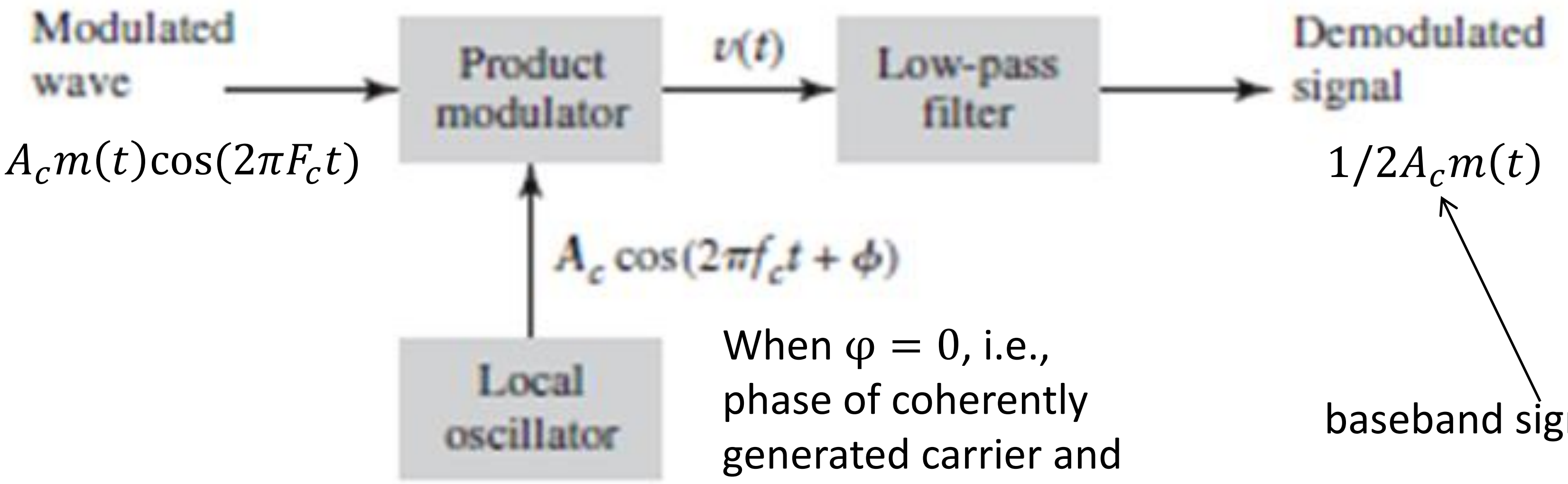
Communication Systems
EE-351

Lecture 7

Coherent Detector (block diagram)



$x(t) = A_c m(t)\cos(2\pi F_c t)$

Incoming signal

$1/2A_c m(t)$

baseband signal is recovered

When $\varphi = 0$, i.e., phase of coherently generated carrier and phase of carrier in incoming signal are equal.

Non-coherent Demodulation:

$$x(t) \times \cos(2\pi F_c t + \varphi)$$
$$= A_c m(t) \cos(2\pi F_c t) \times \cos(2\pi F_c t + \varphi)$$
$$= \frac{A_c m(t)}{2} cos\varphi + \frac{A_c m(t)}{2} \cos(4\pi F_c t + \varphi)$$

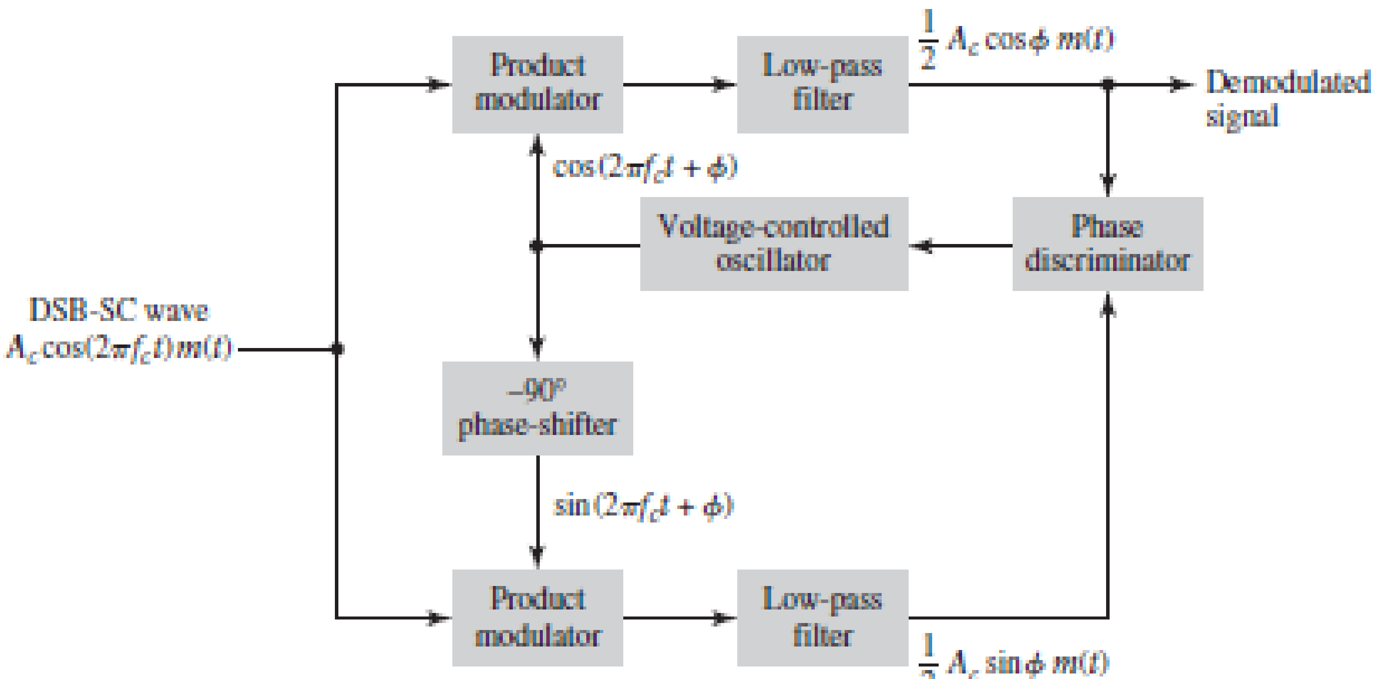
When passes through LPF, gives $\frac{A_c m(t)}{2} cos\varphi$

$cos\varphi$ is additional factor previously absent in coherent demodulation.
φ is phase offset.

Costas Receiver

- Purpose is to synchronize phase of locally generated carrier with that of incoming signal.

I-channel In-phase coherent detector



quadrature-phase coherent detector

Q-channel

Costas Receiver

- O/p of upper product modulator:

$$m(t)A_c\cos(2\pi F_c t) \times \cos(2\pi F_c t + \varphi)$$
$$= \frac{A_c m(t)}{2}\{cos\varphi + \cos(4\pi F_c t + \varphi)\}$$

After passing through LPF, $\frac{A_c m(t)}{2} cos\varphi$

O/p of lower product modulator:

$$m(t)A_c\cos(2\pi F_c t) \times \sin(2\pi F_c t + \varphi)$$
$$= \frac{A_c m(t)}{2}\{sin\varphi + \sin(4\pi F_c t + \varphi)\}$$

After passing through LPF, $\frac{A_c m(t)}{2} sin\varphi$

Costas Receiver

- Phase discriminator (PD) o/p $= \frac{A_c m(t)}{2} cos\varphi \frac{A_c m(t)}{2} sin\varphi$

$$= \frac{{A_c}^2 m^2(t)}{4} cos\varphi sin\varphi$$

$\Longrightarrow$If φ>0, PD = $\frac{{A_c}^2 m^2(t)}{4} cos\varphi sin\varphi \geq 0$

$\Longrightarrow$If φ <0, PD = $\frac{{A_c}^2 m^2(t)}{4} cos\varphi sin\varphi < 0$

Thus, VCO is configured such that:

PD>0 $\Longrightarrow$ phase error decreases

PD<0 $\Longrightarrow$ phase error increases

$\Longrightarrow$phase offset is eventually driven to 0

$\therefore$ phase synchronization is achieved.

Costas Receiver

- O/p of upper product modulator:

$$m(t)A_c\cos(2\pi F_c t)\times\cos(2\pi F_c t+\varphi)$$
$$=\frac{A_c m(t)}{2}\{cos\varphi+\cos(4\pi F_c t+\varphi)\}$$

After passing through LPF, $\frac{A_c m(t)}{2}cos\varphi$

O/p of lower product modulator:

$$m(t)A_c\cos(2\pi F_c t)\times\sin(2\pi F_c t+\varphi)$$
$$=\frac{A_c m(t)}{2}\{sin\varphi+\sin(4\pi F_c t+\varphi)\}$$

After passing through LPF, $\frac{A_c m(t)}{2}sin\varphi$

Costas Receiver

- Phase discriminator (PD) o/p $= \frac{A_c m(t)}{2} cos\varphi \, \frac{A_c m(t)}{2} sin\varphi$

$$= \frac{{A_c}^2 m^2(t)}{4} cos\varphi sin\varphi$$

$\Longrightarrow$If φ>0, PD = $\frac{{A_c}^2 m^2(t)}{4} cos\varphi sin\varphi \geq 0$

$\Longrightarrow$If φ <0, PD = $\frac{{A_c}^2 m^2(t)}{4} cos\varphi sin\varphi < 0$

Thus, VCO is configured such that:

PD>0 $\Longrightarrow$ phase error decreases

PD<0 $\Longrightarrow$ phase error increases

$\Longrightarrow$phase offset is eventually driven to 0

$\therefore$ phase synchronization is achieved.

Problem 3.18, 3.23, and 3.25