BITS ERROR RATE CALCULATION OF BPSK AND QPSK USING MATLAB

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ABSTRACT

In order to choose the most suitable modulation, several criteria such as power efficiency, bandwidth efficiency, and bit error rate are used for evaluation. This paper focuses on error performance of phase modulation schemes in different channel conditions and on the method to reduce bit error rates with the help of convolutional coding which is extensively used in GSM cellular system's encoder. A brief description of theoretical aspects of phase modulation schemes commonly used in satellite communications such as BPSK and QPSK is also given here along with simulations carried out with the help of Matlab and AnsoftSerenade tools.

1. INTRODUCTION

In any phase modulation scheme the information is expressed in terms of phase of the carrier. Phase of the carrier signal is shifted according to the input binary data. Two-state phase shift keying (PSK) is called BPSK where the phase of the radio carrier is set to 0 or π according to the value of the incoming bit. Each bit of the digital signal produces a transmit symbol with duration T_s, which is equal to the bit duration T_b. Four-state or quadriphase PSK is called QPSK, in which two bits are combined and the radio carrier is phase-modulated according to the four possible patterns of two bits. Transmitting a symbol takes twice as long as a bit ($T_s = 2 \cdot T_b$) which means that the bandwidth efficiency of QPSK is twice that of BPSK.

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. There are many ways of reducing BER. Here, we focus on channel coding techniques.

A channel in mobile communications can be simulated in many different ways. The main considerations include the effect of multipath scattering, fading and Doppler shift that arise from the relative motion between the transmitter and the receiver. In our simulations, we have considered the two most commonly used channels: the Additive White Gaussian Noise (AWGN) channel where the noise gets spread over the whole spectrum of frequencies and theRayleigh fading channel.

2. BLOCK DIAGRAM

a. BPSK BLOCK DIAGRAM

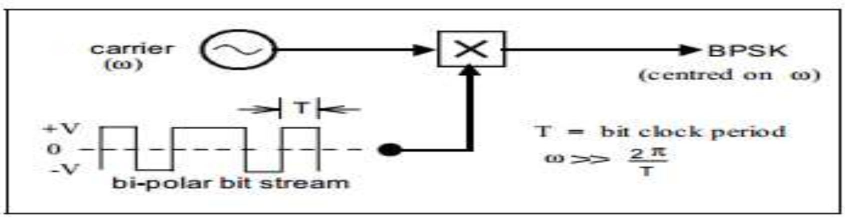

Figure 1: generation of BPSK

b. QPSK BLOCK DIAGRAM

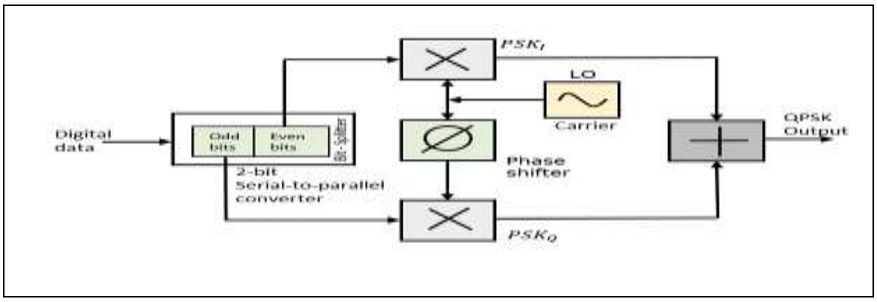

Figure 2: generation of QPSK

3. MATLAB PROGRAM AND CODE EXPLANATION FOR BER OF BPSK

```
%This program simulates BER of BPSK in AWGN channel%
 clear all; close all; clc;
 num_bit=100000;                          %Signal length
 max_run=20;                              %Maximum number of iterations for a single SNR
 Eb=1;                                    %Bit energy
 SNRdB=0:1:9;                             %Signal to Noise Ratio (in dB)
 SNR=10.^(SNRdB/10);
 hand=waitbar(0,'Please Wait....');
 for count=1:length(SNR)                  %Beginning of loop for different SNR
     avgError=0;
     No=Eb/SNR(count);                    %Calculate noise power from SNR

     for run_time=1:max_run               %Beginning of loop for different runs
         waitbar((((count-1)*max_run)+run_time-1)/(length(SNRdB)*max_run));
         Error=0;

         data=randint(1,num_bit);         %Generate binary data source
         s=2*data-1;                      %Baseband BPSK modulation

         N=sqrt(No/2)*randn(1,num_bit);   %Generate AWGN

         Y=s+N;                           %Received Signal

         for k=1:num_bit                  %Decision device taking hard decision and deciding 
error
             if ((Y(k)>0 && data(k)==0)||(Y(k)<0 && data(k)==1))
                 Error=Error+1;
             end
         end

         Error=Error/num_bit;             %Calculate error/bit
         avgError=avgError+Error;         %Calculate error/bit for different runs
     end                                  %Termination of loop for different runs
     BER_sim(count)=avgError/max_run;     %Calculate BER for a particular SNR
 end                                      %Termination of loop for different SNR
 BER_th=(1/2)*erfc(sqrt(SNR));            %Calculate analytical BER
 close(hand);

 semilogy(SNRdB,BER_th,'k');              %Plot BER
 hold on
 semilogy(SNRdB,BER_sim,'k*');
 legend('Theoretical','Simulation',3);
 axis([min(SNRdB) max(SNRdB) 10^(-5) 1]);
 hold off
```

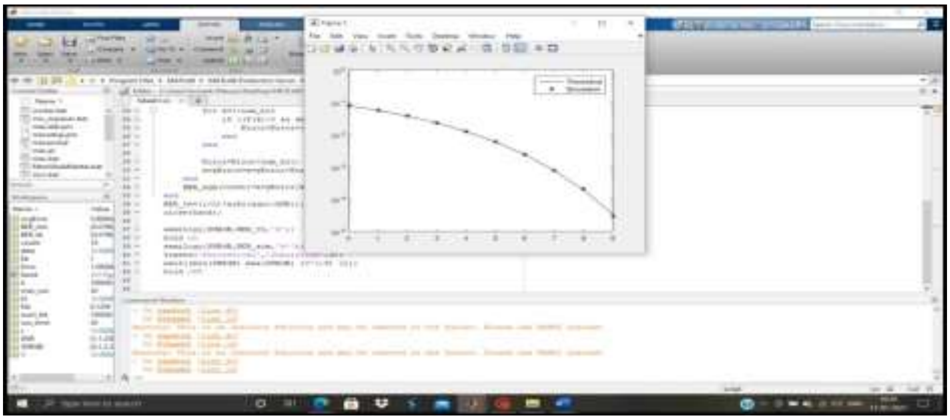

Figure 3: Simulation result of BPSK

4. MATLAB PROGRAM AND CODE EXPLANATION FOR BER OF QPSK

```
clear all;
close all;
l=10000;
snrdb=1:1:10;
snrlin=10.^(snrdb/10);
for snrdb=1:1:10
    si=2*(round(rand(1,l))-0.5);
    sq=2*(round(rand(1,l))-0.5);
    s=si+j*sq;
    w=awgn(s,snrdb,'measured');
    r=w;
    si_=sign(real(r));
    sq_=sign(imag(r));
    ber1=(l-sum(si==si_))/l;
    ber2=(l-sum(sq==sq_))/l;
    ber(snrdb)=mean([ber1 ber2]);
end
%semilogy(snrdb, ber,'o-')
snrdb=1:1:10;
snrlin=10.^(snrdb./10);
tber=0.5.*erfc(sqrt(snrlin));
semilogy(snrdb,ber,'-bo',snrdb,tber,'-mh')
title('QPSK with awgn');
xlabel('Signal to noise ratio');
ylabel('Bit error rate');
grid on;
```

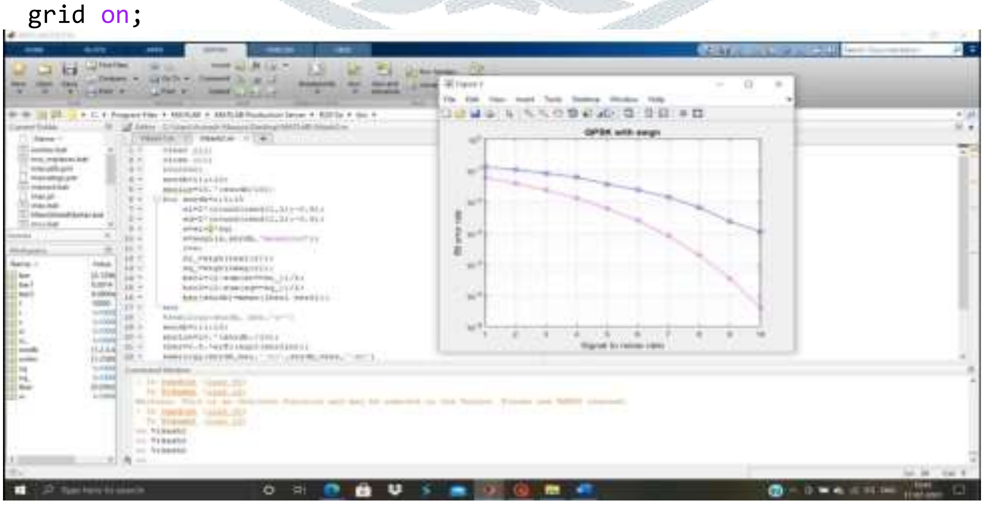

Figure 4: Simulation result of QPSK

5. DESCRIPTION OF SIMULATIONS

Coded and uncoded BPSK & QPSK schemes have been simulated using the Serenade Symphony tool. BER has been measured by comparing the transmitted signal with the received signal and computing the error count over the total number of bits. For any given modulation, the BER is normally expressed in terms of signal to noise ratio (SNR).

Convolutional coder takes a binary input sequence and outputs a convolutionally encoded binary sequence according to the specified parameters of the model, in which everyK input bits are encoded into N output bits. The rate of the coder is given by the ratio K/N.

In Matlab, we focused only on BER performance in terms of signal to noise ratio per bit for PSK, considering AWGN and Rayleigh channels. PSK signal was created with the help of Matlab function *y = dmod(x, Fc, Fd, Fs, 'psk', M)* which performs M-phase shift keying modulation. *X* denotes values (modulating signal) of random bits generated with the help of function *randint(m, n)*, which generates an *m*-by-*n* binary matrix, *Fc* is carrier frequency and *Fs* is sampling frequency. Such a signal was mixed with noise and later detected by convolving the distorted signal and the signal from matched filter-representation of carrier recovery circuit. This signal was passed through a decision device to get the final data. The bit error rate measurements were carried out subsequently.

6. RESULTS AND ANALYSIS

Figure 5 shows the BER performance to AWGN channel, where BPSK and QPSK systems are compared. BPSK requires 3 dB less of signal to noise ratio than QPSK to achieve the same BER. This outcome will hold true only if we consider BER in terms of SNR per carrier. In terms of signal to noise ratio per bit the BER is same for both QPSK and BPSK.

The effect of convolutional coding on BPSK for different convolutional code rates is displayed in figure 6, and for example, coding with rate K/N = 1/2 results in a saving of 4 dB and with rate 1/3 more than 5 dB (example is for BER = 10^{-3}).

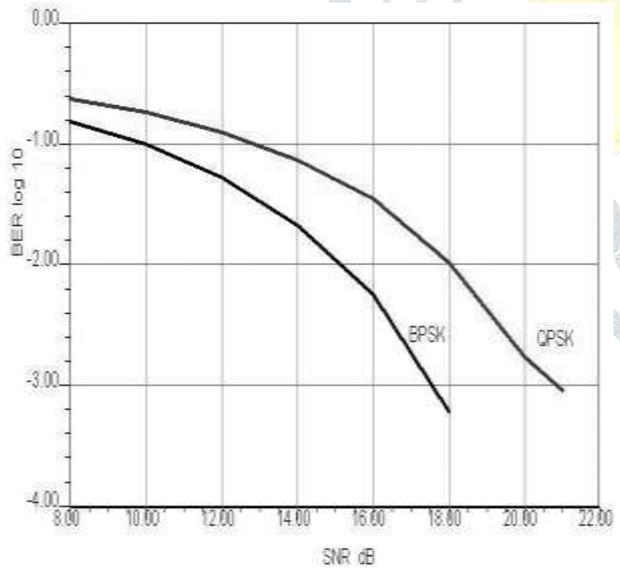

Fig. 5: *Bit error performance in terms of SNR per carrier for BPSK and QPSK*

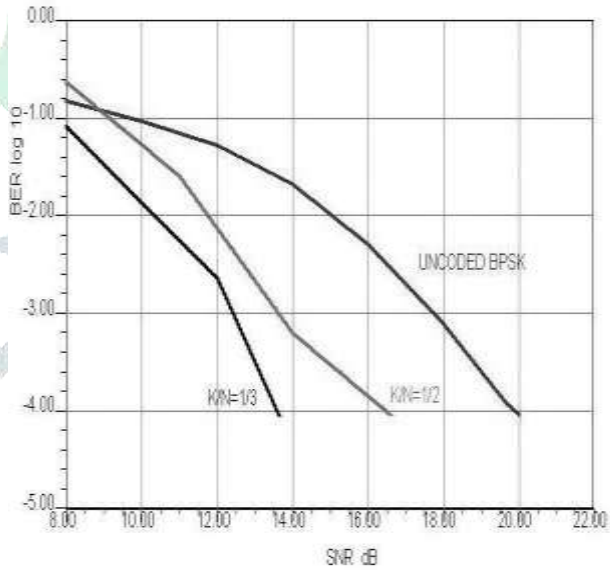

Fig. 6: *Effect of convolutional coder with different rates for BPSK system*

The effects of AWGN and Rayleigh fading channels were simulated in Matlab. The results are displayed in figure 7. Here we can compare the resistance to error for two different channels. In Rayleigh channel, the signal is more prone to errors and for example, at a biterror rate of 10^{-3} we need 20 dB more of signal to noise ratio than for AWGN to achieve the same bit error rate. The probability of error is identical for BPSK and QPSK because the BERhas been measured in terms of signal to noise ratio per bit.

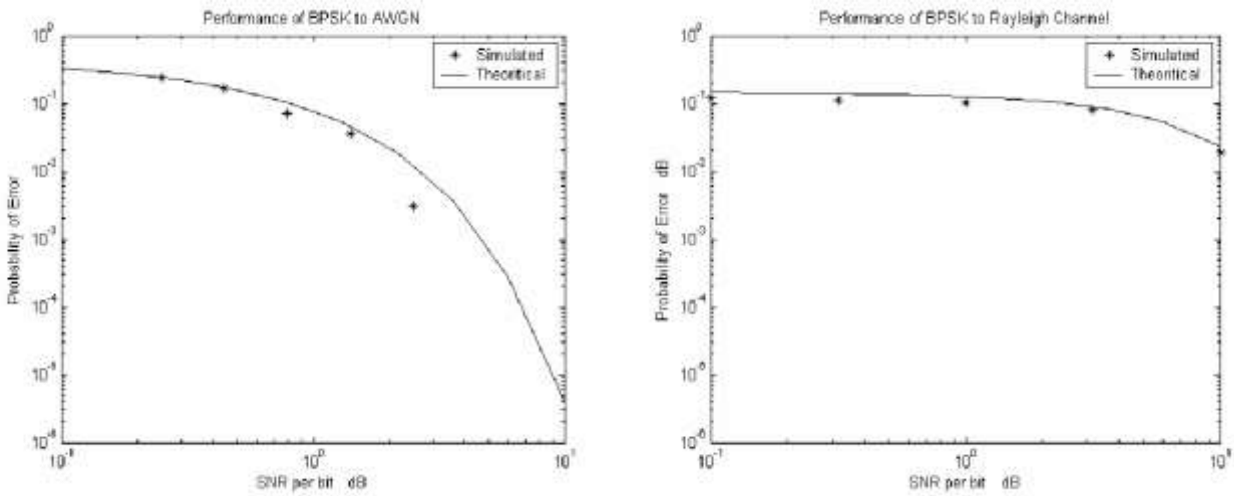

Fig. 7: *Comparison between AWGN and Rayleigh Fading Channel for BPSK and QPSK in terms of signal to noise ratio per bit.*

7. CONCLUSION

The main purpose of this paper has been to present the commonly used modulation schemes in satellite communication systems and demonstrate the performance of PSK modulated systems in the presence of a noisy channel along with the ways to reduce the BER.

From our results, it is evident that BPSK modulation is preferred in cases where weneed to consider small amounts of transmitting energy. The main reason is that the BPSK offers acceptable BER while transmitting signals of relatively low energy. This paper further focuses on the ways to reduce BER and thus increase power efficiency. For our application, it is observed that the introduction of the convolution coding scheme has helped to decrease the bit error rate significantly. This in turn, results in the transmission of signals of specified quality with a smaller transmit power. In other words, it leads to higher power efficiency, but on the other hand, the bit rate is half (or third) that of the uncoded scheme.

The results of simulations in Matlab are displayed in figure 7, which clearly illustrates the diverse error performance of PSK to different channel models.

8. FUTURE WORK SCOPE

The work in this project is Bit Error Rate and the E_b/N_0 vs BER for BPSK and QPSK modulation over the AWGN Channel (Additive White Gaussian Channel) for coded signal. The future work is bit error rate and the E_b/N_0 vs. BER for BPSK and QPSK modulation over Rayleigh Fading channel for coded signal using convolution codes and the Viterbi Algorithm. The most important method of modulation of communication signal in mobile communication can be improved by reducing the bit error rate (noise) of the massage signal over carrier signal.

9. REFERENCES

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