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# Performance Analysis of Broadband Jammer for BPSK System Using Maximal Sequences

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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]. Broadband-jammer is relatively low-level noise jammer since its power is spreaded in entire signal bandwidth. 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, BPSK, Processing Gain, SNR.

## I. INTRODUCTION

Jammers can degrade the communication link performance by two methods. a) Jam the entire spreaded signal with equal amount of power so that a little power is available to degrade entire signal. b) Jam the portion of transmitted signal with high power concentrated in small bandwidth ignoring the remaining bandwidth portion [2]. Jammers waveform includes in practice are broad band, partial band, pulsed tone, single tone, multi tone jammer [1]. In this paper we restrict our discussion to broadband jammer signals.

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. If jammer is transmitting the signals with power Pt, then only part of transmitted power is received, since receiver is at finite distance from jammer i.e. path loss is included. J=Pt/ (4*pi*R/ƛ) ^2. Here gains of transmitting and receiving antenna are considered as unity [3]. R is distance from transmitter to receiver and ƛ is propagating signal wavelength and J is jammer power at receiver.

The power spectral density of jammer before spreading is J/W. where W is message bandwidth, J is jammer transmitted power. If the received signal is despreaded at receiver, implies spreading the jammer wave form, the power spectral density of spreaded jammer signal is Jo=J/Wss [4] where Wss is spreading bandwidth and it is equivalent to processing gain (PG) times of message bandwidth (W). Mathematically Wss represent as Wss=PG*W. The value of processing gain is equal to length of Pseudo Noise sequence used in spreading. If Jammer wave is despreaded then the reduction in jammer signal noise spectral density is 1/PG. where (PG=N, length of Pseudo Noise sequence). Note that jammer waveform is spreaded once at receiver where as message signal is spreaded at transmitter and despreaded at receiver. When the signal is despreaded at receiver jammer power is reduced by the factor of processing gain [5].

## II. NUMERICAL SIMULATION

A computer program in matlab software is used to simulate the Bit Error Rate performance in AWGN channel with noise power spectral density $N_o$, in the presence of broad band jammer signal. In this paper results are obtained by assuming that the jammer wave form corrupts the signal in additive fashion considering double sided power spectral density and jammer is laying at very close to receiver, ideally the jammer and receiver is at zero distance. Hence the values obtained from following calculations are peak values. Results are obtained for Line Of Sight signal only neglecting multipath case are shown in Table2. The presence of jammer increases this noise power spectral density from $N_o$ to ($N_o$+$J_o$). Thus average Bit Error Probability for a coherent BPSK system in the presence of broad band jamming is

$$P_{BER}=Q\left(\text{sqrt}\left(E_b/\left(N_o+J_o\right)\right)\right),$$

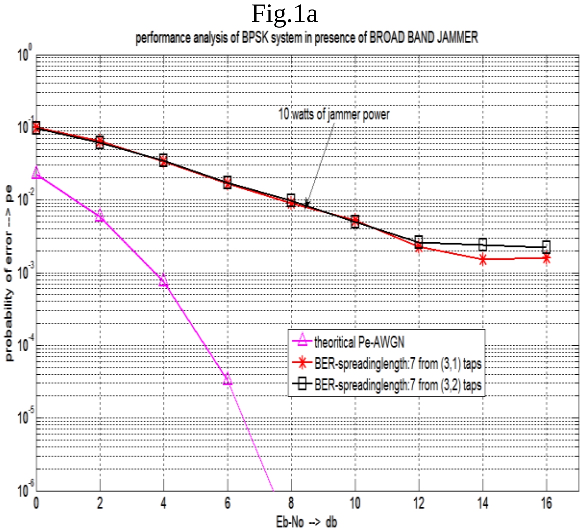
The following table1 shows the values of different parameters used in matlab code.

Table 1

| Parameter | Value |
|---|---|
| Spreading code | PN (Maximal)sequences |
| Code length | 7,15,31,63,127,255 |
| SNR(db) | 0 to 17 |
| Jammer type | Broad band jammer |
| Channel | AWGN |
| Modulation | BPSK(Base Band) |
| Power(Jo) | 10^-7, ..,10, 100, 200,..etc. |
| Total bits | 1,00,000 (one lakh) |

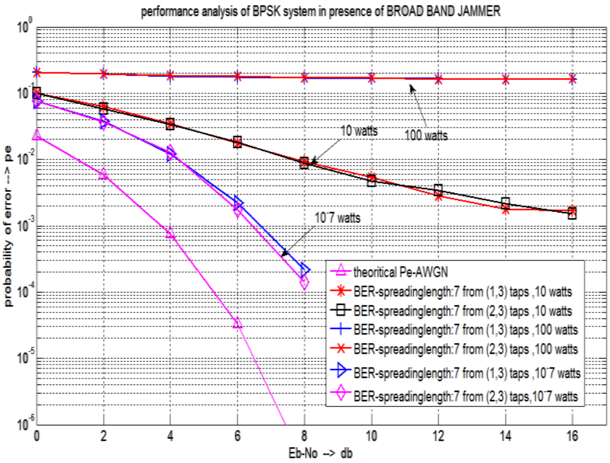
Generation of PN sequences with ‘m’ stage feedback shift register produces maximal sequences of length N=2^m-1 [4]. Different maximal sequences of same length (N) are generated with various valid tap combinations. Fig.1a shows the Performance of Base Band BPSK system in presence of Broadband jammer for fixed ten watts of power received in message (J=10) 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.1b three different transmitting powers are used for N=7 spreading code.

Fig.1a



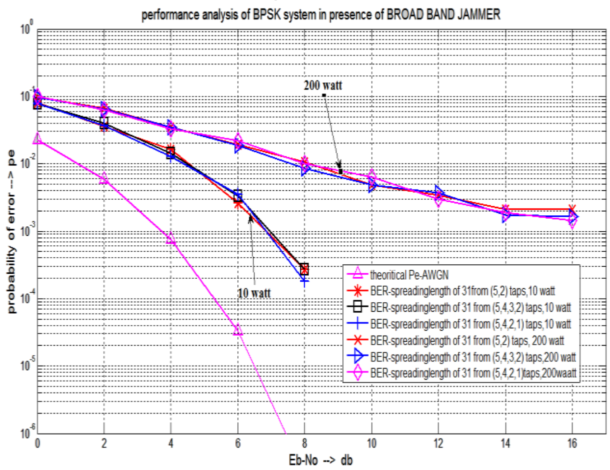

From above we conclude that BER curves are similar for fixed length spreading codes i.e. Performance is same for particular length spreading codes generated from various tap combinations by a fixed length linear feedback shift register.

Fig.1b




For a particular received jammer power the BER curves are similar for fixed length spreading codes and increase in jammer power degrades the performance. 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 fig.1c.

Fig.1c




The following results are obtained for Binary Phase Shift Keying modulation scheme in presence of Broadband jammer presented in tabular form and values are noted at $E_b\_N_o$=8 db with transmission and reception of one lakh bits using m-sequences as spreading codes in Additive White Gaussian Noise channel. Where Jo is measured in watts and Jo=J/N and N is spread code length.

BER=10^-3

| N | 7 | 15 | 31 | 63 | 127 | 255 |
|---|---|---|---|---|---|---|
| Jo | 0.43 | 1.0 | 2.85 | 3.5 | 7.9 | 11.8 |

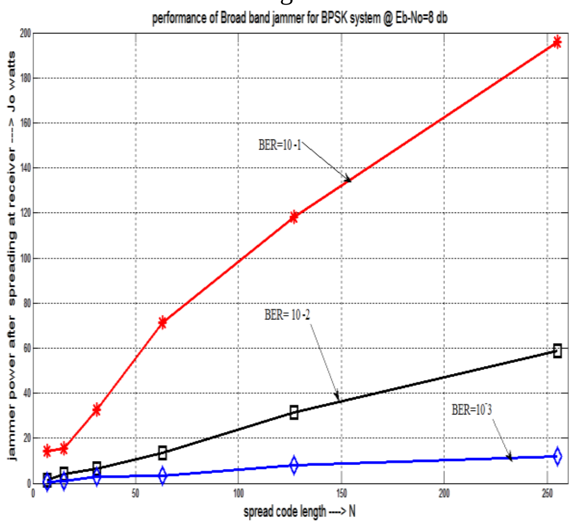
BER=10^-2

| N | 7 | 15 | 31 | 63 | 127 | 255 |
|---|---|---|---|---|---|---|
| Jo | 1.43 | 4.0 | 6.45 | 13.5 | 31.5 | 58.8 |

BER=10^-1

| N | 7 | 15 | 31 | 63 | 127 | 255 |
|---|---|---|---|---|---|---|
| Jo | 14.3 | 15.3 | 32.2 | 71.4 | 118 | 196 |

Fig.2




The above figure shows the amount of peak transmitted power required in watts after spreading the jammer waveform with different length maximal sequences at receiver for particular Bit Error Rate, at $E_b$-$N_o$ of 8 db. The above tabulated values are different if calculations are performed at $E_b$-$N_o$ other than 8db.

## III. CONCLUSION

Pseudo Noise sequences that are generated from the various valid taps combination using fixed length linear feedback shift register, posse's similar BER curve for broadband jammer i.e. performance is independent of bit order in fixed length m- sequence used.

Performance in presence of jammer varies with spreading length, i.e. for a particular jammer power at receiver bit error rate decreases with increase in length of spreading sequence.

The performance of broadband jammer for different spreading sequences like gold and orthogonal variable spreading (OVSF) codes has to be estimated for awgn channel. Similarly the performance of different jammers has to be estimated for AWGN as well as multipath fading channel using different spreading sequences of various lengths for different modulation techniques.

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