

# **EE354 Learning Objectives**

## **Lecture 1: Intro to Communications**

1. Describe the basic block diagram of a communication system.
2. Describe the purpose of Modulation and Demodulation.

## **Lecture 2: Review of Statistics (1/2)**

1. Calculate the probability of an event, as well as joint and conditional probabilities of multiple events.
2. Describe what a random variable is and how it is defined.
3. Calculate the PDF and CDF of a random variable, and use these distributions to evaluate the probability of an event.

## **Lecture 3: Review of Statistics (2/2)**

1. Calculate the expected value of a function.
2. Evaluate the probability of error for a bit received in the presence of AWGN
3. Understand the concept of random processes and their properties, including autocorrelation, and crosscorrelation
4. Understand the difference between time averages and ensemble averages.

## **Lecture 4: Review of Fourier Series and Transforms (1/2)**

1. Calculate the trigonometric and exponential Fourier coefficients.
2. Perform a Fourier series expansion of a function.
3. Calculate the Fourier Transform and Inverse Fourier Transform of a function.

## **Lecture 5: Review of Fourier Series and Transforms (2/2)**

1. Understand the  $\delta$ -function and how to apply its properties.
2. Understand the fundamental properties of the Fourier Transform.
3. Apply the properties of the Fourier Transform to solve communications problems.

## **Lecture 6: Communication Systems and Noise**

1. Describe the basic block diagram of a communication system.
2. Define Analog, Discrete, and Digital signals.
3. Transition from linear units to dB units.
4. Determine the impact that noise will have on a signal and calculate the SNR.

## **Lecture 7: Filtering and Distortion**

1. Determine the impact that distortion will have on a signal.
2. Calculate the output of a filter given the input signal and filter characteristic.

## **Lecture 8: Sampling Theorem**

1. Understand how the sampling theorem allows us to represent an analog signal as a discrete time signal.
2. Understand and apply the sampling theorem to determine Nyquist rate as well as the sampling rate of a system and frequencies present in the sampled spectrum.
3. Determine the frequencies present in a sampled spectrum when aliasing occurs.

## **Lecture 9: ADC/DAC Conversion and SQNR**

1. Explain the difference between impulse, natural, and flat-top sampling.
2. Understand the three types of errors that occur in sampling and how they impact the sampled signal.
3. Understand how quantizing discretizes a signal in both time and amplitude, and calculate the number of bits required to achieve a specific SQNR.

## **Lecture 10: Shannon Capacity Theorem**

1. Mathematically calculate the amount of information (entropy) contained in a message.
2. Calculate the information rate for a communication link.
3. Apply the Shannon Capacity formula to a particular communication channel and determine its maximum performance either in terms of information rate, bandwidth, or SNR.

## **Lecture 11: Pulse Amplitude Modulation**

1. Explain the difference between Natural and Flat-Top Sampling.
2. Explain how Natural or Flat-Top Sampling is used to generate PAM signals.

## **Lecture 12: Time Division Multiplexing**

1. Explain the difference between FDM, TDM, and CDM.
2. Explain conceptually how TDM operates.
3. Explain how ISI limits digital communications.
4. Understand the reason for using the Raised Cosine pulse shape.
5. Design a TDM system for a given number of signals with multiple different bandwidths/sampling frequencies.

## **Lecture 13: PWM, PPM, and Pulse Shaping**

1. Explain the difference between PWM, PPM, and PAM.
2. Understand how pulse shapes contribute to intersymbol interference.

### **Lecture 14: Baseband Digital Signaling**

1. Describe the different types of digital signaling (Polar/Bipolar, RZ, NRZ, AMI).
2. Understand how to generate and analyze digital line codes.
3. Map a series of bits into a specific digital signal.

### **Lecture 15: T-1 Communications**

1. Understand the basic block diagram of T-1 Communications.
2. Calculate the bit rate requirements at any point in the T-1 Link.

### **Lecture 16: Pulse Coded and Delta Modulation**

1. Understand the basic operation of PCM.
2. Specify the parameters of a PCM system, including  $f_s$ ,  $R_b$ , and SQNR.
3. Understand how Delta-Modulation differs from PCM.
4. Specify the parameters of a Delta Modulation system, including:  $\Delta$ ,  $f_s$ , and SQNR.

### **Lecture 17: Analog and Discrete Baseband Reception**

1. Understand the difference between analog, discrete, and digital baseband receivers.
2. Design a simple baseband receiver for analog, discrete, or digital signals.
3. Explain how noise power / noise spectral density impacts the performance of an analog receiver.

### **Lecture 18: Digital Baseband Reception and Matched Filters**

1. Explain how the matched filter operates.
2. Explain the assumptions/conditions under which the matched filter receiver is the ideal receiver.
3. Describe the properties of AWGN and how they impact the performance of a digital receiver.

### **Lecture 19: Analog/Discrete Baseband Performance**

1. Calculate the SNR for an arbitrary analog signal.
2. Explain the assumptions/conditions under which the matched filter receiver is the ideal receiver.
3. Describe the properties of AWGN and how they impact the performance of an analog receiver.
4. Calculate the SNR ( $E_b/N_0$ ) of an arbitrary digital signal.

### **Lecture 20: Digital Baseband Performance**

1. Describe the properties of AWGN and how they impact the performance of a digital receiver.
2. Calculate the SNR ( $E_b/N_0$ ) of an arbitrary digital signal.

### **Lecture 21: Bit Error Rate**

1. Evaluate the performance of a digital baseband receiver for an arbitrary signal set.
2. Compare the performance of the matched filter receiver with the threshold receiver.

### **Lecture 22: Intro to AM Modulation**

1. Describe the general form of an AM signal with transmitted/suppressed carrier component.
2. Determine the time domain and frequency domain representation of a DSB-TC and DSB-SC AM signal.
3. Calculate the bandwidth of an AM signal.
4. Understand and calculate the modulation index of an AM Signal.
5. Explain how to use AM to multiplex signals in the frequency domain.

### **Lecture 23: AM Properties and ASK**

1. Calculate the power in the carrier and sidebands of an AM signal.
2. Understand the relationship between power (efficiency) and modulation index.
3. Calculate the envelope of an AM signal – maximum and minimum value.
4. Explain how to use AM to multiplex signals in the frequency domain.
5. Explain how AM can be used to transmit digital signals.
6. Calculate the bandwidth, power, and data rate of an M-ary ASK communication system.

### **Lecture 24: AM and ASK Demodulation**

1. Describe mathematically how to demodulate AM signals.
2. Understand the conditions under which an envelope detector may be used.
3. Design either a coherent or incoherent AM demodulator.
4. Understand and describe how to demodulate ASK signals through either a coherent or incoherent demodulator.

### **Lecture 25-26: AM and ASK Performance**

1. Determine the SNR for AM signals demodulated by either a coherent or incoherent detector.
2. Design the matched filter receiver for an M-ary ASK signal set.
3. Calculate the SNR ( $E_b/N_0$ ) for an M-ary signal set.
4. Calculate the BER/data rate of an M-ary ASK communication system.
5. Compare the performance of M-ary ASK communication systems for various values of M.

## **Lecture 27: Superheterodyne Transmitters and Receivers**

1. Explain the fundamental reasons for the development of the superheterodyne receiver over the direct conversion receiver.
2. Understand the use of a variable local oscillator to downconvert a signal to a fixed IF.
3. Calculate the frequency of the variable local oscillator.
4. Calculate the value of the image frequency, explain the need for an image reject filter.

## **Lecture 28: Intro to FM**

1. Describe the general form of an FM signal.
2. Determine the instantaneous frequency of an FM signal.
3. Calculate the frequency deviation and  $\beta$  for an FM transmission.

## **Lecture 29: Communication Systems Design**

1. Understand how system design differs from component or subset design.
2. Understand how to evaluate design tradeoffs and impacts.
3. Develop a system-level block diagram.
4. Develop requirements for each block in the system block diagram.
5. Design each block in the system block diagram.
6. Integrate each block and evaluate the performance of the end-to-end design through analysis, simulation, or hardware.

## **Lecture 30: FM Transmitters and Receivers**

1. Design a VCO-based FM Transmitter.
2. Describe mathematically how to demodulate FM signals.

## **Lecture 31: FM Modulation and Demodulation**

1. Describe mathematically how to demodulate FM signals.
2. Design either a coherent or incoherent FM demodulator.
3. Implement an FM demodulator using software.
4. Generate an FM signal using laboratory equipment.

## **Lecture 32: FSK Modulation and Demodulation**

1. Explain how FM can be used to transmit digital signals.
2. Calculate the bandwidth, power, and data rate of an M-ary FSK communication system.
3. Understand and describe how to demodulate FSK signals through either a coherent or incoherent demodulator.

### **Lecture 33: FM Noise and Performance**

1. Calculate the SNR of an FM signal.
2. Explain why FM signals have a higher SNR than AM signals.

### **Lecture 34: FSK Noise and Performance**

1. Design a coherent or incoherent receiver for an M-ary FSK signal set.
2. Calculate the SNR ( $E_b/N_0$ ) for an M-ary signal set.
3. Calculate the BER/data rate of an M-ary FSK communication system.
4. Compare the performance of M-ary FSK communication systems for various values of M.

### **Lecture 36: Intro to PM**

1. Describe the general form of a PM signal.
2. Determine the instantaneous frequency of a PM signal.
3. Calculate the frequency deviation and  $\beta$  for a PM transmission.

### **Lecture 37: Intro to PSK**

1. Describe the general form of a PSK signal.
2. Explain how information can be transmitted in the phase of a signal.
3. Understand and describe PSK signal constellation sets.

### **Lecture 38: PSK Modulation / Demodulation**

1. Understand and describe how to create PSK signals.
2. Evaluate the Bandwidth, SNR, and BER for an M-ary signal set.
3. Understand how to recover data from an M-ary PSK signal set.