Design a Low-Cost Air Pollution Monitoring IoT System

B. Sridhar, R. Mounika, P. Nagendra Babu, Y. Pavan Kumar, and S. Y. Ravi Raja

Abstract Air pollution is a big problem these days. Air pollution, which has become a major problem all over the world, is the most serious, dangerous, and most dangerous pollution among other pollutants such as water pollution, soil pollution, water pollution, soil pollution, and water pollution. Quality detection and control are essential. Air pollution, including noise pollution, light pollution, and heat pollution, is a major cause of diseases such as asthma, cancer, bronchitis, birth defects, and diseases such as the immune system. Therefore, we propose an air quality monitoring system that can find and check air quality in real time through the Internet of Things. It uses air sensors to detect the proximity of destructive gases in its environment and sends this information to a microcontroller. The proposed system implements a combination of Android applications, server, and gas sensor (CO_2 and DHT11) to detect ambient air quality and display the actual air condition. Sensors synthesize this information and send it to the web. This allows you to detect air pollution in different areas and take steps to prevent it. There is also a temperature sensor that estimates the room temperature. By solving the shortcomings of the existing air quality sensor, it is possible to perform several monitoring operations simultaneously. The hardest thing is that this system provides real-time data and displays the air quality based on the standard air quality. The system is used to display the air quality to the user and informs the user of how polluted or safe the surrounding air is according to the specified criteria.

Keywords Internet of Things · Arduino · Node MCU · Cloud computing · Air sensors · Sensor node technology

1 Introduction

Air pollution monitoring systems are primarily a measure of the severity of air pollution, and higher numbers indicate that air quality is more dangerous to human

B. Sridhar (✉) · R. Mounika · P. Nagendra Babu · Y. Pavan Kumar · S. Y. Ravi Raja
Department of Electronics and Communication Engineering, Lendi Institute of Engineering and Technology, Vizianagaram, India

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health. The unexpected weather that has occurred in our country in recent months has exposed the environment to natural disasters, resulting in a particularly foggy environment. Fog definitely affects the specific area where the fire is occurring [1–5]. On the other hand, industrial waste such as non-supplied gas can affect the atmosphere, especially near industrial parks. These days, people who want to have an air pollution monitoring system have to pay a lot of money to install it because it is expensive. The large size makes it uncomfortable to wear. These systems are often used by government agencies and large companies with industrial plants to monitor air quality. The paper has been suggested to be portable, requires a cheaper version of the air pollution monitoring system, has a lower cost of materials, and is readily available from the Arduino and Node MCU [6–10].

The main objective of this work is the disinfection of unpolluted cities and people in our country. Air pollution estimates in smart cities these days are becoming very erratic, and there is a certain period of time to detect air pollution without knowing whether the air pollution has filled up or not. This leads to air pollution in some areas, causing unrelated diseases. Therefore, the proposed work starts monitoring all kinds of pollution to keep cities clean. When air pollution is not controlled, send a message to higher authorities at a specific place. This reduces pollution and increases human health. This is how our project helps the community maintain a good environment [11–16].

There are several steps to be achieved at the end of this work [17, 18]. They are:

(a) Design of low-cost portable air pollutant monitoring systems that use gas sensors
(b) Integration of Sensor, Arduino, and Node MCU to form a complete air pollution monitoring system.
(c) Transmission and reception of air pollution data via short message service (SMS) using the Node MCU.

Various areas for achieving the purpose of the process work are described in steps [19, 20]

(i) Detection of ambient air pollutants using appropriate sensors and signal conditioning circuits.
(ii) Create a suitable codec to read the sensor data to the Arduino.
(iii) The data received from the Arduino creates an appropriate command for the Node MCU and sends the data to Short Message Service (SMS).
(iv) Connect the cloud server and monitor the data online.

The paper is divided into six main parts, and each one can be conceptually divided into two parts.

The first introduction relates to the capabilities monitoring unit, and the second relates to the vision unit. In Sect. 2, we analyze past applications of air pollution systems and the articles in the literature that inspire us to develop this project. In Sect. 3, we describe the theoretical and practical technical background applied to the development of this project. Section 4 introduces the hardware interface problem, starts with the common features, and then gets into the details that will show you

how to build the unit step by step. Section 5 introduces hardware functioning and results. Finally, Sect. 6 presents results and conclusion remarks with results obtained from real-world scenarios of air pollution systems and some potential use cases, also final session to explain some suggestions for future work.

2 Background

2.1 IoT-Based Air Quality Solution

Close monitoring is a particularly difficult part of air quality management. In order to monitor the entire cities, many monitoring stations are required to continuously monitor the air quality, which makes it difficult for experts to accurately measure the level of urban air pollution and its impact on urban life. The advent of the Internet of Things (IoT) could change these challenges. Advances in low-power wide-area networks (LPWA) have increased the availability of small, always-on handheld sensors.

With low data rates and long distances, LPWA sensors can be connected to bicycles, outdoor furniture, or people to measure and report air quality more regularly and accurately. The power of big data, such as weather and transport, can improve the background of the data and can provide insight into the causes and changes in air pollution levels. While they are reluctant to replace traditional monitoring networks, governments around the world are investing in policies and partnerships to find IoT-based air quality solutions. For example, Chongqing is currently working with China Mobile to improve the weather with built-in sensors. Quality control, on the other hand, Telefónica and Orange works with cities in Portugal, Spain, France, and Brazil [18].

Kim and Paulos [19] have developed and implemented a system called air that can measure, visualize, and transmit data on indoor air quality. Air quality from the DC 1100 is used to measure indoor air pollution, an AVD-based Arduino is built into an air quality monitor, and the iPod Touch processes, displays, and transmits data to the Arduino wirelessly. Data is transmitted every 15 s while the Arduino encodes the data as a series of beeps. It is like the iPod Touch reading your modem through the microphone port. We can use Wi-Fi to exchange real-time data from a central server.

Air pollution is a vital issue for a country. An air polluted country falls prey to many different environmental issues and health hazards. Recently in India, there are various debatable and questionable conditions which arises when it comes to air pollution, cause, from different foreign surveys it is found that, the air quality in India is very hazardous, and it is one of the worst's in the world ranking [12]. In 2002, continuous air quality monitoring was commenced through the establishment continuous air quality monitoring station (CAMS) by Department of Environment (DoE) under the worlds bank financed Air Quality Management Project (AQMP) [15]. But there is no organization or any government projects that work in detail on air pollution and air

quality. There are some international websites where they display the live air quality and unfortunately, they do not have enough data about India's air quality in their database. For India, the AQI measured by US embassy is followed widely. But the problem remains about the accuracy because the measurement device is installed on the premise of US embassy, and it can only detect quality of the surrounding air. This value cannot represent the AQI for all the cities, even the other part of Delhi City [21–25].

- The main goal of our work is to detect the gases responsible for air pollution and measure the air quality and view the pollution level so that we can evaluate which gases are responsible for pollution in which area the most and in which rate the air is being affected.

3 Experimental Studies

This section describes the project methodology applied to the project. Guidelines are used to complete the project from start to finish. The procedure includes several activities implemented under the project: successful completion [26].

3.1 System Design

This session will discuss in detail the progress made in the development of a real-time air quality reporting system. Thus, this chapter deals with the design and construction of the original system as shown in Fig. 1. The system can be divided into two types: Those are description of hardware and software implementation [23].

3.2 Hardware Development Part

The low-cost system consists of the Arduino and Node MCU sensor node system. To connect Wi-Fi and fast monitoring of the sensors data Node MCU included in the work, which accesses the network easily and remote server. Arduino Uno interfaces with DHT11 sensor for monitoring temperature and humidity of the given environment and process the data based on threshold value with reference of the other sensors those are barometric pressure and air quality sensor, which are interfacing with Node MCU. The gas sensor are detecting the carbon dioxide and carbon monoxide gases with reference of pressure and DHT11 sensors [14].

The threshold values are adjusted in the system as per the quality standards of air. This can continuously monitor with IoT could server-ThinkSpeak. Users can access the data either by using Android mobile or by Internet. When the gases have reached above the threshold value, the system has sent immediate alarm to the users. So they

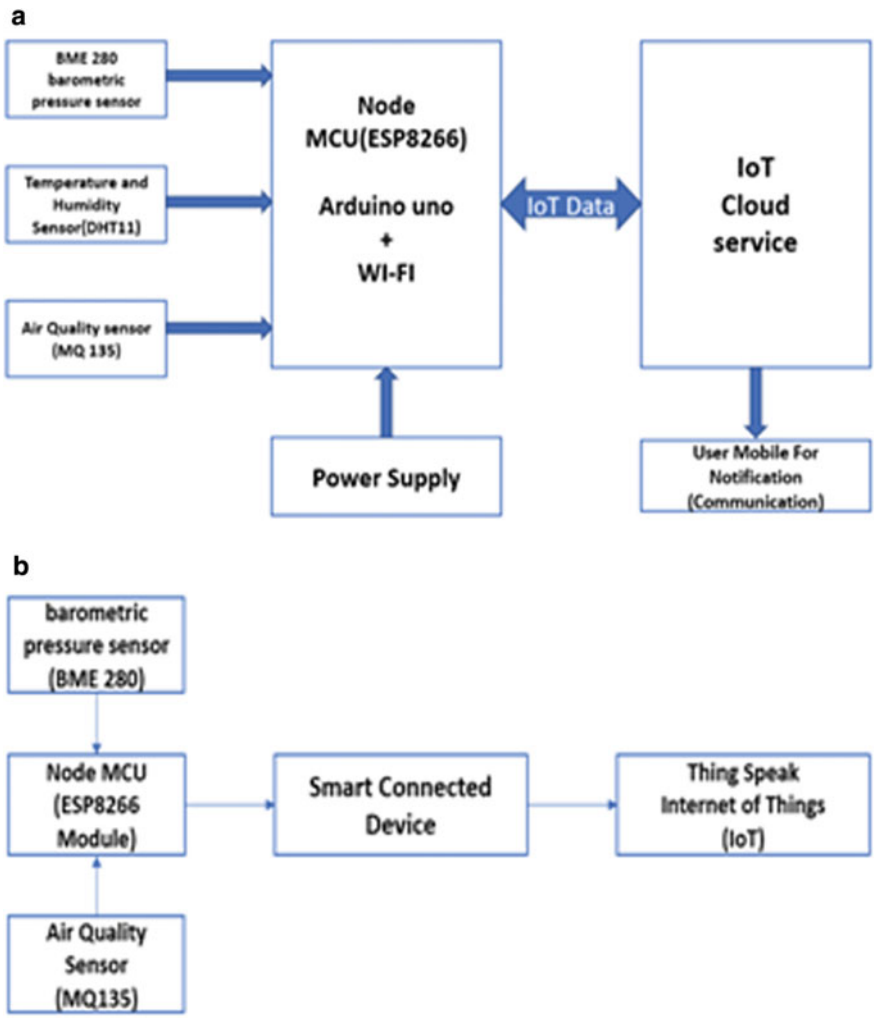

Fig. 1 **a** Block diagram of air quality monitoring and sensing. **b** Block diagram of sending the data to ThingSpeak using NodeMCU

immediately save their lives, and also, the proposed system has connected exhaust fans to exhaust the gas from that environment. The detailed hardware has shown in the block diagram Fig. 1.

3.3 Software Development Part

The process of the software development has given in flowchart Fig. 2. Flowchart for system programming, another flowchart is for displaying temperature, humidity and air quality on an LCD. Results of the obtained data to send temperature, humidity to ThingSpeak in order to display the data.

4 Results and Discussions

Connections

As shown in the picture, 3 DHT11 voltages are connected to ground +5 and 0 V, and all signal pins of Arduino Uno can be connected to 8 pins, and the rest of the components like MQ135 voltage level and ground to +5 V and analog PIN connectors. The analog pins of the Arduino Uno [22] are connected to A0 (Fig. 3).

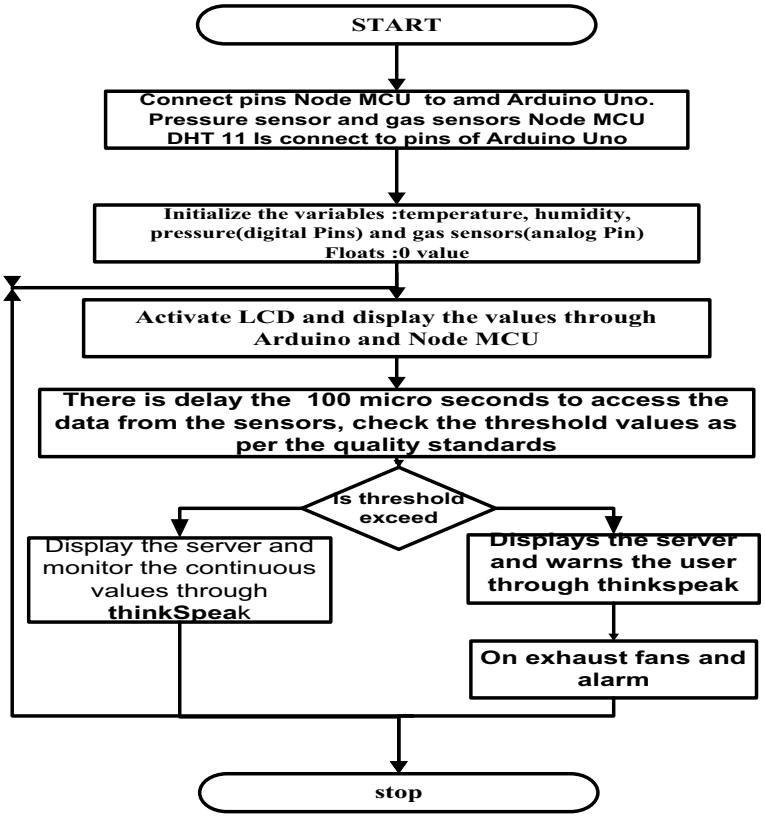

Fig. 2 Flowchart: programming for the system

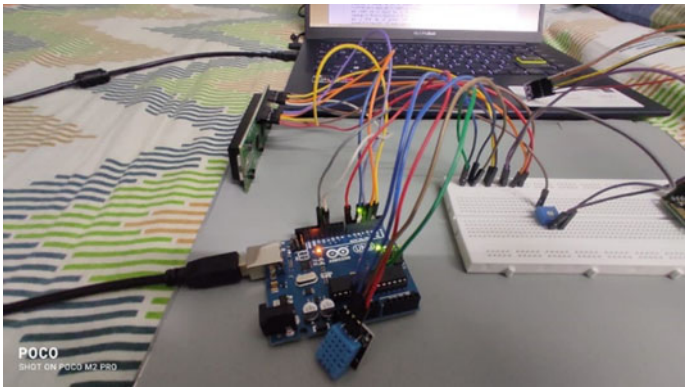

Fig. 3 Connections of Arduino with LCD

Fig. 4 Temperature and humidity display on LCD

- As shown in the picture, 4 RS pins to pin 12, pin 11, pin 4 to digital pin 5, D5 to digital pin, D6 to pin 2, R7 W pin to ground, VSS pin to ground, VCC to 5 pin V, resistor from 10 kΩ to +5 V and output to ground and dehumidifier VO PIN (Fig. 4).

The DHT11 info buttons connect to the digital pin of the MCU node, and the MQ135 connects to the analog pin as shown in Fig. 5.

4.1 Process Code Execution Process

Programs are written using Arduino software (IDE) as shown in the figure are called sketches. The editor has the ability to cut/paste and find/modify text. The scope of the message provides feedback on recording and exporting and also indicates errors.

The console displays text results through the Arduino software (IDE), including error messages and other information. The configuration board and serial port are displayed in the lower right corner of the window. The toolbar button allows us to test and load applications, sketch, open and save, and open serial monitors [24] (Fig. 6).

The complete proposed work execution of the program is shown in Fig. 7

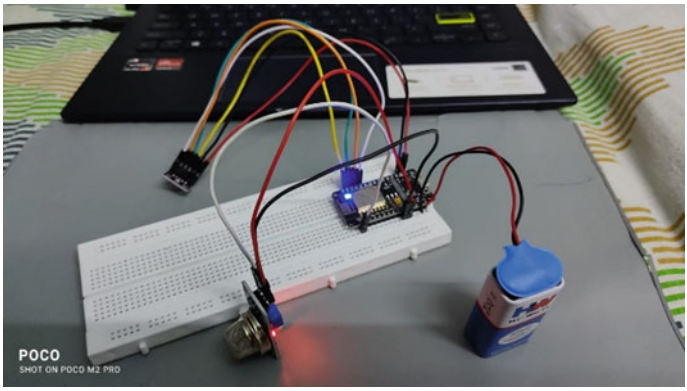

Fig. 5 Connection of DHT11 and MQ135 with NodeMCU

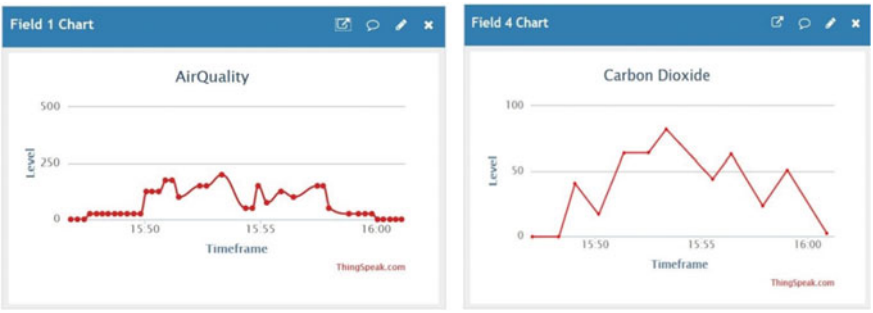

Fig. 6 ThingSpeak cloud server data display

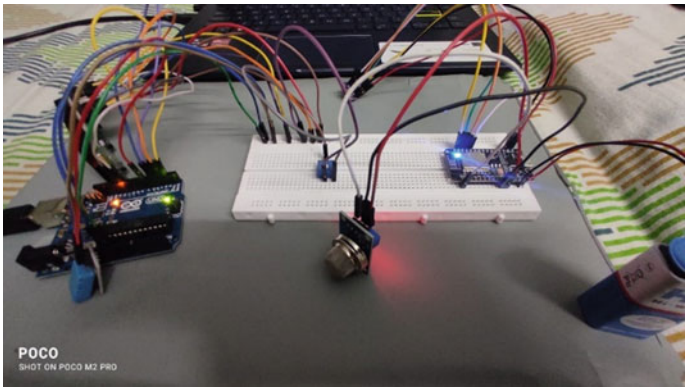

Fig. 7 Execution state of the proposed work

The proposed work is well-advanced, and the sensors are easily accessible, simple, compact, and convenient to use. The sensors have a longer lifespan and are less expensive. Air quality can be checked both indoors and outdoors and determines a wide range of physical parameters, including carbon dioxide. The proposed work will be implemented in several directions, depending on the type of environment. This is indoor air quality monitoring. Monitoring of industrial parameters and roadside pollution monitoring is available to the common man [24].

5 Device Impact

In this chapter, we have discussed the different impacts of the device in different aspects. Besides this we have also discussed cost analysis and economic impact of this device.

5.1 Health and Safety Impact

Our prototype model is designed in a way, so that it can be helpful to people with safety issues. In recent days, in our society gas leakage is a common incident nowadays. Many people lose their valuable lives because of this. For this reason, we have designed a prototype model of air pollution monitoring system where our system will automatically detect harmful gas presence. After detecting, our system will send the SMS by using ThinkSpeak. So we can see, for health and safety issues our system can bring a very powerful impact on society [11].

5.2 Lower Energy Consumption

Another major problem of our society is wastage of energy, and in recent days, this problem is becoming more acute. As the fastest developing country, many factories and mega malls are being established, and as a result, we are facing the energy problem. To reduce these kinds of problem, many agendas and project works are developing but still this problem has not been solved properly. So we all should come forward in order to solve excess energy consumption; otherwise in near future, we will face more energy issues. As it is designed for rooms and open areas, so it can be installed in home, office, schools, colleges, and many more places easily. It only consumes 5 V power supply. As a result, huge amount of energy and electricity can be saved [15].

5.3 Cost Analysis and Economic Impact

There are many systems related to air pollution monitoring system available in the market but most of them are highly priced and not affordable for every person. But our system is an integrated system which has many important features and its easily affordable for any person. Because it only costs under **2000 Rupees**, most importantly our system can be installed in many places, like room of homes, office rooms, schools, colleges, or university classroom. So it is really an additional plus point for our prototype model that it can perform multiple important operations at a time as well as it costs very less than the air pollution monitoring system available in market [16–20].

6 Conclusions

The proposed IoT-based air pollution system consists of a hardware that include Arduino and Node MCU with various types of sensors. The proposed system implements a combination of Android applications, server, and gas sensor (CO_2 and DHT11) to detect ambient air quality and display the actual air condition. Detects parameters causing contamination, each time the parameter level increases, the sensor detects the situation and sends a message to the authorized person via the Node MCU. Authorities can close down the power in polluting area via the Internet of Things. Sensors synthesize this information and send it to the web for real-time monitoring. This allows you to detect air pollution in different areas and take steps to prevent it. There is also a temperature sensor that estimates the room temperature. The proposed system is accurate and dynamically provides current situation at any place to check the air quality. The proposed system can be installed in every industry to monitor the various types of the emissions check the hazards for human. The system is also implemented in the home to check the air quality.

References

1. Alonso M, Finn EJ (1967) Fundamental university physics, vol 2. Addison-Wesley Reading
2. Continental Automated Buildings Association (2013) Impact of smart grid on connected homes landmark research study. In: Impact of smart grid on connected homes, pp 1–106
3. Cui Y, Kim M, Gu Y, Jin Jung J, Lee H (2014) Home appliance management system for monitoring digitized using cloud computing technology in ubiquitous sensor network environment. Int J Distrib Sens Netw 10(2):174097
4. Deepa K, Kumar PA, Krishna VS, Rao PNK, Mounika A, Medhini D (2017) A study of comparative analysis of different PWM techniques. In: 2017 international conference on smart technologies for smart nation (SmartTechCon), pp 1144–1149
5. Erfani S, Ahmadi M, Chen L (2017) The internet of things for smart homes: an example. In: 2017 8th annual industrial automation and electromechanical engineering conference (IEMECON), pp 153–157

6. Fernandes R, Matos JN, Varum T, Pinho P (2014) Wi-fi intruder detection. In: 2014 IEEE conference on wireless sensors (ICWiSE), pp 96–99
7. Gabriele T, Pantoli L, Stornelli V, Chiulli D, Muttillo M (2015) Smart power management system for home appliances and wellness based on wireless sensors network and mobile technology. In: 2015 XVIII AISEM annual conference, pp 1–4
8. Gu H, Diao Y, Liu W, Zhang, X (2011) The design of smart home platform based on cloud computing. In: Proceedings of 2011 international conference on electronic mechanical engineering and information technology, vol 8, pp 3919–3922
9. Han J, Jeon Y, Kim J (2015) Security considerations for secure and trustworthy smart home system in the IoT environment. In: 2015 international conference on information and communications technology convergence (ICTC), pp 1116–1118
10. Haque SMA, Kamruzzaman SM, Islam MA (2010) A system for smart home control of appliances based on timer and speech interaction. CoRR, abs/1009.4992
11. Hasan N, Khan AAM, Uddin N, Mitul AF (2013) Design and implementation of touchscreen and remote control based home automation system. In: 2013 2nd international conference on advances in electrical engineering (ICAEE), pp 347–352
12. Hassan MA, Abdullah AR, Bahari N, Jidin A (2013) Incorporating brushless DC motor in outdoor fan control of low voltage air-conditioning system. In: 2013 IEEE student conference on research and development, pp 550–555
13. Huaiyu X, Ruidan S, Xiaoyu H, Qing N (2009) Remote control system design based on web server for digital home. In: 2009 ninth international conference on hybrid intelligent systems, vol 2, pp 457–461
14. Huang L-C, Chang H-C, Chen C-C, Kuo C-C (2011) A zigbee-based monitoring and protection system for building electrical safety. Energy Build 43(6):1418–1426
15. Ikuta K, Kage H, Seki M, Hirai T (2011) Human intruder detection with leaky coaxial cables for wide area surveillance system. In: 2011 IEEE international conference on systems, man, and cybernetics, pp 103–108
16. Keshamoni K, Hemanth S (2017) Smart gas level monitoring, booking and gas leakage detector over IoT. In: 2017 IEEE 7th international advance computing conference (IACC), pp 330–332
17. Lei Z, Hu W, Li H, Yang Z (2013) Web-based remote networked control for smart homes. In: Proceedings of the 32nd Chinese control conference, pp 6567–6571
18. Lin H (2012) The development of control and energy usage information modules for smart homes. In: 2012 international conference on control, automation and information sciences (ICCAIS), pp 236–240
19. Liu L, Liu Y, Wang L, Zomaya A, Hu S (2015) Economical and balanced energy usage in the smart home infrastructure: a tutorial and new results. IEEE Trans Emerg Top Comput 3(4):556–570
20. Longe OM, Ouahada K, Rimer S, Zhu H, Ferreira HC (2015) Effective energy consumption scheduling in smart homes. In: AFRICON 2015, pp 1–5
21. Mao X, Li K, Zhang Z, Liang J (2017) Design and implementation of a new smart home control system based on internet of things. In: 2017 international smart cities conference (ISC2), pp 1–5
22. Nag D, Majumder D, Raquib CM, Pramanik S, Basu A, Rana TK, Rana B (2017) Green energy powered smart healthy home. In: 2017 8th annual industrial automation and electromechanical engineering conference (IEMECON), pp 47–51
23. Nguyen TV, Lee DG, Seol YH, Yu MH, Choi D (2007) Ubiquitous access to home appliance control system using infrared ray and power line communication. In: 2007 3rd IEEE/IFIP international conference in Central Asia on internet, pp 1–4
24. Panwar A, Singh A, Kumawat R, Jaidka S, Garg K (2017) Eyrie smart home automation using internet of things. In: 2017 computing conference, pp 1368–1370
25. Quwaider M (2017) Real-time intruder surveillance using low-cost remote wireless sensors. In: 2017 8th international conference on information and communication systems (ICICS), pp 194–199

26. Sahoo SK, Ramulu A, Batta S, Duggal S (2012) Performance analysis and simulation of three phase voltage source inverter using basic PWM techniques. In: IET Chennai 3rd international on sustainable energy and intelligent systems (SEISCON 2012), pp 1–7