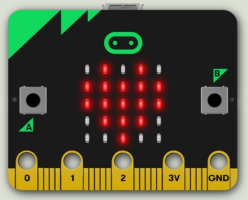
https://www.halvorsen.blog



micro:bit and Thermistor 10K Temperature Sensor

Hans-Petter Halvorsen

Contents

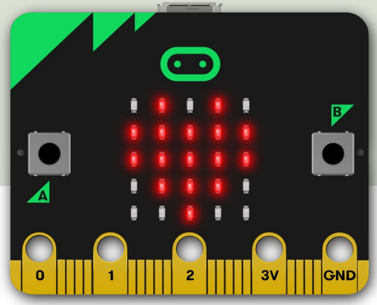
- Introduction to micro:bit and Python/MicroPython
- Using the built-in Temperature Sensor
- micro:bit I/O Pins
  - Analog and Digital Pins used for communication with external components, like LEDs, Temperature Sensors, etc.
- Using a Thermistor 10K Temperature Sensor

Introduction to micro:bit

Hans-Petter Halvorsen

Table of Contents

micro:bit



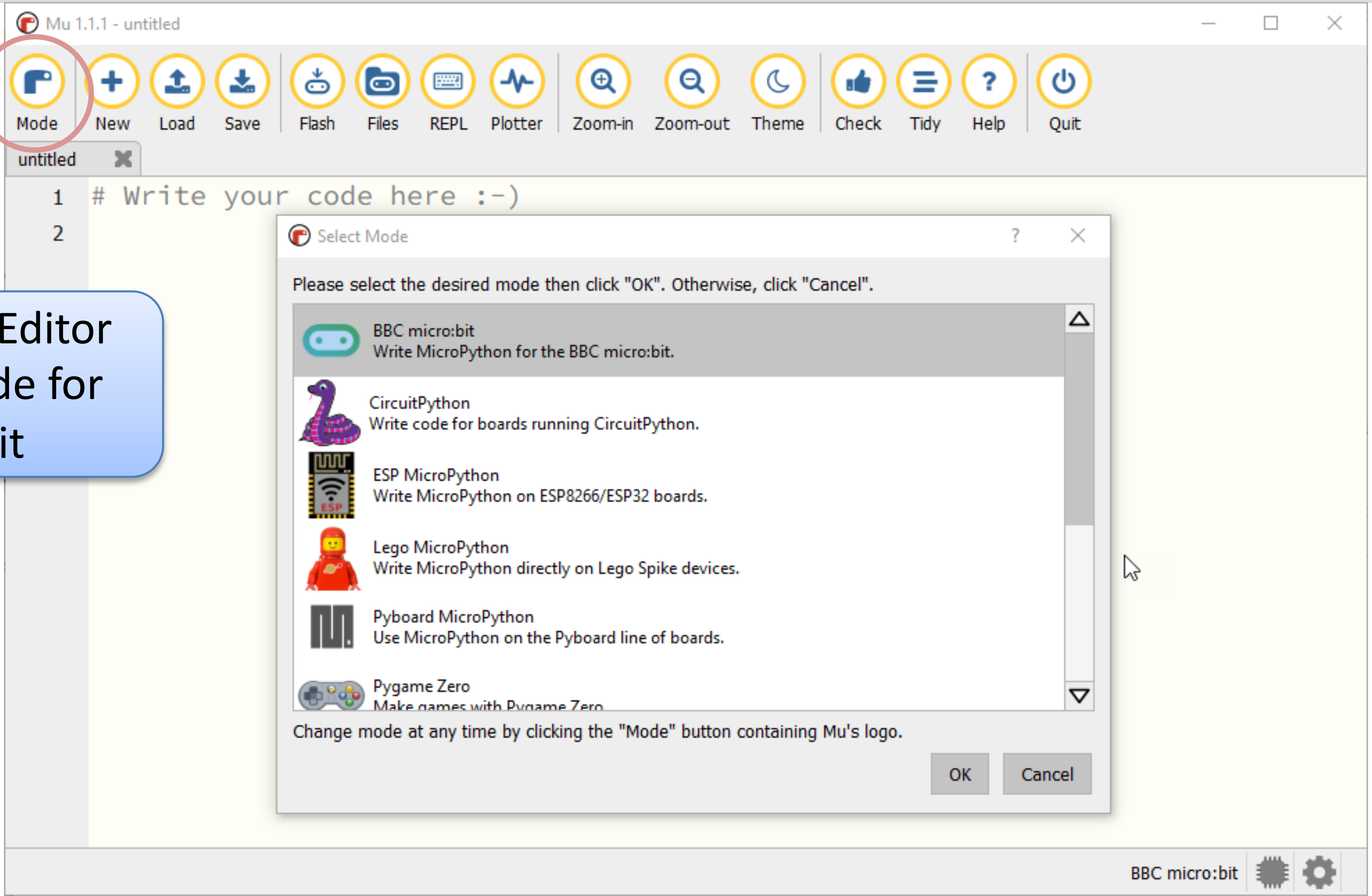
- micro:bit is a small microcontroller
- micro:bit is smaller than a credit card
- Price is about 150-400NOK ($15-30)
- It can be used by kids and students to learn programming and technology
- micro:bit can run a special version of Python called MicroPython
- MicroPython is a down-scaled version of Python

https://microbit.org

Mu Python Editor

- Mu is a Python code editor for beginners
- It is tailor-made for micro:bit programming
- Mu has a “micro:bit mode” that makes it easy to work with micro:bit, download code to the micro:bit hardware, etc.
- Mu and micro:bit Tutorials: https://codewith.mu/en/tutorials/1.0/microbit

Mu Python Editor



The Mu Python Editor has built-in Mode for the micro:bit

Built-in Temperature Sensor

Hans-Petter Halvorsen

Table of Contents

Temperature Sensor

- Micro:bit has a built-in Temperature Sensor (that is located on the CPU)
- This sensor can give an approximation of the air temperature.
- Just use the built-in `temperature()` function in order to get the temperature value from the sensor

Temperature Sensor

In order to read the temperature, you just use the built-in `temperature()` function:

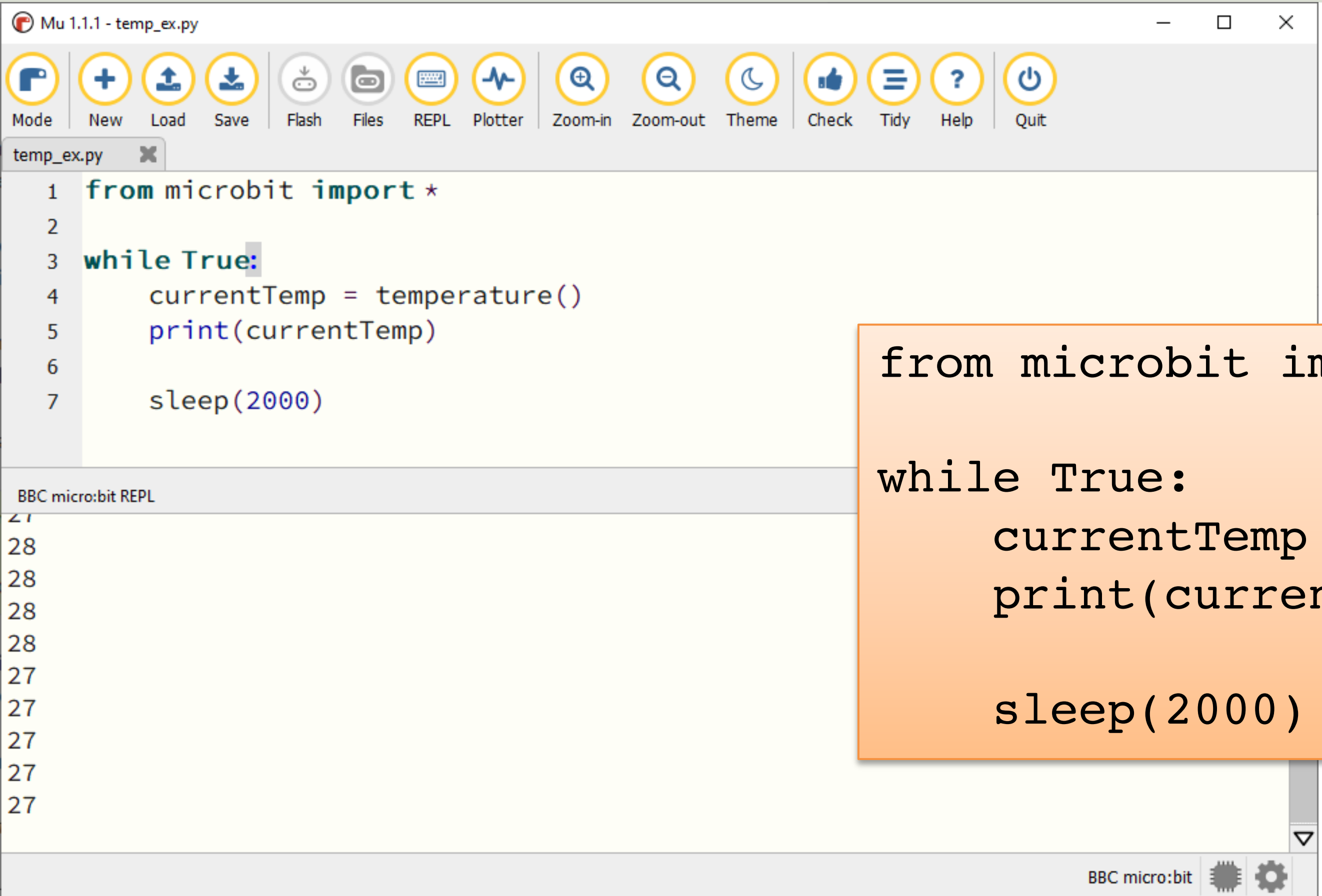
```
from microbit import *

currentTemp = temperature()
```

This examples displays the temperature on the LED matrix:

```
from microbit import *

while True:
    if button_a.was_pressed():
        display.scroll(temperature())
```

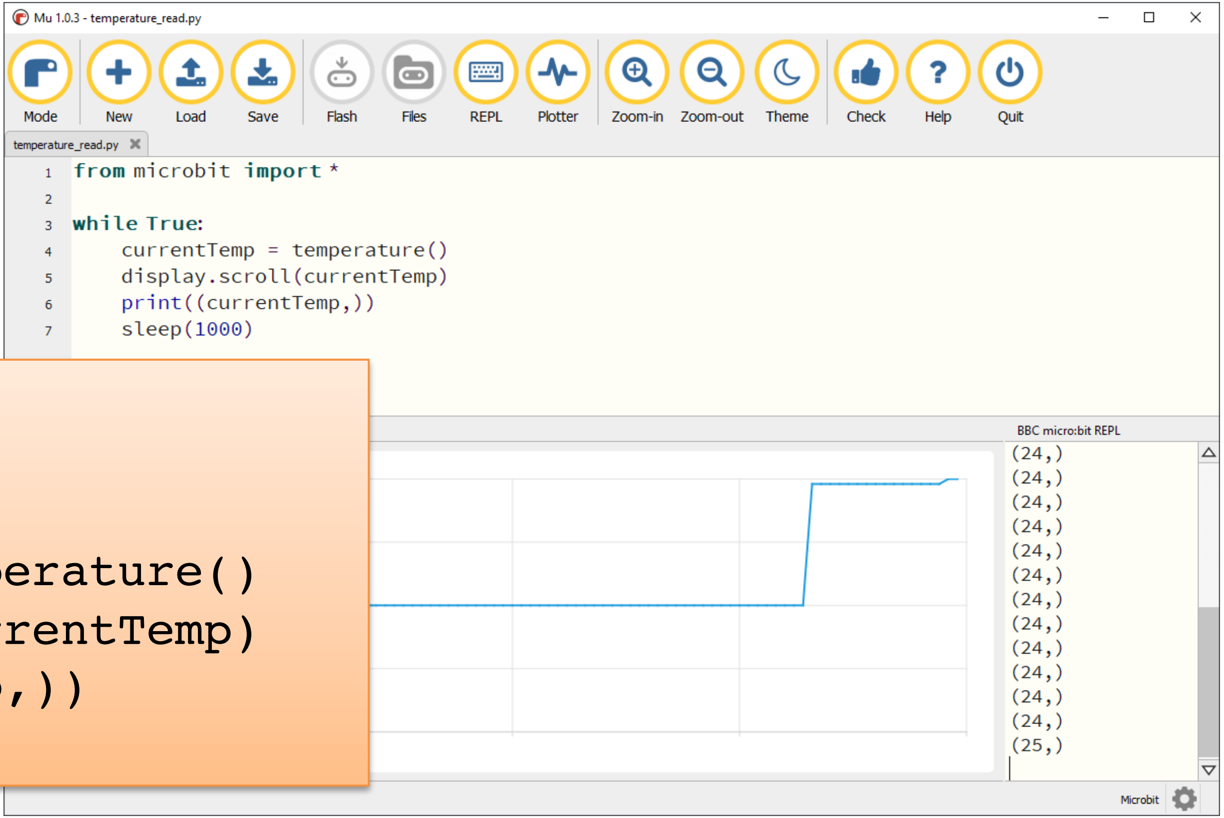
https://microbit.org/get-started/user-guide/features-in-depth/#temperature-sensor

Temperature Sensor




```
from microbit import *

while True:
    currentTemp = temperature()
    print(currentTemp)

    sleep(2000)
```

Temperature Sensor




```
from microbit import *

while True:
    currentTemp = temperature()
    display.scroll(currentTemp)
    print((currentTemp,))
    sleep(1000)
```

Display Min/Max Temperature

```
from microbit import *

currentTemp = temperature()
maxTemp = currentTemp
minTemp = currentTemp

while True:
    currentTemp = temperature()

    if currentTemp < minTemp:
        minTemp = currentTemp
    if currentTemp > maxTemp:
        maxTemp = currentTemp

    if button_a.was_pressed():
        display.scroll(minTemp)
    elif button_b.was_pressed():
        display.scroll(maxTemp)
    else:
        display.scroll(currentTemp)

    print((currentTemp, minTemp, maxTemp))
    sleep(2000)
```

If you do nothing, the LED matrix shows the Current Temperature.

If you click A Button, the Minimum Temperature for the period (since you started the program/turned on the Micro:bit) is shown on the LED matrix

If you click B Button, the Maximum Temperature for the period (since you started the program/turned on the Micro:bit) is shown on the LED matrix

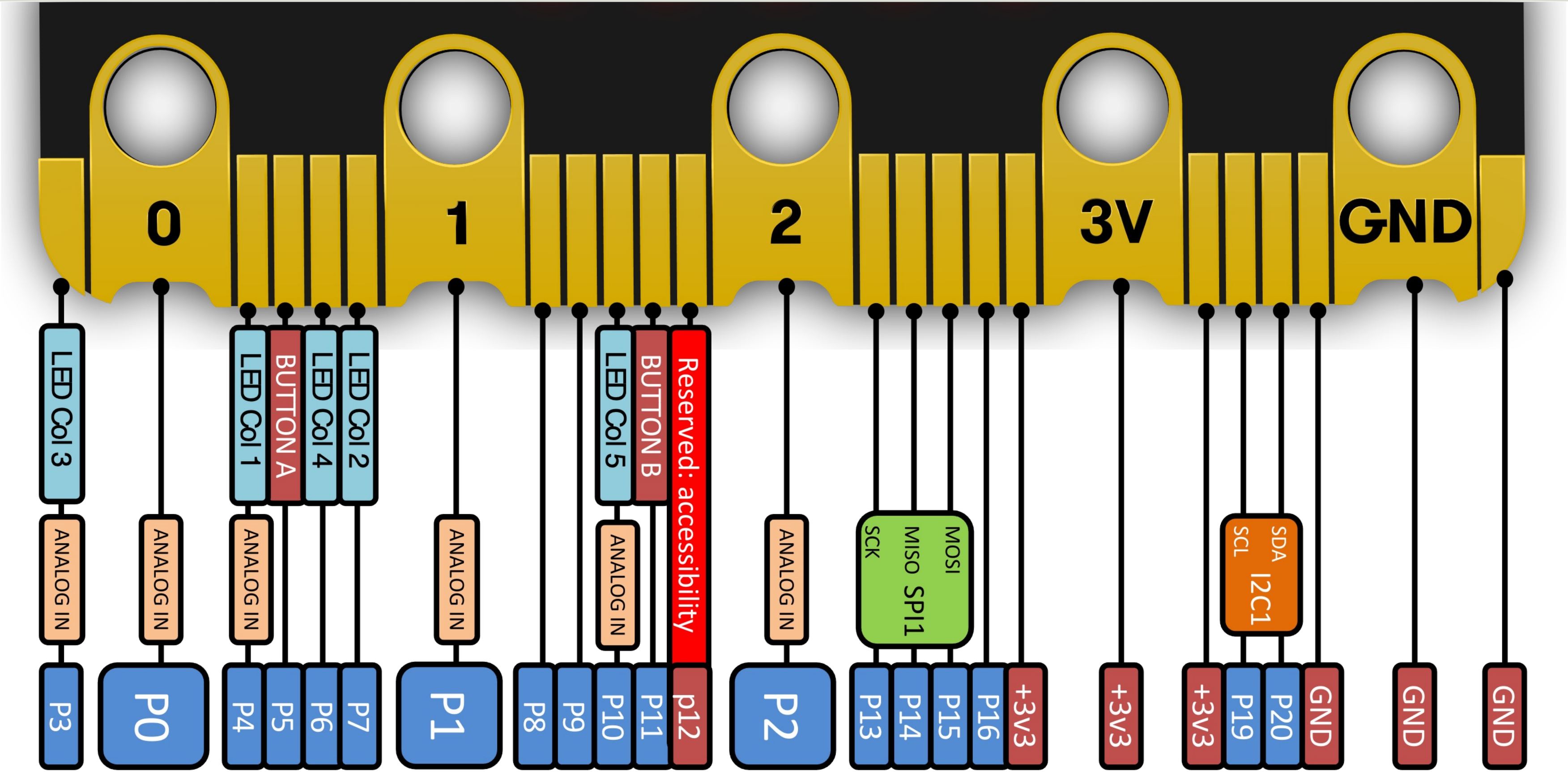
micro:bit I/O Pins

Hans-Petter Halvorsen

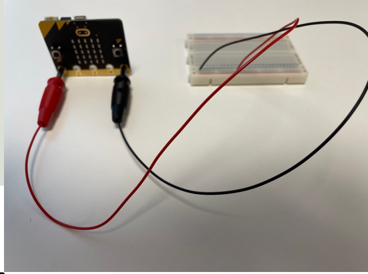
Table of Contents

https://microbit.pinout.xyz/

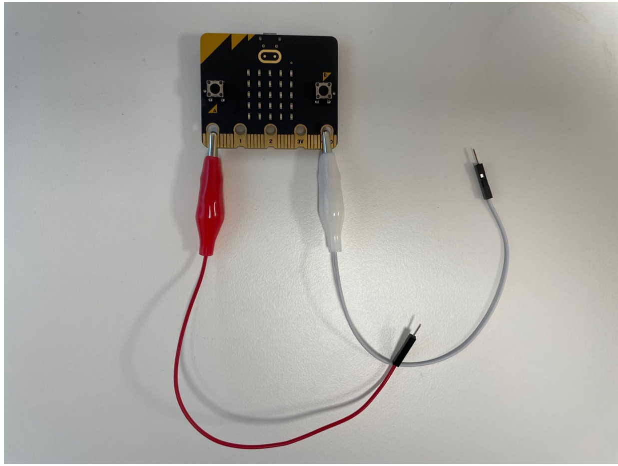
micro:bit I/O Pin Overview



I/O Pins



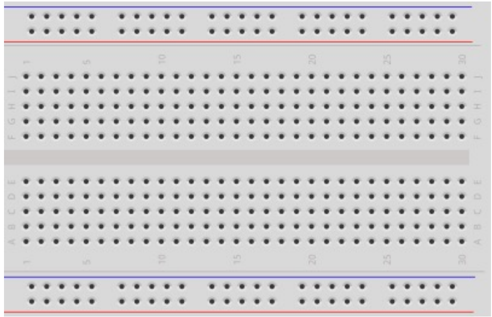
- We use the I/O pins to connect external components like LEDs, different types of Sensors, etc.
- You can use 4mm Banana plugs or Alligator/Crocodile clips
- Typically, you also want to use a Breadboard



https://tech.microbit.org/hardware/edgeconnector/

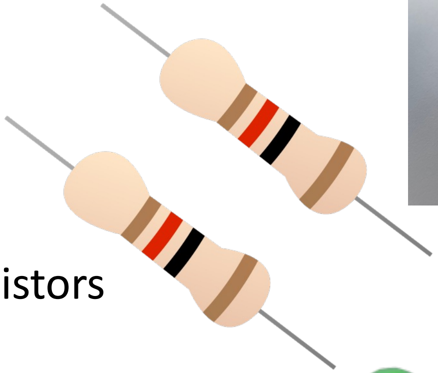
https://makecode.microbit.org/device/crocodile-clips

Component Examples

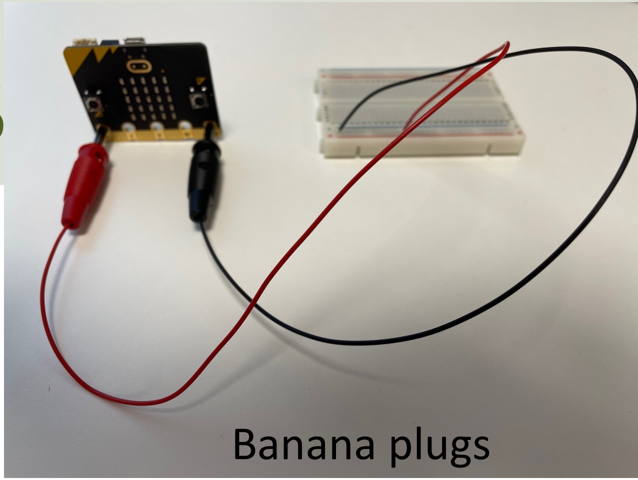


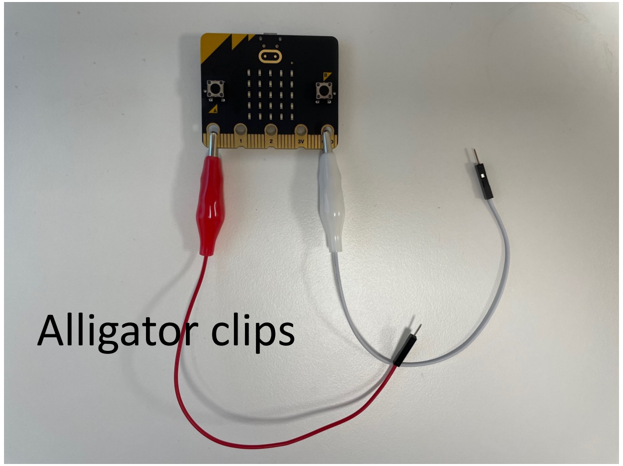
Breadboard

Temperature Sensor

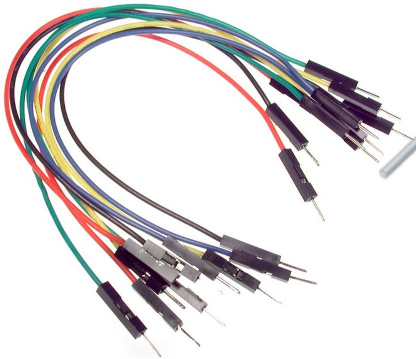


Resistors

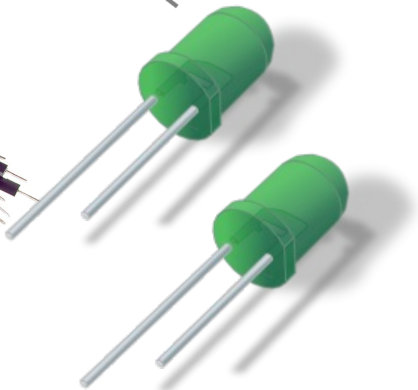




Wires



LEDs



Multimeter

Types of I/O Pins

- Analog/Digital Input/Output Pins
- Pulse Width Modulation (PWM)
- SPI
- I2C
- UART (used for serial communication)

We will only use an Analog Input pin in this Tutorial

Thermistor 10K Temperature Sensor

Hans-Petter Halvorsen

Table of Contents

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**):

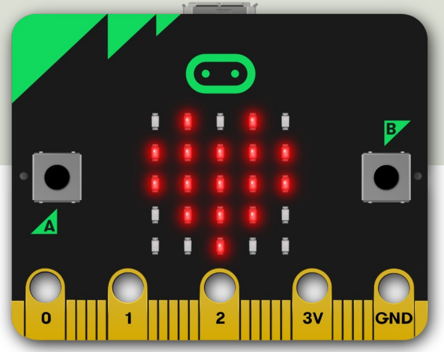
[Wikipedia]

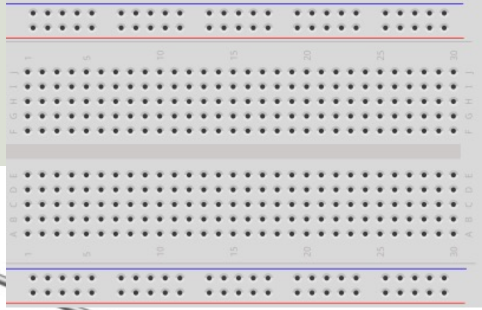
$$\frac{1}{T} = A + B\ln(R) + C(\ln(R))^3$$

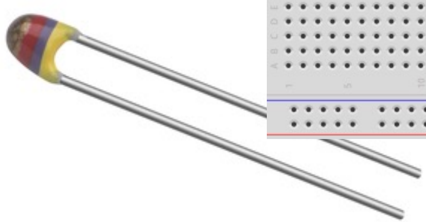
where A, B, C are constants given below

$A = 0.001129148, B = 0.000234125$ *and* $C = 8.76741E-08$

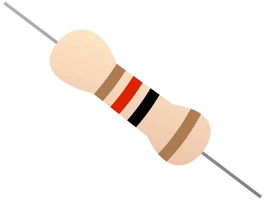
Hardware

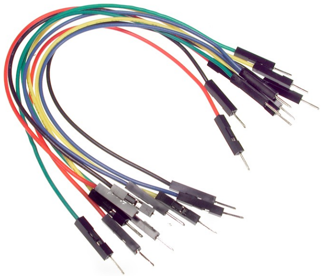


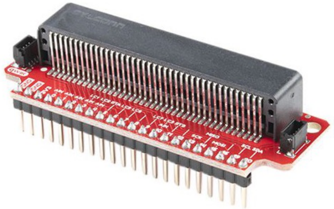




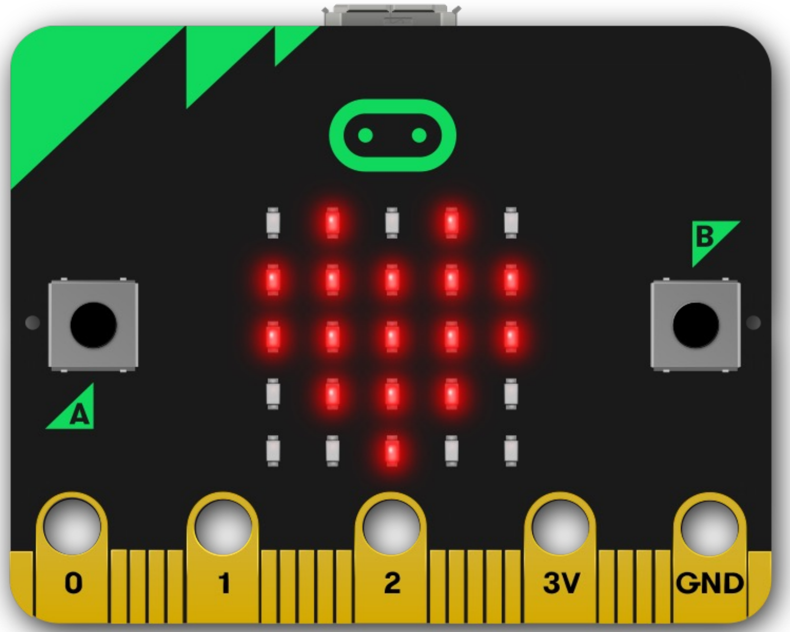
- micro:bit
- Breadboard
- Thermistor 10K (Temperature Sensor)
- Wires (Jumper Wires)
- Resistor 10 kΩ
- We can also use an **Adapter Breakout Board for micro:bit** instead of Alligator/Crocodile clips

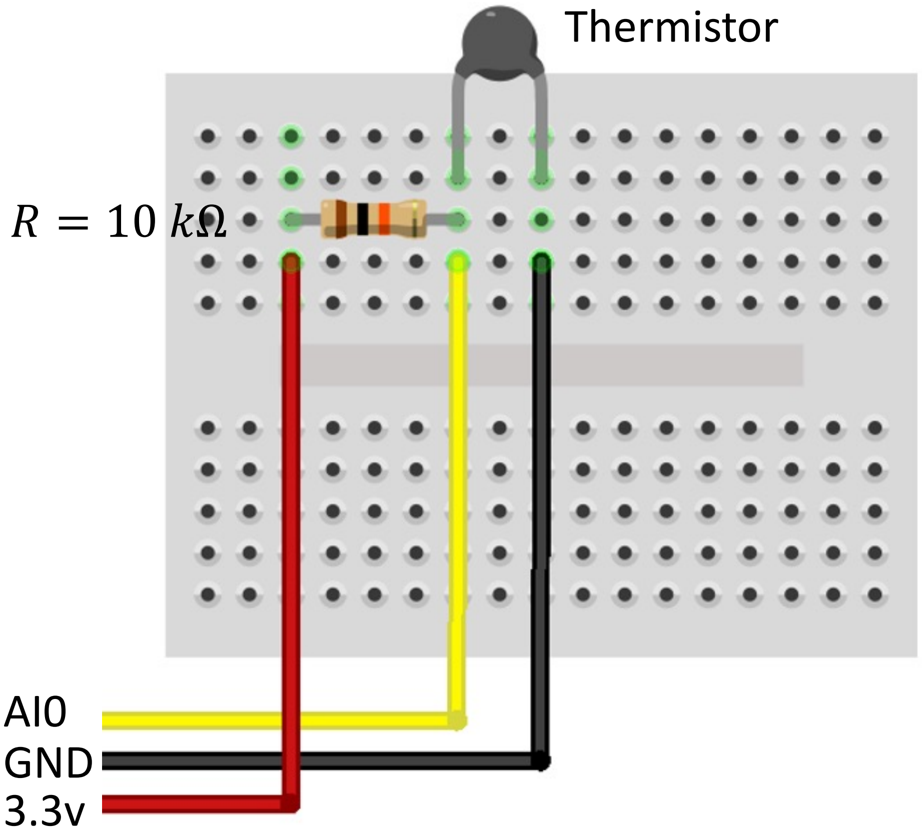






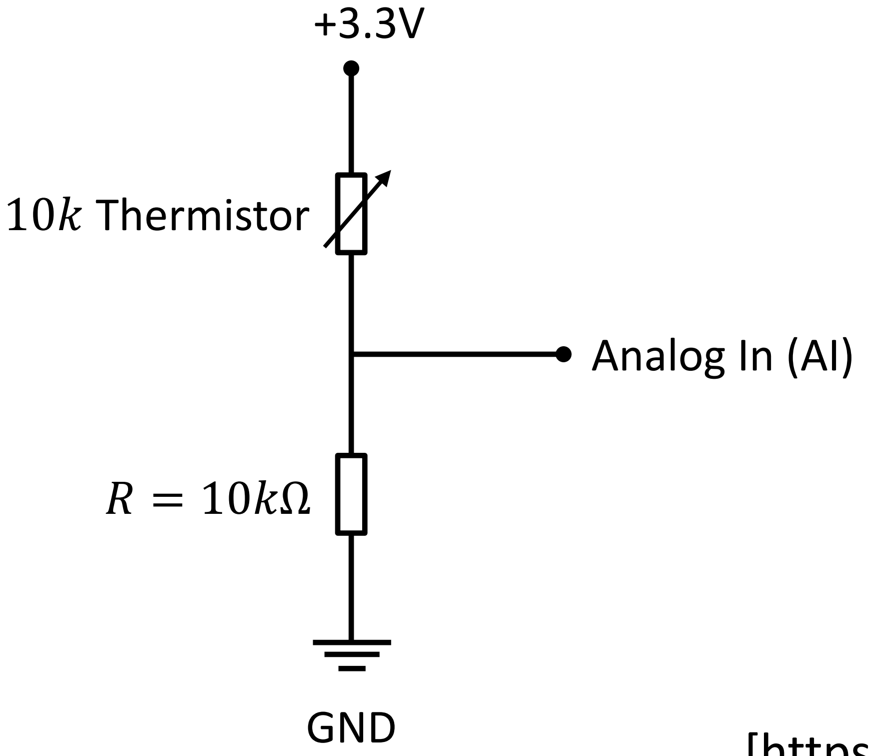
Wiring





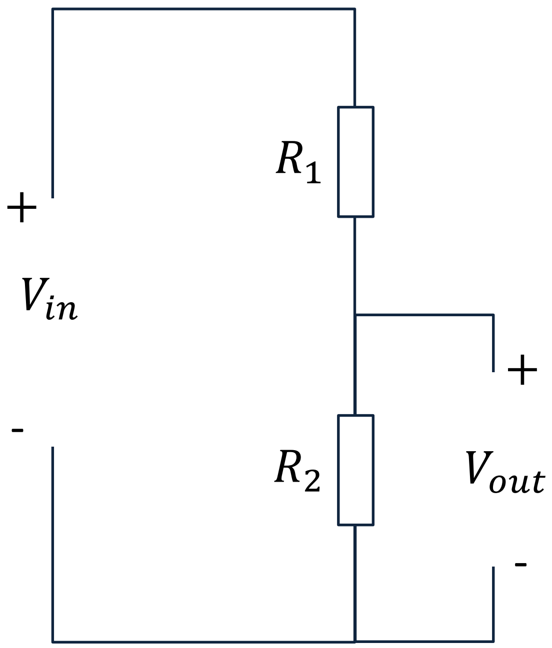
Voltage Divider

The wiring is called a “Voltage divider”:



[https://en.wikipedia.org/wiki/Voltage_divider]

General Voltage Divider



We want to find V_{out}

Formula:

$$V_{out} = V_{in}\frac{R_2}{R_1 + R_2}$$

https://learn.sparkfun.com/tutorials/voltage-dividers/all

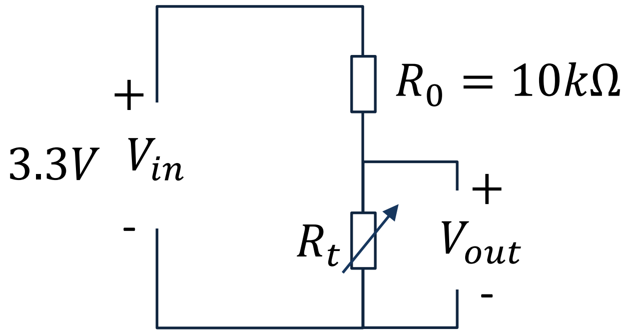
Voltage Divider for our System

Voltage Divider Equation:

$$V_{out} = V_{in} \frac{R_t}{R_0 + R_t}$$

We want to find R_t:

$$R_t = \frac{V_{out} R_0}{V_{in} - V_{out}}$$



R_t - 10k Thermistor. This varies with temperature. From Datasheet we know that $R_t = 10k\Omega$ @25℃

<u>Steps:</u>

1. We wire the circuit on the Breadboard and connect it to the DAQ device
2. We measure V_{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

Steinhart-Hart Equation

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

$$A = 0.001129148$$
$$B = 0.000234125$$
$$C = 0.0000000876741$$

The Temperature in degrees Celsius will then be:

$$T_C = T_K - 273.15$$

Pseudo Code

1. Get V_{out} from the DAQ device (Arduino UNO)
2. Calculate $R_t = \frac{V_{out} R_0}{V_{in} - V_{out}}$
3. Calculate $T_K = \frac{1}{A + B\ ln(R_t) + C(ln(R_t))^3}$
4. Calculate $T_C = T_K - 273.15$
5. Present T_C in the User Interface

Pseudo Code

```
float Vin = 3.3;
float Ro=10000;
float Rt = (Vout*Ro)/(Vin-Vout);

//Steinhart constants
float A = 0.001129148;
float B = 0.000234125;
float C = 0.0000000876741;

//Steinhart-Hart Equation
float TempK = 1 / (A + (B * ln(Rt)) + (C * ln(Rt)**3));

//Convert from Kelvin to Celsius
float TempC = TempK - 273.15;
```

Mu 1.1.1 - thermistor_ex.py

Mode | New | Load | Save | Flash | Files | REPL | Plotter | Zoom-in | Zoom-out | Theme | Check | Tidy | Help | Quit

thermistor_ex.py

```python
from microbit import *
import math

# Voltage Divider
Vin = 3.3
Ro = 10000  # 10k Resistor

# Steinhart Constants
A = 0.001129148
B = 0.000234125
C = 0.0000000876741

while True:
    adc = pin0.read_analog()
    Vout = (3.3/1023)*adc

    # Calculate Resistance
    Rt = (Vout * Ro) / (Vin - Vout)

    # Steinhart - Hart Equation
    TempK = 1 / (A + (B * math.log(Rt)) + C * math.pow(math.log(Rt), 3))

    # Convert from Kelvin to Celsius
    TempC = TempK - 273.15

    print(round(TempC, 1))
    display.scroll(round(TempC))

    sleep(5000)
```

BBC micro:bit REPL

```
24.6
24.6
24.6
```

BBC micro:bit

Python

The Code works as follows:

1. Get V_{out} from the DAQ device
2. Calculate $R_t = \frac{V_{out} R_0}{V_{in} - V_{out}}$
3. Calculate $T_K = \frac{1}{A + B\ ln(R_t) + C(ln(R_t))^3}$
4. Calculate $T_C = T_K - 273.15$
5. Present T_C in the User Interface

```
from microbit import *
import math

# Voltage Divider
Vin = 3.3
Ro = 10000  # 10k Resistor

# Steinhart Constants
A = 0.001129148
B = 0.000234125
C = 0.0000000876741

while True:
    adc = pin0.read_analog()
    Vout = (3.3/1023)*adc

    # Calculate Resistance
    Rt = (Vout * Ro) / (Vin - Vout)
    # Rt = 10000  # Used for Testing. Setting Rt=10k should give TempC=25

    # Steinhart - Hart Equation
    TempK = 1 / (A + (B * math.log(Rt)) + C * math.pow(math.log(Rt), 3))

    # Convert from Kelvin to Celsius
    TempC = TempK - 273.15

    print(round(TempC, 1))
    display.scroll(round(TempC))

    sleep(5000)
```

Python

Thermistor Application:

Here, I have made a separate Python function for the thermistor logic. This makes it easy to use this part in several Applications.

thermistor.py

```
import math

def thermistorTemp(Vout):

    # Voltage Divider
    Vin = 3.3
    Ro = 10000  # 10k Resistor

    # Steinhart Constants
    A = 0.001129148
    B = 0.000234125
    C = 0.0000000876741

    # Calculate Resistance
    Rt = (Vout * Ro) / (Vin - Vout)

    # Steinhart - Hart Equation
    TempK = 1 / (A + (B * math.log(Rt)) + C * math.pow(math.log(Rt), 3))

    # Convert from Kelvin to Celsius
    TempC = TempK - 273.15

    return TempC
```

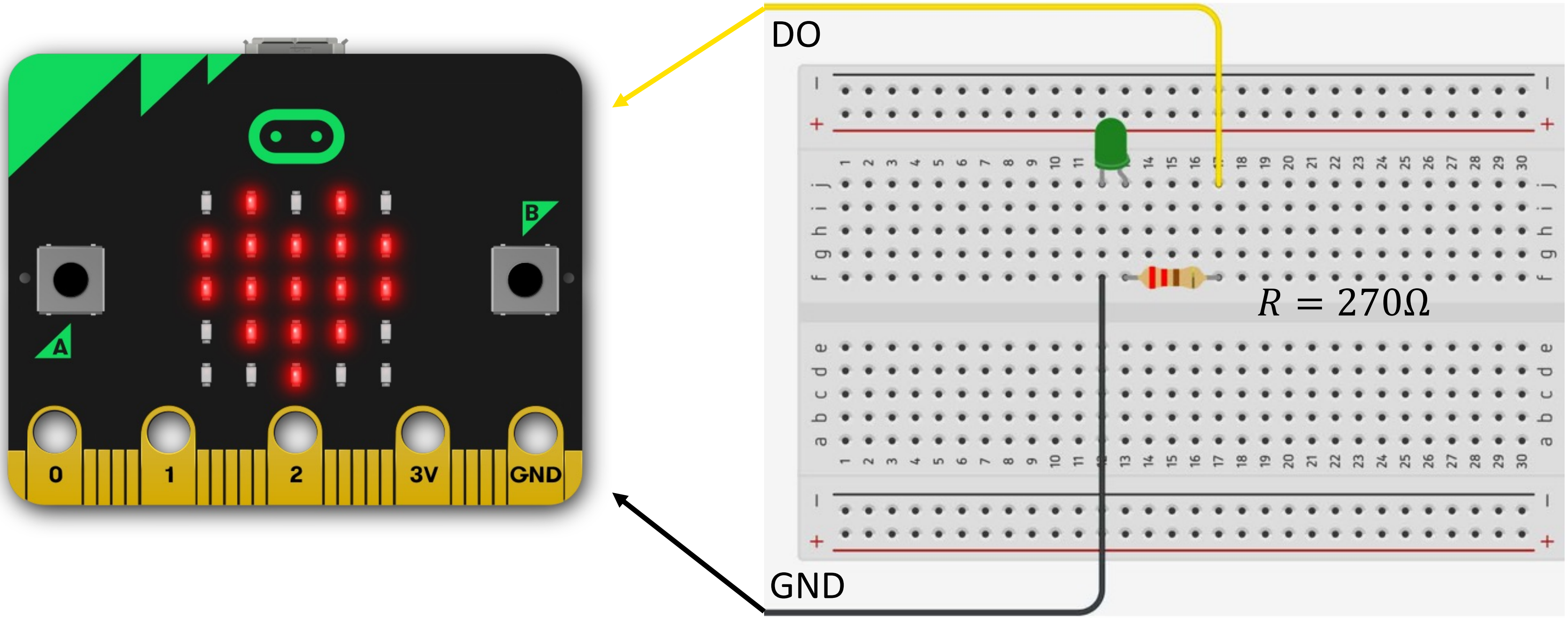
```
from microbit import *
import thermistor

while True:
    adc = pin0.read_analog()
    Vout = (3.3/1023)*adc

    TempC = thermistor.thermistorTemp(Vout)

    print(round(TempC, 1))
    display.scroll(round(TempC))

    sleep(5000)
```

Temperature with Alarm

Hans-Petter Halvorsen

Table of Contents

LED Wiring

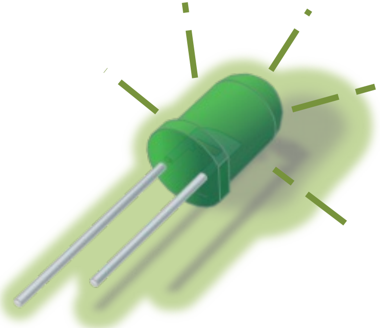


Python

Temperature > Limit?

No

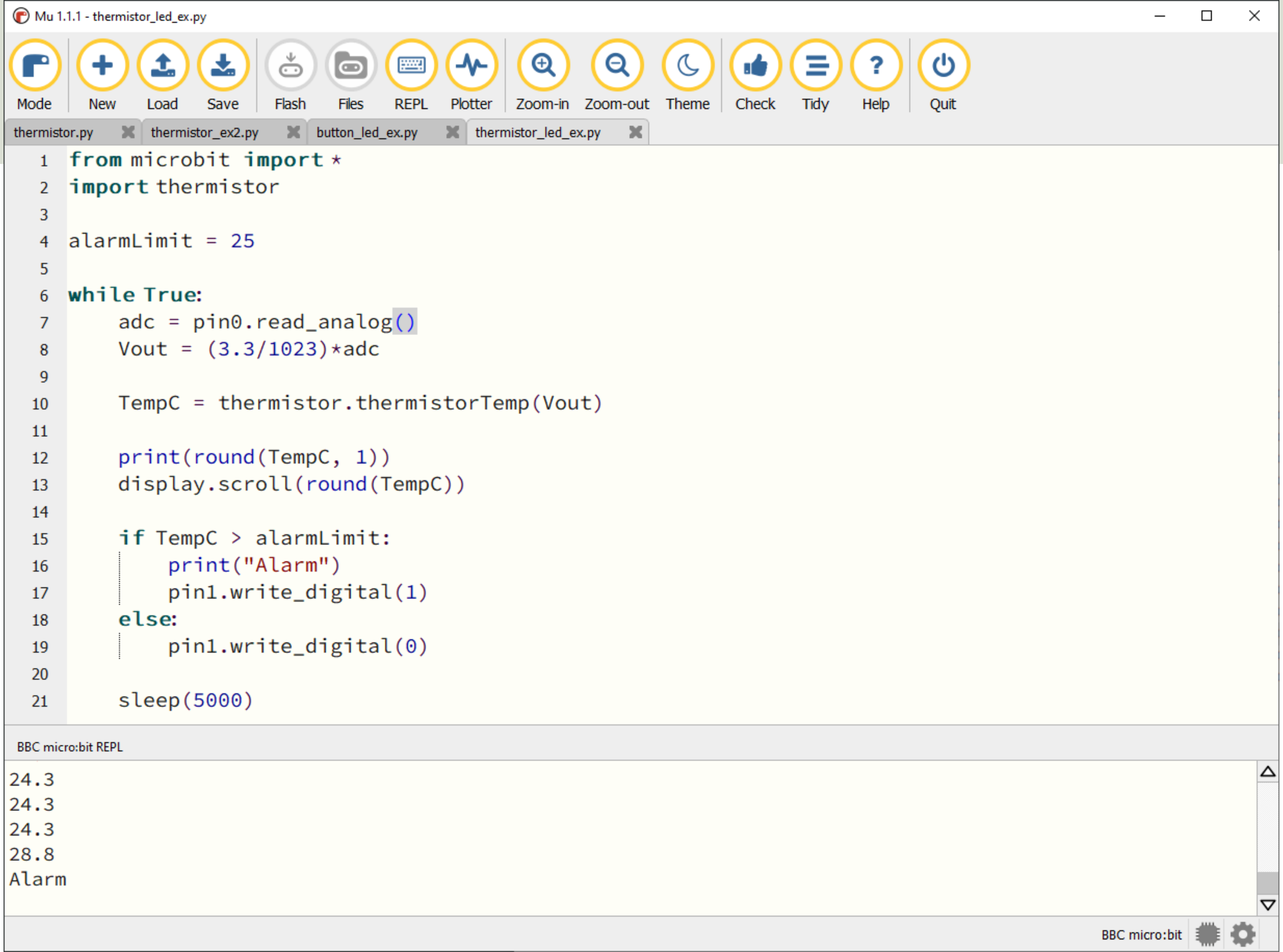
Yes



LED OFF

LED ON

```
from microbit import *
import thermistor

alarmLimit = 25

while True:
    adc = pin0.read_analog()
    Vout = (3.3/1023)*adc

    TempC = thermistor.thermistorTemp(Vout)

    print(round(TempC, 1))
    display.scroll(round(TempC))

    if TempC > alarmLimit:
        print("Alarm")
        pin1.write_digital(1)
    else:
        pin1.write_digital(0)

    sleep(5000)
```


Mu 1.1.1 - thermistor_led_ex.py
Mode
New
Load
Save
Flash
Files
REPL
Plotter
Zoom-in
Zoom-out
Theme
Check
Tidy
Help
Quit
thermistor.py
thermistor_ex2.py
button_led_ex.py
thermistor_led_ex.py
from microbit import *
import thermistor

alarmLimit = 25

while True:
    adc = pin0.read_analog()
    Vout = (3.3/1023)*adc

    TempC = thermistor.thermistorTemp(Vout)

    print(round(TempC, 1))
    display.scroll(round(TempC))

    if TempC > alarmLimit:
        print("Alarm")
        pin1.write_digital(1)
    else:
        pin1.write_digital(0)

    sleep(5000)
BBC micro:bit REPL
24.3
24.3
24.3
28.8
Alarm
BBC micro:bit

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