Arduino Weather Station and the DHT11 Temperature & Humidity sensor

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project "**WEATHER & THE DHT11 TEMPERATURE & HUMIDITY SENSOR**" is the bonafide work of "**MEENA RHOSHINI.C, BARKAVI.R**" who carried out the project work under my supervision.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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ABSTRACT

The Arduino Weather Station with DHT11 Temperature & Humidity sensor is a project that aims to create a simple and cost-effective weather monitoring system. This system uses an Arduino microcontroller to collect data from a DHT11 sensor, which measures both temperature and humidity. The data is then displayed on a 16x2 character LCD display.

The project involves understanding the working of the DHT11 sensor, interfacing the sensor with Arduino, and displaying the data on an LCD display. The DHT11 sensor is a reliable sensor for measuring temperature and humidity, making it ideal for this application.

This project is an excellent opportunity to learn about Arduino programming, sensor interfacing, and data visualization. It can be used in various applications such as home automation systems, weather forecasting, and environmental monitoring. The project provides hands-on experience with hardware and software integration, making it a great learning experience for enthusiasts in the field of electronics and programming.

1.1 INTRODUCTION

The Arduino Weather Station with DHT11 Temperature & Humidity sensor is an innovative project that combines hardware interfacing and software programming to create a practical and educational tool. This project leverages the capabilities of the Arduino microcontroller, a versatile and accessible platform for electronics enthusiasts of all levels.

The heart of this weather station is the DHT11 sensor, a reliable and cost-effective component capable of measuring both temperature and humidity. These measurements are essential for a wide range of applications, from home automation to environmental monitoring.

The data collected by the DHT11 sensor is processed by the Arduino and then displayed on a 16x2 character LCD display. This provides a real-time, easy-to-read output of the current temperature and humidity levels.

This project not only serves as a functional weather station but also provides a hands-on learning experience in hardware interfacing, Arduino programming, and data visualization. Whether you're an experienced developer or a beginner looking to explore the world of electronics, this Arduino Weather Station project offers an engaging and practical way to expand your skills.

1.2 BACKGROUND

The Arduino Weather Station project with the DHT11 Temperature & Humidity sensor is rooted in the increasing need for real-time, localized weather data. Traditional weather stations are often located far from residential areas, leading to discrepancies in the data they provide. This project aims to address this issue by enabling individuals to set up their own personal weather stations at home or in their local community.

The project utilizes the Arduino platform, a popular open-source electronics platform based on easy-to-use hardware and software.

Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online.

The DHT11 sensor is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding
air and spits out a digital signal on the data pin (no analog input pins needed). Its fairly simple to use but requires careful timing to grab data.

This project is not only practical but also educational. It provides an excellent opportunity for students and hobbyists to learn about Arduino programming, sensor interfacing, and data visualization. The skills learned from this project can be applied to other IoT (Internet of Things) projects as well, making it a great stepping stone for anyone interested in this field.

1.3 PROJECT OBJECTIVE

The objective of the Arduino Weather Station project with the DHT11 Temperature & Humidity sensor is multi-fold:

- **Real-Time Weather Monitoring:** The primary objective is to design and implement a system that can provide real-time temperature and humidity readings. This allows users to monitor weather conditions in their immediate environment.

- **Educational Purpose:** This project serves as a practical learning experience for those interested in electronics, programming, and Internet of Things (IoT) applications. It provides hands-on experience with hardware interfacing, Arduino programming, and data visualization.

- **Cost-Effective Solution**: Another objective is to create a weather monitoring system that is not only effective but also affordable.

- **Promoting DIY Culture:** This project encourages the Do-It-Yourself (DIY) culture, empowering individuals to create their own devices and solutions.

- **Scalability:** The project is designed in a way that it can be easily scaled or modified. Additional sensors can be added to monitor other environmental parameters such as air pressure, wind speed, etc.

- **Home Automation Applications:** The data from this weather station can be used for various home automation applications. For example, it can be used to control HVAC systems based on the current temperature and humidity levels.

1.4 SCOPE

The scope of the Arduino Weather Station project with the DHT11 Temperature & Humidity sensor encompasses several areas:

- **Hardware Interfacing:** The project involves interfacing the Arduino microcontroller with the DHT11 sensor and a 16x2 character LCD display. This provides hands-on experience with hardware components and their operation.

- **Software Programming:** The project requires programming the Arduino to collect data from the DHT11 sensor and display it on the LCD. This provides an opportunity to learn and apply programming concepts.

- **Data Visualization:** The project includes displaying real-time temperature and humidity data on an LCD display. This aspect of the project provides experience with data visualization techniques.

- **Environmental Monitoring**: The weather station can be used to monitor environmental conditions in real-time, making it useful for a variety of applications, from home automation to agriculture.

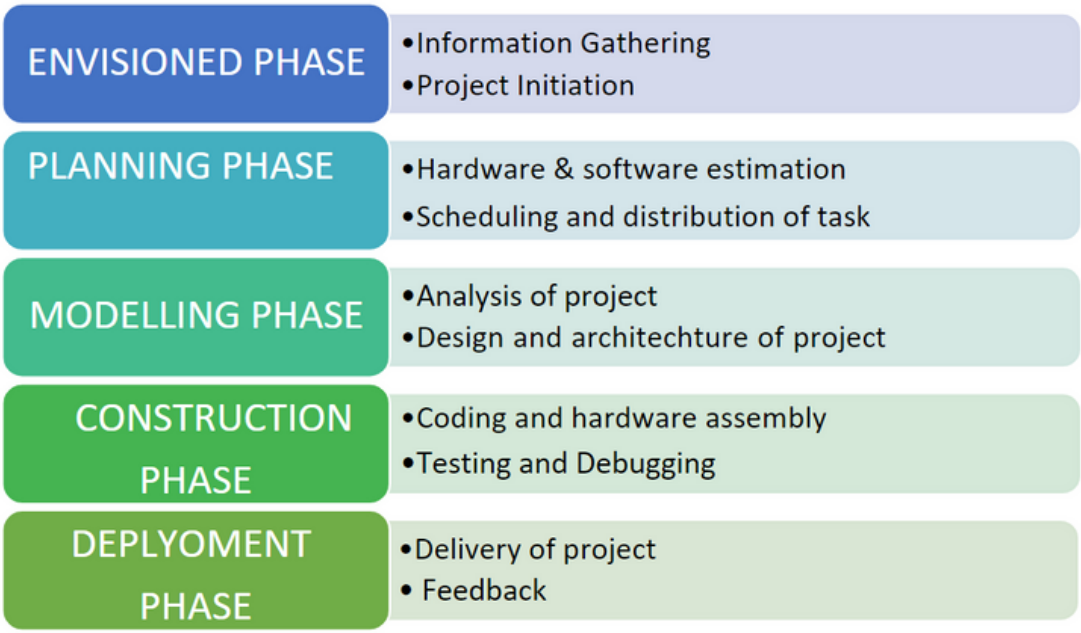
- **Scalability:** The design of this project allows for additional sensors to be added, increasing its functionality and making it adaptable to a variety of needs.

- **Education and DIY Culture:** This project is an excellent educational tool for students and hobbyists interested in electronics, programming, and IoT applications. It promotes the DIY culture, encouraging individuals to create their own devices and solutions.

By covering these areas, this project provides a comprehensive learning experience while also producing a functional and practical device.

1.5 PROJECT MANAGEMENT

Management of any project can be briefly disintegrated into several phases. Our project has been decomposed into the following phases:



Model of phases in project management

1.6 OVERVIEW & BENEFITS

The Arduino Weather Station project with the DHT11 Temperature & Humidity sensor offers several benefits:

- **Educational Value:** This project provides a hands-on learning experience in electronics, programming, and Internet of Things (IoT) applications. It helps in understanding the working of sensors, microcontrollers, and data visualization techniques.

- **Real-Time Data:** The weather station provides real-time temperature and humidity data, which can be more accurate and relevant than data from distant weather stations.

- **Cost-Effective:** The components used in this project, such as the Arduino and DHT11 sensor, are relatively inexpensive. This makes it a cost-effective solution for personal weather monitoring.

- **Versatility:** The skills learned from this project can be applied to other IoT projects as well. The design of the project allows for additional sensors to be added, increasing its functionality.

- **Promotes DIY Culture:** This project encourages the Do-It-Yourself (DIY) culture, empowering individuals to create their own devices and solutions.

- **Home Automation Applications:** The data from this weather station can be used for various home automation applications. For example, it can be used to control HVAC systems based on the current temperature and humidity levels.

- **Environmental Awareness:** By monitoring local weather conditions, users can become more aware of their environment and the impact of climate change.

2. LITERATURE REVIEW

The Arduino Weather Station project with the DHT11 Temperature & Humidity sensor has been the subject of various studies and literature. Here are some key findings from the literature:

- **Climate Monitoring:** A study titled "Climate Monitoring Using an Arduino-Based Mobile Weather Station and Open-Source Codes" discusses how a low-cost Arduino-based mobile weather station can enable learners to follow up with climate change within their immediate environment1. The study found that learners had a greater appetite to study climate change using the mobile weather station1.

- **Arduino-Based Weather Monitoring System:** Another study on Academia.edu discusses the development of a weather monitoring system based on temperature and humidity variables obtained from a DHT11 sensor2. The system was able to report if weather is Hot, Normal, or Cold based on the exact temperature and relative humidity within a 20-meter area2.

- **Design and Development of Weather Monitoring and Controlling System:** This paper discusses the design and development of a weather monitoring system3

- **IoT and Arduino Based Weather Station:** This paper discusses the use of an AVR microcontroller Atmega2560 to access data from integrated temperature and humidity sensors and process them into engineering data4.

These studies highlight the effectiveness of Arduino-based weather stations in monitoring environmental conditions, promoting experiential learning, and contributing to climate change awareness.

3.1 ARDUINO WEATHER

3.1.1 INTRODUCTION

The Arduino Weather Station is a fascinating project that combines the power of the Arduino microcontroller with the precision of the DHT11 Temperature & Humidity sensor to create a compact and efficient weather monitoring system.

This project is designed to provide real-time temperature and humidity readings, making it an excellent tool for anyone interested in weather monitoring, be it for educational purposes, hobby projects, or practical applications like home automation.

The Arduino Weather Station is not just a functional device but also an educational one. It offers a hands-on experience in working with hardware components like the Arduino and DHT11 sensor, as well as software programming for data collection and display.

Whether you're a seasoned developer or a beginner in the world of electronics, this project offers an engaging and rewarding way to explore the capabilities of Arduino and sensor interfacing.

3.1.2 MATERIALS NEEDED

The materials required for building an Arduino Weather Station with a DHT11 Temperature & Humidity sensor are as follows:

- **Arduino Uno (or a compatible board):** This is the microcontroller that will be used to process the data from the DHT11 sensor12.
- **DHT11 Sensor:** This sensor measures temperature and humidity12.
- **16x2 LCD Display**: The LCD display is used to show the temperature and humidity readings12.
- **Jumper Wires:** These are used to connect the components together3.
- **Breadboard:** This is used to make the connections between the components3.
- **USB Cable:** This is used to connect the Arduino Uno to your computer for programming.

3.1.3 HOW DO DH11 SENSOR WORKS?

If you open up a DHT11 sensor, you will see that it contains two sensing elements: a humidity sensing element and an NTC (thermistor).

The humidity sensing element consists of two electrodes with a moisture holding substrate in between. The sensor measures the resistance between the electrodes, which changes depending on the amount of moisture in the air.

On the back of the sensor, you will find a small IC that measures and processes the analog signal. It also stores the calibration coefficients and does the analog to digital conversion.

3.1.3.1 WHAT IS RELATIVE HUMIDITY?

When you look at the datasheet of the DHTxx sensors, you will see that they measure the relative humidity (RH) of the air and not the absolute humidity. But what's the difference? The absolute humidity is the amount of water vapor in the air (expressed in g/m^3), regardless of temperature. The relative humidity does take temperature into account.

Relative humidity is the ratio between the actual amount of water vapor present in the air and the maximum amount of water vapor that the air can hold at a given temperature.

Warm air can hold more water than cold air. This means that for the same amount of water vapor in the air, the relative humidity in cool air will be higher than that in warm air. At 100 percent relative humidity, the air is saturated and is at its dewpoint.

Relative humidity is defined as the ratio of the amount of water vapor actually present in the air to the greatest amount possible at the same temperature1. It is usually expressed as a percentage1. The relationship between humidity and temperature is inversely proportional.

Relative Humidity

3.1.3.2 DH11 SPECIFICATIONS

Operating voltage	3.3 – 5.5 V
Operating current	Measuring: 0.3 mA, standby: 60 µA
Humidity measuring range	5 – 95 % RH ± 5 % RH
Temperature measuring range	-20 – 60 °C ± 2 °C
Communication protocol	1-Wire
Sampling period	> 2 seconds
Body dimensions	15.5 x 12 x 5.5 mm
Pin dimensions	8 mm length, 2.54 mm spacing
Advantage	Ultra low cost

3.1.4 IMPORTANCE & FUNCTIONALITY

The Arduino Weather Station project with the DHT11 Temperature & Humidity sensor is of significant importance and offers multiple functionalities:

- **Educational Tool:** This project serves as a practical learning experience for those interested in electronics, programming, and Internet of Things (IoT) applications. It provides hands-on experience with hardware interfacing, Arduino programming, and data visualization.

- **Cost-Effective Solution:** By using cost-effective components like the Arduino and DHT11 sensor, this project aims to make weather monitoring accessible to everyone. This makes it a cost-effective solution for personal weather monitoring.

- **Versatility:** The skills learned from this project can be applied to other IoT projects as well. The design of the project allows for additional sensors to be added, increasing its functionality.

3.1.5 FEATURES

- **Promotes DIY Culture:** This project encourages the Do-It-Yourself (DIY) culture, empowering individuals to create their own devices and solutions.

- **Home Automation Applications:** The data from this weather station can be used for various home automation applications. For example, it can be used to control HVAC systems based on the current temperature and humidity levels.

- **Environmental Awareness:** By monitoring local weather conditions, users can become more aware of their environment and the impact of climate change.

- **Practicality:** The device is compact and easy to set up, making it practical for everyday use.

3.2 DH11 TEMPERATURE & HUMIDITY SENSOR

3.2.1 INTRODUCTION

The DHT11 sensor is a low-cost digital sensor used to measure temperature and humidity1. It can be easily interfaced with microcontrollers such as Arduino and Raspberry Pi1. The sensor uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin1.

The DHT11 sensor works based on the principle of capacitive humidity sensing and thermistor-based temperature sensing1. The humidity sensing component of the DHT11 sensor is a moisture-holding substrate with electrodes applied to the surface. When water vapor is absorbed by the substrate, ions are released by the substrate which increases the conductivity between the electrodes1.

For temperature measurement, the DHT11 uses a Negative Temperature Coefficient (NTC) thermistor, which decreases its resistance value with an increase in temperature1. This allows for a larger resistance value even for the smallest change in temperature1.

The DHT11 sensor can measure temperature from 0°C to 50°C with a 2-degree accuracy and relative humidity from 20% to 80% with an accuracy of 5%12. The sensor is small in size, operates from 3.5V to 5.5V, and uses a maximum of 2.5mA while measuring2.

3.2.2 PINOUT CONFIGURATION

The DHT11 sensor has a simple pinout configuration12:

1. Vcc: This is the power supply pin, which can accept voltages from 3.5V to 5.5V1.
2. Data: This pin outputs both temperature and humidity data as a digital signal1.
3. NC (No Connection): This pin is not used1.
4. Ground: This pin is connected to the ground of the circuit1.

If you're using a DHT11 sensor module, the pinout configuration is similar but only includes three pins12:

If you're using a DHT11 sensor module, the pinout configuration is similar but only includes three pins12:

1. Vcc: Power supply (3.5V to 5.5V)1.
2. Data: Outputs both temperature and humidity data as a digital signal1.
3. Ground: Connected to the ground of the circuit1.

Remember, when interfacing with microcontrollers like Arduino, the Data pin of the DHT11 sensor should be connected to a digital I/O pin on the microcontroller3. Also, a pull-up resistor (typically 5K to 10K ohms) is often required between the Vcc and Data pins for proper communication4.

3.2.3 SPECIFICATION

The DHT11 sensor has the following specifications123:

- **Operating Voltage**: 3.5V to 5.5V123
- **Operating Current:** 0.3mA (measuring), 60uA (standby)123
- **Output**: Serial data123
- **Temperature Range:** 0°C to 50°C123
- **Humidity Range:** 20% to 90%123
- **Resolution**: Temperature and Humidity both are 16-bit123
- **Accuracy**: ±1°C and ±1%123

The DHT11 sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability, and cost-effectiveness2.

3.2.4 HOW TO USE DH11 SENSOR

To use the DHT11 sensor, you need to follow these steps1:

- **Connect the DHT11 sensor:** Connect the DHT11 sensor to an Arduino or ESP8266 board using a breadboard and jumper wires. The sensor has three pins: 5V, GND, and DATA.

- **Install a DHT11 library in the Arduino IDE:** You can find the library online or use the Library Manager in the IDE1.

- **Write a sketch:** Write a sketch that uses the library to read and display the temperature and humidity values from the sensor. You can use the serial monitor or a display module to show the results1.

Here is an example of how you can use it:

```
#include <dht11.h>#define DHT11PIN 4

dht11 DHT11;

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

void loop(){
  Serial.println();

  int chk = DHT11.read(DHT11PIN);

  Serial.print("Humidity (%): ");
  Serial.println((float)DHT11.humidity, 2);

  Serial.print("Temperature (C): ");
  Serial.println((float)DHT11.temperature, 2);

  delay(2000);
}
```

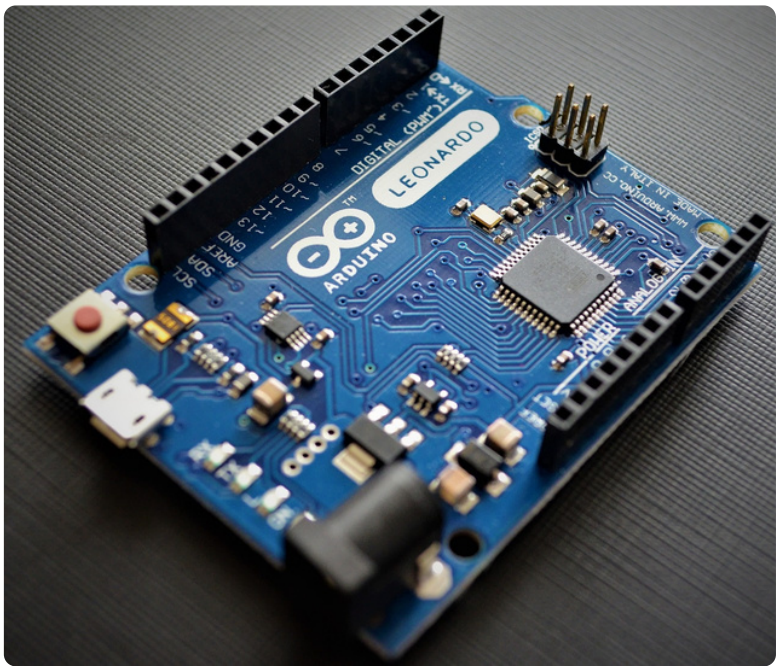
In this code, we first include the DHT11 library and define the pin to which our DHT11 sensor is connected1. We then initialize our DHT11 object. In our setup function, we start our serial communication with a baud rate of 96001. In our loop function, we read from our DHT11 sensor and print out the humidity and temperature values1.

4.1 SUPPLIES

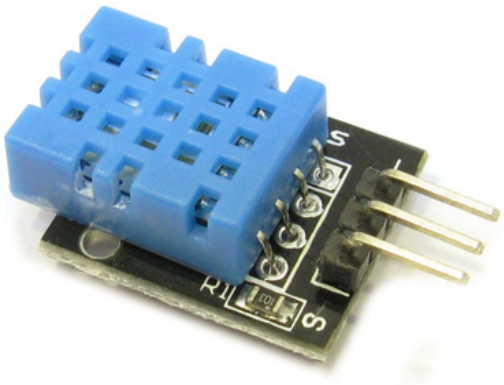
4.1.1 HARDWARE COMPONENTS

Here are the hardware components required for the Arduino Weather Station project with the DHT11 Temperature & Humidity sensor:

- **Arduino Uno:** This is the microcontroller that will be used to process the data from the DHT11 sensor12.

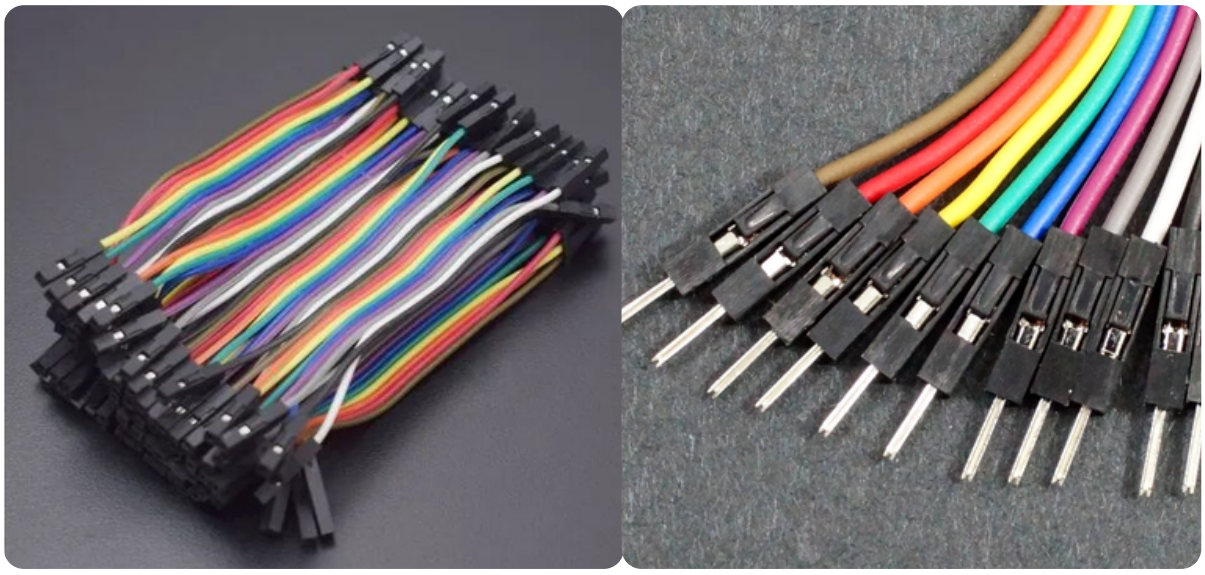


- **DHT11 Sensor:** This sensor measures temperature and humidity12.

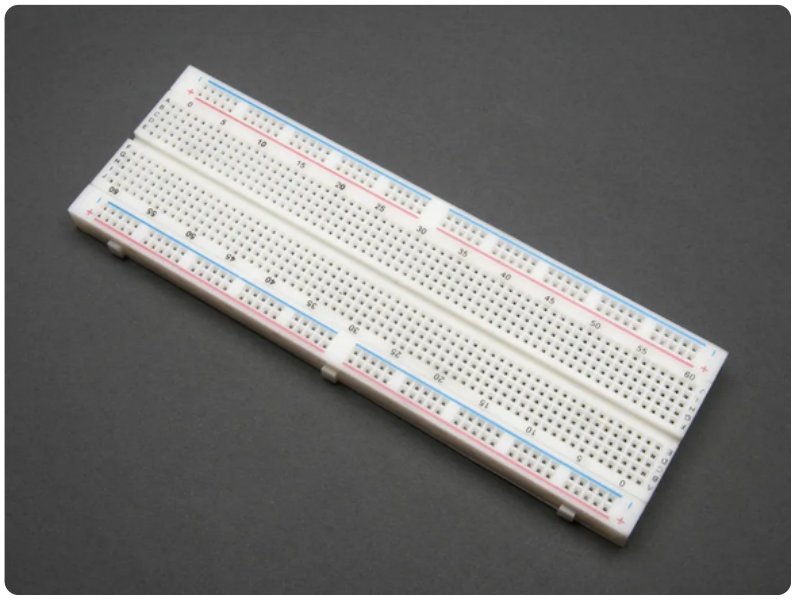


- **16x2 LCD Display:** The LCD display is used to show the temperature and humidity readings12.

- **Jumper Wires:** These are used to connect the components together3.



- **Breadboard:** This is used to make the connections between the components3.



- **USB Cable:** This is used to connect the Arduino Uno to your computer for programming1.

Please note that you will also need a computer with the Arduino IDE installed for programming the Arduino Uno2.

4.1.2 SOFTWARE

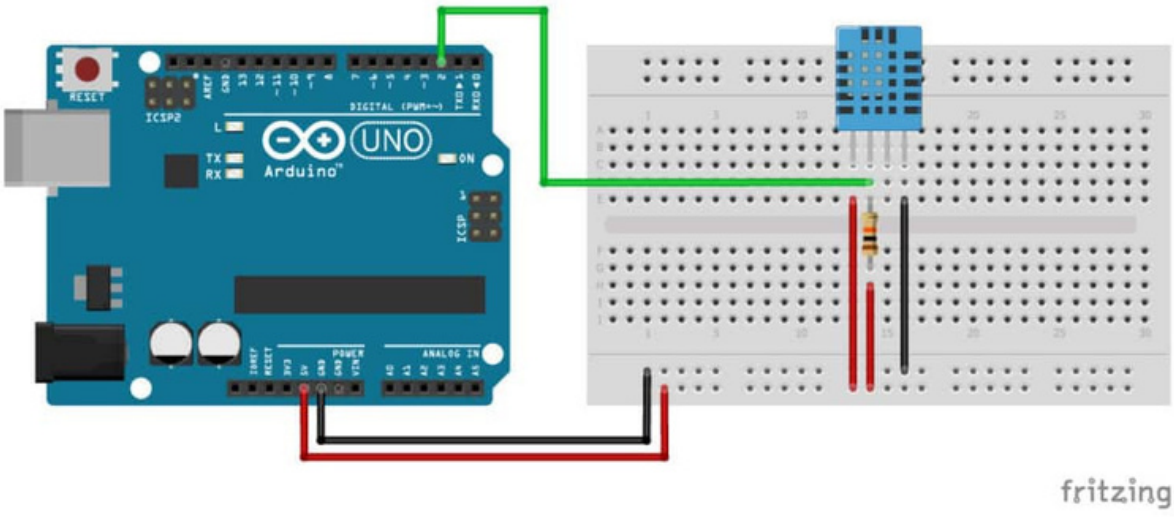
The software requirements for a weather station project using the DHT11 sensor can vary depending on the specific hardware and platform you're using. Here are some possibilities:

If you're using an Arduino, you might need:

- Arduino IDE
- DHT library (available on GitHub)

4.2 WIRING - CONNECTING DH11 TO ARDUINO UNO

The wiring diagrams/schematics below show you how to connect 3 or 4 pin temperature and humidity sensors to the Arduino Uno. A 10 kΩ pull-up resistor is needed between the signal line and 5 V to make sure the signal level stays high by default

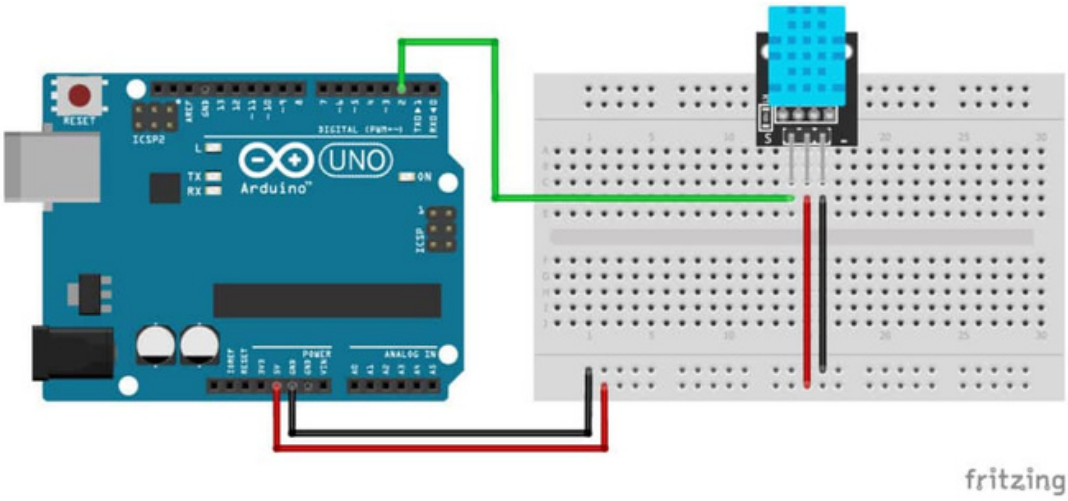


Wiring 4 pin DHT11 temperature and humidity sensor to Arduino Uno

4.2.1 PIN DH11 CONNECTIONS

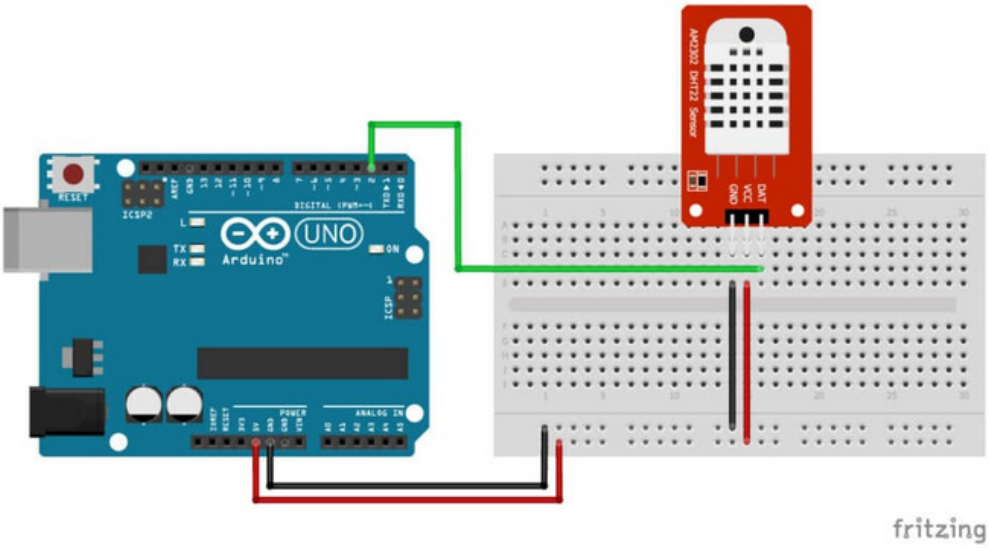
You can also buy the sensors mounted on a small PCB (3 pin sensors). These breakout boards make it easier to connect the sensor to the Arduino and also already include a pull-up resistor.

Pin 1	5 V
Pin 2	Connect to digital pin 2 and to 5 V via 10 kΩ resistor
Pin 3	Not connected
Pin 4	GND



4.1.2 3 PIN DH11 CONNECTIONS

s	Digital pin 2
+	5 V
–	GND



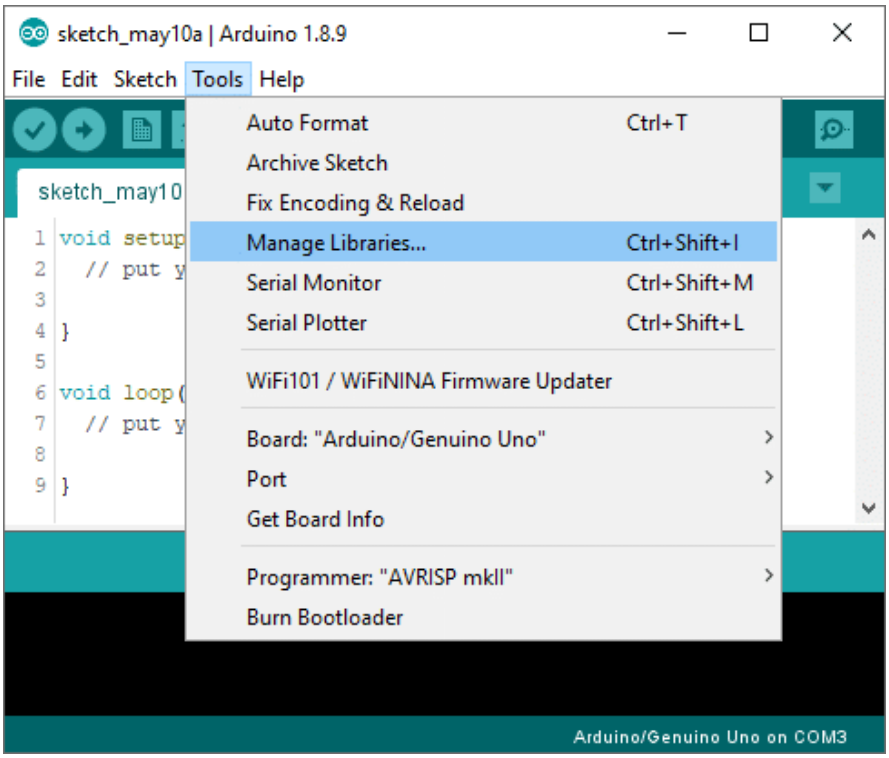
4.2.3 3 PIN DH22/AM2302 CONNECTIONS

DAT	Digital pin 2
VCC	5 V
GND	GND

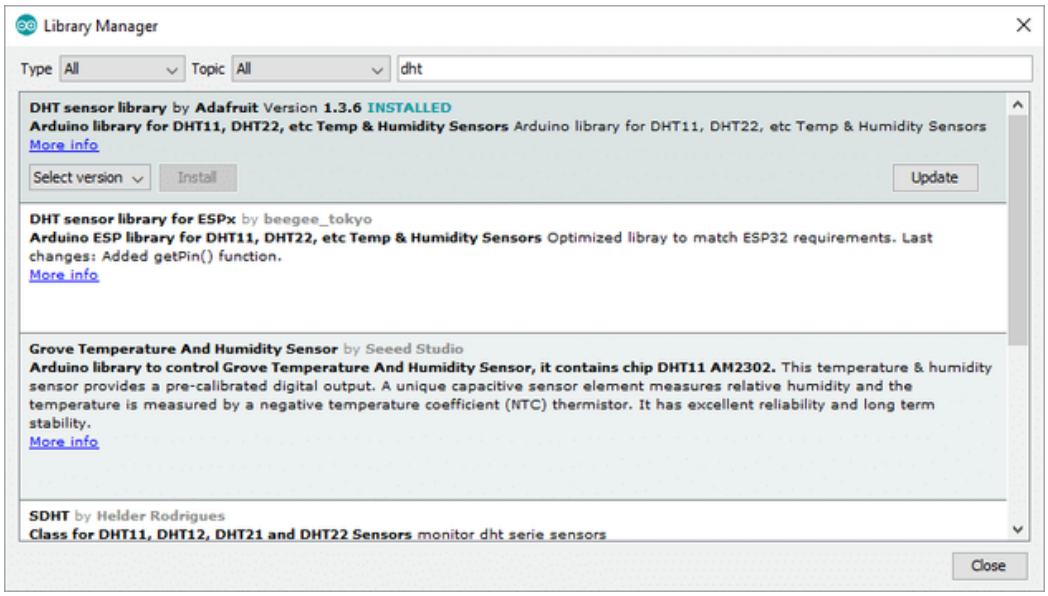
4.3 INSTALLING THE REQUIRED ARDUINO LIBRARIES

The code below uses the **Adafruit DHT sensor library** which you can download here on GitHub. This library only works if you also have the **Adafruit Unified Sensor** library installed, which is also available on GitHub.

You can install the library by going to **Sketch** > **Include Library** > **Add .ZIP Library** in the Arduino IDE.
Another option is to navigate to **Tools** > **Manage Libraries...** or type **Ctrl + Shift + I** on Windows. The Library Manager will open and update the list of installed libraries.



You can search for **'dht'** and **'adafruit unified sensor'** and look for the library by Adafruit. Select the latest version and then click Install.



4.4 WRITING THE CODE

```
//infinite Xpro
// firstly need to add i2c library

#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);  // set the LCD address to 0x27 for a 16 chars and 2 line display
byte degree_symbol[8] =
            {
              0b00111,
              0b00101,
              0b00111,
              0b00000,
              0b00000,
              0b00000,
              0b00000,
              0b00000
            };
```

```
int gate=11;
volatile unsigned long duration=0;
unsigned char i[5];
unsigned int j[40];
unsigned char value=0;
unsigned answer=0;
int z=0;
int b=1;
void setup()
{
 lcd.init();                    // initialize the lcd
 lcd.init();
 lcd.backlight();
 lcd.print("Temp = ");
 lcd.setCursor(0,1);
 lcd.print("Humidity = ");
 lcd.createChar(1, degree_symbol);
 lcd.setCursor(9,0);
 lcd.write(1);
 lcd.print("C");
 lcd.setCursor(13,1);
 lcd.print("%");
}

void loop()
{

 delay(1000);
 while(1)
 {
  delay(1000);
  pinMode(gate,OUTPUT);
  digitalWrite(gate,LOW);
  delay(20);
  digitalWrite(gate,HIGH);
```

```
  pinMode(gate,INPUT_PULLUP);//by default it will become high due to
internal pull up
 // delayMicroseconds(40);


  duration=pulseIn(gate, LOW);
  if(duration <= 84 && duration >= 72)
  {
      while(1)
      {
        duration=pulseIn(gate, HIGH);
        if(duration <= 26 && duration >= 20){
        value=0;}
        else if(duration <= 74 && duration >= 65){
        value=1;}
        else if(z==40){
        break;}
        i[z/8]|=value<<(7- (z%8));
        j[z]=value;
        z++;
      }
    }
answer=i[0]+i[1]+i[2]+i[3];
if(answer==i[4] && answer!=0)
{
lcd.setCursor(7,0);
lcd.print(i[2]);
lcd.setCursor(11,1);
lcd.print(i[0]);
}

z=0;
i[0]=i[1]=i[2]=i[3]=i[4]=0;
 }
}
```

4.5 WORKING PRINCIPLE

The working principle of a weather station using the DHT11 sensor and Arduino is as follows:

- **DHT11 Sensor:** The DHT11 sensor measures temperature and humidity1. It uses a negative temperature coefficient to convert the temperature into equivalent resistance change2. The DHT11 detects water vapor by measuring the electrical resistance between two electrodes. The humidity sensing component is a moisture-holding substrate with electrodes applied to the surface. When water vapor is absorbed by the substrate, ions are released by the substrate which increases the conductivity between the electrodes3.

- **Data Processing:** The sensors gather the readings and send them to the microcontroller (Arduino), then the microcontroller processes them4.

- **Display:** The processed data is then outputted to a 16x2 LCD Display4.

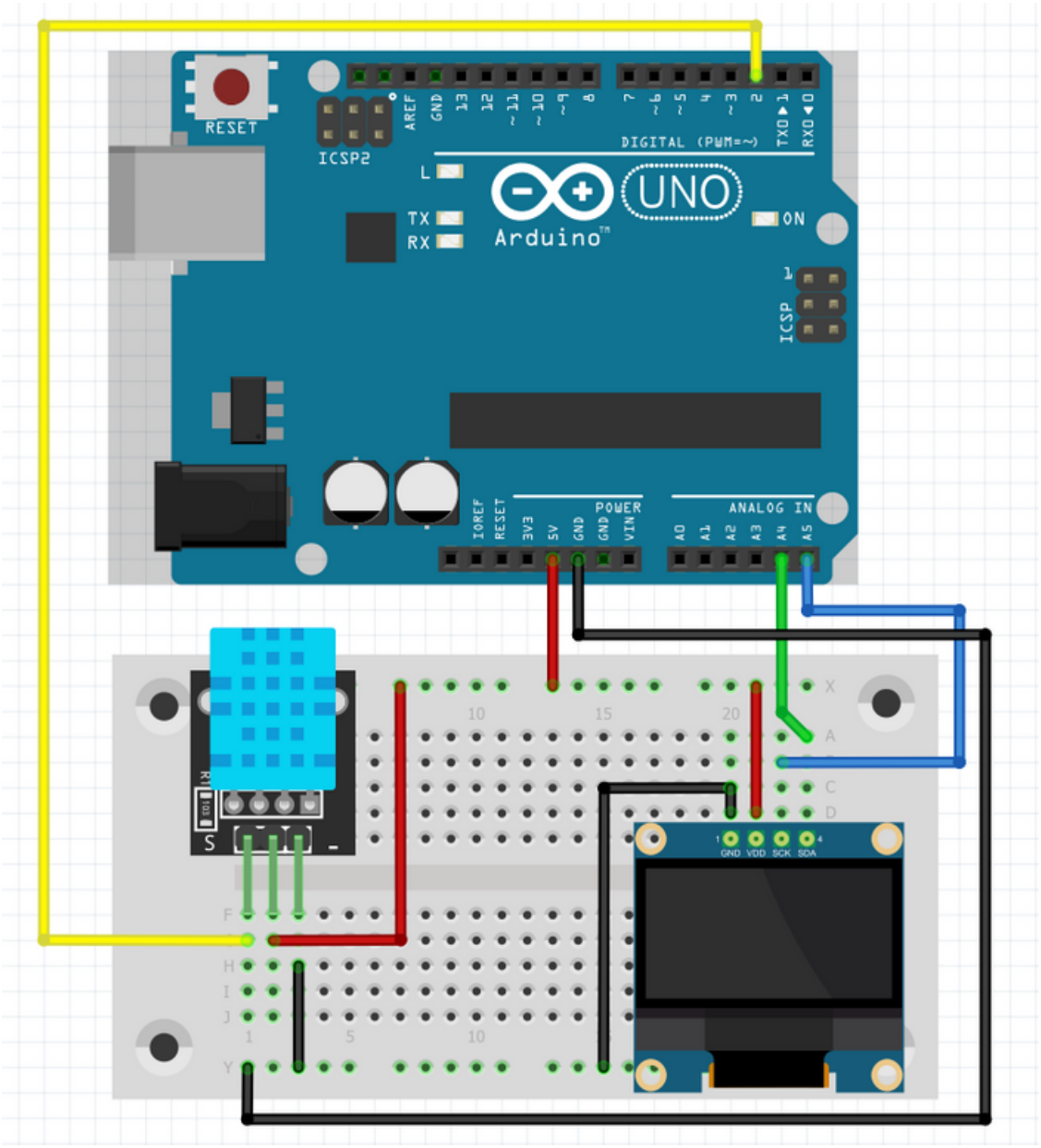
4.6 DHT11/DHT22 TROBLESHOOTING GUIDE

4.6.I FAILED TO READ THE DHT SENSOR!

This message can appear in the serial monitor when the sensor does not return a reading. This can have several causes:

- **Sensor type:** Make sure you have uncommented the correct DHTTYPE in the code setup. Check the example above.
- **Sampling rate:** The DHT sensors are quite slow, the maximum sampling rate is around 2 seconds. Increasing the delay between measurements might solve this error.
- **Power:** Although the DHTxx sensors can work from 3.3 to 5 V, the manufacturer recommends 5 V. In some cases, powering the sensor with 5 V solves the problem. Make sure that your microcontroller also supports 5 V on the GPIO pins.

4.7 SCHEMATIC



4.8 CONCLUSION

Using a display to view the temperature and humidity of your environment can be possible using the DHT11 sensor with the easy to use Arduino. For this project, we will be using the Oled I2C SSD1306 display module to display the temperature and humidity readings gathered from the environment using the DHT11 temperature and humidity sensor.

4.9 FUTURE SCOPE

The future scope of a weather station project using the DHT11 sensor and Arduino is quite promising. Here are a few possibilities:

- **Home Automation:** The weather station can be integrated into a home automation system to control HVAC (Heating, Ventilation, and Air Conditioning) systems based on the current temperature and humidity1.

- **Garden Monitoring:** The system can be used in a smart garden setup to monitor the temperature and humidity levels. This data can be used to automate watering schedules and optimize growth conditions1.

- **Weather Forecasting:** By collecting and analyzing weather data over time, the system could potentially be used to make short-term weather forecasts2.

- **Data Logging:** The weather data can be logged and sent to a cloud server for further analysis. This could be useful for climate studies or optimizing energy usage in a home or office3.

- **IoT Integration:** The weather station can be part of an IoT (Internet of Things) network, sharing its data with other devices and making automated decisions4.

- **Educational Purposes:** This project can serve as an excellent educational tool for students learning about weather, climate, or IoT systems23.

Remember, the possibilities are endless when it comes to expanding this project. It all depends on your creativity and what you want to achieve with it.