Unit-2
CS 6304-M-ary PSK(8PSK & 16PSK) QAM (8QAM)

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Objective

1. To understand about M-ary modulation modulation

2. To Discuss about various types of M-ary PSK and QAM modulation

M-PSK

- In the binary PSK system, symbols 1 and 0 are differentiated by two phase angles. It can be 0° for symbol 1 and 180° for symbol 0. In M-ary PSK, M-different symbols are identified or differentiated by M-different phase angles.
- For example, in the 8-PSK system, eight different symbols are differentiated by eight different phase angles and each symbol carries three bits.
- Eight different phase angles can be $0°, 45°, 90°, 135°, 180°, 225°, 270°$, $315°$ and .

Mathematical Representation

- In M-ary PSK, the phase of the carrier takes any one of *M* possible values, namely $\theta_i = 2i\pi/M$ where $i = 0,1,.....M-1.$
- The M-ary PSK signal can be mathematically represented as,

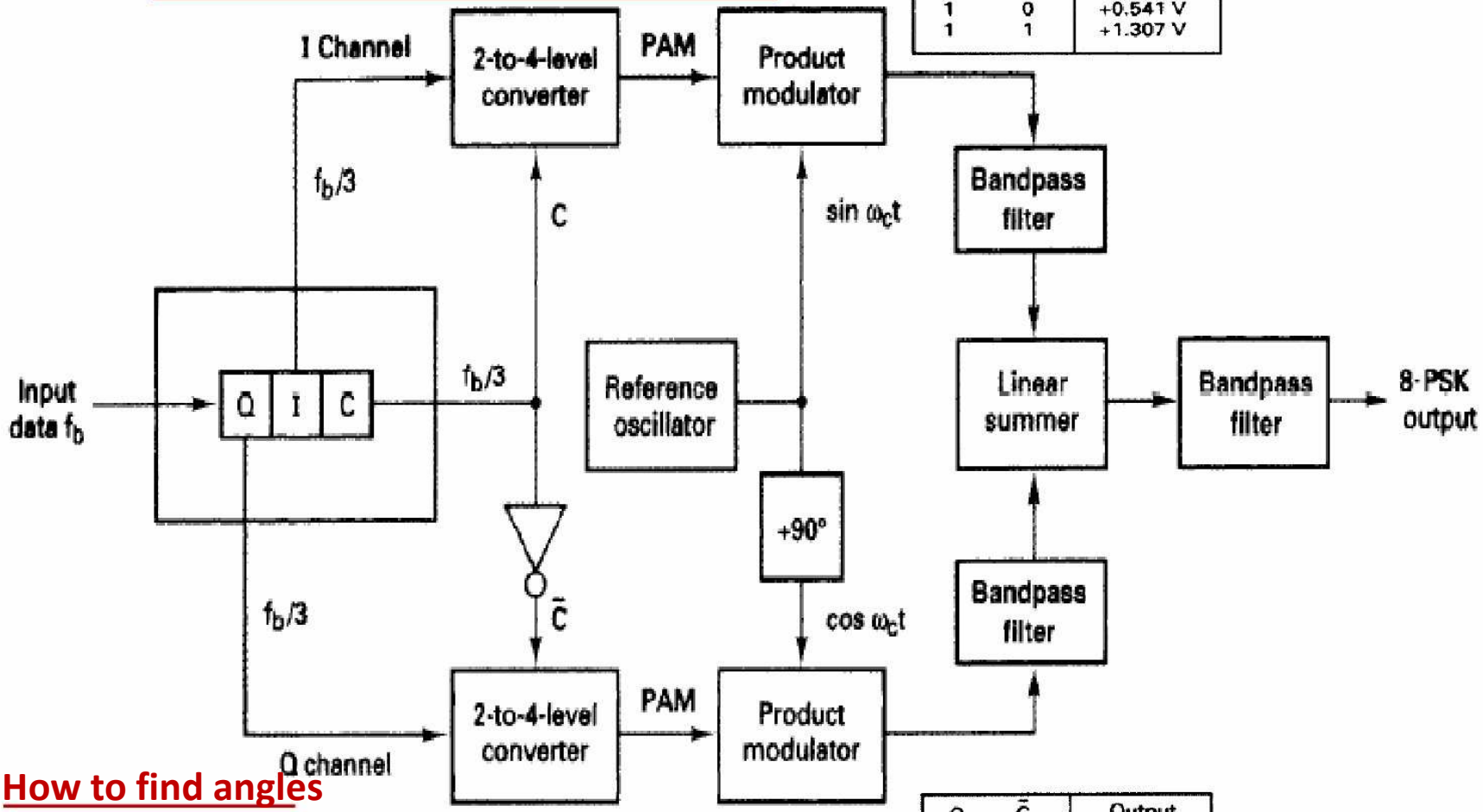
$$S_i(t) = \sqrt{\frac{2E}{T}} \cos\left(2\pi f_c t + \frac{2i\pi}{M}\right) \quad i = 0,1,\ldots,M-1$$

where *E*-is signal energy per symbol, *T*- symbol duration.

$$\varphi_1(t) = \sqrt{\frac{2}{T}} \cos(2\pi f_c t) \quad 0 \le t \le T$$

$$\varphi_2(t) = \sqrt{\frac{2}{T}} \sin(2\pi f_c t) \quad 0 \le t \le T$$

8-PSK transmitter.



I	C	Output
0	0	−0.541 V
0	1	−1.307 V
1	0	+0.541 V
1	1	+1.307 V

Q	$\bar{C}$	Output
0	1	−1.307 V
0	0	−0.541 V
1	1	+1.307 V
1	0	+0.541 V

How to find angles

For 111 input

Output= 1.307sinwt+0.541 coswt

Angle= tan^-1(.541/1.307) in 1st quadrangle

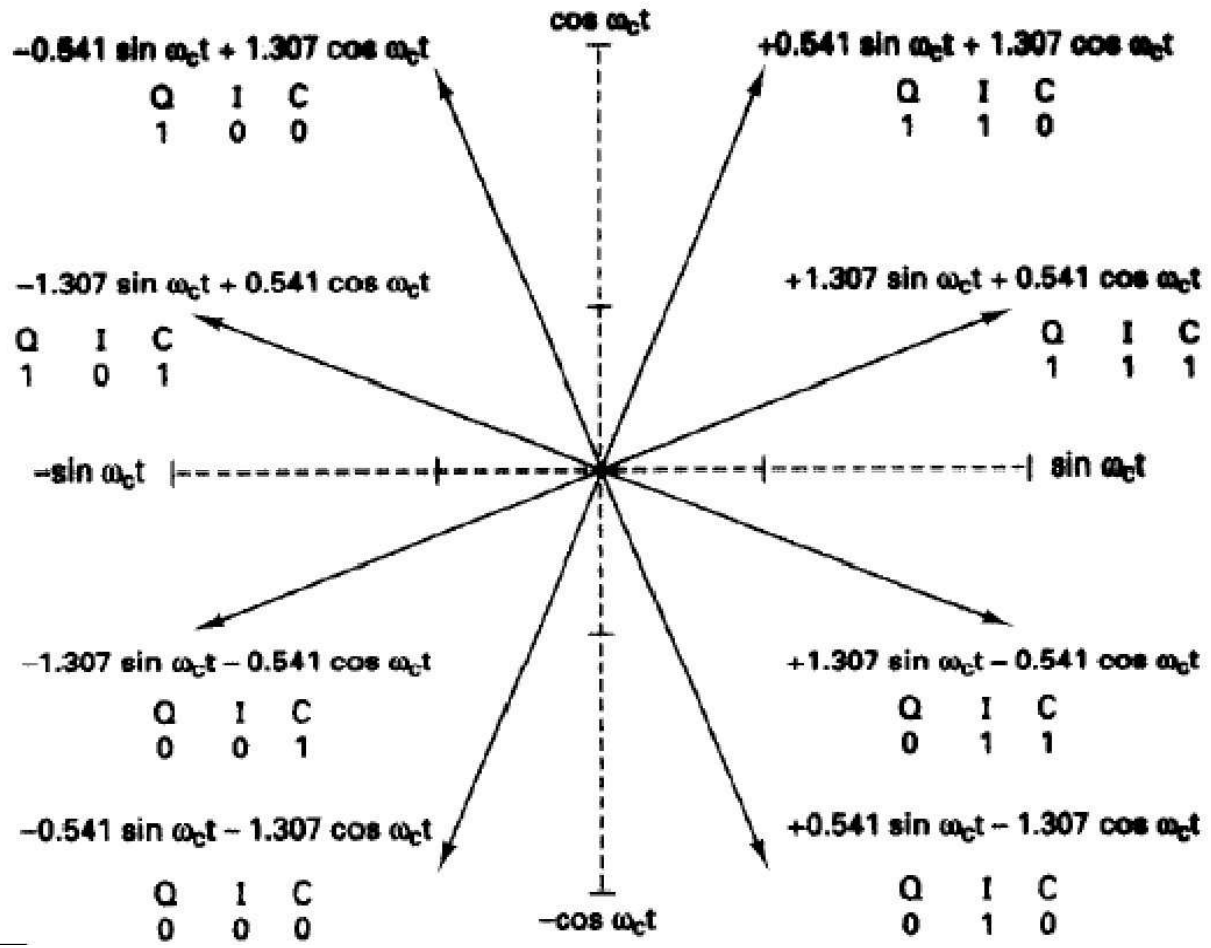
=67.5°

Output Phases

Note
Phases are +/-(22.5°+45°)

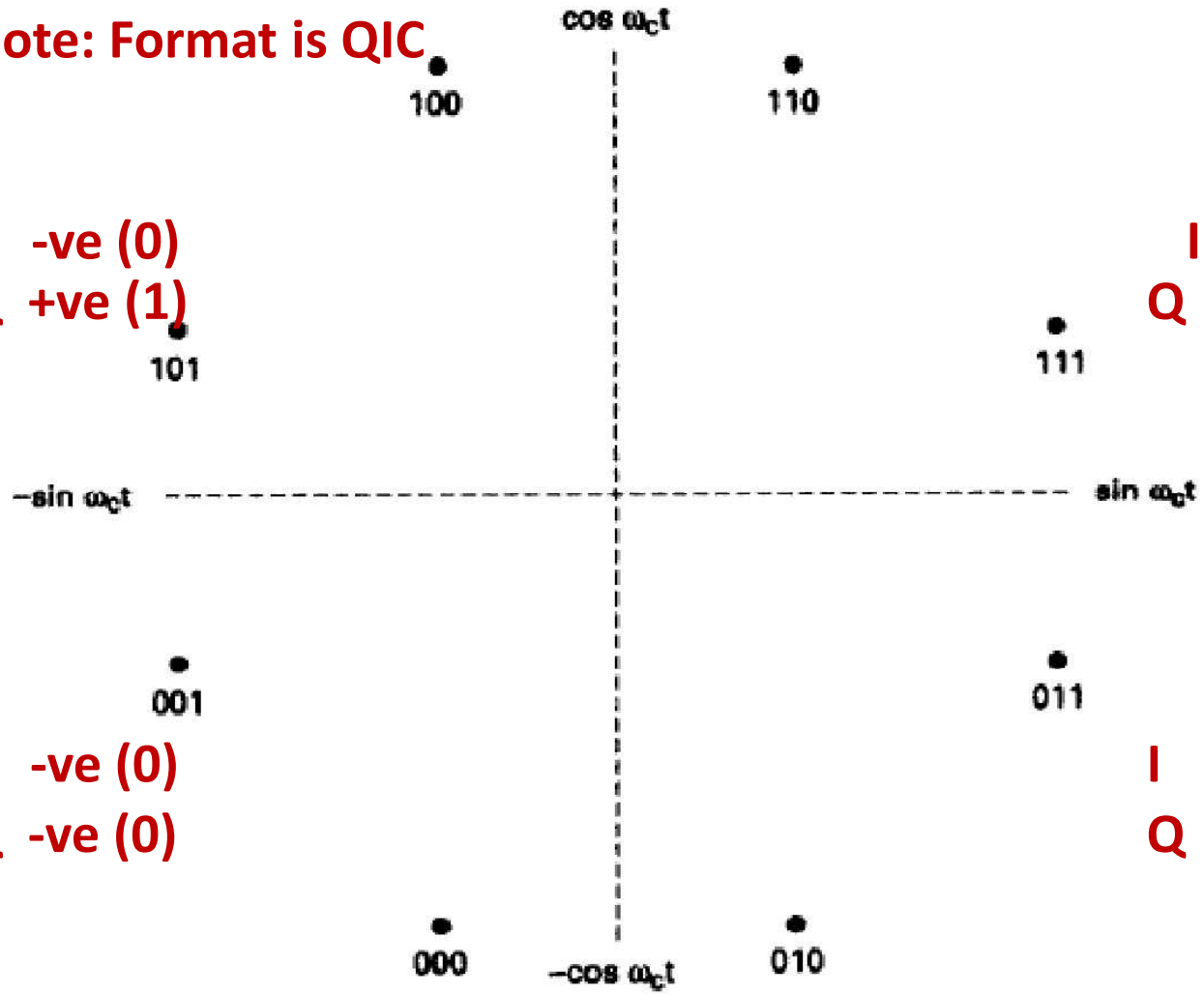
Binary input			8-PSK output phase
Q	I	C	
0	0	0	–112.5°
0	0	1	–157.5°
0	1	0	–67.5°
0	1	1	–22.5°
1	0	0	+112.5°
1	0	1	+157.5°
1	1	0	+67.5°
1	1	1	+22.5°

Phasor Diagram



Constellation Diagram: 8 PSK

Note: Format is QIC



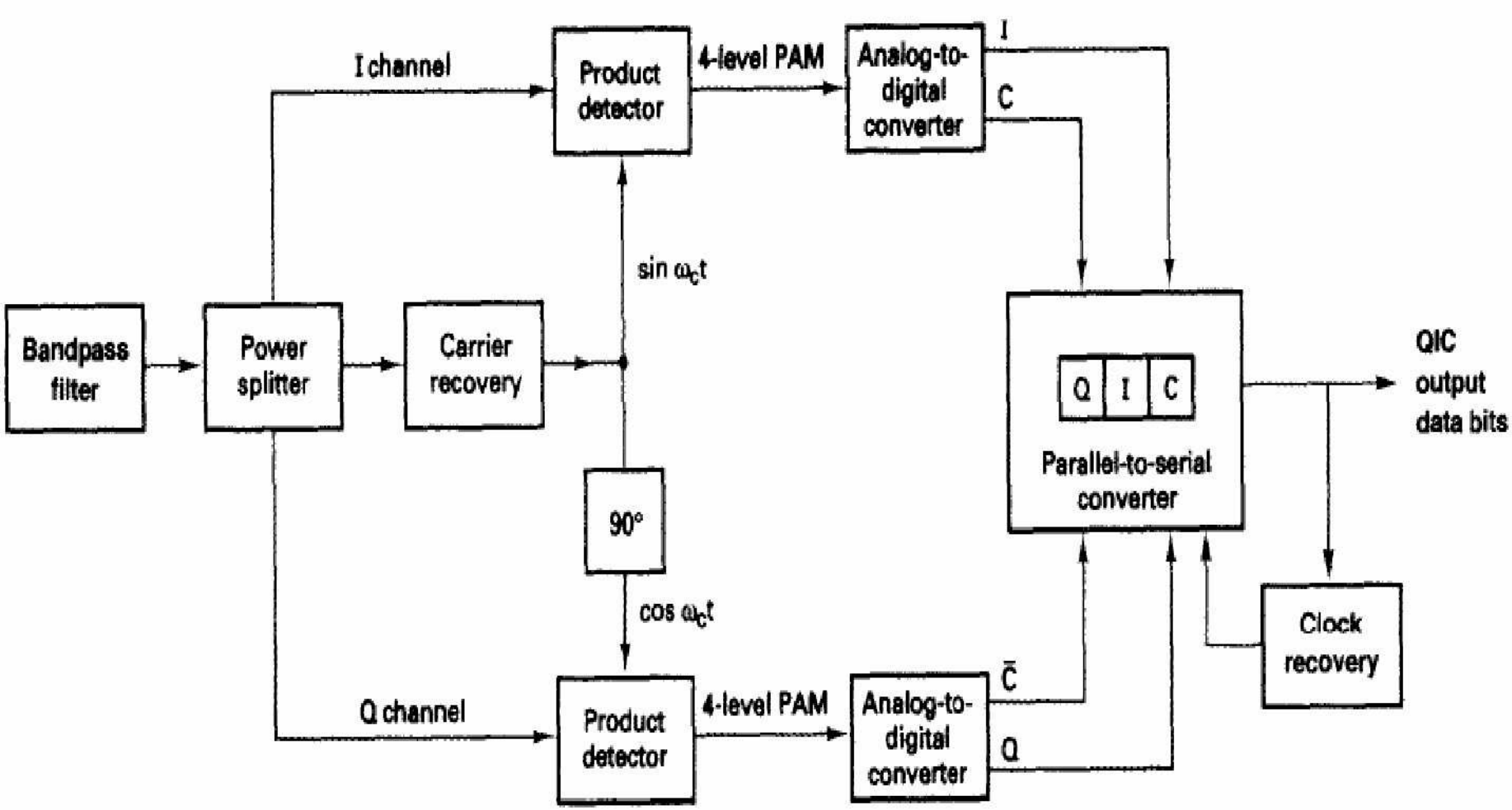
I -ve (0)
Q +ve (1)

I +ve (1)
Q +ve (1)

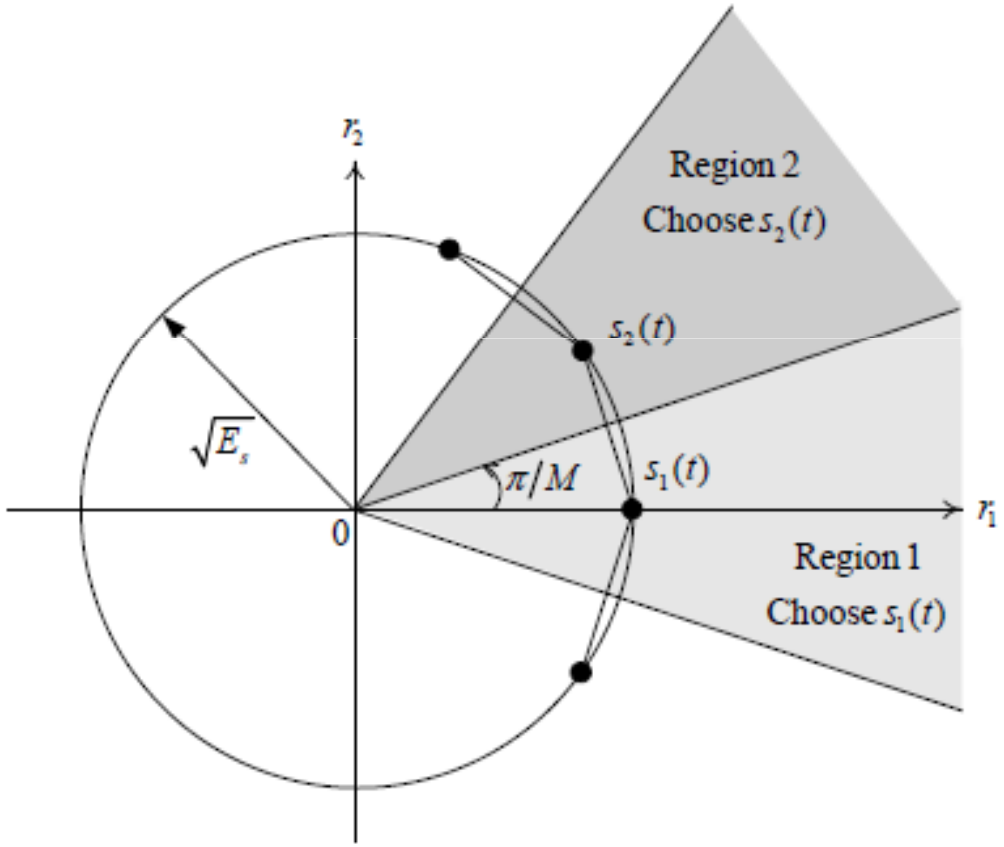
I -ve (0)
Q -ve (0)

I +ve(1)
Q -ve(0)

M-PSK Reception



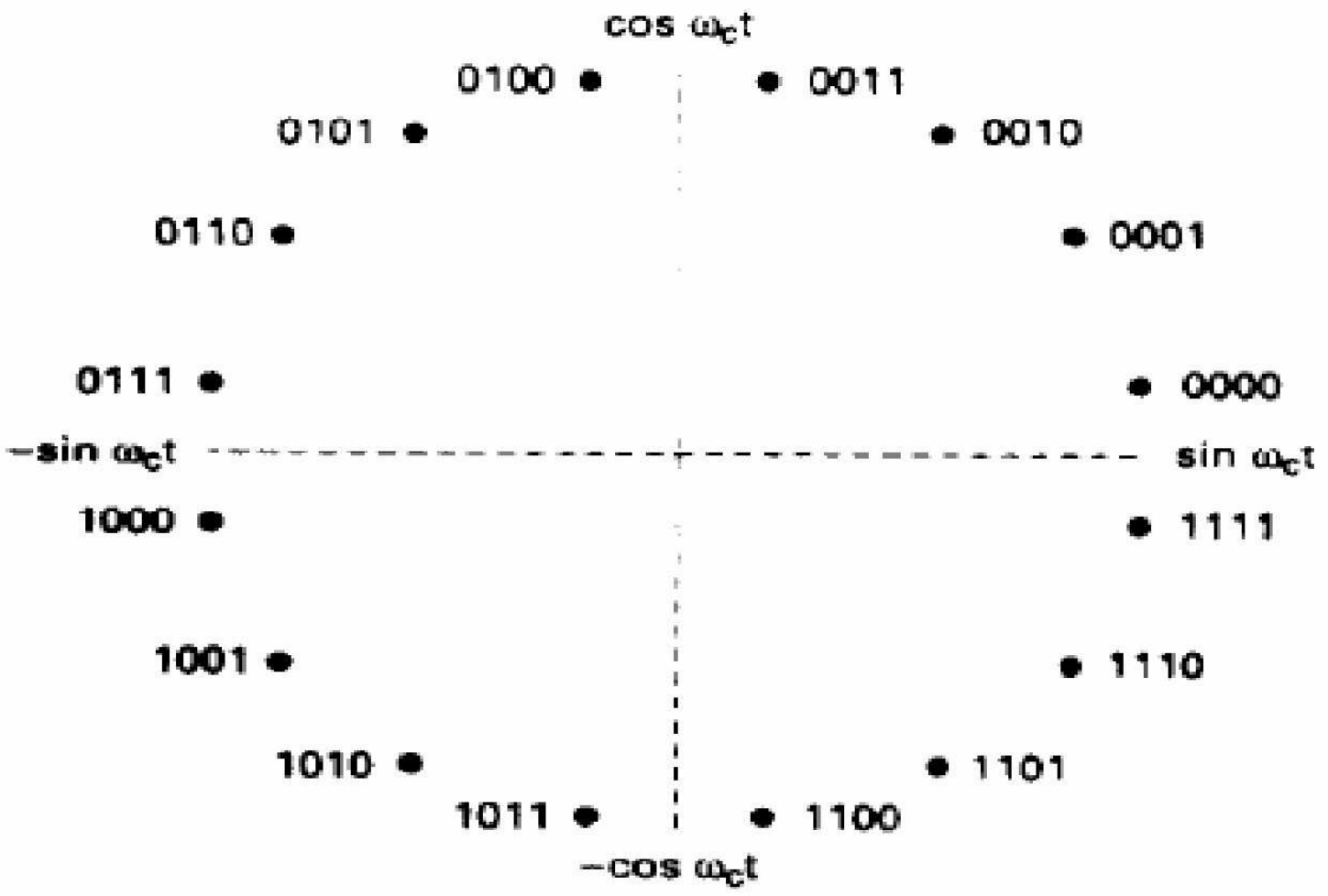
Decision region for M-ary PSK.



16-PSK

Bit code	Phase	Bit code	Phase
0000	11.25°	1000	191.25°
0001	33.75°	1001	213.75°
0010	56.25°	1010	236.25°
0011	78.75°	1011	258.75°
0100	101.25°	1100	281.25°
0101	123.75°	1101	303.75°
0110	146.25°	1110	326.25°
0111	168.75°	1111	348.75°

Constellation diagram

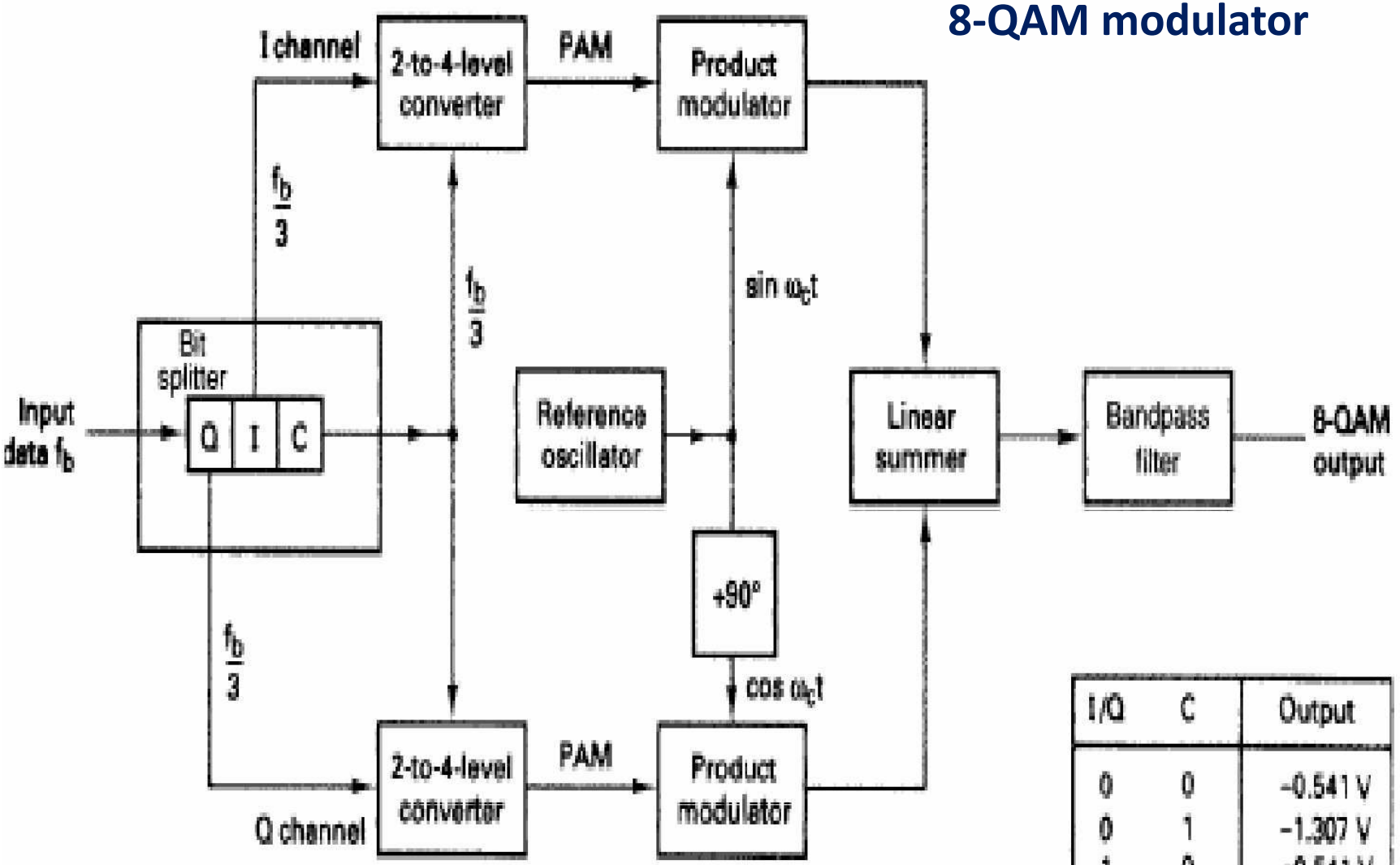


QUADRATURE – AMPLITUDE MODULATION

8-QAM

- 8-QAM is an M-ary encoding technique where M = 8.
- Unlike 8-PSK, the output signal from an 8-QAM modulator is not a constant-amplitude signal.

8-QAM modulator



I/Q	C	Output
0	0	−0.541 V
0	1	−1.307 V
1	0	+0.541 V
1	1	+1.307 V

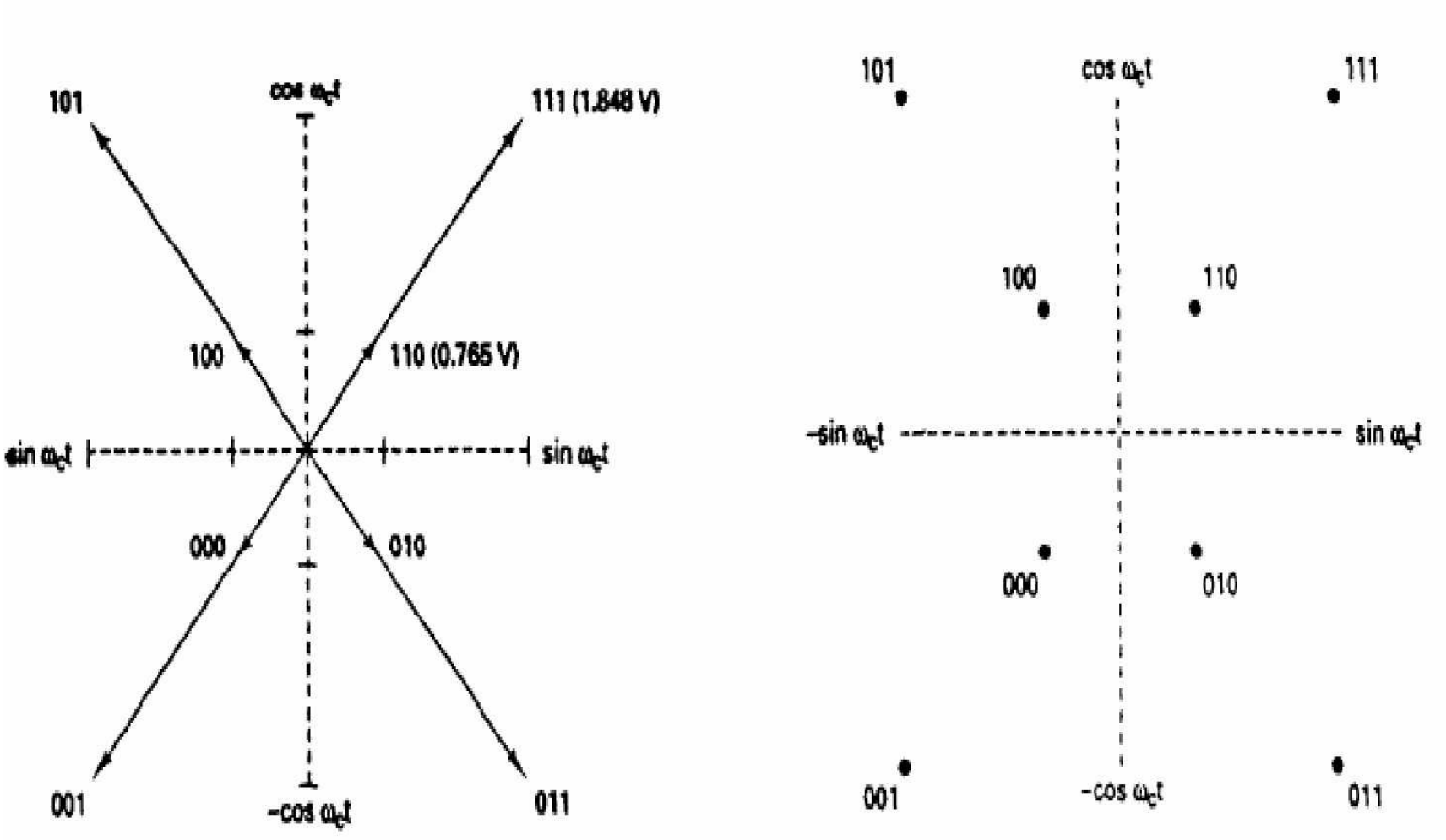
8-QAM modulator

- The incoming data are divided into groups of three bits (tribits): the I, Q, and C bit streams.
- Each stream has a bit rate equal to one-third of the incoming data rate.
- The I and Q bits determine the polarity of the PAM signal at the output of the 2-to-4-level converters
- The C channel determines the magnitude.
- Because the c bit is fed un-inverted to both the i and the q channel 2-to-4-level converters, the magnitudes of the I and Q PAM signals are always equal.
- Their polarities depend on the logic condition of the i and q bits different.and,

Truth Table

Binary input			8-QAM output	
Q	I	C	Amplitude	Phase
0	0	0	0.765 V	−135°
0	0	1	1.848 V	−135°
0	1	0	0.765 V	−45°
0	1	1	1.848 V	−45°
1	0	0	0.765 V	+135°
1	0	1	1.848 V	+135°
1	1	0	0.765 V	+45°
1	1	1	1.848 V	+45°

Phasor and constellation diagram



8-QAM receiver.

- An 8 QAM receiver is almost identical to the 8-PSK receiver