Lecture Three

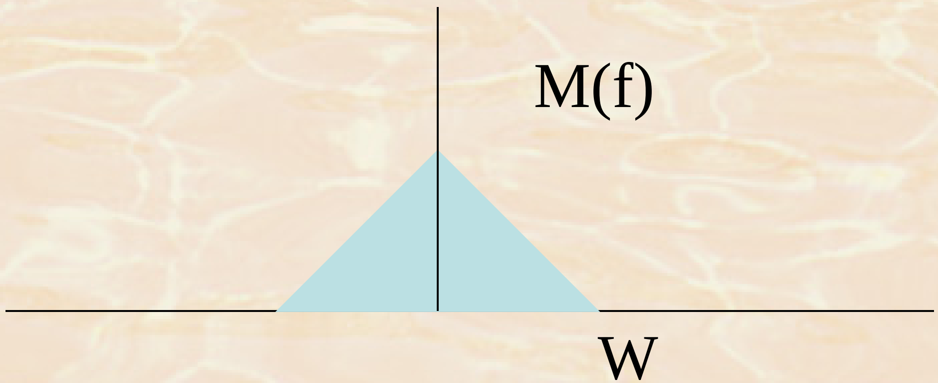
Double-side band modulation- Suppressed Carrier

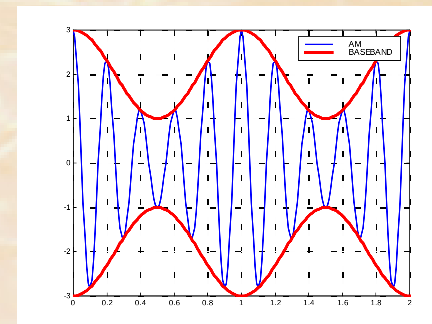
Quadrature -carrier Multiplexing

AM-Large Carrier

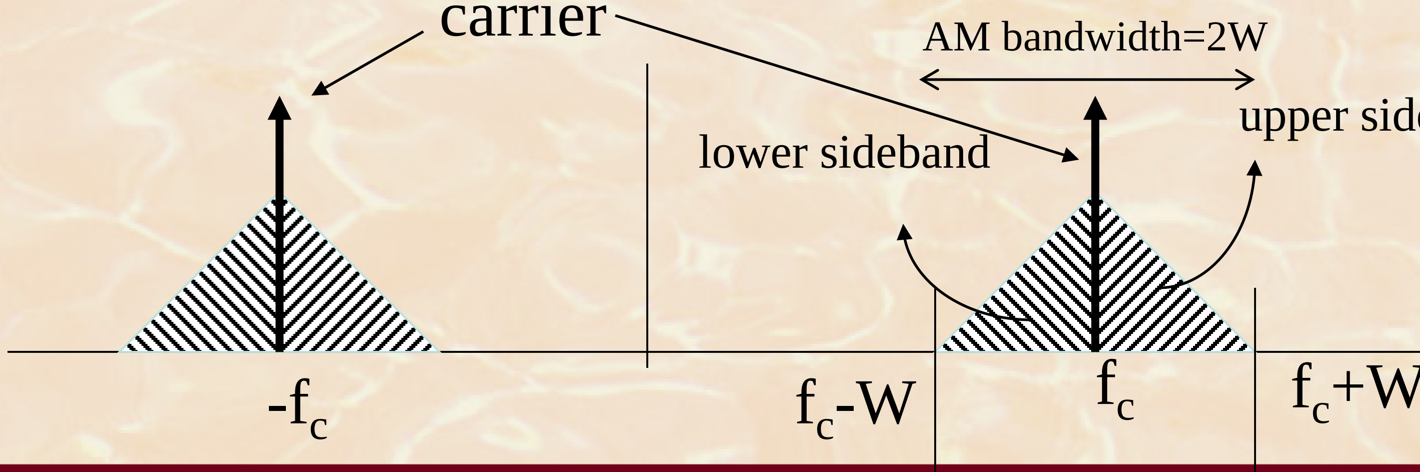
$$s(t) = A_c[1 + k_a m(t)]\cos(2\pi f_c t) = A_c\cos(2\pi f_c t) + A_c k_a m(t)\cos(2\pi f_c t)$$

Baseband





AM



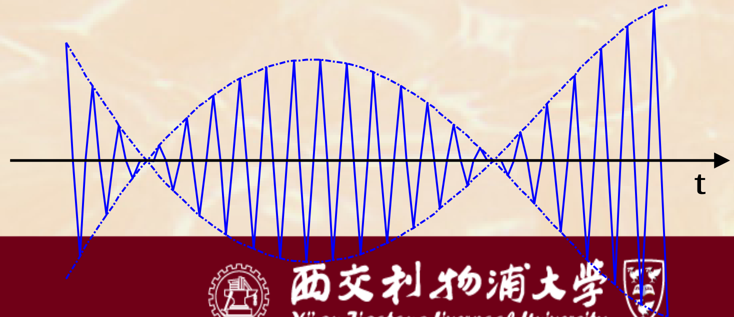
Double Sideband, Suppressed Carrier (SC)

To conserve power, we drop the carrier term from the AM-LC expression

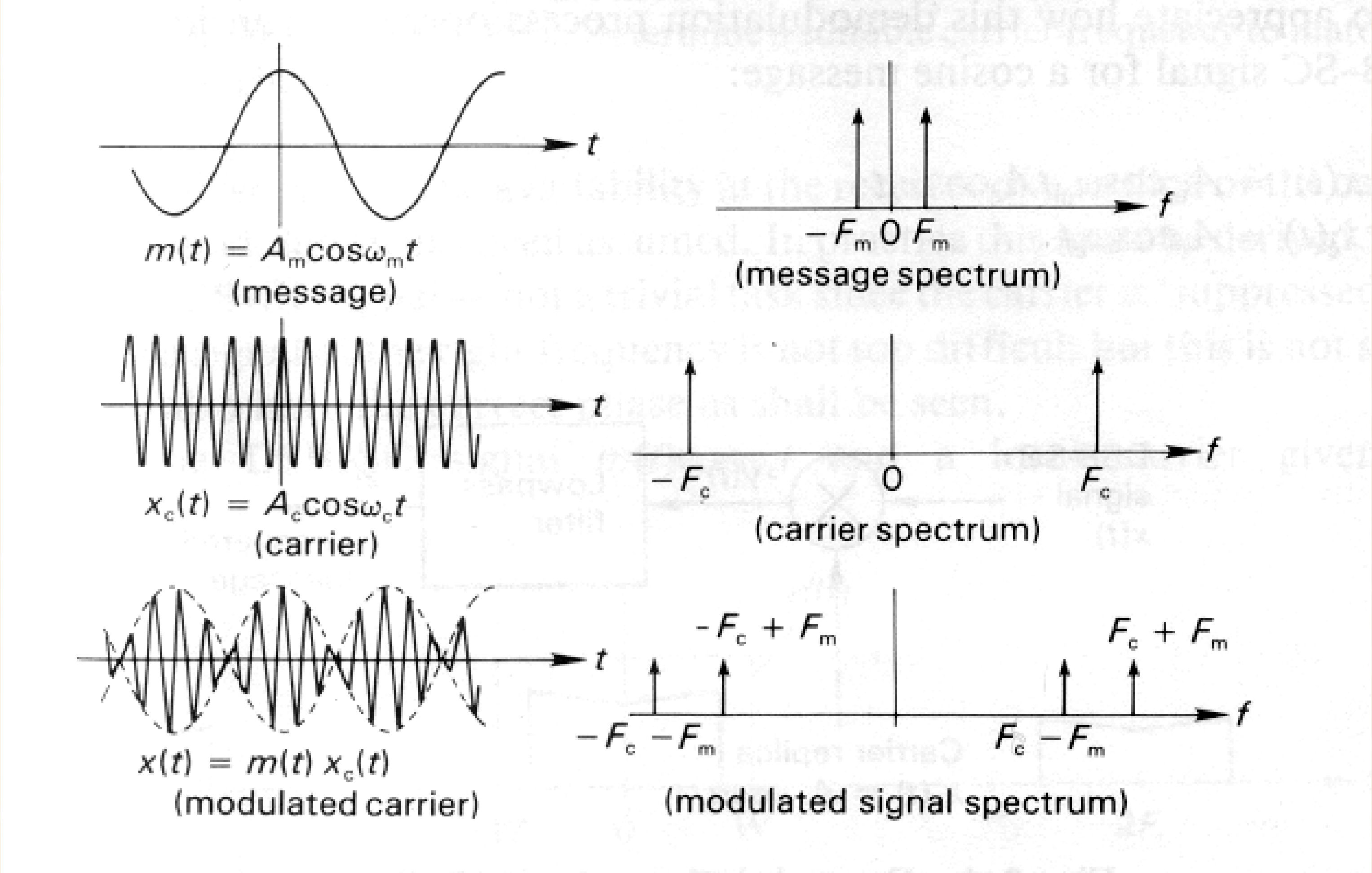
$$s(t) = A_c\left[1 + k_a m(t)\right]\cos\left(2\pi f_c t\right) = A_c \cos\left(2\pi f_c t\right) + A_c k_a m(t)\cos\left(2\pi f_c t\right)$$

DSB-SC (suppressed carrier) is then given by

$$s(t) = carrier \times message = A_c m(t)\cos\left(2\pi f_c t\right)$$



Spectrum of DSB-SC signal (a)



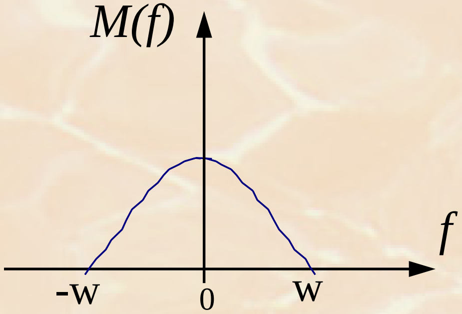
Double sideband modulation

Double sideband suppressed carrier modulation may be represented by

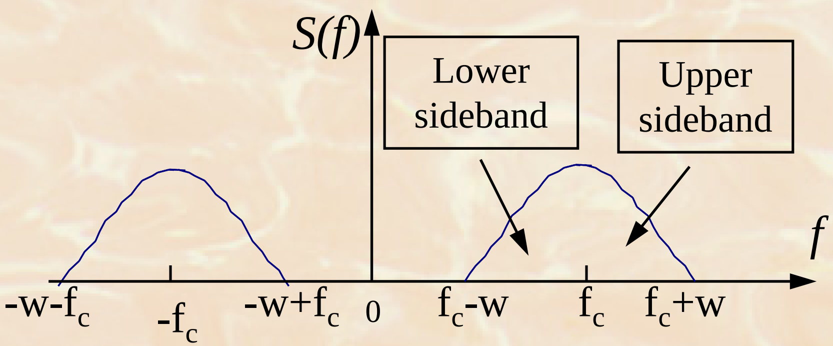
$$s(t) = m(t) A_c \cos(2\pi f_c t)$$

- *s(t)* undergoes a phase jump whenever the sign of *m(t)* changes: envelope of DSB-SC is NOT the same as *m(t)*

- In DSB-SC modulation the base band signal m(t) is simply translated in frequency and no carrier frequency is present.



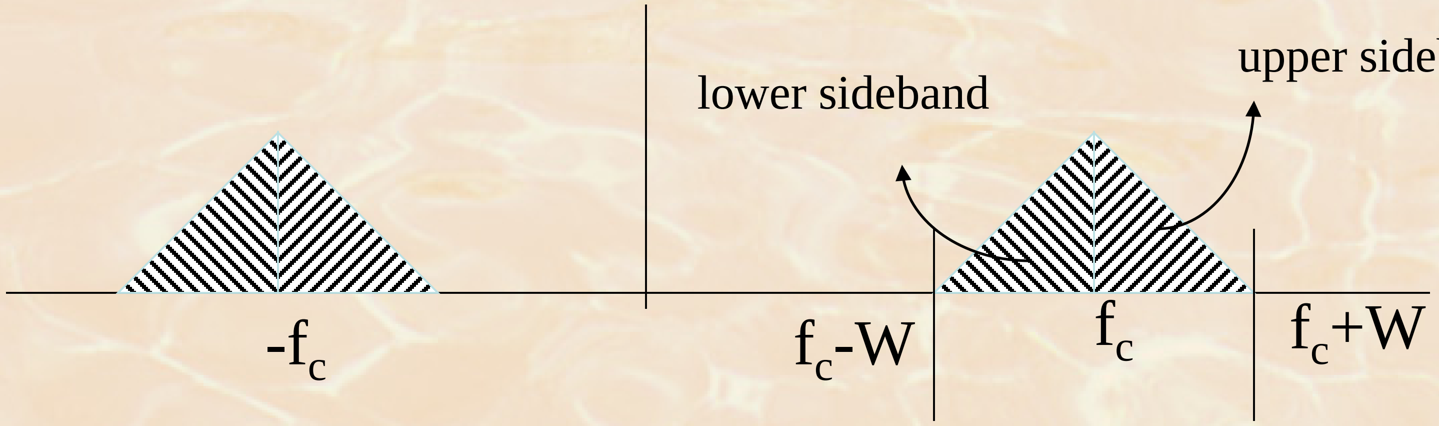
Base band spectrum



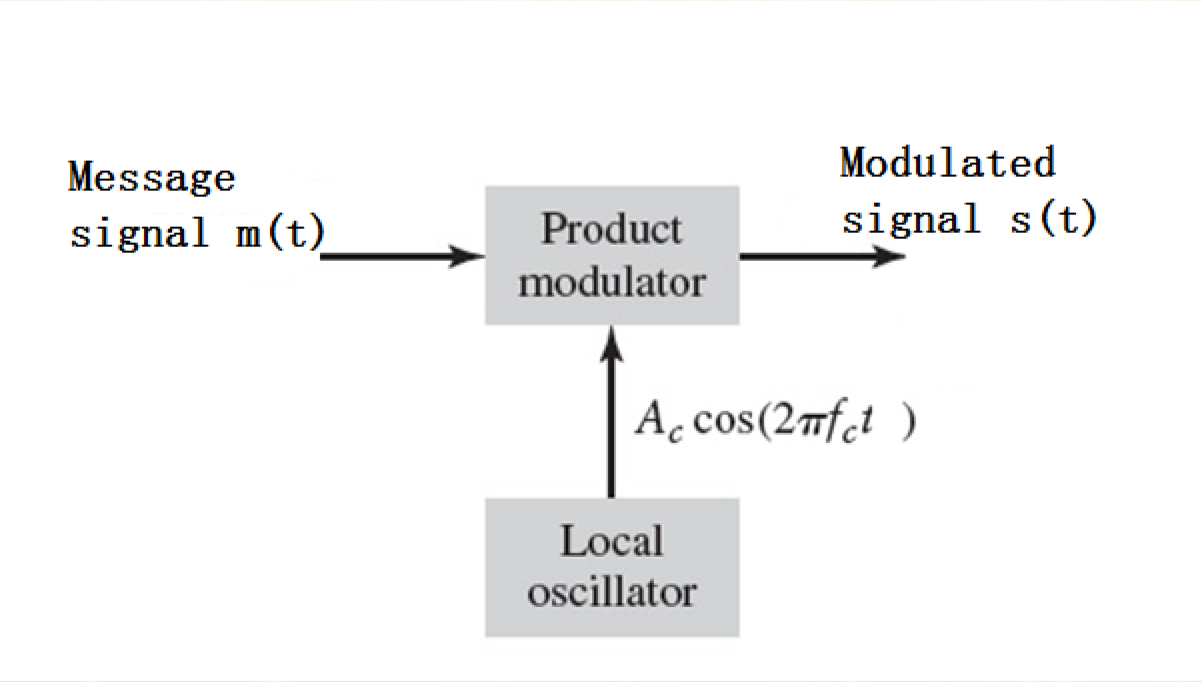
DSB-SC spectrum

Spectrum of DSB-SC signal (b)

Spectrum is identical to AM signal except for the removal of the carrier(two impulses)



DSB-SC modulator



Implementation also: Ring modulator in Text.

DSB-SC receiver- Coherent detection

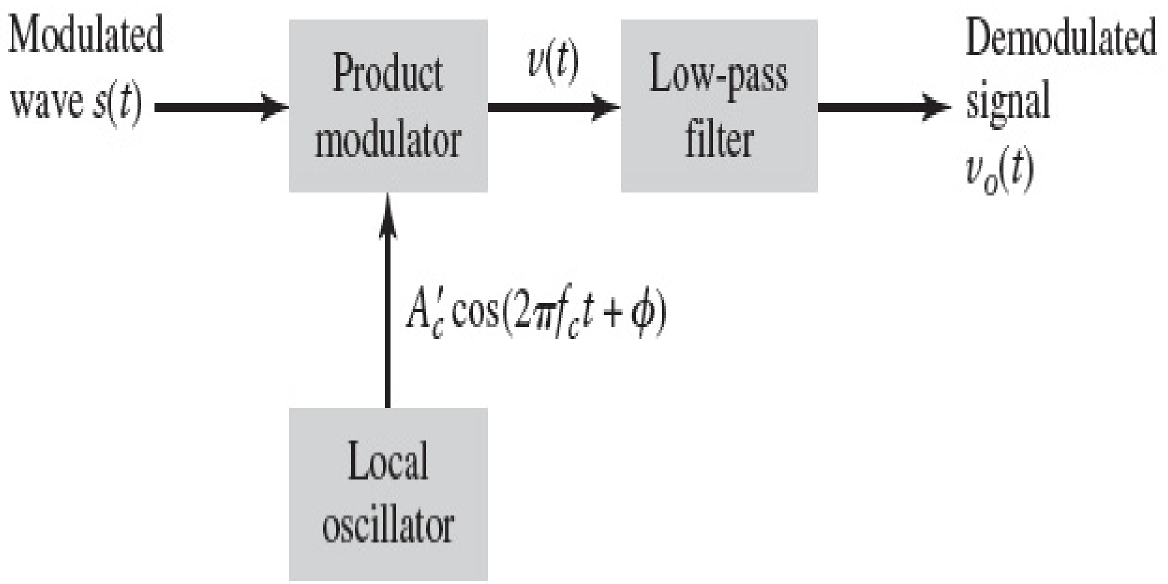


FIGURE 3.12 Block diagram of coherent detector, assuming that the local oscillator is out of phase by ϕ with respect to the sinusoidal carrier oscillator in the transmitter.

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

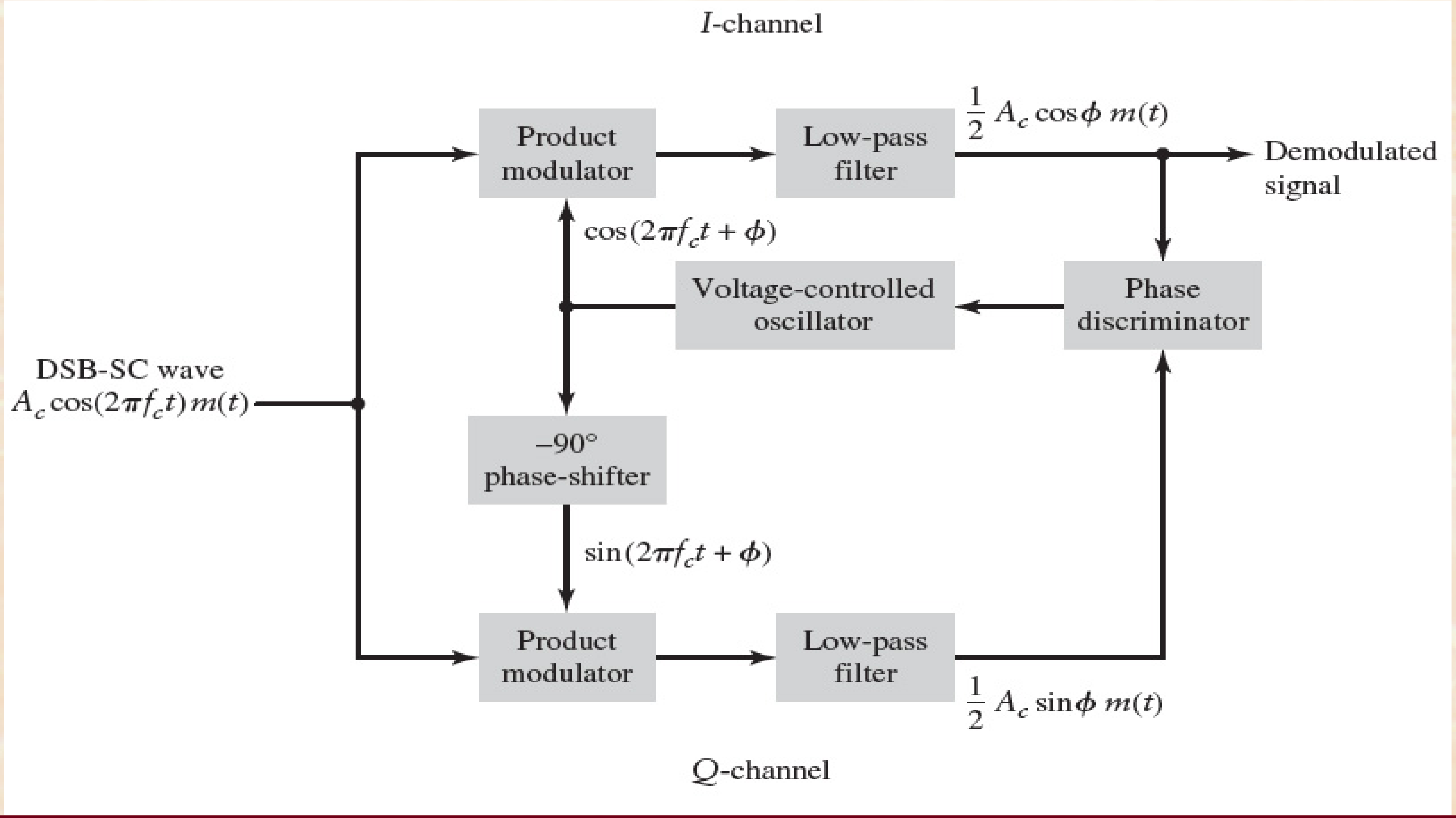
VIP Math Process

$$
\begin{aligned}
s(t) &= A_c m(t) cos(2\pi f_c t) \\
v(t) &= A_c^{'} s(t) cos(2\pi f_c t + \phi) \\
&= A_c^{'} A_c m(t) cos(2\pi f_c t) cos(2\pi f_c t + \phi) \\
&= \frac{A_c^{'} A_c}{2} (cos(4\pi f_c t + \phi) + cos(\phi)) m(t) \\
&= \frac{A_c^{'} A_c}{2} cos(4\pi f_c t + \phi) m(t) + \frac{A_c^{'} A_c}{2} cos(\phi) m(t)
\end{aligned}
$$

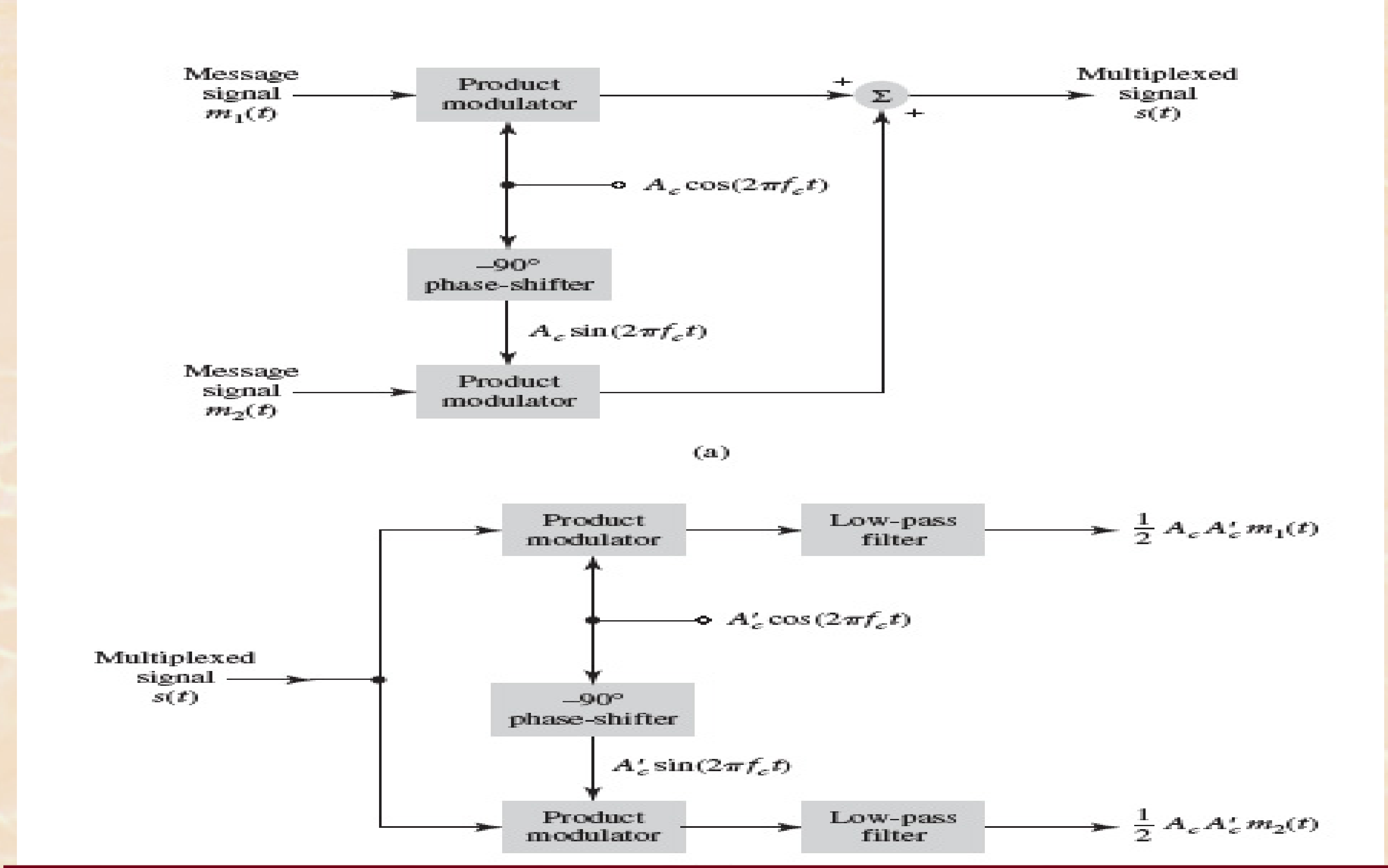
Following a low pass (LP) filter

$$
v_o(t) = \frac{A_c^{'} A_c}{2} cos(\phi) m(t)
$$

Receiver with Phase Lock Loop



Quadrature -carrier multiplexing



Class activity

- Drill problem

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