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A Survey on Platinum Temperature Sensor

Ranjana Trivedi, Geetika Mathur, Ashish Mathur

Abstract— **These days, specially adapted designs make it possible to cover a multitude of applications over the temperature range from –200 to +850 °C. Platinum thermometers can thus be used not only in industrial measurement technology, but in sectors such as HVAC engineering, household equipment, medical and electrical engineering, as well as in automobile technology. Wire wound platinum temperature sensors on a glass or ceramic core as well as platinum chip sensors made in thin-film technology is incorporated as the temperature-sensitive heart of the resistance thermometer. Here we studied different platinum sensors according to their properties. Some typical features are also explained. So this paper presents the survey about platinum temperature sensor.**

Index Terms— **Platinum, Special features, Temperature range, Temperature sensors.**

I. Introduction

As we know that the change of electrical resistance of metals as a result of changes in temperature could be utilized for the measurement of temperature itself. The material to be used should be a noble metal: platinum, since platinum shows characteristics that are not shared by other metals. In 1886 the platinum resistance thermometer was developed by taking appropriate precautions, constructed a precision resistance thermometer that was suitable for measuring high temperatures. Since then, platinum resistance thermometers have been used as indispensable devices for measuring temperature as a physical variable.

An analog temperature sensor is pretty easy to explain, it's a chip that tells you what the ambient temperature is! These sensors use a solid-state technique to determine the temperature. That is to say, they don't use mercury (like old thermometers), bimetallic strips (like in some home thermometers or stoves), nor do they use thermistors (temperature sensitive resistors). Instead, they use the fact as temperature increases, the voltage across a diode increases at a known rate. (Technically, this is actually the voltage drop between the base and emitter - the Vbe - of a transistor. By precisely amplifying the voltage change, it is easy to generate an analog signal that is directly proportional to temperature. There have been some improvements on the technique but, essentially that is how temperature is measured.

Because these sensors have no moving parts, they are precise, never wear out, don't need calibration, work under many environmental conditions, and are consistent between sensors and readings. Moreover they are very inexpensive and quite easy to use.

In many industrial sectors and fields of research, temperature measurement is one of the most important parameters which determine product quality, security, and reliability. Temperature sensors are available in several types all of which have a unique performance characteristic. The performance capabilities of the various sensors are a result of the manufacturing process and component materials associated with their technologies and intended application. So here we discuss first the sensor construction then some typical features of platinum temperature sensors, which show the properties of platinum temperature sensors.

Then this paper shows the comparative study among the different available platinum sensors available in market like Type c, Type l, Type MN, Type M and Type H.

II. Sensor Construction

The temperature sensor consists of a photo-lithographically structured, high-purity platinum coating arranged in the shape of a meander. The platinum thin-film structures are laser trimmed to form resistive paths with very precisely defined basic value of the resistivity. The sensors are covered with a glass passivation layer; to protect the sensor against mechanical and chemical damage. The bonded lead wires which are additionally covered with a drop of glass make electrical contacts to the resistive structure

III. Typical Features

A. *Response Time*

The response time $T_{0.63}$ is the time the sensors need to respond to 63% of the change in temperature. The response time depends on the sensor dimensions

B. *Long-Term Stability*

The change of ohm age after 1,000 hrs at maximum operating temperature amounts to less than 0.03%.

C. *Self Heating*

To measure the resistance an electric current has to flow through the element, which will generate heat energy resulting in errors of measurement. To minimize the error the testing current should be kept low (approximately 1 mA for pt-100). Temperature error _T = RI2 / E; with E = self-heating coefficient in mW/K R = resistance in k_, I = measuring current in mA

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Ranjana Trivedi, ECE Department, JIET Group of Institution, Jodhpur, India, 09460893920, (e-mail:ranjana.trivedi@gamil.com)
Geetika Mathur, ECE department, Rajasthan Technical University, Jodhpur, India, 09928334427, (e-mail: bhatigeetika@gmail.com).
Ashish Mathur, ECE Department, Rajasthan Technical University, Jodhpur, India, 09829444456, (e-mail: ashish.mathur@gmail.com).

IV. COMPARISON OF DIFFERENT TYPES OF PLATINUM TEMPERATURE SENSOR

Properties	Type C (Cryo	Type L (Low)	Type MN	Type M (Medium	Type H (High)
Applications	Cryo aerospace, chemical and power generation plants and analytical equipment)	HVAC, process industry and all applications, where soft solderability is required	Applications with high consumer volumes, typically in the automotive, white goods	Automotive, white goods, HVAC, energy management, medical and industrial equipment	Applications with high consumer volumes, e.g. white goods, heating power and process technology
Tolerance class	Class B resp. F 0.3	Class 1/3 B resp. F 0.1 Class A resp. F 0.15 Class B resp. F 0.3	Class A resp. F 0.15 Class B resp. F 0.3 Class 2B resp. F 0.6	Class 1/3 B resp. F 0.1 Class A resp. F 0.15 Class B resp. F 0.3 Class 2B resp. F 0.6	Class B resp. F 0.3 Class 2B resp. F 0.6 tolerance defined by HST
Nominal resistances	Class B resp. F 0.3	00 Ω, 500 Ω and 1000 Ω at 0 °C	100 Ω, 500 Ω, 1000 Ω at 0 °C	100 Ω, 500 Ω, 1000 Ω, 2000 Ω and 10000 Ω at 0 °C	100 Ω and 1000 Ω at 0 °C
Soldering connection	AgPd leads	AgPd leads	Ni leads	Pt coated Ni wire	PtPd, PtNiCr, Pt leads
Long-term stability	Typical R0-drift 0.03 % after 1000 h at 150 °C	Typical R0-drift 0.04 % after 1000 h at 400 °C		Typical R0-drift 0.04 % after 1000 h at 500 °C	HM: 1000 h at 600 °C (energized
Measuring current	at 100 Ω: 0.3 to 1.0 mA at 1000 Ω: 0.1 to 0.3 mA (self-heating has to be considered)	at 100 Ω: 0.3 to 1.0 mA at 500 Ω: 0.1 to 0.7 mA at 1000 Ω: 0.1 to 0.3 mA (self-heating has to be considered)	at 100 Ω: 0.3 to 1.0 mA at 500 Ω: 0.3 to 1.0 mA at 1000 Ω: 0.1 to 0.3 mA (self-heating has to be considered	at 100 Ω: 0.3 to 1.0 mA at 500 Ω: 0.1 to 0.7 mA at 1000 Ω: 0.1 to 0.3 mA at 2000 Ω: 0.1 to 0.3 mA	100 Ω: 0.3 to max 1 mA 1000 Ω: 0.1 to max 0.3 mA (self-heating has to be considered
Environmental conditions	Use unprotected only in dry environments	Use unprotected only in dry environments	Unhoused for dry environments only, with operating temperatures > 450 °C in housings with ventilation	Use unprotected only in dry environments	HM version Unprotected only for use in dry ambient. HL version
Insulation resistance	> 100 M Ω at 20 °C	> 100 M Ω at 20 °C; > 2 M Ω at 400 °C	> 100 M Ω at 20 °C; > 2 M Ω at 500 °C	> 100 M Ω at 20 °C; > 2 M Ω at 500 °C	> 100 MΩ at 20 °C; > 2 MΩ at 650 °C
Packaging	Shipment < 500 pcs. in plastic box > 500 pcs.	Plastic box, plastic bag	Plastic tube	Blister reel, plastic bag	Plastic bag

This table explains the comparison of different types of platinum temperature sensors. Here the different properties like tolerance class, nominal resistances, Long term stability, measuring current at different resistances and Insulation resistance for different types of platinum sensors is shown. Some other points like applications, soldering connections, Environmental conditions and packaging are also covered within the table.

D. *Nominal values*

The nominal or rated value of the sensor is the target value of the sensor resistance at 0° C. The temperature coefficient α is defined as

$$\alpha = \frac{R_{100} - R_0}{100 \cdot R_0} \quad [K^{-1}]$$

and has the numerical value of 0.00385 K^{-1} according to DIN IEC 751.

In practice, a value multiplied by 10^6 is often entered:

$$TCR = 10^6 * \frac{R_{100} - R_0}{100 \cdot R_0} \quad [ppm/K].$$

In this case, the numerical value is 3850 ppm/K.

E. *Measurement current*

Measurement current causes heating of the platinum thin-film sensor. The resulting temperature error is given by: $\Delta T = P/E$ with P, the power loss = I^2R and E, the self heating coefficient in mW/K. The amount of thermal transfer from the sensor in application determines how much measuring current can be applied. There is no bottom limit of the measurement current with platinum thin-film. The measurement current depends highly on the application in use.

It recommended at:

100 Ω: typ. 1mA max. 5 mA
500 Ω: typ. 0.5 mA max. 3 mA
1000 Ω: typ. 0.3 mA max. 2 mA
2000 Ω: typ. 0.2 mA max. 1 mA
10000 Ω: typ. 0.1 mA max. 0.3 mA

F. *Temperature Characteristic Curve*

The characteristic temperature curve determines the dependence of the electrical resistivity on the temperature. The following definition of the temperature curve according to the DIN EN 60751 standard applies:

-200 to 0°C $R(t) = R0 (1 + A * t + B * t^2 + C * [t-100] * t^3)$

0 to 850°C $R(t) = R0 (1 + A * t + B * t^2)$

Platinum (3850 ppm/K):
$A = 3.9083 * 10^{-3} [°C^{-1}]$; $B = -5.775 * 10^{-7} [°C^{-2}]$;
$C = -4.183 * 10^{-12} [°C^{-4}]$

Platinum (3750 ppm/K):
$A = 3.8102 * 10^{-3} [°C^{-1}]$; $B = -6.01888 * 10^{-7} [°C^{-2}]$;
$C = -6 * 10^{-12} [°C^{-4}]$

R0 = Resistance value in ohm at 0°C
t = temperature in accordance with ITS 90

V. Conclusion

In recent generations of household appliances, there has been a noticeable increase in the use of electronic circuits. The use of such control circuits has led to increased appliance functionality, a reduction in the use of resources, and effective and lasting savings in household costs. Exact temperature measurements combined with carefully designed electronic controllers extend the lifetime of both an appliance and its components. For precise temperature measurement, the electronic control circuit requires the signal from an accurate temperature sensor.

In principle platinum sensors can be used for applications in the temperature range -200°C to +1,000°C. In the kitchen, temperatures typically ranging between 200°C and 600°C are measured. The ability to accurately measure lower temperatures opens the possibility of using platinum sensors in fridges, freezers, washing machines and tumble dryers. Given these prospects, it is clear that the end of the road leading to the intelligent kitchen and household has not yet been reached.

This survey shows the different properties of different platinum temperature sensors, which will give a helping platform to reach the goal of intelligent kitchen and household. This gives the view to select a proper sensor according to requirement.

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Mrs. Ranjana Trivedi, received the Post Graduate degree in Digital Communication from the MBM Engineering College, Jodhpur, India in 2010,and the B.E. degree from Engineering college Bikaner, India in 2005.She has Joined as Senior Member of the Department of ECE of JIET Group of Institution, India in the year 2008 with the teaching experience of various college by 2005 .Since then she is also active member in many curricular and non curricular activities. She has also presented paper in more then 10 National and International Conferences and attended various workshops. She have also written a paper on Fractal Antennas for an International Journal and again she is an author of a book on "Antenna and Wave Propagation" by Scientific Publisher. She is also member of UACEE.

Mrs. Geetika Mathur, received the Post Graduate degree in Digital Communication from RTU, India in 2011, and the B.E. degree from Modi college of Engineering, India in 2005.She has Joined as Senior Member of the Department of ECE of JIET Group of Institution, India in the year 2008 with the teaching experience of various college from 2005 .Since then she is also active member in many curricular and non curricular activities. She has also presented paper in more then 10 National and International Conferences and attended various workshops. She has also written a paper on "Fractal Antennas: shrinking the size of antenna"

for an International Journal and again she is an author of a book on "Antenna and Wave Propagation" by Scientific Publisher. She is also a member of UACEE.

Mr. Ashish Mathur, received the Post Graduate degree in Digital Communication from RTU, India in 2011, and the B.E. degree from SBCET Engineering college, India in 2005.He has Joined as Senior Member of the Department of ECE of JIET Group of Institution, India in the year 2008 with the teaching experience of various college from 2005 .Since then he is also active member in many curricular and non curricular activities. He has also presented paper in more then 10 National and International Conferences and attended various workshops. He has also written a paper on "Fractal Antennas: shrinking the size of antenna" for an International Journal and again she is an author of a book on "Antenna and Wave Propagation" by Scientific Publisher. He is also a member of UACEE.