An Improved PAPR Reduction Technique for Adopting Genetic Algorithm based SLM

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ABSTRACT:
Orthogonal Frequency Division Multiplexing (OFDM) technique has been widely adopted in many wireless communication systems due to its high data-rate transmission ability and robustness to the multipath fading channel. One of the major disadvantages of OFDM technique is the high PAPR in the time domain signal. The larger peak-to-average power ratio (PAPR) would cause the fatal degradation of BER performance and undesirable spectrum regrowth. One of the promising PAPR reduction methods is the Selective Mapping method (SLM) which can achieve better PAPR performance without signal distortion. The simulation results show that the proposed based SLM-OFDM system provides better PAPR reduction compared to conventional SLM OFDM system.

Keywords:
Orthogonal Frequency Division Multiplexing (OFDM), Peak-to-Average Power Ratio (PAPR), Selected mapping (SLM), Genetic Algorithm (GA).

I.INTRODUCTION:

Initial proposals for OFDM were made in the 60s and the 70s. It has taken more than a quarter of a century for this technology to move from the research domain to the industry. The concept of OFDM is quite simple but the practicality of implementing it has many complexities. So, it is a fully software project. OFDM depends on Orthogonality principle. Orthogonality means, it allows the sub carriers, which are orthogonal to each other, meaning that cross talk between co-

channels is eliminated and inter-carrier guard bands are not required. This greatly simplifies the design of both the transmitter and receiver, unlike conventional FDM; a separate filter for each sub channel is not required. Orthogonal Frequency Division Multiplexing (OFDM) is a digital multi carrier modulation scheme, which uses a large number of closely spaced orthogonal sub-carriers. A single stream of data is split into parallel streams each of which is coded and modulated on to a subcarrier, a term commonly used in OFDM systems. Each sub-carrier is modulated with a conventional modulation scheme (such as Quadrature amplitude modulation) at a low symbol rate, maintaining data rates similar to conventional single carrier modulation schemes in the same bandwidth. Thus, the high bit rates seen before on a single carrier is reduced to lower bit rates on the subcarrier. In practice, OFDM signals are generated and detected using the Fast Fourier Transform algorithm. OFDM has developed into a popular scheme for wideband digital communication, wireless as well as copper wires. Actually, FDM systems have been common for many decades. However, in FDM, the carriers are all independent of each other. There is a guard period in between them and no overlap whatsoever. This works well because in FDM system each carrier carries data meant for a different user or application. FM radio is an FDM system. FDM systems are not ideal for what we want for wideband systems. Using FDM would waste too much bandwidth. This is where OFDM makes sense. In OFDM, subcarriers overlap. They are orthogonal because the peak of one subcarrier occurs when other subcarriers are at zero. This is achieved by realizing all the subcarriers together using Inverse Fast Fourier Transform (IFFT). The demodulator at the user capacity of around three times. This was achieved by compressing the voice waveforms before transmission

2.OFDM is one of the many multicarrier modulation techniques, which provides high spectral efficiency, low implementation complexity, less vulnerability to echoes and non – linear distortion. Due to these advantages of the OFDM system, it is vastly used in various communication systems. But the major problem one faces while implementing this system is the high peak – to – average power ratio of this system. A large PAPR increases the complexity of the analog – to – digital and digital – to – analog converter and reduces the efficiency of the radio – frequency (RF) power amplifier. Regulatory and application constraints can be implemented to reduce the peak transmitted power which in turn reduces the range of multi carrier transmission. This leads to the prevention of spectral growth and the transmitter power amplifier is no longer confined to linear region in which it should operate [1]. This has a harmful effect on the battery lifetime. Thus, in communication system, it is observed that all the potential benefits of multi carrier transmission can be out - weighed by a high PAPR value. There are a number of techniques to deal with the problem of PAPR. Some of them are amplitude clipping, clipping and filtering, coding, partial transmit sequence (PTS), selected mapping (SLM) and interleaving [2]. These techniques achieve PAPR reduction at the expense of transmits signal power increase, bit error rate (BER) increase, data rate loss, computational complexity increase. Presence of large number of independently modulated sub-carriers in an OFDM system the peak value of the system can be very high as compared to the average of the whole system. This ratio of the peak to average power value is termed as Peak-to-Average Power Ratio. Coherent addition of N signals of same phase produces a peak which is N times the average signal [3].

II.OFDM SYSTEM BLOCK DIAGRAM

The OFDM signal is a sum of subcarriers that they are modulated individually by using either quadrature amplitude modulation (QAM) or phase shift keying (PSK) and then they are simultaneously transmitted as data stream [4]. The baseband OFDM signals is given as:

$$x(t)=\sum_{m=0}^{N-1} X_m \exp\left(j2\pi \frac{m}{T} t\right), \quad 0 \le t \le T \quad (1.1)$$

where - m^{th}subcarrierfrequency

X_m -Correspondingtransmittedsymbol– output of M – QAM

N – No. Of sub-carriers

T – Symbol duration

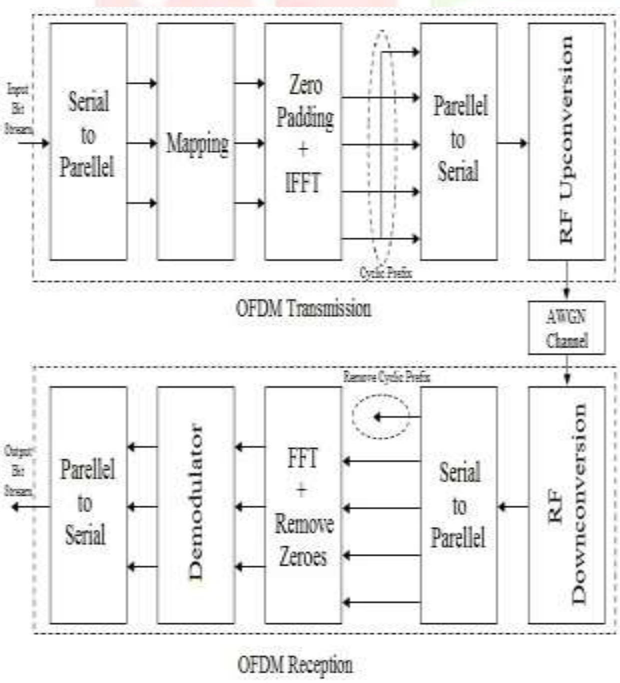

Fig1.1: OFDM System Block Diagram

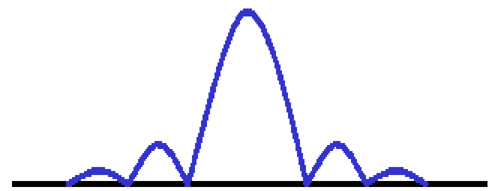

Fig1.2: Spectrum of Normal Time Domain Sequence

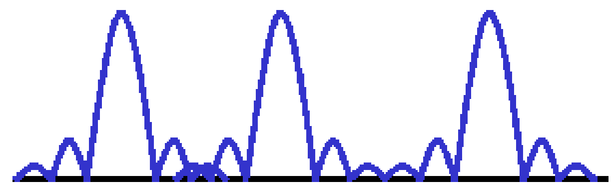

Fig1.3: Spectrum of Classical Frequency Division Multiplexing (FDM)

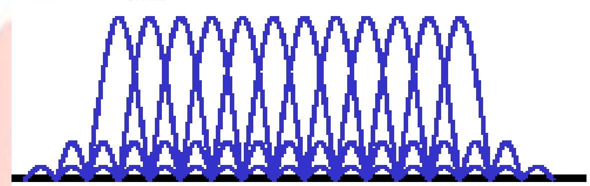

Fig1.4: Spectrum of OFDM

III.PAPR Method

A large PAPR increases the complexity of the analog to digital and digital to analog converter and reduces the efficiency of the radio – frequency (RF) power amplifier. Regulatory and application constraints can be implemented to reduce the peak transmitted power which in turn reduces the range of multi carrier transmission. This leads to the prevention of spectral growth and the transmitter power amplifier is no longer confined to linear region in which it should operate. This has a harmful effect on the battery lifetime. Thus, in communication system, it is observed that all the potential benefits of multi carrier transmission can be out - weighed by a high PAPR value[4].

There are a number of techniques to deal with the problem of PAPR. Some of them are amplitude clipping, clipping and filtering, coding, partial transmit sequence (PTS), selected mapping (SLM) and interleaving. These techniques achieve PAPR reduction at the expense of transmit signal power increase, bit error rate (BER) increase, data rate loss, computational complexity increase.

Presence of large number of independently modulated sub-carriers in an OFDM system the peak value of the system can be very high as compared to the average of the whole system. This ratio of the peak to average power value is termed as Peak-to-Average Power Ratio. Coherent addition of N signals of same phase produces a peak which is N times the average signal.

IV. PAPR OFA MULTICARRIER SIGNAL:

Let the data block of length N be represented by a vector $X = [X_0, X_1, \dots., X_{N-1}]^T$. Duration of any symbol $X_k$in the set X is T and represents one of the sub-carriers chosen to transmit the signal are orthogonal to each other, so we can have $\{f_n, n = 0,1, \dots, N-1\}$set. As the N sub carriers chosen to transmit the signal are orthogonal to each other, so we have $f_n = n\Delta f$, where $n\Delta f = \frac{1}{NT}$ and NT is the duration of the OFDM data block X. The Complex data block X. The complex data block for the OFDM signal to be transmitted is given by:

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n . e^{j2\pi n\Delta f t}, \quad 0 \le t \le NT \tag{4.1}$$

The PAPR of the transmitted signal is defined as

$$PAPR = \frac{\max\limits_{0<t<NT} |x(t)|^2}{1/NT \int_0^{NT} |x(t)|^2 dt} \tag{4.2}$$

Reducing the $max|x(t)|$ is the principle goal od PAPR reduction techniques. Since discrete-time signal are dealt with in most system, many PAPR technique are implemented to deal with amplitudes of various samples of *x(t).* Due to symbol spaced output in the first equation we find some of the peaks missing which can be compensated by oversampling the equation by some factor to give the true PAPR value. The crest factor or peak-to-average ratio (PAR) or peak-to-average power ratio (PAPR) is a measurement of a waveform, calculated from the peak amplitude of the waveform divided by the RMS value of the waveform .It is therefore a dimension less quantity. While this quotient is most simply expressed by a positive rational number, in commercial products it is also commonly stated as the ratio of two whole numbers[5]. In signal processing applications it is often expressed in decibels(dB).The minimum possible crest factor is 1, 1:1 or 0 dB.

V. PAPR in OFDM:

However, OFDM is not without drawbacks. One critical problem is its high peak-to-average power ratio (PAPR). High PAPR increases the complexity of analog-to-digital (A/D) and digital-to-analog (D/A) converters and lowers the efficiency of power amplifiers. Over the past decade various PAPR reduction techniques have been proposed, such as block coding, selective mapping (SLM) and tone reservation, just to name a few. Among all these techniques the simplest solution is to clip the transmitted signal when its amplitude exceeds a desired threshold. Clipping is a highly nonlinear process, however. It produces significant out-of-band interference (OBI). A good remedy for the OBI is the so-called companding. The technique 'soft' compresses, rather than 'hard' clips, the signal peak and causes far less OBI. The method was first proposed in, which employed the classical μ-law transform and showed to be rather effective. Since then many different companding transforms with better performances have been published. This paper proposes and evaluates a new companding algorithm. The algorithm uses the special airy function and is able to offer an improved bit error rate (BER) and minimized OBI while reducing PAPR effectively. OFDM is a powerful modulation technique being used in many new and emerging broadband communication systems.

Using MATLAB software simulation analysis of PAPR reduction is performed by averaging over 104 randomly OFDM symbols with QPSK modulation. The analysis of PAPR performance for original OFDM, the conventional SLM-OFDM and GA based SLM-OFDM systems is presented in terms of CCDF. The simulation parameters used through the comparative study are stated in Table 5.1

Table 5.1: Simulation parameters.

System parameters	Value
Number of subcarriers	128
Modulation type	QPSK
Phase rotations	-1, 1, j, -j
Size of initial population	150
Number of iteration	10
Mutation probability	0.3
Crossover probability	0.7

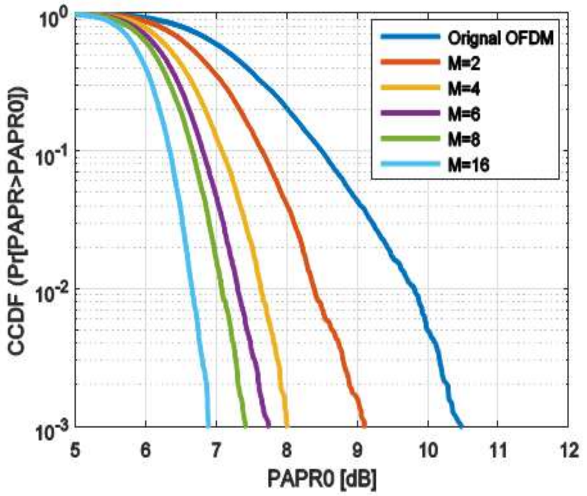

Fig.5.1 CCDF of the OFDM for SLM Technique with Different Number of Phase Sequences.*M* and *N* = 128 subcarrier.

As shown in Figure 5.1, it can be observed that the conventional SLM method displays a better PAPR reduction performance than the original OFDM signal which is free of any PAPR reduction scheme. The probability of high PAPR is significantly decreased. Increasing the number of phase sequences M leads to the improvement of PAPR reduction performance. If the probability is set to 10-2 and then the CCDF curves with different M values are compared.

The PAPR value of case M = 2 is about 1.5 dB smaller than the unmodified one M = 1. Under the same condition, the PAPR value of case M = 16 is about 3.2 dB smaller than the original one M = 1. However, from the comparison of the curve M=8 and M=16, we learned that the performance difference between these two cases is about 0.5 dB. This proves that we will not be able to achieve a linear growth of PAPR reduction performance with further increase the value of M (like $M \geq 8$), the PAPR reduction performance of OFDM signal will not be considerably improved and it will also add more computational complexity.

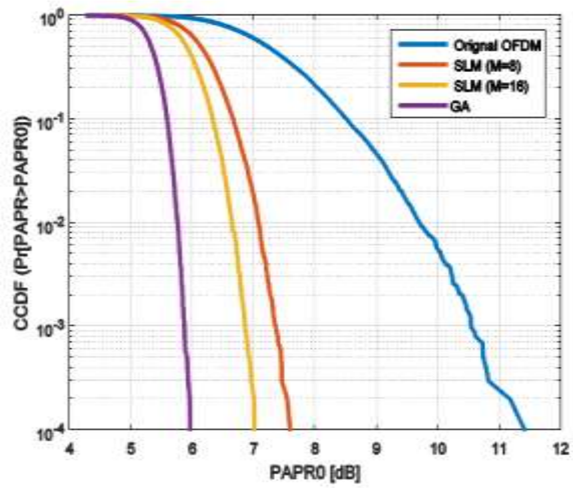

Fig.5.2 CCDF of the Original OFDM, GA based OFDM-SLM and OFDM-SLM Techniques with (*M* = 8,16).

The PAPR Reduction performance of proposed GA based SLM-OFDM system is compared with conventional SLMOFDM system in Fig.5.2. The simulation depicts that GA based SLM-OFDM is more effective in reducing the PAPR than SLM-OFDM. At CCDF probability of 10-2, GA based SLM-OFDM attains 5.8 dB PAPR, while the SLM-OFDM with (= 16) attains 6.7 dB with reduction gain of 0.9 dB. We can notice also that the PAPR reduction gain of the GA based SLM-OFDM compared with original OFDM is about 4 dB.

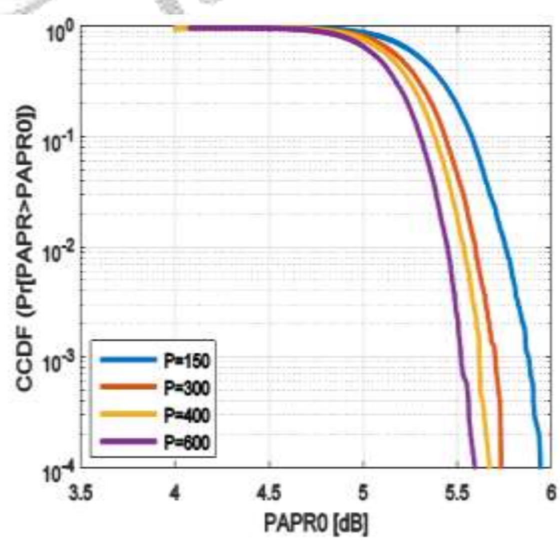

Fig7.3 CCDF of the GA based OFDM-SLM Technique with Different Population Size *P*.

From Fig.5.3, it can be seen that the proposed GA based OFDM-SLM algorithm undeniably improves the performance of OFDM system, moreover, with the increasing of population size *P*, the improvement of PAPR reduction performance becomes better and better. Assume that we fix the probability of PAPR at 10-2 and compare the CCDF curve with different *P* values. From the Fig.5.4, we notice that the CCDF curve has nearly 0.2 dB improvement when *P* = 300 compared to *P* = 150. When *P* = 600, the 10-2 PAPR is about 5.4 dB, so an optimization of more than 0.35 dB is achieved compared to *P* = 150.

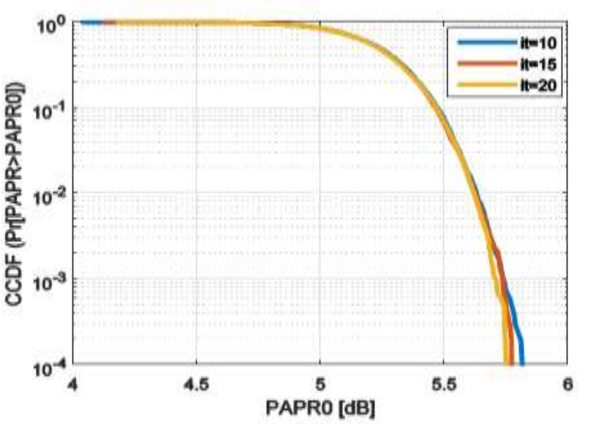

Fig.5.5 CCDF of the GA Based OFDM-SLM Technique with Different Iteration Values.

Fig.5.5 shows the effect of the iterations on the PAPR performance. It can be seen that the PAPR is reduced clearly by increasing the number of iterations.

VI.CONCLUSION:

In this project, an efficient technique based on GA is proposed to achieve PAPR reduction. The PAPR reduction performance of the proposed SLM-OFDM system using GA for optimum phase rotation factors searching was compared with the original OFDM and conventional SLMOFDM systems. According to the simulation results, the proposed GA based SLM-OFDM outperforms the compared systems with low computational complexity.

VII. Future Scope:

The future work may include the implementation on investigating and quantifying further the influence of PAPR as a function of different modulation mapping schemes, OFDM subcarrier levels, and phasing schemes. OFDM is one of the most widely used modulation schemes in wireless communication but for next generation wireless communication multicarrier communication schemes are required which are more spectral efficient and can support higher data transmission rate.

VIII. References

[1] Y. J. Shi, D. Z. He, W. Huang, Y. Xu, Y. F. Guan, and J. Sun, "Constellation Shifting Based on QAM with Gray Coding for PAPR Reduction of OFDM Systems," IEEE International Symposium on Broadband Multimedia Systems and Broadcasting, pp.1-3, 2013.

[2] S. Pyla, K. P. Raju, and N. Balasubrahmanyam, "PAPR Reduction in OFDM Systems Using PTS and Various Modulation Scheme," 15th International Conference on Advanced Computing Technologies, pp.1-6, 2013.

[3] J. W. Ji and G. L. Ren, "A New Modified SLM Scheme for Wireless OFDM Systems without Side Information," IEEE Signal Processing Letters, vol.20, no.11, pp.1090-1093, 2013.

[4] Y. Wang, W. Chen, and C. Tellambura, "Genetic algorithm based nearly optimal peak reduction tone set selection for adaptive amplitude clipping PAPR reduction," IEEE Trans. on Broadcast., vol. 58, no. 3, pp. 462- 471, Sept. 2012.

[5] S. S. H. Masoumian, M. Shabani, and B. M. Tazehkand, "A New PAPR Reduction Method Based on Clipping Technique Using Compressive Sensing," 6th International Symposium on Telecommunications, pp.238- 242,2012.

[6] J. C. Chen and C. P. Li, "Tone reservation using near-optimal peak reduction tone set selection algorithm for PAPR reduction in OFDM systems," IEEE Signal Process. Lett., vol. 17, no. 11, pp. 933-936, Nov. 2010.

[7] T. Jiang and Y. Y. Wu,"An Overview: Peak-to-Average Power Ratio Reduction Techniques for OFDM Signals," IEEE Trans. Broadcast., vol. 54, no. 2, pp. 257–268, June 2008.

[8] S. J. Heo, H. S. Noh, J. S. No and D. J. Shin "A Modified SLM Scheme With Low Complexity for PAPR Reduction of OFDM Systems", IEEE Trans. on Broadcasting, vol. 53, no. 4, pp. 802- 808, Dec. 2007.

[9] S. H. Han & J. H. Lee, "An overview of peak-to-average power ratio reduction techniques for multicarrier transmission," IEEE Wireless Communications Magazine, Vo. 1210, No. 2, pp.56-65, Apr. 2005.

[10] IEEE 802.16d, Air interface for fixed broadband wireless access systems, IEEE 802.16, May 2004

[11] A.R.S. Bahai, M. Singh, A.J. Goldsmith and B.R. Saltzberg "A new approach for evaluating clipping distortion in Multicarrier systems," in IEEE Journal on Selected Areas in Communications, vol. 20, 2002, pp. 3–11.

[12] H. Ochiai and H. Imai "Performance analysis of deliberately clipped OFDM signals," in IEEE Transactions on Communications, vol. 50, no. 1, Jan. 2002, pp. 89–101.

[13] E. Costa and S. Pupolin "M-QAM-OFDM system performance in the presence of a nonlinear amplifier and phase noise," in IEEE Transactions on Communications, vol. 50, 2002, pp.462–472.

[14] C. V. Chong and V. Tarokh, "A Simple Encodable/Decodable OFDM QPSK Code with Low Peakto-Mean Envelope Power Ration,"IEEE Trans. Info. Theory, vol. 47, no. 7, Nov. 2001, pp. 3025–29.

[15] R. V. Nee & R. Prasad, "OFDM wireless multimedia communications," Artech House, 2000.

[16] P. Banelli and S. Cacopardi "Theoretical analysis and performance of OFDM signals in nonlinear AWGN channels," in IEEE Transactions on Communications, vol. 48, no. 3, March 2000, pp. 430–441.

[17] S. Muller and J. Huber, "OFDM with reduced peak-to-average power ratio by optimum combination of partial transmit sequences," Electronics Letters, vol. 33, no. 5, pp. 368–369, 1997

[18] R. W. Bauml, R. F. H. Fisher and J. B. Huber, "Reducing the Peak-toAverage Power Ratio of Multicarrier Modulation by Selected Mapping", Electronics Letters, vol. 32, no. 22, pp. 20562057, Oct. 1996

[19] M. Srinivas and L.M. Patnaik, "Genetic algorithms: A survey," IEEE Computer, vol. 27, no. 6, pp. 17–26, June 1994

[20]. S. Forrest and M. Mitchell, "What Makes a Problem Hard for a Genetic Algorithm? Some Anomalous Results and their Explanation," in Machine Learning, Vol. 13, 1993, pp. 285-319.

[21] L. Davis, Handbook of Genetic Algorithms, Van Nostrand Reinhold, 1991

[22]. D.E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Addison-Wesley, Reading, Mass.,1989.

[23]. S. Kirkpatrick, C.D. Gelatt, and M.P. Vecchi, "Optimization by Simulated Annealing," Science, Vol. 220, No. 4598, May 1983, pp. 671-681.

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