Application Guide R-32
Thermal EMF

RESISTORS · CAPS & COILS · DELAY LINES

Whenever there is a junction between dissimilar metals, a small voltage is produced. The level of voltage varies with temperature. As such it is called a Thermal EMF (Electro-Motive Force) or "thermocouple" effect, since in fact it is the same principal which enables thermocouples to act as temperature sensors. Since resistor leads are generally made from a material which is different than that the resistance material, thermal EMF's result from a heat source, either external and/or internal (self heating). The voltage produced is either positive or negative depending on the orientation of the resistor. All resistors have intermetallic combinations and since most are connected to copper as a final intermetallic junction, copper is utilized as the standard reference metal. Resistor users can minimize thermal EMF levels via product selection and by circuit layout to ensure uniform junction temperatures.

Product Selection

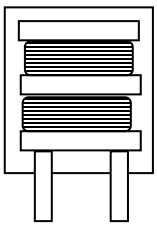
RCD's Option E design utilizes resistance wire and constructions which enable very low thermal EMF's, typically .1 to 2uV/ºC depending on resistor value and size. Conventional wirewound resistors made by RCD and other manufacturers have thermal EMF levels up to 25 times this level (also highly dependent on resistance value). Some other types of resistors, such as carbon composition models, may have even much greater levels…

Typical Resistor Thermal EMF Levels

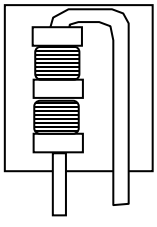
- Carbon Composition: up to 400uV/ºC typ.
- Metal Film: up to 20uV/ºC typ.
- Power Wirewound: up to 50uV/ºC typ.
- RCD Option E : 0.1 to 2uV/ºC typ.

Circuit designers should give consideration to a resistor's internal construction to ensure that one end of resistor is same temperature as the other, particularly in radial lead models…

Radial Lead Resistor Designs



Low Thermal EMF
(both leads same temp)



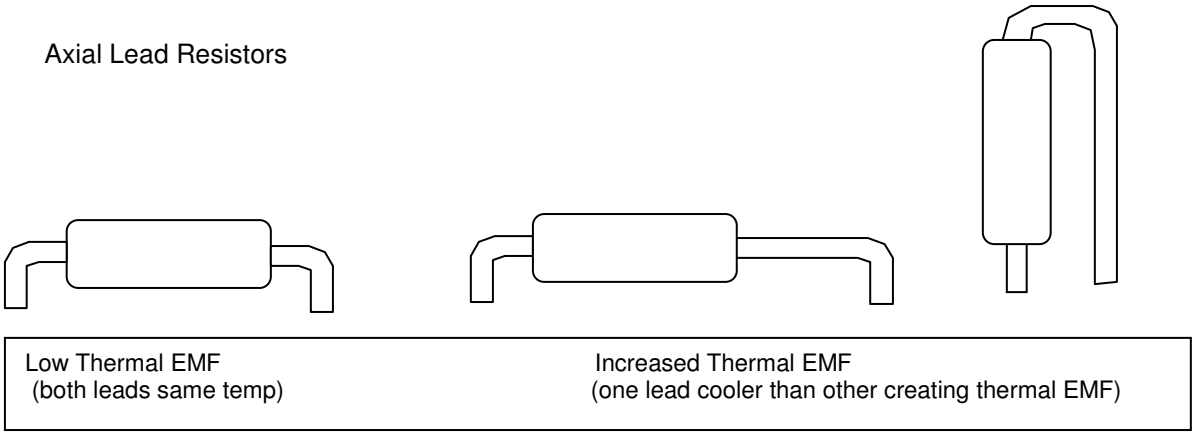
Increased Thermal EMF
(one lead cooler than other creating thermal EMF)

RCD Option E: Low Thermal EMF Design Application Guide

Circuit Layout

Consideration should be given to component placement to ensure uniform body temperature (i.e. don't position heat generating component at one end of resistor, don't tie one lead to cool ground plane, etc).

Axial Lead Resistors



Thermal EMF can be an important consideration in low-ohmic resistors used in DC circuits (generally low importance in AC circuitry), especially if the resistor is not at uniform temperature. In some current sense applications, the thermal EMF could be larger than the signal being discriminated.

As noted earlier, thermal EMF's have polarity and so, for example, one end of Option E resistor might be +2uV/º generator and the other end is a -2uV/º generator. In the ideal situation of both ends of the resistor being at the same temperature, the thermal EMFs are self-cancelling, resulting in an actual in-circuit thermal EMF near zero.

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