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Temperature Measurement using Thermistors and Thermocouples

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Abstract

The temperature measurement plays a very vital role in almost every other branch of engineering and technology including fields like sciences, technologies, and many more. The consistent and accurate measurement of temperature is required in industrial process, medical equipment, environmental monitoring system and in research laboratories. Among the various temperature sensor available, thermistors and thermocouples are widely used due to their efficiency, simplicity, and reliability. The thermistors and thermocouples give the most consistent and precise readings whenever we are measuring temperature in laboratories or industries. This conference paper presents you the in-depth study of temperature measurement using the two most reliable, temperature measuring instruments called thermistors and thermocouples. The paper included all key details of these two widely used devices which includes their construction – where we shall discuss how these materials are constructed manufactured. Their working principle – where we shall dive in the ocean of, thermistors and thermocouples discussing how these materials operate and functions primarily. The various characteristics, calibration techniques, advantages and disadvantages shall also be discussed in latter part of our well researched conference paper in very detailed manner, followed by the comparative analysis of these two devices.

Keywords: Temperature Measurement; Thermistors; Thermocouples; Sensors; Calibration Techniques

How to Cite This Article

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Introduction

The temperature measurement is the one of the most frequently measured physical quantity in the engineering system. Many industrial processes such as the chemical reactions power generation, food processing and manufacturing depends heavily on the accurate temperature monitoring and control. Inaccurate temperature monitoring can lead to system inefficiency, product defects, safety hazards, and equipment damage. The temperature sensor are the devices which converts the temperature into measurable electrical signals. Different types of temperature detectors like RTD'S thermistors, thermocouples, infrared sensors and semiconductor-based sensors are readily available. Among these the thermistors and thermocouples are widely preferred due to their ease of use, low cost, wide range of applications. This paper focuses on a detailed study of thermistors and thermocouples used for temperature measurement.

Thermistors

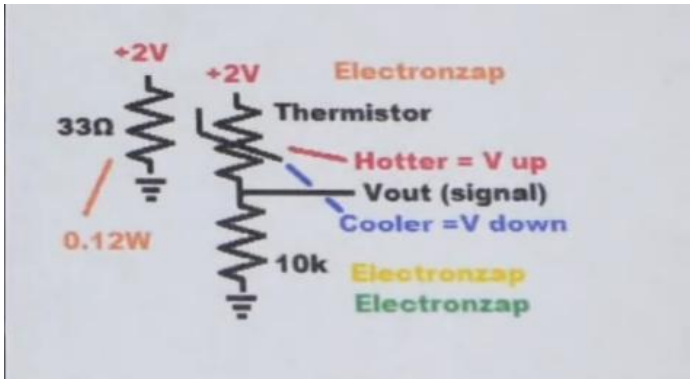

Fig. 1. *Thermistor Voltage Divider Circuit (Temperature Sensing Output Vout)*

A thermistor is a temperature sensitive resistor whose resistance changes significantly with temperature. The word thermistors is derived from the combination of the word thermal and resistor. Thermistors are generally made from the semiconductor materials such oxide of manganese and metal., nickel, cobalt and copper. The thermistors are widely used in the applications where high sensitivity and accurate temperature measurement are required over the limited range of temperature. The material is constructed by the compressing semiconductor material in the desired shape, such as the heads, discs or the rods. The material is the is sintered at high temperature to achieve the mechanical strength and the stability. The assembly is coated with the protective material such as epoxy and glass. The small size of it helps to quickly respond to the quick change in temperature very easily. They tend to operate very effectively to -50 to 150 degrees Celsius. The non-linear resistance temperature characteristics are major limitations using the signal conditioning or software algorithms.

Principle of operation

The operation of the thermistor is based on the variation of the electrical resistance with the temperature. Most of the thermistors exhibit a negative temperature coefficient meaning that their resistance decreases as temperature increases. Positive temperature coefficient thermistors exhibit the property to increased with temperature as the resistance increases gradually. The resistance temperature relationship is generally non linear requiring the calibration for accurate measurement

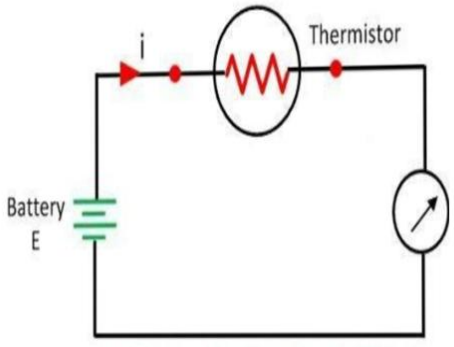

Fig. 2. *Thermistor Voltage Divider Circuit for Temperature Sensing Output (Vout)*

Characteristics

Thermistors offer the high sensitivity and good accuracy property over limited temperature range of the device. They posses' fast response time which inherently makes them very suitable for precise temperature measurement. However, due to non-linear characteristics, additional signal conditioning or software-based linearization is required. These are basically characterized by their high sensitivity, high accuracy and fast response property. However, due to their usable temperature range is limited compared to the thermocouples. They tend to operate

effectively at -50 to 150 degrees Celsius. The non-linear resistance is major limitations, but it can be compensated using signal conditioning and the software algorithms. They are widely used in medical devices, temperature compensation circuits and battery management system and household appliances such as refrigerators and air conditioners.

Thermocouples

A thermocouple is the temperature sensor that operates based on See beck effect which is voltage. The material is constructed using the two dissimilar metals, which are joined and smoothed together at the one end of measuring junction. It consists of two metallic wires joined together at one end, known as measuring or hot junction. The other ends form the reference or cold junction. Thermocouples are widely used for measuring high temperatures and in harsh industrial environments. They are basically made from the metals such as the iron constantan and chrome. These metals are insulated from each other except at junction. The junction may be welded tested twisted, tilted or brazed depending upon the application. Protective sheaths are often used to protect the thermocouples from the corrosive environments and mechanical damage.

Principle of Operation

When two dissimilar metals are joined together and their junction are maintained at different temperatures a small electromotive force is generated. The phenomena is known as the See beck effect. The generated voltage is directly proportional to the temperature difference between hot and cold measuring junctions. By measuring the voltage and knowing the reference temperature, the temperature at measuring junction can be determined very easily. The thermocouples are operated typically from -200 to 1800 degree Celsius depending on the type of material used. However, their accuracy and sensitivity are lower compared to thermistors. Basically, cold junction compensation is required for accurate temperature measurements in thermocouples

Characteristics

The thermocouples are basically capable of measuring the wide range of temperature ranging from typically from -200 degree Celsius to 1800 degree Celsius depending on the type of material used. They are rugged, durable, and suitable for harsh environments. However, their sensitivity is very low compared to thermistors. Basically, cold junction, compensation is required in them for accurate temperature measurement. They are widely used in the temperature boiler, furnaces, power plants, automotive exhaust system and industrial process control where high temperature measurement is required.

Experimental Procedures

The experimental study was conducted to compare the performance characteristics of thermistors and thermocouples under various temperature conditions. Temperature calibration was performed using a precision temperature control chamber with accuracy of +- 0.5C.

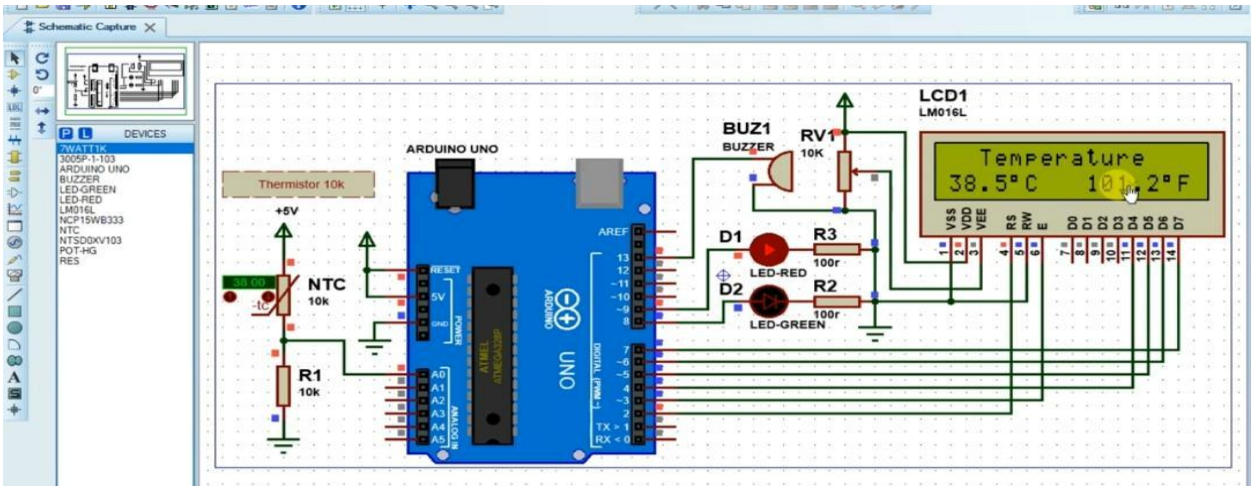

Fig. 3. *Arduino-Based Temperature Monitoring System Using Thermistor with LCD Display*

From the above diagram we can easily see how can we measure temperature using thermistor and thermocouples device. It is basically a siftwarebased device used to monitor temperature using thermistors (NTC) with vary with temperature.

Thermistor testing Procedures

Thermistors were tested over the temperature range of -50 to 150 degree Celsius. A precision digital multimeter with +- 0.05% accuracy was used to measure resistance values. The temperature -resistance relationship was plotted and analysed for linearity. Response time was measured by subjecting thermistor to step temperature changes and recording the time to reach 63.3 percent of final value.

Thermocouples Testing Procedures

Thermocouples were tested over temperature range of -50 to +300 degree Celsius. A high-resolution data acquisition system with cold junction compensation was employed to measure the generated voltage. The voltage -temperature relationship was established using the standard reference junctions. Response time measurements were conducted using the same step change methodology as thermistor testing.

Results and discussion

A comparative analysis shows the distinct advantages and limitations of both sensors' types. Thermistor demonstrated superior sensitivity and accuracy for the precise measurements applications while thermocouples excelled in harsh industrial environments and extreme temperature applications from (-200 to 1800-degree celcius) exhibiting good stability and ruggedness despite lower absolute accuracy of +-1-to-2-degree celcius and longer response time for 5 to 10 seconds.

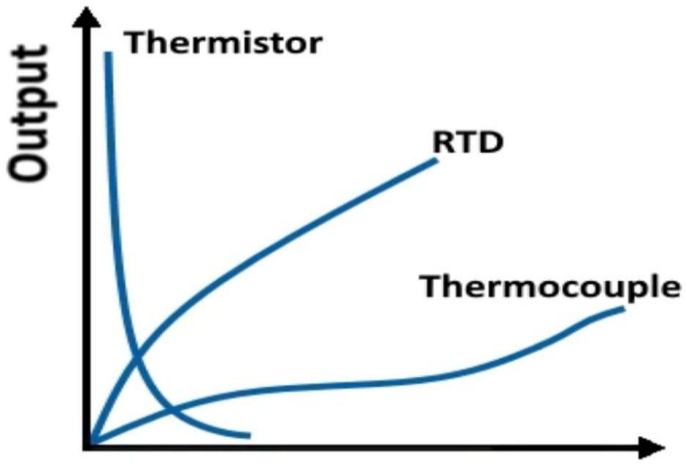

Fig. 4. *Comparative Output Characteristics of Thermistor, RTD, and Thermocouple Sensors*

Conclusion

Temperature measurement is a fundamental requirement in engineering and scientific applications. Thermistors and thermocouples are two most important temperature sensor with distinct characteristics. Thermistors offer the high accuracy and sensitivity for precise measurements over limited, lower temperature ranges. Whereas thermocouples are robust and durable for measuring extremely high temperatures in industrial settings. As a rule of thumb for precise measurements lower temperature range where cost and sensitivity are key factors the thermistor is often preferrable. For ruggedness and very high temperature measurement in industrial settings thermocouple is default choice. The selection is appropriate temperature sensor depends on the factor such as the temperature range accuracy, response time and environmental conditions.

Future work

The tools like Tinkercard can be used for the virtual prototyping of sensor circuits and artificial intelligence techniques can be applied to sensor data analytics for improved temperature measurement and control systems.

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Conflict of Interest Statement

The author declares that there is no conflict of interest.

References

1. 1 D. Patranabis, Sensors and Transducers, 2nd Edition, Prentice Hall of India,2003.
2. J Fraden, Handbook of Modern Sensors, Physics, designs and Applications 6th Edition, , Springer 2016
3. Texas Instruments, "Thermistors Signal Conditioning for Temperature Measurement Application. Note SBAA275, 2020.
4. Analog Devices, "Thermocouples Measurement and Signal Conditioning. 'Technical Article ,2019.
5. IEEE Standards Associate 'IEEE 60584-1 :2013-Thermocouples Part 1: EMFSpecifications and Tolerances, '2013.