LM35 Temperature Sensor Pin out, Interfacing guide, Circuit Construction and Working Principals

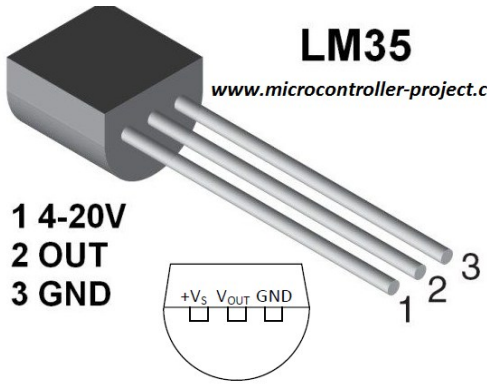
By EG Projects

LM35 is a temperature sensor that outputs an analog signal which is proportional to the instantaneous temperature. The output voltage can easily be interpreted to obtain a temperature reading in Celsius. The advantage of lm35 over thermistor is it does not require any external calibration. The coating also protects it from self-heating. Low cost (approximately $0.95) and greater accuracy make it popular among hobbyists, DIY circuit makers, and students. Many low-end products take advantage of low cost, greater accuracy and used LM35 in their products. Its approximately 15+ years to its first release but the sensor is still surviving and is used in any products.

LM35 Temperature sensor Features

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Operates from 4 V to 30 V
- Less than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

LM35 Pin Out



LM35 Pin out

LM35 can measure from -55 degrees centigrade to 150-degree centigrade. The accuracy level is very high if operated at optimal temperature and humidity levels. The conversion of the output voltage to centigrade is also easy and straight forward.

The input voltage to LM35 can be from +4 volts to 30 volts. It consumes about 60 microamperes of current. Lm35 has many family members a few names are LM35C, LM35CA, LM35D, **LM135**, **LM135A**, **LM235**, **LM335**. All LM35 family members work on the same principles but temperature measuring capacity varies and also they are available in many packages (SOIC, TO-220, TO-92, TO).

LM35 Working Principle (Understanding LM35 Linear Scale Factor)

LM35 scale factor

In order to understand the working principle of LM35 temperature sensor we have to understand the linear scale factor. In the features of LM35 it is given to be **+10 mills volt per degree centigrade**. It means that with increase in output of 10 mills volt by the sensor vout pin the temperature value increases by one. For example, if the sensor is outputting 100 mills volt at vout pin the temperature in centigrade will be 10-degree centigrade. The same goes for the negative temperature reading. If the sensor is outputting -100 mills volt the temperature will be -10 degrees Celsius.

LM35 temperature sensor circuit configuration

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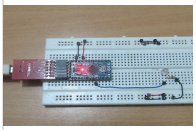
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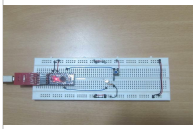
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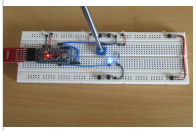
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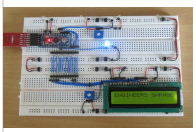
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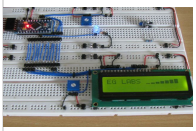
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Designing a Switched Mode Power Supply (SMPS)

LM35 can be used in two circuit configurations. Both yield different results. In the first configuration, you can only measure the positive temperature from 2 degrees Celsius to 150 degrees Celsius. In this first configuration, we simply power lm35 and connect the output directly to analog to digital converters. In the second configuration, we can utilize all the sensor resources and can measure the full range temperature from -55 degree centigrade to 150-degree centigrade. This configuration is a little complex but yields high results. We have to connect an external resistor, in this case, to switch the level of negative voltage upwards. The external resistor value can be calculated from the formula given below the configuration circuit. The second configuration circuit can be made in various ways.To see about the second configuration circuits visit the LM35 **datasheet** by Texas Instruments. Texas Instruments **data sheet** enlists the circuit with clear component values.

Although the first configuration did not need a resistor at the output side, I recommend connecting an 80 k to 100 k resistor between vout and gnd pin. When I performed several experiments I noticed that the readings some time fluctuate and the vout pin floats. So a resistor between vout and gnd tights the vout pin low and prevents the pin from floating.

PARAMETER	VALUE
Accuracy at 25°C	±0.5°C
Accuracy from –55 °C to 150°C	±1°C
Temperature Slope	10 mV/°C

LM35 accuracy level

The accuracy parameters for both configurations are different. The average accuracy level is +- 1 degree Celsius for both configurations. But the accuracy level decreases for temperature between 2 degrees to 25-degree centigrade. Now that we have discussed the LM35 temperature sensor pinout, structure, linear scale factor and accuracy level its time to list down the steps on how to measure temperature using LM35 temperature sensor.

Steps to calculate temperature using LM35 temperature sensor

- Build circuit.
- Power LM35 vcc to +5-20 volts and gnd to ground.
- Connect Vout to analog to digital converter input.
- Sample the ADC reading, vout output voltage.
- Convert the voltage to temperature.

Formula to convert voltage to temperature

The formula to convert the voltage to centigrade temperature for LM35 is

Centigrade Temperature = Voltage Read by ADC / 10 mV(mills Volt)

I divided by 10 mV because Linear scale factor is for LM35 is 10mV.

Following the above steps and tutorial, you can easily interface LM35 temperature sensor with any microcontroller that has a built-in analog to digital converter pins. Almost all the microcontrollers today have built-in ADC.

Some projects that are created using LM35 and different microcontrollers.

LM35 temperature monitor over wifi

LM35 measuring temperature with Arduino

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