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Smart Power Theft Monitoring System

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Abstract:
With the electric industry experiencing change, expanded consideration is being focused on power supply dependability and power quality. Power suppliers as well as users are equally worried about reliable power, regardless of whether the emphasis lies on intrusions, aggravations or extended power outages. Power theft is the major hindrance in providing the quality power to the valued subscribers. Power monitoring can provide reliable data to the power suppliers about power flow and help them identify the reasons for power failures. The proposal in this paper is to monitor the pattern of current flow at the input and output (I/O) terminals of the energy meter installed at the user's location and hence determine the power theft. Once the power theft is confirmed, immediately the supply to that line is cut off and the buzzer is activated. Also, the message is passed on to the concerned authority using wireless data transmission technique to take appropriate action.

Keywords*:Smart Meter, Power Theft, Energy meter*

I. INTRODUCTION

Electrical energy is one of the most sought after utility in the modern world in the absence of which the life will almost come to a grinding halt. Year after year, the increase in per capita production of electricity reflects the improvement in the standard of living of the current generation. Meanwhile, the percentage of power theft is also increasing alarmingly high. So, the major challenge for the power supplier now is to identify such thefts, block the pilferage and provide quality power to the genuine customers. As per a recent study, the power loss in India because of power theft alone is estimated at 29% of the total power generation that approximates to Rs. 450 billion. Also, it should be noted that India is notorious to power theft. The state of Maharashtra alone loses Rs 220 billion per year. Thus, it has become imperative to face this challenge.

The energy meter is used to measure the electrical energy supplied to the electrical appliance. The energy meter may be electronic or electromechanical type. To avoid the high cost of electrical energy consumed by their appliances, unscrupulous elements resort to power theft. Due to the high cost of sophisticated energy meters, the power suppliers provide only the meters with basic features. Thus indirectly inducing the power thieves to tamper the meters and steal energy. In developing / under developed countries like India, Pakistan, Bangladesh, etc tampering electric meters and stealing power have become a common practice. So there is a need to identify various kinds of power theft mechanisms and ways to minimize the revenue pilferage by preventing the power theft.

Usually, electric power is stolen from the lines by tapping the power from the input terminals of the energy meter or reducing the speed of the wheel by placing the natural magnets close to the wheel of the energy meter in the case of mechanical meter[1].

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Taping out wires from the input of the energy meter bypasses the meter. So, it doesn't record the power consumed by the appliances. Also placing magnets prevent AC from forming eddy currents in the rotor of the energy meter. The power theft is identified by measuring the flow of current in the line before and after the energy meter.

In this paper, the aim is to:

- Monitor the pattern of power consumption and hence determine whether power is being stolen.
- Disconnect the power supply when the power theft is detected.
- Activate the buzzer when there is a power theft.
- Inform the operator at the substation by sending out the message when the power theft occurs.

D. Alahakoon et al [1] in their work, presented a survey of various types of smart energy meters and their utilization, focusing on the various aspects of metering, stakeholder interests as well as techniques adopted to fulfill them. They have highlighted the challenges faced and opportunities arisen after the advent of big data and cloud computing.

S. S. Mohammad et al [10] in their work explained how power theft could be minimized by encoding the analog signal at distribution transformer side and decoding the same at the energy meter side. Since the encoded power flows in the circuit, the home appliances can't use it, thus preventing the illegal tapping. This model was implemented using Simulink.

R M Mutupe et al [14] in their work designed a system that detects power theft from a distance and a technique to isolate it. That system monitors electric current supplied from a substation and the one received by the load. The difference gives in indication of power theft.

II. Proposed System

The major components that are used in the proposed system and their functionality are listed below:

Energy Meter

Watt hour meter, commonly referred to as the Energy meter is an integrating type of instrument that is used to measure the power consumed by the load both in residential and industrial units, the unit being Kilowatt hours. In SI units, the power consumed is measured in watts. If one thousand watts of power is used by any appliance in one hour, the total energy utilized by the load corresponds to one kilowatt-hour. It is also referred to as Unit in commercial terms. The energy meters measure the instantaneous value of voltage and current, multiply them together and integrate between the intervals to calculate the energy expended by the load.

The energy meter can be electromechanical type induction meter or electronic type energy meter.

- **Electromechanical Type Induction Meter:** Till recently, this type of meter used to be the most commonly used type of energy meter in developing countries like India to measure the energy consumption. Induction type energy meter measures the energy consumed in any circuit when supply voltage and frequency remain constant.
- **Electronic Type Energy Meter:** This is a very accurate, precise and reliable type of measuring instrument that consumes very less power compared to its conventional counterpart. It starts to measure energy immediately once connected to the load. This type of meter is available in two forms, one being analog and the other digital. In the former, power is converted to the corresponding pulse rate and integrated over a period by the counters where as in the later, power is measured by the processor and integrated by logic circuits to calculate the total energy consumption.

A. Arduino Uno

The Arduino Uno is a very widely used microcontroller board, based on ATmega328P. It has 14 digital I/O pins, 6 analog inputs driven by a 16MHz quartz crystal and a USB port to interface with the peripherals. It starts to work as soon as it is connected to a computer using a USB cable.

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Figure 1: Arduino Uno

B. Line Pulse Sensor

The functionof line pulse sensor in this paper is to measure the current flowing in the line that is connected between the I/O terminals of the energy meter. Here, ACS712 that has the current range of 0-30A is being used as the Current Sensor.

Figure 2: ACS712, the Line Pulse Sensor

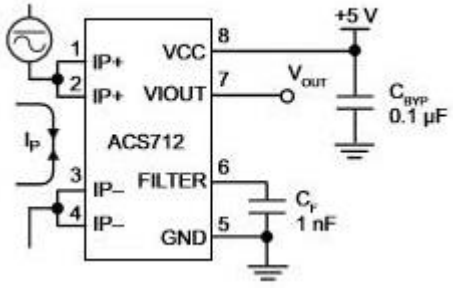

Figure 3: Pin Diagram of ACS712

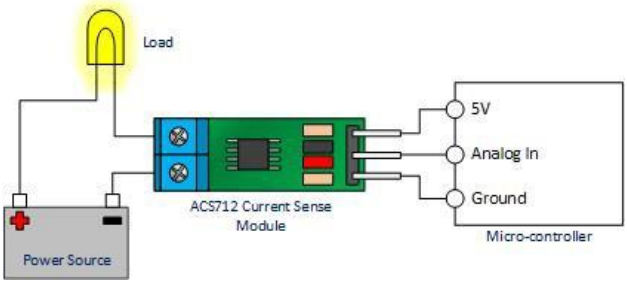

Figure 4: Circuit Connection for measurement of Current

C. Buzzer

A buzzer also called a beeper is device used normally to confirm user actions such as key stroke or click of the mouse button by producing sound. The buzzer could be mechanical or piezoelectric type. The main advantages of Piezo buzzers are that they are light weight, simple to use and cheap. So, it is used in situations like indicating the vehicle reversing, strike of a key in computers etc. It works on the inverse principle of generating piezo electricity. Piezo electricity is generated when pressure is exerted on piezo electric materials.

When a small current flows through the 100 ohms resistor, the magnetic flux gets generated. After a short while, the current ceases to increase which eventually leads to the collapse of the magnetic flux and induce an EMF. As per Lenz' Law, the voltage so induced opposes its very existence. Three wires connected to both the sides of the ceramic substrate expand sideways when an EMF is applied, ultimately generating sound.

The physical connection between the buzzer and the Arduino Uno could be established as depicted in figure 5. One end of the buzzer is connected to the output pin 7 (digital) of the Board and the other end of the buzzer is grounded through the resistor.

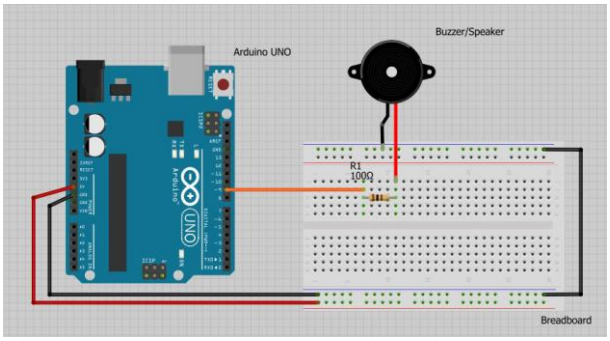

Figure 5: Connection of Buzzer with Arduino Uno

D. Relay Module

Here, the main function of the relay is to turn on and off the circuit using a low current as input.

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Figure 6: Relay Module

E. Interfacing Relay with Arduino Uno

Figure 8 given below depicts how Arduino Uno could be interfaced with a relay module. Here, for example, the relay has to trip LED. In this project, the LED is replaced by the power supply. Here, the Vcc of the relay is connected to 5V and the GND of the relay to GND of the Arduino Uno. The input pin of the relay could be connected to any digital pin of the Arduino Uno (Here it is connected to pin 6).

The following code snippet (Figure 7) could be used to interface the relay with Arduino Uno:

```
void setup()
{
        pinMode(6,OUTPUT); \\ set the digital pin 6 of arduino in output mode
}
void loop()
{
        digitalWrite(6,Low); \\  set the pin 6 in low mode to de-energize relay
        delay(2000); \\ delay of 2000 ms
        digitalWrite(6,High) \\ set the pin 6 in low mode to energize relay
        delay(2000);  \\ delay of 2000 ms
}
```

Figure 7: Code snippet used to establish contact between Arduino Uno and the relay

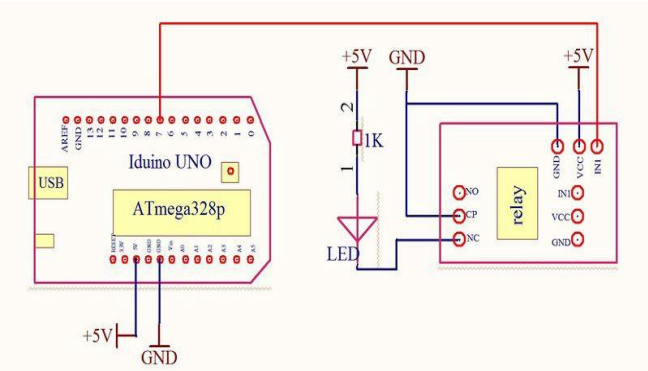

Figure 8: Interconnection between Arduino Uno and the Relay Module

F. Radio Frequency (RF) Module

An RF Module is an electronic device used to send and/or receive RF signals between any two devices. In embedded systems, it is a common practice to communicate with remote devices using radio frequency signals.

In the current paper, the RF transmitter and receiver modules are used to establish communication between the Arduino on site and the Arduino at the substation, upon detecting the power theft.

In RF communication, the electromagnetic waves are generated and sent from a particular source and received at the destination. The electromagnetic field waves travel in air / vacuum at par with the speed of light. It has to be noted that the frequency of an electromagnetic signal is inversely proportional to its wavelength; i.e., lower the frequency, larger the wavelength and vice versa. For example, wavelength of a 2GHz device is shorter than that of a 200MHz device. Normally, longer wavelength signals travel a greater distance than shorter wavelength signals.

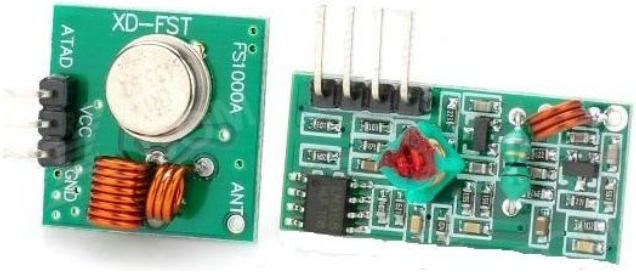

Figure 9: 433MHz RF Module

III. Different Methods Used To Tamper the Meters

Direct hooking from line

This technique is most prevalent practice used across the globe to steal electric power. Approximately 90% of global power theft happens using this technique. In this method, the unauthorized consumer steals power by tapping into a point on the power cable well before the energy meter, thus bypassing the meter. This amounts to loss of power to the supplier.

Injecting foreign element into the energy meter

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In this method, the meters are controlled remotely by placing a small electronic circuit inside the energy meter so that the speed of rotation of the wheel of the electromechanical meter could be controlled as per the wishes of the unauthorized user at any time. This sort of alteration is very difficult to detect by inspection since the meter would look like reasonable as long as the remote is switched off.

Bypassing the Meter

In this case, the I/O terminals of the meter are shorted, thus hindering the meter from recording the power consumed.

IV. Physical Obstruction

It is a very crude method of tampering the meter, but easy to do. It is usually done in electromechanical type of meters having a rotating element. External object (most of the times, a small natural magnet) is positioned in the meter (that could not be located very easily) to reduce the speed of rotation of the disc. When the disc rotates slowly, naturally, the recorded energy consumption is less leading to lesser electricity bill.

V. Proposed Methodology

Commonly used practice to steal power is to place a magnet on the wheel ofthe energy meter or to tap out the wire before the input of the energy meter in which case energy meter is bypassed and no reading is recorded for the energy consumed by the energy meter.

Two Current Sensors are installed to sense the flow of current entering the input terminals and current drawn at the output terminal of the energy meter. These sensors are interfaced with the Arduino Uno installed at the site and thus Arduino Uno records the current at the I/O terminals of the energy meter.

Under normal condition, the currents at both the terminals (I/O) of the meter are equal. When there is power theft, the sensors connected to the I/O terminals of the meter sense a difference in their readings. This triggers the Arduino Uno to trip the Relay module and cut the power flow to that part of the circuit. This activates the buzzer installed at the site and LED starts to glow indicating the operator that there is a power theft. Also, the Arduino Uno installed at the site sends the message to the operator at the substation via RF transmitter.

At the substation, this message is received by the RF receiver that is interfaced with the Arduino Uno.

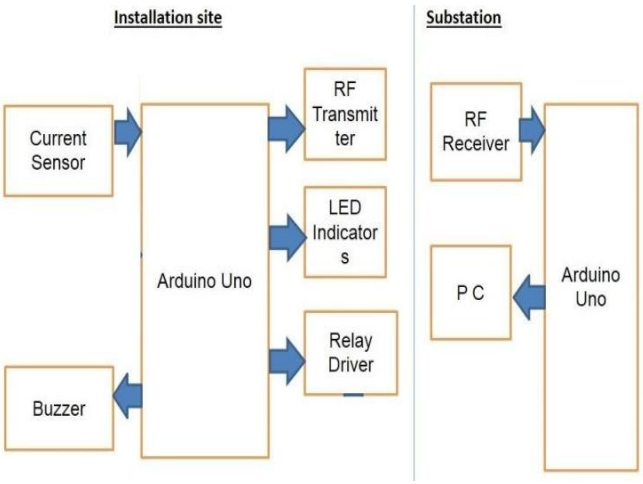

Figure 10: Block Diagram of Methodology

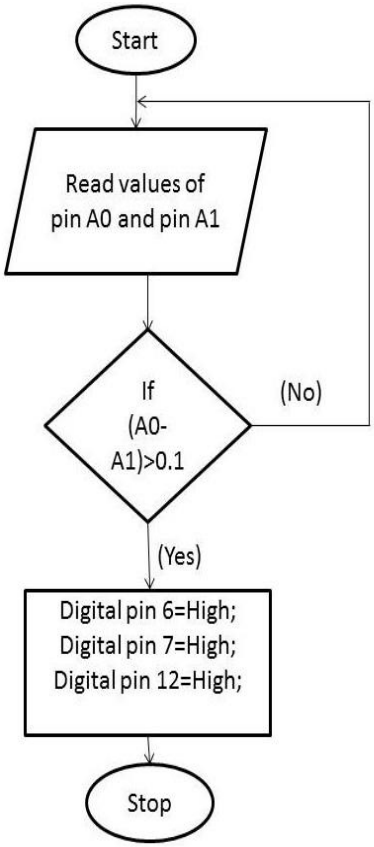

Figure 11: Flow Chart of Methodology

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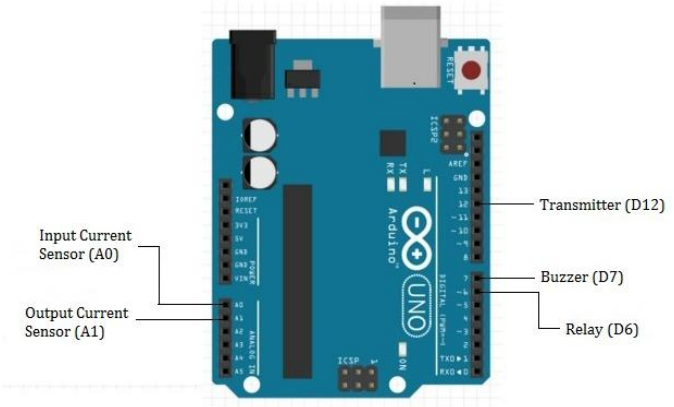

Figure 12: Pin Diagram of Methodology

- Analog pin A0 receives the data from the line pulse sensor available at the input terminal of energy meter.
- Analog pin A1 receives the data from the line pulse sensor available at the output terminal of energy meter.
- When the Digital pin 6 is set to high, the relay gets triggered.
- When the Digital pin 7 is set to high, the buzzer gets activated.
- When the Digital pin 12 is set to high, the message is sent to the transmitter through RF transmitter.

VI. Results and Discussion

The current sensors are interfaced with the Arduino Uno and the current at both the terminals of the energy meter are recorded.

Varying value of current is observed from the current sensor. Arduino Uno is programmed to record only the peak value and consider that value as the current drawn. Further, variation in load leads to variation in the value of current drawn. Thus, Arduino Uno verifies the value of current drawn at regular interval.

Under normal condition (when no power theft occurs) there is a very small difference observed in the values obtained from both the current sensors.

This value is taken as the tolerance value. The Arduino Uno installed at the site is programmed to consider normal condition if the difference in the readings of current sensors is below this tolerance value.

When power theft is being done the difference in the readings of the current sensor exceeds this tolerance value. Arduino Uno is programmed to consider this condition as Power theft.

The Relay Module trips the power supply of the line as soon as power theft is done. Also the buzzer and LED get activated when power theft is done. This information is received at the substation.

VII. Future Scope

In future, a circuit can be designed to measure the power factor of the load. Thus actual power consumed can be calculated. Sometimes problem of low voltage occurs in the line that may damage the electronic devices of the consumer. A voltage sensing circuit can be designed to sense the supply voltage. By sensing the supply voltage, Arduino Uno can be programmed to cut off the supply of the line whenever voltage goes down below a threshold value. This can save the electronic device from getting damaged due to low voltage.

VIII. Acknowledgement

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