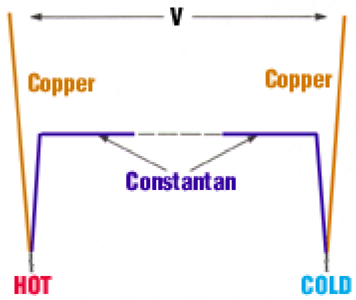
THERMOCOUPLES

The thermocouple is frequently used as the sensing element in a thermal sensor or switch. The principle is that two dissimilar metals always have a contact potential between them, and this contact potential changes as the temperature changes.



The contact potential is not measurable for a single connection (or junction), but when two junctions are in a circuit with the junctions at different temperatures then a voltage of a few millivolts can be detected (Fig. 1.1). This voltage will be zero if the junctions are at the same temperature, and will increase as the temperature of one junction relative to the other is changed until a peak is reached.

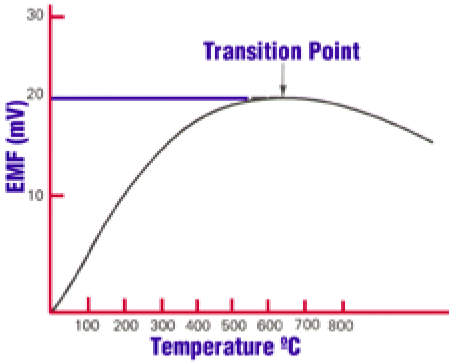


Fig. 1.2

Fig. 1.2 A thermocouple characteristic, showing the typical curvature and the transition point at which the characteristic reverses. A few combinations of metals (like copper/silver) have no transition, but have a very low output.

The shape of the typical characteristic is shown in Fig. 1.2, from which you can see that the thermocouple is useful only over a limited range of temperature due to the non-linear shape of the characteristic and the reversal that takes place at temperatures higher than the turn-over point. The output from a thermocouple is small, of the order of millivolts for a 10°C temperature difference, and Fig. 1.3 shows typical sensitivity and useful range for a variety of the common types of these, the copper/constantan type is used mainly for the lower range of temperatures and the platinum! Rhodium type for the higher temperatures.

Because of the small voltage output, amplification is usually needed unless the thermocouple is used for temperature measurement along with a sensitive millivoitmeter. If the output of the thermocouple is required to drive anything more than a meter movement, then DC amplification will be needed, using an operational amplifier or chopper amplifier.

The type of amplifier that is used needs to be carefully selected, because good drift stability is necessary unless the device is recalibrated at frequent intervals. This makes the chopper type of amplifier preferable for most applications.

Temp. °C	Copper/ constantan	Iron/ constantan	Platinum Plat/rhodium
-20	-0.75	-1.03	
-10	-0.38	-0.52	
0	0.00	0.0	0.0
10	0.39	0.52	0.05
20	0.79	1.05	0.11
30	1.19	1.58	0.17
40	1.61	2.12	0.23
50	2.04	2.66	0.30
60	2.47	3.20	0.36
70	2.91	3.75	0.43
80	3.36	4.30	0.50
90	3.81	4.85	0.57
100	4.28	5.40	0.64
200	9.29	10.99	1.46
300	14.86	16.57	2.39
400	20.87	22.08	3.40
500		27.59	4.46
600		33.28	5.57
700		39.30	6.74
800		45.71	7.95
900		52.28	9.21
1000		58.23	10.51
1200			13.22
1500			17.46

Fig.1.3

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If an on/off switching action is required, the thermocouple must be used along with a controller that uses a Schmitt trigger type of circuit which also permits adjustment of bias so that the switching temperature can be preset. The usual circuitry includes amplification, because the lower ranges of thermocouple outputs are comparable with the contact potentials (the same type of effect) in amplifier circuits, and attempting to use very small inputs for switching invariably leads to problems of hysteresis and excessive sensitivity.

One particular advantage of thermocouples is that the sensing elements themselves are very small, allowing thermocouples to be inserted into very small spaces and to respond to rapidly changing temperatures. The electrical nature of the process means that the circuitry for reading the thermocouple output can be remote from the sensor itself. Note that thermocouple effects will be encountered wherever one metallic conductor meets another, so that temperature differences along circuit boards can also give rise to voltages which are comparable with the output from thermocouples.

The form of construction of amplifiers for thermocouples is therefore important, and some form of zero-setting is needed.