ADC ASSIGNMENT-3

1. A sinusoidal carrier 20V, 2M hz is frequency modulated by a sinusoidal message signal of 10V, 50K hz. Given $K_f = 25$ K hz/V.
   i. Find deviation, modulation index, bandwidth and power.
   ii. Repeat above if message signal amplitude is doubled.

2. An FM signal is given by $S(t) = 10\cos[2\pi 10^6 t + 8\sin 4\pi 10^3 t]$ Find deviation, modulation index, bandwidth and power.

3. A 93.2 Mhz carrier is modulated by a 5Khz sine wave, the resultant fm signal has a frequency deviation of 40Khz Find:
   I. carrier swing
   II. Highest and lowest frequency obtained by the Fm wave
   III. Modulation index.

4. An FM wave is defined as $s(t) = 10\cos[10\pi t + \sin 14\pi t]$ calculate instantaneous frequency.

5. calculate the B.W of a commercial FM transmission assuming deviation as 75 Khz, W = 15Khz.

6. A carrier is frequency modulated by a sinusoidal modulating frequency signal of 2Khz, resulting in a frequency deviation of 5Khz. what is BW occupied by the modulated waveform. now, the deviation of the sinusoid is increased by the factor of 3 and its frequency lowers by 1 KHz. what is the new B.W?

7. Determine the relative power of carrier and sideband frequency when index = 0.2 for a 10KW FM transmitter

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8. A 10Mhz carrier has a peak voltage of 5V, the carrier is frequency modulated by a sinusoidal modulating waveform of f=2khz. such that the frequency deviation is 75khz. The modulated waveform passes through 0 and its frequency is increasing at time t=0. write the expression for the modulated carrier waveform.

Answers:

3 :- The given parameters are:

$f_m = 5\ khz$

frequency deviation, $\Delta f = 40\ khz$.

$f_{max} = 93.2\ Mhz$.

I. carrier swing = ?

wkt ⇒ frequency deviation = $\frac{\text{carrier swing}}{2}$

carrier swing = $\Delta f \times 2$

$CS = 40\ khz \times 2$

$CS = 80\ khz$

II. Modulation index; $\beta = \frac{\Delta f}{f_m} = \frac{\cancel{40}^{8}\ khz}{\cancel{5}\ khz} = 8$

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3 ⇒ II Highest frequency : $f_c + \Delta f$

$= 93.2MHZ + 40KHZ$

$= 9324 \times 10^4 HZ$

Lowest Frequency : $f_c - \Delta f$

$= 93.2MHZ - 40KHZ$

$= 9316 \times 10^4 HZ$

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(4)

(2) :- Given, the eq^n of an FM signal as

$$S(t) = 10 \cos[2\pi 10^6 t + 8\sin 2\pi 2\times10^3 t] \quad -(1)$$

wkt the standard eq^n of an FM wave is

$$s(t) = A_c \cos[2\pi f_c t + \beta \sin(2\pi f_m t)] \quad -(2)$$

By comparing (1) & (2) we get,

Amplitude of carrier signal, $A_c = 10V$.

Freq^n of carrier signal, $f_c = 10^6 HZ = 1 MHZ$

Freq^n of message signal, $f_m = 2\times10^3 HZ = 2 KHZ$.

Modulation index, $\beta = 8$.

Here, the value of modulation index is greater than 1. Hence, it is wide band FM.

W.K.t

$$\beta = \frac{\Delta f}{f_m}$$

$$\Delta f = \beta f_m = 8 \times 2\times10^3 HZ$$

$$\Delta f = 16 KHZ.$$

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$$BW = 2(\beta+1)f_m = 2(8+1)2\,KHZ$$

$$\underline{BW = 36\,KHZ}$$

power of FM wave is

$$P_c = \frac{A_c^2}{2R}.$$

(assume $R = 1\Omega$)

$$P_c = \frac{(10)^2}{2\times 1} = \frac{\cancel{10}\times 10^{5}}{\cancel{2}}$$

$$\underline{P_c = 50W}$$

4:- given, FM wave is,

$$s(t) = 10\cos[10\pi t + \sin 14\pi t]$$

w.k.t $s(t) = A_c \cos[\theta_i(t)]$

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

Here, $\theta_i(t) = 10\pi t + \sin 14\pi t$

$$\frac{d\theta_i(t)}{dt} = 10\pi + \cos 14\pi t\,(14\pi)$$

$$f_i(t) = \frac{1}{2\pi}\left[10\pi + \cos 14\pi t\,(14\pi)\right]$$

Hence,
instantaneous frequency is, $\underline{f_i(t) = 5 + 7\cos 14\pi t}$

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(5):- given, frequency deviation, $\Delta f = 75\,KHZ$

$f_m = W = 15\,KHZ$.

We know that the FM signal bandwidth as

$$B_T = 2(\Delta f + f_m)\ HZ.$$

$$B_T = 2(75\,KHZ + 15\,KHZ)\ HZ$$

$$B_T = 2(90)\ KHZ$$

$\underline{B_T = 180\ KHZ}$ which is six times the 30KHZ bandwidth that would be required for AM modulation.

(6):- given, $f_{m_1} = 2\,khz$

$\Delta f_1 = 5\,khz$

we know that the FM signal bandwidth as

$$BW_1 = 2(\Delta f + f_m)\ HZ$$

$$= 2(5\,khz + 2\,khz)$$

$$= 2(7)\ khz$$

$$\underline{BW = 14\ KHZ}$$

Now, the deviation is increased by 3KHZ

ie $\Delta f_2 =$ ~~Be kHz~~ $5 \times 3\ khz = 15\ khz$

frequency lowers by 1 KHZ

$f_{m_2} = 1\,KHZ$.

Now, the Bandwidth of FM signal is

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$$BW_2 = 2(\Delta f + f_m) \text{ HZ}$$

$$= 2(15+1) \text{ KHZ}$$

$$= 2(16) \text{ KHZ}$$

$$BW_2 = 32 \text{ KHZ}$$

The new Band width is 32 KHZ.

7 :- given, $m_f = 0.2$

$P_t = 10 KW$

w.k.t

$$P_t = P_c\left(1 + \frac{m^2}{2}\right)$$

$$10 \times 1000 = P_c\left(1 + \frac{0.2 \times 0.2}{2}\right)$$

$$10000 = P_c(1 + 0.02)$$

$$10000 = P_c(1.02)$$

$$P_c = \frac{10 \times 1000}{1.02} = 9.8 KW$$

$$P_{LSB} = P_{USB} = \left(\frac{B_{HC}}{2\sqrt{2}}\right)^2 = \frac{B^2 A^2}{8} = \frac{(0.2)^2 (1.96 \times 10^4)}{8}$$

$$= \frac{0.04 \times 1.96 \times 10^4}{8}$$

$$= \frac{0.0784 \times 10^4}{8} = 98W$$

Therefore, power of the carrier is 9.8KW and side band frequencies are 98W.

9:-

given, $A_m = 10V$

$f_m = 50\,khz$

$k_f = 25\,khz$

i) Deviation, $\Delta f = k_f A_m = 25 \times 10\,khz = 250\,khz$

Modulation index, $\beta = \frac{\Delta f}{f_m} = \frac{\cancel{250}^{5}\,khz}{\cancel{50}\,khz} = 5$

Bandwidth, $BW = 2(\beta+1)f_m = 2(5+1)50\,khz$

$= 12 \times 50\,khz$

$= 600\,Khz$

power, $P_c = \frac{A_c^2}{2R} = \frac{\cancel{20}^{10} \times 20}{\cancel{2} \times 1} = 200W$ [assume $R=1$]

ii) given A_m is doubled i.e $A_m = 20V$.

$f_m = 50\,Khz$

$k_f = 25\,Khz$

Deviation, $\Delta f = k_f \cdot A_m = 25khz \times 20 = 500\,khz$

$\beta = \frac{\Delta f}{f_m} = \frac{\cancel{500}^{10}\,khz}{\cancel{50}\,khz} = 10$

$BW = 2(\beta+1)f_m = 2(11)50\,khz$

$= 22 \times 50\,khz$

$= 1100\,khz$

power, $P = \frac{A_c^2}{2R} = \frac{20\times20}{2\times1} = 200W$ [assume $R=1$]

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(8) - given,

carrier frequency, $f_c = 10$ Mhz,

$\Delta f = 75$ khz

$A_c = 5V$

$f_m = 2$ khz

Expression for FM signal is

$$s(t)_{FM} = A_c \cos[2\pi f_c t + \beta \sin 2\pi f_m t] \quad \text{—(1)}$$

w.k.t $\beta = \frac{\Delta f}{f_m} = \frac{75\text{ khz}}{2\text{ khz}} = 37.5$

from eqn (1) substituting the above values

$$s(t)_{FM} = 5 \cos[2\pi \times 10\times10^6 t + \beta \sin 2\pi \times 2\times10^3 t]$$

$$s(t)_{FM} = 5\cos[2\pi \times 10^7 t + 37.5 \times \sin 2\pi(2\times10^3)t]$$

∴ the expression for the modulated carrier waveform is

$$s(t)_{FM} = 5\cos[2\pi\times10^7 t + 37.5 \times \sin 2\pi(2\times10^3)t]$$