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Revamped Electric Eenergy Meter against Higher Utility Prices

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Abstract: Due to an increase in home appliances, the demand for electricity has much increased in recent years. Many people are clueless about the energy consumed by various electric appliances. An electric energy meter has the ability to measure the total amount of energy consumed by home appliances and in business areas. The revamped electric energy meter is a microcontroller-based electronic circuit which facilitates the consumer to set the limit of units for home appliances according to his budget. The proposed energy meter facilitates the user to recharge the balance in meter or to set the number of units according to his requirement;once the half of total balance or units is consumed, the meter will start alerting the user about the current status of billing and unit consumption through SMS and voice module. The modified energy meter mainly aims at the middle-class and lower-class families to bring their electricity bill down with the help of power consumption alert system. It also helps the Government as it helps in reducing the power consumption and can reduce unusual power usage. The proposed electric energy meter also facilitates to monitor the meter reading through SMS alert every thirty days.

Keywords: *Energy meter, Arduino MEGA2560, GSM module, SMS alert, energy consumption*

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I. INTRODUCTION

As the national grids are becoming more flexible, more efficient and smart to renewable energy technologies like wind and solar energy, the proposed electric energy meters will increasingly replace conventional electric energy meters in order to monitor electrical energy more accurately and efficiently [1, 2, 3]. The revamped electric energy meter informs the consumers of the amount of energy they have used via a Liquid Crystal Display (LCD) installed in their home. The Proposed electric energy meter has the cleverness to communicate directly with energy suppliers (i.e., power distribution companies), thereby eliminates the need for the staff of the power supply company to visit homes to read the meter and there is no chance of human error in meter reading. The Proposed electric energy meter enables us to look at the electric system more comfortably and use power resources more efficiently [4]. In Pakistan, the Ministry of power division at this time is looking forward to GSM-based energy meters. The government in the time ahead will need the energy supplier companies to install GSM-based clever electric energy meters for the easiness of the consumers and currently is making rules and regulations to make sure that they do so in a way that is for the benefit of the consumers including the rules about data access, privacy, security and specific requirements for weak or powerless consumers (i.e., elderly and disabled persons). The proposed energy meter is charged by the consumer by sending a particular amount to the Arduino through the GSM module [4]. Once the set amount is reached, the

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supply will cut-off automatically, but before the supply cut-off, it will alert the consumer through SMS and loudspeaker and also through display LCD. It is important to note that the amount to be set by the consumer is virtual.

A. *Problem Statement*

The revamped electric energy meter has a number of advantages over the electromechanical and digital meters. Certain disadvantages of the previous system are given below:

- Consumers face meter reading errors.
- It requires the team of Power Supplier Company for meter readings.
- No precaution about the wastage of power is taken.

II. LITERATURE SURVEY

Following research has been concluded from our studies. In Smart Energy Alert System, they design a circuit which helps the consumer in taking care of the electrical energy consumption, in order to minimize the power utilization.

In GSM-based energy meter, user is informed about his power consumption status. This system will inform the consumer about their usage rate via SMS; once the maximum set value is reached, power is cut off [5]. This system gives the alert to the consumer via SMS only [6]. Furthermore, these systems require manual interference by meter reader for consumed electricity, and there are high chances of human error in the observation of meter readings. The proposed energy meter is used to monitor and alert the consumer of their power usage through SMS alert as well as on loudspeaker and can also alert the consumer through email and on the website, but that will require major amendment in the circuit diagram like instead of Arduino, we shall use Raspberry pi module. In our system, we have covered all the drawbacks of existing system. Our proposed energy meter is based on Arduino MEGA2560 but it can also be built through a microcontroller (ATmega328). Once the set limit is reached, it will alert the consumer about his billing status and will also announce through a loudspeaker so that a consumer who is unable to read the message can also be aware of his billing status.

III. ELECTRICITY CONSUMPTION IN PAKISTAN DURING VARIOUS MONTHS OF THE YEAR

The following graph shows the maximum usage of electricity in Pakistan during the various months of the year. During summer, the power consumption is at the maximum rate.

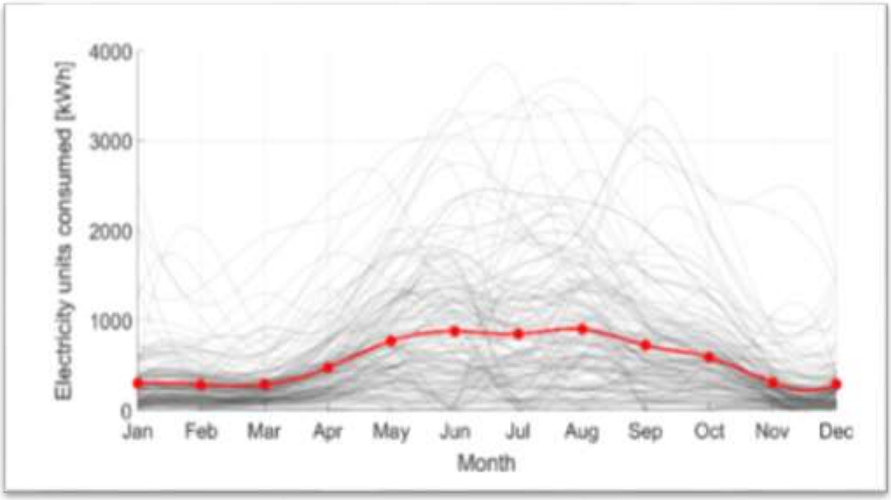

Fig. 1. Electricity consumption in Pakistan during various months of the year

IV. PROPOSED SYSTEM

A. *Objectives*

- Develop user-friendly sustainable appliance control system
- Reduce Electricity Bills
- Design innovative solutions
- Provide hands-free control system
- Provide a unique feature to control different appliance

B. *Methodology*

Project starts working as under. The power supply is given to the energy meter, and load is connected with energy meter through a relay. The supply from energy

meter is continuously given to the Arduino MEGA2560, and Arduino is consistently monitoring the energy consumption by the load. When the set limit is reached, Arduino produces a signal which is given to the GSM module and speaker. GSM module receives a signal from Arduino mega and then sends an SMS (Short Message Service) alert to the user about his current status of balance or units.[5] LCD (Liquid Crystal Display) continuously reads the data from Arduino Mega and displays data according to the instructions from Arduino or microcontroller [7]. This project is powered by external power supply or by stepping down voltage from supply and converting to DC supply. The energy meter consistently sends pulses to the Arduino when the load is connected with it. The impulse ratio can be found by the following relation:

$$Pulse\,rate = \frac{Pulse\,rate\,of\,the\,energy\,meter \times load\,in\,watts \times duration\,of\,load\,in\,seconds)}{(1000 \times 3600)}$$

C. BLOCK DIAGRAM

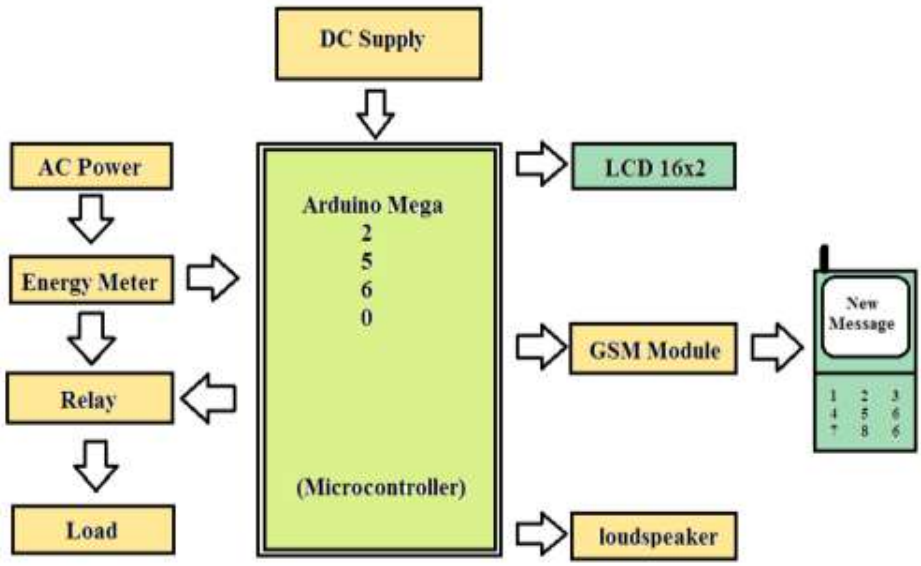

Fig. 2. Block diagram of advanced electric energy meter

D. Design

In the circuit diagram, which is shown below, the energy meter measures the power with respect to the time; the power is calculated by multiplying the current and voltage signals. The energy meter generates a number of pulses according to real power utilization, and there will be blinking of an LED for its every pulse and the speed of LEDs blinking depends upon the load; if a heavy load has been connected, the blinking of LED will be at the higher rate. An optocoupler is connected along with this LED, so the optocoupler will be switched whenever LED blinks. The LED of the energy meter cannot be connected with the Arduino board directly because the LED of the energy meter possesses an analogue output signal while we are working with the Arduino on the digital area. The optocoupler is connected with the pin number (D8) of Arduino for the detection of pulses which are coming from the energy meter. The optocoupler will switch ON when a pulse appears from energy meter, the digital pin D8 of arduino gets digital 0, otherwise it is not active and is in undefined condition. In our proposed prototype, the GSM module is interfaced with the Arduino MEGA2560. The data communication pins (RX & TX), the RX pin of Arduino & TX pin of GSM module are connected with each other and vice versa [8]. A valid SIM card must be installed in the GSM module before connecting with the Arduino, and all the ground (GND) pins are connected with each other. A relay is being used for the switching reason. As we know that the Arduino MEGA 2560 can supply roughly 25mA, therefore, we cannot connect Ar-

duino directly with the relay. So, ULN2003 IC or relay driver is used for relay connection with the Arduino for switching (ON/OFF instructions). A display LCD is connected with (7,6,5,4,3,2) pins of Arduino for the utilized energy and current balance status [9, 10].

E. Circuit Diagram

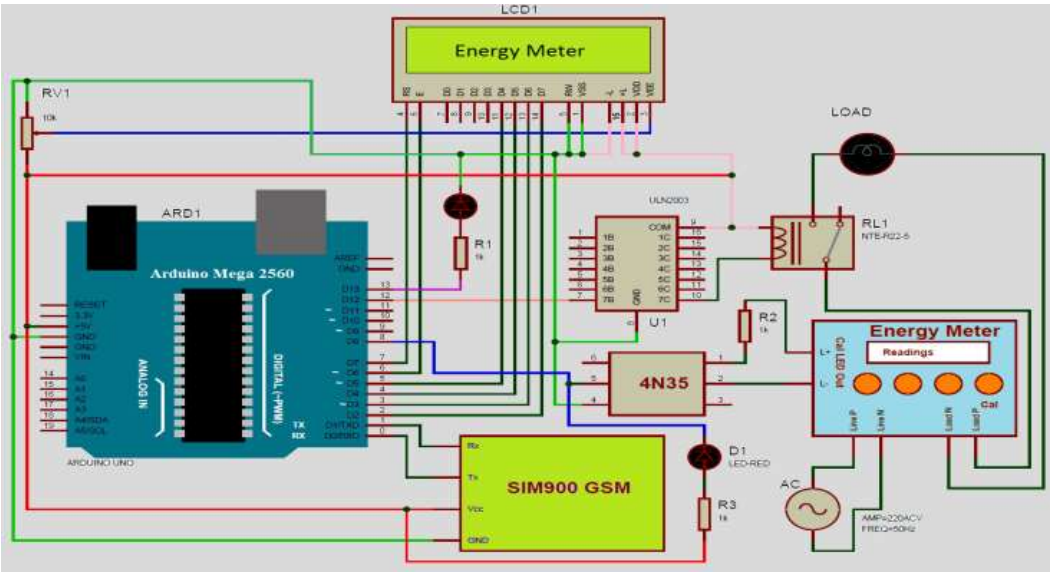

Fig. 3. Circuit diagram of the proposed energy meter

F. Applications

- Apartments
- Industries
- Energy Saving
- Domestic purpose
- Smart Homes Infrastructure
- Load Control & Energy management.

G. Components used

- Single Phase Energy meter
- GSM Module
- Arduino Mega (2560)
- Relay
- Optocoupler
- LCD (16x2)
- Speaker
- Potentiometer
- Jumper wires

H. Software

- Arduino IDE
- PROGRAMINO IDE for Arduino

V. CALCULATION OF UNITS

If the load of 1000 watt is connected for 120 minutes with energy meter of 1600 imp/KWH, then the pulse rate is,

$$Pulse\,rate = \frac{1600 \times 1000 \times 120}{1000 \times 3600} = 53.33$$

The power factor is calculated by:

$$Power\,Factor = \frac{Load\,in\,watts}{60\,minutes \times Pulserate}$$

$$Power\,Factor = \frac{1000}{60 \times 53.33} = 0.3125\,watt$$

Now, the units can be calculated as follows:

$$Units = \frac{Power\,Factor \times Total\,number\,of\,pulses}{1000}$$

$$Total\,pulses\,for\,120\,seconds = 53.33 \times 120 = 6399.6$$

$$Units\,calculation = \frac{(Power\,Factor) \times (Number\,of\,pulses)}{1000}$$

$$Units\,calculation = \frac{0.3125 \times 6399.6}{1000}$$

$$Units\,calculation = 1.999\,units\,per\,24\,hours$$

The above number of units are obtained for the load of 1000 watts when connected for 24 hours.

VI. SHORTCOMINGS OF THE CURRENT STUDY

Like all other devices, this proposed meter also lacks in a way that it requires programming if there is a change in the price of electricity on per unit. So, to overcome this shortcoming, proposed meter is to be sent

to the manufacturing company for the current price of electricity on per unit or technicians are to be trained to resolve this issue. SIM card inserted in the GSM module must have balance for communication with the consumer.

VII. DESCRIPTION

A. *Single Phase Energy Meter*

Energy meter calculates the amount of electric energy used in the residential homes, in the business area or any industry. In electric energy meter installed at homes or business premises for billing purposes, Kilowatt hour (KWH) is the most common type of energy meter being used.

Fig. 4. Single phase energy meter

B. *Arduino MEGA2560*

The Arduino MEGA2560 is a 54 digital pins (for input or output) ATmega2560 microcontroller-based device. It has 16 analogue inputs. It can be empowered with either AC or DC power supply or can also be connected with laptop or PC through USB cable. Arduino MEGA2560 is the main part of the proposed project. In place of Arduino MEGA2560, we can also use Arduino UNO but keeping in a view the memory storage, Arduino MEGA2560 is suitable because Arduino UNO can store less data.

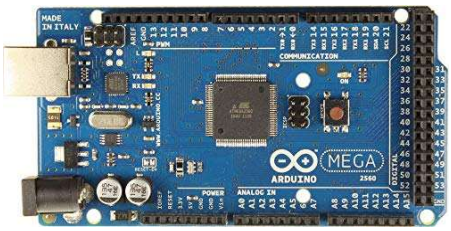

Fig. 5. Arduino MEGA2560

C. *GSM Module*

GSM is used for mobile communication in most of the countries. The GSM module requires a SIM card similar to mobile phones for communication with the network. In our proposed energy meter, the GSM module is used for sending or receiving SMS alert (to or from) customers. The GSM module sends the current status of the consumed balance or units to the consumer around any corner of the world; the only requirement is that the SIM inserted in the GSM module should have balance for communicating with the consumer.

Fig. 6. SIM800L GSM module

D. *Relay*

A relay is used for switching purpose; a relay is used where it is necessary to control a circuit. In our proposed energy meter, a relay is used in order to switch on and switch off the power supply. Once the set limit of units or balance is reached, the relay will cut off the supply from the load. We have used Arduino relay module because it is easier to interface with Arduino than an ordinary electronic relay.

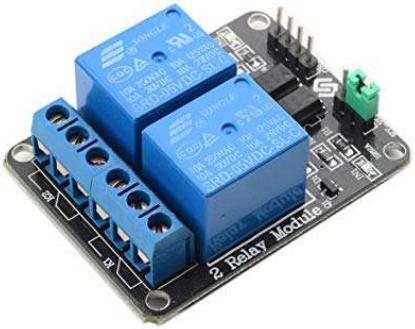

Fig. 7. Arduino relay module

E. *Optocoupler*

Optocoupler (4N35) is used in our proposed energy meter for detecting pulses coming from the energy meter. The reason for using optocoupler is that the output of LED of the energy meter is analogue in nature, but we are working on the digital area of the Arduino. Therefore, 4N35 optocoupler is used which takes the output of

LED and communicates with the Arduino accordingly. It is connected with the digital pin eight (D8) of Arduino MEGA2560.

Fig. 8. 4N35 optocoupler

F. 16x2 LCD

16x2 LCD is interfaced with the (7,6,5,4,3,2) pins of Arduino. The reason for interfacing it with the arduino is to display the current status of balance or units consumed.

Fig. 9. 16x2 LCD

VIII. PICTURES OF THE PROTOTYPE

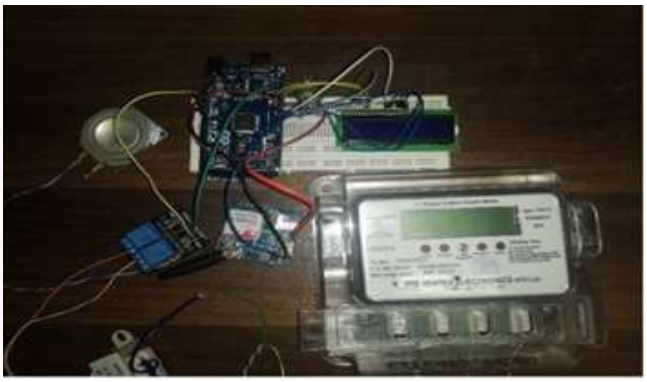

Fig. 10. Picture of the prototype in off mode

Fig. 11. Picture of the prototype in working mode

IX. FINANCIAL DETAILS

In this project, we have used the following components, and their prices are:

TABLE 1
FINANCIAL DETAILS OF COMPONENTS

Components	Price
Arduino Mega 2560	PKR. 1100
Energy Meter	PKR. 2000-2500
LCD	PKR. 180
Relay	PKR. 40
Potentiometer (POT)	PKR. 10
Optocoupler	PKR. 35
Jumper wires	PKR. 70

Note: The above price is in Pakistani rupees

If the manufacturing of this project is done in the industries, then it would be much cheaper because in place of Arduino MEGA2560, only microcontroller (ATMEGA328) is enough which is cheaper one; same goes for other components. As a result, there will be enough reduction in price. This whole project can be set on one board; hence, its size will also shrink.

X. RESULTS

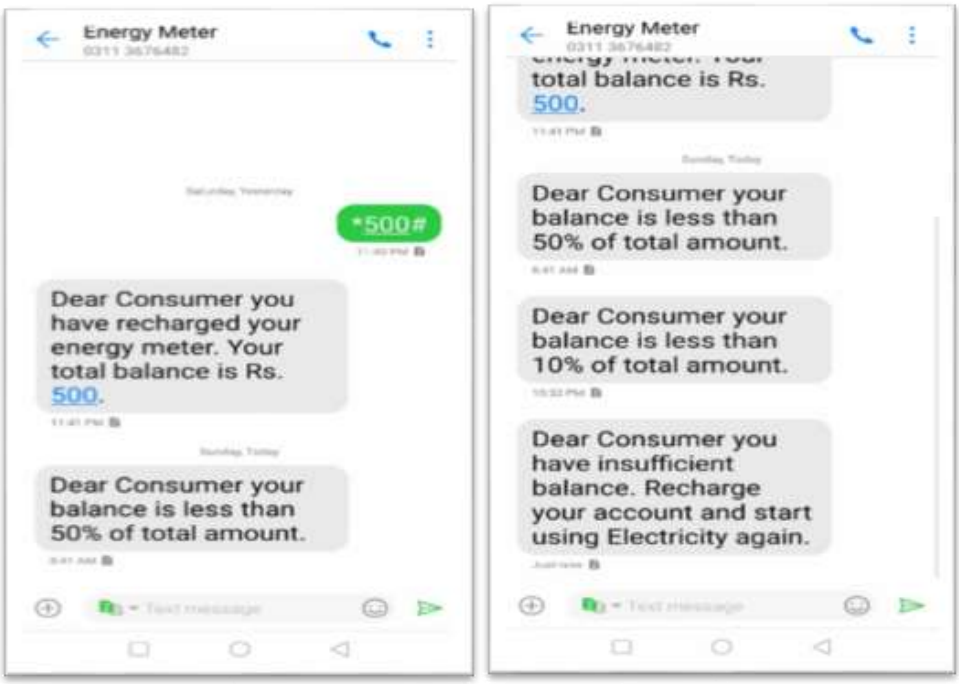

Fig. 12. . Communication between revamped electric energy meter & the consumer

XI. CONCLUSION

The design of the modified electric energy meter technology enables the consumer to pay for the consumed electricity once the 30 days are completed. In this way, the consumers hold their balance or set unit limit in the energy meter by sending a message to the Arduino through GSM module and then use the electricity until the set limit of balance or units is reached. Once the available amount of balance or set unit is reached, the relay module will cut off the supply; by this, the human labour reduces, and the efficiency of the bills for the consumed energy also increases. The proposed energy meters shall reduce the wastage of the power by creating an awareness of the unnecessary usage of power. Zero error previously observed in the existing system has also been omitted. This proposed energy meter shall minimize the power theft and burden of heavy energy bills over the consumers. Similarly, the burden of energy shortfall of the country decreases if people start installing it. In the end, it is expected that this work can help the consumers for better energy management and shall lower their utility bills.

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