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GSM BASED ENERGY MANAGEMENT SYSTEM

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Abstract

In India, the energy meteringis an expensive and time consuming job. This paper provides a convenient and efficient method to avoid this problem, wherein the electricity officetakes the readings of individual consumers using GSM. The main objective of the paper is to control the status of the loads via a GSM modem and develop a wireless based energy meter reading system.The PIC microcontroller takes the reading from the energy meter, i.e. the pulse count coming from the digital energy meter and displays the reading on the LCD. The reading of the energy meter is also sent to the control room by a message via GSM modem.The operators mobile number is auto saved on the microcontrollerthrough a missed call from the user. This GSM modem also receives the commands from any cell phone to control the electrical loads. It uses a standard energy meter that delivers output pulses for the microcontroller to do the counting for necessary action. On receiving the command it switches ON/OFF the load.

1 INTRODUCTION

Electricity is one of the vital requirements for sustainment of comforts of life and should be utilized very judiciously. Several

Energy Management systems are available in literature [1-7]. Power theft is also prevailingin the network and the energy management is a key factor that aids in controlling it [8-11].On the other hand consumers are also not satisfied with the services of power companies. Most of the time consumers have had complaints regarding statistical errors in their monthly bills.Thus it is necessary to present an idea towards the minimization of technical errors and to reduce human dependency at the same time.

It is important to propose a system that aims at receiving the monthly energy consumption from a remote location directly to a centralized office. In this way there is substantial reduction in human efforts needed to record the meter readings.This also provides critical details regarding the average consumption of a locality, which aid in assessing suitable EMS techniques for the same. This helps the officials in deciding the specifications of transformers and other instruments required in power transmission.This idea is economically efficient asit is feasible to get the meter reading at a very low cost. The implementation is done in such a way that a SMS is delivered to the Modem whose reading is to be noted and then that meter replies to the server in the SMS format.

The objective of this paper is remote monitoring and control of the DomesticEnergy meter. This system enables the Electricity Department to read the meter readings regularly without the person visiting each house. This is achieved by the use of Microcontroller unit that continuously monitors and records the Energy Meter readings in its permanent (non-volatile) memory location. This system also makes use of a GSM modem for remote monitoring and control of Energy Meter.The Microcontroller based system continuously records the readings and the live meter reading is sent to the Electricity department on request. This system also disconnects the power supply to the house in case of non-payment of electricity bills. A dedicated GSM modem with SIM card is required for each energy meter.The GSM AMR takes the advantage of available GSM infrastructure nationwide coverage and the SMS cell broadcasting feature to request and retrieve individual houses and building power consumption reading back to the energy provider wirelessly.The Store and

Forwarding feature of SMS allow reliable meter reading delivery when GSM signal is affected by the poor weather conditions. The stored message is archivedby the mobile operator and may be retrieved later for billing purposes.

2 PROPOSED GSM BASED EMS

This paper aims to reduce the cost and man-power of the electricity department and to provide them with better control over energy billing and management of domestic loads. The objectives are:

1. To design a system for the remote monitoring and control of Domestic Energy Meter and Loads via a GSM module.
2. Information from Energy Meter shall be stored in Microcontroller memory and relayed to operator via GSM module.
3. Operator shall receive information (no. of units and amount billed) via SMS and relay information through the same to cut off or turn on load.

2.1 BASIC WORKING

There are basically four steps in the working of this paper:
Step 1: From Supply to Microcontroller: The supply is fed to the energy meter.The internal circuitry converts the analog value to digital value using AD converter.These digital pulses make the cal LED blink. 3200 blinks = 1kwh of consumed power.Pulses are fed to micro-controller via Opto-isolator for calculating total power consumed.Power consumed to be displayed on LCD.
Step 2: From micro-controller to operator via GSM Modem:The microcontroller send the information (command AT+CMGS to send SMS and AT+CMGR to read SMS) to max232 IC in the form of TTL logic.This information is converted to serial output.When a MAX232 IC receives a TTL level to convert, it changes a TTL logic 0 to between +3 and +15 V, and changes TTL logic 1 to between -3 to -15 V. This is sent to the GSM

modem via DB9 connector. The information is then relayed to the operator via SMS on demand or on monthly basis.
Step 3: From operator via GSM modem to microcontroller:Operator send the command via SMS to GSM modem. GSM modem transmits data serially to max232 via DB9 connector. RS232 level is converted into TTL levels and fed into microcontroller.
Step 4: From microcontroller to TRIAC for load cutoff: Operator command to trip load is interpreted by microcontroller.Inputs given to respective pin of respective MOC 3063.This in turn activates the gate of TRIAC ensuring proper conduction of current through load.

2.2 TECHNICAL SPECIFICATIONS

The Specifications of the Energy Management System are as:

1. Power Supply:To the system = 5V (DC); To the GSM modem = 5V (DC); To the loads = 230 V (AC); To the Energy Meter = 230 V (AC)
2. Load Specification = 5 * 10 W bulbs
3. Energy Meter(Digital) Specification:Operating Voltage = 230 V (AC); Pulse Output = 3200 pulses per KWhr
4. GSM modem:Operating Voltage = 5 V (DC); Operating Mode = AT+CMGF (SMS text mode)
5. Microcontroller : PIC16f877A: Operating Voltage = 5 V (DC); Operating Frequency = 4 MHz

2.3 DESIGN APPROACH

2.3.1 POWER SUPPLY

Since the microcontroller (PIC16f877a) works at an operating voltage of 5 V DC and since the supply available is 230 V (AC) so power supply circuit has been designed to convert the 230 VAC to 5 VDC in the following steps.

1. 230 V AC to 12 V AC: This is done with the help of a step down transformer.

2. 12 V AC to 12 V DC: This is achieved by a simple diode bridge rectifier using four diodes.

3. 12 V DC to 5 V DC: This is achieved with the help of a basic configuration of 7805 voltage regulator.

The circuit shown in Figure 1 uses standard power supply comprising of a step-down transformer from 230V to 12V and 4 diodes forming a Bridge Rectifier that delivers pulsating dc which is then filtered by an electrolytic capacitor of about 470F. The filtered dc being unregulated, IC LM7805 is used to get 5V DC constant at its pin no 3 irrespective of input DC varying from 9V to 14V. The input dc shall be varying in the event of input ac at 230volts section varies in the ratio of V1/V2=N1/N2.The regulated 5V DC is further filtered by a small electrolytic capacitor of 10F for any noise so generated by the circuit. One LED is connected to this 5V point in series with a resistor of 330 to the ground i.e., negative voltage to indicate 5V power supply availability. The 12V point is used for other applications as on when required.

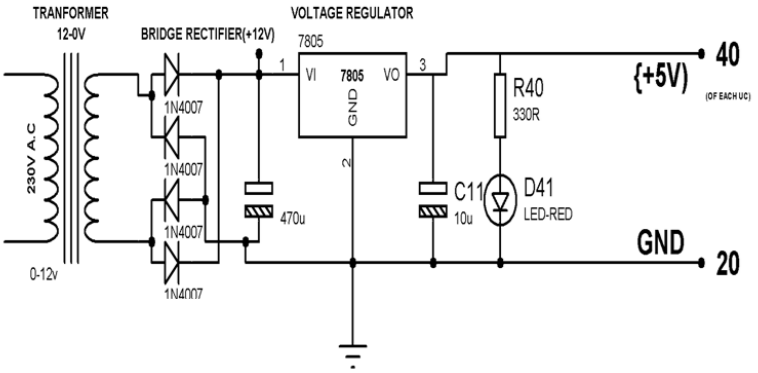

Figure 1: Power Supply Circuit

2.3.2 ENERGY METER

Energy/Billing information shall be obtained from the energy meter by computing the pulse output from the CAL LED of the Digital Energy Meter. This is done by bringing out leads from the CAL LED and connecting that to an Opto-Isolator which in-turn is interfaced with the microcontroller which has a program to calculate the bill.Opto-isolators as shown in Figure 2, or Opto-couplers, are made up of a light emitting device, and a light sensitive device, all wrapped up in one package, but with no electrical connection between the two, just a beam of light. The light emitter is nearly always an LED. The light sensitive device is a phototransistor. When signal is given at pin 1 and 2 is grounded the transistor inside the Opto- isolator conducts between 5 and 4 which is used in the paper by interfacing to the microcontroller for change of logic state from the energy meter unit pulsing led in series with the Opto-led at pin no 1and 2 for pulse counting purpose.

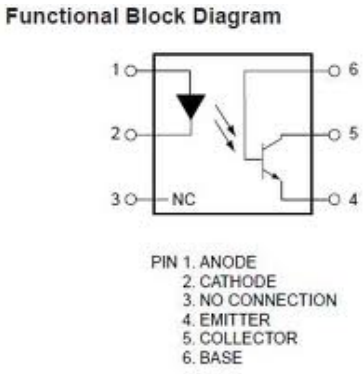

Figure 2: Functional Block Diagram of Opto-Isolator

2.3.3 LOAD INTERFACING

Since this paper is majorly about the remote management of loads via SMS, four 10 W bulbs are interfaced with the system as shown in Figure 3. This is achieved by connecting the loads with Zero

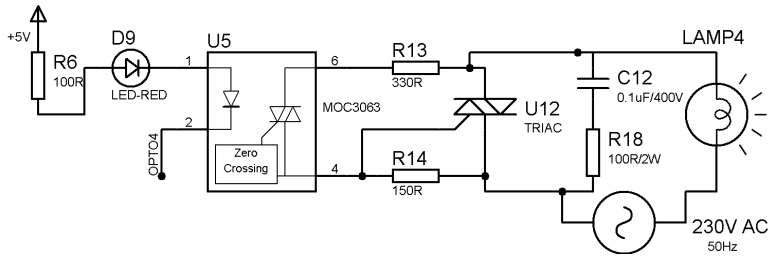

Figure 3: Load Interfacing

Crossing TRIAC Opto Couplers which complete or disconnect the load circuit depending on the pulses from the User via the GSM modem and the microcontroller.An Opto-coupler MOC3061/63 an LED SCR type combination. Additionally while using this IC with microcontroller and one LED can be connected in series with IC LED to indicate when high is given from micro controller such that we can know that current is flowing in internal LED of the Opto-IC. When logic high is given then the current flows through LED from pin 1 to 2. So in this process, LED light falls on SCR causing 6 4 to close only at the zero cross of the supply voltage. During each half cycle current flows through SCR gate, external series resistor and through Opto-SCR for the main thyristor/ TRIAC to trigger for the load at the beginning of the supply cycle always to operate .A TRIAC is said to be as an AC controlled switch. It has three terminals A1, A2 gate. A TRIAC, lamp and a supply voltage are connected in series. When supply is ON at positive cycle then the current flows through lamp, resistor (R13, R14), switches, gate and reaches the supply and then lamp glows. In negative cycle then it is triggered in reverse direction.

2.3.4 GSM MODEM or MAX-232

The only way in which the user/system can interact with the system/user is via the SMS medium using a GSM modem. Now for the interfacing of GSM modem with the microcontroller it is important to convert TTL logic to RS-232 logic as the GSM modem only understands RS-232 logic. This is done with the help of the MAX-232 IC. The MAX-232 is configured in such a way

that it takes information from the UART of the microcontroller in TTL format and converts that to RS-232 logic for the GSM modem and vice-versa.

2.3.5 ALGORITHM

The basic functioning/algorithm fed into the microcontroller is that the microcontroller shall take the pulse reading from the energy meter and convert that reading into KWhr according to the number of pulses received. Then it shall send this information via the UART and the MAX-232 IC to the GSM modem from whence it shall be sent to the user periodically via SMS. Then the user shall send an SMS to cut off or turn on any particular load via the GSM modem to the controller and the controller shall send a pulse to the zero-crossing Opto-isolator of that particular load.

3 RESULTS AND DISCUSSION

3.1 WORKING

A commercial digital energy meter is utilized that derives positive pulses from the same by taking a connection from the pulsing LED. The pulsing LED pulses 3200 times for 1 unit of electrical energy i.e., 1 kilo watt hour. As it is not feasible to wait for consuming 1000 Wt Hr. The program assumes 10 pulses for unit, which is fed to the PIC Microcontroller to send 1 unit consumption through the GSM Modem duly interfaced to the PIC Microcontroller through Max232, Therefore the 1 unit so sent shown have to be read as 1/3200 unit. Upon a missed a call to the paper board GSM modem, the callers number gets stored in the microcontroller for further communication to that number only. This gives the unique flexibility for changing the number by the user at will without going through the cumbersome process of writing the number while burning the program on to the microcontroller. Thus in that case only that number is used for communication and the user has no option to change that. A GSM modem is utilized. The AT commands from which are received by the micro controller through level shifted IC Max232. The program is executed and this drives the TRIAC from the

microcontroller through Opto-isolator IC. Loads are switched ON and switched OFF based on the corresponding command sent from the GSM modem being received after establishing connection from a cell phone. As per the program, an acknowledgement is received by a SMS that is sent from the controller by the user upon the status of the load depending on port A logic outputs responsible for the loads. The complete operation is displayed on the LCD screen.

3.2 CONNECTIONS

The connection diagrams are as shown in Figure 4-6.The output of power supply which is 5v is connected to 11&32 pin of PIC microcontroller and GND is connected to 12&31 pin of PIC microcontroller. Pin 27,28,29,30 of PICMC is connected to data pins i.e., D4 to D7 of LCD display. Pins 19, 21, 22 i.e., RS, RW, EN. Pin 25, 26 of pins of PIC- MC is connected to Max-232. Pin 2,3,4,5 of PIC MC is connected to pin 2 of Opto coupler. Pin 1 & 2 of Opto coupler are connected to energy meter. Pin 14 & 13 of Max232 are given to pins 2 & 3 of DB9 male connector. Pin 2 & pin 5 of DB9 Female Connector are given to GSM modem. Pin 13 of Max232 is connected to pin 2 of DB9 connector. Pin 11 & 12 of Max232 is connected to Pin 25, 26 of PIC MC.

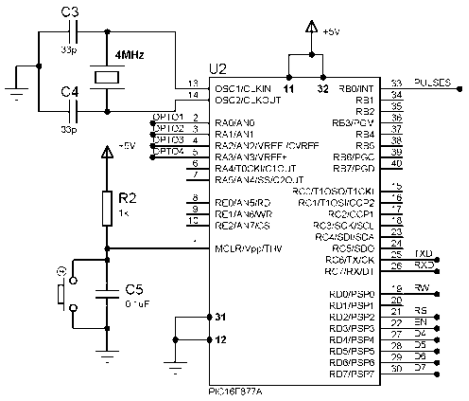

Figure 4: PIC16f877a Connection

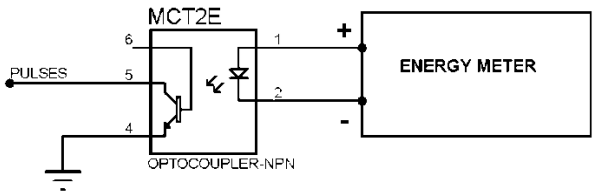

Figure 5: MCT2E Connection

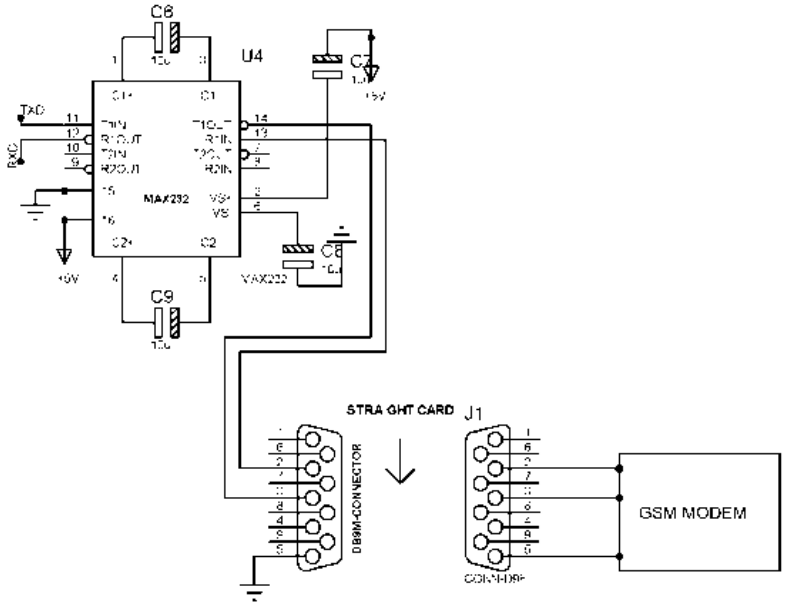

Figure 6: MAX-232 connection

Figure 7: Final hardware setup of Energy Management System

3.3 HARDWARE RESULTS

Figure 7 shows the final hardware setup of the GSM based EMS system. As seen, a call is placed by the user to the SIM present in the GSM modem to store the operators number and the respective information is displayed on the LCD screen. The energy meter takes the energy reading from the five 10W bulbs present to the right of the setup. The operator controls the status (on/off) of the bottom four bulbs by sending an SMS of the appropriate message to the SIM in the GSM modem. Load 1, 2, 3 and 4 are numbered from top to bottom respectively. To control the status of the loads, the messages are sent as per Table 1.

Message	Action
1	Load 1/Bulb 1 turns ON.
2	Load 1/Bulb 1 turns OFF.
3	Load 2/Bulb 2 turns ON.
4	Load 2/Bulb 2 turns OFF.
5	Load 3/Bulb 3 turns ON.
6	Load 3/Bulb 3 turns OFF.
7	Load 4/Bulb 4 turns ON.
8	Load 4/Bulb 4 turns OFF.

S	User gets current status of Loads/Bulbs.

Table 1: Message and appropriate action

4 CONCLUSION

This paper realized a GSM based EMS that controlled the status of the loads. The PIC microcontroller captured the reading from the energy meter and displayed it successfully on the LCD. The reading of the energy meter is sent to the control room by a message via GSM modem. The operators mobile number was auto saved on the microcontroller through a missed call from the user. This GSM modem also received the commands from any cell phone to control the electrical loads. The proposed system is further expanded to include other types of load apart from lamp loads.

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