EEEN 322 PS 5 QUESTIONS

Q1

4.2-8 Two signals $m_1(t)$ and $m_2(t)$, both band-limited to 5000 rad/s, are to be transmitted simultaneously over a channel by the multiplexing scheme shown in Fig. P4.2-8. The signal at point b is the multiplexed signal, which now modulates a carrier of frequency 20,000 rad/s. The modulated signal at point c is transmitted over a channel.

(a) Sketch signal spectra at points a, b, and c.

(b) What must be the bandwidth of the channel?

(c) Design a receiver to recover signals $m_1(t)$ and $m_2(t)$ from the modulated signal at point c.

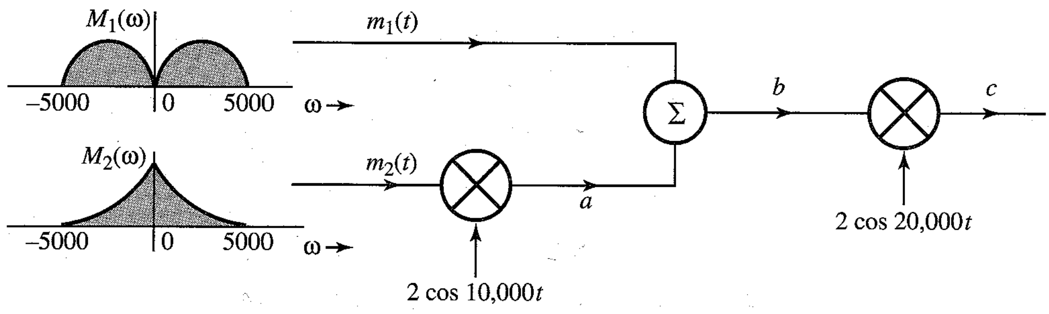

Figure P4.2-8

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Q2

4.2-9 System shown in Fig. P4.2-9 is used for scrambling audio signals. The output $y(t)$ is the scrambled version of the input $m(t)$.

(a) Find the spectrum of the scrambled signal $y(t)$.

(b) Suggest a method of descrambling $y(t)$ to obtain $m(t)$.

A slightly modified version of this scrambler was first used commercially on the 25-mile radio-telephone circuit connecting Los Angeles and Santa Catalina island.

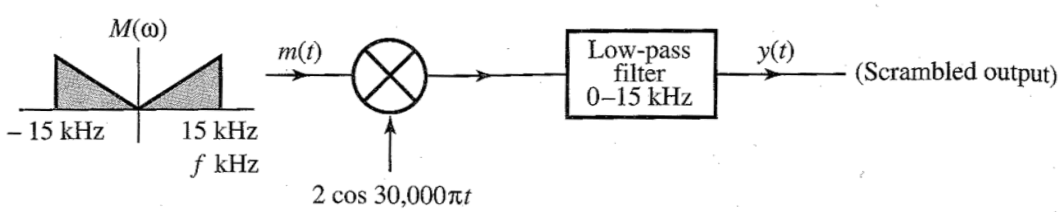

Figure P4.2-9

* *

Q3

4.2-10 A DSB-SC signal is given by $m(t)\cos(2\pi)10^6 t$. The carrier frequency of this signal, 1 MHz, is to be changed to 400 kHz. The only equipment available is one ring modulator, a bandpass filter centered at the frequency of 400 kHz, and one sine wave generator whose frequency can be varied from 150 to 210 kHz. Show how you can obtain the desired signal $cm(t)\cos(2\pi \times 400 \times 10^6 t)$ from $m(t)\cos(2\pi)10^6 t$. Determine the value of c.

* *

Q4

4.6-1 A vestigial filter $H_i(\omega)$ shown in the transmitter of Fig. 4.22 has a transfer function as shown in Fig. P4.6-1. The carrier frequency is $f_c = 10$ kHz and the baseband signal bandwidth is 4 kHz. Find the corresponding transfer function of the equalizer filter $H_o(\omega)$ shown in the receiver of Fig. 4.22.

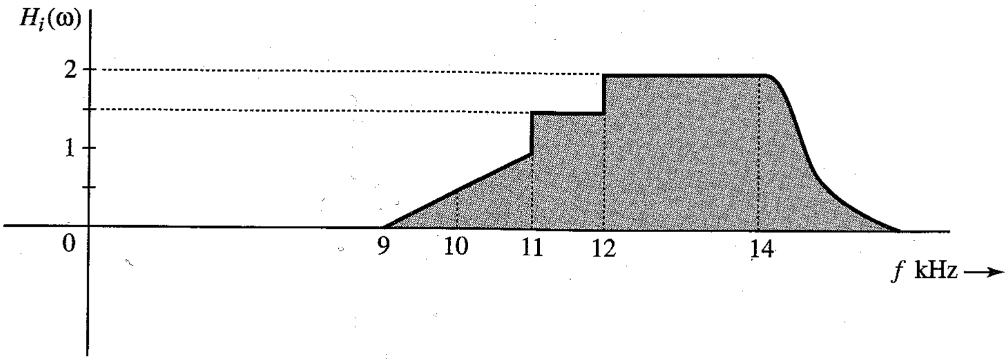

Figure P4.6-1

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EEEN 322 PS 5 SOLUTIONS

Q1

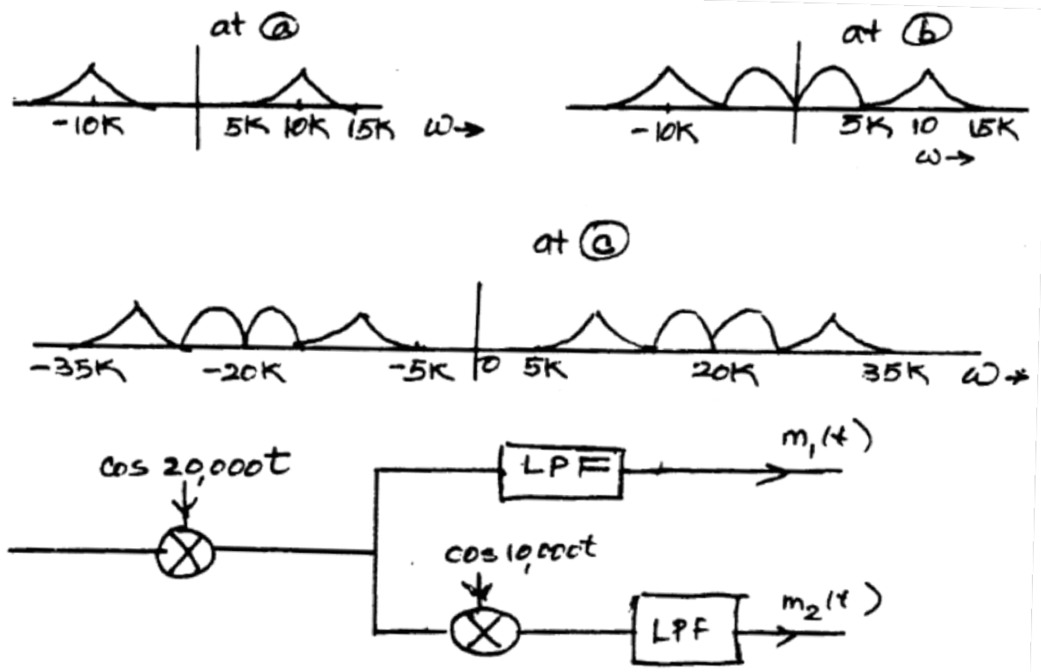

Fig. S4.2-8

4.2-8 (a) Fig. S4.2-8 shows the signals at points a. b. and c.

(b) From the spectrum at point c, it is clear that the channel bandwidth must be at least 30,000 rad/s (from 5000 to 35,000 rad/s.).

(c) Fig. S4.2-8 shows the receiver to recover $m_1(t)$ and $m_2(t)$ from the received modulated signal.

* *

Q2

4.2-9 (a) S4.2-9 shows the output signal spectrum $Y(\omega)$.

(b) Observe that $Y(\omega)$ is the same as $M(\omega)$ with the frequency spectrum inverted, that is, the high frequencies are shifted to lower frequencies and vice versa. Thus, the scrambler in Fig. P4.2-9 inverts the frequency spectrum.

To get back the original spectrum $M(\omega)$, we need to invert the spectrum $Y(\omega)$ once again. This can be done by passing the scrambled signal $y(t)$ through the same scrambler.

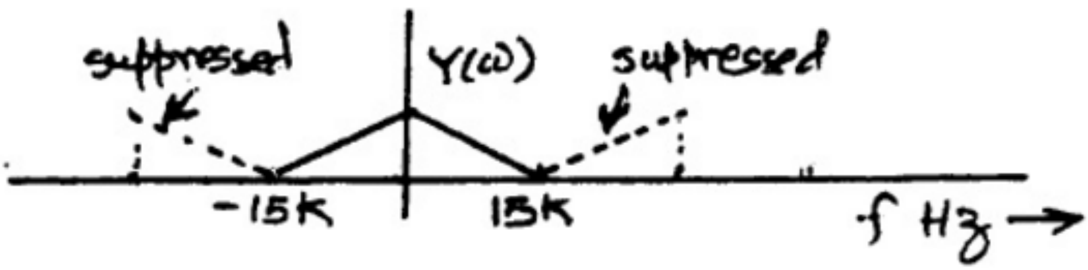

Fig. S4.2-9

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Q3

4.2-10 We use the ring modulator shown in Fig. 4.6, except that the input is $m(t)\cos(2\pi)10^6 t$ instead of $m(t)$. The carrier frequency is 200 kHz [$\omega_c = (400\pi)10^3 t$], and the output bandpass filter is centered at 400 kHz. The output $v_i(t)$ is found in Eq. (4.7b) as

$$v_i(t) = [m(t)\cos(2\pi)10^6 t]w_0(t) = \frac{4}{\pi}m(t)\cos(2\pi)10^6 t\left[\cos(400\pi)10^3 t - \frac{1}{3}\cos 3(400\pi)10^3 t + \frac{1}{5}\cos 5(400\pi)10^3 t + \cdots\right]$$

The product of the terms $(-1/3)\cos 3(400\pi)10^3 t$ and $(4/\pi)m(t)\cos(2\pi)10^6 t$ yields the desired term $-\frac{2}{3\pi}m(t)\cos(800\pi)10^3 t$, whose spectrum is centered at 400 kHz. It alone passes through the bandpass filter (centered at 400 kHz). All the other terms are suppressed. The desired output is

$$y(t) = -\frac{2}{3\pi}m(t)\cos(800\pi)10^3 t$$

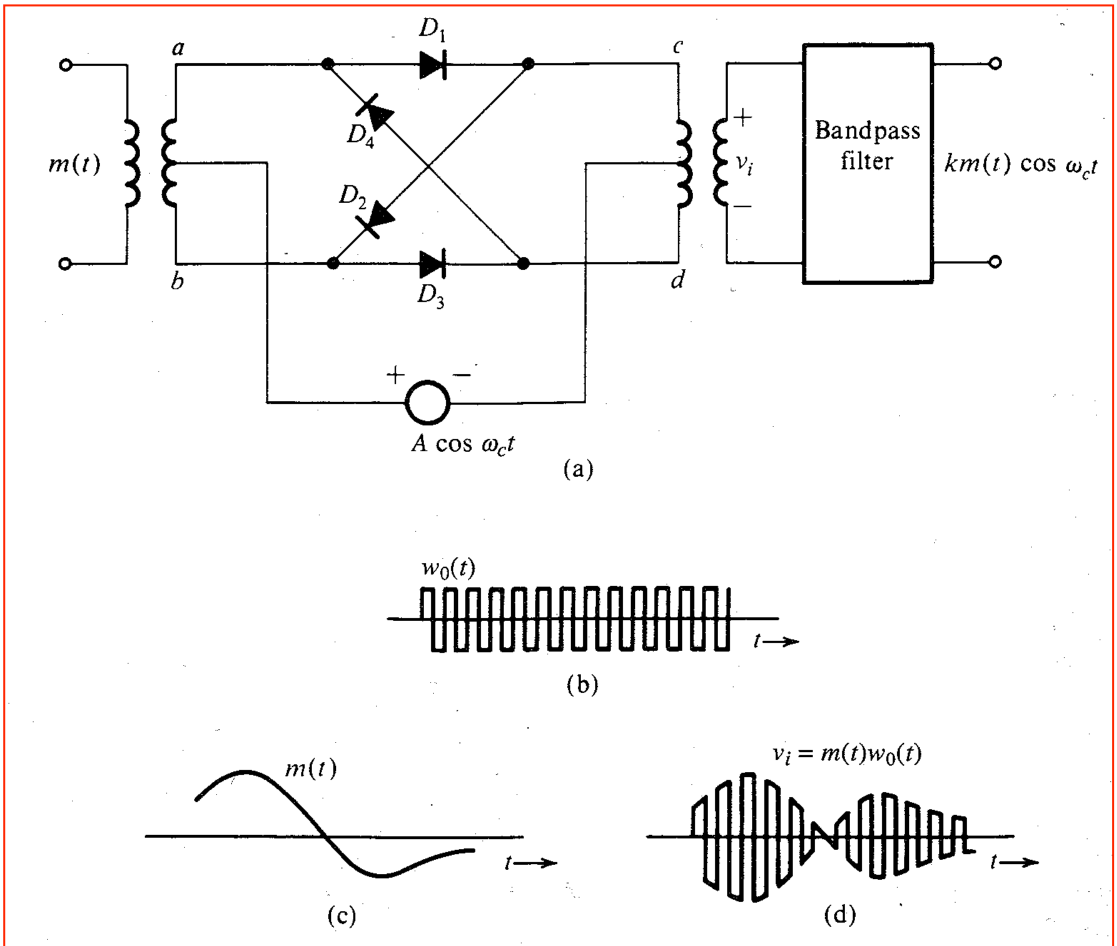


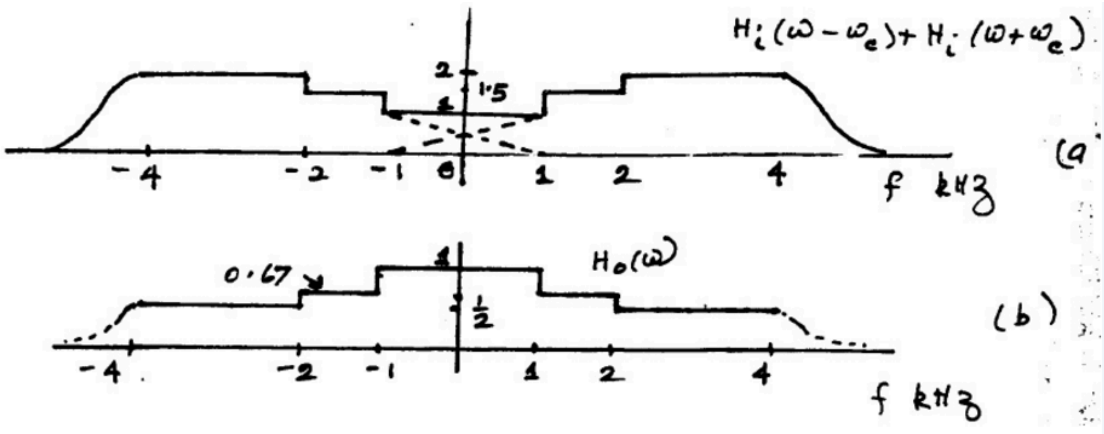
Figure 4.6 Ring modulator.

Q4

4.6-1 From Eq. (4.20)

$$H_o(\omega) = \frac{1}{H_i(\omega + \omega_c) + H_i(\omega - \omega_c)} \qquad |\omega| \le 2\pi B$$

Figure S4.6-1a shows $H_i(\omega - \omega_c)$ and $H_i(\omega + \omega_c)$. Figure S4.6-1b shows the reciprocal, which is $H_o(\omega)$.



$H_i(\omega-\omega_c)+H_i(\omega+\omega_c)$
2
1.5
1
-4
-2
-1
0
1
2
4
f kHz
(a)
0.67
1
$H_o(\omega)$
$\frac{1}{2}$
(b)
-4
-2
-1
1
2
4
f kHz

Fig. S4.6-1

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