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Use of Power Line Communication Technology in Local Networks in Comparison with Twisted-Pair Cable Networks.

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ABSTRACT
This work aims to analyze the feasibility of using PLC – Power Line Communication technology in local networks in comparison with UTP twisted pair metallic cable. The study covers PLC technology for indoor access. In the run of the research is a brief introduction on the PLC and on the technology of data transmission through metal cables of twisted pair UTP, telling a little of its history, operating principles, categories and types of existing cables. The focus of the research is to analyze the feasibility of using PLC technology in local networks where the passage of metallic twisted pair cables is not possible or feasible due to existing physical barriers and among others, as for example pipelines for The passage of the crowded cables or distance between the parties to be intertwined. For this conclusion, a case study was carried out on a laboratory bench analyzing and comparing the two technologies through the HTTP, full page HTTP, ping for Gateway, RDP and speed tests. According to the research, PLC technology is shown to be effective, and it is concluded that it is feasible to use PLC in local networks.

Keywords - Power Line Communication. Broadband Power Line. Internet in the grid. UTP twisted-pair cables.

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I. INTRODUCTION

The Power Line Communication or PLC as it is known arose around 1920 with the idea of using the electrical network as a means of transmitting data, however it was only in 1988 that the researches in order to transmit this data there are high rates of speed takes It is possible to perform the transmissions from 1991. At the time the technology gained prominence on the world stage and brought with it the idea to solve the problems of Internet access in the last mile.

The projects and studies with PLC technology in Brazil emerged on a large scale in the year 1998, and in the year 2001 was implemented the pilot project CEMIG, this provided access to broadband Internet through the secondary network of electrical distribution. In 2003 the results of the project were published and showed that the higher the energy load of the network, the greater was the degradation of users ' access, and the creation of filters to control possible sources of interference was necessary. In the year 2002 was implemented an innovative project in Santa Catarina by Iguaçu power distributor.

The project aimed to pass the Internet and voice communication over the power grid, but the data were compared to project results were never revealed. In 2003, COPEL, an electricity company in the state of Paraná, also started a project leading the broadband internet via electricity to about 50 households in the Curitiba region. According to company data, the results of the teaching process so far show that broadband transmission via the power grid is feasible, but the cost of deployment is 50% higher compared to ADSL technology.

Nowadays Brazil stands out throughout Latin America through the Federal University of Juiz de Fora, which conducts research around PLC technology for implantation in residential and industrial scenarios. The research has returned positive results, since it was developed a transmission system that fits the electricity networks and manages to guarantee a high rate of data transfer and a high quality in the service even with adverse conditions.

PLC technology around the world is maintained in studies and projects that are currently continuing to improve and standardize technology, and to verify the various forms of integration with other existing technologies. In 2014, a total of more than 100 initiatives were detected in PLC covering more than 40 countries and 600 companies. (Annex 1). Among all the projects that have been and are being carried out around the world, it was found that:

• PLC activities on the electrical infrastructure do not affect the electrical service and were executed without incident;

• Technology proved ready for commercial deployments;
• PLC services were commercially implanted as broadband Internet access and voice over IP with great acceptance of users;
• PLC over medium voltage is becoming one of the main options for distribution network;
• Each passing year, PLC shows to be a competitive technology when compared with other access technologies;
• Utilities providers around the world are departing for commercial initiatives.

In view of this scenario, the feasibility of using PLC technology in local networks in comparison with UTP twisted pair metallic cable is presented as a research problem.

The general objective of this work is to analyze the feasibility of using PLC in local networks in comparison with UTP twisted pair metallic cable. As a specific objective, to analyze the feasibility of using the PLC for interconnection between two points in a local network where it is not possible to pass a metallic cable of UTP twisted pair, without the loss of quality in the Internet service, data transfer. For this purpose, a laboratory bench analysis is performed simulating the possible existing scenarios and verifying the feasibility of using the PLC in the interconnection of the network through some tests.

The present work is justified by analyzing the feasibility of using the technology to be used commercially in an Internet provider, for use in residence where for structural reasons it is not possible to pass UTP metallic cables, often Limiting internet access to some points of residence.

The work was developed in six chapters, being the first and the last for introduction and final considerations. The second chapter discusses the PLC technology, telling a bit of its history, working principle, some features and more common applications. The third chapter treats the metallic cabling of twisted pair UTP, also telling a bit of its history, working principle, some of the categories of cables found in the market today. The fourth chapter encompasses the research methodology, characterizing it and showing the methods used for data collection. The fifth chapter exposes the analysis of the data, showing clearly the results obtained with the research.

II. POWER LINE COMMUNICATION

This chapter is addressed the bibliographic review of PLC technology, as well as its definition, history, working principle and main applications.

2.1 ABOUT TECHNOLOGY

Power Line Communications or PLC as it is known, is the technology that makes use of the electrical network as a physical medium for transporting data signals.[1]

According to the National Electric Power Agency (2009) [2], Power Line Communication is a system that allows the transmission of signals from internet, voice, video and digital and analog communication through the electrical network.

Despite being a somewhat old technology, the same is gaining prominence by virtue of solving the problem of the so-called "last mile" of the Internet, that is, it manages to bring connection to areas of difficult access, which do not achieve connections with networks. The broadband PLC technology is also called BPL (Broadband Power Line).[3]

2.2 HISTORY

Initially, the idea of the PLC dates to 1920, when the first proposals were created to use carriers to perform communication in high-voltage networks, using analog modulation in the range of 15 to 50 kHz. [4]

However, it was only in 1930 that the first technique that made possible the use of the electricity grid to transmit data was created. Ripple Control (RC) was born, which aimed to transmit low frequency control signals (0.1 to 0.9 kHz), allowing communication at small rates and high power. This technology was employed until the mid-80 years, allowing a unidirectional communication, being used to perform small tasks such as activating public lighting, telemetry systems, remote control and voice communication. [5]

Already in the decade of 80, some companies in Europe began conducting research to analyze the characteristics of the electrical network and the capacity of this as a communication channel. Among the various tests performed, it was found that the ranges from 5 to 500 kHz were those that had a better usability potential, taking into account mainly the signal-to-noise ratio and the signal attenuation. [1]

In 1988 it was created the first prototype of a modem that through the Spread Spectrum modulation technique or spectral scattering that could transmit data at rates of 60 bps at a distance of up to 1 km. However, it was only in the decade of 90 that the first Systems capable of conducting communication in a bidirectional manner. [6]

In 1991, high-speed communication tests were initiated in England. In 1997, the two major electric power providers from England to Norway and Nortel announced that problems caused by noise or interference had been solved and that Internet access tests were being conducted using Developed technology. [7]

Thus in 1998 emerged the Digital Power line, which was a form of innovative business in the area of telecommunications, and due to the success of the initiative in 1998 Notel and United Utilities constituted a partnership to commercialize technology and take over the new Developments in PLC, then the Nor. Web DPL is created. ([6]

In June 1998, UTC (United Telecom Council), which brings together the electric power utilities, prepared the first PLC forum with 3 Committees: technical, regulatory and commercial. Subsequently, two other forums were held. [1]

The monitoring of developments and advances in Power Line Communication technology was done at the time, in Brazil, by the GCOI Communications Subcommittee, and APTEL, which was created in April 1999, held its first seminar in September 1999, with the Theme: Power line Communications Technology, remembering that in Europe in 1997 was created the PLC Forum and, in 1998, UTC launched in the USA the Power Line Telecommunications Forum (PLTF). [8]

In 2000 some companies in Brazil start testing with PLC technology, some continue to this day, as is the case of COPEL in Paraná. [9]

2.3 OPERATING PRINCIPLE

The principle of operation of PLC technology, consists of overlapping a high frequency signal (MHz), over the 60 Hz arranged in the mains. [10]

According to Malathi, (2007) [11], this signal is transmitted over the wires of the low and medium voltage networks. The signal transmission over alternating current lines is difficult by several factors, among which we can highlight:

• The existence of noise and non-predictable interference, determined by opening and closing circuits, equipment coupled to outlets, etc.

• Irradiations of the frequencies transported in open lines, without any form of shielding, with high potential for interference of systems that act on the same frequencies.

• The topological characteristics of the electrical power distribution lines (open lines, non-linear characteristics, derivation stocks along the entire line, transformers, etc.)

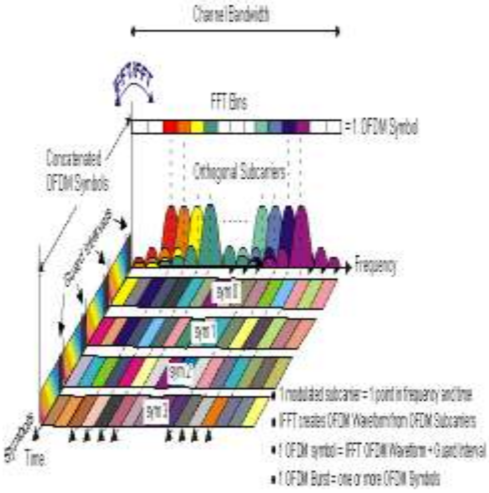
There are ways to reduce these constraints thus allowing the correct functioning of the technology, making the use of some types of modulation and multiplexing. In general PLC Systems, the Frequency Division Multiplex (FDM) and modulation of the Orthogonal Frequency Division Multiplex (OFDM) are used as forms of multiplication. [1]

According to Pinto and Albuquerque (2002, p. 1) [12], The OFDM technique consists of the parallel transmission of data in several subcarriers, with QAM modulation or PSK and transmission rates per subcarrier as low as the number of these employees.

In order to minimize the effects of selectivity in frequency, generated by the hostility caused by attenuation, by dismarriage of impedance along the line and by the noise existing in the electrical network, such division is carried out so that the time of a Certain symbol to be transmitted in each substring is greater than the multipath scattering of the PLC channel. (figure 1) This increases the robustness of the multicarrier system in the face of interference between OFDM symbols. [13]

The OFDM transmission technique (Orthogonal Frequency Division Multiplex) is a special form of multicarrier modulation consisting of the parallel transmission of the data modulating several densely spaced carriers whose frequencies are in order to maintain mutual orthogonality.

Figure 1. Separation of carriers in frequency and time.



Source: BAPTISTA, 2008 [23]

2.4 TOPOLOGIES AND APPLICATIONS

The use of PLC networks with different topologies depends on the application and should be evaluated taking into account a number of aspects such as the needs of the chosen place, the business model to be applied, besides being in agreement with the Regulatory aspects in force. For Vidal (2005) [14]. We can classify the technologies of application of PLC systems in three large groups: a) Indoor PLC topology; b) Topology for access in the last mile; c) Topology for WAN access;

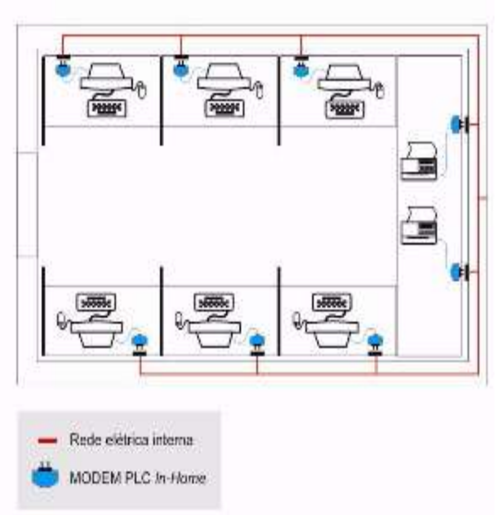
2.4.1 INDOOR PLC TOPOLOGY

This model consists of the electrical distribution network in the low voltage installations, and the modems that will be used to connect the equipment that will be interconnected.

Succinctly this model goes from the user's power meter to the sockets inside the residence.

Numerous modems may be connected to the various power outlets available in a user installation. [15]
Figure 2 illustrates an example of applying Indoor technology to compose a small LAN network, linking some workstations and peripherals in an office.

Figure 2. IN-HOME PLC topology.

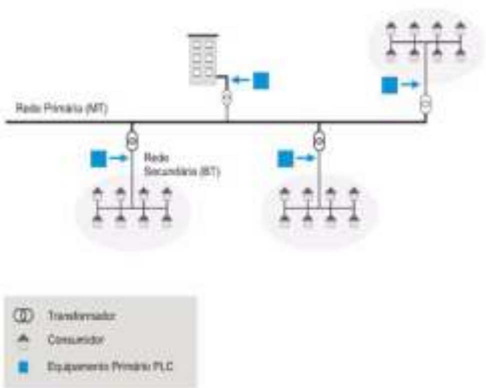


Source: ROSA, 2012.

2.4.2 TOPOLOGY FOR ACCESS AT LAST MILE

In this application the PLC network extends its limits beyond the internal electrical network of a specific location, generating several smaller sub networks. In this type of topology, the PLC signal is coupled to the low voltage networks after the distribution transformer, so that all users of this network have access through MODEN's medium. Figure 3 illustrates the application of PLC technology according to the last mile concept.

Figure 3. Topology application PLC access last mile.

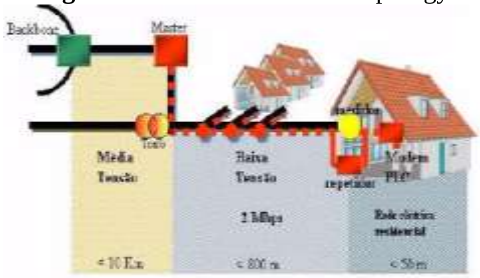


2.4.3. TOPOLOGY FOR WAN ACCESS

The technology applied to WAN networks is used when you need quick access to a medium that can be the Internet, or any other, where a signal from a service provider through an optical fiber, cable modem, or even a medium PLC solution Voltage, extends up to a PLC server equipment, where it makes the distribution of the signal using the low voltage network to all users who are connected to this transformer, the client receives the signal in the electrical power outlet and with the aid of the PLC modem Filters the frequency signals. [16]

With the increase of the distance between each client and the transformer, it is necessary to use a repeater, as can be seen in figure 4.

Figure 4. PLC WAN Access topology



Source: ROSA, 2012.

III. UTP TWISTED PAIR METALLIC CABLE

In this chapter will be approached the bibliographic review for the data transmission technology via UTP twisted pair metal cable, also telling a bit of its history, operating principles, applications, categories and types of existing cables.

3.1 ABOUT TECHNOLOGY

Twisted pair metallic cable is a type of cable that has a pair of wires interlaced one around the other to cancel electromagnetic interference from external sources and mutual interference (cross line or, in English, crosstalk) between cables Neighbors. [17]

For Torres, (p. 504 2014), the twisted-pair name is very convenient, as these cables consist of precisely 4 pairs of interlaced cables. Coaxial cables use a metal mesh that protects the data cable from external interferences, as already cited twisted pair cables use a more subtle type of protection: The cable interlacing creates an electromagnetic field that offers a reasonable External interference protection.

Unshielded Twisted Pair – UTP or unshielded twisted pair is the most widely used in both domestic and large industrial networks due to easy handling, installation, allowing transmission rates of up to 10 Gbps with the use of the CAT 6 cable and CAT6e. Its structure is of four pairs of wires intertwined and coated with a PVC cover and support distances of up to 100 meters. [17]

In Ethernet networks the unshielded twisted pair cables are called 10Base-T, 100Base-T, 1000Base-T or 10GBase-T. The term "Base" indicates the "base band" supported by the cable and the term "T" indicates "twisted Pair". [9]

3.2 HISTORY

In the years 90 it was very common to find computer networks using coaxial cables of 50 Ohms. This was due to ease of installation and connection of the coaxial cables, since they used connectors similar to those of TV and could be installed in any location without suffering any type of interference. [18]

The coaxial cables used at the time were very limited, both in the speed issue, reaching the maximum transfer rate of only 10 Mbps, as in the distance, which can be up to 15 meters. [9]

With the massive increase in computer networks and the need for a high data transfer rate, Bell Laboratories in response to the limitations of coaxial cables created the four-pair UTP cable, which supported a data throughput of up to 20 Mbps. [17]

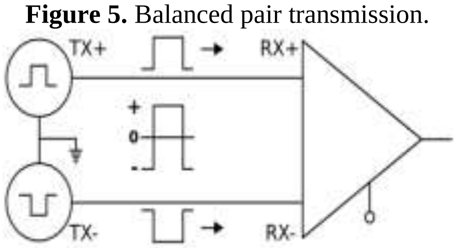
UTP Twisted pair metal cables have evolved over time and currently allow data transfer rates of up to 10 Gbps and support distances of up to 100 meters. [9]

3.3 OPERATING PRINCIPLE

A pair of twisted wires creates a virtual spiral with capacitance and inductance, sufficient to go cancelling external noise through multiple expires, that is, the magnetic field formed by the spiral X, is the inverse of the spiral Y, and so on. If the cable suffers interference at any given time, it will be annulled in reversing the spiral poles. [18]

To potentiate the effect of electromagnetic shielding, the network cards use the transmission system “Balanced pair ", where, within each pair, the two wires send the same signal (and not separate transmissions, as generally thought), but with the Reversed polarity. For a bit “1 ", the first wire sends a positive electrical signal, while the other sends a negative electrical signal. That is, the second wire is used to send an inverted copy of the transmission sent through the first.

Figure 5. Balanced pair transmission.



Source: MORIMOTO, 2013.

3.4 CATEGORIES OF UTP CABLES

According to Torres (p. 507, 2014), the metallic twisted pair cables were categorized by EIA/TIA-568-B and were divided into six categories, considering the safety level and the wire gauge.

According to Morimoto (2013) The metallic twisted pair cables have two more categories not recognized by EIA/TIA, which includes the category one and two cables which were names given by the company Anixter and with category seven cables, which is an informal name for ISO class F cables.

For Torres (p. 508, 2014) The existing categories are currently:

1. Category 1 (Anixter level 1);
2. Category 2 (Anixter level 2);
3. Category 3 (ISO class C);
4. Category 4;
5. Category 5;
6. Category 5e (ISO class D);
7. Category 6 (ISO class E);
8. Category 6a (ISO class EA);

IV. RESEARCH METHODOLOGY

To achieve the objective of analyzing the feasibility of using PLC technology in local networks in comparison with metallic twisted pair cable, the following methodological procedures were stipulated.

The research was characterized as explanatory, because it is concerned with identifying the factors that determine or contribute to the occurrence of the phenomena. According to Gil (2010) This type of research explains why things through the results offered.

From the point of view of the approach of the problem, the survey is quantitative. According to Diehl (2004) [24], quantitative research uses the use of quantification, both in the collection and in the treatment of information, using statistical techniques, aiming at results that avoid possible distortions of analysis and Interpretation, enabling a greater margin of safety.

In relation to the objectives, this research is classified as exploratory. According to Tachizawa (2006), [19] the realization of the exploratory study allows the gathering of elements capable of subsidize the chosen theme.

Exploratory research is part of the process within a scientific study, which has as its purpose, according to Andrade (2005), [20] "facilitating the delimitation of a work theme; Define goals or formulate the hypotheses of a research or discover a type of focus to work. "

From the point of view of technical procedures, the research is experimental laboratory because it seeks to analyze and identify through experiments done on laboratory bench as certain phenomena occur. The author Fonseca (2002, p. 38) [21] defines how to: "The experimental research selects groups of coincidental subjects, submits them to different treatments, verifying the strange variables and checking whether the differences observed in the answers are statistically significant. [...].

The observed effects are related to the variations in stimuli, because the purpose of the experimental research is to apprehend the relationship of cause and effect by eliminating conflicting explanations of the discoveries made".

For Gil (2010), [22] the experimental research consists of determining a study object, selecting the variables that would be able to influence it, defining the forms of control and observation of the effects that the variable produces in the object.

4.1 EXPERIMENTAL PROCEDURE

Aiming to evaluate and arrive at results demonstrating the feasibility of using PLC technology in local networks in comparison with metallic twisted pair cable made if the use of laboratory bench tests using two distinct scenarios, the first being a Local network that works through PLC technology and the second a wired local network.

It was decided to use two scenarios that simulate the most common adversities of everyday life, to verify if in practice would be really feasible the use of PLC technology in local networks for an interconnection between two points within the same residence, where a twisted-pair metallic cable could not be used, for example in a residence where it is not possible to pass a twisted pair metal cable because the passage ducts are obstructed or filled. Each scenario went through 5 tests, being they HTTP, full page HTTP, ping to network Gateway and RDP. The last test performed in each scenario was a test to assess the speed of the Internet link, in order to check if there could be abrupt variations in each scenario.

To measure speed, the speedometer of the site www.speedtest.copel.net was used, a site that was nationally conceptually designed to perform speed tests.

All tests performed in both scenarios, except for the speed test, lasted twenty minutes and were performed at the same time, and data were collected for three consecutive days, each test being repeated three times, in order to Analyze the variation of the results measured.

The velocity test was performed five times during the period of the tests, making an average of the velocity measured at the end.

For the control and monitoring of the tests, the PRTG Monitor software was used. The PLC equipment used were indoor adaptors of the Solimax 85 brand, which second manufacturer support a band up to 85 Mbps and distance up to 300 meters.

4.1.1 SCENARIO 1

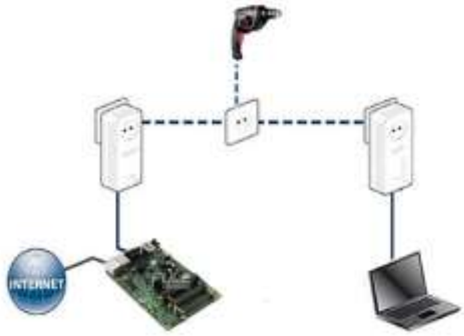
In this scenario, a LAN network was mounted on a laboratory bench and its interconnection by PLC was performed, simulating a residence where it is not possible to pass a twisted pair metal cable from one room to another.

We used to compose the scenario a RouterBoard 433 AH that receives a link of 3 Mbps Internet and is passed to the other room via electrical network, through two Solimax PLC adapters, operating on an electrical network with voltage of 220 volts, and in time of the tests was connected to the same electrical power network a drill of 500 Watts, thus provoking a possible means of interference and applying a load of use in the mains.

It was also used in the composition of the scenario a notebook SonyVaio, Core I5, with 4 GB of memory, for communication with the internal network and data monitoring, since the PRTG software was installed on it.

The figure 6 below demonstrates the network assembly diagram.

Figure 6. Scenario 1



4.1.2 SCENARIO 2

In this scenario, a LAN network was also assembled in a lab bench, but the interconnection of the rooms of the residence is made through a widely used medium, a twisted pair metallic cable.

The composition of the scenario was a RouterBoard 433 AH that receives a link of 3 Mbps Internet and a metal cable of UTP twisted pair category 5e of the brand Nexans for interconnection of the rooms. It was also used in the composition of the scenario the same notebook Sony Vaio, Core I5, with 4 GB of memory, also for communication with the internal network and data monitoring, since the PRTG software was installed on it.

The figure 7 below shows the network assembly diagram.

Figure 7. Scenario 2

4.1.3 TESTS PERFORMED IN SCENARIOS 1 and 2

In this section will be presented the description of the tests performed in Scenario 1 and 2 regarding the observation of the following parameters: Ping for Gateway; HTTP; Full Web page HTTP; RDP; Speed test;

4.1.3.1 PING TO GATEWAY

Ping is a utility that uses the ICMP protocol to monitor connectivity between equipment. Its operation consists of sending packets to the target equipment and "listening" responses, and these responses are obtained in milliseconds. The smaller the result obtained for this parameter, the better the network is understood.

As can be seen in figure 8 and 9, the graphs of the established period were obtained by means of software, indicating the behavior of the parameter in both scenarios. The graph below brings the variable in question, in this case the PING for Gateway, in the time domain (20 minutes) on the horizontal axis, and response time on the vertical axis.

Figure 8. PING parameter for gateway with UTP cable.

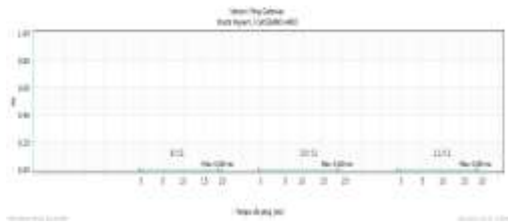
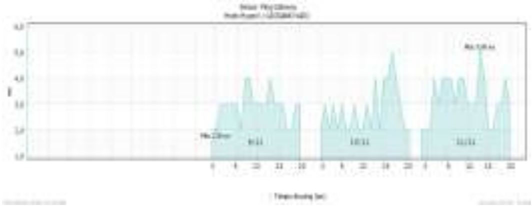


Figure 9. PING parameter for Gateway with PLC.



Data were obtained through monitoring with PRTG software in a 20-minute period.

Monitors a WEB server using Hypertext Transfer Protocol – HTTP. The HTTP protocol uses the client/server model, such as most network protocols, based on the request and response format, and in this parameter the response is also obtained in milliseconds.

4.1.3.2 HTTP

The chart below brings the variable in question, in this case HTTP, in the time domain (20 minutes) on the horizontal axis, and response time on the vertical axis.

Figures 10 and 11 below bring the HTTP variable, in the time domain (20 minutes) on the horizontal axis, and response time on the vertical axis.

Figure 10. HTTP parameter with UTP cable.

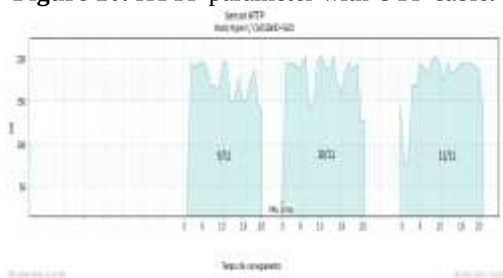
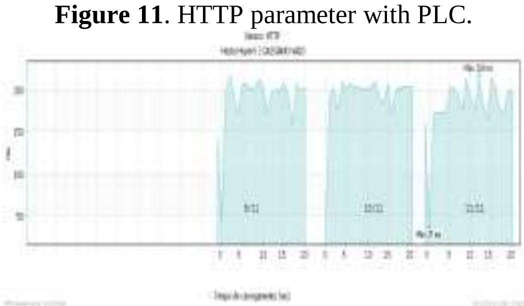


Figure 11. HTTP parameter with PLC.



4.1.3.3 FULL PAGE HTTP

This parameter works the same way as the previous one, but the time count is given depending on the full loading time of a webpage, including images, videos, etc. The response time of the parameter is also in milliseconds.

Figures 12 and 13 below bring the full-page HTTP variable, in the time domain (20 minutes) on the horizontal axis, and response time on the vertical axis. The page chosen as the parameter for download was the website of UFSC (www.ufsc.br).

Figure 12. Full page HTTP parameter with UTP cable.

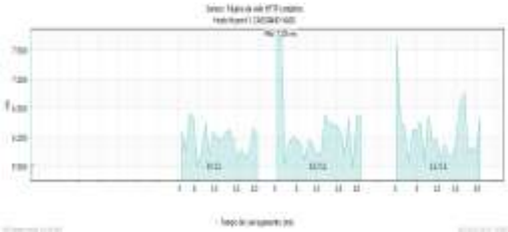
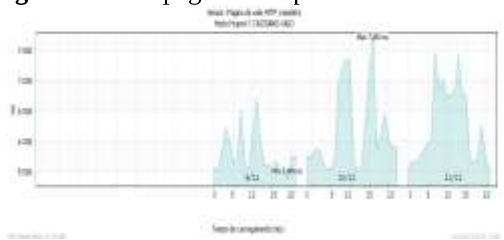


Figure 13. Full page HTTP parameter with PLC.



4.1.3.4 RDP

Remote Desktop Protocol is a multichannel protocol used for a user to connect to a computer running Microsoft Terminal Services. A multi-channel capability protocol provides separate virtual channels for the transport of presentation data, serial device communication.

The response time of the parameter is in milliseconds, and the shorter the response time, the better the speed and reliability of the RDP protocol. Figures 14 and 15 below bring the RDP variable, in the time domain (20 minutes) on the horizontal axis, and response time on the vertical axis.

Figure 14. RDP parameter with UTP cable.

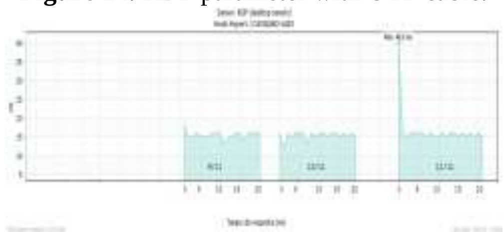
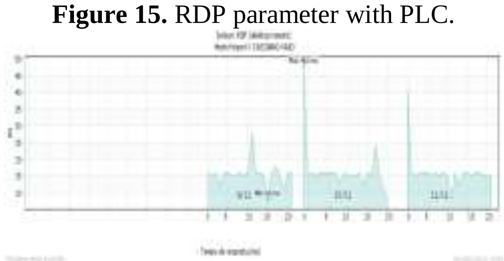


Figure 15. RDP parameter with PLC.



4.1.3.5 SPEED TEST

The speed of the band available at the time of testing was measured using the Speed Test Copel Web meter. In this test, the velocity was measured at three times during the previous tests, and a bandwidth of 3Mbps was available for download and 0, 5Mbps for upload, but in the tests only the download was used as parameter considered to be Measured. Below Figure 16, shows the moment when the speed was being measured by the speedometer of the Speed Test Copel.

Figure 16. Speed Test Copel.

The data were obtained by means of the velocity measured at the following times: 20:00, 20:05, 20:10. 20:15, 20:20, comprising an interval of 5 minutes between each measurement, thus accompanying the other tests that were being monitored via software.

V. PRESENTATION AND DATA ANALYSIS

The objective of this chapter is to analyze the data obtained from experiments carried out in a laboratory bench in scenario 1 and 2, in order to analyze the viability of PLC technology in local networks. Below we present the results of the PLC technology for Scenario 1. The results will be prepared for each parameter, according to the five Tests performed, tracing a comparison between the technologies used.

5.1 PING TO GATEWAY

We observed that, in figures 17 and 18, the response time obtained in the communication test with the network gateway using the UTP twisted pair metal cable was lower than using PLC, but the difference is not significant comparing the two technologies. Therefore, the response time of PLC technology in this condition is considered satisfactory and did not compromise the data transmission at any time.

Figure 17. PING parameter result for gateway

PLC x UTP						
		TIME				
PARAMETER (ms)		0 min	5 min	10 min	15 min	20 min
PING GATEWAY	UTP	0	0	0	0	0
	PLC	2	3	3	3	3

Figure 18. Test result PING parameter for gateway

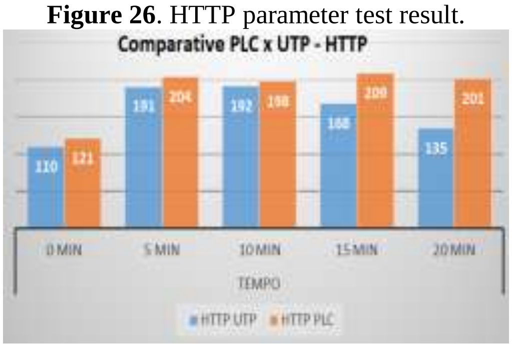
5.2 HTTP

As shown in figures 19 and 20, the PLC technology remained with a higher response time compared to UTP twisted pair cable, but the response time after five minutes became almost constant, as the cable passed. by some swings. Thus, we can conclude that even with a longer but not significant response time, there was also greater stability, thus proving that PLC technology is satisfactory for HTTP transmissions.

Figure 19. Result HTTP parameter.

PLC x UTP						
		TIME				
PARAMETER (ms)		0 min	5 min	10 min	15 min	20 min
	UTP	110	191	192	168	135
HTTP	PLC	121	204	198	209	201

Figure 26. HTTP parameter test result.



5.3 FULL PAGE HTTP

In figures 21 and 22 PLC technology outperformed the full-page load, taking less time to download the full page. Although not a significant difference from the UTP twisted pair cable, the technology proved superior during most tests, thus proving its effectiveness.

Figure 21. Result full page HTTP parameter.

PLC x UTP						
		TIME				
PARAMETER (ms)		0 min	5 min	10 min	15 min	20 min
	UTP	7,141	5,911	5,881	5,929	6,256
HTTP Full Page	PLC	5,632	5,784	6,378	5,654	5,673

Figure 22. Full Page HTTP Parameter Test Result.

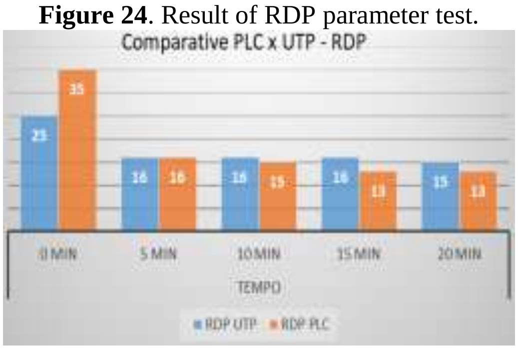
5.4 RDP

In figures 23 and 24, PLC technology was superior during most of the testing progress, except at the beginning of the tests when the PLC network took longer to transfer data from the RDP protocol. The difference between the two technologies was not significant, but we can see that PLC technology proved to be effective in transmitting data via RDP, so it would not affect remote desktop transmission in real time.

Figure 23. RDP parameter Result.

PLC x UTP						
		TIME				
PARAMETER (ms)		0 min	5 min	10 min	15 min	20 min
	UTP	25	16	16	16	15
RDP	PLC	35	16	15	13	13

Figure 24. Result of RDP parameter test.



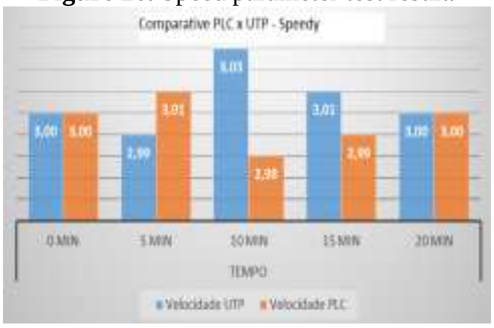
5.5 SPEED TEST

Figures 25 and 26 show us that from the measured speeds the two technologies had small oscillations of the measured band, but nothing very significant and that could make the use of the technologies impossible. Overall the two technologies remained constant and managed to traffic the bandwidth that was available, in this case 3 Mbps. Thus, we can conclude that despite the small oscillations, PLC technology proved to be satisfactory for internet bandwidth transport.

Figure 25. Result parameter speed.

PLC x UTP						
PARAMETER (Mbps)		TIME				
		0 min	5 min	10 min	15 min	20 min
Velocity/speedy	UTP	3,00	2,99	3,03	3,01	3,00
	PLC	3,00	3,01	2,98	2,99	3,00

Figure 26. Speed parameter test result.



VI. FINAL CONSIDERATIONS

Usually when we think of Internet under electrical network we think of something futuristic, out of our reality, but as can be seen with the development of work, it is something real and present in our daily life, but still very little used, both by Physical and structural issues (precarious electrical networks), regulatory (it is still a technology not regulated by the competent organs) and also due to lack of technical and scientific knowledge, because there are several researches in the area , we still lack specialized technical knowledge for application.

However we can emphasize that despite all the obstacles that are present in the path of PLC technology, the same as can be seen through the development of this work is shown increasing and each day that passes gains more adherents, these willing to To make it one of the new means of data transmission.

Through the development of this research it is concluded that the PLC technology is feasible for use in indoor scenarios, in LAN networks, when compared with metallic twisted pair cable.

The technology can be used to link between two points where the passage of metallic twisted pair cables is not possible, as proposed in the study. As we can observe the technology behaved very well, remained stable, did not show any type of loss and in some moments showed superior to the metallic cable of twisted pair.

In a general comparison it was shown to be effective for use in LAN networks, thus achieving the general objective proposed in this work.

In addition to the results obtained the technology has other advantages that we can bring in contact for deployment in local networks, as for example to use the physical structure already existing on the site, since it uses the electricity network to transmit the Data. However, this should be one of the points to be observed at the time of the implementation of the technology, because once we have a poor-quality electrical network, the PLC service will also have a lower quality.

The PLC technology is growing and developing every day that passes, and as already highlighted in the work currently there are several companies around the world that seek to improve the quality of this technology and who knows not to solve problems in scenarios indoors as Was the case of research, but rather in outdoor scenarios, leading to Internet access to the last mile, and performing digital inclusion in these areas, making us increasingly connected.

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