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Adaptive Modulation for OFDM System by Using Convolutional Coding and BCH Coding

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Abstract-Adaptive modulation has been shown to have significant benefits for high-speed wireless data transmission when orthogonal frequency division multiplexing (OFDM) is used. This paper studies the adaptive modulation for coded OFDM system using convolutional code, BCH codes, channel estimation, equalization and SNR estimation. The transmitter according to the estimated SNR select appropriate modulation scheme and coding rate which maintain constant bit error rate lower than the requested BER. Simulation results show that better performance is confirmed for target bit error rate (BER) as compared to conventional modulation schemes. In this paper, we have considered only adaptive modulation. First we have investigated the OFDM system performance of uncoded adaptive modulation using quadrature amplitude modulation (QAM) and phase shift keying (PSK). To further enhance the system, we employ convolutional coding and BCH coding to OFDM system for different modulation techniques over Rician channel. The obtained results from two coding techniques with different modulation schemes is then compare and select one of the coding which shows a significant improvements in terms of bit error rate (BER) and throughput can be achieved demonstrating the superiority of the adaptive modulation schemes compared to fixed transmission schemes. The proposed adaptive modulation and coding Technique for OFDM maintains fixed BER under changing channel condition.

Index Terms— **OFDM, Adaptive Modulation, SNR Estimation, Convolutional Code, Channel Estimation, Bit Error Rate, Rician channel.**

I. INTRODUCTION

During the past few years, there has been an explosion in wireless technology. This growth has opened a new dimension to future wireless communications whose ultimate goal is to provide universal personal and multimedia communication without regard to mobility or location with high data rates. Orthogonal Frequency Division Multiplexing (OFDM) is one of the promising candidates to mitigate the ISI. In an OFDM signal the bandwidth is divided into many narrowband channels. Each sub channel is typically chosen narrow enough to eliminate the effect of delay spread. Equipment vendors are coming together to speed the adoption of OFDM, which will be part of the 4G set of standards. Orthogonal Frequency Division Multiplexing OFDM is a multicarrier transmission technique, many carriers, each one being modulated by a low rate data stream share the transmission bandwidth. Dunlop and Pons asserted that BER at receiver level can be good enough to decide switching scheme. The adaptation rate would be restricted because BER estimation is complicated over short periods.

Adaptive modulation is a way to provide balance between Bit Error Rate (BER) and SNR through the improvement of the Spectral Efficiency. It is possible to make effective use of adaptive modulation in a slowly varying fading channel with noise based on SNR estimation. The main objective of this project is to measure the channel in OFDM systems, and as per the channel suitable modulation and coding rate will be adapted. The performance of OFDM signal transmitted with and without adaptive modulation is done using computer simulations performed using MATLAB. It was found that OFDM signal with adaptive modulation and coding rate performs extremely well than ordinary OFDM signal transmission without adaptive modulation and coding rate. Also it maintains the bit error rate and spectrum efficiency.[2]

The idea of adaptive modulation and coding (AMC) is to dynamically change the modulation and coding scheme in subsequent frames with the objective of adapting the overall throughput or power to the channel condition. In fact, when employing orthogonal frequency division multiplexing (OFDM) over a spectrally shaped channel the occurrence of bit errors is normally concentrated in a set of severely faded sub carriers, which should be excluded from data transmission. On the other hand, the frequency domain fading, while impairing the signal-to-noise ratio

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of some sub-carriers, may improve others above the average signal-to-noise ratio. Hence, the potential loss of throughput due to the exclusion of faded sub carriers can be mitigated by using higher order modulation modes on the sub-carriers exhibiting higher signal-to-noise ratio. In addition, other system parameters, such as the coding rate of error correction coding schemes, can be adapted at the transmitter according to the channel frequency response [1].

II. OBJECTIVE

There are various objectives are achieved by using the adaptive modulation & coding techniques. The main objectives are given as follows-

- To remove the Bit Error rate in OFDM system.
- To provide good protection against co channel interference and impulsive parasitic noise
- To makes efficient use of the spectrum by allowing overlap.
- Using adequate channel coding and interleaving one can recover symbols lost due to the frequency selectivity of the channel.

III. RESEARCH METHODOLOGY

- Convolutional Coding with Rician PSK
- Convolutional Coding with Rician QAM
- Convolution Adaptive Coding with Rician Channels
- Convolutional Coding Result
- BCH Coding with Rician PSK
- BCH Coding with Rician QAM
- BCH Adaptive Coding with Rician Channels
- BCH Coding Result

IV. SYSTEM MODEL

The sub band adaptive transmission schemes are employed to reduce the complexity. In sub band adaptive OFDM transmission, all subcarriers in an AOFDM symbol are split into blocks of adjacent subcarriers referred to as sub bands. The same mode is employed for all subcarriers of the same sub band. The choice of the modes to be used by the transmitter for its next OFDM symbol is determined by the channel quality estimate of the receiver based on the current OFDM symbol. Perfect channel estimation is assumed in this paper. In this simulation the instantaneous SNR of the subcarrier is measured at the receiver. The channels quality varies across the different subcarriers for frequency selective channels. The received signal at any subcarrier can be expressed as.

$$Rn = HnXn + Wn$$

Where H_n is the channel coefficient at any subcarriers, X_n is the transmitted symbol and W_n is the Gaussian noise sample. So the instantaneous SNR can be calculated using

$$SNH_n = \frac{Hn^2}{N0}$$

The conservative approach in threshold based adaptation is by using the lowest quality subcarrier in each sub band for controlling the adaptation algorithm. It means that the lowest value of SNR will be used in mode selection. By using this method, the overall BER in one sub band is normally lower than the BER target. If the overall BER can be Optimize adaptive coding technique to improve performance of OFDM system closer to the BER target by choosing a more suitable modulation mode or code rate, the throughput of the system will be higher.

Therefore a better adaptation algorithm is used in this paper to provide a better tradeoff between throughput and overall BER by choosing a more suitable scheme for each sub band. Instead of using the lowest SNR in each sub band, the average value of the SNR of the subcarriers in the sub band is going to be used.[1]

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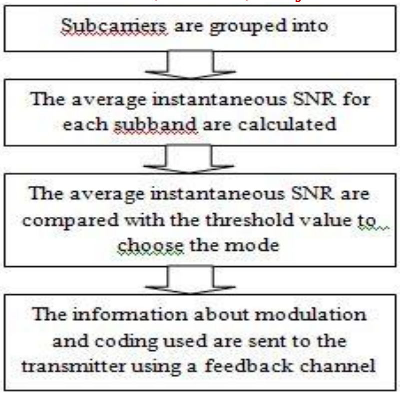

Fig 1. Adaptation Procedure

V. EXPERIMENTAL RESULTS WITH CONVOLUTIONAL CODING

(I) Convolutional coding with Rician PSK: Graph shows the BER performance of QPSK over Rician channel with convolutional coding. BPSK requires 3 dB less of signal to noise ratio than QPSK to achieve the same BER. This outcome will hold true only if we consider BER in terms of SNR per carrier. In terms of signal to noise ratio per bit the BER is same for both QPSK and BPSK. The effects of Rician channel simulated in Matlab. The results are displayed in Graph 1.1. In Rayleigh channel, the signal is more prone to errors and for example, at a bit error rate of 10^{-3} we need 20 dB more of signal to noise ratio than for Rician to achieve the same bit error rate. The probability of error is identical for BPSK and QPSK because the BER has been measured in terms of signal to noise ratio per bit.

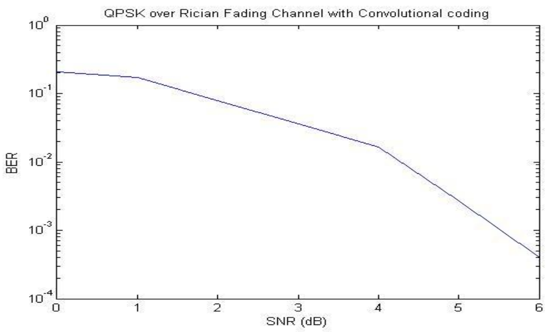

Fig. 2: QPSK over Rician Channel with Convolutional Coding

(II) Convolutional coding with Rician QAM: Graph 3 shows the 16-QAM over Rician Fading Channel with convolutional coding. It represent the matlab result of the signal to noise ratio verses Bit error rate performance. In 64-QAM over Rician Fading Channel with convolutional coding of signal to noise ratio is increases the bit error rate is decreases. Graph 4 shows 64-QAM over Rician Fading channel with Convolutional coding.

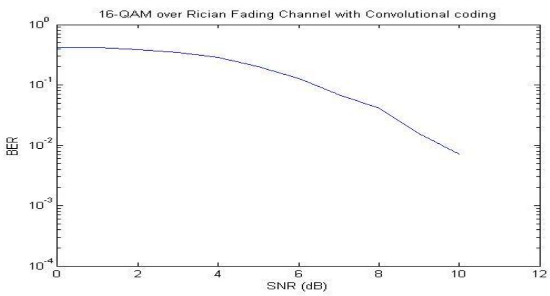

Fig. 3: 16-QAM over Rician Channel with Convolutional Coding

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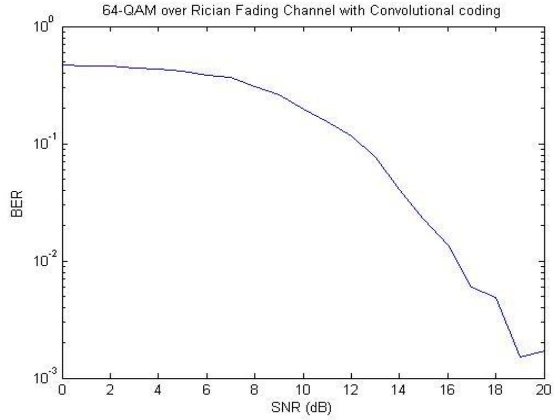

Fig. 4: 64-QAM over Rician Channel with Convolutional Coding

Graph 5 shows M-ary PSK & QAM over Rician Channel with convolutional coding. This figure shows the combination of M-ary 4-PSK, M-ary 16-QAM and M-ary 64-QAM.

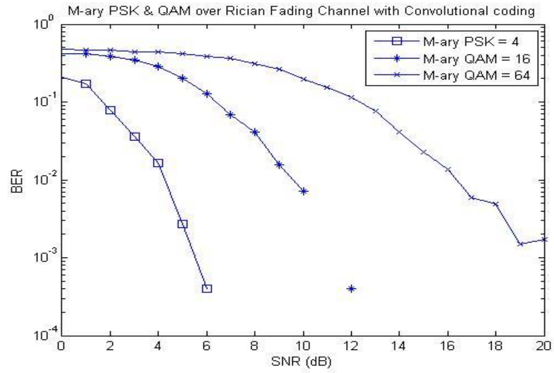

Fig. 5 M-ary PSK & QAM over Rician Channel with Convolutional Coding

(III) Convolutional coding with Adaptive Rician Channels: Graph 6 shows the MATLAB result of PSK & QAM adaptive modulation over Rician Fading Channel with Convolutional coding. In MATLAB the PSK and QAM signal are adaptive by using adaptive modulation and display the result as shown in Graph 1.5

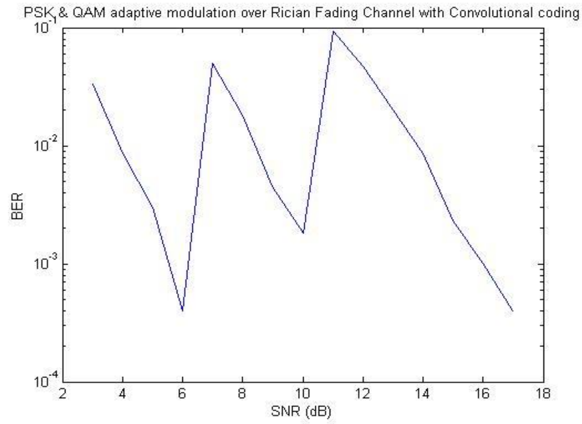

Fig. 6: PSK & QAM adaptive modulation over Rician Channel with Convolutional Coding

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(IV)Convolutional Coding Result with Rician Channels: Graph 1.6 shows the MATLAB result of Adaptive PSK & QAM over Rician Fading Channel with Convolutional coding. In MATLAB the PSK and QAM signal are adaptive by using adaptive modulation and MATLAB gives this result are as shown in Graph 1.6. This figure indicates the Adaptive combination of Adaptive PSK and QAM. In an OFDM system using lower order modulators such as BPSK, 4-QAM and 8-QAM will improve BER but decreases spectral efficiency, on the other hand employing higher order modulators such as 64 QAM, 128 QAM, 256QAM and 512 QAM will increase spectral efficiency but result in poor BER. So to achieve good trade-off between spectral efficiency and overall BER adaptive modulation is used. Graph 7 shows the simulated BER performance of M-ary PSK, 16-QAM, 64-QAM and adaptive modulation scheme for an OFDM system over AWGN channel. The goal of the adaptive modulation algorithm we used in our simulation is to reach and maintain a target BER irrespective of the SNR levels that each individual subcarrier experiences.

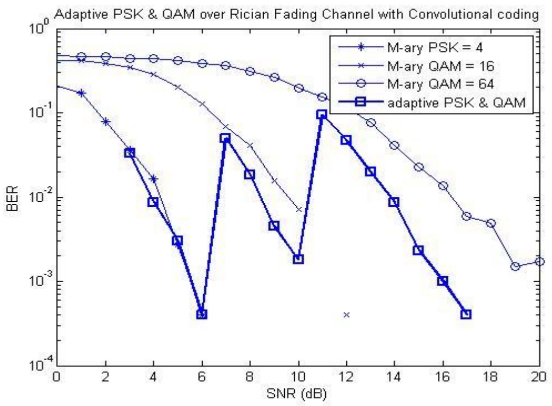

Fig. 7: Adaptive PSK & QAM over Rician Channel with Convolutional Coding

When the SNR of a specific subcarrier exceeds one of the switching thresholds, that carrier's modulation scheme is updated. No signal transmission is performed at SNRs lower than 5 dB as that would put us above the target BER we want to achieve. The last two peaks shown in Figure correspond to the algorithm switching to 16QAM and then 64QAM.

As clearly shown in Graph 7, the BER performance of adaptive modulation has a ripple phenomenon. This is because the BER of adaptive modulation scheme will rise up when the constellation is switched to one with larger constellation size as SNR increases and falls in the next SNR region. The BER will decrease when the SNR keeps increasing within the region boundaries. As the value of SNR increases, the BER decreases and the system will switch to the next higher modulation scheme and again the BER increases but it decreases for the chosen modulation scheme interval. But the adaptive modulation scheme keeps the value of the BER below the target BER.

It is seen that by applying the adaptive modulation techniques the BER performance of 4-PSK, 16-QAM and 64-QAM Adaptive modulation or adaptive OFDM is a technique used in OFDM transmission that adapt bit and power allocation to the amplitude response of a frequency selective channel.

VI. EXPERIMENTAL RESULTS WITH BCH CODING

(I) BCH coding with Rician PSK: Graph 8 shows the BER performance of QPSK over Rician Fading channel with BCH coding. In this figure the SNR increase the Bit error rate is decreases. BPSK requires 3 dB less of signal to noise ratio than QPSK to achieve the same BER. This outcome will hold true only if we consider BER in terms of SNR per carrier. In terms of signal to noise ratio per bit the BER is same for both QPSK and BPSK. The effects of AWGN channel simulated in Matlab. The results are displayed in figure. In Rayleigh channel, the signal is more prone to errors and for example, at a bit error rate of 10-3 we need 20 dB more of signal to noise ratio than for AWGN to achieve the same bit error rate. The probability of error is identical for BPSK and QPSK because the BER has been measured in terms of signal to noise ratio per bit.

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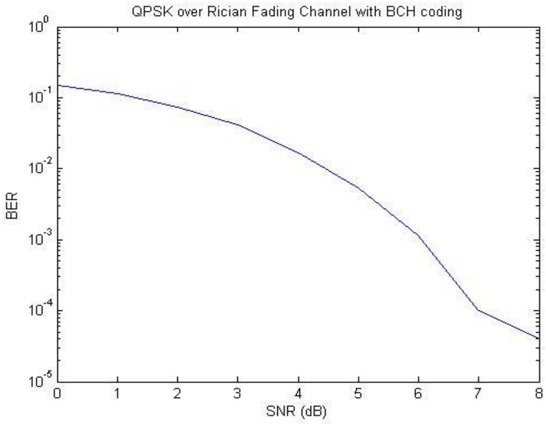

Fig. 8: QPSK over Rician Channel with BCH Coding

(II) BCH coding with Rician QAM: Graph 9 shows the 16-QAM over Racian Fading Channel with BCH coding. It represent the matlab result of the signal to noise ratio verses Bit error rate performance. In 16-QAM over AWGN Channel with BCH coding of signal to noise ratio is increases the bit error rate is decreases. Graph 1.9 shows 64-QAM over Racian Fading channel with BCH coding.

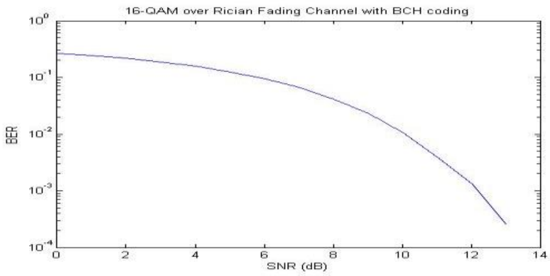

Fig. 9: 16-QAM over Rician Channel with BCH Coding

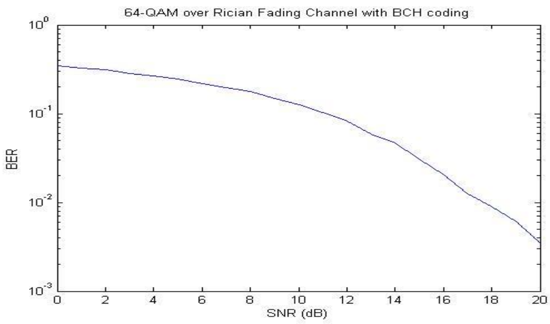

Fig. 10: 64-QAM over Rician Channel with BCH Coding

Graph 10 shows M-ary PSK & QAM over Rician Channel with BCH coding. This figure shows the combination of M-ary 4-PSK, M-ary 16-QAM and M-ary 64-QAM.

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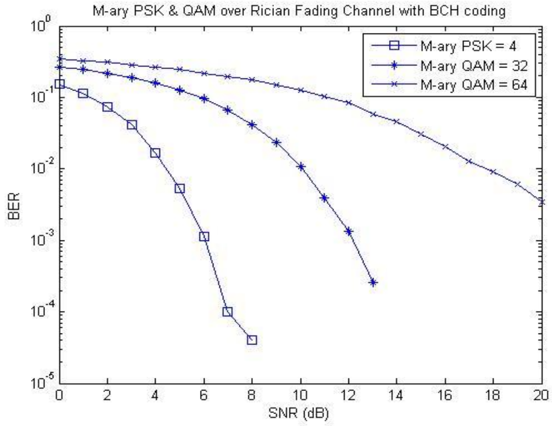

Fig. 11: M-ary PSK & QAM over Rician Channel with BCH Coding

(III) BCH coding with Adaptive Rician Channels: Graph 11 shows the MATLAB result of PSK & QAM adaptive modulation over Rician Fading Channel with BCH coding. In MATLAB the PSK and QAM signal are adaptive by using adaptive modulation and display the result as shown in Graph.

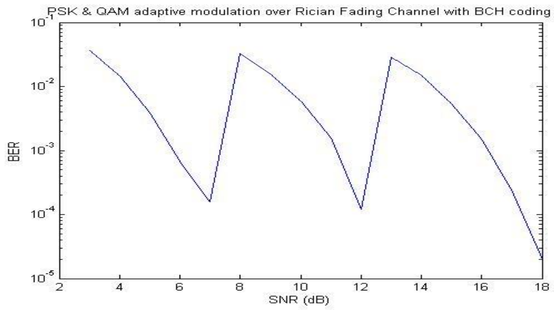

Fig. 12: PSK & QAM adaptive modulation over Rician Channel with BCH Coding

(IV)BCH Coding Result with Rician Channels: Graph 12 shows the MATLAB result of Adaptive PSK & QAM over Racian Fading Channel with BCH Coding. In MATLAB the PSK and QAM signal are adaptive by using adaptive modulation and MATLAB gives this result are as shown in Graph. This Graph indicates the Adaptive combination of Adaptive PSK and QAM. The simulation is followed by using m file. In this approach, the simulation is successfully done using QPSK modulation technique. The desired BER graphs are obtained for simulation in AWGN channel. QPSK and 16-QAM modulation techniques in AWGN channel has good performance when it is compared to that of Multipath Rayleigh channel. Also, the performance of QPSK and 16-QAM degrades when the channel is subjected to Multipath fading with increasing value of Doppler shift (Hz).

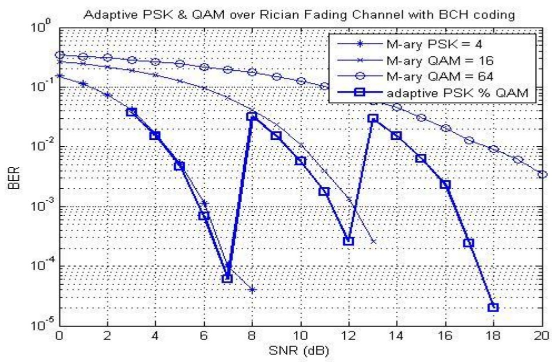

Fig. 13: Adaptive PSK & QAM over Rician Channel with BCH Coding

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VII. CONCLUSION

The detail knowledge of a current key issue in the field of communications named Orthogonal Frequency Division Multiplexing (OFDM). We elaborated on the performance theory of the codes. First we Investigates OFDM system model then try to improve the performance by applying convolutional code and BCH code to our uncoded system over Rician channel. From the study of the system, it can be concluded that we are able to improve the performance of uncoded OFDM by convolution coding and BCH coding scheme. In this project, the performances of adaptive transmission scheme for OFDM have been investigated. The advantage of employing adaptive transmission scheme is described by comparing their performance with fixed transmission system. A better adaptation algorithm is used to improve the throughput performance. This algorithm utilizes the average value of the instantaneous SNR of the subcarriers in the sub band as the switching parameter. The results show an improved throughput performance with considerable BER performance.

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