QPSK Modulation

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WHAT IS PHASE MODULATION ?

In digital communication, Phase Modulation (PM) is a technique where the phase of a carrier signal is altered based on digital data. It is widely used in wireless systems, satellite communication, and modern digital transmission techniques.

HOW DOES IT WORK ?

- A high-frequency carrier wave is used to transmit data.
- The phase of this carrier wave is changed according to the incoming binary data (0s and 1s).
- The receiver detects these phase changes and decodes the original data.

TYPES OF DIGITAL PHASE MODULATION

- Binary Phase Shift Keying (BPSK)
- Quadrature Phase Shift Keying (QPSK)
- 8 - PSK and Higher - Order PSK

BINARY PHASE SHIFT KEYING (BPSK)

Binary Phase Shift Keying (BPSK) is the simplest form of digital phase modulation, where the carrier signal's phase is shifted by 0° or 180° based on the input binary data (0 or 1). It is also known as 2-PSK since it uses two distinct phase states.

WORKING PRINCIPLE

1. A carrier wave is generated at a fixed frequency.

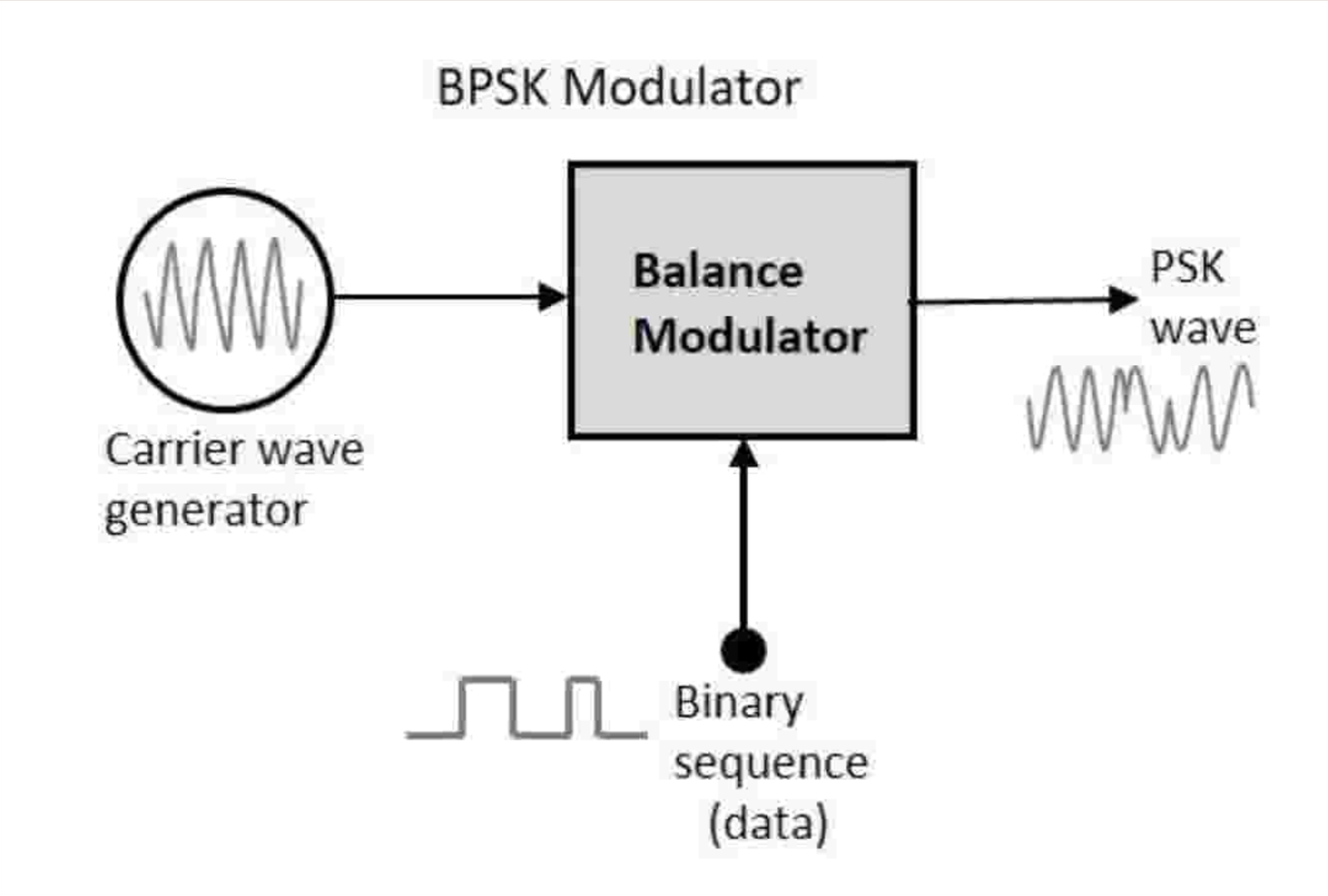
2. The digital input data (0s and 1s) determine the phase of the carrier wave:

Bit '1' → Carrier phase remains 0°.

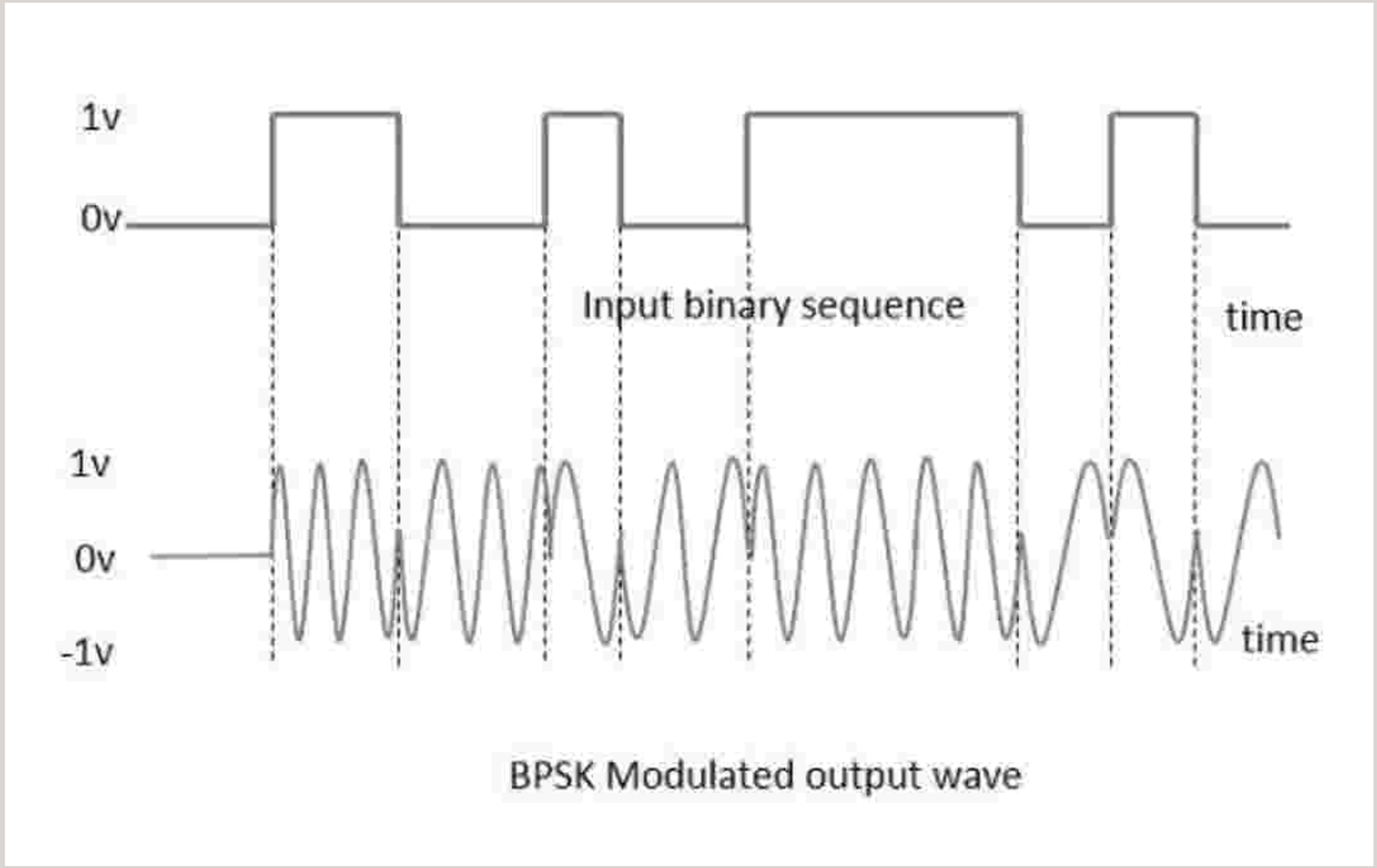
Bit '0' → Carrier phase shifts by 180°.

3. The receiver detects phase changes and decodes the original binary data.

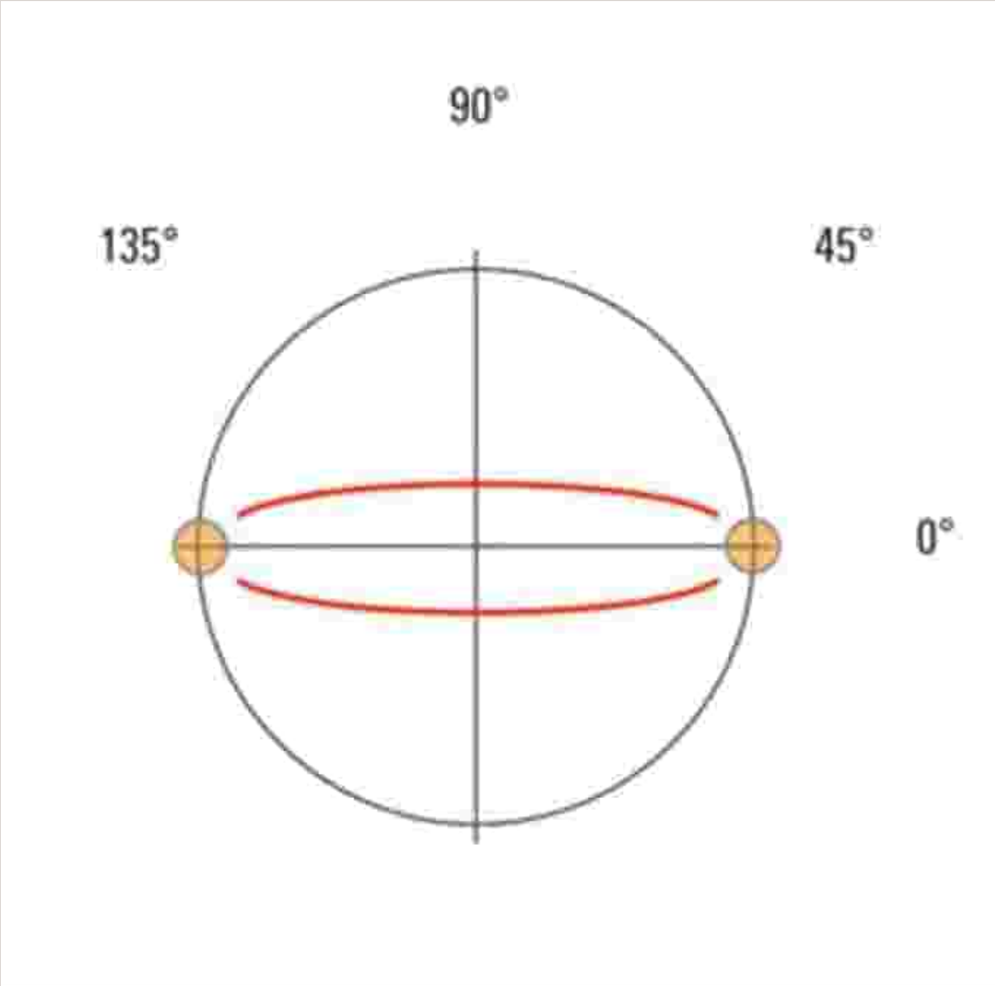
BLOCK DIAGRAM



WAVE DIAGRAM



CONSTELLATION DIAGRAM



QUADRATURE PHASE SHIFT KEYING (QPSK)

Quadrature Phase Shift Keying (QPSK) is a digital modulation scheme that encodes two bits per symbol by shifting the phase of a carrier wave among four different phase states (0°, 90°, 180°, and 270°). This allows QPSK to transmit twice the data rate of BPSK while using the same bandwidth.

WORKING PRINCIPLE

- A high-frequency carrier wave is used for transmission.
- Two consecutive bits (a symbol) determine the phase shift of the carrier:

  $00 \rightarrow 0^\circ$

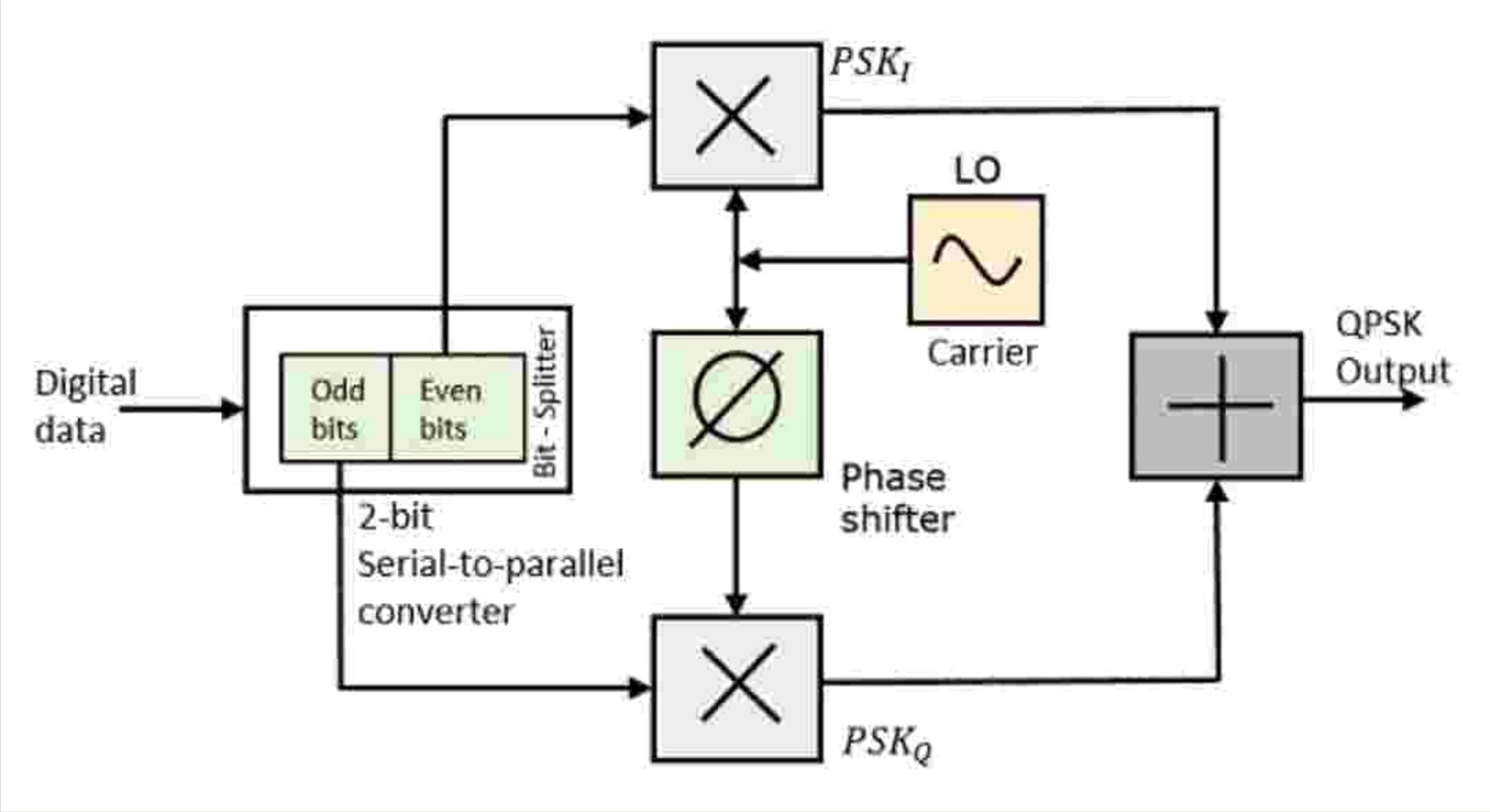
  $01 \rightarrow 90^\circ$

  $10 \rightarrow 180^\circ$

  $11 \rightarrow 270^\circ$

- At the receiver, the phase of the incoming signal is detected and mapped back to the corresponding bit pair.

BLOCK DIAGRAM



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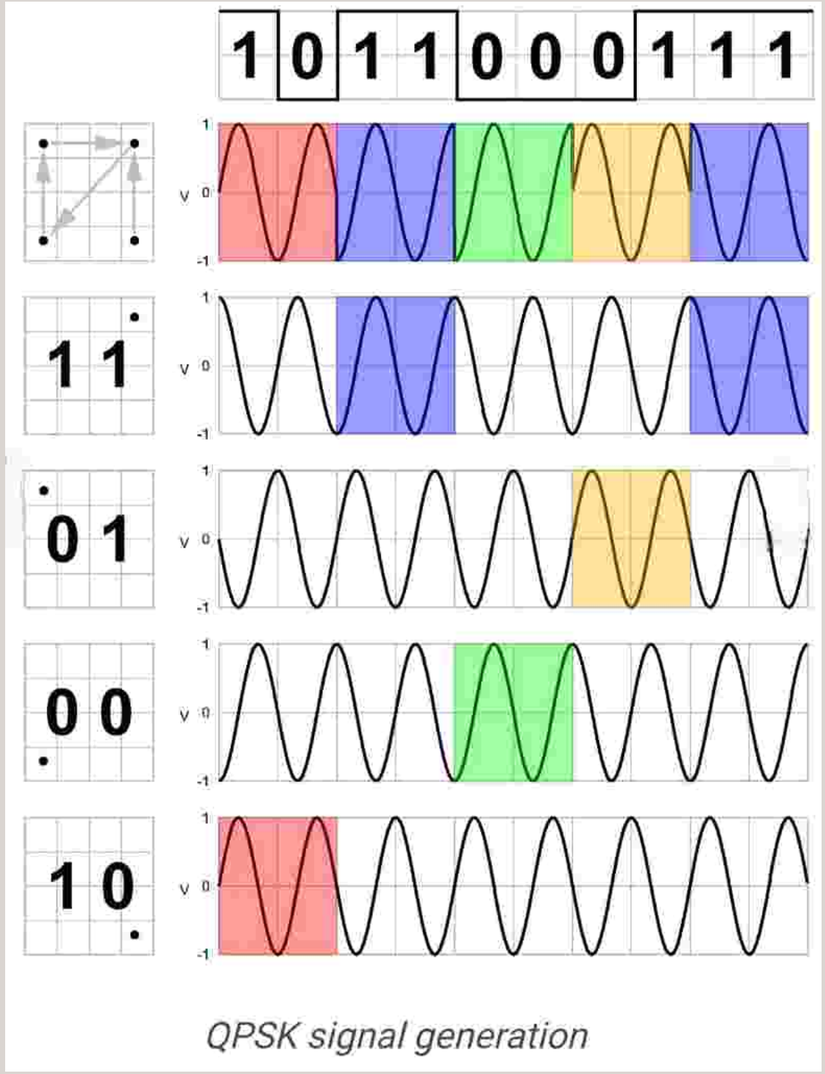
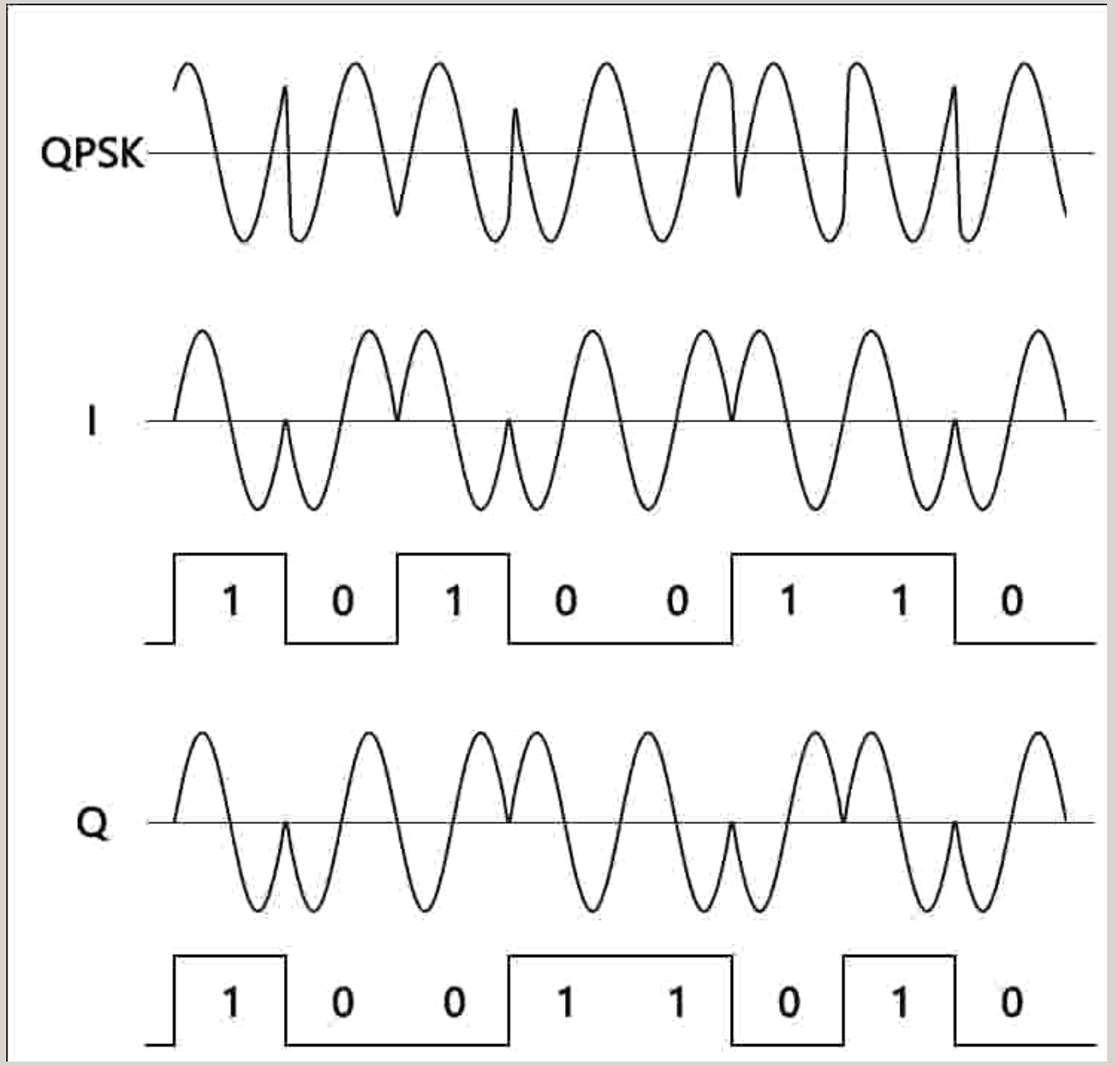
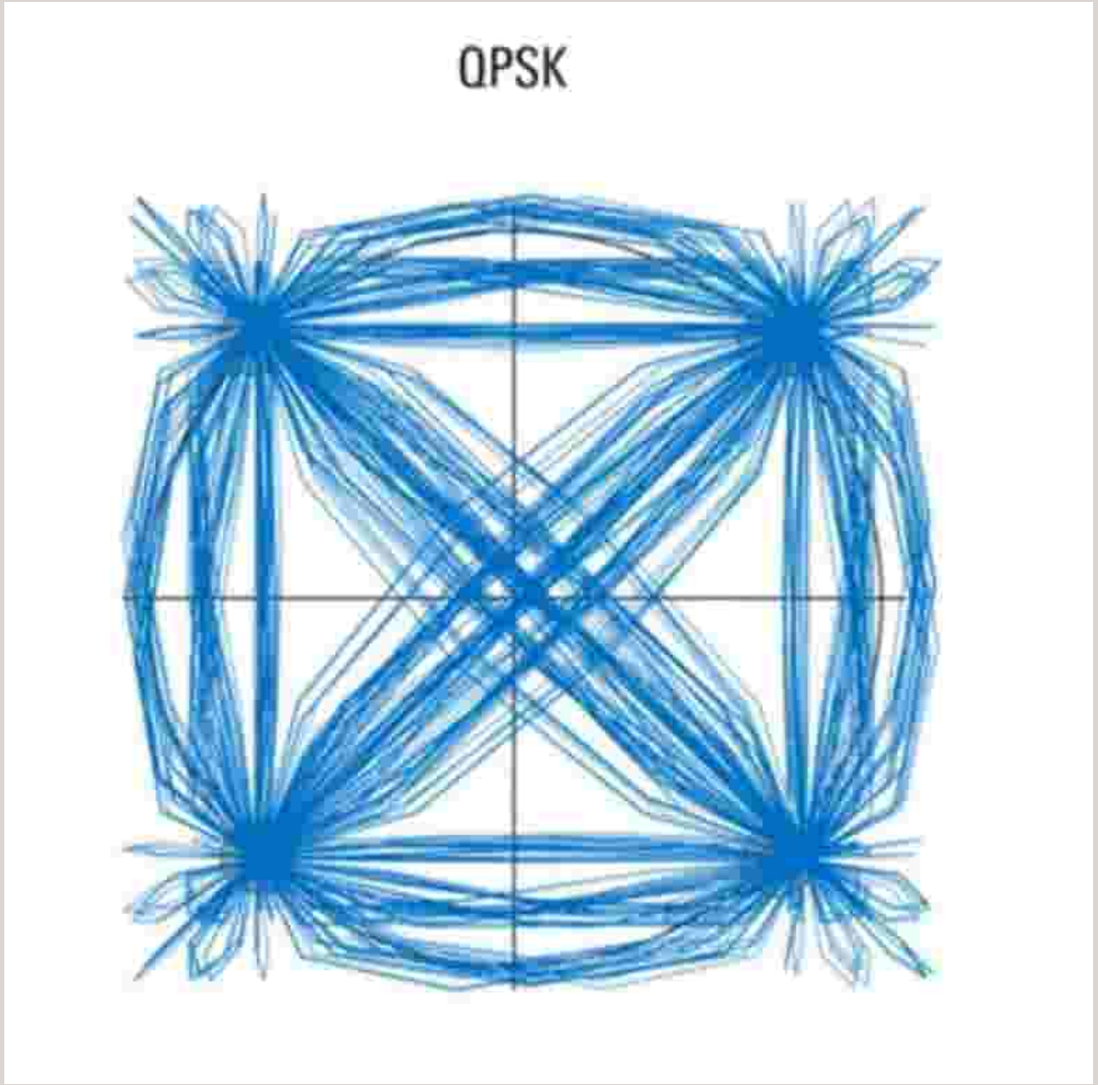


QPSK signal generation



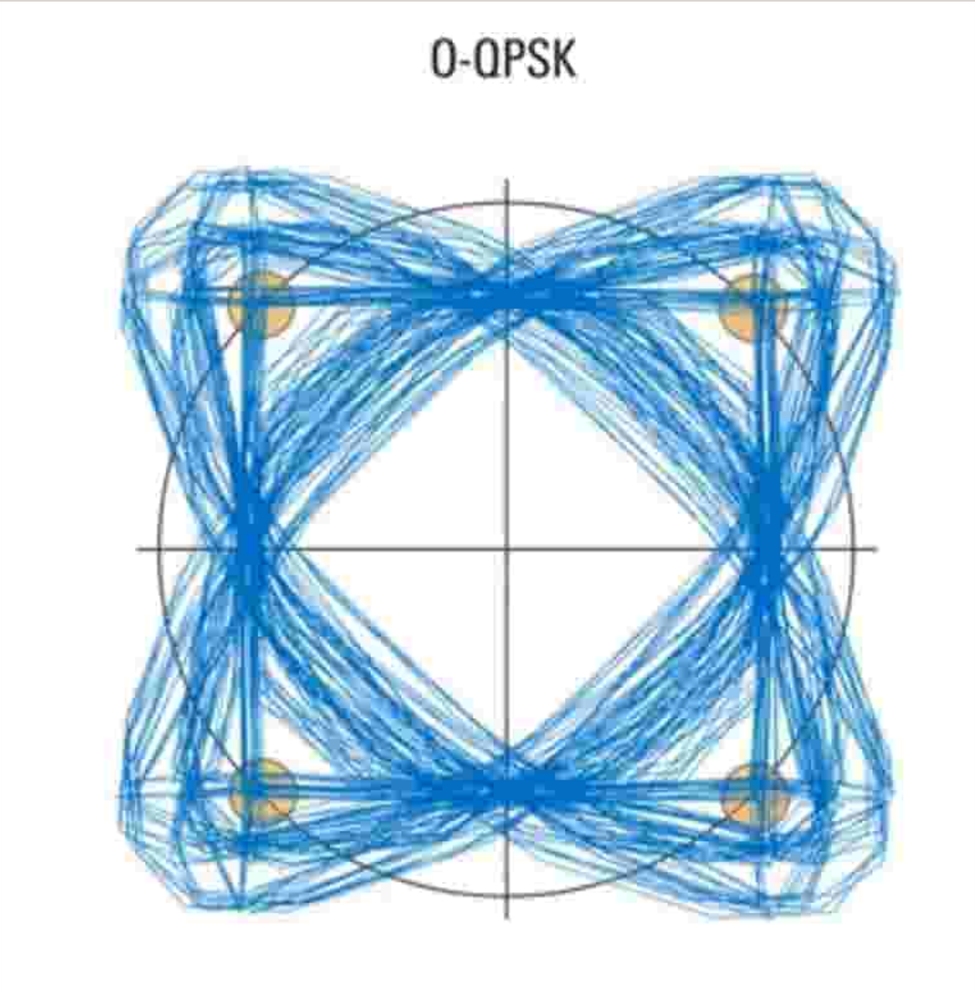
CONSTELLATION DIAGRAM

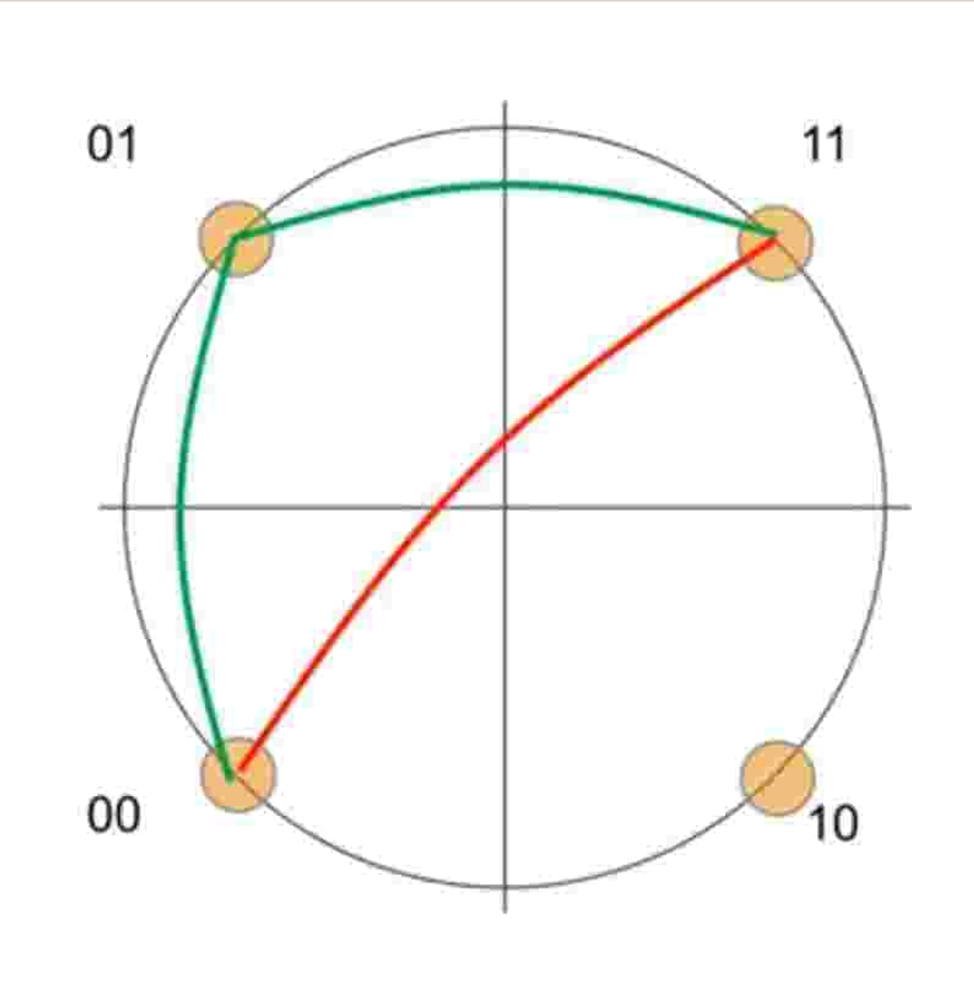


OFFSET QPSK

- Also known as Staggered QPSK.
- The I (In-phase) and Q (Quadrature) components are offset by half a symbol period to reduce sudden phase transitions.
- This reduces signal fluctuations (amplitude variations), making it more power-efficient and reducing signal distortion.

CONSTELLATION DIAGRAMS



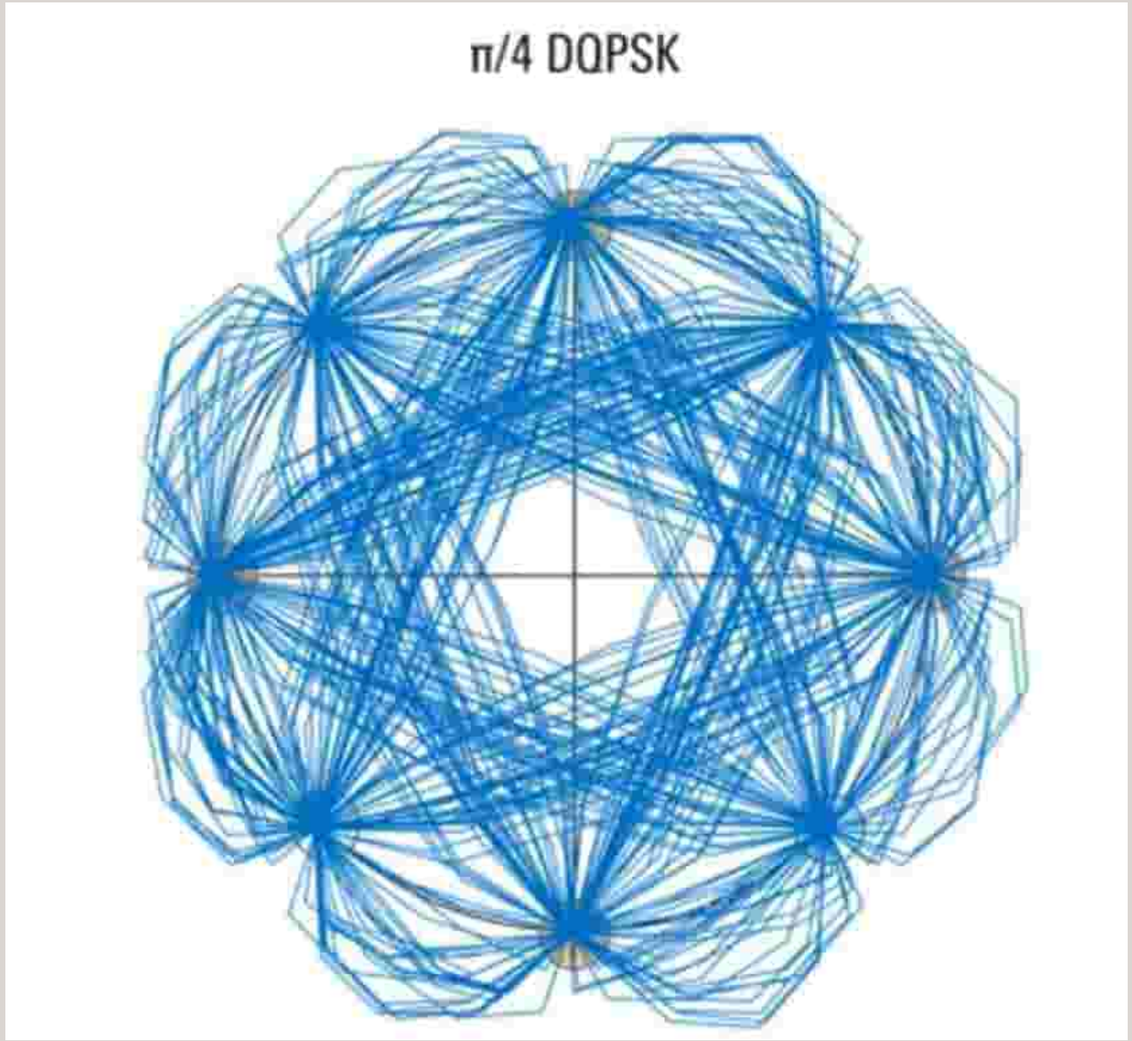


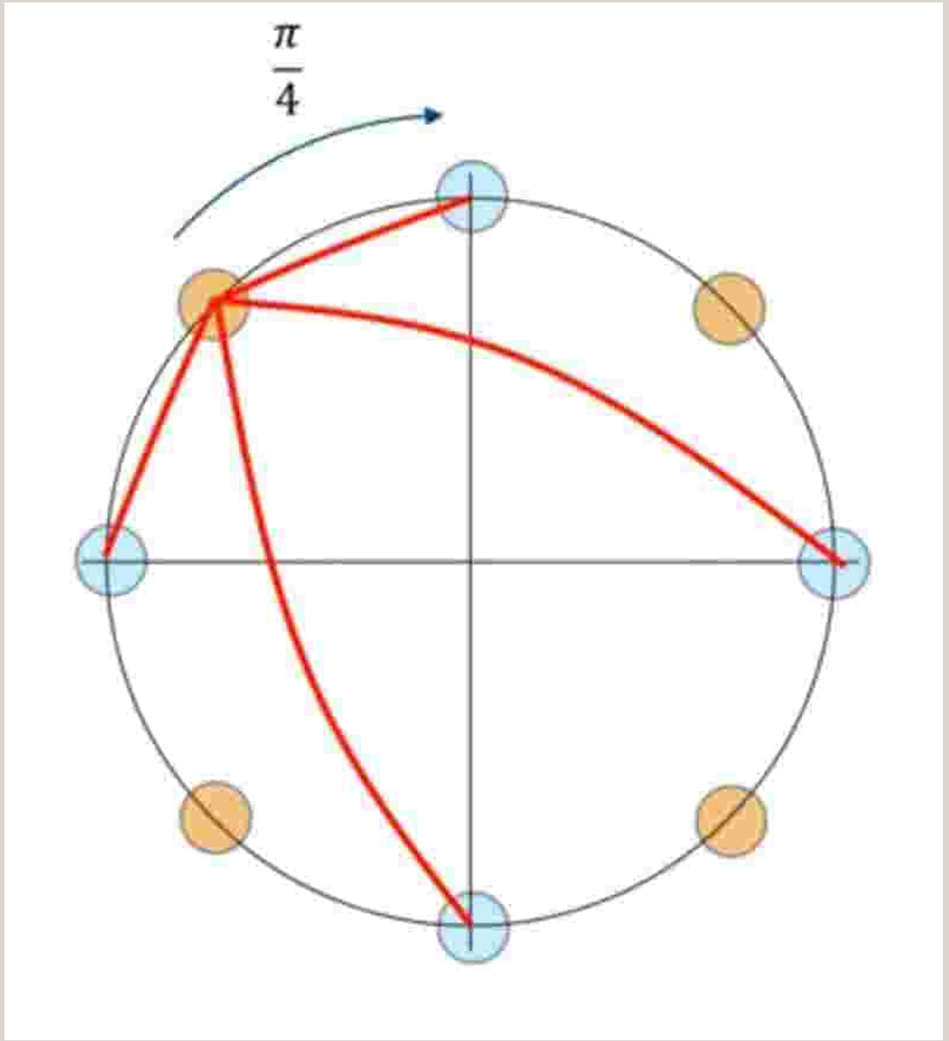
π/4–QPSK (Pi/4 Shift QPSK)

- Each symbol transition changes by ±45° or ±135°, rather than jumping directly between 0°, 90°, 180°, and 270°.

- This ensures smoother phase transitions, reducing signal distortion in nonlinear channels (like mobile communication).

CONSTELLATION DIAGRAMS





8-PSK and HIGHER-ORDER PSK

- Uses 8 or more phase shifts to encode 3 or more bits per symbol, improving spectral efficiency.

- Used in high-speed digital communications like Wi-Fi and 5G networks.

APPLICATIONS

- Wi-Fi (802.11 standards) uses QPSK and 16-QAM (which includes phase modulation).
- 4G LTE and 5G networks rely on QPSK and higher-order PSK for efficient data transmission.
- Satellite and deep-space communication use phase modulation for long-distance, low-power signals.

Thank You