



4-Wire Resistance Measurement Signal Conditioning Plug-on VT1518A

User's Manual

Enclosed is the User's Manual for the VT1518A Signal Conditioning Plug-on. Insert this manual in your VT1413C, VT1415A or an Agilent/HP E1313 or manual behind the "Signal Conditioning Plug-ons" divider.

This SCP will operate in:

A VT1413C or an Agilent/HP E1313 with Flash revision A.06.02 or later, and Driver revision A.09.00 or later.

A VT1415A with Flash revision A.03.00 or later, and Driver revision A.02.00 or later.



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VT1518A

Resistance Measurement Signal Conditioning Plug-on

Introduction

The VT1518A 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 $30\ \mu\text{A}$ or $488\ \mu\text{A}$. Each sense input provides a fixed-gain amplifier (X16) with fixed bandwidth filtering (7 Hz). 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 a VT1508A SCP).

About this Manual

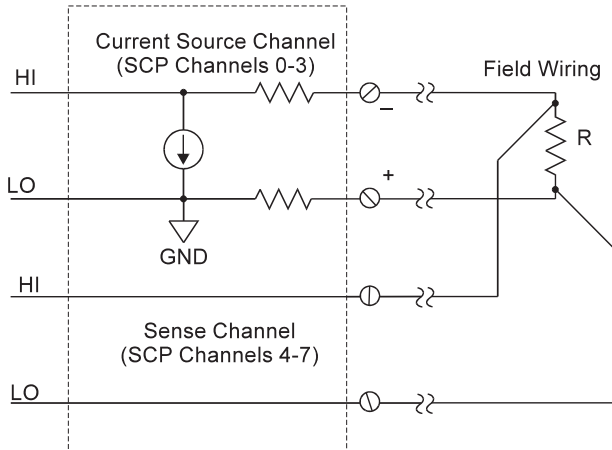
This manual shows you how to control the Signal Conditioning Plug-on (SCP) using SCPI commands as well as Register-Based commands, and explains the capabilities of this SCP. Finally, it covers specifications for this SCP. Installation for this Plug-on is common to several others and is covered in Chapter 1 your VT1413C manual. The contents of this manual are:

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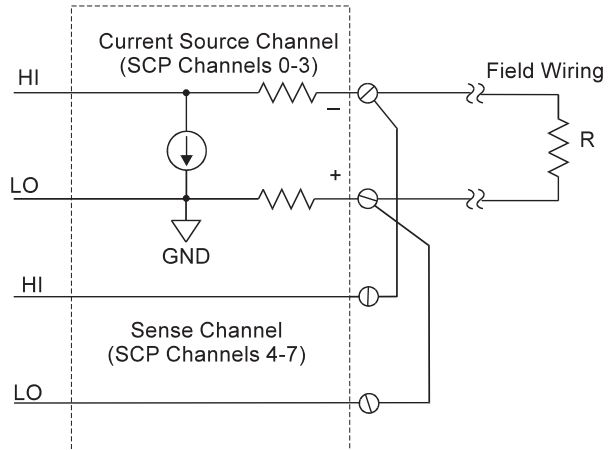
Field Wiring

The VT1518A 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.

Remote Four-Wire Measurement
(Recommended Method)

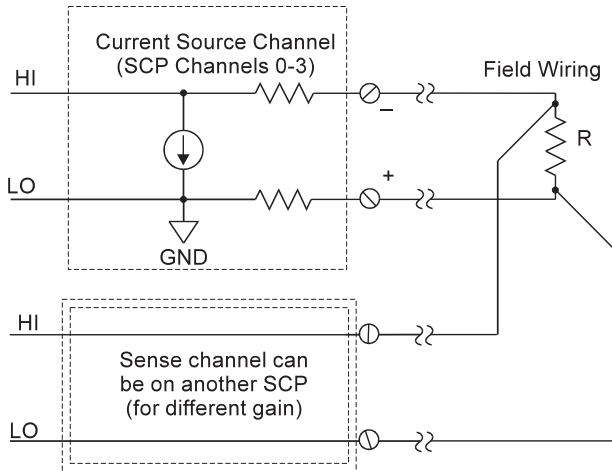


Local Four-Wire Measurement***

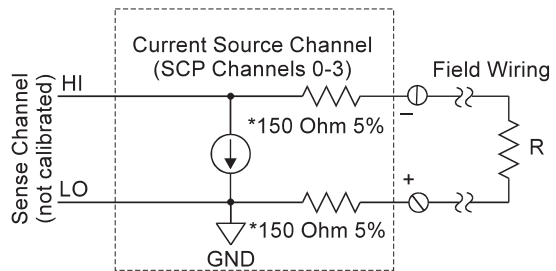


*** Use only when field wiring resistance is very small relative to unknown R.

Remote Four-Wire Measurement
(Sense Through Separate SCP)



Two-Wire Measurement
(not recommended**)



* Because of the 150 Ohm resistor in series with each of the current source outputs, Two-Wire resistance and temperature measurements will have a 300 Ohm offset. In addition, the HI and LO leads from the current sources are NOT CALIBRATED.

** The current source HI terminal is the negative voltage node. The current source LO terminal is the positive voltage node.

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 VT1413C and VT1415A, use the label sheet marked C-size (Figure 2).
- For the Agilent/HP E1313A, use the label sheet marked B-size (Figures 3 and 4).
- No label sheet is included for Agilent/HP E1413A/B connector module. In this case follow the terminal module connection diagram in Figure 5.

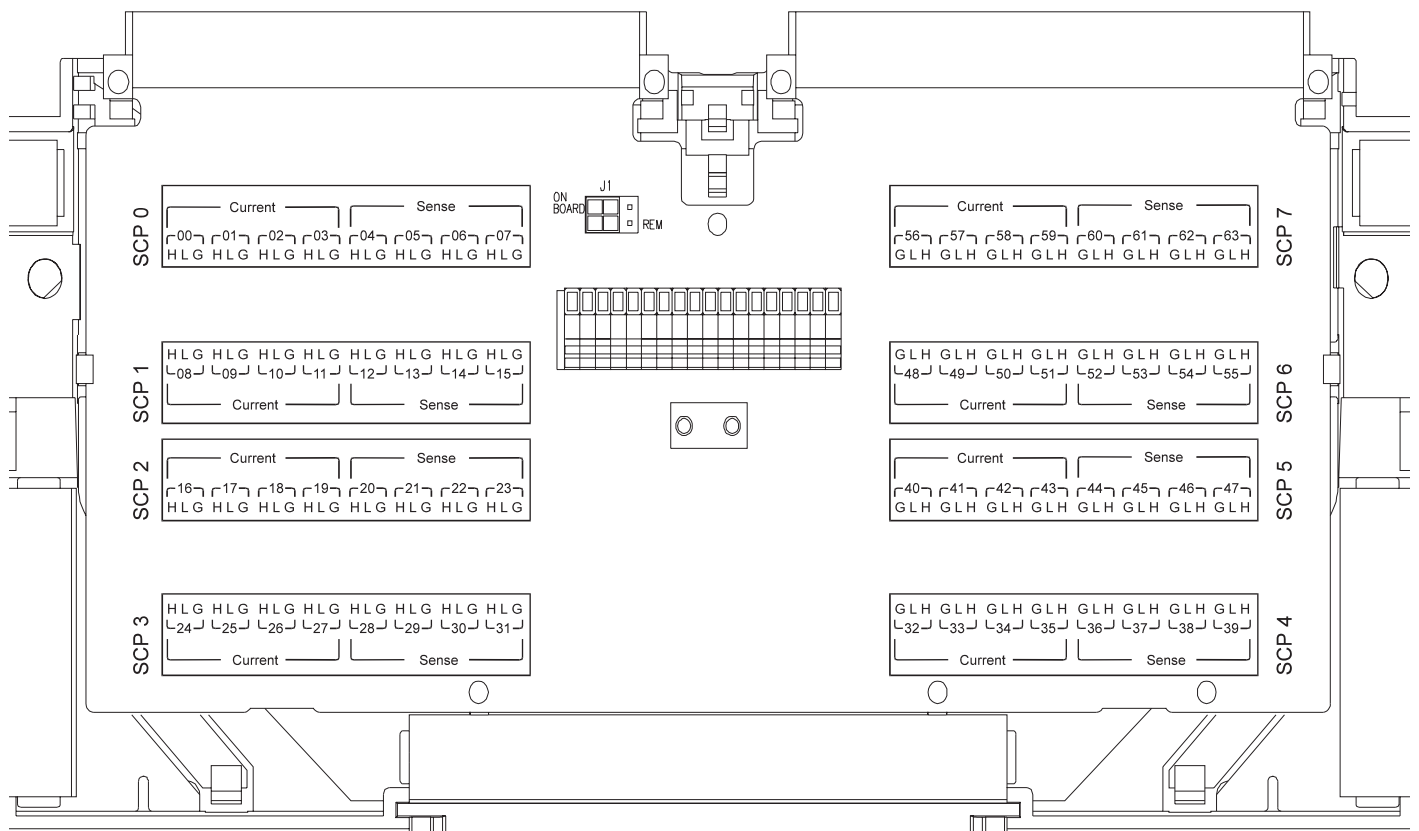


Figure 2. VT1518A C-Size Terminal Module Connections

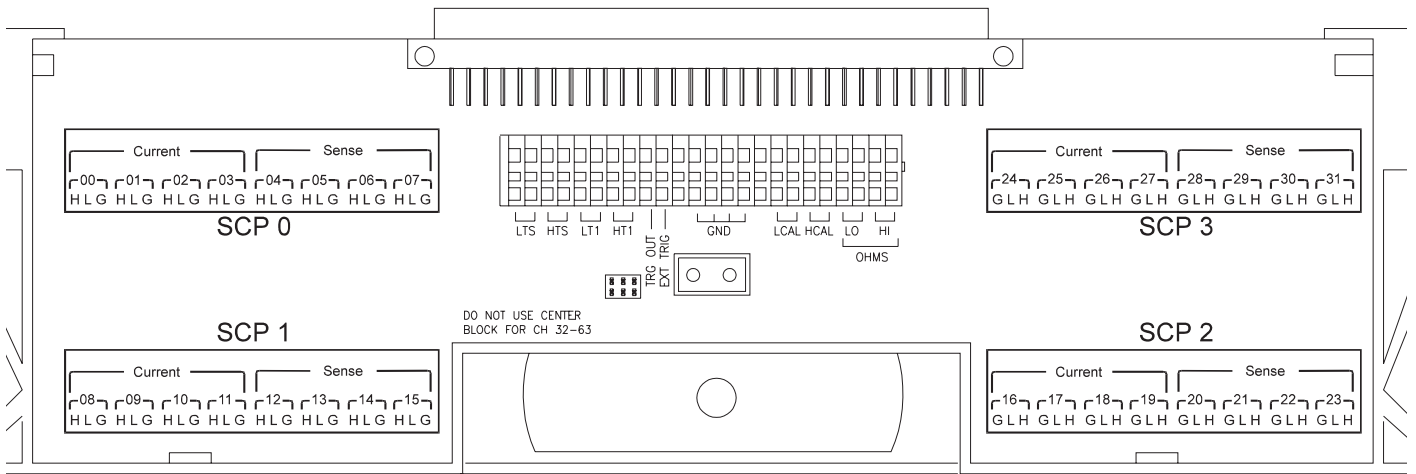


Figure 3. VT1518A B-size Terminal Module Connections (Ch 00-31)

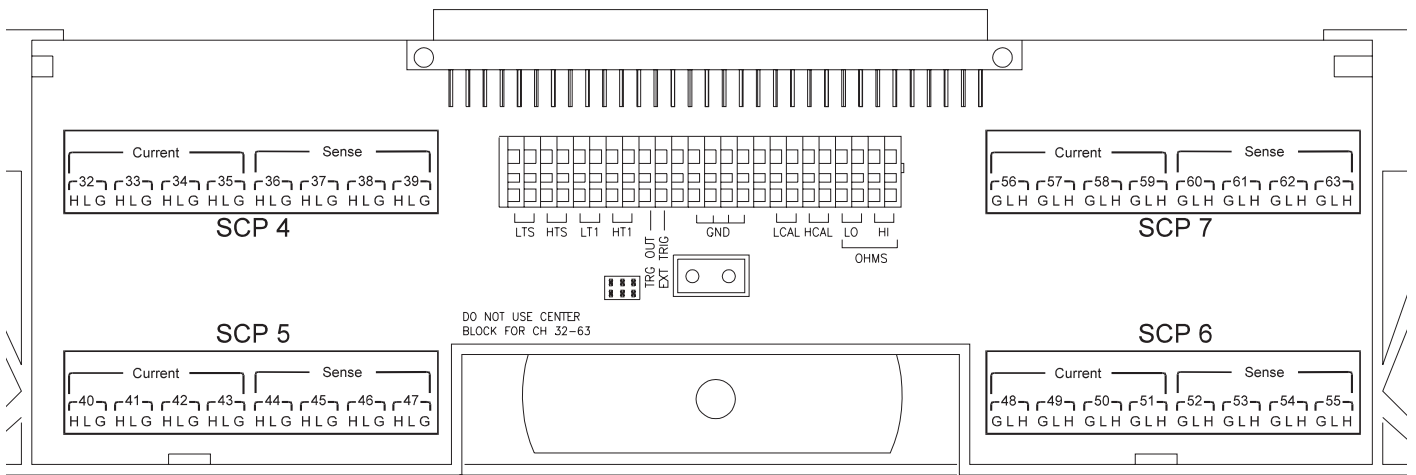


Figure 4. VT1518A B-size Terminal Module Connections (Ch 32-63)

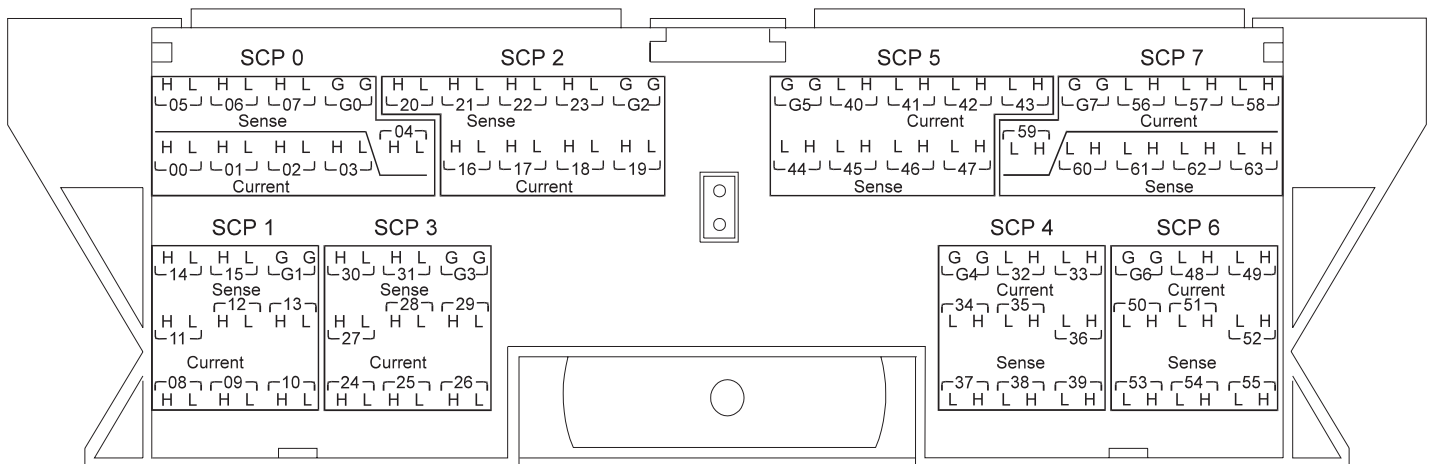


Figure 5. Agilent/HP E1413A/B Terminal Module Connections

Programming With SCPI Commands

The SCPI commands shown here are covered in Chapters 3 and 5 of your VT1413C manual or Chapters 3 and 6 of your VT1415A 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 VT1413C, VT1415A or Agilent/HP E1313 or 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? (<i>@100</i>)	<i>query SCP type @ ch 0</i>
<i>enter statement here</i>	<i>enter response string</i>

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 $30 \mu\text{A}$ ($\frac{1}{32768}\text{A}$) or $488 \mu\text{A}$ ($\frac{1}{2048}\text{A}$). 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 ($30 \mu\text{A}$) and MAX ($488 \mu\text{A}$). Use $488\mu\text{A}$ for resistance measurements under 2000 Ohms and $30 \mu\text{A}$ 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 $488\mu\text{A}$.

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

To set channels 8 through 11 (SCP position 1) to measure 2 kOhm to 32.7 kOhm, 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 VT1518A 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)
enter statement here

query channel 6

Querying the Filter State

While the VT1518A 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 INP: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)
enter statement here

query channel 15

Querying the Channel Gain

While the VT1518A'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 INP: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)
enter statement here

query channel 7

Detecting Open Transducers

VT1518A 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 $0.2 \mu A$ 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.

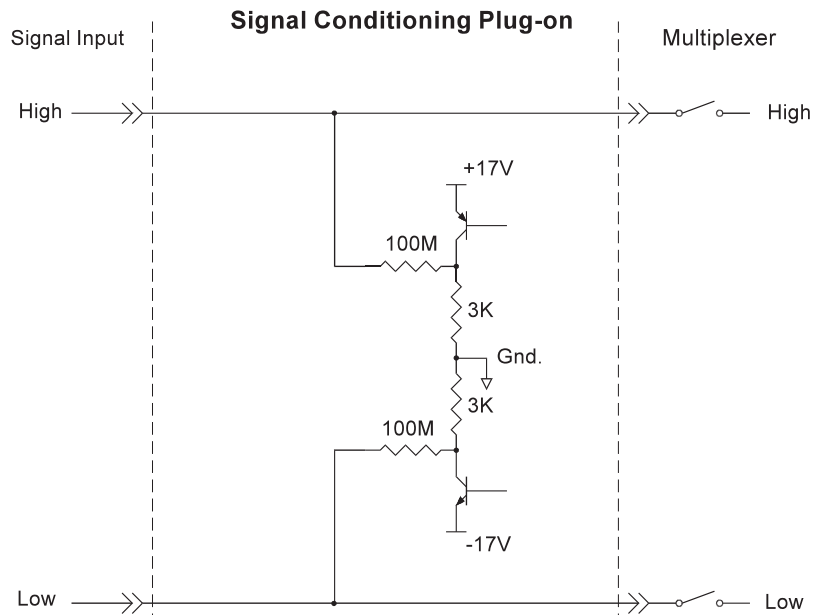


Figure 6 Open Transducer Detect Circuit

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 VT1518A in SCP position 3 send

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

Register Based Programming (VT1413C)

The register-based commands shown here are covered in Appendix D of the VT1413C 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>

VT1518A 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) × 40₁₆

Then write the opcode for SCBREAD? (0800₁₆) 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:

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

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

0000₁₆ = current low, output off

0001₁₆ = current high, output off

0002₁₆ = current low, output on

0003₁₆ = current high, output on

Then write the opcode for **SCBWRITE** (0810₁₆) 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?** (1000₁₆) 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 + 12₁₆)

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	
+5 V	7 mA	10 mA	
+24 V	28 mA*	33 mA*	
-24 V	33 mA*	39 mA*	* with 488 μ A output on all 4 Chs

Current Source Specifications

The general specifications for the VT1518A reflect the performance of the current source section by itself. The resistance performance specification reflects the combined performance of the VT1413C or VT1415A and the SCP.

General Specifications

Compliance	L terminal is at ground H terminal ± 16 V with respect to ground
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Output Amplitude	Nominal (μ A)	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 (μ A)	Output Accuracy
30.518	± 9 nA
488.28	± 60 nA

Temperature Coefficient

Current Amplitude (μ A)	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 (μ A)	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)
32.77k	30.518	16	1
8.192k	30.518	4	0.25
2.048k	30.518	1	0.0625
2.048k	488.28	16	0.0625
512	488.28	4	0.0156
128	488.28	1	0.0039
32	488.28	0.25	0.0009

Resistance Accuracy

(Four-Wire connection)

Gain:*	Current Amplitude	Resistance Accuracy
	30.518 μA	0.035% of reading
	488.28 μA	0.02% of reading

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

Range VDC	Noise @ 30 μA	Noise @ 488 μA
0.0039	-	0.008 Ω
0.0156	-	0.009 Ω
0.0625	0.161 Ω	0.010 Ω
0.25	0.262 Ω	0.016 Ω
1	1.02 Ω	0.063 Ω

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

Range VDC	Noise @ 30 μA	Noise @ 488 μA
0.0039	-	0.007 Ω
0.0156	-	0.009 Ω
0.0625	0.245 Ω	0.015 Ω
0.25	0.917 Ω	0.057 Ω
1	03.70 Ω	0.231 Ω

* Specs apply only with Open Transducer Detect OFF

Sense Channel Specifications

These specifications for the sense section reflect the combined performance of the VT1413C, VT1415A or Agilent/HP E1313 and the VT1518A Signal Conditioning Plug-on. These specifications are not to be added to those presented in the VT1413C or VT1415A User's Manual.

General Specifications

Measurement ranges

DC Volts	± 3.9 mV to ± 1 V FS
Temperature	Thermocouples - -200 to $+1700^{\circ}\text{C}$ Thermistors - (Opt 15 required) -80 to $+160^{\circ}\text{C}$ RTD's - (Opt 15 required) -200 to $+850^{\circ}\text{C}$
Resistance	8 Ohms to 32 kOhms FS (X16 sense channel) 128 Ohms to 524 kOhms FS (X1 sense channel)

Maximum input voltage Operating: $<\pm 16$ V peak Damage level: $>\pm 42$ V peak
(Normal mode plus common mode)

Maximum common mode voltage Operating: $<\pm 16$ V peak Damage level: $>\pm 42$ V peak

Normal mode rejection @ 7 Hz -3 dB, @ 60 Hz >-25 dB

Common mode rejection 0 - 60 Hz -100 dB

Input impedance 100 MOhm $\pm 10\%$ (each differential input to ground)

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

A/D range \pm V F.Scale	16	4	1	0.25	0.0625
Max Offset	0.20009	0.05007	0.01317	0.00349	0.00112

Measurement accuracy DC Volts (90 days) $23^{\circ}\text{C} \pm 1^{\circ}\text{C}$ (with *CAL? done after 1 hr warm up and CAL:ZERO? within 5 min.). If autoranging is ON, add $\pm 0.02\%$ FS to accuracy specifications.
For Agilent/HP E1313, multiply Noise Spec. by 1.4.

Gain 16	Range ±V FS	Linearity % of reading	Offset Error μV (10 Hz)	Noise μV 3 sigma	Noise μV* 3 sigma
	0.0039	0.01	3.8	3.4	2.9
0.0156	0.01	4.2	4.4	3.8	
0.0625	0.01	4.9	7.5	6.3	
0.25	0.01	8	28	23	
1	0.01	31	113	64	

* [SENSe:]FILTeR[:LPASs][:STATe] ON (max scan rate - 100 readings/s/channel)

Temperature Coefficients: Gain - 15ppm/°C. Offset - (0 - 30°C) 0.16 μV/°C, (30 - 40°C) 0.18 μV/°C,
(40 - 55°C) 0.39 μV

Measurement accuracy Temperature

(simplified specifications, see
temperature accuracy graphs in
VT1413C 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 ±0.02% 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°
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

5 k Ω Reference Thermistor

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

100 Ω Reference RTD

A/D Filter	-125 to 70°C
OFF	0.145°C

100 Ω 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

2252 Ω 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

5 k Ω 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

10 k Ω 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
