4.2-4 (a) The signal at point b is

$$g_a(t) = m(t)\cos^3 \omega_c t$$
$$= m(t)\left[\frac{3}{4}\cos\omega_c t + \frac{1}{4}\cos 3\omega_c t\right]$$

The term $\frac{3}{4}m(t)\cos\omega_c t$ is the desired modulated signal, whose spectrum is centered at $\pm\omega_c$. The remaining term $\frac{1}{4}m(t)\cos 3\omega_c t$ is the unwanted term, which represents the modulated signal with carrier frequency $3\omega_c$ with spectrum centered at $\pm 3\omega_c$ as shown in Fig. S4.2-4. The bandpass filter centered at $\pm\omega_c$ allows to pass the desired term $\frac{3}{4}m(t)\cos\omega_c t$, but suppresses the unwanted term $\frac{1}{4}m(t)\cos 3\omega_c t$. Hence, this system works as desired with the output $\frac{3}{4}m(t)\cos\omega_c t$.
(b) Figure S4.2-4 shows the spectra at points b and c.
(c) The minimum usable value of ω_c is $2\pi B$ in order to avoid spectral folding at dc.
(d)

$$m(t)\cos^2\omega_c t = \frac{m(t)}{2}[1 + \cos 2\omega_c t]$$
$$= \frac{1}{2}m(t) + \frac{1}{2}m(t)\cos 2\omega_c t$$

The signal at point b consists of the baseband signal $\frac{1}{2}m(t)$ and a modulated signal $\frac{1}{2}m(t)\cos 2\omega_c t$, which has a carrier frequency $2\omega_c$. not the desired value ω_c. Both the components will be suppressed by the filter, whose center center frequency is ω_c. Hence, this system will not do the desired job.
(e) The reader may verify that the identity for $\cos n\omega_c t$ contains a term $\cos\omega_c t$ when n is odd. This is not true when n is even. Hence, the system works for a carrier $\cos^n \omega_c t$ only when n is odd.

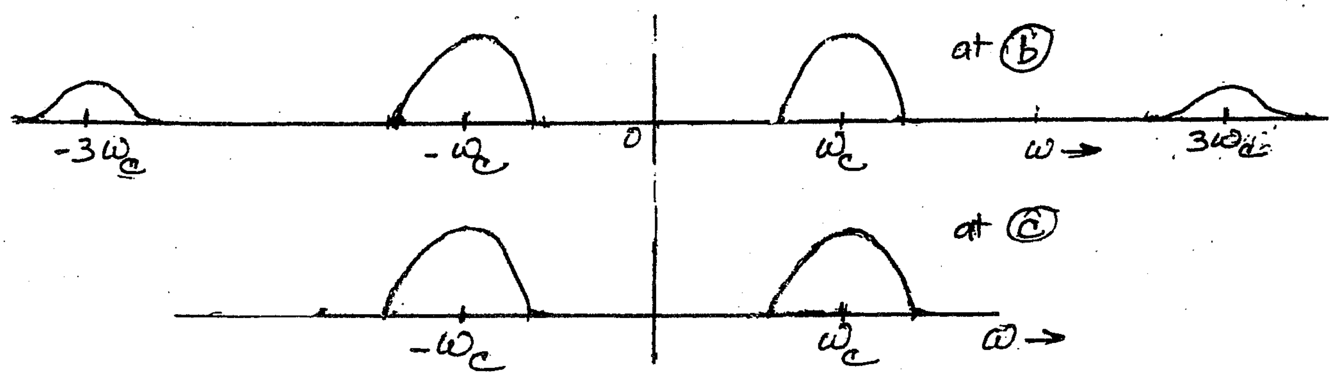

Fig. S4.2-4

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.

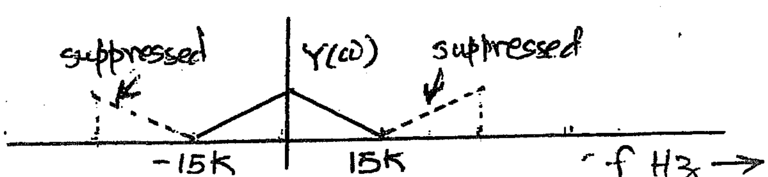

Fig. S4.2-9

4.3-1 $g_a(t) = [A + m(t)]\cos\omega_c t$. Hence,

$$g_b(t) = [A + m(t)]\cos^2\omega_c t$$
$$= \frac{1}{2}[A + m(t)] + \frac{1}{2}[A + m(t)]\cos 2\omega_c t$$

The first term is a lowpass signal because its spectrum is centered at $\omega = 0$. The lowpass filter allows this term to pass, but suppresses the second term, whose spectrum is centered at $\pm 2\omega_c$. Hence the output of the lowpass filter is

$$y(t) = A + m(t)$$

When this signal is passed through a dc block, the dc term A is suppressed yielding the output $m(t)$. This shows that the system can demodulate AM signal regardless of the value of A. This is a synchronous or coherent demodulation.

4.5-6 We showed in prob. 4.5-4 that the Hilbert transform of $m_h(t)$ is $-m(t)$. Hence, if $m_h(t)$ [instead of $m(t)$] is applied at the input in Fig. 4.20, the USB output is

$$\begin{aligned} y(t) &= m_h(t) \cos \omega_c t - m(t) \sin \omega_c t \\ &= m(t) \cos\left(\omega_c t + \frac{\pi}{2}\right) + m_h(t) \sin\left(\omega_c t + \frac{\pi}{2}\right) \end{aligned}$$

4.8-2 The local oscillator generates frequencies in the range 1+8=9 MHz to 30+8=38 MHz. When the receiver setting is 10MHz, $f_{LO} = 10 + 8 = 18$ MHz. Now, if there is a station at $18 + 8 = 26$ MHz, it will beat (mix) with $f_{LO} = 18$ MHz to produce two signals centered at $26 + 18 = 44$ MHz and at $26 - 18 = 8$ MHz. The sum component is suppressed by the IF filter, but the difference component, which is centered at 8 MHz, passes through the IF filter.