Chapter 5
MATLAB Problems

5.1 Generate and plot a WBFM signal and its spectra with single tone message and the following specifications: $A_c = 10$, $f_c = 1200$ Hz, $\beta = 5$, $f_m = 60$ Hz, and $f_\Delta = 150$ Hz. Is the resulting spectra similar to what is shown in Figs. 5.1-5 and 5.1-1?

5.2 Repeat Prob. 5.1 for NBFM with $A_c = 10$, $f_c = 1200$ Hz, $\beta = 0.2$, $f_m = 60$ Hz, and $f_\Delta = 12$ Hz. How does this differ from an AM signal? If filtering or other operations were applied to the signal, what is needed to insure that we still have a NBFM signal?

5.3 Generate an indirect FM signal using the exciter of Prob. 5.2 and a clipper to generate odd multiples of $f_c = 1200$ Hz. Plot the magnitude of the clipper output and see if the spectral components match that of Table 5.1-2.

5.4 Repeat Prob. 5.3 using the same parameters except have $A_m = 2$, but keep $\beta = 0.2$. What observations and conclusions can you draw from your results?

5.5 Add a heterodyne unity to the FM exciter of Prob. 5.2 to cause the carrier frequency to be 6000 Hz. Does changing the carrier frequency via heterodyning affect B_T?

5.6 Design and simulate a slope detector to detect the FM signal of Prob. 5.1. Show your detector works by plotting the time and frequency domains of the demodulated output. Use a Butterworth or similar realizable filter to perform the derivative function. However, you may want to initially use a derivative function to get things working. Be sure to plot the time and frequency versions of the signal at the output of the (a) generator, (b) derivative function, (c) rectifier, (d) LPF, and (e) envelope detector output.

5.7 Repeat 5.4 except insert a limiter before the derivative function.

5.8 Generate two carrier frequencies, one with amplitude of 10 and frequency of 1 kHz and the other at 1.1 kHz with amplitude of 1. Plot their sum in both the time and frequency domain. Input the sum into an envelope detector and plot the output. Do you get the result predicted in Eq. (4) of Sect. 5.4?

5.9 Consider the effects of interference on a crowded nighttime broadcast AM band where stations are transmitting on almost every 10 kHz frequency slot. To speed up computation, we will scale the frequencies by a factor of 1000 and we will use just two stations. Use the following parameters for stations #1 and #2: $f_{c1} = 990$ Hz, $f_{c2} = 1000$, $\mu_1 = \mu_2 = 1$, $A_{c1} = A_{c2} = 10$, $f_{m1} = 1$ Hz, $A_{m1} = 1$,

$f_{m2} = 3$ Hz, and $A_{m2} = 1$. Plot the receiver input and output and describe comment on your results.

5.10 Do Prob. 5.9 except use DSB and a synchronous detector. Compare your results with those of Prob. 5.9 and state any conclusions.

5.11 Let's consider the effects of multipath interference with AM and the envelope detector where the envelope detector receives the direct and multipath versions. The direct signal has the following parameters: $A_{c1} = 10$, $f_{c1} = 990$ Hz, $\mu_1 = 1$, and $f_{m1} = 1$. The multipath interference has the same parameters as the direct signal, except it's phase is uniformly distributed between 0 and $-\pi$ radians. Do several trials and discuss your results.

5.12 Repeat 5.11 except with a DSB signal and a synchronous detector.