Semiconductor Temperature Sensors

Semiconductor temperature sensors are the devices which come in the form of *integrated circuits* i.e. *ICs* hence, popularly known as **IC temperature sensors**. These are the electronic devices manufactured in an identical fashion to present-day electronic semiconductor devices like microprocessors. More than thousands of devices can be fabricated upon thin silicon wafers. A whole new range of semiconductor temperature sensors is arriving from different manufacturers. However, the most popular ones include *AD590* and the *LM35*.
"Their design results from the fact that semiconductor diodes have temperature-sensitive voltage vs. current characteristics. When two identical transistors are operated at a constant ratio of collector current densities, the difference in base-emitter voltages is directly proportional to the absolute temperature."[1]

Main Features

Major characteristics of semiconductor thermometers include:

- They provide reasonably linear output.
- They are available in moderately small sizes
- They are not capable enough to measure high temperatures. Their temperature range is typically limited between -40 to +120°C.
- They give fairly accurate temperature readings if properly calibrated.
- They offer very small interchangeability.
- Semiconductor temperature sensors are not suitably designed for making well thermal contact with external surfaces.
- Use of these temperature sensors enables simple interfacing with other electronic devices like amplifiers, regulators, Digital signal processors, and microcontrollers etc.
- These types of temperature sensors are considered ideal for embedded applications where they are installed within the equipment itself.
- Unlike other temperature sensors like thermocouples and RTDs, their electrical and mechanical performance is not very robust.

Types of Semiconductor Sensors

Semiconductor temperature sensors can be broadly classified into following major five types:

Voltage Output Temperature Sensors

These types of sensors usually need a source of power supply for excitation. They give an effective linear output in the form of voltage signals. Besides, they offer quite low output impedance.

Current Output Temperature Sensors

As opposed to voltage output temperature sensors, the output impedance of these sensors is very high. They usually function as constant current regulators which are designed to pass 1 micro-amp per degree Kelvin. They also need an input voltage which can vary between 4 and 30 V.

Digital Output Temperature Sensors

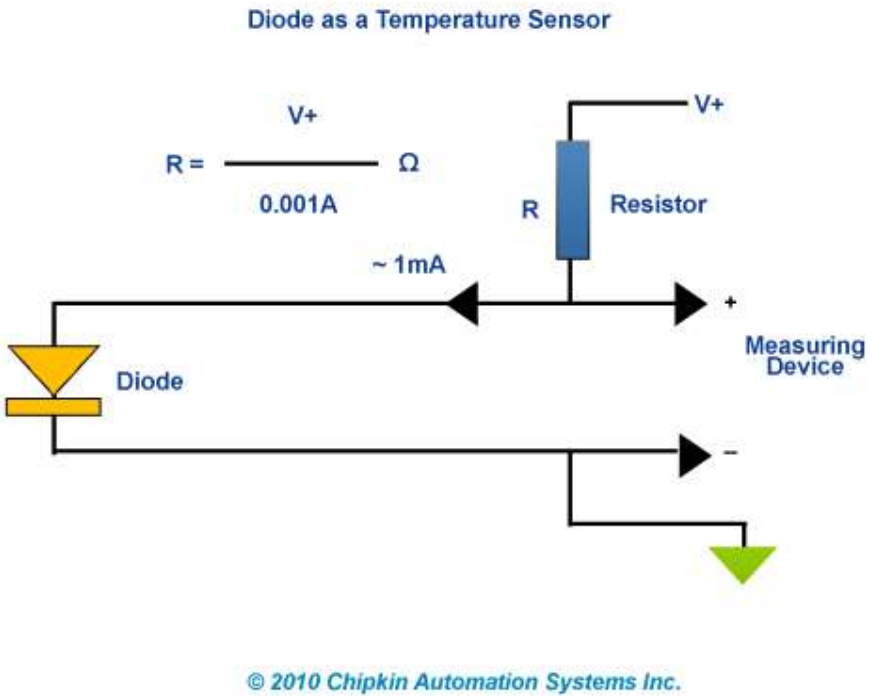
These are the foremost sensors designed for the integration of a sensor and an analog to digital converter on an IC chip. These sensors don't provide standard digital interfaces. Hence, they can not be employed for measurement with standard measuring devices. Some of them are specially fabricated to enable their use with microprocessors for thermal management.

Resistance Output Silicon Temperature Sensors

These are simple temperature sensors designed with the help of typical semiconductor manufacturing equipment. The usual temperature resistance characteristics of semiconductor materials make their use simpler. Besides, these sensors offer high class tolerance to ion migration hence found to be additionally stable as compared to other semiconductor temperature sensors. However, extra care must be exercised while employing these sensors owing to their other characteristics.

Diode Temperature Sensors

These sensors are made up by using regular PN junction diodes. These are the most inexpensive type of temperature sensors which are competent enough to provide very adequate results if constant and steady excitation current is supplied to them. Also, they need a two point calibration for satisfactory operation. An ordinary semiconductor diode provides a sensibly linear forward biased voltage whose temperature coefficient is around 2.3mV/°C. A typical diode temperature sensor is shown in the figure below.



Selection Criteria

While selecting a semiconductor temperature sensor for a particular application, one must keep in mind following key points:

1. Select the level of accuracy needed
2. Choose the desired range of temperature
3. Consider the costing requirements
4. Identify the input capabilities of the measuring devices

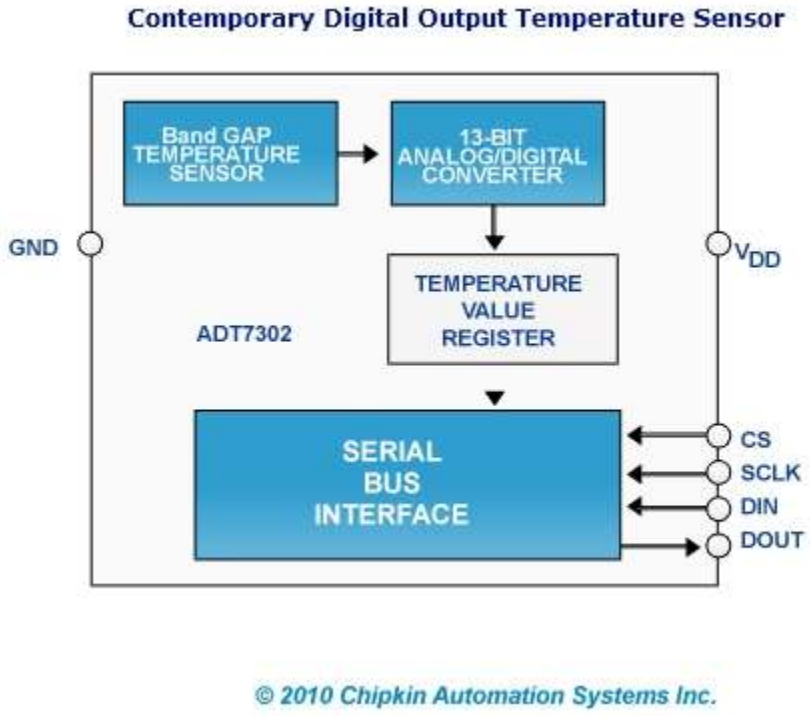
Analog Temperature Sensors

These types of temperature sensors generate a voltage or current output signal which is fundamentally linear and directly proportional to temperature. Introduction of analog temperature sensors purged the requirement of supplementary linearization circuitry which was earlier needed with thermistor solutions for improvement in their nonlinearity.

Digital Temperature Sensors

These sensors are far more advanced than analog temperature sensors. Instead of providing output in current or voltage form, they give out digital signals in the form of 1's and 0's which are normally transmitted digital communication lines like single-wire PWM, two-wire I2C, or a multiple wire SPI connection. Since the field of semiconductor temperature sensors is evolving, this new breed of digital

temperature sensors is bestowed with a variety of useful features and interfaces. They can detect temperature in both local and remote areas. Besides, they can examine other important parameters such as system voltage etc. Other constructive features include fan control, and over or under limit alarms. These temperature sensors are best suited for interfacing to a microcontroller. A contemporary digital output temperature sensor is shown in the figure below.



Other Variations

Although advanced digital output temperature sensors have replaced the use of analog temperature sensors in many areas, yet analog sensors have suitably find their use in areas which do not necessitate output in digital format. Also in applications where final output is required in digital form only, one can use analog temperature sensors integrated with an analog to digital (A/D) converter. This arrangement would simplify the designer job and result in cost, space, and power savings too.