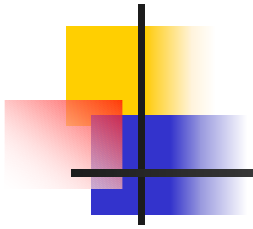
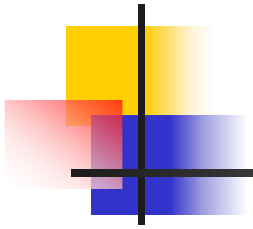


Chapter 7

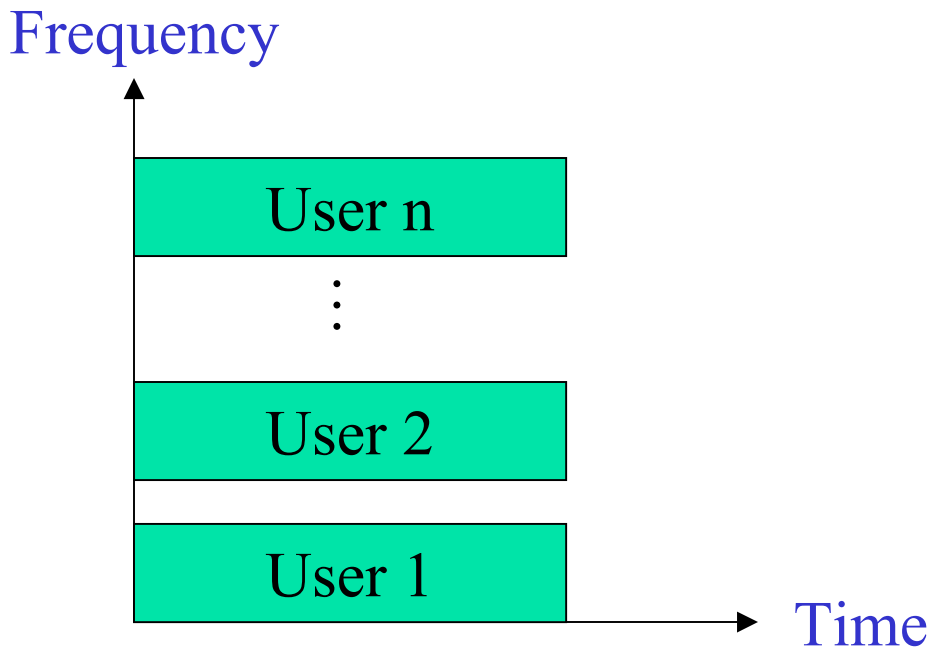
Multiple Division Techniques



Outline

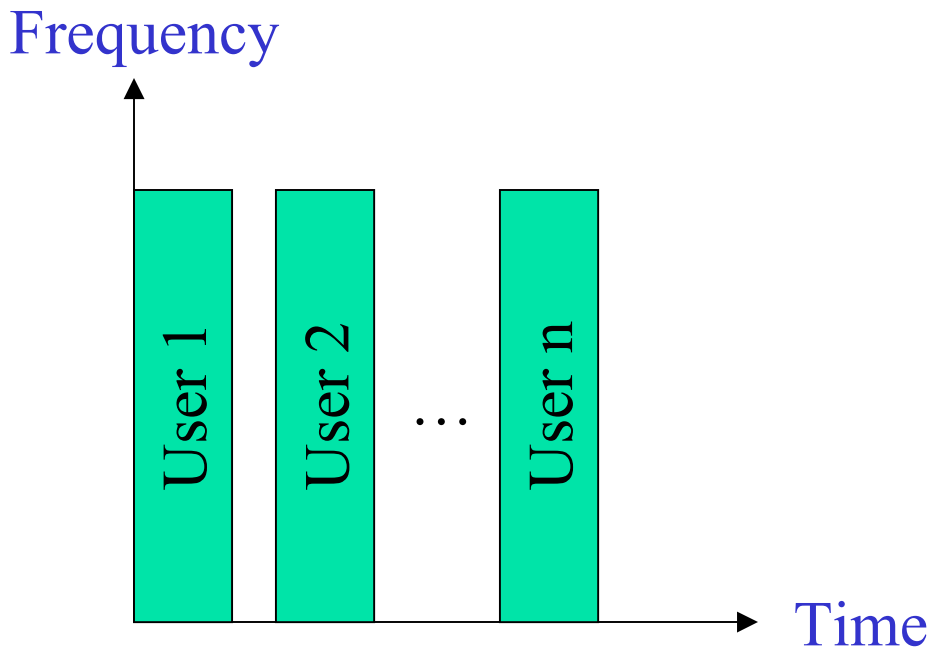
- Frequency Division Multiple Access (FDMA)
- Time Division Multiple Access (TDMA)
- Code Division Multiple Access (CDMA)
- Comparison of FDMA, TDMA, and CDMA
- Walsh Codes
- Near-far Problem
- Types of Interferences
- Analog and Digital Signals
- Basic Modulation Techniques
  - Amplitude Modulation (AM)
  - Frequency Modulation (FM)
  - Frequency Shift Keying (FSK)
  - Phase Shift Keying (PSK)
  - Quadrature Phase Shift Keying (QPSK)
  - Quadrature Amplitude Modulation (QAM)

Frequency Division Multiple Access (FDMA)



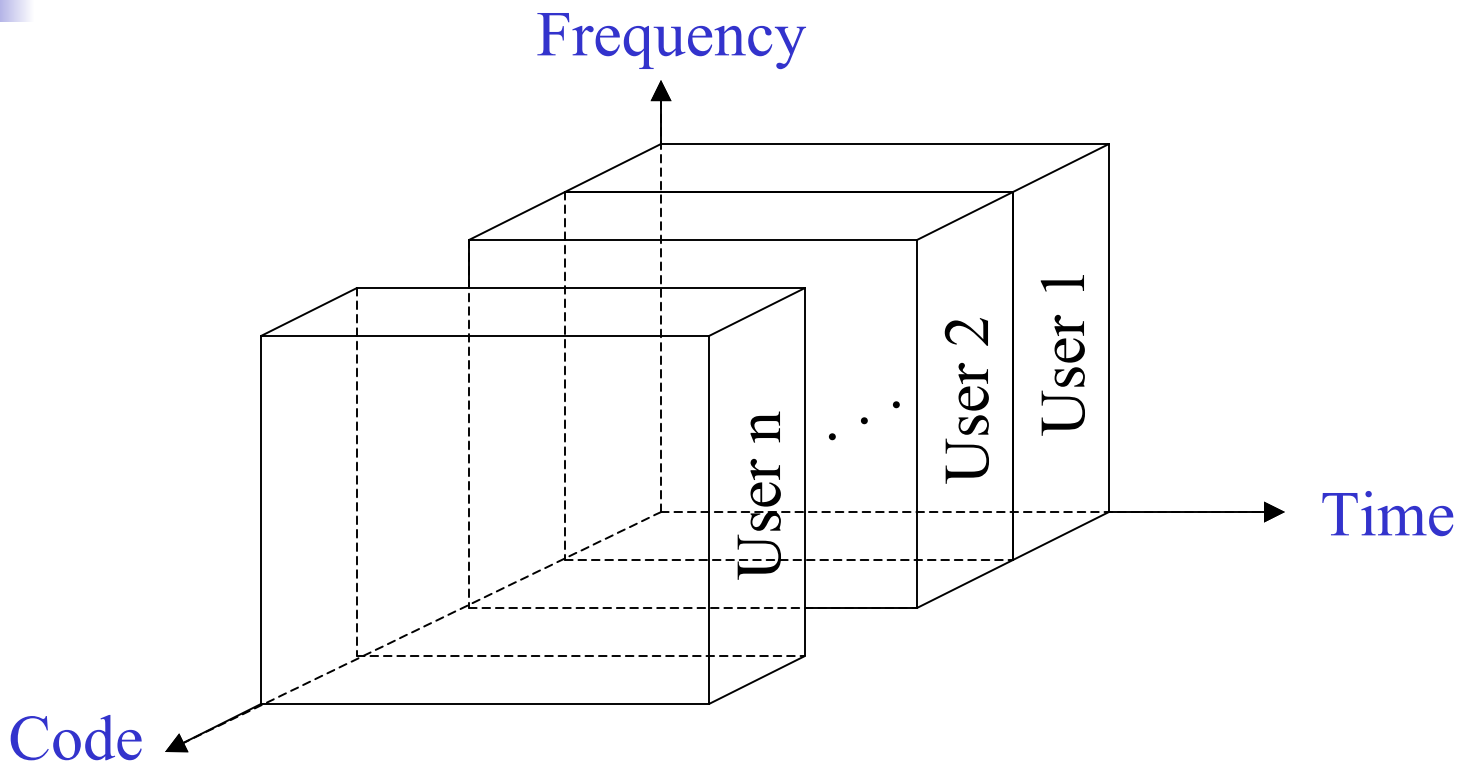
- Single channel per carrier
- All first generation systems use FDMA

Time Division Multiple Access (TDMA)

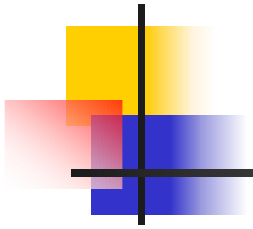


- Multiple channels per carrier
- Most of second generation systems use TDMA

Code Division Multiple Access (CDMA)



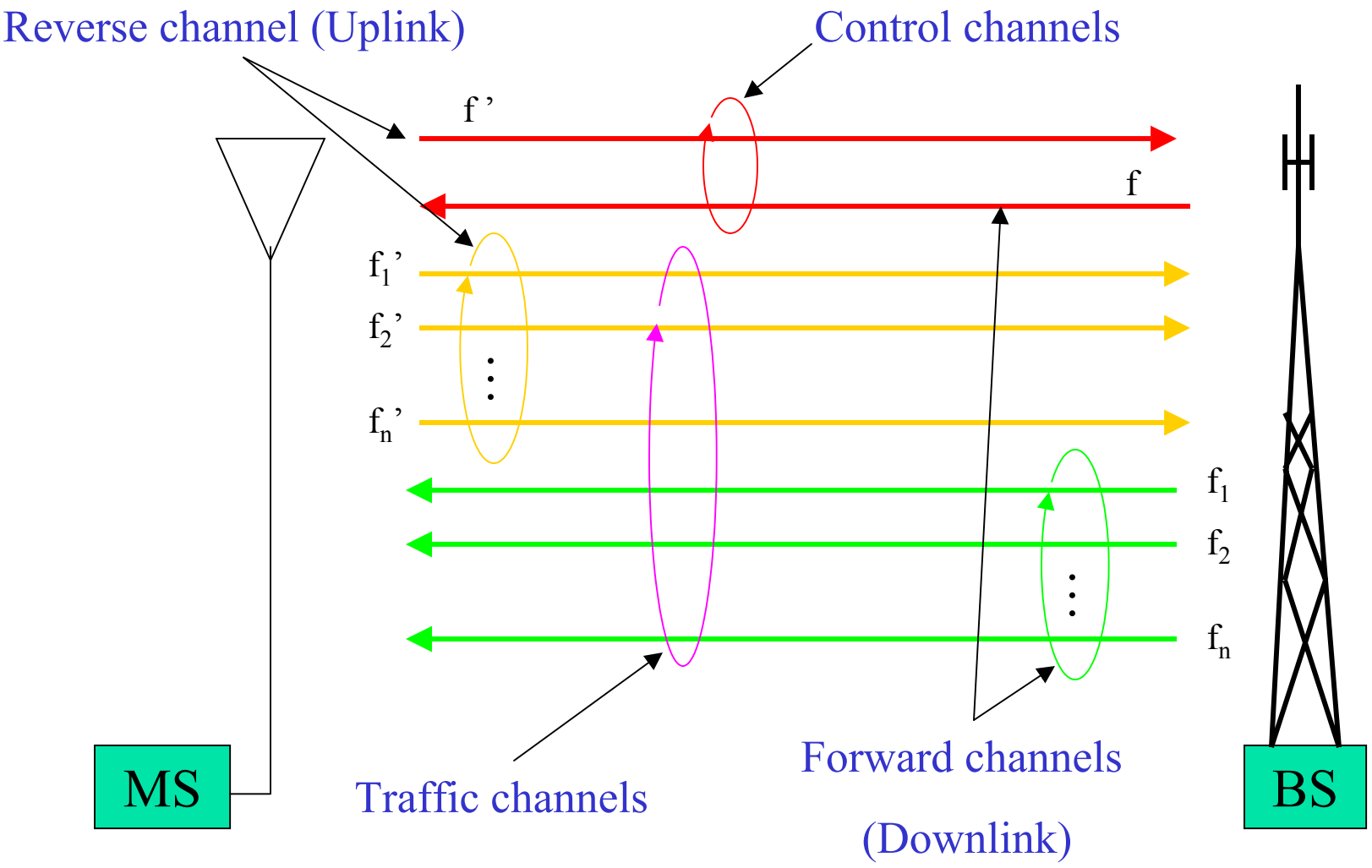
- Users share bandwidth by using code sequences that are orthogonal to each other
- Some second generation systems use CDMA
- Most of third generation systems use CDMA



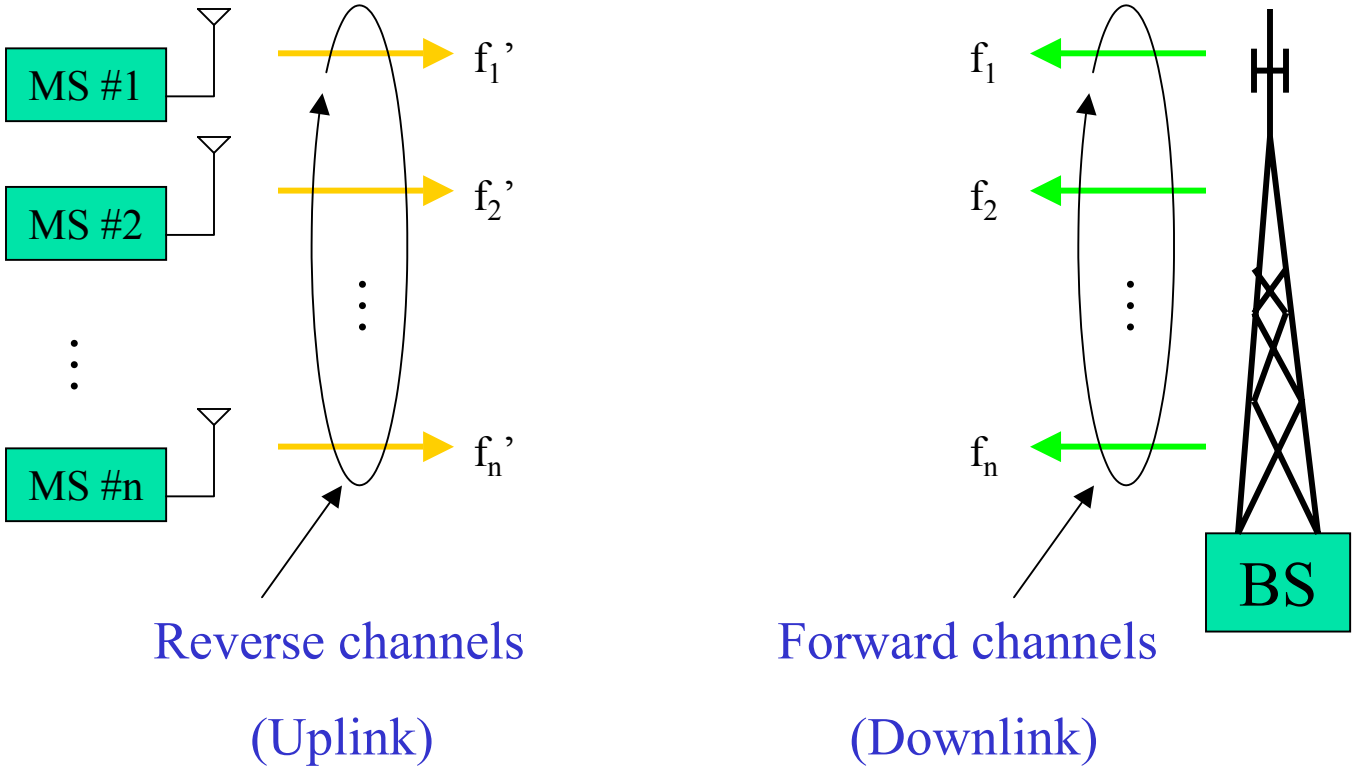
Types of Channels

- Control channel
  - Forward (Downlink) control channel
  - Reverse (Uplink) control channel
- Traffic channel
  - Forward traffic (information) channel
  - Reverse traffic (information) channel

Types of Channels (Cont'd)



FDMA



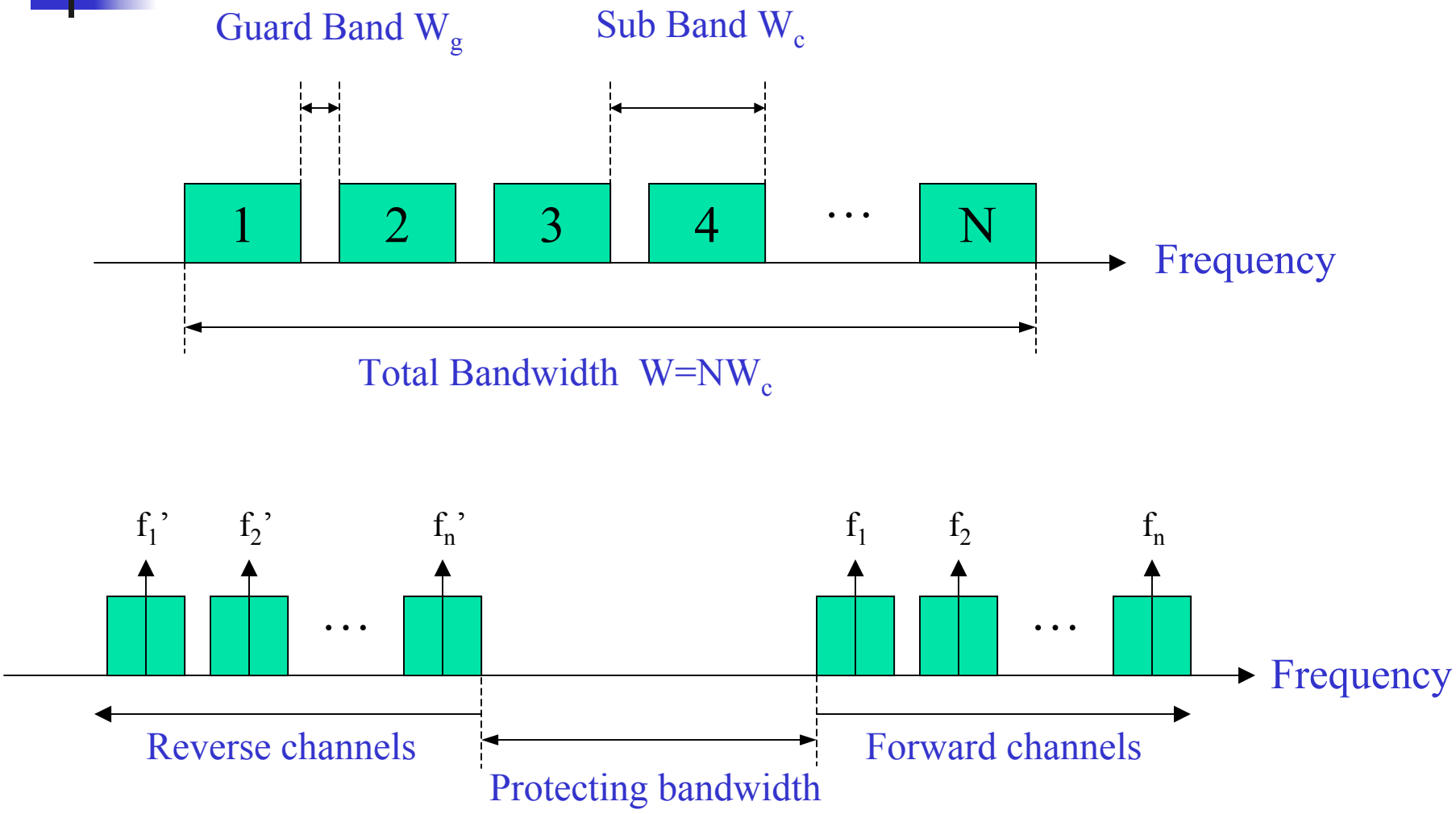
Reverse channels

(Uplink)

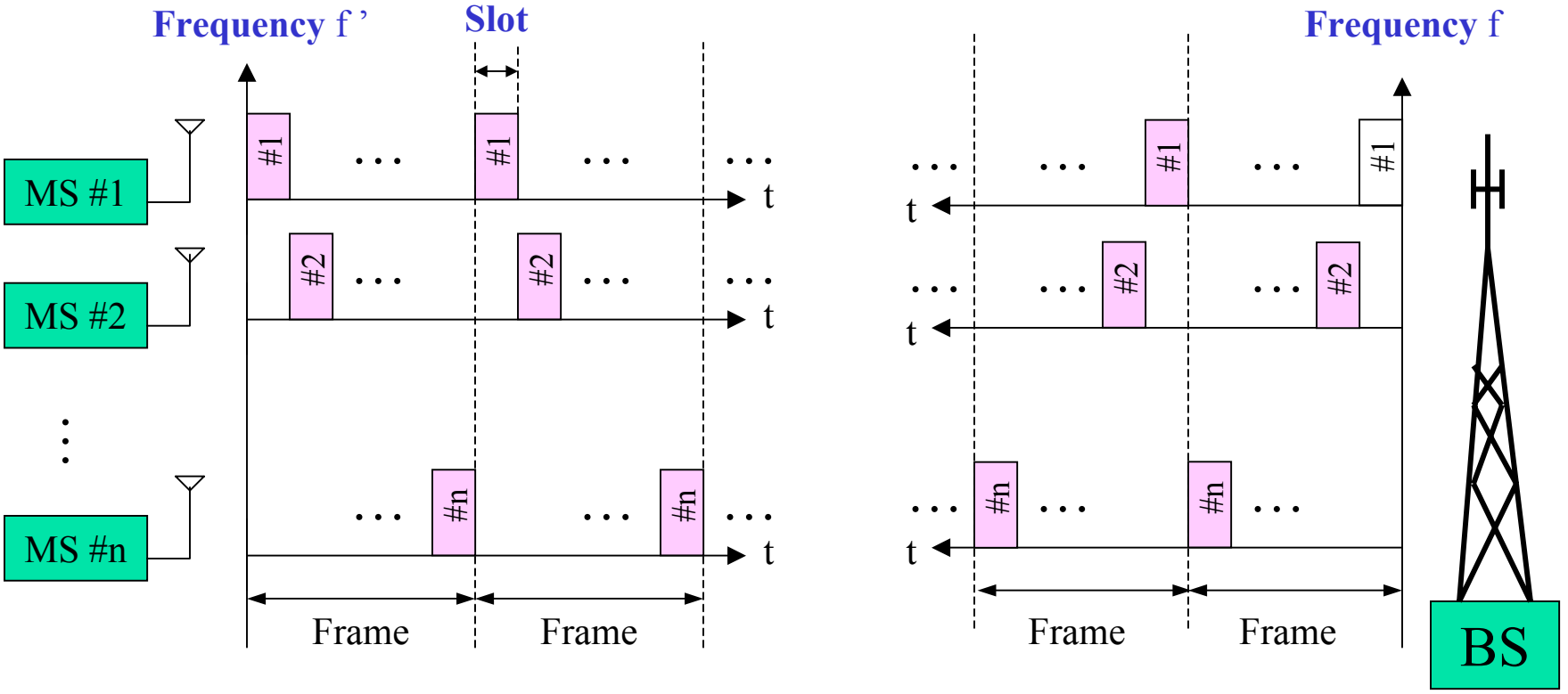
Forward channels

(Downlink)

FDMA: Channel Structure



TDMA



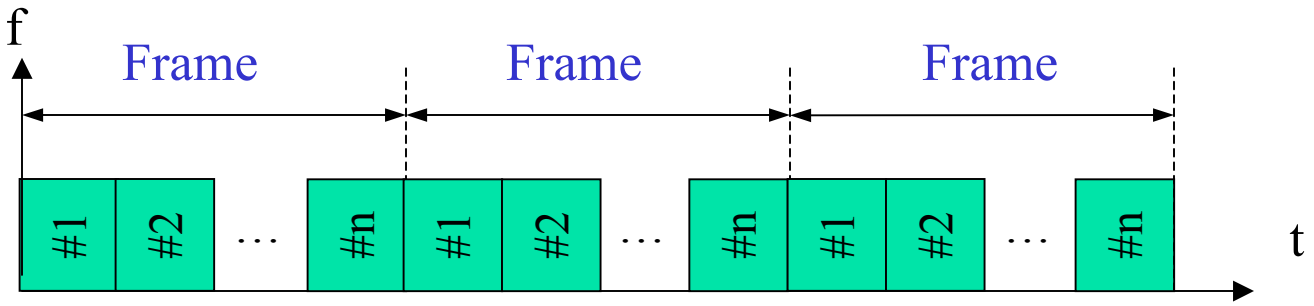
Reverse channels

(Uplink)

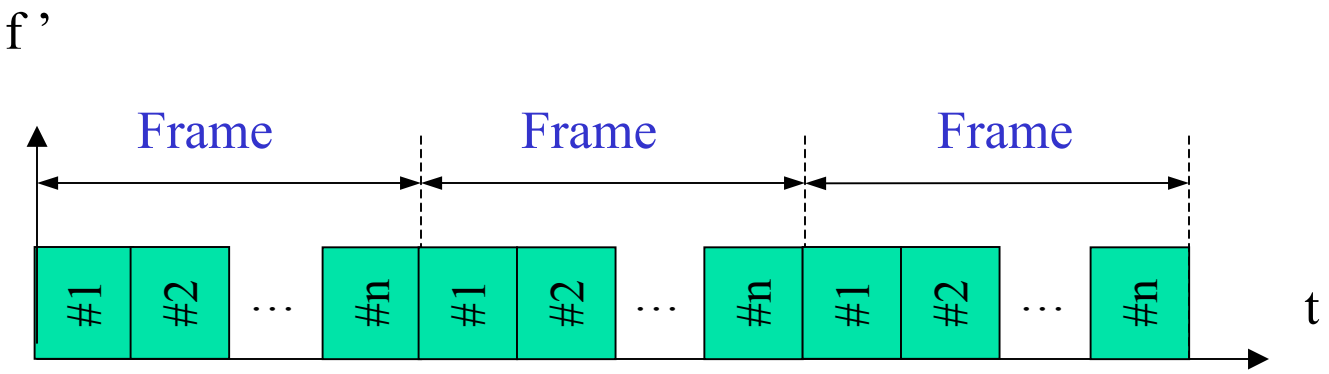
Forward channels

(Downlink)

TDMA: Channel Structure

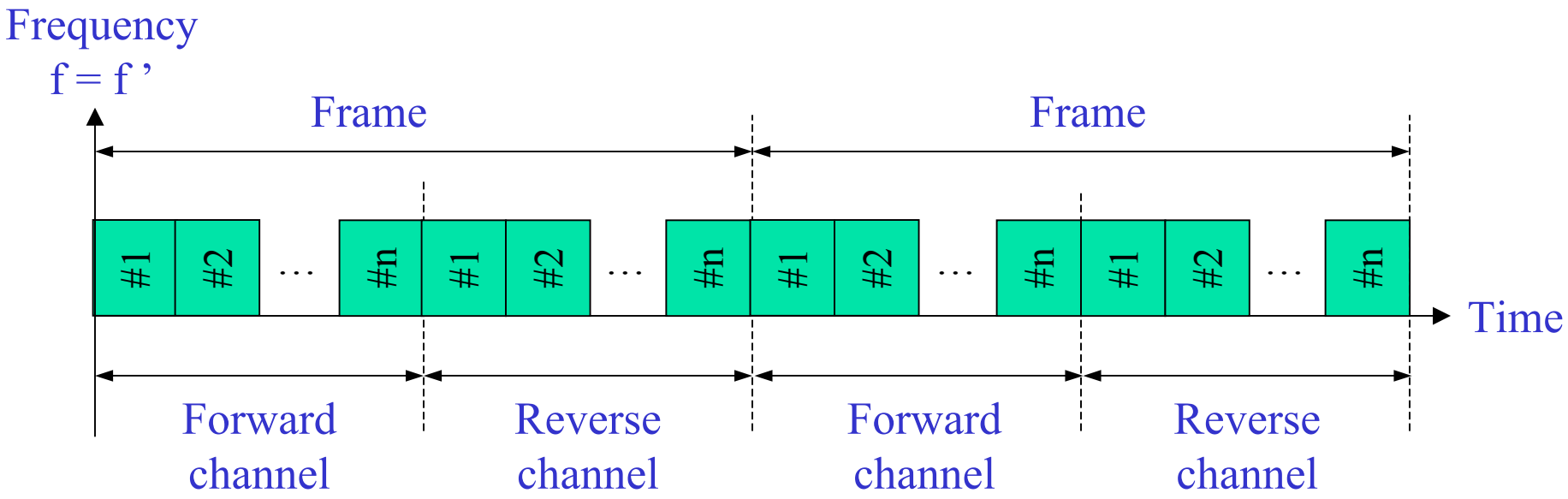


(a). Forward channel

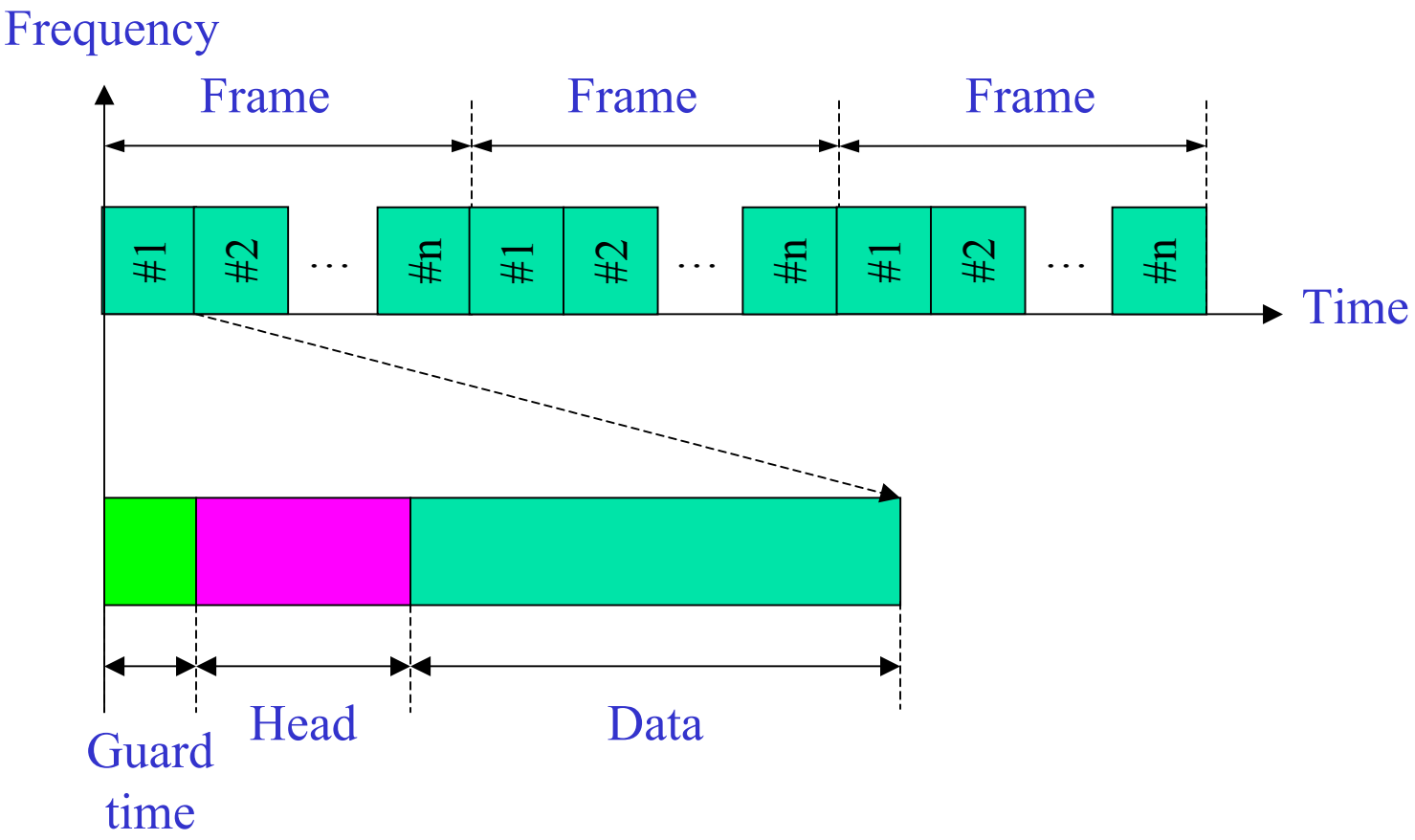


(b). Reverse channel

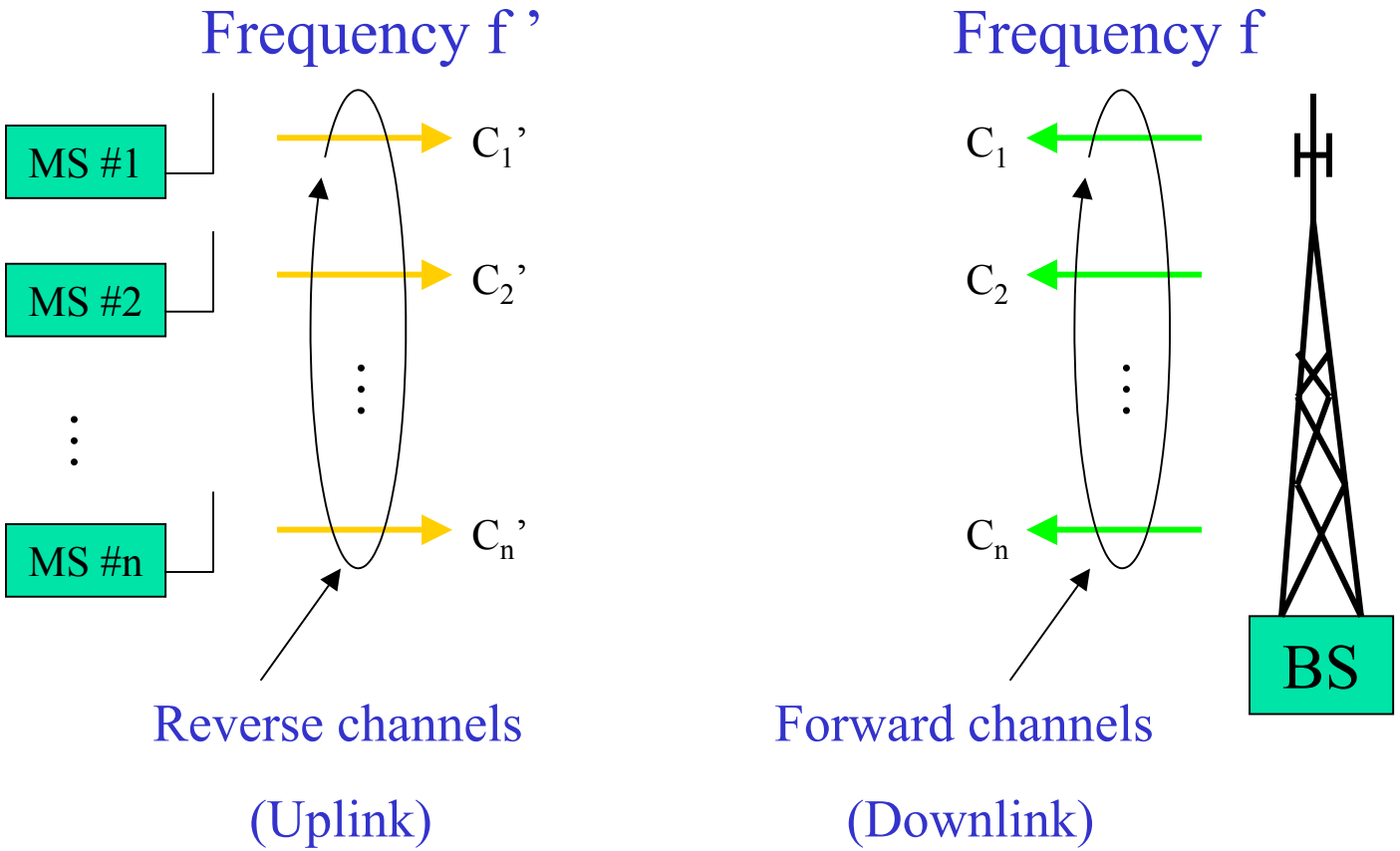
TDMA: Frame Structure (Cont'd)



TDMA: Frame Structure (Cont'd)



Code Division Multiple Access (CDMA)



Note: $C_i' \times C_j' = 0$, i.e., C_i' and C_j' are orthogonal codes,
$C_i \times C_j = 0$, i.e., C_i and C_j are orthogonal codes

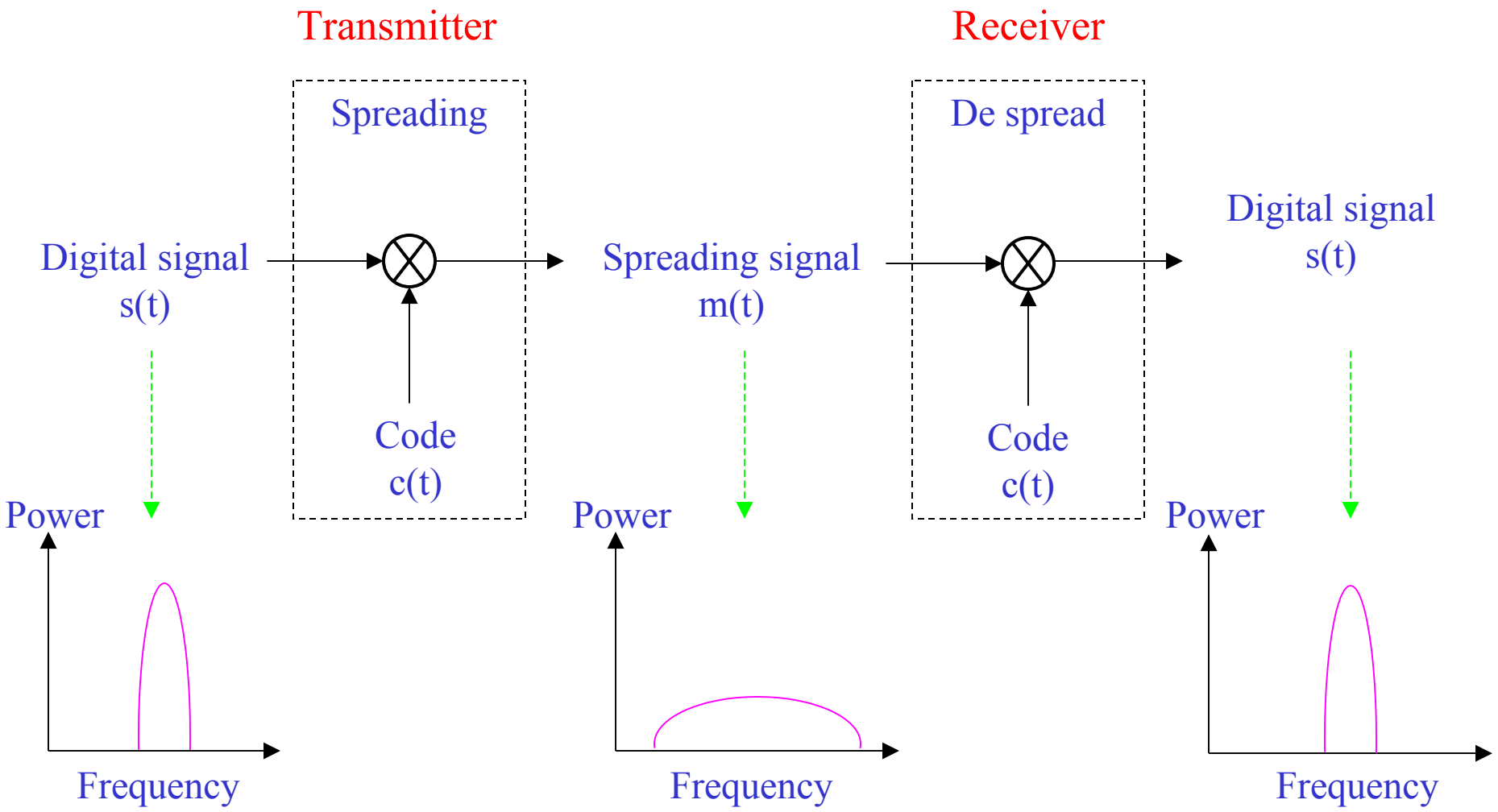
Comparisons of FDMA, TDMA, and CDMA (Example)

Operation	FDMA	TDMA	CDMA
Allocated Bandwidth	12.5 MHz	12.5 MHz	12.5 MHz
Frequency reuse	7	7	1
Required channel BW	0.03 MHz	0.03 MHz	1.25 MHz
No. of RF channels	12.5/0.03=416	12.5/0.03=416	12.5/1.25=10
Channels/cell	416/7=59	416/7=59	12.5/1.25=10
Control channels/cell	2	2	2
Usable channels/cell	57	57	8
Calls per RF channel	1	4*	40**
Voice channels/cell	57x1=57	57x4=228	8x40=320
Sectors/cell	3	3	3
Voice calls/sector	57/3=19	228/3=76	320
Capacity vs FDMA	1	4	16.8

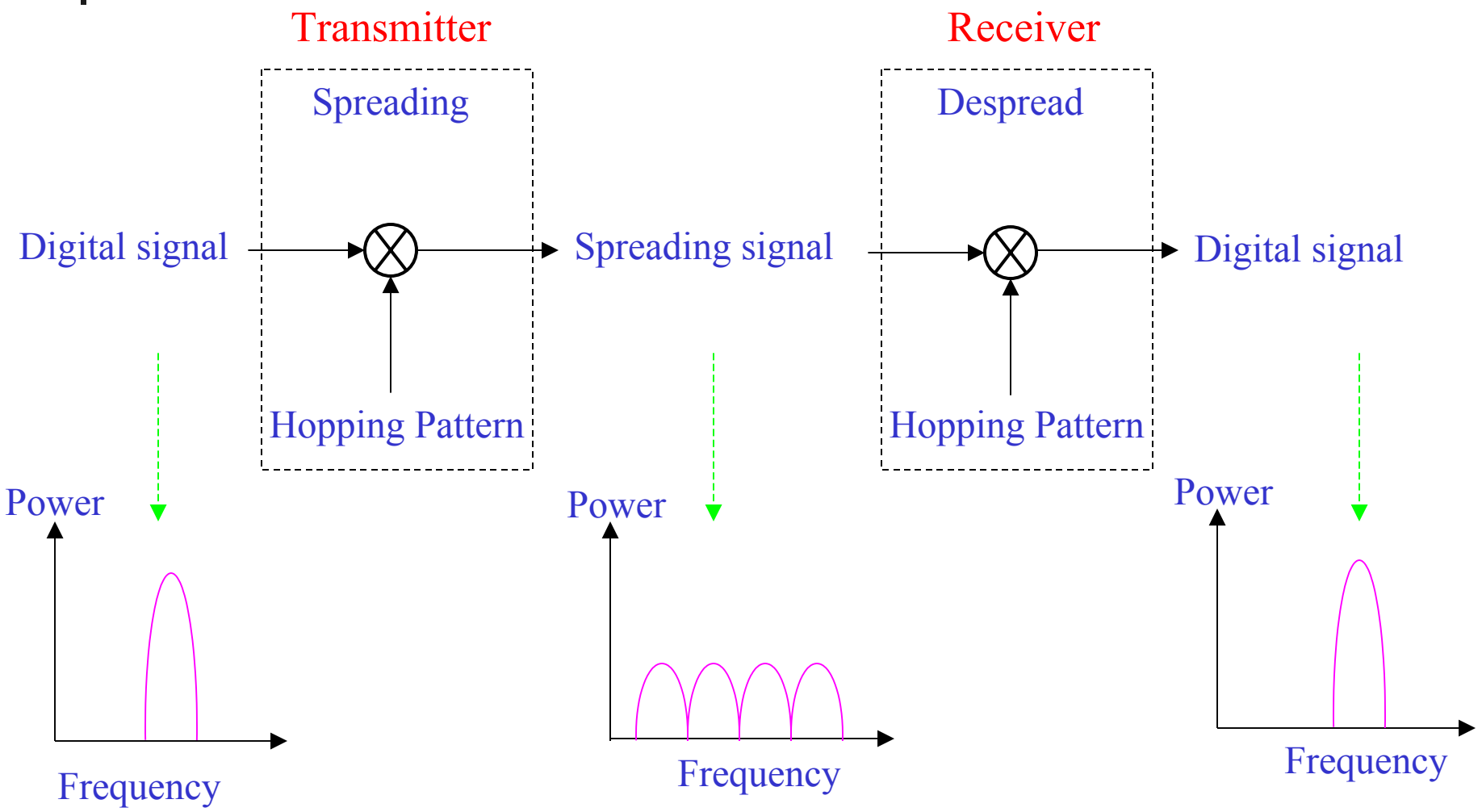
* Depends on the number of slots

** Depends on the number of codes

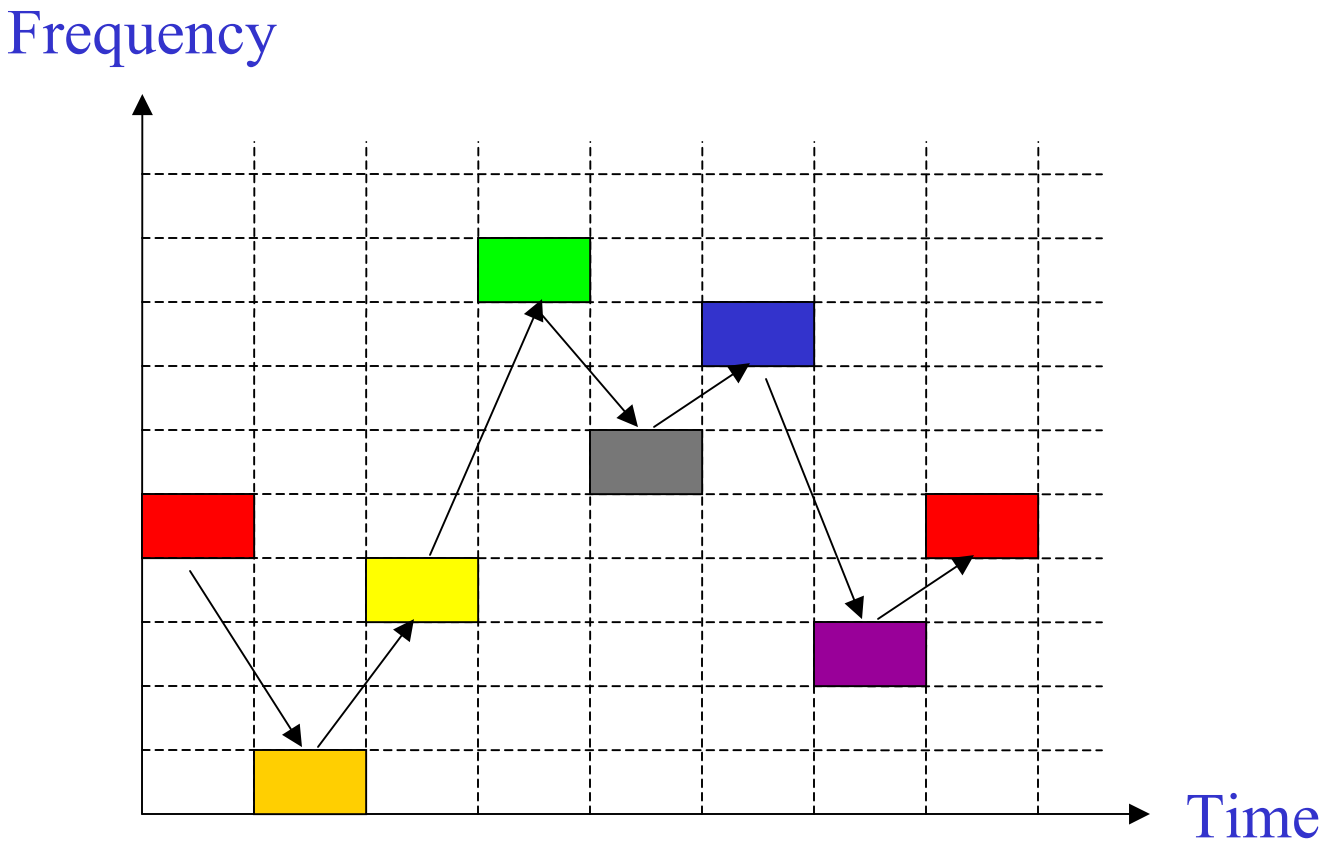
Concept of Direct Sequence Spread Spectrum



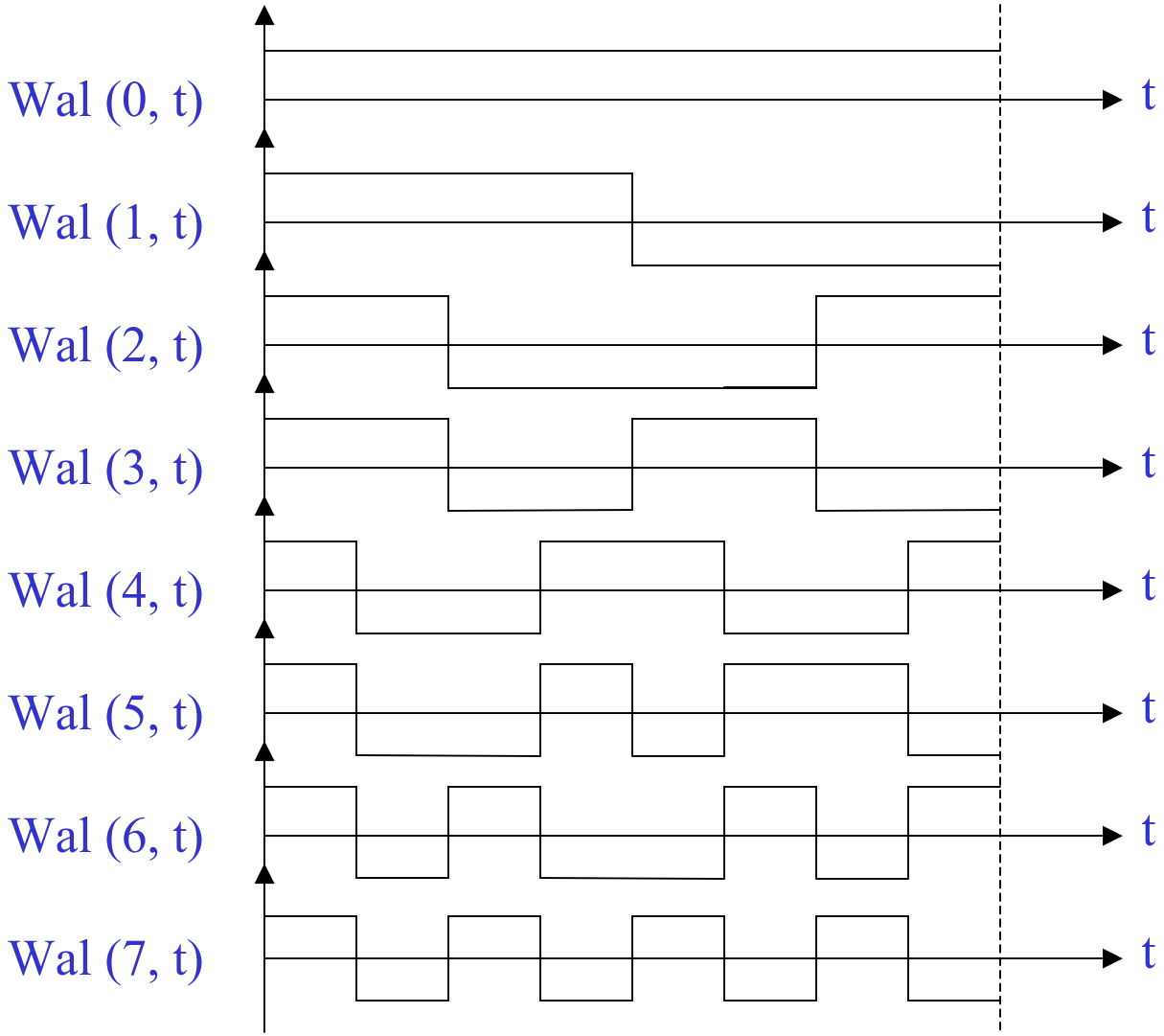
Concept of Frequency Hopping Spread Spectrum



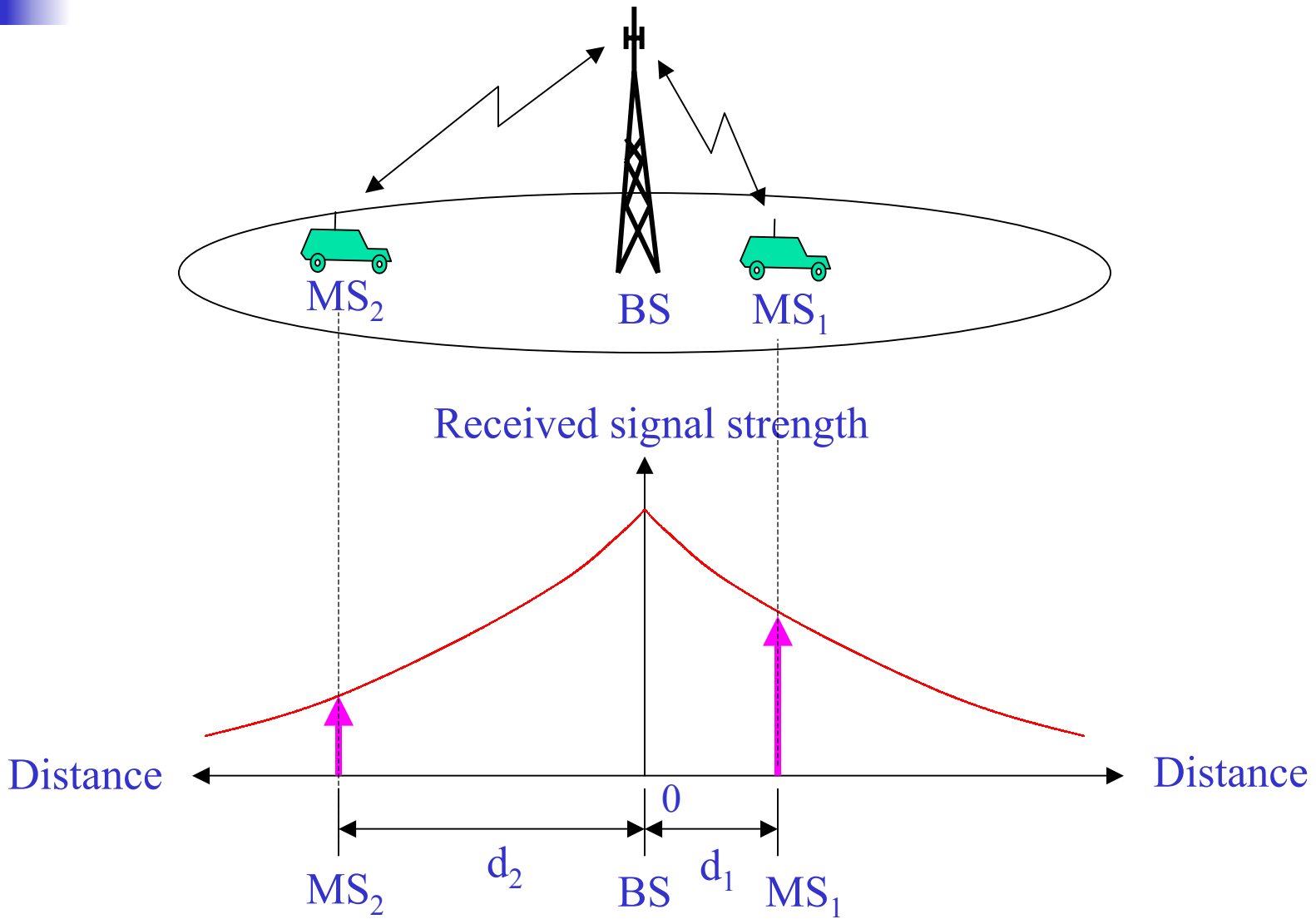
An Example of Frequency Hopping Pattern



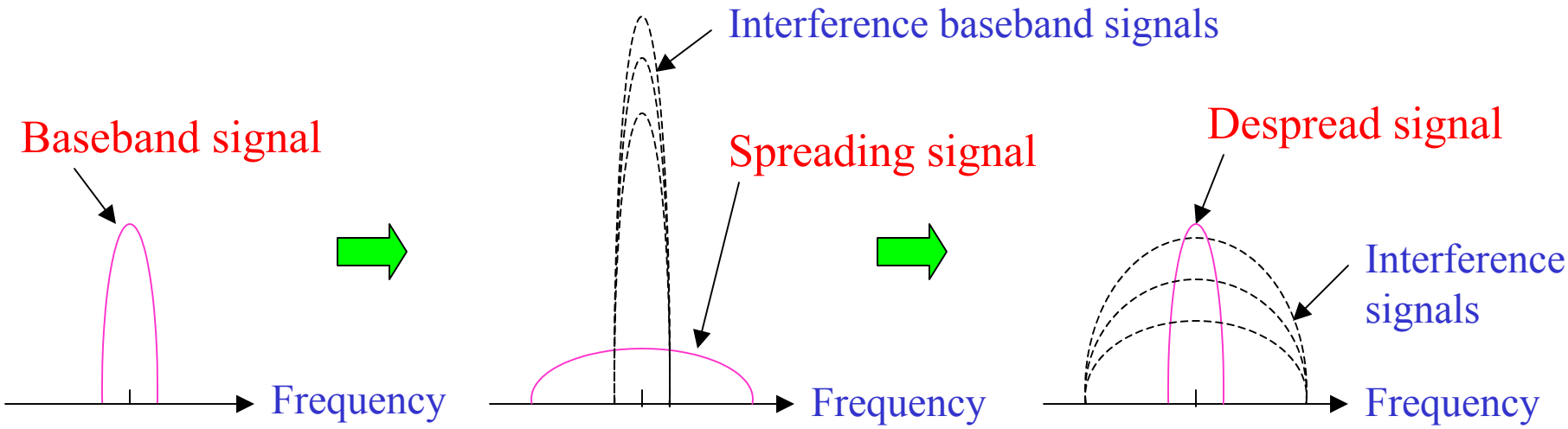
Walsh Codes (Orthogonal Codes)



Near-far Problem

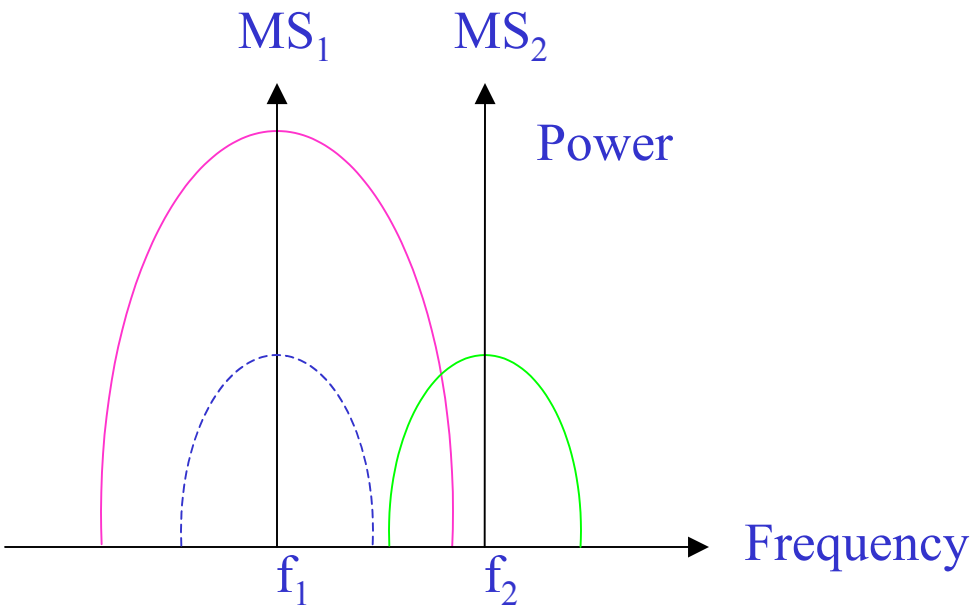


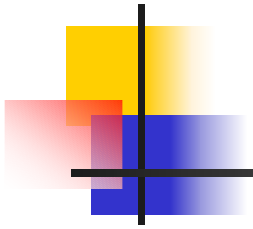
Types of Interference



Interference in spread spectrum system

Adjacent Channel Interference



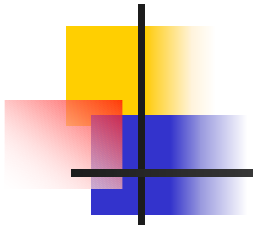


Power Control

Controlling transmitted power affects the CIR

$$\frac{P_r}{P_t} = \frac{1}{\left(\frac{4\pi df}{c}\right)^{\alpha}}$$

P_t = Transmitted power
P_r = Received power in free space
d = Distance between receiver and transmitter
f = Frequency of transmission
c = Speed of light
α = Attenuation constant



Modulation

- Why need modulation?
  - Small antenna size

    Antenna size is inversely proportional to frequency

    e.g., 3 kHz → 50 *km* antenna

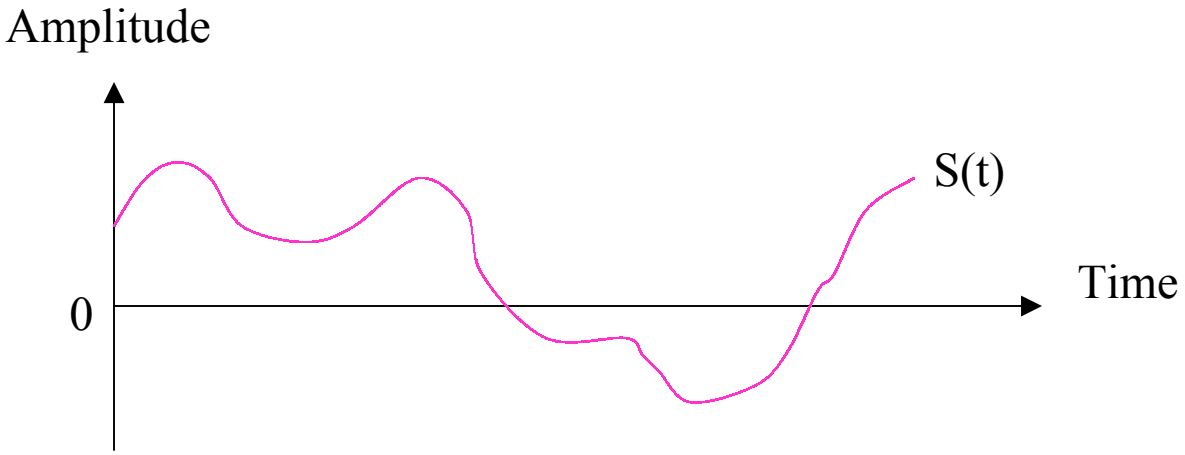
    3 GHz → 5 *cm* antenna
  - Limit noise and interference,

    e.g., FM (Frequency Modulation)
  - Multiplexing techniques,

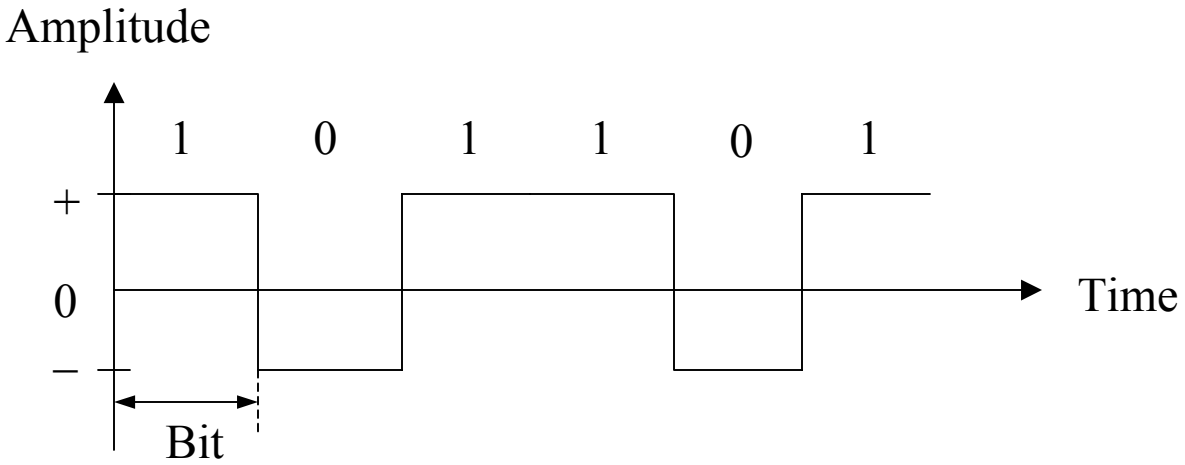
    e.g., FDM, TDM, CDMA

Analog and Digital Signals

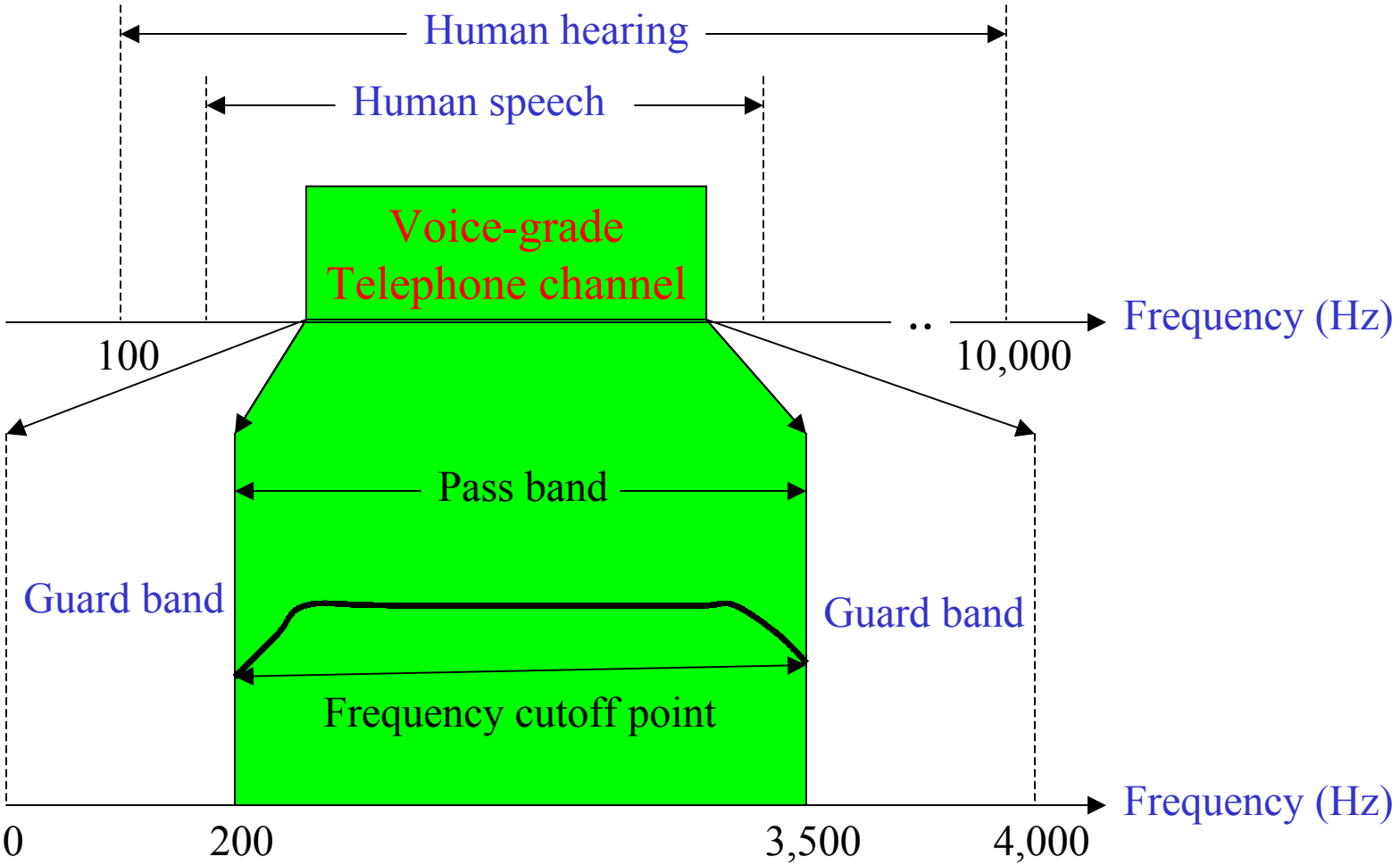
- Analog Signal (Continuous signal)



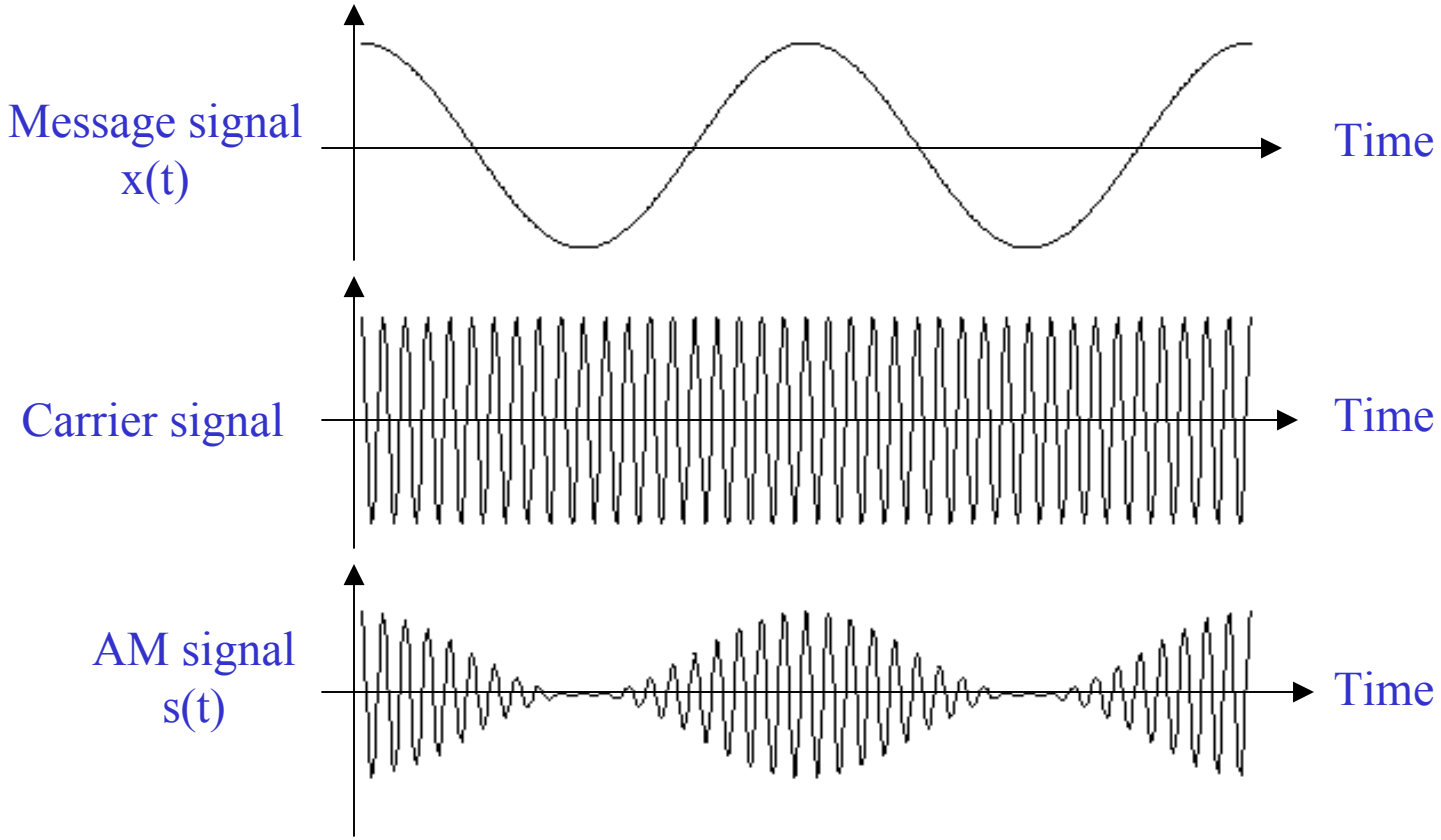
- Digital Signal (Discrete signal)



Hearing, Speech, and Voice-band Channels



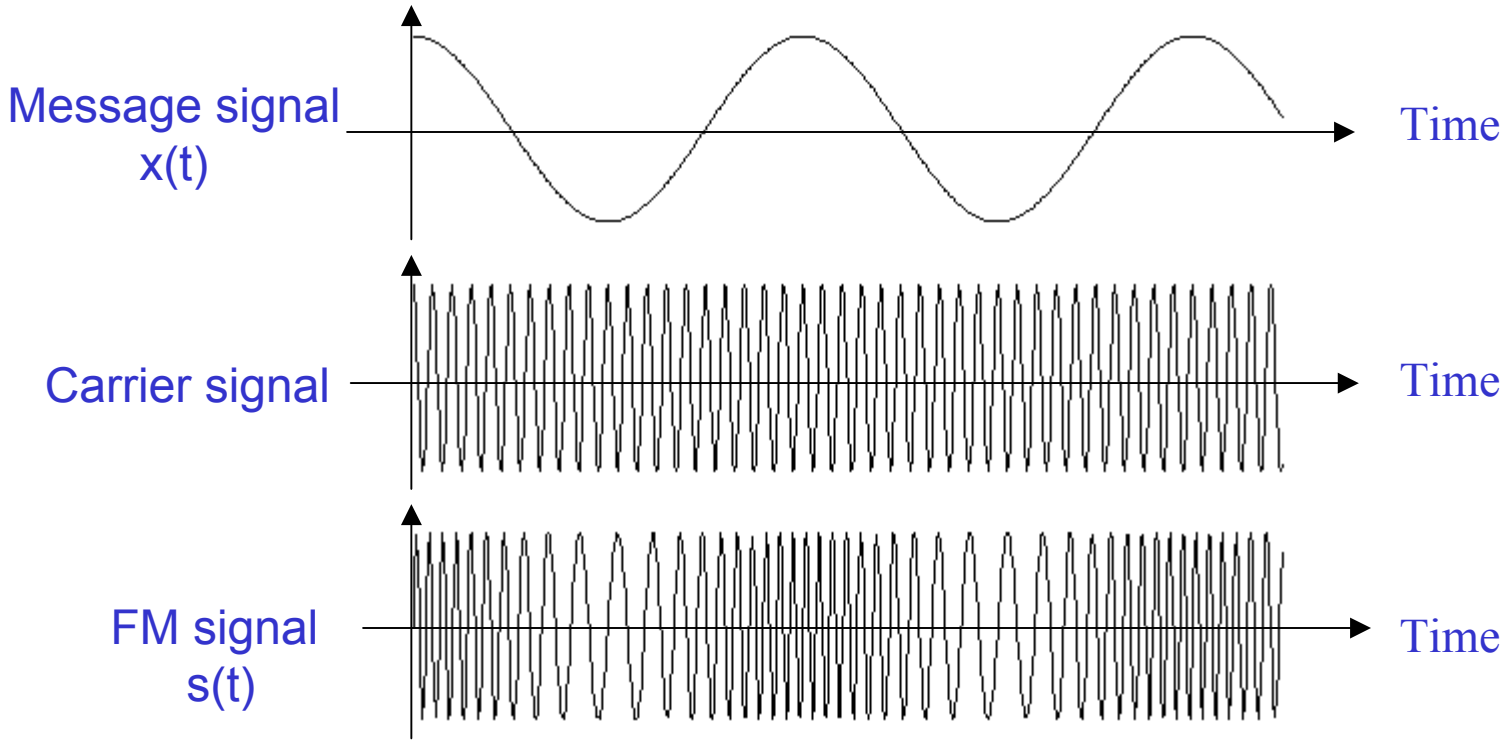
Amplitude Modulation (AM)



Amplitude of carrier signal is varied as the message signal to be transmitted.

Frequency of carrier signal is kept constant.

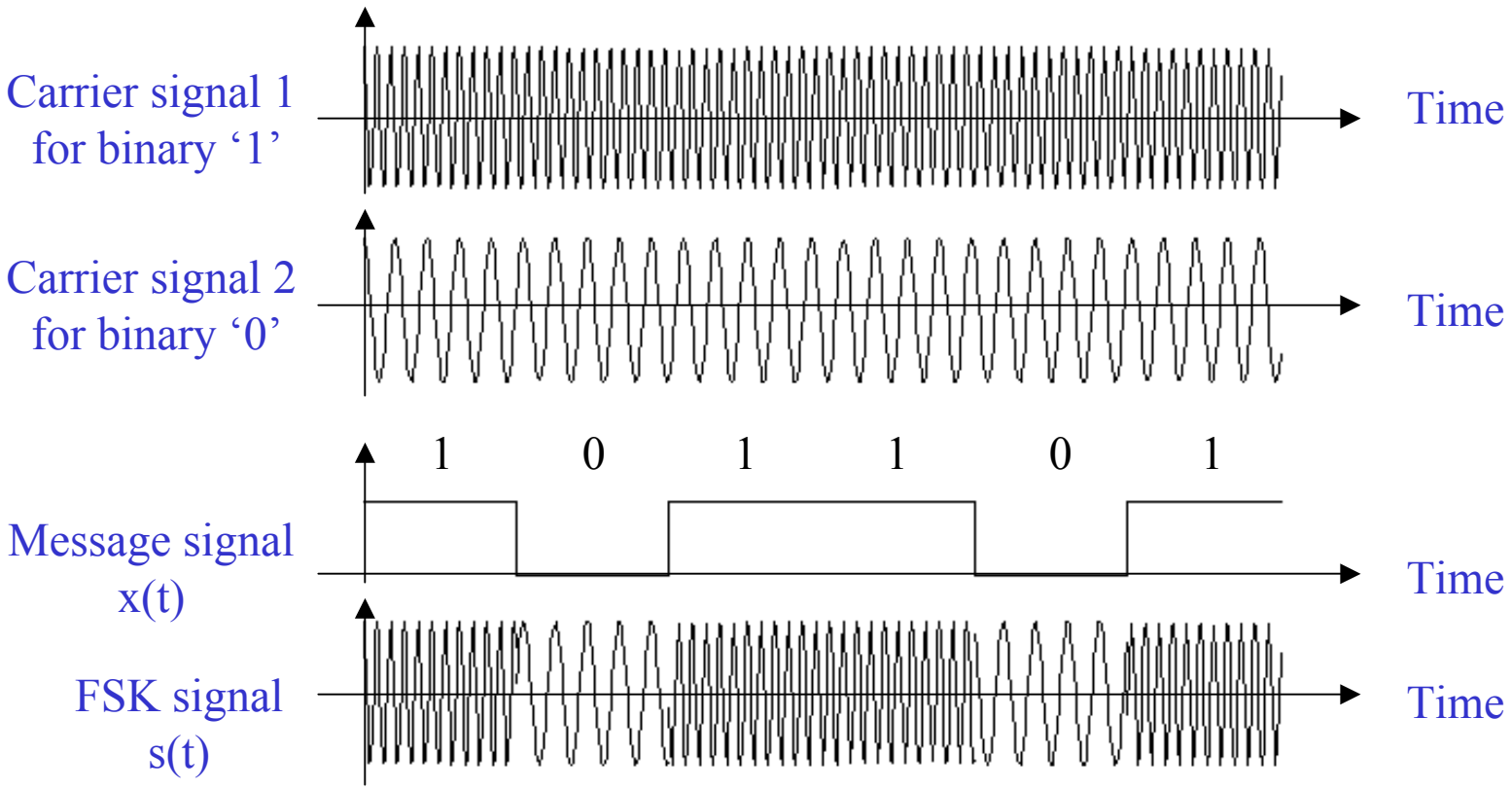
Frequency Modulation (FM)



FM integrates message signal with carrier signal by varying the instantaneous frequency. Amplitude of carrier signal is kept constant.

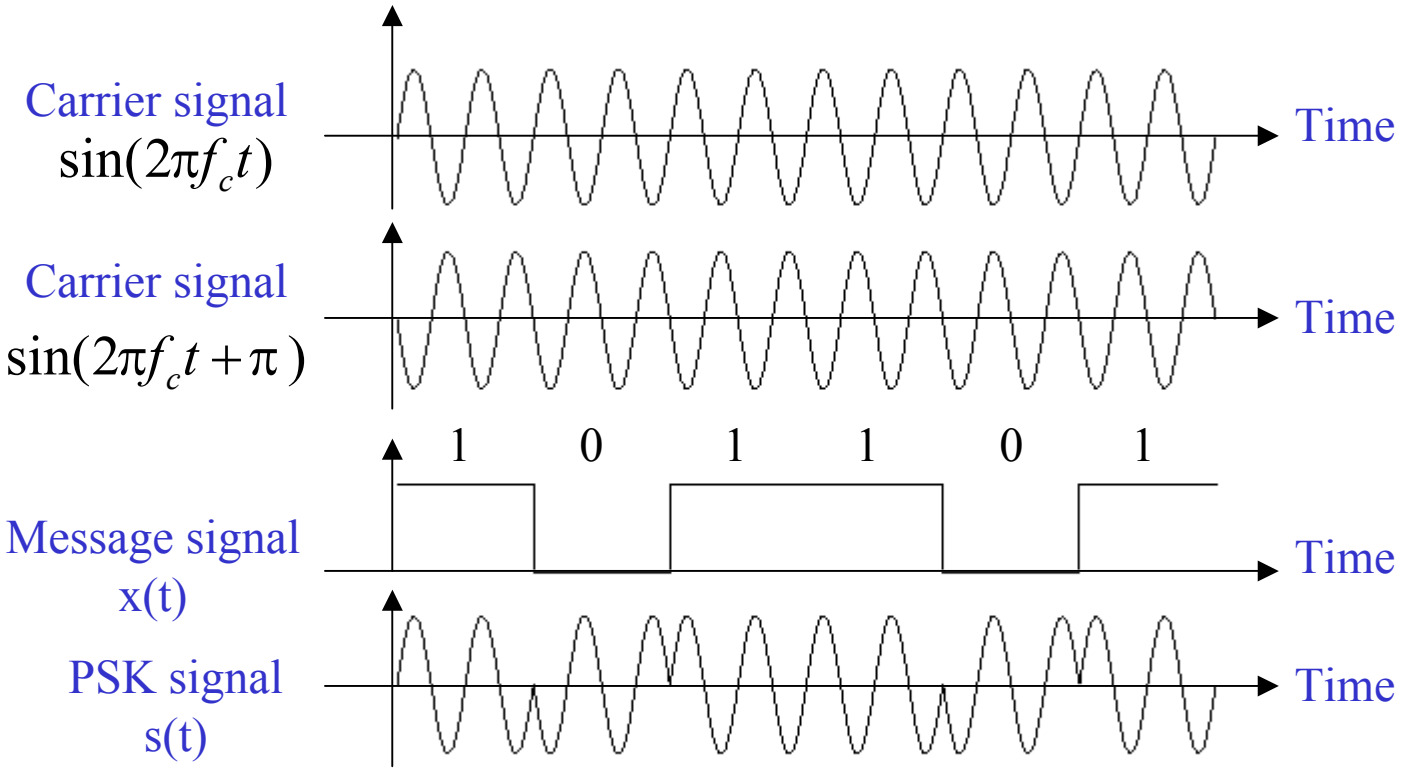
Frequency Shift Keying (FSK)

- 1/0 represented by two different frequencies slightly offset from carrier frequency

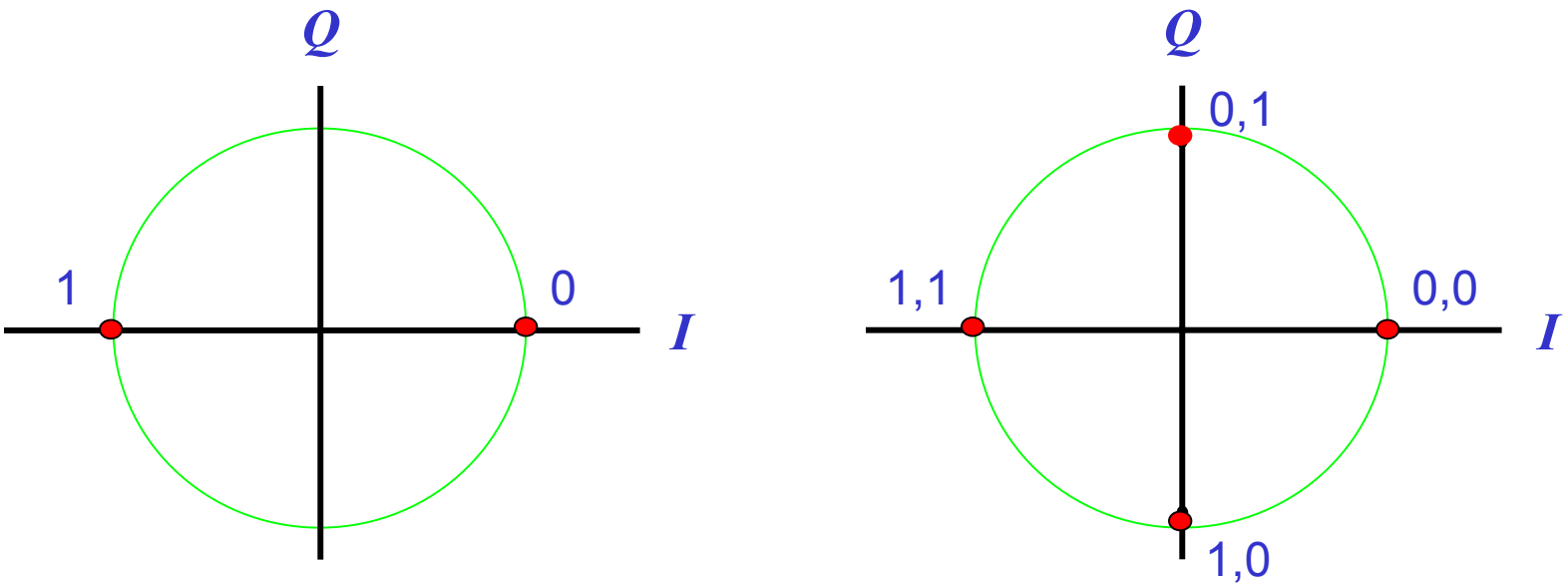


Phase Shift Keying (PSK)

- Use alternative sine wave phase to encode bits



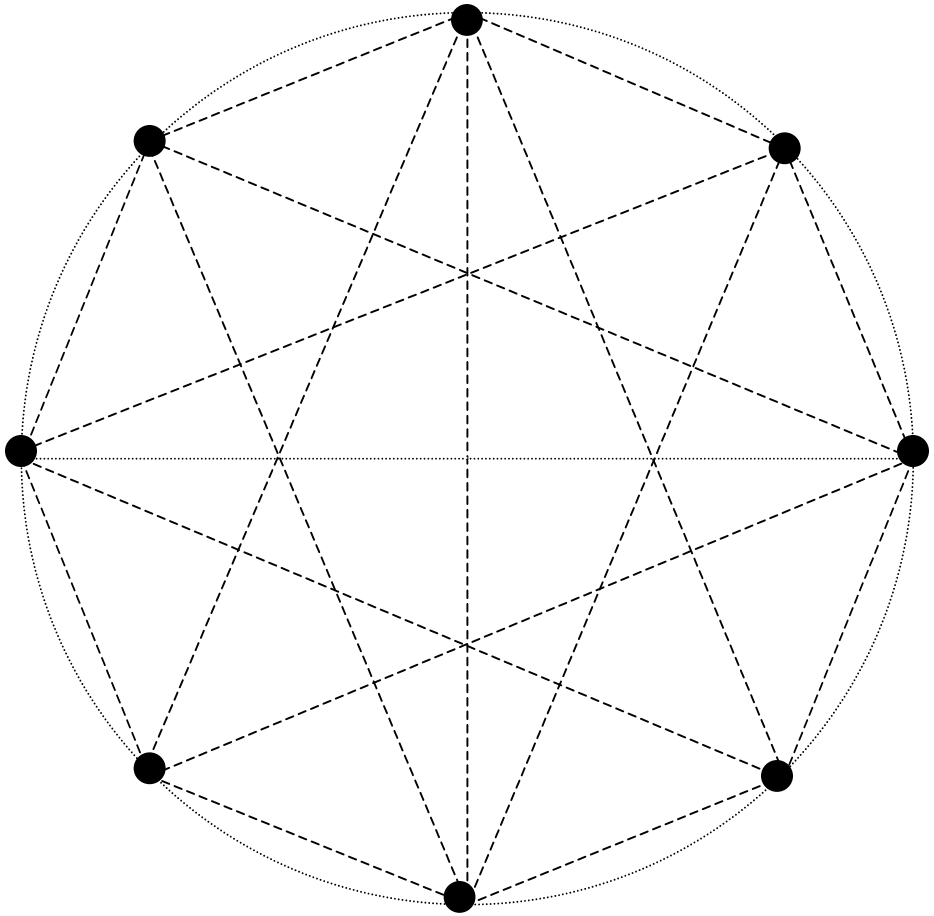
QPSK Signal Constellation



(a) BPSK

(b) QPSK

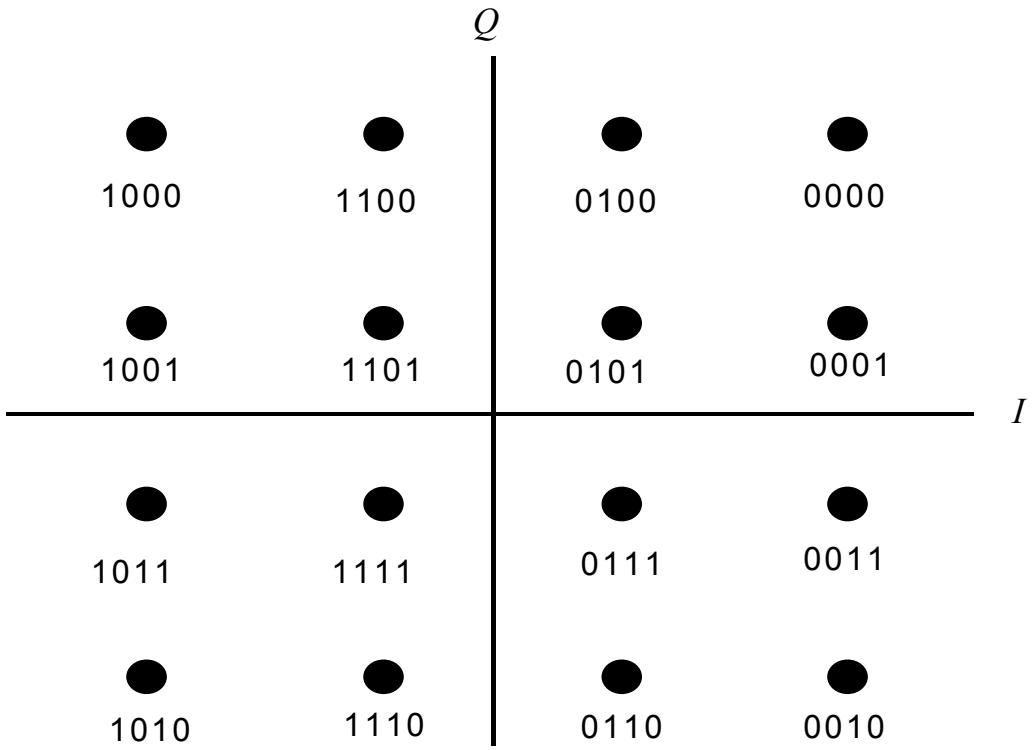
All Possible State Transitions in π/4 QPSK



Quadrature Amplitude Modulation (QAM)

Combination of AM and PSK

Two carriers out of phase by 90 deg are amplitude modulated



Rectangular constellation of 16QAM