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IoT Based Energy Monitoring and Control System

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Abstract **- Modern technologies are used to secure the increasing human needs with the developments of the times as well as the provision of services, and it is considered necessary to remotely control the surrounding devices, especially those that depend on electrical energy for their work, in order to reduce energy consumption and manage and maintain devices. In current study, a system was designed that measures and monitors the energy and can control the devices remotely, as well as the possibility of making a decision to turn off the devices. The system is built by using an ESP-32S Node MCU and a PZEM-004T-100A sensor, and the control and connection to cloud computing is done by the Blynk server. The system connects by Bluetooth technology to the smartphone device through a program running on the Android system Serial Bluetooth Terminal to facilitate the Initializing the system, securing the system connection, and determining the highest value of the current to be consumed, in addition to the presence of a TFT color screen that works with several interfaces, including displaying the reading of electrical measurements, displaying system configuration information, displaying network connection, and displaying the highest value of the specified current. This proposed system is designed in a way that facilitates the process of monitoring and controlling the electric power of homes and making a decision when the threshold limit for the current specified by the user is reached. Where the system provides the house with two paths for the passage of the electric current, the first line connects the electrical devices directly in the system and one of the characteristics of the direct line is that it works to provide the devices with electrical energy and monitor the amount of energy consumed without controlling it remotely. As for the second line, high-capacity electrical devices are indirectly connected to the system, i.e., through a relay. One of the characteristics of the indirect line is to supply electrical energy to the devices. The indirect line can be monitored, controlled, and controlled remotely through the Blynk server.**

Keywords: Internet of Things, PZEM-004T sensor, Energy, Voltage, Power Factor, Current, Power.

1. Introduction

IoT is a modern technology in the field of information technology now and in the future, and it is referred to as (IoT) and is also called the Internet of Every Thing and is abbreviated as (IoE) [1], which aims to connect things such as sensors and connect them to the Internet to communicate data between them automatically, provided that its location is covered by the Internet [10][12].

IoT can connect devices that are not qualified to work with the Internet, where it can collect, send, and process the data it captures from the surrounding environment using sensors and processors, and communicate and interact with devices and people from anywhere in the world [3][14][15].

Electric energy is one of the most important basics of life since it was discovered and cannot be dispensed with because of its many and varied uses in all areas of life [5][7]. Among the most important sources of electrical energy are generators, solar energy, power plants, dry batteries, as well as water and wind energy, which are among the modern methods that preserve the environment from pollution, and since they are considered safe sources that people use, they must be preserved and not wasted and their consumption should be rationalized. One of the most important elements of economic and social development [4][18][20].

The researcher [8] proposed an IoT-based metering grid monitoring system at the University of Runda that enables solar PV customers to monitor how much energy is produced, how much energy is consumed and how much energy is uploaded to the grid. The system is designed using solar panels to generate electrical energy from sunlight, microcontroller Arduino UNO and sensor PZEM-004T, and by means of communication data Global System for Mobile (GSM) data is sent to the cloud by Thing Speak server for real-time data analysis [19]. The monitoring system has proven to contribute to better management of electricity production and consumption, especially for solar energy consumers. This study succeeded in implementing the monitoring of the amount of energy measured by adopting the Internet of Things.

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The research [9] proposed a system based on Wireless Sensor Network (WSN) technologies and IoT for real-time energy management in buildings. The system consists of a wireless sensor network to measure the voltage and current to calculate the power consumption of the connected devices. The readings are transmitted by Zigbee technology to the station, which consists of a Wi-Fi microcontroller, which in turn uploads the data to the cloud [17][21].

In the research [6], the researcher used Arduino UNO and the AC sensor ACS712 in designing the system, as it will measure current only, and the Arduino UNO controller does not contain a Wi-Fi network, which forced the use of the ESP8266 microcontroller that Contains a Wi-Fi network to control the sensors placed. While designing the system in this paper, the PZEM-004T sensor was used, which works to measure electricity scales from (Voltage, Power Factor, Current, Power, Frequency, Energy)[2]. The ESP32 microcontroller was also used, which contains Bluetooth and Wi-Fi [22], which facilitated the work of connecting the system to the Internet. The system also works to make decisions and turn off devices when the current reaches the threshold limit. The system also enables the user to determine the threshold limit for the consumed current and the possibility of remote control Turn off and turn on the devices[13][16].

This research deals with the method used to measure the electrical energy of homes, which relies on modern electronic systems to control and monitor the consumed electrical energy from a distance. This system was designed and tested in a real way, and the results obtained in measuring electrical energy and the effects of modern technologies are tracked by controlling the amount of electrical energy consumed and rationalizing its consumption [11], as well as monitoring current and voltage and controlling electrical appliances and protecting them from damage.

The aim of this study is to develop an electrical energy measurement system based mainly on current values specified by the user in decision making. This is a precedent for smart meters. Where the system was developed based on obtaining the value of the consumed current and making the decision to turn off the electrical appliances to preserve the devices as well as to reduce waste in energy and reduce the amounts of high bills.

This paper is prepared as follows: Section 2: Proposal and Solution; Section 3: Decision of devices off/on in the smart electrical energy meters; Section 4: closes the paper with some concluding remarks.

2. Proposal and Solution

This research was designed based on the Internet in the design of the energy measurement system. Where this study made it possible to achieve monitoring of the energy consumed at home and the possibility of remote control and rationing of the amount of energy consumed, thus saving energy and reducing the price of the bill. One of the most common problems in intelligent systems is how to manage a lot of data in real time, control it in decision-making, and model it for monitoring.

2.1 Design of Energy System Using NodeMCU

The electrical energy metering system initially works on maintaining the connection, updating the data in real time every 12 seconds, taking into account that the design of this system works in real time. The data obtained from the PZEM-004T-100A is passed to the EEPROM memory so that it can be used to upload it to the Blynk server and display it on the 3.0 TFT Color Screen. This system also works depending on the current value previously given by the user, as it turns off the indirect line automatically In the event that the consumed current exceeds the threshold limit. When the main source of electricity is turned on, the status of the indirect line (remotely controlled) is raised and sent to the Blynk server, for remote control in case the line is ON or OFF, while the direct line (not remotely controlled) is also raised to the server for monitoring only as it is controlled manually by the user. As shown in the following flowchart (1).

2.2 Physical connection for Energy System using NodeMCU

The ESP-32S Node MCU has been programmed and ports are allocated that will connect the devices used to the microcontroller, which is the heart of the system. Its speed reaches 240MHZ and contains a large number of GPIO ports and a large storage capacity, and it contains Wi-Fi technology, which makes it an excellent choice for building Internet of Things systems in addition to the presence of Bluetooth technology, which enhances the transmission of data via the mobile phone, which will be used to configure and connect the system to the Internet. The electronic circuit of the electrical energy measurement system was designed by the microcontroller ESP-32S Node MCU. The readings of the consumed energy meters for the electrical loads placed and operated on the system were displayed via the 3.0 TFT Color Screen display, which operates according to the Serial Peripheral Interface (SPI) protocol, and letters can be printed the numbers are in English, in addition to its ability to draw shapes such as squares and circles. In addition, its library is compatible with the ESP-32S Node MCU, which was

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connected to the microcontroller via the ports shown in Figure (2).

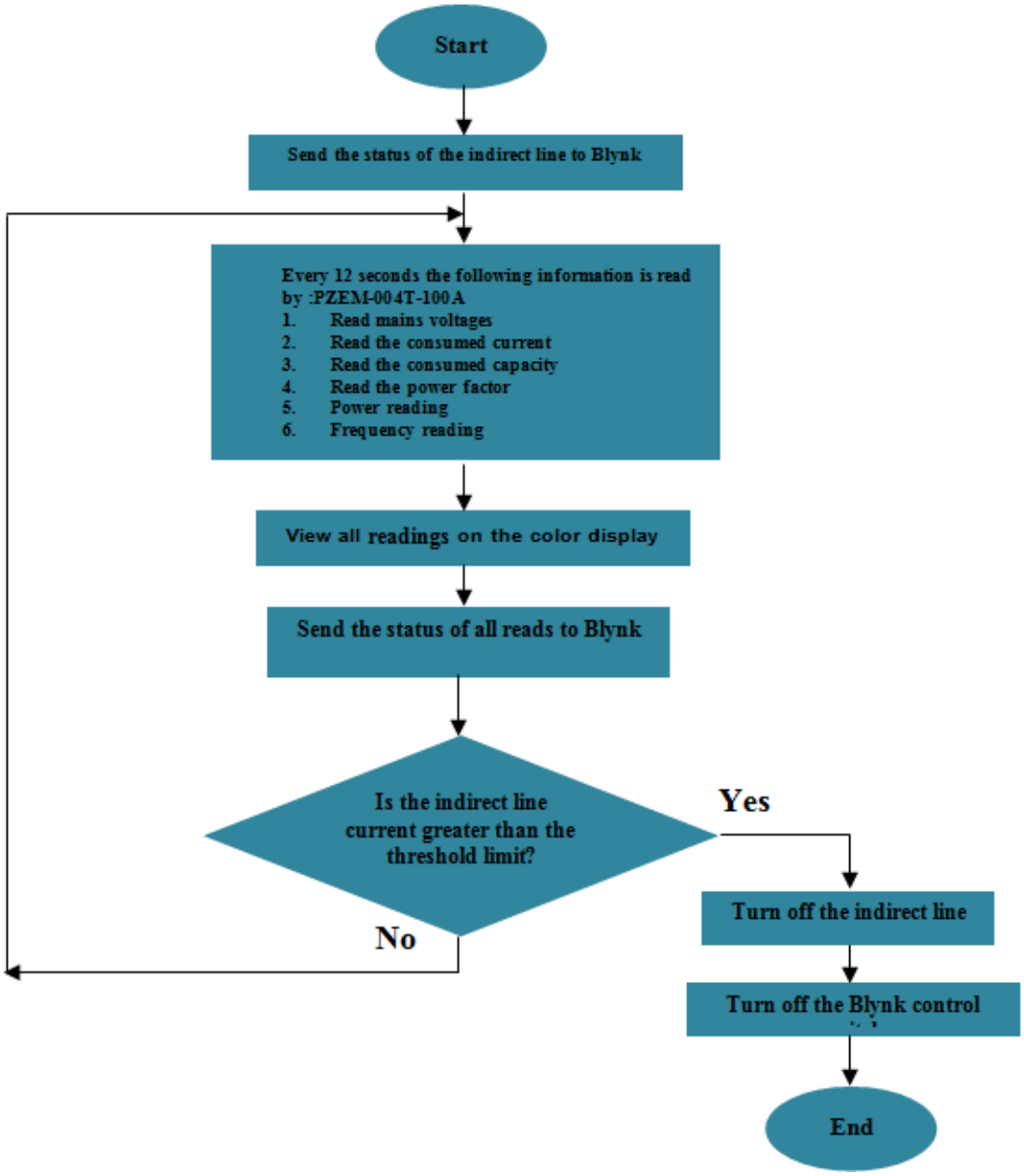

Figure 1: Flowchart for designing an electrical energy metering system

The SSR solid-state relay is placed on a heat sink to avoid the heat generated from it. In addition, the SSR solid-state relay is used to control OFF/ON operations to control electrical appliances loaded on it with a current of less than A100. An integrated circuit ULN2003 was developed to provide a suitable current for the SSR solid-state relay. It contains 7 pairs used to increase the voltage from the 3.3V output of the ESP32 microcontroller to 5V. Only one pair was used and connected via the digital port D22, as shown in Figure (2).

The system is fed with a current of 5V, where a power supply device (Hi-Link) is connected to feed the designed system, except for the sensor, which is fed with a current of 220V, as shown in Figure (2). In order to display the system information on the screen, a switch button was placed and it was linked to the ESP32 microcontroller, and it was also programmed. If pressed, the configuration mode of the system appears on the screen, which will be explained in the fourth chapter when displaying the results.

All components of this system cannot read any electrical energy measurement without the PZEM-004T electrical energy meter sensor, which is a counter used to measure electrical energy consumption, voltage, current, capacity, frequency, and AC power factor. It connects with the ESP32 microcontroller via the serial port.

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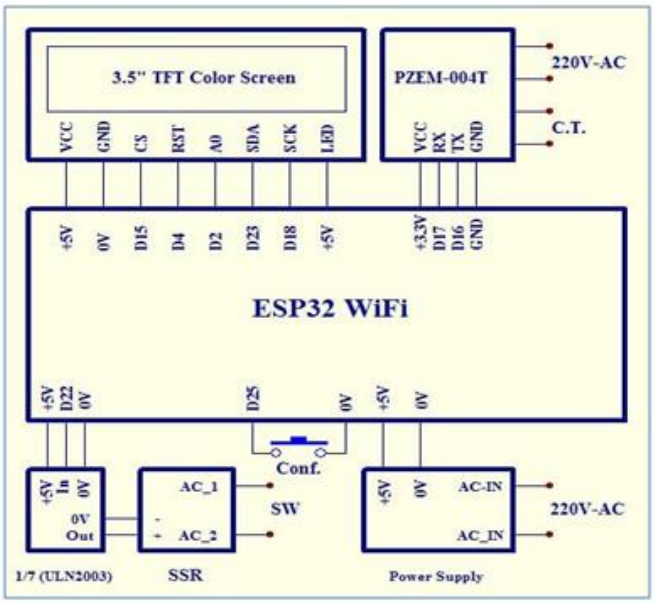

Figure 2: Electronic circuit design of the electrical energy metering system by ESP-32S Node MCU

3. The decision of the power metering System based on the current value specified by the user

Figure (3) When designing the electrical energy metering system, the most important point was taken into account, which is when and how to make the decision to cut off the current to the devices, in order to obtain the best results in the process of reducing electrical energy consumption and preserving devices from damage, in addition to rationing the expenditure of money on electricity bills. In this research, two types of decision-making were developed. The first type is that the consumer prepares the system for a certain value of the current. When this value is reached, the indirect line is automatically turned off and can be restarted remotely by the Blynk server. As for the second type, the consumer can monitor and control remotely by turning off and on the indirect line through the Blynk server.

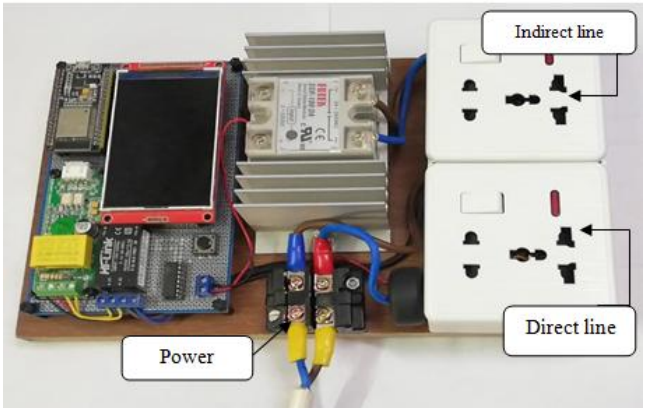

Figure 3: Shows the electronic design of the electrical energy measurement system

The system was tested by applying a value for the current as a maximum consumption, in order to see the ability of the system to control the shutdown of the indirect current line when consuming a certain amount of current. The current has been determined as the highest value, which is 20A, when placing loads on the system less than 20A, the system continues to work normally and does not make any decision, but when placing loads with a value higher than 20A, the system makes a decision, which is to turn off the indirect line, in order to reduce energy consumption This is one of the objectives of the project, as shown in Figure (4).

Figure 4: Shows the decision to turn off the indirect line after the current exceeds the specified value as (a) the system screen (b) Blynk application

Table (1) shows the amount of current consumed in the direct and indirect lines when loads are placed on them, and the total current consumed for the two lines. When the total current of the two lines exceeds 20A, the system makes a decision to automatically turn off the indirect line, but the direct line remains operational, and the benefit from the line Direct is the continuation of supplying the necessary devices with electrical energy in the home.

Table 1: Shows the amount of current consumed in the system and the decision taken when the threshold is reached

The amount of current consumed		Current of the two lines	Make the decision	
Direct line	Indirect line		Direct line	Indirect line
3.40A	4.50A	7.90A	ON	ON
9.30A	12.20A	21.50A	ON	OFF
5.30A	1.40A	6.70A	ON	ON
20.50A	0.00A	20.50A	ON	OFF
0.00A	21.20A	21.20A	ON	OFF

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4. Conclusion

The present study revealed to the energy measurement system based on monitoring and decision making. So, the study made it possible to view the existing systems in this field, study them, and identify their strengths as well as their shortcomings. This system is designed to remotely monitor the electric power of the house and make a decision to turn off the devices when the threshold limit for current is exceeded. The consumed current must not exceed 100A according to the specifications of the devices used. The system also works to reduce energy waste, preserve devices from damage, reduce bill amounts, and enable the user from remote monitoring and control, as well as the user can set the threshold limit for the consumed current.

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