Wireless Networks

CSG 250

Spring 2007

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Outline of the course: Basic topics

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

Outline: Advanced topics

- Mobile IP
- TCP for wireless
- Multihop ad hoc networks
  - MAC and routing protocols
  - Power control and topology control
  - Capacity of ad hoc networks
- Sensor networks
  - Infrastructure, MAC, and routing protocols
  - Algorithms for query processing

Wireless Comes of Age

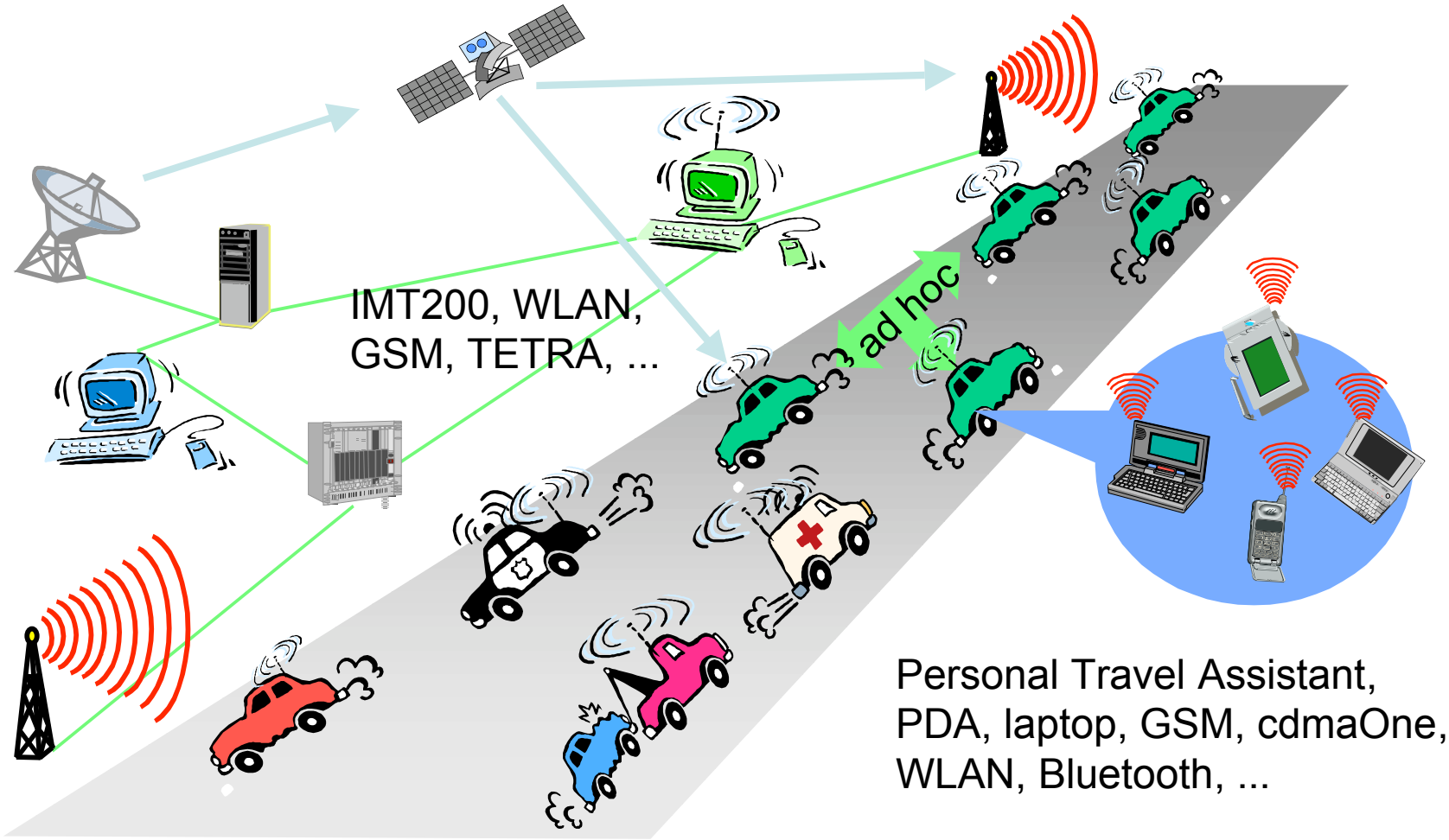
- Guglielmo Marconi invented the wireless telegraph in 1896
  - Communication by encoding alphanumeric characters in analog signal
  - Sent telegraphic signals across the Atlantic Ocean
- Communications satellites launched in 1960s
- Advances in wireless technology
  - Radio, television, mobile telephone, 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, and by 2010 3.3 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
  - E.g., small LCD on a mobile telephone can only displaying a few lines of text
  - E.g., browsers of most mobile wireless devices use wireless markup language (WML) instead of HTML


IMT200, WLAN,
GSM, TETRA, ...
ad hoc
Personal Travel Assistant,
PDA, laptop, GSM, cdmaOne,
WLAN, Bluetooth, ...

Wireless & Mobility

- Wireless:
  - Limited bandwidth
  - Broadcast medium: requires multiple access schemes
  - Variable link quality (noise, interference)
  - High latency, higher jitter
  - Heterogeneous air interfaces
  - Security: easier snooping
- Mobility:
  - User location may change with time
  - Speed of mobile impacts wireless bandwidth
  - Need mechanism for handoff
  - Security: easier spoofing
- Portability
  - Limited battery, storage, computing, and UI

Classification of Wireless Systems

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

Transmission fundamentals

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

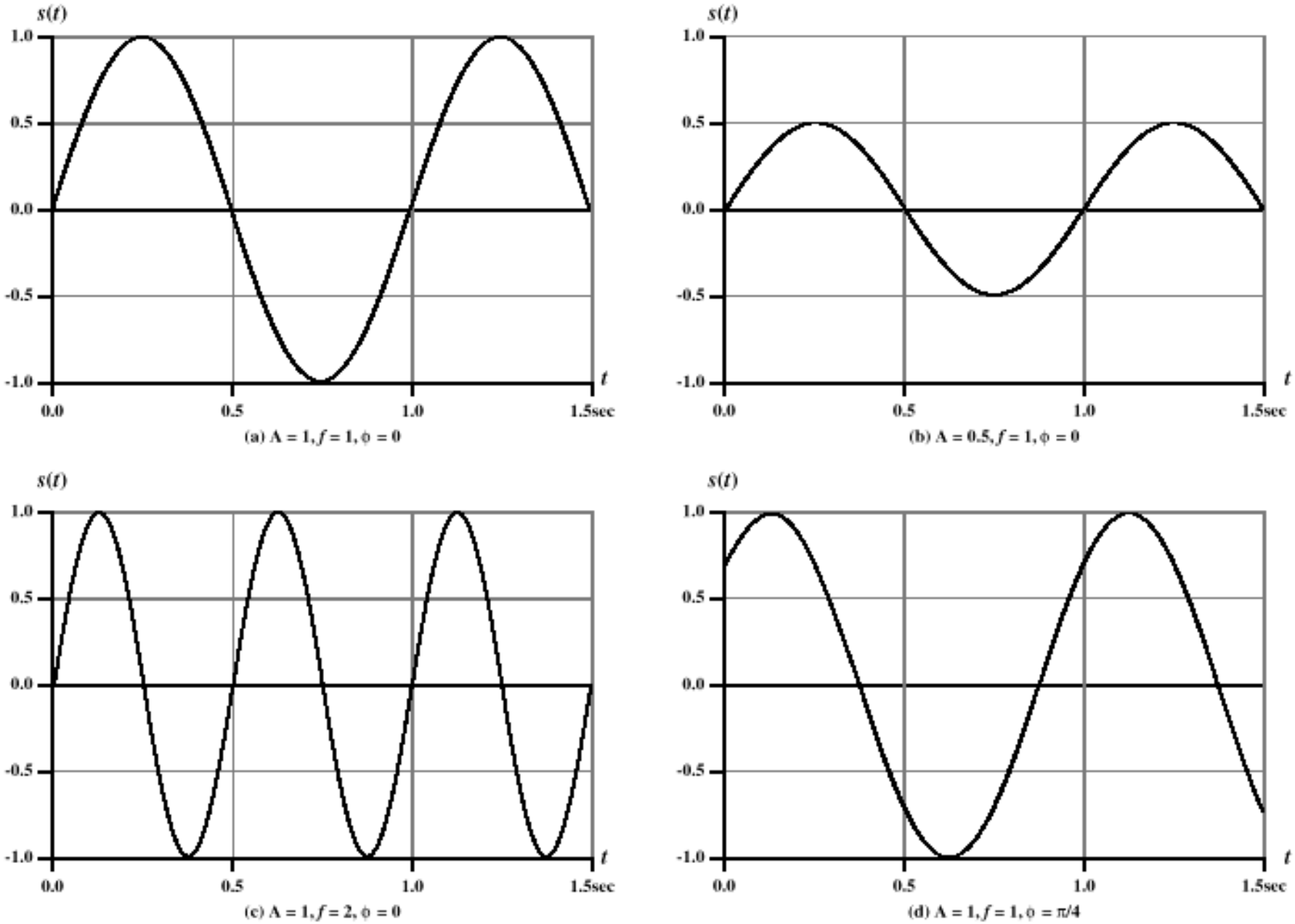
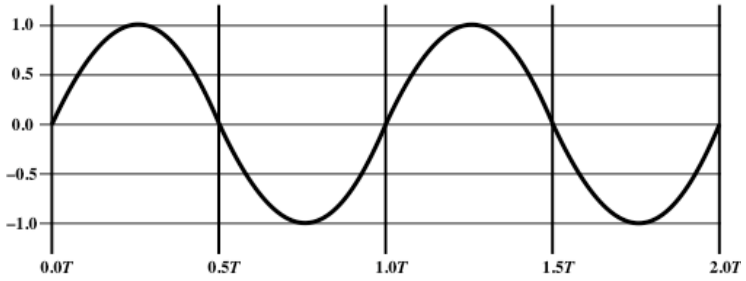
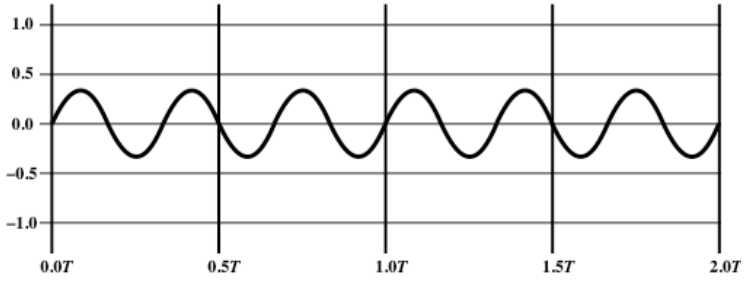


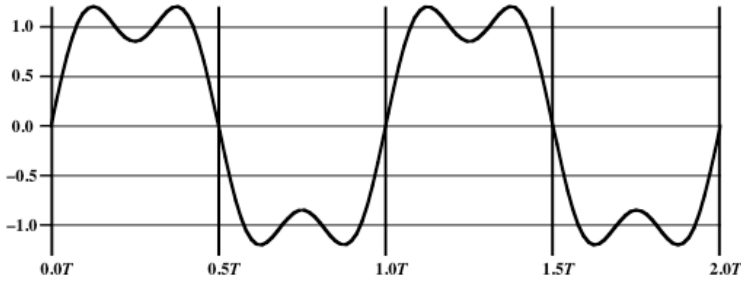
Figure 2.3 $s(t) = A \sin(2\pi ft + \phi)$



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

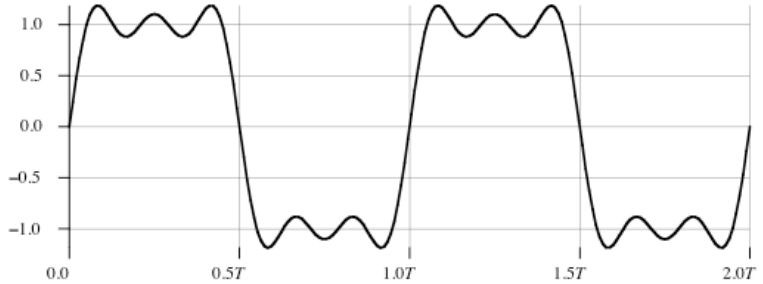


(b) (1/3) sin ($2\pi(3f)t$)

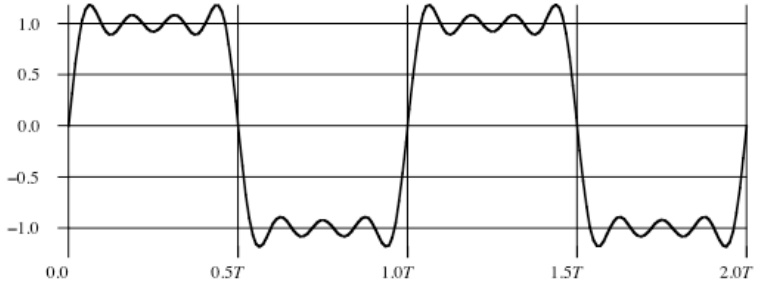


(c) (4/π) [sin ($2\pi ft$) + (1/3) sin ($2\pi(3f)t$)]

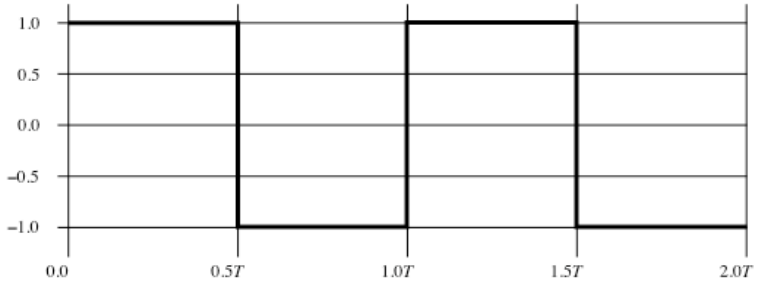
Figure 2.4 Addition of Frequency Components ($T = 1/f$)



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



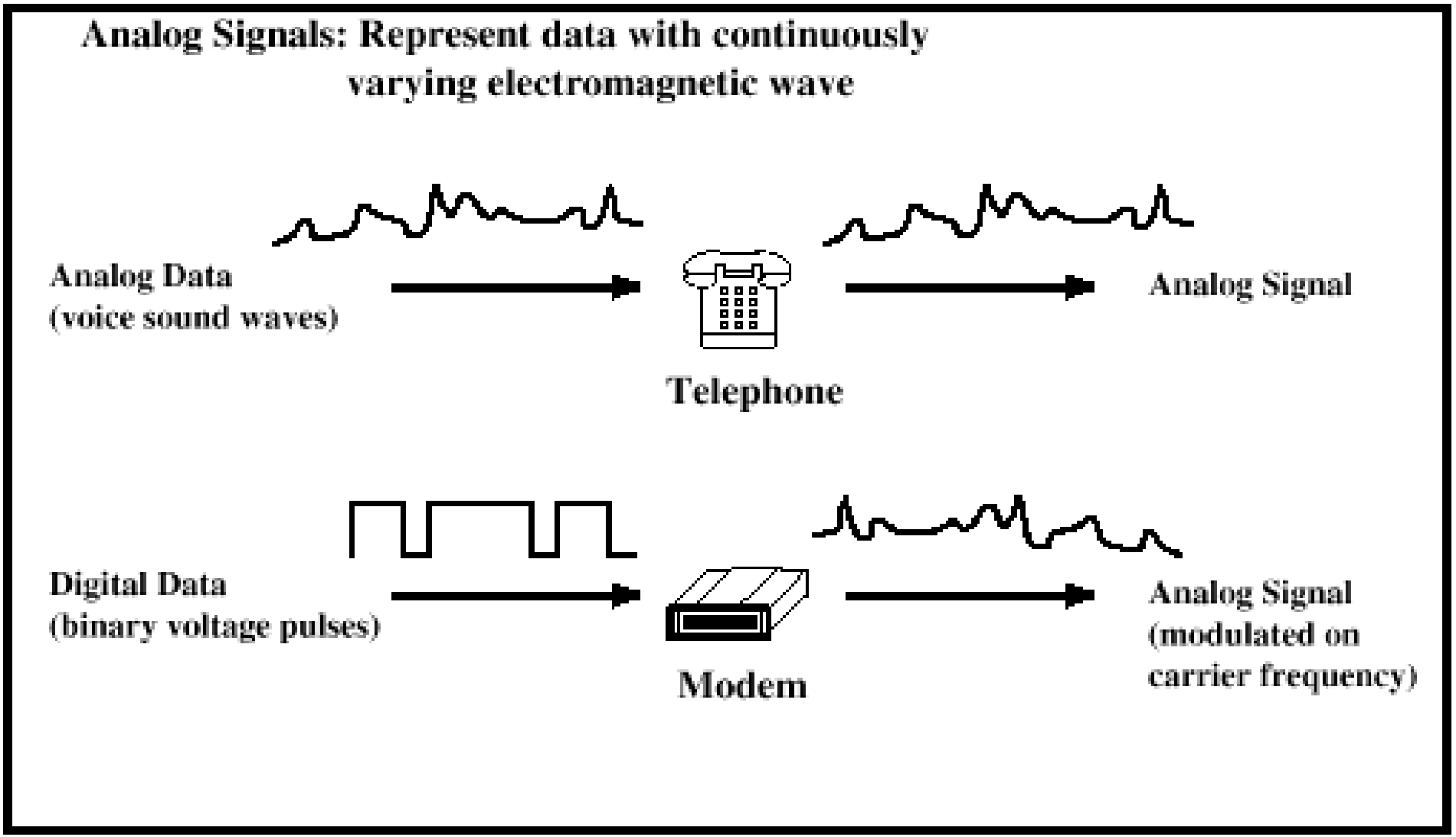
(b) (4/π) [sin ($2\pi ft$) + (1/3) sin ($2\pi(3f)t$) + (1/5) sin ($2\pi(5f)t$) + (1/7) sin ($2\pi(7f)t$)]



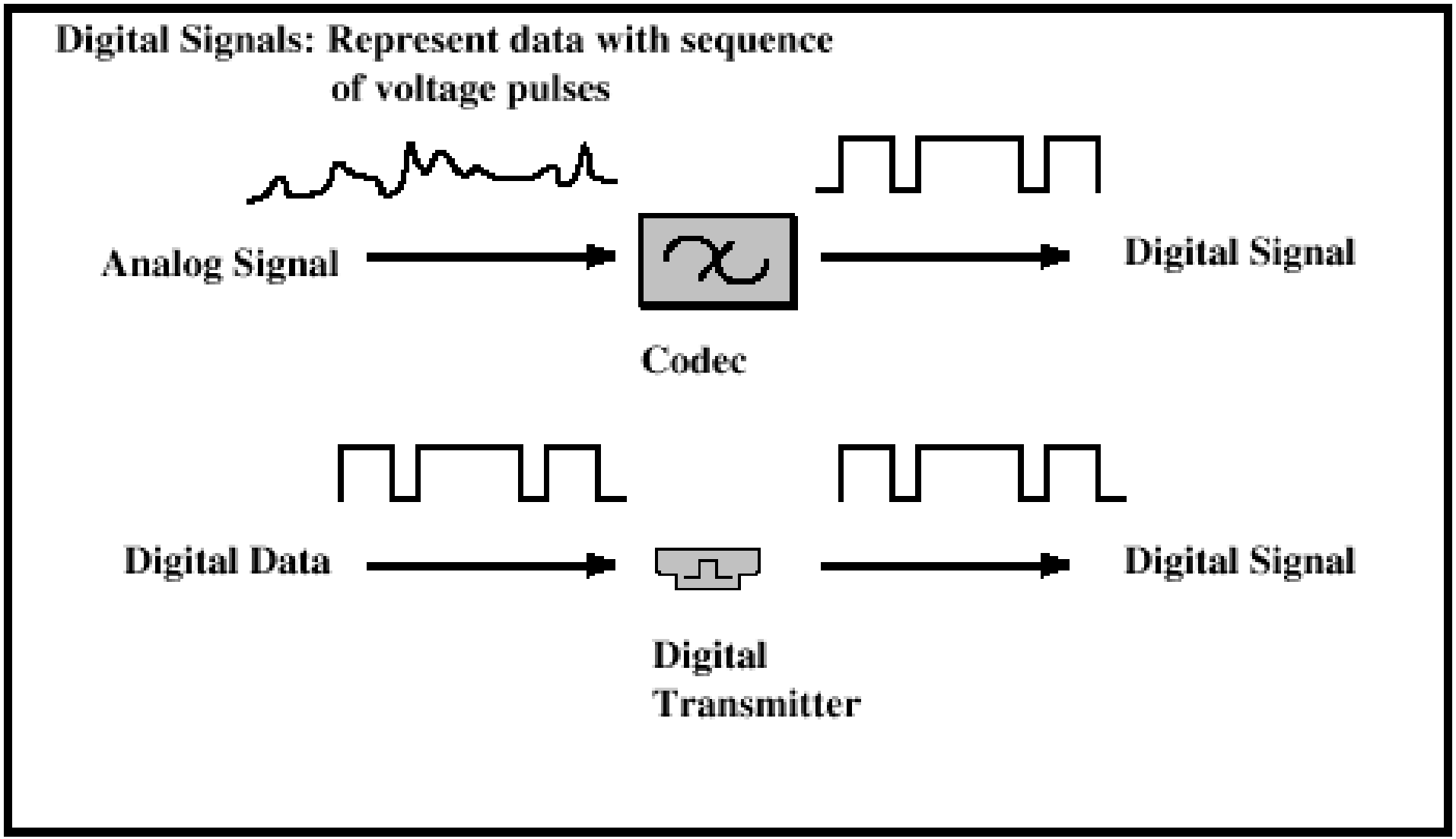
(c) (4/π) $\sum$ (1/k) sin ($2\pi(kf)t$), for k odd

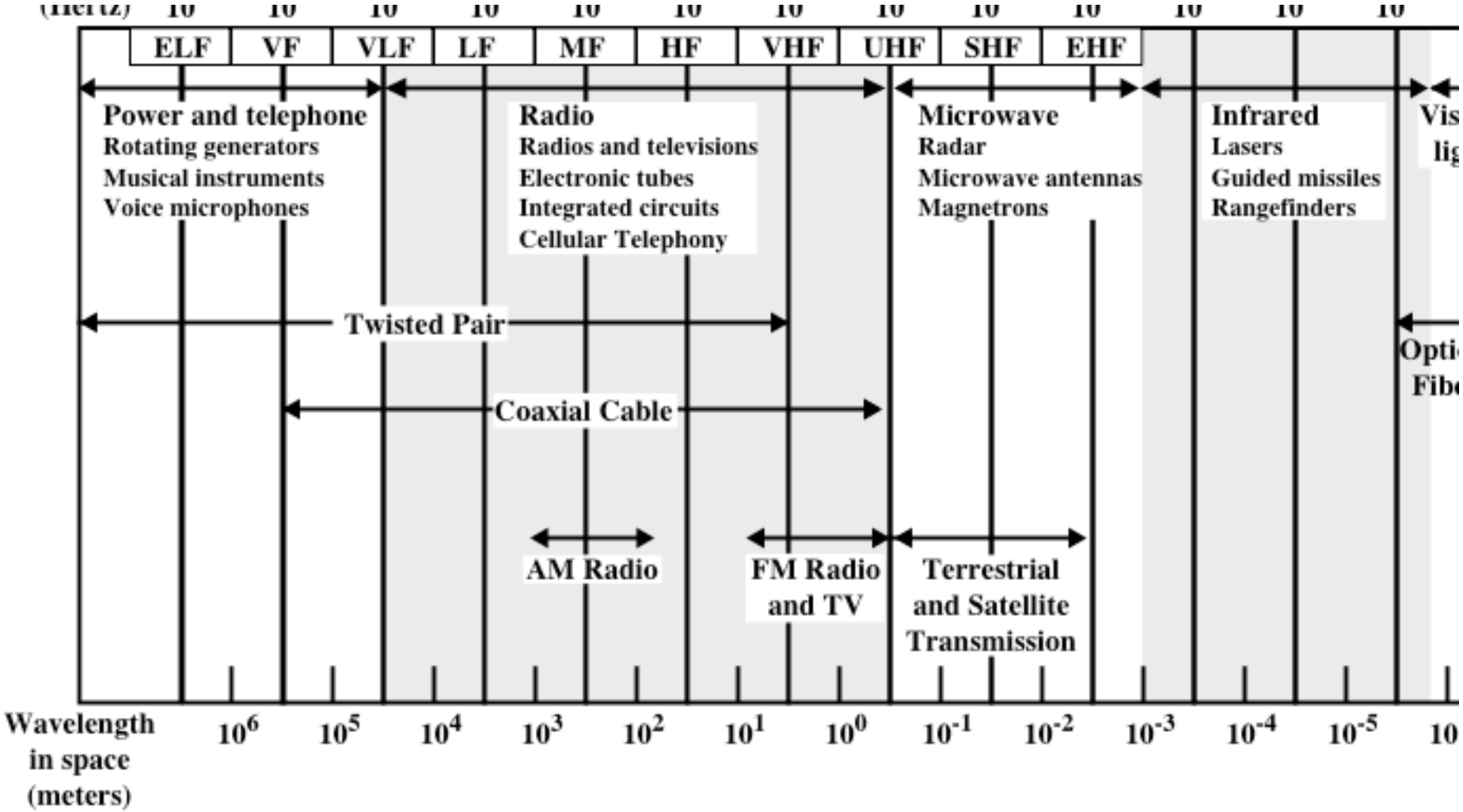
Figure 2.5 Frequency Components of Square Wave ($T = 1/f$)

Analog signaling



Digital signaling





ELF = Extremely low frequency
VF = Voice frequency
VLF = Very low frequency
LF = Low frequency
MF = Medium frequency
HF = High frequency
VHF = Very high frequency
UHF = Ultrahigh frequency
SHF = Superhigh frequency
EHF = Extremely high frequency

Figure 2.10 Electromagnetic Spectrum for Telecommunications

Classification of transmission media

- Transmission medium
  - Physical path between transmitter and receiver
- Guided media
  - Waves are guided along a solid medium
  - E.g., copper twisted pair, copper coaxial cable, optical fiber
- Unguided media
  - Provides means of transmission but does not guide electromagnetic signals
  - Usually referred to as wireless transmission
  - 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
  - 1 GHz to 40 GHz
  - Directional beams possible
  - Suitable for point-to-point transmission
  - Used for satellite communications
- Radio frequency range
  - 30 MHz to 1 GHz
  - Suitable for omnidirectional applications
- Infrared frequency range
  - Roughly, $3x10^{11}$ to $2x10^{14}$ Hz
  - Useful in local point-to-point multipoint applications within confined areas

Terrestrial microwave

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

Satellite microwave

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

Broadcast radio

- Description of broadcast radio antennas
  - Omnidirectional
  - Antennas not required to be dish-shaped
  - Antennas need not be rigidly mounted to a precise alignment
- Applications
  - 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