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Residential Energy Consumption Management Using ATMega2560 MCU

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ABSTRACT: The major purpose of a smart residence is to ensure proper usage of electricity in an economic and optimised manner. In an effort to make push forward the energy management capability of a smart residence, this paper describes the design, development and implementation of an automatic single phase energy consumption management of a residential management of a residential infrastructure. The following paper deals with the measurement of power and energy using the Arduino. The demand for power has drastically increased over the last decade, thereby giving arise to numerous problems in energy management. One of the many ways of tackling the problems of energy management is by reducing the energy usage with the help of a microcontroller in a residential infrastructures. This provides an ample solution by implementing a condensed design prototype that measures, monitors and manages the residential energy consumption by employing the use of an electronic microcontroller. When properly applied in a residential infrastructure, the system will significantly reduce the total energy consumption in a significant saving in electricity bill.

KEYWORDS: Energy Management, Smart Residence, Measurement, Power and Energy, Arduino

I. INTRODUCTION

Energy the capacity to do work. It is partially impossible to estimate the actual magnitude of the part that energy has played in developing the present day utilization the availability of large amount of energy in modern time has resulted in lesser use of man power higher agriculture and industrial production and better transportation facilities. As matter of fact, there is closer relationship between the energy used person and his standard of living. However based on the lines above, we can deduce that energy is very important factor for life. To be particular electrical energy is given at most importance. Therefore, it is our duty spend this energy judiciously and prevent the unnecessary and lavish usage to make way for the future generation to generate energy and use it accordingly. Having said that, it is in the very human nature that rate of negligence these obey resulting in uneconomical use of energy.

Energy exists in different forms in nature but the most important form is the electrical energy. The modern society so much dependent upon the use of electrical energy that is has become a part and parcel of our life. Broadly there are four major energy end use sectors

1. Commercial.
2. Industrial.
3. Residential.
4. Transportation.

This paper deals with the residential end user of electrical energy. We believe, energy can be managing the conserved in many ways. One of such ways is by consumption of electrical energy in a residential infrastructure. Our main focus is to develop a control system which measures, monitors and manage the energy consumption of a residential by effectively managing the loads of the residence. With the help of today's digital technological advancement, we use a microcontroller to manage the loads and monitor them. So that unnecessary use of energy is avoided and a significant savings in the energy is achieved.

The state at which work is done in an electric circuit is called electric power i.e.

$$\text{Electric power} = \frac{\text{Work done in electric circuit}}{\text{Time}}$$

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However, $P = \frac{Work}{t} = \frac{V\,I\,t}{t} = V \times I$ = Voltage in volts × current in amps.

Its unit is Joule/second or Watt. The power consumed in circuit is One Watt if a p.d of 1V causes 1A current to flow through the circuit.

The total work done in an electrical circuit is called Electrical energy.

Electrical energy = Electrical power × Time (in seconds).

Joule or Watt –sec is a very small unit of electrical energy, bigger units via,. Watt hour and kilowatt- hour are used.

1 Watt- hour = 1Watt ×1hour.

= 1Watt × 3600 seconds = 3600 Watt-seconds.

1 kilo-watt hour (kWh) = 1kW × 1Hr = 1000 Watt ×3600 Seconds.

$= 36 \times 10^5$ watt-sec.

II.LITERATURE SURVEY

When talking about load management, the prerequisite issue is to mention about the measurement or rather monitoring of the energy usage in the system. That is when the energy usage is quantified it becomes viable for the consumers to plan the energy savings. Some researchers have already worked in the area of home energy measurements using microcontrollers. T. M. Chung[2] developed a single phase power meter using Arduino microcontroller. The prototype calculates the voltage, current and active power of the load using instantaneous calculation method. The system is 96.54% accurate, though it is limited to measuring active power, voltage and current to a maximum of 13A current.

Similar work has been done by **P. Srividyadevi**[5]in which power and energy of a single phase system is measured using Arduino.

The Power Meter project described by **C. Jao** and **X. Guo**[4]presented another interesting work in power measurement. It is interesting that the opto-isolator IC provides isolation between the main circuit and Arduino. The validation of the project work with a load of 50W using commercial measuring device shows an error of up to 5.13% in current measurement. On the other hand there are researchers that focused on the energy management in their works.

Qinran Hu and **Fanxing Li**[3]presented a hardware design of a smart home energy management system (SHEMS) with communication, sensitivity technology and machine learning algorithm applications. The system is equipped with sensors that detect human activities in the house and intelligently helped the consumers to reduce their total energy consumption automatically. Simulation and testing of the prototype shows that it is capable of reducing the loads during the peak hours by about 10 percent which is significant, though there may be need to extend some of the sensors and load interfaces for increased number of appliances.

Ninad K.[6] developed a non-intrusive load monitoring system utilizing zigbee communication. The system maintains the power consumption below the threshold level by reducing the non-essential loads when it is overloaded.

Abubakar, I & Khalid, S. & Mustafa, Mohd & Mustapha, Mamunu & Shareef, Hussain[1]developed a smart module for load management which involved the use of current sensor, voltage sensor and the switching operation was performed by relays. However, the scope for remote operation of loads was not given.

II.I. HARDWARE COMPONENTS USED

Fig.1. Arduino Mega Board

Arduino Mega: Arduino board is an open-source microcontroller board which is based on ATMega 2560 microcontroller. The growth environment of this board executes the processing or wiring language. These boards have recharged the automation industry with their simple to utilize platform wherever everybody with small otherwise no technical backdrop can start by discovering some necessary skills to program as well as run the Arduino board. These boards are used to extend separate interactive objects otherwise we can connect to software on your PC like Max MSP, Processing, and Flash.

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The microcontroller board like "Arduino Mega" depends on the ATmega2560 microcontroller. It includes digital input/output pins-54, where 16 pins are analogue inputs, 14 are used like PWM outputs hardware serial ports (UARTs) – 4, a crystal oscillator-16 MHz, an ICSP header, a power jack, a USB connection, as well as an RST button. This board mainly includes everything which is essential for supporting the microcontroller. So, the power supply of this board can be done by connecting it to a PC using a USB cable, or battery or an AC-DC adapter. This board can be protected from the unexpected electrical discharge by placing a base plate

ACS712 Current Sensor: Hall Effect Sensors are transducer type components that can convert magnetic information into electrical signals for subsequent electronic circuit processing. Generally, current sensors use the Hall Effect to convert current inputs into voltage outputs. In the Hall Effect, electrons from an electric current flow through a magnetic field plate. The field then causes the electrons to "push" to one side of the plate and produce a voltage difference between the two sides. The difference in voltage from the side of the plate is the output of the sensor.
ACS712 is a current sensor that can operate on both AC and DC. This sensor operates at 5V and produces an analogue voltage output proportional to the measured current. This tool consists of a series of precision Hall sensors with copper lines.

We decided to conduct an experiment in order to determine the operating characteristic of the current sensor. Thus, the following findings were found as shown in Table 1.

Load in Watt	Applied Value of Current in Amps	Sensed Value of Current in Amps	Percentage Error
200	0.86	0.95	10.46
400	1.72	1.72	0
600	2.58	2.55	-1.16
800	3.44	3.42	-0.58
1000	4.30	4.22	-1.86
1200	5.16	4.98	-3.48

Table 1. Current Sensor reading tabulation

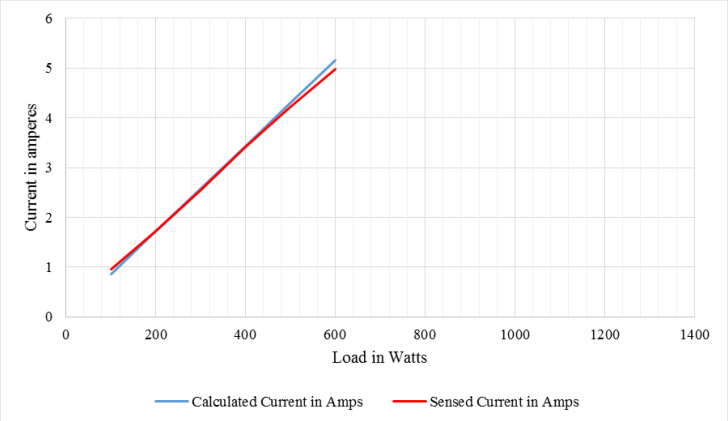

Fig.2. Plot of Calculated current and Sensed Current

ZMPT101B Micro-Transformer based Voltage Sensor: The ZMPT101B voltage sensor module is a voltage sensor made from the ZMPT101B voltage transformer. It has high accuracy, good consistency for voltage and power measurement and it can measure up to 250V AC. It is simple to use and comes with a multi turn trim potentiometer for adjusting the ADC output. The analysis in this paper tends to find more accurate relationship between the input voltage and the ADC output by regression analysis. The ADC output is adjusted using the trim pot to an appropriate value against a reference input. Below is the ZMPT101B voltage sensor module. We found the following results when we carried out an experiment by measuring the voltage with conventional voltmeter and with the voltage sensor.

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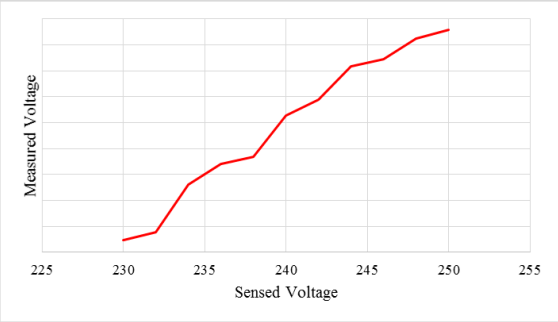

Fig.3. Plot of Measured Voltage and Sensed Voltage

HC-05 Bluetooth Module: The HC-05 is a module which can add two-way (full-duplex) wireless functionality to our projects. We can use this module to communicate between two microcontrollers like Arduino or communicate with any device with Bluetooth functionality like a Phone or Laptop. There are many android applications that are already available which makes this process a lot easier. The module communicates with the help of USART at 9600 baud rate hence it is easy to interface with any microcontroller that supports USART. We can also configure the default values of the module by using the command mode.

III.PROPOSED SYSTEM

It is hard to analytically determine the optimal use of power in residence so this proposed system gives the information about power consumption and tool to manage the power consumption. This proposed system gives scope for the design and implementation of an automatic/user controlled single phase energy consumption management of a smart house.

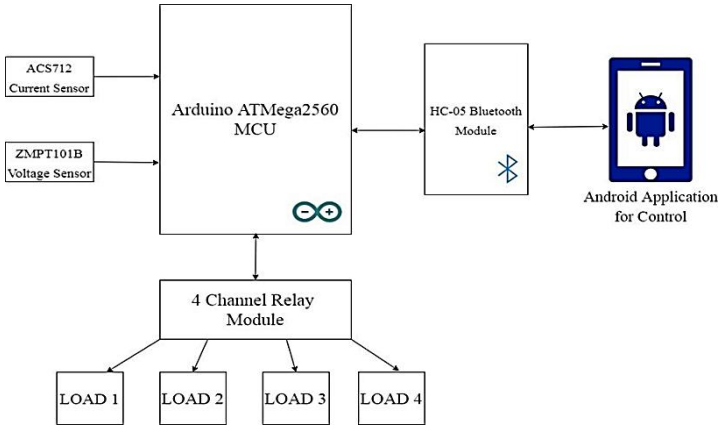

Fig.4. Block Diagram of the module.

Voltage sensor: The voltage sensor takes the input of voltage and converts it into an analogue value and sends it to the microcontroller unit.

Current Sensor: The current sensor takes the input of current and converts into an analogue value and sends it to the microcontroller unit.

Microcontroller Unit: The microcontroller unit (Arduino Mega 2560) receives the output from voltage and current sensors. Since the values will be analogue in nature, the built in analogue to digital converter (ADC) converts the analogue value into digital value. Further, the data from the voltage and current sensors are monitored continuously. If there is an excess of load, the relay will trip and it can be turned ON after the load is below the set limit via bluetooth android application. The microcontroller will wait for the user to switch off any unnecessary load. If not, the microcontroller will perform priority based tripping of relay. The process is real time.

The bluetooth module acts as a communication medium between the mobile application and the microcontroller unit. It is two way communication.

We also developed a mobile application in order to provide user the control of loads remotely, the mobile application communicated with the microcontroller via bluetooth module. The mobile application display the data of consumption

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such as current, voltage and power. Further switching operation is provided in the application in order to operate the relays. If the user doesn't take any action, the relays will be tripped on a priority basis.

The flowchart of operation is given as follows:

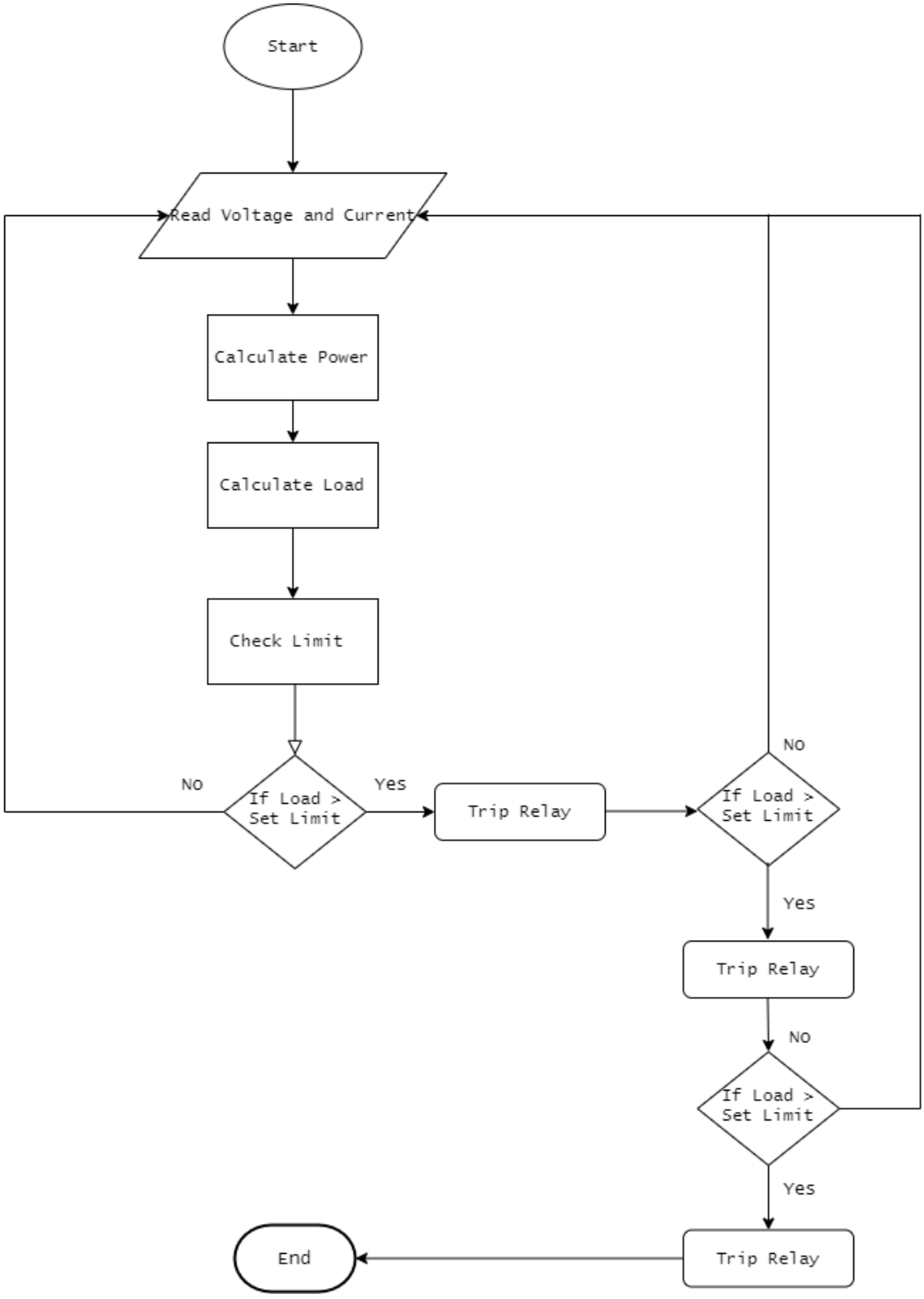

Fig. 5 Flowchart of operation

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IV.RESULT AND DISCUSSION

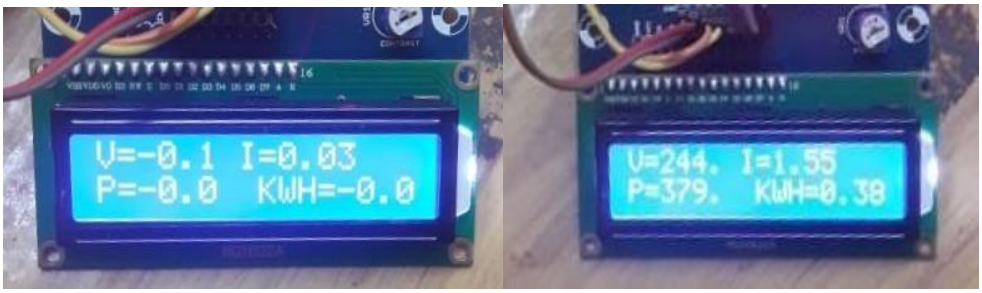

Fig. 6 Display results in LCD

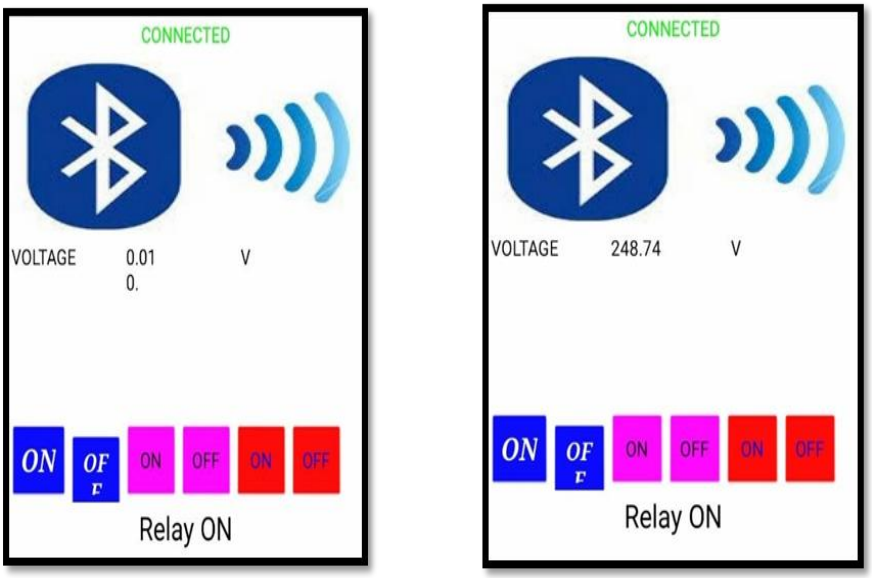

Fig.7 Output Results in mobile application via Bluetooth.

If the power exceeds more than threshold value the relay will trip. For example,

1. For Relay 1 the range is from 0 to 380W if it exceeds threshold value relay 1 will trip.
2. For Relay 2 the range is from 380W to 400W if it exceeds threshold value relay 2 will trip.
3. For Relay 3 the range is from 400W to 420W if it exceeds threshold value relay 3 will trip.

Sl.No	Power limit	Voltage	Current	Power	KWH	Relay Status
1	0 - 420W	0.0	0.0	0.0	0.0	ON
2	Relay 1	244.0	0.63	155	0.155	ON
3		244.5	1.55	379	0.379	ON
4	(0 – 380W)	240.0	1.58	381	0.381	OFF
5	Relay 2	241.0	1.59	385	0.385	ON
6	(380 W– 400W)	249.2	1.57	392	0.392	ON
7		252.0	1.59	401	0.401	OFF
8	Relay 3	255.3	1.60	410	0.410	ON
9	(400 W– 420W)	257.0	1.60	413	0.413	ON
10		243.5	1.72	421	0.421	OFF

Table.2. Output readings from the model.

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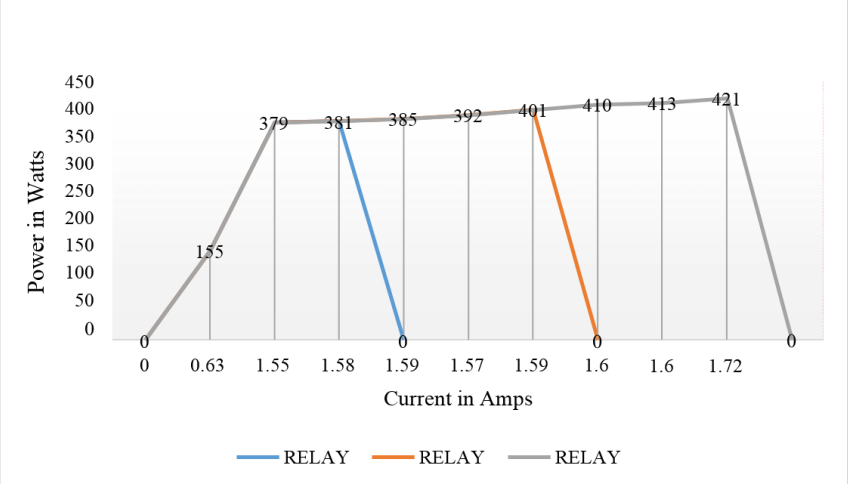

Fig.8.Plot of Power (load) and current.

Advantages

- It is compact in size and user friendly.
- It can be tailored as per the user's need.
- It can be operated remotely via bluetooth.
- Energy saving can be achieved over a period of time thereby resulting in a significant saving in electricity bill.
- It is affordable.

Disadvantages

- The sensors have to be calibrated very accurately or else leads to high error in measurement and as a chain reaction unnecessary tripping of relays takes place.
- Proper protection has to be provided to the module. High currents may lead to damage of the equipment

Future Scope

- The prototype will become more effective when IoT is introduced in it.
- The user interface in the mobile application can be improved in the future.
- More number of loads can be connected using an edge-triggered flip-flop and multiplexer circuits.
- Cost can be reduced when manufactured in bulk quantities.
- In the emerging trend of Artificial Intelligence and Machine Learning, a fully automated module can be developed using the base design and can be designed to operate without human intervention being fully automated.
- Using Machine Learning, the module can be designed to learn usage pattern and adapt accordingly

V. CONCLUSION

This paper serves as a basic idea that enables all future smart residence ideas. In the process of developing this system, a reliable performance analysis was done on the voltage and current sensors, and also their response was found. The prototype is capable of measuring, monitoring and controlling loads effectively such that it does not allow excess consumption of power beyond the threshold limit and a feature of automatic reconnection capability is also provided. The parameters such as voltage, current and power are displayed in the LCD.

REFERENCES

[1] Abubakar, I & Khalid, S. & Mustafa, Mohd & Mustapha, Mamunu & Shareef, Hussain. (2018). Residential Energy Consumption Management Using Arduino Microcontroller. Advanced Science Letters. 24. 3887-3893. 10.1166/asl.2018.11505. pp-2

[2] K. Baraka, M. Ghobril, S. Malek, R. Kanj and A. Kayssi, "Low Cost Arduino/Android-Based Energy-Efficient Home Automation System with Smart Task Scheduling," 2013 Fifth International Conference on Computational Intelligence, Communication Systems and Networks, Madrid, 2013, pp. 296-301, doi: 10.1109/CICSYN.2013.47.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 9, Issue 5, May 2020||

[3] Tiong, Meng Chung and Daniyal Hamdan. "Arduino Based Power Meter Using Instantaneous Power Calculation Method." (2015). VOL. 10, NO. 21, NOVEMBER 2015, ISSN 1819-6608

[4] Jao, C.; Guo, X.;. (2008, May). PowerBox: The Safe AC Power Meter. Retrieved from Cornell ECE476 course site: http://instruct1.cit.cornell.edu/courses/ee476/FinalProjects/s2008/cj72_xg37/cj72_xg37/index.html

[5] Srividyadevi P, Pusphalatha DV, Sharma PM. Measurementof Power and Energy Using Arduino. Research Journal of Engineering Sciences 2013.

[6] Hu, Qinran and Fangxing Li. "Hardware Design of Smart Home Energy Management System With Dynamic Price Response." IEEE Transactions on Smart Grid 4 (2013): 1878-1887.

[7] Ninad Khandekar, Kalpak Thube, Nilesh Patil, Dr P. B. Mane, 2014, Non-Intrusive Appliance Load Monitoring System Using Zigbee Protocol, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) Volume 03, Issue 04 (April 2014).