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Feasibility of Power Line Communication in Bangladesh and Analyzing The Power Spectral Density of Colored Background Noise

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Abstract

Power line communication is a technology which can provide internet services by using conventional medium voltage (MV) and low voltage (LV) electrical wire. In this paper it is shown that the economic benefits of power line communication (PLC) more than optical fiber technology. The cost efficiency of PLC over optical fiber for a certain area is statically analyzed .The power spectral density of background color noise for residential and industrial area has been also analyzed using MATLAB. Comparison shows that PLC is a cheaper technology than optical fiber communication. Due to the nature of the distribution, installation time is also lower. The vision 2021 of spreading internet services all over Bangladesh can be easily and cheaply achieved if power line communication is used.

Keywords: Power Line Communication, Power Spectral Density, Noise, Broadband internet, Colored Background Noise

1. Introduction: Information is the most important resource of the world right now. Internet is the biggest source of getting information. Two types of technologies are used to connect with internet namely wireless communication and wire line communication. Wireless Communication has been more popular to the people of Bangladesh. But customers have to pay more for the service and get a limited data package. On the other hand, Although Broadband wired Internet has no limitation of using data with better data rate and connection reliability, it is not popular because of high transmission cost and difficult distribution process.

Power Line Communication (PLC) can be a superior alternative solution to optical fiber based broadband internet services with minimized cost and easier distribution to spread broadband internet services into the rural areas in Bangladesh.

Power Line Communication is a method which is used to pass broadband internet through the conventional medium voltage (MV) and low voltage (LV) electrical line [1]. It is also known as Power Line Network, Power Line Communication Network, Broadband over Power Line. It has been deployed in USA, UK, China, Saudi Arabia, Canada, Hong Kong, South Africa, Spain, Egypt, Malaysia etc[1] and has been standardized by IEEE-1901, ITU-T 9960, CENELEC, ETSI [11].

PLC was first started in USA in 1905. In 20-30 decades of 1900s, it was used for telemetry supervision purpose by using AM and FM technique with 15-500KHZ frequency [1]. Later, Supervision Control and Data Acquisition (SCADA) was launched which provided voice transmission facility and used ASK, FSK technique in SCADA [1].

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Homeplug V1 could serve internet services with 1.4Mbps data transmission rate from 1997 by using Power Line Communication and Homeplug AV was the upgraded version which provided 200Mbps [1][2]. Recent advancement of PLC is Homeplug AV2 which can provide500Mbps-1Gbps data speed theoretically [10] and AT&T AirGigproject 2017 has offered 1Gbps speed [9]. Comparative cost analysis of different communication systems in 2014 was described in [1][2] and the data is updated in this paper. But the technology has certain weaknesses. Electrical Line damage causes internet disconnection and electrical line quality is also an issue. Noise from various sources [3][4], Attenuation [7], Radiated Power Loss [7], Security issues are also amongst other threats. Comparative cost estimation between Optical Fiber Communication and Power Line Communication for a particular rural area in Bangladesh is analyzed in this work.

Rest of the paper is organized as follows, the basic components of PLC are described in brief in section 2, Design of the PLC distribution network for the selected area of Bangladesh is explained in section 3, setup cost and data charges for PLC based internet services and Optical Fiber based internet services are compared in section 4 and 5. Analysis of Colored background noise is done in Section 6 and the work is concluded in Section 7.

2. Basic Components of PLC:

2.1. Injector: The injector converts light signal into electric signal over the medium voltage power line and vice-versa. Inside the injector there are transmitter and receiver sections as well as signal converter. The transmitter and receiver has different frequencies so that injector is able to perform full duplex transmission. [2]

2.2. Repeater: Power Line is very harsh. Consequently, attenuation is very high and data signal attenuates badly after 300-800m distance. To recover the problem, repeaters are used amplify the signal and push to next leg. [2]

2.3. Extractor: Extractor is also called Bypass box, Bridge. It plays an important role to transmit data signal because it has some functions such as data routing, managing subscriber information, Dynamic Host Configuration Protocol (DHCP), assignment of internet protocol address, encryption and symmetric data transmission to all electrical outlets [2].

2.4. Coupler: Data signal cannot pass through the transformer as the signal power is low. To bypass the low power signal, coupler is used. Couplers are set up with MV and LV line [2].

2.5. Modem/ Wi-Fi Router: Modem is used to collect data from electrical wire of house. It has high immunity to electrical noise persistence in the power line [2].

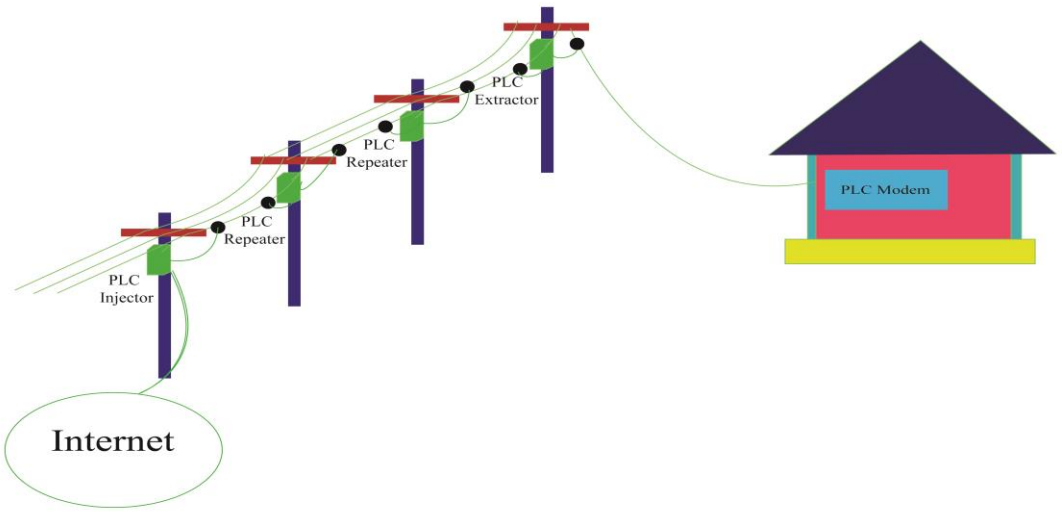

Fig 1: Basic Diagram of Power Line Communication [1]

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3. PLC architecture for selected area: In figure 2, the area is a rural area which is situated in Sonaichori Union, Sitakund Sub-district, and Chittagong district. The area is 0.3km^2[15] and 310 numbers of families live there. Each family is counted as a user in this survey. In figure 3, it is shown that, to establish PLC in the area, one injector, three repeaters, two pairs of couplers, and two extractors are needed. Internet service is coming from internet source (IS). The total distribution line is 2509m long and it has some branches. The distribution area has two MV to LV transformers. Extractors are used to bypass the two transformers.

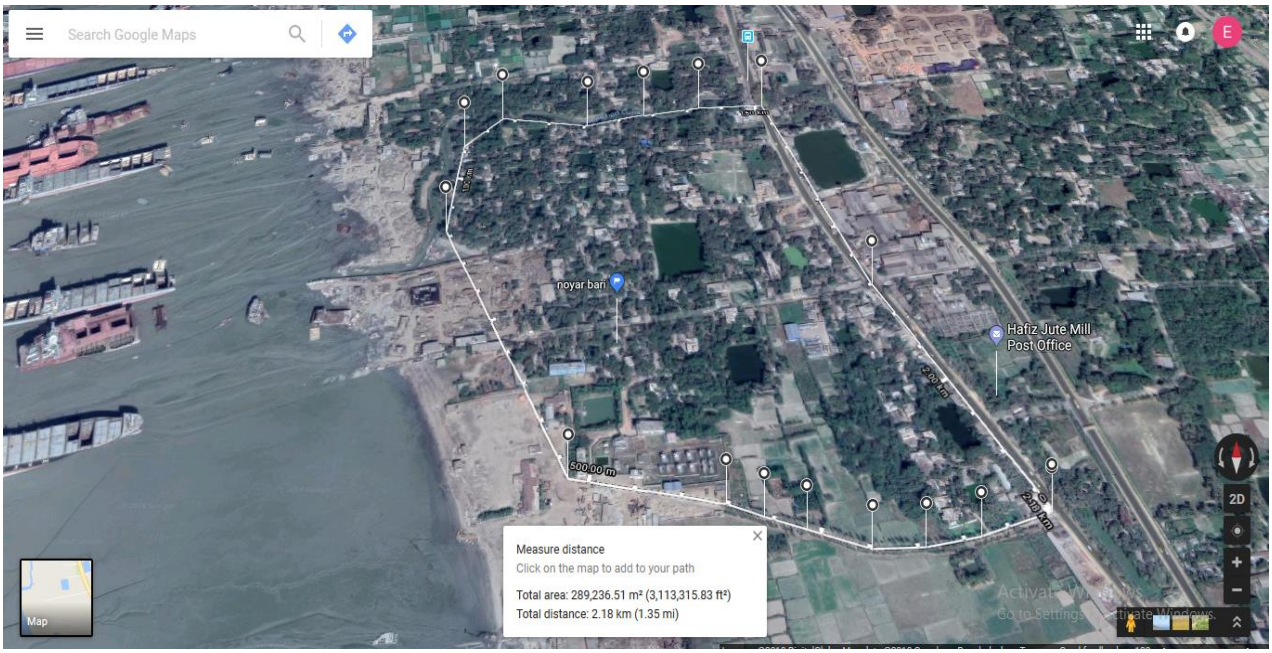

Fig:2 The area is selected for survey. 310 number of users in that area.[15]

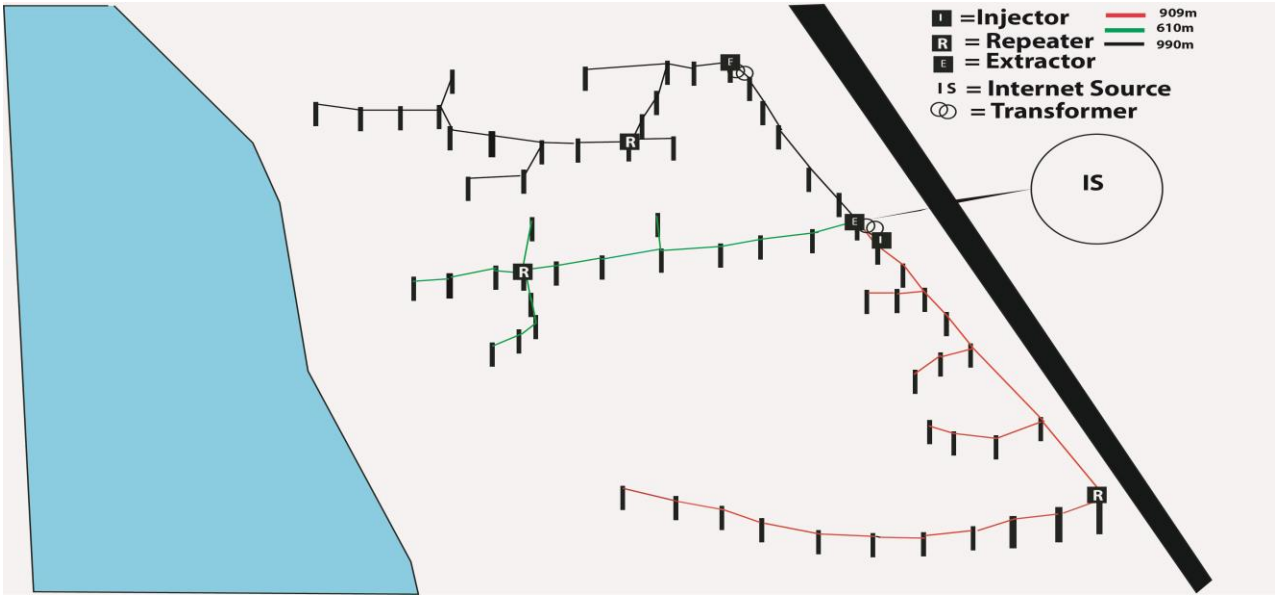

Fig 3: The figure is shown the electrical line and PLC equipment set up in that area. Injector is used to the MV line to push internet service. There has 2 transformers so that 2 extractors, couplers are needed to bypass the data signal. Power line of three different sides of the area is more than 500-600m. So that, three repeaters are used to amplify signal.

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4. Comparative Cost analysis for the area:

Table 1: Distribution cost of Optical Fiber Communication in the projected area

Equipment Name	Amount	Unit Price(tk)	Total Price(tk)	Remarks
Optical Fiber	5629m	16 [14]	90,000	Common & Users Line
UTP Cable	6200m	30 [14]	1,86,000	258 users need only UTP cable to be connected from switch
Switch	45pic	800 [14]	36,000	Eight port switch
Converter	52pic	1400 [14]	72,800	52 users distance is more than 60m.
			Total = 3,84,800	

Table 2: Distribution cost of Power Line Communication in the projected area

Equipment Name	Amount	Unit Price(tk)	Total Price(tk)	Remarks
Injector	1	56,000 [18]	56,000	In MV Line
Repeater	3	40,000 [5]	1,20,000	Amplifier
Extractor	2	12,000 [19]	24,000	Extract
Coupler	2 pair	24,000 [5]	48,000	Bypass data
			Total = 2,48,000	

ISP Company does not provide broadband internet facility into the rural areas because of high infrastructural investment. So that, people of that rural area are deprived of broadband internet. From Table1 and Table 2, it is clear that Power Line Communication is most cost effective in distribution purpose. For this reason, PLC can be a fine alternate to spread broadband internet in rural areas of Bangladesh.

5. Comparative data charge:

Table 3: Monthly data charge for different broadband service are shown [2]

Technology	SPEED	TYPICAL COST PER MONTH, 2018
PLC-Power Line Communication	3 Mbps to up to 5 mbps	900 BDT to 1500 BDT , Depending on speed and features.[2]
Cable—use of cable TV provider's coaxial or fiber-coaxial systems to transmit broadband signals.	256 kbps to 1.5 mbps	300 BDT to 1000 BDT , 15% Vat applicable to all charges connection charge :550 TK [16]
DSL—use of existing copper telephone wires to transmit broadband signal.	1.5 Mbps	1500 BDT to 2600 BDT[16]
Fibre (FTTx)—use of optical fiber lines to home (FTTH) or business (FTTB) to deliver broadband services.	3 Mbps to up to 5 mbps	900 BDT to 1500 BDT , Depending on speed and features.[13]
Satellite	500 Kbps	2600 BDT to 5300 BDT[2]
Wi-Max	3 Mbps	1500 [17]

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Table 3 is an updated data of comparison of broadband access technology of [2]. As ISP Companies will provide broadband services by using Power Line Communication technology, monthly charges for using broadband internet is assumed to be same as the optical fiber communication. Other broadband services are much expensive than optical fiber communication and reliability is not satisfactory.

6. Noise of Power Line Communication:

Four types of noise are found in Power Line Communication. Name and source of the noises are shown in Table 4.

Table 4: Types of Noise, their source and examples are given.

NOISE	SOURCE	EXAMPLE
Colored Background Noise	Multiple low power load[3]	Motor ,Fan
Narrow Band Noise	Broadcasting station[3]	Radio station, Television
Asynchronous impulse Noise	Switching equipment of distribution[3]	Circuit Breaker
Synchronous Impulse Noise	Thyristor[3]	Electronic Device

6.1 Power Spectral Density (PSD) of Colored Background Noise:

PSD of the noise is expressed as [8]:

$$N_{CBN} = N_0 + N_1.e^{-(f/f1)} \quad (1)$$

Here N_0 refers constant noise density and N_1 and f1 refer the parameters of the exponential function. f is data carrier frequency.

PSD of Colored Background Noise is different for residential and industrial power line [8]. Value of N_0 and N_1 are also different.

For residential area [8]: $N_{CBN} = -35 + 35.e^{-(f/3.6)}$ (2)

For industrial area [8]: $N_{CBN} = -33 + 40.e^{-(f/8.6)}$ (3)

Comparative analysis of PSD of Colored Background Noise for both residential and industrial is shown in figure 4. From the figure 4, it is understood that PSD of residential areas is less than industrial area. After 20MHz frequency, PSD is decreasing rapidly for both residential and industrial environment.

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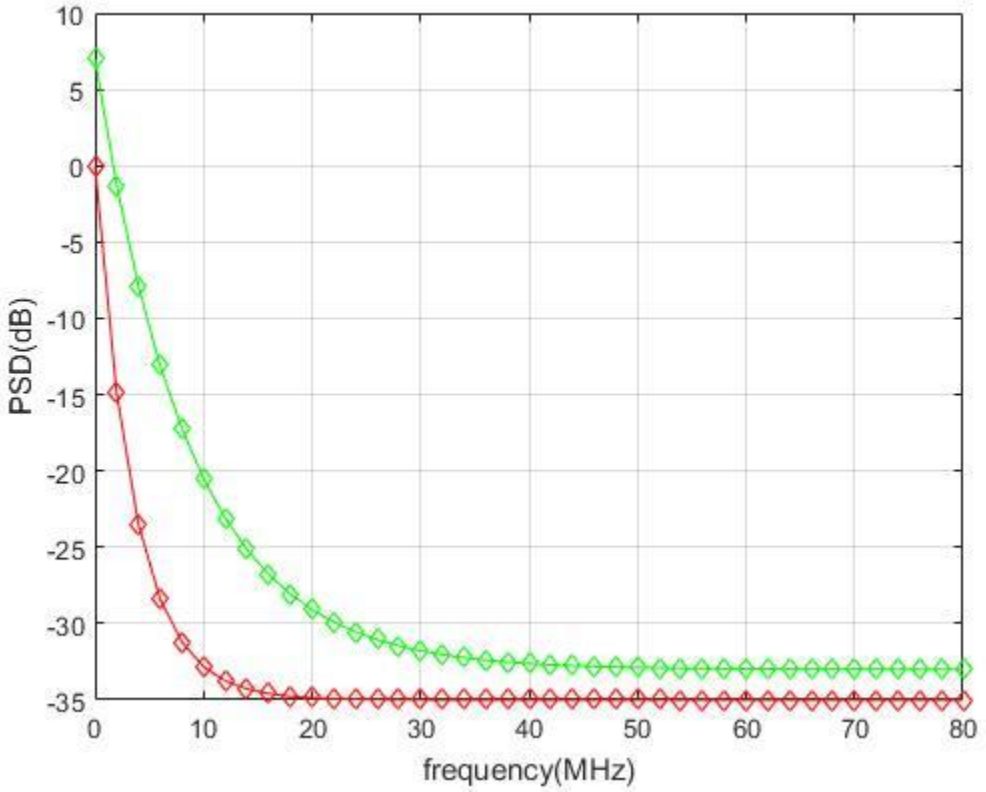

Fig 4: PSD of Colored Background Noise of Power Line Communication signal. Red color curve refers PSD for residential area and Green curve refers PSD for industrial area.

7. Conclusion: Power Line Communication will be the cheapest and more easily executable technology for Bangladesh. Up to 90% people of Bangladesh can be covered under internet facility by using the technology [1]. So, it can be a unique process to reach internet to the rural people. ISP Company will be interested because the distribution cost of PLC is much lesser than Optical fiber service which has been shown in table 1 and table 2. Mitigating noise level and attenuation are main challenges of Power Line Communication.

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Biographies

Mohammad Woli Ullah is an avid learner & academician who is presently serving as a lecturer in Electronic & Telecommunication Engineering in International Islamic University Chittagong. He has also rendered as a faculty member in ADUST before joining IIUC. Mr. Woli has a strong track record of academic achievement. He has completed his B.Sc & M.Engg in EEE from AIUB. He has also received an MBA in a relevant subject to engineering - MIS- from University of Dhaka. Mr. Woli currently pursuing M.Sc in EEE from BUET. A keen learner of EEE; he has been continuing to learn & teach the subject of his interest. Moreover; a number of research publications have been published in various reputed conference and journals. His research interest includes renewable energy, smart grid, PLC and SCADA.

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