

# Wireless Networks

CS 6710

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# Outline of the course: Basic topics

- ❑ Transmission Fundamentals
  - o Analog and digital transmission
  - o Channel capacity
  - o Antennas, propagation modes, and fading
  - o Signal encoding techniques
- ❑ Spread spectrum technology
- ❑ Coding and error control
- ❑ Cellular networks
- ❑ Wireless LANs
  - o IEEE 802.11
  - o Bluetooth

## Outline: Advanced topics

- ❑ WiMAX, Zigbee, UWB, 3G and 4G
- ❑ Mobile Application platforms
- ❑ Mobile IP, TCP for wireless
- ❑ Multihop ad hoc networks
  - o MAC and routing protocols
  - o Power control and topology control
  - o Capacity of ad hoc networks
- ❑ Sensor networks
  - o Infrastructure, MAC, and routing protocols
  - o Algorithms for query processing

# Wireless Comes of Age

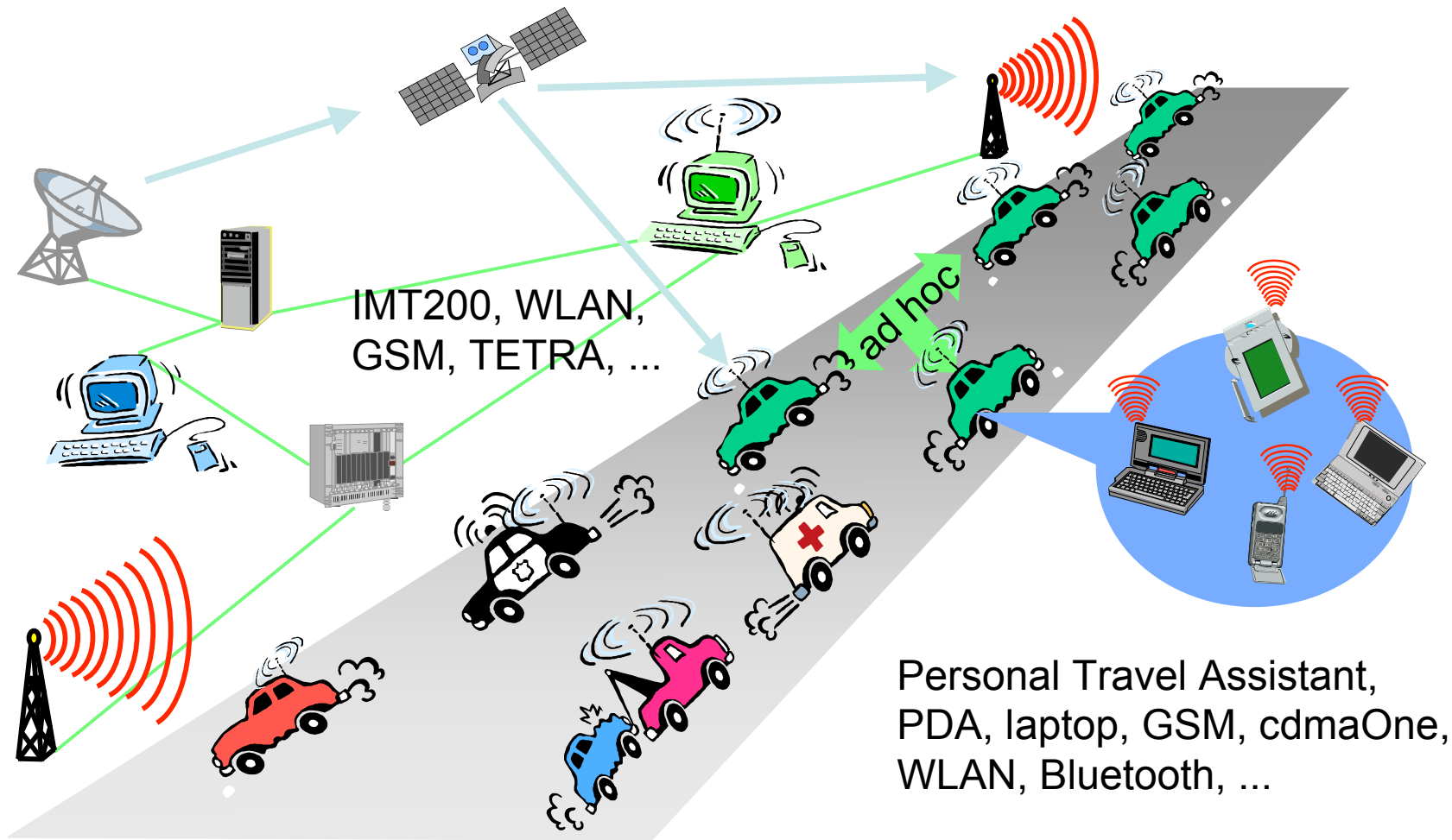
- ❑ Guglielmo Marconi invented the wireless telegraph in 1896
  - Communication by encoding alphanumeric characters in analog signal
  - Sent telegraphic signals across the Atlantic Ocean
- ❑ Communications satellites launched in 1960s
- ❑ Advances in wireless technology
  - Radio, television, mobile telephone, communication satellites
- ❑ More recently
  - Satellite communications, wireless networking, cellular technology, ad hoc networks, sensor networks

# Wireless communication systems

- ❑ Target information systems: “Anytime, Anywhere, Any form”
- ❑ Applications: Ubiquitous computing and information access
- ❑ Market in continuous growth:
  - 35-60% annual growth of PCS
  - Number of subscribers:
    - By 2001: over 700M mobile phones
    - By 2003: 1 billion subscribers
    - By 2005: 2 billion
    - By 2009: 4.6 billion
- ❑ Large diversity of standards and products
- ❑ Confusing terminology

## Limitations and difficulties

- ❑ Wireless is convenient and less expensive
- ❑ Limitations and political and technical difficulties inhibit wireless technologies
- ❑ Lack of an industry-wide standard
- ❑ Device limitations
  - o E.g., small LCD on a mobile telephone can only displaying a few lines of text
  - o E.g., browsers of most mobile wireless devices use wireless markup language (WML) instead of HTML
  - o Switching speed of the material (e.g., silicon)



# Wireless & Mobility

## ❑ Wireless:

- o Limited bandwidth
- o Broadcast medium: requires multiple access schemes
- o Variable link quality (noise, interference)
- o High latency, higher jitter
- o Heterogeneous air interfaces
- o Security: easier snooping

## ❑ Mobility:

- o User location may change with time
- o Speed of mobile impacts wireless bandwidth
- o Need mechanism for handoff
- o Security: easier spoofing

## ❑ Portability

- o Limited battery, storage, computing, and UI

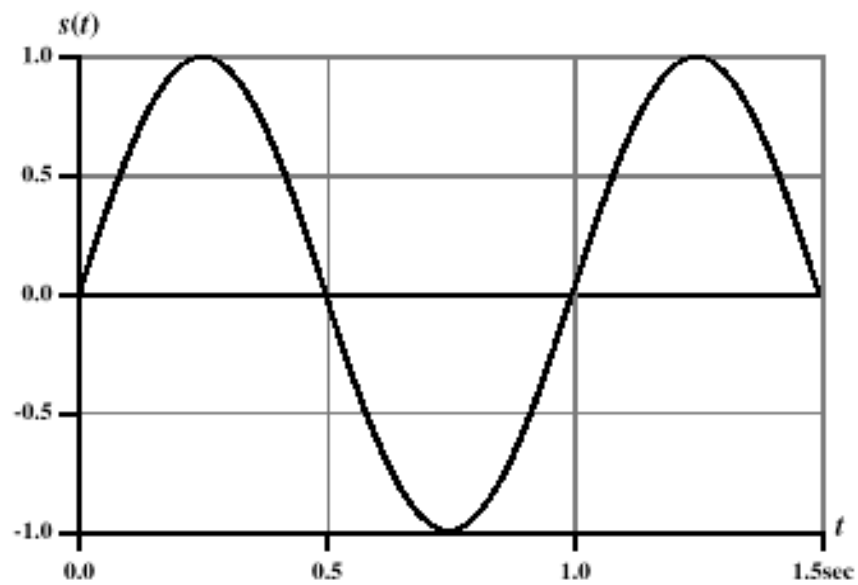


# Classification of Wireless Systems

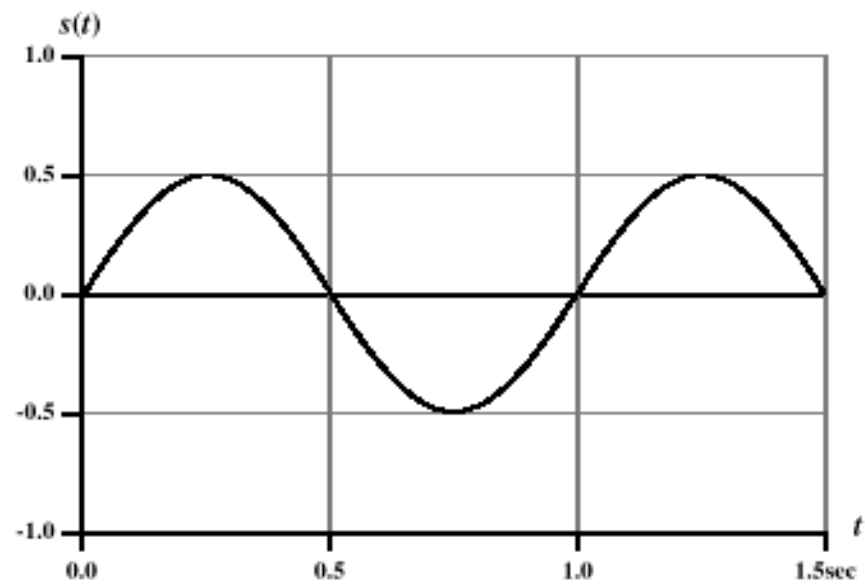
- ❑ Personal communication systems
  - o Focus on voice communication
  - o Limited bit-rate data transmission
  - o Large-scale mobility and coverage
  - o Operate over licensed frequency bands
- ❑ Wireless LANs
  - o Designed for high bit-rate transmission
  - o IP oriented
  - o Low-scale coverage
  - o Use unlicensed ISM frequency bands
- ❑ Multihop ad hoc networks
  - o Have little or no infrastructure
  - o Low-scale coverage
  - o Need new routing protocols
  - o Emerging applications

# Transmission fundamentals

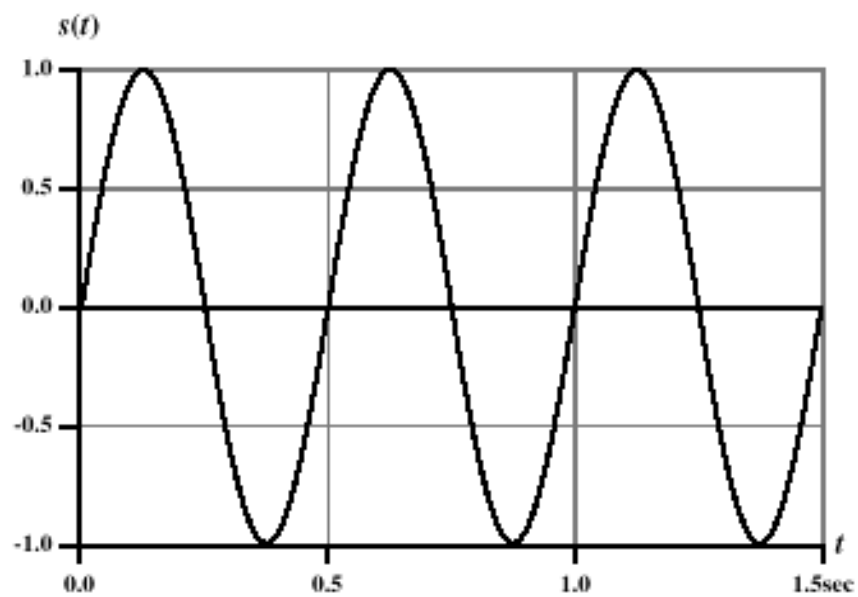
- ❑ Electromagnetic signals
  - o Time domain
  - o Frequency domain
- ❑ Data rate and bandwidth
- ❑ Channel capacity
  - o Nyquist theorem
  - o Shannon capacity theorem
- ❑ Analog and digital data transmission
- ❑ Transmission media



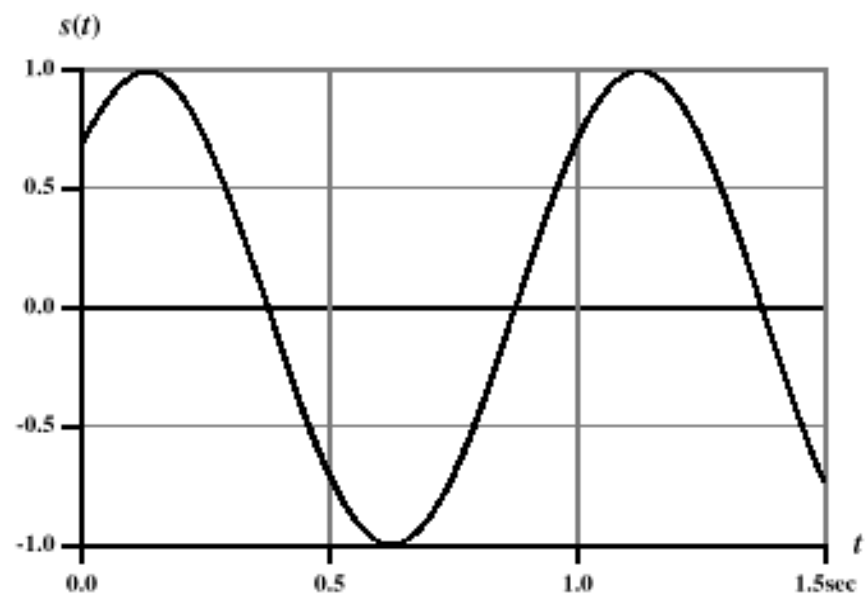
(a)  $A = 1, f = 1, \phi = 0$



(b)  $A = 0.5, f = 1, \phi = 0$

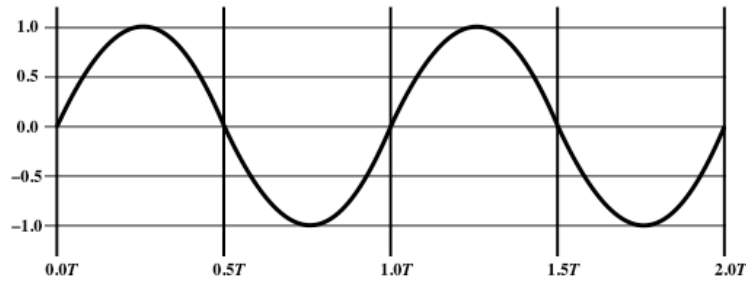


(c)  $A = 1, f = 2, \phi = 0$

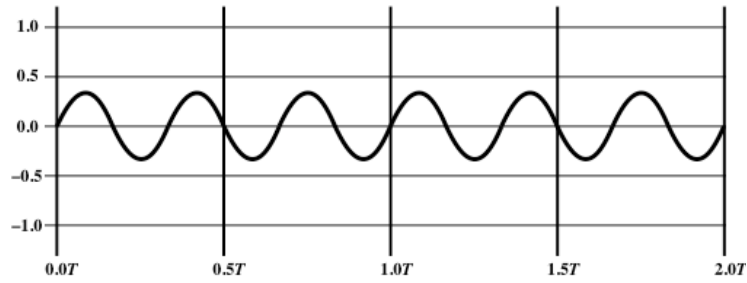


(d)  $A = 1, f = 1, \phi = \pi/4$

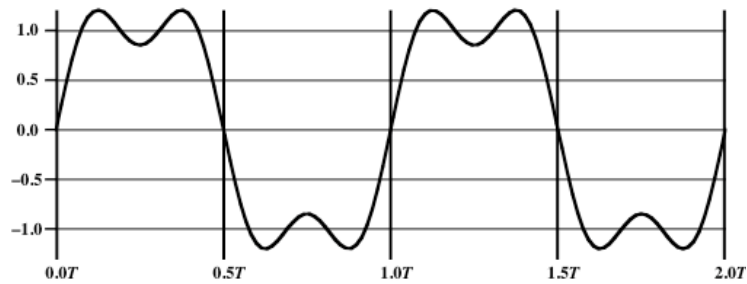
**Figure 2.3**  $s(t) = A \sin (2 ft + \phi)$



(a)  $\sin(2\pi ft)$

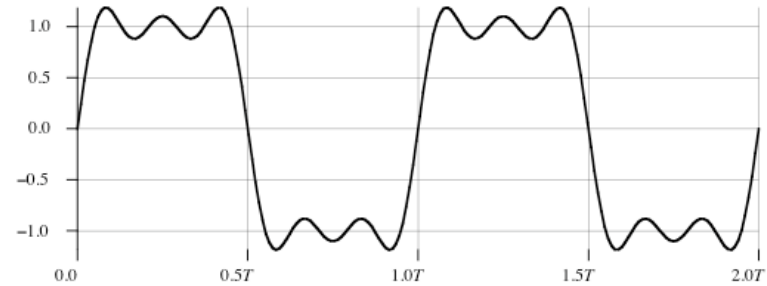


(b)  $(1/3) \sin(2\pi(3f)t)$

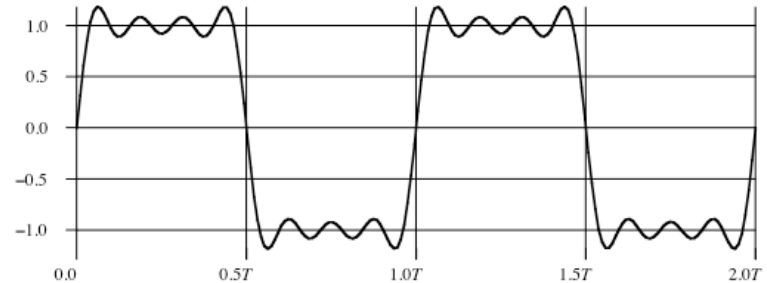


(c)  $(4/\pi) [\sin(2\pi ft) + (1/3) \sin(2\pi(3f)t)]$

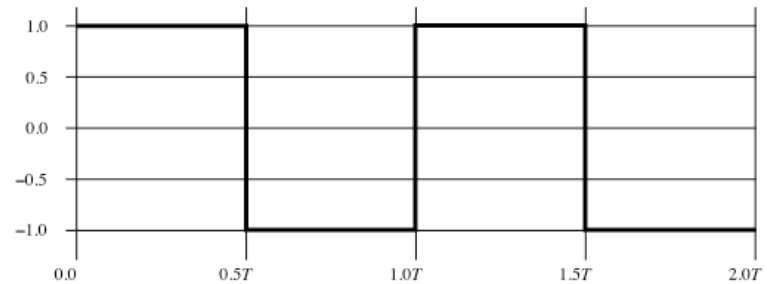
**Figure 2.4 Addition of Frequency Components ( $T = 1/f$ )**



(a)  $(4/\pi) [\sin(2\pi ft) + (1/3) \sin(2\pi(3f)t) + (1/5) \sin(2\pi(5f)t)]$



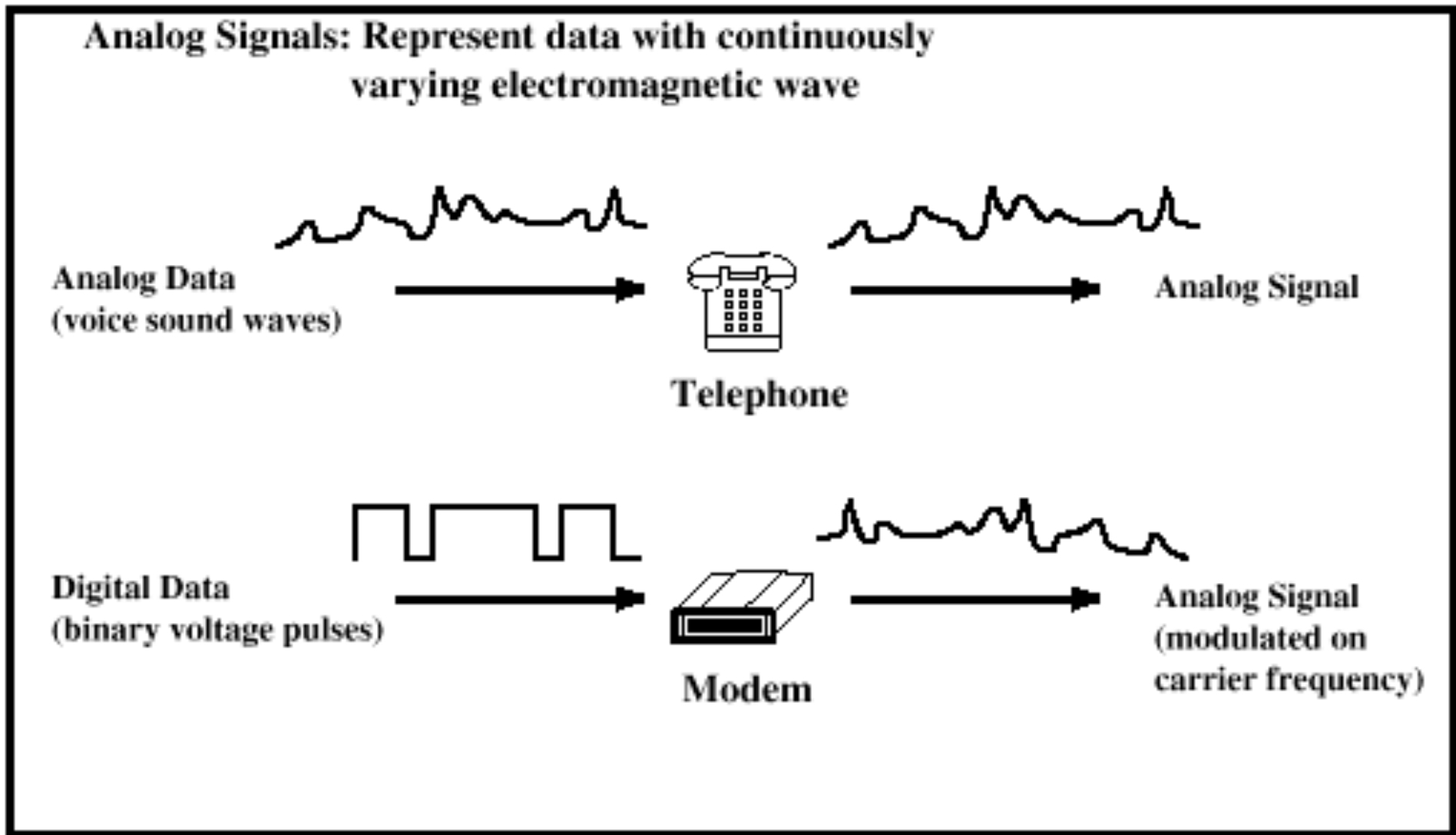
(b)  $(4/\pi) [\sin(2\pi ft) + (1/3) \sin(2\pi(3f)t) + (1/5) \sin(2\pi(5f)t) + (1/7) \sin(2\pi(7f)t)]$



(c)  $(4/\pi) \sum (1/k) \sin(2\pi(kf)t), \text{ for } k \text{ odd}$

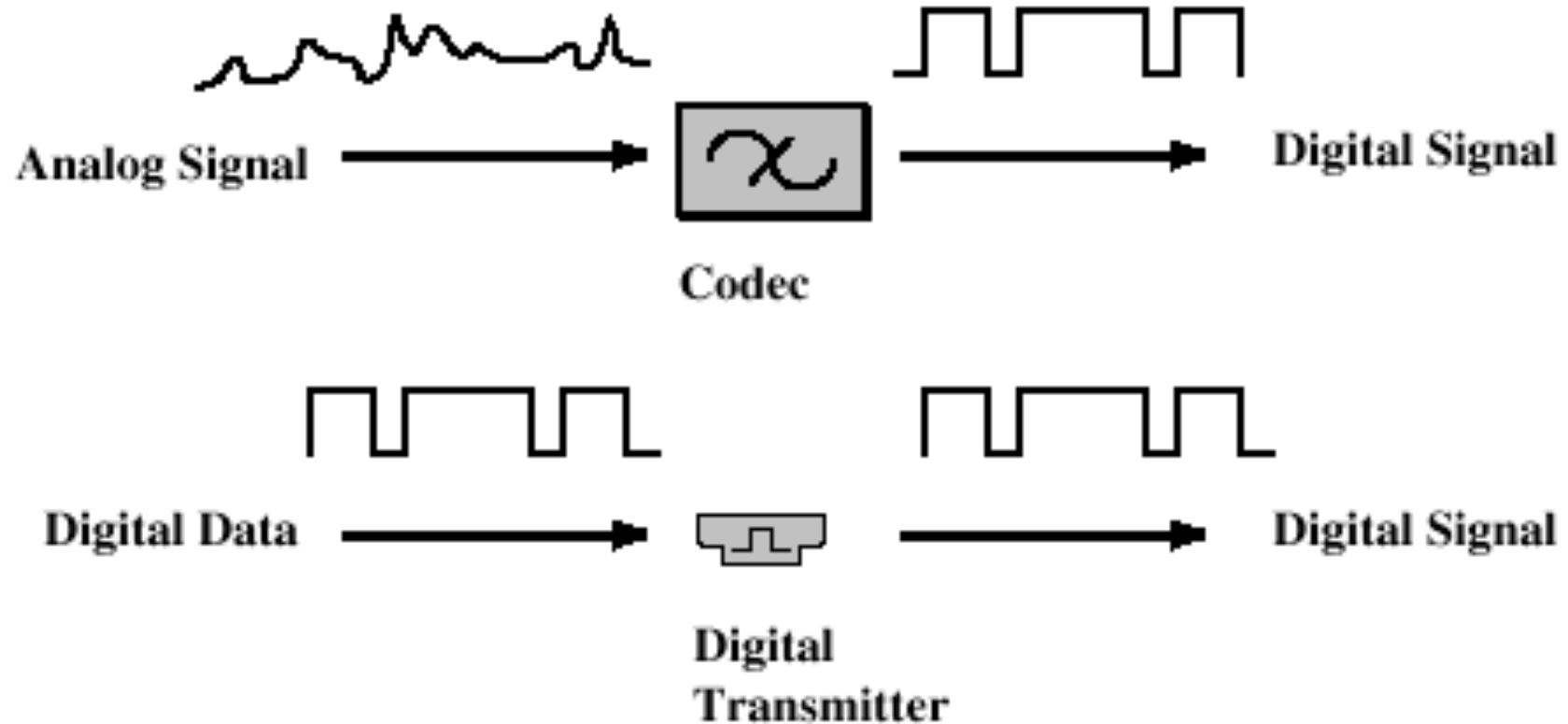
**Figure 2.5 Frequency Components of Square Wave ( $T = 1/f$ )**

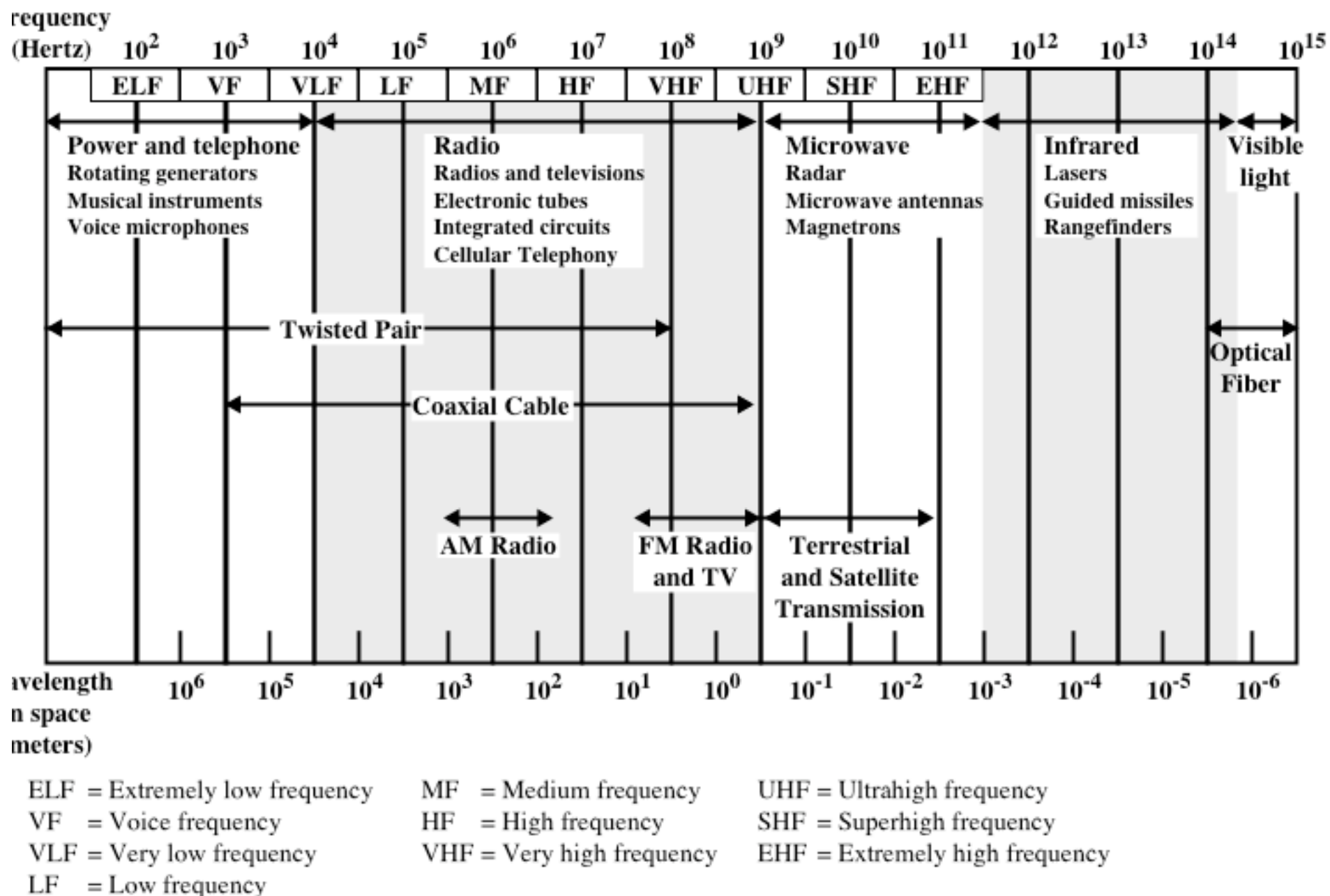
# Analog signaling



# Digital signaling

**Digital Signals: Represent data with sequence of voltage pulses**





**Figure 2.10 Electromagnetic Spectrum for Telecommunications**

# Classification of transmission media

- ❑ Transmission medium
  - o Physical path between transmitter and receiver
- ❑ Guided media
  - o Waves are guided along a solid medium
  - o E.g., copper twisted pair, copper coaxial cable, optical fiber
- ❑ Unguided media
  - o Provides means of transmission but does not guide electromagnetic signals
  - o Usually referred to as wireless transmission
  - o E.g., atmosphere, outer space



# Unguided media

- ❑ Transmission and reception are achieved by means of an antenna
- ❑ Configurations for wireless transmission
  - o Directional
  - o Omnidirectional

# General frequency ranges

## ❑ Microwave frequency range

- o 1 GHz to 40 GHz
- o Directional beams possible
- o Suitable for point-to-point transmission
- o Used for satellite communications

## ❑ Radio frequency range

- o 30 MHz to 1 GHz
- o Suitable for omnidirectional applications

## ❑ Infrared frequency range

- o Roughly,  $3 \times 10^{11}$  to  $2 \times 10^{14}$  Hz
- o Useful in local point-to-point multipoint applications within confined areas

# Terrestrial microwave

- ❑ Description of common microwave antenna
  - o Parabolic "dish", 3 m in diameter
  - o Fixed rigidly and focuses a narrow beam
  - o Achieves line-of-sight transmission to receiving antenna
  - o Located at substantial heights above ground level
- ❑ Applications
  - o Long haul telecommunications service
  - o Short point-to-point links between buildings

# Satellite microwave

- ❑ Description of communication satellite
  - o Microwave relay station
  - o Used to link two or more ground-based microwave transmitter/receivers
  - o Receives transmissions on one frequency band (uplink), amplifies or repeats the signal, and transmits it on another frequency (downlink)
- ❑ Applications
  - o Television distribution
  - o Long-distance telephone transmission
  - o Private business networks

# Broadcast radio

- ❑ Description of broadcast radio antennas
  - o Omnidirectional
  - o Antennas not required to be dish-shaped
  - o Antennas need not be rigidly mounted to a precise alignment
- ❑ Applications
  - o Broadcast radio
    - VHF and part of the UHF band; 30 MHz to 1GHz
    - Covers FM radio and UHF and VHF television

# Infrared

- ❑ Beyond the EHF spectrum
  - o  $10^{12}$  to  $10^{14}$  Hz
- ❑ Transceivers must be within line of sight or reachable via reflection
  - o Does not penetrate walls