Integrated Automation system for Substation and Power Theft Control using PLC

RANJITH N[1]
ASSISTANT PROFESSOR
EEE DEPARTMENT
CIT, GUBBI

SHARATH DN[2]
EEE DEPARTMENT
CIT, GUBBI

***Abstract*—** The Integrated Embedded system is designed and developed for Automation of the substation for charging the line and clearing the line remotely, also controlling the supply of power for the feeder lines on timely basics and maintaining the power factor at the consumer side by creating the awareness of poor power quality by using power line communication method which uses the DSSS modulation technology.

Keywords—IEEE, Modulation, PLC, DSSS, DCSK.

I. INTRODUCTION

Automation control is used for various Control systems for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching in telephone networks, steering and stabilization of ships or aircraft and other applications with minimal or reduced human intervention [1]. Some processes have been completely automated.

The biggest benefit of automation is that it saves labor however it is also used to save energy and materials and to improve quality, accuracy and precision. It essentially involves leveraging the power of technology to reduce the dependency on human presence and decision making for any process [2]. It leverages different electronic equipment (either standalone or interlinked with appropriate applications) to control different parameters of any process and to use the appliances in a smarter way to save energy [3]-[4]. It also enables people to be more energy conscious by enabling them to have a real time status of electric appliances [5]-[6]. And making the system automated also helps reduce peak hour power consumption by enabling people to turn off appliances at will remotely [7]. This facilitates a constant power supply by having varied pricing policies for different times of day and night.

The Aim of this project is to simplify the process of human-machine interaction through the use of a generic interaction system and to make things around us smarter and interactive way.

As per the survey done in the Tumkur Substation (220/110/66 KV) over a month, the maximum problem faced by KPTCL & BESCOM Department employees in operation & maintenance of distribution substation is listed in below table .

Table 1:

Sl/No	PROBLEMS
1	Power Factor Correction & Control
2	Power Theft Control
3	Manually Feeders Power Supply Control
4	Line Charging and line outage control
5	Failure in Automation System

The Theft of the electricity [12-13] is major concern of the transmission and distribution losses in the supply of the electricity worldwide.

The electricity is being stolen via bypassing the poles therefore this system is utilizes to overcome this type of the theft of the electricity and is very beneficial for the authorized agency to control its revenue losses as all of us know that the cost of the cost of the fuel is increasing day by day hence the intensity of stealing the electricity and using it as a substitute is also increasing therefore it is needed much to design a system that can detect the theft of the electricity.

It is a known fact that every investment made by either individuals or government should yield a positive profit returns in order to continue with different projects in other sector of economy. But it has always been a difficult task for the government of the day and the electricity company to achieve their aim due to power theft activities.

A recent research conducted indicates that about 30-40% of profit generated by electrical board goes waste due to power theft.

The commercial losses are occurrence as an outcome of human being activities shown in figure 1. The pilferage is done in many days such as direct tapping method, manipulation of recording in the energy meter and creating magnetic field inside the meter and also by using the jumper to bypass the meter and etc.

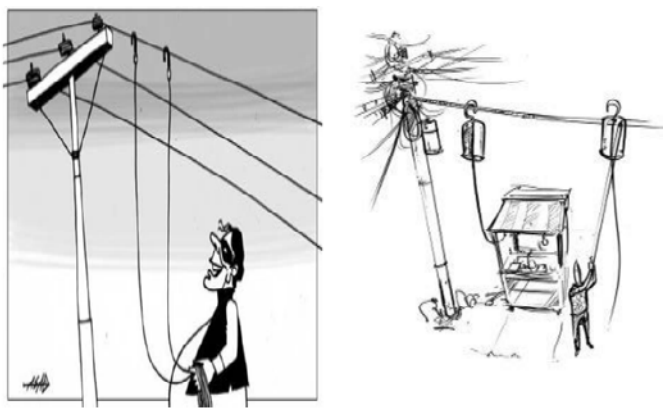

Figure.1

Also the major problem faced by the KPTCL & BESCOM Department employees is the Feeders supply control and LC/LO control which is done by manually where accuracy and timely basis control happens .

The proposed Integrated Embedded system is designed and developed for Automation of the substation for charging the line and clearing the line remotely, also controlling the supply of power for the feeder lines on timely basics and maintaining the power factor, at the consumer side power factor awareness is creating for poor power quality by using power line communication method.

The power line communication method uses direct spread spectrum modulation methods for the data transfer as this modulation method offer less data corruption.

II.SYSTEM DESIGN

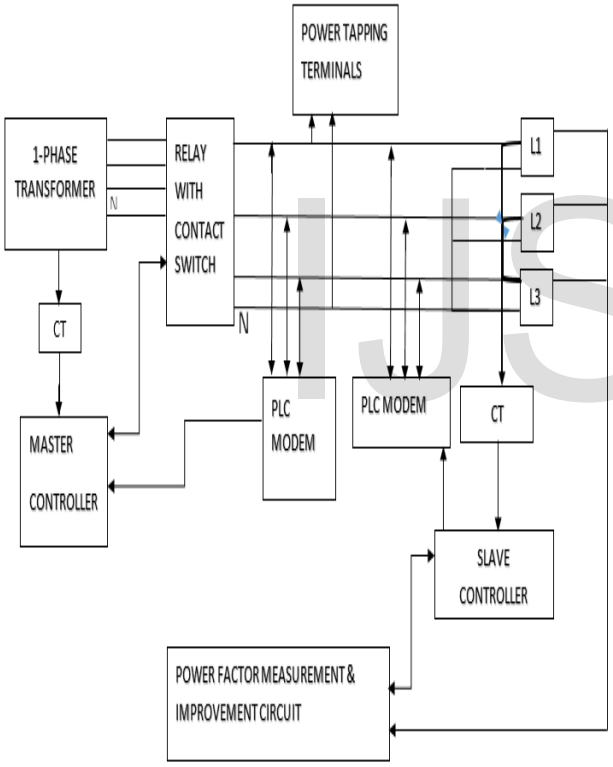

Figure 2: System Design

The System is designed and developed for Automation of the substation for charging the line and clearing the line remotely, also controlling the supply of power for the feeder lines on timely basics and maintaining the power factor.

The block diagram of the experimental setup is shown in above figure 3 The system has been designed such that master microcontroller(RENESAS) monitor the load connected to the transformer and controls the feeders supply, Switching the supply between the feeders on regular time basics, the slave microcontroller monitor the load current of individual load and total load consumption data is send to the master device by using the power line communication technology ,the master compare the data with the exact load connected to the transformer if any mismatches happens the master will detect the power theft from particular feeder lines and intimate the vigilance team.

The salve controller (RENESAS) monitor the low power factor at the consumer side and intimate the consumer by buzzer to maintain the power factor as per the standards**.**

Also the slave controller in substation monitor the feeder power factor and switches the capacitor bank for particular feeder line for the Quality improvement.

B.PLC MODEM

Power Line Communication is a technology which uses power lines as physical media for data transmission. PLC offers a no new wires solution because the infrastructure has already been established. PLC modems are used for transmitting data at a rapid speed through a power line in a house, an office, a building, and a factory, etc. Here, the existing alternating current (AC) power wires serve as a transmission medium by which information is relayed from a transmitter or control station to one or more receivers. The PLC modem is based on the Direct Sequence Spread Spectrum Technology, which ensures high noise immunity and reliable communication.

The Sunrom PLC Modem provide bi-directional half- duplex data communication over the mains of any voltage up to250v a. c., and for frequency of 50 or 60 Hz. It does not require any protocol to function and protocol independent

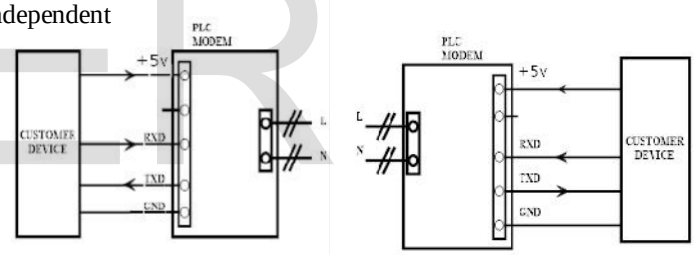

Figure 3

The Figure 3 gives the SUNRON PLC modem connection details for the communication purpose which capable of providing 9600 baud rate.

The SUNROM PLC is a system on chip solution optimally designed to provide the best performance over the Power Line medium. The PLC modem can be configured with Serial communication parameters through a programmable interface. The Line Coupler couples the data to the Power line which operates at the 230V and other side the Power Supply operation is 5volts which provides direct interface to the microcontroller.

C. RENESAS CONTROLLER

RL78 microcontrollers (MCUs) from Renesas Electronics are an advanced family of general-purpose and application-specific MCUs, combining true low power and high performance operation. The RL78 is designed specifically for ultra-low-power applications shown in figure 2.

It is the World's best-in-class performance for an equivalent MCU family, Scalability of physical size including smart pin layout and System cost saving features available, it can operate at Wide voltage & Wide temperature range.

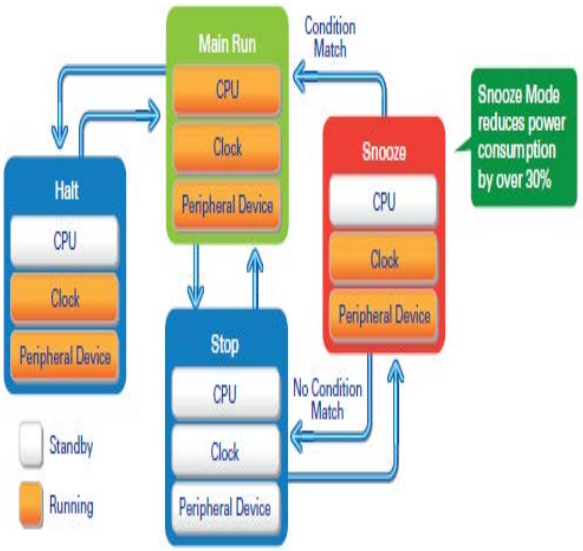

Figure: Power Saving Modes

III. POWER FACTOR CALCULATION

Calculation of Capacitor kVAr For PF Correction, The relation for calculating required kVAr for improving power factor from initial value to desired value is as:

Required kVAr = KW [(tan $\cos_{-1}$ (Initial power factor– tan $\cos_{-1}$ (Final power factor)

Where:

(a) Initial power factor is the existing power factor of the electrical system.

(b) Final power factor is the desired power factor of the electrical system.

(c) KW (killowatt) is the total load on the electrical system for which power factor has to be improved.

Let us take an example of Process Industry. The data is given is:

Motor rating = 11 KW, Normal voltage = 6.6 KV

Over voltage = ± 10%, Initial Power factor of motor = 0.83

Desired power factor = 0.96

Now,

Required kVAr = 1100 [(tan $\cos_{-1}$ 0.83 – tan $\cos_{-1}$ 0.96)]

Required kVAr = 418 kVAr at 6.6 KV.

Various inductive loads are used in all industries deals with the problem of power factor improvement.

Capacitor bank connected in shunt helps in maintaining the power factor closer to unity. They improve the electrical supply quality and increase the efficiency of the system.

The line losses are also reduced. Shunt capacitor banks are less costly and can be installed anywhere.

The apparent power (KVA) in a.c. circuit can be resolved into two components, the in-phase component which supplies the useful power (KW), and the wattles component (kVAr) which does no useful work.

The phasor sum of the two is the KVA drawn from the supply.the cosine of the phase angle between the KVA and the KW represents the power factor of the load.

To improve the power factor, equipment drawing kVAr of approximately the same magnitude as the load kVAr, but in phase opposition (leading), is connected in parallel with the load. The resultant KVA is now smaller and the new power factor (cos □2) is increased and Cos □2 is controlled by the magnitude of the kVAr added. Thus any desired power factor can be obtained by varying the leading kVAr. A typical arrangement of shunt capacitor connected in parallel with a load.

IV. APPLICATION & FUTURE WORK

The automated system is used to overcome the difficulties faced by department employees in operation & maintenance of distribution substation and to provide the high accuracy in operation in regards for the power theft, feeder supply control and LO/LC for the feeder, in substation.

B. FUTURE WORK

Smart meter can be incorporated instead of digital meters in which the data like line voltage, power factor, and current load can be monitored and data can be send to the control center, where data base management can be developed for the record of the actual load consumed by the consumer if any variants in load drawn from the particular feeder line, the same with time and day can be recorded.

V. RESULT &CONCU LSION

The expected results is to achieve fast switching speed with high precision and high reliable operation.

The proposed integrated embedded system using the RENESAS microcontroller is used for the Automation for the substation for feeder supply control, power theft Control, LO/LC for the feeder with high precision, switching speed with less intervention of the Human Machine interface, also the system is used for the power factor correction automatically by switching the capacitor bank.

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RANJITH N
ASSISTANT PROFESSOR
ELECTRICAL & ELECTRONICS
ENGG. CIT, GUBBI
ranju106@gmail.com
Mob no: 9449674117

SHARATH D N
ELECTRICAL & ELECTRONICS
ENGG. CIT, GUBBI
sharathdn4@gmail.com
Mob no: 9066363697