EET-2131: DIGITAL COMMUNICATION FUNDAMENTALS

Cuyahoga Community College

Viewing: EET-2131 : Digital Communication Fundamentals

Board of Trustees:

January 2024

Academic Term:

Fall 2024

Subject Code

EET - Electrical/Electronic Engineer

Course Number:

2131

Title:

Digital Communication Fundamentals

Catalog Description:

A continuation of the Signal Analysis course that expands on elementary digital modulation techniques, types of binary signals, speech coding, signal analysis and network theory. Topics include sampling, coding, bandwidth for baseband digital signals, data communications protocol including TCP/IP and error correction/detection techniques.

Credit Hour(s):

3

Lecture Hour(s):

2

Lab Hour(s):

2

Requisites

Prerequisite and Corequisite

EET-2170 Signal Analysis, or concurrent enrollment.

Outcomes

Course Outcome(s):

Demonstrate by dissection the contents of the three types of packets that are used in Transmission Control Protocol/Internet Protocol (TCP/IP) including packet ID, header(s), payload, trailer(s) and error checking codes (if present) and forward error control codes (if present).

Objective(s):

1. Recognize the different types of digital codes and then compare and demonstrate how they relate to Eb/N0 (the energy per bit to noise power spectral density ratio), specifically, how this relates to bit error rates.
2. Explain the pros and cons of isochronous data packets and demonstrate using a time diagram how their reception can negatively impact other digital traffic.
3. Explain the pros and cons of datagrams.
4. Draw an example of a sliding window protocol with numbered packets and include instances of failure, that is, negative acknowledge (NAK) and lost packet (timeout). Also explain the pros and cons of acknowledged and retransmitted data packets versus datagrams.
5. Demonstrate and explain various data packets and their composition on a protocol analyzer.

Course Outcome(s):

Design simple circuits that demonstrate two of the three methods of handling bit errors in a digital network or transmission environment that include error detection and error correction.

Objective(s):

1. Demonstrate using a time reference why some digital transmission protocols require that bit errors be ignored.
2. Write a report that explains the historical development of the acknowledge and retransmission method of mitigating bit errors, that is, the progenitor of the internet.
3. Demonstrate Forward Error Correction (FEC) by using a vertical and horizontal parity matrix how bit errors can be corrected and then explain the FEC as used in cellular and digital television broadcast regarding the increase of the bit rate.

Course Outcome(s):

Show how software stacks receive data from a higher level and handoff to a lower level. Explain the purpose of the layers associated with TCP/IP and the Open System Interconnect (OSI) models and show why the packet size increases as the data moves toward the physical layer.

Objective(s):

1. Demonstrate in a lab environment using any digital transport medium the handing of a bit stream regarding how the physical layer does not and need not be aware of higher levels in the TCP/IP or OSI models.
2. Compare the layers in Transmission Control Protocol/Internet Protocol (TCP/IP) and Open System Interconnect (OSI) models and then explain their correlation and the function they provide.

Course Outcome(s):

Demonstrate the properties of baseband digital signals using instrumentation and lab equipment.

Objective(s):

1. Explain the properties of various baseband bit transmission methods including Non-Return-to-Zero (NRZ), Return-to-Zero (RTZ), Manchester and Two Bits/One Quaternary (2B1Q).
2. Explain the bandwidth trade-offs between NRZ, RTZ, Manchester and 2B1Q.

Course Outcome(s):

Demonstrate the operation of Pulse Code Modulation (PCM) and similar modulation methods that are Pulse Amplitude Modulation (PAM and Pulse Position Modulation (PPM), in a lab environment and explain the A-to-D (analog to digital converter) process. Show in hardware or simulation software how compression and expansion functions and explain why it is needed.

Objective(s):

1. Demonstrate using mathematics the effect of sampling above the Nyquist limit and then explain the Nyquist sampling theorem in layman's terms.
2. Design an anti-aliasing filter.
3. Plot the frequency response of an anti-aliasing filter for a different number of poles using circuit simulation software or a manufacturer's circuit design software.
4. Design an anti-aliasing filter using ELSIE (Filter design software).

Course Outcome(s):

Explain the sampling theorem and aliasing distortion and demonstrate how different coding methods can reduce sensitivity to aliasing distortion, specifically, how over sampling decreases the importance of a rapid rolloff anti-aliasing filter. Compare PCM to CVSD (Continuously Variable Delta Modulation) in a lab environment.

Objective(s):

1. Demonstrate Pulse Code Modulation (PCM) regarding speech coding in a lab experiment and explain the effect of increasing the sample rate and the number of bits per sample.
2. Use mathematics to show the effects of how doubling the sample rate affects quantizing noise.
3. Use mathematics to show how adding a bit affects the quantizing noise.
4. Explain the PCM decoding process, framing and the digital hierarchy.
5. Explain other decoding methods including differential PCM, adaptive differential PCM, delta modulation and Sigma/Delta modulation.

Course Outcome(s):
Explain the history of multiplexing and demonstrate an understanding of the topic in a lab environment.

Objective(s):
1. Explain and demonstrate using a radio or television how Frequency Division Multiplexing (FDM) functions. Explain how John Carson (Bell Labs) used FDM to establish long-distance telephone communications.
2. Explain the importance of limiting the bandwidth in Frequency Division Multiplexed (FDM) systems.
3. Explain the history of Time Division Multiplexing (TDM) and demonstrate the concept in a lab environment.
4. Explain how the digital hierarchy builds upon the stacking of lower-level Time Division Multiplexed signals.
5. Explain how frequency hopping in a multiplex environment (frequency hopping spread spectrum) operates in a communications environment.
6. Explain how Code Division Multiplexing operates (referred to as code division multiple access). The explanation should include knowledge of cross-correlation, auto-correlation and how the patterns are developed.

Methods of Evaluation:
1. Tests
2. Quizzes
3. Laboratory Assignments/Reports
4. Homework
5. Projects

Course Content Outline:
1. Concepts
    a. Digital signal format
    b. Frequency domain, spectrum analysis and how it relates to frequency division multiplexing
    c. Transmission of time sensitive isochronous data (audio and video)
    d. Pulse amplitude modulation, sampling theorem
    e. Pulse position modulation
    f. Pulse code modulation
    g. Effects of noise
    h. Data communications protocols
    i. TCP/IP
    j. Packet transmission - no error checking
    k. Packet transmission that requires error checking (sliding window protocol)
    l. Packet transmission (time sensitive) that uses error correction
2. Skills
    a. Multiplexing in frequency
    b. Multiplexing in time
    c. Multiplexing in code
    d. Utilizing Protocol Analyzer
    e. Controlling digital communications using (Transfer Control Protocol - Internet Protocol (TCP/IP) and the Open Systems Interconnection (OSI)
    f. Sampling and quantizing noise as related to the number of bits
    g. Utilizing filter design software to design an anti-aliasing filter
3. Issues
    a. Troubleshooting
    b. Error correction/detection techniques

Resources
Sklar, Bernard and Fredric Harris. *Digital Communications: Fundamentals and Applications*. 3rd ed. Pearson, 2021.

Stark, Wayne. *Introduction to Digital Communications*. 1st ed. Cambridge University Press, 2023.

Tanenbaum, Andrew S., Nick Feamster, and David J. Wetherall. *Computer Networks*. 6th ed. Pearson, 2020.

Top of page
Key: 1654