

# Wireless Controlled Smart Digital Energy Meter and theft control using GSM with GUI

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**Abstract**—In modern world intelligent control has become a priority, although the services for providing energy are still being controlled with conventional methods. The conventional method is expensive and time consuming as well as it requires man power for monitoring and data collection of the consumers which may also lead to human errors. The proposed GSM based system integrates digital energy meters installed at consumer unit with an electric supply companies to monitor, profile and control energy flow with the help of Graphical User Interface (GUI). In this two-way communication system, the GSM network is utilized to profile the energy flow with the help of SMS to the energy supplier and showing it on the monitor of the energy supplier using the GUI and can also communicate with the user via SMS. Relay circuit and LCD display is provided to update information like Voltage, Current, Units and billing or sudden power cut to the energy supplier company and is displayed on GUI. Nowadays the main problem in energy supply is that of power theft being done on various scales. Our system can also send an alert to the energy supplier in case of any power theft at the consumer side and cutoff the supply automatically until the power theft is not being cleared. This research highlights the general theory of energy metering system and focuses on our user friendly low power energy metering system design, implementation, power theft control and results.

**Keywords** — *Arduino, smart energy meter, power theft control, digital meter, GSM.*

## I. INTRODUCTION

In smart metering system as proposed in research with the ability to communicate wirelessly, commands are sent to the meter via SMS and the meter replies with the relevant energy consumption readings again via SMS. In this way it allows both the power supply companies and the user to have a better monitoring of the energy consumed by the load. Smart Energy has been an important conceptual paradigm for future energy use. How to make energy use more efficient and effective is very critical for future social and economic developments due to limited availability of non-renewable energy resources and expensive ways of acquiring renewable energies [1].

Over the last few years, Smart Energy Meter has been proposed as an innovative solution aimed at facilitating affordability and reducing the cost of utilities [2]. The existing energy meter has mechanical construction with various erroneous, tiresome and insecure meter reading methods. The problem with this system is that it requires man power, time consuming and causes error. So there is a need of smart

energy meter which will provide bill to consumer both as an SMS along with other inbuilt features such as tamper proof, fault detection etc. [3]. In addition, the online approach generates alerts about consumptions of energy as and when required according to a predefined pricing structure through a call/email/short text message [4].

Unlike traditional meter, a smart meter is well equipped digitally to provide better power theft-detection. Smart meters having capabilities based on different internet protocol to communication reliably for performing real-time operations like billing, quality assurance, load notifications [5-6]. They are digital meters that offer two-way communication, unlike the one-way manual services of traditional meters, allowing for more interactivity between the consumer and utility [7].

Smart meters are widely used around the world such as UK, Japan, New Zealand, Canada, USA, Italy and Netherlands. A lot of research work is being done on this project in countries abroad as well as in some areas of Pakistan [8-9].

### A. Electricity Theft

Operational losses incur with energy distribution which are mainly classified into either technical or non-technical in nature [10]. The authors in [11-12] described power theft control by calculating NTL > 5%, however the external control section disconnection of legal clients is a big issue. The key motivation of this research is the energy crisis of our country since long time [13]. One of the main reasons behind power shortage in Pakistan is the Power Theft. Despite of knowing the whereabouts of the individuals and organizations who are involved in committing this crime, the power companies are helpless to stop this menace. If the lines'men try to cut off the power supply, they are harassed and threatened.

A vital role regarding smart grid, is played by Advanced Metering Infrastructure (AMI) associated with layman's life [14]. Recently, many intelligent electronic devices like digital fault recorders, protective relays etc. are introduced to be attached to smart meters. These IEDs monitor the status of operational activities continuously. In the event of a problem, the providers react promptly and restrict the impacts to a minimum by isolating the system [15].

Our designed meter will not require any physical labor to cut off the power supply, but the supply can be turned off wirelessly by sending a short message to the meter. In case of

any threat to the meter itself the meter will alert the authorities by sending a text. In this way meter tampering can also be prevented.

Another feature of this meter is the efficient system for collection of meter readings. The transfer of data through SMS makes a very cost-effective strategy for the collection of meter readings. Furthermore, there will be no data tampering as there is no middle man needed for the collection of data and the information regarding the energy consumption will be directly sent to the power supply station which saves time and money.

Until the energy crisis is resolved, the process of load shedding is implemented to adjust the energy demands of the country. Our proposed design also helps the utilities to implement selective load shedding. Instead of turning off the supply for the whole region we can selectively turn off the supply for some areas. In this way we can deliver the supply according to the needs of the respective areas.

### B. Scope

The domestic and industrial use of our Smart Energy Metering system is an easy and low power energy metering and theft control system that can be used for calculating the units and their respective energy billing, for selective load shedding and for theft control at a very low price. The whole system works on sending and receiving of SMS between the energy supplier and the user.

### C. Types of Different Commercially used Energy Meters

#### I. Electromechanical Energy Meter

It is the most widely used energy meter which calculates the electrical energy or units consumed by the load based on the mechanical energy of the disk or rotor [16] as shown in Figure 1.

#### II. Digital Energy Meter

Most of the old electro-mechanical meters are being replaced by new electronic meters which are more accurate in taking the readings [17]. The digital energy meter has solved many of the problems with electro-mechanical energy meters. The major disadvantage of the digital energy meter is that it does not address the billing which is a labour consuming process.

## II. PROPOSED SMART METER

In the proposed system the manual work is replaced with automatic meter reading with GSM which simplifies the meter reading and minimizes the chances of energy theft allowing the utility to control the theft effectively, and perform selective load shedding when required. In an existing system for energy billing involves manually collecting readings from

energy meters installed at the customer's house, office etc. There is a higher probability of manual error and with increase in number of customers this process becomes more tedious.

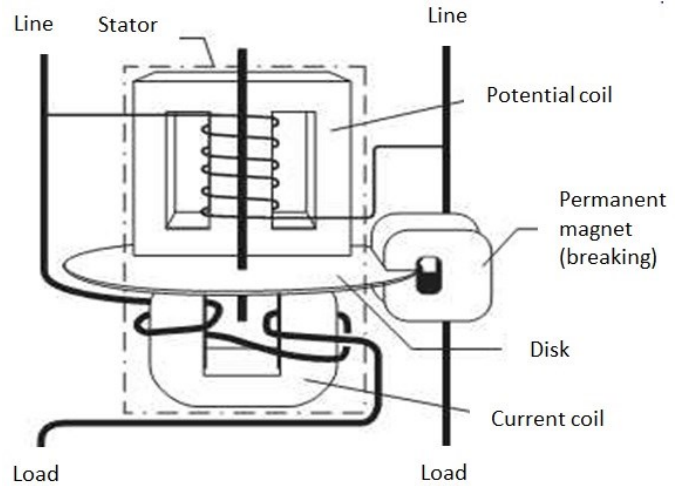


Fig. 1. Electromechanical Meter

Figure 2 shows our proposed design that can be implemented. The next enhancement of energy meter is to make it smart enough to detect any theft and to communicate with energy supplier and user wirelessly via GSM technology. The smart digital energy meter is the upgraded version of the typical digital energy meters with extra features, i.e. a wirelessly controlled system using GSM technology that enables the user and supplier to communicate with the meter via SMS and with a power theft detection, scheduled load shedding and monitoring capability.

### A. Proposed Design and System Overview

This section briefly explains all the processes and methods that were implemented in making of this prototype. Figure 3 shows the overall data flow in the system. The following are ensured in the proposed system.

#### I. Accurate billing

This system of smart meters will ensure that no one is overpaying or underpaying for their energy consumptions and hence an end to the estimated billing.

#### II. Privacy

Privacy is another major concern in many of the areas of our country. With smart meters installed, there will be no need for someone to come to our houses to record meter readings rather the communication will be wirelessly done with the power suppliers.

### AC Supply – 220V

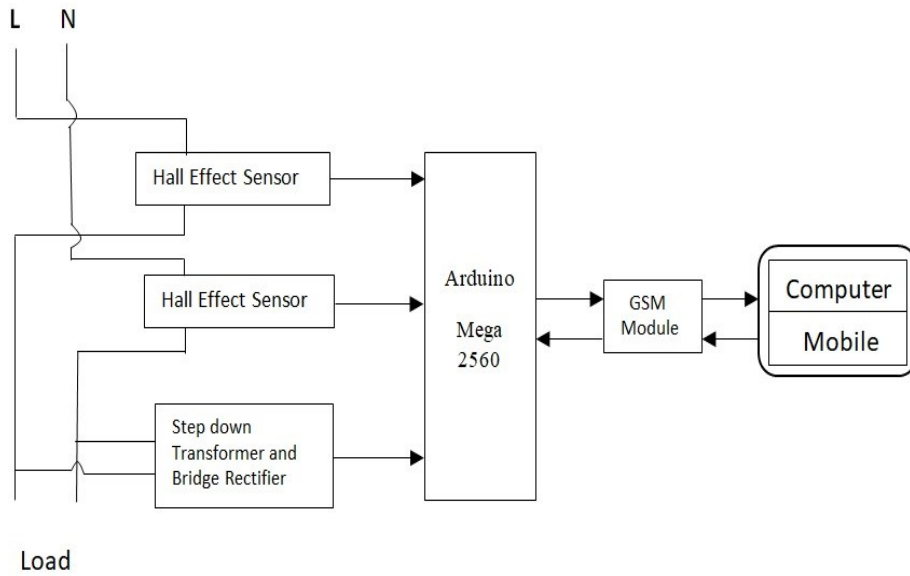


Fig. 2. Proposed Smart metering system

### III. Load Monitoring and Management

Better monitoring and management of our house energy consumptions with real-time data display in our homes and on our mobile phones. This will also enable the supply companies to implement load forecasting more effectively.

### IV. Power theft control

In case of any complaint regarding power theft the utility can selectively cut off the power supply for that house without sending any personnel there.

### V. Tamper detection

In case of any tampering being done to the meter, it will inform the authorities of it by sending an alarm signal.

- Fraud
- Stealing electricity
- Billing irregularities
- Unpaid bills

### A. Power theft Controlling

Power thefts can never be totally eliminated in our country. In the very efficient system of some countries like Japan, Europe and US efforts have devised different methods compulsory to reduce power thefts to acceptable levels.

The first step in electricity theft reduction is to find and investigate theft problems. There are many methods for reducing power thefts in a community including but not limited to: (1) Technical Engineering Methods (2) Managerial Methods (3) System Changes etc.

### B. Proposed Method

Nowadays, electricity theft is being done in such a fashion that there is no current entering the energy meter and due to which the energy meter does not count the units being utilized by the consumer. To reduce such type of electricity theft we have used two identical Current Transformers to measure and detect the current leaving and entering the meter i.e. CTs on the phase and neutral wire and feed it to the microcontroller where they are compared. If both the values are different from each other beyond threshold value, then it is detected by the microcontroller as a sign of theft and the electricity supply will be disconnected and at the same time signal is sent to the energy supplier company via SMS and is displayed. Figure 4 shows the block diagram of the proposed technique.



Fig. 3. Data flow diagram of the system

### III. ELECTRICAL ENERGY THEFT

In 2013 it was reported that Pakistan had lost Rs.90 Billion in electricity theft and line losses during the last 5 years [18]. The government took necessary action and increased the human resources and 35,000 army men were spared to recover the dues and curb the power thefts [19]. There may be various types of thefts, some are mentioned below.

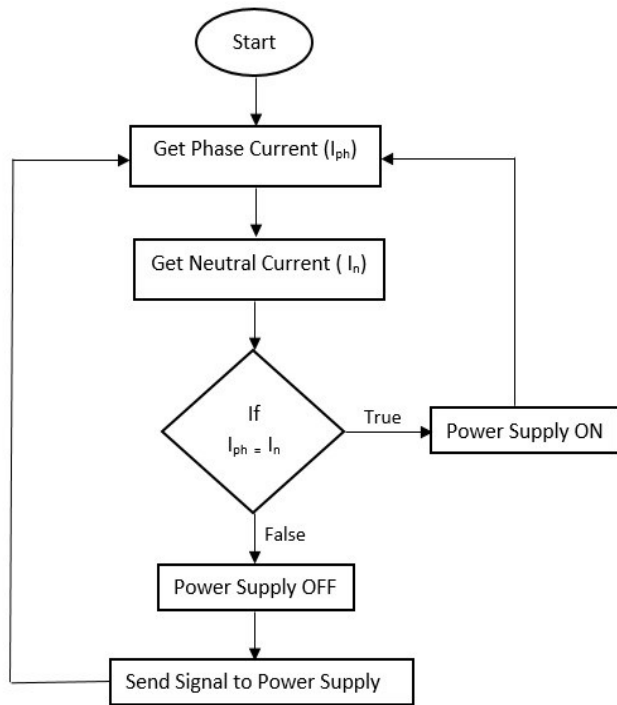


Fig. 4. Proposed theft control flow chart.

#### IV. GRAPHICAL USER INTERFACE

A user-friendly GUI as shown in Figure 5 is designed for the power supply stations that enable them to monitor and control the meter through computers. Once the application is started, a dialog box appears asking for the “com port” at which the GSM is connected. Then the application is connected to the meter and data is received from the meter every 40 seconds and is updated on the application. There is an indicator which is used to show the theft for the meter. In case of any meter tampering, an indicator will alert service provider. For sending a turn on/off signal and to get energy consumption updates instantly, separate buttons are provided on the screen. The user can communicate with the meter via SMS using this window.

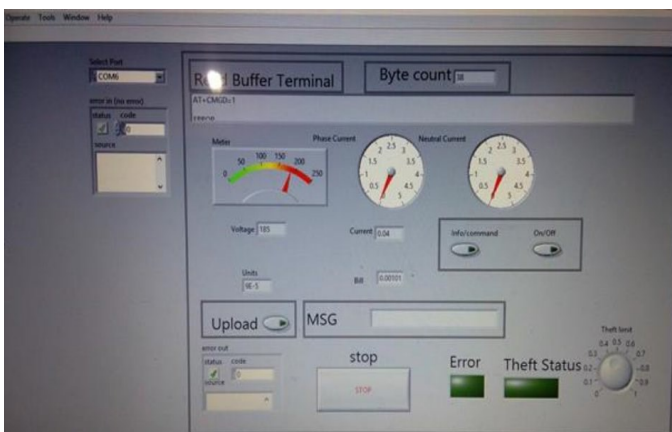


Fig. 5. Graphic User Interface of the proposed system.

#### V. HARDWARE

Arduino Mega 2560 is used in this work along with other required hardware like power supply required for GSM as shown in Figure 6 with the capability to perform multiple tasks at a very high conversion rate. A GSM module is used in the proposed design to communicate between the meter and utility and consumer. The meter reading is updated after every 5 seconds or as required by the consumer.

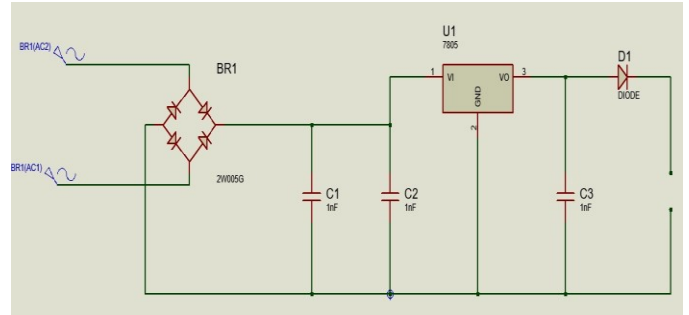


Fig. 6. Power Supply for GSM

A 16x2 LCD (Liquid Crystal Display) as shown in Figure 7 is another efficient and low power consumption component of the equipment interfaced with the Arduino used in this work. It is an electronic-modulated device filled with liquid crystals and arrayed in front of a light source. The LCD used shows the values of current, voltages, units consumed and load (power). Figure 8 - 10 show the detailed circuit diagram of the implemented hardware.

#### VI. SYSTEM TEST

We performed different tests based on connected load to the meter. We assumed to connect 120W and 60W of load to the meter and checked the meter readings displayed on our proposed meter and compared our meter reading with the readings taken on DMM. Table 1 shows the comparison between the DMM readings and reading on our proposed meter.

The values of current and voltage measured on DMM for 120W load is shown in Figure 11. Our proposed meter also shows almost the same values on LCD as shown in Figure 12.

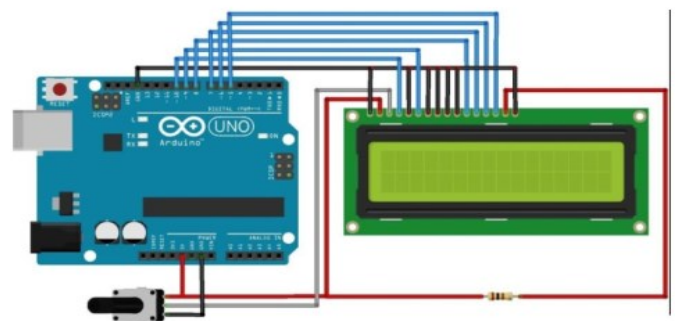


Fig. 7. LCD interfacing with Arduino



Fig. 8. Hardware implementation

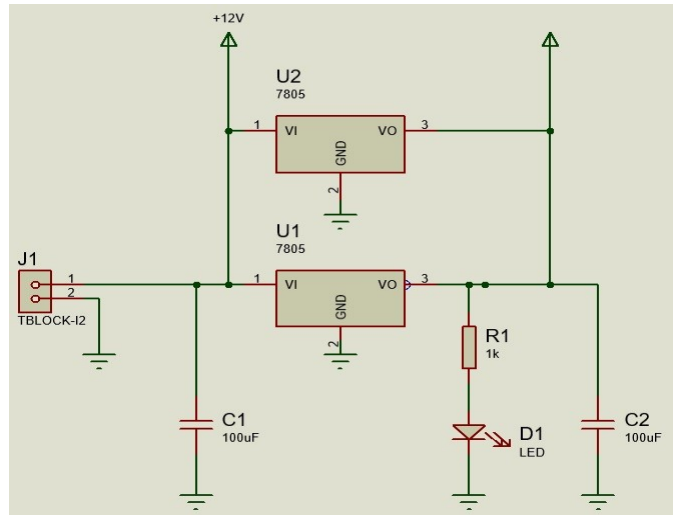


Fig. 10. Power Supply for Arduino

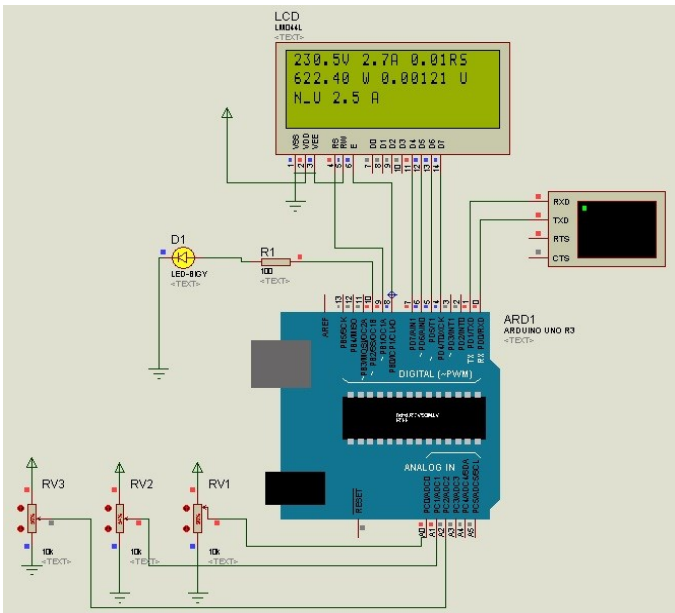


Fig. 9. Proteus Implementation of Digital Energy Meter

TABLE I. VERIFICATION OF RESULTS BY THE PROPOSED USING METER READINGS

Load (W)	DMM Reading		Proposed Energy Meter Reading	
	Current (A)	Voltage (V)	Current (A)	Voltage (V)
120	0.4	220	0.4	220
60	0.2	221	0.2	220

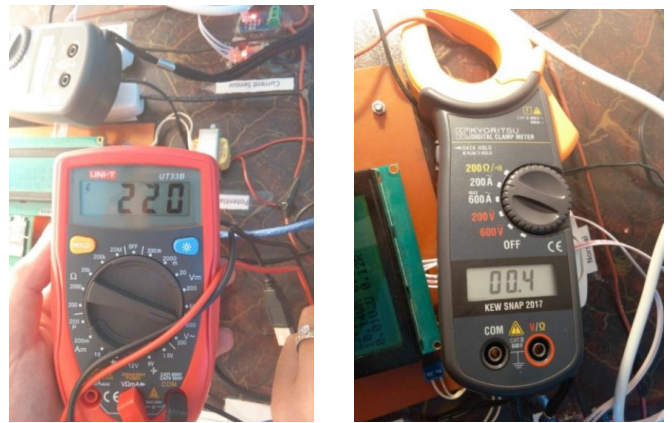


Fig. 11. Current and Voltage on DMM for 120W Load



Fig. 12. Proposed Meter Readings for 120W Load

The values of current and voltage measured on DMM for 60W load is shown in Figure 13. Our proposed meter also shows almost the same values on LCD as shown in Figure 14.

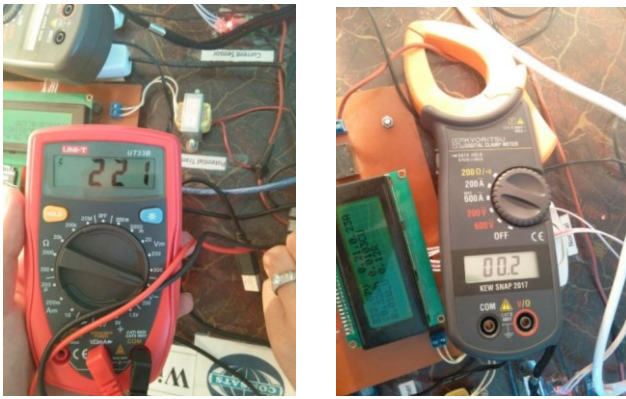


Fig. 13. Current and Voltage on DMM for 60W Load



Fig. 14. Proposed Meter Readings for 60W Load

#### CONCLUSION AND FUTURE WORK

The aim of this research was to bring improvement in the current power systems of the country by introducing a new smart metering system. For this purpose, a GUI based smart energy monitoring and controlling system was proposed. The results discussed, and observations made in this research concluded that smart metering system with GSM communication capabilities will make the current power management better and efficient in many ways. This will enable the energy suppliers to be able to take necessary actions against the culprits. This research has the following future extensions.

- Net Metering – A billing methodology that allows for customers with self-generation to “net” the amount of electricity that they generate against the amount that they use from the grid. Consumers generating power through various energy resources are billed only for their net energy consumption through net metering. This will encourage the consumers to install more renewable power sources at their side thus assisting to compensate the energy crisis.
- Power Factor correction – Capacitor banks added to the unused ports of microcontroller can enable power factor to be closer to unity.

- 3-Phase modification – This research is designed for single phase power and can be modified to 3- phase through appropriate methods and research.

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