

BER Analysis of Constant Envelope CPM-OFDM Signals over Single Carrier -Frequency Domain Equalizer

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Abstract

The continuous phase modulation (CPM) is a adaptive phase modulation technique which performs a vital role in OFDM system than constant envelope based on OFDM. The system combines the frequency diversity and low complexity type of equalizer. The attractive digital modulation adopted two types of equalizers; zero forcing and MMSE equalizer. The constant envelope modulation also used to attract the OFDM in future communications. The digital modulations QPSK, DPSK, 4-FSK and 4-PAM are analyzed to achieve good error rate and QPSK/QAM outperforms the PAM and FSK. The constant envelope OFDM (CE-OFDM) propagates the signal with near ideal PAPR than conventional systems and gives good performance with suitable FDE. In this paper, we proposed CE- CPM based FDE which is feasible than CE –CPM based OFDM and non OFDM systems. The error rate can minimize via selected equalizer which will results in good performance under channel conditions.

Keywords: Constant Envelope CPM, Orthogonal FDM, Bit Error Rate, Signal to Noise Ratio, PAM, QAM, Single carrier –FDE.

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INTRODUCTION

The phase modulations are categorized into digital and continuous phase modulations to transmit the signals. In digital phase modulations carrier phase abruptly resets to zero at the start of every symbol. The single carrier -frequency domain equalizer (sc-fde) plays an important role in wireless communications under channel conditions. When compared to orthogonal frequency division multiple access (ofdma) the single carrier –fde performs low to expected power ratio.at the same time error rate is low due to their effectiveness, less sensitive to synchronization errors, diversity gain, code rate and computational complexity. Whereas the multi carrier systems are degraded than single carrier systems over frequency selective channels.

Several techniques have been proposed by authors in [1-6], the clipping and filtering, companding functions, probabilistic approaches, coding techniques, hybrid techniques to reduce power ratio, error rate. The probabilistic techniques: partial transmit sequence, selective mapping, interleaved, tone reservation and tone injection; coding techniques: convolutional code, turbo code, golay sequence, polar code, reed-muller

code and LDPC codes are most attractive to use in uplink communications. The alternative approaches to mitigate the PAPR, BER via the signal transformations that applied transformation at the transmitter and inverse transformation at the receiver. The phase modulator and phase demodulator are adopted in CPM to generate constant envelope signals. The IFFT is a choice before the phase modulator and FFT is after the phase demodulator to perform superior to conventional systems. The capable of CE-CPM-FDE, CE-CPM-OFDM are additional topology to conventional OFDM methods and OFDM is the extended way to phase modulation.

This paper organized as section II presented the concepts of OFDM and single carrier FDE which enables the error rate suitably. In section III, the proposed phase modulation methods are performed with QAM mapper with suitable equalizer. The section IV deals with evaluation of error rate for constant phase and envelope modulation in OFDM and SC-FDE. Finally, the section V proposed techniques concluded superiority in present wireless communication environment.

BACKGROUND

Wireless communication is revolutionary advancement in the recent decades, which has changed the face to latest telecommunications. The global system for mobile (GSM) cellular standard, which was formulated in 1992 has been rapidly adopted by billions of cellular users for voice communication. The advent of internet packet-based data networks has ushered an ever increasing demand for ubiquitous data access over these wireless networks. This leads to a progressive advancement of wireless communication from traditional voice-based networks to internet, multimedia, and video service networks. In this process, successive generation of wireless standards have evolved to support the rich high data rate wireless ecosystem, which basically comprises the 3G and 4G of growth of radio communications.

Orthogonal FDMA is focused on 4G standards for instance Long Term Evaluation (LTE) as 802.11 a/g/n. the extended kind of OFDMA is single carrier -

FDMA (SC-FDMA) or localized FDMA (LFDMA) to minimize the demerits which are existing in OFDMA and in OFDM. In general OFDM structure is orthogonally placed subcarriers for their efficient use of multi carrier communication in the field of broadcasting networks. But the power ratio is the major problem in these systems at the transmitter level. Unlike TDMA, FDMA, CDMA the OFDM is very attractive to use in LTE standard in mobile communication [7].

Proposed Model

CE-CPM-OFDM model

The CPM-FDE schematic as presented in the Fig. 1 and 2 and $x(n)$ is sample sequence (N), where $n=0,1,2,\dots,N-1$ with mapping. The $x(n)$ is carried via the phase modulator (PM) to form constant envelope $s(n)$ after that cyclic prefix (CP) is added to generate transmitted signal. The $x[n]$ is passed through the phase modulator and the output CPM transmitted signal is expressed as here C is scaling constant.

$$s[n] = e^{jCx[n]} \quad (1)$$

The $s[n]$ be applied through the N_{cp} (added cyclic prefix) and the CE-OFDM signal can be presented as

$$s(t) = Ae^{j\phi(t)} = Ae^{j[2\pi\beta m(t) + \theta]} \quad (2)$$

Here, let A is the signal amplitude, μ is the modulation index, θ be the arbitrary angle. Let us $m(t)$ is real signal and can be written as

$$m(t) = C \sum_{k=0}^{K-1} I_k q_k(t) \quad (3)$$

And $m(t)$ is written as

$$m(t) = C \sum_{k=1}^{N_{QAM}} R\{X[k]\} \cos\left(\frac{2\pi kt}{T}\right) - \sum_{k=0}^{N_{QAM}} I\{X[k]\} \sin\left(\frac{2\pi kt}{T}\right) \quad (4)$$

The subcarriers $N = 2N_{QAM}$ and $M = \sqrt{M_{QAM}}$ are PAM symbols.

$$\text{The message signal is } m(t) = C \sum_{k=1}^N I[k] q_k(t) \quad (5)$$

Here,

$$I_k = \begin{cases} R\{X(k)\} & k \leq 1, 2, \dots, N_{QAM} \\ -I\{X(k - N_{QAM})\} & k > N_{QAM} + 1, \dots, N \end{cases} \quad (6)$$

$I_k \in \{\pm 1, \pm 3, \dots, \pm(M-1)\}$ are M-PAM data symbols

$$q_k(t) = \begin{cases} \cos(2\pi kt / T) & k \leq 1, 2, \dots, N_{QAM} \\ \sin(2\pi(k - N_{QAM})t / T) & k > N_{QAM} + 1, \dots, N \end{cases} \quad (7)$$

Where C is constant and variance of the message $\sigma_m^2 = 1$ and the variance of the phase is

$$\phi(t) = 2\pi\beta m(t), \sigma_\phi^2 = (2\pi\beta)^2 \quad (8)$$

Here, β is the deviation ratio and $C = \sqrt{2/N\sigma_f^2}$

$$\text{Where } \sigma_f^2 = E[|X(k)|^2] = (M^2 - 1)/3$$

The subcarriers are centred at frequencies at $\pm i/T, i = 1, 2, \dots, N/2$.

Finally, the receiver signal is coming from FDE equalizer, familiarly MMSE equalizer is given by

$$W(m) = \frac{H^*(m)}{|H(m)|^2 + N_0/A^2} \quad (9)$$

The equalizer coefficient $W(m)$ is at $m=0, 1, 2, \dots, N_{DFT}-1$, for m^{th} subcarrier and estimated $s(n)$ is

$$\tilde{s}(n) = \frac{1}{N_{DFT}} \sum_{m=0}^{N_{DFT}-1} W(m) R(m) e^{j2\pi mn/N_{DFT}} \quad (10)$$

The FIR filter output can be stated as

$$f[i] = \sum_{n=0}^{L_f-1} g[n] \tilde{s}[i-n] \quad (11)$$

The phase of $f(i)$ can be obtained as

$$\phi[i] = \arg(f[i]) = \phi[i] + \delta[i] \quad (12)$$

The estimated $x(n)$ can be presented as

$$\tilde{x}(n) = \sum_{i=0}^{N_{DFT}-1} \phi[i] q_k[i] \quad (13)$$

$\tilde{x}(n)$ is the estimation of $x(n)$ [1-3].

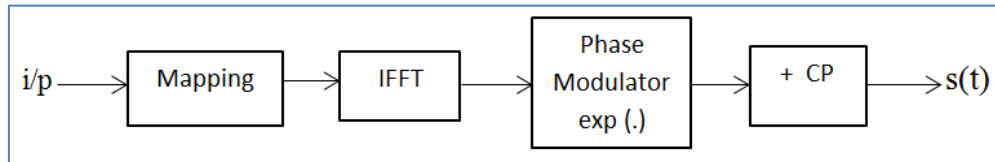


Fig-1: Transmitter Constant Envelope -CPM-OFDM model

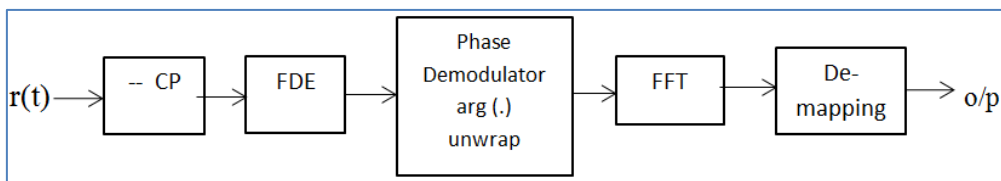


Fig-2: Receiver Constant Envelope -CPM-OFDM model

CE-CPM-SC-FDE model

The single carrier -FDE model described in Figure. 3 and 4 is fully fetched and more dominated than OFDMA in coming uplink transmission. However, little bit circuit complexity arises but it trade off the several criticalities.

The BER analysis is carried out for digital modulation constellation techniques and also the error rate was reduced using frequency domain equalizer. The error rate or error probability is to measure the performance of digital communication systems. The symbol error rate and bit error rate are two possible ways to measure the performance.

$$\text{Symbol Error Rate} = \frac{\text{No. of Symbol in error}}{\text{Total No. of transmitted symbols}} \quad (14)$$

$$BER_{M-QAM} = \frac{4}{\log_2 M} \left(1 - \frac{1}{\sqrt{M}}\right) \sum_{i=1}^{\sqrt{M}/2} Q\left(\sqrt{\frac{3 \log_2 M}{(M-1)} \cdot \frac{E_b}{N_0}}\right) \quad (15)$$

$$SER_{M-PAM} = 2 \left(\frac{M-1}{M}\right) Q\left(2\pi\beta \sqrt{\frac{6 \log_2 M}{(M^2-1)} \cdot \frac{E_b}{N_0}}\right) \quad (16)$$

$$Bit Error Rate_{M-PAM} = \frac{Symbol Error Rate}{\log_2 M} \quad (17)$$

Figure of Merit: E_b/N_0

The E_b/N_0 is a natural figure of merit and which is equal to SNR scaled by bandwidth to error rate in a digital communication system and is defined as

$$\frac{E_b}{N_0} = SNR \cdot \frac{BW}{R_b} \quad (18)$$

The E_b/N_0 is dimensionless parameter and natural figure of merit which is used in digital communications instead of SNR.

In decibels it can be formulated as $10 \log_{10}(E_b/N_0)$ [4-6].

Constellations: The average energy was given as

$$\text{Case i) For PAM, } E_{M-PAM} = \frac{M^2 - 1}{3} \quad (19)$$

$$\text{Constellation points: } 4-PAM = \left\{-\frac{3}{\sqrt{5}}, -\frac{1}{\sqrt{5}}, \frac{3}{\sqrt{5}}, \frac{1}{\sqrt{5}}\right\}$$

$$E_{2-PAM}=1, E_{4-PAM}=5, E_{8-PAM}=21.$$

$$\text{Case ii) For QAM, } E_{M-QAM} = \frac{2}{3}(M-1) \quad (20)$$

$$\text{Constellation points: } 4-QAM = \left\{-\frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right\}$$

$$E_{4-QAM}=2, E_{16-QAM}=10, E_{64-QAM}=42.$$

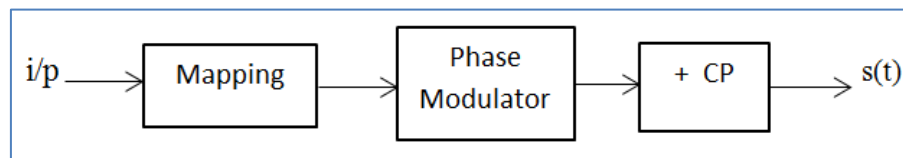


Fig-3: Transmitter Constant Envelope -CPM-SC-FDE model

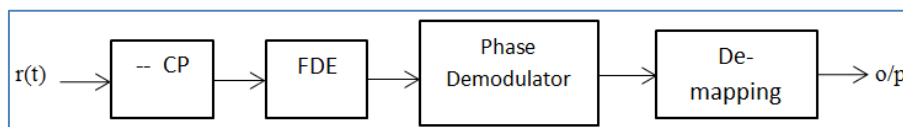


Fig-4: Receiver Constant Envelope-CPM-SC-FDE model

SIMULATION RESULTS

The OFDM and single carrier FDE are more sophisticated systems in mobile communications and in order to measure the system performance, the BER to

be analysed with suitable modulation schemes. In this paper, the modulation schemes 4-PAM, 16-QAM is adopted to analyse error rate. The scheme QPSK/QAM performs better than other modulations but CPM

perform idle PAR which is 0dB. The single carrier FDE outperforms the OFDM through equalizer MMSE [7].

The simulation BER vs E_b/N_0 is to be observed to improve the system performance based on the order

of modulation. The MMSE equalizer outperforms the zero forcing equalizer for constant envelope CPM signals.

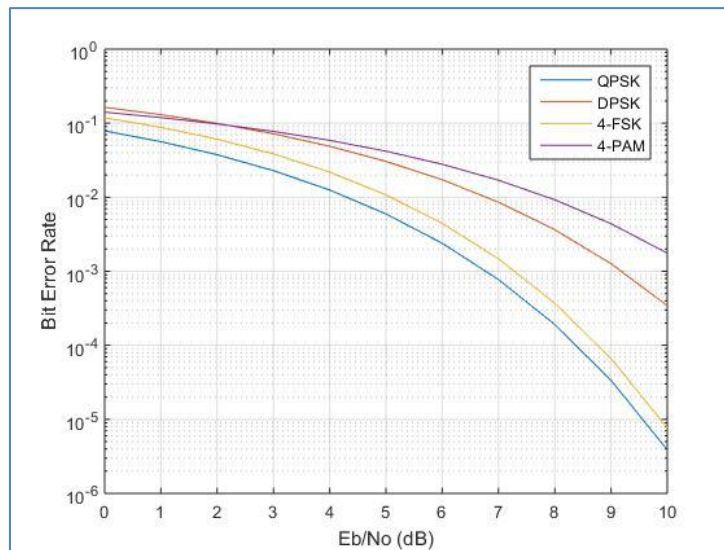


Fig-5: BER of the digital modulation schemes

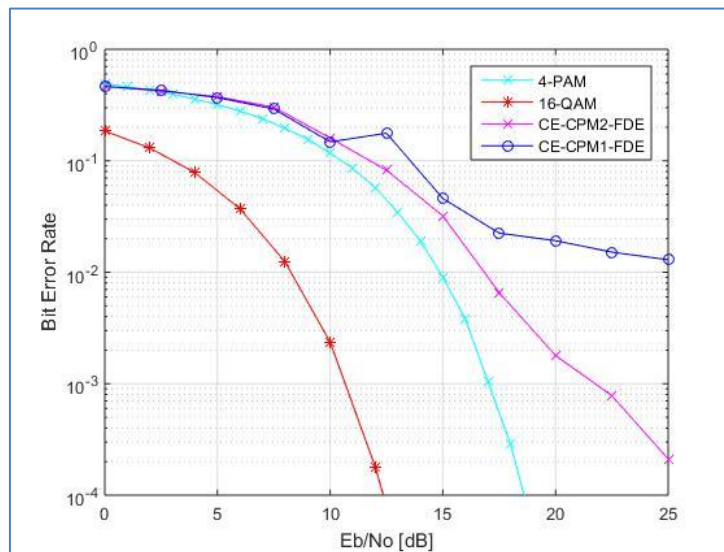


Fig-6: BER of the CE-CPM FDE schemes

The Figure. 5 indicate that QPSK have less error rate than DPSK, 4-FSK and 4-PAM schemes and Figure. 6 illustrates that 16-QAM outperforms other modulation schemes. Also it gives constant envelope CPM-2 better than CPM-1 method when considering MMSE equalizer. The MMSE performs better than zero

forcing because we can reduce errors in communication environment.

Here, the Figure. 7 to 8 presented error rate performances and declared that constant envelope CPM with FDE which outperforms the OFDM based system

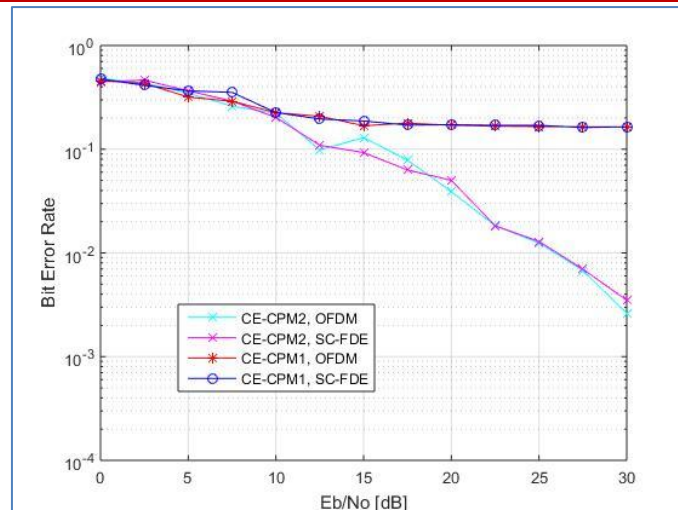


Fig-7: BER of the CE-CPM OFDM vs FDE schemes

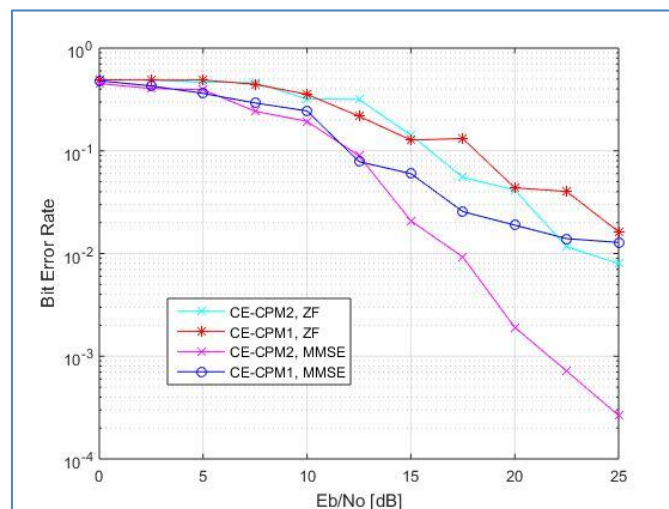


Fig-8: BER of the CE-CPM equalizer schemes

CONCLUSION

In this paper, we observed that a constant envelope CPM dominates the conventional methods and single carrier FDE outperforms the OFDM to reduce error rate and trade off metrics. The equalizer is adopted to reduce the error probability to facilitate the faithful communication.

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