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Review paper on Implementation of Efficient Modulation-Demodulation scheme for Power Line Communication System

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Abstract — *Power line communication uses communication through Power line (Electrical line) that we use in home & offices. In Power line communication the information signal is superimposed to carrier signal using appropriate modulation techniques. This Technology takes the Advantage of existing power line to be used as a base network. The main objective of this work is to review an efficient modulation-demodulation scheme that take binary data, mix with AC main lines signal & Transmit. At the Receiver side we need to demodulate the same to separate the data from AC main Signal.*

Keywords- *Power Line Communication; Bands; Noise; coupling, modulation;*

I. INTRODUCTION

Power Line communication is a basically a technology for transferring data over existing electrical supply (230V / 50Hz) line that we are using in our home. The data travels over the same power line that provides electricity thus allowing the existing power line infrastructure in homes to be used for the purpose of transporting data without adding a new wire.

The Power line communication basically defined as the communication between main base station to home. In other Word communication between 11Kv to 230 V.

Basic Process of Power line communication:

How Power line communication works. Basically the power signal at home is 230 V & 50 to 60 hz AC signal.
Power line communication can be useful for different purpose like automation and controlling, data transferring like Ethernet cable which we are normally using, the advantage of this technology is that there is no need to setup the new network like Ethernet, we are just applying data transferring on existing electrical supply wires which are available at the every corner of the area, we are connected with electrical wires.

II. BLOCK DIAGRAM OF POWER LINE COMMUNICATIONS

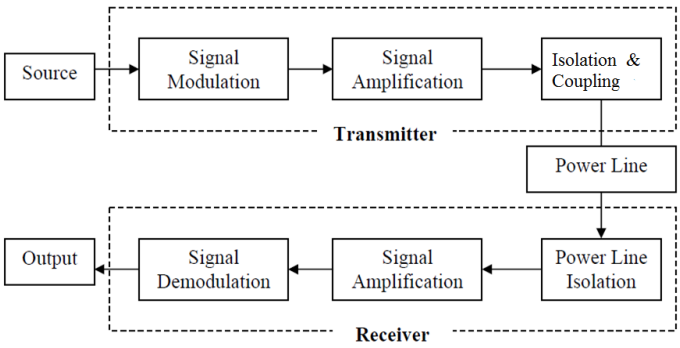

Figure 1: Block Diagram

In these figure there are 2 main parts which is 1.Transmitter (to transmit the signal) & 2.Receiver (to receive the signal). For Transmitter we can use LM566CN is a general purpose voltage controlled oscillator which may be used to generate square and tri-angle waves, the frequency of which is a very linear function of a control voltage.

For the Receiver side this frequency modulated signal is recovered using a phase locked loop chip the- LM565. The LM565 is a general purpose phase locked loop containing a stable, highly linear voltage controlled oscillator for low distortion FM modulation.

2.1 Signal Modulation:
For the signal modulation discuss about the different modulation techniques in power line communication.

2.1.1 Modulation Techniques[1]**:**
The concept of modulation for power line communication is defined as follows.

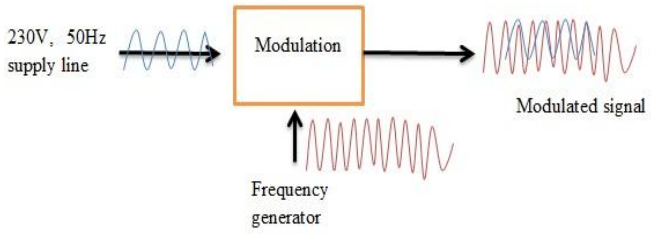

Figure 2: Modulation Techniques

Modulation is defined as the process which some characteristic of a carrier signal varied in accordance with a modulating wave. In digital communications, the modulating wave consists of an binary data or M-ary encoded version of it and the carrier is sinusoidal wave.
For the modulation technique there are the different digital modulation technique is as follows:

2.1.1.1. Amplitude shift keying (ASK)[1]**:**
In a Binary ASK system symbol '1' & '0' are transmitted as

$S_1(t) = \sqrt{\frac{2E_b}{T_b}} Cos2\pi f_1 t$ …….for symbol 1……(1)

$S_2(t) = 0$…….....for symbol 0……(2)

2.1.1.2. Frequency shift keying (FSK) [1]**:**
In a Binary FSK system symbol '1' & '0' are transmitted as

$S_1(t) = \sqrt{\frac{2E_b}{T_b}} Cos2\pi f_1 t$ ……for symbol 1…….(3)

$S_2(t) = \sqrt{\frac{2E_b}{T_b}} Cos2\pi f_2 t$ ……for symbol 0……(4)

2.1.1.3. Phase shift keying (PSK) [1]**:**
In a Binary PSK system the pair of signals $S_1(t)$ and $S_2(t)$ are used to represent binary symbol '1' & '0' respectively

$S_1(t) = \sqrt{\frac{2E_b}{T_b}} Cos2\pi f_c t$ …… for symbol 1……. .(5)

$S_2(t) = \sqrt{\frac{2E_b}{T_b}} Cos(2\pi f_c t + \pi) = -\sqrt{\frac{2E_b}{T_b}} Cos2\pi f_c t$ ..(6)

…...for symbol 0

2.2 Signal Amplification:
Data signal amplitude is very low compare to power line signal which is 230V.Small variation in the information signal can be treated as noise, to prevent this situation Amplification of information signal is added in the system.

2.3 Power Line Isolation & Coupling:
Power Line Coupling: Data & Power Signal:
Coupling is basically defined as the coupled the two signal which is defined the coupled signal. our data information signal & the electrical data this two are coupled.
Our data is in digital form & another is in electrical form. Digital data is high frequency data & electrical signal is low frequency data.
Digital data frequency is 30 Mhz & electrical signal is 230 V & 50 Hz.

2.3.1 Mode 1 Coupling[2]**:**
This coupling method is the most efficient and presents the lowest in losses of all PLC coupling configurations. Mode 1 coupling requires the use of wave traps, coupling capacitors and line tuners on all three phases. The coupling scheme shown in Figure shows the current returning in the center phase to be 1.414 times the current out the outer phases. This is not exactly Mode 1 coupling, but it is very close. It has a mode 1 coupling efficiency of 99% or better. It is the most

expensive type of coupling but offers the lowest coupling loss and provides the most channel redundancy of all the coupling methods.

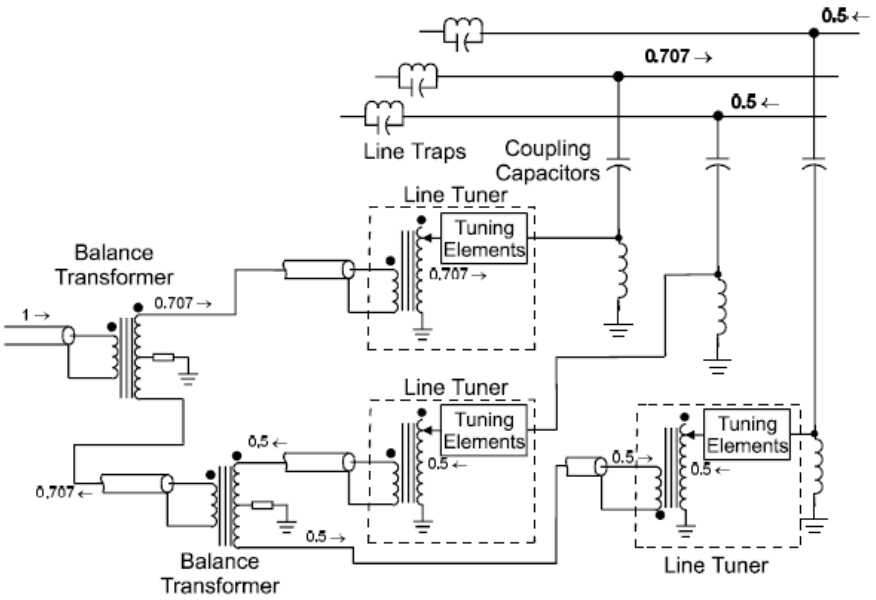

***Figure 3: Mode 1 Coupling*[2]**

2.3.2 Phase-to-Phase Coupling [2]**:**
Phase-to-phase coupling requires wave traps, coupling capacitors, and line tuners on two phases,. This coupling method provides a dependable channel for relay schemes that are more secure and rely on a signal getting through to the remote end of the line to trip. Since most faults are line to ground, the chances for a signal getting through during a fault is greater with this type of coupling allowing the protection engineer to use more secure type of relay schemes.

2.3.3 Phase-to-Ground Coupling [2]**:**
This is the simplest and least cost coupling method and requires the least equipment. One wave trap, one coupling capacitor and one line tuner are required for coupling. Center-phase-to-ground coupling method adds about 3 dB loss over mode 1 coupling but has 2/3 less equipment. Outer-phase-to-ground coupling adds considerably more losses. For the lowest attenuation of this type of coupling, the center phase is used. This is also the least reliable coupling method. Failure of any component will result in the failure of the channel. This failure may cause the pilot portion of the relay system to not operate correctly. Multiple channels may be coupled using this method by using auxiliary tuning components and either wide band or dual frequency wave traps and line tuners.

III. NOISE IN POWER LINE COMMUNICATIONS [3]

Many electrical devices which are connected to the power mains introduce some noise back onto network. The characteristic of the noise from these devices fluctuates usually. Noise generated in the network can be classified into some categories:

3.1 Impulse Noise [3]**:**
Impulsive noise in the electrical line that is sudden any electrical equipment getting start and it generates impulsive or sudden disturbance and gives spike that affects our power line signal(electrical or digital) and can change the our original data. Impulsive noise is generated due to sudden starting of any electrical device like when we switch on and off the device at the starting and stopping time impulsive noise is generated.

3.2 Periodic Noise [3]**:**
Periodic impulsive noise is generated due to dimmers.

3.3 Continuous impulsive Noise [3]**:**
It is generated by the AC motor, vacuum cleaner, Shaver etc.

3.4 Tonal Noise [3]**:**
It is often useful to divide tonal noise into the two sub-categories of unintended and intended interference. The most common sources of unintended tonal noise are switching power supplies. These supplies are present in numerous

electronic devices such as personal computers and electronic fluorescent ballasts. The fundamental frequency of these supplies may be anywhere in the range from 20 kHz to >1MHz. The noise that these devices inject back onto the power mains is typically rich in harmonics of the switching frequency.

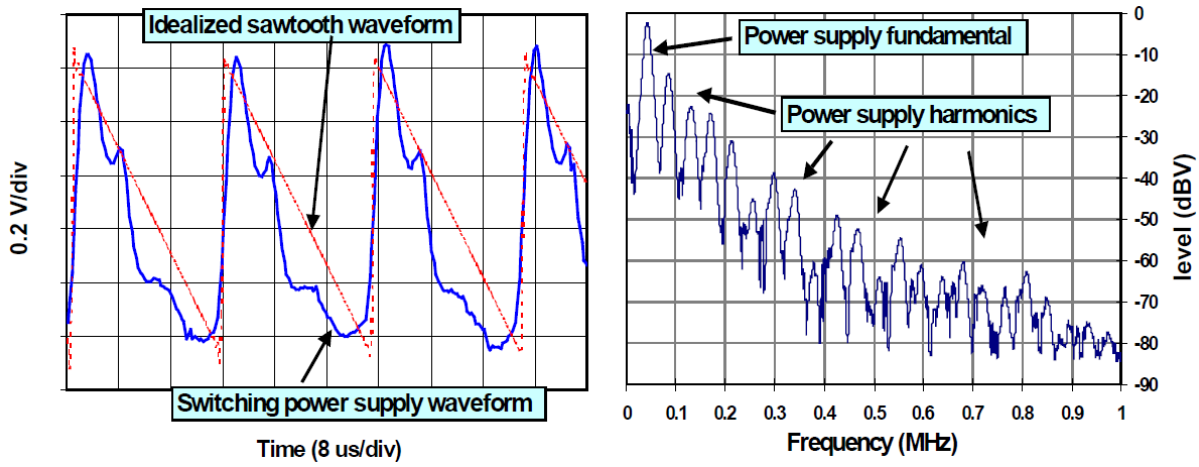

Figure 4: Tonal Noise[3]

Noise from the charging stand of an electronic toothbrush is shown in the plot of figure. Note the similarity between the switching supply noise and an ideal sawtooth waveform.

3.5 High Frequency Impulse Noise [3]**:**

High frequency impulse noise finds its source in a variety of series-wound AC motors. AC type of motor is found in devices as vacuum cleaners & electric shavers and many common kitchen appliances. Commutator arcing from these motors creates impulses at repetition rates in the several kilohertz range. Figure 3 is an oscilloscope plot of noise from a domestic vacuum cleaner on the left and on the right amplitude distribution plots of three main types of impairments. An ideal Gaussian distribution to fitted the vacuum distribution is also shown in the figure..

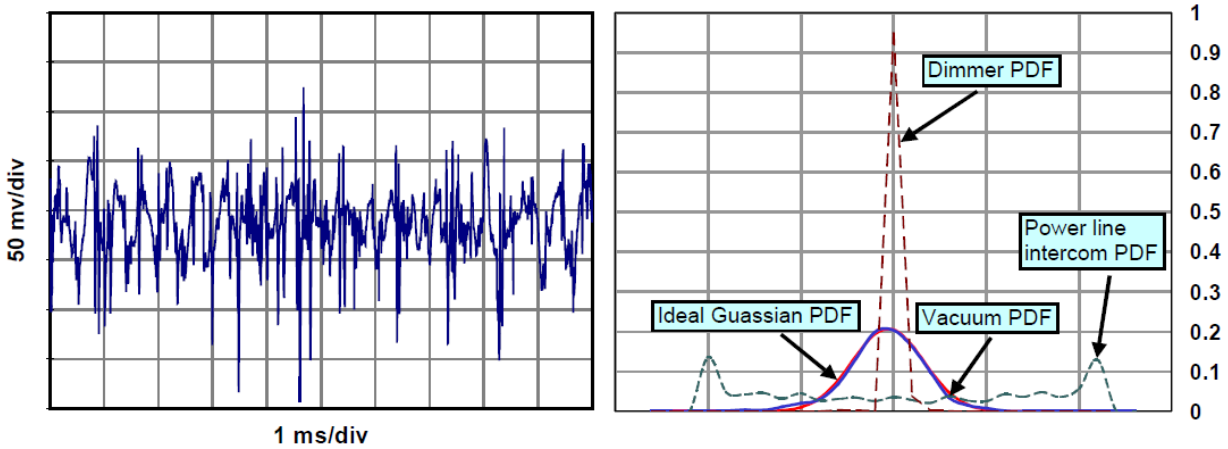

Figure 5: High frequency Impulse Noise[3]

IV. TYPES OF BANDS IN POWER LINE COMMUNICATIONS[4]

4.1 Broadband over power line (BPL) [4]***:***

Broadband over power line (BPL) is system to transmit two way data over the existing electrical distribution wiring in a metropolitan area. This would avoid a expence of the dedicated network of wires for data communication. we used BPL because BPL uses some of the same radio frequencies for the over the radio systems, interferences is a problem BPL would have applications in allowing utility companies to use smart metering & load management, providing two way communication with customer equipment.

4.2 Medium-speed narrow-band [4]**:**
Broadband over power line (BPL) is system to transmit two way data over the existing the distribution line carrier (DLC) systems technology used a frequency range of 9 to 500 kHz with data rate up to 576 Kbit/s.

4.3 Narrow band over power line (NBPL) [4]**:**
Narrow band over power line communication technology can use the electrical power wiring within a home for automation. NBPL is uses as home control for home automation. For example 1.Remote control of lighting & appliances without any control wiring.

Home control power line communication devices use modulating carrier wave between 20 to 200 khz into the household wiring at the transmitter side. The carrier is modulated by digital signal. Each receiver in the system has an address & can be individually commanded by the signal transmitted over the household wiring and decoded or demodulated at the receiver side.

4.4 Low- Speed Narrow band [4]**:**
Narrow band low speed over power line communications began soon after electrical power supply became widespread. For low speed frequency narrow band we can use 15 to 500 Khz. Ripple carrier signal was introduced with 10-20 kV and 240-415 V for distribution systems.

V. SIMULATIONS

5.1 Simulation Result (1):
This graph consists of different modulation techniques like BPSK, 4-PSK, 16-PSK.From the constellation diagram we know that BPSK has 2 bit, 4-PSK is 4 bit, 16-PSK is 16 bit.For B-PSK the BER is ranging from 10^{-1} to 10^{-4}.
For 4-PSK the BER is ranging from 10^{-1} to 10^{-4}.For 16-PSK the BER is ranging from10^{0} to 10^{-1}.
From this graph we can say that BPSK is a good BER rate for the value of SNR is ranging from 0 to 20 dB.

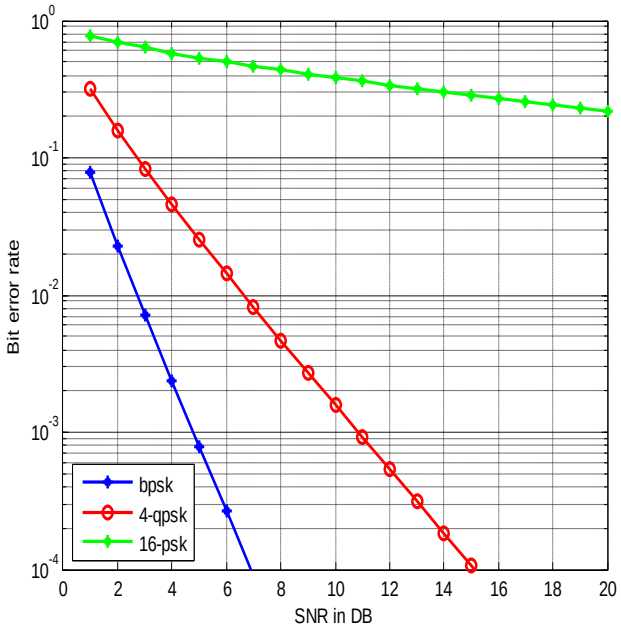

Figure 6: Ideally graph of SNR vs BER

5.2 Simulation Result (2):
This graph consists of different modulation techniques like BPSK, 4-PSK, 16-PSK.For B-PSK the BER is ranging from 10^{-1} to10^{-4}.For 4-PSK the BER is ranging from 10^{-1} to 10^{-4}.For 16-PSK the BER is ranging from10^{-0} to 10^{-2}.
From this graph we can say that BPSK is a good BER rate for the value of SNR is ranging from 0 to 20 dB.

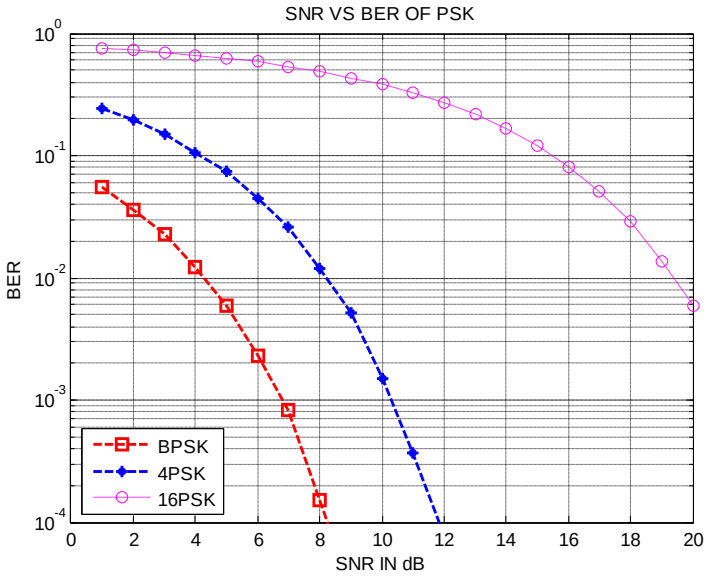

Figure 7: Practically Graph of SNR vs BER

VI. CONCLUSION

It can be concluded from this work that in power line communication is no need to create new network. Power line is already setup in every premise so is don't take extra cost of wired network. A power line network doesn't add any charges to electrical bill. We can create smart network system using wireless and power line communication.

On based of simulation in MATLAB it is observed that binary ASK performs better than other techniques. ASK can be non-coherently detected compare to other modulation schemes. This makes the receiver hardware simpler then PSK or FSK.so for hardware implementation ASK is preferred. Binary modulation gives better BER compared to 4-PSK and 16-PSK.so binary is preferred compared to non-binary modulation.

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