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Low Cost IoT enabled Weather Station

Dushyant Kumar Singh
Embedded Systems, SEEE
Lovely Professional University
Phagwra, Punjab, India.
dushyant.kumar@lpu.co.in

Himani Jerath
Embedded Systems, SEEE
Lovely Professional University
Phagwra, Punjab, India.
himani.22788@lpu.co.in

P.Raja
Embedded Systems, SEEE
Lovely Professional University
Phagwra, Punjab, India.
raja.21019@lpu.co.in

***Abstract*—The recent trends in the variations of climatic conditions are drastic throughout the world and furthermore its growing unpredictability is a major concern. The existing solutions are highly global and are inaccessible to the common man. The weather conditions applicable to a city may not be as such for a farmer of small rural region or a worker of a small town. Hence, humidity and temperature measurement plays an important role in different fields like Agriculture, Science, Engineering and Technology. The proposed work provides an optimal solution for monitoring the weather conditions at extremely local level with low cost, compact Internet of Things (IoT) based system. In this paper the design of the system is presented with the use of Node MCU for realizing the low cost solution. This low cost weather station is a product equipped with instruments and sensors for measuring the atmospheric conditions like temperature, humidity, wing speed, wind direction for the purpose of making weather forecasts. With IoT enabling, weather station is able to upload, without any human intervention, the measured atmospheric parameters i.e. temperature, humidity, wind speed, wind direction to the IoT cloud. From the cloud user can access all the atmospheric parameters being measured through weather station from any location across the world from any connected device – laptop or mobile phone. The "Low cost Compact IoT enabled Weather Station" need not to be physically visited to read out the measured atmospheric parameters and thus does not have any display which also makes it power efficient running at only 80mA to 90mA.**

Keywords—IoT, Weather Station, NodeMCU, Humidity, Temperature

I. INTRODUCTION

Meteorology is the study of atmosphere focusing on the process and forecasting of weather. It always gets associated with human survival and producing activities. With the development in economy and technology, and with the gradual implementation of climate action plan strategies, higher and higher standards of weather monitoring is required. Automatic weather stations are capable of collecting weather related information such astemperature, humidity, air pressure, wind speed, wind direction, visibility, particle level in air etc.of the area where they are installed and sends these parameters to the centralized server for further analysis and information extractions. These systems are reliable for monitoring localized weather/climatic conditions

Internet of things (IOT) allows controls of the systems from remote area over an internet. It can control the sensors which are used at various areas that include common areas like blinding roads, railways grids or harsh areas like high altitudes or dense forests and thus avoid probable errors due to human interventions [1].IOT is the emerging field that involves other areas and made them more reliable, efficient and intelligent. It is engineered now days that by inclusion of new smart sensors along with the respective sensor network such as RF based communications is capable of proving intelligence to the device, precise sensing of the physical parameters and correct identification of the device[2]. Mobile and wireless technologies having their advantages of low, ultra-power, short and long range technologies continue to drive the progress of communications and connectivity in theIoT [3]. Some of the other networks that develops IoTintelligent systems and operate these systems at remote places are GPRS, LTE, GSM, WLAN, WPAN, LPWAN,WiMax, RFID, Zigbee, NFC, Bluetooth [4, 5].

Thus, the concept of IoT makes the internet, even more, omnipresent and deep into every application around. Many of the sensitive/critical parameters can be captured and can be sent over the internet through the different gateways. Some of the examples of these sensors that have become an integral part of our life are found in smart phones, entertainment and health (blood pressure, blood sugar etc.) tracking devices. Air Suspension Controllers in automobiles anticipating information on the health of the road is also another example. The proposed work is combining the use of IoT with the application of monitoring the meteorological parameters. Having used NodeMCU and freeware cloud has enabled to bring down the cost of the system to a larger extent hence making it a way forward over its predecessors.

This paper is divided into four sections further. The first section deals with the related work in this field. The second section exhibits the implementation and hardware of the proposed work. The third section is analyzing all the data and results while the fourth section is concluding the proposed work with outcomes and limitations.

II. RELATED WORK

As the issue is very grave, there has obviously been previous research work done on this specific field. In this

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section, we present previous work carried out in this domain.

Table 1: Previous Work done with Weather stations

Sno.	**Papers**	**Processing Unit**	**Parameters monitored**	**Technology Used**	**Monitoring station**
1.	P. Sushmitha et al. [2014] [6]	ARM 9	Humidity, Temperature, Gas	GSM	PC, Mobile
2.	Purnima et. al.[2012][7]	8052 microcontroller	Humidity, Temperature, Gas-CO2, Moisture	GSM, Bluetooth	PC, Mobile
3.	NorakmarbintiArbain et. al. [2019] [8]	Arduino Uno, Node MCU	Pressure, Humidity, Temperature, Light, Soil Moisture	Wi-Fi	Mobile, Blynk app
4.	Rajinder Kumar M Math et.al.[2018] [9]	Node MCU	Rain, Humidity & Temperature, Pressure, Light	Wi-Fi	Thingspeak
5.	HammadAamer et.al.[2018] [10]	Node MCU	Humidity &Temperature Gas GPS	Wi-fi	Google sheet
6.	YasasPanseluJayasuriya et.al. [2018] [11]	Arduino Mega	RH CO_2 Temperature, Pressure, Light Wind speed Wind Direction Rain Gauge Soil Moisture	Wi-Fi	Splot

III. SYSTEM DESCRIPTION

The system comprises of NodeMCU as the main controlling unit which does the three ways process i.e. receives data from the sensor, applies the calibration equation to the received sensor data and finally upload the calculated meteorological information to the cloud.all the sensor and devices connected to it. Having used the basic components and processing unit makes the system low cost. The block diagram for the same is shown below in figure1:

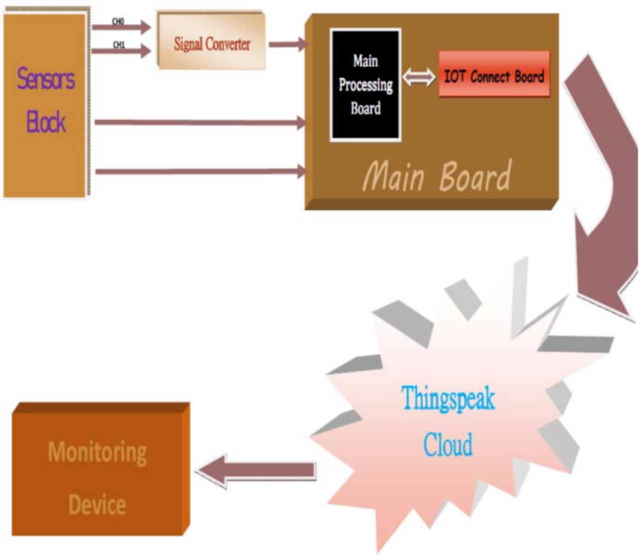

Figure 1: Representation of the System

A. NodeMCU

NodeMCU is an open source freeware hardwareIoT platform which can be programmed using the well knownArduino IDE. It has ESP8266-12EWiFi from Espressif Systems and has flashupto 1Mb. NodeMCU is programmed in Embedded C and firmware was initially developed as an aided project, but the project is now community-supported.There are about 40 different NodeMCU modules supporting almost major IoT protocols like MQTT, HTTP, CoAP, etc.

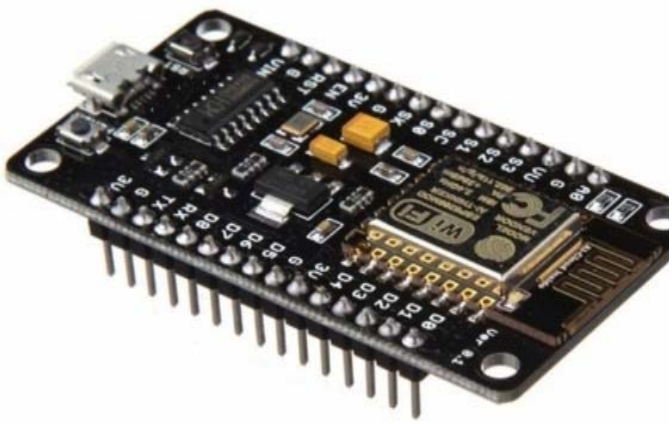

Figure 2: Representative image of NodeMCU

B. Data Acquisition system

The data acquisition system consists of various sensors that are acquiring the data of various meteorological parameters. They include:

(i) Wind speed Sensor
Wind speed sensor measures the rate of wind flow as analog output signal, which is proportional to wind speed. The technical specifications for the sensor are as follows:
Accuracy: + - 1m / s
Start Wind: 0.2-0.4m / s
Voltage output type:
Range: 0 ~ 32.4m / s
Supply voltage: 7V ~ 24VDC
Output signals: 0~5V
Wind speed values :(output voltage -0.4) /1.6*32.4

Figure 3: Representative image of Wind Speed Sensor

(ii) Wind direction Sensor
Wind direction sensor is also an analog sensor providing the analog signal which is further calibrated to give the direction of wind flow.
Technical parameters:
Input supply voltage: DC12-24V
Output Signal level: Voltage :0-5V current :4-20mA
Initial wind speed: 0.5m / s
Accuracy: +/-0.1m / s
System error: ± 3%
Temperaturerange : -20 degrees Celsius to 80 degrees Celsius.
Power consumption: voltage max ≤ 0.3W; the current MAX ≤ 0.7W; digital MAX ≤ 0.3W;
Weight: <1kg
Cable length: 2M

(iii) DHT11 sensor
DHT11 is digital sensor for the measurement of temperature and humidity. It gives the temperature and humidity data in 32-bits data format with 16-bits for temperature and 16-bits for humidity. The humidity sensing component present in DHT11is a substrate that

holds moisture with the electrodes applied to the surface. As soon as the water vapours are absorbed the conductivity of the substrate changes and is inversely proportional to the relative humidity. Higher relative humidity willdecrease the resistance between the electrodes while lower relative humidity will increases the resistance between the electrodes.

Technical parameters:
Supply Voltage: +5 V
Operating Temperaturerange :0-50 °C error of ± 2 °C
Humidity: 20-90% RH ± 5% RH error
Interface: Digital

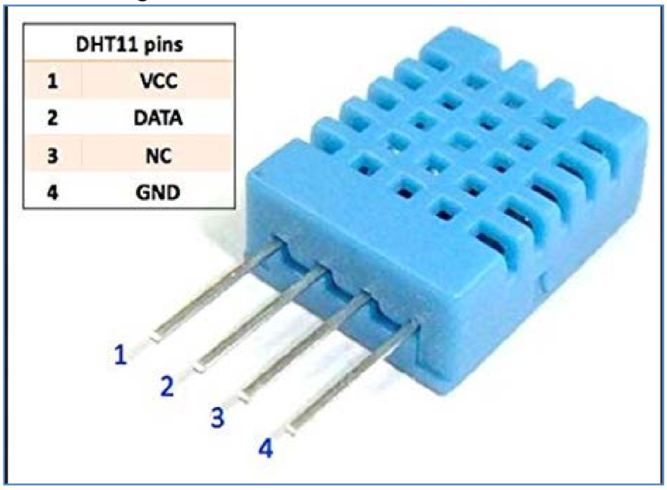

Figure 4: DHT 11 Sensor pin connection

C. Thingspeak Server

Thing Speak is sixth most popular open source Internet of Things (IOT) platform. Thingspeak is capable of displaying the data graphically which makes it user friendly. Its Integration with MATLAB toolmakes it possible to perform mathematical analysis on the obtained data. It also provides low infrastructure as any freeware hardware like Arduino, Raspberry Pi, Node MCU can be used to upload the data on Thingspeak cloud and no cost service is available upto 8 channels.

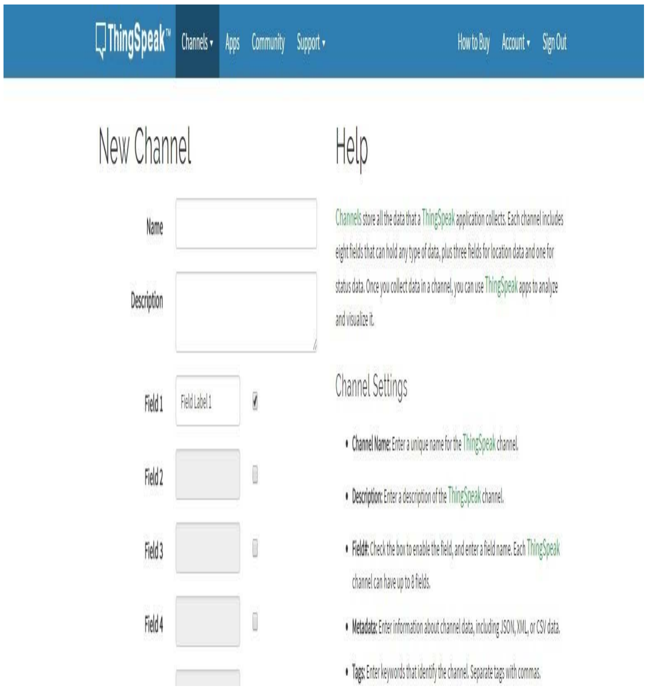

Figure 5: Thing Speak server

IV. IMPLEMENTATION AND DATA ANALYSIS

Figure 6 shows the implementation of weather monitoring system. The data was recorded for a complete span of 1 month and is simultaneously uploaded onto Thing speak server as well.

Figure 6: Proposed system in action

Few readings of the data recorded by the system are shown in the table 2.
From the experiment it was inferred that, the proposed system was able to work continuously for more than 10 hours without any system error generation. Also the system was able to generate many reliable and efficient readings of the parameters being monitored. So the system performs satisfactorily though being low cost and power optimized.
The parameters data has been sent on the thing speak server for remote monitoring. The selection of the thing speak cloud is done because: 1. Its Low infrastructure requirement; 2. easily available graphical representation of information; 3. Provision of tool for mathematical analysis (MATLAB). As per [12] Thingspeak cloud has been ranked 6th most popular cloud. The recorded data uploaded onto the cloud is shown in figure 7.

Table 2: Weather Station Testing Data

Weather Station Testing data:
From 02-12-2018(6:39:14 PM) to 03-12-2018(6:36:39 AM)

(<u>All negative values of Wind speed due to static condition of sensor. Rectified in last few readings</u>)

created_at	entry_id	field1	field2	field3	field4	Remarks
Legend		**Temperature**	**Humidity**	**Wind Speed**	**Wind Direction**	
2018-12-02 13:53:17 UTC	14	21.30 deg C	62.80 RH	10.44 m/s	N	
2018-12-02 14:03:19 UTC	16	21.40 deg C	62.70 RH	6.03 m/s	NE	
2018-12-02 14:25:21 UTC	17					Error
2018-12-02 14:27:33 UTC	18	22.00deg C	62.10RH	-0.67m/s	S	**Continous Running (About 10 Hours)**
2018-12-02 15:27:40 UTC	22	21.40deg C	64.40RH	5.24m/s	W	
2018-12-02 16:27:47 UTC	26	21.20deg C	65.00RH	10.26m/s	SW	
2018-12-02 17:27:49 UTC	30	21.10deg C	65.90RH	7.02m/s	SW	
2018-12-02 18:27:50 UTC	34	20.90deg C	66.10RH	9.08m/s	SW	
2018-12-02 19:27:53 UTC	38	20.80deg C	65.90RH	7.79m/s	SW	
2018-12-02 20:27:54 UTC	42	20.60deg C	66.20RH	7.76m/s	SW	
2018-12-02 21:27:56 UTC	46	21.00deg C	66.30RH	4.08m/s	S	
2018-12-02 22:15:50 UTC	48	20.70Â°C	65.00RH	8.14m/s	S	
2018-12-02 23:15:53 UTC	52	20.30Â°C	64.60RH	8.93m/s	S	

2018-12-02 23:45:54 UTC	54	20.30Â°C	64.50RH	4.95m/s	S	
2018-12-03 00:15:56 UTC	56	20.10Â°C	64.40RH	5.32m/s	S	
2018-12-03 00:59:31 UTC	62	21.00C	62.80RH	-0.81m/s	W	
2018-12-03 01:00:31 UTC	64	21.00C	63.00RH	-0.54m/s	N	
2018-12-03 01:02:51 UTC	66	21.20C	63.20RH	0.17m/s	N	
2018-12-03 01:41:22 UTC	77	20.50C	62.70RH	0.00m/s	E	
2018-12-03 01:41:52 UTC	78	20.50C	62.60RH	0.00m/s	E	

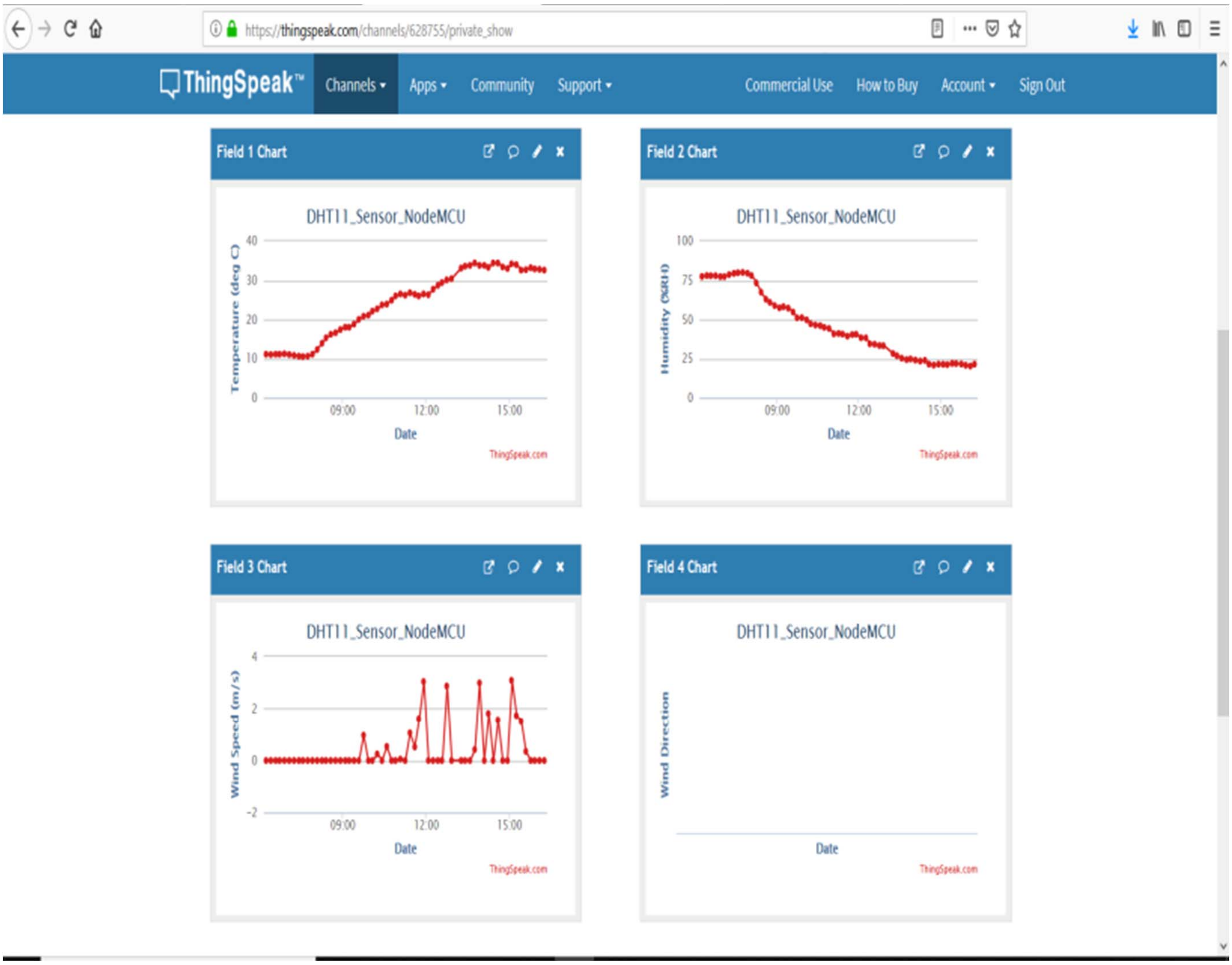

Figure 7: Results updated live on Thing Speak

V. CONCLUSION AND FUTURE SCOPE

To conclude this work we verify that weather monitoring is an important prospective these days and that too at a well localized level for its usage in any field. The IoTtechnology has aided us to engineer a low cost system to monitor weather conditions continuously.

To expand the work further we can add machine learning to the proposed system so that it should be able to anticipate the weather conditions in advance that can be useful for agriculture sector, industrial sector or service sector. There is also the growing issue of Air Quality Index in our country especially during winters due to stubble burning. The general weather monitoring systems provides the data for a large area. However with our proposed work and enhancing further its sensor technologies we can detect the air quality index for a smaller area before hand.

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