Applications

Introduction

Temperature was one of the first physical parameters to be measured in the process field and has been sensed in just about every way imaginable over the years. At one time or another, just about every physical property that changes with respect to temperature has been used as a basis for this measurement. Over the last few years, the development of low cost, small controllers and associated electronics circuitry has allowed for the cost effective measurement and control of temperature that was not possible before. NTC thermistor elements, either alone or as part of temperature sensing assembly, are being utilized more and more where the need to sense or control temperature is needed.

NTC thermistors offer designers many advantages over other type of sensing technologies including the highest sensitivity to temperature changes, high signal to noise ratio, simple operation as well as being low cost. Formerly, the nonlinear resistance versus temperature characteristic was problematic in analog sensing circuits. Today, however, with the advent of digital electronic controls the translation is handled via equations in software or lookup tables. The reliability, performance and longevity of the NTC thermistor as well as its other inherent characteristics has made it the temperature sensing element of choice where precise measurement and control of temperature are necessary.

NTC thermistor applications make use of the characteristics inherent in their composition. Applications are generally broken up into two separate categories that utilize different characteristics of the NTC thermistor.

ZERO POWER SENSING APPLICATIONS

The first category is zero power or sensing applications. These applications utilize the resistance versus temperature characteristics of the NTC thermistor to sense or control temperature with little power being dissipated by the thermistor. The other general category is self-heated applications that utilize the voltage-current characteristics of the NTC thermistor as well as its thermal characteristics and that of the environment.

Temperature measurement

Temperature measurement is the most common application for NTC thermistors. The high sensitivity of thermistors and the ability to manufacture components with tightly controlled temperature accuracy has made the NTC thermistor an ideal device for low cost temperature measurement.

As the cost of digital electronics has dropped while the degree of miniaturization has increased, the ability of the design engineer to utilize a high precision low cost thermistor has increased. Today's microcontrollers allow a number of thermistor sensors to be interfaced to a control system allowing several locations within a building or piece of equipment to be monitored simultaneously. An example of such a system is shown below. Additional zones can be monitored and controlled with the only additional cost being that of the thermistor assembly. The microcontroller will determine the temperature of the thermistor by converting the analog input, either voltage or current, to a temperature value. This is accomplished using either a "look-up" table or by programming into the software the equations that relate resistance to temperature.

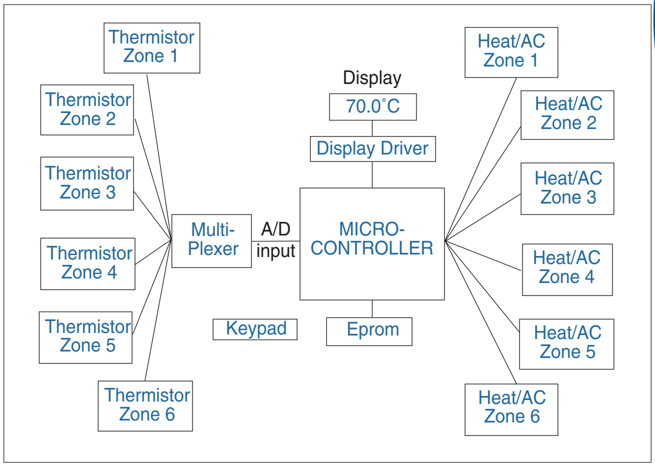

Figure 22: Microcontroller System

Another method of utilizing a thermistor to measure temperature is to use a Wheatstone bridge with the thermistor as one leg of the bridge. The circuit in Figure 23 is one example of a circuit that utilizes a thermistor to sense temperature. As temperature increases, the voltage output increases. The selection of R_1, R_2 and R_3 will determine the sensitivity of the circuit as well as the temperature range for which the circuit is best suited.

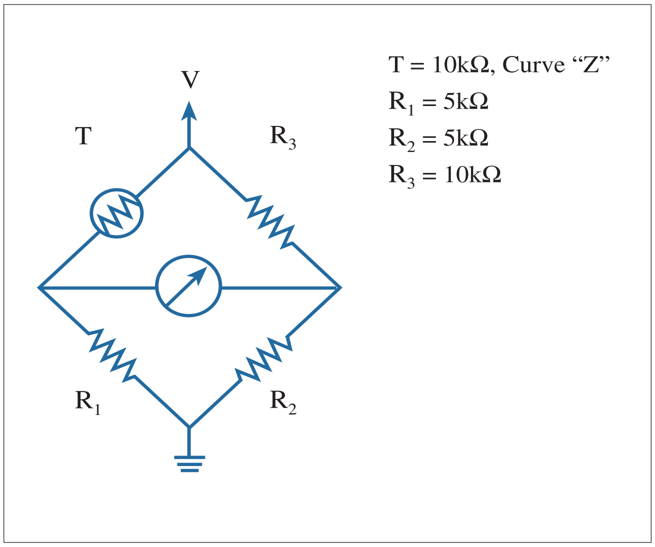

Figure 23: Wheatstone Bridge - Voltage Mode

Temperature alarm

A temperature alarm circuit can be designed by replacing the bridge detection meter in the above circuit with a sufficiently sensitive relay. The alarm set point will be determined by the values of the fixed resistors. The selection of the relay and thermistor/resistor values are critical to the design of the temperature alarm circuit. The bridge output is sufficiently small below the alarm set point which is determined by the fixed resistor legs of the bridge circuit. At a sufficiently high temperature, the thermistor resistance would be reduced causing an imbalance in the circuit and sufficient current to activate the relay.

Temperature compensation

Most electronic components' response will vary with respect to temperature. Often times, it is necessary or desirable to compensate for this change in response with respect to temperature by utilizing NTC thermistors. Some examples of components whose response is compensated for by NTC thermistors are crystal oscillators, infrared LEDs and mechanical meters. Normally, a resistor/thermistor network is used to match the temperature coefficient of the NTC thermistor network to the component. The negative temperature coefficient of the thermistor is much larger than the positive temperature coefficient of the compensated component. The addition of a resistor in parallel to the NTC allows the thermistor/resistor network to offset the response of the coil or other component.

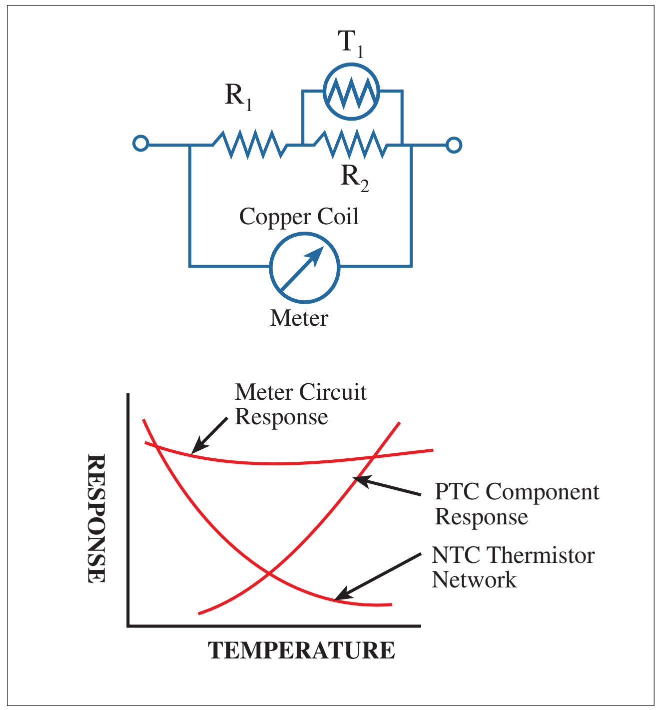

Figure 24: Temperature Compensation

SELF-HEATED THERMISTOR APPLICATIONS

Applications that take advantage of the voltage-current characteristics of an NTC thermistor are said to utilize the self-heated characteristics of the thermistor. A thermistor is said to be self-heated when the power generated internal to the thermistor from current flow is enough to raise the body temperature of the thermistor above that of its surroundings. The amount of self-heat generated will be dependent upon the amount of current flowing, the physical parameters of the thermistor as well as the environment surrounding the thermistor.

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Liquid Level/Air Flow

The NTC thermistor can be used to detect the absence or presence of a liquid by taking advantage of the difference in the amount of heat that can be dissipated by the thermistor between a liquid versus a gas. The dissipation factor, δ, that is listed on thermistor data sheets is based on a specific set of conditions; typically 25˚C still air with minimal heat sinking. The ability of the thermistor to dissipate heat is much better in flowing air or a liquid than it is in still air. A self-heated thermistor can dissipate roughly 4 to 6 times the amount of power in a liquid than it can in air. The key to a successful design for liquid level/air flow is to ensure that the system functions over the entire operating temperature range. For example, the system must be able to detect the difference between the circuit subjected to the hottest liquid as opposed to the coldest air. For applications that require a wide operating temperature range, the addition of a second NTC thermistor to the system that is used as a temperature sensor can be effective. This would allow the circuit to compensate for changes in ambient temperature.

Surge current limiting in Power Supplies

The NTC thermistor can be a cost effective device to limit the amount of inrush current in a switching power supply or other devices when the power is first turned on. For switch-mode power supplies, the large filter capacitors present in the circuit appear as a short circuit at turn on. During this period a large amount of current flows through the circuit until the capacitors have had time to become fully charged. At that point in time, the amount of current will have dropped substantially. An NTC thermistor is a good choice to limit current in these types of circuits because it has a relatively high resistance to start and then drops in resistance due to self-heating. The NTC surge current limiter is normally placed in series with the diode bridge, motor or other components that require inrush current protection. Special NTC devices have been developed to service these types of applications. These NTCs are generally large disc type thermistors with broad resistance tolerances. These devices are designed to handle the large energy surge at turn on that is inherent in many of these applications. Generally speaking, chip thermistors, small disc thermistors, and glass encapsulated thermistors are not suitable for these types of applications because of their higher resistance values and low dissipation constants. However, for applications where the inrush currents are small and the energy surge low, any style of NTC thermistor can function as an effective surge limiter.

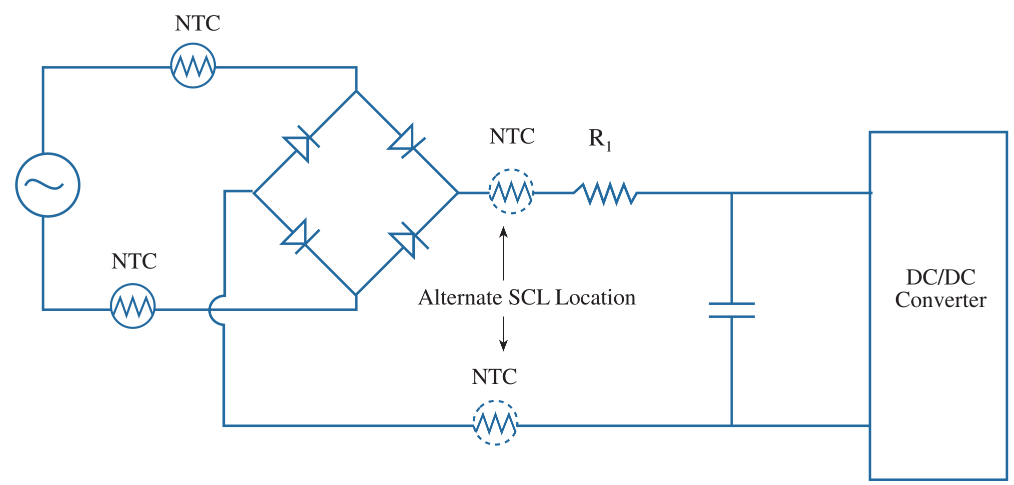

Figure 25: Surge Current Limiting Circuit For Switch Mode Power Supply.