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IoT Based Power Management System Using Arduino

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ABSTRACT

In present circumstances, power measurement and management is an important thing to do in order to promote energy conservation, especially in industries. The values of all electrical quantities like voltage, current consumed by the load, power consumed, energy, etc., are very important when it comes to electrical energy conservation. So management of the loads should also be done properly. This is where IoT (Internet of Things) comes as a helping hand. Using Microcontroller boards like Arduino Uno, ESP-8266, etc., we can easily measure the electrical quantities and manage the loads connected to the power system. We can also store the electrical parameters in the cloud and control the loads from anywhere through the internet. By doing this we can eliminate penalties like maximum demand fees. As the system is connected to the internet, loads can be managed from nearly anywhere in the world as long as there is an internet connection.

Keywords : ESP-8266, Electrical Quantities, Arduino, IoT, Microcontroller

I. INTRODUCTION

With the ever-growing demand for electrical energy across the world, we, as electrical engineers, are tasked to conserve energy as Energy Saved is Energy Generated. In today's world, power saving is very important and difficult. Though many power generation methods exist it has become very difficult due to insufficient resources. So saving power is a need for our society. For that, this paper is based on measuring the consumed power and regulating it.

Measurement: Measurement is one of the important concepts in Power system Automation. The real-time information about equipment is collected and displayed on the mobile or personal computer and stored in a database for further manipulation The information collected can assist in doing network studies like load flow analysis, planning ahead, and preventing disturbances in the Power network. Previously the word Measurement referred to voltage, current, and power, and the word Metering referred to power, reactive power, and energy (KWh). The different terms were used because different instruments were used for these applications, now the two functions are integrated into modern devices hence the terms are used interchangeably in the text.

Monitoring: Monitoring is specified for the maintenance of the Power System Automation. It monitors the sequence of records, status, and condition of the system, maintenance information, relay settings, etc.

Management: Management is specified for managing the electric outlets of the system. For example, turning on or off a Motor, Large lighting, or any other load connected. We can also use it for Safety Purposes. For example, If a Motor is turned On for A long time after the regular usage time, The system can turn it off

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by Detecting the Power Flow by the Voltage And Current Sensors. We can also set some timed operations like Automatically Turning On Lights in the evening time, etc.

Existing System

In the existing system, the energy can only be measured by an energy meter. Only Total energy can be monitored. Energy consumed by each appliance cannot be monitored and cannot be controlled. Load management cannot be done in the existing system. At the same time, Voltage and Current flowing through each load cannot be measured and recorded.

Disadvantages

1. Only total energy can be monitored by a physical energy meter
2. Individual Components like voltage, current cannot be monitored
3. We could not monitor or control the energy consumption if we are away from the site.

Proposed System

In proposed system, The Voltage, Current, Power, and Energy consumed by each load is measured and recorded in a graph. The collected and calculated parameters can be seen from anywhere in the world where Internet is available. The appliances can also be turned On or Off through Internet, which prevents human errors like forgetting to turn off a machine or a load. Timed Operations can also be done to reduce the power consumption even more.

II. BLOCK DIAGRAM OF THE SYSTEM

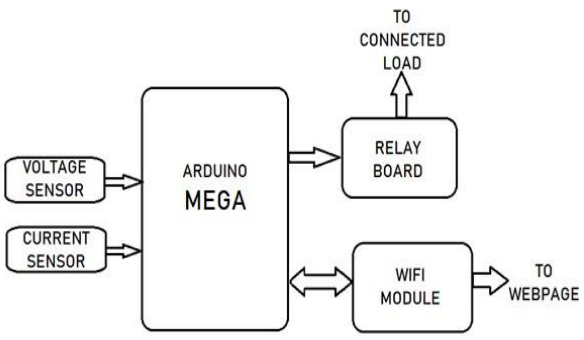


Fig.2.1. Block diagram of the system

III. REQUIREMENTS

1.Arduino Mega
2.ESP8266 WiFi Module
3.ZMPT101B Voltage Sensor
4.ZMCT103C Current Sensor
5.4 Channel 5Volt DC 230 Volt 10 Amp AC Relay
6.16x2 LCD Display with Backlight
7.Wires & Jumper Cables
8.Multimeter (for calibration purposes).
9.Arduino IDE
10.An IoT Platform (Example: Blynk, RemoteXY, Thingspeak, etc.)

IV. HARDWARE DESCRIPTION

Arduino Mega

In this paper, Arduino Mega 2560 is being used. This has 53 Digital Input and Output Pins, of which 13 pins have PWM Capabilities. It also has 16 Analog input pins and other voltage pins such as 5V, 3.3V. The current sensors and voltage sensors will be connected to the Analog inputs of the Arduino Mega and the Wi-Fi Module will also be connected to the Rx and Tx pins of the Arduino Mega.

ESP-82666 Wi-Fi Module

ESP-01 is a Wi-Fi Module through which the parameters can be shared to the website. This module has 8 Pins. It has transmitter and receiver pins, Two GPIO (General Purpose Input and Output) pins, and Supply voltage and ground pins. This module works on 3.3 Volts.

ZMPT101B Voltage Sensor

The voltage sensor used in this system is ZMPT101B Voltage Sensor. This voltage sensor can measure voltage up to 1000 Volts and consume around 2mA of current. The working temperature range of this sensor is around -40 Degrees to 60 Degrees. This has four pins. Two ground pins, one Analog Output pin, and a Vcc Pin. This sensor operates at a voltage of 5 Volts.

ZMCT103C Current Sensor

The current sensor used in this system is ZMCT103C Current Sensor. This sensor can measure upto 5A of current at an operating temperature range of -40 Degrees to 85 Degrees. This sensor also has four pins. Two ground pins, an Analog output pin and a Vcc pin.

Channel 5 Volt DC - 230 Volt 10 Amp AC Relay

The switching device used in this system is a 4-channel DC 5–volt, 230 – Volt, 10 Amp AC Relay. Up to four loads can be connected to this module. It works up to 250 Volts, 10 Amps in AC. This will work as a switch and turns on or off a load according to the signal from the Arduino. This has 6 pins. A Vcc and ground pin. Four input signal pins.

16x2 Backlit LCD Display

A 16 x 2 Backlit LCD Display can be used to show the values in a dedicated display. This display shows the voltage, current, power, and energy. This can be used while monitoring the instantaneous power, voltage and current.

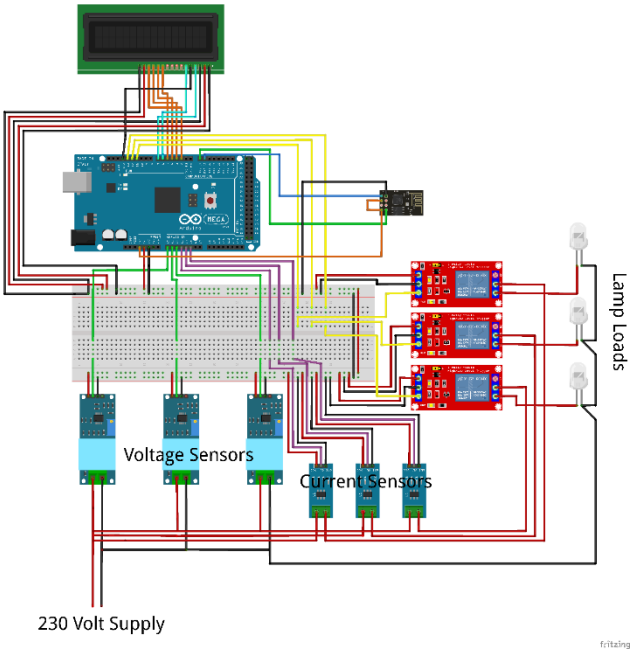
Arduino IDE

The software used to program the Arduino mega is the Arduino IDE. Arduino IDE is a simplified version of C++. This can be used to program Arduino UNO, MEGA, NANO, ESP-8266, and much more. The program can be compiled and uploaded to the Arduino Board with the help of a USB Cable. This is one of the easiest programming languages for Arduino. Other programming languages like Python and C can also be used. But nothing is easy as the Arduino IDE.

Blynk

Blynk is the cloud IoT Platform used here. This app connects with the Arduino Mega through Wi-Fi and fetches the calculated parameters to display it. The loads can also be managed with buttons in the app. This can be used on all Operating Systems.

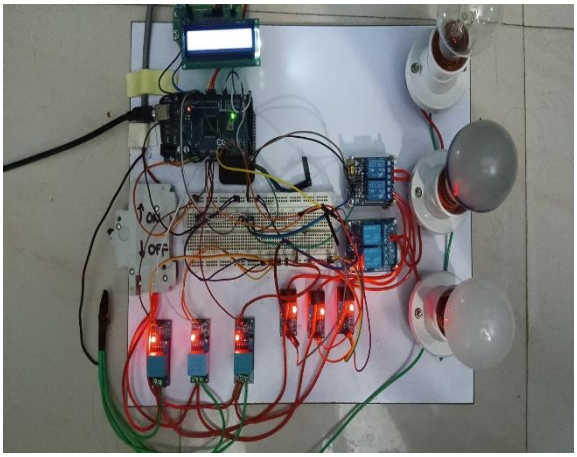
V. SCHEMATIC CONNECTION DIAGRAM



Schematic Connection Diagram

VI. HARDWARE SETUP

Hardware connection and setup is done same as the software connection diagram. All the components like sensors, relay boards and LCD Display is powered by the 5 Volts pin from the Arduino Mega. Breadboard is used for ease of connection. A Miniature Circuit Breaker (MCB) is used for overall protection of the system. The components are connected with jumper wires.

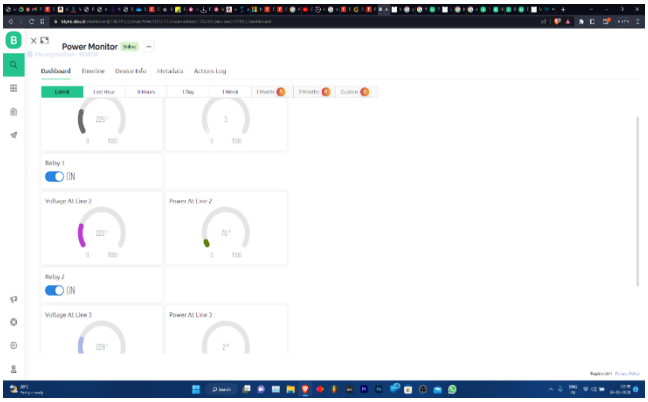


Hardware Setup

VII. FUNCTION

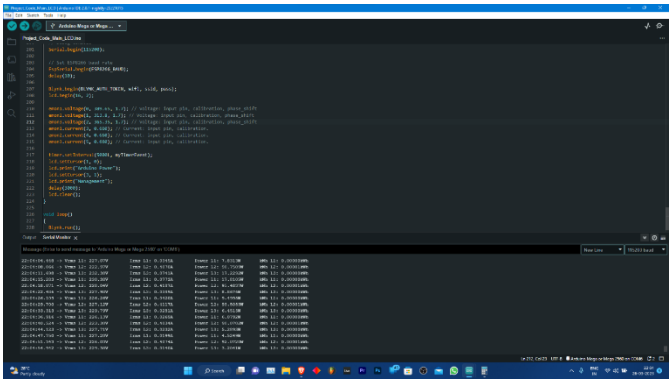
The Voltage sensor is connected parallel and the current sensor is connected in series to the circuit. These sensors sense the voltage and current values of the power line given to the load. A relay is also connected in series with the load which will switch ON or OFF the load. The Arduino board receives the values and calculates the RMS Voltage, RMS Current, Power factor, Real power, and Apparent power based on the values from the sensors. Then the Arduino board shares the calculated parameters with the cloud IoT Platform (Apps like blynk) through the Wi-Fi module (ESP-8266) connected to it. The parameters will be shared via Wi-Fi. The buttons for Turning ON and OFF the loads are also given in the app. The Arduino board can also automatically isolate the load from the power line if there is low voltage, overvoltage or overcurrent through the load. With this poor lagging power factor, low voltages, overloads, etc., can be eliminated. This system reduces repair costs and ensures an efficient operation of loads connected to the power line.

VIII. REAL TIME INTERFACE



Interface

The interface would look like this. In this app, all details of electricity (Voltage, Current, Power, Energy, Power Factor) can be viewed in the app. The parameters can also be recorded in a graph where the values of respective parameters can be seen according to time. Buttons will also be provided to control the load wirelessly from anywhere. This is a very useful and at the same time, efficient method of management of loads from anywhere in the world. Here only Voltage and power of the respective lines are shown here. In the same way, current and energy consumed by the respective line can be shown. The output from the serial monitor in Arduino IDE is similar to what is shown here. In the serial monitor, we can see additional informations like connection status, ping, etc. This can be used for easy debugging.



Output from Serial Monitor

IX. ADVANTAGES AND CONCLUSION

ADVANTAGES:

1.Individual Components like voltage, current and calculated parameters like power and Energy can be monitored.

2.We could monitor and control the energy consumption anywhere.

X. CONCLUSION

This paper is useful in many ways. This can be used where electrical energy is consumed, such as Home, Industries and many more places. This can benefit the user and ensure that the electricity is used in an efficient way. The user can now turn off a load even if he is away from the site. So that he or she can maintain efficient operation. This acts as a power and energy meter so the user can know how much energy is consumed in user's premises. This can also act as a maximum demand controller which can turn off loads in a hierarchical way. So this system gives benefits in many ways. This replaces many meters and controllers. The user can also expand much more and monitor the energy consumption in many different locations where the system is installed. So the user can monitor the electrical energy consumption of other sites from a single place.

This is just a paper with base level components. This system can be upgraded to much more high accurate sensors. The Arduino can be replaced for a raspberry-pi. The voltage and current sensors can be upgraded for much higher rating and accurate sensors. The relay boards can be upgraded for much more higher voltage and current rating. This system can be expanded for more power lines. Up to eight power lines can be monitored with the capabilities of Arduino mega. This number can be extended in case of future upgrading of power lines. So this system is beneficial in upgradability, monitoring and control.

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