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Wireless Transmission of Electricity by using Various Technologies

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Abstract— **Power line communication is basically meant for carrying not only the electric power but also the data over the conductors and as the application alters so do the need to change the technologies, like the requirement to alter the technology in case of home automation and for internet access and in order to create a sufficient level of separation between them, they are usually differentiated by means of frequency alteration. In general the transformer present at the substation usually prevents the propagation of signal. Data rates and the distance vary in accordance with power line communication standards. Power line communication has been emanated as one of the most enduring means of communication for smart grid applications especially while considering the biggest advantage i.e. an already established infrastructure, therefore sending out the control information over the same network will add only a little cost and hence opens the door for a plethora of applications.**

The communication over Power Line is not so new when we are concerned about generation, transmission or deliverance of power but here our main concern is control and management of power rather than transmission or deliverance of power and this purpose can only be accomplished if we are utilizing the available resources in an efficient manner which in turn is dependent on the fast and effective transmission of data or control information over these channels. To ensure the fulfillment of these requisites there is a requirement to analyze the basic topological connections and the circuit modeling and thus determined the various control and traffic problems associated with the transmission of this information which usually varies according to applications.

Therefore OFDM (BPSK, QPSK, and QAM) has been utilized for the purpose of analysis of the channel performance while ensuring the speed and robustness of the channel to be the main criteria for any kind of services or applications .Moreover there usually arises a problem of power failure and reliable communication over remote locations and therefore the solution for it is an interfacing between wired and wireless communication technologies and hence in this work, a comparison of the bit error probability had been shown between the performance of the channel while using OFDM and CDMA and this comparison provides an solution to choose the technology according to the requirement of application .

Index Terms— **OFDM, CDMA, PLC**

I. INTRODUCTION

The Power Line Communication has been emanated in the early 1900's and at that time it was mainly concern about transmission of power to various different utilities and as the year goes by these power lines have started finding its usage for the transmission of voice and data. The main reasons responsible for its origin was that the communication over telephone was very poor therefore the engineers at the operating power plants makes use of Power Lines for management of operation with colleagues. But the communication was very slow and also susceptible to distortion and noise to a large extent till the introduction of digital techniques.

The other reason for the power lines to find its application for data communication is its already established infrastructure and having the capability to switch the devices On/Off, especially those devices which consume a large amount of power such as air conditioners, water heater etc. The advantage of this is to ensure a better management of energy which is more often called as Demand Side Energy Management. [1], [5] the communication over Power Line usually alters in data rate in-accordance with the application and hence to differentiate the communication they had been categorized in frequency i.e. they utilize different frequency bands. Therefore the Power Line Communication is categorized as Ultra Narrowband, Narrowband and Br

A. PLC and Various Technologies

Although the power line communication has been defined on the basis of frequency i.e. the frequency band that it occupies .Moreover it can also be defined corresponding to the voltage level i.e. Power Line Communication for High, Medium and Low voltage networks. It could be a little advantageous to define PLC in terms of voltage levels since the applications can be more precisely defined in terms of voltage levels.

Power Line communication mainly finds its application on the distribution side but over the period of time, it had also started finding some applications at the transmission side. This is mainly useful at this side for the purpose of state determination, Power controlling, surveillance of remote stations and for supervisory control and data acquisition. In the high voltage network, PLC technologies operate up to 1100KV in the frequency band of 40-500 kHz. The level of attenuation is much low at the high voltage side as compared to that at the medium and low voltage side.

The first ever effort in this direction had been made around 1920s for providing operational telephone services and that uses single sideband amplitude modulation schemes. Power Line Communication in addition to provide the connectivity to the transmission side it can also be used for detection of fault at the remote location. The need of a reliable communication on the transmission side is not only necessary but also an essential requirement so as to support several applications as well as managing the things properly. Today the network for power line communication is well established and is proving out to be to useful to serve the stations and the utility centers in around 120 countries with a total length of about millions of kilometers.

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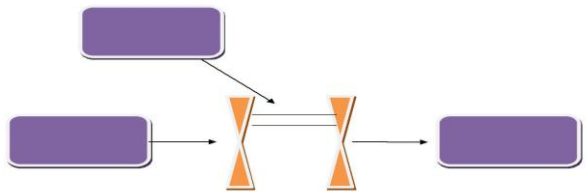


(i) PLC for Low Voltage Networks

The Power Line Communication finds most of the applications on the low voltage side because ultimately the main purpose of any sort of communication means is to provide services to the consumer. Some of these applications involve AMR, PHEV and DSM etc. Without altering the things at the low voltage site the purpose of transformation of grid to a smart grid doesn't get fulfilled. The detailed description of what is Smart Grid and its applications are defined on a later part of this chapter.[1,6]

Power line communication can be used to connect the devices at the low voltage site so as to provide interconnection between the devices (home computer, peripherals and home entertainment devices) to communicate with each other using an Ethernet port. For enabling the signal compatibility, the power line adapters are used to provide connectivity between the devices and the power outlets and hence provide an Ethernet connection using the electrical wiring and thus it can also serve the purpose of home automation i.e. remote controlling of appliances, lightning and power control without requiring any additional wiring for control.

collision detection and carrier sense multiple access with collision As these devices are usually connected using an Ethernet protocol which in general is based on two methodologies – either CSMA/CD or CSMA/CA, which stands for carrier sense multiple access with avoidance.

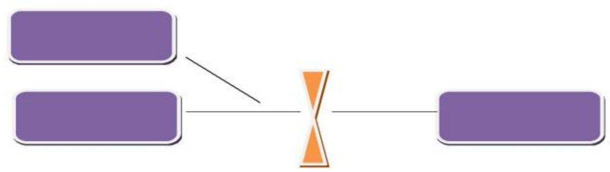
In case of carrier sense multiple access with collision detection, the sending device checks the line first whether it is freely available for the data transmission or not by sending a voltage signal and if there would be any collision then it will be indicated by the high voltage pulse in the line, multiple access refers to the fact the bus connecting all the devices are available for everyone and anyone can access it any point in time provided sensing the channel before making an actual transmission. If there would be any collision and the high voltage pulse be generated the device will wait for a random period of time before starting to transmit the data.

This is the way by which the collision could be detected (by sensing a high voltage pulse on the line) and then by waiting for a random period of time before making the actual transmission it could be avoided.

B. PLC for Medium Voltage Networks

The power for the medium voltage network is mainly concerned about the transmission in between substations within the grid and that is meant for state
Determination of equipment and for power flow conditions. To establish a communication link in between these substations IED's are required to communicate with the external IED's (like switches, re-closers, sectionalizes) for fault locations, fault isolation and service restoration. Moreover, for the voltage distribution on the distribution side requires communication between substation IED's and distribution feeder IED's served by the substation. Some other applications on the medium voltage side also include temperature measurement of oil, measurement of voltage on the secondary side of the transformer, fault surveys and the power quality measurement.

At the medium voltage site it is used to communicate the data in two directions using the electrical distribution wiring between transformer and customer outlets, thus it eliminates the requisites of expenses and endeavors needed for a separate network that may either be a wired network or a wireless network



C. PLC for Low Voltage Networks

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II. Different Approaches of Modeling of Power Line Communication

There is usually a presence of two different approaches for the modeling of high frequency Power Line Communication channels –Top-Down Approach and Bottom-Up Approach.

A. *TOP-DOWN Approach* -

These models are simply based on the measurements. like the Echo model which is extracted from the transfer function measurement and the Resonant Circuit model extracted from impedance measurements.

B. *BOTTOM UP APPORCH:*

In this approach the power lines are considered distributed networks and therefore the two basic/intrinsic parameters characteristic impedance and propagation constant are measured first and then the Transfer function is determined using the scattering matrix or transmission matrix.[7]Although both the approaches find their utility according to applications, however over the period of time Bottom-Up approach had started gaining more importance.

C. *Power Line Channel models*

a) Time-Domain multipath model

The Power Line channel model has been described considering that it is predominantly affected by multipath effects. The multipath nature of Power Line channels arises due to the presence of several branches at which impedance mismatch causes multiple reflections.[2,4]A number of reflected signals affect the quality of the main signal which is required to reach to the receiver reliably for successful completion of data transmission.

If there is a presence of only a bridged gap at B then the distance between A and C is denoted as LAC. For this configuration, the signal follows a first direct path (A→B→C) and virtually infinite number of secondary paths arises as the signal bounces in between B and D.

For i=1 : A→B→D→B→C

For i=2 : A→B→D→B→ D→B→C

The number of reflections and so do the impact on to the main signal increases as the value of i increases and also with the increase in the number of discontinuities.

D. *Physical Signal Propagation Effects*

This section examines the effects on the communication signals over power line networks. The signal propagation takes place not only along a direct line of sight path but additional echoes must also be considered. This results in a multipath scenario with frequency selective fading. All the reflection and transmission factors are less than or equal to unity and the product of it is defined as weighting factor gi. Furthermore the longer the transmission paths the higher the attenuation.

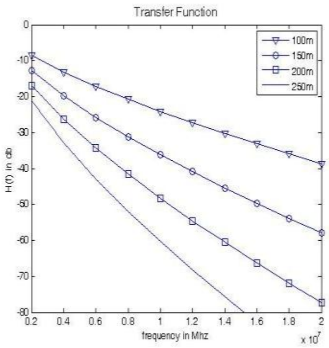
The delay of a path is defined as

$$\tau i = di/vp$$

The losses along the cable increases with length and frequency. Therefore according to this model the overall frequency response is defined as

$$H(f) = \sum_{i=1}^{N} g_i * e^{(-j2\pi f({d_i}/{v_p}))} * e^{-(a_0 + a_1 * f^k)}$$

Where, N is the number of paths and gi, α(f), τi are the gain/weighting factor , attenuation coefficient (which takes into account both the skin effect and dielectric losses) and delay associated of i[th] path respectively.[4]



a) Frequency-Domain multi path model

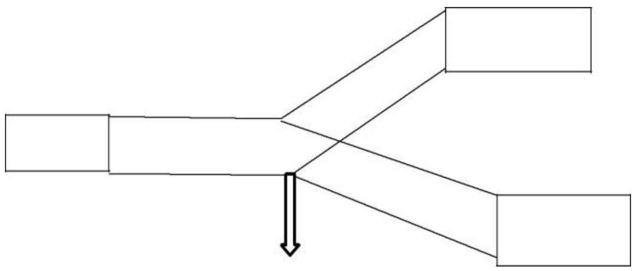
A number of attempts have been made to model the power line channel as a two conductor transmission line using either transmission matrix or scattering matrices but those models led to an incomplete circuit representation and that is not capable of explaining the signal propagation completely since these analysis neglects three major points.

- The presence of a third conductor, which could be solved by using multi-conductor transmission line theory.
- The effects of particular wiring and grounding practices
- Estimation of mode currents

Therefore a more accurate approach to channel modeling based on multi-conductor transmission line has been proposed power line channel and in that case a common wiring topology is used which had been proposed first followed to this is the analysis of the multi conductor Power Line Cables.[4,9]

b) Common Wiring Practices Used in Residential and Business Buildings

In general the power cables used for single phase indoor wiring consist of three or four conductors in addition to the ubiquitous earth ground. These usually include hot (black), return (white), safety ground (green or bare) and the occasional runner(red) wires, all confined by an outer jacket that maintains close conductor spacing between two directions of propagation. The spatial modes are often referred to as differential mode or balanced mode and common mode is referred to as the longitudinal mode.



Ground

c) Analysis of Multi-conductor Power Line Cables

Consider a transmission Line consisting of two isolated conductors. Such a configuration supports four modes of propagation along the transmission line in the TEM approximation, two spatial modes each with two direction of propagation The spatial modes are often referred to as differential mode (or balanced or odd mode) and common mode (or longitudinal mode or even mode).

The differential mode current is almost always the functional current responsible for carrying the data signal along the line. It is possible to excite only a differential propagating mode along a two conductor transmission line e.g. a twisted pair cable, by differential signalling i.e. by driving the signal with antipodal signals. But due to some imbalances there could be a presence of a common mode signal. The differential mode current is almost always the functional current responsible for carrying the data signal along the line. It is possible to excite only a differential propagating mode along a two conductor transmission line e.g. a twisted pair cable, by differential signalling i.e. by driving the signal with antipodal signals. But due to some imbalances there could be a presence of a common mode signal.

Although the presence of a common mode current does not inherently degrade the performance of the differential mode data signals. However if there is a presence of some mechanism to transfer the energy from common mode to differential mode, then the common mode current can become a dominant interference signal. This phenomenon is called as mode conversion or mode coupling.

In case of Indoor Power Line networks, the modes propagating along the cable are not independent and the mode coupling often occurs. In particular strong mode coupling occurs at the point of ground bonding at the breaker box, the mains feed and the lighting circuits interrupted by switches. Since the lighting and outlet circuits are usually fed from separate breakers, the effect of bonding often occurs.[12,13]

d) Analysis of three Conductor Transmission Lines

A three conductor cable supports six propagating modes i.e. three spatial modes (differential, pair, common modes) each for two direction of propagation. The differential mode current Idif represents an odd mode signal with the current confined to the white and black wires and is generally the desired signal.

The pair mode signal Ipr represents an even mode signal with current flowing between the safety ground wire and the white /black wire tied together.

The common mode current in cable acts as an imbalance which creates a current loop with earth ground It highly depends on cable installation and the characteristic impedance for this mode is variable and not readily characterized Zcm ≈ 150-300 Ω.

The voltage and current in a three wire power line cables consists of Vblk (Iblk),Vwht (Iwht) and Vgnd (Ignd) respectively.

The propagating voltages are $V1^{+}=(Vdif^{+},Vpr^{+},Vcm^{+})$and $V1^{-}=(Vdif^{-},Vpr^{-},Vcm^{-})$,correspondingly the current relationship is given by $I1^{+}=(Idif^{+},Ipr^{+},Icm^{+})$ and $I1^{-}=(Idif^{-},Ipr^{-},Icm^{-})$ represents differential , pair and common-mode currents for waves propagating in forward and backward direction .[see-3]

The propagating voltages and current is related to each other by a diagonal matrix of characteristic impedance Z0

$$\begin{bmatrix} V_{dif}^{+} \\ V_{pr}^{+} \\ V_{cm}^{+} \end{bmatrix} \quad \begin{bmatrix} Z_{dif} & 0 & 0 \\ 0 & Z_{pr} & 0 \\ 0 & 0 & Z_{cm} \end{bmatrix} \quad \begin{bmatrix} I_{dif}^{+} \\ I_{pr}^{+} \\ I_{cm}^{+} \end{bmatrix}$$

Similarly the voltage and current in the reverse direction are related as follows

$$\begin{bmatrix} V_{dif}^{-} \\ V_{pr}^{-} \\ V_{cm}^{-} \end{bmatrix} \quad \begin{bmatrix} -Z_{dif} & 0 & 0 \\ 0 & -Z_{pr} & 0 \\ 0 & 0 & -Z_{cm} \end{bmatrix} \quad \begin{bmatrix} I_{dif}^{-} \\ I_{pr}^{-} \\ I_{cm}^{-} \end{bmatrix}$$

Therefore the overall voltage and current along a line consist of the transmitted as well as the reflected signals

$$I_1 = I_1^{+} + I_1^{-}$$

$$\begin{bmatrix} 1 & -1 & 0 \\ \frac{(1-\varepsilon)}{2} & \frac{(1+\varepsilon)}{2} & -1 \\ \frac{(1-\varepsilon)}{2}\theta & \frac{(1+\varepsilon)}{2}\theta & 1-\theta \end{bmatrix} \quad \begin{bmatrix} V_{blk} \\ V_{wht} \\ V_{gnd} \end{bmatrix}$$

Where A and B are related as

$A^{-1} = B^T$ or $B^{-1} = A^T$

Where the parameter $\varepsilon \approx 0.05 - 0.3$ and it describes an asymmetry between black and white wires relative to the ground conductor whereas the factor $\theta \approx 0.5$ -0.15 and it represents the shielding produced by the ground conductor.

The forward and reverse voltage (similarly current) are related to each other by a factor called as reflection coefficient and the relation is given by

$$V_1^- = \rho_v V_1^+ \quad (6)$$

and the reflection coefficient can further be defined in terms of an arbitrary linear network described as Z_{term} which is given by

$$\rho_v = (A^T Z_0^{-1} + Z_{term}^{-1} B^T)(A^T Z_0^{-1} - Z_{term}^{-1} B^T) \quad (7)$$

Where A and B are modal matrices as define in [3, eqs (3) and (4)], Y_{term} is defined as

$$Y_{term} = (Z_{term})^{-1} = A^T Z_0^{-1} A + Y_{sh} \quad (8)$$

On substituting this in the above equation we get

Moreover reflection

$$\rho_v = -(2A^T Z_0^{-1} + Y_{sh} B^T)^{-1} Y_{sh} B^T \quad (9)$$

coefficient is related to resistance under bonding and fault conditions and is described below and these are mainly resulted due to multiple number of shunt branches as depicted in the basic topological

The differential mode reflection coefficients for each case are

$$\frac{-1}{\rho(dif_{sd})} = 1 + \frac{2*R_{sd}}{Z_{dif}}$$

$$\frac{-1}{\rho(dif_{sb})} = 1 + \frac{8*R_{sb}}{(1-\varepsilon)^2 * Z_{dif}} + 4 * \frac{Z_{pr}}{(1-\varepsilon)^2 * Z_{dif}}$$

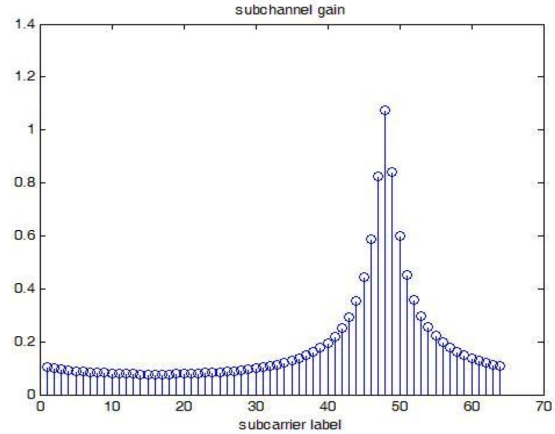
$$\frac{-1}{\rho(dif_{sf})} = 1 + \frac{8*R_{sf}}{(1+\varepsilon)^2 * Z_{dif}} + 4 * \frac{Z_{pr}}{(1+\varepsilon)^2 * Z_{dif}}$$

The reflection coefficient varies as function of resistance and hence the relationship is as shown in fig.for two conditions:-Bonding (Rsf=Rsd=infinite) and Fault (Rsd=Rsb=infinite)

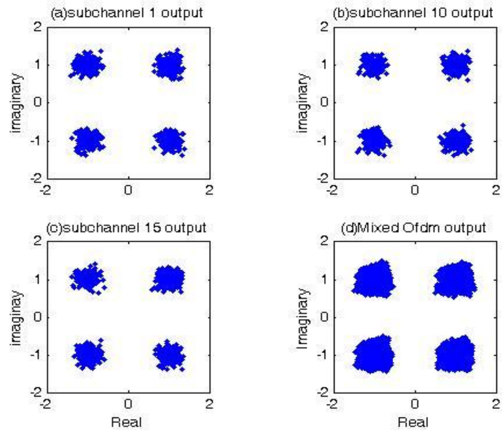
III. RESULT

The Performance Evaluation of Power Line Channel has been accomplished using OFDM (BPSK, QPSK, and 16-QAM) and the OFDM is being used considering the requirement of higher data rate and robustness. The obtained results had been shown below and the results indicate that there is a trade-off between the probability of error and the complexity and the major advantage of using OFDM is the requirement of a simple equalization technique which is an inverse model of the channel model.

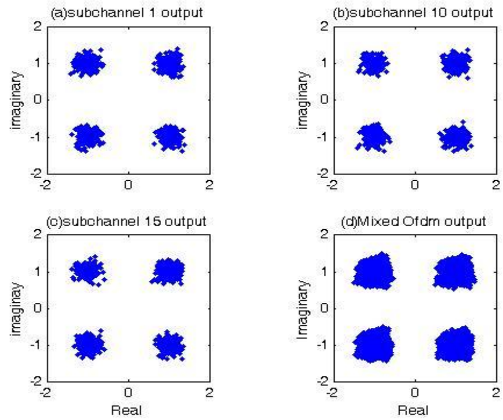
(A)Representation of sub channel gain for length 200 m



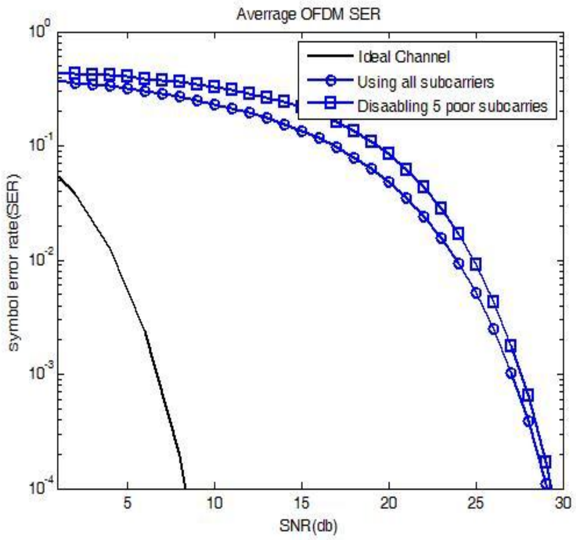
(B) Sub-channel constellation scattering and the mixed ofdm Bpsk-output for the length 200m



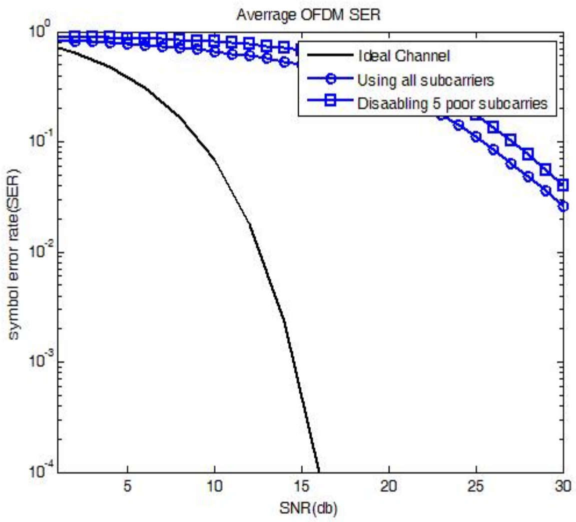
(C) Sub-channel constellation scattering and the mixed OFDM-QPSK output for the length of 200m



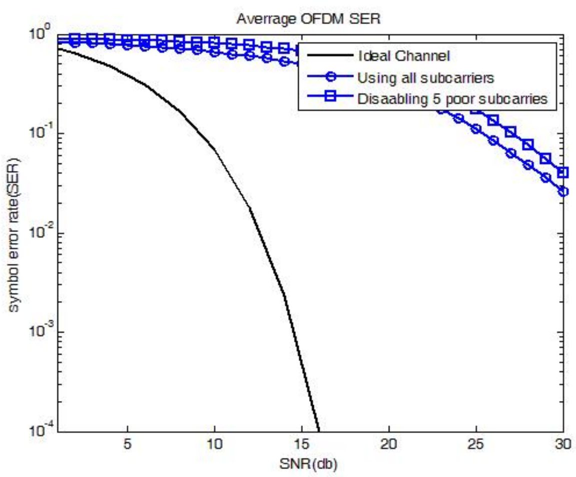
(D) Determination of symbol error rate for OFDM -BPSK using all subcarriers and while suppressing some poor subcarriers, when the length is 200m



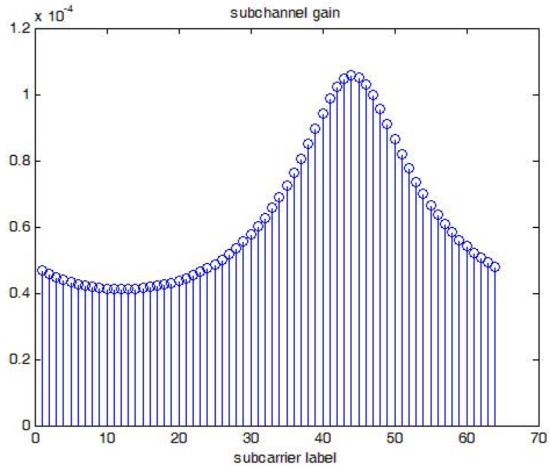
(E) Determination of symbol error rate for OFDM-QPSK using all subcarriers and while suppressing Some poor subcarriers, when the length is 200m



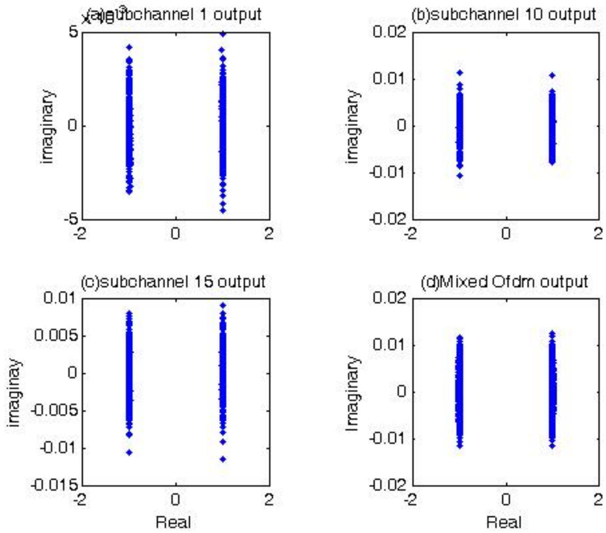
(F) Determination of symbol error rate for OFDM-QAM Using all subcarriers and while suppressing Some poor subcarriers, when the length is 200m



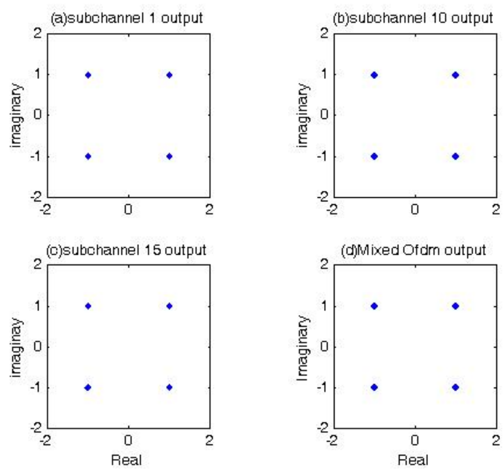
(G)Representation of sub-channel gain for the length of 1000m



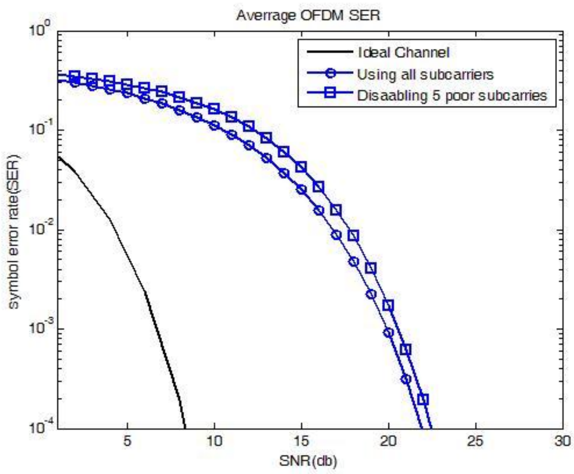
(H) Sub-channel constellation scattering and the mixed ofdm Bpsk-output for the length 1000m.



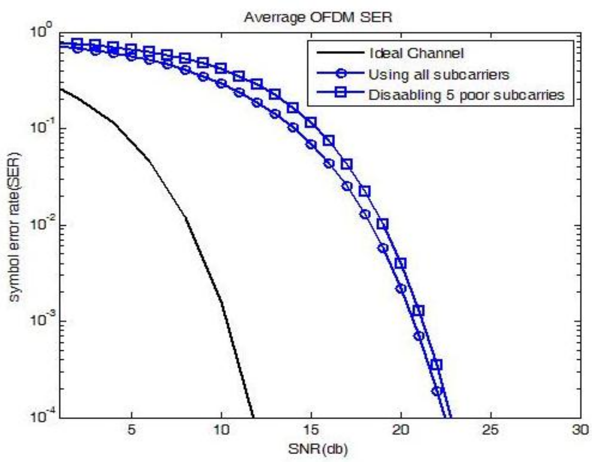
(I) Sub-channel constellation scattering and the mixed OFDM-QPSK output for the length of 1000m



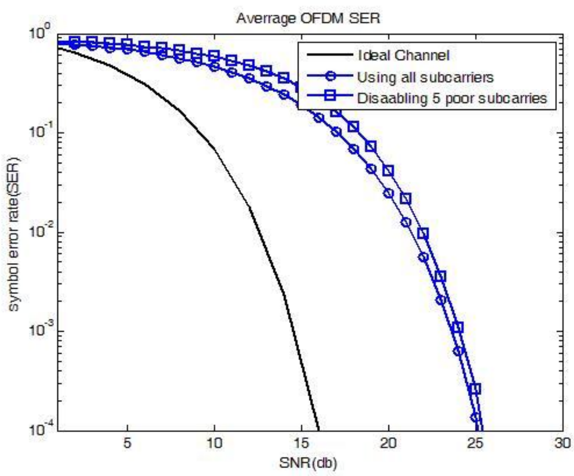
(J) Determination of symbol error rate for OFDM -BPSK using all subcarriers and while suppressing Some poor subcarriers, when the length is 1000m



(K) Determination of symbol error rate for OFDM-QPSK using all subcarriers and while suppressing Some poor subcarriers, when the length is 1000m



(L)Determination of symbol error rate for OFDM-QAM Using all subcarriers and while suppressing Some poor subcarriers, when the length is 200m



IV. CONCLUSION

Performance of power line channel so as to achieve a better rate, security, reliability and uninterrupted services. Under this context some of the major points are listed below.

Analysis of the channel model has been made to determine the major factors responsible for the degradation of performance like interference from other means of communication, due to a presence of multiple numbers of branch terminals from where the reflection occurs resulting in multipath scenario, skin effect and dielectric losses.

Evaluation of Bit Error Rate using different modulation schemes, so as to find the best possible technique is made which is required for the data transmission as this is the most important requirement to accomplish the task of energy management and other services like Broad-Band services.

V. SCOPE OF RESEARCH &FUTURE WORK

Scaling of various parameter is an essential function in .scaling is because increase signal strength and increase target estimation and least square technique algorithm to estimate signal attribute like amplitude frequency and phase in online mode .this technique can be use protection relay digital AVR DGs DSTATCOMs FACT and other power electronics applications is modified to operate on fictitious input signal and precise estimation result insensitive to noise and disturbances this proposed work are simulated by MATLAB Research Directions

TODAY'S consumers demand wireless systems that are low-cost, power efficient, reliable and better system. Controlling the protection of power system is critically dependent on real time estimation of signal attributes the and faster and more precise are the estimate the more reliable are the protection and controlling scheme. Harmonics and noise contamination are major concern for power system. Since they affect the accuracy of estimate and speed of estimation .application of frequency locked loop.

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