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Designing a Low-Cost Weather Monitoring System using NodeMCU

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Abstract - *Despite technological advances, such as improved varieties, genetically modified organisms, and irrigation systems, the weather is still a key factor in agricultural productivity, as well as soil properties and natural communities. The effect of climate on agriculture is related to variabilities in local climates rather than in global climate patterns. A precise weather report is necessary to make agricultural practices effective. The system proposed in this paper is an efficient and cost-effective solution compared to other weather monitoring devices present in the market. The device sends the data collected by sensors to a web app through API. The raw data further goes through a machine learning model and insights are delivered. The notification feature deployed in the application gives real-time updates and helps in faster response in case of a disaster. The compact design of the device makes it easily deployable everywhere. This project can be of great use in the domain of precision agriculture.*

Key Words: NodeMCU, Weather Station, weather monitoring systems, Thingspeak, Microcontrollers, Sensors

1. INTRODUCTION

Monitoring precise weather and soil conditions plays a key role in agricultural production. Storing and analysing the historical data of temperature and local humidity helps in future seed selection, crop rotation activities. Knowing the precise amount of moisture that is beneficial for the soil, helps farmers to regulate the water resource effectively. As an application, a farmer can use the proposed system in the agricultural field to monitor the temperature, humidity, pressure around the crops precisely. It is embedded with a rain sensor that detects rainfall and alerts the farmer in-time. The system has a hybrid power module that can charge the device with the help of solar power.

The weather station transmits a live feed of readings from the field, where the equipment is placed. This system is considered to be a smart system and embedded with sensors, microcontrollers with software application becomes a self-monitored system.

2. WORKING

The device works by taking readings from various sensors at different pins in the microcontroller. NodeMCU is selected as an effective controller as it comes with an inbuilt compatible ESP8266 Wi-Fi chip stacked upon it. It simplifies the entire project. The sensors that are attached to the microcontroller takes 3.3Volts input from the board, except humidity sensor which requires an additional 10k ohm resistor to get the accurate values. The mentioned resistor is used as a 'pull-up' and is placed parallel to the data pin and the input voltage of the humidity sensor. All sensors are soldered to a PCB along with the microcontroller and placed in a 3mm MDF enclosure (fig1 & 2).

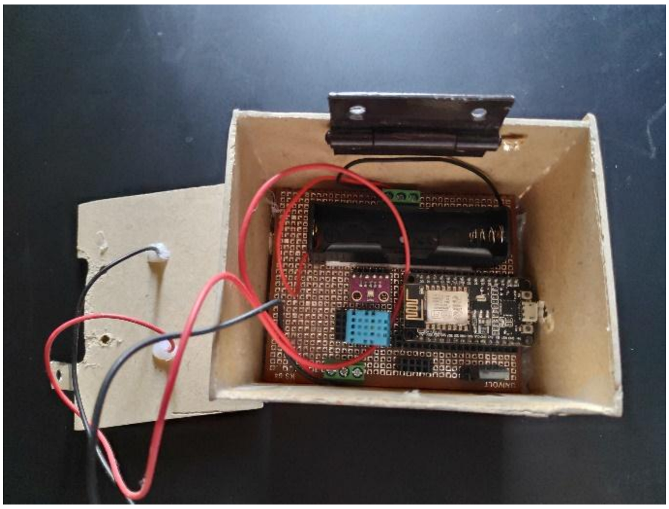

Fig -1: Internal View of the Device

DHT11 temperature sensor gets the temperature and humidity readings, it is connected to digital pin 4 on-board for input signals. It gives a continuous reading of the surrounding environment every two to three seconds. A raindrop sensor module is also attached to the 'A0' Analog pin of NodeMCU. The Raindrop sensor module comes with a potentiometer embedded to it. BMP280 pressure sensor module is attached to measure the amount of pressure. Based on the pressure, the altitude of the field is deduced.

A 18650 rechargeable battery of capacity 1800mah is connected to store the energy required for running the project. The battery can be charged either using a regular 5 Volts charger or by solar power. TP4056 charging board with inbuilt-protection IC is integrated to charge the battery using solar power. 'Deep-sleep' mode of NodeMCU helps in optimizing the power consumption of the system. The combined circuit is so efficient that the device can run for years depending only on solar power without any need of external charging.

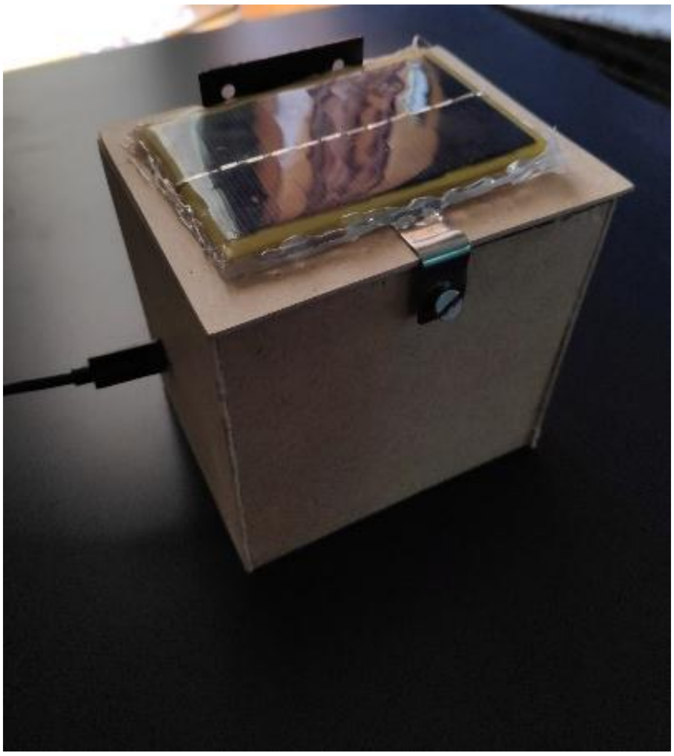

Fig -2: External View of the Device

The additional help for this project is an open-source website, ThingSpeak. Developed by a community of MathWorks. The API's provided by ThingSpeak is used to send the sensor values to the main website. A dedicated channel in ThingSpeak is created for information transmission.

3. DESIGN AND ESTIMATION

All the connections to the sensors and the power supply are illustrated in the below figure (3).

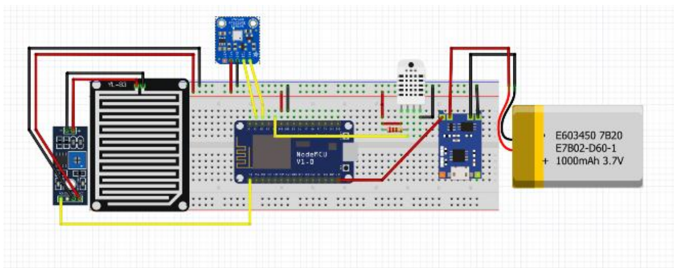

Fig -3: Breadboard Design

To run the project efficiently on solar power, a compatible solar panel has been selected. The NodeMCU must run in deep-sleep mode. This mode puts ESP8266 into hibernation and saves the battery. NodeMCU wakes up at regular intervals in order to transmit the data.

NodeMCU (max power consumption) ----------- 170 mA

NodeMCU (In deep sleep) ------------------------ 0.02 mA

Average consumption for this project (based on the sensors used) -- 120 mA

For a 5 min cycle (4.5 min deep sleep and 0.5 min for transmission)

4.5 min x 0.02 mA --------------- 0.09 mA-mins

0.5 min x 120 mA ---------------- 60 mA-mins

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5 mins --------------------------- 60.09 mA-mins

Thus, the entire Weather station requires 12.018 mA to run.

To run a day, it requires 12.018 x 24 = **288.432 mA**

With an average of 3 hrs of sunlight per day, a solar panel rated 5 Volts/100mA produces **300mA**.

Therefore, it is enough for running the weather station without any need for external charging.

3. COMPONENTS

A **NodeMCU** board is an Arduino with a Wi-Fi shield. The shield can be bought and used as an individual controller; a well-known version is the ESP8266 V1 which has only 2 digital pins. The later version does have more digital pins.

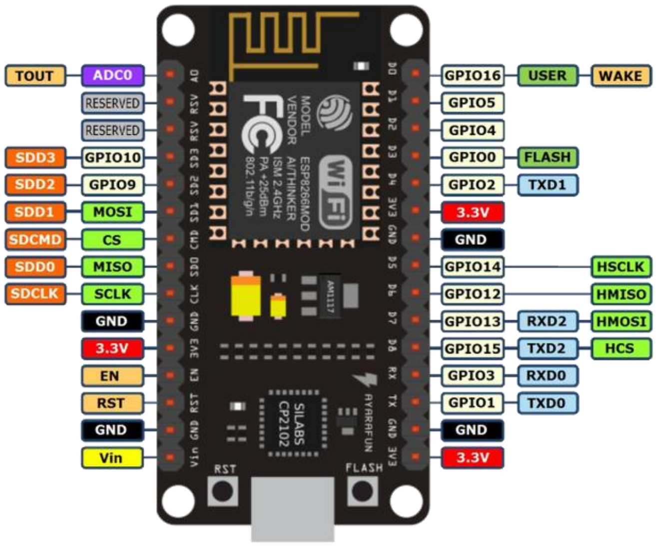

Fig -4: NodeMCU Pin Diagram

To optimize the power consumption, it has the following modes of operation choices to choose from. They all have different purposes and helps in different applications.

Item	Operation Modes		
	Modem-sleep	Light-sleep	Deep-sleep
WIFI	OFF	OFF	OFF
System clock	ON	OFF	OFF
RTC	ON	ON	ON
CPU	ON	Pending	OFF
Average Current	16.2 mA	1.2mA	~20μA

Table -1: Working Modes

3.1 DHT 11

DHT11 is a temperature and humidity sensor. The sensor is connected to the digital pin 4 of NodeMCU, this connection acts as a control stream. The sensor typically consists of 4 pins -- Vcc, Data, NC and GND respectively. The ground point of the sensor is connected to the ground of NodeMCU and Vcc to 5 Volts output.

Humidity Accuracy: ±5% RH

Temperature Accuracy: ±2 Degrees C

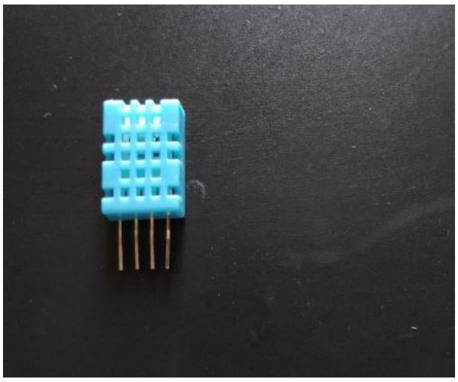

Fig -5: DHT 11 Sensor

The DHT-11 has a successor named DHT-22 which is more accurate as well as expensive. Most of the DHT-11 sensors in the market are available in blue colour and can be distinguished with DHT-22 in White.

Connections:

Data ------- D4

Vin -------- 3.36Volts

GND ------- GND

A 10k ohm resistor is placed between Data and Vin

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3.2 RAIN SENSOR MODULE

The raindrop sensor module is used to detect the presence of rain. The module consists of a rain board on which droplets can be detected, a potentiometer is used to adjust the sensitivity. An LED is connected for power indication. The sensor gives Analog output and is connected to the Analog pin A0 of NodeMCU.

Fig -6: Raindrop Sensor

3.3 BMP280 SENSOR

It is a combination of pressure and a temperature sensor which is connected with an I2C or SPI interface. The BME280 is the immediate successor from Bosch. The further upgraded modules of BME280 is the BMP085/BMP180/BMP183 sensors - with a low altitude noise of 0.25m and fast conversion time. It has 4 pins SDA, SCL, GND and Vin. These pins are connected to D1, D2, GND, 3.3 Volts pins of the NodeMCU respectively.

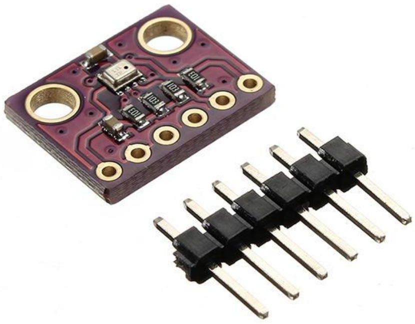

Fig -7: BMP280 Sensor

3.4 TP4056 POWER MODULE

The TP4056 is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Furthermore, the TP4056 can work with USB wall adapter. No additional blocking diode is required due to the internal PMOSFET architecture which prevents negative current. Thermal feedback regulates the charge current to limit the temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2 Volts, and the charge current can be programmed externally with a single resistor. The TP4056 automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

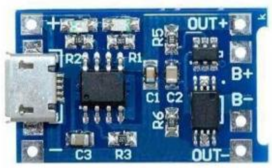

Fig -8: TP4056 Module

3.5 LDO S111733PI

It is a Low-Dropout voltage regulator which gives a constant output of 3.3 Volts for any input voltage. The output from the battery will not be a constant value, as a fully charged battery can output 4.2 Volts which fries the NodeMCU board. The NodeMCU has a 5v and above Vin slot as well as 3 to 3.36v input voltage slot. All the sensors used in the project requires 3.36-3.6 Volts and any above voltage will damage them or shows inaccurate data. Thus, the use of LDO is a must to run the weather station for a long time.

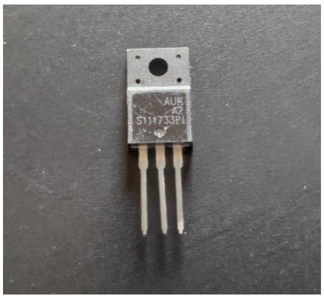

Fig -9: Low Dropout Voltage Regulator

4. RESULTS

The below graphs are plotted on the raw data that has been transmitted from microcontroller to webapp through the ThingSpeak API.

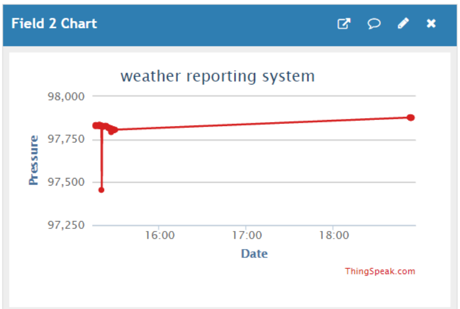

Fig -10: Pressure vs Time Chart

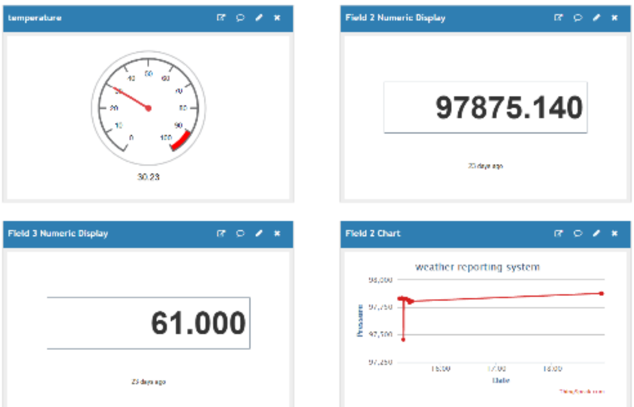

Fig -11: Available Types of Charts

5. CONCLUSION

The proposed Solar-powered weather monitoring device is reliable for efficient monitoring of weather conditions. Wireless monitoring reduces physical mundane tasks. It is cost-effective compared to a wired system. The digital sensors are precise and reliable which helps in reducing error. The system runs on a renewable source of power and is eco-friendly.

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