PILFERAGE/THEFT MANAGEMENT OF INDUSTRIAL ENERGY USING WIRELESS COMMUNICATION TECHNOLOGY

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ABSTRACT

Actual power consumption in India is probably lower than indicated, since there is considerable wastage and pilferage between source and the point of consumption. Utility companies in India estimate that electricity pilferage costs them over a millions of rupees in annual revenues. Increasing the demand of power requires much attention to maintain the utility factor, energy verses cost, reduce T & D loss and controlling of pilferage by scientific approach. In our work we have used perfectly designed electronic circuit using state of art embedded control Technology and the algorithm to find out loss and theft using relay logic, then it communicated immediately through wireless GSM communication to the control centre for further action.

Key words: Pilferage, Nontechnical loss, Wireless communication, embedded controller

1. INTRODUCTION

Starting from Generation, Transmission and Distribution involves many losses. Whereas, losses implicated in generation can be technically defined, but T&D losses cannot be clearly quantified with the sending end information. The Fig.1 shows global comparison of power generation and T&D losses. It can be observed that power generation in India is less compared with other countries. These can also illustrate the involvement of non-technical parameters in T&D of electricity. T & D losses have been a concern for the Indian electricity sector these have been very high when compare with other developed countries. The present T & D losses including unaccounted energy are nearly 18 to 32% i.e., more than 1,000000 crore rupees every year due to poor transmission and distribution. If we save 1% out of it will be good benefit to the power sector and also nature can be retained for some extent.
The T & D losses have two components:

- Technical losses
- Non-technical losses

Technical losses are naturally occurring losses consist mainly of power dissipation in electrical system components such as transmission lines, power transformers, measurement systems and other power system components. Technical losses are computed with the information about total load and the total energy billed.

Non-Technical Losses (NTLs) originating from electricity theft and other customer malfeasances are a problem in the electricity supply industry. Electricity theft is the centre of focus all over the world but electricity theft in India is a significant effect on the Indian economy. Such losses occur due to meter tampering, meter malfunction, illegal connections, billing irregularities and unpaid bills.

Theft may be industrial, domestic or agriculture. Even though the % of theft in industries is low, the energy and financial loss is high due to large amount of electricity distributed, shown in fig.2. One of the real example of industrial theft is, on 17th July 2008, in Mumbai, there was a power pilferage involving companies. They were stealing power from high tension power supply; it leads to huge amount of energy loss and voltage disturbances to other consumers. This shows that might people are indulge in theft of electricity. Therefore we are considered the industrial power theft analysis. The fig.1 also gives sources of power, capacity of each source of generation, transmission utilities and % distribution of power to each sector. The above losses can be reduced by efficient management, best operation and maintenance practices of the transmission and distribution. In our work we developed a real time test model to analyze the above said problems using computers and Embedded Controllers with the help of proper electrical input circuits and wireless communication.
II METHODS OF STEALING

The most common form of electricity stealing is tapping directly from the distribution Feeder and tampering with the energy meter. Another common practice is that people tap a portion of electricity illegally during event gatherings and public functions. Secondary side wires of CTs are called breaking control wires which are generally insulated, but this insulation can be damaged such that electricity from one or both the wires is tapped. Tapping electricity from these wires causes the meter to read less current or even zero current based on the number of the tampered wires.

Tampering with the energy meters is done to stop the rotation of the meter or to give lower reading [2]. Other methods of tampering the meter include, inter-changing the incoming and outgoing terminals of the meter, damaging the pressure coil of the meter, modifying the readings. Other methods to tamper the meter are inserting a film or depositing a highly viscous fluid, and using strong magnets to interrupt the rotation of disc. Radio frequency devices can be employed to tamper the electronic energy meters. In addition to this corrupt staff of the utility companies might take bribes from illegal consumers to help them allow such practices and corrupt employees are responsible for billing irregularities by recording the amount lower than the original consumption.

Sudden inspection of overhead distribution feeders and consumers might yield good results in detecting illegal tapping and meter tampering but it is very difficult to cover all HT and LT consumers, it will take huge man power and time consuming. Government of India takes several steps to modernize the metering system based on advanced technology using microprocessors and LCD displays even then the above thing are continuing. To overcome this we are going for real time automatic theft detecting robust communication.

III EFFECTS OF PILFERAGE

Primarily, electricity theft affects the utility company and then its customers. It will overload the generation unit. Quality of supply is also adversely affected, as the utility company gets difficult to identify and supply electricity to genuine customers as well as illegal consumers. This overload might result in over voltages that can affect the performance and even damage appliances of genuine customers and also it may lead to brownouts and blackouts during in the peak load. This huge amount of NTL might trip the generation unit, which lead to the interruption in power supply to all customers. Load shedding should also be required to compensate the voltage collapse during the peak load period. Maintenance of power factor is very difficult without complete information about the total load flow because of the theft [10]. Fixing of tariff and billing is also very difficult to the power company, it may lead to force the excessive tariff on genuine customers and utility companies also face huge economic losses. Also, illegal tapping of electricity raises safety concerns like electric shocks and even the death of a person. Improper handling of the distribution feeder might pose danger to the whole community during extreme weather conditions. These wires might start sparking and may give rise to fire.

IV CURRENT PILFERAGE SOLUTIONS:

Several methods have been recently proposed to overcome pilferage and minimize the NTL problems in power systems. The most common methods in use are: installing electronic devices like burglar alarm system [1] using hard measurement by installing electronic meters for revenue protection [4], this method is beneficial, despite their high cost and necessary network infrastructure extensions. In addition, Automatic Meter Reading (AMR) proposed in [6] has been used as an intelligent filter, to provide an effective method for measuring losses and electricity theft in the LV transmission and distribution networks [5]. The current methods of minimizing NTLs impose high operational costs and require extensive use of human resources. Several methods have been developed in other countries to minimize
NTL problems. Most electricity supply utilities concentrate on onsite technical inspection of customers, which has high operational costs and occupy much human resources and time [7].

Several data mining and research studies on fraud identification, which include: Artificial Neural Networks (ANNs) [9], Extreme Learning Machine (ELM) [8], Statistical-based Outlier detection [11], Wavelet-based feature extraction with multiple classifiers [12]. Support Vector Machine (SVM) model [3] presents suspected customers to be inspected onsite for fraud based on irregularities and abnormal consumption behavior. Most of the studies cited above used data mining techniques by directly applying them to customer databases as inputs.

V PROPOSED METHOD

According to the Govt. release, in India, power theft amounting more than 35000 crores per year. In Maharashtra state out of 35% loss, theft is 29%, costing very huge. In our design we can identify the industrial power theft systematically with extremely advanced scientific approach.

According to our method, we are on-line monitoring the power dispatched at the substation verses total power consumption by the all users through wireless GSM communication. Once if the above things are equal with little proportional losses, the system keeps excellent utility factor. If not, we have to find out where the loss, or where may be the theft. By using efficient and real time system, we can easily identify the difference as “loss or theft”.

In nature, losses are the prime factors which disturbs utility factor. Possibility of loss is by means of trees, high wind, tiny shorts, etc. In our theme, in case of loss, the particular power flow route alone will be disabled and others will be enabled using perfect relay logic. We are also locating fault area and that will be displayed on the computer screen as well as if necessary it can be spelled out through voice using multimedia. Nowadays all the electrical distribution is carried out using SCADA for making global power management system. Using SCADA distribution is perfectly possible, but our project supports the SCADA for utility factor. To prove our concept, we would like to develop a hardware model with appropriate software design with real time application. Block diagram for the hardware model is shown in fig.3. It consists of a sensing system, signal conditioning electronic circuits, advanced embedded hardware for middle level computing, a powerful computer network for further transmission of data to various places and wireless network to communicate with related control centre. Each one can be explained as follows.

![Fig.3 Proposed system block diagram](image)

In sensing system instrument transformers are used. Instrument transformers are used in the measurement and control of alternating current circuits. Direct measurement of high voltage or heavy currents involves large and expensive instruments, relays, and other circuit components of many designs. The use of
instrument transformers, however, makes it possible to use relatively small and inexpensive instruments and control devices of standardized designs. Instrument transformers also protect the operator, the measuring devices and the control equipments from the dangers of high voltage, the use of instrument transformers results in increased safety, accuracy and convenience. Here we have used current transformer; it will sense the change in current converted in to corresponding voltage and given to embedded microcontroller [EMC].

Signal conditioners are more reliable. The output of secondary isolation system will be AC in nature, must be rectified, conditioned and calibrated as per the requirement of conversion circuits. These circuits are op - Amp based full wave precision rectifiers (or) absolute rectifier. These circuits meet overall standards of measurements. The prime objective of these devices are to rectify, filter, setting up the calibration limits, protecting the high voltage hazards, protecting the inputs and outputs. Output of these circuits will be pure DC in nature with respects to the inputs referred to it.

To perform the various operations and conversions required to switch, control and monitor the devices a processor is needed. The processor may be a microprocessor, microcontroller or embedded controller. In this work an embedded controller has been preferred because of its industrial advantages in power electronics like built in ADC, RAM, ROM, ports, USART, DAC. This leads to lesser space occupation by the circuit and also the speed of embedded controllers are more compared to other processors. The embedded controller selected for this work is PIC16F877A due to its various features. The Hardware of the proposed system is shown in fig.4. Working of the circuit is explained by considering the logic diagram in the following sections.

For on-line data transfer a communication media is required. Over the years many communication techniques have been used in many power system applications as considered in [13].wireless GSM Technology is innovative, latest, and precise. It covers all corners of the world. Early days GSM was merely used for voice communication but now a day this technology is used to pass various kinds of data transfer like voice, SMS etc. It is well fitted to save energy and cost in electrical power system engineering. Therefore in our technology we proposed to use GSM Technology for data transfer and communication for control.

![Fig.4 Hardware model of the proposed system](image_url)

1) Logic Diagram:

To find out theft and loss is very critical in hardware and software. The proposed technology utilizes wireless sending system as well as computerized comparison systems to analyze theft from actual usage.
and loss. The logic diagram is shown in fig.5. It consists of 5 CT’s and 5 Relays used to simulate the real applications. The CT-1 and relay-1 will considered as power delivered from the substation and in case if there is a fault immediately after the substation, relay-1 can be tripped to save energy (This could be the technical loss which used to eliminate because this cannot be recovered).

CT-2 and CT-3 is employed to find out loss, theft and real power consumed by user-1. CT-4 and CT-5 is employed to find out loss, theft and real power consumed by user-2. The KVA passed through CT-2, CT-3 will be compared by software, if both are equal there cannot be loss or theft on the particular line. Similarly CT-4 and CT-5 will be compared; if both are equal there cannot be loss/theft on that particular line. If main power calculated by CT-1 and PT is not equal to the data collected by the user CT’s (CT-3, CT-5) there may be a possibility of theft or loss. In case of loss CT-2 will not be equal to CT-3 at the same time the entire power to tap before the metering short circuit failure will not occur so all the software system will get confused and no activity will be happened. In this situation an intelligent algorithm is required to separate theft from loss.

The algorithm is simple in nature using relay logic. The KVA through CT-2 and CT-3 may be different, that time common software will provide alert message on the computer screen as theft/loss. The engineer available at the substation can trip off the relay so that the user power will be disabled for shorter duration and the mathematical calculations to be carried to indicate loss or theft have considered in mathematical analysis and algorithm shown in fig.6.

![Logic diagram](image)

**Fig.5. Logic diagram**

Where,

- **R-1 TO R-5**: Relays
- **CT-1 TO CT-5**: Current Transformers
- **PT**: Potential Transformer
- **LP**: Loss points
- **TP**: Theft points
- **U1, U2**: Users

2) **Mathematical Modeling of the theft case algorithm:**

Mathematical calculations are considered in software program. Visual basic (VB 6.0) version is the software used to interface hardware and computer for lucid way of communication between human and GSM.

- **Common Bus Voltage**: $Ch_0$
- **Current CT-1**: $Ch_1$
- **Current CT-2**: $Ch_2$
- **Current CT-3**: $Ch_3$
- **Current CT-4**: $Ch_4$
- **Current CT-5**: $Ch_5$
Total Power delivered = \((Ch_0 \times Ch_1) / 1000 = KVA \ 1\)
User-1 Power = \((Ch_0 \times Ch_3) / 1000 = KVA \ 2\)
User-2 Power = \((Ch_0 \times Ch_5) / 1000 = KVA \ 3\)
User-1 Area Loss Power = \((Ch_0 \times Ch_2) / 1000 = KVA \ 4\)
User-2 Area Loss Power = \((Ch_0 \times Ch_4) / 1000 = KVA \ 5\)
If KVA 2 + KVA 3 = KVA 1
If KVA 2 + KVA 3 + 10\% PL (Proportional Cable Loss) = KVA 1
If KVA 2 = KVA 4 \rightarrow No loss or theft on user-1 area.
If KVA 3 = KVA 5 \rightarrow No loss or theft on user-2 area.
Where Ch_0 to Ch_5 are ADC channels

3) Flow Chart

Analyzing loss or theft is carried out by using mathematical model and flowchart shown in fig.6 then the corresponding action is taken, explained in section VI.

![Flow Chart](image-url)
VI Results and Discussion:

Based on the mathematical analysis and flow chart given in fig. 6, program is developed using VB6.0 software and different analysis of theft/loss are carried out and discussed.

Fig. 7(a) shows at normal condition (without loss due to fault and theft). At this condition, no loss due to fault in lines and no theft in users.

Fig. 7(b) shows there is a theft check in line 1 (by indicating red light), after checking by using logic there found a loss in line 1 and this cannot be theft. Immediately, loss trip-1 to be enabled to trip the power to the concerned user.

Fig. 7(c) shows there is a theft check in line 1 (by indicating red light), there found a theft in user 1 after checking by using logic and this cannot be loss because line 1 loss value is very low. The user to be permitted to consume power until it is physically verified.

Fig. 7(d) shows there is a theft check in line 2 (by indicating red light), after checking by using logic there found a loss in line 2 and this cannot be theft. Immediately, loss trip-2 to be enabled to trip the power to the concerned user.

Fig. 7(e) shows there is a theft check in line 2 (by indicating red light), after checking by using logic there found a theft in user 2 and this cannot be loss because line 1 loss value is very low. The user to be permitted to consume power until it is physically verified.
VII CASE STUDY OF INDUSTRIAL FEEDER

Line diagram of 11kv PR Rolling Mill Industrial feeder is shown in fig. 8. It shows different industries connected at different distances.
The total energy loss due to pilferage is calculated, tabulated in tables I & II for two HT numbers and are shown below.

Table 1: HTSCNO: TPT237

<table>
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<tr>
<th>Sl. No</th>
<th>Months Of the year</th>
<th>Productive load (KW)</th>
<th>Anticipated pilferage (KWh)</th>
<th>% Pilferage loss</th>
<th>Energy loss (KWh)</th>
<th>Cost of pilferage (Rs)</th>
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<td>783</td>
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<tr>
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<td>Nov</td>
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<tr>
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</table>

The above values are calculated considering 50% of productive load is being thefted by two industries whose HT numbers are TPT237 and TPT217. These calculations are performed treating 25 working days per month and 6 hrs theft duration per day.

It is observed that the two considered industries take an amount 2171700 Kwh of energy loss and it costs to be Rs 13267800 due of theft. If we consider industries in all over India this figure would be very huge which reflects on our Indian economy. So, implementation of advanced technologies is very much essential for reduction of energy loss. The percentage losses are clearly observed from the graphical representation shown in Fig.9.

Fig.9 Graphical representation of pilferage losses
CONCLUSIONS:

This paper is aimed at reducing the heavy power and energy losses that occur due to power theft by the HT customers. We have implemented a hardware model to detect the pilferage in industries. The proposed design is well evaluated using real time hardware model with resistive loads. The method employed is very unique and cost effective implementation is possible. By this design it can be concluded that power theft can be effectively curbed by detecting where the power theft occurs and inform to authorities for further action. It may also useful to the upcoming deregulated electricity market. A case study is performed on 11 KV PR Rolling mill feeder.

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