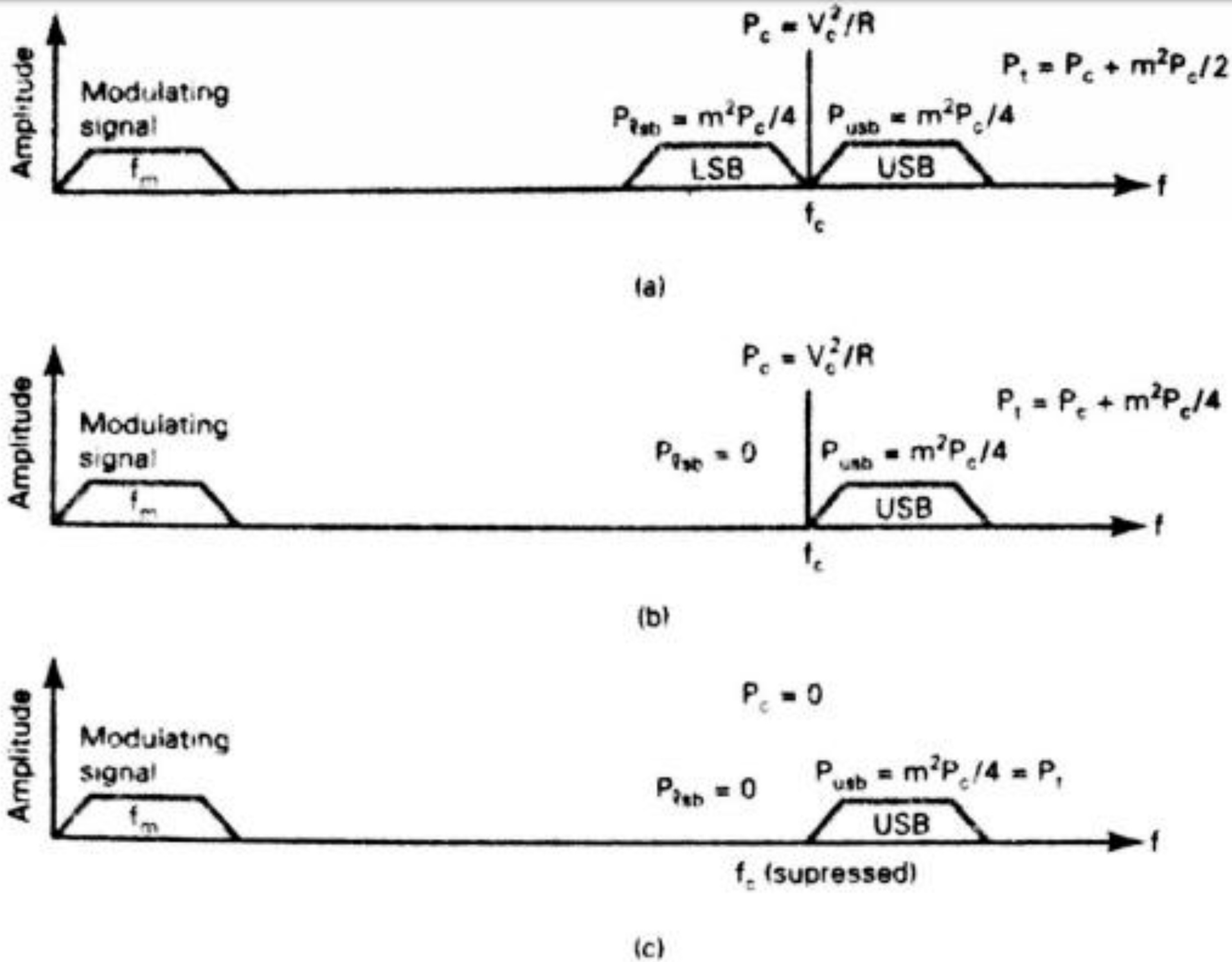
Need and Principle of DSBSC

Conventional AM (DSBFC) requires more bandwidth.

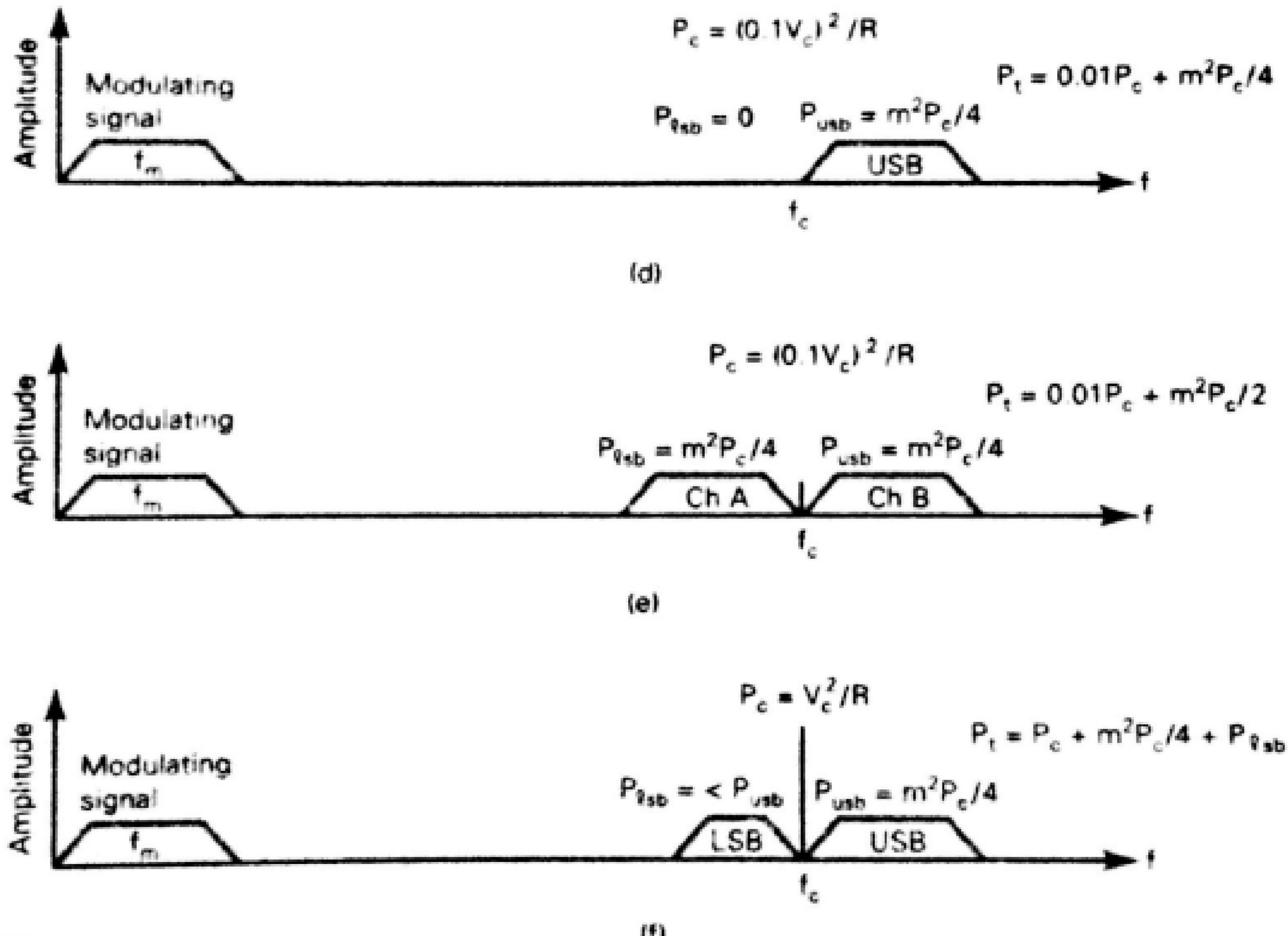
In DSBFC wave more power is consumed in carrier. It does not carry any information.

Sideband carries same information.

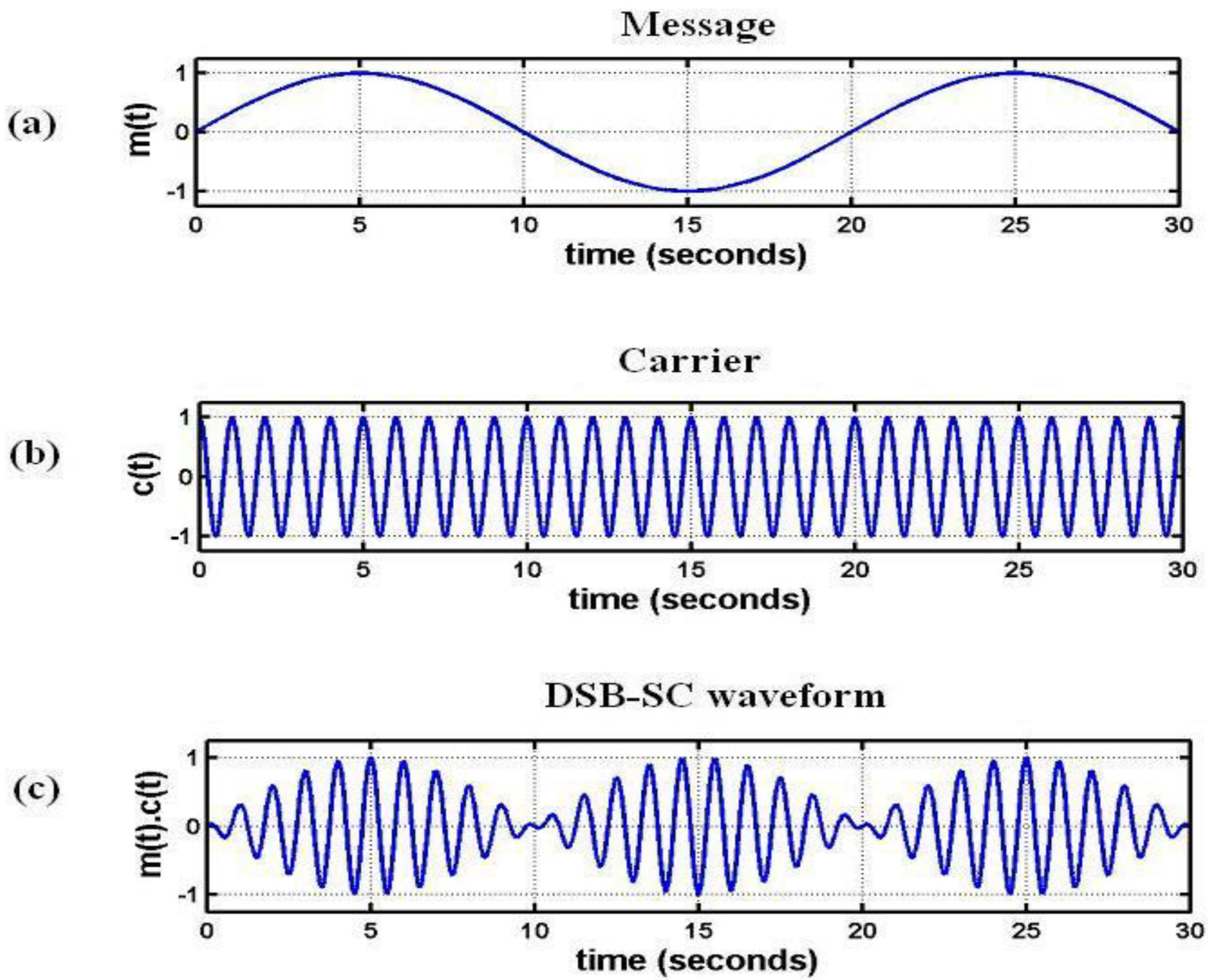
Single Sideband systems



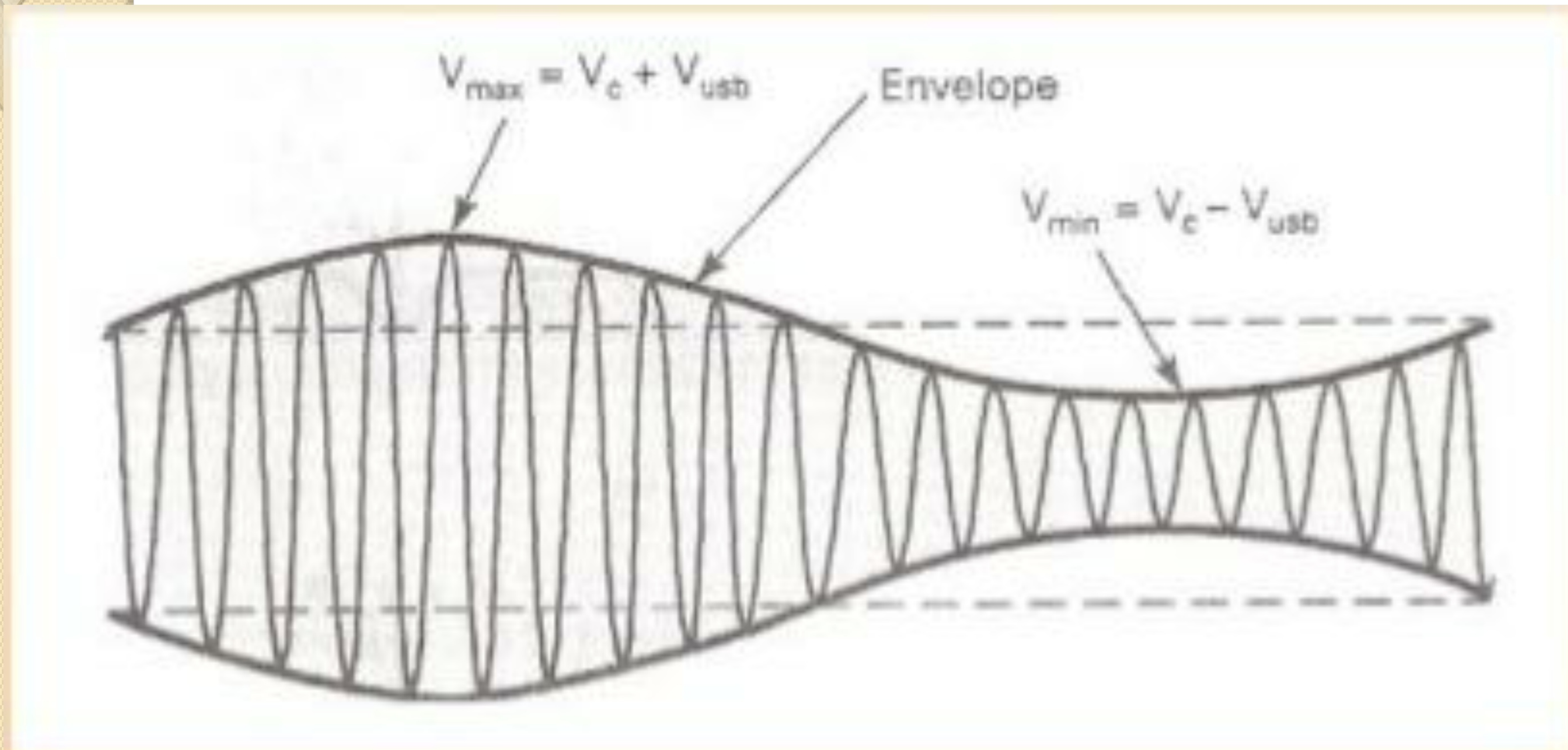
Single Sideband systems



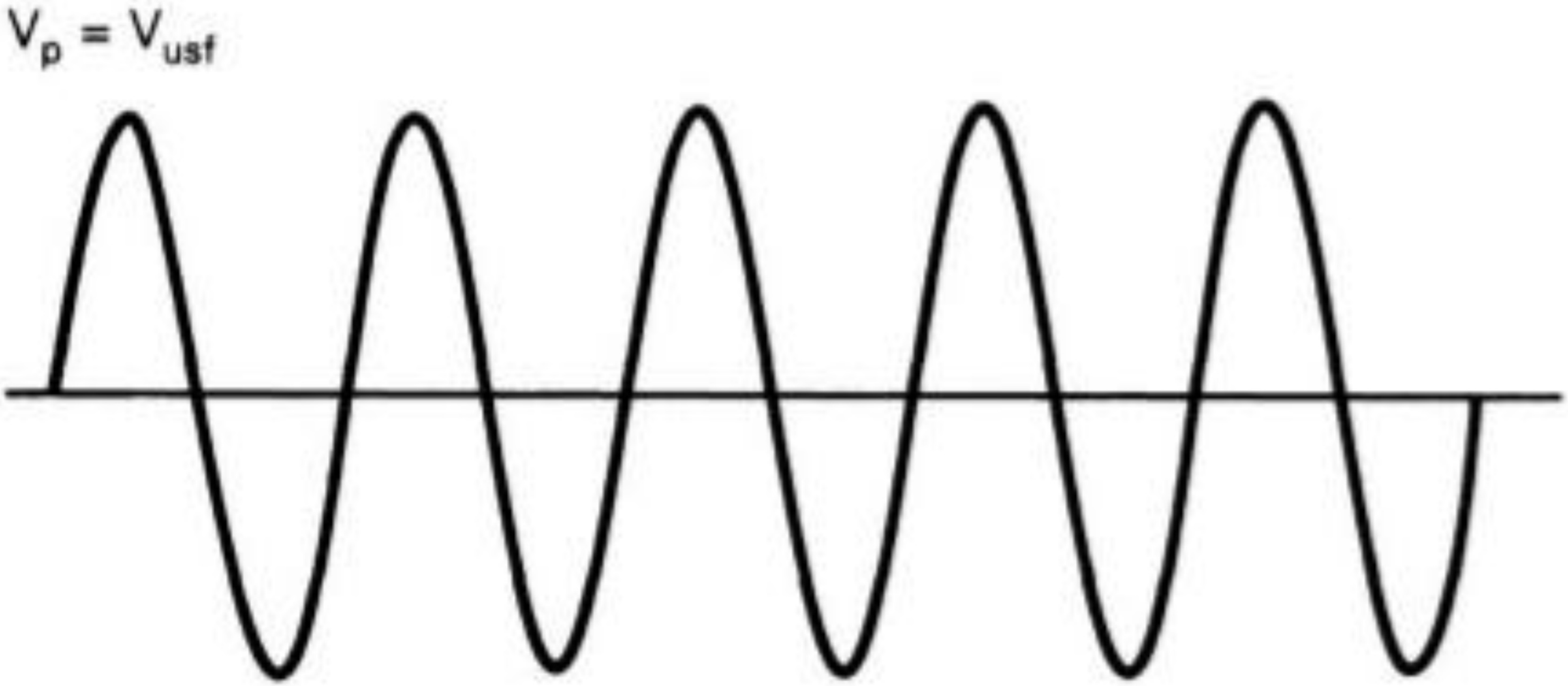
DSBSC Wave


Message
(a)
m(t)
1
0
-1
0 5 10 15 20 25 30
time (seconds)
Carrier
(b)
c(t)
1
0
-1
0 5 10 15 20 25 30
time (seconds)
DSB-SC waveform
(c)
m(t).c(t)
1
0
-1
0 5 10 15 20 25 30
time (seconds)

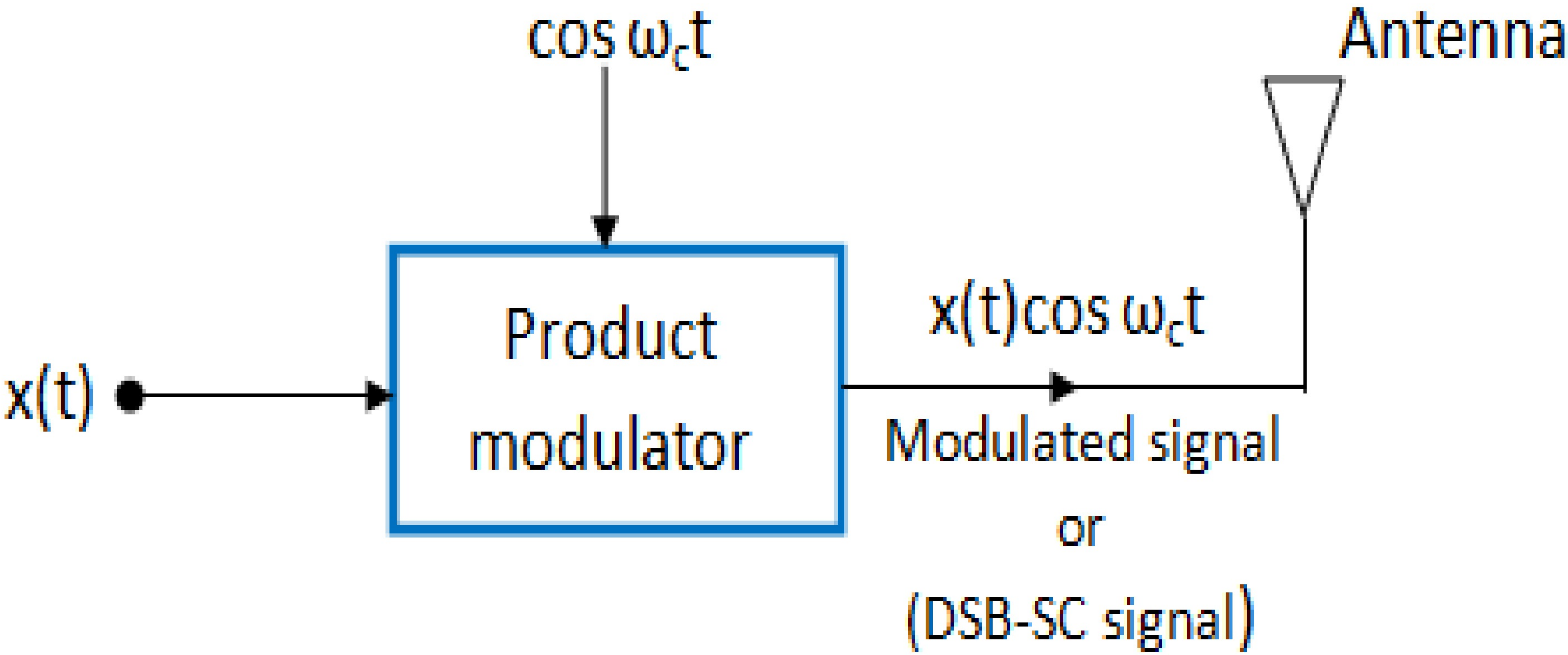
SSBFC Wave



SSBSC Wave



Basic Principle of DSBSC wave



$$x(t)\cos\omega_c(t) \leftrightarrow \frac{1}{2}[X(\omega-\omega_c)+X(\omega+\omega_c)]$$

Basic Principle of DSBSC wave

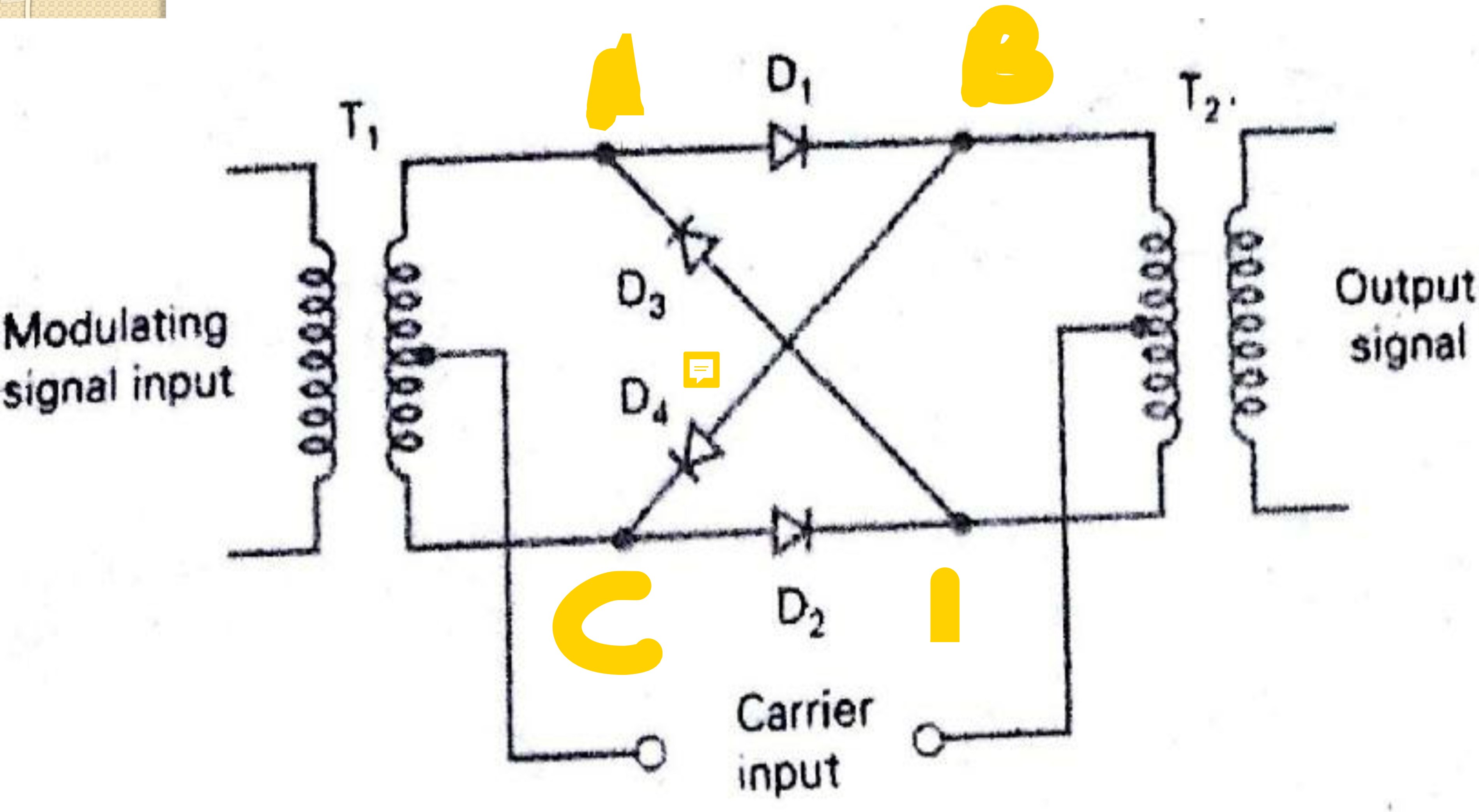
$$V_{am}(t) = [(1 + msin(2\pi f_m t)][V_c \sin(2\pi f_c t)]$$

- **If constant component is removed from the modulating signal then,**

$$V_{am}(t) = [m \sin(2\pi f_m t)][V_c \sin(2\pi f_c t)]$$

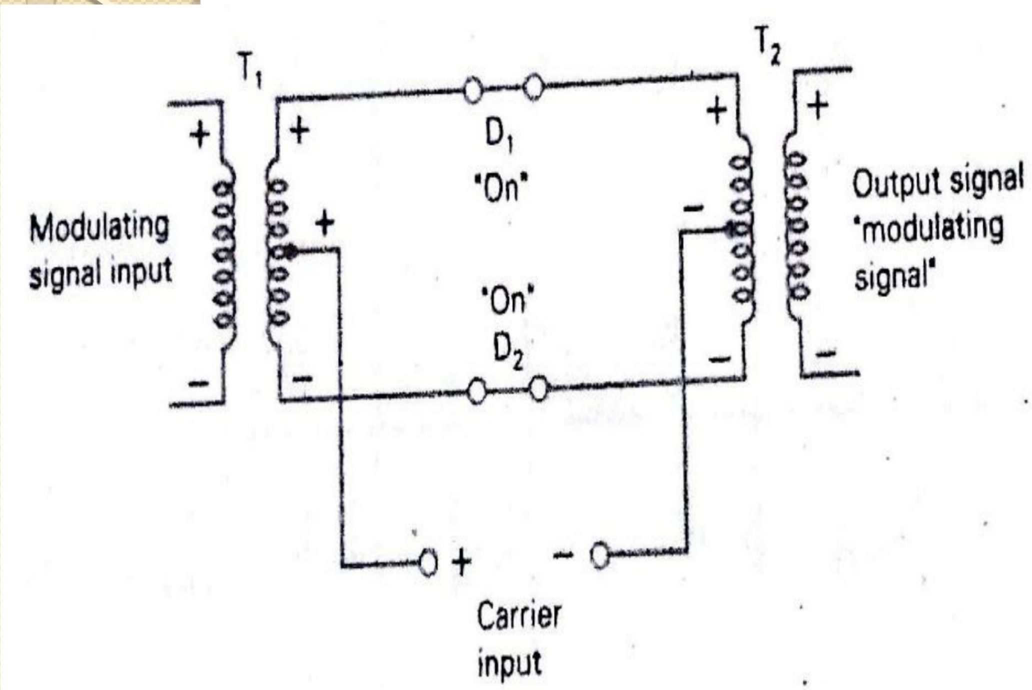
$$V_{am}(t) = \frac{mV_c}{2} \cos[2\pi(f_c - f_m)t] - \frac{mV_c}{2} cos[2\pi(f_c + f_m)t]$$

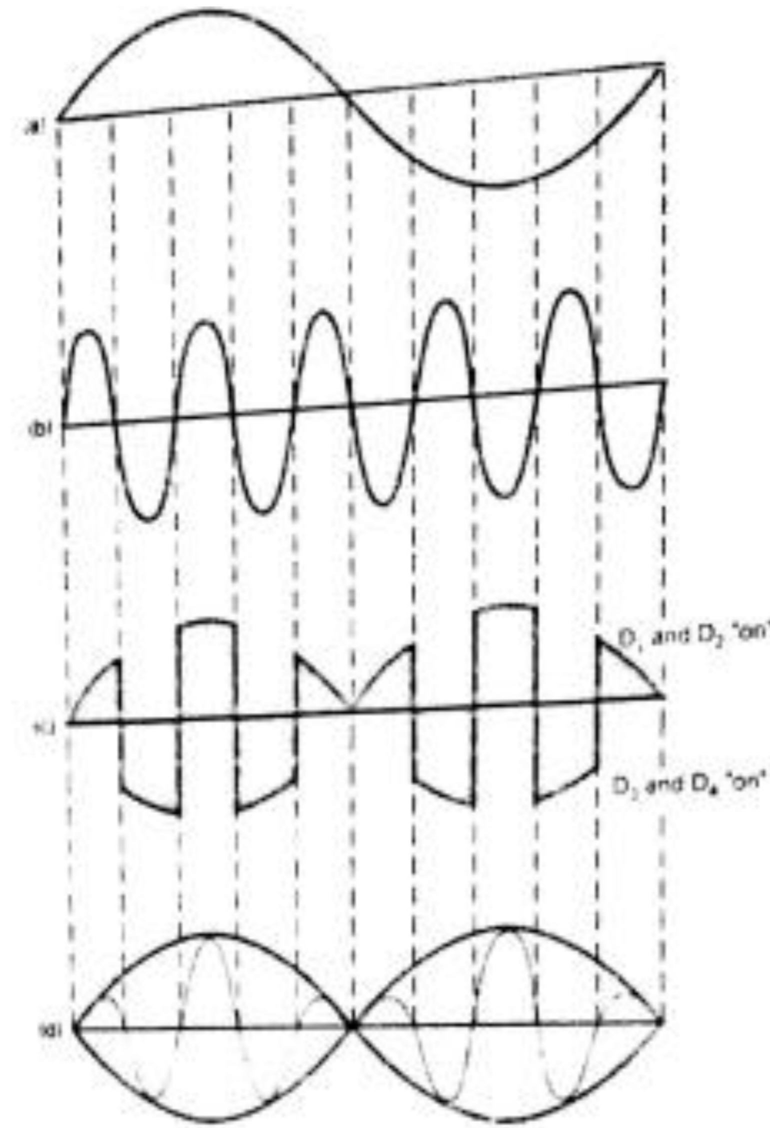
DSBSC Generation- Ring Modulator



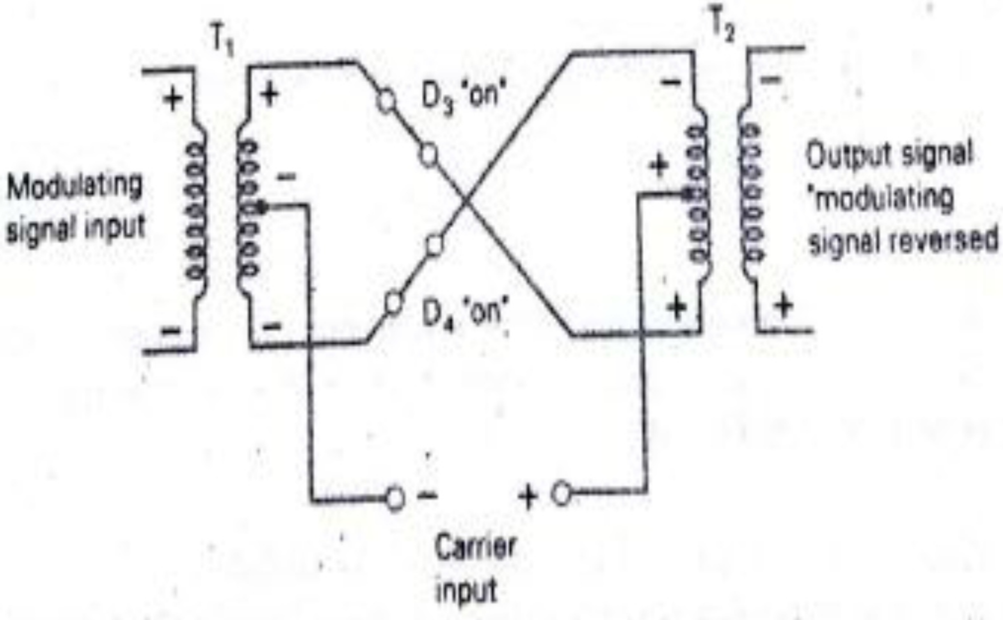
(a)

DSBSC Generation- Ring Modulator

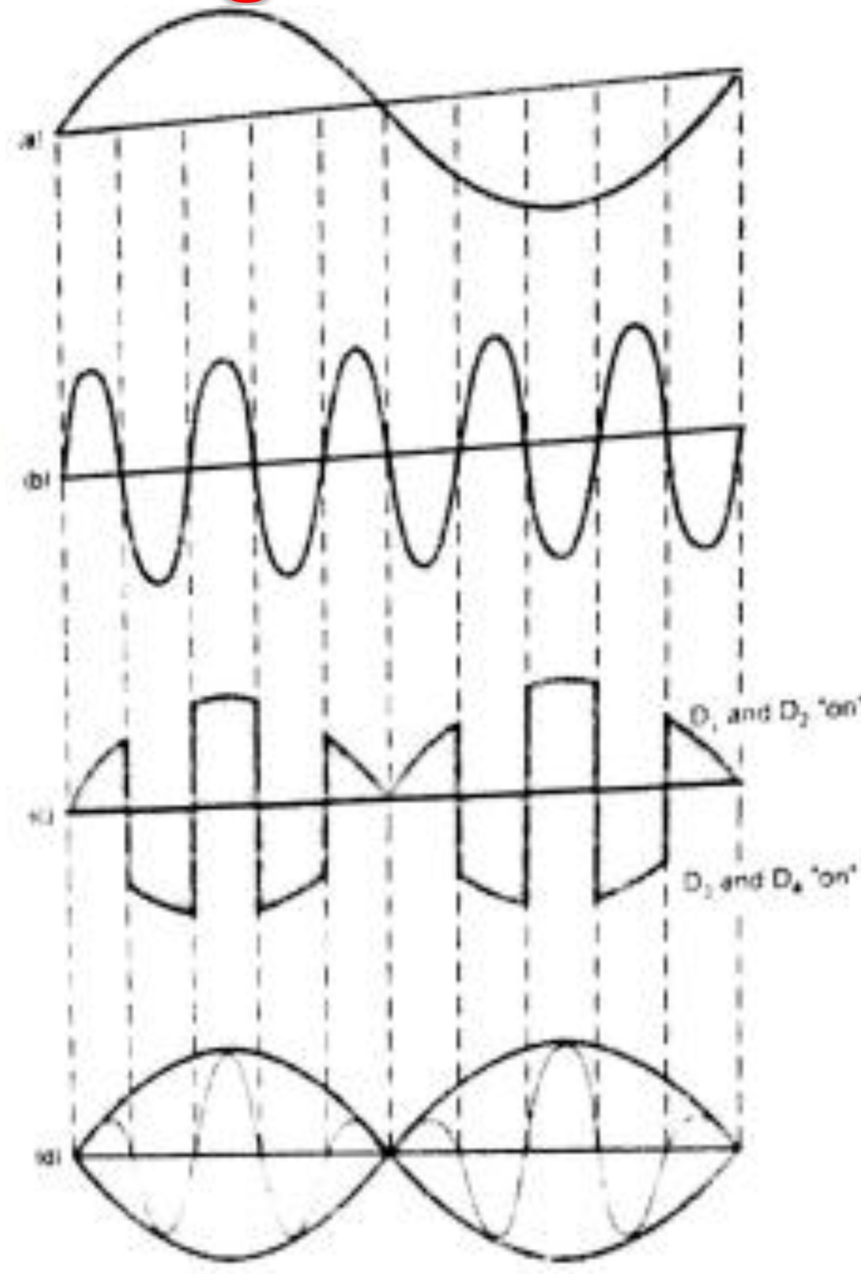




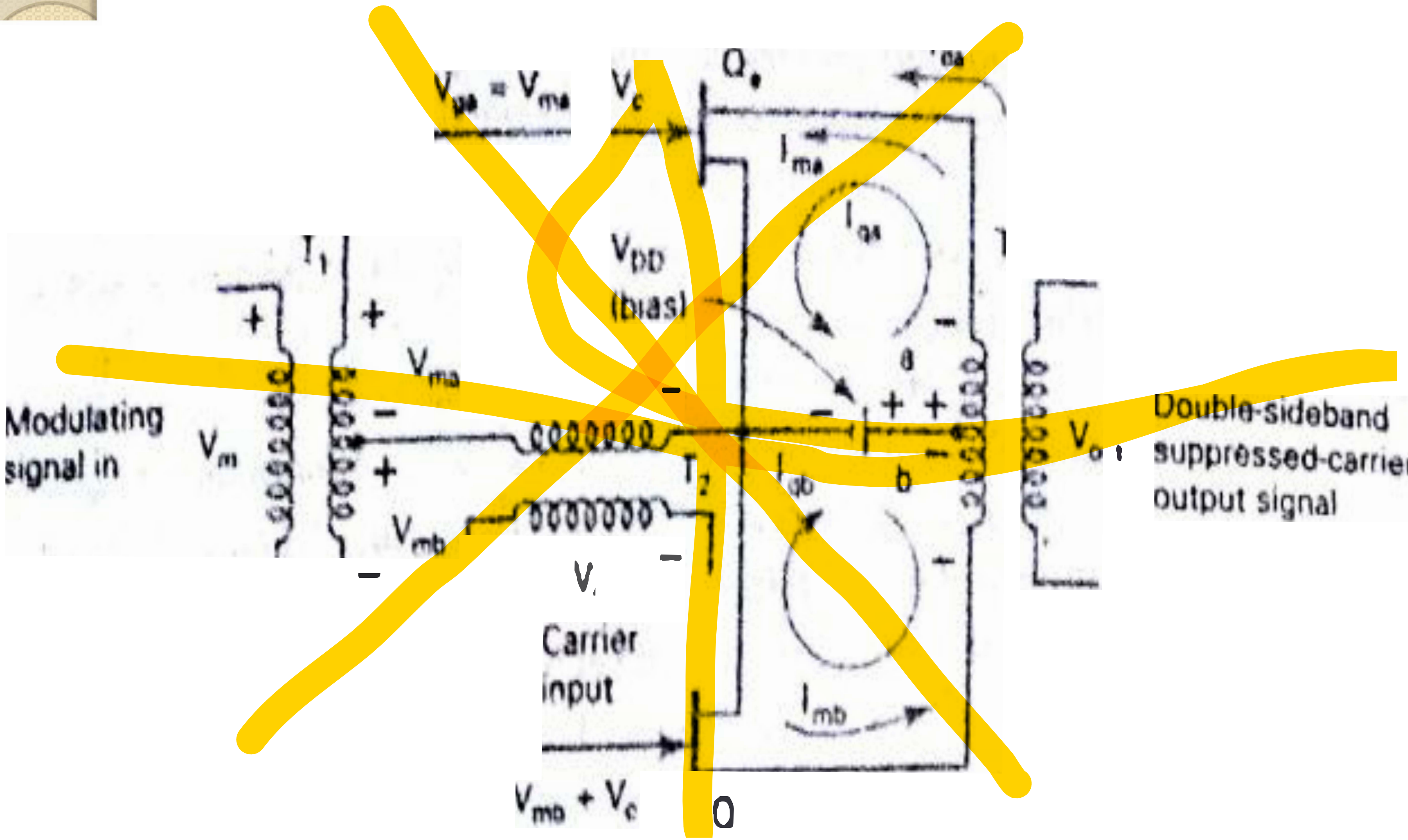
DSBSC Generation- Ring Modulator



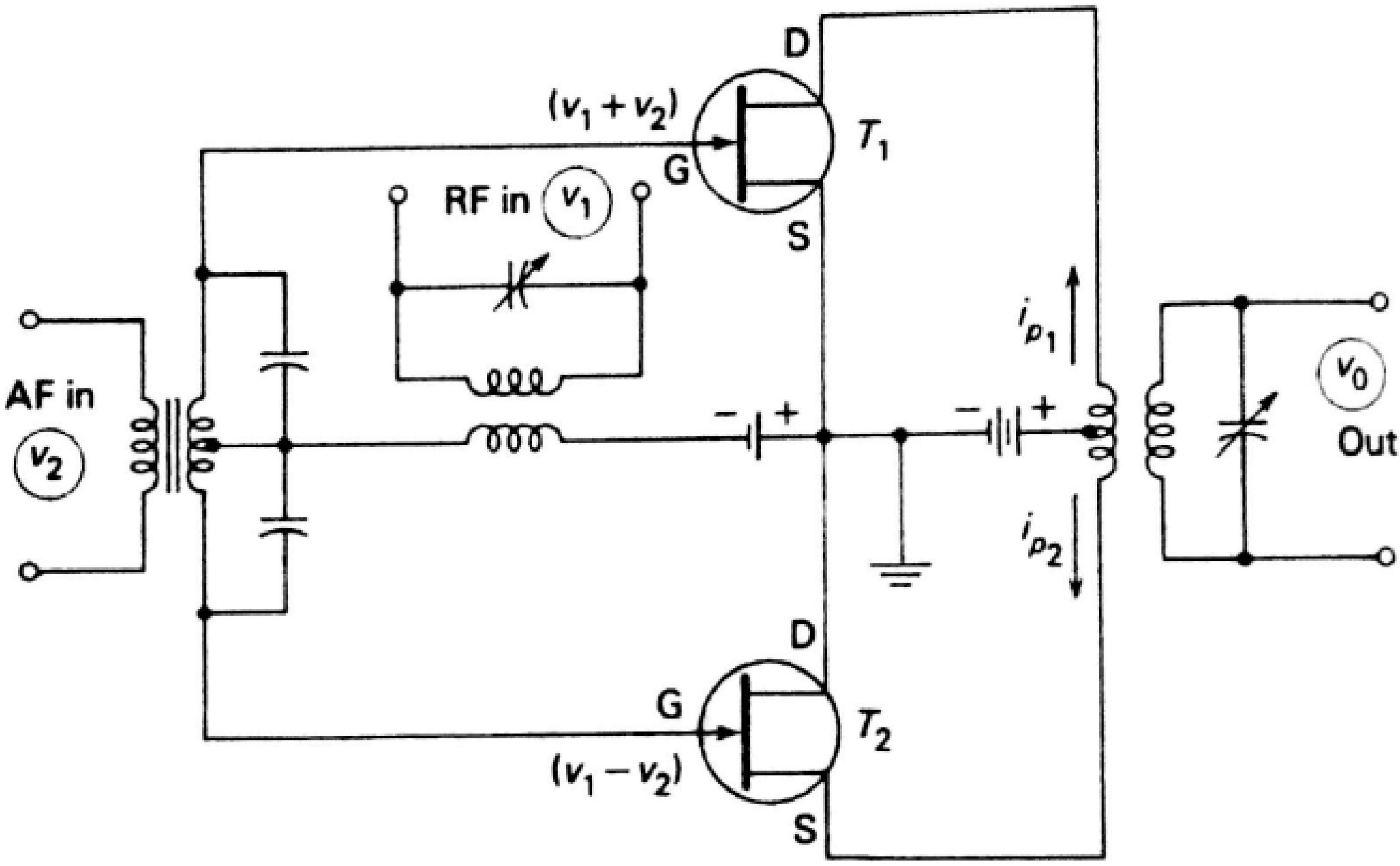
(c)



DSBSC Generation- Balanced Modulator



DSBSC Generation- Balanced Modulator



DSBSC Generation- Balanced Modulator

$$i_{d_1} = a + b(v_1 + v_2) + c(v_1 + v_2)^2$$
$$= a + bv_1 + bv_2 + cv_1^2 + cv_2^2 + 2cv_1v_2. \tag{4-9}$$

$$i_{d_2} = a + b(v_1 - v_2) + c(v_1 - v_2)^2$$
$$= a + bv_1 - bv_2 + cv_1^2 + cv_2^2 - 2cv_1c_2 \tag{4-10}$$

As previously indicated, the primary current is given by the difference between the individual drain currents. Thus

$$i_1 = i_{d_1} - i_{d_2} = 2bv_2 + 4cv_1v_2 \tag{4-11}$$

DSBSC Generation- Balanced Modulator

when Equation (4-10) is subtracted from (4-9).

We may now represent the carrier voltage v_1 by $v_c \sin \omega_c t$ and the modulating voltage v_2 by $V_m \sin \omega_m t$. Substituting these into Equation (4-11) gives

$$
\begin{aligned}
i_1 &= 2bV_m \sin \omega_m t + 4cV_m V_c \sin \omega_c t \sin \omega_m t \\
&= 2bV_m \sin \omega_m t + 4cV_m V_c \tfrac{1}{2}[\cos(\omega_c - \omega_m)t - \cos(\omega_c + \omega_m)t] \qquad \text{(4-12)}
\end{aligned}
$$

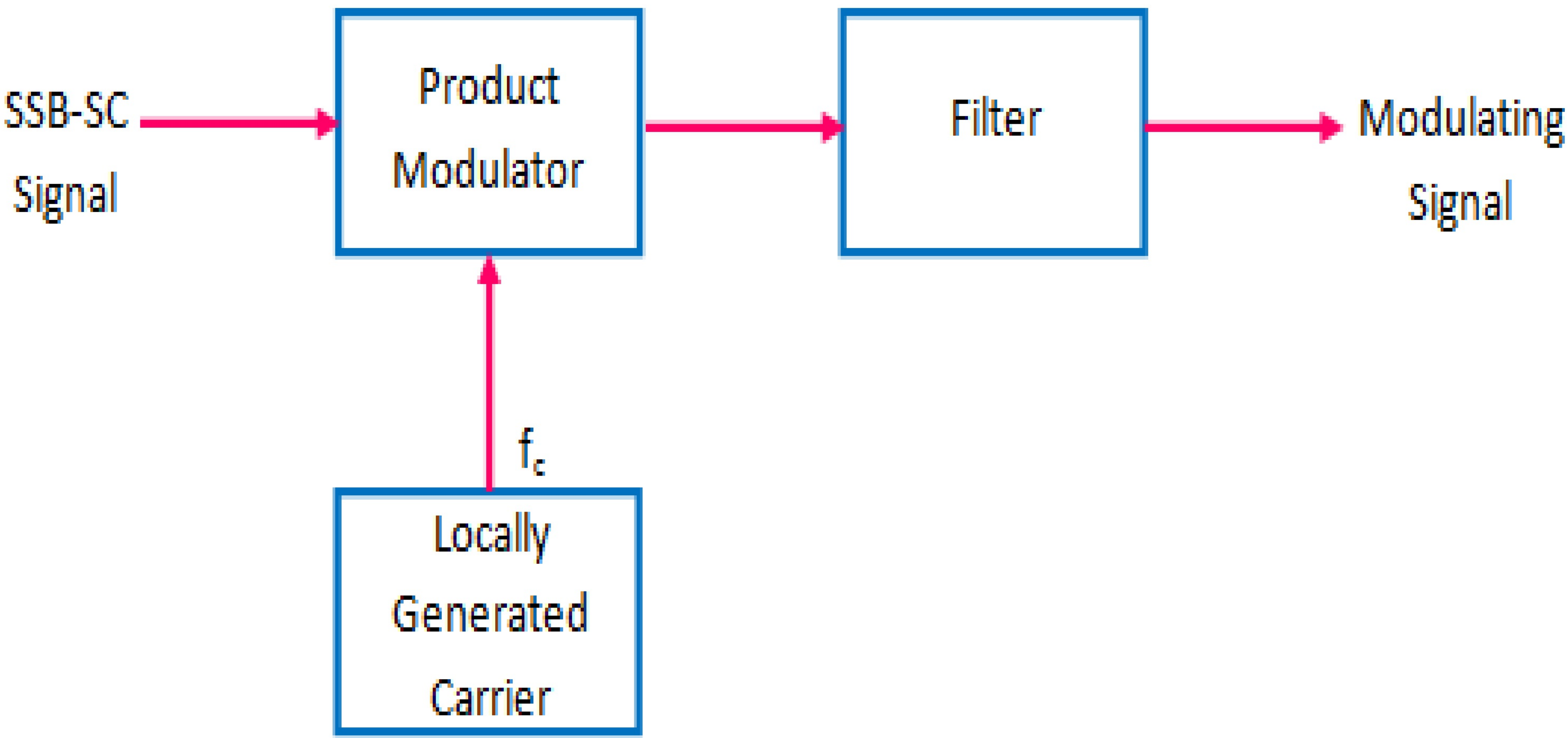
The output voltage v_0 is proportional to this primary current. Let the constant of proportionality be α. Then

$$
\begin{aligned}
v_0 &= \alpha i_1 \\
&= 2\alpha b V_m \sin \omega_m t + 2\alpha c V_m V_c[\cos(\omega_c - \omega_m)t - \cos(\omega_c + \omega_m)t]
\end{aligned}
$$

Simplifying, we let $P = 2\alpha b V_m$ and $Q = 2\alpha c V_m V_c$. Then

$$
v_0 = \underbrace{P \sin \omega_m t}_{\text{Modulation frequency}} + \underbrace{Q \cos(\omega_c - \omega_m)t}_{\text{Lower sideband}} - \underbrace{Q \cos(\omega_c + \omega_m)t}_{\text{Upper sideband}} \qquad \text{(4-13)}
$$

DSBSC Detection (Demodulation)



Mathematical Analysis

Let the output of the local oscillator be given by,

$$c'(t) = \cos(2\pi f_c t + \phi) \quad \text{...(3.92)}$$

Thus its amplitude is 1 (unity), frequency is f_c and the phase difference is arbitrary equal to ϕ. This phase difference has been measured with respect to the original carrier c(t) at the DSB-SC generator. Therefore, the output of the product modulator is given by,

$$m(t) = s(t) \,.\, c'(t) \quad \text{...(3.93)}$$

$$s(t) = \text{DSB-SC input} = x(t) \,.\, E_c \cos(2\pi f_c t)$$

and $\quad c'(t) = \text{Local carrier} = \cos(2\pi f_c t + \phi)$

or $\quad m(t) = x(t) \,.\, E_c \cos(2\pi f_c t) \cos(2\pi f_c t + \phi)$

Therefore, $\quad m(t) = x(t) \,.\, E_c \cos(2\pi f_c t + \phi) \cos(2\pi f_c t) \quad \text{...(3.94)}$

But, $\quad \cos A \cos B = \frac{1}{2}[\cos(A+B) + \cos(A-B)]$

Hence, $\cos(2\pi f_c t + \phi) \cos(2\pi f_c t) = \frac{1}{2}[\cos(2\pi f_c t + \phi + 2\pi f_c t) + \cos\phi] = \frac{1}{2}[\cos(4\pi f_c t + \phi) + \cos\phi]$

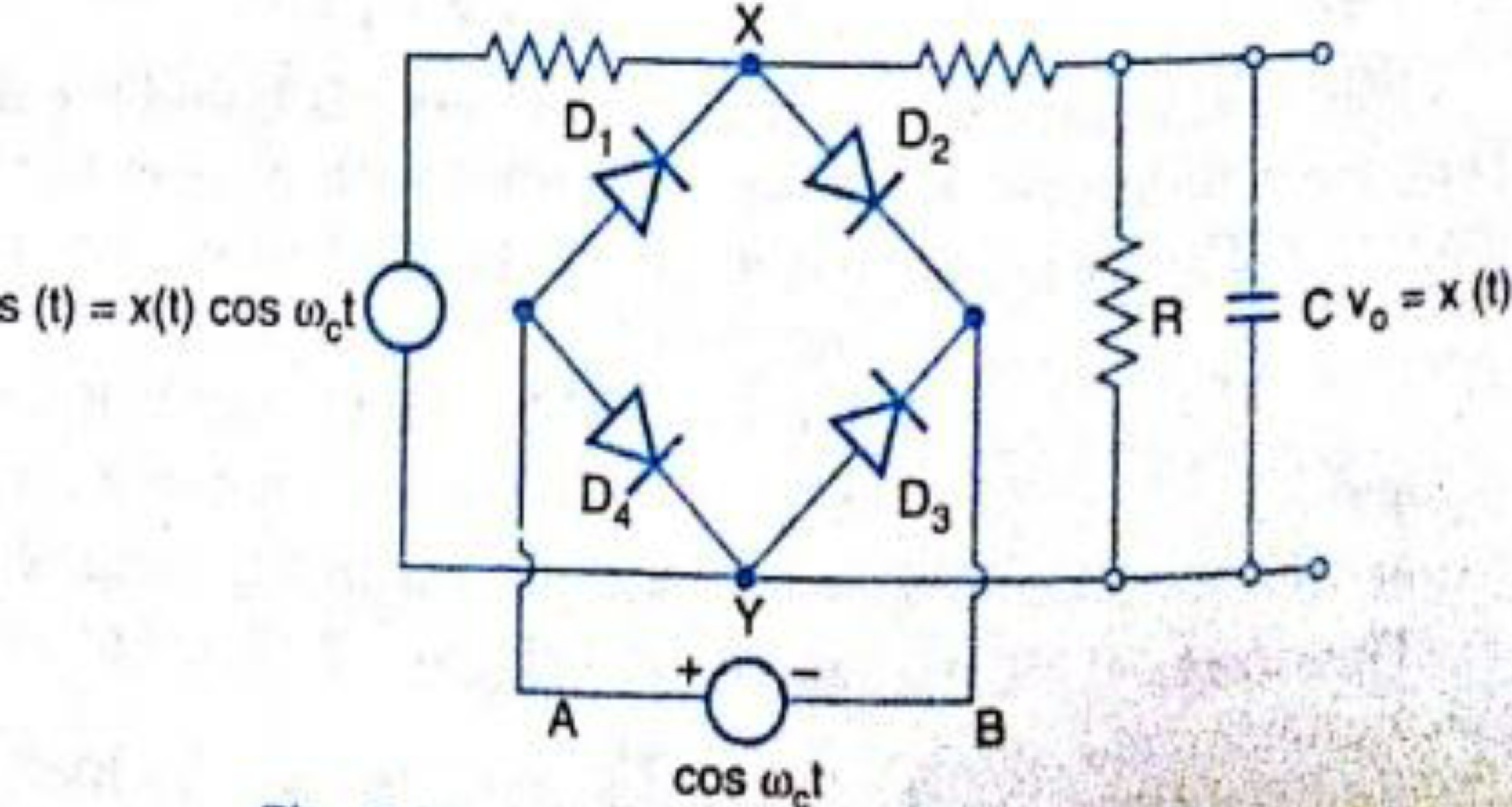
Mathematical Analysis

Thus, $$m(t) = \frac{1}{2} x(t) E_c [\cos(4\pi f_c t + \phi) + \cos\phi]$$

Therefore, $$m(t) = \underbrace{\frac{1}{2} E_c \cos\phi \, x(t)}_{\text{Scaled version of message signal } x(t)} + \underbrace{\frac{1}{2} x(t) E_c \cos(4\pi f_c t + \phi)}_{\text{Unwanted term}}$$

$$v_o(t) = \frac{1}{2} E_c \cos\phi \, x(t)$$

DSBSC Demodulation by switching (chopper) demodulator



DSBSC Demodulation by switching (chopper) demodulator

Thus, $v_0(t) = s(t) \times \cos \omega_c t$

or $v_0(t) = x(t) \cos \omega_c t \times \cos \omega_c t = x(t) \cos^2 \omega_c t$ ...(3.97)

or $$v_0(t) = x(t)\left[\frac{1+\cos 2\omega_c t}{2}\right]$$

Therefore, $$v_0(t) = \frac{x(t)}{2} + \frac{1}{2}\cos(2\omega_c t)$$ ...(3.98)

Taking the Fourier Transform of this expression, we get the spectrum of V_0 as under:

$$F[v_0(t)] = V_0(f) = \frac{1}{2}X(f) + \frac{1}{2}[\delta(f-2f_c) + \delta(f+2f_c)]$$

DSBSC Demodulation by switching (chopper) demodulator