Introduction

1-2, 1-3, 1-6, 1-8

Lecture 2

Introduction

- Analog and Digital Information and System
- Analog and Digital Waveform
- Block Diagram of Communication System
- Channel Characteristics

Analog Information Source

- An analog information source produces messages that are defined on a continuum.

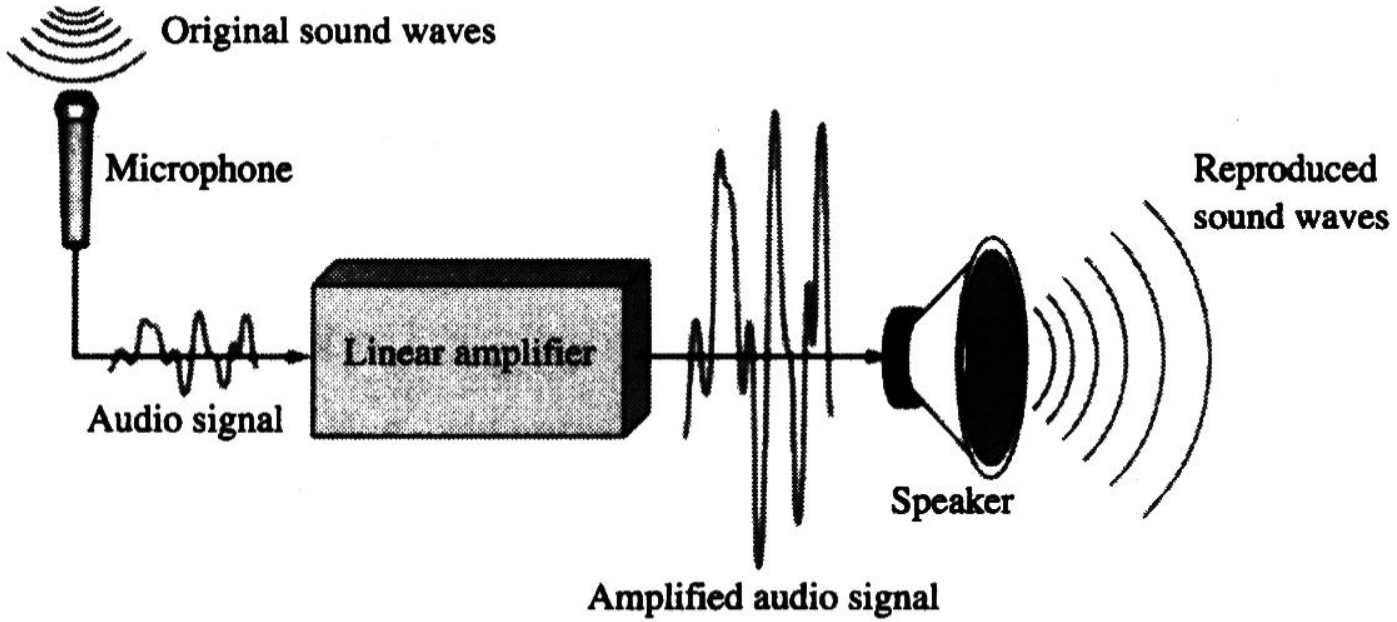


FIGURE 1–3
A basic audio public address system.

Digital Information Source

- A digital information source produces a finite set of possible messages.

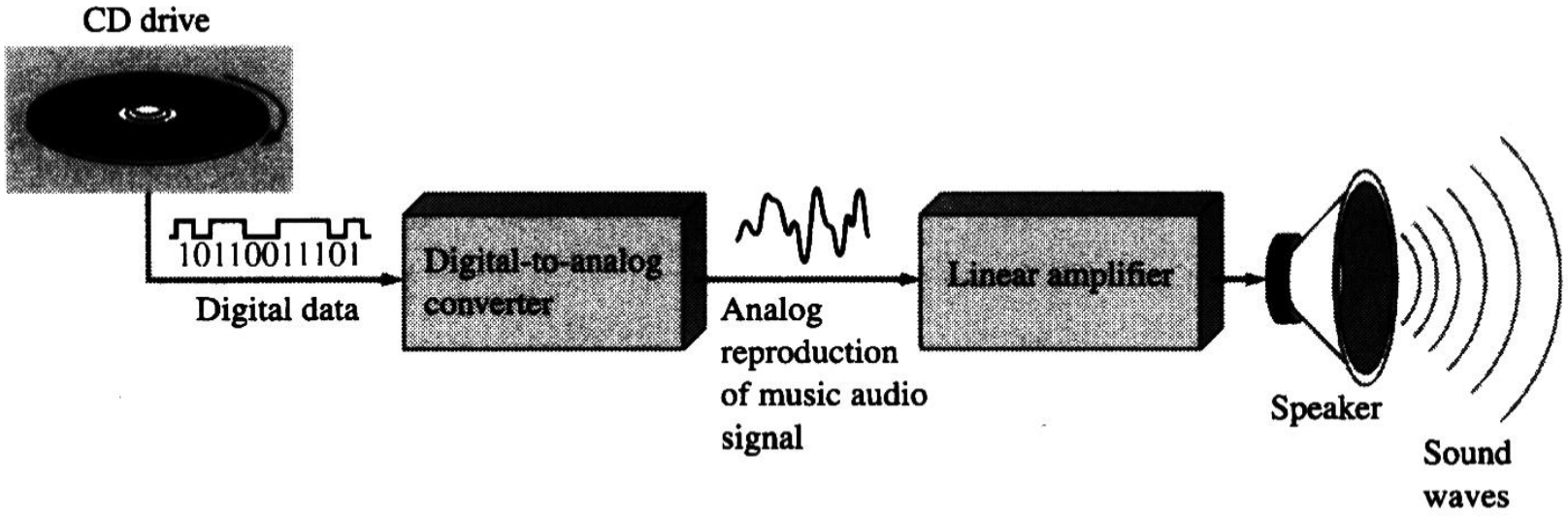


FIGURE 1–4
Basic principle of a CD player. Only one channel is shown.

Analog Communication System

- An analog communication system transfers information from an analog source to the sink.

Digital Communication System

- A digital communication system transfers information from a digital source to the sink.

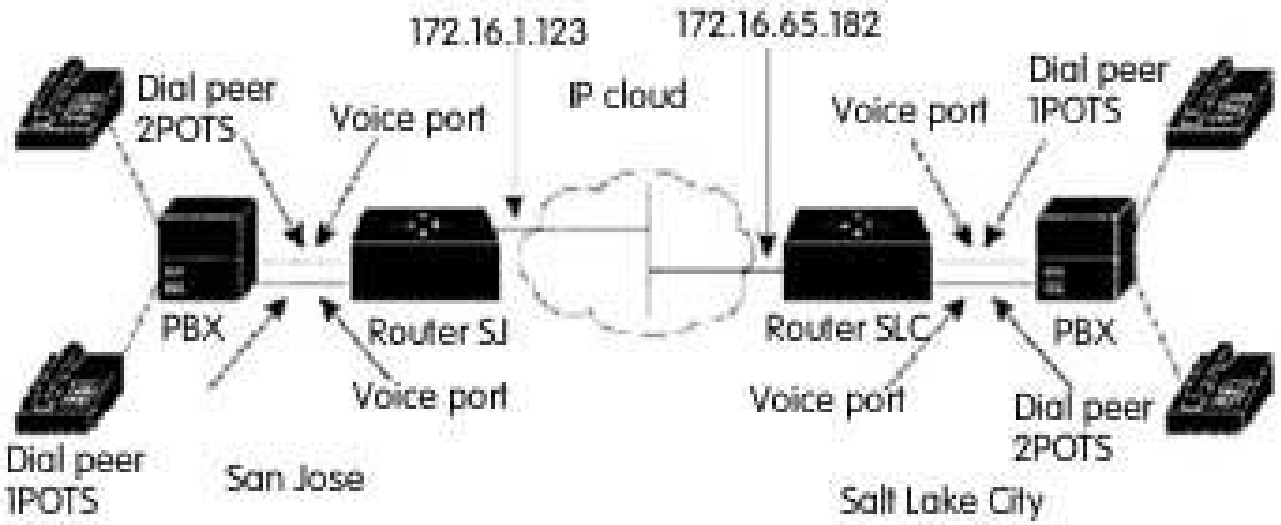
"On the Internet, nobody knows you're a dog."

Trustable Network

- “Trustable Network”(可信任网络)
- Trustable: Dependable, Security, Reliable
- Network: Telecommunication, CATV, Internet
- In next five years, China will build a large scale trustable network testbed. 国家中长期发展规划

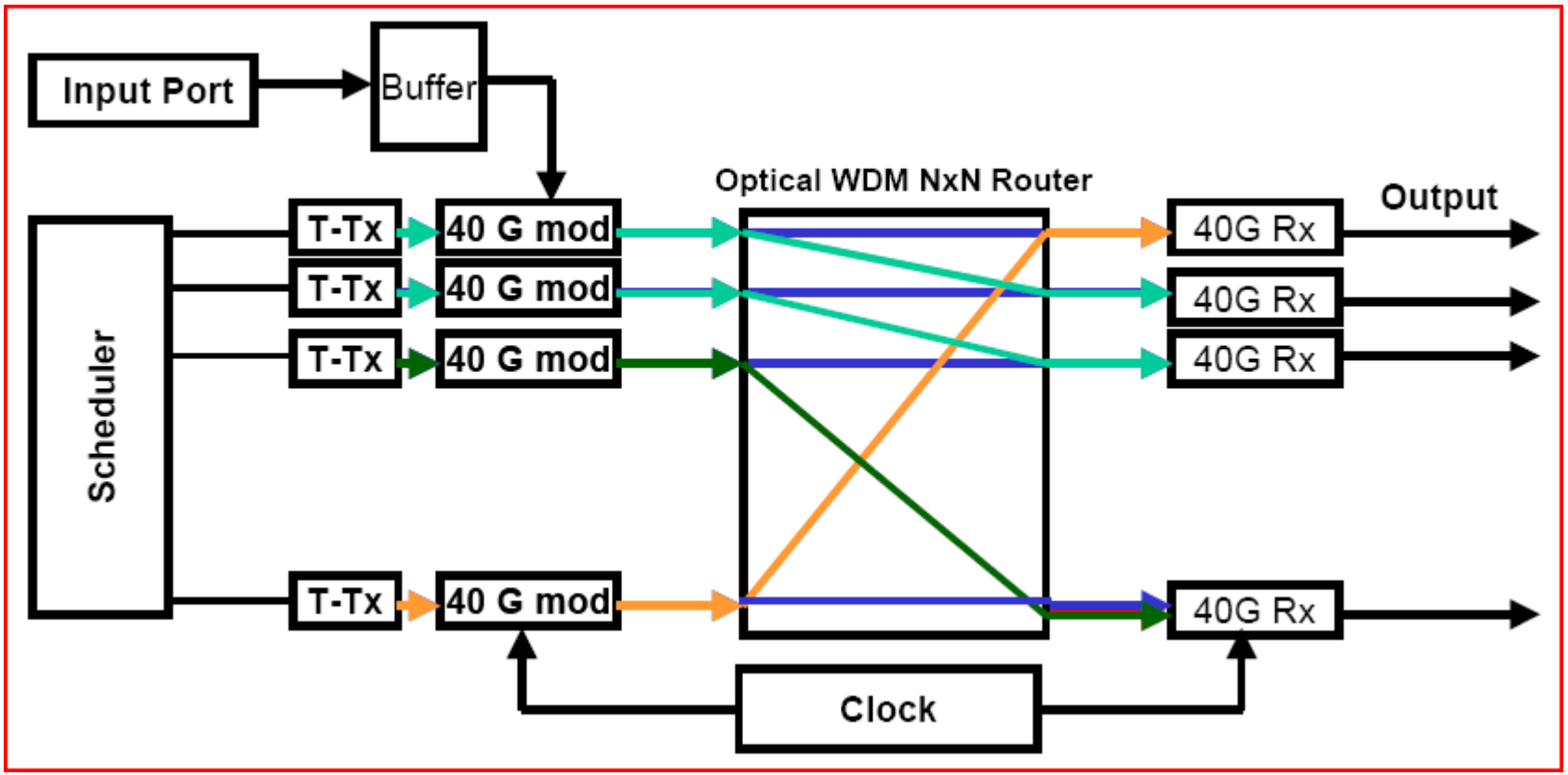
Hybrid Communication System

- Does there exist a digital/analog hybrid communication system?



VoIP system

Another Example: 100T Router



Analog Waveform

- An analog waveform is a function of time that can has a continuous range of values.

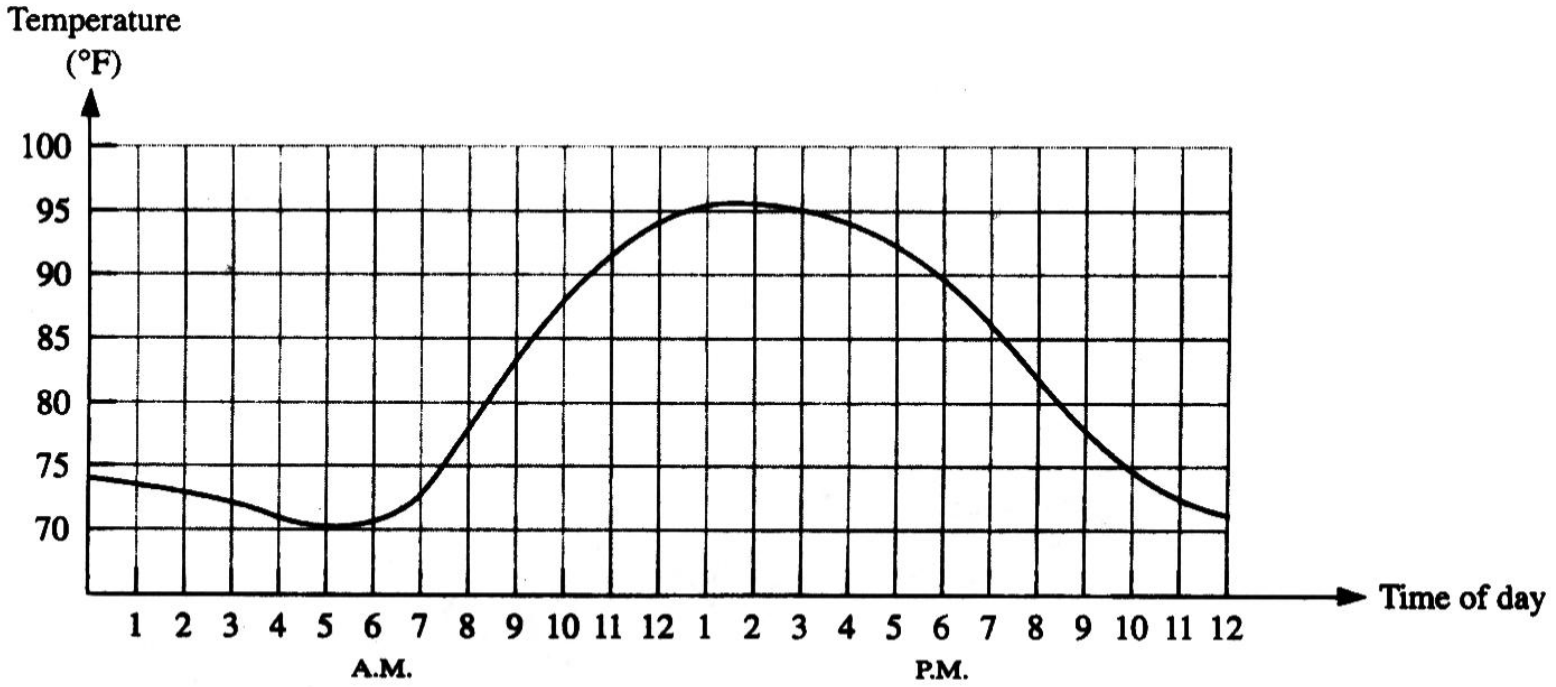
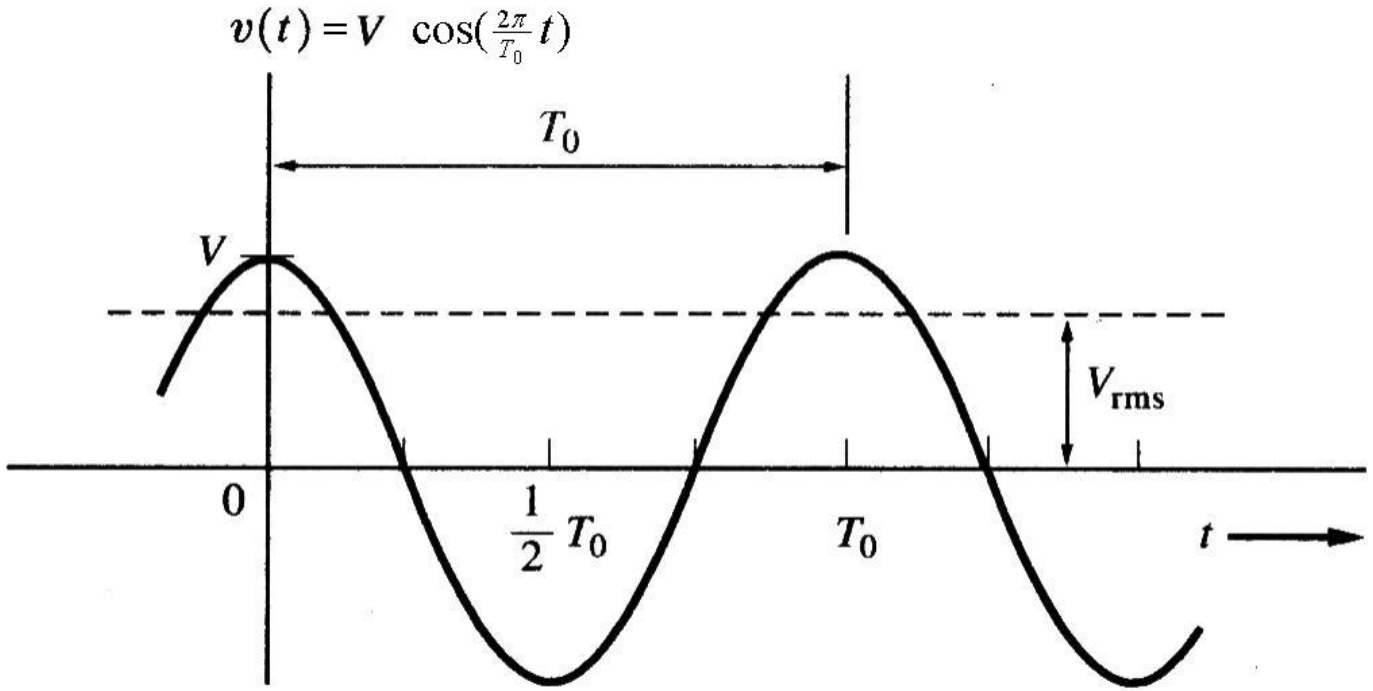


FIGURE 1–1
Graph of an analog quantity (temperature versus time).

Deterministic Waveform

- A deterministic waveform can be modeled as a complete specified function of time.



Random Waveform

- A random waveform (or stochastic waveform) can not be complete specified as a function of time and must be modeled probabilistically.

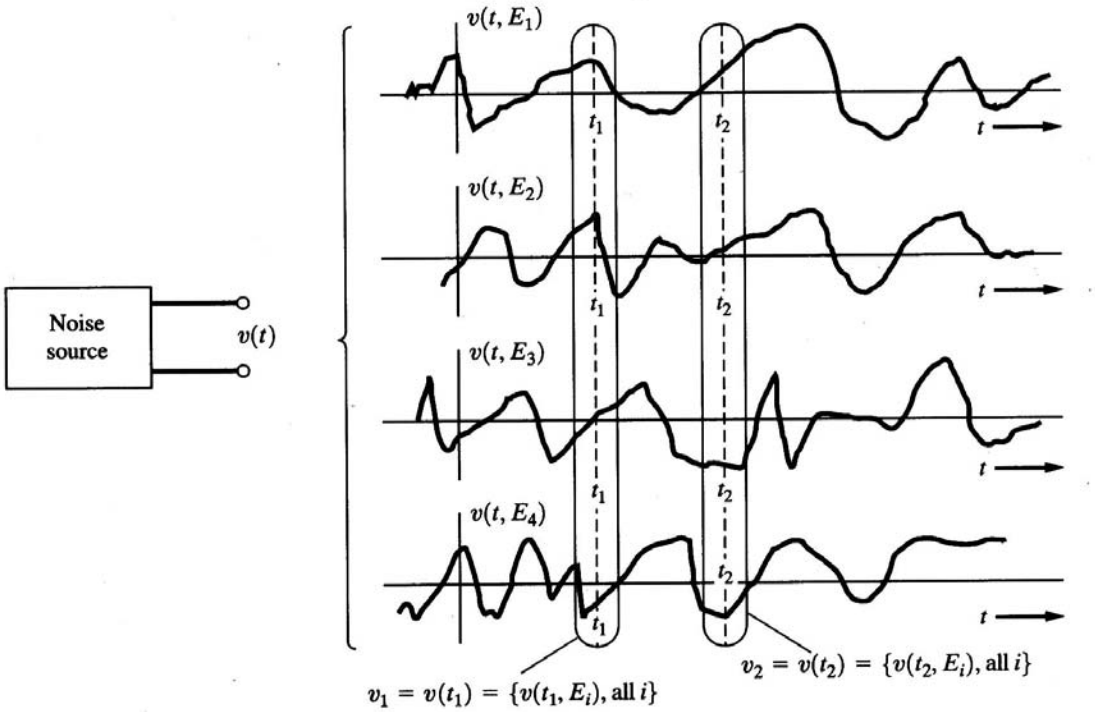
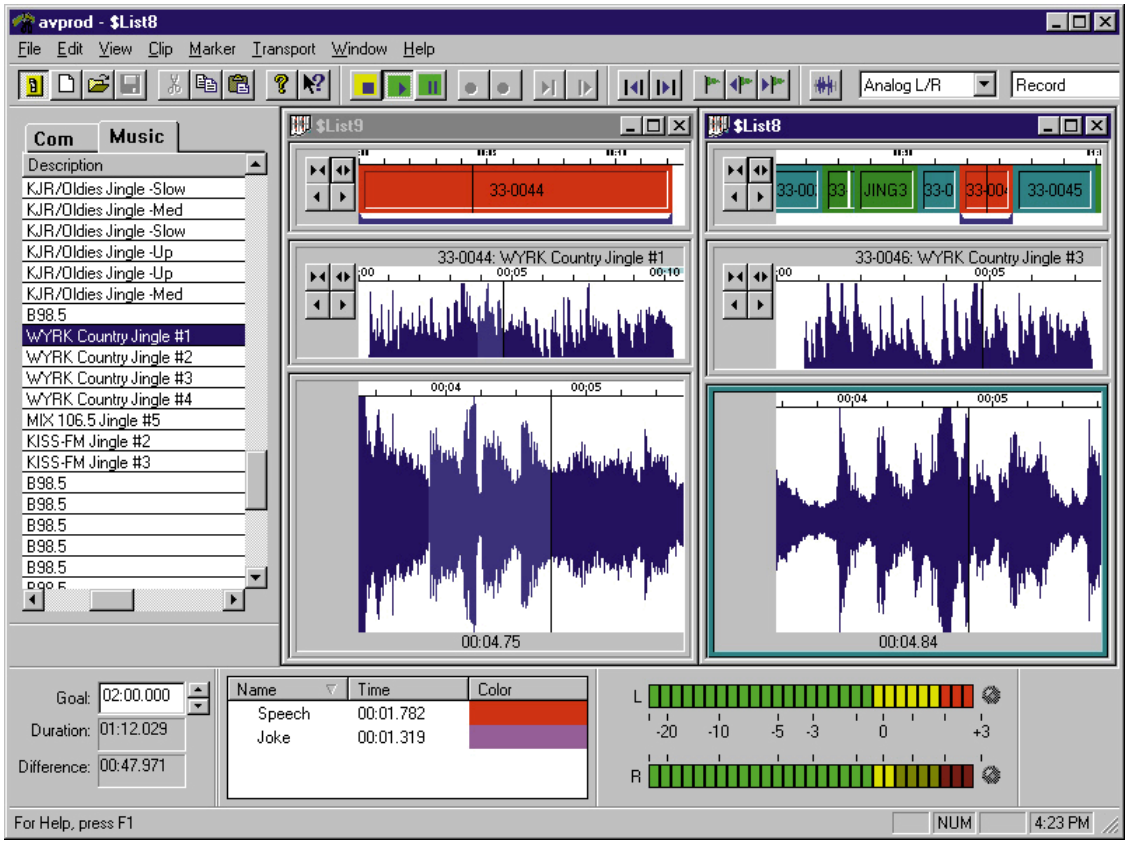


Figure 6–1 Random-noise source and some sample functions of the random-noise process.

Digital Waveform

- A digital waveform is a function of time that can have only a discrete set of values.



Binary Signals

- Binary signal has at most 2 values to represent bit information.

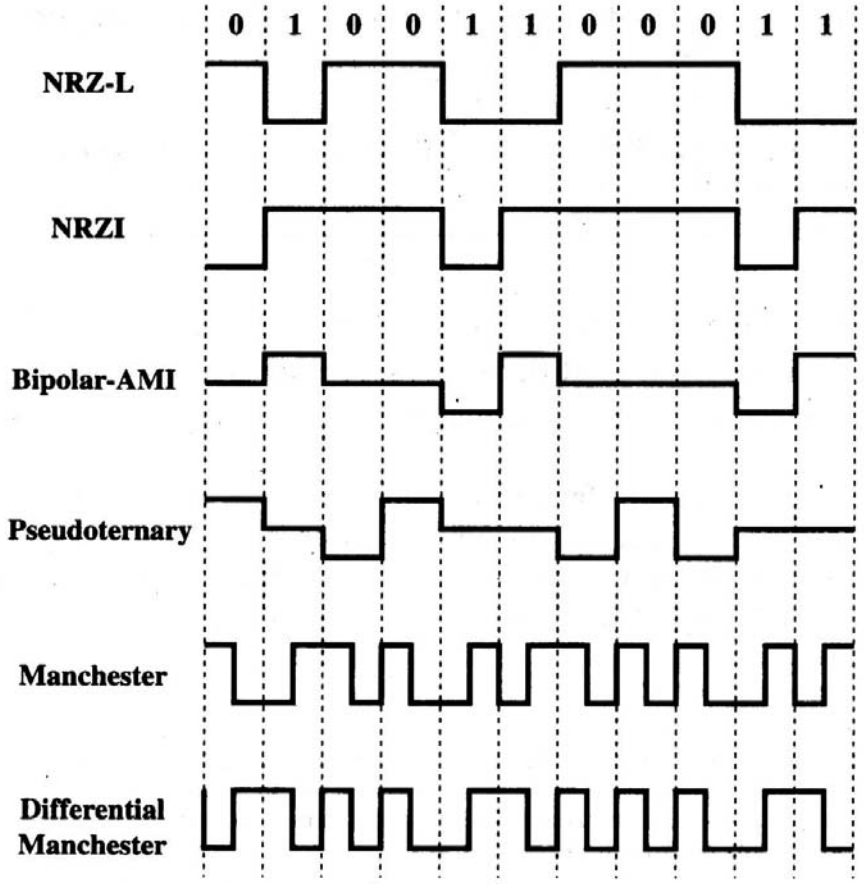


Figure 5.2 Digital Signal Encoding Formats

Block Diagram of a Communication System

- A typical communication system is composed of 3 main subsystems: Transmitter, Channel, and Receiver
- Transmitter
  - The signal processing block conditions the source for more efficient transmission. For example, lowpass filter to restrict bandwidth in an analog system.
  - The transmitter carrier circuit (modulator) couples the message to the channel. Modulation is the systematic variation of some attribute of the carrier, such as amplitude, phase, or frequency, in accordance with a function of the message signal.
  - Why modulation? 1) for ease of radiation; 2) to reduce noise and interference; 3) for channel assignment; 4) for multiplexing several messages over a single channel.

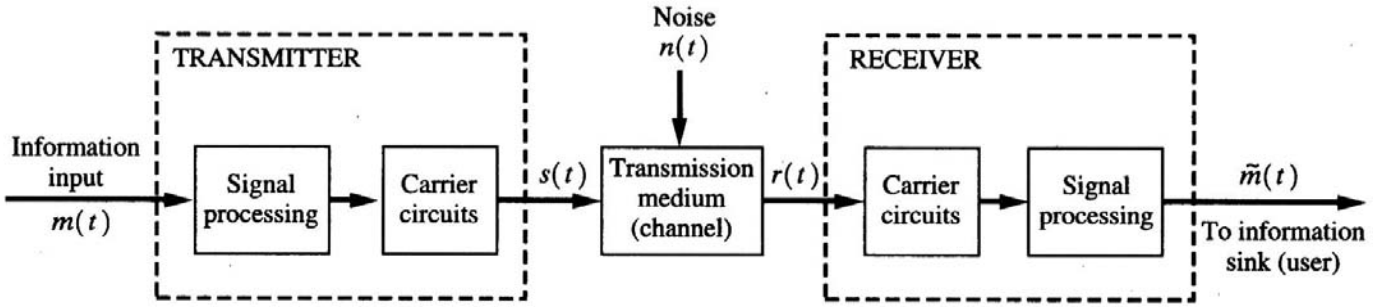
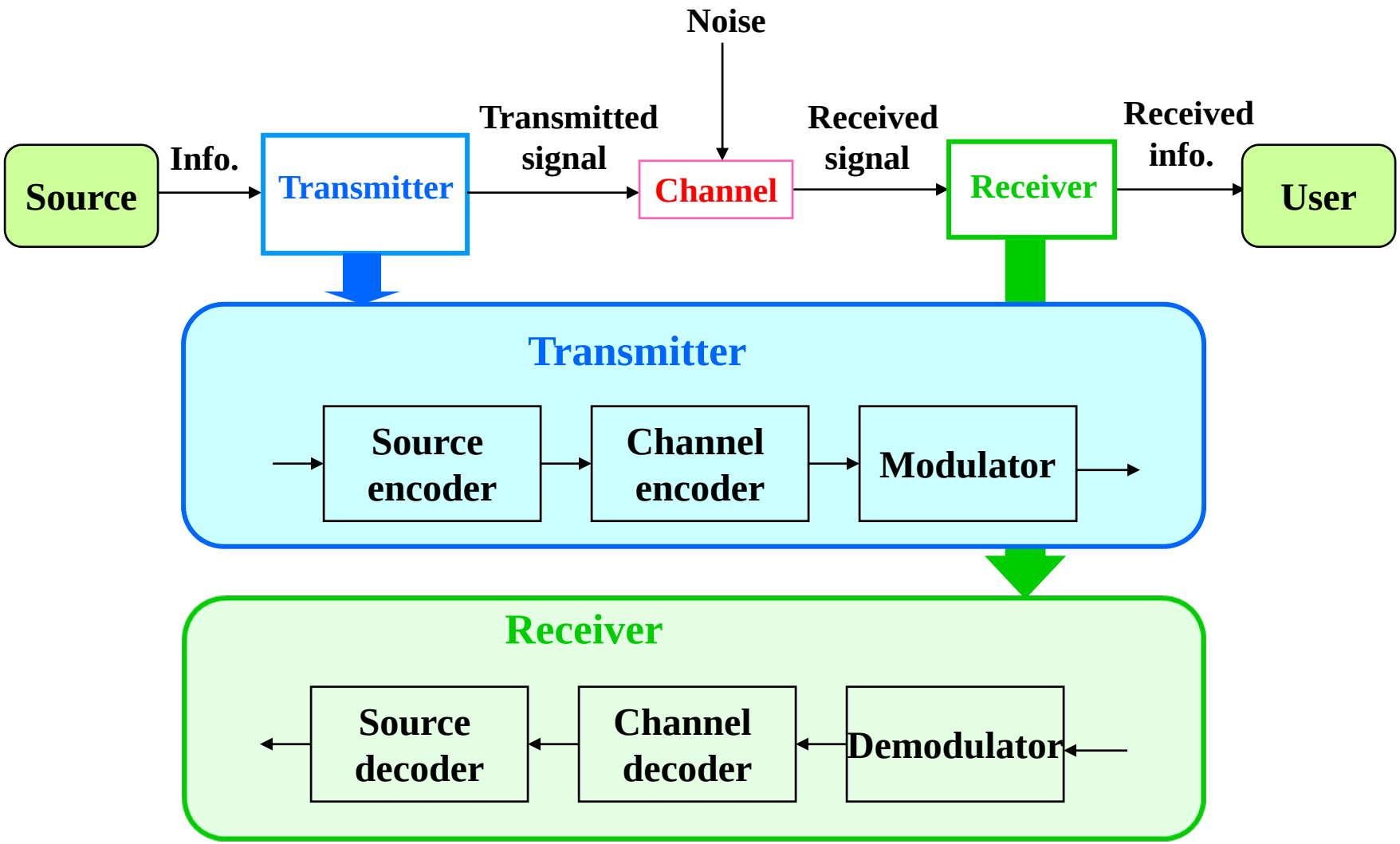


Figure 1–1 Communication system.

Block Diagram of a Communication System

- Channel
  - Channels may be classified into two categories: wire and wireless.
  - The channel noise may arise from natural electrical disturbances (e.g., lighting) or from artificial sources (e.g., switching circuits of a nearby computer).
  - The channel may contain active amplifying devices (e.g., transponders).
  - The channel may provide undesirable multipaths between its input and output that have different time delays and attenuation characteristics. These characteristics may vary with time, which makes the signal fade.
- Receiver
  - The receiver carrier circuits (demodulator) extracts the desired message from the received signal at the channel output and to convert it to a form suitable for the output transducer.
  - As a result of the presence of noise and distortion, the message cannot be ideally recovered.

Digital Communication System



Digital Communication System

- Source Coding produces analog-to-digital conversion and removes redundant information.
- Channel Coding, for a given data rate, can reduce the probability of error, PE, or reduce the required signal-to-noise ratio to achieve a desired PE at the expense of transmission bandwidth or decoder complexity.
- Synchronization has to been done with the received carrier at the receiver in order to be able to generate reference signals especially in a coherent communication system.
- Multiplexing and multi-access procedure combines signals that might have different characteristics or might originate from different sources, so that they can share a portion of the communications resource (e.g. spectrum, time).
- Spectrum spreading can produce a signal that is relatively invulnerable to interference and therefore enhance the privacy of the communicators.

Pros and Cons of Digital Systems

- Pros:
  - Relatively inexpensive digital circuit may be used
  - Privacy is preserved by using data encryption
  - Greater dynamic range is possible
  - Voice, video and data may be converged
  - Noise does not accumulate
  - Errors in detected data may be small, even in a noisy environment
  - Errors may often be corrected by the use of coding
- Cons:
  - More bandwidth is required than that for analog system
  - Synchronization is required

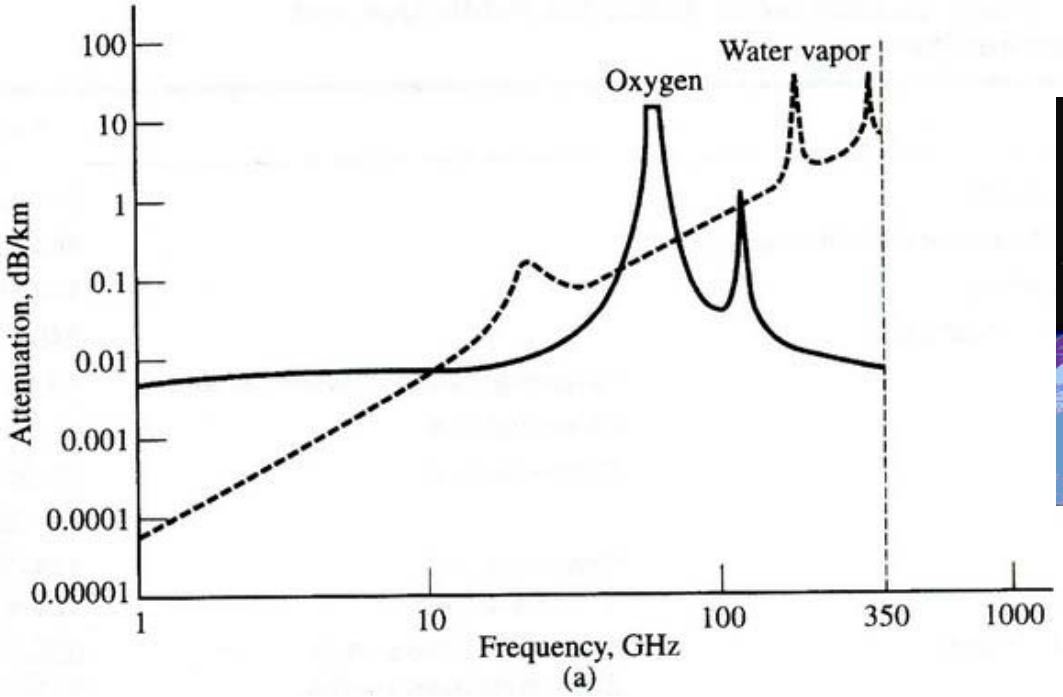
Transmission Channels

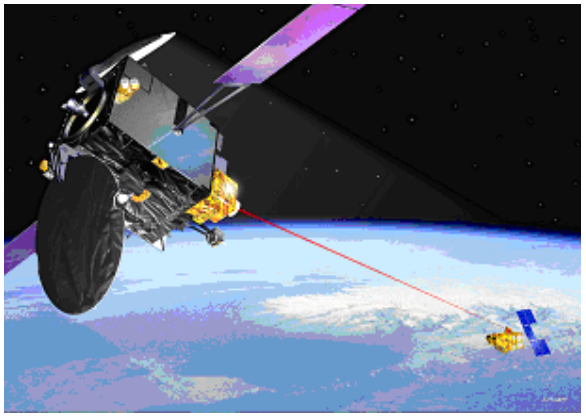
- Wireless (Electromagnetic-Wave Propagation Channel)
  - Antenna, a radiation element couples the electromagnetic energy into a propagation medium, free space or the atmosphere
- Wire (Guided Electromagnetic-Wave Channel)
  - Twisted pair
  - Coaxial cable
  - Millimeter-wave waveguide
  - Optical fiber

* Break the Bandwidth Barrier, http://www.byte.com/art/9609/sec6/art1.htm

Attenuation Spectrum of Air

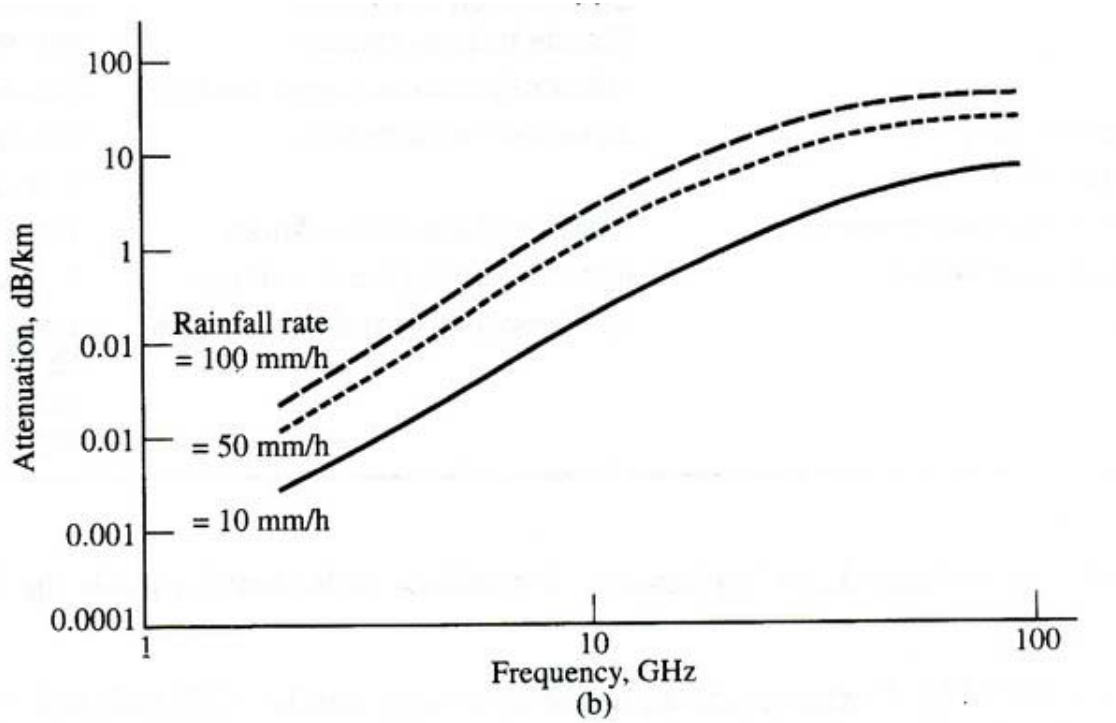
- Absorption peaks, 23, 62, 120, 180, 350 GHz.
- Example: Advanced Technology Satellite, launched in the mid-1990s, employs an uplink frequency band around 20 GHz and a downlink frequency band at about 30 GHz.





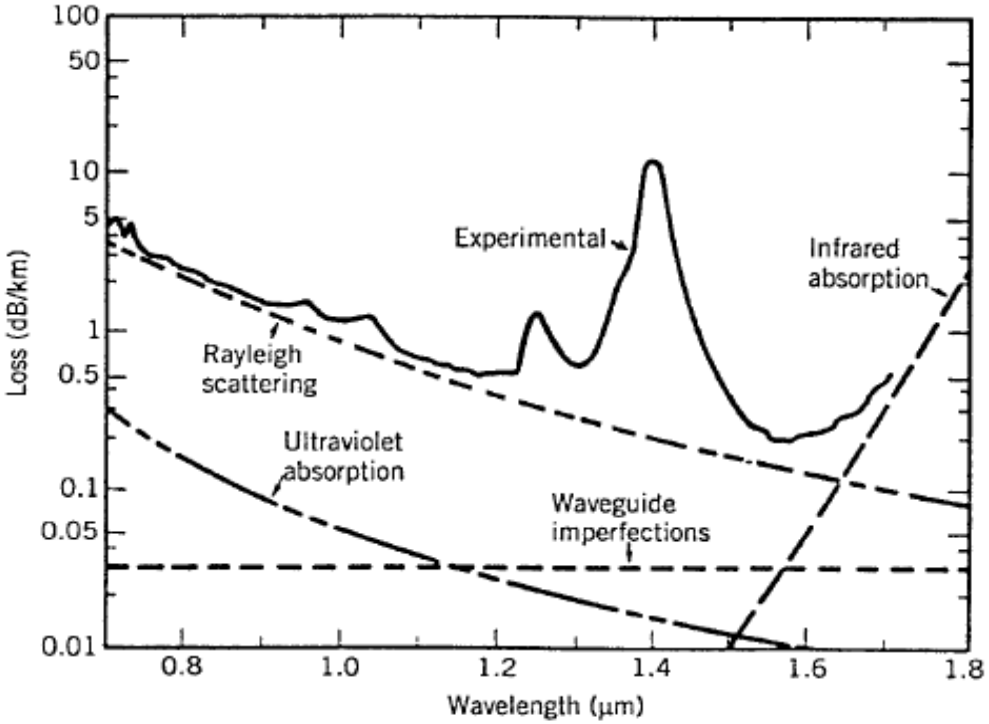
Attenuation Spectrum of Rain

- Somewhere above 1 THz, the propagation of radio waves become optical in character.
- Free Space Optical system is severely influenced by the weather.



Loss Spectrum of Fiber

- Absorption peak at about 1400 nm
- Three windows: 850, 1310, 1550 nm



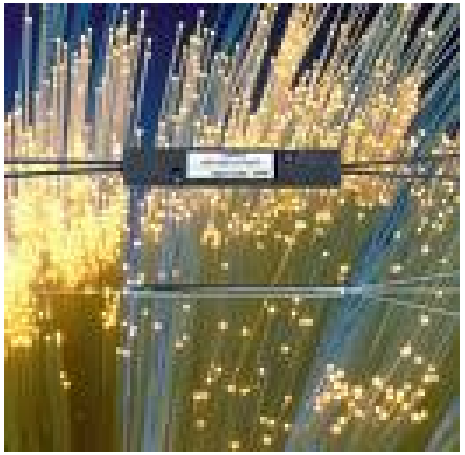


Figure 2.15: Loss spectrum of a single-mode fiber produced in 1979. Wavelength dependence of several fundamental loss mechanisms is also shown. (After Ref. [11]; ©1979 IEE; reprinted with permission.)