Performance Analysis of BER with FHSS System

Manish meena1
Research Scholar at
JNIT, Jaipur
manishbmit@gmail.com

Mr. Manvendra Singh Kuntal
Assistant Professor & Research member in ECED at
CIITM,Jaipur
Manvendra.kuntal@gmail.com

ABSTRACT

A brief theoretical foundation has worked and explain the expands upon QAM and FSK modulation in the application of Frequency Hopped spread spectrum systems FHSS. Here by the help of this paper, we mainly concentrate on the Bit Error Estimation in Frequency Hop Spread Spectrum System by the use of Quadrature Amplitude modulation and Frequency shift keying which are mainly used in the area of defense applications. The performance of transmission modes are evaluated by calculating the probability of Bit Error Rate (BER) versus the Signal Noise Ratio (SNR) under the frequently used three wireless channel models AWGN, Rayleigh and Rician [2]. We consider the data rate and data modulation to analyze the performance that is BER vs. SNR and we also consider multipath received signals. The transmission performance had shown by simulation results, modes under different channel models and the number of antennas. We observed that some transmission modes are not efficient in IEEE 802.11b based on simulation results,. This paper provides a systematic approach for evaluating the performance of FHSS operating with coherent M-ary FSK demodulation. The investigations into the frequency hop spread spectrum systems employing different modulation schemes to decrease the BER. There has been much more work done on computing BER of FHSS systems with error control coding by using industry standard convolution coding.

Keywords: SNR, BER, Rician, AWGN, Rayleigh, Digital Modulation.

1. INTRODUCTION

Spread spectrum techniques may be very advantageous to overcome the communication problems such as efficient usage of power and security. By using of this technique, the transmitted information signal is multiplied with PN code (This can be treated as a general case and it can be any kind of sequence.), known as spreading code signal. The resultant signal which is obtained by the multiplication of PN code is called spread signal which is transmitted. The transmitted signal is acquired by receiver side, is then multiplied by a same spreading code signal, resulting in the original signal. It is seen that the required signal is getting multiplied two times while the interference gets multiplied only once, which results in reduce of the interference and this will be a great protection against jamming. The processing gain can be used to calculate the amount of the improvement of system with the use of spread spectrum system. Processing gain can be said as the difference between the performance of the system by the use of spread spectrum techniques and the performance of the system which is not done by the use of the spread spectrum techniques .Processing gain can also be defined as the ratio of spread signal bandwidth (WSS) to the information rate. The transmitted signal bandwidth is much greater as compared with the bandwidth of the original message and the bandwidth of the transmitted signal is determined by the message which will be transmitted. Spread spectrum system has emerged up as a promising digital technology for mobile systems, with the help of VLSI technology. In this technique, Linear Feedback Shift Register (LFSR) is the basic unit or element, which generates Maximal length PN sequence or m- sequence. In Spread Spectrum system every user is given a pseudo noise sequence (PN) for the aim of spreading as well as de-spreading. Hence PN-sequence generation can be considered to be the heart of SS system.

The maximal length of PN-sequence (m-sequence) is the best-known PN-sequence and the length is equal to its period. All PN-codes can be generated using Linear Feedback Shift register. The generator polynomial provides the necessary feedback taps for the LFSR circuit. The codes which are used in spread spectrum systems are longer in comparison with the codes used in other systems, as they are given for bandwidth spreading rather than transmitting the information. In order to change the system's spreading capability this is necessary to change the coding arrangement [1-2]. All spread spectrum communication systems comprises of a pseudo-noise (PN) code sequence to spread the data modulated carrier at the transmitter end and de-spread the desired carrier at the receiver end. Autocorrelation, cross correlation, and power spectrum of PN codes can be called as main functions which are used to calculate the performance of spread spectrum communication systems [2, 3]. Spreading can be accomplished by multiplication of the information symbols by high rate pseudo-random sequence (so called pseudo-noise, PN) known to the receiver. The resultant signal is wideband and can be demodulated again by multiplying it with a synchronized replica of the PN sequence used by the transmitter. The PN sequence is unique for each user, allowing bandwidth sharing with no compromisation of the information [4].

Spread Spectrum (SS) [6-10] can be defined as a means of transmission in which the signal occupies bandwidth as compared to the minimum necessary to send the information. It is easily and perfectly demonstrable for the intended receiver and it can be seen as random like for others. This randomness by the sequence should satisfy the properties such as balance, run and autocorrelation. A distinct code has also been assigned for every transmitter. So there comes a possibility such as high interference between the users when they come very close to each other. The interference can also be intentional, as we can see in military communications, or it can also be non-intentional as in a spectral overlay system [11]. In any case, the receiver achieves higher signal to noise ratios (SNR's) at the decision device input if an interference rejection filter is used before dispreading [12].

The rejection filter is usually adaptive and relies on the pseudo-white properties of the spread spectrum signal [13]. Spread spectrum communication with the advantages such as strong anti-interference ability, high security, much-speed rate, being not so hard to realize CDMA and less interference with other narrowband systems provided in the same band [14]. The performance of wireless communication system is limited by fading and jamming, the former comes from signals multipath propagation, while the latter results from the reuse of frequencies[15].This is widely used in many areas like military and civilian applications for its excellent performances and the spreading codes has low cross correlation properties and high autocorrelation[16, 17, 18].

II.FREQUENCY HOPPED SPREAD SPECTRUM

A mathematical framework for FHSS techniques and the main benefits of these techniques:

a. Immunity from jamming, noise and multipath distortion

b. For hiding and encrypting signals

c. Several users can independently use the same bandwidth with very little interference

Introducing the theoretical principles of FHSS & starting with the concept of spread spectrum and types of spread spectrum. It includes the comparison of FHSS with other spread spectrum technique. It includes the digital modulation techniques and types of digital modulation techniques. The concept of FSK is followed by an explanation of the interleaving mechanism, and a discussion on the puncturing mechanism strategy. Following the analysis of the design of the encoder, an overview of the turbo decoder system is given, highlighting the manipulation of the received data that is necessary prior to decoding. Finally, mathematical analysis of the two common soft-input soft-output decoding algorithms, SOVA and MAP, and their function in the turbo decoder system is presented. Further to this, variations on the MAP algorithm, namely the Log-MAP algorithms and Max-Log-MAP, are developed.

A. Representation of Digital Communication system

Any Communication system consists of three main components: the transmitter, the channel and the receiver. This generalized model can be applied to both analog and digital systems. This system can be represented by the following block diagram shown in Figure 1. The block diagram has the message S (t) passing through a block labeled transmitter that produces the signal X (t). Transmitted signals pass through the next stage, the channel. The signal can become corrupted by noise, distorted and attenuated. Transmitter and receiver design jointly focus on how to reduce the channel effects on the signal. The channel produces R (t), the signal received by the receiver.

Figure.1: General Model of a Basic Communication System

Fig.2: Transmitter Block diagram for a Digital Communication System

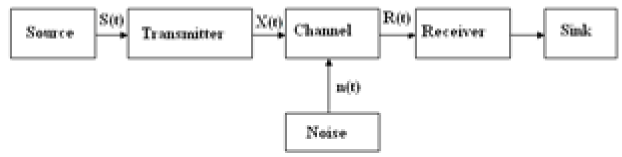
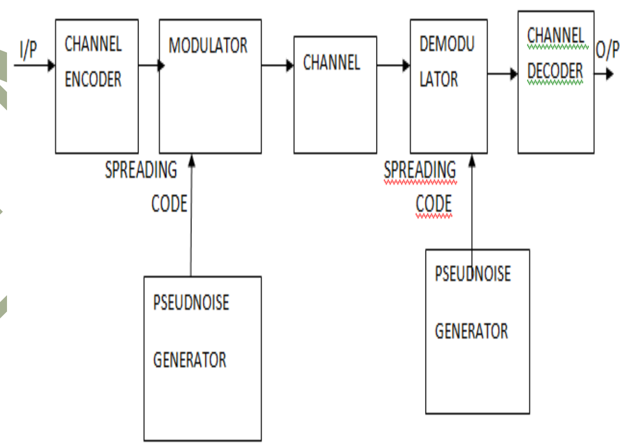


Figure.3: Receiver Block diagram for a Digital Communication System

B. SPREAD SPECTRUM TECHNIQUE & TYPES:

The main design aim of all the modulation technique is to minimize the transmission bandwidth. Spread spectrum employ

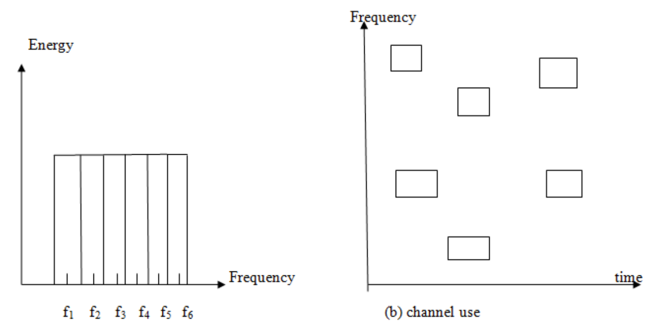
fig.4: general model of spread spectrum digital communication system



a transmission bandwidth that is several orders of magnitude greater than the minimum required signal bandwidth. According to this system, the bandwidth is varying inefficient for a single user; the spread spectrum has advantage that is many users can simultaneously use without significantly interfering with the same bandwidth one another. Spread spectrum systems become very bandwidth efficient in a multiple user, multiple access interference (MAI) environment. First input is given into a channel encoder that produces an analog signal with a narrow bandwidth then this signal is further modulated by using a sequence of digits = spreading code. The spreading code is generated by a pseudorandom number generator. The effect of the modulation is to increase the bandwidth the signal is fed into channel on the receiving end. Out of these DSSS and FHSS are the most common techniques and our basic emphasis will be on these two with an overview of THSS and hybrid techniques.

B.1 Direct Sequence Systems (DSSS)

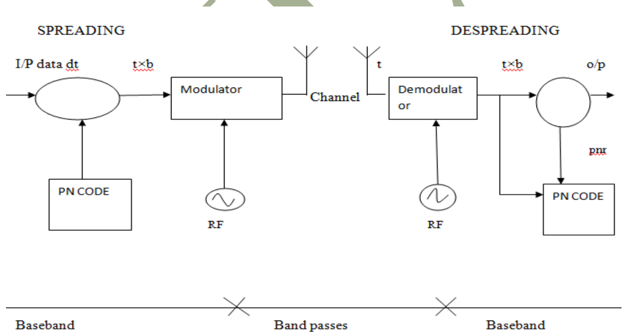
The most commonly used, digital version of spread spectrum is direct sequence. In this system locally generated pseudo noise



(a) Channel assignment (b) channel use

code is used to encode digital data to be transmitted and the code runs at a significantly higher rate than the data rate. This code repeats itself exactly after a given number of bits. The spreading amount is dependent upon the ratio of chips per bit of information (Gp is the processing gain for DSSS). The composite pseudo noise and data can be passed through a data scrambler to randomize the output spectrum (and thereby remove discrete spectral lines). The DSB suppressed carrier modulates the carrier frequency to be transmitted by using direct sequence modulator. DSB suppressed carrier AM modulation can also be thought of as binary phase shift keying (BPSK). A short-code system uses a PN code length equal to a data symbol. The direct sequence is possible with Carrier modulation other than BPSK. So we can say that binary phase shift keying is the most often used SS modulation technique.

At the receiver, we can recover the information by multiplying



the signal with a locally generated replica of the code sequence. Coherent demodulation requires a PSK modulation scheme. The

Fig.4. block diagram of typical dsss system

Basic principle of Direct Sequence Spread Spectrum (DSSS) is used Subscripts: t stands for transmitted, r - received, s - symbol, c - chip.

B.2 Frequency Hopping Systems (FHSS): In FHSS the signal is broadcast over a seemingly random series of radio frequencies. In this hopping from frequency to frequency at fixed intervals and the receiver is synchronized with the transmitter. The ieee 802.11 wireless lan standard uses a 300-ms interval; here the transmitter operates in one channel for a fixed interval. In this the sequence of channels used is dictated by a spreading code and both transmitter and receiver use the same code. Binary data are fed into a modulator using some digital-analog encoding scheme such as fsk or bpsk and the resulting signal is centered around some carrier frequency [11].a pseudorandom number source serves as an index into a table of frequencies in this each k bits of the pn source specifies 2k carrier frequencies and on reception; the same sequence is used. Both transmitter and receiver use the same code.

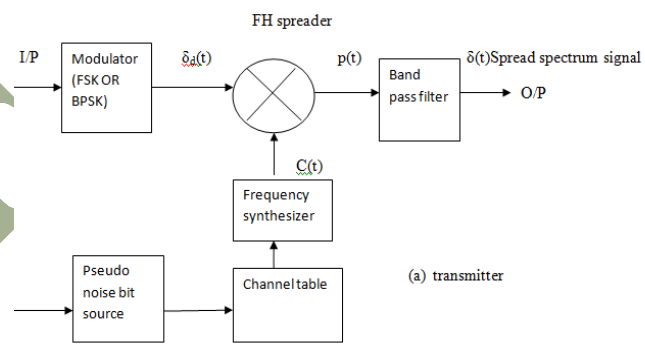


Fig.5. frequency hopping example

A frequency hopped system, unlike direct sequence one, can use both digital and analog carrier modulation and can be designed using conventional narrow band radio techniques. The receiver De-hopping is done by a synchronized pseudo noise code generator that drives the receiver's local oscillator frequency synthesizer.

C. Digital Modulation Techniques:

Digital modulation technique may be classified into non coherent or coherent techniques, depending on whether the receiver is equipped with a phase recovery circuit or not. The phase recovery circuit ensures that the oscillator supplying the locally generated carrier wave receiver is synchronized to the oscillator supplying the carrier wave is used to originally modulate the incoming data stream in the transmitter.

Coherent digital modulation technique:

In this detection method at the receiver the local carrier generated is phase locked with the carrier at the transmitter .thus, by correlating received noisy signal and locally generated carrier detection process is done. This detection is synchronous detection. In this section have three basic forms:

1. Amplitude shift keying
2. Phase shift keying
3. Frequency shift keying

Noncoherent digital modulation technique:

In this detection method no need of receiver carrier to be phase locked to the transmitter carrier. Using this method system become simple but the disadvantage of this system is that increases error probability.

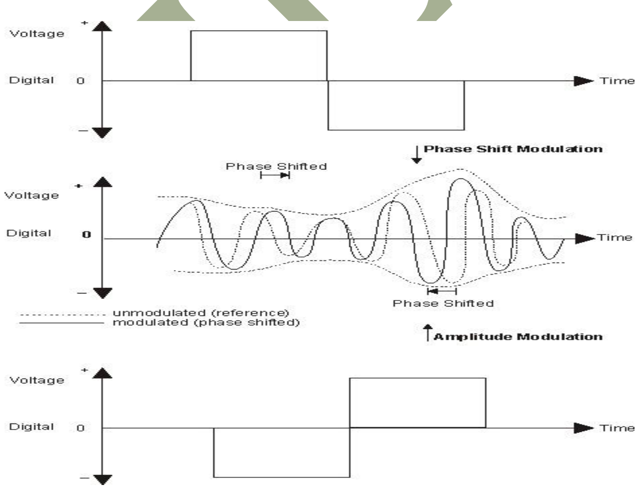
Coherent Binary Amplitude shift keying:

In this method there is only one unit energy carrier and it is switched on or off depending upon the input binary sequence and in this method there is only one unit energy carrier. The waveform of ASK may be represented as:

D. Quadrature Amplitude Modulation or QAM

Quadrature Amplitude Modulation1 or QAM is a form of modulation which is widely used for modulating data signals onto a carrier used for radio communications. QAM offers advantages over other forms of data modulation such as Phase Shift Keying, although many forms of data modulation operate alongside each other so QAM is widely used [12-13].

Quadrature Amplitude Modulation is a signal in which two



carriers shifted in phase by 90 degrees are modulated and the resultant output consists of both phase and amplitude variations. In view of the fact that both amplitude and phase variations are present it may also be considered as a mixture of phase and amplitude modulation.

QAM comparison with other modes

It is necessary to compare QAM with other modes before making a decision about the optimum mode as there are advantages and disadvantages of using the QAM. Some radio communications systems dynamically change the modulation scheme dependent upon the link requirements and conditions – noise, data rate required, signal level, etc.

QAM is widely used in many digital data radio communications and data communications applications. Some of the more common forms include 16 QAM, 32 QAM, 64 QAM, 128 QAM, and 256 QAM Variety of forms of QAM which is available. Here the number of points on the constellation that is the number of distinct states that can exist [15]. In this way there is a balance between obtaining the higher data rates and maintaining an acceptable bit error rate for any radio communications system. The advantage of using QAM is that it is a higher order form of modulation and as a result it is able to carry more bits of information per symbol. By the selection of a higher order format of QAM, the data rate of the link can be increased.

III**. FREQUENCY HOPPED TRANSRECIVER**

In the Frequency- hopped (FH) spread spectrum communication system the available channel bandwidth are subdivided into a higher numbers of contiguous frequency slots. While working with any signaling interval, the transmitted signal can occupy one or more available frequency slots which are available [14-15]. The choosing criteria of frequency slot(s) for each signaling interval is made according to the output derived from PN generator. The modulation technique which is mostly used in FHSS is M-ary FSK and QAM along with convolution coder. The resultant FSK signal is translated in frequency with is calculated with the output sequence from the PN generator, which, in on other hand is used to select a frequency which is synthesized from the frequency synthesizer. This synthesized frequency is mixed with the output of the modulator and the resultant frequency-translated signal is transmitted over the channel. The PN generator generates m-bits which can be used to conclude (2m-1) possible frequency translations. The modulated signal is then transmitted over the AWGN channel [14-16].

At the receiver side, synchronized an identical PN generator with the receiver signal which can be used to control the output of the frequency synthesizer, By transmission of two signals by modulating them by the method of modulation QAM, the resultant transmitted signal will be like.

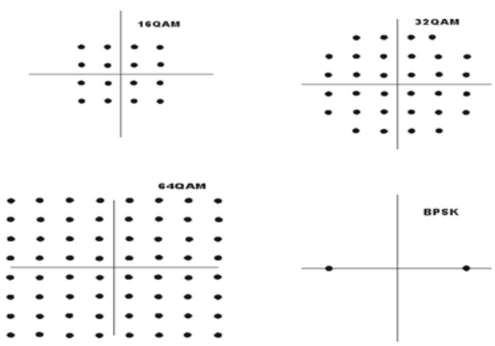


Fig.6. Constellation diagrams for QAM

$$s(t) = I(t)\,cos(2\pi f_0 t) + Q(t) sin\,(2\pi f_0 t)$$

Where I (t) and Q (t) are the modulating signals and f0 is the carrier frequency. At the receiver side, these 2 modulating signals will be demodulated by the use of a coherent demodulator. Receiver like this will multiplies the received signal independently with both cosine and sine signal to give the received estimates of Q (t) and I (t) respectively. Now due to the orthogonality property of the carrier signals, it will be possible to find the modulating signals separately. In the ideal case I (t) is demodulated by multiplying the transmitted signal with a cosine signal: $r_i(t) = s(t)\,cos(2\pi f_0 t)$

Using standard trigonometric identities, we may write it as:

$$ri(t) = \frac{1}{2} I(t) + \frac{1}{2}[I(t)\cos(4\pi f_0 t) + Q(t)\sin(4\pi f_0 t)]$$

Low-pass filtering Ri (t) filters the high frequency terms (containing 4πf0t), giving only the I (t) term. This filtered signal will remain unaffected due to Q (t), showing that the in-phase component may be received independently of the quadrature component. In the same way, we may multiply s (t) by a sine wave and then low-pass filter to extract Q (t) [12-16].

Frequency hopping systems will change the carrier frequency with a rate comparable with (or slower than) the information rate which used to transmit. Frequency hopping can be done coherently or non -coherently. For a coherent FH system the output of the frequency's written as [5]

$$h_T(t) = \sum_{n=-\infty}^{\infty} 2p(t - nT_c)\cos\,(w_n t + \varphi_n)$$

Here p (t) represents pulse of duration TC, along with unit amplitude starting at time 0, ωn and Φn are the radian frequency and phase during the nth frequency hop interval .The frequency wn is taken from a set of 2k frequencies. In FH system k-bits of the spreading code is used. Transmitted signal is the data modulated carrier whose frequency changes to a new carrier Frequency i.e. (wn+ wo) for each FH chip [5]) –

$$s_t(t) = s_d(t) \sum_{n=-\infty}^{\infty} 2p(t - nT_c)\cos\,(w_n t + \varphi_n)] \; sum\ frequency\ componenys$$

Power spectrum of the transmitted signal will be sum frequency term of the convolution of Sd(f) and Sh(f), where Sd(f) will be power spectral density for the data modulated carrier Sh(f) be the power spectral density of the carrier hop hT(t), here these two are independent . The signal hT (t) can or cannot be periodic. If this is periodic, period would be sufficiently long that little error would be made in considering the period infinite. .Fig shows the improvement of FHSS/QAM along with viterbi decoder which reduces the Bit error rate.

IV.SIMULATION and RESULTS

The simulated results for QAM with Rayleigh & AWGN channel. The 16 QAM with AWGN & Rayleigh channel are considered with an analysis of how Eb/N0 vs BER changes for 16-QAM modulation in Rayleigh channel.

A. Analysis of QAM with AWGN & Rayleigh Channel

A model of gray coded 16-QAM with AWGN Channel & Rayleigh Channel has been designed and the BER curve for this has been simulated. Here we try to reduce the bit error ratio Fig.1 comparison of 16 qam with rayleigh & awgn channel to increase the value of Eb/N0. For this the rejection filter is taken adaptive because having the property of high autocorrelation and low cross correlation properties [16-18]. The constellation of transmitted symbols for different SNR IS shown in figure under the Rayleigh channel & AWGN channel.

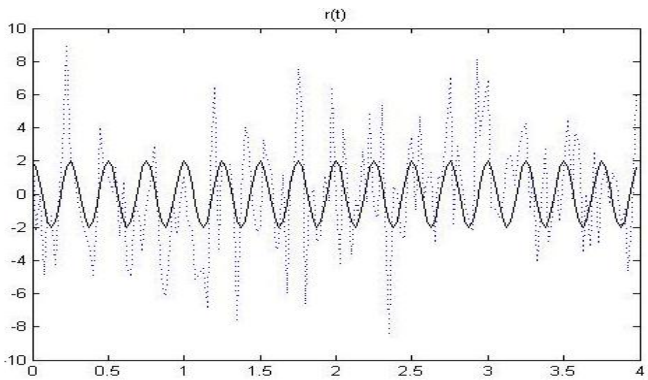


Fig.1. Correlate output

Performance Analysis of BER as

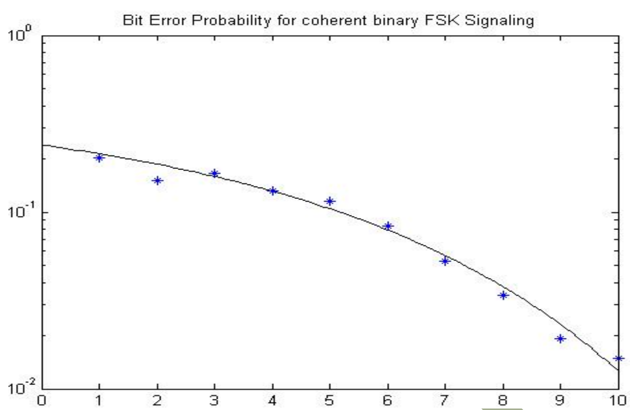


Fig.2. Bit error rate

VI. Conclusion

The spread spectrum process is effective way of transmission with lesser bit error ratio and the FEC employed as a Convolution coding is also productive in obtaining a lowered BER of the FHSS/QAM system. Forward Error correction in reducing the inherent disadvantage of a QAM system that is high signal to noise ratio requirement for a small change in BER. We also demonstrate the development and analysis of Frequency-Hopped Spread Spectrum (FH/SS) transceiver using M-FSK works under the influence of an Additive White Gaussian Noise (AWGN) channel were simulated.

Future Scope

The aim of the dissertation work is to improve the FHSS using QAM/FSK modulation techniques. In this regard, we would like to design the third generation turbo codes.

Channel categorization: In general, performance over various channels can be analyzed by using signal estimation and further can be divided into categories which will be defining performance of each group of channel or individual channel. We can make it happen to utilize multiple accesses in FHSS.

Use of decoders: We would try to improve the BER use of decoders with various process chains (markav/passion).

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VIII. Authors Profile

Manish meena[1] born was 1986 In jaipur rajasthan doing M.Tech from Jagannath univarsity (JNIT) 2011 to 2013 Done B.Tech from BMIT jaipur In 2008.works project on FHSS.

AUTHOR[2]

Manvendra Singh was born in Mathura, Uttar Pradesh, India in 1986. He received the Bachelor degrees in Electronics & Communication Engineering. He has done his Master's Degree in Digital Communication Systems. He is currently associated with CIITM, Jaipur as Assistant Professor and research member in Electronics & Communication Engineering department. His research interest includes Digital Signal Processing, Wireless Communication & Coding Techniques.