LAB 1

Internet of Things and Arduino

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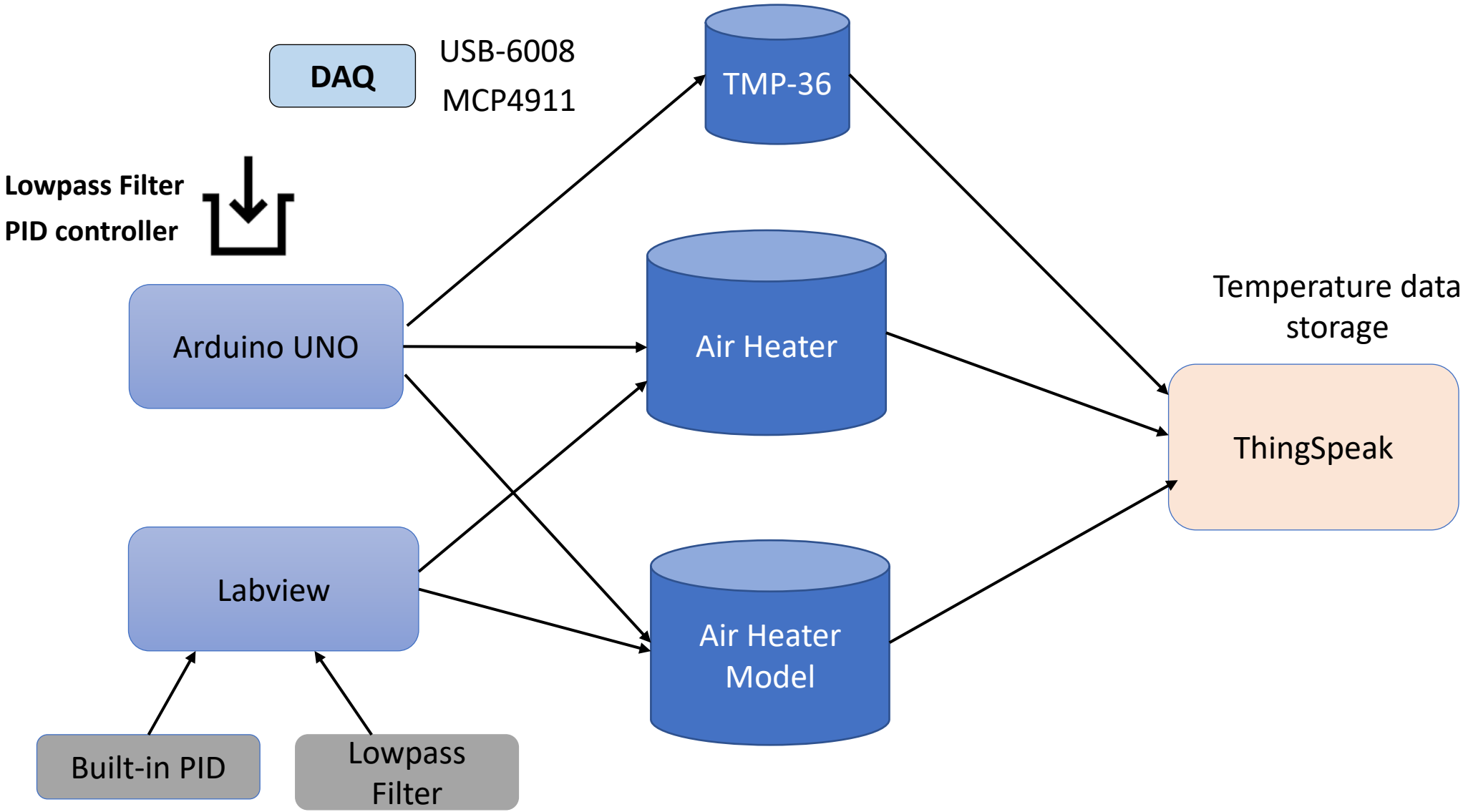
Industrial IT and Automation


DAQ
USB-6008
MCP4911
TMP-36
Lowpass Filter
PID controller
Arduino UNO
Air Heater
Temperature data storage
ThingSpeak
Labview
Air Heater Model
Built-in PID
Lowpass Filter

Create a PI controller using the Arduino Software (IDE)

Discrete PI controller Equation

$$u_k = u_{k-1} + K_p(e_k - e_{k-1}) + \frac{K_p}{T_i} T_s e_k$$

Where $e_k = r_k - y_k$

Simulation_AirHeater_MatModel_PiControl_Filter | Arduino 1.8.19

File Edit Sketch Tools Help

Simulation_AirHeater_MatModel_PiControl_Filter

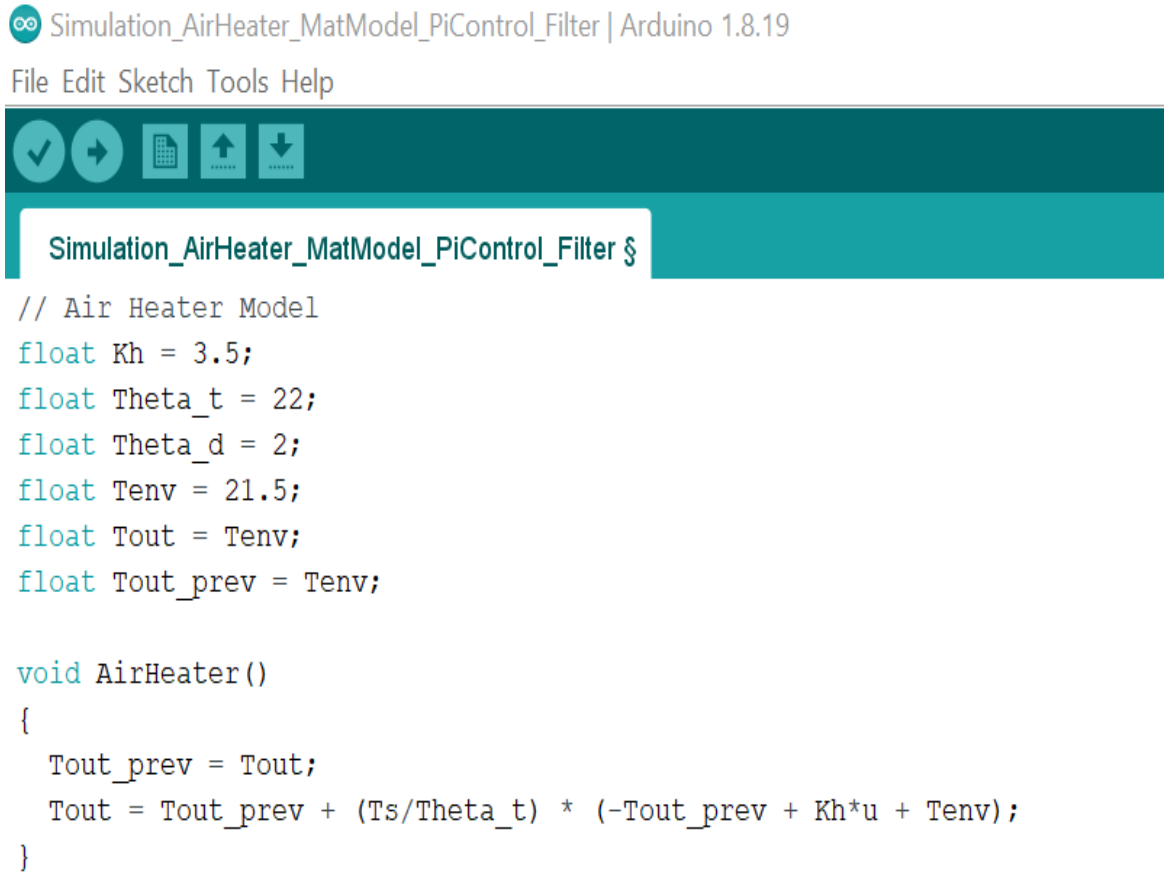
```
void loop()
{
  PiController();
  AirHeater();
  //LowPassFilter();
  SerialPlotter();
  k=k+1;
  delay(wait);
}
void PiController()
{
  u_prev = u;
  e = r - Tout;
  u = u_prev + Kp*(e - e_prev) + (Kp/Ti)*Ts*e;
  if (u < 0)
    u = 0;
  if (u > 5)
    u = 5;
  }
```

Create Air Heater Model using the Arduino Software (IDE)

Discrete Air Heater Model Equation

$$T_{out}(k+1) = T_{out}(k) + \frac{T_s}{\theta_t}\{-T_{out}(k) + [K_h u(k) + T_{env}]\}$$

Considering, Time delay =0



Create Lowpass Filter using the Arduino Software (IDE)

The discrete version of the Lowpass Filter:

$$y_f(k) = (1-a)y_f(k-1) + ay$$

Simulation_AirHeater_MatModel_PiControl_Filter | Arduir

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Simulation_AirHeater_MatModel_PiControl_Filter §

```
//Low Pass Filter
float Tf= 5*Ts;
float a= Ts/(Tf+Ts);
float y;
float yf;
float yf_prev= Tout;

void LowPassFilter()
{
  y = Tout;
  yf = (1-a)*yf_prev + a*y;
  yf_prev = yf;
  Tout = yf;
}
```

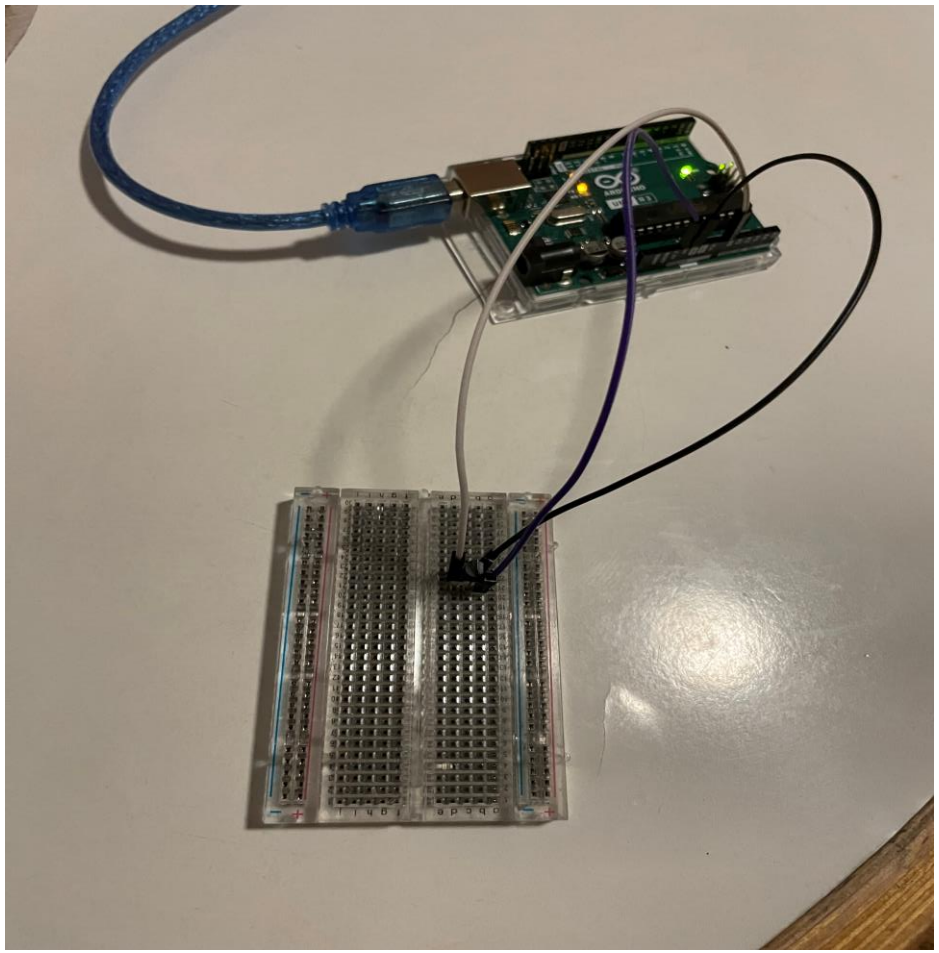
Test Lowpass Filter using a TMP36 Temperature Sensor

Temperature_data_from_TMP36_sensor_with_filter | Arduino 1.8.19

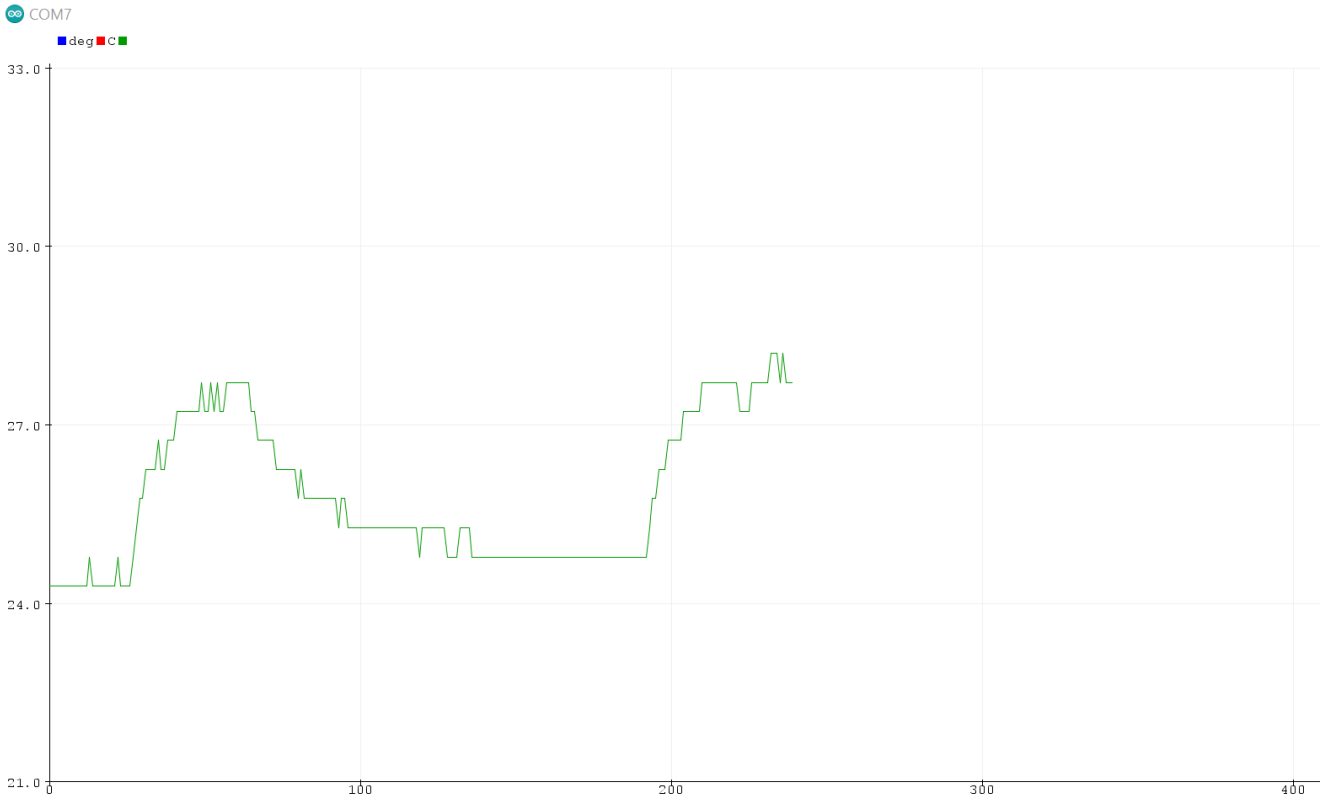
File Edit Sketch Tools Help

Temperature_data_from_TMP36_sensor_with_filter §

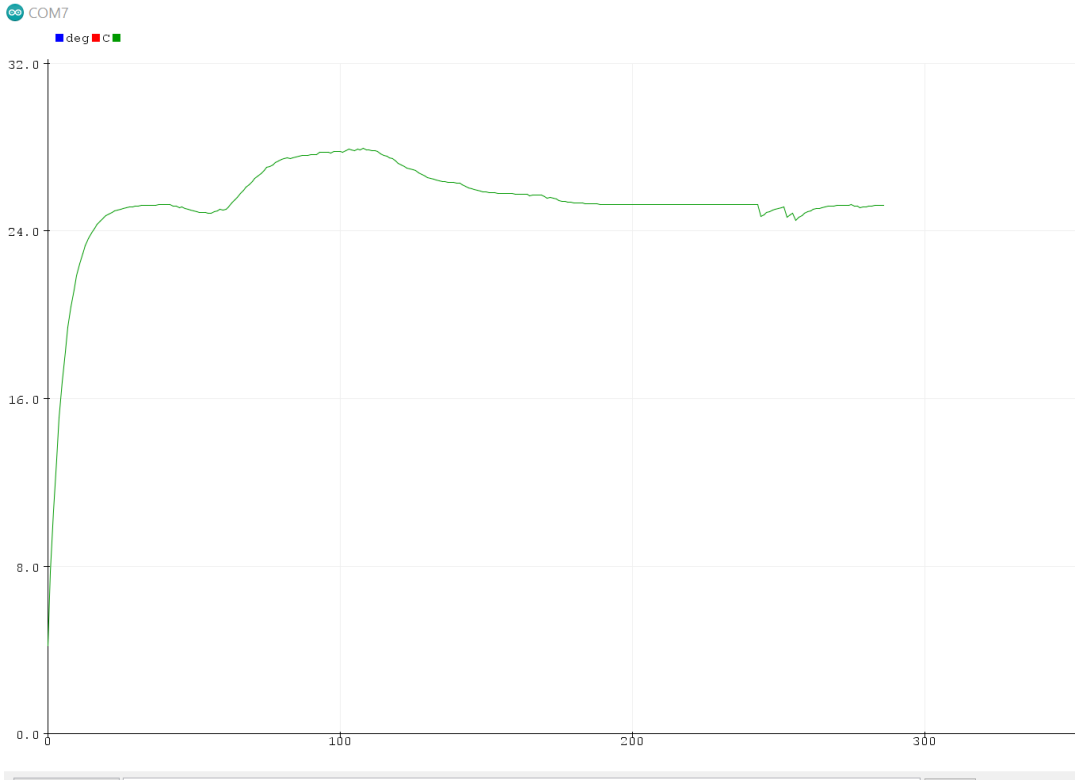
```
Serial.begin(9600);
}

void loop()
{
Temperature_TMP36();
LowPassFilter();
Serial.print(" deg C: ");
Serial.println(degreesC);
delay(1000);
}
void LowPassFilter()
{
  y = degreesC;
  yf = (1-a)*yf_prev + a*y;
  yf_prev = yf;
  degreesC = yf;
}

void Temperature_TMP36()
{
adcValue = analogRead(temperaturePin);
voltage = (adcValue*5)/1023;
degreesC = 100*voltage - 50;
}
```



Comparison of TMP36 sensor data



Temperature data without Lowpass filter



Temperature data with Lowpass filter

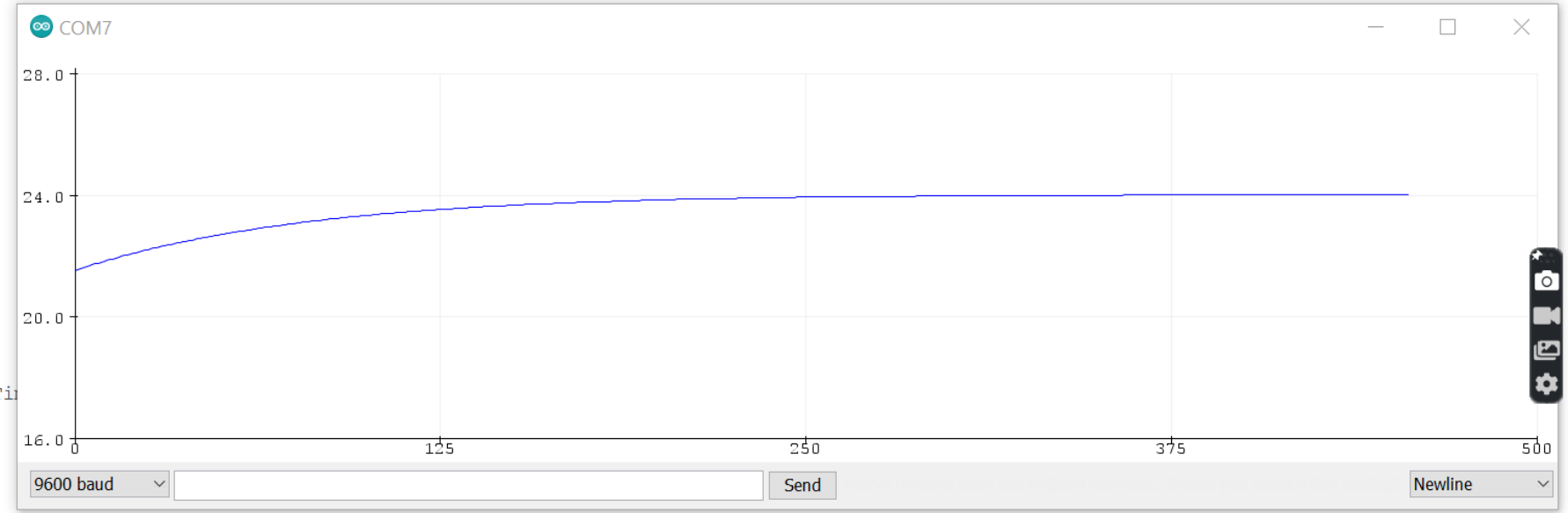
Air Heater Model Data

tempControl_Model_creatingLibrary | Arduino 1.8.19

File Edit Sketch Tools Help

tempControl_Model_creatingLibrary

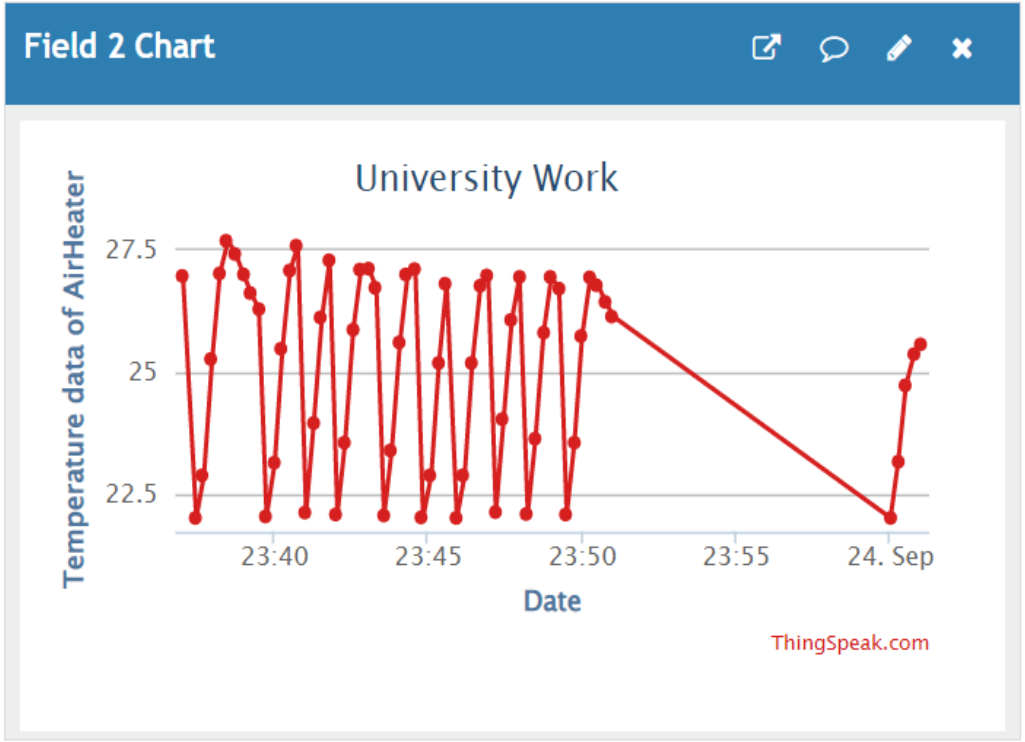
```
#include "TempControl.h"
//Initialization
// Simulation
float Ts = 0.1;
//Controller
float u = 0;
//Model;
float y_init = 21.5;
float y = y_init;
//Constructor
TempControl Tempcontrol(y_init);
void setup()
{
Serial.begin(9600);
//Simulation
Tempcontrol.Ts = Ts; //Sampling Ti
//Controller
Tempcontrol.Kp = 0.8;
Tempcontrol.Ti = 20;
Tempcontrol.r = 24; //Setpoint
}
void loop()
{
u = Tempcontrol.PiController(y);
y = Tempcontrol.AirHeaterModel(u);
```



Air Heater Model Data stored in ThingSpeak

Thingspeak_write_tempData_Model | secrets.h

```
  Serial.print("t=:");
  Serial.print(Ts*k);

  Serial.print(", u=");
  Serial.print(u);

  Serial.print(", Tout=");
  Serial.print(Tout);
  }

void ThingSpeakWrite()
{
  unsigned long myChannelNumber = SECRET_CH_ID;
  const char * myWriteAPIKey = SECRET_WRITE_APIKEY;
  int channelField = 2;

  int x = ThingSpeak.writeField(myChannelNumber, channelField,
  temperatureValue, myWriteAPIKey);
  if(x == 200){
   Serial.println("Channel update successful.");
  }
  else{
    Serial.println("Problem updating channel. HTTP error code " + String(x));
  }
}
```

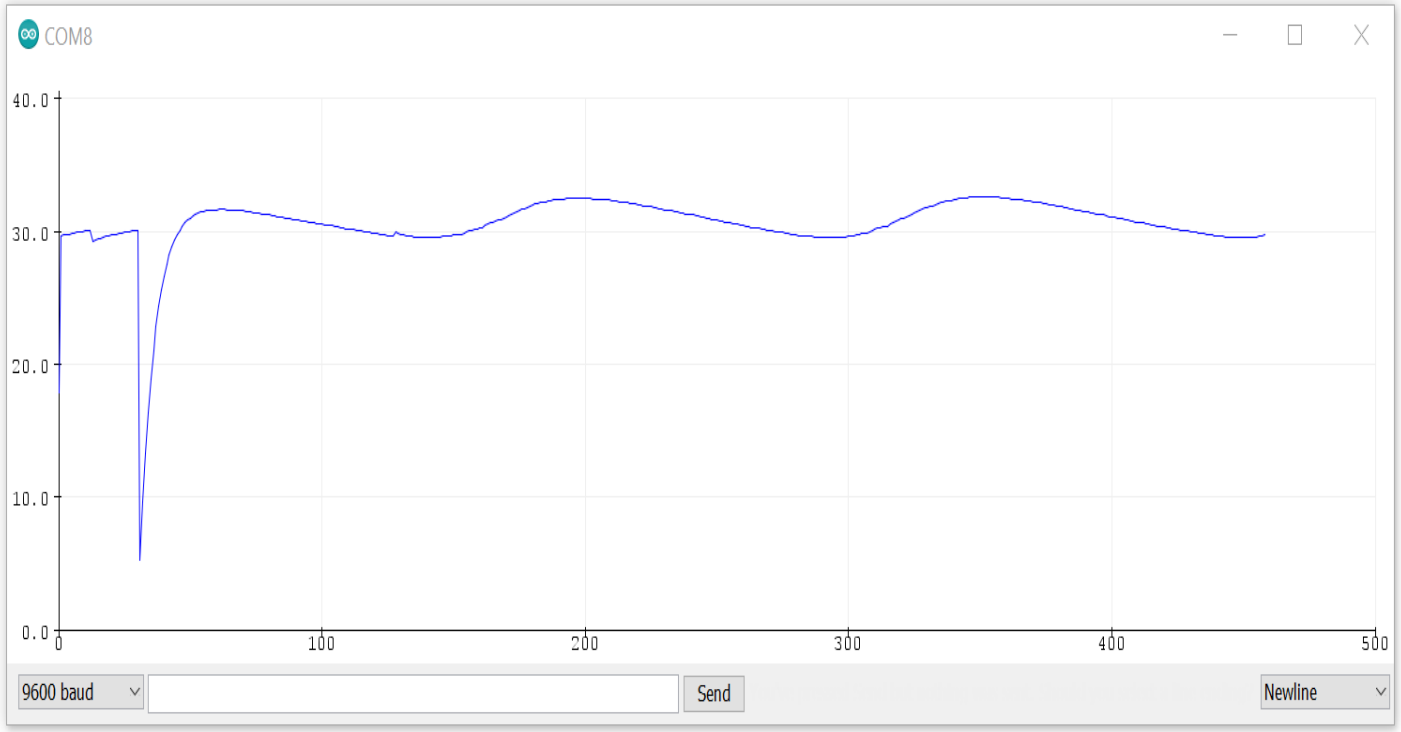


Real Air Heater Data

File Edit Sketch Tools Help

Read_Temperature_fromAirHeater

```
//simulation
float Ts =0.1;
int wait = 1000*Ts;
int k=0;
int TempPin= A0;
float TempValue;
float Voltage_read;
float Deg_read;
int OutPin = 9;
float u_signal;

// Air Heater
float y1 = 20;
float y2 = 50;
float x1 = 1;
float x2=  5;


//PI controller
float r = 30;
float Kp = 0.8;
float Ti = 20;
float u = 0;
float u_prev= 0;
float e = 0;
```



COM8

```
16:17:42.825 -> t=:6.70, u=0.00, Temperature=32.2732.29
16:17:42.919 -> t=:6.80, u=0.00, Temperature=32.2932.31
16:17:43.012 -> t=:6.90, u=0.00, Temperature=32.3132.32
16:17:43.153 -> t=:7.00, u=0.00, Temperature=32.3232.32
16:17:43.248 -> t=:7.10, u=0.00, Temperature=32.3232.32
16:17:43.340 -> t=:7.20, u=0.00, Temperature=32.3232.31
16:17:43.434 -> t=:7.30, u=0.00, Temperature=32.3132.30
16:17:43.527 -> t=:7.40, u=0.00, Temperature=32.3032.30
16:17:43.621 -> t=:7.50, u=0.00, Temperature=32.3032.29
16:17:43.762 -> t=:7.60, u=0.00, Temperature=32.2932.29
16:17:43.856 -> t=:7.70, u=0.00, Temperature=32.2932.29
16:17:43.949 -> t=:7.80, u=0.00, Temperature=32.2932.26
16:17:44.041 -> t=:7.90, u=0.00, Temperature=32.2632.23
16:17:44.135 -> t=:8.00, u=0.00, Temperature=32.2332.19
16:17:44.230 -> t=:8.10, u=0.00, Temperature=32.1932.17
16:17:44.370 -> t=:8.20, u=0.00, Temperature=32.1732.13
16:17:44.462 -> t=:8.30, u=0.00, Temperature=32.1332.11
16:17:44.557 -> t=:8.40, u=0.00, Temperature=32.1132.10
16:17:44.652 -> t=:8.50, u=0.00, Temperature=32.1032.09
16:17:44.744 -> t=:8.60, u=0.00, Temperature=32.0932.07
16:17:44.886 -> t=:8.70, u=0.00, Temperature=32.0732.03
16:17:44.980 -> t=:8.80, u=0.00, Temperature=32.0331.98
16:17:45.073 -> t=:8.90, u=0.00, Temperature=31.9831.95
16:17:45.166 -> t=:9.00, u=0.00, Temperature=31.9531.91
16:17:45.259 -> t=:9.10, u=0.00, Temperature=31.9131.88
16:17:45.352 -> t=:9.20, u=0.00, Temperature=31.8831.87
16:17:45.492 -> t=:9.30, u=0.00, Temperature=31.8731.85
16:17:45.586 -> t=:9.40, u=0.00, Temperature=31.8531.83
16:17:45.680 -> t=:9.50, u=0.00, Temperature=31.8331.78
16:17:45.774 -> t=:9.60, u=0.00, Temperature=31.7831.73
16:17:45.867 -> t=:9.70, u=0.00, Temperature=31.7331.68
16:17:45.960 -> t=:9.80, u=0.00, Temperature=31.6831.64
16:17:46.102 -> t=:9.90, u=0.00, Temperature=31.6431.61
16:17:46.182 -> t=:10.00, u=0.00, Temperature=31.6131.58
16:17:46.274 -> t=:10.10, u=0.00, Temperature=31.58
```