Communication Systems

2018–Ch4 exercises

Problem 1:

The output of a narrowband modulator may be approximated when the input is a tone of frequency f_m. Using a similar approach, derive an approximation to the output of a phase modulator with input $m(t)$, under the condition that $\max\{|m(t)|\} < 0.3$ radians. What is the approximate spectrum of this phase-modulated signal?

Problem 2:

A carrier wave of frequency 100 MHz is frequency modulated by a sinusoidal wave of amplitude 20 volts and frequency 100 kHz. The frequency sensitivity of the modulator is 25 kHz per volt..

Determine the approximate bandwidth of the FM signal, using Carson's rule.

Problem 3:

Figure P4.12 shows the block diagram of a real-time *spectrum analyzer* working on the principle of frequency modulation. The given signal $g(t)$ and a frequency-modulated signal $s(t)$ are applied to a multiplier and the output $g(t)s(t)$ is fed into a filter of impulse response $h(t)$. The $s(t)$ and $h(t)$ are *linear FM signals* whose instantaneous frequencies vary at opposite rates, as shown by

$$s(t) = \cos\left(2\pi f_c t - \pi k t^2\right),$$
$$h(t) = \cos\left(2\pi f_c t + \pi k t^2\right)$$

where k is a constant. Show that the envelope of the filter output is proportional to the amplitude spectrum of the input signal $g(t)$ with kt playing the role of frequency f.

Hint: Use the complex notations described in Chapter 2 for the analysis of band-pass signals and band-pass filters.

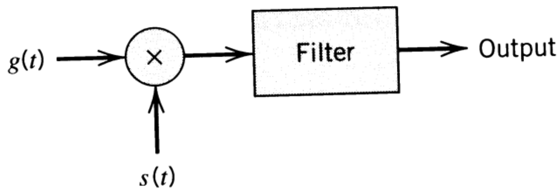

Figure P4.12

Problem 4:

An FM signal is applied to a square-law device with output voltage v_2 related to input voltage v_1 by

$$v_2 = a v_1^2$$

where a is a constant. Explain how such a device can be used to obtain an FM signal with a greater frequency deviation than that available at the input.

Problem 5:

Consider the frequency demodulation scheme shown is Figure P4.18 in which the incoming FM signal $s(t)$ is passed through a delay line that produces a phase-shift of $\frac{\pi}{2}$ radians at the carrier frequency f_c. The delay-line output is subtracted from the incoming FM signal, and the resulting composite signal is then envelope-detected. This demodulator finds application in demodulating microwave FM signals.

Assuming that $s(t) = A_c \cos\left[2\pi f_c t + \beta \sin(2\pi f_m t)\right]$

Analyze the operation of this demodulator when the modulation index β is less then unity and the delay T produced by the delay line is sufficiently small to justify making the approximations $\cos(2\pi f_m T) \approx 1$ and $\sin(2\pi f_m T) \approx 2\pi f_m T$

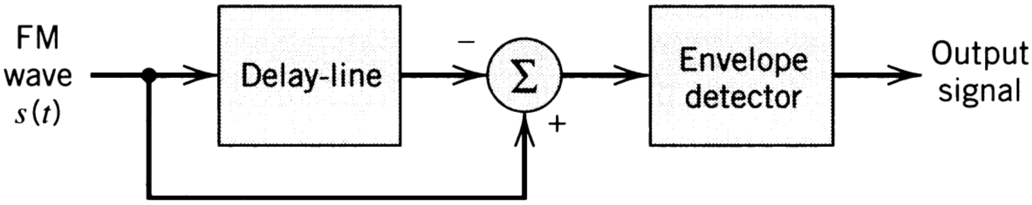

Figure P4.18