4.2-1 For each of the baseband signals: (i) $m(t) = \cos 1000\pi t$; (ii) $m(t) = 2\cos 1000\pi t + \sin 2000\pi t$; (iii) $m(t) = \cos 1000\pi t \cos 3000\pi t$, do the following.

(a) Sketch the spectrum of $m(t)$.

(b) Sketch the spectrum of the DSB-SC signal $m(t) \cos 10{,}000\pi t$.

(c) Identify the upper sideband (USB) and the lower sideband (LSB) spectra.

(d) Identify the frequencies in the baseband, and the corresponding frequencies in the DSB-SC, USB, and LSB spectra. Explain the nature of frequency shifting in each case.

4.2-4 You are asked to design a DSB-SC modulator to generate a modulated signal $km(t)\cos(\omega_c t + \theta)$, where $m(t)$ is a signal band-limited to B Hz. Figure P4.2-4 shows a DSB-SC modulator available in the stock room. The carrier generator available generates not $\cos \omega_c t$, but $\cos^3 \omega_c t$. Explain whether you would be able to generate the desired signal using only this equipment. You may use any kind of filter you like.

(a) What kind of filter is required in Fig. P4.2-3?

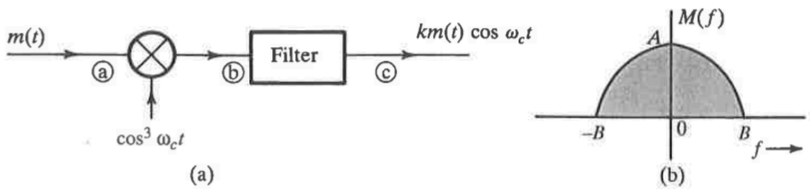
(b) Determine the signal spectra at points b and c, and indicate the frequency bands occupied by these spectra.

(c) What is the minimum usable value of ω_c?

(d) Would this scheme work if the carrier generator output were $\sin^3 \omega_c t$? Explain.

(f) Would this scheme work if the carrier generator output were $\cos^n \omega_c t$ for any integer $n \geq 2$?

gure P.4.2-4



4.2-8 Two signals $m_1(t)$ and $m_2(t)$, both band-limited to 5000 Hz, 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 Hz. 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.

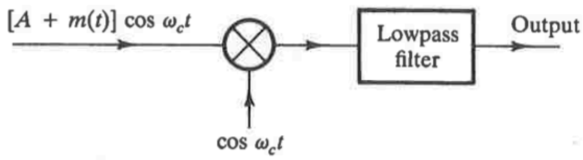
4.2-9 The system shown in Fig. P4.2-9 is used for scrambling audio signals. The output $y(t)$ is the scrambled version of the input $m(t)$.

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

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

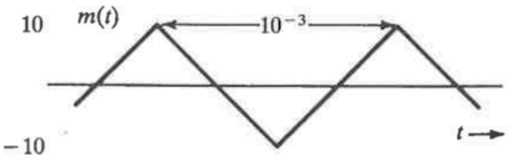
4.3-1 Figure P4.3-1 shows a scheme for coherent (synchronous) demodulation. Show that this scheme can demodulate the AM signal $[A + m(t)]\cos(2\pi f_c t)$ regardless of the value of $A>$

Figure P.4.3-1



4.3-2 Sketch the AM signal $[A + m(t)]\cos(2\pi f_c t)$ for the periodic triangle signal $m(t)$ shown in Fig. P4.3-2 corresponding to the modulation indices **(a)** $\mu = 0.5$; **(b)** $\mu = 1$; **(c)** $\mu = 2$; **(d)** $\mu = \infty$. How do you interpret the case of $\mu = \infty$?

Figure P.4.3-2



4.4-2 A modulating signal $m(t)$ is given by:

(a) $m(t) = \cos\ 100\pi t + 2\cos\ 300\pi t$

(b) $m(t) = \sin\ 100\pi t \sin\ 500\pi t$

In each case:

(i) Sketch the spectrum of $m(t)$.

(ii) Find and sketch the spectrum of the DSB-SC signal $2m(t)\ \cos\ 1000\pi t$.

(iii) From the spectrum obtained in **(ii)**, suppress the LSB spectrum to obtain the USB spectrum.

(iv) Knowing the USB spectrum in **(ii)**, write the expression $\varphi_{\text{USB}}(t)$ for the USB signal.

(v) Repeat **(iii)** and **(iv)** to obtain the LSB signal $\varphi_{\text{LSB}}(t)$.