Principle of Communication (BEC-28)

Amplitude Modulation

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UNIT-1

- Overview of Communication system
- Communication channels
- Need for modulation
- Baseband and Pass band signals
- Comparison of various AM systems
- Amplitude Modulation

○ Double side-band with Carrier (DSB-C)
○ Double side-band without Carrier
○ Single Side-band Modulation
○ SSB Modulators and Demodulators
○ Vestigial Side-band (VSB)
○ Quadrature Amplitude Modulator.

Contents

DSB-SC - *Theory*

General expression: $c(t) = [k_1 m(t) + C]\cos(\omega_c t + \phi_c)$

Let $k_1 = 1$, $C = 0$ and $\phi_c = 0$, the modulated carrier signal, therefore:

$$c(t) = m(t)\cos\omega_c t$$

Information signal $m(t) = E_m \cos \omega_m t$

Thus

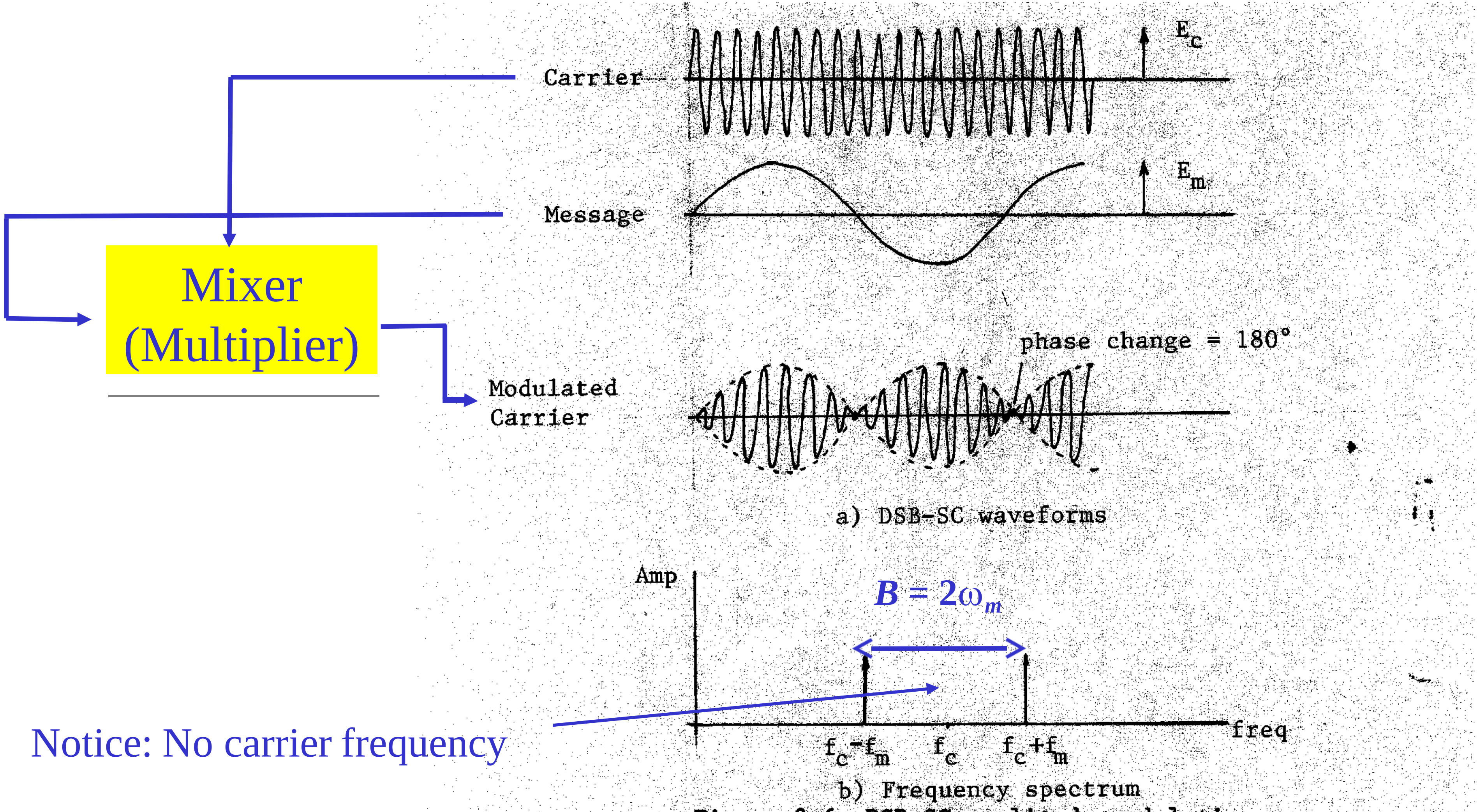
$$c(t) = E_m \cos\omega_m t \ \cos\omega_c t$$

$$= \frac{ME_c}{2}\cos(\omega_c + \omega_m)t + \frac{ME_c}{2}\cos(\omega_c - \omega_m)t$$

upper side band

lower side band

DSB-SC - *Waveforms*



Mixer (Multiplier)

$B = 2\omega_m$

a) DSB-SC waveforms

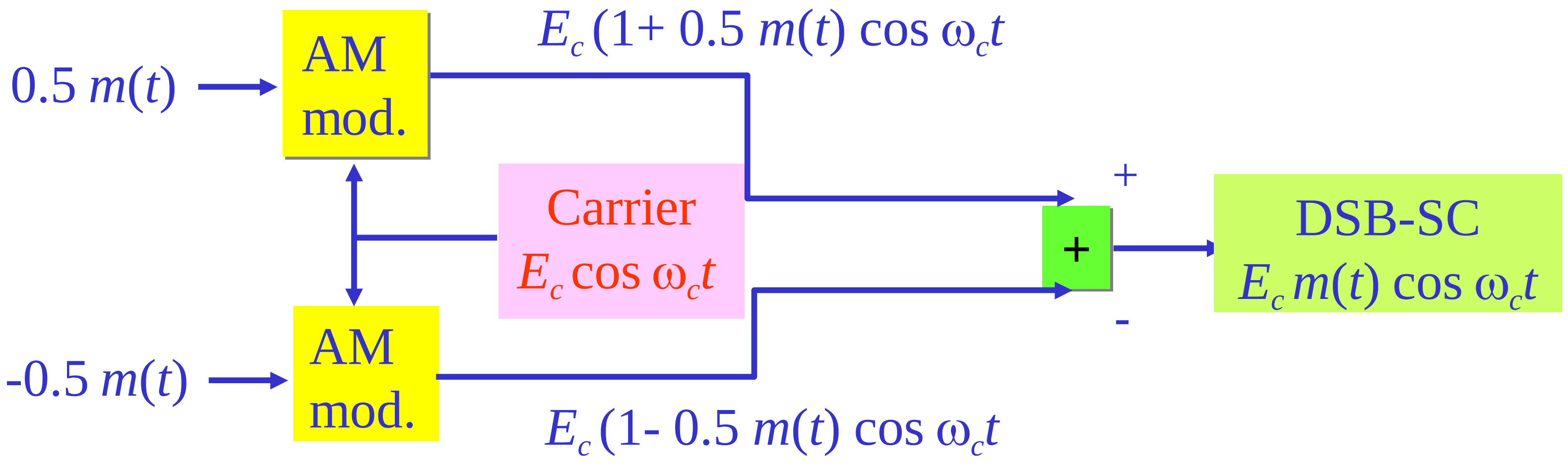
b) Frequency spectrum

Figure 2.6 DSB-SC amplitude modulation

Notice: No carrier frequency

DSB-SC - *Implementation*

- **Balanced modulator**

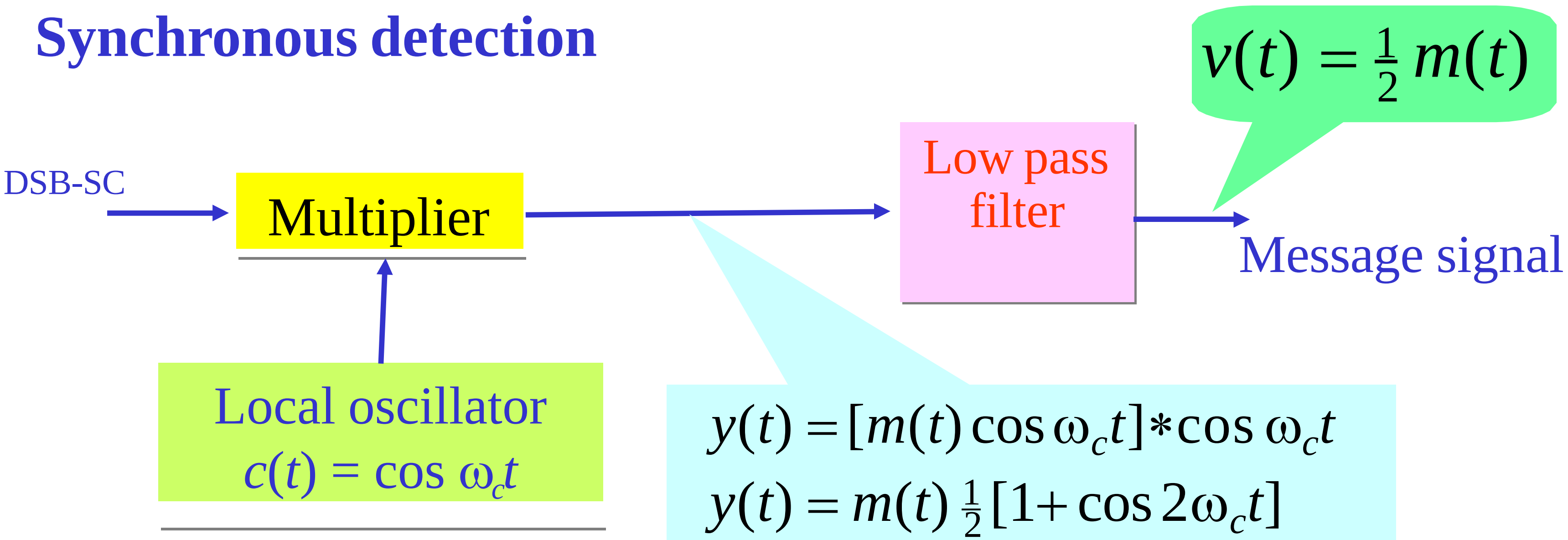


- **Ring modulator**

- **Square-law modulator**

DSB-SC - *Detection*

- **Synchronous detection**



DSB-SC

Multiplier

Local oscillator

$c(t) = \cos \omega_c t$

Low pass filter

Message signal

$$v(t) = \tfrac{1}{2} m(t)$$

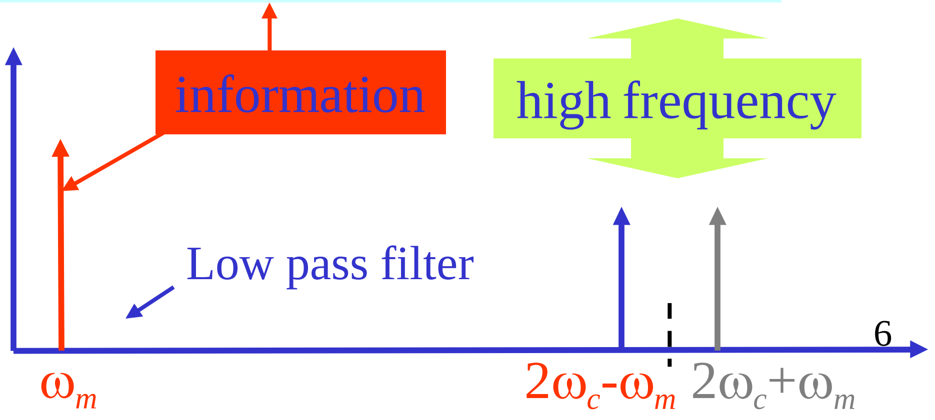
$$y(t) = [m(t) \cos \omega_c t] * \cos \omega_c t$$

$$y(t) = m(t) \tfrac{1}{2} [1 + \cos 2\omega_c t]$$

$$= \frac{1}{2} m(t) + \frac{1}{2} m(t) \cos 2\omega_c t$$

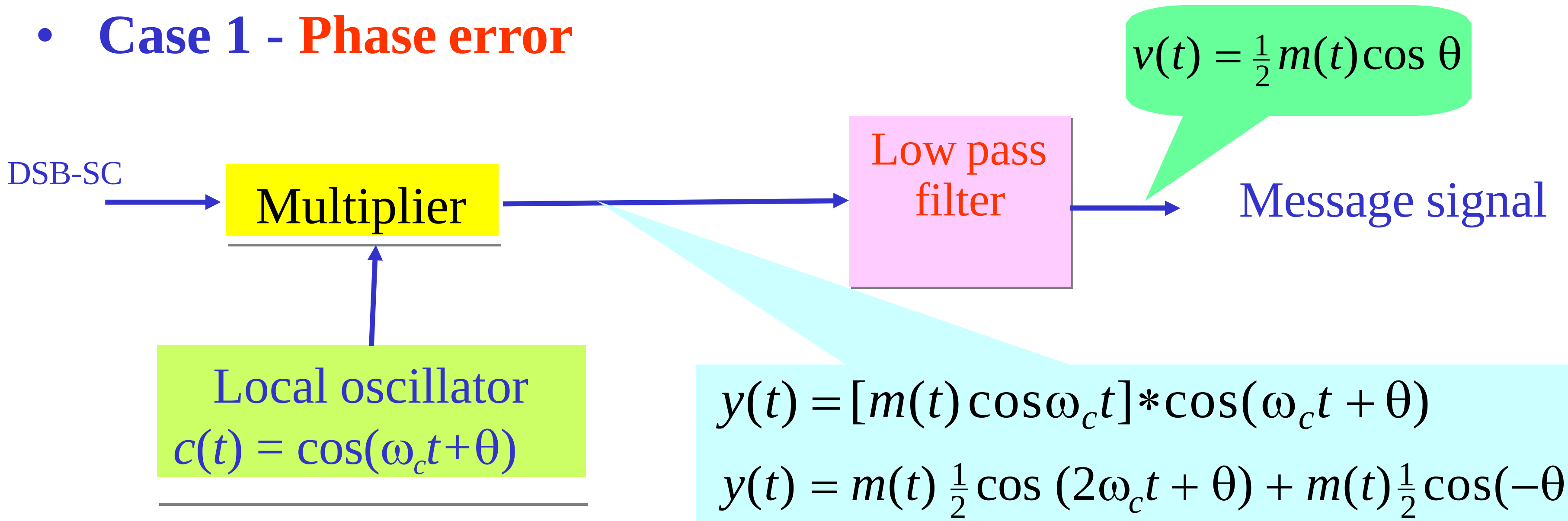
Condition:

- Local oscillator has the same **frequency** and **phase** as that of the carrier signal at the transmitter.



DSB-SC - *Synchronous Detection*

- **Case 1 - Phase error**



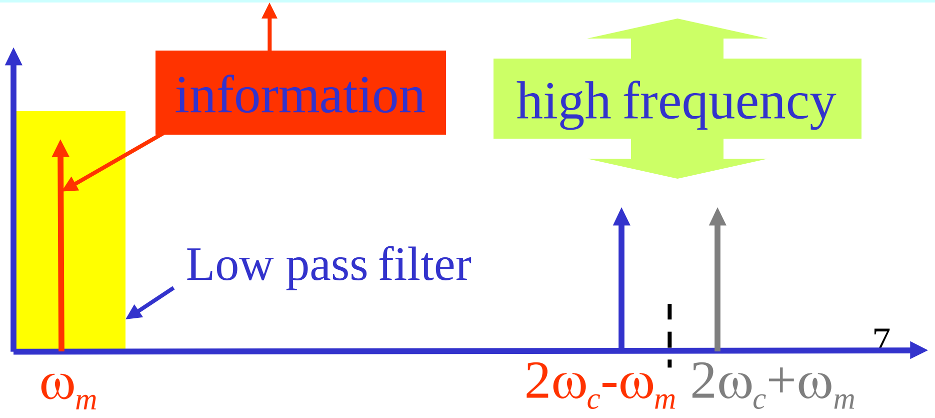
$$y(t) = [m(t)\cos\omega_c t] * \cos(\omega_c t + \theta)$$

$$y(t) = m(t)\,\tfrac{1}{2}\cos(2\omega_c t + \theta) + m(t)\tfrac{1}{2}\cos(-\theta)$$

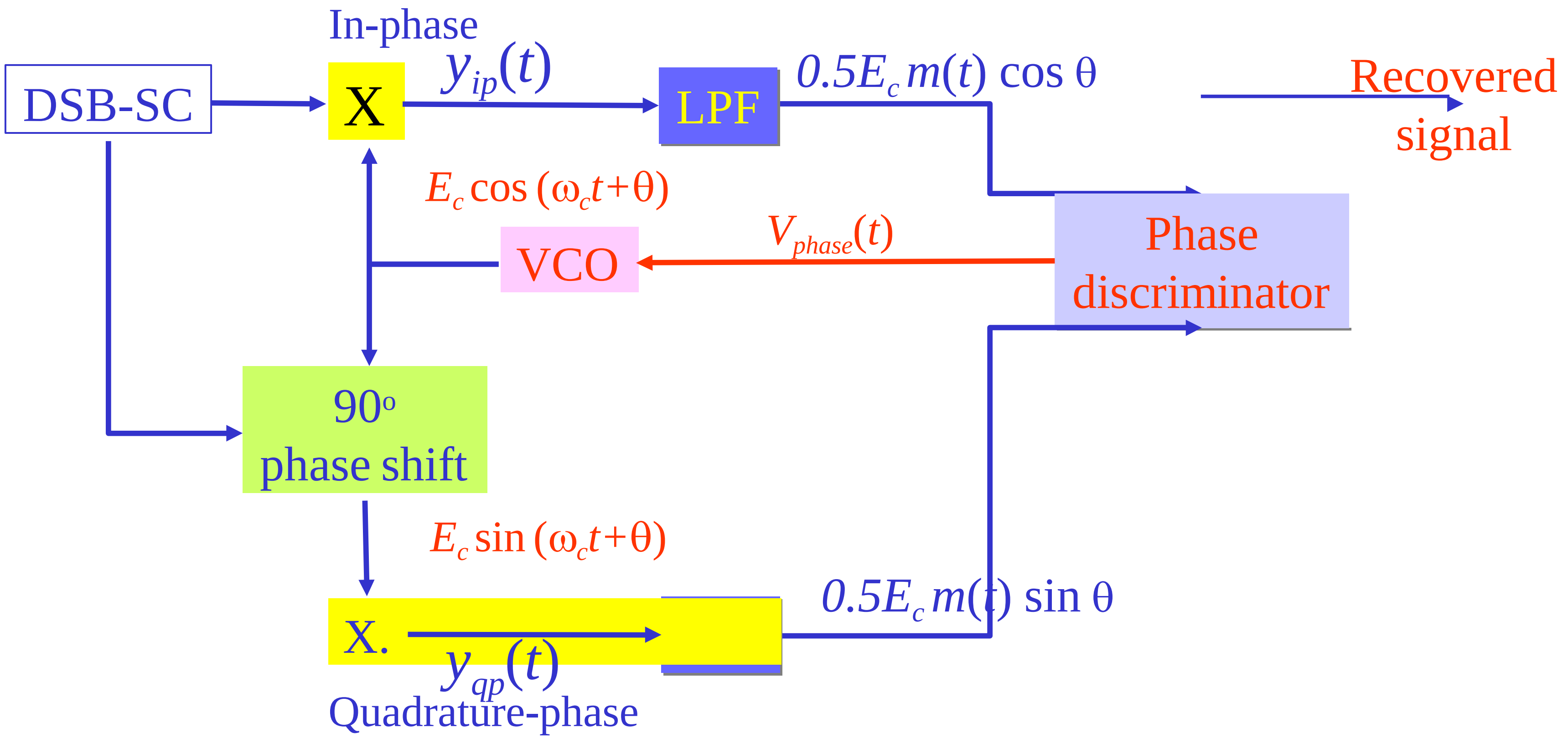
$$= m(t)\,\tfrac{1}{2}\cos\theta + m(t)\,\tfrac{1}{2}\cos(2\omega_c t + \theta)$$

Condition:

- Local oscillator has the same **frequency** but *different* **phase** compared to carrier signal at the transmitter.



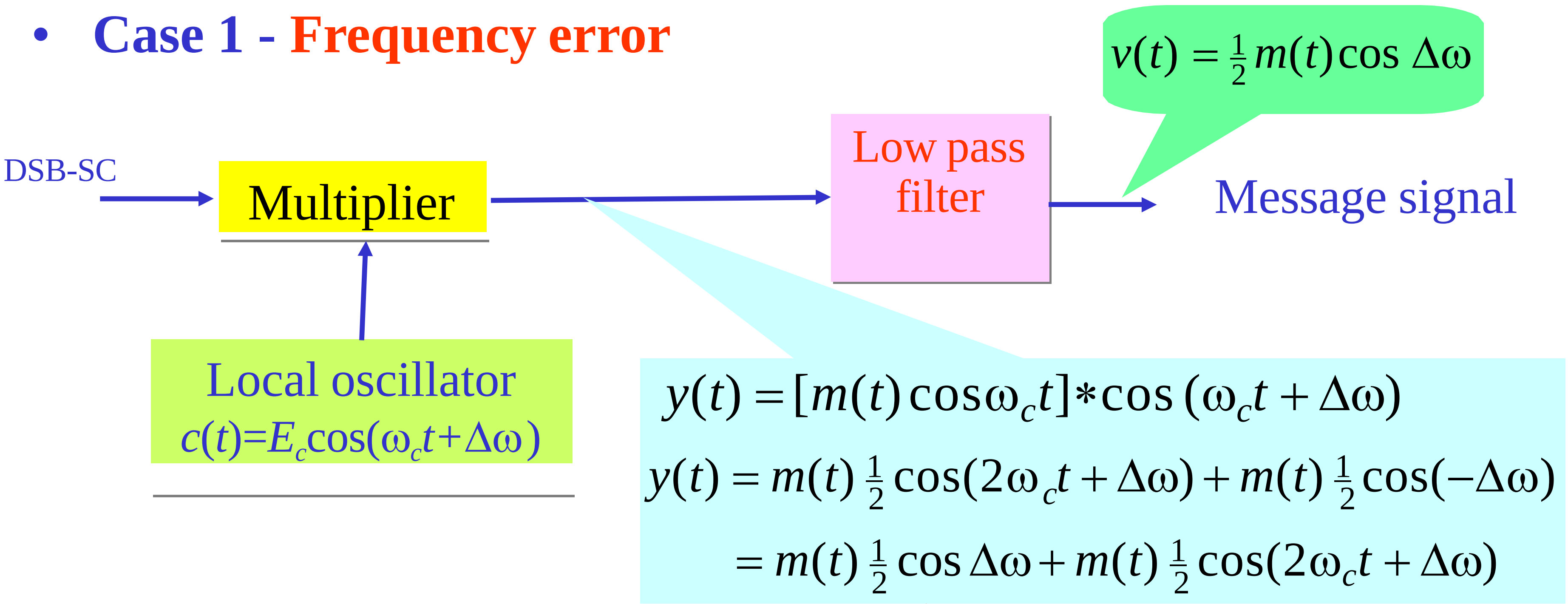
Phase Synchronisation - *Costa Loop*



- When there is no phase error. The quadrature component is zero
- When $\theta \neq 0$, $y_{ip}(t)$ decreases, while $y_{qp}(t)$ increases
- The out put of the phase discriminator is proportional to θ

DSB-SC - *Synchronous Detection*

- **Case 1 - Frequency error**



$$v(t) = \tfrac{1}{2} m(t) \cos \Delta\omega$$

DSB-SC

Multiplier

Low pass filter

Message signal

Local oscillator

$c(t)=E_c\cos(\omega_c t+\Delta\omega)$

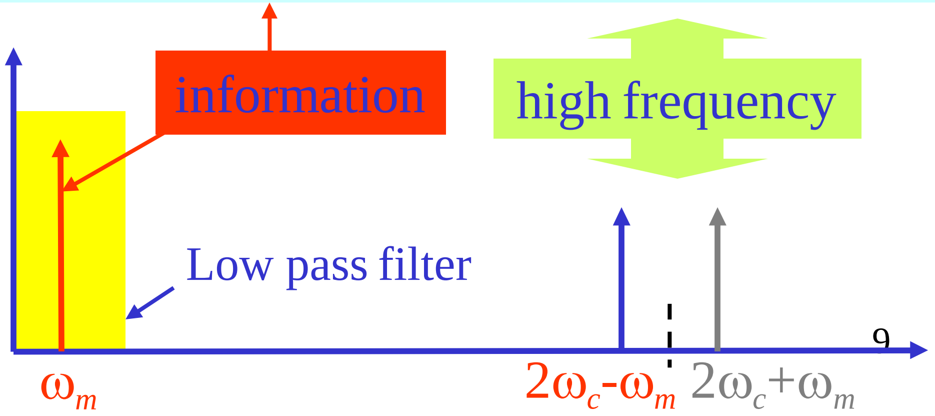
$$y(t) = [m(t)\cos\omega_c t] * \cos(\omega_c t + \Delta\omega)$$

$$y(t) = m(t)\,\tfrac{1}{2}\cos(2\omega_c t + \Delta\omega) + m(t)\,\tfrac{1}{2}\cos(-\Delta\omega)$$

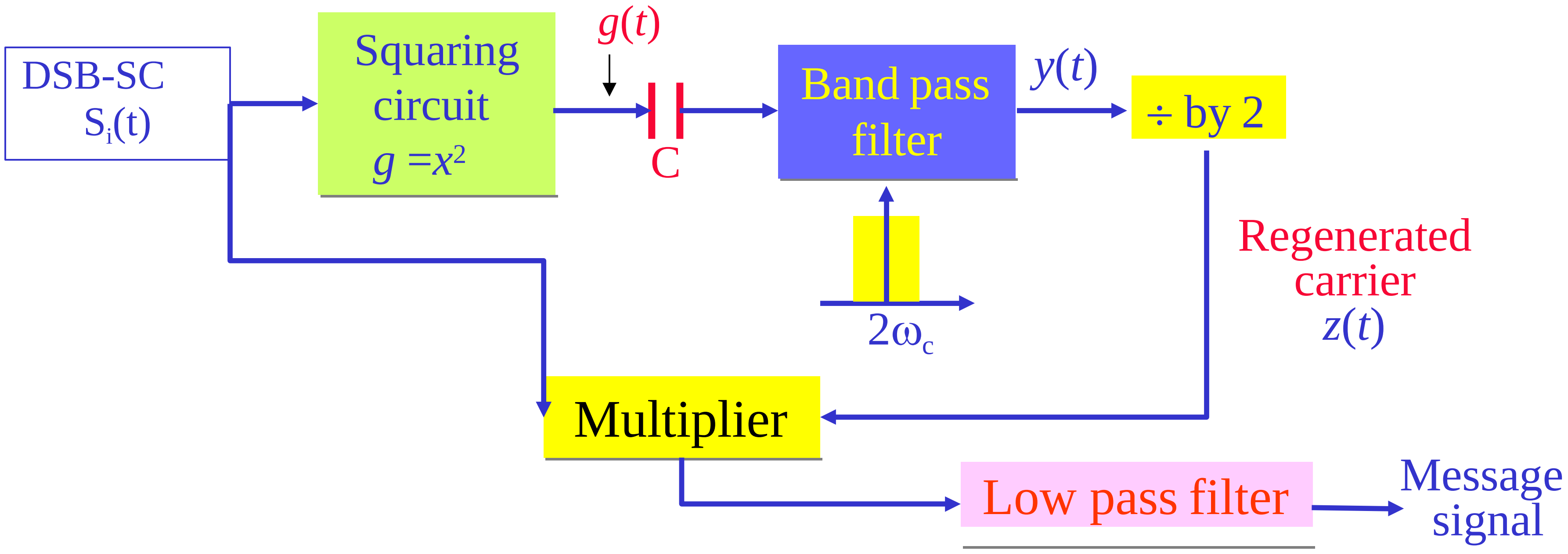
$$= m(t)\,\tfrac{1}{2}\cos\Delta\omega + m(t)\,\tfrac{1}{2}\cos(2\omega_c t + \Delta\omega)$$

Condition:

•Local oscillator has the same **phase** but *different* **frequency** compared to carrier signal at the transmitter.



DSB-SC - *Square Detection*



$$g(t) = S_i^{\,2}(t) = B^2 \cos^2 \omega\, t_m \cos^2 \omega\, t_c$$

$$= B^2 \left(\tfrac{1}{2} + \tfrac{1}{2} \cos 2\, \omega_m t\, \right)\left(\tfrac{1}{2} + \tfrac{1}{2} \cos 2\, \omega_c t\, \right)$$

$$= B^2/4\, [1 + \tfrac{1}{2} \cos 2(\omega_c + \omega_m)t + \tfrac{1}{2} \cos 2(\omega_c - \omega_m)t + \cos 2\omega_m t + \underline{\mathbf{\cos 2}}\, \omega_c t\,]$$

$y(t) = B^2/4 \cos 2w_c t$

$z(t) = B^2/4 \cos w_c t$

DSB-SC - *Power*

- The total power (or average power):

$$P_{T-DSB-SC} = \frac{2}{R}\left[\frac{ME_c/\sqrt{2}}{2}\right]^2$$

$$= \frac{(ME_c)^2}{4R}$$

- The maximum and peak envelop power

$$P_{P-DSB-SC} = \frac{(ME_c)^2}{R}$$

DSB-SC - *Summary*

- **Advantages:**
  - Lower power consumption

- **Disadvantage:**
  - Complex detection

- **Applications:**
  - Analogue TV systems: to transmit colour information
  - For transmitting *stereo* information in FM sound broadcast at VHF

Thank You