

## **THE INVESTIGATION OF THE HIGH SPEED INTERNET TRANSMISSION THROUGH USERS' APPLICATION OF THE POWER LINE CARRIER (PLC)**

**Eisa Khodabandeh<sup>1</sup> and Ali Ghorban Garavand<sup>2</sup>**

<sup>1</sup> *Instructor of IT at the College of Shahid Motahari*

<sup>2</sup> *Instructor of English at the College of Shahid Motahari*

*\*Author for Correspondence*

### **ABSTRACT**

The transmission of the Internet through power lines has long been the focus of attention of most researchers and engineers working in the field of electricity and computer. The technology of PLC, as an abbreviation of “power line carrier”, has been applied for many different purposes over the past couple of years, for instance, for such purposes as controlling, protection goals among power stations, high pressure power posts, controlling centers, establishment of telephone communication between high pressure posts and power stations, transfer of energy, adjustment of voltage and circulation of an entire network and its related protection errands and controlling centers. In fact, the most significant usage of PLC is the transfer of the telecommunications data via power transmission lines, however, this transmission of data is done as analogue, and various methods are applied to the modulation of the sent signals. The frequency scope of these signals is normally equal to kilohertz. Nowadays, PLC operates, as newly used for different applications, at the level of weak and medium voltage of the electrical network. Indeed, with this technology, the information is transmitted to ultimate consumers through which the power customers can enjoy the benefits of the new services of data transmission. In this research, one of the services given by this technology is the use of high speed Internet, however, the type of network and its equipment were examined. Having been of an applied type, the present research was conducted in a descriptive-analytical form via interviewing the experts on electricity and computer in Iran. This technology is being prepared for the establishment.

**Keywords:** *PLC, Distribution, Access, PLT Modem, Internet Services, PSTN Network.*

### **INTRODUCTION**

The Internet transmission to the ultimate consumer through power lines is one of the growing technologies in some developed countries of the world. Today, most developing nations have conducted some studies so as to apply this technology at the level of the power network, moreover, some other have dealt with the installation of it. One of the most outstanding features of using the PLC system is the lack of need to create new network for the exchange of information, and also the use of existing electrical network. Due to being invested with such privilege as not wasting the cost and time needed to build new telecommunications channels, this technology can be an appropriate alternative in the markets with vast width of the band. Since a large portion of an electric network is formed by the low pressure section, this kind of technology is considered as one of the best methods in terms of its geographical coverage.

Nowadays, throughout the world, the electrification is accomplished via both airborne and underground cables. It may, however, seem interesting to know that you are able to connect to the Internet network through the use such cables and do your ordinary virtual tasks with a high and certain speed. Therefore, you may have much less Internet blackout in comparison with the present time because the Internet failure in such a case is dependent on power blackout knowing that the world is currently experiencing rare cases of power blackout, as a result, leading to much more Internet connection. Until recently, most experts viewed such a technology as impossible due to couple of too much technical problems, nevertheless, they continued to work harder and gained achievements in this respect, thus, very well-

## **Review Article**

known companies richly invested with technology such as Google and IBM have declared their readiness to work on this project since three years ago. At present, because of various problems, this technology has failed to remarkably develop, however, in some parts of the world, for instance, Europe in which the power networks are differently and efficiently built, people can take benefit of the high speed Internet services with the help of power cables. The experts interested in the project have stated that this system can to some extent disorganize the radio waves, power companies assured people that their frequencies do not bring about any disorganization in their radio waves frequencies. In this research, we dealt with some definitions of this technology, and also examined the equipment, privileges, flaws, and its related networks. In addition, the distribution networks, Internet access, and home services related to this technology in accordance with the frequency limit of these signals which is normally at the level of kilohertz were examined.

## **Statement of the Problem and Theoretical Framework of the Research**

### **What is PLC?**

PLC is the abbreviated form of the phrase “Power line carrier” which means the transfer of data via power lines. In the early 20<sup>th</sup> century in the USA, the PLC system was applied in order to control the urban light system using a 500 hertz signal which had the possibility of being planned as logical controllers. With the advancement of technology and of micro-processors, considerable developments in the controlling processes came into vogue one of which is the application of the industrial automation science and PLC to the industrial processes. Nowadays, in the world competitions, for an organization to survive, it should plan to create mass products with remarkable quality and variety, and decrease the costs of the production. Hence, the industry owners try to mechanize their production processes as much as possible. In addition, variety in the products regularly make the manufacturers have change and development in their production lines. Thus, the flexibility of production lines should be in line with the objectives of the organization. Today, for production lines to deliver desirable and highly qualified products to customers, a series of operations should be consecutively performed on the products knowing that PLC industrial automation is in charge of such operations. Automation can be clearly defined as application of the electro-mechanical systems so as to automatically do the jobs, and decrease or even delete the man’s intervention in the direction of the production. PLC is a system that controls the industrial processes, however, it was brought into our country (Iran) in 1990. Very recently, the programmable rational controllers are used instead of earlier relay ones, and it seems quite necessary for the power technicians to be familiar with this ever-increasing industry in the production centers. At the beginning, PLC was abundantly used as micro-controllers in the market and private industries, but because of the frequent times of switching and producing some noises in the network, such micro-controllers did not function appropriately in defined processes, leading to the employers’ loss of confidence. But, experts and researchers tried to remove such flaws from this newly-arrived industry, and add more facilities to it since different industries make use of this technology. In 1968, the American company of Alen Bradley entered the first rational controller known as PLC into the market and industry. Therefore, such other companies as the German company of SIEMENS, Japan’s OMRON, Korea’s LG, and the French company of TEFEL, adopted this human knowledge and brought other PLCs each of which with particular characteristics into the industry as it is now being applied in various industries. These days, the automation plays a very significant role in the industry, easily controlling the massively complex and sensitive processes of production.

### **PLC Application**

PLC, due to its facility in the power distribution system (33 KV downwards), was applied in some developed nations of the world like Japan and then in the Europe and America. The main reason for using this system in distribution part was the automation of the distribution network. The distribution

### **Review Article**

automation means monitoring and controlling the distribution system from a main center such a distribution company or regional power. In other words, all commands to power keys, capacitors, reactors, and security errands are remotely controlled. Such an infrastructure in the power industry needs telecommunications channels, knowing that there are too many telecommunications channels available, each with its own particular merits and demerits. In such conditions, PLC, also called DLC in distribution systems, was the simplest alternative at the level of distribution due to existence of electrical conductors. Recently, it is believed that connection to the Internet through joining the power outputs becomes easier. However, it is easier to transmit data via power lines or PLT through the use of electric lines so that the telecommunications band width can be transmitted into the home network, and the delivery of telecommunications services to homes and companies is done with more ease, considering that its most important privilege is the application of the existing power network without the need to establish the new telecommunications channels (K. H. Zuberi, Power Line Carrier, 2003). Despite PLC is invested with many privileges to deliver, factors such as standardization and economic problems have made this technology lag behind. However, it seems impossible to apply PLT as a suitable and safe technology without having development in the creation of universally appropriate standards. Also, this technology has the capability to be applied as an alternative to the existing international telecommunications networks, and provide all homes with different kinds of services such as sonic services, data services, fax, and access to the cost-effective and high speed Internet. In this respect, the main objective is to present a way of exploiting the internal power lines as the local massive networks with high speed so as to carry the digital sonic and pictorial data along with other information.

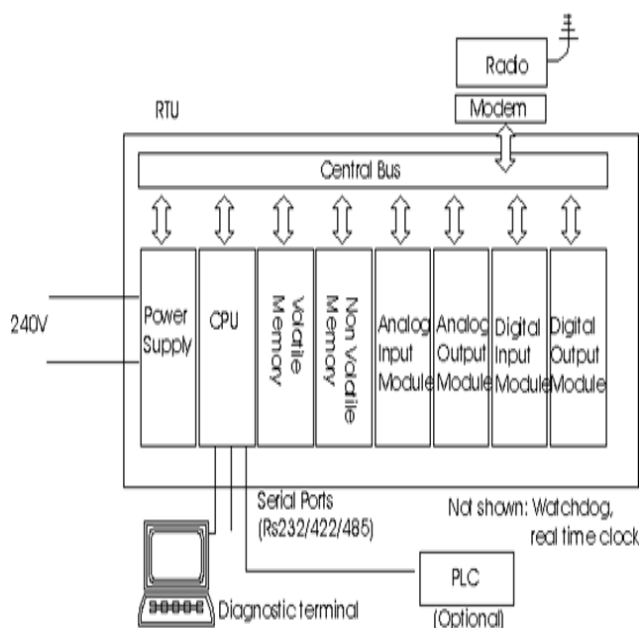
Countless studies and experiments have shown that it is possible to make use of high frequencies and more band width for the transmission through power network, in addition, to achieve the transmission rate up to a maximum of some hundred megabyte per second by using frequencies of almost 1.6 to 30 megahertz, and also applying the capacity of distribution networks in the phases of low voltage, and medium voltage (Paul Topfer, 2003).

This result is a potentially great innovation that can have a considerable economic value, for example, one sample is the access to the Internet via power plugs. It, in fact, causes this greatest human knowledge to be globally available at any time for all people, and remarkably change the high costs of access to the Internet which is now a big problem on the way of users to take benefit of its various services. At the end, we should note that using the electrical networks for the purpose of transmitting data is not devoid of restrictions, suffering from such problems as the electromagnetic disorders of high frequency, and interference with the frequency band of the incumbent amateur radios.

### **The Main Components of a PLC System**

The main components of a PLC system which is now applied at different levels of the power system, are as follows:

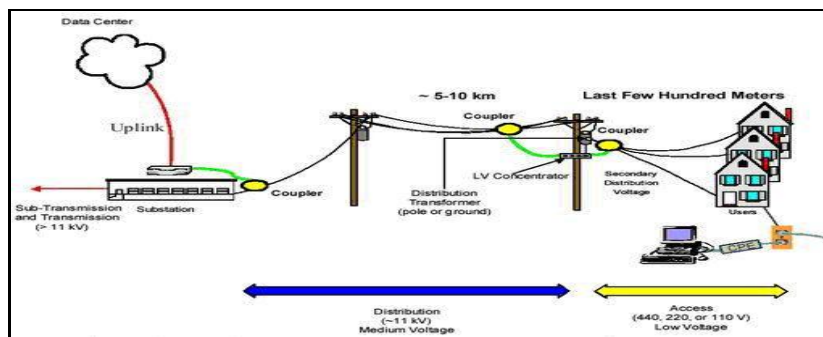
- Remote Terminal Unit (RTU): this system includes a number of digital and analogue inputs and outputs. The main task of the RTU is to change the sent signals into transferable ones through telecommunications channel which holds such parts as CPU, analogue and digital input and output cards, and modem. Picture 1 shows an industrial RTU sample (B. A. Mork, et al, 2005) within the PLC system.
- Equipment of the adaptor with the telecommunications channel (power lines) or LMU8. However, to transmit the maximum power via telecommunications channel, and to prevent the waves from reflection, the sender's impedance should be equal to the channel.
- The isolating system of the telecommunications equipment of high voltage (usually, a capacitor called CVT is applied).
- Telecommunications channel, which are the power lines conductors.
- Line trap whose duty is to prevent the information from entering into sections such as high pressure posts other than telecommunications channel.



**Picture 1: An industrial RTU sample**

As it was earlier mentioned, the increase in PLC’s application at the level of distribution was because of automation of the electric network. In addition to controlling and security objectives in automation, more objectives have come into fashion since the past couple of years so as to continue using it. With the beginning of restructuring in the power industry and also with the advent of the power competitive markets, it was felt as necessary for the consumer, with his active participation, to control the consumption rate, manage the consumption or DSM9, and measure the consumption as real time for the particular objectives. Of course, the requisite for the consumer participation in this market is the existence of effective telecommunications equipment among the industrial, commercial and even residential consumers in the power distribution networks. Thus, PLC is one of the existing choices whose possibility of establishment is rather simple, and it is because at least one of its components (electric conductors) is available without the need for additional installation (M. Hosono et al, 1982).

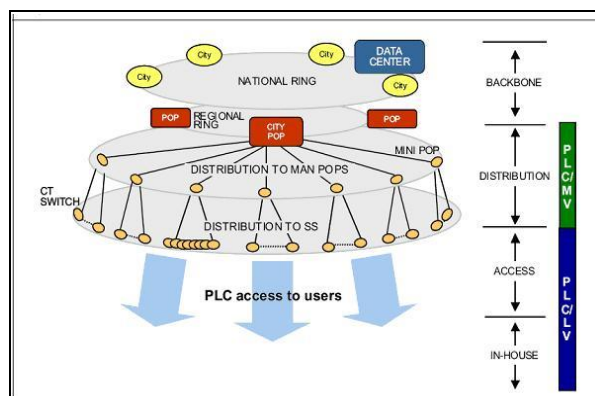
The PLC technology in the north America, makes use of medium voltage (1-50KV) or low voltage (100-240 V) of the power distribution network as the telecommunications infrastructure to transmit the waves of high frequency. The PLC has two main families: a) the distribution telecommunications network whose purpose is to connect the PLCs of MV/LV stations, b) the access network or external PLC which connects the home to outside whose goal is to establish a connection between the customer and station. An overall shape of a PLC system is illustrated in picture 2 below:



**Picture 2: An overall shape of a PLC system**

### Review Article

It should be, however, noted that MV/LV stations in Iran are those 20KV/400V. To transfer the telecommunications signal from this trans, additional equipment in such stations must be used due to the filter characteristic of the trans. In picture 3, these three families and network show the infrastructure of the Internet, and their interconnections. As illustrated in the following picture, the access network is normally placed in the low voltage network, while distribution network is in high voltage network.



**Picture 3: Overall structure of the PLC network and its families in distribution network**

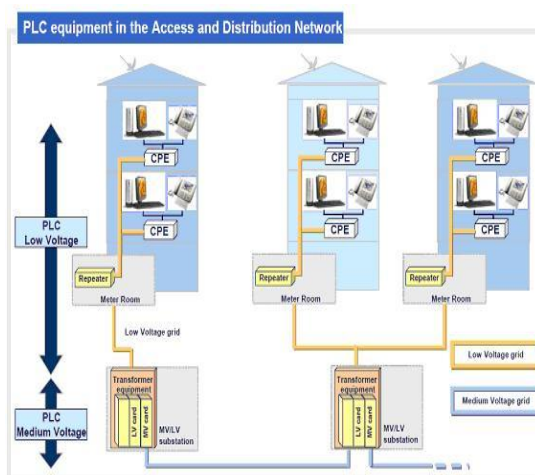
The low voltage network, as the basis of the PLC technology, is formed based on the modulation and demodulation of information via a carrying signal which works with high frequency. Generally, the physical layers and its method of encoding is done based upon the OFDM12 method. Nevertheless, its capability of coping with the interferences and disturbances is taken into account as the most principal concern of its designers. The access network has two sections as follows:

- The section between CPE to repeaters which is connected through the building power lines and in some cases via low voltage network.
- The section among the repeaters TE that is connected via low voltage network. The repeater is a tool which is used to reinforce the PLC signal along with the sending direction.

### The PLC Equipment at level of Distribution

Three main groups of the PLC equipment are: a) CPE, b) repeater or mediating equipment, and c) Transformer equipment that we will deal with their general features (K. Dostert, 1997).

- The needed equipment for PLC customers at the level of distribution



**Picture 4: PLC equipment in distribution and access networks**



## Review Article

Modem or needed equipment of the customers (CPE) is one of the PLC equipment which is put at home that receives both the telecommunications signal and electricity through the electric plug. The CPE separates the sound and information and transfers them to customers' equipment such as computers, and usual phones (with sockets of RJ-11, USB, Ethernet RJ45). There are various kinds of CPE, for instance, CPE, only for the Internet (Ethernet and/or USB), CPE for the Internet and telephone (Ethernet and/or USB+RJ – 11), and finally CPE, only for sound (RJ-11). In below, picture 4 indicates the PLC equipment in distribution and access networks:

### Repeaters:

The repeaters or medium equipment, reinforce and re-inject the signals which come from TE to home's low voltage lines, at the home connection point (a distance of almost 300ms), normally placed at the Meter Room in the building or at some of low voltage points between the MV/LV stations and common home.

### Transformer:

The transformer (TE) is one of the PLC equipment that is installed in the converter stations of MV/LV. This tool injects the input signals coming from the PLC distribution network (Medium Voltage cables, optical fibers, so on), into the access network (low voltage cables). However, the lower class data are transformed to the CPEs or repeaters in two-point up to multi-point combinations via TE.

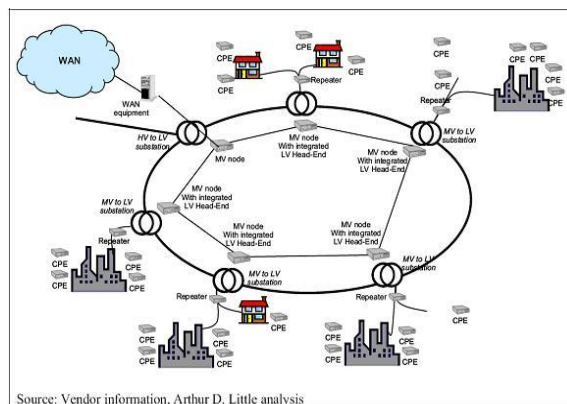
### Coupling:

These tools are, in fact, connecting units, applied in order to correct and inject the telecommunications signals from the PLC equipment to power lines (LV/MV). Moreover, the producers have created the new equipment so as to facilitate the process of installation. Also, the self-formation capabilities are now being used in PLC tools and are in a day by day development. In fact, such a capability makes the person installing the equipment aware of any defect over the process of installation (Paul Topfer, 2003).

## Investigating the Voltage rate and Its Effects

The normal low voltage network of distribution: one of its samples is in Germany, in which the LV is the center of the network. Each electric cable feeds almost 30 to 40 homes whose normal length is less than a kilometer. Most conductors are underground, but in the rural areas the airborne cables are applied where every subscriber connects to the power cable through a sheath (cover).

-The Medium Voltage Network of Distribution: the development of the medium voltage PLCs is of high significance since it causes economic development and technology supply, and makes it possible to use the present tools and equipment of the power network to connect different low voltage stations (K. Dosert, 1997). In picture 5, the way of connecting LV/MV stations to each other is illustrated.



Picture 5: The way of connecting LV/MV stations to each other

### **Review Article**

#### **The Merits of the PLC System:**

- Because of using the power lines, the installation of communicative direction is no longer needed, in other words, no time and cost is wasted for the building of new communicative channel.
- The PLC as one of the telecommunications environments in the power industry is totally independent, controlled and managed by power companies.
- The PLC telecommunications environment is of an airborne wire, moreover, any position at which an error occurs is easily detectable and identifiable.
- It is quite possible and easy to be invested with access to each point of the distribution network at any time, also, its telecommunications network has the capacity to be further developed. Therefore, developing the PLC network has no complexity.
- The PLC system has an acceptable speed in low voltage section and also in the home system. Where PLC is applied in the low voltage section, it is likely to achieve a high speed for the exchange of information since the distances of the signal transmission is not much.
- The PLC's cost of repair and maintenance is low in such a way that no particular periodic services are needed after their installation.

The Demerits of the PLC System: Despite its above-mentioned privileges, this system has some demerits that can restrict its functions. Based on the previous sections in which outstanding problems of this system were explained, some important demerits from the use of this system are listed as follows (Dostert, K, 1997):

- Changes of ampulance
- Over-weakening in the communicative direction and creating stagnant waves along with the direction.
- The existence of the monotonous and accidental impulse noise.
- Interference from the external sources next to high pressure lines.
- The existence of the separating keys
- Vast number of branches
- Little speed of data transmission at the medium level voltage
- High costs of the PLC's transformers and modems

#### **The Technical Problems Using the PLC Technology:**

- Since PLC uses the electric network for communication, any problem in the network has impacts on the PLC's performance. The most critical technical problems facing the PLC system are as follows:
- The capacity of the PLC systems
- The Internet access distance
- Network structure
- The existing restrictions in each country
- The performance of the contracting companies
- The shortage of the primary investment
- Awakening of the related responsible persons

#### **Different Applications of the PLC System**

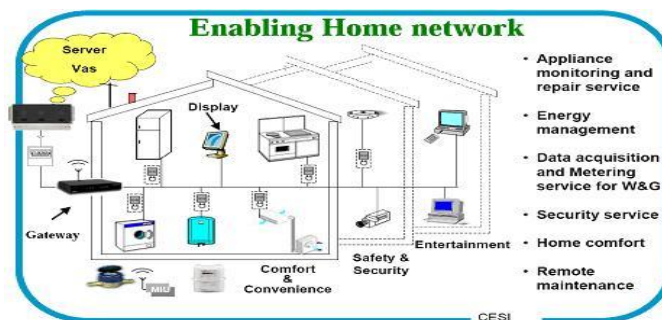
- Controlling the home equipment (G, Duval, 1997): in this method, the PLC's telecommunications channel is the intra-home power wiring. This technique in the automation of the home systems, remotely controls the home appliances, and creates light without the need to install any additional control systems.
- Home networking: another application of the communication technology through power lines, is the use of it for the connection of home computers and side systems. At present, there is no universal standard for communications via power lines. Nevertheless, some standards for networking the home appliances by a number of companies and factories working in this field are now developing (J. Newbury, 1998).
- Access to the Internet: the usage of the PLC technology, is the high speed Internet through the power lines (BPL) that provides the Internet access with broadband over power line, thus, the user can take

**Review Article**

benefit of high speed Internet only by having a computer system or any other instrument with a BPL modem, entering it into the electric plug.

-PLT Modems: such modems can be linked to the existing local networks and connect a large number of users to the Internet simultaneously, however, this property is especially effective for the small companies. Also, this type of modem, at home, can make the ordinary electric plugs become point of connection to high speed Internet and VOIP system.

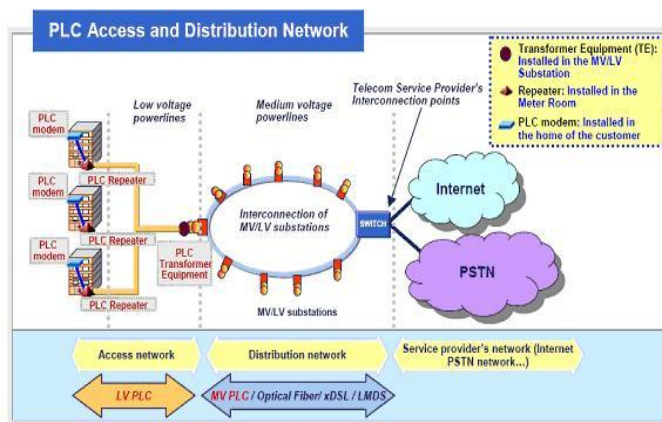
Picture 6, illustrates the way of connecting the access network and home network, and some of the modern applications of PLC such as managing the electric energy, controlling and supervising the home appliances remotely, and measuring the consumption rate of electricity, power, gas, and so on. In the picture, the gateway (the entrance gate from outside) is the tool that connects the home network and larger communicative network, out of building telecommunications links, (Alfredo Vaccaro, 2004).



**Picture 6: The way of home network and greater communicative network connection (out of building telecommunications connections)**

**Connecting the Networks Presenting the Internet and Network Services:**

In some points of the PLC distribution network, it seems necessary to establish connections to service-delivering networks so as to facilitate the access to the Internet and telephone services. As illustrated in picture 7, the Internet and telephone network has been injected into the medium voltage distribution network by a switch. Other added value services such as pictorial and multi-media services can be added to this section of the network, and be at the service of the subscribers directly by the operators presenting PLC. In pictorial services such as cable TVs or HDTV in which the video pictures are sent as Real Time, no new cabling to transfer information is needed.



**Picture 7: The way of the Internet and PSTN to the PLC network**



### **Review Article**

Use of existing infrastructures (incumbent power network) allows to have broader coverage in comparison with other kinds of technologies. Moreover, its quick and easy installation and development within the field of the home appliances, its less and lower expenses as compared with other cable services, and its capability of carrying and transmitting information coupled with providing services with considerable broadband are all taken into account as merits of the PLC technology. However, other technologies such as the optical fiber, Satellite, and wireless are now in their adolescence period and are invested with the capability of being established and used in the country. But, it should be noted that such factors as merits, demerits, and existing problems of application can show the superiority of one method to the other. Of course, in some cases, the mentioned methods are not changeable in place of each other considering that day by day new technologies come into vogue. The PLC technology has been earlier used at the level of transmission network and is now being applied at the home level. Therefore, there is no problem absorbing and accepting such a technology in various parts of the power network. . Although the PLC application with high pressure power lines dates back for couple of decades, nowadays, it is being commercialized at the home levels and access to developed services like high speed Internet, and telephone contact via power lines and smart networks. Samples of PLC uses are experienced in the Europe and America. In general, viewing the life time of the PLC technology, considering the above-mentioned subjects, and also the recent developments in this technology at the low and medium voltage levels into account, it is concluded that this technology can be used and stabilized as a compound method together with other technologies at the home and access levels. In case of this technology's entering into Iran, it is hopefully possible to appropriately standardize it, and optimally install and operate it so as to effectively invest on it giving a longer life time to it.

### **REFERENCES**

- MorkB. A., et al.,(2005).** Power Line Carrier Communications System Modeling, International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June,19-23, Paper No IPST05 – 247.
- G Duval .,(1997).** Ap K.H.plications of power line carrier at Electricity de France", Internat. SymK.H.p. on Power Line Comms and its Applications pp76-80, Proc IEEE Std. 643-1980, IEEE Guide for Power-Line Carrier Application
- Newbury J.,(1998).** Communication requirements and standardsfolow voltage mains signaling, IEEE trans. on Power Delivery, Vol 13 no 1, pp 46-49 , Jan
- K Dostert,(1997),** "Telecommunications over the Pow Distribution Grid- Possibilities and Limitations" ,Proc1997 Internat.Symp. on Power Line Comms and its Applications pp1-9
- ZuberiK.H.,(2003).** Powerline Carrier (PLC) Communications Systems , Master of Science in Internetworking- MS Thesis, Royal Institute of Technology, September
- M HosonoM et al,(1982),** "Improved Automatic meter reading and load control system and its operational achievement",4thinternational conference on metering, apparatus and tariffs for electricity supply pp 90-94, 26-28, IEE , October
- Paul T.,(2003).** Technology Review of Powerline Communications (PLC) Technologies and TheirUse in Australia" , The Department of Communications, Information Technology and the Arts ,
- Alfredo Vaccaro, Domenico Villacci,(2004),** "Performance analysis of low earth orbit satellites for power system communication" , Power System Research Group, University
- Department of Engineering,(2009).** AprilDabbagh Information Technology, "Powerline. broadband", PC Magazine M&NE, communications - Electrifying the