



# HP 75000 SERIES B and C

## Four-Channel Transient Strain Signal Conditioning Plug-on HP E1511A

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### User's Manual

The HP E1511 manual also applies to HP E1413Bs as HP E1413 Option 21.

Enclosed is the User's Manual for the HP E1511 Signal Conditioning Plug-on. Insert this manual in your HP E1413/E1313 manual behind the "Signal Conditioning Plug-ons" divider.

The HP E1511, Four-Channel Transient Strain SCP can be used with the HPE1415A, the HP E1313A, and the HP E1413B&C versions but not with the HP E1413A.



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E1511-90003



# HP E1511A

## Four-Channel Transient Strain Signal Conditioning Plug-on

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### Introduction

HP E1511 is a double wide (i.e., takes the space of these two adjacent slots: 0-1, 2-3, 4-5, or 6-7) Signal Conditioning Plug-on (SCP) that provides 4 channels of strain measurements for the HP E1413 High Speed A/D Module. The SCP provides 4 channels of Strain Completion Circuitry and Excitation Voltages, a programmable filter, and makes the strain measurements on 4 channels using the Sample and Hold method. The SCP provides the strain completion circuitry and the Sample and Hold circuitry. The SCP can be wired for measuring the Excitation Voltage at the bridge connection (Remote Sense) or locally on the Terminal Module.

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**Note** The HP E1511, Four-Channel Transient Strain SCP can be used with the HPE1415A, the HP E1313A, and the HP E1413B&C versions but not with the HP E1413A.

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### About This Manual

Except where noted, references to the HP E1413 also apply to the HP E1313 and HP E1415. This manual shows how to connect to the Terminal Module for sample/hold strain measurements, and also shows how to control the Option 21 Signal Conditioning Plug-on (SCP) using SCPI commands and Register-Based commands. The following also explains the capabilities of the SCP and gives the specifications. The manual contents is:

- HP E1511 Operation . . . . . 4
- Selecting the 1/4 Bridge and 120/350 ohm Jumpers . . . . . 7
- Connecting To The Terminal Module . . . . . 8
- Programming With SCPI Commands . . . . . 14
- Using External Excitation Voltages . . . . . 20
- Register-Based Programming . . . . . 22
- Specifications . . . . . 24

# HP E1511 Operation

There are two circuits on the HP E1511 SCP, one circuit provides the Bridge Excitation Voltage and Bridge Completion circuitry, and the other circuit provides the sample and hold measurement circuitry.

The completion circuitry can output a Bridge Excitation voltage of 0V, 1V, 2V, 5V, or 10V on each channel.

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**Note**

The 10V Excitation level can not be used with a 120 $\Omega$  Full Bridge configuration. This low impedance bridge configuration draws too much current from the excitation supply at 10V (> 50mA supply limit).

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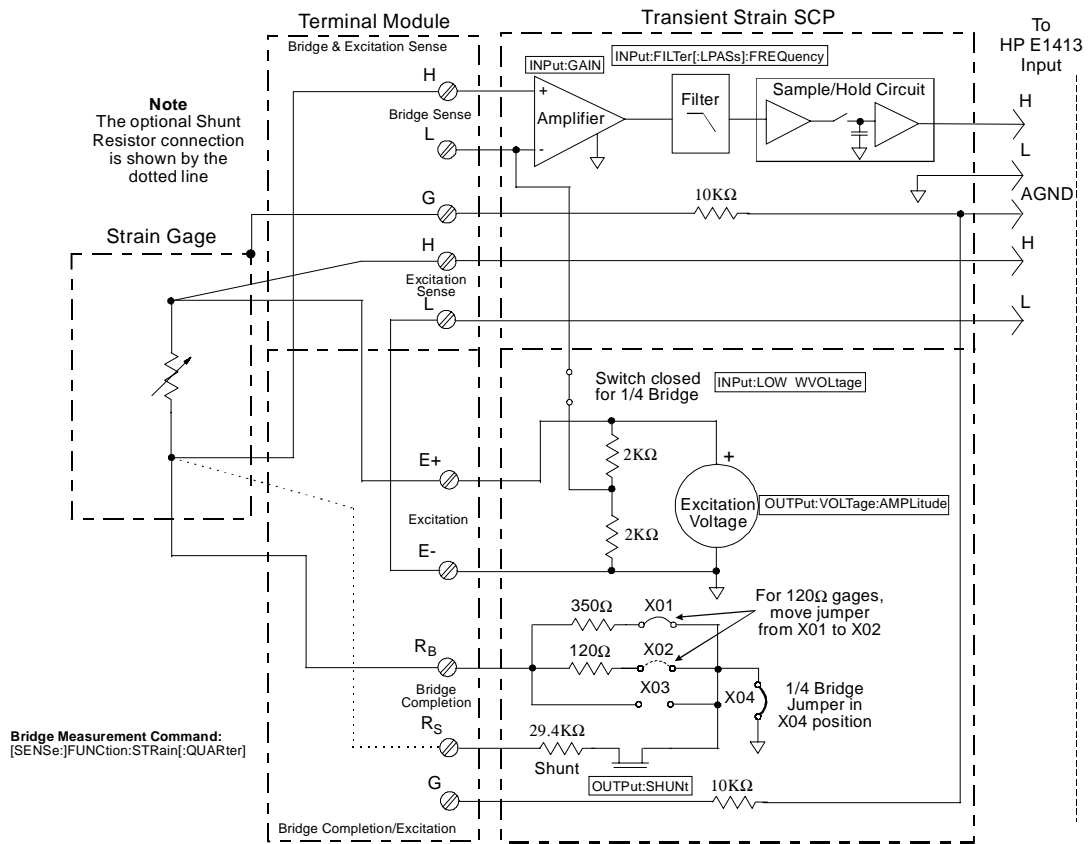
The measurement circuitry provides the measurement path to the HP E1413 for both the excitation voltage and the output voltage of the strain gage bridge. The HP E1413 measures the excitation voltage during calibration and measures the bridge output voltage during a measurement cycle.

The measurement circuitry samples all channels simultaneously and thus reduces the skew introduced by scanning. The amount of skew removed depends on the cutoff frequency setting of the lowpass Filter (see next paragraph). When reducing the filter bandwidth, the propagation delay increases between the channels which causes a larger delay between channels programmed to the same bandwidth (see specifications for delay values). The circuitry provides a voltage gain of .5, 8, 64, or 512 for each bridge output measurement channel.

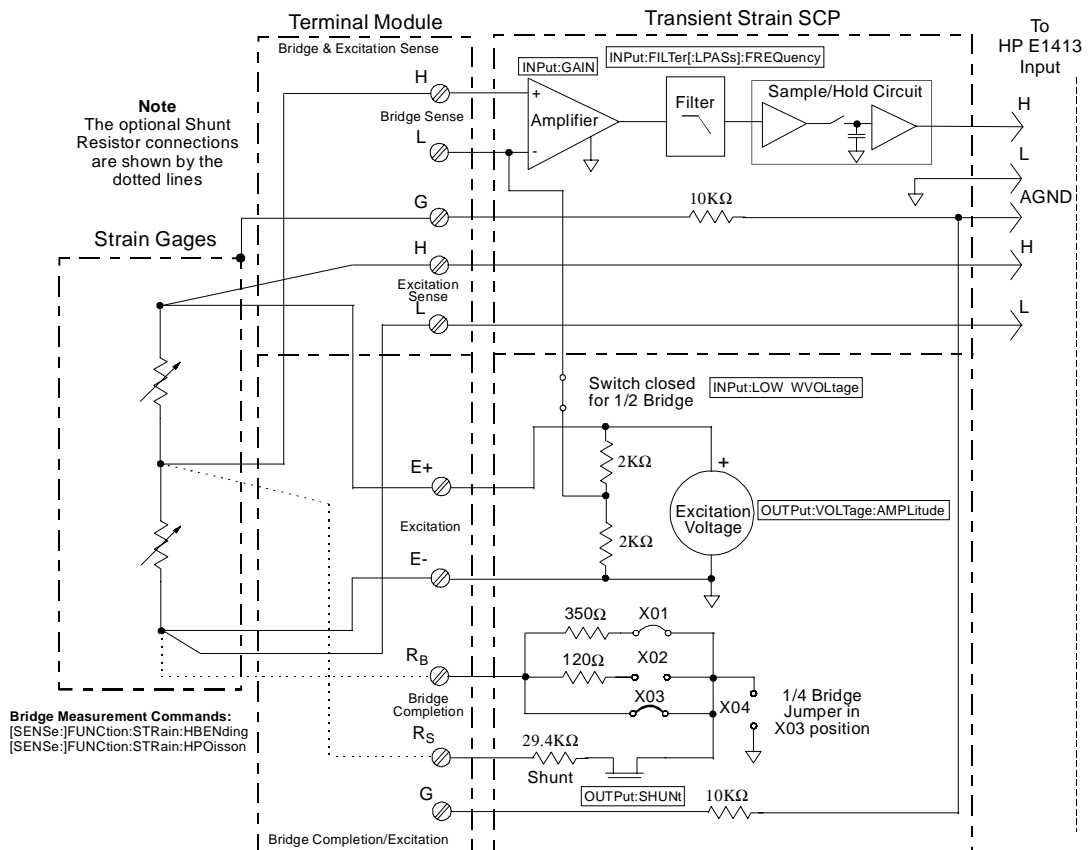
The SCP also has a lowpass Filter on each bridge output measurement channel. The filter is a 6th order Bessel Active RC filter used to provide alias protection and noise reduction. The filter cutoff frequencies are 1kHz, 500Hz, 250Hz, 100Hz, and 15Hz.

There are two ways the HP E1413 can measure the excitation voltage while calibrating the SCP. One way measures the voltages at the bridge connections (remote sense) and the other way measure the voltage locally at the connections in the Terminal Module. The remote sense is more accurate, but requires extra wiring to the bridge.

Figures 1, 2, and 3 show examples of a typical 1/4 Bridge, 1/2 Bridge, and Full Bridge strain gage measurement, respectively. The figures also show the calibration shunt resistor connects to the bridge. When shunt calibration is enabled, the shunt resistor is switched in parallel to one leg of the bridge. This causes a change in the bridge output voltage. Use it to check the bridge wiring.



**Figure 1. Typical 1/4 Bridge Measurement**



**Figure 2. Typical 1/2 Bridge Measurement**

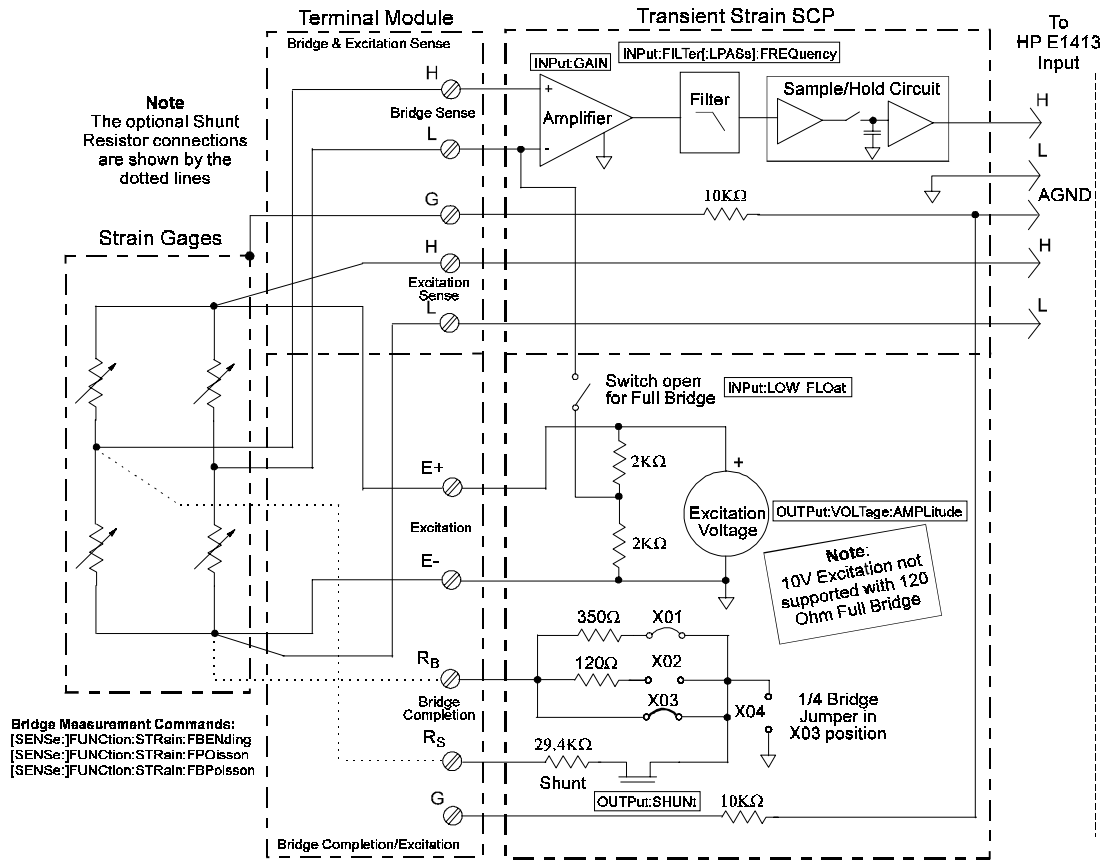


Figure 3. Typical Full Bridge Measurement

# Selecting the 1/4 Bridge and 120/350 ohm Jumpers

Figure 4 shows how to select the 1/4 Bridge Jumper and how to select for either 120Ω or 350Ω bridges.

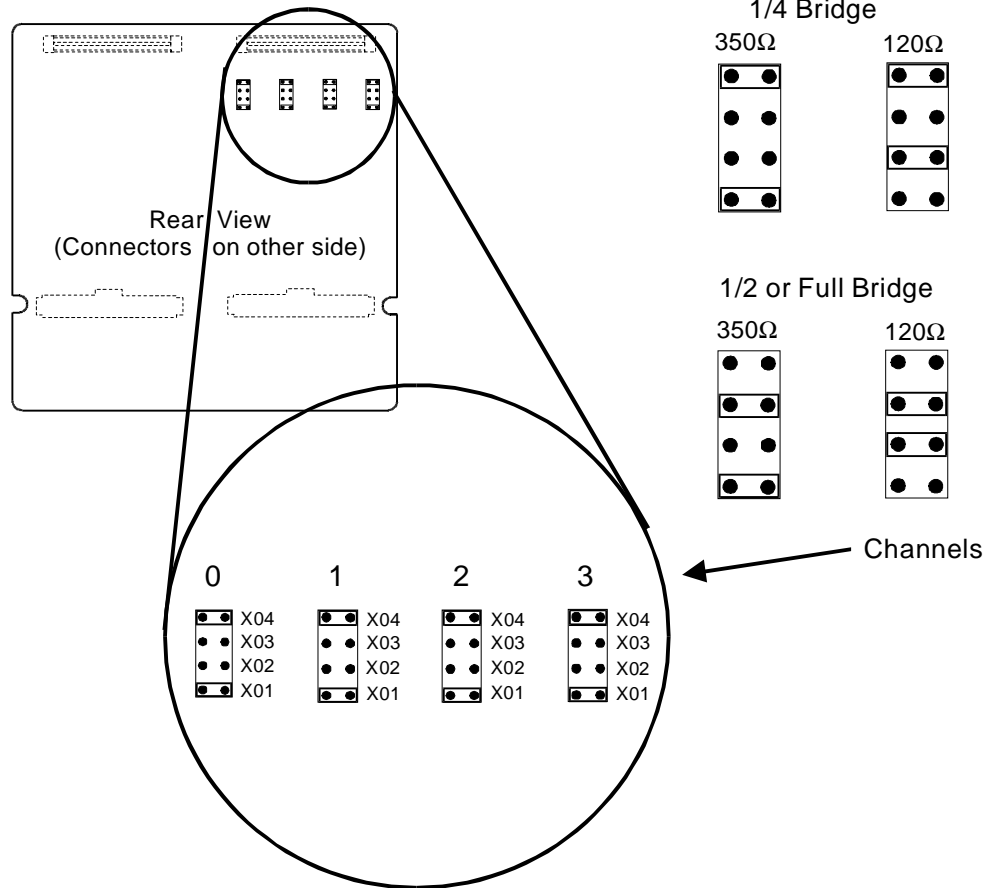


Figure 4. Selecting the 1/4 Bridge and 120/350 ohm Jumpers

# Connecting To The Terminal Module

This section shows how to make 1/4, 1/2, and Full Bridge strain gage connections to the Terminal Module.

The SCP connections for the Terminal Modules are shown on the stick-on labels that came with the SCP. Use the appropriate label for the type of Terminal Module you have. The connections and appropriate stickers are as follows:

- For HP E1413C and above Terminal Modules, use stickers for HP E1510 SCPs. The connections are shown in Figure 5.
- For HP E1313 Terminal Modules, use stickers for HP E1510 SCPs. The connections are shown in Figures 6 and 7.
- For HP E1413B and below Terminal Modules, use stickers for HP E1413 Option 20 SCPs. The connections are shown in Figure 8.

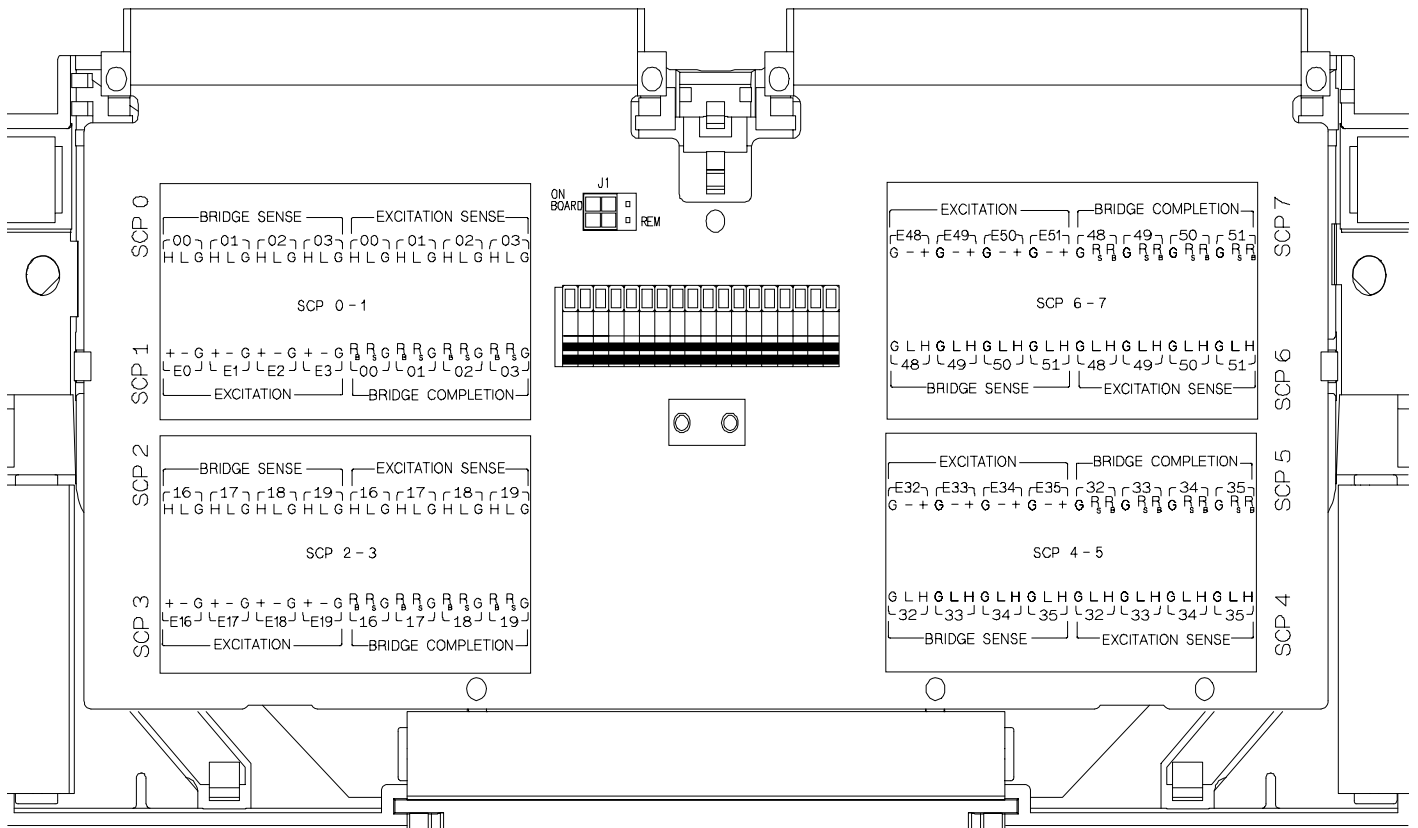
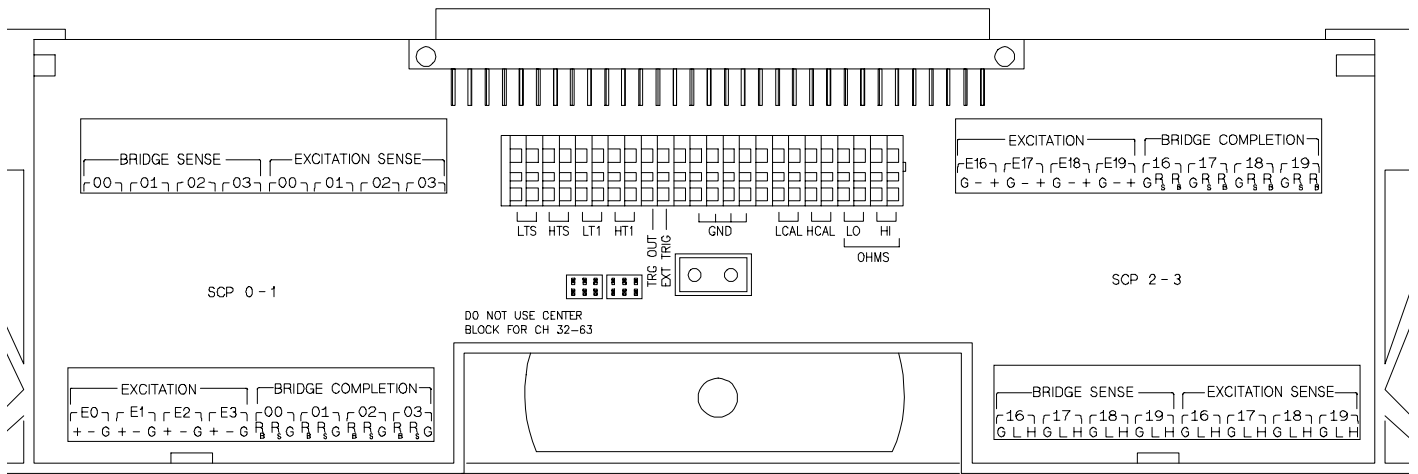
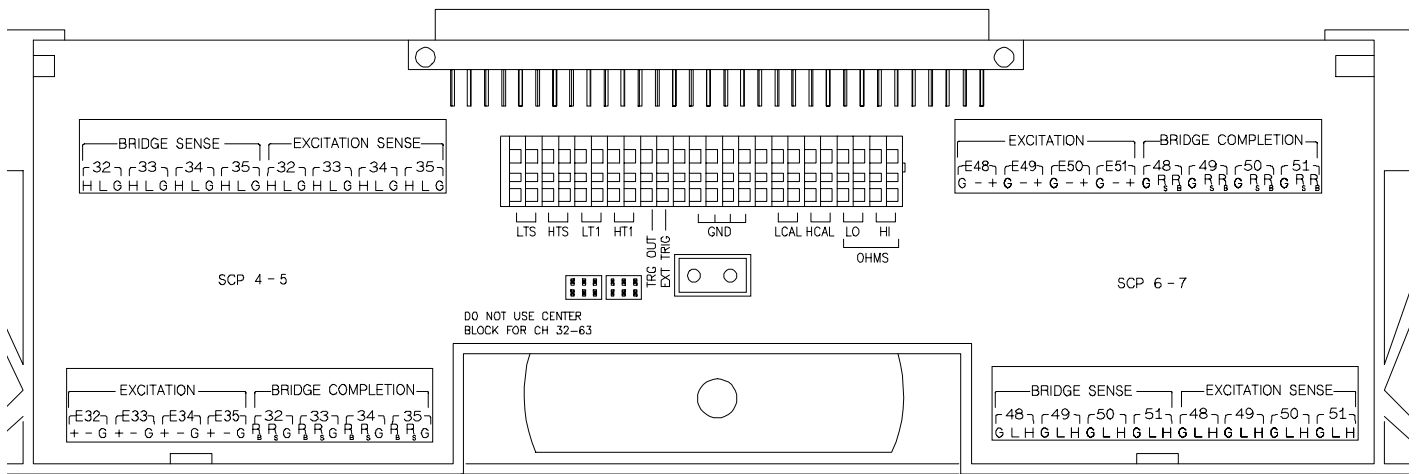


Figure 5 HP E1511 C-Size Terminal Module Connections

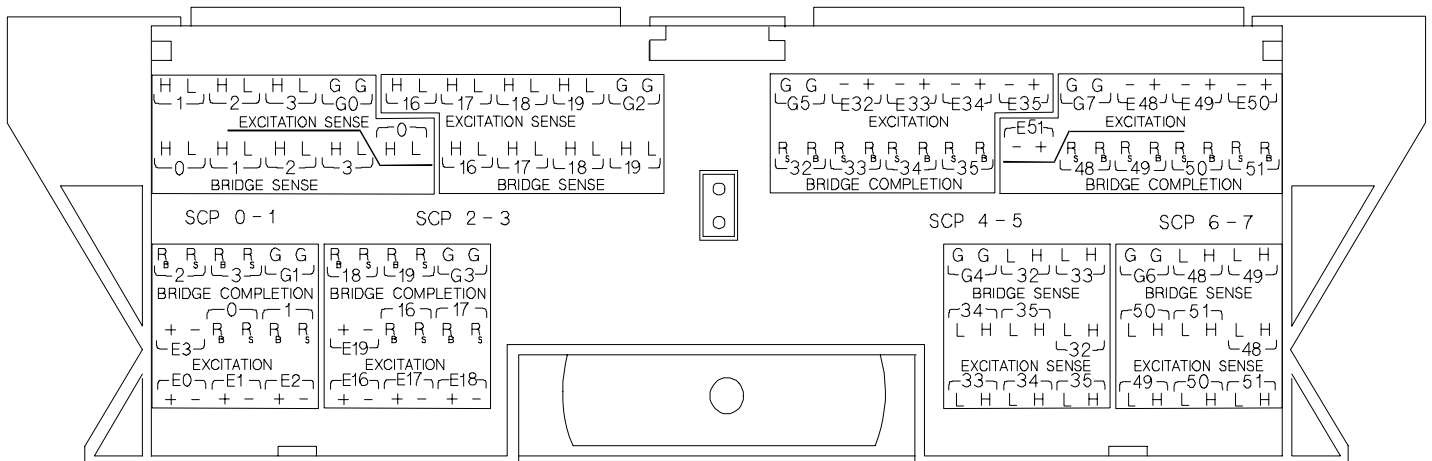




**Figure 6 HP E1511 B-size Terminal Module Connections (Ch 00-31)**



**Figure 7 HP E1511 B-size Terminal Module Connections (Ch 32-63)**



**Figure 8 HP E1413 Option 21 Terminal Module Connections**

## Wiring the Terminal Module

- See “Attaching and Wiring the Terminal Module” in the HP E1413 User’s Manual to wire the strain gages to the Terminal Module.
- For accurate measurements, use a twisted shielded cable for the strain gage connections. Connect the shield to the specimen and to the guard (G) terminal on the Terminal Module.

### Note

The following figures in this section show the connections using SCP 0 as the Strain SCP and SCP 1 as the Direct Input SCP. Use the same technique using other SCPs and other channel numbers.

For example, for a Channel 00 H and L connection on SCP 0, connect to H and L on Channel 57 for SCP 7. See “Opening and Wiring the Terminal Module” in the HP E1413 User’s Manual to wire the strain gages to the Terminal Module.

## 1/4 Bridge Connections

Use Figure 9 for 1/4 Bridge connections to the Terminal Module. *Install* or make sure the 1/4 Bridge Jumper(s) *is installed* in the 1/4 Bridge configuration for all channels that are to make 1/4 Bridge measurements (see Figure 4).

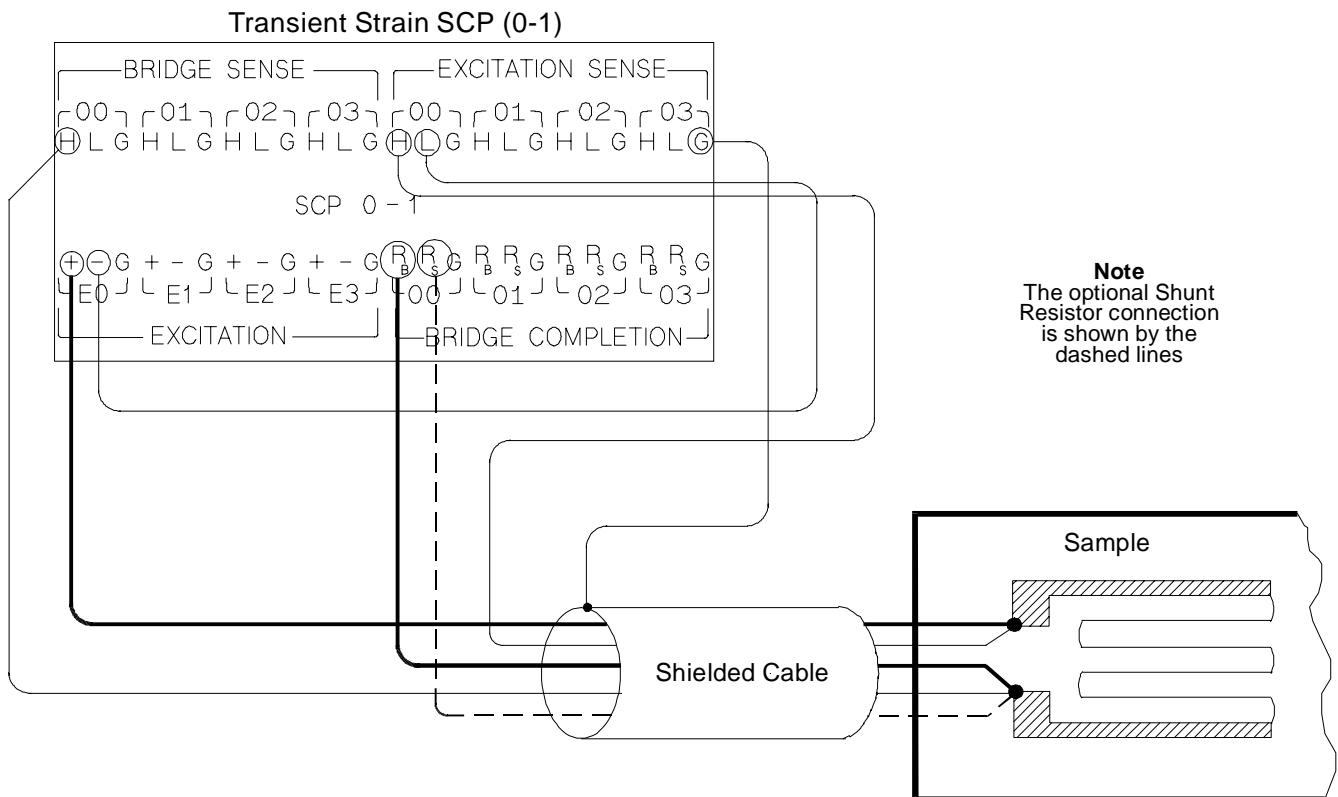


Figure 9. Typical 1/4 Bridge Connections

## 1/2 Bridge Connections

Use Figure 10 for 1/2 Bridge connections to the Terminal Module. Remove or be sure the 1/4 Bridge Jumper(s) *is not installed* in the 1/4 Bridge configuration for all channels that are to make 1/2 Bridge measurements (see Figure 4).

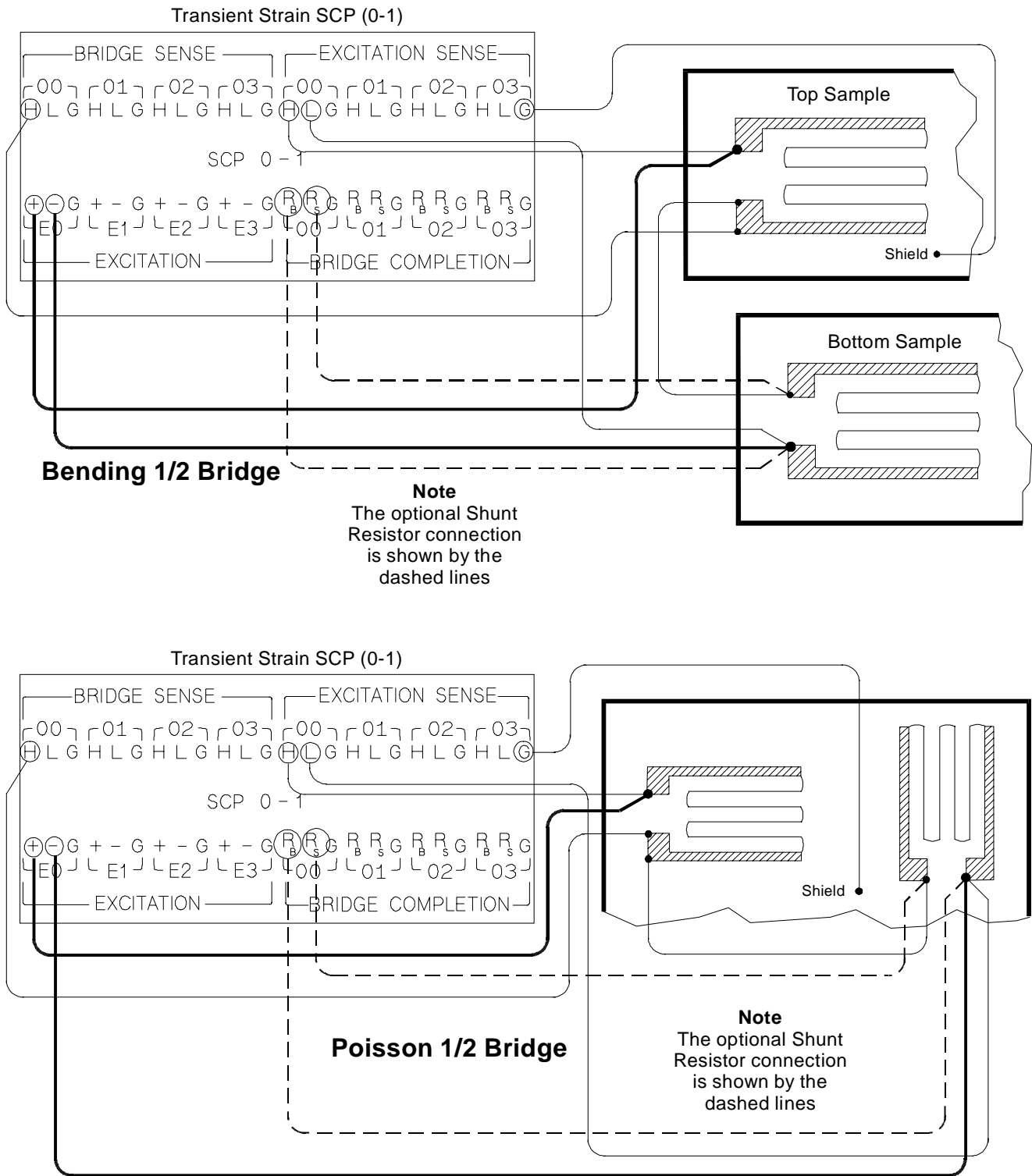


Figure 10. Typical 1/2 Bridge Connections

## Full Bridge Connections

Use Figures 11 and 12 for Full Bridge connections to the Terminal Module. Remove or be sure the 1/4 Bridge Jumper(s) is *not installed* in the 1/4 Bridge configuration for all channels that are to make Full Bridge measurements (see Figure 4).

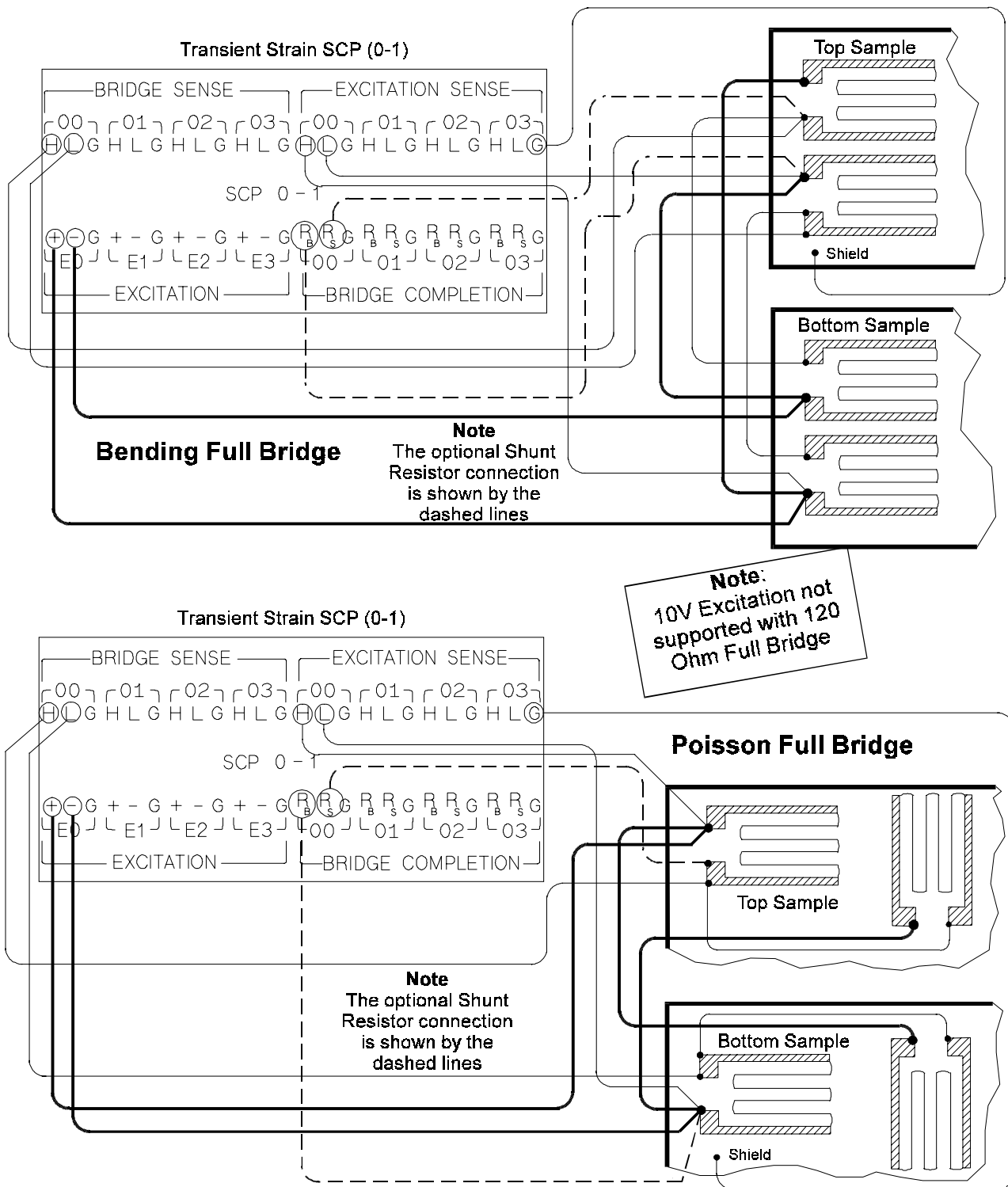
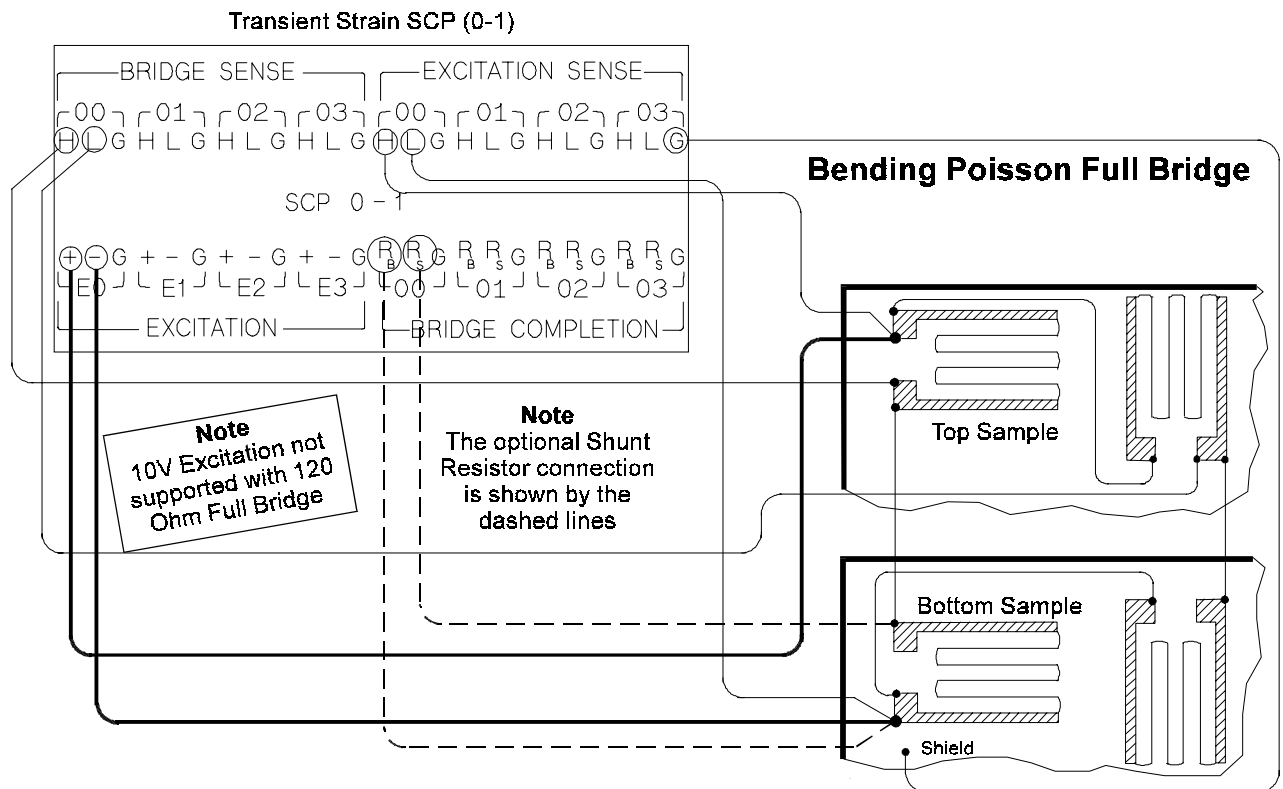


Figure 11. Typical Full Bridge Connections



**Figure 12. Typical Full Bridge Connections (Cont.)**

# Programming With SCPI Commands

The following SCPI commands verify the SCP types installed in the HP E1413 and how to program the HP E1413 for strain measurements using HP E1511 SCPs. The commands listed in this section are below and also in Chapter 5 of the HP E1413 User's Manual.

## SCPI Commands Used

The following table lists all commands used in this section of the manual.

Command	Description
CALibration:TARE (@< ch_list> )	calibrates SCP on specified channels
CALibration:TARE?	returns calibration value
INPut:FILTer[:LPASs]:FREQuency < cutoff_freq> ,(@ch_list> )	selects the SCP's low pass filter cutoff frequency
INPut:GAIN < chan_gain> 5,(@< ch_list> )	selects the sample and hold gain
INPut:LOW FLOat   WVOLTage,(@< ch_list> )	selects the sample & hold amplifier input connection
OUTPut:VOLTage:AMPLitude < amplitude> ,(@ch_list> )	selects the excitation voltage value
[SENSe:]FUNction:STRain:FBPoisson [< range> ,](@< ch_list> )	selects the range for the full bridge bending poisson EU conversion
[SENSe:]FUNction:STRain[:QUARter] [< range> ,](@< ch_list> )	selects the range for quarter bridge EU conversion
[SENSe:]STRain:GFACTor < gage_factor> ,(@< ch_list> )	selects the strain gage factor
[SENSe:]STRain:POISSon < poisson_ratio> ,(@< ch_list> )	selects the poisson ratio
SYSTem:CTYPe? (@< channel> )	returns the SCP type

### Checking the ID of the SCP

Use the “SYSTem:CTYPe? (@< channel> )” command to verify the SCP type(s) in the HP E1413.

- The *channel* parameter specifies a single channel in the channel range covered by the SCP of interest. The first channel numbers for each of the SCP positions are: 0, 16, 32, and 48, if all SCPs are HP E1511 SCPs.

The value returned for the SCP in an HP E1413B is:  
HEWLETT-PACKARD, E1413 Opt 21 4-Ch S/H-Strain Bridge Completion SCP,,0

The value returned for the SCP in an HP E1313A/E1413C is:  
HEWLETT-PACKARD, E1511 4-Ch S/H-Strain Bridge Completion SCP,,0

To determine the type of SCP installed on channels 0 through 7, send:

```
SYST:CTYP? (@100)           query SCP type @ ch 0
enter statement here        enter response string
```

## Making 1/4 Bridge Measurements

The following example shows how to make 1/4 Bridge measurements using channels 0 through 3. Be sure to set the jumper for the 1/4 Bridge configuration (see Figure 4).

### Bridge is *Unstrained*

The following commands select the excitation voltage and specifies the parameters to convert strain gage readings for the specified channels. Do this when the bridge is in the *Unstrained* configuration. The commands are separated into two parts. The first part configures and calibrates the excitation/completion circuitry. The second part configures the module for strain measurements. Execute these commands when the bridge is in the *Unstrained* configuration.

#### Setup and Calibrate Excitation/Completion Circuitry

OUTP:VOLT:AMPL 1,(@100:103)	<i>select the excitation voltage value for channels 0-3 (default is 0V)</i>
INP:LOW WVOL,(@100:103)	<i>selects the Wagner voltage input</i>
INP:FILT:FREQ 1000,(@100:103)	<i>selects the sample and hold lowpass filter frequency (default is 15Hz)</i>
INP:GAIN 8,(@100:103)	<i>selects the gain of the sample and hold circuitry (default is .5)</i>
CAL:TARE (@100:103)	<i>measure the unstrained voltage on channels 0-3</i>
CAL:TARE?	<i>to return the success flag from the CAL:TARE operation</i>
enter CAL:TARE query	<i>wait until success flag from CAL:TARE operation is returned</i>

#### Configure the Measurement

STR:GFAC 2,(@100:103)	<i>specifies the gage factor on channels 0-3 (selected factor 2 is the default value)</i>
FUNC:STR:QUAR 1,(@100:103)	<i>link channels 0-3 to EU conversion for strain measurement (selected IV range value is the default value)</i>

### Bridge is *Strained*

When the bridge is in the *Strained* configuration and the measurements are to be made, scan the selected channels and make the measurements. Use the HP E1413's INITiate and TRIGger commands to make the strain measurement. You must define what triggers, etc., to use to make the measurements (see the "HP E1413 User's Manual" for information).

## Making Full Bending Poisson Bridge Measurements

The following example shows how to make Full Bridge Bending Poisson Bridge measurements using channels 0 through 3. Be sure to set the jumper for the 1/2 or Full Bridge configuration (see Figure 4).

### Bridge is *Unstrained*

The following commands select the excitation voltage and specifies the parameters to convert strain gage readings for the specified channels. Do this when the bridge is in the *Unstrained* configuration. The commands are separated into two parts. The first part configures and calibrates the excitation/completion circuitry. The second part configures the module for strain measurements. Execute these commands when the bridge is in the *Unstrained* configuration.

#### Setup and Calibrate Excitation/Completion Circuitry

OUTP:VOLT:AMPL 1,(@100:103)	<i>select the excitation voltage value for channels 0-3 (default is 0V)</i>
INP:LOW FLO,(@100:103)	<i>selects the floating input</i>
INP:FILT:FREQ 1000,(@100:103)	<i>selects the sample and hold lowpass filter frequency (default is 15Hz)</i>
INP:GAIN 8,(@100:103)	<i>selects the gain of the sample and hold circuitry (default is .5)</i>
CAL:TARE (@100:103)	<i>measure the unstrained voltage on channels 0-3</i>
CAL:TARE?	<i>to return the success flag from the CAL:TARE operation</i>
enter CAL:TARE query	<i>wait until success flag from CAL:TARE operation is returned</i>

#### Configure the Measurement

STR:GFAC 2,(@100:103)	<i>specifies the gage factor on channels 0-3 (selected factor 2 is the default value)</i>
STR:POIS .3,(@100:103)	<i>set Poisson ratio for EU conversion; selected value is .3 (default value)</i>
FUNC:STR:FBP 1,(@100:103)	<i>link channel 0-3 to EU conversion for strain measurement; selected voltage range is 1V</i>

### Bridge is *Strained*

When the bridge is in the *Strained* configuration and the measurements are to be made, scan the selected channels and make the measurements. Use the HP E1413's INITiate and TRIGger commands to make the strain measurement. You must define what triggers, etc., to use to make the measurements (see the "HP E1413 User's Manual" for information).



## Comments

The following explains the commands used in strain measurements.

### How to Link EU Conversions to Channels

The following explains the commands that link the strain EU conversion with the specified channels. The commands tell the HP E1413 to use the EU conversion for strain measurements. The HP E1413 performs the appropriate EU conversion (e.g., 1/4 Bridge measurements) depending on the command used. Thus, each bridge configuration has its own command with the command used for the 1/4 Bridge configuration as the default value. (See “Linking Channels with EU Conversion” in Chapter 3 of the HP E1413 User’s Manual.)

The syntax of a typical command is:

```
[SENSe:]FUNcTion:STRain:HBENding [< range> ,](@< ch_list> )
```

where < range> > is the voltage range of the HP E1413 (default value or no specified parameter is AUTO) and < ch\_list> specifies the channels.

The different bridge types and corresponding EU to Channels Linking commands are in the following table.

Bridge Type	Command
Full Bending Bridge	[SENSe:]FUNcTion:STRain:FBENding
Full Bending Poisson Bridge	[SENSe:]FUNcTion:STRain:FBPoisson
Full Poisson Bridge	[SENSe:]FUNcTion:STRain:FPOisson
1/2 Bending Bridge	[SENSe:]FUNcTion:STRain:HBENding
1/2 Poisson Bridge	[SENSe:]FUNcTion:STRain:HPOisson
1/4 Bridge	[SENSe:]FUNcTion:STRain[:QUARter]

### Notes

1. The strain readings from the HP E1413 are output as micro strain ( $\mu\epsilon$ ) units.
2. Because of the number of possible strain gage configurations, the driver must generate any Strain EU conversion tables and download them to the instrument when INITiate is executed. This can cause the time to complete the INIT command to exceed 1 minute.

### Purpose of Channel Tare Calibration (CAL:TARE)

The CALibration:TARE command measures the voltage across the bridge to determine the unstrained voltage value of the bridge. This corrects for the offset voltage across the bridge when in the *Unstrained* configuration.

The command automatically executes the CAL? command and thus calibrates the internal excitation supply.

The HP E1413 uses the unstrained reading (i.e., offset voltage) in conjunction with the strain gage factor (see “Purpose of the Strain Gage Factor Command (STR:GFAC)” below) to calculate the strain measurements. You normally perform both operations before making the actual strain measurements.

Instead of using CAL:TARE, you can use the [SENSe:]STRain:UNSTrained command to enter the unstrained voltage. In this case you must measure and enter the offset voltage of the bridge, when the bridge is *Unstrained*. The command syntax is:

```
[SENSe:]STRain:UNSTrained < unstrained_v> ,(@< ch_list> )
```

where < unstrained\_v> is the voltage value of the bridge in the unstrained position (default is 0V) and < ch\_list> specifies the channels to be measured.

### **Purpose of the Strain Gage Factor Command (STR:GFAC)**

The [SENSe:]STRain:GFACtor command specifies the gage factor to be used by the HP E1413 to calculate the strain measurements. The default value of the command is a factor of 2. The command syntax is:

```
[SENSe:]STRain:GFACtor < gage_factor> ,(@< ch_list> )
```

where < gage\_factor> is the gage factor value (default is 2) and < ch\_list> specifies the channels to be measured.

### **Purpose of the Poisson Ratio Command (STR:POIS)**

The [SENSe:]STRain:POISson command sets the Poisson ratio to be used by the HP E1413 for EU conversion of strain values measured (see “Linking Channels with EU Conversion” in Chapter 3 of the HP E1413 User’s Manual). This command is only needed if making Poisson strain measurements. It is not needed for making 1/4 Bridge, or 1/2 or Full Bridge Bending measurements. The default value of the command is .3. The command syntax is:

```
[SENSe:]STRain:POISson < poisson_ratio> ,(@< ch_list> )
```

where < poisson\_ratio> is the Poisson ratio (default is 2) and < ch\_list> specifies the channels to be measured.

### **Connecting the Sample and Hold Amplifier Input (INPut:LOW)**

For 1/4 and 1/2 Bridge configurations, the low input of the sample and hold input amplifier should be connected to the negative side of the internal bridge connection on the SCP itself. This is done by a switch on the SCP which provides the Wagner voltage for the bridge (see Figures 1 and 2).

For Full Bridge configuration, the low input of the sample and hold amplifier should be externally connected to the negative side of the bridge. The amplifier input must not be connected to the internal bridge (see Figure 3).

Use the following command for either configuration:

```
INPut:LOW < volt_type> ,< @ch_list>
```

where < volt\_type> can be either FLOat for a floating input (Full Bridge configuration) or WVoltage for a Wagner Voltage connection (1/4 and 1/2 Bridge configurations). respectively, and < @ch\_list> specifies the channels.

## Using The Shunt Resistor

To check if the bridge is operational, you can add a 29.4kΩ Shunt resistor across one leg of the bridge, as illustrated in Figure 13. A FET switch adds or removes the resistor. When the resistor is added, it changes the unstrained offset voltage on the bridge.

The resistor can only affect the bridge balance as long as you follow the connections shown in the dotted lines in Figures 1, 2, and 3, or as shown in Figure 13. Use the OUTPut:SHUNt command to add or remove the resistor from the bridge. The syntax of the command is:

```
OUTPut:SHUNt 1 | 0 | ON | OFF
```

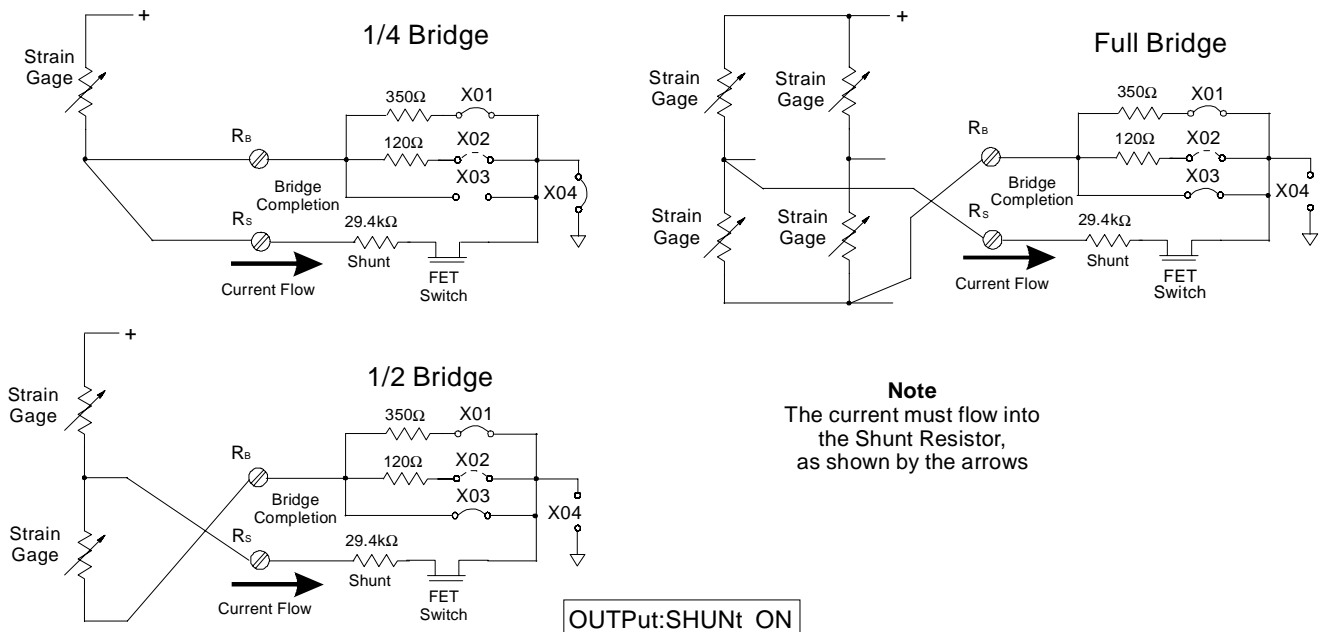


Figure 13. Adding the Shunt Resistor

# Using External Excitation Voltages

You can use your own external excitation voltage instead of using the internal voltage of the SCP. If using an external voltage, you must:

- use your own bridge completion circuitry
- isolate the internal excitation supply from the bridge
- enter the value of the excitation voltage into the HP E1413 so it can make the correct EU conversions for strain measurements

## Connecting the External Supply

Use Figure 14 to connect the external supply to the Terminal Module. Be sure *not* to connect the external excitation voltage to the “E+ ” and “E-” terminals.

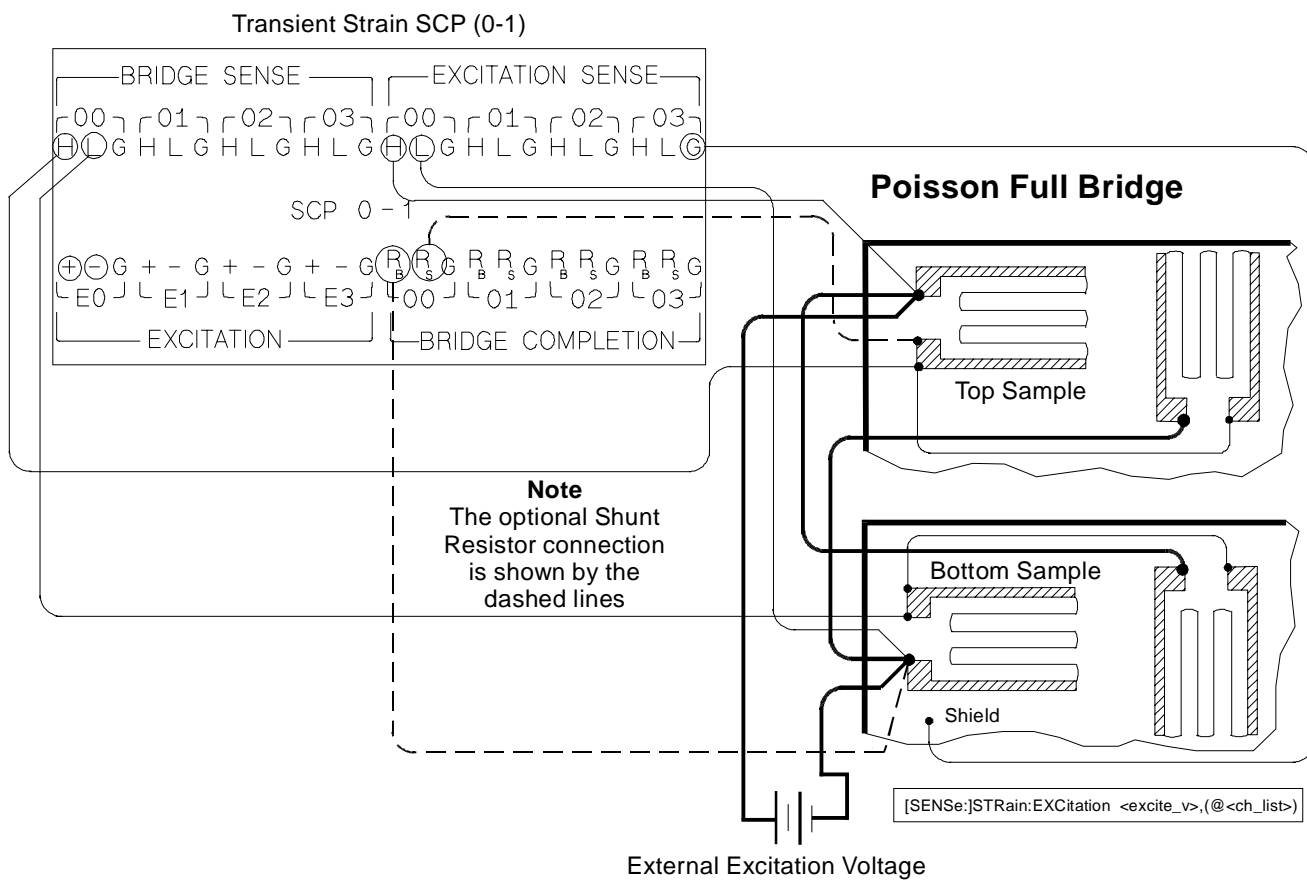
## Enter Excitation Voltage Value

Use the [SENSe:]STRain:EXCitation command to enter the value of the external excitation voltage. The syntax for the command is:

```
[SENSe:]STRain:EXCitation < excite_v> ,(@< ch_list> )
```

where < excite\_v> is the value of the external excitation voltage and < ch\_list> specifies the measurement channels of the SCP.

The default value of the excitation voltage is 3.9V, the minimum allowable voltage value that can be entered is .01V, and the maximum value that can be entered is 99. However, the maximum allowable input voltage of the Sample and Hold Input Amplifier is 16V which may limit the maximum Excitation Voltage to 16V.



**Figure 14. Connecting External Excitation Voltages**

# Register-Based Programming

Appendix D of the HP E1413 User's Manual covers the Register-Based commands shown below. You should read that appendix to become familiar with accessing registers and executing Register-Based commands. This section relates those commands to the parameter values that are specified for this SCP.

When Register Programming an SCP, most communication is through the Signal Conditioning Bus. For that you will use the Register Commands:

SCPWRITE < regaddr> < regvalue>

and

SCPREAD? < regaddr>

Read (returned value)	Write (< regvalue> )	SCP Register*	< regaddr> Value
SCP ID (source) - Opt 21: (6100 <sub>16</sub> )		Whole SCP Reg 0	00ppp000000 <sub>2</sub>
SCP Gain Scale - (XXX3 <sub>16</sub> )		Whole SCP Reg 1	00ppp000001 <sub>2</sub>
<b>Excitation, Wagner Voltage, and Shunt Cal Resistor:</b> Data format is XEVVVVWS <sub>2</sub> where: X= don't care E= enable excitation voltage 1= on, 0= off V= Excit. V bits, 0001 <sub>2</sub> = 1V, 0010 <sub>2</sub> = 2V, 0100 <sub>2</sub> = 5V, 1000 <sub>2</sub> = 10V W= Wagner Voltage to LO, 1= connected, 0= disconnected S= Shunt Cal Resistor, 1= in circuit, 0= out		Channel Reg 0	01pppccc000 <sub>2</sub>
<b>Channel Gain</b> (Sample and Hold channels): (FFF <sub>16</sub> = 0.5, FFF <sub>16</sub> = 8, FFF <sub>216</sub> = 64, FFF <sub>316</sub> = 512) <b>Channel Gain</b> (direct channels): 0000 <sub>16</sub> = 1		Channel Reg 1	01pppccc001 <sub>2</sub>
<b>Channel Frequency:</b> (XXX0 <sub>16</sub> = 15Hz, XXX1 <sub>16</sub> = 100Hz, XXX2 <sub>16</sub> = 250Hz, XXX3 <sub>16</sub> = 500Hz, XXX4 <sub>16</sub> = 1kHz)		Channel Reg 2	01pppccc010 <sub>2</sub>

X= don't care

ppp= Plug-on  
ccc= SCP channel

\* see the SCPWRITE and SCPREAD? commands in Appendix D to learn more on how to read the SCP registers.

## Checking the ID of the SCP

To query an SCP for its ID value, write the following value to Parameter Register 1:

$$(SCP\ number) \times 40_{16}$$

Then write the opcode for SCPREAD? (0800<sub>16</sub>) to the Command Register. The ID value will be written to the Response Register. Read the Response Register for the value.

## Setting the Filter Cutoff Frequency

To set the filter cutoff frequency for an SCP channel, write the following SCP channel address to Parameter Register 1:

$$200_{16} + (SCP\ number) \times 40_{16} + (SCP\ channel\ number) \times 8_{16} + 2_{16}$$

Write one of the following cutoff values to Parameter Register 2:

0000<sub>16</sub> for 15Hz, 0001<sub>16</sub> for 100Hz, 0002<sub>16</sub> for 250Hz,  
0003<sub>16</sub> for 500Hz, 0004<sub>16</sub> for 1kHz

Then write the opcode for SCBWRITE (0810<sub>16</sub>) to the Command Register.

## Setting the Channel Gain

To set the amplifier gain for an SCP channel, write the following SCP channel address to Parameter Register 1:

$$200_{16} + (SCP\ number) \times 40_{16} + (SCP\ channel\ number) \times 8_{16} + 1_{16}$$

Write one of the following gain values to Parameter Register 2:

FFFF<sub>16</sub> for 0.5, FFF1<sub>16</sub> for 8, FFF2<sub>16</sub> for 64, FFF3<sub>16</sub> for 512

Then write the opcode for SCBWRITE (0810<sub>16</sub>) to the Command Register.

## Setting the Channel Excitation Voltage

To set the excitation voltage for an SCP channel, write the following SCP channel address to Parameter Register 1:

$$200_{16} + (SCP\ number) \times 40_{16} + (SCP\ channel\ number) \times 8_{16}$$

Write one of the following values to Parameter Register 2:

FF00<sub>16</sub> for 0V, FF44<sub>16</sub> for 1V, FF48<sub>16</sub> for 2V, FF50<sub>16</sub> for 5V, or  
FF60<sub>16</sub> for 10V

Then write the opcode for SCBWRITE (0810<sub>16</sub>) to the Command Register. The values above will set the stated excitation values as well as the default state for the channel's Wagner Ground and Cal Shunt Resistor (both disconnected).

## Controlling Wagner Ground

To connect the Wagner Voltage to the LO terminal, simply add the value 0002<sub>16</sub> to the Excitation Voltage code sent in the procedure above.

## Controlling Cal Shunt Resistors

To shunt the bridge with the Cal Resistor, add the value 0001<sub>16</sub> to the Excitation Voltage code sent in the procedure above.

# Specifications

## SCP Current Requirements (Amps)

5Vmax	24Vtyp	24Vmax	-24Vtyp	-24Vmax
0.55	.014	.015	.013	.015

## Voltage Measurements

### Accuracy: Gain of X0.5

Range ±FS	Gain error	Offset error	Noise 3 sigma
125 mV	0.02	488 μV	1.5 mV
0.5 mV	0.02	488 μV	1.5 mV
2.0 V	0.02	488 μV	1.5 mV
8.0 V	0.02	488 μV	1.5 mV

### Temperature coefficients

Gain: 10 ppm/° C (after \* CAL)

Offset: add tempco error to above table

Temp	Tempco
(0 - 30)	0 μV/° C
(30 - 55)	.75 μV/° C

### Accuracy: Gain of X8

Range ±FS	Gain error	Offset error	Noise 3 sigma
7.8 mV	0.02	30.5 μV	95 μV
31.25 mV	0.02	30.5 μV	95 μV
125 mV	0.02	30.5 μV	95 μV
0.5 V	0.02	30.5 μV	95 μV

### Temperature coefficients

Gain: 10 ppm/° C (after \* CAL)

Offset: add tempco error to above table

Temp	Tempco
(0 - 30)	0 μV/° C
(30 - 55)	.75 μV/° C



**Accuracy: Gain of X64**

Range ±FS	Gain error	Offset error	Noise 3 sigma
3.9 mV	0.02	15.0 μV	12 μV
15.6 mV	0.02	15.0 μV	12 μV
62.5 mV	0.02	15.0 μV	12 μV

**Temperature coefficients**

Gain: 10 ppm/° C (after \* CAL)

Offset: add tempco error to above table

Temp	Tempco
(0 - 40)	.14 μV/° C
(40 - 55)	.38 μV/° C

**Accuracy: Gain of X512**

Range ±FS	Gain error	Offset error	Noise 3 sigma
7.81 mV	0.04	15 μV	2 μV

**Temperature coefficients**

Gain: 10 ppm/° C (after \* CAL)

Offset: add tempco error to above table

Temp	Tempco
(0 - 40)	.14 μV/° C
(40 - 55)	.38 μV/° C

### Filter Characteristics

Normal mode rejection:

15 Hz lowpass filter (6 pole Bessel)

15 Hz -3 dB

50 Hz > 33 dB

60 Hz > 43 dB

100 Hz lowpass filter (6 pole Bessel)

100 Hz -3 dB

400 Hz > 43 dB

250 Hz lowpass filter (6 pole Bessel)

250 Hz -3 dB

1000 Hz > 43 dB

500 Hz lowpass filter (6 pole Bessel)

500 Hz -3 dB

2000 Hz > 43 dB

1000 Hz lowpass filter (6 pole Bessel)

1000 Hz -3 dB

4000 Hz > 43 dB

Sample time skew between channels:

Because the lowpass filter precedes the sample and hold, the interchannel sample time skew is primarily determined by the matching of the filter propagation delay times. The table below lists the propagation delay for a step function input (measured at 50% of the final value) for each filter setting, as well as the matching between channels programmed to the same filter setting.

Bandwidth	Step Propagation Delay (nominal)	Delay Matching ( $\pm$ from nominal)
1 kHz	427.5 $\mu$ sec	10 $\mu$ sec
500 Hz	854.9 $\mu$ sec	20 $\mu$ sec
250 Hz	1.710 msec	40 $\mu$ sec
100 Hz	4.275 msec	100 $\mu$ sec
15 Hz	28.50 msec	670 $\mu$ sec

Maximum filter overshoot:

< 1% of input step size

Common mode rejection (0 to 60 Hz):

X0.5 gain > 60 dB

X8 gain > 78 dB

X64 gain > 100 dB

X512 gain > 100 dB

Maximum input voltage:

normal mode plus common mode

Operating: <  $\pm 16$  V peak

Damage level: >  $\pm 42$  V peak

Maximum common mode voltage:

Operating: <  $\pm 16$  V peak

Damage level: >  $\pm 42$  V peak

Crosstalk (referenced to input):

350 $\Omega$  source, DC to 1 kHz < 80 dB

-20 log (receiving channel input/source channel gain)

e.g., crosstalk from channel at gain of 0.5 to channel at gain 512: < -80dB -20 log (512/0.5) = -140 dB

Input impedance:

> 100 M $\Omega$

Maximum tare cal offset:

X0.5 gain  $\pm 25\%$  of full scale

X8 gain  $\pm 90$  mV

X64 gain  $\pm 95$  mV

X512 gain  $\pm 95$  mV

## Sample and Hold Characteristics

### Acquisition Time:

---

1  $\mu$ sec

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### Aperature Time:

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2 nsec

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### Aperature Delay:

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35 nsec + delay in skew specification

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### Aperature Jitter:

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150 psec

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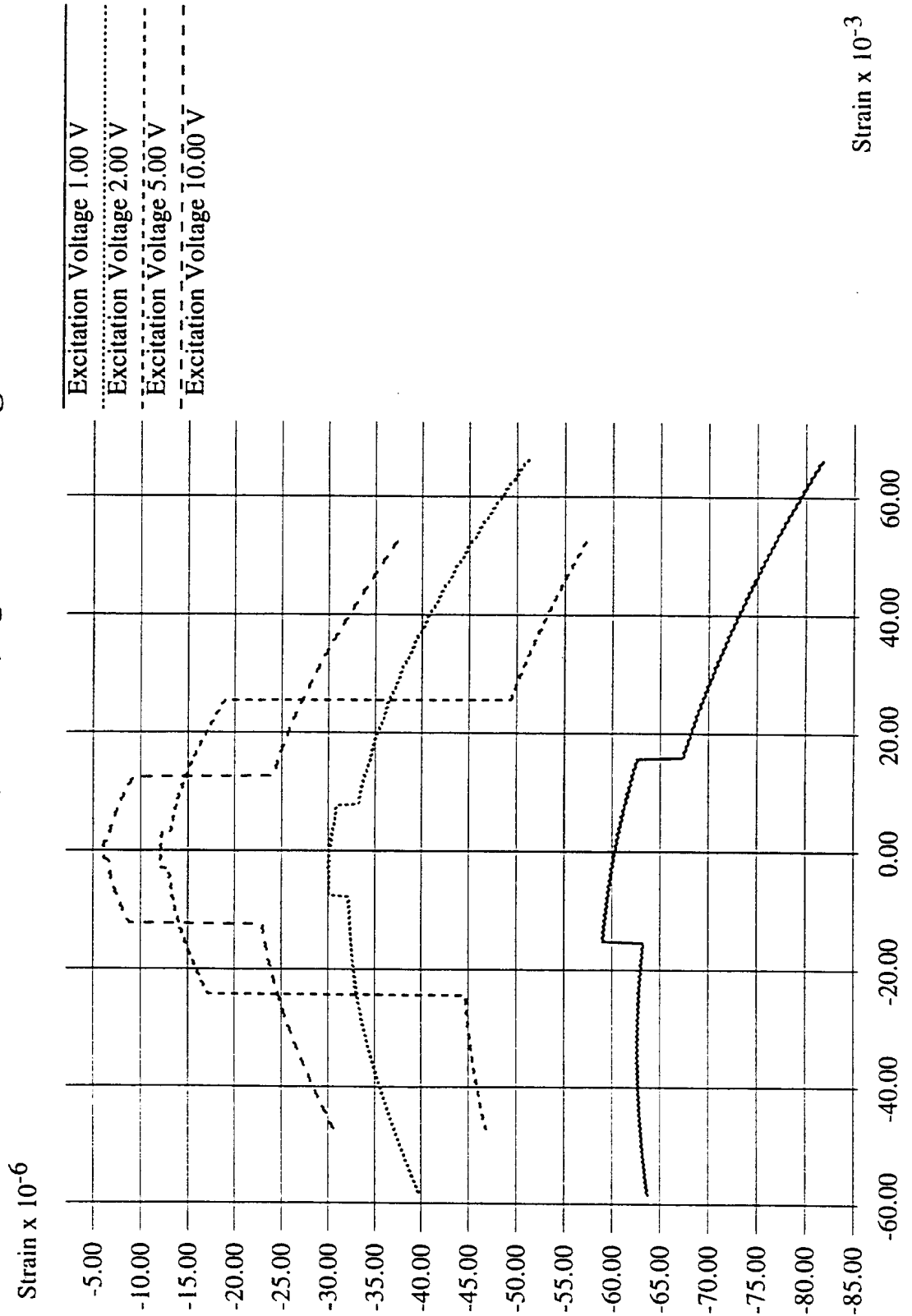
### Droop Rate:

---

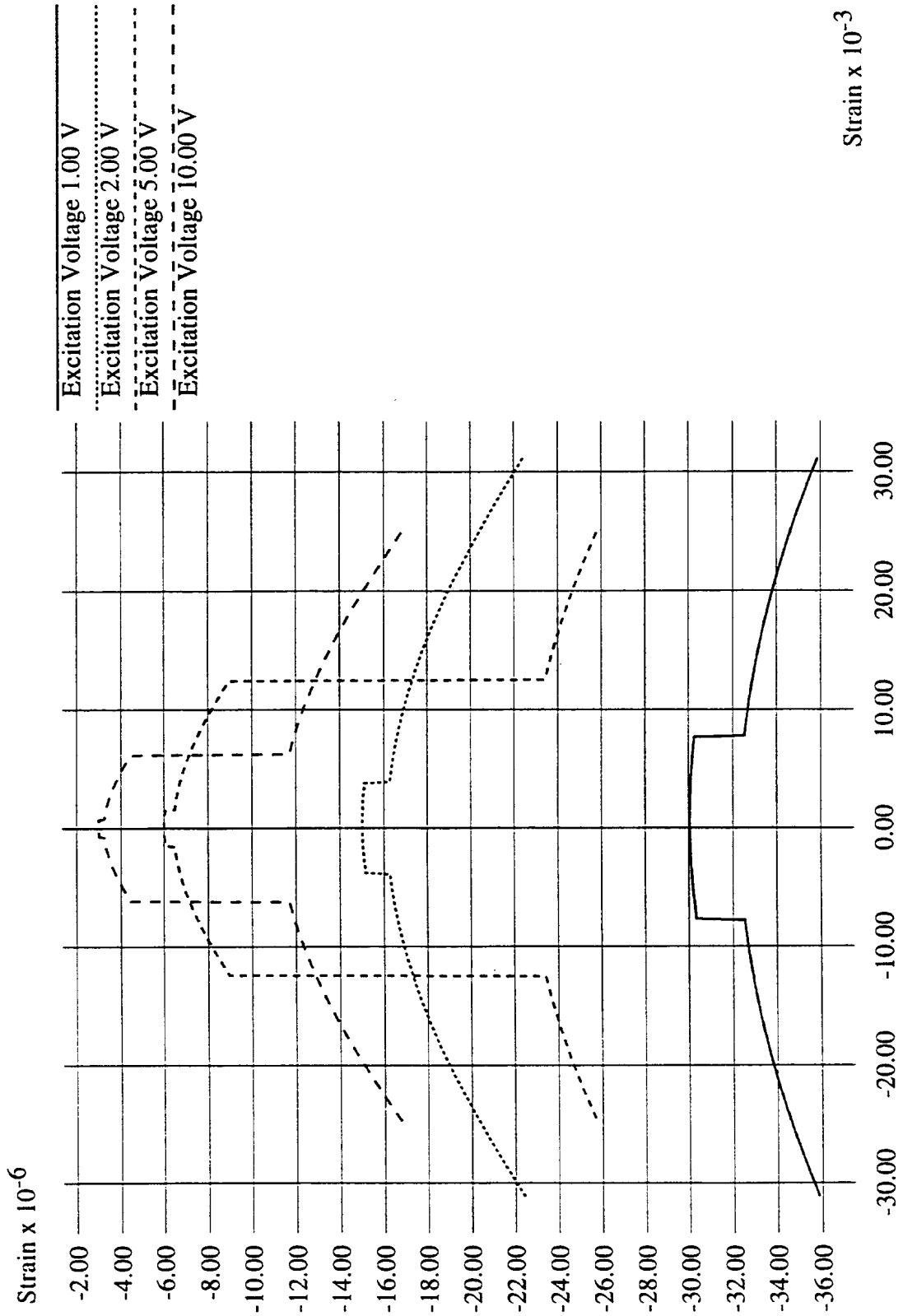
1 volt/sec @ 50°C. Typical is 2-3 mV/sec @25°C. This is referenced to the SCP output so divide by SCP gain setting.

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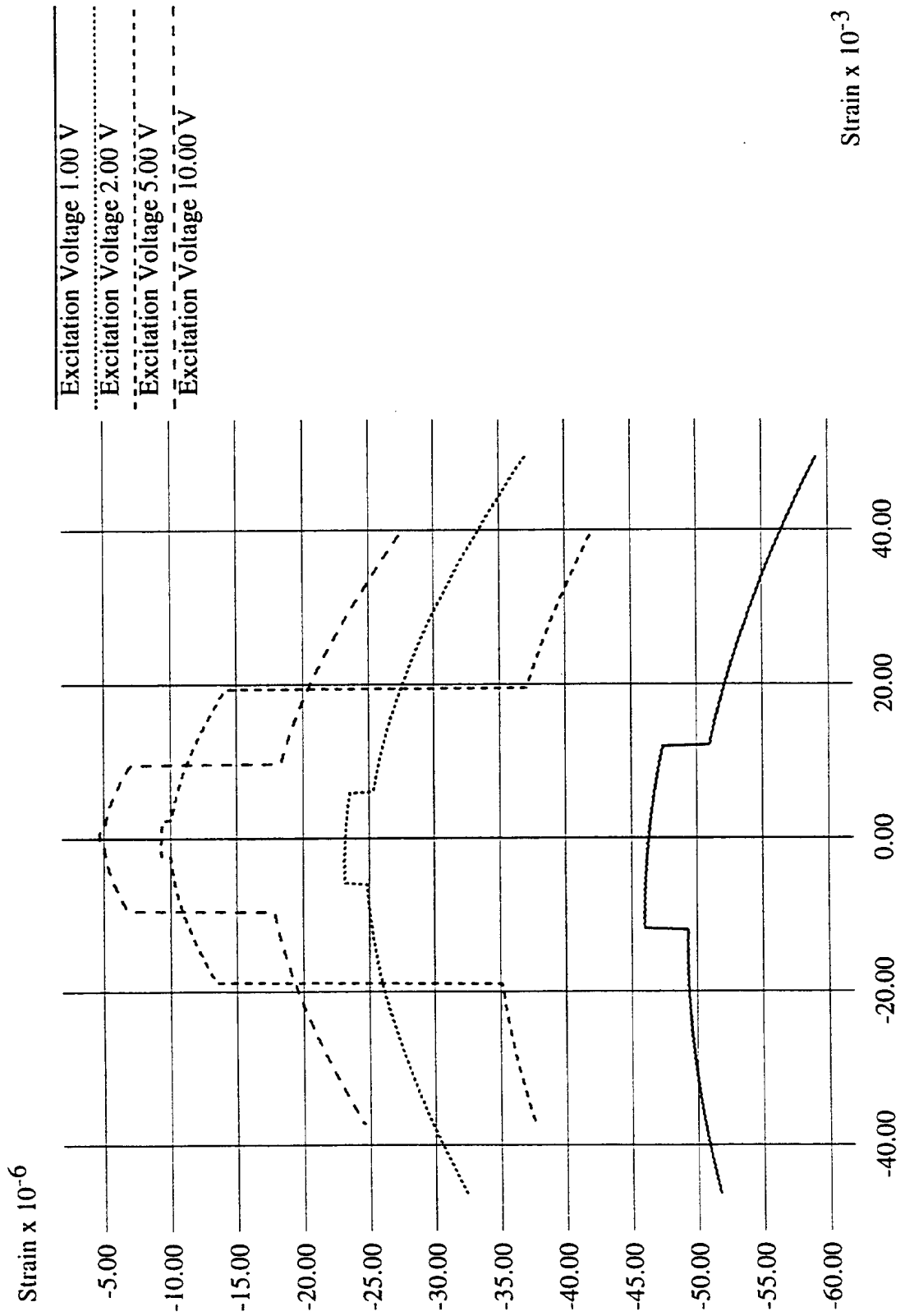
# HP E1511 (OPT 21) Quarter Bridge



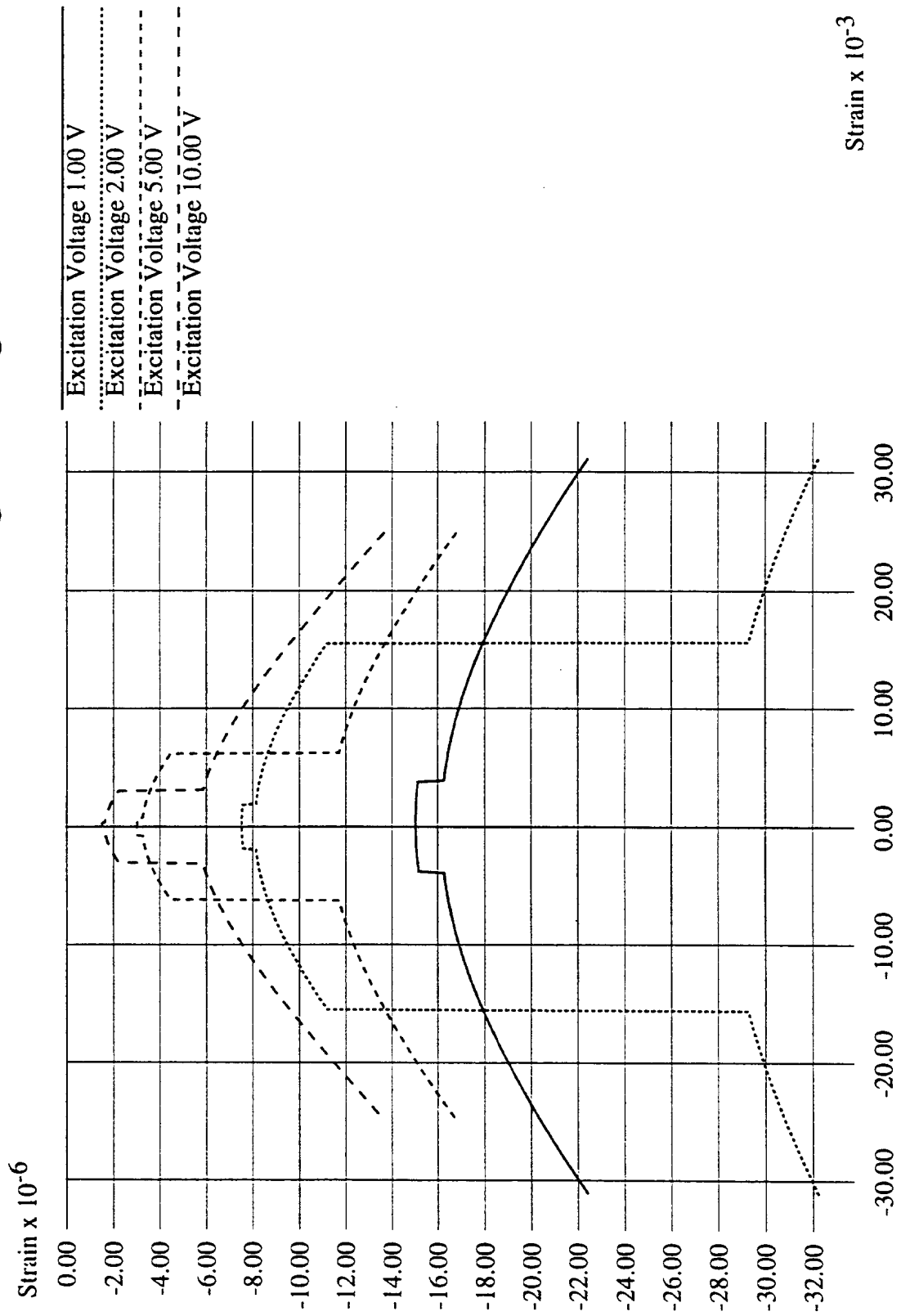
# HP E1511 (OPT 21) Half Bridge Bending



## HP E1511 (OPT 21) Half Bridge Poisson

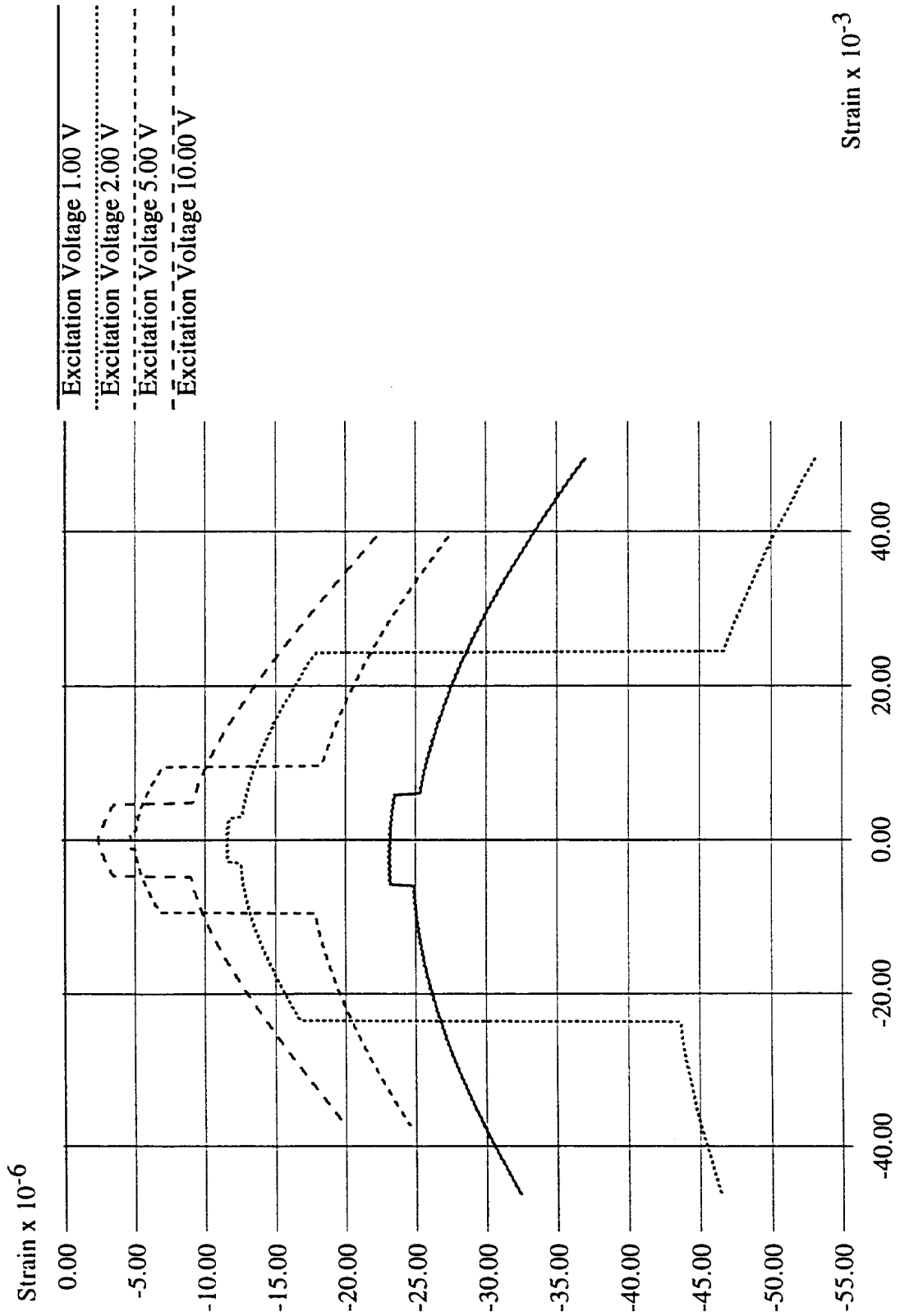


# HP E1511 (OPT 21) Full Bridge Bending





# HP E1511 (OPT 21) Full Bridge Poisson



# HP E1511 (OPT 21) Full Bridge Bending Poisson

