GSM Enabled Embedded System for Energy Measurement & Billing

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Abstract-
Before the advent of electronic Measuring system the procedure for measurement of electrical parameters was more tedious & time consuming. The man power required was more. The customer is supposed to pay first for mistakes done by the service providers & latter on struggle for the correct bill. The aim of the paper is to develop a measuring instrument that enhances the measurement of electrical parameter as well as send these parameters to service providers using GSM technology. The energy meter system can be incorporated with embedded microcontroller with GSM port to transmit the read data. This data can be then fed and integrated into existing energy management system located at power companies & organizations. GSM based energy meter is used for measuring & calculating energy. The results of this evaluation indicate that this meter is a realistic approach of the Energy measurement. It has high degree of accuracy and is also applicable for gas flow, water flow etc.

Key-words: GSM, Microcontroller, Energy Measurement, Serial Port, Real Time Clock

1. INTRODUCTION

The conventional energy metering system is based on analog meters placed at consumer end. This system demands to appoint a person to note the meter reading at regular intervals. This is exhaustive procedure, which involves lot of time and effort, but still does not produce accurate results. There are a lot of complaints regarding errors in the meter readings. The customer has to first pay for the mistakes done by the services provider & later on struggle for the correct bill.

The metering electrical parameters supplied by the various service provider for domestic as well as to the industrial sector is of great importance from the point of view of proper monitoring of the power generated on one end and power consumed on the other end.

The objective of this paper is to develop the measuring instrument that enhances the measurement of electrical parameter as well as send these parameters to service provider using GSM technology.

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In GSM Technology, after a predefined time, the no of units consumed by the consumer will be transmitted to main super computer, with consumer code no. This is achieved by sending the SMS to main server of service provider. One dedicated mobile will be interfaced to the PC of service provider, which will go on receiving SMS from different users. This will result in, no need of person visiting the place and noting down the readings, which then will be passed to the operator.

Thus automatic meter reading helps the consumer, the energy services provider to access the latest and accurate information from the metering devices and provides saving in time, man power and helps in efficient energy management.

In section II brief description of GSM is presented. Section III & IV explains advance and new concept of GSM technology for measurement of Energy. In section VI results and in section VII future scopes are presented.

2. BRIEF DESCRIPTION OF GSM

2.1 GSM COMMUNICATION

The Europeans in 1982, in the conference of Europeans Posts and Telegraphs (CEPT) formed a study group called Group Special Mobile (GSM) to study and develop European public land mobile system. The purpose of this group was to provide-

1. Good subjective speech quality
2. Low terminal and service cost
3. Support for international roaming
4. Ability to support handheld instrument

5. Support for range of new services and facilities
6. ISDN compatibility

2.2 SERVICES PROVIDED BY GSM

●The GSM has ISDN compatibility in terms of services offered and control signaling used

●A GSM user can send and receive data at the rates up to 9600bps to user on POTS (Plain Old Telephones Services)

●Since GSM is a digital network, no modem is required between the GSM and user.

●A unique feature of GSM, not found in older analog system is the facility of SMS (Short Message Service)

SMS is a bidirectional service for short alphanumeric messages as shown below in Fig2.1

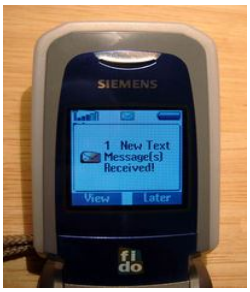

Figure 2.1: Short Message Service

2.3 ARCHITECTURE OF GSM NETWORK

The GSM network can be divided into three broad parts as shown in figure2.2 below. The Mobile Station is carried by the subscriber. The Base Station Subsystem controls the radio link with the Mobile Station. The Network Subsystem, the main part of which is the Mobile services Switching Center (MSC), performs the switching of calls between the mobile users, and between mobile and fixed network users. The MSC also handles the mobility management operations. The Mobile Station and the Base Station Subsystem communicate across the Um interface, also known as the air interface or radio link. The base station subsystem communicates with mobile service switching centre across the A interface.

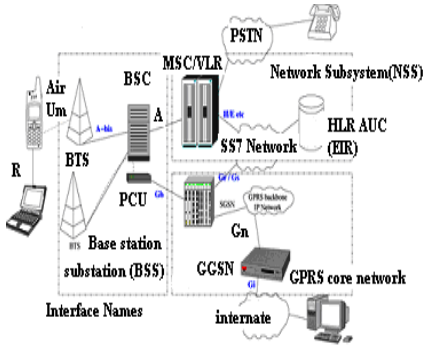

Figure2.2: GSM network structure

3. TECHNICAL SPECIFICATIONS OF THE GSM ENABLED ENERGY METER

3.1 Block Diagram of the system

The schematic block diagram of the system is as shown in fig.3.1. The circuit is classified into two broad categories as Analog section design and the Digital section design.

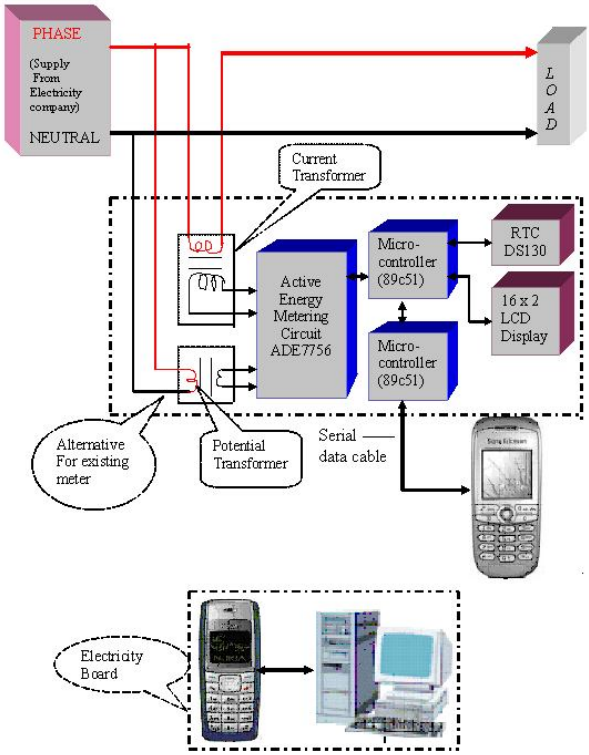

Figure 3.1: Detailed Block diagram of the system

3.1.1 Input signal sensing circuitry

The input signal to be measured is given to the sensing elements for the purpose of basic measurement. This signal is sensed by the potential

and the current transformer which are called 'Prime Sensing Elements'.

3.1.2 Active Energy metering circuitry

Electrical power is given by the product of the voltage and current waveforms. The resulting waveform is called the instantaneous power signal and it is equal to the rate of energy flow at every instant of time. The active power is equal to the dc component of the instantaneous power signal *p(t)*= VI. This is the relationship used to calculate active power in the ADE7756. The instantaneous power signal *p(t)* is generated by multiplying the current and voltage signals. The dc component of the instantaneous power signal is extracted by Low-Pass Filter to obtain the active power information. This process is graphically illustrated in Figure 3.2

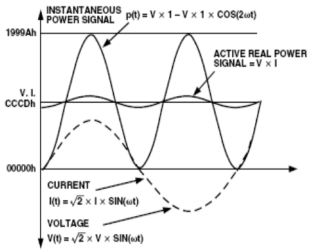

Figure 3.2: Active power calculation

Energy Calculation:

Energy is given as the integral of Power.

$$E = \int P dt$$

The ADE7756 achieves the integration of the Active Power signal by continuously accumulating the Active Power signal. Calculating the Energy, this integration removes any non sinusoidal components that may be in the Active Power signal.

3.1.3 Micro controller

The Microcontroller is the heart of the system. It controls all the units for the purpose of functioning and also for the synchronous operation. It initiates all the process from receiving the input data to the sending the data through the GSM link to the dedicated mobile of the system. The Microcontroller IC89C51 is used as the CPU in the system.

3.1.4 Real Time Clock

Real time clock used mainly for the real time application of the project that is to send the data to the electricity board after a stipulated period. The Real time clock IC DS1307 contains calendar and clock plus 56 bytes of nonvolatile SRAM. The DS1307 address and data are transferred serially via a 2-wire bi-directional bus with the Microcontroller.

3.1.5 LCD Display

The measured energy meter reading has to be displayed on the screen for observation. This is done through the LCD display. This is 16 x 2 displays. It is capable of displaying two lines each of 16 characters.

3.1.6 Serial port

The serial port is interfaced to the microcontroller by using the serial IC DS232A. It provides an easy interface of the serial port to the Microcontroller. The serial port is used to interface the GSM unit to the Microcontroller.

3.1.7 GSM module (Mobile)

GSM mobile is used to send the data to the electricity board regarding the usage of the energy consumed which is displayed on the LCD module. The GSM module used is the Mobile unit on both the sides. A Sony Ericsson set is used on the sender side and the Nokia set is used on the other side to accept the data. The GSM mobile is interfaced with the Microcontroller through the serial port through a serial cable.

4. INTERFACING GSM MOBILE WITH ENERGY METER

4.1Block Diagram

The Sony Ericsson mobile is connected to the communication port of the Energy Meter as shown in figure 4.1. This is connected through the cable. This mobile should be capable of operating in both the PDU and the Text mode. Text mode is require for the SMS operation.

At the receiver end, Nokia mobile is required to connect which will go on receiving the sms send by the Microcontroller.

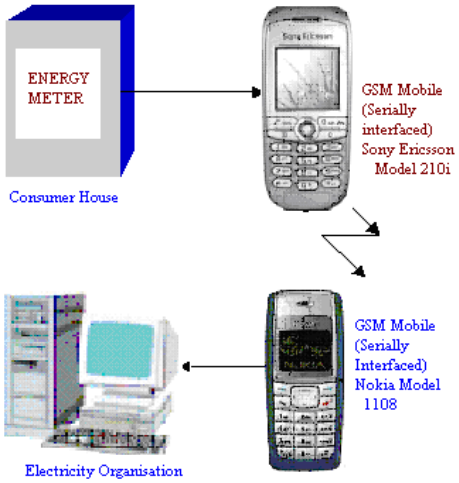

Figure 4.1: Block diagram showing Interfacing of Mobile with the EM

The GSM network offers a wireless infrastructure which extends your reach to anywhere in the world. There are several means to tap onto this infrastructure as a communication medium. One way is to use a direct data call to connect a point-to-point data link from one place to another or, to log into the World-Wide-Web via GPRS. A simple method is also via Short Message System (SMS).

Whichever means is used, a user wants to exchange or send data or information from one point to another. This paper describe here how to use an AT command on mobile phones to be as a GSM communication information node.

4.2 Using and testing the cable and mobile using hyper terminal

1. Both the USB connector and the RS232 must be plugged into PC. Connect the phone to the data cable.
2. Use HyperTerminal which comes with Windows (Start->Accessories->Communications->HyperTerminal). Connect directly to the COM port is connected to the data cable.
3. Select the baud rate to be 9600 bps (actually, the module will accept all the baud rate setting, any selection will work). The other parameters are: Data Bits (8), Parity (None), Stop bits (1), Flow Control (None).
4. Connect to the COM port. Type "AT" on the hyper terminal.
5. The GSM module will respond with an "OK".
6. It is essential to try the network by calling the mobile phone.
7. The module phone will send the "RING" message, when it picks up an incoming call from the network.
8. To accept the call, use the "ATA" command.

4.3 Selecting a Mobile Phone or GSM module

It is necessary to use a phone that is GSM AT compliant. Then, it is possible to communicate with the phone through AT commands1. The other criteria that can be enlisted be that the cable used for connecting a serial port to the mobile should be compatible with all the models of the mobile.

4.4 Mobile AT Commands

A mobile can be controlled in different ways by the microcontroller with the help of commands called as attention commands. With that, it is possible to test out the AT command with the mobile phone. The following are some simple AT commands:

Table: AT commands details

Command	Call control
AT	Attention
ATA	Answer Command
ATD	Dial Command
ATH	Hang Up Call

- Type "AT" on the HyperTerminal. The GSM phone will respond with an "OK".
- This is the simplest command to tell the mobile phone to go on attention. It doesn't do anything. However, this is also a means to test if the phone responds on the baud rate and all the serial settings.
- A phone call can also be made to the mobile phone on this screen shot.
- The GSM phone will send a "RING" message, when it picks up an incoming call from the network.
- To accept the call, one can use the "ATA" command.
- With that, it is possible to communicate to the phone via serial port. Thus, a system can send or receive data remotely.

4.5 SMS AT commands

The following are some simple AT commands to do SMS.

SMS Commands

AT+CMGR - Read Message
AT+CMGS - Send Message

Text mode SMS are available on GSM module. This offers an easier path in which a micro-controller system to implement. For mobile phones, SMS uses PDU encoding in which a message is encapsulated into a fixed format and protocol. This structure of data is passed to the mobile phone in the event of sending out an SMS to the phone. Or when receiving SMS, the data structure is read from the mobile phone via the RS232 port.

4.6 Reading SMS

The AT+CMGR=1 command reads the SMS message at the index location of 1. Each SMS, when

they arrived are stored in indexed memory location of the mobile phone.

4.7 Sending SMS

To send SMS messages, use the GSM command: AT+CMGS.

The AT+CMGS = 27, pre-notifies the GSM mobile phone that a PDU will be sent containing 27 bytes of data (actually it is 27 x 2 bytes of BCD information).

The data passed to the mobile phone after the "AT+CMGS" command follows the PDU description here.

5. SYSTEM PERFORMANCE ANALYSIS

5.1 System Testing

The system is tested using three methods as the Theoretical analysis and the Practical verification of the results. The given system is also tested by comparing the same with the standard power measurement i.e. wattmeter. The given system is also compared directly with the standard Class 1 energy meter.

6. RESULTS AND DISCUSSION

6.1 Conclusions

1) This wireless energy meter is a realistic approach to the energy measurement using the mobile communication.

2) This system will not require the new communication system to be set up, since the mobile technology is already setup thus saving the cost of the final installation

3) It has a high degree of the accuracy for the measurement of the energy consumed.

Energy measurement has been carried out for a typical load. The observations are as given below-

Sr. No.	Energy Measurement with Conventional Method (wh)	Energy Measurement with GSM Technology (wh)	% Error
1	0.946	0.97	0.024
2	0.95	0.97	0.02
3	0.96	0.971	0.011
4	0.95	0.97	0.02

4) The basic principle of monitoring and transmitting of measured parameter can be applied to many other applications such as gas, flow, temperature measurement.

6.2 Applications

1) To monitor power usage in different departments. The power usage in different departments can be monitored, so it can be observed that which department is using maximum power. So, if there is waste of power in any department, it can be limited.

2) It can also be used to monitor total power usage of a small scale company.

3) It can be used in such places where manpower is less or due to environment effects it is difficult to collect the data of power consumed.

4) It can be used in such areas where people manipulate the meter reading.

5) It can be used in houses for monitoring the consumption of the energy. It is helpful for the user also because they do not have to wait for the person coming from the Electricity Board. Also it reduces the human error.

7. CONCLUSION AND FUTURE ENHANCEMENT

1) The system can be modified to monitor three phase supply. The three-phase supply can be monitored using 3 CT's and 3 PT's. So MUX will have 9 inputs including 3 power signals. Software also can be modified accordingly.

2) System also can be modified to monitor Power factor, maximum demand of power in the company.

3) System indication for crossing the upper and lower preset limit of power factor and maximum KVA demand can be made. So as to switch on or switch off necessary capacitor banks/inductive loads to correct power factor and to switch on or switch off some of the loads for load shedding.

4) Data logging to PC and printer can be made available, so that data tabulating and plotting can be done for analysis purpose.

5) System can be build to detect the tampering made by customer (wrong connections, wrong phase sequence etc.)

6) By making some changes in the RTC and the assembly language programming the consumed power can be sent to the mobile.

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