Amplitude Modulation (part three)

EE202

yanyan.wu@xjtlu.edu.cn

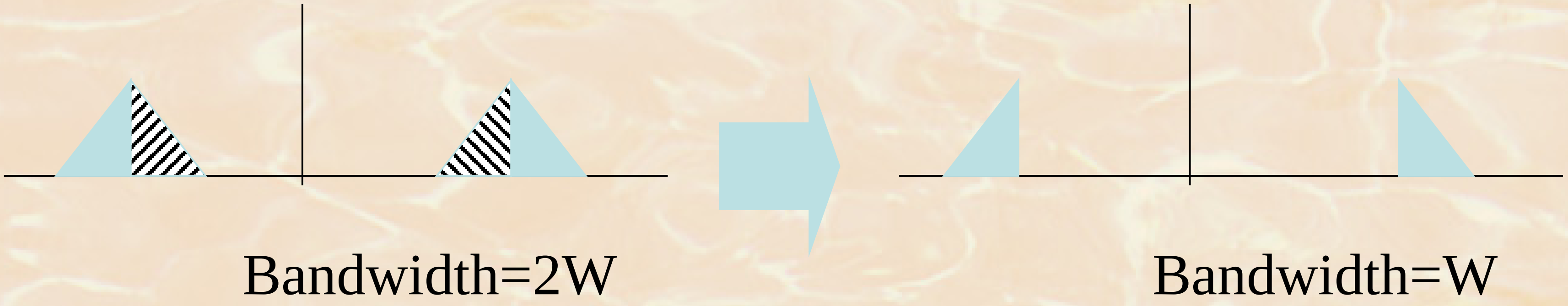
Department of Electronics and Electrical Engineering
Xi'an Jiaotong – Liverpool University

Lecture four

Single-side band modulation (SSB)

Single Sideband (SSB)

- The two sidebands are identical.
- Only one is sufficient to carry all the message information.
- Block either the upper or lower sideband to save BW!



Expression for SSB-AM

Assume that $m(t) = A_m \cos(2\pi f_m t)$

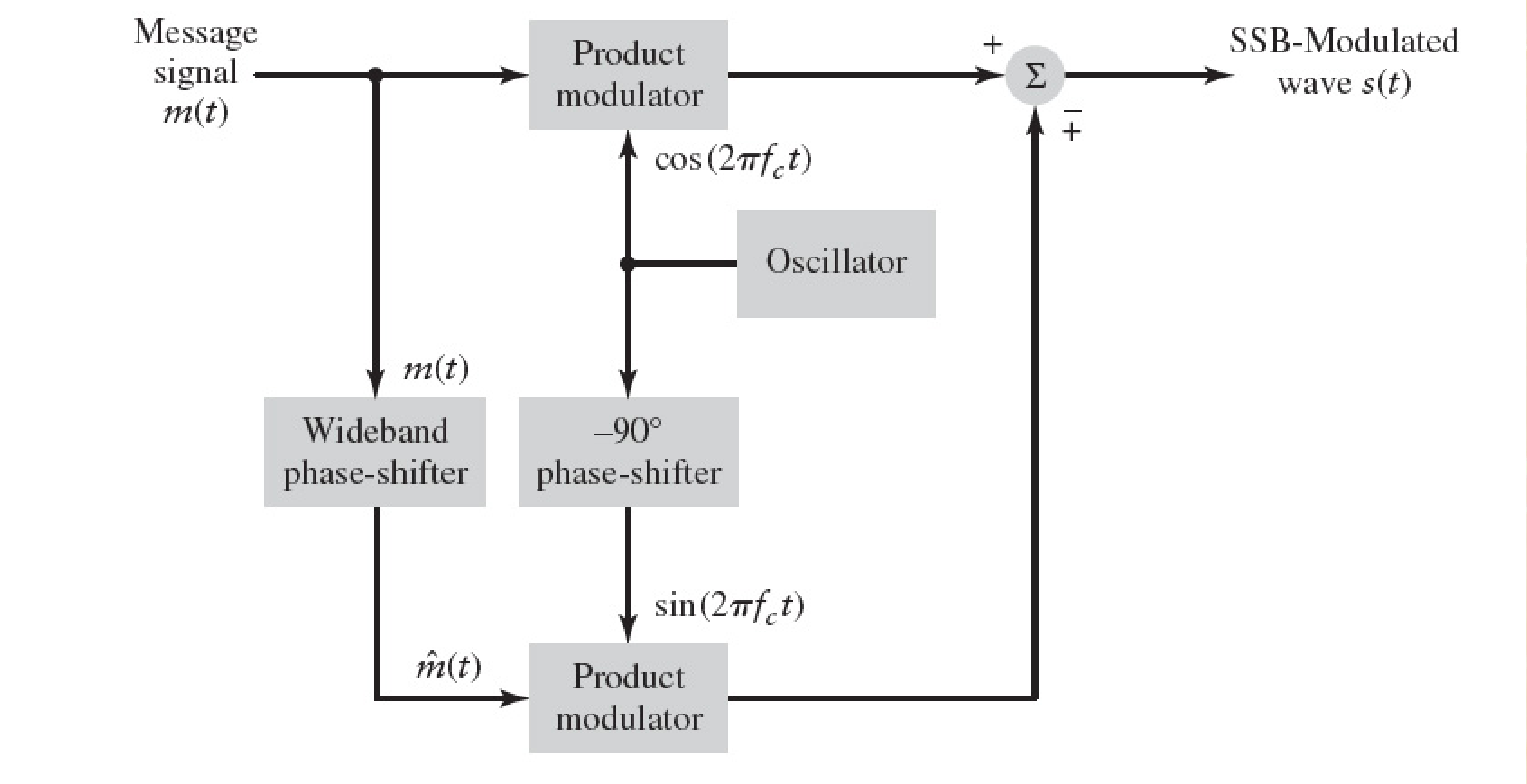
$$s_{DSB-SC} = m(t)A_c\cos(2\pi f_c t) = A_c A_m \cos(2\pi f_c t)\cos(2\pi f_m t)$$
$$= \frac{1}{2}A_c A_m \cos[2\pi(f_c + f_m)t] + \frac{1}{2}A_c A_m \cos[2\pi(f_c - f_m)t]$$

$$s_{USSB}(t) = \frac{1}{2}A_c A_m \cos[2\pi(f_c + f_m)t]$$
$$= \frac{1}{2}A_c A_m \cos(2\pi f_m t)\cos(2\pi f_c t) - \frac{1}{2}A_c A_m \sin(2\pi f_m t)\sin(2\pi f_c t)$$

In general ,

$$s_{USSB}(t) = \frac{A_c}{2}m(t)\cos(2\pi f_c t) - \frac{A_c}{2}\hat{m}(t)\sin(2\pi f_c t)$$
$$where \qquad \hat{M}(f) = -j\,\mathrm{sgn}(f)M(f)$$

Modulators for SSB (a)



SSB: coherent detection

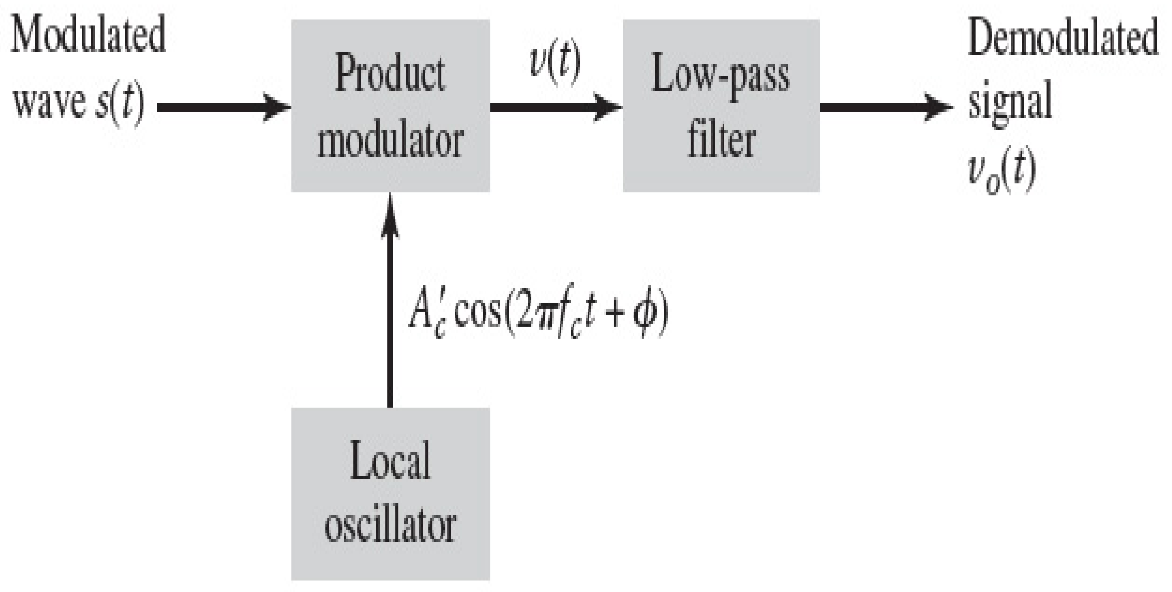


FIGURE 3.12 Block diagram of coherent detector, assuming that the local oscillator is out of phase by ϕ with respect to the sinusoidal carrier oscillator in the transmitter.

For coherent demodulation , we can assume $\phi = 0$

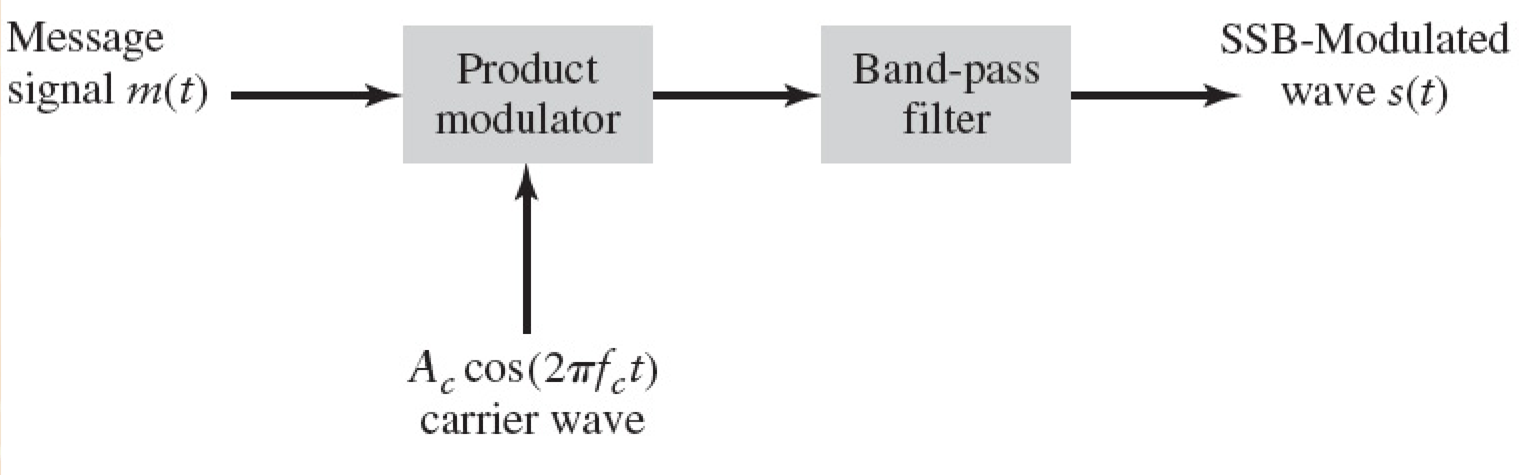
Class activity

- Drill problem

Verify the outputs from the receiver are as indicated in the figure, assuming perfect synchronization between the transmitter and the receiver.

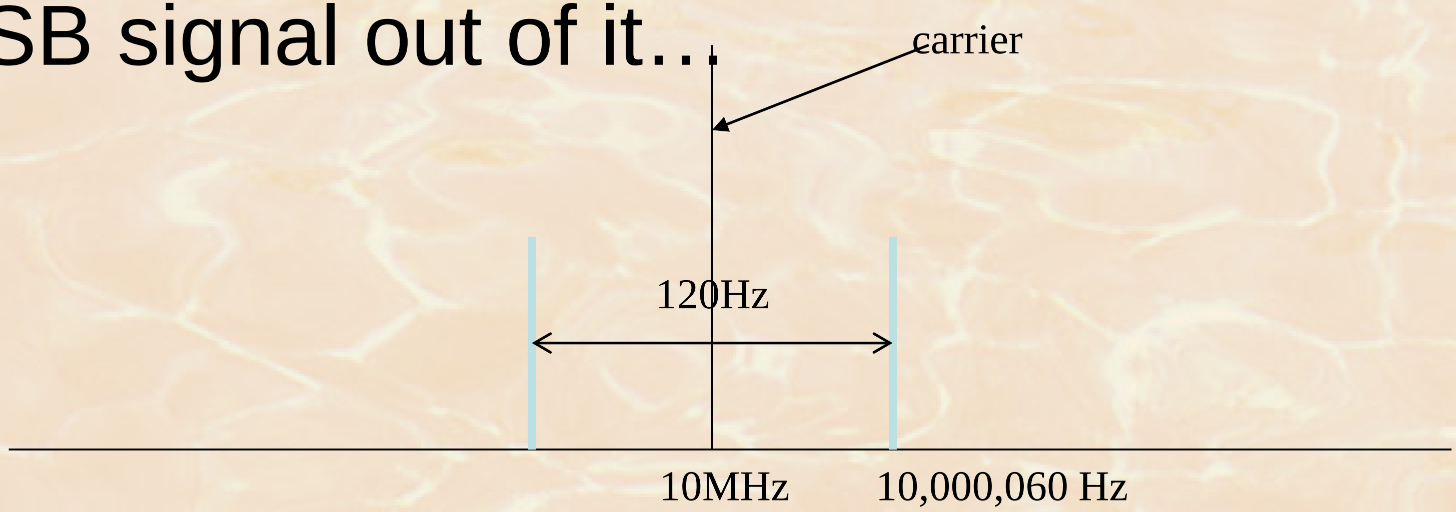
Modulators for SSB (b)

One way to generate an SSB signal is through selective filtering



Issues in Sideband Suppression

Consider a tone modulated signal with carrier frequency of 10MHz, and message frequency of 60Hz. We want to make an SSB signal out of it…



Required Filter Sharpness

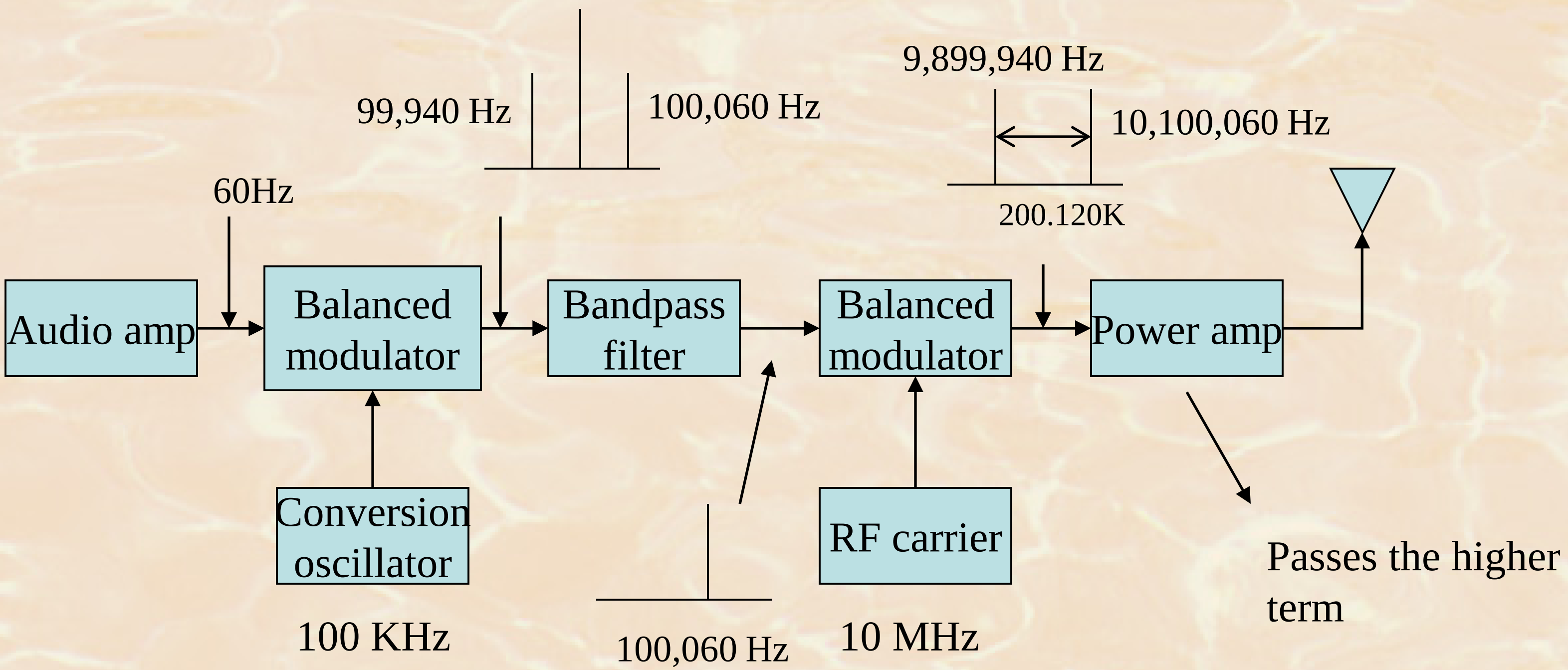
- We are trying to separate a frequency of 10.000060 MHz from 9.999940 MHz at 10 MHz.
- The required Q* is Q=10MHz/60Hz=?   Too high
- Solution: Translate the signal down to 100KHz.
- Q=100KHz/60Hz=1866. Maybe achievable

*The Q of a band pass filter is its *sharpness*, or the ratio of the center frequency to the difference between the frequencies where the signal is attenuated 3 dB (the 3 dB bandwidth):

$\mathbf{Q} = f_o / (f_h - f_l)$

SSB transmitter

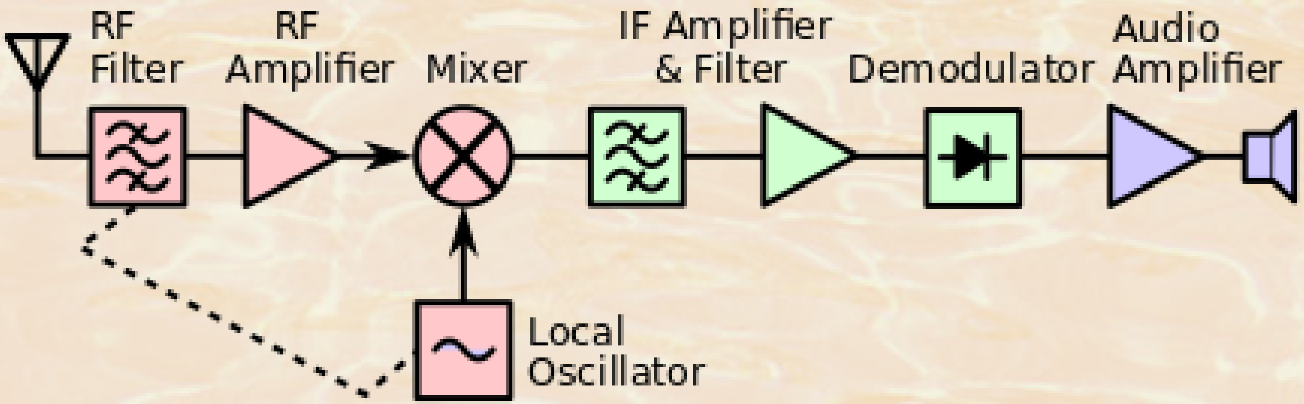
For a 60Hz tone message.



Super heterodyne Receiver

e.g. 1089 KHz.

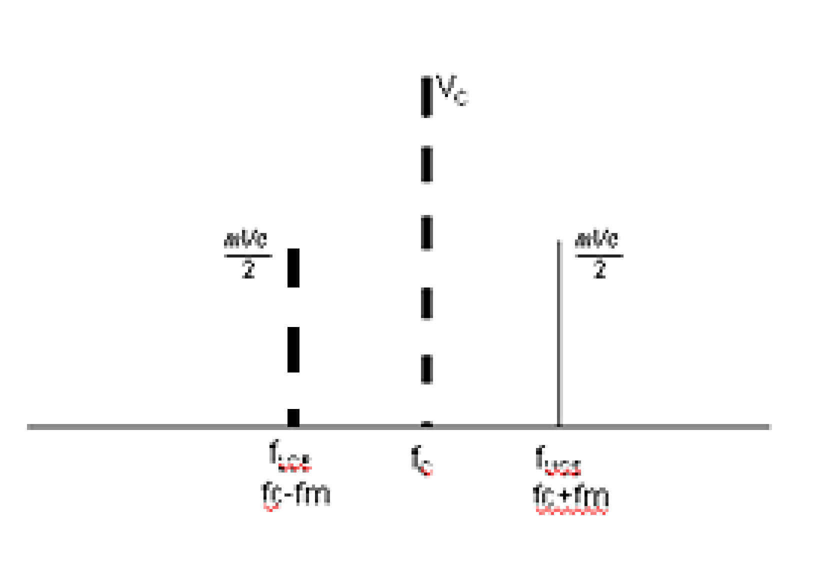
455 KHz



e.g. 634 KHz

Summary (SSB)

- SSB is a process of transmitting one of the sidebands of the standard AM by suppressing the carrier and one of the sidebands



- Advantages:
  - Saving power
  - Reduce BW by 50%
  - Increased efficiency & SNR
- Disadvantages
  - Complex circuits for frequency stability