Theory:

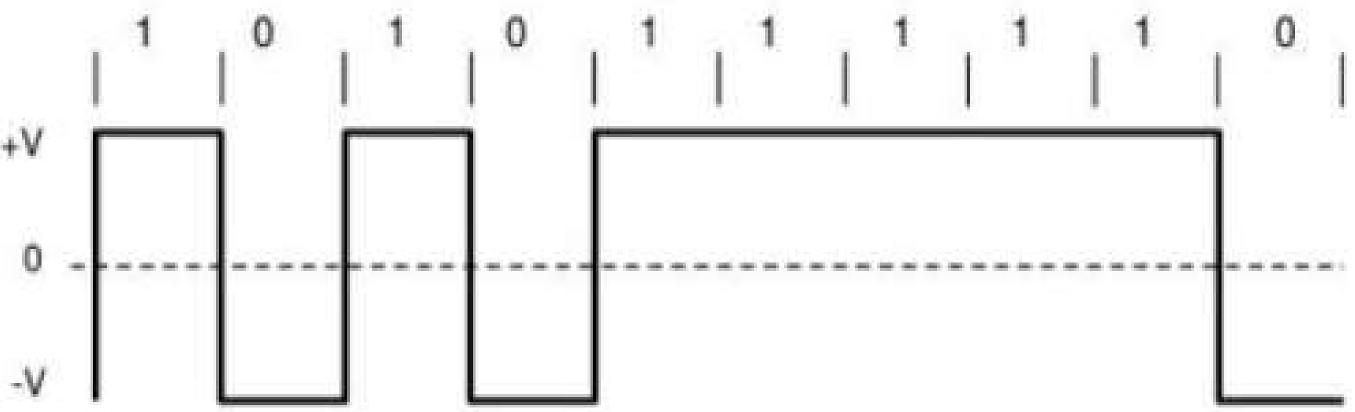
In digital communication, **Polar NRZ** is a type of line coding scheme where:

- **Binary 1** is represented by a **positive voltage level** (+V)
- **Binary 0** is represented by a **negative voltage level** (−V)

Unlike **Unipolar NRZ**, which only uses one polarity and 0V for logic '0', **Polar NRZ** uses both polarities. This has advantages:

- Reduces the **DC component** in the signal.
- Improves **synchronization** over long sequences of similar bits.

The signal does **not return to zero** between bits, maintaining the voltage level throughout the bit interval.


1
0
1
0
1
1
1
1
1
0
+V
0
-V

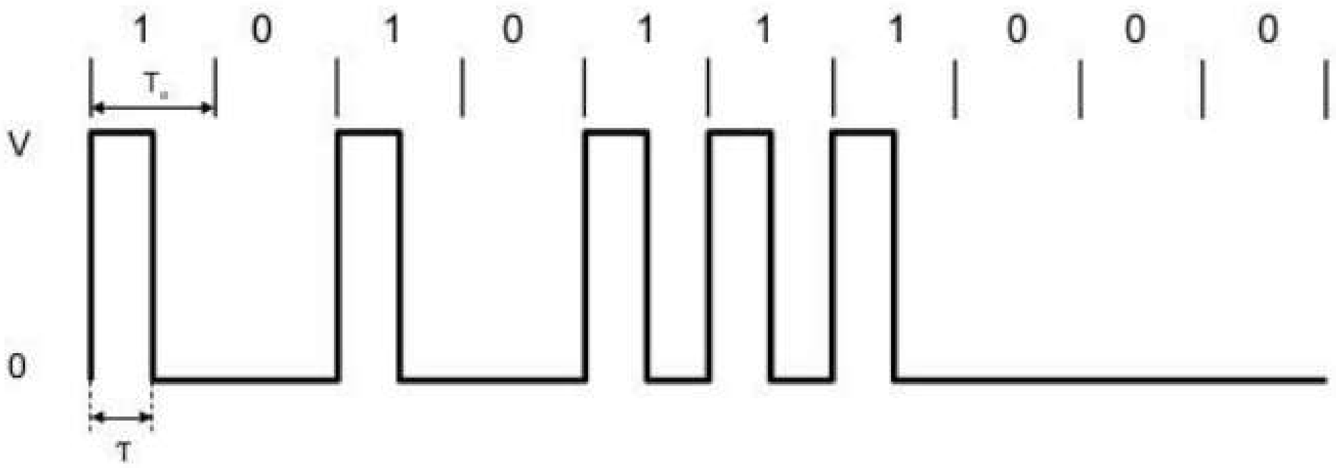
Theory:

In **Uni-polar Return to Zero (RZ)** line coding:

- **Binary 1** is represented by a **positive voltage level** for **half the bit period**, then returns to **zero** for the second half.
- **Binary 0** is represented by **zero voltage** throughout the entire bit duration.

This coding method:

- Reduces the **average power** compared to unipolar NRZ.
- Provides better **clock synchronization** due to transitions for every bit 1.
- However, it is **less bandwidth-efficient** than NRZ.


1 0 1 0 1 1 1 0 0 0
T
V
0
τ

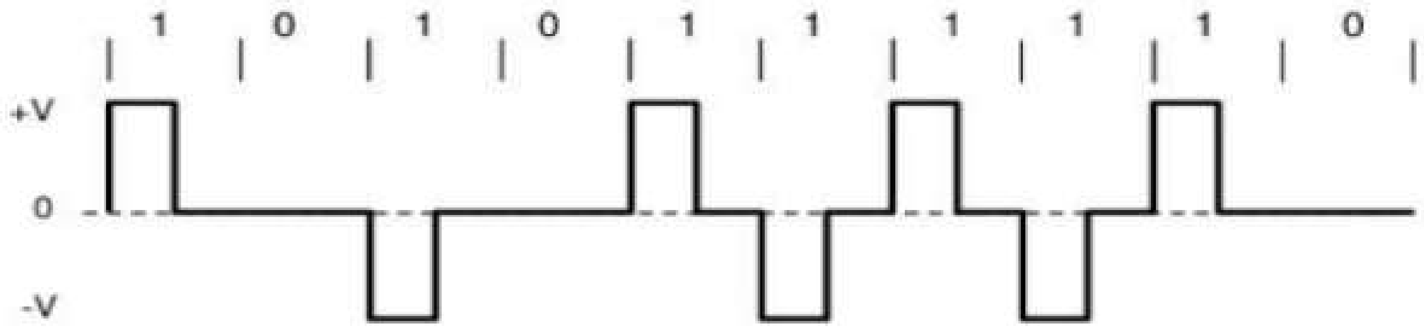
Theory:

In **Bi-polar Return to Zero (RZ)** line coding:

- **Binary 0** is represented by **zero voltage** for the entire bit duration.
- **Binary 1** is represented by an **alternating positive and negative voltage** for the **first half of the bit duration**, and **returns to zero** in the second half.
- This ensures there is **no DC component** and improves **synchronization**.

Advantages:

- No net DC component due to polarity alternation.
- Better for long-distance and transformer-coupled transmission.


1 0 1 0 1 1 1 1 1 0
+V
0
-V

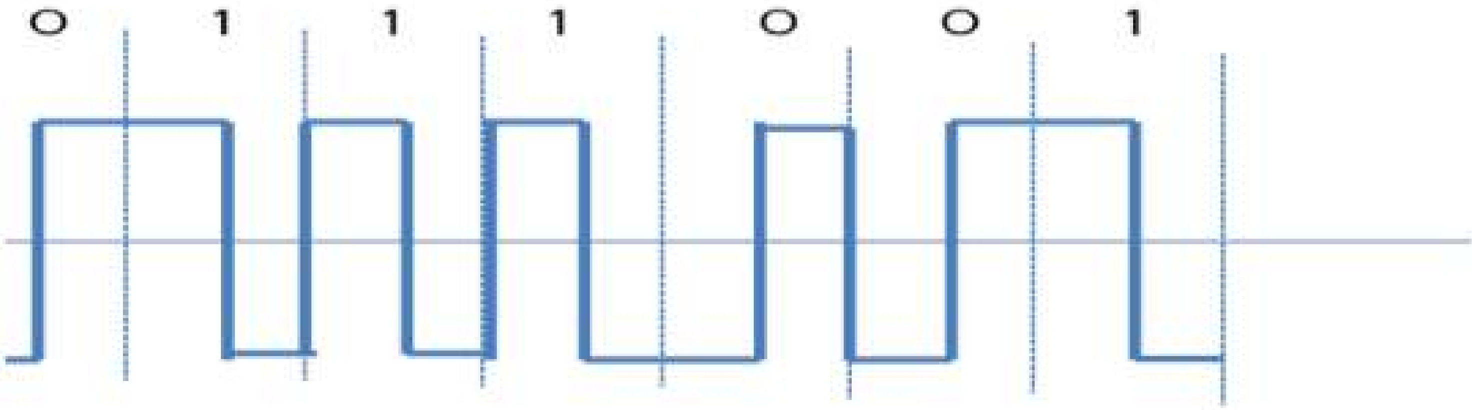
Theory:

Manchester encoding, also known as **split-phase**, is a synchronous line code where:

- Each bit has a **transition in the middle** of the bit interval.
- **Binary 1** is represented by a **high-to-low** transition.
- **Binary 0** is represented by a **low-to-high** transition.

This ensures:

- At least one transition per bit, aiding **clock recovery**.
- No DC component due to equal positive and negative pulse distribution.


0
1
1
1
0
0
1

Theory:

Amplitude Shift Keying (ASK):

Amplitude Shift Keying (ASK) is one of the simplest forms of digital modulation. In ASK, the **amplitude of a high-frequency carrier signal** is varied in accordance with the binary data (1s and 0s) being transmitted.

- When the bit is **1**, a carrier signal of amplitude **A** is transmitted.
- When the bit is **0**, **no carrier** is transmitted (i.e., amplitude is 0).

This is also known as **On-Off Keying (OOK)**.

Modulation Equation:

$$s(t) = \begin{cases} A \cdot \cos(2\pi f_c t), & \text{if bit} = 1 \\ 0, & \text{if bit} = 0 \end{cases}$$

Demodulation (Coherent Detection):

1. Multiply received signal with the same carrier used in modulation.
2. Integrate the product over the bit period.
3. If the result exceeds a threshold, detect bit as 1; otherwise, 0.

Theory:

Frequency Shift Keying (FSK):

Frequency Shift Keying (FSK) is a type of **digital modulation** technique where the **frequency of the carrier signal** is changed according to the digital input binary data.

- **Binary 1** is represented by a carrier of **frequency** f_1.
- **Binary 0** is represented by a carrier of **frequency** f_2.

The amplitude and phase of the carrier remain constant; only the frequency is varied.

Modulation Equation:

$$s(t) = \begin{cases} A \cdot \cos(2\pi f_1 t), & \text{if bit} = 1 \\ A \cdot \cos(2\pi f_2 t), & \text{if bit} = 0 \end{cases}$$

Demodulation:

Demodulation is done using **coherent detection**, where the received FSK signal is **correlated** with both frequencies f_1 and f_2. The one with higher correlation is chosen to determine the transmitted bit.

Theory:

Binary Phase Shift Keying (BPSK):

BPSK is a **digital modulation technique** in which the **phase** of a constant amplitude carrier signal is changed based on the binary input.

- **Binary 1** is represented by a carrier signal with **0° phase** shift.
- **Binary 0** is represented by a carrier signal with **180° phase** shift (i.e., the signal is inverted).

This results in a more power-efficient and bandwidth-efficient modulation scheme compared to ASK and FSK.

Modulation Equation:

$$s(t) = \begin{cases} A \cdot \cos(2\pi f_c t), & \text{if bit} = 1 \\ -A \cdot \cos(2\pi f_c t), & \text{if bit} = 0 \end{cases}$$

Demodulation (Coherent Detection):

The demodulator multiplies the received BPSK signal with the same carrier used during modulation and integrates the result over one bit period. The sign of the result determines the transmitted bit.

Theory:

Quadrature Phase Shift Keying (QPSK) is a type of digital modulation scheme that conveys data by changing (modulating) the phase of a reference signal (the carrier wave). In QPSK:

- Two bits are grouped together to form a symbol.
- Each symbol is represented by a unique phase shift of the carrier: typically 0°, 90°, 180°, or 270°.
- This allows transmission of **2 bits per symbol**, doubling the bandwidth efficiency compared to BPSK.

Mathematical Representation:

Each symbol $s(t)$ can be represented as:

$$s(t) = A\cos(2\pi f_c t + \phi)$$

Where:

- A is the amplitude,
- f_c is the carrier frequency,
- ϕ is the phase corresponding to the bit pair (00, 01, 10, 11).

Demodulation involves separating the received signal into in-phase (I) and quadrature (Q) components and decoding the phase to get the bit pairs.

Theory:

Pulse Amplitude Modulation (PAM) is a modulation technique where the amplitude of regularly spaced pulses is varied in proportion to the instantaneous amplitude of the modulating (message) signal.

Mathematical Representation:

Let $m(t)$ be the message signal and $p(t)$ be the pulse train:

- The PAM signal is:

$$s(t) = m(t) \cdot p(t)$$

Where $p(t)$ is a periodic pulse train:

$$p(t) = \sum_{n=-\infty}^{\infty} \delta(t - nT_s)$$

with T_s as the sampling interval.

In practical systems, instead of delta pulses, rectangular pulses of short duration are used, modulated by the sampled message amplitude.

Demodulation of PAM can be achieved by:

- Sampling the PAM signal at pulse instances.
- Holding or filtering to reconstruct the message signal.

Theory:

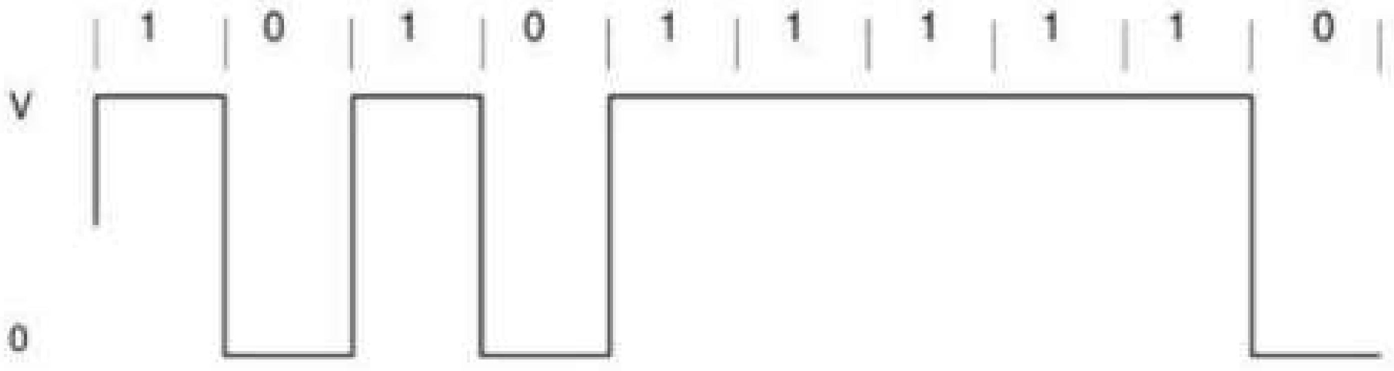
In digital communication, line coding is the process of converting a digital bit stream (binary data) into a form suitable for transmission over a communication channel.

In **Uni-polar Non-Return to Zero (NRZ)** line coding:

- **Binary 1** is represented by a **positive voltage level (V)**.
- **Binary 0** is represented by **zero voltage**.
- There is **no return to zero voltage** between bits, hence the name NRZ.

This technique is simple and uses a **single polarity**. However, it suffers from:

- Lack of synchronization or **clocking information**.
- **High DC components**, which can be problematic especially for long sequences of 0s or 1s.



1
0
1
0
1
1
1
1
1
0
V
0