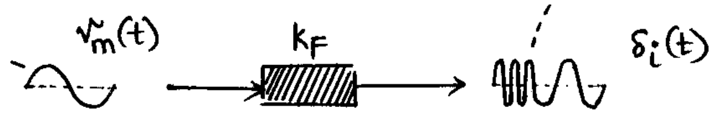
FREQUENCY MODULATION (FM)



Frequency Sensitivity :-

It is a constant (k_F) that depends upon the device/circuit or the system selected which is used to convert instantaneous amplitude of the baseband/modulating signal into proportional variations in the instantaneous frequency of the carrier signal (Hz/V)

Instantaneous Frequency Deviation :-

The instantaneous frequency deviation $\delta_i(t)$ is defined as variations in the carrier signal frequency which take place instantaneously on account of instantaneous amplitude of the baseband/modulating signal $v_m(t)$ which is defined by the following :-

$$\boxed{\delta_i(t) = k_F \cdot v_m(t)} \longrightarrow (1)$$

Maximum Frequency Deviation :-

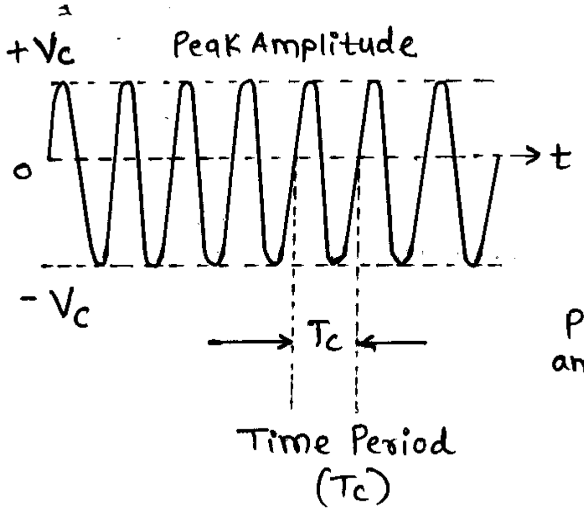
The maximum frequency deviation δ_{max} is defined as the highest possible instantaneous frequency deviation which takes place when the modulating/baseband signal $v_m(t) = V_m \sin \omega_m t$ OR $V_m \cos \omega_m t$ reaches its maximum/peak amplitude of 'V_m' volts :-

$$\boxed{\delta_{max} = k_F \cdot V_m} \longrightarrow (2)$$

Modulation Index for FM :-

For FM the modulation index is defined as the ratio of the maximum possible frequency deviation (δ_{max}) to the frequency of the baseband/modulating signal (f_m) & is a dimensionless/unitless quantity represented by the following equation :-

$$\boxed{m_f = \frac{\delta_{max}}{f_m} = \frac{k_F \cdot V_m}{f_m}} \longrightarrow (3)$$



* carrier signal represented in time domain (t) by the equation :-

$$v_c(t) = V_c \cos\omega_c t \quad \text{OR} \quad v_c(t) = V_c \sin\omega_c t$$

Peak amplitude

frequency $\omega_c = 2\pi f_c$

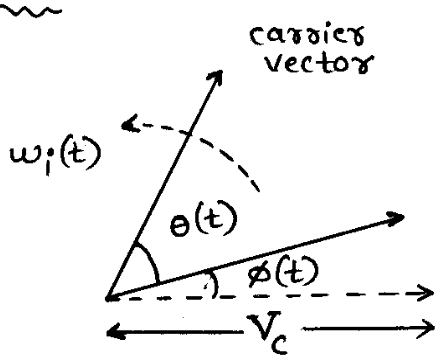
$$f_c = \frac{1}{T_c}$$

→ In terms of vector algebra notation :-

$$v_c(t) = V_c \cos[\theta(t)] \quad \text{OR} \quad V_c \sin[\theta(t)]$$

Peak amplitude

angular component



$$\frac{d\theta(t)}{dt} = \omega_i(t) + \phi(t)$$

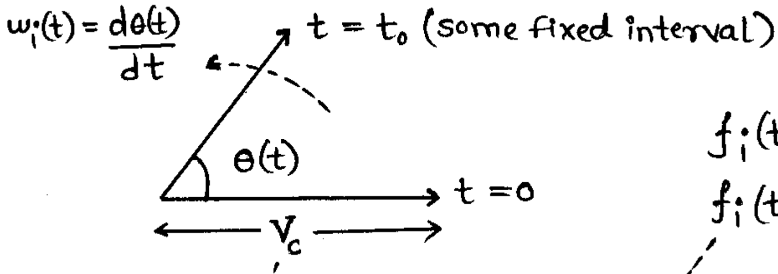
----→ phase angle component

----→ instantaneous angular frequency component

$$\boxed{\omega_i(t) = \frac{d\theta(t)}{dt}}$$

$$\omega_i(t) = 2\pi f_i(t)$$

→ Assuming the carrier signal starts from origin (0) as shown in the diagram above then no phase component exists hence for which $\phi(t) = 0$ hence carrier vector can be drawn as :-



$$f_i(t) = f_c + \delta_i(t) \longrightarrow ①$$

$$f_i(t) = f_c + k_F \cdot v_m(t) \longrightarrow ②$$

frequency modulated carrier vector

instantaneous frequency (Hz)

original carrier frequency (Hz)

frequency sensitivity (Hz/V)

modulating / Baseband signal (V)