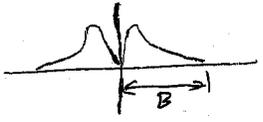


# Single sideband

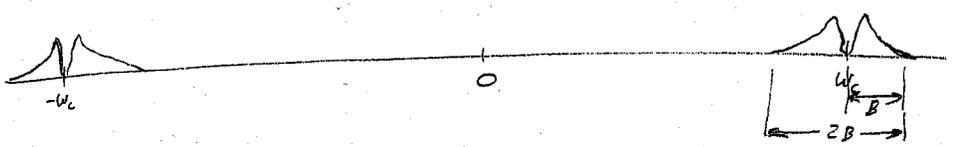
5B-1

There are two sidebands -  
We don't need both.

Baseband:



DSB-SC



Simple way:

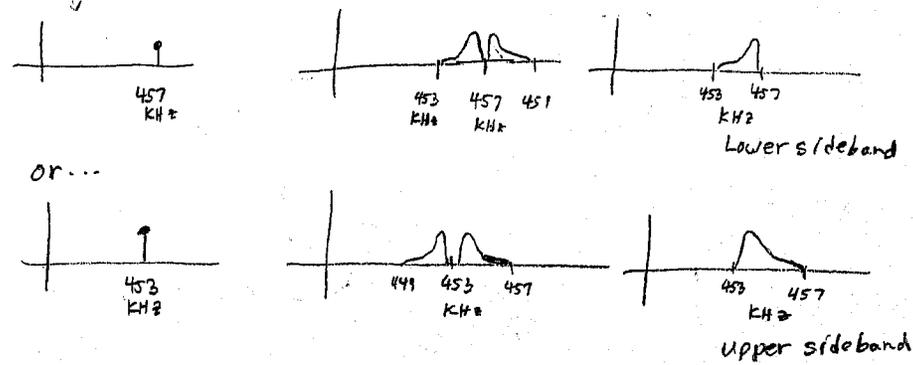
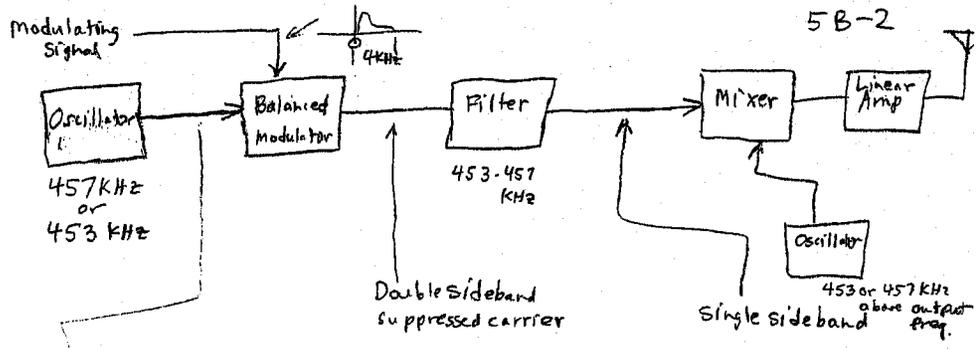
Use a bandpass filter to allow only one to pass -



This needs to be a very good filter -  
as good as the receiver's filter.

How to tune?

Superheterodyne transmitter?



Block diagram of filter type single sideband transmitter,  
(most common type).

Often - the IF is higher -- 9 MHz is common.

The filter is usually a crystal filter -  
very high Q, critical design.

Receiving - use synchronous detection as with DSB.  
Not necessary to match phase -

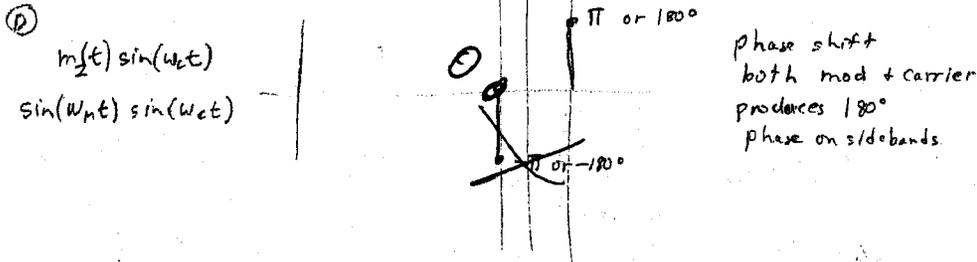
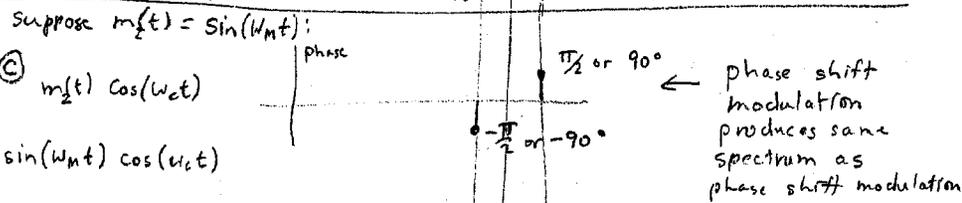
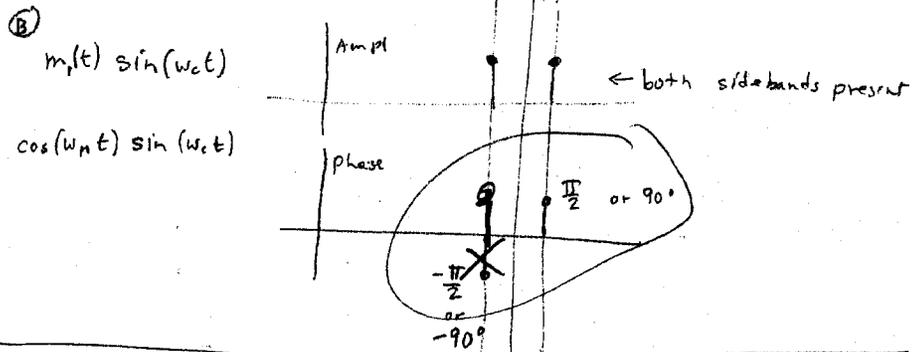
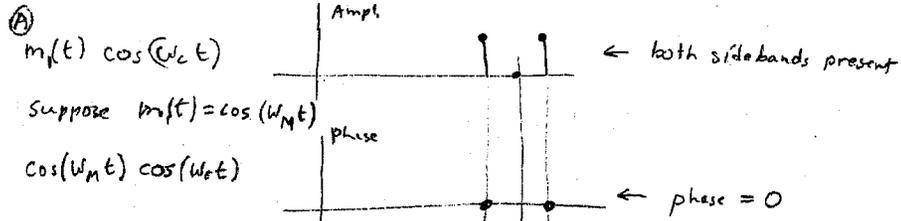
More details later.

Math. analysis of SSB.

5B-3

leads to phase shift method of generating SSB.

Look at the spectrum of QAM:



5B-4

What happens when we add them? - Ⓐ + Ⓓ

$$\cos(\omega_M t) \cos(\omega_c t) + \sin(\omega_M t) \sin(\omega_c t)$$

In frequency domain:

$$\text{at } \omega_c + \omega_M: 1 \angle 0 + \frac{-1}{\angle 180^\circ} = 0 \leftarrow \text{upper sideband suppressed}$$

$$\text{at } \omega_c - \omega_M: 1 \angle 0 + 1 \angle 0 = 1 + 1 = 2 \leftarrow \text{lower sideband passed.}$$

To pass the upper sideband, change the sign of one:

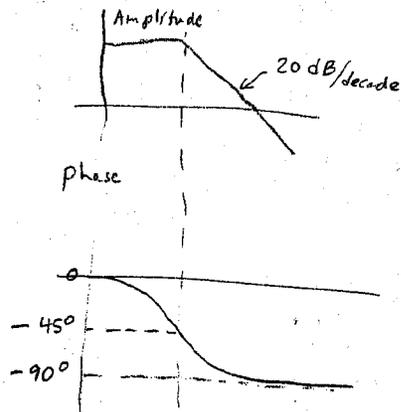
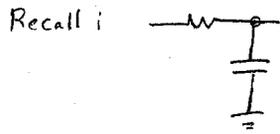
$$\text{at } \omega_c + \omega_M: \frac{-1}{\angle 180^\circ} + \frac{-1}{\angle 180^\circ} = 2 \angle 180^\circ \leftarrow \text{upper sideband passed}$$

$$\text{at } \omega_c - \omega_M: 1 \angle 180^\circ + 1 \angle 0 = 0 \leftarrow \text{lower sideband suppressed.}$$

# How to generate the 90° phase shift!

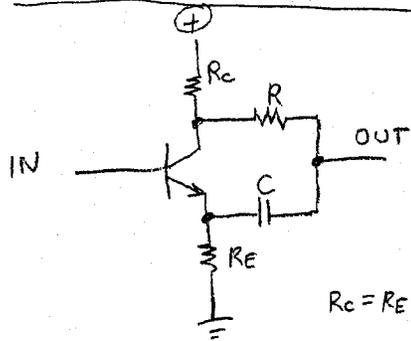
5B-5

At one frequency:



Doesn't quite get there -

Amplitude response varies. This isn't it.



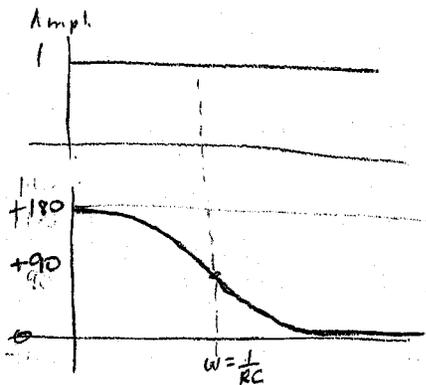
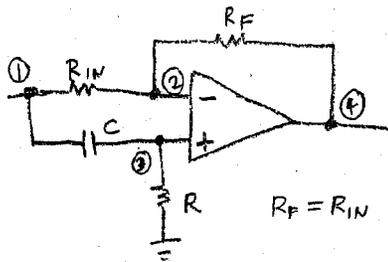
Either of these works!

Low freq: inverted phase from collector

High freq: in phase from emitter

at  $\omega = \frac{1}{RC}$ ; +90°

All-pass filter



Analysis:

5B-6

at node 2:  $\frac{V_1 - V_2}{R_{IN}} + \frac{V_4 - V_2}{R_F} = 0$

at node 3:  $(V_1 - V_3)C_S + \frac{V_3}{R} = 0$

$V_3 = V_2, R_{IN} = R_F$ :

2:  $\frac{V_1 - V_2}{R_F} + \frac{V_4 - V_2}{R_F} = 0$

3:  $(V_1 - V_2)C_S + \frac{V_2}{R} = 0$

Solve for  $V_2$ :

2:  $\frac{V_1 - V_2 + V_4 - V_2}{R_F} = 0$

$V_1 - V_2 + V_4 - V_2 = 0$

$V_1 + V_4 = 2V_2$

$V_2 = \frac{V_1 + V_4}{2}$

3:  $V_1 C_S - V_2 C_S + \frac{V_2}{R} = 0$

$V_1 C_S = V_2 C_S - \frac{V_2}{R}$

$V_1 C_S = V_2 (C_S - \frac{1}{R})$

$V_2 = \frac{V_1 C_S}{C_S - \frac{1}{R}}$

Substitute:

$\frac{V_1 + V_4}{2} = \frac{V_1 C_S}{C_S - \frac{1}{R}}$

Substitute:

$\frac{V_1 + V_4}{2} = \frac{V_1 C_S}{C_S - \frac{1}{R}}$

$V_1 + V_4 = \frac{2V_1 C_S}{C_S - \frac{1}{R}}$

$V_4 = \frac{2V_1 C_S}{C_S - \frac{1}{R}} - V_1$   
 $= V_1 \left( \frac{2C_S}{C_S - \frac{1}{R}} - 1 \right)$

$\frac{V_4}{V_1} = \frac{2C_S}{C_S - \frac{1}{R}} - 1$

$= \frac{2C_S - C_S + \frac{1}{R}}{C_S - \frac{1}{R}}$

$= \frac{C_S + \frac{1}{R}}{C_S - \frac{1}{R}}$

$\frac{V_4}{V_1} = \frac{s + \frac{1}{RC}}{s - \frac{1}{RC}}$

90° phase shift over wide band:

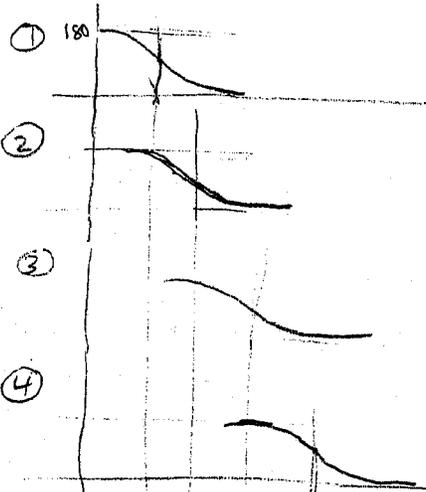
5B-7

- Can't do it -

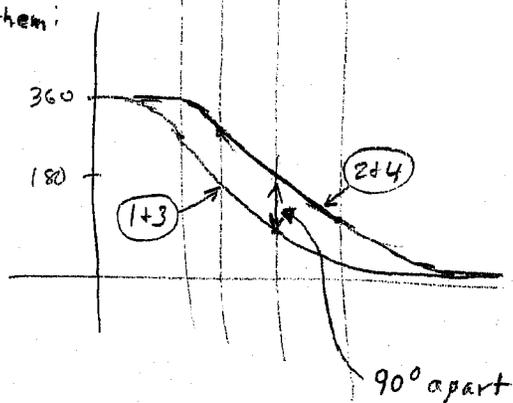
However - Use the network described 5B-5 -  
several of them -

to provide 2 signals that differ by 90°

use 4 filters:

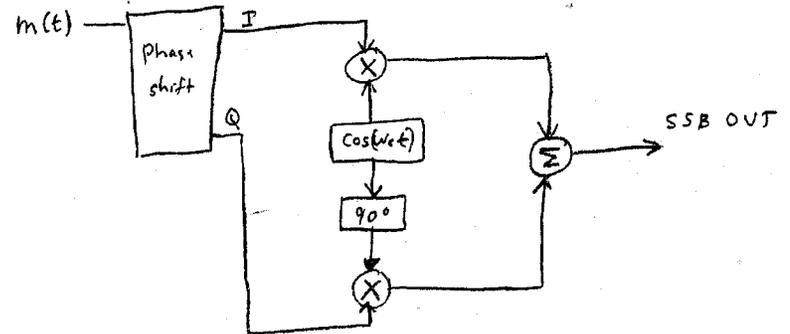


combine them:



Phasing type transmitter ...

5B-8



Usually, a heterodyne system is used,  
so SSB is generated at an IF,  
then shifted to the desired frequency.  
That way, for the modulator,  $\omega_c$  is always the same.

The phasing method is sometimes used in  
receivers, too. (but rarely)