HEWLETT PACKARD

SERVICE MANUAL

HP 16532A
1 GSa/s Digitizing Oscilloscope

Manual Part No. 16532-97002

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Table 1-1. HP 16532A Specifications

HP 16532A SPECIFICATIONS

Type: 2-channel simultaneous acquisition

Bandwidth(*,1): dc to 250 MHz (real time, dc-coupled)

Maximum Sample Rate: 1 Gigasample per second

Number of Channels: 2, 4, 6, 8 simultaneous channels using the same time base setting(s)

OR

Up to 10 channels with independent time bases for each pair of channels.
Up to 18 channels with the HP 16501A Expansion Frame.

Rise Time(2): 1.4 ns

ADC: 8-bit real time

Vertical Resolution: 8 bits over 4 vertical divisions (± 0.4%)

Waveform Record Length: 8000 points

Time Interval Measurement Accuracy(*,3,6): $\pm[(0.005\% \times \Delta t) + (2 \times 10^{-6} \times \text{delay setting}) + 150\ \text{ps}]$

Vertical (dc) Gain Accuracy(4): ±1.5% of full scale

DC Offset Accuracy(*): ±(1.0% of channel offset + 2.0% of full scale)

Voltage Measurement Accuracy(*,5): ± [(1.5% of full scale + offset accuracy) + (0.008 x V/div)]

Trigger Sensitivity(*): dc to 50 MHz: 0.063 x full scale, 50 to 250 MHz: 0.125 x full scale

Input Coupling: 1 MΩ: ac and dc, 50 Ω: dc only

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

Input C: Approximately 7 pF

NOTES:

* Specifications (valid within ± 10° C of auto-calibration temperature, excluding bandwidth—see note 1 for bandwidth specification.)

1. Upper bandwidth reduces by 2.5 MHz for every degree C above 35° C.
2. Rise time is calculated from the formula: $t_r = \frac{0.35}{bandwidth}$
3. Specification applies to the maximum sampling rate. At lower rates, the specification is: $\pm[(0.005\% \times \Delta t) + (2 \times 10^{-6} \times \text{delay setting}) + (0.15 \times \text{sample interval})]$ for bandwidth limited signals (t_r = 1.4 x sample interval). Sample interval is defined as $\frac{1}{sample\ rate}$
4. Vertical gain accuracy decreases 0.08% per degree C from software calibration temperature.
5. Digitizing level = (#vertical divisions)$(\frac{1}{2})(\frac{1}{LSB})$, where LSB = $2^{\#\ bits\ in\ ADC}$
6. The Time Interval Measurement Accuracy deteriorates across multiple modules connected as one unit with each added module.

Table 1-2. HP 16532A Operating Characteristics

HP 16532A OPERATING CHARACTERISTICS

VERTICAL (at BNC)

Vertical Sensitivity Range (1:1 Probe):

4 mV/div to 10 V/div in 1-2-4 increments

DC Offset Range (1:1 Probe):

Vertical Sensitivity	Available Offset
4 mV/div to 100 mV/div	±2 V
>100 mV/div to 500 mV/div	±10 V
>500 mV/div to 2.5 V/div	±50 V
>2.5 V/div to 10 V/div	±250 V

Probe Factors:

Any integer ratio from 1:1 to 1000:1

Maximum Safe Input Voltage:

1 MΩ: ±250 V [dc + peak ac (< 10 KHz)]
50 Ω: ±5 VRMS

Channel-to-Channel Isolation:

dc to 50 MHz: 40 dB, 50 MHz to 250 MHz: 30 dB

TIMEBASE

Range:

1 ns/div to 5 s/div

Resolution:

20 ps

Delay Pre-trigger Range:

Time/div Setting	Available Delay
1 μs to 5 s/div	-8 x (s/div)
1 ns to 500 ns/div	-4 μs

Delay Post-trigger Range:

Time/div Setting	Available Delay
100 ms to 5 s/div	2.5 ks
1 μs to 50 ms/div	33,500 x (s/div)
1ns to 500 ns/div	16.7 ms

Table 1-2. HP 16532A Operating Characteristics (cont.)

TRIGGERING

Trigger Level Range:

Within display window (full scale and offset)

Trigger Modes:

Immediate:

Triggers immediately after arming condition is met.

Edge:

Triggers on rising or falling edge of any internal channel or external trigger, count adjustable from 1 to 32,000.

Pattern:

Triggers on entering, exiting, duration greater than, duration less than, and duration in range for a specified pattern of both internal channels and external trigger, count adjustable from 1 to 32,000. Duration time range is adjustable from 20 ns to 160 ms in 10 ns steps. Duration accuracy is approximately ± 3% ± 2 ns.

Auto-Trigger:

If enabled, the module will self-trigger if no trigger condition is found within approximately 50 ms after arming.

Events Delay:

The trigger can be set to occur on the nth edge or pattern, as specified by the user. The number of events (n) can be set from 1 to 32,000 events. Maximum count frequency is 70 MHz.

Intermodule:

Arms another measurement module or triggers the rear panel BNC.

External:

If enabled, the oscilloscope will trigger on an ECL level signal (-1.3 V).

DIGITIZER

Resolution: 8 bits (1 part in 256)

Digitizing Rate: Up to 1 Gigasample per second

Digitizing Technique: Real-time digitizing; each 8000 samples are acquired on a single acquisition

Acquisition Memory Size: 8000 samples per channel

Table 1-2. HP 16532A Operating Characteristics (cont.)

WAVEFORM DISPLAY

Displayed Waveforms:

Eight waveform windows maximum, with scrolling across 96 waveforms.

Display Formats:

Waveforms can be displayed in an overlapping and/or non-overlapping format. Display capability of A−B and A+B is also provided.

Display Resolution:

500 points horizontal, 240 points vertical

DISPLAY MODES

Normal (Single):

New acquisition replaces old acquisition on screen.

Accumulate:

New acquisition is displayed in addition to previous acquisitions until screen is erased.

Average:

New acquisitions are averaged with old acquisitions, with the updated waveform displayed until erased. Maximum number of averages is 256.

Overlay:

Up to 8 acquired waveforms from separate channels can be overlayed in the same display area.

Connect-the-dots:

Provides a display of the sample points connected by straight lines.

Waveform Reconstruction:

When there is insufficient data to fill every horizontal location, a post acquisition reconstruction filter fills in missing data points for time base < 50 ns/div.

Waveform Math:

Display capability of A−B and A+B functions is provided.

Table 1-2. HP 16532A Operating Characteristics (cont.)

MEASUREMENT AIDS

Time Markers:

Two vertical markers, X and O, are provided for measurements of time and voltage. Capabilities are: measure voltage at point where X and O markers cross each analog waveform; measure time from trigger to X, trigger to O, and X to O; automatic marker placement by specifying percentage of edge, edge number, and rising or falling edge type; run until X to O > than, < than, in range, and not in range provides selective event search; X to O statistics (mean, max, and min) provide analysis of time interval deviation.

Automatic Search:

Searches for a percentage or an absolute voltage level at a positive or negative edge, count adjustable from 1 to 100.

Auto Search Statistics:

Mean, maximum, and minimum values for elapsed time from X to O markers for multiple runs. Number of valid runs and total number of runs available.

Automatic Measurements:

The following pulse parameter measurements can be performed automatically:

Frequency	Rise time	+pulse width
Period	Fall time	−pulse width
V p-p	Preshoot	$V_{amplitude}$*
	Overshoot	

(*gives difference between top and base voltages; only available over bus)

Grid:

Graticules can be displayed in backround of waveform.

Voltage Markers:

Two horizontal markers, A and B, are provided for voltage measurements. These markers can each be placed on any acquisition channel trace. A delta voltage display provides delta V between markers on the same channel or between two channels.

Table 1-2. HP 16532A Operating Characteristics (cont.)

SETUP AIDS

Autoscale:

Autoscales the vertical and horizontal ranges, offset, and trigger level to display the input signals. Requires a frequency between 50 Hz and 250 MHz.

Presets:

Scales the vertical range, offset, and trigger level to predetermined values for displaying ECL or TTL waveforms.

Calibration:

Vertical, trigger, delay, and all defaults. Calibration factors stored in NV-RAM on the circuit board.

Probe Compensation Source:

External BNC supplies a square wave approximately 0.0 mV to -800 mV into the open circuit at approximately 1000 Hz.

OPERATING ENVIRONMENT

Temperature:

Instrument, 0° to 55° C (+32° to 131° F). Probes and cables, 0° to 65° C (+32° to 149° F).

Humidity:

Instrument, up to 95% relative humidity at +40° C (+104° F). Recommended disk media, 8% to 80% relative humidity at +40° C (+104° F).

Altitude:

To 4600 m (15,000 ft).

Vibration

Operation:

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); and swept sine resonant search, 5-500 Hz, 0.75 g (0- peak), 5 minute resonant dwell @ 4 resonances per axis.

Table 1-3. Recommended Test Equipment

EQUIPMENT	CRITICAL SPECIFICATIONS	RECOMMENDED MODEL	USE*
Signal Generator	Frequency: 1 - 250 MHz at approx . 170 mV RMS resolution Output Accuracy: ± 1 dB 1 MHz time base accuracy 0.25 ppm	HP 8656B Option 001	P
Dc Power Supply	Range: −35.000 to +35.000 Vdc, ±1 mV	HP 6114A	P
Digital Multimeter	0.1 mV resolution Accuracy: better than 0.005% Resistance measurement: better than 0.25% accuracy	HP 3458A	P
Power Meter/Sensor	1 - 250 MHz ±3% accuracy	HP 436/8482A	P
Power Splitter	Outputs differ by <0.15 dB	HP 11667B	P
Blocking Capacitor	50 Ω BNC (m-to-f), 0.18 μF, ±200 V	HP 10240B	P
Adapter	50 Ω BNC (m)(m)	HP 1250-1236	C
Adapter	50 Ω Type N(m)-to-BNC(m)	HP 1250-0082	P
Adapter	50 Ω BNC(f)-to-Dual Banana Plug	HP 1251-2277	P
Adapter	50 Ω Type N(m)-to-BNC(f)	HP 1250-0780	P
Tee Adapter	50 Ω BNC (m)(f)(f)	HP 1250-0781	P,C
Cable	Type N(m-to-m) 24-inch	HP 11500B	P
Cable	50 Ω BNC (m-to-m) 48-inch	HP 10503A	P
Cable	50 Ω BNC (m-to-m) 9 inch	HP 10502A	C
Cable	50 Ω BNC-SMB	HP 16532-61601	C

*P = Performance Tests C = Calibrations

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Performance Tests

SECTION III
Performance Tests

3-1. Introduction

The procedures in this section test the oscilloscope module's electrical performance using the specifications listed in Section I as the performance standards. All tests can be performed without access to the interior of the instrument. At the end of this section is a form that can be used as a record of performance test results.

3-2. Recommended Test Equipment

Equipment recommended for performance tests is listed in table 1-3. Any equipment that satisfies the critical specifications given in the table may be substituted for the recommended models.

3-3. Test Record

Results of performance tests may be tabulated on the Performance Test Record (table 3-1) at the end of the procedures. The test record lists all of the tested specifications and their acceptable limits.

The results recorded on the test record may be used for comparison in periodic maintenance and troubleshooting or after repairs and adjustments have been made.

3-4. Performance Test Interval

Periodic performance verification of the HP 16532A Oscilloscope Module is required at one-year intervals. The instrument's performance should be verified after it has been serviced, or if improper operation is suspected. Calibration should be performed before any performance verification checks.

3-5. Performance Test Procedures

All performance tests should be performed at the environmental operating temperature of the instrument, after a 30-minute warmup period.

3-6. DC CAL OUTPUT Test

The DC CAL OUTPUT port on the rear panel is used for instrument calibration and probe calibration. Though calibrator accuracy is not specified in the performance specifications, it must be within limits in order to provide accurate calibration.

Test Limits:

5.000 V ±10 mV

Equipment Required:

The following equipment is required for the test.

Equipment Required	Critical Specification	Recommended Model/Part Number
Digital Multimeter	0.1 mV resolution, better than 0.005% accuracy	HP 3458A
Cable	50 Ω BNC (m to m) 48-inch	HP 10503A
Adapter	50 Ω BNC (f) to Dual Banana Plug	HP 1251-2277

Procedure:

1. Use the BNC-to-banana adapter to connect the BNC cable between the multimeter and the oscilloscope module DC CAL OUTPUT connector.

2. On the oscilloscope module set the following parameters in the order given:

Menu	Selection	Setting
Calibration	Mode Procedure DC Volts	Service Calibration DC Cal BNC 0 V

3. The DVM should read close to 0.0000 V. Record the reading to four decimal places.
   V1 = _____.

4. In the Calibration menu set the DC Volts to 5 V.

5. The DVM should read close to 5.0000 V. Record the reading to four decimal places.
   V2 = _____.

6. In the Calibration menu set the DC Volts to 0 V.

7. Subtract V1 from V2. The difference should be between 4.990 and 5.010 V. Record the reading in the performance test record.

3-7. AC CAL OUTPUT Test

The AC CAL OUTPUT port on the rear panel is used for instrument calibration and probe compensation. Though calibrator accuracy is not specified in the performance specifications, it must be within limits in order to provide accurate calibration.

Test Limits:

1000 Hz ±10%, 0.8 Vp_p ±10%

Equipment Required:

The following equipment is required for the test.

Equipment Required	Critical Specification	Recommended Model/Part Number
Cable	50 Ω BNC (m to m) 48-inch	HP 10503A

Procedure:

1. Use the BNC cable to connect the AC CAL OUTPUT to channel 1 input of the oscilloscope module.
2. On the oscilloscope module set the following parameters in the order given:

Menu	Selection	Setting
Calibration	Mode	Service Calibration
	Procedure	Oscillator Output
	Signal	Probe Compensation
Channel	Coupling	1 MΩ/DC
	Probe	1:1

3. In the Calibration menu select AUTOSCALE.
4. In the Auto-Measure menu verify that the waveform is approximately 0.8 Vp_p at approximately 1000 Hz. Record the reading in the performance test record.

3-8. INPUT RESISTANCE

This test verifies the input resistance of the oscilloscope module. A four-wire measurement is used for accuracy at 50 Ω.

Specification:

1 M Ω ± 1% and 50 Ω ± 1%

Equipment Required:

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

Equipment Required	Critical Specification	Recommended Model/Part Number
Digital Multimeter	Measure resistance (4-wire) better than 0.25% accuracy	HP 3458A
Cables (2)	50 Ω BNC (m to m) 48-inch	HP 10503A
Adapter	50 Ω BNC Tee (m)(f)(f)	HP 1250-0781
Adapters (2)	50 Ω BNC (f) to Dual Banana Plug	HP 1251-2277

Procedure:

1. Set up the multimeter to make a 4-wire resistance measurement.
2. Use the BNC-to-banana adapters to connect one end of each BNC cable to the 4-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 oscilloscope module. Set up the oscilloscope module according to the following parameters in the order given:

Menu	Selection	Setting
Channel	Input	1
	Probe	1:1
	V/Div	20 mV
	Offset	0 V
	Coupling	50 Ω / DC
Trigger	Mode	Immediate

4. Select RUN - SINGLE. The clicking of attenuator relays should be audible. Verify resistance readings on the digital multimeter of 50 Ω ± 0.5 Ω (49.5 to 50.5 Ω).

5. In the Channel menu change the Coupling field to 1 MΩ/DC.

6. Select RUN. The clicking of attenuator relays should be audible. Verify resistance readings on the digital multimeter of 1 MΩ ± 10 kΩ (0.990 to 1.010 MΩ).

7. In the Channel menu change the Coupling field to 50 Ω/DC and V/Div to 200 mV/Div. Repeat steps 4 through 6.

8. In the Channel menu change the Coupling field to 50 Ω /DC and V/Div to 1 V/Div. Repeat steps 4 through 6.

9. In the Channel menu change the Coupling field to 50 Ω /DC and V/Div to 4 V/Div. Repeat steps 4 through 6.

10. Connect the male end of the BNC tee to the channel 2 input of the oscilloscope module.

11. Repeat steps 3 through 9 for channel 2, replacing channel 1 with channel 2 where applicable.

Note

If a reading is not within limits, then the attenuator for the out-of-bounds channel should be replaced. See "Service" in Section VI.

3-9. VOLTAGE MEASUREMENT ACCURACY

This test verifies the DC voltage measurement accuracy of the instrument. This procedure uses a dual cursor measurement that nullifies offset error, resulting in the following measurement:
± [(1.5% of full scale) + (0.016 x V/div)].

Specification:

± [(1.5% of full scale + offset accuracy) + (0.008 x V/div)]

Equipment Required:

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

Equipment Required	Critical Specification	Recommended Model/Part Number
DC Power Supply	-14 Vdc to +14 Vdc, 0.1 mV resolution	HP 6114A
Digital Multimeter	Better than 0.1% accuracy	HP 3458A
Cable	50 Ω BNC (m to m) 48-inch	HP 10503A
Adapter (cable to power supply)	50 Ω BNC (f) to Dual Banana Plug	HP 1251-2277
Adapter	50 Ω BNC tee (m)(f)(f)	HP 1250-0781
Blocking Capacitor	50 Ω BNC (m to f) 0.18 μF, 200 V	HP 10240B

Procedure:

1. Using a BNC adapter, connect one end of the cable to the power supply. Connect the BNC tee, the blocking capacitor, and the shorting endcap to the other end of the cable. Refer to figure 3-1.

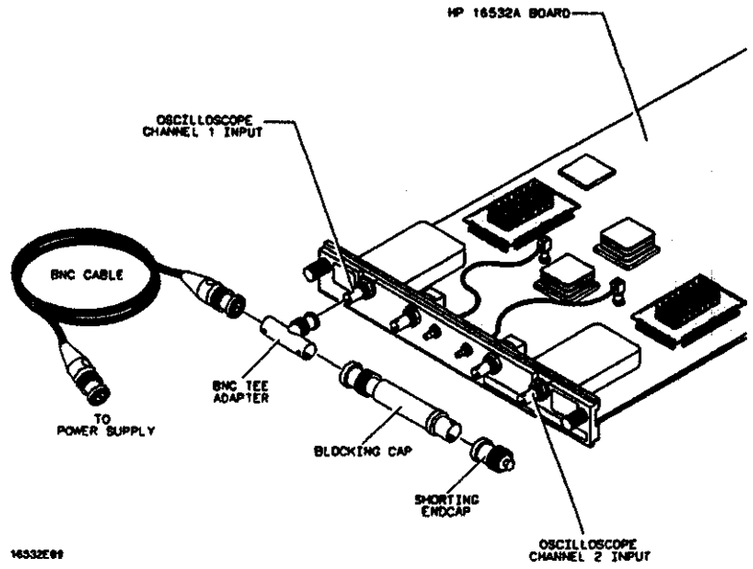


Figure 3-1. Voltage Measurement Accuracy Test

2. In the Waveform Selection menu delete channel 2. If channel 1 is not inserted, insert channel 1. Set the following parameters in the order given.

Menu	Selection	Setting
Channel	Input Probe Coupling s/Div	1 1:1 1 MΩ / DC 500 ns
Trigger	Mode	Immediate
Display	Mode Average # Grid Markers	Average 8 On On

CAUTION

Set the Channel **Coupling** *field to 1 MΩ/DC or damage to the equipment will result.*

Use the following table for steps 3 through 9.

V/Div	Offset	Supply	Upper Limit	Lower Limit
4 V/Div	-7.0 V	-14.0 V	-13.7 V	-14.3 V
1 V/Div	-1.75 V	-3.50 V	-3.43 V	-3.57 V
400 mV/Div	-700.0 mV	-1.40 V	-1.37 V	-1.43 V
40 mV/Div	-70.0 mV	-140.0 mV	-137.0 mV	-143.0 mV
40 mV/Div	70.0 mV	140.0 mV	143.0 mV	137.0 mV
400 mV/Div	700.0 mV	1.40 V	1.43 V	1.37 V
1 V/Div	1.75 V	3.50 V	3.57 V	3.43 V
4 V/Div	7.0 V	14.0 V	14.3 V	13.7 V

3. With the power supply disconnected from the channel input, set the Channel menu to the V/Div range and offset values shown in the first line of the table.

4. On the oscilloscope, select RUN - REPETITIVE and wait for approximately five seconds, then select STOP. Read the voltage displayed under the channel label on the left of the display. Enter this value on the performance test record in the "Zero Input" column.

5. Set the power supply to the first supply value listed in the table. Connect the power supply to the channel input as shown in figure 3-1.

6. On the oscilloscope, select RUN - REPETITIVE and wait for approximately five seconds, then select STOP. Read the voltage displayed under the channel label on the left of the display. Enter this value on the performance test record in the "Measured" column.

7. To obtain the test results, subtract the Zero Input voltage from the Measured voltage listed in the performance test record. For example: (Measured) - (Zero Input) = (Actual). When calculating the results, observe the plus or minus value of the voltage measurements. Record the results in the performance test record in the "Actual" column.

8. Repeat steps 3 through 8 for the second line of the table, then for the rest of the lines of the table for channel 1.

9. In the Waveform Selection menu, select Input channel 2. Delete channel 1 and insert channel 2. Repeat steps 2 through 8 for channel 2, replacing channel 1 with channel 2 where applicable.

3-10. OFFSET ACCURACY

This test verifies the offset accuracy.

Specification:

± (1.0% of channel offset + 2.0% of full scale)

Equipment Required:

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

Equipment Required	Critical Specification	Recommended Model/Part Number
DC Power Supply	−35.000 to +35.000 Vdc, ± 1 mV resolution	HP 6114A
Digital Multimeter	Better than 0.1% accuracy	HP 3458A
Cable	50 Ω BNC (m to m) 48-inch	HP 10503A
Adapter	50 Ω BNC (f) to Dual Banana Plug	HP 1251-2277

Procedure:

Zero-Input Offset

1. Disconnect all cables and probes from the oscilloscope inputs. In the Waveform Selection menu delete channel 2. If channel 1 is not inserted, insert channel 1. Then set up the oscilloscope module according to the following parameters in the order given:

Menu	Selection	Setting
Channel	Input	1
	Probe	1:1
	v/Div	4 V
	Offset	0 V
	Coupling	1 MΩ / DC
	s/Div	500 ns
Trigger	Mode	Immediate
Display	Mode	Average
	Average #	32
	Grid	On
	Markers	On

2. With the DC power supply disconnected from the channel input, make sure the markers are near the center of the display.

3. Select RUN - REPETITIVE. Wait approximately 15 seconds (averaging complete), then select STOP. The display should read 0.00 V ±320.0 mV as read from the markers voltage field. Record the reading in the performance test record.

4. In the Channel menu, change the vertical sensitivity to 1 V/Div. Select RUN - REPETITIVE and wait approximately 15 seconds (averaging complete), then select STOP. The display should read 0.00 V ±80.0 mV. Record the reading in the performance test record.

5. In the Channel menu, change the vertical sensitivity to 100 mV/Div. Select RUN - REPETITIVE and wait approximately 15 seconds (averaging complete), then select STOP. The display should read 0.00 V ±8.0 mV. Record the reading in the performance test record.

6. In the Channel menu, change the vertical sensitivity to 10 mV/Div. Select RUN - REPETITIVE and wait approximately 15 seconds (averaging complete), then select STOP. The display should read 0.00 V ±800.0 μV. Record the reading in the performance test record.

DC Input Offset

CAUTION

Set the Channel **Coupling** *field to 1MΩ / DC or damage to the equipment will result.*

7. Use the BNC-to-banana adapter to connect the BNC cable between the power supply and channel 1 input. Monitor the power supply using a voltmeter.

8. Use the following table for the next steps:

V/Div	Offset	Supply	Min	Max
1 V/Div	−35.00 V	−35.00 V	−35.4 V	−34.6 V
100 mV/Div	−10.00 V	−10.00 V	−10.1 V	−9.90 V
20 mV/Div	−2.00 V	−2.00 V	−2.02 V	−1.98 V
20 mV/Div	+2.00 V	+2.00 V	+1.98 V	+2.02 V
100 mV/Div	+10.00 V	+10.00 V	+9.90 V	+10.1 V
1 V/Div	+35.00 V	+35.00 V	+34.6 V	+35.4 V

9. In the Channel menu set the V/Div range and offset per the first line of the table. Set the power supply per the first line of the table.

10. On the oscilloscope, select RUN - REPETITIVE and wait approximately 15 seconds (averaging complete), then STOP.

11. Read the voltage from the markers voltage field. It should be within the limits given in the table. Record the reading in the performance test record.

12. Repeat steps 7 through 10 for the remaining lines of the table using the V/Div range, offset, and supply voltages given in the table.

13. In the Channel menu select channel 2. In the Waveform Selection menu delete channel 1 and insert channel 2.

14. Repeat steps 1 through 12 for channel 2, replacing channel 1 with channel 2 where applicable.

3-11. BANDWIDTH

This test checks the bandwidth of the oscilloscope module.

Specification:

Bandwidth (dc coupled) dc to 250 MHz

Equipment Required:

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

Equipment Required	Critical Specification	Recommended Model/Part Number
Signal Generator	1 - 250 MHz at approx 170 mVrms	HP 8656B
Power Meter/Sensor	1 - 250 MHz ± 3% accuracy	HP 436/8482A
Power Splitter	Outputs differ by <0.15 dB	HP 11667B
Cable	Type N (m to m) 24-inch	HP 11500B
Adapter	50 Ω 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 of the oscilloscope module.
3. In the **Waveform Selection** menu delete channel 2. If channel 1 is not inserted, insert channel 1. Set the following parameters.

Menu	Selection	Setting
Channel	Input	1
	Probe	1:1
	v/Div	80 mV
	Offset	0 V
	Coupling	50 Ω / DC
	s/Div	200 ns
Trigger	Mode	Edge
	Level	0 V
Display	Mode	Average
	Average #	32
	Grid	On
	Markers	Off

4. Set the signal generator for 1MHz at −2.4 dBm. On the oscilloscope, select RUN - REPETITIVE. The signal on the screen should be two cycles at three divisions amplitude.

5. After the measurement settles (averaging complete, about 15 seconds), select STOP. In the Auto-Measure menu note the $V_{p\text{-}p}$ reading. V_{1MHz} = _____ mV.

6. Set the power meter Cal Factor % to the 1MHz value from the calibration chart on the power splitter. Then press dB[REF] to set a 0 dB reference.

7. Change the signal generator to 250 MHz. Set power meter Cal Factor % to the 250 MHz value from the chart.

8. Adjust the signal generator amplitude for a power reading as close as possible to 0.0 dB[REL]. Reading = _____ dB.

9. Set the oscilloscope s/Div for 2 ns/Div and select RUN-REPETITIVE.

10. After the measurement settles (averaging complete), select STOP. In the Auto-Measure menu note the $V_{p\text{-}p}$ reading. V_{250MHz} = _____mV.

11. Calculate the response using the formula:

$$response\ (dB) = 20\log_{10}\frac{V_{250Mhz}}{V_{1MHz}} = 20\log_{10}(\_\_\_\_) = \_\_\_\_\_dB$$

12. Correct the result from step 11 with any differences in the power meter from step 8. Observe signs. For example:

    Result from step 11 = −2.3 dB
    Power meter reading = −0.2 dB[REL]
    then true response = (−2.3) − (−0.2) −2.1dB

    (_____) − (_____) = _____ dB

13. The result from step 12 should be ≤ −3.0 dB. Record the result in the Performance Test Record.

14. In the **Channel** menu select channel 2. In the **Waveform Selection** menu delete channel 1 and insert channel 2.

15. Repeat steps 2 through 14 for channel 2, replacing channel 1 with channel 2 where applicable.

Note

Failure of the bandwidth test can be caused by a faulty attenuator or main assembly.

3-12. TIME MEASUREMENT ACCURACY

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

Specification:

$\pm[(0.005\% \times \Delta t) + (2 \times 10^{-6} \times \text{delay setting}) + 150\ \text{ps}]$

Equipment Required:

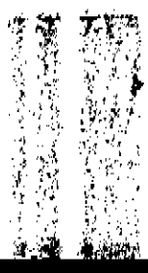
The following equipment is required for this test. Procedures are based on the model or part number recommended.

Equipment Required	Critical Specification	Recommended Model/Part Number
Signal Generator	200 MHz, timebase accuracy 0.25 ppm	HP 8656B Opt. 001
Cable	50 Ω BNC (m to m) 48-inch	HP 10503A
Adapter	50 Ω Type N (m) to BNC (f)	HP 1250-0780

Procedure:

1. Set the signal generator to 181.81818 MHz (5.5 ns period) and approximately 600 mV rms.
2. Use the N-to-BNC adapter to connect the cable to the signal generator. Connect the free end of the BNC cable to the channel 1 input.
3. In the Waveform Selection menu delete channel 2. If channel 1 is not inserted, insert channel 1. Set the following parameters in the order given:

Menu	Selection	Setting
Channel	Input	1
	Probe	1:1
	v/Div	400 mV
	Offset	0.0 V
	Coupling	50 Ω / DC
	s/Div	2.00 ns
Trigger	Mode	Edge
	Source	Chan 1
	Level	0.0 V
	Slope	Positive
Display	Mode	Normal
	Grid	On



4. Select the Markers Auto menu, and set the following parameters:

Menu	Selection	Setting
Markers Auto	X→	Set on chan 1 at Level 50% Slope Positive Occur 1
	O→	Set on chan 1 at Level 50% Slope Positive Occur 2
	Statistics	On

5. Select DONE. On the oscilloscope module select RUN - REPETITIVE. If the waveform is clipping, reduce the signal generator output voltage level until the waveform no longer clips. Allow the oscilloscope module to run approximately two minutes, then select STOP.

6. In the statistics field, check to see that the MEAN X-O field is approximately 5.500 ns. Check that both the MIN X-O and the MAX X-O are within 150 ps of the MEAN X-O. Record the results in the performance test record.

7. Select the Markers Auto menu, and set the following parameters:

Menu	Selection	Setting
Markers Auto	X→	Manual
	O→	Set on chan 1 at Level 50% Slope Positive Occur 1
	Statistics	On

8. Select DONE. In the Display menu, set MODE AVERAGE #8 and DELAY 99.00 ns. Select RUN-REPETITIVE and allow the oscilloscope module to run approximately two minutes. Select STOP.

9. In the statistics field, check to see that the MEAN X-O field is approximately 99.000 ns. Check that both the MIN X-O and the MAX X-O are within 155 ps of the MEAN X-O. Record the results in the performance test record.

Note

Failure of the time measurement accuracy test can be caused by a defective main assembly.

3-13. TRIGGER SENSITIVITY

This test checks channel triggers for sensitivity at rated bandwidth.

Specification:

dc to 50 MHz : 0.063 x full scale (0.25 division)
50 to 250 MHz : 0.125 x full scale (0.5 division)

Equipment Required:

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

Equipment Required	Critical Specification	Recommended Model/Part Number
Signal Generator	50 and 250 MHz, 30-80 mV $_{rms}$ output	HP 8656B Opt. 001
Cable	50 Ω BNC 48-inch	HP 10503B
Adapter	50 Ω Type N (m) to BNC (f)	HP 1250-0780

Procedure:

1. In the Waveform Selection menu delete channel 2. If channel 1 is not inserted, insert channel 1. On the oscilloscope module set the following parameters in the order given:

Menu	Selection	Setting
Channel	Input	1
	Probe	1:1
	v/Div	400 mV
	Offset	0 V
	Coupling	50 Ω / DC
	s/Div	20 ns
Trigger	Mode	Edge
	Source	Chan 1
	Level	0 V
Display	Mode	Average
	Average #	8
	Grid	On
	Markers	Off

2. With an N-to-BNC adapter and BNC cable, connect the signal generator to channel 1 input.

3. Set the signal generator for a 50 MHz and 35 mV rms signal. On the oscilloscope module select RUN - REPETITIVE.

4. In the **Auto-Measure** menu read V_{p_p}. Adjust the signal generator output level so that the signal is close to and not more than 100 mV_{p_p}.

5. In the **Trigger** menu adjust the trigger level for a stable display. The test passes if the trigger is stable. Record whether the trigger is stable or is not stable.

6. On the oscilloscope module select STOP. Set the signal generator frequency to 250 MHz and 70 mV rms signal level.

7. In the **Channel** menu change s/Div to 5 ns/Div and select RUN.

8. In the **Auto-Measure** menu read V_{p_p}. Adjust the signal generator output level so that the signal is close to and not more than 200 mV_{p_p}.

9. In the **Trigger** menu adjust the trigger level for a stable display. The test passes if the trigger is stable. Record whether the trigger is stable or is not stable in the performance test record.

10. On the oscilloscope module select STOP. In the **Channel** menu select channel 2. In the **Trigger** menu select Source channel 2. In the **Waveform Selection** menu delete channel 1 and insert channel 2.

11. Repeat steps 1 through 9 for channel 2, replacing channel 1 with channel 2 where applicable.

Note

Failure of the trigger sensitivity test can be caused by a defective main assembly.

Table 3-1. Performance Test Record

Hewlett-Packard Model 16532A Oscilloscope Module Serial No.: _____	Recommended Performance Verification Interval: 12 Months	Tested by _____ Work Order No. _____ Date Tested _____
Paragraph No.	**Test**	**Results**
3-6	DC CAL OUTPUT 5.000Vdc ±10mV	Minimum 4.990Vdc Maximum 5.010Vdc Actual _____Vdc
3-7	AC CAL OUTPUT 0.8Vp_p ±10% 1000Hz ±10%	Minimum 0.72Vp_p Maximum 0.88Vp_p Actual _____Vp_p Minimum 900Hz Maximum 1100Hz Actual _____Hz
3-8	Input Resistance 50Ω± 0.5Ω (49.5 to 50.5Ω) 1MΩ± 10KΩ (0.990 to 1.010MΩ)	Channel 1 Reading 50Ω @ 20mV/Div _____Ω 1MΩ @ 20mV/Div _____Ω 50Ω @ 200mV/Div _____Ω 1MΩ @ 200mV/Div _____Ω 50Ω @ 1V/Div _____Ω 1MΩ @ 1V/Div _____Ω 50Ω @ 4V/Div _____Ω 1MΩ @ 4V/Div _____Ω Channel 2 Reading 50Ω @ 20mV/Div _____Ω 1MΩ @ 20mV/Div _____Ω 50Ω @ 200mV/Div _____Ω 1MΩ @ 200mV/Div _____Ω 50Ω @ 1V/Div _____Ω 1MΩ @ 1V/Div _____Ω 50Ω @ 4V/Div _____Ω 1MΩ @ 4V/Div _____Ω
3-9	Voltage Measurement Accuracy Upper Limit / Lower Limit -13.7V / -14.3V -3.43V / -3.57V -1.37V / -1.43V -137.0mV / -143.0mV 143.0mV / 137.0mV 1.43V / 1.37V 3.57V / 3.43V 14.3V / 13.7V	Channel 1 Zero Input / Measured / Actual _____ / _____ / _____V _____ / _____ / _____V _____ / _____ / _____V _____ / _____ / _____mV _____ / _____ / _____mV _____ / _____ / _____V _____ / _____ / _____V _____ / _____ / _____V

Table 3-1. Performance Test Record (Continued)

Paragraph No.	Test	Results
3-9	Voltage Measurement Accuracy (continued) Upper Limit / Lower Limit -13.7V / -14.3V -3.43V / -3.57V -1.37V / -1.43V -137.0mV / -143.0mV 143.0mV / 137.0mV 1.43V / 1.37V 3.57V / 3.43V 14.3V / 13.7V	Channel 2 Zero Input / Measured / Actual _____ / _____ / _____V _____ / _____ / _____V _____ / _____ / _____V _____ / _____ / _____mV _____ / _____ / _____mV _____ / _____ / _____V _____ / _____ / _____V _____ / _____ / _____V
3-10	Offset Accuracy Zero-input Offset-Channel 1	V/Div Setting / Reading / Actual 4V/Div 0.00V±320.0mV _____V 1V/Div 0.00V±80.0mV _____V 100mV/Div 0.00V±8.0mV _____V 10mV/Div 0.00V±800.0µV _____V
	Offset Accuracy DC Input Offset-Channel 1	Supply / Min / Max / Actual -35.00V / -35.4V / -34.6V / -_____V -10.00V / -10.1V / -9.90V / -_____V -2.00V / -2.02V / -1.98V / -_____V +2.00V / +1.98V / +2.02V / +_____V +10.00V / +9.90V / +10.1V / +_____V +35.00V / +34.6V / +35.4V / +_____V
	Offset Accuracy Zero-input Offset-Channel 2	V/Div Setting / Reading / Actual 4V/Div 0.00V±320.0mV _____V 1V/Div 0.00V±80.0mV _____V 100mV/Div 0.00V±8.0mV _____V 10mV/Div 0.00V±800.0µV _____V
	Offset Accuracy DC Input Offset-Channel 2	Supply / Min / Max / Actual -35.00V / -35.4V / -34.6V / -_____V -10.00V / -10.1V / -9.90V / -_____V -2.00V / -2.02V / -1.98V / -_____V +2.00V / +1.98V / +2.02V / +_____V +10.00V / +9.90V / +10.1V / +_____V +35.00V / +34.6V / +35.4V / +_____V
3-11	Bandwidth ≤ −3.0dB	Channel 1: Actual Reading= _____ dB Channel 2: Actual Reading = _____ dB

Table 3-1. Performance Test Record (Continued)

Paragraph No.	Test	Results
3-12	Time Measurement Accuracy 5.500ns ± 150ps	MEAN X-0 _____ns MIN X-0 _____ns MEAN X-0 - MIN X-0 = _____ps MAX X-0 _____ns MAX X-0 - MEAN X-0 = _____ps
	99.00ns ± 155ps	MEAN X-0 _____ns MIN X-0 _____ns MEAN X-0 - MIN X-0 = _____ps MAX X-0 _____ns MAX X-0 - MEAN X-0 = _____ps
3-13	Trigger Sensitivity	Channel 1: Trigger Stable @ 100mVp_p Yes ____ No ____ Trigger Stable @ 200mVp_p Yes ____ No ____ Channel 2: Trigger Stable @ 100mVp_p Yes ____ No ____ Trigger Stable @ 200mVp_p Yes ____ No ____

TABLE OF CONTENTS

Calibration

SECTION IV
Calibration

4-1. Introduction

This section provides information on calibrating the HP 16532A 1 GSa/s Oscilloscope module. Information is included about when to calibrate the module, the module warm up interval required prior to calibration, and how to do the actual calibration of the module. Also included are safety requirements to observe when working on the equipment, a list of recommended test equipment, and equipment setups for the different calibration procedures. Although the module has no hardware adjustments, it does contain a calibration PROTECT/UNPROTECT switch that you use before and after calibration. Actual calibration of the module is performed in software.

4-2. Safety Requirements

WARNING

Read the safety summary at the front of this manual before any replacement, maintenance, or repair is performed.

Specific warnings, cautions, and instructions are placed wherever applicable throughout the manual. These must be observed during all phases of operation, service, and repair of the module. Failure to comply with them violates safety standards of design, manufacture, and intended use of this module. Hewlett-Packard assumes no liability for the failure of the customer to comply with these safety requirements.

4-3. Calibration Interval

To maintain proper calibration, perform calibration at approximately six-month intervals, or every 1000 hours, when the instrument is being used under normal operating conditions. Immediate calibration is required if one of the following occurs:

- Oscilloscope module is installed, repaired, or replaced, or if the card slot configuration is changed.
- The oscilloscope software changes revision number and asterisks (*) are on the calibration menu.
- Ambient temperature changes more than 10 °C.

If you add or delete a card(s) from a calibrated multicard oscilloscope module, you must perform the Time Null calibration.

4-4. Maintaining System Integrity

Calibration factors depend on the mainframe, module, and module configuration all staying together. If oscilloscope modules are interchanged between mainframes, or the oscilloscope module slot configuration is changed, calibration must be repeated. In an environment in which the possibility of sharing oscilloscope modules exists, Hewlett-Packard recommends taking the following precautions in order to maintain system integrity:

With the system turned off, place the PROTECT/UNPROTECT switch (all switches in a single or a chained, multiple oscilloscope module configuration) in the UNPROTECT position.

Boot the system and perform calibration for each module.

Turn off the system, place the PROTECT/UNPROTECT switch (all switches in a single or a chained, multiple oscilloscope module configuration) in the PROTECT position, then seal the mainframe.

4-5. Calibration Protection Switch

Each HP 16532A board stores the calibration factors for that board in non-volatile RAM on the board itself. The HP 16532A board contains a calibration protection (PROTECT/UNPROTECT) switch. With the switch in the PROTECT position, calibration values cannot be changed.

To run the scope calibration, the switch must be in the UNPROTECT position. When you have more than one HP 16532A board in a mainframe, this must be done for each one of the boards. After calibration is complete, all the switches must be set to the PROTECT position to save the calibration values. Also, all the modules or filler panels must be reinstalled in the mainframe, then a seal should be placed on the equipment such that the seal touches both the top-most module and the mainframe. This is done to assure that calibration integrity is maintained.

4-6. Recommended Test Equipment

The only test equipment required for calibration are cables and adapters. These are listed in paragraph 4-10 and are called out in the applicable calibration procedure.

4-7. Instrument Warmup

Calibrate the oscilloscope module at its environmental ambient temperature, after a 30-minute warmup period of the HP 16500A/16501A mainframe with the module installed.

4-8. Calibration

This section provides software calibration procedures for the HP 16532A oscilloscope module. There are no hardware adjustments on the oscilloscope module. The calibration is performed without access to the interior of the instrument.

When ordered with a system, oscilloscope modules are calibrated at Hewlett-Packard as single units (not chained together). If you need to use the modules as one unit (chained together), perform the Time Null Calibration in section 4-12.

The calibration procedure sets the oscilloscope calibration factors and stores them in non-volatile RAM on the board. The procedures use signals generated in the oscilloscope module itself to calibrate channel sensitivity, offset, and trigger parameters. The calibration factors set up the module each time the instrument is turned on.

The calibration procedures in this section should be followed in their entirety and in the sequence listed in table 4-1. Though in this section the default calibrations are loaded before calibration, calibration can be done without loading them. However, if they are loaded, they should be loaded before an actual calibration is done.

When calibrating the module, it must be installed in the mainframe, and the mainframe covers and filler panels must be in place. The module must be warmed up (refer to "Instrument Warmup" given earlier in this section).

Calibration procedures require the use of cables and adapters only. Non-service personnel can perform the calibration, however, to do the calibration, it is necessary to unprotect the current calibration values. This may not be allowed in some circumstances -- check with your Calibration Laboratory or Service Department before you attempt calibration. To perform calibration, follow the "Self Cal Menu Calibration" procedures given later in this section.

Table 4-1. Calibration Sequence

Sequence	Calibration	Paragraph
1	Set the PROTECT/UNPROTECT Switch to UNPROTECT	4-9
2	Default (Not required as part of the calibration procedures)	4-11
	Self Cal Menu	
3	Vertical Calibration (all channels)	4-12
4	Delay Calibration–Channel 1	4-12
	Delay Calibration–Channel 2	4-12
5	Time Null Calibration (all channels)	4-12
6	Logic Trigger - Channel 1	4-12
7	External Trigger Null Calibration	4-12
8	Set the PROTECT/UNPROTECT Switch to PROTECT	4-13

4-9. Setting the PROTECT/UNPROTECT Switch to UNPROTECT

CAUTION

The effects of ELECTROSTATIC DISCHARGE can damage electronic components. Use grounded wrist straps and mats when you are performing any kind of service on this module.

The oscilloscope board contains a calibration PROTECT/UNPROTECT switch. This switch must be set to UNPROTECT before calibration can be done. Set the switch to UNPROTECT as follows:

1. Remove power from the instrument. Pull halfway out all of the modules located above the oscilloscope and remove the filler panels and cards located above the oscilloscope. See figure 4-1 for the removal sequence.

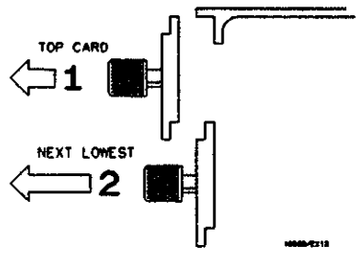


Figure 4-1. Endplate Overlap - Top Sequence

2. Remove the oscilloscope module and set the PROTECT/UNPROTECT switch to the UNPROTECT position. See Figure 4-2 to locate this switch.

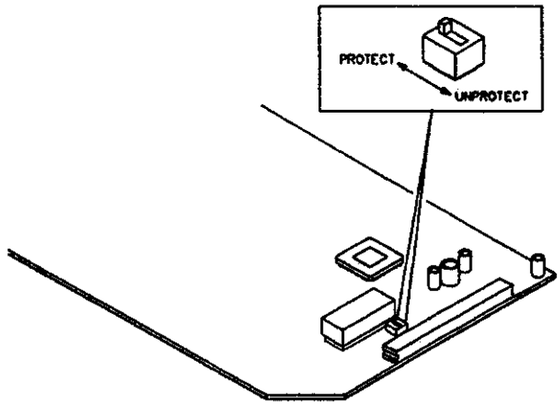


Figure 4-2. Location of the PROTECT/UNPROTECT Switch

3. Repeat step 2 for every oscilloscope module if this is a multimodule calibration.

4. Reinstall the modules and filler panels in reverse order of steps 1 and 2.

4-10. Equipment Required for Calibration

The equipment listed below is required for calibration:

Cable (2)	50Ω BNC, 9-inch (equal length)	HP 10502A
Cable	50Ω BNC - SMB	HP 16532-61601
Adapter	50Ω BNC tee (m)(f)(f)	HP 1250-0781
Adapter	50Ω BNC (m)(m)	HP 1250-1236

4-11. Loading the Default Calibration Factors

CAUTION

Once the default calibration factors are loaded, all calibrations must be done. This includes all of the calibrations in the Self Cal menu. The calibration must be performed in the exact sequence listed in table 4-1.

Note

The calibration PROTECT/UNPROTECT switch on the oscilloscope board must be set to UNPROTECT.

Load the default calibration factors as follows:

1. Touch the menu field (top row, second from the left), then select **Calibration** from the pop-up menu.
2. Touch the **Mode** field, then select **Service Cal** from the pop-up menu.
3. Touch the **Procedure** field, then select **Default Values** from the pop-up menu.

Note

After you touch the Start field, you can abort the calibration procedure either by touching the Cancel field, if it is available in the menu, or by touching either the Mode or Procedure fields if the continue field is still displayed on the screen.

4. Touch the **Start** field and follow the instructions on the display. The display should now look similar to the display shown in figure 4-3.

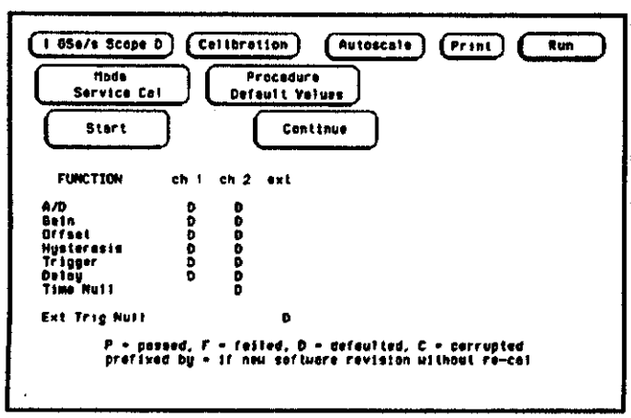


Figure 4-3. Default Calibration Display

4-12. Self Cal Menu Calibrations

Note

After you touch the Start field, you can abort the calibration procedure either by touching the Cancel field, if it is available in the menu, or by touching either the Mode or Procedure fields if the continue field is still displayed on the screen.

Messages will be displayed as each calibration routine is completed to indicate calibration has passed or failed. The resulting calibration factors are automatically stored to nonvolatile RAM at the conclusion of each calibration routine.

The Self Cal menu lets you calibrate vertical sensitivity (Vert Cal) for channels 1 and 2 individually or both channels on a board simultaneously if it is a stand alone scope. Also, the Self Cal menu lets you calibrate delay (Delay) for channel 1 and 2 separately, then Time Null for each channel separately (except channel 1 of the master board), and Ext Trig Null for the external trigger (ECL).

Calibrate Vert Cal of the Self Cal menu as follows:

1. Connect two BNC 50-Ω, 9-inch cables to the BNC tee adapter.

Note

When you touch Start, the instrument will prompt you to connect the cables to the appropriate locations on the rear panel of the module.

2. Touch the **Mode** field, then select **Self Cal** from the pop-up menu.
3. Touch the **Procedure** field, then select **Vert Cal** from the pop-up menu.
4. Touch the **Channel** field, then select a channel choice from the pop-up menu.
5. Touch the **Start** field and follow the instructions on the display.
6. After completion of vertical calibration remove the cables from the rear panel of the oscilloscope.

Calibrate Delay of the Self Cal menu as follows:

1. Obtain a BNC 50-Ω, 9-inch cable.

Note

When you touch Start, the instrument will prompt you to connect the cable to the appropriate location on the rear panel of the module.

2. Touch the **Procedure** field, then select **Delay** from the pop-up menu.

3. Touch the **Channel** field, then select **S1** from the pop-up menu (where S is the slot letter where the oscilloscope module is installed in the mainframe).
4. Touch the **Start** field and follow the instructions on the display.
5. After completion of channel 1 delay calibration, remove the cable from the rear panel of the oscilloscope.
6. Repeat steps 3 through 5 for channel **S2**.
7. After completing all of the channel delay calibrations, remove the cable from the rear panel of the oscilloscope.

Calibrate the Time Null of the Self Cal menu as follows:

1. Connect two BNC 50-Ω, 9-inch cables to the BNC tee adapter.

Note

When you touch Start, the instrument will prompt you to connect the cables to the appropriate locations on the rear panel of the module.

2. Touch the **Procedure** field, then select **Time Null** from the pop-up menu.
3. Touch the **Channel** field, then select **S2** from the pop-up menu (where S is the slot letter where the oscilloscope module is installed in the mainframe).
4. Touch the **Start** field and follow the instructions on the display.
5. Repeat steps 3 through 4 for each channel, replacing **S2** with the appropriate channel number.
6. At the conclusion of the time null calibration, remove the cables from the rear of the module.

Calibrate the Logic Trigger of the Self Cal menu as follows:

1. Obtain one BNC 50 Ω 9-inch cable.

Note

When you touch Start, the instrument will prompt you to connect the cables to the appropriate locations on the rear panel of the module.

2. Touch the **Procedure** field, then select **Logic Trigger** from the pop-up menu.
3. Touch the **Start** field, then follow the instructions on the display.
4. At the conclusion of the Logic Trigger calibration, remove the cable from the rear of the module.

Calibrate the Ext Trig Null of the Self Cal menu as follows:

1. Connect the cables, BNC adapter, and BNC tee adapter together as shown in figure 4-4.

Note

When you touch Start, the instrument will prompt you to connect the cables to the appropriate locations on the rear panel of the module.

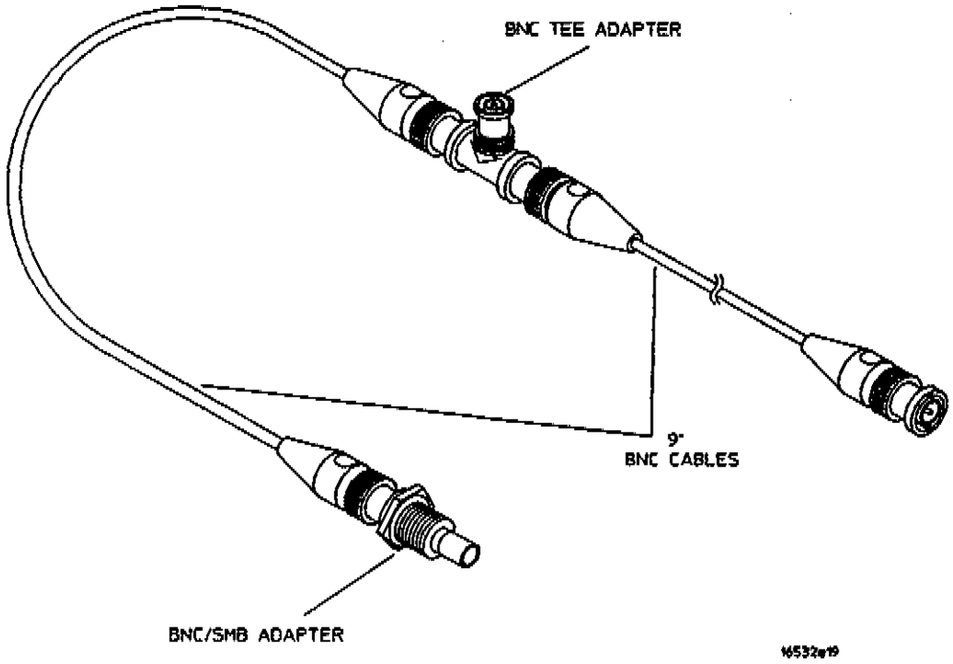


Figure 4-4. Ext Trig Null Calibration Connections

2. Touch the **Procedure** field, then select **Ext Trig Null** from the pop-up menu.
3. Touch the **Start** field and follow the instructions on the display.
4. At the conclusion of the ext trig null calibration, remove the cables from the rear of the module.

Messages will be displayed as each calibration routine is completed to indicate calibration has passed or failed. The resulting calibration factors are automatically stored to nonvolatile RAM at the conclusion of each calibration routine.

This is the conclusion of the calibration procedures. The display should now look similar figure 4-5.

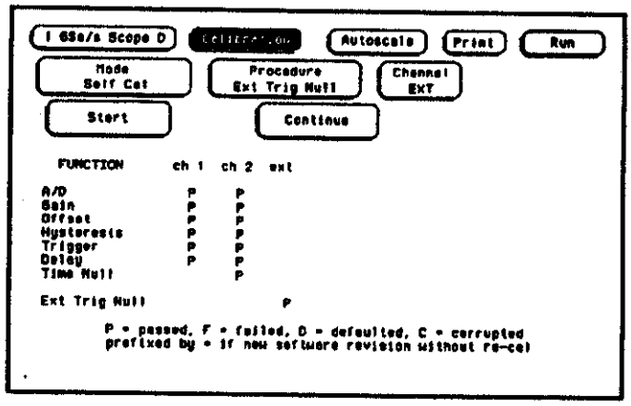


Figure 4-5. End of Calibration Display

4-13. Setting the PROTECT/UNPROTECT Switch to PROTECT

CAUTION

The effects of ELECTROSTATIC DISCHARGE can damage electronic components. Use grounded wrist straps and mats when you are performing any kind of service on this module.

The PROTECT/UNPROTECT switch must be set to PROTECT after calibration is finished. Set the switch to PROTECT as follows:

1. Remove power from the instrument. Pull the modules located above the oscilloscope halfway out, then remove the filler panels and cards located above the oscilloscope. See figure 4-6 for the removal sequence.

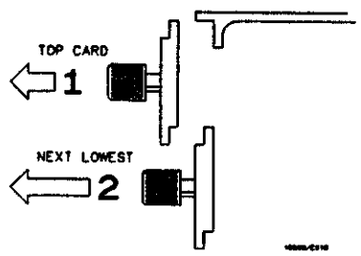


Figure 4-6. Endplate Overlap - Top Sequence

2. Remove the oscilloscope module and set the PROTECT/UNPROTECT switch to the PROTECT position. See Figure 4-2 to locate this switch.

3. Repeat step 2 for each module calibrated.

4. Reinstall the modules and filler panels in reverse order of steps 1 and 2.

4-14. Sealing the Mainframe

After calibration has been completed, the mainframe should be sealed to protect the integrity of the system. Place a seal on the equipment such that the seal touches both the top-most module (or filler panel) and the mainframe.