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20/20

ECE 405 QUIZ #5 20 POINTS

1. A message $m(t) = 5\cos(2\pi\times3000t)$ frequency modulates a carrier of frequency 30 MHz. Let $k_f = 2\pi\times3000$ rad/s/V and let the amplitude of the modulated wave be 0.2 V. Determine the output signal-to-noise ratio in dB if the one-sided noise power spectral density of the receiver is $N_o = 10^{-6}$ W/Hz (no deemphasis circuit is used).

2. A message $m(t) = 5\cos(2\pi\times3000t)$ frequency modulates a carrier of frequency 30 MHz. Let $k_f = 2\pi\times3000$ rad/s/V and let the amplitude of the modulated wave be 0.2 V. Determine the output signal-to-noise ratio in dB if the one-sided noise power spectral density of the receiver is $N_o = 10^{-6}$ W/Hz and deemphasis is used at the receiver with $\omega_a = \pi f_m$ and $B = f_m$.

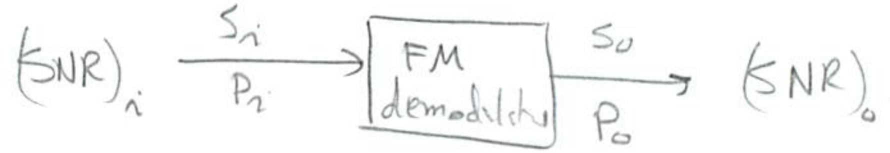
3. Determine the minimum value for the carrier amplitude A_c if the output signal-to-noise ratio is 25 dB, and the one-sided noise power spectral density of the receiver is $N_o = 10^{-7}$ W/Hz, $\beta = 5$, $f_m = 15$ kHz.

$m(t) = 5\cos(2\pi\, 3000 t)$ $\quad A_m = 5, \; f_m = 3000$ Hz.

$K_f = 2\pi\, 3000$ rad/s/v.

$A_c = 0.2$ V.

this is FM. so



$$(SNR)_o = \frac{3}{4}\,\frac{A_c^2\,\beta^2}{N_o\, B{=}f_m}$$

But $\beta = \dfrac{k_f A_m}{2\pi f_m} = \dfrac{(2\pi\, 3000)(5)}{2\pi(3000)} = \boxed{5}$

so $(SNR)_o = \dfrac{3}{4}\,\dfrac{(0.2)^2(5)^2}{(10^{-6})(3000)} = 250.$

so $(SNR)_{o,\,db} = 10\log_{10}(250) = \boxed{23.979}$ db

#2

$m(t) = 5\cos(2\pi 3000 t)$

$K_f = 2\pi\, 3000$ rad/s/V.

$A_c = 0.2V$.

$$(SNR)_o = \frac{2\pi A_c^2 K_f^2 \overline{m^2(t)}}{2 N_o \omega_a^2 \left[2\pi B - \omega_a \tan^{-1}\left(\frac{2\pi B}{\omega_a}\right)\right]}$$

$\overline{m^2(t)} = \frac{A_m^2}{2} = \frac{25}{2} = \boxed{12.5 \text{ watt}}$

$\omega_a = \pi f_m = \pi(3000)$

$A_c = 0.2$

$$\text{hence } (SNR)_o = \frac{\pi (0.2)^2 (2\pi 3000)^2 (12.5)}{(10^{-6})(\pi 3000)^2 \left[2\pi(3000) - \pi 3000 \tan^{-1}\left(\frac{2\pi 3000}{\pi 3000}\right)\right]}$$

$$= \frac{\pi (0.2)^2 (12.5)(4)}{(10^{-6})\left[2\pi(3000) - \pi 3000 \tan^{-1}(2)\right]}$$

$\boxed{\tan^{-1}(2) = 1.1071}$ → radians

$$\text{so } (SNR)_o = \frac{6.28318}{(10^{-6})\left[18849.55 - 10434.17\right]} = \frac{6.28318}{0.008415} = 746.63$$

$$\text{so } (SNR)_{o,dB} = 10\log_{10}(746.63) = \boxed{28.73}$$

#3

$$(SNR)_o = \frac{3}{4} \frac{A_c^2 \beta^2}{N_o B}$$

so $10 \log_{10} \left(\frac{3}{4} \frac{A_c^2 \beta^2}{N_o B} \right) = 25$

But $\beta = 5$, $B = 15 \times 10^3$ hz, $N_o = 10^{-7}$.

so $\log_{10} \left(\frac{3}{4} \frac{A_c^2 (5)^2}{(10^{-7})(15 \times 10^3)} \right) = 2.5$

so $\log_{10} \left(12500 \, A_c^2 \right) = 2.5$

so $12500 \, A_c^2 = 10^{2.5}$

so $A_c^2 = \frac{10^{2.5}}{12500} \Rightarrow A_c = \sqrt{\frac{10^{2.5}}{12500}}$

so $\boxed{A_c = 0.159 \text{ Volt}}$ ✓

so min $A_c = 0.159$ V.