



EEEN 464 – DIGITAL COMMUNICATION
LINE CODING - STUDY GUIDE/REVISION

1. INTRODUCTION TO LINE CODING

1. **Definition:** Line coding converts digital data (binary bits) into electrical/optical signals for transmission over physical media (e.g., cables, fibre optics).
2. **Purpose:**
 - Enable synchronization between transmitter/receiver.
 - Reduce transmission errors.
 - Minimize signal distortion (e.g., DC component).
3. **Key Concepts:**
 - **Symbol:** A voltage/current level representing one or more bits.
 - **Pulse:** A signal waveform (e.g., positive/negative voltage, zero).

2. KEY CHARACTERISTICS OF LINE CODES

CHARACTERISTIC	DESCRIPTION
Polarity	Unipolar (one voltage level), Polar (positive/negative levels), Bipolar (three levels).
Voltage Levels	Number of signal states (e.g., 2 levels for binary).
Bit Rate vs. Baud Rate	Bit rate = data speed; Baud rate = signal changes per second.
DC Component	Presence of low-frequency signal drift; undesirable in transformers/capacitors.
Self-Clocking	Built-in timing information for synchronization.
Bandwidth	Minimum frequency range needed for transmission.
Noise Immunity	Resistance to signal corruption.

3. COMMON LINE CODING SCHEMES

1. UNIPOLAR NRZ (NON-RETURN-TO-ZERO)

Encoding:

- $0 = 0V$
- $1 = +V$
- **Pros:** Simple.
- **Cons:** DC component; no synchronization for long 0/1 sequences.

2. POLAR SCHEMES

- **NRZ-L** (NRZ-Level):
 - $0 = +V, 1 = -V$.
- **NRZ-I** (NRZ-Invert):
 - $0 = \text{no change}, 1 = \text{voltage inversion}$.
- **RZ** (Return-to-Zero):
 - Each bit ends at zero (half-duration pulse).
 - E.g., $1 = +V \rightarrow 0V; 0 = -V \rightarrow 0V$.
- **Pros:** Reduced DC component (RZ).
- **Cons:** Higher bandwidth (RZ), no clocking (NRZ).

3. BIPHASE SCHEMES

- **Manchester:**
 - $0 = \text{Low} \rightarrow \text{High transition}; 1 = \text{High} \rightarrow \text{Low transition (mid-bit)}$.
 - **Pros:** Self-clocking; no DC component.
- **Differential Manchester:**
 - Transition at mid-bit = clocking.
 - $0 = \text{additional transition at start}; 1 = \text{no transition}$.
 - **Pros:** Robust noise immunity.

4. BIPOLAR SCHEMES

- **AMI** (Alternate Mark Inversion):
 - $0 = 0V; 1 \text{ alternates between } +V/-V$.
- **HDB3/B8ZS:**
 - AMI variants that prevent long zero sequences.
- **Pros:** No DC component; error detection.

4. SELECTION CRITERIA

- **Bandwidth Efficiency:** RZ uses 2x NRZ bandwidth.
- **Synchronization:** Manchester/AMI support self-clocking.

- **Complexity:** Unipolar is simplest; Bipolar needs advanced encoders.
- **Error Detection:** AMI detects errors via polarity violations.
- **DC Balance:** Bipolar/Manchester avoid DC drift.

5. ADVANTAGES/DISADVANTAGES

Scheme	Advantages	Disadvantages
Unipolar NRZ	Simple implementation.	DC component; no synchronization.
Polar NRZ	Low bandwidth.	Baseline wander; no clocking.
RZ	Self-clocking; no DC drift.	Double bandwidth.
Manchester	Self-clocking; no DC; error tolerance.	High bandwidth.
AMI	No DC; error detection; low bandwidth.	Complex; loses sync for long zeros.

6. PRACTICE PROBLEMS

1. Encode 1011001 using:

- **Unipolar NRZ**
- **Manchester**
- **AMI**

Solutions:

- Unipolar: +V 0V +V +V 0V 0V +V
- Manchester: H→L, L→H, H→L, H→L, L→H, L→H, H→L (mid-bit transitions).
- AMI: +V 0V -V +V 0V 0V -V (alternating 1s).

2. Which scheme is ideal for Ethernet?

- *Answer:* Manchester (used in classic Ethernet).

3. Why does AMI avoid DC drift?

- *Answer:* Equal positive/negative pulses average to zero DC.