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HP 75000 SERIES B and C

Four-Channel Sample & Hold Input Signal Conditioning Plug-on HP E1510A

User's Manual

The HP E1510 manual also applies to HP E1413Bs as HP E1413 Option 20.

Enclosed is the User's Manual for the HP E1510 Signal Conditioning Plug-on. Insert this manual in your HP E1413/E1313 manual behind the "Signal Conditioning Plug-ons" divider.

The HP E1510, Four Channel Sample and Hold SCP can *only* be used with an HP E1413B/E1410C 64-Channel High Speeed Scanning A/D or HP E1313A 32-Channel High Speed A/D, and not with a model HP E1413A High Speed Scanning A/D. And only four HP E1510s can be installed in an HP E1313A.

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HP E1510
Four-Channel Sample and Hold Signal Conditioning Plug-on

Introduction

HP E1510 is a Signal Conditioning Plug-on (SCP) that provides 4 channels of Sample and Hold inputs and 4 channels of direct inputs for the HP E1413 High Speed A/D Module.

Notes

1. The HP E1510, 4 Channel Sample and Hold SCP can *only* be used with the HP E1313A and HP E1413B/E1413C 64-Channel High Speeed Scanning A/D and *not* with a model E1413A 64-Channel High Speed A/D (flash version 4.0 or above; downloadable driver version 6.0 or above).
2. The HP E1313A B-size 32/64-Channel High Speeed Scanning A/D can only support a maximum of four (4) HP E1510A 4-Channel Sample and Hold SCPs.

About This Manual

Except where noted, references to the HP E1413 also apply to the HP E1313. This manual shows how to connect to the Terminal Module and also shows how to control the HP E1510 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 content is:

- HP E1510 SCP Operation 4
- Connecting To The Terminal Module 5
- Programming With SCPI Commands 8
- Register-Based Programming 14
- Specifications 16

HP E1510 SCP Operation

The HP E1510 SCP provides 4 channels of sample and hold inputs and 4 channels of direct inputs (similar to an HP E1501, Direct Input SCP). The sample and hold and direct input channels can be used independently.

The sample and hold inputs 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 channel.

The SCP also has a lowpass Filter on each sample and hold 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.

If measuring transducers, like strain gages, that may have an initial offset voltage, the SCP uses an autobalancing circuit that can null out the offset voltage.

Figure 1 shows a simplified block diagram of the SCP. The figure shows both the sample and hold and direct inputs.

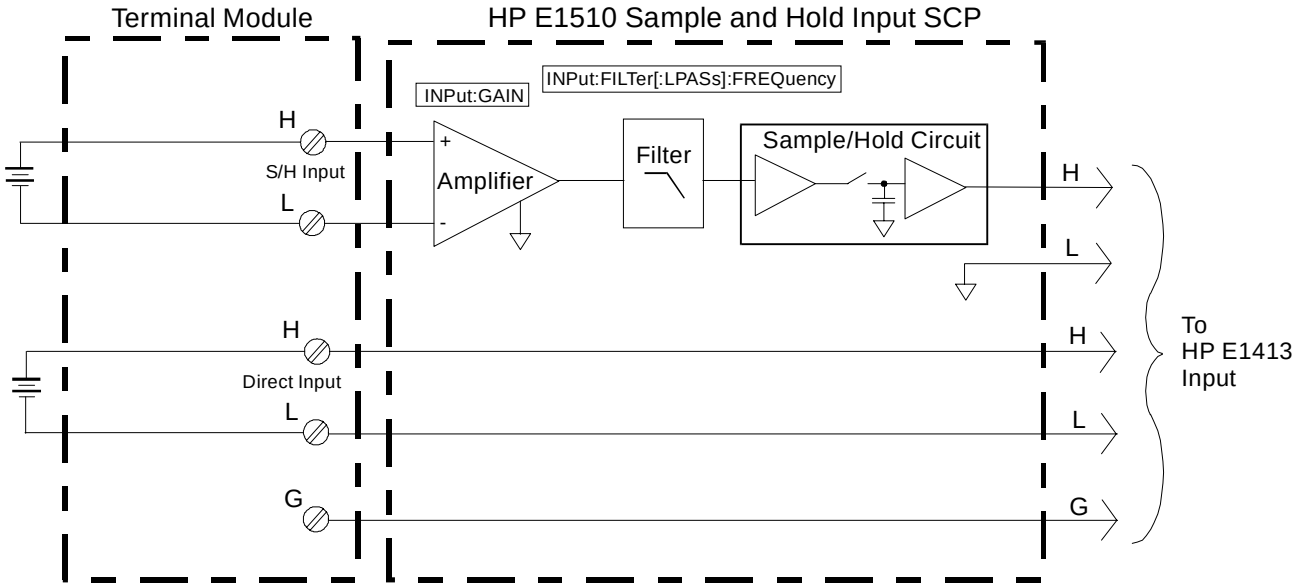


Figure 1 HP E1510, Simplified Block Diagram

Connecting To The Terminal Module

This section shows how to make 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 2.
- For HP E1313 Terminal Moduless, use stickers for HP E1510 SCPs. The connections are shown in Figures 3 and 4.
- For HP E1413B and below Terminal Modules, use stickers for HP E1413 Option 20 SCPs. The connections are shown in Figure 5.

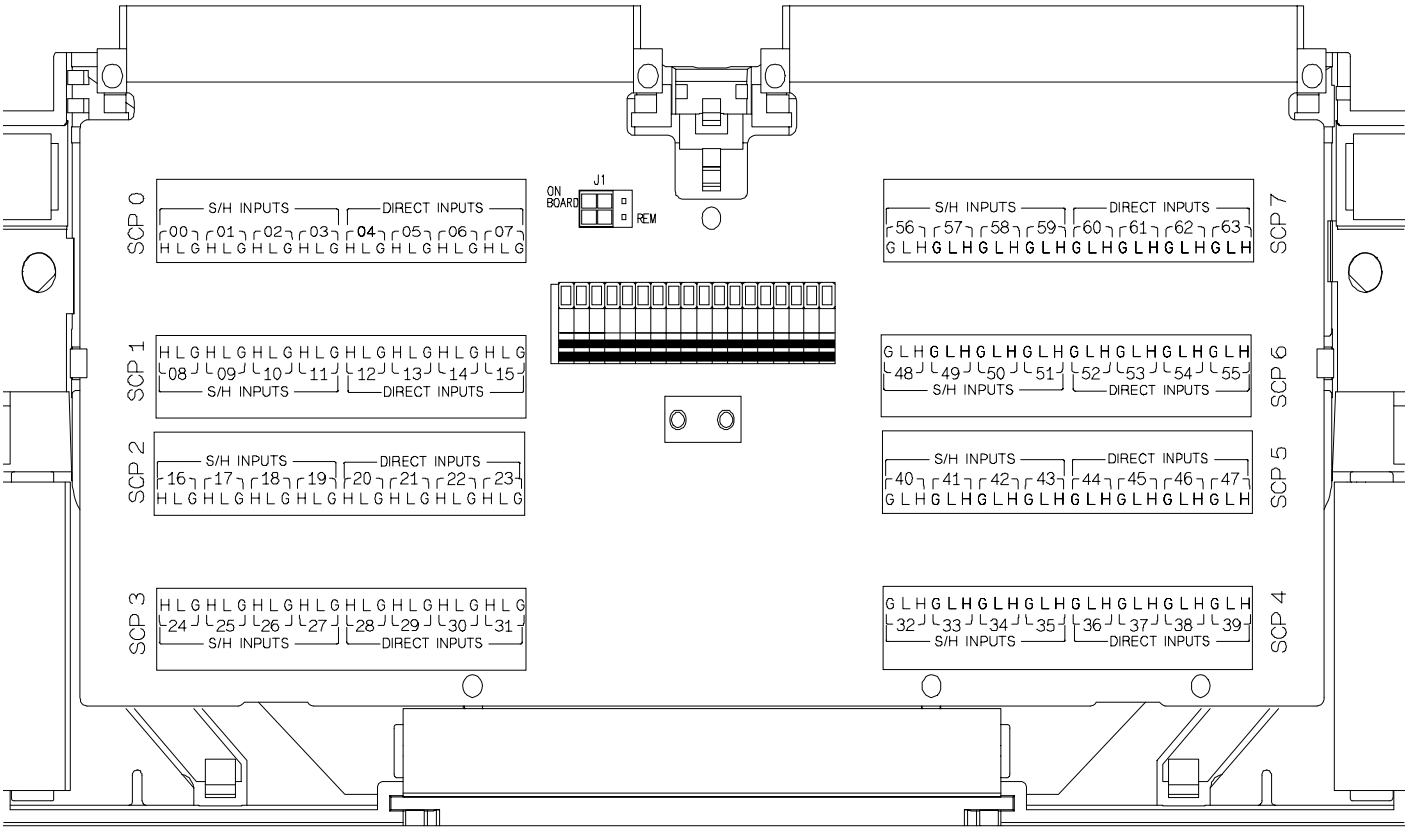


Figure 2 HP E1510 C-Size Terminal Module Connections

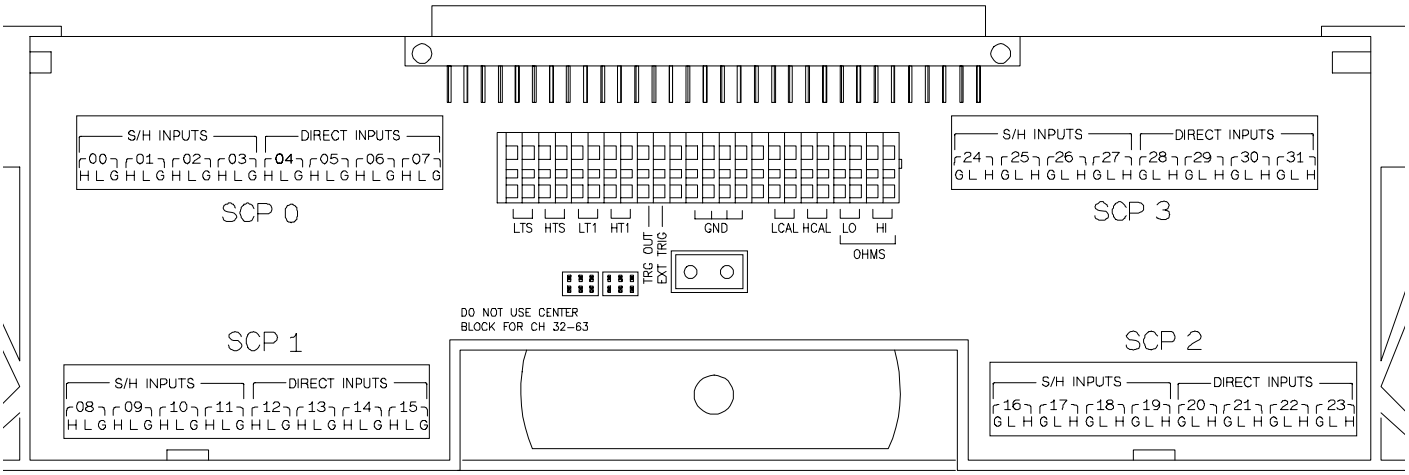


Figure 3 HP E1510 B-size Terminal Module Connections (Ch 00-31)

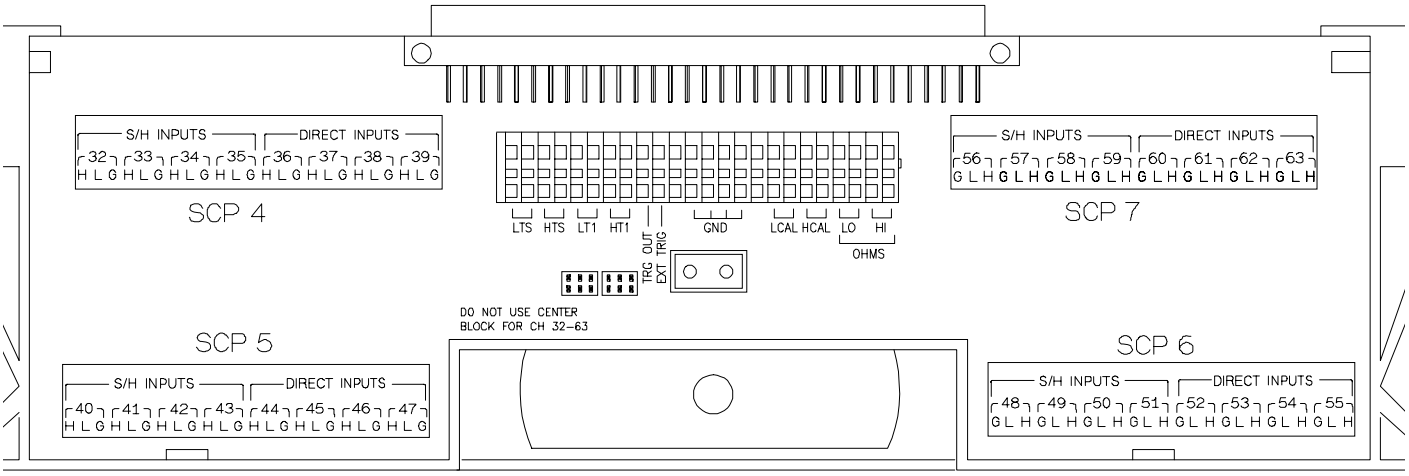


Figure 4 HP E1510 B-size Terminal Module Connections (Ch 32-63)

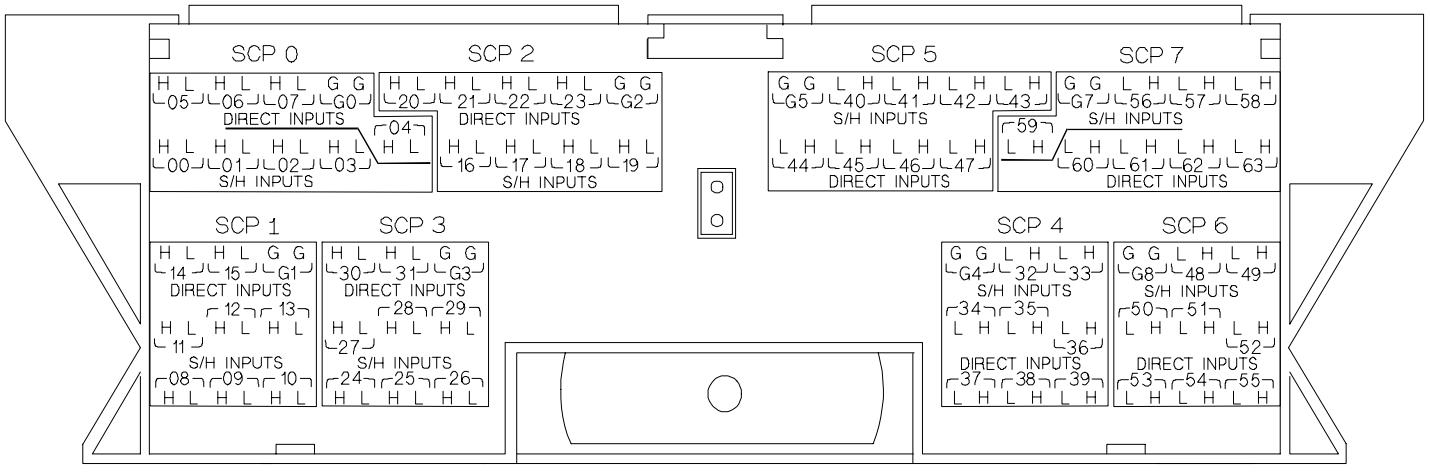


Figure 5 HP E1413 Option 20 Terminal Module Connections

Typical Connections to the Terminal Module

Figures 6 and 7 show some typical connections for regular DC volts measurements and for a strain gage measurement.

Wiring the Terminal Module

See "Opening and Wiring the Terminal Module" in the HP E1413 User's Manual to wire the Terminal Module.

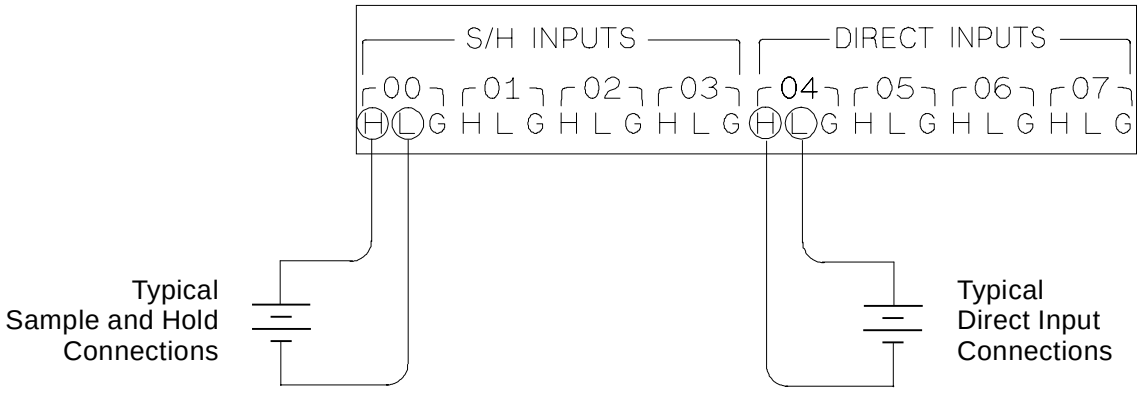


Figure 6 Typical Measurement Connections

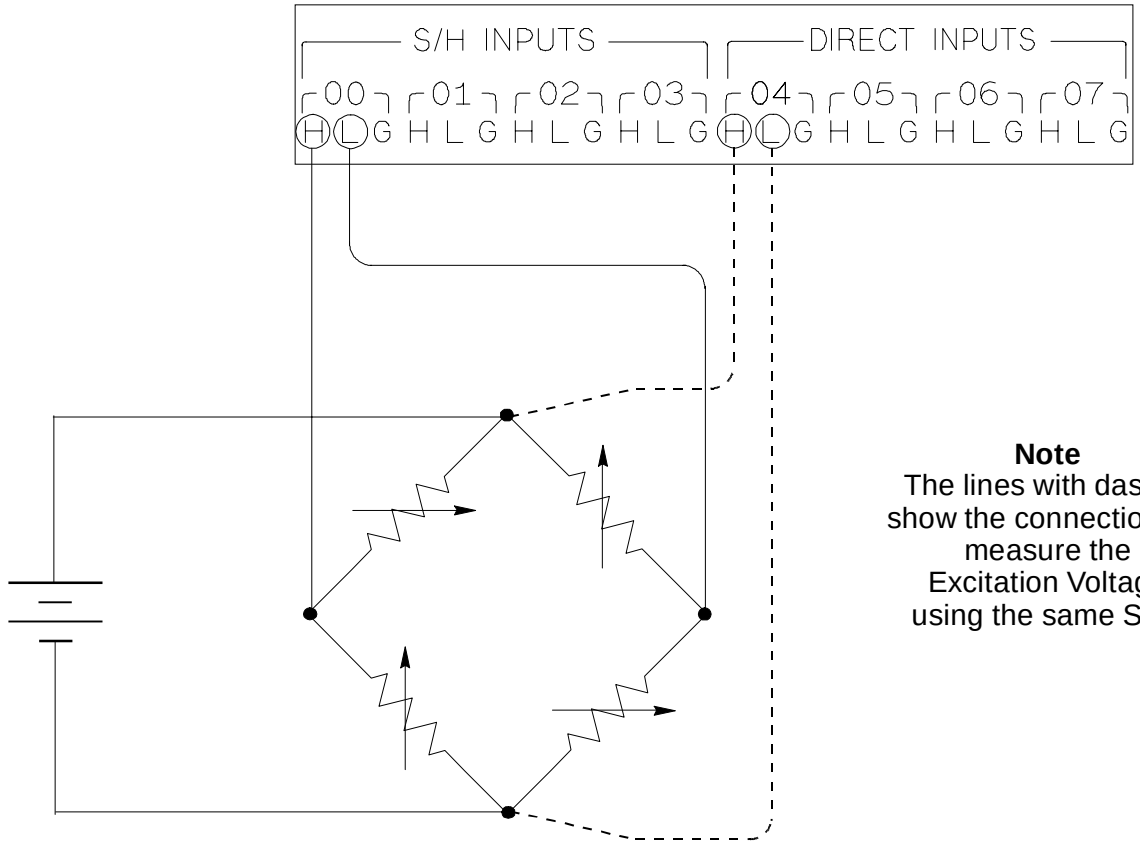


Figure 7 Typical Strain Gage Connections

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 sample and hold measurements using HP E1510 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:SETup	calibrates all of the SCPs
CALibration:SETup?	returns a value when CALibration:SETup is done
CALibration:TARE (@< *ch_list*>)	calibrates SCP and external offsets on the specified channels
CALibration:TARE?	returns a value when CALibration:TARE is done
DIAGnostic:OTDetect < *enable*> ,(@< *ch_list*>)	enables or disables Open Transducer Detection
INPut:FILTer[:LPASs]:FREQuency < *cutoff_freq*> ,(@< *ch_list*>)	selects the low pass filter cufoff frequency
INPut:GAIN < *chan_gain*> ,(@< *ch_list*>)	selects the sample and hold gain
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 eight SCP positions are: 0, 8, 16, 24, 32, 40, 48, and 56.

The value returned for the SCP in an HP E1413B is:
HEWLETT-PACKARD, E1413 Opt 20 4-Ch Sample and Hold Input SCP,0,0

The value returned for the SCP in an HP E1313A/E1413C is:
HEWLETT-PACKARD, E1510 4-Ch Sample and Hold Input SCP,0,0

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 Sample and Hold Measurements

The following example shows how to make sample and hold measurements.

```
INP:FILT:FREQ 1000,(@100:103)      set the cutoff filter frequency
INP:GAIN 4,(@100:103)              select sample and hold gain
CAL:SET                            calibrate all of the SCPs
CAL:SET?                           to return the success flag from the
                                   CAL:SET operation
FUNC:VOLT 1,(@100:107)             link channels 0-7 to EU conversion
initiate and trigger HP E1413      start measurement process
```

Comments

The following explains two different ways to calibrate the SCP.

Using the CALibration:SETup Command

The above example uses the CALibration:SETup command to calibrate the SCPs. This command calibrates the A/D offset, and channel Gain/Offset for all 64 channels. This command is similar to the *CAL? command (see Chapter 5 of the "HP E1413 User's Manual" for more information).

Using the CALibration:TARe Command

If using the SCP for measuring transducers, like strain gages, you can use the CALibration:TARE (@< *ch_list*>) command to null out small offset voltages produces by the transducers. The command also enables the *CAL? command and thus calibrates the A/D offset, and channel Gain/Offset for all 64 channels. When using the CALibration:TARE command, use the CALibration:TARE? command to determine when calibration is complete. For example:

```
CAL:TARE (@100:107)                calibrate SCP and offset voltage
                                   (on channels 100 to 107)
CAL:TARE?                          to return the success flag from the
                                   CAL:TARE operation
```

Setting the Filter Cutoff Frequency

To set the sample and hold channel cutoff frequency, use the INPut:FILTer[:LPASs]:FREQuency < *cutoff*> ,(@< *ch_list*>) command.

- The *cutoff* parameter can specify 15Hz, 100Hz, 250Hz, 500Hz, 1000Hz, MIN, or MAX. MIN specifies 15Hz and MAX specifies 1000Hz.

To set channels 0 through 3 to the 100Hz cutoff frequency, send:

```
INP:FILT:FREQ 100,(@100:103)       send cutoff frequency command
```

Notes

The *RST and Power-On condition for the cutoff frequency is MIN (15Hz) for all sample and hold channels.

The cutoff frequency is only applicable for sample and hold channels (lowest four channels) and not the direct input channels (highest four channels).

Querying the Filter Cutoff Frequency

To query any sample and hold channel for its cutoff frequency, use the INPut:FILTer[:LPASs]:FREQuency? (@< *channel*>) command. The INP:FILT:FREQ? command returns the cutoff value currently set for the specified channel.

- The *channel* parameter must specify a single channel.

To query the cutoff frequency for channel 3 send:

```
INP:FILT:FREQ? (@103)          query channel 3
enter statement here           returns 15, 100, 250, 500, or 1000
```

Setting the Amplifier Gain

To set the channel gain for the sample and hold channels, use the INPut:GAIN < *gain*> ,(@< *ch_list*>) command.

- The gain parameter can specify 0.5, 8, 64, 512, MIN, or MAX. MIN specifies 0.5 and MAX specifies 512.

- Since the SCP can only output a maximum of ±5V, use the 4V range (A/D gain of 4) of the HP E1413 for most measurements.

To set sample and hold channels 0 through 3 to a gain of 8, send:

```
INP:GAIN 8,(@100:103)          send gain command
```

Notes

The *RST and Power-On condition for the amplifier gain is MIN (0.5) for all sample and hold channels.

The amplifier gain is only applicable for sample and hold channels (lowest four channels) and not the direct input channels (highest four channels).

Querying the Amplifier Gain

To query the sample and hold channels to determine the gain setting, use INPut:GAIN? (@< *channel*>) command. The INP:GAIN? command returns the current gain value of the specified channel.

- The *channel* parameter must specify a single channel.

To query the gain of channel 2, send:

```
INP:GAIN? (@102)          query channel 2
enter statement here       returns 0.5, 8, 64, or 512
```

Detecting Open Transducers

The SCP provides a method to detect open transducers on all channels of the SCP. When Open Transducer Detect (OTD) is enable, the SCP injects a small current into the HIGH (H) and LOW (L) input of each applicable channel. The polarity of the current pulls the HIGH inputs toward + 17V and the LOW inputs toward -17V. If a transducer is open, measuring that channel returns an over-voltage reading. OTD is available on a per SCP basis. Thus, all eight channels are enabled or disabled together. See Figure 8 for a simplified schematic diagram of the OTD circuit.

Note

1.) When OTD is enabled, the inputs have up to 0.2µA injected into them. If this current will adversely affect your measurements, but you still want to check for open transducers, you can do the following:

enable OTD
wait for a while (about 2 seconds; see note 2)
make a single scan
check CVT for over-voltage readings
disable OTD and make your regular measurement scans

The specifications only apply when OTD is off.

2.) When using Open Transducer Detect, allow a 2 seconds for the input filter on the SCP to charge.

To enable or disable Open Transducer Detection, use the DIAGnostic:OTDetect < *enable*> ,(@,< *ch_list*>) command.

- The *enable* parameter can specify ON or OFF (OFF is default value).

- An SCP is addressed when the ch_list parameter specifies a channel number contained on the SCP. The first channel on each SCP is:
  0, 8, 16, 24, 32, 40, 48, and 56

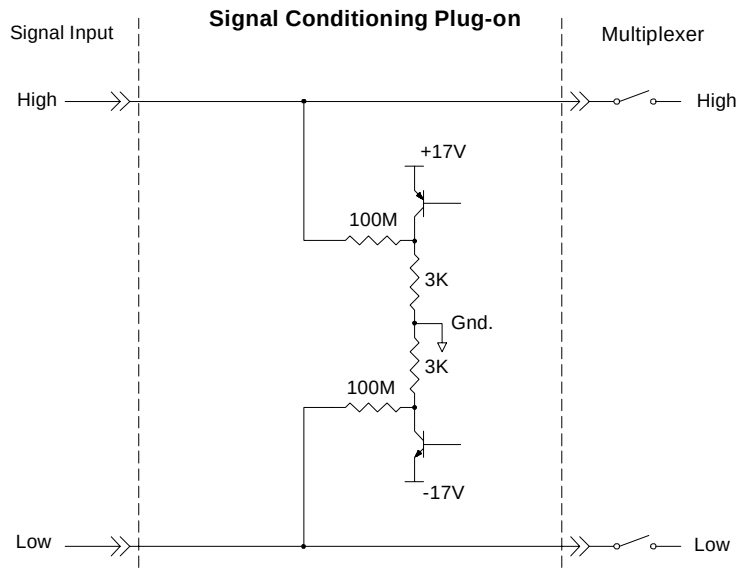


Figure 8. Open Transducer Detect Circuit

To enable Open Transducer detection on all channels on SCPs 1 and 3, send:

```
DIAG:OTD  ON,(@100,116)          0 is on SCP 1 and 16 is on SCP 3
```

To disable Open Transducer Detection on all channels on SCPs 1 and 3, send:

```
DIAG:OTD  OFF,(@100,116)
```

Measuring Strain Gages

The following example shows how to make a sample and hold strain measurements. The example uses channels 100:103 (sample and hold inputs) for the sample and hold measurement and channels 104:107 (direct inputs) to measure the external excitation voltage (see Figure). The example assumes a full bending poisson strain measurements.

Bridge is *Unstrained*

The following commands calibrates the module, reads and stores the external excitation voltage, and reads the bridge output voltage. Do this when the bridge is in the *Unstrained* configuration. The commands are separated into three parts. The first part calibrates the SCP. The second part reads and stores the excitation voltage. The third part configures module for strain measurements. Execute the following commands when the bridge is in the *Unstrained* configuration.

Calibrate Module

CAL:TARE (@100:103)	*measure the unstrained voltage on channels 0-3*
CAL:TARE?	*to return the success flag from the CAL:TARE operation*
enter CAL:TARE query	*wait until success flag from CAL:TARE operation is returned*

Read and Store Excitation Voltage

FUNC:VOLT:DC (@104:107)	*setup module to measure the excitation voltage on channels 4-7*
trigger module	*initiate and trigger module to read channels 0-4*
read and store into array	*store excitation data into an array*
STR:EXC < excite_v> ,(@100:103)	*enter excitation voltage values from array for channels 0-3*

Configure the Measurement

INP:FILT:FREQ 1000,(@100:103)	*selects the sample and hold lowpass filter frequency (default is 15Hz)*
INP:GAIN 64,(@100:103)	*selects the gain of the sample and hold circuitry (default is .5)*
STR:GFAC 2,(@100:103)	*specifies the gage factor on channels 0-3 (selected factor 2 is the default value)*
STR:POIS .3,(@100:103)	*set Poisson ratio for EU conversion; selected value is .3 (default value)*
FUNC:STR:FBP 1,(@100:103)	*link channel 0-3 to EU conversion for strain measurement; selected voltage range is 1V*

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).

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 - Opt 20: (6000_{16})		Whole SCP Reg 0	$00ppp000000_2$
SCP Gain Scale ($XXX3_{16}$)		Whole SCP Reg 1	$00ppp000001_2$
Channel Gain (Sample and Hold channels): ($FFFF_{16}$= 0.5, $FFF1_{16}$= 8, $FFF2_{16}$= 64, $FFF3_{16}$= 512) **Channel Gain (direct channels):** 0000_{16}= 1		Channel Reg 1	$01pppccc001_2$
Channel Frequency ($XXX0_{16}$= 15Hz, $XXX1_{16}$= 100Hz $XXX2_{16}$= 250Hz, $XXX3_{16}$= 500Hz, $XXX4_{16}$= 1kHz)		Channel Reg 2	$01pppccc002_2$

XXX= 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_{16}) 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) x 40_{16} + (SCP channel number) x 8_{16} + 2_{16}

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

0000_{16} for 15Hz, 0001_{16} for 100Hz, 0002_{16} for 250Hz,
0003_{16} for 500Hz, 0004_{16} for 1kHz

Then write the opcode for SCBWRITE (0810_{16}) 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*) x 40_{16} + (*SCP channel number*) x 8_{16} + 1_{16}

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

$FFFF_{16}$ for 0.5, $FFF1_{16}$ for 8, $FFF2_{16}$ for 64, $FFF3_{16}$ for 512

Then write the opcode for SCBWRITE (0810_{16}) to the Command Register.

Detecting Open Transducers

Open Transducer Detection (OTD) is controlled by bits in the Card Control Register. For more information on OTD, see Figure 8.

Card Control Register **(Base + 12_{16})**

15	14	14-13	12	11	10-8	7-0
PSI Pwr Reset	FIFO Mode	unused	FIFO Clear	VPPEN	A24 Window	Open Transducer Detect

Writing a one (1) to a bit enables open transducer detect on that signal conditioning module. Writing a zero (0) to a bit disables open transducer detect.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
SCP 7	SCP 6	SCP 5	SCP 4	SCP 3	SCP 2	SCP 1	SCP 0

Specifications

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 (± from nominal)
1 kHz	427.5 µsec	10 µsec
500 Hz	854.9 µsec	20 µsec
250 Hz	1.710 msec	40 µsec
100 Hz	4.275 msec	100 µsec
15 Hz	28.50 msec	670 µsec

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: < ±16 V peak
Damage level: > ±42 V peak

Maximum common mode voltage:

Operating: < ±16 V peak
Damage level: > ±42 V peak

Crosstalk (referenced to input):

350Ω 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 MΩ

Maximum tare cal offset:

X0.5 gain ±25% of full scale
X8 gain ±90 mV
X64 gain ±95 mV
X512 gain ±95 mV

Sample and Hold Characteristics

Acquisition Time:
1 µsec

Aperature Time:
2 nsec

Aperature Delay:
35 nsec + delay in skew specification

Aperature Jitter:
150 psec

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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