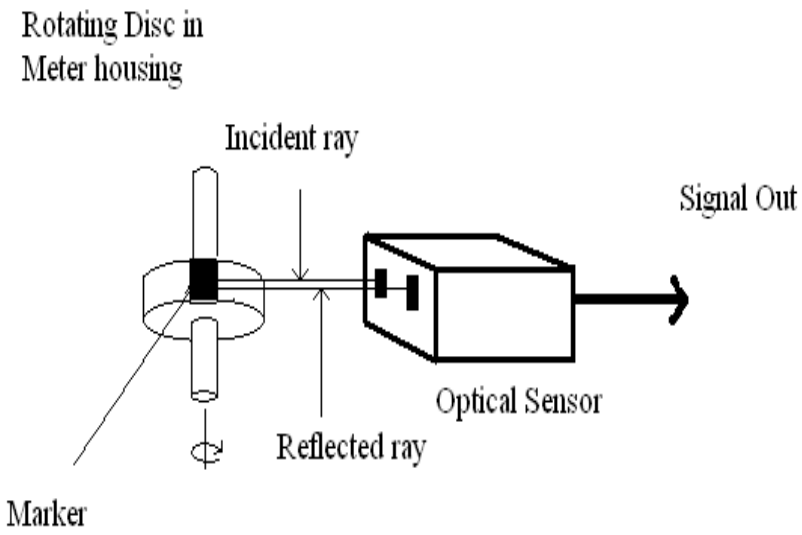
Remote Control Of Power Thefting Using PLCS

Power Theft Detection

Abstract:

Power line communication (PLC) presents an interesting and economical solution for Automatic Meter Reading (AMR). If an AMR system via PLC is set in a power delivery system, a detection system for illegal electricity usage may be easily added in the existing PLC network. In the detection system, the second digitally energy meter chip is used and the value of energy is stored. The recorded energy is compared with the value at the main kilo Watt-hour meter. In the case of the difference between two recorded energy data, an error signal is generated and transmitted via PLC network.

The detector and control system is proposed. The architecture of the system and their critical components are given. The measurement results are given.



1. Introduction

India, the largest democracy with an estimated population of about 1.04 billion, is on a road to rapid growth in economy. Energy, particularly electricity, is a key input for accelerating economic growth.

The theft of electricity is a criminal offence and power utilities are losing billions of rupees in this account. If an Automatic Meter Reading system via Power line Communication is set in a power delivery system, a detection system for illegal electricity usage is possible.

Power line communications (PLC) has many new service possibilities on the data transferring via power lines without use of extra cables. Automatic Meter Reading (AMR) is a very important application in these possibilities due to every user connected each other via modems, using power lines. AMR is a technique to facilitate remote readings of energy consumption.

The following sections will describe the proposed detection and control system for illegal electricity usage using the power lines.

2. Detection of illegal electricity usage

In this section the discussion is on how a subscriber can illegally use the electricity and the basic building blocks for the detection using power line communication.

2.1 Methods of illegal electricity usage

In illegal usage a subscriber illegally use electricity in the following ways,

1) Using the mechanical objects:

A subscriber can use some mechanical objects to prevent the revolution of a meter, so that disk speed is reduced and the recorded energy is also reduced.

2) *Using a fixed magnet:*

A subscriber can use a fixed magnet to change the electromagnetic field of the current coils. As is well known, the recorded energy is proportional to electromagnetic field.

3) *Using the external phase before meter terminals:*

This method gives subscribers free energy without any record.

4) *Switching the energy cables at the meter connector box:*

In this way, the current does not pass through the current coil of the meter, so the meter does not record the energy consumption.

Although all of the methods explained above may be valid for electromechanical meters, only the last two methods are valid for digital meters. Therefore, this problem should be solved by electronics and control techniques [1].

2.2 Building blocks for detection

2.2.1. Automatic Meter Reading (AMR):

The AMR system starts at the meter. Some means of translating readings from rotating meter dials, or cyclometer style meter dials, into digital form is necessary in order to send digital metering data from the customer site to a central point. In most cases, the meter that is used in an AMR system is the same ordinary meter used for manual reading but the difference with conventional energy meter is the addition of some device to generate pulses relating to the amount of consumption monitored, or generates an electronic, digital code that translates to the actual reading on the meter dials. One such technique using optical sensor is shown in Figure 1.

The three main components of AMR system are,

1. Meter interface module: with power supply, meter sensors, controlling electronics and a communication interface that allows data to be transmitted from this remote device to a central location.

2. Communications systems: used for the transmission, or telemetry, of data and control send signals between the

meter interface units and the central office.

3. Central office systems equipment: including modems, receivers, data concentrators, controllers, host upload links, and host computer [4].

2.2.2 Power Line Communication (PLC):

Power line carrier communications take place over the same lines that deliver electricity. This technique involves injecting a high frequency AC carrier onto the power line and modulating this carrier with data

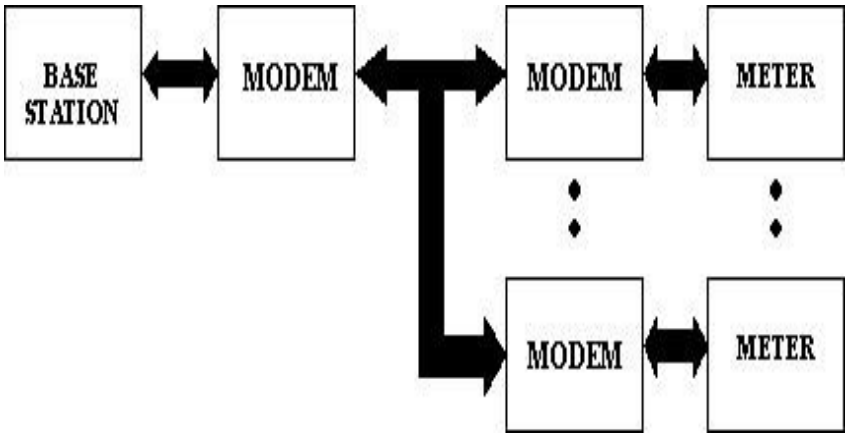


Figure 2: AMR communication set up [5].

originating from the remote meter or central station. Power line communications has many new service possibilities on the data transferring via power lines without use of extra cables. AMR is a very important application in these possibilities due to every user connected each other via power lines. In this power network, every user connected to each other via modems with data originating from the remote meter or central station.

Electrical power systems vary in configuration from country to country depending on the state of the respective power sources and loads. The practice of using medium-voltage (11-to-33kV) and low-voltage (100-to-400V) power distribution lines as high-speed PLC communication means and optical networks as backbone networks is commonplace.

Under normal service conditions, they can be broadly divided into open-loop systems, each with a single opening, and tree systems with radial arranged lines. In the case of tree systems, connection points for adjacent systems are provided in order that paths/loads may be switched when necessary for operation. Additionally, in terms of distribution line types, there are underground cables and overhead power distribution lines. Where transformers are concerned, they can be divided into pole-mounted transformers, pad-mounted transformers and indoor transformers.

High-speed PLC applications of the future include Automatic Meter Reading (AMR), power system fault detection, power theft detection, leakage current detection, and the measurement/control/energy-management of electrical power equipment for electrical power companies, as well as home security, the remote- monitoring/control of electrical household appliances, online games, home networks, and billing [3].

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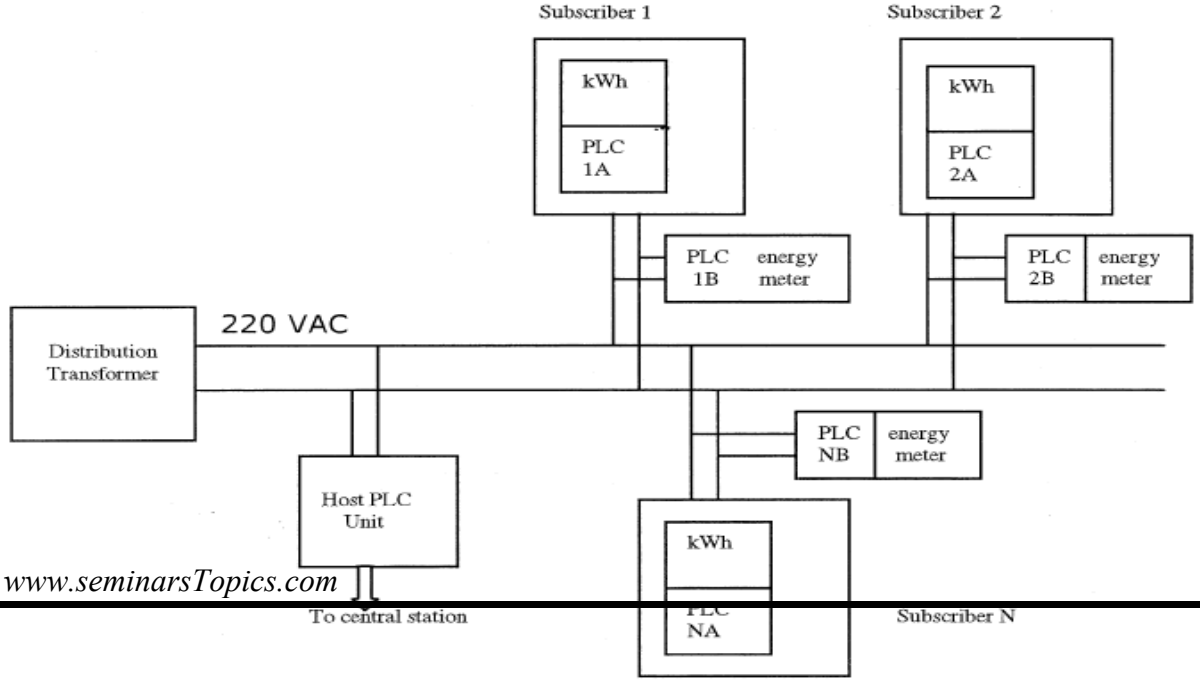
Figure 3: Schematic illustration of detection system of illegal electricity usage. [1]

Detection and Control System

The proposed control system [1] for the detection of illegal electricity usage is shown in Fig.3. PLC signaling is only valid over the low voltage VAC power lines. The system should be applied to every low-voltage distribution network. The system given in Fig. 3 belongs only one distribution transformer network and should be repeated for every distribution network. Although the proposed system can be used uniquely, it is better to use it with automatic meter reading system. If the AMR system will be used in any



network, the host PLC unit and a PLC modem for every subscriber should be contained in this system. In Fig. 3, the host PLC unit and other PLC modems are named PLC1A, PLCNA

and are used for AMR. These units provide communication with each other and send the recorded data in kilowatt-hour meters to the PLC unit. In order to detect illegal usage of electrical energy, a PLC modem and an energy meter chip for every subscriber are added to an existing AMR system. As given in Fig. 3, PLC1B, PLCNB and energy meter chips belong to the detector.

The detector PLC s and energy meters must be placed at the connection point between distribution main lines and subscriber's line. Since this connection point is usually in the air or at underground, it is not suitable for anyone to access, such that its control is easy. The main procedure of the proposed system can be summarized as follows.

PLC signaling must be in CENELEC standards. In Europe, CENELEC has formed the standard EN-50 065-1, in which the frequency bands, signaling levels, and procedures are specified. 3–95 kHz are restricted for use by electricity suppliers, and 95–148.5 kHz are restricted to consumer use.

The recorded data in kilowatt-hour meters for every subscriber are sent to host PLC modem via PLC modems, which is placed in subscriber's locations. On the other hand, energy meter chips are located at the connection points and read the energy in kilowatt-hours and also send the data to host PLC unit. This proposed detector system has two recorded energy data in host PLC unit, one, which comes from the AMR-PLC, and the other, which comes from

the PLC modem at the connection points. These two recorded energy data are compared in the host PLC; if there is any difference between two readings, an error signal is generated. This means that there is an illegal usage in the network. After that, the subscriber address and error signal are combined and sent to the central control unit. If it is requested, a contactor may be included to the system at subscriber locations to turn off the energy automatically, as in the case of illegal usage.

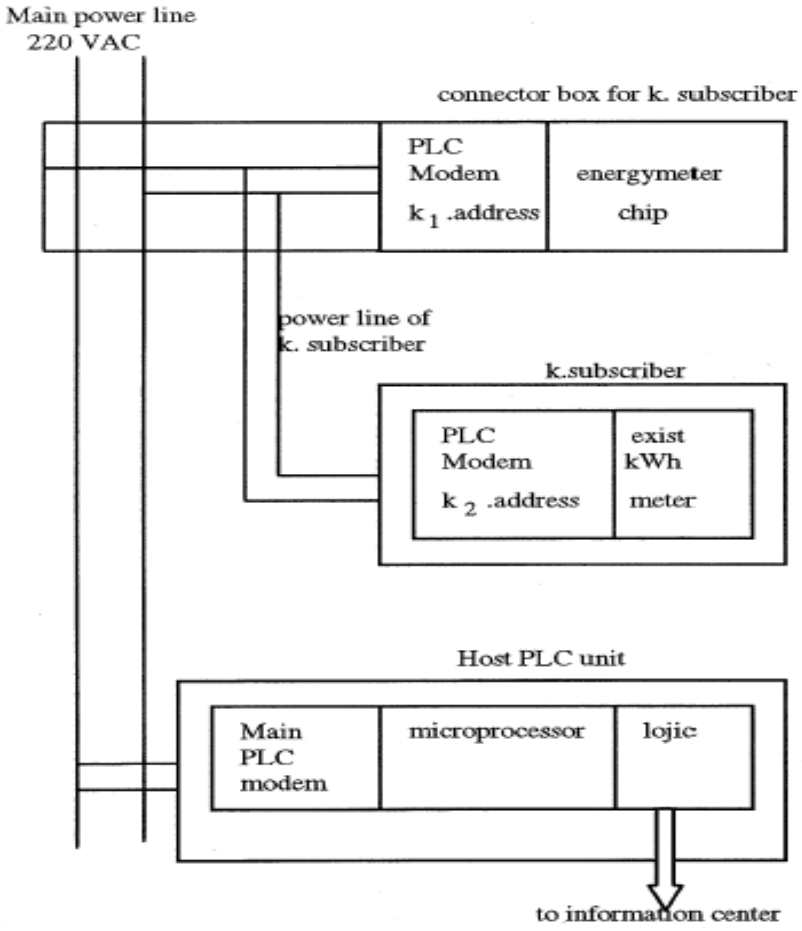


Figure 4: Illegal detector system for one subscriber. [1]

3.1 Simulation

The system model and simulation of the detection system of illegal electricity usage is shown in Fig. 4. It contains a host PLC modem, an energy meter chip and its PLC modem, an electromechanical kilowatt-hour meter and its PLC modem, and an optical reflector sensor system is loaded at the same phase of the power grid. The energy value at the electromechanical kilowatt-hour meter is converted to digital data using by optical reflector sensor. Disk speed of the kilowatt-hour meter is counted and obtained data is sent to PLC modem as energy value of the kilowatt-hour meter. At the system model, an illegal load may be connected to the power line before the kilowatt-hour meter via an S switch. While only a legal load is in the system, two meters are accorded each other to compensate for any error readings. The host PLC unit reads two recorded data coming from metering PLC units. If the S switch is closed, the illegal load is connected to the system, and therefore two recorded energy values are different from each other.

The host PLC unit is generated when it received two different records from the same subscriber. This is the detection of the illegal usage for interested users. In these tests, the carrier frequency is selected at 132 kHz, which is permitted in the CENELEC frequency band. In real applications, the AMR system may be designed in all CENELEC bands. The data rate between the host and other PLC modems is 2400 b/s.

Data signaling between PLC modems has a protocol, which includes a header, address, energy value data, error correction bits, and other serial communicati changed according to the

properties of the required system and national power grid architecture.

Fig.5 shows the detection system for an electromechanical kilowatt-hour meter system. In the digital energy meter system, the recorded energy may be received in the digital form directly using the port of the meter. Therefore, there is no need for an optical reflector system in digital meters. The results of the tests show that this system may solve this problem economically because the budget of the proposed system is approximately U.S. $ 20–25 per subscriber. It is very economical and is a reliable solution when it is compared with the economic loss caused by illegal usage [1].

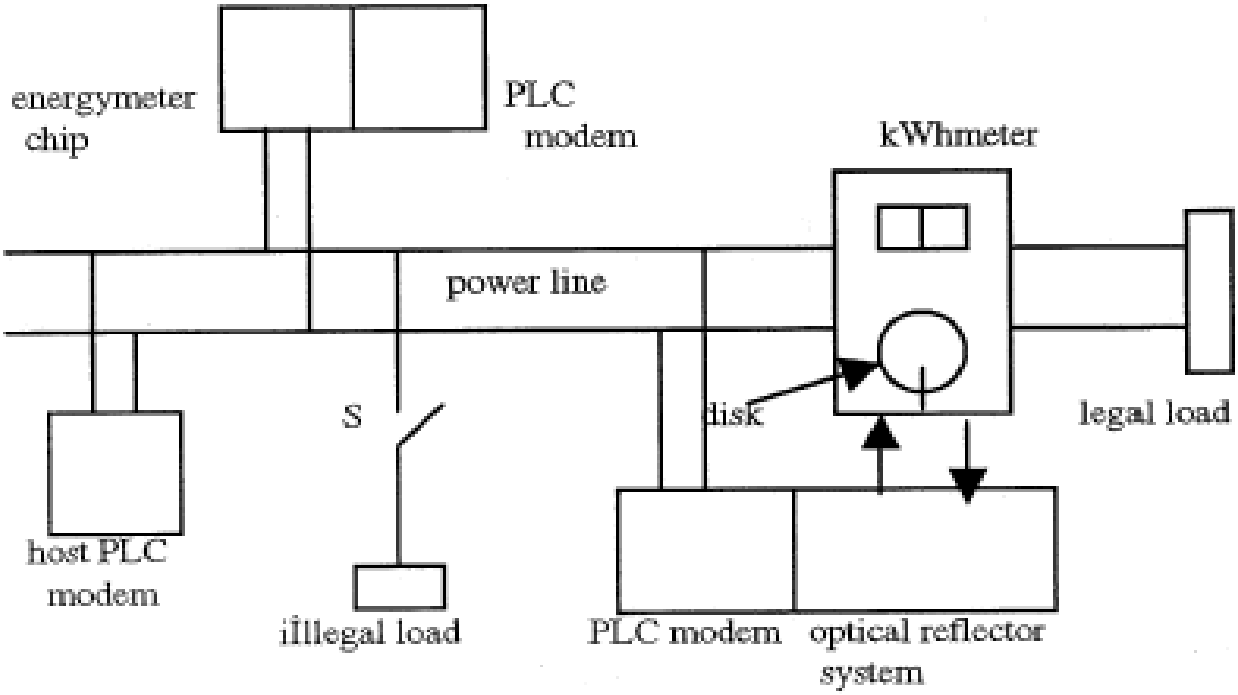


Figure 5: System simulation and modeling of the detection system of illegal electricity usage for electromechanical kilowatt-hour meters. [1]

4. Overview of the proposed Detector System

The proposed detector system is the equipment and procedure for controlling more remote stations from a master control station. It includes PLC modems, energy meters, control logics, and the system software. The PLC modems are host and target modems for two-way communications to and from the host station and the remotely controlled targets. The energy meters include on bits such as parity and stop bits. The protocol may also be

Metering chips and some circuit elements; the control and logic units compare and generate the error signal in the illegal usage. The system software has two parts: assembler program for the micro controller and the operating software for the management of the overall system. Operating software may be downloaded from a PC and should be placed in the main center of the system.

An AMR system including an illegal detector performs the following functions.

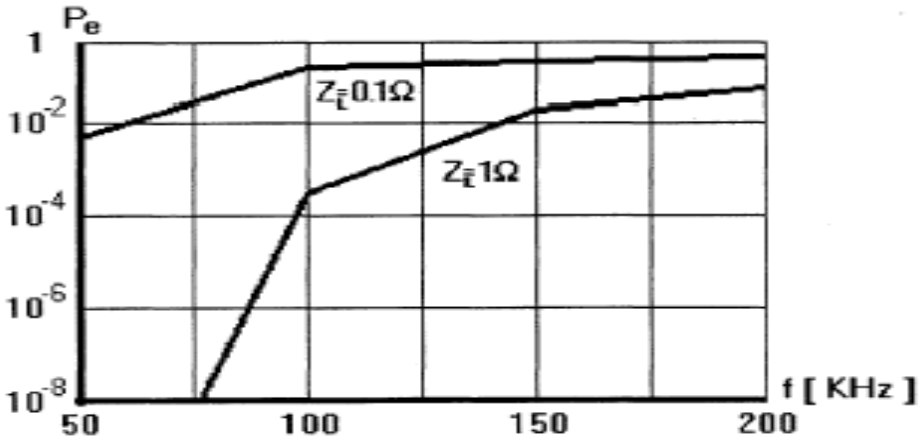


Figure 6: Effects of distance of the source-receiver on the loss for various [2]
frequency-load combinations [21].

1) Every user has two PLC modems; one is for AMR and the other is used to send the data from second energy meter chip to host PLC modem.
2) An energy meter must be installed in the connection box between a home line and main power lines.
3) The host PLC unit must be placed in the distribution transformer and the configuration of the addressing format of PLC signaling must be designed carefully.
4) The host PLC modems and its controller must include two addresses per every user: one is the AMR and the other for the energy meter. These two addresses must be selected sequentially.
5) Operating software must be designed for the information of every subscriber in every sub power network: subscriber identification number, billing address, etc.
6) The system has two values of the energy consumption for every user, so if there is a difference between them, an error signal is generated for the illegal user,
7) The proposed equipment is the only one distributed in the power network. So this system should be repeated for all distribution power networks. All host units in each distribution transformer may be connected to only one main center station via phone lines, fiber-optic cable, or RF links.

Results and the variations of the measurements are shown in Figs. 6–7 [2]. The relations between frequency, length, and bit-error probability are given in these figures [1].

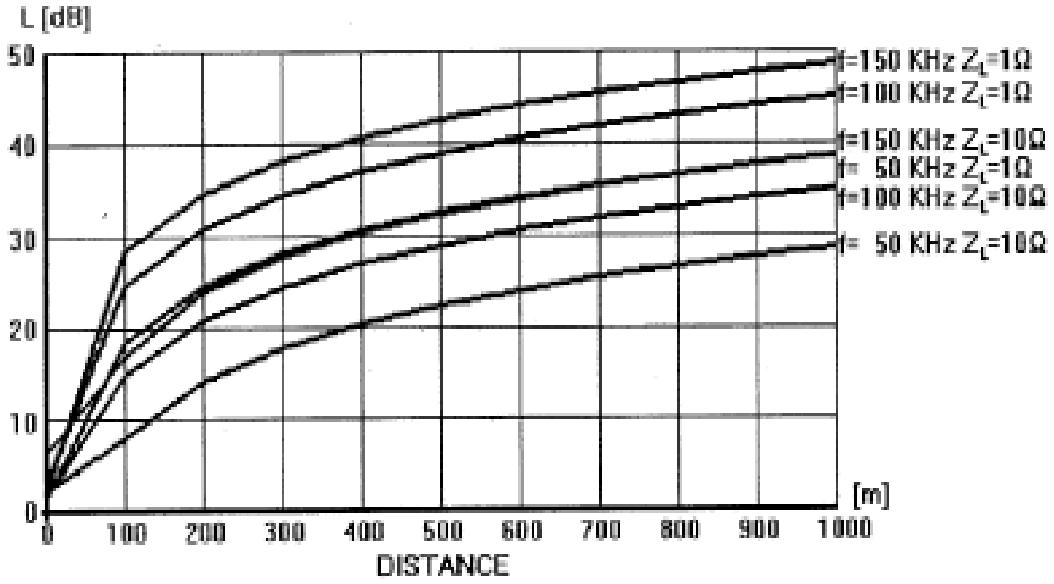


Figure 7: Bit-error probability with frequency and load impedance for 1000-m [2] line [21].

Research work has been taking place in the CPRI, Bangalore for the remote metering and detection of power theft and will soon be helpful to electricity boards in India.

Conclusion

The proposed detector system to determine illegal electricity usage via power line communications is examined in the laboratory conditions. Results proved that if AMR and detector system are used together illegal usage of electricity might be detected. Once this proposed detection systems are tried in real power lines, the distribution losses in India can be reduced effectively.

7. References:

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