# Design and Implementation of Secure Low Cost Novel Remote Metering System Using GPRS

[1] Mr.Nagaraj A.Hanchinamani [2] Mrs.Chandrakala.V
Dr. AMBEDKAR INSTITUTE OF TECHNOLOGY BANGALORE – 560056

## Abstract

*Improvement of Automatic Meter Reading System (AMRS) technology could be one-step ahead by using GPRS/EDGE. AMRS based on GPRS provides many advantages compared to other remote metering techniques. It uses TCP/IP and PPP protocol for communication and GPRS is an extension of GSM provides higher data transmission speed and more security. The benefits of implementing such system include robust data transmission, wide area network coverage, lowering power consumption, cost-effective and reliable. An interface system (IS) has been developed that can be plugged in existing digital energy meter and a new meter can also be developed with this IS. The proposed IS collects meter data and send that data to the server using GPRS modem. Each IS is capable of two-way communication. To send meter data existing GPRS networks have been used. This paper describes the detail hardware design of an interface system, step by step procedure of TCP/IP, PPP protocol implementation. The paper also shows the data transmission and reception with server end in real world.*

***Keywords*:** AMR, GSM, GPRS, IS, TCP/IP.

## 1. Introduction

Electricity is the source of power behind the development of any country. Due to increase number of power consumers in every sector such as residential, commercial and in industrial and scarcity in fossil fuel, it is essential to ensure proper use of energy and to generate correct bills and invoices and to reduce corruption. The conventional method of collecting meter data is done manually by assigning a person. It may involve dilemma such as human error and corruption. The Automatic Meter Reading System (AMRS) has completely changed the process of collecting meter readings. There are two types of AMR system: wire-based and wireless. Power Line Carrier (PLC) and Telephone Line Network are wire-based AMR system. The problems of wire-based AMR system are transmission distance, transmission cost, maintenance and security of data transmission. GSM, GPRS, WiFi, WiMax are the typical wireless based AMRS system. The wireless based AMRS system provides higher data collection speed and more efficiency. As there is no human intervention in the entire process, there is no chance of human error and corruption. In addition to this, the meter reading can be collected after any desired time interval such as hourly, daily, weekly, or monthly basis. Moreover, the electric supplier can take advantage of the wireless communication companies for remote monitoring and providing information to the customers anytime and anywhere. The Retail Providers will also be able to offer new innovative products in addition to customizing packages for their customers. In Automatic meter reading system, it is very essential to develop a proper networking mechanism where the data transfer will be in high speed, will provide great security and will be cost-effective. The utilization of existing telecommunications systems to transmit meter reading automatically in fast, secured and accurate manner. The communication networks like the internet, GSM/GPRS networks provide useful means of communication due to its good area coverage capability and cost effectiveness. GPRS also supports for leading communication protocol such as IP and X.25 and the most important step GPRS is on the path to 3G. If SMS over GPRS is used, an SMS transmission speed of about 30 SMS messages per minute may be achieved. This is much faster than using the ordinary SMS over GSM, whose SMS transmission speed is about 6 to 10 SMS messages per minute. The gradual improvement of AMRS could be one-step ahead by using the GPRS/EDGE.

1. Nagaraj A.Hanchinamani, M.Tech student in Department of Telecommunication Engineering Dr .AIT Bangalore-560056, India
2. Mrs.Chandrakala.V, Assistant Professor in Department of Telecommunication Engineering Dr .AIT Bangalore-560056, India

## II. AMRS SYSTEM OVERVIEW

In this paper, an interface system (IS) has been developed which will communicate with the digital meter and GPRS/EDGE modem. The IS generates meter reading based on the meter pulses and sends that reading to the server database. Each IS is capable of two-way communication hence the meter can be controlled form the server for some specific purposes. The billing office should have a highly secure database system through which only the authorized staff members of the electricity supply company able to read and print electricity bills. Other systems may be connected to the server for further process such as the online billing operation, providing security code, alarm system, temper detection. The system architecture of automatic meter reading system has given below in figure-1 through a block diagram.

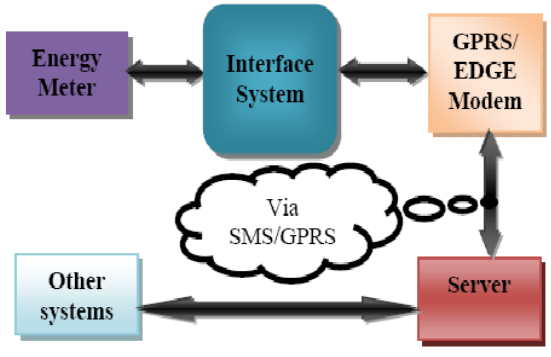


Figure 1 Block Diagram of Automatic Meter Reading System.

## III. Interface System

The interface system consists of a MCT2 Optocoupler, Microcontroller (MCU), modem and power regulation unit.

• MCT2 Optocoupler
Interfacing can be done in many ways with the meter – by hacking the MCU of the meter and then capture the data, or by decoding the display output or by counting the pulses of the meter, or placing a parallel meter with the actual meter embedding an AMR system. Counting pulse and using that counting value to generate meter data is a great solution. So in the IS, light dependent resistors is used to sense the LED blinking. Generally two basic sensor circuits can be developed. The first is activated by darkness; the second is activated by light. In this paper, a light activated sensor circuit has been developed for a number of reasons to reduce the interference between the circuits, simultaneous separation and intensification of a signal and high voltage separation.

• The Core Microcontroller Unit

The main function of the microcontroller unit (MCU) is to control the communication among the remote unit, the modem, and other different components. To select a suitable MCU for this project several matters have to keep in mind such as program memory size and type, speed, connectivity, USB On-The-Go (OTG) compatibility, analog to digital converter (ADC) features, USART etc. PIC24 and PIC32 series by Microchip MCU have been chosen because it satisfies the requirements of the project such as low power consumption, two-wire communication port, full duplex UART, ADC etc.

• Interfacing with Modem.

Interfacing the USB device with microcontroller is typically based on the operating mode of microcontroller whether the microcontroller is in host mode or it is in device mode. If the microcontroller is in device mode then again two conditions arises that it is Bus power device or Self power device. If the microcontroller is in Host mode then the microcontroller has to be run with either external 3V to 3.6V power supply or external 5V power supply.

• Power regulation unit.
For a proper function of any microcontroller, it is necessary to provide a stable source of supply; a sure reset when you turn it on and an oscillator. According to technical specifications by the manufacturer of PIC microcontroller, supply voltage should move between 2.0V to 6.0V in all versions. The simplest solution to the source of supply is using the voltage stabilizer LM7805 which gives stable +5V on its output. The power regulation unit also provides power to other part of the circuitry.

• Counting the pulse of energy meter
To count the meter pulse, ADC module of MCU has been chosen. The output from the Optocoupler unit will go to the ADC input channel of MCU. The MCU then performs ADC conversion on this input. The ADCH and ADCL registers will keep this conversion result. After the conversion meter data is count to generate the amount of power usage.

### *A. Design of interface system*

Following Design assumptions are made in the Interface System design.

1. The meter should satisfy KEB power systems requirements. It runs with 230V/50Hz supply.
2. The designed meter had a single-phase system mainly due to the budget allocation. Nevertheless, the theory of implementing a three-phase is

identical to a single-phase wireless automatic meter-reading system.

3. The meter can handle maximum current of 60 A.

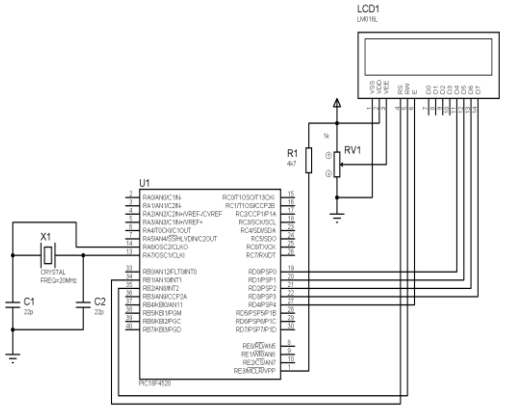


Figure 2: LCD and MCU Interfacing

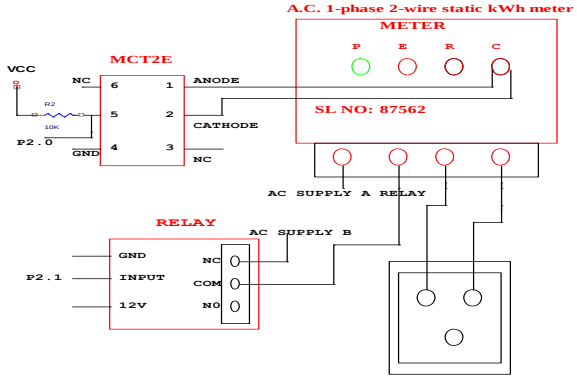


Figure 3:MCT2E and Energy meter section.

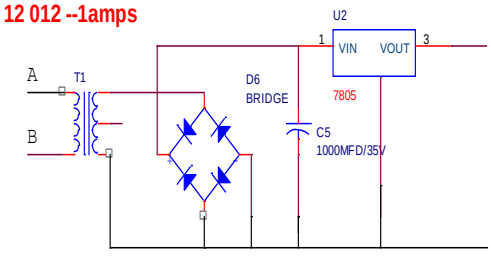


Figure 4: Power regulation unit Section

## IV. NETWORK MANAGEMENT AND CONNECTIVITY

Today internet is used in embedded system to control and monitor equipments. Several protocols are used for this purpose such as HTTP, PPP and TCP/IP. As the small 8-bit MCU holds very small memory space the conventional structure of these protocol are not applicable for embedded system. In general, the microcontrollers are made up with 128kbytes to 256kbytes of memory space. Therefore, to configure network in MCU only the minimum requirement is used to establish a protocol. Typical embedded IP stacks range from 14kB up to and exceeding 500kB. However, several protocols and works should have under consideration for connection establishment

### *A. Modem initialization*

Each modem will have different initialization parameters called Hayes AT command that must be sent to the modem. The application simply requests the modem to dial the server using Hayes AT command. The initialization step performs of checking the connection between modem and MCU.

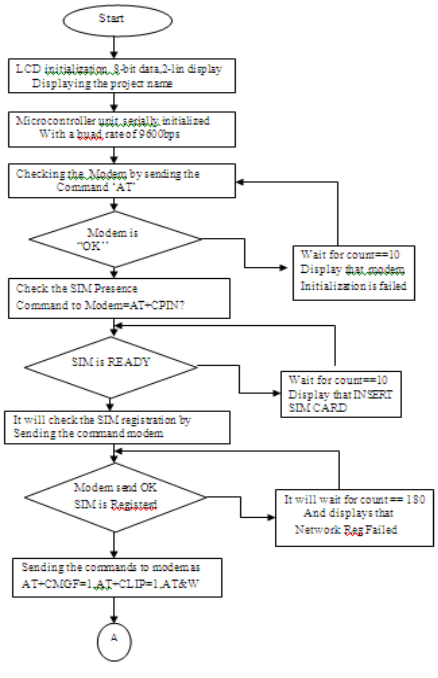


Figure 5: Flowchart for Modem initialization

### *B. Activate GPRS Connection*

Each mobile network will have different zparameters that must be set on the modem before connecting to their GPRS network. These parameters are Access Point Name (APN) and Access Number. The AT+CGDCONT command is used to set the APN and Packet Data Protocol (PDP) type as IP on the modem. After that, ATDT*99#" command is sent finally to connect with network. As shown in the below fig3

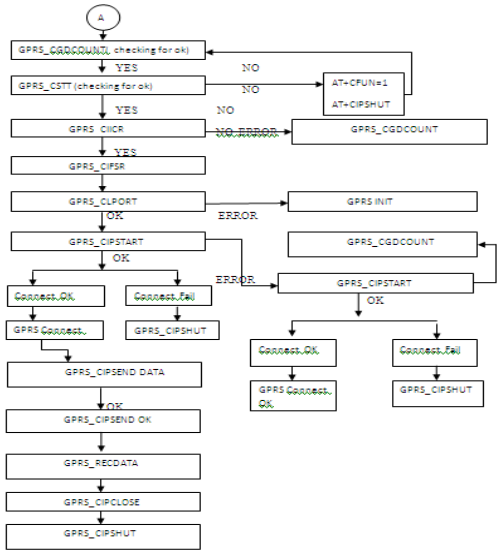


Figure 5: Flowchart for GPRS activation

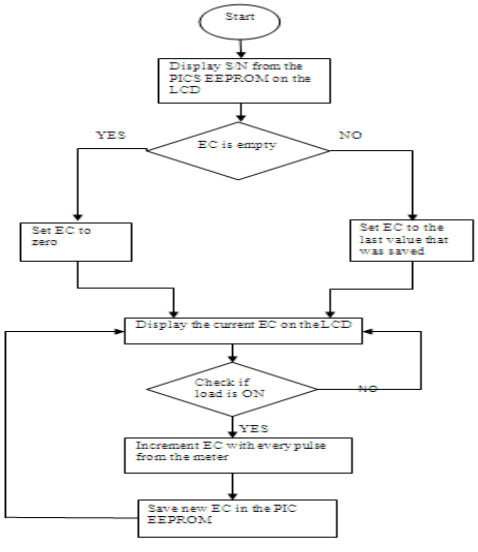


Figure 6: Flowchart for Meter Reading Terminal

### *C. Establish Point to Point Protocol (PPP)*

PPP is a set for various other protocols where each of the protocol is negotiated independently. As the PPP need to send these protocols over point-to-point links, it uses a special frame structure to encapsulate the PPP packets. International Organization for Standardization (ISO) has defined the High-Level Data Link control (HDLC) frame structure for PPP. Create a PPP connection on an embedded system at least Link Control Protocol (LCP), Internet Protocol Control Protocol (IPCP), and a user authentication protocol Password Authentication Protocol (PAP) or Challenge-Handshake Authentication Protocol (CHAP).

### *D. TCP/IP Stack*

TCP is one of the most reliable and connection oriented protocol. It sends packet through segmentation, checksum calculation, addressing, and flow control. The TCP/IP stack typically consists of IP, UDP and TCP protocols. The TCP/IP stacks those are implemented for embedded processors use a simplified model of the traditional TCP/IP stack to reduce the code size as well as the memory utilization. For embedded applications, a single global buffer is used in which the device driver puts an incoming packet. The buffer can hold a packet of maximum size that is defined for it. For receiving case, when a packet enters from the server, the device driver puts it in the buffer and calls the TCP/IP stack. If the packet contains data, the TCP/IP stack will notify the corresponding application. For sending case, when the application sends data to the server, first it goes into the buffer. Then TCP/IP stack calculate the checksums, and fill in the necessary header fields on that data and finally send the packet to the server.

## V.THE BILLING SERVER

The collected power consumption reading is sent to the central billing server where it is stored. Many commercial servers as well as management software are available in the market. However the cost of such server and software management system are very expensive. To decrease the cost of the proposed AMR system, in-house software is developed using JAVA Technology and is used to control the central server.

The implemented meter data management system will have the following functions:

a) Remote metering: The meter reading is sent automatically to the server and customers can remotely get their consumption at any time.

b) Bill issuing: The billing system shall provide monthly bill for customer who does not remotely access the server.

c) Customer tracking: The billing should include better customer tracking, bill forwarding identification of customer financial accounts information, and use of monetary deposits for account closing requirements.

d) Apply different tariff for different customers: Houses, schools, factories are treated different and the bill should be calculated according to the corresponding tariff assigned by electricity authority in Karnataka.

## VI. APPLICATION

- Automatic per day bill generation and monitoring of meter.
- Used for water meter control and monitoring System

- Industrial electrical energy conservation.
- Used for distribution and maintains in supply sector.

## VII. CONCLUSION

In this paper, a remote metering system based on GPRS has been discussed. To keep pace with the present technology implementation of GPRS communication with the Energy meter facilitates more data transfer with more speed between remote meter and server. Here different issues of hardware and firmware have been discussed that need to establish the interface system to communicate with energy meter. The existing meter in the market can utilize this interface system to transfer meter reading and a new meter can also be developed with this interface system. However, with this implementation any meter equipment such as Water meter and Gas meter as well as any data acquisition system can be used with necessary modification to transfer the data to a server.

## VIII. REFERENCES

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