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# DIGITAL COMMUNICATION

- Prof. N. B. Kanirkar

## What is Electronic Communication?

"The systems and processes that are used to convey information from a source to a destination efficiently and reliably, especially by means of electricity or radio waves."

# History

## Milestones in the history of electronic communication.

| When? | Where or Who? | What? |
|---|---|---|
| 1837 | Samuel Morse | Invention of the telegraph (patented in 1844). |
| 1843 | Alexander Bain | Invention of facsimile. |
| 1866 | United States and England | The first transatlantic telegraph cable laid. |
| 1876 | Alexander Bell | Invention of the telephone. |
| 1877 | Thomas Edison | Invention of the phonograph. |
| 1879 | George Eastman | Invention of photography. |
| 1887 | Heinrich Hertz (German) | Discovery of radio waves. |
| 1887 | Guglielmo Marconi (Italian) | Demonstration of "wireless" communications by radio waves. |
| 1901 | Marconi (Italian) | First transatlantic radio contact made. |
| 1903 | John Fleming | Invention of the two-electrode vacuum tube rectifier. |
| 1906 | Reginald Fessenden | Invention of amplitude modulation; first electronic voice communication demonstrated. |
| 1906 | Lee de Forest | Invention of the triode vacuum tube. |
| 1914 | Hiram P. Maxim | Founding of American Radio Relay League, the first amateur radio organization. |
| 1920 | KDKA Pittsburgh | First radio broadcast. |
| 1923 | Vladimir Zworykin | Invention and demonstration of television. |
| 1933–1939 | Edwin Armstrong | Invention of the superheterodyne receiver and frequency modulation. |

## Milestones in the history of electronic communication.

| | | |
|---|---|---|
| 1939 | United States | First use of two-way radio (walkie-talkies). |
| 1940–1945 | Britain, United States | Invention and perfection of radar (World War II). |
| 1948 | John von Neumann and others | Creation of the first stored program electronic digital computer. |
| 1948 | Bell Laboratories | Invention of transistor. |
| 1953 | RCA/NBC | First color TV broadcast. |
| 1958–1959 | Jack Kilby (Texas Instruments) and Robert Noyce (Fairchild) | Invention of integrated circuits. |
| 1958–1962 | United States | First communication satellite tested. |
| 1961 | United States | Citizens band radio first used. |
| 1973–1976 | Metcalfe | Ethernet and first LANs. |
| 1975 | United States | First personal computers. |
| 1977 | United States | First use of fiber-optic cable. |
| 1982 | United States | TCP/IP protocol adopted. |
| 1982–1990 | United States | Internet development and first use. |
| 1983 | United States | Cellular telephone networks. |
| 1993 | United States | First browser Mosaic. |
| 1995 | United States | Global Positioning System deployed. |
| 1996–2001 | Worldwide | First smartphones by BlackBerry, Nokia, Palm. |
| 1997 | United States | First wireless LANs. |
| 2000 | Worldwide | Third-generation digital cell phones. |
| 2009 | Worldwide | First fourth-generation LTE cellular networks. |
| 2009 | Worldwide | First 100 Gb/s fiber optical networks. |

# Harry Nyquist (1928)

"Certain topics in telegraph transmission theory", Trans. AIEE, vol. 47, pp. 617–644, Apr. 1928

## Sampling Theorem

Continuous-time ⇨ Discrete-time

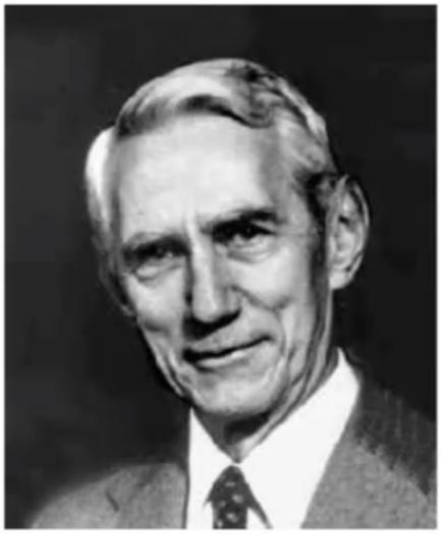
# Historical Review

- 1838: telegraph (S. Morse)
- 1876: telephone (A. Bell)
- 1895: radio by Marconi
- 1901: trans-atlantic communication

Nobel Prize for Physics (1909)

- Early 20th century:
  - Most communication systems are analog.
  - Engineering designs are ad-hoc, tailored for each specific application

# Claude Shannon (1948)



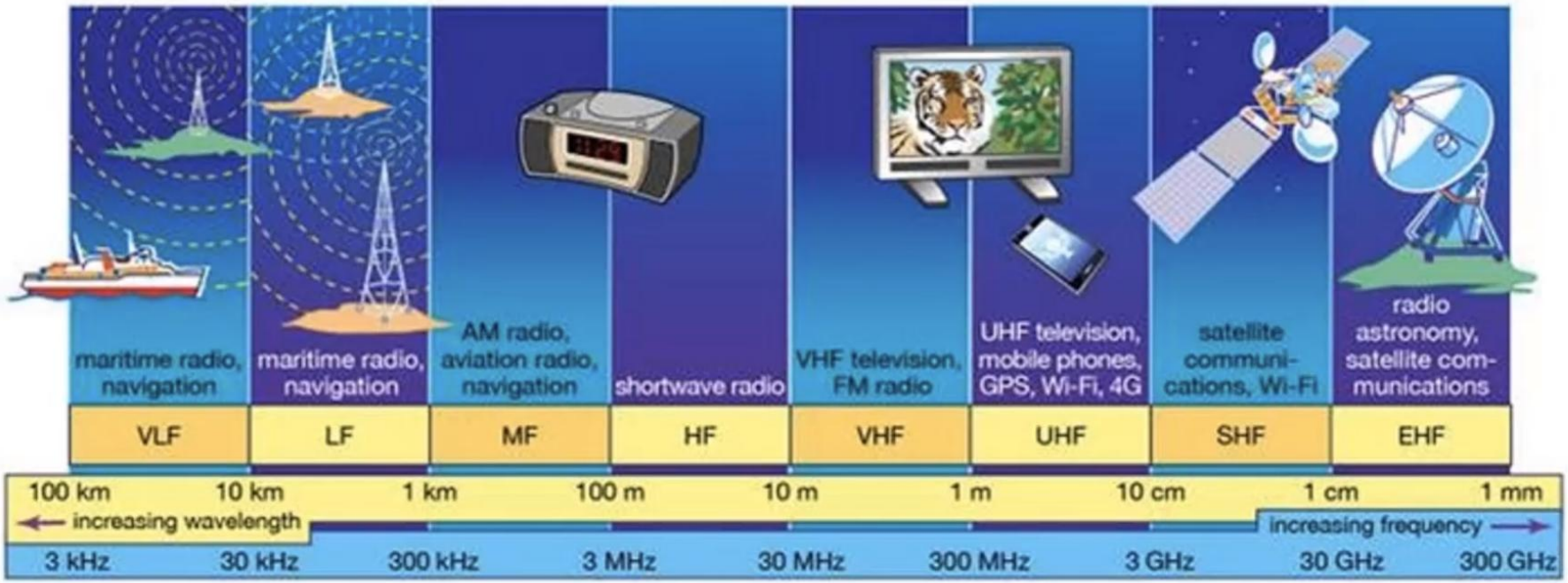
"A Mathematical Theory of Communication",
*Bell System Technical Journal*. 1948

## Information Theory

Fundamental limits of source compression rate and channel transmission rate

Analog communication ⇨ Digital communication

# Frequency Spectrum



# Frequency Spectrum

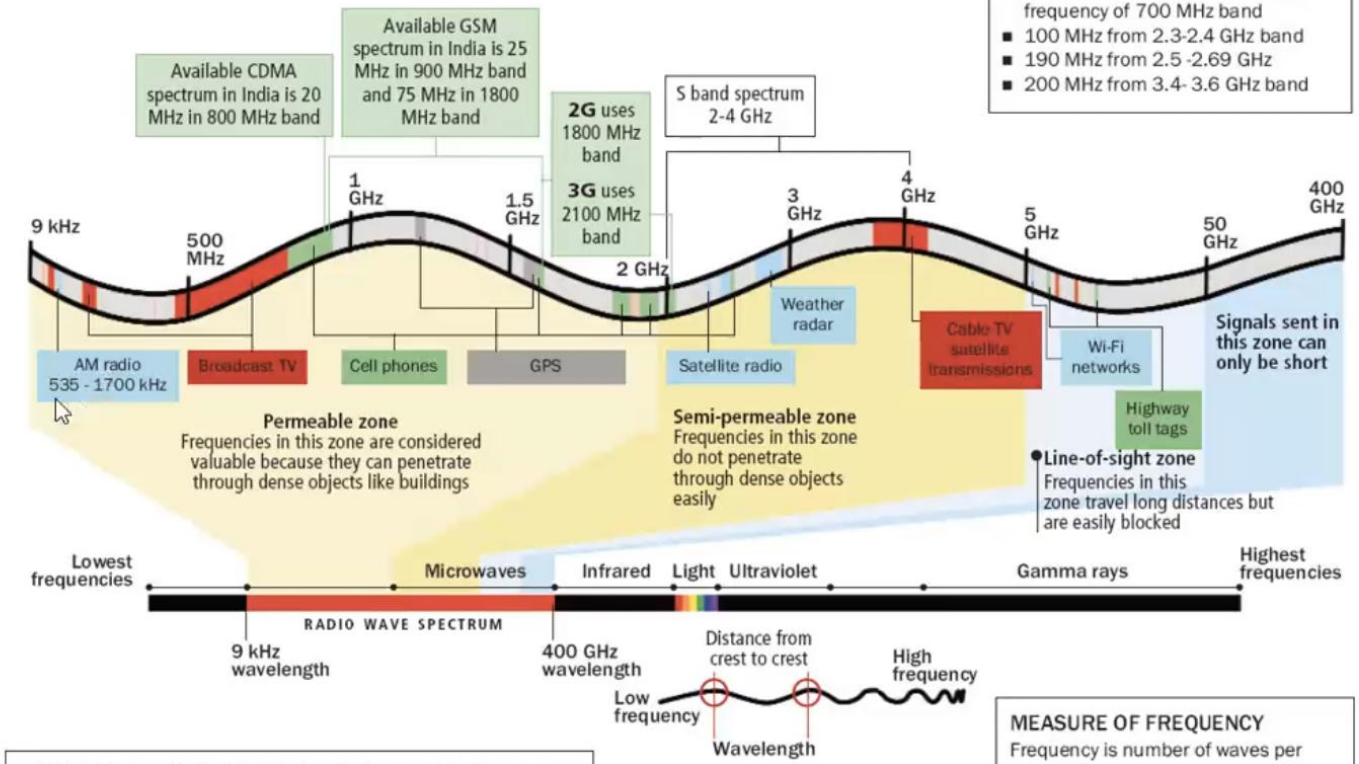
## Radio Frequency Spectrum: Ranges

| Designation | Abbreviation | Frequencies | Wavelengths |
|---|---|---|---|
| Very Low Frequency | VLF | 3 kHz - 30 kHz | 100 km - 10 km |
| Low Frequency | LF | 30 kHz - 300 kHz | 10 km - 1 km |
| Medium Frequency | MF | 300 kHz - 3 MHz | 1 km - 100 m |
| High Frequency | HF | 3 MHz - 30 MHz | 100 m - 10 m |
| Very High Frequency | VHF | 30 MHz - 300 MHz | 10 m - 1 m |
| Ultra High Frequency | UHF | 300 MHz - 3 GHz | 1 m - 100 mm |
| Super High Frequency | SHF | 3 GHz - 30 GHz | 100 mm - 10 mm |
| Extremely High Frequency | EHF | 30 GHz - 300 GHz | 10 mm - 1 mm |

| | Frequency | Common Uses |
|---|---|---|
| VLF | 3-30 kHz | underwater communications |
| LF | 30-300 kHz | AM radio |
| MF | 300-3000 kHz | AM radio |
| HF | 3-30 MHz | AM radio, long distance aviation communications |
| VHF | 30-300 MHz | FM radio, television, short range avaiation communications, weather radio |
| UHF | 300-3000 MHz | television, mobile phones, wireless networks, Bluetooth, satellite radio, GPS |
| SHF | 3-30 GHz | satellite television and radio, radar systems, radio astronomy |
| EHF | 30-300 GHz | radio astronomy, full body scanners |

# Radio Spectrum

## RADIO SPECTRUM




### WAYS TO FULFILL DEMAND

Telecom industry is looking towards new sources, including:

- 108 MHz from the broadcasting frequency of 700 MHz band
- 100 MHz from 2.3-2.4 GHz band
- 190 MHz from 2.5 -2.69 GHz
- 200 MHz from 3.4- 3.6 GHz band

### EVOLVING MOBILE TECHNOLOGY

- 1G: Short for first generation wireless telephone technology. Mobile phone was first launched in the 1980s in this technology. Radio signals on 1G networks were analog, where information is transmitted by modulating a continuous signal, like sound waves. Used frequency band 824-894 MHz
- 2G: Short for second generation wireless telephone technology. Mobile phone in India was launched based on this technology. Radio signals on 2G networks are digital. It allows data services for mobile phones, including text messages and downloading of ringtones. Uses 1800 MHz band
- 3G: Short for third-generation wireless telephone technology. It supports services like mobile TV and high-resolution video. Uses 2.1 GHz band

### BANDS AVAILABLE FOR MOBILE PHONE SERVICES

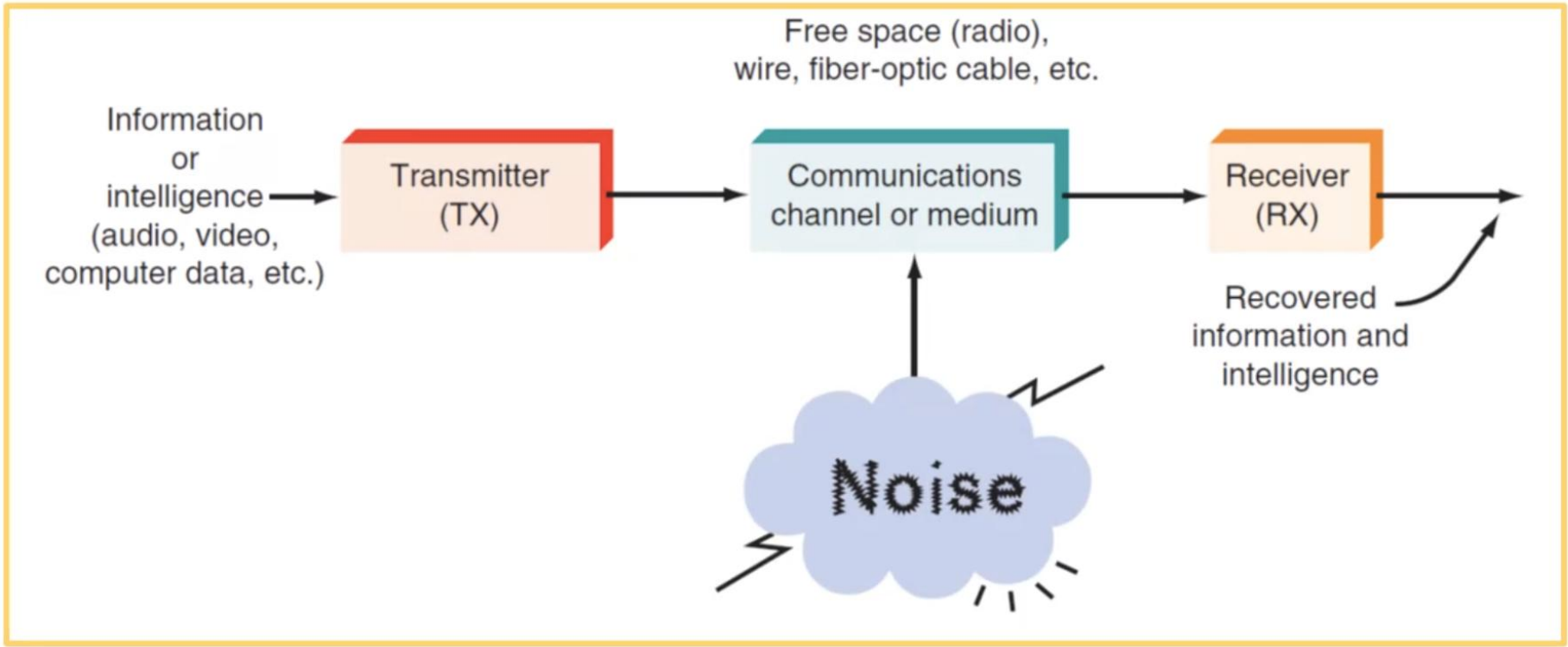
800 band = 824-844/869-889 MHz
900 band = 890-915 MHz/935-960 MHz
1800 band = 1710-1785/1805-1880 MHz
2100 band (2.1 GHz) = 1920-1980 MHz/2110-2170 MHz

### MEASURE OF FREQUENCY

Frequency is number of waves per second. It is measured in hertz.
1 hertz = waves per second
1 kilohertz (kHz) = 1000 hertz
1 megahertz (MHz) = 1000 kHz
1 gigahertz (GHz) = 1000 MHz

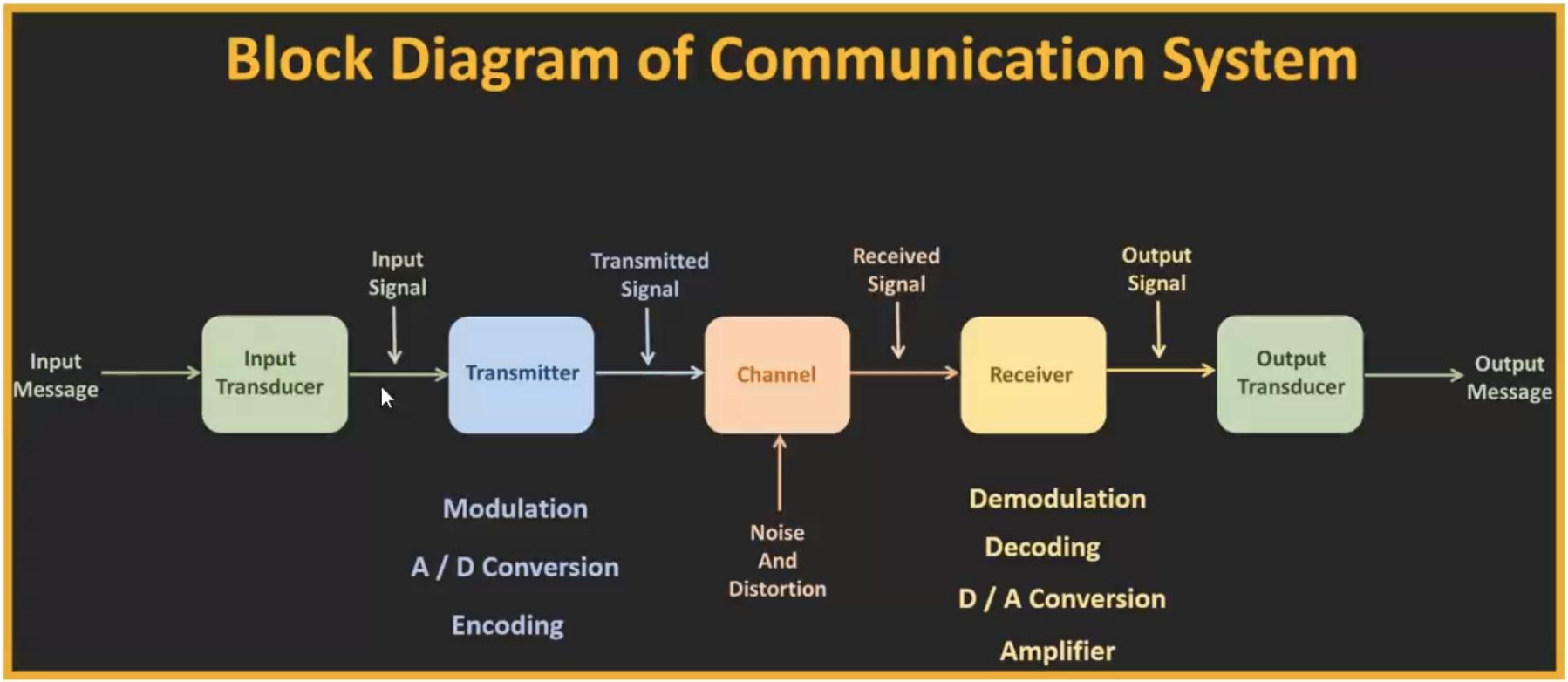
# Basic Communication


# General Model of all Communication Systems




A general model of all communication systems.

# Extended Block Diagram



# Basic Elements of a Communication System

- Free space
- Wireline
- Twisted Pair
- Coaxial Cable
- Optical Fiber etc.


- voice
- Image
- text
- video

etc.

- Microphone
- Measuring Instruments (Geophone, Hydrophone)
- Video Camera

etc

- Modulation
- Coding
- Amplification
- Filtering

Attenuation, Distortion, Noise and Interference

- Amplification
- Filtering
- Demodulation
- Decoding

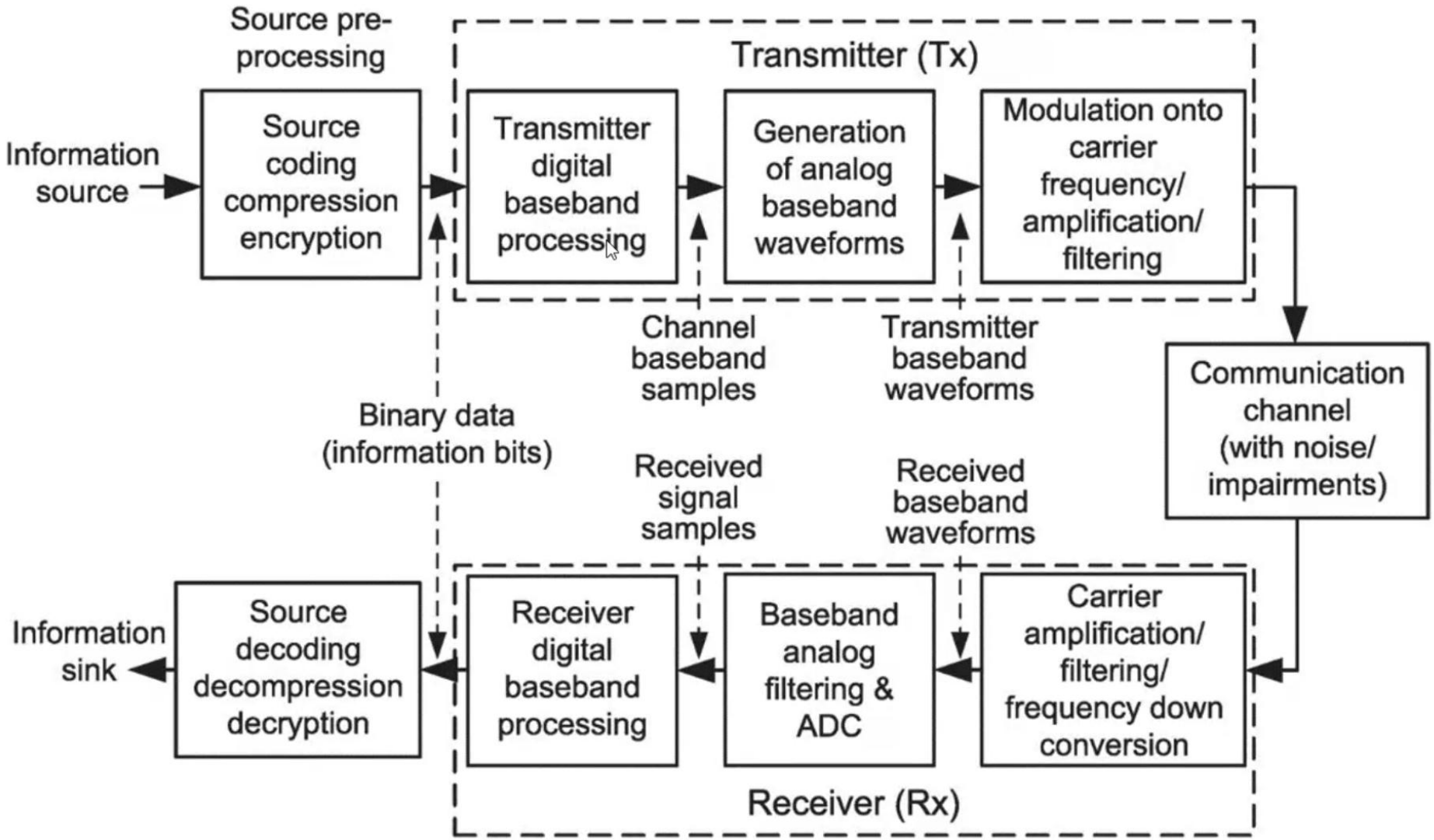
- Loudspeaker
- Personal Computer
- Tape Recorders
- Printers

etc.

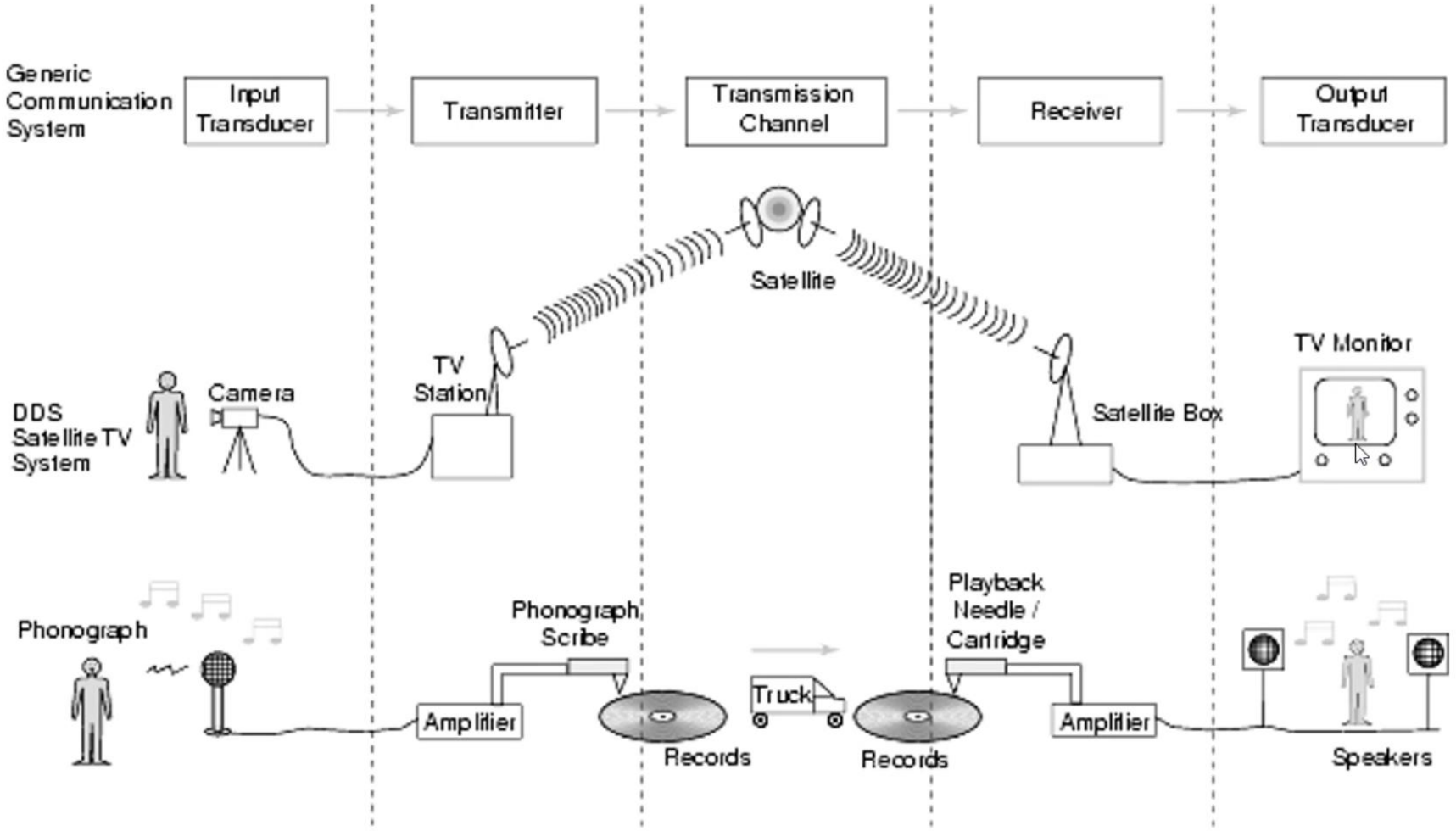
**Channel Limitations :**

- Propagation Loss
- Frequency Selectivity
- Time Variation
- Nonlinearity
- Multiplexing or Shared usages
- Noise
- Interference

# Block Diagram of Complex Comm. System



# Basic View of Communication System



## Transmitter

The first step in sending a message is to convert it into electronic form suitable for transmission. For voice messages, a microphone is used to translate the sound into an electronic *audio* signal. For TV, a camera converts the light information in the scene to a video signal. In computer systems, the message is typed on a keyboard and converted to binary codes that can be stored in memory or transmitted serially. Transducers convert physical characteristics (temperature, pressure, light intensity, and so on) into electrical signals.

The *transmitter* itself is a collection of electronic components and circuits designed to convert the electrical signal to a signal suitable for transmission over a given communication medium. Transmitters are made up of oscillators, amplifiers, tuned circuits and filters, modulators, frequency mixers, frequency synthesizers, and other circuits. The original intelligence signal usually modulates a higher-frequency carrier sine wave generated by the transmitter, and the combination is raised in amplitude by power amplifiers, resulting in a signal that is compatible with the selected transmission medium.

## Communication Channel

The *communication channel* is the medium by which the electronic signal is sent from one place to another. Many different types of media are used in communication systems, including wire conductors, fiber-optic cable, and free space.

**Electrical Conductors.** In its simplest form, the medium may simply be a pair of wires that carry a voice signal from a microphone to a headset. It may be a coaxial cable such as that used to carry cable TV signals. Or it may be a twisted-pair cable used in a local-area network (LAN).

**Optical Media.** The communication medium may also be a fiber-optic cable or "light pipe" that carries the message on a light wave. These are widely used today to carry long-distance calls and all Internet communications. The information is converted to digital form that can be used to turn a laser diode off and on at high speeds. Alternatively, audio or video analog signals can be used to vary the amplitude of the light.

**Free Space.** When free space is the medium, the resulting system is known as radio. Also known *as wireless, radio* is the broad general term applied to any form of wireless communication from one point to another. Radio makes use of the electromagnetic spectrum. Intelligence signals are converted to electric and magnetic fields that propagate nearly instantaneously through space over long distances. Communication by visible or infrared light also occurs in free space.

# Receivers & Transceivers

## Receivers

A *receiver* is a collection of electronic components and circuits that accepts the transmitted message from the channel and converts it back to a form understandable by humans. Receivers contain amplifiers, oscillators, mixers, tuned circuits and filters, and a demodulator or detector that recovers the original intelligence signal from the modulated carrier. The output is the original signal, which is then read out or displayed. It may be a voice signal sent to a speaker, a video signal that is fed to an LCD screen for display, or binary data that is received by a computer and then printed out or displayed on a video monitor.

## Transceivers

Most electronic communication is two-way, and so both parties must have both a transmitter and a receiver. As a result, most communication equipment incorporates circuits that both send and receive. These units are commonly referred to as *transceivers.* All the transmitter and receiver circuits are packaged within a single housing and usually share some common circuits such as the power supply. Telephones, handheld radios, cellular telephones, and computer modems are examples of transceivers.

## Attenuation

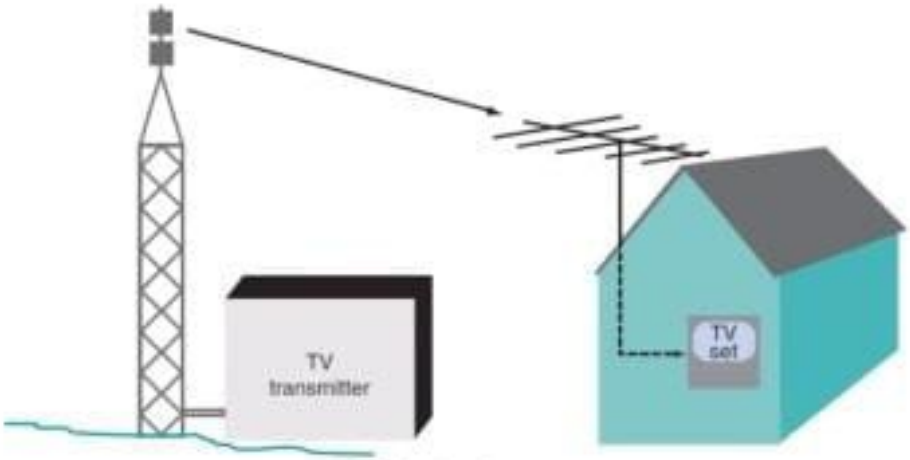
Signal *attenuation,* or degradation, is inevitable no matter what the medium of transmission. Attenuation is proportional to the square of the distance between the transmitter and receiver. Media are also frequency-selective, in that a given medium will act as a low-pass filter to a transmitted signal, distorting digital pulses in addition to greatly reducing signal amplitude over long distances. Thus considerable signal amplification, in both the transmitter and the receiver, is required for successful transmission. Any medium also slows signal propagation to a speed slower than the speed of light.

## Noise

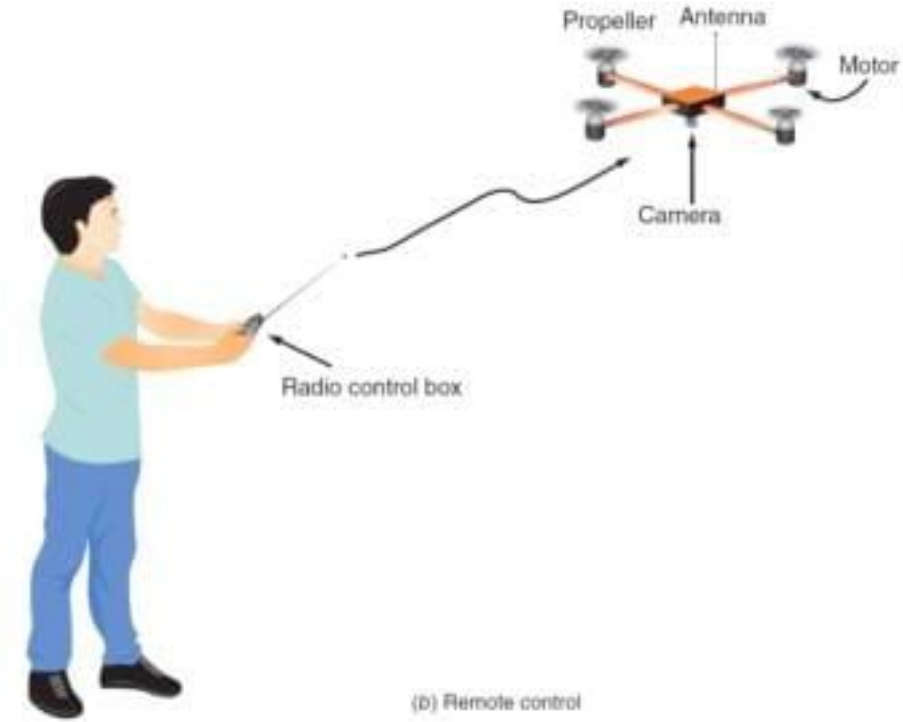
Noise is mentioned here because it is the bane of all electronic communications. Its effect is experienced in the receiver part of any communications system. For that reason, we cover noise at that more appropriate time in Chapter . While some noise can be filtered out, the general way to minimize noise is to use components that contribute less noise and to lower their temperatures. The measure of noise is usually expressed in terms of the signal-to-noise (*S/N*) ratio (SNR), which is the signal power divided by the noise power and can be stated numerically or in terms of decibels (dB). Obviously, a very high SNR is preferred for best performance.

# Types of Electronic Communication

Simplex communication.

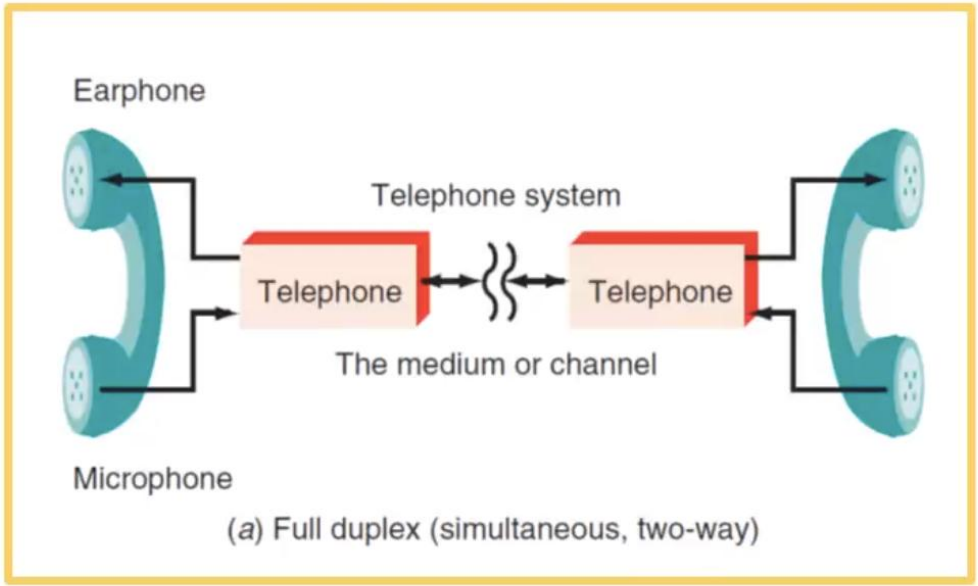



(a) TV broadcasting



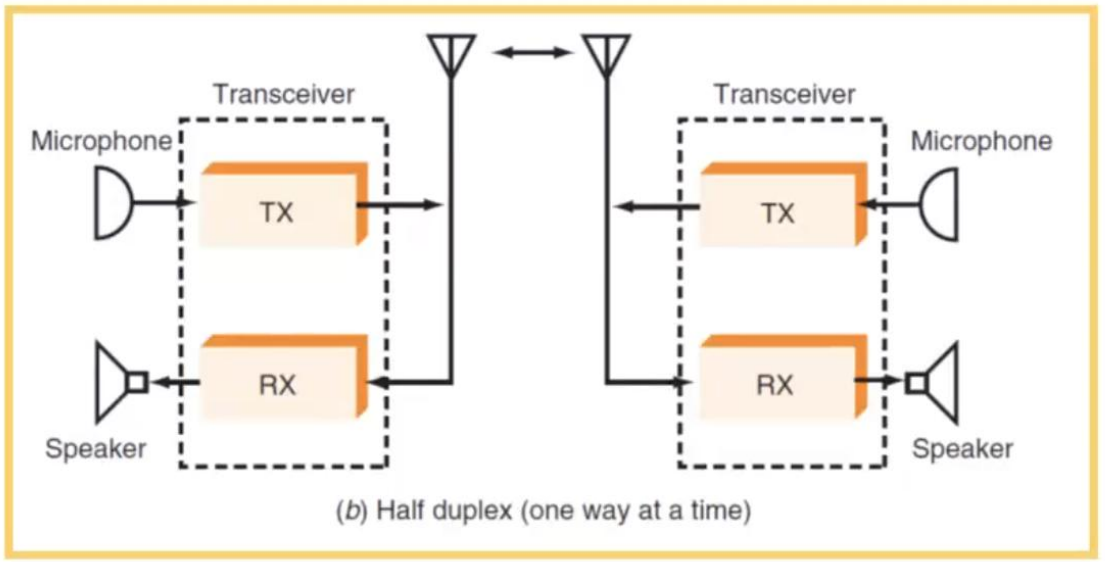

(b) Remote control

# Types of Electronic Communication



(*a*) Full duplex (simultaneous, two-way)

Duplex communication
(a) Full duplex (simultaneous two-way).
(b) Half duplex (one way at a time).



(*b*) Half duplex (one way at a time)

# Types of Electronic Communication

## Simplex

The simplest way in which electronic communication is conducted is one-way communications, normally referred to as *simplex communication.* Examples are shown in Fig. The most common forms of simplex communication are radio and TV broadcasting. Another example of one-way communication is transmission to a remotely controlled vehicle like a toy car or an unmanned aerial vehicle (UAV or drone).

## Full Duplex

The bulk of electronic communication is two-way, or *duplex communication.* Typical duplex applications are shown in Fig. For example, people communicating with one another over the telephone can talk and listen simultaneously, as Fig. ·(*a*) illustrates. This is called *full duplex communication.*

## Half Duplex

The form of two-way communication in which only one party transmits at a time is known as *half duplex communication* [see Fig. ·(*b*)]. The communication is two-way, but the direction alternates: the communicating parties take turns transmitting and receiving. Most radio transmissions, such as those used in the military, fire, police, aircraft, marine, and other services, are half duplex communication. Citizens band (CB), Family Radio, and amateur radio communication are also half duplex.


Bye


Thank you