Detection of Power Theft using GSM

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***Abstract*—At present energy theft is a serious problem in the developing countries like India, Pakistan, Srilanka, etc. If the electricity is illegally used it effects the economic status of the country. In real time application it is very difficult to verify theft occurred and solve it at individual level. Various kinds of energy theft comprised of meter tampering, bypassing the energy meter, direct hooking from line, etc. This paper proposes the detection of energy theft using Arduino and GSM module. LCD is provided to display the data of power usage and also the power being theft i.e., the difference between the consumers load and the theft load which is sent to the GSM module. Further this information is sent to the electricity board and also to the consumer as a message which embodies the distribution transformer details. The power is fed from the transformer to the Arduino which is being stepped down. The major advantage of this paper is when compared to the existing system, it detects the power theft and sends the information of the corresponding feeder using GSM module to electricity board directly without manually filing a complaint and also in case of power failure, the message is sent without any interruption as Arduino is facilitated with power backup.**

***Keywords*—Arduino, GSM, Energy theft, Current transformer.**

I. INTRODUCTION

Energy theft means illegal usage of energy or using the energy without the consent of electricity board. There are innumerable ways to theft the energy while some are simple and some are difficult. It includes the physical obstruction, hooking the service lines, meter tampering, etc. Also a meter can be inverted which shows less power usage. It results in revenue loss to the government and consumers will get affected.

The energy theft is one of the major problems in India. The losses are determined as 5 to 10% of the power transmitted, If the loss in the power distributed is beyond the limit, then it is an indication for the energy theft. Thus energy theft affects the electricity tariff rates [1], [2].

In order to avoid the problems like overbilling, meter tampering and to assure the cost effective operation, a prepaid electricity system has been introduced. In this, the consumer has to purchase the units and if the units purchased is consumed, a warning will be sent to the consumer. The drawback of this system is consumer must know the units required which may vary regularly and also the power usage is limited [3], [4].

The major modes of power theft are hooking in the service line and bypassing energy meter [5]. Solution to the power theft done by bypassing of energy meter are proposed in which energy meter will be placed in the system and as soon as the power theft takes place, it will alert the electricity board by sending SMS to the control unit of electricity board [6-8].

Due to the energy theft, unbalanced load sharing [9] reduces the efficiency which is one of the consequences that results in frequent tripping thereby causing damage to the home appliances [10],[11].

In this paper, it is possible to know under which distribution transformer the theft is taking place. GSM is used to send the message to electricity board and to the consumer. CT's are used to measure the current and Arduino is used to control the system. By placing this circuit in every meter and also near the distribution transformer it will be easy to know under which distribution transformer the theft is taking place. This is aimed to reduce the manual interference and accomplishes the control of power theft at the distribution side.

II. EXISTING SYSTEM

A. *Existing System*

The existing wireless communication system of energy meter has been done using ZIGBEE, relay control and GPRS. This method is mainly used to secure the communication channel and ZIGBEE is used for the transmission of data in a serial process. The limitation of this system is that meter readings can be collected only by going to the particular range of area and power is shut down manually if needed.

ZIGBEE is mainly served as a purpose for transmission of communication only for the shorter ranges. It cannot be used to transmit the communication or the message for larger distances because of their properties like low complexity, low data speed, high maintenance cost, etc.

B. *Proposed System*

In this paper GSM technology is implemented for transmitting the information about power theft to the supplier. The system is being interfaced with Arduino and transformers which are used to sense the problem, if any problem is detected then the message will be sent to the electricity board via GSM. This will prevent the electricity theft as much as possible. This paper gives the solution for the existing problems like power theft, wastage of energy that is faced by the authorized power suppliers.

III. System Architecture

A. Block Diagram

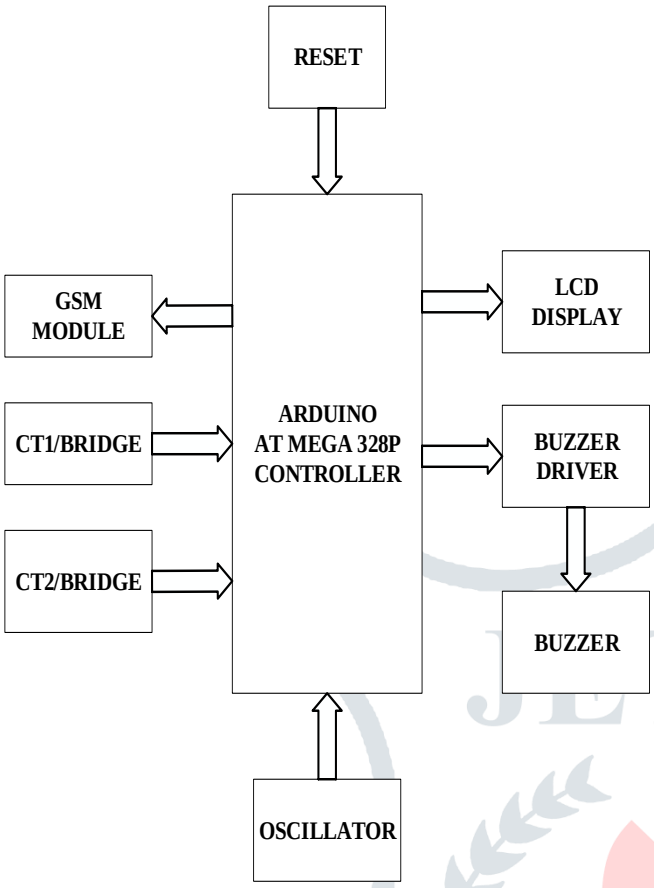


Fig. 1. Block Diagram

B. Arduino

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital i/p & o/p pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. [12].

The difference between Uno from the other boards is it doesn't use the FTDI USB-to-serial driver chip but it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. The 8U2 HWB present in UNO is lined to ground through resistor which makes it easier to put into DFU mode. [13].

The Arduino Uno's power supply is given through USB or it can be provided through an external power supply. The external power source selection is done automatically.

External (non-USB) power comes either from an adapter or battery. The adapter connection is done by using a 2.1mm centre-positive plug in power jack of UNO board. The battery leads are inserted in Ground and Vin pin headers.

The operation of the board can be done by an external supply of 6-20V (volts). If less than 7V is provided, however, the 5V pin may supply less than five volts to the board and it leads to the instability of the board. If using more than 12V, the voltage regulator may overheat and the board gets damaged. The recommended range is 7 to 12 volts.

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Each of the 14 digital pins on the Uno can be used as an input or output, using pinmode, digital write, and digital read functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 K-Ohms. In addition, some pins have specialized functions [14], [15].

C. GSM

GSM which is abbreviated as Global System for Mobile communications is a cellular network. It means that the mobile phones in the nearby vicinity gets connected to the device.GSM networks operate mainly upon the four different frequency ranges [16]. Most of the GSM networks operate in the ranges between 900 MHz or 1800 MHz bands and some countries like the USA use the 850 MHz and 1900 MHz bands because the 900 and 1800 MHz . GSM-900 and GSM-1800 are the most commonly used but countries like Canada uses GSM-850 [17], [18].

D. Buzzer

A buzzer or a beeper is a electronic signalling device, commonly used in automobiles. Recently, a ceramic based piezo-electric sounder is being used. Sonalert is one of the examples of piezo-electric sounder. Generally, these were hooked up to driver circuits that changes the pitch of the sound or gives pulsed for sound on and off correspondingly.

The buzzer ON and OFF is usually controlled by the switching transistors (BC547). To the transistor collector terminal the buzzer is connected. When a high pulse signal is given to base of the transistors, the transistors conducts, by which the buzzer gets energized and then produces the sound.

The transistor is turned off to a low pulse signal given to base of transistor and the current in the buzzer doesn't flow such that the buzzer is OFF.

E. Current transformer

The current transformer senses the current from ac supply and transfers the reading to Arduino board. It operates from the range of 5V and gives an analog voltage as output which is proportional to the current sensed on the terminals. The applications of current transformer include motor control, detection of load, the switch mode supplies and the over current fault protection and management.

F. Liquid Crystal Display

Vcc and Vss are supply pins and VEE (Pin no.3) is used for controlling LCD contrast. Pin No.4 is Rs pin for selecting the register, there are two very important registers are there inside the LCD. The RS pin is used for their selection as follows. If RS=0, the instruction command code register is selected, allowing the user to send data to be displayed on the LCD. R/W is a read or writes Pin, which allows the user to write information to the LCD or read information from it. R/W=1 when reading R/W=0 when writing.

The LCD uses the enable (E) to fasten the information presented to its data pins. The 8-bit data pins, D0-D7, are used to send information to the LCD or read the contents of the LCD's internal registers. To display letters and numbers, we must send ASCII codes for the letters A-Z, and number 0 -9 to these pins while making RS=1 [19].

Table. 1. Pin description of LCD

Pin	Symbol	Function
1	V_{SS}	Power Supply (GND)
2	V_{DD}	Power Supply (5v)
3	V_{EE}	Contrast Adjust
4	RS	Instruction/ Data register select
5	R/W	Data bus line
6	E	Enable signal
7-14	DB0-DB7	Data bus line
15	A	Power supply for LED B/L (+)
16	K	Power supply for LED B/L (-)

G. *Step down transformer*

The transformer is a device which transfers the electrical energy from one electrical circuit to the other electrical circuit through the medium of magnetic field without a change in frequency. The primary winding receives the electrical energy from the supply and the secondary winding delivers the energy to the load.

The device is very practical with which, it is feasible to multiply or divide voltage & current in AC circuits easily. The long distance transmission of electrical has come to actuality due to transformer. For reduced wire resistance power losses along power lines connecting generating stations with loads, we can step up the ac voltage and can be step down the ac current. For safer operation and less expensive equipment, at either end for both the generator and at the loads, voltage levels are reduced by the transformers. A step-up transformer is namely a transformer that increases voltage from primary to secondary. Similarly, a step-down transformer designed to do just the opposite of what the step-up transformer operation.

The step-down transformer is evidently identified by the high turn count of the primary winding and the low turn count of the secondary. The step-down transformer converts low current, high voltage power into high current low voltage power. To increase current, a larger gauge wire has been utilized. The primary winding is made of smaller-gauge wire as it doesn't have to conduct much current.

It is a fact that we can operate either of these transformer types backwards (powering the secondary winding with an AC source and letting the primary winding power a load) to perform the opposite function: a “step-up transformer” can function as a “step-down transformer” and visa-versa. As we referred in the first section of this chapter, transformer can be operated efficiently when individual winding inductances be engineered for specific operating ranges of voltage and current, so if we want transformer is to operate "backwards" as mentined above it must be employed within the original design parameters of voltage and current for each winding, inorder to eschew to be inefficient or to avoid it be damaged by excessive voltage or current.

H. *Diode*

A diode consists of a P-N junction as it is a two terminal device formed either in Ge or Si crystal. A P-N junction is formed when a P type material is merged with a N type material. It acts as switch. The switch is closed when diode is in forward bias and is opened in reverse bias condition.

In forward bias condition, an external voltage is applied to P-N junction in such a direction that it cancels the potential barrier and allows the flow of current while in reverse bias condition, an external voltage is applied in such a direction that it increases the potential barrier. In order to apply a forward bias, P type semiconductor is connected to the positive terminal of the battery while N type semiconductor is connected to the negative terminal. For reverse bias, the positive terminal of a battery is connected to an N type semiconductor while the negative terminal is connected to P type semiconductor.

Thus P-N junction diode is a unidirectional device which offers low resistance when forward biased and acts like an insulator when reverse biased. Hence, it is used for converting alternating current into direct current i.e., a rectifier [20].

I. *Voltage regulator*

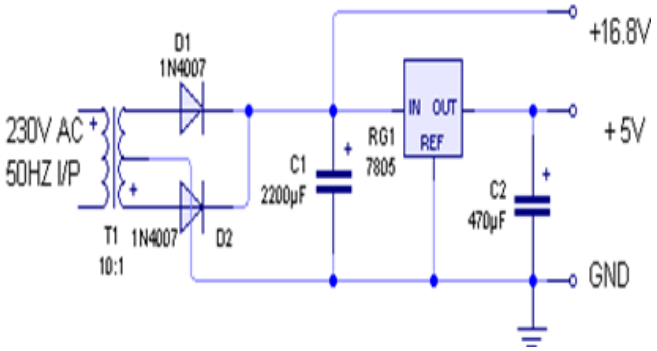
The Digi-lab board can utilize any power supply that provides a DC voltage between 6-12 volts. Inspite of the voltage available at the J12 connector a 5V voltage regulator (7805) is used to ensure that not more than 5V is delivered (provided that voltage is less than 12VDC). The regulator operates by using a diode to clamp the output voltage at 5VDC regardless of the input voltage - excess voltage is converted to heat and dissipated through the body of the regulator. If a DC supply of greater than 12V is used, excessive heat will be generated, and the board may be damaged. Insufficient voltage will be available at the o/p of the regulators, if a DC supply of less than 5V is used.

If a voltage more than 7 or 8 volts is provided by power supply, a significant amount of heat will be dispersed. The "fin" present on the body of the regulator helps to dissipate excess amount of heat to more efficiently. The regulator needs to dissipate more amounts of heat if higher currents are required by the board. For this case, the regulator can be secured to the circuit board by fastening it with a screw and nut. If the regulator is secured tightly to the circuit board, excess amount of heat can be sent to the board and then can be radiated away.

J. *Crystal oscillator*

In oscillator section we have used 11.0592 MHz crystal Oscillator connected to the pins No.18 & 19 of Micro Controller along with the 33PF capacitor connected to the ground. The crystal generates a sine wave that is internally converted into square wave subsequently divided by 12 for general operation.

IV. HARDWARE IMPLEMENTATION



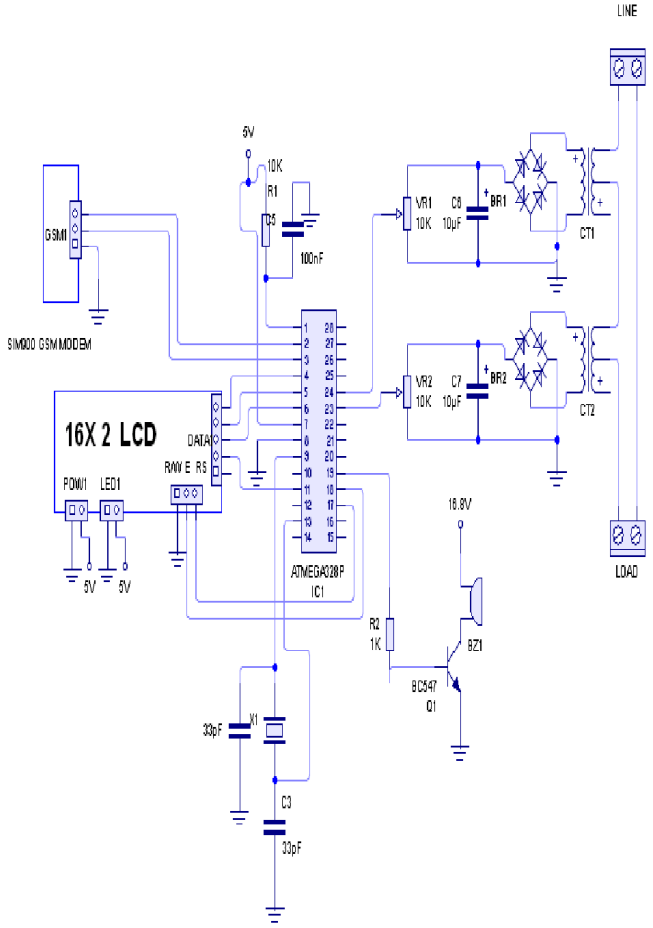


Fig. 2. Circuit Diagram

Initially, a 230v AC supply is given to the circuit as a power supply. This voltage is stepped down to 12v and is given to the Arduino board by using a step-down transformer which is placed in between the voltage transformer and Arduino. A capacitor is placed to filter the voltage and a voltage regulator is also utilized in order to regulate this stepped voltage to 5v. A current transformer is placed at the supply side whose secondary is connected to Arduino through diode rectifier as shown in fig.2.

Here, two 60W bulbs are considered to be two consumers and a 100W bulb is used as a theft detector. The two bulbs are connected across two CT's whose secondaries are connected to the Arduino. LCD display is used to indicate the amount of theft which is being done. A buzzer is placed such that it indicates the theft which is being occurred though the alarming sound.

Arduino is interfaced with GSM which acts as a transmitter to the message. Initially the LCD display shows the power consumed by the source and consumers as shown in the fig.. When the theft is detected by Arduino, it displays the amount of power theft on LED and moves the buzzer position to ON. This amount of power theft value and the transformer number at which the theft is occurred is sent as SMS to the electricity board though GSM module.

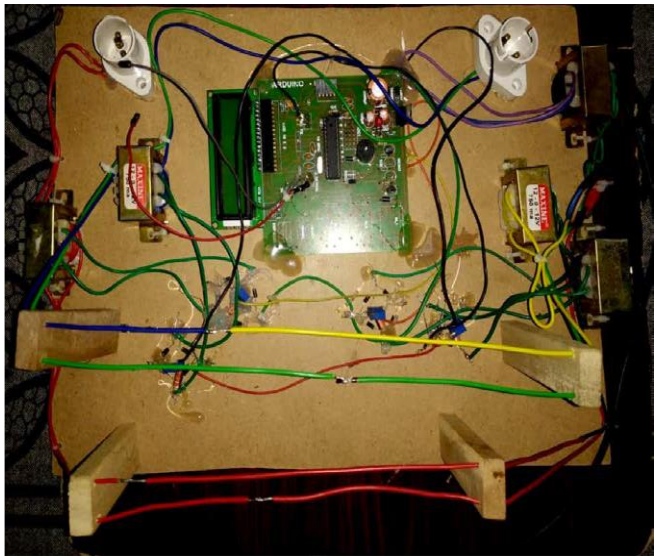


Fig. 3. Overall view of the energy theft system

V. SOFTWARE IMPLEMENTATION

The arduino programs can be written in any programming language with the help of a compiler concept that produces executable binary machine code. Atmel attempts to bring an improvement in this environment for proposed systems in "microcontrollers", "AVR Studio" and the "newer Atmel studio". A variety of arduino microcontrollers are available in the market.

The most common of them used is the Arduino UNO, but there are some specific specialized variations. Before starting the building process, a little survey is to be done to find out which version will be best suited for the system which is proposed.

So, the proposed system in this paper has the programming done in the software called Arduino IDE. The programming is executed in the way such that the mobile numbers to which the power theft details must be sent are inserted properly and also the data of power at the source and the load sides must be displayed properly when the theft is being done as shown in fig.4.

VI. RESULT & DISCUSSION

The hardware model of the proposed system is shown in fig 3. The input 230v AC supply using a step down transformer is stepped down to 12v and this voltage is given to the Arduino through voltage regulator and filters, where the regulator converts AC into DC supply and the filter is used in this case in order to remove the ripple content. Here two lines (bulbs) are taken from supply which is considered as two streets. Now when the theft is done i.e. when a bulb is connected to any one of the two lines, buzzer gets activated.

The Arduino is programmed such that it compares the input and the output powers and also displays the data at both source and load side as shown in the fig.4 on the LCD. If there is any difference (with some tolerance) then it is considered as a theft and that difference is sent as SMS to the electricity board through GSM technology. The transformer number i.e. at which the theft occurs is also sent as message to electricity board and also to the consumer.

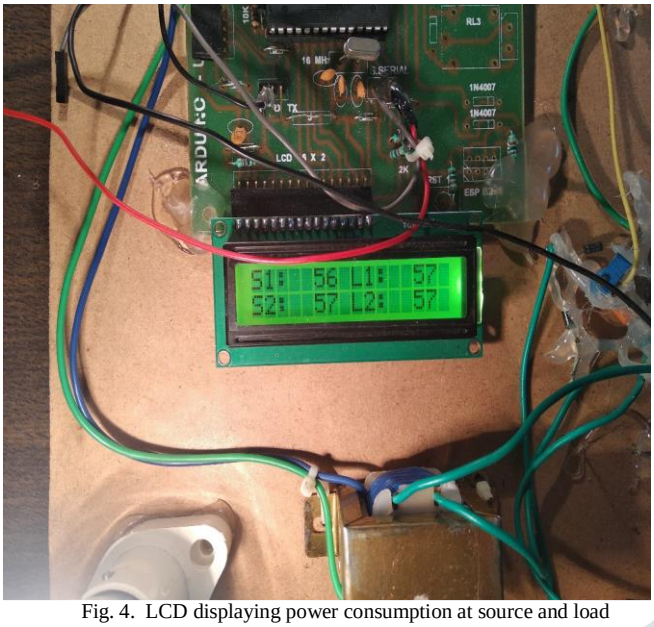


Fig. 4. LCD displaying power consumption at source and load

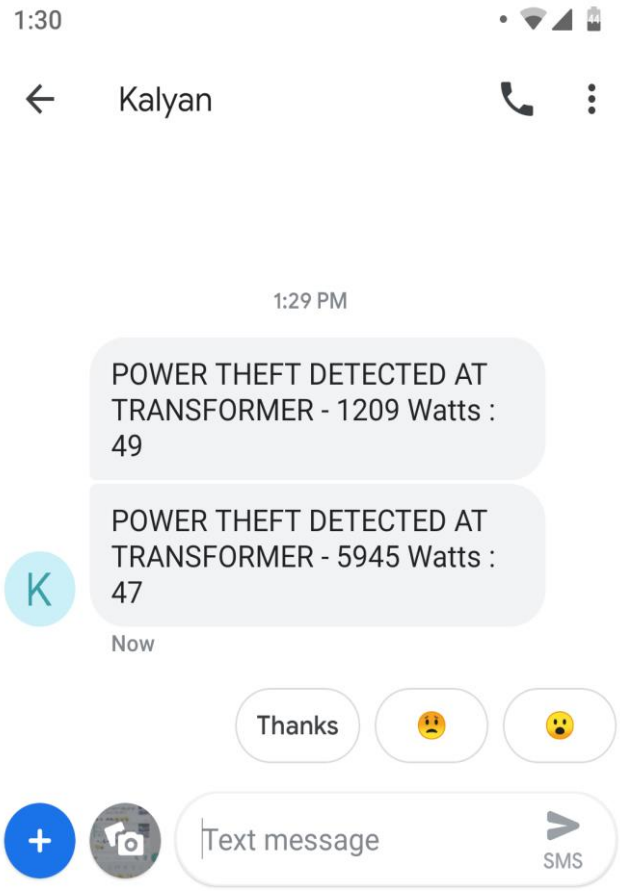


Fig. 5. Message sent to the mobile

VII. CONCLUSION

The main agenda of proposed system in this paper is to reduce the complex problems like 'heavy power', 'revenue loss', 'power tapping' that prevail while the power is being theft in the distribution side. This system will be placed in such meters and whenever an attempt is made for the theft, it will send a SMS alert to both the electricity board & also to the consumer using GSM modem. Consequently, by the above proposed design of the system we can effectively and successfully minimise the problems that come under power theft without any manual interference.

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