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Prepayment of Electricity Units with Theft Controlling System

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Abstract: *In this system a smart energy meter is installed in every consumer unit and a server is maintained at the service provider side. Both the meter and the server are equipped with GSM module which facilitates bidirectional communication between the two ends using the existing GSM infrastructure. Consumers can easily recharge their energy meter by sending a PIN number hidden in a scratch card to the server using SMS. This paper presents how to detect electricity theft by bypassing and tampering the meter. The bidirectional GSM communication using SMS ensures the effectiveness of these measures. Pilferage of electricity can be substantially reduced by incorporating the proposed measures along with the prepaid metering scheme. Legal actions against dishonest consumers can also be taken.*

Keywords: *GSM, SMS, Energy Meter*

1. INTRODUCTION

Electricity theft has emerged as a serious problem in power sectors especially in the developing countries. A huge amount of revenue is lost due to electricity theft. In some countries this is so severe that governments are incurring losses instead of revenue. In some cases government has to provide subsidies to the power sector to maintain a reasonable price of electricity. The financial loss results in shortage of funds for investments to expand the existing power capacity and as a result governments are failing to satisfy the ever increasing demand of electricity. In some cases this problem has become so extreme that the affected power systems are near bankrupt. Power theft is a concerned issue even in the most efficient power systems like in USA and moderately efficient system like in Malaysia. However, in developing and under developed countries the practice of power theft is so common that it is often kept out of discussion. Electricity theft includes tampering meters to show a low meter reading, stealing electricity bypassing a meter, billing irregularities and unpaid bills. Billing irregularities comprise inaccurate meter reading taken by bribed service man and intentional fixing of the bill by office staffs in exchange of illicit payments from the consumer. Different non technical and technical methods were proposed in the past to detect electricity pilfering. Non technical methods may include inspection of the customers with suspicious load profile. Although periodic inspection can substantially reduce theft, such measure requires large manpower and huge labour. Such effort also fails in most cases due to the dishonesty of the staffs. 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. However, these technical approaches can be effectively implemented only if proper communication is ensured between the central control station and the appropriate test points.

2. PROPOSED SYSTEM

In the proposed system the power utility maintains a server and each consumer are provided an energy meter. The server and prepaid meters use GSM modem and GSM module respectively to communicate with each other using the GSM network. The energy meter consists of a Microcontroller (ARM7), GSM module, current transformers, potential transformers, LCD display and a relay. The Microcontroller calculates the energy consumption by counting the output of current and potential transformers on an interrupt basis. The Microcontroller uses AT command set to communicate with the GSM module (mobile phone). A battery backup is also available in the energy meter. The backup is required to detect electricity theft. The C programming language and the Keil uvision4 software have been used to program

the Microcontroller. The recharging process in real time metering system is similar to that of recharging balance in a mobile phone. The user has to buy a scratch card and scratch it to uncover the secret pin number of the corresponding energy unit he has bought. For example, if a user wants to buy 100 units (KWh), he has to pay for the 100 units and obtain a scratch card which holds the secret pin number of the corresponding 100 units. The user has to send the pin number to the server through SMS. The server then checks whether the pin number is valid or not. If the pin number is valid, the server then extracts the information of energy-unit from the pin number (in this case 100 units) and sends it to the meter of the user through GSM network. The household meter then receives the corresponding unit and is activated. As the user consumes energy, the corresponding units are deducted from the total balance and the remaining units are displayed using LCD. After the consumption of the allocated energy, the meter automatically disconnects the load from the main power line using the relay until the user recharges again. Thus the system avoids the irregularities associated with traditional billing system and ensures revenue collection. In the proposed system manually I will be sending the recharge units. The system receives the units and will update the previous balance.

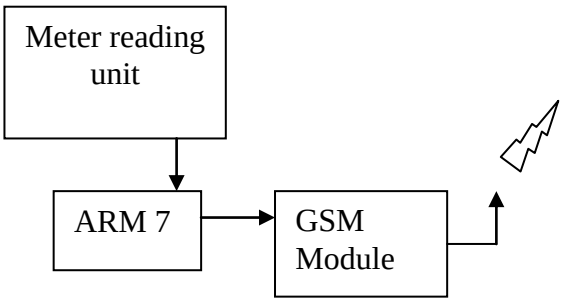

Fig 1. *Overview of Proposed System*

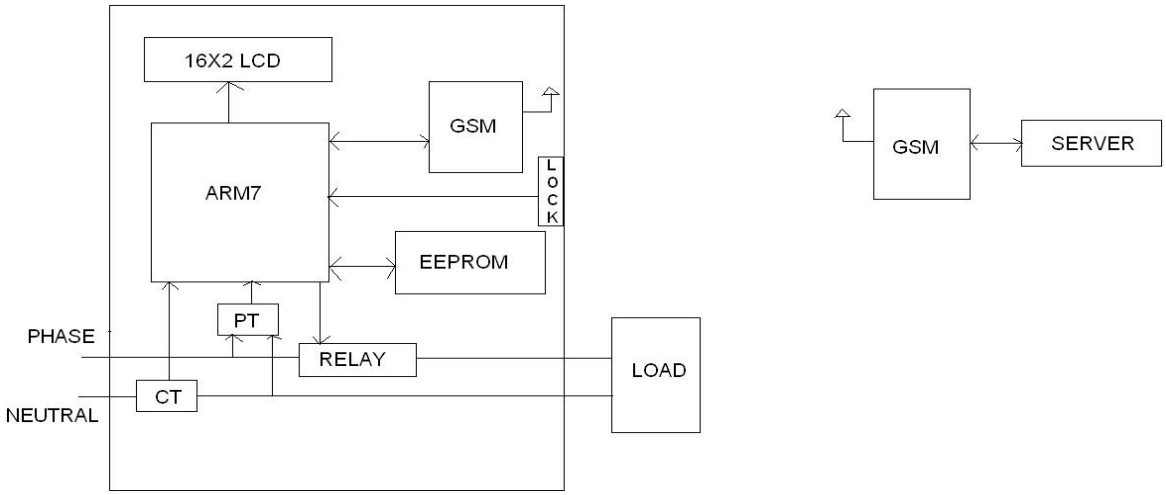

Fig 2. *Block Diagram of Prepayment of Electricity Units with Theft Controlling System*

3. THEFT CONTROL MEASURES

3.1 Protection Against Shorting the Phase Line and Disconnecting the Neutral Line

A popular method to bypass conventional meter is shorting the phase line shown in Fig 2. Another method of bypassing is to disconnect the neutral line as shown in Fig 3. In this case the potential measured by the potential transformer will be zero and no energy consumptions will be registered by the meter. The output voltages of CT and PT are provided to the ADC inputs of the Microcontroller. If the phase line is shorted or the neutral line is disconnected then there will be difference between the output voltages of CT and PT. The Microcontroller compares the voltages of CT and PT and if any significant difference is found, it disconnects the load immediately using the relay. In such events the energy meter

warns the server of the corresponding bypassing through SMS. Upon receiving SMS, the server blocks the energy meter and informs the authority. The authority can take legal action against the consumer.

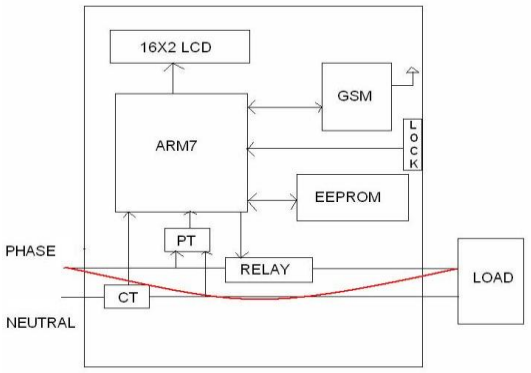

Fig 3. *Shorting Phase line*

3.2 Protection Against Whole Meter Bypassing

In extreme cases the whole meter can be bypassed as shown in Fig 5. As a result the meter will detect no energy consumption. To prevent this kind of theft, our proposed energy meter takes several steps. The output of PT is calculated and if it is found below the threshold values then the Microcontroller sends the corresponding information to the remote server. When the whole meter is disconnected PT detects no voltage and an interrupt is sent to the Microcontroller. The energy meter then requests the power status of the area, where the meter is located, to the server. If the server confirms that the power supply is available in that area, then the meter immediately disconnects the load and informs the server about the electricity theft. During the whole operation backup from a rechargeable battery is available.

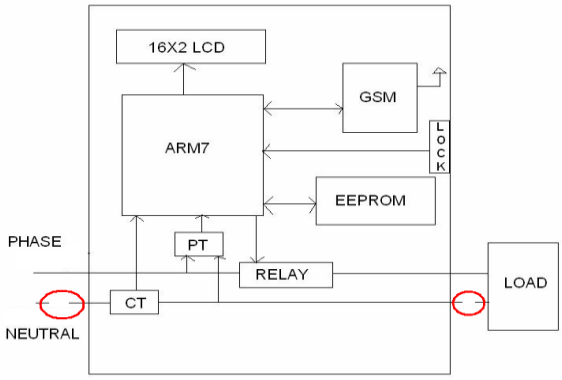

Fig 4. *Disconnecting Neutral line*

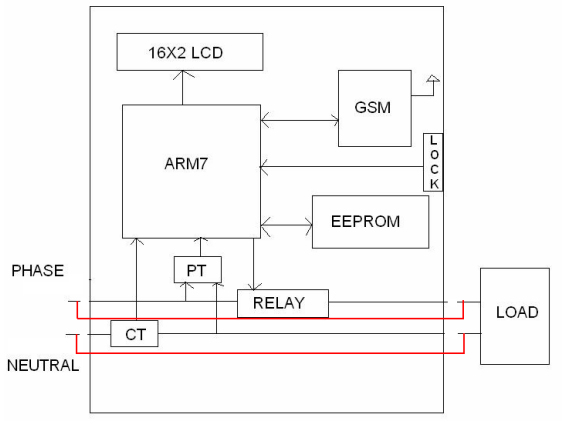

Fig 5. *Whole Meter Bypassing*

3.3 Protection against Tampering

Consumers or professional ones may try to open the energy meter and tamper it to show low or no energy consumptions. To get rid of this problem, one IR pair is used at opening side of the proposed energy meter. Output of IR pair is connected to external interrupt pin of the Microcontroller. In normal conditions, the IR pair will be closed and the Microcontroller will detect 5V at its external interrupt pin. If consumer tries to open the energy meter the IR pair will be opened and the Microcontroller will detect 0V at its external interrupt pin. If this occurs, the Microcontroller immediately notifies the server and disconnects the load from the supply.

4. HARDWARE IMPLEMENTATION

Continuing with the present reading system will result in further loss of precious energy. This is not affordable in the present energy crisis. The urgent and important requirement is a low cost system that can be integrated into the present day meters, which provides energy efficient meter reading. The proposed system uses Microcontroller to efficiently measure electrical energy consumption. Energy is calculated by measuring line voltage and current continuously using generic electronic components which have an advantage of low cost compared to components used in present day power meters. The system measures voltage by attenuating it using a potential transformer. The stepped down voltage is rectified by a precision rectifier to eliminate voltage drop across diodes encountered in typical bridge rectifier configuration. The pulsed D.C. voltage obtained is passed through a capacitor reduce ripple resulting in a smooth waveform. The residual ripple, passing through the rectifying capacitor, is removed by using a choke and capacitor in series and parallel respectively. At this stage a fairly ripple free non-varying waveform is obtained. Further, the system attenuates this D.C. level to a level which is compatible with the ADC. The voltage level is then converted into digital form by the inbuilt ADC peripheral of the LPC2148. The power line current is measured by passing it through a current transformer, output of which is a current proportional to the line current, the turns ratio being the constant of proportionality. A precision resistor converts the output current into equivalent alternating voltage. The voltage across resistor passes through precision rectifier, ripple eliminator and voltage divider stages before being finally fed to the inbuilt ADC peripheral of the Microcontroller. Current transformer, for current measurement, is an efficient measurement technique compared to shunt resistor (which changes the line voltage at higher line current), thus having higher linearity and virtually zero burden current.

The microcontroller used is the LPC2148, featuring a 10 bit ADC, which enables measurement of minute changes in line voltage and current. Power consumption is computed, every second, using the measured values of voltage and current. Summing power consumption over a given period of time gives energy used by the consumer. The on chip Timer interrupts the controller every second. This is extremely important since if this time duration it self has error then the measurement would be erroneous as it is calculated at an interval of every 1 second. The system utilizes two voltage levels, one of ±9 V for the signal conditioning circuitry and other of 3.3 V for the microcontroller. Both voltage levels are provided using a single power supply board. The system consumes a maximum of 3 VA or on monthly basis approximately 2 units which is lower than currently available metering systems.

A SIMCON sim900a GSM module is interfaced to the microcontroller so that SMS is generated after regular interval of time which can be sent to the local database for further processing. The on chip UART communicates the usage information to the GSM module.

The process of getting values from inbuilt ADC and computing power takes a fraction of second, thus controller switches into ultra-low power mode saving energy and consequently decreasing the burden power. The controller deducts the no of units consumed. The database contains information like customer identification number, meter no and no of unit consumed. This helps the database to link the power consumption to previously stored data. Additionally, the system notifies Power Company immediately upon power theft or meter tampering. A limit switch inside the meter casing changes state when casing is removed i.e. tampered. This interrupts the controller which immediately notifies the power company via SMS containing warning of meter tampering, customer ID and meter no.

5. HARDWARE & RESULTS

Fig 6. *Prototype of the Proposed System*

Fig 7. *Internal Connections of CT & PT*

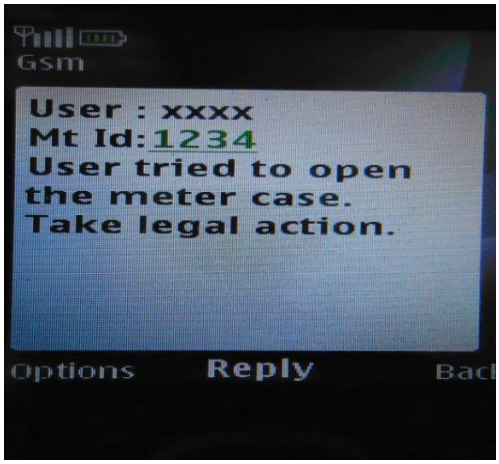

Fig 8. *Message Received When User Tried to Open the Meter Case*

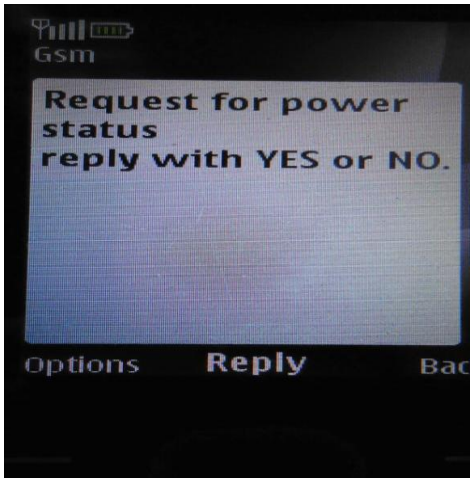

Fig 9. *Message Received When Meter Shows no Reading*

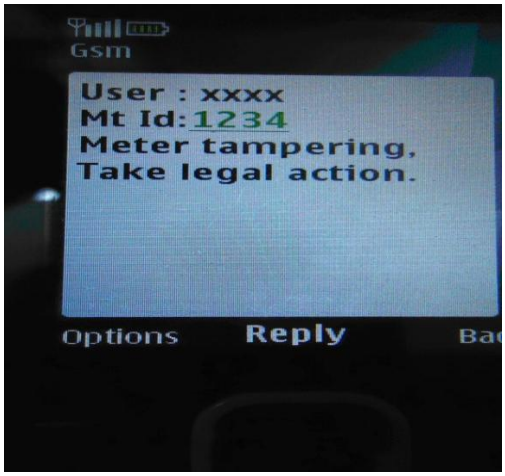

Fig 10. *Message Received When User Tries to Steal the Electricity*

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