A WEARABLE MEDICAL MONITORING AND ALERT SYSTEM OF COVID-19 PATIENTS

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***Abstract* - Currently, Corona-virus disease (COVID-19), one of the most infectious diseases in the 21st century, is a highly contagious viral infection with a severe impact on global health. It also affected the global economy very badly. This virus threatens human's life, and it is necessary to design a monitoring device to monitor the patient's health remotely to avoid the spread of infection to doctors or nurses. In this paper, a wearable device which contains two sensors are used to measure blood oxygenation, body temperature, and heart rate. Then send these readings to the server to analyze them and send warning notifications to the patient's assistant phone to inform him of whether the oxygen level is low, the heart rate is irregular or the patient's temperature is high to perform a certain procedure to aid the patient.**

Index Terms - IoT; internet of medical things (IOMT); wearable device; node MCU; Covid-19.

I. INTRODUCTION

The systematic advancement of the Internet of Things (IoT) and its use in medical research has increased the efficacy of remote health monitoring systems. Wearable devices have recently become increasingly popular with wide-ranging applications in health monitoring systems (IoMT) [1]. Also, wearable devices have been defined as devices a person can wear that can continuously track the behavior of a person without interruption. [2,3]. Many sensors are used by these wearable devices and the most important of these sensors are (acceleration sensor, optical sensor, temperature sensor, breathing sensor, carbon dioxide sensor, EKG sensor, pressure sensor, gyroscope sensor, oxygen saturation in blood sensor, humidity sensor, and blood pressure sensor). Such devices can Continuously monitor the patient's health via technologies such as Bluetooth, Wi-Fi and ZigBee [4,5]. Wearable devices can also be attached to mobile phones, laptops and other devices [6,7]. Thus, they are commonly used to track human health in medical treatment, athletics, and exercise [8,9]. As wearable technology matures and upgrades, the IoMT shapes gradually with the key technologies of Physiological information perception and remote data transmission [10,11]. Recently, more kinds of diseases such as covid-19 threaten people's life, thus individual health monitoring becomes significant not only for the patients but also for the aged and the healthy persons with potential health risk. The IoMT provides incomparable changes for healthcare, as people equipped with wearable devices can monitor their health signals continuously and transmit them to the gateway within 3-6 meters [12,13]. The IOMT fulfills the remote transmission to the doctors or families utilizing 5G or fiber networks (i.e. passive optical network (PON)) via the link between the gateway and the external network. [14].

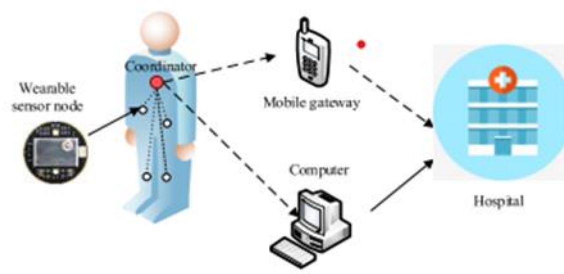

Fig 1. The architecture of IoMT-based individual health monitoring Sys. [15].

II. LITERATURE REVIEW

In some articles we see that the author defines a tracking device that can detect physiological parameters from several patient bodies by using a supervisor node connected to the patient's body which gathers all signals from wireless sensors. The main advantage of this system in comparison to previous systems is it reduces the energy consumption to prolong the network lifetime, speed up and extend the communication coverage to increase the freedom for enhancing patient quality of life [16].

For real-time gesture recognition, the device uses a finger-mounted sensor. This work produces a sensor that can detect the heart rate, the temperature of the body and Oxygen rate in blood, but the advantage of our sensor is that we are using high accuracy sensors. The accuracy of the sensors could amount to around 98% and 99% [18].

Another study discusses the use of wearable fitness trackers and the problems posed, specifically user experience in the use of the wearable sensor [19].

There is also another work that provides a general description of the different types of medical sensors, their characteristics, and the wireless technologies used to transmit data. It is also the first to provide a review of the wearable technology and the brand of sensors available in the market, in addition to its interface forms of connections [20].

Another paper worked on the development of IoT, which reflects that the digital transformation in health care is proceeding at a high pace. The objective was the creation of a special web application for remote high-risk group to achieve patient's heart rate tracking with a fitness bracelet (fitness tracker) [21].

On the other hand, several health parameters were established in a special work, i.e. Pulse rate, temperature, and blood pressure electrocardiogram (ECG), using wearable sensors. An Intel Edison Board is attached to these sensors. When attached to the internet, the Intel Edison Board gathers data from sensors and sends them to the server, then we can track these data on any remote smart computer, like laptops or smartphones linked to the same network [22].

In one of the studies, the author focused mainly on the development of the edge-IoMT computing architecture for a smart healthcare system. Novel edge-IoMT computing architecture is proposed to enhance bandwidth efficiency and reduce latency. A functional smart healthcare monitoring platform is developed for revealing an effective real-time monitoring system that provides patients personalized online service–oriented architecture for highly accurate diagnostic solutions under remote medical examination condition [23].

III. Theoretical Concepts, System Design and Implementation

A. *Theoretical concepts*

1) MAX30100 sensor: The MAX30100 is a sensor that combines pulse oximetry and a heart rate monitor. It detects pulse oximetry and heart rate signals using two LEDs, a photodetector, calibrated optics, and low-noise analog signal processing. The MAX30100 operates from 1.8V and 3.3V power supplies and can be powered down through software with negligible standby current, permitting the power supply to always remain connected [24].

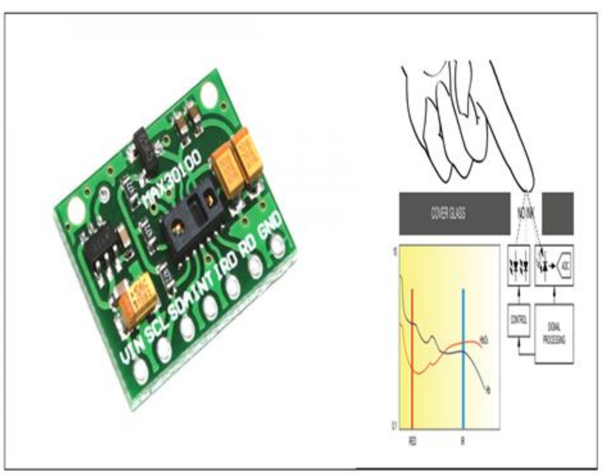

Fig 2. MAX30100 Sensor.

2) MLX90614 sensor: The MLX90614 is an infrared thermometer for non-contact temperature measurements. Both the IR sensitive thermopile detector chip and the signal conditioning ASIC are integrated in the same TO-39 can. Integrated into the MLX90614 are a low noise amplifier, 17-bit ADC and pow-earful DSP unit, thus achieving high accuracy and resolution of the thermometer [25].

Fig 3. MLX90614 Sensor

3) Ubidots Platform: Ubidots is an IoT platform that will be used in this project. This framework is used to send and retrieve sensor data to the cloud from every smartphone or laptop connected to the internet, and then transform it into useful information. The Ubidots platform was chosen because of its many advantages, including [26,27]:

a. Optimizing computation, recovery and visualization of the IoT data storage.
b. Having a simple GUI, that is easy to be used.

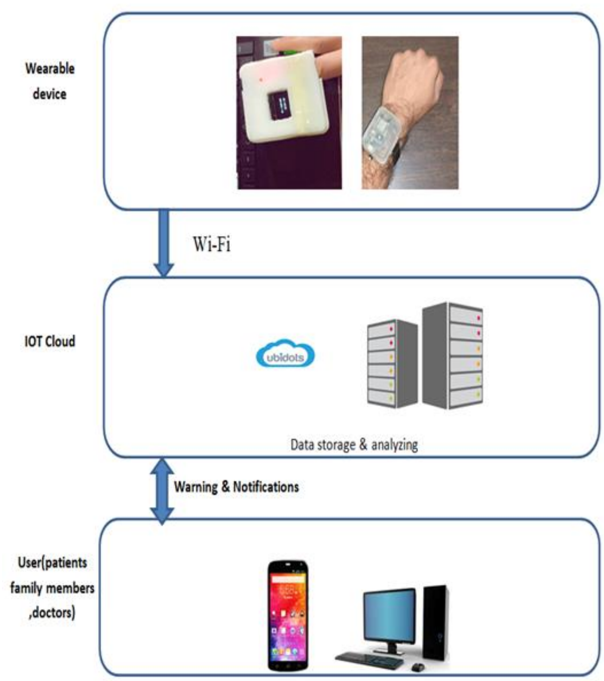

Fig 4. System architecture

B. System design

The designed system architecture for the proposed IoMT-based healthcare monitoring system using a wearable device which contains two sensors (the Max30100 sensor to measure oxygen saturation and heart rate, and the MLX90614 IR sensor to measure body temperature) and we also used the node MCU(esp8266) that transmits the sensors readings continuously to the Ubidots server to visualize the analyzed data and send alert messages to the nearest hospital or health center via e-mail to continuously control the health status of patients with covid-19 and avoid cases of suffocation of patients or high temperature, as well as to monitor them remotely to avoid the spread of the virus to the medical staff or the patient's assistant as shown in figure 5.

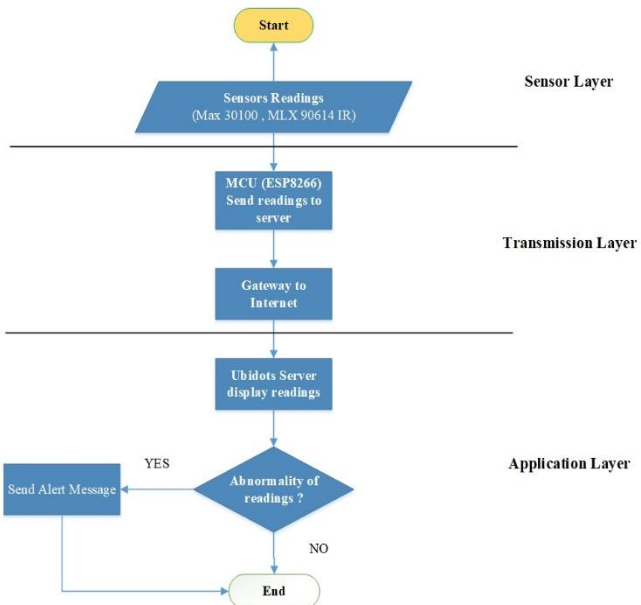

Fig 5. Flowchart to explain the processes in the system

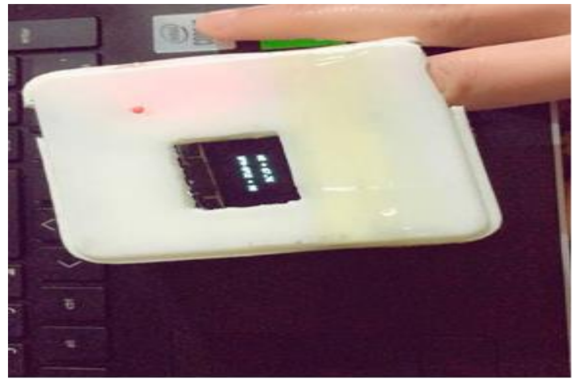

Fig 6. I mage of the Final Design

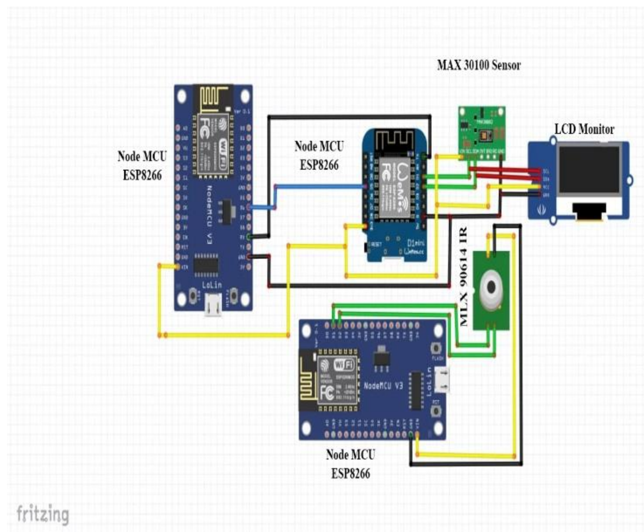

Fig 7. Full circuit for the designed device

C. Implementation

The full circuit of the device designed in this work is shown in Figures (6,7,8). Circuit connecting parts can be summarized as follows:

The max30100 sensor is connected to the node MCU(esp8266) using the I2C protocol, but we encountered a problem in this work, which is that the MAX30100 sensor does not bear any delay when connected to Internet consequently it gives incorrect values for that. Therefore, the node MCU(ESP8266) board is connected to another node MCU(ESP8266) as a master-slave through serial ports TX, RX. The MLX90614 temperature sensor is connected to another node MCU(ESP8266) using the I2C protocol, after that the Arduino is programmed to transfer the sensor readings to the IoT server using the MQTT protocol, and obtain medical readings with the highest possible accuracy.

Fig 8. Image of the Inner Connection of the Circuit

IV. RESULTS

This aspect of the system covers the process of signing-in to the account of monitoring patient's system in the Ubidots server as shown in figure 9.

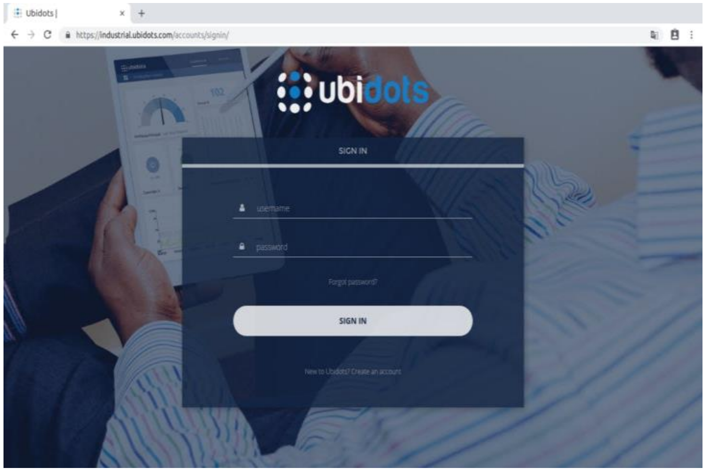

Fig 9. Sign-in page of the system

Ubidots server account can access all wearable devices that connected to. After signing-in, it will be shown whether the wearables have access to server or not. When the wearable device is connected to internet the Ubidots server will received all readings from it as shown in figure 10.

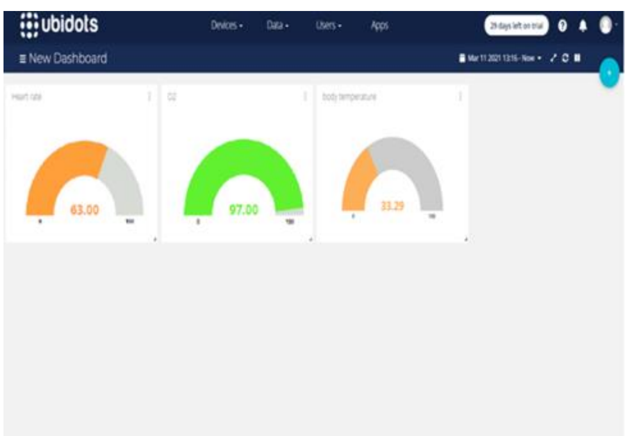

Fig10. Patient's monitor system using Ubidots server

This Ubidots server can be accessed to from any smart devices or computers. It can send notifications via email and SMS when readings of patient are abnormal. As you see in figure 11 the Ubidots server can provides analyzing charts about the readings that comes from wearable device.

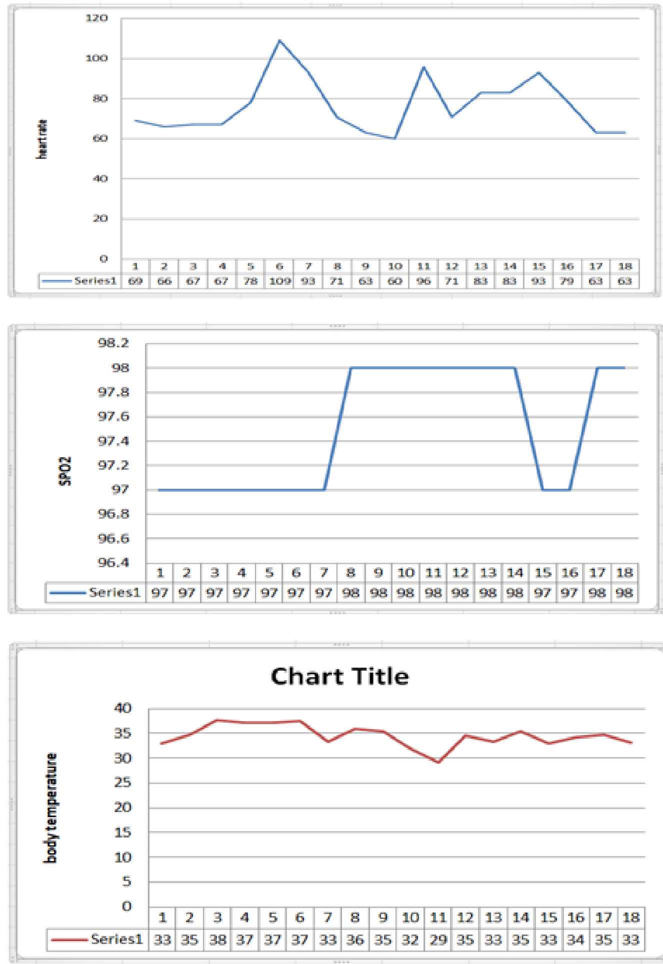

Fig 11. readings (heart rate, SPO2, body temperature)

V. LIMITATIONS

This monitor system has some limitations:

1. The size of the wearable device is somewhat large.
2. Internet speed to transfer health parameters readings to the Ubidots server.
3. Ubidots server have a limited time for trial then you have to pay for it.
4. If you need any additional services like storage readings or analyzing chart service, you have to pay for this service to make it available.

Conclusion

In this paper, we proposed an IOT principle-based control system that is divided into three layers: sensor layer, transmission layer, and application layer. The sensor layer is the part of data acquisition mainly from the sensors worn by patients or carried by patients. We designed a wearable device to monitor the health status of Covid-19 patients through high-precision sensors to measure blood oxygenation, temperature, and heart rate, as these parameters are one of the most important criteria to watch for COVID-19 patients. These healthy parameters are transmitted through the transport layer and then to the Ubidots server to be monitored from a smart phone or laptop to display warning messages in the event of an abnormal condition of the patient. Through IOMT technology, we were able to reduce the spread of covid-19 virus to the medical staff or patient's assistant and we can monitor the patient’s status that live far away from hospitals in villages or cities.

References

[1] M. A. Khan, ‘‘An IoT framework for heart disease prediction based on MDCNN classifier,’’ IEEE Access, vol. 8, pp.34717–34727,2020,DOI: 0.1109/ACCESS.2020.2974687.

[2] Haghi, M.; Thurow, K.; Stoll, R. Wearable Devices in Medical Internet of Things: Scientific Research and Commercially Available Devices. Health. Inform. Res. 2017, 23, 4–15. [CrossRef] [PubMed].

[3] Wei, J. How Wearables Intersect with the Cloud and the Internet of Things: Considerations for the developers of wearables. IEEE Consum. Electron. Mag. 2014, 3, 53–56. [CrossRef].

[4] Manogaran G, Vijayakumar V, Varatharajan R, Kumar PM, Sundarasekar R, Hsu CH (2017) Machine learning based big data processing framework for cancer diagnosis using hidden Markov model and GM clustering. Wirel Pers Commun118.https://doi.org/10.1007/s112770175044zhttps ://doi.org/10.1007/s11277- 017-5044-z

[5] Manogaran G, Lopez D (2017) A Gaussian process-based big data processing framework in cluster computing environment.Clust Comput 1– https://doi.org/10.1007/s10586-017-0982-5.

[6] B. V. Vishakh and M. K. Khwaja, ‘‘Wearable device for hearing impaired individuals using ZigBee protocol,’’ in Proc. 9th Asia Modelling Symp.(AMS), Sep. 2015, pp. 181–184.

[7] A. I. Hussein, ‘‘Wearable Com-puting: Challenges of implementation and its future,’’ in Proc. 2015 12th Learn. Technol. Conf., Apr. 2015,pp. 14–19. [8] Y. Jin, ‘‘Low-cost and active control of radiation of wearable medical health device for wireless body area network,’’ J. Med. Syst., vol. 43, no. 5,p. 137, 2019.

[9] Z. Ning, F. Xia, N. Ullah, X. Kong, and X. Hu, ‘‘Vehicular social networks: Enabling smart mobility,’’ IEEE Commun. Mag., vol. 55, no. 5, pp. 16–55, May 2017.

[10] Z. Ning, P. Dong, and X. Wang, ‘‘Mobile edge computing enabled 5G health monitoring for Internet of medical things: A decentralized game-theoretic approach,’’ IEEE J. Sel. Areas Commun., to be published.

[11] W. Saadeh, S. A. Butt, and M. A. B. Altaf, ‘‘A patient-specific single sensor IoT-based wearable fall prediction and detection system,’’ IEEE Trans. Neural Syst. Rehabil. Eng., vol. 27, no. 5, pp. 995–1003, May 2019.

[12] G. Fang and E. Dutkiewicz, ‘‘BodyMAC: Energy efficient TDMA-based MAC protocol for wireless body area networks,’’ in Proc. ISCIT, 2009, pp. 1455–1459.

[13] S. Marinkovic, C. Spagnol, and E. Popovici,‘‘Energye fficientTDMA Ba-sed MAC protocol for wireless body area networks,’’ in Proc. SENSORCOMM, Athens, Greece, 2009, pp. 604–609. [14] S. A. Rokni and H. Ghasemzadeh, ‘‘Autonomous sensor-context learning in dynamic human-centered Internet-of-Things environments,’’ in Proc. 35th Int. Conf. Comput.-Aided Design (ICCAD), 2016, pp. 1–6.

[15] K. Wei, L. Zhang, Y. Guo, and X. Jiang, “Health Moni-toring Based on Internet of Medical Things: Architecture, Ena-bling Technologies, and Applications,” IEEE Access, vol. 8, pp.27468 –27478, 2020, DOI: 10.1109 /ACCESS .2020.2971654..

[16] Media Aminian ,Hamid Reza Naji. “A hospital healthcare monitoring system using wireless sensor networks”. Journal of Health and Medical Informatics. Aminian and Naji, J Health Med Inform 2013, 4:2.DOI:10.4172/2157-7420.1000121.

[17]Hanady S.Ahmed, Abduladhem Abdul kareem Ali. “Wireless sensor network for medical applications”. Iraq J. Electrical and Electronic Engineering. (2015).https://www.researchgate.net/publication/27918703 8.

[18]Chowdhury, D.; Banerjee, S.J.; Sanyal, K.; Chattopadhyay, M. A real time gesture recognition with wrist mounted accelerometer. In Information Systems Design and Intelligent Applications; Springer: Berlin, Germany, 2015; pp. 245–253. [Google Scholar].

[19] Shih, P.C.; Han, K.; Poole, E.S.; Rosson, M.B.; Carroll, J.M. Use and adoption challenges of wearable activity trackers. Available online: http://hdl.handle.net/2142/73649 (accessed on 21 October 2015).

[20] Nadine Boudargham, Jacques Bou Abdo, Jacques Demerjia, Christophe Guyeux. “Exhaustive study on medical sensors”.https://www.researchgate.net/publication/3217603 27_Exhaustive_Study_o n_Medical_Sensors.(2017).

[21] T.V. Skryl, V.S. Osipov, and A.S. Paramonov, “Study of practical implementation of IoMT: Creating a web application for distant high-risk group patient’s heart-rate tracking,” Espacios, vol. 39, no. 45, 2018.

[22] R. Singh, “IoT based smart health care,” CEUR Workshop Proc., vol. 2544, no. 11, pp. 58–64, 2019.

[23] C. Dilibal, “Development of Edge-IoMT Computing Architecture for Smart Healthcare Monitoring Platform,” 4th Int. Symp. Multidiscip. Stud. Innov. Technol. ISMSIT 2020,Proc.,2020,doi:10.1109/ISMSIT50672.2020.9254501.
[24] Maxim Integrated, “Pulse Oximeter and Heart-Rate Sensor IC for Wearable Health,” Lect. Notes Energy, vol. 38, pp. 1–29, 2014, [Online]. Available: www.maximintegrated.com.
[25] B. Mostafa, A. Miry, and T. Salman, “Healthcare Monitoring and Analytic System Based Internet of Thing,” Iraqi J. Electr. Electron. Eng., vol. sceeer, no. 3d, pp. 30–36, 2020, doi: 10.37917/ijeee.sceeer.3rd.5.
[26] Leo Raju,Sajna G.,Prithika rani M, "IoT Based Advance Energy Management of Micro-Grids", International Journal of Pure and Appliedx Mathematics, Vol. 120, No. 6, pp. 1443-1453, 2018.
[27] N. S. Mohammed and N. H. Selman, “Home Energy Management and Monitoring Using Ubidots Platform,” Al-Furat J. Innov. Electron. Comput. Eng., vol. 1, no. 3, p. 14, 2020, doi: 10.46649/150920-03.