History of Communication

Communication - the process of exchanging information or intelligence.

WHEN	WHERE/WHO	WHAT
1876	Alexander Bell	Invention of telephone
1887	Heinrich Hertz	Discovery of radio waves
1948	BELL Laboratories	Invention of transistor
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
1995	United States	Global Positioning System deployed
1997	United States	First Wireless LANs
2009	Worldwide	First 100 Gb/s fiber optical networks

Table 1.1 Historical Milestone of Electronic Communication

Block Diagram of Communication Systems

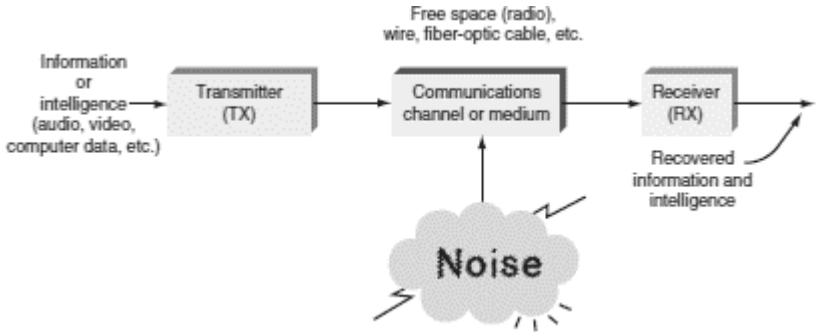

Figure 1.1 Communication Systems Block Diagram

Retrieved from: Frenzel L., Principles of Electronic Communication Systems, Page 4

- **Transmitter** converts the electrical signal to a suitable signal for transmission over a medium.
- **Channel** or **Medium** is the material in which electronic signal is sent.
- **Receiver** accepts the transmitted signal from the medium and converts it back to a form understandable by human.
- Undesired current or voltages that occur in a circuit are called **Noise.**
- Circuits that can transmit and receive signals are called **Transceivers**.

Modulation and Communication Theories

Types of Electronic Communication

- One-way communication is called **Simplex**; it can send information in one direction only.
- **Full Duplex** is a two-way communication system where both parties can talk and listen simultaneously.
- **Half-Duplex** is also a two-way communication system but applies alternating direction.

Analog Communication

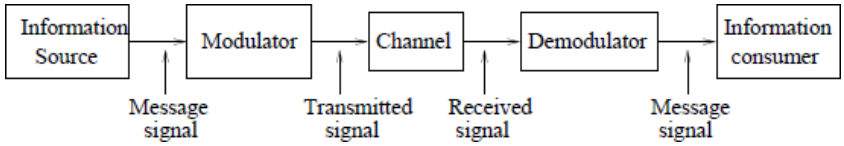

Figure 1.5 Analog Communication Block Diagram

Retrieved from: Madhow U., Introduction to Communication Systems, Page 16

- **Information Source** is the information or intelligence to be sent.
- **Message Signal** is the information or intelligence in electrical form.

- **Modulator** transforms the message signal into the transmitted signal.
- Signals that are suitable for transmission are called **Transmitted Signal**.
- **Channel/Medium** is the pathway of signals.
- **Demodulator** converts the signal back to a form understandable by human.
- **Information Consumer** is the recipient of information or intelligence.

Digital Communication

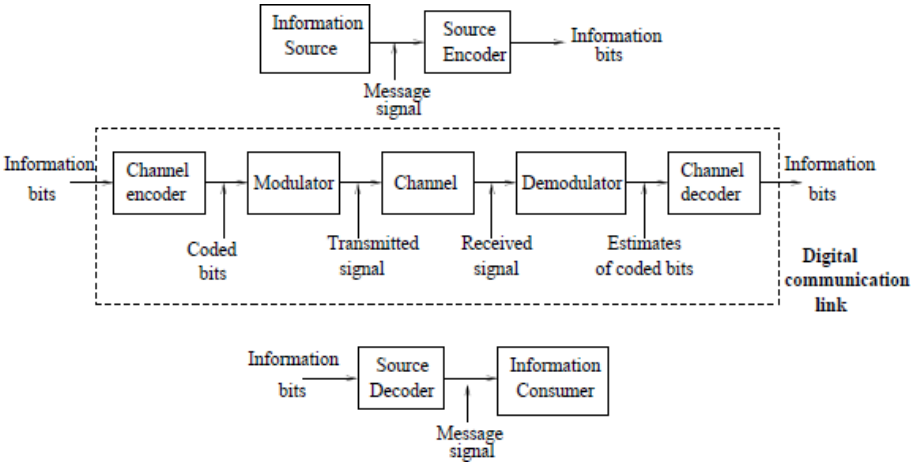

Figure 1.6 Digital Communication Block Diagram

Retrieved from: Madhow U., Introduction to Communication Systems, Page 17

- **Information Source** is the information or intelligence to be sent.
- **Source Encoder** converts the message signal into a sequence of bits.
- **Information Bit** is a basic unit of data/message used in digital communications.
- **Channel Encoder** adds redundancy to facilitate error recovery after transmission.
- **Modulator** maps the coded bits to be sent to the channel.
- **Channel/Medium** is the pathway of signals.
- **Demodulator** performs signal processing; produces bit estimates to be feed to the channel decoder.
- **Channel decoder** processes the imperfect bit estimates from the demodulator.
- **Source Decoder** processes the estimated information bits to obtain an estimate of the message.
- **Information Consumer** is the recipient of information or intelligence.

Modulation

- **Modulation** is an electronic method for transmitting information from a place to another.
- It is the process by which information or intelligence is modified by the **carrier.**
- **Carrier** is a high-frequency signal, usually a sine-wave generated by an oscillator.
- Original information or intelligence are called **baseband signals.**
- **Baseband Transmission** is the process of putting the baseband signal directly into a medium.

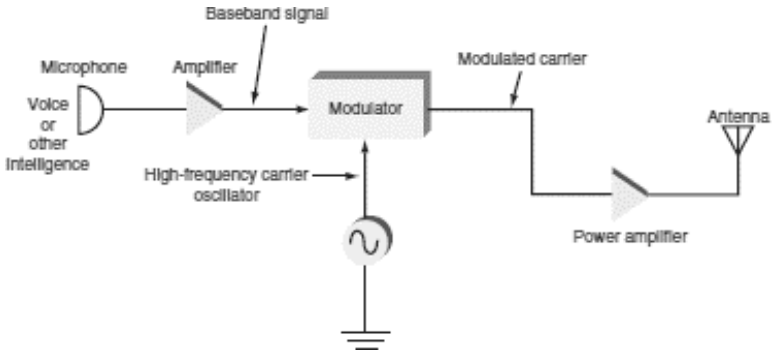

Figure 1.7 Digital Communication Block Diagram

Retrieved from: Frenzel L., Principles of Electronic Communication Systems, Page 9

- **Information** or **intelligence** is sent upon the carrier.
- **Carrier** is fed to the modulator along with the baseband signal.
- The *intelligence signal* will be converted as a **modulated carrier** through *high-frequency carrier oscillator* and *modulator*.
- The *modulated carrier* is amplified and sent to the *antenna* (or any other channel/medium) for transmission.

Frequency (f)

- The number of cycles of a repetitive wave
- Measured in cycles per second (cps) or Hertz (Hz)
- Given as: $f = \frac{1}{T}$

Note: $1cps = 1Hz$

where:

f= frequency (Hz)
T= Period (seconds)

Wavelength (λ)

- The distance of a wave occupied by one cycle
- Usually expressed in meters or miles
- Given as: $\lambda = \frac{c}{f}$

where:

c = speed of light
f= frequency (Hz)

Note**:* Speed of light is given as ***3x10^8 m/s or ***186,000mi/s***

Electromagnetic Spectrum

Electromagnetic Spectrum is the total span of frequencies and wavelengths used in communication systems. It is divided into different section bands. Each band has a name and boundary and is used for many communication applications. Each service or user must use an assigned frequency band to avoid interfering with other users who may be broadcasting at the same time. The allocation of the communication services within the overall spectrum is made by a general worldwide agreement under the control of the International Telecommunications Union (ITU).

NAME	FREQUENCY (f)	WAVELENGTH (λ)	USAGE
Extremely low frequencies (ELFs)	30-300 Hz	10^7 - 10^6 m	AC power line frequencies
Voice frequency (VF)	300 - 3000Hz	10^6 – 10^5 m	Normal range of human speech
Very low frequencies (VLFs)	3–30 kHz	10^5 – 10^4 m	Higher-end of the human hearing (15-20kHz), musical instruments, government and military communications
Low frequencies (LFs)	30–300 kHz	10^4 – 10^3 m	Aeronautical and marine navigation
Medium frequencies (MFs)	300 kHz–3 MHz	10^3 – 10^2 m	AM radio broadcasting
High frequencies (HFs)	3–30 MHz	10^2 – 10^1 m	Amateur radio and CB communication
Ultrahigh frequencies (UHFs)	300 MHz–3 GHz	1 – 10^{-1} m	UHF TV channels, land mobile communication, cellular phone
Microwave and Superhigh frequencies (SHF)	3GHz – 30GHz	10^{-1} – 10^{-2} m	Microwave oven, satellite communication, radar, WLAN
Extremely high frequency (EHF)	30GHz – 300GHz	10^{-2} – 10^{-3} m	Satellite communication, telephony, computer data, short-haul cellular network, specialized radar

Bandwidth (BW)

- Portion of electromagnetic spectrum occupied by a signal
- Determines the maximum speed of data pulses the medium can handle
- Expressed in Hertz (Hz)
- Given as: $\boldsymbol{BW = f_U - f_L}$ where:
  $\boldsymbol{f_U}$ = upper limit frequency
  $\boldsymbol{f_L}$ = lower limit frequency

Gain, Attenuation, and Decibels

- **Gain** (**A**) is the amplification of a signal.
- **Attenuation** (**A**) refers to the loss of power of a signal.
- **Gain** and **Attenuation** are both the ratio of the output to the input of a circuit or antenna.
- Given as: $\boldsymbol{A = \frac{\text{output}}{\text{input}}}$
- For cascaded circuits, the **total gain or attenuation** ($\mathbf{A_T}$) is the product of all **gain** and **attenuation** factors. $\mathbf{A_T = (A_1)(A_2)(A_3)\ldots(A_n)}$
- **Gain** and **Attenuation** are unitless or in **Decibels** (**dB**)
- **Decibels** (**dB**) is a unit of measurement of the human hearing response.
- Formulas to convert a unitless **gain** or **attenuation** to decibels are:

$\boldsymbol{dB = 20log\ \frac{V\text{out}}{V\text{in}}}$	**voltage gain** or **attenuation**.
$\boldsymbol{dB = 20log\ \frac{I\text{out}}{I\text{in}}}$	**current gain** or **attenuation**
$\boldsymbol{dB = 10log\ \frac{P\text{out}}{P\text{in}}}$	**power gain** or **attenuation**

Metric Unit Guide

Prefix	Symbol	Multiplier
Tera	T	10^{12}
Giga	G	10^{9}
Mega	M	10^{6}
Kilo	k	10^{3}
Milli	m	10^{-3}
Micro	μ	10^{-6}
Nano	n	10^{-9}
Pico	p	10^{-12}

***NOTE*:** Use the table above as a guide for the units that will be used for the rest of the subject.

References:

Beasley, J. & Miller, G. (2014). *Modern electronic communication, ninth edition*. London: Pearson Education Limited

Frenzel, L. (2016). *Principles of communication systems*. New York: McGraw-Hill Education

Madhow, U. (2014). *Introduction to communication systems*. California: University of California, Santa Barbara