Keysight Technologies

Making High-Accuracy Temperature Measurements With the 34970A and 34972A Data Acquisition Switch Units

Application Note

KEYSIGHT TECHNOLOGIES

Introduction

If you want to make more accurate measurements with your Keysight Technologies, Inc. 34970A or 34972A data acquisition switch unit and the Keysight 34901A 20-channel multiplexer module, you can use an external isothermal terminal panel, or "patch panel," such as the VTI Instruments VT1586A rack-mount terminal panel. The VT1586A has an aluminum isothermal reference that allows you to make temperature measurements with less than ± 0.53 °C error. The accuracy of relative measurements is better than ± 0.35 °C across 39 channels.

This application note explains how to wire the VT1586A remote isothermal panel and use it to make high-accuracy temperature measurements with a 34970A or 34972A data acquisition switch unit and 34901A 20-channel multiplexer module.

Wiring the VT1586A remote isothermal panel

The VT1586A remote isothermal panel is designed for up to 32 channels with three wires per channel (HI, LO, GND) and comes from the factory with the front panel markings for three-wire channels. Front panels manufactured after Jan. 1, 2003 also have a silk-screened diagram on the rear of the panel for up to 48 two-wire channels. To use these two-wire markings with the 34970A or 34972A, remove the two screws, turn the panel over (left to right) and replace the screws. On this panel, the channels are divided into two sections with 24 channels each. One VT1586A panel can be used with a 34901A module to measure 19 channels. The first channel in the 34901A module is used to measure the reference temperature, leaving 19 channels for thermocouple measurements. A second 34901A module can be added to measure up to 39 channels with a single VT1586A panel.

When you are using the 34970A/34972A and 34901A module you will want to use the two-wire markings. The right side of the panel has the channels configured the same way; you can use it with a second 34901A module.

To wire the panel to one 34901A MUX module, you need a SCSI cable. One SCSI cable can accommodate one 34901A module (20 channels). The first channel of the first 34901A module is required for the thermistor reference on the VT1586A and will therefore provide 19 channels of thermocouple measurements. A second 34901A module and a second cable will provide another 20 channels for a total of 39 thermocouple channels and one channel for the thermistor reference.

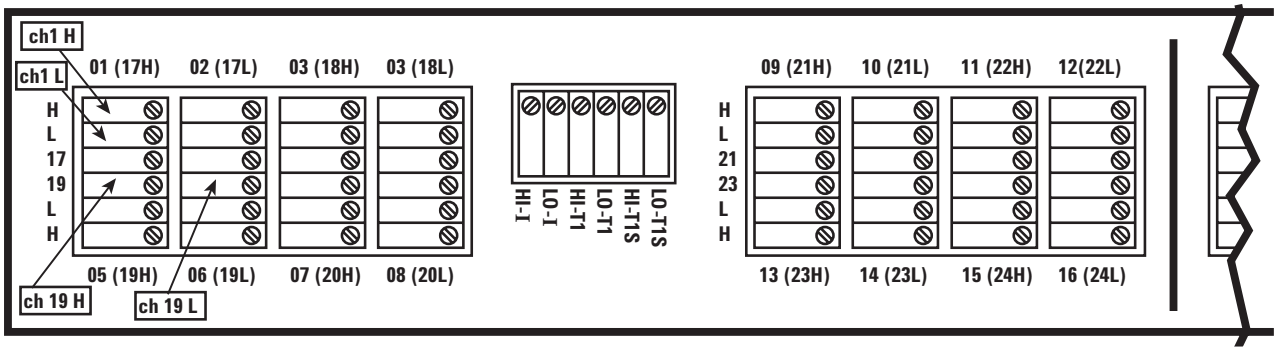

Figure 1. Left side of the VT1586A terminal panel, shown with two-wire markings

Table 1. Wiring table

34901A channel	Twisted pair First color is solid color	Painted left, JI9	Painted right, J20	Aluminium left, JI9	Aluminium right, J20
Ch01 H	Brown/white	0 HI	16 HI	Ch 01 H	Ch 01 H
Ch01 L	White/brown	0 LO	16 LO	Ch 01 L	Ch 01 L
Ch02 H	Brown/orange	1 HI	17 HI	Ch 02 H	Ch 02 H
Ch02 L	Orange/brown	1 LO	17 LO	Ch 02 L	Ch 02 L
Ch03 H	Brown/yellow	2 HI	18 HI	Ch 03 H	Ch 03 H
Ch03 L	Yellow/brown	2 LO	18 LO	Ch 03 L	Gh 03 L
Ch04 H	Brown/blue	3 HI	19 HI	Ch 04 H	Ch 04 H
Ch04 L	Blue/brown	3 LO	19 LO	Ch 04 L	Ch 04 L
Ch05 H	Brown/violet	4 HI	20 HI	Ch 05 H	Ch 05 H
Ch05 L	Violet/brown	4 LO	20 LO	Ch 05 L	Ch 05 L
Ch06 H	Tan/brown	5 HI	21 HI	Ch 06 H	Ch 06 H
Ch06 L	Brown/tan	5 LO	21 LO	Ch 06 L	Ch 06 L
Ch07 H	Tan/white	6 HI	22 HI	Ch 07 H	Ch 07 H
Ch07 L	White/tan	6 LO	22 LO	Ch 07 L	Ch 07 L
Ch08 H	Tan/orange	7 HI	23 HI	Ch 08 H	Ch:08 H
Ch08 L	Orange/tan	7 LO	23 LO	Ch 08 L	Ch 08 L
Ch09 H	Tan/yellow	8 HI	24 HI	Ch 09 H	Ch 09 H
Ch09 L	Yellow/tan	8 LO	24 LO	Ch 09 L	Ch 09 L
Ch 10 H	Tan/blue	9 HI	25 HI	Ch 10H	Ch 10 H
Ch 10 L	Blue/tan	9 LO	25 LO~	Ch 10 L	Ch 10 L
Ch 11 H	Tan/violet	10 HI	26 HI	Ch 11 H	Ch 11 H
Ch 11 L	Violet/tan	10 LO	26 LO	Ch 11 L	Ch 11 L
Ch 12 H	White/pink	11 HI	27 HI	Ch 12 H	Ch 12 H
Ch 12 L	Pink/white	11 LO	27 LO	Ch 12 L	Ch 12 L
Ch 13 H	White/orange	12 HI	28 HI	Ch 13 H	Ch 13 H
Ch 13 L	Orange/white	12 LO	28 LO	Ch 13 L	Ch 13 L
Ch 14 H	White/green	13 HI	29 HI	Ch 14 H	Ch 14 H
Ch 14 L	Green/white	13 LO	29 LO	Ch 14 L	Ch 14 L
Ch 15 H	White/blue	14 HI	30 HI	Ch 15 H	Ch 15 H
Ch 15 L	Blue/white	14 LO	30 LO	Ch 15 L	Ch 15 L
Ch 16 H	White/gray	15 HI	31 HI	Ch 16 H	Ch 16 H
Ch 16 L	Grey/white	15 LO	31 LO	Ch 16 L	Ch 16 L
Ch 17 H	Brown/pink	0 G	16 G	Ch 17 H	Ch 17 H
Ch 17 L	Pink/brown	1 G	17 G	Ch 17 L	Ch 17 L
Ch 18 H	Brown/green	2 G	18 G	Ch I8 H	Ch I8 H
Ch 18 L	Green/brown	3 G	19 G	Ch 18 L	Ch 18 L
Ch 19 H	Brown/gray	4 G	20 G	Ch 19 H	Ch 19 H
Ch 19 L	Gray/brown	5 G	21 G	Ch 19 L	Ch 19 L
Ch 20 H	Tan/pink	6 G	22G	Ch 20 H	Ch 20 H
Ch 20 L	Pink/tan	7 G	23 G	Ch 20 L	Ch 20 L
Not used	Tan/green	8 G	24 G	Ch 21 H	Ch 21 H
	Green/tan	9 G	25 G	Ch 21 L	Ch 21 L
Not used	Tan/gray	10 G	26 G	Ch 22 H	Ch 22 H
	Gray/tan	11 G	27 G	Ch 22 L	Ch 22 L
Ch01 H	White/yellow	12 G	28 G	Ch 23 H	Ch 23 H
Ch01 L	Yellow/white	13 G	29 G	Ch 23 L	Ch 23 L
Not used	White/violet	14 G	30 C;	Ch 24 H	Ch 24 H
	Violet/white	15 G	31 G	Ch 24 L	Ch 24 L
Earth	Orange/pink	I-Hi	Trig	I-Hi	Trig
Earth	Pink/orange	I-Lo	Gnd	I-Lo	Gnd

Caution: *Your cable may have different color codes for each wire. This is a Computer Cable Makers PN SCS2-1000-003 wiring table.*

The SCSI cable must have 25 color-coded twisted pairs, a HD-50 male metal connector on one end and no connector on the other end. An 80 cm (2.5 ft) SCSI-2 to SCSI-1 cable is available for about US$20.00 from Computer Cable Makers (www.cablemakers.com, PN SCS2-1000-003) and from Cables to Go (www.cablestogo.com).

Wiring is straightforward. Insert the cable into J19 on the left rear of the VT1586A terminal panel and cut off the connector on the other end of the cable. Strip the outer insulation back about 20 cm (8 in). Strip the outer and inner shield back 19 cm (7.5 in). Fold the outer shield back on the insulation and cover it with heat shrink. Insert the cable in the 34901A module and fasten it with a tie wrap.

Connect an ohmmeter set to continuity and make contact with the H side of channel 1. Find the corresponding twisted pair (brown/org, org/brown), strip both wires, and check to make sure it is the correct wire pair. Now cut the pair to the proper length and insert in the channel 1H and 1L of the module. Repeat for channel 2-20. Similarly wire another cable and module to the right side of the panel (J20) for channels 21 to 40. Wire the twisted pair indicated in Table 1 to Earth in both of the 34901A modules.

On the first 34901A module, reduce the resistance of channel 1 to below 0.5 ohm by connecting the twisted pair in the cable for channel 23 to channel 1 of the 34901A terminal block. This will parallel two twisted wire pairs for channel one. See wiring table.

To connect the reference thermistor on the VT1586A, connect channel 01H and 23H to HI-T2S, and channel 01L and 23L to LO-T2S.

To connect the shield and the ground on the VT1586A, connect together HI-I, LO-I, GND, and TRIG. The wiring from the 34901A module to the VT1586A is now complete. See the wiring table for detailed connections. Wire the thermocouple wires to the channels corresponding to the channels in the 34901A modules. See the wiring table for panel labeling.

Making accurate temperature measurements

You can mount the VT1586A terminal panel in a standard-size instrument rack or place it on your bench. To minimize any variation between channels, keep the terminal panel away from heat sources and drafts. Do not place the terminal panel directly next to instruments, or directly on top of a powered instrument. To isolate the panel from any heat source beneath the panel, place a section of foam or Styrofoam under the full length of the terminal panel. To protect the terminal panel from drafts, cover or wrap it in a towel or cloth or surround it with Styrofoam.

When you mount the terminal panel in a rack, mount it away from heat sources. The bottom of the rack is usually best. Take particular care to minimize the temperature difference across the horizontal width of the terminal panel, since it is most susceptible to horizontal temperature gradients across its longest dimensions. Avoid mounting the terminal panel directly above or below instruments that have hot air exits on their sides.

Channels closest to the center near the reference thermistor will have the best accuracy. When relative measurements are important, put those channels physically close together on the terminal panel. Channels closest together will have the best agreement among each other.

Table 2 shows the measurement uncertainty for the individual error contributions when you use a J-type thermocouple. The errors for other thermocouples and temperature ranges will be different depending on the error of the voltmeter, the temperature measured, thermocouple type and voltage level of the thermocouple. The error due to the thermocouple is not included in the calculation.

Summary

If you use the VT1586A patch panel with the 34970A/34972A and 34901A MUX module, your temperature measurement accuracy will be about twice as good as it is without the patch panel.

Table 2. Measurement uncertainty

Source of error	**Absolute accuracy J type**	**Relative accuracy J type**
Isothermal termination, VT1586A	± 0.2 °C (± 10 µV)	0.2 °C difference across 40 channels
Thermocouple conversion	± 0.05 °C	± 0.05 °C
Ref. Thermistor Measurement	± 0.08 °C	N/A
Ref. Thermistor accuracy	± 0.1 °C	N/A
Ref. Thermistor lead resistance	- 0.003 °C (< 0.5 ohms)	N/A
Voltmeter accuracy	± 0.08 °C (± 4 uV at 0.0 mV), 25 °C	± 0.1 °C (± 5 uV at 26 mV), 500 °C
Total	± 0.53 °C not including sensor	± 0.35 °C not including sensor

Glossary

J-type thermocouple- iron-constantan thermocouple with a temperature range of -210 to 1200°C

Thermocouple- a temperature sensor consisting of two dissimilar metals joined together. When a temperature gradient exists (one end is a different temperature from the other), a voltage is generated. Different types of thermocouples are constructed from different metals, with differing temperature ranges and accuracies.

Thermistor- a ceramic temperature sensor that exhibits a change in resistance as a function of temperature. With most thermistors, resistance decreases as the temperature increases.

Related Keysight Literature

Product overview- *34970A Data Acquisition/Switch Unit,* pub. no. 5965-5290EN

Application Note- *Practical Temperature Measurements,* pub. no. 5965-7822E

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Note: this document was formerly known as Application Note 1425

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