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# An IoT-Based Weather Monitoring System.

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***Abstract –*** Monitoring and predicting of weather conditions is vital to planning several human activities and instrumental to numerous industrial activities. Therefore, in this project, an IoT based weather monitoring system is designed and implemented. The system was designed using an Arduino Nano and sensors for collecting the weather data. A GSM module was included in the design to transmit the sensor data to the cloud where it will be displayed on a dashboard. The entire system was designed to be solar powered using a 6V 3W solar panel. The system was designed to read and transmit weather data every 20 minutes. The entire system was implemented using the C++ language and Arduino IDE. The cloud service used for designing the dashboard is the Thingspeak cloud service. The design and implementation of this project provides an affordable means of automated monitoring of the weather conditions of any location and easy visualization and real-time access to the weather data via the internet from any location.

*Keywords – Arduino, IoT, Weather, Thingspeak, DHT11*

## I. Introduction

In today's world, the monitoring and predicting of weather conditions is vital to planning several human activities. Therefore, collection of information about the temporal dynamics for changing weather has become very important [1]. As a result of the importance of monitoring weather conditions, instruments have been developed to monitor several weather parameters. These include the thermometer for measuring temperature, the hygrometer for measuring humidity, the rain gauge for measuring precipitation. These various instruments when pooled together form a Weather Monitoring System. A Weather Monitoring System is therefore a collection of different instruments and apparatus used to measure different weather parameters like temperature, humidity, wind speed, rainfall amount etc. [2]. Traditional weather monitoring systems lack self-sustainability, autonomous logging capabilities and the ability to transmit data wirelessly. Furthermore, professional weather monitoring systems are too expensive for the average consumer and they typically have a limited range of transmission [5]. Such weather monitoring systems tend to be bulky and require trained professionals to interact with the system from time to time in order to take measurements and to monitor the overall functioning and performance of the system. Contemporary weather monitoring systems make use of electronic sensors and data acquisition systems for wireless remote monitoring of weather conditions. These systems might either be on ground systems or meteorological satellites. However, conventional weather monitoring systems are preferred due to their better accuracy even at higher cost [4]. Furthermore, these new systems can easily be configured to connect with other devices such as smart phones and web servers to extend their accessibility. This connectivity of the system to other devices is made possible through the Internet of Things (IoT). The term "Internet of Things" (IoT), coined by Kevin Ashton in 1999, essentially refers to giving objects representation in the digital realm through giving them a unique ID and connecting them in a network [5]. This means that different objects or things can have the ability to communicate with each other in a network hence the term "Internet of Things". Nowadays, with the advent of IoT and the advancement of electronics design, weather monitoring systems are available to provide weather related information on commercial basis for various applications such as agriculture, renewable energy, weather forecasting, flood prevention etc without the need for any human interaction with the system. These weather monitoring systems are typically referred to as Automated weather monitoring systems.

In this article, the design of an automated weather monitoring system is considered. The system is designed to measure temperature, atmospheric pressure, light intensity and amount of precipitation. The measured data is transmitted wirelessly to a web server via a GSM Module and can be accessed via a mobile phone, tablet or laptop. An Arduino Nano was used as the microcontroller, a DHT11 sensor was used for measuring temperature and humidity, a BMP180 sensor was used for measuring atmospheric pressure, and an LDR was used for measuring sunlight intensity. The entire system is designed to be low-cost, energy efficient and portable so as to allow for easy deployment and for operation without the need for human interaction.

## II. Materials and Method

The steps involved in the design and implementation of the project work are explained in this section. The working principle of the system, the hardware components used in the implementation of the system and the system's software design are discussed here. The block diagram of the system is shown in Fig. 1 and the flowchart of the software design is shown in Fig. 2.

### The Power Supply Unit

The system's power supply is obtained from the sun using a solar panel. A 6V, 3W solar panel along with a 1500mAh Li-ion battery was selected.

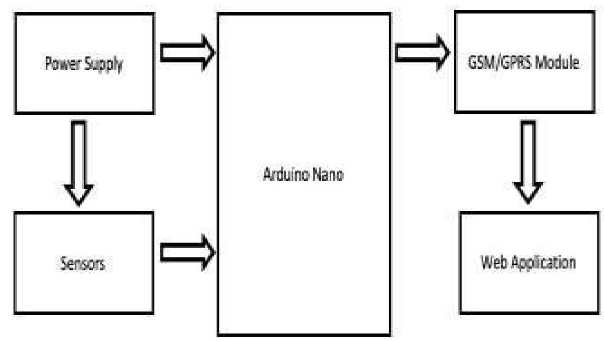


Fig.1. Block Diagram of the overall system

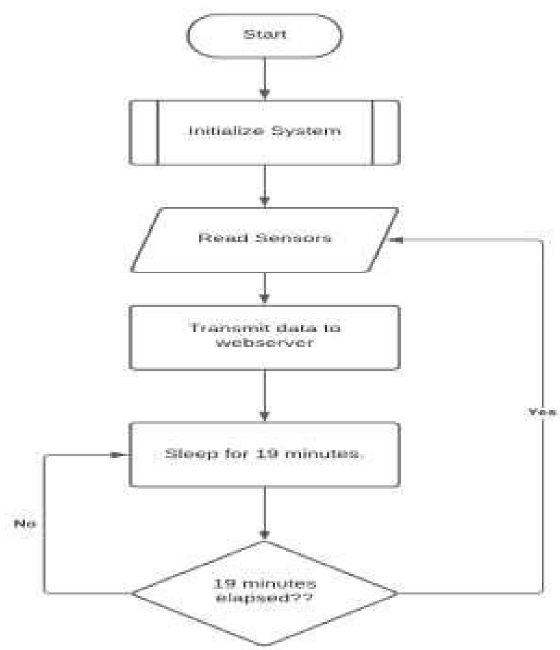


Fig.2. Flowchart of the system

### The Control Unit

The system's control unit utilizes an ATmega328 microcontroller surface-mounted on the Arduino Nano prototyping board. This microcontroller is from the Atmel family and has 14 General-Purpose Input/Output (GPIO) pins, 6 analog pins, 16Kb flash memory, 2Kb SRAM and a 16MHz clock UART, TTL and $I^2C$ communication protocols along with a 10-bit analog-to-digital converter (ADC) [6]

The control unit is programmed to receive data from the various sensing units, convert the data into digital form and to transmit the converted data to the communication unit. Fig. 3 shows an Arduino Nano.

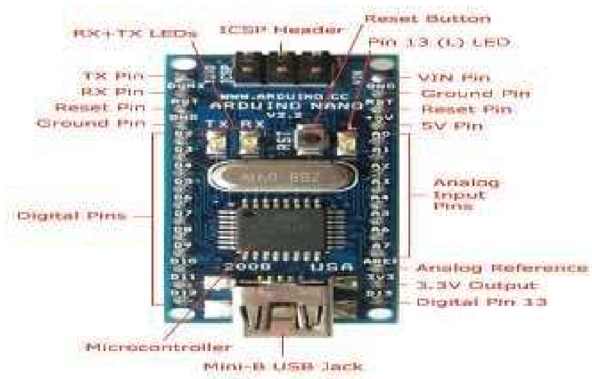


Fig. 3. An Arduino Nano

**Temperature and Humidity Sensing Unit**

The DHT11 digital temperature and humidity sensor is a calibrated digital signal output of the temperature and humidity combined sensor [7].This sensor measures temperature in the range of 0°C to 50°C and humidity between 20% to 90%. The sensor uses a one-wire serial interface to communicate with external digital circuits. Fig. 4 shows a DHT11 sensor.

Fig. 4. DHT11 Sensor

**Atmospheric Pressure Sensing Unit**

The BMP180 consists of a piezo-resistive sensor, an analog to digital converter and a control unit with E2PROM and a serial I2C interface. The BMP180 delivers the uncompensated value of pressure and temperature. This sensor measures pressure in the range of 300 to 1100hPa [8]. This sensor also utilizes a one-wire serial interface for communication with other digital circuits. A BMP180 sensor is shown in Fig. 5.

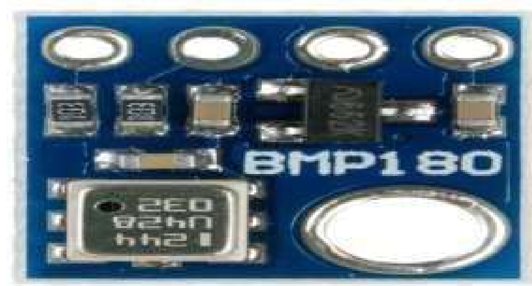


Fig. 5. BMP180 Sensor

**Light Intensity Sensing Unit**

This sensor measures the amount of sunlight intensity falling on the earth at any point in time. A Light Dependent Resistor (or a photoresistor) attached to a control unit is used as the sensor. The Light Dependent Resistor's resistance value decreases with an increase in sunlight intensity. Fig. 6 shows an LDR.

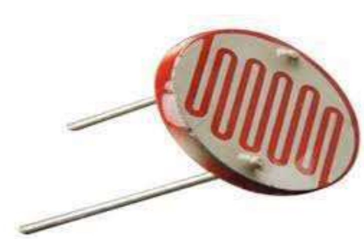

Fig. 6. Light Dependent Resistor

**Rainfall Sensing Unit**

The sensor used for measuring rain is the FC-37 sensor. This sensor detects rainfall using a sensing module attached to a control module. Increase in amount of rainfall decreases the sensor's resistance [9]. The sensor consists of a sensing module and a control module and its sensitivity can be increased via an on- board potentiometer. Fig. 7 shows the rainfall sensor.

Fig. 7. Rain Sensor

**GSM Module**

The GSM (Global System for Mobile Communications) Module which is sometimes called the GPRS (General Packet Radio Service) Module is a chip that uses a modem to establish communication between a computing machine and a GSM or GPRS system [10].

GS M / GPRS Modules allow microcontrollers to have a wireless communication with other devices and instruments. The SIM800L GSM/GPRS module (Fig. 8) was utilized in the system.

Fig. 8. SIM800L GSM/GPRS Module

**Circuit Diagram**

Fig. 9 shows the circuit diagram of the system. The entire system is powered via the 6V solar panel. A charge controller is connected to the battery to prevent overcharging. All the sensors are interfaced with the Arduino Nano via analog pins and the GSM module is connected to the Arduino Nano via digital pins to enable serial communication. An LCD display was also interfaced with the Arduino Nano via the I2C ports. The LCD displays the status of the system. The system is programmed to gather data every 20 minutes and then transmit the data to the Thingspeak server. The reading and transmission steps take a minute on average and the system goes to sleep for 19 minutes. The system consumed 482mA during operation and 12.03mA on sleep. On average, the system consumes 711.6mA per day and this was considered while selecting the 1500mAh battery. Hence, the system can function continuously even on heavily overcast days.

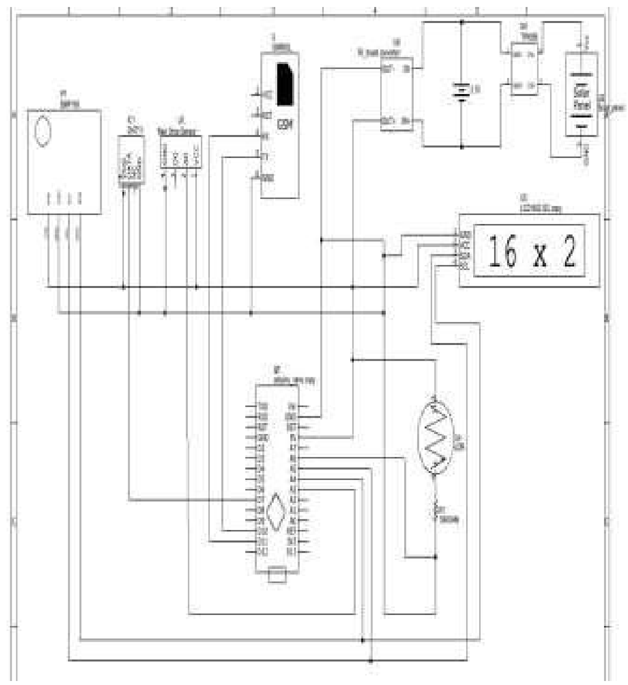


Fig. 9. Circuit Diagram of the System

## III. RESULTS

The system was tested for a week. The system responded as expected with a few delays from the communication unit owing to the poor internet connectivity at the test site. Table 1 shows the average daily readings of the system for the total period of testing.

Table 1. Daily Average Readings from the System

| Day | Temperature (°C) | Humidity (%) | Atmospheric Pressure (KPa) |
|---|---|---|---|
| Day 1 | 28.00 | 80.00 | 32.70 |
| Day 2 | 27.00 | 88.00 | 32.59 |
| Day 3 | 26.00 | 86.43 | 32.48 |
| Day 4 | 29.67 | 77.67 | 32.52 |
| Day 5 | 29.56 | 79.89 | 32.39 |

| | | | |
|---|---|---|---|
| Day 6 | 29.00 | 78.43 | 32.52 |
| Day 7 | 29.00 | 81.36 | 32.75 |

The plots of the sensor readings over time were generated and displayed on the web dashboard. The plots are shown in Fig. 10.


Fig. 10: Plots of the System's Readings

## IV. DISCUSSION

The accuracy of the system was measured by comparing the daily readings of the temperature sensing unit against an existing weather monitoring application. IBM's weather.com application was selected as the benchmark. On average, an error of 1.795 was found between the two readings.

## V. CONCLUSION

In this paper, an IoT based weather monitoring system was discussed with real-time data monitoring capabilities. From the results obtained while testing the prototype system, it can be inferred that a highly accurate system with efficient management capabilities was achieved. Hence, such a system can be readily deployed to remotely monitor the weather conditions of any location from anywhere in the world

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