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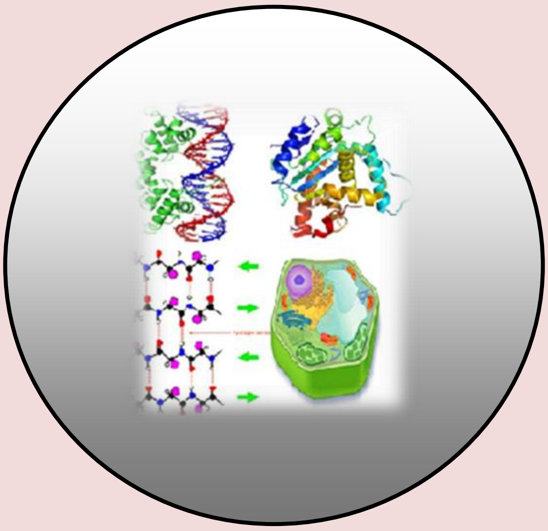

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REVIEW ARTICLE

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A Study on Heat Sensors and their types: A Review

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ABSTRACT

The "Heat sensors" or the "Temperature sensors" are the tools that measure the hotness or the coolness of any object, actually the sensor measures the atomic activity and the movement of that object. Whenever the "heat sensor" reads an object that has zero atomic activity, the temperature of the object is "absolute zero." It is seen that when the substance gets heated, it generally changes it's from phases from solid to liquid and then to gaseous state until the atomic activity begins increasing. According to thermodynamics, the temperature changes as a function of the average energy of molecular movement and when the heat is added to the system the molecular motion starts increasing and the system start experiencing an increase in temperature. This is the reason why these heat sensor devices and the temperature regulators were invented that process the signals that they receive from the appliances. These temperature sensors are very useful in chemical engineering like they were used to maintain the temperature of chemical reactors.
Keywords: Heat sensors, Temperature, Regulators, Sensors, Thermostats and Energy.

INTRODUCTION

The heat sensors are important for so many products such as household appliances, and the all rely on the temperature "maintenance" and "control" so that they can function in proper manner. In chemical factories the temperature sensors maintains the temperature and also monitors the temperature of runway reactions for the safety of the workers, and also maintain the temperature of the steam that is released in the atmosphere to reduce its harmful effects. Generally, the humans sense the temperature and know about the hotness, coolness and its neutral state of temperature but the chemical engineering needs to measure the temperature in very précised manner so that the process can be controlled in accurate way. Since it is tough to measure the energy of the molecular movement directly, the heat sensors were designed to measure the temperature. These sensor devices were calibrated with the traditional temperature scale with the help of the standards like boiling point of water at known pressure **(Temperature sensors, 2017)**.

Mercury or alcohol thermometer is an example of thermal sensor in which the "volume of mercury" expands on increasing the temperature and measure the temperature with temperature scale. "Thermo couples, resistance thermometers, silicon sensors and radiation thermometers are the thermal sensors that were used to measure the temperature of big machines **(Huynh, 2015)**. "Contact sensors" and the "Non-contact sensors" are the two kinds of temperature sensors like "thermometers, resistance temperature detectors, and thermocouples" that were used to measure the physical property like volume of the liquid, current through the wire etc that changes as the function of the temperature.

Contact Sensors measure the temperature of the object in which they are in contact by "assuming" or "knowing" that two of them the "sensor and the object" are in "thermal equilibrium" and there is no flow of heat between them, e.g. "thermocouple, RTD (Resistance Temperature Detector), Full system thermometers, bimetallic thermometers". **Non -contact temperature sensor** were used in commercial and scientific purposes that measures the "thermal radiant power" of infra-red and optical radiations, e.g. pyrometer.

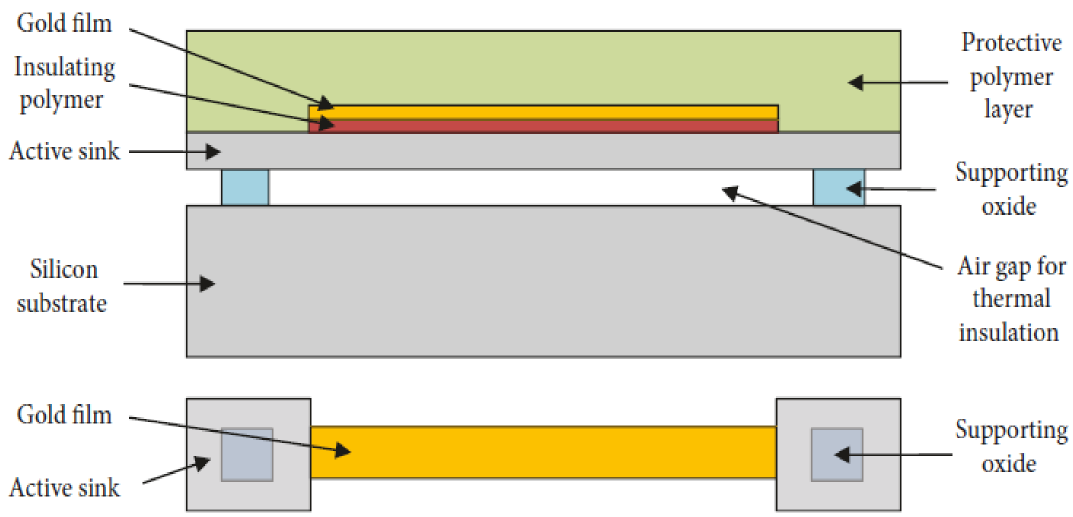

Figure 1. Temperature Sensor with Active Sink.

Thermometers: these are the commonly used temperature sensor that measures the temperature in day to day life, e.g. "Filled System and Bimetal thermometers."

Filled System Thermometer: it contains liquid in an enclosed tube and the volume of the liquid changes as a function of temperature. When the temperature is increased the molecular movement also increases and due to this the fluid expands and starts moving with the markings that were calibrated. It is important for the fluid to have comparatively high "thermal expansion coefficient" in order to detect little change in temperature.

Bimetal Thermometer: steel and copper metal that have different "thermal expansion coefficient" are fixed with each other and as the temperature of the strip increase, the metal that has high "thermal expansion coefficient expands and this causes stress in the material and shows deflection. The degree of deflection is a "function of temperature."

Thermocouples: this temperature is commonly used in the industries and it provides "electrical measurement" of the temperature just like RTD (Resistance Temperature Detectors).

Pyrometers: these are non-contact temperature sensor that measures the amount of "heat" which is radiated instead of the "heat" which is conducted and converted to the sensors as in the "thermometer, RTD and the thermocouple."

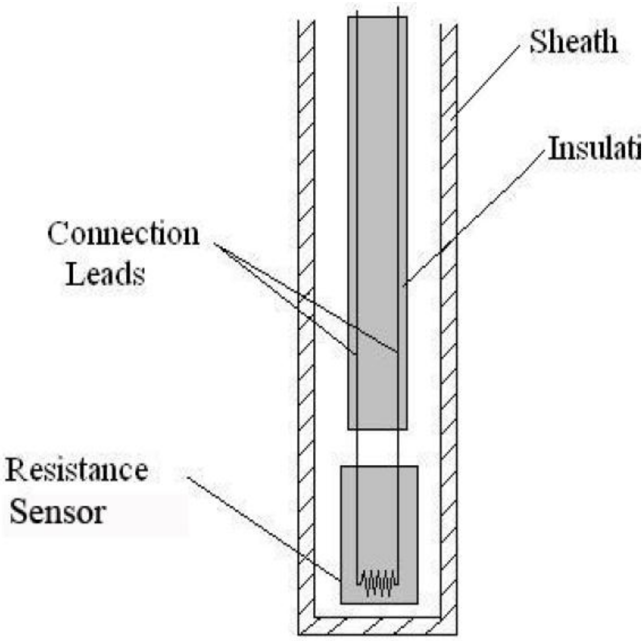

Figure 2. Resistance Temperature Detectors.

These electronic devices are the important part of the appliances that helps in measuring the temperature and converting the input data into the digital data for recording, monitoring and signalling the temperature changes.

Literature Review

It is very important to address the target list of the requirements while designing and purchasing any heat sensor system. It is better to differentiate between short and long term flow on one side and on the side the "resolution, precision, and accuracy" as well. "Transistors, thermocouples, and thermopiles are commonly used elements to sense the temperature in smart sensors and MEMS (micro-electromechanical systems) and these elements are compatible with integrated circuit technology also. The "Pt resistors, thermostats, and IR sensors" are considered to be very important at the system level. Thermopile is best for the temperature sensors that measure the difference between the temperatures. It transfuses the signals first in thermal quantity and to electrical quantity to measures the physical quantity and generally in these kinds of sensors, a "reference temperature" is measured with the help of "bipolar transistor." We calibrate and adjust the characteristic of the sensors on the basis of their physical property with the help of single point trimming. These features are helpful while the designing and fabricating any smart temperature sensor **(Meijer, Wang & Heidary, 2018)**. The highest range of temperature of the "smart temperature sensor" that usually ranges from about -50^{0}C to +140^{0}C is restricted to that of the "electronic circuitry." However, while using the non-conventional sensing element like "thermal delay line," the smart sensor is possibly fabricated for much wider range of temperature **(Makinwa, 2010)**.

In addition, there are some electronic circuits in "conventional integrated-circuit (IC) technology" that work at high temperature also like 300^{0}C. Therefore, it is expected to use to other kind sensor at high temperature like "platinum (Pt) resistors" which is a temperature sensor and can work at the high temperature of nearly -260^{0}C to +1000^{0}C , and at the same time there are some "thermocouple" that can work on the temperature of about -270^{0}C to +3500^{0}C.

For the health of humans it is very important to measure the temperature of their skin surface that helps in knowing the temperature of their body. This helps in the diagnosis of "hypothermia" or "hyperthermia" and also very useful in the heat therapies in human beings which is known as thermo therapy. The elements of "corporal temperature sensor" is been analysed and due to their good characteristic dynamics it is suggested that there is no need of a "monitoring system" to measure the temperature, only a "static device" is more than enough as generally it can detect the change in body temperature even if it is very slow **(Rezki, Ayad and Saoudi, 2017)**.

Features	Transistors (BJTs)	Thermocouples	Platinum resistors	Thermistors
Temperature range (°C)	Medium −50 to +180	Very large −270 to +3500	Large −260 to +1000	Medium −80 to +180
Accuracy	Medium	Problematic because of the reference junction	High over a wide range	High over a small range
Accuracy for measuring small temperature differences	Medium	High	Medium	Medium
Suited for integration on a silicon chip	Yes	Yes	Not in standard technology	Not in standard technology
Sensitivity	High ($2\,mVK^{-1}$)	Low (0.05–$1\,mVK^{-1}$)	Low ($0.4\%K^{-1}$)	High ($5\%K^{-1}$)
Linearity	Good	Good	Good	Very strong nonlinearity
Electrical quantity representing the temperature	Voltage	Voltage	Resistance	Resistance

Figure 3. Main features of various types of temperature-sensing elements.

Thermal sensor measures the intensity of Infra-red radiations in which the radiation converts into heat at a "heat absorbing membrane" and with the help of a well characterized thermal conductor the heat is conducted to the sensor in huge amount. The heat which is absorbed is measured in the form of "temperature difference" between the ends of the thermal conductor.

The see beck sensor is a very good option to measure the "temperature difference" because of its capability of allowing the "temperature difference" to be measured off set free. The output voltage of these sensors has some kind of non-linearity but it is proportional to the "temperature difference" between the 2 junctions **(Herwaarden, 2008)**. In these kinds of applications, it is good to measure the temperature of one junction so as to overcome the effect of the "temperature dependency" of the "heat conductance" and "see back coefficient." Generally, the "accuracy" which is required for the heat sensors is very low as compared to the requirement of temperature difference sensors.

Different kind of temperature sensing elements were used in different sensors and all of them have the key features of their own. Generally, incorporated sensors are used in "smart temperature sensor system" and "micro electro mechanical systems (MEMS)" that helps in combining the sensing element with the edges of electronics which is required for the communication purposes like the micro controllers. Additionally, a separate sensing element is been attached with these incorporated sensor systems that are commonly used for "calibration" and "testing" purposes. These discrete elements that were used in the environment works on the temperature that is above the range that these "interface electronics" are able to tolerate. **(Meijer, 2008a)** had summarized the key features of some common "on chip" and "discrete sensing elements" for the temperature sensing system and micro electro mechanical systems (MEMS).

The "discrete temperature sensing elements" were commonly used in the systems of industries due to their "high accuracy" and excellent "long term stability" feature. "Pt resistors, thermocouples, and thermistors" are the elements that were generally used due to their stability. The "platinum resistors" were positioned in "International temperature scale" in the year 1990 as the "interpolating temperature standard" in the range of "-259.4^{0}C to 961.9^{0}C temperature" **(Michalski et al., 2001)**. Due to "low cost" and "high reliability" the discrete thermo couple are commonly used in the industries where they work for different range of temperature.

Thermistors are very sensitive, small in size and low cost sensors that works with the temperature range of -80^{0}C to 180^{0}C but at the same time, the processing of thermistors signals gets complicated due to their high non linearity. This "linearization" can be achieved by the use of "shunt" and "series" resistors at the price of reducing the sensitivity. There are certain "sensor interfaces" like "universal sensor interface" **Smartec (2016a)**, that offers special processing mode for "thermistors" that includes linearization.

The implementation of "smart temperature sensor" is good with output signal as they are compatible with micro controllers like a signal that is modulated with frequency, signal modulated with period, or signal that is modulated with duty cycle. The "duty cycle modulator was the first smart temperature sensor which was marketed and implemented in "BICMOS" technologies. In recent years this "BICMOS" sensor was again designed and implemented as "CMOS" technology whose cost is very low **(Smartec, 2016b)**. High resolution is the key feature of "smart sensor" with "DCM" output which is achieved by consuming low energy also.

Chopping is used in the sensor system to modulate or chop the sensor signal that has low frequency in order to get the signals of higher frequency. These signals of high frequency can be easily differentiated from the signals of low frequency of "non-ideal ties of amplifiers" like "offset and 1/f noise."

The demodulation is done again at the “amplifier end” in order to revert the process and sensor signals get their initial values and at the same time “and 1/f noise is converted into higher frequencies so that it can be removed with a low-pass filter.” Now days there are so many “precision instrumentation amplifiers” that has built in choppers **(Huijsing, 2014)**. In the sensor system the chopper can be attached in the physical domain in order to get the advantage of the technology in the huge part of the “signal processing chain.”

The process of overlapping can be seen in the concept of “DEM (duty-cycle-modulated (DEM) and chopping” because whenever chopping or modulation is done inter changing the input terminal of the amplifiers and this part is same when inter changing of 2 branches of the “differential input amplifier” is done in “DEM (duty-cycle-modulated).” **Wang et al. (2017)** studied that “DEM” and “chopping” both is done in smart temperature sensors which shows that both of these techniques can be combined and synchronised with each other easily with the help of same clock signal.

CONCLUSION

The temperature of any metal or devise can be sensed by toughing it but there are devices like temperature sensors that are used in different electronic devices and also in industries to measure the temperature. These “heat sensors” are characterised to measure the temperature of different ranges such as from 40°C to less than −60°C. These are designed to measure even very little fluctuation of the temperature with the “expressed intent” of having the capability to be combined with “compliant capacitive pressure sensors” that is already present there. It is found that if the sensor is silicon based them it has a significant heat loss to the substrate and this is the reason why the sensors can be incorporated with the “active heat sink.” The “active sink” and the “temperature sensor” have different proportional controllers that allow their individual temperature to maintain a stable equal value in spite of any external temperature. If the “active sink” and the “temperature sensor” are kept at same temperature it will show the heat loss from the heat sensor to the substrate which is prevented so as to measure the changes of “heat flux” which is obtained by the change in “external temperature” directly and accurately.

REFERENCES

Herwaarden van, A.W. (2008). Thermal sensors. In: Meijer, G.C.M. (Ed.), Smart Sensor Systems. Wiley, Chichester, pp. 151e183.

Huijsing, J.H. (2014). Precision instrumentation amplifiers. In: Meijer, G.C.M., Pertijs, M.A.P., Makinwa, K.A.A. (Eds.), Smart Sensor Systems: Emerging Technologies and Applications. Wiley, Chichester, pp. 42e67.

Makinwa, K.A.A. (2010). Smart temperature sensors in standard CMOS. In: Proc. Euro sensors, pp. 930e939.

Meijer, G.C.M. (2008a). Smart temperature sensors and temperature-sensor systems. In: Meijer, G.C.M. (Ed.), Smart Sensor Systems. Wiley, Chichester, pp. 151e183.

Meijer, Gerard C.M., Wang, G. and Heidary, A. (2018). *Smart Sensors and MEMs || Smart temperature sensors and temperature sensor systems. , (), 57–85.* doi:10.1016/B978-0-08-102055-5.00003-6 .

Michalski, L., Eckersdorf, K., Kucharski, J. and McGhee, J. (2001). Temperature Measurement, second ed. Wiley, Chichester.

Rezki, M., Ayad, M. and Saoudi, K. (2017). Elements to study corporal temperature's sensor, The American Journal of Innovative Research and Applied Sciences, 172-176.

Smartec (2016a). Datasheet Universal Transducer Interface. www.smartec-sensors.com.

Smartec (2016b). Temperature Sensors, Datasheet SMT172. www.smartec-sensors.com.

T. Huynh (2015). Chapter 2: Fundamentals of Thermal Sensors, Springer Science and Business Media New York 2015 C.M. Jha (ed.), Thermal Sensors, DOI 10.1007/978-1-4939-2581-0_2.

TemperatureSensors,http://www.idconline.com/technical_references/pdfs/instrumentation/ Temperature_Sensors.pdf (Accessed on 28 October 2017).

Wang, G., Heidari, A., Makinwa, K.A.A., Meijer and G.C.M. (2017). An accurate BJT-based CMOS temperature sensor with duty-cycle-modulated output. IEEE Transactions on Industrial Electronics 64, 1572e1580.

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