Thermocouple Monitor

SR630 — Thermocouple monitor (16-channel)

SR630 Thermocouple Monitor

- **16 channels**
- **B, E, J, K, R, S and T type thermocouples**
- **0.1 °C resolution**
- **Displays °C, °F, K and VDC**
- **2,000 point non-volatile memory**
- **Four analog outputs proportional to to temperature**
- **GPIB, RS-232 and printer interfaces**

Temperature Monitor

The SR630 is a 16-channel thermocouple monitor designed to read, scan, print and log temperatures or voltages. You can use any one of seven standard thermocouple types to read temperatures from –200 °C to +1700 °C. For remote monitoring applications, the SR630 can time-stamp and store up to 2000 readings in non-volatile memory for later analysis.

Temperature readings from the SR630 can be viewed on the front panel or queried via the instrument's standard RS-232 or GPIB interfaces. In addition, the standard Centronics printer port provides convenient hardcopy output in either tabular or strip chart format.

Voltage Monitor

The SR630 can also be configured as a 16-channel DC voltmeter with full-scale ranges from 30 mV to 100 V (1 mV resolution). As a voltmeter, the unit has 0.05 % accuracy and 1 µV input offset drift. Each channel can be set independently to monitor either temperature or voltage, giving the SR630 even more flexibility in your application. Four rear-panel outputs are also available to provide a voltage proportional to the temperature of the first four input channels. The voltage outputs can be used to drive recorders or to control external instrumentation.

Inputs

Sixteen screw-terminal inputs are mounted on a rear-panel isothermal block for cold junction compensation. The isolated differential inputs have a 250 V breakdown level, allowing the SR630 to tackle difficult applications such as temperature profiling of electrically live equipment. Each of the 16 channels may be independently set to display in units of °C, °F, K, mV or V. Similarly, thermocouple type, nominal temperature, temperature limit, and alarms may be uniquely set for each channel, providing complete flexibility in the configuration of the instrument. Access to any channel parameter is provided through the front panel or via the computer interfaces. The SR630 can store up to nine instrument configurations including thermocouple type and temperature limits for all 16 channels.

Outputs

There are four analog outputs that are proportional to the readings on channels one through four. Both the slope (m) and offset (b) of the equation, Vout = ±mX + b, are changed by setting the nominal temperature and chart span for the corresponding channel. X is either temperature or voltage, depending on the setting for each channel.

You may use the analog outputs to drive chart recorders, or they can provide a feedback signal for proportional temperature control systems. They may also be used as fixed-level, analog control signals (set via the computer interfaces).

Alarms

Each channel can be programmed individually with an upper and lower temperature limit. An audio alarm and a relay closure indicate when any channel exceeds its preset temperature or voltage limits. The front-panel LED display will indicate which channel has exceeded its limit.

Data Logging

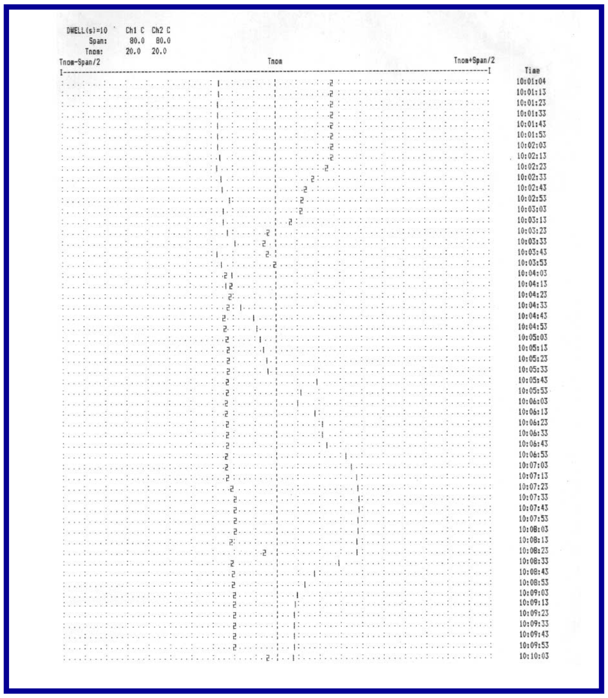
An internal, battery backed-up clock/calendar is used to time-stamp temperature readings. The SR630 can be set to scan, time-stamp, and record data on up to 16 channels at intervals from 10 to 9999 seconds. Data is either sent immediately to the printer or stored in the internal 2,000 point buffer for output at a later time (via GPIB or RS-232).

TIME	DATE	Ch1 C	Ch2 C	Ch3 C	Ch4 C	Ch5 C	Ch6 C	Ch7 C	Ch8
10:31:05	25/06/92	20.5	37.6	29.4	20.4	27.4	27.3	27.4	27.
10:31:15	25/06/92	20.5	37.5	29.3	20.3	27.5	27.5	27.5	27.
10:31:25	25/06/92	20.0	37.1	29.3	19.8	27.7	27.8	27.8	27.
10:31:35	25/06/92	19.4	36.2	28.6	18.5	28.1	27.9	28.3	28.
10:31:45	25/06/92	20.1	36.1	27.8	17.6	30.6	30.5	30.6	30.
10:31:55	25/06/92	20.5	36.5	27.6	16.6	31.2	31.1	31.3	31.
10:32:05	25/06/92	20.0	35.0	26.0	14.6	32.1	31.7	32.2	32.
10:32:15	25/06/92	15.1	29.5	20.9	10.3	33.1	32.5	33.0	33.
10:32:25	25/06/92	10.4	26.1	18.0	8.2	34.9	34.4	34.8	34
10:32:35	25/06/92	11.5	26.9	19.6	9.9	38.1	38.0	38.5	38.
10:32:45	25/06/92	12.9	28.5	20.1	10.9	38.8	38.8	38.8	38
10:32:55	25/06/92	13.5	28.9	20.3	11.5	38.5	38.5	38.5	38.
10:33:05	25/06/92	14.3	29.6	20.9	12.3	38.6	38.6	38.7	38
10:33:15	25/06/92	15.4	30.7	22.5	13.4	38.7	38.7	38.7	38.
10:33:25	25/06/92	16.3	31.6	23.5	14.6	38.6	38.6	38.6	38
10:33:35	25/06/92	17.0	32.5	24.6	15.6	38.5	38.4	38.4	38.
10:33:45	25/06/92	17.8	33.3	25.8	16.4	38.2	38.3	38.2	38
10:33:55	25/06/92	18.3	33.9	26.3	17.2	38.0	38.0	38.0	38.

Tabular output

Built-In Printer Interface

A standard Centronics printer interface makes it simple to get hardcopy output of temperature or voltage scans. Two hardcopy formats are provided. The SR630 can print a continuous strip chart showing up to 16 different temperatures (see the example below). In addition, data can be printed in a tabular format (see the example below and left) which logs the time, date, and temperature or voltage for each channel.



Strip chart output

Analog Multiplexer

The SR630 can also function as a 1:15 analog multiplexer. Any of the first 15 input channels can be switched out to channel 16 and passed on to other instruments. This feature is useful in ATE systems and many other monitoring applications.

Available Thermocouples

Although the SR630 will read types B, E, J, K, R, S and T type thermocouples, for many applications type K (Chromel/Alumel) will serve well. K-type thermocouples offer a wide temperature range (-200 °C to +1250 °C), low standard error, and good corrosion resistance.

Thermocouple

Channels	16
Thermocouple types	B, E, J, K, R, S, T
Display units	°C, °F and K
Display resolution	0.1 °C
Temperature displays	Actual, Nominal, or Offset
Accuracy	0.5 °C for J, K, E and T 1.0 °C for R, S and B Errors are for the SR630 only. Standard errors for thermocouple wire are 2 to 5 times the error due to the SR630.

Inputs

Channels	16
Input type	Independent, floating and differential
Input resistance	10 MΩ between + and – terminals, >1 GΩ to ground
Input capacitance	0.001 µF
Input bias current	<100 pA
Input protection	250 Vrms
Open circuit check	250 µA
Common mode	±200 VDC

Voltmeter

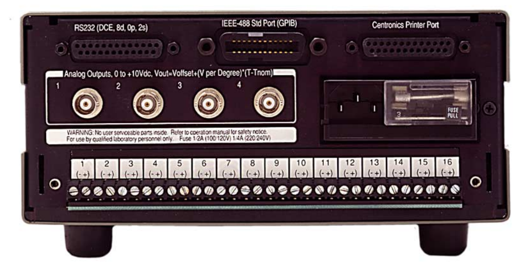
Full-scale display	(±9.999, ±99.99 or ±999.9) mVDC, (±9.999 or ±99.99) VDC
Range select	Automatic
Resolution	±1 of least significant displayed digit
Offset	±2 of least significant displayed digit
Gain accuracy	0.05 %
Conversion rate	10/s for 50 Hz line, 12/s for 60 Hz
Line rejection	>100:1

Scanning and Data Logging

Scanning	Selected channels will be scanned. Dwell time between scans is set from 10 s to 9999 s.
Alarm	Temperature or voltage limit for each channel
Scan enable	All channels may be scanned or skipped
Printer output	Voltages, temperatures, time and date as a list or in a graphical format
Data memory	Last 2000 measurements in battery backed-up memory

General

Analog outputs	Four analog voltage outputs proportional to temperature of channels 1, 2, 3 and 4
Relay output	Switching 10 A
Store and recall	Nine locations for instrument set-up
Interfaces	RS-232, GPIB and Centronics ports (standard). All instrument functions may be set and read via RS-232 or GPIB.
Power	10 W, 100/120/220/240 VAC, 50/60 Hz
Dimensions	8.5" × 3.5" × 13" (WHD)
Weight	9 lbs.
Warranty	One year parts and labor on defects in materials and workmanship



SR630 rear panel

Ordering Information

SR630	Thermocouple monitor
O630KF1	K-type thermocouples, 5', fiberglass, qty. 5
O630KF2	K-type thermocouples, 10', fiberglass, qty. 5
O630KT1	K-type thermocouples, 5', teflon, qty. 5
O630KT2	K-type thermocouples, 10', teflon, qty. 5
O630RMD	Double rack mount kit
O630RMS	Single rack mount kit

The Thermocouple Effect

It has been known for a long time (Seebeck, 1822) that a voltage exists across the junction of dissimilar metals. Figure 1 shows a thermocouple junction formed by joining two metallic alloys, A and B. The voltage across the thermocouple junction depends on the type of metals used and the temperature of the junction. The mechanism responsible for this voltage is quite complicated; however, there are certain phenomenological results which make the effect useful for measuring temperature.

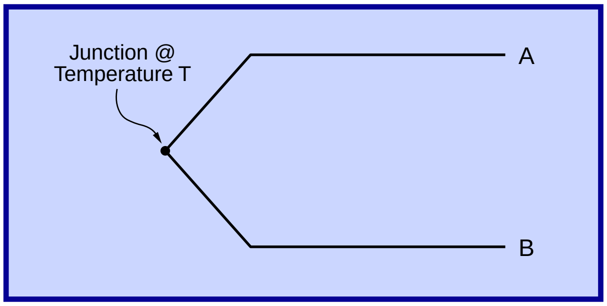


Fig. 1 Thermocouple junction

The first of these results is that the voltage is approximately linear with temperature. The change in junction voltage as a function of junction temperature is given by the equation:

$$\Delta V = a \times \Delta T$$

where "a" is the Seebeck coefficient. The magnitude of this coefficient depends on the metals used to form the junction; typical values range from 0 to 100 µV/°C.

Nonlinearities

Unfortunately, the magnitude of the coefficient depends on temperature. It is generally smaller at low temperatures, and may change by more than a factor of two over the useful operating range of a thermocouple. Despite this non-linearity, the induced voltage is (usually) a monotonically increasing function of temperature, and the voltages generated by certain pairs of dissimilar metals have been accurately tabulated. These tabulated values are referenced to the voltage seen across a junction at 0 °C.

Additional Junctions

A problem arises when measuring the voltage across a dissimilar metal junction—two additional thermocouple junctions form where the wires connect to the voltmeter (Fig. 2). If the wire leads which connect to the voltmeter are made of alloy "C", then there exist thermal EMFs at the A−C and B−C junctions. There are two approaches to solve this problem: use a reference junction at a known temperature, or make corrections for the thermocouples formed by the connection to the voltmeter.

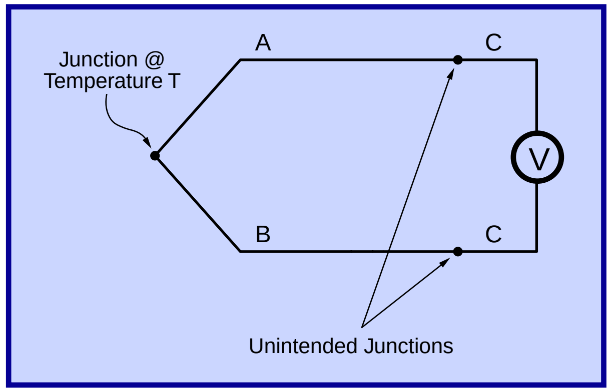


Fig. 2 Additional junctions

Figure 3 shows the use of a "reference" or "compensating" junction. With this arrangement, there are still two additional thermocouple junctions formed where the compensated thermocouple is connected to the voltmeter. However, the junctions are identical (they are both junctions between alloys A and C). If the junctions are at the same temperature, then the voltages across each junction will be equal and opposite, and will not affect the measurement. Typically, the reference junction is held at 0 °C (by an ice bath, for example) so that the voltmeter readings may be used to look up the temperature.

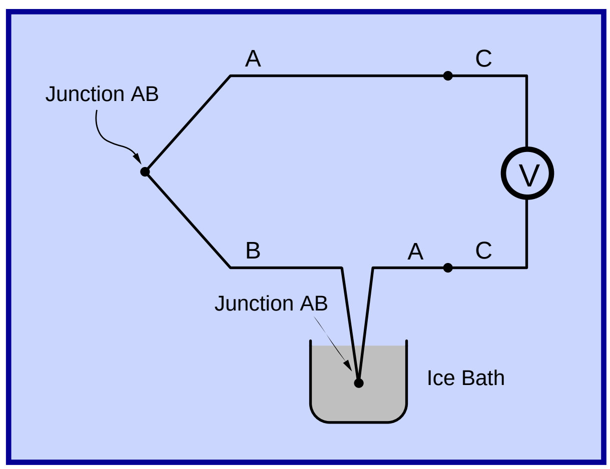


Fig. 3 Reference junction compensation

Compensation Without Reference Junctions

The second approach to the problem relies on the fact that the voltage across the junction A–C plus the voltage across the junction C–B is the same as the voltage across a junction of A–B. As long as all the junctions are at the same temperature, the presence of an intermediate metal (C) has no effect. This allows us to correct for the voltage seen by the voltmeter in Figure 2 by measuring the temperature at the A–C and B–C junctions, and subtracting the voltage which we would expect for an A–B junction (at the measured temperature). In the SR630, the temperature of the A–C and C–B junctions is measured with a low-cost, high-resolution semiconductor detector, and the subtracted voltage is the tabulated voltage of the A–B thermocouple at the measured temperature of the A–C and C–B junctions. The advantage of this method is that any type thermocouple may be used without having to change compensation junctions or maintain ice baths.

Characteristics of Thermocouple Types

Any two dissimilar metals may be used to make a thermocouple. Of the infinite number of thermocouple combinations which can be made, the world has standardized seven types which exhibit a range of desirable features. These thermocouple types are known by a single letter designation: J, K, T, E, R, S or B. While the composition of these thermocouples are international standards, the color codes of the wires are not. For example, in the USA, the negative lead is always red, while the rest of the world uses red to designate the positive lead. Often, the standard thermocouple types are referred to by their trade names. For example, K-type is sometimes called Chromel-Alumel, which is the trade name of the Ni-Cr and Ni-Al wire alloys.

It is important for a good thermocouple to have a large, stable Seebeck coefficient, wide temperature range, corrosion resistance, etc. Generally, each wire of the thermocouple is an alloy. Variations in the alloy composition and the condition of the junction between the wires are sources of error in temperature measurements. The standard error of thermocouple wire varies from ±0.8 °C to ±4.4 °C, depending on the type of thermocouple used.

Voltage vs. temperature measurements have been tabulated by NIST for each of the seven standard thermocouple types. These tables are stored in the read-only memory of the SR630. The instrument operates by converting a voltage measurement to a temperature, with the internal microprocessor interpolating to achieve 0.1 °C resolution.

The K-type thermocouple is recommended for most general purpose applications. It offers a wide temperature range, low standard error, and has good corrosion resistance. The K-type thermocouples provided by SRS have a standard error of ±1.1 °C—half the standard error designated for this type.

Type	B	E	J	K	R	S	T
Positive Material	Pt/Rh (30 %)	Ni/Cr	Fe	Ni/Cr	Pt/Rh (13 %)	Pt/Rh (10 %)	Cu
Negative Material	Pt/Rh (6 %)	Cu/Ni	Cu/Ni	Ni/Al	Pt	Pt	Cu/Ni
Positive Color (USA)	Grey	Purple	White	Yellow	Black	Black	Blue
Negative Color (USA)	Red	Red	Red	Red	Red	Red	Red
Lowest Temperature	50 °C	−200 °C	0 °C	−200 °C	0 °C	0 °C	−200 °C
Highest Temperature	1700 °C	900 °C	750 °C	1250 °C	1450 °C	1450 °C	350 °C
Minimum Std. Error	±4.4 °C	±1.7 °C	±2.2 °C	±2.2 °C	±1.4 °C	±1.4 °C	±0.8 °C

Figure 4: Thermocouple reference data