- Complex Exponential & Sinusoidal

  Amplitude Modulation & Demodulation

- Frequency-Division Multiplexing
- Single-Sideband Sinusoidal Amplitude Modulation
- Amplitude Modulation with a Pulse-Train Carrier

  » Time-Division Multiplexing

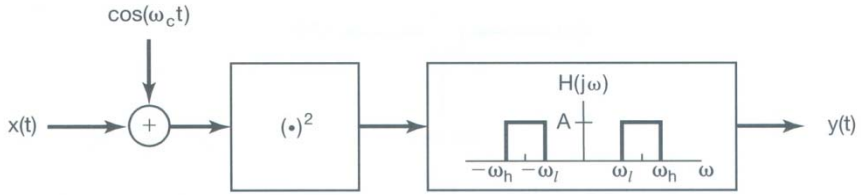
- Pulse-Amplitude Modulation
- Sinusoidal Frequency Modulation
- Discrete-Time Modulation

8.34: AM by Nonlinear Function

8.34. In discussing amplitude modulation systems, modulation and demodulation were carried out through the use of a multiplier. Since multipliers are often difficult to implement, many practical systems use a nonlinear element. In this problem, we illustrate the basic concept.

In Figure P8.34, we show one such nonlinear system for amplitude modulation. The system consists of squaring the *sum* of the modulating signal and the carrier and then bandpass filtering to obtain the amplitude-modulated signal.

Assume that $x(t)$ is band limited, so that $X(j\omega) = 0$, $|\omega| > \omega_M$. Determine the bandpass filter parameters A, ω_l, and ω_h such that $y(t)$ is an amplitude-modulated version of $x(t)$ [i.e., such that $y(t) = x(t)\cos\omega_c t$]. Specify the necessary constraints, if any, on ω_c and ω_M.



8.36: DeMultiplexing-DeModulation of Radio-Television Signals

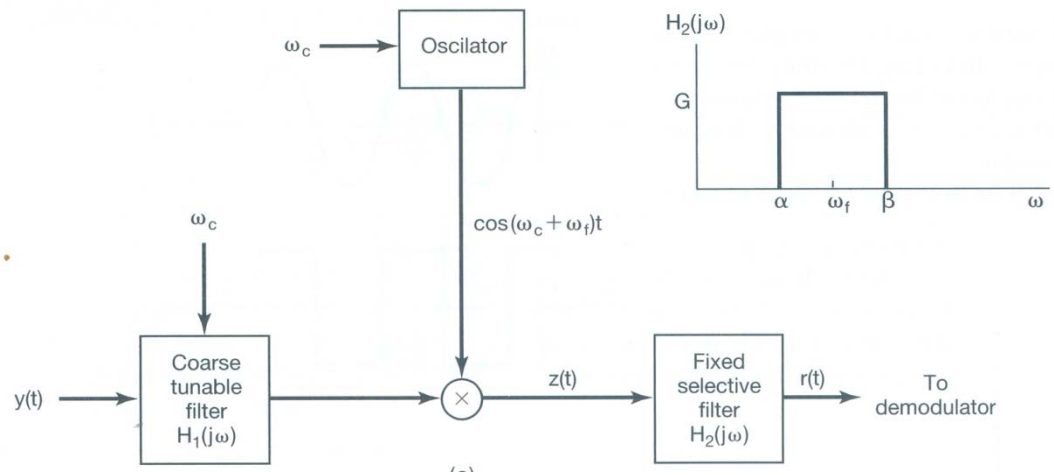
8.36. The accurate demultiplexing-demodulation of radio and television signals is generally performed using a system called the superheterodyne receiver, which is equivalent to a tunable filter. The basic system is shown in Figure P8.36(a).

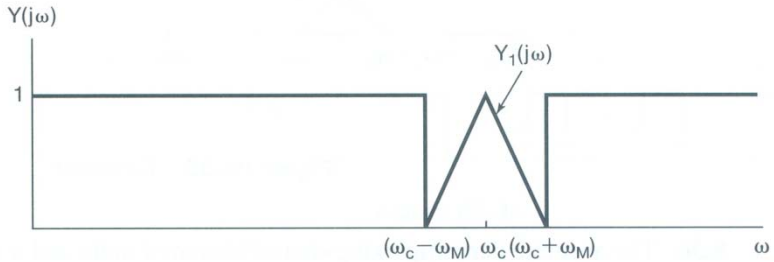
(a) The input signal $y(t)$ consists of the superposition of many amplitude-modulated signals that have been multiplexed using frequency-division multiplexing, so that each signal occupies a different frequency channel. Let us consider one such channel that contains the amplitude-modulated signal $y_1(t) = x_1(t)\cos\omega_c t$, with spectrum $Y_1(j\omega)$ as depicted at the top of Figure P8.36(b). We want to demultiplex and demodulate $y_1(t)$ to recover the modulating signal $x_1(t)$, using the system of Figure P8.36(a). The coarse tunable filter has the spectrum $H_1(j\omega)$ shown at the bottom of Figure P8.36(b). Determine the spectrum $Z(j\omega)$ of the input signal to the fixed selective filter $H_2(j\omega)$. Sketch and label $Z(j\omega)$ for $\omega > 0$.

(b) The fixed frequency-selective filter is a bandpass type centered around the fixed frequency ω_f, as shown in Figure P8.36(c). We would like the output of the filter with spectrum $H_2(j\omega)$ to be $r(t) = x_1(t)\cos\omega_f t$. In terms of ω_c and ω_M, what constraint must ω_T satisfy to guarantee that an undistorted spectrum of $x_1(t)$ is centered around $\omega = \omega_f$?

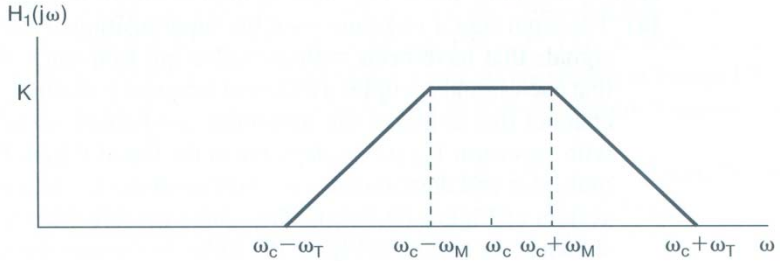
(c) What must G, α, and β be in Figure P8.36(c) so that $r(t) = x_1(t)\cos\omega_f t$?

8.36: DeMultiplexing-DeModulation of Radio-Television Signals





Input signal



Coarse tunable filter

8.46: FM, Instantaneous Frequency, Frequency Chirp

8.46. Consider the complex exponential function of time,

$$s(t) = e^{j\theta(t)}, \qquad \text{(P8.46–1)}$$

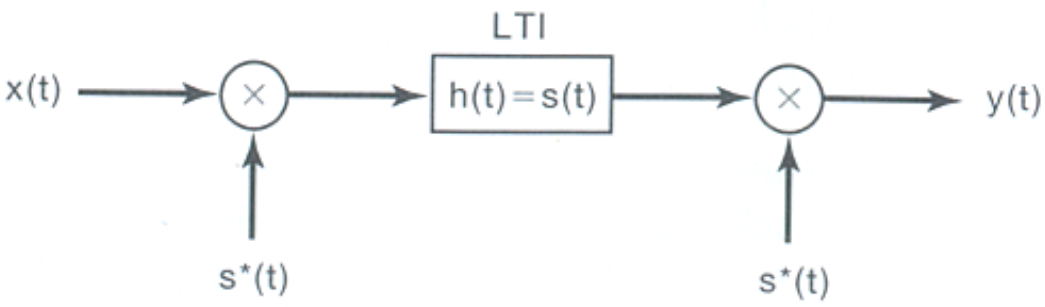
where $\theta(t) = \omega_0 t^2/2$.

Since the instantaneous frequency $\omega_i = d\theta/dt$ is also a function of time, the signal $s(t)$ may be regarded as an FM signal. In particular, since the signal sweeps linearly through the frequency spectrum with time, it is often called a frequency "chirp" or "chirp signal."

(a) Determine the instantaneous frequency.

(b) Determine and sketch the magnitude and phase of the Fourier transform of the "chirp signal." To evaluate the Fourier transform integral, you may find it helpful to complete the square in the exponent in the integrand and to use the relation

$$\int_{-\infty}^{+\infty} e^{jz^2}\,dz = \sqrt{\frac{\pi}{2}}(1+j).$$



8.17: DT Modulation – Insertion of Zero-Valued Samples

8.17. Consider an arbitrary finite-duration signal $x[n]$ with Fourier transform $X(e^{j\omega})$. We generate a signal $g[n]$ through insertion of zero-valued samples:

$$g[n] = x_{(4)}[n] = \begin{cases} x[n/4], & n = 0, \pm 4, \pm 8, \pm 12, \ldots \\ 0, & \text{otherwise} \end{cases}.$$

The signal $g[n]$ is passed through an ideal lowpass filter with cutoff frequency $\pi/4$ and passband gain of unity to produce a signal $q[n]$. Finally, we obtain

$$y[n] = q[n] \cos\left(\frac{3\pi}{4} n\right).$$

For what values of ω is $Y(e^{j\omega})$ guaranteed to be zero?