EE23BTECH11054 - Sai Krishna Shanigarapu*

GATE EC 2021

49. A sinusoidal message signal having root mean square value of 4V and frequency of 1 kHz fed to a phase modulator with phase deviation constant 2 rad/volt. If the carrier signal is $c(t) = 2\cos(2\pi 10^6 t)$, the maximum instantaneous frequency of the phase modulated signal (rounded off to one decimal place) is _____ Hz. (GATE 2021 EC)

**Solution:**

| Parameter | Description | Value |
|---|---|---|
| $f_m$ | Message signal frequency | 1 kHz |
| $c(t)$ | Carrier signal | $2\cos(2\pi 10^6 t)$ |
| $k_p$ | Phase sensitivity factor | 2 rad $V^{-1}$ |
| $m(t)$ | message signal | $A_m \sin 2\pi f_m t$ |
| $f_c$ | Carrier signal frequency | 1 kHz |
| $A_c$ | Amplitude of carrier signal | 2 |
| $A_m$ | Amplitude of message signal | |

TABLE I
INPUT PARAMETERS

| Parameter | Description | Formula |
|---|---|---|
| $m(t)_{rms}$ | rms value of $m(t)$ | $\frac{A_m}{\sqrt{2}}$ |
| $s(t)$ | Phase modulation | $A_c\cos[2\pi f_c t + \theta_i(t)]$ |
| $\theta_i(t)$ | phase | $k_p\, m(t)$ |

TABLE II
FORMULAE

$$m(t)_{rms} = 4V \tag{1}$$

$$A_m = 4\sqrt{2} \tag{2}$$

From Table I, eq (1) and eq (2)

$$m(t) = 4\sqrt{2}\sin\left(2\pi 10^3 t\right) \tag{3}$$

$$\tag{4}$$

From Table I, II, using phase modulation, instantaneous frequency is given as,

$$f_i(t) = f_c + \frac{1}{2\pi}\frac{d}{dt}\theta_i(t) \tag{5}$$

$$= f_c + \frac{1}{2\pi}\frac{d}{dt}\left[k_p m(t)\right] \tag{6}$$

$$= f_c + \frac{1}{2\pi}\frac{d}{dt}\left(4\sqrt{2}\sin\left(2\pi 10^3 t\right)\right) \tag{7}$$

$$= f_c + \frac{2}{2\pi}\,4\sqrt{2}\,\left(2\pi 10^3\right)\,\left(\cos\left(2\pi 10^3 t\right)\right) \tag{8}$$

$$= 1000 + 8\sqrt{2}\text{ x }10^3\cos\left(2\pi 10^3 t\right) \tag{9}$$

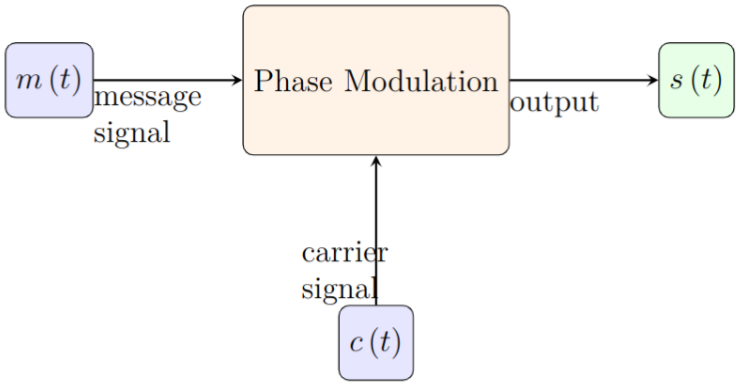


Fig. 1. Block diagram of phase modulation

Thus,

$$\implies f_{i_{max}} = 1011313.7\,Hz \tag{10}$$

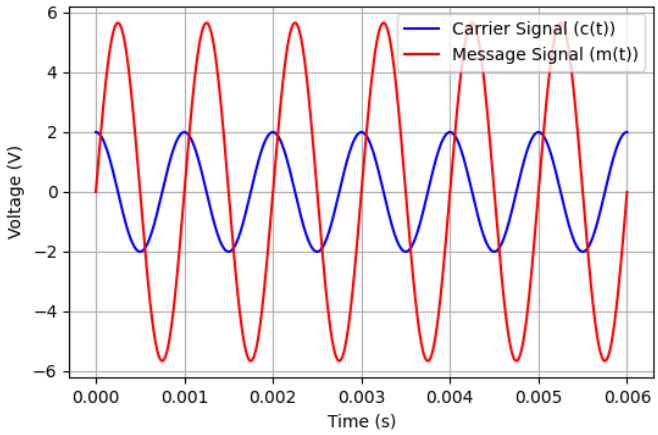


Fig. 2. plot of $m(t)$ and $c(t)$