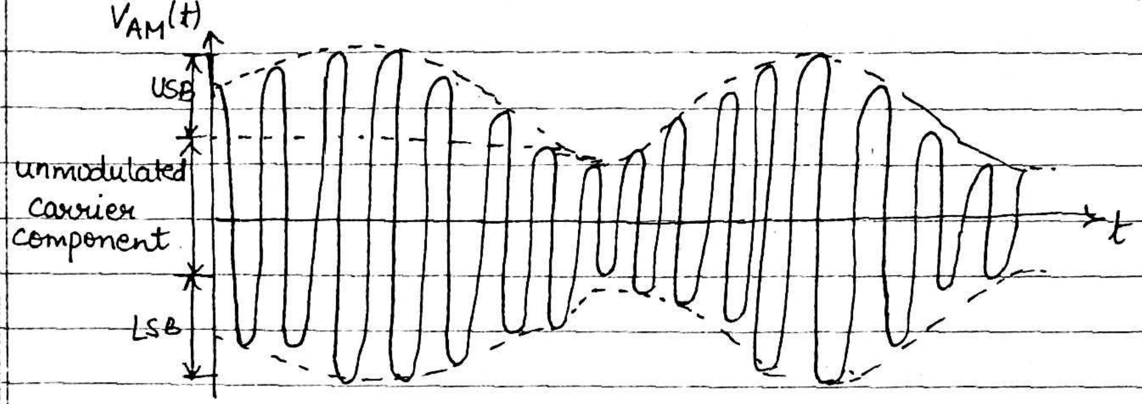
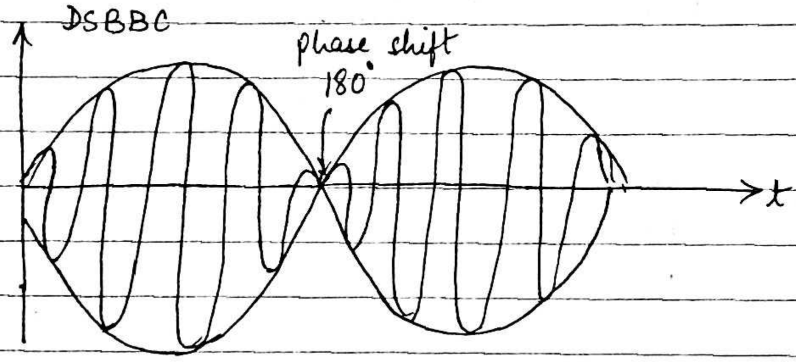
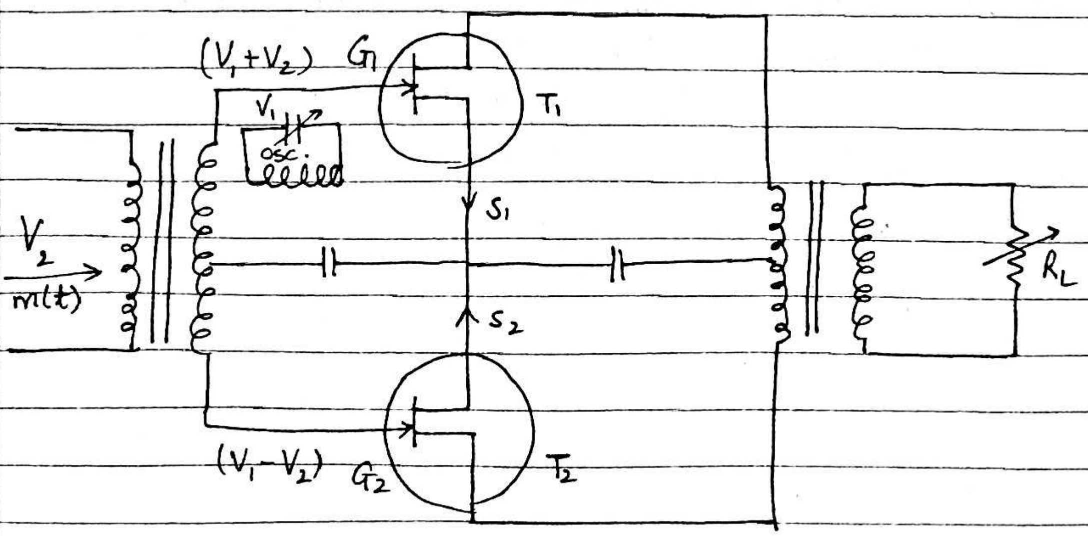




Product modulators

1. Balanced modulator circuit
2. Ring modulator circuit

Balanced modulator



$V_2 = V_m \sin w_m t = m(t)$
$V_1 = V_c \sin w_c t = c(t)$

For non linear devices : $i = a + bv + cv^2$: current characteristics

$$i_{d_1} = a + b(V_1 + V_2) + c(V_1 + V_2)^2$$

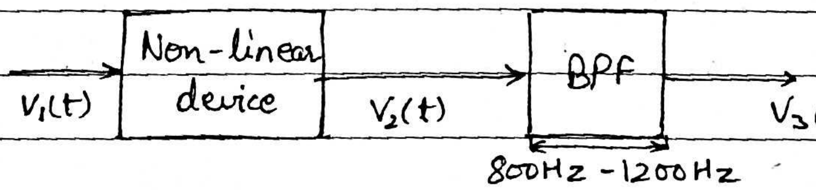
$$i_{d_2} = a + b(V_1 - V_2) + c(V_1 - V_2)^2$$

Current at centre tapped position :

$$\Delta i = i_{d_1} - i_{d_2}$$
$$= a + b(V_1 + V_2) + c(V_1 + V_2)^2 - a - b(V_1 - V_2) \mp c(V_1 - V_2)^2$$
$$= a + bV_1 + bV_2 + cV_1^2 + cV_2^2 + 2cV_1V_2 - a - bV_1 + bV_2 \mp cV_1^2 \mp cV_2^2 + 2cV_1V_2$$
$$= 2bV_2 + 4cV_1V_2$$

$$\Delta i = 2bV_m \sin w_m t + 4cV_c \sin w_m t V_m \sin w_c t$$

Soln 1. $V_1(t) = 10\cos(2000\pi t) + 4\sin(2000\pi t)$
$V_2(t) = V_1(t) + 0.1 V_1^2(t)$



$$V_2(t) = 10\cos(2000\pi t) + 4\sin(2000\pi t) + 0.1\left(10\cos(2000\pi t) + 4\sin(2000\pi t)\right)^2$$

$$= 10\cos(2000\pi t) + 4\sin(2000\pi t) + 0.1\left(100\cos^2(2000\pi t) + 16\sin^2(2000\pi t) + 80\cos(2000\pi t)\sin(2000\pi t)\right)$$

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$$V_2(t) = 10\cos(2000\pi t) + 4\sin(2000\pi t) + 0.1\left(\frac{(\cos(4000\pi t)+1)}{2}\right)100$$

$$+(1-\cos(4000\pi t))\frac{16}{2} + \frac{80}{2}\left(\sin(2200\pi t) - \sin(1800\pi t)\right)$$

$$V_2(t) = 10\cos(2000\pi t) + 4\sin(2000\pi t) + 0.1\big(50 + 50\cos 4000\pi t$$
$$+8 - 8\cos 4000\pi t + 40\sin 2200\pi t - 40\sin 1800\pi t\big)$$

$$V_2(t) = 10\cos(2000\pi t) + 4\sin(200\pi t) + 5 + 5\cos 4000\pi t + 0.8 -$$
$$0.8\cos 400\pi t + 4.0\sin 2200\pi t - 4.0\sin 1800\pi t$$

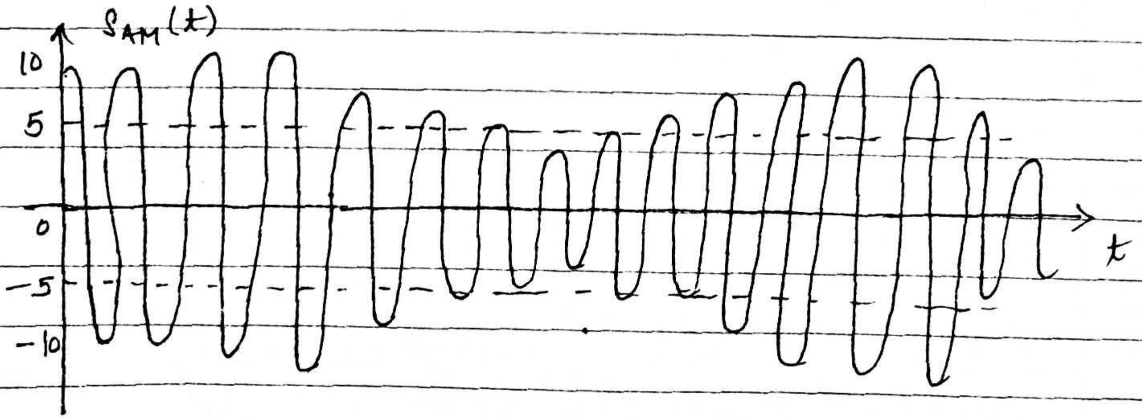
$$V_2(t) = 10\cos 2\pi(1000)t + 4\sin 2\pi(100t) + 5 + 5\cos 2\pi(2000)t +$$
$$0.8 - 0.8\cos 2\pi(200)t + 4.0\sin 2\pi(1100)t - 4.0\sin 2\pi(900)t$$

On passing it through the BPF :

$$V_3(t) = 10\cos 2000\pi t + 4\sin 2\pi(1100)t - 4\sin 2\pi(900)t$$

$$\therefore V_3(t) = 10\cos 2000\pi t + 4\sin 2200\pi t - 4\sin 1800\pi t$$

Q. An amplitude modulated waveform shown in fig.
Determine: i) modulation index (m),
ii) efficiency
iii) find out amplitude of carrier signal which must be added to attain $m = 0.1$



Soln: i) $m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$

$= \frac{10-5}{10+5} = \frac{5}{15} = \frac{1}{3} = 33\%$

ii) $\eta = \frac{m^2}{2+m^2}$

$= 0.053\%$

$= 5.3\%$

$V_{max} = V_c + V_m$

$= V_c + mV_c$ —— (i)

$V_{min} = V_c - V_m$

$= V_c - mV_c$ —— (ii)

$V_c = \frac{V_{max} + V_{min}}{2} = \frac{10+5}{2} = 7.5\,V$

$V_c = \frac{V_{max} - V_{min}}{2m} = \frac{10-5}{2 \times \frac{1}{3}} = 7.5\,V$

iii) $m' = 0.1$

$V_c' = \frac{V_{max} - V_{min}}{2m'}$

$= \frac{10-5}{2 \times 0.1} = \frac{5}{0.2}$

$= 25\,V$

$V_c' - V_c = 25 - 7.5 = 17.5\,V$

Q. Using the message signal $m(t) = \frac{t}{1+t^2}$. Obtain the expression for AM wave when the % of modulation are : i) 50%

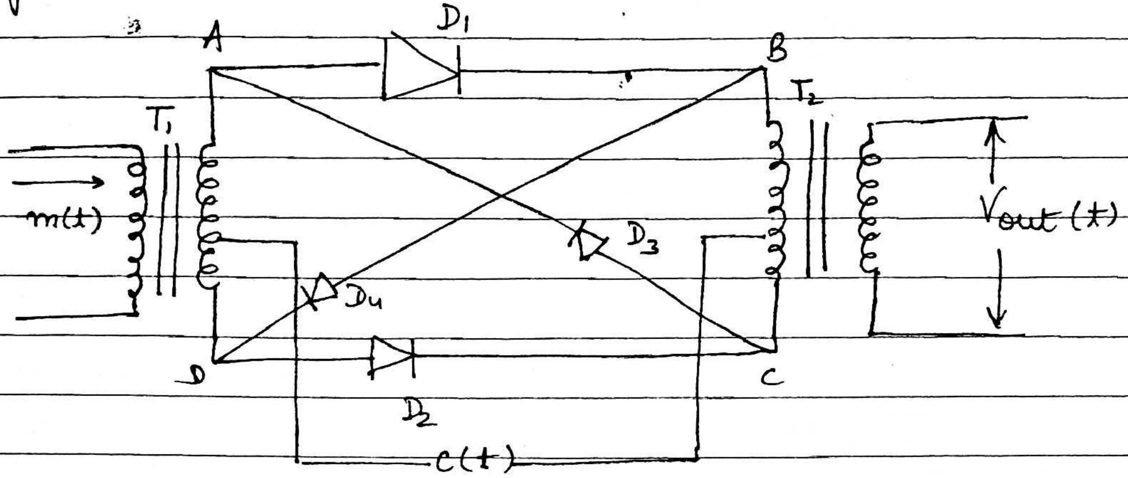
ii) 100%.

Soln: $v(t) = V_c(1 + m\sin\omega_m t)\sin\omega_c t$

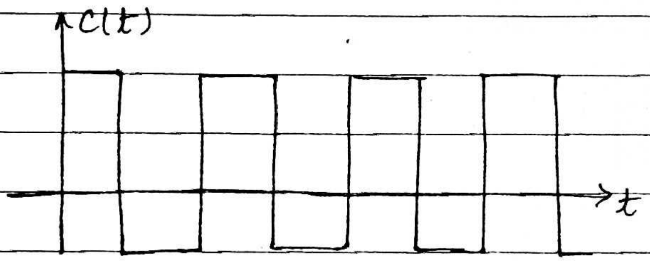
$= V_c(1 + k_a m(t))\sin\omega_c t$

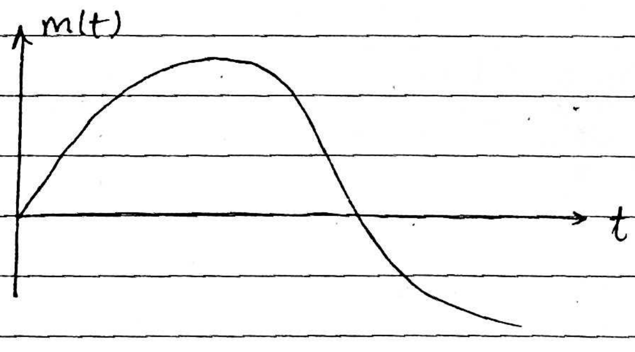
$\frac{dm(t)}{dt} = 0$ for maximum value.

Ring Modulator



Theory - Book





1. For +ve half cycle of $m(t)$

Case 1 : For +ve half cycle of $c(t)$

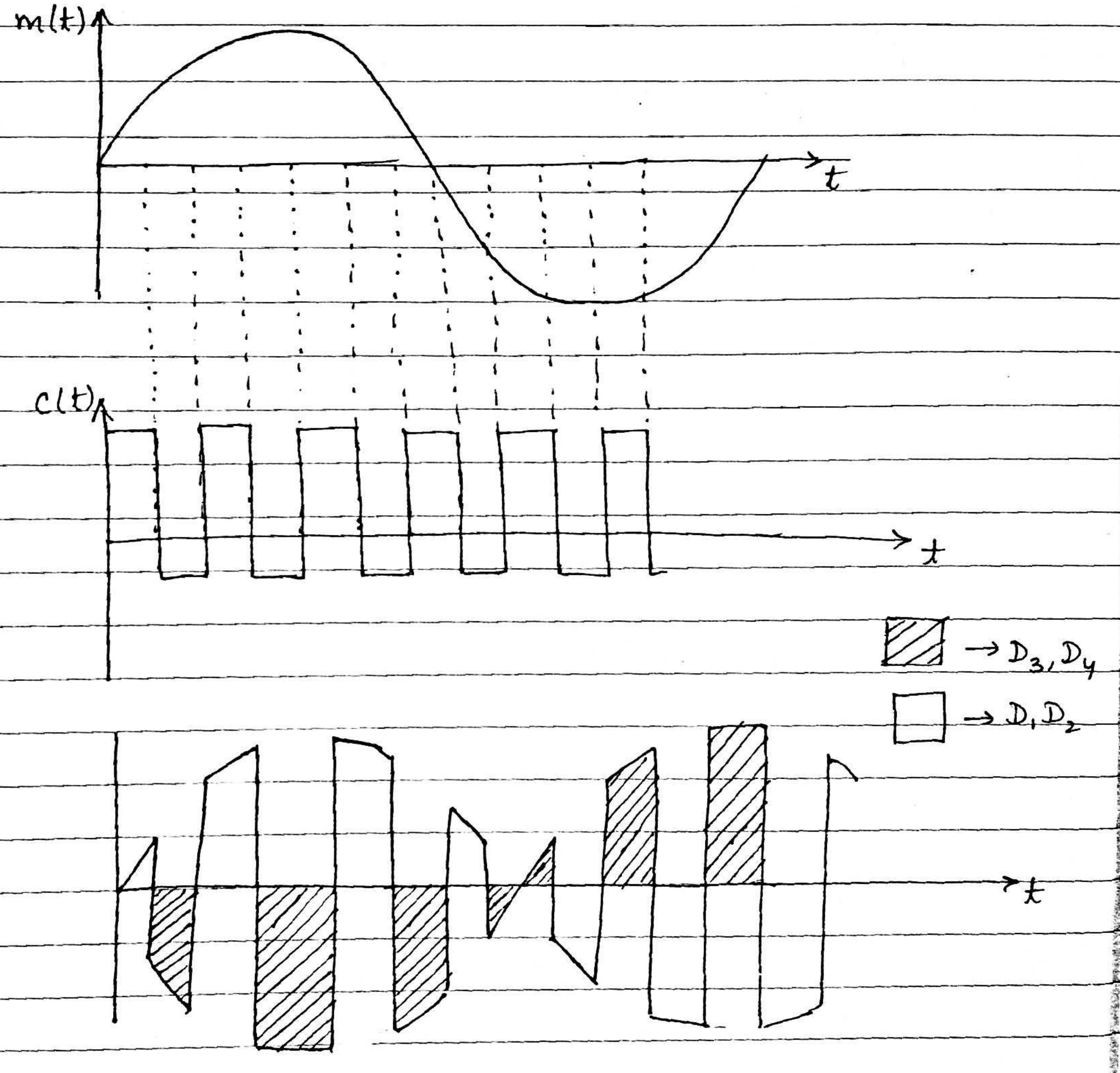
$D_1 \cdot D_2$ = ON
$D_3 \cdot D_4$ = OFF

Case 2 : For -ve half cycle of $c(t)$

$D_1 \cdot D_2$ = OFF
$D_3 \cdot D_4$ = ON

2. For -ve half cycle of $m(t)$

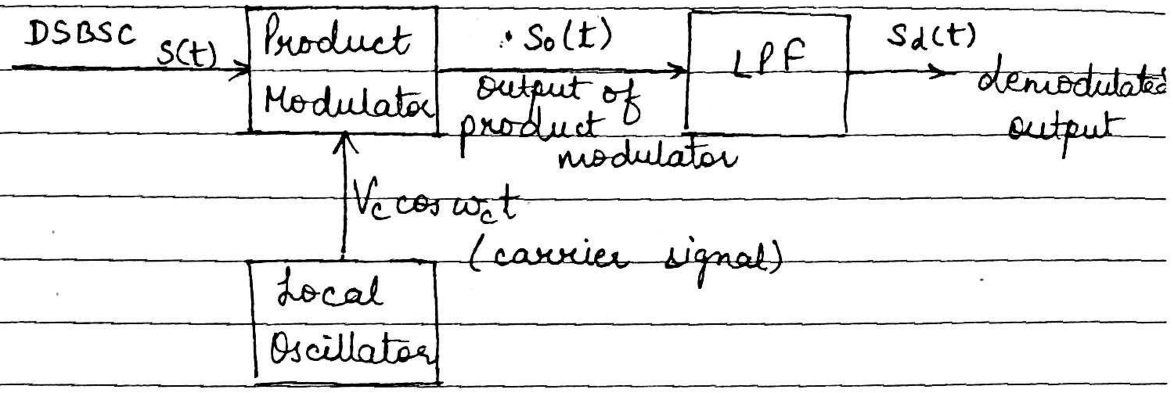
Voltage at D_1 and D_2 = -ve
Voltage at D_3 and D_4 = +ve



Demodulation of DSBSC :

i) Coherent / synchronous demodulation
ii) Carrier Re-insert technique.

Coherent / synchronous demodulation



$$DSBSC = s(t) = V_m \cos w_m t \times V_c \cos w_c t$$

$$S_o(t) = S(t) \cdot V_c \cos w_c t$$
$$= V_c \cos w_c t \cdot m(t) \cdot V_c \cos w_c t$$
$$= V_c \cos w_c t \cdot V_m \cos w_m t \cdot V_c \cos w_c t$$
$$= V_c^2 \cos^2 w_c t \cdot V_m \cos w_m t$$
$$= V_c^2 V_m \left(\frac{1 + \cos 2w_c t}{2} \right) \cos w_m t$$

$$S_o(t) = \frac{V_c^2 V_m \cos w_m t}{2} + \frac{V_c^2 V_m}{2} \cos 2w_c t \cdot \cos w_m t$$

The output of low pass filter :

$$S_d(t) = \frac{V_c^2 V_m}{2} \cos w_m t \quad = \frac{V_c V_c' m(t)}{2}$$

There are 2 types of error -

i) Phase error
ii) Frequency error

Phase error - When the frequency of local oscillator generated by the carrier signal matches with the frequency of original oscillator and there is arbitrary phase difference between these two signals then the error is called phase error.