

Wireless Networks

CS 6710

Spring 2010

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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

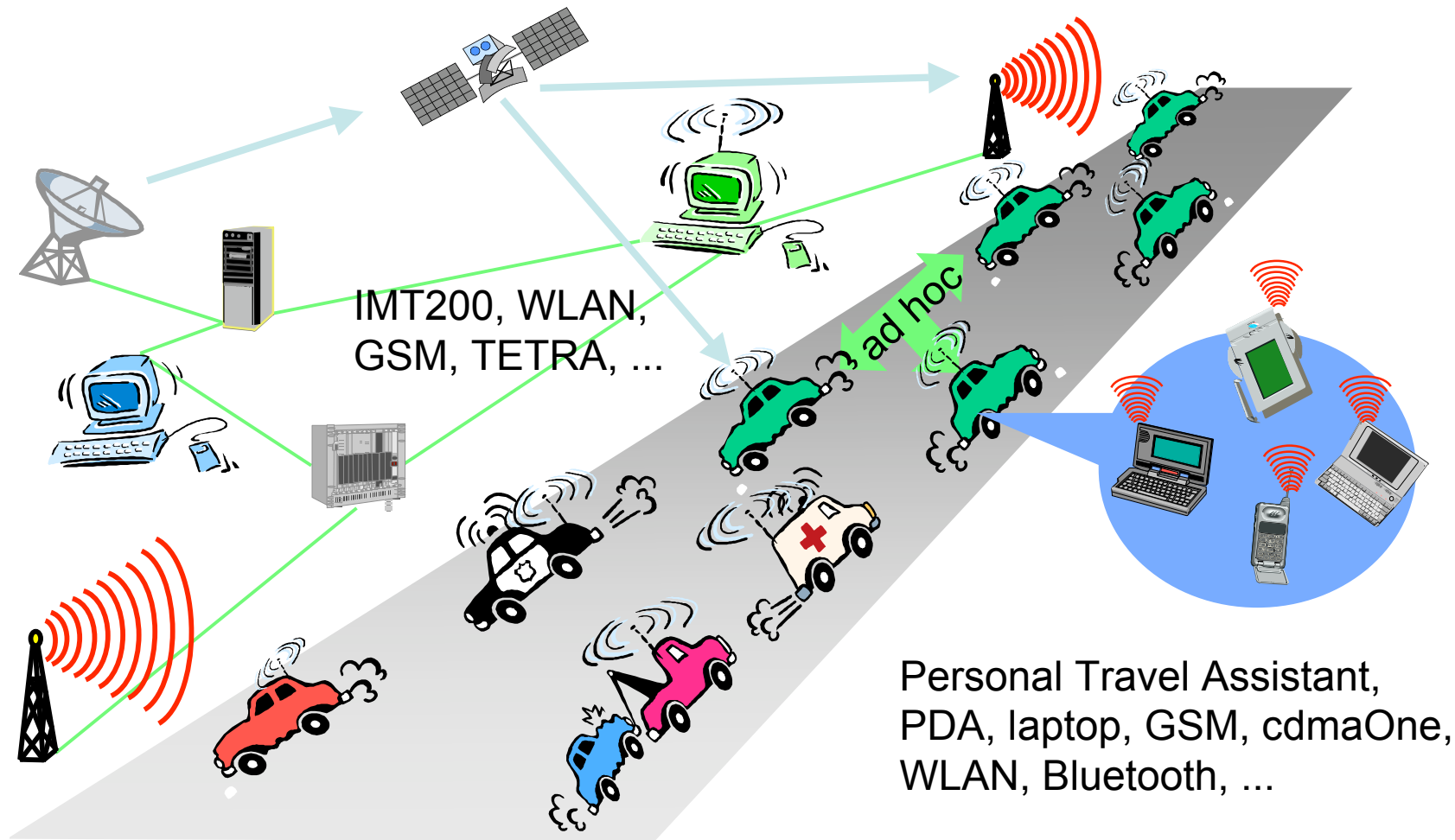
- ❑ Guglielmo Marconi invented the wireless telegraph in 1896
 - o Communication by encoding alphanumeric characters in analog signal
 - o Sent telegraphic signals across the Atlantic Ocean
- ❑ Communications satellites launched in 1960s
- ❑ Advances in wireless technology
 - o Radio, television, mobile telephone, communication satellites
- ❑ More recently
 - o 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:
 - o 35-60% annual growth of PCS
 - o 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

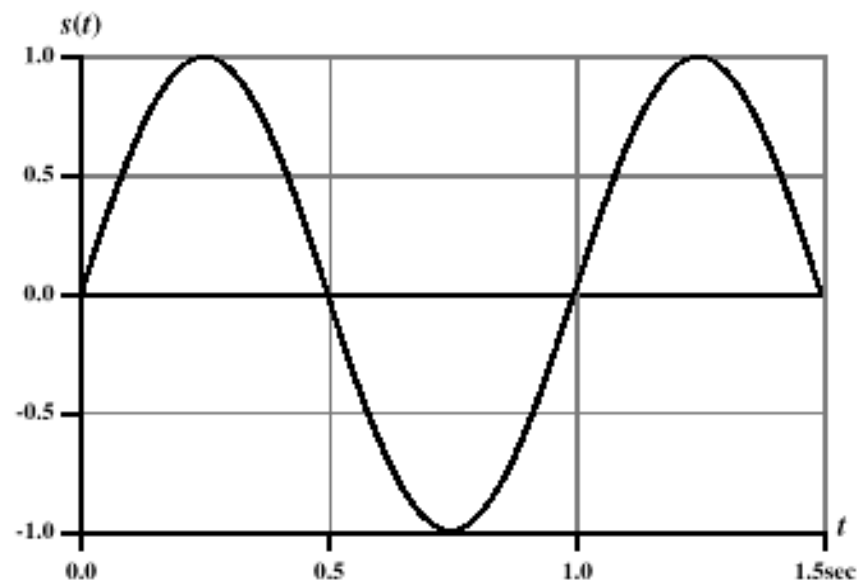
- o Designed for high bit-rate transmission
- o IP oriented
- o Low-scale coverage
- o Use unlicensed ISM frequency bands

❑ Multihop ad hoc networks

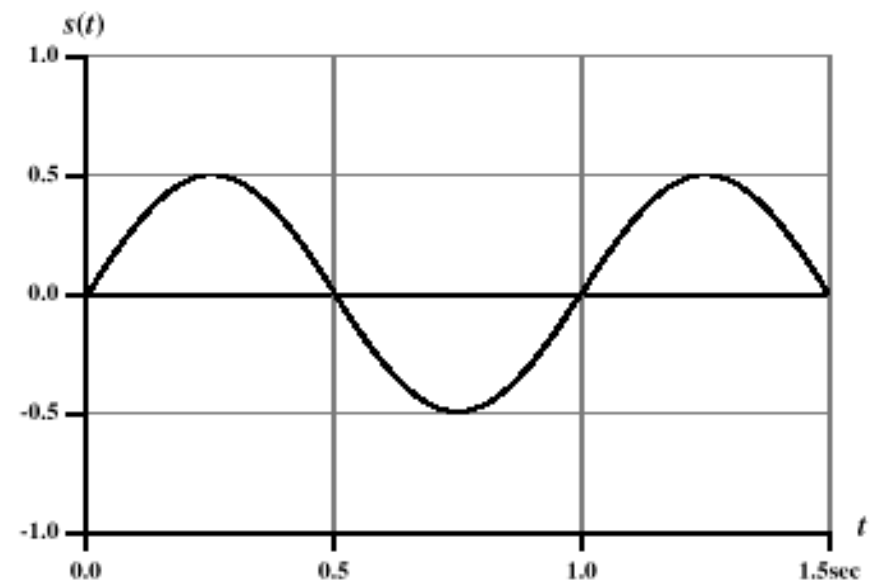
- o Have little or no infrastructure
- o Low-scale coverage
- o Need new routing protocols
- o Emerging applications

Transmission fundamentals

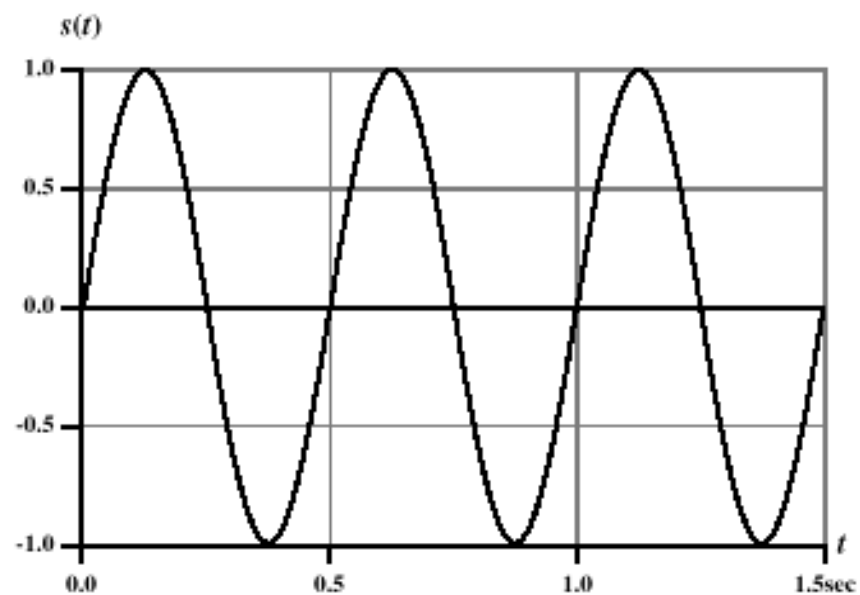
- ❑ Electromagnetic signals
 - o Time domain
 - o Frequency domain
- ❑ Data rate and bandwidth
- ❑ Channel capacity
 - o Nyquist theorem
 - o Shannon capacity theorem
- ❑ Analog and digital data transmission
- ❑ Transmission media



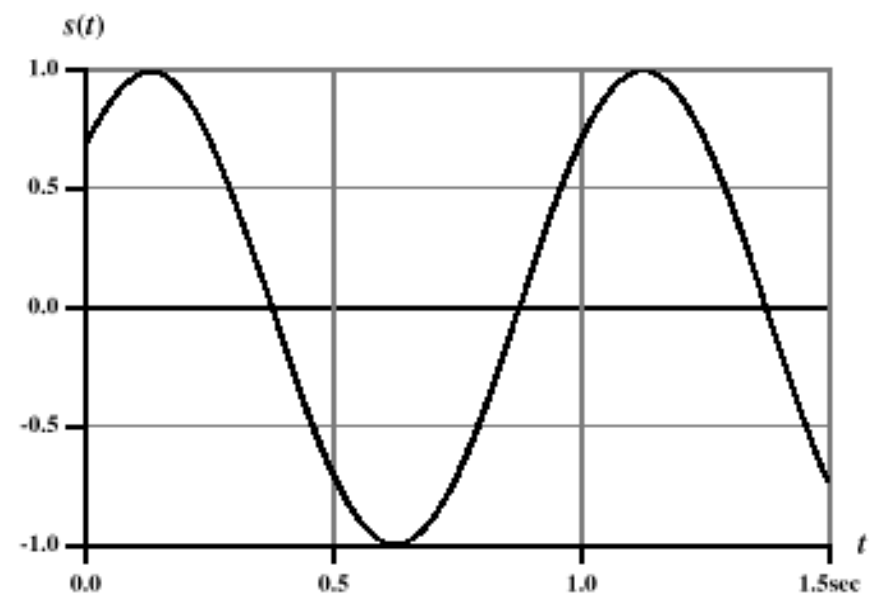
(a) $A = 1, f = 1, \phi = 0$



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

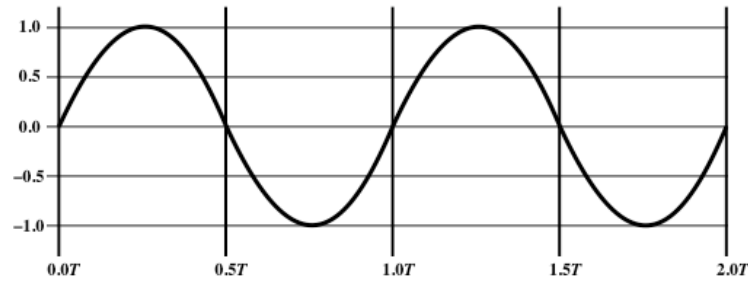


(c) $A = 1, f = 2, \phi = 0$

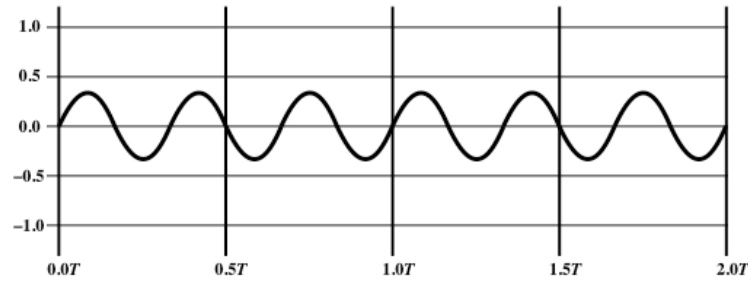


(d) $A = 1, f = 1, \phi = \pi/4$

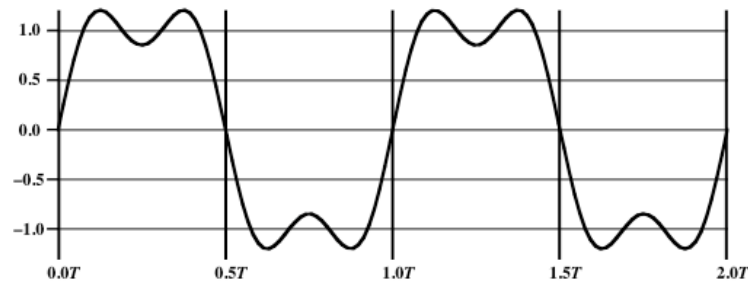
Figure 2.3 $s(t) = A \sin (2 ft + \phi)$



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

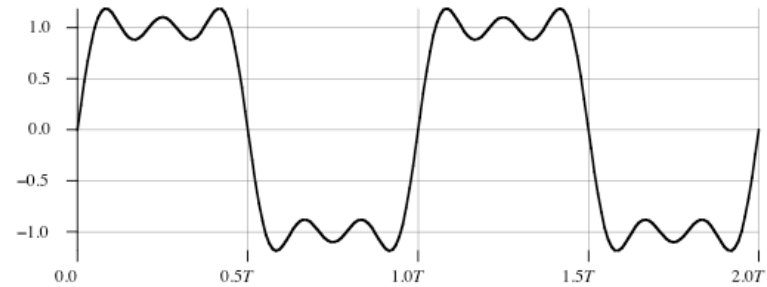


(b) $(1/3) \sin(2\pi(3f)t)$

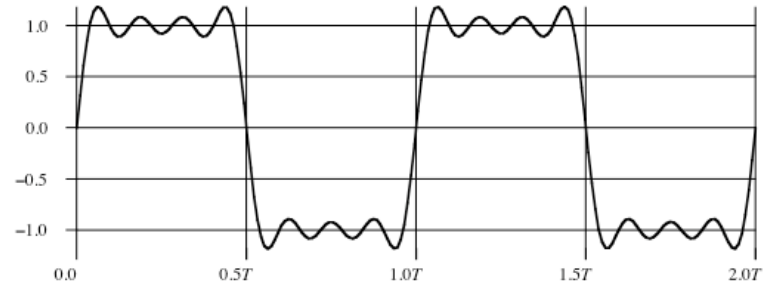


(c) $(4/\pi) [\sin(2\pi ft) + (1/3) \sin(2\pi(3f)t)]$

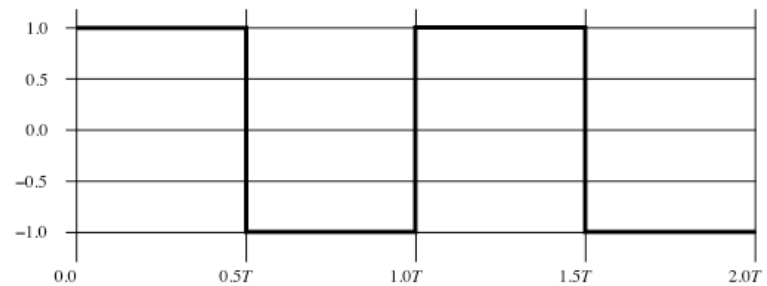
Figure 2.4 Addition of Frequency Components ($T = 1/f$)



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



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

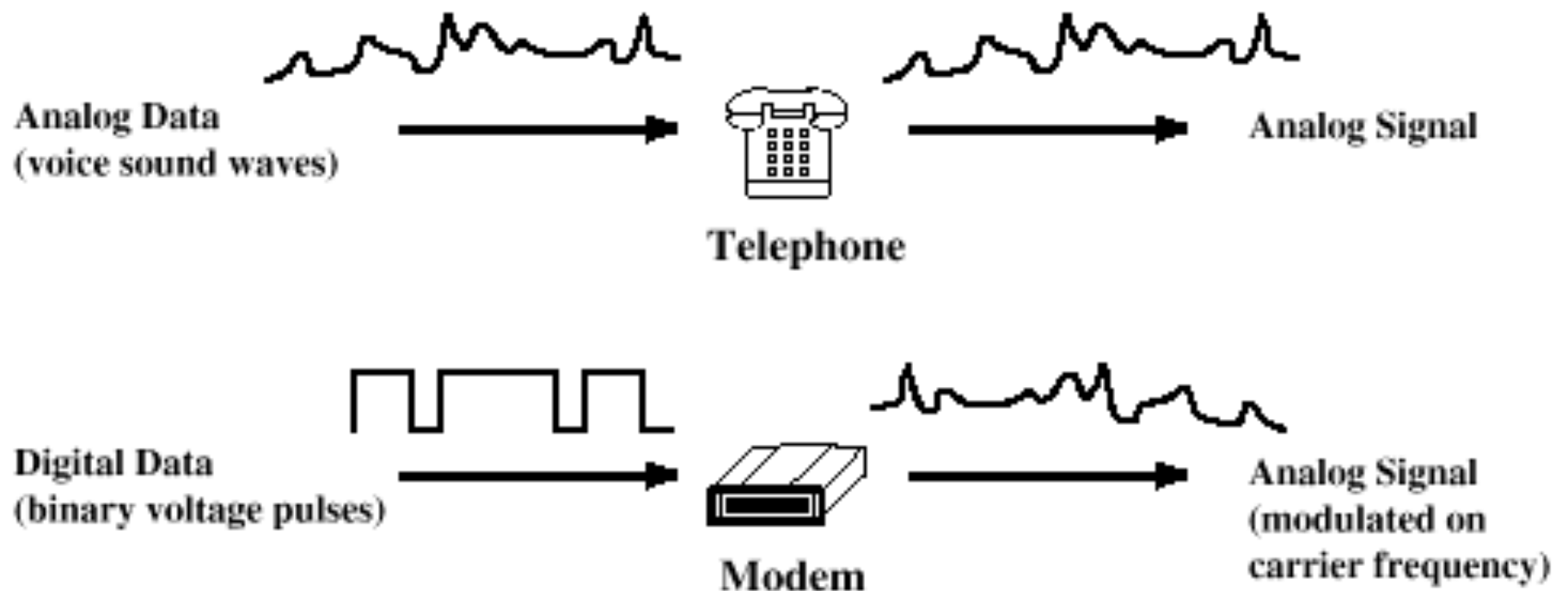


(c) $(4/\pi) \sum (1/k) \sin(2\pi(kf)t), \quad \text{for } k \text{ odd}$

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

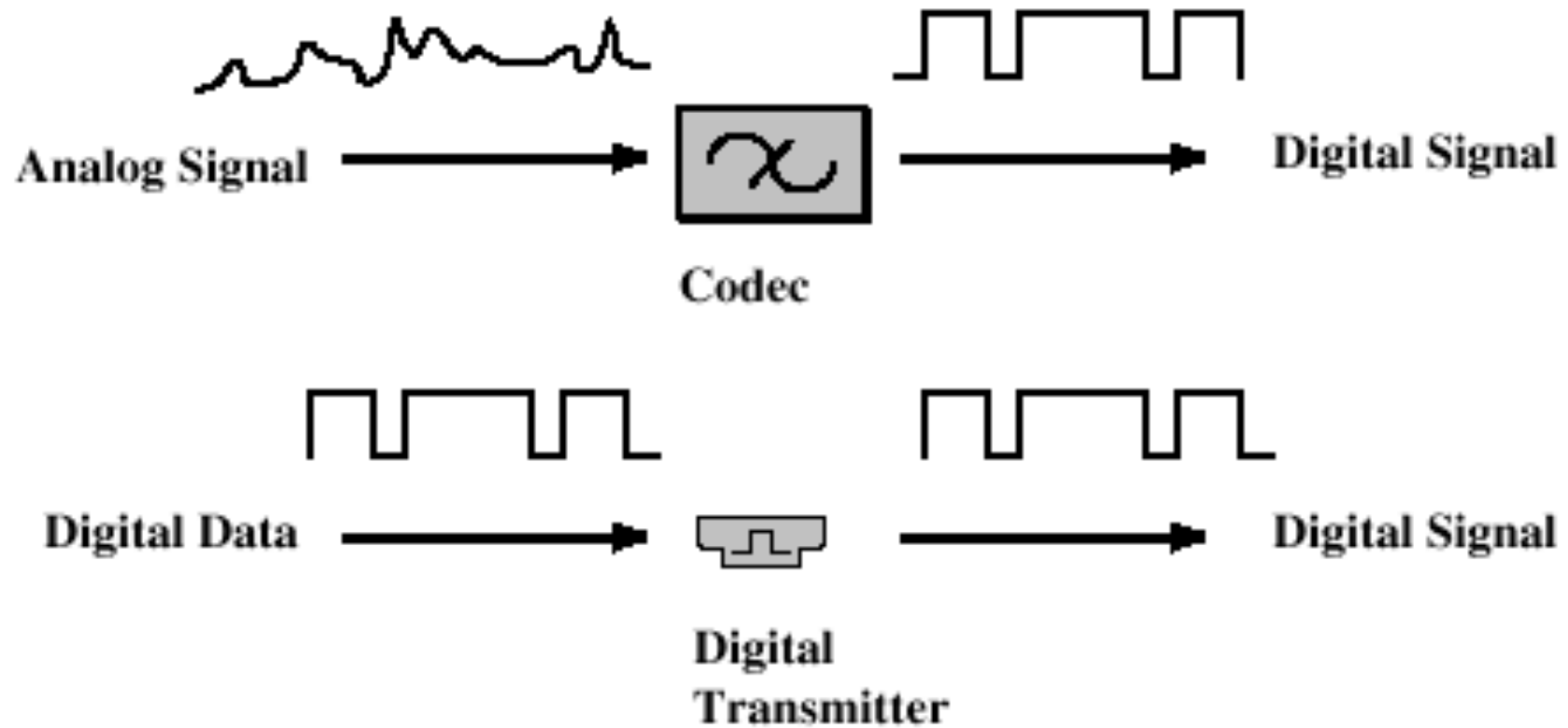
Analog signaling

Analog Signals: Represent data with continuously varying electromagnetic wave



Digital signaling

Digital Signals: Represent data with sequence of voltage pulses



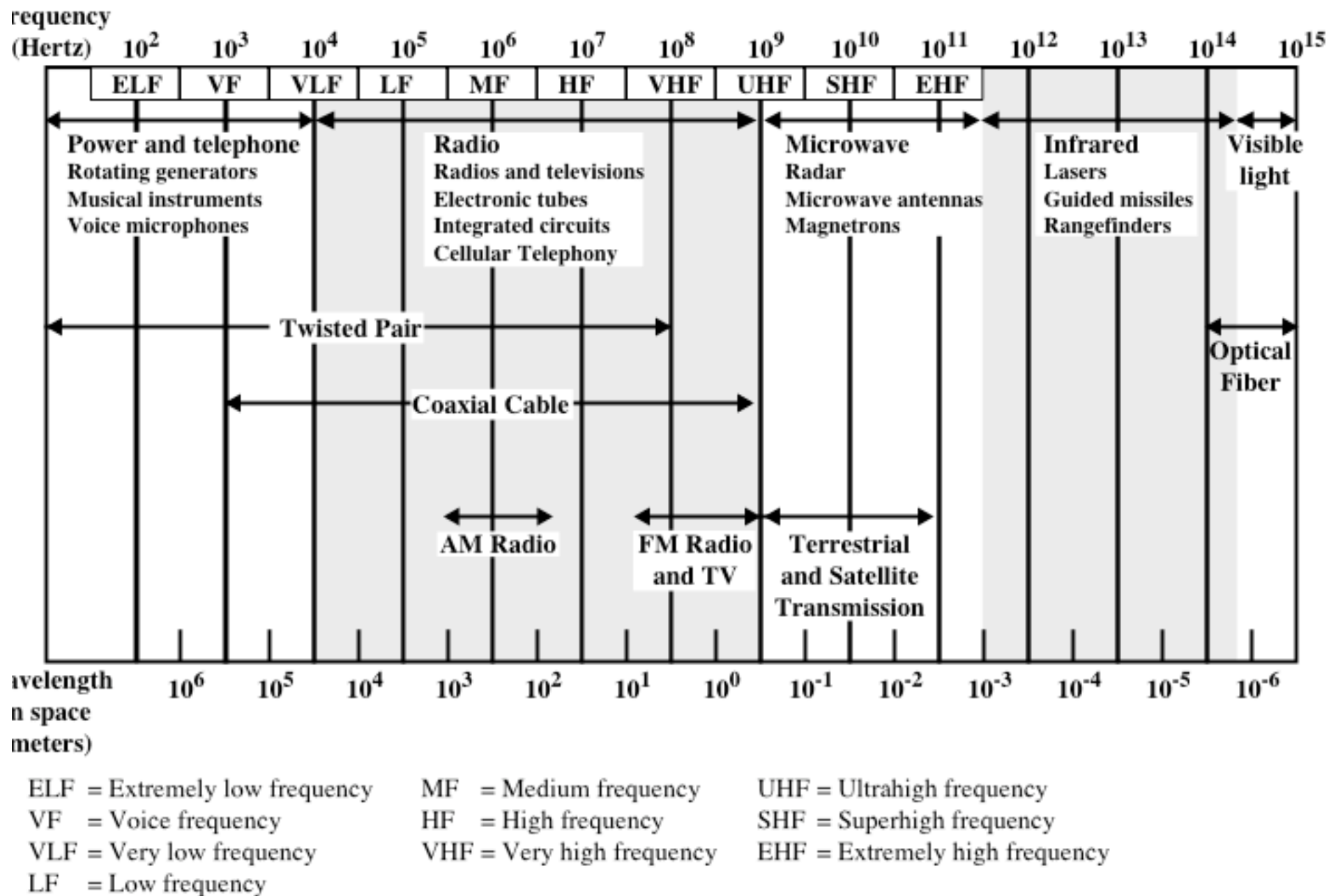


Figure 2.10 Electromagnetic Spectrum for Telecommunications

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, 3×10^{11} to 2×10^{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