EE3008 Assignment 1

(Due Date: 5 pm, Feb. 19, 2024)

Question 1 (32 marks)

For **each** of the following three cases shown in Fig. 1:

1. Plot the Fourier spectrum of $y(t)$; (6 marks)
2. Determine whether the signal $y(t)$ is a power-type or energy-type signal. State your reason; (3 marks)
3. If $y(t)$ is an energy-type signal, determine its signal energy and plot the energy spectrum. If $y(t)$ is a power-type signal, determine its signal power and plot the power spectrum; (4 marks)
4. Determine the bandwidth of $x(t)$. (3 marks)

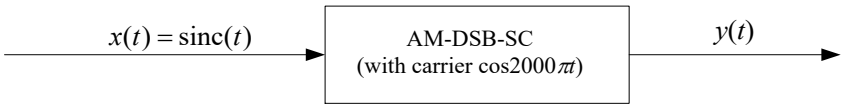


Fig. 1a

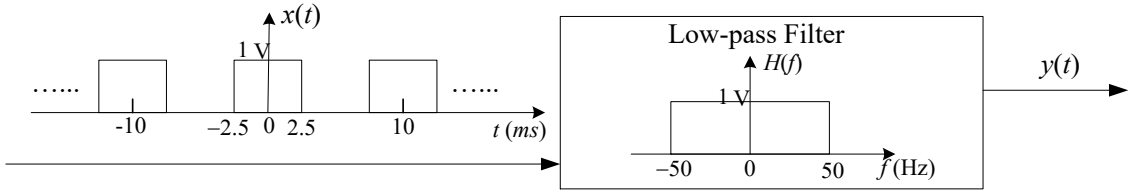
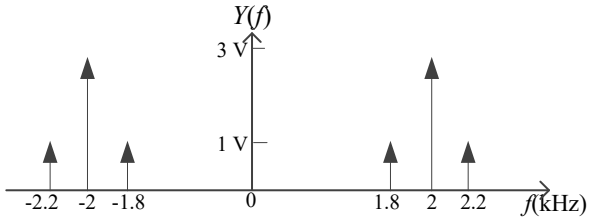


Fig. 1b

Question 2 (36 marks)

An input signal $x(t)$ is applied to an AM-DSB-C modulator, and the Fourier spectrum $Y(f)$ of the output signal $y(t)$ is given in the following figure.



1. Determine the minimum required channel bandwidth such that all the frequency components of the modulated signal $y(t)$ can pass through; (4 marks)
2. Determine the modulation index; (4 marks)
3. Determine the expression of $y(t)$; (6 marks)
4. Determine whether $y(t)$ is a power-type signal or an energy-type signal. For energy-type signals,

determine the energy spectrum and the signal energy. For power-type signals, determine the power spectrum and the signal power; (8 marks)

5. 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; (10 marks)
6. If the DC offset of the AM-DSB-C modulator is cut in half, determine whether the modulated signal $y(t)$ can be properly detected by an envelope detector. State your reason. (4 marks)

Question 3 (32 marks)

The output signal of an FM system is given by:

$$s_{FM}(t) = 20\cos[10^8 \pi t + 1000\pi \int_{-\infty}^{t} \cos(10^3 \pi \tau) d\tau].$$

1. Determine the peak frequency deviation; (4 marks)
2. Determine the modulation index; (4 marks)
3. Determine the output power at the second sidebands; (4 marks)
4. Determine the output power at 49.9999 MHz and 49.9995 MHz, respectively; (6 marks)
5. Determine the minimum channel bandwidth required for transmitting those sidebands whose magnitudes are larger than 5% of the magnitude of the carrier component; (6 marks)
6. Suppose that the 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. (8 marks)

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	*	*	*	*	*	*	*	*	*