HP 75000 SERIES B and C

4-Wire Resistance Measurement Signal Conditioning Plug-on HP E1518A

User's Manual

Enclosed is the User's Manual for the HP E1518A Signal Conditioning Plug-on. Insert this manual in your HP E1413/E1313 or HP E1415 manual behind the "Signal Conditioning Plug-ons" divider.

This SCP will operate in:

An HP E1413/E1313 with Flash revision A.06.02 or later, and Driver revision A.09.00 or later.

An HP E1415 with Flash revision A.03.00 or later, and Driver revision A.02.00 or later.

HEWLETT® PACKARD

E1518-90001

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HP E1518A
Resistance Measurement
Signal Conditioning Plug-on

Introduction

The HP E1518 is a Signal Conditioning Plug-on (SCP) that provides four excitation current sources and four corresponding sense input channels. Each current source can be programmed to provide either 30μA, or 488μA. Each sense input provides a fixed-gain amplifier (X16) with fixed bandwidth filtering (7Hz). Also provided is input over-voltage detection on all channels and Open Transducer Detection on the four sense channels.

The SCP's current source channels can be used with other input SCPs (different gain and filter combinations) to provide a wide range of resistance measurement capability. Also, this SCP's sense inputs can be used as general purpose voltage inputs with X16 gain (same characteristics as an HP E1508A SCP).

About this Manual

This manual shows you how to control the Signal Conditioning Plug-on (SCP) using SCPI commands as well as Register-Based commands, and explains the capabilities of this SCP. Finally, it covers specifications for this SCP. Installation for this Plug-on is common to several others and is covered in Chapter 1 your HP E1413/E1313 manual. The contents of this manual are:

Field Wiring

The E1518 SCP supplies excitation current from its four output channels (the SCP's first 4 channels) and senses voltage on its four input channels (the SCP's last 4 channels). Figure 1 shows the general method of connection for both 4-wire and 2-wire connections.

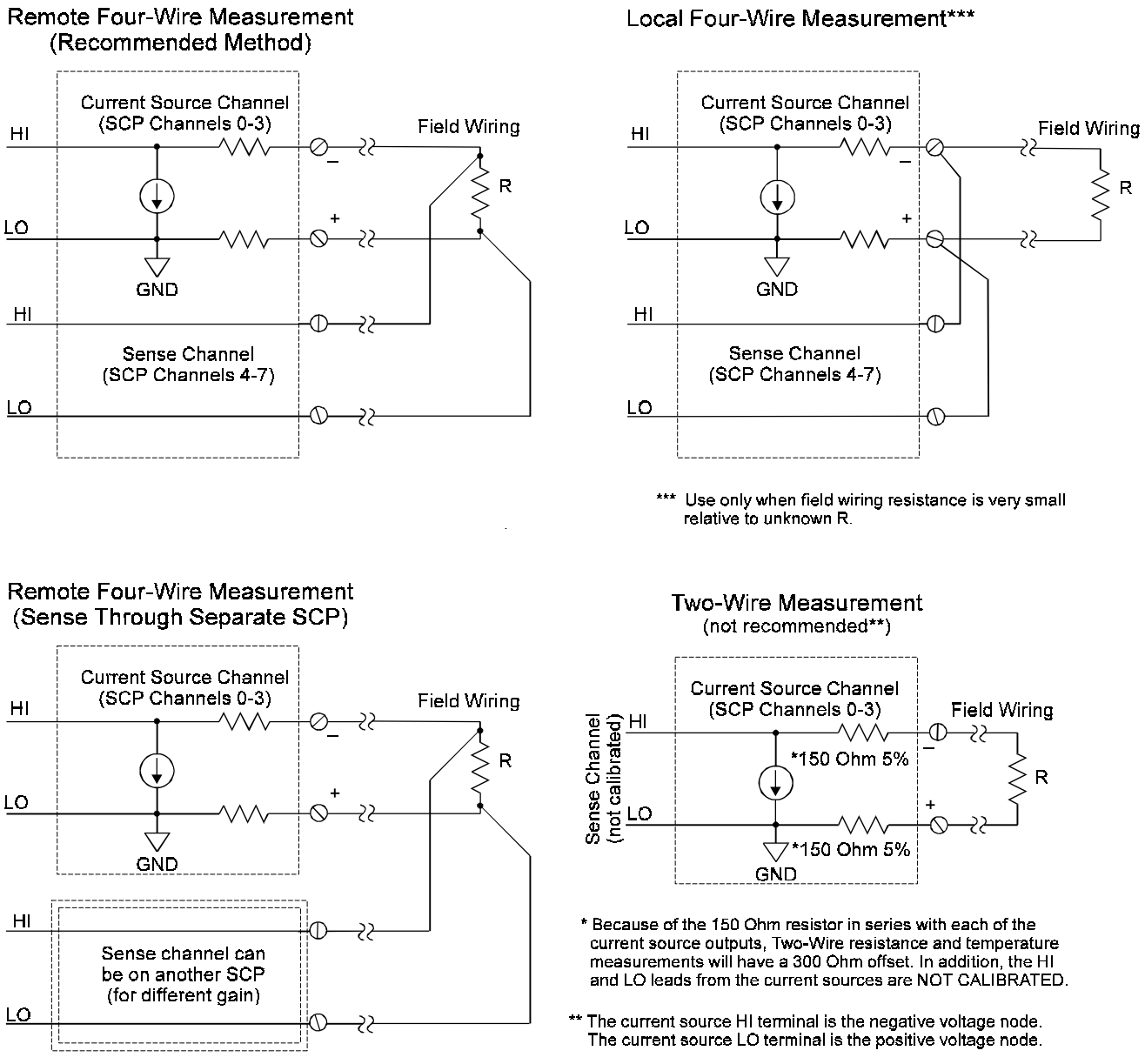

Figure 1 Wiring for Resistance and Temperature

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:

- For the HP E1413C and HP E1415A, use the label sheet marked C-size (Figure 2).
- For the HP E1313A, use the label sheet marked B-size (Figures 3 and 4).
- No label sheet is included for HP E1413A/B connector module. In this case follow the terminal module connection diagram in Figure 5.

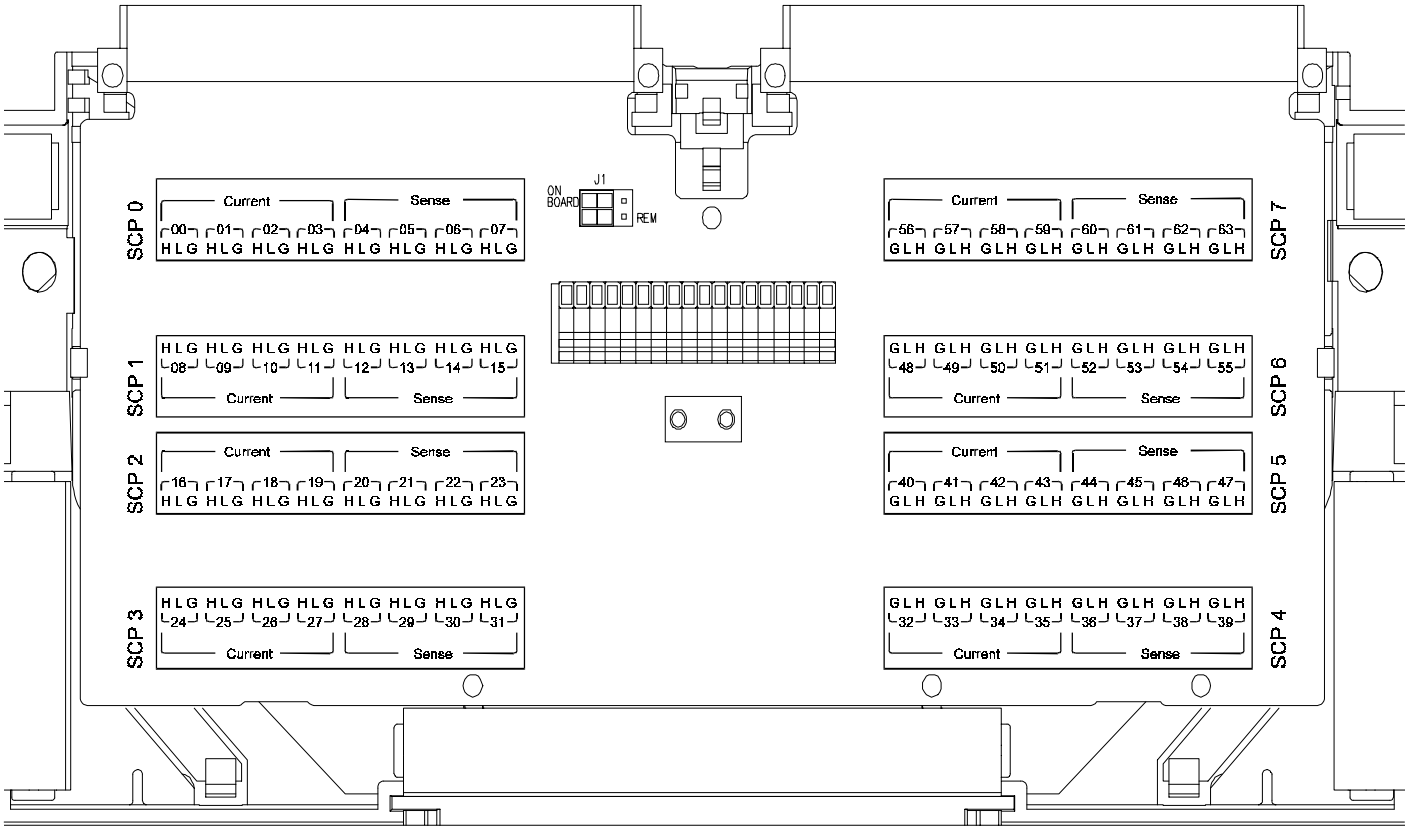

Figure 2 HP E1518 C-Size Terminal Module Connections

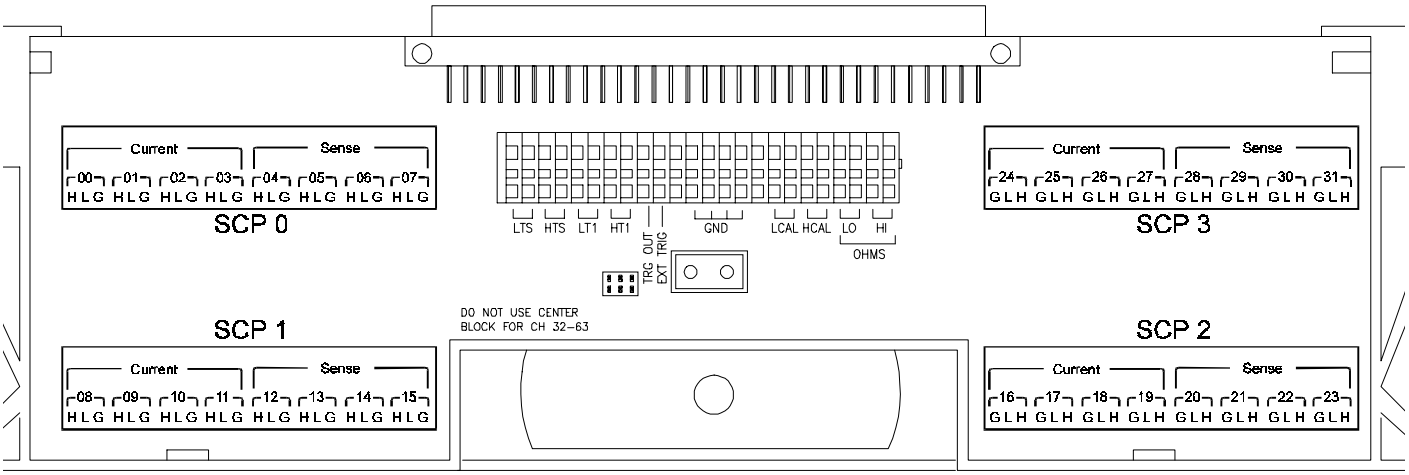

Figure 3 HP E1518 B-size Terminal Module Connections (Ch 00-31)

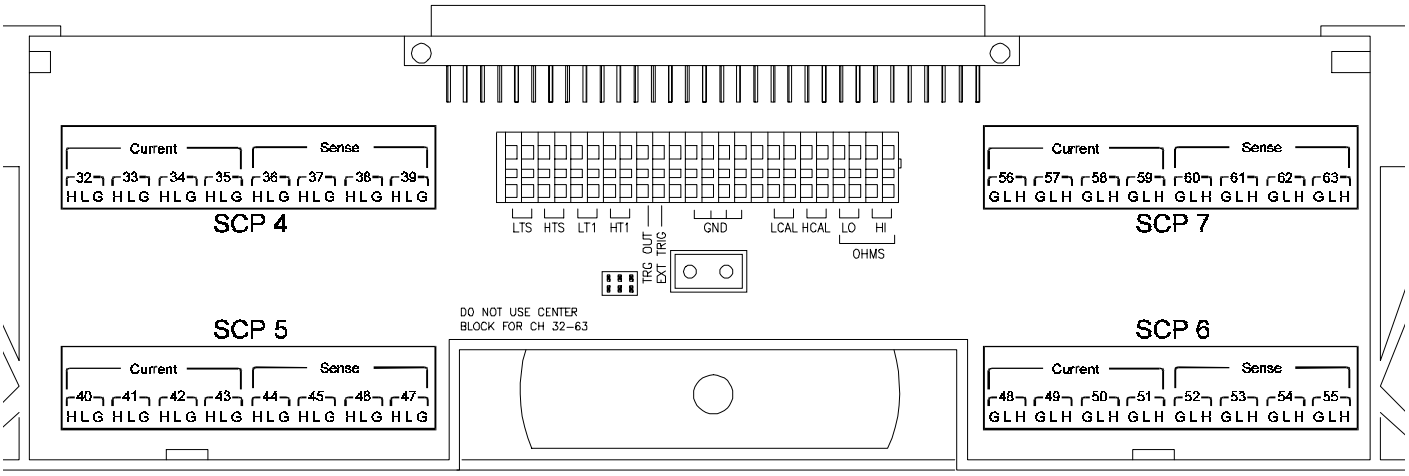

Figure 4 HP E1518 B-size Terminal Module Connections (Ch 32-63)

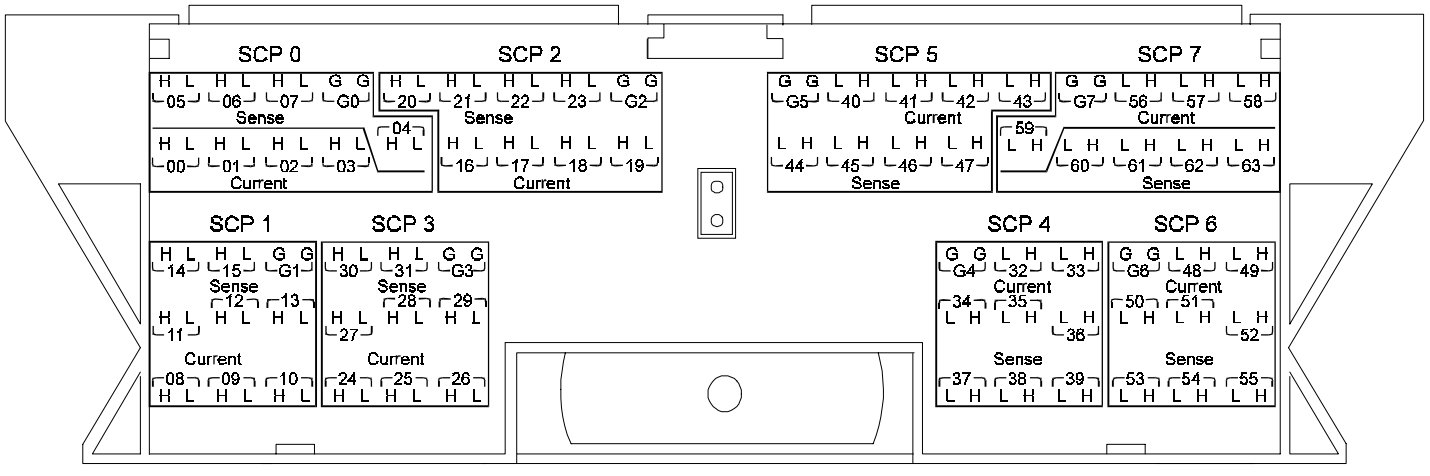

Figure 5 HP E1413A/B Terminal Module Connections

Programming With SCPI Commands

The SCPI commands shown here are covered in Chapters 3 and 5 of your HP E1413/E1313 manual or Chapters 3 and 6 of your HP E1415 manual. This section will relate those commands to the parameter values which are specific to this SCP.

Checking the ID of the SCP

To verify the SCP type(s) installed on the HP E1413/E1313 or HP E1415 use the SYSTem:CTYPe? (@<channel>) command.

- The *channel* parameter specifies a single channel in the channel range covered by the SCP of interest. The first channel number for each of the eight SCP positions are; 0,8,16,24,32,40,48, and 56.

The value returned is:
HEWLETT-PACKARD,E1518A 4-Wire Resistance 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*

Setting Current Output Level

To set the current output level use the OUTPut:CURRent:AMPLitude <*level*>,(@<*ch_list*>) command.

- The *level* parameter can set the current output level to either 30µA ($\frac{1}{32768}$A)or 488µA ($\frac{1}{2048}$A). The default unit for *level* is Amps DC. You may also include a units suffix to specify milliamps (ma), or microamps (ua). The level parameter will also accept MIN (30µA) and MAX (488µA). Use 488µA for resistance measurements under 2000 Ohms and 30µA for resistances of 2000 Ohms and greater.
- *ch_list* must specify one or more of the SCP's first four channels.
- The *RST condition is 488µA.

To set channels 0 through 3 (SCP position 0) to measure < 2K Ohm, send
OUTP:CURR:AMPL 488E-6, (@100:103)

To set channels 8 through 11 (SCP position 1) to measure 2K Ohm to 32.7K Ohm, send OUTP:CURR:AMPL 30ua,(@108:111)

Querying the Current Level

To query any channel to determine the current level use the OUTPut:CURRent:AMPLitude? (@<*channel*>) command. The OUTP:CURR? command returns either +4.88E-4 or +3.0E-5.

- *channel* must specify a single one of the SCP's first 4 channels.

To query the current level of channel 2 send

```
OUTP:CURR:AMPL? (@102)          query channel 2
enter statement here            returns 4.88e-4 or 3.0e-5
```

Turning Current Source Channels Off and On

To disable or enable the current source channel use OUTPut:CURRent[:STATe] <*enable*>,(@<*ch_list*>) command.

- The *enable* parameter can take the values ON or 1, and OFF or 0.
- *ch_list* must specify one or more of the SCP's first four channels.
- The *RST condition is OFF.

To disable current source channels 0 through 3 (SCP position 0), send

```
OUTP:CURR:STAT  OFF, (@100:103)
```

To enable current source channels 8 through 11 (SCP position 1), send

```
OUTP:CURR:STAT  ON,(@108:111)
```

Querying the Current Source State

To query any channel to determine the current source output state use the OUTPut:CURRent[:STATe]? (@<*channel*>) command. The OUTP:CURR? command returns either a 1 for ON or a 0 for OFF.

- *channel* must specify a single one of the SCP's first 4 channels.

To query the current state of channel 2 send

```
OUTP:CURR:STAT? (@102)          query channel 2
enter statement here            returns 1 or 0
```

Querying the Filter Cutoff Frequency

While the HP E1518 does not provide programmable cutoff frequency the filter frequency can be queried. The response to this query will always be 7. To query any channel for its cutoff frequency use the INPut:FILTer[:LPASs]:FREQuency? (@<*channel*>) command. The INP:FILT:FREQ? command returns the numeric cutoff value currently set for the channel specified.

- *channel* must specify a single one of the SCP's last 4 channels.

To query the cutoff frequency of channel 6 (SCP position 0) send

```
INP:FILT:FREQ?  (@106)          query channel 6
enter statement here
```

Querying the Filter State

While the HP E1518 does not allow controlling whether the filters are enabled or disabled, this state can be queried. The response to this query will always be 1. To query any channel to determine if it is enabled or disabled use the INPut:FILTer[:LPASs][:STATe]? (@<*channel*>) command. The INP:FILT? command returns a 0 if the channel is OFF or a 1 if the channel is ON.

- *channel* must specify a single one of the SCP's last 4 channels.

To query the filter state of channel 15 (SCP position 1) send

```
INP:FILT?  (@115)          query channel 15
enter statement here
```

Querying the Channel Gain

While the HP E1508's amplifiers have fixed gain, the channel gain can be queried. The response to this query will always be 16. To query any channel to determine its gain setting use the INPut:GAIN? (@<*channel*>) command. The INP:GAIN? command returns the current gain value for the specified channel.

- *channel* must specify a single one of the SCP's last 4 channels.

To query the gain setting of channel 7 send

```
INP:GAIN?  (@107)          query channel 7
enter statement here
```

Detecting Open Transducers

HP E1518 provides a method to detect open transducers connected to its 4 sense channels. When Open Transducer Detect (OTD) is enabled, the SCP injects a small current into the HIGH and LOW input of each channel. The polarity of the current pulls the HIGH inputs toward +17 volts and the LOW inputs towards -17 volts. If a transducer is open, measuring that channel will return an over-voltage condition. OTD is available on a per SCP basic. all eight channels of an SCP are enabled or disabled together. See Figure 6 for a simplified schematic diagram of the OTD circuit.

NOTES

1) When OTD is enabled, the inputs have up to 0.2µA injected into them. If this current will adversely affect your measurement, but you still want to check for open transducers, you can enable OTD, make a single scan, check

the CVT for bad measurements, then disable OTD and make your regular measurement scans. The specifications apply only when OTD is off.

2) Allow 5 minutes before checking for open transducers to allow filter capacitors to charge.

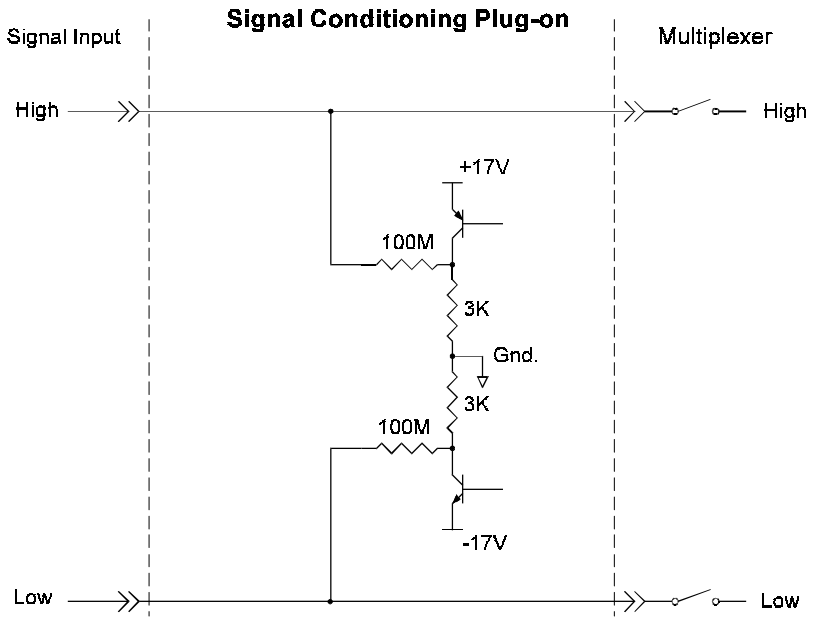

Figure 6 Open Transducer Detect Circuit

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

- The *enable* parameter can specify ON or OFF
- The *RST condition is OFF.
- An SCP is addressed when the *ch_list* parameter specifies one of the channel numbers contained on the SCP. The first channel on each SCP is:
  0, 8, 16, 24, 32, 40, 48, and 56

To enable Open Transducer Detection on all 4 sense channels on SCP 1:

```
DIAG:OTD ON, (@112)
```

To disable Open Transducer Detection on all 4 sense channels on SCP 3:

```
DIAG:OTD OFF, (@128)
```

Querying the OTD State

To determine the OTD state use the SCPI command
DIAGnostic:OTDetect[:STATe]? (@<*channel*>)

- *channel* must specify a single one of the SCP's last 4 channels.

To check the state of OTD for the HP E1518A in SCP position 3 send

```
DIAG:OTD? (@128)                    ch is first sense chan on SCP 3
enter statement here
```

Register Based Programming (HP E1413/E1313)

The register-based commands shown here are covered in Appendix D of the HP E1413/E1313 manual. You should read that section first to become familiar with accessing registers and executing Register-Based Commands. This section will relate those commands to the parameter values which are specific to this Plug-on.

When Register Programming an SCP most communication is through the Signal Conditioning Bus. For that we'll use the Register Commands:

SCBWRITE <*regaddr*> <*regvalue*>
and
SCBREAD? <*regaddr*>

HP E1518 Register Map

Read (returned value)	Write(<*regvalue*>)	SCP Register	<*regaddr*> Value
SCP ID ($AF00_{16}$)		Whole SCP Reg 0	$00ppp000000_2$
SCP Gain Scale (0202_{16})		Whole SCP Reg 1	$00ppp000001_2$
Channel Control (ch 0-3 only) ($XXX0_{16}$=Off&Low, $XXX1_{16}$=Off&High, $XXX2_{16}$=On&Low, $XXX3_{16}$=On&High)		Channel Reg 0	$01pppccc000_2$ ($ccc=000_2$ - 011_2)
Channel Gain(Ch 0-3) ($XX00_{16}$)		Channel Reg 1	$01pppccc001_2$
Channel Gain(Ch 4-7) ($XX02_{16}$)		Channel Reg 1	$01pppccc001_2$
Channel Freq(Ch 0-3) ($XX03_{16}$)		Channel Reg 2	$01pppccc001_2$
Channel Freq(Ch 4-7) ($XX01_{16}$)		Channel Reg 2	$01pppccc001_2$
	Calibration ($Xnnn_{16}$) where nnn=Cal Value	Channel Reg 7	$01pppccc111_2$

XX=don't care

ppp=Plug-on
ccc=SCP channel

Checking ID of 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 SCBREAD? (0800_{16}) to the Command Register. The ID value will be written to the Query Response Register.

Controlling Current Source Channels

To set current amplitude and enable or disable 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 control values to Parameter Register 2:

0000_{16} = current low, output off
0001_{16} = current high, output off
0002_{16} = current low, output on
0003_{16} = current high, output on

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

Channel Calibration Register

The channel calibration registers control DACs that adjust the current output of each current source channel. The Register-Based command CARDCAL? (1000_{16}) controls these registers and the user should not write to them.

Detecting Open Transducers

Open Transducer Detection (OTD) is controlled by bits in the Card Control Register. For more information on OTD see Figure 1.

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

SCP Current Requirements

Supply	Typical	Maximum	
+5V	7mA	10mA	
+24V	28mA*	33mA*	
-24V	33mA*	39mA*	* with 488µA output on all 4 Chs

Current Source Specifications

The general specifications for the HP E1518 reflect the performance of the current source section by itself. The resistance performance specification reflects the combined performance of the HP E1413/E1313 or HP E1415 and the SCP.

General Specifications

Compliance

L terminal is at ground
H terminal ±16 V with respect to ground

Output Amplitude

Nominal µA	Actual A
30	$\frac{1}{32768}$
488	$\frac{1}{2048}$

Output Accuracy

(90 days) 23°C ±1°C (with *CAL? done after 1 hr warm up)

Current Amplitude µA	Output Accuracy
30.518	±9 nA
488.28	± 60 nA

Temperature Coefficient

Current Amplitude µA	Temperature Coefficient
30.518	±0.9 nA/°C
488.28	± 6 nA/°C

Ripple and Noise

(7.5 KOhm resistor to L, 3 sigma)

Current Amplitude µA	Ripple and Noise
30.518	±9 nA
488.28	± 15 nA

Off Leakage Current (7.5 KOhm resistor to L)

0 - 30 °C	Less than ±10 nA
30 - 55 °C	Less than (±10 nA + 1.6 nA/°C)

Resistance Specifications (90 days) 23°C ±1°C (with *CAL? done after 1 hr warm up and CAL:ZERO? within 5 min.).

Range FS Ohms	Current Amplitude μA	(A/D Range VDC)	Maximum Resolution Ω
32.77 K	30.518	16	1
8.192 K	30.518	4	.25
2.048 K	30.518	1	.0625
2.048K	488.28	16	.0625
512	488.28	4	.0156
128	488.28	1	.0039
32	488.28	.25	.0009

Resistance Accuracy (Four-Wire connection)

Gain:*

Current Amplitude	Resistance Accuracy
30.518 μA	.035% of reading
488.28 μA	.02% of reading

Offset: Ω* $\frac{\textit{offset of input SCP (in Volts)}}{\textit{current source value (in Amps)}}$

Range VDC	Noise @ 30μA	Noise @ 488μA
.0039	-	.008 Ω
.0156	-	.009 Ω
.0625	.161 Ω	.010 Ω
.25	.262 Ω	.016 Ω
1	1.02 Ω	.063 Ω

Noise: Ω* $\frac{\textit{noise of input SCP (in Volts)}}{\textit{current source value (in Amps)}}$

Range VDC	Noise @ 30μA	Noise @ 488μA
.0039	-	.007 Ω
.0156	-	.009 Ω
.0625	.245 Ω	.015 Ω
.25	.917 Ω	.057 Ω
1	3.70 Ω	.231 Ω

* Specs apply only with Open Transducer Detect OFF

Sense Channel Specifications

These specifications for the sense section reflect the combined performance of the HP E1413/E1313 or HP E1415 and the HP E1518 Signal Conditioning Plug-on. These specifications are not to be added to those presented in the HP E1413/E1313 or HP E1415 User's Manual.

General Specifications

Measurement ranges

DC Volts	±3.9mV to ±1V FS
Temperature	Thermocouples - -200 to +1700 °C Thermistors - (Opt 15 required) -80 to +160 °C RTD's - (Opt 15 required) -200 to +850 °C
Resistance	8 Ohms to 32K Ohms FS (X16 sense channel) 128 Ohms to 524K Ohms FS (X1 sense channel)

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

Normal mode rejection

@ 7Hz -3dB, @ 60Hz >-25dB

Common mode rejection

0-60Hz -100dB

Input impedance

100 Mohm ±10% (each differential input to ground)

Maximum tare cal offset

(Maximum tare offset depends on A/D range and SCP gain)

A/D range ±V F.Scale	16	4	1	0.25	0.0625
Max Offset	.20009	.05007	.01317	.00349	.00112

Measurement accuracy DC Volts

(90 days) 23°C ±1°C (with *CAL? done after 1 hr warm up and CAL:ZERO? within 5 min.). If autoranging is ON, add ±.02% FS to accuracy specifications. **For E1313, multiply Noise Spec. by 1.4.**

Gain 16	Range ±V FS	Linearity % of reading	Offset Error µV (10Hz)	Noise µV 3 sigma	Noise µV* 3 sigma
	.0039	0.01	3.8	3.4	2.9
	.0156	0.01	4.2	4.4	3.8
	.0625	0.01	4.9	7.5	6.3
	.25	0.01	8	28	23
	1	0.01	31	113	64

* [SENSe:]FILTer[:LPASs][:STATe] ON (max scan rate - 100 rdgs/sec/channel)

Temperature Coefficients: Gain - 15ppm/°C. Offset - (0 - 30°C) .16µV/°C, (30 - 40°C) .18µV/°C, (40 - 55°C) .39µV

Measurement accuracy Temperature

(simplified specifications, see temperature accuracy graphs in HP E1413/E1313 manual for details)

(90 days) 23°C ±1°C (with *CAL? done after 1 hr warm up and CAL:ZERO? within 5 min.). If autoranging is ON, add ±.02% FS to accuracy specifications.

The temperature accuracy specifications include instrument and firmware linearization errors. The linearization algorithm used is based on the IPTS-68(78) standard transducer curves. Add your transducer accuracy to determine total measurement error.

Thermocouples

Type E	A/D Filter	-200 to 0 °C	0 to 200 °C	200 to 400 °C	400 to 800 °C
	OFF	1.30°C	0.14°C	0.14°C	0.20°C
Type EEXtended	A/D Filter	-200 to 0 °C	0 to 200 °C	200 to 800 °C	800 to 1000 °C
	OFF	1.80°C	0.30°C	0.20°C	0.35°C
Type J	A/D Filter	-200 to 0 °C	0 to 280 °C	280 to 600 °C	600 to 775 °C
	OFF	1.60°C	0.15°C	0.22°C	0.22°C
Type K	A/D Filter	-200 to 0 °C	0 to 375 °C	375 to 800 °C	800 to 1400°C
	OFF	2.50°C	0.20°C	0.25°C	0.40°C
Type R	A/D Filter	0 to 100 °C	100 to 200 °C	200 to 600 °C	600 to 1000 °C
	OFF	1.80°C	0.90°C	0.70°C	0.60°C
Type S	A/D Filter	0 to 100 °C	100 to 200 °C	200 to 800 °C	800 to 1750 °C
	OFF	3.50°C	1.75°C	0.80°C	0.85°C
Type T	A/D Filter	-200 to -100°C	-100 to 0 °C	0 to 200 °C	200 to 400 °C
	OFF	1.55°C	0.32°C	0.18°C	0.18°C

5KΩ Reference Thermistor

A/D Filter	-10 to 65 °C	65 to 85 °C
OFF	0.012°C	0.013°C

100Ω Reference RTD

A/D Filter	-125 to 70°C
OFF	0.145°C

100Ω RTD

A/D Filter	-200 to 75 °C	75 to 300 °C	300 to 600 °C	600 to 970 °C
OFF	0.08°C	0.21°C	0.27°C	0.37°C

2252Ω Thermistor

A/D Filter	0 to 30 °C	30 to 70 °C	70 to 80 °C	80 to 100 °C
OFF	0.006°C	0.013°C	0.010°C	0.014°C

5KΩ Thermistor

A/D Filter	0 to 30 °C	30 to 70 °C	70 to 85 °C
OFF	0.012°C	0.014°C	0.019°C

10KΩ Thermistor

A/D Filter	0 to 30 °C	30 to 60 °C	60 to 90 °C	90 to 115 °C
OFF	0.015°C	0.016°C	0.018°C	0.022°C

Notes