International Institute of Information Technology - Hyderabad

EC5.203 - Communication Theory
Mid Exam

February 25, 2025

- Number of questions: 4 ; Total points: 20; Time Limit: 90 minutes.
- Use of calculator is permitted.
- This is a closed book exam.
- Clearly write your assumptions or use of any properties at each step.
- Even if the final answer is correct, only *partial marks* will be given if the approach or methodology is incorrect or is not presented clearly.
- Even if the final answer is incorrect or incomplete, *partial marks* may be given if the approach or methodology is presented clearly.

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1. State whether the following statements are True or False. Also give your reasons in few (not more than 2-3) sentences! No step-marks for this question! **(5 points)**

   (a) If $X(f)$ is frequency response of a real signal $x(t)$, then signal $y(t)$ having the frequency response $Y(f) = X(f - f_c)$ is also a real signal.

   (b) SSB modulation can be used for the following message signal: $x(t) = e^{j2\pi 100t}$.

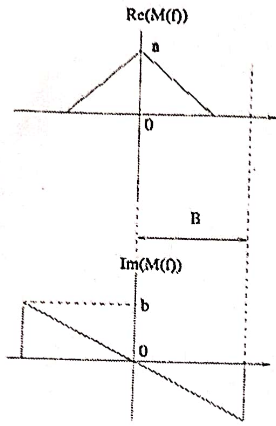
   (c) Second order non-linearity does not affect AM signal.

   (d) If $\hat{m}(t)$ is the Hilbert transform of $m(t)$, then the Hilbert transform $\hat{m}(t)$ is $m(t)$.

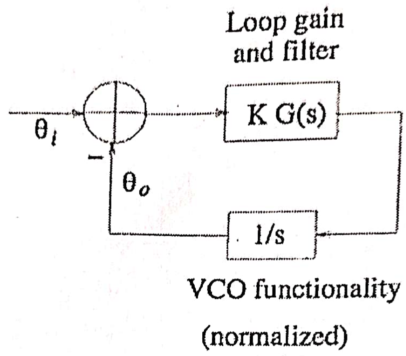
   (e) For superheterodyne receiver, the bandpass filter at the RF stage is needed eventhough there is a bandpass filter at the IF stage.

2. The message $m(t) = 2\sin(2000\pi t) - \cos(4000\pi t)$ is used in AM system with a modulation index of 70% and carrier frequency of 580 KHz. Answer the following **(5 points)**

   - What is the power efficiency?
   - If the net transmitted power is 10 W, find magnitude spectrum of the transmitted signal.



(a) Figure for Q.3



(b) Figure for Q.4

3. Consider a real message signal $m(t)$ with frequency response as shown in Fig. 1(a). Let the DSB signal be denoted by $u_{\text{DSB}}(t) = Am(t)\cos(2\pi f_c t)$. Let $l(t) = l_c(t) + jl_s(t)$ denote the complex envelope for LSB signal corresponding to $u_{\text{DSB}}(t)$ while $L(f) = L_c(f) + jL_s(f)$ denote the Fourier transform of $l(t)$. Also let $u_{\text{LSB}}(t)$ denote the passband signal corresponding to $l(t)$. Plot the DSB and LSB spectrums for this problem. Next, derive expression for $u_{\text{LSB}}(t)$ in terms of $m(t)$ and $\check{m}(t)$, where $\check{m}(t)$ denotes the Hilbert transform of $m(t)$. **(5 points)**

$m(t)\cos 2\pi f_c t + \check{m}(t)\sin 2\pi f_c t$

4. Consider the PLL shown in Fig. 1(b) with $G(s)$ given as

$$G(s) = 1 + a/s \qquad a > 0$$

Assume PLL is tracking well. If the input frequency suddenly jumps, i.e., $f_i(t) = \Delta f I_{[0,\infty)}(t)$, then solve the following **(5 points)**

- Find $f_o(t)$ and $\theta_o(t)$ in terms of $f_i(t)$ and $\theta_i(t)$. $\rightarrow \theta_i$
- Also find steady state error $f_e(t)$ and $\theta_e(t)$.

You can assume the following expressions for $H_e(s)$ and $H(s)$ to be known and there is no need to derive them:

$$H_e(s) = \frac{\Theta_i(s) - \Theta_o(s)}{\Theta_i(s)} = \frac{s}{s + KG(s)},$$

$$H(s) = \frac{\Theta_o(s)}{\Theta_i(s)} = \frac{KG(s)}{s + KG(s)}.$$