Development of an Automatic Weather Monitoring System

E.L. Omoze¹, T.J. Timiyo², P.E. Orukpe³

^{1,3} Department of Electrical/Electronic Engineering, Faculty of Engineering, University of Benin, Ugbowo, Benin City, Edo State, Nigeria

²Engineering/Technical Support Unit, Space-Earth Environment Research Laboratory, Centre for Atmospheric Research, National Space Research and Development Agency, NASRDA, University of Benin, Ugbowo Campus, Benin City, Edo State, Nigeria.

Abstract: Weather is the state of the atmosphere at a given time and place with respect to cloudiness, hotness, heat, dryness, sunshine, wind, rain, etc.and it is difficult to predict. Weather monitoring plays an important role in various human endeavor. In this paper, we present the development of a low cost server-based automatic weather station for remote locations. This work is built around a microcontroller unit (Arduino mega 2560 microcontroller), weather parameter sensors and a laptop computer. The data from the sensors were collected either hourly, daily, monthly or on a yearly basis. A webpage and a serial data capturing application were developed using notepad, hypertext markup language version 5 and advanced serial data logger software respectively that logs and display real time weather conditions on the PC which can be monitored, accessed and downloaded by users remotely. The developed system worked satisfactorily.

Keywords: Advanced Serial Data Logger Software; Arduino Mega 2560MCU;Automatic Weather Station; Server-based; Weather Parameters

Date of Submission: 18-11-2019 Date of Acceptance: 04-12-2019

I. Introduction

An Automated Weather Station (AWS) is defined as an automated type of the traditional weather station which is used either to save human labour or to enable measurements from remote areas¹. It is an electronic instrument that is made up of a microcontroller and the various weather parameters sensors which measures and records meteorological or weather parameters without human intervention. The measured weather parameters can be stored either in a storage device, a built-in data logger or can be transmitted to a remote location through a communication link. If the data is stored in a data logger, the logged data must be downloaded physically to a computer at a later time for further processing. However, this is not a feasible option especially when the weather station is located at a remote area. Therefore, the remote access and monitoring systems are essential elements in an automatic weather station.

Different automated weather stations have been developedby atmospheric equipment designing companies, research institutes, space scientists, meteorologist, researchers, and engineers²⁻¹⁵. However, these weather stations do not have the capability of remote data download and data are not logged either on hourly, daily, monthly, or yearly basis.

Thus, this work is aimed at developing a low cost server-based automatic weather station with remote data download and data logging either on hourly, daily, monthly or yearly basis capabilities.

II. Design Methodology

The design methodology is subdivided into five stages as follows:

Stage 1–The weather station design and prototype development

The weather station (the hardware) was designed using an Arduino mega 2560 microcontroller and some weatherparameters sensors as given in Fig. 1(a). These sensors were connected to the respective analogue and digital pins of the Arduino board to take measurements. The measurements taken include air temperature, relative humidity, soil moisture level, rain rate, light intensity, soil temperature, wind speed, wind direction, barometric pressureand ozone (O_3) gas. Fig. 1(a) shows the block diagram of the weather station while Fig. 1(b) shows the system architecture.

Development of an Automatic Weather Monitoring System



Presented in Table 1 is the list of components and the different atmospheric parameters sensors that we reconnected together to develop the low cost server-based automatic weather station.

	mponents and atmospheric p	
Sensors/Components	Туре	Characteristics
Microcontroller	Arduino mega 2560	It has 54 digital input/output pins ¹⁶ . It is used to
		power all the sensors.
Soil moisture sensor	Spark fun	Conductivity between the pads is proportional
		to soil moisture level ¹⁷
Temperature and relative humidity sensor	AM2302	Calibrated digital output signal ¹⁸
Light intensity sensor	BPW34	High speed and highly sensitive photodiode
Soil temperature sensor	DS18B20	Accurate to $\pm 0.5^{\circ}$ C in the range of -10° C to
		+85°C and its working range is -55°C to
		+125°C
Barometric pressure sensor	BMP180	Best low cost that can be used as an altimeter
Wind speed sensor	Locally made available using	Where
-	$V = P\left(\frac{2.25}{T}\right) \times 0.44704$	V is speed in miles per hour.
	$V = P(-T) \times 0.44704$	P is number of pulses per sample period.
		T is the sample period in second
Wind direction sensor	Locally made	Low cost
Rainfall sensor	Locally made tipping bucket	0.01 inches or 0.03cm of rain was collected as
		at the time of this work
Ozone sensor	MQ-131	Senses O ₃ concentration in the range of 10ppm
		to 1000ppm
Computer	Laptop	It is used for software installation of Arduino
		IDE, advanced serial data logger and displays
		sensor data

 Table 1: Components and atmospheric parameters sensors

Stage 2 – Firmware development for the Arduino mega 2560 MCU

The Arduino IDE was used to develop the firmware for the Arduino mega 2560 board. After the firmware was developed, it was sent to the Arduino board through the USB to the serial cable. The flowchart for developing the firmware is shown in Fig. 2(a), while the process of developing the firmware is shown in Fig. 2(b)





Fig. 2(b): Firmware development process.

Stage 3 – Configuring the advanced serial data logger

The advanced serial data logger (ASDL) software [19] was configured to capture the atmospheric data present at the serial port of the computer, log the data in an Excel file format to a specified folderin the computer. The advanced serial data logger was configured to log data on hourly basis – that is, at the end of each hour.Fig. 3(a) shows a flowchart on how the Advanced Serial Data Logger was configured to capture, log, and display data.Fig. 3(b) shows the process of setting up the communication parameters. Fig. 3(c) shows the process of setting up the log rotation to log data on hourly basis. Fig. 3(d) shows the configuration process of the Excel Pro that comes with the advanced serial data logger to log atmospheric data in an Excel file format.

Development of an Automatic Weather Monitoring System



configured

	Configuration options ? ×						
0.00,135,0.0	COM port	COM port	settings				
0.00,278,0.0	COM port settings	COM ports					
		Spy mode Connection par-					
	Data flow	Polling mode	Use event word (fast, b		~		
	control	-			~		
	0-	Baud rate	9600 ~	Add custom	\times		
	Additional	Data bits	8 ~				
	options	Parity	None 🗸				
		Stop bits	1 ~				
		RS485 interfa	ce mode				
-		🖂 At data receiv	e error clean incoming buffe				
	Log file		ter an unsuccessful attemp				
	Other	I ty to	open after XXX seconds 3	0			
	Modules						
				ок с	ancel		

6

Y

1

[]]

<u>____</u>

0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 13, 1002 Configuration options ? × 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options ? × 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options ? × 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options ? × 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options ? × 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options ? × 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options ? × 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options ? × 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options Pile for data received 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options Pile for data received 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options Pile for data received 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options Pile for data received 0.00 25 00, 93 90, 30, 11, 1948, 03, 18, 03, 1002 Image: Configuration options Pile for data received 0.00 25 00, 93 9		4,0.00,213, 7,0.00,213, 9.0.00,213.	0.13 0.13 0.13
00.25 00.99 9.03 0.16 1348 03 18 03 1002 00.25 00 99 9.03 01 61 1348 03 18 03 1002 00.25 00 99 9.03 01 11 1348 03 18 03 1002 00.25 00 99 9.03 01 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 10 99 9.03 03 11 1348 03 18 03 1002 00.25 10 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 10 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 16 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 1348 03 18 03 1002 00.25 00 99 9.03 03 11 13	00,25.00,99.90,30.16,1954.55,18.03,1002.		
00. 25 00. 99 90. 30 16. 1948 03. 180 03. 1002 00. 25 00. 99 90. 30 11. 1948 03. 180 03. 1002 00. 25 00. 99 90. 30 11. 1948 03. 180 03. 1002 00. 25 00. 99 90. 30 11. 1948 03. 180 03. 1002 00. 25 00. 99 90. 30 11. 1948 03. 180 03. 1002 00. 25 00. 99 90. 30 11. 1948 03. 180 03. 1002 00. 25 00. 99 90. 30 11. 1948 03. 180 03. 1002 00. 25 00. 99 90. 30 16. 1948 03. 180 03. 1002 00. 25 00. 99 90. 30 16. 1948 03. 180 1002 00. 25 00. 99 90. 30 16. 1948 03. 180 1002 00. 25 00. 99 90. 30 16. 1948 03. 180 1002 00. 25 00. 99 90. 30 16. 1948 03. 180 1002 00. 25 00. 99 90. 30 16. 1948 03. 180 1002 00. 25	00,25.00,99.90,30.16,1948.03,18.03,1002.	-	Log rotation
00.25.00.99.90.30.06,1948.03.18.03.1002. Modules Modu	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Log rotation	Create log files on disk Write to log file for data received Write to log Write to log file before parsing Log file path C-Wsers/PC/Documents/Projects Materials/L(2) New file Hourly File name prefix/extension This/WorkData Limit size 0 Add data source ID to file name Add data source ID to file name Write data/time stamp to File name
00.25 00.99.90.30.11.1948.03.18.03.1002. 00.25 00.99.90.30.11.1948.03.18.03.1002. 00.25 00.99.90.30.11.1948.03.18.03.1002. 00.25 10.99.90.30.16.1948.03.18.03.1002. 00.25 00.99.90.30.16.1948.03.18.03.1002.58.0.00.213.0.13 00.25 10.99.90.30.16.1948.03.18.03.1002.58.0.00.213.0.14 00.25 10.99.90.30.16.1948.03.18.03.1002.55.0.00.213.0.14 00.25 10.99.90.30.16.1948.03.18.03.1002.55.0.00.213.0.14 00.25 10.99.90.30.16.1948.03.18.03.1002.55.0.00.213.0.14	00,25.00,99.90,30.06,1948.03,18.03,1002.		
00, 25, 00, 99, 90, 30, 11, 1948, 03, 18, 03, 1002, 00, 25, 0, 09, 99, 90, 30, 11, 1954, 55, 18, 03, 1002, 59, 00, 00, 213, 0, 13, 002, 59, 00, 00, 213, 0, 13, 002, 59, 00, 00, 213, 0, 13, 002, 55, 00, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 59, 0, 00, 213, 0, 13, 002, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 99, 90, 30, 16, 1948, 03, 18, 03, 1002, 55, 0, 00, 213, 0, 14, 000, 25, 10, 90, 100, 100, 100, 100, 100, 100,	00,25.00,99.90,30.11,1948.03,18.03,1002.	riodules	
2019-09-10 04-02-37 ICOM3I Excel Export. Data have been processed successfully	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	9,0.00,213, 2,0.00,213, 5,0.00,213, 8,0.00,213,	0.13 0.14 0.14
	2019-09-10 04:02:37 [COM3] Excel Export. Data have been proce	ssed successfully	

Fig. 3(c): Setting up of the log rotation to log data on hourly basis.

D. 1002 91.0.00, 2 1002 92.0.00, 2 1002 92.0.00, 2 1002 95.0.00, 1 1002 95.0.00, 1 1002 95.0.00, 1 1002 95.0.00, 1 1002 95.0.00, 1 1002 95.0.00, 1 1003 01.0.00, 1 1003 01.0.00, 1 1003 00, 0.00, 1 1002 99.0.00, 2 1002 99.0.00, 2	D 1002 91, 0 00 2 1 002 92, 0 00 0 1 002 92, 0 00 0 1 002 92, 0 00 0 1 002 95, 0 00 1 1 003 01, 0 00 0 1 003 00, 0 00 1 1 003 01, 0 00 0 1 003 00, 0 00 1 1 003 01, 0 00 0 1 003 00, 0 00 1 1 003 01, 0 00 0 1 002 99, 0 00 1 1 002 90 0 00 1 1 0 0 0 1 1 0	File	
L, 1002, 92, 0, 00, 0, 00, 0, 1 1002, 95, 0, 00, 2 1002, 92, 0, 00, 28 1002,	L, 1002, 92, 0, 00, 0, 00, 0, 1 1002, 95, 0, 00, 2 1002, 92, 0, 00, 28 1002,		
1002.95.0.00.1 + HAIN_HATE [Han_Hate 1002.95.0.00.1 + DHT_TEMP [dkt_Temp] 1002.98.0.00.1 + DHT_REMP[dkt_Temp] 1003.00.0.00.1 + SOIL_TEMPERATURE [1003.00.0.00.1 + SOILMOISTURELEVEL I 1002.99.0.00.11 + SOILMOISTURELEVEL I 1002.99.0.00.11 + SOILMOISTURELEVEL I 1002.99.0.00.11 + WINDDIRECTION (winc 1002.99.0.00.12 + WINDDIRECTION (winc 1002.99.0.00.13 + WINDDIRECTION (winc 1002.99.0.00.13 + WINDDIRECTION (winc 1002.99.0.00.13 + WINDDIRECTION (winc 1002.99.0.00.13 + About 1002.99.0.00.13 + WINDDIRECTION (winc 1002.99.0.00.2 + Oally 1002.99.0.00.1 + Winc 1002.99.0.00.2 + + 1002.99.0.00.2 + + 1002.99.0.00.2 + + 1002.99.0.00.2 + + 1002.99.0.00.2 + > 1002.99.0.00.2	1002.95.0.00.1 + HAIN_HATE [Han_Hate 1002.95.0.00.1 + DHT_TEMP [dkt_Temp] 1002.98.0.00.1 + DHT_REMP[dkt_Temp] 1003.00.0.00.1 + SOIL_TEMPERATURE [1003.00.0.00.1 + SOILMOISTURELEVEL I 1002.99.0.00.11 + SOILMOISTURELEVEL I 1002.99.0.00.11 + SOILMOISTURELEVEL I 1002.99.0.00.11 + WINDDIRECTION (winc 1002.99.0.00.12 + WINDDIRECTION (winc 1002.99.0.00.13 + WINDDIRECTION (winc 1002.99.0.00.13 + WINDDIRECTION (winc 1002.99.0.00.13 + WINDDIRECTION (winc 1002.99.0.00.13 + About 1002.99.0.00.13 + WINDDIRECTION (winc 1002.99.0.00.2 + Oally 1002.99.0.00.1 + Winc 1002.99.0.00.2 + + 1002.99.0.00.2 + + 1002.99.0.00.2 + + 1002.99.0.00.2 + + 1002.99.0.00.2 + > 1002.99.0.00.2	1P(D	
1002 95 0.00 00 1002 95 0.00 00 1003 0.00 00 100 100 1003 0.00 00 100 100 100 1003 0.00 00 100 100 100 100 1003 0.00 00 1 100 <td< td=""><td>1002 95 0.00 00 1002 95 0.00 00 1003 0.00 00 100 100 1003 0.00 00 100 100 100 1003 0.00 00 100 100 100 100 1003 0.00 00 1 100 <td< td=""><td>india L</td><td></td></td<></td></td<>	1002 95 0.00 00 1002 95 0.00 00 1003 0.00 00 100 100 1003 0.00 00 100 100 100 1003 0.00 00 100 100 100 100 1003 0.00 00 1 100 <td< td=""><td>india L</td><td></td></td<>	india L	
1002, 95, 0, 00, 31 Create a new file With a prefix and extension Workly Weekly Weekly User format Every packet in a separate file Use a template Use a template Data sheet number Save data to file Save data to file Weekly	1002, 95, 0, 00, 31 Create a new file With a prefix and extension Workly Weekly Weekly User format Every packet in a separate file Use a template Use a template Data sheet number Save data to file Save data to file Weekly		
1002.92,0.00,28 Data sheet number 1 Save data to file	1002.92,0.00,28	/ Ligi VEL I With a prefix and extension REINI Spee Daily Monthly Wieckly User format Every packet in a separate file	
		Data sheet number	
OK Cancel	OK Cancel	Save data to file	
UKCancer	UK Cancer	OF Count	
		Cancer	
			PP (D) C:\Users\PC\Documents\Projects Materials\Logs\Logs1 Rate File name prefix DHT ThisProjectData IThisProjectData Create a new file VEL I Create a new file VEL I O with a prefix and extension BEINI Image: Create a new file VEL I O with a prefix and extension BEINI Image: Create a new file VEL I O with a prefix and extension BEINI Image: Create a new file VEL I O with a prefix and extension BEINI Image: Create a new file User format Image: Create a new file Image: Use a template Image: Create a new file Image: Data sheet number Image: Create a new file Image: Save data to file Image: Create a new file

Fig. 3(d). The configuration process of the web server.

Next, the web server was configured to enable users to monitor and access the data remotely. Fig.4 shows configuration process of the web server plug-in that comes with the advanced serial data logger.

COM port Data ex		
Web Server 4.0.30 build	102 ?	×
Web server Data format Ho	w to connect	
Templates		
	d serial data logger\plugins\webserver\Web\Templa	ates 🔄
Web root	d serial data logger\plugins\webserver\Web\Root\	
Listen port	1688 🚖	
Authentication password		
Allowed IP addresses (empty fie	d allows all connections)	
		~
	OK Cancel	
-		
	UK	ancel
	ОК	Cancel

Fig. 4. Configuration process of the web server

Stage 4 – Designing a simple webpage

A simple webpage was designed using notepad and html5. A link to the folder containing the logged files was created and from the web server, a link was created to the webpage so that when the web server is launched, users monitoring the atmospheric data remotely can also access and download data remotely through the link.

Stage 5 – Setting up a network system

To monitor, access, and download data from the weather station, network is needed. Though, the weather station can also be accessed through the internet if the website is hosted using its own internet protocol (IP) address (which is quite expensive to acquire). In this work, a wireless local area networkwas set up using a phone hotspot to access the weather station. For a user to monitor, access, and download data, such user must be connected to the network which the server is connected to. During the field test, all the users that were connected to the network which the server also used, were able to monitor, access, and download data to their devices.

III. The Developed Low Cost Server-based Automatic Weather Station Board.

Figure 5(a) shows the developed low cost server-based automatic weather station. Fig. 5(b) shows the constructed low cost server-based automatic weather station with sensors connected and placed inside the case.

Development of an Automatic Weather Monitoring System



Fig. 5(a): The constructed low cost server-based automatic weather station



Fig. 5(b): The constructed low cost server-based automatic weather station with sensors connected

Testing the Weather Station

After the various sensor modules were connected to the Arduino board and the Arduino board was programmed with the firmware, the low cost, server-based automatic weather station was put to test. Fig. 6shows the setup for the testing of the weather station.



Fig. 6: Testing the weather station.

IV. Results After the testing of the automatic weather station, data were logged in both notepad and Excel file formats as shown in Fig. 7(a) and Fig. 7(b)respectively.

an From From From Othe cess Web Text Sources*	Page Layout Existing Connections	Refresh All + Se Ec	ata Review Vie onnections operties fit Links Z↓ Sort	Filter	Text to Remove Columns Duplicates Vi		-If Group Ungr	oup Subtotal	ow Detail de Detail	∾ (?) = (
Get External Data	<i>f</i> ∗ Da	Conned teTimeStamp	lions	Sort & Filter		Data Tools		Outline	Γø.	
	B	С	D	E	F	G	Н	1	J	K
DateTimeStamp Rain_	Rate(m Air_Te	emp(Degree (Re	elative_Humidity(R%)	Soil_Temp(Degree Cel)	Light_Intensity(Lux)	Soil_Moisture_Level(cm: B	arometric_Press(Wind_Speed(m/s)	Wind_Direction(Degre	Ozone(in PPM)
06/09/2019 11:08:20	0	25.6	96.9	29.91			1004.57	0	150	0.02
06/09/2019 11:08:26	0	25.6	96.8	29.77			1004.56	0	150	0.02
06/09/2019 11:08:31	0	25.6	96.8	29.72			1004.59	0	150	0.02
06/09/2019 11:08:36	0	25.6	96.8	29.77			1004.57	0		0.02
06/09/2019 11:08:41	0	25.6	96.8	29.77		68.3	1004.59	0		0.02
06/09/2019 11:08:47	0	25.6	96.8	29.77			1004.65	0		0.02
06/09/2019 11:08:52	0	25.6	96.8	29.91			1004.58	0	150	0.02
06/09/2019 11:08:57	0	25.6	96.7	29.86			1004.59	0		0.02
06/09/2019 11:09:03	0	25.6	96.8	29.86			1004.65	0		0.02
06/09/2019 11:09:08	0	25.6	96.8	29.86		68.89	1004.54	0		0.02
06/09/2019 11:09:13	0	25.6	96.7	29.77			1004.56	0		0.02
06/09/2019 11:09:19	0	25.6	96.7	29.86			1004.58	0		0.02
06/09/2019 11:09:24	0	25.6	96.6	29.81			1004.54	0		0.02
06/09/2019 11:09:29	0	25.6	96.7	29.77			1004.63	0		0.02
06/09/2019 11:09:35	0	25.6	96.7	29.72			1004.56	0		0.02
06/09/2019 11:09:40	0	25.6	96.6	29.72			1004.57	0		0.02
06/09/2019 11:09:45	0	25.6	96.5	29.77			1004.57	0	5	0.02
06/09/2019 11:09:51	0	25.6	96.4	29.77			1004.6	0		0.02
06/09/2019 11:09:56	0	25.6	96.4	29.77			1004.58	0		0.02
06/09/2019 11:10:01	0	25.7	96.4	29.67			1004.55	0		0.02
06/09/2019 11:10:07	0	25.6	96.3	29.81			1004.62	0	100	0.02
06/09/2019 11:10:12	0	25.7	96.4	29.72			1004.53	0		0.02
06/09/2019 11:10:17	0	25.6	96.4	29.77			1004.56	0	150	0.02
06/09/2019 11:10:22	0	25.6	96.4	29.72			1004.56	0	- 100 -	0.02
06/09/2019 11:10:28	0	25.6	96.3	29.77			1004.66		150	0.02
06/09/2019 11:10:33	0	25.6	96.3 96.3	29.81			1004.6	0		0.02
06/09/2019 11:10:38 06/09/2019 11:10:44	0	25.6 25.6	96.3	29.81 29.81			1004.57	0		0.02
	0	25.6 25.6	96.3	29.81			1004.61			0.02
06/09/2019 11:10:49	U	25.6	96.2	29.86	1882.88	68.99	1004.59	0	150	0.02
dv Sneet1 / Ca									100% (-	

Fig. 7(a): Data logged in Excel file

	🔲 > Thi	s PC > Docume	nts > Proje	ects Materia	als > Log:	s > Logs1			
Clipbor	^	Name			1	Date modified	Туре	Size	
📌 Quick acc	ess	ThisWorkD	ata20190906	5		9/6/2019 1:09 PM	Text Document	61	KВ
- Downlos	ThisWo	orkData20190906 -	- Notepad						
	File Edit	Format View	Help						
				.88.68.	69.1004	.57,0.00,150	0.02		
Pictures						.56,0.00,150			
Logs1						.59,0.00,150,			
Paper W						.57,0.00,150,			
Papers (.59,0.00,150,			
Templat	0.00,25.	60,96.80,29	91 1882	.88,68	50 1004	.58,0.00,150,	0.02		
	0.00.25.	60.96.70.29	.86.1889	.39.68.	89,1004	.59,0.00,150,	0.02		
OneDrive						.65,0.00,150			
💻 This PC						.54,0.00,150,			
Desktop	0.00,25.	60,96.70,29	.77,1882	.88,68.	79,1004	.56,0.00,150,	0.02		
Docume	0.00,25.	60,96.70,29	.86,1882	.88,68.	19,1004	.58,0.00,150, .54,0.00,150	0.02		
						.63,0.00,150,			
						.56,0.00,150,			
Music						57,0.00,150,0			
Pictures						57,0.00,150,0			
Videos						50,0.00,150,0			
🏪 Local Di						.58,0.00,150, 55,0.00,150,0			
						52,0.00,150,0			
2 items 1 ite						.53,0.00,150,			
						.56,0.00,150,			
						56,0.00,150,0			
	0.00,25.	60,96.30,29	.77,1882	.88,67.	32,1004	.66,0.00,150,	0.02		

Fig. 7(b): Data logged in note Pad file.

Data were logged on hourly basis as shown in Fig. 8.

→ * ↑ -> T	his PC > Local Disk (C:) > Program Files (x8	36) > Advanced Serial Data L	ogger > Plugins > \	webserver > Web > Templates > Log
	Name	Date modified	Туре	Size
Quick access	ThisProjectData2019091003	9/10/2019 3:59 AM	Microsoft Excel 97	139 KB
🔜 Desktop 🛛 🖈	ThisProjectData2019091004	9/10/2019 4:59 AM	Microsoft Excel 97	140 KB
🕹 Downloads 🛛 🖈		9/10/2019 5:59 AM	Microsoft Excel 97	141 KB
🗄 Documents 🛛 🖈		9/10/2019 6:59 AM	Microsoft Excel 97	140 KB
📰 Pictures 🛛 🖈		9/10/2019 7:59 AM	Microsoft Excel 97	142 KB
Logs1	ThisProjectData2019091008	9/10/2019 8:59 AM	Microsoft Excel 97	141 KB
Paper Work	ThisProjectData2019091009	9/10/2019 9:59 AM	Microsoft Excel 97	140 KB
Project pics	ThisProjectData2019091010	9/10/2019 10:59 AM	Microsoft Excel 97	141 KB
and a state of the state of the state of the	ThisProjectData2019091011	9/10/2019 11:59 AM	Microsoft Excel 97	141 KB
Templates	ThisProjectData2019091012	9/10/2019 12:26 PM	Microsoft Excel 97	66 KB
OneDrive	ThisWorkData2019091003	9/10/2019 3:59 AM	Text Document	40 KB
TI: DC	ThisWorkData2019091004	9/10/2019 4:59 AM	Text Document	40 KB
This PC	ThisWorkData2019091005	9/10/2019 5:59 AM	Text Document	40 KB
E Desktop	ThisWorkData2019091006	9/10/2019 6:59 AM	Text Document	40 KB
Documents	ThisWorkData2019091007	9/10/2019 7:59 AM	Text Document	40 KB
🖶 Downloads	ThisWorkData2019091008	9/10/2019 8:59 AM	Text Document	40 KB
Music	ThisWorkData2019091009	9/10/2019 9:59 AM	Text Document	40 KB
Pictures	ThisWorkData2019091010	9/10/2019 10:59 AM	Text Document	40 KB
Videos	ThisWorkData2019091011	9/10/2019 11:59 AM	Text Document	40 KB
Local Disk (C:)	ThisWorkData2019091012	9/10/2019 12:26 PM	Text Document	18 KB
Network				
- NELWOIK				
Notice of the				
tems				
O Type here	to search	(D) 은 🧮		2 W4

Fig. 8: Data logged on hourly basis.

Users were able to access, monitor, and download the data logged by the weather station remotely. Fig. 9 shows the remote monitoring of the weather station. The users (two users) while using their phones were connected to the wireless local area network that was setup. The users were able to view and monitor the data logged by this weather station remotely.



Fig. 9: Two users viewing and monitoring the low cost server-based automatic weather station remotely

The process required to download data from the weather station is as presented in Fig. 10(a) to Fig. 10(e). Fig. 10(a) shows the remote display of the data with data download link at the bottom left of the screen. Clicking on this link will take you to Fig. 10(b)

🎽 游戏中心 📓 AliExpress							. Mobile	e bookma
	All data							
		Search:		🖉 Refresh automat		seconds. 😈		
	Data source 🔺	Name	+	Value	Last update	History		
	СОМЗ	BMP180_PRESSUREINMBAR	1002.70		9/6/2019 12:57:30 PM	>>>		
	СОМЗ	DATA_SOURCE_NAME	COM3		9/6/2019 12:57:30 PM	>>>		
	СОМЗ	DATE_TIME_STAMP	9/6/2019	0 12:57:30 PM	9/6/2019 12:57:30 PM	>>>		
	СОМЗ	DHT_RH	91.30		9/6/2019 12:57:30 PM	>>>		
	COM3	DHT_TEMP	26.50		9/6/2019 12:57:30 PM	>>>		
	СОМЗ	LIGHT_INTENSITY	1882.88		9/6/2019 12:57:30 PM	>>>		
	СОМЗ	O3_IN_PPM	0.02		9/6/2019 12:57:30 PM	>>>		
	СОМЗ	RAIN_RATE	0.00		9/6/2019 12:57:30 PM	>>>		
	COM3	SOILMOISTURELEVEL	27.34		9/6/2019 12:57:30 PM	>>>		
	СОМЗ	SOIL_TEMPERATURE	29.72		9/6/2019 12:57:30 PM	>>>		
	СОМЗ	WINDDIRECTION	135		9/6/2019 12:57:30 PM	>>>		
	СОМЗ	WINDSPEED	0.00		9/6/2019 12:57:30 PM	>>>		
	Showing 1 to 12 of 12 entries				Pr	evious Next 🕨		

Fig. 10(a): Remote display of the data with data download link at the bottom left of the screen

Fig. 10(b) also shows a download link. Clicking on this link will take you to the page where the logged files are listed (see Fig. 10(c)).



Welcome to this Project Data Downloading Page!

Click here to download this project data!



In order to download the data in the third (from top to bottom) file, the file was double clicked on. After which, a new page as presented in Fig 10(d) was displayed.

→ • ↑ <mark> </mark>	~ 11n	s PC > Local Disk (C:) > Program Files (x8	Date modified	Type	Size	ogse
Quick access						
Desktop	#	ThisProjectData2019091003	9/10/2019 3:59 AM	Microsoft Excel 97	139 KB	
Downloads	#	ThisProjectData2019091004	9/10/2019 4:59 AM	Microsoft Excel 97	140 KB	
•		ThisProjectData2019091005	9/10/2019 5:59 AM	Microsoft Excel 97	141 KB	
Documents	A	ThisProjectData2019091006	9/10/2019 6:59 AM	Microsoft Excel 97	140 KB	
Pictures	A	ThisProjectData2019091007	9/10/2019 7:59 AM	Microsoft Excel 97	142 KB	
Logs1		ThisProjectData2019091008	9/10/2019 8:59 AM	Microsoft Excel 97	141 KB	
		ThisProjectData2019091009	9/10/2019 9:59 AM	Microsoft Excel 97	140 KB	
Project pics		ThisProjectData2019091010	9/10/2019 10:59 AM	Microsoft Excel 97	141 KB	
Templates		ThisProjectData2019091011	9/10/2019 11:59 AM	Microsoft Excel 97	141 KB	
		ThisProjectData2019091012	9/10/2019 12:26 PM	Microsoft Excel 97	66 KB	
OneDrive		ThisWorkData2019091003	9/10/2019 3:59 AM	Text Document	40 KB	
This PC		ThisWorkData2019091004	9/10/2019 4:59 AM	Text Document	40 KB	
		ThisWorkData2019091005	9/10/2019 5:59 AM	Text Document	40 KB	
Desktop		ThisWorkData2019091006	9/10/2019 6:59 AM	Text Document	40 KB	
Documents		ThisWorkData2019091007	9/10/2019 7:59 AM	Text Document	40 KB	
Downloads		ThisWorkData2019091008	9/10/2019 8:59 AM	Text Document	40 KB	
Music		ThisWorkData2019091009	9/10/2019 9:59 AM	Text Document	40 KB	
Pictures		ThisWorkData2019091010	9/10/2019 10:59 AM	Text Document	40 KB	
Videos		ThisWorkData2019091011	9/10/2019 11:59 AM	Text Document	40 KB	
Local Disk (C:)		ThisWorkData2019091012	9/10/2019 12:26 PM	Text Document	18 KB	
Network						
ems						

Fig. 10(c): Logged data files

From the download dialogue box that popped up (see Fig. 10(d)), the "Download" button was clicked and the data was downloaded. The downloaded data is shown in Fig. 10(e).

Web Server - Data	X This_Project_Data_Downloadi X	Index of C:\Program Files (x86 × +		n 0°	-	٥	×
∆ C D• <	1 file:///C:/Program%20Files%20(x86)/Advance	d%20Serial%20Data%20Logger/Plugins/webserver/Web/Root/Logs2/	🔺 👻 😮 😵 🐇 Google		Q	÷	Ξ
☆ ■ 游戏中心 ■ A	liExpress				Mobile	book	marks

Index of C:\Program Files (x86)\Advanced Serial Data Logger\Plugins\webserver\Web\Root\Logs2\

Name	Size	Date Modified
[parent directory]		
ThisProjectData2019091003.xls	139 kB	9/10/19, 3:59:57 AM
ThisProjectData2019091004.xls	140 kB	9/10/19, 4:5
ThisProjectData2019091005.xls	141 kB	9/10/19, 5:5
ThisProjectData2019091006.xls	140 kB	9/10/19, 6:5 ThisProjectData2019091005.xls (140 KB)
ThisProjectData2019091007.xls	142 kB	9/10/19, 7:5 file:///C:/Program%20Files%20(x86)/Advanced%20Serial%2
ThisProjectData2019091008.xls	141 kB	9/10/19, 8:5
ThisProjectData2019091009.xls	140 kB	9/10/19, 9:5
ThisProjectData2019091010.xls	141 kB	9/10/19, 10:5 C:\Users\PC\Downloads 431.13GB Free left # Path
ThisProjectData2019091011.xls	141 kB	9/10/19, 11:5
ThisProjectData2019091012.xls	66.0 kB	9/10/19, 12:2
ThisWorkData2019091003.log	39.7 kB	9/10/19, 3:5 Open directly Download
ThisWorkData2019091004.log	39.7 kB	9/10/19, 4:5
ThisWorkData2019091005.log	39.7 kB	9/10/19, 5:5
ThisWorkData2019091006.log	39.7 kB	9/10/19, 6:5. 9/10/19, 6:5.
ThisWorkData2019091007.log	39.7 kB	9/10/19, 7:59:59 AM
ThisWorkData2019091008.log	39.7 kB	9/10/19, 8:59:59 AM
ThisWorkData2019091009.log	39.7 kB	9/10/19, 9:59:58 AM
ThisWorkData2019091010.log	39.7 kB	9/10/19, 10:59:57 AM
ThisWorkData2019091011.log	39.7 kB	9/10/19, 11:59:56 AM
ThisWorkData2019091012.log	17.5 kB	9/10/19. 12:26:26 PM

	> This	PC > Local Disk (C:) > Users > PC > Do	wnloads			
Quick access		Name	Date modified	Туре	Size	
Desktop	*	ThisProjectData2019091005	9/10/2019 12:41 PM	Microsoft Excel 97	141 KB	
Downloads	#	UCBrowser_V7.0.185.1002_4601_(Build180		Partial Download	6,400 KB	
Documents	*	UCBrowser_V7.0.185.1002_windows_pf10	7/29/2019 8:34 PM	Application	1,662 KB	
Pictures	*					
Logs1						
Paper Work						
Project pics						
Templates						
OneDrive						
This PC						
Desktop						
Documents						
Jownloads						
Music						
Pictures						
Videos						
Local Disk (C:)	L.					
Network						

V. Comparison of Some of the Data Obtained from this Weather Station with Corresponding Data Obtained from Campbell Weather Station

The developed weather station was placed outdoor for 12 hours to record atmospheric data. At the end of 12 hours, some of the data obtained from this our weather station was compared with some of the data obtained from Campbell weather station at the same time interval.

Comparison of Air Temperature Data

Figure 11(a) shows air temperature data obtained from the two weather stations, while Fig. 11(b) shows the graph of air temperature data from the two weather stations.

= 10 0 1009

	Cut	Times Ne	w Roman	n - 11	- A A	= =		Wrap
Past	e SFormat Painter	BZ	<u>u</u> -		3 · A ·			🚝 🔤 Merg
	Clipboard 15		Fo	nt	15		Alig	gnment
	A1 .		f=	Campl	bell			
-	А			в		С	D	E
	Campbell		The De	v. AWS				
2 4	AirTC_Avg (Degree	C)	Air_Te	mp(Deg	gree Cel)			
3		26.56			26.5			
4		26.56			26.5	7		
5		26.34			26.3			
6		26.41			26.			
7		26.55			26.5	-		
8		26.45			26.4			
9	26.27 26.43		26.3					
10				26.4				
11				26.				
12		26.38			26.3			
13		26.59			26.	-		
14		26.73			26.7			
15		26.44			26.4			
16		26.34			26.3			
17		26.39			26.4			
18		26.28			26.2			
19		26.47			26.4	-		
20		26.87			26.8			
21		26.92						
22				26.9				
23		26.88			26.8			
24 25		26.39			26.4		-	
4 4	> > Sheet1 Sh				20.4	1		b

Fig. 11(a): Air temperature data obtained from the two weather stations



Fig 11(b): Graph of the air temperature data obtained from the two weather stations.

Comparison of Relative Humidity Data

Figure 12(a) shows relative humidity data obtained from the two weather stations, while Fig. 12(b) shows the graph of relative humidity data obtained from the two weather stations.

Paste Clipboard A1		Times New Roman	Times New Roman \cdot 11 \cdot $\mathbf{A}^* \mathbf{A}^*$ B $\mathbf{I} \mathbf{U} \cdot$ $\mathbf{\Theta} \cdot$ $\mathbf{\Phi} \cdot$ \mathbf{A}^*			= 😑 🚿	
		B Z U -					
					5	AI	
		- fr Campbel		bell			
-	А	B		С	D	D E	
	Campbell	The Dev. AWS					
2	RH%	Relative_Humidity					
з	Smp	(RH%)					
4	66.11	66.	12				
5	66.13	66.	13				
6	66.87	66.	87				
7	67.1	6	5.8				
8	68.04		68				
9	68.91	6	3.9				
10	66.8		5.8				
11	66.93	66.9					
12	66.93		5.9				
13	65.33		5.9				
14	65.86		5.9				
15	67.9		68				
16	69.04		69				
17	68.67		3.8				
18	68.94	68.					
19	67.5	67.					
20	67.47	67.				-	
21	66.57	66.					
22	64.56		1.5			-	
23	65.46	65.					
24	66.06	6					
25	66.13	66.	15				

Fig 12 (a): Relative humidity data obtained from the two weather stations



Fig 12(b): Graph of the relative humiditydata obtained from the twoweather stations.

Comparison of Rain Fall Data

Figure 13(a) shows rain fall data obtained from the two weather stations, while Fig. 13(b) shows the graph of rain fall data obtained from the two weather stations.

File	Home		Page Layout F			
	Copy -	Times	New Roman * 11	• A	A = =	= <u> </u>
Paste	Sormat Pain	ter BB .	<u> u </u>	3- A	- = 1	
(Clipboard	15	Font		154	Alig
	A1	- (-	<i>f</i> ∗ Cam	pbell		
-	А		В	С	D	E
1 Ca	mpbell	The	e Dev. AWS			
2 R.a	in_mm_tot	Rai	n_Rate(mm)			
з		0	0			
4		0	0			
5		0	0			
6		0	0			
7		0	0			
8		0	0			
9		0	0			
10		0	0			
11		0	0			
12		0	0			
13		0	0			
14		0	0			
15		0	0			
16		0	0			
17 18		0	0			
18		0	0			
20		0	0			
21		0	0			
22		0	0			
23		0	0			
24		0	0			
25		0	0			
4 4 4	M Sheet1	Sheet2	Sheet3 /	2	-17	1
Ready						

Fig 13(a): Rain fall data obtained from the two weather stations



Fig 13(b): Graph of the rain fall data obtained from the two weather stations.

Comparison of Barometric Pressure Data

Figure 14(a) shows barometric pressure data obtained from the two weather stations, while Fig. 14(b) shows the graph of barometric pressure data from the two weather stations.

-	Cut 1	imes New Roma	n ~ 11	- A A	=	
Pa	ste	B <u> </u>	1333 -	3 - A -	= =	
	Format Painter					10 24
	Clipboard Ta	Fo		15	à	Alig
	A1 - (- fx	Campt	pell		
-	A	В		С	D	E
1	Campbell	The Dev. AW				
2	BarPress_Abg	Barometric_P	ress			
3	mbar	(mbar)				
4	1002.33		02.32			
5	1002.33	10	02.32			
6	1002.35	10	02.36			
7	1002.33	10	02.32			
8	1002.3	1	002.3			
9	1002.3	10	02.29			
10	1002.3	10	02.31			
11	1002.25	10	02.25			
12	1002.34	10	02.34			
13	1002.35	10	02.35			
14	1002.3	10	02.31			
15	1002.3	10	02.29			
16	1002.29	10	02.27			
17	1002.35	10	02.34			
18	1002.31	10	02.31			
19	1002.31	10	02.31			
20	1002.25	10	02.25			
21	1002.39	10	02.37			
22	1002.3	10	02.29			
23	1002.38	10	02.36			
24	1002.33	10	02.32			
25	1002.31	10	02.29			
	Sheet1 Sheet	t2 Sheet3	12			h/i
Rea	ady					

Fig. 14(a): Barometric pressure data obtained from the two weather stations



Fig 14 (b): Graph of the barometric pressure obtained from the two weather stations

Looking at the data we compared closely, you will see that the data obtained from this work's weather station are very close to that obtained from the Campbell weather station (see Fig. 11 to Fig. 14). Thus, there is a good agreement between the values obtained using the two weather stations.

VI. Conclusion

In this work, the development of a low cost server-based automatic weather station which logs data on hourly basis and with remote data download capability is presented. With the existing technology today, this weather station can be built locally and installed at remote locations to log atmospheric data at regular intervals. The accuracy of the data was compared with data obtained from Campbell weather station, and it was found that the data obtained from this system (low cost server-based automatic weather station) are in good agreement with that obtained from the Campbell weather station. The data obtained using this developed system can be used in environment and energy applications where there is need for metrological data.

References

- Wikipedia, "Automatic Weather Station", http://en.m.wikipedia.org/wiki/Aotomatic_weather_station [1].
- M. Popa and C. lapa, "Embedded Weather Station with Remote Wireless Control", 2011 IEEE 19th Telecommunications Forum [2].
- (TELFOR) Proceedings of Papers, Serbia, Belgrade, 22-24November, 2011.Doi: 10.1109/TELFOR.2011.6143539. R.M. Weerasinghe, M. S. M. Aroos, A. S. Pannila, M. K. Jayananda, and U. Sonnadara, "Construction of an Automated Weather [3]. Station for Ground Level Weather Measurements". Annual Transactions of IESL, pp.450-455, 2011.
- Adnan Shaout, Yulong Li, Mohan Zhou, and SelimAwad, "Low Cost Embedded Weather Station with Intelligent System", 978-1-4799-5241-0114 / Pp. 100-106 IEEE 10th International Computer Engineering Conference (ICENCO), 2014.Doi: [4]. 2014.Doi: 10.1109/ICENCO.2014.7050439.
- O. Krejcar, "Low Cost Weather Station with Remote Control," SAMI 2012. 10th IEEE Jubilee International Symposium on [5]. Applied Machine Intelligence and Informatics. 26 -28 January, 2012 · Herl'any, Slovakia. Doi:10.1109/SAMI.2012.6209011
- [6]. A. Ghosh, A. Srivastava, A. Patidar, C.Sandeep, and S. Prince, "Solar Powered Weather Station and Rain Detector" 2013 Texas Instruments India Educators' Conference
- L. Rafael, A. Jorge, P. Jose, and S. Tomas, "Ultra Low Power Wireless Weather Station", 2007 International Conference on Sensor [7]. Technologies and Applications (SENSORCOMM 2007), Valencia, Spain, pp. 469-474, 2007.
- Satyanarayana KNV, Reddy SRN, Sai Teja PVYN & Habibuddin B, "IOT Based Smart Weather Station Using Raspberry-PI3", [8]. Journal of Chemical and Pharmaceutical Sciences, Vol. 2016, No. 10, pp. 1-6, 2016.
- C. D. Gustavo, M. G. Alonso, and R. M. Felipe, "Monitoring System of a Weather Station via IP", JEEE 2010 ANDESCON, Bogota, Colombia, pp. 1-6, 2010. Doi: 10.1109/ANDESCON.2010.5632377. [9].
- Krejcar O, "Low Cost Weather Station with Remote Control", 2012 IEEE 10th International Symposium on Applied Machine [10]. Intelligence and Informatics (SAMI), Herl'any, Slovakia, pp. 463-468, 2012. Doi: 10.1109/SAMI.2012.6209011
- T. Savić& M. Radonjić, "One approach to weather station design based on Raspberry Pi platform", 2015 23rd Telecommunications [11]. Forum Telfor (TELFOR), Belgrade, Serbia, pp. 623-626, 2015.
- [12]. R. Lajara, J. Alberola, J. Pelegri, T. Sogorb, and J.V. Llario, "Ultra Low Power Wireless Weather Station," 2007 IEEE DO110.1109/SENSORCOMM.2007.61.
- [13]. H. Saini, A. Thakur, S. Ahuja, N. Sabharwal, and N. Kumar, "Arduino based automatic wireless weather station with remote graphical application and alerts", 2016 3rd International Conference on Signal Processing and Integrated Networks (SPIN), Noida, India, pp. 605 – 609, 2016.
- P. Mircea and I. Catalin, "Embedded weather station with remote wireless control", 2011 19th Telecommunications Forum [14]. (TELFOR) Proceedings of Papers, Belgrade, Serbia, pp. 297-300, 2011.
- Campbell Scientific, Data loggers, Sensors and Weather stations. [Online] Available: http://www.campbellsci.co.uk/ [15].
- [16]. ARDUINO MEGA 2560 MANUAL. Arduino, Somerville, MA, United States, 2005.
- SparkFun Soil Moisture Sensor. SparkFun Electronics, 6333 Dry Creek Parkway, Niwot, CO 80503, United States, 2003. [17].
- Digital-output Relative Humidity and Temperature Sensor Module. AosongElectronicsCo., Ltd, GuangZhou, China, 2011, pp. 1-10. [18]. AggSoftwaere, "Advanced Serial Data Logger". [Online]. Available: https://www.aggsoft.com/serial-data-logger.htm. [19].
- [20]. "Anenometer". [Online].pp. Available: Davis Instruments, 2
- https://www.davisinstruments.com/product_documents/weather/spec_sheets/7911_SS.pdf. SUTRON Conversions and Calculations, "Velocity Conversion Table". Available: https://www.sutron.com/wp-[21]. content/uploads/2013/12/Velocity_Length_Distance.pdf

E.L. Omoze. " Development of an Automatic Weather Monitoring System" IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) 14.6 (2019): PP 61-78.
