Power Monitoring and Theft Detection System using IoT

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Abstract—Electricity thefts are increasing every year across domestic as well as industrial domains which affect the economic status of the country. Various wireless communication systems are available to detect the power theft, but lacks the required infrastructure needed to employ them. The project’s aim is to design a system to monitor the power consumed by load and to detect and eliminate the power theft in transmission lines and energy meters. This work is also focused on communicating the theft information to Electricity Board (EB) through IoT. As a network of devices is connected like sensors it has the ability to exchange real time information through internet. In this project Raspberry Pi is utilized to detect power theft and send command to GSM module which sends the theft information message to EB. The implementation of this system will help save large amount of electricity.

Keywords—Power; theft detection; IOT; Electricity Board; GSM ; Raspberry pi ; Arduino;

1. INTRODUCTION

The most common problem in our country is electrical power theft. Population in India is very high and the electrical theft is also increasing day by day. Every year, the country is facing number of domestic electricity thefts and power thefts in industrial supply, that results in loss of distributed power to the supplier. Because of power theft, the country is facing continuous problems like power cut both in urban and rural sectors. It is estimated that India’s power sector loss is around $16.2bn every year due to theft alone. This project helps to minimise and avoid problems currently faced by the whole country. The studies on power theft detection are undertaken by various researchers [1, 2]. Prepaid electricity billing meter is proposed by some researchers to monitor household electrical appliances [3, 4]. A microcontroller based billing system for single-phase meters of distributed clients is proposed [5]. There are numerous ways using which electricity theft can be done, so it is difficult to track how a theft has occurred. Our proposed project is an electricity theft detecting system which is used to detect the theft automatically whenever either the transmission line or the meter is bypassed. In this method a current transformer is used to sense the total amount of current consumed by the load. If any tapping has done in the transmission lines or additional load is introduced, the sensor draws more current. This makes the ADC values increases the specified value and detects the theft and sends commands through GSM Module (SIM900a) to EB. The EB gets real-time monitoring of various household loads through Iot analytical webpage Ubidots Education and can switch the desired load using relay.

2. METHODOLOGY

A. Existing System

The existing wireless communication system of energy meter has been done utilizing ZIGBEE and GPRS [6,7]. This method is mainly used to secure the communication channel and ZIGBEE for the transmission of data in a serial process. The drawback of this system is that real time monitoring of the loads is not possible and location of theft is not determined.
B. Proposed System

In this proposed system IoT and GSM technology is implemented for transmitting the information about power theft to the EB and prevents the current scenario. This system is being interfaced with Raspberry pi and Arduino via serial communication and sensors are interfaced with raspberry pi to sense the load current and voltage. This will prevent the electricity theft as much as possible. The current system gives solution for the existing problems like power theft, wastage of energy and transmission line fault that are faced by the authorized power suppliers.

3. HARDWARE IMPLEMENTATION OF THE PROPOSED SYSTEM

In this work, Raspberry Pi model 3 B+ is used to detect the power theft and to send the command to GSM module to send the theft information message.

A. Processor Description and Block Diagram

Raspberry Pi is a single board computer processor speed ranges of 1.4 GHz and memory range from 256 MB to 1 GB RAM. It has 4 USB ports and HDMI for video interfacing and an Ethernet port. It has total of 40 pins in which 17 GPIO ports can be controlled through program. The raspberry is programmed using Python 2.7. Arduino Uno is a 10-bit microcontroller which purpose is to monitor the ADC values coming from current transformer and voltage transformer connected with the load. It contains ATmega328. Arduino IDE(Integrated Development Environment) software is used to program the Arduino. The Block diagram of theft detection system is shown in Figure 1.

![Block Diagram of Power Monitoring System](image)

**Fig.1: Block Diagram of Power Monitoring System**

B. Power Supply Unit

A regulated power supply unit is used to give input to the circuit. The 230 V AC input from the main supply is step down to 12V AC by a step-down transformer. The AC input is rectified to DC by a rectifier. The rectifier output which is a pulsating DC voltage is then fed to a filter to remove the AC components and to get a pure DC voltage of 5V. This 5V DC output voltage is used to power the Arduino and the current and voltage transformer are connected with the same supply of 230 V in primary side and output of voltage transformer is 9 V AC connected to rectifier unit to get in
analogue values and relay is operated by 12 V relay module which gets supply from 12 V. Table 1 shows the description of the components used in the current project.

**TABLE 1: DESCRIPTION OF COMPONENTS**

| Description of the components used | Current measurement unit | Current transformer 50:1, Rectifier circuit |
|------------------------------------|--------------------------|---------------------------------------------|
| Current measurement unit           | Arduinuo Uno             | 5 Analog pins, 13 Digital pins, Tx and Rx Pin |
| Voltage Measurement Unit           | Raspberry pi 3           | 17 GPIO Pins, Inbuilt WiFi Module, Tx and Rx Pin |
| SIM900 GSM Module                  |                          | Quad-Band 850 MHz, Input 4.5V, GPRS Class B |
| 16x2 LCD Matrix                    |                          | Input 5V                                    |
| 12V Relay Module                   |                          | Max current 10A                              |
| Meter tampering circuit            |                          | LDR and LED is used                          |

C. **GSM Modem (SIM900a) and Current Measurement Unit**

GSM technology (GSM Modem-SIM900a) is implemented for transmitting the information about power theft to the EB. The current transformer in the ratio 50:1 is used and is connected in series with the load to get the readings continually and is connected to the rectifier to get values in DC and get the ADC values.

D. **Voltage Measurement Unit**

It consists of voltage transformer of 230-9V AC and is connected in parallel to the load. It is connected to a rectifier unit to get in DC and get the ADC values

\[ V_{rms} = (230/1024) \times \text{Voltage} \]

Where, voltage = analogue read value through circuit

\[ 1024 = \text{maximum resolution for 10-bit ADC} \]

\[ 230 = \text{Rated voltage} \]

Power is calculated by:

\[ \text{Power} = V_{rms} \times I_{rms} \]
E. Energy Tampering Unit

It consists of a basic LDR and LED connection separated by a barrier between the two which is directly attached to meter. Initially the circuit remains closed as of the barrier, but when the meter is open the connection becomes closed as LED will send signal to the LDR and signal is generated in the LDR as resistance changes and is connected to GPIO pin of Raspberry Pi and send message to EB that “meter is opened”.

F. Relay Module

Relay acts like a switch and it is used to control the high power devices. As the operating voltage of Raspberry pi is 5v it can’t control higher voltage devices directly, so a 12V relay can be used to switch the 230V load and control by signal pin which is connected to GPIO pin of Raspberry Pi. A relay is said to be in open contact when it is normally open (NO) i.e. NC pin connected to COM and connected when INT1 is set high and thereby relay is not energized. A relay contact is a closed contact when it is normally closed (NC) i.e. disconnected when INT1 is high, and hence there will be no supply to relay.

4. SOFTWARE IMPLEMENTATION

A. IoT Webpage Ubidots

It is web analytical IoT service used specialized in connected hardware and software solutions to remotely monitor, control, and automate processes through Arduino or Raspberry pi.

By giving the necessary command lines in python data can be collected from sensors and transmitted over the internet and control of devices can also be established.

B. Python 2.7

Python is a high end, versatile language which is trending in nowadays due to its significance in machine learning and AI. It is used as the front end for Raspberry Pi to run the commands. The main advantages is that syntax can be reduced compared to other languages.

5. HARDWARE DESIGN

The 230V power supply and AC load is given to the current measurement unit and voltage measurement unit, through the relay. The input of 5V for arduino is given by rectifier circuit and a voltage regulator LM7805 from the 230V supply. The analog output pin from the current measurement unit is given to analogue A0 pin and the output pin of voltage measurement unit is given to A1 pin of Arduino. From Arduino serial connection is established with help of serial port and given USB port in Raspberry pi. The interfacing of GSM and 12V relay module is made across the load from the Raspberry pi GPIO pins. The values from the sensors can be displayed through IoT sites like Ubidots and the load current being consumed can be seen and if repeated theft is coming across a particular load the EB can switch off using the relay. For the working of the proposed model, three different loads like 40 W, 60 W, and 100 W bulbs are used. The current and voltage measurement units are used to measure the load current and voltage. With the help of Arduino, the ADC values are decoded which is shown by the flowchart represented in Figure 2. The decoded value has been sent serially to Raspberry Pi. In this work, it checks the predefined ADC values already written in the Python code.e.g for 60 W the ADC value from current unit will be 400 and if it goes above this value, the theft will be detected. From here signal is sent to GSM module which sends SMS to EB and if meter is opened it sends signal to raspberry pi and send SMS.
Through Ubidots, real time monitoring of the consumer load is possible and if a consumer repeatedly continues to do this EB has the right to switch off the load. Figure 3 shows the voltage and power in IoT webpage. The top and front view of the hardware implementation is shown in Figure 4. Also the flow chart is shown in Figure 5 for power theft detection using Raspberry pi.

Fig. 2: Flowchart for Arduino

Fig. 3: Voltage and Power in IoT webpage
6. CONCLUSION
A Wireless Electricity Theft Detection and monitoring system has been designed and developed with proper integration of both the hardware and the software. Without any human interface this system provides an effective and easy way to detect electrical theft. The use of IoT helps in achieving the numerous advantages of wireless network communications. Power theft is actually bypassing the
energy meter but in our project we have indicated the theft by increasing the load also and this method is cost efficient

7. REFERENCES

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