Experiment-7

U19CS095

Date 15/10/20

Effect of AWGN on AM and FM.

AWGN → Additive white Gaussian noise

Aim: ⇒ Examining the how addition of noise in modulated signal (AM, FM) distort the original message signal.

Objective: ⇒ To study the transmission amplitude modulated (AM) and frequency modulated (FM) signal under the Additive Gaussian noise channel (AWGN) on AM and FM signal using the Matlab/ Simulink and draw the distorted waveform for different signal to noise ratio (SNR) values.

Theory: ⇒ AWGN is a basic noise model used to mimic the effect of many random process that occurs in nature.
Channel produces Additive white Gaussian Noise.

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Additive - The received signal equals the transmit signal plus some noise, where the noise is statistically independent of signal.

$$r(t) = s(t) + w(t)$$

$s(t)$ → message signal

$w(t)$ → noise

White: It refer that the noise has some power distribution at every frequency OR it has uniform power across the frequency band for the information system.
It is an analogy to the color white which has uniform emission at all frequency in the visible spectrum. ~~if~~ if we focus a beam of light for each color on the visible spectrum onto a single spot, that combination would result in a beam of white light, as consequence, power spectral Density (PSD) of white noise is constant for all frequency ranging from $-\infty$ to $+\infty$, as shown in figure

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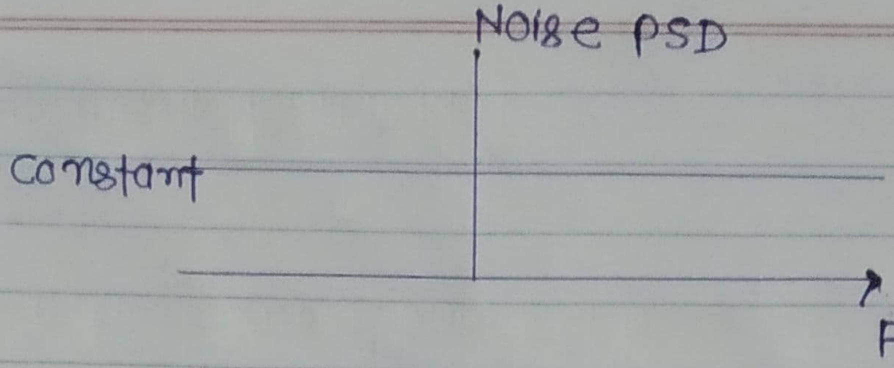
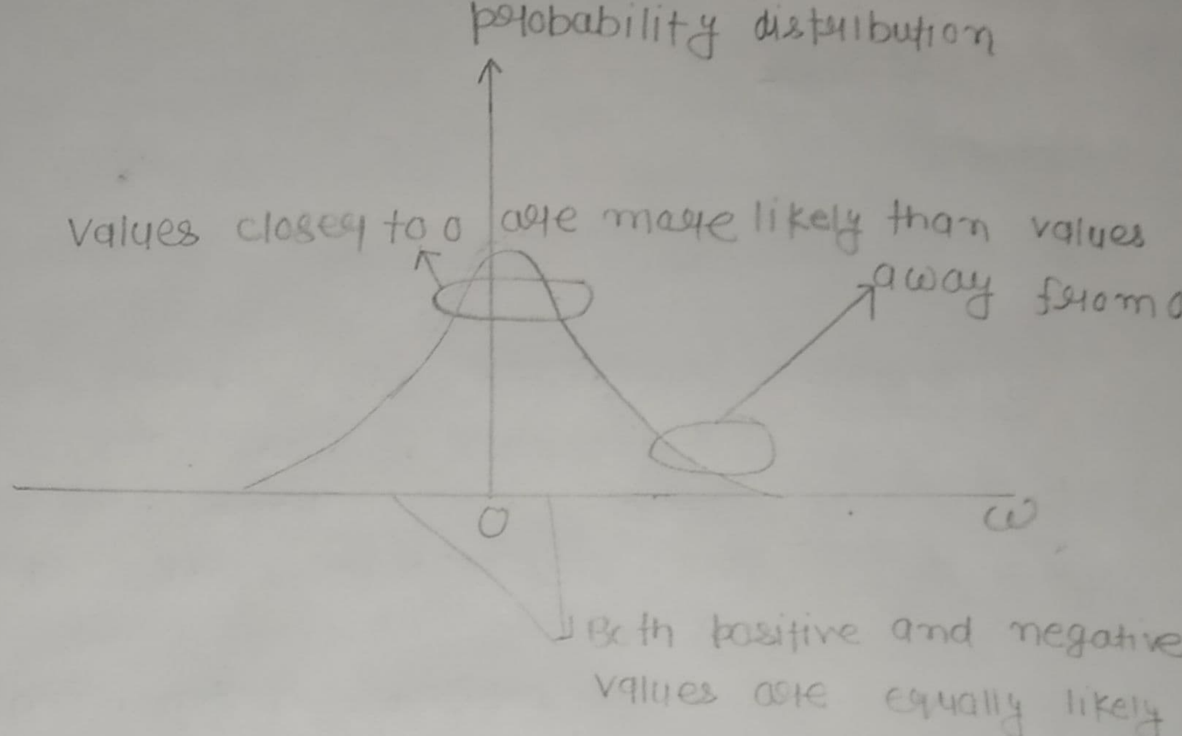


Gaussian- Gaussian distribution, or a normal distribution, has an average of zero in time domain, and is represented as a bell-shaped curve.

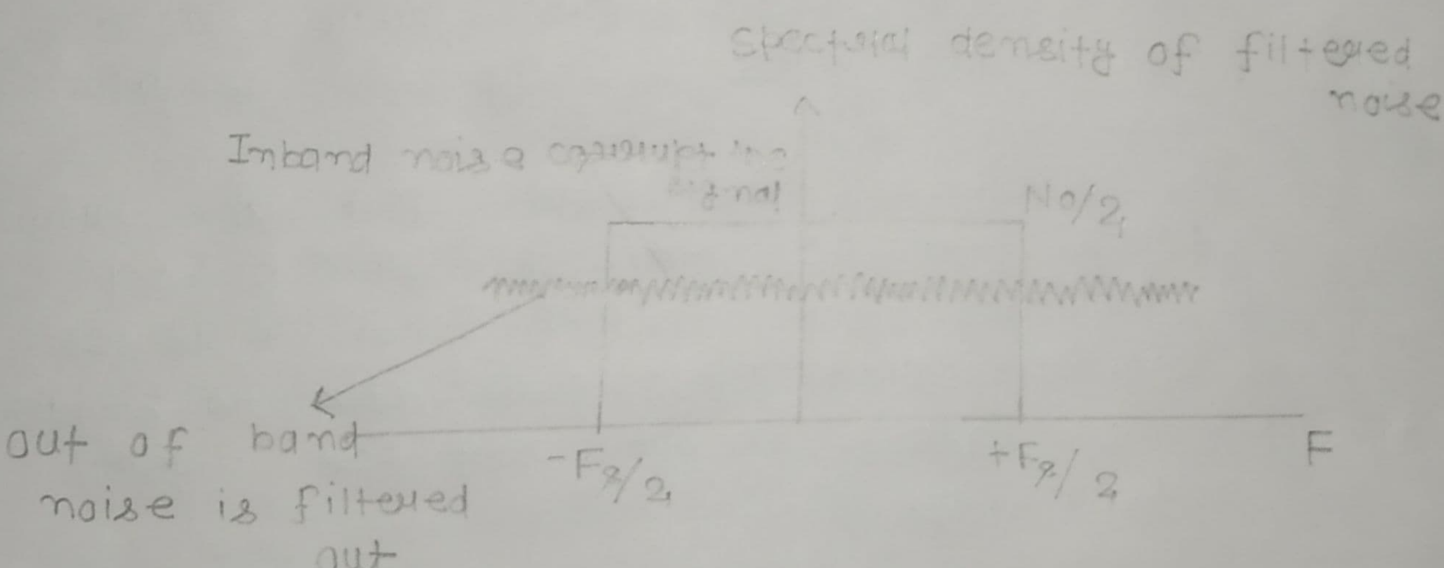
The probability distribution of the noise sample is Gaussian with a zero mean.

The value close to zero have a higher chance of occurrence while the values far away from zero are less likely to appear.

In reality, the ideal flat spectrum from $-\infty$ to $+\infty$ is true for frequency of interest in wireless communication. (a few KHz to hundreds of GHz) but not for higher frequency.



probability distribution
Values closer to 0 are more likely than values away from 0
0
ω
Both positive and negative values are equally likely



Spectral density of filtered noise
Inband noise corrupt the signal
No/2
out of band noise is filtered out
-Fs/2
+Fs/2
F

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Signal - to - Noise Ratio

The SNR or S/N is a measure used in science and engineering that compare the level of a desired signal to the level of background noise. It is defined as the ratio of signal to power to noise power, often expressed in decibal. A ratio higher than 1:1 (greater than 0dB) indicate more signal than noise.
SNR, bandwidth, and channel capacity of communication channel are connected by shannon - Hartley theorem.

$$SNR_{dB} = 10 \log_{10} \left(\frac{P_{signal}}{P_{noise}} \right)$$

Shannon - Hartley - theorem : it indicates that channel capacity (bits per second) OR information rate of data that can be communicated at low error rate using an average received signal power through communication channel subject to a AWGN of power

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$$C = B \log_2 \left(1 + \frac{S}{N}\right)$$

where B is bandwidth of channel in hertz.

we can see that it is related to SNR.

Different case for SNR values

5dB - 10dB → is minimum level to establish a connection, due to noise level being nearly indistinguishable from desired signal.

25dB - 40dB → is deemed to be good

41dB or higher → is considered to be excellent

AWGN over AM (amplitude modulation)

let $E_m(t) = E_m \sin \omega_m t$ be messege signal

and $E_c(t) = E_c \sin \omega_c t$ be carrier signal

then we know that

$$e_m(t) = (E_c + E_m(t)) \sin \omega_c t$$

$$e_m(t) = (E_c + E_m \sin \omega_m t) \sin \omega_c t$$

U19CS095 Matlab code for performing the AWGN effect over AM

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1)

```
clc ;
clear all;
t = 0: 0.001 : 1;
vm = 6 ;
vc = 12 ;
fm = 5 ;
fc = 30;
m = vm* sin(2*pi * fm*t);
c = vc * sin( 2* pi * fc*t);
amp = vc + vm* sin( 2* pi * fm*t);
am = amp * sin( 2*pi * fc *t);
y = awgn (am, 15; 'measured');
subplot (4, 1, 1);
plot (t, m);
xlabel ( 'time');
ylable ('amplitude');
title (' message signal');
subplot ( 4,1, 2 ); plot ( t, c);
xlablel ('time');
ylabel (' amplitude');
title(' carrier signal');
subplot ( 4,1, 3); plot( t, am);
x label ('time');
ylabel ('amplitude');
title (' amplitude modulated signal');
```

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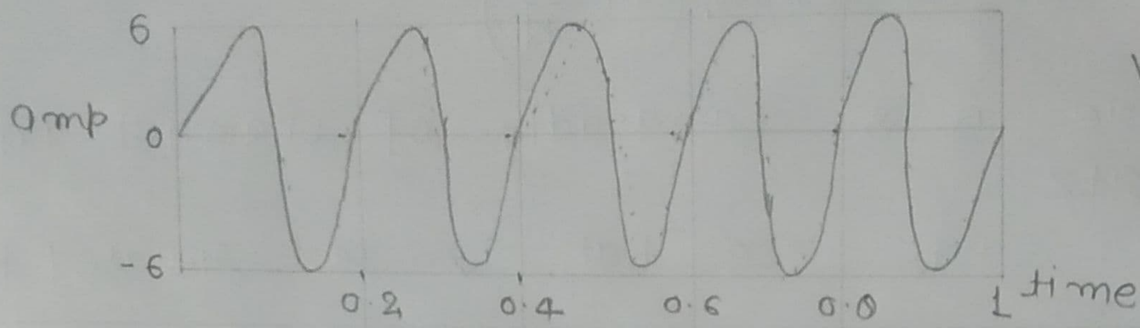
```
subplot (4,1,4);
  plot(t, y);
xlabel ('time');
ylabel (' amplitude');
title ( 'amplitude modulated signal with AWGN')
```

1)

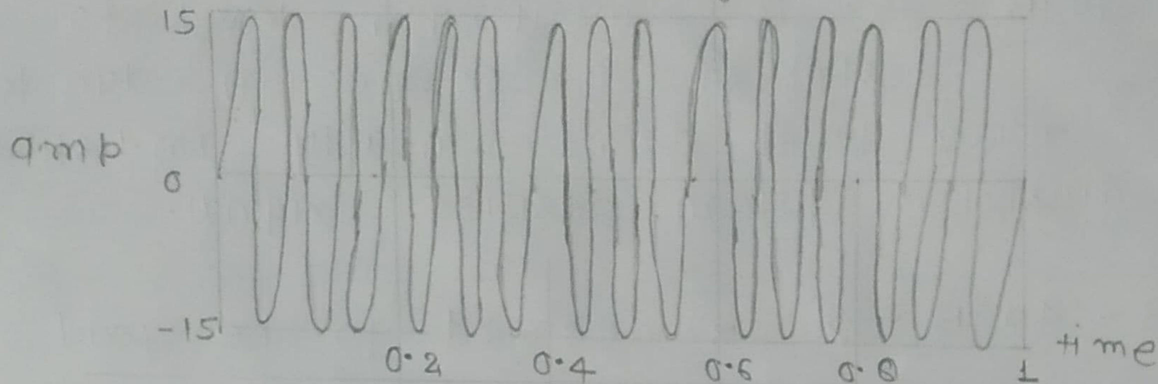
Messege signal



$V_m = 6$

$f_m = 5$

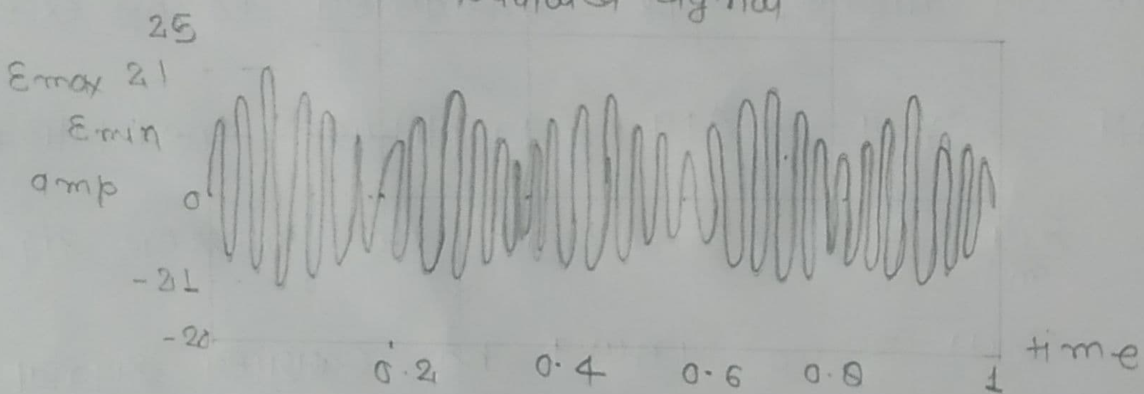
carrier signal



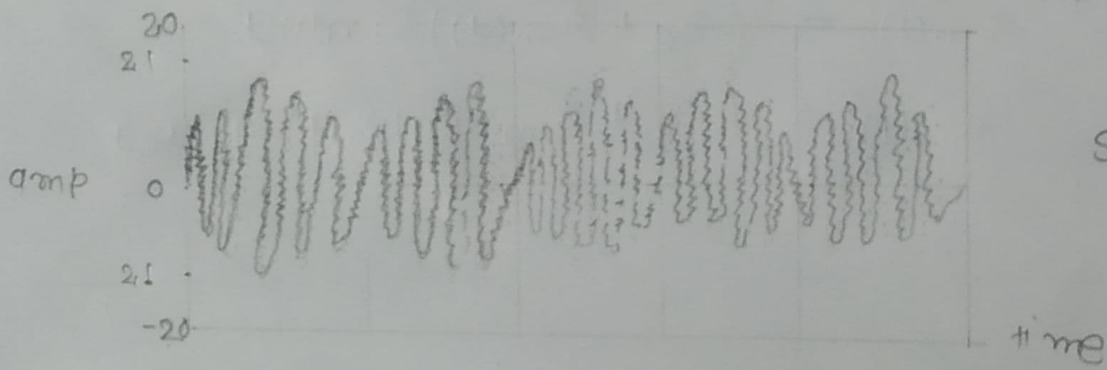
$V_c = 15$

$f_c = 15$

modulated signal

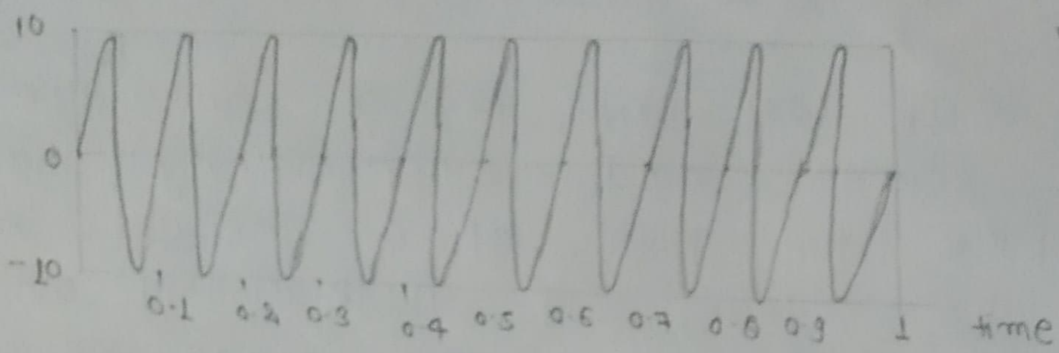


AWGN effect on modulated signal (A1a)



SNR → 15

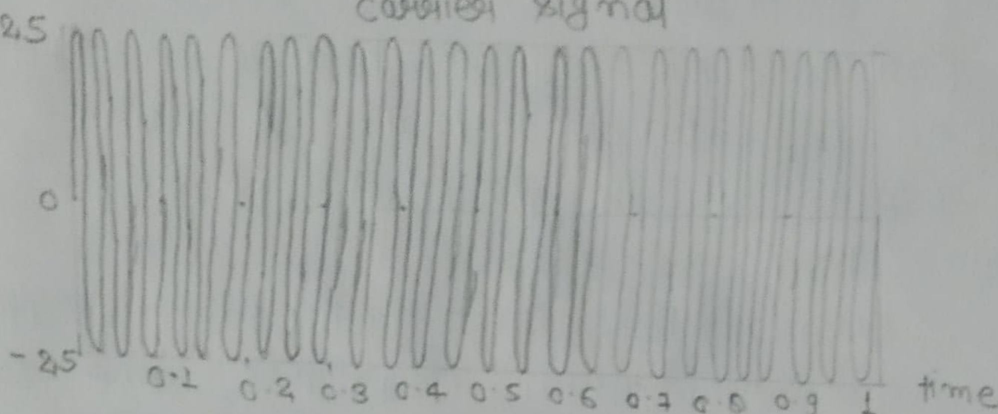
messege signal



$V_m = 10$

$f_m = 10$

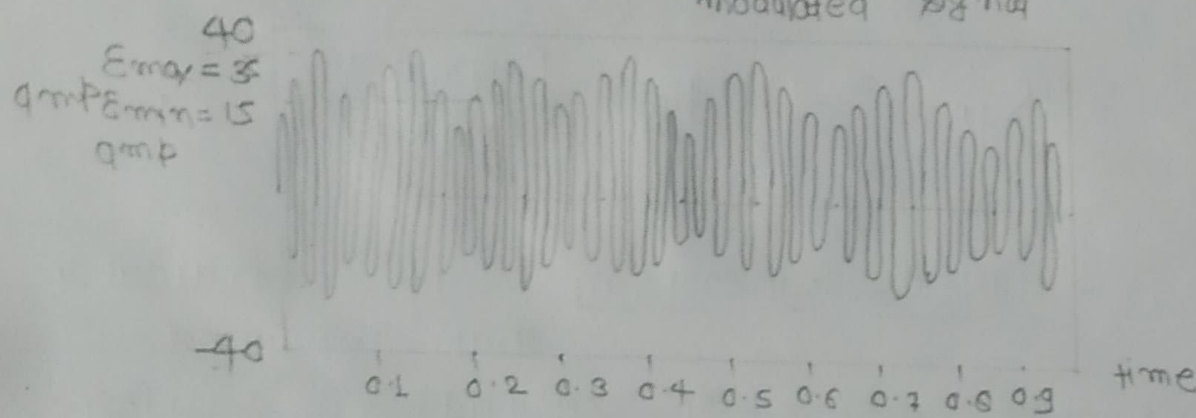
carrier signal



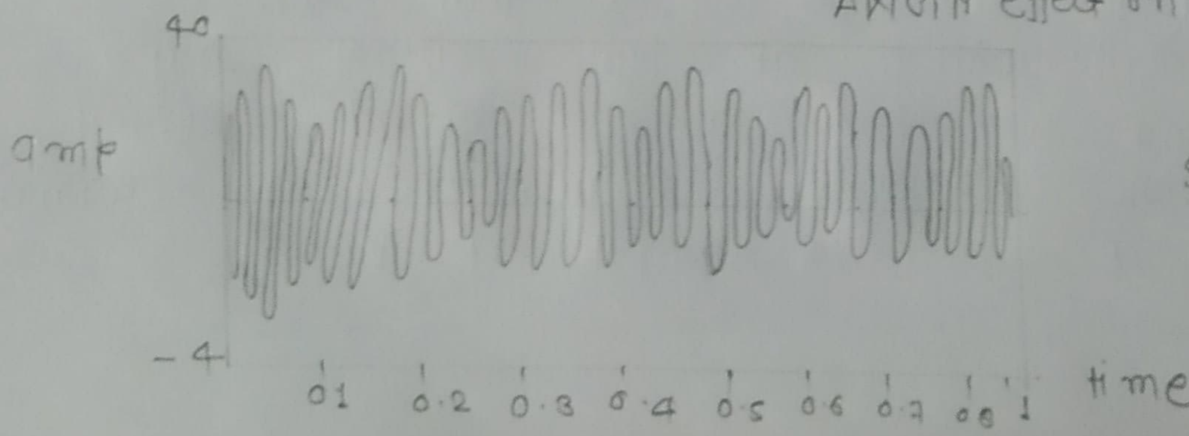
$V_c = 25$

$f_c = 40$

modulated signal

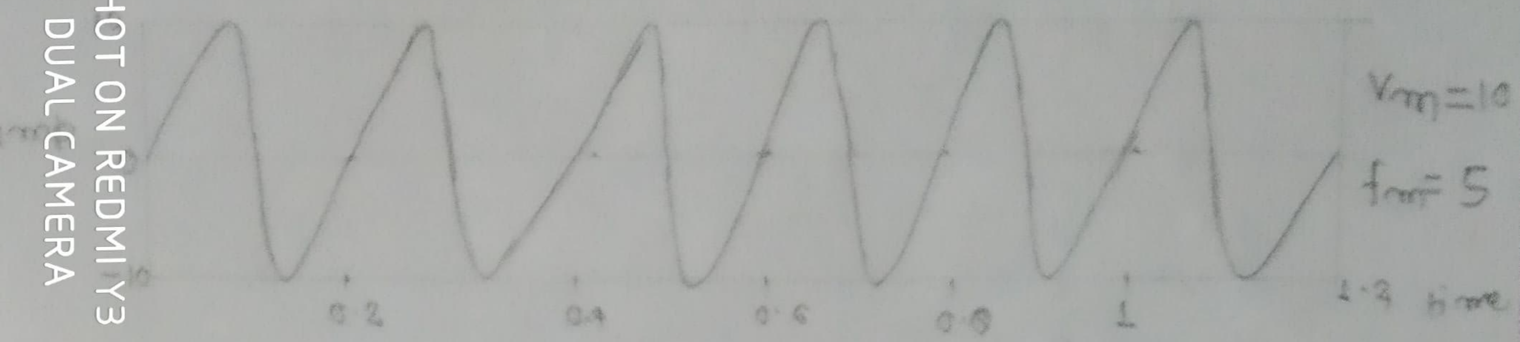


AWGN effect on Arq

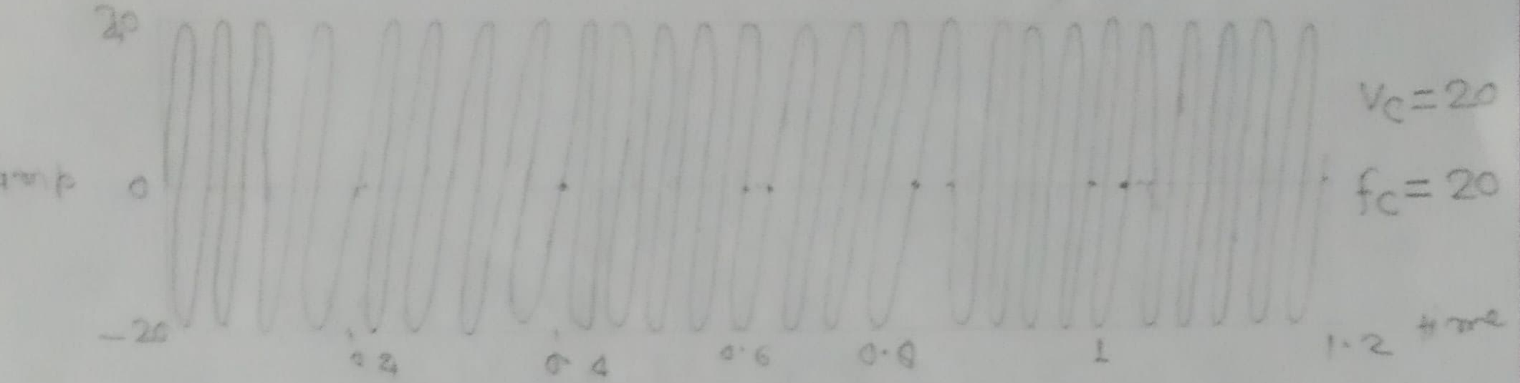


SNR → 40

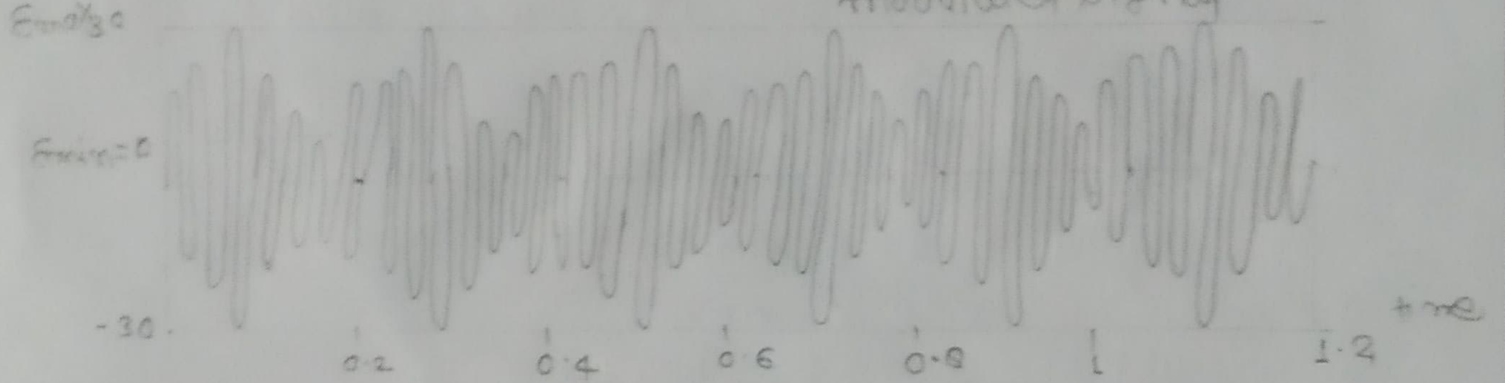
message signal



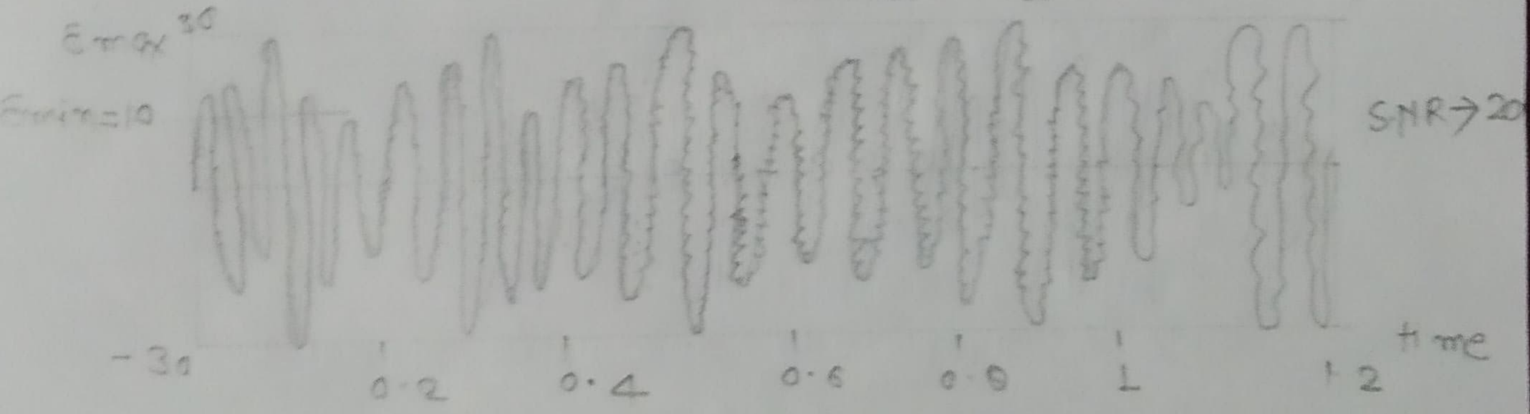
carrier signal



modulated signal



AWGN effect on AM



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Matlab code for AWGN effect over FM

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```
clc;
fm= 5;
fc = 20;
Vm= 10;
Vc = 20;
m= Vm* Sin(2* Pi * fm * t);
C= Vc * Sin(2* Pi* fc *t);
fm= Vc* Sin(2*Pi *fc *t + 10* Cos(2*Pi* fm*t));
y = awgn (fm, 25, 'measured');
subplot (4,1,1);
plot ( t, m);
xlabel ('time');
ylabel ('amplitude');
title ('message signal');
Subplot (4,1,2);
plot ( t, c);
xlabel ('time');
ylabel ('amplitude');
title (' carrier signal');
Subplot (4,1,3);
plot ( t, fm);
xlabel ('time');
ylabel ('amplitude');
title(' modulated signal');
```

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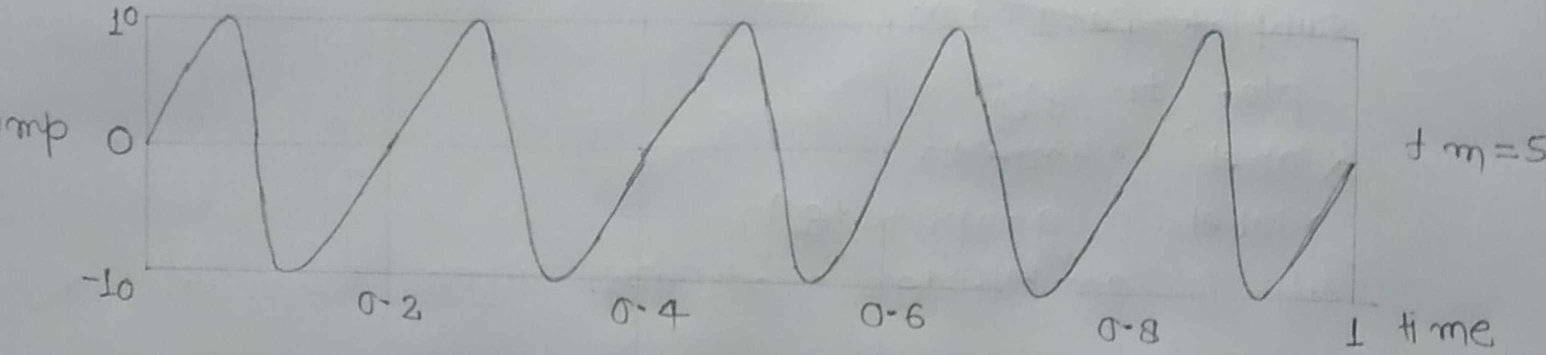
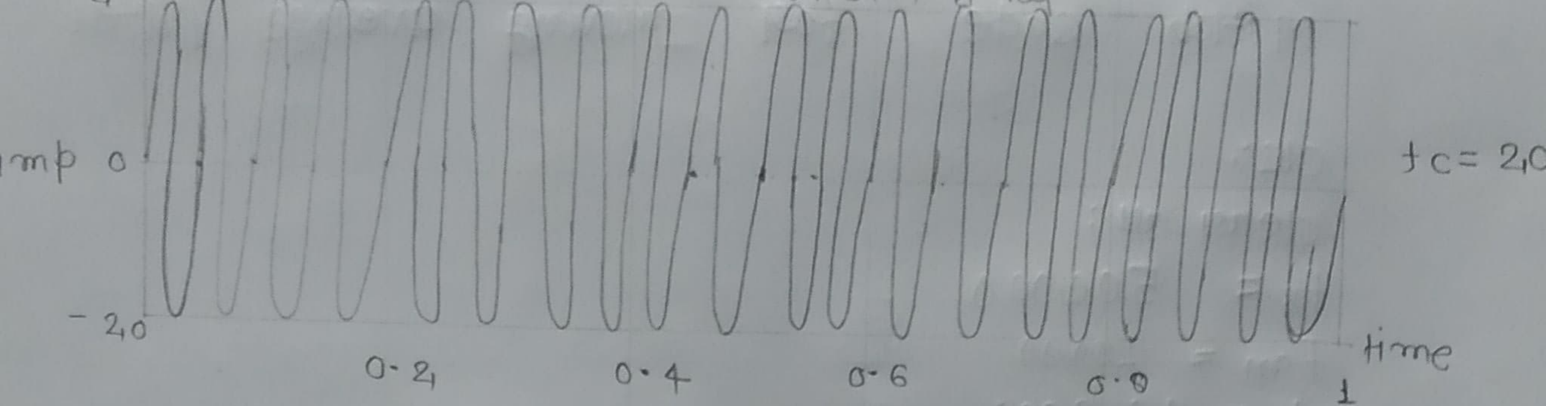
```
subplot (4,1,4);
 plot( t,  y);
x label ('time');
 y label (' amplitude');
title ( 'amplitude modulated signal with AWGN')
```

D) FM

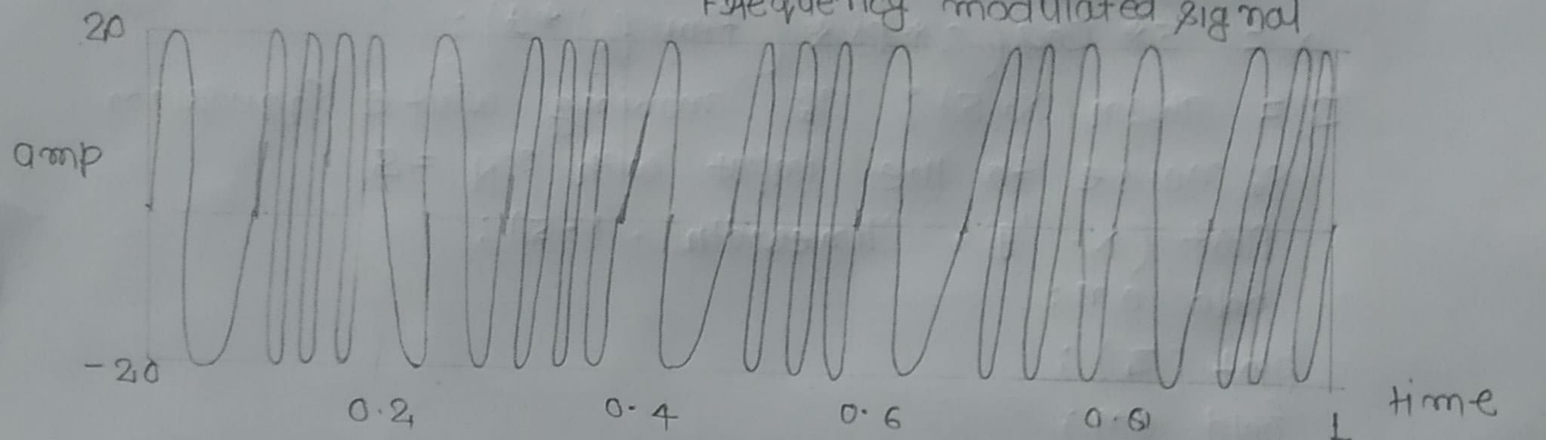
message signal



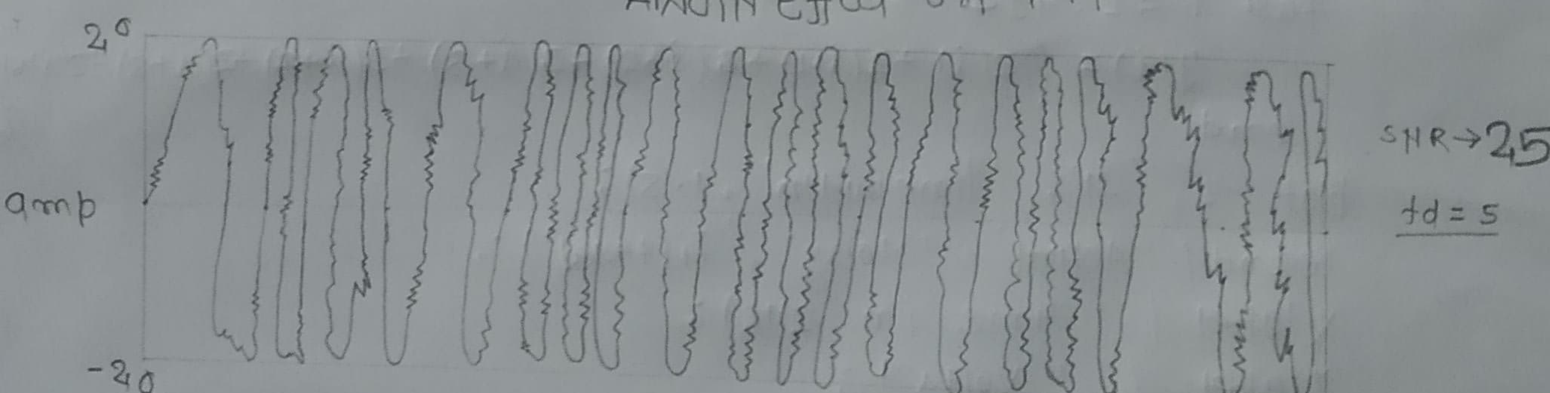
carrier signal



Frequency modulated signal



AWGN effect on FM

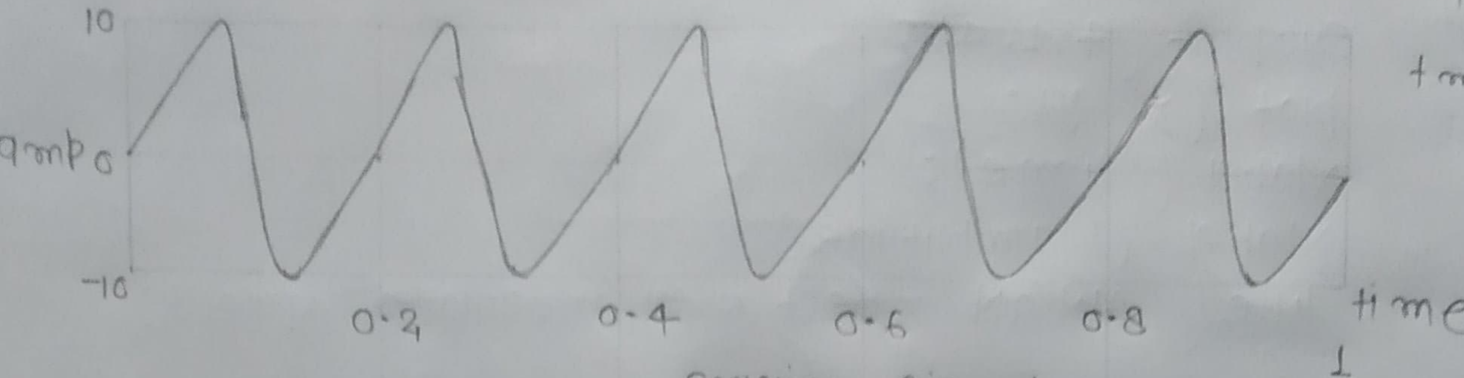


2)

message signal

$V_m = 10$

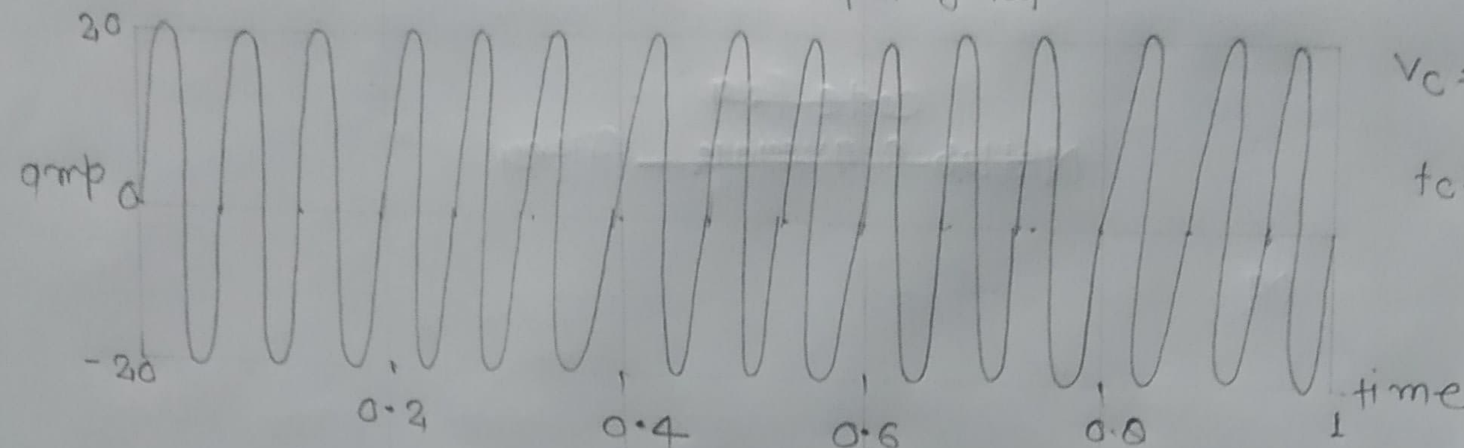
$f_m = 5$



carrier signal

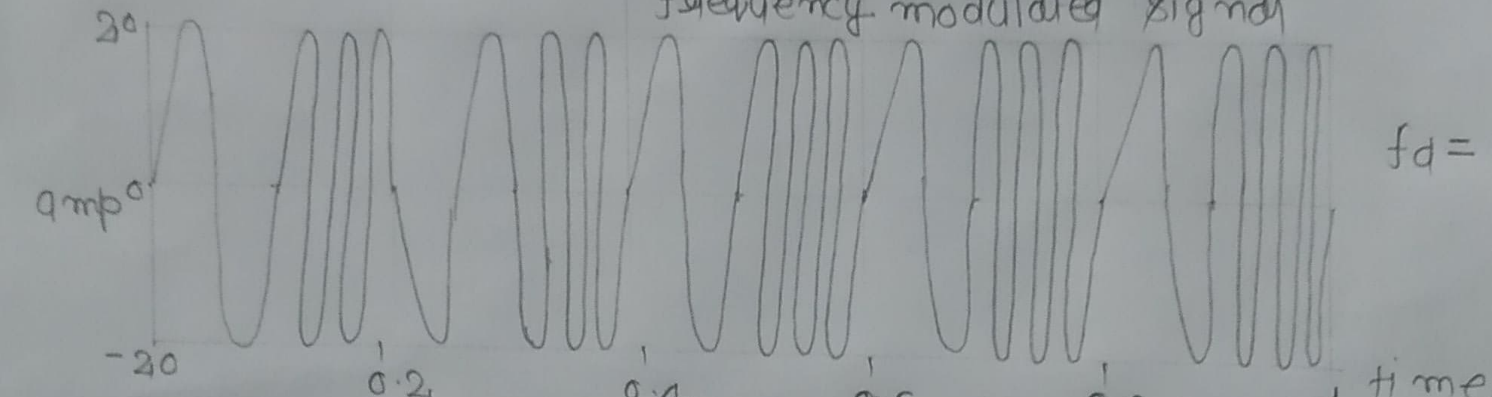
$V_c = 20$

$f_c = 15$



frequency modulated signal

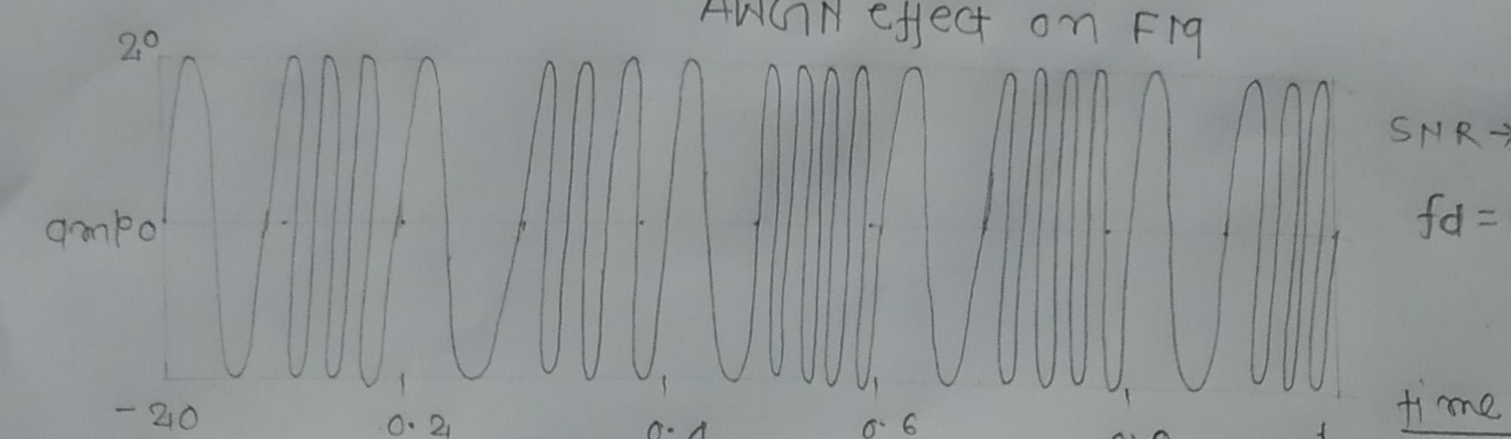
$f_d = 10$



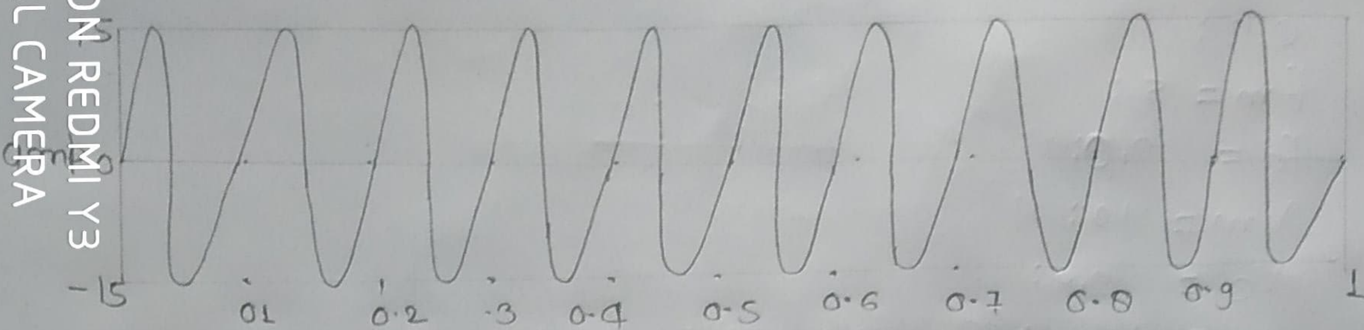
AWGN effect on FM

SNR → 40

$f_d = 10$



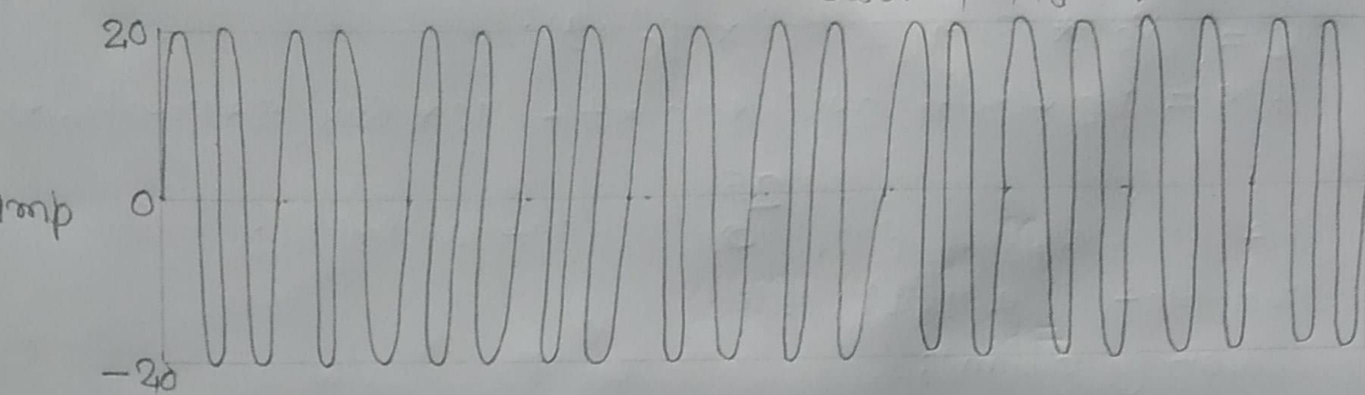
message signal



$V_m = 15$

$f_m = 10$

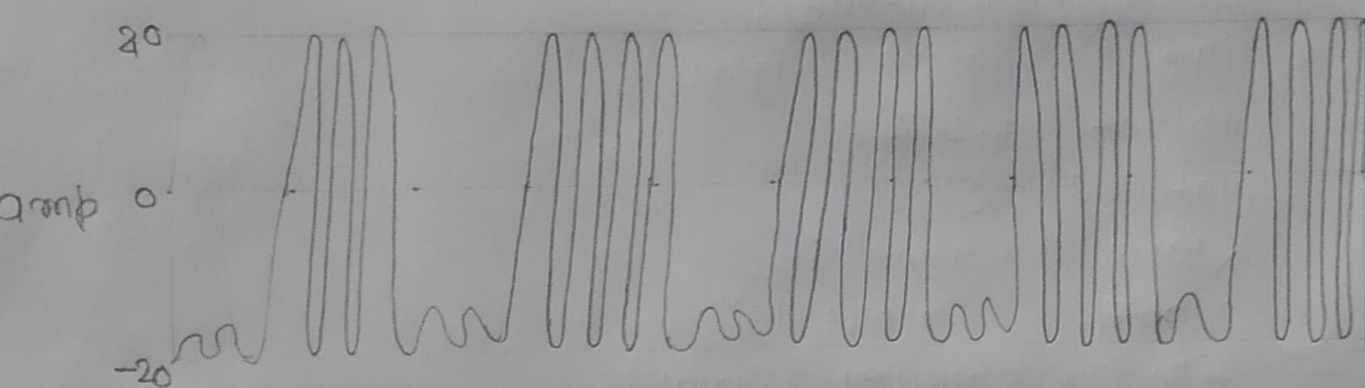
carrier signal



$V_c = 20$

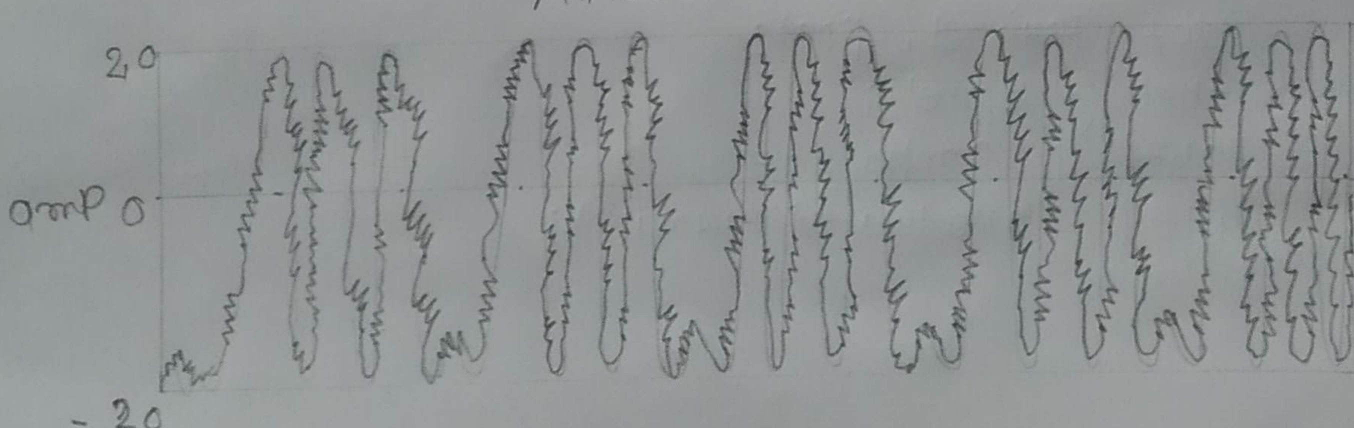
$f_c = 20$

frequency modulated signal



$f_d = 4$

AWGN effect on FM



SNR → 20

$f_d = 4$

Matlab code for moving average filter

```
clc;
clear all;
fs = 500000
fm = 10000
t = 1: 200;
x = 5* cos( 2* pi * (fm/fs) *t);
z = awgn(x, 5); % moving white Gaussian
% noise to the input with S/N = 5
plot (x, 'g', 'linewidth', 1.5);
hold on;
plot (z);
hold on;
for i = 1: 194
    y(i)= (z(i) +z(i+1) +z(i+2) +z(i+3) +z(i+4) +z(i+5) +z(i+6))/6
end
plot (y, 'r', 'linewidth', 1.5);
legend('Actual', 'Noisy', 'Filtered');
x label (' time in 2ys);
y label ( ' Volts');
title ('moving Average filter');
```

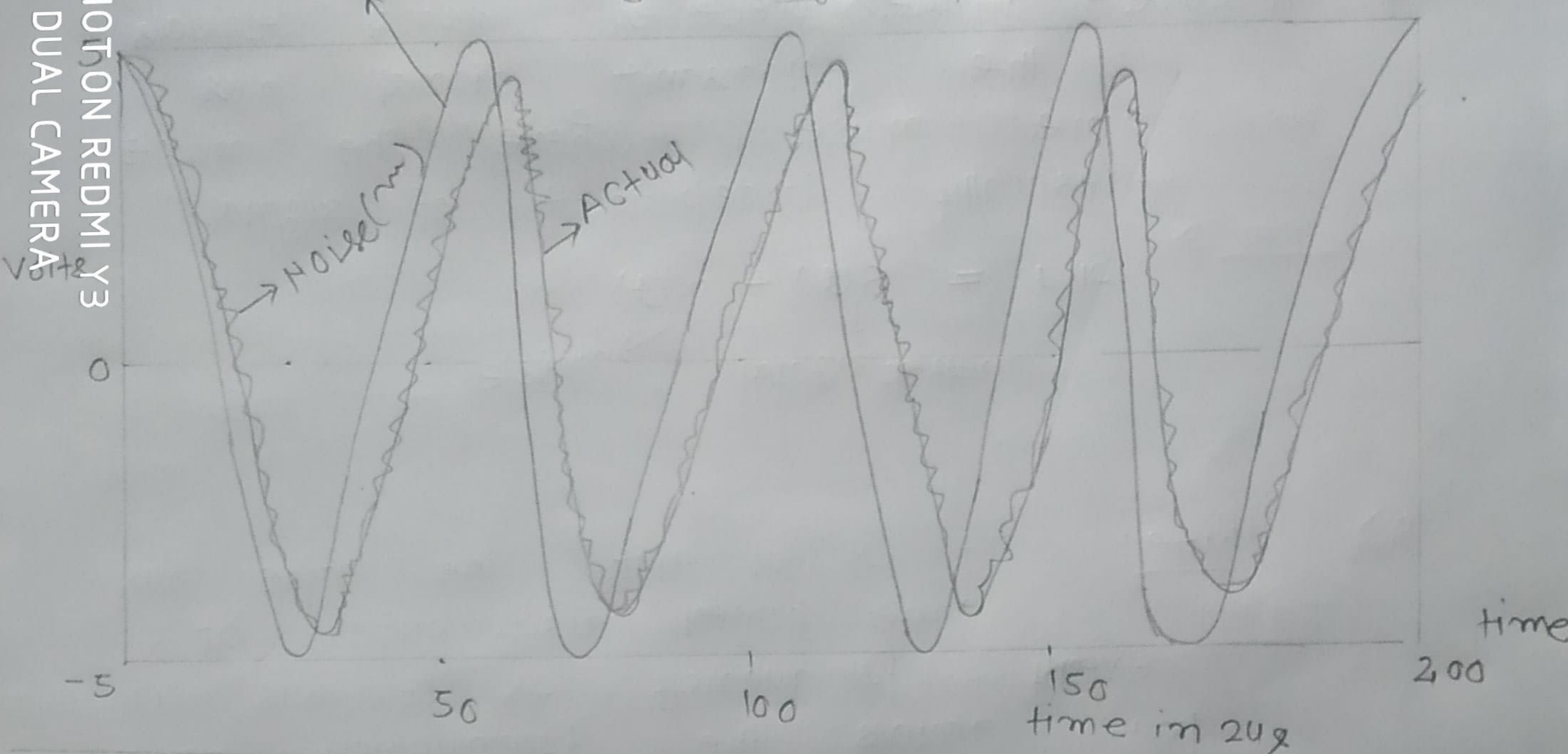
1)

$f_s = 500000$

$f_m = 10000$

$SNR = 10$

moving Average Filter



2)

$f_s = 400000$

$f_m = 10000$, $SNR = 5$

moving Average Filter