

IN-2022

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QUESTION:

A sinusoidal carrier wave with amplitude A_c and frequency f_c is amplitude modulated with a message signal $m(t)$ having frequency $0 < f_m \ll f_c$ to generate the modulated wave $s(t)$ given by $s(t) = A_c (1 + m(t)) \cos(2\pi f_c t)$. The message signal that can be retrieved completely using envelope detection is

- 1) $m(t) = 0.5 \cos(2\pi f_m t)$
- 2) $m(t) = 1.5 \sin(2\pi f_m t)$
- 3) $m(t) = 2 \sin(4\pi f_m t)$
- 4) $m(t) = 2 \cos(4\pi f_m t)$

Solution:

| Parameter | Description |
|-----------|-----------------------------|
| $s(t)$ | Amplitude Modulated Wave |
| $M(t)$ | Message Signal |
| $c(t)$ | Carrier Signal |
| f_c | Frequency of Carrier Signal |
| f_m | Frequency of Message Signal |

TABLE I

VARIABLES AND THEIR DESCRIPTIONS

$$c(t) = A_c \cos(2\pi f_c t)$$

$$M(t) = A_m \cos(2\pi f_m t)$$

$$s(t) = (A_c + M(t)) \cos(2\pi f_c t)$$

$$= A_c \left(1 + \frac{A_m}{A_c} \cos(2\pi f_m t) \right) \cos 2\pi f_c t \quad (4)$$

$$= A_c (1 + m(t)) \cos 2\pi f_c t \quad (5)$$

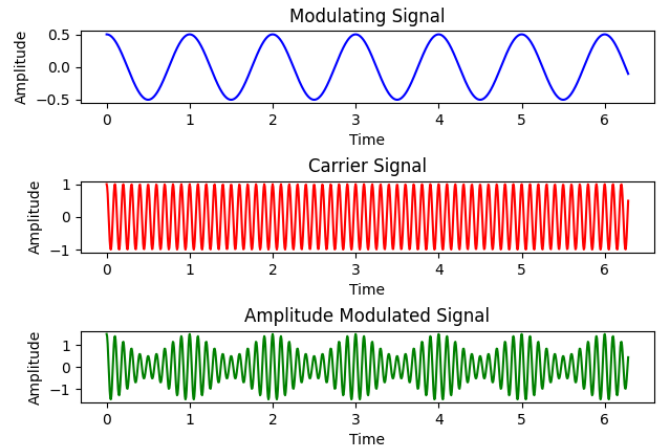
Modulation Index of $s(t) = \mu = \frac{A_m}{A_c}$

- $\mu < 1$ Signal is Can be detected
- $\mu = 1$ Signal Cannot be detected
- $\mu > 1$ Over modulation

$$1) m(t) = 0.5 \cos(2\pi f_m t)$$

$$\frac{A_m}{A_c} = 0.5 \quad (6)$$

$$\mu < 1 \quad (7)$$



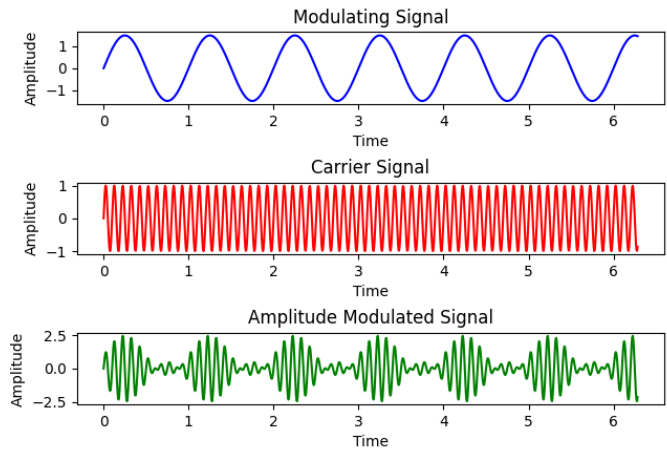
\therefore Signal can be retrieved completely.

$$2) m(t) = 0.5 \sin(2\pi f_m t)$$

$$\frac{A_m}{A_c} = 1.5 \quad (8)$$

$$\mu > 1 \quad (9)$$

\therefore Signal cannot be retrieved completely.

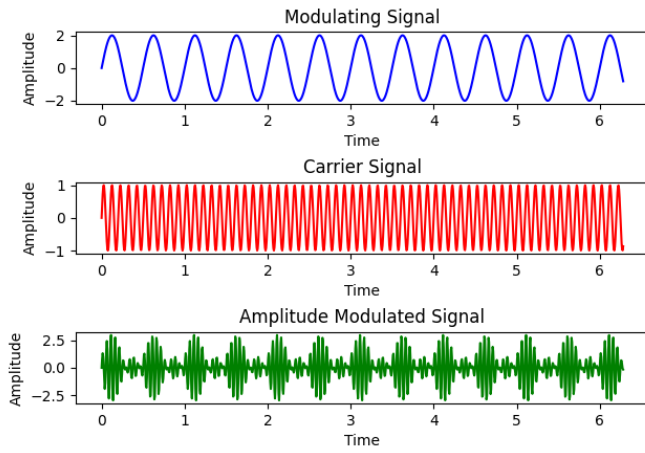


$$3) m(t) = 2 \sin(4\pi f_m t)$$

$$\frac{A_m}{A_c} = 2 \quad (10)$$

$$\mu > 1 \quad (11)$$

\therefore Signal cannot be retrieved completely.



$$4) m(t) = 2 \cos(4\pi f_m t)$$

$$\frac{A_m}{A_c} = 2 \quad (12)$$

$$\mu > 1 \quad (13)$$

\therefore Signal cannot be retrieved completely.

