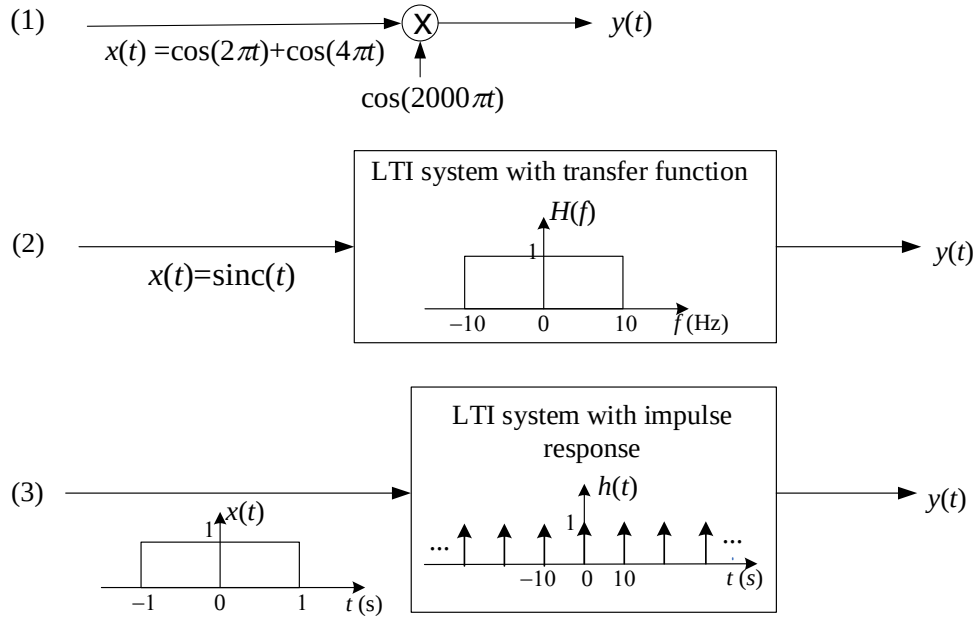
EE3008 Test 1

(1:00-2:30pm, Feb. 24, 2020)

Question 1 (33 marks)

For each of the following cases:

1. Determine whether the signals $x(t)$ and $y(t)$ are power-type or energy-type. For energy-type, plot the energy spectrum and determine the signal energy. For power-type, plot the power spectrum and determine the signal power; (27 marks)
2. Determine the bandwidth of $y(t)$. (6 marks)



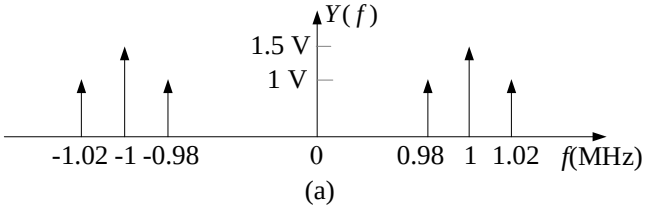
Question 2 (30 marks)

An input signal $x(t)$ with peak amplitude 10 V is applied to an AM-DSB-C modulator, and the Fourier spectrum $Y(f)$ of the output modulated signal $y(t)$ is shown in Fig. 2(a).

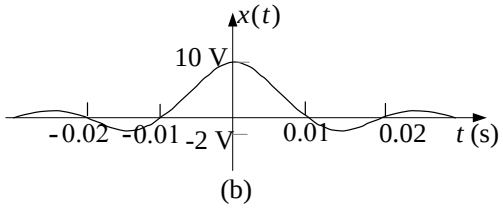
1. Determine the carrier frequency f_c, the modulation index and the DC offset of the AM-DSB-C modulator. (9 marks)
2. Specify whether the modulated signal $y(t)$ can be properly detected by an envelope detector. If yes, sketch and label the output waveform of the envelope detector. If no, determine the minimum DC offset for the envelope detector to properly work. (3 marks)
3. Suppose that the input signal $x(t)$ is now changed to a sinc-shaped signal, as shown in Fig. 2(b).
    1) Specify whether the modulated signal $y(t)$ can be properly detected by an envelope detector. If yes, sketch and label the output waveform of the envelope detector. If no, determine the minimum DC offset for the envelope detector to properly work. (6 marks)
    2) Determine the bandwidth of the modulated signal $y(t)$. (4 marks)

3) Can all the frequency components of the modulated signal $y(t)$ pass through a channel with the frequency range of [999 kHz, 1000 kHz]? If yes, state your reason. If no, specify the required frequency range of the channel so that all the frequency components of $y(t)$ can pass through. (4 marks)

4) Describe how to convert $y(t)$ into an AM-SSB signal. (4 marks)



(a)



(b)

Question 3 (37 marks)

The output signal of an FM system is given by:

$$s_{FM}(t) = 100\cos[10^8 \pi t + \sin(10^3 \pi t)].$$

1. Determine the peak frequency deviation, modulation index, carrier frequency, and the total output power; (12 marks)
2. Determine the percentage of the output power at the second sidebands; (4 marks)
3. Determine the output power at 50 MHz, 49.998 MHz and 50.0001MHz, respectively; (9 marks)
4. Determine the channel frequency range to include at least 99.9% of the output power; (6 marks)
5. Suppose that the peak amplitude of the input signal is carefully increased until the output signal at 50.0005MHz is zero. Determine the effective bandwidth of the output signal according to Carson's rule. (6 marks)

Appendix

Table 6-1 Values of Bessel Function of the First Kind $J_n(\beta)$ for Various Values of n and β

n	$\beta = 1$	$\beta = 2$	$\beta = 3$	$\beta = 4$	$\beta = 5$	$\beta = 6$	$\beta = 7$	$\beta = 8$	$\beta = 9$
0	0.7652	0.2239	−0.2601	−0.3971	−0.1776	0.1506	0.3001	0.1717	−0.0903
1	0.4401	0.5767	0.3391	−0.0660	−0.3276	−0.2767	−0.0047	0.2346	0.2453
2	0.1149	0.3528	0.4861	0.3641	0.0466	−0.2429	−0.3014	−0.1130	0.1448
3	0.0196	0.1289	0.3091	0.4302	0.3648	0.1148	−0.1676	−0.2911	−0.1809
4	0.0025	0.0340	0.1320	0.2811	0.3912	0.3576	0.1578	−0.1054	−0.2655
5	0.0002	0.0070	0.0430	0.1321	0.2611	0.3621	0.3479	0.1858	−0.0550
6	*	0.0012	0.0114	0.0491	0.1310	0.2458	0.3392	0.3376	0.2043
7	*	0.0002	0.0025	0.0152	0.0534	0.1296	0.2336	0.3206	0.3275
8	*	*	0.0005	0.0040	0.0184	0.0565	0.1280	0.2235	0.3051
9	*	*	0.0001	0.0009	0.0055	0.0212	0.0589	0.1263	0.2149
10	*	*	*	0.0002	0.0015	0.0070	0.0235	0.0608	0.1247
11	*	*	*	*	0.0004	0.0020	0.0083	0.0256	0.0622
12	*	*	*	*	0.0001	0.0005	0.0027	0.0096	0.0274
13	*	*	*	*	*	0.0001	0.0008	0.0033	0.0108
14	*	*	*	*	*	*	0.0002	0.0010	0.0039
15	*	*	*	*	*	*	0.0001	0.0003	0.0013
16	*	*	*	*	*	*	*	0.0001	0.0004
17	*	*	*	*	*	*	*	*	0.0001
18	*	*	*	*	*	*	*	*	*
19	*	*	*	*	*	*	*	*	*