Improve Performance of MIMO-OFDM system using Hybrid Equalization technique

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ABSTRACT

MIMO-OFDM is the base for further advanced wireless local area network (Wireless LAN) and mobile broadband network standards because it achieves the maximum spectral efficiency and, delivers the maximum capacity, data throughput and higher data rates. But, as the environment is wireless, the information being sent in such systems causes attenuation, path dispersion and lSI (Inter Symbol Interference).

In wireless communication systems like MIMO-OFDM, the channel for the transmission of information could be varied quickly with time and may result in the loss of orthogonality of information signal causing ISI or overlapping of the signal bits. This would increase the bit error rate and the system performance degrades. Here is an idea of building an equalizer which would minimize this ISI and the corresponding BER. We make the use of existing linear and nonlinear equalizers from the literature and propose a combination of these two kinds by hybridizing the MMSE, SIC, MRC, MLSE equalizers. The proposed equalizer simulations would be performed in MATLAB along with use of GUI so as to check the error rate at different values of SNR making it user friendly and would result in minimized BER at improved SNR with high receiver diversity.

Keyword: *- mimo, equalizer*

I. INTRODUCTION

The continuous development of wireless communication has changed the view of exchanging information and pursue entertainment. It has made it possible to have the connectivity in pockets through cell phones. The applications are not only limited to voice telephony, but also the voice over internet, web browsing, streaming media, online gaming and much more. The target of future wireless communication systems is to offer high speed wireless access at high quality of service. The increasing requirements of multimedia services and the interest of users for internet related contents lead to increasing competition for high speed communications. This requires large bandwidth and the use of efficient transmission methods that would match the properties of wideband channels, especially in wireless environment where the channel is foundto be a scarce resource. MIMO-OFDM proves to be an excellent transmission technique in wireless environments

MIMO-OFDM-In MIMO system there is a path/channel among each of the transmitters and receiver antennas.

MIMO-OFDM shows brilliant transmission method in wireless environment. The MIMO-OFDM in combination shows beneficial, as MIMO means additional number of antennas which would offer greater bandwidths and OFDM means effective utilization of resources. The MIMO-OFDM technique have improved the spectral efficiency, diversity gains, and provides wide-ranging bandwidth management in widely used WLAN and WMAN networks such as Wi-Fi and WiMAX .

However, in wireless medium the information signal is traveling from the source to the destination through a number of different channels, termed as multipath. When the information propagates along various paths, power falls off mainly due to three effects i.e. packet loss, slow fading and fast fading. This outcome to the impairments in the signal behavior called ISI. The ISI raises the bit error rates and decreases the signal to noise ratio (SNR). This leads to the degradation in the performance of the system. Thus ISI is essential to mitigate. The ISI could be removed if the channel's fastly changing conditions could be estimated in some way. The channel is estimated by equalizing it. Thus equalization technique is used to battle inter symbol interference. Numerous equalizers are in literature and those which adapt themselves with channel's conditions called adaptive equalizers like DFE, FSE, LMS and RLS. A major work is done by the two main types of adaptive equalizers called linear and non-linear equalizers. The paper emphases on examining these types and tried to work on enhancing the performance of the wireless MIMO-OFDM system.

II. EQUALIZER

Equalizer is a digital filter which provides an approximate inverse of path/channel frequency response. Equalization is to alleviate the effects of ISI to reduce the probability of errors that occur without suppression of ISI, but this reduction of ISI effect has to be balanced with the prevention of noise power enhancement.

Equalizers are of 2 types as discussed below

(a) Linear equalizer: In linear equalizer the output is not sent back to the input for comparison. The ZF (zero-forcing) and MMSE are the linear equalizers and simple in structure, and gives linear response.

(b). Nonlinear equalizer: In nonlinear equalizer there is fedback to change the subsequent outputs of the equalizer, the equalization is non-linear. The MLSE, SIC, and DFE (decision feedback equalizer) are nonlinear equalizers, with non-linear response and are more complex

III. PROBLEM FORMULATION

SYSTEM MODEL

The system model taken for proposed technique is 2x2 MIMO-OFDM as shown in fig. 1

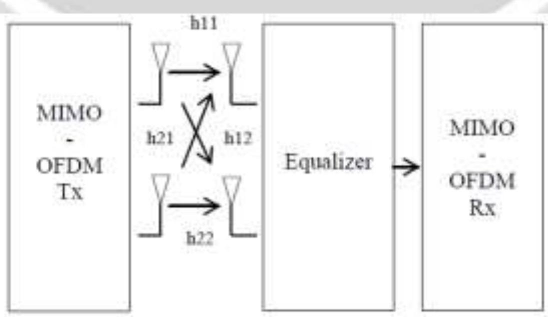


FIG.1 2x2 MIMO-OFDM model

The signal received on the first receiver antenna is

$y_1 = h_{11}x_1 + h_{22}x_2 + n_1$

The signal received on the second receiver antenna is

$y_2 = h_{21}x_1 + h_{22}x_2 + n_2$

y_1 and y_2 represents the signal received on the first and second antenna respectively,
h_{11} being the coefficient of channel sent by 1st transmit antenna to 1st receive antenna,
h_{12} being the coefficient of channel sent by 2nd transmit antenna to 2nd receive antenna,
h_{21} being the coefficient of channel sent by 1st transmit antenna to 2nd receive antenna,
h_{22} being the coefficient of channel sent by 2nd transmit antenna to 2nd receive antenna, x_1 and x_2 are the original symbols and n1 and n2 is the noise in 1st and 2nd receive antennas respectively.
Hence using above equations,

Y=HX+N

1. Zero forcing

Zero forcing gives linear equalization response but

does not involve the effects of noise. We require a matrix Wzf which makes W_{Zf}=1. The zero forcing equalizer meets this restraint by using following as:

$$W=(H^H H)^{-1} H^H$$

$$H^H H = \begin{pmatrix} h_{11}^* & h_{12}^* \\ h_{21}^* & h_{22}^* \end{pmatrix} \begin{pmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{pmatrix}$$

Where, W is Equalization matrix and y is denoted as received signal.

2. MINIMUM MEAN SQUARE EQUALIZER

MMSE estimates and minimizes the mean squared error.The error to be minimized is

$$E\left\{[W_y - x]\,[W_y - x]^H\right\}$$

Solving,

$$W = [H^H H + N_0 I]^{-1}\, H^H$$

3. Maximum likelihood sequence equalizer

Maximum likelihood detection calculates the product of all the probable transmitted signal vectors of the given channel H and determines the Euclidean distance between these and the received signal vector.

The receiver compares the time response with actual received signals and determines the most possible signal. In cases that are computationally straightforward, root mean square derivation can be use as the decision criterion for lowest error probability.

Algorithm

1. Generate input signal bits (data)

2. Define SNR (1-25dB)
3. Make two copies of a signal for using it in 2x2 MIMO-OFDM system

4. Modulate (BPSK) the signal

5. Send the data through Rayleigh Channel and add AWGN noise

6. Implement ZF equalizer:
   ZF Signal = Wzf .y

7. Implement MMSE equalizer:
   Detected MMSE signal, y_1 = WMMSE. Y

8. Hybrid the MMSE with SIC:
   Detected signal S = Wsic .y_1

9. Use MRC for enhancing receiver diversity:
   $y=[y_1 y_2 \ldots y_N]^T$ (Gains of each signal are multiplied together)

10. Detection of the received signal (r) using MLSE:

$$r = |y - H\,\hat{x}|^2$$

IV. **PROPOSED TECHNIQUE**

As discussed earlier, the signal being sent on wireless channel undergoes channel impairments due to the multip ath in wireless channel which causes random time diffusion and weakening of the signal. The equalization removes the effect such as lSI, phase dispersion, multipath fading of the wireless channel and allows the correct estimation of the received signal. Various algorithms are employed for these such as linear and nonlinear equalizers which are having individual advantages, but still there is research for reducing lSI and maintaining the diversity. The paper focuses on hybridizing the linear and nonlinear advantages to enhance the error performance.

The proposed technique is based on the hybridization of linear and nonlinear equalizers and focus on reducing the BER at improved SNR, also increasing receiver diversity and obtaining high throughput. In this, we first implemented ZF and MMSE and compare the BER performance in terms of SNR and found

MMSE outperforms the ZF equalizer. So, a combination of those equalization techniques is made which have outperform others existing. Thus the combination is of MMSE, SIC, MRC and MLSE equalizers.

The proposed hybridization is simulated in MATLAB, such that firstly, the input bits are generated or any random data is taken and is formatted for 2x2 MIMOOFDM system, the one used as the system model (figure I). The SNR values of the bits will be defined and the data is BPSK modulated. Once the data is modulated, it is passed through the Rayleigh channel and A WGN noise is added. As now the data have got mixed with the noise and the channel problems such as lSI has been occurred, this is the time the equalizer will be placed. For this, ZF equalizer is developed first and then MMSE as it will include noisy effects of the channel not considered by a zero forcing equalizer. MMSE, the minimum mean square equalizer is the ideal one that tries to cancel the effect of interference and reduce noise power enhancement, but the lSI is not completely removed so the result of this is further enhanced by combining it with SIC. SIC (successive interference cancellation) covers the received signal by protecting it from other antenna interference using ideal ordering the SIC process. The equalizers will minimize the error by updating their coefficients and the BER which is the ratio of error calculated dividing by the total number of bits is calculated at different SNR after each equalizer being used. To detect the signal correctly at the receiver, the ML equalizer is used as a detection technique which minimizes the probability of errors and maximizes the chances of correct estimation of receiving signal using the Euclidean distance. The received signal is optimized using Maximal Ratio Combining (MRC) which will obtain the weights that maximize the output SNR, i.e., it is optimal in terms of SNR and reducing the BER.

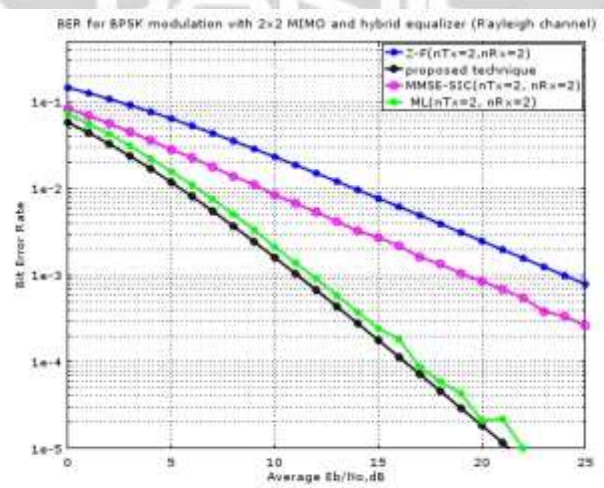
V. SIMULATION RESULTS

The performance evaluation is done in MATLAB using the simulation parameters given in table

TABLE I. Parameters

No	Parameter	Value
1	Modulation technique	BPSK
2	Channel	Rayleigh
3	Mimo system	2X2
4	Noise	AWGN
5	SNR level	0-25 dB
6	data	10^6 bits

Fig 2: BER comparison b/w ZF, MMSE,MLSE and Proposed technique



The results show that the proposed technique has better error rate performance at different SNRs taken.

Table 2

BER for proposed equalizer	BER for MMSE-SIC	BER for MLSE
0.001 at 11 dB	0.001 18 dB	0.001 at 13dB

VI. CONCLUSION

The paper gives an introduction of the multiple input multiple output OFDM system and the impact of lSI at it. The author gives a review of equalizers and its types discuss the problem formulation and proposed a hybrid equalizer for Rayleigh channel in MIMO-OFDM system, which outperforms existing ZF and MMSE equalizers. The simulation results performed in MATLAB show that the proposed technique, in contrast to existing Zeroforcing and MMSE, gives reduced BER at improved SNR with higher receiver diversity.

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