1 Test Specifics

1. No questions from lab (prelab, writeup, etc). Material will be from lecture.
2. No calculators, note sheets, or any other outside devices.
3. BE ABLE TO DO THE HOMEWORK PROBLEMS!!!!

2 Chapter 1

1. Block diagram of a communications system.

3 Chapter 2

1. All definitions in Section 2.1-2.2.
2. Understand AND be able to derive delta function properties on page 21-22 and from HW.
3. Know the definitions of continuous Fourier transform (CFT) and inverse CFT (e.g.,
   \( X(f) = \int_{-\infty}^{\infty} x(t)e^{-j2\pi ft}dt \), etc.) Be able to prove \( \mathcal{F}^{-1}\{\mathcal{F}\{x(t)\}\} = x(t) \) and \( \mathcal{F}\{\mathcal{F}^{-1}\{X(f)\}\} = X(f) \) using integral expressions.
4. Know AND be able to show the symmetries of the CFT for real \( x(t) \).
5. Be able to prove i.) linearity, ii.) \( X(t) \leftrightarrow x(-f) \) if \( x(t) \leftrightarrow X(f) \), iii.) \( X(-f) \leftrightarrow x(f) \) if \( x(t) \leftrightarrow X(f) \), iv.) time and frequency scaling, v.) time-shift and modulation, and vi.) time-shift and scaling.
6. Know the convolution integral. Also be able to show analytically (using integration properties) that \( \mathcal{F}\{h(t) \ast x(t)\} = \mathcal{F}\{h(t)\} \mathcal{F}\{x(t)\} \).
7. Know and be able to prove Parseval’s Theorem \( \int |x(t)|^2 dt = \int |X(f)|^2 df \).
8. Know the functions and Fourier transform relations involving rect, sinc, triangle, sgn, and delta functions.
9. Know the definition of correlation (see text).
10. Know the definition of \( \Delta(t) \). Know the time scaling property of \( \Delta(t) \).
11. Know the definition of the complex Fourier series (CFS).
12. Know how to compute the CFT of the CFS.
13. Be able to compute the CFT of \( \Delta(t) \).
14. Know the sampling theorem. Know the interpolation expression for reconstructing the
sampled signal. Know how to compute the Fourier transform of the sampled signal.
15. Know the formula for the discrete Fourier transform.
16. Know the definition of a linear system, a time invariant system, a causal system, and a linear-time invariant system. Know the relationship between convolution and an LTI system response.
17. Know how to use the LTI input-output expressions in the frequency domain. Know how this relates to the energy spectral density.
18. Know how to compute the system response to a periodic input. This will involve knowing the actual derivation covered in class.
19. Know the frequency and time definition of the Hilbert transform.
20. Know AND be able to prove the Hilbert transform properties i.) double transformation equals negation, ii.) energy equivalence, and iii.) transform of lowpass times bandpass is equal to lowpass times transform of bandpass.
22. Know the Hilbert transform of a lowpass signal times a high frequency cosine of sine wave.
23. Know the definition of an analytic signal.
24. Know the definition of envelope.
25. Be able to derive the spectrum of $X_p(f)$ is $x_p(t)$ is the analytic signal of $x(t)$.
26. Know how to derive the complex envelope $\tilde{x}(t)$ of an analytic signal. Know what inphase and quadrature components are.
27. Be able to derive the Fourier transform of $X(f)$ in terms of the lowpass complex envelope $\tilde{X}(f)$.
28. Know how to derive the lowpass equivalent relations for a bandpass system.

4 Chapter 3 (Linear Mod)

1. Know the basic problem we are trying to solve with analog communications. (i.e., centers on conveying a continuous time message $m(t)$).
2. Know the formula and definition for linear modulation.
3. Know the i.) modulator structure (be able to draw these), ii.) demodulator structure, iii.) time representation of transmitted signal, iv.) frequency representation of transmitted signal, and iv.) definition of upper sideband (USB) and lower sideband (LSB). Be sure to be able to derive the relations that allow modulation and demodulation. Be sure to know how to graphically show these results.
4. Know what happens if the transmitter and receiver oscillators are not synchronized (i.e. there is a phase offset). What happens if the phase offset is time-varying? What happens if it is not time-varying? (Know the time effect at a high level, e.g., be able to draw)
5. Know the benefits and problems with DSB. These include knowing transmission bandwidth, efficiency, and implementation issues.
6. Know the formulas and graphical descriptions of AM systems. Know all the modulator parameter definitions (ex. $A, A_c, A'_c, a, m_n(t)$, etc). Know how to demodulate AM. What is the circuit used for envelope detection? Be sure to be able to describe these graphically.
7. Know the benefits and problems with AM. These include knowing transmission band-
width, efficiency, and implementation issues.
8. Know how to derive the efficiency equation.
9. Be able to show transmitter and receiver structure for SSB. What is the reason for using SSB? Be sure to be able to derive all mathematical relations for transmission and reception.
10. Know the benefits and problems with SSB. These include knowing transmission bandwidth, efficiency, and implementation issues.
11. Know the frequency domain graphical presentation of VSB. What is the reason for using VSB?
12. Know the mathematics behind frequency translation and mixing. Know the definition and problems of the image frequency. Know the definition of a heterodyne receiver. Be able to draw a tunable super-heterodyne receiver. Know the definition of low-side tuning and high-side tuning.

5  Chapter 3 (Angle Mod)

1. Know the equation for the transmitted signal \( x_c(t) \) for angle modulation.
2. Know the definition of instantaneous phase and instantaneous frequency.
3. Know the definition of phase deviation and frequency deviation.
4. Know the equations for generating the phase deviation \( \phi(t) \) for phase modulation and frequency modulation.
5. Be sure to remember the phase deviation constant \( k_p \) and the frequency deviation constant \( k_f \) (in rad/s) or \( f_d \) (in Hz).
6. Be able to draw the time signals for PM and FM given a message. As well, be able to roughly sketch a message given a PM or FM signal.
7. What are the conditions on \( \phi(t) \) for narrowband angle modulation?
8. Know the power series of \( e^x \).
9. Be able to derive the narrowband signal expression in 3.92.
10. Know the implementation benefits of narrowband angle modulation.
11. Be able to compute the spectrum of an angle modulation signal with \( \phi(t) = \beta \sin(\omega_m t) \).
12. Know all the steps to compute the Fourier transform (see #11).
13. Be able to compute the Fourier series of \( \exp(j\beta \sin(\omega_m t)) \).
14. Know the Fourier transform of i.) a cosine or sine wave, ii.) a delayed delta function, iii.) a rectangle wave, iv.) a train of delta functions (like \( \Delta(t) \)), and v.) a sinc wave.
15. Know the integral definition of a Bessel function.
16. Know the order symmetry properties in (3.111) and (3.112).
17. Be able to compute the Fourier transform of (3.103).
18. Know how to use (3.113). You do not need to memorize this.
19. Be able to compute \( \beta \) if you are given a message \( A \sin(\omega_m t) \) for PM or \( A \cos(\omega_m t) \) for FM.
20. Know how to draw the amplitude spectrum of an angle modulation signal.
21. Be able to derive and compute the power of angle modulation.
22. Know how to use the asymptotic approximation of a Bessel function (3.119). You do not need to memorize this. What happens as the order gets large?
23. Know the definition and how to compute the power ratio \((3.121)\) and \((3.122)\).
24. Know how to compute the bandwidth of an angle modulated signal given a power ratio.
25. What is the bandwidth of a narrowband angle modulated cosine or sine? This can be done using the relationship between AM and the narrowband expression.
26. Know Carson’s Rule. If a cosine or sine is the message, the corresponds to a 0.98 power ratio.
27. Understand and know how to derive that a narrowband angle modulation can be used to generate a wideband angle modulation signal.
28. Know how to demodulate FM and PM using a frequency discriminator.
29. Know the approximation for a frequency discriminator using a differentiator.

6 Chapter 4

1. Know the definition of PDF and CDF.
2. Know how to compute the mean and variance.
3. Understand Gaussian random variables.

7 Chapter 5

1. Understand the definitions of strict-sense stationary (sometimes just called stationary) and wide-sense stationary.
2. Be able to compute auto-correlation and cross-correlation.
3. Know how to compute power spectral densities.
4. Know the relations of correlation and PSD to variance.
5. Know what happens to the power spectral density of a stationary random process passing through an LTI system (covered in class).

8 Chapter 6

1. Know how to compute the SNR for baseband systems.
2. Why should we filter out bands that are not of interest?
3. Know how to compute the SNR for DSB modulation.