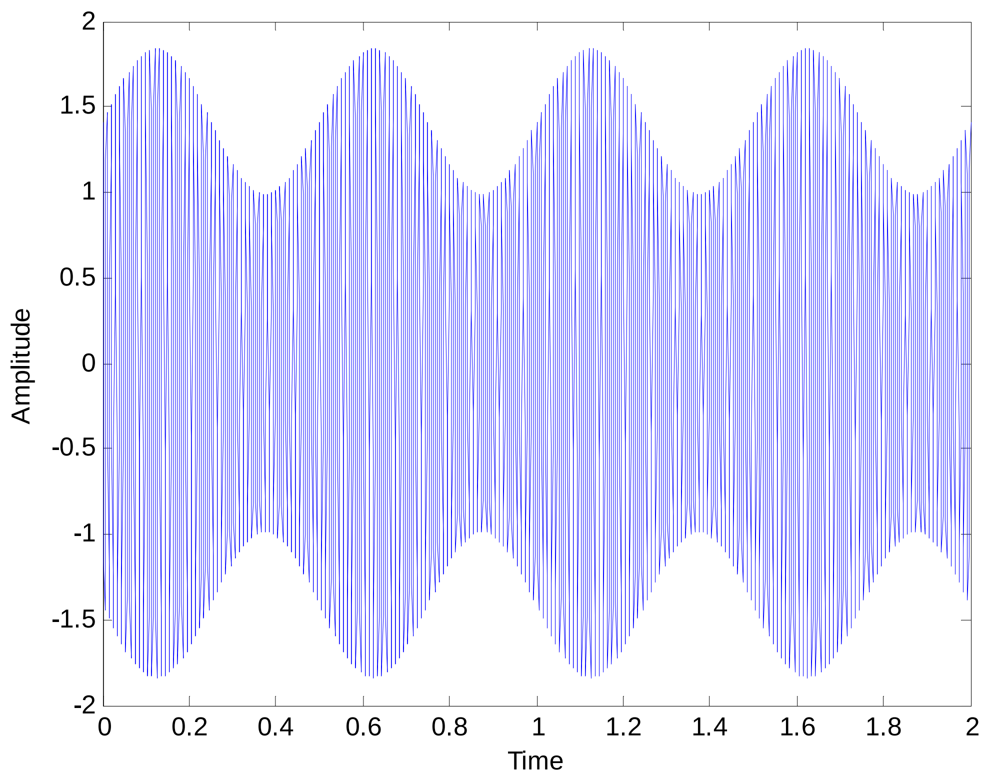
Problem 9.26 In this experiment we investigate the performance of amplitude modulation in noise. The MatLab script for this AM experiment is provided in Appendix 8 and simulates envelope modulation by a sine wave with a modulation index of 0.3, adds noise, and then envelope detects the message. Using this script:
(a) Plot the envelope modulated signal.
(b) Using the supporting function "spectra", plot its spectrum.
(c) Plot the envelope detected signal before low-pass filtering.
(d) Compare the post-detection SNR to theory.

Using the Matlab script given in Appendix 7 we obtain the following plots

(a) By inserting the statements

plot(t,AM)
xlabel('Time')
ylabel('Amplitude')

at the end of Modulator section of the code, we obtain the following plot of the envelope modulated signal:



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Problem 9.26 continued

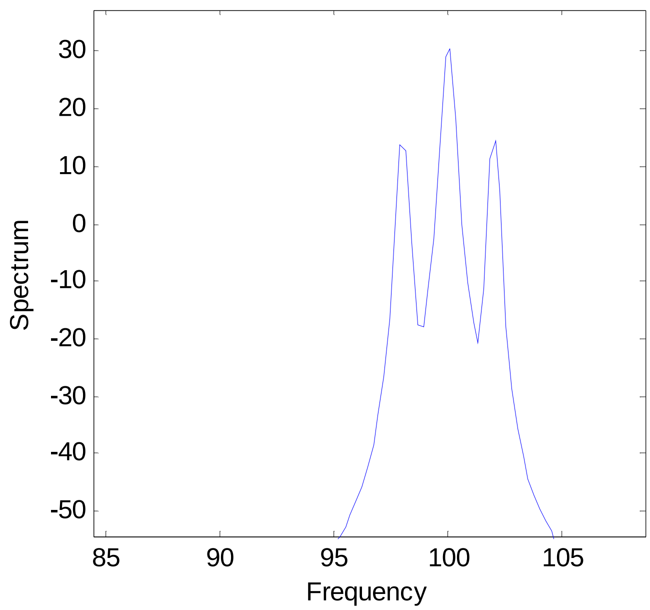
(b) The provided script simulates 2 seconds of the AM signal. Since the modulating signal is only 2 Hz, this is not a sufficient signal length to accurately estimate the spectrum. We extend the simulation to 200 seconds by modifying the statement

t = [0:1/Fs:200];

To plot the spectrum, we insert the following statements after the AM section

```
[P,F] = spectrum(AM,4096,0,4096,Fs);
plot(F,10*log10(P(:,1)))
xlabel('Frequency')
ylabel('Spectrum')
```

We use the large FFT size of 4096 to provide sufficient frequency resolution. (The resolution is *Fs* (1000 Hz) divided by the FFT size. We plot the spectrum of decibels because it more clearly shows the sideband components. With a linear plot, and this low modulation index, the sideband components would be difficult to see. The following figure enlarges the plot around the carrier frequency of 100 Hz.



(c) To plot the envelope-detected signal before low-pass filtering, we insert the statements (Decrease the time duration to 2 seconds to speed up processing for this part.)

```
plot(AM_rec)
xlabel('Time samples')
ylabel('Amplitude')
```

The following plot is obtained and illustrates the tracking of the envelope detector.

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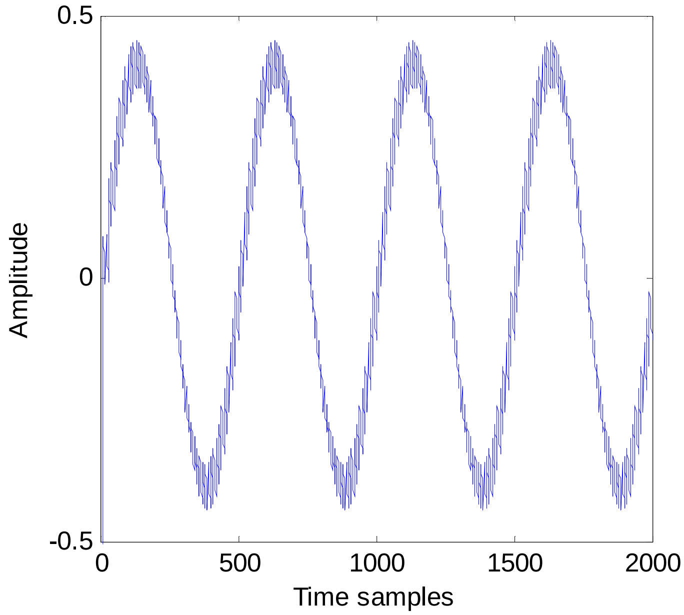
Problem 9.26 continued



(d) To compare the simulated post detection SNR to theory. Create a loop around the main body of the simulation by adding the following statements

```
for kk = 1:15
        SNRdBr = 10 + 2*kk
           ….
        PreSNR(kk) = 20*log10(std(RxAM)/std(RxAMn-RxAM));
        No(kk) = 2*sigma^2/Fs;
        ….
        SNRdBpost(kk) = 10*log10(C/error);
        W = 50; P = 0.5;
        Theory(kk) = 10*log10 ( A^2*ka^2*0.5 / (2*No(kk)*W));
end

plot(PreSNR, SNRdBpost)
hold on,
plot(PreSNR, Theory,'g');
```

The results are shown in the following chart.

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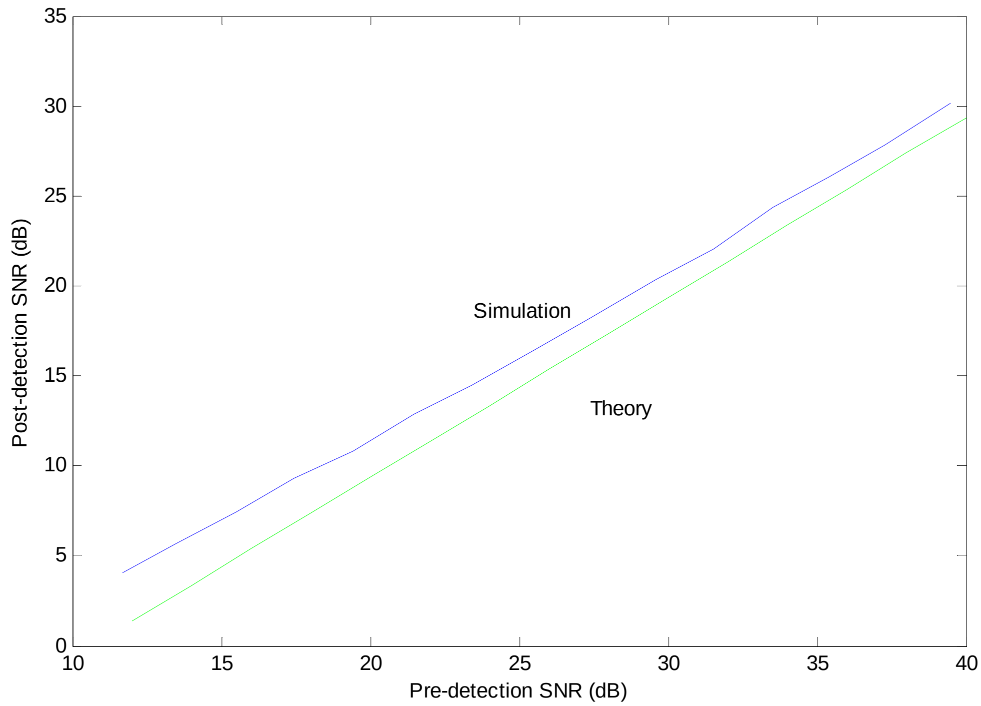
Problem 9.26 continued



These results indicate that the simulation is performing slightly better than theory? Why? As an exercise try adjusting either the frequency of the message tone or the decay of the envelope detector and compare the results.