

GSM Based Automatic Energy Meter Reading Using Smart Energy Meter

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Abstract: An automatic remote meter-reading system based on GSM is presented in this paper. This paper is useful to obtain meter reading when desired so meter readers don't need to visit each customer for the consumed energy data collection and to distribute the bill slips. Microcontroller can be used to monitor and record the meter readings. In case of a customer defaulter, no need to send a person of utility to cut-off the customer connection. Utility can cut off and reconnect the customer connection by short message service (SMS). Furthermore, the customer can check the status of electricity (load) from anywhere. In this system energy meter readings are being transferred by making use of GSM.

Keywords: Smart Energy Meter (SEM), Automatic Meter Reading (AMR), Global System for Mobile (GSM), Short Messaging System (SMS).

1. Introduction

Utility billing is yet unavoidable in the World as for concern post-paid energy meter. In Pakistan, utilities are using a conventional way of billing. A meter reader goes Home to home takes the meter reading and note down it, manually. These readings are brought to utility administration office. The criterion of utility billing is applied according to the utility service rules and regulations. The employee of the utility goes door to door again and gave the bill slips of the utility to the respective consumer. [1-3].

Detailed load flow can be provided by smart energy meters to the consumers so they can manage their load effectively [4]. Smart energy meter is used for Automatic Meter Reading (AMR) to increase the accuracy of meter reading. For instance, a utility person might not read the correct value of the total energy consumed that is displayed on energy meter or may intentionally give lower value than the exactly read one [5]. Power Line Communication (PLC) can also be used for obtaining the meter readings but interference and noise makes it inadequate. Metering information can be transmitted via Wi-Fi and Zig-Bee but their range is limited and they do not provide a cost effective solution [6]. However, for larger remote distance GSM communication system is much efficient than others.

Auto billing is one of the suitable ways to overcome the flaws

of conventional billing; since conventional billing contains wastage of time and resources as well. In auto billing there is no more need of manual meter reading and bill slips.

1) Flows in conventional billing

There are many flaws and errors in conventional billing. Some human mistakes may also occur in manual billing. Analysing the conventional billing some of the common observed errors and mistakes are:

- It's a time consuming procedure
- There is always a chance of human error while taking the manual meter reading
- There is no check and balance and verification procedure of this meter reading
- There is always a chance of theft and corruption
- Extra human power is required
- Consumer is not updated of his usage
- Consumer may not get the bill slip within due date

2. Smart energy meter

The size of smart meters and traditional meters is same and smart meters are digital [7]. Smart Energy Meter measures more detailed readings than Kwhr so that utility can plan the expansion of network and power quality [8],[9],[10]. The Smart Energy Meter is designed so that it measures voltage and load currents by the use of voltage and current sensors instead of potential and current transformers and then feeds these values of voltage and current into power factor controller IC and energy metering IC the power factor and power calculations respectively.

The design of Smart Energy Meter involves the measuring of load current and voltage using sensors and then feeding them to energy metering IC which converts it into the real power consumed by the load. Power factor is measured by measuring the phase shift between voltage and load current. Microcontroller used to perform the calculations related to power and energy consumed and shows the reading on LCD as well as it sends the reading of Smart Energy Meter with the help of GSM modem.

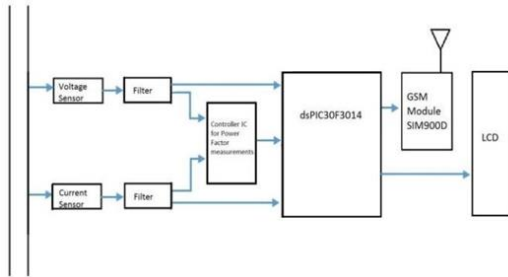


Fig. 1. Simple block diagram of smart energy meter.

Active power, reactive power, voltage, load current, power factor and units (kWh) are measured and displayed successfully. Meter reading are sent from GSM modem and received on mobile successfully. Two-way communication is done by smart energy meter between the meter and utility administration as well as between meter and customer so that customer is able to check the status of his consumed energy units and can manage his load accordingly to reduce his bill. The main features of smart energy meter are listed as follows;

- Get automatic reading of Energy Meter and sent it to consumer as well as to utility.
- In reading it measures Voltage, Load Current, Real power, Reactive power, Power factor and units consumed.
- Utility is able to cutoff/restore the supply of the defaulter through SMS.
- Measuring energy meter reading any time we want through the use of SMS i.e. energy meter responds to the message and send u reading whenever it is asked.
- Consumer is able to check the status of his load from anywhere in the world by SMS.

1) Working of Smart Meter.

GSM communications network is used to transfer the electricity consumed data to the utility administration as well as to the customer when demanded. Antenna, attached on or near meter box, can be used for improvement of signal strength in GSM communication. Smart metering communication is centralized meter reading, so meter readers don't need to visit each customer for data collection. However, for testing and maintenance meters may need to observe occasionally.

The main duty of Smart Energy Meter is to measure the meter reading and sends it to utility when demand as well as to costumer. The voltage and current sensors measure the RMS values of voltage and current and feed them to microcontroller, where calculations for active and reactive power are performed. In Smart Energy Meter we used sensors to measure voltage and current instead of current and voltage transformers. The reading from Utility administration SMS is being received by smart energy meter programmable interface and the action is performed by the meter according to provided information.

A major feature of Smart Energy Meter is that utility company can cut off and reconnect the connection of energy of any user with the help of SMS without sending the person to

perform the task manually. It can be utilized in case when the utility company needs to disconnect a consumer due to nonpayment of bills or some other reasons. Another major feature of Smart energy meter is that it gives alarm when the consumer load is exceeding the upper limit for which he got the utility connection. In case consumer does not reduce his load meter automatically cut off the consumer connection. GSM communications network is used to transfer the electricity consumed data to the utility administration as well as to the customer when demanded. Antenna, attached on or near meter box, can be used for improvement of signal strength in GSM communication.

2) Main parts of smart energy meter

Smart Energy Meter is comprised of three main parts:

- A. Voltage and current measurements
- B. Power factor measurements
- C. GSM portion

B. Voltage and current measurements.

In our project we used current and voltage sensor to measure voltage and load current. We used ACS712ELC-20A as current sensor that gives us RMS value of currents. Both AC and DC signals current measurement is precisely obtained by this current sensor. Current is measured by this sensor up to 20A. Overall power consumption, metering and measurements are taken by these sensors. Sensitive measurements of current are handled by using OPAMP stage. By adjusting the gain, we measure very small currents. ACS712ELC-20A output voltage has linear variation with measured currents. Similarly, we measured voltage by ACS712ELC-20A.

C. Power factor measurements

Power factor is the cosine of angle between voltage and current. It actually measures how effectively the power is being converted into useful work. In our project we measured it by taking XOR of voltage and current waves with the help of microcontroller and LM358. We used LM 358 to convert weak sinusoidal signals to large square signals. After XOR we get signal of double frequency as shown in figure 4. We calculated the time of XOR signal and it is the power factor. For 50Hz the output of XOR can be 10 ms if power factor is 0. And "0" if power factor is unity. So the output of XOR lies between 0 -1 for a certain value of power factor.

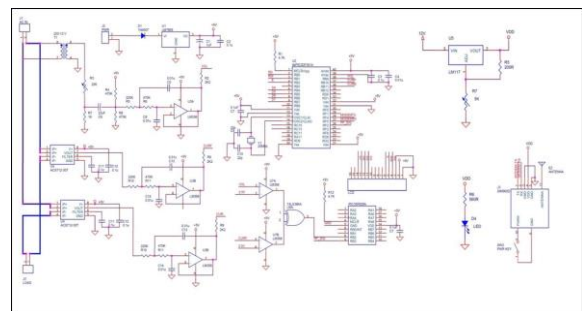


Fig. 2. Detailed circuit diagram of smart energy meter

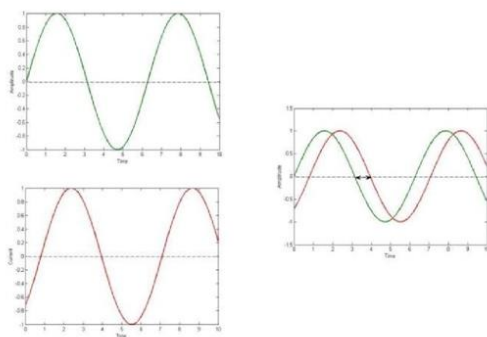


Fig. 3. The sine wave of voltage and current, Showing the phase difference between voltage and current Solution

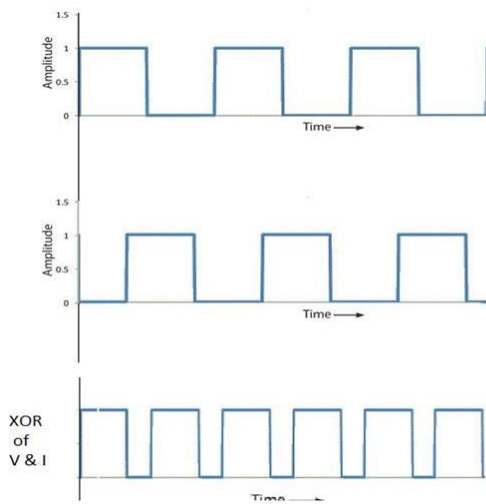


Fig. 4. The square wave of voltage and current and their resultant after XOR operation

D. Wireless portion

There are many technologies that are being used for AMR as Power Line Carrier (PLC) communications, Supervisory Control and Data Acquisition (SCADA), telephone modem, internet, Ethernet, Embedded RF Module, Wi-Fi, Bluetooth, and ZigBee.

Power Line Carrier (PLC) and Telephone Line Network are the example of wire-based AMR system and GSM and Bluetooth are the examples of wireless AMR system. The transmission system of Smart Energy Meter utilizes the existing GSM network. A GSM modem is used as mobile equipment/ Data Communication Equipment to send the information regarding the numbers of units of electricity consumed to our desired mobile number. We used SIM900 GSM modem in our project. A SIM is used inside the modem for data communication.

Power Line Communication (PLC) can also be used for obtaining the meter readings but interference and noise makes it inadequate. Metering information can be transmitted via Wi-Fi and ZigBee but their range is limited and they do not provide a cost effective solution. However, for larger remote distance

GSM communication system is much efficient. We used SIM900 GSM modem in our project. A SIM is used inside the modem for data communication.

3. Testing and results

The accuracy of Smart Energy Meter is checked by comparing the readings that are displayed on the LCD of SEM and that are received by SMS. Smart Energy Meter is also checked by connecting and disconnecting the customer's connection. We connected different loads 100W, 200W, and 1000W and checked its performance.



Fig. 5. Smart energy meter in working

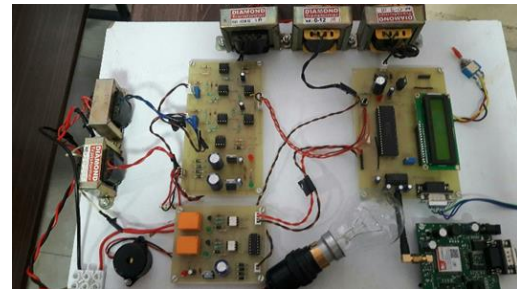


Fig. 6. The internal circuitry of smart energy meter.

The testing of SEM provided accurate results, hence verifying the performance and accuracy of the system.

4. Conclusion

The project describes the design and working of Smart Energy Meter and represents how Smart Energy Meter can be used for Automatic Meter Reading. It is the most economical implementation to develop mankind in this era of technology. With the present enhancement in the use of technology to facilitate mankind, it is an efficient and practical utilization of present networks. This paper also shows that how customer can manage the load by using Smart Energy Meter. It provides ease in taking the meter readings, accuracy, detection of faulty conditions, power factor calculation, less operation cost and removal of possible corruption related to meter reading.

5. Future recommendations

I thought there are few possibilities which can also be done on this project in future as I have provided flexibility in the

project especially in controller section. The future research should include the proper methodology for measuring the power factor of the load.

Recommendations for future are as follows:

- Instead of GSM networks, some other means of communication should be used.
- In case of GSM, there must be security of GSM so that it can't be hacked.
- Power factor must be measured by different techniques.
- Linking of the data received by GSM to computer and developing a program which incorporates the tariff related to specific consumer and calculating the bill directly on the computer. In this way the computer will calculate the bill directly using the data received through GSM network.
- Smart energy Meter can be modified for the detection of illegal use of electricity.

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