EE341 Exam 1
March 6, 2002
Closed Book, 1 crib sheet, Justify all work

Good Luck

NAME____________________

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>/20</td>
</tr>
<tr>
<td>2</td>
<td>/10</td>
</tr>
<tr>
<td>3</td>
<td>/20</td>
</tr>
<tr>
<td>4</td>
<td>/10</td>
</tr>
<tr>
<td>5</td>
<td>/20</td>
</tr>
<tr>
<td>6</td>
<td>/20</td>
</tr>
<tr>
<td>TOTAL</td>
<td>/100</td>
</tr>
</tbody>
</table>


1) (20) Consider a baseband signal, \( M(\omega) = \Pi(\omega/(2\pi)) \).

a) Plot magnitudes of the Fourier Transforms of the following signals carefully labeling significant points.

\( x(t) = 100 \, m(400t) \).
\( y(t) = 100 \, m(100t) \cos (1200 \, \pi t) \).
\( z(t) = x((t-1)/2) + x((t+1)/2) \).

b) From part a) determine which of the signals will pass relatively undistorted through the system \( h(t) \) specified below. If a signal is distorted, specify the type of distortion.
2) (10) Consider the following instantaneous nonlinearity $y = g(x) = x^3 + x^2 + x$. If a sinusoid $x(t) = \cos(\omega_0 t)$ is passed through $g()$, determine the output THD.
3) (20) Consider the following system shown below.

\[ x(t) \rightarrow 2\cos(\omega_0 t) \rightarrow v(t) \rightarrow H_1(\omega) \rightarrow w(t) \rightarrow y(t) \rightarrow H_2(\omega) \rightarrow z(t) \]

If \( h_1(t) \) is an ideal lowpass filter with cutoff frequency \( \omega_1 \), \( h_2(t) \) is an ideal lowpass filter with cutoff frequency \( \omega_2 \), \( \omega_1 < \omega_0 \), \( \omega_0 - \omega_1 < \omega_2 < \omega_0 \), and \( X(\omega) \) is shown below sketch \( V(\omega), W(\omega), Y(\omega), \) and \( Z(\omega) \) labeling important points. What does the system implement?
4) (10) Find matlab commands to generate $x_p(t)$ (USB of SSB signal) with carrier frequency $\omega_0$. In matlab, you are given the baseband information signal $m$ and the time index $t$. Also find matlab commands to recover $m(t)$ from $x_p(t)$ assuming baseband signal, $m(t)$ has bandwidth $B_m << \omega_0$. 
5) (20) Consider an AM signal contaminated by an additive narrowband noise term, 
\[ n(t) = n_c(t) \cos(\omega_0 t) - n_s(t) \sin(\omega_0 t) \] centered at \( \omega_0 \),
\[ x(t) = A(1 + a m(t)) \cos(\omega_0 t) + n(t). \]

The receiver is a square-law detector that consists of an instantaneous nonlinearity that squares the input followed by a lowpass filter and then a coupler that removes D.C. components.

If \(|n(t)| \ll A\), find the approximate output of the square-law detector when the input is \(x(t)\). Discuss the significant terms that contribute to distortion.
6) (20) Consider the following FDM signal \( x(t) \) that is composed of three modulated baseband signals; \( a(t) \), \( b(t) \), and \( c(t) \). The three baseband signals all have bandwidth \( 20K \pi \) radians. We have \( |a(t)| \ll 1 \), \( \hat{a}(t) \) representing the Hilbert transform of \( a(t) \), and \( \omega_0 = 1 M \pi \) radians.

\[
x(t) = (1 + a(t)) \cos(\omega_0 t) + \hat{a}(t) \sin(\omega_0 t) + (c(t) - b(t)) \cos(2\omega_0 t) + (c(t) + b(t)) \sin(2\omega_0 t).
\]

a) For the transmitted signal \( x(t) \), draw a diagram in the frequency domain where modulated versions of \( a(t) \), \( b(t) \), and \( c(t) \) reside.

b) If possible, construct receivers to recover the three baseband signals from the transmitted signal \( x(t) \).