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Smart Energy Meter Using GSM

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ABSTRACT

This paper focuses on developing a smart energy meter which eases the work of human. In early days this metering technology was fully analog. Due to rapid technological developments nowadays it has become digital but not fully automatic it too needed a huge human work force. The above mentioned two techniques have a lot of drawbacks like erroneous and needed a lot of time for repair, gives faulty unit readings ,the second one gives readings digitally with some accuracy but cannot be sent to the billing point directly . It needed a lot of human work force regularly to take readings. The GSM technology introduced here eliminates all the above mentioned drawbacks by fully automating the energy meter .i.e. the meter readings are taken and sensed automatically and sensed units are regularly sent to the billing point using the GSM and corresponding bills are calculated and sent to the user at the correct time. It reduces the time, it reduces the human work force, will give accurate readings. This system replaces traditional energy meter reading methods and enables remote accessing of existing energy meter by the energy provider. They can monitor the readings regularly without visiting the person's house.

Keywords: Smart energy meter, GSM technology and Automation.

1. INTRODUCTION

Electric power has become indispensable to human survival and progress. Apart from the efforts to meet the growing demand, automation in the energy distribution is also necessary to enhance people's life standard. Traditional meter reading is inefficient to meet the future residential developmental needs. So there is increased demand for Automatic Meter Reading (AMR) systems, which collect meter readings electronically and its application is expanding over industrial, commercial and of the analog and mechanical nature of the components in these meters .Collection of meter reading is also in efficient because a meter reader has to physically be onsite to utility environment. Traditional electro mechanical meters used today, are prone to drift over temperature.

This method of collecting of meter readings becomes more problematic and costly when readings have to be collected from vast and often scattered rural areas. The older electro mechanical and present electronic meter readings are taken by the persons involved in the job and the amount is noted down in the EB card, this may consume lot of time and doubtlessly require many persons and the consumers may be out if station. Apart from being a boon (AMR) wipes out all the cons of conventional systems.

AMR is a sophisticated system which allows companies to note down the readings and calculate bills without visiting the site. AMR includes various techniques like GPRS, SCADA, PLC, RF, Radio frequency, GSM, etc. But among these GSM is the best technology available since it has numerous number of users and gives a good range for the data to be transmitted. It helps the consumer and energy service provider to access accurate data and updated data from the energy meter. This data is sent to the central system for trouble shooting and calculation process. This system can be a postpaid and a prepaid one. The data used for billing are stored in the server for updating and for later use. The data which is calculated and stored in the server can be accessed and analyzed very accurately. The generation of bill is done according to the set up amount for each unit. The units which are received through the GSM modem are stored and multiplied by the amount such as 5 for each unit and multiplied and the amount is calculated and sent to the consumer through the recognized phone number. This generated bill can be paid and accessed from anywhere around the world as the GSM is widespread all over the world. This technology holds good for IT parks, commercial buildings, industries. The development of GSM over the past two decades has made the energy metering wireless. The GSM infrastructure which has nationwide coverage is used to request and retrieve power consumption notification over individual houses and flats.

2. LITERATURE SURVEY

2.1 Design of electric energy meter for long distance data information transfers which based upon GPRS

With the popularization of internet in China as GPRS service improved increasingly electric energy meter transmits the data information and controlling command remotely and wirelessly based on the current electric energy meter with the well functioned ARM kernel microprocessor ,it not only finishes the power data measuring and processing ,but also realizes the TCP/IP by cutting .By ARM kernel microprocessor controlling GPRS module ,electric energy meter could be linked to the internet by use of GPRS service. The overall system is stable and reliable because it is managed by mu C/OS-2 operating system .This is especially for some outlying areas where the cable network has not been popularized.

2.2 Automatic power meter reading using GSM network

The development of a GSM automatic power meter reading system consists of GSM digital power meters installed in every consumer unit and an electricity EB link System at the energy provider side. The GSM digital power meter is a single phase IEC61036std compliance digital KILOWATT power meter with embedded GSM modem which utilize the GSM network to send its power usage reading using short messaging system back to the energy provider wirelessly. At the power provider side an EB link system is used to manage all received SMS meter reading, compute the billing cost, update the database and to publish the billing notification to its respective consumer through SMS or email. A working prototype of the GAPMR system was built to demonstrate the effectiveness of automatic meter reading billing and notification through the use of GSM network.

2.3 Electronic meter with instant billing

It presents the design of the simple low cost wireless GSM energy meter and its associated web interface , for automatic billing and managing the collected data globally .The proposed system replaces traditional meter reading methods and enables remote access of existing energy meter by the energy provider .A GSM based wireless communication module is integrated with electronic energy meter of each entity to have remote access over the usage of electricity .A PC with a GSM receiver at the other end which contains the database acts as the billing point .live meter reading from the GSM enables energy meter is sent back to this billing point periodically and these details are updated in a central database .net frame work and c# with proper authentication ,users can access the developed web page details from anywhere in the world .The complete monthly usage and due bill is messaged back to the customer after processing these data .

2.4 Wireless automated digital energy meter

Electricity is one of the basic requirements of human beings which is widely used for domestic, industrial and agricultural purposes. There is a great demand for electricity. Though there are very well developed alternate sources for electricity, there are lot of problems in connection with distribution and metering. The traditional electro mechanical meters still widely used today are prone to drift over temperature and time as a result of mechanical nature of the components in the meter .The problem worsens further in collecting the meter readings and generating the bill. This suggests a method where telecommunication system is utilized for automated transmission of data to facilitate bill generation and payment of the same at the customer's place.

2.5 Embedded energy meter-A new concept to measure the energy consumed by the consumer and to pay the bill

A new concept of energy meter is shown, where maximum demand of energy of a consumer will be indicated in the meter used by the consumer after exceeding the maximum demand the meter and hence the connection will automatically be disconnected by an embedded system inserted in the meter itself .According to the maximum demand the consumer will purchase a cash card of amount depending on the consumption of energy and after the full consumption the consumer again has to purchase another cash card or recharge the same and thus the hassle related to go to the billing office to stand in a long queue and to submit the bill can be avoided. Also this system helps to eliminate the drawback of billing management system such as to take the reading from the meter to create the bill, to print the bill, to send the bill to the proper address and to collect the amount for the bill. Hence this system can effectively reduce the manpower required to a greater extent. Also a new concept of distributor has been dealt here which is used to disconnect a line if the energy consumption per day of a consumer greatly exceeds a pre demand energy consumption per day.

3. DESIGN OF AMR

AMR is a method of automating the prevailing energy metering system. It uses the components which will lasts long and which are less prone to temperature variations and which have a good lifetime. The main components of this technique are as follows:

a) Digital energy meter
b) Current sensor.

These two components are mainly required to sense down the readings automatically for the applied load. The energy meter which works digitally will have a LCD display showing down the voltage, power, current etc., to note down all the values clearly and also they are shown on the screen for better accuracy. Then if the load is applied the current will be sensed by the current sensor which will have its own regulators .Then these sensed units of current can be sent to the billing point by the following means.

The AMR system consists of four main subassemblies namely
a) Load
b) Sensing point
c) Microcontroller
d) Printed circuit board
e) GSM modem

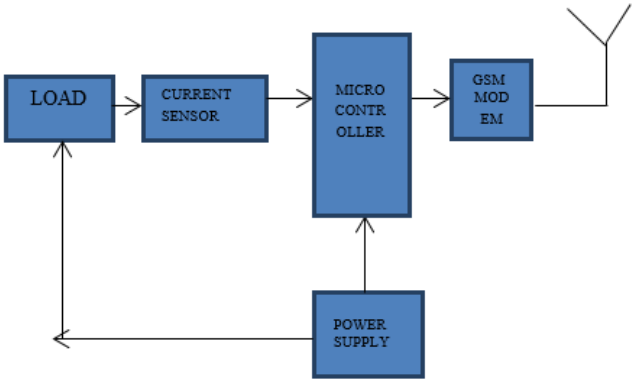
The PCB controls the electrical inputs and outputs to the circuits provided .The load is applied here which consumes the current and ensures the working of energy meter for the acquired units. The sensing point includes the current sensor, voltage sensor etc to automatically sense the units acquired by the applied load.

4. WORKING OF AMR

The proposed system is composed of a sensing unit, transmitting unit and billing unit. The system consists of load, current sensor, PIC controller and GSM modem. The load is made to run such that it automatically consumes the current. Then current sensor is used to sense the amount of current being consumed by the load. Then this is interfaced to the billing point through the GSM modem. The load applied consumes some amount of current this is sensed by the sensor which gets the current value from the meter, 3600 pulses per second or 16 units of power is kept as a single unit. Then this is sent to the microcontroller unit wherein these values are used for the calculation of the bill .to calculate the bill for a particular user GSM modem and a web page is created for all

of the consumers. There the microcontroller periodically collects the values from individual users and calculates the bill by the amount set for a single unit. This bill is sent to the users mobile number regarding the used units and the amount periodically and also checks the status of the consumer. By this way it eases the work of EB department and also the consumer's.

5. SYSTEM ARCHITECTURE



Block Diagram of AMR

This architecture consists of the components mainly needed for the automation of the already prevailing energy meter. It just needs the supplementary components circuits to support the automation .the main components in this system are:

a) Load

An electricity meter ,electric meter, electrical meter or energy meter is a device that measures the amount of electric energy consumed by a residence, a business or an electrically power device. This electrically power device which consumes the current and makes the meter to run for the readings is called a load from which the sensor is connected to sense the current.

b) Current sensor

A current sensor is a device that detects electric current in a wire and generates a signal proportional to it. The generated signal could be analog voltage or current or even digital output. It can be then utilized to display the measured current in an ammeter or can be stored for further analysis in a data acquisition system or can be utilized for control purpose. Here the generated signal is used for data acquisition where the data stored is sent to the microcontroller. It is a device that detects and converts current to an easily measured output voltage which is proportional to the current through the measured path .Indirect sensing involves measurement of magnetic field surrounding a conductor through which current passes. Current sensor operates from 5V and outputs analog voltage proportional to current measured on the sensing terminals. Sensing terminal can even measure current for loads operating at high voltages like 230V AC mains while output sensed voltage is isolated from measuring part.

c) Microcontroller

PIC 16F877 is one of the most advanced microcontroller from Microchip. This controller is widely used for experimental and modern applications because of its low price, wide range of applications, high quality, and ease of availability. It is ideal for applications such as machine control applications, measurement devices, study purpose, and so on. The PIC 16F877 features all the components which modern microcontrollers normally have. This controller has many special features to support the designed system.it has an EEPROM memory which has the capability to update the data acquired by the current sensor. It has a RTC called real time clock which is needed to keep the timings update in the event of current failures. The controller is programmed in such a way that it gets the values from the current sensor as digital units. This unit is fed to the controller unit where in the calculations are done to calculate the bill. These units updating is done in such a way that the counting pulses will be consecutively read even if the load is removed. The controller accepts the DC power so it is provided with a VCC of 5 volt where in a rectifier is provided to convert the AC power from the mainline to DC supply, through this the controller works perfectly for all other calculations. The controllers is also fed with a rate for each units so that it gets multiplied with the units received and gives out the bill. These works are done at the billing point where the server will be maintained for large number of consumers. The GSM unit is connected to this microcontroller unit using an interface.

d) UART interface

A universal asynchronous receiver/transmitter is a computer hardware device for asynchronous serial communication in which the data format and transmission speeds are configurable. The electric signaling levels and methods (such as differential signaling, etc.) are handled by a driver circuit UARTs are commonly used in conjunction with communication standards such as TIA. A UART is usually an individual integrated circuit used for serial communications over a computer or peripheral device serial port. UARTs are now commonly included in microcontrollers. A dual UART, or DUART, combines two UARTs into a single chip. Similarly, a quadruple UART or QUART, combines four UARTs into one package, such as the NXP 28L194. An octal UART or OCTART combines eight UARTs into one package, such as the Exar XR16L788 or the NXP SCC2698. A related device, the UniversaLSynchronous/AsynchronousReceiver/Transmit ter (USART) also supports synchronous operation.

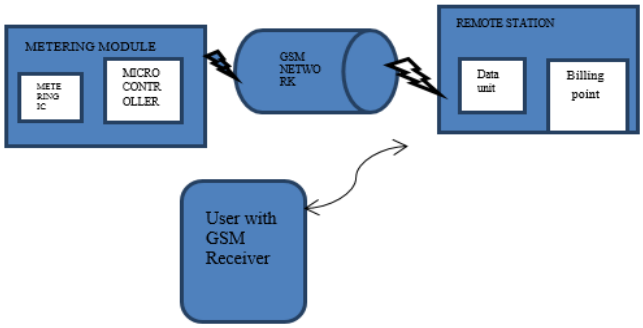
D1) RS232 features

An RS-232 serial port was once a standard feature of a personal computer, used for connections to modems, printers, mice, storage, uninterruptible power supplies, and other peripheral devices. However, RS-232 is hampered by low transmission speed, large voltage swing, and large standard connectors. In modern personal computers, USB has displaced RS-232 from most of its peripheral interface roles. Many computers do not come equipped with RS-232 ports and must use either an external USB-to-RS-232 converter or an internal expansion card with one or more serial ports to connect to RS-232 peripherals. Nevertheless, RS-232 devices are still used, especially in industrial machines, networking equipment, and scientific instruments. It directly control various hardware devices, such as relays or lamps. Using few input and output instructions an

application program can change the state of RS-32. All servo drives, PLC are programmable via RS-232. Here the users data are sent as time-series of bits. For an asynchronous transmission we need not place parity bits here.

e) GSM meter

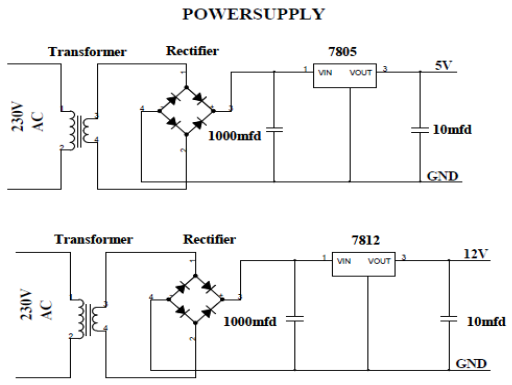
When developing a technology that might replace one which has been in use for more than 30 years , not only the key issue needs to be addressed but added functionality and solutions presented by the previous technology need to be addressed. Even existing meter readers and other employers have to accept the quality and effectiveness of the proposed one.



The developed AMR system consists of three main parts namely a digital GSM power meter installed in every individual consumer unit, transmission facility and billing server at the energy provider side. The GSM energy meter is constructed using the microchip single phase dedicated energy metering IC, a LCD display is also needed, a PIC microcontroller, and modem. A 10A class 1 single phase meter is designed with embedded GSM modem which utilizes the existing GSM network to send its power usage value as SMS to the energy provider wirelessly. While sending the message each time, the same data is also stored in the associated nonvolatile memory (EEPROM).RTC module is also integrated in the meter to have time stamped recording of the usage details.

f) Power supply

The microcontroller and other devices get power supply from AC to DC adapter or from direct ac lines through voltage regulator. The adapter output voltage will be 12V DC unregulated. The 7805 regulators are used to convert 12V DC value to 5V DC value.



The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

F1) Working principle

Transformer

The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op–amp. The advantages of using precision rectifier are it will give peak voltage output as DC, rest of the circuits will give only RMS output.

Bridge rectifier

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners.

Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.

The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow.

The path for current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. this path is indicated by the solid arrows. Waveforms (1) and (2) can be observed across D1 and D3.

One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. Waveforms (3) and (4) can be observed across D2 and D4. The current flow through RL is always in the same direction. In flowing through RL this current develops a voltage corresponding to that shown waveform (5). Since current flows through the load (RL) during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of

the conventional full-wave circuit. This may be shown by assigning values to some of the components shown in views A and B. assume that the same transformer is used in both circuits. The peak voltage developed between points X and y is 1000 volts in both circuits. In the conventional full-wave circuit shown—in view A, the peak voltage from the center tap to either X or Y is 500 volts. Since only one diode can conduct at any instant, the maximum voltage that can be rectified at any instant is 500 volts. The maximum voltage that appears across the load resistor is nearly-but never exceeds-500 v0lts, as result of the small voltage drop across the diode. In the bridge rectifier shown in view B, the maximum voltage that can be rectified is the full secondary voltage, which is 1000 volts. Therefore, the peak output voltage across the load resistor is nearly 1000 volts. With both circuits using the same transformer, the bridge rectifier circuit produces a higher output voltage than the conventional full-wave rectifier circuit.

g) IC voltage regulators

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.

A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, Vo, from a second terminal, with the third terminal connected to ground.

The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts.

6. CONCLUSION

The described system is to achieve the smart energy meter automation using GSM technology. Sensor systems are used to sense the various values. In this module current sensor is used to measure the value of the current consumed by the applied load. The PIC is used to get the values from the sensor as a digital one. The PIC is programmed in such a way that it accepts data according the time set up. Then RS232 is used for the serial communication of data asynchronously since synchronous leads to a tedious process. This data which is carried is sent to the GSM modem which is present at the billing point and sends the information called the calculated bill to the respective consumer of that data. This reduces risk since it reduces the human intervention. And it also reduces the problems caused by Serial communication. Various electronic meters have been developed and are still being developed. However the use of GSM in this particular system provides numerous advantages over methods that have been previously used. Data transmission is charged at standard SMS rates. Transmission of readings to the billing point is also very much cost efficient. The system does the elimination of drawbacks like even though it miss out the message acknowledgement it does not affect the system performance. It reduces safety risks since human intervention is minimized.

7. FUTURE SCOPE

The concept of AMR has attracted of lot of consumers since it is more advantageous and more useful one for today's life. This system in future can be extended to the water and gas meter reading systems. In future this project can be extended to the wide number of states and also it can be made to work for three phase power supplies. Then web portals can be added to extend the idea to the worldwide energy providers. Power factor improvements can be added.

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