# Improving of LTE 3GPP Transceiver Baseband by Phase Matrix under Different Channel Environments

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## Abstract

3GPP LTE is the evolution of the Third-generation of mobile communications, UMTS, to the Fourth generation technology that is fundamentally a wireless broadband Internet system with voice and other services built with high technique. In these paper goals to improvement the LTE 3GPP Baseband transceiver using Phase Matrix under multipath and selective fades channels also to analyze, and the performance of the system. The bit error rates BER numerical results show that the better performance of the LTE 3GPP Baseband transceiver with phase matrix can be attained obtained when comparing with system without using phase matrix. As simulation results, it can be seen that the proposed technique present a high performance improvement was obtained over the conventional LTE 3GPP Baseband transceiver, and the BER is reduced under different channel performances and the BER improvement compared with conventional LTE 3GPP Baseband.

**Keywords: LTE 3GPP, OFDM, IFFT, DFT, Phase matrix.**

# تحسين جهاز الارسال والاستقبال LTE 3GPP بواسطة مصفوفة الطور المختلف ببيئات قنوات التلاشي

**الخلاصة:**

LTE3GPP هو تطور الجيل الثالث من الاتصالات المتنقلة، UMTS، إلى تقنية الجيل الرابع التي هي في الأساس ذات النطاق العريض لنظام الإنترنت اللاسلكي بوجود الصوت وغيرها من الخدمات التي بنيت على أعلى تقنية.أهداف البحث هو تحسين جهاز الإرسال والاستقبال LTE3 GPP بواسطة مصفوفة الطور في قنوات التلاشي متعددة المسارات والقنوات الاختيارية المقترحة اضافة الى اداء تحليل اداء النظام

GPP LTE3 بمصفوفة الطور. نتائج نسبة معدل الخطأ تبين الحصول على افضل اداء عند مقارنته مع النظام بدون مصفوفة الطور يمكن ان نحصل منه على اداء افضل عند مقارنة جهاز الارسال والاستقبال LTE 3GPP مع مصفوفة الطور مع نفس جهاز الارسال والاستقبال بدون مصفوفة الطور . من نتائج المحاكاة ان التقنية المقترحة تملك اعلى تحسين لأداء النظام عند المقارنة مع النظام التقليدي بحيث انه نسبة معدل الخطأ قلت بمختلف قنوات التلاشي البيئية عند مقارنتها مع جهاز الارسال والاستقبال التقليدي.

# 1. Introduction

The conditions identified with to long term evolution (LTE) are legitimately distinguished as the advanced universal mobile telecommunication system (UMTS) physical radio access (E-UTRA) and advanced UMTS terrestrial radio access network (E-UTRAN), however are further typically alluded to the venture name LTE. The beginning necessities of LTE are exhibited in [1, 2], where the boss focuses for this advancement are highlighted. LTE is intended to build information rates and cell edge bit rates, created range proficiency (unicast and additionally telecast) and permitted range adaptability (1.25, 2.5, 5, 10, 15 and 20 MHz) for adaptable radio arranging. LTE additionally is utilized to decrease parcel inactivity, the key limitation for ongoing administrations, for example, VoIP or video conferencing, diminish radio access system cost and in addition financially savvy movement from past 3GPP discharges and streamline its system to a level all-IP bundle based system development where all the client plane radio functionalities are evolved node B (eNodeB).3GPP began to take a shot at the Evolution of the UMTS with the radio access systems (RAN) advancement work shop in November 2004 and recently, on December 2008, 3GPP had acknowledged the utilitarian stop of LTE as a component of Release 8. Hence, this point of interest achievement will allow the administrators to understand their underlying sending arranges in conveying this innovation. LTE is meant to give the genuine worldwide portable broadband experience for clients put high need on enhancing ghastly effectiveness and decreased expense. A synopsis of all Release 8 highlights with their related 3GPP LTE particular archives is introduced in [3]. LTE ought to at any rate bolster a prompt downlink top information rate of 100Mbps inside of a 20 MHz downlink range distribution (5 bps/Hz) and quick uplink top information rate of 50 Mbps inside of a 20 MHz uplink range allotment (2.5 bps/Hz) considering 2 get radio wires and 1 transmit reception apparatus at user equipment (UE). The underlying purpose of LTE concentrate thing was initially propelled on the meaning of necessities to portray the objectives for information rate, limit, range proficiency and inactivity. Excessively business viewpoints comparative expenses for introducing and working the system were considered. In light of these necessities, the critical elements of LTE are the use of various access structures, versatile adjustment and coding, multiple input multiple input systems (MIMO), hybrid automatic repeat request (HARQ) technology and distributed or localized radio resource allocation methods. A general overview of LTE is given in [1, 2]. The numerous entrance frameworks that uses LTE are OFDM with Cyclic Prefix (CP). Orthogonal recurrence division multiplexing (OFDM) have been chosen by 3GPP on account of its quality to multipath engendering in wideband channels, intrinsic backing for recurrence assorted qualities and ease mix. Inside each subcarrier a Modulation is connected with 16-QAM and code rate.

The LTE determinations acquire all the recurrence groups characterized for UMTS and include further groups and characterize both Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD) to unmistakable uplink and downlink activity. Recently, remote frameworks, for example, 3GPP LTE have excessively received OFDM based transmissions, making it impossible to defeat the analyses of Non Line Of Sight (NLOS) engendering in light of the fact that OFDM is an innovation that has been appeared to be appropriate to the versatile radio circumstance for high rate and interactive media administrations [6]. OFDM accomplishes high information rate and proficiency by utilizing various covering transporter signals as a part of its place of only one bearer. The imperative advantage of OFDM over single transporter balance frameworks is the ability to subdivide the data transfer capacity into various recurrence sub-bearers which convey the data streams, are orthogonal to each other and convey higher transmission capacity proficiency. OFDM licenses higher information amount even notwithstanding difficult situations, for example, NLOS joins experiencing essential corruption in view of multipath circumstances. A guard time is added in each OFDM symbol to combat the channel delay spread. The term delay spread defines the amount of time delay at the receiver from a signal traveling from the transmitter along dissimilar paths. The delay induced by multipath is able to cause a symbol received along a delayed path to interfere with subsequent symbol arriving at the receiver via a more direct path. This result is mentioned to as inter-symbol interference (ISI). The guard time may be divided into a prefix (inserted at the beginning of the useful OFDM symbol and called cyclic prefix (CP) and a postfix (inserted at the end of the previous OFDM symbol). The overview of the CP can eliminate ISI in the time domain as long as the CP duration is longer than the channel delay spread. The CP is normally a repetition of the previous samples of data portion of the OFDM block that is appended to the beginning of the data payload and makes the channel seem circular in order to permit low-complexity frequency domain equalization. This procedure is appropriate in situations where the cyclic prefix (CP) can adapt well to all the multipath spread. In any case, if the channel length surpasses the span of the CP, OFDM experiences Inter Symbol Interference (ISI) and Inter Carrier Interference (ICI), debasing a definitive connection quality [7]. The relative movement in the middle of collector and transmitter, or versatile medium among them, will bring about the Doppler Effect. The Doppler impact the nature of a phone discussion in a moving auto. On the other word, the way defer causes a vacillation in the got flag and prompts a between image obstruction [8]. In this work LTE 3GPP handset with stage matrix [9] is utilized to diminish the Doppler Effect and improvement a BER for LTE 3GPP Transceiver. This paper is organized as takes after. In Section one the presentation of the LTE 3GPP Transceiver is portrayed. Area two portrays the framework model. Area three abridges the outcomes. Finally, closes the paper.

## 2. System Model

The block diagram of the proposed LTE 3GPP Baseband transceiver is shown in Figure 1.

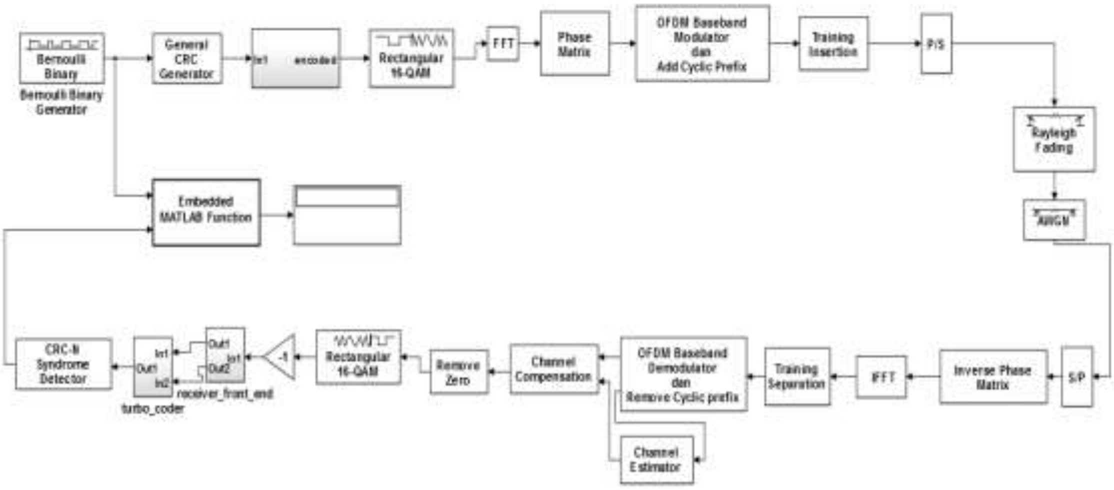


Fig. 1. Block Diagram of the Proposed LTE 3GPP Baseband Transceiver with Phase Matrix

Assume the raw binary bits are ready to transmit from eNodeB to UEs. Downlink signal is produced during numerous stages defined below [3, 4]. Transport block cyclic redundancy check (CRC) attachment: CRC bits are deliberated and attached to the initial raw bits. Code block segmentation & Code block CRC attachment: This stage divides the bits into blocks. The block size Z=6144 and every blocks should perform further CRC attachment. After the processing, the blocks are going to achieve channel coding. Turbo coding: For each block, turbo coding is achieved. The system of turbo encoder is a Parallel Concatenated Convolutional Code (PCCC) with two 8-state constituent encoders and one internal inter-leaver for scattering error burst. The coding rate is 1/3. Turbo coding delivers error correction function. Interleaving: The three output bit streams derived from turbo coding are interleaved distinctly. The purpose of this process is to avoid burst errors. Rate matching: Rate matching is to match the block size to the radio frame by repeating bits to increase the rate or puncturing bits to reduce the rate. Code block concatenation: This stage is to concatenate the coded blocks. Scrambling: The block of bits is scrambled with a UE-specific scrambling sequence prior to modulation [5]. The main aim of scrambling here is to making the transmitted data further discrete to meet maximum power spectral density requirements [6]. Modulation mapping: This stage maps the binary bits into complex value symbols by using 16-QAM modulation system. Which modulation system will be used is determined by the channel quality and the necessities of data rates for transmission.

Layer mapping: For each code word, the complex-valued modulation symbols will be mapped onto one, two, three or four layers. Two types of layer mapping are supported in LTE for spatial multiplexing. Pre-coding: Pre-coding is achieved to map the complex-valued modulation symbols from the layers to multiple antennas. Pre-coding has two schemes according to different layer mapping means. Layer mapping and pre-coding are also recognized as antenna mapping. Pilot Insertion: Pilot symbols are produced and inserted to complex-valued modulation symbols on each antenna port. Resource element mapping: This stage is to map the complex-valued modulation symbols to the physical resource blocks at antenna port. The mapping shall be in increasing order of first resource block index *k* over the assigned physical resource blocks and then the index *l*, starting with the first slot in one sub frame [3]. IFFT: N-point IFFTs are achieved to convert the signal from frequency domain to time domain after the resource element mapping starting from symbol index *l*=0. The size of N. Add CP & PS: Attach CP into every symbol and then perform PS. The CP length is defined in [3]. SP & Remove CP: Perform SP and then remove CP. FFT: N-point FFTs are achieved to convert the signal from time domain to frequency domain. User Extraction: Extract every user's symbol data on dissimilar subcarriers according to their PRBs shapes. Channel Estimation: Based on the pilot symbols extracted from the frame, estimate channel matrix H. Since this is a computational intensive part at the baseband, detailed discussion with complexity examination is followed in the later section [4]. Equalization: Based on the estimated channel matrix H, achieve equalization on the whole slot. Remove Pilot: Remove pilot symbol from the modulation symbol frame. Resource element de-mapping: De-mapping the complex-valued modulation symbol frame into blocks. [7] IFFT: M-point IFFTs are achieved to convert the data from frequency domain to time domain. Here the size of M is not power-of-2, so the radix-2 FFT algorithm is not applicable [8]. Turbo decoding: Turbo decoder is built in the like method as the encoder. It uses soft decision to give the code block bits. Code block CRC Removal: Perform CRC check and then remove 24 parity bits in each code blocks. Code block de-segmentation: Combine all the code blocks and get the binary bits with parity bits. Transport block CRC Removal: Achieve CRC check and then remove 24 parity bits [9]. At the receiver, if there is an error occurred due to multipath, and then at the output of the FFT there will be a high error occurred at the other bits due to mixing of phases and values of signal by FFT. Thus, if there is a method that can have the capacity to hinder the blunder in this bit from spreading or influencing on alternate bits at the yield of the FFT at the recipient then, the BER will reduction, such methodology should be possible by duplicating the transmitted sign by a Phase Matrix (PM) at the transmitter side and the Inverse of Phase Matrix (IPM) at the beneficiary side. This property can be checking on the grounds that the same bits are adjusted on unique subcarriers. Along these lines, it is likely to transmit every piece on divergent requested stage. In the same time if the yield of IFFT vectors are specifically duplicated by a stage vector, then it is difficult to orchestrate the yield periods of transmitted vector in a consistent expanding or diminishing request, in light of the fact that each piece out of IFFT at the transmitter side has a related stage esteem and the augmentation of this vector by a requested vector won't have the capacity to position the stage values.

Another advantages of stage lattice related with the force of the transmitted sign by means of the channel, the yield signal force from the IFFT will be diminished to a low level contrasted with the information esteem with it, the stage grid will have the capacity to recover the sign energy to its typical level as the same data mean quality to the IFFT. The transmitted image which comprise of N-IFFT canisters can be increased by a Phase Matrix (PM) which can be basically created as in Eq. (1) [9]

$$\boldsymbol{X(n,i)} = \sum_{v=0}^{N-1} \boldsymbol{X(n^{*}N - (N-1) + v, i)\, e^{-j\left(\frac{2\pi}{N}\right)i,v}} \qquad (1)$$

Where;

n: data bit stream number.

I: frequency bin of the FFT or IFFT (from 1 to N)

N: the window size of FFT.

It can be recognized that the Phase Matrix in equation (1) is a square matrix with a dimension of N*N points. The phase of this matrix is changed as the frequency bin of the FFT is changed. If the FFT has 64 points, then the Phase Matrix in Eq. (1) can be expressed in the form [10]

$$\boldsymbol{PM} = \begin{bmatrix} e^{-j\left(\frac{2\pi}{64}\right)*0} & \cdots & e^{-j\left(\frac{2\pi}{64}\right)*63} \\ \vdots & \vdots & \vdots \\ e^{-j\left(\frac{2\pi}{64}\right)*0} & \cdots & e^{-j\left(\frac{2\pi}{64}\right)*4032} \end{bmatrix} \qquad (2)$$

And the phase values in degree can be written in the form[10]:

$$\boldsymbol{Y_{receiver}} = \boldsymbol{y_{received\ signal}} * \text{ Inverse Phase Matrix} \qquad (3)$$

Update that the last comparison is a typical mathematical statement, which implies it relies on upon the site of the got signal that should be handled, and this area subject to the transmitter side, in light of the fact that at the collector the backwards process will be done to prepare the sign.

## 3. Simulation Results

In this part, the set of classical LTE 3GPP and the proposed LTE 3GPP with phase matrix will be present, the simulation of the two schemes has been made using Math Works TM in the MATLAB® R20014a software package. And the BER performance of the two systems will be considered AWGN, and AWGN+ frequency selective fading channel, with a bit rate of 5 Mbps and 64 subcarriers are used in this simulation. Table.1 shows the parameters of the system used in the simulation

Table.1: Simulation Parameters

| | |
|---|---|
| Transmission Bandwidth | 2.5 MHz |
| Sub-frame duration | 0.5ms |
| Sub-carrier spacing | 15KHz |
| Sampling Frequency | 3.84MHz |
| FFT Size | 256 |
| OFDM symbol per slot (short/long CP | 7/6 |
| CP length (µsec/samples) | SHORT (4.69/18) x 6<br>(5.21/20) x 1<br>LONG (16.67/64) |
| Modulation type | 16QAM |
| Channel coding | Turbo |
| Channel type | AWGN, Flat Fading, Selective Fading |
| Receiver decoder type | Soft sphere detection (SSD) |
| Number of iterations | 1000 |
| Nominal Bitrates (Mb/s) | 36Mbit/s |

### 3.1 Performance of the Proposed LTE 3GPP Transceiver with Phase Matrix in AWGN Channel

Figure 2 shows BER performance of proposed model under AWGN. From this Figure.2, it is found that the proposed system LTE 3GPP Transceiver with phase matrix does worked with S/N = 6.8dB at BER=$10^{-3}$, while in the classical LTE 3GPP Transceiver the bit error rate of BER=$10^{-3}$at S/N=16.2dB, It is shown clearly that the proposed model is much better than classical model.

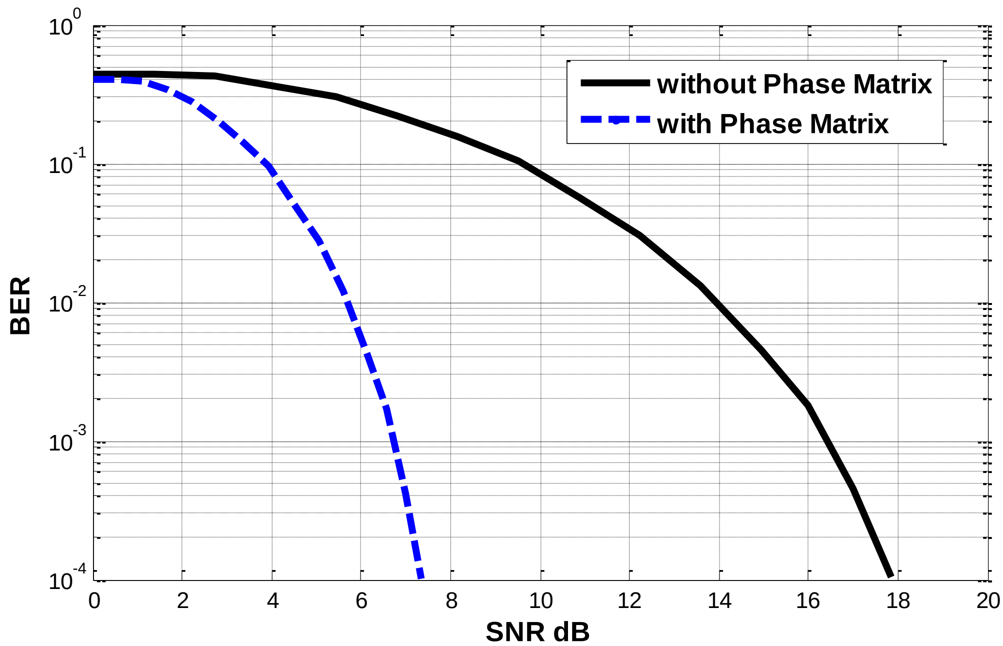


Fig. .2 BER performance of proposed model in AWGN

## 3.2 Performance of the Proposed LTE 3GPP Transceiver with Phase Matrix in Flat Fading Channel

In this kind of channel, the signal will be affected by the flat fading in addition to AWGN; in this situation all the frequency components in the signal will be affected by a constant attenuation and linear phase distortion of the channel, which has been selected to have a Rayleigh's distribution. A Doppler frequency of 10 Hz is used in this simulation. From Figure 3, it can be seen that for BER= $10^{-3}$ the S/N essential for LTE 3GPP Transceiver with phase matrix is about S/N= 13.8dB, while in LTE 3GPP Transceiver without phase matrix the S/N is about 20.1dB. Alternative Doppler Shifts are used, the values taken are 100Hz, 500Hz and the BER vs. S/N are given in the two Figure.4 and Figure.5 below. From all preceding Figures the S/N essential achieving a BER at $10^{-3}$is reduced for the proposed system as the path gain was changed according to the vector values, while it is increased for the classical one.

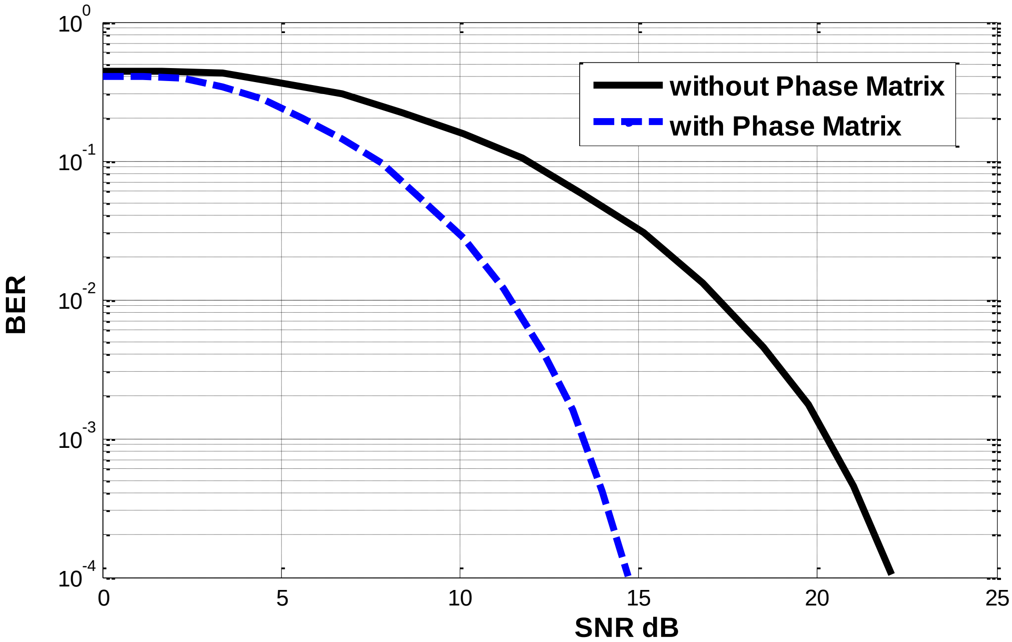


Fig.3. BER performance of proposed model in flat fading channel at maximum Doppler shift 10 HZ

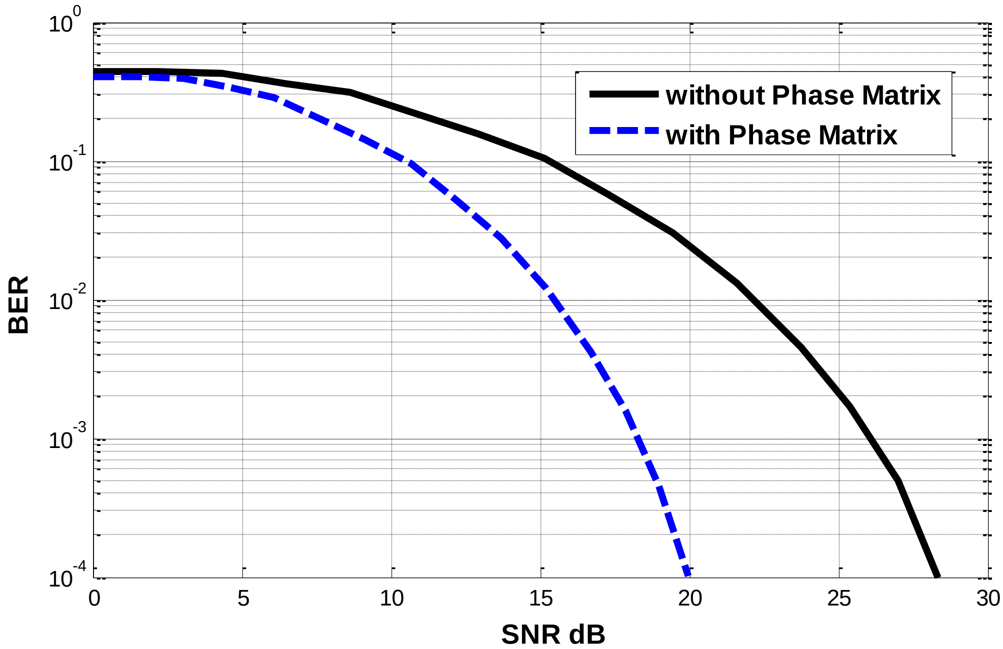


Fig.4. BER performance of proposed model in flat fading channel at maximum Doppler shift 100 HZ

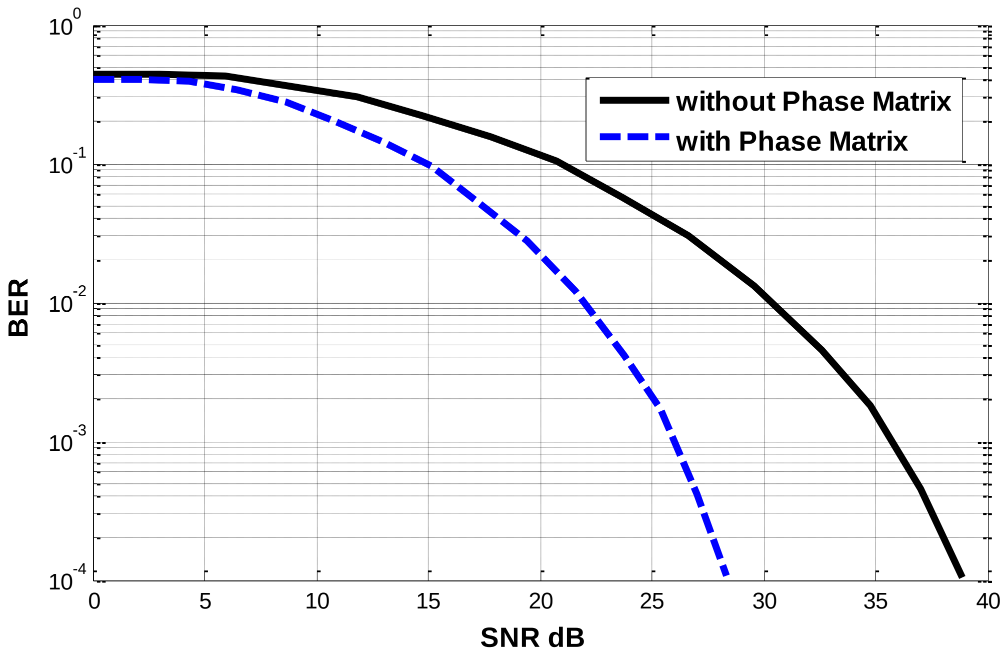


Fig.5. BER performance of proposed model in flat fading channel at maximum Doppler shift 500 HZ

## 3.3 Performance of the Proposed LTE 3GPP Transceiver with Phase Matrix in Selective Fading Channel

In this part, the channel model is supposed to be selective fading channel, where the parameters of the channel in this case corresponding to multipath with two paths are selected. The line of sight (LOS) path has Average Path Gain equal 0dB and Path Delay 0, while the second path has Average Path Gain -8dB and path Delay one sample as displayed in Figure 6 at maximum Doppler shift 10Hz it is clear from this Figure, that BER performance of for LTE 3GPP transceiver with phase matrix is improved too than the other schemes. The proposed model has gain SNR at $10^{-3}$ about (32-12.2) dB comparing with system without PM. After that, the three schemes are tested on other parameter by changing first the Maximum Doppler Shift, setting the parameter to 100Hz and then to 500Hz, the values are displayed in Figure 7 and Figure 8 for Doppler Shift parameter test, the LTE 3GPP Transceiver with Phase Matrix is performing improved than the classical LTE 3GPP Transceiver without Phase Matrix

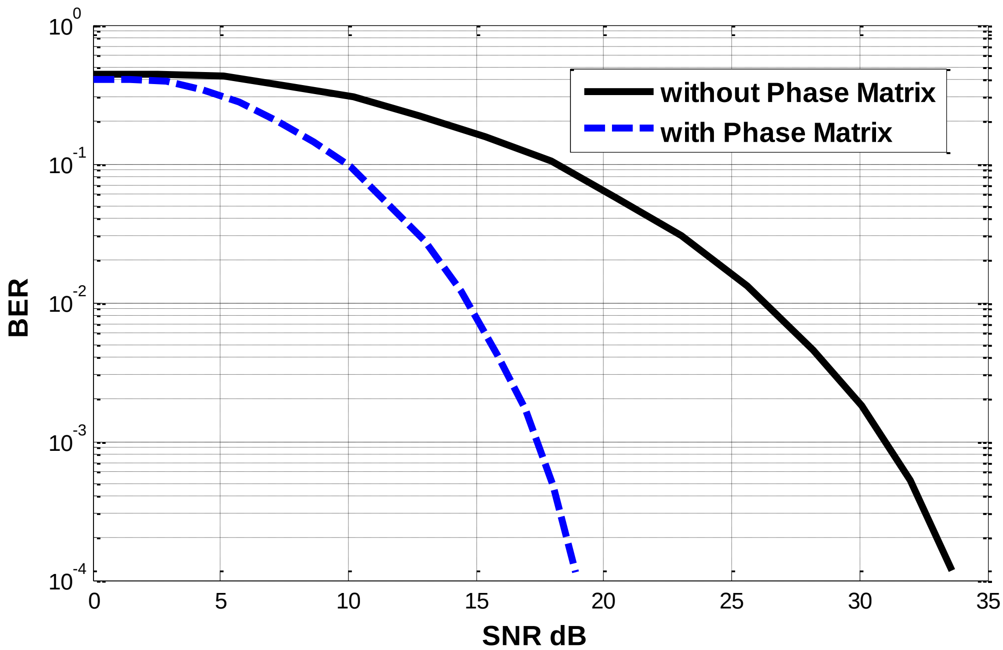


Fig.6. BER performance of proposed model in selective fading channel at maximum Doppler shift 10HZ

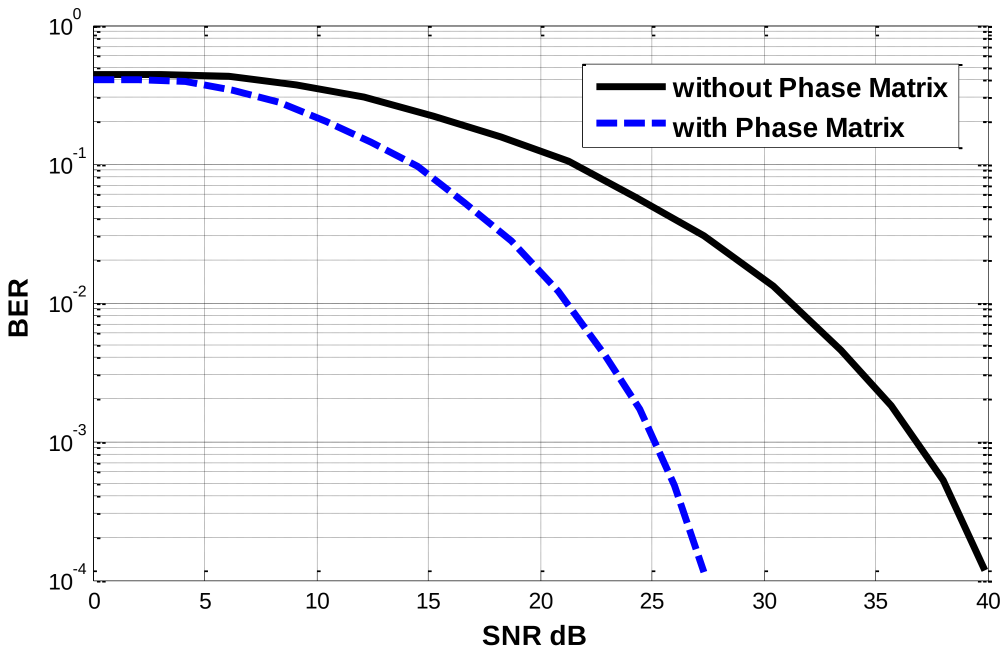


Fig.7. BER performance of proposed model in selective fading channel at maximum Doppler shift100 HZ

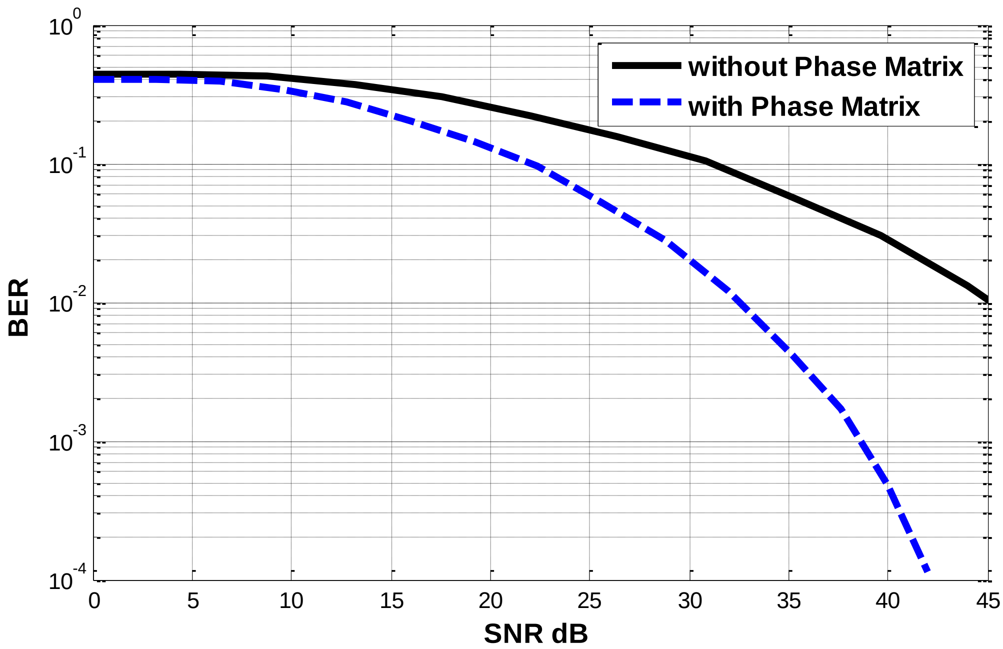


Fig.8. BER performance of proposed model in selective fading channel at maximum Doppler shift 500 HZ

## 4. Conclusion

This paper gives a diagram of the LTE physical layer (PHY) Transceiver, including stage grid that are consider another thought connected to this framework additionally exhibited the disparate outline conditions for LTE 3GPP Transceiver in the presence of channel blurring model. The reproduction of the recommended and traditional LTE 3GPP Transceiver frameworks has been capable. It has been demonstrated that another LTE 3GPP Transceiver with stage lattice is further dynamic to work under some diverse channel conditions. The proposed model is less influenced by changing the way pick up and the way defer and much lower the BER is mainly lessened under different channel exhibitions for recurrence particular blurring and the AWGN channel and S/N improvement contrasted with traditional LTE 3GPP.

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