4.2-1

(i) $m(t) = \cos \omega_m t = \cos 2\pi f_m t = \cos 1000\pi t \rightarrow f_m = 500\text{Hz}.$
$M(f) = 0.5\delta(f - 500) + 0.5\delta(f + 500).$
See Fig. S4.2-1a(i).

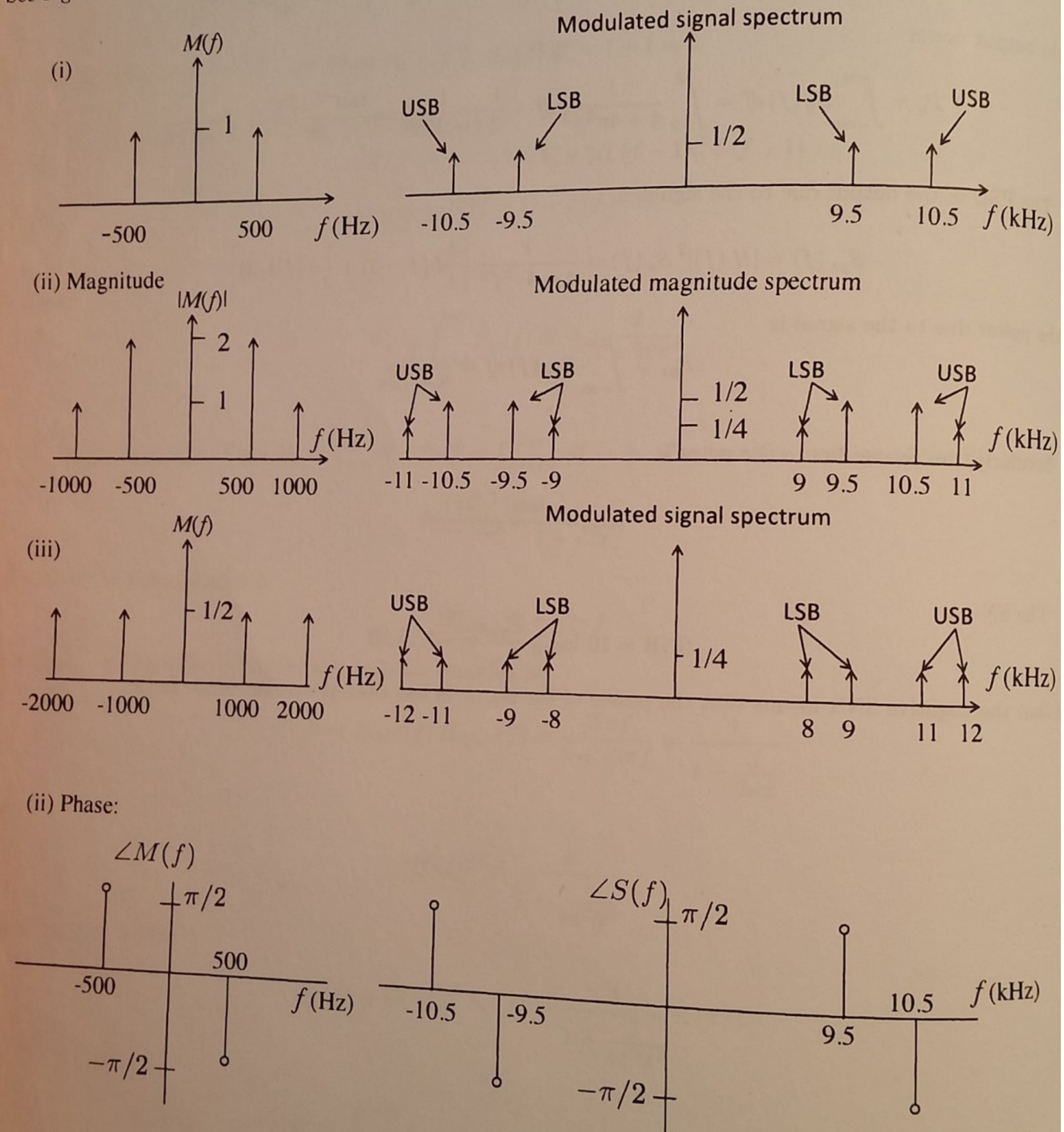

Fig. S4.2-1a

(ii) $m(t) = 2\cos \omega_{m,1}t + \sin \omega_{m,2}t = 2\cos 2\pi f_{m,1}t + \sin 2\pi f_{m,2}t = 2\cos 1000\pi t + \sin 2000\pi t$
$\rightarrow M(f) = \delta(f - 1000) + \delta(f + 1000) - 0.5j\delta(f - 500) + 0.5j\delta(f + 500)$
$|M(f)| = \delta(f - 1000) + \delta(f + 1000) + 0.5\delta(f - 500) + 0.5\delta(f + 500)$

$$\angle M(f) = \begin{cases} -\pi/2, & f = 500 \\ \pi/2, & f = -500 \\ 0, & \text{else} \end{cases}$$

See Fig. S4.2-1a(ii) for its magnitude plot.

(iii) $m(t) = \cos\omega_{m,1}t \cdot \cos\omega_{m,2}t = \cos 1000\pi t \cdot \cos 3000\pi t = \frac{1}{2}(\cos 2\pi f_{m,1}t + \cos 2\pi f_{m,2}t) = \frac{1}{2}(\cos 2000\pi t + \cos 4000\pi t) \rightarrow$
$f_{m,1} = 1000\text{Hz}$ $f_{m,2} = 2000\text{Hz}$

See Fig. S4.2-1a(iii) for the graphical results.

(iv) Since $m(t) = e^{-10|t|}$, we have

$$\mathcal{F}(m(t)) = M(f) = \frac{20}{100 + 4\pi^2 f^2}$$

See Fig. S4.2-1b.

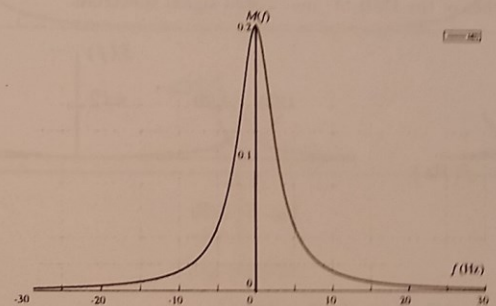

Fig. S4.2-1b

(v) Using frequency shift property on the result of part **(iv)**, we have $\mathcal{F}(m(t)) = M(f) = \frac{10}{100+4\pi^2(f-f_c)^2} + \frac{10}{100+4\pi^2(f+f_c)^2}$. See Fig. S4.2-1c.

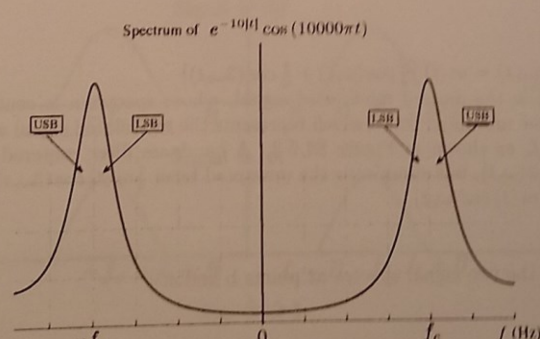

Fig. S4.2-1c

4.2-5 We denote $w(t)$ as the switching signal (see text). The resistance of each diode is r ohms while conducting and ∞ when off. When the carrier $A\cos(\omega_c t)$ is positive, the diodes conduct (during the entire positive half-cycle) and when the carrier is negative the diodes are open (during the entire negative half-cycle). Thus, during the positive half-cycle, the voltage $\frac{R}{R+r}\phi(t)$ appears across each of the resistors R. During the negative half-cycle, the output voltage is zero. Therefore, the diodes act as a gate in the circuit that is basically a voltage divider with a gain

$$\frac{2R}{(R+r)}$$

The output is therefore:

$$e_o(t) = \frac{2R}{R+r} w(t)\, m(t)$$

The period of $w(t)$ is $T_o = 2\pi/\omega_c$. Hence, from Eq. (2.86)

$$w(t) = \frac{1}{2} + \frac{2}{\pi}\left[\cos(\omega_c t) - \frac{1}{3}\cos(3\omega_c t) + \frac{1}{5}\cos(5\omega_c t) + \ldots\right]$$

The output $e_o(t)$ is:

$$e_o(t) = \frac{2R}{R+r} w(t) m(t) = \frac{2R}{R+r} m(t)\left[\frac{1}{2} + \frac{2}{\pi}\left(\cos(\omega_c t) - \frac{1}{3}\cos(3\omega_c t) + \frac{1}{5}\cos(5\omega_c t) + \ldots\right)\right]$$

(a) If we pass the output $e_o(t)$ through a bandpass filter (centered at ω_c), the filter suppresses the signal $m(t)$ and $m(t)\cos(n\omega_c t)$ for all $n \neq 1$, leaving intact only the modulated term

$$\frac{4R}{\pi(R+r)} m(t)\cos(\omega_c t)$$

Hence, the system acts as a DSB-SC modulator.

(b) The same circuit can be used as a demodulator if we use a basepass filter at the output. In this case, the input is $\phi(t) = m(t)\cos(\omega_c t)$ and the output is

$$\frac{2R}{\pi(R+r)} m(t).$$

4.2-7

(a) Figure S4.2-7 shows the signals at points a,b and c.

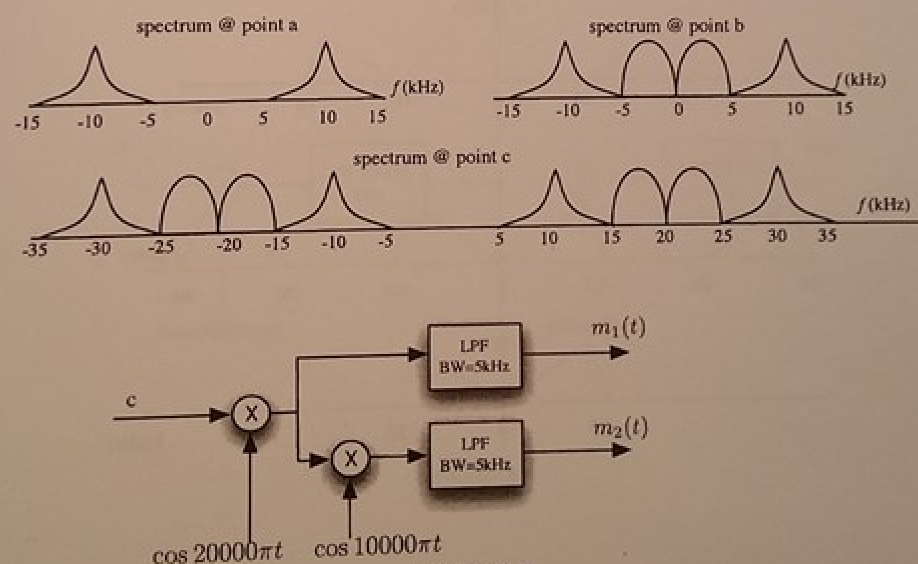

Fig. S4.2-7

(b) From the spectrum at point c, it is clear that the channel bandwidth must be at least 30000 Hz (from 5000 Hz to 35000 Hz).

4.3-3

(a) According to Eq. (4.10a), the carrier amplitude is $A = \frac{m_p}{\mu} = \frac{10}{0.75} = 13.34$. The carrier power is $P_c = \frac{A^2}{2} =$ 88.89

(b) The sideband power is $\overline{m^2(t)}/2$. Because of symmetry of amplitude values every quarter cycle, the power of $m(t)$ may be computed by averaging the signal energy over a quarter cycle only. Over a quarter cycle $m(t)$ can be represented as $m(t) = 40t/T_0$ (see Fig. S4.3-3). Note that $T_0 = 10^{-3}$ Hence,

$$\overline{m^2(t)} = \frac{1}{T_0/4} \int_0^{T_0/4} \left[\frac{40t}{T_0}\right]^2 dt = 33.34$$

The sideband power is

$$P_s = \frac{\overline{m^2(t)}}{2} = 16.67$$

The efficiency is

$$\eta = \frac{P_s}{P_c + P_s} = \frac{16.67}{88.89 + 16.67} \times 100\% = 15.79\%$$

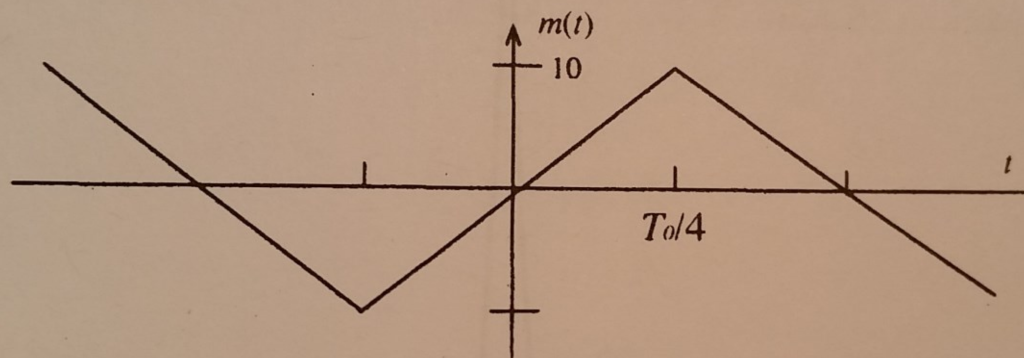

Fig. S4.3-3

4.3-6 When an input to a DSB-SC generator is $m(t)$, and the corresponding output $m(t)\cos(\omega_c t)$. Clearly, if th input is $A + m(t)$, the corresponding output will be $[A + m(t)]\cos(\omega_c t)$, the corresponding output will be $A + m$ This is precisely the AM signal. Thus, by adding a dc of value A to the baseband signal $m(t)$, we can use a DSB-S generator to generate AM signals.

The converse is generally not true. However, we can use two AM generators to generate DSB-SC signals if we two identical AM generators in a balanced scheme as shown in Fig. S4.3-6 to remove the carrier component.

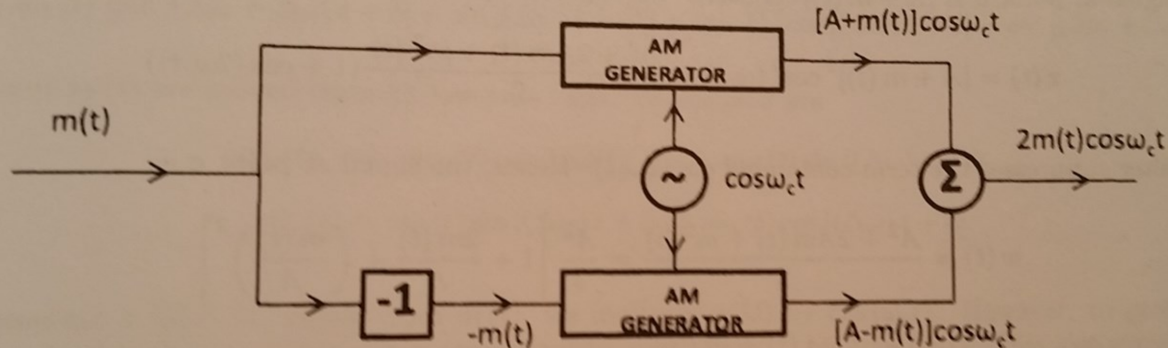

Fig. S4.3-6

4.4-2 To generate a DSB-SC signal from $m(t)$, we multiply $m(t)$ by $\cos(\omega_c t)$. However, to generate the SSB signals of the same relative magnitude, it is convenient to multiply $m(t)$ by $2\cos(\omega_c t)$. This also avoids the nuisance of the fractions $1/2$, and yields the DSB-SC spectrum

$$M(\omega - \omega_c) + M(\omega + \omega_c)$$

We suppress the USB spectrum (above ω_c and below $-\omega_c$) to obtain the LSB spectrum. Similarly, to obtain the USB spectrum, we suppress the LSB spectrum (between $-\omega_c$ and ω_c) from the DSB-SC spectrum. Figures S4.4-2a and S4.4-2b show the three cases.

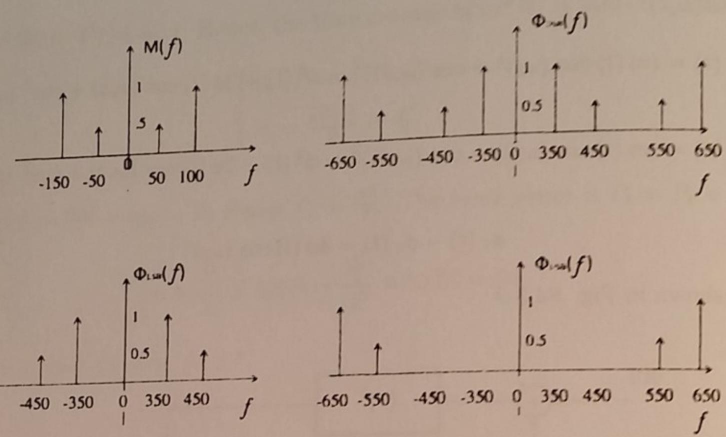

Fig. S4.4-2a

(a) From Fig. S4.4-2a, we can express $\phi_{LSB}(t) = 2\cos(700\pi t) + \cos(900\pi t)$ and $\phi_{USB}(t) = \cos(1100\pi t) + 2\cos(1300\pi t)$.

(b) From Fig. S4.4-2b, we can express:
$\phi_{LSB}(t) = \frac{1}{2}[\cos(400\pi t) + \cos(600\pi t)]$ and $\phi_{USB}(t) = \frac{1}{2}[\cos(1400\pi t) + \cos(1600\pi t)]$.

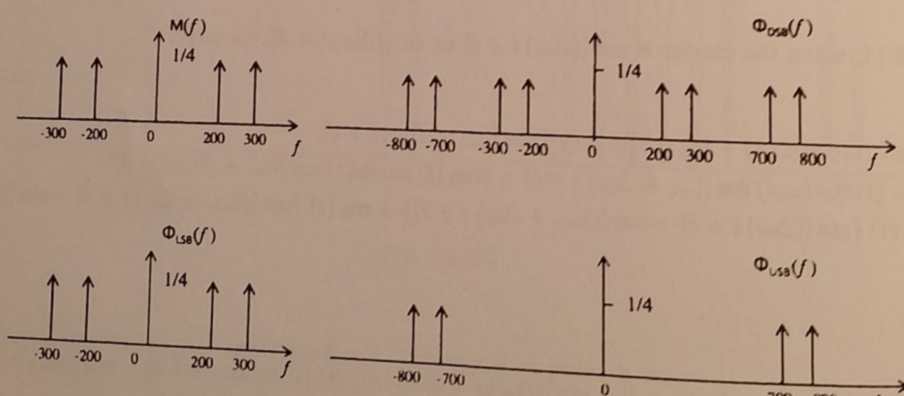

Fig. S4.4-2b

4.5-1 From Eq. (4.25)

$$H_0(f) = \frac{1}{H_i(f+f_c) + H_i(f-f_c)} \qquad |f| \le 2\pi B$$

Figure S4.5-1 shows $H_i(f-f_c) + H_i(f+f_c)$ and the reciprocal, which is $H_0(f)$.

4.5-2 We use 1.5 MHz as the carrier frequency. Thus, the VSB uses all the lower sideband width until 1.496 MHz.

(a) Figure S4.5-2a shows the receiver block diagram. Without a receiver filter $H_R(f)$, the correction is performed solely by output filter $H_o(f)$ on

$$H_i(f) = H_T(f)\,H_R(f) = H_T(f)$$

(b) $B = (1501 - 1496) = 5$ kHz.

(c) Fig. S4.5-2c shows $H_i(f+f_c) + H_i(f-f_c)$ and the corresponding design of $H_0(f)$ spectrum.