Analysis and Simulation of CDMA QAM-16 for AWGN and RAYLEIGH Channel

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Abstract – In a Code Division Multiple Access (CDMA) system, a lot of users use concurrently the entire frequency band to transmit their data and users’ data is separated on the basis of their unique spreading code. The aim of Communication System i.e. Communication at anytime, anywhere and by anybody is still not fulfilled but the technology like CDMA can fulfill the aim of communication system if it is properly analyzed. For a downlink transmission Quadrature Amplitude Modulation (QAM), Quadrature Phase Shift Keying (QPSK) and Binary Phase Shift Keying (BPSK) modulation Techniques are considered in a Wideband Code Division Multiple Access System. The work design and evaluate CDMA Transmitter and Receiver for QAM-16 modulation Scheme and deal with BER performance of WCDMA, when the design is subjected to a number of users as well as noise and interference in the AWGN channel and Rayleigh Fading channel.

Keywords – WCDMA, AWGN, FADING, QAM, BER.

I. INTRODUCTION

W-CDMA (Wideband Code-Division Multiple Access), an ITU standard originated from Code-Division Multiple Access (CDMA), is officially known as IMT-2000 direct spread. W-CDMA is a third-generation (3G) mobile wireless technology that promises much better-quality data speeds to mobile and moveable wireless devices than typically offered in today's market. High data rate signal communication can be transmit over the air by means of W-CDMA system, thus enabling video streams and high resolution pictures to end users. Thus, we need a suitable modulation technique and inaccuracy correction mechanism to be used in W-CDMA system. Since 2G in which Gaussian Minimum Shift Keying (GMSK) modulation scheme is mostly used in GSM (Global System for Mobile Communication) could not deliver the high data bit rate as it transmits the data at the rate of 1 bps. Thus, this modulation scheme is not suitable for next generation system. So, there is a need to study the performance of Modulation technique that may deliver higher data rate efficiently in a real world condition [1].

Modulation schemes which are capable of delivering more bits per symbol are more immune to errors caused by noise and interfering in the channel. In addition, errors can be simply formed as the amount of users is increased and the mobile terminal is subjected to mobility. Thus, it has encouraged a lot of researches into the application of higher order modulations. With growing attractiveness and usage of the third generation networks, the cost efficient optimization of network capacity and worth of service will turn into essential to cellular operators [2]. CDMA technique is based on the spread spectrum communication. The CDMA with existing modulation Technique have disadvantage that the occurrence of a well-built interferer can shift up the noise significantly for other channels which can cause communication to be close down under serious condition and also it need huge quantity of power which result in implementation of extra hardware to normalize the power requirement [3]. In a CDMA transmitter, the information is modulated by a spreading code, and in the receiver it is linked with a duplication of the identical code. Thus, low cross-correlation between the preferred and interfering users is important to hold back the multiple access interference. Good auto-correlation properties are necessary for reliable synchronization and reliable division of the multipath components. Having good auto-correlation properties is also a sign of good randomness of a progression, which allows us to attach other important sequences correctly [4].

II. REVIEW OF SIMILAR WORK

CDMA is similar to the example where people talking the similar language can understand each other, but not other people. Similarly, in radio CDMA, each group of users is given a shared code. Many codes exist in the same channel, but only users associated with a particular code can communicate [5]. Here the work done by Mr. Tripathim.et.al is concerned with the performance evaluation of the BPSK modulated CDMA system with AWGN channel and it is found that the bit error rate of BPSK is quiet low as compared to other modulation techniques such as DPKS, ASK, FSK.[6]. The performances of DS- CDMA are drastically affected in Rayleigh channel. [7]. The Bit error rate performance of CDMA system with OFFSET QPSK modulation method has been evaluated with the AWGN (additive white Gaussian noise).Offset QPSK has a lesser amount of bit error rate in contrast of other modulation schemes such as ASK (amplitude shift keying), FSK (frequency shift keying), BPSK (binary phase shift keying) and DPSK (differential phase shift keying) that’s having greatest data loss and least bit rate in comparison of QPSK.[8]. A work done by Ghamin et.al shows that QAM gives less bit error rate that makes CDMA more flexible and suitable for mobile communication for next generation technology [9]. A review done by Bhardwaj et.al [10] Shows over the years researchers have hunted a ways to extend the user capacity of CDMA systems either by employing optimum [maximum likelihood (ML)] detection, interference cancellation (IC) methods, or other methods such as the de-correlating receiver. A CDMA designed by Ramon et al shows that the multiple access interference can be restrain if CDMA shows low cross correlation between desired and interference signal [11]. Mr.Tahir found that
the performance of QPSK is improved than QAM when
the system is subjected to AWGN and Rayleigh Fading
cannel [12]. Recently simulation performed by Mr. Arun
et.al shows that in a CDMA transmitter, the information is
modulated by a spreading code, and in the receiver it is
correlated with a replica of the same code and claim
QPSK modulation technique has a better performance
compared to BPSK, FSK and ASK[3]. The simulation of
different modulation system has been generated and
compared. From the comparison Mr. Arun.et.al has
conclude that BPSK modulation is optimum modulation
scheme for CDMA system with less BER as compared to
QAM and QPSK [4].

III. ADDITIVE WHITE GAUSSIAN NOISE
(AWGN)

Additive white Gaussian noise (AWGN) is a basic noise
model used in Information theory to imitate the effect of
many random processes that occur in nature.

3.1. Rayleigh Fading Channel:

It is a communication channel having a fading envelope
in the form of Rayleigh Probability Density Function.

IV. QAM

The 16 QAM signal (M= 16) correspond a 16 States and
therefore each symbol represent 4 bits .The result for 16 –
QAM is 4x 6= 24Mbps. The 64-QAM signal (M = 64)
represents 26 = 64 states, and therefore each symbol
represents 6 bits. The QAM is sent over the system with
symbol rates of roughly 5 Mbps (plus change). The result
for 64-QAM is simply the product 5 x 6 = 30 Mbps. Note
that this is just the raw bit rate in the channel, not all of
which represents payload information, since forward error
correction requires redundancy. For M=256, each symbol
represents 8 bits, and thus a roughly 40 Mbps rate, or a
(40-30)/30 = 33% increase in bandwidth efficiency. For a
1024-QAM carrier, the bandwidth efficiency is derived by
noting hat 210 = 1024 states, ensuing in about 50 Mbps
carrier. This represents a 25% increase in bandwidth
efficiency above 256-QAM, and a 67% increase above 64-
QAM. Each increase in M, therefore, provides more
efficient use of accessible bandwidth. This comes, of
course, at the expense of channel fidelity requirements
[13]. When transmitting two signals by modulating them
with QAM, the transmitted signal will be of the form:

\[ r(t) = \frac{1}{2} \bar{l}(t)[1 + \cos(4\pi f_0 t)] - 1/2q(t)[\sin(4\pi f_0 t)] \]

\[ r(t) = \frac{1}{2} \bar{l}(t) + \frac{1}{2} q(t)\cos(4\pi f_0 t) - Q(t)\sin(4\pi f_0 t) \]

Using standard trigonometric identities, we can write it as:

\[ r(t) = s(t) * \cos(2\pi f_0 t) \]

\[ r(t) = l(t)[\cos(2\pi f_0 t) * \cos (2\pi f_0 t)] \]

\[ -Q(t)[\sin(2\pi f_0 t) * \cos(2\pi f_0 t)] \]

Fig.1. Proposed Block diagram of 16QAM for Rayleigh
Fading Channel

Low-pass filtering remove the high frequency terms
leaving only the i(t) term. This filtered signal is unaffected
by q(t), showing that the in-phase component can be
received separately of the quadrature component.
Likewise, we may multiply s(t)by a sine wave and then
low-pass filter to extract. The phase of the received signal
is supposed to be known exactly at the receiver. If the
demodulating phase is even a little off, it results in cross-
talk between the modulated signals. This concern of
carrier synchronization at the receiver must be handled
somehow in QAM systems. The coherent demodulator
needs to be exactly in phase with the received signal, or
otherwise the modulated signals cannot be independently
received [15].

V. BLOCK DIAGRAM ANALYSIS OF CDMA

As shown in Figure 1 and Fig.2, The Bernoulli Binary
Array generate a 16 M-array random binary number using
a Bernoulli distribution. The convolution encoder encodes
sequences of binary input vector to produce a sequence of
binary output vector. The interleaver rearranges the
element of input vector without repeating or omitting any
element. The QAM modulates the input data which is
given to spreader which spread the signal. The filter used
here will remove the unwanted signals. The channel used
here is AWGN and Rayleigh Fading channel. At the
receiver the raised cosine filter filters the input signals and
down sample it if it is selected. The integrator and dump
integrates over number of samples in integration period
and reset at the end of integration. The QAM demodulator
demodulates the signals whose output is given to D-
interleaver which reorder the element of inputs and finally
dercoder decodes the convolutionally encoded signals.
VI. SIMULATION RESULT

Fig.2. Proposed Block diagram of 16QAM for AWGN Channel

Fig.3. Transmitted Signal of 16-QAM CDMA for AWGN Channel

Fig.4. Transmitted Signal of 16-QAM CDMA for Rayleigh Fading Channel

Fig.5. Scatter plot for QAM 16 AWGN Channel

Fig.6. Scatter plot for QAM 16 Rayleigh Fading Channel

Fig.7. Received Signal of QAM16 for AWGN Channel.

Fig.8. Received Signal of QAM16 for Rayleigh Fading Channel

Fig.9. Received Scatter plot of QAM16 for AWGN channel.
VII. EXPLANATION OF SIMULATION RESULT

The Fig.3. and Fig.4. represent the input signal which is a periodogram of random number generated Bernoulli Binary generator. For AWGN channel the maximum signal transmission is at 200 to 300 MHz and minimum signal transmission is at 100 to 200 MHz. Similarly for Rayleigh Channel the maximum signal transmission is at -200 to 300 MHz and minimum signal transmission is at 100 to 200 MHz. The Fig.5 and Fig.6. represents a 16bit QAM modulated signal constellation in its signal space which is a plot of in-phase component versus Quadrature Component of AWGN and Rayleigh Channel. The Fig.7. represents a output of AWGN Channel where maximum peak represent a excellent reception of signal, medium peak represent a good reception of signal and zero peak represent a poor reception of signal. The output waveform shows an efficient performance of CDMA in AWGN channel as compare to Rayleigh channel waveform Fig.8. Where reception of signal is not so good due to multipath interference of signals. Fig.9. and Fig.10. represent 16 bit QAM demodulated signal constellation in its space which is plot of in-phase component versus Quadrature Component of AWGN and Rayleigh Channel. Here we can see that for AWGN the spacing between the signal is less due to fading effect but the signals are not overlapped with each other as compare to fig.10 where Inter symbol interference are more due to fading effect and consequently BER is more for Rayleigh channel. The Fig 11. represent an eye diagram of AWGN channel which is open (means efficient) as compared to eye diagram (Fig.12) of Rayleigh Channel which is closed that represent the interference between the signals. An eye diagram is a common indicator of quality of signals in high speed digital transmission. Fig.13 and Fig.14 represent trajectory path signal of AWGN and Rayleigh Channel.

VIII. DISCUSSION AND CONCLUSION

Although CDMA is a well known and developed technology by several active research groups all over the globe. But many real issues are not discussed by well known for strategic reasons the CDMA QAM-16 with AWGN and Rayleigh channel is designed and analyzed.
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REFERENCES


Acknowledgment

The analysis of above simulation is given in Table.1.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Parameter</th>
<th>QAM AWGN</th>
<th>QAM Rayleigh</th>
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<tr>
<td>1.</td>
<td>BER</td>
<td>0.4998</td>
<td>0.5007</td>
</tr>
<tr>
<td>2.</td>
<td>Num of Error</td>
<td>2.309e-10</td>
<td>1.313e-10</td>
</tr>
<tr>
<td>3.</td>
<td>Total bit</td>
<td>1.424e-10</td>
<td>3.669e-10</td>
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</table>

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Dr. Gupta is an Associate Professor in the Department of Physics at JECRC University. She has 14 years’ of experience in the field of Teaching and Research. She was awarded Ph.D. from University of Rajasthan, on “Computer aided designing of Microstrip patch and array antennas in different environmental conditions”. She has published papers in various national and international journals and conferences. One of her papers was awarded a certificate of merit by Institution of Engineers National conferences. She has also been awarded “Rajasthan Energy Conservation Award-2010” by Hon. Chief Minister Mr. Ashok Gehlot for outstanding contribution in the field of Energy conservation.

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