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PAPR Reduction of MIMO-OFDM System using Modified SLM Technique

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ABSTRACT: OFDM is a form of multicarrier modulation technique with high spectral efficiency and immunity to interference. One major drawback of OFDM systems is the high peak to average power ratio (PAPR) which leads to power inefficiency and signal distortion with practical power amplifiers used at the transmitter. Selective Mapping (SLM) is a distortion less technique that can reduce PAPR efficiently without increase in power requirement and incurring data rate loss. The simulation result shows that proposed SLM technique has better PAPR reduction performance. The capacity of the system can be boosted by increasing the system bandwidth, therefore the use of millimeter wave spectrum is recommended for utilizing the full potential of large available bandwidth but associated heavy path losses due to environmental absorption are one of the prime challenges to be addressed. In this paper a hybrid SLM and ZCT for a MIMO-OFDM system with eight, sixteen and thirty two antennas has been proposed as a means of achieving superior PAPR performance. The simulation results demonstrate that the proposed method outperforms the prior technique in terms of PAPR reduction.

KEYWORDS: SLM, MIMO-OFDM, PAPR, BER

I. INTRODUCTION

The capacity of the system can be boosted by increasing the system bandwidth, therefore the use of millimeter wave spectrum is recommended for utilizing the full potential of large available bandwidth but associated heavy path losses due to environmental absorption are one of the prime challenges to be addressed. In this paper a hybrid SLM and ZCT for a MIMO-OFDM system with eight, sixteen and thirty two antennas has been proposed as a means of achieving superior PAPR performance. The simulation results demonstrate that the proposed method outperforms the prior technique in terms of PAPR reduction of carriers do not cause interference at receiver side. Orthogonality between carriers minimizes interference. This is achieved if the frequency separation between carriers (Δf) is equal to reciprocal of OFDM symbol period ($1/T_s$) [3]. In spite of its numerous merits, OFDM systems have some drawbacks. One major drawback of OFDM systems is high peak-to-average power ratio (PAPR), which degrades the efficiency of power amplifier. Therefore, PAPR reduction is very important for OFDM systems [4]. An OFDM signal consists of many individual sinusoidal carriers. When these sinusoids align in phase at the IFFT input, and are added coherently, OFDM signal can have large amplitude resulting in a high PAPR at the IFFT output. The large peak amplitude of the OFDM signal is due to N subcarriers and it is N times that of a single-carrier system. When these large peaks with high PAPR exceed the saturation region of power amplifier used at the transmitter and/or receiver, the OFDM signals will suffer from nonlinear distortion, out of band distortion and also inter-modulation interference among OFDM subcarriers [5]. Due to this, bit-error-rate (BER) increases at the receiver. Use of power-amplifiers with a large saturation region can reduce distortion or BER. However, it leads to high equipment cost and high battery power consumption. To deal with this problem, several algorithms have been introduced for reduction of high PAPR [7] such as clipping, coding, partial transmit sequences, selective mapping and tone reservation. Selective mapping technique for reducing PAPR is discussed in this paper.

II. PTS SCHEMES

In the SISO-SLM scheme, the original data sequence in the frequency domain is partitioned into M disjoint, equal length sub blocks X_v ($v = 1, 2, \dots, M$) as follows [8].

$$X = \sum_{v=1}^M X_v \quad (1)$$

By multiplying some weighting coefficients to all the subcarriers in every subblock, we can get the new frequency sequence.

$$X' = \sum_{v=1}^M b_v X_v \quad (2)$$

Finally, at each transmitting antenna, there are (V-1) sub blocks to be optimized, and the candidate sequence with the lowest PAPR is individually selected for transmitting. Assume that there are W allowed phase weighting factors. To achieve the optimal weighting factors for each transmitting antenna, combinations should be checked in order to obtain the minimum PAPR [9].

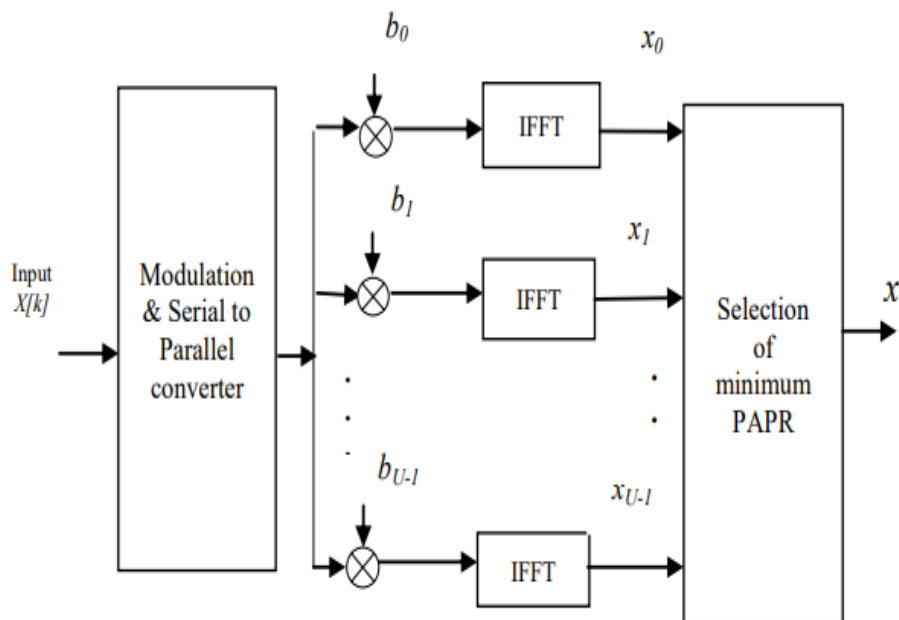


Figure 1: Block Diagram of SLM Scheme

In, the idea of alternate optimization is introduced, and it can be also applied to SLM in multiple antennas OFDM systems, denoted as alternate SLM. Different from ordinary SLM, phase weighting factors are needed only for half of the sub blocks in SLM. That is to say, starting from the first sub block, every alternate sub block is kept unchanged and phase weighting factors are optimized only for the rest of the sub blocks, which leads to the reduction of computational complexity. In this way, the computational complexity is greatly reduced at the expense of PAPR performance degradation [11]. Employed spatial sub block circular permutation for A-PTS scheme to increase the number of candidate sequences which improves the PAPR performance further.

Next, the conversion of the optimum weighting coefficient is discussed. In order to maintain the conjugate and symmetric relations between the two antennas after scrambling sequence methods, we should convert the optimum weighting coefficient $a(\text{opt})$ at antenna 1 into that of antenna 2 denoted as $b(\text{opt})$ by the inverse conjugate and symmetric transformation. For example, when the optimum weighting coefficient $a(\text{opt})$ is $[1, 1, j, -j]$, the optimum weighting coefficient for antennas 2 is $b(\text{opt}) = [1, 1, -j, j]$. The SLM scheme can be also applied to the MIMO-OFDM system with more transmits antennas.

Based on advance SLM, an approach to solve the contradiction between the PAPR performance and computational complexity in STBC MIMO-OFDM system is proposed. Let us consider a STBC MIMO-OFDM system that employs Alamouti scheme. The coding matrix is:

$$G = \begin{pmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{pmatrix} \quad (3)$$

Simulation experiments are conducted to evaluate the transmit spectrum, bit error rate (BER), peak average to peak ratio (PAPR) reduction performance of the MIMO-OFDM scheme using PTS technique. In addition, it is assumed that the data are QPSK, 16-QAM modulated and are transmitted using 256 FFT.

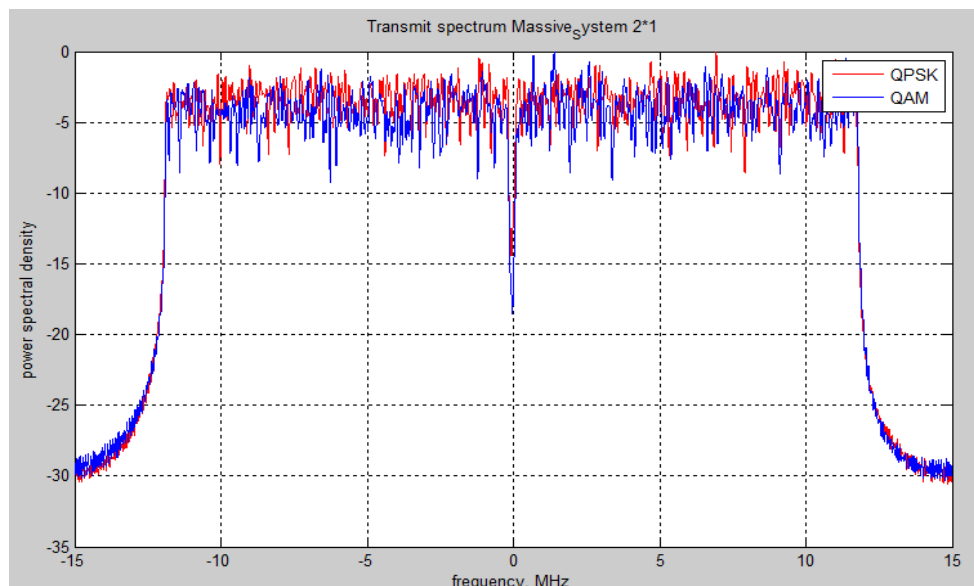


Figure 2: Power Spectral Density of MIMO 2x1 System

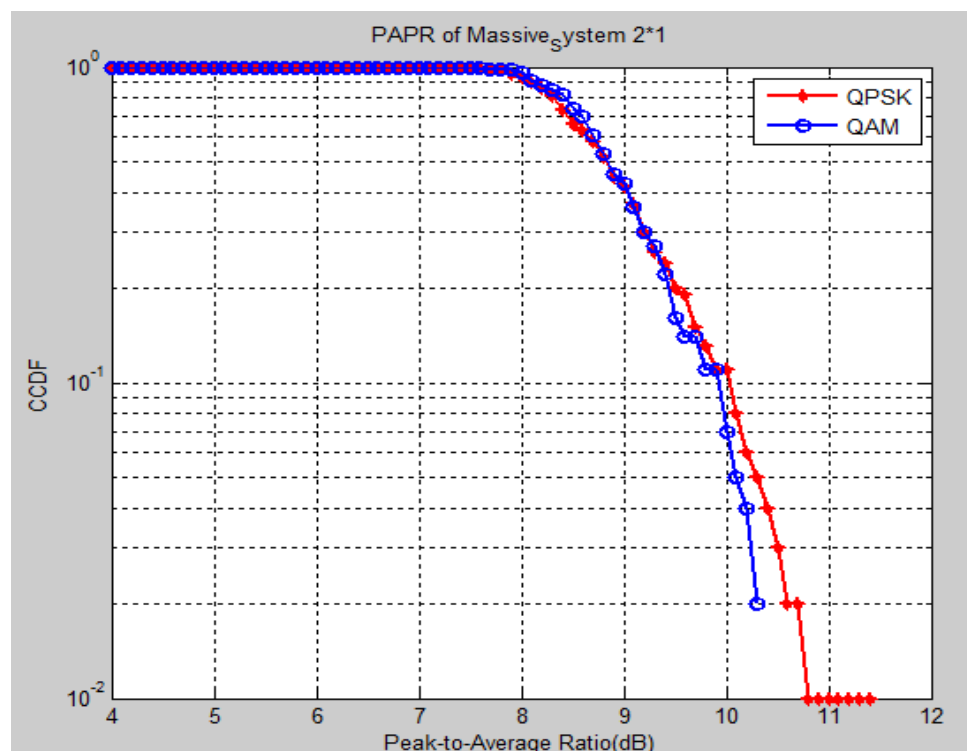


Figure 3: PAPR Performance of MIMO 2x1 System

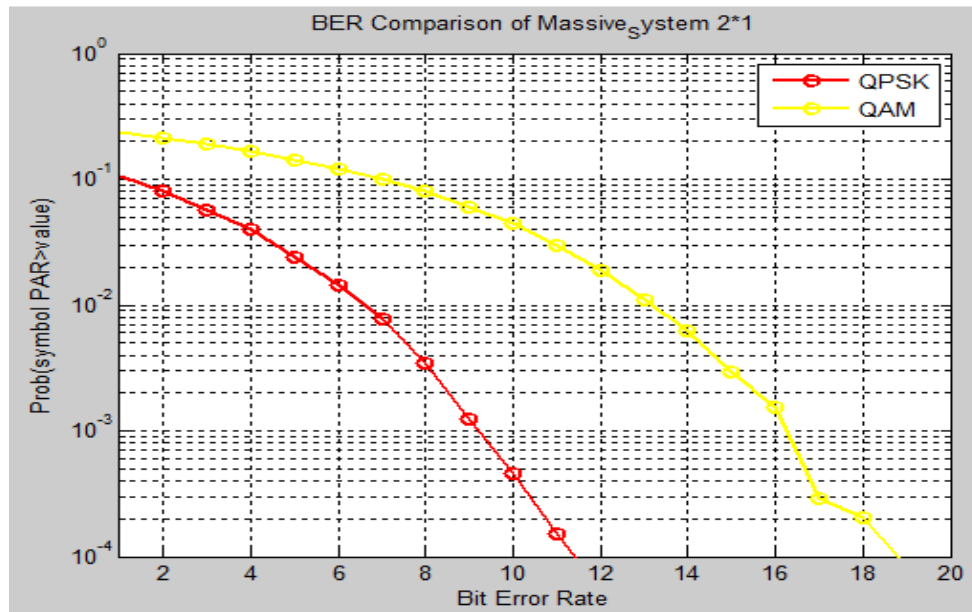


Figure 4: BER Performance of MIMO 2x1 System

III. PROPOSED METHODOLOGY

Zadoff Chu Sequences are complex valued mathematical sequences with optimum correlation properties which, when applied to radio signals, gives rise to an electromagnetic signal of constant amplitude. Zadoff–Chu Sequences are an improvement over the Walsh–Hadamard codes used in Universal Mobile Telecommunications Service (UMTS) because they result in a constant-amplitude output signal, reducing the cost and complexity of the radio's power amplifier. Zadoff Chu Sequences are used in the 3GPP LTE (Long Term Evolution) air interface in the Primary Synchronization Signal (PSS), random access preamble (PRACH), uplink control channel (PUCCH), uplink traffic channel (PUSCH) and sounding reference signals (SRS). Zadoff-Chu sequences possess good correlation properties which are essential in a variety of engineering applications such as establishing timing synchronization between a mobile terminal and a base station, performing channel estimation, and reducing peak-to-average power ratio. Zadoff Chu Sequences of length N is defined as follows

$$z_n = \begin{cases} e^{\frac{j2\pi r}{N} \left\{ \frac{k^2}{2} + qk \right\}}, & \text{for } N \text{ even} \\ e^{\frac{j2\pi r}{N} \left\{ \frac{k(k+1)}{2} + qk \right\}}, & \text{for } N \text{ odd} \end{cases} \quad (4)$$

where $k=0,1,2,\dots,N-1$, q is any integer, r is an integer relatively prime to N and $j=\sqrt{-1}$. ZCT matrix Transform is obtained by filling the ZCT kernel column wise $k = m+1L$ precoding matrix Z of dimension $N=L \times L$ and it is applied to baseband modulated symbol vector to form a new modified symbol vector passed through IFFT to reduce the PAPR ratio.

$$Z = \begin{bmatrix} z_{00} & z_{01} & \dots & z_{0(L-1)} \\ z_{10} & z_{11} & \dots & z_{1(L-1)} \\ \vdots & \vdots & \ddots & \vdots \\ z_{(L-1)0} & z_{(L-1)1} & \dots & z_{(L-1)(L-1)} \end{bmatrix} \quad (5)$$

IV. SIMULATION RESULT

The CCDF is generally used to evaluate the performance of PAPR reduction on MIMO-OFDM system (IEEE 802.16e) signals for a statistical pair of view. The CCDF is defined as the probability that the PAPR as in equation and $PAPR_0$ as shown in the following:

$$PAPR\{Y\} = \arg \max_{k=1,2,3,\dots,N_T} (PAPR\{Y_k\})$$

Where Y_k , $k=1,2,3,\dots,N_T$ represents the time-domain transmitted signal of the k-th antenna

$$CCDF(PAPR_0) = \Pr(PAPR\{Y\} > \{PAPR_0\})$$

QAM-16 offers the most efficient PAPR when compared to BPSK. Zhitong Xing et al. [1] provide a 3.9 dB PAPR for companding methods, 4.3 dB PAPR for HCC, FHCC and MHCC methods. Ebubekir Memisoglu et al. [2] provide a 10.8 dB PAPR for numerology =1, 9.9 dB PAPR for numerology <1 and 10.9 dB PAPR for numerology >1. The proposed method provides 8.1 dB PAPR of QAM-16, 10.2 dB PAPR of QPSK and 10.5 dB PAPR of BPSK. Clearly, the proposed methods represent an 18.18% improvement over Ebubekir Memisoglu et al. [2].

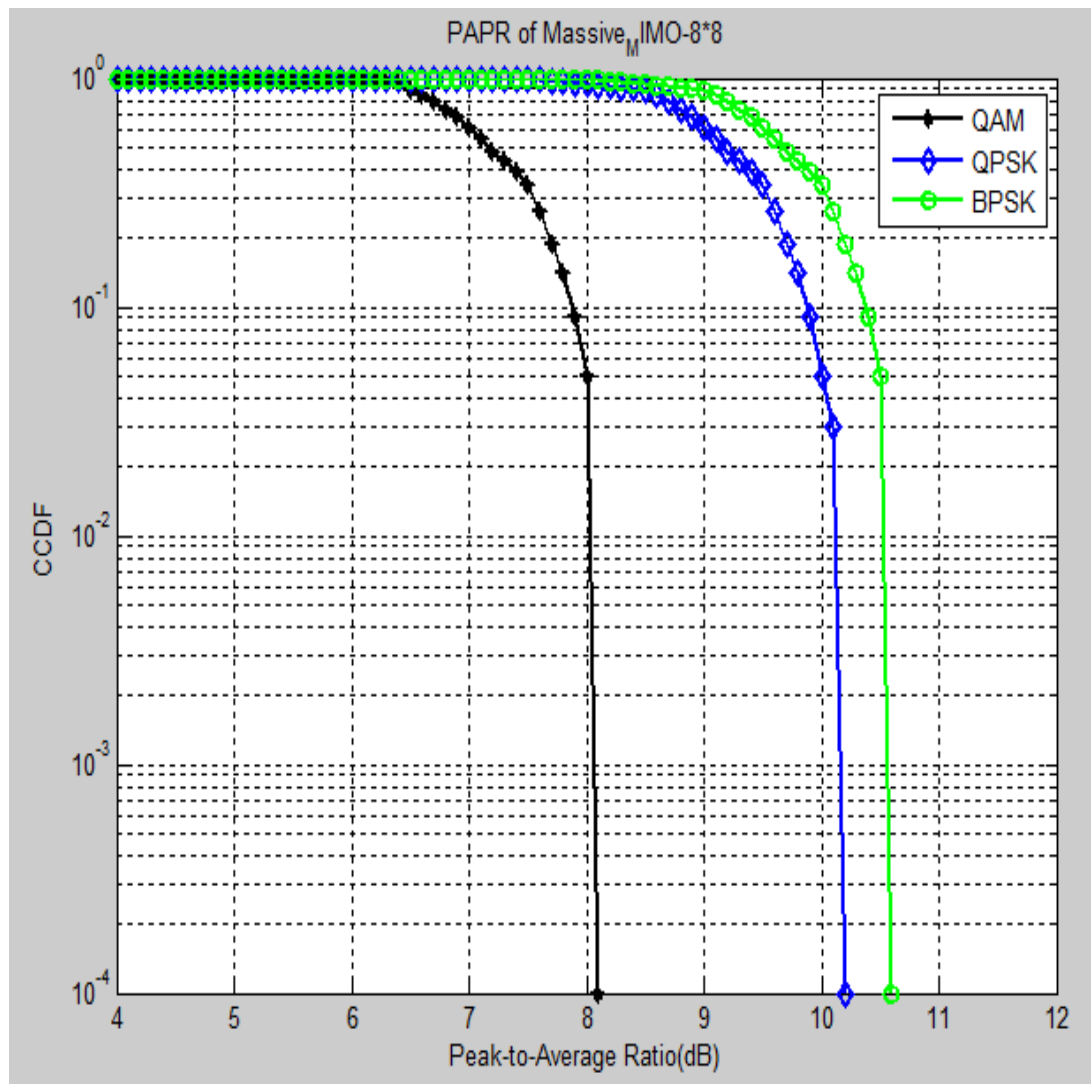


Figure 5: Estimating the PAPR of a Massive 8x8 System using ZCT and SLM

QAM-16 offers the most efficient PAPR when compared to BPSK. Zhitong Xing et al. [1] provide a 3.9 dB PAPR for companding methods, 4.3 dB PAPR for HCC, FHCC and MHCC methods. Ebubekir Memisoglu et al. [2] provide a 10.8 dB PAPR for numerology =1, 9.9 dB PAPR for numerology <1 and 10.9 dB PAPR for numerology >1. The proposed method provides 7.8 dB PAPR of QAM-16, 9.8 dB PAPR of QPSK and 10.1 dB PAPR of BPSK. Clearly, the proposed methods represent a 41.41% improvement over Ebubekir Memisoglu et al. [2].

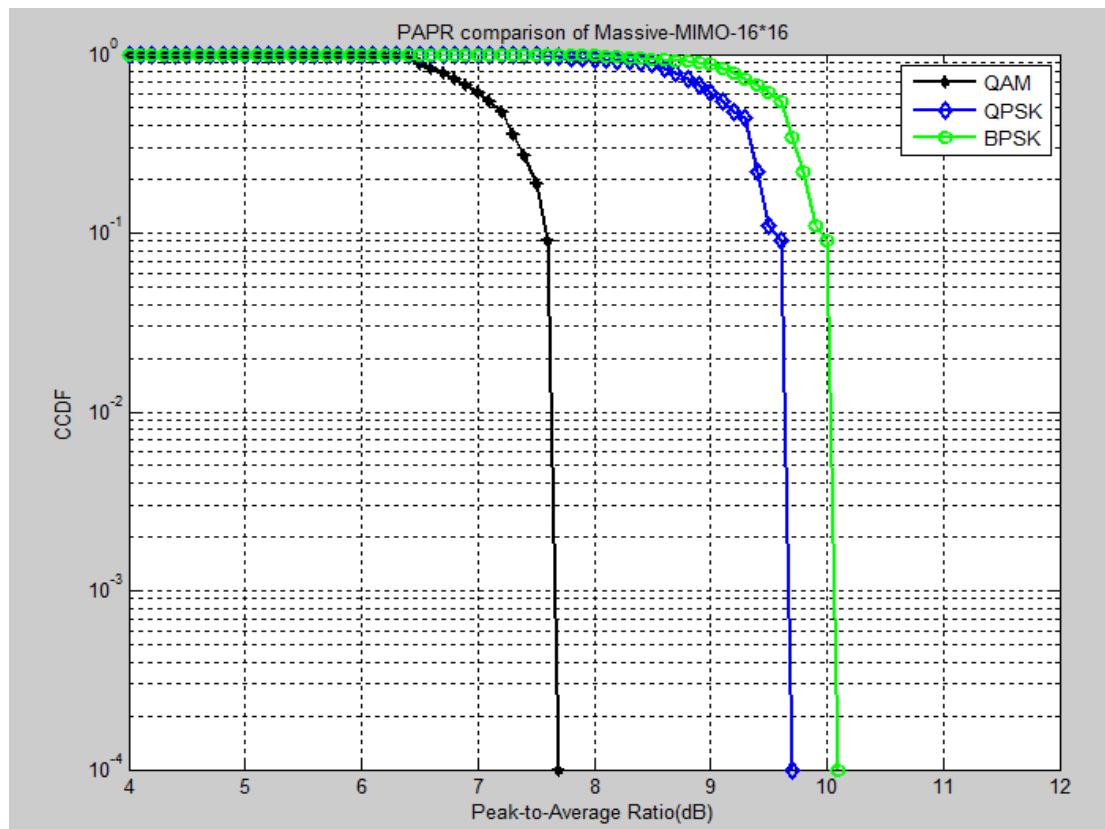


Figure 6: Estimating the PAPR of a Massive 16×16 System using ZCT and SLM

V. CONCLUSION

MIMO-OFDM is a very agreeing method for the new wireless digital communication system. Along with the simplicity of equalization in Orthogonal Frequency Division Multiplexing (OFDM) modulation, it combines the capacity and diversity gain of MIMO systems for better performance. However, like conventional OFDM, MIMO-OFDM has a major challenge called high PAPR. Hence, it requires high dynamic range power amplifier, which makes more cost of system and decreases the efficiency of power.

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