$$P_t = P_c \left\{ 1 + \frac{m^2}{2} \right\}$$

$$I_t^2 R = I_c^2 R \left\{ 1 + \frac{m^2}{2} \right\}$$

$$I_t^2 = I_c^2 \left\{ 1 + \frac{m^2}{2} \right\}$$

$$\therefore I_t = I_c \sqrt{1 + \frac{m^2}{2}}$$: Current relation

$$P_c = \frac{V_c^2}{2R}$$ [Take $R = 1\,k\Omega$ when not given]

Transmission efficiency :

$$\eta = \frac{P_{SB}}{P_t}$$

$$\eta = \frac{P_c m^2/2}{P_c\left(1 + \frac{m^2}{2}\right)} = \frac{m^2}{2 + m^2}.$$

For 100% modulation $m = 1$

$$\eta = \frac{1}{2+1} = \frac{1}{3} = 33\%$$

Bandwidth of AM wave :

$$B_T = 2f_m$$ f_m = highest component frequency of message signal or modulating signal

Eg: $5\cos 200\pi t$

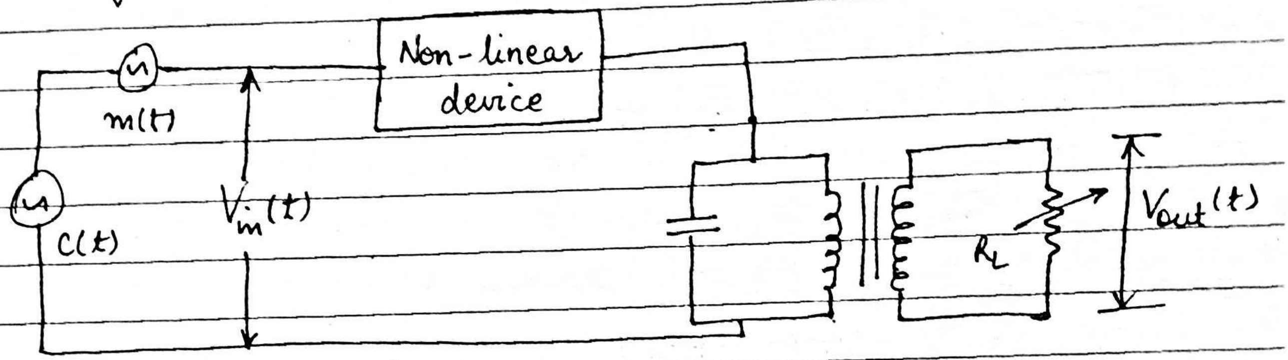
~~f_m~~ $f_m = 100\text{ Hz}$

$m(t) = 5\cos 200\pi t + 10\sin 500\pi t + 5\sin 300\pi t$

1) High level generation - AM generation or AM modulation

A.M. Modulation

i) Square Law Modulators / Power Law Modulator
ii) Switching Modulator



Tuned Circuit

$m(t) = V_m \sin \omega_m t$
$c(t) = V_c \sin \omega_c t$
$V_{out}(t) = a_1 V_{in}(t) + a_2 V_{in}^2(t)$

$V_{in}(t) = m(t) + c(t)$
$= V_m \sin \omega_m t + V_c \sin \omega_c t$

$V_{out}(t) = a_1 [V_m \sin \omega_m t + V_c \sin \omega_c t] + a_2 [V_m^2 \sin^2 \omega_m t + V_c^2 \sin^2 \omega_c t$
$+ 2 V_m V_c \sin \omega_m t \sin \omega_c t]$

$V_{out}(t) = a_1 V_m \sin \omega_m t + a_1 V_c \sin \omega_c t + a_2 V_m^2 \sin^2 \omega_m t + a_2 V_c^2 \sin^2 \omega_c t$
$+ 2a_2 V_m V_c \sin \omega_m t \sin \omega_c t$

band pass (fc - fm) to (fc + fm)

When it passes through the filter then we get:

$V_{out}(t) = a_1 V_c \sin \omega_c t + 2a_2 V_m V_c \sin \omega_m t \sin \omega_c t$

$V_{out}(t) = a_1 V_c [\sin \omega_c t + 2 a_2 V_m \sin \omega_m t \sin \omega_c t]$

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$$V_{out}(t) = a_1 V_c \left[1 + \frac{2a_2}{a_1} V_m \sin \omega_m t \right] \sin \omega_c t$$

$$V_{out}(t) = a_1 V_c \left[1 + k_a m(t) \right] \sin \omega_c t$$: Standard eqn

k_a = Amplitude sig senstivity of modulating system

$= \frac{2a_2}{a_1}$

Amplitude censtivity of modulating system depends on the applied parameter or designed parameter.

Proof:

$$A = V_c + m(t)$$

$$V(t) = A \sin \omega_c t$$

$$= \{V_c + m(t)\} \sin \omega_c t$$

$$= V_c \left[1 + \frac{m(t)}{V_c} \right] \sin \omega_c t$$

$$k_a \propto \frac{1}{V_c}$$

$$k_a = C \frac{1}{V_c}$$ C = Value of designed parameter

$$V(t) = V_c \left[1 + k_a m(t) \right] \sin \omega_c t$$

$$m = k_a V_m$$

$$= k_a \, m(t)\big|_{max}$$

$$\left[\because \frac{m}{V_m} = \frac{1}{V_c} = k_a \right]$$

Q. The carrier wave is represented by the equation $c(t) = 10 \sin \omega_c t$. Draw the waveform of AM wave if modulation index $m = 0.75$.

Soln. $V_c = 10V$

$m = \frac{V_m}{V_c}$

$\therefore V_m = mV_c$

$= 0.75 \times 10$

$= 7.5V$

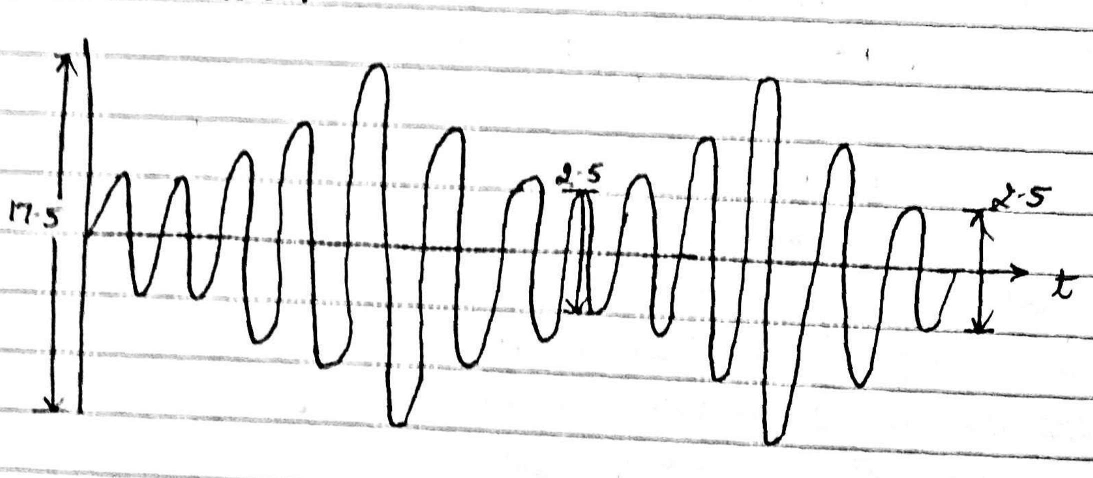
Max. amplitude of A.M. wave $= V_{max} = V_c + V_m$

$= 10 + 7.5 = 17.5V$

$V_{min} = V_c - V_m$

$= 10 - 7.5$

$= 2.5V$

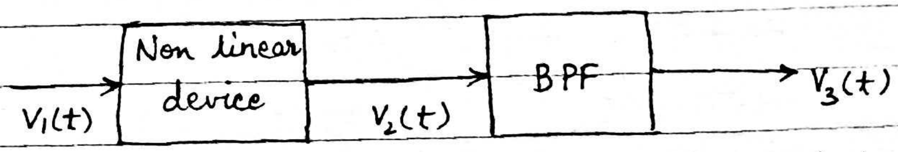


Q. The AM wave shown on the CRO screen. Determine the value of modulation index. $V_{max} = 10.5$, $V_{min} = 2.5$

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

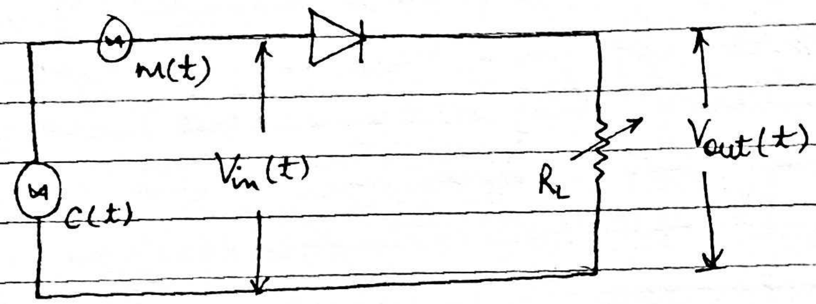
ii) 100%

Q.1 Obtain an expression for the signal $V_3(t)$ as shown in the fig. $V_1(t) = 10\cos(2000\pi t) + 4\sin(200\pi t)$. Assume that $V_2(t) = V_1(t) + 0.1 V_1^2(t)$ and the band pass filter is an ideal unity gain filter with pass band from 800 Hz to 1200 Hz.



(done after balanced modulator)

Switching Modulator



The on-off status of diode depends on the amp. of carrier signal. When amp. of carrier signal is sufficiently large then diode is on otherwise off.

$$V_{out}(t) = \begin{cases} V_{in}(t)\, g_p(t) & \text{for } c(t) > 0 \\ 0 & \text{for } c(t) < 0 \end{cases}$$

$c(t) = V_c \sin \omega_c t$

$m(t) = V_m \sin \omega_m t$

$V_{in}(t) = m(t) + c(t)$

$= V_c \sin \omega_c t + V_m \sin \omega_m t$

$$V_{out}(t) = V_{in}(t) \cdot g_p(t) \quad \text{———} \text{(ii)}$$

$g_p(t)$ = A periodic pulse train of fixed duty cycle

$$= \frac{1}{f_c}$$

$$g_p(t) = \frac{1}{2} + \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{(2n-1)} \sin 2\pi f_c t\,(2n-1)$$

$$V_{out}(t) = \left(V_c \sin w_c t + V_m \sin w_m t\right)\left\{\frac{1}{2} + \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{2n-1} \frac{\sin 2\pi f_c t}{(2n-1)}\right\}$$

for $n = 1$

$$V_{out}(t) = \left(V_c \sin w_c t + V_m \sin w_m t\right)\left(\frac{1}{2} + \frac{2}{\pi} \frac{1}{1} \sin 2\pi f_c t\right)$$

$$= \left(V_c \sin w_c t + V_m \sin w_m t\right)\left(\frac{1}{2} + \frac{2}{\pi} \sin \underbrace{2\pi f_c}_{w_c} t\right)$$

$$= \underbrace{\frac{V_c \sin w_c t}{2}}_{1} + \underbrace{\frac{V_m \sin w_m t}{2}}_{2 \text{ modulating signal}} + \underbrace{\frac{2}{\pi} \sin 2\pi f_c t \sin^2 w_c t\, V_c}_{3 \text{ Second harmonics of carrier signal}}$$

$$\underbrace{\frac{2}{\pi} \sin w_c t \sin w_m t\, V_m}_{4}$$

On passing it through the band pass filter:

$$V_{out}(t) = \frac{V_c}{2} \sin w_c t + \frac{2}{\pi} \sin w_c t \sin w_m t\, V_m$$

$$V_{out}(t) = \frac{V_c}{2}\left\{1 + \frac{4}{\pi V_c} V_m \sin w_m t\right\} \sin w_c t$$

$$V_{out}(t) = \frac{V_c}{2}\left[1 + \frac{4}{\pi V_c} m(t)\right] \sin w_c t$$