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Smart grid-Power factor Correction and Maintenance in Consumer Side Using RFID Based Power Line Carrier

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ABSTRACT

Smart grid is a grouping of information and communication technology and intelligent common infrastructure. Talking about smart grid the consumers and suppliers are very much important inorder to manage,monitor and control all energy issuses smartly. Easy instalation and high reliablity data communication over power line carrier is an important requirment to make a smart grid more constructive than fixed grid system.Therefore a latest RFID based power line technology has been developed unlike conventional system carrying data through antenna. RFID based power line carrier technology is used for detection and payment inorder to keep up the grid smart. With this technology, power factor correction and maintanance techniques are included inorder to improve the power system stability. Whenever the non-linear load is connected in load side, the proposed system will automatically detect and connect the power factor correction circuit(capacitor bank) for maintain the power factor in consumer side.

Keywords

Power factor, Power Line Communication (PLC), Radio Frequency Identification (RFID),Capacitor bank, Smart grid.

1.INTRODUCTION

Today's electrical infrastructure have remained electrical grid has been ageing infrastructure, the demand for electricity has gradually increased. The demand and utilization of electricity increased by 2.5% annually over the last 20 years. Today the electric power distribution network be very complex. Among the deficiencies are a lack of some ideas and switching mechanically causes slow response system, due to lack of system response blackouts were occurred over past few years. The various factors are the growing population, the demand for the energy, the global climate condition, equipment failures problem, the capability limitations of electricity generation, energy storage problems, one-way communication and decrease in fossil fuels.

Consequently, a new grid infrastructure is straight away needed to address these challenges. Smart grid is a new trend in electric power grid infrastructure to improve the overall efficiency and reliability of the system.Smartgrid is the best technique for smooth integration of renewable energy sources through automated control and modern two way communications technologies [9].

The wireless RFID (Radio Frequency Identification) technology is widely used throughout the world. Its high-security system, used in a wide range of applications such as cashless payment ticketing systems for transportation and home appliances. For example in departmental stores, the people be able to pay the payments more easier, by holding an RFID card over a reader/writer. Radio-Frequency Identification (RFID) be an automatic identification system, relying on storing and retrieving data using devices called RFID tags otherwise transponders. RFID includes RFID reader and RFID tag[8].

In conventional electricity billing system, a person from electricity office has to come to the consumers premises and note down the reading of the electricity kWh. The consumer must pay the required amount to the electricity board. If the consumer did not reimburse the amount, the person from electricity board again has to come and trip the supply to consumers. Inorder to avoid human required to do the billing and tripping process, a new technology were developed to enhance the grid to be real smart. This paper proposes a new technique to make the present electrical grid system into very smart by by means of RFID based power line carrier technology with power factor maintenance and correction in load side. The proposed system suggests the RFID tag which can be used for data transmission between the consumer and suppliers.With this technology,whenever nonlinear load is connected in the consumer side,the powerfactor can be automatically corrected by the power factor correction circuit to avoid penalty to consumers. The user should buy one RFID card from electricity board. The card number have to be registered in the data base of the electricity board.

The power factor plays an significant role inorder to design an energy saving scheme in load side. The power losses in the electrical network is increased due to lagging power factor in the output power[7].The non -linear load will be the major cause for lagging power factor. The designed scheme is concerning about maintaining the power factor of load side.

Power factor be the cosine of the angle between the voltage and current. The current and voltage is sensed by with current and voltage transformer. The phase angle between the voltage and the current is calculated and the result will be compared in the microcontroller. These processes are continuously carried out by microcontroller and maintain the power factor automatically [1-2][5].

2.HARDWARE DESCRIPTION

2.1 Smart grid

Smart grid has been a recent phenomenon which has attracted the attention of engineers and researchers of both the electric power and communication sectors. The idea of smart grid has appeared in recent literature in different techniques used to control the power grid operation. It has been called as the 'grid of the future', while some refer to it as the 'intelligent grid'. The primary objective of the smart grid concept is to provide the consumers with more efficient and reliable power supply, which the power grids of today may not be able to supply in future. Smart grid can be used a two-way communication among the suppliers and consumers of electric power. The bi-directional communication indicates the ability of smart grid to accept the end users and their power requirement demands to the utility suppliers.

A smart grid can be rightly defined as a modernized electrical grid which uses the information and communication technology to collate and assimilate ideas and behavior of the suppliers and consumers automatically in order to enhance the efficiency and uniqueness in the production and distribution of electricity. The efficient and real time information of the smart grid becomes the most notable factor for the reliable delivery of power to the consumers from the suppliers. The impact of apparatus failures or damage, capacity constraints, and natural accidents which creates some problems in monitoring, diagnostics and protection of power system [9]. The communication system is the most significant component of the smart grid infrastructure. Different communications technologies are used for data transmission between measuring equipments and electric power utilities. In some cases wired communications have some advantages over wireless technologies such as low-priced and maintenance. The transmission path may cause the signal to attenuate. On the other hand, wired solutions do not include interference problems and their functions are not dependent on batteries, as wireless solutions often do.

It could be said that two types of information infrastructure are required for information transmission system of smart grid, the one is from the electrical appliances to smart meter and the other is from the smart meter to the utility's data center. As suggested in [9], the data transmission can be accomplished by power line communication or wireless communications, such as ZigBee, RFID, Z-wave etc,.

2.2 Power Line Communication

Smart Grid functions include the integration of intermittent renewable energy sources into the electricity supply chain, affording reliable electricity delivery to the consumers, and using the existing electrical infrastructure more effectively. Power line communication (PLC) carries data going on a conductor that can also be used for AC electric power transmission or electric power distribution to customers. Power line communication (PLC) is a unique technique in the transmission system that can handle data signals from one device to the other.

It has been the first choice for communication with the electricity meter owing to the direct connection with the meter and successful implementations of AMI (Automatic Metering Infrastructure) in urban areas whereas other solutions struggle to meet the needs of utilities. PLC systems based on the low voltage distribution network have been one of the research topics for smart grid applications in China [9].

Features of PLC

- PLC is an innovative and dedicated technology for smart grid applications. It is so because of the fact that the existing infrastructure significantly decreases the installation cost of the communication infrastructure.
- The efforts on standardization on power line communication networks, the high cost, ubiquitous nature, and is used in wide applications. It is also to be noted that the home area applications is one of the biggest areas where PLC technology has been applied.
- Smart metering, monitoring and control application can be well suited for urban areas by this technology, since the PLC infrastructure covers the areas that are in the range of the service territory of utility companies.

Although there are strong wireless and wire line communication competitor, it is believed that power line communications (PLCs) will complete various communication tasks in upcoming Smart Grid deployments as PLC provides the natural upgrade from simple electricity conductors to mixture and bidirectional electricity and data communication solutions.

2.3 Radio Frequency Identification

The one automatic identification method is the Radio-frequency identification (RFID), relying on storing and remotely retrieve data by means of strategy called RFID tags or transponders. An RFID tag can be applied to a product and radio waves is used for identifying and tracking the users. The RFID tag is able to read from several meters away and beyond the line of sight of the reader. Electronically program with unique information. Many types of RFID systems are available in the bazaar. Depending upon the frequency range they are classified as follows:

- Less-frequency (30 KHz to 500 KHz)
- Medium-Frequency (900KHz to 1500MHz)
- High Frequency (2.4GHz to 2.5GHz)

The above frequency ranges mostly depends on the length of the tag. For example, low frequency tag ranging from 3m to 5m, mid-frequency tag ranging from 4m to 16m and high frequency tag ranging from 5ft to 95ft. There are different

types of frequencies or spectra by using that RFID tags communicates with readers. For illustration, low-frequency tags are incredibly cheaper and better than Ultra High-Frequency (UHF) tags that is it uses a little amount of power and are it has the ability to penetrate in non-metallic substances. Scanning the objects is also possible with high water content, for example fruit, are at close range. The data transfer is faster in ultra high frequencies which have a better range, when compare to every other frequencies. More power is needed to pass through the materials. So UHF tags are used into wood, paper, cardboard or clothing products.UHF tags were very much useful for scanning goods in ware house.

2.3.1 Data Capacity

The amount of bits stored on the tag can varying from 16 bits on the low end to as much as several thousand bits on the high end. Of course, if the storage capacity is high the price per tag is high.

2.3.2 Passive versus Active

Passive and active tags are different from each other. There is no battery for “Passive” tags and it "broadcast" their data at only after energized by a reader."Active" tags are having batteries so it use its own battery power to broadcast their data .Another difference is that the ranges of read are much greater for active tags than for passive tags. The read range of active tags and the extra capability are higher however, this will be more cost where as passive tags read ranges is less than the active tags but cost effective.

For high-value objects active tags are much more likely to be used that may be trailers, where the cost is minimal compared to the item value, and very long read ranges are required. The passive tags are mostly used in conventional supply chain applications, such as RFID-based track and agreement programs emerging in the consumer goods retail chain and it is cost effective than active tag.

2.3.3 Typical Applications of RFID

- Automatic Vehicle identification
- Payment system
- Access management
- Tracking animals

2.3.4 RFID Merits over Bar coding

- No "line of sight" requirements: Bar code read can sometimes be limited or problematic due to the need to have a direct "line of sight" among a scanner and a bar code. RFID tags are able to read through materials without line of sight.
- More automated reading: RFID tags can be able to read automatically when a tagged product comes past or near a reader, reducing the manual labor required to scan product and allowing more proactive, real-time tracking.
- Improved read rates: RFID tags finally offer the promise of higher read data rates than bar codes, particularly in high-speed operations such as container sortation. Larger data capacity: RFID tags can be easily encoded with item details such as cluster and batch, weight, etc.
- "Write" capabilities: since RFID tags can be rewritten with new data as supply chain actions are completed, tagged products carry updated information as they move throughout the supply chain.

2.4 Power Factor

The main purpose of this proposed system is to develop an energy efficient scheme in load side. Due to this proposed system, network losses are decreased and system stability level is improved. The designed topology is mainly concerned for improving the power factor in the load side. Industrial power distribution networks encounters increase in power losses and raise in the type of load is accompanied with low power factor which leads to huge transfer of reactive power from the utility through the network. The main limits of presence of non linear load are increase in the network losses and reduce the voltage magnitude. It can result in poor reliability and higher energy costs.

Power factor is defined as the ratio linking real power or actual power to apparent power. The general definition can be applied to all cases. The actual amount of power being used by a circuit is called true power. The power being used by the capacitors and inductors is called reactive power. The linear combination of real power and reactive power is called apparent power.

Three major loads in the power system are resistive, inductive, capacitive loads. Some of the resistive loads are kettles electric radiators and electric heaters. In the same way Inductive loads are arc furnance, induction motors and reactors and at last capacitive loads are various capacitors, capacitor banks and over excited synchronous motor. Inductive loads are mainly used in industry sectors than domestic area. This industry load value can be changed time to time due to the presence of inductive load and it causes power factor problem more than the domestic area. So that there is a requirement of power factor correction [7].

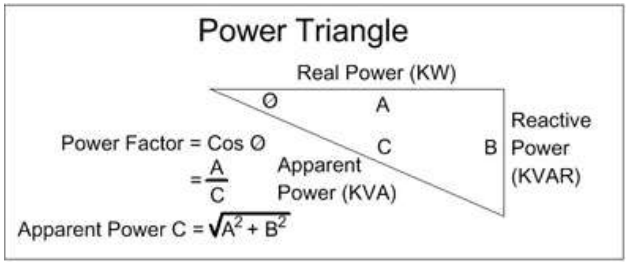


Fig.1. Power Factor Triangle

In an AC circuits there exist a phase angle difference between voltage and current. The term be also known as power factor of the circuit.

Power factor=Active power (kw)/Apparent power (kvar)

A purely resistive load (kettles ,electric radiators and electric heaters) would include a power factor of 1.0 (unity).If the circuit is inductive, the current value lags voltage value with 90 degree and the power factor is called as lagging power factor. If the circuit is capacitive then current value lead to the voltage value by 90 degree and power factor is said to a be leading power factor. The average power in an AC circuit is uttered in terms of rms current and voltage, P= VI cosΦ.

2.5 Non-Linear Load Power Factor

In present scenario electrical power utility companies have been increased a quantity and magnitude of nonlinear loads being linked to their power systems. Loads such as induction motor, microprocessor-driven equipment, fluorescent lights, power supplies and variable speed drives are well dispersed to cause a major negative impact on the power system. This paper deal about the concept of nonlinear load. Subsequently, non linear load power factor is discussed with practical example. In AC power distribution systems, harmonics occur during the normal electric current waveform is unclear by non-linear loads. Most loads in modern electrical distribution systems are inductive. Examples include transformers, motors and induction furnaces. The induction motor may operate at a lagging power factor. This power factor value may vary between 85 to 90 percentage of the load. Due to the of air-gap between the stator and rotor of an induction motor increases the reluctance of the magnetic circuit, so induction motor draws a large magnetizing current to produce the required flux in the air-gap.

The power factor of the electrical power system is represented by the equation:

$$\text{Power factor} = \cos\Phi \qquad (1)$$

The power factor can also be calculated by using active power and apparent power of the system. When the load consumes low delivered power as a working power and reactive power, causes the power factor get reduced. The reactive component of the power generated should be reduced to achieve the good efficiency. The displacement angle of the voltage and current should be maintain inorder to maintain the power factor or else reactive component in the total power get increases.

Power factor maintenance is a technique which involve in the concept of controlling the power factor of the load. The requirement of Power factor modification is necessary for an electrical power transmission utility to improve the constancy and efficiency of the transmission network or correction may be installed by individual electrical customers to reduce the cost charges to them by their electricity suppliers [7]. Power factor maintenance is also reducing the penalty cost to the customers. Auto transformer is used as a inductive load for varying the power factor.

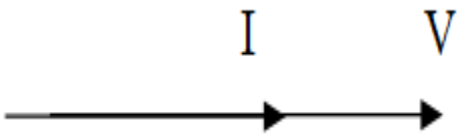


Fig. 2. Phasor Diagram for Resistive Load

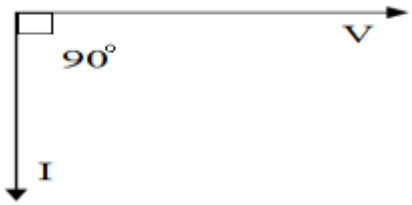


Fig. 3. Phasor Diagram for inductive Load

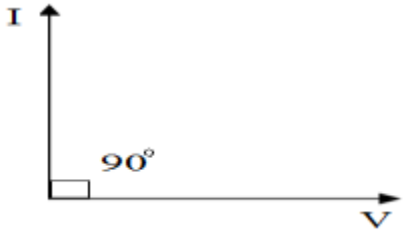


Fig. 4. Phasor Diagram for capacitive Load

3. EXISTING SYSTEM

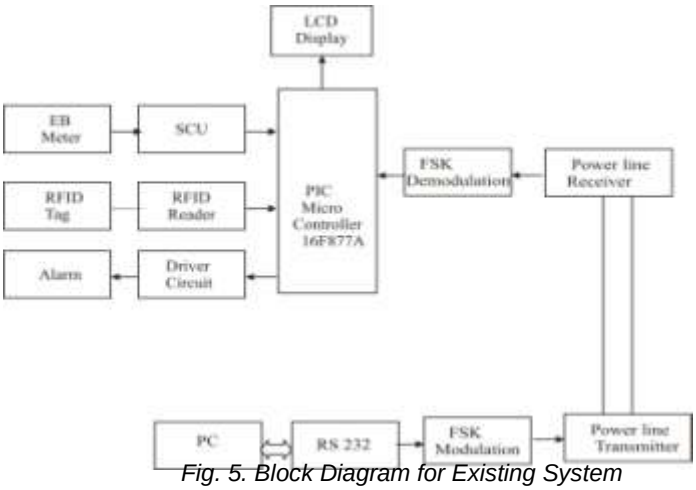


Fig. 5. Block Diagram for Existing System

Easily installable and greatly reliable data communications over power line is a requirement to make Smart Grid more convenient and helpful than fixed grid systems. Therefore RFID (Radio-Frequency Identification) over Power Line technology be developed. Unlike conventional RFID carrying data wirelessly by antenna, radio-frequency signals for identification and payment runs from side to side the power line in Smart Grid. The appliances embedded with IC card chips are detected and recognized when their electrical plug connectors are insert into the outlets in the electrical grid equipped by reader/writers. This system has the potential to revolutionize the practice of Power Line Communications with applications such as automatic detection, power control, and payment/ticketing all the way through the power lines.

RFID over Power Line is the applied technology of usual RFID, NFC (Near Field Communication), or contactless IC card. It is also Power Line Communication transfer high frequency signals of RFID over power line to detect appliances which are connected to the electrical grid and to pick up their encrypted data.An RFID tag chip or contactless IC card chip is embedded in an appliance and is connected to the power line. It holds written data and thus holds identity information. The RFID tag chip or contactless IC card chip is read by a reader/writer connected to the power line in Smart Grid. The reader/writer transmits scanned signals into the power line, and scans an area of Smart Grid continuously.When the plug (connector) of the appliance is inserted to the electrical outlet (i.e. when the appliance joins Smart Grid), the IC chip is activated by electromagnetic waves transferred from the reader/writer, and the high-speed data transmission is induced. It can provide secure and convenient prepayment of electricity and other utilities.

The existing block diagram which uses the principle of power line carrier technology for electricity billing and recharge for making the system to be smart.Existing system can be extended for power factor detection circuit in the previous work.Further the system is applied for the new concept of power factor correction and compensation purpose.

4.PROPOSED SYSTEM

4.1 Proposed System Block Diagram

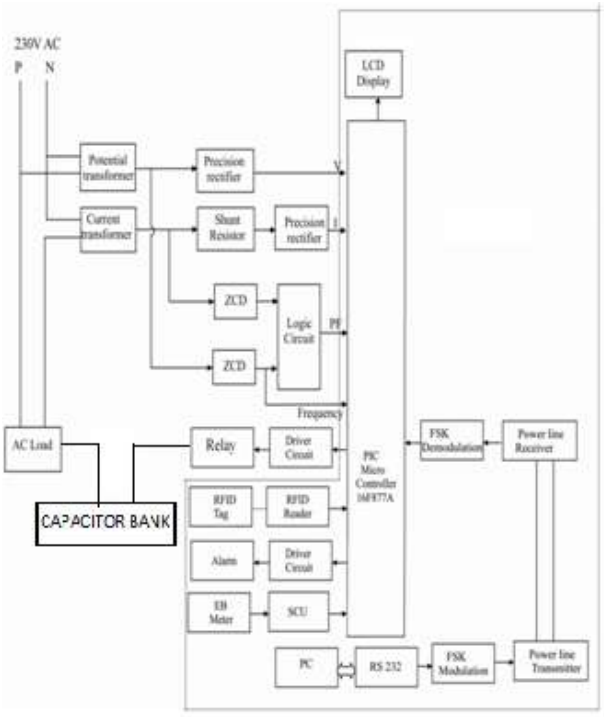


Fig. 5. Block Diagram for Proposed System

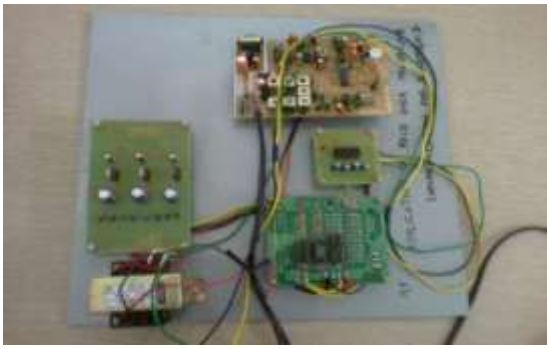
4.2 Performance of the Proposed System

This proposed system is separated into two parts: consumer and supplier. The consumer side consists of a energy meter, logic circuit, an RFID reader base on a microcontroller, and the supplier consists of a PC with data base of consumers. Credit id which is read by RFID reader is verified by the supplier and sent to the consumers from which microcontroller take action based on that information. The microcontroller manages all the system work in the consumers. The ID and its information can be transmitted among each consumers and the supplier through Power Line Communication(PLC) and also this proposed system perform the operation based on the signals are obtained from instrument transformers like potential and current transformers. The square waveform is converted into compatible waveform with the help of suitable logic circuit. The Counter is located in the microcontroller and converted wave form is fed into the counter. The counted pulses are distorted into corresponding value of phase angle Φ.Relay mainly performs the opening and closing of a connection of load from side to side supply mains depending upon the amount present in the RFID card and the presence of non-linear load (inductive load) at a moment.

4.3 Experimental Setup

Energy Meter will be generally used to show the electrical pulses proportional to the power consumed by the consumer. Microcontroller obtains the details of energy consumed by the consumer through the output of Energy Meter and act according to the programs full on the microcontroller. RFID Card interfaces with the microcontroller unit in which the amount recharged by the customer are written. When the amount is reduced below 10 percentage, the alarm circuit will get on. Relay primarily performs the operation that connecting and disconnecting the load through supply mains depending upon the account balance present in the smart card at a moment whenever the non-linear load is come into play. The voltage and current magnitude are given as data into the microcontroller inorder to find the phase angle difference between the voltage and current. The cosine of the phase angle difference between the voltage and current is known as displacement factor. According to the displacement factor the relay will connect or disconnect the non-linear load. The signal on or after microcontroller (either 0 or 1) is used to operate the relay.

4.4 Hardware Snapshot



Supplier Side

Consumer Side

4.5 Features of Proposed Systems

- Remotely Connect / Disconnection of Power supply from side to side PLC. Automation of all features including communication from the sub -station to the customer.
- It involve less cost to communicate. PLC is a quick reaction. Once the power line is connected, identification and transaction can be done within 0.1 second. This system increases productivity.
- The power factor maintenance is used to increase the stability of power system.

5.CONCLUSION

In this modern era various technologies were available all over the world for calculating and collecting the electricity billing process in India appears to have become very absolute and is still lagging behind and is unable to meet the latest available technology. However in this project above mentioned process is completely automated and the communication is entirely made possible through the power line communication. The communication between the transmitter and receiver is bi-directional and data rate will be fast for long distance. When the system is user friendly it will be more beneficial to the customers. The EB billing procedure has the ability of fulfilling a set of needs for the user and the EB workers. This proposed power factor detection and maintanance circuit experimentally tested with auto transformer. Electric energy is very much essential to our daily life**.** It is used in Industry applications. The power factor adjustment is primarily used to maintain the stability of the power system.

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