Frequency Modulated Wave generation

Methods of FM generation

- Direct method
  - Reactance modulation
  - Varactor diode modulator
- Indirect method
  - Armstrong method

(1). Parameter Variation method (Direct method)

→ In this method the modulating (msg) signal is directly used in the modulation of the carrier.

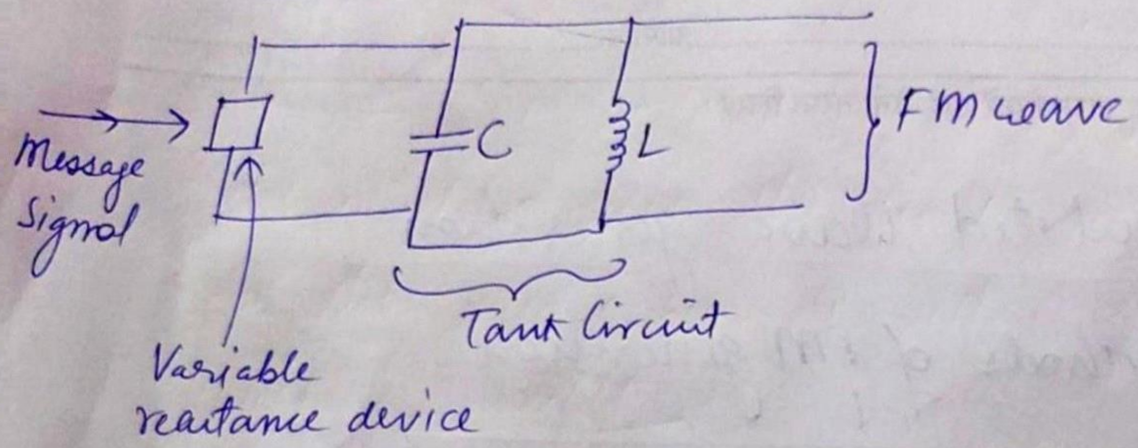
→ The carrier signal is generated by an electronic oscillator. The oscillator uses parallel L-C circuit and the frequency of oscillation of the carrier is given as

$$\omega = \frac{1}{\sqrt{LC}}$$

The carrier frequency ω_c can be made to vary according to the message signal $m(t)$, ~~if~~ if L or C ~~are~~ is changed depending upon $m(t)$. Such an

Oscillator whose frequency is controlled by a modulating voltage is called voltage controlled oscillator (VCO).

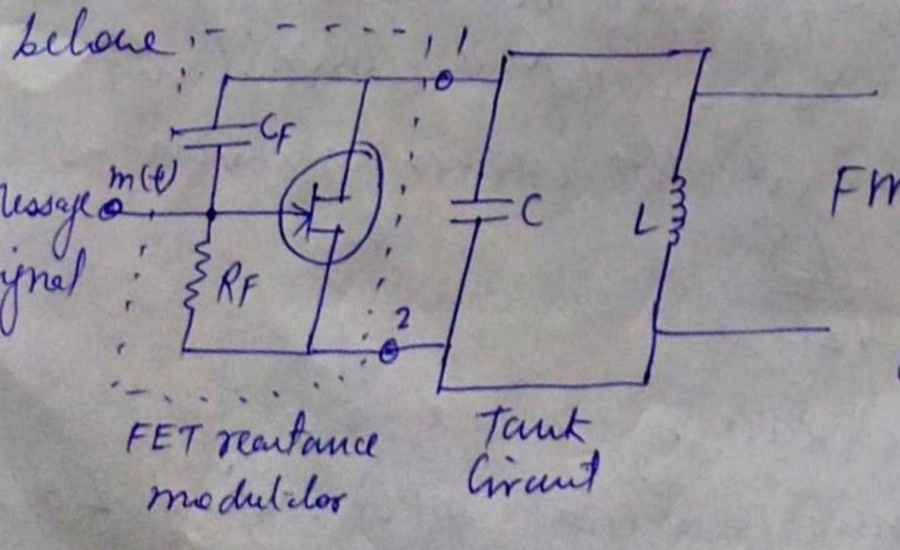
a)- Reactance Modulator:

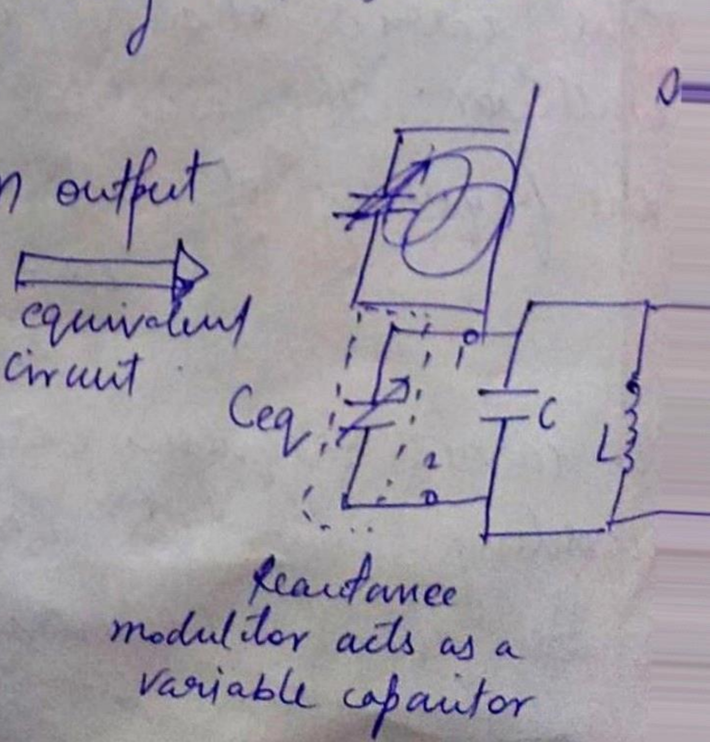


→ A reactance modulator is basically an amplifier which ~~app~~ can be made to appear ~~as~~ either inductive or capacitive, such that its inductance or capacitance can be controlled by the modulating signal.

→ In the reactance modulator, a transistor or FET is operated as a variable reactance (inductive or capacitive)

The basic reactance modulator using FET is shown below:-

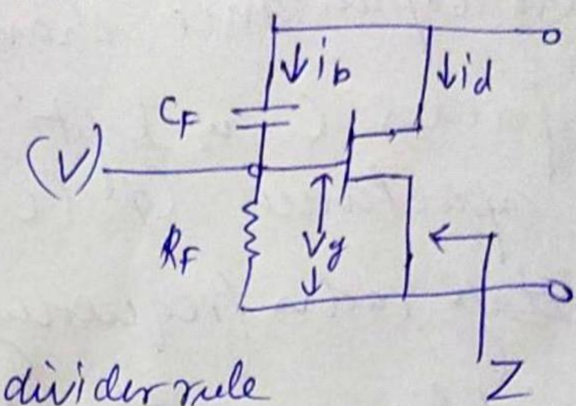




~~Assump~~

Assumption made are -

① $i_b \ll i_d$, ② $X_C \gg R$



From the figure

$$V_g = i_b \cdot R$$

$$= V \cdot \frac{R_F}{R_F - jX_{C_F}} \quad \text{using voltage divider rule}$$

Transconductance of FET $g_m = \frac{i_d}{V_g}$.

$$\Rightarrow i_d = g_m \cdot V_g = g_m \cdot \frac{V \cdot R_F}{R_F - jX_{C_F}}$$

Since ~~id~~ $i_b \ll i_d$, then $Z = \frac{V}{i_d}$

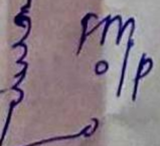
$$\Rightarrow Z = \frac{V}{g_m \frac{V R_F}{R_F - jX_{C_F}}} = \frac{R - jX_{C_F}}{g_m \cdot R_F} = \frac{1}{g_m}\left[1 - j\frac{X_C}{R_F}\right]$$

$$Z = \frac{-1}{g_m}\left[j\frac{X_C}{R_F} - 1\right]$$

Since $X_C \gg R_F$ hence impedance $Z = \frac{-jX_{C_F}}{g_m \cdot R_F}$

& ~~Let~~ $X_{C_F} = \frac{1}{2\pi f C_F}$

$$\Rightarrow Z = -j\frac{1}{2\pi f \cdot C_F \cdot g_m R_F} = -jX_{eq} \quad — ①$$



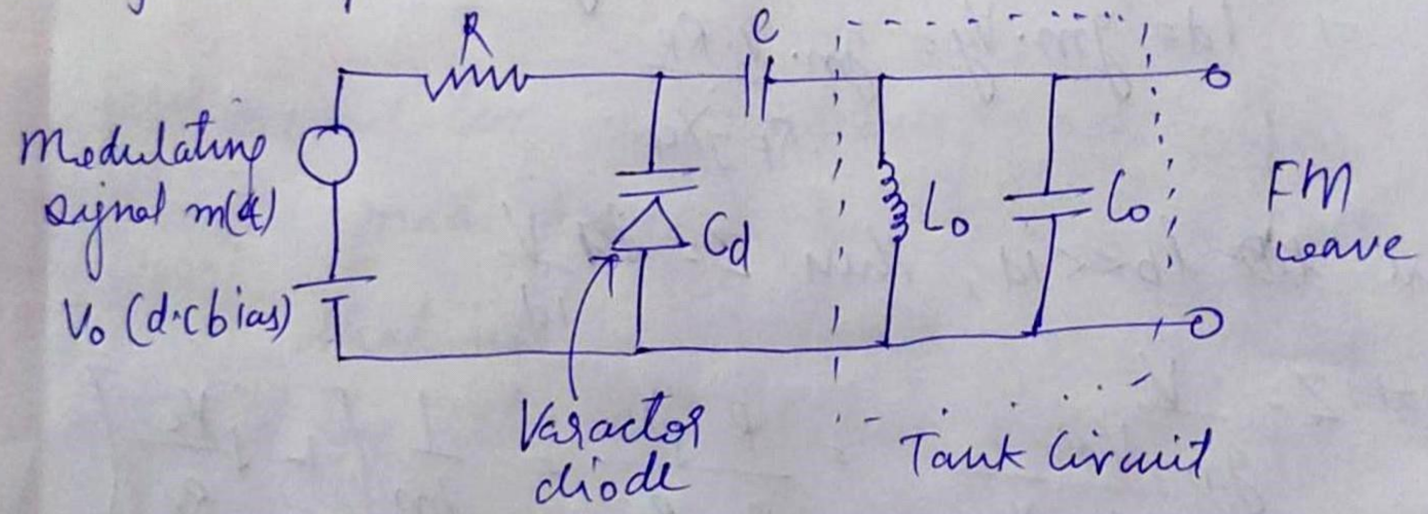
where $X_{eq} = \frac{1}{2\pi f \cdot C_{eq}}$ and $C_{eq} = C_F \cdot g_m \cdot R_F$

From eq-①, it can be Z (impedance) is capacitive in nature and its capacitance $C_{eq} = g_m \cdot R_F \cdot C_F$

b) - Varactor diode method for FM generation

The varactor diode is a semi-conductor device whose junction capacitance changes with d.c. bias voltage. The capacitor C is kept much smaller than the diode capacitance Cd ($C << C_d$). In order to keep the ~~voltage~~ radio frequency (R.F.) voltage from the oscillator across the diode small as compared to the reverse bias dc. voltage.

Working Principle



Total voltage applied to the varactor diode is $V_d = V_0 + m(t)$

V_d = instantaneous voltage across varactor diode

Relation b/w junction capacitance and applied voltage across varactor diode is $C_d \propto \frac{1}{\sqrt{V_d}}$

or $C_d = k \cdot V_d^{-1/2}$

$= k\left[V_0 + m(t)\right]^{-1/2}$

where k is proportionality constant

Total capacitance $= C_o + C_d + C$

since $C << C_d$

$= C_o + C_d$.

hence instantaneous frequency of oscillation

$$\cancel{\omega_i = \frac{1}{\sqrt{L_o C_o}}} \qquad \omega_i = \frac{1}{\sqrt{L_o(C_o + C_d)}}$$

$$\Rightarrow \omega_i = \frac{1}{\sqrt{L_o\left(C_o + k[V_o + m(t)]^{-1/2}\right)}}$$

here ω_i is dependant upon the message signal $m(t)$ and hence frequency modulated wave is generated

<u>Disadvantages of Direct method</u>

① In this method, it is difficult to obtain the stability at high carrier frequency.

② In varactor diode method ω_i varies non-linearly with $m(t)$ which causes unstability.