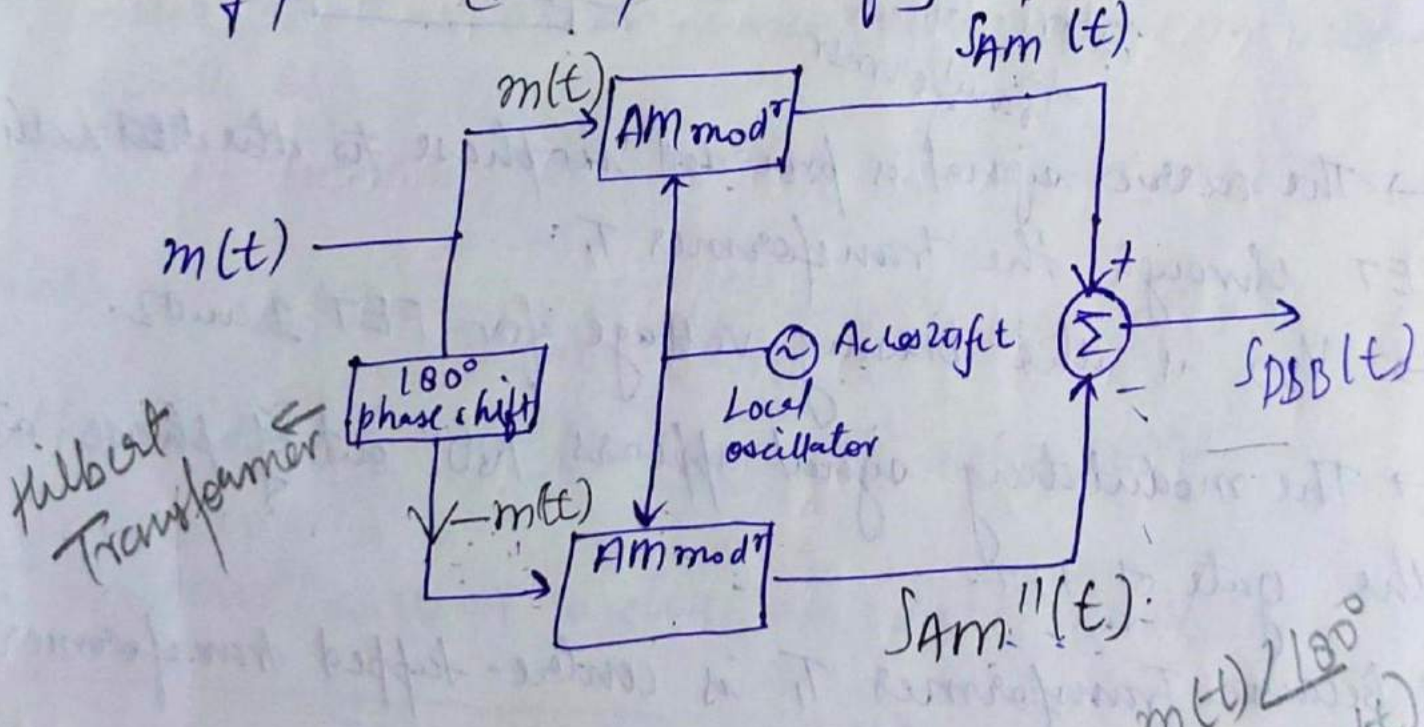
(2) Balanced Modulator →

→ In this two product modulators are used.
→ Modulating signals are provided to the PM in out of phase [180° phase shift]



$$m(t) \longrightarrow \boxed{180°\ PS} \longrightarrow -m(t)$$

thus $S_{Am}'(t) = A_c[1+k_a \cdot m(t)]\cos 2\pi f_c t$

$$S_{Am}''(t) = A_c[1-k_a \cdot m(t)]\cos 2\pi f_c t$$

$$S_{DSB}(t) = S_{Am}'(t) - S_{Am}''(t)$$

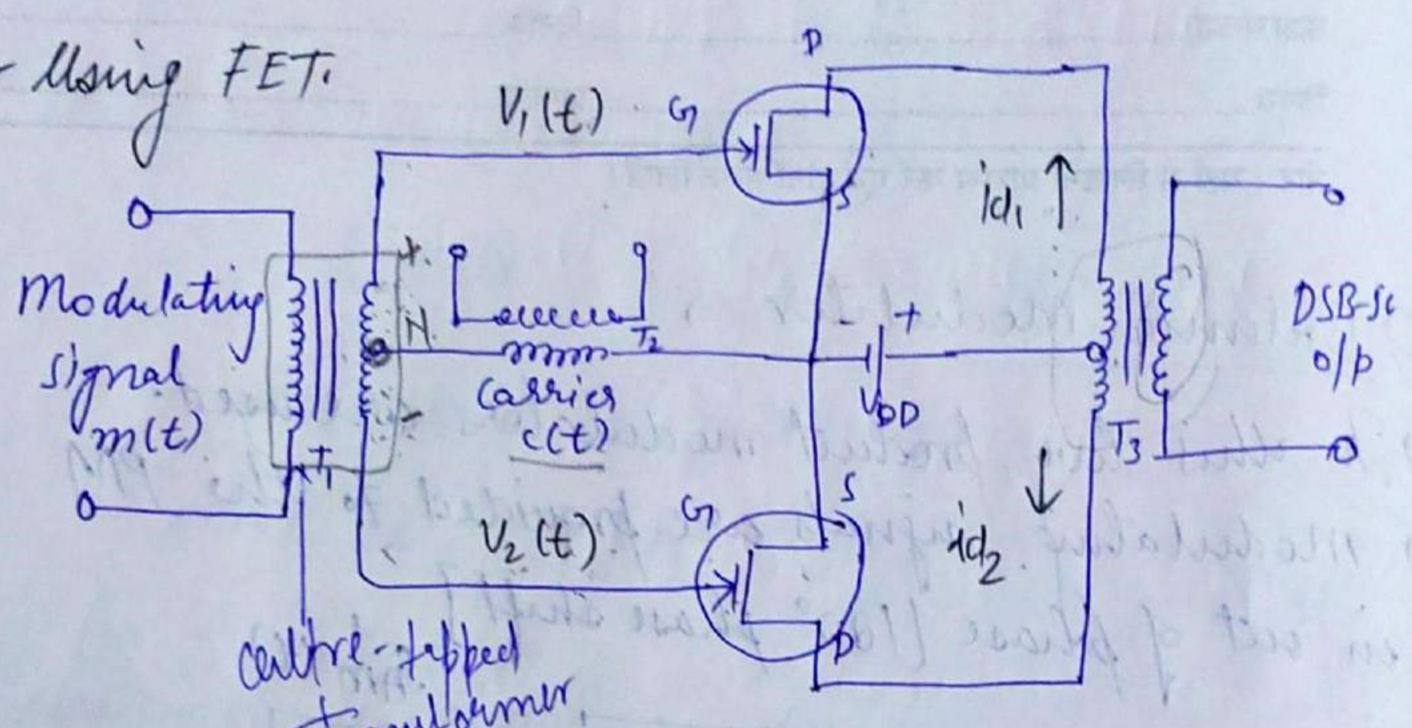
$$= A_c[1+k_a \cdot m(t)]\cos 2\pi f_c t - A_c[1-k_a \cdot m(t)]\cos 2\pi f_c t$$

$$S_{DSB}(t) = \underbrace{2 \cdot A_c \cdot k_a}\cdot m(t) \cdot \cos 2\pi f_c t$$

$$\Rightarrow S_{DSB}(t) = A_c' \cdot m(t) \cdot \cos 2\pi f_c t$$

where $A_c' = 2A_c \cdot k_a$.

i) - Using FET.



→ The carrier signal is provided in-phase to ~~the FET~~ both FET through the transformer T_1.

→ V_{DD} is the biasing voltage for FET 1 and 2.

→ The modulating signal appears 180° out of phase at the gate of FET.

→ Because Transformer T_1 is centre-tapped transformer.

Mode of operation

① · Absence of modulating signal:

since $m(t) = 0$,

$$V_1(t) = V_2(t) = c(t)$$

→ $V_1(t)$ and $V_2(t)$ are in-phase.

→ So the drain current developed (i_{d_1} and i_{d_2}) will equal and in-phase to each other.

→ At transformer T_3, the drain are in equal amplitude and phase, but are in opposite direction,

→ So the net resultant voltage in the secondary winding of T_3 will be zero.

→ And thus the carrier is suppressed.

(2) when modulating signal is present

since $m(t) \neq 0$,

$$V_1(t) = \cancel{V} c(t) + m(t)$$

$$V_2(t) = c(t) - m(t)$$

~~thus~~ since FET is a non-linear device, the v-i relation will be

$$\cancel{i =}\ a \quad i = a_1 V(t) + a_2 V(t)^2 + a_3 V(t)^3 + \cdots$$

thus $\quad i_{d_1}(t) = a_1 V_1(t) + a_2 V_1(t)^2 + a_3 V_1(t)^3 + \cdots$

$$i_{d_2}(t) = a_1 V_2(t) + a_2 V_2(t)^2 + a_3 V_2(t)^3 + \cdots$$

Net resultant current a due to $i_{d_1}(t)$ and $i_{d_2}(t)$ will be

$$i(t) = i_{d_1}(t) - i_{d_2}(t)$$

$$i(t) = a_1 (V_1(t) - V_2(t)) + a_2 (V_1(t)^2 - V_2(t)^2) + a_3 (V_1(t)^3 - V_2(t)^3) + \cdots$$

$$\cancel{= a_1(2m(t)) + a_2(c^2(t) + m^2(t)) + a_3 + \cdots}$$

$$= \underbrace{a_1(2m(t))}_{1 \quad f_m} + \underbrace{a_2(4\,c(t)\cdot m(t))}_{\substack{2 \\ f_c+f_m,\ f_c-f_m}} + \underbrace{a_3 + \cdots}_{3}$$

using a BPF of passband from ~~fc~~ $(f_c - f_m)$ to $(f_c + f_m)$ the higher frequency and the lower frequency terms are eliminated and finally only ②-terms is through BPF and thus we have

$$S_{DBS}(t) = \underbrace{4a_2 \cdot A_c} \cdot m(t) \cos 2\pi f_c t$$

$$S_{DSB}(t) = A_c' \, m(t) \cdot \cos 2\pi f_c t$$

where $A_c' = 4a_2 \cdot A_c$.

③ Collector Modulator

→ High level AM modulation technique.

→ Modulating signal and carrier signal are amplified before modulation.

→ The output AM wave is obtain from the collector terminal of BJT, hence it is called collector modulator.

→ Carrier signal is applied at the base-terminal of the transistor T_1.

→ Transistor T_1 acts as a RF class-C amplifier, to amplify the carrier signal.

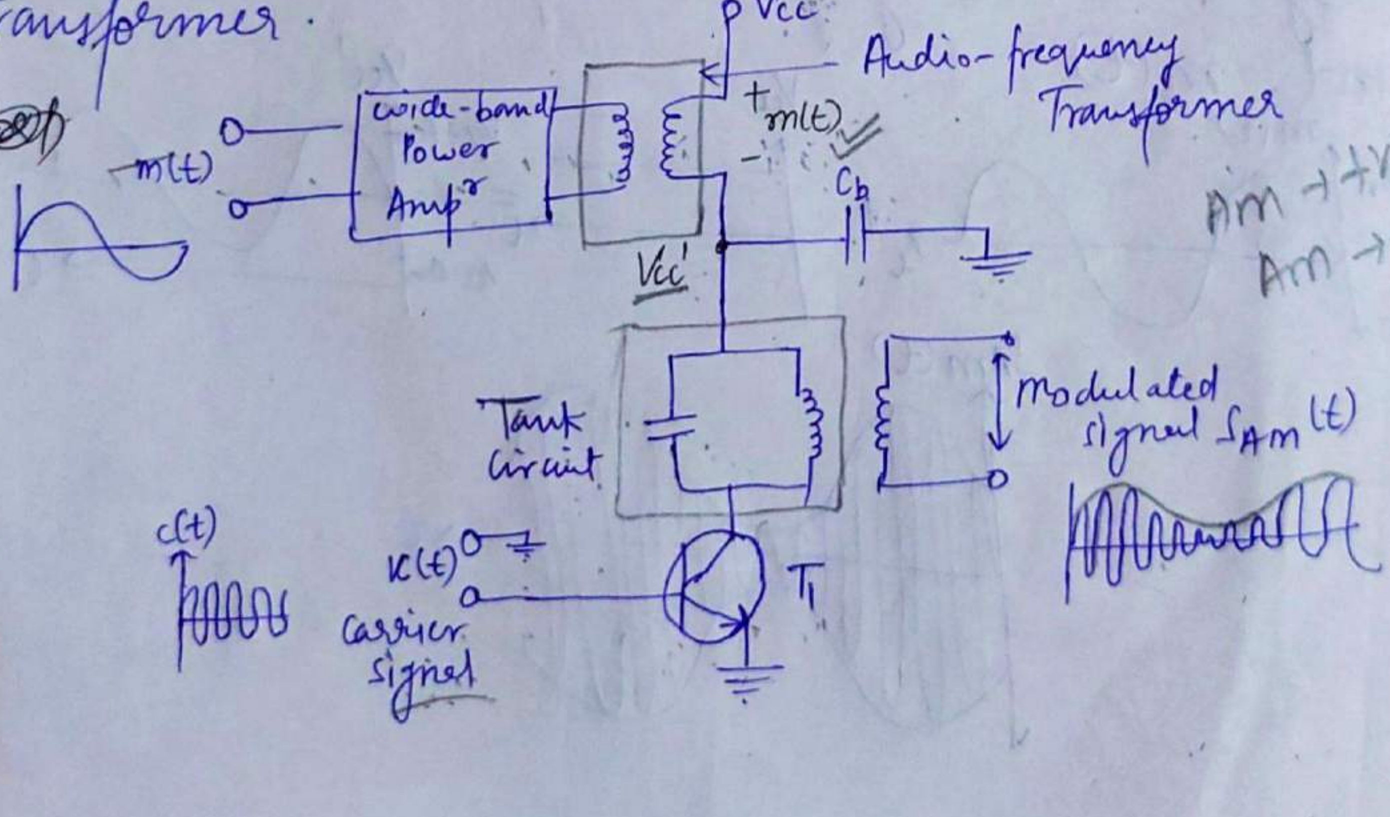
→ Vcc is ~~applied~~ a DC collector supply used for biasing of T_1.

→ Modulating signal is amplified using a ~~f~~ wide-band power amplifier, and then it is applied at the primary winding (coil) of ~~the~~ a audio-frequency transformer (20 Hz - 20 kHz).

→ Tuned LC circuit is used to remove distortions from the class-C amplifier.

~~Working~~:

→ The bypass capacitor C_b prevents the high frequency carrier pulses to reach to the audio-frequency transformer.



Working:

→ The amplified modulating signal m(t) appears at the secondary winding of the AF-Transformers.

→ V_{cc} and m(t) appear in series and so they get added or subtracted depending upon the amplitude. (added if Am is +ve, subtracted if Am is -ve).

→ So the supply voltage to T_1, V_{cc}' will now be equal to

$$V_{cc}' = V_{cc} + m(t).$$

and amplitude of V_{cc}' will vary according to the amplitude of m(t).

→ Now, due to the varying supplying voltage V_{cc}', the amplitude of the current pulses will also vary according to V_{cc}'.

→ As a result, the amplitude of the carrier sine wave is now changing according to the message signal m(t).