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 $0 < f_m << f_c$ 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

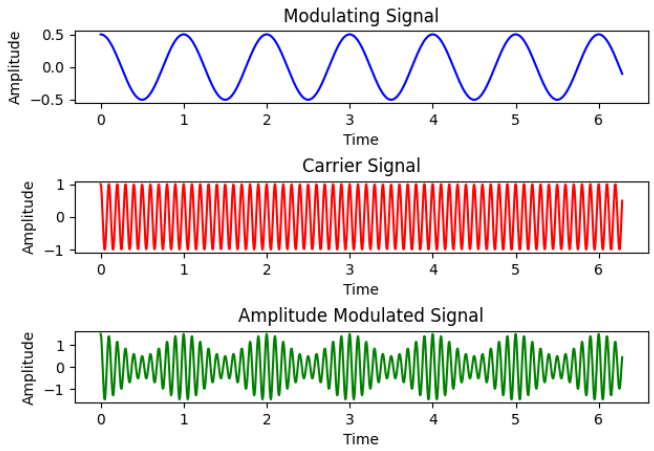
$$c(t) = A_c\cos(2\pi f_c t) \tag{1}$$
$$M(t) = A_m\cos(2\pi f_m t) \tag{2}$$
$$s(t) = (A_c + M(t))\cos(2\pi f_c t) \tag{3}$$
$$= A_c\left(1 + \frac{A_m}{A_c}\cos(2\pi f_m t)\right)\cos 2\pi f_c t \tag{4}$$
$$= A_c(1 + m(t))\cos 2\pi f_c t \tag{5}$$

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 modualtion

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

$$\frac{A_m}{A_c} = 0.5 \tag{6}$$
$$\mu < 1 \tag{7}$$

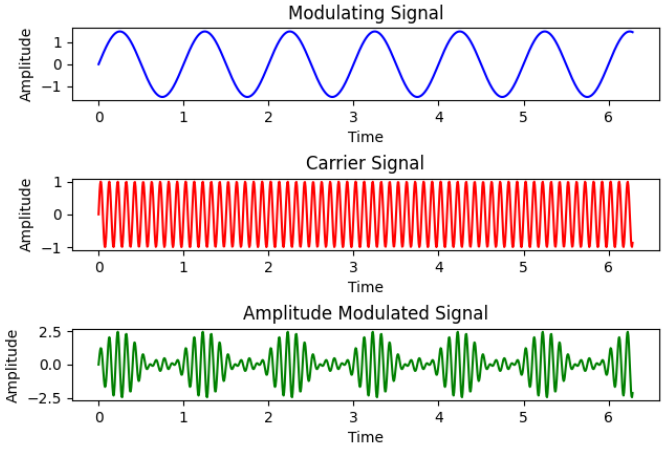


$\therefore$ Signal can be retrieved completely.

2) $m(t) = 1.5\sin(2\pi f_m t)$

$$\frac{A_m}{A_c} = 1.5 \tag{8}$$
$$\mu > 1 \tag{9}$$

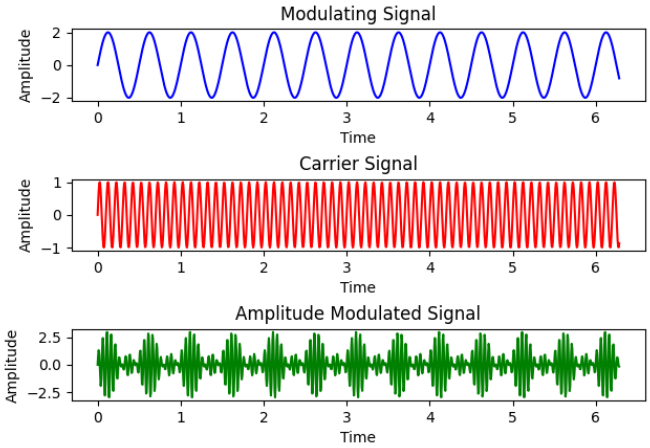
$\therefore$ Signal cannot be retrieved completely.



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

$$\frac{A_m}{A_c} = 2 \tag{10}$$
$$\mu > 1 \tag{11}$$

$\therefore$ Signal cannot be retrieved completely.



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

$$\frac{A_m}{A_c} = 2 \tag{12}$$

$$\mu > 1 \tag{13}$$

$\therefore$ Signal cannot be retrieved completely.