

Radio Frequency Identification Based Communication of Smart Grid with Advance Metering Infrastructure survey

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Abstract

Developing countries like Pakistan facing the power theft and blackout issues are in severe need of making the system automated, reliable and efficient to better of its economy with the advantages of system. This could be made possible by the easy installation and highly reliable data communication through smart grids. In our research, RFID devices are employed to work in synchronization with AMI meters to make the smart grid efficient and less time communicated. The major problems of power theft and severe blackouts are controlled by employing special types of AMI stage 2 types of meters. The RFID unlike wirelessly, here is employed so that the economy levels are sustained. Unfortunately the conventional grid being used in developing countries like Pakistan are not much able to cope with the future challenges like increasing energy demands and blackouts etc. Conventional grids employ single way communication between the supplier and consumer thus restricting supply to one way which in turn limits the feedback and timely responses. Energy crisis in a country like Pakistan are happening because of the reasons like inability to use hybridization techniques, theft and the bulky old economy is maintained. RFID over power line conventional grid system. The major reasons for such technology makes the two way communication in a much better way and reduces the cost of separate conductors. Different types of RFID possibilities and ways are analyzed in the research and they are used for power line carrier technology. The proposed system has the ability to revolutionize the power line communication technology with the applications such as payment, ticketing, tracking and leads to the new emergent technologies.

Keywords

AMI, Smart meter, Power line communication (PLC), Smart grid, RFID

1. INTRODUCTION

Power grid is traditionally the term used for a power system with interconnection of generation, transmission, efficient distribution and power control. In order to accomplish the efficient distribution of utility to load centers or consumers the grid should be such that which actively regulates the supply with the needs of consumer thereby keeping the reliability, efficiency, economic and controllability at the proper causes are the use of manpower and inefficient old system that is too far from the replaceable capacity and also not capable to involve the modern techniques of hybridization and power controllability. [1] Thus to make the system more efficient and reliable keeping in view the economy we come across the smart grid also known as future grid, intelligent grid, which is a grid of 20th century. Smart grid generally employs the two way communication mechanism between the supplier and consumer which results in timely responses enabling the power control in a better way. On the other hand smart grid employs the hybridization of more than one resource thus avoiding the severe blackouts other than the physical damages.

Smart grid controls all the parameters of power system by a central location avoiding the theft as no manpower is induced and also the bulky old conventional system is avoided which is generally creating many disturbances and flaws subjected to climate conditions. The mechanism by which the two way communication is being held is very important from the reliability and economical point of view. In this research paper our main focus is on the radio frequency identification devices (RFID) in conjunction with smart metering to make the system automated and more accurate. This would generally lead to the elimination of theft, reliability, efficiency and also for the betterment of

economy.

RFID based smart metering technique is used for two way communications between the supplier and consumer which retrieves the peak demand, average load, power factor, the hours of need and also the automated billing procedure. The amount of utility consumed by the consumer is detected by the smart meters at consumer terminals and the RFID tags moves in proportional to the amount recharged by the customer. The interfacing of RFID and smart meters with the microcontrollers generally produce the results that is sent to the supplier over the power line technology.

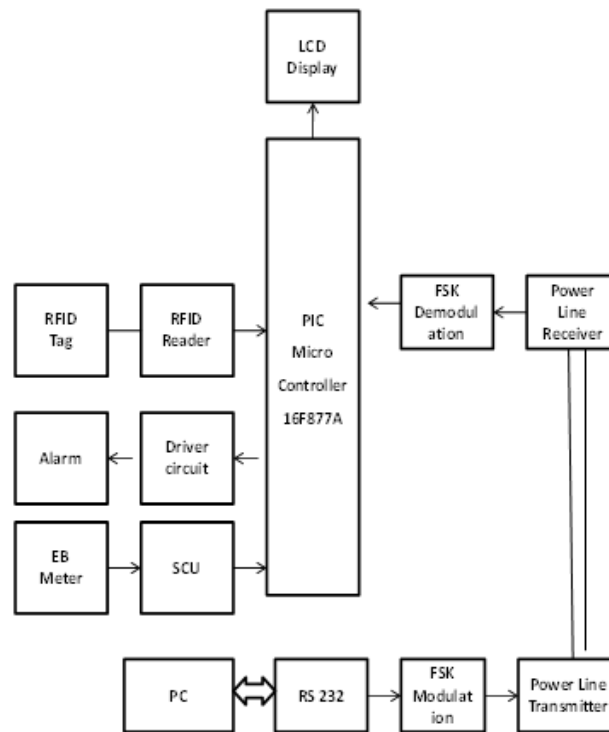


Figure 1. Consumer and supplier interconnection block diagram [1]

II. SMART GRID COMMUNICATION TECHNIQUES

To make the smart grid efficient, reliable and to sustain the short comings of today's traditional grids, the two way data traffic between the supplier and consumer must be managed through a proper communication network.[2] The communication network can be wireless or wire based. Wired communication can be possible in two ways either by the lines carrying the AC power or by using separate kind of cables for only data transmission. Since all the elements in power system are connected through some power lines so it's better to use the power line communication for the sake of economy and speed increasing the reliability of system [3]. In our study we are basically concerned with the proper mode of communication devices that is RFID over power line communication (PLC);

A. Power line communication

Reliable and efficient way of sending or retrieving data in a half-duplex manner through same cable that is simultaneously being used for electrical power transmission is the power line communication technology. In this the reliable command and efficient load management can be done by using the power line communication infrastructure. [4]. It can be understood by considering its classification in broad way, i.e.

1. Narrowband PLC
2. Broadband PLC

The above two types of PLC differ in about the operating frequencies and the working ranges. Narrowband PLC works in frequency range of 3-500 kHz sending data of 100s of kbps for the range of several kilometers while the range

can be extended by the use of repeaters. In broadband PLC the frequency range is high of the order of 1.8-250 MHz high data rates of 100s of Mbps but used for a shorter range application. Narrowband PLC is gaining much attention because of their wide range application such as in smart grids. [5]

Power line communication can also be classified on the basis of its distribution viz AC or DC. However PLC-AC is most widely used but PLC-DC also has applications like the communication networks of transportation (electronic controls in aviation, trains and automobiles).

B. Working

Power line communication works in a much similar way as any other communication system that, injects the data to be sent after modulating it, onto the medium and then receiver retrieves the data by demodulating the signal. The difference is only that PLC does not need any extra power cabling. The existing wire can be reused again and also all the line-powered devices can be monitored or controlled. [6] The basic functioning of the power line carrier technology could be explained by the following circuitry;

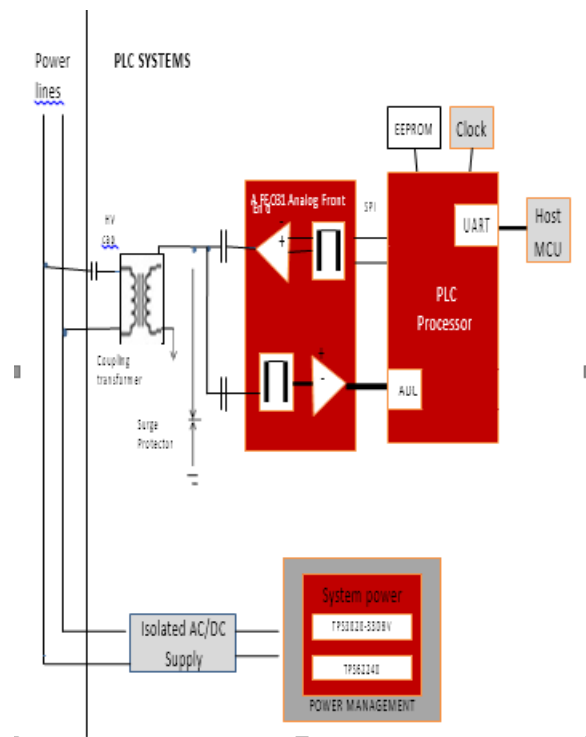


Figure 2. Basic power line communication used in systems [7]

C. Power line communication specification

Often the integrated system of DSP with MAC and external PHY circuitry or an optimized system on silicon chip (SoC) solution is used as a complete PLC – MAC & PHY [8]. DSP is the digital signal processor and MAC is the software realization used for PLC solutions. The example of this is cypress CY8CPLCXX series with a ready to use physical and network layer and a user programmable application layer. The communication standards of different specifications are given as [9]

TABLE I. CLASSIFICATION OF PLC TECHNOLOGY ON THE BASIS OF DATA RATE

	Low data rate	Medium data rate	High data rate
Data rate	0-10 kbps	10kbps-1Mbps	>1Mbps
Modulation	BPSK, FSK, SPSK, QAM	PSK+OFDM	PSK+OFDM
Standards	IEC 61334, ANSI/EIA 709.1, .2,	PRIME, G3, P1901.2	G.hn, IEEE 1901
Frequency range	Up to 500kHz	Up to 500kHz	In MHz
Application	Control and command	Control and command, voice	Broadband over power line, home networking

D. Modulation Schemes

There are variety of modulation schemes used for this technique all depending upon the bandwidth efficiency and complexity (cost).

TABLE 2. COMPARISON OF MODULATION SCHEMES

Modulation scheme	Bandwidth efficiency	Complexity
BPSK	Medium	Low
FSK	Medium	Low
SFSK	Low	Medium
OFDM	High	High

Standards:

There are various standards developed for ensuring the reliable communication and inert-operability especially for smart grid and home networking, examples are,

TABLE 3. SPECIFICATIONS OF NARROWBAND PLC STANDARDS

Standard	Technology	Frequency band	Bit rate (kbps)
G-3 PLC	OFDM	36-90.6 kHz	5.6-45
PRIME	OFDM	42-89 kHz	21.4-128.6
IEEE P1901.2	OFDM	9-500 kHz	Coming soon
ANSI/EIA 709.1,.2	BPSK	86-131 kHz	3.6-5.4
KNX	S-FSK	125-140 kHz	1.2
IEC61334	S-FSK	CENELEC-A	2.4

E. Frequencies

The different regions of world has different frequencies allocated to narrowband PLC, examples are enclosed in table;

TABLE 4. NARROWBAND PLC FREQUENCY RANGES FOR DIFFERENT REGIONS

Region	Regulatory body	Frequency band	Note
Europe	CENELEC	3-95 kHz 95-125 kHz 125-140 kHz 140-148.5 kHz	Energy provides For users For users, Regulated CSMA access For users
Japan	ARIB	10-450 kHz	
China	EPRI	3-90 kHz 3-500 kHz	Not regulated
USA	FCC	10-490 kHz	

F. Application

Application examples of power line communication includes [10]

- ✚ Lighting control
- ✚ Home/building automation
- ✚ Automatic metering infrastructure
- ✚ Smart energy management

III. RFID OVER POWER LINE TECHNOLOGY

Radio frequency identification devices (RFID) or contactless IC are most widely and commonly used for different types of applications like cash payment, ticketing system and for many type of transaction by only holding an IC card over reader/writer. The application of such RFID devices to make the grid smart is worthily noticeable.

Unlike the conventional RFID carrying the data wirelessly, the RFID over power line technology carries the communication data over the power line that is simultaneously being used for transmitting the AC power. Wireless way of carrying the data results in signal attenuation which could be made better by the use of boosters that add too much cost to the power system [11].

In such type of systems RFID card and readers both are used to communicate by the appliances attached to the electrical grid. The RFID chip called contactless IC is placed inside the appliance and this IC is read by the RFID reader/writer at power grid through the power lines. The RFID tag is carrying the information of the consumer which can be read by reader only when the appliance gets connected to the electrical grid by inserting plug into the electrical socket. The IC is then activated by the electromagnetic waves possibly a high frequency signal running through a power line.

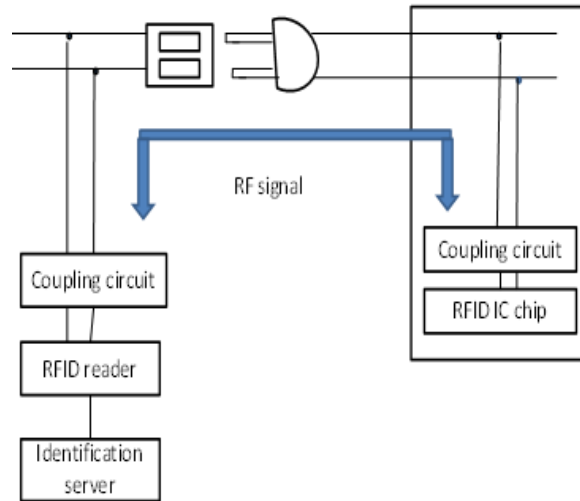


Figure 3.FIG.RFID over power Line Technology block diagram

A. RFID types

Different types of RFID systems have been working, but installing and using them for efficient data transmission by cutting cost and increasing efficient is challenging. So it is must to have a proper type of RFID for proper application. RFID systems most broadly can be classified in two types, Active & passive tags [12].

Active Tags

Active tags usually have some power source like battery and they are self-powered and use to send the data to reader/writer [13]. The RFID tags are having the unique ID and other possible information of the consumer. Active tags can be beacons or transponders. Transponders can be woken by the signal from the reader and they are used at toll payment collection, check point control and others.

Whereas beacons type of tags actively generate signals at their own at different sub intervals and this signal is read by the writer. The frequency ranges of active tags are 455 MHz, 2.5 GHz or 5.8 GHz and typically they are used to read range of 60 to somewhat 300 feet.

Passive Tags

Passive tags simply don't have any transmitting source and they reflect back same energy typically RF waves coming from antenna of reader. These are made of silicon chip in many ways. They are used for different frequency ranges low, medium, high and ultra-high frequencies. Systems for low frequency usually operate at 124 kHz, 125 kHz and 135 kHz. Systems for high frequency generally operate 13.56 MHz. The systems for ultra-high frequency use a band between 860 MHz to 960 MHz.

B. Tagging locations

The RFID reader is installed at the power grid and connects to the RFID tag through radio waves. The tagging location of RFID tags is very important in order to offer the proper communication channel. There are three types of tagging locations with respect to RFID tags embedded at home appliances. In one arrangement the RFID tag is placed in each appliance at consumer terminals and when any appliance is put in connection to the grid through switch that gets activated. But this is uneconomical to add a separate IC in each appliance. So second arrangement is by using a common adapter carrying single contactless IC and all the appliances are connected to grid through this only adapter switch. In third and most efficient way of tagging is by using the IC card in conjunction with smart metering infrastructure. In this there is placement of antenna connection to the power line via coupling circuit and the user's IC is inserted in it which communicates to the grid. All the types of tagging possibilities are shown below in block diagrams [14].

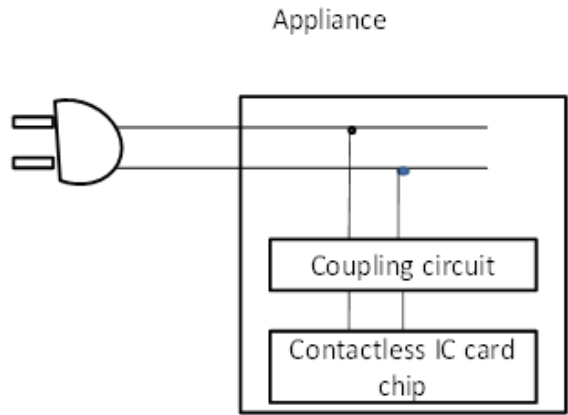


Figure 4.RFID chip embedded in appliance

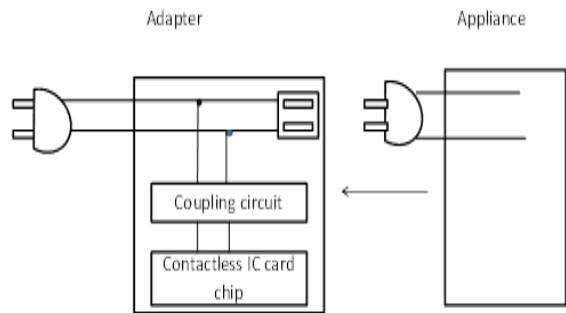


Figure 5.RFID embedded in common adapter

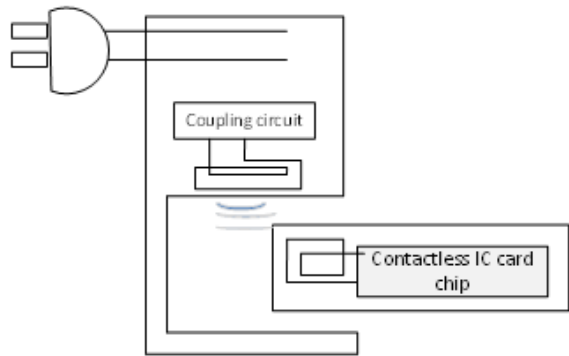


Figure 6.RFID chip is embedded via antenna

IV. SMART METERING INFRASTRUCTURE

RFID based power line technology for the smart grid is used in conjunction with smart metering infrastructure. Smart meters installed at consumer terminals are advanced metering infrastructure (AMI) type meters used for the two way communication. The old types of meters are only used for one way communication and send the consumption of utility to supplier. AMI type are updated and digital version of old ones and they only sends information about the consumption of utility but also provide information about the time at which utility is supplied [15] The other information like pricing and energy information is also supplied by the smart grid (two way communication).

Each smart meter is having a particular type of IP address that is used to communicate with the utility supplier. The prime goal of such type of smart meters is to provide utility supplier companies with real time data about power consumption and the pricing information at the particular time of use.

A. Benefits of AMI

Benefits of AMI are as follows

- Information regarding accurate and timely billing data to avoid estimates and adjustments
- It provide complete time of use rates and load control desirous to consumer
- Tools and data to improve power quality and protect revenues
- To provide smart grid a tool to express it timely responses
- For consumers to understand their energy usage in better way which in turn cuts the cost

The AMI includes software, hardware, communication network and other consumer associated devices [16]. The overall function of AMI is to send data from consumers' smart meters to the utility centers and other is remote management. The remote management includes load balancing, remotely connect/disconnect load in case of no payment and smart meter software up gradation. All the data including demand response, load management, power factor and any factor associated with reliability and efficiency is done by the AMI system.

In our research we are concerned with the smart meters (AMI) with RF type of communication and this is done by *MicroTech* industries in Pakistan with the collaboration of some participating organizations [17] The key benefits and purposes for this infrastructure are;[18]

- Better load management in demand side
- Auditing of energy
- Reporting in a customized way
- Improvement in collection of revenue

B. R283RF Meters

The type of AMI meters used for RFID communicated smart grid are R283RF meters. Such meters with RF communicated mechanism (433 MHz) are single phase electronic meters designed for domestic and commercial applications. The major and key benefit of such type meters is to avoid power theft and they are specially designed for the regions or places where such power theft is a concerned issue to be resolved. The key characteristic of this model is that it is equipped with anti- tempering features. Digital signal processor and a special kind of integrated circuit have been embedded for the measurement of the energy (kWh) consumption. Special current sensors are especially provided at the phase and neutral wire for the measurement of current in different tempering environments. [19].

C. Features

- Especially designed by accuracy requirements of class 1, IEC 62052.
- Protection is provided against magnetic field interference of AC/DC, surge immunity and electrostatic discharge (ESD) according to requirements of IEC 61000-X-X
- Seven digits register showing kWh consumption of energy
- LCD display showing energy (kWh) reading on display for the consumption in outage or power failure
- Capable of measuring phase and neutral current and voltage
- After 75% battery life, indication for low battery is activated
- Error indication for faults either software faults or hardware ones
- Display of Pulse output (3200 pulses/kWh) on
- LCD display
- Self-memory diagnosis
- LCD protected from UV influence
- Meter accuracy is free from any tilt effect

- Free from dust and moisture deterioration

The RFID communication technology in conjunction with smart metering technology brings about smart grid to a wider level of benefits for the economy and prosperity of a country like Pakistan. Thus in order to maintain all this the efficient way of communication is brought in line so that it may results in more possibilities. The power theft in a developing country like Pakistan and a definite time lag in communication leads to the severe blackouts and uncertainties. Thus to make system work in a better way hybridization and smart grid communication are employed.

CONCLUSION

The proposed methodology of RFID based smart grid with AMI metering technique is useful for the country like Pakistan where power theft and severe blackouts are common. To make the region better of the economy, reliability and efficiency of the system must be well structured. So this technology improves all the features as the time required for communication is very less and also the two way communication is made possible through RFID devices that can be used for tracking or other purposes. The timely responses of consumer's demand and usage are managed and also manpower is completely eliminated as the system is surely automated remote managed. Only a single person is controlling number of consumers at a particular station. The type of meters and devices are selected on the behalf of speed of operation and reliability. All such arrangement of system makes the continuous supply of energy possible without any serious blackout or problems occurring.

References

- Tang, Grace Q. "Smart grid management & visualization: smart power management system." Emerging Technologies for a Smarter World (CEWIT), 2011 8th International Conference & Expo on. IEEE, 2011.
- Güngör, Vehbi C., et al. "Smart grid technologies: communication technologies and standards." Industrial informatics, IEEE transactions on 7.4 (2011): 529-539.
- Erol-Kantarci, Melike, and Hussein T. Mouftah. "Energy- Efficient Information and Communication Infrastructures in the Smart Grid: A Survey on Interactions and Open Issues." Communications Surveys & Tutorials, IEEE 17.1 (2015): 179-197.
- Amin, S. Massoud, and Bruce F. Wollenberg. "Toward a smart grid: power delivery for the 21st century." Power and Energy Magazine, IEEE 3.5 (2005): 34-41.
- DOE, US. "Communications requirements of Smart Grid technologies." US Department of Energy, Tech. Rep (2010): 1-69.
- Carcelle, Xavier, and Thomas Bourgeau. "Power Line Communication Technology Overview." The Internet of Things: Connecting Objects to the Web: 97-128. communication. John Wiley & Sons, Inc., 2001.
- Aalamifar, Fariba, Hossam S. Hassanein, and Glen Takahara. "Viability of powerline communication for the smart grid." Communications (QBSC), 2012 26th Biennial Symposium on. IEEE, 2012.
- Pavlidou, Niovi, et al. "Power line communications: state of the art and future trends." IEEE Communications Magazine 41.4 (2003): 34-40.
- Larson, Rodney L. "Communication over power lines." U.S. Patent No. 5,452,344. 19 Sep. 1995.
- Vaidya, Bhaskar, DimitriosMakrakis, and Hussein T. Mouftah. "Authentication mechanism for mobile RFID based Smart grid network." Electrical and Computer Engineering (CCECE), 2014 IEEE 27th Canadian Conference on. IEEE, 2014.

Basics and differences of RFID systems, [online] available, <http://blog.atlasrfidstore.com/active-rfid-vs-passive-rfid>

Froehlich, Jon, et al. "Disaggregated end-use energy sensing for the smart grid." *IEEE Pervasive Computing* 1 (2010): 28-39.

Washirot, Takanori. "Applications of rfid over power line for smart grid." *Power Line Communications and Its Applications (ISPLC)*, 2012 16th IEEE International Symposium on. IEEE, 2012.

McLaughlin, Stephen, Dmitry Podkuiko, and Patrick McDaniel. "Energy theft in the advanced metering infrastructure." *Critical Information Infrastructures Security*. Springer Berlin Heidelberg, 2010. 176-187.

Kumar, Vijay, and Muzzammil Hussain. "Secure communication for advance metering infrastructure in smart grid." *India Conference (INDICON), 2014 Annual IEEE*. IEEE, 2014. MicroTech industries to implement largest AMI project in Pakistan, [online] available, http://www.mtilimited.com/newsroom/largest_ami_project.php 19 Single phase smart meters

Bennett, Coalton, and Darren Highfill. "Networking AMI Smart meters." *Energy 2030 Conference, 2008*. ENERGY 2008. IEEE. IEEE, 2008.

Haque, MdMejbaul, et al. "Microcontroller based single phase digital prepaid energy meter for improved metering and billing system." *International Journal of Power Electronics and Drive Systems (IJPEDS)* 1.2 (2011): 139-147.

Biographies

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