PROJECT for EE 483

COMMUNICATIONS SYSTEMS I - Fall 2004

Computer Assignment 5: Angle Modulation-Demodulation

Exercise 1: ***Angle Modulation*** (40%)
Let the information bearing signal $m(t)$ be given by

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

The modulated carrier $v(t)$ when Phase and Frequency modulation is used, is given by

$$\begin{array}{ll} v(t) = A_c \cos[2\pi f_c t + k_p m(t)] & \text{Phase modulation.} \\ v(t) = A_c \cos[2\pi f_c t + 2\pi k_f \int_0^t m(\tau)d\tau] & \text{Frequency modulation.} \end{array}$$

In MATLAB the integral $\int_0^t m(\tau)d\tau$ can be evaluated using the function `cumsum`. For example to plot the above integral when t ranges from 0 to 10 using increments of 0.01 and $m(\tau) = \cos(\tau)$, you can do the following:

```
T=0.01;
tau=0:T:10;
t=tau;
m=cos(tau);
im=T*cumsum(m);
plot(t,im);
```

Let the carrier frequency be $f_c = 10$, the carrier amplitude be $A_c = 1$, and the constants k_p, k_f be equal to 1.

(a) Plot the signal $m(t)$, where t ranges from 0 to 10, using increments of 0.01.

(b) Plot the modulated carrier using the PM method.

(c) Plot the modulated carrier using the FM method.

Exercise 2: ***Frequency Modulation/Demodulation*** (60%)

To demodulate an FM signal, one must first find the phase of the modulated signal $v(t)$. This phase is $2\pi k_f \int_0^t m(\tau)d\tau$, which can be differentiated and divided by $2\pi k_f$ to obtain $m(t)$. Note that in order to restore the phase and undo the effect of 2π phase foldings, one can employ the unwrap.m function of MATLAB. Hints for finding the phase of $u(t)$ are given in the Appendix.

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

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

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 $k_f = 100$.

(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) Compare the demodulated message and the original message signal.

To evaluate the amplitude spectra you may use the function `fouriert` given in Assignment 2.

Appendix

The following function returns the envelope and the phase of the bandpass signal x.

```
function [v,phi]=env_phas(x,ts,f0)
%               [v,phi]=env_phas(x,ts,f0)
%                     v=env_phas(x,ts,f0)
%               f0 is the center frequency.
%               ts is the sampling interval.
%
if nargout == 2
  z=loweq(x,ts,f0);
  phi=angle(z);
end
v=abs(hilbert(x));
```

The following function returns the lowpass equivalent of the signal x. Function `loweq` is called in function *env_phas*.

```
function xl=loweq(x,ts,f0)
%               xl=loweq(x,ts,f0)
%               f0 is the center frequency.
%               ts is the sampling interval.
%
t=[0:ts:ts*(length(x)-1)];
z=hilbert(x);
xl=z.*exp(-j*2*pi*f0*t);
```

Note

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