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Agilent Technologies

The HP 1660E and 1670E-Series Benchtop Logic Analyzers

Technical Data

**Affordable logic analyzers
designed for your exact needs**

HP's new family of benchtop logic analyzers includes four new series of products, enabling design engineers to purchase an affordable logic analyzer that meets their exact needs and matches their budget. The units include a VGA resolution color flat panel display to help you find information quickly and the well designed user interface gets you to the answer in less time. Users can use either a mouse or the front panel to easily navigate through the user interface. An optional PC style keyboard is also supported. A compact all-in-one design also helps save space on a crowded lab bench.

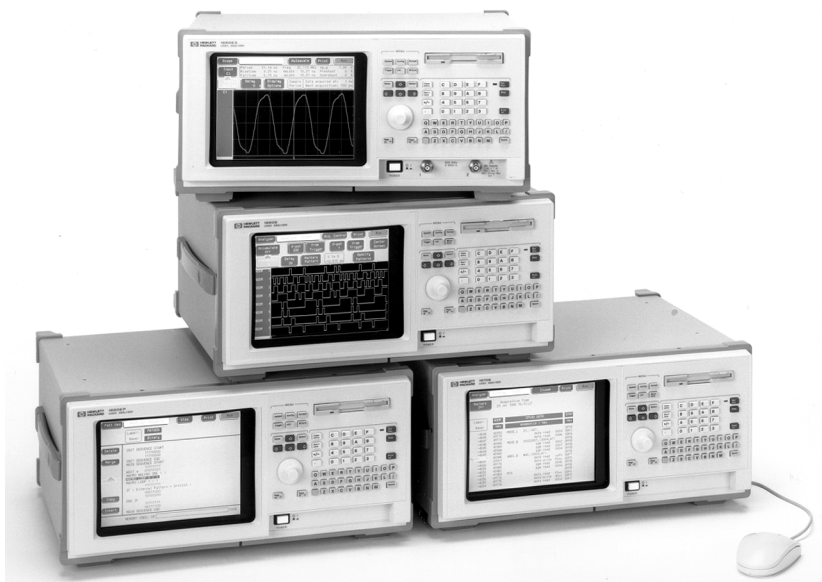


Figure 1. HP's new family of benchtop logic analyzers with color displays

The HP 1660ES-Series models come with a built-in, 500-MHz, 2-GSa/s oscilloscope that can be triggered by the logic analyzer. Some of the toughest hardware debug problems can be found only with the digital triggering capabilities of a logic analyzer and can only be solved with the analog resolution of an oscilloscope.

The pattern generator capability in the HP 1660EP-Series allows designers to substitute for missing sub-systems during development.

The HP 1670E-Series help simplify the capture and analysis of complex events with 1M deep memory. Deep memory is a valuable logic analyzer feature for debugging embedded microprocessor systems.

| | | | | |
|---------------------|--------------------------------|----------|----------|----------|
| Model Number | HP 1660E | HP 1661E | HP 1662E | HP 1663E |
| Channels | 136 | 102 | 68 | 34 |
| Application | General purpose logic analysis | | | |

| | | | | |
|---------------------|--|-----------|-----------|-----------|
| Model Number | HP 1660EP | HP 1661EP | HP 1662EP | HP 1663EP |
| Channels | 136 | 102 | 68 | 34 |
| Application | Hardware simulation and stimulus-response testing with integrated 32-channel pattern generator | | | |

| | | | | |
|---------------------|--|-----------|-----------|-----------|
| Model Number | HP 1660ES | HP 1661ES | HP 1662ES | HP 1663ES |
| Channels | 136 | 102 | 68 | 34 |
| Application | Parametric and mixed-signal testing with integrated two-channel oscilloscope | | | |

| | | | |
|---------------------|--|----------|----------|
| Model Number | HP 1670E | HP 1671E | HP 1672E |
| Channels | 136 | 102 | 68 |
| Application | Complex debugging and troubleshooting with deep memory | | |

HP 1660E/ES/EP Series Logic Analyzer key Specifications and Characteristics

| HP Model Number | 1660E/ES/EP | 1661E/ES/EP | 1662E/ES/EP | 1663E/ES/EP | 1664A |
|---------------------------|---|-------------|-------------|-------------|--------|
| State and Timing Channels | 136 | 102 | 68 | 34 | 34 |
| Timing Analysis | Conventional: 250 MHz all channels, 500 MHz half channels Transitional: 125 MHz all channels, 250 MHz half channels Glitch: 125 MHz half channels | | | | |
| State analysis speed | 100 MHz, all channels | | | | 50 MHz |
| State Clock/Qualifiers | 6 | 6 | 4 | 2 | 2 |
| Memory Depth per Channel | 4k per channel, 8k in half-channel modes | | | | |
| LAN Port | Standard for all E/ES/EP models | | | | N/A |

HP 1660EP Series Pattern Generator Key Specifications and Characteristics

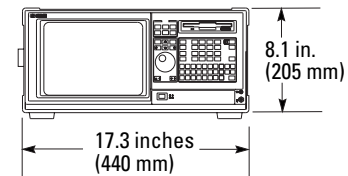
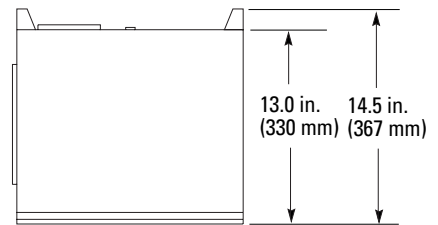
| HP Model Number | 1660EP, 1661EP, 1662EP, 1663EP | | |
|--------------------------|--------------------------------|---------|---------|
| Maximum Clock Speed | 200 MHz | 100MHz | 50 MHz |
| Number of Data Channels | 16 | 32 | 32 |
| Memory Depth, in vectors | 258,048 | 258,048 | 258,048 |
| "IF" Command | No | No | Yes |

HP 1670E-Series Logic Analyzer Key Specifications and Characteristics

| HP Model Number | 1670E | 1671E | 1672E |
|---------------------------|---|-------|-------|
| State and Timing Channels | 136 | 102 | 68 |
| Timing Analysis | Conventional: 125 MHz all channels, 250 MHz half channels | | |
| State Analysis Speed | 100 MHz, all channels | | |
| State Clocks/Qualifiers | 4 | 4 | 4 |
| Memory Depth per Channel | 1M per channel, 2M in timing half-channel mode | | |

HP 1660ES Series Oscilloscope Key Specifications and Characteristics

| | |
|--------------------------|----------------------------------|
| HP Model Number | 1660ES, 1661ES 1662ES, 1663ES |
| Channels | 2 |
| Maximum Sample Rate | 2 GSa/s per channel |
| Bandwidth | dc to 500 MHz (dc coupled) |
| Rise Time | 700 ps |
| Vertical Resolution | 8 bits |
| Memory Depth per Channel | 32k samples |



Weight = 28.6 lbs. (13kg)

Figure 3. Logic analyzer dimensions and weight

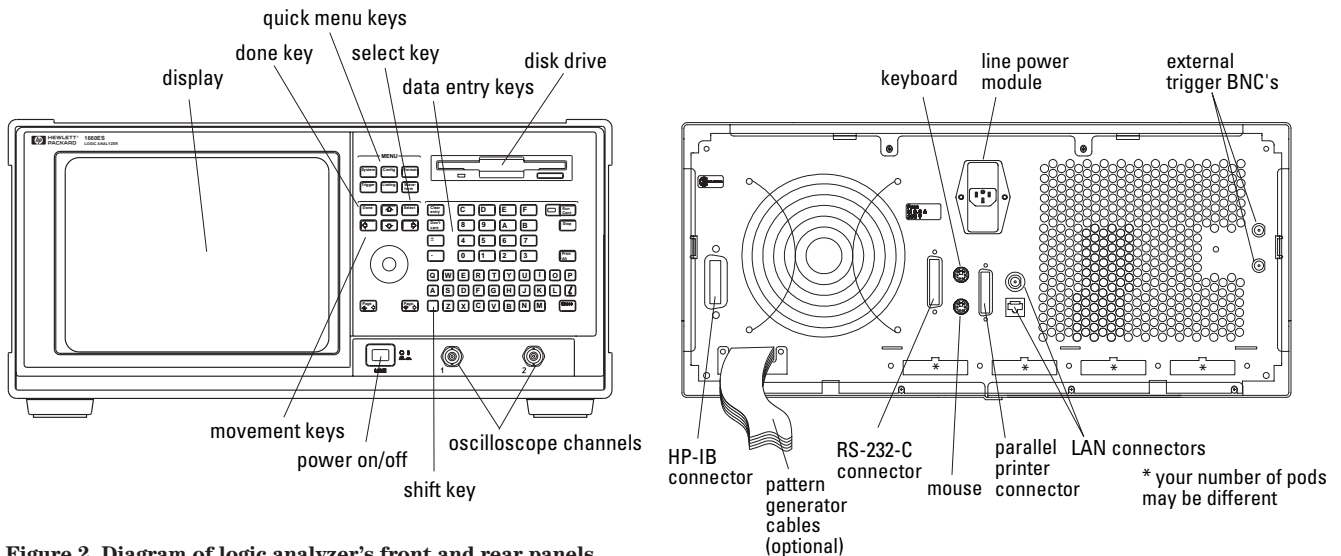


Figure 2. Diagram of logic analyzer's front and rear panels

HP 1660E and 1670E-Series Logic Analyzer Specifications and Characteristics

Human Interface

Front Panel A knob and keypad make up the front-panel human interface. Keys include control, menu, display navigation, and alpha-numeric entry functions.

Mouse A DIN mouse is shipped as standard equipment. It provides full instrument control. Knob functionality is replicated by holding down the right button and moving the mouse left or right. ^[1]

Keyboard The logic analyzer can also be operated using a DIN keyboard. Order the HP Logic Analyzer Keyboard Kit, model number HP E2427B. ^[1]

Input/Output, Control, and Printing

I/O Ports All units ship with a Centronics parallel printer port, RS-232, and HP-IB as standard equipment.

LAN Interface An Ethernet LAN interface is standard. The LAN interface comes with both Ethertwist and ThinLan connectors. The LAN supports FTP and PC/NFS connection protocols. It also works with X11 windows packages. ^[1]

Programmability Each instrument is fully programmable from a computer via HP-IB, RS-232 and LAN connections. ^[1]

HP Printer Support Printers which use the HP Printer Control Language (PCL) and have a parallel Centronics, RS-232 or HP-IB interface are supported: HP DeskJet, LaserJet, QuietJet, PaintJet, and ThinkJet models

Alternate Printers Supported The Epson FX80, LX80 and MX80 printers with an RS-232 or Centronics interface are supported in the Epson 8-bit graphics mode.

Hard Copy Output Screen images can be printed in black and white or color from all menus using the *Print* field. State or timing listings can be also be printed in full or part (starting from center screen) using the *Print All* selection.

Mass Storage Files and Software

Updating the Operating System The operating system resides in Flash ROM and can be updated from the flexible disk drive or from the internal hard disk drive. ^[1]

Mass Storage Supported by an internal hard disk drive and by a 1.44 Mbyte, 3.5-inch flexible disk drive. Supports DOS and LIF formats. ^[1]

Screen Image Files An image file of any display screen can be stored to disk via the display's *Print* field in black & white or color TIFF, color PCX, or black & white Encapsulated PostScript™ (EPS) formats.

ASCII Data Files State or timing listings can be stored as ASCII files on a disk via the display's *Print* field. These files are equivalent in character width and line length to hard-copy listings printed via the *Print All* selection.

Configuration and Data Files Logic analyzer and oscilloscope files that include configuration and data information (if present) are encoded in a binary format. They can be stored to or loaded from the hard disk drive or a flexible disk.

Recording of Acquisition and Storage Times Binary format configuration/data files are stored with the time of acquisition and the time of storage. ^[1]

Acquisition Arming

Initiation Arming is started by *Run*, *Group Run*, or the Port In BNC.

Cross Arming Analyzer machines and the oscilloscope or pattern generator can cross-arm each other.

Output An output signal is provided at the Port Out BNC.

PORT IN Signal and Connection Port In is a standard BNC connection. The input operates at TTL logic signal levels. Rising edges are valid input signals.

PORT OUT Signal and Connection Port Out is a standard BNC connection with TTL logic signal levels. A rising edge is asserted as a valid output.

Skew Adjustment Correction factors for nominal skew between displayed timing and oscilloscope signals are built into the operating system. Additional correction for unit-by-unit variation can be made using the *Skew* field. An entered skew value affects the next (not the present) acquisition display.

^[1] Please refer to HP 1664A Product Specifications and Characteristics on page 7.

HP 1660E and 1670E-Series Logic Analyzer Specifications and Characteristics (cont.)

| | |
|---|--|
| PORT IN Arms Logic Analyzer [2] | 15 ns typical delay from signal input to a <i>don't care</i> logic analyzer trigger. |
| PORT IN Arms Oscilloscope | 40 ns typical delay from signal input to an <i>immediate</i> oscilloscope trigger. |
| Logic Analyzer Arms PORT OUT [2] | 120 ns typical delay from logic analyzer trigger to signal output. |
| Oscilloscope Arms PORT OUT | 60 ns typical delay from oscilloscope trigger to signal output. |
| Operating Environment | |
| Power | 115 Vac or 230 Vac, -22% to +10%, single phase, 48-66 Hz, 320 VA max |
| Temperature | Instrument, 0° to 50° C (+32° to 122° F). Disk media, 10° to 40° C (+50° to 104° F). Probes and cables, 0° to 65° C (+32° to 149° F) |
| Humidity | Instrument, up to 95%, relative humidity at +40° C (+140° F). Disk media and hard drive, 8% to 85% relative humidity. |
| Altitude | To 3,048 m (10,000 ft) [1] |
| Vibration: Operating | Random vibrations 5-500 Hz, 10 minute per axis, ~ 0.3 g (rms). |
| Vibration: Non Operating | Random vibrations 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. |

[1] Please refer to HP 1664A Product Specifications and Characteristics on page 7.

[2] Time may vary depending upon the mode of logic analyzer operation.

* Warranted specification.

[3] Full channel /half channel modes

Physical Factors

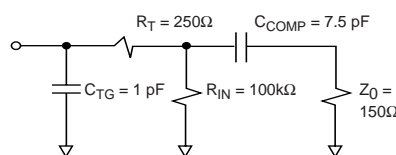
| | |
|---------------|--|
| Safety | IEC 348/ HD 401, UL 1244, and CSA Standard C22.2 No. 231 (series M-89) |
|---------------|--|

EMC

| |
|--|
| CISPR 11:1990/EN 55011 (1991): Group 1 Class A |
| IEC 801-2:1991/EN 50082-1 (1992): 4kV CD, 8 kV AD |
| IEC 801-3:1984/EN 50082-1 (1992): 3 V/m |
| IEC 801-4:1988/EN 50082-1 (1992): 1kV |

Logic Analyzer Probes

| | |
|--------------------------|-----------------------------|
| Input Resistance | 100 k Ω \pm 2% |
| Input Capacitance | approx. 8 pF (see figure 4) |



High Frequency Model for Probe Inputs

Figure 4

| | |
|------------------------------------|---|
| Minimum Input Voltage Swing | 500 mV peak-to-peak |
| Minimum Input Overdrive | 250 mV or 30% of input amplitude, whichever is greater |
| Threshold Range | -6.0 V to +6.0 V in 50-mV increments |
| Threshold Setting | Threshold levels may be defined for pods (17-channel groups) on an individual basis |
| Threshold Accuracy* | \pm (100 mV +3% of threshold setting) |
| Input Dynamic Range | \pm 10 V about the threshold |
| Maximum Input Voltage | \pm 40 V peak |

| | |
|-------------------------------|---|
| +5 V Accessory Current | 1/3 amp maximum per pod |
| Channel Assignment | Each group of 34 channels (a pod pair) can be assigned to Machine 1, Machine 2 or remain unassigned. The HP 1663E/ES/EP and the HP 1664A do not have a Machine 2. |

State Analysis

| | |
|-----------------------------|-----------------------------------|
| Maximum State Speed* | 100 MHz ^[1] all models |
|-----------------------------|-----------------------------------|

Memory Depth per Channel

| | |
|------------------------------|--|
| HP 1660E/ES/EP Series | 4k samples std. Time tags on: 2k samples |
|------------------------------|--|

| | |
|------------------------|--|
| HP 1670E Series | 1M samples standard Time Tags On: 500k samples Compare Mode On: 250k samples Compare Mode and Time Tags On: 120k samples |
|------------------------|--|

| | |
|---------------------|--|
| State Clocks | Clock edges can be ORed together and operate in single phase, two-phase demultiplexing, or two-phase mixed mode. Clock edge is selectable as positive, negative, or both edges for each clock. |
|---------------------|--|

| | |
|------------------------------|---|
| State Clock Qualifier | The high or low voltage level of up to 4 of the 6 clocks can be ANDed or ORed with the clock specification. |
|------------------------------|---|

| | | |
|------------------------|-------------------------|---|
| Setup/Hold* [4] | one clock, one edge | 3.5/0 ns to 0/3.5 ns (in 0.5 ns increments) |
| | one clock, both edges | 4.0/0 ns to 0/4.0 ns (in 0.5 ns increments) |
| | multi-clock, multi-edge | 4.5/0 ns to 0/4.5 ns (in 0.5 ns increments) |

HP 1660E and 1670E-Series Logic Analyzer Specifications and Characteristics (cont.)

| | |
|---|---|
| Minimum State Clock Pulse Width* [4] | 3.5 ns |
| Minimum Master to Master Clock Time* [4] | 10.0 ns |
| Minimum Slave to Slave Clock Time [4] | 10.0 ns |
| Minimum Master to Slave Clock Time [4] | 0.0 ns |
| Minimum Slave to Master Clock Time [4] | 4.0 ns |
| Clock Qualifiers Setup/Hold [4] | 4.0/0 ns (fixed) |
| State Tagging [5] | Counts the number of qualified states between each stored state. Measurement can be shown relative to the previous state or relative to trigger. Max. count is 4.29×10^9 . |
| Time Tagging [5] | Measures the time between stored states, relative to either the previous state or to the trigger. Max. time between states is 34.4 sec. Min. time between states is 8 ns. |
| Time Tag Resolution | 8 ns or 0.1% (whichever is greater) |

Timing Analysis

Conventional Timing Data stored at selected sample rate across all timing channels.

HP 1660 Series
Sample Period [3] 4 ns/2 ns minimum, 8.38 ms maximum

HP 1670 Series
Sample Period [3] 8 ns/4 ns minimum, 41 ms/10 ms maximum

| | |
|---|--|
| Time Covered by Data [3] | Sample period \times memory depth |
| Transitional Timing | (HP 1660E/ES/EP Series only) Sample is stored in acquisition memory only when the data changes. A time tag stored with each sample allows reconstruction of waveform display. Time covered by a full memory acquisition varies with the number of pattern changes in the data. |
| Time Covered by Data [3] | 16.3 μ s minimum, 9.7 hrs./6.5 hrs. maximum |
| Maximum Time Between Transitions | 34.4 s |
| Number of Captured Transitions [3] | 1023-2047/682-4094 Depending on input signals |
| Glitch Capture Mode | (HP 1660E/ES/EP Series only.) Data sample and glitch information is stored every sample period. |
| Maximum Timing Speed | 125 MHz |
| Sample Period | 8 ns minimum, 8.38 ms maximum |
| Minimum Glitch Width* | 3.5 ns |
| Maximum Glitch Width | Sample Period – 1 ns |
| Memory Depth per Channel | 2048 samples |
| Time Covered by Data | Sample Period \times 2048: 16.3 μ s minimum, 17.1 sec maximum |

Time Interval Accuracy

| | |
|---------------------------------------|---|
| Sample Period Accuracy | $\pm 0.01\%$ |
| Channel-to-Channel Skew | 2 ns typical, 3 ns maximum |
| Time Interval Accuracy | \pm (Sample Period Accuracy + channel-to-channel skew + 0.01% of time interval reading) |
| Maximum Delay After Triggering | Sample Period 2-8 ns : 8.389 ms Sample Period > 8 ns: $1,048,575 \times$ sample period |

Trigger Specifications

| | |
|---|--|
| Trigger Macros | Trigger setups can be selected from a categorized list of trigger macros. Each macro is shown in graphical form and has a written description. Macros can be chained together to create a custom trigger sequence. |
| Pattern Recognizers | Each recognizer is the AND combination of bit (0,1, or X) patterns in each label. Ten pattern recognizers are available. |
| Minimum Pattern and Range Recognizer Pulse Width | >125 MHz timing modes: 13 ns + channel-to-channel skew \leq 125 MHz timing modes: $1.01 \times$ (1 sample period + 1 ns + channel-to-channel skew) |

[3] Full Channel /Half Channel Modes

[4] Specified for an input signal $V_H = -0.9V$, $V_L = -1.7V$, slew rate = 1V/ns, and threshold = -1.3V

[5] Time or state-tagging (Count Time or Count State) is available in the full-channel state mode. There is no speed penalty for tag use. Memory is halved when time or state tags are used unless a pod pair (34-channel group) remains unassigned in the Configuration menu.

* Warranted specification.

HP 1660E and 1670E-Series Logic Analyzer Specifications and Characteristics (cont.)

| | | | | | |
|---|--|---|--|------------------------------|---|
| Range Recognizers | Recognize data which is numerically between or on two specified patterns (ANDed combination of zeros and/or ones). Two range recognizers are available. | Maximum Sequencer Speed | 125 MHz | Trigger | Displayed as a vertical dashed line in the timing waveform, state waveform and X-Y chart displays and as line 0 in the state listing and state compare displays. |
| Range Width | 32 channels | State Sequence Levels | 12 | Activity Indicators | Provided in the Configuration, State Format, and Timing Format menus for monitoring device-under-test activity while setting up the analyzer. |
| Edge/Glitch Recognizers | Trigger on glitch or edge on any channel. Edge can be specified as rising, falling or either. | Timing Sequence Levels | 10 | Labels | Channels may be grouped together and given a 6-character name called a <i>label</i> . Up to 126 labels in each analyzer may be assigned with up to 32 channels per label. Trigger terms may be given an 8-character name. |
| Edge/Glitch Recognizers | 2 (in timing mode only) | Timers | Timers may be Started, Paused, or Continued at entry into any sequence level after the first. | Measurement Functions | |
| Edge/Glitch Recovery Time | Sample Period 2-8 ns: 28 ns Sample Period > 8 ns: 20 ns + sample period | Timers | 2 | Markers | Two markers (x and o) are shown as dashed lines in the display. |
| Qualifier | A user-specified term that can be any state, no state, any recognizer, (pattern, ranges or edge/glitch), any timer, or the logical combination (NOT, AND, NAND, OR, NOR, XOR, NXOR) of the recognizers and timers. | Timer Range | 400 ns to 500 seconds | Time Intervals | The x and o markers measure the time interval between events occurring on one or more waveforms or states (available in state when time tagging is on). |
| Branching | Each sequence level has a branching qualifier. When satisfied, the analyzer will branch to the sequence level specified. | Timer Resolution | 16 ns or 0.1% whichever is greater | Delta States | The x and o markers measure the number of tagged states between any two states (state only). |
| Occurrence Counters | Qualifiers may be specified to occur up to 1,048,575 times before advancing to the next level. Each sequence level has its own counter. The maximum occurrence count is 1,048,575. | Timer Accuracy | ± 32 ns or $\pm 0.1\%$, whichever is greater | Patterns | The x or o marker can be used to locate the nth occurrence of a specified pattern before or after trigger. The o marker can also find the nth occurrence of a pattern before or after the x marker. |
| Storage Qualification (state only) | Each sequence level has a storage qualifier that specifies the states that are to be stored. | Timer Recovery Time | 70 ns | | |
| | | Acquisition, Measurement and Display Functions | | | |
| | | Run | Starts acquisition of data in specified trace mode. | | |
| | | Stop | In single trace mode or the first run of a repetitive acquisition, stop halts acquisition and displays the current acquisition data. For subsequent runs in repetitive mode, stop halts acquisition of data and does not change current display. | | |
| | | Trace Mode | Single mode acquires data once per trace specification; repetitive mode repeats single mode acquisitions until stop is pressed or until pattern time interval or compare stop criteria are met. | | |

HP 1660E and 1670E-Series Logic Analyzer Specifications and Characteristics (cont.)

| | | | | |
|-------------------------------|--|--------------------------------|---|---|
| Statistics | x to o marker statistics are calculated for repetitive acquisitions. Patterns must be specified for both markers, and statistics are kept only when both patterns can be found in an acquisition. Statistics are minimum x to o time, maximum x to o time, average x to o time, and ratio of valid runs to total runs. | Data Display | | |
| Compare Mode Functions | Performs post-processing bit-by-bit comparison of the acquired state data and compare image data. | Display Modes | State listing, state waveforms, state chart, state compare listing, compare difference listing, timing waveforms, timing listing, interleaved time-correlated listing of two state analyzers (time tags on), and time-correlated state listing with timing waveforms on the same display. | label. When data display is "Symbol", mnemonic is displayed where the bit pattern occurs. |
| Compare Image | Created by copying a state acquisition into the compare image buffer. Allows editing of any bit in the compare image to a 1, X or 0. | State X-Y Chart Display | Plots value of a specified label (on y-axis) versus states or another label (on x-axis). Both axes can be scaled. | Range Symbols User can define a mnemonic covering a range of values. |
| Compare Image Boundaries | Each channel (column) in the compare image can be enabled or disabled via bit masks in the compare image. Upper and lower ranges of states (rows) in the compare image can be specified. Any data bits that do not fall within the enabled channels and the specified range are not compared. | State Waveform Display | Displays state acquisitions in waveform format. | Symbol Utility Symbolic information extracted from popular object module formats can also be used. |
| Stop Measurement | Repetitive acquisitions may be halted when the comparison between the current state acquisition and the current compare image is equal or not equal. | Timing Listing Display | Displays timing acquisition in listing format. | Number of Symbols 1000 maximum. |
| Compare Mode Displays | Reference Listing display shows the compare image and bit masks; difference listing display highlights differences between the current state acquisition and the compare image. | Timing Waveform Display | | System Performance Analysis SPA includes state histogram, state overview and time interval measurements to aid in the software optimization process. These tools provide a statistical overview of your synchronous design. |
| | | Accumulate | Waveform display is not erased between successive acquisitions. | |
| | | Overlay Mode | Multiple channels can be displayed on one waveform display line. When waveform size is set to large, the value represented by each waveform is displayed inside the waveform in the selected base. | |
| | | Displayed Waveforms | 24 lines maximum on one screen. Up to 96 lines may be specified and scrolled through. | |
| | | Bases | Binary, octal, decimal, hexadecimal, ASCII (display only), user-defined symbols, two's complement. | |
| | | Symbols | | |
| | | Pattern Symbols | User can define a mnemonic for the specific bit pattern of a | |

The HP 1664A Specifications and Characteristics

The HP 1664A is a low-cost version of the HP 1660E/ES/EP-series logic analyzer family. The HP 1664A has some specifications and characteristics that are different from the HP 1660E/ES/EP-series logic analyzers.

The HP 1664A:

- Supports a maximum of 50 MHz state acquisition
- Weight 26 pounds (11.8 kg)
- Altitude To 15,000 ft (4,752 m)
- Boots from the floppy disk drive—it does not have flash ROM
- It cannot be upgraded to include an oscilloscope or pattern generator
- The mouse and keyboard connectors are HP HIL standard
- For the optional keyboard order HP E2427A
- It does not support the symbol utility
- It does not support the software performance analysis (SPA) software
- It does not have a real time clock
- It does not have a hard disk drive
- It does not have a LAN port

HP 1660ES-Series Oscilloscope Specifications and Characteristics

General Information

| | |
|---|--|
| Model Numbers | HP 1660ES, 1661ES, 1662ES, 1663ES |
| Number of Channels | 2 |
| Maximum Sample Rate | 2 GSa/s per channel |
| Bandwidth [6] [10] | dc to 500 MHz (real time, dc coupled) |
| Rise Time [7] [10] | 700 ps |
| Vertical Resolution | 8 bits full scale |
| Memory Depth | 32k samples |
| Oscilloscope Probing | |
| Input Coupling | 1 M Ω : ac, dc 50 Ω : dc only |
| Input R [10] | 1M Ω \pm 1% 50 Ω \pm 1% |
| Input C | ~ 7pF |
| Probes Included | Two HP 1160A probes; 10:1, 10 M Ω , 9 pF 1.5 meters |
| Vertical (at BNC) | |
| Maximum Safe Input Voltage | 1 M Ω : \pm 250 V 50 Ω : 5 V rms |
| Vertical Sensitivity Range (1:1 Probe) | 16 mV full scale to 40 V full scale |
| Probe Factors | Any integer ratio from 1:1 to 1000:1 |
| Vertical (dc) Gain Accuracy [8] | \pm 1.25% of full scale |
| dc Offset Range (1:1 probe) | \pm 2V to \pm 250V (depending on the vertical sensitivity) |
| dc Offset Accuracy [10] | \pm [1.0% of channel offset + 2.0% of full scale] |
| Voltage Measurement Accuracy [10] | \pm [1.25% of full scale + offset accuracy + 0.016 V/div] |
| Channel-to-Channel Isolation | dc to 50 MHz – 40 dB 50 MHz to 500 MHz – 30 dB |

Horizontal

| | |
|---|---|
| Time Base Range | 0.5 ns/div to 5 s/div |
| Time Interval Measurement Accuracy [9] [10] | \pm [(0.005% of Δt) + ($2 \times 10^{-6} \times$ delay setting) + 150 ps] |
| Oscilloscope Triggering | |
| Trigger Level Range | Bounded within chan- nel display window |
| Trigger Sensitivity [10] | dc to 50 MHz: 0.063 \times Full Scale 50 MHz to 500 MHz: 0.125 \times Full Scale |

Trigger Modes

| | |
|-----------|--|
| Immediate | Triggers immediately after arming condition is met. (Arming condition is Run, Group Run, cross arming signal, or Port In BNC signal). |
| Edge | Triggers on rising or falling edge from channel 1 or 2. |
| Pattern | Triggers on entering or exiting logical pattern specified across channels 1 or 2. Each channel can be specified as high (H), low (L), or don't care (X) with respect to the level settings in the edge trigger menu. Patterns must be >1.75 ns in duration to be recognized. |

| | |
|-------------------------------|--|
| Time-Qualified Pattern | Triggers on the exiting edge of a pattern which meets the user-specified duration criterion. Greater than, less than, or within range duration criterion can be used. Duration range is 20 ns to 160 ns. Recovery time after valid patterns with invalid duration is <12 ns. |
|-------------------------------|--|

| | |
|---------------------|--|
| Events Delay | Triggers on the nth edge or pattern as specified by the user. Time-qualification is applied only to the 1st of n patterns. |
|---------------------|--|

| | |
|---------------------|--|
| Auto-Trigger | Self-triggers if no trigger condition is found ~ 50 ms after arming. |
|---------------------|--|

Measurement Functions

| | |
|-------------------------------|---|
| Time Markers | Two markers (x and o) measure time intervals manually, or automatically with statistics. |
| Voltage Markers | Two markers (a and b) measure voltage and voltage differences. |
| Automatic Measurements | Period, frequency, rise time, fall time, +width, –width, peak-to-peak voltage, overshoot, and undershoot. |

[6] Upper bandwidth reduces by 2.5 MHz for every degree C above 35°C.

[7] Rise time calculated as $t_r = \frac{0.35}{\text{bandwidth}}$

[8] Vertical gain accuracy decreases 0.08% per degree C from software calibration temperature.

[9] Specification applies at the maximum sampling rate. At lower rates, replace 150 ps in the formula with (0.15 \times sample interval) where sample interval is defined as 1/sample rate.

[10] Specifications (valid within \pm 10°C of auto-calibration temperature)

HP 1660EP-Series Pattern Generator Characteristics

| | |
|--|-----------------|
| Maximum memory depth | 258,048 vectors |
| Number of output channels at 100 MHz to 200 MHz clock | 16 |
| Number of output channels at ≤ 100 MHz clock | 32 |
| Maximum number of "IF Condition" blocks at ≤ 50 MHz clock | 1 |
| Maximum number of different macros | 100 |
| Maximum number of lines in a macro | 1024 |
| Maximum number of parameters in a macro | 10 |
| Maximum number of macro invocations | 1,000 |
| Maximum loop count in a repeat loop | 20,000 |
| Maximum number of repeat loop invocations | 1,000 |
| Maximum number of Wait event patterns | 4 |
| Number of input lines to define a wait pattern | 3 |
| Maximum width of a label | 32 bits |
| Maximum number of labels | 126 |

Lead Set Characteristics

| | |
|------------------------------------|--|
| HP 10474A 8-channel probe lead set | Provides most cost effective lead set for the HP 1660EP-series clock and data pods. Grabbers are not included. |
| HP 10347A 8-channel probe lead set | Provides 50 Ω coaxial lead set for unterminated signals, required for HP 10465A ECL Data Pod (unterminated). Grabbers are not included. |

Data Pod Characteristics

HP 10461A TTL DATA POD

| | |
|----------------------|-----------------------------------|
| Output type | 10H125 with 100 Ω series |
| Maximum clock | 200 MHz |
| Skew (note 1) | typical < 2 ns; worst case = 4 ns |
| Recommended lead set | HP 10474A |



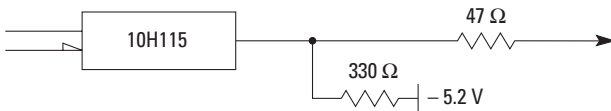
HP 10462A 3-STATE TTL/CMOS DATA POD

| | |
|----------------------|---|
| Output type | 74ACT11244 with 100 Ω series; 10H125 on non 3-state channel 7 (note 2) |
| 3-state enable | negative true, 100 K Ω to GND, enabled on no connect |
| Maximum clock | 100 MHz |
| Skew (note 1) | typical < 4 ns; worst case = 12 ns |
| Recommended lead set | HP 10474A |

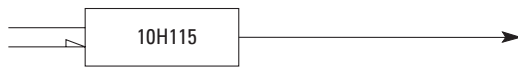


HP 10464A ECL DATA POD (TERMINATED)

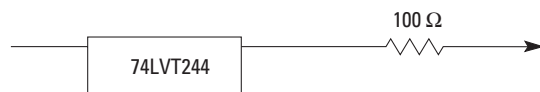
| | |
|-----------------------------|---|
| Output type | 10H115 with 330 Ω pulldown, 47 Ω series |
| Maximum clock | 200 MHz |
| Skew (note 1) | typical < 1 ns; worst case = 2 ns |
| Recommended lead set | HP 10474A |

**HP 10465A ECL DATA POD (UNTERMINATED)**

| | |
|-----------------------------|-----------------------------------|
| Output type | 10H115 (no termination) |
| Maximum clock | 200 MHz |
| Skew (note 1) | typical < 1 ns; worst case = 2 ns |
| Recommended lead set | HP 10347A |

**HP 10466A 3-STATE TTL/3.3 VOLT DATA POD**

| | |
|-----------------------------|---|
| Output type | 74LVT244 with 100 Ω series; 10H125 on non 3-state channel 7 (note 2) |
| 3-state enable | negative true, 100 K Ω to GND, enabled on no connect |
| Maximum clock | 200 MHz |
| Skew (note 1) | typical < 3 ns; worst case = 7 ns |
| Recommended lead set | HP 10474A |

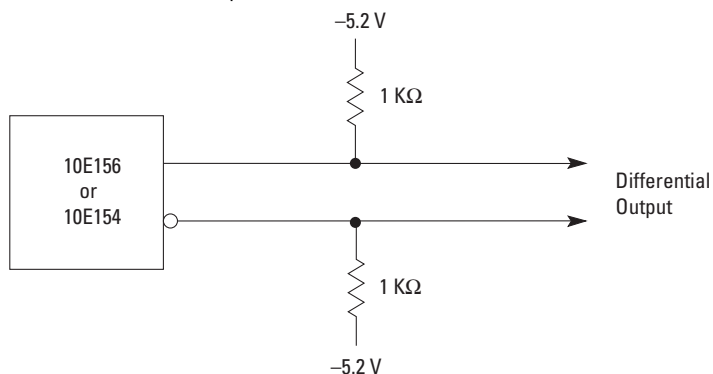


Note 1: Typical skew measurements made at pod connector with approximately 10 pF/50 K Ω load to GND; worst case skew numbers are a calculation of worst case conditions through circuits.

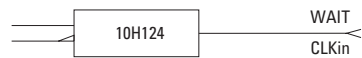
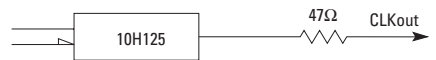
Note 2: Channel 7 on the 3-state pods has been brought out in parallel as a non 3-state signal. By looping this output back into the 3-state enable line, the channel can be used as a 3-state enable.

Data Cable Characteristics Without a Data Pod

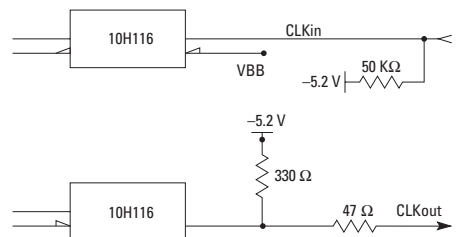
The HP 1660EP data cables without a data pod provide an ECL terminated (1 K Ω to -5.2V) differential signal (from a type 10E156 or 10E154 driver). These are usable when received by a differential receiver, preferably with a 100 Ω termination across the lines. These signals should not be used single ended due to the slow fall time and shifted voltage threshold (they are not ECL compatible).

HP 1660EP Data Cable Output**Clock Pod Characteristics****10460A TTL CLOCK POD**

| | |
|----------------------------------|---|
| Clock output type | 10H125 with 47 Ω series; true & inverted |
| Clock output rate | 100 MHz maximum |
| Clock out delay | 11 ns maximum in 9 steps |
| Clock input type | TTL – 10H124 |
| Clock input rate | dc to 100 MHz |
| Pattern input type | TTL – 10H124 (no connect is logic 1) |
| Clock-in to clock-out | approximately 30 ns |
| Pattern-in to recognition | approx. 15 ns + 1 clk period |
| Recommended lead set | HP 10474A |

**10463A ECL CLOCK POD**

| | |
|----------------------------------|--|
| Clock output type | 10H116 differential unterminated; and differential with 330 Ω to -5.2V and 47 Ω series |
| Clock output rate | 200 MHz maximum |
| Clock out delay | 11 ns maximum in 9 steps |
| Clock input type | ECL – 10H116 with 50 K Ω to -5.2v |
| Clock input rate | dc to 200 MHz |
| Pattern input type | ECL – 10H116 with 50 K Ω (no connect is logic 0) |
| Clock-in to clock-out | approximately 30 ns |
| Pattern-in to recognition | approx. 15 ns + 1 clk period |
| Recommended lead set | HP 10474A |



Probing Alternatives for the HP 1660E/ES/EP and 1670E-Series Logic Analyzers

Probing the device under test is both one of the potentially most difficult and certainly one of the most important tasks in debugging a digital design. That is why HP provides a wider variety of probing solutions than anyone else in the industry—each with a different set of advantages particular to a given situation. We like to think of it as helping you get your signals off to a great start.

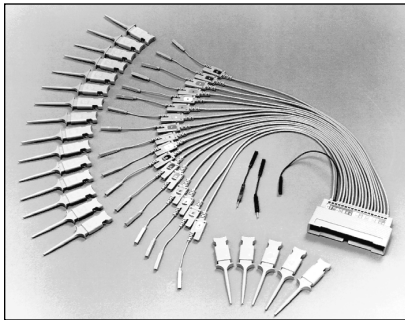


Figure 5. General-purpose lead sets

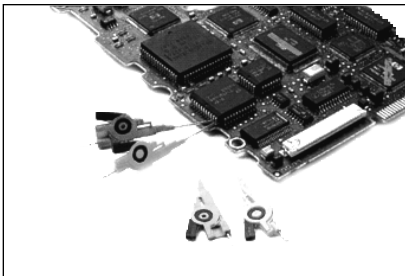


Figure 6. Ultra-fine pitch surface mount device clips

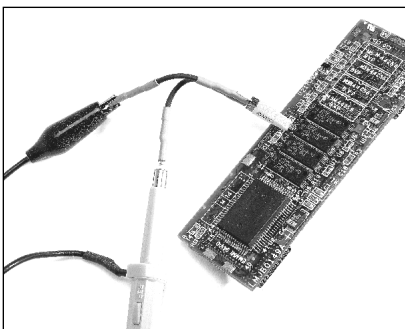


Figure 7. HP Wedge probe adapters for QFP package

| Probing Alternative | Advantages | Limitations |
|---|---|---|
| General Purpose Lead Sets and Surface Mount Grabbers | Most flexible method. Works in conjunction with SMD clips and Wedge adapters listed below. Included with logic analyzer purchase. | Can be cumbersome when connecting a large number of channels |
| Ultra-Fine Pitch Surface Mount Device Clips | Smallest IC clips in the industry to date (down to 0.5 mm). Works with both logic analyzer and scope probing systems. | Same as above plus small incremental cost |
| HP Wedge probe adapter for QFP Packages | Compressible dual conductors between adjacent IC legs make 3-8 adjacent signal leads available to logic analyzer and scope probing systems. | Same as above plus small incremental cost |
| Elastomeric and Locator Base Solutions for Generic QFP Packages | Provides access to all signal leads for generic QFP packages (including custom ICs). Uses combination of one probe adapter and four flexible adapters, plus general-purpose lead sets. | Requires minimal keep out area. Moderate to significant incremental cost. |
| Direct Connection to Device Under Test via Built-In Connectors | Very reliable and convenient probing system when frequent probing connections are required (mfg. or field test for example). Connectors can be located at optimal position in the device under test. Can work in conjunction with HP provided inverse assemblers. | Requires advance planning to integrate into design process. Moderate (normal density) to significant (high density) incremental cost. |
| HP Analysis Probes for Specific Processors and Buses | Support for over 200 different processors and buses. Includes reliable logic analyzer probe pod connectors, logic analyzer configuration files and device specific inverse assemblers. | Requires moderate clearance around processor or bus. Moderate to significant extra cost depending on specific processor or bus. |

HP Wedge Probe Adapter

| IC leg spacing | Number of signals | Number of Wedges in pack | HP model number |
|----------------|-------------------|--------------------------|-----------------|
| 0.5 mm | 3 | 1 | HP E2613A |
| 0.5 mm | 3 | 2 | HP E2613B |
| 0.5 mm | 8 | 1 | HP E2614A |
| 0.65 mm | 3 | 1 | HP E2615A |
| 0.65 mm | 3 | 2 | HP E2615B |
| 0.65 mm | 8 | 1 | HP E2616A |

Probing Solutions

| Package type | Pin Pitch | Elastomeric solutions | Locator base solutions |
|-------------------|-----------|---|--|
| 304-pin PQFP/CQFP | 0.5 mm | | HP E5331A probe adapter HP E5333A flexible adapter |
| 240-pin PQFP/CQFP | 0.5 mm | HP E5363A probe adapter HP E5371A 1/4-flexible adapter | HP E5315A probe adapter HP E5316A flexible adapter HP E5330A rigid adapter |
| 208-pin PQFP/CQFP | 0.5 mm | HP E5374A probe adapter HP E5371A 1/4-flexible adapter | HP E5318A probe adapter HP E5316A flexible adapter HP E5330A rigid adapter |
| 184-pin PQFP/CQFP | 0.5 mm | | HP E5343A probe adapter HP E5316A flexible adapter HP E5330A rigid adapter |
| 176-pin PQFP | 0.5 mm | HP E5348A probe adapter HP E5349A 1/4-flexible adapter | |
| 160-pin QFP | 0.5 mm | HP E5377A probe adapter HP E5349A 1/4-flexible adapter | |
| 160-pin PQFP/CQFP | 0.65 mm | HP E5373A probe adapter HP E5349A 1/4-flexible adapter | HP E5319A probe adapter HP E5316A flexible adapter HP E5330A rigid adapter |
| 144-pin PQFP/CQFP | 0.65 mm | HP E5361A probe adapter HP E5340A 1/4-flexible adapter | |
| 144-pin TQFP | 0.5 mm | HP E5336A probe adapter HP E5340A 1/4 flexible adapter | |

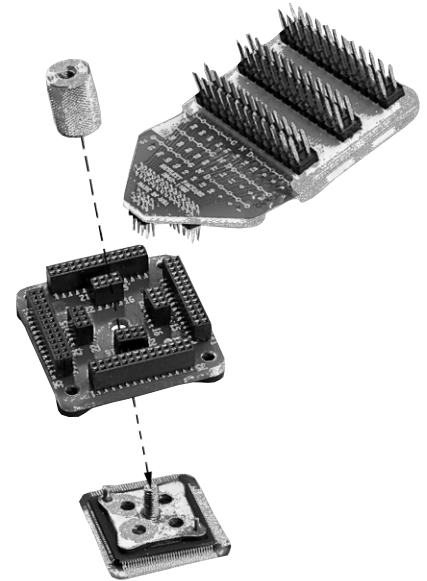


Figure 8. Elastomeric probing solution

HP Analysis Probes for Specific Processors and Buses

Please see *Processor and Bus Support for HP Logic Analyzers* (pub. no. 5966-4365E) for detailed information and ordering instructions for HP Analysis Probes. This document also contains additional and up to date information on the other probing alternatives described previously.

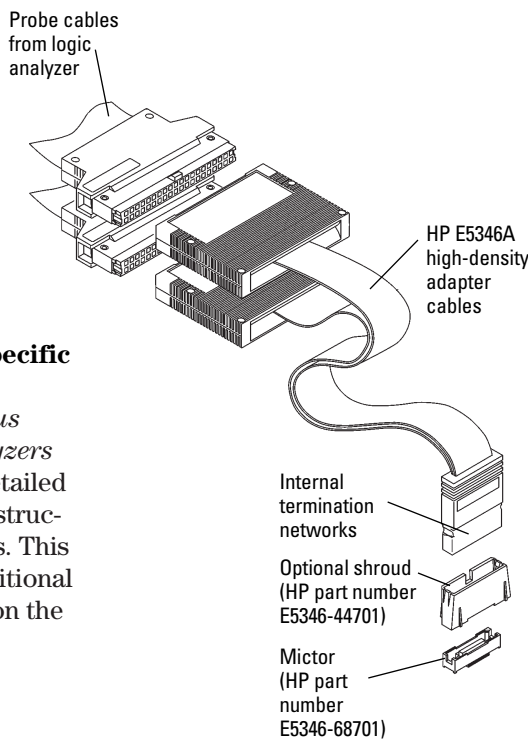


Figure 9. High density direct connection solution

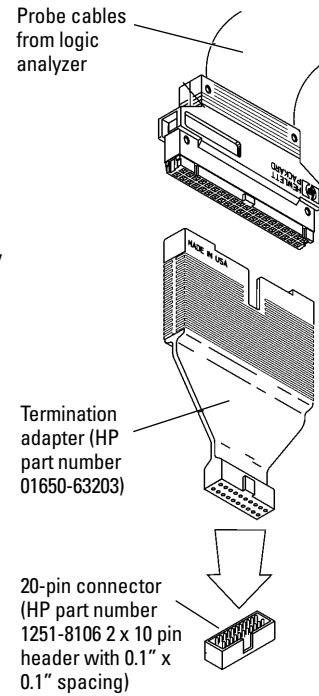


Figure 10. Normal density direct connection solution

Accessories for the HP 1660ES Series Logic Analyzers

Oscilloscope Probes

HP 1160 Family of Miniature Passive Probes

The HP 1160 family of miniature probes was developed as a result of intensive market research on probing. We developed a probe with a browser that won't slip off the test point being probed and short to some adjacent point. The browser uses a crown point that digs into solder, and won't slip. These probes include a variety of ground leads and 50 mil SMD clips for attaching to different grounding points. Each HP 1660ES series logic analyzer ships with the HP 1160 family passive probes.

Each HP 1160 family probe includes:

- 1 probe assembly
- 1 general-purpose retractable hook tip
- 1 browser
- 2 barrel insulators
- 4 spring grounds
- 1 alligator ground lead
- 1 socketed ground lead
- 1 dual lead adapter
- 2 SMD grabbers
- 1 spare browser pogo pin
- 1 spare probe tip
- 1 screwdriver
- 1 users' reference
- 3-year warranty

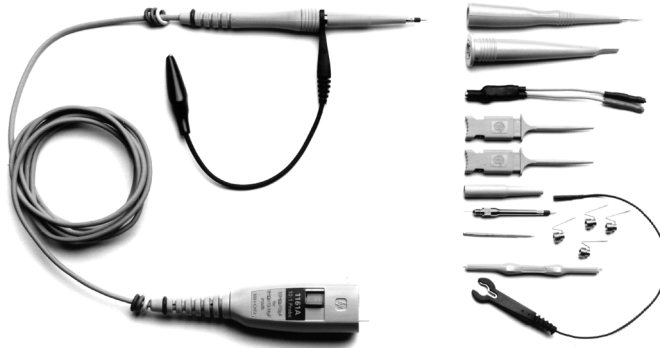


Figure 11. HP 1160 probes and accessories



Figure 12. HP 1182A standard testmobile



Figure 13. HP 1184A deluxe testmobile

HP 1660E/ES/EP Series Ordering Information

HP 1660E/ES/EP and 1670E Series Benchtop Logic Analyzers

| | |
|-----------|--|
| HP 1660E | 136 Channel Color Logic Analyzer |
| HP 1661E | 102 Channel Color Logic Analyzer |
| HP 1662E | 68 Channel Color Logic Analyzer |
| HP 1663E | 34 Channel Color Logic Analyzer |
| HP 1660ES | 136 Channel Color Logic Analyzer with 2 channel, 500 MHz oscilloscope |
| HP 1661ES | 102 Channel Color Logic Analyzer with 2 channel, 500 MHz oscilloscope |
| HP 1662ES | 68 Channel Color Logic Analyzer with 2 channel, 500 MHz oscilloscope |
| HP 1663ES | 34 Channel Color Logic Analyzer with 2 channel, 500 MHz oscilloscope |
| HP 1660EP | 136 Channel Color Logic Analyzer with 32 channel, 100 Mvectors/sec pattern generator |
| HP 1661EP | 102 Channel Color Logic Analyzer with 32 channel, 100 Mvectors/sec pattern generator |
| HP 1662EP | 68 Channel Color Logic Analyzer with 32 channel, 100 Mvectors/sec pattern generator |
| HP 1663EP | 34 Channel Color Logic Analyzer with 32 channel, 100 Mvectors/sec pattern generator |
| HP 1670E | 136 Channel Color Logic Analyzer with 1M deep acquisition memory |
| HP 1671E | 102 Channel Color Logic Analyzer with 1M deep acquisition memory |
| HP 1672E | 68 Channel Color Logic Analyzer with 1M deep acquisition memory |
| HP 1664A | 34 Channel Monochrome Logic Analyzer |

HP 1660E/ES/EP Series and HP 1670E Series Product Options

| | |
|---------|--------------------------------------|
| Opt OB1 | Additional User Manual |
| Opt OB3 | Add Service Manual |
| Opt OBF | Add Programming Manual |
| Opt ICM | Rack Mount Kit |
| Opt IBP | MilStd 45662 Calibration |
| Opt ABJ | Japanese localization of user manual |
| Opt UK9 | Front Panel Cover |
| Opt W30 | 3-year extended repair service |
| Opt W50 | 5-year extended repair service |

HP 1660EP Series Product Options for the Pattern Generator

At least one clock pod and lead set must be ordered for the pattern generator of the HP 1660EP Series. Also, order a data pod for every eight output channels used. There is a total of one clock pod and four data pods on each HP 1660EP series pattern generator.

| | |
|-----|--|
| 011 | TTL Clock Pod and Lead Set |
| 012 | Tri-State TTL/3.3V Data Pod and Lead Set |
| 013 | Tri-State TTL/CMOS Data Pod and Lead Set |
| 014 | TTL Data Pod and Lead Set |
| 021 | ECL Clock Pod and Lead Set |
| 022 | ECL (terminated) Data Pod and Lead Set |
| 023 | ECL (unterminated) Data Pod and Lead Set |

HP 1660E/ES/EP Series Ordering Information (Cont.)

Probing Alternatives for HP Benchtop Logic Analyzers

| | |
|----------------|---------------------------------------|
| HP 10467-68701 | 0.5 mm SMD clips (Qty 4) |
| HP E2613A | HP Wedge, 0.5mm, 3 signal (Qty1) |
| HP E2613B | HP Wedge, 0.5mm, 3 signal (Qty 2) |
| HP E2614A | HP Wedge, 0.5mm, 8 signal (Qty 1) |
| HP E2615A | HP Wedge, 0.65mm, 3 signal (Qty1) |
| HP E2615B | HP Wedge, 0.65mm, 3 signal (Qty 2) |
| HP E2616A | HP Wedge, 0.65mm, 8 signal (Qty. 1) |
| HP E5346A | High Density Termination Adapter |
| HP E5346-44701 | Shroud for High Density T.A. |
| HP E5346-68701 | Mictor High Density Connector (Qty 5) |
| HP 01650-63203 | Normal Density Termination Adapter |
| HP 1251-8106 | Normal Density 20-pin Connector |

Optional Oscilloscope Probes for HP 1660ES Series Logic Analyzers

| | |
|----------|-----------------------------------|
| HP 1145A | 2 Channel, 750 MHz Active Probes |
| HP 1142A | External Power Supply for HP 1145 |

Testmobiles for HP Benchtop Logic Analyzers

| | |
|----------|---------------------|
| HP 1182A | Standard Testmobile |
| HP 1184A | Deluxe Testmobile |

Accessories for HP Benchtop Logic Analyzers

| | |
|--------------|-------------------------------------|
| HP E2427B | DIN (PC-Style) Keyboard |
| HP E2427A | HIL Keyboard (HP 1664A only) |
| HP 1540-1066 | Soft Carrying Case |
| HP 5062-7379 | Rack Mount Kit (same as option ICM) |

HP 1660E Series Post Purchase Upgrades

The following two upgrades can be added to an HP 1660E Series logic analyzer at a later date if the additional functionality is desired.

| | |
|------------|--|
| HP E2460ES | Upgrade to add two-channel, 500-MHz bandwidth, 2-GSa/s, 32k memory oscilloscope to an HP 1660E Series model |
| HP E2495A | Upgrade to add thirty-two channel, 100 MVectors/sec, 256k memory pattern generator to an HP 1660E Series model |

Replacement Part Numbers for Logic Analyzer Probes

| | |
|----------------|--|
| HP 5959-9333 | Five gray probe leads |
| HP 5959-9334 | Five short ground leads |
| HP 01650-61608 | 16-Channel probe lead set |
| HP 5090-4356 | Surface-mount grabbers (package of 20) |
| HP 5959-0288 | Throughhole grabbers (package of 20) |

Replacement Model Numbers for Pattern Generator Probing

As a convenience, the individual model numbers for the HP 1660EP series pattern generator clock/data pods and lead sets are listed here. Normally these are ordered as product options at the time of purchase. They are listed here for any future needs that may arise.

| | |
|-----------|---|
| HP 10460A | TTL Clock Pod for the HP 1660EP-Series |
| HP 10461A | 8-channel TTL Data Pod for the HP 1660EP-Series |
| HP 10462A | 8-channel 3-state TTL/CMOS Data Pod for the HP 1660EP-Series |
| HP 10463A | ECL Clock Pod for the HP 1660EP-Series |
| HP 10464A | 8-channel ECL (terminated) Data Pod for the HP 1660EP-Series |
| HP 10465A | 8-channel ECL (unterminated) Data Pod for the HP 1660EP-Series (use HP 10347A lead set) |
| HP 10466A | 8-channel 3-state TTL/3.3V Data Pod for the HP 1660EP-Series |
| HP 10474A | 8-channel Probe Lead Set for the HP 1660EP-Series |
| HP 10347A | 8-channel (50-ohm Coaxial) Probe Lead Set |

Related HP Literature

| Title | Publication Description | HP Pub. Number |
|---|-------------------------|----------------|
| <i>Logic Analysis and Emulation Solutions Version 3.0</i> | CD-Rom | 5965-7502E |
| <i>Processor and Bus Support for HP Logic Analyzers</i> | Configuration Guide | 5966-4365E |

Warranty Information

All Hewlett-Packard products described in this document are warranted against defects in material and workmanship for a period of one year from date of shipment. Three-year and five-year return-to-HP repair services are also available. Refer to individual product manuals for detailed descriptions and terms of warranty. As an added benefit to HP 1664A customers, this product comes standard with a three-year return to HP warranty.

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For more information about Hewlett-Packard test and measurement products, applications and services, visit our web site:

<http://www.hp.com/go/tmdir>.

For more information on HP 1660 and 1670E-Series benchtop logic analyzers, visit our website:

<http://www.hp.com/go/benchtopLA>.

You can also contact one of the following centers and ask for a test and measurement sales representative. If you plan to purchase a new logic analyzer within the next 3 months and have budget approved for the purchase, HP can arrange for you to test drive a unit.

United States:

Hewlett-Packard Company
Test and Measurement Call Center
P.O. Box 4026
Englewood, CO 80155-4026
1 800 452 4844

Canada:

Hewlett-Packard Canada Ltd.
5150 Spectrum Way
Mississauga, Ontario
L4W 5G1
(905) 206 4725

Europe:

Hewlett-Packard
European Marketing Centre
P.O. Box 999
1180 AZ Amstelveen
The Netherlands
(31 20) 547 9900

Japan:

Hewlett-Packard Japan Ltd.
Measurement Assistance Center
9-1, Takakura-Cho, Hachioji-Shi,
Tokyo 192-8510, Japan
(81) 426 56 7832

Latin America:

Hewlett-Packard
Latin American Region Headquarters
5200 Blue Lagoon Drive
9th Floor
Miami, Florida 33126
U.S.A.
(305) 267 4245/4220

Australia/New Zealand:

Hewlett-Packard Australia Ltd.
31-41 Joseph Street
Blackburn, Victoria 3130
Australia
1 800 629 485 (Australia)
0 800 738 378 (New Zealand)

Asia Pacific:

Hewlett-Packard Asia Pacific Ltd
17-21/F Shell Tower, Times Square,
1 Matheson Street, Causeway Bay,
Hong Kong
(852) 2599 7777

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