Tutorial 6: Automatic thermostat system

1. Introduction

Automatic thermostats offer numerous benefits. With them, you can effortlessly regulate the climate in your home without the need for manual adjustments. Whether you're inside your house or away, these thermostats enable you to maintain the ideal room temperature with ease. This not only enhances your comfort but also helps you save energy and reduce utility costs.

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1.1. Learning Objectives

- Understand the DHT sensor and its characteristics.

- Work with a DC motor, TIP-120 module, and diode for fan control.

- Create an automatic temperature control system.

- Integrate the thermostat system into the SmartHome4Seniors house model.

1.2. Theoretical background

1.2.1. What is a DHT11 Sensor?

The DHT11 Sensor is a compact digital temperature and humidity sensor, widely used for accurate readings in weather stations, home automation, and environmental monitoring.
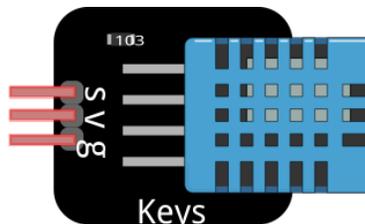
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Figure 1 DHT11 Sensor

Here are some key features and information about the DHT11 Sensor:

1. Detection Method: The DHT11 sensor utilizes a combination of a capacitive humidity sensor and a thermistor to detect temperature and humidity in the surrounding environment.
2. Operating Principle: When in operation, the DHT11 sensor provides both digital and analog signals. The analog signal represents the temperature, while the digital signal encodes both temperature and humidity information. This output can be interfaced with microcontrollers for further processing.

3. Accuracy and Calibration: The DHT11 sensor is designed for reasonable accuracy in measuring temperature and humidity. It's crucial to note that, like any sensor, its accuracy may be influenced by factors such as calibration, environmental conditions, and manufacturing tolerances.

4. Compatibility:The DHT11 sensor is compatible with various microcontroller platforms, including popular ones like Arduino and Raspberry Pi. This versatility makes it a go-to choice for hobbyist projects and DIY applications.

5. Integration with Microcontrollers: To use the DHT11 sensor, you'll typically connect it to a microcontroller through its designated pins. The sensor's datasheet or documentation provides detailed information on the pin configuration, ensuring accurate wiring.

6. LED Indicator: Unlike the KY-026 flame sensor, the DHT11 sensor does not come with an integrated LED indicator. Instead, the data output is processed by the connected microcontroller, which can be programmed to indicate the sensor's status through other means like LEDs or displays.

7. Use Cases: Common applications for the DHT11 sensor include weather stations, climate control systems, and home automation projects where monitoring temperature and humidity is essential for decision-making.

When working with the DHT11 sensor, connecting it to a microcontroller is a typical requirement. Writing code to interpret the sensor's output and trigger appropriate actions based on temperature and humidity readings is necessary. The specifics of wiring and code will depend on the chosen microcontroller and project requirements. Always refer to the DHT11 sensor's datasheet and documentation for precise information on its usage, pin configuration, and integration details.

1.2.2. What is a DC Motor (Fan)?

A DC motor fan is a vital electronic component used for converting electrical energy into rotational motion, generating airflow to cool electronic components, computers, and appliances.
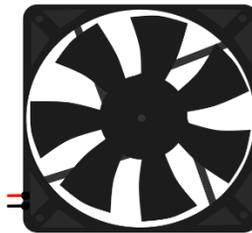

Figure 2 DC Motor (fan)

Operating on a direct current (DC) voltage, typically around 5 volts, the fan's blades initiate rotation, creating a flow of air. This functional design positions DC motor fans as essential contributors to preventing overheating and maintaining optimal operational temperatures in various electronic systems. With diverse sizes and configurations, these fans find

widespread application in electronic devices and appliances, offering efficient cooling capabilities tailored to specific system requirements. Users can adjust the voltage applied to the fan, allowing for flexibility in controlling airflow and rotational speed to meet distinct cooling needs in different applications. As a result, the DC motor fan stands as a cornerstone in electronic thermal management.

1.2.3. What is a TIP-120 Module?

The TIP-120 module is a pivotal electronic component known for its role as an NPN (negative-positive-negative) power transistor. Widely utilized as a switch, the TIP-120 module excels in controlling high-power devices such as DC motors, solenoids, and high-intensity LEDs. Its functionality relies on the amplification and control of current flow through a load by applying a small current at its base. This mechanism enables precise control over high-power components, making the TIP-120 module a go-to choice for electronic circuits and projects demanding accurate control.

Figure 3 TIP-120 Module

With its versatile applications, the TIP-120 module finds a place in various electronic systems where the need for controlled power distribution is paramount. Its capability to manage high-power devices efficiently positions it as a valuable asset in projects requiring sophisticated control over electrical components. When integrated into circuits, the TIP-120 module ensures reliable and precise control, enhancing the overall performance of electronic systems. As with any electronic component, it's imperative to consult the manufacturer's datasheet or specifications to ensure proper usage and adherence to recommended operating parameters.

1.3.   Material

For this tutorial you will need the following material:

- Plywood pieces
- Fan (DC motor)
- Diode
- Several male-to-male jumper wires
- DHT11 sensor

- Raspberry Pi Pico
- Breadboard

- Micro-USB cable
- TIP-120 transitor

2. Initial steps & Connectivity

Open Thonny Python, then go to File → Save as…, choose Raspberry Pi Pico, and save your file under the name `thermostat.py`. Then it is time to connect the electronics and write your program. Please follow the instructions below.

To connect all these components, please follow the wiring diagram below

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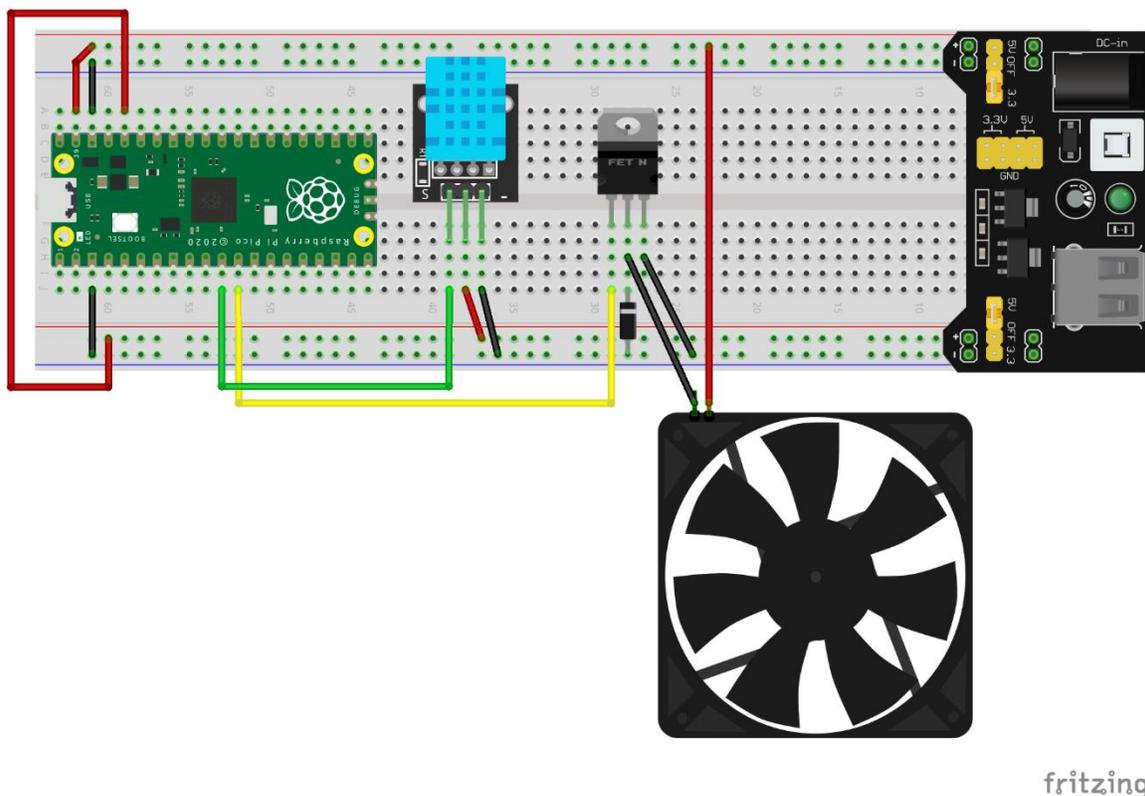
Connect the electronics as follows:

DHT11:

- VCC (red cable) is connected to 3v3 rail (+)
- GND (black cable) is connected to GND rail (-)
- S (green cable) is connected to GPIO8 pin

Fan:

- Red cable is connected to 5V rail (+)
- Black cable from the fan is connected to the middle pin of the TIP-120 transistor
- Black cable from the TIP-120 transistor is connected to GND rail (-)

- Diode is connected from the middle pin of the TIP-120 transistor to the GND rail (-)
- Yellow cable is connected to GPIO9 pin

3. MicroPython code

You can either develop your own Python program or use existing libraries available online. Downloading an existing library can simplify the process. Ensure to save the library with the same name on your microcontroller.

Example code for temperature and humidity sensing using the DHT11 sensor and DC motor and MicroPython:

```
thermostat.py

1   from machine import Pin
2   from time import sleep
3   from dht import DHT11
4
5   #Define pins for each component
6   PIN_DHT = 8
7   PIN_FAN = 9
8
9   #Setup DHT sensor
10  dht = DHT11(PIN_DHT)
11
12  #Setup DC fan
13  fan = Pin(PIN_FAN, Pin.OUT)
14
15  while True:
16      dht.measure()
17      temp = dht.temperature()
18      hum = dht.humidity()
19
20      print("Room Temp:", temp, "°C")
21      print("Room Humidity:", hum, "%")
22
23      # Adjust the temperature threshold as needed
24      temperature_threshold = 25
25
26      if temp > temperature_threshold:
27          fan.value(1)
28          print("Fan ON")
29      else:
30          fan.value(0)
31          print("Fan OFF")
32      sleep(3)
33
```

```
Console

Python 3.10.11 (/Applications/Thonny.app/Contents/Frameworks/Python.framework/Versions/3.10/bin/python3.10)
>>>

                                                        Python 3 local · Python de Thonny ≡
```

Save the program by clicking the Save icon on the top left-hand side, or by pressing Ctrl+S on your keyboard.

thermostat.py

```
from machine import Pin
from time import sleep
from dht import DHT11

#Define pins for each component
PIN_DHT = 8
PIN_FAN = 9

#Setup DHT sensor
dht = DHT11(PIN_DHT)

#Setup DC fan
fan = Pin(PIN_FAN, Pin.OUT)

while True:
    dht.measure()
    temp = dht.temperature()
    hum = dht.humidity()

    print("Room Temp:", temp, "°C")
    print("Room Humidity:", hum, "%")

    # Adjust the temperature threshold as needed
    temperature_threshold = 25

    if temp > temperature_threshold:
        fan.value(1)
        print("Fan ON")
    else:
        fan.value(0)
        print("Fan OFF")
    sleep(3)
```

4. Application on SmartHome

Now it is time to test your code and circuit on your SmartHome. Make sure to save the MicroPython code in the Raspberry Pi Pico under `thermostat.py` name, as instructed at the beginning of the tutorial.

Install the system in your house model.

There are some electronics that need to be mounted on the back-side wall. These are the flame sensor, the air-quality sensor and the DHT11 temperature and humidity sensor. You need to use the following items:

- **Flame sensor**: 1 x bolt and 1 x nut. Mount it through the middle section of the sensor and make sure the sensor (black part) looks up.
- **Air-quality sensor**: 2 x bolt and 2 x nut. Mount it through the top left and top right mounting holes.

- **DHT11**: 2 x bolt and 2 x nut. You need to bend the sensor (blue part) forward to access the mounting holes. Then mount the sensor through the top left and top right mounting holes.

On the left-side piece you will need to mount a **DC fan** and an **LED** light. For the **DC fan** you will use the bolts and nuts that come in its package (4 x bolts and 4 x nuts). Insert the **LED** to the mounting hole and friction will keep it in place.
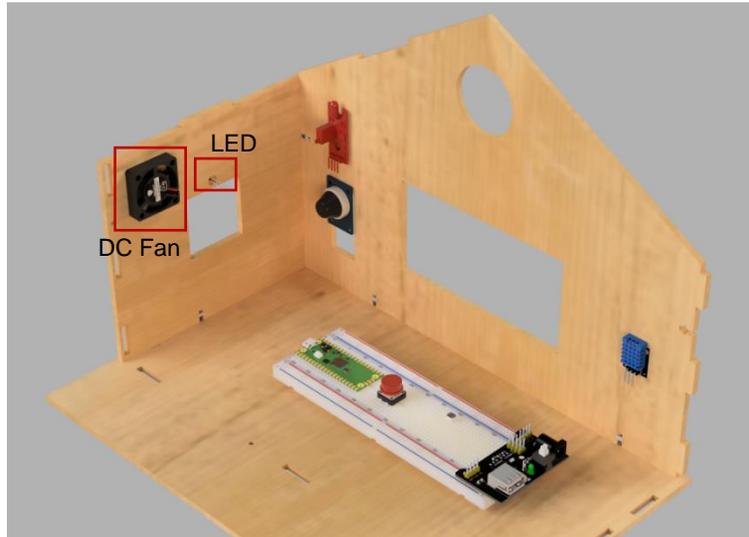
After the installation of all components, you can click the Play button in Thonny.

5. Summary

In this tutorial, we present an innovative approach to temperature control within your home using a smart thermostat system. The core components of this system include:

- The DHT11 sensor to accurately measure temperature and humidity, enabling precise environmental monitoring.
- The integration of a DC motor fan to offer effective heating or cooling to maintain your desired indoor climate based on sensor readings.
- Utilizing the TIP-120 module and diodes, this system ensures efficient temperature control, guaranteeing comfort and energy efficiency.

This guide takes you through the installation, connection, and programming steps to set up the thermostat system within your home.