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Equalization and Channel Estimation for Cellular MIMO-OFDM

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Abstract*— *In this paper, the efficient channel estimation and equalization techniques for a high-rate multi-input multi-output orthogonal frequency division multiplexing (MIMO-OFDM) system is implemented. In particular the article presents the implementation of MLD along with Alamauti receiver technique for implementation of MIMO-OFDM. Finally, we evaluate the BLER and BER for the proposed schemes by comparing with a multi-input single-output OFDM (MISO-OFDM) system.

Index Terms: MIMO, OFDM, Channel Estimation, Alamauti, MLD

I. INTRODUCTION

Multiple input multiple-output orthogonal frequency division multiplexing (MIMO-FDM) has received much more attention due to its large potential capacity and high-speed data rates for present day need. To maximize the performance advantage of MIMO-OFDM systems in wireless communication, the reliable channel impulse response is required for coherent signal detection. The subspace-based channel estimation method is one of the most promising approach due to its bandwidth efficiency and good performance [1]–[3] .This has been promoted as a high data rate technique in many standards (WiFi, WiMAX [4], and 3GPP-LTE [5]). MIMO-OFDM combines advantages from both MIMO and OFDM, and provides spatial multiplexing (diversity) and robustness for frequency-selective fading channels. Due to their potential gravity to enhance the link reliability and achieve high spectral efficiency, multiple-input multiple-output (MIMO) systems have received a great deal of attention during the last decade. When MIMO is combined with orthogonal frequency-division multiplexing (OFDM), also referred to as MIMO-OFDM, it is widely known that the benefit of MIMO can be also extended for frequency selective channels [6], [7].

MIMO techniques have been developed to improve spectral efficiency, which provide a linear growth of capacity with number of antennas without increasing band width or transmit powers. As mimo-ofdm techniques do not require complicated equalizer, combined with bit interleaved coded modulation the mimo-ofdm system provides extremely high spectral efficiency as well as good diversity gains for high speed broad band applications and so adopted in fourth generation cellular standards.

II. SYSTEM MODEL

Multiplexing (OFDM) is a special case of multicarrier transmission, where a single data stream is transmitted over a number of lower rate subcarriers. the OFDM model is given in Fig 1. The main reason to use OFDM is to increase the robustness against the selective fading or narrowband interference. In single carrier system if signal get fade or interfered then entire link gets failed where as in multicarrier system only a small percentage of the subcarriers will be affected. The total signal bandwidth, in a classical parallel data system, can be divided into N non-overlapping frequency sub-channels. Each sub-channel is modulated a separate symbol and then N sub channels are frequency multiplexed. The general practice of avoiding spectral overlap of sub channels was applied to eliminate inter-carrier interference (ICI). This is show

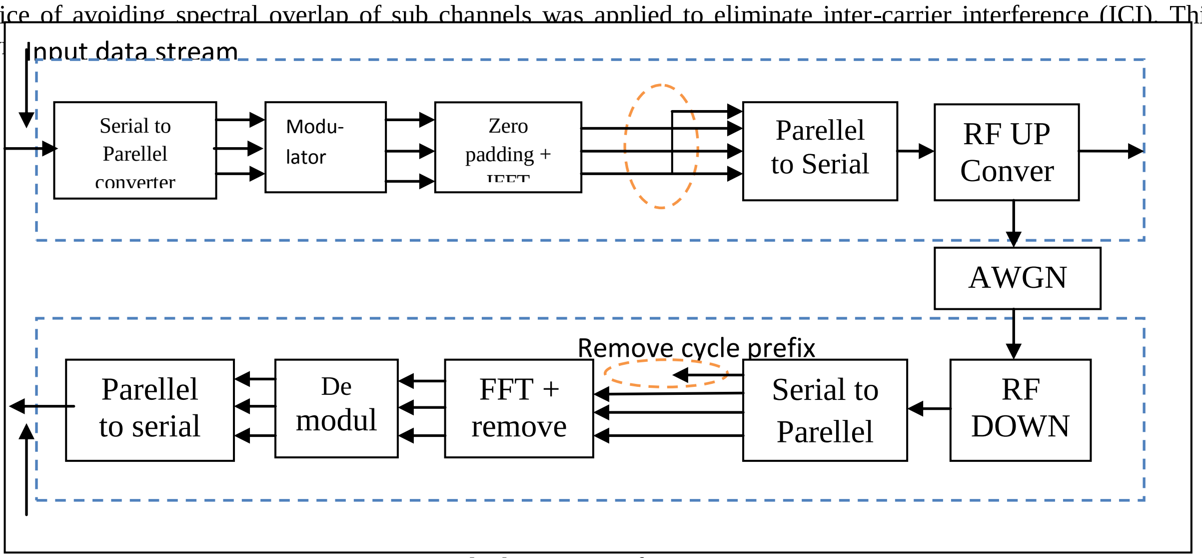

Fig.1: Block Diagram of OFDM system

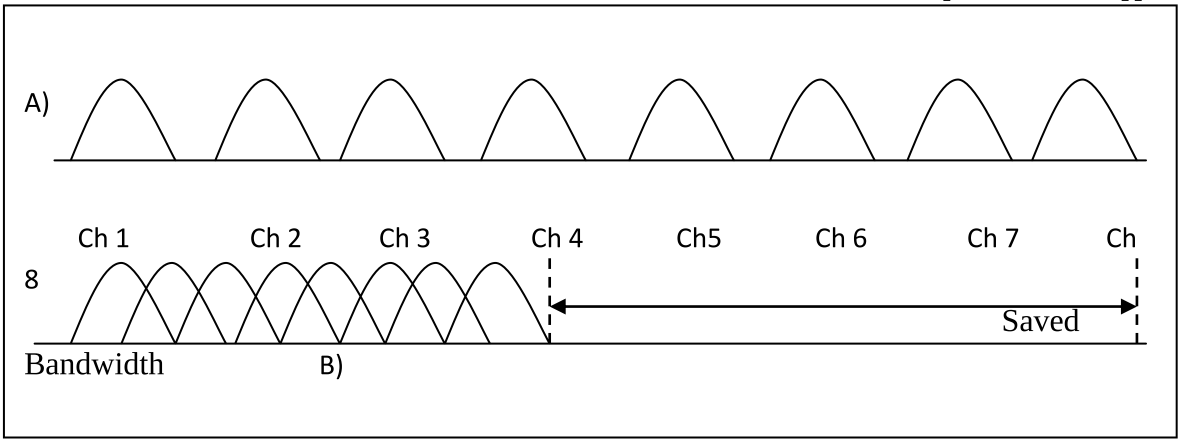

Fig.2: Orthogonal distribution of Sub carrier in OFDM technique

A. OFDM using Inverse DFT

The use of Discrete Fourier Transform (DFT) in the parallel transmission of data using Frequency Division Multiplexing was investigated in 1971 by Weinstein and Ebert.Consider a data sequence d_0, d_2, …, d_{N-1}, where each dn is a complex symbol. (The data sequence could be the output of a complex digital modulator, such as QAM, PSK etc).Suppose we perform an IDFT on the sequence 2dn (the factor 2 is used purely for scaling purposes), we get a result of N complex numbers Sm (m = 0,1…,N-1) as:

$$S_m = 2\sum_{n=0}^{N-1} d_n \exp(j2\pi \frac{nm}{N}) = 2\sum_{n=0}^{N-1} d_n \exp(j2\pi f_n t_m) \ [m = 0,1,..N-1] \quad 2.1$$

$$f_n = \frac{n}{NT_s} \text{ and } t = mT_s \quad 2.2$$

Where, Ts represents the symbol interval of the original symbols. Passing the real part of the symbol sequence represented by equation (2.1) thorough a low-pass filter with each symbol separated by a duration of Ts seconds, yields the signal,

$$y(t) = 2\mathrm{Re}\left\{\sum_{n=0}^{N-1} d_n \exp(j2\pi \frac{n}{T} t)\right\}, \text{for } 0 \le t \le T \quad 2.3$$

From equation 2.3 the length of OFDM signal y(t) is T along with N orthogonal sub-carriers having intercarrier spacing of 1/T. The OFDM symbol-rate is N times the original baud rate.

2.2 MLD Decoder

It is often operating in conjection with other decoders and another receiver units means that the decoded codeword not only must meet the constraint of the current parity check

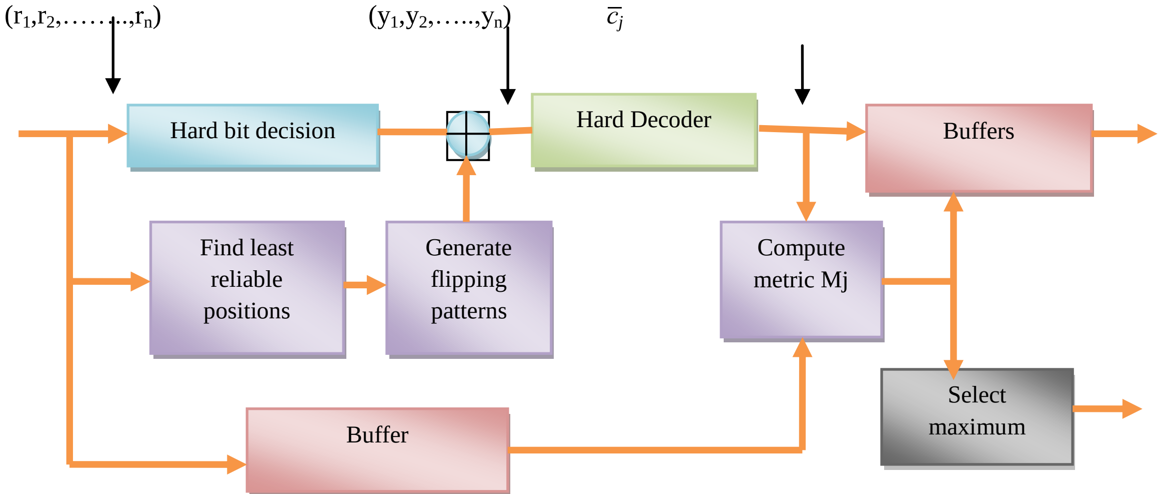

Fig 3.Block diagram of soft ML Decoding

matrix but also satisfy other constraints. Hence a soft decoder can output multiple possible codeword, each with a possible reliability. This kind of soft decoding can allow other units in the receiver to jointly select the best codeword by utilizing the soft information from the decoder along with other relevant constraints that the codeword must satisfy. the block diagram of MLD Decoder by means of BPSK Modulation is given in figure 3.which represent whole step of decoding and its result is given in fig 4 and 5.

III. SIMULATION

In this section, we provide the link level simulation results to demonstration of various parameters. In figure no.4 the BLER estimation curve against SNR is illustrated for the proposed link error prediction technique for the MIMO-MLD. Here the assumed parameters for OFDM system with Nc =64 and the CP length of 16 samples We assume block Rayleigh fading channels with a 10-tap exponentially decaying delay profile. The curve is drawn using vertical hamming code (7 4) and (15 11) hamming code and from figure it is clear that BLER exponentially decreases with respect to SNR . In this scheme Maximum Likelihood receiver is utilized for encoding hamming code at receiver side.

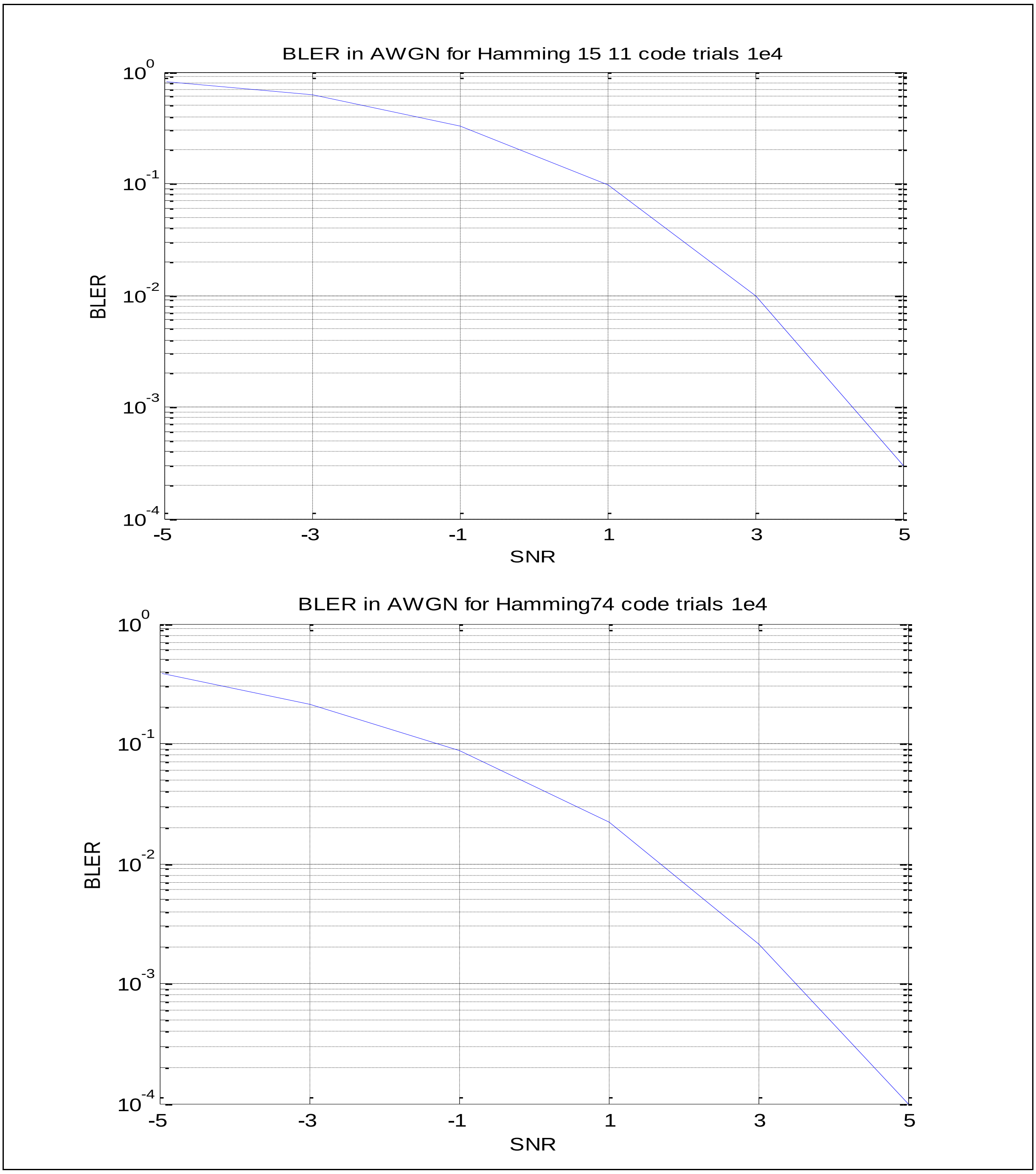

Fig 4 Plot of BLER Vs SNR for scheme utilizing vertical Hamming codes(7,4) and (15,11) in MLD Reciever

As we compare the two different hamming code it is clear that as SNR values of received codewords increases the block error rate for (7,4) hamming code has less values as compared to (15,11) hamming code for the same value and calculation time is also reduced for the same.Hence (7,4) hamming code provide better result against (15,11) hamming code. The comparision of both represented in the same graphin figure 5. In next segment the effect increasing the order of MIMO is illustrated in figure no.6 and shows the comparative graph between transmitting and receiving antenna.

From figure 6 it is clear that as number of number of transmitting and receiving antenna increases, the channel capacity is also increases. Here in this model water filling algorithm is utilized for energy allocation among the various channels. From this it can be easily concluded that as the no. of multiple transceivers increases the data rate increment also exponentially increases.

Table-1 comparison of BLER for (7,4) and (15,11) Hamming code

SNR (dB)	BLER FOR 74 HAMMING CODE	BLER FOR 15 11 HAMMING CODE
-5	0.3807	0.8072
-3	0.2145	0.6195
-1	0.0874	0.3285
1	0.0220	0.0979
3	0.0021	0.0098
5	0.0001	0.0003

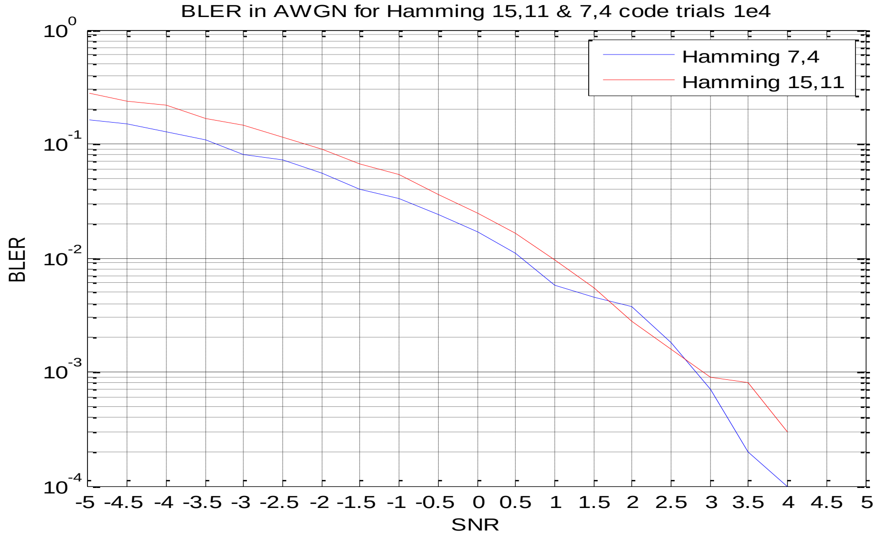

Fig 5. comparison plot between BLER and SNR for [7 4]and [15 11] hamming code

Fig 7 shows the implementation of MIMO with Alamouti scheme. This present best way for MIMO OFDM implementation, from figure it is self explanatory that BER performance for (2x2) system utilizing Alamouti scheme is far better in comparison to SISO, SIMO, MISO type of system .It represent that as signal energy to noise ratio increases, the BER decreases more in MIMO case as compared to SISO,SIMO,MISO for same value of signal energy to noise ratio.

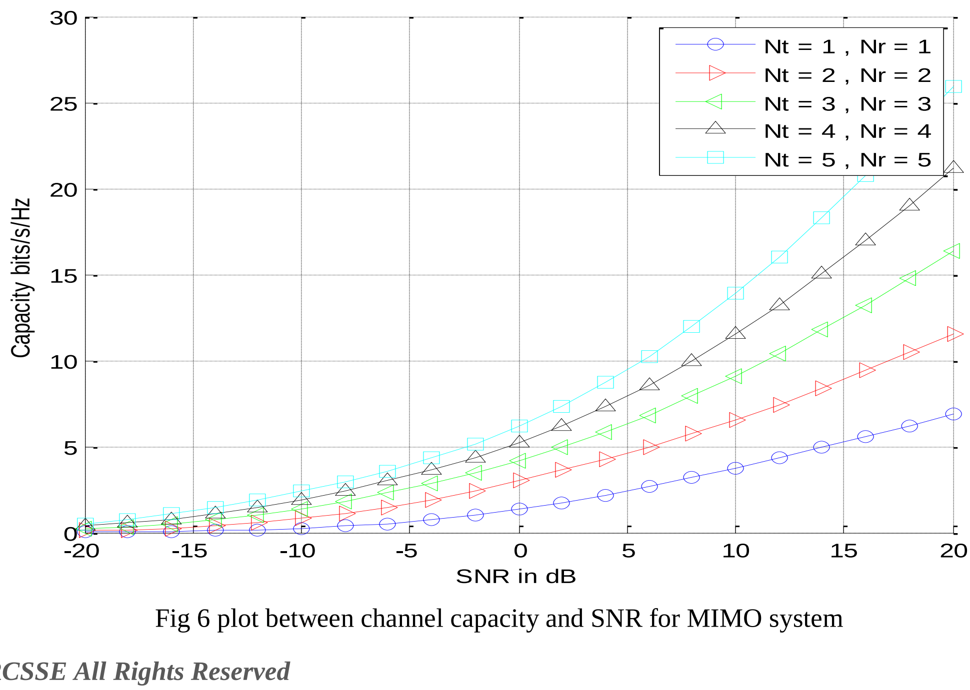

Fig 6 plot between channel capacity and SNR for MIMO system

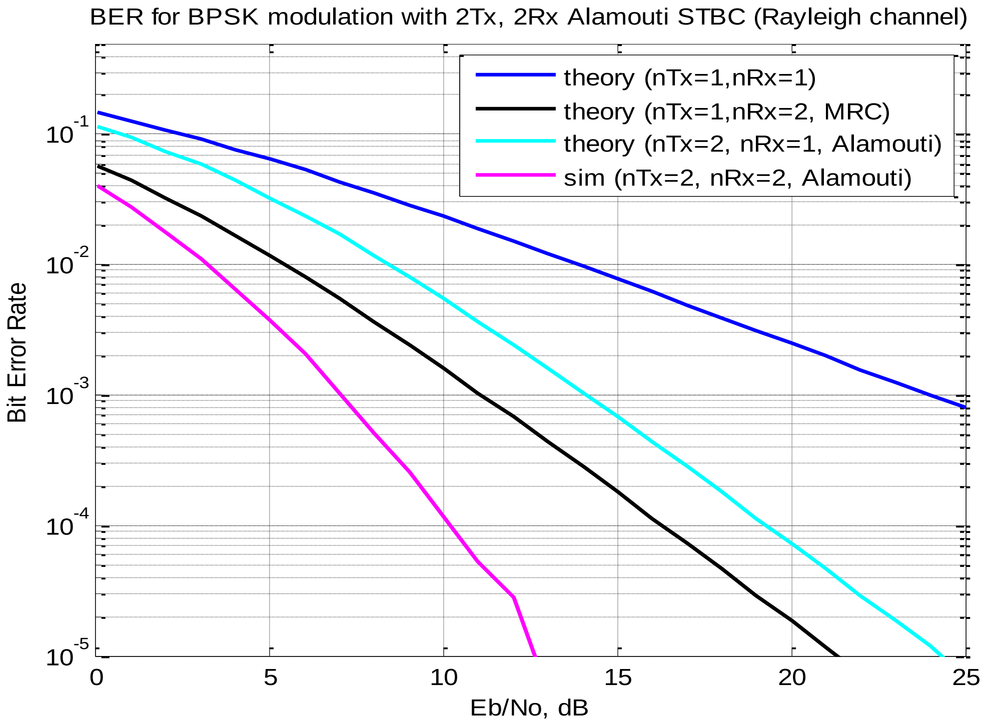

Fig 7 BER Performance comparisons

IV. CONCLUSION AND DISCUSSION

From the above simulation result it is clear that MIMO OFDM quite capable for providing diversity combination as well as the channel capacity goes on increasing as number of MIMO order increases. In this reference it is out of noticeable from figure 4 that BLER decreases when we apply any decoder which is based upon the difference of transmitted and received signal sample. As in case of MLD decoder or sphere decoder for simulation. It is clear that MIMO OFDM technique which can provide higher bit rate or data rate for the application of modern data rate wireless communication that is 3G and 4G and still now Alamouti is the best suitable technique for maximum throughput of MIMO OFDM technique.

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