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Adaptive OFDM Implementation Using Fuzzy Inference System

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Abstract— Adaptive communication is one of the key technologies used to enhance the capabilities of future communication systems. Many adaptive modulation techniques have been investigated in the literature for enhancement of transmission rate in combination with Orthogonal Frequency Division Multiplexing (OFDM). The proposed work in this paper to design a new scheme to adapted modulation technique using Fuzzy Rule Base System (FRBS) to enhance the achievable data rate in an OFDM system. The obtain result clearly shows that the BER performance of proposed adaptive modulation is much better than the fixe modulation scheme.

Keywords— Fuzzy Inference System (FIS) , Matlab, OFDM, QAM.

I. INTRODUCTION

Adaptive Orthogonal Frequency Division Multiplexing is one of the successful candidates for many 3rdand 4th Generation Systems. In this technique a single very high data stream is divided into several low data rate streams. Then these streams are modulated over different orthogonal subcarriers. Concept of adaptive communication is though not new, however, it was confined to adaptive modulation only in past decade. The combination of adaptive modulation with OFDM was proposed as early as 1989 by Kalet[1] which was further developed by Chow [3] and Czylwik [2]. Specifically the results obtained by Czylwik showed that the required SNR for the BER target 10-3 can be reduced by 5dB to 15dB compared to fixed OFDM depending on the scenario of radio propagation. The performances of turbo-coded adaptive modulation are investigated in [4]. Three different modulation mode allocation algorithms were discussed and compared. Further studies on the application of turbo code in adaptive modulation and coding is conducted in [5]. This paper proposed an optimal approach based on prediction of the average BER over all sub carriers. In [6], an adaptive OFDM system with changeable pilot spacing has been proposed. The results showed that a significant improvement in the BER performance is achieved with sacrificing a small value of the total throughput of the system. A work is done on several strategies on bit and power allocation for multi-antenna assisted OFDM systems in [7]. They found out that sometimes power and bit adaptation is required for efficient exploitation of wireless channels in some system conditions. The performance analysis of OFDM systems with adaptive sub carrier bandwidth is investigated by [8]. Further investigations on sub carrier adaptive modulation scheme of pre coded OFDM is presented in [9] under multipath channels.

SNR estimation is typically employed in power control, mobile assisted hand-off and soft decoding procedure. Lots of SNR estimators are data aided (DA) in the sense that the training sequence limits system through-out. Therefore the problem of non-data aided (NDA) SNR estimation has been investigated in some papers recently, but they have almost all studied the SNR estimation only for MPSK signals and to the best. of our knowledge, the research results of SNR estimation for QAM Model with the change of signal rate ie. 4, 8, 16, 32, 64 and so on. PSK, the SNR estimation of QAM and, especially, the high-order QAM signal is more difficult. By using the ways of statistics' like [I1]. [12]. Adaptive Modulation for OFDM system through separating of real and imaginary of input data by K. Seshadri Sastry[17].

This paper gives the detail about SNR estimation algorithm using fuzzy method for QAM signals in AWGN channels.

II. PROBLEM DESCRIPTION

In modulation, the precise Knowledge of SNR is also play important role in OFDM model. Many algorithms require the knowledge of SNR for their optimal performance, and on the other hand, the value of SNR estimation can give us some information to select better performance algorithms in a certain SNR range for adaptive demodulation.

Recently there is lots of research work on SNR estimation with different process but they have almost all studied the SNR estimation only for MPSK signals, Lots of SNR estimators are fixed model base, there modeling technique fix. Therefore the problem of other model 'if the modulation system are not fix then how will system work on depends on input data stream. To the best of our knowledge, the research results of SNR estimation for adaptive manner for QAM signals using fuzzy logic identify the best one Signal to noise ratio depends on modulation techniques, fix modulation work on fixed condition and signal to ratio describe the quality and quantity of error in messages signal, performance and capacity of system. Adaptive system gives the better performance as compare to fixed modulation system and capacity of system is also improved by adaptive system.

III. **PROPOSED** SCHEME

Proposed scheme uses adaptive OFDM (Table-1.1) QAM modulation system, Signal to Noise ratio algorithm implemented in Fuzzy logic Inference. OFDM model work in two main part modulation or demodulation, Incoming bits are pass though in different stage of modulation process then after channel, these channel pass the output from channel to fuzzy logic set, fuzzy box compare the present order of model which is coming from OFDM channel and past order which is store in fuzzy memory box.

Quadrature amplitude modulation order is identify by the ratio of BER(bit error rate) or SNR(signal to noise ratio), fuzzy Inference work with some set of rule (…) output of fuzzy set control both modulation and demodulation of the system.

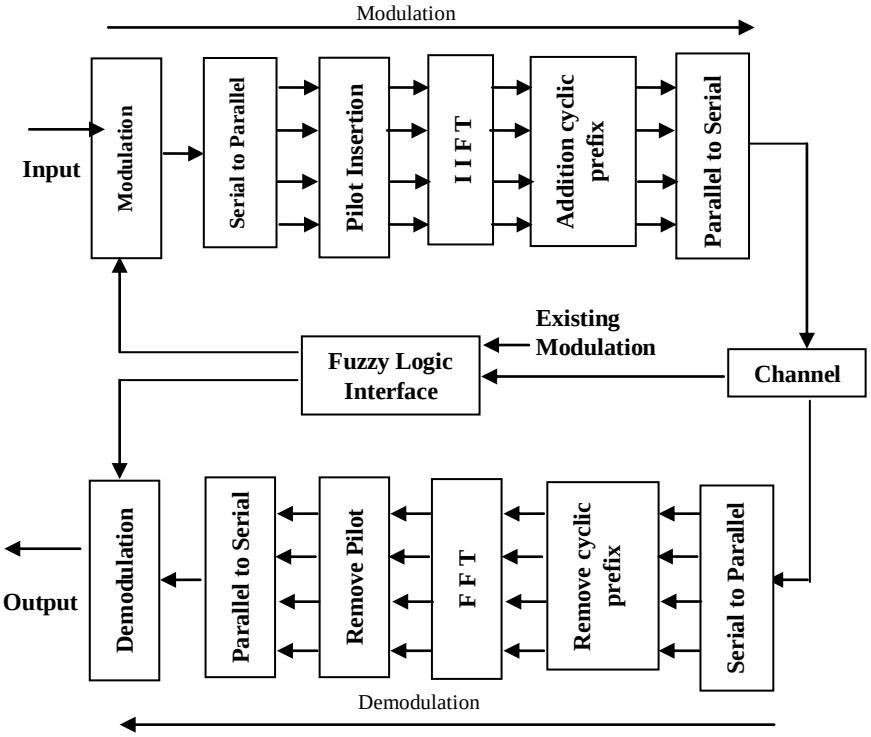

Figure -1 Block Diagram of OFDM Model

A. Input parameter of OFDM

Table 1.1

Parameter	**Value**
Information data rate	208000
Modulation	2QAM, 4QAM, 8QAM, 16QAM, 32QAM, 64QAM, 128QAM, 256QAM.
Total number of subcarriers	52
OFDM symbol duration	4e+003
Number of data subcarriers	52
FFT size	64

B. Fuzzy Inference system

Fuzzy Inference system is modeled in Fuzzy Inference system editor. Fuzzy Inference system consists of two input functions SNR and MOD (modulation) and one output function QAM order.

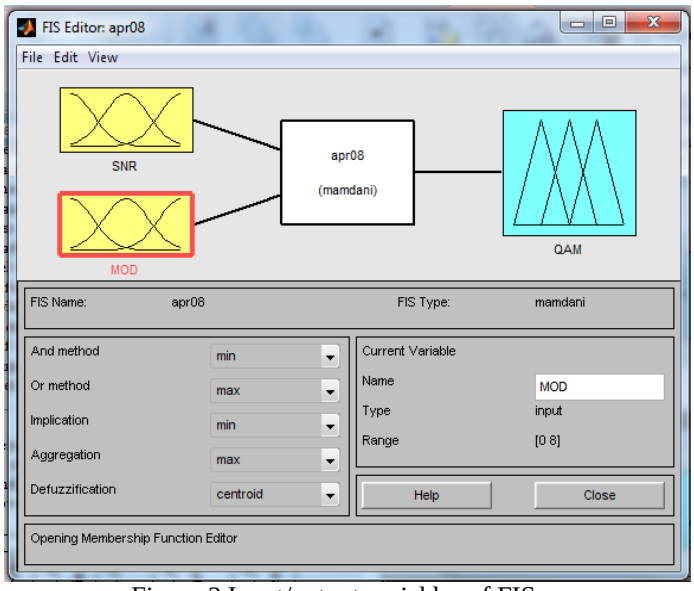

Figure 2 Input/output variables of FIS

- ***Input/output variable:***

In this proposed model the two Input function are use "SNR" and "MOD" they both consists of seven membership functions L,ML,M, MH, H, HM, HH. And model order is K-QAM $K=2^N$, where N represent the range from 1to 8. Input function the range of signal to noise ratio start from 1 to 40 these SNR is divide in seven sections.

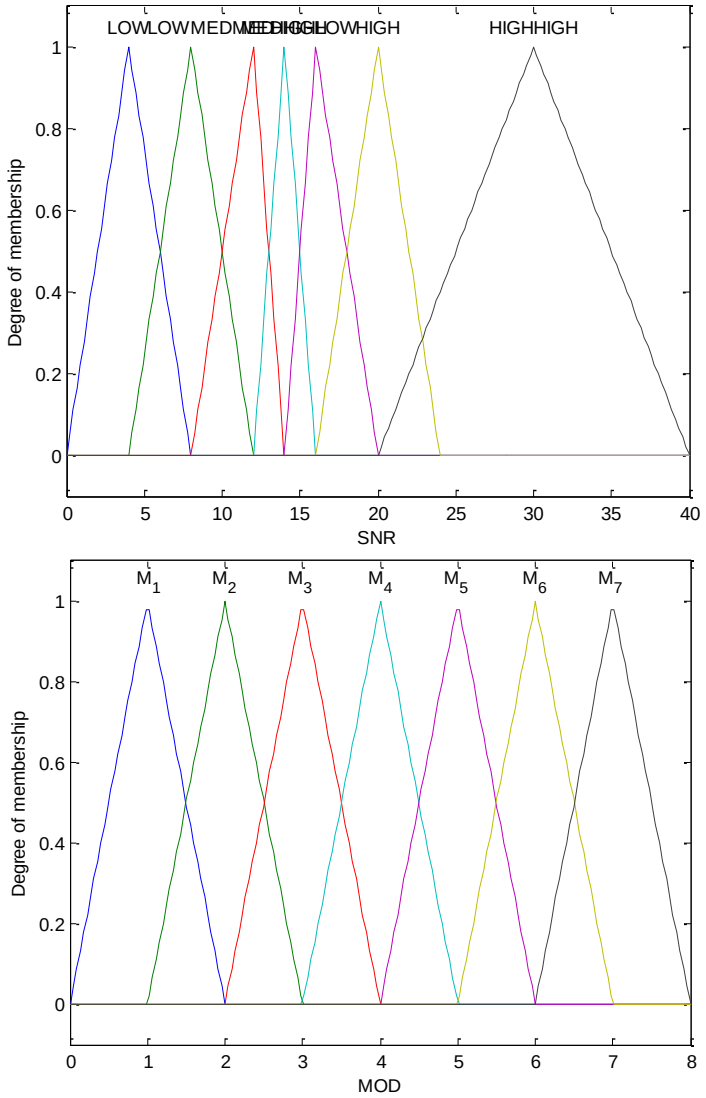

Figure -2 Input variables

- ***Output*** variable

Output function "QAM" consists of seven membership functions too .the range of SNR is 0 to 30 and the modulation order is start from 2 to 128.

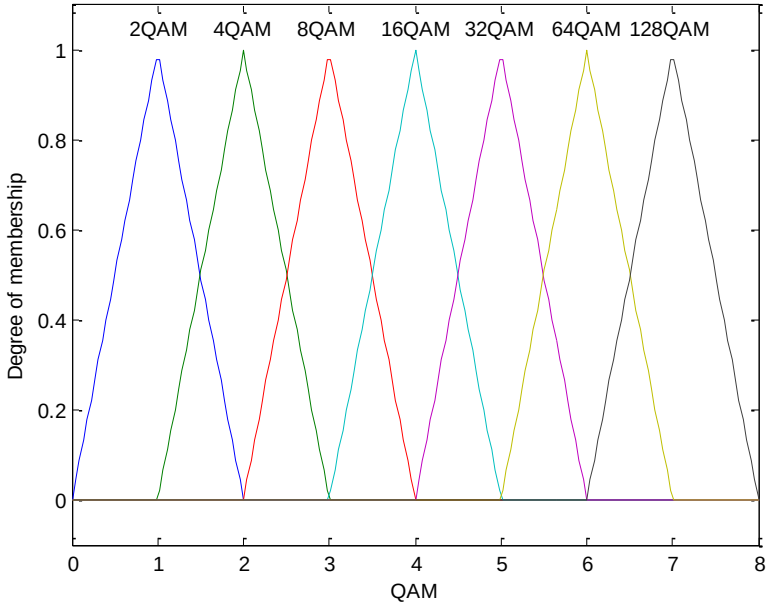

Figure- 3 Output variables

Rules are edited in fuzzy logic rules editor.

if SNR is **L** and if MOD is **L** then QAM is **L**
if SNR is **L** and if MOD is **LM** then QAM is **L**
if SNR is **LM** and if MOD is **LM** then QAM is **LM**
if SNR is **HM** and if MOD is **HH** then QAM is **HM**
if SNR is **HH** and if MOD is **HH** then QAM is **HH**

The rule set in Fuzzy inference system .When the Signal to Noise Ratio or Modulation order of present signal is low and modulation order of past signal is low the output of model order is minimum, it mean system order is not change .similarly when the Signal to Noise Ratio or Modulation order of present signal is high (HH) and modulation order of past signal is high (HH) the output of model order is maximum it mean system order is not change. This change only when the Signal to Noise Ratio or Modulation order of present signal is high medium and modulation order of past signal is high medium the output of model order is l it mean system order is not change. The Rule viewer of FIS gives the batter description of all fuzzy logic set of rule.

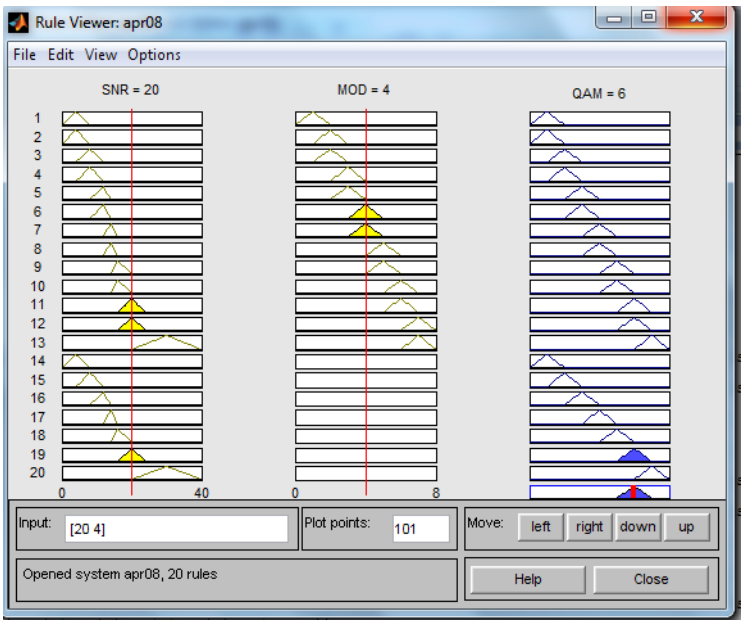

Figure 4 Rule viewers of FIS

Performance of the system on the basis of fuzzy rule in show figure 5. Every slop are represent order of modulation from 2QAM to 128QAM

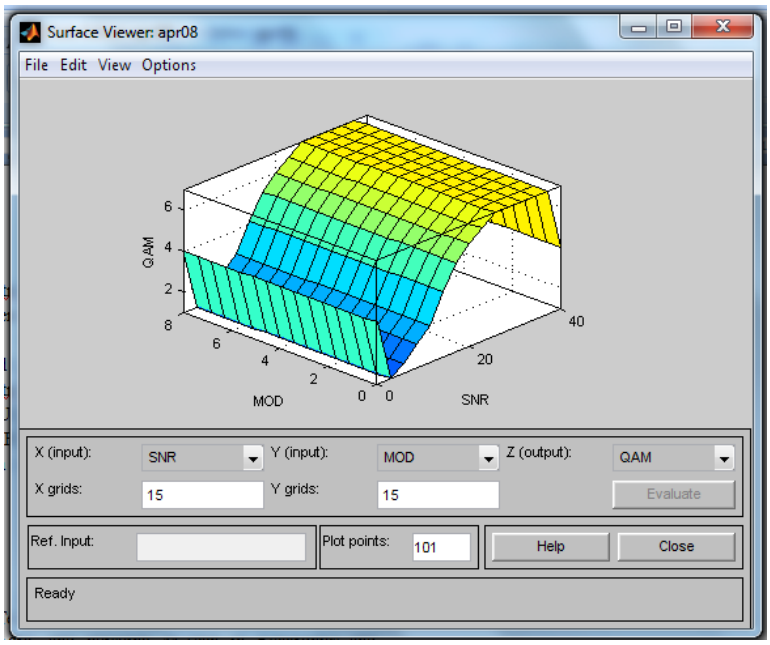

Figure 4 Surface viewers of FIS

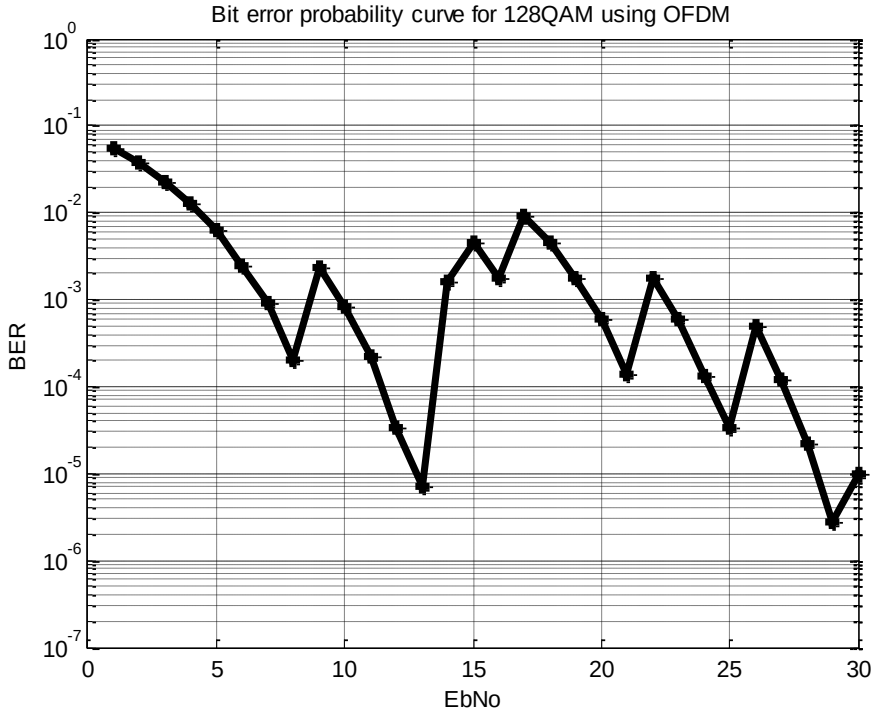

Figure 5 Result of Adaptive OFDM using FIS

As we know that the SNR and BER are reciprocal and on behalf of performance the graph show the reciprocity of SNR or BER. Increase of SNR and model order is increase but BER is reduce, every stage of SNR, model will effected and bit error rate reduce and system will be adaptive it works on fuzzy rule base.

IV. CONCLUSION & FUTURE WORK

The proposed work designs an adaptive modulated OFDM system which estimates the Bit Error Rate as well as modulation order QAM scheme of the required system using fuzzy Inference system (FIS).The performance of the proposed system is in adaptive nature its change with the values of SNR or BER . The obtain result clearly shows that the BER performance of proposed system is much better than using fuzzy system. The bit error rate of 2QAM fuzzy model is 10^{-4} for 16QAM model BER is $10^{-2.9}$ for 128QAM bit error rate is $10^{-5.9}$. For future work, the Adaptive OFDM design through some other method ANFIS or PSO may be they give batter result.

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