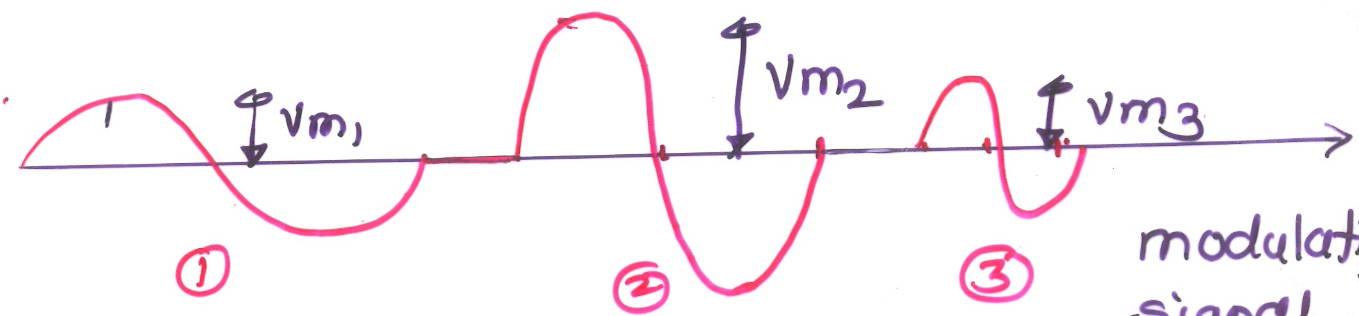
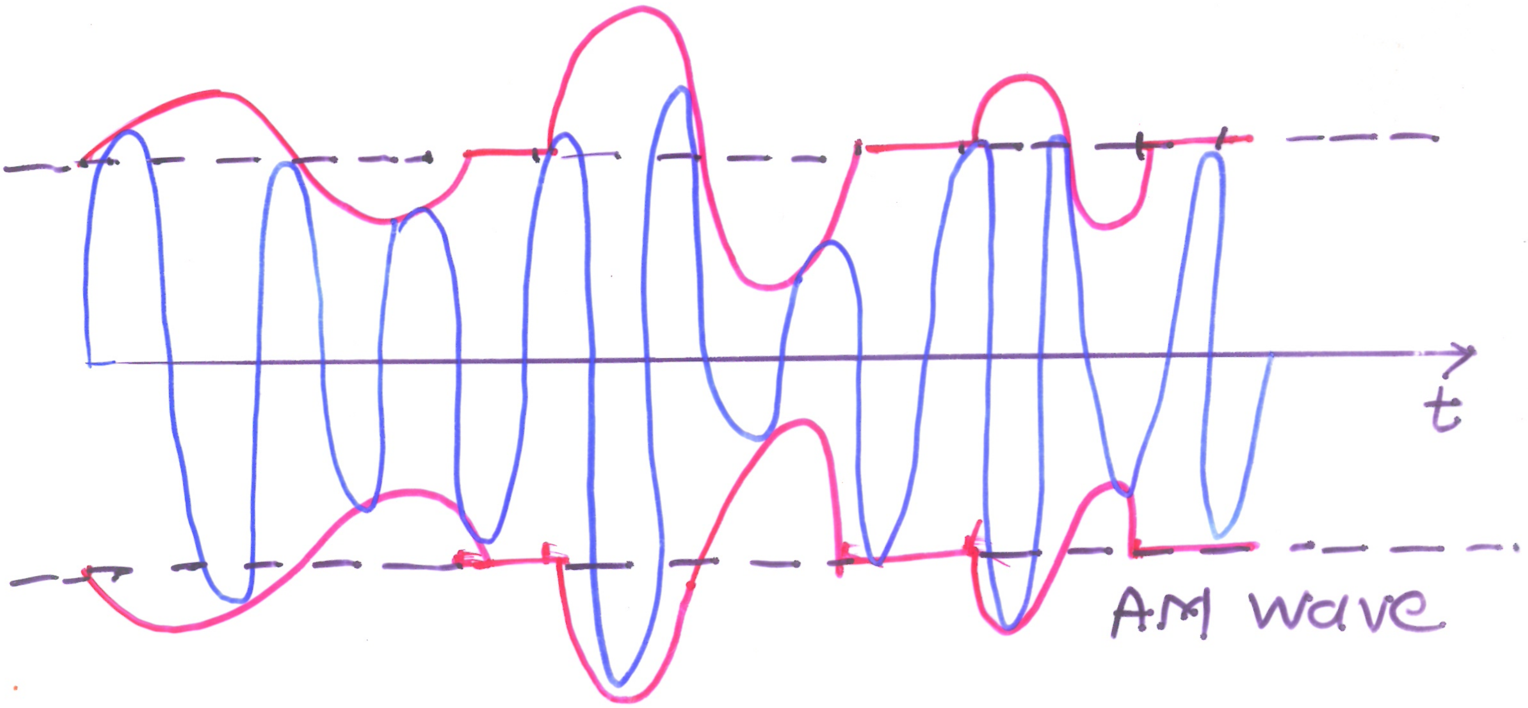
Single Sideband Techniques

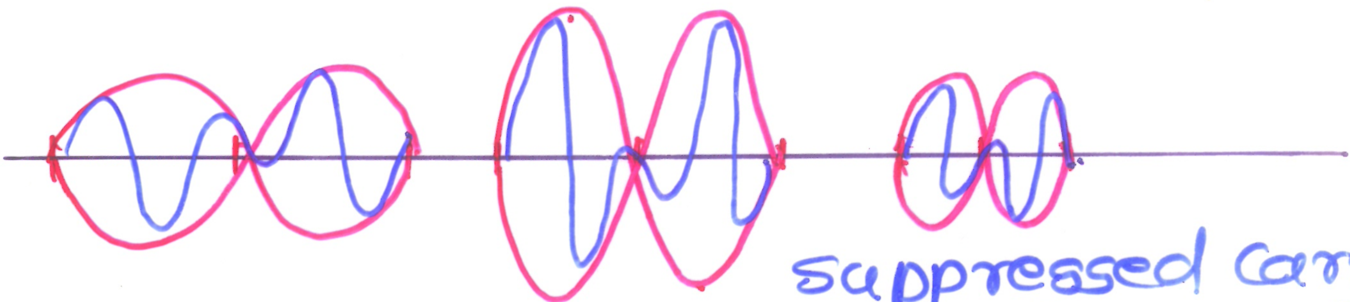


modulating signal

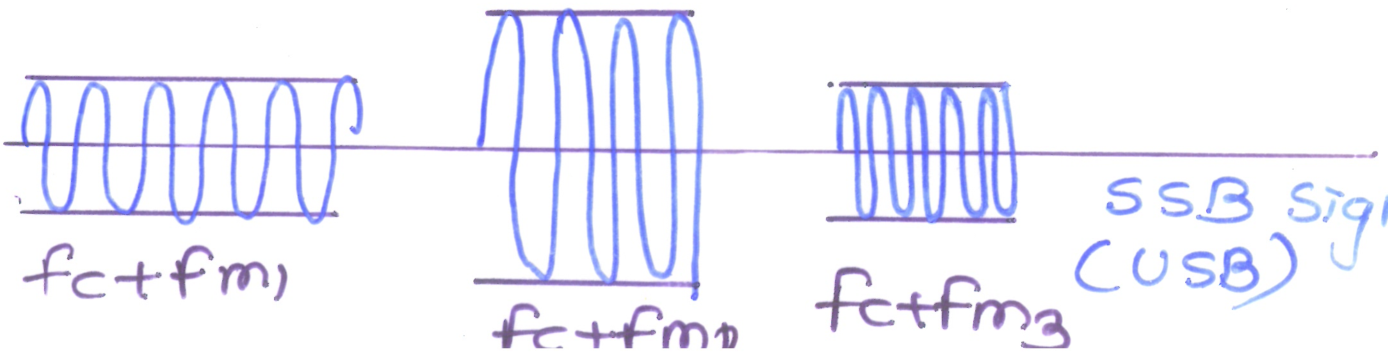
$v_{m1} = v_{m3}$, $f_{m1} = f_{m2}$



AM wave



suppressed carrier wave (DSBSC)



SSB Signal (USB)

Advantages of S.S.B over DSBFC [1B]

① Less B.W requirement BW = f_m
This allows more signals to be transmitted in the same freq range

② power saving 83.33% for m=1

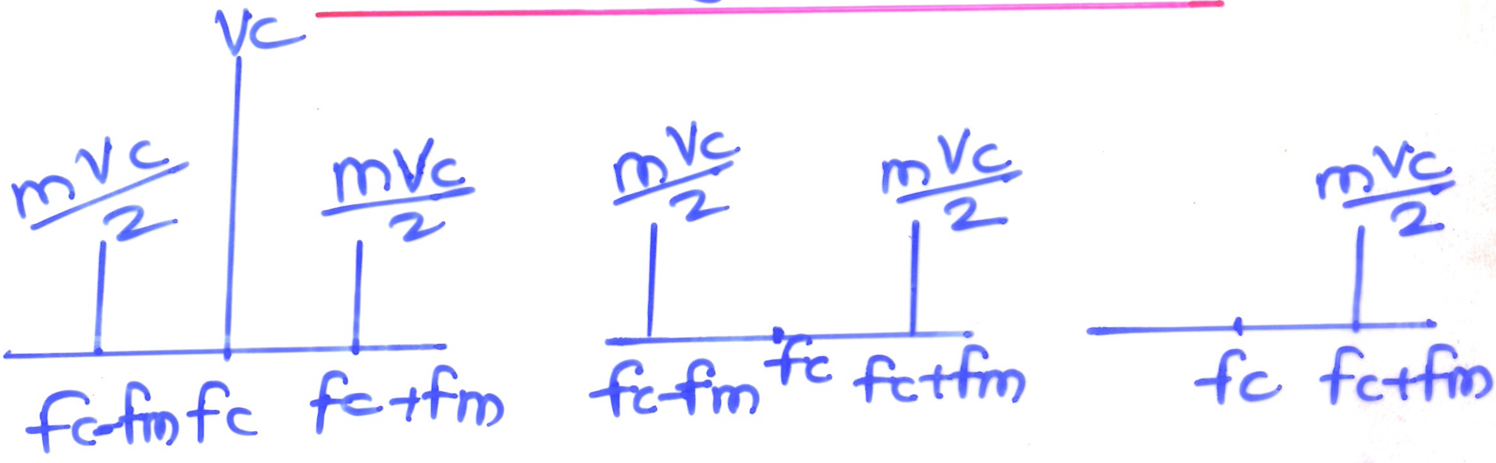
③ Reduction in interference due to noise
BW reduces so noise also reduces

Disadvantages

① Generation & reception of S.S.B signal is complicated.

② S.S.B Tx^r & Rx^r need to have excellent freq stability
A slight change in frequency will hamper the quality of transmitted & received signal. Therefore S.S.B is not generally used for transmission of good quality of music. It is used for speech communication

frequency spectrum



DSBFC DSBSC SSB

Effect of Nonlinear Resistance

Relationship b/n voltage & current in a linear resistance is given by

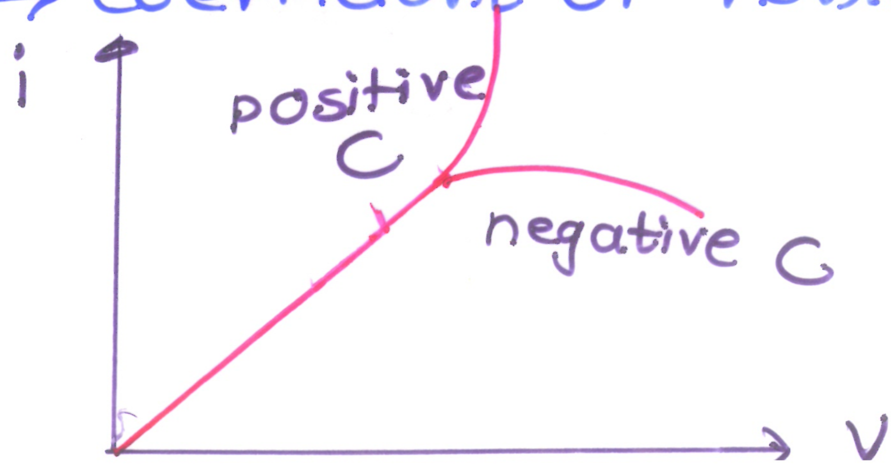
$$i = bV \quad \rightarrow (1)$$

b → constant of proportionality
for Resistor b is called transconductance

If we apply the eq^n to nonlinear resistance

$$i = a + bv + cv^2 + dv^3 + \text{higher powers of } v \quad \rightarrow (2)$$

where a → dc component
b → transconductance
c → coefficient of nonlinearity



Two input voltages V_1 and V_2 are applied simultaneously to the gate of FET

Let $V_1 = V_c \sin \omega_c t \rightarrow (3)$

$V_2 = V_m \sin \omega_m t \rightarrow (4)$

$$i = a + bv + cv^2 \rightarrow (5)$$

$$i = a + b(V_c \sin \omega_c t + V_m \sin \omega_m t) + c(V_c \sin \omega_c t + V_m \sin \omega_m t)^2 \rightarrow (6)$$

$$= a + bV_c \sin \omega_c t + bV_m \sin \omega_m t + cV_c^2 \sin^2 \omega_c t + cV_m^2 \sin^2 \omega_m t + 2cV_c \sin \omega_c t \, V_m \sin \omega_m t$$

$$= a + bV_c \sin \omega_c t + bV_m \sin \omega_m t + \frac{c}{2} V_c^2 (1 - \cos 2\omega_c t) + \frac{cV_m^2}{2}(1 - \cos 2\omega_m t) + \frac{2cV_cV_m}{2}\left[\cos(\omega_c - \omega_m)t - \cos(\omega_c + \omega_m)t\right]$$

$$= \underset{(1)}{\left(a + \frac{1}{2}cV_c^2 + \frac{1}{2}cV_m^2\right)} + \underset{(2)}{bV_c \sin \omega_c t} + \underset{(3)}{bV_m \sin \omega_m t} - \underset{(4)}{\left[\frac{1}{2}cV_c^2 \cos 2\omega_c t + \frac{1}{2}cV_m^2 \times \cos 2\omega_m t\right]}$$

$$+ cV_cV_m \cos(\omega_c - \omega_m)t \; (5)$$

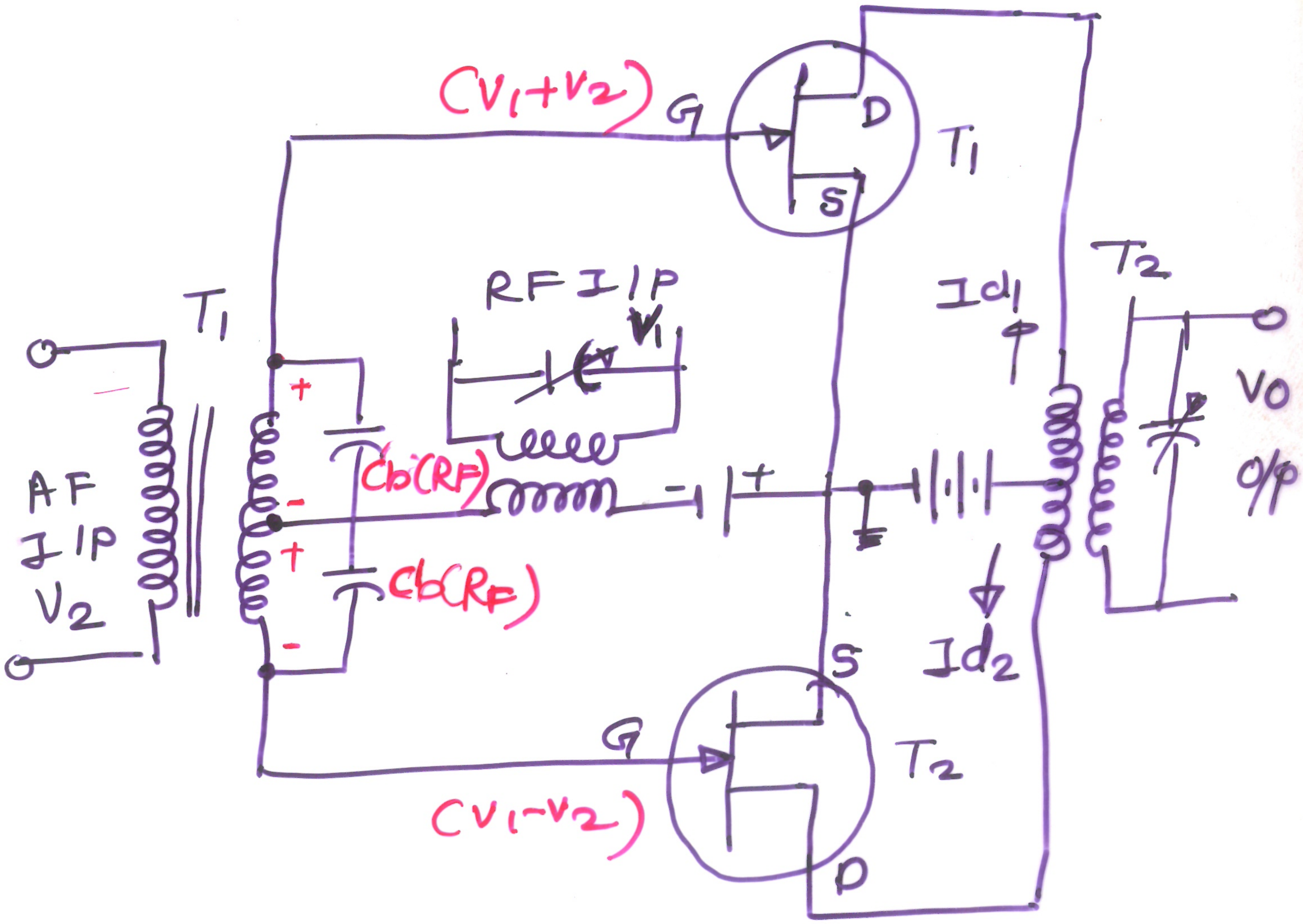
$$- cV_cV_m \cos(\omega_c + \omega_m)t \; (6) \rightarrow (7)$$

irst term is the dc component.
Second term is the carrier component
Third term is the modulating signal
Fourth term consists of harmonics of the carrier and modulating signal
) Fifth term represents the lower side band voltage
) Sixth term represents the upper sideband voltage.

Eq^n 6 shows that when two frequencies are passed through a non-linear resistance, the process of amplitude modulation takes place.

In Practical modulation cct, the voltage would be developed across a cct tuned to the carrier freq: Bandwidth is large enough to pass two sideband frequencies but no others.

Balanced Modulator



modulating voltage V_2 is fed in pushpull.

carrier voltage V_1 is fed in parallel to a pair of identical diodes or FETs.

I/P voltage is V_1+V_2 at gate of FET_1 (T_1) and V_1-V_2 at gate of FET_2 (T_2)

(6)

Assume perfect symmetry. Then proportionality constants will be same for both FETs

$$I_{d1} = a + b(v_1 + v_2) + c(v_1 + v_2)^2 \rightarrow (1)$$

$$I_{d2} = a + b(v_1 - v_2) + c(v_1 - v_2)^2 \rightarrow (2)$$

$$i = I_{d1} - I_{d2} \rightarrow (3)$$

$$= 2bV_2 + 4cV_1V_2 \rightarrow (4)$$

In absence of modulating signal drain currents are equal in magnitude but opposite in direction so induces zero secondary voltage.

∴ carrier gets suppressed.

Replace $v_1 = V_c \sin \omega_c t$
$V_2 = V_m \sin \omega_m t$] → (5)

$$i = 2bV_m \sin \omega_m t + 4cV_cV_m \sin \omega_c t \sin \omega_m t$$

$$= 2bV_m \sin \omega_m t + 2cV_cV_m [\cos(\omega_c - \omega_m)t - \cos(\omega_c + \omega_m)t] \rightarrow (6)$$

O/P voltage $v_o = \alpha i$

$$v_o = 2\alpha bV_m \sin \omega_m t + 2\alpha cV_cV_m \times [\cos(\omega_c - \omega_m)t - \cos(\omega_c + \omega_m)t] \rightarrow (7)$$

Let $P = 2b\alpha V_m$, $Q = 2\alpha C V_c V_m$ (7)

modulating signal

$V_o = P\sin\omega_m t + Q\cos(\omega_c - \omega_m)t$ → LSB

$- Q\cos(\omega_c + \omega_m)t$ → (8)

→ USB

Tuning of o/p amplifier will remove modulating signal. Only two side-bands will be present in o/p