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Economical Way of GPRS Based Fully Automated Energy Metering System

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Economical Way of GPRS Based Fully Automated Energy Metering System

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I. Introduction

Designing and implementing of automatic system has been becoming a prominent feature in our modern life in commercial as well as industrial systems. Due to enhancing automated networking system and modern information technology, automatic meter reading systems [1] and industrial sensor networks are getting acquainting with multifarious communication media [2].

For conventional systems, meter reader has to go to meter to get reading then we have to put the reading from their reading books. Sometimes, the meter keeps in lock then the meter reader can't get the reading.

Again, the operators put the wrong reading from their record book of reading. Moreover for reconciliation, we have to entry the collection amount from payment information of the consumer. This approach requires human involvement and it is tiresome and time consuming.

By using PSTN network, we can get meter reading [3]. Again, automatic meter reading networks introduced in [4], [5].

For high speed data control we have to use fiber optic communication but in rural area distribution system with more dispersed Distributed Energy Resources (DERs), it is not economical to deploy fiber-optic communication. Hence, wireless communication technologies are more feasible. The protection, control, monitoring, and metering between Distribution Automation Systems (DAS), and DERs have been studied in reference [6].

GPRS play an important role for transmitting data at a favorable price from residential buildings to central billing centers and providing extra services for the user. Due to high–speed, unlimited transmission range, GPRS is very appropriate for the power applications. This cellular network consists of cells, which are formed by many low power wireless transmitters. With the moment of mobile devices having cellular modem, transmission of data is also exchanged between cells to cell, which facilitates non interrupted data flow. This way it forms a point to point architecture. This technology offers extensive data coverage, no maintains costs and network fully maintained by carrier [7].

The user can obtain the status of the energy consumption and the billed amount by sending the corresponding commands from the mobile phone to the GSM modem. Then it sends the commands to the microcontroller section and the required information is sent to the user mobile through the GSM modem. Also they can obtain their consumption and billing status from specific website which is provided by Power Distributor Company. This increases the efficiency of the distribution system.

II. The System Architecture

The system architecture of economical way of GPRS based fully automated energy metering system is shown in figure 1.

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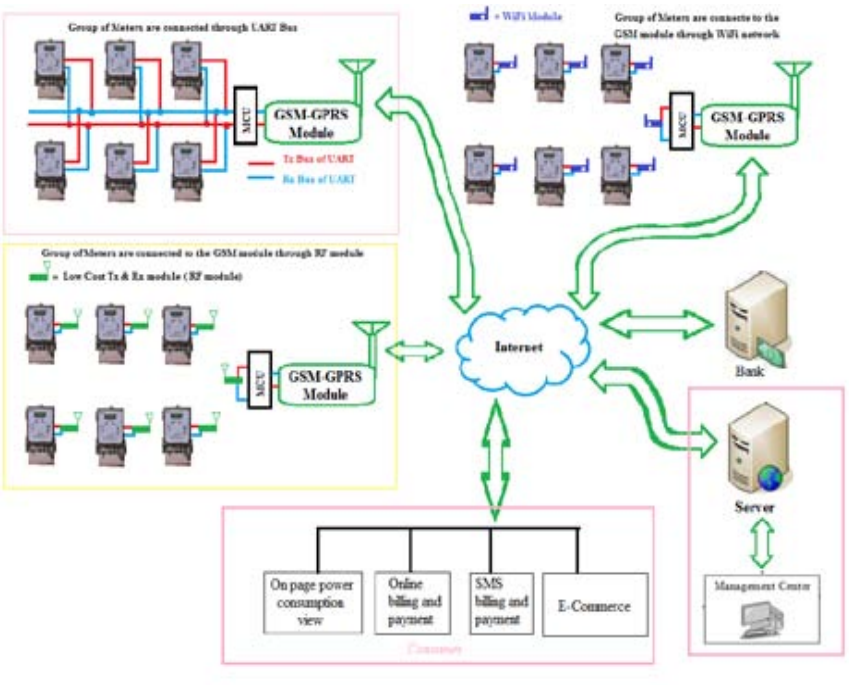

Figure 1 : System Architecture of EGFAEM System

The proposed EGFAEM system design consist of four main parts: Energy meters part, Communication part over GPRS, Server and Management part and consumer end for billing and payment.

In this system a group of meters are connected into a GSM-GPRS module by three different techniques which are shown in the figure 1. In the first system, group of meters are connected into a same bus through UART of meter MCU which connection process is done by I^2C (Intrigued Inter Connection) system and then connected to GSM-GPRS controller MCU. In second system, group of meters are connected into GSM-GPRS controller MCU through TX-RX (Transmitter and Receiver) module. And the third one, group of meters is connected into GSM-GPRS module via Zigbee or low-cost Wi-Fi module. In this paper we will present only first method of those systems.

a) Metering Part

Although a group of meters is used in the system but for example, a single phase energy meter is implemented for this purpose.

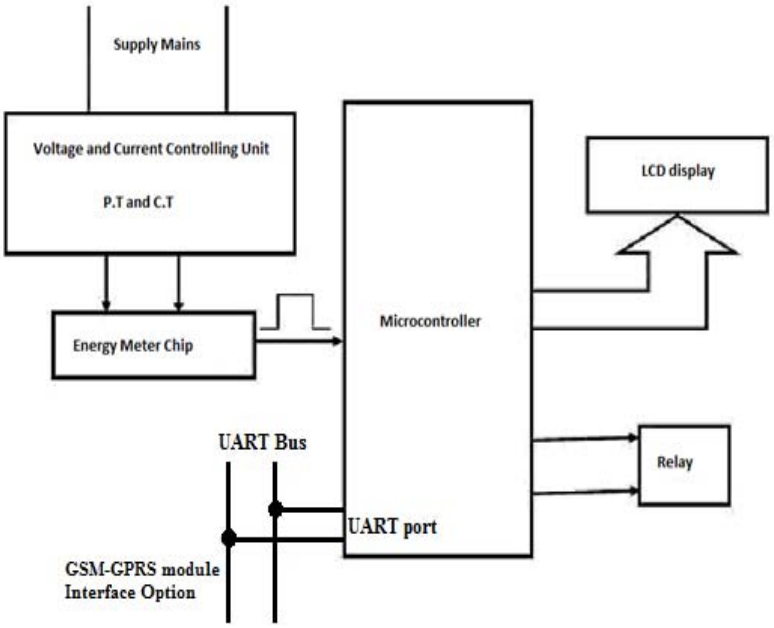

Figure 2 : Block diagram of Energy Meter

The energy meter part consist of Energy Meter IC, Voltage and Current controlling unit, Microcontroller, relays, UART bus and Liquid Crystal Display (LCD).[8]

- At first, supply mains are connected to the Voltage and Current regulating unit.
- This Voltage and Current regulating units feeds the actual voltage and current of the consumer load to the Energy meter IC with a specific ratio.
- Energy meter IC produces electrical pulses proportional to the power consumed by the consumer supply and the power supply of this metering system.
- The pulses of the energy meter chip are counted by the Microcontroller internal counter and then Microcontroller calculates the energy consumed of the consumer. It also maintains the all communication, control and display process.
- Microcontroller UART port (TXD and RXD pin) be connected to the GSM-GPRS module through UART bus for transmit the energy reading (KWh) data and receive the command from the server end.
- Relay mainly performs the opening and closing of a connection between energy meter and load through supply mains depending upon the command given from the server end.
- Liquid Crystal Display shows the energy consumption, date, time, etc. or any necessary message if the service center wants to give.

b) Communication Part

The Communication part block diagram is shown in figure 3.

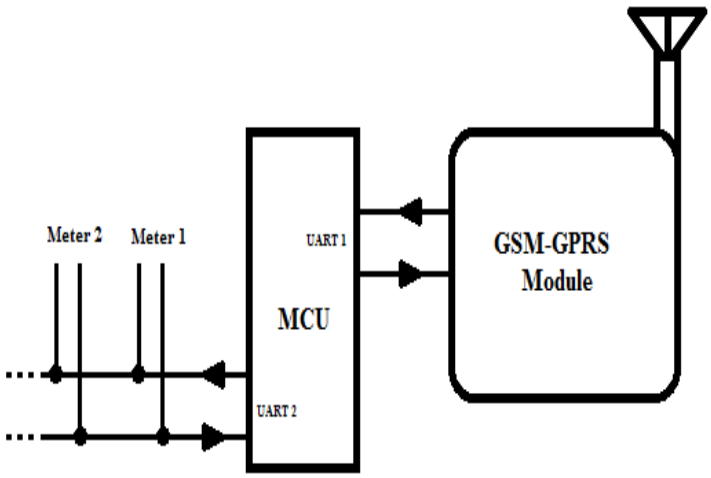

Figure 3 : Block Diagram of Communication Part

The communication part consists of UART bus, Microcontroller and GSM-GPRS module.

- GSM-GPRS module has been used to maintain the communication between meters and server thought its GSM and GPRS functions.
- Microcontroller drives the GSM-GRPS module via AT command and it also keeps communication to the Meters MCU though UART bus.

c) Server and Management Part

The Collected power consumption reading is sent to the computer server database where it is stored. As it is fully automated so, controlling or managing the consumer power supply like disconnection-reconnection, reading collection is done by the server managerial system.

d) Consumer Part

In this system, all consumer service like billing information, power consumption (KWh) reading and payment option is provided by specific website, SMS or by any other e-commerce system. So, that consumer can read and check unit consumption and pay their bill from home.

III. Hardware Development of Egfaem System

The hardware development of EGFAEM system can be divided into three parts. This are circuit diagram of energy meter unit, circuit diagram of communication unit and hardware development of management center. The description of these three parts is introduced as follows.

a) Circuit Diagram of Energy Meter Unit

The circuit diagram of energy meter unit is shown in fig. 4. The energy consumption is measured and calculated by energy meter IC and Microcontroller.

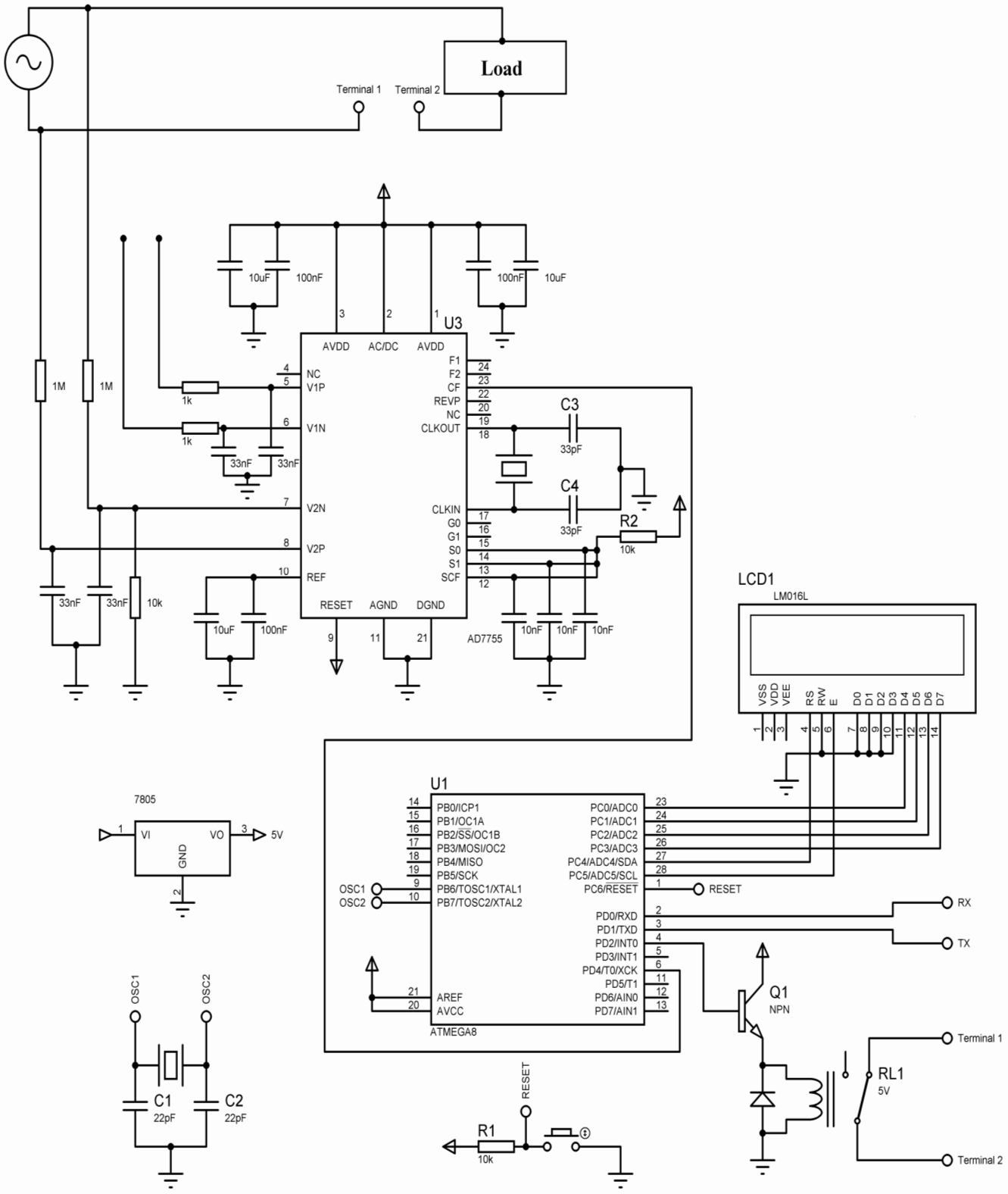

Figure 4 : Circuit Diagram of Energy Meter

In the following circuit diagram VDD represent the positive supply and GND represent the Ground. The circuit description is separately introduced as follows:

i. *Voltage and Current Transducer*

In this scheme,

ii. *Energy Metering IC*

At this project we use AD7755 as an Energy Metering IC. It is a high accuracy electrical energy measurement IC. The part specifications surpass the accuracy requirements as quoted in the IEC1036 standard. The only analog circuitry used in the AD7755 is in the ADCs and reference circuit. All other signal processing (e.g., multiplication and filtering) is carried out in the digital domain. This approach provides superior stability and accuracy over extremes in environmental conditions and over time [9]. It has two ADCs that digitalize the voltage signals from voltage and current transducer. These ADCs are second order sigma-delta converters and it's over sample rate is 900 KHz. The real power calculation is derived from the instantaneous power signal which is generated by a direct multiplication of the current and voltage signals. In order to extract the real power component (i.e., the dc component), the instantaneous power signal is low-pass filtered. The low frequency output of this AD7755 is generated by accumulating this real power information. This low frequency inherently means a long accumulation time between output pulses. The output frequency is therefore proportional to the average real power. This average real power information can, in turn, be counted by a microcontroller counter to generate real energy information.

iii. *Microcontroller*

It is a small computer on a single integrated circuit containing a processor core, memory, and programmable input-output peripherals. As its small size and low cost it is popularly used in automatic control system. In this scheme, ATmega8 Microcontroller is used. The number of pulses per second present at pin CF (pin 22) of Energy Meter IC is directly proportional to the instantaneous real power information for a particular load and microcontroller counts this pulses that appear at counter pin (pin 1) of Microcontroller within every 20 seconds [10]. The information such as power, energy and maximum demand are stored in the EEPROM of the Microcontroller. Also Microcontroller's UART port (TXD and RXD pin) be connected to the UART bus for communicating between Energy Meter and GSM-GPRS module controller MCU.

iv. *Display Unit*

In this scheme, a 16x2 LCD display module is used for this project. It is mainly used to display energy consumption of the load and maximum demand of the consumer.

v. *Relay Control Unit*

This is a very important part of the Energy Meter. It provides the useful functionality of remotely disconnect and reconnect the consumer power supply which is operated by Microcontroller. It consists of a protective relay, breaker control circuit & line breaker.

vi. *Power Supply Unit*

As Energy Meter IC, Microcontroller, relay and LCD operate on 5 volts supply. Therefore, we used a constant 5 volt DC power supply. This small energy is taken from consumer supply.

b) Circuit Diagram of Communication Unit

The circuit diagram of communication unit is shown in fig. 5. It is mainly two part GSM-GPRS module part and microcontroller part. These are separately discussed as follows.

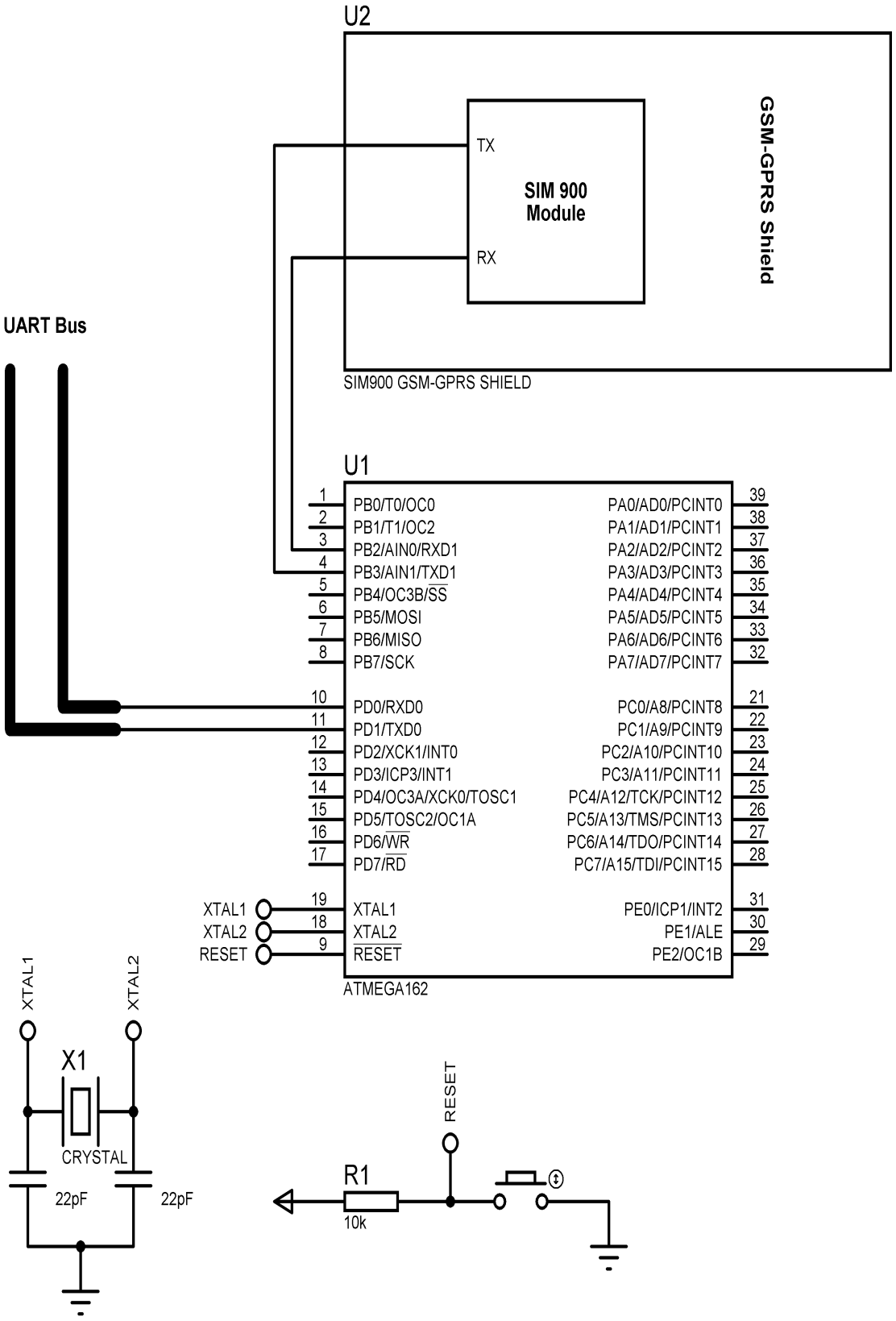

Figure 5 : Circuit Diagram of Communication Unit

i. *GSM-GPRS Module*

GSM stands for Global System for Mobile and GPRS stands for General Packet Radio Service is widely used in mobile communication architecture in most of the countries. In this scheme, we use SIM900 GSM module which is manufactured by SIMCON Limited. SIM900 is a Tri-band GSM/GPRS engine that works on frequencies EGSM 900 MHz, DCS 1800 MHz and PCS1900 MHz It is designed with power saving technique, the current consumption to as low as 2.5mA in SLEEP mode. The SIM900 is integrated with the TCP/IP, HTTP, FTP and SMTP protocols; extended AT commands are also developed for using these protocol easily. We use a GSM-GPRS Arduino shield module in the prototype implementation which has an on board SIM holder to place the SIM card and also it has GSM antenna. The transmit pin (TXD1) of the microcontroller's UART1 serial communication port is connected with the receive pin (RX) of the GSM module [11]. The transmit pin (TX) of the GSM module is connected to receive pin (RXD1) of microcontroller's UART1 serial transmission pin. Therefore the commands and their results are transmitted and received in a triangular fashion [12]. The serial communication protocol operate at the baud rate of 9600bps, one start bit, eight data bit, one parity bit and one stop bit. The AT (ATtension) commands are used to communicate with this module.

ii. *Microcontroller*

In this scheme, we use ATmega162 as a GSM-GPRS Module operator microcontroller. It has two USART ports for this reason we have chosen this IC. One is used for operating the GSM-GPRS Module and other one (TXD0 and RXD0 pin) is used for communicating the Energy Meter through UART bus.

c) Hardware Development of Management Center

In this prototype implementation, we use an internet connected Server Computer with necessary computer application and software. Meter reading collection, process and stored to the server database and reconnect and disconnect the consumer power supply (if needed), billing information publish to the web portal and automatic bill collection by web portal is done by this Server Computer of the Management Center.

IV. The Software Development of Egfaem System

In the meter and communication unit, the system software is implemented by C language and the developed code is compiled and debugged by mikroC PRO for AVR compiler.

a) Algorithm for Meter Part of EGFAEM System

1. Start.
2. Initialize the device and display.
3. Check whether the UART data ready or not. If the receive data available of the UART port then go to next or go to step 6.
4. Check the instruction command which is received by the meter and sent by the communication unit. Is the Meter ID of the instruction is matched to ID of the Meter then go to next or go to step 6.
5. Check the op-code (operation code), whether it is "Active", "Deactive" or sending the meter status command. If the command is "Active" then connect the load with the supply mains and set "active" in specific memory location for further determination or the command is sending the meter status then send meter ID and reading status to the communication unit Microcontroller via UART. After complete both process then go to step 7. If the command is "Deactive" then disconnect the load from supply mains by triggering the relay then go to step 3.
6. At this stage meter will check its specific memory location, is it previously set by "Active" means continuing supply to the load or "Deactive" means disconnecting the load from the supply. If yes then go to step 7 otherwise go to step 3.
7. Microcontroller internal counter count the pulses which are provided by AD7755 Energy Meter IC and Calculate power consumption, Energy and unit uses.
8. Store the energy, power reading and units' uses into the EEPROM of ATmega8 Microcontroller for future use.
9. Display the reading status on LCD.
10. Repeat the step 3.

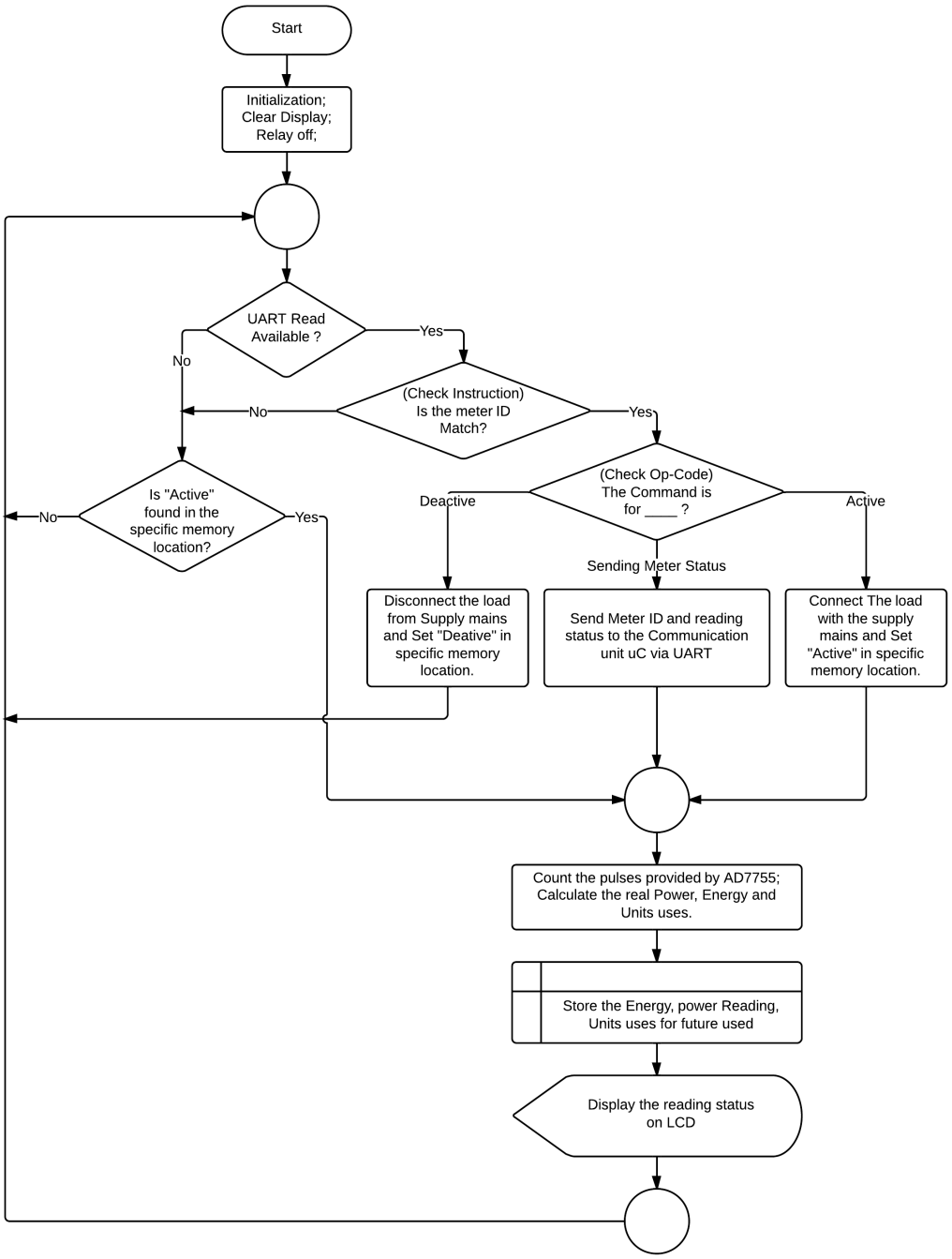

Figure 6 : Flowchart of Meter Part

b) Algorithm for Communication Unit

1. Start.
2. Initialize the device and switch on the GSM-GPRS Module.
3. Set content type as GPRS parameters, set APN, set GPRS profile to use with HTTP, set the URL direction from where it will take the instruction command. All this setting is done by specific AT command of the SIM900 module.
4. Connect with the HTTP server and check and read the instruction command. If the module ID of the read instruction command is matched with the ID of the Module then go to next or go to step 6.
5. At this stage, communication unit send the meter ID and op-code of the read instruction command which is declared by the server. This instruction byte is send by the UART0 port of the microcontroller.
6. Check the UART0, whether any data is available? If yes, the read the data like Meter ID and Meter Reading and write or upload this data to the server database through GPRS. If not then skip the read and write process.
7. Repeat step 4.

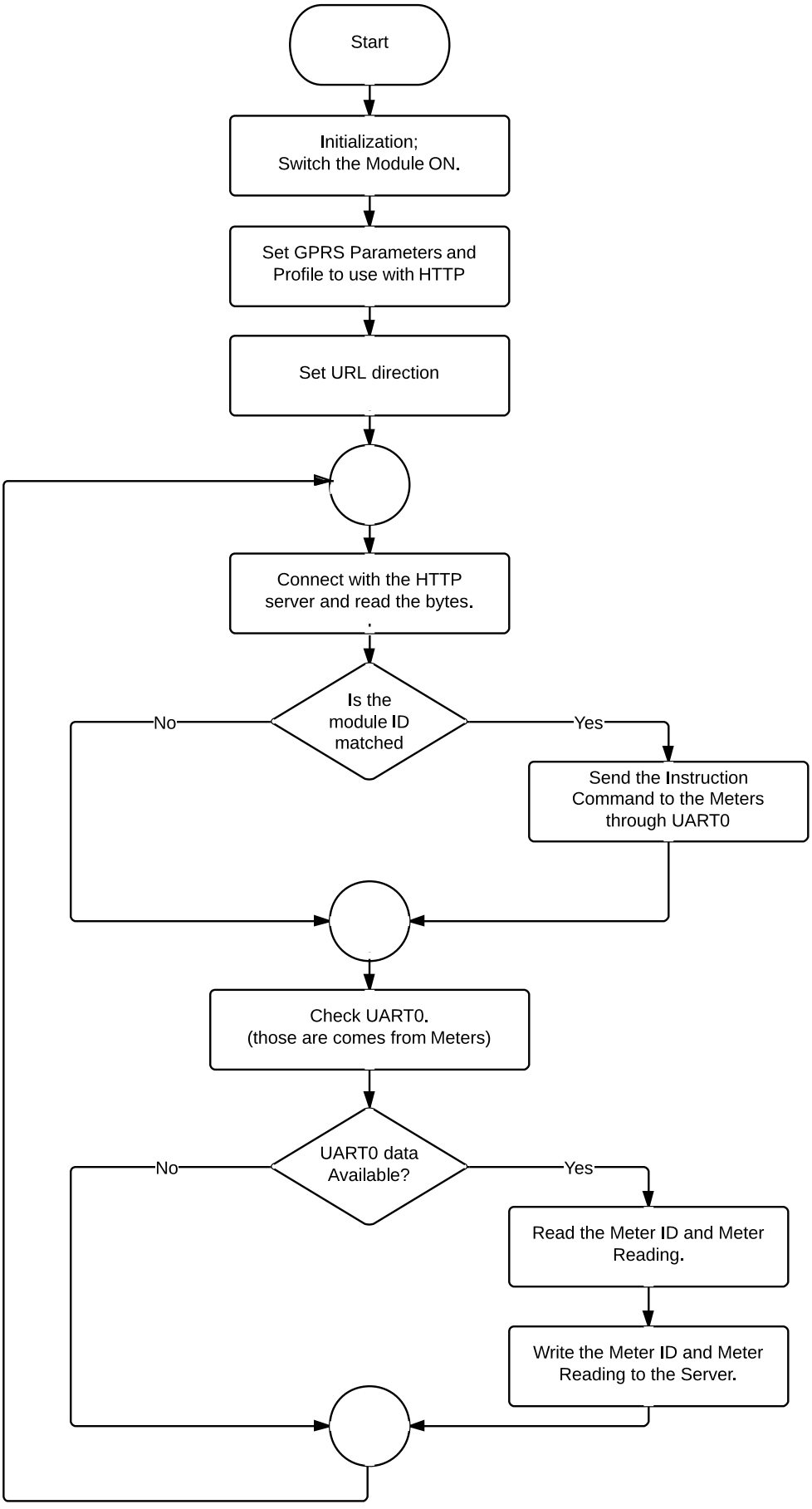

Figure 7 : Flowchart of the Communication Unit

V. Experimental Views

This experiment four energy meters with GPRS Communication box are installed in Electrical Lab at IUBAT. Each meter contains 0.5KW load by 20 one hundred bulb each of 5. Then the meter reading and terminal on-off control are successfully tested. Below Fig.8 shows the control and management web portal where consumers unit (KWh) uses, bill info, control option, current load etc can be shown.

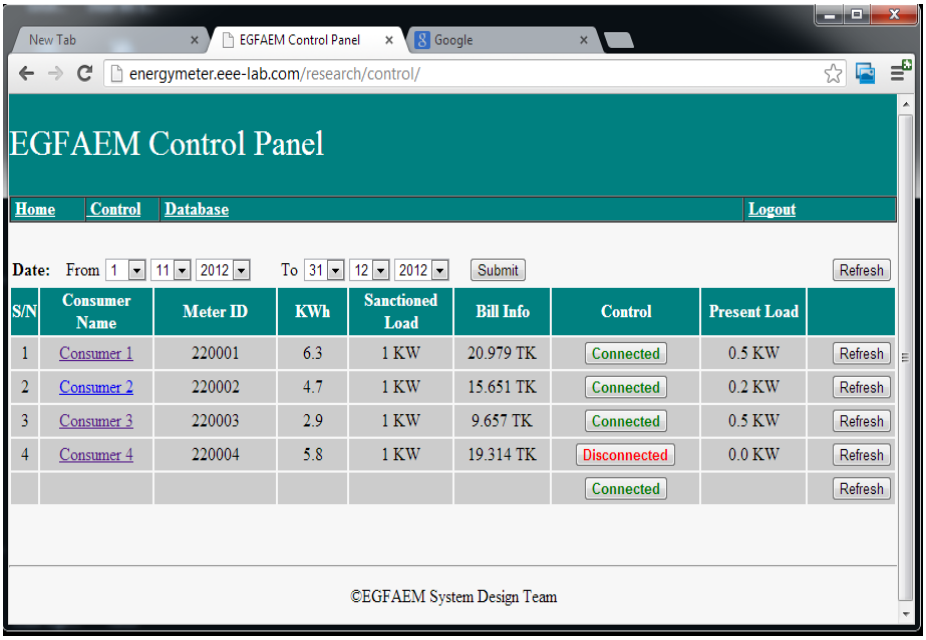

Figure 8 : Server Control Panel

Fig. 9 shows the consumer panel where consumer can check and read their billing information, unit (KWh) uses, billing history and also online payment option are added so that consumer can pay their bill from home.

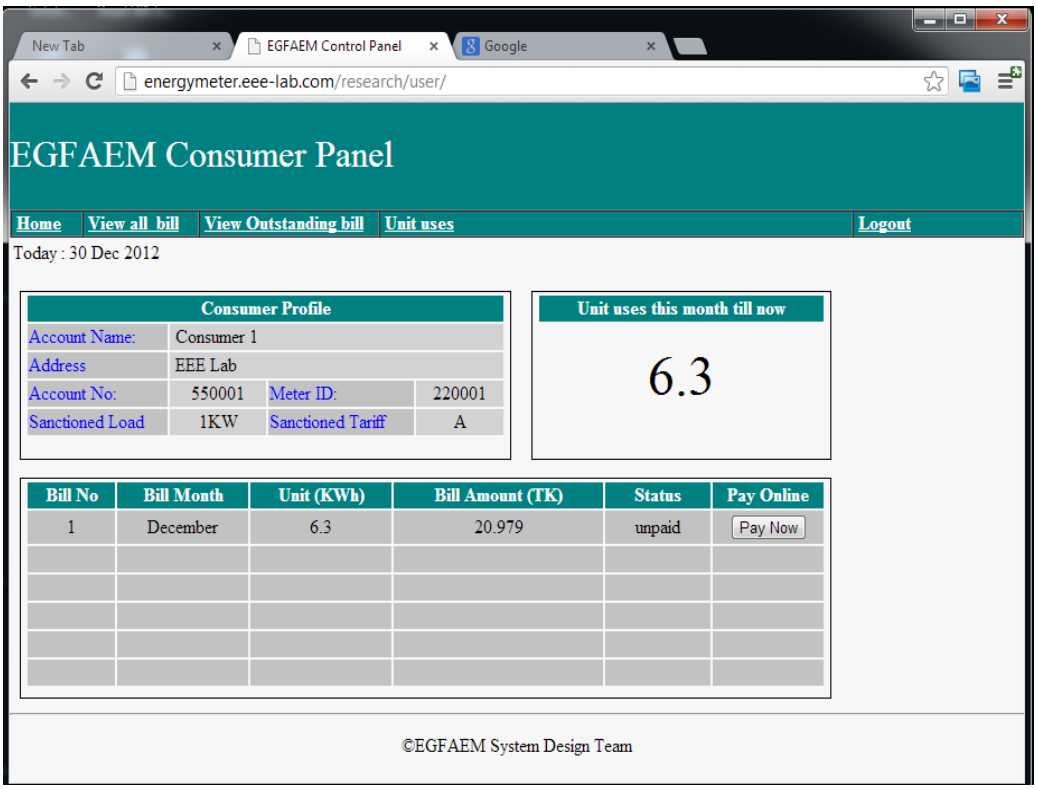

Figure 9 : Consumer Panel

VI. Conclusion

The economical way of GSM-GPRS based fully automated energy metering (EGFAEM) system has developed for efficient, secure and low cost automatic meter reading, billing and control from management center. As GSM network has covered all the housing and billing area which leads low infrastructure installation cost. This EGFAEM system can be use as both the post-paid and pre-paid metering purpose. So, that distributor can customize their package for different types of consumers which will ensure efficient business planning for the company. The management center gives automatic billing and payment system so, no man power require for meter reading and billing collection purpose which reduce human operator meter reading operation cost that's very efficient and economical for any power distribution company. Instant control (disconnection and reconnection of power supply) of individual consumer from management center gives secure and reliable power distribution because if any inconvenience situation occurred at any individual consumer then distributor can quickly disconnect that specific individual consumer supply. Consider all this things, it can be stated that EGFAEM system can bring a great change in power distribution companies of Bangladesh if the distribution companies apply this system on their field.

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