SERVER BASED REAL-TIME ENVIRONMENTAL PARAMETERS LOGGING AND MONITORING SYSTEM

Aung Zaw Oo[1]

Abstract

This research work presents the real-time environmental parameters monitoring system using Wi-Fi network in order to create a remote environmental monitoring solution. DHT22 sensor and BMP085 pressure sensor are used to measure the environmental parameters such as temperature, relative humidity, atmospheric pressure, dew point and heat index. ENC28J60 Ethernet module is used to read the sensor data from Arduino and sendsthe measured data to database server. Measured data are logged in a database file using WAMP web server which enables immediate access to sensor readings through Wi-Fi network. Router is used to assign IP address of server and Ethernet module. Users can view the real-time environmental data on web pages. The measured values are also recorded in a database filefor historical review and data analysis. The recorded data are displayed in line graph by using Java script chart. To monitor the recorded data remotely, router connects the multiple wireless devices via the Wi-Fi network.

Keyword: Environmental parameters, WAMP web server, Wi-Fi network

Introduction

Environmental monitoring establishes the processes and activities of environment. The measurement of environmental parameters such as temperature, relative humidity, atmospheric pressure, dew point, heat index, becomes an integral part of the study to observe the change in global climate, species, plants and animal populations.

In this research work, real-time environmental parameters (temperature, relative humidity, atmospheric pressure, heat index and due point temperature) measuring and logging system is constructed. To sense temperature and relative humidity, DHT22 sensor is used. BMP085 sensor measures atmospheric pressure of environment. Heat index and dew point temperature are calculated from measured temperature and relative humidity.

_____
[1]. U, Lecturer, Department of Physics, Pyay University

Arduino microcontroller senses the data from two sensors in every fifteen minutes and puts these data to server computer through Wi-Fi network by using ENC28J60 Ethernet module and router. The collected data are store in database file in My SQL database.GSM router sets up the IP addresses of Ethernet module and server computer.

The router connects multiple wireless devices such as smart-phone, tablet and laptop. Logged data can be viewed from web browser by using Wi-Fi devices which are all connected within the same LAN (local area network). Real-time data and logged data are shown in line graph in web page. Functional block diagram is shown in Figure 1.
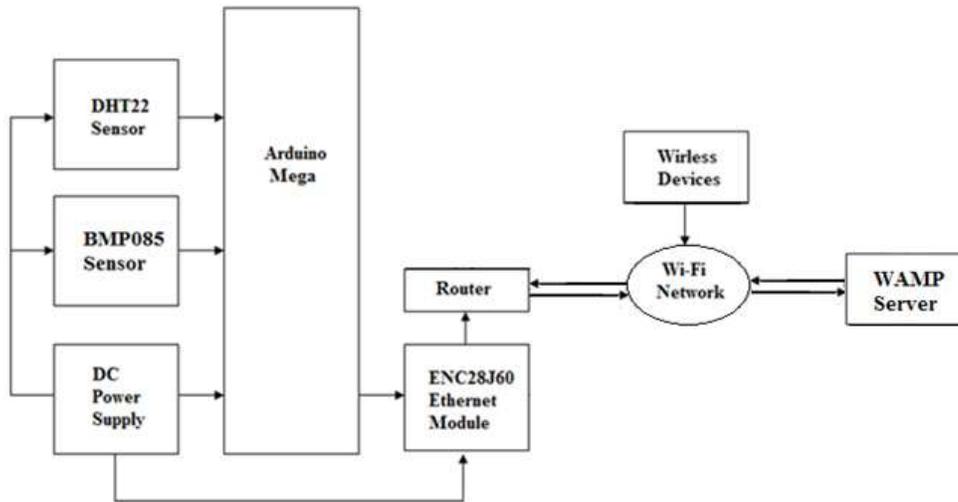

Figure 1. Functional block diagram of *constructed system*

Material and Method

Constructed system is based on Arduino platform and the system is designed to monitor the real-time environmental parameters over the Wi-Fi network. This monitoring system is a combination of hardware and software components. Arduino Mega 2560 microcontroller board, *DHT22temperature and humidity sensor,*BMP085 pressure sensor, *ENC28J60Ethernet module and* Huawei GSM Router are hardware components. Hardware components are divided in three parts: main controller, sensor devices and Wi-Fi

accessible modules. Arduino IDE software and WAMP software are used as software components.

Main Control Devices

Arduino Mega 2560 microcontroller board is used as main controller device. Arduino Mega is based on Atmel ATmega2560 microcontroller. Mega 2560 board has 54 digital input/output pins, 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header (In-Circuit Serial Programming), and a reset button. Photograph of Arduino Mega board is shown in Figure 2. (Arduino Mega 2560 Datasheet)

Figure 2. Photo of Arduino Mega 2560 microcontroller board

DHT22 Temperature and Humidity Sensor

The DHT22 is a 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. Sensor readings can be up to 2 seconds long. It has an operating temperature range of –40°C to +80°C and ±0.5°C accuracy. It has an operating humidity range of 0 to 100% RH and ±2% to ± 5% accuracy. Figure 3 shows the photo of DHT22 temperature and humidity sensor.
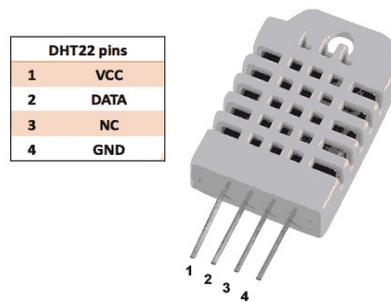
Figure 3. Photo of DHT22 temperature and humidity sensor

BMP085 Barometric Presser Sensor

BMP085 is a high-precision, low-power digital barometer. The BMP085 offers a pressure measuring range of 300 to 1100 hPa with accuracy down to 0.02 hPa. It's based on piezo-resistive technology for high accuracy and long term stability. These come factory-calibrated, with the calibration coefficients already stored in ROM. Photo of BMP085 presser sensor is shown in Figure 4.
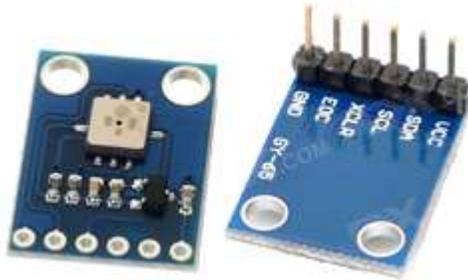
Figure 4. BMP085 barometric presser sensor

ENC28J60 Ethernet Module

The **ENC28J60**Ethernet module allows an Arduino board to connect to the internet. This chip has 28 pins and contains a stand-alone Ethernet controller for a 10BASE-T network connection with an SPI interface. The Ethernet module has a standard RJ-45 connection. This Ethernet chip provides

a network IP address which connects to the internet via an Ethernet cable (RJ45) connection. Figure 5 shows the photo of **ENC28J60**Ethernet module.

Figure 5. ENC28J60 Ethernet module

Huawei GSM Router

A router is a networking device that forwards data packets between computer networks. Routers perform the traffic directing functions on the Internet. The Huawei GSM router easily connects multiple devices such as smart-phone, tablet and laptop. This can be done via the fast Wireless network or the LAN ports. WLAN is usually password protected, but may be open, which allows any device within its range to access the resources of the WLAN network. Figure 6 shows Wi-Fi connection of router and wireless devices.

Figure 6. Huawei GSM Router

Software Preparation

WAMP Server is installed to computer to create and manage the database. It allows creatingthe web applications with Apache2, PHP and a MySQL database.

Pushing Data to PHP Server

       To record the measured data of temperature and relative humidity, atmospheric pressure, heat index and due point temperature, Arduino has to connect to MySQL server. Measured data are pushed to database file in server. In the created sketch, Arduino is set as a client and its IP address of Ethernet module is determined by DHCP(Dynamic Host Configuration Protocol). The MAC address of **ENC28J60**Ethernet module is manually assigned in Ardiono sketch. IP address of server is 192.168.1.2 and subnet mask is 255.255.255.0.**ENC28J60**Ethernet module is connected to Huawei GSM router. Software flowchart of Arduino sketch is shown in Figure 7.
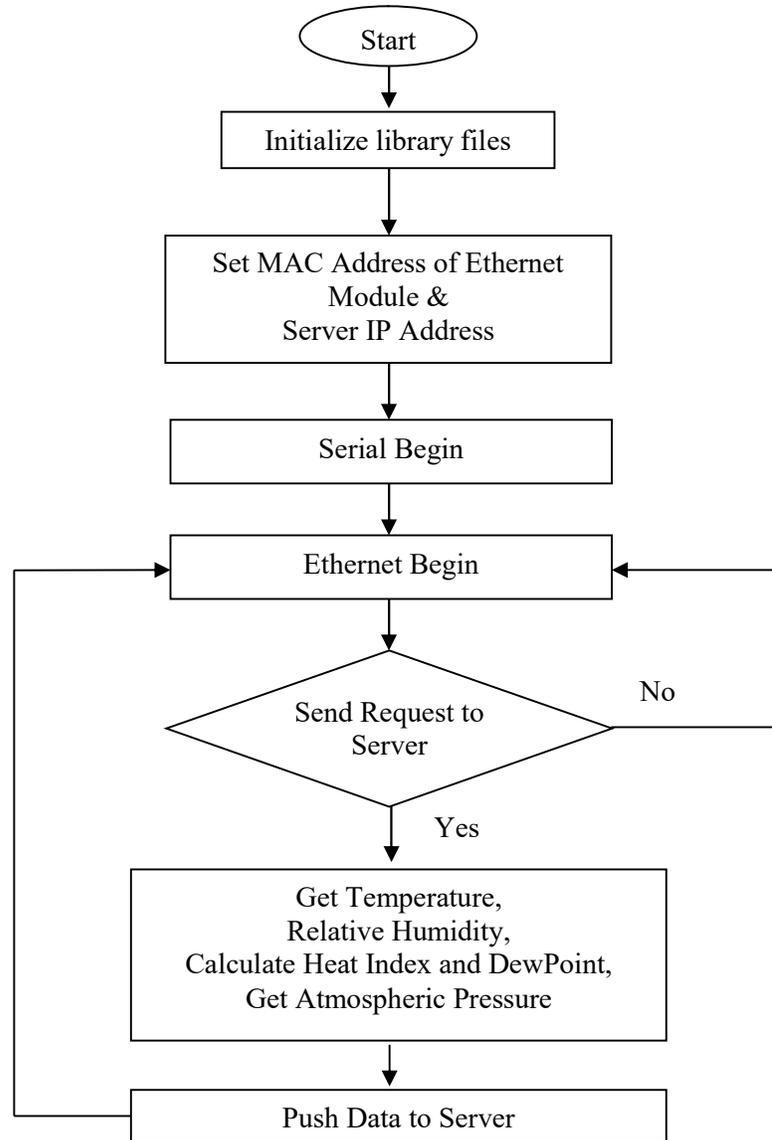
Figure 7. Software flowchart

Creating MySQL Database in WAMP Server

To record and review the measured sensor data send from Arduino, MySQL database and a web development environment is required. Firstly, it has to be established a database connection using **PHP** code on a web page. This code sends incoming data to MySQL database table Figure 8 shows the menu of MySQL database in WAMP server. WAMP server is a Windows web development environment. To push recorded data to database file, MySQL *server address, username, password* and *database name is created in a PHP page. MySQL server address is set to static IP of 192.168.1.2.*

A php file of **data_TRH.php** is created with user name of "root". Password is set to "env". MySQL database is managed with phpMyAdmin. Database name is "test" and database table is "inout_temp_rh". Constructed database field in MySQL database is shown in Figure 9. Figure 10 shows the recorded data in MySQL database.
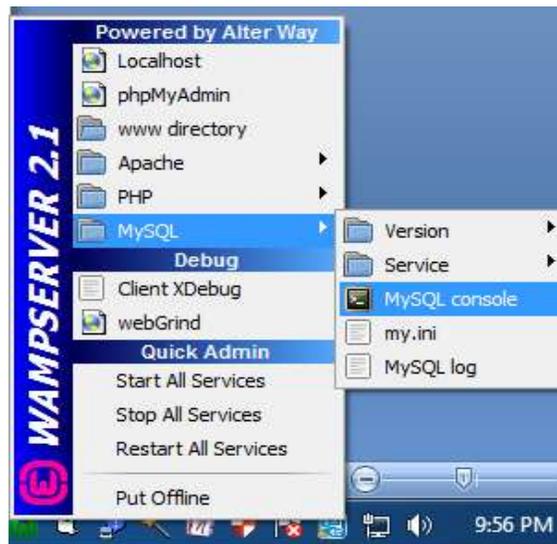
Figure 8. Menu of MySQL database in WAMP server

Figure 9. Database field in MySQL database

Figure 10. Example of recorded data in MySQL database.

Creating Chart

AmCharts is a JavaScript-based interactive chart for data visualization. Web page is created with PHP script that connects to MySQL server, loads the data and shows data in chart. PHP code for chart is shown inFigure 11.

```html
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01//EN" "http://www.w3.org/TR/html4/strict.dtd">
<html>

    <head>

        <meta http-equiv="Content-Type" content="text/html; charset=utf-8">
        <title>Environmental</title>

    <meta http-equiv="refresh" content="60"; url=http://192.168.1.2/envdata/view_G_TRH8.php">
        <link rel="stylesheet" href="style.css" type="text/css">
        <script src="../amcharts/amcharts.js" type="text/javascript"></script>
        <script src="../amcharts/serial.js" type="text/javascript"></script>
    <h1 align="center">Environmental Data of Pyay</h1>

      <script>
    AmCharts.loadJSON = function(url) {
      // create the request
     if (window.XMLHttpRequest) {
     // IE7+, Firefox, Chrome, Opera, Safari
        var request = new XMLHttpRequest();
     } else {
     // code for IE6, IE5
     var request = new ActiveXObject('Microsoft.XMLHTTP');
     }
```

Figure 11. Using AmChart library in PHP code

Managing Router

Wireless broadband routers establish a wireless network using a name called a Service Set Identifier (SSID). A router's SSID can be accessed from its administrator configuration pages shown in Figure 12. SSID name of constructed system in Wi-Fi access is "pyayenv" with dynamic IP address of 192.168.1.3. Figure 13 shows SSID name and password of constructed WI-Fi access. Figure 14 shows the IP address of Ethernet module connected with Arduino.

Figure 12. Administrator configuration pages of router
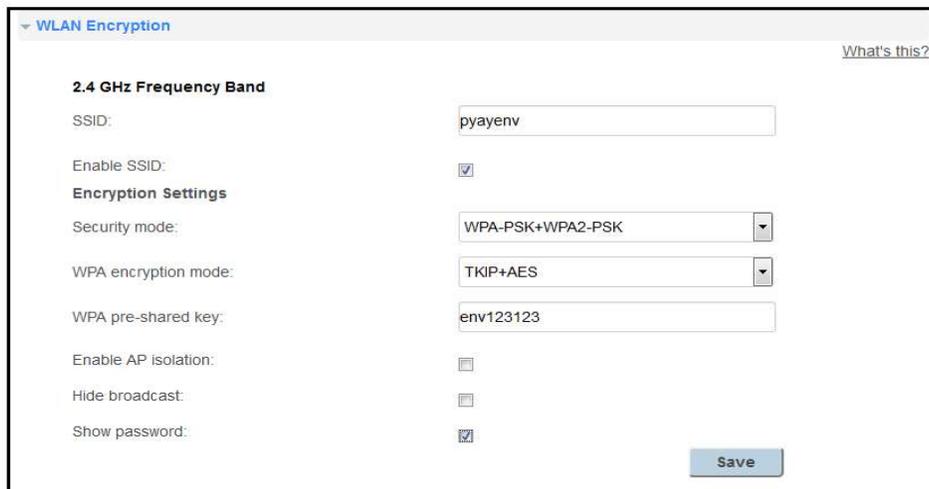
Figure 13. SSID name and password created in router configuration

Figure 14. IP address of Ethernet module

Results and Discussion

To show detailed visualizations of data over the periods of time, measured data are record in database server. Record data are logged in a database file and these data are viewed by web page written in php code. The http address is http://localhost/envdata/data_log.php. Figure 15 shows the data logger of measured data shown from web page, updated with the received sensors data. All Wi-Fi accessible devices can view the data logger page by joining Wi-Fi network. The browser was made to refresh every 15 minutes so that newly received data from the web page could be seen on the browser. Figure 15 shows recorded data in data logger web page.

Recorded database table in MySQL server can be exported to Excel file and every day data can be stored in computer. Table 1 shows the sample of exported Excel file. Each of these *line graphs shows* a change in *data* over time. L*ine graph* is useful for *displaying data* or information which changes continuously over time. The multiple line graph with different zoom is created using Amchart library. It is shown in Figure 16 and address of this PHP page is 192.168.1.2/envdata/envdat8.php. This chart page shows real time value of temperature, relative humidity, due point temperature and heat index. *Historical data can also be viewed by clicking the mouse pointer on the graph.* Figure 17 shows complete circuit diagram of constructed system. Photograph of constructed system is shown in Figure 18.

Figure 15. Data logger web page in PHP format

Table 1. Temperature, relative humidity, dew point temperature and heat index
           data in excel file (Sample)

id	event	out_temp	out_RH	dew	h_indexc	h_indexf	p
1	2017-01-14 11:11:17	26.8	42.2	12.91	27	80.28	100860
2	2017-01-14 11:24:28	29.0	36.1	12.48	28	82.91	100834
3	2017-01-14 11:28:47	29.6	35.3	12.67	29	83.83	100836
4	2017-01-14 11:29:45	29.4	35.0	12.36	29	83.43	100835
5	2017-01-14 11:30:46	29.8	34.1	12.32	29	83.99	100826
6	2017-01-14 11:31:46	30.0	33.0	11.99	29	84.18	100820
7	2017-01-14 11:32:46	30.0	32.7	11.86	29	84.13	100819
8	2017-01-14 11:33:46	29.8	32.5	11.59	29	83.76	100816
9	2017-01-14 11:34:46	29.4	32.8	11.38	28	83.13	100820
10	2017-01-14 11:35:46	29.6	32.8	11.55	29	83.46	100814
11	2017-01-14 11:36:46	29.7	32.9	11.69	29	83.64	100813
12	2017-01-14 11:37:46	29.8	33.0	11.82	29	83.83	100812
13	2017-01-14 11:38:46	29.5	33.1	11.60	29	83.33	100809

id	event	out_temp	out_RH	dew	h_indexc	h_indexf	p
14	2017-01-14 11:39:46	29.6	33.1	11.69	29	83.5	100808
15	2017-01-14 11:40:46	29.5	33.0	11.56	29	83.32	100810
16	2017-01-14 11:41:46	29.7	32.9	11.69	29	83.64	100812
17	2017-01-14 11:42:46	29.8	33.0	11.82	29	83.83	100810
18	2017-01-14 11:43:47	29.9	33.1	11.95	29	84.02	100797
19	2017-01-14 11:44:47	30.0	32.9	11.95	29	84.16	100800
20	2017-01-14 11:45:47	29.9	32.7	11.77	29	83.96	100800
21	2017-01-14 11:46:47	29.7	32.5	11.50	29	83.59	100789
22	2017-01-14 11:47:47	30.0	32.4	11.72	29	84.09	100795
23	2017-01-14 11:48:47	30.3	32.0	11.79	29	84.56	100787
24	2017-01-14 11:49:47	30.3	31.7	11.65	29	84.51	100789
25	2017-01-14 11:50:47	30.8	31.8	12.13	30	85.45	100789
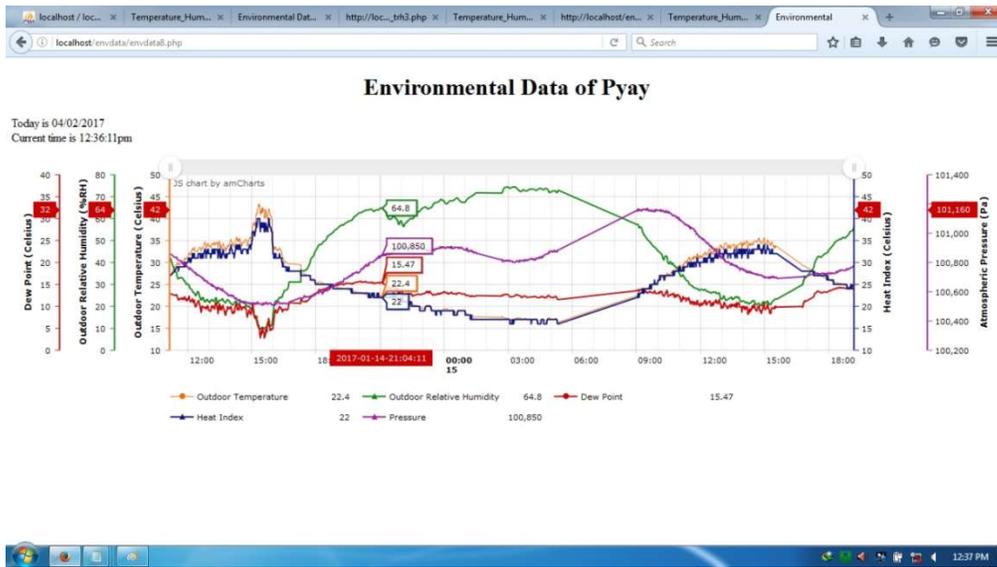
**Figure 16.** Real time information of data displayed on web page
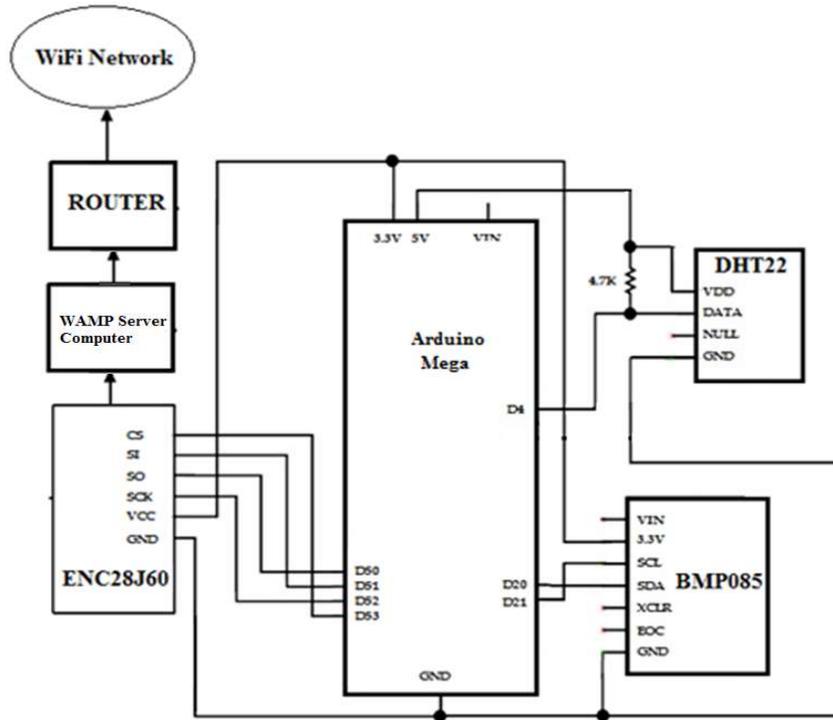
**Figure 17.** Circuit diagram of constructed system
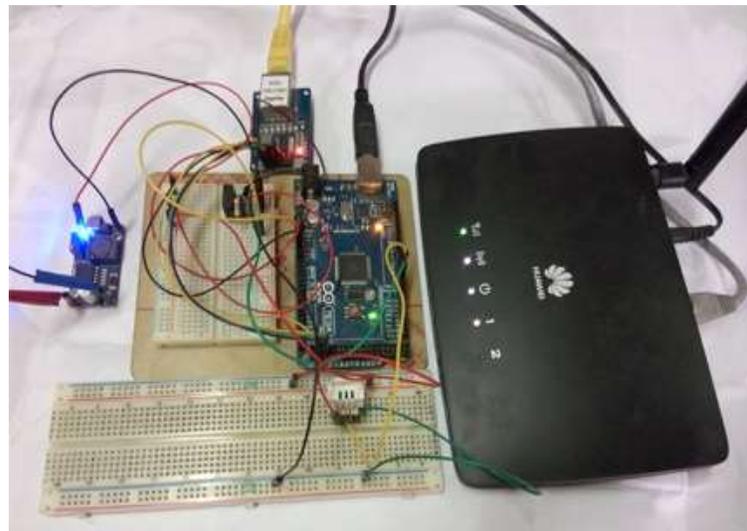
Figure 18. Photograph of constructed system

Conclusion

In this research work, server based real-time environmental parameters monitoring system has been constructed for logging and monitoring of environmental parameters. Constructed system offers a large range of data loggers for long-term recording of measurement data by using database server. For monitoring purpose, Wi-Fi accessible web page is developed using PHP code. This page shows real time data in multiple line graphs. The system can be used as remote temperature monitoring device by using smart phone or tablet by accessing Wi-Fi connection, browsing web page and entering URL of page.

Any change in the climate of an area can affect the plants and animals living there, as well as the makeup of the entire ecosystem. Constructed real-time environmental parameters monitoring system can be used in environmental research fields such as global temperatures warming and climate changing effect on ecosystems.

Acknowledgements

References

1. Delisle M., (2008) *Mastering php My Admin 2.11 for Effective MySQL Management (*Packt Publishing)
2. Gertz E., Di Justo P. , (2012)*Environmental Monitoring with Arduino* (Sebastopol, California: O'Reilly Media)
3. Paul Du Bois, (2013) *MySQL* (Addison-Wesley)
4. Sklar D., Trachtenberg A., (2003) *PHP Cookbook* (Sebastopol, California: O'Reilly Media)
   https://dev.mysql.com/doc/refman/5.1/en/what-is-mysql.html
   http://*www.microchip.com/downloads/en/devicedoc/39662a.pdf*
   http://php.net/manual/en/index.php