Development of IoT Based Meteorological Measurement System

G Raja Kullayappa, Shahid Ali, A Chandra Shekhar, P Kanaka Raju, C Mani Kumar

Abstract: ***The atmospheric parameter sensing is pivotal in the forecasting of the weather. The meteorological parameters like temperature, humidity and pressure are measured with the usage of sensors. The DHT11 sensor is employed for measurement of humidity where as the BMP180 sensor is used for the monitoring of temperature and atmospheric pressure. The sensors are interfaced to NodeMCU ESP-32S module. The humidity sensor is interfaced with the single-wire two-way serial protocol and the pressure sensor is interfaced with the I2C protocol. The Arduino IDE is employed for scripting the software of the system. The developed prototype is connected to IoT with the help of inbuilt Wi-Fi module in the NodeMCU EPS-32S. The data collected is portrayed on a web page developed in the IDE. The system is compact and easy to use with its plug and play nature. The prototype can be deployed over various areas such as home automation, industries, healthcare centers.***

Keywords*: *Atmospheric pressure sensor, Humidity sensor, Arduino IDE, I2C, Temperature.

I. INTRODUCTION

The meteorological monitoring has gained a significant importance in day to day life. The weather forecasting techniques has been moving from conventional physical measurement to advanced embedded systems with relatively stable performance at low cost. The physical parameters are sensed with the usage of different type of sensors in the embedded systems. The temperature can be monitored using sensors such as LM35 [1], LM70, DHT11, DHT22, BMP085 and BMP 180. The DHT and BMP sensors are directly calibrated in digital as a consequence the need of an external ADC is eliminated. The ongoing development in the field of Internet of Things has presented a chance to make all these sensors to be connected. The development boards like Arduino, Raspberry Pi, and NodeMCU ESP-32S have provided an opportunity to design and develop handheld systems.

NodeMCU ESP-32S is a development board built using the ESP32-WROOM-32. ESP32-WROOM-32[2] module consists of chip microcontroller unit, Wi-Fi, Bluetooth and BLE. The module supports General Purpose Input/Output (GPIO) along with a wide variety of I/O protocols namely, SPI, I2C, and UART. It can be operated at a voltage of 3.3Vand an average current of 80mA. The 40 MHz crystal and the flash memory of 4MB make it one of the front runners for the low-power sensor networks for real time applications. The built-in Wi-Fi supports the data communications with a speed of 150Mbps.

DHT11 [3] is digital humidity and temperature sensor. The fast responding sensor contains an NTC component and a restive-type component to measure the temperature and humidity respectively. The sensor measures the relative humidity with an accuracy of ±5% and a resolution of 1%. The sensor can measure the temperature from 0 to 50 °C with a resolution and accuracy of ±2°C and 0.1°C respectively. The sensor can be driven with a power supply ranging from 3V/0.25mA to 5.5V/2.5mA. It can be operated with a sampling period of 1 second.

BMP180 [4] sensor is a barometric pressure sensor which can measure the parameters such as atmospheric pressure, elevation and temperature. The sensor employs I2C as a communication protocol. The sensor works with a voltage of 3.3V and uses maximum of 1mA current during the conversion time. BMP180 has a typical accuracy of ±1.5hPa (hectopascal) and a resolution of 0.01hPa. The temperature measurement of the BMP180 sensor ranges from 0 to 65°C with a typical accuracy of ±1°C and a resolution of 0.1°C. The sensor can also measure elevation up to 9000 meters with respect to sea level.

II. METHODOLOGY

A. Hardware Implementation

The block diagram of the meteorological measurement system is depicted in Fig.1. The NodeMCU [5] ESP-32S development is connected to a personal computer with serial communication. The personal computer is loaded with Arduino Integrated Development Environment (IDE) and the required library files to operate the NodeMCU ECP-32S. There are four pins in DHT 11 two pins are employed for power supply with 3.3V, ground and one pin is connected to one of the GPIO pins (GPIO-23) of the development board. The unused pin of DHT11 is provided for robustness of the package and it is not needed to connect.

Revised Manuscript Received on December 13, 2019.

***** Correspondence Author

G Raja Kullayappa, Dept. of Electronics and Physics, GITAM deemed to be University, Visakhapatnam, India, Email: rajaseworld@gmail.com

Shahid Ali, Dept. of Electronics and Physics, GITAM deemed to be University, Visakhapatnam, India, Email: ckp786shahid@gmail.com

A Chandra Shekhar, Dept. of Electronics and Physics, GITAM deemed to be University, Visakhapatnam, India, Email: chandrasekhar.angani@gitam.edu

P Kanaka Raju, Dept. of Electronics and Physics, GITAM deemed to be University, Visakhapatnam, India, Email: kanakaraju.pappala@gitam.edu

C Mani Kumar*, Dept. of Electronics and Physics, GITAM deemed to be University , Visakhapatnam, India, Email: mani.chimpineni@gitam.edu

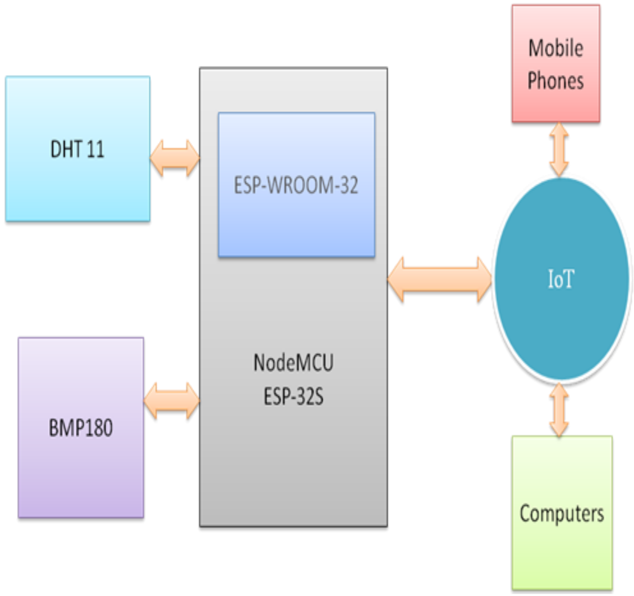

Fig. 1 Block diagram

The BMP180 sensor's SDA and SCL are connected to GPIO-21 and GPIO-22 pins of the NodeMCU ESP-32S. The SDA and SCL pins are pulled-up with suitable resistors. The I2C protocol is limited with the bus capacitance hence the pull up resistors should be connected to avoid clock stretching. The VCC and Ground pins of BMP180 are connected to the respective counter parts of the development board. The detailed circuit implementation is presented in Fig. 2.

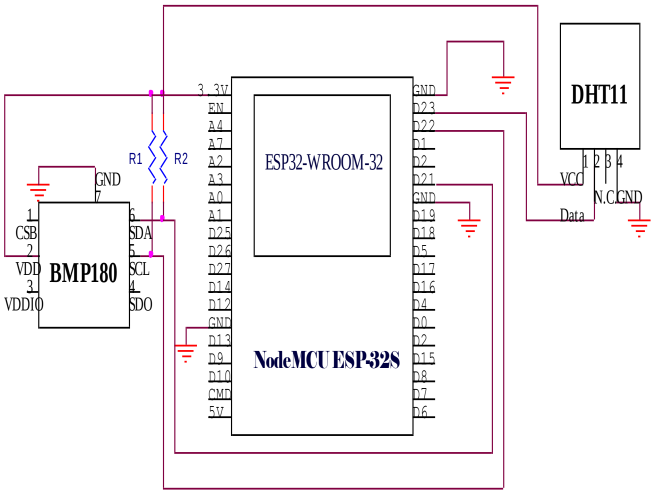

Fig. 2 Circuit schematic

B. Software Development

The development board NodeMCU ESP-32S is popularly used with MicroPython [6] and Arduino IDE [7] for programming. The open source IDE, Arduino, is used in this work for developing the software to interface the sensors. The DHT11 is communicated with single-wire two-way communication serial protocol. The development board sends the start signal to the humidity sensor and waits for the response from the sensor.

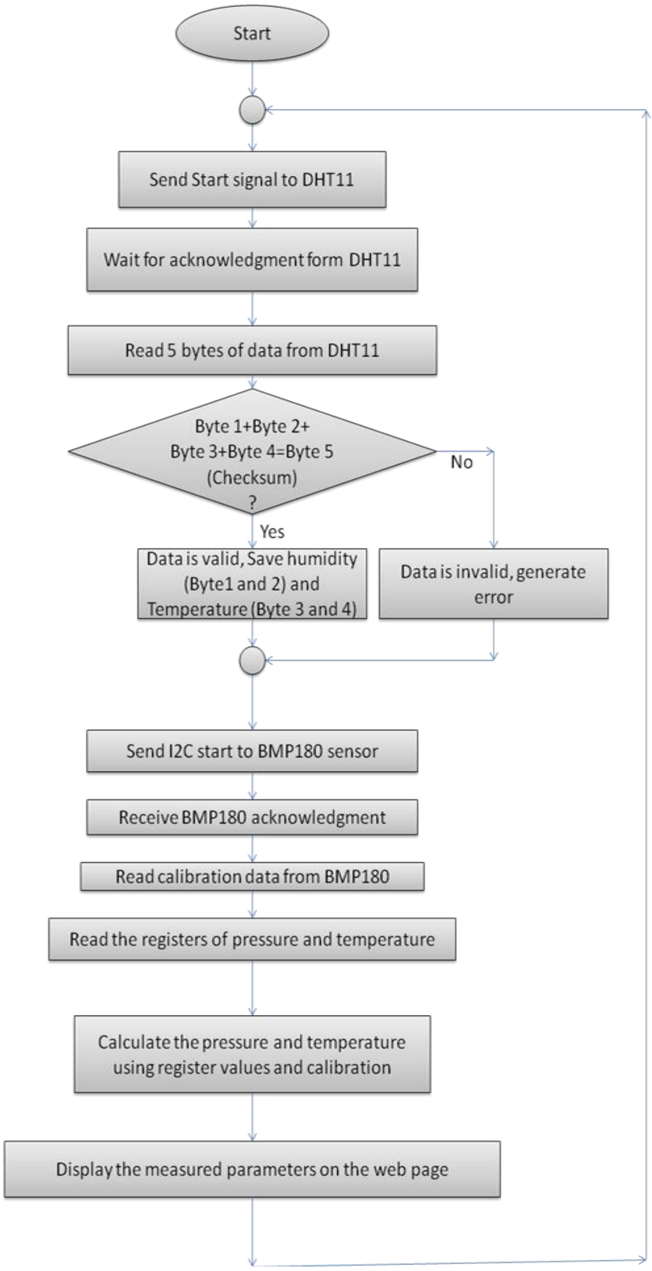

Fig. 3 Flowchart

The sensor sends a response signal by pulled-down followed by a pulled-up signal and then it transmits the 40 bits of data to the NodeMCU ESP-32. The first two bytes gives the relative humidity and the next couple of bytes indicate the temperature. The last byte is used as the checksum to verity whether the data read is valid or not. The sum of first four bytes has to be same as the check sum to consider the data as a valid data. The development board receives the data and separates the temperature and humidity data. Further, the development board sends start signal to the atmospheric pressure sensor using the I2C [8] pins with the seven bit address 0x77 followed by write bit. After the acknowledgement from BMP180 the controller reads the registers to get the temperature and pressure values. The flowchart of the code is depicted in the Fig. 3.

Retrieval Number: B10171292S319/2019©BEIESP
DOI: 10.35940/ijitee.B1017.1292S319

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

III. RESULTS AND DISCUSSION

The performance of the system is analyzed over a period of one week. The data collected from the sensors is visualized on the computer monitor as well as on a mobile phone screen wirelessly connected to the system. The values are tabulated in the Table.1.

The tabulated values of temperature, humidity and atmospheric pressure are plotted in Fig. 4, Fig. 5 and Fig. 6 respectively. As the experimentation is done in the winter season the temperature and humidity are lower than normal range. As the system is operated in an indoor laboratory building in Visakhapatnam which is near to the sea because of this the atmospheric pressure is high. The average values of temperature, humidity and atmospheric pressure over the seven days are 28.26°C, 34% and 1011.73hPa.

Table.1 Atmospheric parameters measured with the system

Time	Day	9:00am	10:00am	11:00am	12:00am	01:00pm	02:00pm	03:00pm	04:00pm	05:00pm
Temperature (in °C)	1	27.6	28.1	28.3	29	28.6	28.3	28	27.9	28
	2	27.9	28.1	28.5	29.2	29.1	28.4	28.2	28.6	27.7
	3	27.8	28	28.4	29.3	28.6	28.3	28	28	27.8
	4	28	28.2	28.3	29.4	28.5	28.2	28.1	28	27.9
	5	28	28.1	28.2	29.5	28.3	28.1	28.5	28.2	28.1
	6	27.9	28	28.2	28.3	28	28.1	28.1	28	28
	7	27.8	28	28.7	28.9	29	28.7	28.4	28	27.5
Relative Humidity (in %)	1	31	30	30	41	31	36	35	37	38
	2	30	31	36	34	36	32	37	36	37
	3	31	32	35	38	34	34	32	34	35
	4	32	31	32	34	38	36	31	38	34
	5	34	33	33	33	33	34	35	33	34
	6	34	34	34	34	35	34	35	39	34
	7	34	34	34	33	33	33	34	35	34
Pressure (in hPa)	1	1011.84	1013.45	1012.56	1012.24	1011.86	1011.05	1010.35	1011.16	1011.25
	2	1011.34	1014.15	1013.24	1011.24	1011.61	1011.25	1011.28	1011.02	1010.42
	3	1011.54	1013.45	1012.84	1011.63	1011.25	1011.77	1011.04	1010.85	1011.35
	4	1013.42	1014.12	1012.92	1011.34	1011.46	1010.24	1011.22	1011.18	1010.17
	5	1011.35	1014.44	1013.86	1011.43	1011.92	1012.34	1011.07	1011.13	1011.13
	6	1013.24	1014.11	1012.02	1012.82	1011.38	1010.01	1009.96	1010.03	1010.19
	7	1013.12	1013.23	1012.32	1011.78	1011.36	1010.46	1010.25	1011.23	1010.24

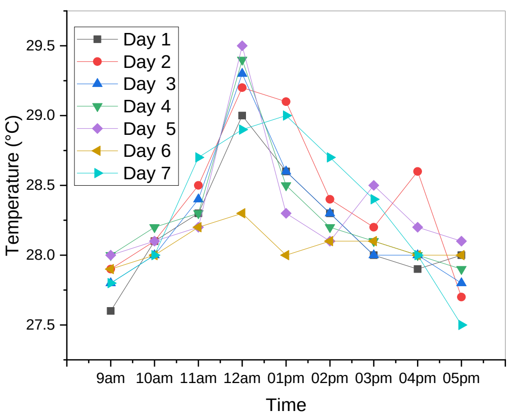

Fig. 4 Plot of measured temperature

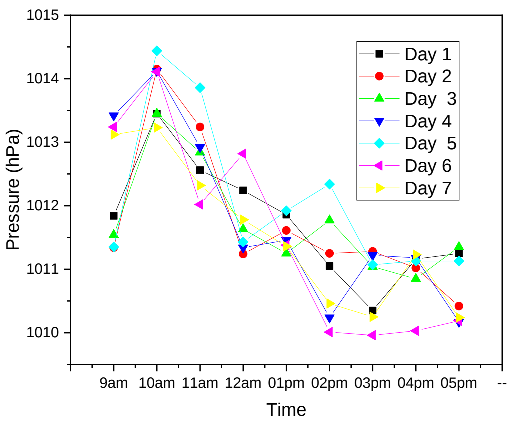

Fig. 5 Plot of measured atmospheric pressure

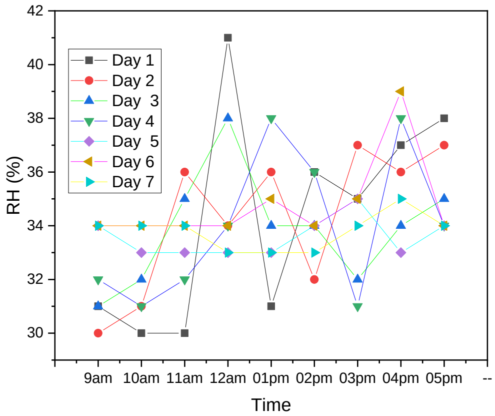

Fig. 6 Plot of measured relative humidity

IV. CONCLUSION

A cost-effective module to sense the atmospheric parameters is developed and its performance is verified. Fig. 7 and Fig. 8 show the pictorial view of designed system. The values obtained from the system are compared against conventional mercury based devices. The records of temperature, humidity and pressure are obtained with an accuracy of ±1C°, ±5% and ±1.5hPa. The portable system can work seamlessly with low power consumption. The system can handle more sensors and the artificial intelligence algorithms can be employed for better weather forecasting.

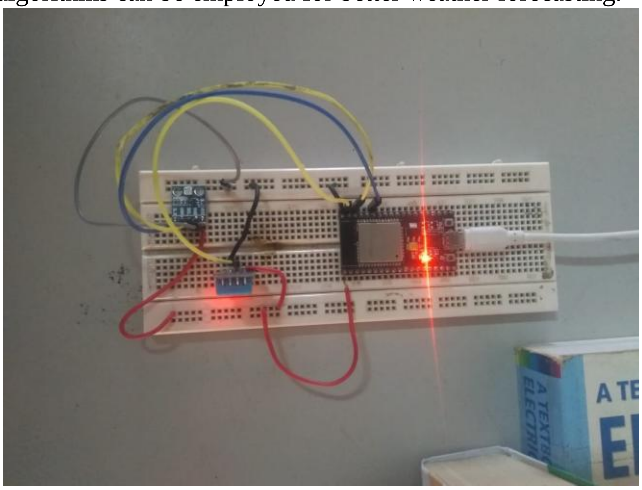

Fig. 7 Picture of designed System

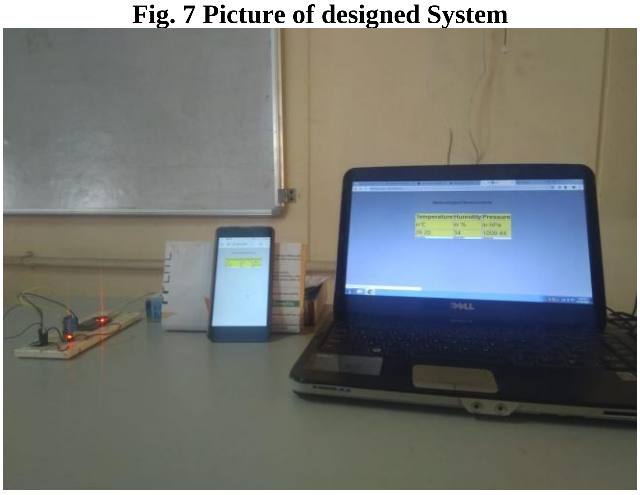

Fig. 8 Results displayed on webpage

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AUTHORS PROFILE

G. Raja Kullayappa has received his M.Sc. in Electronics and communications from Sri Krishnadevaraya University. He is pursuing his PhD degree in GITAM University. His research areas are Embedded Systems and Biomedical Instrumentation.

Shahid Ali has received his M.Sc. in Electronics Science from GITAM University. He is pursuing his PhD degree in GITAM University. His research areas are Embedded Systems and Environmental parameter monitoring.

Chandra Sekhar Angani obtained his M.Sc. degree in Electronics in 2005 from Andhra University, India, and Ph.D. degree in Materials Engineering in 2011 from Chungnam National University, South Korea. His Specialization is Nondestructive Evaluation (NDE). He is currently working as an Assistant Professor in GITAM University, India. His research interests include Electromagnetic NDE of conductive materials, Electronics Instrumentation and Measurement, Sensor Development and Signal Processing

P. Kanaka Raju has received his M.Sc. in Electronics from Andhra University. He has received his PhD degree in Andhra University. He is currently working as an Assistant Professor in GITAM University. His research areas are Embedded Systems, Systems Design and Instrumentation.

C. Mani Kumar has received his M.Sc. in Electronics from Sri

Krishnadevaraya University. He is received his PhD degree in Sri Krishnadevaraya University. He is currently working as an Assistant Professor in GITAM University. His research areas are Embedded Systems, Biomedical Electronics and Instrumentation.