# WIRELESS SENSOR NETWORK FOR ATMOSPHERIC TEMPERATURE, PRESSURE READING USING XBEE AND PYTHON WITH SOLAR POWERED REMOTE NODE BATTERY MONITORING

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***Abstract:*** **In this era of science and technology, weather forecasting and monitoring has seen several technological developments, because of its tremendous benefits in human's everyday life. These technological developments were necessary due to the challenges faced in conventional weather forecasting systems such as, inaccurate predictions and expensive equipment. The authors of this paper after analyzing these problems have designed a low-cost Portable Wireless Weather monitoring system using an Arduino microcontroller and Xbee radios. To calculate weather variables such as barometric pressure and temperature, sensors are integrated with the, implemented Weather Monitoring System. The developed system includes some capabilities, such as a graphical interface that receives, sensed data available through the base station (PC or laptop equipped with Xbee radios), which is accomplished by seamless contact between the base station and the remote nodes (Arduino equipped with sensor and Xbee radios). In addition, another feature is also introduced in this paper to control the remote node's energy consumption. To introduce an inexpensive weather monitoring system, the weather monitoring system is powered using a solar panel with a Power Supply Unit. This power supply unit is connected to the rechargeable battery later connected to the Arduino (remote node). The PSU enables the battery to shut-down at a certain interval of time, which drastically reduces the overall power consumption of the weather monitoring system.**

***Keywords: Xbee Radios, Python, Wireless Sensor Networks, Solar Energy, PSU.***

## 1. Introduction

Weather forecasting has become a vital part of everyday life for the smooth running of day to day activities. Weather forecasting using the traditional method is becoming more ineffective [1]. The drastic changes in the climate are inefficiently captured in traditional systems in which infeasible real-time forecasting is possible [2]. Energy availability is a major issue in wireless sensor networks [3]. Successful low-cost energy goals are shifting toward sources of renewable energy such as wind, solar, and biomass. [4]. In this era, weather data collection and transmission have become challenging and require robust instruments to provide timely and accurate predictions [5]. The automated weather stations can give accurate results with increasing density of weather station networks [6]. The high costs of such networks hinder their acquisition in developing countries [7]. To achieve efficient accurate networks, lowest sensor networks are made possible in our present work. The system we have developed can plot real-time graphical information of temperature and pressure as well as the energy levels of the battery. The data captured through a sensor are transmitted wirelessly to a remote computer (base station) to make it available for the users. The system uses energy from a renewable solar energy power, with a timer to achieve energy preservation.

## 2. Related Works

Several researchers have designed weather forecasting systems, and also approached energy constraints. The weather monitoring system is capable of sensing weather parameters and uses meteorological sensors and for communication Xbee radios are used. Both software and hardware devices are used to monitor the weather [5]. This system compares humidity and temperature of an indoor space; it is a system for controlling temperature at a low cost, which can improve the thermal comfort of the room but lacks with automatic control of the environment [6]. Temperature analysis using a sensor and creation of wireless sensor network using Xbee radios and analysis of synchronization between Arduino and Xbee [7].Two wireless sensors are used and communication is established using Xbee radios, the temperature monitoring of a moving robot in X-Y direction is performed[8].Comparison between the fixed irrigation system and the proposed system is performed, the conventional irrigation system has several draw backs over the proposed system including detecting the moisture area and broken pipes [9]. The system can monitor temperature of a shrimp farm with maximized accuracy using zigbee technology [10] and LabVIEW.

## 3. Methodology

The proposed sensor networks' overarching architecture is described in Fig.1. Its working component consists of Arduino microcontroller, Xbee S2C modules, Xbee SD shields, temperature and pressure sensors, solar panel, rechargeable





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batteries, timer and voltage regulator. In addition to that there is a program designed using Python to plot real time graph.

### 3.1. Materials and Methods

#### 3.1.1. Arduino Uno

The Arduino Uno is used to connect various sensors in the proposed work [8].

#### 3.1.2. BMP180

BMP 180 Barometric Pressure/Temperature/Altitude is one of the sensors of BMPXXX series fig (2(b)). Barometric pressure is used as the fluctuations in the pressure [9].

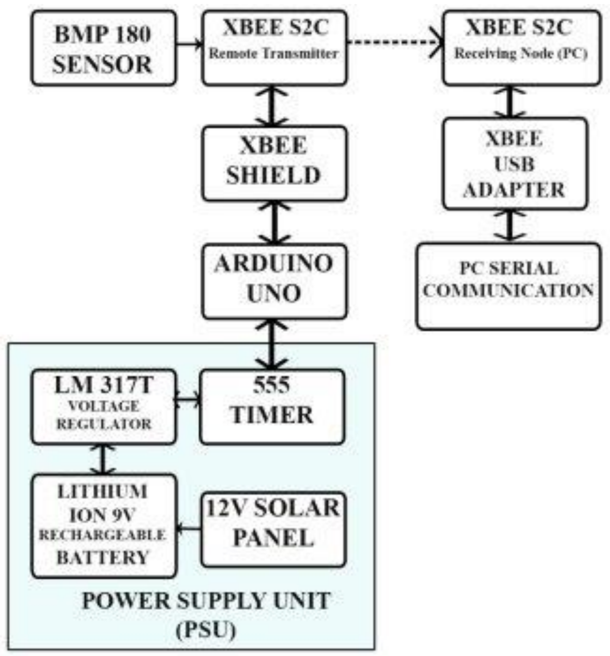


**Fig. 1:** Overall system architecture.

#### 3.1.3. XBee S2C

XBee S2C is a RF module provides wireless communication or data exchange and XBee is a module designed by 'DiGi' [10] fig (2(c)). ZigBee is the protocol used by XBee modules for establishing wireless communication [11].

#### 2.1.4. Xbee USB Adapter

The XBee Explorer USB adapter board is used for configuring the XBee module fig (2(d)). Using a USB adapter the XBee series and the X-CTU Software can be interconnected [12]. Xbee USB adapter is connected to a computer USB port with a mini USB cable and becomes a gateway between Xbee and the Computer X-CTU software [13].

#### 3.1.5. The Arduino Xbee shield

The Xbee shield was used to allow Arduino board for wireless communication via Zigbee fig (2(e)). The Xbee shield mounted on the Arduino later Xbee mounted on Xbee shield, which is known as The Xbee module can communicate with line-of-sight up to 100 feet indoors or 300 feet outdoors, depending on the RF range. Xbee Shield, replaces the usage of USB cable and directly stacked on to Arduino for achieving various networking options [14].

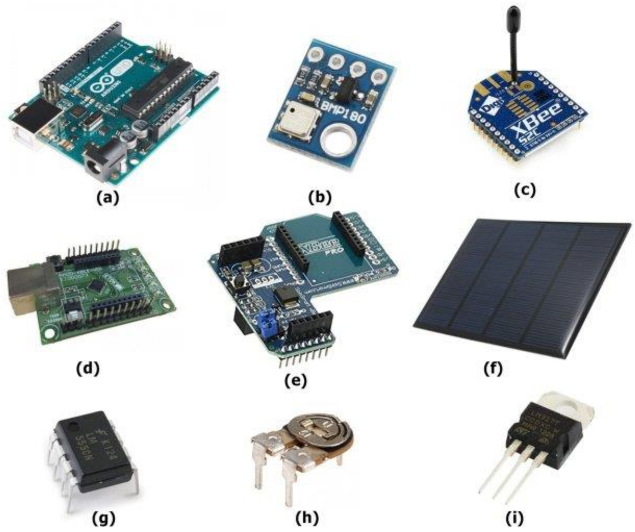


**Fig. 2:** a) an Arduino Uno (b) BMP 180 (c) Xbee S2C d) Xbee USB Adapter e) Arduino Xbee Shield f) Solar Panel 12 V g) 555 Timer h) Variable Resistor Preset 10k i)LM317 voltage regulator.

#### 2.1.6. 12 V Solar Panel

Solar Panel is a small board, which can charge 9 V Rechargeable lithium-ion battery and can be used to power the Arduino Uno fig (2(f)). It is essential when any wireless sensor run 24 h in a day.

#### 2.1.7. 555 Timer

The 555-timer in fig (2(g)) is common because it can produce a string of stabilized waveforms of 50 to 100 percentage duty cycles [15].

#### 2.1.8. Variable Resistor Preset

A preset resistor is a smaller version of a potentiometer that can be mounted on the PCB using 3 terminal pins [16] fig (2(h)). These are useful where adjustment or configuration of a circuit needs to be made such as in this system it is used to maximize and minimize the time delays of 555-timer.

#### 2.1.9. LM317T voltage regulator

The LM317T is a three-terminal positive voltage regulator that can be modified [17].

## 4. Design of Hardware/Software components

### 4.1. Design of Remote Sensor Node

The sensor node developed in this paper is equipped with a sensor and wireless communication module. The Xbee shield is then attached to the Arduino Uno Fig.3 connected to the temperature and pressure sensor BMP 180. The Xbee shield Fig.4 allows data to be transmitted to the receiving node. The Xbee shield



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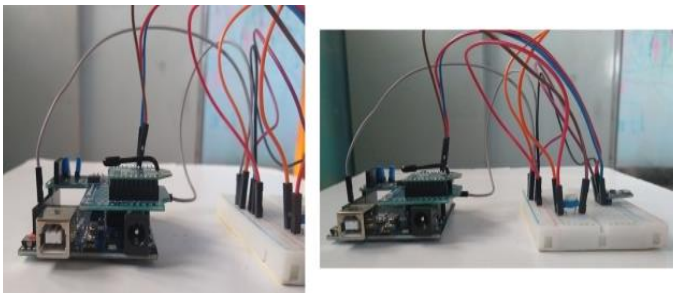

**Fig. 3:** XBee Shield with Arduino and Sensor.

is mounted on to the Arduino Uno Fig.3 later connected to the BMP 180 temperature and pressure sensor Fig.4. The Xbee shield allows data to be transmitted to the receiving node.

### 4.2. Design of Energy Aware Solar module

Factors such as cost and power consumption are also taken in to consideration for developing this research. Hence, the energy aware solar module is used to power Arduino with power supply unit,as shown in Fig (5). This solar module uses a 12 V solar panel and a compatible 9 V rechargeable lithium-ion battery. The Xbee S2C module used in this system requires 2.7 V to 3.6 V as operational voltage. In the remote sensor node Xbee power consumption can be set using sleep or wake up mechanism. Sleeping and waking up in this module is performed for data transmission at regular intervals [18–21], which is achieved using a 555-timer chip by setting time delays Fig (7). In Fig (6) LM317T, a bench power supply with a choice of positive or negative fixed or variable voltages is made possible by adding extra circuitry to the PSU output.

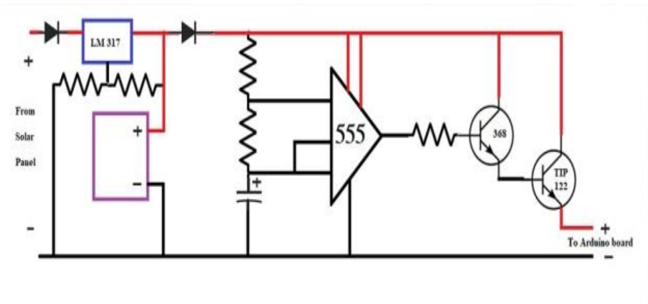


**Fig. 4:** Schematic diagram of solar module.

The feedback resister R1 has the voltage 1.25 V, the output and adjustment terminals emit Vref.. The adjustment terminal has a constant current of 100uA.

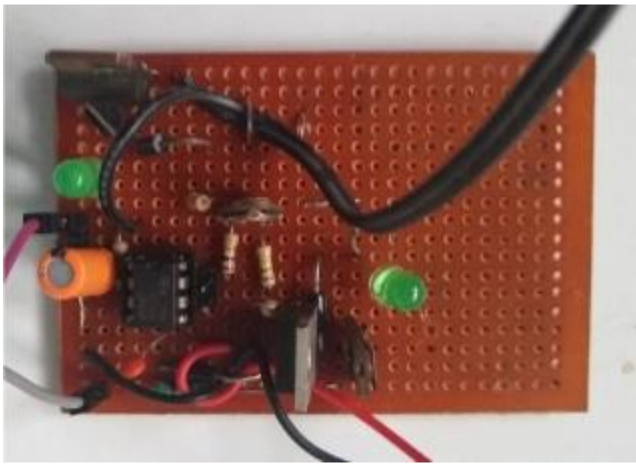

**Fig. 5:** Power supply unit with 555 timer chip.

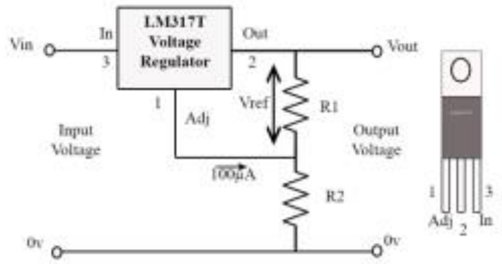


**Fig. 6:** Schematic diagram of LM317T

The other resistor R2 will conduct a constant current i yielding an output voltage of µ.

V out = 1.25 (1 + R1/R2)

### 5. Software

The software includes uploading the Arduino Integrated Development Environment via the (IDE). For graph programming, Python is also used. Combined with Arduino, Python is a versatile combination to program Arduino to achieve results in real time [24] Fig.(8).





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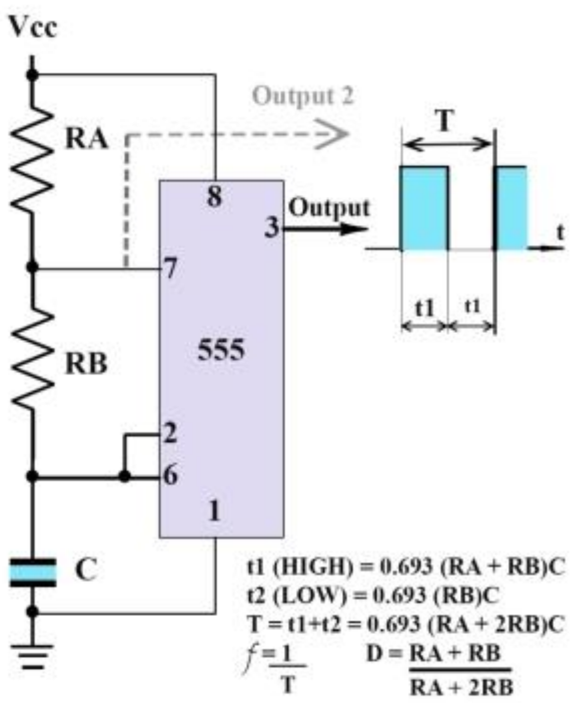


**Fig. 7:** Schematic diagram of 555 timer chip.

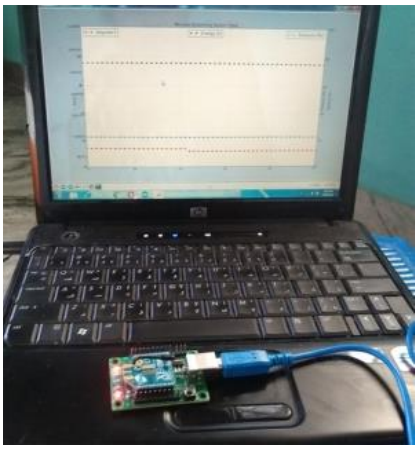

**Fig. 8:** Receiving Node connected to a graphical interface.

## 6. Results

The experiment is conducted in an open environment to collect wide solar light. The locations are changed to observe the variations. In the month of December, tests for cooling cases are carried out. The reading is taken at an interval of one minute each, and then the system is turned off to

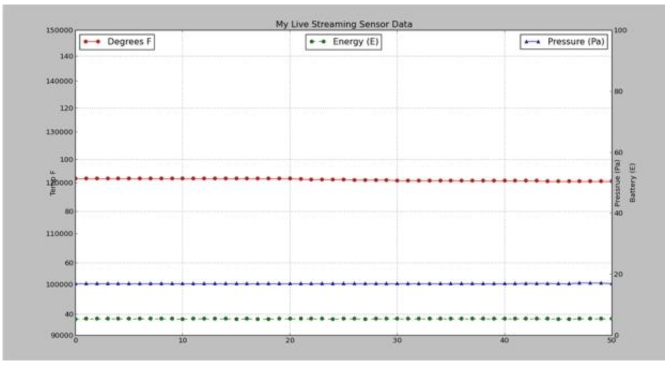


**Fig. 9:** Initial visualization of Normal Condition.

reduce energy usage. It can be observed in Fig.9 in the normal condition's temperature ranges from 90 F to 97 F and the barometric pressure is between 100450 Pa to 100550 Pa.

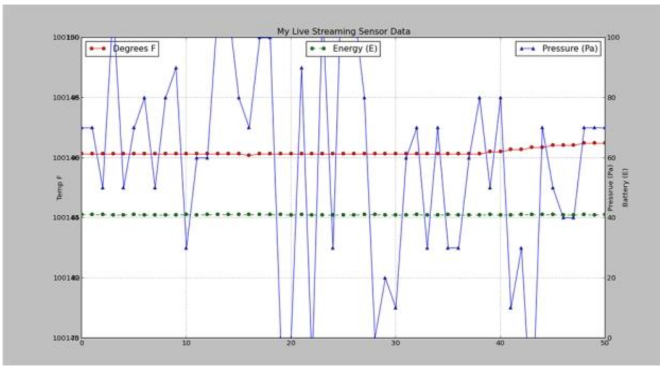


**Fig. 10:** Multiple visualization of variation.

The reading shown in Fig.11 obtained by changing the values of coordinates to display the variations. The energy percentage of the battery is initially 37% and the voltage gradually increases, after solar energy charges the battery. The voltage variation of the battery is shown in the graph Fig.12. The graph shown in Fig.11 shows the variations in barometric pressure. In the charts, sample measurement results collected at Sensor Node are presented. Database storage is beyond the scope of this paper, the data obtained from this system can be used for processing and analysis as an input to various environmental applications [25].

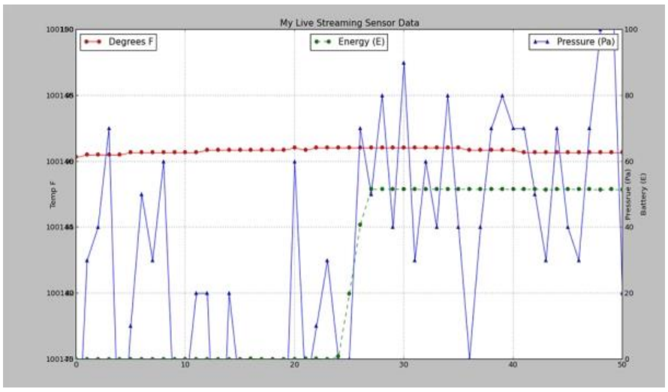


**Fig. 11:** Multiple visualization of variation in energy level.

**Conclusion**



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This paper has presented an inexpensive wireless weather monitoring system designed with Arduino, Xbee, sensors and open-source software packages such as Python and Arduino IDE. The device can be installed in a variety of locations. The system can demonstrate several features, first, the interaction between the Xbee radios and the remote sensor nodes using Python programming, and can create a mesh network. Second, keep track of the charge level of a connected battery, a solar panel with a PSU later connected to a remote sensor node. Third, a real-time temperature, pressure and the graph of battery power level was created to investigate weather and energy patterns. As future work, in various ways, the device design outlined in this paper can be extended. Additional sensors, for instance, can be added to satisfy the needs of different monitoring applications. The Python interface can be modified to provide more functionality in data visualization, management, and analysis, among other things, to provide a better user interface and experience. It's also a good idea to incorporate a database server. Also energy consumption of the sensors can be compared between various wireless technologies.

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