# Four-Channel Sample & Hold Input Signal Conditioning Plug-on VT1510A

## User's Manual

The VT1510A manual also applies to Agilent/HP E1413Bs as HP E1413 Option 20.

Enclosed is the User's Manual for the VT1510A Signal Conditioning Plug-on. Insert this manual in your VT1413C or Agilent/HP E1313 manual behind the "Signal Conditioning Plug-ons" divider.

The VT1510A, Four Channel Sample and Hold SCP can *only* be used with an Agilent/HP E1413B/E1410C 64-Channel High Speeed Scanning A/D or Agilnet/HP E1313A 32-Channel High Speed A/D and not with an Agilent/HP E1413A High Speed Scanning A/D. Only four VT1510As can be installed in an Agilent/HP E1313A.



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# VT1510A
# Four-Channel Sample and Hold Signal Conditioning Plug-on

## Introduction

VT1510A is a Signal Conditioning Plug-on (SCP) that provides 4 channels of Sample and Hold inputs and 4 channels of direct inputs for the VT1413C High Speed A/D Module.

**Notes**

1. The VT1510A, 4 Channel Sample and Hold SCP can *only* be used with the VT1413C, Agilent/HP E1313A and Agilent/HP E1413B 64-Channel High Speeed Scanning A/D and ***not*** with an Agilent/HP E1413A 64-Channel High Speed A/D (flash version 4.0 or above; downloadable driver version 6.0 or above ).
2. The Agilent/HP E1313A B-size 32/64-Channel High Speeed Scanning A/D can support a maximum of four (4) VT1510AA 4-Channel Sample and Hold SCPs.

## About This Manual

<u>**Except where noted, references to the VT1413C also apply to the Agilent/HP E1313**</u>.This manual shows how to connect to the Terminal Module and also shows how to control the VT1510A 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:

# VT1510A SCP Operation

The VT1510A SCP provides 4 channels of sample and hold inputs and 4 channels of direct inputs (similar to a VT1501A, 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 0.5, 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 1 kHz, 500 Hz, 250 Hz, 100 Hz and 15 Hz.

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.

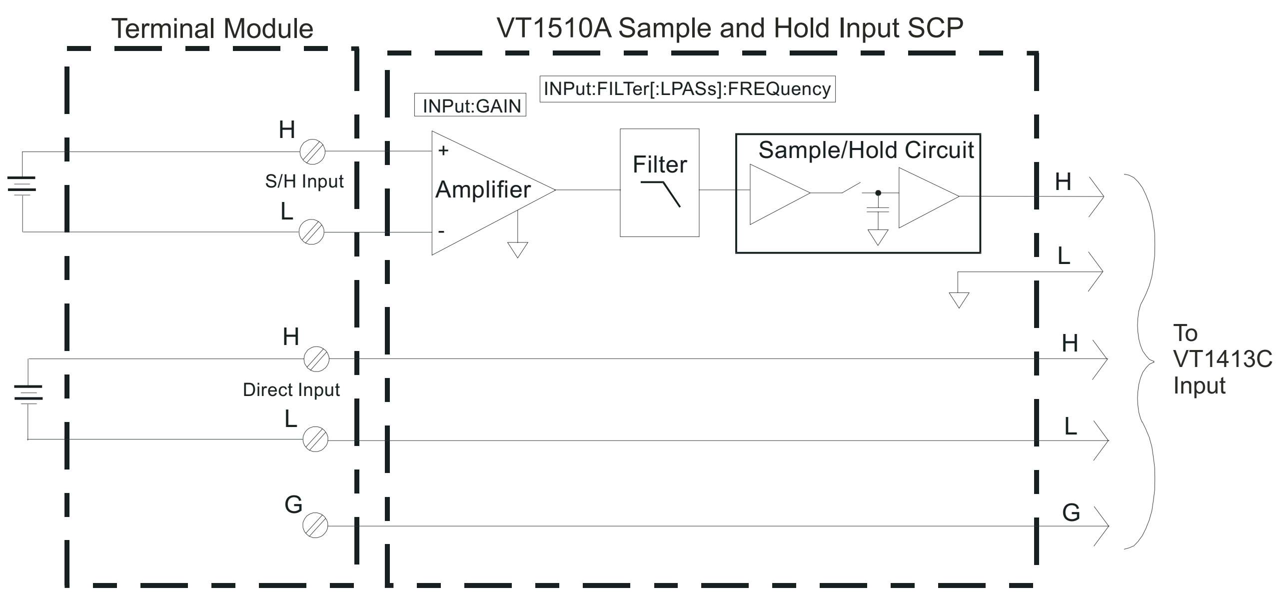


**Figure 1. VT1510A, Simplified Block Diagram**

# 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 VT1413C and above Terminal Modules, use stickers for VT1510A SCPs. The connections are shown in Figure 2.
- For Agilent/HP E1313 Terminal Modules, use stickers for VT1510A SCPs. The connections are shown in Figures 3 and 4.
- For Agilent/HP E1413B and below Terminal Modules, use stickers for Agilent/HP E1413 Option 20 SCPs. The connections are shown in Figure 5.

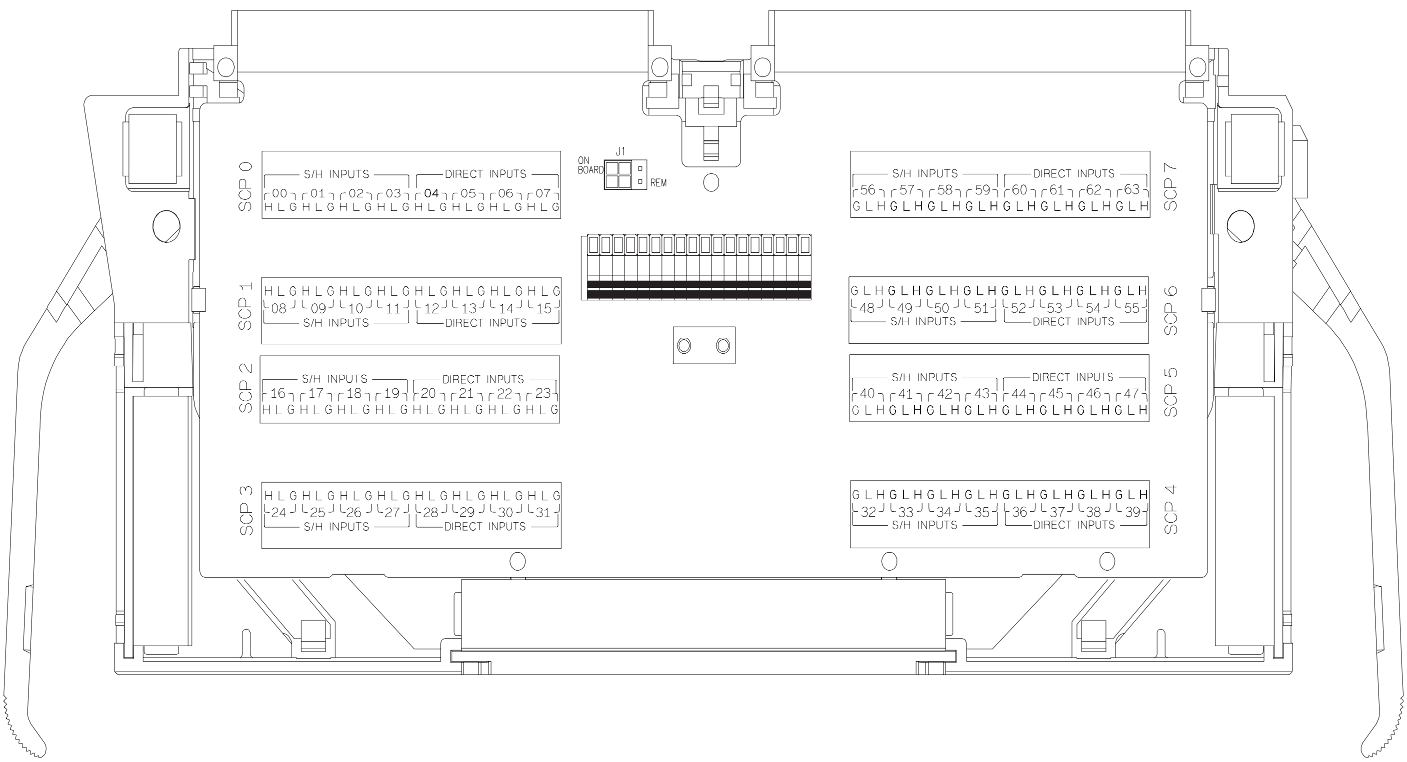


**Figure 2. VT1510A C-Size Terminal Module Connections**

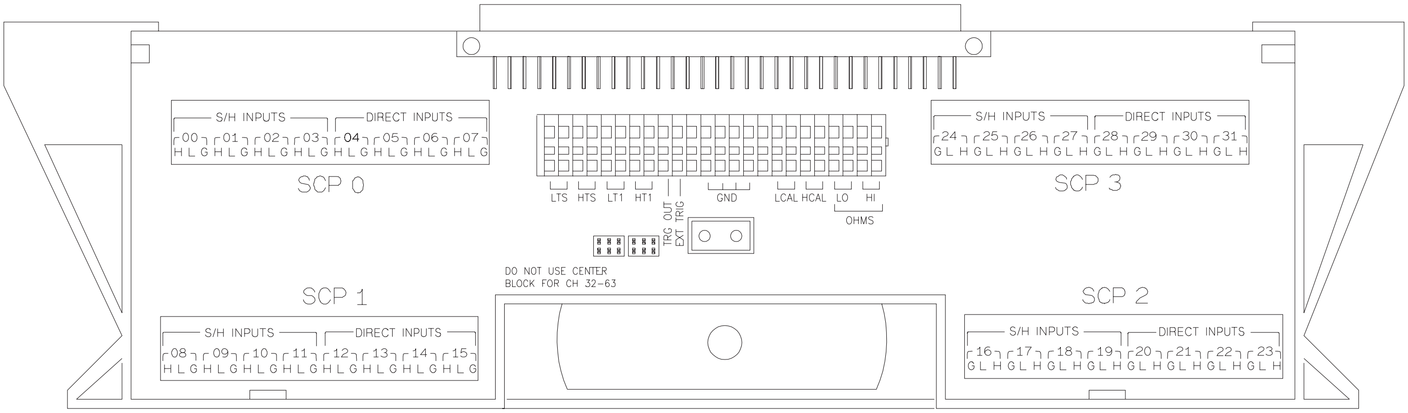


**Figure 3. VT1510A B-size Terminal Module Connections (Ch 00-31)**

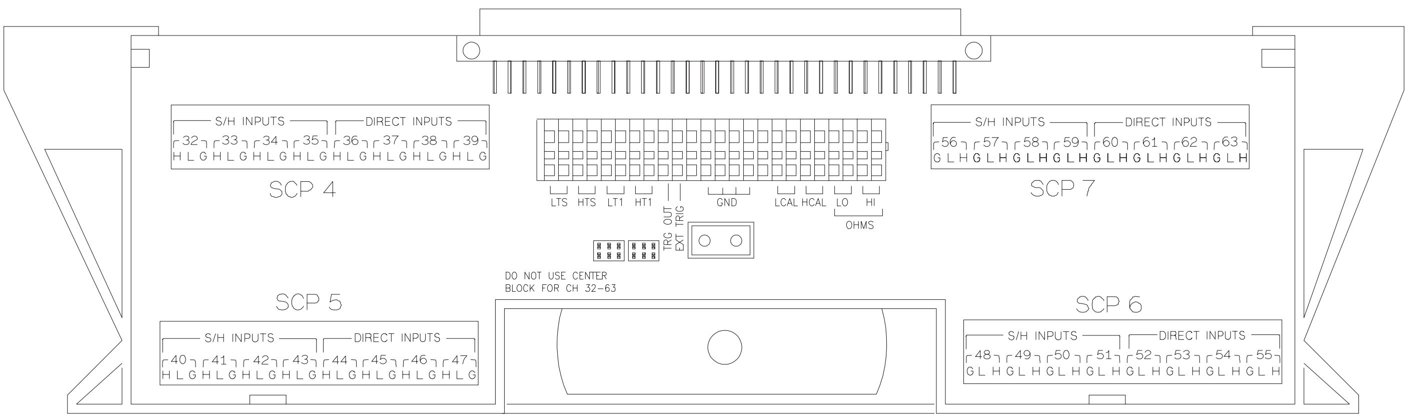


**Figure 4. VT1510A B-size Terminal Module Connections (Ch 32-63)**

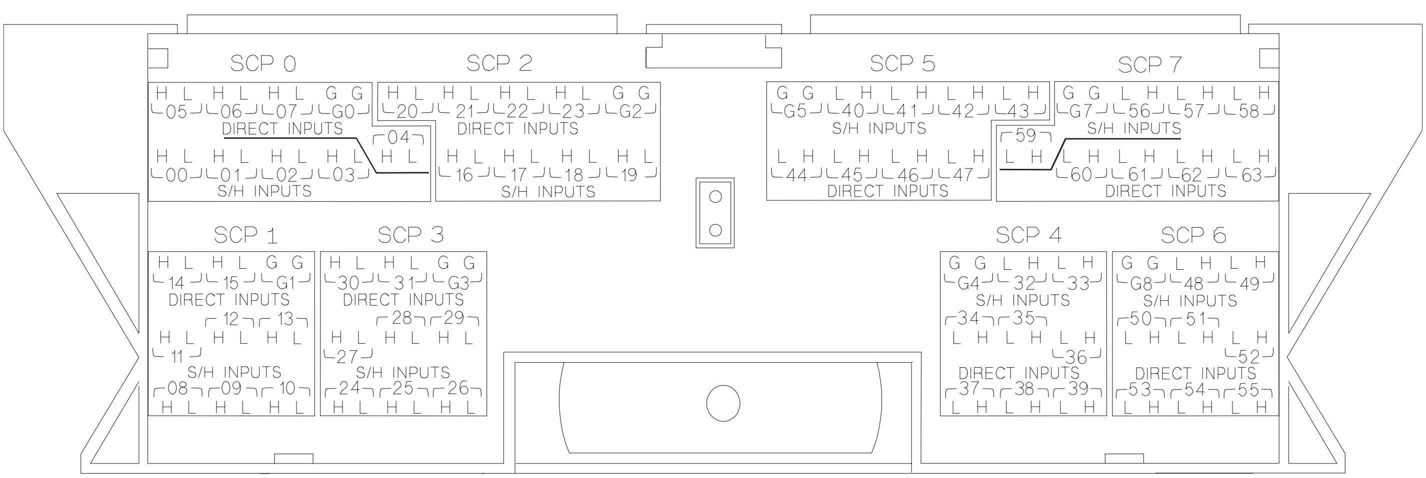


**Figure 5. Agilent/HP E1413 Option 20 Terminal Module Connections**

## 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 VT1413C User’s Manual to wire the Terminal Module.

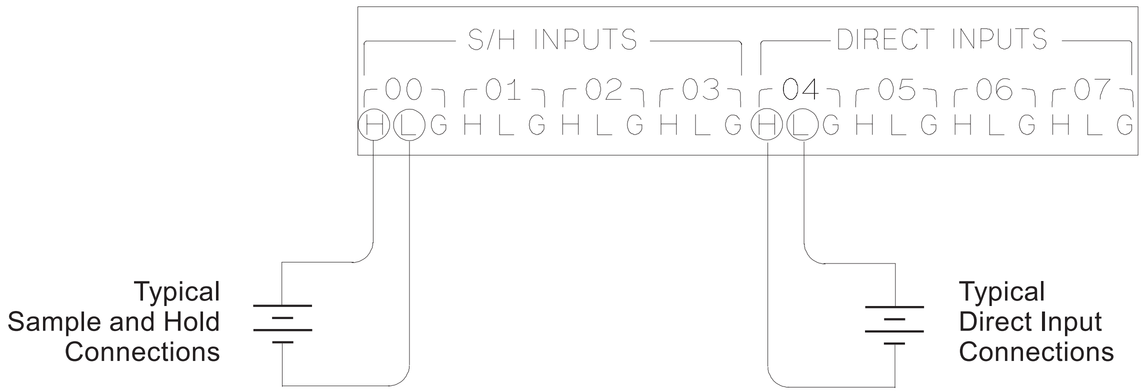


**Figure 6. Typical Measurement Connections**

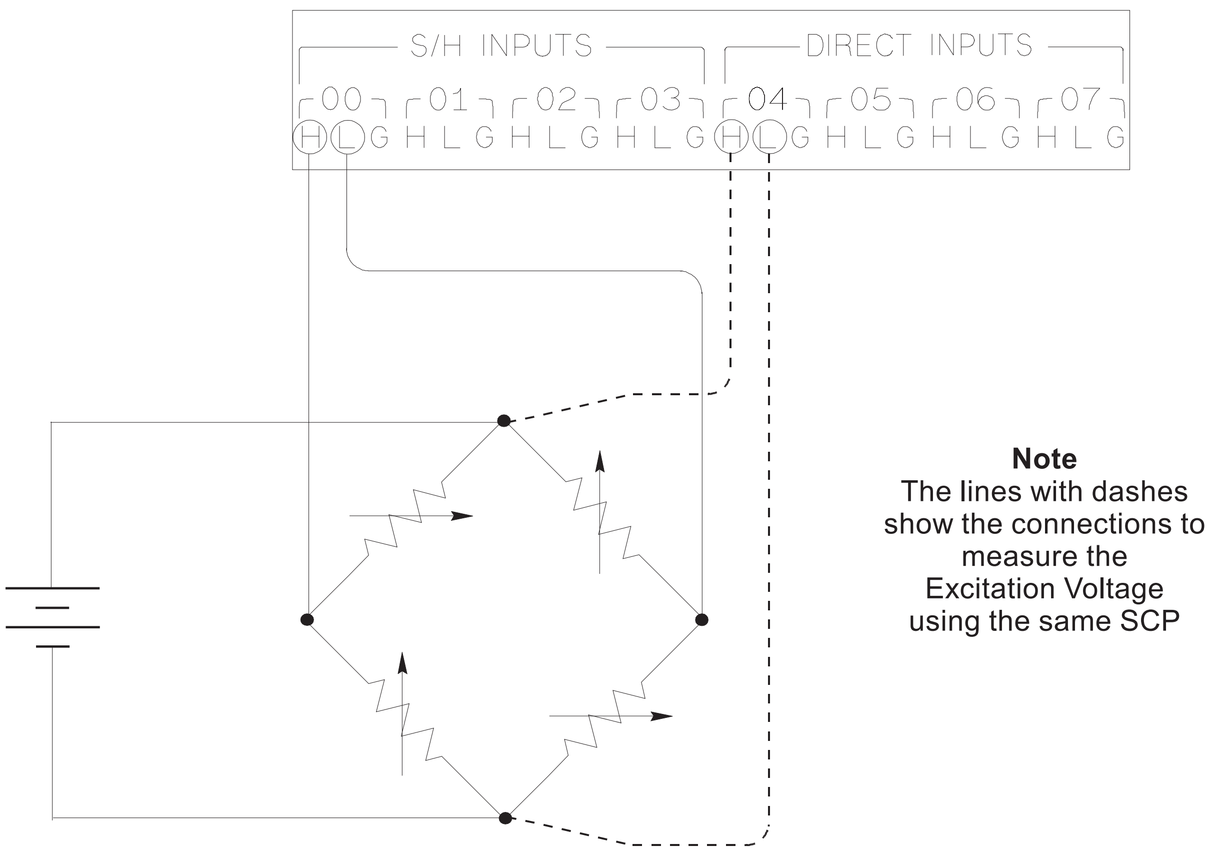


**Figure 7. Typical Strain Gage Connections**

# Programming With SCPI Commands

The following SCPI commands verify the SCP types installed in the VT1413C and how to program the VT1413C for sample and hold measurements using VT1510A SCPs. The commands listed in this section are below and also in Chapter 5 of the VT1413C 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 VT1413C.

- 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 a VT1413C or Agilent/HP E1313A 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 VT1413C | *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 "VT1413C 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 15 Hz, 100 Hz, 250 Hz, 500 Hz, 1000 Hz, MIN or MAX. MIN specifies 15 Hz and MAX specifies 1000 Hz.

To set channels 0 through 3 to the 100 Hz 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 (15 Hz) 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 VT1413C 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 +17 V and the LOW inputs toward -17 V. 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.

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**Note** 1.) When OTD is enabled, the inputs have up to 0.2 $\mu$A 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

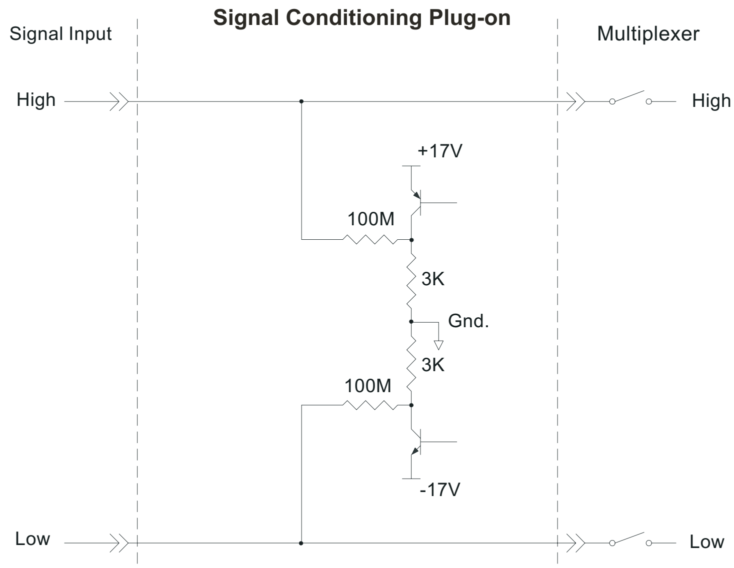


**Figure 8. Open Transducer Detect Circuit**

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 15 Hz)* |
| INP:GAIN 64,(@100:103) | *selects the gain of the sample and hold circuitry (default is 0.5)* |
| 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 1 V* |

## 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 VT1413C's INITiate and TRIGger commands to make the strain measurement. You must define what triggers, etc., to use to make the measurements (see the "VT1413C User's Manual" for information).

# Register-Based Programming

Appendix D of the VT1413C 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) | 0.75 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) | 0.75 μV/°C |

**Accuracy:** Gain of X64

| Range ±FS | Gain error | Offset error | Noise 3 sigma |
|---|---|---|---|
| 3.9 mV | 0.02 | 15.0 $\mu$V | 12 $\mu$V |
| 15.6 mV | 0.02 | 15.0 $\mu$V | 12 $\mu$V |
| 62.5 mV | 0.02 | 15.0 $\mu$V | 12 $\mu$V |

**Temperature coefficients**

Gain: 10 ppm/°C (after *CAL)

Offset: add tempco error to above table

| Temp | Tempco |
|---|---|
| (0 - 40) | 0.14 $\mu$V/°C |
| (40 - 55) | 0.38 $\mu$V/°C |

**Accuracy:** Gain of X512

| Range ±FS | Gain error | Offset error | Noise 3 sigma |
|---|---|---|---|
| 7.81 mV | 0.04 | 15 $\mu$V | 2 $\mu$V |

**Temperature coefficients**

Gain: 10 ppm/°C (after *CAL)

Offset: add tempco error to above table

| Temp | Tempco |
|---|---|
| (0 - 40) | 0.14 $\mu$V/°C |
| (40 - 55) | 0.38 $\mu$V/°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 $\mu$s | 10 $\mu$s |
| 500 Hz | 854.9 $\mu$s | 20 $\mu$s |
| 250 Hz | 1.710 ms | 40 $\mu$s |
| 100 Hz | 4.275 ms | 100 $\mu$s |
| 15 Hz | 28.50 ms | 670 $\mu$s |

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):

350 Ω 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 μs |

| Aperature Time: |
|---|
| 2 ns |

| Aperature Delay: |
|---|
| 35 ns + delay in skew specification |

| Aperature Jitter: |
|---|
| 150 ps |

| Droop Rate: |
|---|
| 1 V/s @ 50°C. Typical is 2-3 mV/s @25°C. This is referenced to the SCP output so divide by SCP gain setting. |