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PERFORMANCE EVALUATION OF DIRECT SEQUENCE SPREAD SPECTRUM UNDER PHASE NOISE EFFECT WITH SIMULINK SIMULATIONS

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ABSTRACT

In this work we have shown that the effect of phase noise on Direct Sequence spread spectrum signal when the phase noise level densities are high over AWGN and Fading channels. We have used the values generated by the Error-rate Calculation. Values generated by the Error-rate block for different noise levels where shown in table 1. The phase noise level density (PNLD) was varied from -20dBc/Hz to -120dBc/Hz in step of -20dBc/Hz. For each substitution, the model was simulated and results obtained and tabulated. In all, results showed that phase noise on DS-SS decreases as values of PNLDs in the Phase Noise block decreases. I have also compared the results which showing that BER is more in case of fading instead of AWGN. It also shown that BER is minimum when there are no phase noise considerations. In this work we have also compare two user's BER transmitting at same time with different PN Sequence and shown that each having no effect over each other. I have used different PN Sequence for simulations and each shown in table 3.

Keywords: Phase Noise, Direct Sequence Spread Spectrum, PN Sequence, BER, Error-rate

I. INTRODUCTION

In some situations it is required that a communication signal be difficult to detect, and difficult to demodulate even when detected. Here the word 'detect' is used in the sense of 'to discover the presence of'. The signal is required to have a low probability of intercept - LPI.

In other situations a signal is required that is difficult to interfere with, or 'jam'. The 'spread spectrum' signal has properties which help to achieve these ends. Spread spectrum signals may be divided into two main groups - direct sequence spread spectrum (DSSS), and frequency hopping spread spectrum (FHSS). This paper is concerned with demonstrating some of the principles of the first.

A transmission technique in which a pseudo-noise code, independent of the information data, is employed as a modulation waveform to "spread" the signal energy over a bandwidth much greater than the signal information bandwidth. At the receiver the signal is "despread" using a synchrpnized replica of the pseudo- noise code.

In DS-SS, the carrier (data signal) is modulated by the PN code sequence, which is of a much higher frequency than the desired data rate.

Here we are using DS-SS binary PSK system which is shown below in figure 1.

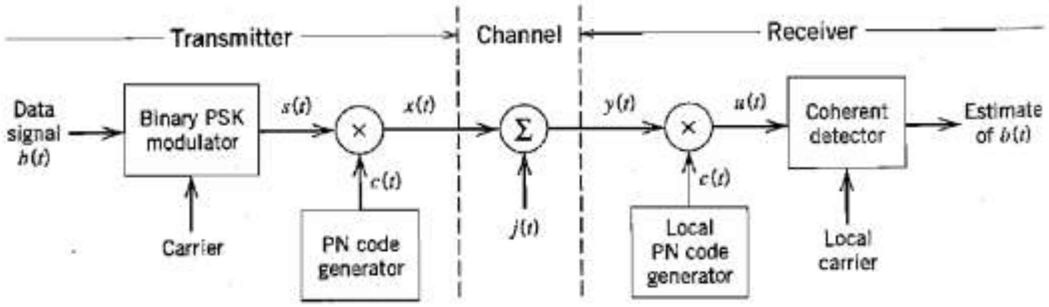

Fig 1 DS-SS BPSK System

II. SYSTEM AND SIGNAL MODEL WITHOUT PHASE NOISE

2.1 Transmitted and Received Signals

A functional diagram of the transmitter is shown in Fig. 1.

The user's data waveform (transmitter input) is

$$x(t) = \sum \sqrt{\frac{2E_b}{T_b}} d_n p_{T_b}(t - nT_b)$$

PN Sequence waveform as shown in Fig 1. is

$$\boldsymbol{c}(\boldsymbol{t}) = \sum c_i(n) p_{T_c}(t - nT_c)$$

Received waveform as shown in Fig 1 is

$$\boldsymbol{y}(\boldsymbol{t}) = \left\{ \sum \sqrt{\frac{2E_b}{T_b}} d_n p_{T_b}(t - nT_b) c_i(n) p_{T_c}(t - nT_c) * \cos\{2\pi(f_c)t\} \right\} + j(t)$$

Correlator output

$$u_i = \int_0^{T_b} r(t) * \sqrt{2} * \cos\{2\pi(f_c)t\} * c_j(t) dt$$

$$u_i = \sqrt{\frac{E_b}{T_b}} \int_0^{T_b} c_i(t)\, c_j(t) \{\cos\{2\pi(f_c)t * \cos\{2\pi(f_c)t\} dt + j(t) * \sqrt{2} * \cos\{2\pi(f_c)t * c_j(t)$$

III. SYSTEM AND SIGNAL MODEL UNDER PHASE NOISE

3.1 Transmitted and Received Signals

A functional diagram of the transmitter is shown in Fig. 1.

The user's data waveform (transmitter input) is

$$x(t) = \sum \sqrt{\frac{2E_b}{T_b}} d_n p_{T_b}(t - nT_b)$$

PN Sequence waveform as shown in Fig 1. is

$$\boldsymbol{c}(\boldsymbol{t}) = \sum c_i(n) p_{T_c}(t - nT_c)$$

Received waveform as shown in Fig 1 is

$$y(t) = \left\{ \sum \sqrt{\frac{2E_b}{T_b}} d_n p_{T_b}(t - nT_b) c_i(n) p_{T_c}(t - nT_c) * \cos\{2\pi(f_c + f_i)t + \theta_i\} \right\} + j(t)$$

Correlator output

$$u_i = \int_0^{T_b} r(t) * \sqrt{2} * \cos\{2\pi(f_j)t + \theta_j\} * c_j(t) dt$$

$$u_i = \sqrt{\frac{E_b}{T_b}} \int_0^{T_b} c_i(t)\, c_j(t) \{\cos\{2\pi(f_c + f_i)t + \theta_i + 2\pi(f_j)t + \theta_j\} + \cos\{2\pi(f_c + f_i)t + \theta_i - 2\pi(f_j)t - \theta_j\}\} dt$$
$$+ j(t) * \sqrt{2} * \cos\{2\pi(f_j)t + \theta_j\} * c_j(t)$$

IV. METHODOLOGY AND RESULTS

The experiments were performed using a similink model (contained in MATLAB 2013) that is capable of simulating the Effect of Phase Noise in DS-SS. The model is shown in figure 1. Here in this experiment I have considered DS-SS BPSK system. Different simulations have been performed for different cases listed below:

1) BER for AWGN without Phase Noise
2) BER for AWGN under Phase Noise
3) BER for Fading without Phase Noise
4) BER for Fading under Phase Noise
5) BER for AWGN under Phase Noise with Scattered Plot
6) BER for Fading under Phase Noise with Scattered Plot

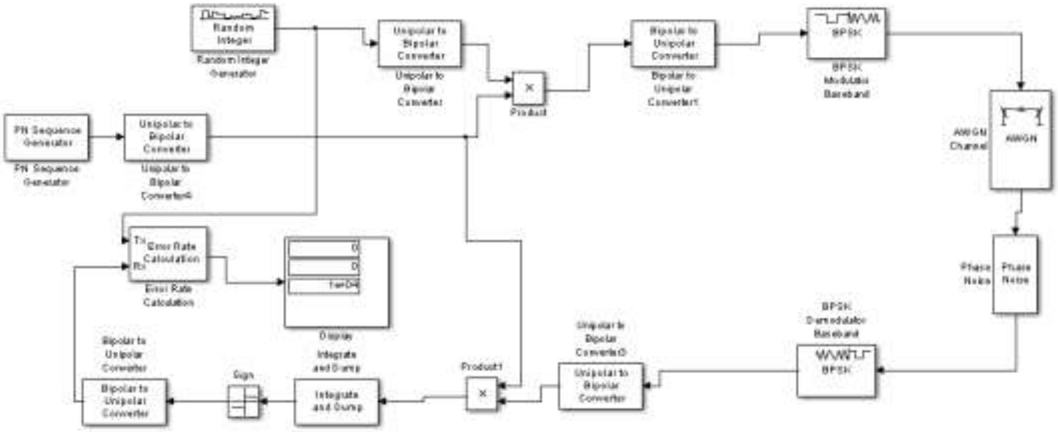

Fig 2 Simulink Model for Single user DS-SS over AWGN

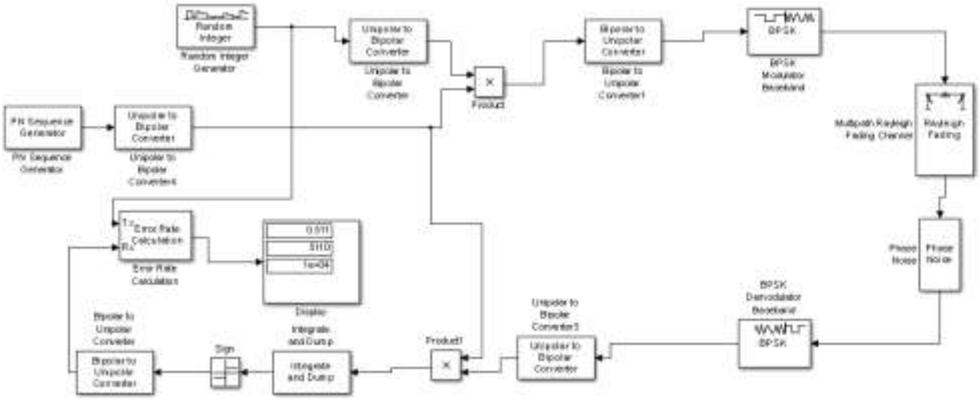

Fig 3 Simulink Model for Single user DS-SS over Rayleigh channel

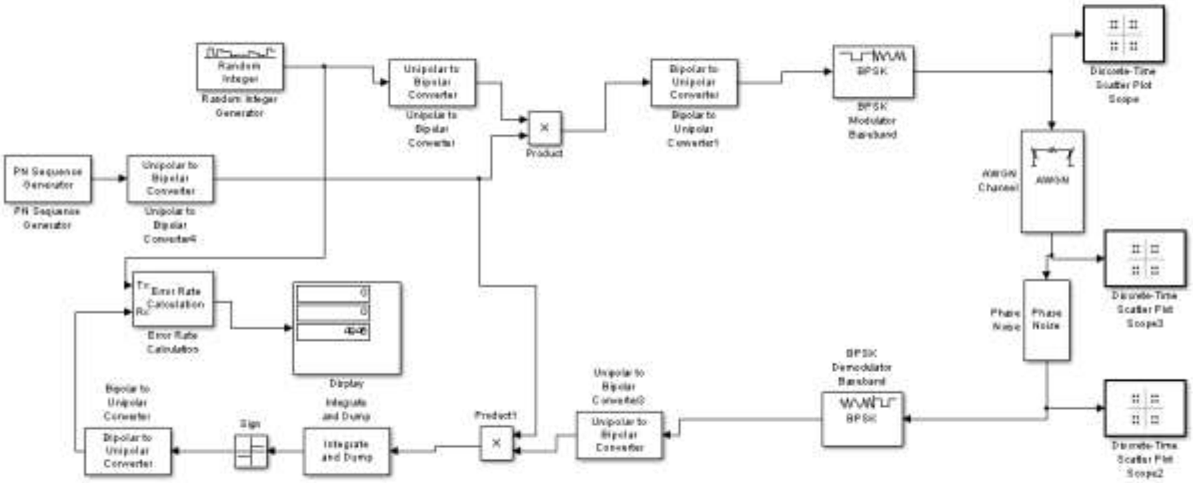

Fig 4 Simulink Model for Single user DS-SS over AWGN with scatters

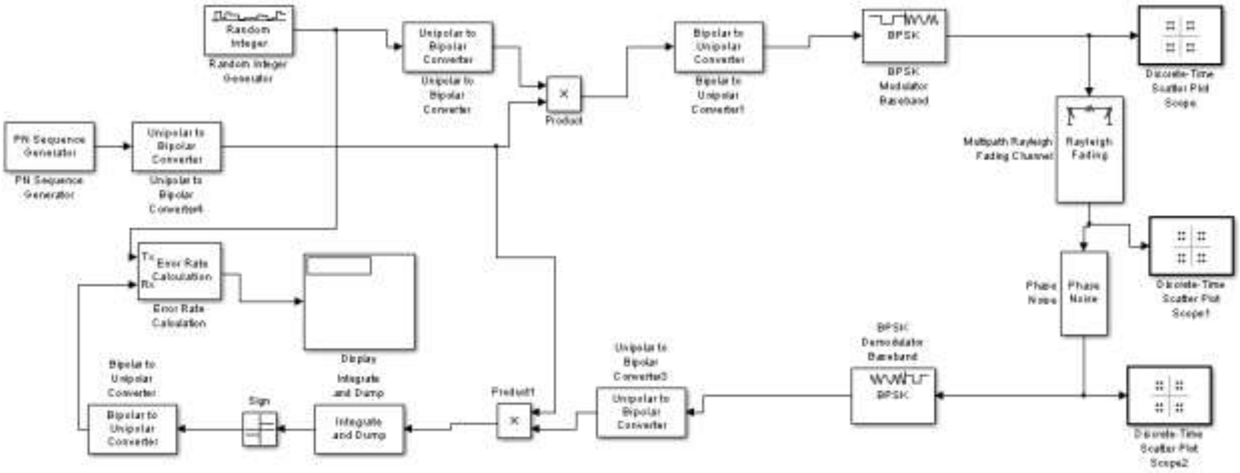

Fig 5 Simulink Model for Single user DS-SS over Fading channel with scatters

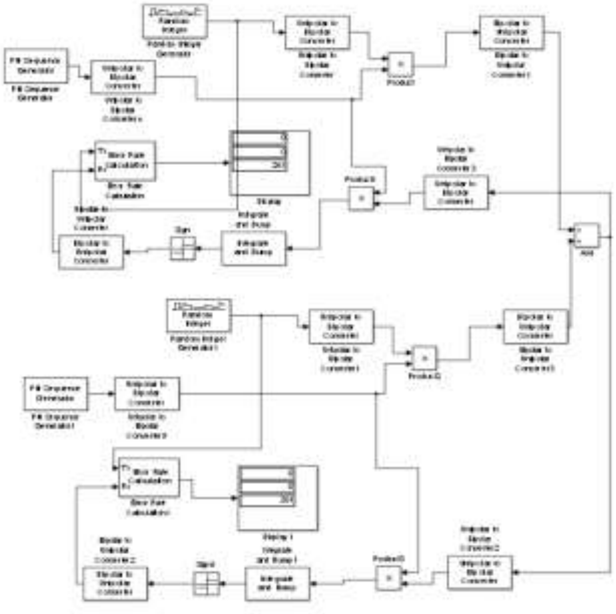

Fig 6 Simulink Model for Two user DS-SS over AWGN

These models were then used to study how phase noise affects DS-SS via Error Rate Calculation Block. Before proceeding with the experiments, the value of the signal to noise ratio in the AWGN channel was varied, such that the channel itself would not have any effect on the modulated signal. This was confirmed by attaching two scatter plot scopes before and after the AWGN channel.

For Fading Doppler frequency can be varied as per requirement of the experiment. After these, the experiment was performed taking values of PNLD from –20 dBc/Hz to – 120dBc/Hz, in step of – 20dBc/Hz; for frequency offset of 200Hz. With each variation, the model was simulated. Results were displayed by the Error rate calculation Block. Before proceeding to the results, let us first of all look at the ‘parameters’ that were used in each of the Blocks for the simulation.

V. RESULTS

Table 1 for AWGN PN Sequence [1 0 0 1 1 0 1]

PNLD(dbc/Hz)	**Number of symbols compared**	**No of errors occurred**	**Error rate**
-20	10000	5012	0.5012
-40	10000	4	0.0004
-60	10000	0	0
-80	10000	0	0
-100	10000	0	0
-120	10000	0	0

Table 2 for Rayleigh Fading

Doppler's Frequency 100 Hz

PN Sequence [1 0 0 1 1 0 1]

PNLD(dbc/Hz)	Number of symbols compared	No of errors occurred	Error rate
-20	10000	4994	0.4994
-40	10000	5099	0.5099
-60	10000	5069	0.5069
-80	10000	5106	0.5106
-100	10000	5110	0.5110
-120	10000	5111	0.5111

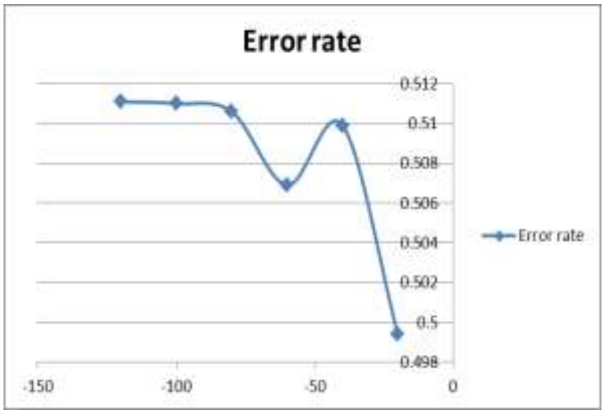

Fig 7 BER vs Phase Noise for Fading

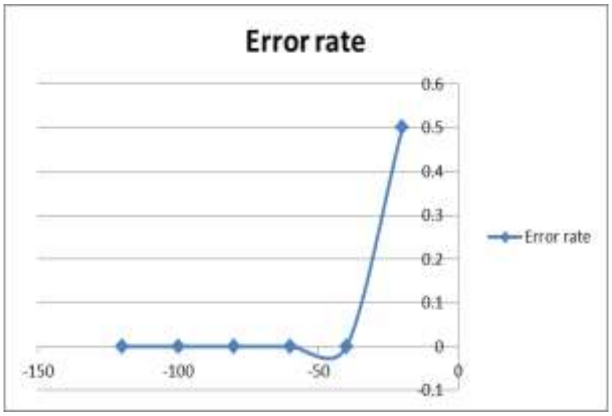

Fig 8 BER vs Phase Noise for AWGN

As we can see from fig 7 and fig 8 that DS-SS more affected in fading as compare to AWGN under phase noise. As value of phase noise decreases error rate in AWGN also decreases but in fading error rate increases.

5.1 Error Rate for different PN Sequence

Table 3 for Different PN Sequences for AWGN for Phase Noise -40dBc/Hz

S.N	PN Sequence	Error Rate
1	[1 0 0 1 1 0 1]	0.0004
2	[1 0 0 1 1 0 0 1]	0.0003
3	[1 0 0 1 1 0 0 0 1]	0.0001
4	[1 0 0 1 1 0 0 0 0 1]	0.0003
5	[1 0 0 1 1 0 0 0 0 0 1]	0.0003

Fig 9. Error Rate Variation for Different PN Sequences

As we can see from table 3 that if we keep on increasing the length of PN sequence firstly error rate decreases then it reaches some constant error rate.

VI. CONCLUSION

It was discovered that DS-SS was greatly affected by phase noise, particularly in cases where the phase noise level densities were high. This should be checked in communication system to enable signal transmission with little or no distortion. I concluded that BER is more in case fading with compare to AWGN. It is also concluded that if I increase the length of PN sequence BER firstly decreases then reaches a constant value. In this study that also shown that when two user's transmitting at same time phase noise having same effect on each user as in the case of single user.

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