Design Presentation of a Solar Powered Microcontroller-Based Weather Station for the Acquisition of Atmospheric Parameters

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Abstract

Accessing real time weather information is still a challenge to atmospheric researchers. This work developed a solar powered Arduino microcontroller weather station that will measure atmospheric temperature, relative humidity, pressure and wind speed and wind direction using appropriate meteorological sensors such as DHT22 sensors for atmospheric temperature and humidity measurement, BMP180 sensors for pressure measurement, a three cup anemometer with reed switch sensor for wind speed measurement and a wind vane with a variable resistor for wind direction measurement. An Arduino Atmega 2560 microcontroller processes the output of the sensors, transfer them to the LCD for display and also transmit it to the Wi-Fi module which uploads the data to an online server to enable out-of-site end users to access the measured weather information.

Keywords: Weather station, Microcontroller, Monitoring Sensors, Wi-Fi module, solar panel.

1.0 INTRODUCTION

Weather tracking is of great importance in agriculture, communications, air transportation, industries and to atmospheric physicist (Anthony *et al.*,2017). For example in agriculture, weather determines how much success that can be recorded, because crop yield depend on weather in providing energy and water for it sustenance (Abubakar and Sulaiman,2018). Research has proved that climate change will have great effect on agricultural yield and human activities in the next century (Walthall *et al.*,2018). Hence there is need to have an effective means of monitoring atmospheric parameter at all times. Such a weather station should have an independent power source such as solar energy, for all time weather monitoring. A microcontroller weather station reads and records atmospheric parameters using sensors without any external intervention (Tajedinn and Abdelrasoul, 2015). The recorded atmospheric parameters can be processed as wired information, which means that it will be downloaded in a computer or through a server as in wireless communication. The aim of this work is to design a low cost solar powered weather station which will transmit real time weather information to an online server for multiple retrievals.

2.0 METHODOLOGY

The block diagram of the design considered for the solar powered weather station is shown in figure 1:

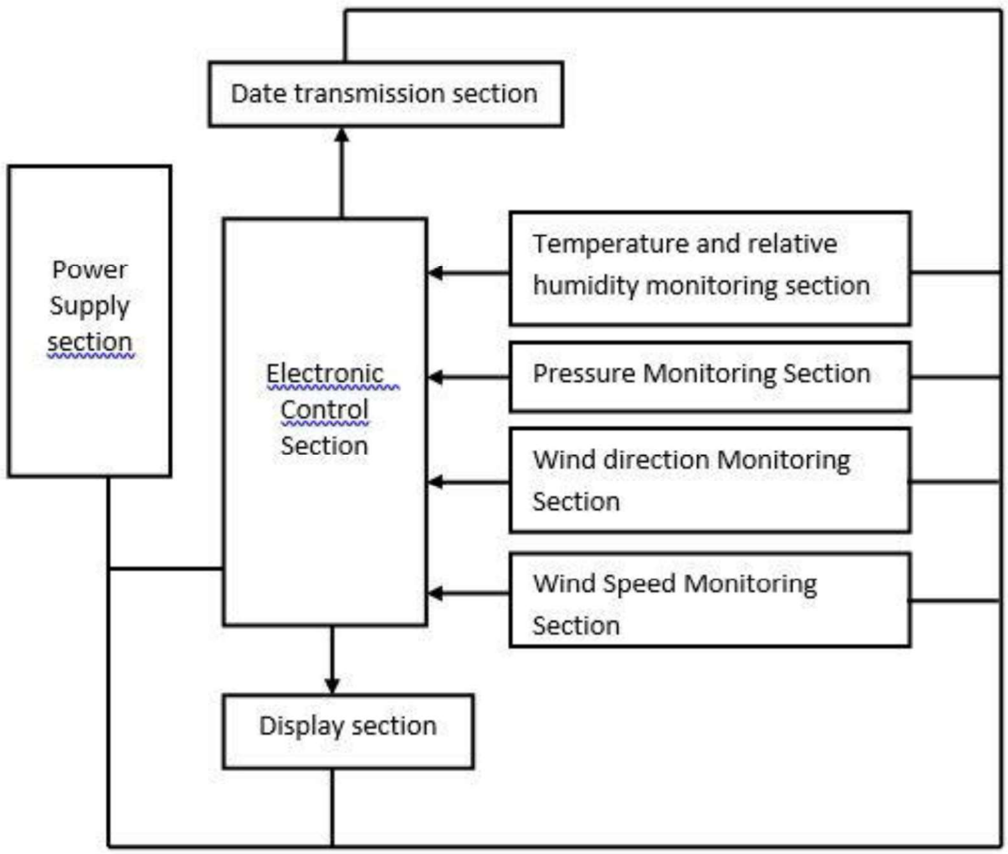


Figure 1: Block Diagram of the Device

The section by section design of the block diagram is explained below:

2.1 Power supply section

The power supply section provides the electrical energy required by the device. For round the clock monitoring device, a renewable energy is appropriate. As such, the device shall be powered using the enormous energy of the tropical African sun, solar energy. The block diagram of the power supply section is shown in Figure 2.

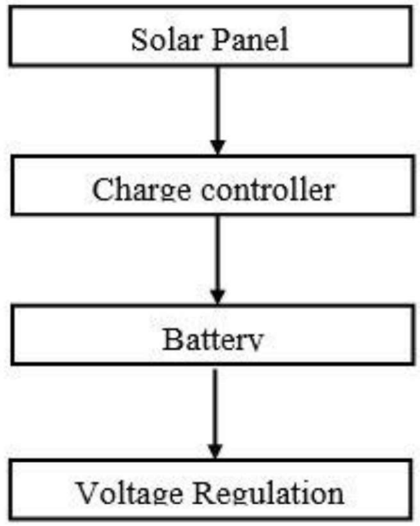


Figure 2: Block Diagram of the Power Supply Section

Sub sections of the proposed power supply design are explained below:

2.1.1 Solar Panel

A monocrystalline solar panel provides DC voltage source to the system to enhance continuous atmospheric data acquisition. The electrical rating of the solar panel considered is given in Table

Table 1: **Electrical Rating of Solar Panel**

ELECTRICAL RATING	VALUES
Maximum power (P_{max})	50W
Open circuit (V_{oc})	21.5V
Short circuit current (I_{sc})	3.05A
Maximum power current (I_m)	2.77A
Output tolerance (%)	+3
Operating temperature (°C)	-40°C - +80°C

Length (mm)	670
Width (mm)	540
Height (mm)	30
Weight (kg)	4.35

All data at standard test condition (STC) $E = 1000Wm^{-2}$, AM = 1.5, $T_c = 25^oC$.

The 50W, 18V rating of the solar panel significantly provide the needed guide to choosing the panel.

2.1.2 Charge Controller

The charge controller acts as a switching device between the solar panel and the battery, it regulate the output voltage from the solar panel to the required charging voltage of the battery, the charge controller switches off the charging of the battery when it is fully charge to prevent over charging. It also prevent the battery from draining back it charge to the solar panel when it is not charging it. A 10A, 12V charge controller is appropriate so as to match the battery it is interfacing.

2.1.3 Battery

A 12V rechargeable deep cycle battery provides the DC voltage source to the device. The battery discharges very small current for a lengthy period.

2.1.4 Voltage Regulation

Voltage regulation is necessary to peg the 12V output from the battery to a level tolerated by constituent components. A maximum of voltage of +5V is sufficient and as such, a 7905 voltage regulator was chosen.

2.2. Electronic control sections

The electronic control unit is made up of Arduino Atmega2560 microcontroller. It is responsible for the reception of analogue and digital signal from the atmospheric sensors .The microcontroller process the output of the sensors using c++ programming language into useful weather information for the purpose of analysis. Arduino Atmega2560 microcontroller has 54 digital input/output pins and 16 analogue input pins.4 UARTS (hard ware serial pins),a 16MHz crystal oscillator. The table below shows the features of Arduino Atmega2560

Table 2: Features of the Arduino Atmega2560

Specification	**Values**
Operating Voltage	5V
Input Voltage	7-12V
Input Voltage (limits)	6-20V
Didital I/O pins	54(of which 14 provide PWM output)
Analog input pins	16
DC Current per 1/O pins	40 Ma
DC Current for 3.3 V pin	50 mA
Flash Memory	256 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock speed	16 MHz

All the atmospheric sensors will be connected to the microcontrollers input via appropriate pins, it manipulates such inputs in line with programmed instructions and produce output through the output pins to the output devices.

2.3 Temperature and Relative Humidity Monitoring Section

This section has the DHT22 sensor. It has capacitive humidity sensing element and a high precision temperature measuring device. DHT22 sensor is small in size, low power consumption and long distance transmission. DHT22 sensor has the following features as shown in Table 3.

Table 3: Features of DHT22

Specification	**Values**
Model	DHT22
Power supply	3.36V DC
Output signal	Digital signal via single-bus
Sensing element	Polymer capacitor
Operating range	Humidity 0-100%RH;temperature -40-80Celsius
Accuracy	Humidity +-2%RH(Max+-5%RH);temperature <+-0.5 Ceius
Resolution or sensitivity	Humidity 0.1%RHtempeture o. 1Celsius
Repeatability	Humidity +-1%RHtemperatture 0+.2Celsius
Humidity hysteresis	+-0.3%RH
Long-term stability	+-.5%RH/year
Sensing period	Average;2s

DHT22 has a single-bus data communication with the microcontroller. When microcontroller sends start signal, DHT22 change from low power consumption mode to running mode when microcontroller finishes sending the start signal, DHT22 will send response signal that reflect the relative humidity and temperature information.

2.4 PRESSURE MONITORING SECTION

This section has BMP180 sensor which measures atmospheric pressure and give analogue output to the microcontroller. The microcontroller converts the analogue signal from the BMP180 to digital signal and display on the LCD. BMP180 makes use of I^2C communication protocol. The specifications of the BMP180 atmospheric pressure sensor ire enumerated below:

- Operating voltage of BMP180: 1:3V – 3.6
- Input voltage of BMP180MODULE: 3:3V to 5:5V
- Peak current : 100uA
- Consumes 0.1uA standby
- Maximum voltage at SDA, SCL : VCC + 0.3V
- Operating temperature: - 40^0C to 80^0C

2.5 WIND SPEED MONITORING SECTION

A three cup anemometer device is used to measure the wind speed. The three cup anemometer is mounted on a shaft at the base of the shaft there is a magnet attached to the shaft and a reed switch is positioned so that it is perpendicularly facing the magnet. When the three cup anemometer rotate due to the effect of wind, and the magnet passes, the reed switch for every rotation, this triggers the reed switch to send a logic zero to the microcontroller. The process continues and the microcontroller counts the triggers. For every rotation made after the selected interval of time the microcontroller calculate the wind speed using Davis equation;

$$V = P(2.25/T) \quad (1)$$

where V is the speed in miles per hour (m/h), P is the number of pulse during sampling period and T is the period per second.

2.6 WIND DIRECTION MONITORING SECTION

A wind vane is assembled such that the shaft is coupled directly to a continuous moving variable resistor that gives an output of 0V to 5V which is mapped to 0° to 360°, north direction serves as the reference degree which is 0° while east, south and west are 90°, 180° and 270° respectively.

2.7 DISPLAY SECTION

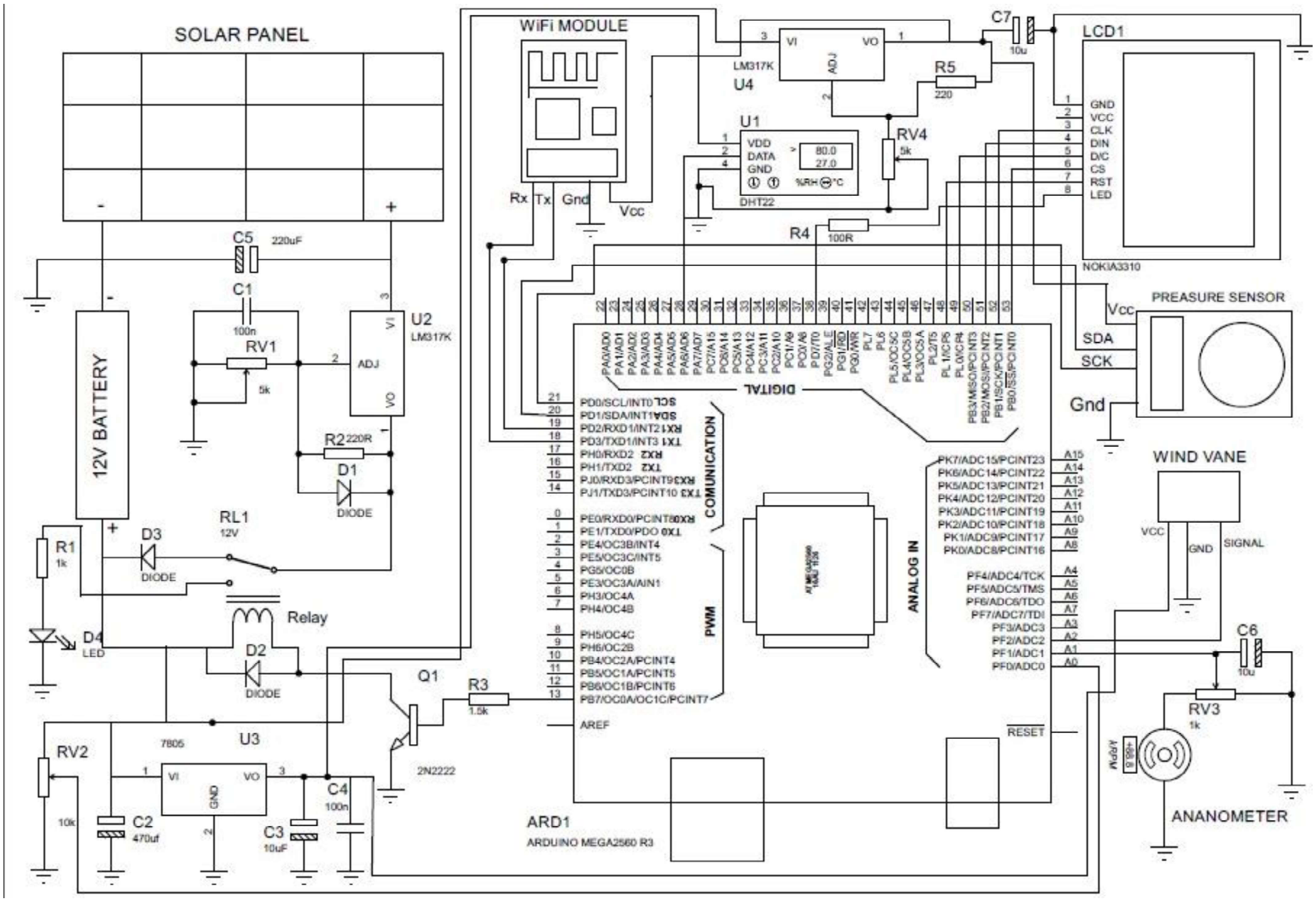
The display section has 84 by 48 pixel LCD display with 8 input pins which are connected to the microcontroller through which measured atmospheric data are displayed as output. The LCD uses serial peripheral interface (SPI) communication protocol.

2.8 DATA TRANSMISSION SECTION

A Wi-Fi module serves as the data transmission link using universal asyndrionous receiver and transmitter (UART). The Wi-Fi module sends signal to the microcontroller during it initialization process, thereafter the microcontroller sends signals of processed atmospheric data to the Wi-Fi module to upload to an online server. Through the online server, real time weather information can be accessed.

3.0 RESULT AND DISCUSSION

The result of the design description presented so far constitutes the overall design and when in visuals; it's the overall circuit diagram. The diagram shows all the sections intra connections, inter connections and signal flow. The overall circuit diagram of the proposed Arduino microcontroller weather station is shown in Figure 3.



From the above circuit diagram, it is clear that the central part of the design is the microcontroller. All sensors which interact with atmospheric elements were directly connected to it and all channels in which the manipulations of the sensed inputs are expressed were all connected from it. Its role is similar to that of the human heart connected to veins and arteries. Hence, the heart of the device is the microcontroller and from where the device derived its name, “microcontroller-based” weather station. All sections of the design, hardware and software are therefore expected to function in perfect synergy for overall electrical and signal harmony of the system. The choice of solar power considering the study area, Minna, North-central Nigeria is a guarantee for all day and all year long uninterrupted power for the acquisition of atmospheric data.

4.0 CONCLUSION

The aim of this work which is to design a low-cost, mobile, microcontroller-based weather station that can provide real time weather information has been achieved. The focus of future research borders on:

1. Transforming the design concept of this work into physical reality for the benefit of mankind.
2. Performance evaluation of the constructed device by comparing acquired data using the device with those acquired using other weather measuring devices for same location and period. This is to help place performance comment on the device with respect to accuracy and error margin.

The designed microcontroller based weather station combined the benefit of low-cost, portability, real-time acquisition and efficiency all in one, thus making weather information acquisition, storage, transmission and reception possible from the comfort zone of the end user.

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