

NETW-310

Wired, Optical, and Wireless Communications

Final Course Project

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Date Submitted:
August 27, 2023

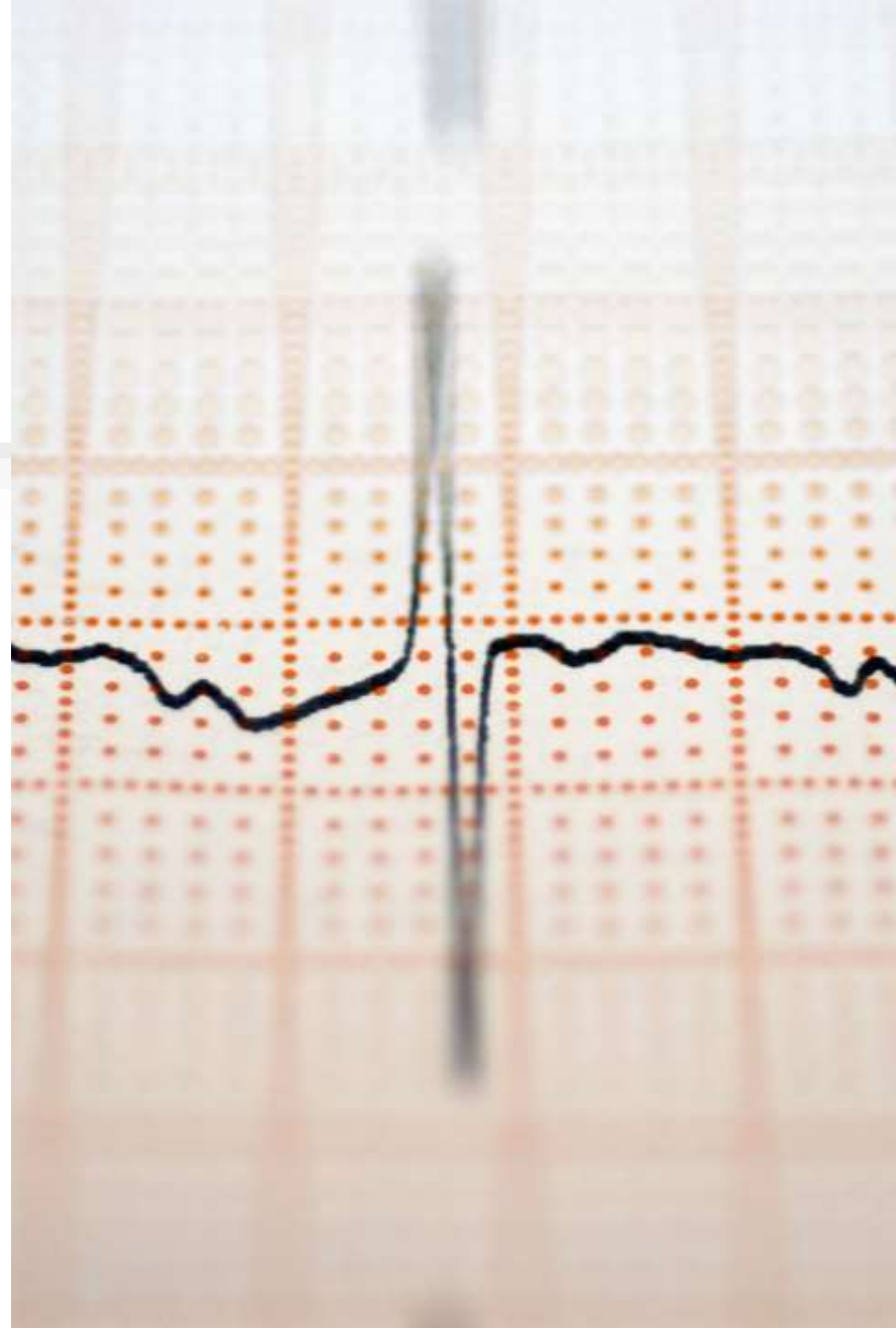
Purpose

- This objective of this presentation is to demonstrate the various stages of developing and applying skills related to wired, optical, and wireless technologies and implementing best practices and standards as defined by Information Technology Professionals and Organizations.



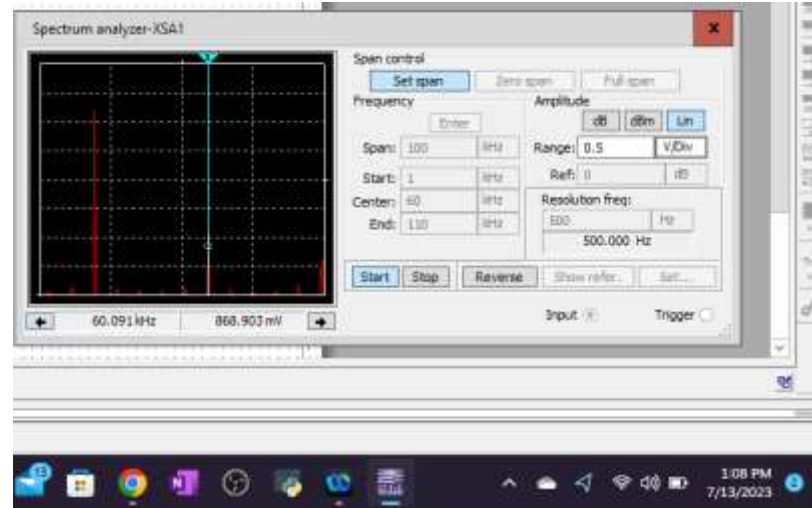
Baseband and AM/FM Signals

- This module introduces the use of instrumentation for setting parameters and measuring harmonic frequencies and voltages in signals at various frequencies.
- The Spectrum Analyzer and Oscilloscope are used to demonstrate readings of AM signals applying specific settings.
- Using algebraic formulas, develop equations to determine the carrier and modulating signals and plot the equation for the composite modulated signal.
- Demonstrate time and frequency domain characteristics of square wave using the Oscilloscope and Spectrum Analyzer.



Baseband Signals - AM

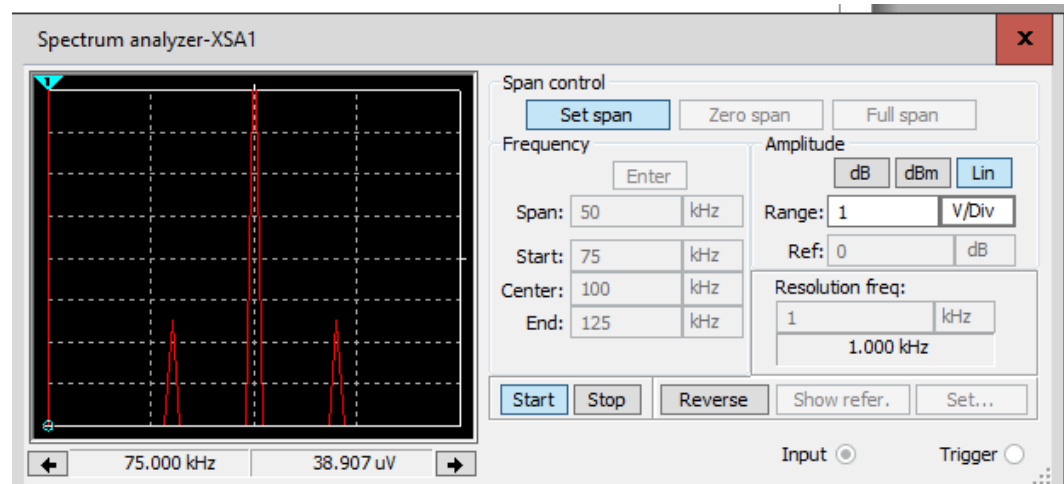
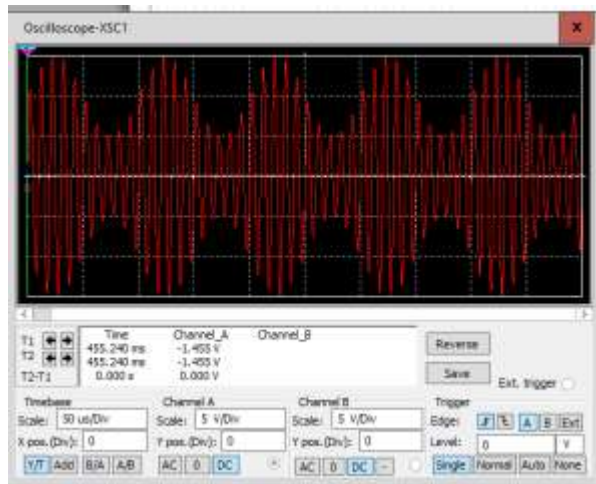
- Spectrum analyzer displaying the signal's harmonic spectrum, its panel settings, and signal voltage at each of the frequencies in the table.



Harmonic Frequency	Signal (Volts)
20 kHz	3.131 mV
40 kHz	0.0 mV
60 kHz	868.9 mV
80 kHz	0.0 mV
100 kHz	416.69 mV

AM Signals

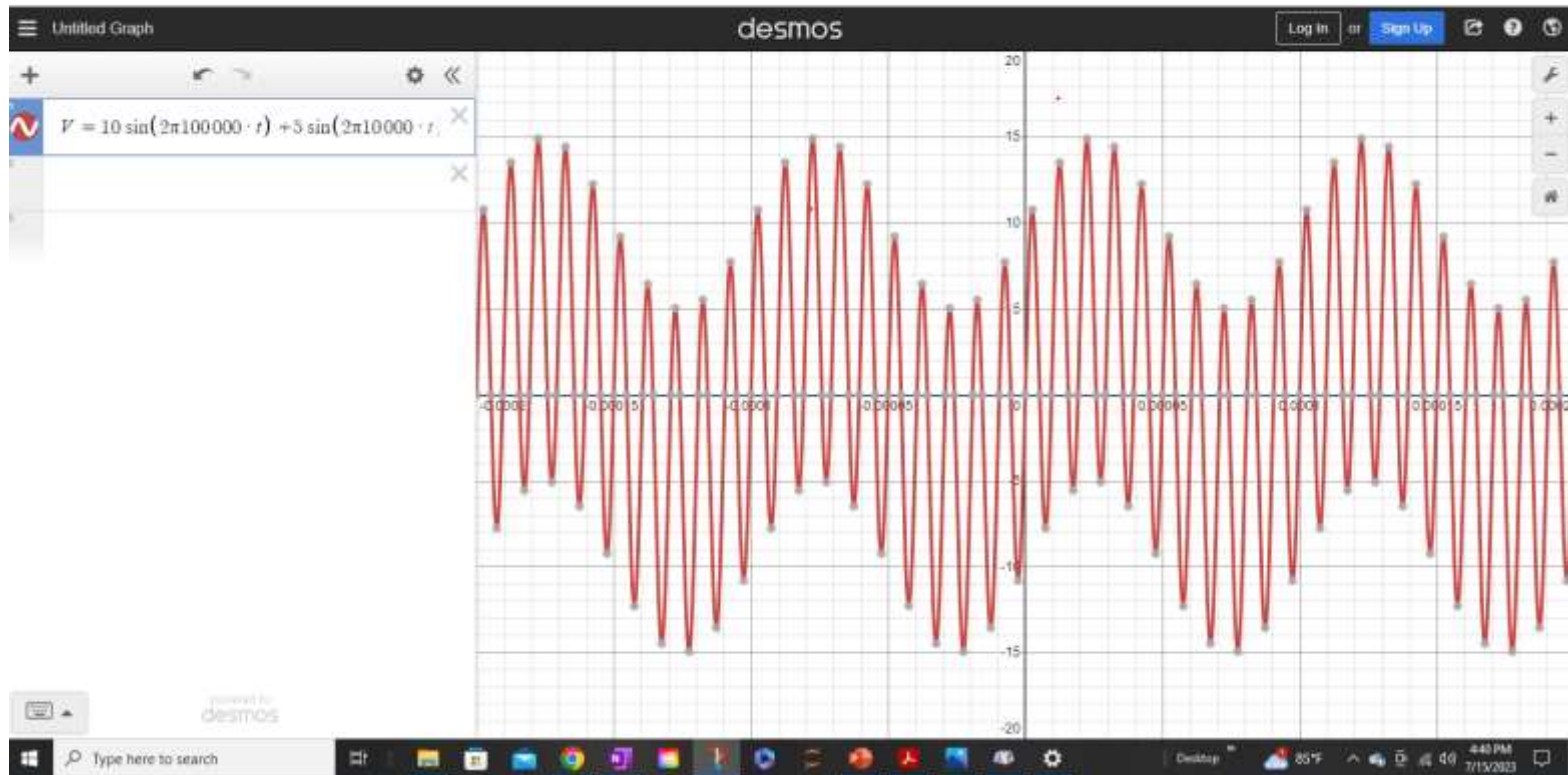
The Oscilloscope and the Spectrum Analyzer displaying settings and frequencies.



AM Modulation	Frequency (kHz)
Lower side band	89.9kHz
Carrier	100kHz
Upper side band	109.9kHz

AM Signals Cont.

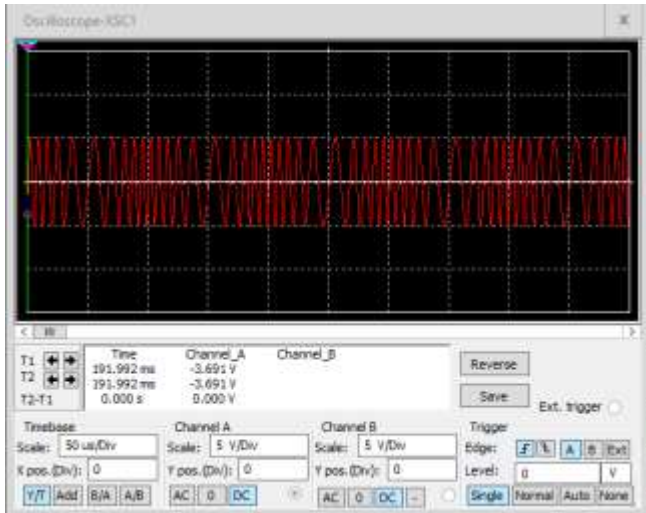
Equations for the carrier and modulating signals and plot of the equation for the composite modulated signal V_{AM} .



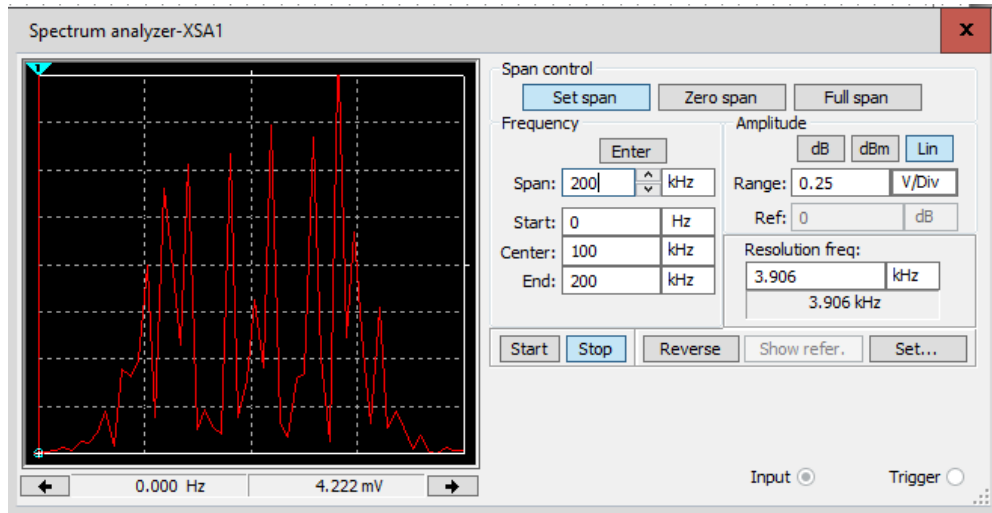
FM Signals

the signal and the panel settings of the Oscilloscope and the Spectrum Analyzer.

Oscilloscope



Spectrum Analyzer



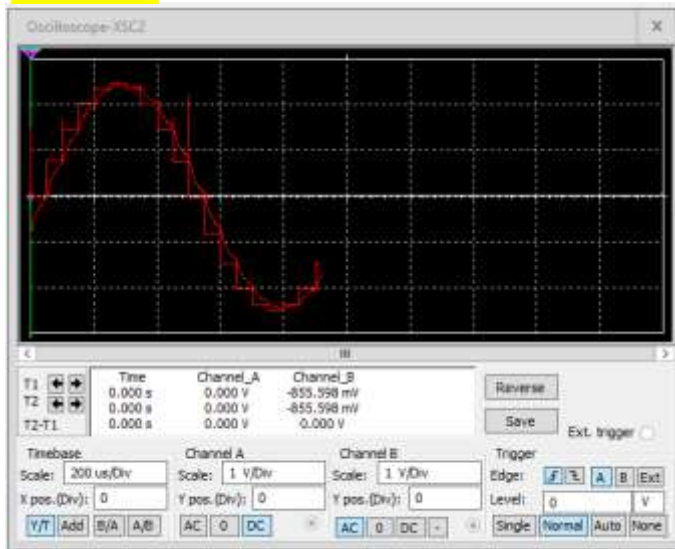
The carrier frequency of the signal:
100.000 kHz

Pulse Code Modulation (PCM) and Line Codes

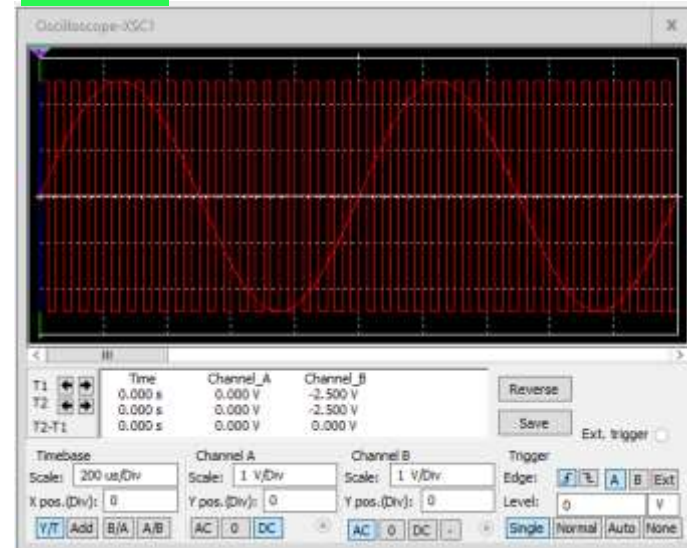
- This module will present the results of simulating a Pulse Code Modulation PCM system and comparing the original input signal at the transmitter to the recovered signal at the receiver.
- The next step is to plot the power spectral densities of common line codes and compare their required frequency spectrum.
- Oscilloscopes are used to display readings of input and output signals.
- Line Code readings are then plotted on a line graph demonstrating four power spectral densities.

Pulse Code Modulation (PCM)

XSC1



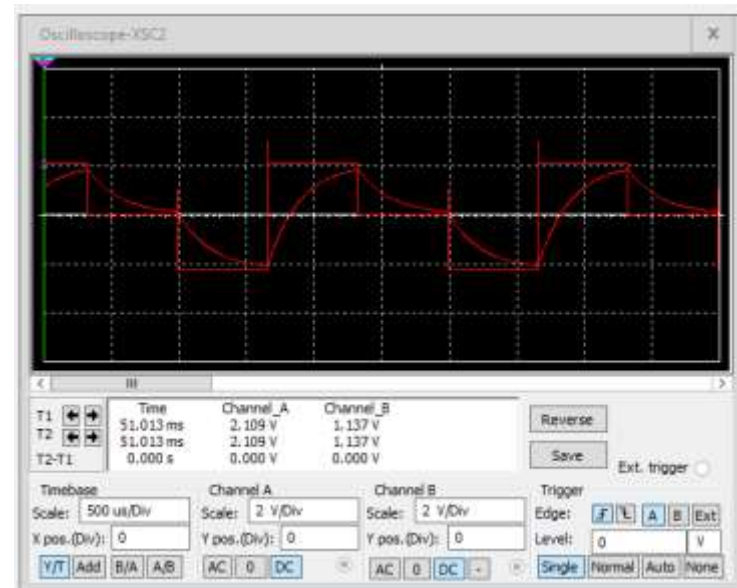
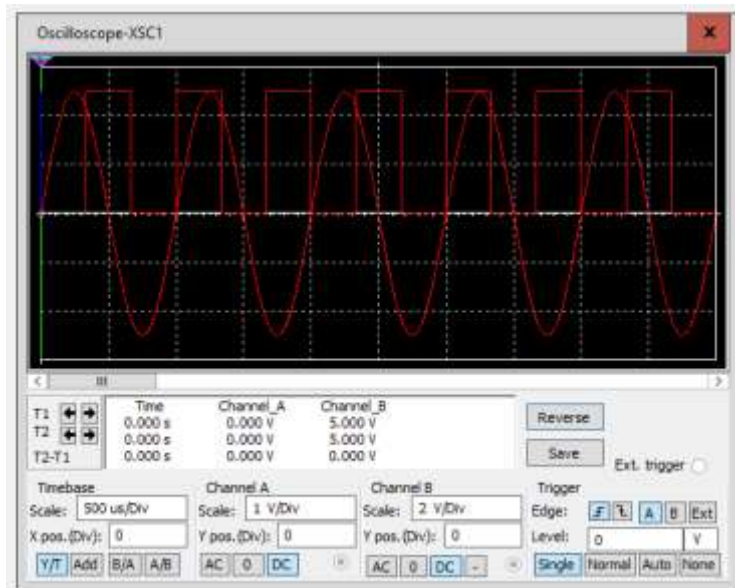
XSC2



- Oscilloscope-XSC1 displaying the analog input signal and sampling clock at the input to the ADC.
- Oscilloscope-XSC2 displaying the output of the DAC.

Pulse Code Modulation (PCM)

- Oscilloscope-XSC1 displaying the analog input signal and sampling clock at the input to the ADC.
- Oscilloscope-XSC2 displaying with the output of the DAC.

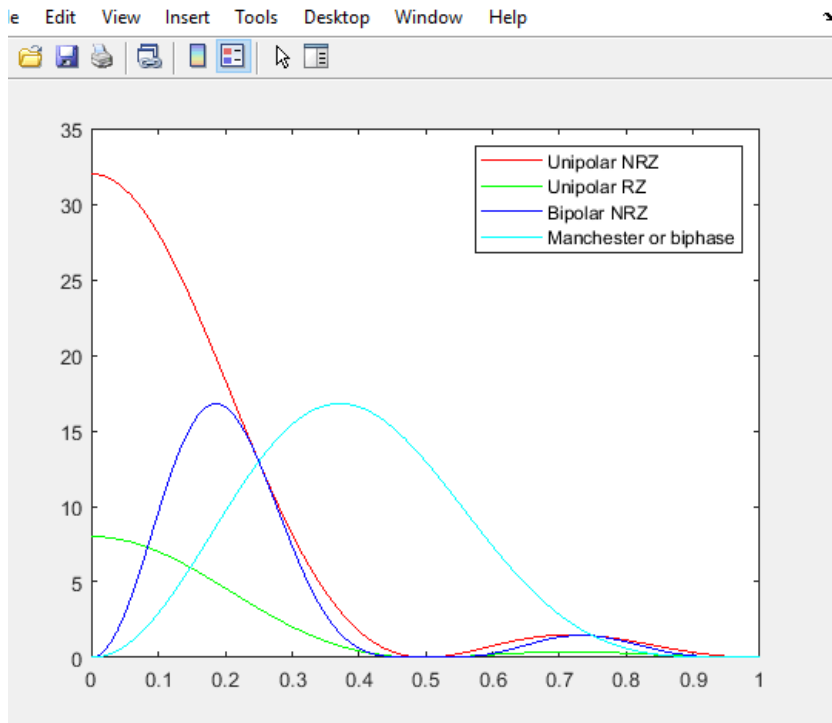


The effects of increasing or decreasing the sampling rate results in changes in frequency or bandwidth. A higher sampling rate will result in a higher resolution waveform.

Line Codes

This screenshot should show the power spectral densities of four-line codes: NRZ-Polar, NRZ-Unipolar, NRZ-Bipolar, and Manchester-Polar.

MATLAB Diagram Here



Compare the NBR-Polar and Manchester polar codes in the diagram.

Which one requires more bandwidth?

Answer: Manchester or bi-phase

Cables and Structured Cabling

This informational module poses questions and answers of required knowledge for professionals in the electrocommunications industry.

- 1. Why must the twisting in the individual wires be maintained in a UTP cable?
 - **Answer:** The number of twists per inch in UTP determine the grade characteristics of the cable. Maintaining consistency of the twists in the wires reduces crosstalk and EMI on the signal.
- 2. How many inches should UTP cable be separated from 110 volts electrical cable?
 - **Answer:** The minimum recommended spacing between electrical and non-electrical cable is 2 inches according to the National Electrical Code (NEC). The recommended distance will also be determined by the rating of the cable being used.
- 3. Horizontal cabling connects what areas to each other?
 - **Answer:** Horizontal cabling connects the telecommunications or server room to individual work areas and outlets used by end devices.

Cables and Structured Cabling (Cont.)

- Cables and Structured Cabling (Cont.)
- 4. What is a plenum rated cable?
 - **Answer:** Plenum rated cable can be either coaxial or twisted pair cable with an outer jacket made of fire-resistant material that will not emit toxic fumes if it burns or is overheated. The specifications are a standard of the NEC.
- 5. What is a riser tube used for?
 - **Answer:** A riser tube is used to carry cable between floors of a building i.e., backbone cable for network infrastructure.
- 6. Is the grounding of equipment mostly a safety or a performance concern?
 - **Answer:** The primary concern of grounding any electrical system is to provide safe pathways for electrical current to enter the ground. Performance is a secondary consideration for grounding sensitive electronic equipment as this allows proper amounts of power distribution.

Antenna Gain and Free Space Path Loss

Antenna Gain

1. What is the maximum theoretical antenna gain of a common dish antenna at the 2.4 GHz band? [4 points]

Answer: 22.3 dB

2. What is the maximum theoretical antenna gain of a common dish antenna at the 5 GHz band? [4 points]

Answer: 29.07 dB

3. Given the same sized reflector, which signals, high-frequency, or low-frequency, can be more efficiently focused by a common dish antenna (i.e., result in a higher antenna gain)? [5 points]

Answer: High-frequency

4. What is the maximum theoretical antenna gain of the dish antenna used in the VLA radio telescopes in New Mexico at the 5 GHz band? [4 points]

Answer: 63.06 dB

5. Given the same signal frequency, which dish antennas, large-sized or small-sized, are more efficient at focusing the signal (i.e., result in a higher antenna gain)? [5 points]

Answer: Large-sized

Free Space Path Loss

1. What is the free space path loss in dB at the 2.4 GHz band? [4 points] **Answer: -80.4 dB**

2. What is the free space path loss in dB at the 5 GHz band? [4 points] **Answer: -87.2 dB**

3. How does the free space path loss at a higher frequency (e.g., the 5 GHz band) compare with that at a lower frequency (e.g., the 2.4 GHz band)?

Answer: Higher frequency results in more moderate increase in free space path loss

4. What is the free space path loss in dB over 20 meters at the 2.4 GHz band? [4 points]

Answer: -66.4 dB

5. What is the free space path loss in dB over 40 meters at the 2.4 GHz band? [4 points]

Answer: -72.4 dB

6. What is the free space path loss in dB over 80 meters at the 2.4 GHz band? [4 points]

Answer: -78.4 dB

7. When the distance doubles, how does free space path loss in dB change approximately?

Answer: Approximately 6 dB increase in free space path loss as the distance doubles.

8. Use a scientific calculator to calculate Delta L_{fS} for $D1 = 20$ meters and $D2 = 40$ meters. **Answer: Delta $L_{fS} = -6.02$ dB**

9. Is your calculation approximately the same as the result from Part 1 Step 2? [4 points]

Answer: No. In Part 1 Step 2 the gain is +63.06

Bit Error Rate of Fading Channels

AWGN Channel and Rician Channel

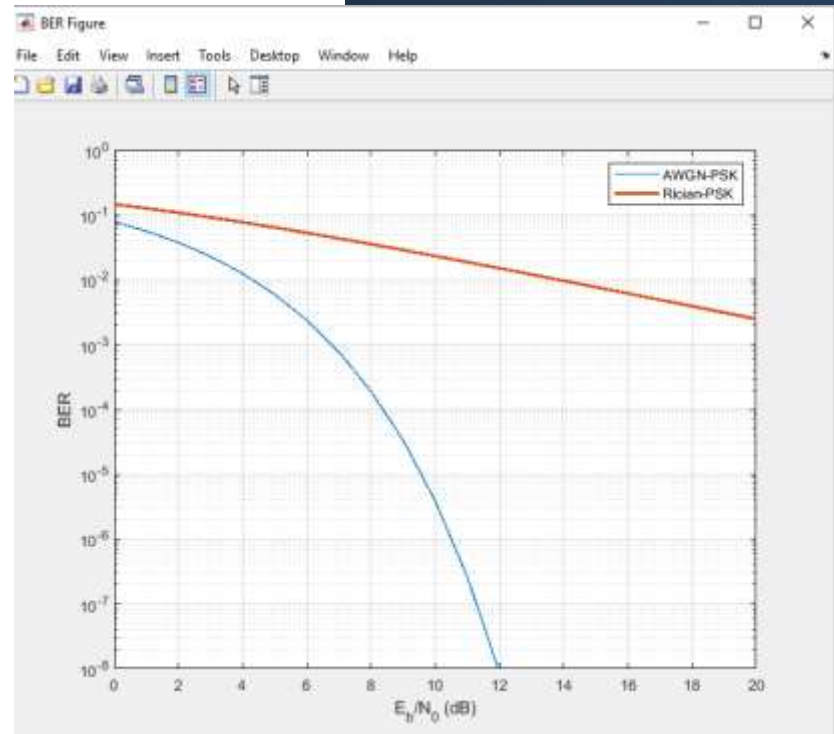
The objective of this module is to compare and contrast the bit error rate (BER) performance of Phase Shift Keying (PSK) over a noise limited Additive White Gaussian Noise (AWGN) transmission channel to the performance of PSK over a Rician channel at 5- and 10-dB Signal to Noise Ratio (E_b/N_0), respectively.

The question presented is, does a significant difference in BER performance of PSK occur between the AWGN channel and Rician channel?

Answer: Yes. As stated by IEEE, there hasn't been significant study of the data on BER, but according to Science Alert <https://scialert.net/> there is support of the theory that when there is a higher SNR in transmission of a signal on an AWGN channel, the BER decreases making it perform better compared to a Rician channel.

AWGN and Rician Channel

- This screenshot should show the bit rate error performance of both AWGN and Rician fading channels.



Challenges Encountered and Career Skills Developed in the Course

Challenges

- One challenge I faced at the beginning of the course was establishing a schedule for completing weekly assignments.
- Comprehending and memorizing specific formulas for measuring various types of waves, frequencies, and signals was another challenge.
- Becoming familiar and confident with using various instrumentation and web-based technology platforms took some time.

Career Skills Acquired

- Comprehensive understanding of telecommunications standards.
- Ability to determine the appropriate methods for testing and measuring various electromagnetic signals.
- Knowledge of various power, wave, and signal transmission methods and properties.
- In-depth exposure to several antenna types the corresponding transmission protocols.

Conclusion



In conclusion I believe this course has provided me the resources needed to broaden and strengthen my IT knowledge base and prepare me for entering the technology field with the confidence.



The course materials and content afforded me information on an abundance of required wired, optical, and wireless communications technology standards and best practices in the IT industry.



Professor Khan generously provided access to his wealth of knowledge as a subject matter expert in the field of Telecommunications.

References

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