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Design of Smart Energy Meter with power Theft detection and a novel of billing Payment

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Abstract*: *The advent in technology has made the necessity of electrical and electronics devices by human beings in order to live a comfortable and secured life. Electricity being the important element of human beings for powering electrical and electronics applications like domestic, agricultural and industrial purposes. Power theft being a major issue had become a threat to our grid systems, creating a loss to electricity boards. These situations are more frequently observed in countries like India. Resolving this issue can save a lot of power thereby creating an uninterruptable power supply to the costumer and there by strengthening the economic aspects of the electricity markets. Implementation of Smart energy meter can resolve this issue. Smart Energy Meter (SEM) is an electric device used for monitoring the energy consumption patterns and uses a wireless protocol for transferring data and communicating in a bidirectional way. This paper presents power theft detection and an automated billing process using smart energy meter. With smart meter the rate at which energy is consumed is monitored and their corresponding amount will be displayed thereby transferring the data to the base station. The data transferred between the consumer and the utility helps in controlling and detecting power theft. This smart energy meter can be configured as post-paid or prepaid meter. The proposed system interchanges conventional meter reading techniques and facilitates the energy provider to access the energy meter remotely.

Index Terms*: *Smart Energy Meter (SEM), GSM, RFID.

I. INTRODUCTION

With the constant growth in technology, the need of automated meter reading systems is also growing. The conventional meter is not suitable for accurate meter readings and involves large man power to take the meter readings, analyzing the data and generating the bill amount. This leads to misreading of the energy consumed and results in great economic loss to the consumers as well as to the utility providers. With the advent in technology and ever increasing human population has created a demand of generation of electricity at higher rates. This has created an imbalance between the generation, distribution and consumption of electricity. The conventional meter reading systems involves manpower to visit to the consumers place and generates bill amount according to energy consumed. The absence of the consumers creates a difficulty for the operator to revisit the consumer place again thereby wasting a lot of time, resources. Lack of payment of the bill generated creates situation where the operator has to manually disconnect the electrical supply. It is a prolonged process and also very problematic to manage these situations.The authorized electrical operators find it challenging to identify unsanctioned connections or power theft carried out by the end users in order to stop or reduce the meter reading creating a huge economic loss in the global economic scenario. This scenario can be reframed efficiently by gathering the rate of energy consumed from the smart meter and transmitting the gathered data wirelessly to central database where it can be further processed, analyzed, and organized for the accurate billing purposes. The smart energy mete can communicate between the consumer and distribution hub in a bidirectional way. It involves the active participation of the consumer in the grid system where in the conventional metering system there is no interaction between the electrical grid and the consumers. The implementation of the smart energy meter enables the user to remotely access their home appliances and monitor their energy consumption rates so that energy consumption pattern can be changed accordingly their by reducing the carbon foot prints and supplying the consumers with uninterrupted power supply.

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II. BLOCK DIAGRAM OF PROPOSED MODEL

The proposed model has two subdivisions mainly, one is base substation and the other is the consumer's location. Communication between these subdivisions is done through wireless protocol in a bidirectional way. This smart energy meter loads, helps in processing data gathered, analyzing the data and thereby giving the customers a proper suggestion on electricity management. Energy consumed by the consumer and the equivalent amount will be showed on the LCD constantly and data is transferred to the governing base station. The power theft can be identified and monitored through a feedback mechanism from the end users. The SMS message includes cyclic bill amount along with the due period is sent to the corresponding meter proprietor through a GSM module which is present in the governing substation. This component also helps in notifying the certified electrical board members through an SMS at the time of power theft.

RFID is a part of AIDC it is mostly used in tracking objects via RFID tags. The implementation and design of a GSM based smart meter system has been discussed in this paper. RFID tag will be explored as a medium of communication in smart metering system. The block diagram of the proposed model is shown in Fig.1.

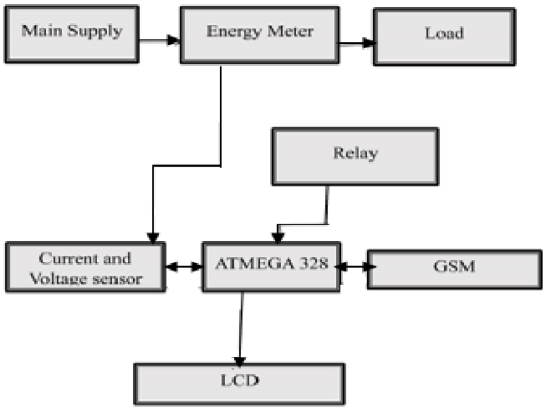

Fig.1 Architecture of Smart Energy Meter.

III. System Hardware

The elementary hardware components required for the Project are listed below:

1) RFID Reader
2) Power Supply
3) Rectifier
4) LCD
5) ATMEGA
6) GSM Module
7) Current Transformer and Potential Transformer
8) Relay Control unit.

A. RFID

The proposed system design employs an EM-18 RFID reader which is most commonly used to read tags. These RFID tags can be used for reading 125 KHz tags. The EM-18 RFID is a low frequency RFID system. The merits of this device includes low power consumption, low cost, compact size, form factor is small and the usability of the device becomes easy. The operating voltages varies from 3.5to 5.5v and the operating frequency is at 125KHz.The device can directly interacted with the microcontroller through two supported protocols namely Wiegand 26 and TTL serial as per the proposed system design. The RFID reader detects the smart card and displays the balance amount present in the card so the consumer can recharge the card for uninterrupted power supply.

B. POWER UNIT

The power source is the power house of every electrical and electronics projects circuit that activates all the components in the circuit. The power source block comprises of step-down transformer, rectifier, and IC 7805 voltage regulator. The ATMega 328 in the Arduino board requires 5V power supply which obtained from a voltage regulator. The microcontroller is the main block which follows a lot of algorithm to process information and issues command to the peripheral device. The energy meter is coupled with the Arduino using an interfacing device called Optocoupler. The 230V AC power supply is given to operate the loads. The wireless communication channel also requires power supply for its operation and transmission. The power supply blocks helps in the efficient functioning of the smart energy meter.

C. LCD

The proposed system employs a 16x2 Character panel liquid crystal display (LCD).It is an electronic visual display device that possess (LCs) liquid crystals with light modulating characteristics. LCD comprises of two transparent electrodes in which layers of molecules are aligned, polarizing filters and the axis of transmission of light are perpendicular to each other in most cases. The light transmitted through the first filter would be obstructed by the second (crossed) polarizer during the absence of LC's in the polarizing filters. Double refraction is most common in case of LCs. The liquid crystal which are in contact with electrodes are to be treated in order to align the LC's particles in a particular direction.

D. MICROCONTROLLER UNIT

The proposed design uses a PIC16f877A. The controller has a built-in SPI master and enough I/O lines to satisfy current needs. All internal communications takes place through the microcontroller. The PIC16F877A features self-programming, 256 bytes of EEPROM data memory, 10-bit Analog-to-Digital (A/D) converter, an ICD, 8 channels of 2 Comparators, 2 capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI) or the 2-wire Integrated Circuit (IC) bus and a Universal Asynchronous Receiver Transmitter (USART). All of these features make it ideal for more advanced level A/D applications in industrial, automotive, and consumer applications.

E. GSM

The Communication channel includes a GSM Module. It is used for transmitting the data from remote location to the regulatory operator. The serial communication with the modem is 1 stop bit, no parity, 115200 bauds and full duplex 8 bits. This modem consist of a Subscriber Identification Module (SIM) for communication purposes. Its specifications are:

1) Tri-Band GSM 1800 MHz
2) Supply voltage varies from 3.4V to 4.5V
3) Power consumption is less.
4) Operating temperature varies from -20°C to +60°C
5) Debug interface and Serial interface
6) Interfacing LCD is possible.

7) Keypad interfacing is possible.
8) Antenna pad
9) Antenna connector.

F. RELAY CONTROL UNIT

Relay unit serves the purpose of interrupting the electricity supply when the balance in the customer's account goes below a threshold level. Whenever the amount in the customer account is sufficient the electricity is continued through the relay module. The relay circuit is controlled by the PIC16f877A microcontroller. The system transfers the data with the utility database wirelessly. The PIC16f877A commands the functioning of the relay unit to resume or shut off the power supply base on the information stored in the database.

IV. RESULTS

The proposed smart meter design helps in efficient way of managing power consumption by both the consumers and the distribution network. By implementing this smart energy meter load imbalance can be reduced and lot of energy can be saved leaving less carbon footprints. The design also integrates the presence of Anti –Theft system which alerts the user if some unknown load is connected to our system. Combination of both technology i.e. smart energy meter and Anti-theft system provides end to end encryption for the user without affecting their privacy. The hardware implementation

of Smart Meter is shown in Fig.2

Fig.2. Smart meter Hardware setup when it is switched ON.

After the indicating the Turn ON condition of the smart energy meter the Smart energy meter checks the signal strength of the GSM module connected to the Smart meter which is shown in Fig.3.Once the Signal strength is good the Smart meter is ready to send and receive messages which is shown in Fig.4.

Fig.3.Checking of Network strength.

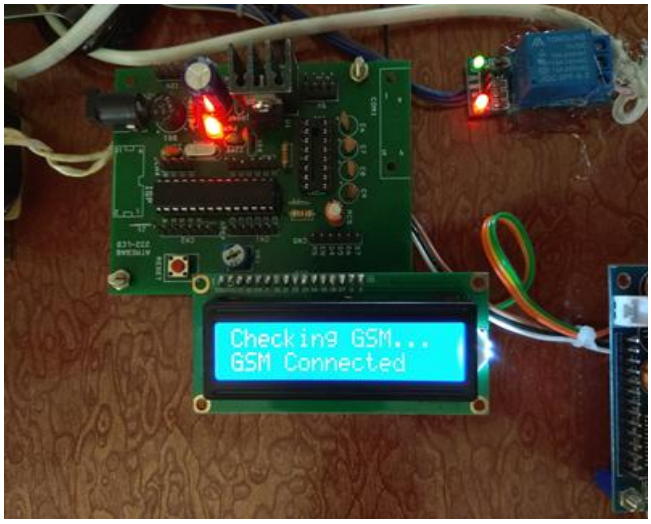

Fig .4. Establishment of network connection.

Once the network is established the smart energy meter is ready to send and receive messages and a test message is initiated through SMS in order to check the proper functioning of the Smart meter which is shown in Fig.5.The test message received by the users is shown in Fig.6

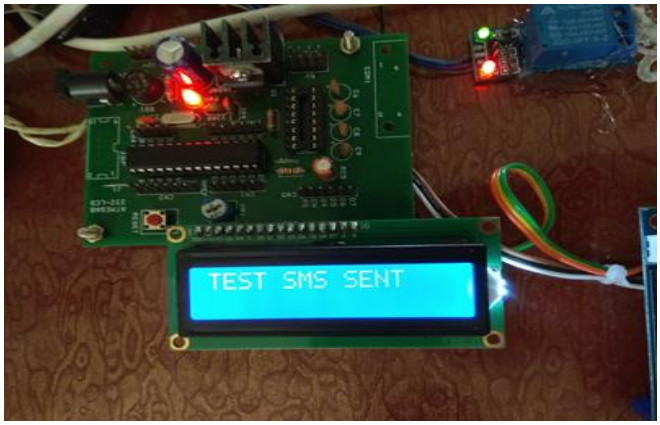

Fig.5. Initiation of Test message.

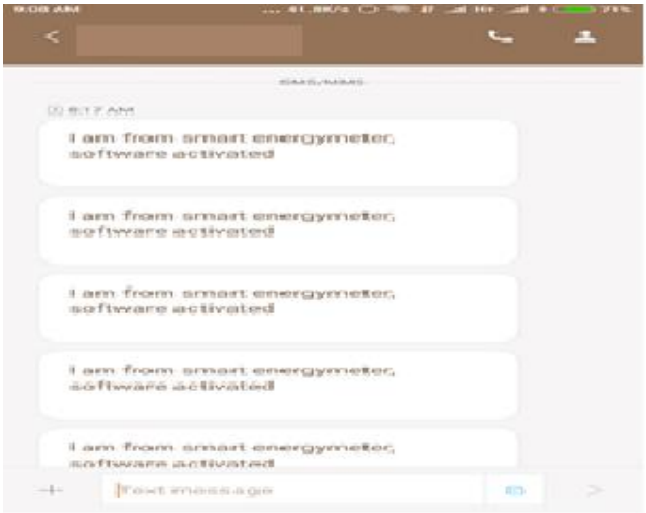

Fig.6. Test message sent to the User

The smart energy meter displays the No. of units consumed by the user and the calculated cost of the units consumed by the user. The costs per unit is set in the smart meter according to the Tariff set by the Energy Market or the government.
The units and price displayed when it is not connected to the load is shown in Fig.7 and when it is loaded it is shown in

Fig.7. Readings displayed under NO Load condition

Fig.8. Readings displayed under loaded condition.

If the cost price of the units consumed exceeds the balance present in the smart meter, the smart meter disconnects itself from the load and asks the user to recharge their account which is shown in Fig.9.

Fig.9.Indication of low balance.

The customers can recharge their account using a smart card which is sensed by the RFID reader and the amount present in the smart card is transferred to their account which is shown in Fig.10.

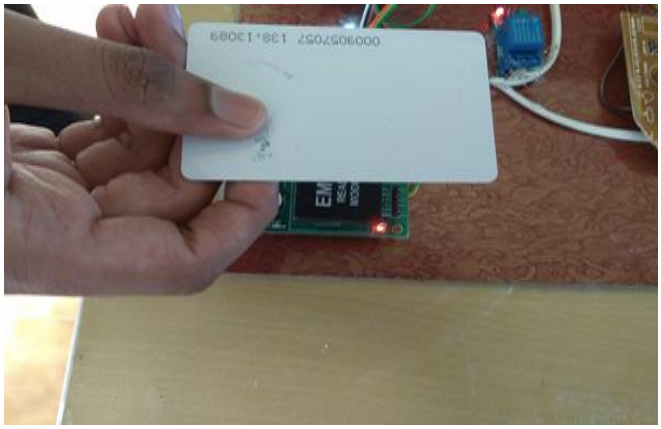

Fig.10. Recharging done through smart card

After recharging sufficient amount into the account the smart indicated the user the amount being added into their account which is shown in Fig.11.

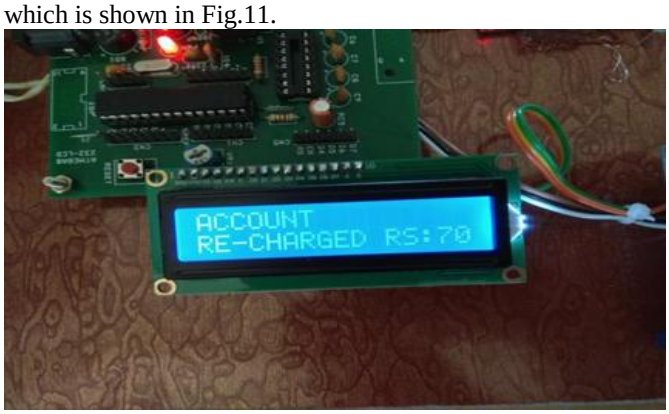

Fig.11. Acknowledgement for the recharged amount.

The presence of Anti-Theft system in the smart energy meter protects the users by indicating them if unknown loads are connected to their system. This helps in encrypting of the data present in the device and provides privacy for the customers. Once the Theft is detected the smart energy meter send SMS to the user about the theft through the GSM module present in the hardware setup which is shown in Fig.12.

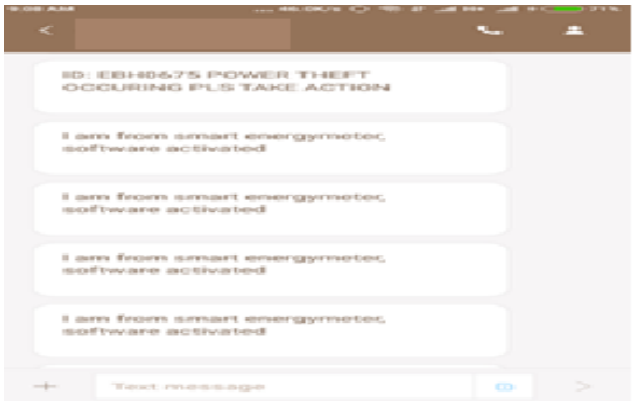

Fig.12.Theft Message sent to the User.

V. Conclusion

Smart energy meter is a device which communicates with both the customer and the distribution network in a bi-directional way thereby creating opportunities for energy saving, proper balancing of the load, Energy management studies, Energy data analytics,
and new electrical products.

The proposed smart meter technology shows the consumer the energy consumed and the cost for the energy consumption and thereby efficient use of electrical energy without creating any stress to the distribution network. The integration of the Anti-theft system to the hardware helps the user in identifying whether their system is being tampered. Implementation and integration of all these technology into a single hardware product will have a huge market in the global society.

VI. FUTURE SCOPE

The proposed hardware method can be improvised using RTOS (Real Time Operating System) which runs the energy meter functions and commands in real time clock which ultimately reduces the error present in the billing process. Other features like online monitoring systems can be implemented in this system in order to make active participation of the consumers in the grid system.

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