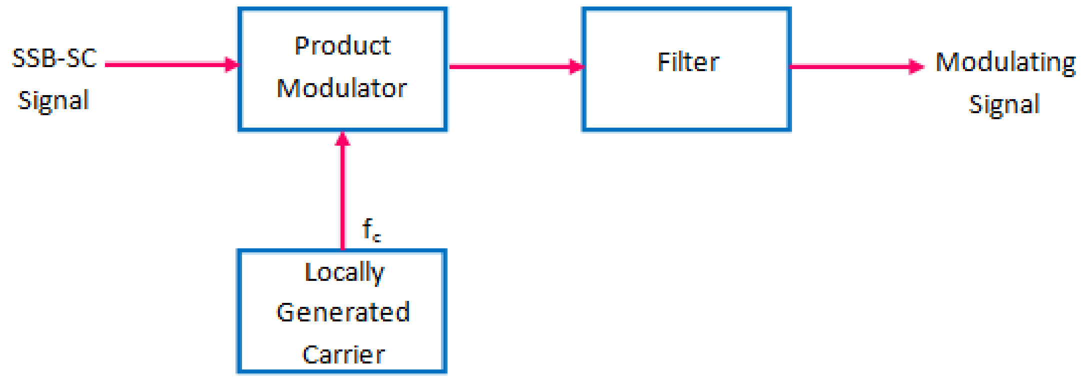
<u>EXPERIMENT</u> – <u>3</u>

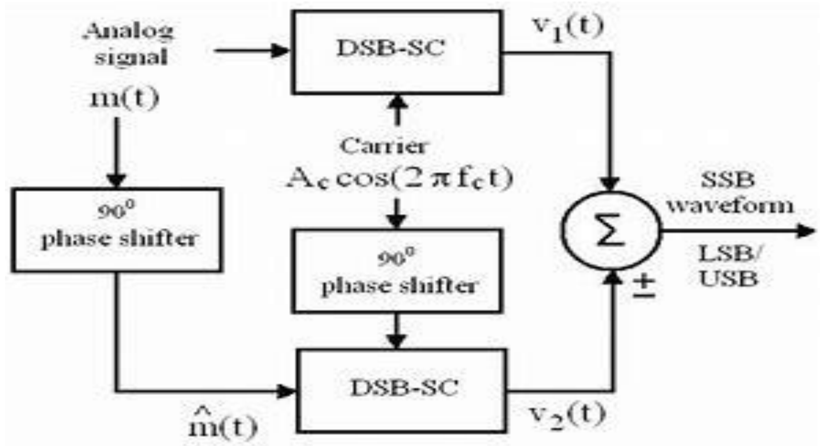
AIM

TO GENERATE SINGLE SIDEBAND SIGNAL FOR A GIVEN MODULATING SIGNAL AND CARRIER SIGNAL AND DEMODULATION OF SINGLE SIDEBAND SIGNAL.
(USING SIMULATION TOOLS: MAT LAB AND SIMULINK)

BLOCK DIAGRAM



SSB MODULATION



SSB DEMODULATION

THEORY

It is an also a type of amplitude modulation and similar like double sideband suppressed carrier but in this only one sideband is given as modulated signal i.e. either LOWER or UPPER SIDEBAND.
It is used for removing lower side band or upper sideband for making the bandwidth efficient, i.e half the bandwidth.
In DSB-SC AM there is both **LOWER SIDEBAND (LSB)** and **UPPER SIDEBAND (USB)**, if the DSB-SC AM signal is suppressed as a result it gives either LSB or USB, such scheme in which only one sideband is transmitted is known as **SINGLE SIDEBAND TRANSMISSION**.

Message signal m(t).

In SSB there is a message signal of a low frequency and as the amplitude is directly proportional to message signal m(t).

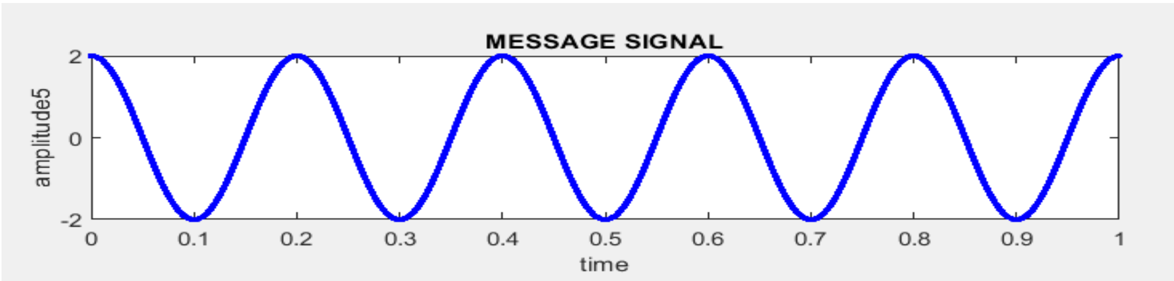
Mathematical expression for message signal is:

$$\boxed{m(t) = A_m * \cos(2\pi f_m t)}$$

where A_m = Amplitude of message signal, f_m = Frequency of message signal

EXAMPLE OF MESSAGE SIGNAL GENERTAED USING MATLAB:

```
ENTER THE AMPLITUDE OF MESSAGE SIGNAL : 2
ENTER THE FREQUENCY OF MESSAGE SIGNAL : 5
```



CARRIER SIGNAL c(t)

Carrier signal can be defined as a high frequency signal that is modulated by the modulating or the information signal. This carrier signal increases the range and distance the information signal can travel.

Mathematical expression for message signal is:

$$\boxed{c(t) = A_c * \cos(2\pi f_c t)}$$

where A_c = Amplitude of carrier signal, f_c = Frequency of carrier signal

EXAMPLE OF CARRIER SIGNAL GENERTAED USING MATLAB:

```
ENTER THE AMPLITUDE OF CARRIER SIGNAL : 10
ENTER THE FREQUENCY OF CARRIER SIGNAL : 50
```

MODULATED SIGNAL Ψ(t)

In the SSB MODULATION, the modulating signal and carrier signal is passed from modulator (for product 1) , also modulating signal is pass from the process of Hilbert transformation to give shifted modulating signal($m_h(t)$). This shifted modulating signal and shifted carrier signal (shifted by pi/2) is passed from the modulator (for product 2).

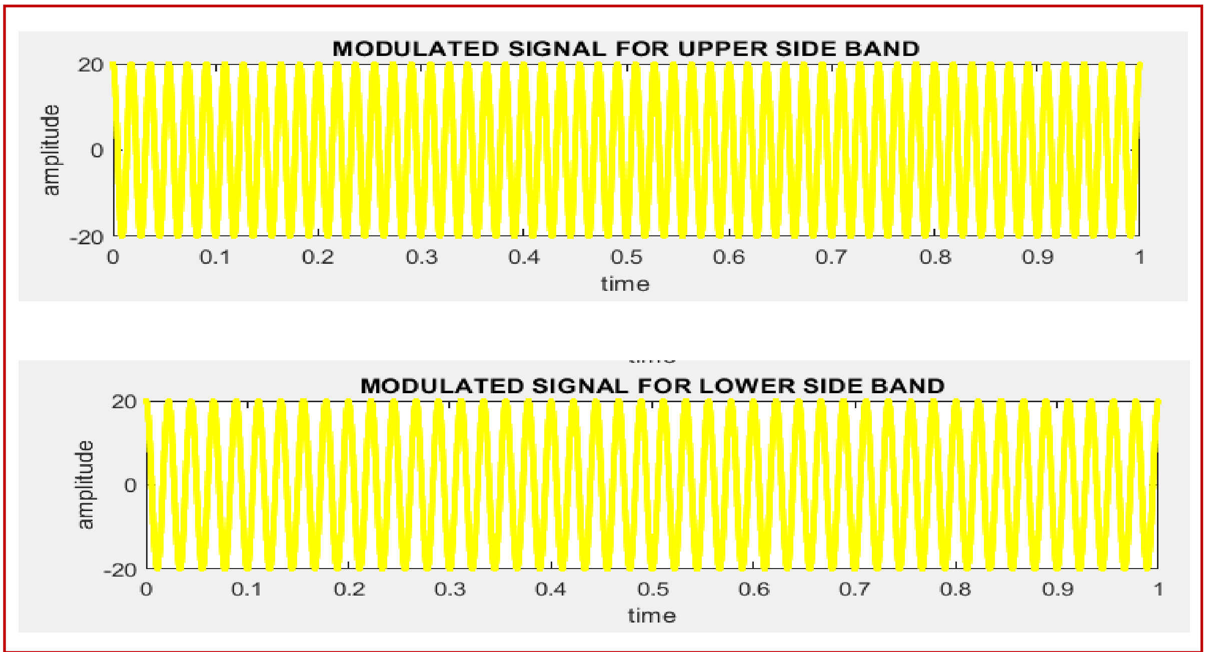
The product 1 and product 2 is added for producing LOWER SIDEBAND (LSB) MODULATED SIGNAL.

The product 1 and product 2 is subtracted for producing LOWER SIDEBAND (LSB) MODULATED SIGNAL.

Mathematical expression for modulated signal is:

$$\Psi_{USB}(t) = m(t)*\cos(2*pi*Fc*t) - m_h(t)*\sin(2*pi*Fc*t)$$
$$\Psi_{LSB}(t) = m(t)*\cos(2*pi*Fc*t) + m_h(t)*\sin(2*pi*Fc*t)$$
$$\Psi_{SSB}(t) = m(t)*\cos(2*pi*Fc*t) \pm m_h(t)*\sin(2*pi*Fc*t)$$

EXAMPLE OF MODULATED SIGNAL (LSB AND USB)OF ABOVE MESSAGE SIGNAL AND CARRIER SIGNAL GENERTAED USING MATLAB:



DEMODULATED SIGNAL d(t)

The demodulation of SSB MODULATED SIGNAL is same as the DSB-SC.

The demodulation of modulated signal is done by multiplying the incoming carrier signal at receiver side, the incoming carrier signal should be synchronized with the carrier signal of modulated signal.

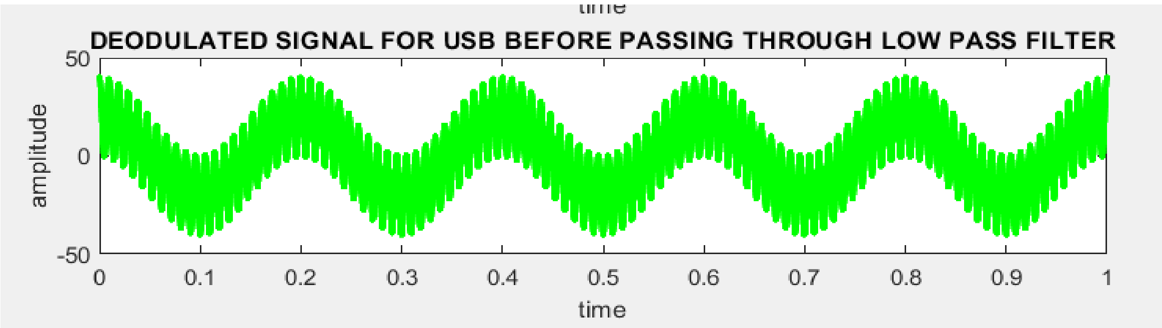
After that the signal is passes through the low pass filter that filtrates the low frequency signal (message signal) from the high frequency signal (carrier signal).

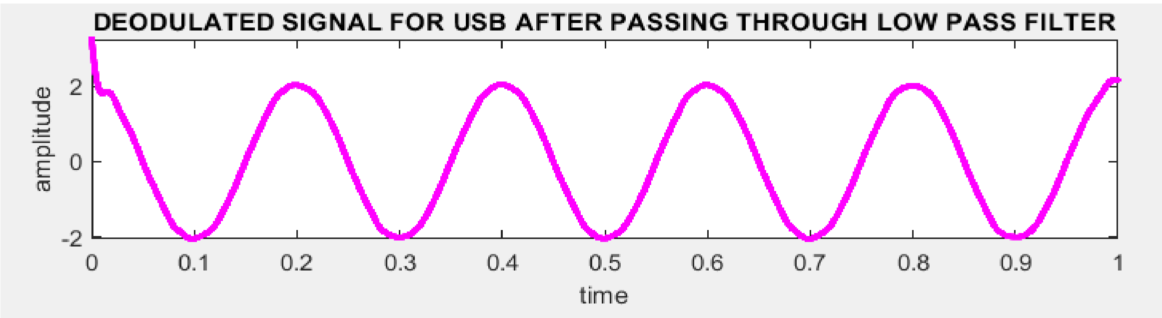
Mathematical expression for demodulation of signal is given as:

$$d_{ssb}(t) = \Psi_{SSB}(t)*\cos(2*pi*Fc*t)$$
$$= (m(t)*\cos(2*pi*Fc*t) \pm m_h(t)*\sin(2*pi*Fc*t))*\cos(2*pi*Fc*t)$$

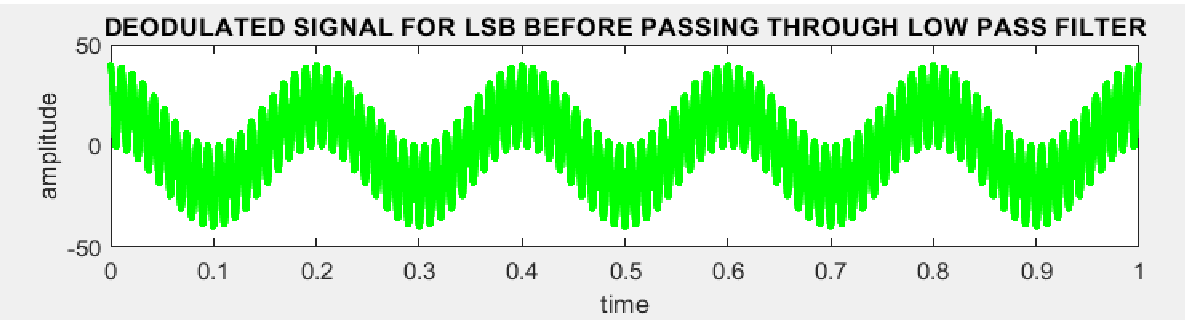
EXAMPLE OF DEMODULATED SIGNAL (LSB AND USB)OF ABOVE MESSAGE SIGNAL AND CARRIER SIGNAL GENERTAED USING MATLAB:

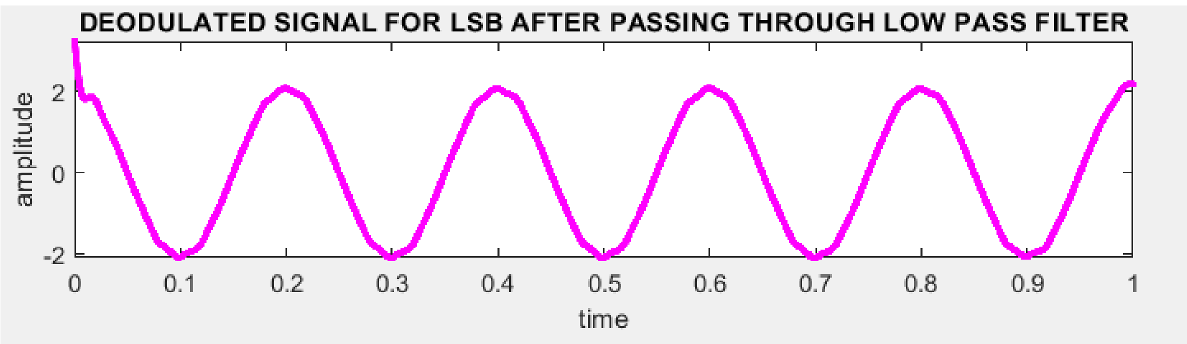
UPPER SIDE BAND (USB)





LOWER SIDE BAND (LSB)





MATLAB CODE

Editor - C:\Users\PREDEEP KUMAR\Documents\MATLAB\SSB.m

SSB.m

```matlab
Am = input('ENTER THE AMPLITUDE OF MESSAGE SIGNAL : ');
Fm = input('ENTER THE FREQUENCY OF MESSAGE SIGNAL : ');
Ac = input('ENTER THE AMPLITUDE OF CARRIER SIGNAL : ');
Fc = input('ENTER THE FREQUENCY OF CARRIER SIGNAL : ');
Fs=200e3;
T = 1/Fs;
t = 0:T:1-T;
MS = Am.*cos(2*pi*Fm*t);
MH = Am.*sin(2*pi*Fm*t);
CS = Ac.*cos(2*pi*Fc*t);
CH =Ac.*sin(2*pi*Fc*t);
M1=MS.*CS;
M2=MH.*CH;
USB = M1-M2;
LSB = M1+M2;
DM1 =USB.*(2*cos(2*pi*Fc*t));
DM2= LSB.*(2*cos(2*pi*Fc*t));
[b,a]=butter(5,Fc*2/Fs);
Y1=DM1/Ac;
Y1=filtfilt(b,a,Y1);
Y2=DM2/Ac;
Y2=filtfilt(b,a,Y2);
subplot(421);
plot(t,MS,".-","Color","b");
xlabel('time');
ylabel('amplitude5');
title('MESSAGE SIGNAL');
subplot(422);
plot(t,CS,".-","Color","r");
xlabel('time');
ylabel('amplitude');
title('CARRIER SIGNAL');
subplot(423);
plot(t,USB,".-","Color","y");
xlabel('time');
ylabel('amplitude');
title('MODULATED SIGNAL FOR UPPER SIDE BAND');
subplot(424);
plot(t,LSB,".-","Color","y");
xlabel('time');
ylabel('amplitude');
title('MODULATED SIGNAL FOR LOWER SIDE BAND');
subplot(425);
plot(t,DM1,".-","Color","g");
xlabel('time');
ylabel('amplitude');
title('DEODULATED SIGNAL FOR USB BEFORE PASSING THROUGH LOW PASS FILTER');
subplot(426);
plot(t,DM2,".-","Color","g");
xlabel('time');
ylabel('amplitude');
title('DEODULATED SIGNAL FOR LSB BEFORE PASSING THROUGH LOW PASS FILTER');
subplot(427);
plot(t,Y1,".-","Color","m");
xlabel('time');
ylabel('amplitude');
title('DEODULATED SIGNAL FOR USB AFTER PASSING THROUGH LOW PASS FILTER');

subplot(428);
plot(t,Y2,".-","Color","m");
xlabel('time');
ylabel('amplitude');
title('DEODULATED SIGNAL FOR LSB AFTER PASSING THROUGH LOW PASS FILTER');
```