Simulation of Wireless Communication Based Adaptive System

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Abstract: **In wireless communications, fading is deviation of the attenuation affecting a signal over certain propagation media. The fading may vary with time, geographical position or radio frequency, and is often modeled as a random process. A fading channel is a communication channel comprising fading. Fading mitigation techniques are used to avoid the attenuation presented in a wireless communication system. Adaptive systems are the examples of the fading mitigation techniques. In this paper an adaptive system is simulated using MATLAB, which can switch its transmission and reception characteristics according the bit error rate (BER) between the sent and received data. The system will commute in a certain value that will be established by the user. The characteristics of the system based on the standard wireless communication system. So, an adaptive system was created with two modes: one with only modulation (64QAM) and the other with modulation (64QAM) and coding (Reed Solomon (64,48). The BER value is established by the user, getting a more efficient system according to the necessities**.

Keywords: **adaptive system, QAM, fading mitigation techniques, adaptive modes.**

I.   Introduction

Attenuation is a major limitation on performance of wireless communication systems. So it is necessary to define certain parameters based on the worst operating conditions to avoid the attenuation presented in a wireless communication system; however, when the conditions get better, the system make a bad use of its resources (power, modulation levels, etc.). A simple way to evade these attenuations is adding modes to a communication system.

A mode is a block (in the transmitter and receptor) that can have a combination of any type of modulation or coding established in a standard.

The fading mitigation techniques (FMT) are a good option, including the adaptive modes.

Adaptive modes are those that allow making changes in the transmission and reception characteristics in a communication system [1].

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For example, let's call modulation 1: 64QAM; modulation 2: QPSK; coding 1: Reed Solomon (64, 48); and coding 2 convolution coding 2/3. In these adaptive modes, the system can switch between these modes:

Coding 1 and modulation 1
Coding 1 and modulation 2
Coding 2 and modulation 1
Coding 2 and modulation 2

There are many other combinations to switch the characteristics. But, in this paper, the switch is only made between 64QAM and 64QAM with Reed Solomon (64, 48) coding [2, 3, 4].

Bit Error Rate (BER) is the important parameter in communications, which is an historical record of a system's actual bit error performance. The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage. The bit error probability is the expectation value of the BER. The BER can be considered as an approximate estimate of the bit error probability. This estimate is accurate for a long time interval and a high number of bit errors. The bit error rate is measured, and compared with the error probability expected, then the performance of the system is evaluated and, finally it would be decided if the system switches its characteristics.

The methodology used in this paper is explained next. First, a reference BER value is established, where the performance of the system is good enough. The initial condition is a system with modulation and a coding technique and it will switch to a system with only modulation. When the bit error rate is less than the value established at the beginning, a message will be sent in order to change the characteristics of the system and then, if it is necessary, return to the initial condition if the channel characteristics get worse again. All this proceeding was simulated with MATLAB.

In the design of a system is very important to watch some parameters, for example, the type of modulation and coding. These parameters must be chosen according to the necessities and conditions presented, for example, bandwidth, bit rate, etc.

An OFDM structure was chosen, with the characteristics of the standard wireless communication system with 64QAM modulation and Reed Solomon coding (64,48), which is a new technology that it is being developed [5].

The bit error rate is another important parameter in wireless communication system, which can be obtained with mathematical formulas. In a system with QAM modulation and Reed Solomon coding, the symbol error probability must be known (which is based in the PAM error probability) P_{eb} in order to obtain the bit error probability, with the next relations [6, 7, 8]:

$$P_{eb} = \frac{2^{(k-1)}}{2^k - 1} P_{es} \tag{1}$$

$$P_{es} = \frac{1}{N} \sum_{i=t+1}^{N} i \begin{bmatrix} n \\ i \end{bmatrix} (P_M)^i (1-P_M)^{N-i} \quad (2)$$

Where, P_{es} is the symbol error probability for a codeword when Reed Solomon coding is added; P_M is the probability of a symbol error without coding; N and K are the parameters from Reed Solomon (n, k).

II. Description Of Simulated Wireless Communication System

The system is based in an OFDM structure [9] with the standard wireless communication system characteristics, as it was mentioned above. The components of the system with modulation and coding are described in following steps:

1. Coding: the type of coding used in the Simulations was Reed Solomon (64, 48).
2. Modulation: the type of modulation used in the Simulations was M-QAM modulation, where M is the number of levels and it is determined by the user or the Conditions presented. In this case, M = 64.
3. Interleaving: block size 768.
4. Gaussian channel.

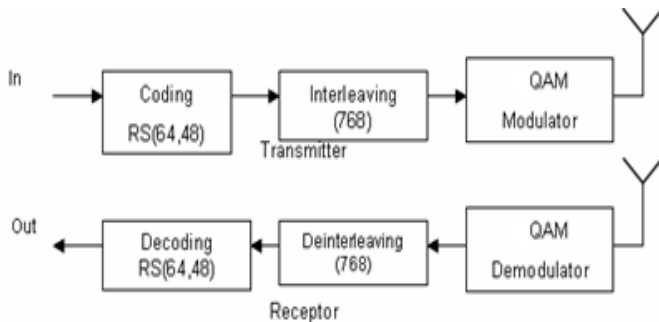The diagram for the system with these characteristics is shown in figure 1.

Figure 1. Block diagram for the system with modulation and coding

Following are the elements of the system with only modulation are:

- The M-QAM modulation is used in this system, where M is the number of levels and it is determined by the user or the conditions presented. In this paper, M is considered 64.
- Gaussian channel.

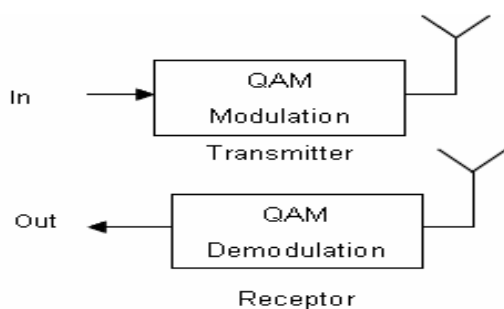The system with only modulation is shown in figure 2.

Figure 2. Block diagram for the system with modulation and coding

III. Simulation Results & Discussion

In this section, we present simulation results to show the BER performance of the standard wireless communication system with and without coding, and switching of the system between two modes. The characteristics of the mode 1 are 64QAM and Reed Solomon (64, 48) coding; and mode 2 has only 64QAM. Simulation has been done in MATLAB and following parameters have been considered for simulation purpose:

TABLE 1. SIMULATION PARAMETERS

Simulation parameters	Type/Value
MODULATION	64QAM
CODING	RS(64,48)
INTERLEAVING BLOCK SIZE	768
CHANNEL	GAUSSIAN

The objective of these simulations is to develop a system which can switch between two modes, if it is necessary. That is when the channel conditions, are bad, the system will have a robust modulation and coding technique, and when the channel conditions get better, and it will have a modulation with more levels because it will be less error probability. The BER performance of the wireless communication system (without switching) is shown in the Figure 3.
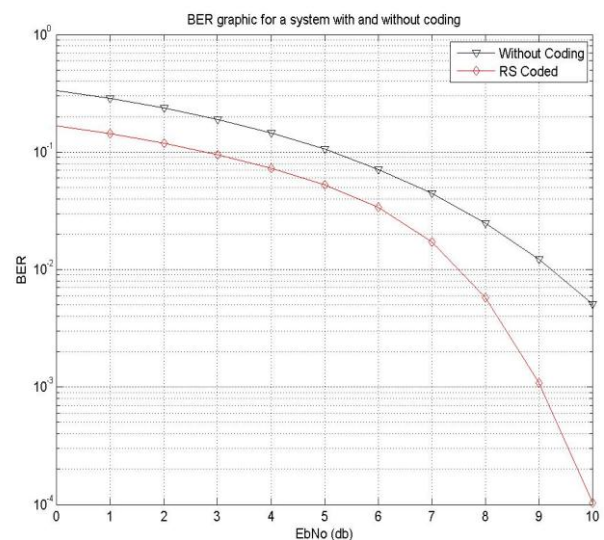

Figure 3. BER performance of a system with & without coding

From the Figure 3, it can be seen that when the channel conditions are not the best, coding can be used, that is when the SNR per bit is very low, coding used; and, when the channel conditions get better, that is when the SNR value is higher, the coding can be omitted. All these condition can be made with all the possible combinations, for example, with a more robust coding technique than RS (64, 48), or a modulation with less or more levels.

The level in which the standard wireless communication system must switch will depend on the user necessities, but in this case, to demonstrate all this, it was determined three BER
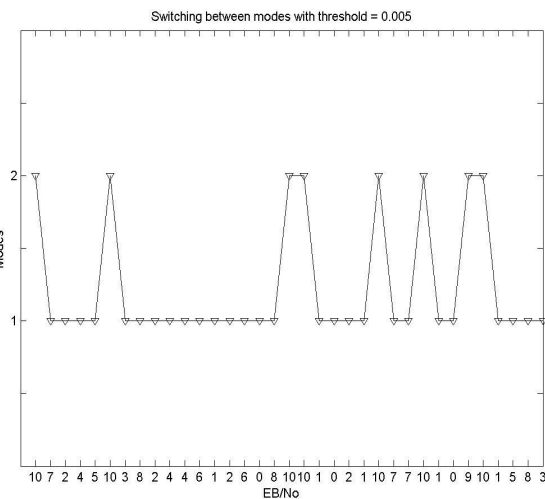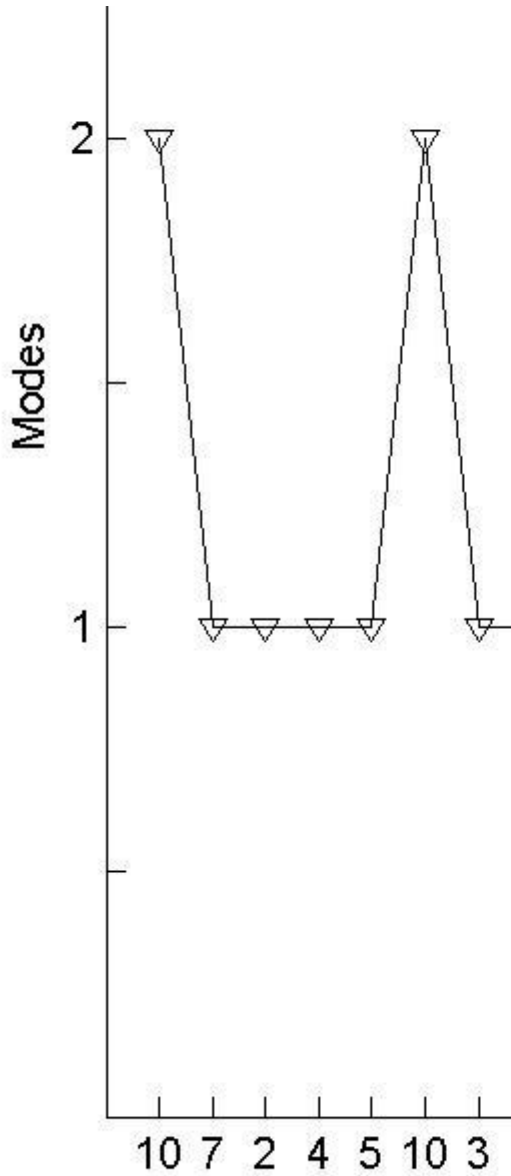
system was in mode 2. So, the probability that system would operate in mode 1 is higher than the system will operate in mode2.

Now again, when BER limit was changed to 0.01, it is shown by Figure 6. From the simulation results of Figure 6 it can be observe that the probability that the system operates in mode 1 is 54.2857% & mode 2 is 45.714%. So, the probability that system would operate in mode 1 or mode 2 is almost the same. Thus by analyzing simulation result for different value of threshold BER it can be observe that for small value of BER the channel is in good conditions.
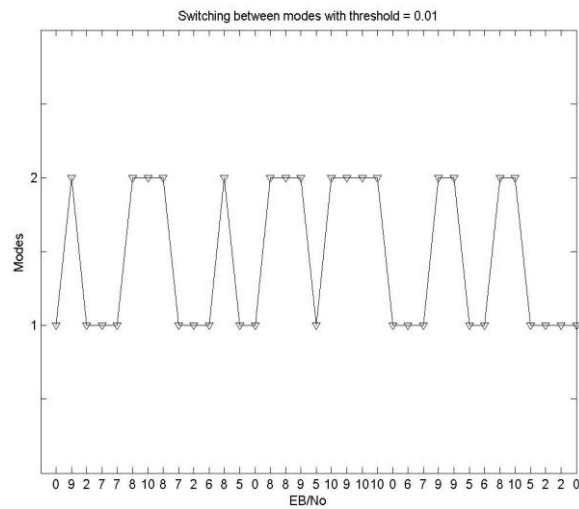

Figure 6. Switching between modes with threshold = 0.01

From these simulations, it was proved that the system will change when it is needed, according to the BER value established by the user, this could depend on the necessities of the user.

IV. Conclusions

An adaptive wireless communication system with specifications of an OFDM system (with QAM modulation, Reed Solomon coding and interleaving) is simulated in this paper. The characteristics used in these simulations were based in the standard wireless communication system. For more efficient system an adaptive system can be created with different threshold value of BER.

In this paper, switching of a system between two modes with 64 QAM modulations & RS (64, 48) coding was analyzed for different threshold value of BER. The characteristics of the simulated system can be switched between the different modes for different chosen value of bit error probability. So, a system which can adapt its characteristics according to threshold BER and SNR was simulated in this paper. However, this is not the unique possible way to make an adaptive system; a number of combinations can be used to make adaptive system is unlimited.

Thus from the simulation result it can be conclude that a wireless communication system with an adaptive modulation offers better efficiency, performance and less error probability.

Figure 5. Switching between modes with threshold = 0.005

Figure 5 represent the case when BER limit was changed to 0.005. In this case, it is observed that the 77.142% of the times system was in the mode 1 and the 22.857% of the times

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