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Reduction of PAPR using Companding with Kalman filter Based MIMO SC-FDMA System for Uplink Communication

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ABSTRACT

MIMO is the multiple inputs and multiple outputs modern theme for the global wireless research. MIMO is to improve quality as data rate (bits/sec) and bit error rate by using multiple transmitter/receiver antennas. OFDMA is orthogonal frequency division multiple access suffers commencing difficulty of high (PAPR) peak to average power ratio which may be particularly difficult in uplink transmissions as costly high-power linear amplifiers are needed in user terminals. SCFDMA is Single carrier frequency division multiple access technique has develop into an substitute to OFDMA technique, due to its low PAPR. In this paper MIMO SCFDMA can achieve significant reduction of PAPR of 4.0dB at roll off factor of 0.22 and on increasing the roll of factor to 0.82, the PAPR is reduced to 1.8dB using superframe & companding with kalman filter scheme. The above achievements show the less power consumption of mobile terminal.

Keywords: Multiple Inputs and Multiple Outputs (MIMO), PAPR, OFDMA, SCFDMA.

1. INTRODUCTION

The higher data rates are aimed in order to provide advanced multimedia services with present access in each generation of wireless mobile systems. Thus, modern mobile technologies require wireless channels that are narrow in bandwidth and power over must struggle with problems deriving from high-data rate transmissions. Till now, the most popular multi-carrier communication technique used to overcome these limitations is the (OFDM) orthogonal frequency-division multiplexing due to its toughness in opposition to frequency selective fading channels [1]. However, it suffers from trouble of high peak to average power ratio (PAPR) which may be particularly difficult in uplink transmissions as costly high-power linear amplifiers are needed in user terminals. These features are rooted by (OFDMA) orthogonal frequency division multiple access technique, the multiple access technique based on OFDM. Single carrier frequency division multiple access has develop into an substitute to these techniques since, due to its low PAPR, it was chosen as the uplink multiple access plan in third generation partnership project long term growth. This technique is placed on the use of single-carrier modulation (SCFDMA) with frequency-domain equalization (SCFDE) and it can be characterized as a version of OFDMA in transmitter and receiver ends respectively are added pre-coding and inverse pre-coding stages [1, 2]. The PAPR reduction in the uplink transmission results in a mitigation on the constraints concerning power efficiency in user terminals and thus in lesser manufacturing costs.

It contains multiple antennas in cooperation the receiver and transmitter in MIMO wireless communication system [3]. MIMO technology has paying concentration in wireless communications, as the following reason. It provides important increases in data throughput and link range without supplementary bandwidth or broadcast power. It provides higher spectral effectiveness. It provides link consistency. Because

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of these properties, MIMO is a recent idea of international wireless research. It takes the benefit of multi-path. "Multi-path" occurs when the dissimilar signals reach our destination at the receiver at a variety of times [4].

2. TRANSMISSION OF DATA IN MIMO-OFDM SYSTEMS

Today MIMO use either to maximize data rate or diversity or both. By maximizing the data rate we improve average capacity by performing spatial multiplexing. We can get good result in diversity by using multiple antennas. But it does not increase data rate [5].

The "Secret Sauce" of MIMO is spatial multiplexing. Delivers parallel streams of data to receiver by exploiting multi-path using Spatial Multiplexing. It can quadruple (4× 4) or double (2 × 2 MIMO) capability and throughput [5]. Spatial Multiplexing gives privileged capacity when radio frequency conditions are good and users are nearer to the base transceiver station. Spatial time block code (STBC) and spatial multiplexing are joints in a transmitter which provides equal STBC coding defense on all data streams [6]. Such a grouping of STBC with spatial multiplexing for MIMO transmission results in presentation enhancements and high throughput. There are basic terms related to MIMO systems as follows:

2.1. Capacity of MIMO System

The first projected by Claude Shannon for additive white Gaussian channels is basic hypothesis of communication channel capacity (C). The highest error-free information rate that a channel using this theorem stipulates that is given by [5, 6]:

$$C = \log_2(1+\rho) \;\; bps/Hz, \tag{1}$$

The represents of Shannon bound an upper limit in spectral competence where is the signal to noise ratio (SNR). The ergodic channel capacity is used as an alternative in stochastic channels. This capability uses the band average capacity over allocation of channel gains [8].

$$C = E\{\log_2(1+\rho\,|\,h\,|^2)\} \;\; bps/Hz, \tag{2}$$

Single input single output system with a random compound channel gain h, the diversity takes from the ergodic channel capacity.

The probability of slopes curves at the reception case the ratio can be found in the diversity gain (Gd), as a function of SNR on a log–log scale there both error probability curves are plotted. The probability of error at the high-SNR area satisfies, in favor of a wireless connection with (Gd) diversity gain,

$$\log\left(\frac{P_e(\rho_1)}{P_e(\rho_2)}\right) \propto (-G_d)\log\left(\frac{\rho_1}{\rho_2}\right), \tag{3}$$

Where ρ_1 and ρ_2 are SNRs for two channel conditions.

3. CHANNEL MODELING IN MIMO SYSTEM

A multiple streams in MIMO systems, send by multiple transmit antennas in transmitter side. A matrix channel through going transmit streams which made of multiple paths between the receiver sides multiple receives antennas and in multiple transmits antennas at the transmitter. Then, decodes the received signal vectors into the unique information and the received signal receiver gets vectors by the multiple receive antennas. Here MIMO system model [6]:

$$\mathrm{Y} = \mathrm{H\,X} + \mathrm{G} \tag{4}$$

Where the channel matrix are H and G and noise vector, X and Y are transmit and receive vectors respectively.

A 3×3 channel matrix is:

$$H = \begin{pmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{pmatrix} \tag{5}$$

Previous to arriving to channel matrix H there has to be a number of extra properties also included, such as impact of fading, power delay and spatial correlation functions. Without noise the MIMO channel and with representation of the channel matrix H can be spoken as:

$$H(\mathrm{t}) = \sum_{l=1}^{L} H_l \delta(\tau - \tau_l) \tag{6}$$

Where H(τ) is the matrix of the channel impulse responses and L is the number of taps of the channel model.

4. COMPANDING TRANSFORM WITH KALMAN FILTER

To decrease the range of a signal by rising the amplitudes of the lesser signals by using Companding and Kalman filter based algorithm. The standard signal power is increased with this method. To an amount if range is reduced the PAPR is reduced. Our aim in this work at the transmitter side involves applying *u*-law companding to reduce distortion. Principles of *u* ranging stuck between 0.12 and 64 were use in the learn because the best performance be establish to be intrinsic in within this range of process [7].

Let $x_{dat}(n)$ be the baseband OFDM signal linked with the data symbol. In *u*-law companding for a chosen *u*, the dense OFDM signal, $x_c(n)$, is produced as

$$x_c(n) = K(u)x_{\max} \frac{\ln[1 + u\frac{|x_{dat}(n)|}{x_{\max}}]}{\ln[1+u]} sign[x_{dat}(n)] \tag{7}$$

Where

$$x_{\max} = \max_n (x_{dat}(n)) \tag{8}$$

and such that the standard power of the companded signal is equal to the standard power of the uncompanded signal where K(*u*) is a normalization constant. A projected approximation for K(*u*) is [17]

$$K(u) \approx \frac{\ln(1+u)}{u} \tag{9}$$

Though, this estimate is not highly precise, and it would lead to unnecessary dreadful conditions in the demodulation presentation. Numerically-determined standards of K(*u*) were employed instead and computed and to alleviate errors introduced by normalization inaccuracies, where long-standing power averages were numerically predictable to find K(*u*) [7, 8].

In OFDM system to decrease the PAPR of a novel technique depend on companding and Kalman Filter is projected in this paper. The method gives the chance to keep the PAPR to a sufficient level by responsibility the task of various companding which is illustrated by underneath given steps [8].

The explanation signal of steps is described as follows:

Pace i: Binary data is given and modulation is performed in arrange to create vector X_m.

Pace ii: The performed IFFT on vector $X_{m,}$ and the IFFT output is represented in the form as given.

$$x = [\mathrm{x}(1), \mathrm{x}(2), \ldots\ldots\ldots, \mathrm{x}(\mathrm{N})]^T \tag{10}$$

Pace iii: The PAPR threshold value is based on requirement is put for judgment here level 4 the assessment of the threshold is put

$$PAPR_{th} = 4db$$

Pace iv: Calculate the and it is compared through.

$$PAPR_{th}$$

Pace v: If, $PAPR_1 \leq PAPR_{th}$ then signal is transmitted the unique Transmitted signal is, $t_r(n) = x(n)$

Pace vi: It is initialized a counter to point to how several times companding is perform,

Transmitted signal is, $t_r(n) = x(n)$

Pace vii: If $PAPR_1 \leq PAPR_{th}$, A companding transform is then useful to $x(n)$ by with Kalman Filter

$$x_1(n) = C\{x(n)\} \tag{11}$$

Pace viii: Step 4 & step 2 are repetitive for $x_1(n)$. Then the calculated PAPR for $x_1(n)$ is $PAPR_2$.

Pace ix: If $PAPR_2 \leq PAPR_{th}$ then, $t_r(n) = x_1(n)$ and $a = 1$.

Pace x: If, $PAPR_2 \leq PAPR_{th}$ one more companding transform is practical to $x_1(n)$.

Pace xi: This whole process is recurring unless $PAPR_m \leq PAPR_{th}$ Where $m = 1, 2, 3, 4$ . .

4.1. Kalman Filter Functioning

This tool is arithmetic which consists of a place of arithmetical equations. The equations give a proficient computational revenue in arrange to approximation the condition of a process. That is a method that the mean of the squared error is reduced [8].

In arrange the state to estimate $x \in \Re^n$ of a discrete-time forbidden procedure which is known by the linear stochastic difference equation underneath:

$$x_k = Ax_{k-1} + Bu_{k-1} + w_{k-1} \tag{12}$$

The measurement $z \in \Re^m$ that is given by Eqn. (12)

$$z_k = Hx_k + v_k \tag{13}$$

Where *H* may change with each time step, but here we take for granted it is constant. With the help of feedback control the Kalman filter estimates a process. The Kalman filter obtains feedback in the form of measurements and estimate the process state at some time.

In Figure 1 Kalman filter equations are divided into two groups (1) *Time Update* equations (2) *Measurement Update* equations. The equations of time update and measurements update are given underneath.

The time update equations can also be consideration of as predictor equations [8].

Initial estimates for $\hat{x}_{k-1}$ and P_{k-1}

↓

Time update ("predict") equations

(1) Scheme the state ahead

$$\hat{x}_k^- = A\hat{x}_{k-1} + Bu_{k-1}$$

(2) Scheme the error covariance ahead

$$P_k^- = AP_{k-1}A^T + Q$$

↓ ↑

Measurements update ("correct") equations

(1) Calculate the kalman Gain

$$K_k = P_k^- H^T \left(HP_k^- H^T + R\right)^{-1}$$

(2) Bring up to date the estimate with measurement z_k

$$\hat{x}_k = \hat{x}_k^- + K_k\left(z_k - H\hat{x}_k^-\right)$$

(3) Bring up to date the error covariance

$$P_k = \left(I - K_k H\right)P_k^-$$

Figure 1: Complete operation of the kalman filter [8]

5. PROPOSED SUPERFRAME WITH COMPANDING & KALMAN FILTER BASED MIMO SC-FDMA SYSTEM

However, when MIMO is applied to SC-FDMA, it increase the PAPR. So in order to obtain PAPR in acceptable level we will have reduce it. Here proposed companding with kalman filter is used for this operation. Figures 2 and 3 show the block diagram of the proposed scheme used in MIMO- SCFDMA systems.

In the superframe scheme N subcarriers in B frames will be joint into one super frame [10]. The consecutive B transferred frames $x_n = [x_n(0), x_n(1), x_n(N-1),]$ $(n = 1, 2, \ldots B)$ in time domain are shaped into one super frame, x^5 with N.B symbols. Now, the system performs Discrete Fourier Transform (DFT) in order to obtain a super frame X_k^s with N.B symbols and one of the $M(> N.B)$ orthogonal subcarriers $(M = Q.N.B)$ output of maps each of the N.B-DFT using interleaved mapping to create $\tilde{X}_l^s$. Similar to OFDMA, the M-point inverse-DFT transforms the subcarrier amplitudes to a multifaceted time domain signal x_m^s. Then the super frame with lowered PAPR is alienated back into B frames $\tilde{x}_m = [\tilde{x}_m(0), \tilde{x}_m(1), \tilde{x}_m(N-1)]$ $(m = 1, 2, \ldots. B)$. Therefore, the final B SC-OFDM frames will be transmitted with their own guard intervals (GI).

For interleaved–FDMA (IFDMA), the frequency samples after subcarrier mapping $\tilde{X}_l^s$ can be described as follows [11, 12].

$$\tilde{X}_l^s = \begin{cases} X^s_{l/Q} & ,l = Q.k, \left(0 \le k \le N.B - 1\right) \\ 0 & ,otherwise \end{cases} \tag{14}$$

$$\tilde{x}_m (= x_{N.B.q+n}) = \frac{1}{M}\sum_{l=0}^{M-1} \tilde{X}_l^s . e^{j2\Pi \frac{m}{M} l} = \frac{1}{Q}.\frac{1}{N.B}\sum_{k=0}^{N.B-1} X_k^s . e^{j2\Pi \frac{m}{Q.N.B} Q.k}$$

$$= \frac{1}{Q}.\frac{1}{N.B}\sum_{k=0}^{N.B-1} X_k^s . e^{j2\Pi \frac{N.B.q+n}{Q.N.B} Q.k}$$

$$= \frac{1}{Q}\left[\frac{1}{N.B}\sum_{k=0}^{N.B-1} X_k^s . e^{j2\Pi \frac{N.B.q}{N.B} k} . e^{j2\Pi \frac{n}{N.B} k}\right]$$

$$= \frac{1}{Q}\left[\mathrm{IDFT}\{X_k^s\}\right] = \frac{1}{Q} x_n \tag{15}$$

A replication of the unique input symbols X_n with a scaling factor of 1/Q and the resulting time symbols $\tilde{X}_m$ and some phase turning round in the time domain. Frequency domain equalization as those of MIMO OFDMA system is a technique that has alike performance MIMO SCFDMA system [13].

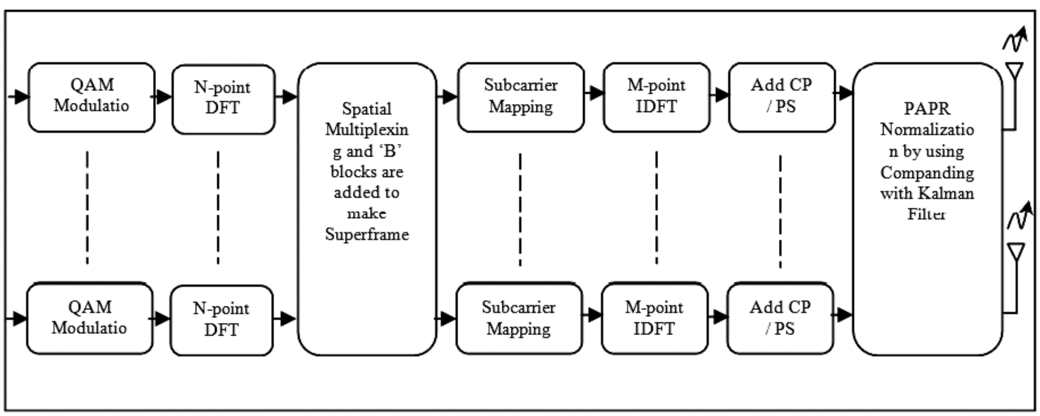

Figure 2: MIMO SCFDMA based Superframe using companding with kalman filter Transmitter

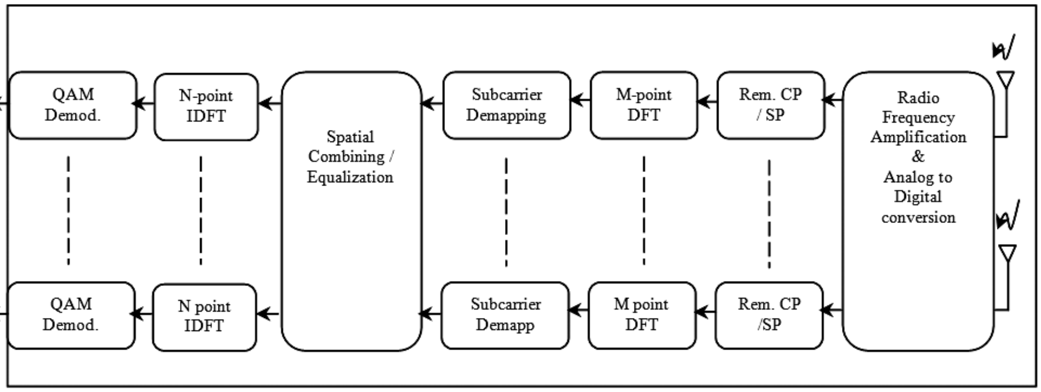

Figure 3: MIMO SCFDMA based Superframe using companding with kalman filter Receiver

MIMO SC-FDMA has strained great consideration as an attractive option to MIMO OFDMA [14], particularly in the uplink communications where lower PAPR to the highest level benefits the mobile terminal in conditions of transmit power efficiency.

6. SIMULATION RESULTS

6.1. PAPR Performance MIMO-SCFDMA systems

In MIMO-SC-FDMA system simulation with a sub-carrier of N = 64, 128, 512 and quaderture amplitude modulation was measured. Here we can estimate the presentation of the PAPR..

Figure 4 shows PAPR characteristics of different types of MIMO-SCFDMA systems with Companding cum Kalman filter at roll off factor 0.22. The results show the super frame based IFDMA with companding

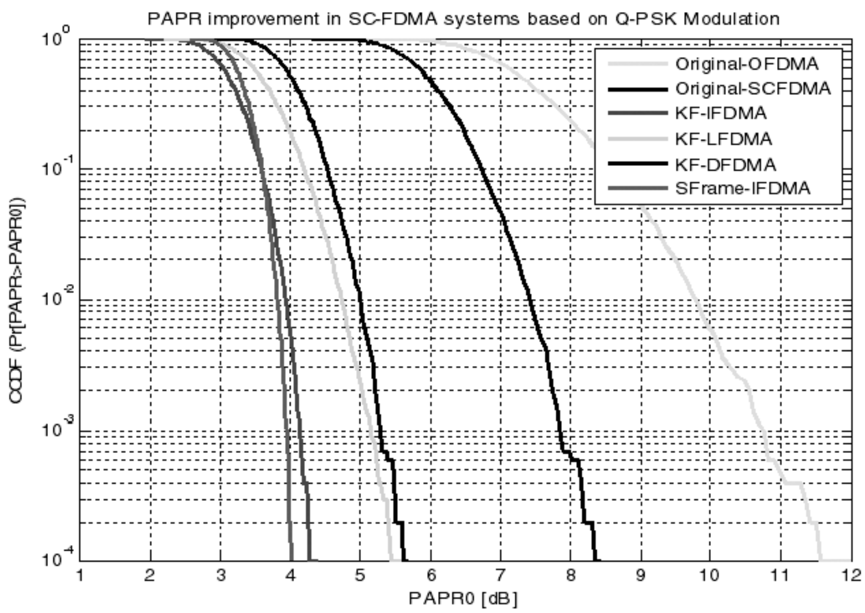

Figure 4: PAPR reduction in 2 by 2 MIMO SCFDMA using super frame with Companding & Kalman filter with roll of factor 0.22

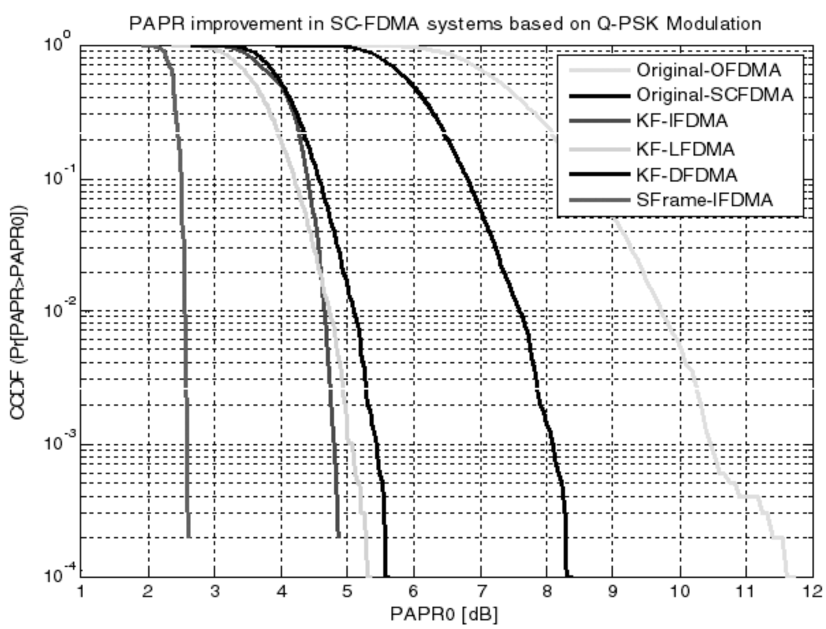

Figure 5: PAPR Reduction in 2 by 2 MIMO SCFDMA using Super frame with Companding & Kalman Filter with roll of factor 0.42

& kalman filter based system provides best results among other types of MIMO-SCFDMA systems at roll of factor 0.22.

Figure 5 shows PAPR characteristics of different types of MIMO-SCFDMA systems with Companding cum Kalman filter at roll off factor 0.42. The results show achieve the PAPR 2.6 dB at roll of factor 0.42 using super frame based IFDMA with companding & kalman filter based system provides best results among other types of MIMO-SCFDMA systems

The figure 6 results show achieve the PAPR 1.8 dB at roll of factor 0.42 using super frame based IFDMA with companding & kalman filter based system provides best results among other types of MIMO-SCFDMA systems.

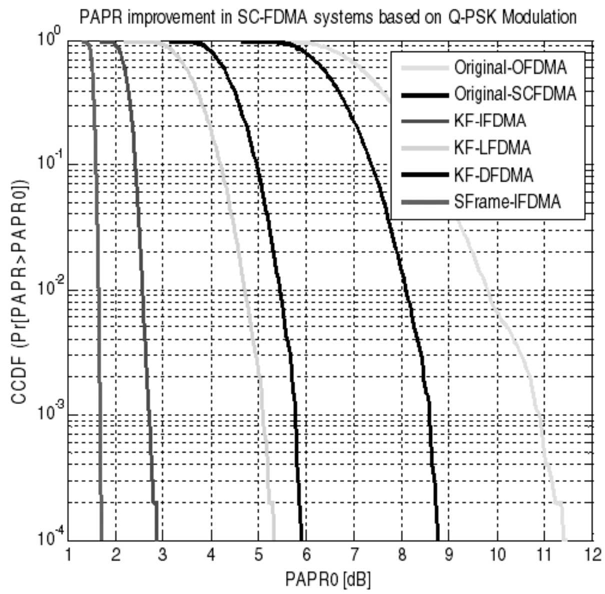

Figure 6: PAPR Reduction in 2 by 2 MIMO SCFDMA using Super frame with Companding & Kalman Filter with roll of factor 0.82

Table 1
Comparison of PAPR reduction scheme in 2 by 2 MIMO SC-FDMA system with QPSK modulation

Peak to Average Power Ratio 0.22, 0.42, 0.82	Conventional MIMO SC-FDMA IFDMA at roll off factor 0.22, 042, 0.82	Proposed Superframe with Companding algorithm & Kalman filter based MIMO at roll off factor
PAPR	6.5dB, 4.7dB, 2.8dB	4.0dB, 2.6dB, 1.8dB

Peak to Average Power Ratio of Conventional MIMO SC-FDMA IFDMA at roll off factor 0.22, 042, 0.82 the PAPR is 6.5dB, 4.7dB, 2.8dB respectively. The Proposed Superframe with Companding algorithm & Kalman filter based MIMO at roll off factor 0.22, 0.42, 0.82 the PAPR is achieved 4.0dB, 2.6dB, 1.8dB respectively.

Thus from the Table 1 displays a comparison among 2 by 2 MIMO-SC-FDMA system. From the table 1 observed that the proposed super frame with companding and kalman filter based scheme provides outperforms results among all other schemes.

7. CONCLUSION

Performance results are showing the latent of MIMO collective with signal processing techniques in achieving high data rates and low PAPR through SC-FDMA. In MIMO SC-FDMA can achieve significant reduction of PAPR of 4.0 dB at roll off factor of 0.22 and on increasing the roll of factor to 0.82 the PAPR is reduced to 1.8 dB. The above achievements show the less power consumption of mobile terminal and more data transfer without error which is more suitable for next generation broadband wireless communication.

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