Fundamentals of Telecommunications

CSE-472

Telecommunications

Telecommunications refers to the exchange of information by electronic and electrical means over a significant distance. A complete telecommunication arrangement is made up of two or more stations equipped with transmitter and receiver devices. A single co-arrangement of transmitters and receivers, called a transceiver, may also be used in many telecommunication stations.

Telecommunications devices include telephones, telegraph, radio, microwave communication arrangements, fiber optics, satellites and the Internet. Telecommunications is also known as telecom.

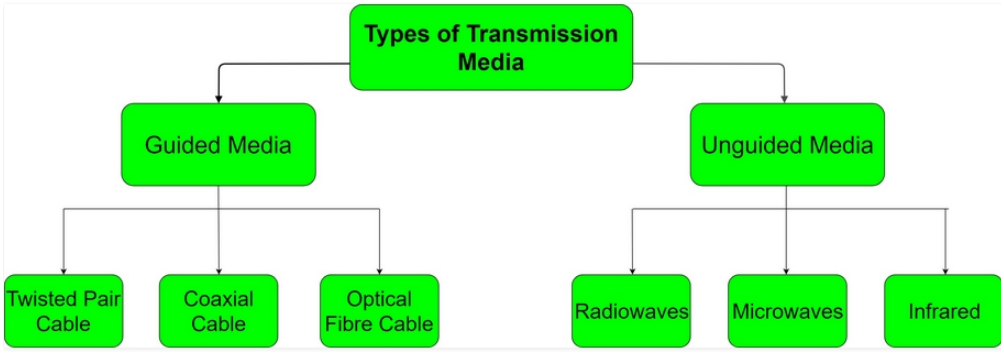
Traditionally it consists of two distinct disciplines:

1) Switching: selects and directs communication signals to a specific user or a group of users
2) Transmission: delivers the signals in some way from source to the far-end user with an acceptable signal quality

Transmission Media

Types of Transmission Media

A transmission medium is a physical path between the transmitter and the receiver i.e it is the channel through which data is sent from one place to another. Transmission Media is broadly classified into the following types:



Guided Media:

It is also referred to as Wired or Bounded transmission media. Signals being transmitted are directed and confined in a narrow pathway by using physical links.

Features:

- High Speed
- Secure
- Used for comparatively shorter distances

Unguided Media:
It is also referred to as Wireless or Unbounded transmission media. No physical medium is required for the transmission of electromagnetic signals.

Features:

- Signal is broadcasted through air
- Less Secure
- Used for larger distances

The dB in Communications
The db (decibel) is a relative unit of measurement commonly used in communications for providing a reference for input and output levels. The term dB or decibel are used to specify measured and calculated values in audio systems, microwave system gain calculations, satellite system link-budget analysis, antenna power gain, light-budget calculations and in many other communication system measurements. In each case the dB value is calculated with respect to a standard or specified reference.

The dB value is calculated by taking the log of the ratio of the measured or calculated power (P2) with respect to a reference power (P1). This result is then multiplied by 10 to obtain the value in dB. The formula for calculating the dB value of two ratios is shown in following equation.

$$\text{dB} = 10 \log_{10} \frac{P_2}{P_1}$$

It can be modified to provide a dB value based on the ratio of two voltages. By using the power relationship P = V 2 /R

$$\text{dB} = 10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{V_2^2/R}{V_1^2/R} = 20 \log_{10} \frac{V_2}{V_1}$$

dBm and dBW
dBm indicates that the specified dB level is relative to a 1 milliwatt reference.

$$\text{dBm} = 10 \log_{10} \frac{P_2}{0.001\text{W}}$$

$$\text{dBW} = 10 \log_{10} \frac{P_2}{1\ \text{W}}$$

If Power is expressed in watts instead of milliwatts. the dB unit is obtained with respect to 1 watt and the dB values are expressed as dBW.

dB value = $10 \log_{10} 4/2 = 10 \log_{10} 2 = 10 \times 0.3010 = +3.01\text{dB} \approx 3\text{dB}$

The amplifying network has a 3-dB gain because the output power was the double the input power

Telephony

Telephony is a technology which allows voice and/or interactive communication between two points through the usage of appropriate equipment. Analog sound signals are translated into electrical signals after a communication request is initiated. These electrical signals are converted back to analog sound signals once received at the destination.

- The telephone is connected to Public switched telecommunications network (PSTN) for local, national , and international voice communications.
- The same connections can carry data and image information (television).

Voice Telephony

Transmission of the human voice

- Voice is a sound signal

Analog voice-band channel

- A channel that is suitable for transmission of speech or analog data and has the maximum usable frequency range of 300 to 3400 Hz.
- The local serving switch is the point of the connectivity with the PSTN
- It is the point where the analog signal is digitized.

Telephone Subset

It is a device which converts human speech in the form of sound waves produced by the vocal cord to electrical signals. These signals are then transmitted over telephone wires and then converted back to sound waves for human ears.

1) Microphone
2) Earphone
3) Signaling functions

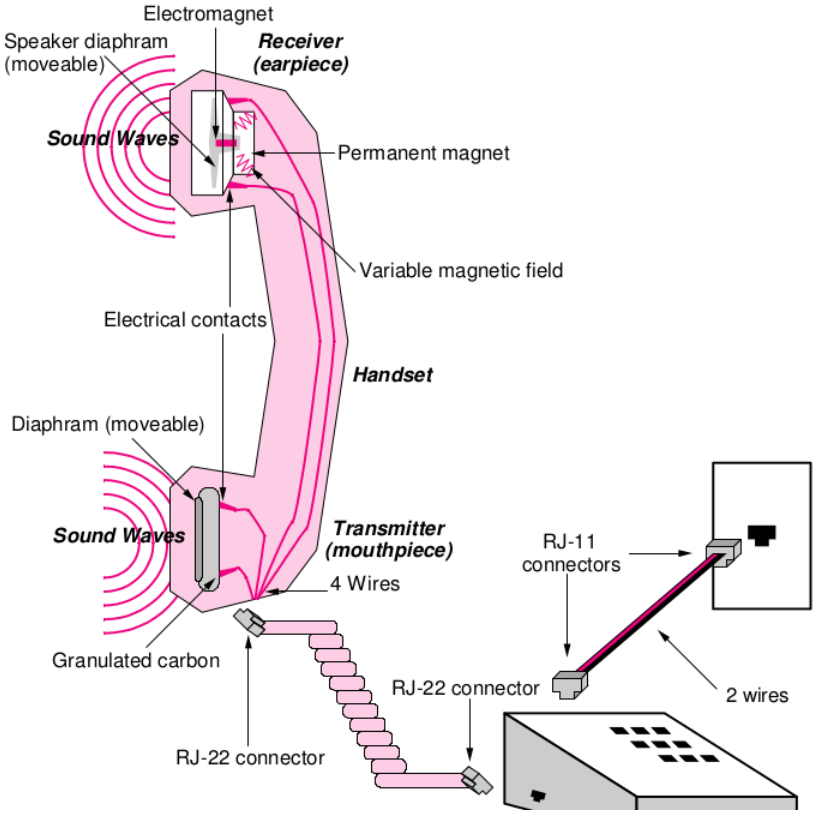
Telephone Handset

Microphone (mouthpiece)

- Consists of a movable speaker diaphragm that is sensitive to both amplitude and frequency
- The diaphragm contains carbon particles that can conduct electricity.
- As the human voice spoken into the transmitter varies, the amount of carbon granules that strike the electrical contacts in the mouthpiece also varies—thereby sending varying analog electrical signals out into the voice network.

Earphone (earpiece)

- Acts in an opposite direction to the mouthpiece.
- The electrical signal/waves produced by the transmitter are received at an electromagnet in the receiver.
- Varying levels of electricity produce varying levels of magnetism—that, in turn, cause the diaphragm to move in direct proportion to the magnetic variance.
- The moving diaphragm produces varying sound that corresponds to the sound waves that were input at the transmitter.



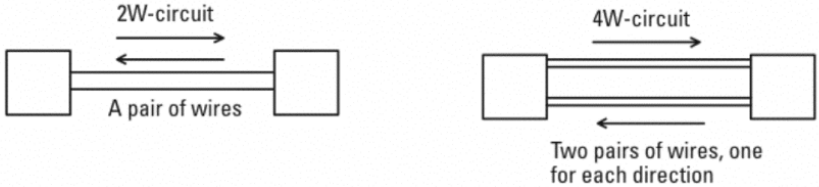
Dual-tone multi-frequency signaling

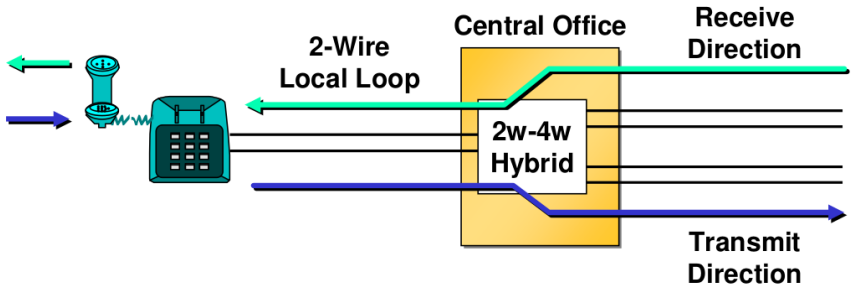
The DTMF keypad is laid out in a 4×4 matrix, with each row representing a low frequency, and each column representing a high frequency. Pressing a single key (such as '1') will send a sinusoidal tone for each of the two frequencies (697 and 1209 hertz [Hz]). The original keypads had levers inside, so each button activated two contacts. The multiple tones are the reason for calling the system multi-frequency. These tones are then decoded by the switching center to determine which key was pressed

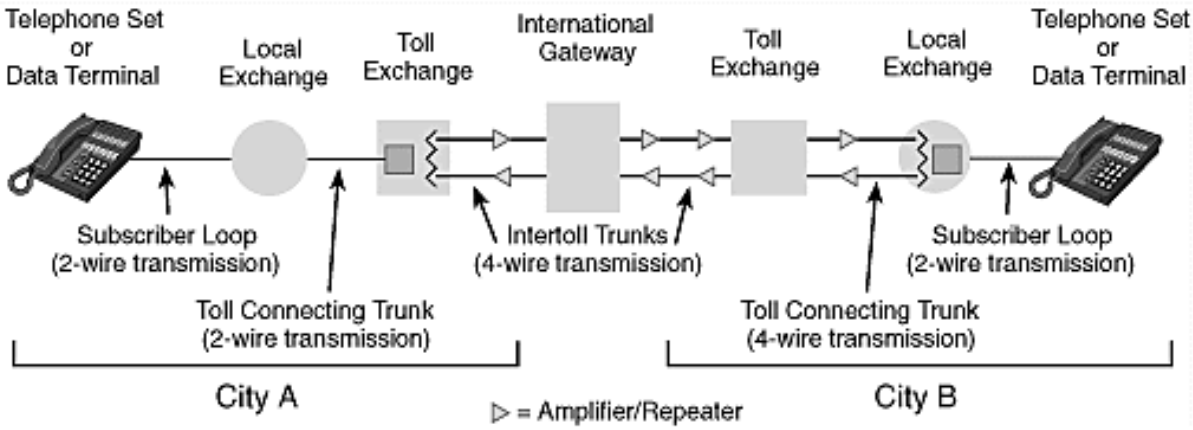
1	2	3	697Hz
4	5	6	770Hz
7	8	9	852Hz
*	0	#	941Hz
1209Hz	1336Hz	1477Hz	

Subscriber Loop Design

- Any use of telephone channels involves two unidirectional paths, one for transmission and one for reception.
- The local loop, which connects a telephone to a local exchange is a two-wire (2W) circuit that carries the signals in both transmission directions.
- Even asymmetrical digital subscriber lines (ADSLs) use this same 2W local
- To connect a 2W local loop to a 4W network a circuit called a 2W/ 4W hybrid is needed







Two-Wire-to-Four-Wire Conversion

- Basic conversion function is provided by hybrid circuits
- Impedance matching is important
- Impedance mismatch causes “echo”

Two-Wire versus Four-Wire

- All subscriber loops in the telephone network are implemented with a signal pair of wires
- Both directions of transmission
- Conversations are superimposed on the wire pair
- Two directions of longer distances are separated

Transmission Systems

Link characteristics

1. information carrying capacity (bandwidth)
   - information sent as symbols
   - 1 symbol >= 1 bit
2. propagation delay
   - time for electromagnetic signal to reach other end
   - light travels at 0.7c in fiber ~8 microseconds/mile
   - NY to SF => 20 ms; NY to London => 27 ms
3. attenuation
   - degradation in signal quality with distance
   - long lines need regenerators
   - optical amplifiers are here

Bonus Content.

Don’t worry. It doesn’t include in Final EXAM.

The Telephone

In 1876, Alexander Graham Bell invented his telephone.
Bell's greatest success was achieved on 10th March 1876, which marked not only the birth of the telephone but the death of the multiple telegraph as well. The communications potential contained in his demonstration of being able to « talk with electricity » far outweighed anything that simply increasing the capability of a dot-and-dash system could imply.

First voice - Mr. Watson, come here. I want to see you.
Alexander Graham Bell's notebook entry on 10th March 1876 describes his successful experiment with the telephone. Speaking through the instrument to his assistant Thomas A. Watson, who is in the next room, Bell utters these famous first words, « Mr. Watson – come here -- I want to see you ».

First phone call
On 9 th October 1876, Alexander Graham Bell and his assistant Thomas Watson conducted the first long distance call in the world from Boston to Cambridge through the telegraph line.

The first telephone company
In 1877, Mr. Bell formed the Bell Telephone Company. In 1877, construction of the first regular telephone line from Boston to Somerville (97 km), was completed. By the end of 1880, there were 47,900 telephones in the United States

Fun Story

Hello Myth

People generally fake a story behind “Hello” that when Alexander Graham Bell called his girlfriend, “Margaret Hello”, for the first time, he said “hello!”

The Actual credit behind coining the term “Hello” goes to Thomas Edison. He was the one who proposed “hello” as the proper greeting to the chagrin of his arch-rival Alexander Graham Bell. He expressed his surprise which was misheard as “**Hullo”** Initially, Graham Bell decided “**Ahoy”** (as in really the ahoy on the Ships) as the telephone greeting. But later Edison wrote to Central District and Printing Company of Pittsburgh that call bell hello! isn’t required. We very well know how often it’s used! Also, there are various pronunciations for hello such as *Hullo, hallo, holla, hola, halloo, etc.*

--- Happy learning ---