Keysight Technologies E5400-Pro Series Soft Touch Connectorless Probes

User's Guide

KEYSIGHT TECHNOLOGIES

Notices

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CAUTION

A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Contents

6 Recommended Reading

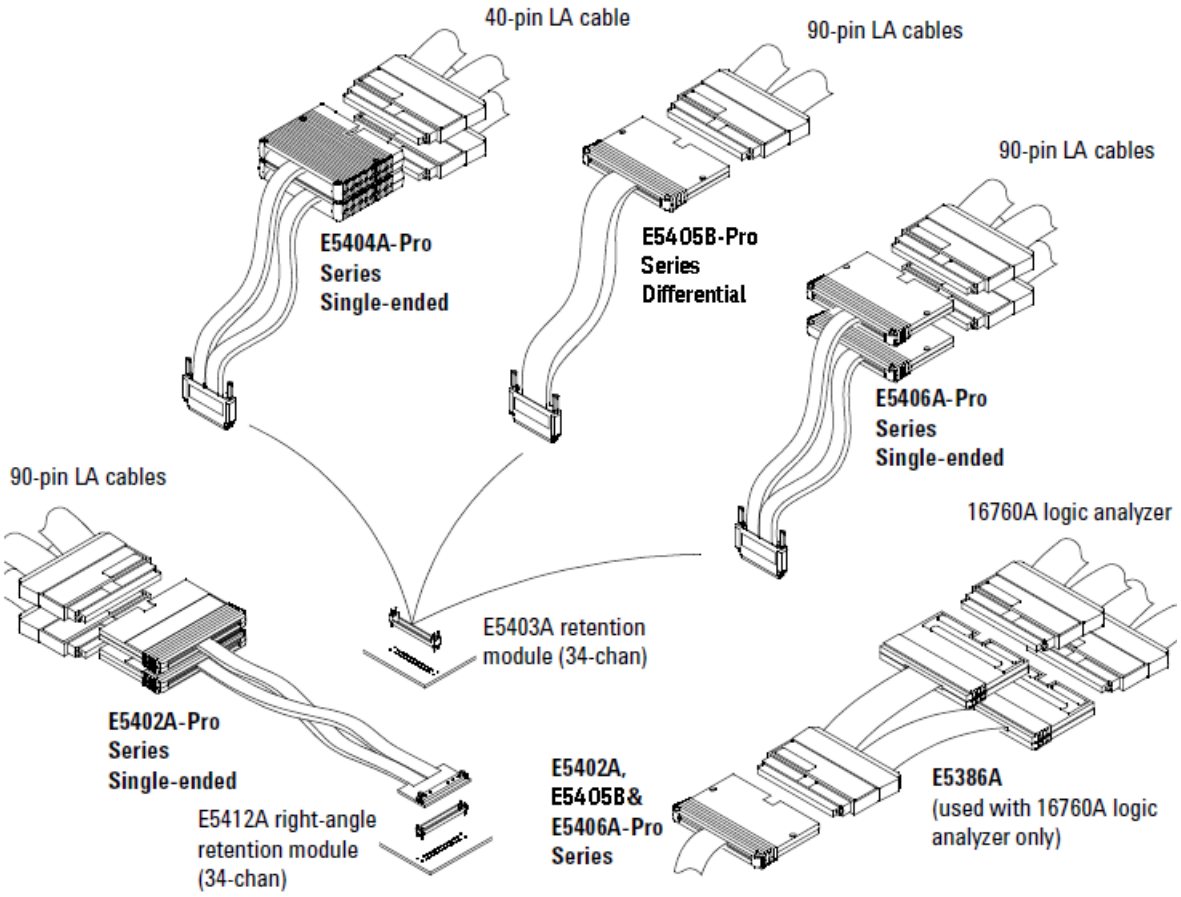
Keysight E5400-Pro Series Soft Touch Connectorless Probes

User's Guide

1 Overview, Installation, and Selection of Probing Options

KEYSIGHT TECHNOLOGIES

The E5400-Pro Series Soft Touch Probes — at a Glance



The new Keysight E5400-pro series soft touch probes are ultra-low-load connector-less probes that work with the Keysight logic analysis modules. The probes attach to the PC board using a retention module which ensures pin-to-pad alignment and holds the probe in place.

- The E5402A-pro series probe is a low-profile right-angle 34-channel single-ended connector-less soft touch probe (for analyzers with 90-pin cable connectors).

- The E5404A-pro series probe is a 34-channel single-ended connector-less soft touch probe (for analyzers with 40-pin cable connectors).
- The E5405B-pro series probe is a 17-channel differential connector-less soft touch probe (for analyzers with 90-pin cable connectors).
- The E5406A-pro series probe is a 34-channel single-ended connector-less soft touch probe (for analyzers with 90-pin cable connectors).

Use the following information to design your target system board for use with the Keysight soft touch probes.

Installation Instructions

1 Use the information provided in Chapter 2 to design pads on your board and holes for mounting the retention module.

The soft touch probes are attached to the PC board using a retention module which ensures pin-to-pad alignment and holds the probe in place.

2 Use flux as necessary to clean the board and pins before soldering the retention module to the board.

3 If your board has Organic Solder Preservative (OSP) finish, apply solder paste to the footprint pads prior to re-flow or hand soldering.

Typically, dipped and coated finishes do not require extra solder paste.

4 Attach the retention module to the board from either the top or bottom of the board:

Top-side attach

Can be used with most board thicknesses.

a Insert the retention module into the board noting the keying pin.

b Solder alignment pins from the top ensuring that solder is added until a fillet is visible on the pin.

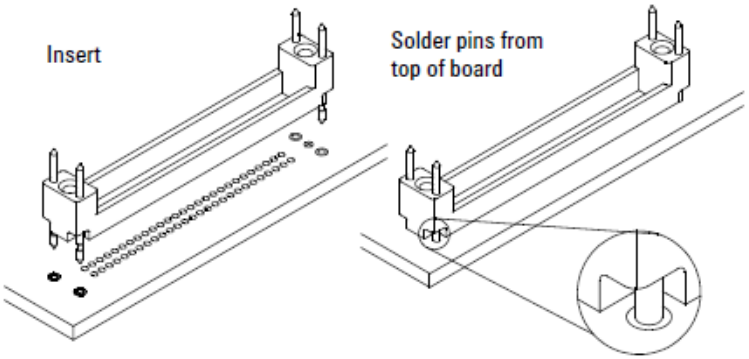


Figure 1 Solder retention module from the top.

Bottom-side attach

Can be used for board thickness of 2.54 mm (0.100 in.) or less.

a Insert the retention module into the board noting the keying pin.

b Solder the alignment pins to the back side of the board.

5 Insert the probe into the retention module.

Ensure proper keying by aligning the Keysight logo on the probe with the one on the retention module and place the probe end into the retention module.

6 Alternate turning each screw on the probe a little until both screws are finger tight like you would attach a cable to your PC.

Selection of Probing Options

This chapter provides descriptions of the logic analyzer probes and adapters to help you select the appropriate probe for your application. The first table shows how many probes are required to provide connections to all channels of your logic analyzer module. The second table gives you the maximum state speed that is supported by the combination of a probe and your logic analyzer module.

Table 1 Number of Probes Required

Keysight Probe	Keysight Logic Analyzer Module						
	16760A	16753A, 16754A, 16755A, 16756A, 16950A	1670 Series (34ch), 1680/90 Series (34ch)	1670 Series (68ch), 1680/90 Series (68ch), 16715/16/17A, 16740/41/42A, 16750/51/52A& B, 16911A	1670 Series (102ch), 1680/90 Series (102ch), 16710/11/12A, 16910A	1670 Series (136ch), 1680/90 Series (136ch)	U4154A U4154B U4164A
E5402A right-angle 34-channel single-ended soft touch probe (90-pin)	1	2	n/a	n/a	n/a	n/a	n/a
E5404A 34-channel single-ended soft touch probe (40-pin)	n/a	n/a	1	2	3	4	n/a
E5405B 17-channel differential soft touch probe (90-pin)	2	4	n/a	n/a	n/a	n/a	4
E5406A 34-channel single-ended soft touch probe (90-pin)	1	2	n/a	n/a	n/a	n/a	2

Table 2 Maximum State Speed Supported

Probe	Logic Analyzer Module			
	16760A	16753A, 16754A, 16755A, 16756A 16950A	1670 Series 1680/90 Series, 16710/11/12A, 16715/16/17A, 16740/41/4A, 16750/51/52A&B	16910A/16911A
E5402A right-angle 34-channel single-ended soft touch probe	1.5 Gb/s	800 Mb/s	n/a	n/a
E5404A 34-channel single-ended soft touch probe	n/a	n/a	400 Mb/s	500 Mb/s
E5405B 17-channel differential soft touch probe	1.5 Gb/s	800 Mb/s	n/a	n/a
E5406A 34-channel single-ended soft touch probe	1.5 Gb/s	800 Mb/s	n/a	n/a

Retention Modules

A retention module ensures pin-to-pad alignment and holds the probe in place. A kit of five retention modules is supplied with each probe. Additional kits (of 5) can be ordered from Keysight Technologies at http://www.keysight.com/find/softtouch/.

Table 3 Ordering retention modules

Probe	Keysight Model Number (kit of 5)
E5402A right-angle 34-channel single-ended soft touch probe	E5412A
E5404A 34-channel single-ended soft touch probe	E5403A
E5405B 17-channel differential soft touch probe	E5403A
E5406A 34-channel single-ended soft touch probe	E5403A

The E5402A-Pro Series Low-profile Right-angle 34-channel Single-ended Soft Touch Probe (for analyzers with 90-pin cable connectors)

The Keysight E5402A-pro series probe is a 34-channel, single-ended, soft touch probe compatible with the Keysight logic analysis modules listed in Table 1 on page 12. It is capable of capturing data up to the rated maximum state (synchronous) analysis clock rates of all the supported analyzers, with signal amplitudes as small as 250 mV peak-to-peak. A retention module must be installed on the target system board to attach the probe to the board. There is a key on the retention module that indicates the egress of the cable when the probe is attached.

A kit of five retention modules are supplied with each probe. Refer to "Ordering retention modules" on page 13 for information on ordering more.

See "Mechanical Considerations" on page 19 for information on designing your target system board.

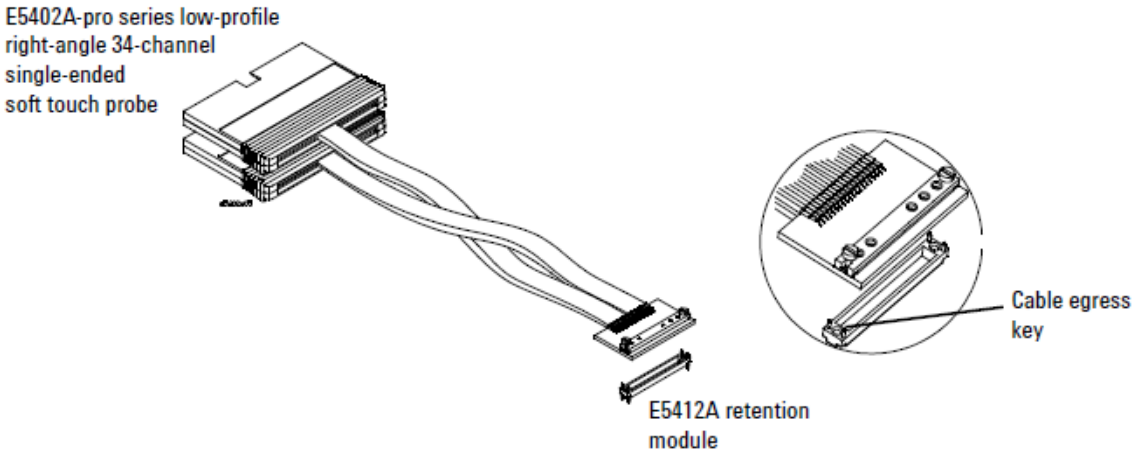


Figure 2 E5402A-pro series right-angle single-ended soft touch probe and E5412A retention module

The E5404A-Pro Series 34-channel Single-ended Soft Touch Probe (for analyzers with 40-pin cable connectors)

The Keysight E5404A-pro series probe is a 34-channel, single-ended, soft touch probe compatible with the Keysight logic analysis modules listed in Table 1 on page 12. It is capable of capturing data up to the rated maximum state (synchronous) analysis clock rates of all the supported analyzers, with signal amplitudes as small as 500 mV peak-to-peak. A retention module must be installed on the target system board to attach the probe to the board.

A kit of five retention modules are supplied with each probe. Refer to "Ordering retention modules" on page 13 for information on ordering more.

See "Mechanical Considerations" on page 19 for information on designing your target system board.

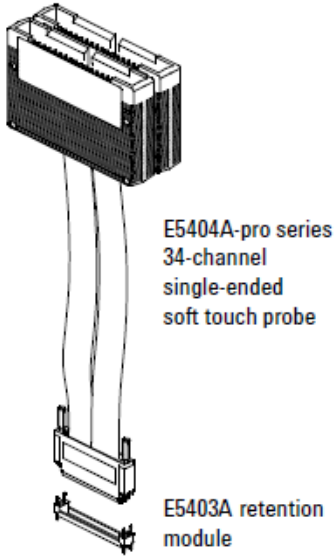


Figure 3 E5404A-pro series single-ended soft touch probe and E5403A retention module

The E5405B-Pro Series 17-channel Differential Soft Touch Probe (for analyzers with 90-pin cable connectors)

The Keysight E5405B-pro series probe is a 17-channel, single-ended, soft touch probe compatible with the Keysight logic analysis modules listed in Table 1 on page 12. It is capable of capturing data up to the rated maximum state (synchronous) analysis clock rates of all the supported analyzers, with differential signal amplitudes as small as 200 mV peak-to-peak. A retention module must be installed on the target system board to attach the probe to the board.

A kit of five retention modules are supplied with each probe. Refer to "Ordering retention modules" on page 13 for information on ordering more.

See "Mechanical Considerations" on page 19 for information on designing your target system board.

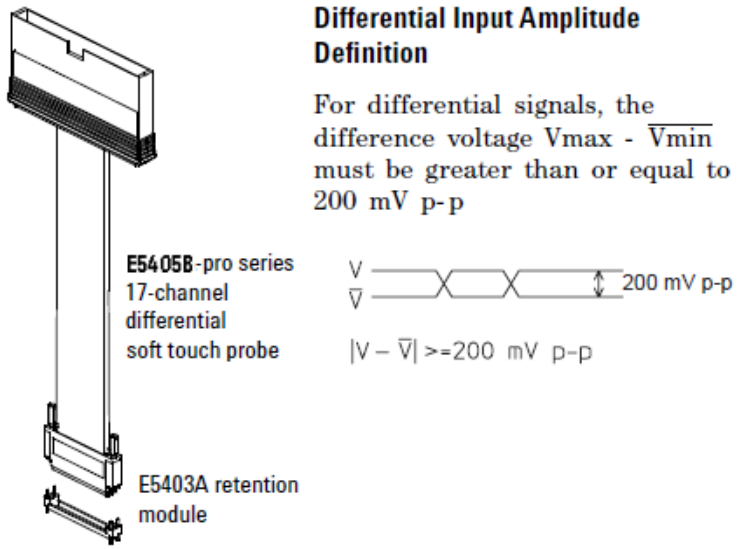


Figure 4 E5405B-pro series differential soft touch probe and E5403A retention module

The E5406A-Pro Series 34-channel Single-ended Soft Touch Probe (for analyzers with 90-pin cable connectors)

The Keysight E5406A-pro series probe is a 34-channel, single-ended, soft touch probe compatible with the Keysight logic analysis modules listed in Table 1 on page 12. It is capable of capturing data up to the rated maximum state (synchronous) analysis clock rates of all the supported analyzers, with signal amplitudes as small as 250 mV peak-to-peak. A retention module must be installed on the target system board to attach the probe to the board.

A kit of five retention modules are supplied with each probe. Refer to "Ordering retention modules" on page 13 for information on ordering more.

See "Mechanical Considerations" on page 19 for information on designing your target system board.

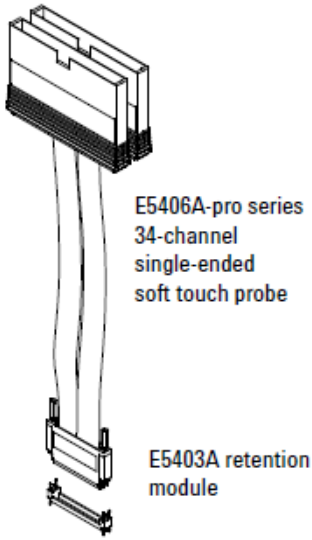
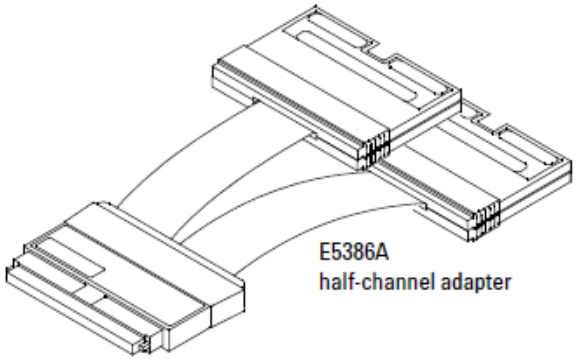


Figure 5 E5406A-pro series single-ended soft touch probe and E5403A retention module

The E5386A Half-channel Adapter (for use with the 16760A logic analyzer)

The E5386A Half-channel Adapter is intended to be used with the Keysight 16760A logic analyzer in half-channel state mode and supports the E5402A, E5405B, and E5406A probes.



The E5386A Half-channel Adapter has its own ID code. When using the adapter, the 16760A logic analyzer recognizes its code rather than that of the probe which is attached to the target. Therefore, the user interface format menu doesn't automatically set thresholds to the proper values. You need to go into the threshold menu and select (differential, custom, or standard settings).

When using the adapter in half-channel state mode:

- Clock-bits are not available in half-channel state mode (although JCLK on the master is still used).
- Be sure to connect Master pod 1 of the logic analyzer to the upper bits, 8-15 + clk, on the half-channel adapter. This is necessary to connect the clock in the system under test to the logic analyzer system clock.
- Using the E5386A does not reduce the performance of the 16760A logic analyzer and the soft touch probes.

If the E5386A is used in full-channel state mode, the thresholds on the unused (odd) bits are floating. This could result in spurious activity indicators in the format menu.

2 Mechanical Considerations

Use the following mechanical information to design your target system board.

Characteristics

Electrical considerations such as equivalent probe loads, input impedance, and time domain transmission are shown in chapters 3 and 4 of this manual. Other characteristics are dependent on the logic analyzer module you are using.

Probe Dimensions

The following figures show the dimensions of the Keysight E5400-pro series soft touch probes.

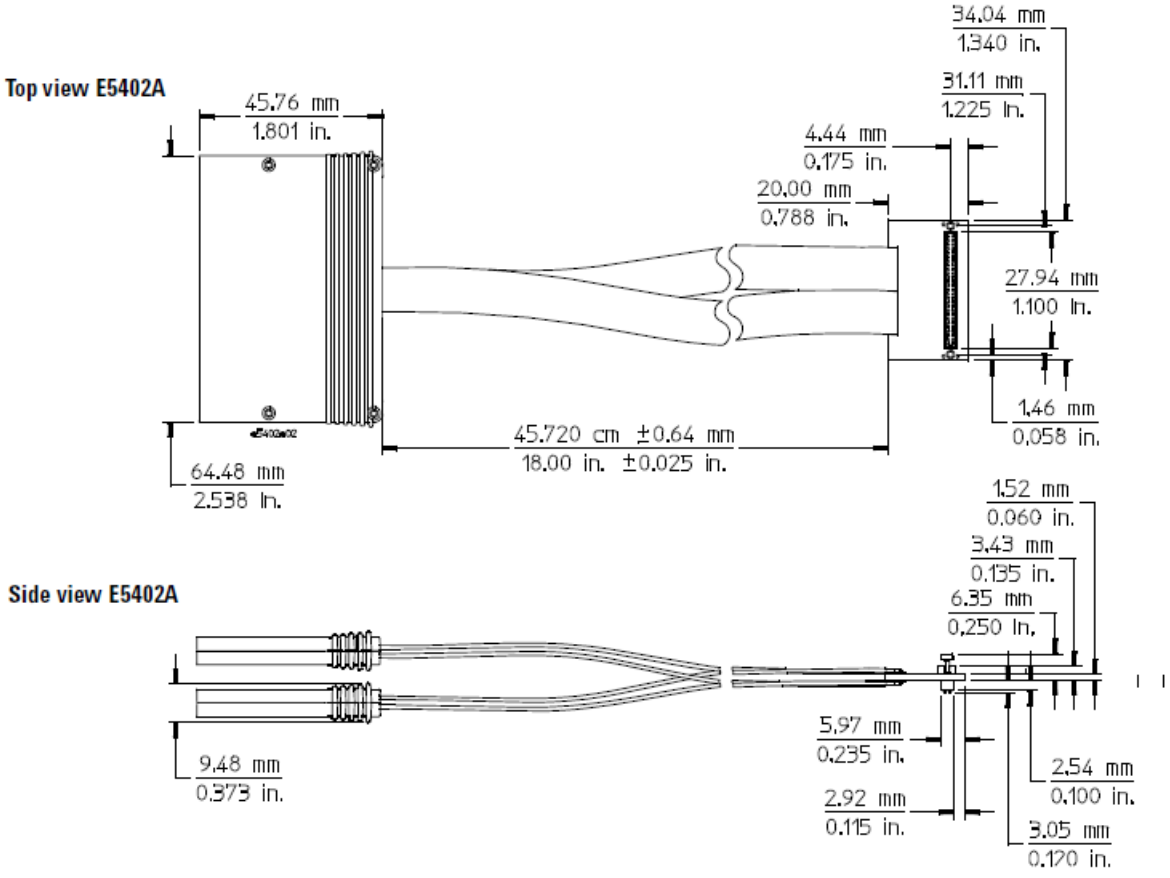


Figure 6 E5402A probe dimensions

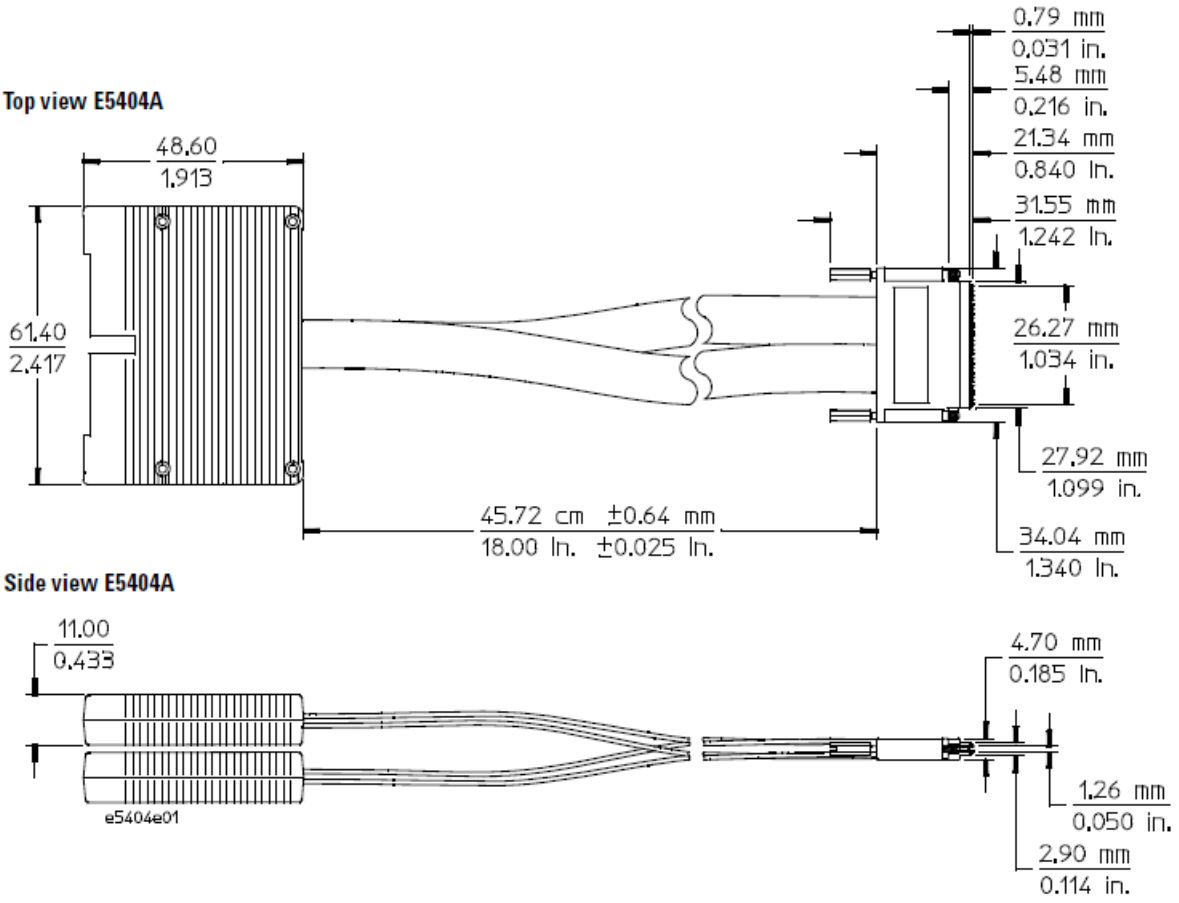


Figure 7 E5404A probe dimensions

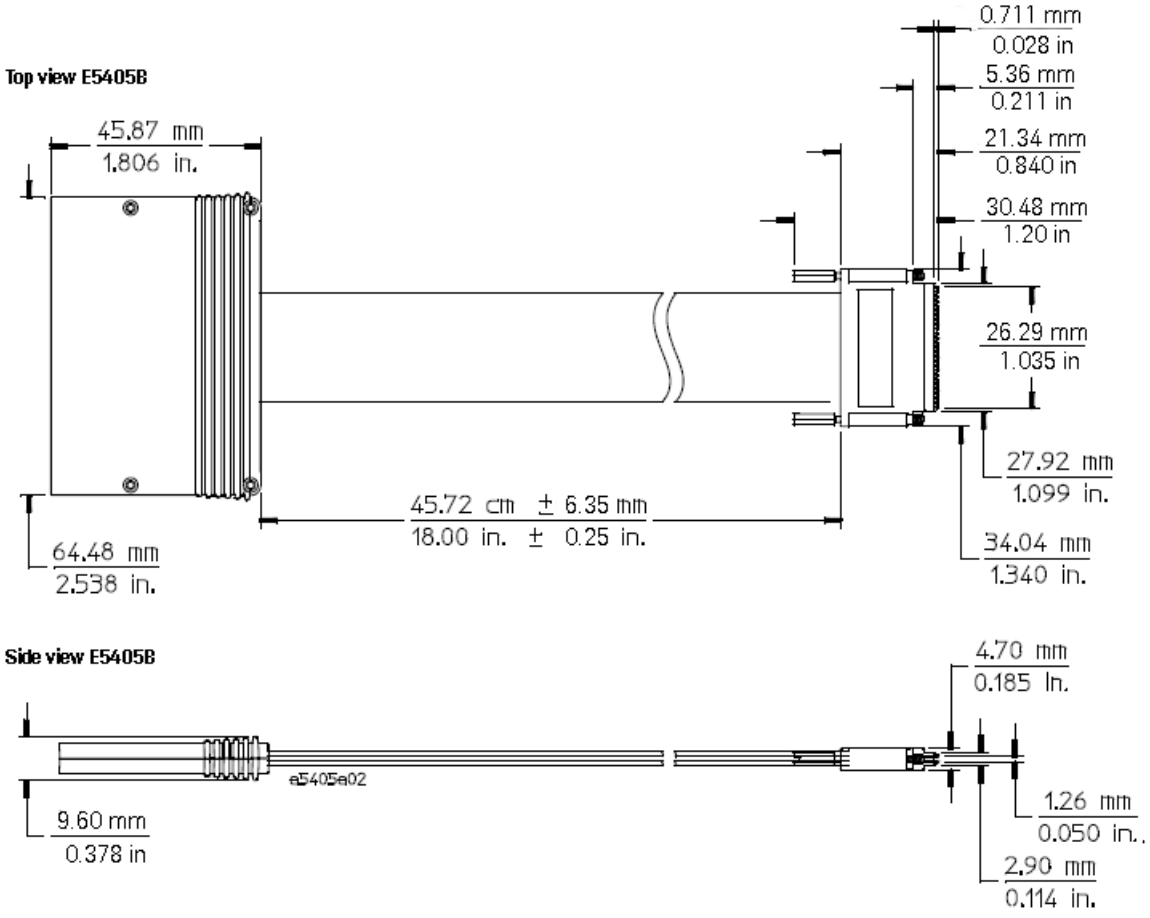


Figure 8 E5405B probe dimensions

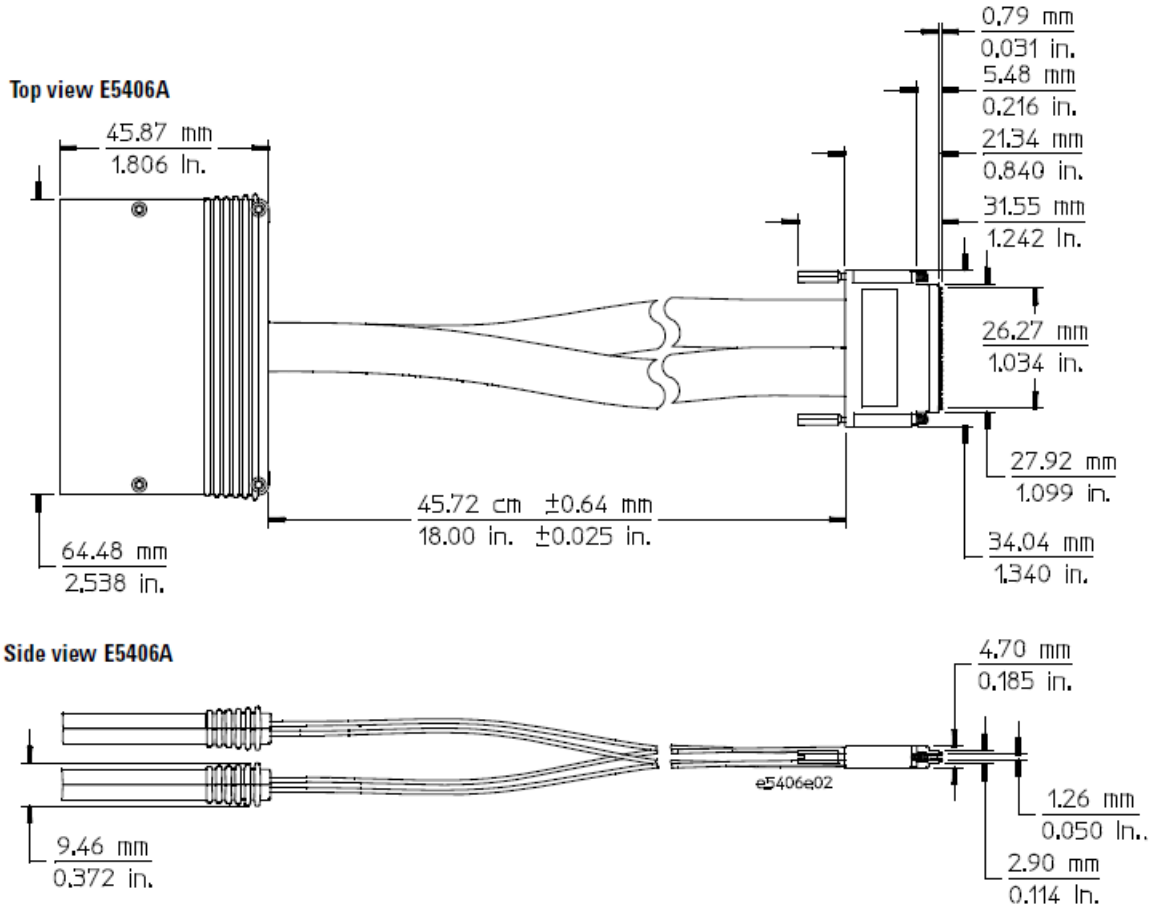


Figure 9 E5406A probe dimensions

Board Layout Dimensions

Use the following dimensions to layout your PC board pads and holes for use with the soft touch probes.

Retention Module Dimensions

NOTE

Unless otherwise specified, dimensions are in inches and have the following tolerances.

Linear

X.X = +-0.1

X.XX = +-0.01

X.XXX = +-0.005

X.XXXX = +-0.0005

Angular

X = +-1

X.X = +-0.5

X.XX = +-0.25

X.XXX = +-0.125

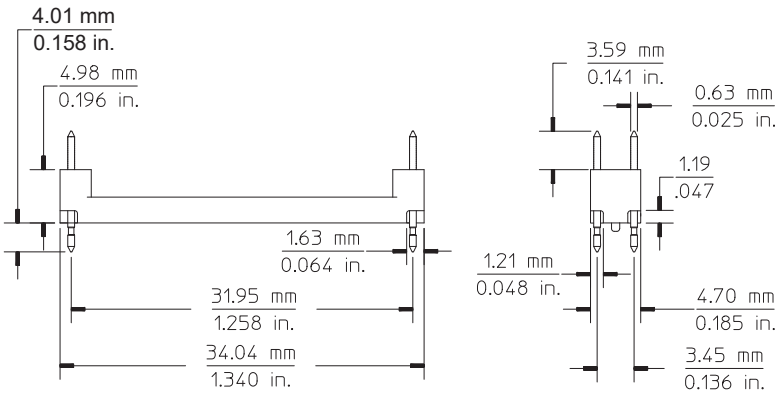


Figure 10 E5403A retention module dimensions

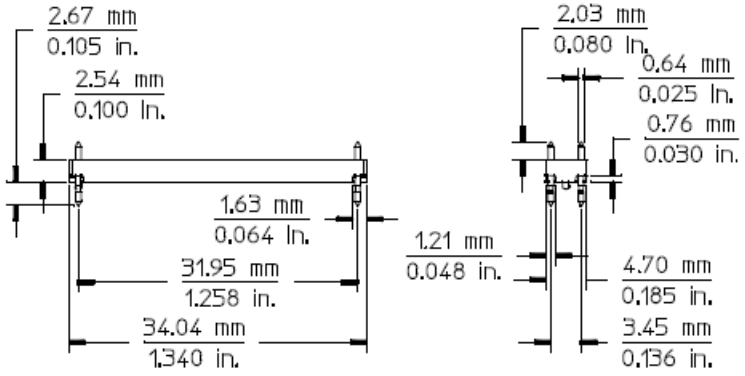


Figure 11 E5412A retention module dimensions

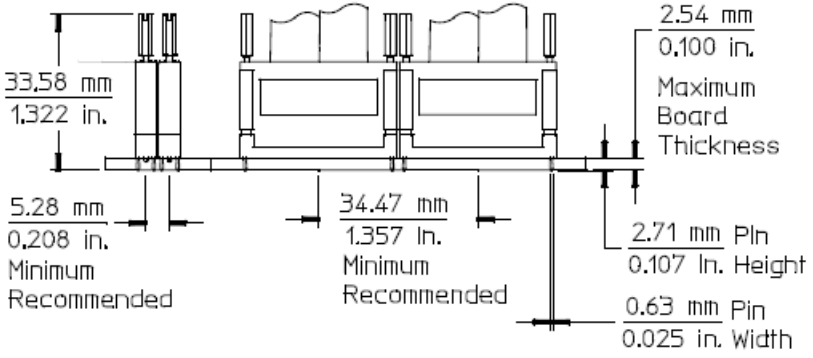
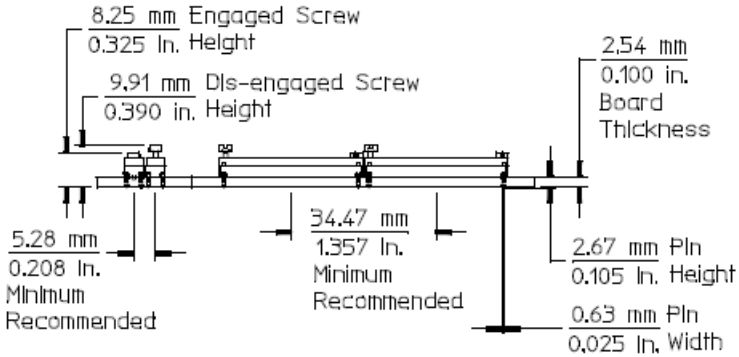


Figure 12 E5403A side-by-side dimensions



Optimal board thickness for this top-side mount retention module is shown above. Retention modules can be hand soldered into thicker boards, but will not form a bottom-side solder fillet.

Figure 13 E5412A side-by-side dimensions

Footprint Dimensions

The retention module alignment is symmetrical around the pad footprint.

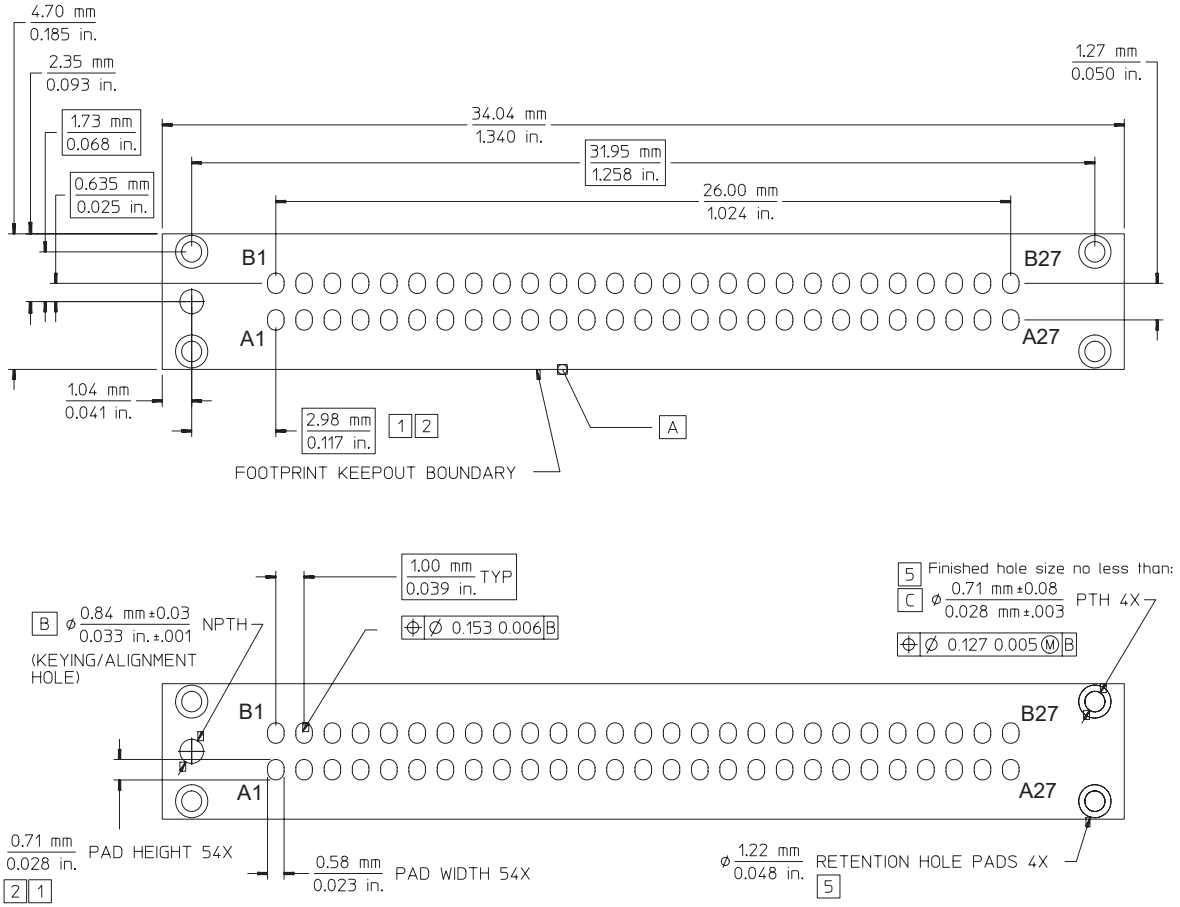


Figure 14 Top view footprint dimensions (drawing notes next page).

NOTE The above view is looking down onto the footprint on the printed-circuit board.

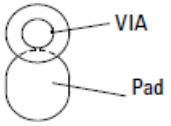
1 Maintain a solder mask web between pads when traces are routed between the pads on the same layer. The solder mask may not encroach onto the pads within the pad dimension shown.

2 VIAs not allowed on these pads. VIA edges may be tangent to pad edges as long as a solder mask web between VIAs and pads is maintained.

3 Surface finishes on pads should be HASL immersion silver, or gold over nickel.

4 This footprint is compatible with retention module Keysight model number E5403A.

5 Plated through hole should not be tied to ground plane for thermal relief.



Pin Outs for the Probes

NOTE

If you will be using the soft touch probes with a 16900-series logic analyzer running V2.5 or higher, probe types can be defined in XML configuration files. To get the latest Probes.xml file, go to www.keysight.com/find/probe-definitions. Install the file in C:\Program Files\Keysight Technologies\Logic Analyzer\AddIns\Keysight\. Refer to the logic analyzer on-line help for more information.

Probing with E5404A-Pro Series Probe

The following footprint provides pin out and pad numbers for the E5404A single-ended probe for use with 40-pin logic analyzers.

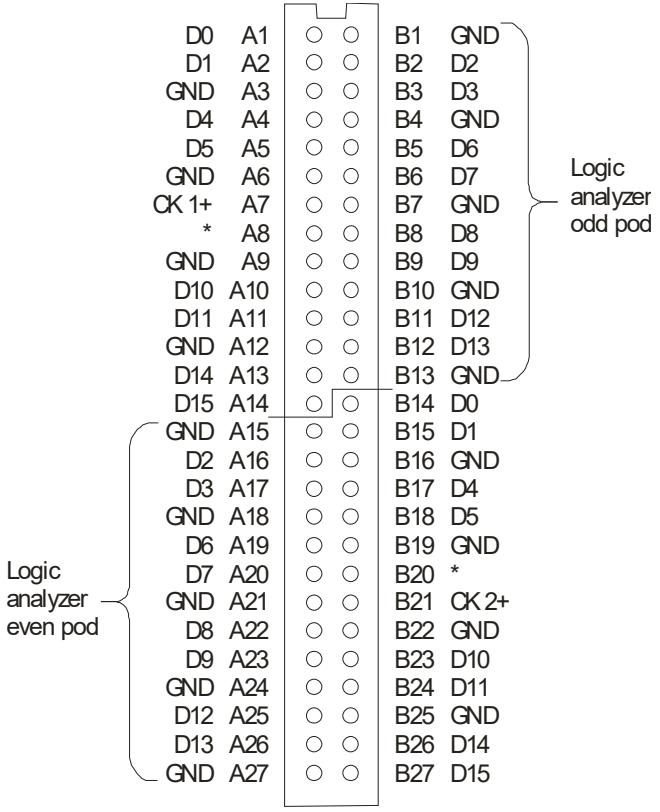


Figure 15 Pad numbers for E5404A-pro series.

* If you only plan to use the E5404A 40-pin probe with single-ended clocking to probe the following footprint, then A8 and B20 are unused. They can be grounded, not connected, left floating, or driven. These pads are not probed with the E5404A probe.

If you ever plan on upgrading from a 40-pin to a 90-pin logic analyzer to take advantage of higher state speed and differential probing on the clock channel, some steps should be taken so that the original footprint will work for both the E5404A and the E5406A probes.

- If you are driving only single-ended clocks into A7 (CK1+) and B21 (CK2+), then you should ground A8 and B20. A8 and B20 are where CK1- and CK2- are driven in the E5406A probe. Grounding these pads will allow the user-defined threshold in the analyzer to be used as in normal single-ended operation.
- If you are using differential clocks, route the Odd pod clock such that the positive side of the pair goes to A7 (CK1+) and the negative side of the pair goes to A8 (CK1-). Similarly, route the Even pod clock such that the positive side of the pair goes to B21 (CK2+) and the negative side of the pair goes to B20 (CK2-). When using the E5404A probe, A8 and B20 are unused. However, when using the E5406A probe, A8 and B20 are where the probe connects to the negative sides of the clocks' differential pair.

E5404A 34-channel Single-ended Probe		Logic Analyzer	
Signal Name	Pad #	Channel	Pod
D0	A1	0	Whichever pod is connected to "Odd" on the E5404A probe
D1	A2	1	
Ground	A3		
D4	A4	4	
D5	A5	5	
Ground	A6		
Clock 1+	A7	Clock	
GND/NC/ Clock 1-	A8	See * pg 30	
Ground	A9		
D10	A10	10	
D11	A11	11	
Ground	A12		
D14	A13	14	
D15	A14	15	

E5404A 34-channel Single-ended Probe		Logic Analyzer	
Signal Name	Pad #	Channel	Pod
Ground	B1		Whichever pod is connected to "Odd" on the E5404A probe
D2	B2	2	
D3	B3	3	
Ground	B4		
D6	B5	6	
D7	B6	7	
Ground	B7		
D8	B8	8	
D9	B9	9	
Ground	B10		
D12	B11	12	
D13	B12	13	
Ground	B13		
D0	B14	0	Whichever pod is connected to "Even" on the E5404A probe

E5404A 34-channel Single-ended Probe		Logic Analyzer		E5404A 34-channel Single-ended Probe		Logic Analyzer	
Signal Name	Pad #	Channel	Pod	Signal Name	Pad #	Channel	Pod
Ground	A15		Whichever pod is connected to "Even" on the E5404A probe	D1	B15 →	1	
D2	A16 →	2		Ground	B16		
D3	A17 →	3		D4	B17 →	4	
Ground	A18			D5	B18 →	5	
D6	A19 →	6		Ground	B19		
D7	A20 →	7		Ground/NC/Clock 2-	B20 →	See * pg 30	
Ground	A21			Clock 2+	B21 →	Clock	
D8	A22 →	8		Ground	B22		
D9	A23 →	9		D10	B23 →	10	
Ground	A24			D11	B24 →	11	
D12	A25 →	12		Ground	B25		
D13	A26 →	13		D14	B26 →	14	
Ground	A27			D15	B27 →	15	

Probing with the E5405B-Pro Series Probe

The following footprint provides pin out and pad numbers for the E5405B differential probe for use with 90-pin logic analyzers.

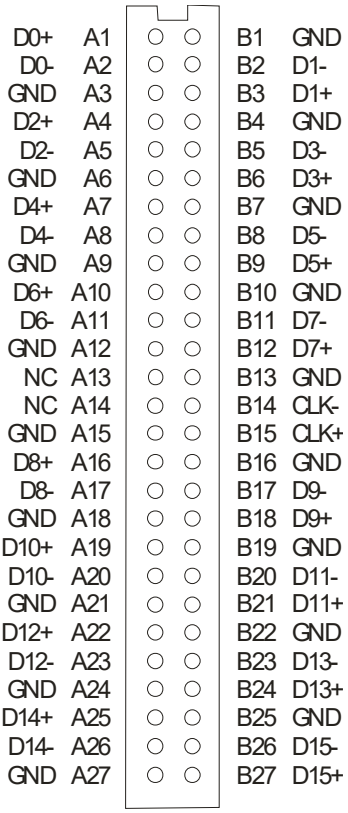


Figure 16 Pad numbers for E5405B-pro series.

E5405B Differential Probe			Logic Analyzer		E5405B Differential Probe			Logic Analyzer	
Signal Name	Pad#		Channel	Pod	Signal Name	Pad#		Channel	Pod
D0 (+)	A1	→	0	Whichever pod is plugged into the E5405B probe	Ground	B1			Whichever pod is plugged into the E5405B probe
D0 (-)	A2				D1 (-)	B2			
Ground	A3				D1 (+)	B3	→	1	

E5405B Differential Probe			Logic Analyzer		E5405B Differential Probe			Logic Analyzer	
Signal Name	Pad#		Channel	Pod	Signal Name	Pad#		Channel	Pod
D2 (+)	A4	→	2		Ground	B4			
D2 (-)	A5				D3 (-)	B5			
Ground	A6				D3 (+)	B6	→	3	
D4 (+)	A7	→	4		Ground	B7			
D4 (-)	A8				D5 (-)	B8			
Ground	A9				D5 (+)	B9	→	5	
D6 (+)	A10	→	6		Ground	B10			
D6 (-)	A11				D7 (-)	B11			
Ground	A12				D7 (+)	B12	→	7	
NC	A13				Ground	B13			
NC	A14				Clock -	B14			
GND	A15				Clock +	B15	→	Clock	
D8 (+)	A16	→	8		Ground	B16			
D8 (-)	A17				D9 (-)	B17			
Ground	A18				D9 (+)	B18	→	9	
D10 (+)	A19	→	10		Ground	B19			
D10 (-)	A20				D11 (-)	B20			
Ground	A21				D11 (+)	B21	→	11	
D12 (+)	A22	→	12		Ground	B22			
D12 (-)	A23				D13 (-)	B23			
Ground	A24				D13 (+)	B24	→	13	
D14 (+)	A25	→	14		Ground	B25			
D14 (-)	A26				D15 (-)	B26			
Ground	A27				D15 (+)	B27	→	15	

Probing with the E5402A/E5406A-Pro Series Probe

The following footprint provides pin out and pad numbers for the E5402A/E5406A single-ended probe for use with 90-pin logic analyzers.

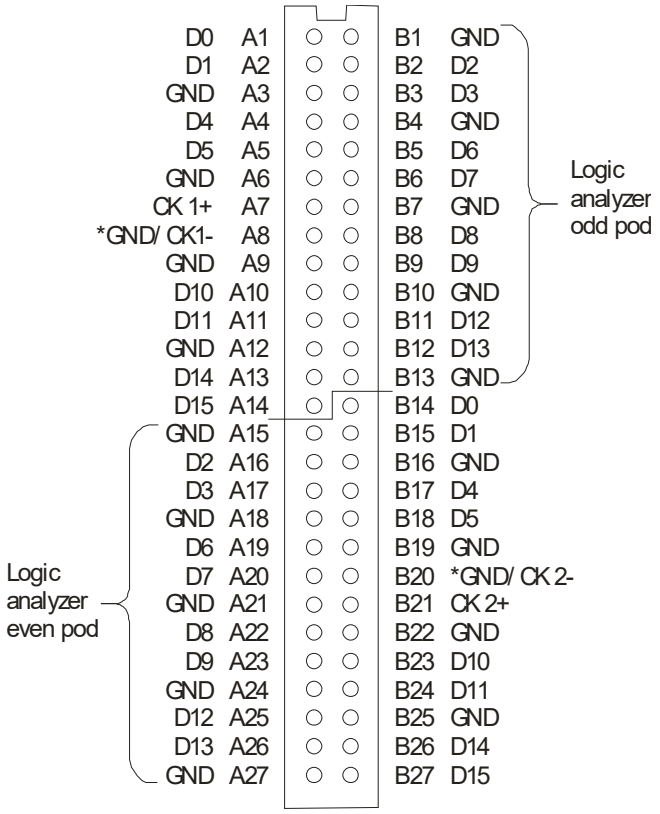


Figure 17 Pad numbers for E5402/E5406A-pro series

E5402A/E5406A 34-channel Single-ended Probe			Logic Analyzer		E5402A/E5406A 34-channel Single-ended Probe			Logic Analyzer	
Signal Name	**Pad #**		**Channel**	**Pod**	**Signal Name**	**Pad #**		**Channel**	**Pod**
D0	A1	→	0	Whichever pod is connected to "Odd" on the 5402A/ E5406A probe	Ground	B1			Whichever pod is connected to "Odd" on the E5402/ E5406A probe
D1	A2	→	1		D2	B2	→	2	
Ground	A3				D3	B3	→	3	
D4	A4	→	4		Ground	B4			
D5	A5	→	5		D6	B5	→	6	
Ground	A6				D7	B6	→	7	
Clock 1+	A7	→	Clock		Ground	B7			
GND/ Clock 1-	A8	→	Clock		D8	B8	→	8	
Ground	A9				D9	B9	→	9	
D10	A10	→	10		Ground	B10			
D11	A11	→	11		D12	B11	→	12	
Ground	A12				D13	B12	→	13	
D14	A13	→	14		Ground	B13			
D15	A14	→	15		D0	B14	→	0	Whichever pod is connected to "Even" on the E5402A/ E5406A probe

E5402A/E5406A 34-channel Single-ended Probe		Logic Analyzer		
Signal Name	Pad #		Channel	Pod
Ground	A15			Whichever pod is connected to "Even" on the E5402A/ E5406A probe
D2	A16	→	2	
D3	A17	→	3	
Ground	A18			
D6	A19	→	6	
D7	A20	→	7	
Ground	A21			
D8	A22	→	8	
D9	A23	→	9	
Ground	A24			
D12	A25	→	12	
D13	A26	→	13	
Ground	A27			

E5402A/E5406A 34-channel Single-ended Probe		Logic Analyzer		
Signal Name	Pad #		Channel	Pod
D1	B15	→	1	
Ground	B16			
D4	B17	→	4	
D5	B18	→	5	
Ground	B19			
Ground/ Clock 2-	B20	→	Clock	
Clock 2+	B21	→	Clock	
Ground	B22			
D10	B23	→	10	
D11	B24	→	11	
Ground	B25			
D14	B26	→	14	
D15	B27	→	15	

E5386A Half-channel Adapter Dimensions

The E5386A half-channel adapter works with the 16760A logic analyzer and the soft touch probes.

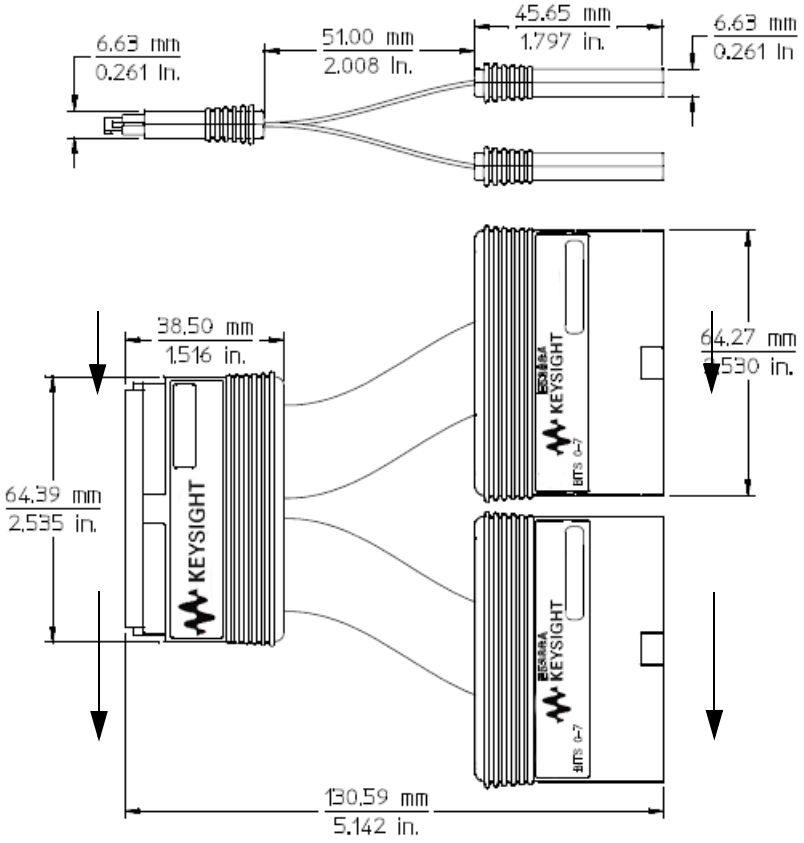


Figure 18 E5386A dimensions

Pin out for the E5386A half-channel adapter when connected to E5405B

When used with the E5405B-pro series differential soft touch probe, you need only one half-channel adapter. The table below shows the pin assignments.

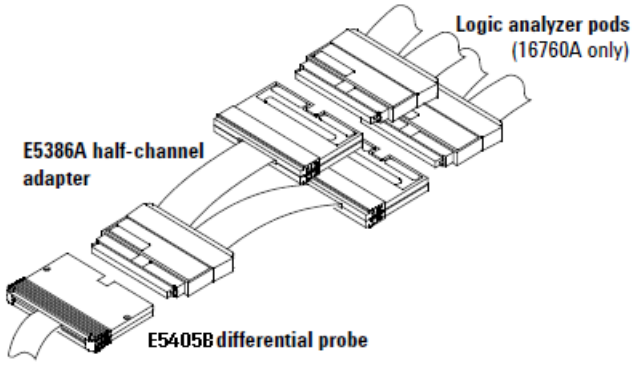


Figure 19 Half-channel adapter with E5405B-pro series

Table 4 Pin-out table for E5386A connected to an E5405B

E5405B Differential Probe						
Negative Signals		Positive Signals			Logic Analyzer	
Signal Name	Pin#	Signal Name	Pin#		Channel	Pod
D0(-)	A2	D0(+)	A1	→	0	Whichever pod is plugged into bits 0-7
D1(-)	B2	D1(+)	B3	→	2	
D2(-)	A5	D2(+)	A4	→	4	
D3(-)	B5	D3(+)	B6	→	6	
D4(-)	A8	D4(+)	A7	→	8	
D5(-)	B8	D5(+)	B9	→	10	
D6(-)	A11	D6(+)	A10	→	12	
D7(-)	B11	D7(+)	B12	→	14	
D8(-)	A17	D8(+)	A16	→	0	Whichever pod is plugged into bits 8-15
D9(-)	B17	D9(+)	B18	→	2	
D10(-)	A20	D10(+)	A19	→	4	
D011(-)	B20	D11(+)	B21	→	6	
D12(-)	A23	D12(+)	A22	→	8	
D13(-)	B23	D13(+)	B24	→	10	
D14(-)	A26	D14(+)	A25	→	12	
D15(-)	B26	D15(+)	B27	→	14	
D16(-)/Clk(-)	B14	D16(+)/Clk(+)	B15	→	Clock	

Pin out for two E5386A half-channel adapters connected to one E5402A or E5406A

When used with the E5402A/E5406A-pro series single-ended soft touch probe, you need two half-channel adapters, one adapter for Odd data and one for Even data. The table below shows the pin assignments.

The E5386A that is connected to the end of the E5402A/E5406A labeled 'odd' becomes the 'odd' E5386A adapter.

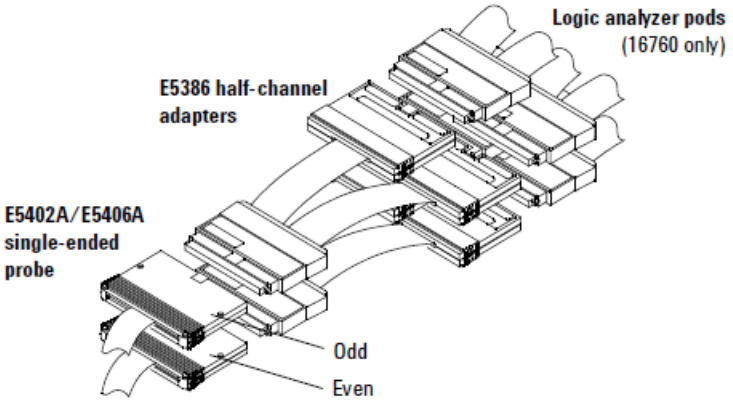


Figure 20 Two half-channel adapters with E5402A/E5406A-pro series

Table 5 Pin-out table for two E5386A adapters connected to an E5402A or E5406A

E5386A Adapter Odd					E5386A Adapter Even				
E5402A/E5406A 34-channel Single-ended Probe			Logic Analyzer		E5402A/E5406A 34-channel Single-ended Probe			Logic Analyzer	
Signal Name	Pin #		Channel	Pod	Signal Name	Pin #		Channel	Pod
D0	A1	→	0	Whichever pod is connected to bits 0-7 on the odd E5386A	D0	B14	→	0	Whichever pod is connected to bits 0-7 on the even E5386A
D1	A2	→	2		D1	B15	→	2	
D2	B2	→	4		D2	A16	→	4	
D3	B3	→	6		D3	A17	→	6	
D4	A4	→	8		D4	B17	→	8	
D5	A5	→	10		D5	B18	→	10	
D6	B5	→	12		D6	A19	→	12	
D7	B6	→	14		D7	A20	→	14	
D8	B8	→	0	Whichever pod is connected to bits 8-15 on the odd E5386A	D8	A22	→	0	Whichever pod is connected to bits 8-15 on the even E5386A
D9	B9	→	2		D9	A23	→	2	
D10	A10	→	4		D10	B23	→	4	
D11	A11	→	6		D11	B24	→	6	
D12	B11	→	8		D12	A25	→	8	
D13	B12	→	10		D13	A26	→	10	
D14	A13	→	12		D14	B26	→	12	
D15	A14	→	14		D15	B27	→	14	
D16(+)/Clk(+)	A7	→	Clock(+)		D16(+)/Clk(+)	B21	→	Clock(+)	
D16(-)/Clk(-)	A8	→	Clock(-)		D16(-)/Clk(-)	B20	→	Clock(-)	

3 Operating the E5404A-Pro Series Probes

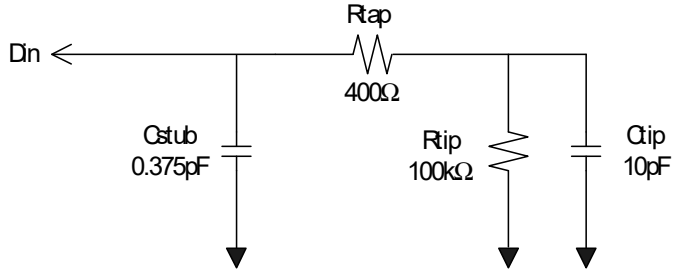
Electrical considerations such as equivalent probe loads, input impedance, and time domain transmission (TDT).

KEYSIGHT TECHNOLOGIES

Equivalent Probe Loads

The following probe load models are based on in-circuit measurements made with a Keysight 8753E 6 GHz network analyzer and a Keysight 54750A TDR/TDT using a 50 Ω test fixture. The following schematic accurately models the probe load out to 6 GHz. The figure on the following page shows the agreement between measured impedance and this model.

Simple
(Does not include capacitive coupling between channels or inductance of the spring pins)



Complex
(Includes capacitive coupling between channels and inductance of spring pins.)

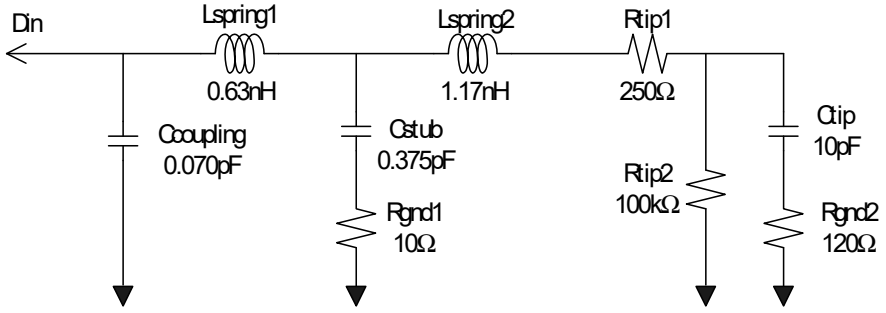


Figure 21 Probe load models (E5404A)

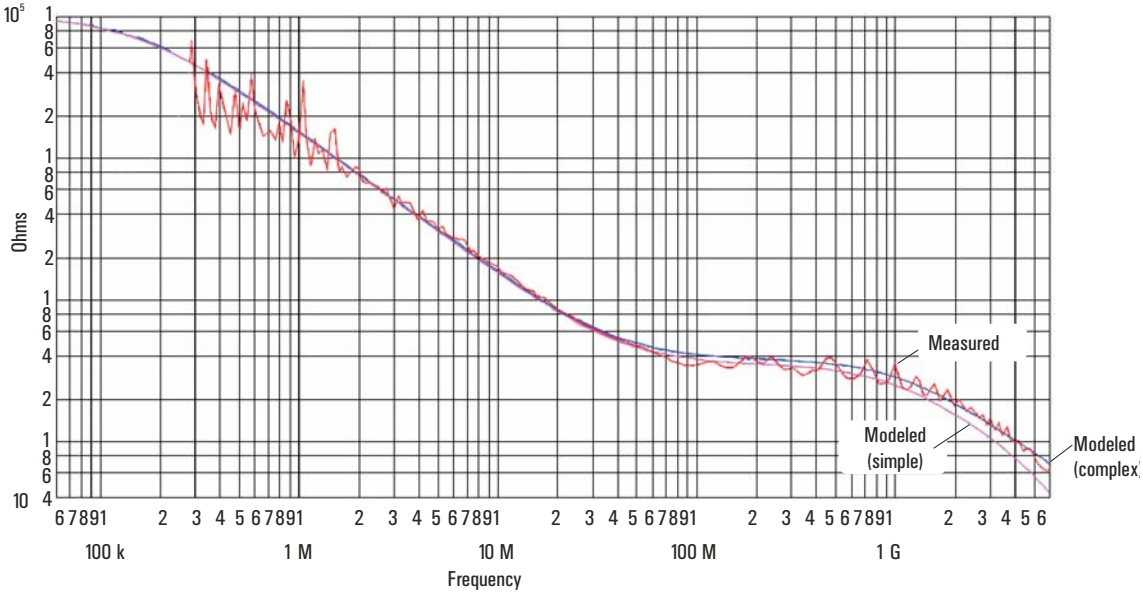


Figure 22 Measured versus modeled input impedance (E5404A)

Time Domain Transmission (TDT)

All probes have a loading effect on the circuit when they come in contact with the circuit. Time domain transmission (TDT) measurements are useful for understanding the probe loading effects as seen at the target receiver. The following TDT measurements were made mid-bus on a 50Ω transmission line load terminated at the receiver. These measurements show how the soft touch probes affect an ideal step seen by the receiver for various rise times.

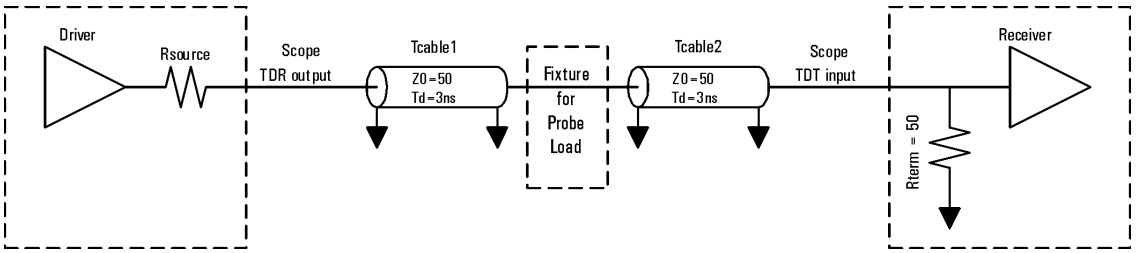


Figure 23 TDT measurement schematic (E5404A)

The following plots were made on a Keysight 54750A oscilloscope using TDT.

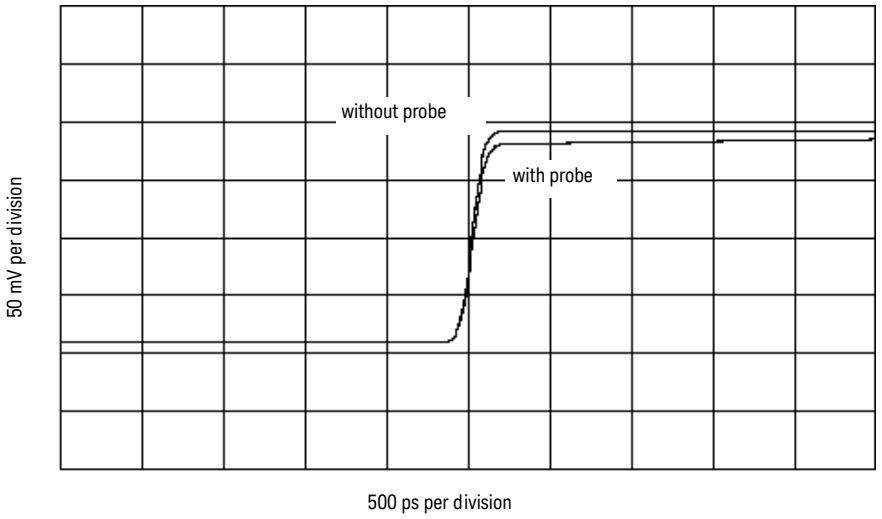


Figure 24 TDT measurement at receiver with and without probe load for 150 ps rise time

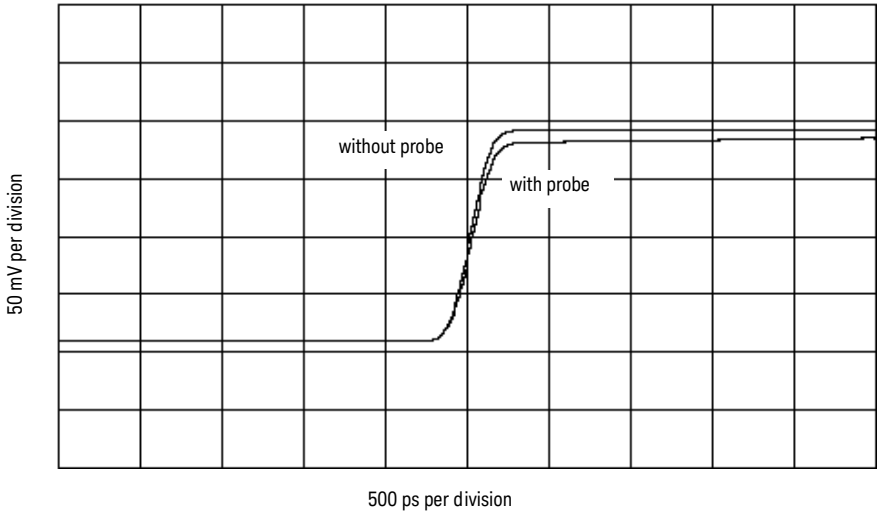


Figure 25 TDT measurement at receiver with and without probe load for 250 ps rise time

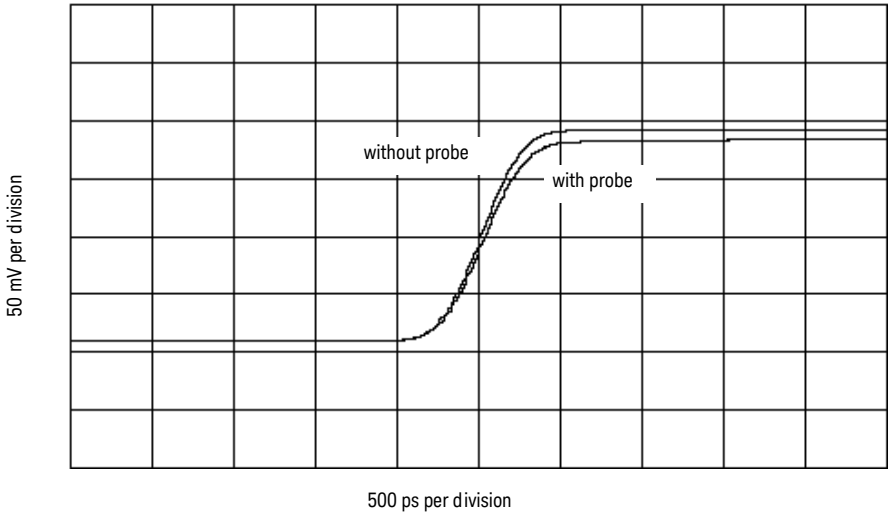


Figure 26 TDT measurement at receiver with and without probe load for 500 ps rise time

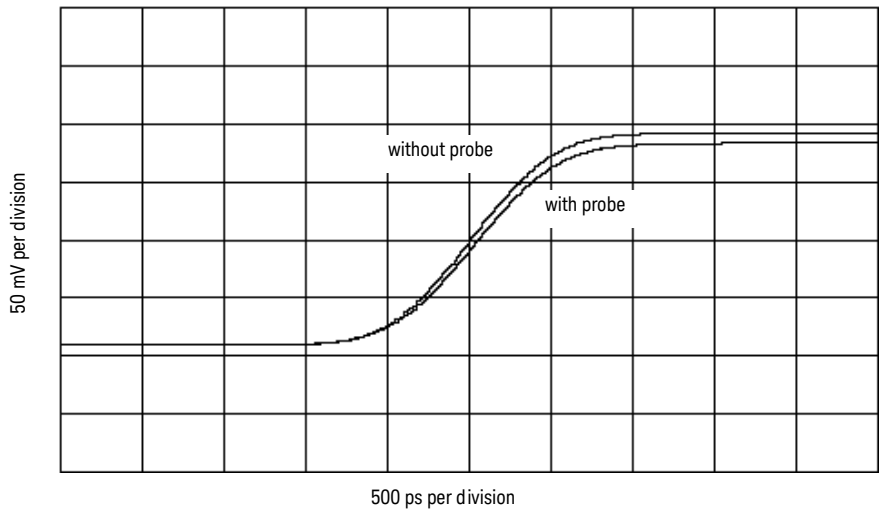


Figure 27 TDT measurement at receiver with and without probe load for 1000 ps rise time

4 Operating the E5402A, E5405B, and E5406A-Pro Series Probes

Electrical considerations such as equivalent probe loads, input impedance, time domain transmission (TDT), step inputs, and eye opening.

KEYSIGHT TECHNOLOGIES

Equivalent Probe Loads

The following probe load models are based on in-circuit measurements made with a Keysight 8753E 6 GHz network analyzer and a Keysight 54750A TDR/TDT using a 50 Ω test fixture. The following schematic accurately models the probe load out to 6 GHz. The figure on the following page shows the agreement between measured impedance and this model. PC board pads are not included.

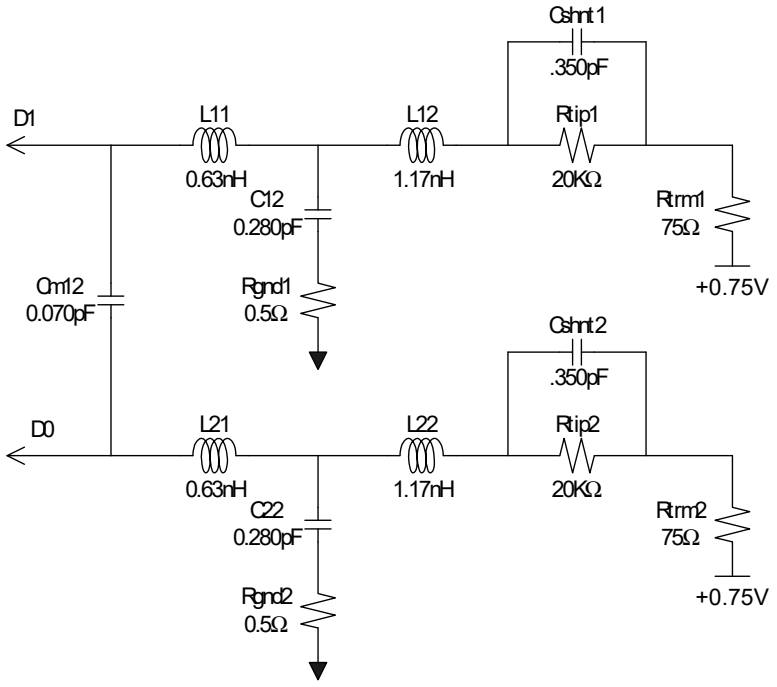


Figure 28 Probe load model (E5402A, E5405B, and E5406A)

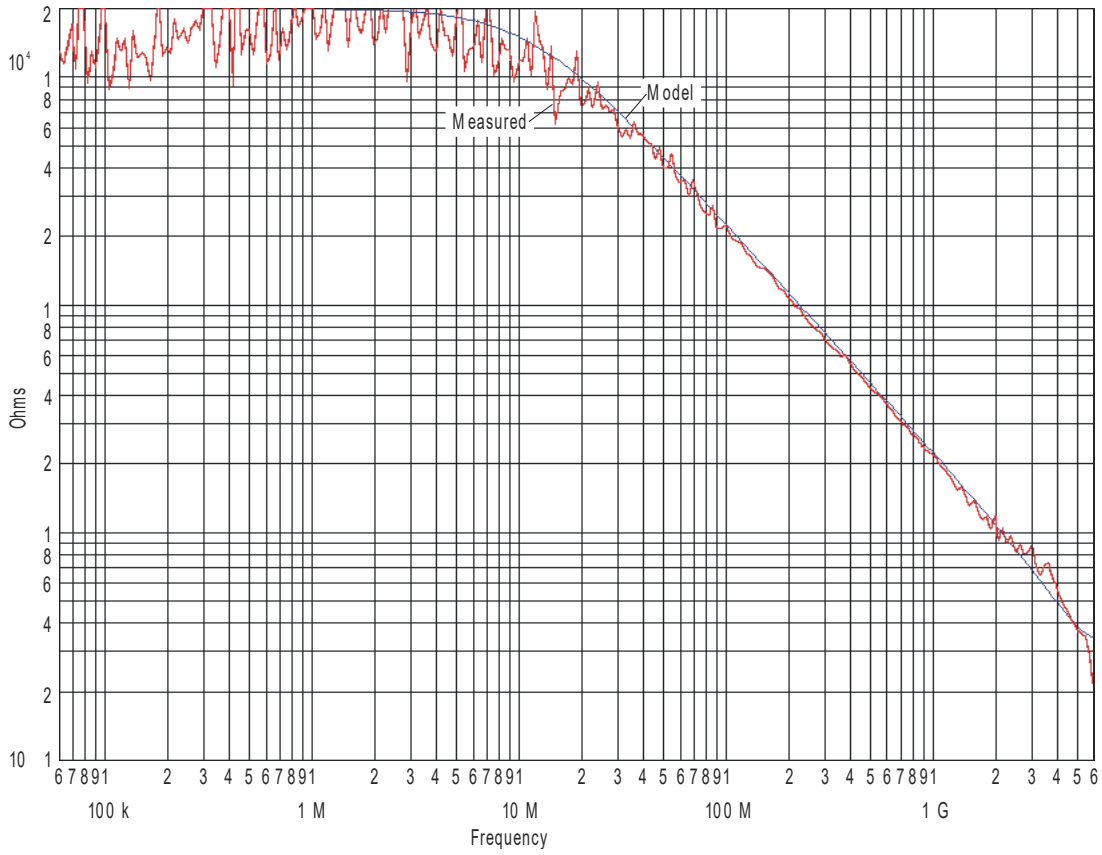


Figure 29 Measured versus modeled input impedance (E5402A, E5404A, and E5406A)

Time Domain Transmission (TDT)

All probes have a loading effect on the circuit when they come in contact with the circuit. Time domain transmission (TDT) measurements are useful for understanding the probe loading effects as seen at the target receiver. The following TDT measurements were made mid-bus on a 50Ω transmission line load terminated at the receiver. These measurements show how the E5402A, E5405B, and E5406A-pro series soft touch probes affect an ideal step seen by the receiver for various rise times.

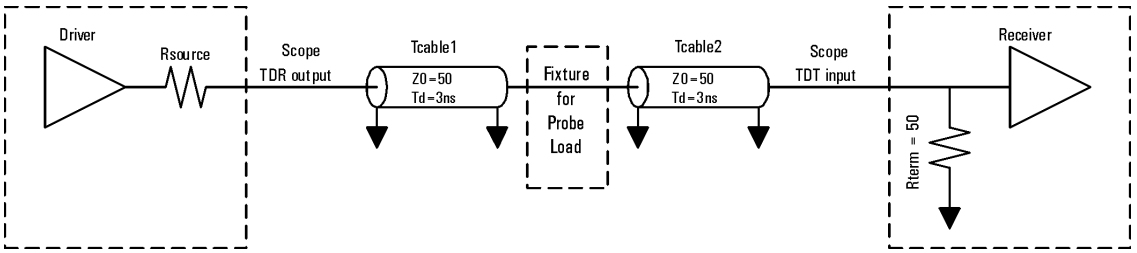


Figure 30 TDT measurement schematic (E5402A, E5405B, and E5406A)

The following plots were made on a Keysight 54750A oscilloscope using TDT.

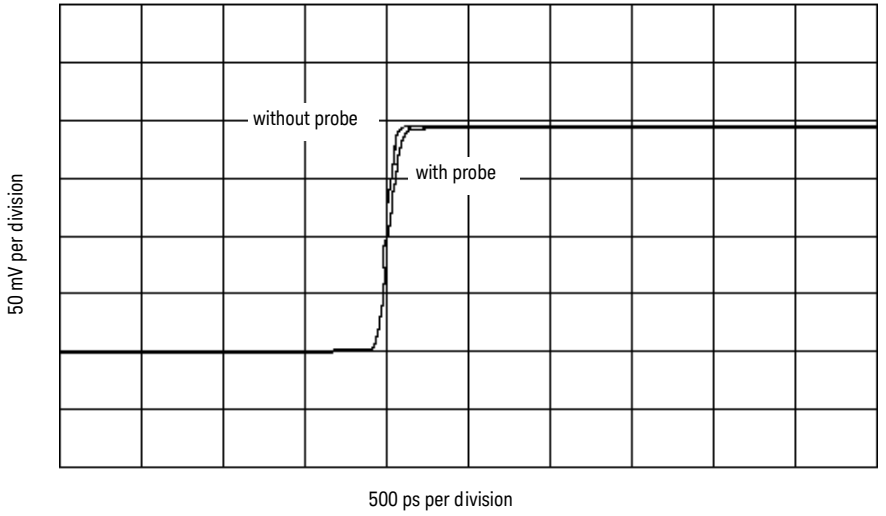


Figure 31 TDT measurement at receiver with and without probe load for 100 ps rise time

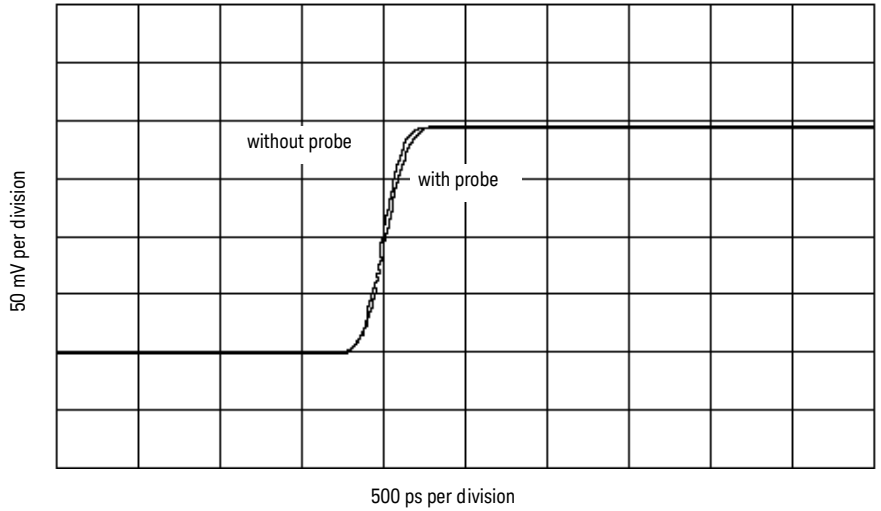


Figure 32 TDT measurement at receiver with and without probe load for 250 ps rise time

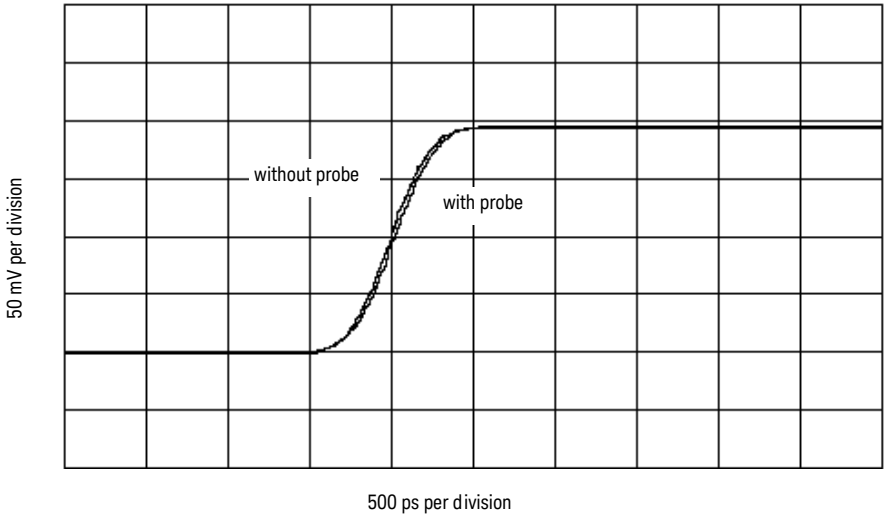


Figure 33 TDT measurement at receiver with and without probe load for 500 ps rise time

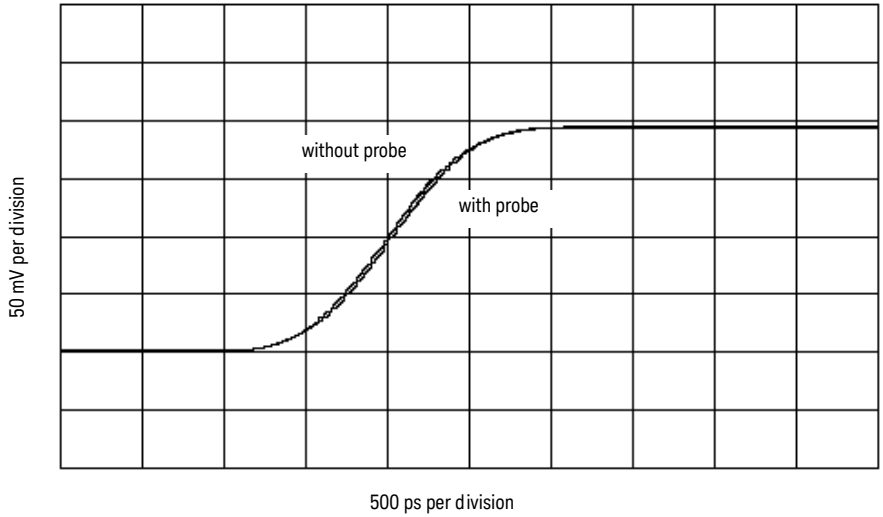


Figure 34 TDT measurement at receiver with and without probe load for 1000 ps rise time

Step Inputs

Maintaining signal fidelity to the logic analyzer is critical if the analyzer is to accurately capture data. One measure of a system's signal fidelity is to compare V_{in} to V_{out} for various step inputs. For the following graphs, V_{in} is the signal at the logic analyzer probe tip. Eye Scan was used to measure V_{out}, the signal seen by the logic analyzer. The measurements were made on a mid-bus connection to a 50Ω transmission line load terminated at the receiver. These measurements show the logic analyzer's response while using the E5402A, E5405B, and E5406A-pro series soft touch probes.

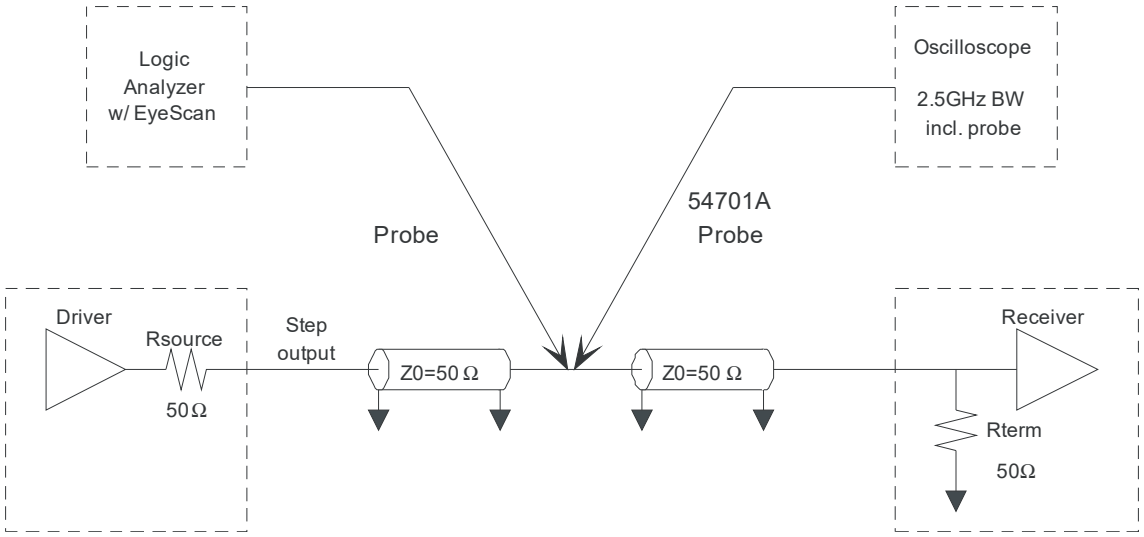


Figure 35 Step input measurement schematic (E5402A, E5405B, and E5406A)

The following plots were made on a Keysight 54750A oscilloscope and a Keysight 16760A logic analyzer using a Keysight 8133A pulse generator with various rise time converters.

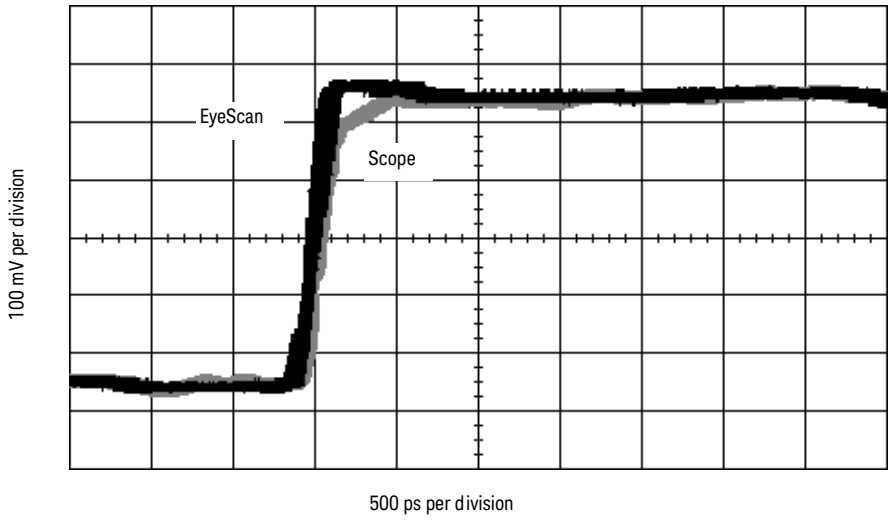


Figure 36 Logic analyzer's response to 150 ps rise time

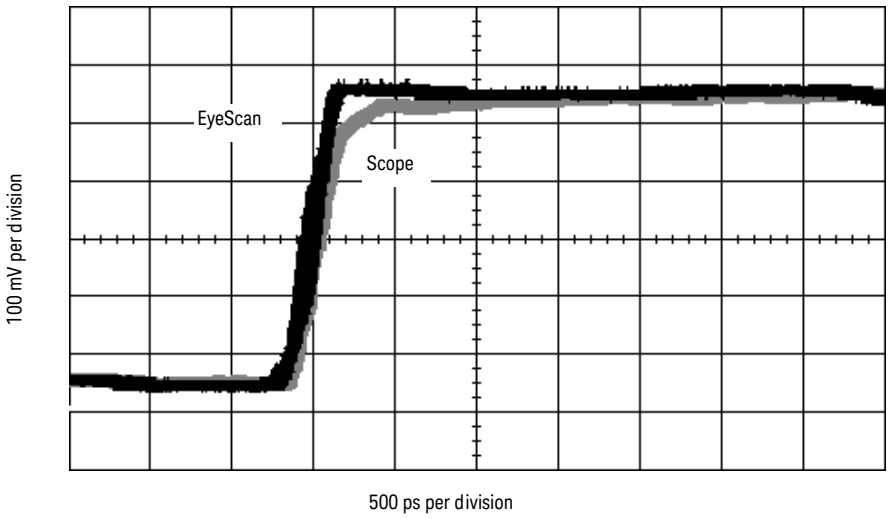


Figure 37 Logic analyzer's response to 250 ps rise time

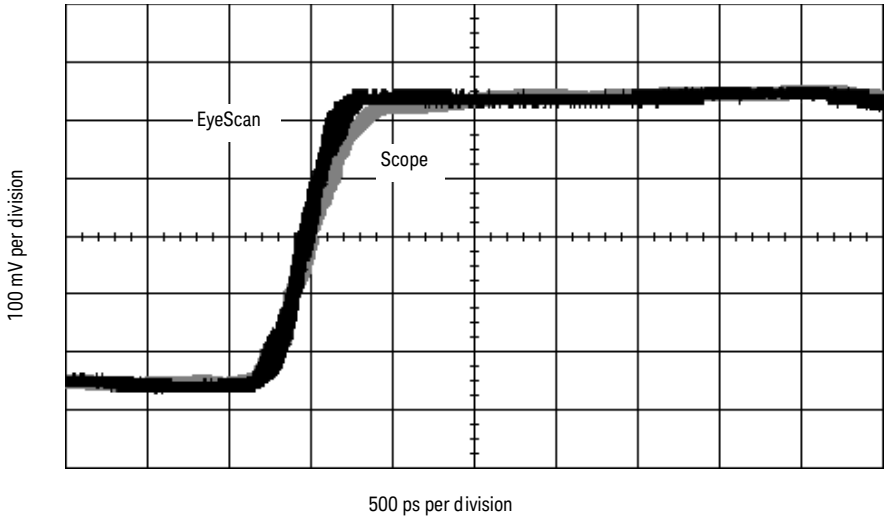


Figure 38 Logic analyzer's response to 500 ps rise time

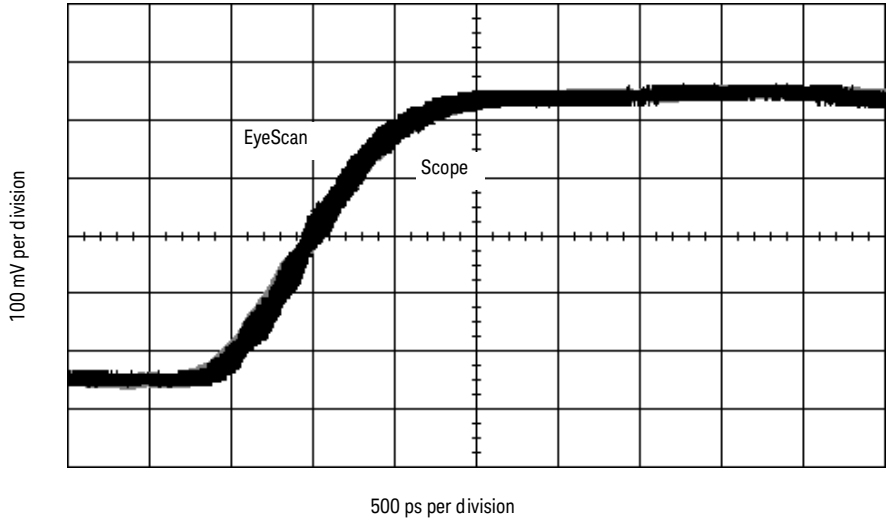


Figure 39 Logic analyzer's response to 1000 ps rise time

Eye Opening

The eye opening at the logic analyzer is the truest measure of an analyzer's ability to accurately capture data. Seeing the eye opening at the logic analyzer is possible with Eye Scan. The eye opening viewed with Eye Scan helps the user know how much margin the logic analyzer has, where to sample and at what threshold. Any probe response that exhibits overshoot, ringing, probe non-flatness, noise, and other issues all deteriorate the eye opening seen by the logic analyzer. The following eye diagrams were measured using E5402A, E5405B, and E5406A-pro series soft touch probes and Eye Scan while probed mid-bus on a 50Ω transmission line load terminated at the receiver. The data patterns were generated using a 2^{23}-1 pseudo random bit sequence (PRBS).

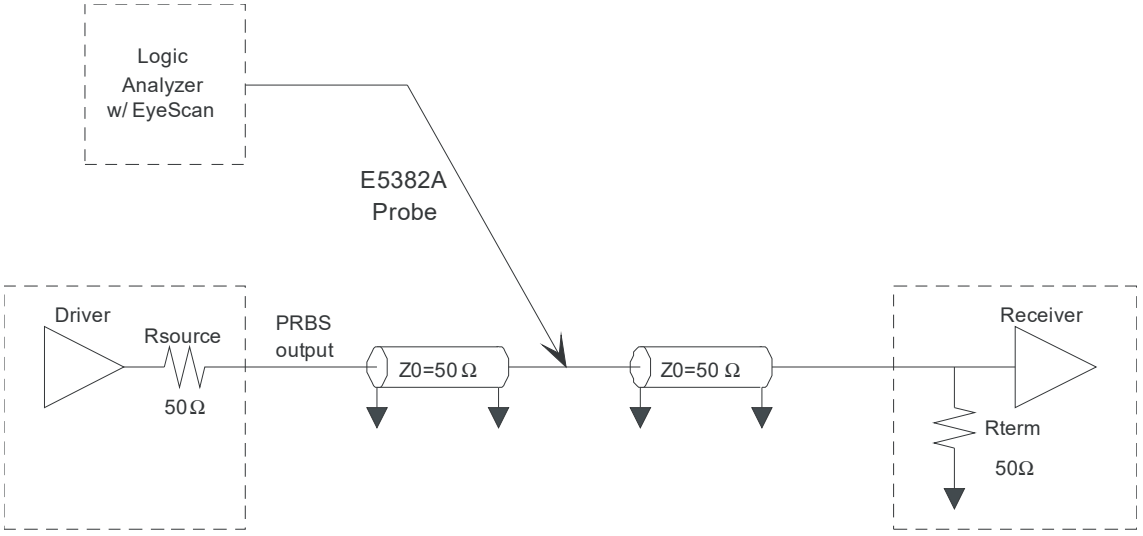


Figure 40 Eye opening measurement schematic (E5402/05/06A)

The following plots were made on a Keysight 16760A logic analyzer using a Keysight 8133A pulse generator with a 250 ps rise time converter. The following measurements use Eye Scan to show the margin at 800, 1250, and 1500MT/s. The amplitudes are indicated in the captions.

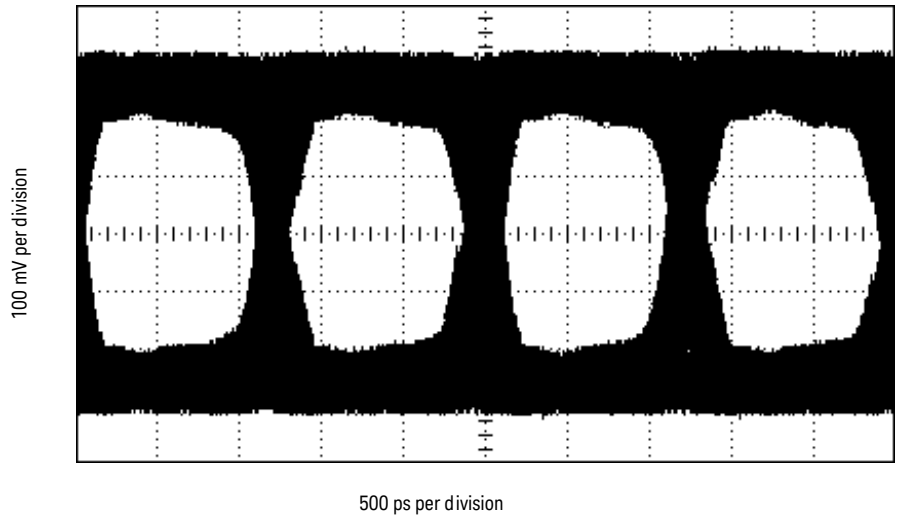


Figure 41 Logic analyzer eye opening for a PRBS signal of 500 mV p-p, 800 MT/s data rate

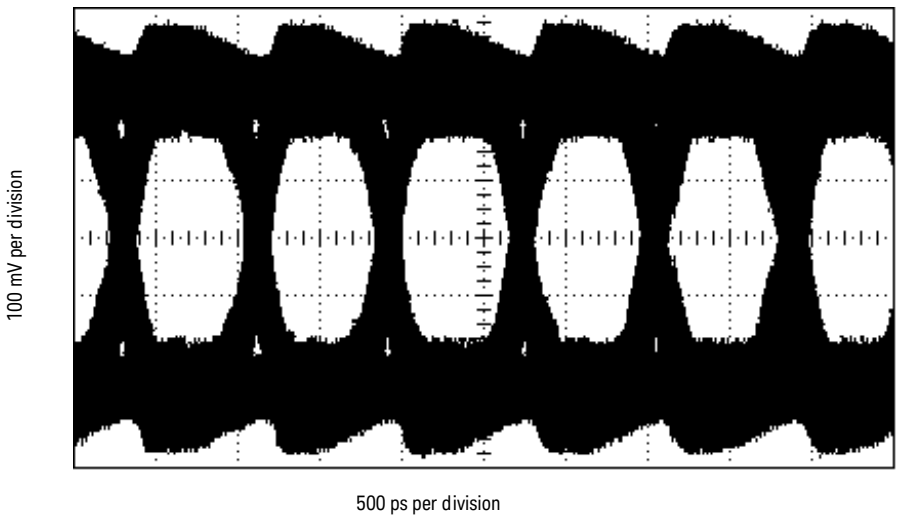


Figure 42 Logic analyzer eye opening for a PRBS signal of 500 mV p-p, 1250 MT/s data rate

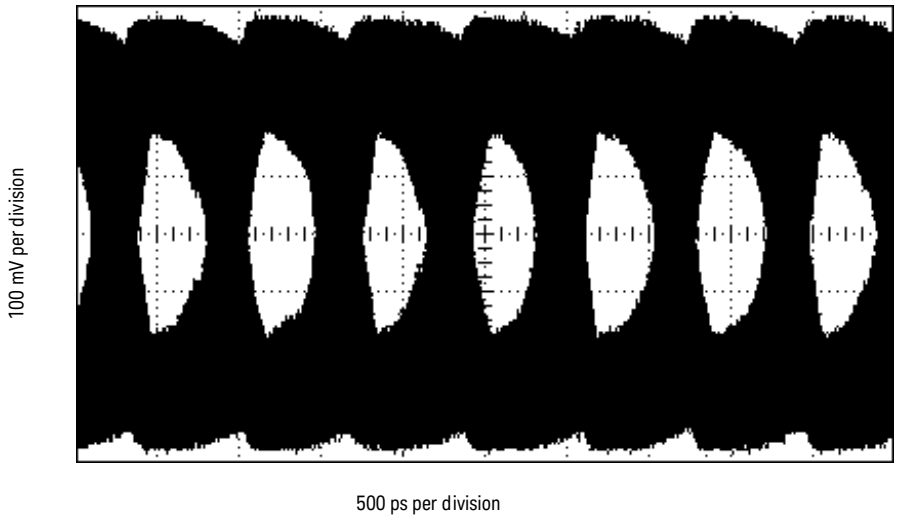


Figure 43 Logic analyzer eye opening for a PRBS signal of 500 mV p-p, 1500 MT/s data rate

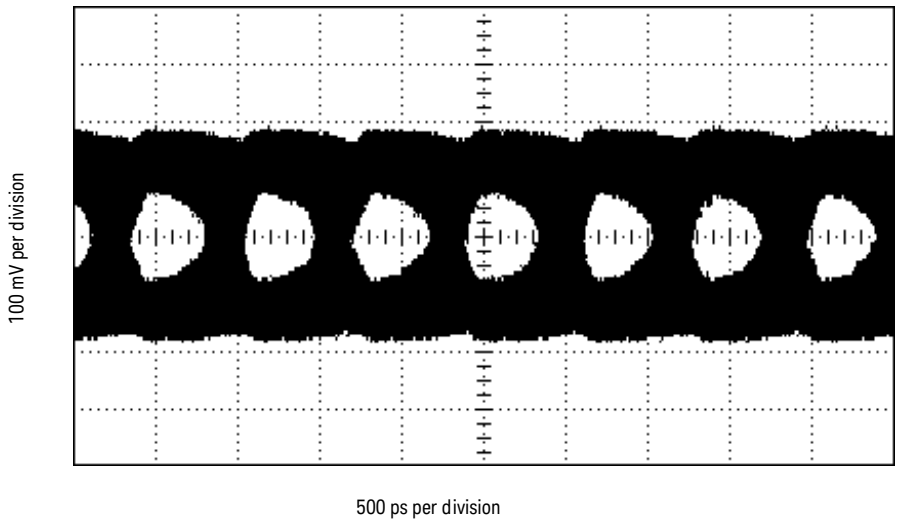


Figure 44 Logic analyzer eye opening for a PRBS signal of 200 mV p-p, 1500 MT/s data rate

5 Circuit Board Design

Design considerations when you layout your circuit board.

Transmission Line Considerations

Stubs connecting signal transmission lines to the connector should be as short as feasible. Longer stubs will cause more loading and reflections on a transmission line. If the electrical length of a stub is less than 1/5 of the signal rise time, it can be modeled as a lumped capacitance. Longer stubs must be treated as transmission lines.

Example: Assume you are using FR-4 PC board material with a dielectric constant of ~4.3 for inner-layer traces (stripline). For example, A 0.28 cm long stub in an inner layer has a propagation delay of ~20 ps. Therefore, for a signal with a rise time of 100 ps or greater, a 0.28 cm stub will behave like a capacitor.

The trace capacitance per unit length will depend on the trace width and the spacing to ground or power planes. If the trace is laid out to have a characteristic impedance of 50 Ω it turns out that the capacitance per unit length is ~1.2 pF/cm. Therefore the 0.28 cm stub in the previous example would have an effective capacitance equal to ~0.34 pF.

This trace capacitance is in addition to the probe load model.

Recommended Routing

Two rows of compliant contacts in the probe make contact with pads laid down on the surface of the PC board. These contacts provide an extremely low probe load (<0.70 pF per channel), and make a good electrical connection with a small amount of compression force on a choice of standard PCB platings. Additionally, the pin contact points are free from the contamination effects that plague other connector-less probing technologies.

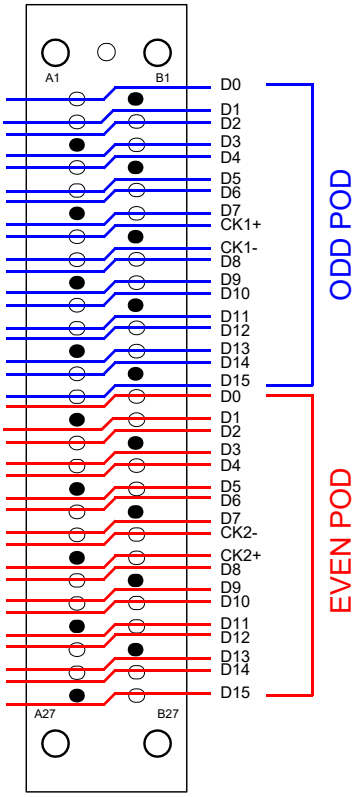


Figure 45 34-bit single-ended routing (E5402A, E5404A, and E5406A)

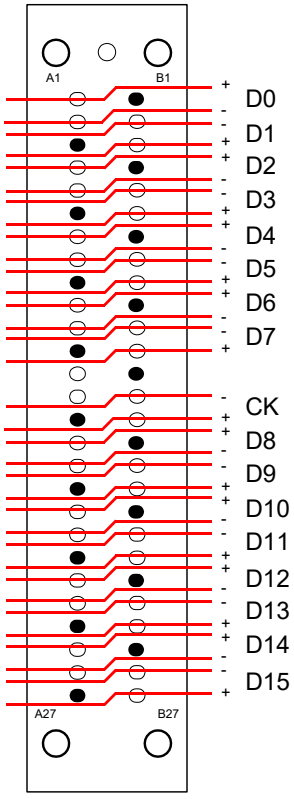


Figure 46 17-bit differential routing (E5405B)

Data and Clock Inputs per Operating Mode

The following table shows the number of data and clock inputs for each connector on your target system for the various operating modes of your logic analyzer.

Table 6 16760A logic analyzer

Operating Mode	E5405B 17-channel differential soft touch	E5405B with half-channel adapter E5386A	E5402A or E5406A 34-channel single-ended soft touch	E5402A or E5406A with half-channel adapter E5386A
Synchronous (state) analysis 200 Mb/s, 400 Mb/s, 800 Mb/s	16 data plus 1 clock input (see note 1)	N/A	32 data plus 2 clock inputs (see note 1)	N/A
Synchronous (state) analysis 1250 Mb/s 1500 Mb/s	8 data plus 1 clock input (see note 2)	16 data plus 1 clock input (see note 2)	16 data plus 1 clock input (see note 2)	16 data plus 1 clock input (see note 2)
Eye scan mode 800 Mb/s	16 data plus 1 clock input (see note 1)	N/A	32 data plus 2 clock inputs (see note 1)	N/A
Eye scan mode 1500 Mb/s	8 data plus 1 clock input (see note 2)	16 data plus 1 clock input (see note 2)	16 data plus 1 clock input (see note 2)	16 data plus 1 clock input (see note 2)
Timing mode	16 data plus 1 clock input (see note 3)	N/A	32 data plus 2 clock inputs (see note 3)	N/A

Note 1: In the 200 Mb/s, 400 Mb/s, and 800 Mb/s synchronous (state) analysis modes, and the 800 Mb/s eye scan mode, there is one clock input which must be routed to the clock input on pod 1 (of the master module, in a multi-card set). The clock inputs on other pods can be assigned to labels and acquired as data inputs.

Note 2: In the 1250 Mb/s and 1500 Mb/s synchronous (state) analysis modes, and in the 1500 Mb/s eye scan mode, the clock inputs on other pods cannot be assigned to labels and acquired as data inputs.

Note 3: In asynchronous (timing) analysis, all inputs including clocks can be acquired and assigned to labels.

- To realize 17 data inputs (in full-channel mode) while using time tags in addition to a clock input on a single 16760A module or on the master module in a multi-card set, you must route the data signals to pod 2 and the clock to pod 1. A convenient way to avoid laying out a second connector to connect only the clock signal is to use the Keysight E5382B flying-lead set to make the connection to the clock.

- To use the qualifier input for eye scan, the qualifier signal must be routed to the clock input on pod 2 (K clock), and the clock must be routed to the clock input on pod 1 (J clock), each on the master module in case of a multi-card set.

- In a multiple-card set, the clock used for synchronous (state) analysis must be routed to the clock input on pod 1 of the master module. On a single card, the clock must be routed to the clock input on pod 1.

Table 7 16753/54/55/56A and 16950A logic analyzers

Operating Mode	E5405B 17-channel differential soft touch	E5402A or E5406A 34-channel single-ended soft touch
Synchronous (state) analysis 300 Mb/s 800 Mb/s,	16 data plus 1 clock input (see note 1)	32 data plus 2 clock inputs (see note 1)
Eye scan mode 300 Mb/s 600 Mb/s	16 data plus 1 clock input (see note 1)	32 data plus 2 clock inputs (see note 1)
Timing mode	16 data plus 1 clock input (see note 1)	32 data plus 2 clock inputs (see note 3)

Note 1: In 600 Mb/s mode, there is one clock input which must be routed to the clock input on pod 1 of the master module in a multi-card set. The clock inputs on the other pods can be assigned to labels and acquired as data inputs.

Table 8 1670 Series, 1680/90 Series, 16710/11/12A, 16715/16/17A, 16740/41/4A, 16750/51/52B, 16910/11A logic analyzers

Operating Mode	E5404A 34-channel single-ended soft touch
Synchronous (state) analysis 250 Mb/s, 500 Mb/s,	32 data plus 2 clock inputs (see note 1)
Timing mode	32 data plus 2 clock inputs (see note 1)

Note 1: In 500 Mb/s mode, there is one clock input which must be routed to the clock input on pod 1 of the master module in a multi-card set. The clock inputs on the other pods can be assigned to labels and acquired as data inputs.

Thresholds

E5404A-pro series single-ended soft touch probes

Data inputs

The threshold can be changed on a “per pod” basis (16 data + 1 clock). This is accomplished using the “user defined threshold” window in the logic analyzer software.

E5405B-pro series differential soft touch probe

Data inputs

If you are using the E5405B differential soft touch probe to acquire differential signals, you would normally allow the logic analyzer to discriminate between high and low states based on the crossover of the data and data inputs.

You may also use the E5405B differential probe to acquire single-ended signals. If you are using the E5405B probe to acquire single-ended signals, you should either ground the data inputs or connect them to a dc power supply. You may:

- Ground the data inputs and adjust the threshold in the user interface.

Or

- Supply a threshold reference voltage to the data inputs. In this case, the threshold in the user interface should be set to zero.

If your circuit uses a resistive divider to provide a threshold reference, make sure the thevinen equivalent resistance is around 50 Ω.

NOTE **The data thresholds can only be changed on a 16-bit per pod basis (16 data). All clock thresholds can be changed individually.**

Clock input

The same choices exist for the clock input on the E5405B differential probe as outlined above for the data inputs. The clock input has a separate, independent threshold adjustment.

E5402A and E5406A-pro series single-ended soft touch probes

Clock input

The clock input to the E5402A and E5406A probe is differential. If you supply a differential clock, you should select the “differential” option in the clock threshold user interface.

If your system uses a single-ended clock signal, the $\overline{\text{clock}}$ input should be either grounded or connected to a dc power supply. You may:

- Ground the $\overline{\text{clock}}$ input and adjust the clock threshold from the user interface to between -3V dc and +5V dc.

Signal Access

Labels split across probes

If a label is split across more than one pod, this leads to restrictions in triggering. Refer to “Triggering with the Keysight 1675x and 1676x" (Keysight publication number 5988-2994EN) for more details.

Reordered bits

If bits need to be reordered within a label, this leads to additional restrictions in triggering. Specifically, equalities can be used to evaluate the value of a label with reordered bits, but inequalities cannot be used. You may be able to avoid the need to reorder bits in a label by routing signals to appropriate pins on the probe connector. Refer to “Triggering with the Keysight 1675x and 1676x" (Keysight publication number 5988-2994EN) for more details.

Half-channel 1.25 and 1.5 Gb/s modes (16760A only)

In the half-channel 1.25 and 1.5 Gb/s modes, the 16760A analyzer accesses only the even channels (0,2,4, etc.). In the Format user interface, only the even data bits will be connected to the analyzer.

Note that in the 1.25 and 1.5 Gb/s half-channel mode, the clock inputs cannot be assigned as bits in a label.

E5386A Half-channel Adapter

The E5386A can be used with the E5405B-pro series differential soft touch probe or the E5402A/E5406A-pro series single-ended probes to map the signals from the PC board pads to the 16760A when operating in half-channel state mode.

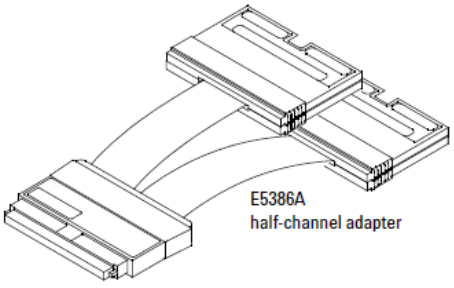


Figure 47 E5386A Half-channeled adapter

6 Recommended Reading

A list of recommended reading for more information about systems and high-speed digital design.

For More Information

For more information on Keysight logic analyzers, refer to http://www.keysight.com/find/logicanalyzer. For more information on your specific analyzer, refer to the online help in the product.

For information on other Keysight probing solutions, refer to http://www.keysight.com/find/logic_analyzer_probes.

MECL System Design Handbook

Blood, William R. Jr., "MECL System Design Handbook," 4th edition, 1988, published by Motorola. This handbook can be obtained from ON Semiconductor on the web. Go to <http://onsemi.com>. Click on "On-line ordering" under “Documentation” Click on the link “General search.” Type in “HB205” in the “Document number” field. Click “Submit.” To view the document online, click on “PDF” in the right-hand column titled “PDF MFAX.” Or order a hardcopy of the handbook on-line.

High-speed Digital Design

Johnson, Howard W., and Martin Graham, “High-speed Digital Design,” Prentice-Hall, 1993, ISBN 0-13-395724-1

Designing High-speed Target Systems for Logic Analyzer Probing

“Designing High-speed Target Systems for Logic Analyzer Probing” Keysight Technologies application note publication number 5988-2989EN.

Safety Notices

This apparatus has been designed and tested in accordance with IEC Publication 1010, Safety Requirements for Measuring Apparatus, and has been supplied in a safe condition. This is a Safety Class I instrument (provided with terminal for protective earthing). Before applying power, verify that the correct safety precautions are taken (see the following warnings). In addition, note the external markings on the instrument that are described under “Safety Symbols.”

Warnings

- Before turning on the instrument, you must connect the protective earth terminal of the instrument to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. You must not negate the protective action by using an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.
- Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short-circuited fuse holders. To do so could cause a shock or fire hazard.
- If you energize this instrument by an auto transformer (for voltage reduction or mains isolation), the common terminal must be connected to the earth terminal of the power source.
- Whenever it is likely that the ground protection is impaired, you must make the instrument inoperative and secure it against any unintended operation.
- Service instructions are for trained service personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.
- Do not install substitute parts or perform any unauthorized modification to the instrument.
- Capacitors inside the instrument may retain a charge even if the instrument is disconnected from its source of supply.
- Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.
- Do not use the instrument in a manner not specified by the manufacturer.

To clean the instrument

If the instrument requires cleaning: (1) Remove power from the instrument. (2) Clean the external surfaces of the instrument with a soft cloth dampened with a mixture of mild detergent and water. (3) Make sure that the instrument is completely dry before reconnecting it to a power source.

Safety Symbols

Instruction manual symbol: the product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product.

Hazardous voltage symbol.

Earth terminal symbol: Used to indicate a circuit common connected to grounded chassis.

Index

R

S

T

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