

**Wireless Automatic Meter Reading System With Power Factor Correction**Anjaly Joseph T<sup>1</sup>, Elizabeth Paul<sup>2</sup>, Bail J Paul<sup>3</sup><sup>1</sup>Electronics and Communication Engineering, Mar Athanasius College of Engineering, Kerala, India<sup>2</sup>Electronics and Communication Engineering, Mar Athanasius College of Engineering, Kerala, India<sup>3</sup>Electronics and Communication Engineering, Mar Athanasius College of Engineering, Kerala, India

**Abstract** —] The problem associated with traditional meter reading is increasing day by day, due to various reasons such as rapid growth in population, tedious location, environmental conditions etc. In this paper we discuss about Wireless Automatic Meter Reading system with power factor correction. The system uses a 32 bit ARM microprocessor together with energy meter IC ADE7758 for reading power consumption and communicates this data to the utility server for power data processing. GSM network is used for communication with utility server in two way communication link. Power data is used for various purposes such as bill management, for measurement of static power parameters etc. Control systems contains relay circuit, used for disconnection power supply when consumer fails to pay electricity bill in due time. The power factor correction unit is also included to increase the overall efficiency of the system.

**Keywords**- Meter IC, Microcontroller, GSM module, Server Design, Power factor

**I.INTRODUCTION**

An energy meter is a device that measures the amount of electric energy consumed by a residence, a business, or an electrically powered device. Problem associates with traditional meter reading have been increased day by day, due to various reasons such as rapid growth in population, tedious location, environmental conditions etc. But with new developments of microcontroller, there are many improvements in automating various industrial aspects for reducing manual efforts. In traditional meter reading system in which utility usages are written on paper by workers, there is lot of chances of human errors. These will cost more to the utility company. Also there are chances that of unavailability of consumers during utility worker's visit for meter reading. In such cases, billing process will be pending & utility workers again require to visit to consumer. Going to each & every consumer's house & generating the bills is very laborious task & require lot of time. It becomes very much difficult in natural calamities specially in rainy season. Moreover it is also difficult for utility workers to find out unauthorized connections or malpractices carried out by consumers manually. This all will result in loss of revenue generation for utility company. So in order to eliminate these problems we have implemented meter reading system based on latest GSM technology.

The conventional meter reading system also require large amount of human power. In order to eliminate these problems automatic meter reading system is used. The proposed system is designed using electric meter, ARM controller LPC1769 as core processor, and GSM module for distant communication. This system performs tasks such as taking meter reading and cutting and reconnection of flow of energy automatically. This model can lead to great deal of costs saving, man power saving, and time saving electricity metering.

To reduce losses in the distribution system, and to reduce the electricity bill, power factor correction, usually in the form of capacitors, is added to neutralize as much of the magnetizing current as possible. Capacitors contained in most power factor correction equipment draw current that leads the voltage, thus producing a leading power factor. If capacitors are connected to a circuit that operates at a nominally lagging power factor, the extent that the circuit lags is reduced proportionately.

**II. LITERATURE SURVEY**

Over the past years electric energy meters have undergone phenomenal changes and are expected to become even more sophisticated, offering more and more services. The electromechanical based energy meters are rapidly being replaced by digital energy meters which offer high accuracy and precision. Now the generation of electric energy meters is that of automatic energy meter readings (AMRs). Various features offered by AMR are given below:

- Higher speed
- Automatic billing invoice
- Real time energy cost

In the paper GSM based automatic energy meter reading system with instant billing[1], Ashna K. and Sudhish N. George proposed the design of a simple low cost wireless GSM energy meter and its associated web interface, for automating 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. Also they can monitor the meter readings regularly without the person visiting each house. 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 enabled energy meter is sent back to this billing point periodically and these details are updated in a central database. 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.

In the paper development of an automatic meter reading system based on Zigbee PRO smart power profile[2], Champ Prapasawad, Kittitach Pornprasitpol and Wanchalerm Pora proposed the development of an automatic meter reading system focusing on the design for an energy meter implemented with ZigBee wireless communication protocol conforming to IEEE 802.15.4 standard. In this they used a microcontroller STM32L152VBT6 to manage energy data and ZigBee to enable communication between the energy meter and data centers.

In the paper secure low cost AMR system based on GPRS technology[3], Alauddin Al Omary, Wael El-Medany, and Sufyan Al-Irhayim, presented the design and implementation of a secure low cost AMR system that measures and transmits the total electrical energy consumption to main server using general packet radio service (GPRS) technology provided by GSM networks. The proposed AMR system consists of three main parts: Accurate digital meter, a transmission facility and the billing server. To make affordable AMR system a low cost off-the-shelf materials are used.

In Wireless ARM-Based Automatic Meter Reading and Control System[4], Amit Biranje, and Dr. Mrs. S. S. Lokhande discussed about Wireless ARM Based Automatic Meter Reading with control system (WAMRCS). This System is used with 32 bit ARM microprocessor for reading power consumption & communicates this data to the utility server for power data processing. GPRS networks are used for communication with utility server in two - way communication link. Power data is used for various purposes such as bill management, for measurement of static power parameters etc. Control systems contains relay circuit, used for disconnection power supply when consumer fails to pay electricity bill in due time.

In ARM based automatic energy meter reading using GSM[5], By D.A.Shaikh, Prasad Nirmal and Kiran Nirmal, Poonam Ghorpade discussed about an Automatic Meter Reading system that is used for the remote monitoring and control of the domestic energy meter. This system allows the electricity department to read the meter reading orderly without the person visiting each house. This can be attained by the use of ARM unit that continuously monitors and records the energy meter readings in its persistent (non-volatile) memory location. This system is used with 32-bit LPC2148 ARM microcontroller used for reading power consumption and communicates this data to the utility center. In utility center power data processing is done. The communication between utility center and an ARM based embedded system is done with the help of GSM. Measurement of static parameters such as current, voltage and power, bill management are done with the help of power data. The control system includes relay circuit and breaker which are used for disconnection or resume the power supply.

In Implementation of automatic meter reading system using wireless sensor network[6] by Amruta kotasthane and Hate S.G presented a meter reading system based on latest ZigBee technology. In this model they designed and implemented wireless sensor network for measuring utilities such as electricity, water. The system is designed using electric meter, flow sensor for measuring utilities, ARM controller LPC2138 as core processor, and ZigBee module in close communication with GSM for distant communication. This system performs tasks such as taking meter reading, distribution of bills, sending notice, cutting and reconnection of flow automatically. This model can lead to great deal of cost saving in water, electricity metering. In the above papers, the efficiency of system is less due to the reactive components present in the system. So in order to increase the efficiency of the system, in this proposed project; power factor correction circuitry is used and a user friendly web portal is provided to control the power supply of individual consumer.

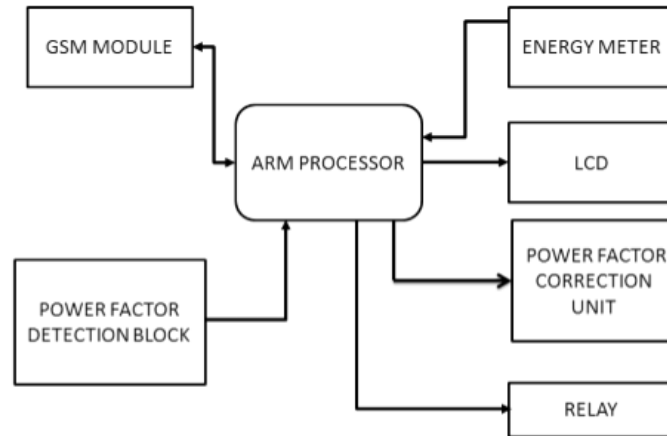
### **III. PROPOSED SYSTEM DESIGN**

Electric meters are typically calibrated in billing units, the most common one being the kilowatt hour. Periodic readings of electric meters establish billing cycles and energy used during a cycle. Automatic meter reading system is a technology which automatically gathers data from energy metering devices and transfers it to the central office in order to analyse it for billing purpose. Objectives of proposed project are

- To design a system for reading power consumption and communicates this data to the central server for power data processing.
- To introduce fast communication between consumer and utility server.
- To create a user friendly web portal to communicate with the consumer.

- To create an automatic disconnection and reconnection of power supply from the distant server.
- To correct the power factor of the system.
- To increase the efficiency of the system

The block diagram of wireless automatic meter reading system with power factor correction consist of an ARM processor, energy meter, GSM module, power factor detection block, power factor correction unit and relay unit.



**Fig.1 Block diagram of general energy meter**

### 3.1. ARM processor

ARM processor is the central part of wireless automatic meter reading system with power factor correction circuitry. ARM processor controls the operation of relay circuitries, LCD and GSM based on the inputs from energy meter and power factor detection block. UART communication is used between processor and GSM module. Output from energy meter is applied as the interrupt signal to the ARM processor.

### 3.2. Energy meter

An energy meter is a device that measures the amount of electrical energy consumed by a house hold, a business, or an electrically powered device. The IC used is ADE7758 and the first pin of the same is connected to the ARM processor for energy calculation. The ADE7758 is a high accuracy, 3-phase electrical energy measurement IC with a serial interface and two pulse outputs. The ADE7758 incorporates second-order  $\Sigma\Delta$  ADCs, a digital integrator, reference circuitry, a temperature sensor, and all the signal processing required to perform active, reactive, and apparent energy measurement and RMS calculations.

### 3.3. GSM module

GSM module is used to broadcast the amount of energy consumption from each node to the central server. SIM900a is used as the GSM module. The operational frequency of GSM module is 900MHz.

### 3.4. Liquid-crystal display

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. Here LCD is used to display the amount of energy consumption in form of counts, power factor of the system, time deviation between voltage and current waveforms and frequency of supply. 16\*2 LCD is used for this purpose. 16\*2 LCD means it can display 16 characters per line and there are 2 such lines.

### 3.5. Relay

A relay is an electrically operated switch. Relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. Here relay is used for the automatic disconnection and reconnection of power supply as per the status of bill payment also in the power factor correction purpose.

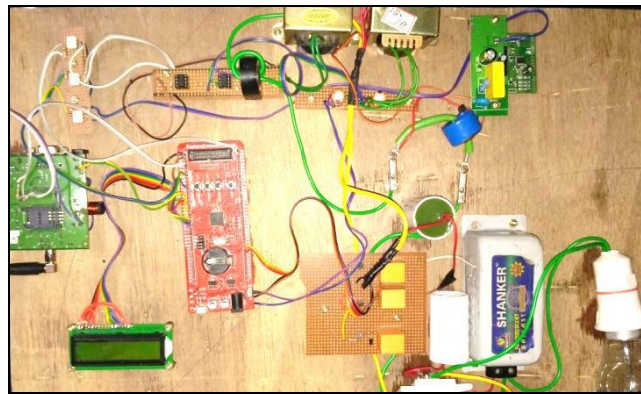
### 3.6. Power factor detection and correction

The power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensionless number in the closed interval of  $-1$  to  $1$ . A power factor of less than one means that the voltage and current waveforms are not in phase, reducing the instantaneous product of the current and voltage. Real power is the capacity of the circuit for performing work in a particular time. Apparent power is

the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power. A negative power factor occurs when the device generates power, which then flows back towards the source, which is normally considered as the generator.

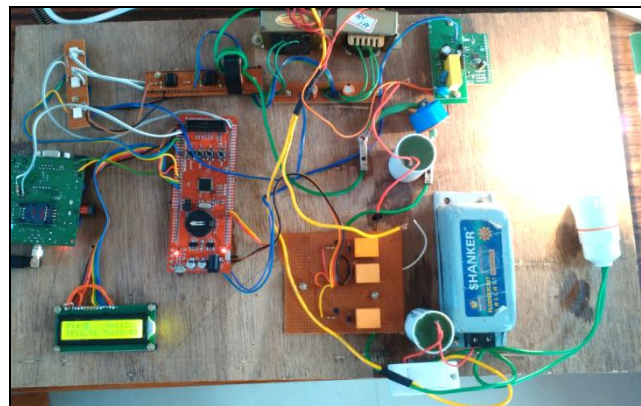
#### IV. RESULTS

The system is tested in place of traditional meter and achieved good results. For demonstration purpose, 100W bulb is used as a load to check our system. The bulb is connected to load and signal conditioning unit, which is used to measure the average real power information. This test is performed and power consumption is calculated. During the test, voltage and currents parameters are read for specified time interval to generate the bill. Based on this reading, power is also calculated and voltage, current and units are displayed on LCD. After payable date, the arm- based embedded system turned off the bulb through relay control unit, which proves the accuracy of our system in terms of the power calculation and remote controlling. Zero crossing detectors and opto-couplers are used to perform power factor detection part and by using capacitors, correction is performed.



**Fig. 2 Meter setup in power off condition**

Fig 2 shows the prototype modal of GSM based energy meter. In this project the pulse and unit (meter reading) count continuously recorded according to load connected.



**Fig. 3 Meter setup in power on condition**

The Fig 4 represents the LCD output of energy meter without power factor correction and it shows a power factor of 0.98 due to the inductive reactance present in the system.



**Fig. 4 LCD without power factor correction and time delay as 0.39 ms**

In order to check the accuracy of energy meter, difference between voltage and current in time domain value is also recorded as time in milli seconds (Tms). Count is the 34 corresponding value that represents the power consumed by the load and F denotes the main supply frequency in Hertz. In power factor detection circuitry, two separate zero crossing detectors are used to find zero crossing points of the voltage and current waveforms and these signals are applied as interrupts to the ARM processor. Time in milli seconds is calculated from the time difference between these two signals, and thereby calculates the power factor.

The Fig 5 represents the LCD output of energy meter with power factor correction circuitry and it shows a corrected power factor of 0.99.



**Fig. 5 LCD with power factor correction and time delay as 0.13 ms**

In correction circuitry, capacitors are added to compensate the inductive reactance present in the system. Capacitors are added to the main system through the relay circuitry and these relay units are controlled by the ARM processor. In order to check the accuracy of corrected energy meter, again difference between voltage and current in time domain value is also recorded as time in milli seconds (Tms) and converts it to the form of angle. Cosine value of this angle gives the power factor of system.

The Fig 6 represents the user friendly web portal created for the wireless automatic meter reading system with power factor correction. The “Turn On” and “Turn Off” buttons are used to control the power supply to remote consumers. The individual consumer number of customers (CN), amount of power consumption (Unit) and cost of power consumed (Amount) are displayed on the web portal. In this specific design, one rupee is charging for one unit of power consumption.



**Fig. 6 Web portal**

## **V. ADVANTAGES, LIMITATIONS**

### **Advantages:-**

- Increases overall efficiency of the system by improving the power factor
- Reduces the workload by the use of GSM module communication link
- Possible to avoid man-made errors because of sending real time power consumption updating system in every three seconds
- Provides good user interface where the user can see the power consumption and thereby they can adjust the usage rate
- Possible to correct power factor to 0.99 for the specific load
- Automatic disconnection and reconnection of power supply is possible through the relay circuitry and can avoid the continuous visit.

### **Limitations:-**

- Difficult to obtain ideal power factor 1.
- Not possible to correct the power factor of varying loads with the same circuitry.
- Circuit operation is limited to inductive loads
- Network errors may occur

## **VI. APPLICATIONS AND FUTURE SCOPE**

- The wireless energy meter system could find application in every distribution company for reading the energy consumption. It can also be extended for metering and monitoring other utility commodities such as drinking water consumption, internet access etc.
- The wireless energy meter reading system with power factor correction can be extended to capacitive loads thereby increasing the overall efficiency of the system, reduces cost and make it more wide spread all over the world. The same power factor correction circuit can be extended to adjustable loads.
- The mode of payment by the consumer can be extended to mobile banking, debit cards etc. This makes the wireless energy meter system simpler and user friendly.
- The protection against power theft and energy meter tampering can be incorporated with this project.
- Instead of using single phase, the energy meter can be extended to three phase supply.

## **VII. CONCLUSION**

Wireless automatic meter reading system (WAMRS) with power factor correction is one of the latest machine to machine application that remove all the problems associated with the traditional meter reading system such as error in taking reading, inaccuracy, external conditions affecting reading and delayed work. So to overcome from these problems we have designed a GSM based energy monitoring system which provides the technology of automatically collecting consumption and status data from energy metering devices and transferring that data to a central database, billing, power factor detection and correction. In the designed project wireless automatic meter reading system with power factor correction, the three key elements are consumption measurement, transmission of measured data and control the remote consumer with a user friendly web portal and efficiency enhancement. The system consists of an accurate digital meter, ARM processor, GSM module, relay control and power factor circuitry. WAMRS is cost effective; that is, cost of implementation and maintenance is less while providing robust and reliable performance. Another advancement in the system is an additional power factor detection and correction circuitry which helps to reduce the phase difference between voltage and current and increases the overall efficiency of system. User friendly web portal is created to display the consumption information, amount and payment status. The portal also controls the ON-OFF status of remote devices if the customer fails to pay the due on time.

## **ACKNOWLEDGEMENT**

The author wish to thank all the staff members and students of PG studies, Department of Electronics and Communication Engineering, Mar Athanasius College of Engineering, India.

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