iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** X **Month of publication:** October 2015

DOI:

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Home Automation and Energy Management Using Smart Phone

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Abstract – This paper is about the prototype project of design and implementation of wireless remote control system for automation of home appliances and energy management using smart phone. In this system microcontroller remotely controls the appliances through GSM module at any time and any place provided with cellular network coverage. This system is very useful for the determination of energy or power consumption of appliances and calculation of electricity bill according to power consumption, user can monitors the power consumption and electricity bill on its smart phone at any time and any place provided with GSM coverage. A separate hardware module is designed for Power Factor measurement. Instantaneous current is sensed by SCT-013 current sensor and voltage is sensed by voltage transformer, the Arduino Uno board is used to calculate Power Factor.
Keywords-GSM Module, Microcontroller 8051, Arduino Uno, Current Sensor.

I. INTRODUCTION

In recent years, the smart home concept has been growing among the consumers. Smart homes have many, connected devices such as home amusement consoles, warning devices, flashing, and admission control systems and monitoring system. Intelligent home automation system is integrated into smart homes to deliver comfort, satisfaction, and safety to homeowners. Home automation system depicts and outlines the status of the linked devices in an instinctive, user-friendly interface permitting the user to communicate and manage various appliances with the stroke of a few buttons. Some of the important communication technologies employed by today's home automation system cover Wi-MAX, Bluetooth, Wireless LAN (Wi-Fi), Zig-bee, and Global System for Mobile Communication (GSM). Among all GSM is one of the most broadly used wireless technologies in the world. With the rise in the number of GSM customers, research and development is duly supported in advance investigating the GSM implementation. Among the wireless technologies, GSM network is selected for the communication between the home devices and the user due to its broad spread coverage another benefit of using the GSM network in home automation is its highly shielded infrastructure, which provides maximum accuracy whereby other people cannot observe the information transmitted and received. Hence, this research work executes SMS based command for home appliances using android application interfaced with the GSM architecture without accessing the local network. Today's competitive world, the power and energy sector of any country plays a major role in the growth of domestic, industrial, agricultural, telecommunication, and education sectors. Electricity is the crucial requirement for living a comfortable life and it has to be properly used and managed electrical metering instrument technology has come a long way from what it was more than 100 years ago. From originally bulky meters with heavy magnets and coils, there have been many innovations that have resulted in size & weight reduction and also, improvement in features and specifications of meters. An electric meter or Energy Meter is a device that measures the amount of electrical energy supplied or consumed by a residence, business or machine. The most common type is a kilowatt hour meter. Modern electricity meters operate by continuously measuring the instantaneous voltage (volts) & current (amperes) and finding the product of these to give instantaneous electrical power (watts) which is then integrated against time to give energy used (joules, kilowatt-hours etc). The meters fall into two basic categories, namely the electromechanical meter and the electronic meters. The most common type of electricity meter is the Thomson or electromechanical induction watt-hour meter, invented by Elihu Thomson in1888. Resolution and accuracy of the meter has seen substantial improvements over the years. Presently, microcontrollers are playing a major role in metering instrument technology. The Automatic Meter Reading system is intended to remotely collect the meter readings of a locality using a communication system, without persons physically going and reading the meters visually.

II. HARDWARE IMPLEMENTATION

To implement the automation and energy management system analog Energy Meter, microcontroller, opt coupler, MAX232, ULN

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2003 Relay driver IC, Relays, LCD Display, Controlled load, resistors, capacitors, LM7805 Voltage regulator, Diodes, step down transformer, smartphone are used. Input command is given by the user from a smart phone. The command received by the microcontroller through GSM module. The microcontroller execute these commands. The power consumed by the load calculated by the analog Energy Meter, LED blinks on the analog Energy Meter proportional to the power consumed by the load. The microcontroller calculates the power by using the frequency of blinking of LED. Microcontroller sends the power consumed and status of the appliances to smart phone using GSM module. Arduino microcontroller connected to the load through current and voltage transformer. The hardware platform developed consists of following modules.

AT89C51 Microcontroller
Arduino Microcontroller
Energy Meter
Relay module
Current Transformer
Optocoupler
GSM module
Liquid crystal display

A. Overview Of AT89S52

The operation of the Smart Meter is based on the program embedded in the AT89S52 Microcontroller. The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly flexible and cost-effective solution to many embedded control applications. The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents, but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.

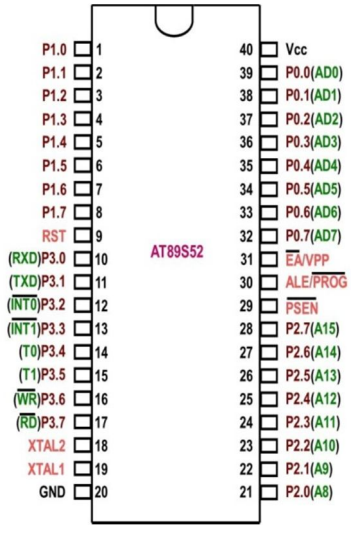

Fig.1 AT89S52Microcontroller PIN Diagram

B. Overview Of Energy Meter

Electronic Energy Meter is based on Digital Micro Technology (DMT) and uses no moving parts. So the EEM is known as "Static Energy Meter" In EEM the accurate functioning is controlled by a specially designed IC called ASIC (Application Specified

Integrated Circuit). ASIC is constructed only for specific applications using Embedded System Technology. Similar ASIC is now used in Washing Machines, Air Conditioners, Automobiles, and Digital Camera etc. In addition to ASIC, analogue circuits, Voltage transformer, Current transformer etc. Are also present in EEM to "Sample" current and voltage. The 'Input Data' (Voltage) is compared with a programmed "Reference Data' (Voltage) and finally a 'Voltage Rate' will be given to the output. This output is then converted into 'Digital Data' by the AD Converters (Analogue- Digital converter) present in the ASIC. The Digital Data is then converted into an "Average Value". Average Value / Mean Value is the measuring unit of power. The output of ASIC is available as "Pulses" indicated by the LED (Light Emitting Diode) placed on the front panel of EEM. These pulses are equal to the Average Kilo Watt Hour (kWh / unit). Different ASIC with various kWh are used in different makes of EEMs. But usually 800 to 3600 pulses / kWh generating ASIC s are used in EEMs. The output of ASIC is sufficient to drive a Stepper Motor to give display through the rotation of digits embossed wheels. The output pulses are indicated through LED. The ASIC are manufactured by Analogue Device Company. ADE 7757 IC is generally used in many countries to make EEMs.

Fig. 2.0 Energy Meter

C. Overview Of GSM Modem

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to the mobile operator, just like a mobile phone. From the mobile operator perspective, a GSM modem looks just like a mobile phone. When a GSM modem is connected to microcontroller, this allows the microcontroller to use the GSM modem to communicate over the mobile network. While these GSM modem is most frequently used to provide the internet connectivity, many of them can also be used to send and receive the SMS and MMS messages.

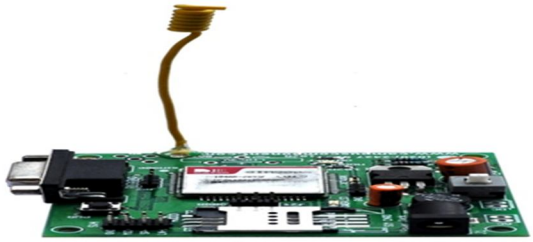

Fig.3 GSM Modem

D. Overview Of Arduino

Arduino is an open-source electronics prototyping platform, mostly based on small, easy-to-use hardware and software. Analog pins of Arduino receives instantaneous analog voltage and current. Arduino is programmed to calculate the Power Factor. The instantaneous Power Factor is observed on the Arduino serial port..

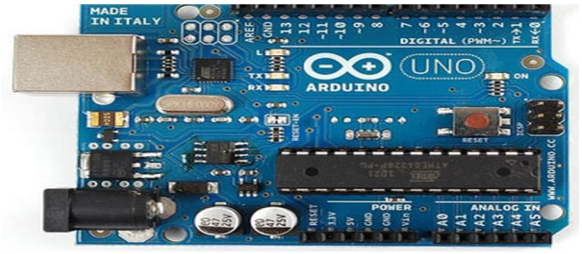

Fig.4 Arduino Uno

The Adruino UNO board as shown in Fig.3 features an ATmega328 microcontroller operating at 5V with 2KB of RAM, 32KB of flash memory for storing programs and 1KB of EEPROM for storing parameters. The clock speed is 16 MHz, which translates to about executing about 300,000 lines of C source code per second. The board has 14 digital I/O pins and 6 analog input pins. The Arduino programming language is a simplified version of C/C+ If anyone one knows C programming the The Arduino Uno will be

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familiar. If not, know C, no need to worry as only a few commands are needed to perform useful functions. We can implement any logic with C programming in Arduino.

III. WORKING OF PROJECT

The figure shown below is the simple block diagram of the project. It is the simple illustration how the implemented project and various parts involved in it. From the below representation. The first smart phone is used as a transmitting section from which user sends text messages that contain a command and instruction to the GSM module. The GSM module is installed in a specific location where automation system is Located. The mobile phone indicated in the block diagram is used to send the message. The received message is stored in the SIM memory, then extracted by the microcontroller and processed accordingly carry out specific operation. The relay driver is used to drive the relay circuits which switches different appliances connected to the interface. The LCD is used to indicate the status of operation performed by the microcontroller. The microcontroller continuously monitors and records the Energy Meter reading in its permanent memory location. The GSM modem is used to transmit Energy Meter reading. The store and forwarding feature of SMS allow reliable Energy Meter reading delivery. The stored message is archived in smart phone can retrieve for billing purpose.

The Arduino in the block diagram is programmed for Power Factor measurement calculation. The Arduino block is connected to current conditioning circuit and voltage conditioning circuit. The voltage and current conditioning block are basically the potential divider circuit consist of capacitors and resistors and is used to convert the voltage to the Arduino voltage level. so that it can be easily compatible with Arduino. The current and voltage transformer measures the instantaneous current and voltage of the load.

IV. CIRCUIT DIAGRAM OF COMPLETE SYSTEM

The below figure shows the complete circuit diagram. As show in the circuit diagram microcontroller port 1 pins are connected to the data pins of the LCD. In the circuit common ground terminal is used. The microcontroller X1 and X2 pins are connected to the crystal oscillator. The analog Energy Meter is connected to the microcontroller through Optocoupler and relay circuit. Port P2.0 monitors and records the pulses of the Energy Meter.

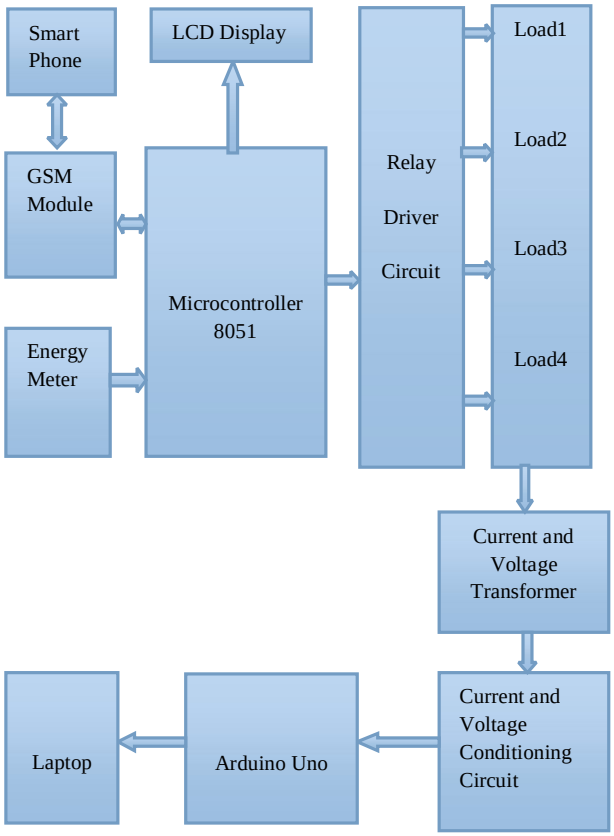

Fig. 5 Block Diagram

The port P2.2 of the microcontroller is connected to the GSM modem interrupt pin. On miss call the interrupt signal of GSM modem gets enabled. Port3 pin number P3.0 and P3.1 are connected to transmit and receiving pin of the GSM modem through MAX232 IC and port0 of the microcontroller is connected to the relay driver IC ULN2003A.Relay driver IC is then connected to the relay module later to the appliances. In the circuit a separate regulated power is being used 5V power supply used to drive the circuit.

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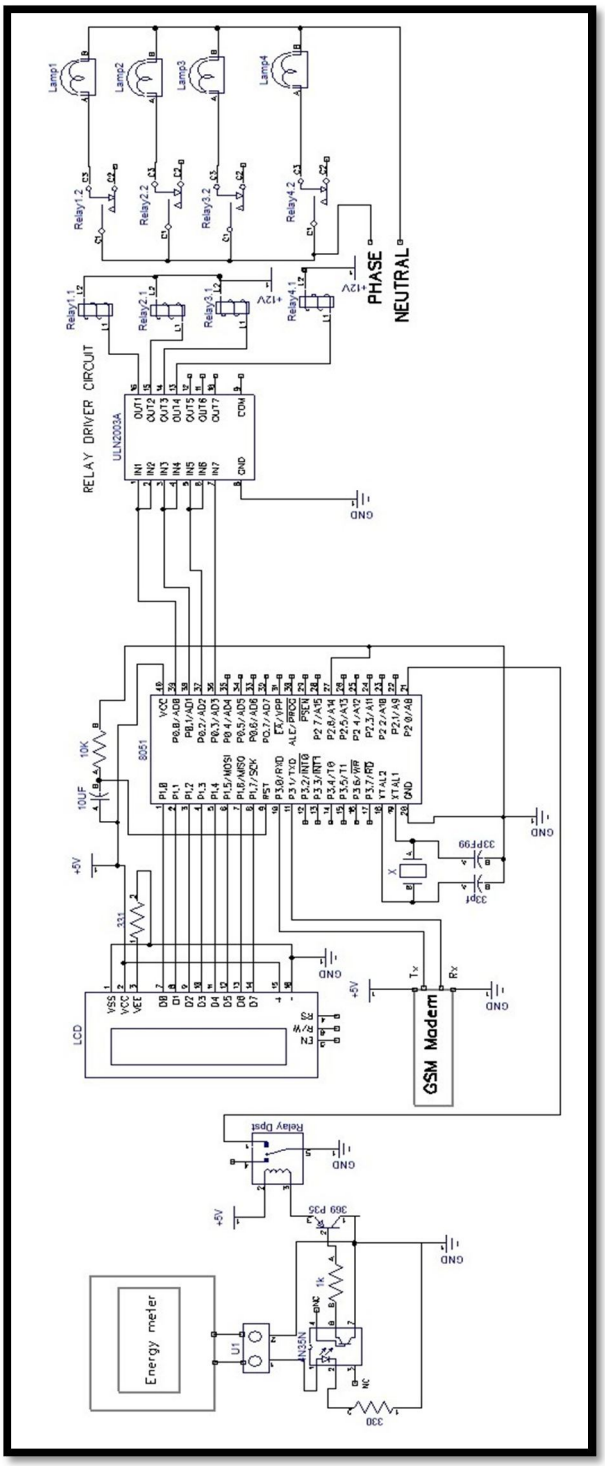

Fig.6 Circuit Diagram

V. FLOW CHART

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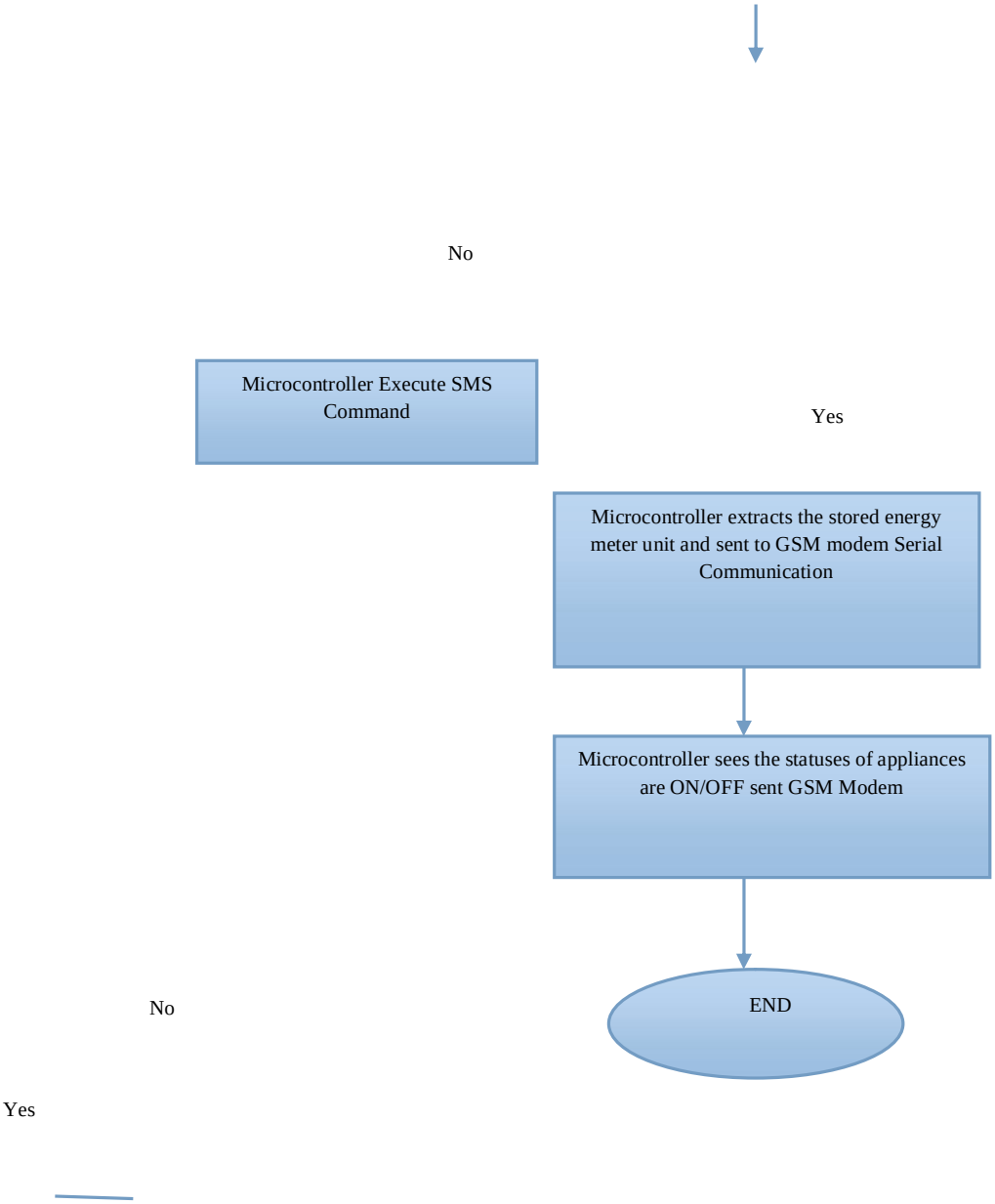

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VI. RESULT AND DISSCUSSION

After designing, developing and implementing the Home Automation and Energy Management System for controlling the home appliances by sending the SMS from mobile phone at any remote location, also can get the status of number of appliances are ON and OFF and the energy consumed by the appliances. The power management circuit in the project measures the voltage, current, and Power Factor.

Table 1 SMS Commands to control load

LIST OF COMMANDS FROM MOBILE	EXPLANATION OF COMMANDS
X_1	It makes load 1 ON
X_2	It makes load 2 ON
X_3	It makes load 1 and load 2 ON
X_4	It makes load 3 ON
X_5	It makes load 1 and load 3 ON
X_6	It makes load 2 and load 3 ON
X_7	It makes load 1, load 2 and load 3 ON
X_8	It makes load 4 ON
X_9	It makes load 4 and load 1 ON
X_a	It makes load 4 and load 2 ON
X_b	It makes load 4, load 2 and load 1 ON
X_c	It makes load 4, load 3 ON
X_d	It makes load 4, load 3 and load 1 ON
X_e	It makes load 4, load 3 and load 2 ON
X_f	Status of number of loads are ON/OFF and calorie consumed by load

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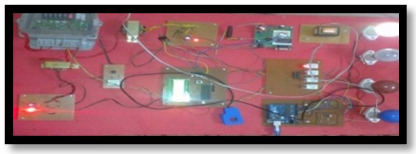
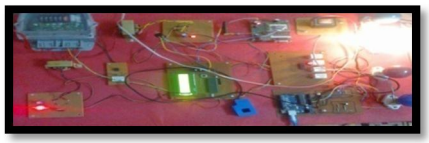
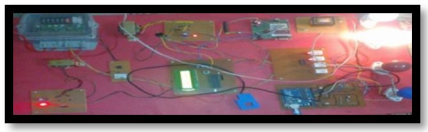
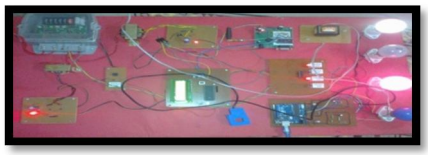
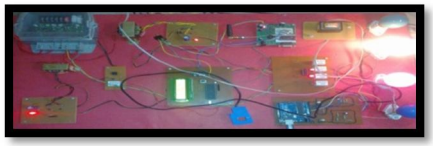
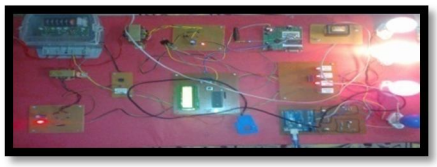
Table 2 SMS Commands and Output

COMMAND	OUTPUT
X_1	
X_2	
X_3	
X_4	
X_5	
X_6	
X_7	

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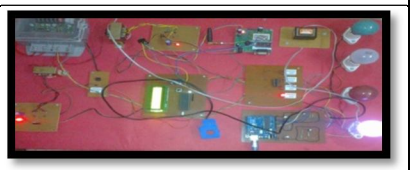
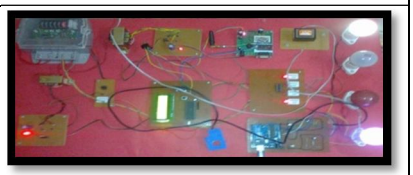
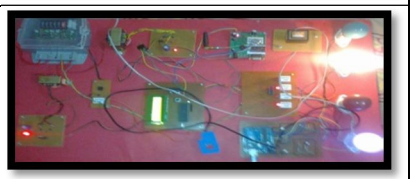
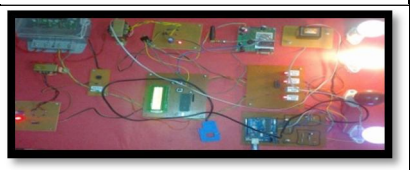
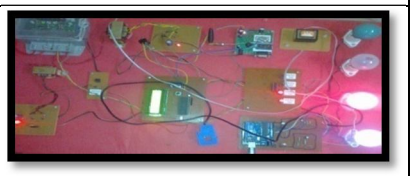
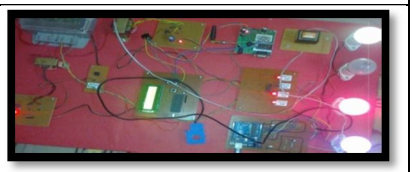
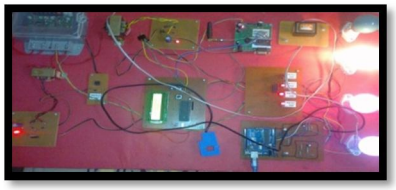
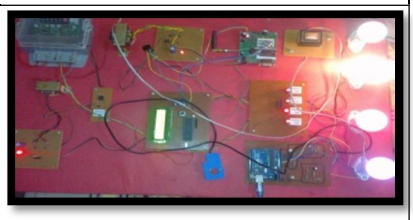
COMMAND	OUTPUT
X_8	
X_9	
X_a	
X_b	
X_c	
X_d	
X_e	
X_f	
LCD OUTPUT	

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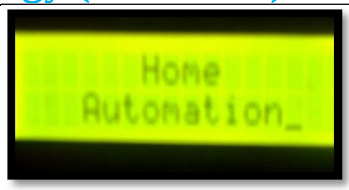
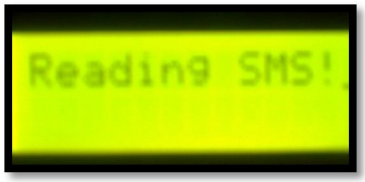
Initially LCD Displays "Home Automation"	
On Miss call to GSM Module Number	
Energy consumed by the loads is expressed in terms of calories	
Displays of "calories: -- and SMS Sent" on LCD	

Power Factor Reading at Arduino Serial Port

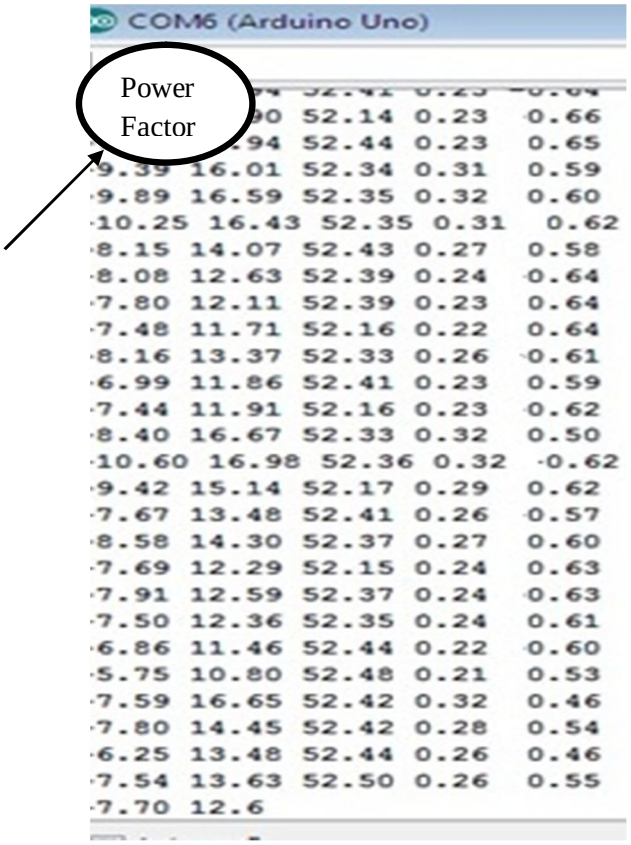


Fig. 7 Arduino Uno (COM6) Output

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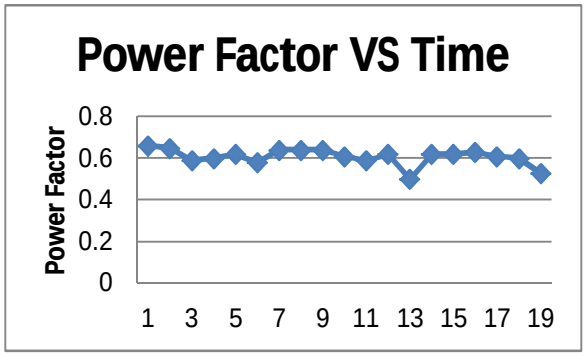
Power Factor Vs Time



VII. CONCLUSIONS

A flexible, economical and echo-friendly Home Automation and Energy Management System using Android, GSM and Microcontroller has been designed to meet the rising energy demand . The designed system comprises a Smart Meter at the consumer end and a server at utility end. The smart meter has been designed using a low cost AT89S52 microcontroller, DS137 RTC, 16x2 LCD, ULN2003 relay drive, SPDT relay and GSM module. The circuit for the Smart Meter was simulated in "Proteus 7" and the microcontroller embedded programming was done on "Kiel µvision 3". Printed Circuit Board (PCB) was designed using "Orcad 9". Separate monitoring of energy consumption, sending the energy consumption data as well as code corresponding to energy theft detect alert and activating/deactivating the consumer power supply on utility commands are achieved by the program embedded on the microcontroller of the smart meter generating electricity bill automatically. The designed system is having the following merits.

Economical: Implementation of home automation and energy management will, not only makes the public vigilant in their electricity bill and hence the electrical energy consumption, but also create awareness among the public about significance of energy conservation. This decreases the electricity bill of the consumer. Eliminates the labor of meter data collection: Automatic Meter Reading is one of the features of the Smart Metering. Since smart meter measures the energy consumption data wirelessly, the laborious and inappreciable task of manual data collection will be eliminated. This will also eliminates the corruption possibility made in meter data collection. Remote detection of energy theft and meter fault: Smart Meter detects energy theft and faulty meters remotely. The utility can take actions as the earliest on these situations. This will decrease the financial loss due to missing of energy consumption data. Automatic Generation of Electricity Bill: At the end of the billing span, microcontroller program automatically generate electricity bill and store in the secondary memory of the server. This decrease the hard work of data entry person .

VIII. FUTURE SCOPE OF THE WORK

Home Automation and Energy Management based on controlling of appliances and daily electricity expenditure can be used to save and manage the energy efficiently.

If designed by using artificial intelligence and can be used efficiently.

Complexity of code used in the project can be minimized with the help of user friendly software.

It can be used at large scale very easily if it is properly programmed.

It can be used at large scale very easily if it is properly programmed.

Now days, energy crisis is getting serious issue. Energy management is one of the methods to control the energy crisis and utilize the electrical energy in proper and efficient way. This software will give a new insight to normal people in managing the electrical energy properly.

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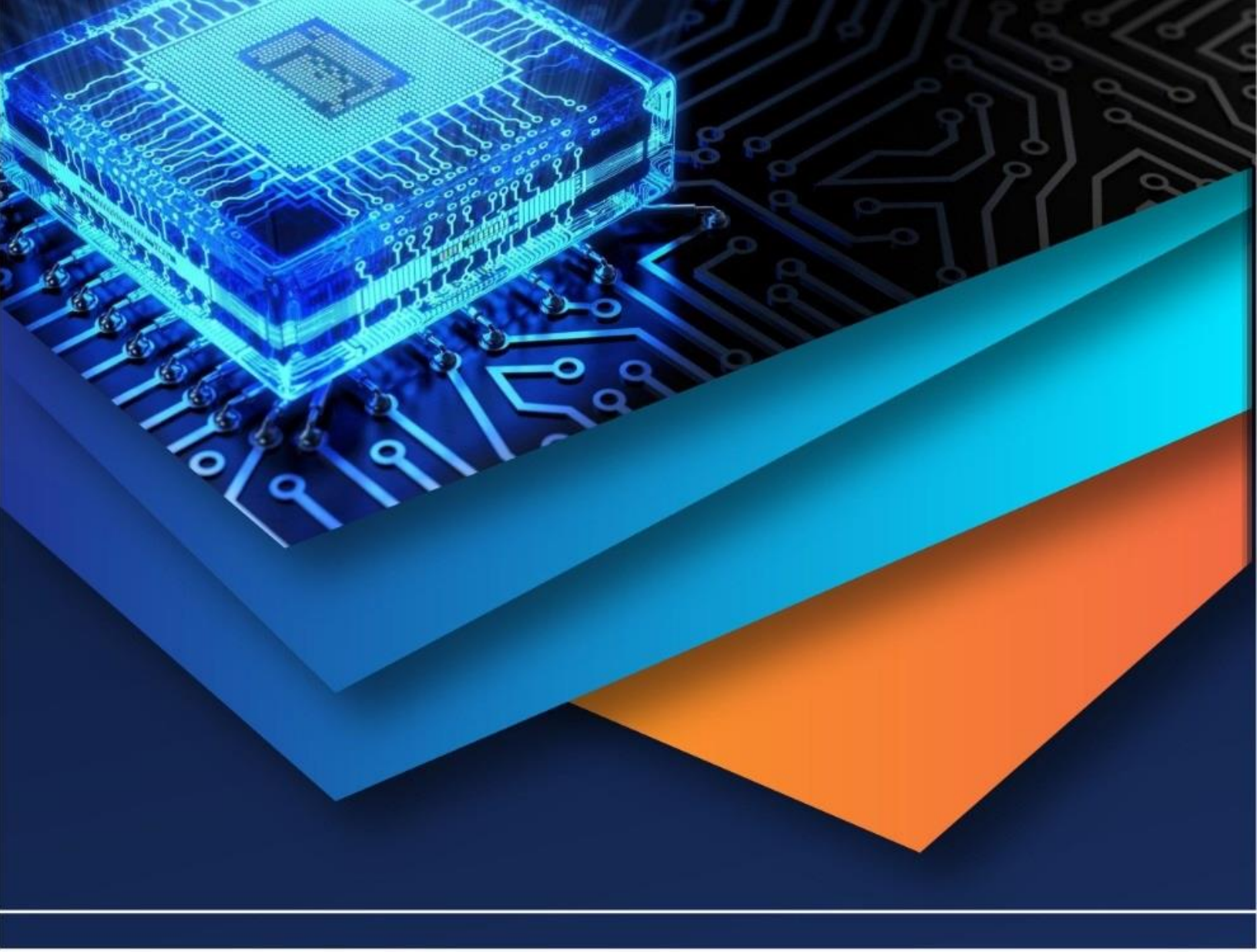

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