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RASPBERRY PI AND GSM BASED SMART ENERGY METER FOR ADVANCED METERING AND BILLING SYSTEM

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Abstract: ***The research project aims at proposing a system that will reduce the loss of power and revenue due to power thefts and other illegal activities. Power theft is the biggest problem in recent days which causes lot of loss to electricity boards. In countries like India, these situations are more often. If we can prevent these thefts we can save lot of power. This is done using Smart Energy Meter (SEM). SEM is an electric device having energy meter chip for measuring the electric energy consumed and a wireless protocol for data communication. This paper presents a smart energy meter for an automatic metering and billing system. The work system adopts a totally new concept of "Prepaid Electricity". The GSM technology is used so that the consumer would receive messages about the consumption of power (in watts) and if it reaches the minimum amount, it would automatically alert the consumer to recharge. The feedback from the user helps in identifying the usages between authorized and unauthorized users which helps in controlling the power theft. This technology holds good for all electricity distribution companies, private communities, IT parks and self-containing housing projects. The implementation of this project will help in better energy management, conservation of energy and also in doing away with the unnecessary hassles over incorrect billing. The automated billing system will keep track of the real time consumption and will leave little scope for disagreement on consumption and billing.***

Keywords: *Smart Energy meter, GSM technology, Raspberry pi Microcontroller.*

I. INTRODUCTION

The present system of energy metering as well as billing in India which uses electromechanical and somewhere digital energy meter is error prone and it consumes more time and labor. The conventional electromechanical meters are being replaced by new electronic meters to improve accuracy in meter reading. Still, the Indian power sector faces a serious problem of revenue collection for the actual electric energy supplied owing to energy thefts and network losses. One of the prime reasons is the traditional billing system which is inaccurate many times, slow, costly, and lack in flexibility as well as reliability [1]. Meters, in the past and today in a few countries, were electromechanical devices with poor accuracy and lack of configurability. Theft detection was also a challenge. Recent developments in this direction seem to provide opportunities in implementing energy efficient metering technologies that are more precise, accurate, error free etc[2]. A Prepaid Energy Meter enables power utilities to collect electricity bills from the consumers prior to its consumption. The prepaid meter is not only limited to Automated Meter Reading but is also attributed with prepaid recharging ability and information exchange with the utilities pertaining to customer's consumption details. The use of electronic token prepayment metering has been widely used in UK for customers with poor record of payment [3]. A paper suggests a design of a system which can be used for data transmission between the personal computer and smart card [4]. Poly phase prepaid energy metering systems have also been proposed and developed based on local prepayment and a card reader [5]. Wireless prepaid energy metering system has been proposed which incorporate RF based system [6]. Digital energy metering system as an alternative for the electromechanical system has been proposed and developed with the Peripheral Interface Controller (PIC) and necessary software [7]. Due to the low cost of microcontrollers, Prepaid Energy Meter has been developed using a microcontroller from the Microchip Technology Inc PIC family [8]. The proposed system automatically reads the energy meter data and sends it to the customer and service provider on reception of a specific message from service provider. It uses a GSM modem for this purpose. The system can also provide the facility to disconnect the supply of a customer in case of any payment related issue and also if the amount falls below certain amount, then it will be indicated by the microcontroller through buzzer

and also send message service to the customer by using GSM modem.

II. EXISTING SYSTEMS

For this work existing meter reading techniques in India are analysed and conducted an extensive study on different energy measuring instruments available now. In existing system either an electronic energy meter or an electro-mechanical meter is fixed in the premise for measuring the usage. The meters currently in use are only capable of recording kWh units. The kWh units used then still have to be recorded by meter readers monthly, on foot. The recorded data need to be processed by a meter reading company. For processing the meter reading, company needs to firstly link each recorded power usage datum to an account holder and then determine the amount owed by means of the specific tariff in use. Wireless electric power management and control system for short distance is developed using Zigbee technique. For this IEEE 802.15.4 standard protocol is used as a Zigbee standard, microcontroller is used to manage energy data and Zigbee to enable communication between the energy meter and data centres. The secure mobile agent concept was presented in, instead of one person for one meter according to geographical area energy meters can be organized. For one location energy meters a security manager can do his work. Local mobile agent can do his duty for a specific location to avoid the visit of external mobile agent to energy meters directly. If there are any queries of security manager local mobile agent can solve at his level and visit energy meters. The embedded energy meter concept is based on the prepaid recharge concept of mobile recharge, where maximum demand of energy of a consumer is indicated in the meter. After exceeding the maximum demand, the meter and hence the connection will automatically be disconnected by an embedded system inserted in the meter itself. The major disadvantage of a post-paid system is that there is no control of usage from the consumer's side. There is a lot of wastage of power. Since the supply of power is limited, as a responsible citizen, there is a need to use electricity in a improved and efficient way. There are clear domino effect from many countries everywhere a prepaid system has reduced the usage (wastage) by a great quantity. Additional advantage of the prepaid system is that the human errors made reading meters and processing bills can be reduced to a great amount. Wireless meter can be used in residential apartments and especially in industrial consumers where bulk energy is consumed. Advancements in technology have made exchange of information in very high-speed, protected and truthful. Advance in wireless technology caused rapid change in field of telecommunication system. Communication system like Internet and GSM are available in India.

III. PROPOSED WORK

To implement this system, a Raspberry pi microcontroller based board is used. It is low cost ARMv7 processor in this proposed system we are used Raspberry pi Zero. It is 1GHz ARM processor with 512 MB RAM with on- chip ADC, timer/counter module, PWM and UART module to interface a GSM modem and energy meter. The energy meter which generates the pulses as well as count the energy consumed is used. The digital energy meter is having a LED which blinks for a specific number of times to indicate the energy consumed (e .g. 1 Unit = 1600 pulses). These pulses are fed to ARMv7 based system which is programmed to count these pulses. The system reads these pulses and after counting specific number of pulses it increments the internal counter by one which indicates the number of units consumed and LCD display is used to display the balance amount. To recharge the meter, consumer needs to buy electricity in advance according to his/her requirement. The consumer can buy electricity by generating an SMS by the registered user's mobile number. The meter is credited with the amount of recharge bought and supply is switched on automatically at load side. As the consumer's balance reaches the below the emergency limit provided by the utility, meter issues an alarm and also send message to the consumer. The consumer needs to recharge the meter at this point. If recharged in time then the load is not disconnected. However, if even after warning, a consumer does not recharge their meter and all available balance is exhausted then meter automatically disconnects the supply at load side. The controller instructs the relay to disconnect load.

A) Calculation of Pulses and Units:

Before proceeding for the calculations, first we have to keep in mind the pulse rate of energy meter. There are two pulse rates of energy meter first is 1600 imp/kwh and second is 3200 imp/kwh. So lets calculate 3200 imp/kwh pulse rate energy meter. So first we need to calculate the Pulses for 100watt, means how many times Pulse LED will blink in a minute, for the load of 100 watts.

Pulse= (Pluse_rate*watt*time)/ (1000*3600)

So pulses for 100 watt bulb in 60 seconds, with energy meter of 3200 imp/kwh pulse rate can be calculated as below:

Pulses=3200*100*60/1000*3600

Pulses = ~5.33 pulse per minute

Now we need to calculate Power factor of a single pulse, means how much **electricity will be consumed in one pulse**:

PF= watt/(hour*Pulse)

PF=100/60*5.33

PF=0.3125 watt in a single pulse

Units= PF*Total pulse/1000

Total pulses in an hour is around 5.33*60=320

Units = 0.3125*320/1000

Units = 0.1 per hour

If a 100 watt bulb is lighting for a day then it will consume

Units =0.1*24

Units = 2.4 Units

And suppose unit rate is at your region is 5 rupees per unit then

You have to pay for 2.4 Units Rs:

Rupees= 2.4*5 = 12 rupees

B) Sequence of Execution

Load Connected to the relay is Direct Load and Load connected to the hang switch is fake Load. If you turn on the switch then it detects as theft. Insert SIM with SMS balance and connect 12 v adapter for Kit and 5v adapter for Raspberry Pi and Insert 2 bulbs . After power on GSM will get initialized and ask or Num1 and Num2.

Send Msg like *7396782761, 9491939290, while the first number is authority and 2 number is user, the numbers will get displayed on LCD and start showing currents.

Now the main power will get ON

- ➔ To switch ON the real load send *L1
- ➔ To switch OFF the real load send *L0

Case 1 : Send *L1 then controller read the in and out currents and if they are equal then it is ok , if not equal it means theft. To simulate that turn on the electrical switch then the current will be different. Then theft message will send to authority and main power will off.

Case 2: Meter Bypass: Slide the toggle switch ten it will detect the meter short and then also main power will off and send sms to the authority.

Case 3: Balance: In this case donot turn ON the toggle switch or electrical switch and the default balance is 25. If you turn ON the main load then the balance starts decrements. If the balance is over then the power will get automatic Off and SMS will be sent to the user. To recharge send commands *R100 for a balance of rupees 100.

IV. SYSTEM ARCHITECTURE

The high level block diagram of the prepaid meter reading system is shown in the Figure1. The Power Supply section supplies all other components with required Power. The Raspberry pi microcontroller module takes the data from the energy meter and performs the necessary control operations like breaking the circuit through Relay control unit and the required information to the mobile phone via the communication module GSM. The UART is a serial communication interface for the GSM modem for transmitting the data from the controller to the mobile phone. The recharge unit is stored with in the Internal memory of Raspberry pi which has volatile memory and this recharge unit is display in Liquid Crystal display (LCD) and a message “recharge successful” also display balance reaches the below the emergency limit then the buzzer starts indicating that we should recharge our meter soon and the controller send the message to customers.

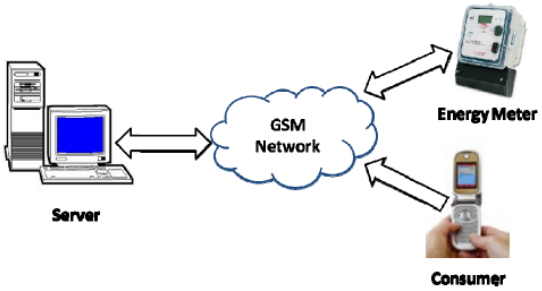

Fig 1: High Level Block Diagram Implementation

V. SYSTEM HARDWARE

The basic hardware components used in the Project are listed below:

A. Raspberry pi Zero
B. Energy meter
C. GSM Modem
D. Relay control unit

A. Raspberry Pi Zero

The Raspberry Pi is a low cost single board computer which is controlled by a modified version of Debian Linux optimized for the ARMv7 architecture. We are using model B, 700 MHz ARM processor with 512 MB RAM. The Ethernet is 10/100 BaseT Ethernet socket. The CPU of the microcontroller is 700 MHz Low Power ARMv7 Applications Processor.

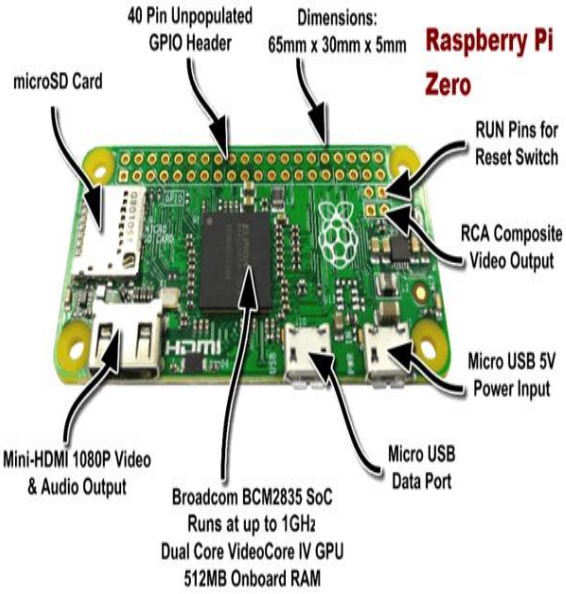

Fig2: Raspberry Pi Zero

B. Energy Meter

Energy meter module is composed of ADE7757 which is energy metering IC with integrated oscillator and load and which produces the analog signal can be converted into digital signal and that digital signal in the form of pulses and ADE7757 outputs average real power information based on the load. These outputs are interfaced with the microcontroller .One of the feature in ADE7757 to enhance the capability of this work is having a power supply monitoring circuit on the VDD supply pin of the ADE7757. Due to this, proper device operation is achieved at power up and power down modes. High degree of immunity to false triggering from noisy supplies is attained due to built in hysteresis and filtering operations in power supply monitor of the ADE7757.

Fig 3: ADE7757 Energy Meter

C. GSM Modem

The Communication Module consists of GSM Modem. It is used to transfer the data of the user meter from raspberry pi controller to remote station by GSM wireless module. The serial communication with the modem is full duplex 8 bits, no parity, 1 stop bit and at 115200 bauds. We have used Subscriber Identification Module (SIM) in the modem.

Specifications:

- Tri-Band GSM/GPRS 900/1800/1900 MHz
- Supply voltage range is 3.4V to 4.5V
- Low power consumption
- Operating temperature is -20°C to +60°C
- Serial interface and debug interface
- LCD interface
- Keypad interface
- Antenna connector and antenna pad

RS-232 Communication (UART)

RS-3202 communication enables point-to-point data transfer. It is commonly used in data acquisition applications, for the transfer of data between the microcontroller and a PC. The voltage levels of a Modules and PC are not directly compatible with those of RS-232, a level transition buffer such as MAX3232 be used.

- Insert SIM card: Press to remove the tray from the SIM cardholder. After properly fixing the SIM card in the tray, lock the tray in the slot provided.
- Connect Antenna: Screw the RF antenna on the RF cable output provided.
- Connect RS232 Cable to the Host device:
- Default baud rate is 9600 with 8-N-1, no hardware handshaking.
- Connect the power Supply (9V-AC/DC) to the power jack. In case of DC polarity should be Center +ve and outer –ve on DC jack.
- Network LED indicating various status of GSM module eg. Power on, network registration & GPRS connectivity.
- After the Modem registers the network, led will blink in step of 3 seconds. At this stage you can start using Modem for your application.

D. Relay Control Unit

Relay control unit is used to shutting off the electric power supply when the due date is over. Whenever the user pays the bill or recharges the electric power supply is resumed by the relay module. The relay is driven by the raspberry pi controller. The user can monitor power consumption details on LCD.

VI. RESULTS

Fig 4: GSM Module getting Initialized

Fig 5: Send the Registered mobile no and users mobile number

Fig 6: LCD displays Registered and users mobile no

Fig7: LCD displaying Balance amount

Fig 8: Real Time implementation of our Research work

VII. Conclusion

The paper is intended to present an overview of prepaid energy meter, which can control the usage of electricity on consumer side to avoid wastage of power. Prepaid energy meter is a concept to minimize the Electricity theft with a cost efficient manner. From all these we can conclude that if we implement this prepaid energy meter then it can become more beneficial. The system designed reduces the efforts of manual data collection of energy meter. The users are not bound to pay excesses amount of money, users have to pay according to their requirement. Prepaid energy meter is more reliable, accurate and user friendly.

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