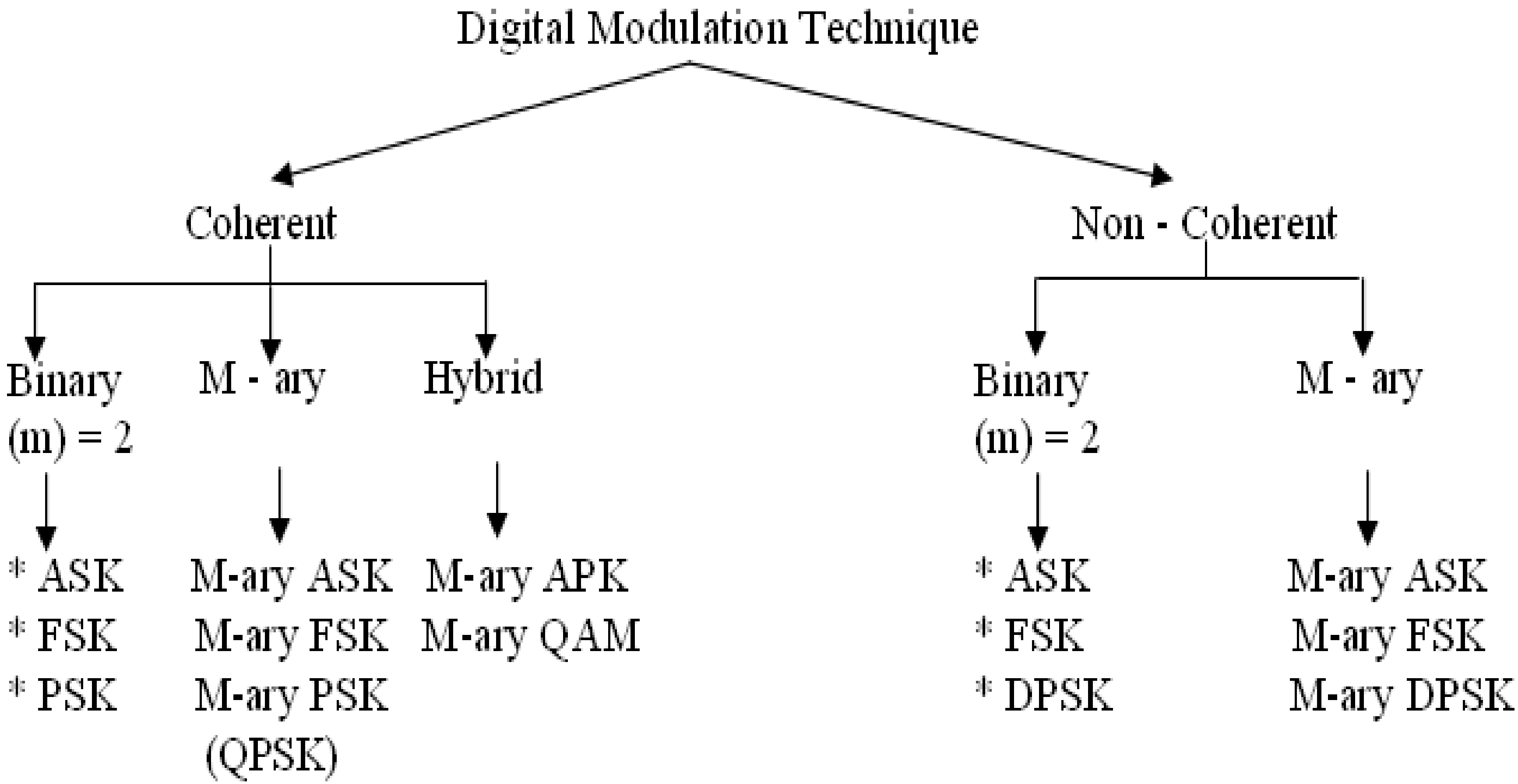
Subject : Digital Communication

Code : UEC 639

Credit : 4

Dr. Amit Mishra

Hierarchy of digital modulation technique



Need of Noncoherent detection

In coherent detection we need to generate a reference signal corresponding to frequency and phase of transmitter carrier. The reference signal helps in correct detection of transmitting symbols. But this makes the receiver module complex due to additional circuit to generate reference signal at receiver.

Noncoherent schemes on the other side does not need reference signal for detection and offers a simpler receiver circuit. But it deteriorates the performance of the receiver (BER, SER).

Differential Phase-Shift Keying

DPSK is a noncoherent version of PSK. The distinguishing feature of this scheme is that it eliminates the need for synchronizing the receiver to the transmitter by combining two basic operations at the transmitter:

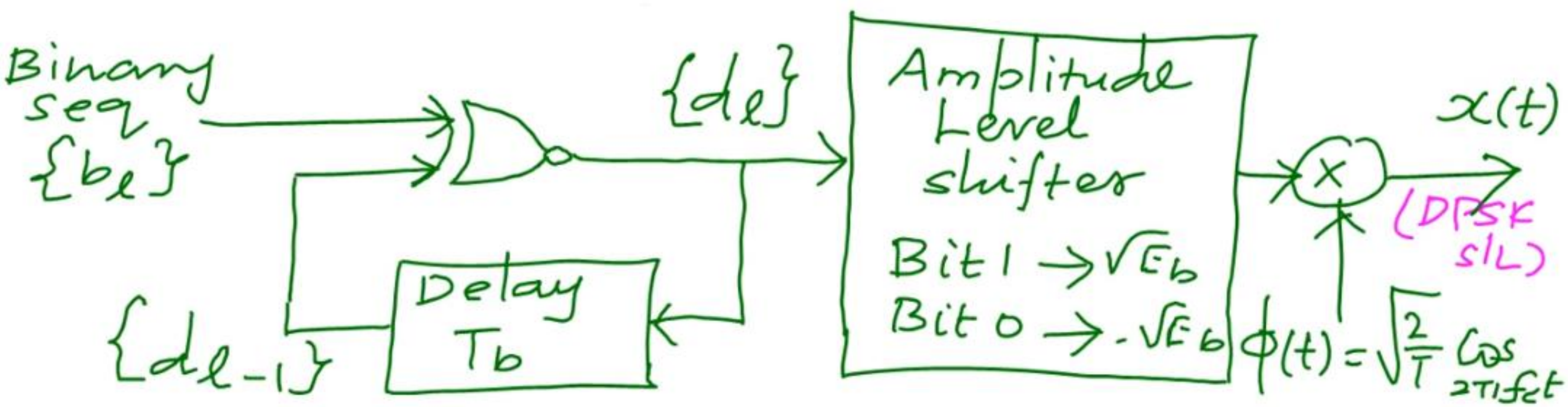
- ***differential encoding*** **of the input binary sequence and**
- ***PSK*** **of the encoded sequence**

Differential Encoding + PSK = DPSK

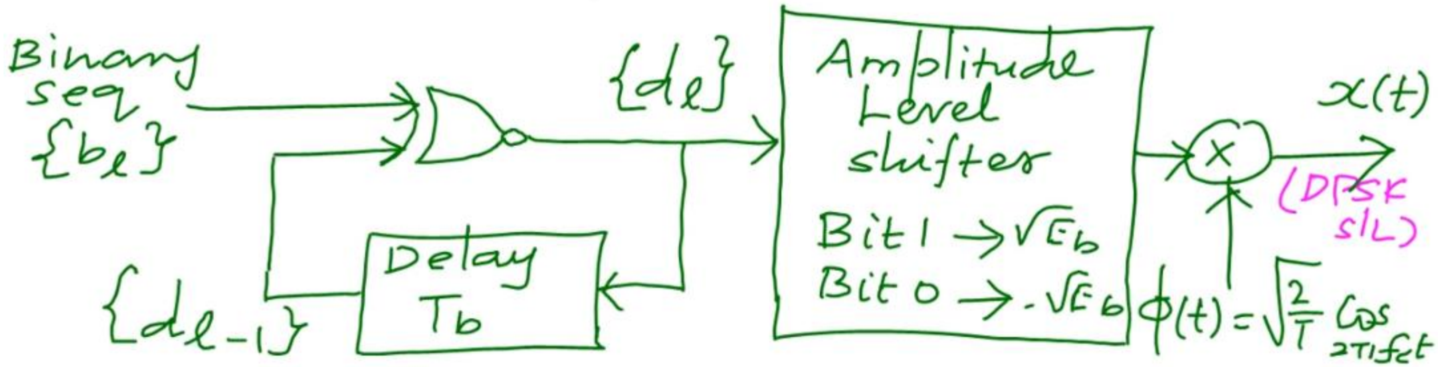
Differential encoding starts with an arbitrary first bit, serving as the *reference bit (*symbol 1). The differentially encoded sequence, denoted by **$\{d_l\}$,** is used to shift the sinusoidal carrier phase by zero and 180°, representing symbols 1 and 0, respectively. Thus, in terms of phase-shifts, the resulting DPSK signal follows the two-part rule:

Rule-1: To send symbol 1, the phase of the DPSK signal remains unchanged.

Rule-2: To send symbol 0, the phase of the DPSK signal is shifted by 180°.



Example:

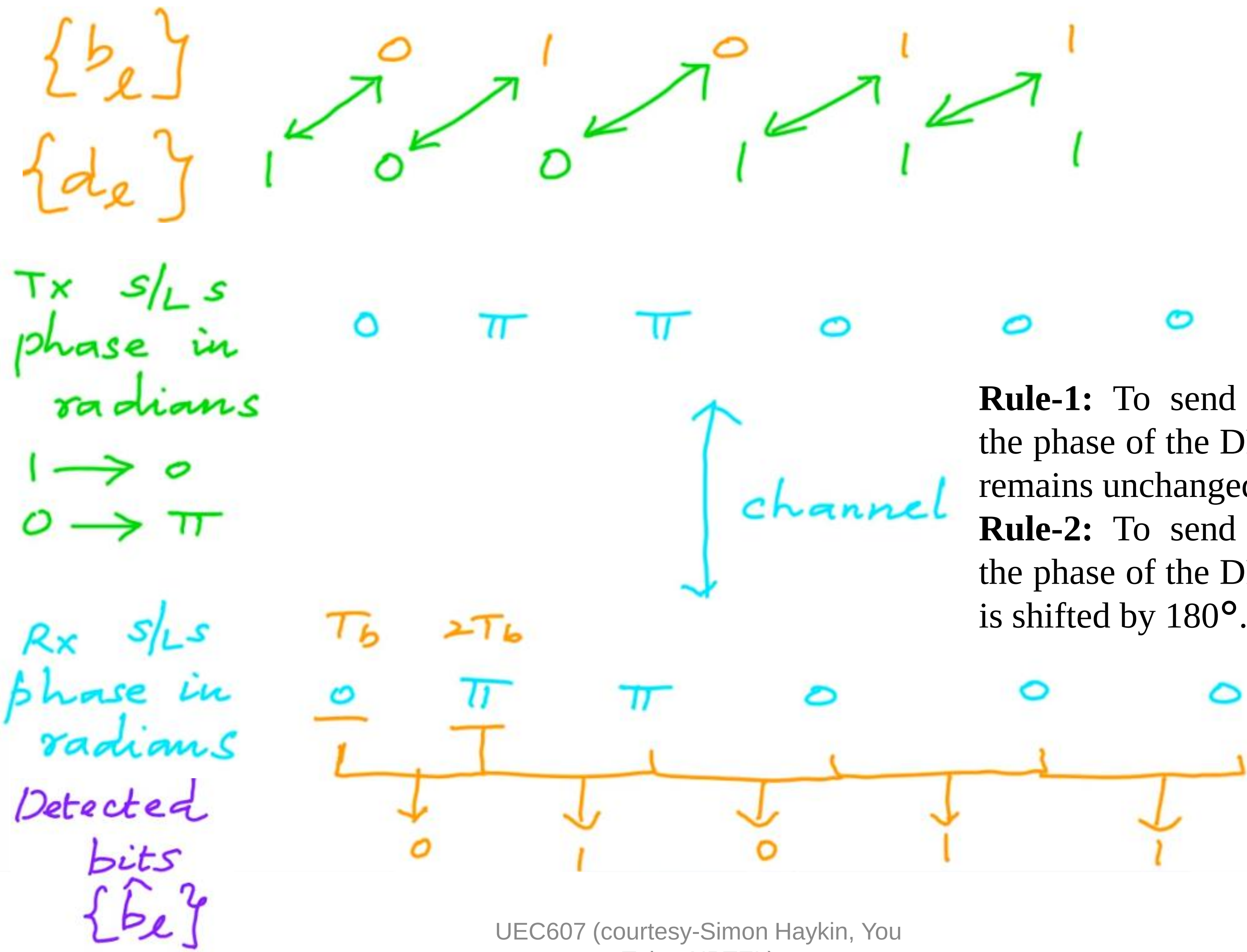


Differential coder o/p

$$d_l = \overline{b_l \oplus d_{l-1}}$$

$\{b_l\}$		0	1	0	1	1
$\{d_l\}$	1	0	0	1	1	1

Continued…



Rule-1: To send symbol 1, the phase of the DPSK signal remains unchanged.

Rule-2: To send symbol 0, the phase of the DPSK signal is shifted by 180°.

Determination of transmitted phase

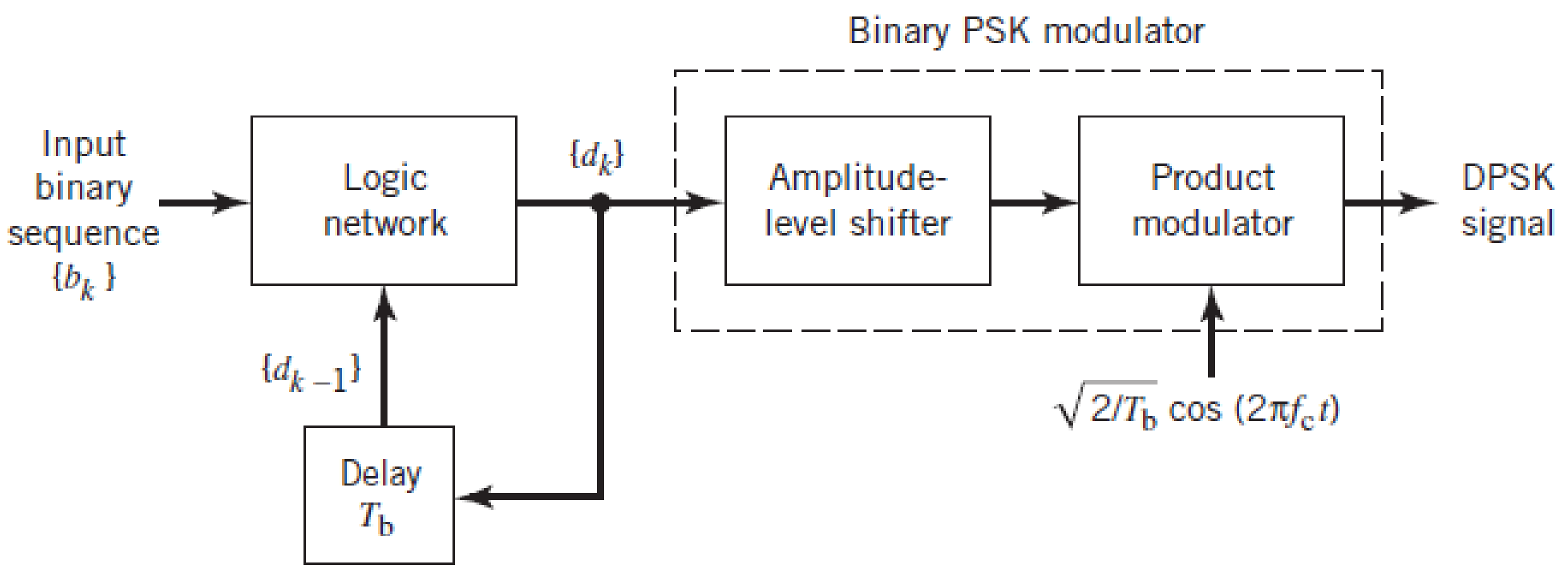
Consider the input binary sequence $\{b_k\}$, to be 10010011. Let $\{d_k\}$ denote the differentially encoded sequence and $\{d_{k-1}\}$ denote its delayed version by one bit. The complement of the modulo-2 sum of $\{b_k\}$ and $\{d_{k-1}\}$ and defines the desired $\{d_k\}$.

$\{b_k\}$		1	0	0	1	0	0	1	1
$\{d_{k-1}\}$		1	1	0	1	1	0	1	1
	reference								
Differentially encoded sequence $\{d_k\}$	1	1	0	1	1	0	1	1	1
Transmitted phase (radians)	0	0	π	0	0	π	0	0	0

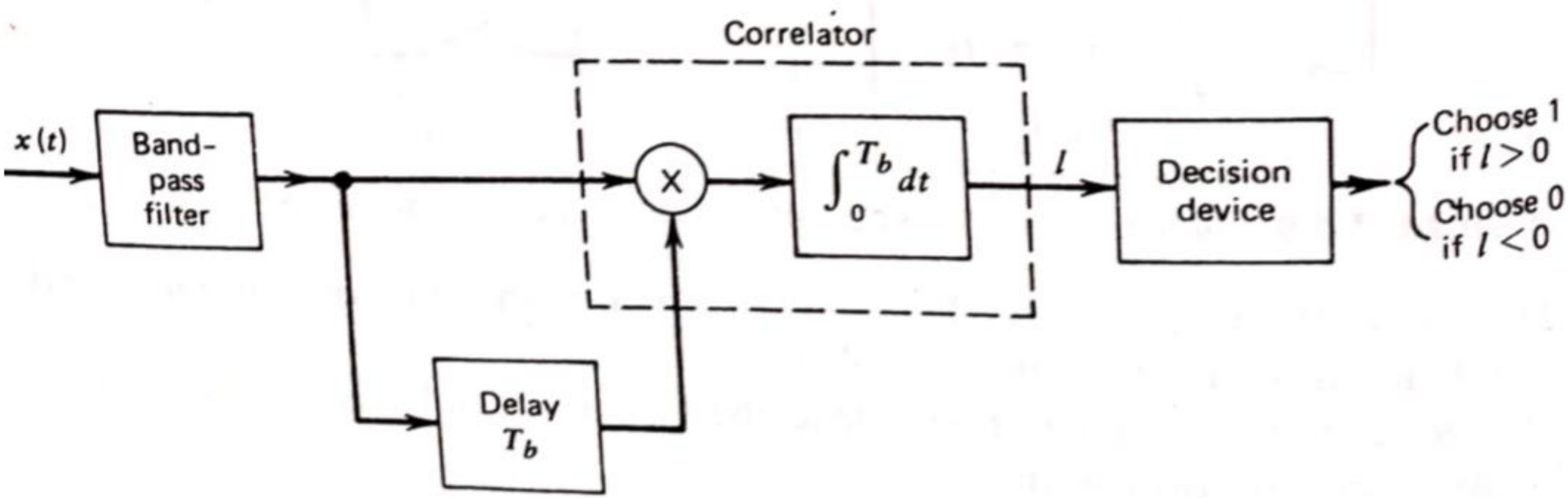
Generation of DPSK Signal

The DPSK transmitter consists of two functional blocks:

- *Logic network and one-bit delay (storage) element*, which are interconnected so as to convert the raw input binary sequence $\{b_k\}$ into the differentially encoded sequence $\{d_k\}$.
- *Binary PSK modulator*, the output of which is the desired DPSK signal.



Optimum Receiver for DPSK

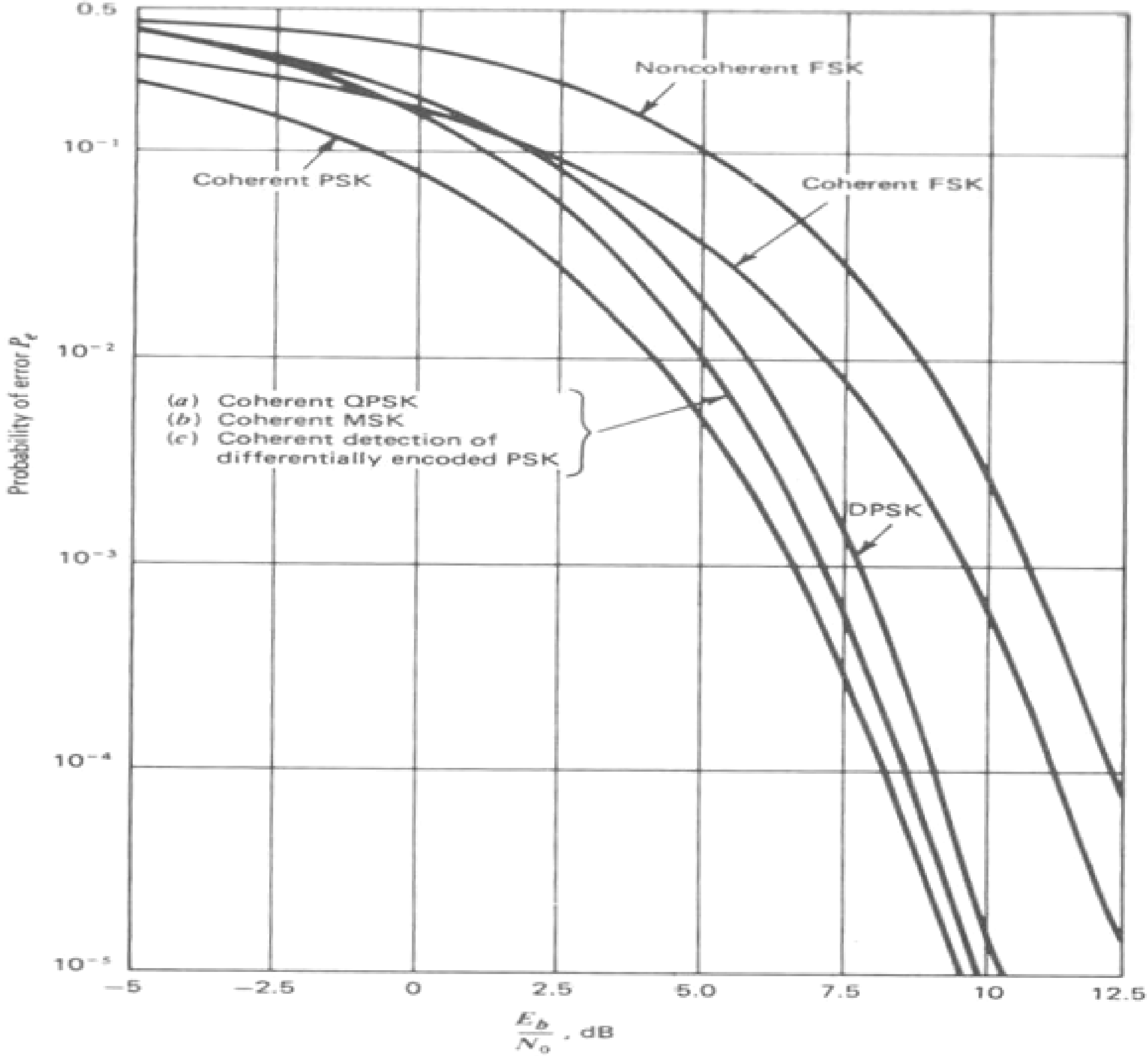


Consider the input The resulting correlator output is proportional to the cosine of the difference between the carrier phase angles in the two correlator inputs.

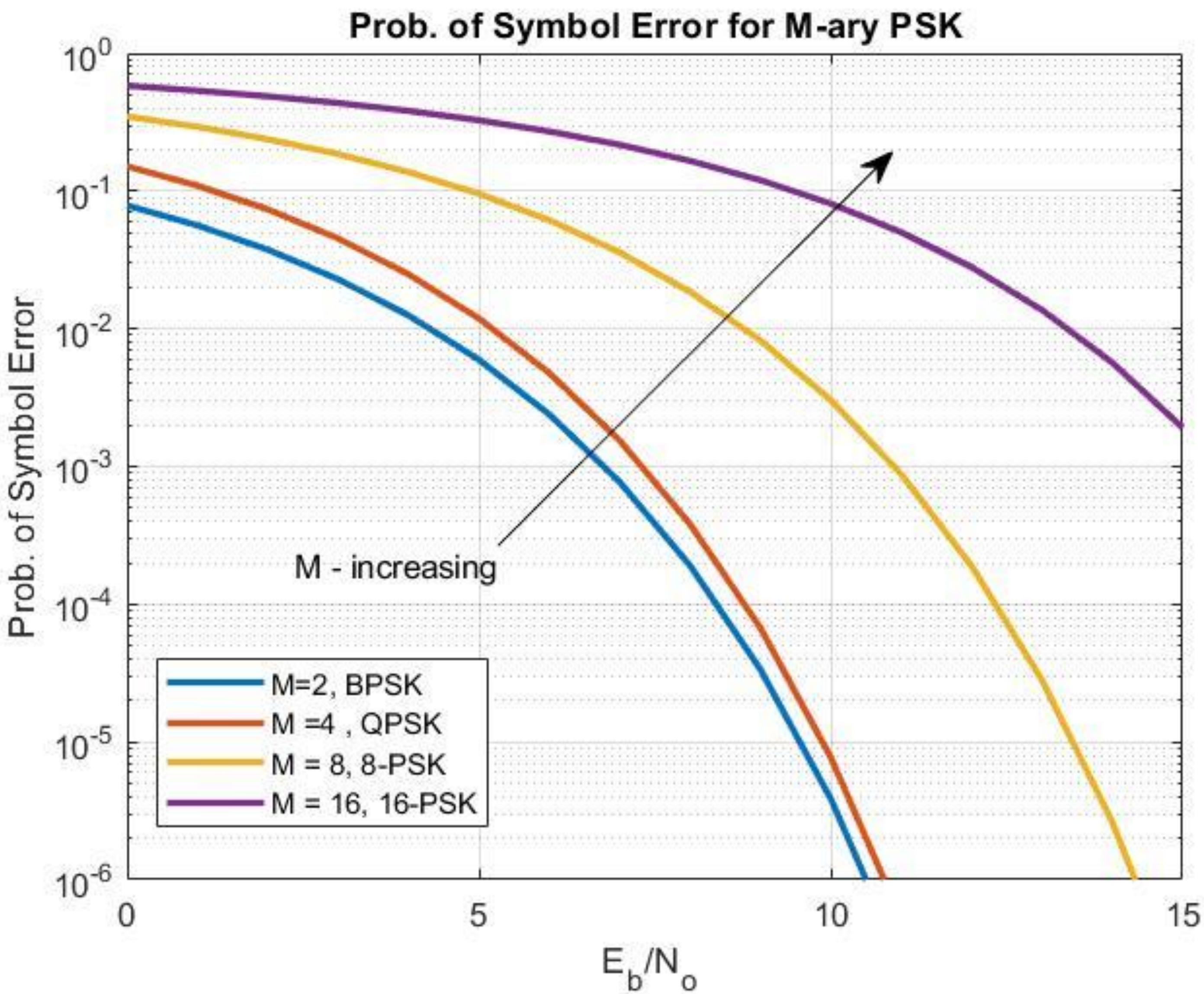
Comparison of Binary and Quaternary Modulation Techniques

	Error Probability, P_e
Coherent binary signaling	
a) Coherent PSK	$\frac{1}{2} erfc(\sqrt{E_b / N_0})$
b) Coherent detection of differentially encoded PSK	$erfc(\sqrt{E_b / N_0}) - \frac{1}{2} erfc^2(\sqrt{E_b / N_0})$
c) Coherent FSK	$\frac{1}{2} erfc(\sqrt{E_b / 2N_0})$
Noncoherent binary signaling :	
a) DPSK	$\frac{1}{2} \exp(-E_b / N_0)$
b) Noncoherent FSK	$\frac{1}{2} \exp(-E_b / 2N_0)$
Coherent Quadrature signaling:	
a) QPSK b) MSK	$erfc(\sqrt{E_b / N_0}) - \frac{1}{4} erfc^2(\sqrt{E_b / N_0})$

Comparison of Noise Performances

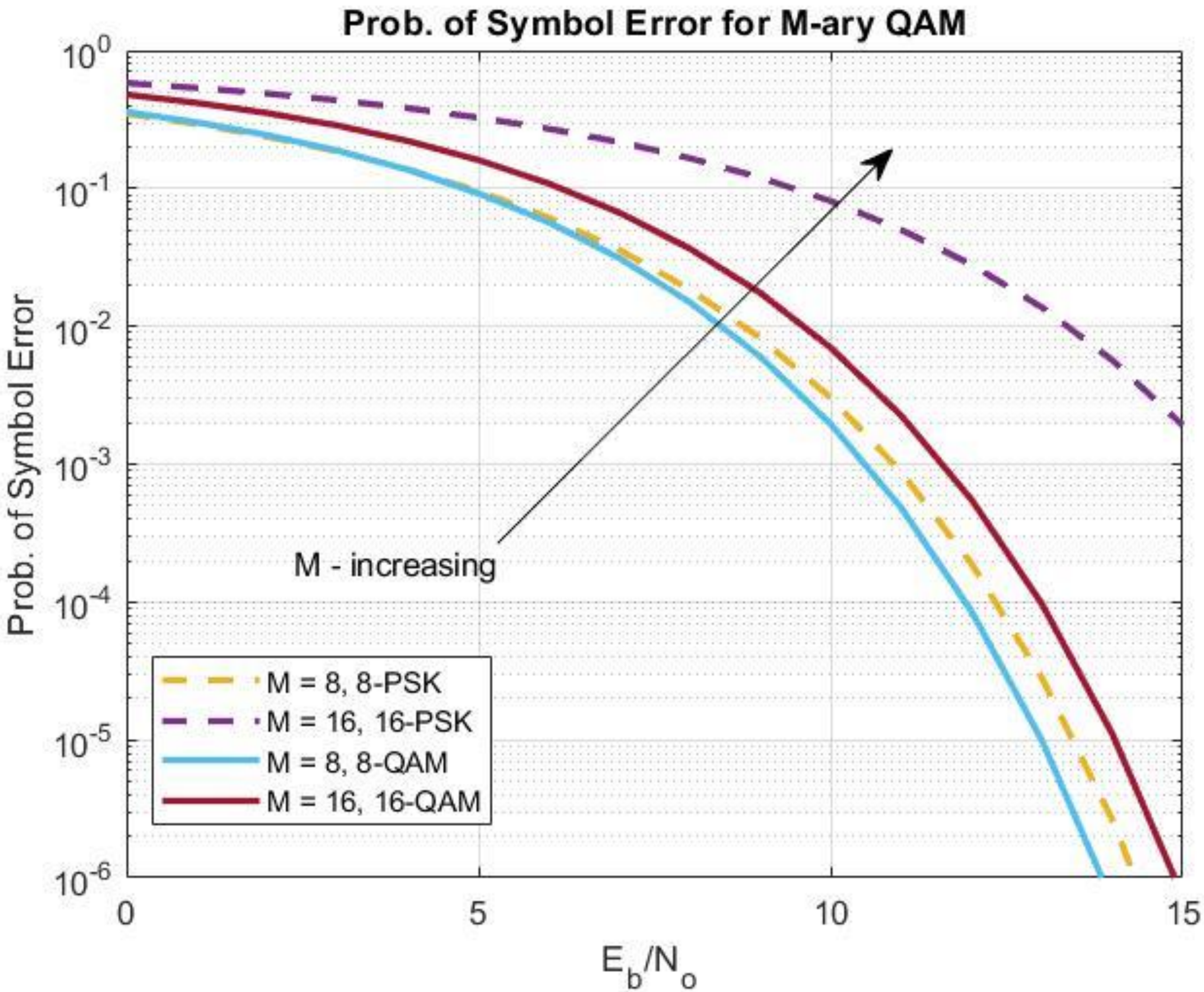


Error Rate



Prob. of Symbol Error for M-ary PSK
Prob. of Symbol Error
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0
5
10
15
E_b/N_o
M - increasing
M=2, BPSK
M =4 , QPSK
M = 8, 8-PSK
M = 16, 16-PSK

Error Rate



Prob. of Symbol Error for M-ary QAM
Prob. of Symbol Error
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0
5
10
15
E_b/N_o
M - increasing
M = 8, 8-PSK
M = 16, 16-PSK
M = 8, 8-QAM
M = 16, 16-QAM

Thanks !