International Journal of Research
Available at
https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 09
August 2017

SUI modeling for a novel integrated technique for PAPR reduction in OFDM

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Abstract

The recent studies under LTE (long term evolution) will give us the knowledge about how to increase the performance of the transmission systems as well as how to increase the data rate. OFDM (Orthogonal Frequency Division Multiplexing) is recent technology which is studied under the LTE. The main advantages of OFDM systems are their ability of providing high data rate as well as low complexity as compared with previous techniques such as TDMA, FDMA and CDMA. The primary advantage of OFDM is its high data rate. But, as we require more and more data rate there is problem with transmission of data i.e. nonlinear distortions are present. This nonlinear distortion famously known as PAPR (peak to average power ratio) another drawbacks like bit error rate, ICI, etc. Several methods are implemented to overcome the drawback of PAPR. Traditional techniques like SLM and PTS, but they are having some drawbacks so there is need to develop the system which will work effectively compared to state of art techniques. Among the available techniques we used here improved PTS technique by applying CSS (cyclic shifted sequence),which will shift OFDM sequence cyclically and after that cyclically shifted sequence is used to generate alternative signal sequence by combining it for PAPR reduction. Execution results in MATLAB shows that the selected SV sets proposed system is giving enhanced output. To get optimized output we applied piecewise linear companding. Piecewise linear Companding is a novel technique which can be integrated with CSS by proper selecting the SV-set. Piecewise linear companding is a signal distortion technique, which will directly applied for publishing.

Index Terms: *Companding, piecewise linear Companding, CSS, PAPR, OFDM, PTS, SV-sets.*

I. INTRODUCTION

The OFDM study comes under LTE(long term evolution study).In ancient years, the Communication system business has started that specialize in fourth generation mobile communication systems which come under LTE studies. From past some years, the Communication business has started that specialize in fourth generation (4G) mobile communication systems. Current day's we've got high demand for wireless application in day today that have high speed knowledge transmission for long distances. At this time number of mobile applications such as recently low date organizations area unit obtainable. In transmission applications the demand of high knowledge rates area unit developing to achieve the desirable data size. OFDM i.e. 4^{th} generation technique could be a stand-out one in every of multicarrier modulation, that segments the complete entire frequency selective attenuation channel into totally different orthogonal narrowband level flat-fading sub channels, to transmittal the higher data rate consider like 12 Mb, knowledge steram's in parallel over varied lower rate(3Mb) subcarrier. For data transmission OFDM uses multiple slender band subcarriers rather than employing a single wide band subcarrier.

A large range of closely spaced orthogonal frequency is calculated. The orthogonality of the carriers means every carrier has associate degree number of cycles over a total amount. Also the spectrum of every carrier features a null at the middle frequency of every of the opposite carriers within the OFDM system and ends up in no interference between the carriers. This enables the carriers to be separated as we are going to use this proposed work. And so the spectral potency is improved. There is need to develop such algorithm that gives us very less non-linear interferences and complexity should be very less.

To transmit the huge amount of data through OFDM for every subcarriers the info divided into many parallel data streams because there is availability of multicarrier in OFDM. Then the Quadrature Amplitude Modulation is applied for every subcarrier with low data. The entire rate in OFDM is maintained same information measure for each single subcarrier modulation technique.

In wireless communication system OFDM is best technique for achieving higher information transmission and multipath weakening in systems. OFDM could be a special style of multicarrier modulation that is especially fitted to transmission over a dispersive channel. Here the carriers square measure orthogonal to every channel. That's the carrier's square measure wholly. The drawback of the use of multiple carriers is as number of carrier increases the phase shift between the subcarrier also decreased to certain extent .So, as there is very less phase between subcarrier means the subcarriers are overlapping with each other as there is more and more overlapping there is non-linear interference named as PAPR.

For transmission of the OFDM symbols we used multiple narrow band subcarriers instead of use of a wide band signal for transmission. A large number of closely spaced subcarriers we will use to carry data. The meaning of orthogonality of the carriers is nothing but each carrier must have an integer number of cycles over a symbol period. Spectrum of each carrier has a null at the center frequency of each of the other carriers in the OFDM system and used to reduce the interference between the carriers as interference is less there is more data efficiency compared to existing state-of-art techniques. This allows the carriers to be separated as close as possible by using some techniques like SLM, PTS. And thus the spectral efficiency is again improved to certain extent.

OFDM is known as one of the modulation scheme for improvement of the data and it works based on the "orthogonality principle" which is provided for subcarriers. OFDM mainly used for its ability to provide high data and supports many LTE based advance applications.OFDM is having advantages over all state of art traditional communication models which are mostly suffering from the drawbacks like timing jitter, relative fading, distortion as well as PAPR. The PAPR present while transmission will mostly result in Gaussian distributed output samples of OFDM which are insignificant. Inter-modulation between sub-carriers of OFDM transmission and unwanted Out-of-Band Interference which are the main resultant of PAPR production.

There are main two three types for PAPR reduction.PAPR presence has been considerable area in OFDM for its speed consideration and huge amount of research has done with the help of different techniques like Companding Transform (CT), segmental mapping(SLM),Partial transmission sequence, Clipping and Filtering (CF), Tone Reservation (TR), etc. But this all techniques will not produce the state-of-art results while transmission.

Partial transmit sequences (PTS) is one of the low complexity techniques for the PAPR in OFDM. Therefore the OFDM signal is dividing with the help of different subcarriers in sub-blocks and then subblocks are phase rotated as well as they are finally combined to generate OFDM sequence. In this paper we proposed cyclic shift sequence (CSS) with the help of already existing PTS method. In this proposed work how we can reduce the PAPR in OFDM system by selecting good SV Set values which will follow autocorrelation functions. Finally this system is integrated with linear piece-wise Companding to produce best results for PAPR reduction in OFDM.

II. RELATED WORK

There are different techniques which are used for reduction of PAPR in OFDM system. Those techniques are broadly divided into three types such as signal distortion technique, signal scrambling technique and signal coding scheme. Signal distortion techniques we have to distort the signal and in signal scrambling technique we will check the probability of the transmission for different phase angles.

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Under the development of signal scrambling techniques we discussed PTS (partially transmitted sequence).PTS is one of the best technique for the reduction of PAPR, which is famous for its lowest complexity. In this PTS scheme the transmission signal is divided into number of sub-blocks and each and every sub-block is assigned a specific phase factor. This technique will apply the phase factor after application of IFFT, which is nothing but after converting signal into frequency domain to time domain, for time domain signal we will apply phase factor. But the main problem is as sub-block will increase there is an effective increase in complexity of the system. So, to overcome this type of drawback from PTS system there is development of parametric minimum cross entropy method (PMCE) to search optimal combination of the search parameters.

Chin-Liang Wang and Yuan Ouyang (2005) planned for the particular segment mapping technique (SLM). The SLM is additionally will provide us efficiency which is used to know OFDM -PAPR to bring to less extent. SLM provides higher result, however the issue is it needs of Inverse fast Fourier Transforms (IFFTs) to get a group of candidate transmission signals is somewhat complex so that results in high machine quality of the signal and this can results additional Impact on the signal.

In SLM there are in all two novel schemes were planned with lesser quality like the primary technique uses only one IFFT block to get the set of candidate signals, whereas the second uses two IFFT blocks to get the same desired signal. The simulation results of each the theme area unit nearly an equivalent with less performance and rate. Chin Liang wang continues his investigation by oversampling two-fold of the OFDM signals by applying peak search and partial interpolation technique. The planned theme with twofold oversampling has best PAPR estimation performance than the previous work while compared it with conventional scheme.

In literature mostly they compared two basic techniques for PAPR reduction which are SLM (segmental mapping) and PTS(partial transmit sequence).These both are widely known signal scrambling techniques. Compared with SLM and PTS we will get the point that they are working in two different domain.SLM is very easy for implementation but if there is primary consideration of complexity then PTS will outperform the any other conventional techniques.

3. PROPOSED METHODOLOGY

A. PAPR

Basic calculation of PAPR can be given in given formula,

$$PAPR=\frac{\text{Peak power}}{\text{Average Power}}=\frac{max|x(t)|^2}{E[|x(t)|^2]} \quad (1)$$

Where E [·] denotes expected value.

For better performance PAPR should be very less, because this PAPR is nothing but non-linear distortion present in system.

B. Cyclic Shifted Sequences (CSS)

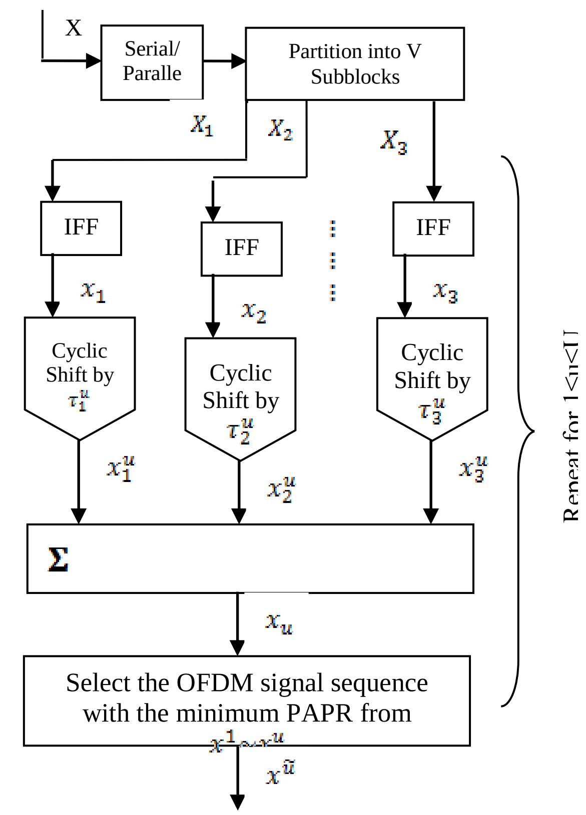

Fig.1: Block diagram of proposed CSS scheme

As there shown in above figure, the CSS scheme procedure is described with a set of symbols. Firstly, the original signal *X* is divided into number of parallel sequences. Then again the parallel sequences are divided into some fine partitions which are named as *V* disjoint sub-blocks, input symbol subsequences *X1, X2, . . . , XV*. Then IFFT converts the *V* sub-blocks in frequency area to the V OFDM sign subsequences in time domain can be x1, x2, . . .

, xV, where as *xv = xv(0), xv(1),. . . , xv(N − 1), 1 ≤ v ≤ V.*

For low complexity, we are going to assume both *N* and *V* are integers of power of two. After that, the *V* OFDM signal subsequences are shifted cyclically and combined for next processing on it which is the u-th *(1 ≤ u ≤ U)* alternative OFDM symbol sequence as,

$$x^u = \sum_{v=1}^{V} x_v^u \qquad (2)$$

Where, x_v^u is known as the leftward cyclically shifted version of xv with given integer by τ_v^u (1 ≤ v ≤ V). That is,

$$x_v^u = \{x_v(\tau_v^u), x_v(\tau_v^u+1), \ldots, x_v(N-1), x_v(0), \ldots, x_v(\tau_v^u-1)\} \qquad (3)$$

The cyclic shift sequence they will compulsory follow orthogonality between the input symbols X(k)'s because, as there is cyclic shifting in time domain is equivalent to multiplying a corresponding linear phase vector in frequency domain. As the SLM or PTS schemes, the candidate with all-time low PAPR,$x^{\tilde{u}}$, is chosen by thoroughgoing hunt for transmission with the term $\log_2$ U bits facet info. By mistake any bits remained giving more BER then that should be considered under calculation.

In implementation we are going to represent τ_v^u as a shift value as well as $\bar{\tau}^u = \{\tau_1^u, \tau_1^u, \ldots, \tau_V^u\}$ is the SV set for u-th alternative OFDM sequence for transmission. We are going to construct U SV sets as $(\bar{\tau}^1, \bar{\tau}^2, \ldots, \bar{\tau}^U)$ to implement the CSS for alternative symbol sequences.

In CSS there are in all three partition strategies, i.e., random partitioning, adjacent partitioning, and interleaved partitioning strategies. It is widely considered that the random partition technique offers the simplest PAPR reduction performance and the next partitioning whereas the interleaved partitioning will not give better PAPR reduction performance however it wants the lowest machine quality for better performance.

C. Desirable Shift Value Sets In the CSS Scheme

In proposed CSS scheme, the PAPR performance is totally depends on U-SV sets which are going to provide the alternative signal. The CSS is the recent technique which is having better PAPR performance, some threshold level given to OFDM sequences are used rather than to reduce the PAPR for the alternative OFDM signal sequence itself, we've got less PAPR values after consideration of U SV sets that is used to generate OFDM signal sequences as statistically independent are performing better.

A. Desirable Shift Value Sets of proposed OFDM sequences

In fact, the elements in an OFDM signal subsequence don't seem to be mutually independent, which can be shown within the next subdivision. However for currently, we have a tendency to assume that the components within the OFDM signal subsequences are unit reciprocally will provide the better simplicity. That is represented below,

$$E[x_{v_1}(n_1).\{x_{v_2}(n_2)\}^*] = \begin{cases} \sigma^2, & v_1 = v_2 \text{ and } n_1 = n_2 \\ 0, & otherwise \end{cases} \qquad (4)$$

Where, σ^2 shows us that the component power of an OFDM signal subsequence and $\{.\}^*$ shows the complex conjugate.

We represent the symbols like correlation between the $n\,th$ component of the $i\,th$ alternative OFDM signal sequence and the $m\,th$ component of the $j\,th$ alternative OFDM signal sequence can be given as below,

$$\rho_{i,j}(n,m) = E[x^i(n).\{x^j(m)\}^*] \qquad (5)$$

It may be known that the correlation only depends on the time difference between n and m. That is, (6) can be expressed as

$$\rho_{i,j}(n,m) = E[x^i(n).\{x^j(n-\delta \bmod N)\}^*] = \rho_{i,j}(\delta) \qquad (6)$$

where $0 \le \delta \le N-1$.

In this situation, we may have

$$x^1 = \left\{\sum_{v=1}^{V} x_v(0), \sum_{v=1}^{V} x_v(1), \ldots, \sum_{v=1}^{V} x_v(N-1),\right\} \qquad (7)$$

Also, using (4), x^2 by the SV set is given by the equations,

$$x^2 = \left\{\sum_{v=1}^{V} x_v(\tau_v^2), \sum_{v=1}^{V} x_v(\tau_v^2+1 \bmod N), \ldots, \sum_{v=1}^{V} x_v(\tau_v^2+N-1 \bmod N)\right\} \qquad (8)$$

$$\rho_{1,2}(\delta) = E[x^1(n).\{x^2(n-\delta \bmod N)\}^*] \text{ using } (7)$$
$$= E[x^1(0).\{x^2(-\delta \bmod N)\}^*]$$
$$= E\left[\sum_{v=1}^{V} x_v(0).\left\{\sum_{v=1}^{V} x_v(\tau_v^2-\delta \bmod N)\right\}^*\right] \text{ using } (8)\&(9)$$
$$= \sum_{v=1}^{V} E\left[x_v(0).\left\{\sum_{v=1}^{V} x_v(\tau_v^2-\delta \bmod N)\right\}^*\right] \text{ using}(5) \qquad (10)$$

Where, the value of n may not affect $\rho_{1,2}(\delta)$, and thus we use n = 0. Using (5), the inside term given in eq(10) becomes represented by

$$E[x_v(0).\{x_v(\tau_v^2 - \delta \bmod N)\}^*] = \begin{cases} \sigma^2, & \tau_v^2 = \delta \\ 0, & otherwise \end{cases} \quad (11)$$

Then, using (10) and (11), we have

$$\rho_{1,2}(\delta) = \alpha_\delta \sigma^2 \quad (12)$$

D. ACF of OFDM Signal Subsequences

The v-th OFDM sequence is x_v and then S_v is the discrete power spectrum which is present in that OFDM signal. It is represented as below equation,

$$S_v = \{p(0), p(1), \dots, p(N-1)\} \quad (13)$$

Where, p(k) $=E[|X_v(k)|^2]$, and the value of p(k) will having one and zero. Because, the modulation order of all the sub-carriers present in ofdm subsequences of the signal are equal. And also the average power is set to one. If we consider one example, if the interleaved partition is calculated as given below, $S_1 = \{10101010\}$ *and then* $S_2 = \{01010101\}$ whe n N=8 and V=2.

After applying IDFT to theS_v *set*. We will get ACF $R_{x_v}(m)$ and the X_v is considered as the input symbol sequence and it is having N-N/V zeros in a certain pattern is calculated and with respect to this ACF $R_{x_v}(m)$ is going to have a specific shape compared to OFDM. Here we are going to calculate magnitude of ACF because in the OFDM signal sequence, high peak is closely related with presented magnitude of the components.

1) For interleaved partition: Here S_v is nothing but impulse train having interval of V. Then, the ACF will become impulse train as below,

$$|R_{x_v}(m)| = \begin{cases} \frac{\sqrt{N}}{V} & if\ m = 0 \bmod \frac{N}{V} \\ 0 & otherwise \end{cases} \quad (14)$$

2) For Adjacent Partition: Here S_v is nothing but a rectangular function having a width of N/V. Then the ACF will can be calculated as below,

$$|R_{x_v}(m)| = \begin{cases} \frac{\sqrt{N}}{V} & if\ m = 0 \\ \frac{\sin(m\pi/V)}{\sqrt{N}\sin(m\pi/N)} & if\ m \neq 0. \end{cases} \quad (15)$$

3) For Random Partition: here S_v shown as a binary pseudo random sequence. Then the ACF is nothing but that having same shape of a delta function, but the components are near about zero, except m=0.

In fig. 2 we can see the example of the magnitudes of ACFs compared to given spectrum when N=32 and V=2; $S_1 = \{1010 \dots 1010\}$ For given interleaved partition; $S_1 = \{11 \dots 1100 \dots 00\}$For given adjacent partition;

$c = \{10010110011111000110111010000\}$For a random partition, which is a one zero padded m-sequence with length 31; Clearly, S_2 is a complement of S_1In each partitioning and the shapes of $|R_{x_v}(m)|$ For v=1 and v=2 are same.

IV. EXPERIMENTAL RESULTS

In the proposed work we implemented a novel integrated technique for PAPR reduction using CSS and another one is piecewise linear companding. Piecewise linear companding is algorithm for PAPR reduction under different signal distortions is analyzed and finally concluded that the proposed integrated technique outperforms excellent.

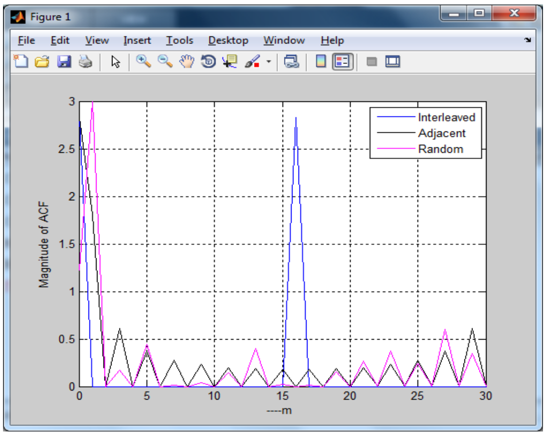

Figure.2: Performance of proposed work is discussed for three different partitioning techniques.

Here we got graphs of m vs. ACF using different partitioning techniques such as interleaved, adjacent and random partitioning. By subjective and objective analysis we can conclude which is going to give better results under the same condition. We can observe here that the interleaved partitioning is better compared with previous technique.

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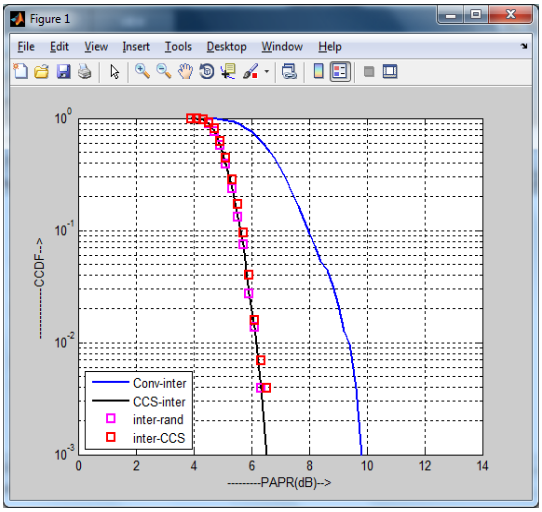

Figure .3: Comparisons by CCDF for different partitioning with conversional and proposed work.

CCDF (complementary cumulative distributive function) is one of the best parameter to check the performance of proposed work as well as conventional work. Calculation of CCDF is nothing but probability calculation.The CCDF should be less for better transmission system.

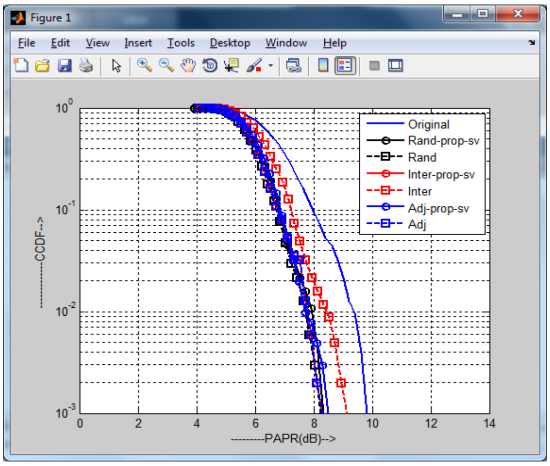

Figure.4: CCDF comparison for different partitioning techniques with a proper SV-set and without SV-set.

Analysis of this system is done by CCDF which is very interesting probability calculation technique. Those are having less probability of PAPR are shown downward in graph.

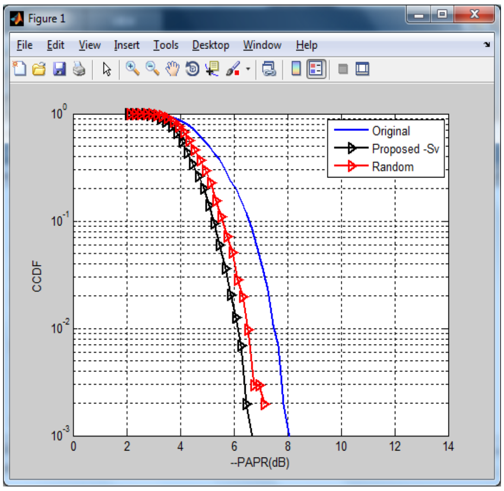

Fig.5: The optimality of the proposed SV sets for different partitioning also.

Analysis: we compared here the CCDF for different transmission overheads like original signal, random partitioned signal and proposed transmission using CSS-SV set. We can observe here that the proposed work is having very less CCDF values compared with original and only partitioning methods. So we can say that proposed work outperforms the existing techniques.

EXTENSION

There are in all basic two types are there for PAPR reduction. We used both transmission types and combination of these both will provide a better result compared to all existing state of art techniques.one is signal distortion technique and another is signal scrambling technique. In this we combined two techniques one is signal distortion which is using the piecewise linear companding transform and another one from signal scrambling technique which is CSS(cyclic shifted sequence).

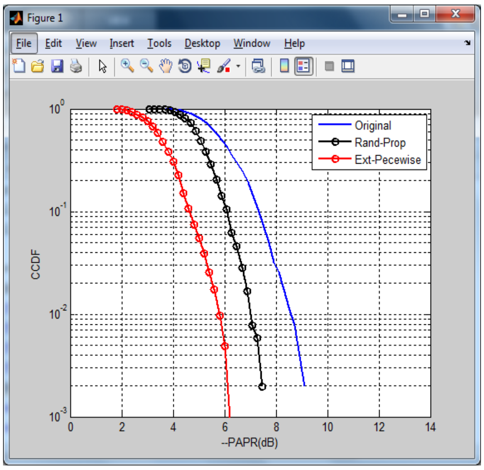

Figure 6: Comparisons by CCDF for Original, proposed and linear piecewise transform as extension methods

As we need less complexity or somewhat similar complexity but our aim is to get more data rate at given signal power. As simulation results are showing in above figure we can conclude that the PAPR for linear piecewise companding is very less compared to other techniques such as it is compared with original signal and CSS with SV-set. By graphical analysis we got the better performance of extension system compared all other techniques.

5. CONCLUSION

There are different state-of-art techniques for reduction of PAPR in OFDM. But compared to existing techniques we are getting better results for performance of this system which analyzed by MATLAB execution results. Proposed work is extension to existing technique PTS (partially transmit sequence).In this we used technique for selecting best SV-set value which will give us idea about PAPR reduction in cyclic shifted sequence(CSS) method. With the help of existing technique PTS which will provide less complexity, we will combine it with cyclic shifted sequence for lowest PAPR and high data rate. With the help of MATLAB execution we can show the improvement in performance of proposed work compared with conventional work. We extended this system by integrating CSS with piecewise linear companding which is a basic module of signal distortion technique. Finally we will prove the extension system will gives us better data rate as well as robustness of the work is improved.

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