EE470 – Electronic Communication Theory

Exam I

*Open text, closed notes.*

*To receive any partial credit, you must show all work and you must work neatly!!!*

Date: September 24, 2014

Name: _________________________________

1. [30%] Problems related to signals and transforms:

   (a) [6%] Simplify the following expression: \( \left( \frac{j \omega - 3}{\omega^2 + 9} \right) \delta(\omega) \)

   (b) [6%] Evaluate the following integral: \( \int_{-2}^{2} (t^3 + 4) \delta(1-t) dt \)

   (c) [6%] Find the energy spectral density function, \( \Psi_s(f) \), of the energy signal \( g(t) = 10u(t) - 10u(t-1) \).

   (d) [6%] Find the auto-correlation function, \( \psi(\tau) \), of the signal in part (c).

   (e) [6%] How much energy is contained in the signal in part (c)?
2. [22%] The frequency response of a certain communication channel can be modeled as

\[ H_c(f) = \frac{10}{\sqrt{1 + (f/a)^2}} e^{-j2\pi(f/a)^2} \text{ where } a = 1000 \text{ Hz} \]

(a) [6%] What is the phase response, \( \theta(f) \), of this channel?

(b) [6%] What are the phase delay \( t_d \) and group delay \( t_g \) of this channel at \( f = 2000 \text{ Hz} \)?

(c) [6%] A filter is to be used at the receiver input that eliminates all channel distortion. What is the frequency response of a filter that will accomplish this?

(d) [4%] This channel causes what type of distortion? (Circle the correct answer.)

i. amplitude  
ii. phase  
iii. both amp and phase
3. [28%] Power signal, \( x(t) \), has the following auto-correlation function

\[
R_x(\tau) = 10 \text{sinc}(2000 \tau)
\]

This signal is passed through a filter with transfer function \( H(f) = e^{-j2\pi f/1000} \Pi(f/500) \).

(a) [7%] How much power, \( P_x \), is contained in the input signal?

(b) [7%] What is the input signal power spectral density function, \( S_x(f) \)?

(c) [7%] What is the auto-correlation function, \( R_y(\tau) \), of the output signal? Hint: Sketches of \( |H(f)| \) and \( S_x(f) \) may prove helpful.

(d) [7%] How much power, \( P_y \), is contained in the output signal?
4. [20%] Answer the following questions by circling the correct answer.

(a) [2%] One of the purposes of modulation is to __________.
   i. allow multiplexing  ii. improve signal quality

(b) Periodic signals are typically ______ signals.
   i. energy  ii. power

(c) \[ \int_{-\infty}^{\infty} \varphi(t) \delta(t-10) dt = \]
   i. \( \varphi(10) \)  ii. \( \varphi(10) \delta(t-10) \)

(d) If all of the \( b_n \) (sine) coefficients in the trigonometric Fourier series are zero, the corresponding function is __________.
   i. even  ii. odd

(e) Parseval's theorem allows us to determine the signal power that lies within a certain ____ interval.
   i. time  ii. frequency

(f) Decreasing the width of a pulse causes a corresponding ______ in the signal bandwidth.
   i. decrease  ii. increase

(g) Multiplication by a high frequency sinusoid is also known as _________________.
   i. modulation  ii. convolution

(h) A distortionless filter has a constant phase response over the signal bandwidth.
   i. TRUE  ii. FALSE

(i) Nonlinear distortion will typically cause spreading (dispersion) in the ______ domain.
   i. time  ii. frequency

(j) The power within a frequency band can be obtained by integrating the signal ______ over the frequency band.
   i. autocorrelation  ii. power spectral density