ECE 44000 (Fall 2022)
HW 3 (Probs. 10–13)
Due: 9/21/2022

Problem 10: Z&T 6th Ed., Problem 3.13 (7th Ed., Problem 3.14).

3.13. Consider the system shown in Figure 3.72. Assume that the average value of $m(t)$ is zero and that the maximum value of $|m(t)|$ is M. Also assume that the square-law device is defined by $y(t) = 4x(t) + 2x^2(t)$.

a. Write the equation for $y(t)$.

b. Describe the filter that yields an AM signal for $g(t)$. Give the necessary filter type and the frequencies of interest.

c. What value of M yields a modulation index of 0.1?

d. What is an advantage of this method of modulation?

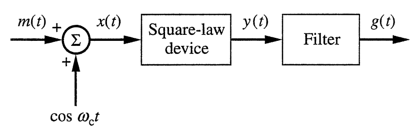


Figure 3.72

Problem 11: Z&T 7th Ed., Computer Exercises 3.2 (page 155).

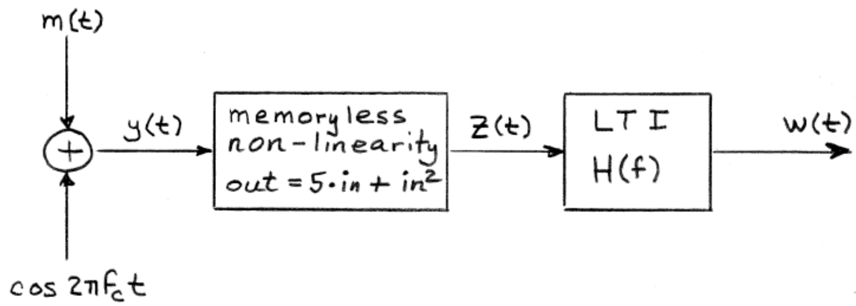
3.2. The purpose of the exercise is to demonstrate the properties of SSB modulation. Develop a computer program to generate both upper-sideband and lower-sideband SSB signals and display both the time-domain signals and the amplitude spectra of these signals. Assume the message signal

$$m(t) = 2\cos(2\pi f_m t) + \cos(4\pi f_m t)$$

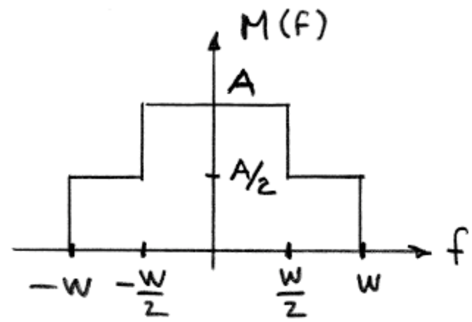
Select both f_m and f_c so that both the time and frequency axes can be easily calibrated. Plot the envelope of the SSB signals, and show that both the upper-sideband and the lower-sideband SSB signals have the same envelope. Use the FFT algorithm to generate the amplitude spectrum for both the upper-sideband and the lower sideband SSB signal.

Problem 12: A voice signal occupying the frequency band 0.3 – 3.4 kHz is to be SSB modulated onto a carrier wave of frequency 11.6 MHz. Assume the availability of bandpass filters which provide an attenuation of 50 dB in a transition band that is one percent of the mid-band frequency. Design a system to generate this SSB wave using the frequency discrimination method.

Problem 13: [Fall 2007 Exam 1] In the modulator shown below, the message waveform $m(t)$ and a sinusoid at the intended carrier frequency f_c are added to produce $y(t) = m(t) + \cos(2\pi f_c t)$, which is then passed through a memoryless non-linearity described by $z(t) = 5y(t) + y^2(t)$.



(a) Assume that $m(t)$ is real and even with the Fourier transform $M(f)$ shown. Find and carefully sketch $Z(f)$. Assume that $W \ll f_c$.



(b) Choose (and sketch) a filter frequency response $H(f)$ such that $w(t)$ is an AM large carrier wave at carrier frequency f_c. Write down the resulting time-domain waveform $w(t)$.

(c) Consider the AM-LC wave $w(t)$ found in (b). Find a value of K such that if

$$\max_t |m(t)| < K$$

then $w(t)$ will not be overmodulated (i.e., such that $m(t)$ could be recovered from $w(t)$ using an envelope detector).

(d) For the spectrum $M(f)$ given in part (a) find the inverse transform $m(t)$ and sketch it. This part can be solved independently of the rest of the problem.

(e) From the sketch of (d) and the solution to (c) what bound should we place on the product AW to be certain there is no overmodulation?