B_07_Sneha Araseed

AC Assignment (1)

Q.1. A carrier signal with an RMS voltage amplitude of 2V & a frequency of 1.5 MHz is amplitude modulate by a modulating sine wave with a frequency of 500Hz & RMS amplitude level of 1V.

a) Write an expⁿ for the resulting AM signal.

b) Calculate amplitude modulation, ma & percent Ma

c) Rewrite the expⁿ for AM wave by considering value of ma as 0.5

Sol: Given: $V_c = 2V$, $f_m = 500\,Hz$ } frequency of modulating signal

frequency of carrier signal = 1.5 MHz or 1.5×10^6 Hz

$V_m = 1V$, $V_c = 2 \times \sqrt{2}\,V = 2.8\,V$

a) $V_{AM}(t) = [V_c + V_m \sin(2\pi f_m t)] \sin(2\pi f_c t)$

$= [2.82 + 1.41 \sin(2\pi\, 500t)] \sin 2\pi(1.5 \times 10^6 t)]$ volt

b) AM modulatⁿ index,

$m_a = \frac{V_m}{V_c} = \frac{1.41}{2.82} = \boxed{0.5}$

$M_a = m_a \times 100 = 0.5 \times 100 = \boxed{50\%}$

c) Consider $m_a = 0.5$

$V_{AM}(t) = 2.82 [(1 + 0.5 \sin(2\pi \times 500t)) \sin(2\pi \times 1.5 \times 10^6 t)]$

Q.2)

Sol: The modulatⁿ index of AM signal is,

$m_T = \sqrt{m_{a_1}^2 + m_{a_2}^2 + m_{a_3}^2}$

$= \sqrt{(0.2)^2 + (0.4)^2 + (0.5)^2} = \sqrt{0.04 + 0.16 + 0.25}$

$\boxed{m_T = 0.67}$

Q 3)

Sol: Given: unmodulated carrier power (P_c) = 10 KW

Max. percentage modulatⁿ, M_a = 40%.

We know,

modulation index $m_a = \frac{M_a}{100} = \frac{40}{100} = \underline{\underline{0.4}}$

∴ The total modulated power, $P_t = P_c\left[1+\frac{m_a^2}{2}\right]$

i.e. $= 10\left[1+\frac{(0.4)^2}{2}\right]$

$= 10\left[1+0.08\right]$

$\boxed{P_t = 10.8\ KW}$

When $m_a = 0.3$ (reduced modulation index $= \frac{M_a}{100} = \frac{30}{100}$)

& max unmodulated carrier power = P'_c

So,

$P_t = P'_c\left[1+\frac{m_a^2}{2}\right]$

$P'_c = \frac{P_t}{\left[1+\frac{m_a^2}{2}\right]} = \frac{10.8}{\left[1+\frac{(0.3)^2}{2}\right]} = \frac{10.8}{1.045}$

$\boxed{P'_c = 10.335\ KW}$

Q 4)

Sol: Given: $m_a = 0.5$, $V_c = 10V$, $R_L = 10\Omega$

a) The carrier power

$P_c = \frac{V_c^2}{2R_L} = \frac{(10)^2}{2\times10} = \frac{100}{20} = 5$

$\therefore \boxed{P_c = 5W}$

b) The lower side band & upper side band

$$P_{LSB} = P_{USB} = \frac{m_a^2 P_c}{4} = \frac{(0.5)^2 \times 5}{4}$$

$$= \frac{0.25 \times 5}{4} = \frac{0.125}{4}$$

$$\therefore \boxed{P_{LSB} = P_{USB} = 0.3125\ W}$$

c) Total side band power,

$$P_{Sb} = \frac{m_a^2 \times P_c}{2}$$

$$= \frac{(0.5)^2 \times 5}{2}$$

$$= \frac{0.125}{2} \quad \therefore \boxed{P_{Sb} = 0.625\ W}$$

d) Total AM Power. $P_{AM} = P_c \left(1 + \frac{m_a^2}{2}\right)$

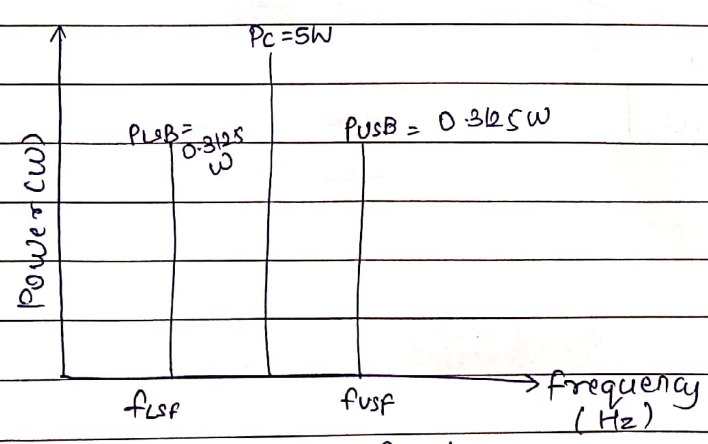
$m_a = 0.5, \quad P_c = 5$

$$\therefore P_{AM} = 5\left(1 + \frac{(0.5)^2}{2}\right) = 5 \times 1.125$$

$$= 56.25\ W$$

$$\therefore \boxed{P_{AM} = 56.25\ W}$$

e) Sketch the AM power spectrum.



AM Power Spectrum

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Q 5)

Sol: a) $V_{AM}(t) = [10(1 + 0.5 \sin(2\pi \times 10^3 t) + 0.2 \sin(4\pi \times 10^3 t))]$ Volt

compare above eqn with,

$V_{AM}(t) = [V_c \sin(2\pi f_c t) + m_a \sin(2\pi f_c t) \sin(2\pi f_{ma_1} t) + m_{a_2} \sin(2\pi f_c t) \sin 2\pi f_{ma_2} t)]$

we get, $m_{a_1} = 0.5$ & $m_{a_2} = 0.2$

$\therefore \quad m_T = \sqrt{(0.5)^2 + (0.2)^2} = \boxed{0.539}$

b) Unmodulated carrier power

$P_c = \frac{V_c^2}{2} = \frac{(10)^2}{2} = \frac{100}{2} = 50W$

$\therefore \boxed{P_c = 50W}$

c) Sideband power

$P_{sb} = \frac{m_a^2 \cdot P_c}{2} = \frac{(0.5)^2 \times 50}{2}$

$= 0.125 \times 50$

$\boxed{P_{sb} = 7.25W}$

d) Total power of AM signal

$P_{AM} = P_c\left(1 + \frac{m_a^2}{2}\right)$

$= 50\left[1 + \frac{(0.5)^2}{2}\right]$

$= 50 \times 1.125$

$\boxed{P_{AM} = 56.25W}$

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AC Assignment No - 2

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Q.1) A communication receiver has a noise power bandwidth of 10 kHz. A resistor that matches its i/p impedance is connected across its antenna terminals. Determine the noise power contributed by the external resistor in the receiver bandwidth. Assume the operating temperature of 27°C. ($K = 1.38 \times 10^{-23}$ J/K)

Sol: Given: BW = 10 KHz, $K = 1.38 \times 10^{-23}$ J/K

$T = 27°C = 300$ K

Thermal Noise Power = N =

$10 \log(K) + 10 \log(T) + 10 \log(B)$ dBW

$= 10 \log(1.38 \times 10^{-23}) + 10(\log 300) + 10 \log(10 \times 10^3)$ dBW

$= -228.60 + 24.77 + 40$

$= -163.83$ dBW

∴ Noise power contributed by external resistor is -163.83 dBW.

Q.2) An electronic ckt is perfectly noiseless & adds no extra noise to the signal. The SNR at the i/p is equal to the SNR at the o/p. What is the noise figure of the ckt?

Sol: Given: $SNR_o = SNR$

We know, Noise Factor $(F) = \frac{SNR\ i/p}{SNR\ o/p} = 1$

Noise figure $(NF) = 10 \times \log_{10}(F)$

$= 10 \times \log_{10}(1)$

$\therefore \boxed{NF = 0\ dB}$

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Q.3) A practical amplifier ckt has i/p signal power of 2×10^{-10} W, input noise power of 2×10^{-18} available power gain of 10^6. Determine i/p SNR (dB) & o/p signal power

Sol: Given:

i/p signal power = 2×10^{-10} W

i/p noise power = 2×10^{-18} W

Available power gain = 10^6

$$\text{i/p SNR(dB)} = 10\times\log\left(\frac{\text{i/p signal power}}{\text{i/p noise power}}\right)$$

$$= 10\times\log_{10}\left(\frac{2\times10^{-10}}{2\times10^{-18}}\right)$$

$$= 10\times\log(10^8)$$

$\therefore$ $\boxed{\text{i/p SNR(dB)} = 80\text{ dB}}$

Now,

o/p signal power = i/p signal power $\times$ available power gain

$$= 2\times10^{-10}\times10^6$$

$$= 2\times10^{-4}$$

$$= 0.0002\text{ W}$$

$\therefore$ $\boxed{\text{o/p signal power} = 200\ \mu W}$

Q.4) A practical amplifier ckt has i/p signal power 2×10^{-10} W, i/p noise power of 2×10^{-18} W, available power again of 10^6 & internal noise of 6×10^{-12} W. Determine o/p noise power & o/p SNR (dB)

Sol: Given:

i/p signal power = 2×10^{-10} W

i/p noise power = 2×10^{-18} W

available power again = 10^6

Internal noise = 6×10^{-12} W

O/p noise power = [i/p noise power × power gain] + internal noise

$= (2\times10^{-18} \times 10^{6}) + 6\times10^{-12}$

$= (2\times10^{-12}) + (6\times10^{-12})$

$\therefore \boxed{\text{O/p noise power} = 8\times10^{-12}\text{ W}}$

Now,

$$\text{O/p SNR(dB)} = 10\times\log\left(\frac{\text{O/p signal power}}{\text{O/p noise power}}\right)$$

& O/p signal power = i/p signal power × power gain

$= 2\times10^{-10} \times 10^{6}$

$= 2\times10^{-4}$

$= 0.002$ W

$$\therefore \text{O/p SNR(dB)} = 10\times\log\left(\frac{2\times10^{-4}}{8\times10^{-12}}\right)$$

$$= 10\times\log\left(\frac{1}{4}\times10^{8}\right)$$

$$= 10\times\log(0.25\times10^{8})$$

$\therefore$ O/p SNR(dB) = 73.97

$\therefore \boxed{\text{O/p SNR} = 73.97\text{ dB}}$

Q.5) A practical amplifier ckt has i/p SNR of 1×10^{8} W & O/p SNR of 2.5×10^{7} W. Determine noise factor (ratio) & noise figure (dB)

Sol: Given:

i/p SNR = 1×10^{8} W

O/p SNR = 2.5×10^{7} W

$$\text{Noise Factor (ratio)} = \frac{\text{i/p SNR}}{\text{o/p SNR}} = \frac{1\times10^{8}\text{ W}}{2.5\times10^{7}\text{ W}} = 4$$

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& Noise figure $= 10 \log(NF)$
(NF)
$= 10 \log(4)$
$= 6.02$
$\boxed{NF = 6\,dB}$

Q.6) Determine equivalent noise temperature corresponding to noise figure of 6dB. Assume 290K for reference temperature

Sol: Given:

Reference temp (T) = 220 K

Noise figure (NF) = 6dB

We know,

$T_e = T(NF-1)$
$= 290K(6-1)$
$\boxed{T_e = 1450\,K}$

∴ Equivalent Noise temperature = 1450 K.