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An OFDM PAPR Reduction Technique using Perfect Random Sequences and DAPM-DWT for 5G Technology

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ABSTRACT

Orthogonal frequency division multiplexing (OFDM) systems suffers from high peak to average power ratio (PAPR). In this paper, PAPR is reduced for OFDM systems for 5G wireless networks by proposing a scheme which employs perfect random sequences to reduce the PAPR for different channels like A White Gaussian Noise (AWGN), flat fading channel and frequency selective channel with DWT, DFT and DCT by using Differential Amplitude and Phase modulation (DAPM), Quadrature Amplitude Modulation (QAM) and Pulse Amplitude Modulation (PAM) modulation techniques. Simulation results show that the proposed method has less PAPR value for DAPM-DWT and less BER for DAPM-DWT for flat fading and frequency selective channels and also as compared with DCT, DFT with QAM and PAM modulation techniques.

KEY WORDS: OFDM, PAPR, RANDOM SEQUENCES, 5G, DWT, DAPM.

INTRODUCTION

OFDM could be a modulation with many carriers that is employed in several wireless communication standards and this method has higher spectral potency and has better information rates in channels (G. Wunder et.al.,2013).In DWT based OFDM cyclic prefix may not be required because of the overlapping properties and this avoids ISI because the subcarriers are of restricted length. The linear power amplifier cause the inter carrier modulation which produces large peak amplitudes in the OFDM signal, this causes large PAPR and BER. OFDM is having high PAPR which may be the disadvantage within the multicarrier transmitted signals (J G Proakis, 1995).

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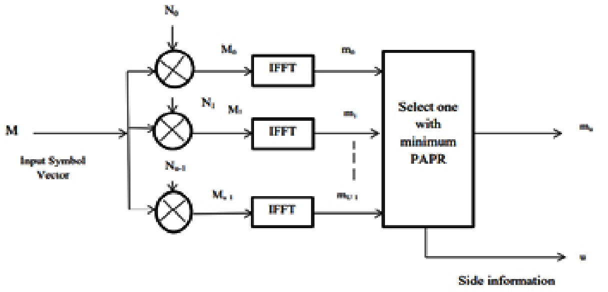
The encoding used by the 5G networks is OFDM that is almost same as that to the encoding used by 4G LTE. Compared to the LTE, the air interface has flexibility and lower latency and 4G has identical airwaves. Because of the economical encoding, the 5G radio system can go with 30% higher speed. Also 5G networks use channels larger than 4G networks. with 20MHz secured up to 100MHz with exploitation of the foremost amount as 800MHz at a time (paolo Banelli et. all., 2014).

Within the literature several strategies are planned for reducing the PAPR in OFDM systems (S Zhang, 2016 & S P Delmarco, 2018) .In (Si-Yu Zhang et. all., 2020) a scheme that reduces PAPR consists of 2 stages. The primary stage that constructs a collection of QAM outcomes with the littlest potential range of IFFTs and also the second stage relies on the changed category III SLM (Selected Mapping) scheme planned that a bank is of parallel blocks. Every block uses circular convolution and circular shifting to generate additional sequences from QAM outcomes by passing this information via collection of many blocks. In (Si- Yu Zhang et. al., 2018) the changed version of the standard SLM technique is planned. during this paper while not increasing the quantity of IFFTS, the performance of the SLM scheme is improved with respect to PAPR and also the simulation results shows that this technique has less PAPR performance than the standard SLM for a given range of IFFTs with no further facet info.

In (Puneeth Kumar D N et al., 2020) DWT-DAPM technique is employed to scale back the PAPR and BER within which the PAPR is reduced to 4.497 at 10-3 CCDF(Complementary Cumulative Distributive function) and different transforms like DFT,DCT area unit used and area unit modulation techniques like QAM and PAM area unit used and also the results area unit compared. In (H B Jeon et. al., 2011), the procedure quality while not touching BER and PAPR by exploitation the extra memory to save lots of the additive mapping signal sequences is reduced with QAM modulation technique. In (Hyun- Seung Joo et.al.,2017) two partial transmit sequence (PTS) while not facet info (SI) area unit planned for reducing the PAPR of OFDM signals and from the numerical analysis the performance of the BER isn't degraded when put next with the standard PTS with good SI. In (Pingyuan et. al., 2015) tone reservation technique is employed within which the kernel matrix in the time domain to come up with reducing the height of the signals with the kernel generated in time domain onetime or offline and within the peak reduction iterations there are not any IFFT/FFT operations and also the simulation results shows that hardware and time quality of this scheme area unit. In (H B Jeon et. al., 2009) SLM technique supported bit exploitation QAM modulation technique within which the magnitudes and phases are modified.

In this paper PAPR reduction methodology using the transforms like DWT, DFT and DCT by applying many modulation schemes such as PAM, DAPM and QAM with perfect random sequences as well as 10 iterations OFDM system has been proposed considering 64,128,512 sub-carriers and the input message size of 1500 bits. The performance analysis is done based on PAPR and BER for this system.

Figure 1: Concept of Conventional SLM technique.



Organisation of the paper: Section II deals with the SLM scheme where as in the next section better proposed method is discussed. Research outcomes are discussed in the section IV and in the section V conclusion inference are drawn.

The Conventional Slm Technique: Here short information concerning SLM technique is mentioned. For the first time the idea of SLM was given in (R J Baxley et. all., 2013), within the literature it's been shown that SLM technique will cut back PAPR with less distortion when put next to different strategies. The block diagram of SLM technique is shown in figure 1.

At the transmitter side X parallel bit streams are produced due to the multiplexing of the bit streams of 0s and 1s of the OFDM system. Then this M bit stream which are in parallel leading to the vector :

$$M=[M[0],M[1],\ldots\ldots\ldots\ldots M[X-1]]^T \quad (1)$$

M[k] being for k=0 to N-1 are the symbols which are present in the PSK and QAM. In the traditional SLM techniques U phase vectors are given as

$$N_U=[N_u[0],N_u[1],\ldots\ldots\ldots N_u[X-1]]T \quad (2a)$$

$$M_u[k]=e^{j\Phi n[k]} \quad (2b)$$

where Φ_u [k] € (0, 2π) for u=0 to u-1 with k=0 to N-1. To generate a set of U

sequences $[M_u]_u$=0u-1 (3)

And $M_u=[M_u[0],M_u[1],\ldots\ldots,M_u[N-1]]^T$..

With components $M_u[k]=M_u[k]M[k]$ (4)

For u= 0 to U-1 and k=0 to N-1,

the equation 4 can be written in the form

$$M_u=N_u\times M_u=0,1,\ldots\ldots U-1 \quad (5)$$

where x is a product of component.

From the set {±1} or { ±1,±j} of the phase rotation factors Nu the integers multiples of π and π/2 phase shifts are used. Then, the sequences are passed through U. In time domain, N point IFFTs are given as

$$M_u= \text{IFFT } [M_u] \; u=0,1,\ldots,U-1 \quad (6)$$

Where M_u=[$M_u[0]$, $M_u[1]$,...,Mn[N-1]]^T

Where $F_{\Gamma_z}(\gamma)=p_r(\Gamma_x\leq\gamma)$ is the cumulative distribution function of Γ_m.

The lowest PAPR is selected for the SLM for all the U candidate sequences.

With components

$$M_u[n]=\frac{1}{X}\sum_{k=0}^{N-1} Mu[k]e^{j2\pi kn/N}, \quad (7)$$

n=0 to N-1

The PAPR of the cand sequence is calculated as

$$PAPR\{m_u\} = \frac{\max\limits_{n=0,1,\ldots N-1} |m_u(n)|^2}{\frac{1}{N}\sum\limits_{n=0}^{N-1} E[|m_u[n]^2|]} \quad (8)$$

E[.] I being the expectation.

For the U cand sequence, the scheme selects one which …d by m_u.

$$\tilde{u} = \arg\min_{u=0,1,\ldots U-1} PAPR\{m_u\} \quad (9)$$

The performance of the scheme for the reduction of PAPR is measured by the Complementary cumulative distribution function (CCDF) which is nothing but the probability that block of OFDM symbol X is greater than given thresholdγ.

$$F^c_{\Gamma_x}(\gamma) = 1 - F_{\Gamma_x}(\gamma)$$
$$= 1 - p_\gamma[PAPR(m) \le \gamma] \quad (10)$$
$$= p_\gamma[PAPR[m] \ge \gamma]$$

Proposed Method: The conceptual diagram of the proposed method is shown in figure 2. At the transmitter side of the OFDM the bits consisting of 1s and 0s are de-multiplexed into parallel bit streams of 1s and 0s.The resultant of this will be vectors from N parallel bit streams which are mapped independently,

$S_i(t)=X=[X(0),X(1),\ldots\ldots,X(N-1)]^T$ (11)

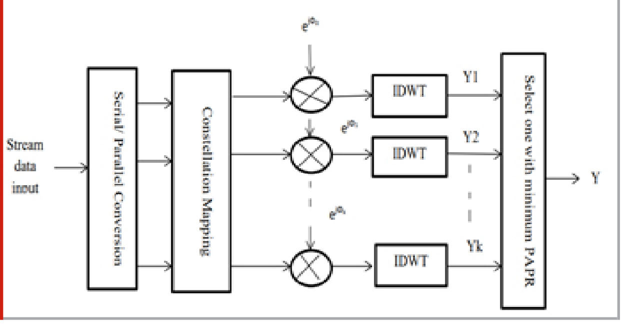
where x[k] for k=0,1,........, N-1 are symbols in a given constellation such as DAPM.

In the random sequence, D special sequences are generated and are applied to the input signals.

The signals are statically independent and are represented as.

$A_i=[e^{j\Phi 0},e^{j\Phi 1},\ldots\ldots\ldots,e^{j\Phi k-1}]^T$ (12)

Figure 2: Block diagram of the proposed method for 5G network



Applying a phase modulation sequence to the OFDM signal yield.

$Y_i(t)=[S_i(t)0e^{j\Phi 0},Si(t)1e^{j\Phi 1},\ldots,Si(t)_{k-1}e^{j\Phi k-1}]$ (13)

The output of IDWT corresponding to y_i (t) can be given as

$$y_i(t) = IDWT\{y_i(t)\} \quad (14)$$

Where $1 \le i \le D$

Select the signal having minimum PAPR

$$y(t) = \min_{1\le i\le D}\{y_i(t)\} \quad (15)$$

DWT-OFDM: Wavelet refers to a small wave with limited duration. Wavelets form the basis of DWT which are asymmetric as well as irregular. Compared to the Fourier transform, variations in time-frequency resolutions are provided by wavelet transform which is a top advantage over FT. Data is split into different frequency components by the wavelet basis function and in contrast the component is chosen based on its scale. At different frequencies of variable size the wavelet function is split into windows which will cause the variation in time-frequency resolution, unlike the Fourier function that is divided into square windows of fixed sizes which doesn't provide variation in time-frequency resolution. The variation in time-frequency resolution provides functions infinite in number for wavelet transform but only one basis function for Fourier transform.

DWT and IDWT formulas are as given in equations (16) and (17) respectively.

$$D_k = \sum_{k=0}^{N-1} d(k)\,\Psi(2k-n) \quad (16)$$

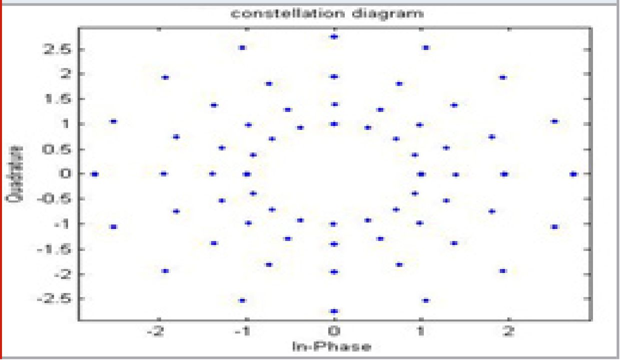
$$d(k) = \sum_{m=0}^{\infty}\sum_{n=0}^{\infty} D_k\,\Psi(2k-n) \quad (17)$$

Table 1. Amplitude value for 64-DAPM

Last two Amplitude bits			
00	01	10	1 1
1	b	b_2	b_3
b	b2	b_3	1
b_2	b_3	1	b
b_3	1	b	b_2

Where, Ψ is the wavelet kernel Filters-LPF and HPF are required for practical implementation of DWT with less complexity. The interference is low due to the DWT overlapping properties and hence cyclic prefix is not used in DWT-OFDM systems and a very low data is present in side lobes and majority of the information is being present in the major lobe (N Neurohr et. al., 1998).

Figure 3: Simulated 64-DAPM constellation diagram.



64-DAPM: The bits are modulated into a group of six before they are modulated. The number of subcarriers are the N number of rows present in the matrix and the subcarriers is the signal from serial to parallel and OFDM symbol represents each column in the matrix. There are six bits out of which 16-DPSK were modulated by first four bits and next two bits are amplitude demodulated in accordance with table (1). (H Y S Xu et. all.,2005).

Perfect Random Sequence: From the discrete time OFDM transmission concept, a constellation plot is created for symbols N number block of data, where N is the number of subcarriers to be used. By multiplying the independent phase vectors, a number of independent cand vectors are produced. Consider X(k) as the mapped sub symbol with data X, where, k={0,1,2,.........N-1}. Let the u^th phase vector be represented as (u) , where u={1,2,..........U}. X(u) is the phase vector obtained by multiplying data block with the u^th candidate vector . So from the u^th candidate vector to get the k^th element equation is represented as

$$X^{(u)}(k) = X(k)\,B^{(u)}(k) \tag{18}$$

IDWT operation is done for each candidate vector to get U number of alternate OFDM signals, So for the nth symbol of U^{th} alternative OFDM signal can be represented as

$$x^{(u)}(n) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} X^{(u)}(k)\, e^{j\left(\frac{2\pi nk}{N}\right)} \tag{19}$$

For U number of alternate OFDM, the signal with less PAPR is selected. $x^{(\overline{u})}(k)$ is the selected OFDM signal.

By using the independent phase vectors alternative OFDM symbols will be generated. From equation 18, the u^th phase vector for K^{th} value is $B^{\wedge(u)}$ (k) as given in equation 20.

$$B^{(u)}(k) = e^{j\phi^{(u)}(k)} \tag{20}$$

φ(k) is being the random phase value. Accordingly, the criteria for mutual independence of b(m)(n) and b(l)(n) can be given as

$$E[e^{j\phi}] = 0 \tag{21}$$

ϕ should be distributed uniformly in [0,2π] so as to satisfy the above condition.

Simulation Results: Simulation results of the proposed method are discussed based on two performance indices i.e. PAPR and BER considering AWGN channel in the system with Rayleigh fading.

Papr Performance: Figure 4 shows the PAPR and CCDF performances of the combination of DWT, DCT and DFT with modulation techniques DAPM, QAM and PAM. Here Number of subcarriers are 64,128,256 with input message size is 1500 bits, Number of cyclic prefix samples=16 and perfect random sequences are selected and the phase rotation factors are 4 with 10 iterations. Figure 4 shows the comparisons of PAPR and CCDF performances with various modulation methods PAM, DAPM and QAM with different transformation such as DWT, DCT and DFT. The results are obtained for all these combinations. The combination of DWT- DAPM gives PAPR of 3.421 db at 10-1 CCDF, DWT-QAM gives 3.929 at 10-1 CCDF and DWT-PAM gives 5.057 at 10-1 CCDF. Similarly all the different combinations of transformation and modulation techniques are tabulated in table II. Figure 5 shows the better modulation technique is DAPM modulation technique that has less PAPR value when compared to other modulation systems. Figure 6 shows that DWT is the better method for PAPR reduction.

Figure 4: PAPR of different transforms and modulation technique.

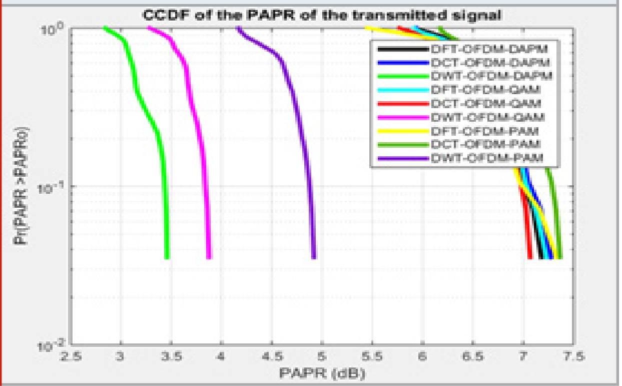
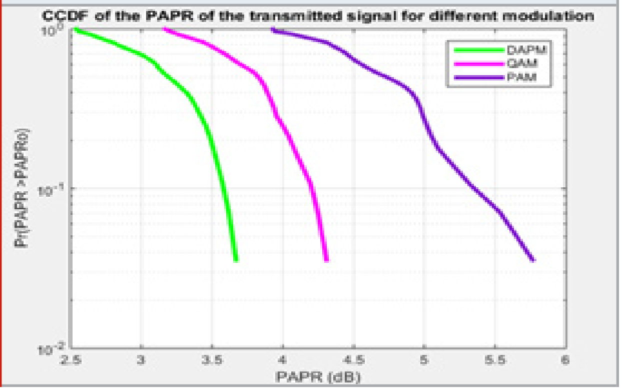


Figure 5: PAPR of different modulation techniques



Ber Performance: The performance of this parameter is evaluated by considering modulation techniques. and transforms. Fig. 7, 8, 9, 10 and 11 shows the results of BER performances and these are tabulated in table 3, 4 and 5. In the AWGN channel QAM modulation technique has less BER value because it has only amplitude and there is no phase but in case of frequency selective and flat fading channel the BER is less in DAPM – DWT combination. Table 6 shows the comparison of the proposed system with other systems. In existence. Table 7 shows the considered parameters while simulation.

Figure 6: PAPR performances for different transforms

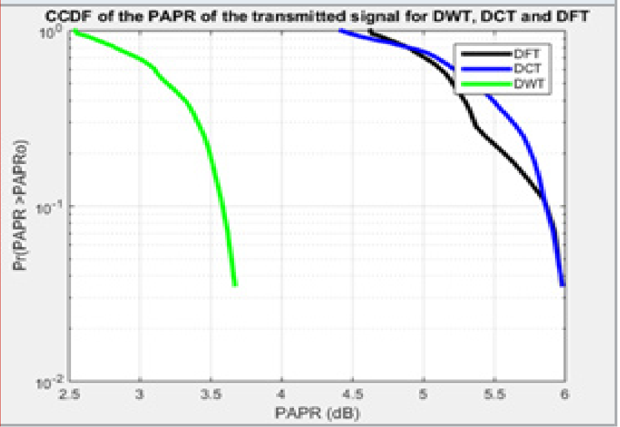


Table 2. PAPR performances for different transforms and modulation technique at 10-1 CCDF

Modulation technique-Transform	PAPR (dB)
DAPM-DWT	3.421
QAM-DWT	3.929
PAM-DWT	5.057
DAPM-DCT	7.088
QAM-DCT	7.201
PAM-DCT	7.146
DAPM-DFT	7.146
QAM-DFT	7.146
PAM-DFT	7.146

Table 3. BER performances of different transforms and modulation technique at 20dB SNR.

Modulation technique-Transform	BER
DAPM-DWT	0.01742
QAM-DWT	0.0009533
PAM-DWT	0.1828
DAPM-DCT	0.0479
QAM-DCT	0.0133
PAM-DCT	0.2205
DAPM-DFT	0.0479
QAM-DFT	0.04542
PAM-DFT	0.2205

Figure 7: BER vs SNR for DW, DC &DF transforms as well as DPCM, PAM, QAM techniques for AWGN Channel.

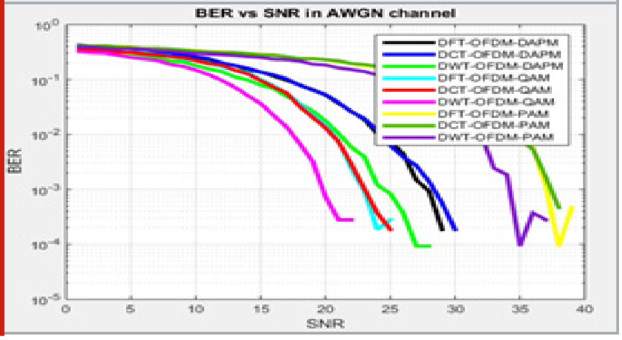


Figure 8. BER vs SNR for different modulation techniques for AWGN channel.

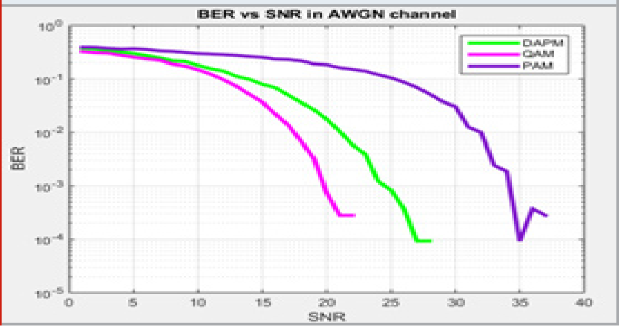


Figure 9. BER vs SNR for DW,DC &DF transforms.

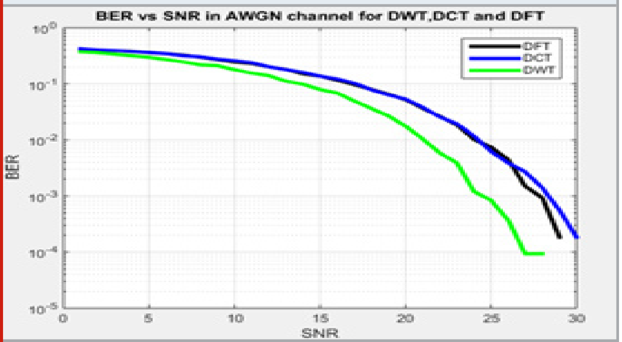


Figure 10: BER vs SNR in flat fading channel for different modulation techniques.

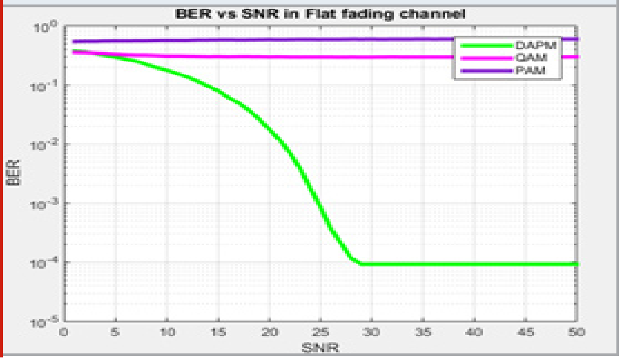


Table 4. BER performances of modulation methods at 20db SNR for flat fading channel.

Modulation Technique	DAPM	QAM	PAM
BER	0.01783	0.6964	0.4716

Table 5. BER performances of different modulation techniques at 20db SNR for frequency selective fading channel.

Modulation Technique	DAPM	QAM	PAM
BER	0.01716	0.5033	0.687

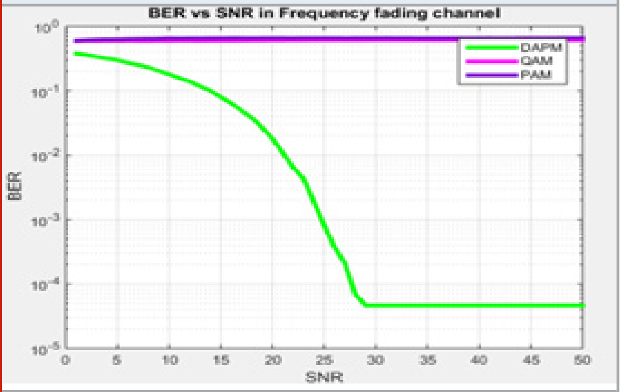
Table 6. PAPR and BER Comparison of the system proposed with the methods in existance

Performance Indices	PAPR (dB)	BER	Modulation Technique
Proposed method	3.437	0.01742	DAPM
Reference 6	7.00	--------	QAM
Reference 7	8.6	--------	QAM

Table 7. Comparison of the proposed system based on the parameters.

Sl No	Considered parameters	System Proposed
1.	No.of Subcarriers	64,128,512
2.	Input message size	1500 bits
3.	Transformation	DWT, DFT, DCT
4.	Modulation	DAPM, QAM, PAM

Figure 11: BER vs SNR in frequency fading channel for different modulation techniques.



CONCLUSION

In this paper, an efficient PAPR reduction technique for OFDM system is proposed. This scheme employs perfect random sequence with transforms DWT, DCT, DFT and modulation techniques DAPM, QAM, PAM and also it is also modelled with AWGN as well as channels with frequency selective fading and flat fading for reducing the PAPR. Simulation results emphasises that the proposed methodology has less PAPR and BER for DWT-DAPM technique which is employed for 5G networks.

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