The Pt100 Sensor.

DESCRIPTION

Pt100 is the common abbreviation for the most common type of resistance temperature sensor used in industry.

It has a specified resistance of 100.00 ohms at 0°C and is made of Platinum which has an accurately defined resistance vs. temperature characteristic.

There are two minor variations, the most common giving 138.50 ohms at 100°C (DIN standard) and the other giving 139.00 ohms at 100°C (popular in Japan). *It is most important to know which you are using when ordering or calibrating instrumentation.*

Because accurate tables of resistance v. temperature are available it is common practice to calibrate instruments using precision decade boxes from table values.

Pt100 sensors were originally made with platinum wire wound on a ceramic former but are now made more cheaply by depositing a platinum film onto a ceramic substrate.

Typical accuracies are 0.2%, 0.1% and 0.05% of value at 0°C. The higher the accuracy the higher the price.
Note that there are two error characteristics, an offset error (ie. how far out it is at 0°C) and a span or gain error (ie. how the resistance change with tempearture agrees with the theoretical figure). The gain error depends on the offset error and the impurities in the platinum.

These sensors are also made in 200, 500, and 1000 ohms values.

Although the sensors are sold loose, it is usual to buy them made up into stainless steel probes for insertion into processes.

TEMPERATURE CHARACTERISTICS

Pt100 elements are specified over a temperature range of -200°C to 850°C however the actual operating temperature is determined by the construction of the probe into which they are incorporated. Typical low cost probes are made by soldering the Pt100 to PVC or silicon insulated copper wires. Obviously these are limited by the maximum temperature of the insulation. For higher temperature work the Pt100 is silver soldered or crimped onto mineral insulated wires and embedded in an insulating medium such as aluminium oxide powder.

At higher temperatures the platinum film can slowly evaporate which permanently changes the resistance of the sensor.

ERRORS

The low resistance of the Pt100 means that lead resistance can introduce noticeable errors. Lead resistance introduces two errors, an offset error caused by the lead resistance itself (which can be trimmed out) and a change in lead resistance with temperature (which cannot be trimmed out). These can both be overcome by the use of 3-wire and 4-wire compensation circuits.

Most probes are made in 3-wire configuration with one wire attached to one terminal and two wires attached to the other. In a bridge circuit the two wires end up in opposite arms of the bridge and their resistances cancel.

Note that 3-wire compensation is theoretically perfect only in constant current bridges. Constant voltage bridges are only perfect when the bridge is balanced, however in most cases the error is insignificant.

For two wire operation (normally very short cables) the twin wires are usually joined together.

Another cause of error is internal self heating. Because a current must be passed through the sensor to obtain a voltage signal for the electronics there is a small amount of power generated which causes the sensor to warm up and thereby changing its resistance. A large current will give a nice big signal for the electronics but also a larger self heating error. A small current reduces this error but lower drift electronics is required to minimize errors from the circuit. The best trade off depends on the application however generally currents of the order of 1mA or less are typically used. Self heating errors are larger when measuring gas temperatures because of the poorer heat dissipation from the sensor.

The resistance/temperature characteristic of a Pt100 is not linear although for many applications the error is acceptable without correction.

A typical example: 0°C = 100ohm, 50°C = 119.4ohm, 100°C = 138.5ohm. Calibrating an instrument such that 0°C = 0% and 100°C = 100% will give a reading at 50°C = 50.4%.

There are several differing techniques for correcting the non-linearity of a Pt100 sensor including break point linearizers, and look up tables, but a simple technique is to slightly vary the current through the sensor as its value changes. Careful component selection can reduce the error by a factor of 10 or better.

DISADVANTAGES?

Most people regard the major disadvantages of the Pt100 sensor over other industrial sensors, such as thermocouples, as response time and physical strength.

Modern Pt100 sensors are now so small and light that the response time no longer depends on the sensor itself. The response time of a Pt100 in a stainless steel sheath will be almost identical to that of an insulated thermocouple in an identical sheath because the thermal characteristics of the sheath are the major contributing factor.

The physical strength of a thermocouple is still superior but a Pt100 sensor properly packed in aluminiun oxide in a stainless steel sheath should withstand everything short of a direct blow from a hammer.

COMPARISON OF SENSORS

	THERMOCOUPLE	PT100	THERMISTOR	SOLID STATE DEVICES
OPERATING RANGE	Very wide: Type T can go down below -200°C. Type W5 can approach 1800°C	Wide: -200°C to 600°C	Narrow. Typically -40°C to 300°C	Very narrow: Typically -40°C to 125°C
PRICE	Generally inexpensive although type R & S use expensive platinum wire.	Fairly inexpensive	Low accuracy types very inexpensive - high accuracy types more expensive than Pt100	Inexpensive
ACCURACY	Moderate	Excellent	Poor to excellent	Moderate
LINEARITY	Poor	Good	Terrible	Very good
PHYSICAL STRENGTH	Excellent	Poor to very good - Depends on probe construction	Poor to very good - Depends on probe construction	Good to very good - Depends on probe construction
CHANGE IN CHARACTERISTIC WITH TEMPERATURE	Small	Reasonable	Very large	Large
LONG TERM STABILITY	Reasonable	Excellent	Poor to excellent	Reasonable
PREFERRED APPLICATIONS	Industrial processes where temperature range or physical requirements preclude other devices.	All industrial processes within operating range where accuracy and repeatability are required.	Preset temperature applications. Control where narrow hysteresis is required.	Simple control applications and ambient compensating circuits.

MY OPINION

The Pt100 is my preferred sensor for all industrial applications from -200°C to 600°C. It is accurate, relatively inexpensive and easy to use. Its output change with temperature is relatively large compared to thermocouples which means lower drift errors on the electonics.

For the majority of applications Pt100 probes may be replaced with no recalibration of instruments.

Because its resistance bears an absolute relationship to temperature (unlike a thermocouple whose output depends on the difference between the hot junction and cold junction) no special compensating circuit needs to be provided in the electronics.

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MORE TO BE ADDED AS TIME PERMITS.

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