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Prepaid Metering System by using PLC and SCADA

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ABSTRACT: There are certain losses which affect the economy of the power system. In India the percentage of power losses has been quite high. The most prominent forms of non-technical losses in India are electricity theft and non-payment of bills. This is great loss for government. It is estimated that electricity theft and non-payment of bills cost in our country is in billions a year. The objective of this research work is present a design of Prepaid Metering System by using PLC (Programmable Logic Controller) and SCADA (Supervisory Control and Data Acquisition). In the proposed Automatic meter reading (AMR) system, the post paid energy meters are replaced by digital energy meters. All meters can be monitored online on centralized SCADA. As the whole proposed system is prepaid and the consumer has to pay before using the electricity. If the amount falls below certain minimum amount, then a message will be sent to the consumer on the mobile phone.This system not only reduces the labor cost but also increase meter reading accuracy and save hugs amount of time.

Keywords: Non-payment of bills, Prepaid Metering, System, PLC, SCADA, AMR, digital energy meters.

I. INTRODUCTION

We know that there are certain losses which affect the economy of the power system. Power system losses can be divided into two categories: Technical losses and Non-technical losses. Technical losses are naturally occurring losses and consist mainly of power dissipation in electrical system components such as transmission lines, power transformers, measurement systems, etc. Technical losses are possible to compute and control. Non technical Losses (NTL), on the other hand, are more difficult to measure because these losses are often unaccounted for by the system operators and thus have no recorded information [8]. NTLs occur as a result of theft, error in meter reading, unmetered energy, billing problem and non-payment of bills.

A. Present System

After an interval of time we can see a person standing in front of our house from electricity board whose duty is to read the energy meter and handover the electric bills to the owner of that house. According to that reading we have to pay the bills. The main drawback of this system is that person has go area by area to read the meter of every house and it is very time consuming process. As the meter reading is manual process, so there are a lot of chances of human errors.

B. Proposed System

In the proposed system, the post paid energy meters are replaced by digital energy meters having communication option. By using modbus communication of the digital energy meters, all meters can be monitored online on centralized SCADA. As the meter reading is recorded automatically by the SCADA. So, there is no chance of human errors.
The whole proposed system is prepaid and the consumer has to pay before using the electricity.

C. Automatic Meter Reading (AMR) System

Automatic meter reading system is a technology which is used to gather data from energy metering devices and transfer it to a central station in order to process it for billing purposes. Automatic meter reading system helps the customer and energy provider to access the accurate and updated data from the meters. AMR system can fetch energy consumption in hourly, monthly, yearly basis on request or even in Real Time. This Real time energy usage can be seen by the users to control the use of power and be more economical. With the help of the collected data the service provider will be able to send energy saving ideas to the users.

This kind of real time data collected from each of the individual houses is really a boon to data scientists, who use machine learning and data mining tools to build a predictive model over this valuable data to predict the future energy demands starting from every single house, area, city to the entire planet. Thus leading to sophisticated and predictive energy production, conservation and management [21].

II. AUTOMATION

The use of methods for controlling a process automatically is known as automation. Automation is necessary to reduce human efforts, reduce operation time and work handling time and to improve the consistency of processes, productivity and quality. It is also reduced direct human labor costs and expenses.

A. SCADA

SCADA stands for Supervisory Control And Data Acquisition, a computer system for gathering and analyzing real time data. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining, transportation, etc.

B. PLC

A Programmable Logic Controller is an industrial computer control system that continuously monitors the state of input devices and makes decisions based upon a custom program to control the state of output devices. A PLC controls machines and processes. It uses a programmable memory to store instructions and execute specific functions that include ON/OFF control, timing, counting, sequencing, arithmetic and data handling.

III. PROBLEM FORMULATION

A. Objectives

Considering the literature review and the software we are using is used for monitoring and measuring energy, so, our objectives in this case study are as:

(i) To introduce modern technologies to monitor reliability of supply like LT system measurement automation, providing adequate communication infrastructure, DMS (Distribution Management Systems),

(ii) To introduce the prepaid system in metering (AMR technologies) in power system over existing system to improve the financial sustainability.

B. Proposed Methodology

Step 1: Investigate the existing system parameters.

Step 2: After analyzing the system, find the billing problem and non-payment of bills (defaulting amount).

Step 3: After analyzing the above discussed problems, I introduced PLC, SCADA and prepaid metering system to monitor the existing system.

Step 4: After installing the advanced metering system, I studied the advantages of proposed system over existing system.

Step 5 : In last compare both type of systems.

IV. CASE STUDY

In this work, a case study of 66 kV substation, village Heran was undertaken. For sake of simplicity, in this case, a pillar box-1 on 63 KVA transformer of Heran grid (Feeder category-1) was undertaken. At the outgoing of this transformer 6 pillar boxes are installed for the distribution of electricity to the 70 consumers. In these pillar boxes the post paid energy meters are installed. As shown in the figure: 1, pillar box 1 has 7 consumers.

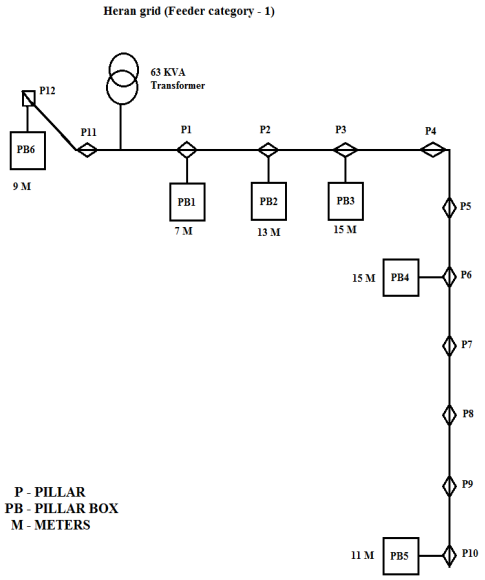

Fig. 1. Single Line Diagram Of 63 KVA Transformer.

After an interval of 2 months, a person from electricity board visits the village and manual records the meter readings. According to these readings the consumers pay the charges to the electricity board. Sometimes some consumers don't pay electricity bills. Due to these unpaid amounts, there is a great loss to the government. According to the recent records January 2016, among the 7 consumers from pillar box-1, 2 consumers didn't pay bills of electricity. The loss calculation percentage of village Heran is explained below:

Table 1: The loss calculation of village Heran.

	No. of Consumers	Balance Amount
Total	1047	443769
Default	48	112307
Loss	4.58%	25.30%

It is important to note that the defaulting amount of January 2016 in one village in Punjab is more than one lac. This gives an indication that in whole Punjab the unpaid bills cost is in millions a year.

V. TO IMPROVE REVENUE LOSSES BY USING PROPOSED SYSTEM

The development of Advanced Metering Infrastructure or AMI system has brought the greatest change in the technology of energy metering. The technology upgrades from mechanical rotating disc energy meter to electronic energy metering device and then to intelligent energy meter, having modbus communication option. This technology helps to send energy consumption data from buildings, factories and houses to the utilities for load curve, power quality analysis and consumers' billing purposes. In the meantime, the Advanced Metering Infrastructure (AMI) is also introduced to integrate the meter with grid and households for better analysis of transmitted power and usage. The AMI technology includes two-way communication between utility companies and customers' smart meter [12].

Energy Meters, PLC's and PC's are used for performing its operations. Multiple energy meters are connected with a single Ethernet gateway which in turn connects with a PC. Modbus TCP/IP communication is used to facilitate the communication between the Ethernet Gateway and PC. A PLC is also used for switching of power ON/OFF at the consumer end. Several PLC's and Ethernet gateways in a network can also be used. The network is obviously connected using CAT 6 cables, which provide universality. SCADA-Supervisory Control and Data Acquisition of industrial processes used to facilitate communication between the programmable logical controllers, Ethernet gateways and computer as shown in figure: 2

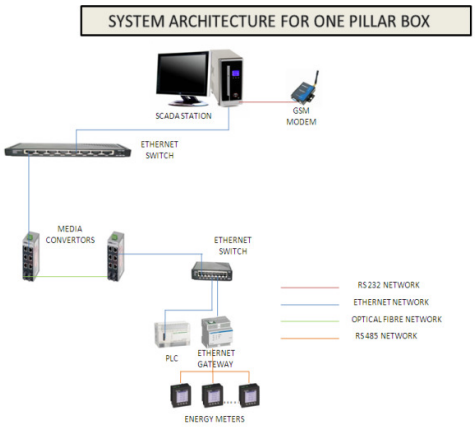

Fig. 2. System architecture for Pillar Box.

As shown in the above system architecture, a PLC and an Ethernet gateway can be installed at pillar box location. Ethernet gateway can be used to communicate with the energy meters and PLC can be used to switch ON/OFF the main circuit breaker of the consumer houses. Pillar box location can be connected to the centralized server by Ethernet and Optical fiber network. Media convertor is used to convert Ethernet network to optical fiber network and vice versa. A GSM modem can be connected with the centralized server to send the messages to the consumers during the recharge and during the warning situations.

Electronic Energy meters and GSM modem will be uses to improve the billing system, where consumer have to buy energy unit advance and the number of unit is depend on consumer. When the number of energy unit tends to finish, customer will get a warning SMS "You Have Left XX unit energy only. Keep Recharge for Uninterrupted Service" (XX is the no. of energy unit left) [16].

When balance is zero GSM modem will send SMS to customer for further recharge of energy units and power cut off until recharge is done.

The below figure: 3 shows the communication status and meter status (faulty or healthy) of all energy meters, which are connected with the server. Whenever the communication between the server and any energy meter fails or meter is not working, it shows a RED alarm indicator on the particular energy meter. In case of healthy communication, it shows a GREEN indicator on the particular energy meter. This figure also shows the running KWs of all energy meters along with the account numbers. So, EB person can easily identify the running load of each account holder easily.

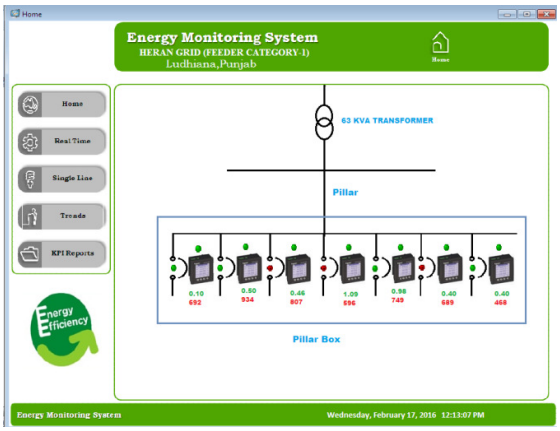

Fig. 3. Single Line Diagram of Transformer.

Below figure: 4 shows the various tabs and these are used to view the details of each pillar box individually.

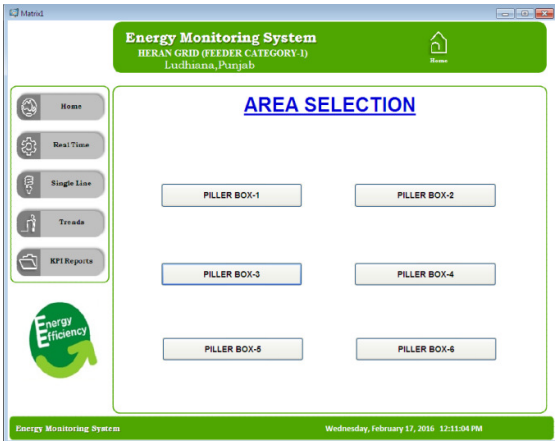

Fig. 4. Area Selection to View Meters.

The figure: 5 shows, the detail readings of 7 energy meters along with the consumer names, their account numbers and their meter numbers, which are installed under the pillar box-1. It shows the real time values like Voltage, Ampere, KW and KWh. By this System, EB person can monitor or record the KWH readings without visiting at the consumer end. It also reduces the probability of man made errors. EB person can recharge the account or view the account status like balance amount, balance units, breaker status etc. by clicking on the consumer name.

As shown in the below figure: 6, by clicking the consumer name, EB person can view this screen. He can recharge the account by entering the amount. Then according to the unit price, consumer can buy the electricity units. Total consumption parameter shows the difference of final running value and initial value (initial value after recharge).

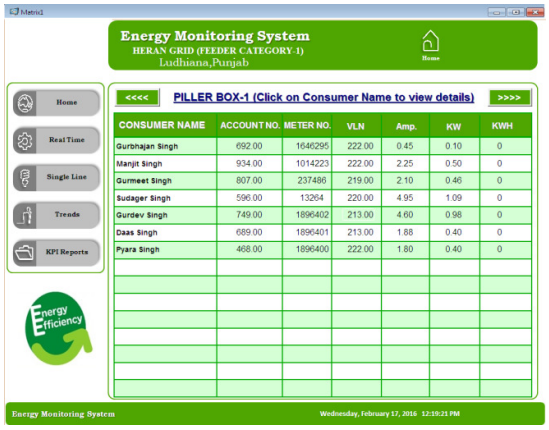

Fig. 5. View Detail Of Pillar Box Meters.

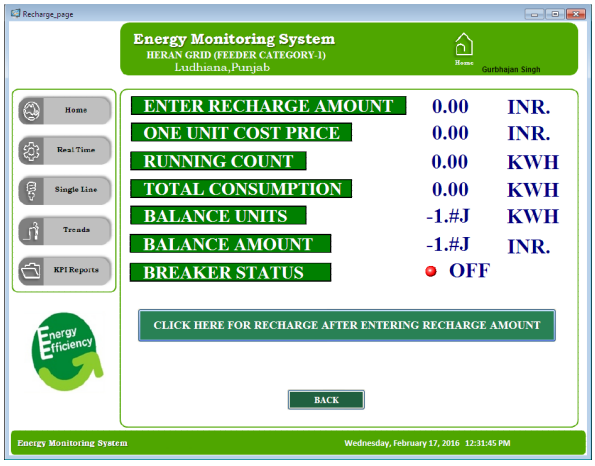

Fig. 6. Meter Recharge Screen.

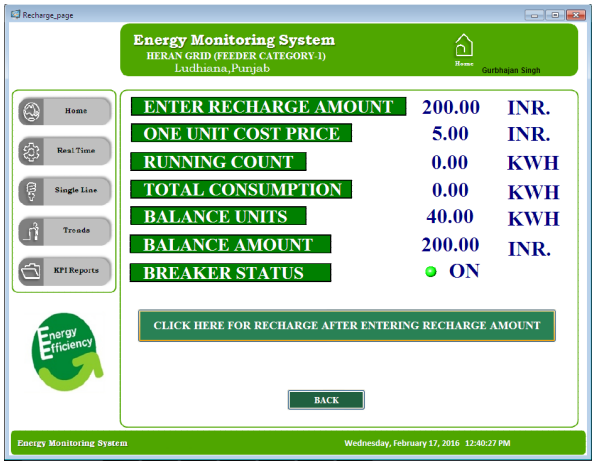

Fig. 7. Consumer Account Detail.

Balance units parameter shows the value of the units, the customer have balance in his account. Balance amount is same as that of balance units in terms of INR. Breaker status indicator shows the status of the main breaker of the consumer home. As shown in the below figure: 7, EB person recharged an account by 200 INR and the unit price is 5 INR. So the consumer has purchased 40 electricity units for usage. He has a balance amount of 200 INR and 40 units. The breaker status indicator is green as the consumer has electricity units' balance and he can use the electricity.

As shown in the below figure: 8, the consumer has used 31 units and he has only 9 units balance in his account. So the system automatically shows an alarm message on the screens and automatically sends a warning message on his mobile by using the GSM modem to recharge his account. So that he can avail uninterrupted service of electricity. Below figure: 9 shows when the consumer used his entire balance units and the balance amount is zero, then the power supply will be cut off automatically It also send message to consumer "LOW BALANCE, RECHARGE IMMEDIATELY".

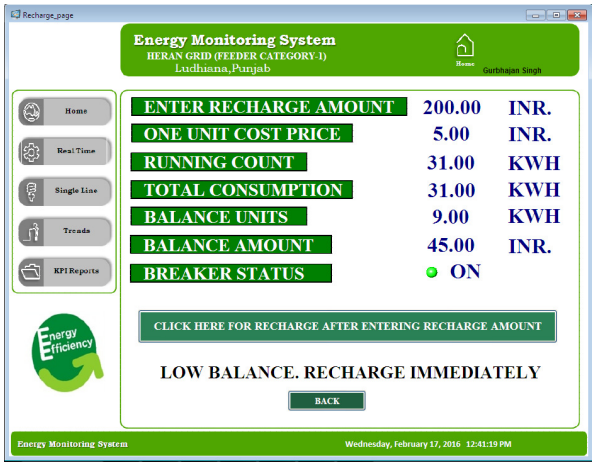

Fig. 8. Low Balance message.

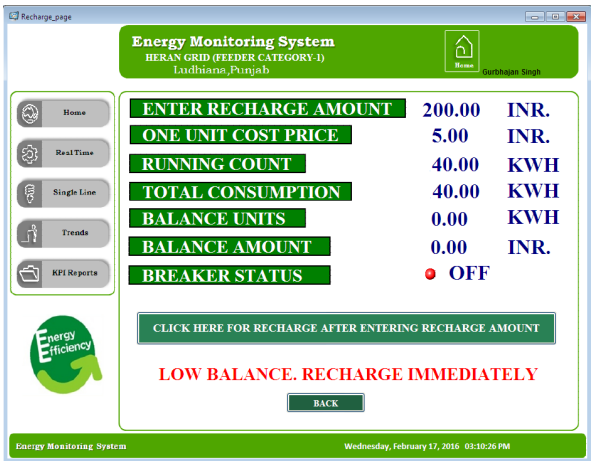

Fig. 9. Breaker Status when balance is Zero.

VI. COMPARE BOTH TYPE OF SYSTEMS

In the present system, there is no online monitoring of distribution of electricity. As the meter reading is manual process, so there is a lot of chances of human errors. Sometimes the electricity board person knowingly records the incorrect meter reading of the known consumer. Non-payment of bills by individuals, government institutions and untouchable VIPs results in utility running at a loss and a must continually increase in electricity charges. It increases tariff on the legal consumers.

In the proposed system, the post paid energy meters are replaced by digital energy meters. All meters can be monitored online on centralized SCADA. So, there is no chance of human errors. As the whole proposed system is prepaid and the consumer has to pay before using the electricity, due to this defaulting amount (unpaid amount) is zero.

VII. CONCLUSION & FUTURE SCOPE

Here we concluded that if we implement the Advance Automation System, there is high initial investment. But with passage of years, a lot of benefits i.e. solve billing problems, Reliability, customer satisfaction. However, in starting, there is a big challenge to implement this system. Because India is developing country and high populated nation, so there are more non technical losses and much problem in revenue. To improving revenue and reliability should be important.
In future, we can be achieved the goal of reduction of the AT & C losses. The "Prepaid Metering System by Using PLC And SCADA" will eliminate the possibility of non-payment of bills done by the customer

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