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Zigbee Based Energy Monitoring System with E-Billing through GSM Network

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Abstract: *The technology of E-Metering (Electronic Metering) has gone through rapid technological advancements and there is increased demand for a reliable and efficient Automatic Meter Reading (AMR) system. This paper presents the design of a simple low cost wireless Zigbee energy meter and its associated user 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 Zigbee based wireless communication module is integrated with electronic energy meter of each entity to have remote access over the usage of electricity. A personal computer with a Zigbee receiver at the other end, which contains the database acts as the billing point. Live meter reading from the Zigbee enabled energy meter is sent back to this billing point periodically and these details are updated in a central database. A new interactive, user friendly graphical user interface is developed using LabVIEW. The complete monthly usage and due bill is messaged back to the customer after processing these data.*

Keywords: *Automatic Meter Reading (AMR), Short Messaging Service (SMS), LabVIEW, GSM, Zigbee.*

1. INTRODUCTION

Electrical power has become indispensable to human survival and progress. Apart from efforts to meet growing demand, automation in the energy distribution is also necessary to enhance people's life standard. Traditional meter reading by human operator is inefficient to meet the future residential development needs. So there is increased demand for Automatic Meter Reading (*AMR)* systems which collects meter readings electronically, and its application is expanding over industrial, commercial and utility environment. Electronic utility meters are an important step towards automating the utility metering process. Automated utility meters have many new features that help to reduce the cost of utilities to customers and the cost of delivering utilities to the utility provider.

Traditional electro-mechanical meters, still widely used today, are prone to drift over temperature and time as a result of the analogue and mechanical nature of the components in these meters. Collection of meter readings is also inefficient, because a meter reader has to physically be onsite to take the readings. This method of collecting of meter readings becomes more problematic and costly when readings have to be collected from vast, and often scattered rural areas. Meter readers are reluctant to make the effort to travel to such areas and will often submit inaccurate estimations of the amount of electricity consumed.

There exists chance for missing bills, absence of consumer etc. Even though these conventional meters were replaced with more efficient electronic energy meters these problems still persists. So a system which will provide the bill in users mobile will be more suitable in the current scenario.

Here a new method of post-paid electronic energy metering is introduced in this paper which will automatically sense the used energy, records these reading continuously, then sends it to the billing point through the existing GSM network. Finally after processing the collected data bill is

generated using a developed system software and is send back to the customer as *SMS* (Short Messaging System).

2. EXISTING SYSTEM

Conventional reading is suitable for a yearly reporting and billing. Service technicians arrange target dates with the inhabitants in the flats, read out the displayed values on the different meters, e.g. heat cost allocators, water and heat meters, gas and electricity meters, and register them in paper form. These values will be then sent to the billing centre after a time period in order to generate the bills. The manual meter reading is in general associated with many disadvantages. In this context we can mention high operational costs, since a service technician has to go to the premises and read out all the values of the meters. The inhabitant should be also present to allow the service technician to read out the meter values, which is non-convenient. The manual reading out leads also to errors, since the service technician is always under stress and has to read out the values in a short time.

2.1. Disadvantage of the Present System

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. The present system suffers from the following disadvantages:

- Meter reader has to visit the place every month.
- The reading is to be fed into the computer.
- The bill generated is to be sent.
- The consumer pays the amount at the electricity board office.
- The consumer will have to stand in long queue for making payment.
- Delay in initiating action for non-payment.

3. PROPOSED SYSTEM

Automatic meter reading (*AMR*) [3], [4] 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 purposes.

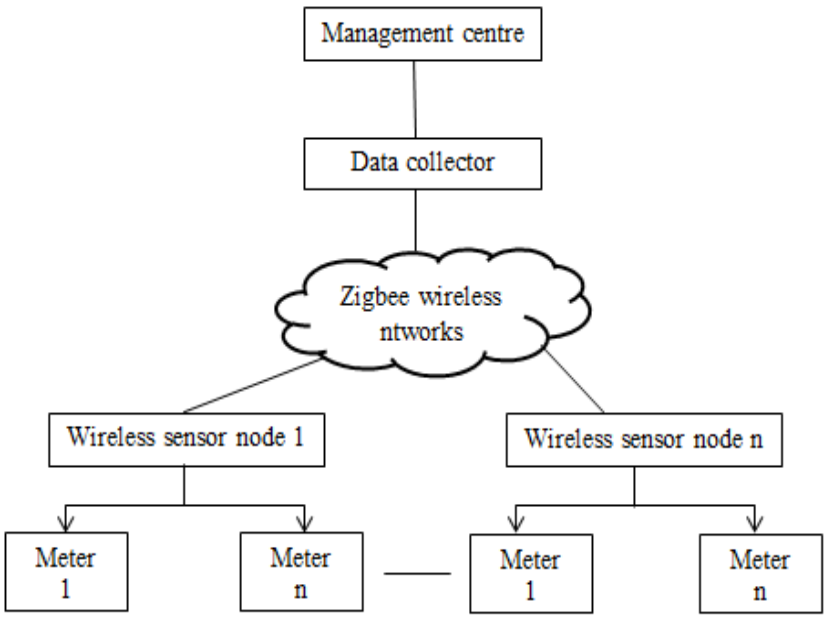

Fig1.1. *Structure of AMR System*

Data are read remotely, without the need to physically access the meter. Figure 1.1 Shows the Structure of System which is consists of measure meters, sensor nodes, data collector (gateway),

management centre (server) and wireless communication networks. The data transmit from the sensor nodes to the data collector using the *Zigbee* communication network. The data transmit from the data collector to the server, system uses Ethernet. The data collector in this system act as gateway, it is the protocol conversion used to transform a data package in *Zigbee* protocol to TCP/IP protocol before transmitting and a data package in TCP/IP protocol to Zigbee protocol.

The Figure 1.2 indicates *AMR* system consists of three primary components, namely, the meter interface module, communication system as well as the central control unit or data concentrator, which is used to store the transmitted meter readings data. In this scheme, we will be using Zigbee network for Automatic Meter Reading (*AMR*). We will send the instantaneous voltage and current to server / service provider side and then further process will be done. The data concentrator is a compact computer type electronic unit, located at an easy accessible point for processing the data received from the end units.

The AMR approach leads to many advantages such as more convenience for customer, since the presence is no more necessary, Minimization of errors from human factors, Improvement of the meter reading accuracy, Reduction of operational costs for data collection, frequent reporting, e. g. daily or monthly, Power demand analysis and Centralized billing.

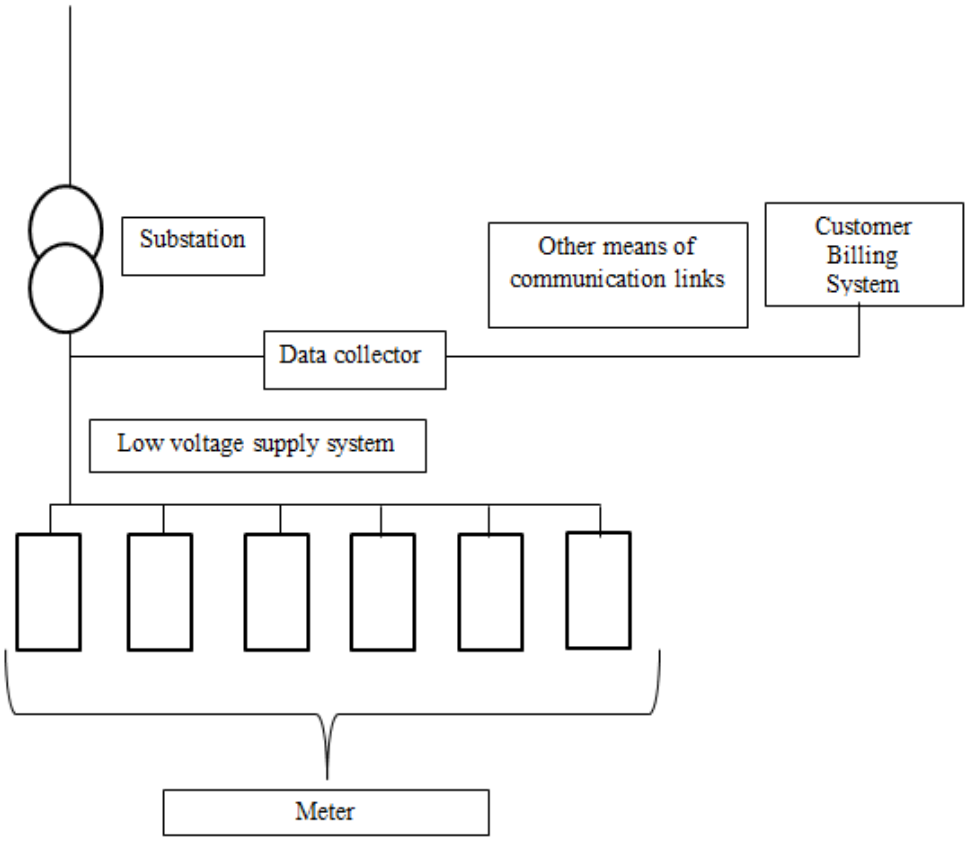

Fig1.2. *AMR System*

3.1. Electrical Meter

An electronic device that measures the amount of electrical energy supplied to a residence or business. It is electrically fed and composed of electronic controllers. It has an interface which allows data to be transmitted from the remote terminal to the central device.

3.2. Central Office

Equipped with a system which includes receivers, data concentrators, modems, and computers that are able to store and to process received information

3.3. Communication System

A communication system needs to be implemented in order to transmit data and to control the different signals between the remote device and the central office. *AMR* includes mobile

technologies, based on radio frequency, transmission over the electric cables(power line), or telephonic platforms (wired or wireless).

Automated meter reading (*AMR*) is performed with fixed networks in order to provide information without the intervention of human factor or the deployment of handhelds. *AMR* is generally appropriate to provide information daily and in special cases hourly. Therefore this is the only way to realize the smart metering approach.

4. IMPLEMENTATION OF THE SCHEME

In this heading proposed Meter implementation is explained.

4.1 Energy Meter Side

The Fig 2.2 shows the Block Diagram in which the microcontroller is connected to different devices through its different ports, in which the Sensors, *LCD* for displaying purpose.

Fig 2.3 shows the circuit diagram of the scheme. The circuit mainly consists of power supply, ATMega32 IC, LCD and *Zigbee* modem.

4.1.1. Power Supply

The microcontroller and other devices require DC power. 12V AC input is obtained from transformers. This 12V AC is converted into 12V DC by rectifiers. This 12V DC is converted into 5V DC using DC Regulator (7805).

4.1.2. ATMEGA 32 IC

The *ATMEGA32* is a low-power CMOS 8-bit microcontroller based on the *AVR* enhanced *RISC* architecture. By executing powerful instructions in a single clock cycle, the *ATMEGA32* achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

The *AVR* core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (*ALU*), allowing two independent registers to be accessed in one single instruction executed in one clock cycle.

The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional *CISC* microcontrollers. Fig 2.4 shows the pin diagram of ATMEGA 32 IC.

Software for ATMega 32 is developed using *AVR* Studio. The *AVR* Lib c package provides a subset of the standard C library for Atmel *AVR* 8-bit *RISC* microcontrollers. In addition, the library provides the basic start up code needed by most applications.

Once the program is written in *AVR* studio it's debugged. After debugging and finalizing then click on the icon shown by red arrow mark, the second window displayed as shown select STK500 and auto and press on connect. In the window select the device as *ATMEGA32* and press on ERASE all the contents are deleted, make proper clk selection Select the path were the program is saved, in the saved path after debugging and compile will create the hex file select it and press PROGRAM. The program hex code is burned to the chip.

4.1.3. ZIGBEE Modem

ZigBee is a Home Area Network device designed specifically to replace the proliferation of individual remote controls [1], [5]. The main motive behind the creation of *Zigbee* is to satisfy markets need for a cost effective, standard based wireless network that supports low data rates, low power consumption, security and reliability.

A smart home and a smart office with flexibility and seamless mobility, all without wires, are some of the promises of the *ZigBee* wireless solution. Fig 2.1 shows the structure of the scheme using *Zigbee*.

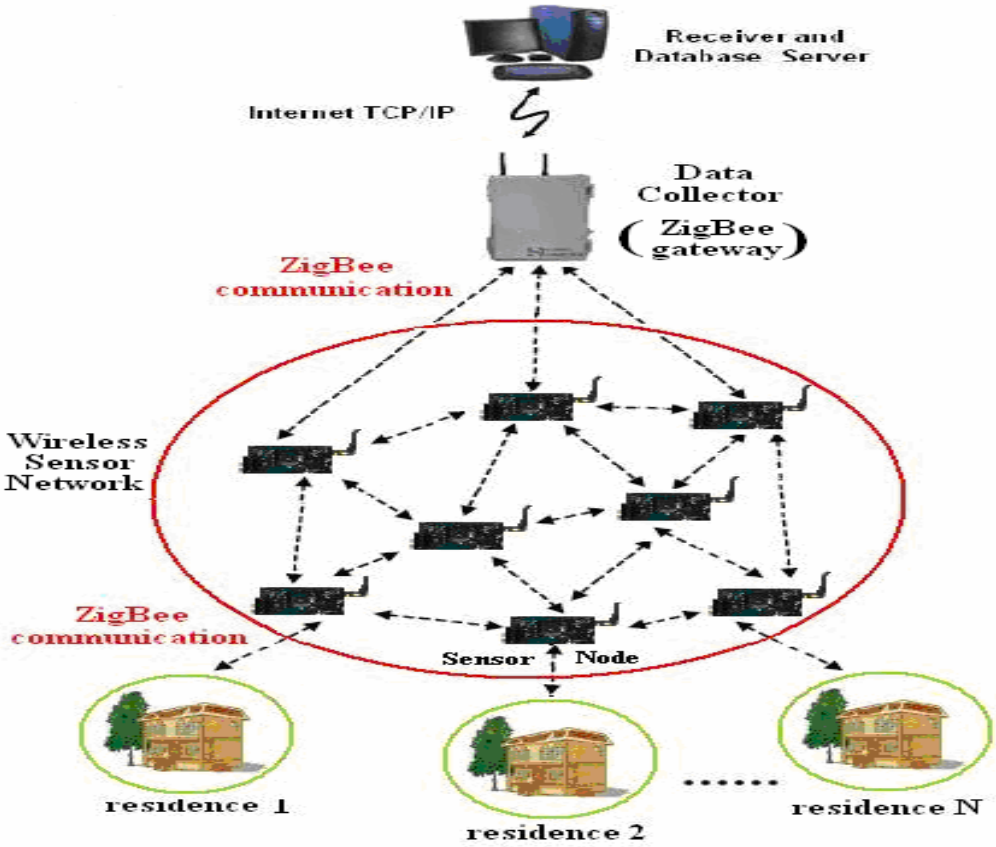

Fig2.1. *Structure Diagram of Scheme*

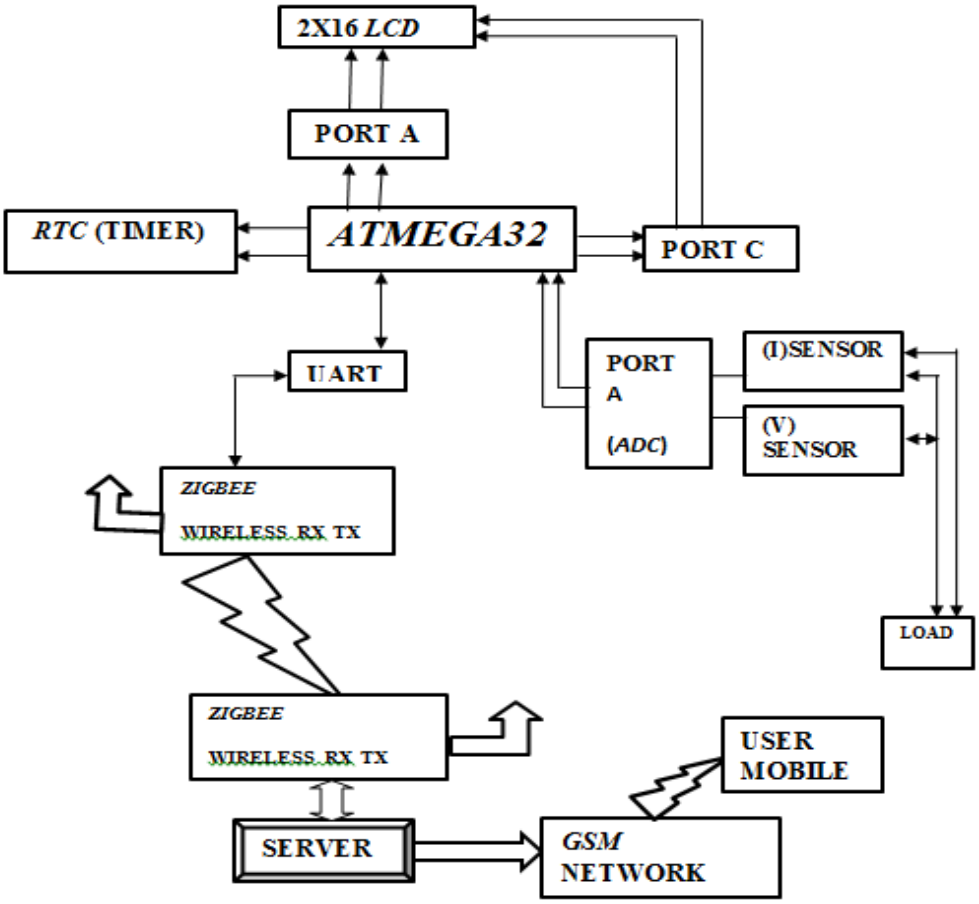

Fig2.2. *Blocks Diagram of The Scheme*

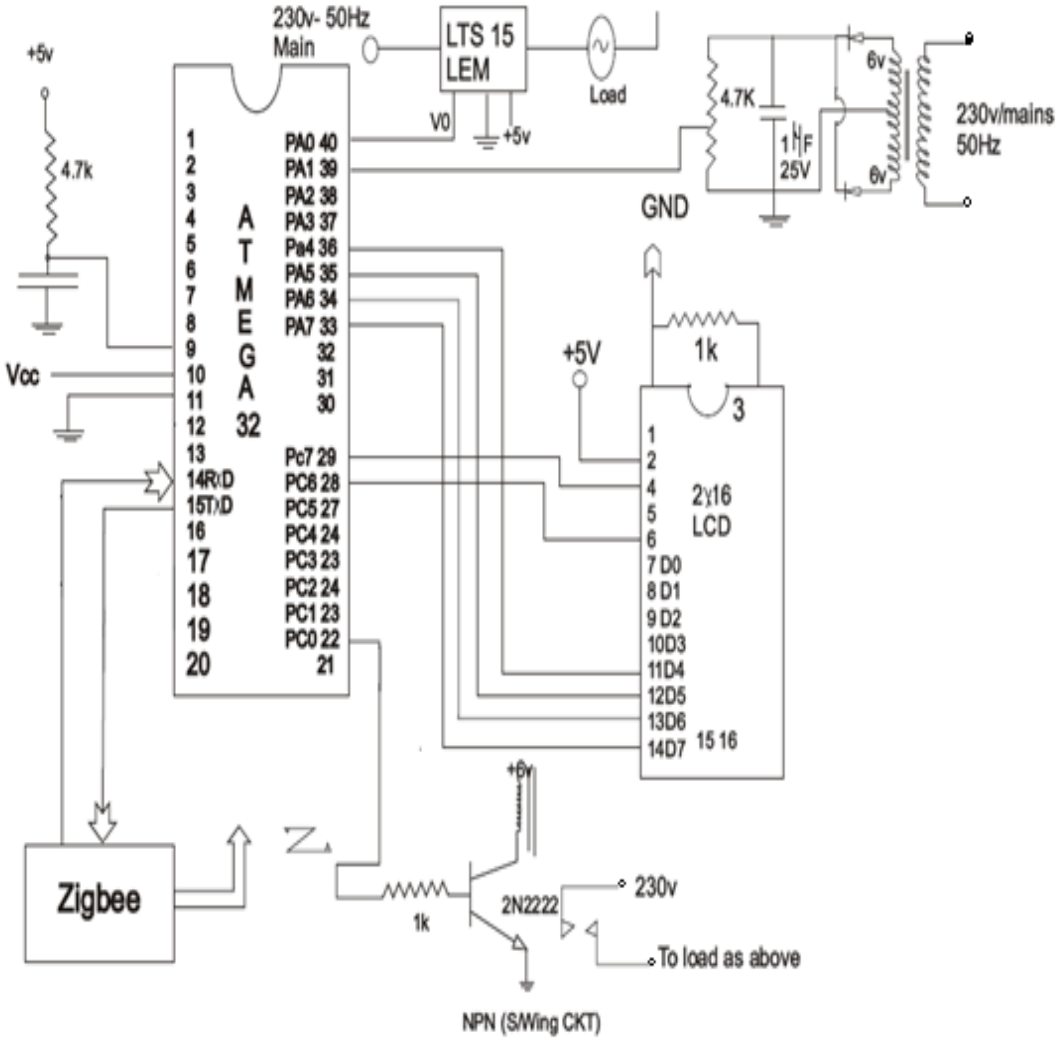

Fig2.3. *Circuit Diagram of Scheme*

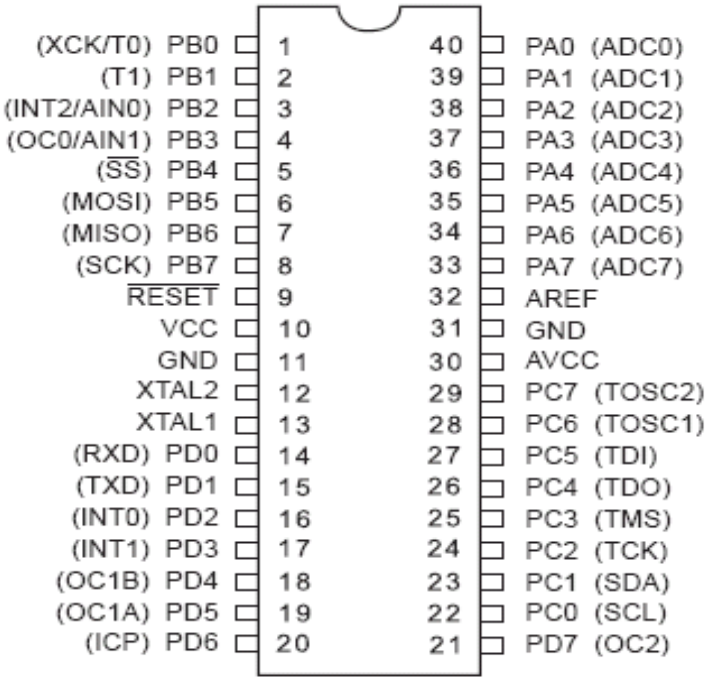

Fig2.4. *Pin Configuration of Atmega 32 Ic*

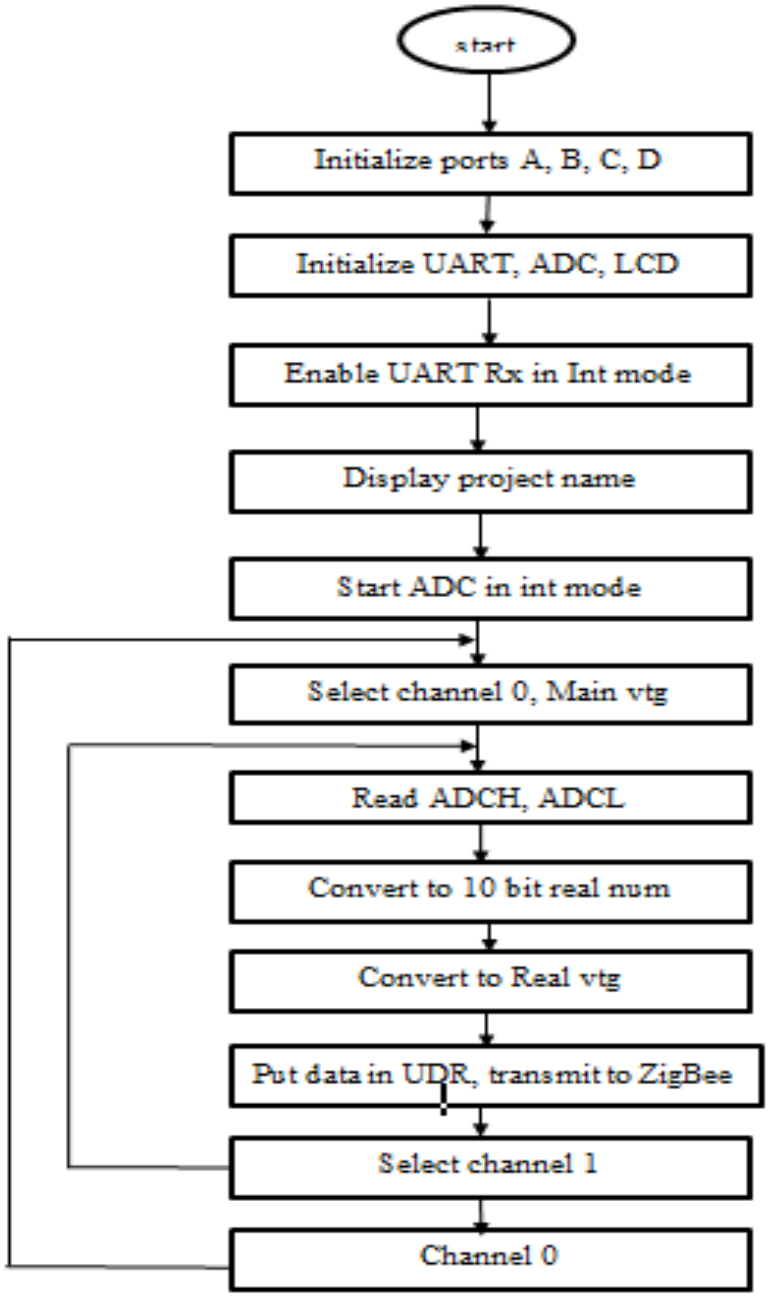

Fig2.5. *Flow Chart at the Energy Meter Side*

4.2 Central Office Side

At the receiver side a user interface program is developed using *LabVIEW*. LabVIEW stands for Laboratory Virtual Instrument Engineering Workbench. LabVIEW is a highly productive development environment for creating custom applications that interact with real-world data or signals in fields such as science and engineering.

First we will initialize the *GSM* modem and also the *ZigBee* modem. Data is received from channel 0 and channel 1. Remove the Extra information on channel I0 and I1.The data will be in the form of a string, so convert the string to Decimal number and calculate real Voltage and Current. And also calculate the Power and Energy with system time and also the total amount corresponding to the Energy Utilized. This amount is sent to the user mobile through *GSM* network through message [6], [7].

As soon as the message is sent for the month the total energy consumed, amount will be made zero. In case if the payment is not made then will be giving signal such that the relay at the energy meter side trips thus disconnecting the supply.

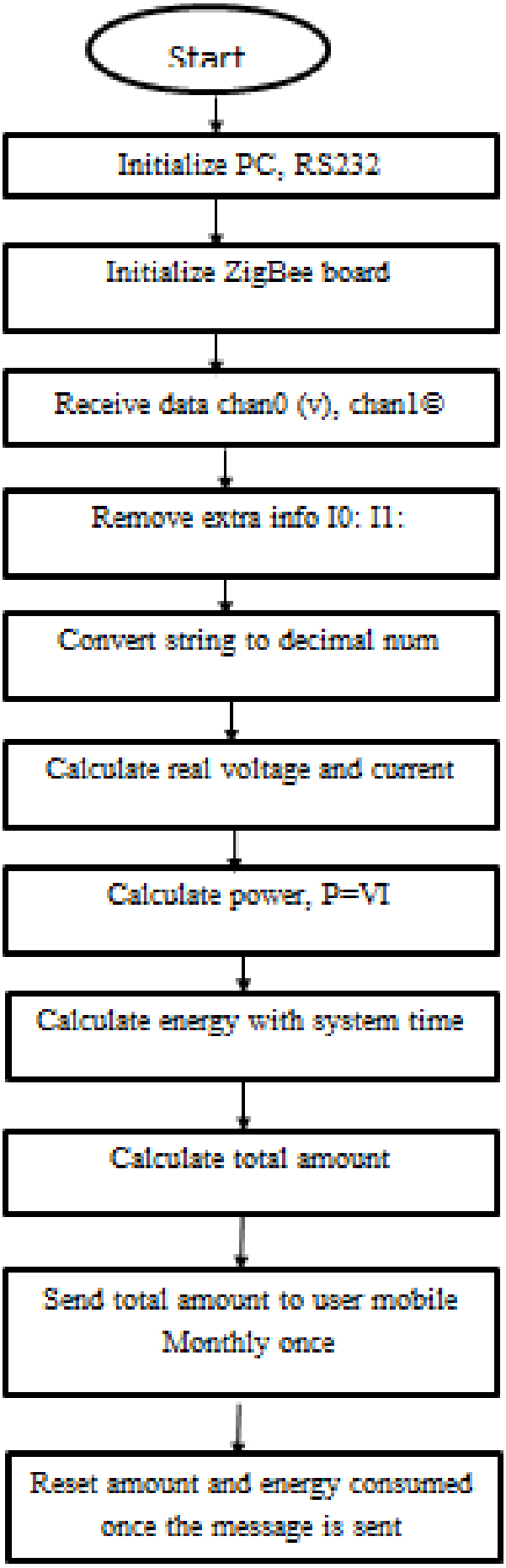

Fig2.6. *Flowchart of Billing Software*

5. RESULTS AND DISCUSSION

5.1 Electric Energy Equations

The active power consumed in one period T is defined as

$$P = \frac{1}{T}\int_0^T p(t)\,dt \tag{3.1}$$

P is given in watts. Where the instantaneous power p(t) is obtained by the voltage and current product. This gives the energy in KWh. This is multiplied with tariff.

Tariff is the rate of payment of schedule of rates on the energy bill of the consumer is prepared. This can be of different types depending on the load, maximum demand, time at which load is required, power factor of the load and the amount of energy consumed.

5.2 Calculation of Energy in System

- As we seen in the flowchart of meter side the voltage and current value will be sent through *ZigBee* in form of string. The value of the current is the *CT* current.
- This value of current and voltage is received by receiver *ZigBee***,** this *ZigBee* can receive up to 100 signals at time and can segregate easily.
- As the value received is in string form, we will convert it to decimal form and the value of *CT* current is converted into actual load current by calibrating it.

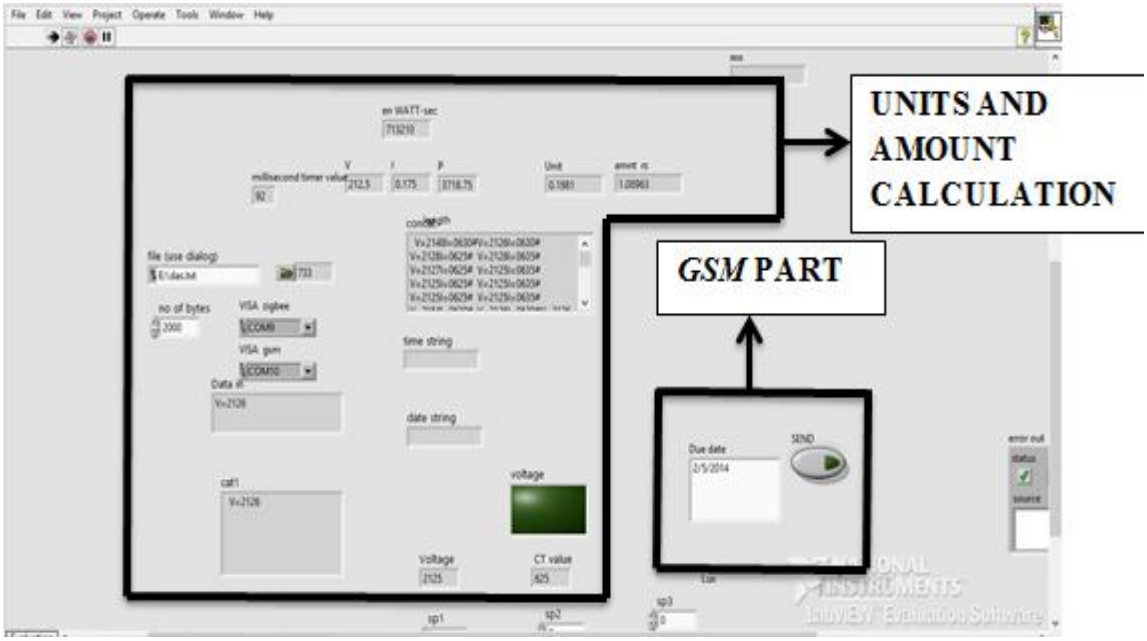

Fig3.1. *Front View of Program at Server Side*

- The value of current and voltage is multiplied to obtain power and this obtained power is multiplied with time to get energy consumed.
- This energy taken for an hour gives unit (KWh), this is taken and multiplied with tariff based on rates the consumers are assigned.
- For demo purpose we have taken Rs 5.50/ unit.
- As shown in FIG 3.1 shows the front view of energy monitoring system where, VISA *ZigBee* is the port number to which *ZigBee* modem is connected. VISA *GSM* is the port number to which *GSM* is connected.
- FIG 3.2 shows block diagram of the energy monitoring system. This whole block is placed in While loop whose termination is given by STOP button.

- As this is for only one user, for many users we need to create a database as shown in FIG 3.3 this will give contain Revenue Register Number of the meter, Name of the consumer, Energy consumed as per month, Number for which message to be sent and Other Number(optional).
- In database we will be having energy consumed for that particular month and amount. These can be accessed any time with authentication.

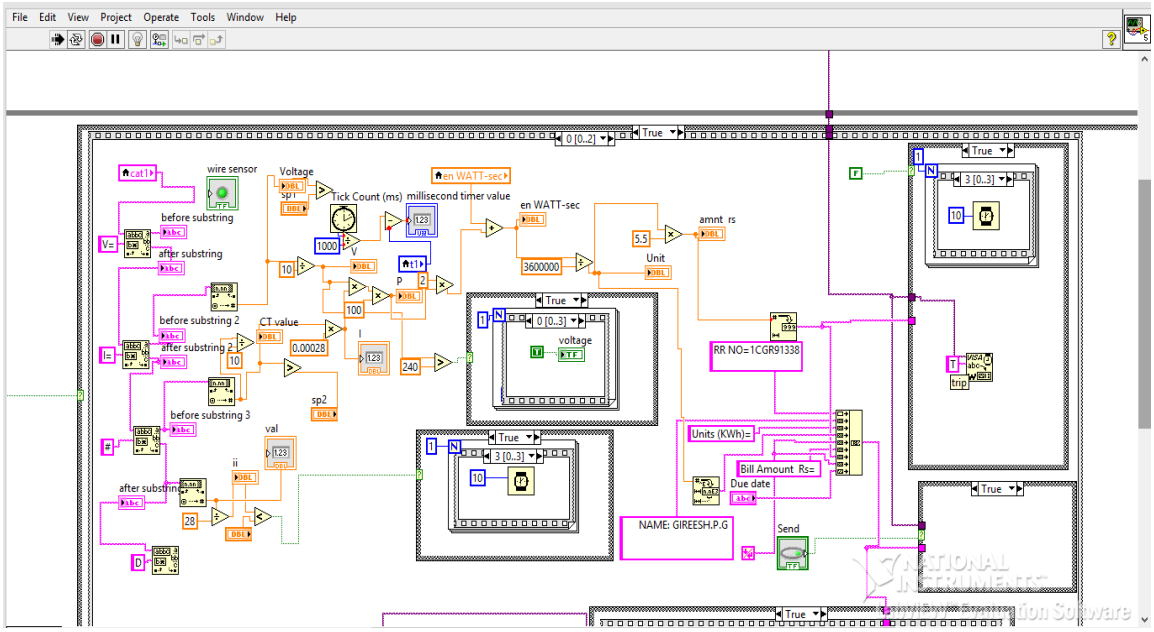

Fig3.2. *Blocks Diagram of Program at Server Side*

RR NO	NAME OF THE CONSUMER	PHONE NUMBER	OTHER NUMBER(OPTIONAL)	ENERGY CONSUMPTION AND BILL AMOUNT											
				JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC

Fig3.3. *Database View*

5.3 E-Billing Through GSM Network

- FIG 3.4 shows the snapshot of message recived to the user mobile.
- This contains the Revenue Register Number (given by the utility and is unique), Name of the user, Units consumed, bill amount and the due date.
- This message can be sent on date of billing in the present system.
- The number for sending messages can be any service provider.
- Once the message is sent to the user the energy consumed for that month and the bill amount will bee reseted and it will be updated to the database.

Fig3.4. *Snap Shot of the Message Received*

6. CONCLUSION

To overcome from the *Issues* with Stand-alone meter reading which are highly *Person* dependant and human errors cannot be avoided. The manual reading of electromechanical meter for the purpose of billing is fraught with many social and management problems. Some of these problems are possible lock-out of a meter from easy accessibility, human error in reading, gross inaccurate estimated reading, controversial billing, lack of information on detailed breakdown of energy consumption over a period of time, irregularities in billing time, tampering prone, high overhead cost of meter reading, and possible misplaced paper bill. So to overcome from these problems we have proposed *Zigbee* based energy monitoring system which provide Automatic meter reading is the technology of automatically collecting consumption, diagnostic, and status data from energy metering devices, mainly electricity and transferring that data to a central database for billing, troubleshooting, and analysing.

To overcome the misplace of bills, bills being erased we will be sending a message containing Revenue Register Number, Name, Units consumed, amount and the due date to the user mobile through an *SMS*. This is called E-billing. In this project, we present a design of a *Zigbee* enabled Energy Meter to read the energy meter wirelessly. Two features, which can retrieve the meter reading with little human intervention, are proposed and implemented in the *AMR* (Automatic Meter Reading) system. It helped in saving cost and time as compared to the conventional method of getting the meter reading.

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