PROJECT for EE 483

COMMUNICATIONS SYSTEMS I - Fall 2004

Computer Assignment 8: Noise in Continuous Wave Modulation Systems

Exercise 1: ***Noise suppression in band-limited signals.***

Let the information bearing signal $m(t)$ be given by

$$m(t) = \text{sinc}(t/\pi) = \frac{\sin(t)}{t}.$$

The signal $m(t)$ is transmitted through an Additive White Gaussian Noise (AWGN) channel that corrupts the transmitted signal by 0-mean, 0.3 variance Gaussian noise. The receiver will try to suppress the noise by lowpass filtering the received signal $x(t)$.

(a) Plot the signal $m(t)$, where t ranges from -10 to 10 using increments of 0.01.

(b) Plot the amplitude spectrum $|M(f)|$ of the signal $m(t)$.

(c) Add white gaussian noise of zero mean and variance $N_0 = 0.3$ to the signal $m(t)$. Plot the resulting signal $x(t)$, along with its amplitude spectrum $|M(f)|$.

(d) Pass the signal $x(t)$ through a low-pass filter with cut-off frequency $5Hz$. Plot the output signal $x_{out}(t)$, along with its amplitude spectrum $|X_{out}(f)|$. Hints for lowpass filtering were given in Assignment 3.

Exercise 2: *Noise in AM*

Let the information bearing signal $m(t)$ be

$$m(t) = \begin{cases} sinc(100t), & -t_0 \leq t \leq t_0 \\ 0, & \text{otherwise.} \end{cases} \tag{1}$$

where $t_0 = 0.1$. This message modulates a carrier $c(t) = \cos(2\pi f_c t)$, where $f_c = 250$Hz, using a conventional AM scheme. The amplitude sensitivity is $k_a = 3.5$.

(a) Plot the message signal in the time (using time increments of 0.001) and frequency domain.

(b) Plot the modulated signal in the time (using time increments of 0.001) and frequency domain.

(c) Plot the envelope of the modulated carrier.

(d) Using envelope detection, demodulate the message signal and plot it in the time and frequency domain. Compare the demodulated message and the original message signal.

(e) Assuming that the message signal is periodic with a period equal to $T_o = 0.2$ s determine the power of the message signal and the power of the modulated signal. If a Gaussian noise is added to the modulated signal such that the resulting SNR at the demodulator output is 16 dB, calculate the noise power. Plot the noisy modulated carrier in time and frequency. Demodulate your signal in noise using envelope detection. Compare this case with the case there is no noise present. For your calculations assume that the SNR at the output of the demodulator is the same as if a coherent detector (product demodulator followed by a LPF) was used instead.

Exercise 3: *Noise in DSB*

In this exercise we will examine the effect of additive noise in DSB-SC receivers using the model shown in Fig. 1.

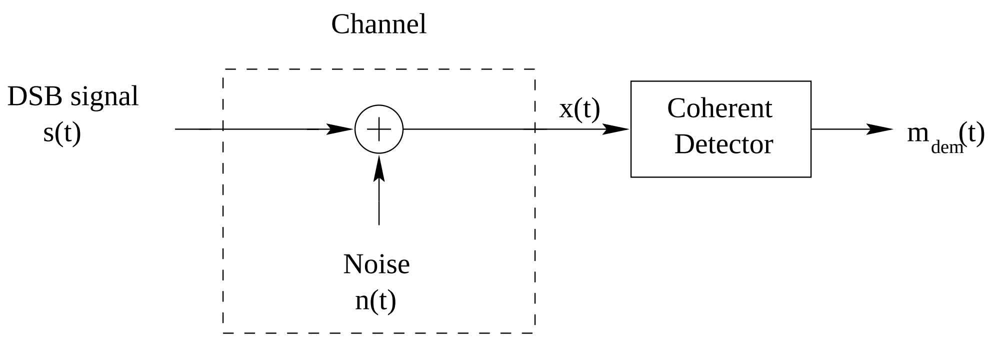

Fig. 1: Model of DSB-SC receiver using coherent detection.

Let the information bearing signal $m(t)$ be given by (1) Let also the carrier $c(t)$ be given by

$$c(t) = A_c \cos(2\pi f_c t),$$

where the carrier frequency $f_c = 250Hz$ and the carrier amplitude is $A_c = 1$.

(a) Plot the DSB modulated carrier in the time (using time increments of 0.001) and frequency domain.

(b) If a Gaussian noise is added to the modulated signal such that the resulting SNR at the detector output is 16 dB, calculate the noise power. Plot the modulated signal plus noise in both time and frequency domain.

(c) Demodulate the channel output using a coherent detector. Plot the demodulated signal $m_{dem}(t)$. Assume that the phase difference ϕ is 0. For the lowpass filter of the coherent detector use a cutoff frequency equal to f_c Hz. You may use any value for the amplitude A'_c of the local oscillator. Compare this case with the case there is no noise present. Can you further improve the performance of your detector without distorting the signal. Provide a solution.

Exercise 4: *Frequency Modulation/Demodulation* (60%)

Let the information bearing signal $m(t)$ be

$$m(t) = \begin{cases} sinc(100t), & -t_0 \le t \le t_0 \\ 0, & \text{otherwise.} \end{cases}$$

where $t_0 = 0.1$. This message modulates (in frequency) a carrier $c(t) = \cos(2\pi f_c t)$, where $f_c = 250$Hz. The deviation constant is $k_f = 100$. At the receiver side the modulated signal passes through a detector that encompasses an angle demodulator (hints for finding the phase of an FM signal were given in assignment 5) and a low pass filter (LPF).

(a) Plot the modulated signal in the time (using time increments of 0.001) and frequency domain.

(b) If a Gaussian noise is added to the modulated signal such that the resulting SNR at the detector output is 16 dB, calculate the noise power. Plot the modulated signal plus noise in both time and frequency domain.

(c) Demodulate the channel output. For the lowpass filter use a cutoff frequency equal to W Hz, where W is the message bandwidth. Compare this case with the case there is no noise present.

(d) Use a LPF with a cut-off frequency of $f_c/2$. Demodulate the modulated signal and compare it with the previous case.

Appendix

Some Hints

In Exercise 1 you have to employ an envelope detector to demodulate the AM signal. Recall that if an envelope detector is used to demodulate the signal and the carrier is removed by a dc block, then the original message signal is recovered. After the envelope detector separates the envelope of the modulated signal, the dc component of the signal is removed and the signal is scaled to generate the demodulator output. To find the envelope you may use the function `env_phas` introduced in Assignment 5 or create your own according to theory.
To calculate the power of a periodic signal you can use the formula given in Theory. However, since your signal in matlab is in discrete time instances

(vector) you can also calculate the power of the signal (vector) by taking the square of the vector norm and divide by the vector length.
In Exercise 3 and 4 you must lowpass a signal. Hints for lowpass filtering were given in Assignment 4.

Note

Your report should include all plots and M-files you are asked to create in Exercises 1, 2, 3 and 4.