

Research

Smart Prepaid Energy Meter

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Email: NA**DOI:** 10.62896/ijmsi.1.2.06**Conflict of interest:** NIL**Abstract:**

The goal of this study is to create a smart prepaid energy meter that can address some of the problems India's present metering system is now facing. The majority of energy meters in India are electrochemical in design, although digital and electronics metros are progressively taking their position as more reliable and accurate energy meters. Power theft, inaccurate meter reading and invoicing, and consumers who are reluctant to pay their electricity bills on time all contribute to the loss of a significant amount of money from the sale of electricity. Delivering the same amount that was paid before consumption will generate significant revenue from customers. This study recommends a smart prepaid energy meter that offers services including prepaid billing and electricity theft. For a prepaid system, our suggested design model includes an Arduino UNO and GSM technology. For the purpose of detecting electricity theft, the model uses CT and PT to detect the current and voltage differential, respectively. Over the proteus platform, the proposed model is tested and simulated.

Keywords: Prepaid Meter, Theft detection, Power theft, smart meter, GSM.

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Introduction

In developing countries like India there is huge loss revenue due to electricity theft. This can be controlled using this proposed multi featured prepaid- post-paid energy meter system. These features are automatic billing, prepaid system and electricity theft. This proposed system can efficiently monitor and control the energy consumption and efficiently measure the output voltage and current. If the consumer tries to theft the electricity it can be detected by this system and disconnect the load at consumer side. In such way that electricity theft and irregular billing will stop and revenue loss of power utility is greatly reducing. This will have an overall effect on the nation's economy as the revenue collection increases [1]. There is loss in Power Company due to improper meter reading and charging framework. Mistakes are observed at every stage of system with conventional meters. There is solution for this may be prepaid system. Most of the developing countries are in process to shifting their

conventional meters with prepaid meters. The idea of prepayment solves the problem regarding with unpaid bill and manmade mistakes in meter reading [2]. In this modern era of digitalization, the main objective is to digitalize electric power consumption and billing framework. This can be achieved with the help of smart energy meter. Smart energy meter introducing automation in power consumption and to improve efficiency. This method enables consumers to access their accounts remotely, enabling them to check the condition of their power balance from a distance and take appropriate action [4]. Electricity theft causes enormous losses for power utilities. This paper offers a method for preventing electricity theft that makes use of prepaid energy metering systems. This method enables meter manipulation and bypassing to control theft. GSM is set up in this system with a server and end user for two-way communication. For the theft detection system, the CT and PT are employed to detect the current and voltage difference. Under this

method, information about electricity theft is immediately notified to the appropriate party [5-7]. Power utilities are having trouble collecting electricity bills under the current system. With the elimination of the shortcomings of the current method, this study offered an open framework for prepaid metering. The primary goal of this system is to simultaneously control and monitor the pre-paid meters in order to localize energy theft and, in turn, put unlawful energy use under accounting [6]. It was suggested in this study that a way be used to make pre-paid energy meters function similarly to pre-paid cell phones. With the help of mobile communication infrastructure, this system's prepaid card talks with the electric company [8].

Proposed System

In our proposed smart prepaid energy meter, each and every consumer is provided with a smart prepaid energy meter. In this system the GSM module is used to communicate with consumer and proposed system. The above figure the overview of proposed system. This meter consists various type of component like microcontroller (ATmega328P) which controller every component according to the instruction provided to it, GSM module (900A) which provides interfacing between consumer and energy meter, Current Transformer (CT) which is used to sense the current, Potential Transformer (PT) which is used to sense the availability of supply, Energy metering chip (ADE7751) which is used to generate the interruption provided to microcontroller according to the status of current transformer and potential transformer.

Initially when the available balance is zero then, system will sense zero unit and that time the relay will be in off state according to instruction provided to the controller. When energy meter is recharge with X amount then that time X amount of unit will be added in existing available unit and alert is sent on consumer's smartphone like "Meter is Recharge with X amount" it will be sensed by the microcontroller and according the programming instruction is sent to the ULN2003 drive and relay will be close and load is turned on. After the X amount of consumption, the balance will be reached to its minimum set value that time alert will be sent to consumer's smartphone like "Low Balance Recharge it!", again if consumers not recharged their energy meter, then system will sense

zero unit and relay will be trip and load are disconnected from supply.

Along with it in existing system anybody can theft the electricity with various method. In case of existing energy meter there was huge chances of theft of electricity. This theft of electricity includes meter tempering which denotes the less consumption of electricity which leads to huge loss of Government instead of revenue. Along with it there are technical and non- technical methods to detect the theft of energy which is like inspection of costumer with suspicious load consumption as well as periodic inspection may reduce the chances of theft of electricity which requires large man power or hug labor. Even if applying such methods to reduce the pilferage there could be again chances of theft of energy due to dishonest of staff. Following are some methods of theft of electricity are as follows:

- By shortening the phase line without neutral wire.
- By shortening the neutral wire without phase wire.
- By shortening both phase and neutral wire.

In this system protection against theft is provided by following methods:

1. Protection against cutting the phase line short without the neutral wire: With this strategy, anyone can cut the phase wire short without the neutral wire. CT1 and CT2 are connected in series with the phase wire and the neutral wire, respectively, in the block diagram above. When someone tries to steal electricity by skipping the phase, a voltage difference will develop at the output of CT1 and CT2, which is detected by the microcontroller, and a warning will be sent to both the authorized person and that specific customer.

2. Protection against shortening neutral line without phase wire: In this method anybody can short the neural wire without phase wire. From the above diagram CT1 is connected in series with phase and CT2 is with neutral. If anybody tries to theft the electricity then voltage difference at output of CT1 and CT2 will be occurs which is sensed the microcontroller and alert will be sent to the authorized person as well as to that particular costumer.

3. Protection against shortening both phase and neutral wire: In this method when someone is tries to theft the electricity by bypassing both phase and

neutral line then potential across phase and neutral will be zero. Once zero potential is detected by energy measurement chip it will generate interrupt and pass

to microcontroller and then according to instruction alert will be send to both authorized person as well as to particular consumer.

Methodology

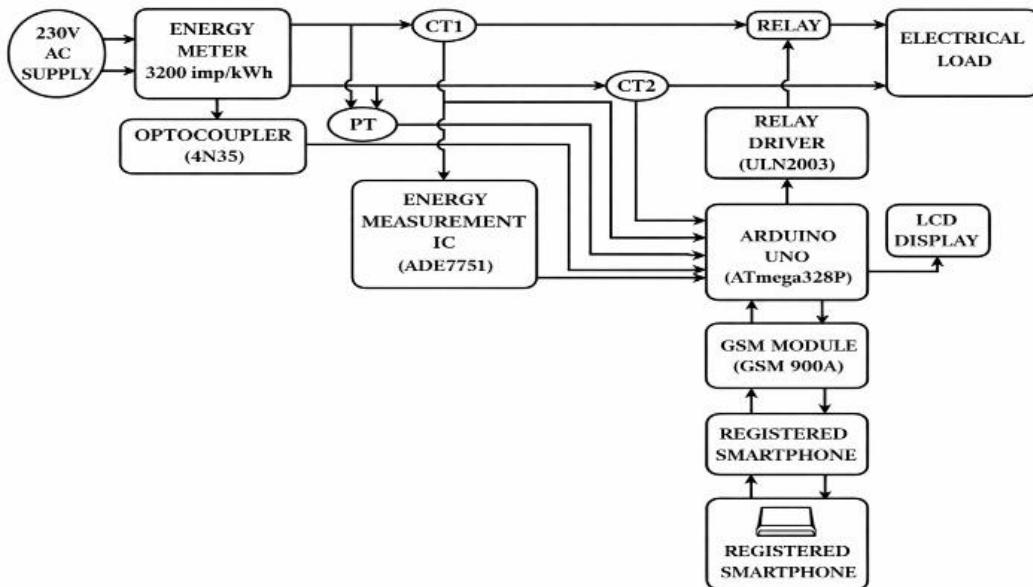


Figure 1. Block Diagram of Prepaid Energy Meter

The above figures show the block diagram of Smart Prepaid Energy Meter. It contains the various blocks. These different blocks are connected to each other Unidirectional and Bidirectional.

Initially 230-volt AC supply is provided to the load through current transformer and relay. The current transformer is used in order to measure the magnitude of current in order to detect the theft of electricity. Meanwhile switching relay is used for switching purpose according to instructions provided by the Arduino UNO microcontroller. This proposed energy meter is provided with three main features i.e., remotely access, prepaid energy meter and theft detection. When supply is given to load, there will be consumption of electricity which measured by energy meter. Practically this energy meter is calibrated in such way that when X number of pulses are generated then that particular energy meter will be considered it as one unit has been consumed. But in simulation five pulses are set as one unit consumption. Once these five pulses are generated system will consider as one unit has been consumed. As soon as one unit is

A. Prepaid Energy System

consumed load will isolate from the supply. From the above block diagram energy meter is recharged with the help of smartphone with X unit of balance through GSM module. Meanwhile consumption of electricity is detected by Arduino UNO microcontroller as microcontroller is interface to energy meter through optocoupler. Due to consumption when balance will be low that time alert message will send to consumers smartphone like "Low Balance, Recharge Meter" through GSM module. When that balance will get zero that time load will be disconnect from supply.

In case of simulation of theft detection, when current flowing in phase and neutral will be same with some tolerance limit then that time it will be considered as no theft detection or normal condition. On another hand when difference is occurs between phase and neutral current then as will be considered as there is theft of electricity and message will be sent to registered mobile like "Meter is Tempered".

Result AND Discussion

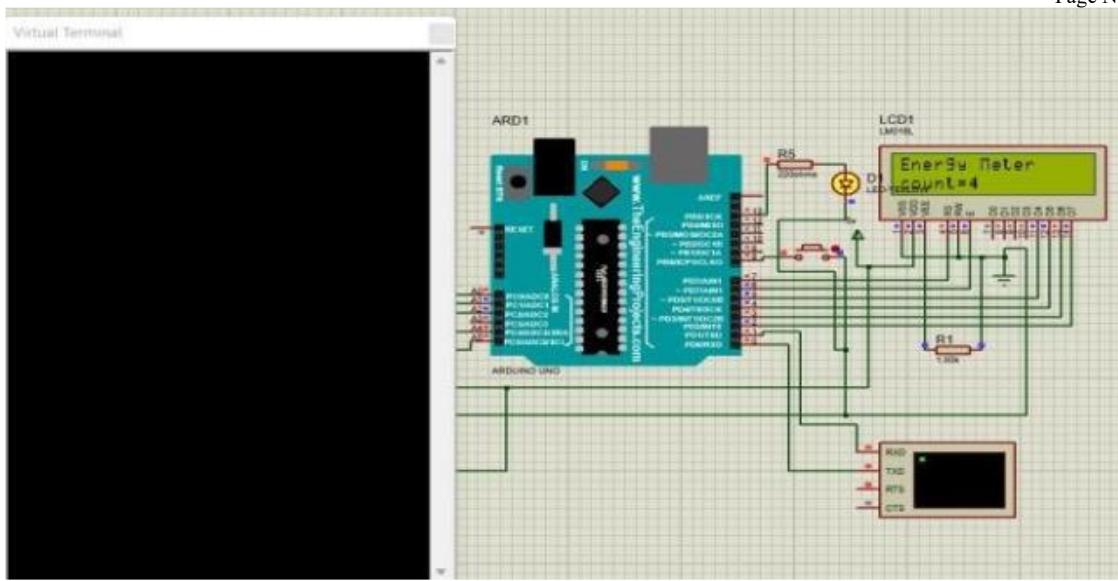


Figure 2. Interfacing of Prepaid System with Virtual Terminal.

The above figure 2 expose the Interfacing of Prepaid System with Virtual Terminal. In which virtual terminal is used to show the status of simulation. Initially when supply will turn ON and power is consuming by load. Practically, when power is being consuming it is measured by Energy Meter and the existing energy meter is designed in such way that once 3200 impulses are generated by the microcontroller of meter it will be considered as “One

Unit" has been consumed. Therefore, on existed energy meter "3200 imp/kWh" is mentioned. In market there are different rating of digital energy meters are available for example 3200 imp/kWh, 6400 imp/kWh, 1600 imp/kWh. But in simulation this energy meter is designed in such way that there are only five counts/pulses are considered. After the count of five pulses, it will consider as "One Unit" is consumed.

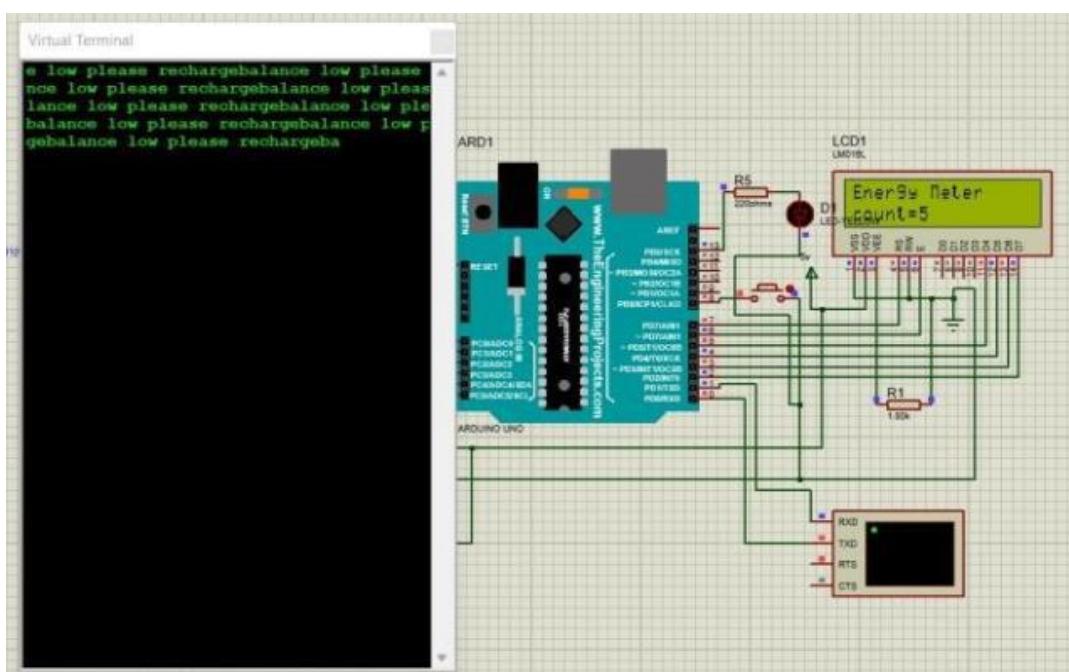


Figure 3. Interfacing of prepaid system with Results

The above figure represents Interfacing of Prepaid System with Results. In this system as count/pulses is goes on increasing as consumer is consuming the electricity. Once the pulses/count is reached at their set value then it will display alert message i.e., "Low Balance Please Recharge". So, in this case when fives pulses are generated at that time the message "Low Balance Please Recharge" is displays on virtual terminal. Practically, when 3200 impulses are generated, it will be calculated by the microcontroller

with the help of Cal LED out on existing energy meter. Once 3200 impulses are generated it will consider as "One Unit" consumed. Therefore, there is flexibility to set value of impulse on which messages should send to consumer "Low Balance Please Recharge". If meter is not recharge even after getting alert message of Low Balance, then meter will be automatically disconnecting the supply as balance is zero as well as there is provision to display the same message on LCD display.

B. Theft detection of system of meter

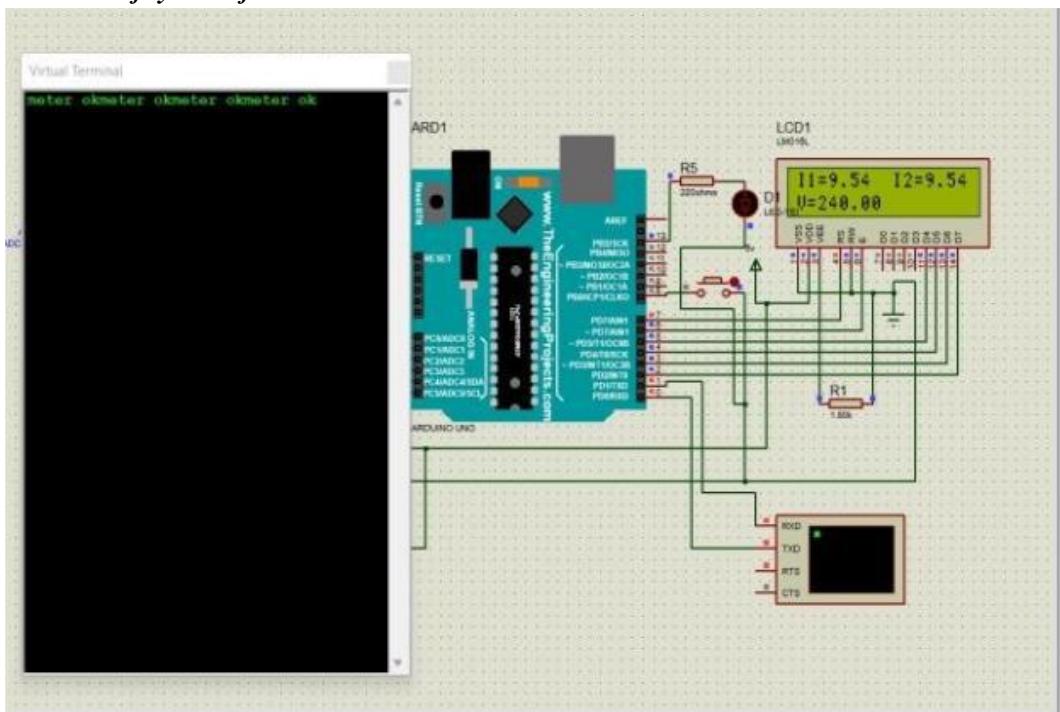


Figure 4. Interfacing of Theft System.

The theft interfacing system is depicted in the above diagram. Electricity theft is frequently committed by shorting the phase, bypassing the circuit, and disconnecting the neutral wire. Two current transformers, one for phase and one for neutral, are utilized independently to stop this theft, and the output of the second current transformer is again provided to the microcontroller. In this simulation two current sensors are used. The first current transformer is connecting in the series with phase wire and another current transformer is connected in the series neutral. The output of current transformer is voltage. The status of theft of electricity is display on virtual terminal. In this, there are two ways to theft of

electricity. First is by shortening the phase and another one is to bypassing neutral wire. Therefore, with the help of both current transformers theft of electricity can be detected as alert to both consumers and authorized person.

The below figure shows the Interfacing of theft system with results. In this system two current transformers are connecting in series both phase and neutral respectively. The incoming current should be equals to outgoing current. Electricity can be theft either by shorting the phase or bypassing the neutral. Practically, when theft of electricity occurs by shorting the phase then that time current will starts flow through the shorted wire as well as neutral wire.

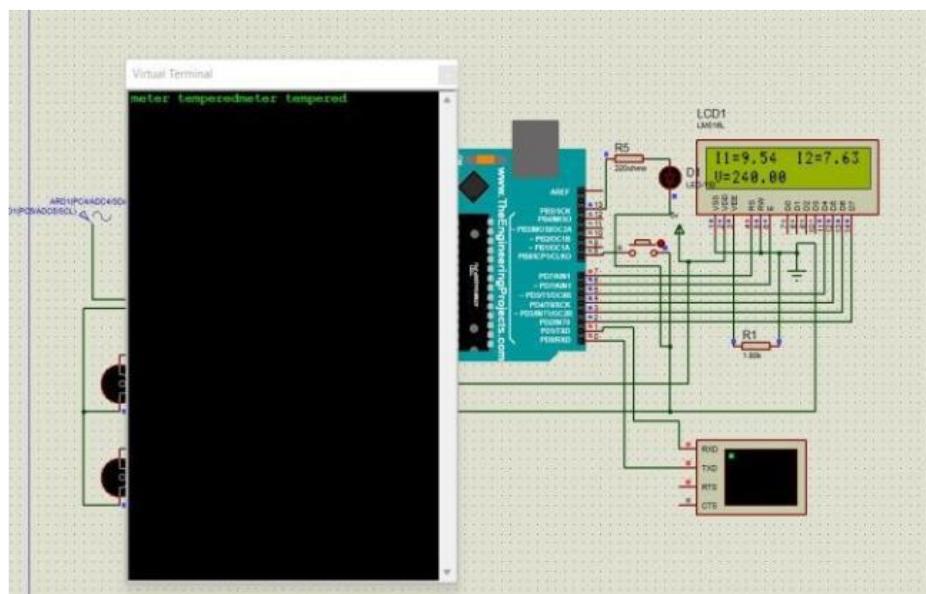


Figure 5. Interfacing of Theft System with Results

Current will flow through a current transformer linked in series with the phase of another wire, but it will also flow through a current transformer connected in series with the neutral. The output of both current transformers will therefore experience a voltage differential that the microcontroller can detect. Once the microcontroller notices the discrepancy, alarms will be issued to the consumer and any authorized individuals with the aid of a GSM module, and the meter will be removed from the supply, preventing electricity theft. In simulation, at normal condition phase current is equals to neutral current. But when current difference will occur it will display the alerts messages i.e., "Meter is tempered".

Conclusion

This result of project of Smart Prepaid Energy Meter. Proetus 8.6 and Arduino software is used to design discussed in details. Setup and installation of all the software is outlined systematically to ensure the effectiveness function of all tools mentioned in software. These all tools required to develop prepaid energy meter as well as Theft detection system. In addition to that the output of both of the system is displays on virtual terminal as virtually it is not possible to send and receive commands from consumers to system or system to consumer. This simulation is made in such way that at one time only code can be dump either of prepaid energy meter or detection of theft of electricity.

References

- [1] Kumar Ask, Navneet Kumar Singh, et al. "Design and Simulation of Smart Prepaid-Postpaid Energy Meter with Alarm and Theft Control." UPCON 2018 5th IEEE Uttar Pradesh Section International Conference on Electrical, Computer and Electronics.
- [2] Dinesh Yadav, Atharva Parab, et al. "Prepaid Energy Meter using GSM and Arduino." International Journal of Scientific Research and Engineering Trend Volume 7, Issue 3, May-June-2021, ISSN(Online): 2359-566X.
- [3] Kanwal Naz Shaikh, Imran Mustafa, et al. "Design and Implementation of RFID and GSM based Smart Prepaid Energy Meter." International Journal of Electrical Engineering and Emerging Technology, Vol. 04, No. SI 01, Feb 2021, pp33-36.
- [4] Abdul Ahad, Shuva Mitra, et al. "Implementation and Feasibility Analysis of GSM Based Smart Meter for Digitalized Power Consumption with Advanced Features." 2018 International Seminar on Intelligent Technology and its application (ISITIA).
- [5] Nabil Mohammad, Anomadarshi Barua, et al. "A Smart Prepaid Energy Metering System to Control Electricity Theft." 2013 International Conference on Power, Energy and Control (ICPEC).
- [6] Shahnaz Parvin, S.M. Lutful Kabir, et al. "A Framework of a Smart System for Prepaid Electric Metering Scheme."
- [7] Somefun T.E., Awosome C.O.A., et al. "Smart

Prepaid Energy Metering System to Detect Energy Theft with Facility for Real Time Monitoring.” IJECE Vol. 9, No. 5, October 2019, pp. 4184-4191 ISSN: 2088-8708, DOI: 10.11591/ijece. v9i5.pp4184-4191.

[8] Amit Jain, Mohnish Bagree, et al. “A Prepaid Meter using Mobile Communication.” International Journal of Engineering, Science and Technology. Vol. 3, No. 3, 2011, pp. 160-166.

[9] Nazmat Toyin, Nasir Faruk, et al. “Development of an Internet Based Prepaid Energy Meter.” IEEE African 2017 Proceedings.

[10] Uzair Ahmed Rajput, Khalid Rafique, et al. “Modelling of Arduino-based Prepaid Energy Meter using GSM Technology.” IJACSA Vol. 9, No. 5, 2012
