Part B

Date : **Experiment No.**

Error Performance of BPSK

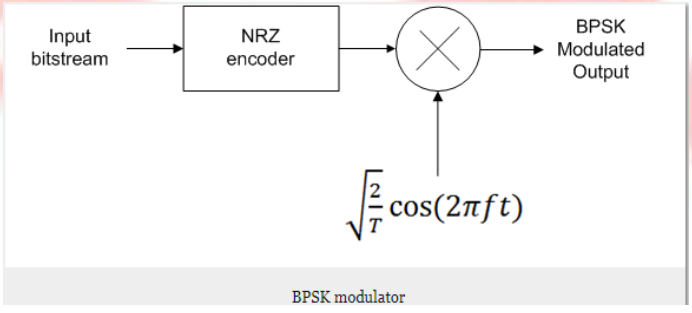
Aim : 1. To generate a string of message bits.

2. To encode using BPSK with energy per bit E_b and represent it using points in a signal-space.
3. To simulate transmission of the BPSK modulated signal via an AWGN channel with variance $N_0/2$.
4. To detect using an ML decoder and plot the probability of error as a function of SNR per bit E_b/N_0.

Brief theory:

Phase Shift Keying is the digital modulation technique in which the phase of the carrier signal is changed by varying the sine and cosine inputs at a particular time. PSK is widely used for wireless LANs, bio-metric, contactless operations, along with RFID and Bluetooth communications.

Binary Phase Shift Keying BPSK is also called as 2-phase PSK or Phase Reversal Keying. In this technique, the sine wave carrier takes two phase reversals such as 0° and 180°. BPSK is basically a Double Side Band Suppressed Carrier DSBSC modulation scheme, for message being the digital information. Figure 1 shows the block diagram of BPSK modulator. Figure 2. Shows the BPSK in time domain and frequency domain. Figure 3 shows the block diagram of BPSK receiver.



BPSK modulator

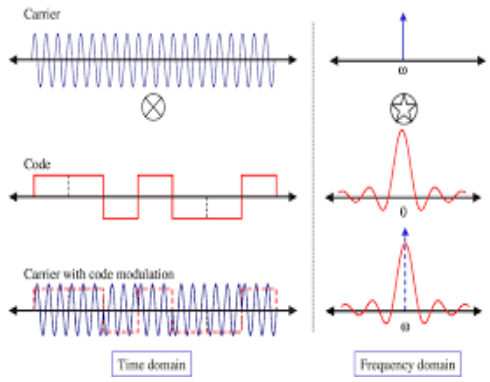


Fig 2. Waveforms

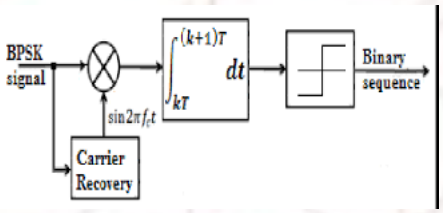


Fig 3. BPSK detector

Bit error rate (BER) of a communication system is defined as the ratio of number of error bits and total number of bits transmitted during a specific period. It is the likelihood that a single error bit will occur within received bits, independent of rate of transmission. For any given modulation, the BER is normally expressed in terms of signal to noise ratio (SNR). The bit error probability is given by

$$P_b = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_0}}\right)$$

Bit error probability depends on the energy contents of the signal. It does not depend on the signal shape. As the energy increases, the error reduces , so bit error probability also decreases.

The simulations are done as follows:

A randomly generated bit stream is generated and converted to BPSK waveforms. BPSK waveforms are transmitted through an AWGN channel with a fixed SNR . The received symbols are converted again to bits. The received bits are compared with transmitted bits and error is calculated. The

signal to ratio is then varied and the process is repeated. Monte Carlo simulation is used to calculate Bit error probability.

Monte Carlo simulation describes a simulation in which a parameter of a system, such as the bit error rate (BER), is estimated using Monte Carlo techniques. Monte Carlo estimation is the process of estimating the value of a parameter by performing an underlying stochastic, or random, experiment.

Sample programs

Program Monte Carlo simulation

```
from numpy import sqrt
from numpy.random import rand, randn
import matplotlib.pyplot as plt

N = 5000000
EbNodB_range = range(0,15)
itr = len(EbNodB_range)
ber = [None]*itr

for n in range (0, itr):
    EbNodB = EbNodB_range[n]
    EbNo=10.0**(EbNodB/10.0)
    x = 2 * (rand(N) >= 0.5) - 1
    noise_std = 1/sqrt(2*EbNo)
```

```
    y = x + noise_std * randn(N)

    y_d = 2 * (y >= 0) - 1

    errors = (x != y_d).sum()

    ber[n] = 1.0 * errors / N


    print ("EbNodB:", EbNodB)

    print ("Error bits:", errors)

    print ("Error probability:", ber[n] )


plt.plot(EbNodB_range, ber, 'bo', EbNodB_range, ber, 'k')

plt.axis([0, 10, 1e-7, 0.1])

plt.xscale('linear')

plt.yscale('log')

plt.xlabel('EbNo(dB)')

plt.ylabel('BER')

plt.grid(True)

plt.title(' BER of BPSK Modulation')

plt.show()
```

Result:

```
runfile('C:/Users/APARNA/.spyder-py3/ber of bpsk.py', wdir='C:/Users/APARNA/.spyder-py3')

EbNodB: 0

Error bits: 392847

Error probability: 0.0785694
```

EbNodB: 1

Error bits: 281515

Error probability: 0.056303

EbNodB: 2

Error bits: 187605

Error probability: 0.037521

EbNodB: 3

Error bits: 114474

Error probability: 0.0228948

EbNodB: 4

Error bits: 62889

Error probability: 0.0125778

EbNodB: 5

Error bits: 30004

Error probability: 0.0060008

EbNodB: 6

Error bits: 11992

Error probability: 0.0023984

EbNodB: 7

Error bits: 3821

Error probability: 0.0007642

EbNodB: 8

Error bits: 969

Error probability: 0.0001938

EbNodB: 9

Error bits: 161

Error probability: 3.22e-05

EbNodB: 10

Error bits: 18

Error probability: 3.6e-06

EbNodB: 11

Error bits: 1

Error probability: 2e-07

EbNodB: 12

Error bits: 0

Error probability: 0.0

EbNodB: 13

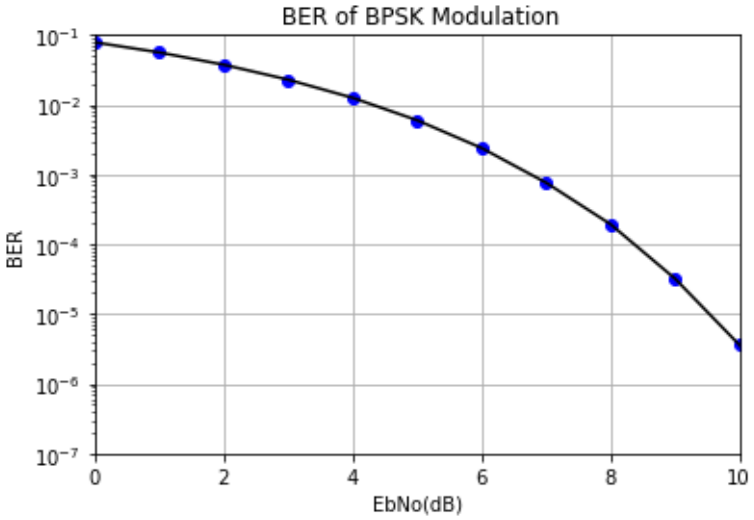
Error bits: 0

Error probability: 0.0

EbNodB: 14

Error bits: 0

Error probability: 0.0


BER of BPSK Modulation
BER
EbNo(dB)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
0
2
4
6
8
10