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Improved FHSS using QAM/FSK modulation techniques

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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. 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 defence applications. Our main aim is to find the bit error performance of a frequency hopping spread spectrum model, where the presence of AWGN channel is available. This paper give us a systematic approach for evaluating the performance of FHSS working with coherent M-ary FSK demodulation. There are many investigations for the frequency hop spread spectrum systems using different modulation schemes to reduce the bit error ratios. So much work has been done on computing BER of FHSS systems with error control coding by the use of industry standard convolution coding.

Keywords: FSK, QAM, BER, AWGN

I. INTRODUCTION

Spread spectrum techniques may be very advantageous to overcome the communication problems such as security and efficient usage of power. By the use of this technique, the information signal which is to be transmitted 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. Spread Spectrum modulation techniques can be explained as the technique in which the bandwidth of the transmitted signal is much greater as compared with the bandwidth of the original message, and the bandwidth of the transmitted signal is determined by the message to 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 PN-sequence (m-sequence) is the best-known PN-sequence whose length is equal to its period. Various PN-codes can be generated using Linear Feedback Shift register (LFSR).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. Spreading codes have good correlation properties so that each spread spectrum signal is uncorrelated with every other signal sharing the same bandwidth. 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 high autocorrelation and low cross correlation properties.[16-18].

II. FREQUENCY HOPPED TRANSRECEIVER

In a 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. 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 an 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 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 may be used to conclude 2m-1 possible frequency translations. The modulated signal is then transmitted over the AWGN channel. At the receiver side, an identical PN generator, synchronized, with the receiver signal, which can be used to control the output of the frequency synthesizer. Thus, the pseudorandom frequency translation introduced at the transmitter is removed at the receiver by mixing the synthesizer output with the received signal. The resultant signal is then demodulated by the use of an M- FSK demodulator. Signal used for maintaining synchronism of the PN generator with the frequency – translated received signal is usually from the received signal. The improvement of FHSS/QAM along with viterbi decoder decreases the Bit error rate.

By transmission of two signals by modulating them by the method of modulation QAM, the resultant transmitted signal will be like

$$\boldsymbol{s(t) = I(t)\cos(2\pi f_0 t) + Q(t)\sin(2\pi f_0 t)}$$

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

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estimates of I (t) and Q (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:

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

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).

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]) –

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

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 1 shows the improvement of FHSS/QAM along with viterbi decoder which reduces the Bit error rate

III. RESULTS

16 QAM with AWGN & Rayleigh Channel

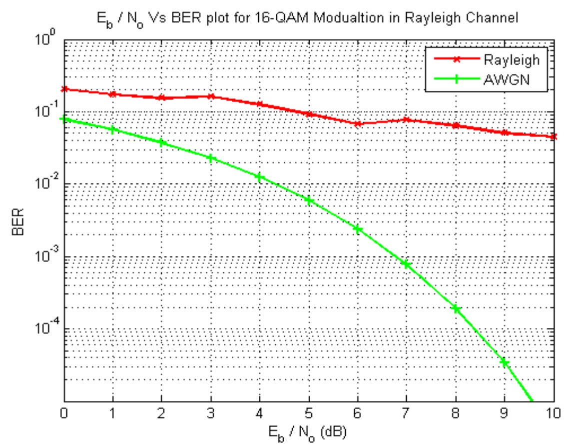


Fig1. Comparison of 16 QAM with AWGN & Rayleigh Channel

Result for Constellation of Transmitted Symbols

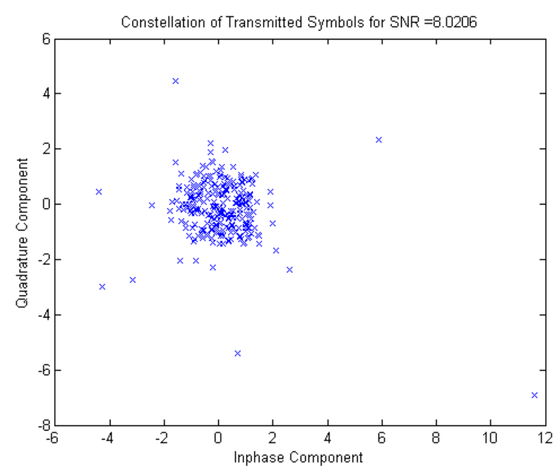
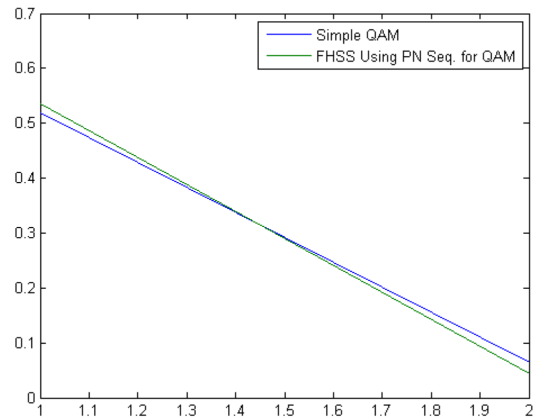


Fig2. Comparison of 16 QAM with AWGN & Rayleigh Channel

Simple M-QAM & FHSS QAM Modulated



Characteristics

Fig3. Comparison of M-QAM & FHSS QAM Characteristics

FHSS FSK Modulated Characteristics

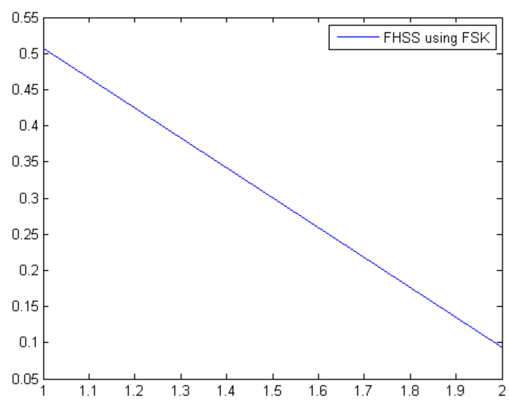


Fig4. Comparison of M-QAM & FHSS QAM Characteristics

A model of gray coded 16-QAM with AWGN Channel & Rayleigh Channel has been designed and the BER curve for this has been simulated as shown in Fig1. Constellation of the Symbols transmitted is shown inFig2.

The result is close to the theoretically expected plot of BER vs. Eb/No of an ideal 16-QAM system without error coding. Fig 3. shows the BER performance using frequency hopping modulation without Forward error correction using QAM respectively. Using FHSS systems with FEC as shown in Fig 4. decreases the BER per Eb/No and hence improves the BER performance. The bit error rate calculation for FHSS using FSK modulation is achieved with Good synchronization.

IV. 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.

V. ACKNOWLEDGEMENT

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