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PERFORMANCE EVALUATION OF MAXIMAL SEQUENCES IN PRESENCE OF BROADBAND JAMMER FOR BAND PASS BFSK SYSTEM OVER AWGN CHANNEL

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Abstract: Spread spectrum modulation techniques ensure protection against externally generated interfering signals i.e. signals generated from jammers, developed initially for military applications. This protection against jamming waveforms is achieved by forcing the information signal to occupy bandwidth many times greater than the signal bandwidth, this makes the transmitted signal to appear as noise, making impossible to detect for unintended user, listening to the channel [1].The objective of this paper is to evaluate the Bit Error Rate performance of maximal sequences as spreading codes in presence of broadband jammer for binary phase shift keying modulation under additive white Gaussian channel conditions. The effect of the broadband jammer i.e. BER versus SNR is shown using graphical approach using MATLAB®.

Keywords: AWGN (Additive White Gaussian Noise), BER, BFSK, Processing Gain, SNR.

1. INTRODUCTION

Binary frequency shift keying (BFSK) is one of the nonlinear modulation techniques which is a power efficient scheme occupies large bandwidth than linear modulation techniques [2]. Jammers are used to degrade the communication link performance. In broad band jammer technique, the jamming waveforms disturb entire spread spectrum signal bandwidth. Broad band jammer waveform is wideband noise that jams entire bandwidth. In binary frequency shift keying, the frequency of the carrier signal is switched between two values according to the two possible message states. Hence the bit, ones and zeros are distinguished from each other by transmitting one of the two sinusoidal waves that differ in frequency by a fixed amount [3]. The two pair of sinusoidal waves is described by

$$S_i = \cos(2*pi*f_i*t) \qquad 0 \le t \le T_b$$

$$= 0 \qquad t < 0 \text{ and } t > T_b$$

Where i=1,2 and carrier frequency $f_i=(n_c+i)/T_b$, for some fixed integer n_c and i=1,2. The following plot shows the binary frequency shift keying transmitted waveform for binary data without spreading. with one cycle per bit having bit duration of one second.

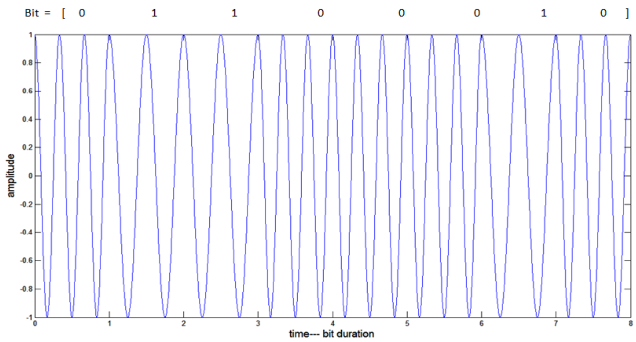
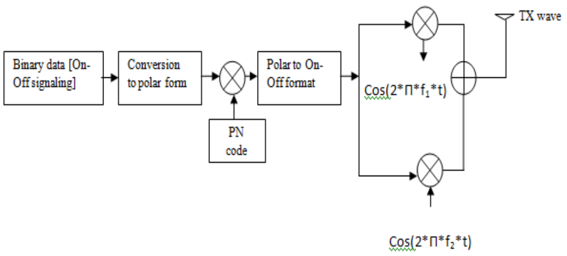


Fig.1 BFSK modulated wave

One obvious way to generate an FSK signal is to switch between two independent oscillators according to whether the data bit is a 0 or a 1. This method of FSK wave generated results in a waveform that is discontinuous at switching times and for this reason this form of FSK is called Discontinuous FSK. Since phase discontinuities pose a several problems such as spectral spreading and spurious transmissions. This type of FSK is not used in highly regulated wireless systems. Hence continuous phase FSK has been always preferable. The fig.2 depicts the block diagram of band pass binary frequency shift keying transmitter and coherent binary FSK receiver with spread spectrum modulation. Fig.2 FSK Transmitter with Direct Sequence Spread spectrum.



The Fig.3 shows the coherent BFSK transmitted waveform spreading with PN sequence {1 1 1 0 1 0 0} for bit stream {1,0} respectively incorporating one cycle in chip.

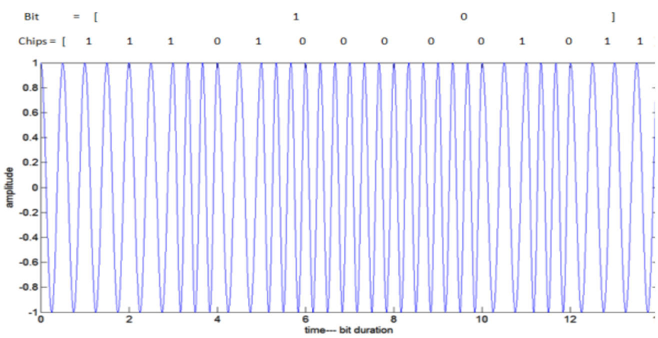


Fig.3 BFSK modulated wave with spreading

The input binary data is on-off signaling format, converted to a polar form before spreading. The pseudo noise sequences are used to spread the binary data resulting in the formation of chips. The chips are again converted to on off signaling format. Such that chip one is represented with some constant voltage and chip 0 is represented with zero volts. By using the inverter in the lower channel we make sure that chip one at the input, the oscillator with frequency f_1 in the upper channel is switched on while the other oscillator with frequency f_2 in lower channel is switched off as a result frequency f_1 is transmitted. Similarly, if chip value is zero at the input, the oscillator in the upper channel is switched off and the oscillator in lower channel is switched on, thereby transmitting the frequency f_2. If the two oscillators used in the transmitter are synchronized, or by using a single keyed voltage controller oscillator frequency of modulated wave is shifted with a continuous phase in accordance with the input binary wave i.e. the phase continuity is maintained including the inter-bit switching times. This form of digital modulation is called as continuous phase frequency shift keying.

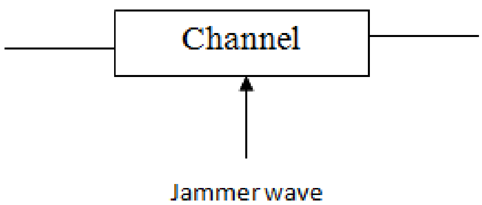


Fig.4 Corrupted FSK signal by jammer wave

The transmitted BFSK wave is corrupted with noise and interference from jammer is then received at receiver input.

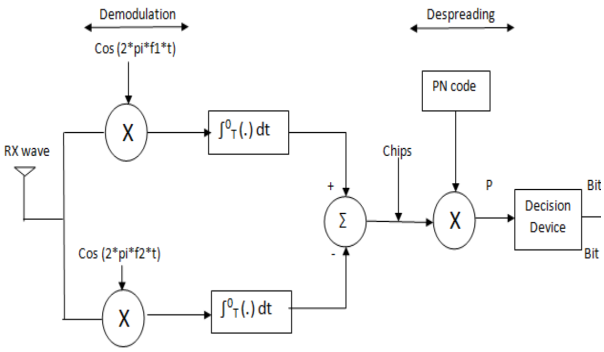


Fig.5 Coherent binary FSK receiver structure

The coherent binary FSK receiver consists of two correlators with common input, which are supplied with locally generated coherent reference signals. The correlators outputs are then subtracted one from another to produce chips. Despreading at the receiver is performed by using a synchronized replica of PN code that used at the transmitter and the resulting values are applied to decision device with the thrash hold of zero volts. If p>0 the receiver decides in favor of ‘bit 1’. On the other hand, if p<0, it decides in favor of ‘bit 0’. The decision boundary is specified by Signal space diagram.

If the jamming signal is modeled as a zero-mean wide sense stationary Gaussian noise process with a flat power spectral density over the frequency range of interest, then for a fixed jammer received power, J, the jammer power spectral density before despreading the signal at receiver is J_o=J/W [5], where W is the bandwidth that the jammer chooses to occupy. If the jammer is designed to jam the entire spread spectrum bandwidth, with its fixed power, the jammer is referred as wideband jammer and jammer power spectral density after despreading the received signal is $J_o'=J/W_{SS}$.The bit error probability P_B for a coherently demodulated BFSK system (without channel coding) is P_B=Q (sqrt (E_b / N_o)) [5]. The single sided noise power spectral density N_o represents thermal noise at the front end of the receiver. The presence of jammer increases this noise power spectral density from N_o to N_o+J_o. [4]. Thus the average BER for a coherent BFSK system in the presence of broadband jamming is P_B=Q (sqrt (E_b / (N_o+J_o))).

2. NUMERICAL SIMULATION

A computer program in Matlab software is used to simulate the bit error rate performance of Binary phase shift keying system in AWGN channel in the presence of broadband jammer signal. Results are obtained by assuming that the jammer wave form corrupt the signal in additive fashion considering the double sided power spectral density and jammer is laying at very close to the receiver, ideally the jammer and receiver is at zero distance. If jammer is transmitting the signals with power P_t, then only part of transmitting power is received, since the receiver is a finite distance from jammer i.e. path loss is included given as Jr=P_t/ $(4*pi*R/\lambda)^2$, the gains of transmitting and receiving antenna are considered as unity [4], R is the distance from transmitter to receiver and λ is propagating signal wavelength and Jr is jammer power at receiver and Jr=J_o, if path loss is neglected. Different Simulation parameters used in Matlab code for band pass BFSK are shown in table 1. The value of bit energy obtained from above values used in Matlab code is 42, 90,186,378,762, 1530 for spreading length 7,15,31,63,127,255 respectively. The signal power (S) is given by the product of Bit Energy (E_b) and Bit Rate (R_b) i.e. S=E_b*R_b, Transmitting power S=E_b, for R_b=1;

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Parameter	Value
Spreading code	PN (Maximal) sequences
Code length (N)	7,15,31,63,127,255
SNR (dB)	0 to 17
Jammer type	Broadband gamer
Channel	AWGN
Modulation	BFSK (Band pass)
Bit rate (R_b)	1 (Bits/Sec)
Chip rate (RC)	$N*R_b$ (Chips/Sec)
No. of cycles/chip (C)	1
Carrier frequency (f_c)	$C*R_c$ (Cycles/Sec)
No. of Samples per Cycle (d)	4
Sampling frequency (f_s)	$d*f_c$ (Samples/Sec)
Power (Jo)	10^-3,…., 10, 110, 200,….. etc..
Bit energy (E_b)	Varies {∑ [(Samples in a bit) ^2]}
Total bits Considered	5000.

Table1 Band pass BFSK Simulation data

J_o= J/W is defined as spreaded jammer power in entire radio frequency bandwidth i.e. broadband jammer power spectral density [5].

$(J/S)_{reqd}$ is defined as ratio of jammer power to signal power. The ratio $(J/S)_{reqd}$ is a figure of merit that provides a measure of how invulnerable a system for interference [5]. In another way, it is specified as how much noise power relative signal power is required in order to degrade the system specified error performance.

3. RESULTS AND DISCUSSION FOR BAND PASS BFSK

Generation of PN sequences with 'm' stage feedback shift register produces maximal sequences of length $N=2^m-1$. Different maximal sequences of the same length (N) are generated by various valid tap combinations. Fig.1a shows the Performance of BFSK system in presence of broadband jammer for fixed twenty three watts of power received in the message (J=23) bandwidth with spreading sequences of same length say N=7, generated from (1,3) and (2,3) valid taps for three stage linear feedback shift register. Similarly from Fig.4.16 three different transmitting powers are used for N=7 spreading code.

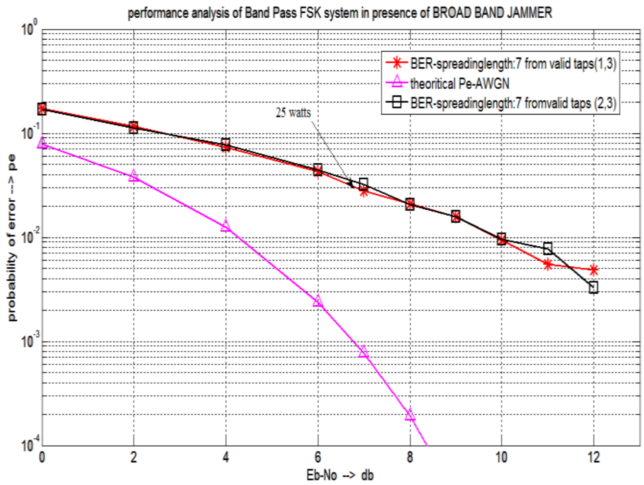

Fig.6 Performance of BFSK for 7-length M-sequences with fixed J_o

From above Fig.6 we conclude that BER curves for band pass binary phase shift keying modulation scheme are similar for fixed length, spreading codes, i.e. Performance is same for a particular

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length, spreading codes generated from various tap combinations by a fixed length linear feedback shift register.

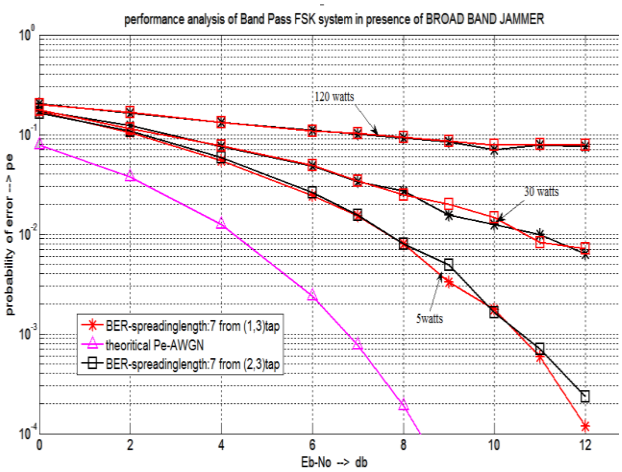

Fig.7 Performance of BFSK for 7-length M-sequences with varying J_o

For any received jammer power the BER curves are similar for fixed length, spreading codes and with increase in jammer power degrade the performance, i.e. BER curves shift upwards for increase in jammer power. The above mentioned conclusions are verified for N=31 length sequences generated from five stage linear feedback shift register with (5,2) (5,4,3,2) and (5,4,2,1) valid taps and the results are proved to be same from below the plot.

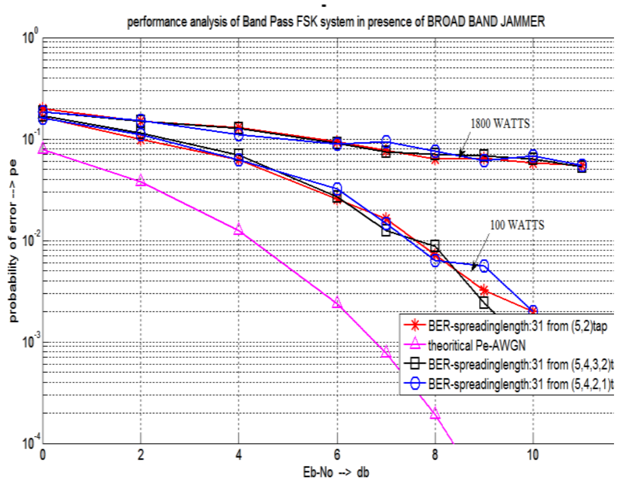

Fig.8 Performance of BFSK for 31-length M-sequences with J_o

The following results are obtained for BFSK modulation scheme in presence of broadband jammer presented in tabular form and values is noted at $E_b\_N_o$=10 dB with transmission and reception of five thousand bits using m-sequences as spreading codes having one cycle per chip and four samples per cycles.

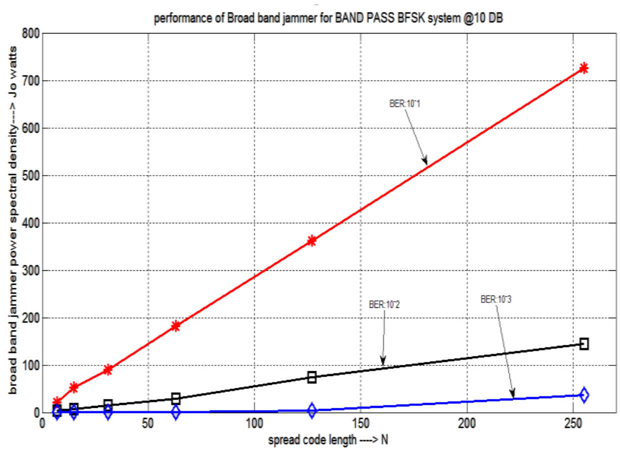

Fig.9 Jammer PSD (J_o) Vs Code length (N)

The above figure depicts the amount of peak power spectral density of jammer required in radio frequency transmission bandwidth for different length maximal sequences as spreading codes at a particular BER, for E_b-N_o of 10 dB.

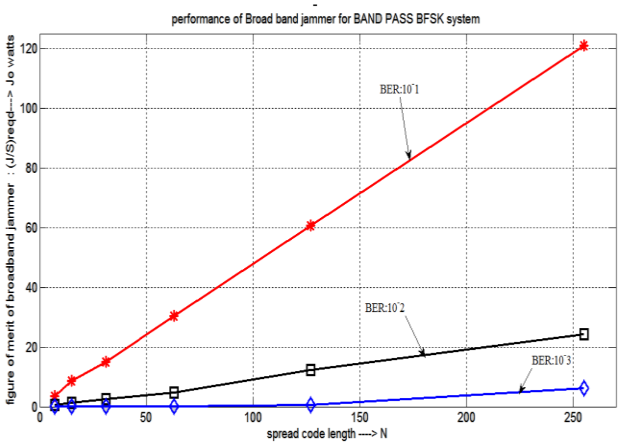

Fig.10 Jammer power to signal power $(J/S)_{reqd}$ Vs Code length(N)

The fig.10 depicts the amount of noise power relative signal power required, in order to degrade the system specified error performance with respect to various lengths spreading codes (maximal sequences) for a particular Bit Error Rate, at E_b-N_o of 10 dB. The above tabulated values are different if they are taken at E_b-N_o other than 10dB.

From above Fig.9 and Fig.10 for band pass binary phase shift keying system with R_b=1, C=1, d=4 and a carrier frequency of f_c =N*R_c, jammer power spectral density is exactly six times of ratio of jammer power to signal power i.e. J_o= 6*$(J/S)_{reqd.}$

4. CONCLUSION

This work presents that for a broadband jammer Bit error rate (BER) increases with the increase in jammer transmitting power, i.e. The Performance curves plot between the signals to noise ratio Vs probability of error shifts upwards with the increase in jammer power spectral density.

Pseudo noise sequences that are generated from the various valid taps combinations using fixed length linear feedback shift register, posse's similar BER curves for a finite broadband jammer transmitted power, i.e. performance is independent of bit order for the fixed length m-sequence used.

For a fixed jammer power, the probability of error decreases in the increase in the length of pseudo noise sequences.

For the band pass systems the jammer power spectral density is integral times of the ratio of jammer power to signal power, i.e J_o= n*$(J/S)_{reqd.}$ Where n is a rational number.

5. REFRENCES

[1] Simon Haykin, ''*communication systems*", Wiley student, 4th edition, 2001

[2] Rappaport, "*Wireless Communications Principles and Practice*", Prentice, 2nd edition, hall.

[3] Michel Moher, Simon Haykin , "Modern wireless communication", Pearson publications, 1st edition.

[4] K.D.Prasad, "*Antenna and wave propagation*", 3rd edition, tech India publications.

[5] Bernard Sklar, "*Digital Communications*". Prentice-Hall, 1988.