Ω: 5 V_{rms}

Offset Accuracy:[4] ±(0.5% of ch. offset + 2% of full scale)

Voltage Measurement Accuracy (dc) [4,5]
Dual Cursor: ±(1.25% of full scale + 0.032 × V/div)
Single Cursor: ±(1.25% of full scale + offset accuracy + 0.016 × V/div)

Horizontal

Time Base Reference Accuracy: 0.005%

Delta-t Accuracy
Real time: ±(2% × s/div + 0.005% × delta-t + 100 ps)

Trigger

Trigger Sensitivity

≥5 mV/div
dc to 100 MHz: 0.063 × full scale
100 MHz to 500 MHz: 0.156 × full scale

< 5mV/div
dc to 100 MHz: 2.5 mV
100 MHz to 500 MHz: 6 mV

NOTES: Specifications valid for temperature range ±10°C from software calibration temperature with eitht or more averages selected.

1. Upper bandwidth reduces by 2.5 MHz for each °C above 35°C.
2. Rise time figure is calculated from: tr = 0.35/Bandwidth.
3. On ranges ≤50 mV/div the maximum overdrive of the input must not exceed 1,000 times the V/div setting.
4. Expansion is used below 7 mV/div range so vertical resolution and accuracies are correspondingly reduced.
5. Accuracy decreases 0.08% per °C from software calibration temperature.

Performance Characteristics

The following are performance characteristics of the HP 54503A Digitizing Oscilloscope.

Vertical

Switchable Bandwidth Limits
ac-coupled (lower -3 dB frequency): 90 Hz
LF reject (lower -3 dB frequency): 450 Hz
bandwidth limit (upper -3dB frequency): 30 MHz

Number of channels:[1] 4

Vertical Sensitivity Range (all channels): 1 mV/div to 5 V/div

Vertical Gain Accuracy (dc):[2,3] ±1.25%

Vertical Resolution:[3] ±0.4% (8-bit A/D)
±0.1% (10 bits via HP-IB with averaging)

Maximum Sample Rate: 20 MSa/s

Waveform Record Length[4]
501 points (display)
1024 points (via HP-IB)

Input C: 7 pF nominal

Input coupling: ac, dc

Offset Range:

Vertical Sensitivity	Available Offset
1 mV - 50 mV/div	±2 V
>50 mV - 250 mV/div	±10 V
>250 mV - 1.25 V/div	±50 V
>1.25 V - 5 V/div	±250 V

Dynamic range (dc + peak ac): ±1.5 × full scale from center of screen

Channel-to-channel Isolation
(with channels at equal sensitivity)
40 dB: dc to 100 MHz
30 dB: 100 to 500 MHz

NOTES: Specifications valid for temperature range ±10°C from software calibration temperature with eithi or more averages selected and channel(s) in sensitivity range 1, 2, or 5.

1. Simultaneous acquisition on two channels. channels 1 and 4 are acquired simultaneously. If four channels are used, data is acquired alternately by channels 1 and 4, then 2 and 3.

2. Accuracy decreases 0.08% per °C from software calibration temperature.

3. Expansionis used below 7 mV/div range so vertical resolution and accuracies are correspondingly reduced.

4. For single-shot via HP-IB, waveform record length is 500 points. In repetitive mode:
200 ps/div time base range, waveform record length is 100 points
500 ps/div time base range, waveform record length is 250 points
1 ns/div time base range, waveform record length is 500 points
≥ 2 ns/div time base range, waveform record length is 1,000 points

Horizontal

Time Base Range: 200 ps/div to 5 s/div

Time Base Resolution: 20 ps

	Time/div Setting	Available Delay
Delay Range (post-trigger)	50 ms - 5 s	40 × (s/div)
	100 µs - 20 ms	1 s
	200 ps - 50 µs	10,000 × (s/div)
Delay Range (pretrigger)	5 µs - 5 s	−39.96 × (s/div)
	10 ns - 2 µs	−99.9 µs
	200 ps - 5 ns	−10,000 × (s/div)

Trigger

Trigger Pulse Width (minimum): 1.5 ns

Trigger Level Range: ±1.5 × full scale from center of screen

Operating Characteristics

Vertical

Deflection Factors: All channels: With single screen selected, attenuation factors are adjustable from 1 mV/div to 5 V/div in a 1-2-5 sequence with the knob. Finer adjustments can be made using direct keypad entry or the knob with the fine key selected.

Probe Attenuation Factors: Values from 0.9 to 1,000 may be entered to scale the oscilloscope for external probes or attenuators attached to the channel inputs. When probe tip calibration is done, this value is calculated automatically.

Input Impedance: 1 MΩ or 50 Ω selectable for each input.

Bandwidth Limit (HF Reject): Can be selected for each input individually. Provides low pass filter with a −3 dB point at approximately 30 MHz for both triggering and signal display.

LF Reject: Can be selected for each input individually. Provides high pass filter with a −3 dB point at approximately 450 Hz for both triggering and signal display.

AC Coupling: Can be selected for each input individually. Provides high pass filter with a −3 dB point at approximately 90 Hz and a two-pole rolloff for both triggering and signal display.

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

Horizontal

Dual Time Base Windowing: Allows user to zoom in on portions 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 can be set to provide as much as a 20:1 expansion ratio.Waveform measurements are performed on the the dual time base window information when windowing is turned on.

Delay Between Channels: Difference in delay between channels can 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 can be located at the left edge, center, or right edge of the display. The reference point is equal to trigger point plus the delay time.

Trigger Modes

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

Pattern Trigger: A pattern can be specified using all four of the inputs. Each of the inputs can be specified as a *high, low,* or *don't care* with respect to the level setting in the edge trigger menu. The trigger can 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 < [time]
- pattern present > [time]
- range – pattern present > [time1] and < [time2]

The time settings are adjustable from 20 ns to 160 ms ($\pm 3\%$ ± 2 ns). The time filter recovery time is ≤ 12 ns. In the "pattern present < [time]" mode, the pattern must be present > 1.5 ns for the trigger to respond.

Glitch Trigger: Use "pattern present < [time]" with [time] selected such that it is just less than the pulse width of the signal you are analyzing. The minimum glitch width is 1.5 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 specfied 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.

Delayed Trigger

Event-Delayed Mode: The trigger can be qualified by an edge, pattern, time qualified pattern, or state. The delay can be specified as a number of occurrences of a rising or falling edge on any one of the four inputs. After the delay, an occurrence of a rising or falling edge on any one of the four inputs will generate the trigger. The occurrence value of the edge to trigger on is selectable from 1 to 16,000,000. The maximum edge counting rate is 70 MHz.

Time-Delayed Mode: The trigger can be qualified by an edge, pattern or state. The delay is selectable from 30 ns to 160 ms. After the delay, an occurrence of a rising or falling edge on any one of the four inputs will generate the trigger. The occurrence value of the edge to trigger on is selectable from 1 to 16,000,000. The maximum edge counting edge is 70 MHz.

TV Trigger

60 Hz / 525 Lines: Source is selected to be any one 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: Source is selected to be any one 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 313 for field 1 and 314 to 625 for field 2. This TV trigger mode is compatible with broadcast standards B, C, D, G, H, I, K, K1, L, and N.

User-Defined Mode: Source is 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 (±3% ±2 ns). 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 pod to provide clamped video output that can be used in conjunction with the HP 54503A's TV triggering capabilities.*

Trigger Holdoff: Trigger can be held off by either time or events over the ranges:

- Time: 40 ns - 320 ms
- Events: 2 - 16,000,000

An Event is defined as the specified trigger condition. A separate holdoff setting (time or events) is available for each trigger mode except delayed trigger, which is set to 40 ns.

Noise Reject Trigger: Improves triggering on noisy signals by increasing hysteresis.

Display

Data Display Resolution: 451 points horizontally by 256 points vertically.

Number of Screens: 1, 2, or 4 screens can be selected. This enables overlapping channels or memories for comparison, or displaying them in 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 new data is acquired for a particular horizontal position.

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

Averaging: The number of averages (n) can 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 the specified number of averages.

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

Graticules: The user may choose 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: In the Auto Mode at settings from 200 ms/div to 5 s/div the 54503A automatically selects the scroll mode display. It will also select scroll display in the triggered mode with delay reference (= left and delay ≥0). Scroll mode updates each data point on the displayed waveform as the data is acquired.

Delta t /Delta V

Markers: Dual voltage markers and dual time markers are available. Voltage markers can be independently assigned to channels, memories, or functions.

Waveform Math

Two independent functions are provided for waveform math. The operators are +, −, ×, vs, invert, and only. The vertical channels and the waveform memories can be used as operands for the waveform math. Sensitivity and offset for these functions can be adjusted independently.

Waveform Save

Four non-volatile waveform 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 waveform memory, 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.

Automatic Pulse Parameter Measurements

The 54503A offers 16 automatic pulse parameter measurements from the front panel (shown below) 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."

Automatic measurements available on the HP 54503A.

Rise time	Pulse Width +	Volts amp	Volts avg	Preshoot
Fall time	Pulse width −	Volts base	Volts max	(HP-IB only)
Frequency	Duty Cycle	Volts top	Volts min	Overshoot
Period	Delay	Volts p-p	Volts RMS	(HP-IB only)

User-Definable Measurement Thresholds

The HP 54503A allows you to set your own thresholds for automatic measurements. Both the upper and lower thresholds can be set, either in % or Volts, as long as the upper threshold value is always ≥ the lower threshold. The mid threshold is always equal to the midvalue between the upper and lower threshold.

Continuous Measurements: Allows automatic measurements to be continuously updated, and most recent measurement results displayed. With continuous measurements off, the voltage and time markers are placed on the waveform to indicate the last measurement is taken.

Measurement Statistics: The maximum, minimum, and average of continuously updated measurements are calculated and displayed. Any three measurements can be selected for simultaneous display.

Measurement Limit Test: Maximum and minimum limits can 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 in a memory or the screen can be sent to a printer. In addition, the HP-IB Service Request line can be set to flag the controller. Measurement limit test can be set to stop after test limits have exceeded, or to continue testing.

Setup Aids

Autoscale: Pressing the Autoscale button automatically adjusts the vertical and horizontal deflection factors and 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. Autoscale is operative only for relatively stable input signals.

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

Recall Clear: Resets the HP 54503A to its factory default settings.

Recall 0: If Autoscale, ECL or TTL preset, or recall setup are inadvertently selected, recall 0 restores the instrument to its last state prior to selection.

Show

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

Hardcopy

The CRT display contents, including menus and measurement answers, can be transferred directly to an HP-IB raster graphics printer, including the HP 2225A Thinkjet.

Full HP-IB Programmability

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 Waveform Transfer Rate: A 500-point waveform 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/division setting of 5 μsec/div.

Data Transfer Rates: Approximatly 120 kBytes/sec.

Probe Compensation, AC Calibrator Output: An approximate 1.5 kHz 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, as described in the Service Manual. This same BNC connector is used for trigger output. The utility menu allows the user to switch the BNC from probe compensation and calibration signals to a trigger output pulse. The leading (rising) edge, with amplitude from approximately −400 mV to 0V (when terminted into 50 Ω), is synchronous with system trigger. The trailing (falling) edge of this pulse occurs approximately at the end of holdoff. The leading (rising) edge should be used as the edge synchronous with trigger.

DC Calibrator Output: this output is used for vertical calibration of the 54503A, as described in the Service Manual.

Product Support

Built-in Self-Test and Calibration Routines: Internal self-test capabilities provide a 90% confidence that the instrument is operating properly. External test procedures in the service manual provide 100% confidence. Self-calibration routines, also selected through the front panel "utility" menu, ensure that the instrument is operating with its greatest accuracy and requires no external test equipment.

Low Cost of Ownership: The HP 54503A carries a three-year warranty. Hewlett-Packard's board exchange program assures economical and timely repair of units, reducing the cost of ownership.

Solutions: Hewlett-Packard's System Engineering Organization can help you configure an HP-IB system and provide software support for your application. Contact your HP Sales and Service office for more information.

General Characteristics

Environmental Conditions

Temperature
Operating: 0°C to +55°C (32°F to +131°F)
Non-operating: −40°C to +70°C (−40°F to +158°F)

Humidity
Operating: up to 95% relative humidity (non-condensing) at +40°C (+104°F)
Non-operating: up to 90% relative humidity at +65°C (+149°F)

Altitude
Operating: up to 4,600 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 minute 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 at 4 resonances per axis.

Power Requirements

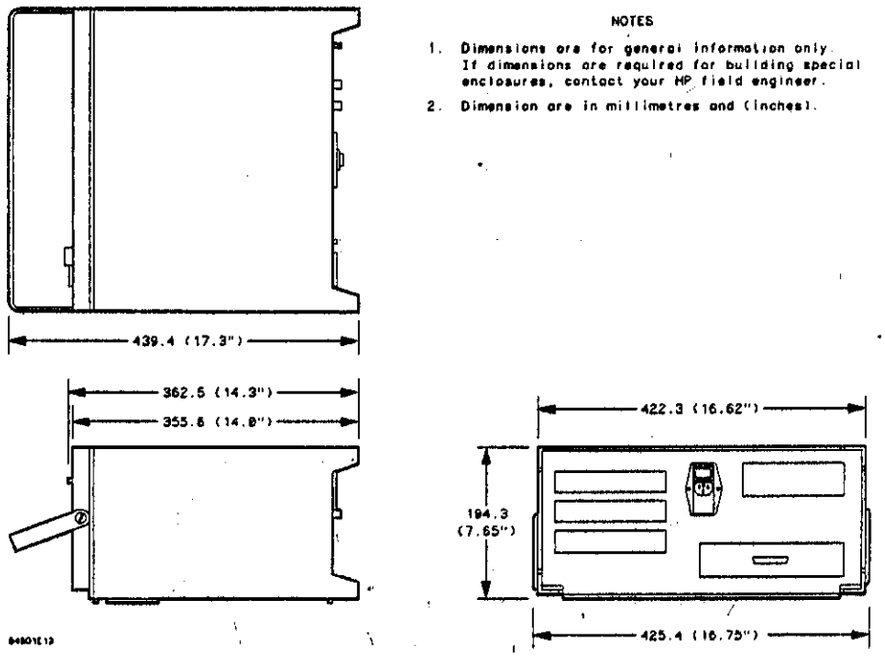
Voltage: 115/230 V ac, − 25% to + 15%, 48-66 Hz.
Power: 350 VA maximum.

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. Dimension are in millimetres and (inches).

Recommended Test Equipment

Table 1-1 shows a list of the test equipment required to test performance, make adjustments, and troubleshoot this instrument. 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 the table.

Table 1-1. Recommended Test Equipment

Equipment Required	Critical Specifications	Recommended Model	Use *
Signal Generator	1 - 500 MHz, sine wave amplitude 3-170 mV_{rms} time base accuracy ±0.001%	HP 8656B	P
Power Meter/ Power Sensor	1 - 500 MHz, -70 dBm to 0 dBm, ±1.2% accuracy	HP 436A/8432A	P
DMM	5 1/2 digit resolution dc voltage accuracy ±0.025% 4-wire resistance accuracy ±0.25%	HP 3478A	P, A, T
Power Supply	7 mV - 35 V dc, 0.1 mV resolution	HP 6114A	P
Pulse Generator	T_r ≤70 ps, amplitude approx. 200 mV	TEK TYPE 284	A
Oscilloscope	General-purpose	HP 54501A	P, T
Power Splitter	50 Ω type N, outputs differ by < 0.15 dB	HP 11667A	P
Cable	Type N - 3 foot	HP 11500B	P
Cable (2)	BNC - 3 foot	HP 10503A	P, A, T
Cable (4)	BNC - 9 inch	HP 10502A	P, A, T
Adapter	N (m) to BNC (m)	HP 1250-0082	P
Adapter	N (m) to BNC (f)	HP 1250-0780	P
Adapter	GR874 to BNC (f)	General Radio	A
Adapter (3)	BNC tee (m)(f)(f)	HP 1250-0781	P, A, T
Adapter	BNC (f)(f)	HP 1250-0080	A, T
Adapter (2)	BNC to dual banana	HP 1251-2277	P
Cable Extender	no substitute	HP 54503-61604	A, T
Resistor	2 Ω 25 W	HP 0811-1390	T

* P = Performance Tests, A = Adjustments, T = Troubleshooting

3

Performance Tests

Introduction

The procedures in this section test the instruments electrical performance using Performance Specifications given in section 1 as performance standards. Specifications applicable to individual tests are noted at the test for reference.

Testing Interval

The performance test procedures may be performed for incoming inspection of the instrument and should be performed periodically thereafter to ensure and maintain peak performance. The recommended test interval is yearly or every 2,000 hours of operation. Amount of use, environmental conditions, and the user's experience concerning need for testing will contribute to verification requirements.

The calibration cycle is covered in the Adjustment procedures.

Equipment Required

A complete list of equipment required for the performance tests is in the Recommended Test Equipment table in Section 1. Equipment required for individual tests is listed in the test. Any equipment satisfying the critical specifications listed may be substituted for the recommended model.

Self-test Verification

To verify system operation with high confidence, without the test equipment and time required for performance tests, perform the self-tests. These internal tests verify many functions on the Main Assembly. The functions tested are the six separate memories and six other system functions.

To start the self-tests, press **UTIL** then **self-test.** A message is displayed with the instruction to remove all inputs to the instrument. Press **test all**, which starts a loop which runs all the self-tests in succession. During execution of the self-tests, the following messages are displayed as each self-test is completed:

```
PASSED  Display RAM                    PASSED  Acquisition RAM
PASSED  System RAM                     PASSED  Logic Trigger
PASSED  Non-Volatile RAM               PASSED  Analog Trigger
PASSED  Protected Non-Volatile RAM     PASSED  Timebase
PASSED  System ROM                     PASSED  D/A Converter
PASSED  HP-IB                          PASSED  A/D Converter
```

If one of the self-tests fails, `FAILED` is displayed rather than `PASSED`, and a 16-bit diagnostic code is displayed. This code is used by factory service personnel when troubleshooting the Main Assembly. Failure of a self-test indicates a failure on the Main Assembly which must be returned to the factory for service. For more information on service, refer to section 6 of this manual.

Note 

The loop test in the **selftest menu** is a troubleshooting aid for factory service only.

Test Record

The results of the performance tests may be tabulated on the Test Record provided at the end of this section. The Test Record lists the performance tests and provides an area to mark test results. The results recorded in the table at incoming inspection may be used for later comparisons of the tests during periodic maintenance, troubleshooting, and after repairs or adjustments.

Operating Hints

Some knowledge of operation of the HP 54503A is helpful; however, procedures are written so that little experience is necessary. The following two hints will speed progress of the testing.

Clear Display

When using many averages, it often takes awhile for a waveform display to stabilize after a change. When a control on the HP 54503A is changed, averaging automatically restarts. When just the input signal is changed, the instrument must average new data with the old so it takes a long time for the waveform to stabilize. Press CLEAR DISPLAY while changing input signals. The instrument will restart averaging and give a quick indication of the result of the signal change.

Averaging

Averaging is used to assure a stable signal for measurements. It is not necessary to wait for complete stability of the signal (averaging complete) as long as the measurement is well within the limits of the test.

Performance Test Procedures

Performance test procedures start with the next paragraph. Procedures may be done individually or in any order.

Note

Allow the instrument to warm up for at least 15 minutes prior to beginning performance tests.

DC Calibrator Test

The DC CALIBRATOR output on the rear panel is used for self-calibration and probe calibration. Though calibrator accuracy is not specified in the performance specifications, it must be within limits in order to provide accurate self-calibration.

Test Limits 5.000 V ±10 mV

DC Calibrator Test

Equipment Required

The following equipment is required for this test. Procedures are based on the model or part number recommended.

Equipment Required	Critical specifications	Recommended Model/Part
Digital Multimeter	0.1 mV resolution, better than 0.025% accuracy	HP 3478A

Procedure

1. Connect the multimeter to the rear panel DC CALIBRATOR output.
2. Press UTIL then service menu, then press cal select to select cal select 3 (3: DC cal BNC verify). Press dac output to select 0 Volt.
3. The DVM should read close to 0.000 V. Record the reading to four decimal places. V1 = _____
4. Press dac output to select 5 Volt. The DVM should read near 5.000 V. V2 = _____
5. Subtract V1 from V2. The difference should be between 4.990 and 5.010 V. Record the reading in the performance test record.

Note

If the difference is not within the limits repair is necessary. See troubleshooting in section 6.

Input Resistance

This test checks the input resistance of the vertical inputs. A four-wire measurement is used for accuracy at 50 Ω.

Specification

1 MΩ ± 1% and 50 Ω ± 1%

Equipment Required

The following equipment is required for this test. Procedures are based on the model or part number recommended.

Equipment Required	Critical specifications	Recommended Model/Part
Digital Multimeter	Measure resistance (4-wire) better than 0.25% accuracy	HP 3478A
Cables (2)	BNC	HP 10503A
Adapter	BNC Tee (m)(f)(f)	HP 1250-0781
Adapter (2)	BNC (f) to banana (m)	HP 1251-2277

Procedure

1. Set up the multimeter to make a four-wire resistance measurement.
2. Use the BNC-to-banana adapters to connect one end of each BNC cable to the four-wire resistance connections on the multimeter, and connect the free ends of the cables to the BNC tee.
3. Connect the male end of the BNC tee to the channel 1 input of the HP 54503A.
4. Press **CHAN** and select channel 1 with the top softkey.
5. Use the impedance softkey (second from bottom) to select 1 MΩ, then 50Ω DC, and verify resistance readings of 1 MΩ ± 10 kΩ and 50 Ω ± 0.5 Ω respectively. Record the readings in the performance test record.
6. Repeat steps 3-5 for channels 2, 3, and 4.

Note

Failure of this test indicates a faulty attenuator if resistance is out of specifications. The main assembly also may be at fault if input resistance cannot be changed. See troubleshooting in section 6.

Voltage Measurement Accuracy

This test verifys the voltage measurement accuracy of the instrument. A dual cursor measurement is made so offset errors are not a factor.

Specification

Dual Cursor: ±(1.25% of full scale + 0.032 × V/div)
Single Cursor: ±(1.25% of full scale + offset accuracy + 0.016 × V/div)

Equipment Required

The following equipment is required for this test. Procedures are based on the model or part number recommended.

Equipment Required	Critical specifications	Recommended Model/Part
Power Supply	7 mV to 35 Vdc, 0.1 mV resolution	HP 6114A
Digital Multimeter	Better than 0.1% accuracy	HP 3478A
Cable	BNC	HP 10503A
Adapter	BNC (f) to banana (m)	HP 1251-2277

Procedure

1. Use the banana-to-BNC adapter to connect the BNC cable to the power supply. Monitor the supply with the DVM.
2. Press RECALL then CLEAR to set HP 54503A to default conditions, then set the following parameters.

MENU	SELECTION	SETTING
DISPLAY	(mode)	avg
	# of avg	32
Δt ΔV	ΔV markers	on

3. Use the following table for the next steps.

RANGE	OFFSET	SUPPLY	TOLERANCE	LIMITS
5 V	17.5000 V	35.00 V	±0.66 V	34.34 V to 35.66 V
2 V	7.00000 V	14.00 V	±0.26 V	13.74 V to 14.26 V
1 V	3.50000 V	7.000 V	±0.132 V	6.868 V to 7.132 V
500 mV	1.75000 V	3.500 V	±0.066 V	3.434 V to 3.566 V
200 mV	700.000 mV	1.400 V	±0.026 V	1.374 V to 1.426 V
100 mV	350.000 mV	700.0 mV	±13.2 mV	686.8 mV to 713.2 mV
50 mV	175.000 mV	350.0 mV	±6.6 mV	343.4 mV to 356.6 mV
20 mV	70.000 mV	140.0 mV	±2.6 mV	137.4 mV to 142.6 mV
10 mV	35.000 mV	70.0 mV	±1.3 mV	68.7 mV to 71.3 mV
5 mV	17.500 mV	35.0 mV	±1.8 mV	33.2 mV to 36.8 mV
2 mV	7.000 mV	14.0 mV	±0.8 mV	13.2 mV to 14.8 mV
1 mV	3.500 mV	7.0 mV	±0.7 mV	6.3 mV to 7.7 mV

4. Press CHAN and set **5.00 V/div**, and **17.5000 V offset.**
5. With supply disconnected from channel input (see note below), press **Δt ΔV** and set **Vmarker 1** to overlay the trace near the bottom of the display.

   Note: For 5, 2, and 1 mV/div ranges the power supply should stay connected and be set to 0.0 mV as measured on the DVM.

6. Set power supply to 35.00 V per the first line of the table.
7. Connect power supply to the channel input and set **Vmarker 2** to overlay the trace near the top of the display.
8. The **delta V(1)** reading at the bottom of the display should be within the limits given in the table. Record the reading in the test record.
9. Repeat steps 3 through 8 for line 2 of the table and the rest of the ranges of channel 1.
10. Press CHAN and set the active channel **off** and the next channel **on**.
11. Repeat steps 3 through 10 for channels 2 and 3, and steps 3 through 9 for channel 4.

Note

Voltage measurement errors can be caused by the need for self calibration. Perform self calibration, **0. vertical cal**, (see Adjustment procedures, section 4) before troubleshooting instrument. If self-calibration fails to correct problem, the cause may be the attenuator or main assembly.

Offset Accuracy

This test verifys offset accuracy.

Specification

±(0.5% of channel offset + 2.0% of full scale)

Equipment Required

The following equipment is required for this test. Procedures are based on the model or part number recommended.

Equipment Required	Critical specifications	Recommended Model/Part
Power Supply	0.5 V to 2 Vdc, ±1 mV accuracy	HP 6114A
Cable	BNC	HP 10503A
Adapter	BNC (f) to banana (m)	HP 1251-2277

Procedure

1. Use the banana-to-BNC adapter to connect the BNC cable between the power supply and channel 1 input.
2. Press RECALL then CLEAR to set HP 54503A to default conditions. Press DISPLAY, select **avg**, and set **# of avg** to 32.
3. Use the following table for the next steps.

RANGE	OFFSET	SUPPLY	TOLERANCE	LIMITS
500 mV	20.0000 V	20.000 V	±180 mV	19.820 to 20.180 V
200 mV	10.0000 V	10.000 V	±82 mV	9.918 to 10.082 V
100 mV	5.00000 V	5.000 V	±41 mV	4.959 to 5.041 V

4. Press CHAN and set for **500 mV/div** and **20.0000 V** offset per first line of table.
5. Set the supply to 20.000 V.
6. Readjust **offset** so the trace is as close to the horizontal center line of the graticule as possible after it has settled (averaging complete).
7. Read the offset voltage. It should be at its original setting, within the limits given in the table. Record the reading.
8. Repeat steps 3 through 7 for the 200 mV/div and 100 mV/div ranges using the appropriate offset and supply voltages in the table.
9. Connect the power supply to the next channel input.
10. Turn the active channel **off** and the next channel **on**. Repeat steps 3 through 10 for channels 2 and 3, and steps 3 through 8 for channel 4.

Note

Offset errors can be caused by the need for self calibration. Perform self calibration, **0. vertical cal**, (see Adjustments) before troubleshooting instrument. If self calibration fails to correct problem, the cause may be the attenuator or main assembly.

Bandwidth

This test checks the repetitive and real time bandwidths of the HP 54503A.

Specification

Bandwidth: dc coupled
Repetitive - dc to 500 MHz
Single-shot - dc to 2 MHz (not tested)

Equipment Required

The following equipment is required for this test. Procedures are based on the model or part number recommended.

Equipment Required	Critical specifications	Recommended Model/Part
Signal Generator	1 - 500 MHz at ≈170 mVrms	HP 8656B
Power Meter/ Sensor	1 - 500 MHz ±1.2% accuracy	HP 436A/8482A
Power Splitter	outputs differ by < 0.15 dB	HP 11667B
Cable	Type N (m) 24 inch	HP 11500B
Adapter	Type N (m) to BNC (m)	HP 1250-0082

Procedure

1. With the N cable, connect the signal generator to the power splitter input. Connect the power sensor to one output of the power splitter.
2. Using an N-to-BNC adapter, connect the other power splitter output to the channel 1 input.
3. Press RECALL then CLEAR to set default conditions, then set the following parameters.

MENU	SELECTION	SETTING
TIMEBASE	(time/div)	200 ns/div
CHAN 1	(sensitivity)	40 mV/div
	(input R)	50Ω DC
DISPLAY	(mode)	avg
	# of avg	32

4. Set the signal generator for 1 MHz at -2.4 dBm. The signal on screen should be two cycles at six divisions amplitude.
5. Press SHIFT (blue), V P-P, and 1 (active channel) to make an automatic peak-to-peak measurement.
6. After the measurement settles (averaging complete, about 10 seconds) note the Vp-p reading (bottom of screen): V_{1MHz} = _____ mV.
7. Set power meter Cal Factor % to 1 MHz value from the cal chart on the probe, then press dB[REF] to set a 0 dB reference.
8. Change signal generator to 500 MHz and set power meter Cal Factor to 500 MHz % value from chart.
9. Adjust signal generator amplitude for a power reading as close as possible to 0.0 dB(REL). Reading = _____.

10. Press TIME BASE and set to **500 ps/div.**

11. After the measurement settles (averaging complete) note the **Vp-p** reading: V_{500MHz} = _____ mV.

12. Calculate the response using the formula:

$$\text{response(dB)} = 20 \log_{10} \frac{V_{500MHz}}{V_{1MHz}} = 20 \log_{10} \frac{\quad}{\quad} = \_\_\_\_\_ \text{dB}$$

13. Correct the result from step 12 with any difference in the power meter from step 9. Observe signs. For example:

```
Result from step 12 = -2.3 dB
Power meter reading = -0.2 dB(REL)
then true response = (-2.3)-(-0.2) = -2.1 dB
```

(_____) - (_____) = _____dB

14. The result from step 13 should be ≤-3.0 dB. Record the result in the Performance Test Record.

15. Connect the power splitter to the next channel to be tested.

16. On the HP 54503A, set the following parameters.

MENU	SELECTION	SETTING
TIMEBASE	(time/div)	200 ns/div
CHAN	(previous)	off
	(next)	on
	(sensitivity)	40 mV/div
	(input R)	50Ω DC
TRIG	source	(active channel)

17. Press SHIFT (blue) then CLEAR, then repeat steps 4 through 17 for channels 2 and 3, and steps 4 through 14 for channel 4.

Note 

Failure of the bandwidth test can be caused by faulty attenuator or main assembly, or the need for high-frequency pulse response adjustment.

Time Measurement Accuracy

This test uses a precise frequency source to check the accuracy of time measurement functions.

Specification

Delta-t accuracy

±(2.0% × s/div + 0.005% × delta-t + 100 ps)

Equipment Required

The following equipment is required for this test. Procedures are based on the model or part number recommended.

Equipment Required	Critical specifications	Recommended Model/Part
Signal Generator	1 MHz and 500 MHz	HP 8656B
Cable Adapter	50 Ω BNC 24 inch Type N (m) to BNC (f)	HP 10503A HP 1250-0780

Procedure

1. Set the signal generator to 500 MHz at approximately 150 mV_{rms} and connect to the channel 1 input.
2. Press RECALL then CLEAR, then set the following parameters.

MENU	SELECTION	SETTING
TIMEBASE	(time/div)	500 ps/div
CHAN	(sensitivity)	50 mV/div
	(input R)	50Ω DC
	# of avg	128

3. Press TRIG and adjust trigger level so positive edge of signal crosses the graticule exactly at center screen or some other convenient reference. For more control, set knob to **fine**.
4. Use the following table for the next steps.

DELAY	TOLERANCE	LIMITS
8 ns	±110 ps	7.890 to 8.110 ns
128 ns	±116 ps	127.884 to 128.116 ns
400 ns	±130 ps	399.870 to 400.130 ns
800 ns	±150 ps	799.850 to 800.150 ns

5. Press TIME BASE then **delay**. For the first line of the table, use the entry keys to set the delay, then use the knob to set the positive edge of the signal to the reference from step 3.
6. Check that the delay value is within the limits in the table. Record the result.
7. Repeat steps 5 and 6 for the other delays in the table and record each result.
8. Set the signal generator to 1 MHz and press AUTOSCALE.
9. Press TIME BASE and set **200 ns/div**.
10. Press TRIG and set trigger level so positive edge of signal crosses exactly at center screen or another convenient reference.

11. Press TIME BASE, then delay, and use the entry keys to enter 500.000 us delay.

12. Use the knob to set the positive edge of the signal to center screen (reference). The delay should read 500.000 us ±29.1 ns, 499.9709 us to 500.0291 us. Record the result.

Note

Time Measurement Accuracy failure is caused by a defective main assembly.

Trigger Sensitivity

This test checks channel and external triggers for sensitivity at rated bandwidth.

Specification

≥5 mV/div
dc to 100 MHz: 0.063 × full scale
100 MHz to 500 MHz: 0.156 × full scale

< 5mV/div
dc to 100 MHz: 2.5 mV
100 MHz to 500 MHz: 6 mV

Equipment Required

The following equipment is required for this test. Procedures are based on the model or part number recommended.

Equipment Required	Critical specifications	Recommended Model/Part
Signal Generator	100 and 500 MHz, 3-150 mV_{rms}	HP 8656B
Cable	50 Ω BNC 36 inch	HP 10503A
Adapter	Type N (m) to BNC (f)	HP 1250-0780

Procedure

1. Press RECALL then CLEAR to set default conditions, then set the following parameters.

MENU	SELECTION	SETTING
TIMEBASE	(time/div)	2 ns/div
CHAN	1	on
	2, 3 ,4	off
(all)	(sensitivity)	200 mV/div
	(input R)	50Ω DC
DISPLAY	(mode)	avg
	# of avg	16
	(graticule)	grid

2. With an N-to-BNC adapter and BNC cable, connect signal generator to channel 1 input BNC.
3. Set signal generator to 100 MHz and adjust output level for 0.5 division of vertical deflection.
4. Press TRIG and adjust **trigger level** for a stable display. The test passes if triggering is stable. Record result.
5. Press TIME BASE and set **1 ns/div.**
6. Set signal generator frequency to 500 MHz and amplitude for 1.25 division of vertical deflection. (Use offset to position waveform for easier measuring.)
7. Press TRIG and adjust trigger level for a stable display. The test passes if triggering is stable. Record result.
8. Set trigger level to **0.00000 V**, then press CHAN and set sensitivity to **1 mV/div** and offset to **0.00000 V.**
9. Adjust signal generator for 6 divisions of vertical deflection.

10. Press TRIG and adjust trigger level for a stable display. The test passes if triggering is stable. Record result.
11. Press TIME BASE and set **5 ns/div.**
12. Set signal generator to 100 MHz and adjust amplitude for 2.5 divisions of vertical deflection.
13. Press TRIG and adjust trigger level for a stable display. The test passes if triggering is stable. Record result.
14. To set up **next** channel, press CHAN and set active channel **off** and next channel **on**. Press TRIG and set source to presently active channel. (All other parameters were set in step 1.)
15. Connect the signal generator to the active channel.
16. Repeat steps 3 through 15 for channel 2 and 3, and steps 3 through 13 for channel 4.

Note Trigger sensitivity test failure is caused by a defective attenuator or main assembly.

Oscillator Output Check

These tests are optional. The oscillator outputs are not specified in the instrument performance specifications. The values given are typical. Results are not recorded in the test record.

Equipment Required

Equipment requirement is not critical and choices are at the discretion of the user. A high quality oscilloscope should be sufficient.

Procedure

1. Use a BNC cable to connect the rear panel AC CALIBRATOR output to the channel 1 input of the HP 54503A under test and press AUTOSCALE.
2. Make automatic measurements of the signal. Press blue (shift), V P-P, then 1 for amplitude and blue, FREQ, then 1 for frequency.
3. Signal into 1 MΩ should be an approximately 800 mV square wave at approximately 1500 Hz. Into 50 Ω the amplitude is approximately 400 mV.
4. Disconnect the AC CALIBRATOR from the channel 1 input and connect it to another oscilloscope.
5. Press UTIL, service menu, then cal select to select cal select 2.
7. The signal should be approximately 19.716 MHz and 800 mV_{p-p} into 1 MΩ.

Table 3-1. Performance Test Record

HEWLETT PACKARD

HP 54503A Digitizing Oscilloscope

Tested by _____

Serial No. _____

Work Order No. _____

Recommended Test Interval - 1 Year/2000 hours

Date _____

Recommended Next Testing _____

Temperature _____

TEST	LIMITS	RESULTS
Calibrator Amplitude	4.990 to 5.010 Vdc	_____
Input Resistance		CHAN 1 / CHAN 2 / CHAN 3 / CHAN 4
	1MΩ 990K to 1.010M	_____ _____ _____ _____
	50Ω 49.50 to 50.50	_____ _____ _____ _____
Voltage Measurement Accuracy	RANGE	CHAN 1 / CHAN 2 / CHAN 3 / CHAN 4
	5 V 34.34 V to 35.66 V	_____ _____ _____ _____
	2 V 13.74 V to 14.26 V	_____ _____ _____ _____
	1 V 6.868 V to 7.132 V	_____ _____ _____ _____
	500 mV 3.434 V to 3.566 V	_____ _____ _____ _____
	200 mV 1.374 V to 1.426 V	_____ _____ _____ _____
	100 mV 686.8 mV to 713.2 mV	_____ _____ _____ _____
	50 mV 343.4 mV to 356.6 mV	_____ _____ _____ _____
	20 mV 137.4 mV to 142.6 mV	_____ _____ _____ _____
	10 mV 68.7 mV to 71.3 mV	_____ _____ _____ _____
	5 mV 33.2 mV to 36.8 mV	_____ _____ _____ _____
	2 mV 13.2 mV to 14.8 mV	_____ _____ _____ _____
	1 mV 6.3 mV to 7.7 mV	_____ _____ _____ _____
Offset Accuracy	RANGE	CHAN 1 / CHAN 2 / CHAN 3 / CHAN 4
	500 mV 19.820 to 20.180 V	_____ _____ _____ _____
	200 mV 9.918 to 10.082 V	_____ _____ _____ _____
	100 mV 4.959 to 5.041 mV	_____ _____ _____ _____

Table 3-1. Performance Test Record (cont'd)

TEST	LIMITS	RESULTS
Bandwidth	down <3.0 dB at 500 MHz	CHAN 1 _____ CHAN 2 _____ CHAN 3 _____ CHAN 4 _____
Time Measurement Accuracy	8 ns 7.890 to 8.110 ns 128 ns 127.884 to 128.116 ns 400 ns 399.870 to 400.130 ns 800 ns 799.850 to 800.150 ns 500 us 499.971 to 500.029 us	_____ _____ _____ _____ _____
Trigger Sensitivity	200 mV/div 0.5 div at 100 MHz 1.25 div at 500 MHz 1 mV/div 6 div at 500 MHz 2.5 div at 100 MHz	CHAN 1 _____ CHAN 2 _____ CHAN 3 _____ CHAN 4 _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____