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HP 4155B/4156B

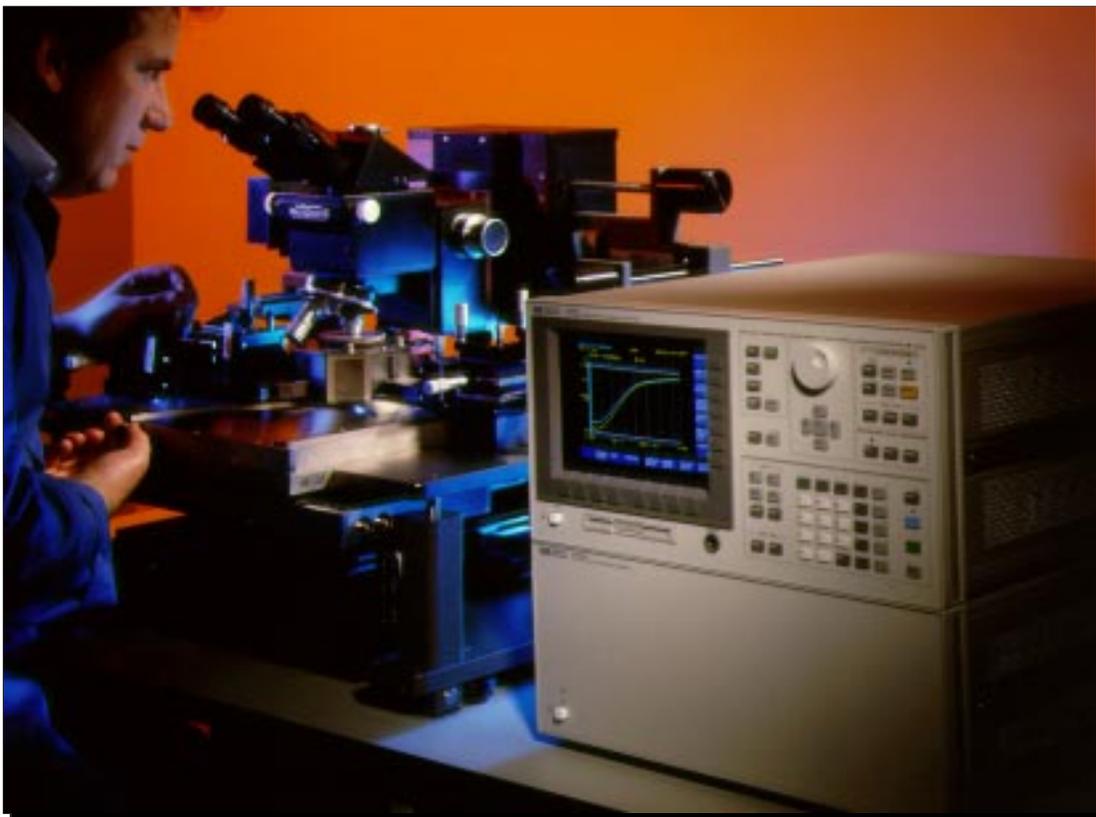
Semiconductor Parameter Analyzer

Product Note-3

Prober Connection Guide

HP 4155B/4156B

**Semiconductor Parameter
Analyzer**



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Safety Symbols

The general definitions of safety-symbols used in this product note are listed below.

WARNING

The warning sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

CAUTION

The caution sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

1. Introduction

This guide provides information on how to connect a probe to the HP 4155B/4156B Precision Semiconductor Parameter Analyzer. It also provides the necessary part numbers, and tips for making measurements.

2. General Information

2-1. Safety Precautions

When you perform measurements, always use a shielding box and an interlock circuit for safety

Shielding Box

Measurements should be performed in a shielding box in order:

- To prevent the operator from receiving an electric shock from the output voltage or current of the HP 4155B/4156B.
- To minimize the effects of environmental noise and ambient light.

Use a grounded shielding box to minimize the effects of environmental noise and ambient light. To ground the shielding box, connect it to the chassis ground of the HP 4155B/4156B.

Interlock circuit

When you use a shielding box, you must install an interlock circuit. To prevent an operator from receiving an electric shock from high voltage (more than ± 40 V), connect the interlock (Intlk) terminal on the connector plate to a switch. The switch should turn on when the shielding box door is closed, and turn off when the shielding box access door is opened. (Refer to **3-2. Interlock Connections.**)

2-2. Low Current Measurement

To reduce leakage current, you can use the guarding technique.

Guarding

Guarding reduces the leakage current between the measurement points and the instrument. This is important when you are measuring low current.

Fig. 1 illustrates the theory of guarding. The buffer amplifier (x1) keeps the potential of the GUARD conductor at the same potential as the FORCE conductor, so current does not flow between the FORCE and GUARD conductors. Therefore, the current measured by the SMU is the same as the current at the measurement point, because there is no leakage.

For highly accurate measurements and minimal leakage, surround all FORCE lines from the SMU by a GUARD as far as possible.

WARNING

Do not touch the GUARD terminal with your bare hands, because of the danger of high voltage electrical shock. The potential of the GUARD terminal is equal to the output voltage.

CAUTION

Never connect the GUARD terminal to any other output, including CIRCUIT COMMON, FRAME GROUND, or the GUARD terminal of any other unit. Doing so may damage the unit..

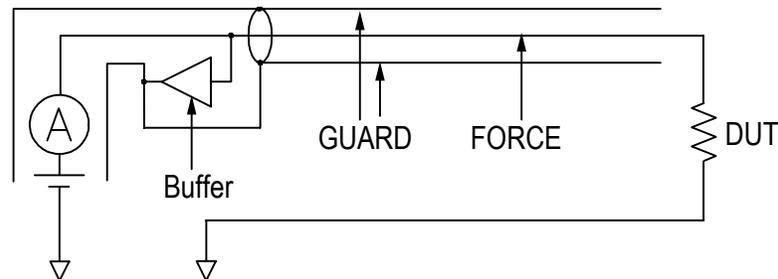


Fig. 1 Guarding

2-3. Low Resistance Measurement

To measure low resistance, connect the FORCE and SENSE terminals of the SMU to the DUT using the shortest possible connection (For HRSMU and HPSMU only).

When you measure a low resistance, high current flows through the DUT. This high current increases the measurement error caused by the residual resistance of cables and contacts. To cancel the effect of this resistance, use Kelvin connections (4-wire) to extend the FORCE and SENSE lines separately to the DUT.

Kelvin connections

Kelvin connections give good measurement results when you force high current. Fig. 2 shows the equipment circuits for Kelvin and non-Kelvin connections.

With non-Kelvin connections, the voltmeter measures the voltage drop of resistance $rF1$, R_{DUT} , and $rF2$.

With Kelvin connections, the voltmeter measures the voltage drop

of resistance R_{DUT} only. The impedance of the voltmeter is very high. Ideally, no current flows through $rS1$ and $rS2$, so the voltage drop across these resistances is negligible.

Kelvin connections are effective even when forcing voltage. The voltage drop due to the residual resistance of the FORCE line wiring is fed back to the voltage source via a comparator in the SENSE line, thereby ensuring the specified voltage output at the sense point (where the FORCE and SENSE lines intersect). The input impedance of the comparator is high, so the current flow into the SENSE line is very low. Therefore, the output error is not significant if the SENSE line wiring has a residual resistance of $10\ \Omega$ or less.

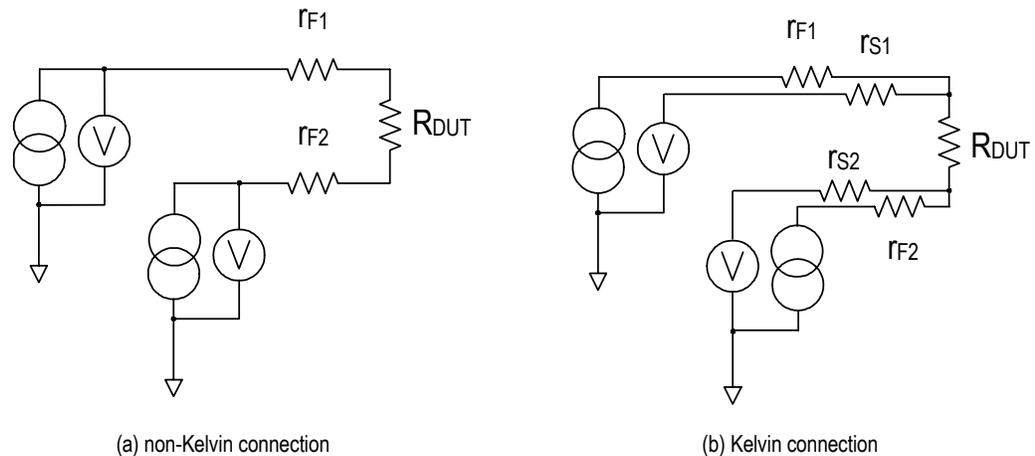


Fig. 2 Kelvin connection

2-4. Probe

Usually, a prober will have probes consisting of a probe cable and needle. One side of the probe cable is connected to a probe needle. The other side is connected to the HP 4155B/4156B through the shielding box.

HP recommends use of a full guarded needle, because non-guarded needles can cause leakage.

Fig. 3 shows possible connections for a full guarded needle. The prober vendor may let you select either triaxial or coaxial connectors. HP recommends using a triaxial connector to connect the SMU of the HP 4155B/4156B. To connect a triaxial connector to a coaxial connector of VSU/VMU/PGU, use a triaxial - coaxial adapter (1250-2649). (Refer to **5. Appendix.**)

If you have problems with these connections, you may want to solder them. HP provides two types of connector plates, a Connector Type and a Solder Type. Select the proper connection type for your prober. (Refer to **3-1. Installing the Connector Plate.**)

If your probe doesn't have a probe cable, you may be able to use another recommended cable as a probe cable. (Refer to **5. Appendix.**)

When you use a probe card, these points are available.

WARNING

Be sure to use a shielding box and Intlk when you make a measurement.

Do not use the adapters in Table 18 when the GUARD line connects to the outer conductor of the connector or adapter. Because they connect GUARD line and outer conductor of the connector or adapter, the potential of the GUARD terminal is equal to the output voltage and there is a potential for high voltage electrical shock at the adapter and connector.

3. Connecting to a Prober

This chapter provides information on connecting the prober. This information is for example only. If you need to know more about the connections between the connector plate and the prober, contact your prober vendor.

3-1. Installing the Connector Plate

Mount the HP 16495H/J connector plate on the side panel of your prober shielding box. One side of the plate is for connecting the cable from the HP 4155B/4156B. The other side of the plate is for connecting the cable to the prober.

The HP 16495H/J have two options, Connector Type (opt. 001) and Solder Type (opt. 002). Use the Connector Type when the probe cable has a triaxial or coaxial connector. Use the Solder Type when the probe cable has no connector, or you have problems with the connection.

Fig. 4 shows how to mount the connector plate. Table 1 and Fig. 5, Fig. 6, and Fig. 7 show more information about the connector plates.

To install the connector plate, follow these steps.

- (1) Before installing the connector plate, make sure that the HP 4155B/4156B and the HP 41501B are turned off.
- (2) Create the necessary openings and screw holes on your shielding box to match the connector plate.
- (3) Attach the connector plate with screws, nuts, and washers.
- (4) To prevent electric shock, make sure to install an interlock circuit. (Refer to **3-2. Interlock connections.**)
- (5) Connect the cables between the HP 4155B/4156B and the connector plate.

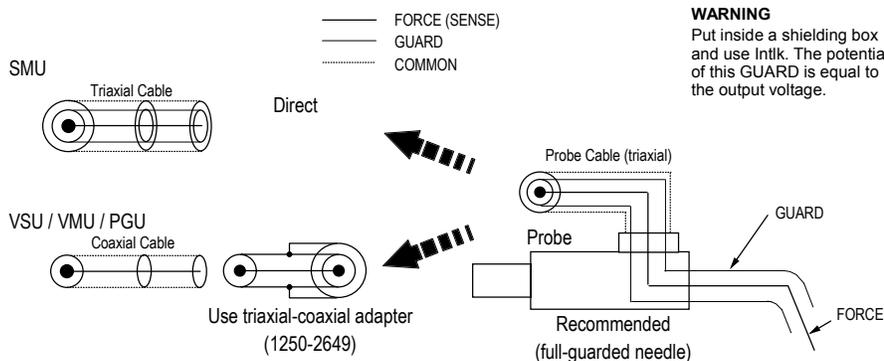


Fig. 3 Probe Cable

The screws, nuts, and washers are not furnished. Each connector plate has four screw holes (3.2 mm in diameter).

If you use a low noise probing system that has a built-in shield box, you may not need to install the connector plate and cables. This depends on the manufacturer. However, if the noise is not low enough, you will need to use a shielding box.

If your prober has a connector assembly, you can connect cables to the connector plate of the shielding box through this connector assembly. When using this method, be aware of the limit of guard capacitance, and so on. (Refer to 4. **In Case of Difficulty.**)

Table 1 Provided Connector Plates

HP 4155B/4156B Option	Stand-alone Product	No. of Connectors	Connector Type (Front to Rear)
Opt. 301	HP 16495H w / opt. 001	6 x Triax / 6 x Coax / 1 x Intlk / 1 x GNDU	Connector - Connector
Opt. 302	HP 16495H w / opt. 002	6 x Triax / 6 x Coax / 1 x Intlk / 1 x GNDU	Connector - Solder
Opt. 311	HP 16495J w / opt. 001	8 x Triax / 4 x Coax / 1 x Intlk / 1 x GNDU	Connector - Connector
Opt. 312	HP 16495J w / opt. 002	8 x Triax / 4 x Coax / 1 x Intlk / 1 x GNDU	Connector - Solder

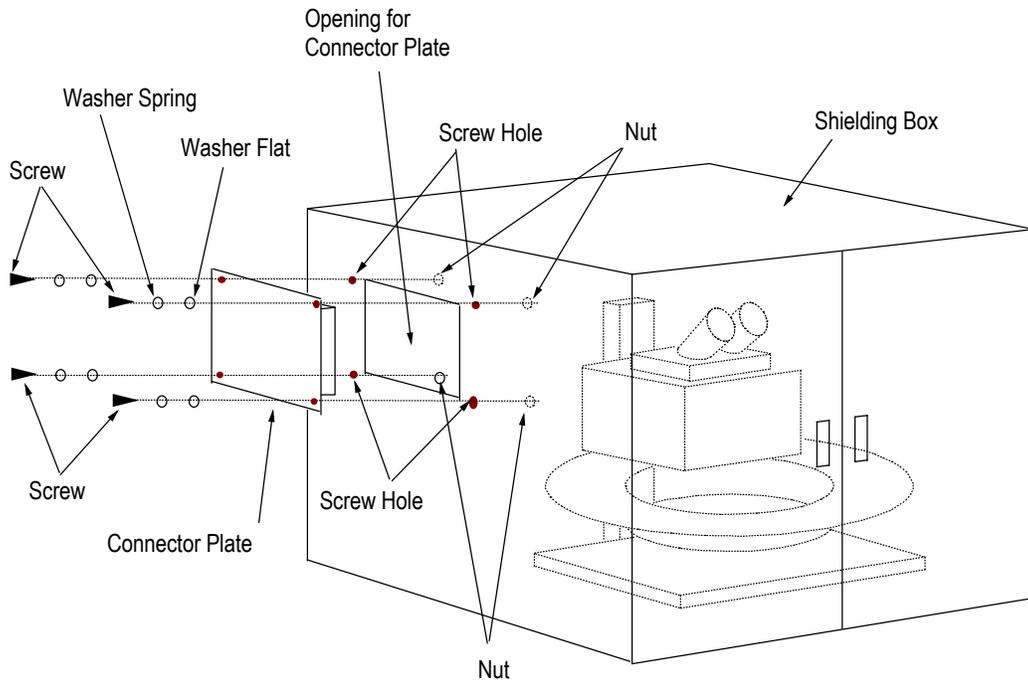
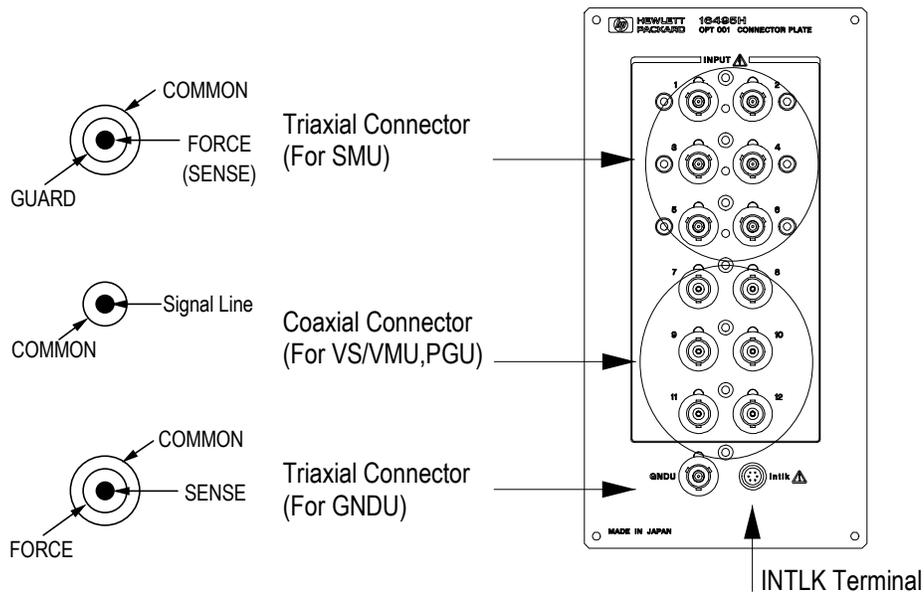
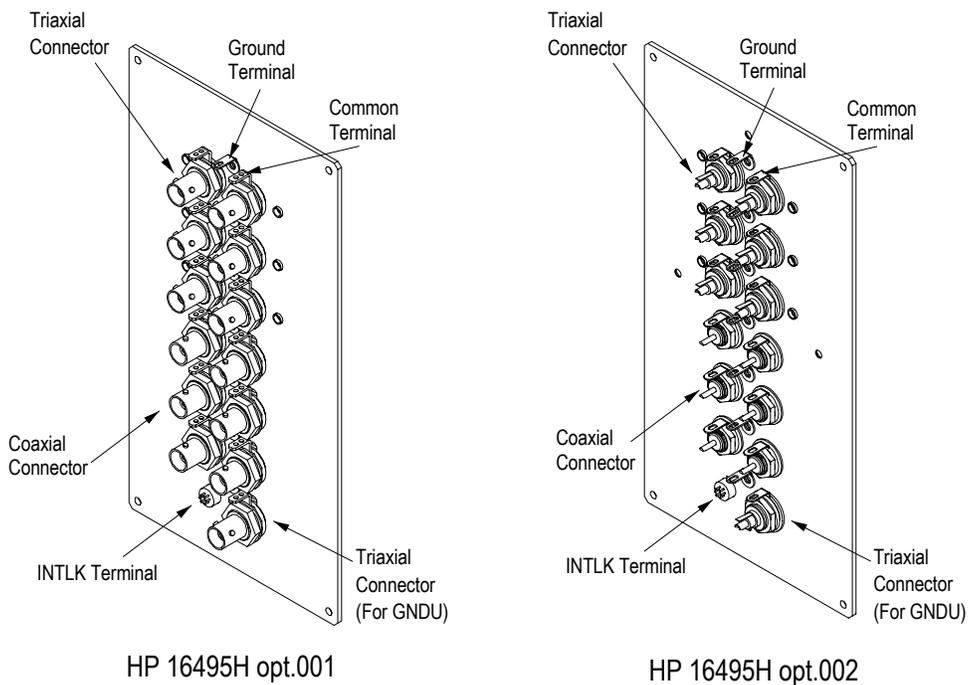


Fig. 4 Mounting Connector Plate



(a) Front View



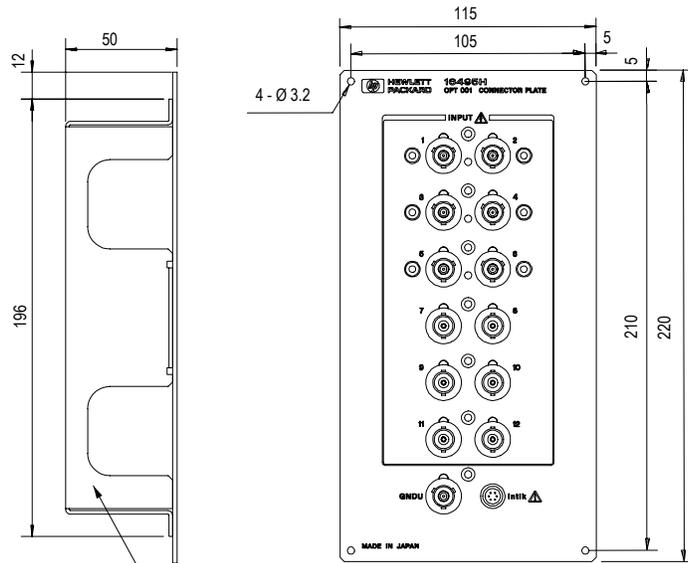
HP 16495H opt.001

HP 16495H opt.002

(The difference between the HP 16495H and J is the number of the Triax. and Coax. connectors)

(b) Rear View

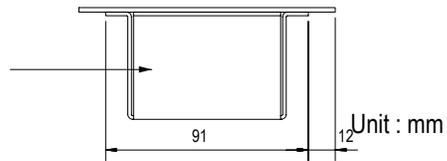
Fig. 5 Front View and Rear View of Connector Plate



HP 16495H opt. 002

(Difference between the HP 16495H and J is the number of the Triax. and Coax. connectors)

Metal Cover



Note : Metal cover is for preventing electrical shock.
Metal cover is furnished with opt. 002 only.

Fig. 6 Dimensions of the Connector Plate (HP 16495H/J)

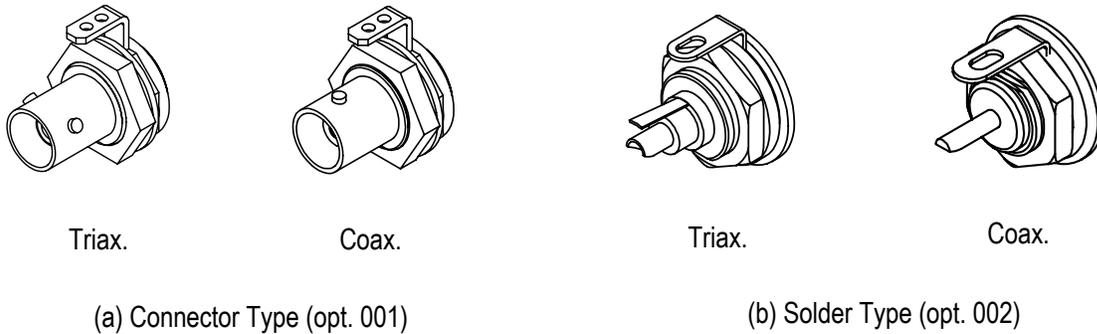


Fig. 7 Connection Type of Connector Plate (Rear)

3-2. Interlock Connections

Fig. 8 (a) shows the interlock circuit needed for the shielding box, and Fig. 8 (b) and (c) show the pin assignments of the interlock connector on the connector plate.

First, install the switches to interlock the opening and closing of the door. For safety, use two switches in series. When more than ± 40 V is forced from an SMU, the LED lights to indicate *high voltage output*.

If the door of shielding box is open (the interlock terminals are open), the SMU cannot force more than ± 40 V. If the door is opened while the SMU output is more than ± 40 V, the HP 4155B/4156B immediately drops the outputs of all units to 0 V.

Conversely, if the door is closed (interlock terminals are shorted), this function is disabled, and you can force more than ± 40 V.

The connector plate and the HP 4155B/4156B have terminals for an interlock cable. To connect the interlock circuit, use an HP 16493J interlock cable .

To prevent electric shock, make sure the interlock connection is as shown in Fig. 8.

WARNING

Dangerous voltages of up to the maximum voltage of SMUs may be present at the FORCE, GUARD, and SENSE terminal when the interlock terminals are shorted.

Interlock Cable Adapter

If you already have an interlock circuit with a BNC coaxial connector, you can use an HP 16435A Interlock Cable Adapter.

Switch and LED

For dimensions of the switches and the LED, see Fig. 9, Fig. 10 and Fig. 11. For recommended parts, see table 2 .

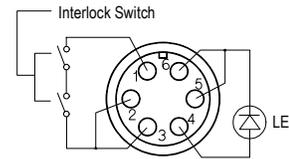
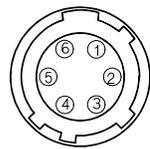
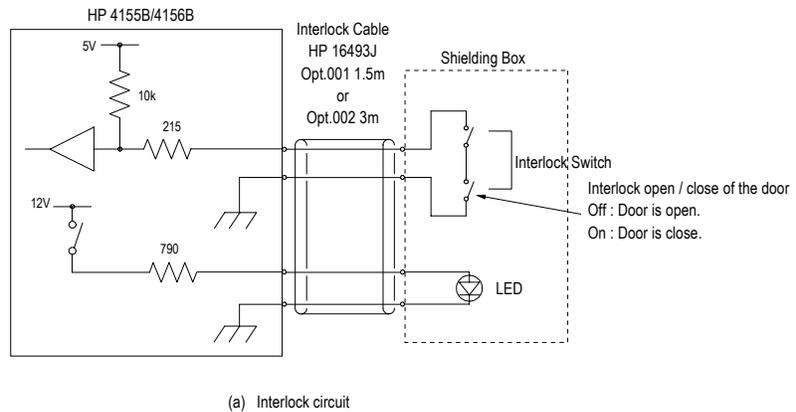
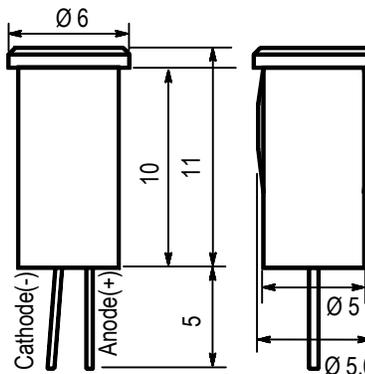


Fig. 8 Interlock Circuit



Units: mm

Fig. 9 Dimensions of LED

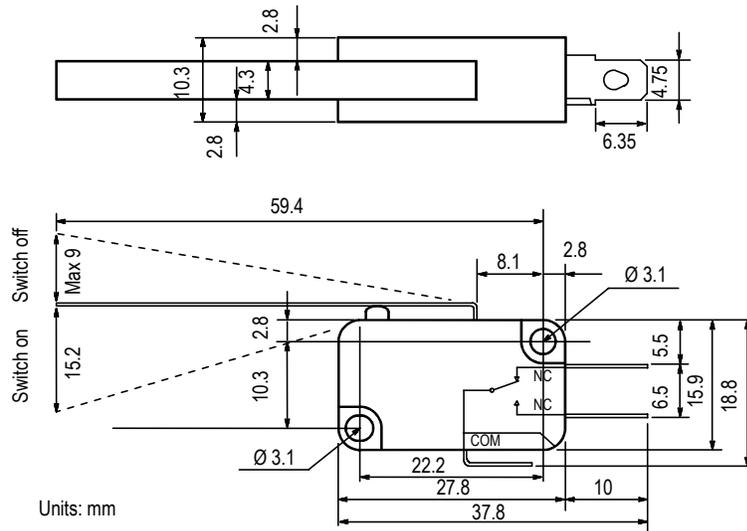


Fig. 10 Dimensions of Interlock Switch (3101-0302)

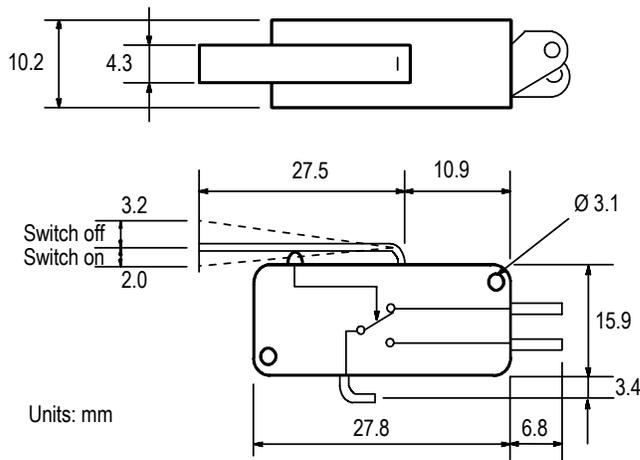


Fig. 11 Dimensions of Interlock Switch (3101-3241)

Table 2 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Interlock Cable - 1.5m	1	-	HP16493J	001
Interlock Cable - 3.0m	1	-	HP16493J	002
Interlock Cable Adapter	1	-	HP16435A	-
Switch	1	3101-3241	-	-
Switch	1	3101-0302	-	-
LED (VF ~ = 2.1V @ IF = 10mA)	1	1450-0641	-	-

3-3. GNDU Connections

An SMU has FORCE (SENSE), GUARD, and COMMON, but a GNDU has SENSE, FORCE, and COMMON as shown in Fig. 12. A GNDU terminal has no GUARD line. When you connect it, pay attention to this connection.

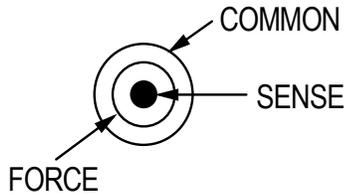


Fig. 12 GNDU Terminal

CAUTION

Do not use the HP 16493C triaxial cable for an SMU to connect the GNDU to a DUT. The GNDU can sink up to 1.6 A, and the maximum current rating for that cable is 1 A. Use an HP 16493H triaxial cable for a GNDU.

When you connect to the prober, be sure to connect the FORCE line to the probe. Current flows only in the FORCE line, not the SENSE line.

(Connector Type)

Connect the triaxial connector using an adapter for GNDU (1250-2654) as shown in Fig. 13. For this part, see Table 18 in 5.

Appendix.

For parts information, see Table 3.

(Solder Type)

Solder the SENSE line, and short SENSE and FORCE as shown in Fig. 14. To connect the GNDU quickly for measurements where accuracy is not important, connect to the prober without shorting SENSE and FORCE.

For parts information, see Table 4.

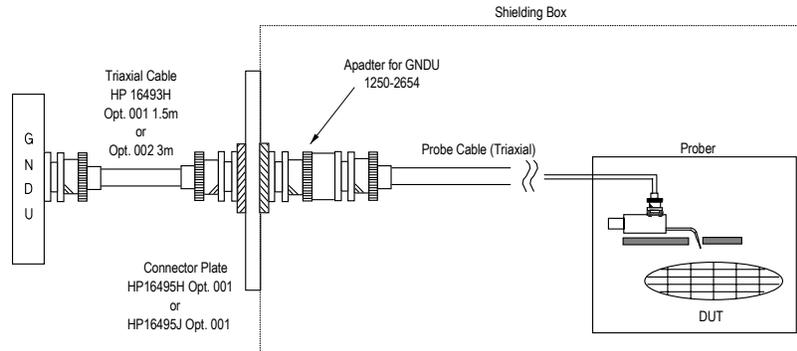


Fig. 13 Example of a GNDU non-Kelvin Connection
(Connector Plate Type: connector)

Table 3 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Triaxial Cable -1.5m	1	-	HP16493H	001
Triaxial Cable -3.0m	1	-	HP16493H	002
Connector Plate (Connector Type)	1	-	HP16495H	001
Connector Plate (Connector Type)	1	-	HP16495J	001
Adapter for GNDU (triaxial (m) - triaxial (f))	1	1250-2654	-	-

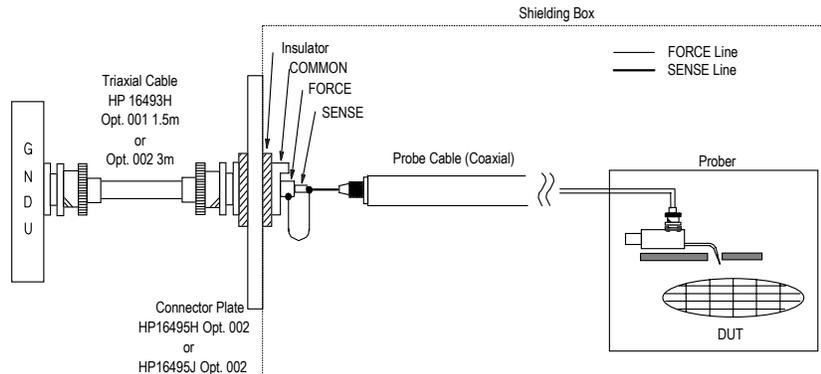


Fig. 14 Example of a GNDU non-Kelvin Connection
(Connector Plate Type: solder)

Table 4 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Triaxial Cable -1.5m	1	-	HP16493H	001
Triaxial Cable -3.0m	1	-	HP16493H	002
Connector Plate (Solder Type)	1	-	HP16495H	002
Connector Plate (Solder Type)	1	-	HP16495J	002

3-4. SMU Connections

An SMU terminal is shown in Fig. 15.

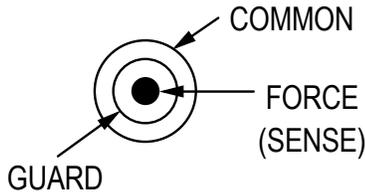


Fig. 15 SMU Terminal

(1) Kelvin connections

These instructions apply when all connections are Kelvin. Two probes must contact the wafer in this connection.

Connect an HP 16493K Kelvin triaxial cable (or two HP 16493C triaxial cables) between the SMU and the connector plate. Connect the FORCE and SENSE lines to probes separately. (Only for HRSMU and HPSMU)

(Connector Type)

Connect the triaxial connector on the probe cable as shown in Fig. 16. To prevent oscillations, use short cables. (Refer to 4. **In Case of Difficulty.**)

For parts information, see Table 5.

(Solder Type)

Solder the FORCE line, SENSE line, and GUARD line as shown in Fig. 17. If the probe cable is triaxial, also solder the COMMON line. To prevent oscillations, use short cables. (Refer to 4. **In Case of Difficulty.**)

For parts information, see Table 6.

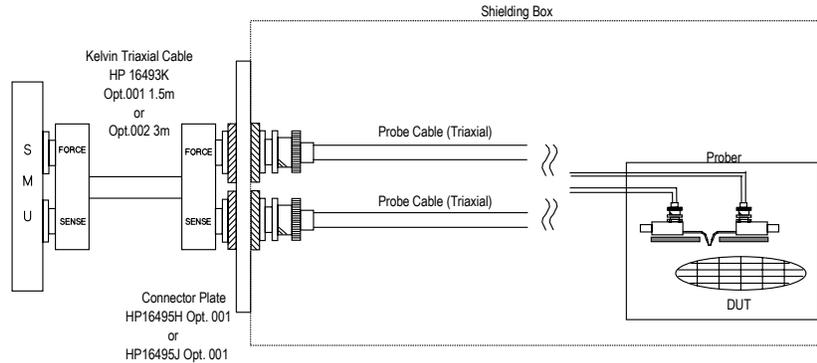


Fig. 16 Example of an SMU Kelvin Connection (Connector Plate Type: connector)

Table 5 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Kelvin Triaxial Cable -1.5m	1	-	HP16493K	001
Kelvin Triaxial Cable -3.0m	1	-	HP16493K	002
Triaxial Cable -1.5m	1	-	HP16493C	001
Triaxial Cable -3.0m	1	-	HP16493C	002
Connector Plate (Connector Type)	1	-	HP16495H	001
Connector Plate (Connector Type)	1	-	HP16495J	001

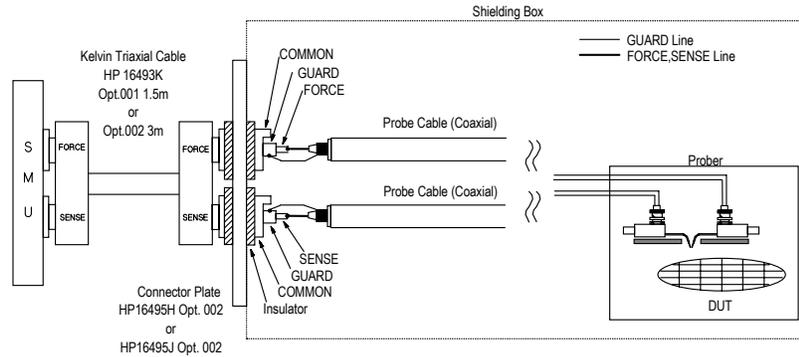


Fig. 17 Example of an SMU Kelvin Connection (Connector Plate Type: solder)

Table 6 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Kelvin Triaxial Cable -1.5m	1	-	HP16493K	001
Kelvin Triaxial Cable -3.0m	1	-	HP16493K	002
Triaxial Cable -1.5m	1	-	HP16493C	001
Triaxial Cable -3.0m	1	-	HP16493C	002
Connector Plate (Solder Type)	1	-	HP16495H	002
Connector Plate (Solder Type)	1	-	HP16495J	002

(2) Kelvin to non-Kelvin

These instructions apply when the connections up to the Connector Plate are Kelvin, but the probe is a non-Kelvin connection.

Connect an HP 16493K Kelvin triaxial cable (or two HP 16493C triaxial cables) between the SMU and the Connector plate. (Only for HRSMU and HPSMU)

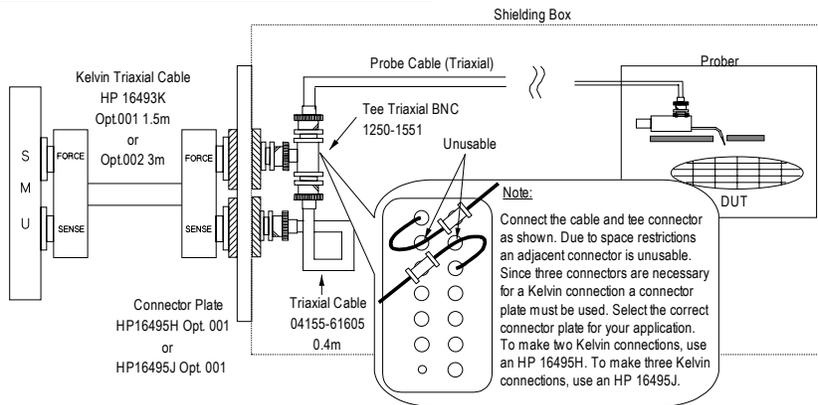


Fig. 18 Example of an SMU Kelvin - non-Kelvin Connection (Connector Plate Type: connector)

(Connector Type)

Connect the triaxial connector on the probe cable as shown in Fig. 18.

Connect the FORCE and SENSE lines on this side of the probe input terminal. A Tee Triaxial BNC adapter can be used.

For parts information, see Table 7.

Note:

When connecting the cable and tee connector as shown in Fig 18, space restrictions make an adjacent connector unusable. Since three connectors are necessary for a Kelvin connection a connector plate must be used. Select the correct connector plate for your application. To make two Kelvin connections, use an HP 16495H. To make three Kelvin connections, use an HP 16495J.

Table 7 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Kelvin Triaxial Cable -1.5m	1	-	HP16493K	001
Kelvin Triaxial Cable -3.0m	1	-	HP16493K	002
Triaxial Cable -0.4m	1	04155-61605	-	-
Triaxial Cable -1.5m	1	-	HP16493C	001
Triaxial Cable -3.0m	1	-	HP16493C	002
Tee Triaxial BNC	1	1250-1551	-	-
Connector Plate (Connector Type)	1	-	HP16495H	001
Connector Plate (Connector Type)	1	-	HP16495J	001

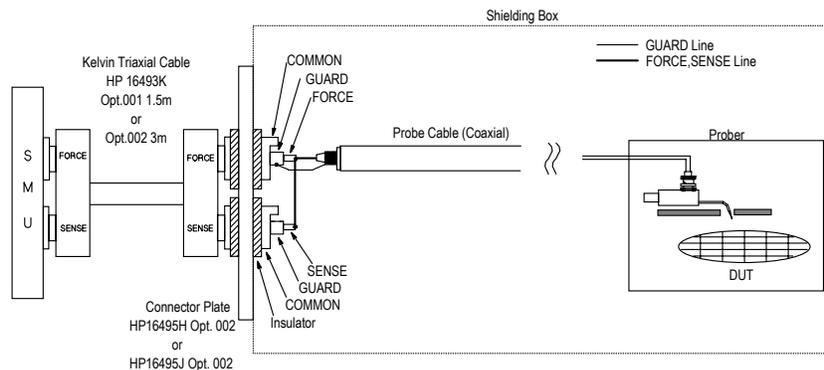


Fig. 19 Example of an SMU Kelvin - non-Kelvin Connection (Connector Plate Type: solder)

(Solder Type)

Connect the FORCE and SENSE lines on this side of the probe input terminal. Solder the FORCE line and the GUARD line, and short FORCE and SENSE as shown in Fig. 19. If the probe cable is triaxial, also solder the COMMON line.

For parts information, see Table 8.

Table 8 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Kelvin Triaxial Cable -1.5m	1	-	HP16493K	001
Kelvin Triaxial Cable -3.0m	1	-	HP16493K	002
Triaxial Cable -1.5m	1	-	HP16493C	001
Triaxial Cable -3.0m	1	-	HP16493C	002
Connector Plate (Solder Type)	1	-	HP16495H	002
Connector Plate (Solder Type)	1	-	HP16495J	002

(3) non-Kelvin to non-Kelvin

These instructions apply when all connections are non-Kelvin.

Connect the HP 16493C triaxial cables between the SMU and the Connector plate.

(Connector Type)

Connect the triaxial connector on the probe cable as shown in Fig. 20.

For parts information, see Table 9.

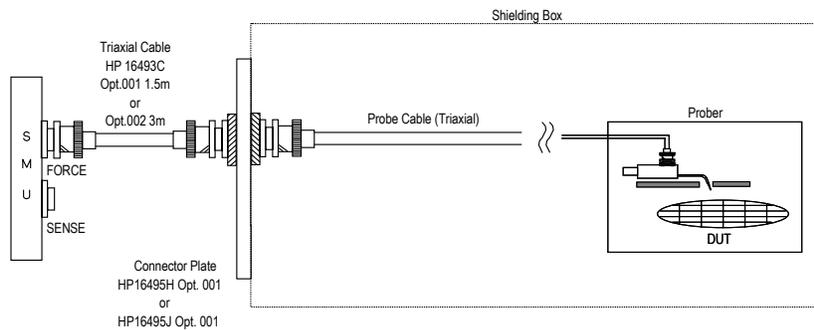


Fig. 20 Example of an SMU non-Kelvin - non-Kelvin Connection (Connector Plate Type: connector)

Table 9 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Triaxial Cable -1.5m	1	-	HP16493C	001
Triaxial Cable -3.0m	1	-	HP16493C	002
Connector Plate (Connector Type)	1	-	HP16495H	001
Connector Plate (Connector Type)	1	-	HP16495J	001

(Solder Type)

Solder the FORCE line and the GUARD line as shown in Fig. 21. If the probe cable is triaxial, also solder the COMMON line.

For parts information, see Table 10.

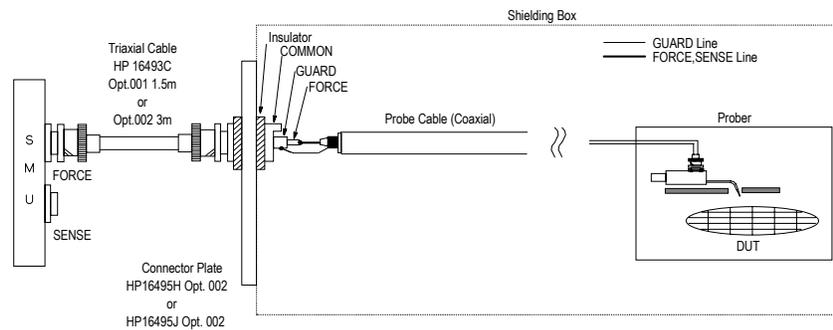


Fig. 21 Example of an SMU non-Kelvin - non-Kelvin Connection (Connector Plate Type: solder)

Table 10 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Triaxial Cable -1.5m	1	-	HP16493C	001
Triaxial Cable -3.0m	1	-	HP16493C	002
Connector Plate (Solder Type)	1	-	HP16495H	002
Connector Plate (Solder Type)	1	-	HP16495J	002

3-5. VSU/VMU Connections

A VSU/VMU terminal is shown in Fig. 22.

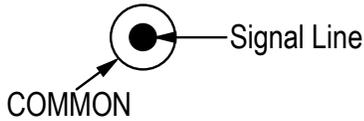


Fig. 22 VSU/VMU Terminal

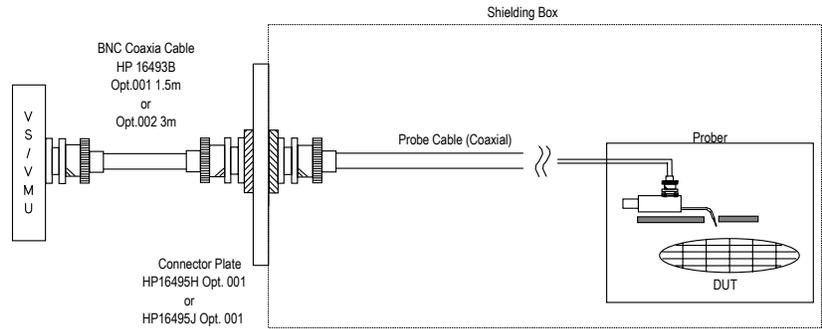


Fig. 23 Example of a VSU/VMU Connection
(Connector Plate Type: connector)

Connect the HP 16493B coaxial cable between the VSU/VMU and the connector plate.

(Connector Type)

Connect the coaxial connector on the probe cable as shown in Fig. 23.

If the probe cable is triaxial, use a triaxial - coaxial adapter (1250-2649).

For parts information, see Table 11.

(Solder Type)

Solder the signal line as shown in Fig. 24.

For parts information, see Table 12.

Table 11 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Coaxial Cable -1.5m	1	-	HP16493B	001
Coaxial Cable -3.0m	1	-	HP16493B	002
Connector Plate (Connector Type)	1	-	HP16495H	001
Connector Plate (Connector Type)	1	-	HP16495J	001
Triaxial(f) - Coaxial(m) Adapter	1	1250-2649	-	-

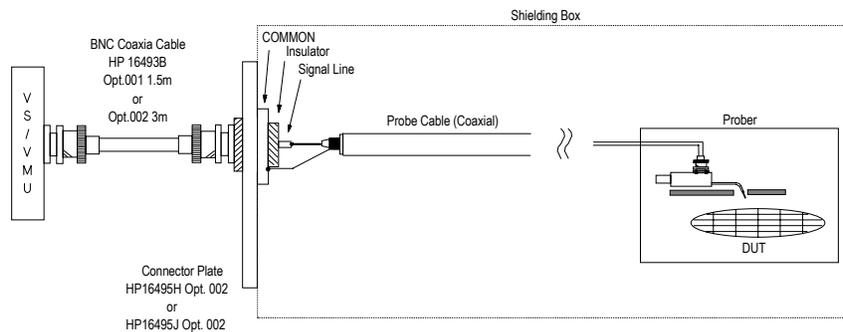


Fig. 24 Example of a VSU/VMU Connection
(Connector Plate Type: solder)

Table 12 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Coaxial Cable -1.5m	1	-	HP16493B	001
Coaxial Cable -3.0m	1	-	HP16493B	002
Connector Plate (Solder Type)	1	-	HP16495H	002
Connector Plate (Solder Type)	1	-	HP16495J	002

3-6. PGU Connections

A PGU terminal is shown in Fig. 25.

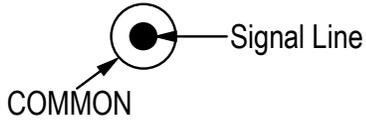


Fig. 25 PGU Terminal

Connect the HP 16493B coaxial cable between the PGU and the Connector plate.

(Connector Type)

Connect the coaxial connector on the probe cable as shown in Fig. 26.

If the probe cable is triaxial, use a triaxial - coaxial adapter (1250-2649).

For parts information, see Table 13.

(Solder Type)

Solder the Signal line and COMMON as shown in Fig. 27.

For parts information, see Table 14.

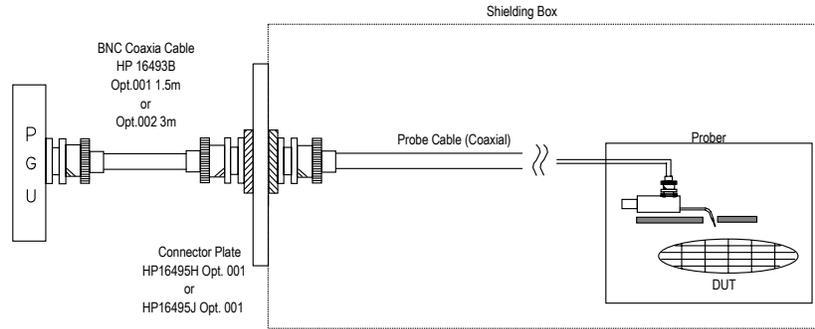


Fig. 26 Example of a PGU Connection
(Connector Plate Type: connector)

Table 13 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Coaxial Cable -1.5m	1	-	HP16493B	001
Coaxial Cable -3.0m	1	-	HP16493B	002
Connector Plate (Connector Type)	1	-	HP16495H	001
Connector Plate (Connector Type)	1	-	HP16495J	001
Triaxial(f) - Coaxial(m) Adapter	1	1250-2649	-	-

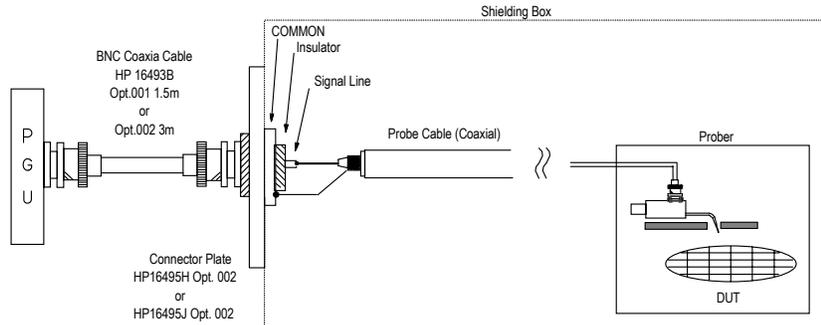


Fig. 27 Example of a PGU Connection
(Connector Plate Type: solder)

Table 14 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Coaxial Cable -1.5m	1	-	HP16493B	001
Coaxial Cable -3.0m	1	-	HP16493B	002
Connector Plate (Solder Type)	1	-	HP16495H	002
Connector Plate (Solder Type)	1	-	HP16495J	002

3-7. Conclusion of Chapter 3

You can connect a prober to the HP 4155B/4156B using the previous instructions and examples. When making the connections, remember these points:

- (1) Before making a measurement, confirm that the shielding box and interlock circuit are in place for safety and lowering noise effects. Mount connector plates in the shielding box as needed.
- (2) Use Kelvin connections when you measure low resistance (high current).
- (3) Use guarding (for example, a full guarded needle) when you measure low current.

- (4) Cables must be short and stable for accurate measurement.

The prober documentation may show different methods of connection. The connections described here are only examples.

Fig. 28 shows the prober setup.

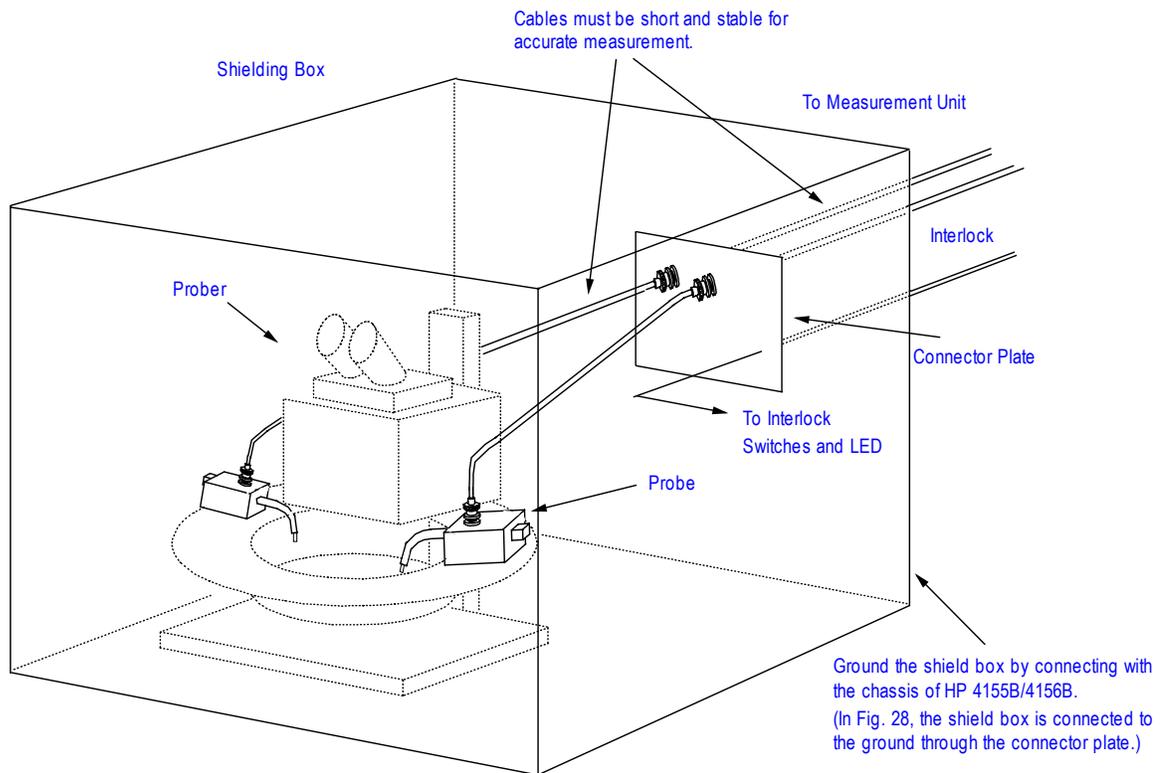


Fig. 28 Example Cabling to Prober

4. In Case Of Difficulty

4-1. SMU Oscillations due to Exceeding the Limits

The HP 4155B/4156B have low current forcing and measurement capability through their SMUs. An SMU uses a feedback circuit to maintain very high stability of current / voltage sourcing. Therefore, the guard capacitance (a load for SMUs) of all connections to the SMU must be within certain limits to prevent SMU circuit oscillation. Select the proper cable type and length to keep guard capacitance low.

For SMU limits, refer to **4-3. Restriction of Measurement Units**.

4-2. Device Oscillations

When measuring parameters of high-frequency devices, such as GaAs MESFETs or high-frequency bipolar transistors, oscillation may cause measurement problems.

To solve this problem:

- For FETs, add resistive ferrite beads as close as possible to the gate.
- For bipolar transistors, add resistive ferrite beads (9170-0029) as close as possible to the base or emitter, as shown in Fig. 29.
- Keep cables as short as possible. Long cables cause oscillation because of their large inductance.

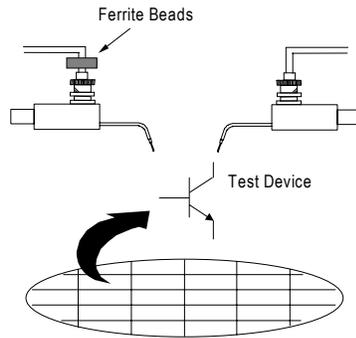


Fig. 29 Example of Ferrite

4-3. Negative Resistance

If the DUT has negative resistance characteristics as shown in Fig. 30 (b) and (d), the SMUs may oscillate, because SMUs operate as negative feedback amplifiers.

To solve this problem:

- For a voltage-controlled negative resistance device:

Connect G in parallel with the DUT to cancel negative resistance as shown in Fig. 30 (a). To obtain an output I-V curve, use the following equation.

$$I_y = I - G \times V$$

- For current-controlled negative resistance device:

Connect R in series with the DUT to cancel negative resistance as shown in Fig. 30 (c). To obtain an output I-V curve, use the following equation.

$$V_z = V - R \times I$$

If the resistance of the DUT is less than 1 MΩ, you can use an R-Box.

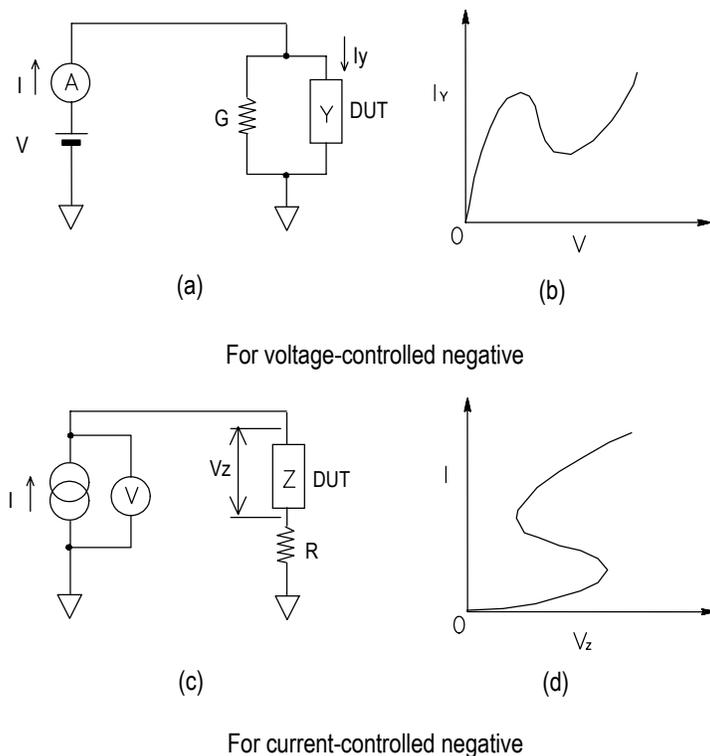


Fig. 30 Negative Resistance

4-4. Restrictions of Measurement Units

The conditions in Table 15 are required for Measurement Units to measure accurately. (If the capacitance exceeds the limits, Measurements Units cannot measure accurately because of the SMU's oscillations.)

Because high cable resistance causes an error in the feedback circuit of the SMUs, keep cables as short as possible. This is especially important when making high current measurements.

For more information on cables, see Table 16 and Table 17.

Table 15 Restrictions of Measurement Units

Unit	Maximum Capacitive Load	Maximum GUARD Capacitance	Maximum Shield Capacitance	Cable Resistance	Typical Voltage Source Output Resistance
HRSMU	1000pF	900pF	5000pF	Maximum allowable cable resistance when using Kelvin connections 10Ω (FORCE,SENSE)	FORCE line/ non-Kelvin connection 0.2Ω
MPSMU	1000pF	900pF	5000pF	-	Max. 0.3Ω
HPSMU	1000pF	900pF	5000pF	Maximum allowable cable resistance when using Kelvin connections FORCE: 0.7Ω (100mA to 1A) FORCE: 10Ω (≤100mA) SENSE: 10Ω	FORCE line/ non-Kelvin connection 0.2Ω
VSU	10uF	-	-	-	-
GNDU	≤1uF	-	-	FORCE: ≤1Ω SENSE: ≤10Ω	-

GUARD capacitance:

Capacitance between FORCE (SENSE) and GUARD line

Shield capacitance:

Capacitance between GUARD and COMMON line

Table 16 Cable Reference Data

PRODUCT	OPT	DESCRIPTION	LENGTH	CAPACITANCE	RESISTANCE	MAXIMUM CURRENT
HP 16493B	001	BNC cable	1.5m	160pF	Resistance of FORCE line 220mΩ	1A
	002	BNC cable	3.0m	330pF	Resistance of FORCE line 400mΩ	1A
HP 16493C	001	SMU triaxial cable	1.5m	GUARD capacitance: 120pF Capacitance between GUARD and COMMON line: 900pF	Resistance of FORCE line 160mΩ	1A
	002	SMU triaxial cable	3.0m	GUARD capacitance: 240pF Capacitance between GUARD and COMMON line: 1800pF	Resistance of FORCE line 320mΩ	1A
HP 16493H	001	GNDU triaxial cable	1.5m	Capacitance between FORCE and COMMON line: 550pF Capacitance between FORCE and SENSE line: 350pF	Resistance of FORCE line 80mΩ	1.6A
	002	GNDU triaxial cable	3.0m	Capacitance between FORCE and COMMON line: 1100pF Capacitance between FORCE and SENSE line: 700pF	Resistance of FORCE line 150mΩ	1.6A
HP 16493K	001	Kelvin triaxial cable	1.5m	GUARD capacitance: 140pF	Resistance of FORCE line 170mΩ	1A
	002	Kelvin triaxial cable	3.0m	GUARD capacitance: 260pF	Resistance of FORCE line 340mΩ	1A

Table 17 Cable Reference Data

PART-NUMBER	DESCRIPTION	CAPACITANCE	RESISTANCE	DIELECTRIC WITHSTAND VOLTAGE TEST	JACKET EXTERNAL DIAMETER	VOLTAGE RATING	COLOR
8120-3674	Coaxial cable	77pF/m	Resistance of center conductor: 133mΩ/m maximum	500Vrms, 1minute	3.0mm	-	-
8120-4461	Low-noise coaxial cable	130pF/m	Resistance of center conductor: 114mΩ/m maximum	1000Vrms, 1minute	2.7mm	-	-
8120-0102	Coaxial cable	102pF/m	Resistance of center conductor: 139mΩ/m maximum	1500Vrms, 1minute	3.0mm	-	-
8150-2639	AWG22 insulated wire (0.634mm in diameter)	-	56mΩ/m	-	-	600V	Black
8150-0447	AWG24 insulated wire (0.511mm in diameter)	-	89mΩ/m	-	-	300V	Black
8150-0448	AWG24 insulated wire (0.511mm in diameter)	-	89mΩ/m	-	-	300V	Brown
8150-0449	AWG24 insulated wire (0.511mm in diameter)	-	89mΩ/m	-	-	300V	Red
8150-0451	AWG24 insulated wire (0.511mm in diameter)	-	89mΩ/m	-	-	300V	Yellow

5. Appendix

5-1. Parts Information

(1) Adapter Information

If you need to make a connection between a triaxial connector and a coaxial connector, use a triaxial - coaxial adapter. Table 18 shows the adapter information provided by HP. If you need an adapter which is not provided, contact a local parts vendor.

WARNING

Be sure to use a shielding box and Intlk when you make a measurement.

Do not use the adapters in Table 18 when the GUARD line connects to the outer conductor of the connector or adapter. Because they connect GUARD line and outer conductor of the connector or adapter, the potential of the GUARD terminal is equal to the output voltage and there is a potential for high voltage electrical shock at the adapter and connector.

(2) Cable Information

If your probe has no probe cable, you can use other recommended cables. Table 19 shows the recommended cables.

If you use a PGU with an HP 16440A selector, use a low-noise coaxial cable (8120-4461).

(3) Other Parts

If you need parts to fix a connector plate, see Table 20. Order the quantity you need. (The number of holes in a connector plate is four.)

If you need ferrite beads for preventing oscillation, see Table 21.

Table 18 Adapter Information

DESCRIPTION	QTY	PART-NUMBER	ILLUSTRATION
Triaxial(m) - Coaxial(f)	1	1250-2648	
Triaxial(f) - Coaxial(m)	1	1250-2649	
Triaxial(f) - Coaxial(f)	1	1250-1830	
Triaxial(m) - Coaxial(f)	1	1250-2650	
Triaxial(f) - Coaxial(m)	1	1250-2651	
Triaxial(f) - Coaxial(m)	1	1250-2652	
Triaxial(m) - Coaxial(f)	1	1250-2653	
Triaxial(m) - Triaxial(f) (for GNDU)	1	1250-2654	

Table 19 Cables Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Coaxial Cable for GNDU	1	8120-3674	-	-
Low-noise Coaxial Cable for SMU and PGU (with selector)	1	8120-4461	-	-
Coaxial Cable for PGU	1	8120-0102	-	-
AWG 22 Insulated Wire for GNDU (Black)	1	8150-2639	-	-
AWG 24 Insulated Wire for VS/VMU (Black)	1	8150-0447	-	-
AWG 24 Insulated Wire for VS/VMU (Red)	1	8150-0449	-	-
AWG 24 Insulated Wire for VS/VMU (Yellow)	1	8150-0451	-	-
AWG 24 Insulated Wire for VS/VMU (Brown)	1	8150-0448	-	-

Table 20 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Screw	1	0515-0986	-	-
Spring Washer	1	2190-0584	-	-
Terminal Washer	1	3050-0891	-	-
Nut	1	0535-0031	-	-

Table 21 Parts Information

DESCRIPTION	Qty	PART-NUMBER	PRODUCT	OPT.
Ferrite Beads	1	9170-0029	-	-

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