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Analysis of FHSS-CDMA with QAM-64 over AWGN and Fading Channels

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Abstract – *CDMA is a type of channel access method in which users using the same channel will use the same frequency band and also can access the channel at the same time. Using CDMA, more users can be allocated in the channel compared to TDMA and FDMA. CDMA can be achieved using Direct sequence spread spectrum(DSSS) and Frequency hopping spread spectrum(FHSS). FHSS-CDMA consumes less power compared to DSSS-CDMA. High data rate modulation schemes are used along with FHSS-CDMA to deliver high quality multimedia content. High data rate modulation techniques have good bandwidth efficiency in FHSS-CDMA. In wireless communication, QAM is one of the most commonly used modulation technique. Due to noise and interference, high data rate modulation techniques are prone to errors. FHSS-CDMA with QAM-64 is simulated over AWGN , Rician and Rayleigh fading channels using MATLAB 10 version. It is observed from the simulation that, Rician fading channel gives less bit errors compared to Rayleigh fading channel due to line of sight communication.*

Key Words: **CDMA, DSSS, FHSS, QAM-64, AWGN, Rician Fading, Rayleigh Fading.**

1.INTRODUCTION

W-CDMA is a 3-G wireless technology which is officially known as IMT-2000 direct spread. W-CDMA with QAM-64 gives high data rates for multimedia contents which enables high resolution images and high quality videos to the end users. GSM which is a 2-G technology used GMSK modulation technique which transmits the bits at a rate of 1bps. Due to increase in number of users and mobility the bit errors in communication will also be increased with GMSK . Thus GMSK modulation scheme is not suitable for next generation systems. So, there is a need to study new modulation techniques which supports more number of bits per second and improved performance in real world condition . The performance of M-ary modulation techniques is better compared to low level modulation techniques in terms of bit error probability for audio transmission[1]. Higher order modulation techniques supports faster data rates with higher levels of spectral efficiency for the radio communications system. The disadvantage is that, they are less resilient to noise and interference.

CDMA technique is based on the spread spectrum communication. The CDMA with existing modulation technique have some disadvantages. In CDMA, well-built interferer can shift up the noise for other channels which can cause interference in communication and also it needs huge amount of power which result in implementation of extra hardware to normalize the power requirement. [2] Frequency-hopping spread spectrum (FHSS) is a method of transmitting radio signals by rapidly switching a carrier among many frequency channels using a pseudo random sequence known to both transmitter and receiver. FHSS-CDMA consumes less power compared to DSSS-CDMA. High data rate modulation schemes are used along with FHSS-CDMA to deliver high quality multimedia content. QAM-64 modulation technique as good bandwidth efficiency with wideband FHSS-CDMA. Author in [4], discusses about broadband wireless access techniques. For 4G systems data rates up to 100 Mbps will be necessary[4].In a CDMA transmitter, the information is modulated by a spreading code and in receiver, the information is retrieved using the same spreading code used at the transmitter.QAM, Quadrature amplitude modulation is widely used in many digital radio communications and data communication applications. Various forms of QAM are available and some of them are QAM16, QAM32,QAM64,QAM128 etc. QAM is used when the data rates required is more than that of 8PSK. The rest of the paper is organized as follows : Section 2 & 3 deals about AWGN, Rayleigh & Rician channel. Section 4 deals about QAM and its variants. Section 5 gives details about Frequency hopping spread spectrum and Section 6 details about the system model.

2. ADDITIVE WHITE GAUSSIAN NOISE(AWGN)

It is a basic and generally accepted model for thermal noise in communication channels. The assumptions made in this model are: The noise is additive and white(i.e, the power spectral density is flat).Another assumption is that the noise samples have a Gaussian distribution. AWGN model is normally used in information theory to imitate the effect of many random processes that occur in nature.

3. RAYLEIGH AND RICIAN FADING CHANNELS

Rayliegh channel is a statistical model for the effect of a propagation environment on a radio signal such as that used by wireless devices. In Rayleigh fading channels the magnitude of the signal will fade according to rayleigh distribution. Rayleigh fading is applicable when there is no dominant propagation along the line of sight between the transmitter and the receiver. Rician fading or Ricean fading is a stochastic model for radio propagation. The signal arrives at the receiver by several different paths which causes multipath interference. Rician fading is

applicable when there is a dominant propagation along the line of sight . In Rician fading, typically line of sight signal is much more stronger than the signal coming from different paths.

4. QUADRATURE AMPLITUDE MODULATION

Quadrature amplitude modulation(QAM) is widely used in many digital radio communications and data communication applications . QAM is modulated using two carriers shifted in phase by 90 degrees, The resultant output consists of both amplitude and phase variations. The QAM64 signal (M= 64) corresponds to a 64 states and therefore each symbol represent 6 bits. The quadrature amplitude modulation (QAM) modulates an in-phase signal $m_I(t)$ and a quadrature signal $m_Q(t)$ using

$$Y(t)=M_I(t)\cos(2\pi fct+\phi_c)+M_Q(t)\sin(2\pi fct+\phi_c)$$

where Y(t) is the modulated signal, fc is the carrier frequency (Hertz), and φc is the initial phase (rad). Because the sine and cosine signals are orthogonal, the original signals can be recovered later using demodulation techniques. The corresponding demodulation method QADM, recovers both the in-phase and quadrature signals, $m_I(t)$ and $m_Q(t)$ respectively from the modulated signal y(t).[5]

5. FREQUENCY HOPPING SPREAD SPECTRUM(FHSS)

The WCDMA technology employs the spectral spreading of the transmitted signal. If the transmitted signal has large envelope variations, it will create large envelope fluctuations as it propagates through the transmitter. These envelope variations can be eliminated by using the pulse shaping filter placed at the transmitter and receiver part of the system[3]. FHSS is a type of spread spectrum technique used to transmit radio signals by rapidly changing the carrier among many frequencies channels. In frequency hop spread-spectrum communication, the binary data sequence modulates the frequency of the carrier signal resulting in an MFSK signal. The MFSK signal finally modulates a carrier which hops randomly. This type of spread-spectrum in which the carrier hops randomly from one frequency to another is called frequency-hop(FH) spread-spectrum. If several symbols are transferred in each frequency hop then it is called as slow-frequency hopping spread-spectrum system. If carrier frequency hop several times during the transmission of one symbol then it is called fast-frequency-hop spread-spectrum system. In this work ,slow –frequency-hop spread spectrum system is used to analyze FHSS-CDMA with QAM-64 over AWGN and Fading Channels. High data rate modulation schemes are used along with FHSS-CDMA to deliver high quality multimedia content.

6. SYSTEM MODEL

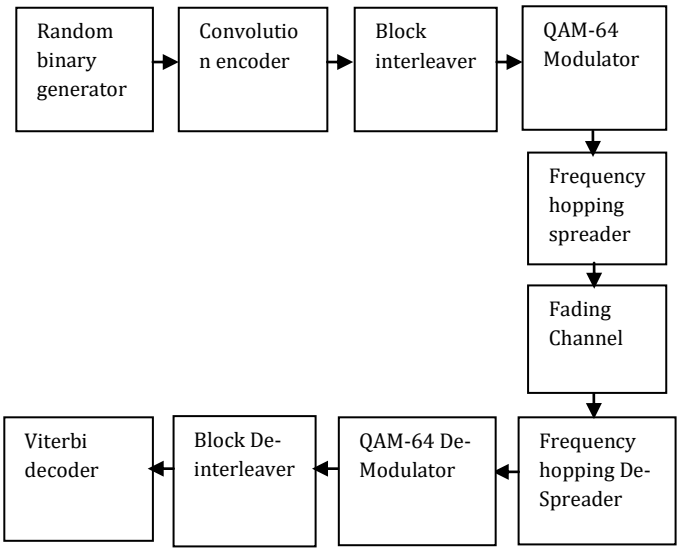

Figure.1: Block Diagram for FHSS-CDMA with QAM-64 over AWGN and Fading Channels

Figure 1 shows the block diagram of FHSS-CDMA with QAM-64 over AWGN and fading channels. Random binary generator in Matlab generates random binary bits and these bits are given as the input to the convolution encoder. Constraint length and rate used in the work is 5 and 1/4 respectively. Convolution encoder encodes the data(Converts the input binary vector to the output binary vector) and gives it to the Block interleaver. Block interleaver process the data and rearranges the data without omitting any bits. Block interleaving is a technique used by mobile wireless systems to combat the effects of bit errors introduced during the transmission of frame [6]. In wireless communication, QAM is one of the most commonly used modulation technique. QAM -64 is one of the variants of QAM. Both Phase and Amplitude are varied in QAM. In QAM-64 each 6 bits will be considered as one sequence and the amplitude and phase will be varied for each 6 bits. QAM-64 modulation technique as good bandwidth efficiency with wideband FHSS-CDMA. Frequency hopping spreader spreads the QAM modulated signal by consuming less power. The spread signal is analyzed by sending it into AWGN, Rician and Rayleigh fading channels. At the receiver the faded signal is picked and de-spread using frequency hopping de-spreader and demodulated using QAM-64 demodulator. Block De-interleaver rearranges the data. Viterbi decoder is used to decode the data sent. Viterbi decoder is a maximum- likelihood decoder, which is optimum for a white Gaussian noise channel. The demodulated data from AWGN, Rayleigh and Rician fading channel is compared with transmitted data.

7. Simulations & Result analysis

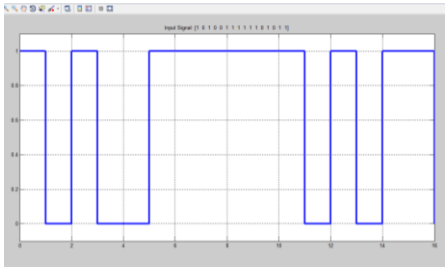

Figure 2:Unipolar NRZ format for 1010011111101011

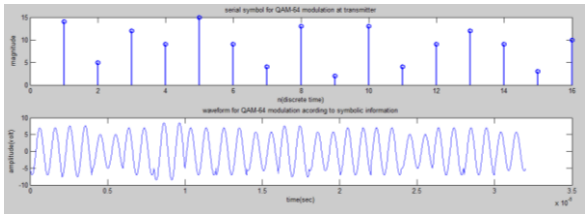

Figure 3: Waveform of QAM-64 modulation for convolution encoded data sequence.

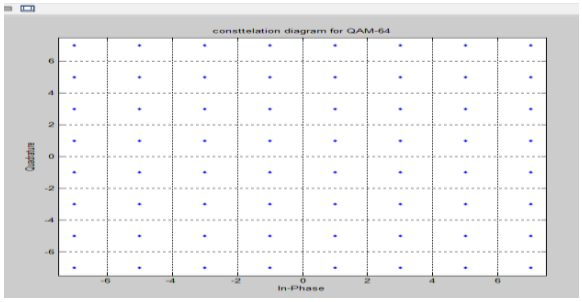

Figure 4: Constellatation diagram for QAM-64

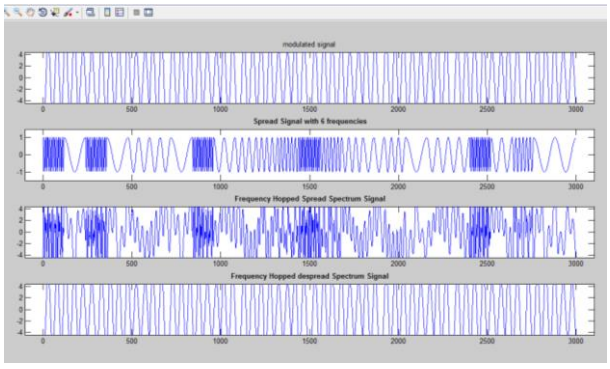

Figure 5: QAM-64 Modulated Signal with Frequency hopped Spread Spectrum using 6 Different Frequencies

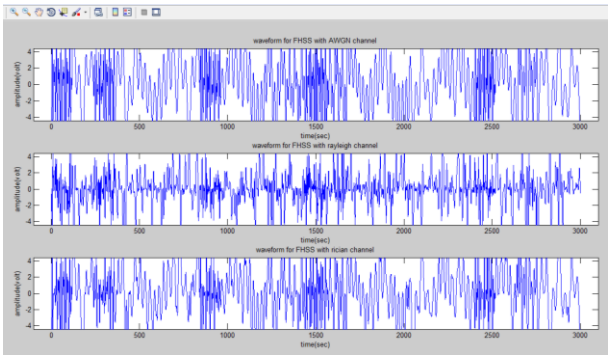

Figure 6: FHSS QAM-64 signal with AWGN, Rayleigh and Rician fading channels

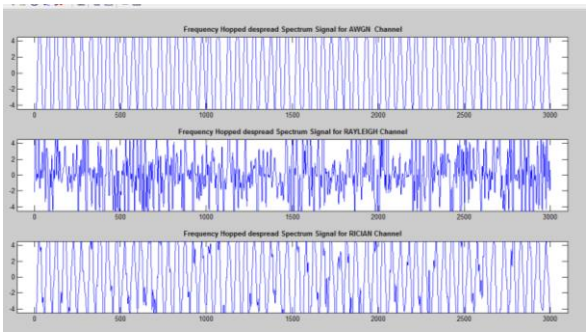

Figure 7: De-spread signal from AWGN, Rayleigh and Rician fading channels

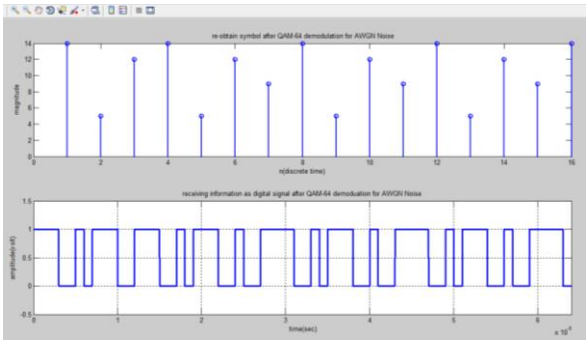

Figure 8: Demodulated signal from AWGN channel

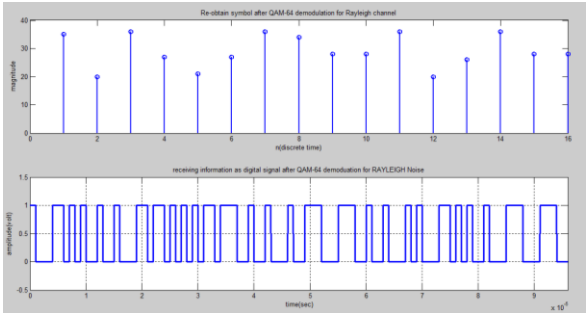

Figure 9: Demodulated signal from Rayleigh channel

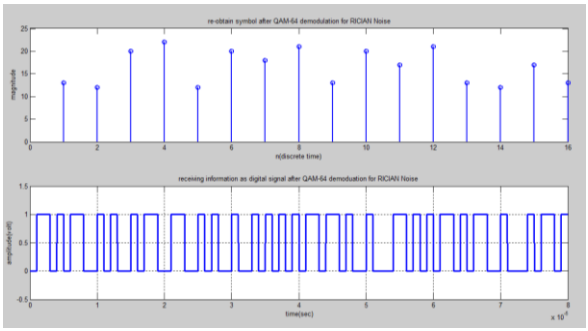

Figure 10: Demodulated signal from Rician channel

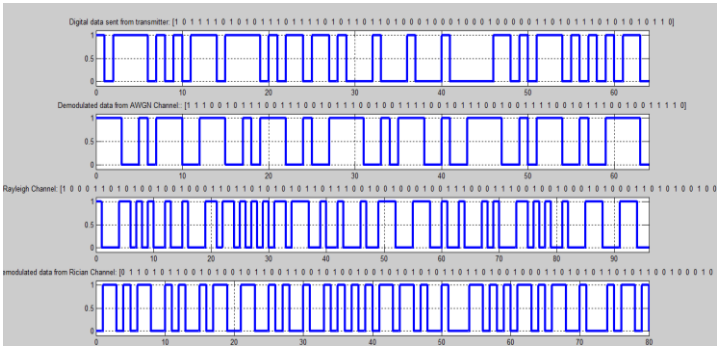

Figure 11: Comparison of convolution encoded data at the transmitter with demodulated data from AWGN, Rayleigh and Rician fading channels.

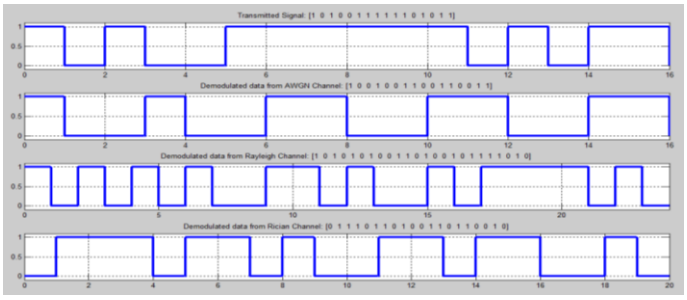

Figure 12: Comparison of transmitted and received binary bits from different fading channels

8. Conclusion

FHSS-CDMA with QAM-64 modulation technique is developed and analyzed with AWGN and fading channels. Efficient use of these channels will go a long way in the development of CDMA technology in future. From the results obtained it can be concluded that AWGN always gives less errors compared to Rician and Rayleigh fading channels. From the results it is observed that Rician fading channel gives less bit errors compared to Rayleigh fading channel due to line of sight component present in it. By increasing bit energy, bit errors can still be reduced in AWGN channel.

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BIOGRAPHIES

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