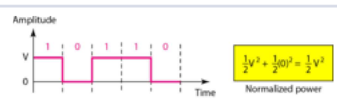
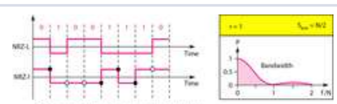
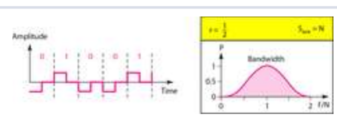
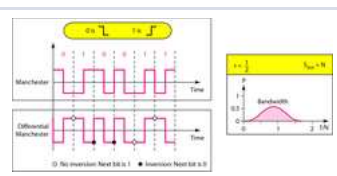
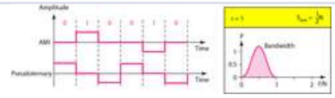
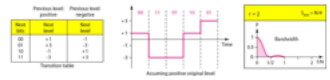
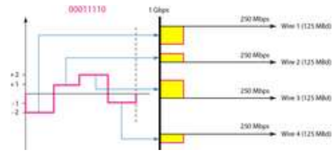
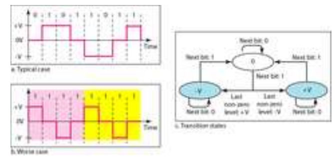
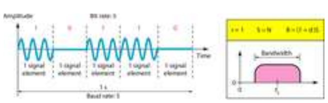
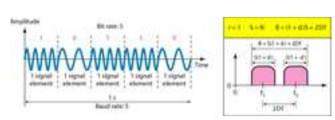
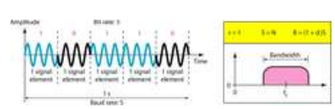
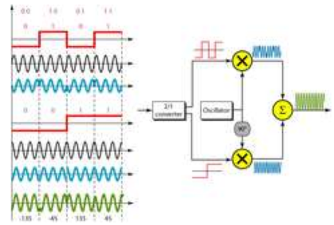
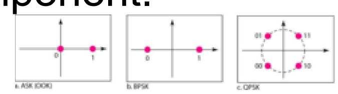
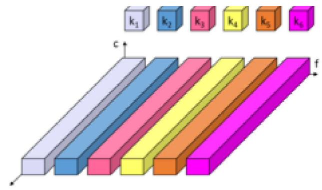
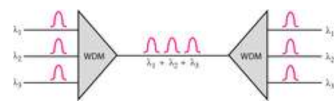
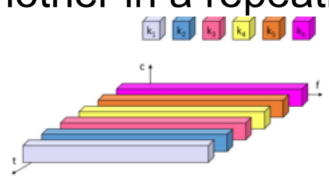
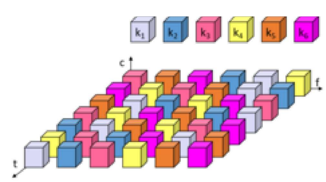
Transmission impairment	- Attenuation (Loss of signal) - Distortion (Change in signal shape) - Noise
Attenuation	When a signal travels through a medium it loses energy overcoming the resistance of the medium Amplifiers are used to compensate for this loss of energy by amplifying the signal.
Distortion	Distortion occurs in composite signals. Each frequency component has its own propagation speed -> don't arrive at the same time so some parts of the signal have a phase shift.
Noise	- thermal : electrons make noise by moving more heat more moving - Induced :From spools (induction) that are active in the system - Crosstalk : From signals through wires - Impulse : Voltage spikes in powerplanes (Lightning, power lines)
Nyquist Theorem	Nyquist gives the upper bound for the bit rate of a transmission for a noiseless channel
Nyquist Theorem (Formula)	capacity = 2 * bandwidth log2(number of signal levels)
Shannon's Theorem	Shannon's theorem gives the capacity of a system in the presence of noise.
Shannon's Theorem (Formula)	capacity = bandwidth * log2 (1 + SNR)
Performance metrics	- Bandwidth : (Messages per minute * Message size)/60 - Propagation Delay : Distance/Propagation speed - Transmission Delay: Message size/bandwidth bps - Latency: Propagation delay + Transmis-

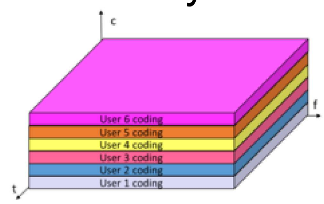
	sion delay + Queueing time + Processing time
Line Coding key problems	- Baseline wandering - DC components - Self-synchronization - Error detection - Noise and interference - Complexity
Baseline wandering	A voltage offset in the baseline caused by long runs of 0s or 1s.
DC components	Most mediums are band-pass, so low frequencies (long runs of 0s or 1s) are filtered out.
Self-synchronization	Misalignment of sender and receiver clocks, leading to errors.
Error detection and correction	Preventing / detecting errors that occur during transmission due to line impairments.
Noise and interference	Some encoding techniques make the signal more resistant to noise and interference.
Complexity	More robust and resilient encoding methods are often more complex to implement, impacting baud rate or required bandwidth.
Unipolar NRZ-L	
Polar NRZ-L & NRZ-I	
Polar RZ	
Manchester & Differential Manchester	

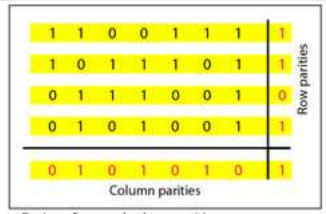
AMI & pseudoternary	
Multi-level Encoding	
4D-PAM5	
MLT-3	
Digital to Digital : Block Coding	Block coding takes smaller chunks of bits (blocks) and interprets them into larger blocks to introduce redundancy. This redundancy helps with error detection and correction.
Scrambling	Scrambling modifies problematic bit patterns (e.g., those causing DC components, baseline wandering, or self-synchronization issues) into predetermined patterns that are easier to transmit and decode. For example, 0000 might be scrambled into 1010. The receiver uses the same pattern to unscramble the data during decoding.
Transmission Modes	- parallel - Asynchronous - Synchronous - Isochronous
Transmission Modes : parallel	Multiple bits are transmitted simultaneously over multiple channels or wires, typically used for short-distance communication, such as within a computer or between a computer and a peripheral.
Transmission Modes : Isochronous	Data is transmitted at consistent intervals, ensuring predictable timing for real-time applications (e.g., audio or

	video) that require continuous, time-sensitive data streams.
Transmission Modes : Asynchronous	In this mode, a start bit (0) is sent at the beginning and one or more stop bits (1s) at the end of each byte, with possible gaps between bytes.
Transmission Modes : Synchronous	Bits are transmitted continuously without start or stop bits or gaps. The receiver is responsible for grouping the bits correctly.
Digital-to-Analog Conversion	- Amplitude Shift Keying (ASK) - Frequency Shift Keying (FSK) - Phase Shift Keying (PSK) - Quadrature Phase Shift Keying (QPSK)
Amplitude Shift Keying (ASK)	ASK alters the amplitude of a carrier signal to represent digital data. Different amplitude levels correspond to binary 0s and 1s. 
Frequency Shift Keying (FSK)	FSK changes the frequency of a carrier signal based on the digital data stream: - A "1" is represented by ($f_1 = f_c + \Delta f$). - A "0" is represented by ($f_2 = f_c - \Delta f$). 
Phase Shift Keying (PSK)	PSK modifies the phase of the carrier signal to represent digital data. It is more reliable than ASK, as it is less affected by noise, which primarily alters signal amplitude. 

Quadrature Phase Shift Keying (QPSK)	QPSK enhances PSK by encoding two bits per symbol. The bit stream is split into pairs, each modulating a carrier frequency. One carrier is phase-shifted by 90° (in quadrature) relative to the other, enabling higher data rates while maintaining robustness. 
Concept of a Constellation Diagram	- The X-axis represents the in-phase carrier component. - The Y-axis represents the quadrature carrier component. 
Analog-to-Analog Conversion	- Amplitude Modulation (AM) - Frequency Modulation (FM) - Phase Modulation (PM)
Amplitude Modulation (AM)	The amplitude of the carrier wave is varied in proportion to the information signal.
Frequency Modulation (FM)	The frequency of the carrier wave is varied based on the information signal
Phase Modulation (PM)	The phase of the carrier wave is altered to convey the information signal.
Multiplexing	- Frequency Division Multiplexing (FDM) - Wavelength Division Multiplexing (WDM) - Time Division Multiplexing (TDM) - Hybrid TDM/FDM - Code Division Multiplexing (CDM)

Frequency Division Multiplexing (FDM)	FDM divides the available bandwidth into multiple frequency bands, with each band assigned to a different signal. This allows simultaneous transmission without interference. 
Wavelength Division Multiplexing (WDM)	WDM is similar to FDM but is used specifically in optical fiber communication. It combines multiple light wavelengths (colors) into a single fiber, with each wavelength carrying separate data streams. 
Time Division Multiplexing (TDM)	TDM divides the available bandwidth into time slots, with each slot assigned to a different signal. Signals are transmitted one after another in a repeating cycle. 
Hybrid TDM/FDM	Hybrid TDM/FDM combines the principles of both techniques. FDM is used to divide the bandwidth into frequency bands, and TDM is applied within each band to share time slots among multiple signals. 

Code Division Multiplexing (CDM)	CDM allows multiple signals to share the same frequency spectrum by assigning a unique code to each signal. These codes ensure that signals can be separated and decoded correctly at the receiver. 
Direct Sequence Spread Spectrum (DSSS)	TBD
Frequency Hopping Spread Spectrum (FHSS)	TBD
Error Detection and Correction : Block coding	- Codewords - Parity Checks - Hamming code
Cyclic Codes	- Cyclic Redundancy Check (CRC) - Checksum
Codewords	Codewords are carefully chosen so that each is distinct and separated by a minimum distance. If a bit flip occurs, the message will not match any valid codeword, allowing the receiver to detect the error and discard the message.
Parity check	Parity checks are a simple error detection mechanism: - One-Dimensional Parity Check: A single parity bit is added to each block to ensure the total number of 1s is even (even parity) or odd (odd parity). - Two-Dimensional Parity Check: Parity bits are added for both rows and columns of a data matrix, allowing for detection of more complex errors.



a. Design of row and column parities

Hamming Code

The Hamming Code is a type of error-correcting code that can detect and correct single-bit errors. The First-Order Hamming Code is the simplest form of Hamming code, using redundant parity bits placed strategically within the data.

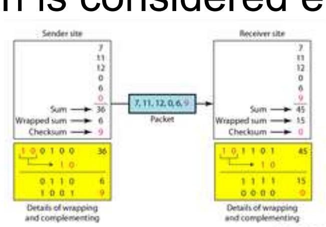
Bit position	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Parity bit	P0		X		X		X		X		X		X	
Data bit		P1	X			X	X			X	X			X
				P2	X	X	X					X	X	X
								P3	X	X	X	X	X	X

Cyclic Redundancy Check (CRC)

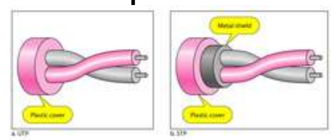
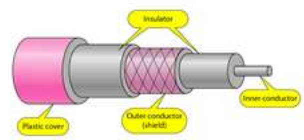
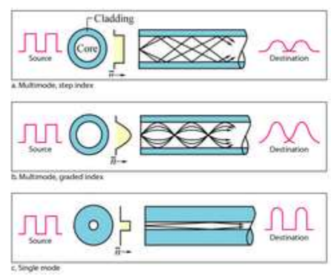
TBD

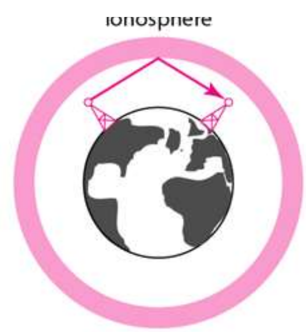
Checksum

A checksum is a method used to verify the integrity of transmitted data. To calculate it, you start by adding up all the data, such as 17, 02, 11, 07, 03. Convert the values into binary and split them according to the size of your checksum. For example, with a 4-bit checksum, you would represent 40 as 0010 1000. Then, add the two 4-bit chunks together, which gives 1010 (decimal 10), known as the wrapped checksum. Next, invert the bits, resulting in 0101 (decimal 5), and append this value to the original data, forming the message 17, 02, 11, 07, 03, 05. On the receiving side, you repeat the same process. If the checksum results in 0 at the end of the calculation, the transmission is considered error-free.



guided Media

	- UTP & STP - Coaxial Cable - Fiber optic
UTP vs STP	UTP is unshielded which makes it prone to noise also cheaper STP is shielded which makes it better to noise but more expensive 
Coaxial Cable	A single copper wire surrounded by layers of plastic insulation and sheathing. always resistance/impedance matched 
Fiber Optics Cable	TBD 
Unguided Media	- Ground Propagation (x < 2 MHz) - Sky Propagation (2 MHz < x < 30 MHz) - Line-of-Sight Propagation (30 MHz < x)
Ground Propagation (x < 2 MHz)	In ground propagation, signals travel along the curvature of the Earth. Signal loss occurs due to scattering around obstacles.

	
Sky Propagation (2 MHz < x < 30 MHz)	Sky propagation involves signals traveling through the air and reflecting off the ionosphere's surface. This enables long-distance communication by "bouncing" signals between the Earth and the ionosphere. 
Line-of-Sight Propagation (30 MHz < x)	In line-of-sight propagation, signals travel directly through the air, with the transmitting antenna aimed at the receiving antenna in clear line-of-sight. 
Fresnel zone	The Fresnel Zone defines the area around the line of sight where signal energy is concentrated. - Partially Obscured Fresnel Zone: Leads to reduced signal quality. - Fully Obscured Fresnel Zone: Results in no signal reception