IoT- based Real time Temperature and Humidity Monitoring System for Hill Stations

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Abstract— **Building a cloud-based monitoring system is very important to reduce the cost of maintaining servers, to avoid data losses and to make the access easy with multiple internet connected devices(computer, tablet, mobile phone) at the same time anywhere in the world. There are various hill station areas that requires monitoring of temperature and humidity because they need to keep track of information about the climate there because they are major tourist spots for people and also the agricultural fields that yield crops grown mainly by contour farming. As hill stations are located far above the plains, hence temperature and humidity are an important factor in hill stations. This paper aims at making use of the advantages of the evolving technology i.e. IoT and help the workers in hill stations keep a record of humidity and temperature of the climate and fields, and monitor them and thus reducing their work load of being present at the location. The feature of this paper includes a simple design of a system which can monitor temperature and humidity through a sensor i.e. DHT11 sensor and a NodeMCU ESP8266 IoT module and uploading the information over the Wi-Fi network to the ThingSpeak server, and hence the respective authorities in the hill stations can take actions depending on the information.**

Keywords- Internet of Things, Hill Stations, DHT11, NodeMCU ESP8266, ThingSpeak.

I. INTRODUCTION

Hill stations constitute one of the important factors in India not only in terms of economy but also in terms of beauty. Hill stations in India produce a large number of agricultural crops that are used for domestic use as well as to export in other countries. Also hill stations are a major contributor to the Indian economy as a lot of tourists gather there all around the year. Studies show that foreign tourism in India has helped to grow the economy of the country. The hill stations in Tamil Nadu account for over 22.2% of the tourism in India. The state of Uttarakhand which has a lot of hill stations has seen a large number of tourists visiting them. According to these statistics, the number of domestic tourists is increasing sharply by more than doubling from approximately 10 million tourists visiting Uttarakhand in 2001 to 21.9 million tourists in 2009. While the number of foreign tourists is only about 1 tenth of the number of domestic tourists, there was close to a twofold increase from approximately 55,000 in 2001 to 106,000 in 2009 [1]. Here monitoring of temperature and humidity is required because by doing so the officials present in the hill stations can determine when it is the perfect time to visit the hill stations as recently due to many climatic changes, challenging situations like landslides like occurring in hill stations which pose a dangerous threat to the tourists.

Many studies show that relative humidity and temperature plays a great role in the agriculture in hill stations that are very important because India is an agricultural country and most of its population depends on the crops yielded. For example, in case of tea cultivation, it needs a low temperature between 18 and 21 degree Celsius and a high humidity of 70% to 90%. If the humidity falls below 40% then the growth is inhibited. Studies show that the production of crops in hill stations is decreasing due to the climatic changes there. Hence humidity and temperature need to be maintained for the growth of these crops. Figure 1 shows the average relative humidity in Shimla.

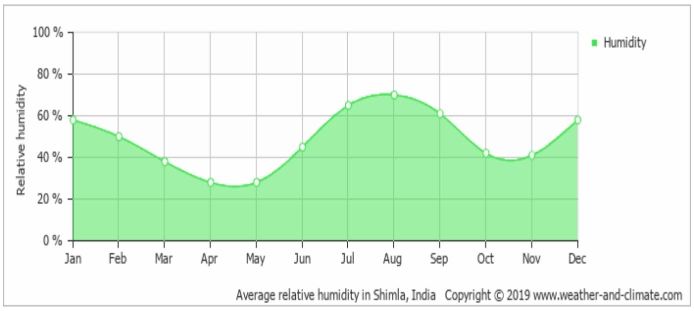

Figure 1. Average relative humidity in Shimla

The Internet of Things (IoT) is a technology that connects people with things and enables real-time communication and data exchange. It is used to record, analyze, and evaluate data important for decision-making or achieving target conditions. Currently, the Internet of Things technology has been widely applied in various fields, such as measuring the amount of sunlight, temperature, and humidity suitable for agriculture [2], turning home appliances on and off with a smart home mobile application through the Internet [3], monitoring the amount of water and biogas as well as activating fire alarms in animal farms [4], providing flood warnings [5], and recording cardiac rhythms with an ECG measuring sensor [6]. Moreover, the

Internet of Things can be compatibly combined with smartphones, making them more and more popular. There are mobile applications that are easy to use and support the Internet of Things such as Blynk, NETPIE, and Line Notify. Also, there are applications that support IoT on computers, like ThingSpeak. In 2016, there were 31.7 million smartphone users, accounting for 50.5 % of the total population [7]. Figure 2 shows that the global number of devices connected to the Internet of Things and communication technology has steadily increased.

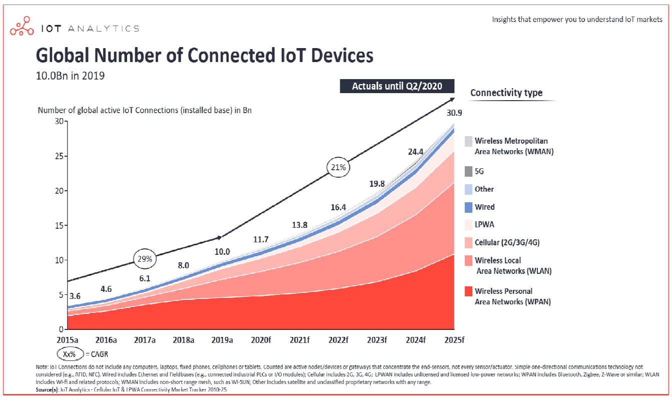

Figure 2. Global number of IoT devices connected[10]

The proposed system is very cost effective and can be employed in hill stations. The proposed system is a sensor based hardware module which monitors the relative temperature and humidity of the place and directly sends the information to the IoT server via the Internet that shows the real time values of the parameters to the user. The collected data can be used to analyze and determine what steps should be taken to counter the effect of the climatic changes after monitoring the temperature and humidity.

II. LITERATURE REVIEW

A. *Internet of Things*

The Internet of Things(IoT) is a network of physical devices, that are embedded with sensors, software and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet. The term “Internet of Things” was coined by Kevin Ashton of Procter & Gamble, later MIT’s Auto-ID Center, in 1999. The IoT aims to unify everything in our world under a common infrastructure, giving us not only control of things around us, but also keeping us informed of the state of the things. There are similar technologies that are already related to IoT such as Machine-to-Machine(M2M), the Internet of Everything(IoE), ubiquitous computing and embedded Internet Systems. Physical objects must contain sensors and microcontrollers in order to smartly connect with each other. These microcontrollers and sensors will send data to an IoT cloud server that will act as a hub for data exchange. In farms, the IoT is used to monitor the environment of mushroom cultivation houses [8]. The IoT has been extensively applied in various fields, as shown in Figure 3. It is estimated that the number of IoT connected devices worldwide will be almost 38.6 billion in 2025 and 50 billion in 2030. The IoT wireless communication technologies that are widely used include Wireless Local Area Network(WLAN), the Low-Power Wide Area Network(LPWAN), the narrow band Internet of Things(NB-IoT) and Sigfox. The IoT network protocols widely known are MQTT, CoAP and AMQP.

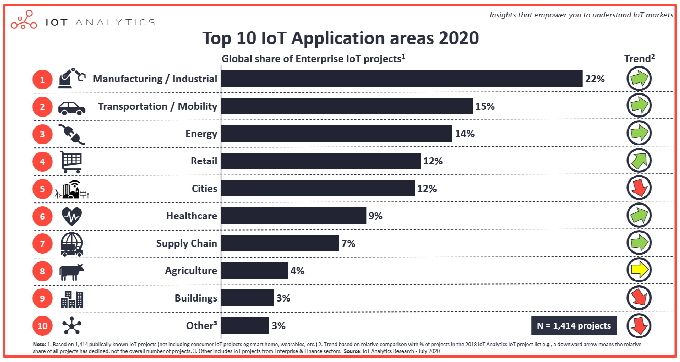

Figure 3. Applications of Internet of Things[11]

B. *ThingSpeak*

ThingSpeak is an IoT analytics platform service that allows us to aggregate, visualize and analyze live data streams in the cloud. It is compatible with many types of microcontrollers, such as NodeMCU ESP8266, Arduino, Rasberry Pi and ESP32 over the Internet. Also with the ability to execute MATLAB code in ThingSpeak we can perform online analysis and processing of the data as it comes in. ThingSpeak provides instant visualization of data posted by the devices to ThingSpeak. ThingSpeak is often used for prototyping and proof of concept IoT systems that require analytics. The details are shown in Figure 4.

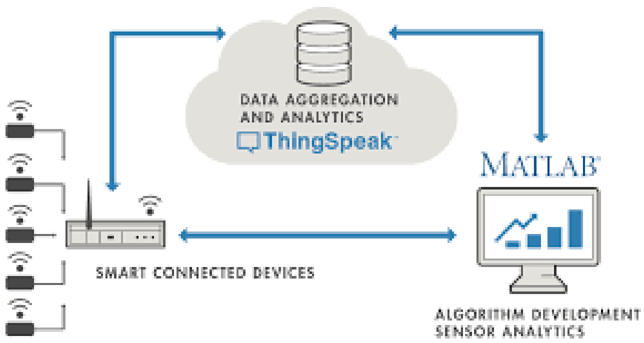

Figure 4. ThingSpeak Application working diagram

C. *NodeMCU ESP8266*

The NodeMCU is an open-source for the IoT platform that was invented in 2014. ESP8266 is a microcontroller [9] with a 160 MHz single-core CPU, a 32-bit reduced instruction set computer(RISC), IEEE802.11b/g/n 2.4 GHz Wi-Fi, and +19.5 dBm output at the antenna. NodeMCU was created shortly after the ESP8266 came out. The ESP8266 is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core, widely used in IoT applications. It can operate in a wide temperature range of -40 degree Celsius to 125 degree Celsius. The chip dimension is 18 x 23 x 3 mm. Figure 5 shows the pin diagram of NodeMCU ESP8266.

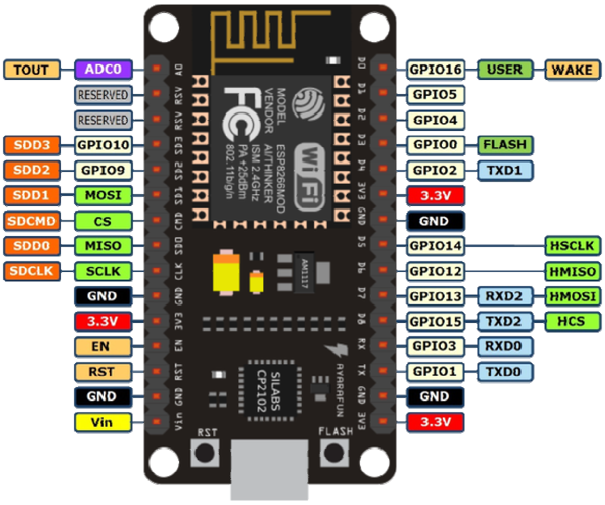

Figure 5. NodeMCU ESP8266 pin diagram[12]

D. Sensor

The DHT11 sensor is a commonly used temperature and humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. It is an affordable and easy to use sensor with high precision. The sensor can measure temperature from 0 degree Celsius to 50 degree Celsius and humidity from 20% to 90% with an accuracy of ±1 degree Celsius and ±1%. The supply voltage ranges from 3.5V to 5.5V. Figure 6 shows the DHT11 sensor.

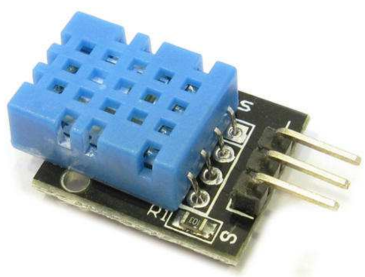

Figure 6. DHT11 temperature and humidity sensor

E. Programming

The Arduino Integrated Development Environment(IDE) is an open-source application software that is used to write programming codes for microcontrollers in the Arduino family. The C/C++ programming language was used.

III. System Design And Implementation

A. Block Diagram

The block diagram of the proposed system in shown in Figure 7. Temperature and humidity data are sent from the DHT11 sensor to the NodeMCU ESP8266 microcontroller before being forwarded to and stored in the ThingSpeak server through wireless communication. When users want to view the data they need, they just need to open the ThingSpeak application on their computers.

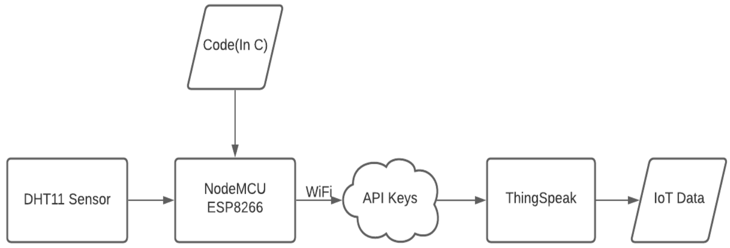

Figure 7. Block diagram of the monitoring system

B. Circuit Diagram

It was essential to design a circuit diagram consisting of a microcontroller, sensor and power supply as shown in Figure 8, because faulty wiring and mistakes could cause damage to the related devices.

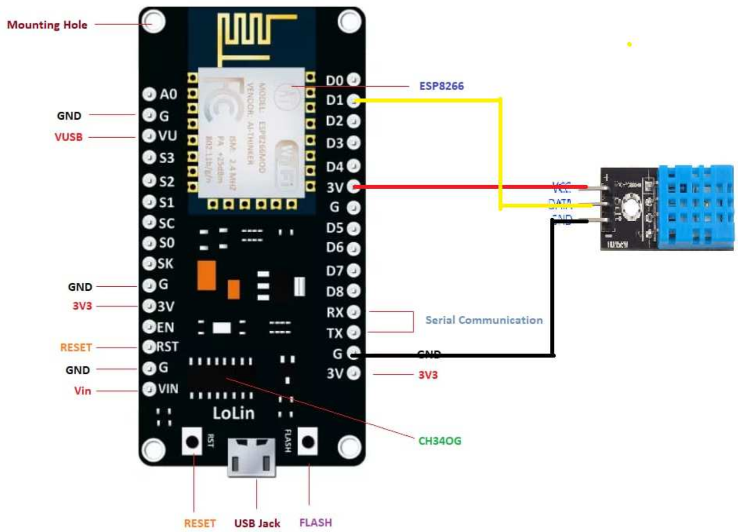

Figure 8. Circuit design

C. Experiment

The circuit was designed and implemented so that the system could accurately measure the temperature and humidity of a place. The data obtained were displayed in the ThingSpeak on a real-time basis. Figure 9 shows the experimental setup of the system.

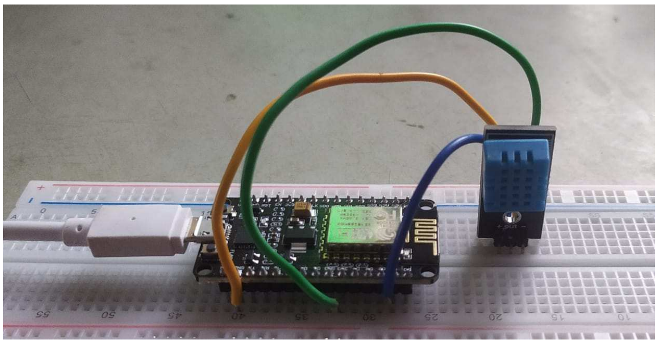

Figure 9. Experimental setup

IV. RESULTS

The results of this experimental setup are obtained as follows.

- The temperature and humidity data are displayed on the monitor through the use of the ThingSpeak application. Figure 10 and Figure 11 show the value of temperature and humidity at that particular instant of time.

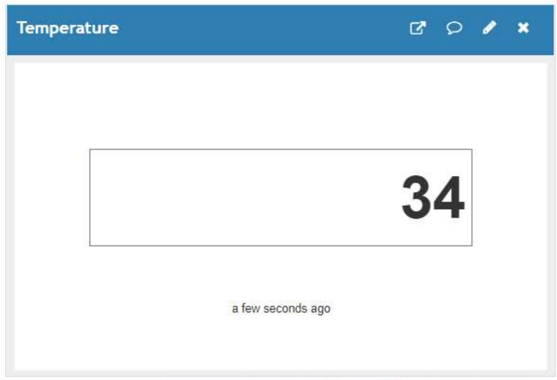

Figure 10. Real-time value of temperature

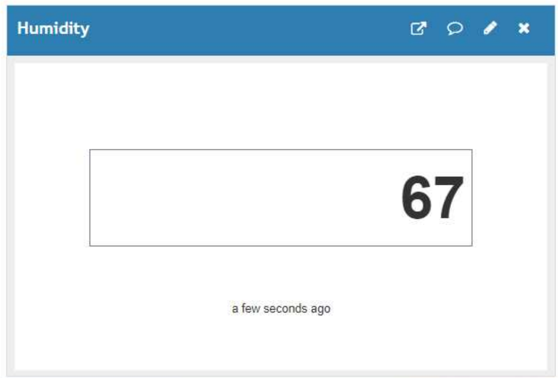

Figure 11. Real-time value of Humidity

- The real-time graphs of temperature and humidity are also obtained on the screen through the use of ThingSpeak application. With the help of these graphs, the workers can easily compare and monitor the changes in the temperature and humidity on a real-time basis, hourly or on a daily basis. Figure 12 and Figure 13 show the trends of the graphs obtained.

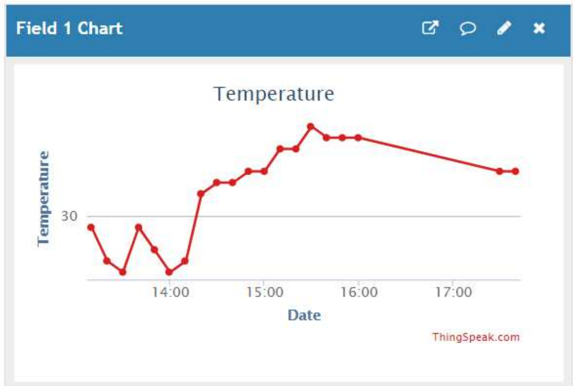

Figure 12. Temperature graph obtained on ThingSpeak

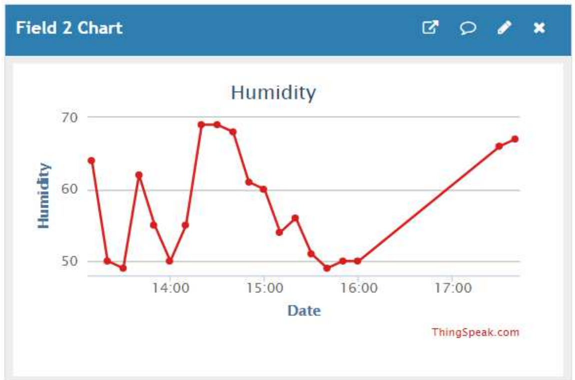

Figure 13. Humidity graph obtained on ThingSpeak

- There is also an alert system consisting of two lamp indicators, one for temperature and the other for humidity, on the ThingSpeak application which glows in red color whenever the temperature and humidity crosses a given threshold value. The threshold values can be set accordingly to the requirement of the workers varying from one hill station to another from the widgets option on the ThingSpeak application. Figure 14 shows the lamp indicators.

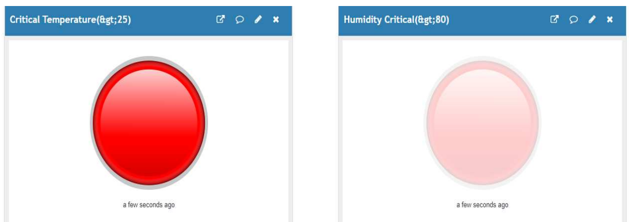

Figure 14. Lamp indicators for temperature and humidity

- Also, the temperature and humidity displayed are collected in the database to create a report. The report will be sent to the specified email address in the form of a comma-separated values (CSV) file, as shown in Figure 15. The date and time when the temperature and humidity data are recorded are clearly shown, making it easier to identify the changes in the parameter levels. The obtained data can be further analyzed for future reference.

1	created_a	entry_id	temperatu	humidity
2	2021-04-1:	1	26	61.00
3	2021-04-1:	2	26	61.00
4	2021-04-1:	3	26	62.00
5	2021-04-1:	4	27	62.00
6	2021-04-1:	5	27	64.00
7	2021-04-1:	6	27	64.00
8	2021-04-1:	7	28	66.00
9	2021-04-1:	8	28	66.00
10	2021-04-1:	9	28	64.00
11	2021-04-1:	10	28	62.00
12	2021-04-1:	11	28	60.00
13	2021-04-1:	12	28	59.00
14	2021-04-1:	13	28	62.00
15	2021-04-1:	14	27	59.00
16	2021-04-1:	15	26	47.00
17	2021-04-1:	16	23	53.00
18	2021-04-1:	17	22	68.00
19	2021-04-1:	18	22	71.00
20	2021-04-1:	19	22	68.00
21	2021-04-1:	20	23	65.00

Figure 15. CSV file from ThingSpeak server

V. CONCLUSION

As temperature and humidity are an important factor in hill stations, this experimental setup used the IoT technology to measure and monitor the parameters. The proposed real-time monitoring system can measure the temperature and humidity at any place. Once the temperature and humidity of the required locations in hill stations are obtained, the officials and workers could determine what steps they need to take to counter the effects of the climatic changes. From the results, we can conclude that the Thingspeak application works well and the users can use basic widgets for free. The proposed system can effectively measure the temperature and humidity. Also, the ThingSpeak application is able to effectively display all of the data and monitor the parameter changes on a real-time basis. This indicates that the proposed system can be used for monitoring real-time temperature and humidity for hill stations.

VI. FUTURE WORK

Future work should be conducted to improve the shortcomings of the present study. For example, a prototype can be made for installing a meter which will automatically monitor the climatic parameters and show their changes and will be easier to install and remove in the required locations. We can apply communication technologies that are more compatible with the IoT, such as LoRa and NB-IoT. Also, there can be an automated control mechanism to regulate the temperature and humidity as per the requirements for better results.

REFERENCES

[1] Nakajo Akihito, “Development of Tourism and Tourist Industry in India : A Case Study of Uttarakhand”, Article, Journal of Urban and Regional Studies on Contemporary India, pp. 3-5

[2] C. Yoon, M. Huh, S. Kang, J. Park and C. Lee, "Implement smart farm with IoT technology," 2018 20th International Conference on Advanced Communication Technology (ICACT), Chuncheon-si Gangwon-do, Korea (South), 2018, pp. 749-752. doi: 10.23919/ICACT.2018.8323908

[3] H. Durani, M. Sheth, M. Vaghasia and S. Kotech, "Smart Automated Home Application using IoT with Blynk App," 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT), Coimbatore, India, 2018, pp. 393-397. doi: 10.1109/ICICCT.2018.8473224

[4] M. H. Memon, W. Kumar, A. Memon, B. S. Chowdhry, M. Aamir and P. Kumar, "Internet of Things (IoT) enabled smart animal farm," 2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, 2016, pp. 2067-2072.

[5] N. A. Z. M. Noar and M. M. Kamal, "The development of smart flood monitoring system using ultrasonic sensor with blynk applications," 2017 IEEE 4th International Conference on Smart Instrumentation, Measurement and Application (ICSIMA), Putrajaya, 2017, pp. 1-6. doi: 10.1109/ICSIMA.2017.8312009

[6] S. P. Kumar, V. R. R. Samson, U. B. Sai, P. L. S. D. M. Rao and K. K. Eswar, "Smart health monitoring system of patient through IoT," 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), Palladam, 2017, pp. 551-556. doi: 10.1109/I_SMAC.2017.805824

[7] http://www.nso.go.th/sites/2014/Pages/ActivityNSO/A24-05-60.aspx

[8] O. Chieochan, A. Saokaew and E. Boonchieng, "IOT for smart farm: A case study of the Lingzhi mushroom farm at Maejo University," 2017 14th International Joint Conference on Computer Science and Software Engineering (JCSSE), Nakhon Si Thammarat, 2017, pp. 1-6. doi: 10.1109/JCSSE.2017.8025904

[9] https://www.espressif.com/en/products/hardware/esp8266ex/overview

[10] https://iot-analytics.com/state-of-the-iot-2020-12-billion-iot-connections-surpassing-non-iot-for-the-first-time/

[11] https://iot-analytics.com/top-10-iot-applications-in-2020/

[12] https://iotbytes.wordpress.com/nodemcu-pinout