Temperature Sensors

Here are some examples of Temperature Sensors:

• TMP36 Temperature Sensor
• Thermistor 10K
Hardware

- DAQ Device (e.g., USB-6008)
- Breadboard
- TMP36 Temperature Sensor
- Thermistor 10K (Temperature Sensor)
- Resistor, $R = 10k\Omega$
- Wires (Jumper Wires)
Breadboard

A breadboard is used to wire electric components together.
The Breadboard is used to connect components and electrical circuits.

Make sure not to short-circuit the components that you wire on the breadboard.
TMP is a small, low-cost temperature sensor and costs about $1 (you can buy it “everywhere”)
<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature measurement range</td>
<td>-40…+125 °C</td>
</tr>
<tr>
<td>Accuracy</td>
<td>±2 °C</td>
</tr>
<tr>
<td>Power supply</td>
<td>2.3…5.5 V</td>
</tr>
<tr>
<td>Package</td>
<td>TO-92</td>
</tr>
<tr>
<td>Temperature sensitivity, voltage</td>
<td>10 mV/°C</td>
</tr>
</tbody>
</table>
TMP36 Temperature Sensor

A Temperature sensor like TM36 use a solid-state technique to determine the temperature.

They use the fact as temperature increases, the voltage across a diode increases at a known rate.

https://learn.adafruit.com/tmp36-temperature-sensor
TMP36 Datasheet

![Graph showing output voltage vs. temperature forTMP35, TMP36, and TMP37 with +VS = 3V.](http://no.rs-online.com/webdocs/14cd/0900766b814cd0a1.pdf)
Linear Scaling

Convert form Voltage (V) to degrees Celsius

From the Datasheet we have:

\[(x_1, y_1) = (0.75V, 25^\circ C)\]
\[(x_2, y_2) = (1V, 50^\circ C)\]

There is a linear relationship between Voltage and degrees Celsius:

\[y = ax + b\]

We can find a and b using the following known formula:

\[y - y_1 = \frac{y_2 - y_1}{x_2 - x_1} (x - x_1)\]

This gives:

\[y - 25 = \frac{50 - 25}{1 - 0.75} (x - 0.75)\]

Then we get the following formula:

\[y = 100x - 50\]
Necessary Equipment

- PC
- DAQ Module, e.g., USB-6008
- Breadboard
- TMP36
- Wires (Jumper Wires)
Here you see a wiring examples using Arduino. You make the same wiring using a DAQ device like USB-6008 or similar.
We connect the TMP36 to LabVIEW using a USB DAQ Device from National Instruments, e.g., USB-6001, USB-6008 or similar. I have used a breadboard for the wiring.
We want to present the value from the sensor in degrees Celsius:

1. Read Signal from DAQ Device (0-5V)
2. Convert to degrees Celsius using information from the Datasheet
3. Show/Plot Values in your Application GUI
LabVIEW Example
const int temperaturePin = 0;

float adcValue;
float voltage;
float degreesC;

void setup()
{
  Serial.begin(9600);
}

void loop()
{
  adcValue = analogRead(temperaturePin);
  voltage = (adcValue*5)/1023;
  degreesC = 100*voltage - 50;
  Serial.print("ADC Value: ");
  Serial.print(adcValue);
  Serial.print("  voltage: ");
  Serial.print(voltage);
  Serial.print("  deg C: ");
  Serial.println(degreesC);
  delay(1000);
}
Celsius to Fahrenheit Conversion

In Norway we typically use Celsius as temperature unit, while in US they use Fahrenheit.

Conversion between these are as follows:

\[ T_F = \frac{9}{5} T_C + 32 \]
Thermistor 10kΩ

https://www.halvorsen.blog
Thermistor

A thermistor is an electronic component that changes resistance to temperature - so-called Resistance Temperature Detectors (RTD). It is often used as a temperature sensor.

Our Thermistor is a so-called NTC (Negative Temperature Coefficient). In a NTC Thermistor, resistance decreases as the temperature rises.

There is a non-linear relationship between resistance and excitement. To find the temperature we can use the following equation (Steinhart-Hart equation):

$$\frac{1}{T} = A + B \ln(R) + C (\ln(R))^3$$

where $A, B, C$ are constants given below

$A = 0.001129148, B = 0.000234125$ and $C = 8.76741E−08$
To find the Temperature we can use Steinhart-Hart equation:

$$\frac{1}{T_K} = A + B \ln(R) + C (\ln(R))^3$$

This gives:

$$T_K = \frac{1}{A + B \ln(R) + C (\ln(R))^3}$$

Where the Temperature $T_K$ is in Kelvin

$A, B$ and $C$ are constants

The Temperature in degrees Celsius will then be:

$$T_C = T_K - 273.15$$
Necessary Equipment

- PC
- DAQ Module, e.g., USB-6008
- Breadboard
- Thermistor
- Resistor 10 kΩ
- Wires (Jumper Wires)
Here you see a wiring example using Arduino. You make the same wiring using a DAQ device like USB-6008 or similar.
We connect the TMP36 to LabVIEW using a USB DAQ Device from National Instruments, e.g., USB-6001, USB-6008 or similar. I have used a breadboard for the wiring.
The wiring is called a “Voltage divider”:

[https://en.wikipedia.org/wiki/Voltage_divider]
General Voltage Divider

\[ V_{out} = V_{in} \cdot \frac{R_2}{R_1 + R_2} \]

https://learn.sparkfun.com/tutorials/voltage-dividers/all
Voltage Divider for our system

Voltage Divider Equation:

\[ V_{\text{out}} = V_{\text{in}} \frac{R_t}{R_0 + R_t} \]

We want to find \( R_t \):

\[ R_t = \frac{V_{\text{out}}R_0}{V_{\text{in}} - V_{\text{out}}} \]

Steps:

1. We wire the circuit on the Breadboard and connect it to the DAQ device
2. We measure \( V_{\text{out}} \) using the DAQ device
3. We calculate \( R_t \) using the Voltage Divider equation
4. Finally, we use Steinhart-Hart equation for finding the Temperature

\( R_t \) - 10k Thermistor. This varies with temperature. From Datasheet we know that \( R_t = 10k\Omega \) @25℃
const int temperaturePin = 0;

void setup()
{
  Serial.begin(9600);
}

void loop()
{
  int temperature = getTemp();
  Serial.print("Temperature Value: ");
  Serial.print(temperature);
  Serial.println("*C");
  delay(1000);
}

double getTemp()
{
  int RawADC = analogRead(temperaturePin);
  long Resistance;
  double Temp;

  // Assuming a 10k Thermistor. Calculation is actually: Resistance = (1024/ADC)
  Resistance=((10240000/RawADC) - 10000);

  // Utilizes the Steinhart-Hart Thermistor Equation:
  // Temperature in Kelvin = 1 / {A + B[ln(R)] + C[ln(R)]^3}
  // where A = 0.001129148, B = 0.000234125 and C = 8.76741E-08

  Temp = log(Resistance);
  Temp = 1 / (0.001129148 + (0.000234125 * Temp) + (0.0000000876741 * Temp * Temp * Temp));
  Temp = Temp - 273.15; // Convert Kelvin to Celsius
  return Temp;  // Return the Temperature
}
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