Roll no: 42428
Date: 18/02/2021

Experiment No: 6

Title: GMSK MODULATION

Aim: Set up and carry out experiment on GMSK Modulation

Pre-requisites:

1. Concepts of GMSK Modulation

Apparatus:

1. MATLAB

Theory:

What is GMSK Modulation - Gaussian Minimum Shift Keying

Gaussian Minimum Shift Keying or Gaussian filtered Minimum Shift Keying, GMSK, the form of modulation with no phase discontinuities used to provide data transmission with efficient spectrum usage. GMSK, is a form of modulation used in a variety of digital radio communications systems. It has advantages of being able to carry digital modulation while still using the spectrum efficiently. One of the problems with other forms of phase shift keying is that the sidebands extend outwards from the main carrier and these can cause interference to other radio communications systems using nearby channels.

In view of the efficient use of the spectrum in this way, GMSK modulation has been used in a number of radio communications applications. Possibly the most widely used is the GSM cellular technology which is used worldwide and has well over 3 billion subscribers.

GMSK basics

GMSK modulation is based on MSK, which is itself a form of continuous-phase frequency-shift keying. One of the problems with standard forms of PSK is that sidebands extend out from the carrier. To overcome this, MSK and its derivative GMSK can be used.

MSK and also GMSK modulation are what is known as a continuous phase scheme. Here there are no phase discontinuities because the frequency changes occur at the carrier zero crossing points. This arises as a result of the unique factor of MSK that the frequency difference between the logical one and logical zero states is always equal to half the data rate. This can be expressed in terms of the modulation index, and it is always equal to 0.5.

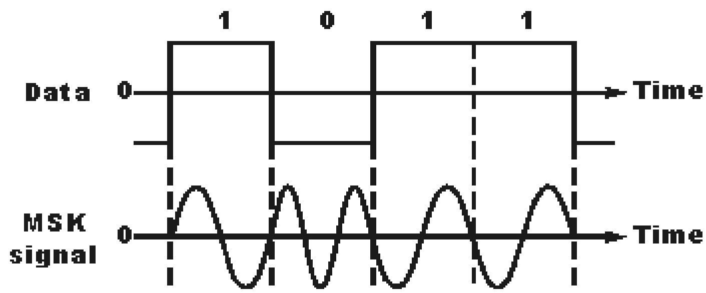


Fig 1. Signal using MSK modulation

A plot of the spectrum of an MSK signal shows sidebands extending well beyond a bandwidth equal to the data rate. This can be reduced by passing the modulating signal through a low pass filter prior to applying it to the carrier. The requirements for the filter are that it should have a sharp cut-off, narrow bandwidth and its impulse response should show no overshoot. The ideal filter is known as a Gaussian filter which has a Gaussian shaped response to an impulse and no ringing. In this way the basic MSK signal is converted to GMSK modulation.

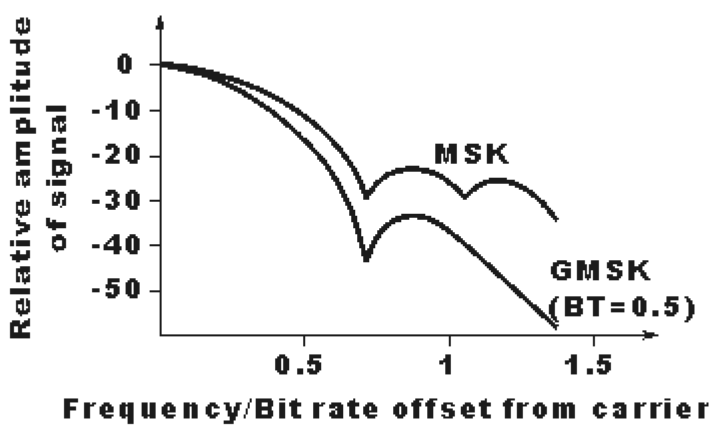


Fig 2. Spectral density of MSK and GMSK signals

Generating GMSK modulation

There are two main ways in which GMSK modulation can be generated. The most obvious way is to filter the modulating signal using a Gaussian filter and then apply this to a frequency modulator where the modulation index is set to 0.5. This method is very simple and straightforward but it has the drawback that the modulation index must exactly equal 0.5. In practice this analogue method is not suitable because component tolerances drift and cannot be set exactly.

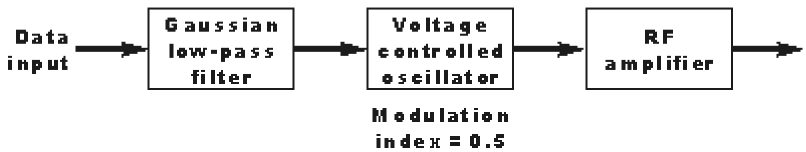


Fig 3. Generating GMSK using a Gaussian filter and VCO

A second method is more widely used. Here what is known as a quadrature modulator is used. The term quadrature means that the phase of a signal is in quadrature or 90 degrees to another one. The quadrature modulator uses one signal that is said to be in-phase and another that is in quadrature to this. In view of the in-phase and quadrature elements this type of modulator is often said to be an I-Q modulator. Using this type of modulator the modulation index can be maintained at exactly 0.5 without the need for any settings or adjustments. This makes it much easier to use, and capable of providing the required level of performance without the need for adjustments. For demodulation the technique can be used in reverse.

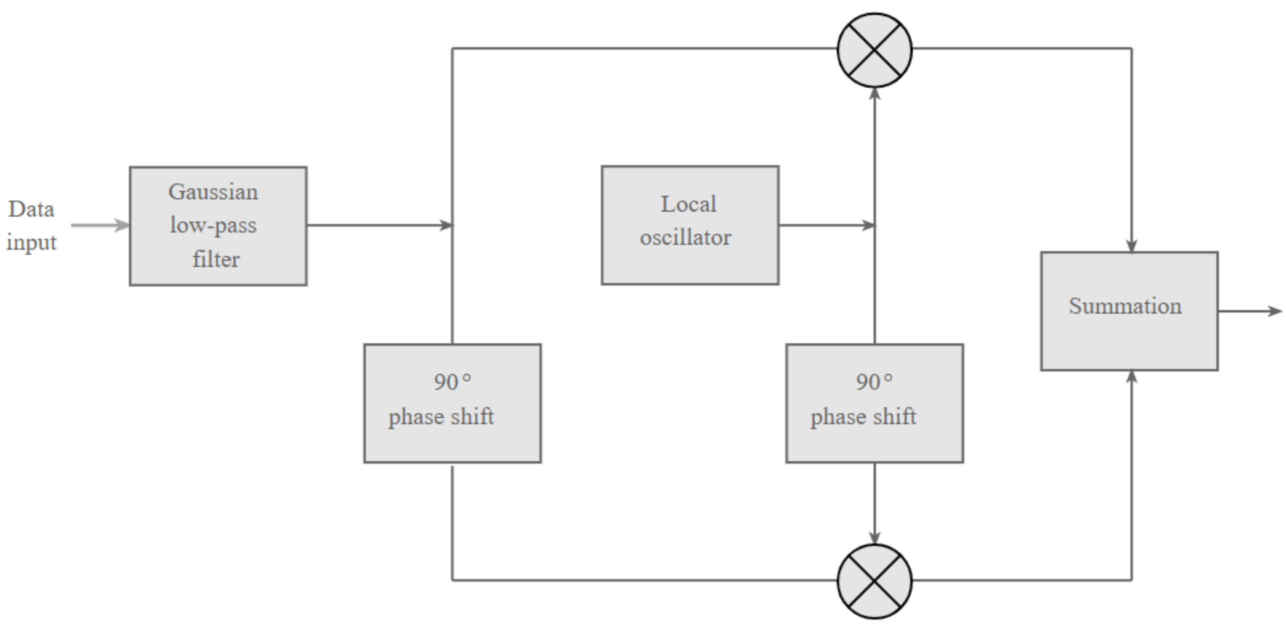


Fig 4. Block diagram of I-Q modulator used to create GMSK

Advantages of GMSK modulation

There are several advantages to the use of GMSK modulation for a radio communications system. One is obviously the improved spectral efficiency when compared to other phase shift keyed modes.

A further advantage of GMSK is that it can be amplified by a non-linear amplifier and remain undistorted This is because there are no elements of the signal that are carried as amplitude variations. This advantage is of particular importance when using small portable transmitters, such as those required by cellular technology. Non-linear amplifiers are more efficient in terms of the DC power input from the power rails that they convert into a radio frequency signal. This means that the power consumption for a given output is much less, and this results in lower levels of battery consumption; a very important factor for cell phones.

A further advantage of GMSK modulation again arises from the fact that none of the information is carried as amplitude variations. This means that is immune to amplitude variations and therefore more resilient to noise, than some other forms of modulation, because most noise is mainly amplitude based.

Why GMSK modulation is used in GSM?

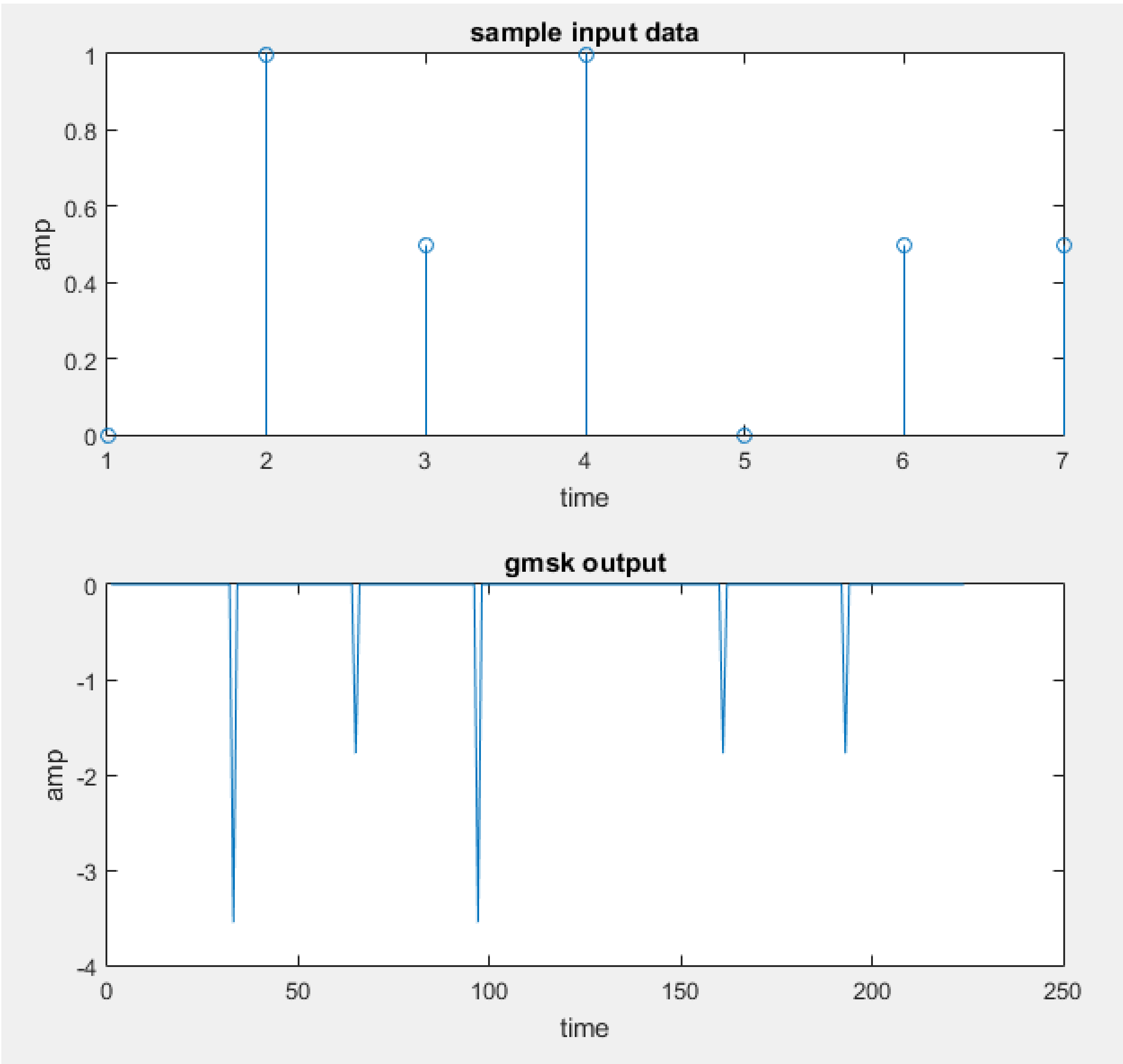
The phase of the transmitted signal in GMSK scheme is continuous and smoothed by a Gaussian filter. This results in more compact spectrum which enables better utilization of the available frequency spectrum. The side lobe energy for GMSK is less and hence channel spacing can be tighter. The compact spectrum is beneficial in a scenario where the operators pay premium for bandwidth.

Simulated Results:

Gaussian :

```
clear all;
close all;
clc;
nrz_data=[0 1 0.5 1 0 0.5 0.5]; %sample code
pi=3.14;
Tb=1; %bit duration
BT=0.3; %BT product of filter
sps=32;
Ts=Tb/sps; %sample period
t=0.5;
Tb=(-2*Tb:Ts:2*Tb);
alpha=2*pi*BT/(sqrt(log(2)));
gauss=(alpha*(2*t-0.5))-(alpha*(2*t+0.5));
K=pi/2;
gauss=K*gauss;
nrz=upsample(nrz_data,sps);
nrz_gauss=conv(gauss,nrz);
subplot(2,1,1);
stem(nrz_data);
title('sample input data');
xlabel('time');
ylabel('amp');
subplot(2,1,2);
plot(nrz_gauss);
title('gmsk output');
xlabel('time');
ylabel('amp');
```

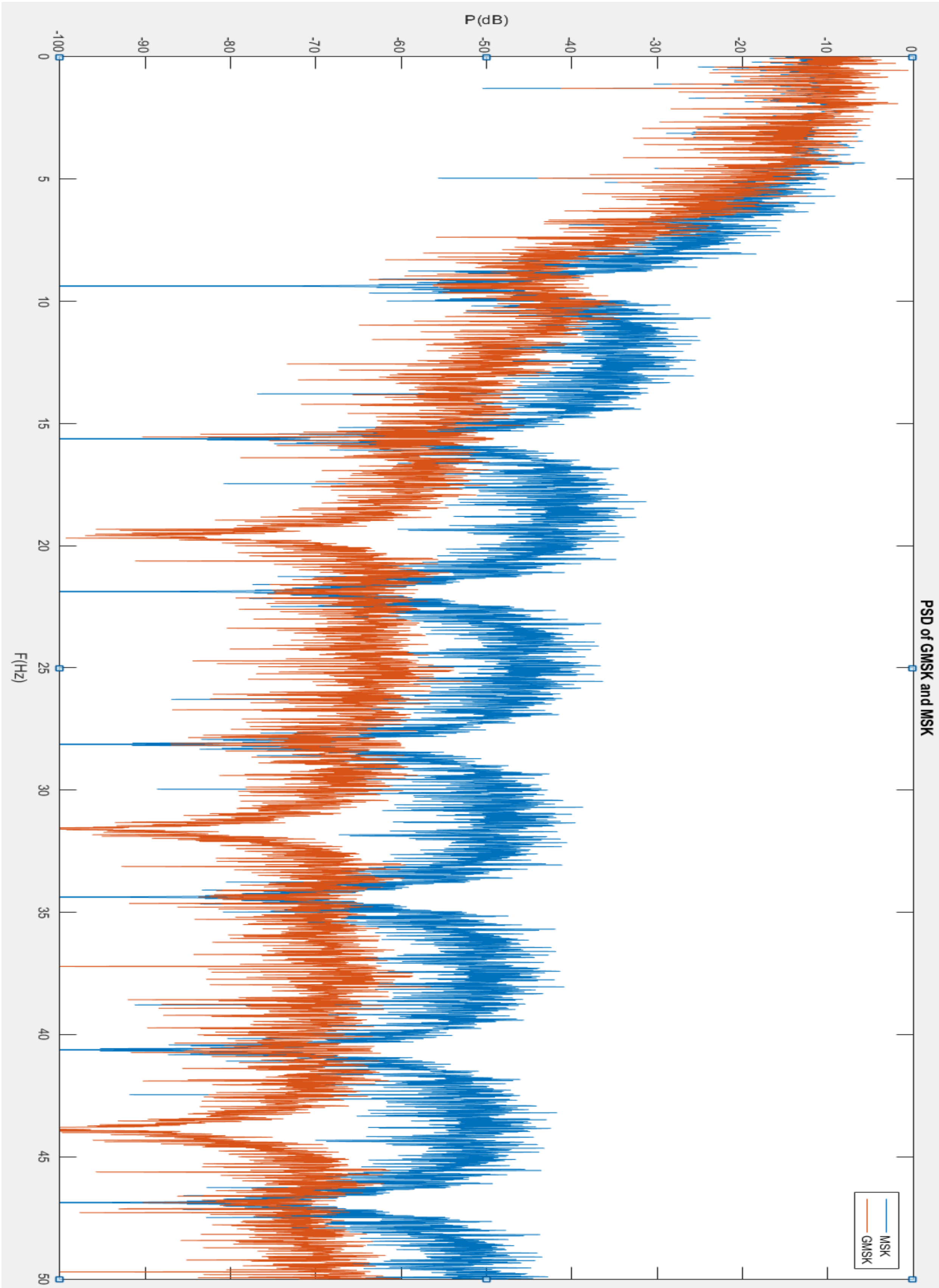
Output


sample input data
amp
time
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
gmsk output
amp
time
0
-1
-2
-3
-4
0
50
100
150
200
250

GMSK :

```
clear all;
close all;
clc;
% Set the samples per symbol variable.
sps = 8;

% Generate random binary data.
data = randi([0 1],1000,1);

% Create GMSK and MSK modulators that accept binary inputs. Set the
PulseLength property of the GMSK modulator to 1.
gmskMod =
comm.GMSKModulator('BitInput',true,'BandwidthTimeProduct',0.3,'Pulse
Length',2,'SamplesPerSymbol',sps);
mskMod = comm.MSKModulator('BitInput',true,'SamplesPerSymbol',sps);

% Modulate the data using the GMSK and MSK modulators.

modSigGMSK = step(gmskMod,data);
modSigMSK = step(mskMod,data);

Fs=100;

% PSD of GMSK and MSK
[Pxx,F] = periodogram(modSigGMSK,[],length(modSigGMSK),Fs);
[Pxx1,F] = periodogram(modSigMSK,[],length(modSigMSK),Fs);

plot(F,10*log10(Pxx1),F,10*log10(Pxx));
title('PSD of GMSK and MSK');
xlabel('F(Hz)');
ylabel('P(dB)');

legend('MSK','GMSK');
```

Output :


PSD of GMSK and MSK
P(dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
F(Hz)
0
5
10
15
20
25
30
35
40
45
50
MSK
GMSK

Conclusion:

In this experiment we understood the GMSK technique and implemented a matlab code to simulate the PSD distribution of GMSK and MSK and compared them. GMSK performs far better than MSK as we get low amplitudes of side lobes as compared to MSK. GMSK gives improved spectral efficiency when compared to other phase shift keyed modes. GMSK signal can be amplified by a non-linear amplifier and remain undistorted. This is because there are no elements of the signal that are carried as amplitude variations. This advantage is of particular importance when using small portable transmitters, such as those required by cellular technology. Non-linear amplifiers are more efficient in terms of the DC power input from the power rails that they convert into a radio frequency signal. This means that the power consumption for a given output is much less, and this results in lower levels of battery consumption, a very important factor for cell phones. As no information is carried in the amplitude variations, it is immune to noise distorting amplitude variations and therefore more resilient to noise, than some other forms of modulation, because most noise is mainly amplitude based.

Signature