Measurement of Characteristic value of thermal sensor

Objective

- Get a precise relation function between temperature and unknown temperature sensor value.

Equipment

1. Target heated bed (attached target sensor)*
2. Multi-Meter*
3. 850 Universal interface (Pasco, UI-5000)
4. PasPort Non-Contact Temperature Sensor; Infrared light measurement (Pasco, PS-2197)
5. PasPort Temperature Sensor (Pasco, PS-2125)
6. Stand
7. DC-Power Supply
8. Hot water*
9. Ice*

Theory and previous works

Circuit of heating bed

On Fig 1, the 472 rectangle is a SMD resistance whose value is 4.72 kΩ, the gray rectangle is a capacitance whose value is 8.59 µF. The rectangle above all components is a thermistor.

To figure out the real circuit, test the resistance value between nodes in Fig 1.

The result is Fig 2; the real circuit diagram.

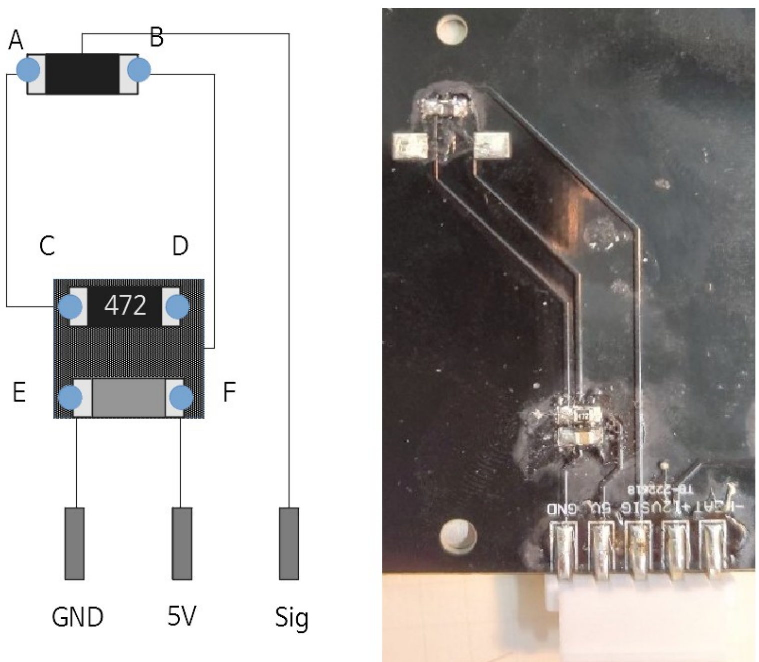

Fig 1: Outline circuit and node points

Arduino test of Sig node signal.

At 23~25C°, the 'analogRead()' function shows 974 value on Sig voltage it means≈ 4.75V(exists in range of *PASCO* interface) and its value decrease as the temperature increase. With circuit on Fig 2, we can know that it is a NTC resistance.

The NTC(Negative thermal coefficient) resistance decreases as temperature rises.

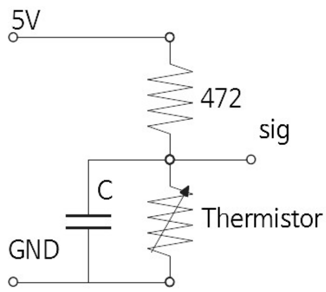

Fig 2: Thermistor circuit

NTC; B parameter equation

The usual model equation of thermistor is a *Steinhart-Hart equation.*

$$\frac{1}{T}=a+b\ln R+c(\ln R)^3$$

If thermistor is a NTC type then, coefficients are $a=1/T_0-(1/B)\ln R_0, b=1/B$ and $c=0$.

Then, the thermistor resistance can be calculated with next equation.

$$R=R_0 e^{B(\frac{1}{T}-\frac{1}{T_0})}$$

T_0 : The standard temperature (25 ºC = 298.15 K),
R_0 : The resistance at temperature T_0

On Fig 2, the resistance R can be calculated from sig voltage as

$$R=R_1(\frac{V_{sig}}{V_o-V_{sig}})$$

V_0 : The source voltage in case 5V,
R_1 : 472 Ω resistance value 4.72 kΩ,
V_{sig} : The voltage of signal point

Therefore, the V-T relationship is

$$T=\frac{B}{\ln(\frac{V_{sig}}{V_o-V_{sig}}\frac{R}{R_0}\exp(\frac{B}{T_0}))}$$

Calculation of max distance from surface to infrared sensor.

The sensor lenz area is $2.25\,mm^2$ for surface area source it must be in viewing angle lower than 92º as in Fig 1.

Therefore, the max distance from sensor to surface is

$$H_{max}=\frac{r+R}{\tan(46^o)}$$

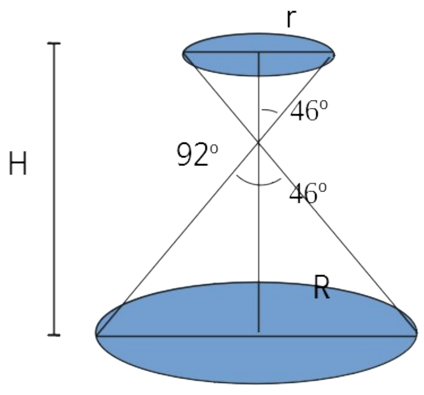

Fig 3: Calculation of max distance from object surface to sensor

Experimental Procedure	

Pilot experiment for get k value.

1. Fill the cup with hot water.

2. Connect temperature sensor to Interface.

3. Set infrared sensor closed to water surface but not touched.

4. Set capstone program plot the graph of $V = k(T_s^2 - T_d^2)$.

5. Collect data and add some ice to cool until 20K.

6. Linear fitting and calculate k value.

Measurement of Heating bed sensor value.

1. Set up the circuit as shown in Fig 3. The heated bed get heated just after the 12V power supplied, connecting 12V power last procedure. The height less than

2. The Heated bed is a 120mm x 120mm dimension rectangle shape.

3. Connect Infrared Sensor and Signal node of Bed to Analog input on interface.

4. Connect the 5V and GND node to interface.

5. Turn on the computer set x-axis as temperature, y-axis as signal voltage.

6. Collect data until it is heated up to 130 ℃ and cool down. Using $T = (kV_d + T_d^4)^{(1/4)}$

7. Fitting the curve.

$$T = \frac{B}{\ln\left(\frac{V_{sig}}{V_o - V_{sig}} \frac{R}{R_0} \exp\left(\frac{B}{T_0}\right)\right)}$$

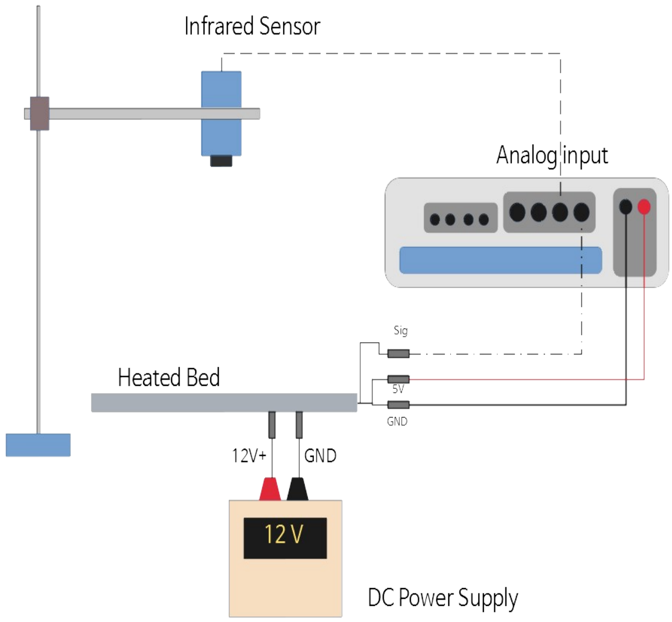

Fig 4: circuit setup