Birla Institute of Technology & Science, Pilani, Rajasthan
First Semester 2022-2023
Mid-Semester Exam (Close Book)

EEE F311 Communication Systems

Date: 05-11-2022, Duration: 90 Minutes, Maximum Marks: 50

Make suitable assumptions, if any. Put the final answers in a box.

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1. (a) $m(t) = 2 + 4\sin 20\pi t$ amplitudes modulates a carrier signal $c(t) = 6\cos 100\pi t$. Find the power efficiency (in %) of the modulated AM signal. [**Marks: 2**]

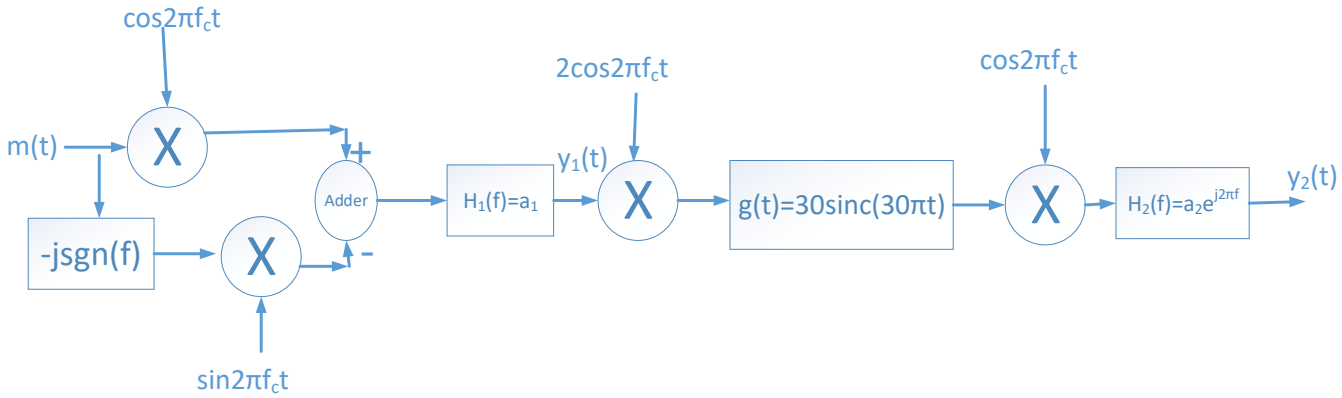
   (b) A NBFM signal has a carrier frequency of 100 Hz and frequency deviation of 2 Hz. Find the frequency deviation if the NBFM is passed through a mixer at 50 Hz and multiplier having a frequency doubler. [**Marks: 2**]

   (c) A broadcasting system has a spectrum in the range of 2000KHz-4000KHz and employs superhetrodyne receiver. Find the minimum IF frequency such that image frequency falls beyond the allocated spectrum. [**Marks: 2**]

   (d) Draw the Costas loop for the demodulation of DSB-SC signal. [**Marks: 2**]

   (e) A message bit stream 10110 is line encoded using bipolar NRZ to generate pulse stream $m(t)$. Sketch $m(t)$ considering a rectangular pulse width of $\frac{1}{5}$ second and amplitude 1. Also sketch $m(t)\cos 4\pi t$ for 1 second. [**Marks: 2**]

2. The signal $m(t)$ in the following figure has a bandwidth 10 Hz.



   (a) Find the signal $y_1(t)$ in terms of the input signal $m(t)$. [**Marks: 3**]

   (b) Find the output signal $y_2(t)$ in terms of the input signal $m(t)$. [**Marks: 3**]

   (c) Apply synchronous detector on $y_2(t)$. [**Marks: 4**]

3. An FM signal is given by $x(t) = 50\cos(2000\pi t + 2\sin 200\pi t)$ with the parameter $k_f = 2$ Hz/Volt. [**Marks:** 2×5]

   (a) Find the message signal $m(t)$.

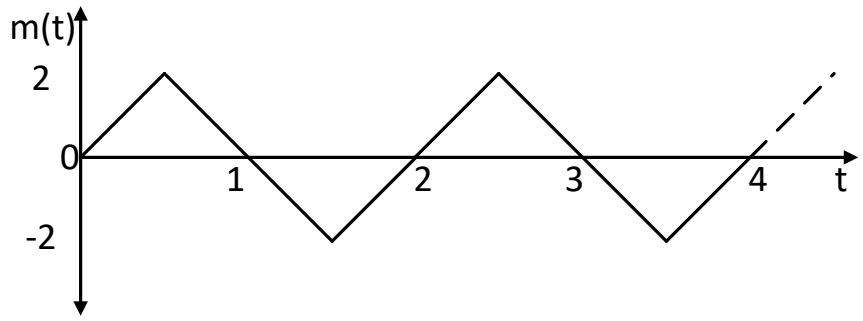
   (b) Find the modulation index β of the FM signal.

   (c) Find the bandwidth of the FM signal using Carson's rule.

   (d) An alternate representation of $x(t) = 50\cos(2000\pi t + 2\sin 200\pi t)$ is given by $x(t) = \sum_{n=-\infty}^{\infty} 50J_n(\beta)\cos(2\pi(f_c + nf_m)t)$, where f_c is the carrier frequency and f_m is the message frequency and β is the modulation index. Plot $|X(f)|$ (in terms of Bessel function) for $n = 0$ and $n = 1$ clearly labeling the x-axis and y-axis.

   (e) The signal $x(t)$ is passed through a channel $h(t) = 100sinc(100\pi t)\cos 2000\pi t$. Find the output power in terms of Bessel function.

4. A periodic message signal $m(t)$ (as shown in figure) is to be converted to binary bit-stream using PCM and DM techniques.



   (a) The signal is sampled at a rate of 1000 samples per second and encoded using the PCM. Find the minimum bandwidth required to transmit the data to achieve an SQNR of 256. [**Marks:** 5]

   (b) Find the minimum step-size of the DM to avoid slope-over load condition achieving the same data rate transmission as that of the PCM (as obtained in part (a)). [**Marks:** 5]

5. (a) Use the time-domain criteria to show that the pulse $p(t) = \frac{\cos(\pi R_s t)}{1-(2R_s t)^2} sinc(\pi R_s t)$ satisfies the Nyqist criteria for zero ISI. [**Marks: 3**]

   (b) How much time (in seconds) will be required to transfer a movie data of 1 GB over a bandwidth of 10 MHz using Nyquist pulse $p(t) = \frac{\cos(\pi R_s t)}{1-(2R_s t)^2} sinc(\pi R_s t)$ with NRZ binary polar encoding, where R_s denotes the transmission rate. Take 1 GB $= 10^9$ bits. [**Marks: 3**]

   (c) A message signal $m(t) = \sum p(t - nT)$, where $p(t) = \frac{\cos(\pi\alpha R_s t)}{1-(2\alpha R_s t)^2} sinc(\pi R_s t)$ is transmitted with pulse rate satisfying Nyquist criterion for zero-ISI. Sketch the frequency response of the pulse i.e., $P(f)$ (both-sided) for $n = 0$ and $n = 1$ in the same plot satisfying the Nyqist criteria for zero ISI for (i) $\alpha = 0$ and (ii) $\alpha = 1$. [**Marks: 2+2**]
