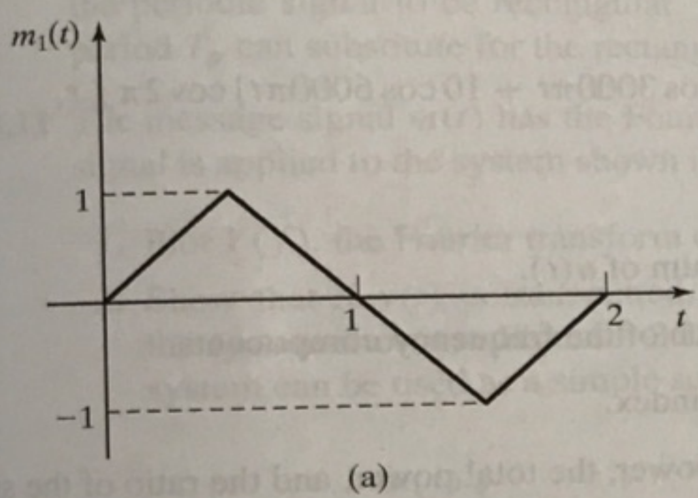
3.1 The message signal $m(t) = 2\cos 400t + 4\sin(500t + \frac{\pi}{3})$ modulates the carrier signal $c(t) = A\cos(8000\pi t)$, using DSB amplitude modulation. Find the time-domain and frequency-domain representations of the modulated signal and plot the spectrum (Fourier transform) of the modulated signal. What is the power content of the modulated signal?

3.2 In a DSB system, the carrier is $c(t) = A\cos 2\pi f_c t$ and the message signal is given by $m(t) = \text{sinc}(t) + \text{sinc}^2(t)$. Find the frequency-domain representation and the bandwidth of the modulated signal.

3.3 The two signals (a) and (b), shown in Figure P-3.3, DSB modulate a carrier signal $c(t) = A\cos 2\pi f_0 t$. Precisely plot the resulting modulated signals as a function of time and discuss their differences and similarities.



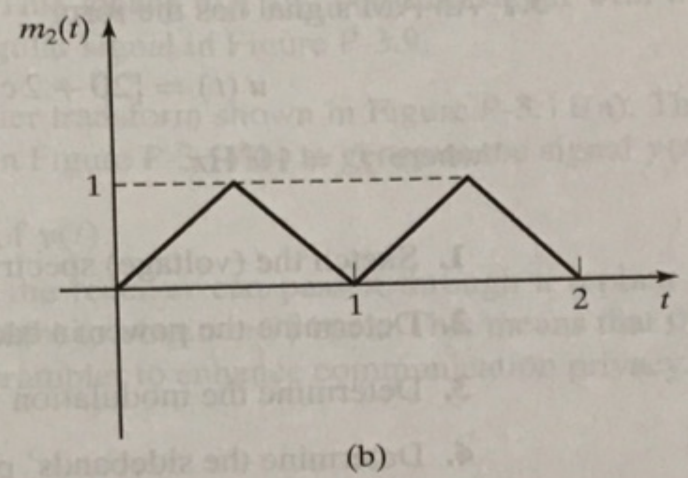


Figure P-3.3

3.4 Suppose the signal $x(t) = m(t) + \cos 2\pi f_c t$ is applied to a nonlinear system whose output is $y(t) = x(t) + \frac{1}{2}x^2(t)$. Determine and sketch the spectrum of $y(t)$ when $M(f)$ is as shown in Figure P-3.4 and $W \ll f_c$.

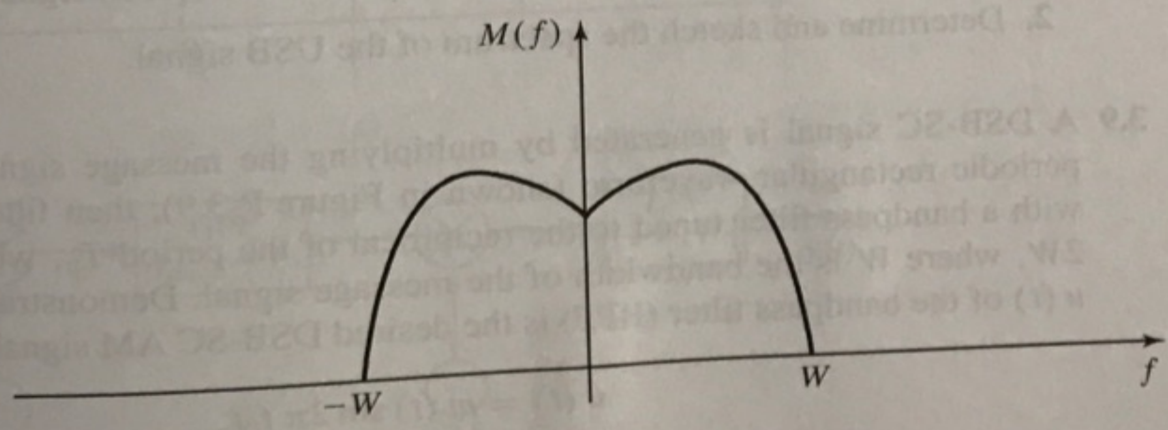


Figure P-3.4

3.5 The modulating signal

$$m(t) = 2\cos 4000\pi t + 5\cos 6000\pi t$$

is multiplied by the carrier

$$c(t) = 100\cos 2\pi f_c t,$$

where $f_c = 50$ kHz. Determine and sketch the spectrum of the DSB signal.

3.6 A DSB-modulated signal $u(t) = Am(t)\cos 2\pi f_c t$ is mixed (multiplied) with a local carrier $x_L(t) = \cos(2\pi f_c t + \theta)$, and the output is passed through a lowpass filter with a bandwidth equal to the bandwidth of the message $m(t)$. The signal power at the output of the lowpass filter is denoted by P_{out}. The modulated signal power is denoted by P_U. Plot $\frac{P_{out}}{P_U}$ as a function of θ for $0 \leq \theta \leq \pi$.

3.7 An AM signal has the form

$$u(t) = [20 + 2\cos 3000\pi t + 10\cos 6000\pi t]\cos 2\pi f_c t,$$

where $f_c = 10^5$Hz.

1. Sketch the (voltage) spectrum of $u(t)$.
2. Determine the power in each of the frequency components.
3. Determine the modulation index.
4. Determine the sidebands' power, the total power, and the ratio of the sidebands' power to the total power.

3.13 An AM signal is generated by modulating the carrier $f_c = 800$ kHz by the signal

$$m(t) = \sin 2000\pi t + 5\cos 4000\pi t.$$

The AM signal

$$u(t) = 100[1 + m(t)]\cos 2\pi f_c t$$

is fed to a 50-Ω load.

1. Determine and sketch the spectrum of the AM signal.
2. Determine the average power in the carrier and in the sidebands.
3. What is the modulation index?
4. What is the peak power delivered to the load?

3.17 Weaver's SSB modulator is illustrated in Figure P-3.17. By taking the input signal as $m(t) = \cos 2\pi f_m t$ where $f_m < W$, demonstrate that by proper choice of f_1 and f_2, the output is an SSB signal.

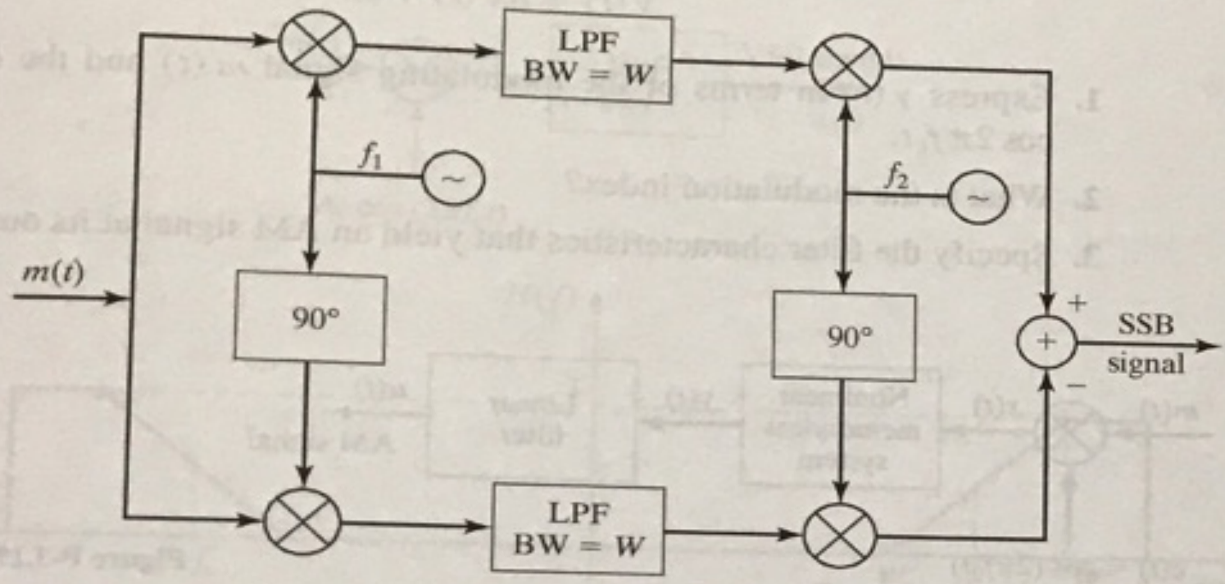


Figure P-3.17

3.18 The message signal $m(t)$, whose spectrum is shown in Figure P-3.18, is passed through the system shown in that figure.

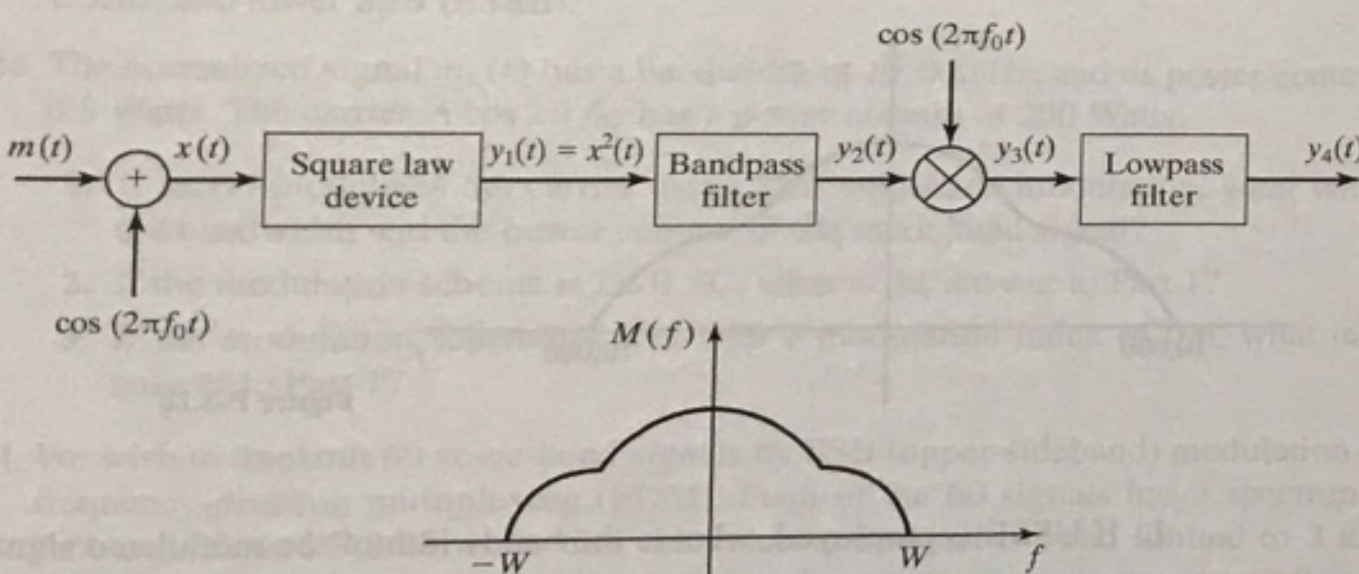


Figure P-3.18

The bandpass filter has a bandwidth of $2W$ centered at f_0, and the lowpass filter has a bandwidth of W. Plot the spectra of the signals $x(t)$, $y_1(t)$, $y_2(t)$, $y_3(t)$, and $y_4(t)$. What are the bandwidths of these signals?

3.19 The system shown in Figure P-3.19 is used to generate an AM signal. The modulating signal $m(t)$ has zero mean and its maximum (absolute) value is $A_m = \max|m(t)|$. The nonlinear device has the input–output characteristic

$$y(t) = ax(t) + bx^2(t).$$

1. Express $y(t)$ in terms of the modulating signal $m(t)$ and the carrier $c(t) = \cos 2\pi f_c t$.
2. What is the modulation index?
3. Specify the filter characteristics that yield an AM signal at its output.

adder

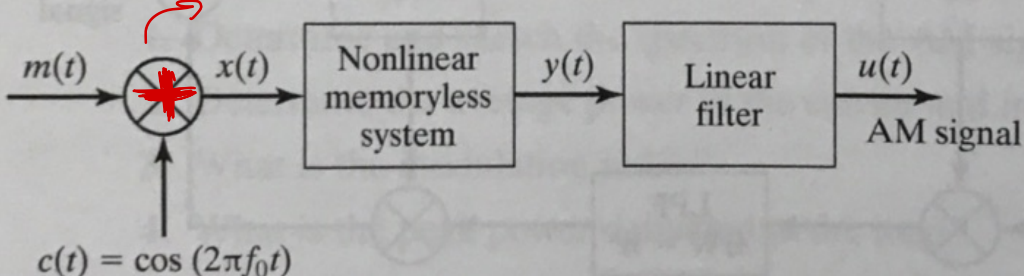


Figure P-3.19

3.22 Find expressions for the in-phase and quadrature components, $x_c(t)$ and $x_s(t)$, as well as the envelope and phase, $V(t)$ and $\Theta(t)$, for DSB, SSB, conventional AM, USSB, and lower SSB (LSSB).

3.23 The normalized signal $m_n(t)$ has a bandwidth of 10,000 Hz, and its power content is 0.5 Watts. The carrier $A \cos 2\pi f_0 t$ has a power content of 200 Watts.

1. If $m_n(t)$ modulates the carrier using SSB amplitude modulation, what will be the bandwidth and the power content of the modulated signal?
2. If the modulation scheme is DSB SC, what is the answer to Part 1?
3. If the modulation scheme is AM with a modulation index of 0.6, what is the answer to Part 1?