Design of an ARM Based Prepaid Energy Meter to Control Electricity Theft

Ms. Tajeen K Hundekari[1] Prof. G. P. Jain[2]
[1]Department of Electronics Engineering [2]Department of Electronics & Telecommunication Engineering
[1]Walchand Institute of Technology

Abstract— Electricity plays a vital role in the development of our country. In India there are many sectors that have attained rapid developments but only a few developments are made in the electricity board sector. The present billing system in India is monotonous and time consuming. This paper presents a prepaid energy metering system [EMS] to control electricity theft. The energy meter makes use of the global system for mobile communication [GSM] network to incorporate the facility of prepaid metering system and remote load control. A prepaid energy meter is installed in every consumer unit which uses an ARM 7[LPC 2148] microcontroller to calculate the energy consumed and a server unit is maintained at the service provider side. Both the units are well equipped with GSM modem. LCD display is used to display the amount of energy consumed. As the balance becomes zero the power is cut down and the GSM modem will inform the customer to recharge the meter through a SMS. The proposed microcontroller based prepaid energy metering system deals with different aspects of electricity theft to find illegal usage and legal actions against defendant can be taken with the help of this system.

Key words: energy metering system, GSM

I. INTRODUCTION

Despite of the rapid development in majority of the sectors in India only few developments are made in electricity sector. As limited non-renewable resources are present in our daily life, electricity is one of them which is utilized in every country that results in abundant losses due to electricity larceny. Electric energy is a vital resource in everyday life and a backbone of every industry. As electricity is limited resource its proper use and measurement is very important [1]. Before utilization of electricity it passes through some phases. It is first Generated (G) then Transmitted (T) over long distances and finally Distributed (D) to consumers. In this process of GTD energy losses take place. Energy loss is defined as the difference between energy generated and consumption. There are mainly two types of losses, namely:

A. Technical Losses

Technical losses are those losses which occur due to properties of materials used in transmission and distribution system. For example, energy dissipated due to resistance of conductor used in transmission lines.

B. Non-Technical Losses

Non-technical losses are those losses which occur due to theft in electricity. Non-technical losses cannot be precisely computed, but can be estimated from the difference between the total energy supplied to the customers and the total energy billed [2].

An electricity meter or energy meter is a device that measures the amount of electric energy consumed by a residence, business, or an electrically powered device. The most common unit of measurement on the electricity meter is the kilowatt hour [kWh]. The existing systems for measurement of electricity consumption are divided into two categories:

C. Electromechanical Meter

As commercial use of electric energy spread in the, it became increasingly important that an electric energy meter, similar to the then existing gas meters, was required to properly bill customers for the cost of energy, instead of billing for a fixed number of lamps per month. Many experimental types of meter were developed for this purpose.

An early type of DC electrochemical meter used in the United Kingdom was the 'Reason' meter. This consisted of a vertically mounted glass structure with a mercury reservoir at the top of the meter. As current was drawn from the supply, electrochemical action transferred the mercury to the bottom of the column. Like all other DC meters, it recorded ampere-hours. Once the mercury pool was exhausted, the meter became an open circuit. It was therefore necessary for the consumer to pay for a further supply of electricity, whereupon, the supplier's agent would unlock the meter from its mounting and invert it restoring the mercury to the reservoir and the supply [2].

A modern form of AC ampere-hour meter was later developed by Westinghouse Electric Corporation using an induction disc whose rotational speed was made proportional to the power in the circuit. The electromechanical induction meter operates by counting the revolutions of a non-magnetic, but electrically conductive, metal disc which is made to rotate at a speed proportional to the power passing through the meter. The number of revolutions is thus proportional to the energy usage. The disc drives a register mechanism which counts revolutions, much like the odometer in a car, in order to render a measurement of the total energy used [2].

D. Electronic Meter

Electronic meters display the energy used on an LCD or LED display, and some can also transmit readings to remote places. The meter has a power supply, a metering engine, a processing and communication engine (i.e. a microcontroller), and other add-on modules such as RTC, LCD display, communication ports/modules and so on.

The metering engine is given the voltage and current inputs and has a voltage reference, sample and quantizing circuits which are followed by an ADC section to yield the digitized equivalents of all the inputs. These inputs are then processed using a digital signal processor to calculate the various metering parameters such as powers, energies etc. The processing and communication section has the responsibility of calculating the various derived quantities from the digital values generated by the metering engine. This also has the responsibility of communication

using various protocols and interface with other add-on modules connected as slaves to it [2].

A common method of tampering on mechanical disk meters is to attach magnets to the outside of the meter. Strong magnets saturate the magnetic fields in the meter so that the motor portion of a mechanical meter does not operate. Lower power magnets can add to the drag resistance of the internal disk resistance magnets. Magnets can also saturate current transformers or potential transformers in electronic meters, though countermeasures are common [3] [4].

Different nontechnical and technical methods were proposed in the past to detect electricity pilfering. Although periodic inspection can substantially reduce electricity theft but such measure requires large manpower and huge labor [5]. Some of the technical ways to detect pilferage are use of central observer meter at secondary terminals of distribution transformer, harmonic generator, genetic support vector machines, extreme learning machine and power line impedance technique [6]. However, these technical approaches can be effectively implemented only if proper communication is ensured between the central control station and the appropriate test points. Traditional electromechanical meters still widely used today are prone to drift over temperature and time as a result of the analog and mechanical nature of the components in these meters. Collection of meter readings is also inefficient, because a meter reader has to physically be on- site to take the readings. This method becomes more problematic and costly. There exists chance for missing bills, absence of consumer etc.

II. PROPOSED SYSTEM

The major drawbacks of post paid electric energy metering system are uncontrolled usage of electricity from the consumer's side and lot of wastage of power due to the consumer's lack of planning in electricity consumption. In this paper we have proposed to design a prototype of GSM based prepaid energy meter which will consist of a server to maintain the supply of electricity to the users, a consumer unit to perform the power billing and communicate it to the server as well as user through SMS, also detect electricity thefts and substantially reduce it using the algorithms designed.

According to the proposed system a server unit is installed at the power utility side and every user is provided with a consumer unit which is the actual prepaid energy meter. The GSM modem makes use of the GSM network to establish communication between the server unit, the consumer unit as well as with the user also. The server unit consists of a microcontroller (ARM 7-LPC2148), GSM modem (SIM 900), 16x2 LCD display and an observer energy meter. The consumer unit consists of a microcontroller (ARM 7-LPC 2148), GSM modem (SIM 900), 16x2 LCD display, current transformers, potential transformer and relay. The output signal of the current and potential transformers is provide to the in-built ADC of the microcontroller of the consumer unit. The microcontroller calculates the power consumption using the output pulses from the ADC. A battery back-up is provided to the consumer unit to detect electricity theft. Fig. 1 and Fig. 2 show the block diagram of server unit and consumer unit. The circuit diagram of consumer and server unit is as shown in Fig. 3 and Fig. 4.

In this system the consumer initially needs to send a message to the server requesting to recharge his/her energy meter with the particular number of units. The server unit then sends back the count value for particular number of units to the GSM modem of consumer unit. As soon as the controller in the consumer energy meter receives a message from GSM modem it activates the relay and connects the power supply line to the load. As the user consumes energy, the corresponding number of units is deducted from the total balance and the remaining units along with the number of units already used are displayed using the LCD display. The microcontroller uses AT command set to communicate with the GSM module. After the consumption of the complete allocated energy (i.e. number of units recharged), the meter automatically disconnects the load from the main power line using the relay until the user recharges his/her meter again. Whenever there is any type of theft, billing irregularity or illegal practices detected at the consumer end the energy meter immediately disconnects the load from the mains supply and reports this malfunctioning to the server by sending a message trough the GSM modem. The central authority can take actions against the defendants. Thus this system avoids the irregularities associated with traditional billing system and ensures revenue collection.

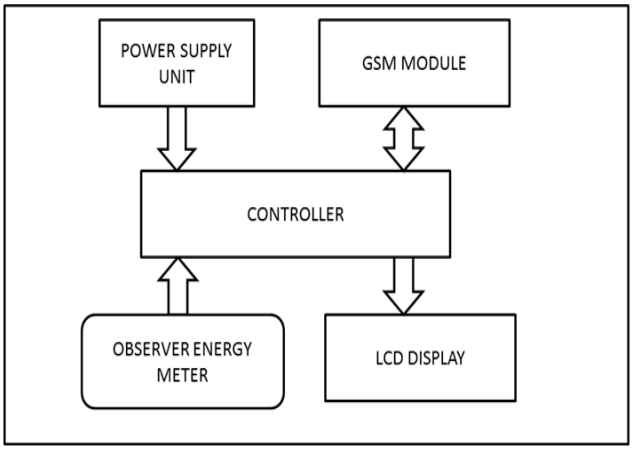

Fig. 1: Block diagram of server unit

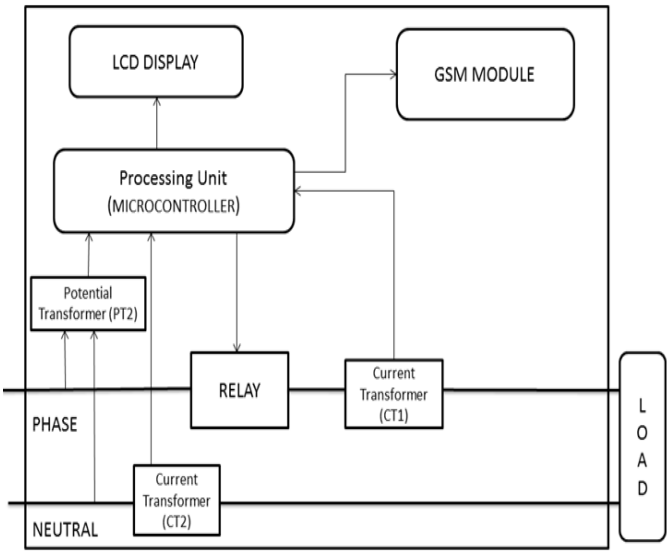

Fig. 2: Block diagram of consumer unit

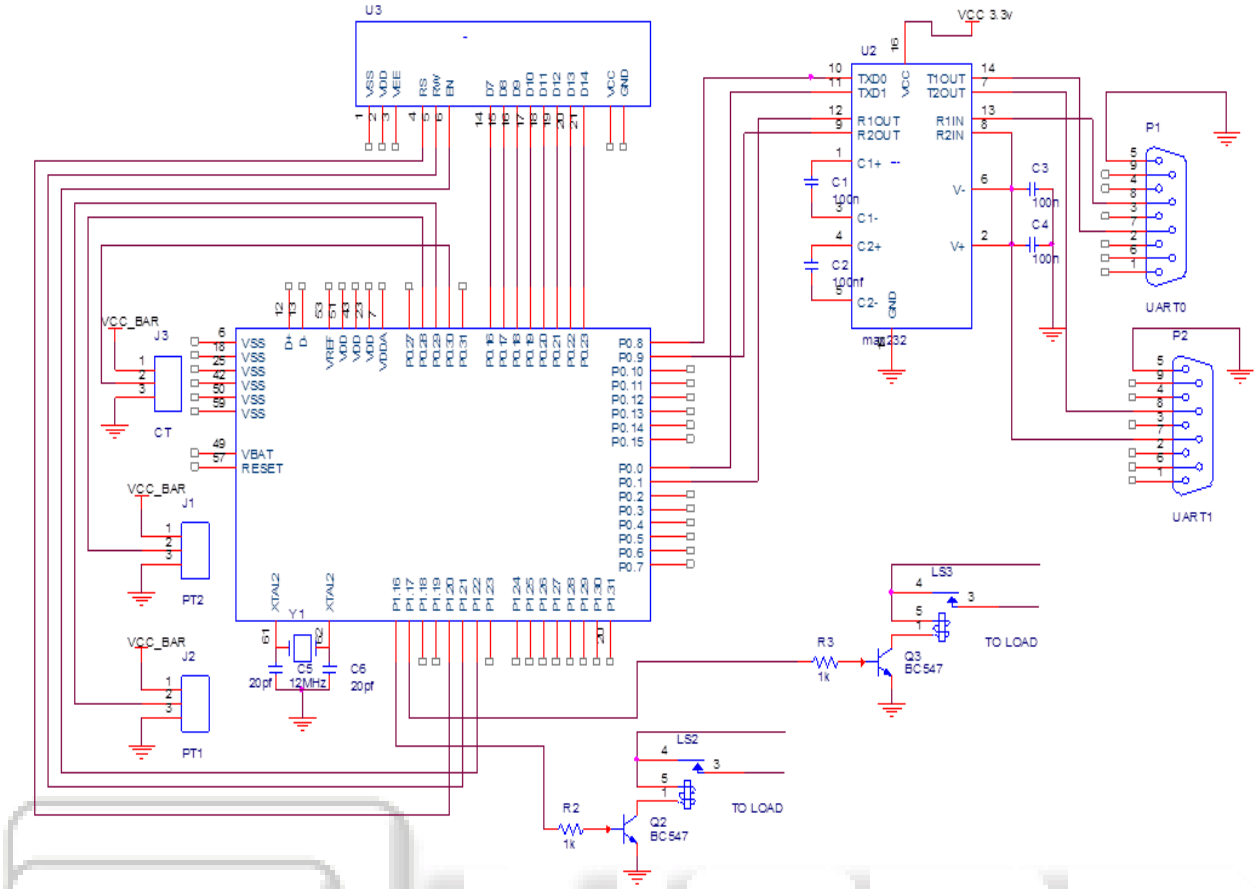

Fig. 3: Circuit diagram of consumer unit

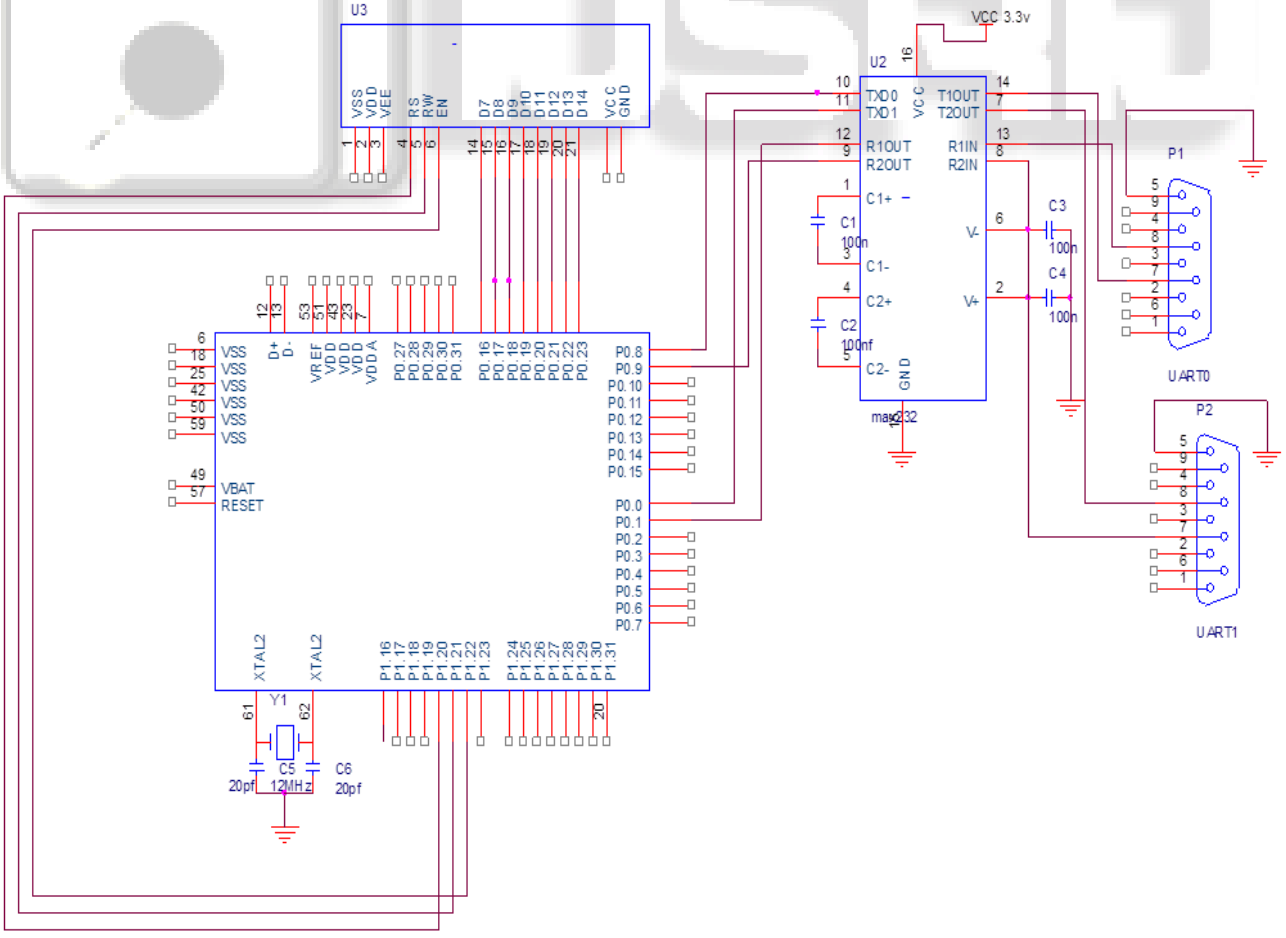

Fig. 4: Circuit diagram of server unit

III. CONCLUSION

This paper presents the concept of prepaid energy meter wherein step by step approach needs to be followed while designing the energy meter to control electricity theft. This system proves to be quite efficient and has several advantages over existing systems by reducing maintenance. The GSM communication will not only implement the idea of prepaid consumption of electricity but also facilitate the utilities to control energy theft by using this smart energy meter. The system also reports the information of electricity theft to the central authority therefore; utilities can take immediate legal action against the accused consumer and hence control electricity theft to a great extent.

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