Keysight U4421A MIPI D-PHY Protocol Analyzer and Exerciser

Hardware and Probing Guide

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Notices

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Warranty

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Safety Notices

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.

Safety Summary

Safety Symbols on Instruments

Safety Symbol	Description
⚠	Indicates warning or caution. If you see this symbol on a product, you must refer to the manuals for specific Warning or Caution information to avoid personal injury or damage to the product.
⏚	Frame or chassis ground terminal. Typically connects to the equipment's metal frame.
⚡	Indicates hazardous voltages and potential for electrical shock.
⚠	Indicates that anti static precautions should be taken.
⚠	Indicates hot surface. Please do not touch.
☢	Indicates laser radiation turned on.
CSA	CSA is the Canadian certification mark to demonstrate compliance with the Safety requirements.
CE ICES/NMB-001 ISM GRP 1-A	CE compliance marking to the EU Safety and EMC Directives. ISM GRP-1A classification according to the international EMC standard. ICES/NMB-001 compliance marking to the Canadian EMC standard.

General Safety Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument.

Keysight Technologies Inc. assumes no liability for the customer's failure to comply with these requirements.

Before operation, review the instrument and manual for safety markings and instructions. You must follow these to ensure safe operation and to maintain the instrument in safe condition.

General

This product is a Safety Class 1 instrument (provided with a protective earth terminal). The protective features of this product may be impaired if it is used in a manner not specified in the operation instructions.

All Light Emitting Diodes (LEDs) used in this product are Class 1 LEDs as per IEC 60825-1.

Environment Conditions

This instrument is intended for indoor use in an installation category II, pollution degree 2 environment. It is designed to operate at a maximum relative humidity of 95% and at altitudes of up to 2000 meters.

Refer to the specifications tables for the ac mains voltage requirements and ambient operating temperature range.

Before Applying Power

Verify that all safety precautions are taken. The power cable inlet of the instrument serves as a device to disconnect from the mains in case of hazard. The instrument must be positioned so that the operator can easily access the power cable inlet. When the instrument is rack mounted the rack must be provided with an easily accessible mains switch.

Ground the Instrument

To minimize shock hazard, the instrument chassis and cover must be connected to an electrical protective earth ground. The instrument must be connected to the ac power mains through a grounded power cable, with the ground wire firmly connected to an electrical ground (safety ground) at the power outlet. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury.

Do Not Operate in an Explosive Atmosphere
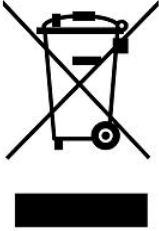
Do not operate the instrument in the presence of flammable gases or fumes.

Do Not Remove the Instrument Cover

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made only by qualified personnel.

Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

Environmental Information

Safety Symbol	Description
	This product compiles with the WEEE Directive (2002/96/EC) marking requirements. The affixed label indicates that you must not discard this electrical/ electronic product in domestic household waste. Product Category: With reference to the equipment types in WEEE Directive Annex I, this product is classed as a "Monitoring and Control instrumentation product. **Do not dispose in household waste.** **To return unwanted products, contact your local Keysight office, or see www.keysight.com/environment/product/ for more information.**

About This Guide

This guide describes the stimulus and acquisition probing options available for use with the U4421A module. It describes how to make probing connections from the device under test (DUT) to the Keysight U4421A module for various probing situations.

See Also
- For information on Keysight AXIe chassis, U4421A module, how to set up the chassis, module, and host computer and how to obtain and install the associated software components, see: *"Keysight AXIe based Logic Analysis and Protocol Test Modules Installation Guide"*. This guide is available on www.keysight.com and is also installed with the Logic Analyzer software.
- For information on how to use the U4421A module for stimulus and analysis, refer to the *Keysight Logic and Protocol Analyzer software's online help*.
- Detailed information on Keysight probes supported for the U4421A module (such as the Keysight E5381A differential flying lead probe) is available by searching for the probe's product number at www.keysight.com.

Keysight U4421A MIPI D-PHY Analyzer and Exerciser Hardware and Probing Guide

Contents

1   U4421A Module

This chapter provides information on the hardware components of the U4421A module.

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U4421A Module Hardware Components

The Keysight U4421A MIPI D-PHY Protocol Analyzer and Exerciser module (hereafter referred to as the U4421A module) provides digital serial stimulus and acquisition capabilities to test and debug a D-PHY component independently or an integrated D-PHY based mobile design. This module can emulate a master D-PHY component to provide stimulus to a D-PHY endpoint. You can also use this module to capture D-PHY traffic and then analyze and debug D-PHY packets using various Keysight tools and viewers available in the Keysight Logic and Protocol Analyzer GUI.

For information on Keysight AXIe chassis, U4421A module, how to set up the chassis, module, and host computer and how to obtain and install the associated software components, see: ⅃ *"Keysight AXIe based Logic Analysis and Protocol Test Modules Installation Guide"*. This guide is available on www.keysight.com and is also installed with the Logic Analyzer software.

Refer to the *Keysight Logic and Protocol Analyzer Online Help* installed and integrated with the Keysight Logic Analyzer software to learn how to use this module.
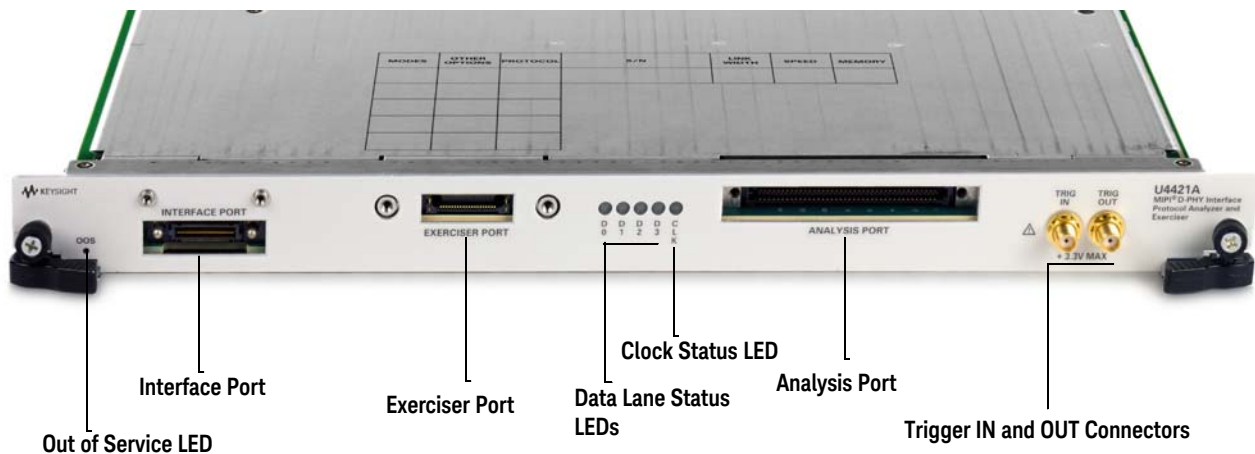

Figure 1   U4421A Module

As shown in Figure 1, the U4421A module has the following components:

Component	Description
Interface Port	This component is used to share information with another U4421A module in the same chassis. The features of this component are not yet supported.
Exerciser Port	This component is used to connect the U4421A module with a DUT using the Keysight U4422A SMA stimulus probing cable. You use this component when you plan to use the U4421A module as an Exerciser to provide stimulus to the DUT.

Lane Status LEDs	The module supports four lanes. For each of these lanes, a lane status LED is provided, labeled 0 to 3, to indicate the status of the lane. The following color coding is used for these LEDs to indicate the lane status.
	▪ **Red** - This means that the lane is in the STOP state with LP11.
	▪ **Blinking Red** - This means that the lane is in the STOP state with LP00. This lane status usually indicates:
	  ▪ LP lines are not probed
	  ▪ ultra-low power mode
	▪ **Green** - This means that the lane has moved to LP00 via a HS request and it is waiting for the sync pattern. This lane status occurs when something is wrong, for instance, incorrect probing setup or the lane not receiving correct HS data.
	▪ **Blinking Green** - This means that the line is between HS sync and HS exit. and the lane is receiving HS data.
	▪ **Yellow** - This means that the lane is in the Escape mode and data is being transmitted from master to slave. Escape mode includes bus turn around (BTA), escape mode data transmission, and ULPM request.
	▪ **Blinking Yellow** - This means that the lane is in the Escape mode and data is being transmitted from slave to master. Escape mode includes bus turn around (BTA), escape mode data transmission, and ULPM request.
	▪ **Off** - This means that the lane is not configured/available. Based on the link width that you select in the U4421 Connection Setup tab of the Logic and Protocol Analyzer GUI, the number of lanes on the U4421A module are used. The LEDs of only the used lanes glow. For example, if you are using the x2 link width, then the LEDs of only two lanes being used will glow and the rest of the LEDs will be off.
	All Lane Status LEDs will be off until the host computer has established a connection to the chassis and module and the Logic and Protocol Analyzer application has started.

Clock Status LED	This LED indicates the status of the clock lane.
	The following LED color coding is used to indicate the state activity on the clock lane.
	▪ **Red** - This means that the lane is in the STOP state with LP11.
	▪ **Blinking Red** - This means that the lane is in the STOP state with LP00. This lane status usually indicates:
	  ▪ LP lines are not probed
	  ▪ ultra-low power mode
	▪ **Green** - This means that the line is between HS sync and HS exit. and the lane is receiving HS data.
	▪ **Yellow** - This means that the lane is in the Escape mode which includes bus turn around (BTA), escape mode data transmission, and ULPM request.
	The Clock Status LED will be off until the host computer has established a connection to the chassis and module and the Logic and Protocol Analyzer application has started.

Analysis Port	This component is used to connect the U4421A module with Keysight differential flying lead or soft touch probe via a U4201A 90-pin cable. You use this component when you plan to use the U4421A module as an Analyzer to capture and analyze data from DUT.

Component	Description
Trigger In/Out	These connectors are used to listen to an external trigger in from a device or to send an external trigger out to another device. However, these connectors on the U4421A module are not currently functional. Instead of using these connectors, you can use the Trigger In/Out connectors located on the Embedded System Module (ESM) of the Keysight AXIe chassis to send or receive external trigger in and out events. The following are some important points about the Trigger In/Out connectors: ▪ The Trigger In connector of the AXIe chassis has an adjustable threshold input of +/-5V range and 250 mV minimum swing. ▪ The Trigger Out connector of the AXIe chassis extends the parallel trigger bus to external instruments. The trigger out characteristics are 3.3V CMOS, 50W line drive, and 3-state. ▪ Maximum trigger input voltage should not exceed 3.3 V. ▪ Trigger Out and 10 MHz Out have nominal output level of 2.0 V with 20 ns minimum pulse width. ▪ Minimum Trigger In duration is 20 ns.
OOS (Out of Service) LED	Indicates the power-ready status of the U4421A module. This LED may turn red during the power-on-self-test phase of the chassis boot cycle. The LED then turns off when the U4421A module is in a power-ready state. The LED turns red again only when a power fault condition occurs for the module. ▪ **Red, steady** - If the LED remains red and does not turn off, then it indicates a power fault condition. In such a situation, the module may require repair/service. Contact your Keysight representative to replace or service the module. ▪ **Off** - The module has detected no power failures and is in a power-ready status.

WARNING   Do not directly touch any component on the U4421A module. It may be hot.

CAUTION   Components on the U4421A module are sensitive to static electricity. Therefore, take necessary anti-static precautions, such as wear a grounded wrist strap, to minimize the possibility of electrostatic damage.

2 Setting up a Stimulus Probe Configuration for U4421A Module

This chapter provides information on how to connect the U4422A SMA stimulus probe with the U4421A module and DUT.

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U4422A SMA Stimulus Probe- Introduction

The Keysight U4422A SMA stimulus probe connects the U4421A module (emulating a master D-PHY component) to the DUT. It allows you to transmit the generated digital signals from the U4421A module to the DUT.

The stimulus probe can control the Link layer as well as send MIPI packets. The U4422A SMA stimulus probe has a high density module connector on one end and thirteen coaxial cables with SMA connectors on the other end.

Module Connector

Coaxial cables with SMA Connectors
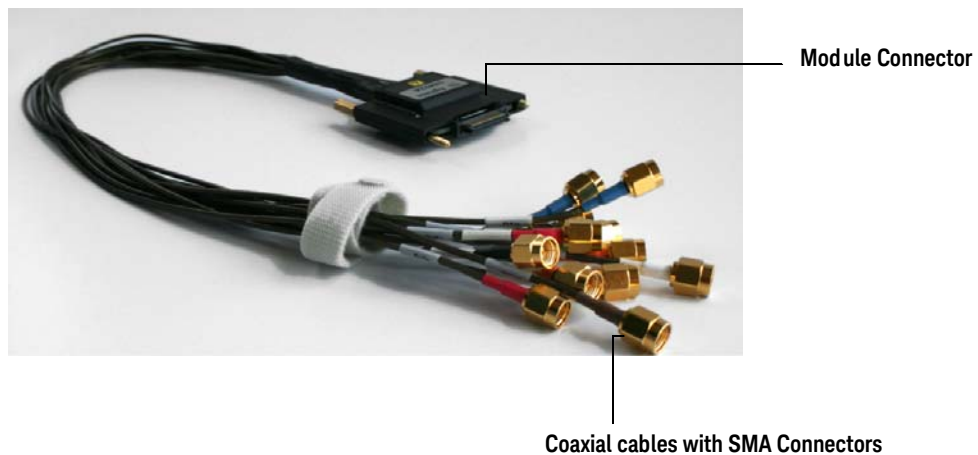
Figure 2   U4422A SMA Stimulus Probe

Labelling and Color Coding of Coaxial Cables

To help you identify the appropriate coaxial cable to use in a given situation, the thirteen coaxial cables of the U4422A probe are labelled and color coded. The following table lists the label, color coding, and specific purpose of each of these coaxial cables.

Table 1   Labelling and color coding of the coaxial cables of U4422A probe

Label	Color Coding	Signal Direction	Description/Usage of cable
Clkp	Brown	From U4421A module to DUT	For transmitting D-Phy clock lane positive signal
Clkn	Brown with white	From U4421A module to DUT	For transmitting D-Phy clock lane negative signal
D0p	Black	From U4421A module to DUT	For transmitting D-Phy data lane 0 positive signal
D0n	Black with white	From U4421A module to DUT	For transmitting D-Phy data lane 0 negative signal
D1p	Blue	From U4421A module to DUT	For transmitting D-Phy data lane 1 positive signal
D1n	Blue with white	From U4421A module to DUT	For transmitting D-Phy data lane 1 negative signal
D2p	Orange	From U4421A module to DUT	For transmitting D-Phy data lane 2 positive signal
D2n	Orange with white	From U4421A module to DUT	For transmitting D-Phy data lane 2 negative signal
D3p	Green	From U4421A module to DUT	For transmitting D-Phy data lane 3 positive signal
D3n	Green with white	From U4421A module to DUT	For transmitting D-Phy data lane 3 negative signal

Label	Color Coding	Signal Direction	Description/Usage of cable
Refp	Red	To U4421A module	Emulator reference clock input positive signal
Refn	Red with white	To U4421A module	Emulator reference clock input negative signal
Vsen	White	To U4421A module	For transmitting target system supply voltage sense signal

Connecting the U4422A Probe to the U4421A module and DUT

The U4422A stimulus probe connects to the DUT via 50-ohm coaxial cables using SMA connectors.

CAUTION	The output voltage of the U4422A stimulus probe is user- configurable. You can turn on and set the output voltages using the Keysight Protocol and Logic Analyzer GUI.
	Be careful to set voltage levels correctly before plugging the stimulus probe into your board. If the output voltage level is configured at a level too high for your board, your board may be damaged.

1   Plug the module connector (refer Figure 2) of the stimulus probe to the Exerciser port on the front panel of the U4421A module.

Exerciser port on U4421A module

2   Hand-tighten the thumb screws on both sides of the module connector of the probe.

3   Connect the appropriate coaxial cables (with SMA connectors) of the probe to the DUT. (You can refer to Table 1 to verify which coaxial cables to connect.)

  a   Connect the cables for D-Phy clock lane positive and negative signals (labelled *Clkp* and *Clkn*). In the stimulus mode, the U4421A module emulates a master and transmits the clock to the D-Phy link partner. Therefore, you must always connect the set of clock signal cables, Clkp and Clkn.

  b   Based on the link width needed, connect the set of cables for D-Phy data lanes 0 to 3.

    i   For a x1 link, connect the cables for D-Phy data 0 lane positive and negative signals (labelled *D0p* and *D0n*).

    ii For a x2-x4 link, connect the additional cables for D-Phy data 1 to 3 lane positive and negative signals (labelled *D1p* and *D1n*, *D2p* and *D2n*, and *D3p* and *D3n*).

    You may leave the coaxial cables for the unused data lanes disconnected.

  c   If you plan to configure the U4421A module to use an external reference clock, then connect the coaxial cables (labelled *Refp* and *Refn*) for accepting the external reference clock input signals. These signals then supply the external reference clock to the U4421A module and set the HS bit rate for the module. Refer to the topic "Supplying External Reference Clock to the U4421A Module" on page 17 to know more.

  d   Connect the cable for the DUT's supply voltage sense signal (labelled *Vsen*) to the DUT's power supply. The DUT sends this signal to the U4421A module to indicate when the module can actively send D-Phy signals to the DUT.

> **NOTE**
>
> You can set the *Target VDD* for the *Vsen* signal in the Keysight Logic And Protocol Analyzer GUI. Setting this value ensures that the U4421A module sends D-PHY signals to the DUT if the *Vsen* signal is above this value divided by two. If the *Vsen* signal is below the set Target VDD divided by two, the module will tri-state all the D-Phy signals. Refer to the *U4421A MIPI D-PHY Protocol Analyzer and Exerciser Online Help* to know how to set and enable/disable the Target VDD.

Supplying External Reference Clock to the U4421A Module

You can connect the *Refp* and *Refn* coaxial cables of the stimulus probe to accept the external reference clock input signals.

The following table lists some important points that you should consider while making connections for supplying the external reference clock to the U4421A module.

Supplying the Refp and Refn signals to the U4421A module	Use either of the following two methods: • From a piece of test equipment such as a signal generator • By probing a signal on the DUT - Place 1K Ohm isolation resistor in series with the Ref[pn] signals.

Refp and Refn input signals specifications	• This input can be provided:
	  • single-ended - Ensure that the unused input from the single-ended source is terminated with 50 Ohms to ground.
	  • differentially
	• Minimum input signal amplitude
	  • typically 20mV if supplied directly
	  • 400mV if supplied by probing a signal
	• Maximum input signal amplitude - 2V pp
	• Signals are AC coupled and terminated with 50 Ohms.
	• The supplied signal should have a 50% duty cycle. Since this signal is AC coupled, the DC common mode of the supplied signal does not affect the signal detection but must be kept to a voltage of less than 10V.

Reference Clock Frequency	1/10 the bit rate for bit rates < = 700mbps 1/20 the bit rate for rates > 700mbps

> **NOTE**
>
> Once you have connected the probe cables for supplying the external reference clock to the U4421A module, you also need to configure the U4421A module to use the external reference clock. You do this configuration by specifying the Clock Source as External in the U4421A Setup dialog box in the Keysight Logic and Protocol Analyzer GUI. To know more, refer to the *U4421A Online Help*.

3 Determining the Extent of Signal Degradation with Acquisition Probes

Before you start designing the setup for a particular acquisition probing solution that you plan to use with U4421A module, you should simulate the signal integrity with that probing solution. This helps you assess the extent of signal degradation in a specific target system on attaching the probes to signals in that target system.

Some extent of signal degradation is always present. To determine if this signal degradation is significant in a specific target system, you should run a simulation with the probe loads for the probing method(s) to be used.

The amount of signal degradation that a target system can tolerate can vary widely depending on signal rise times, design margins and system noise.

The following table provides some guidelines for the acquisition probing method used for U4421A module vs. bit rate assuming a "typical" target system (Note that this includes the effect of two probes per signal):

Probe	Attachment	Maximum Bit Rate
E5405A Soft Touch	Connectorless	>1.5 Gbps
E5381A Flying Leads	Coaxial Tip Resistors (82 Ohms)	>1.5 Gbps
E5381A Flying Leads	3-Pin Headers	1.0 Gbps
E5381A Flying Leads	Socket Adapters	1.0 Gbps
E5381A Flying Leads	Damped Wires (160 Ohms)	0.8 Gbps

NOTE When the E5381A or E5405A probe is used with the U4421A module, each signal is probed twice. Therefore, when simulating the electrical impact of these probes, you must attach two probe loads to each signal.

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Probe Load Model for E5405A Soft Touch Probe
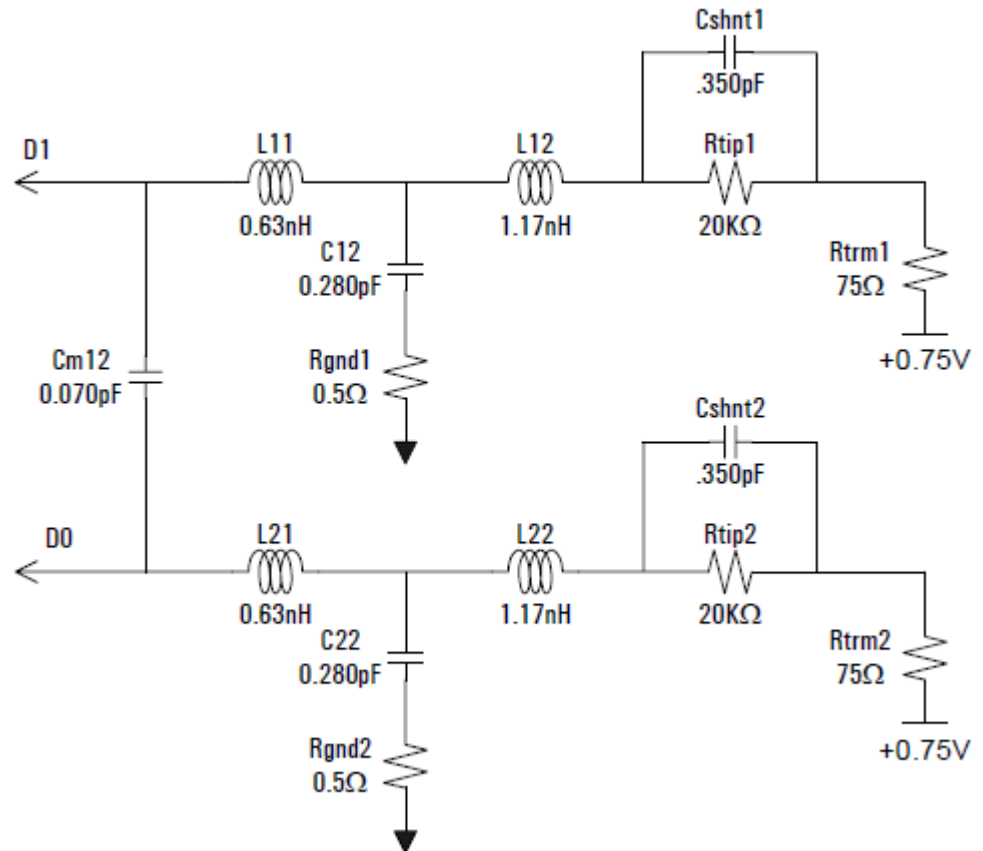
Probe Load Model for E5381A Flying Probe

The E5381A probes have an input impedance which varies with frequency, and depends on which probe attachment accessories (see page 30) are being used to connect the flying leads of the probe to DUT. The following screens show the circuit load model for the input impedance of the probe with various supplied accessories..

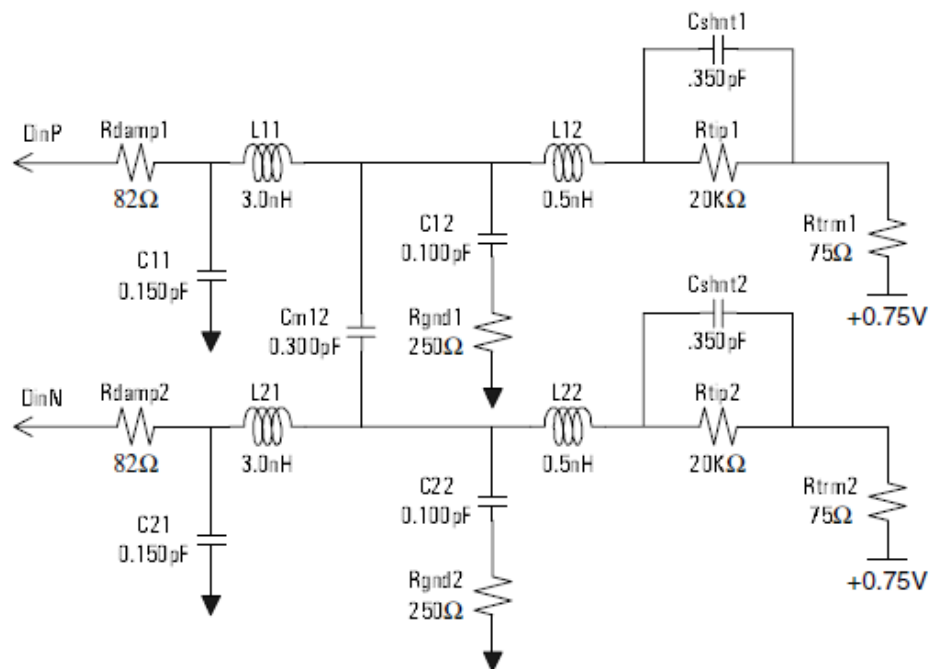Figure 3   Equivalent probe load model when using the Coaxial Tip Resistor as the attachment accessory
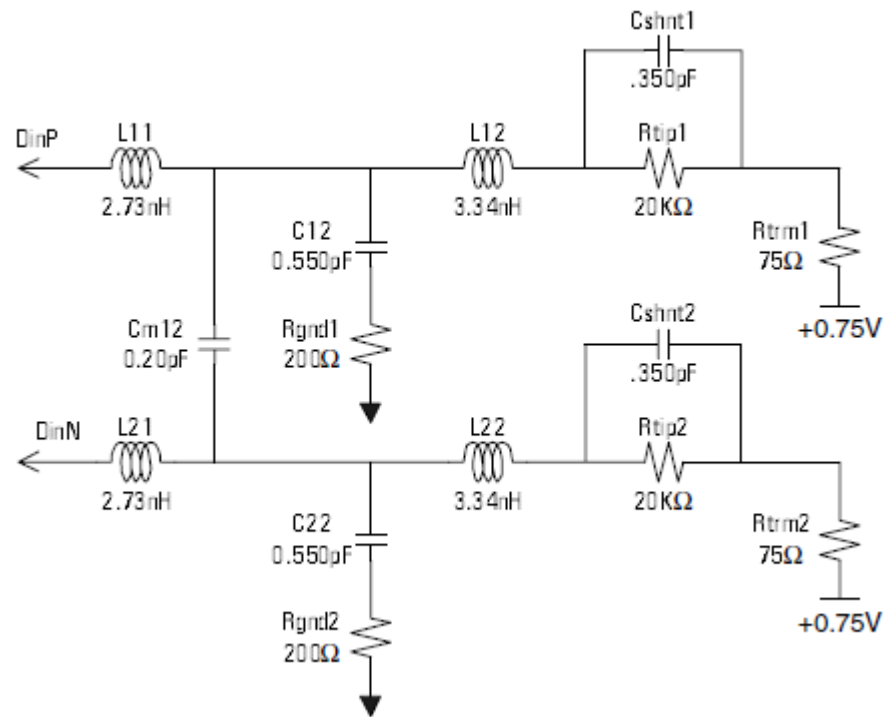
Figure 4   Equivalent probe load model when using the 3-pin header as the attachment accessory
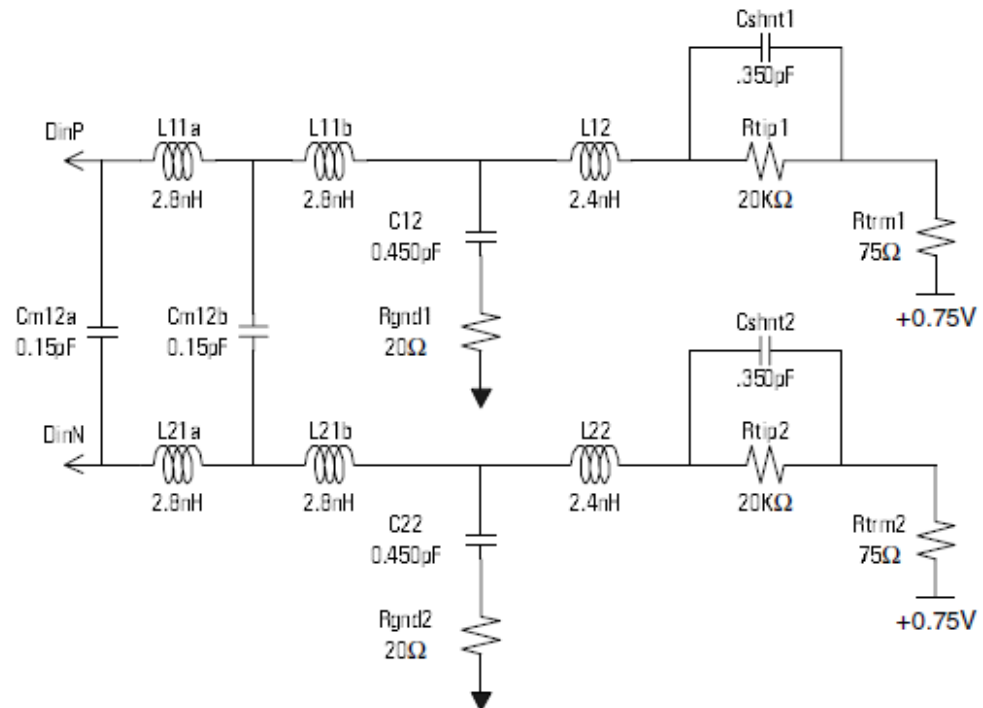
Figure 5   Equivalent probe load model when using the socket headers as the attachment accessory

Figure 6   Equivalent probe load model when using the damped wire as the attachment accessory

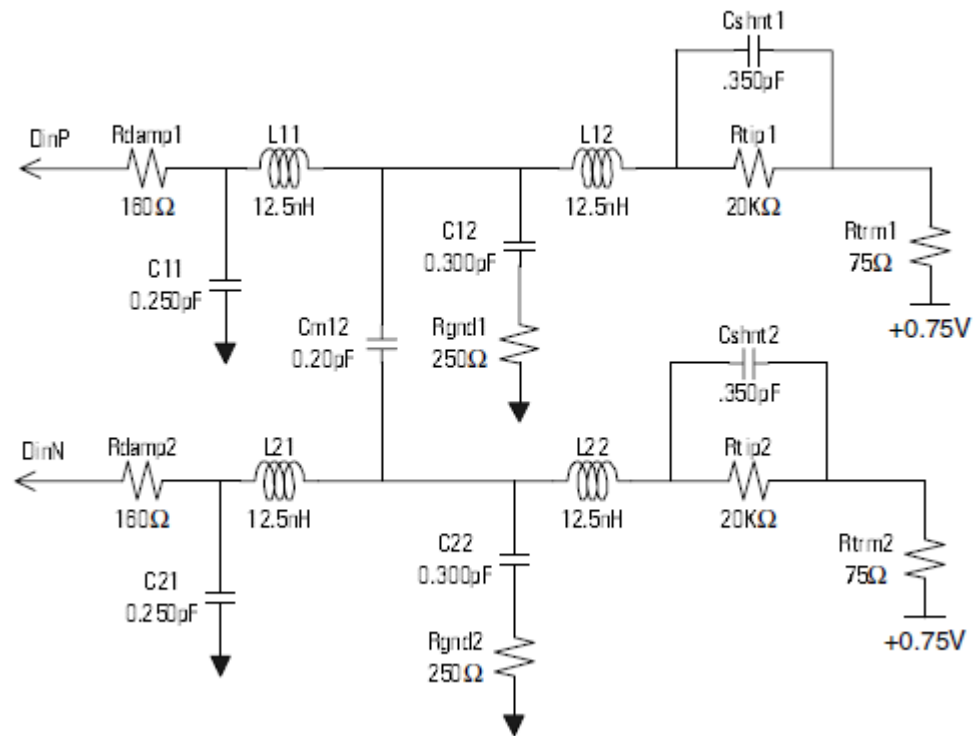# 4 Setting up an E5381A Differential Flying Lead Probe Configuration for U4421A Module

This chapter provides information on how to set up the E5381A differential flying lead probe with the U4421A module for capturing D-PHY data.

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E5381A Differential Flying Lead Probe - Introduction

The E5381A is a 17-channel differential flying lead probe that you can use with the U4421A module to probe D-PHY signals.

You can use this probe to probe differential as well as single-ended signals. A single E5381A probe provides support for probing one to four data lanes and one clock lane of a D-PHY link.

You connect an E5381A probe to the DUT by connecting the leads of the probe via the supplied probe accessories to the DUT. This allows flexible connections to individual signals

When to use an E5381A Flying Lead Probe

An E5381A flying lead probe is suitable for use in situations such as:

- When you want to probe individual signals from multiple randomly located points on the target system. You can connect the leads of the probe directly to these multiple points and thereby eliminate the need to have signals routed to one probing point.
- When there is a space constraint on the DUT and the footprint for the E5405A soft touch probe cannot be incorporated on the DUT. In such situations, you can use E5381A probe and connect individual flying leads to the DUT.

E5381A Probe Components

The following figure displays an E5381A probe with labels pointing to the components of this probe.

Cable Connector

Flying Leads

Component	Description
Cable Connector	This component connects the E5381A probe to the U4421A module via the U4201A/N2815A cable.
Flying Lead Cables	This component connects the E5381A probe to the DUT via the attachment accessories supplied with the probe. There are 17 flying lead cables in each probe. Each flying lead cable when connected to a DUT allows you to probe a lane which refers to either a forward direction differential pair OR a reverse direction differential pair for a given lane. Each flying lead has two cables: • the dark grey cable accepts the negative side of the differential probe input. • the light grey cable accepts the positive side of the differential probe input. When probing single-ended signals (see page 36) using the E5381A probe, you must connect the dark grey (negative side) cable of the used flying leads to the ground. The tip of the each flying lead has positions for three pins. One pin connects to the negative side of the differential probe input. other to the positive side, and the middle pin is not electrically connected to anything:
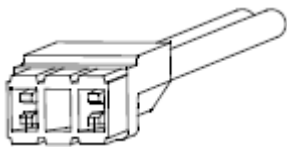
Color Coding used for E5381A Flying Leads

The flying leads of the E5381A probe are color coded to help you identify the appropriate flying lead cable to be used for probing a specific D-PHY signal. The cable connector component of the probe displays this mapping between the colors of the seventeen flying leads and the channel number assigned to each of these flying leads.

Figure 7   Color coding for flying lead cables

The following table maps the channel number of the flying leads with their color coding and lists the D-PHY signal connection to be probed by each of these cables.

Channel Number of the flying lead	Color of the flying lead	D-PHY Signal Connection	
		Positive (light grey) side of the flying lead	Negative (dark grey) side of the flying lead
0	Black	D0p	GND
1	Brown	D0p	D0n
2	Red	D0n	GND
3	Orange	D1p	GND
4	Yellow	D1p	D1n
5	Green	D1n	GND
6	Blue	Not used	Note used
7	Purple	Not used	Not used
8	Black	D2p	D2n
9	Brown	D2n	GND
10	Red	D3p	GND
11	Orange	D3p	D3n
12	Yellow	D3n	GND
13	Green	CLKp	GND
14	Blue	CLKp	CLKn
15	Purple	CLKn	GND
Clk	White	D2p	GND

D-PHY Signals to Flying Leads Mapping

In a E5381A probe, there are:

· Two flying leads for probing D-PHY clock positive and negative signals.
· Two flying leads for probing D-PHY data lane 0 positive and negative signals.
· One flying lead each for probing D-PHY data lane 1, 2, and 3, if used.

Based on the number assigned to each flying lead (see Figure 7), the following table lists which flying lead of the probe to be used to probe different D-PHY signals.

Signal to be probed	Flying Lead to be used	Notes/Usage of flying lead
Clkp	Ch 13	Connect the Positive (Light grey) cable of the flying lead to acquire signal. Connect the Negative (Dark grey) cable of the flying lead to ground.
Clkn	Ch 15	Connect the Positive (Light grey) cable of the flying lead to acquire signal. Connect the Negative (Dark grey) cable of the flying lead to ground.
Clk diff	Ch 14	Connect the Positive (Light grey) cable of the flying lead to the Clkp signal and Negative (Dark grey) cable of the flying lead to the Clkn signal.
Data Lane 0 p	Ch 0	Connect the Positive (Light grey) cable of the flying lead to acquire signal. Connect the Negative (Dark grey) cable of the flying lead to ground.
Data Lane 0 n	Ch 2	Connect the Positive (Light grey) cable of the flying lead to acquire signal. Connect the Negative (Dark grey) cable of the flying lead to ground.
Data Lane 0 diff	Ch 1	Probe differentially Connect the Positive (Light grey) cable of the flying lead to the D0p signal and Negative (Dark grey) cable of the flying lead to the D0n signal.
Data Lane 1	Ch 4	Probe differentially Connect the Positive (Light grey) cable of the flying lead to the D1p signal and Negative (Dark grey) cable of the flying lead to the D1n signal.
Data Lane 2	Ch 8	Probe differentially Connect the Positive (Light grey) cable of the flying lead to the D2p signal and Negative (Dark grey) cable of the flying lead to the D2n signal.
Data Lane 3	Ch 11	Probe differentially Connect the Positive (Light grey) cable of the flying lead to the D3p signal and Negative (Dark grey) cable of the flying lead to the D3n signal.

NOTE	The Data Lane 0p, Data Lane 0n, Clkp, and Clkn signals are probed both as single-ended and differential. This is done to allow the U4421A module to detect LP and HS modes. When probed as single-ended, you must connect the negative sides of the single-ended connections to ground.

The Data Lane 1, 2, and 3 each are probed differentially using a single channel per data lane used.

The U4421A module can capture LP data and display it in "raw" mode on these data lanes. If you want to capture LP data on these lanes, then you must probe these lanes single-ended using the following signal to probe's channel mapping:

D1p - Ch 3

D1n - Ch 5

D2p - Clk

D2n - Ch 9
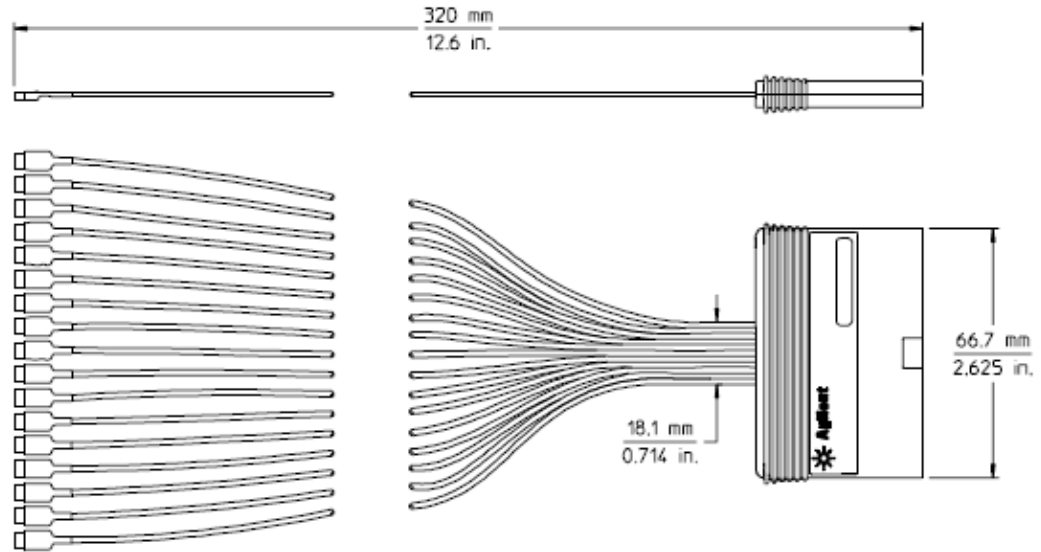
D3p - Ch 10

D3n - Ch 12

E5381A Probe Dimensions

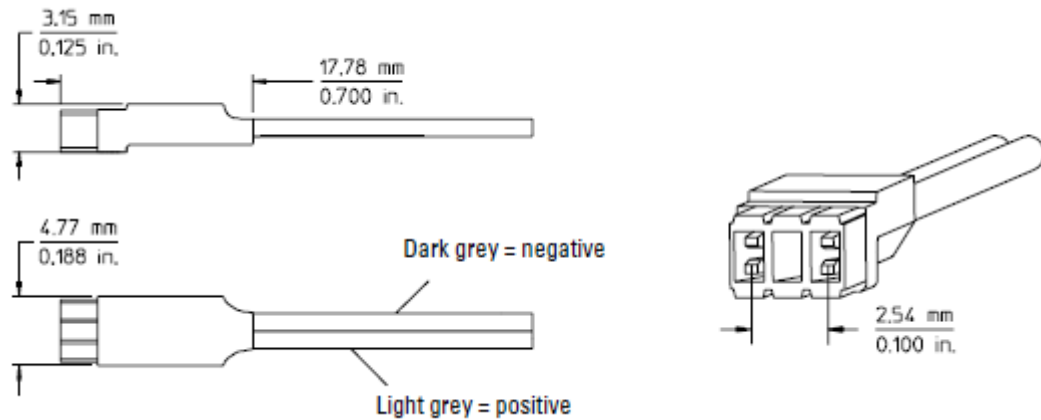Figure 8   Dimensions of the E5381A probe set

Figure 9   Dimensions of the E5381A flying lead tip

Probe Accessories

Various accessories are provided with the E5381A probe to connect the flying leads of the probe to the DUT. The usage of these accessories vary based on the type of component on which you want to access signals.

The probe shipment includes a fixed number of these attachment accessories. If you need more than the quantity shipped with the probe, you can order these at www.parts.keysight.com using the part number of accessories.

The following table lists these accessories along with their part numbers, quantity shipped, and usage.

Probe Accessory	Keysight Part Number	Quantity Shipped	Usage
Coaxial Tip Resistor	E5381-82101	34	Recommended for solder-down probing of individual test points if headers are not available on your board.
3-pin Header	E5381-82104	34	Recommended for loading during PC board assembly or hand soldering in place at a later time.
Socket Adapters	E5381-82102	34	Recommended if you already have 0.635 mm (0.025 inch) pins on 2.54 mm (0.1 inch) centers as test points where you wish to connect the probe. The E5381A probe only accepts 0.508 mm (0.020 inch) pins. The probe will be damaged if 0.635 mm (0.025 inch) pins are forced into the probe receptacle. The socket adapter provides a means of probing these headers while protecting the flying lead probe tip.
Damped Wire	E5381-82103	34	Recommended for probing constricted regions of the target. It provides flexibility and isolation between the target and probe capacitance.

Connecting the Probe Accessories to the Probe and DUT

The following screens illustrate how to use a particular probe accessory to connect the E5381A probe's flying leads to the DUT.
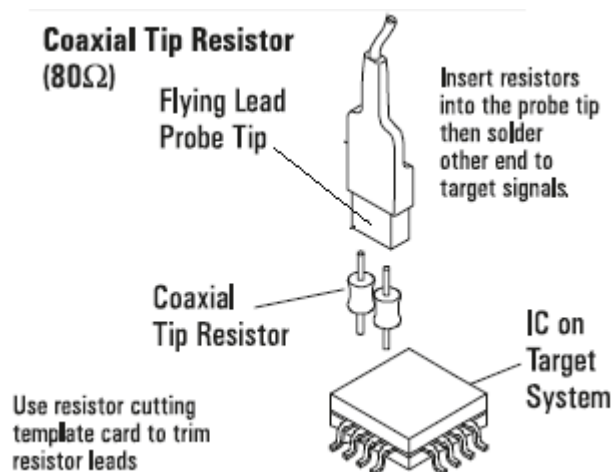
Connecting Coaxial Tip Resistors

Figure 10   Coaxial Tip Resistor used as the probe attachment accessory
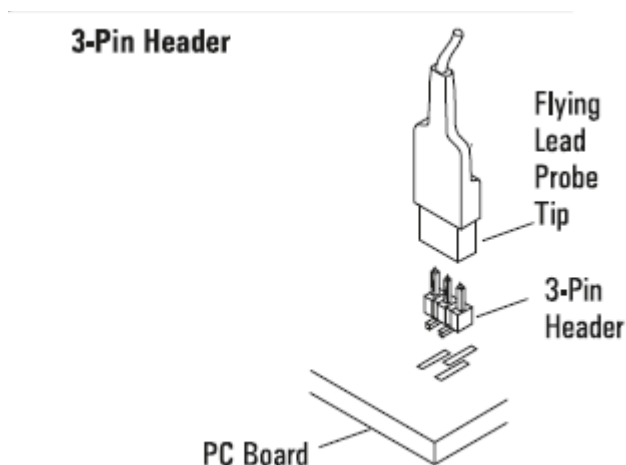
Connecting 3-pin Headers

Figure 11   3-pin Header used as the probe attachment accessory

When using 3-pin headers, probe as close as possible to the chip that receives the high-speed data. In other words, place the connector near the pads of the master IC.

You can probe D-Phy Data Lane 0p and Data Lane 0n using two 3-pin connectors laid side-by-side as follows:
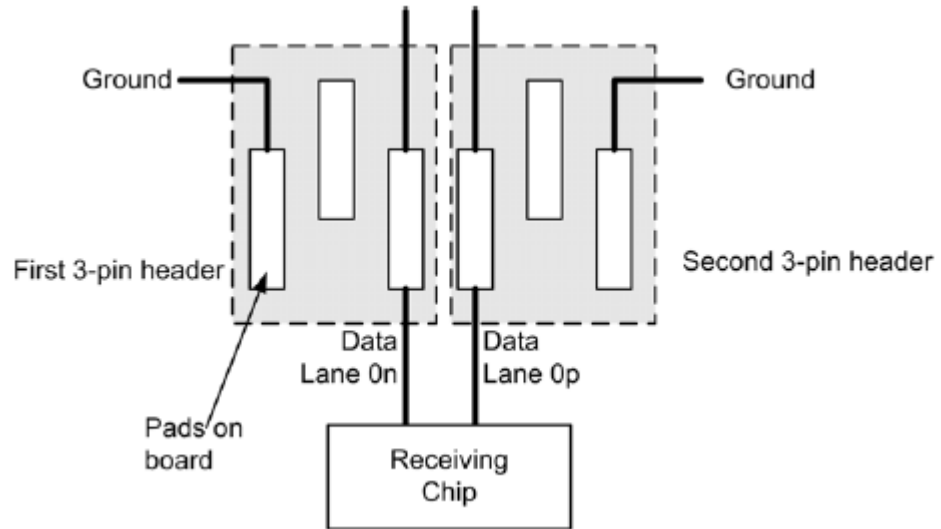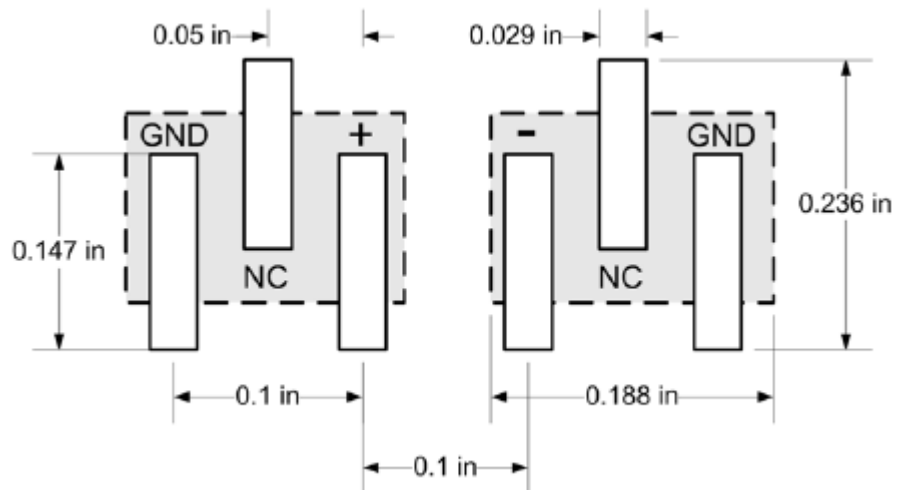

Figure 12   Using two 3-pin headers side-by-side to probe Data Lane 0 p and Data Lane 0 n

There must be 0.1 inch spacing between the 3-pin headers placed side-by-side.

For other D-Phy signals, probe as close as possible to the chip which receives the high-speed data. The connector dimensions are the same as described for Data Lane 0, but both the positive and negative sides of the signal will be connected to the same flying lead.
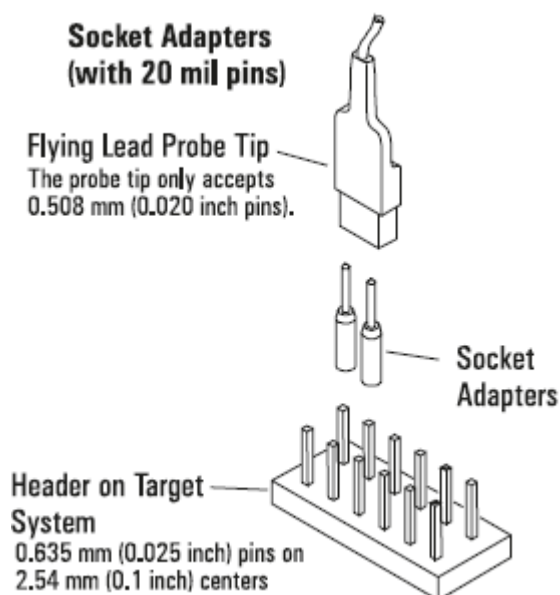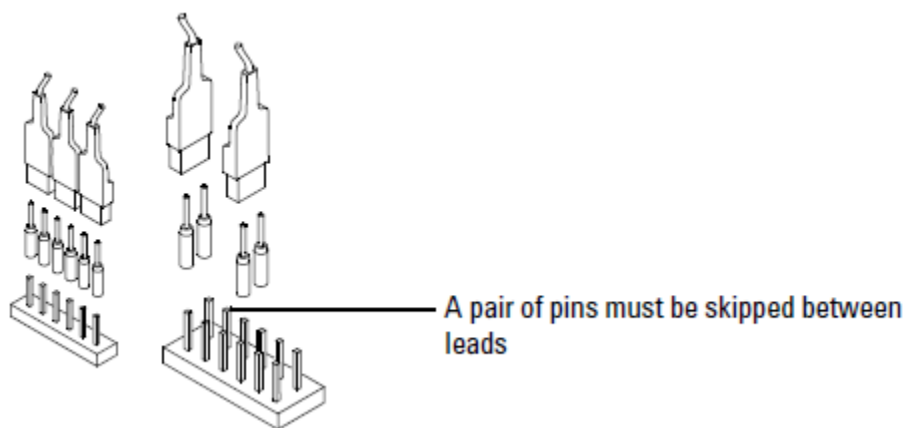
Connecting Socket Adapters

Figure 13   Socket Adapter used as the probe attachment accessory

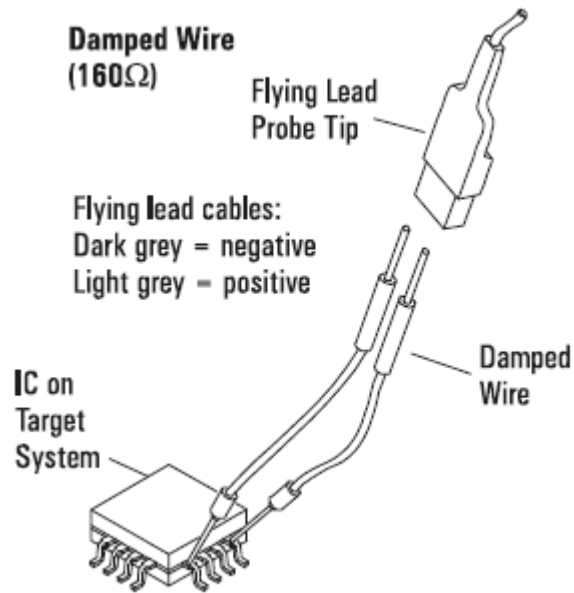| NOTE | You can connect multiple socket adapters side by side to pins or in tandem by skipping one or more pins but back to back connection of socket adapters to pins is not supported. |

Connecting Damped Wires

Damped Wire
(160Ω)   Flying Lead
             Probe Tip

Flying lead cables:
Dark grey = negative
Light grey = positive

IC on
Target
System   Damped
                              Wire

Figure 14   Damped wire used as the probe attachment accessory

Connecting the E5381A Probe to the U4421A Module and DUT

The E5381A probe connects to the DUT via the supplied probing accessories and to the U4421A module via the U4201A/N2815A cable.

1   Connect the E5381A probe to the U4421A module.

  a Plug the module connector of the U4201A/N2815A cable into the Analysis port on the front panel of the U4421A module.

Analysis port on U4421A module

  b The module connector of the cable has two thumb screws. Hand-tighten these screws. Do not over tighten the screws.

  c Connect the other end of the U4201A/N2815A cable to the cable connector component of the flying lead probe.

> **NOTE**   The U4201A cable has two probe connectors - Odd and Even. If you are using this cable, then connect the probe to the connector labeled "Odd"on the cable. The probe connector labeled "Even" on the cable is not used with the U4421A module.

2   Connect the E5381A probe to the DUT.

  a Attach the appropriate probe accessories (supplied with the probe) to the DUT. Refer to the topic "Connecting the Probe Accessories to the Probe and DUT" on page 32.

  b Connect the appropriate flying lead cables of the probe to the accessories attached to the DUT in the previous step. Refer to the topic "D-PHY Signals to Flying Leads Mapping" on page 28 to know which flying lead to connect for probing a particular signal.

Probing Single-ended Signals

To use the E5381A probe for probing single-ended signals

1   Connect the positive side (light grey colored cable) of the flying lead tip to the signal.

2   Connect the negative side (dark grey colored cable) of the flying lead tip to the ground.

> **NOTE**   You can connect the negative side of the flying lead tip to the ground using the same connection method that you used for connecting the positive side of the lead to the signal. For instance, if you used the coaxial tip resistor probe accessory to connect the positive side to the signal, then you can use the coaxial tip resistor to connect the negative side to the ground.

5 Setting up an E5405A Soft Touch Midbus Probe Configuration for U4421A Module

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E5405A Soft Touch Midbus Probe – Introduction

The Keysight E5405A probe is a 17-channel, differential, soft touch probe that you can use with the U4421A module to probe D-PHY signals.

The E5405A probe connects to the DUT via the E5403A retention module and to the U4421A module via the U4201A/N2815A cable.

Probe tip to connect to the E5403A retention module

Cable Connector to connect to the U4201A/N2815A cable

Figure 15   E5405A probe

The setup of the E5405A probe broadly involves:

1   Designing a footprint on the target system board (see page 39)
2   Installing the E5403A retention module on the target system board (see page 44)
3   Connecting the E5405A probe to the DUT and U4421A module (see page 46)

When to use an E5405A Probe

An E5405A probe is suitable for use when the DUT has incorporated the footprint for the E5405A probe. It provides quick connection to many signals in a small footprint without a header designed into the target.

You can also use this probe if the DUT's D-Phy signals are going to SMA connectors and you have a University of North Carolina IOL "MIPI Soft Touch Keysight Probe Board v2" and the University of New Hampshire - InterOperabilty Laboratory (UNH-IOL) "MIPI DPhy Reference Termination Board".

Two useful configuration using this board are:

- If the U4421A module is the master then place the board between the U4421A and DUT.
- If the DUT is the master then place the board between the DUT and a dynamic termination board such as the University of New Hampshire – InterOperabilty Laboratory (UNH-IOL) "MIPI DPhy Reference Termination Board".

Designing the Footprint on the DUT

This topic provides probe and retention module dimensions, probe pad dimensions, and pinout information that you will need to design the footprint on your DUT for use with the E5405A soft touch probe.

Probe and Retention Module Dimensions
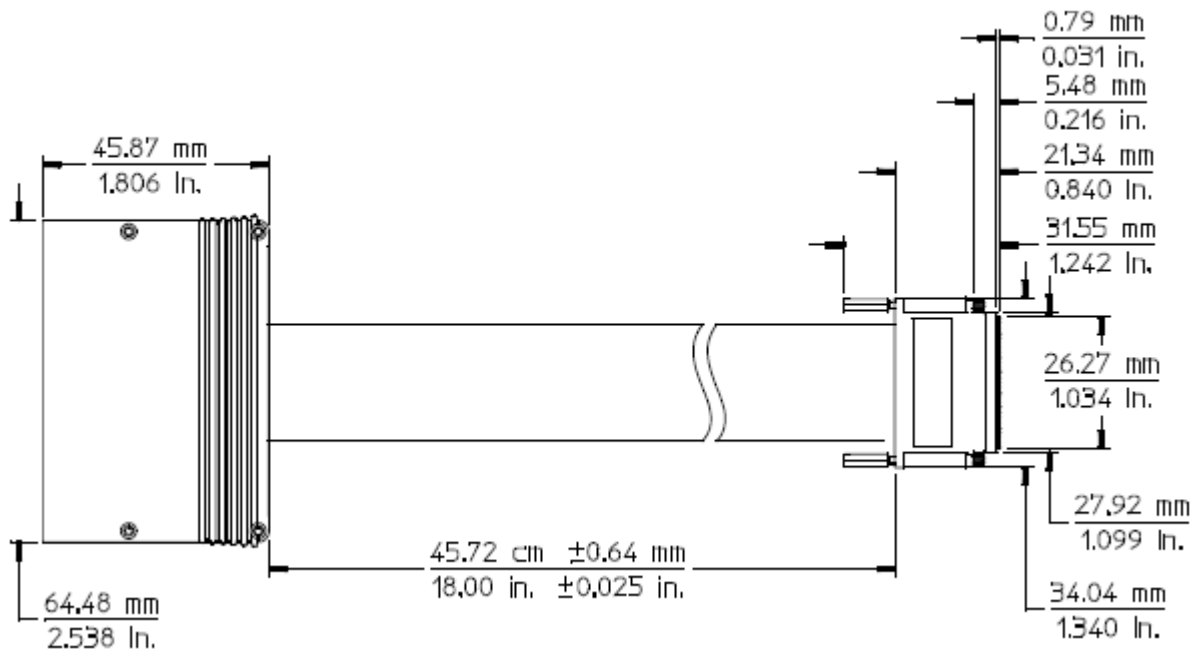
Figure 16   Top view of E5405A probe
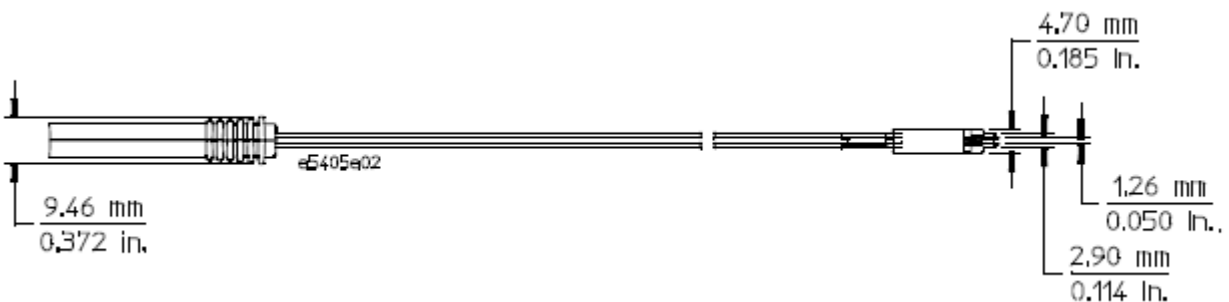
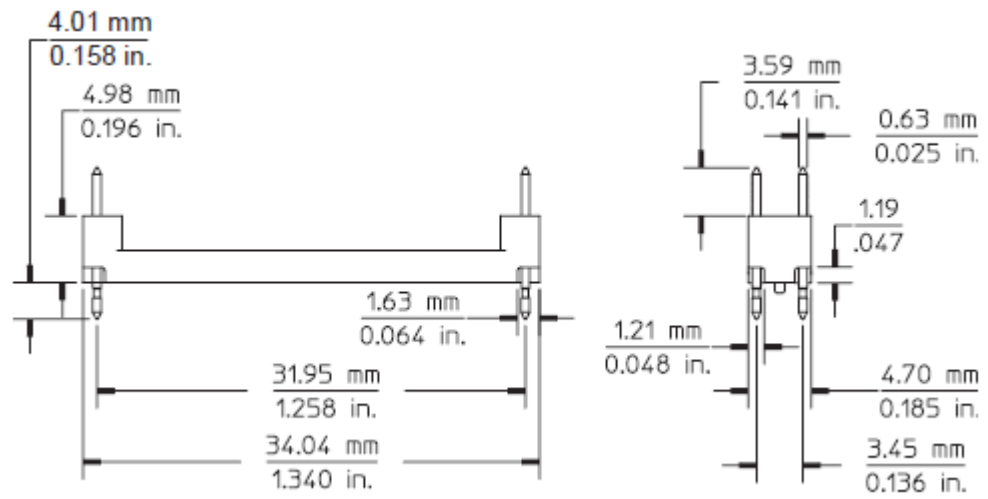Figure 17   Side view of E5405A probe

Figure 18   E5403A retention module dimensions

Probe Pad Layout / Footprint Dimensions

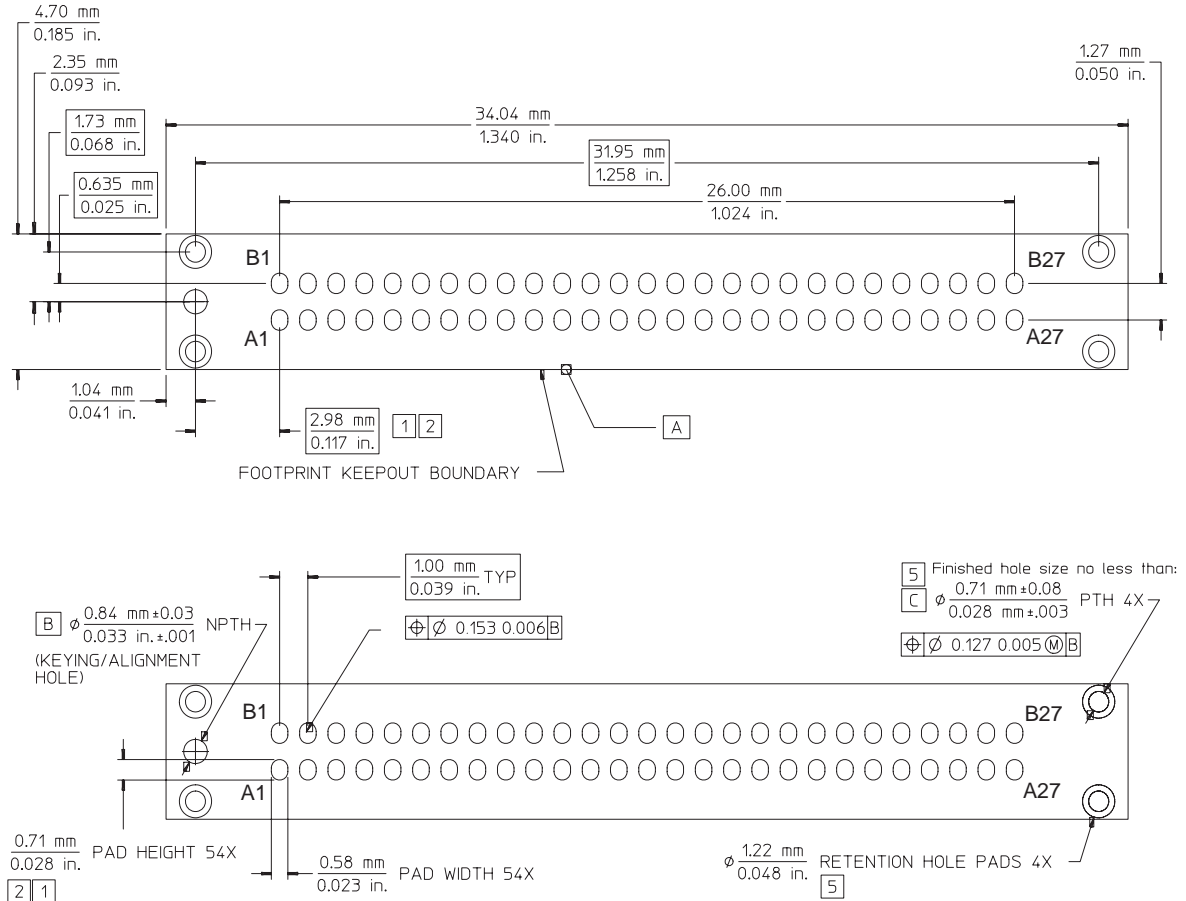The retention module alignment is symmetrical around the pad footprint.

Figure 19   Top view footprint dimensions (drawing notes below).

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

Drawing notes:

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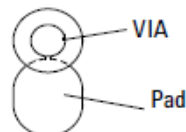
3   Surface finishes on pads should be HASL immersion silver, or gold over nickel.

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

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

Pinout Details for E5405A Probe

The following table shows the pinout details for the E5405A probe. While designing the DUT circuit board to which the E5405A probe is connected via a retention module, you need to follow the pinout details tabled below.

Pin	SoftTouch Signal Name	D-Phy DUT Connection	Pin	SoftTouch Signal Name	D-Phy DUT Connection
A1	D0+	GND	B1	GND	GND
A2	D0-	D0-P	B2	D1-	D0-P
A3	GND	GND	B3	D1+	D0-N
A4	D2+	D0-N	B4	GND	GND
A5	D2-	GND	B5	D3-	GND
A6	GND	GND	B6	D3+	D1-P
A7	D4+	D1-P	B7	GND	GND
A8	D4-	D1-N	B8	D5-	D1-N
A9	GND	GND	B9	D5+	GND
A10	D6+	n.c.	B10	GND	GND
A11	D6-	GND	B11	D7-	GND
A12	GND	GND	B12	D7+	GND
A13	n.c.	n.c.	B13	GND	GND
A14	n.c.	n.c.	B14	CK-	GND
A15	GND	GND	B15	CK+	D2-P
A16	D8+	D2-P	B16	GND	GND
A17	D8-	D2-N	B17	D9-	D2-N
A18	GND	GND	B18	D9+	GND
A19	D10+	GND	B19	GND	GND
A20	D10-	D3-P	B20	D11-	D3-P
A21	GND	GND	B21	D11+	D3-N
A22	D12+	D3-N	B22	GND	GND
A23	D12-	GND	B23	D13-	GND
A24	GND	GND	B24	D13+	CLK-P
A25	D14+	CLK-P	B25	GND	GND
A26	D14-	CLK-N	B26	D15-	CLK-N
A27	GND	GND	B27	D15+	GND

Figure 20   Pinout table for E5405A probe

Suggested Signal Routing with E5405A Probe

The E5405A probe has two rows of compliant pins to make contact with pads that you laid down on the surface of the target system board. The following figure illustrates the suggested D-Phy signal routing when using the E5405A probe with the U4421A module.
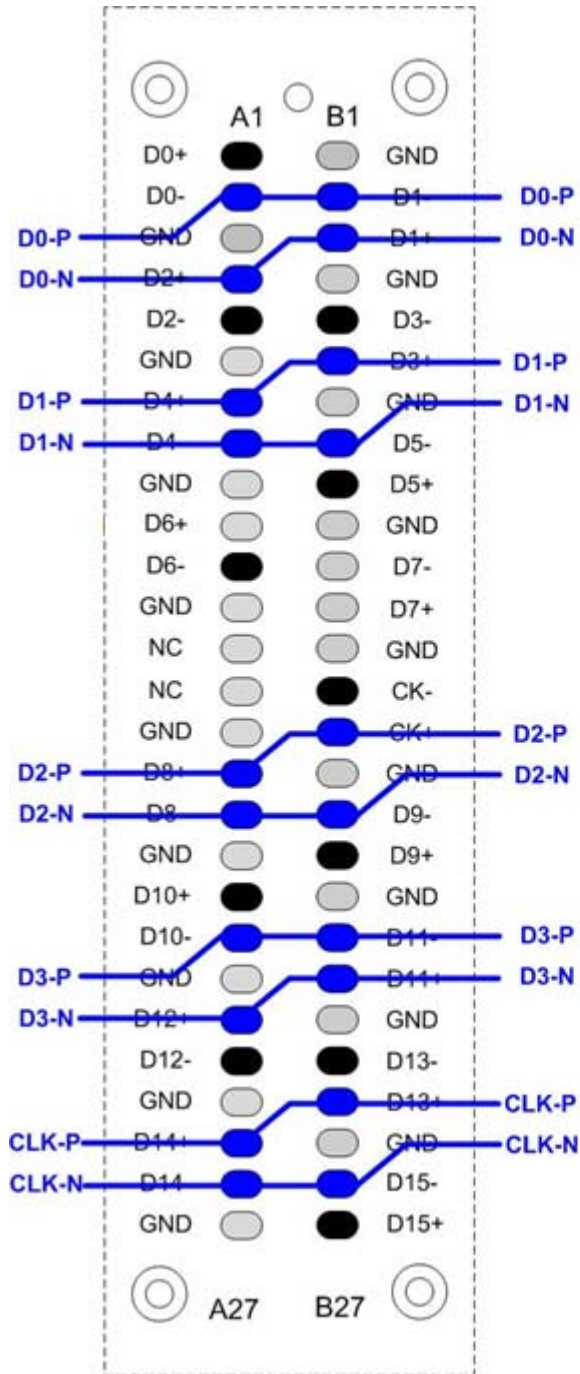

Figure 21   Suggested signal routing for E5405A probe

NOTE	You must connect the pins colored black in Figure 21 to GND on the target system.

Installing a Retention Module on the Target System Board

You must install an E5403A retention module on the target system board. The retention module attaches the E5405A probe to the target system board and ensures soft touch pin-to-PC board pad alignment. A kit of five retention modules are supplied with each E5405A probe. If you need more retention modules than the number of modules included in the probe shipment, you can order the part number *E5403A* that contains a set of 5 retention modules.
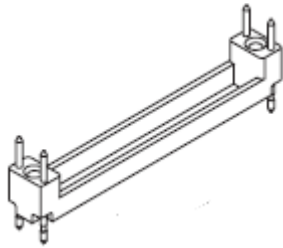
Figure 22   E5403A Retention Module

To install a retention module

1   Mount the retention module on the probing footprint that you designed on the target system board. Align and then insert the retention module into the footprint.
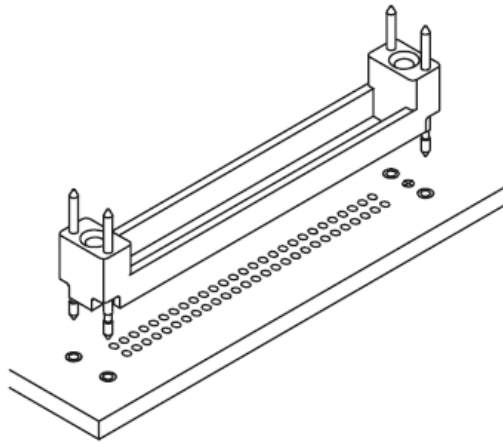
2   Solder the pins on the retention module to the footprint on top of the target system board.
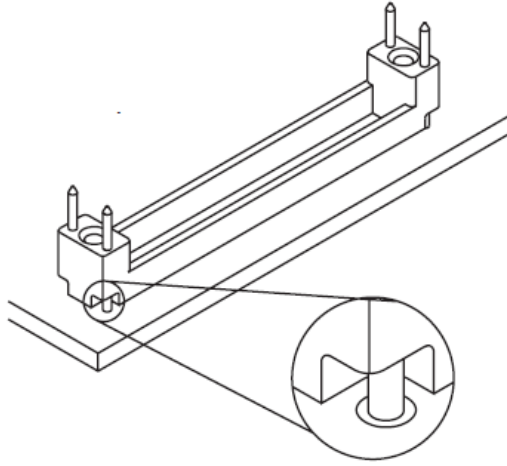
Connecting the E5405A probe to the DUT and U4421A Module

The E5405A probe connects to the DUT via a retention module and to the U4421A module via the U4201A/N2815A cable.

1   Connect the E5405A probe to the U4421A module.

    a Plug the module connector of the U4201A/N2815A cable into the Analysis port on the front panel of the U4421A module.

Analysis port on U4421A module

    b The module connector of the cable has two thumb screws. Hand-tighten these screws. Do not over tighten the screws.

    c Connect the other end of the U4201A/N2815A cable to the cable connector component of the soft touch probe.

NOTE	The U4201A cable has two probe connectors - Odd and Even. If you are using this cable, then connect the probe to the connector labeled "Odd"on the cable. The probe connector labeled "Even" on the cable is not used with the U4421A module.

2   Connect the E5405A probe to the DUT.

    a Note the location of the keying feature on the E5405A probe tip and the matching feature on the E5403A retention module that you mounted on the DUT circuit board.

    b Orient the probe so that the keying features align.

    c Carefully align the probe tip to the retention module and insert the probe tip into the retention module. Fully compress the pins evenly across the array of pins. You must push the probe tip down evenly.

    d Hand-tighten the thumb screws on both sides of the probe tip.

Supported Probe Configurations

A single E5405A probe can probe four D-Phy data channels and one clock channel. It can support:

- a x1 to x4 unidirectional D-PHY link configuration
- a x1 to x4 bidirectional D-PHY link configuration.

Index

Keysight U4421A MIPI D-PHY Analyzer and Exerciser Hardware and Probing Guide