Monitoring, Controlling & Conserving of Electrical Energy Using IOT

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Abstract: Energy consumption refers to the amount of energy consumed by an individual or organization which has been taken for granted in daily life by consumers especially at home.A circuit is designed, to take care of electrical energy consumption which helps the consumers to focus on the extra charges incurred due to minor changes in slab categories which affect the consumer's bill severely[1]. This system utilizes a sensor module that is connected with ARDUINO along with GSM, ESP 8266, and energy meter to measure the power consumption at the home[2].The main aim of this paper is to make consumers aware of the power consumption and to control the excess power consumption, by using a IoT Based Electrical Energy Consumption Live Monitoring & Controlling System.The power consumption data is collected and stored in to IoT cloud services[3]. Daily usage is updated to the consumer periodically through a mobile application which helps to reduce over usage of power.

Keywords: Energy consumption, ARDUINO, IoT cloud services

1. Introduction

The energy consumption can be monitored by using an electric device called an energy meter. The cost and the regular usage of power consumption are informed to the user to overcome high bill usage. The energy meter shows the amount of units consumed and transfers the data to both the customer and to the electrical board so this helps in reducing man-power[1]. The user can check their power usage from anywhere and at any time interval. The IoT is used to turn on/turn off the household appliances using relay and Arduino interfacing. The objective of this system is to monitor the amount of electricity consumed.

The development of Internet of Things (IoT), smart power meters and smart electrical appliances are used by the consumers to closely monitor the energy consumed and to determine their consumption[3]. This is made possible to capture and analyze sensor data in real time. The proposed system uses IoT infrastructure to monitor, smartly measure and schedule the consumption of electricity resources in real time. Energy management platform is a great example of using the Internet of Things for energy monitoring and management. This solution transforms the way people and companies use and control electricity, electrical devices, loads and power storage. It consists of smart hardware, software and data tools. Once equipped with this system, a house, office building or any other facility turns into a smart space with a rich set of features and capabilities for power consumption monitoring and control.

1.2 Objective

The main objective of the paper is to monitor the energy and control the electrical appliances by using microcontrollers and Arduino. The experimental study is carried out by performing load tests using different domestic loads and observed the energy consumption of various loads.

2. Overview

Awareness of electricity consumption in the home or building is a first step towards saving energy. The combination of alternative energy and pervasive technologies for monitoring and controlling energy consumption is a powerful vehicle for reducing energy demand. With effective feedback about energy consumption and control of household appliances, users can be motivated and encouraged to change their behavior on energy use such as turning off lights or reducing heat. These small changes in behavior can lead to significant energy savings.
The proposed system can monitor and measure electricity usage in real-time. With the proposed system, users can remotely control real-time electricity usage by monitoring the loads through which energy conservation can be monitored[1,2].

2.1 Advantages:

The following are the advantages of energy consumption monitoring and controlling are:

- Managing all of the home devices from a remote place.
- Maximizing home security.
- Increased energy efficiency.
- Save Energy with Smart Energy Consumption.
- Customize as per your Convenience.

- Ease of using smart home technology.

2.2 Limitations:

The following are the disadvantages of energy consumption monitoring and controlling are:

- Significant installation costs
- Reliable internet connection is crucial
- Security issues
- Technological problems in connected homes
- Maintenance and repair issues.

3. Methodology

The smart energy meter monitoring system is shown in figure 3.1. The block diagram consists of Arduino, energy meter, WIFI module and IoT, Relay and transformer[3]. Energy meter used here is a clamp energy meter[1].

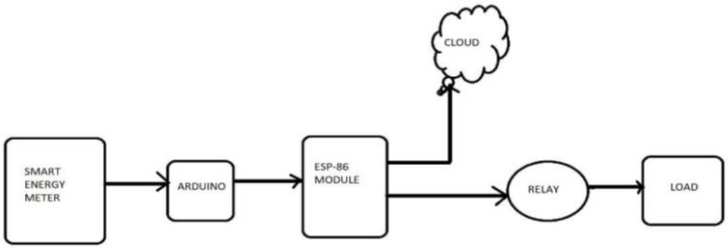

Fig 3.1: Block Diagram for Real Time Monitoring System

A 230V AC main is the input given to the transformer and AC mains is converted to low voltage by using a step down transformer. Bridge rectifier is used to convert the 12V AC to 12V DC. Arduino is a microcontroller which controls the loads and sends the signals to the cloud devices like(mobiles phones, laptop, tabs). The relay receives the signal from the cloud device and controls the loads.

3.1 Real -time home automation monitoring:

In the home network the various electrical and electronics appliances are connected through the internet to the home server. The measured data from the devices has to be stored and the storage function is carried out by the server for analysis purposes. The gadgets may be wearable for aged or elderly people where the device monitors the persons residing at home. The actuators are bridged to these devices with the support of technology such as ESP86 Wifi module to send signals to the web server to execute required actions[9].
Thus, actuators send instructions based on the location of the server using ESP86 Wifi module[2]. The electronic devices are made to perform specific tasks when even the user's presence is unavailable at home location by accessing the home server using a different data network.

3.2 Internet of Things (IoT)

The concept of the Internet of Things was invented by and coined by Peter T. Lewis in September 1985 in a speech he delivered at a U.S. Federal Communications Commission (FCC) supported session at the Congressional Black Caucus 15th Legislative Conference. Internet of Things (IoT) is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as "the infrastructure of the information society"[7].

Over the past few years, IoT has become one of the most important technologies of the 21st century. Now that we can connect everyday objects like kitchen appliances, cars, thermostats, baby monitors to the internet via embedded devices, seamless communication is possible between people, processes, and things[7]. By means of low-cost computing, the cloud, big data, analytics, and mobile technologies, physical things can share and collect data with minimal human intervention. In this hyperconnected world, digital systems can record, monitor, and adjust each interaction between connected things. The physical world meets the digital world and they cooperate.

4. Hardware Description

4.1 Equivalent Circuit Model:

An approximated model of IoT based electrical energy consumption live monitoring and controlling has been done in live. The electrical equivalent circuit of this model is as shown in the figure 4.1

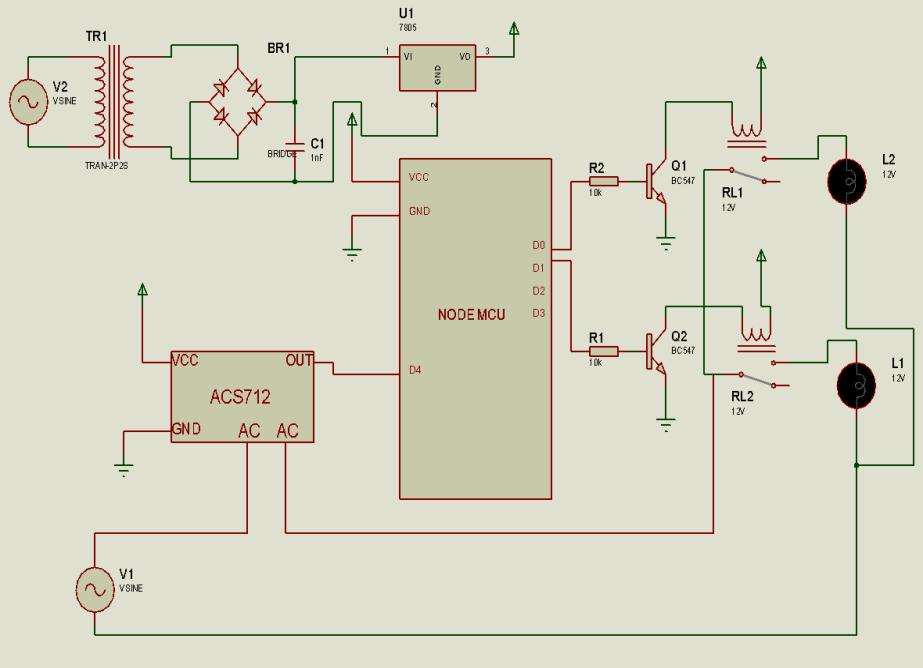

Fig 4.1: Equivalent Circuit Model

The output of this model is to control the appliances and monitor the appliances consumption units and charge how much it consumes. Firstly, an AC signal of 230 V is stepped down to 12V and by using a rectifier circuit 12V AC signal is converted to 12V DC signal which is given as an input to Arduino. The capacitive filter is used to reduce ripples in the signal & Voltage regulator is used to maintain constant 12V DC signal to Arduino. Arduino is used to collect the data from the current sensor and send it to the cloud device like(mobile phones, personal computer, tabs, laptops ..etc). from the cloud device it takes the signal and gives it to the relay controls[12]. The transistor is a quick switching device to operate the relay. The relay is used to control the load device.

4.2 Hardware Developed:

The below figure 4. shows the developed system for monitoring power.

Fig 4.2: Hardware Developed

Under normal conditions, the supplier sets the reference value of the system which was placed after the transformer as 230W. Hence power consumption of that particular area will be in the range of (0-230)W but not more than the final limit.

4.3 Case Study:

Case 1: Two lighting loads are used-

When two bulbs of 15W are placed as shown in figure 4.3 & power supply of the system is turned on then current starts flowing. When bulbs of load 1 and load 2 are switched on then load is varied & the consumption can be seen by cloud device.

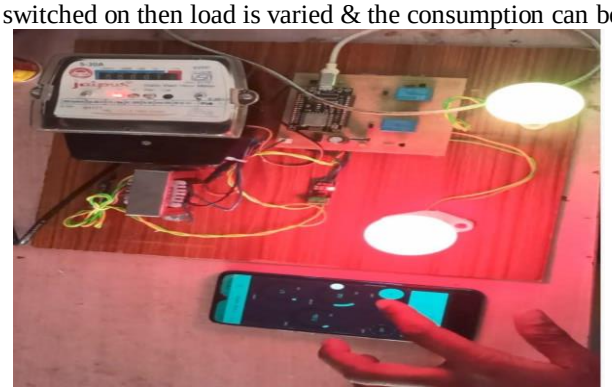

Fig 4.3: **Two lighting loads are used**

The figure 4.4 shows the output of two lighting loads for 4hr.The units consumed by two lighting loads is 2 kw/ hr.

Fig 4.4: **Output of two lighting loads**

Case 2: One lighting load and One Suction Motor

When one bulb of 15W and motor of 18W is placed in the home model as shown in figure 4.5 & power supply of the system is turned with load 1 and load 2 are switched on then load varies

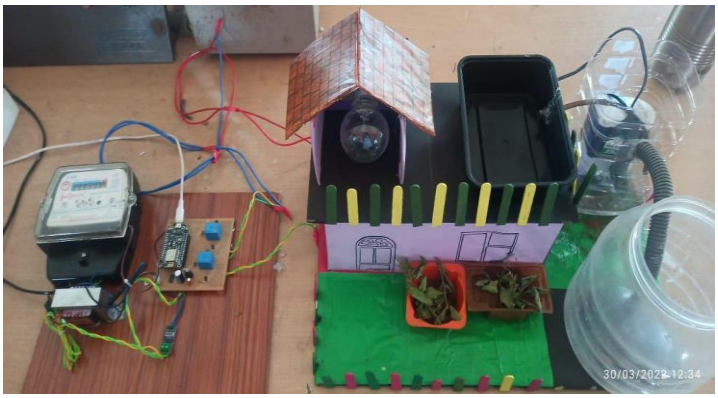

Fig 4.5: **One lighting load and One Suction Motor**

The figure 4.6 shows the output of One lighting load and One Suction Motor for 2hr. The units consumed of two lighting loads is 10 kw/ hr.

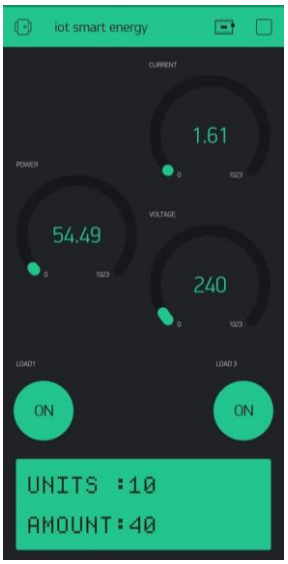

Fig 4.6: **One lighting load and One Suction Motor**

5. Energy Conservation

The information regarding energy meter status was received and displayed in the mobile application used for measuring the energy consumption. As the utilization of current increases the power consumed is also increased [11]. So, from the data received on the mobile application by the authorized person can perform the following operations regarding the power consumption:

1. Switching off the unnecessary loads in order to avoid the unnecessary consumption.
2. Can monitor & control the power consumption from a remote place.
3. Can analyze the daily energy consumption.

Energy consumption of different types of loads is shown in table 5.1 from which the energy can be conserved by turning off the appliances consuming more wattage. This in turn reduces the problem of voltage drop at home & conserves the energy consumption.

Table 5.1: Energy consumption of different loads

S.No.	Name of the Appliances	Quantity	Watts consumed
1.	Television	1	70W
2.	Ceiling Fan	4	75W
3.	Grinder	1	150W
4.	Refrigerator	1	250W
5.	Mixer Grinder	1	550W
6.	Washing Machine	1	70W
7.	Air Conditioner	1	1740W
8.	Tube light	3	58W
9.	LED bulb	3	60W
10.	Bed lamps	2	15W

5. Conclusion & Future Scope

Awareness of electricity consumption is the first step towards saving energy. An IoT-based smart energy management system for homes and buildings is presented in this paper. The proposed system can monitor and measure the current, voltage, and power consumption in real-time. The proposed system consists of a prototype for monitoring, storing, accessing electricity usage details in cloud using IoT Energy Meter. Wifi connectivity is used for frequent up gradation of energy used details. With the proposed system, users can access and analyze their hourly or daily usage details of the electricity & also remotely control real-time electricity usage through mobile Blynk application. With effective feedback about energy consumption and control of household appliances, consumers can be motivated and encouraged to change their behavior on energy usage such as turning off unnecessary loads. These small changes can lead to significant energy savings. In future, the proposed system is extended to the other sectors such as industries, agriculture & transport through modernisation of machinery, equipment and infrastructure such as motors, drives & capacitors.

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