

# HY-330

fall semester 2021

## Introduction to telecommunication systems theory

University of Crete  
Computer Science Department

Stefanos Papadakis



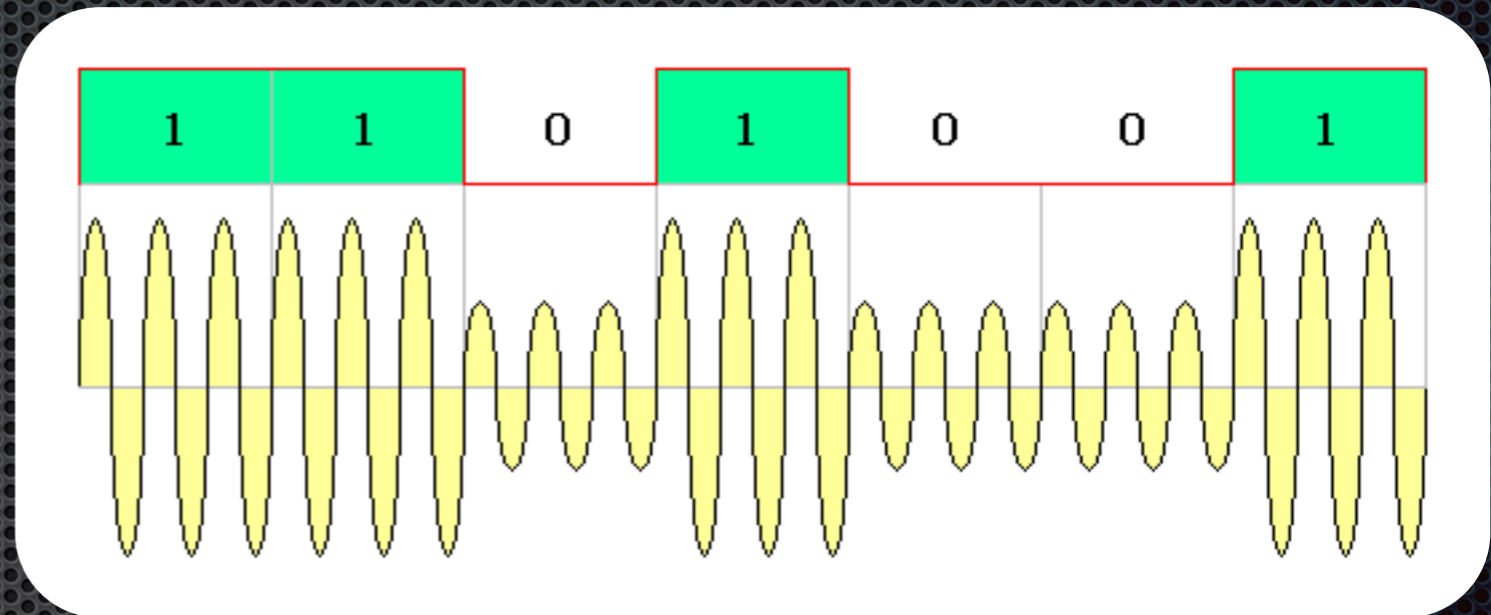
# Digital Modulations

- ✦ QAM
- ✦ PSK
- ✦ Examples

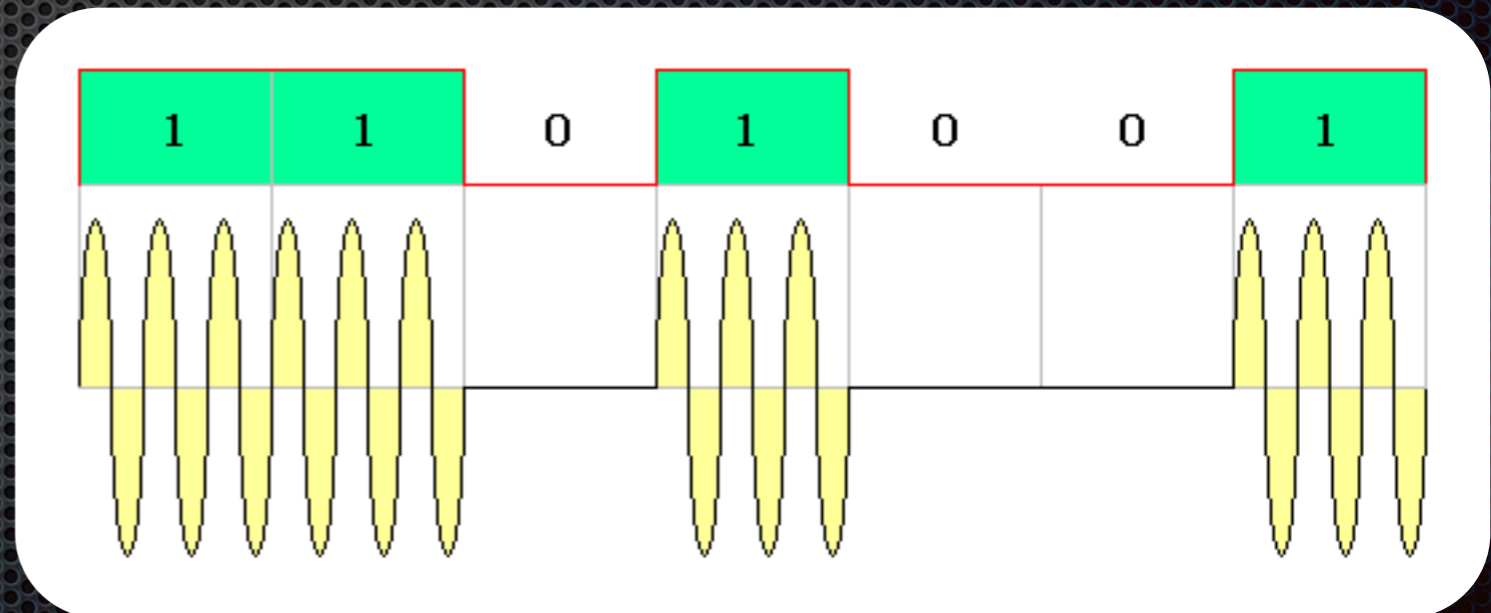


# Amplitude Modulation

- Amplitude Shift Keying (ASK)



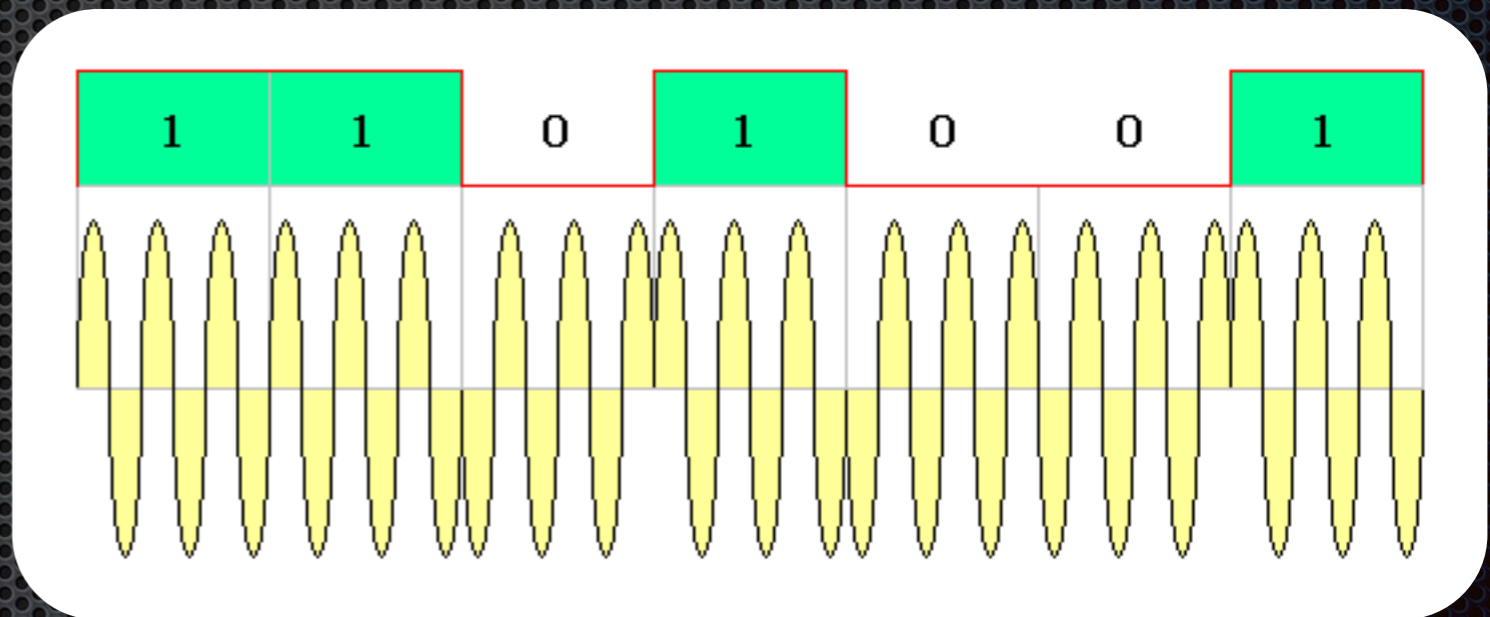
- On Off Keying (OOK)





# Phase Modulation

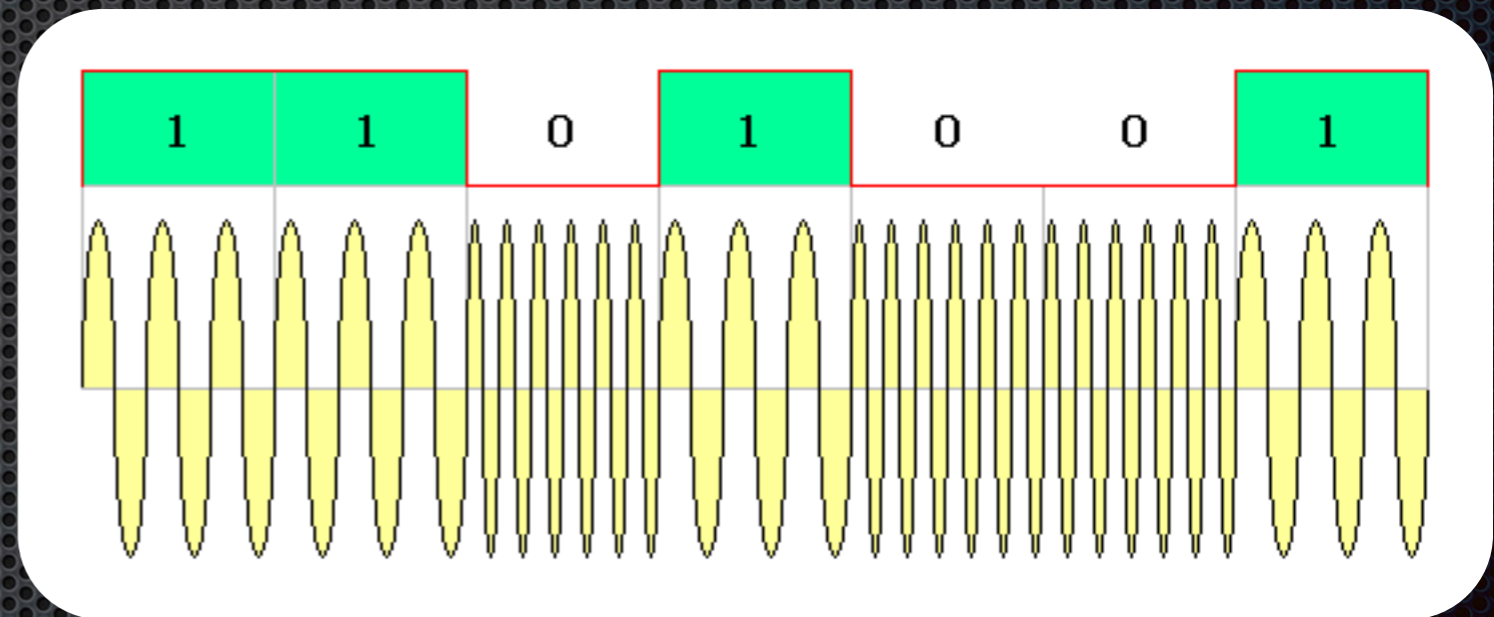
- Phase Shift Keying (PSK)





# Frequency Modulation

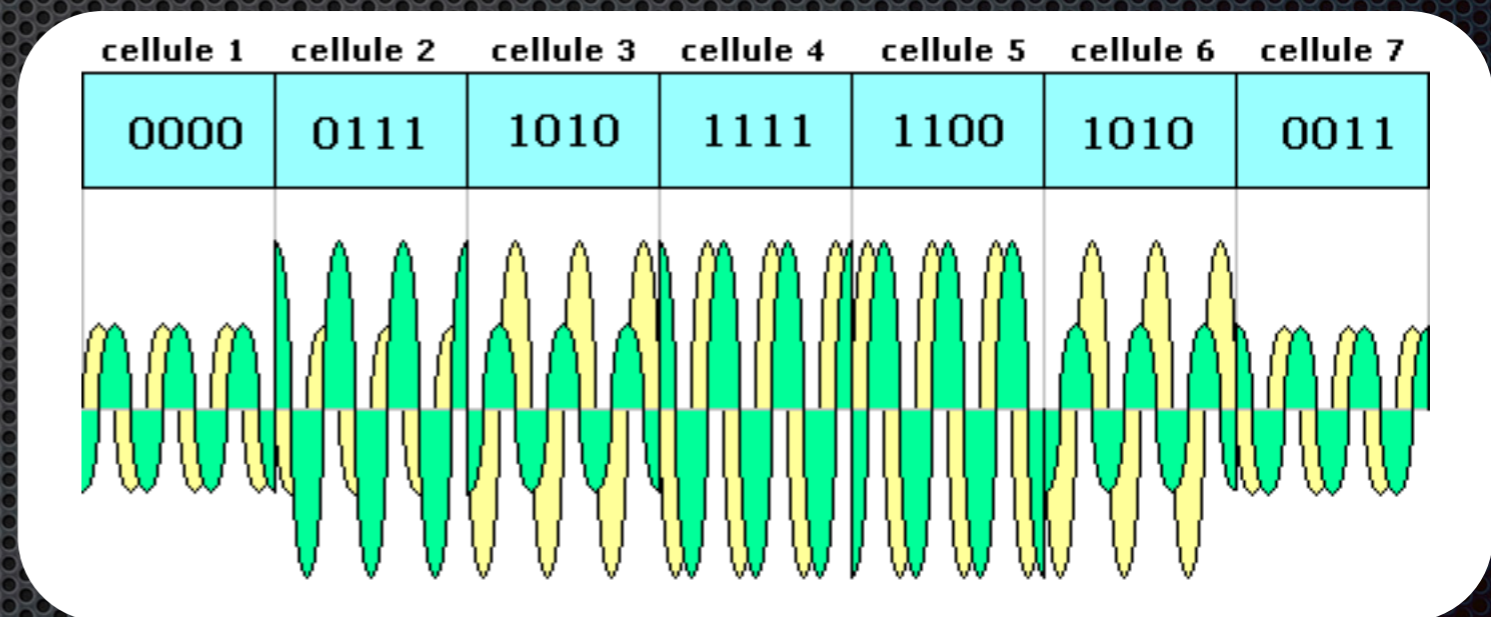
- Frequency Shift Keying (FSK)





# Amplitude & Phase Modulation?

- ✦ Quadrature Amplitude Modulation (QAM)





# Quadrature Modulation

- Complex Number

$$z = x + i \cdot y$$

- Real  $\leftrightarrow$  In-phase

$$I(t)$$

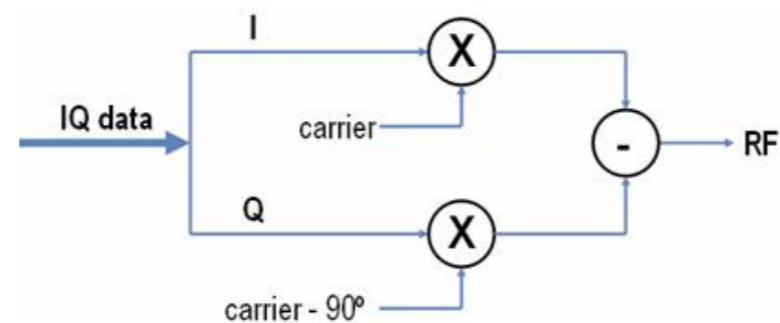
- Imaginary  $\leftrightarrow$  Quadrature

$$Q(t)$$

$$z(t) = I(t) \cdot \cos(\omega_c t) - Q(t) \cdot \sin(\omega_c t)$$

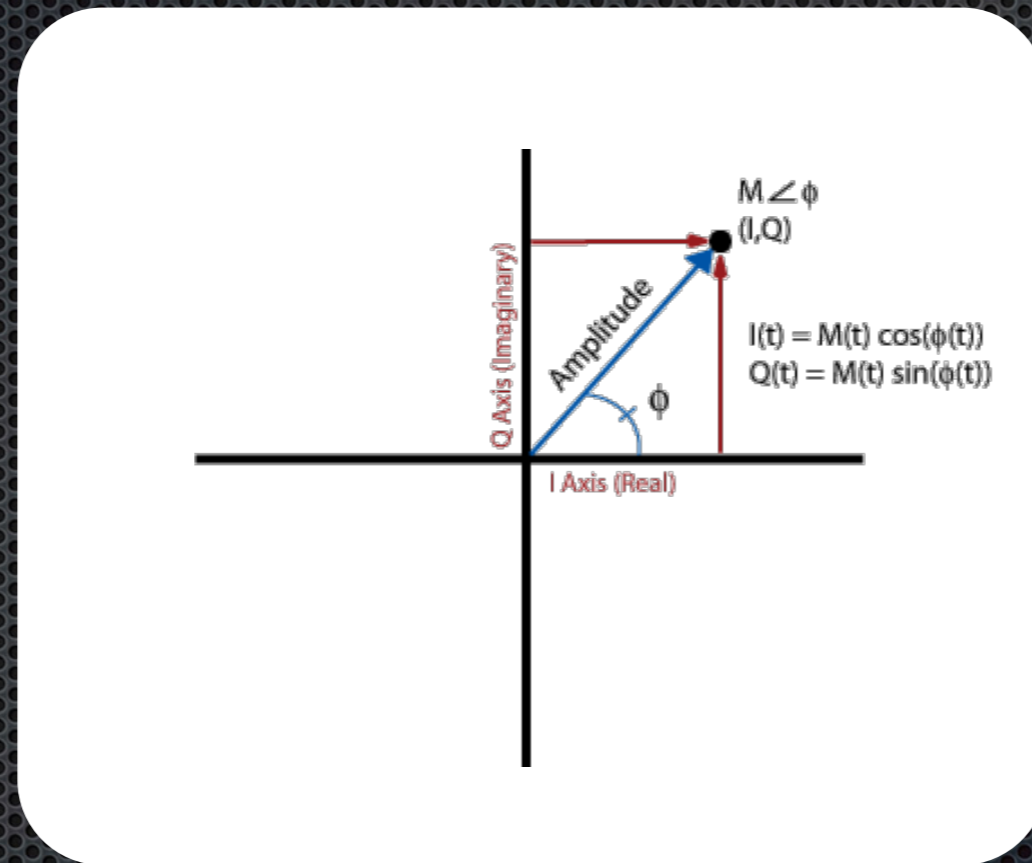


# Quadrature Amplitude Modulation



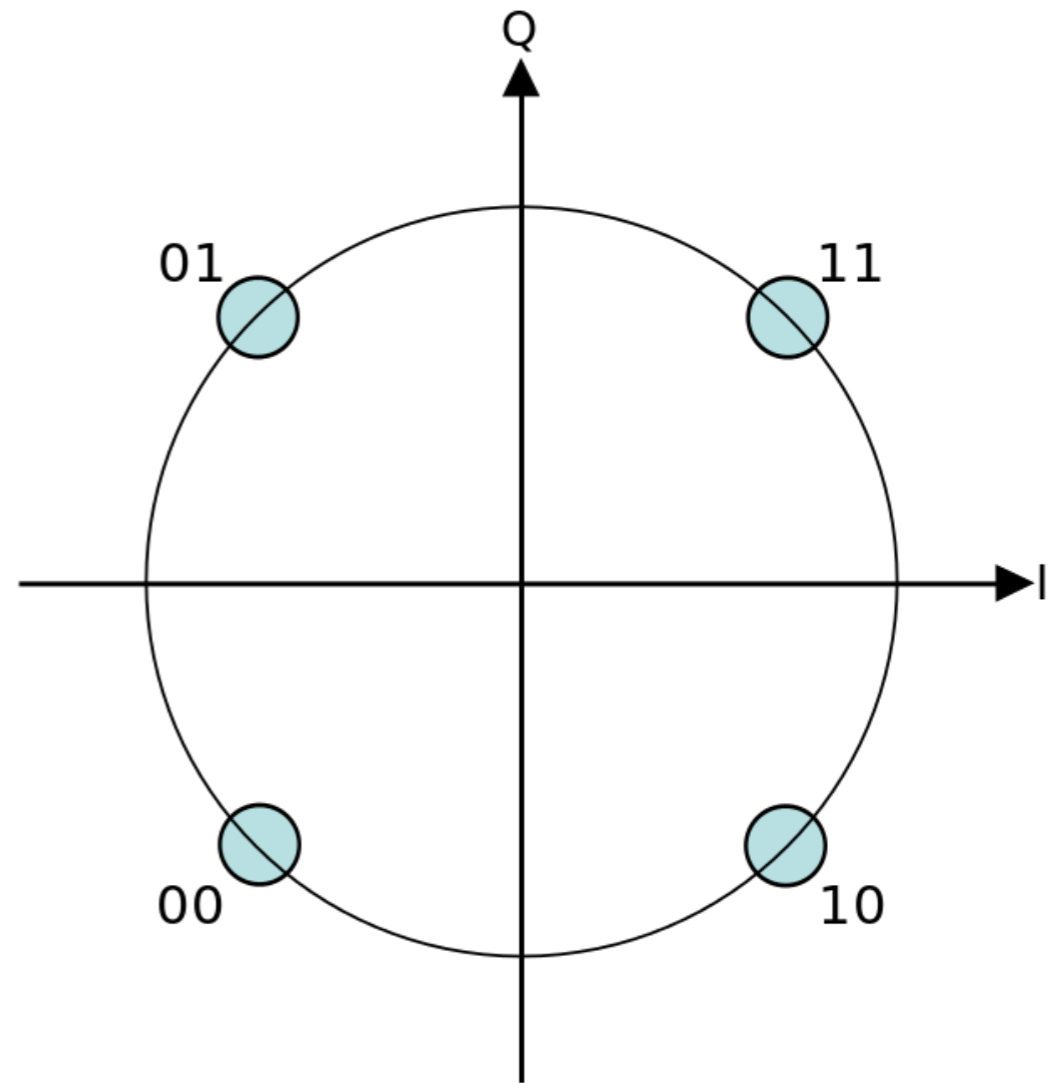
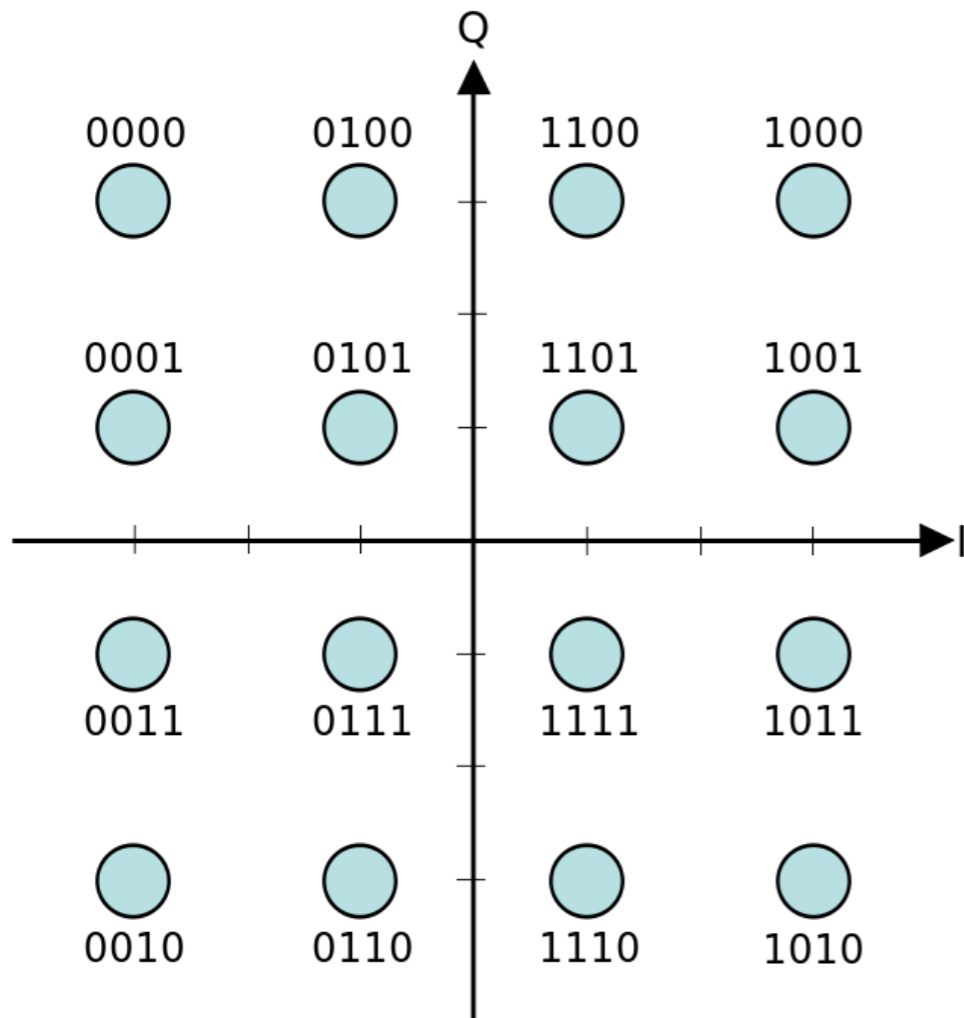


# Quadrature Amplitude Modulation



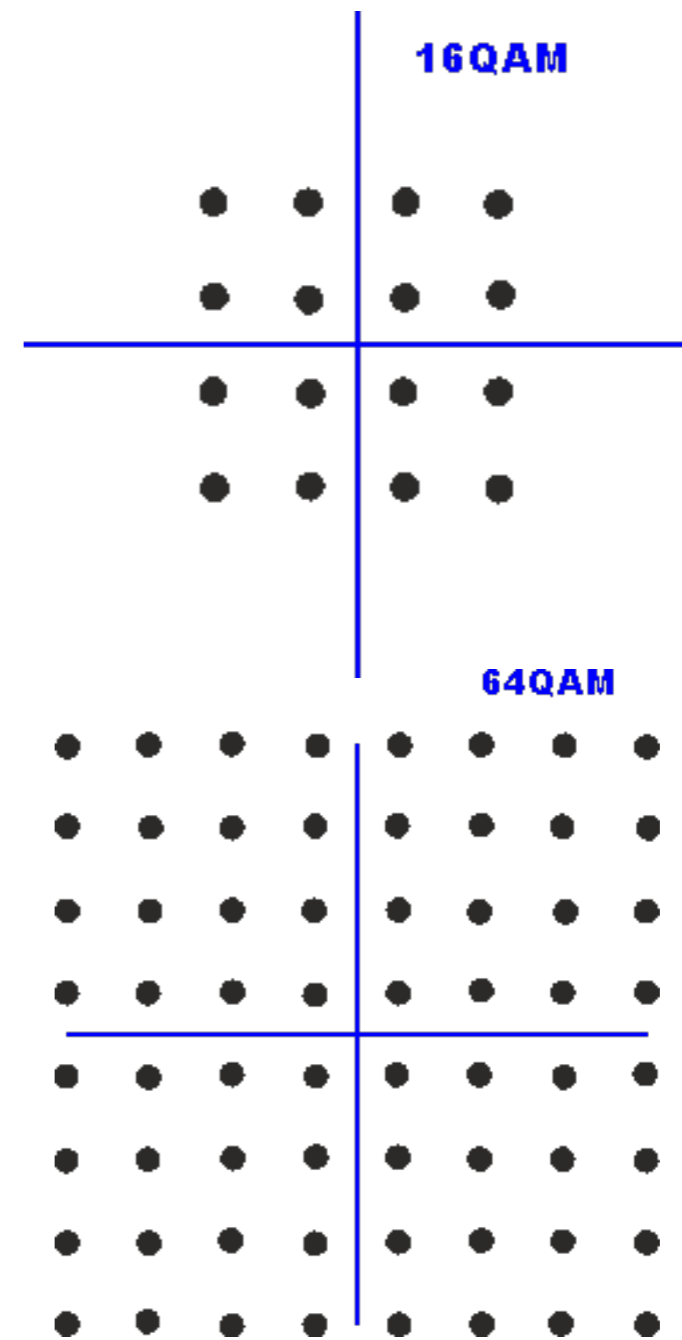
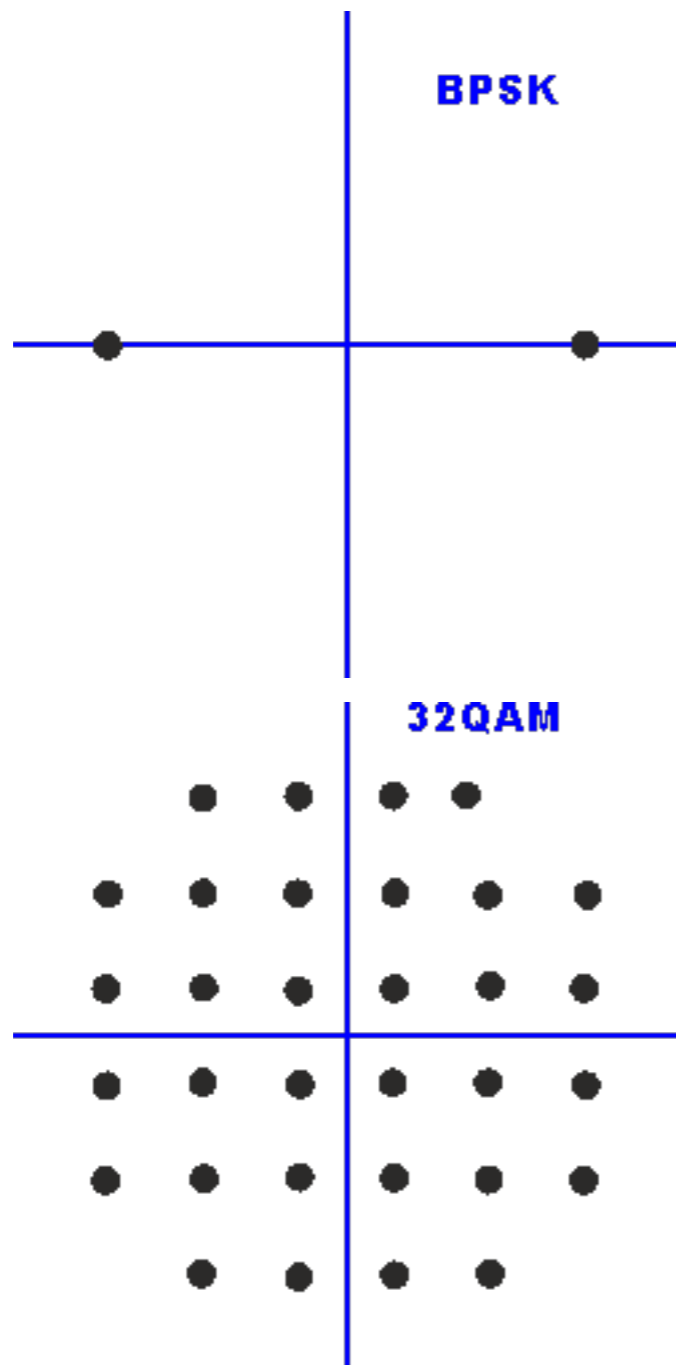


# Constellation Diagram





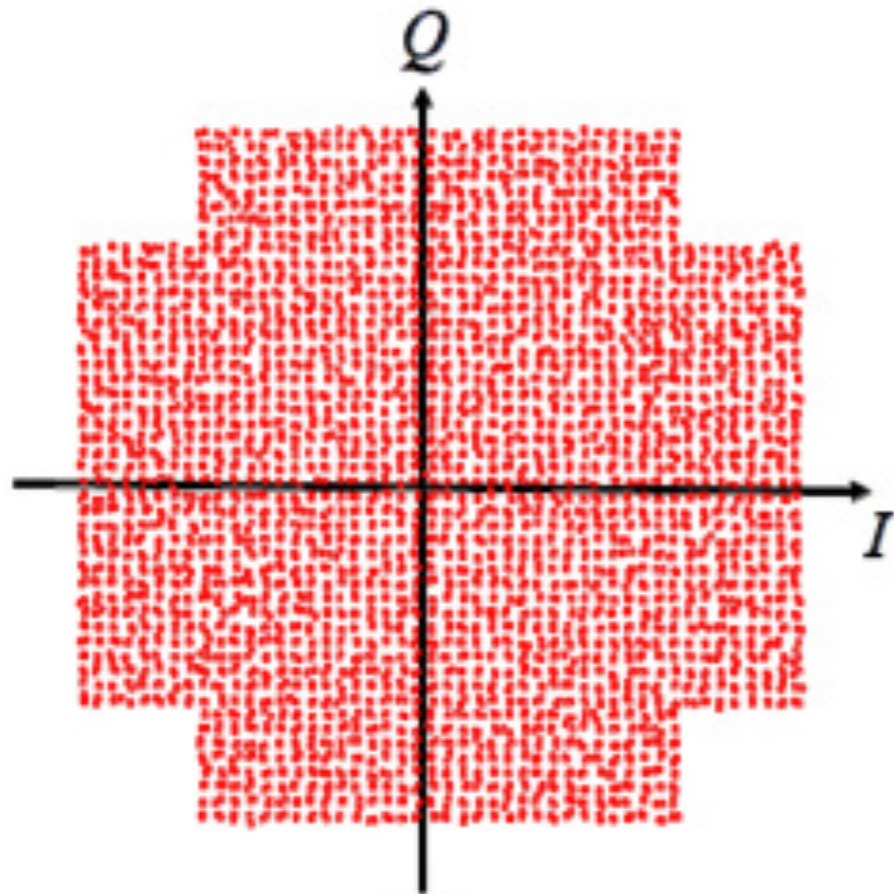
# Constellation Diagram



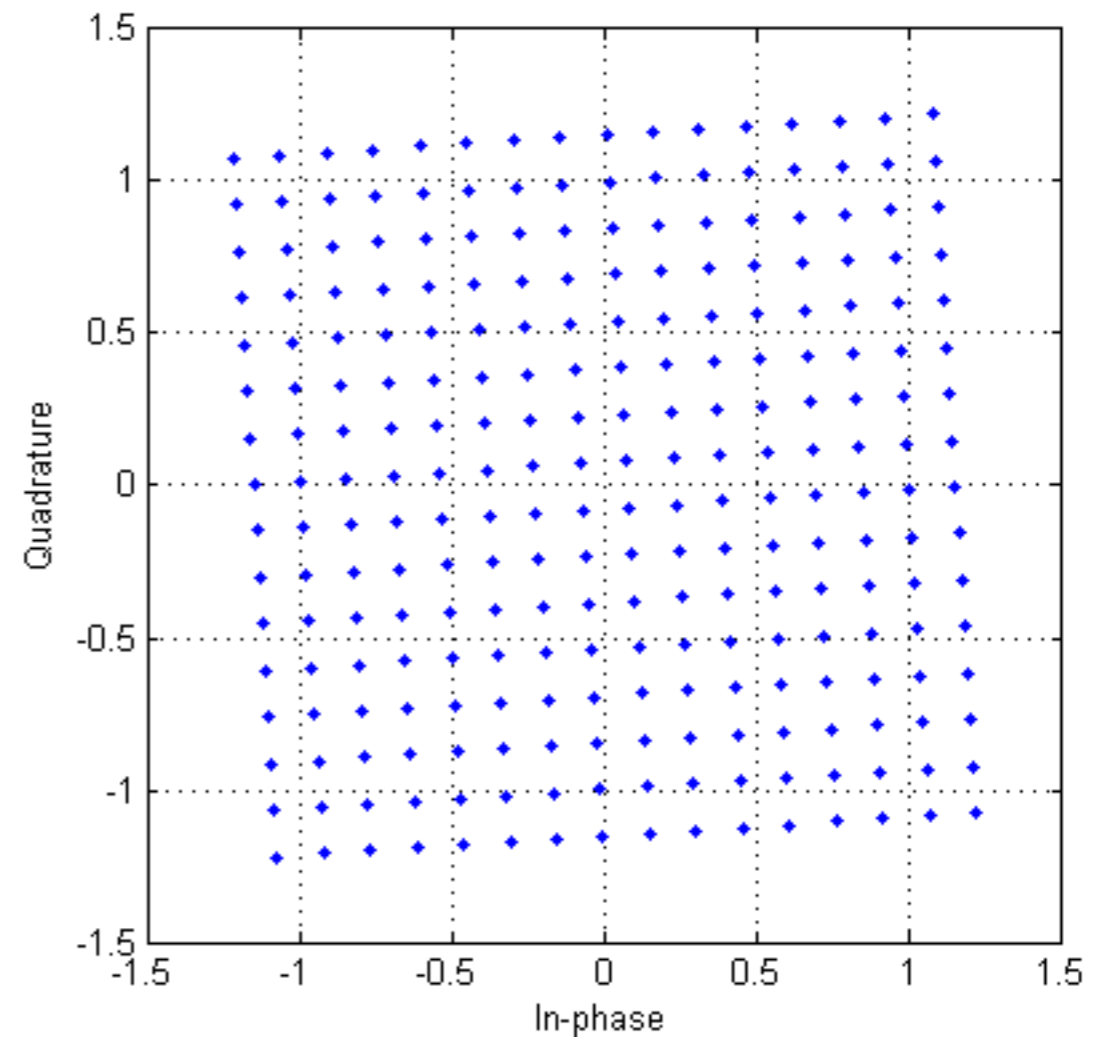


# Constellation Diagram

512-QAM

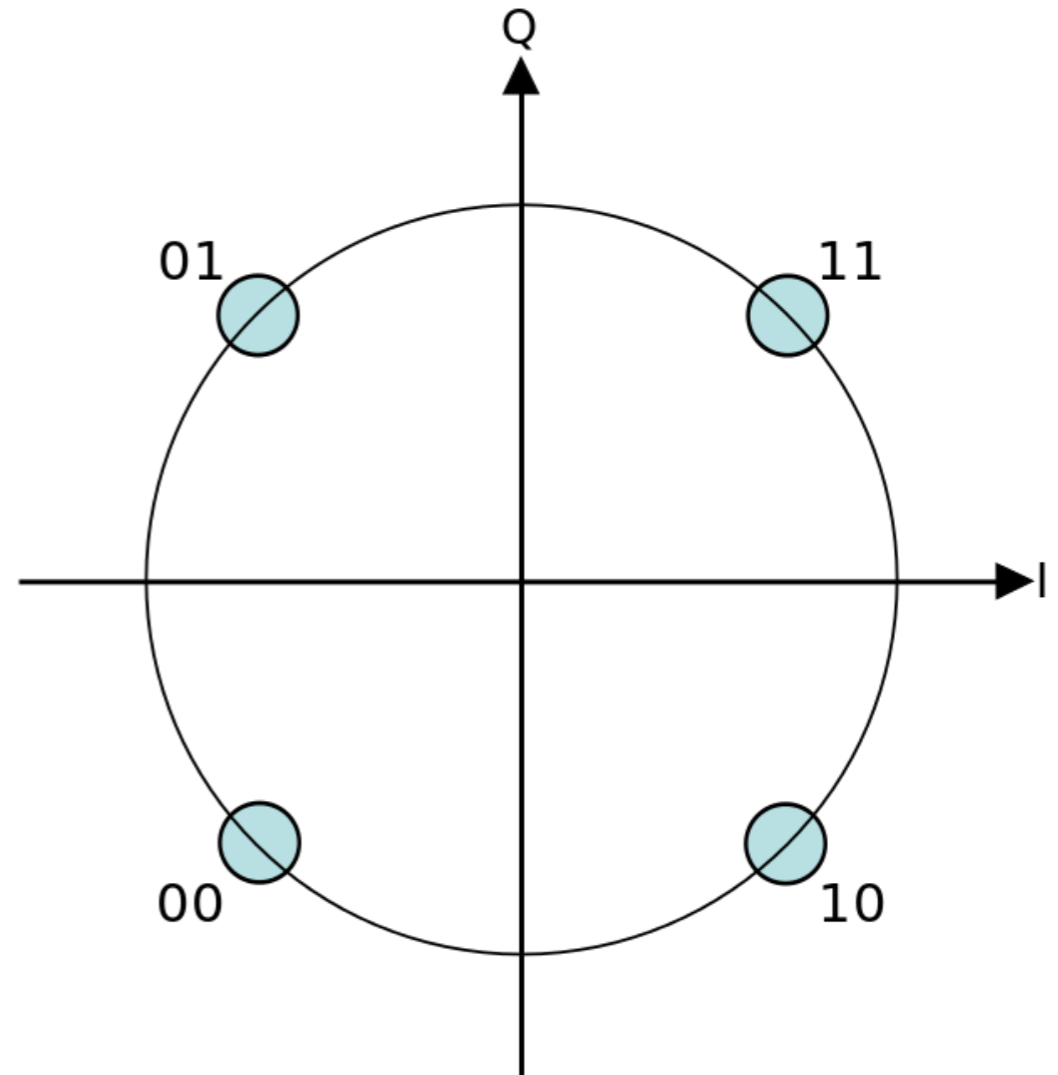
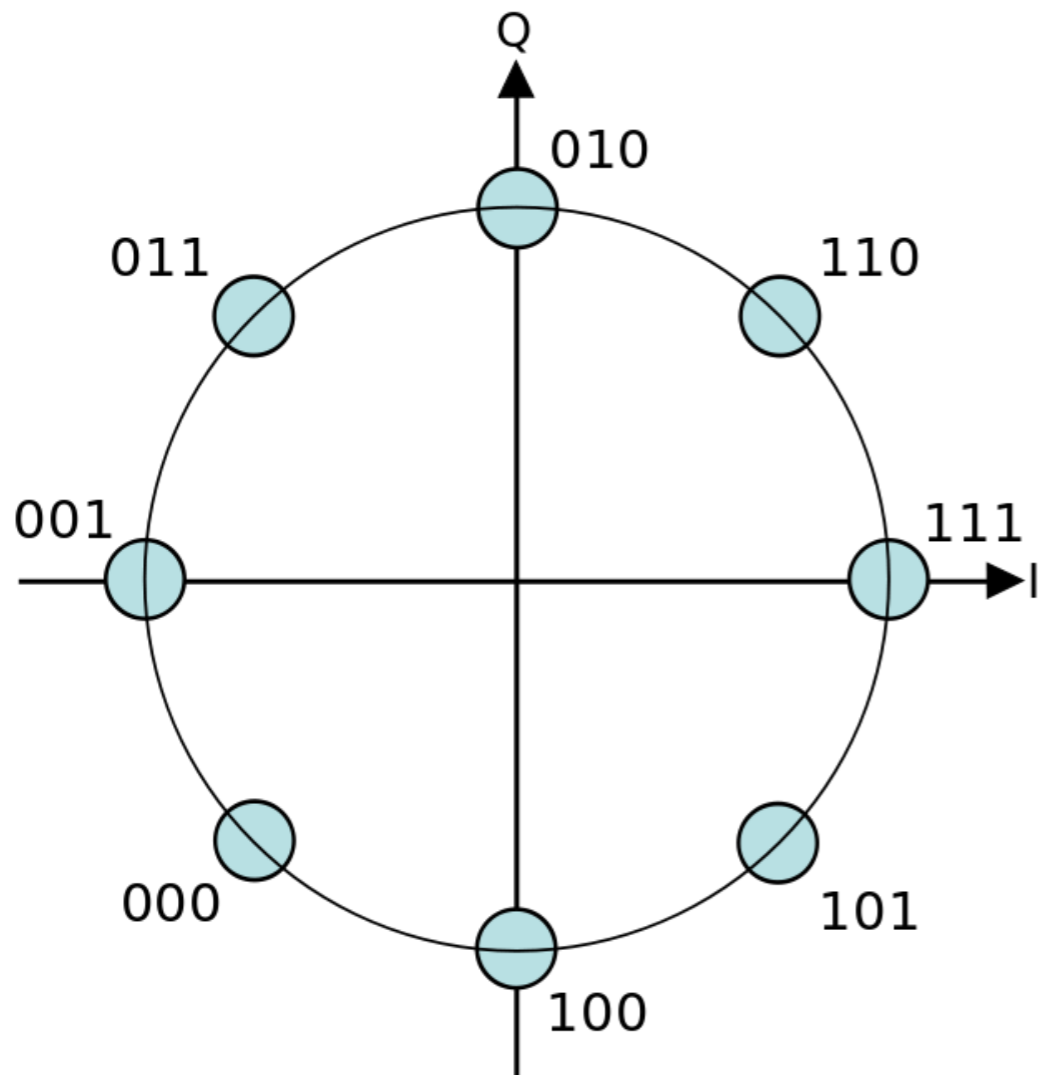


tilted 256-QAM





# Phase-shift keying





# Constellation

- BPSK: 1 bit/symbol
- QPSK: 2 bit/symbol
- 8-PSK: 3 bit/symbol
- 16-QAM: 4 bit/symbol
- 64-QAM: 6 bit/symbol
- 256-QAM: 8 bit/symbol
- 1024-QAM: 10 bit/symbol



# Decision Regions

