Al-Mustaqbal University
College of Engineering & Technology
Computer Techniques Engineering Department

Digital Communication

Lecture 12

Differential Phase Shift Keying (DPSK)

Principles, Generation, Bandwidth, and Advantages/Disadvantages

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Introduction to DPSK

- **Definition:**
  - DPSK (Differential Phase Shift Keying) is a digital modulation method that does **not** require a coherent carrier at the receiver.
  - Instead of detecting absolute phase changes, it **compares the phase** of the current bit with the previous bit.
- **Key Concept:**
  - The phase of a transmitted bit depends on the previous bit.
  - If the input bit is "1", the phase **changes**; if "0", the phase **remains the same**.

DPSK Generator

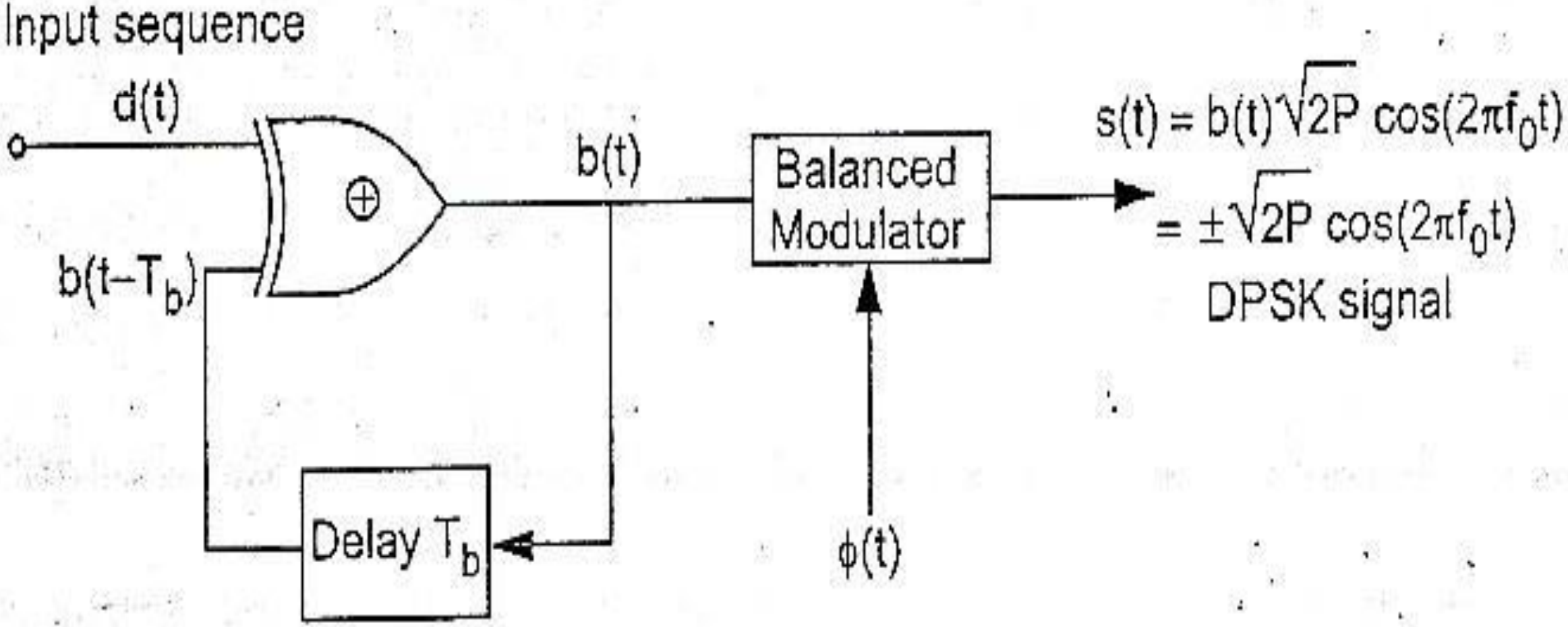
- **Components:**
  1. **Input Binary Sequence** $d(t)$
  2. **Previous Output** $b(t - T_b)$ **(Delayed by one bit period)**
  3. **Exclusive OR (XOR) Gate** generates the new sequence $b(t)$.
- **Truth Table:**

$d(t)$	$b(t - T_b)$	$b(t)$ **(Output)**
0	0	0
0	1	1
1	0	1
1	1	0

- **Equation:**

$$b(t) = d(t) \oplus b(t - T_b)$$

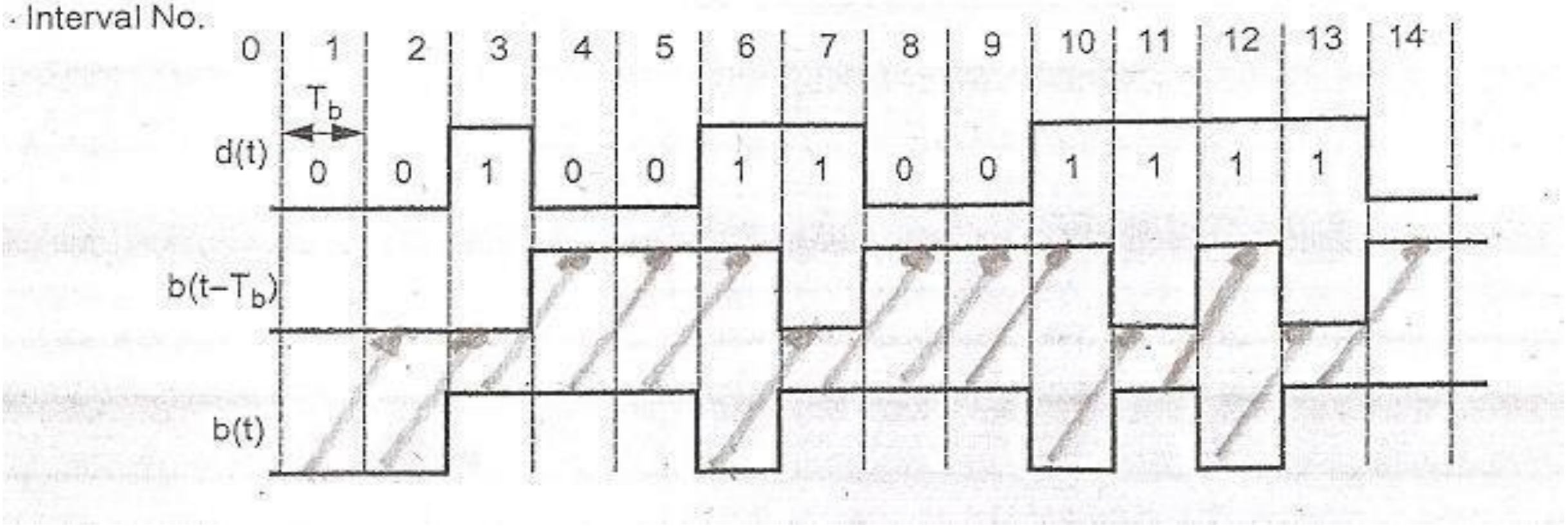
DPSK Generator Block Diagram



DPSK Waveform Representation

Waveform Explanation:

- If d(t)=1d(t) = 1d(t)=1, the **phase changes**.
- If d(t)=0d(t) = 0d(t)=0, the **phase remains unchanged**.



DPSK waveform

DPSK Modulation Process

- The **DPSK signal** is generated using a **balanced modulator** with a carrier:

$$S(t) = b(t) \cdot \sqrt{2P}\cos(2\pi f_0 t)$$

  - Where $b(t)$ is the differentially encoded sequence.

- **Key Feature:** The **phase changes** only when $d(t) = 1$.

DPSK Receiver Structure

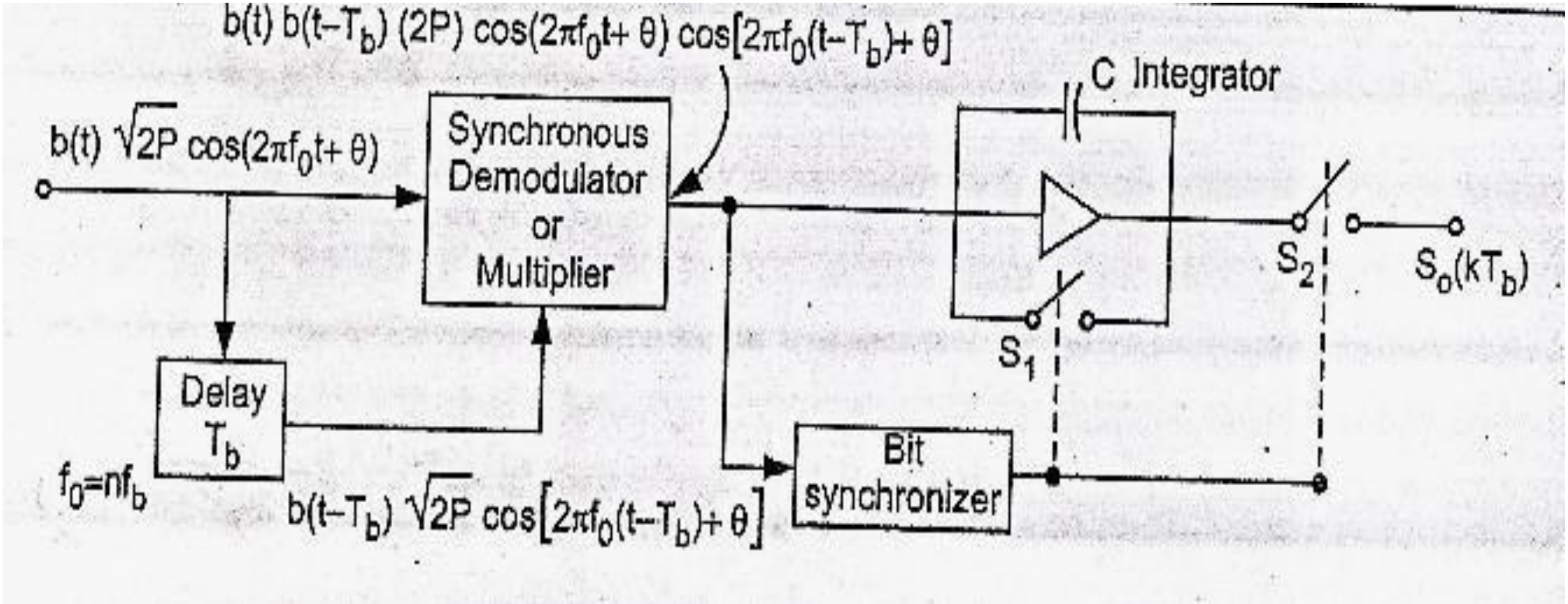
- **How It Works:**
  - The received signal undergoes a **phase shift θ during transmission**.
  - The **delayed version** of the received signal is **multiplied** with the current received signal.
  - This removes the need for a **coherent reference carrier**.
- **Equation:**

$$\text{Received Signal} = S(t) \cdot \sqrt{2P} \cos(2\pi f_0 t + \theta)$$

  - Multiplier Output:

$$S(t) \cdot S(t - T_b) \cdot (2P) \cos(2\pi f_0 t + \theta) \cos(2\pi f_0 (t - T_b) + \theta)$$

DPSK Receiver Block Diagram



Bandwidth of DPSK

- **Symbol Duration:**
  - Since one previous bit is used to determine the phase of the next bit, **each symbol consists of two bits**.
  - **Symbol duration** $T = 2T_b$.
- **Bandwidth Formula:**

$$BW = \frac{1}{T} = f_b$$

  - **Bandwidth is the same as the bit rate**.

Advantages of DPSK

- **No Carrier Synchronization Needed** – Unlike BPSK, DPSK does not require a reference carrier at the receiver.
- **Lower Bandwidth Requirement** – Uses less bandwidth than BPSK.

Disadvantages of DPSK

- **Higher Bit Error Rate (BER)** – More susceptible to noise than BPSK.
- **Error Propagation** – Errors in one bit **affect the next bit**, leading to more transmission errors.
- **Noise Sensitivity** – More affected by channel distortions.

Comparison of BPSK, BFSK, BASK, and DPSK

Feature	BPSK (Binary Phase Shift Keying)	BFSK (Binary Frequency Shift Keying)	BASK (Binary Amplitude Shift Keying)	DPSK (Differential Phase Shift Keying)
Modulation Technique	Phase Shift	Frequency Shift	Amplitude Shift	Phase Shift (relative to previous bit)
Bandwidth Requirement	**Moderate** (Lower than BFSK)	**High** (Wider spectrum)	**Low** (Efficient but noisy)	**Same as BPSK**
Power Efficiency	**High**	**Moderate**	**Low**	**Moderate**
Noise Immunity	**High**	**Moderate (Better than ASK)**	**Low (Highly affected by noise)**	**Lower than BPSK**
Receiver Complexity	**High** (Coherent detection required)	**Moderate**	**Low** (Simplest detection)	**Lower than BPSK (No carrier synchronization)**
Error Probability	**Lower BER** (Better performance)	**Higher BER** than BPSK	**Very High BER** (Noise-sensitive)	**Higher BER due to error propagation**
Application	Satellite Communication, Wi-Fi, 5G	Bluetooth, RFID, Radio Transmission	Optical Communication, Low-power RF	Wireless LAN, Bluetooth, Data Links

Conclusion

- ✓**DPSK is a simple alternative to BPSK** that eliminates the need for a coherent carrier.
- ✓**It achieves phase shift by comparing with previous bits** rather than absolute values.
- ✓**However, it has higher error rates and is more sensitive to noise**.

Thank You