“COMMUNICATION AND DATA TRANSMISSION NETWORKS”

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Communication and Data Transmission Networks

5 Data transmission Interfaces

6 Data transmission media:

a. Guided media: cables, coaxial cable, waveguide, and fiber optics

b. Non-guided media: broadcast, microwaves, satellite.

c. Transmission deterioration

d. Comparison of media

5 Data transmission interfaces

Definition of Interface:

An interface is the frontier defined by common physical interconnection characteristics with properly defined exchange signals.

5 Data transmission interfaces

- Most of the recommendations include specifications for signaling between the data terminal equipment (DTE) and the data circuit terminal equipment (DCE).
- In a limited way, they include procedures for signaling between two DTEs.

5 Data transmission interfaces

- According to ITU-T, EIA, and TIA recommendations, the interfaces are as follows:
  - ***ITU-T recommendations*** list the following interfaces:
    - V.10, V.11, V.24, V.28, V.35, V.36, and X.21
  - The ***EIA and TIA standards*** include the following interfaces:
    - EIA/TIA 232E, EIA/TIA-232E Alt A, RS 422 A, RS 423 A, RS 366, RS 449, RS 488, ANSI/EIA-530, EIA/TIA-574, and RJ-12

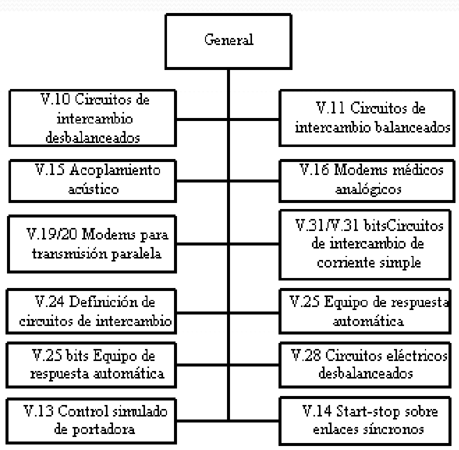
ITU-T: International Telecommunications Union - Telecommunications

EIA: Electronic Industries Association

TIA: Telecommunications Industries Association

5 Data transmission interfaces

ITU-T



5 Data transmission interfaces

V.10 INTERFACE

- This recommendation, entitled ***"Electric characteristics of double current <u>asymmetric</u> link circuits for general use with integrated circuits equipment for data transmission",*** specifies non-balanced connections.
- The expression non-balanced in this context means that every interface circuit has a live conductor and shares a common grounding with the other circuits. Voltage is measure with respect to grounding.

5 Data transmission interfaces

V.11 INTERFACE

- This recommendation in the blue book is entitled: ***"Electric characteristics of double current <u>symmetric</u> link circuits for general use with integrated circuits equipment for data transmission".***
- The expression ***<u>balanced</u>*** in this context means that each interface circuit has two conductors :
  - one for the signal, and
  - the other for return.

5 Data transmission interfaces

V.11 INTERFACE

- ***Symmetric link circuit*** means a symmetric generator connected to a symmetric receiver *via* a symmetric interconnection pair.
- In a symmetric generator, the algebraic sum of the potentials of its two terminals in relation to the grounding must be constant for all transmitted signals.

5 Data transmission interfaces

V.24 INTERFACE

- This standard entitled "**List of definitions of the circuits for the exchange between data terminal equipment and data circuit terminal equipment**" is one of the most widely used and its importance rests on the fact that it defines the functions of the exchange circuits that exist between the DTE (terminal) and the DCE (modem or multiplexor or concentrator or node).

5 Data transmission interfaces

V.24 INTERFACE

- Without these definitions, it would not be possible to connect equipment from different brands.

- It regulates the exchange circuits for the transfer of data, control, timing, and grounding signals. This standard does not specify the electric characteristics or the physical dimensions of the circuits and their corresponding connectors, which are established by standards such as V.10. V.11 , and V.28

5 Data transmission interfaces

V.24 INTERFACE

- Standard 2110 is used for the physical dimensions.
- V.24 is in a sense a super-set of standards.
- This standard applies to:
  - Synchronous and asynchronous communications
  - Dedicated and switched lines
  - 2- and 4- wire circuits
  - End-to-end and multipoint circuits
  - Certain public data networks

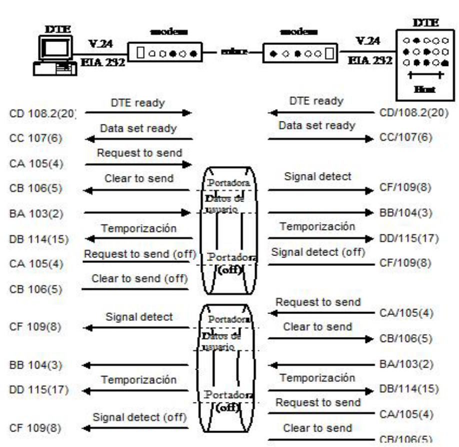
5 Data transmission interfaces

V.24 INTERFACE

- This interface has two groups of circuits: the 100 series and the 200 series.
- ***The circuits of the 100 series*** conform to standard V.24.
- ***The circuits of the 200 series*** are used in accordance with the application.

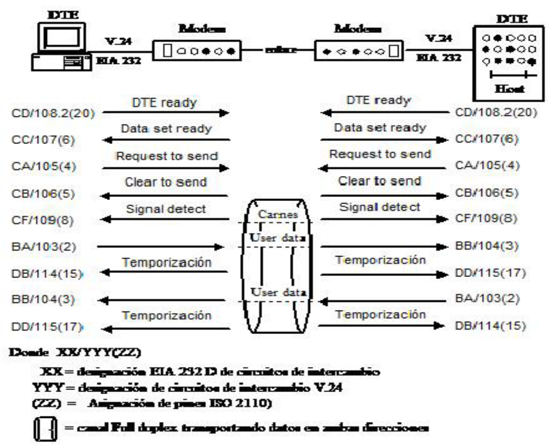
5 Data transmission interfaces

V.24 Half Duplex Operation



5 Data transmission interfaces

V.24 Full Duplex Operation



5 Data transmission interfaces

V.28 INTERFACE

This recommendation, entitled “**Electric characteristics of asymmetric link circuits for double current transmission**”, specifies the electric characteristics of the interface (transmission and reception) between the modem and the terminal.

5 Data transmission interfaces

V.35 INTERFACE

- This interface is a combination of the V.35 standard and EIA standard 232, and is not a true CCITT connector.
- All data and timing terminals conform to the V.35 specification (balanced circuits and low voltage) and control signals have EIA 232 voltages (non-balanced).

5 Data transmission interfaces

V.35 INTERFACE

- All data and timing pins are added to the V.35 specification, which are balanced and low-voltage circuits.
- Yet, all control pins are non-balanced EIA-232 voltages.
- The test, local loop, and remote loop functions are assigned according to each manufacturer.

5 Data transmission interfaces

V.36 INTERFACE

- The recommended transmission speed for this interface is from 48 to 72 Kbps.
- Recommendation V.10 defines the electric characteristics of its non-balanced control and command lines.

5 Data transmission interfaces

V.36 INTERFACE

- Balanced data and timing lines are regulated by recommendation V.11.
- Standard V.24 defines the functions of the other interface lines and has a 37-pin connector (ISO standard 4902).

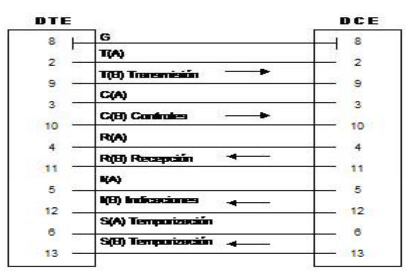
5 Data transmission interfaces

X.21 INTERFACE

- The X.21 interface approach is to use more logic in the DTE-DCE interface in order to provide less circuits.
- Presently, X.21 is not used at logical level, but it is at physical level, although very scarcely.

5 Data transmission interfaces

X.21 INTERFACE



5 Data transmission interfaces

- The Electronic/Telecommunications Industries Association (EIA/TIA) and the Institute of Electrical and Electronic Engineers (IEEE) provide most of the engineering standards for communication equipment.
-
- The American National Standard Institute (ANSI) validates firm documents.

5 Data transmission interfaces

List of EIA/TIA Interfaces

1. EIA/TIA 232E	7. RS 408
2. EIA/TIA-232E Alt A	8. RS 449
3. RS 422 A	9. RS 488
4. RS 423 A	10. ANSI/EIA-530
5. RS 357	11. EIA/TIA-574
6. RS 366	12. RJ-12

5 Data transmission interfaces

EIA-232E (25-pin) INTERFACE

- In July 1991, the basic EIA-232 standard was reviewed to achieve several things. One of them was to eliminate the EIA-232D standard (a 9-pin interface) since there was widespread misunderstanding that it was replacing the old EIA RS-232.
- It originated from the telecommunications industry using a small interface with the same electric characteristics as those of EIA 232.

5 Data transmission interfaces

EIA/TIA 232E (25-pin) INTERFACE (cont.)

- The standard that replaces the 9-pin interface is ANSI/EIA/TIA-574-1990 or EIA-574.
- Another greater revision of EIA-232E was the introduction of a smaller interface called EIA-232E Alt A, a 26-pin interface.
- This interface could become the interface of the future because it is similar to the 9-pin interface, but with much more capacity.

5 Data transmission interfaces

EIA/TIA 232E (25-pin) INTERFACE (cont.)

- EIA-232-type interfaces are limited to 20 Kbps; for faster speeds, the recommendation is:
  - EIA-530 standard (which replaces the EIA-449 standard)
  - EIA-561 standard (RJ45-type or 8-position miniature)
  - EIA-574 standard (9-pin replacement for EIA-232B.
- The EIA-232 standard has a *male interface* for the *data terminal equipment (DTE)* and a *female connector* for the *data communication equipment (DCE)*. It is necessary to fully verify the pins in the manufacturer's manuals.

5 Data transmission interfaces

RS-422A INTERFACE

- This is an interface called "**Balanced differential electric circuit interface**", which uses balanced differential-voltage circuits, capable of high data speeds over distances greater than those of the RS-232-C standard and is fully compatible with V.11 and X.27 recommendations.
- Can transmit up to 100 Kbps at 1200 meters and up to 10 Mbps at 12 m (40 feet)

5 Data transmission interfaces

RS-423A INTERFACE

- Known as "**Electric characteristics of non-balanced voltage interface digital circuits**", it is similar to the EIA RS-232 C standard.
- This interface is made up by bipolar voltage circuits without termination of one single terminal.
- It has a range of 1200 meters at a speed of 3 Kbps or up to 12 meters at a speed of up to 300 Kbps.

5 Data transmission interfaces

RS-366 INTERFACE Automatic calling unit

- This standard defines the mechanical, electrical, and functional characteristics of the automatic calling unit placed between the modem and the terminal. Its electric characteristics are compatible with the RS 232 C standard.

5 Data transmission interfaces

RS-499 INTERFACE

- This interface, known as "**37-pin and 9-pin general purpose interface for serial data exchange equipment**", has all of the RS 232C capabilities.
- Introduces 10 new exchange circuits to improve interface characteristics.

5 Data transmission interfaces

RS-499 INTERFACE

- This interface establishes the standard for a 37-pin connector and a 9-pin connector.
- Allows speeds of up to 2 Mbps and increased length of the interconnection cable up to 200 m.

5 Data transmission interfaces

RS-499 INTERFACE

- The 10 additional circuits defined in the RS 449 interface include:
-
  - Three circuits for control and status of DCE test functions (circuit LL, local LL, and remote loop, and TM circuit test mode),
  - Two circuits for control and status of DCE transfer to a telecommunications facility (SS circuit, selective standby, and SB circuit, standby indicator)
  - A circuit for the selection of the DCE transmission frequency (SF circuit, select frequency).
  - A circuit that provides an out-of-service function under the terminal control (DTE) (IS circuit, Terminal In Service)
  - A circuit to provide a new signal function (NS circuit, New Signal)
  - Two common wires

5 Data transmission interfaces

RS-485 INTERFACE

- Interface specialized in data acquisition processes.
- The RS-485 interface supports 32 drivers and 32 receivers.
- It uses half duplex, multi-drop communications over 1 or 2 twisted pairs.
- A network using this interface can connect with 2 or 4 wires, with a maximum length of 4000 feet because it uses differential voltage transmission.

5 Data transmission interfaces

RS-488 INTERFACE FOR PROGRAMMABLE INSTRUMENTS

- This interface is designed for instrumentation systems that require limited-distance communications (about 20 meters).
- This standard defines as many variables as possible, without defining the use of the interface, or giving a reference of the hardware used for its implementation.

5 Data transmission interfaces

ANSI/EIA-530 INTERFACE

- The EIA-530 is the answer to claims about the large size of the EIA RS-449 37-pin interface, while retaining the frequency spectrum of up to 2 Mbps.
- Presently, the EIA 530 interface uses the same mechanical connector as the EIA-232 standard, but uses the balanced voltages of the EIA-422 A standard or the non-balanced voltages of the EIA-423 A standard.

5 Data transmission interfaces

ANSI/EIA-530 INTERFACE

- While it is physically possible to connect a EIA-530 to a EIA-232, they are not compatible. Voltages are different and do not have the same pin designations.
- When balanced voltages are used, pins labeled A and B are used for each corresponding circuit. If non-balanced voltages are used, the interface will only use pins labeled with letter A and the common signal return pin.

5 Data transmission interfaces

ANSI/EIA-574 INTERFACE

- The EIA/TIA-574 interface replaces the EIA-232D interface, but in essence, it creates a new 9-pin connector.
- This connector is not electronically compatible with the EIA-232D standard, which uses 5 to 15 volt signals and accepts speeds below 20 Kbps.
- This new 9-pin interface is capable of faster data speeds and is driven by a +/- volt power unit. What is interesting is that it uses the same female plug connections.

5 Data transmission interfaces

RJ-11 – RJ-12 VOICE INTERFACE

- Connectors for telephone units are mini-modular 4-pin (RJ-11) and 6-pin (RJ-12) jacks, and connector cables have male connectors on either end.
- Since most telephone operations only use two-wire devices, some connectors will have only 4 contacts, in this case contacts 1 and 6 are not placed.
- Having four connectors is excessive for the two-wire operation, but is suitable for four-wire devices.

6 Data transmission media

a. Guided media: cables, coaxial cable, waveguide, and fiber optics

b. Non-guided media: broadcast, microwaves, satellite.

c. Transmission impairment

d. Comparison of media

6 Data transmission media

a. Guided media:

- Twisted pair cable
- Coaxial cable
- Waveguide
- Fiber Optics

Medio de Transmisión	Velocidad binaria	Ancho de banda	Distancia entre repetidores
Par trenzado	4 Mbps	250 KHz	2 – 10 km.
Cable coaxial	500 Mbps	350 MHz	1 - 10 km.
Fibra óptica	2 Gbps	2 GHz	10 – 100 km.

6 Data transmission media

Twisted pair cable

▪Consists of two isolated copper wires in a regular spiral pattern. Typically, a set of these pairs is grouped to make a multi-pair cable, wrapped in a thick protection cladding.

▪Threads or wires are between 0,016 and 0,036 inches (0,040 mm to 0,129 mm) thick, which correspond to gauges 26 to 16

▪Common gauges are 19, 22, 24, and 26. Cables are twisted together into a regular spiral pattern of 2 to 6 inch full twist, to minimize interference by placing adjacent pair in multi-pair cables.

Figure 4-4

Twisted-Pair Cable

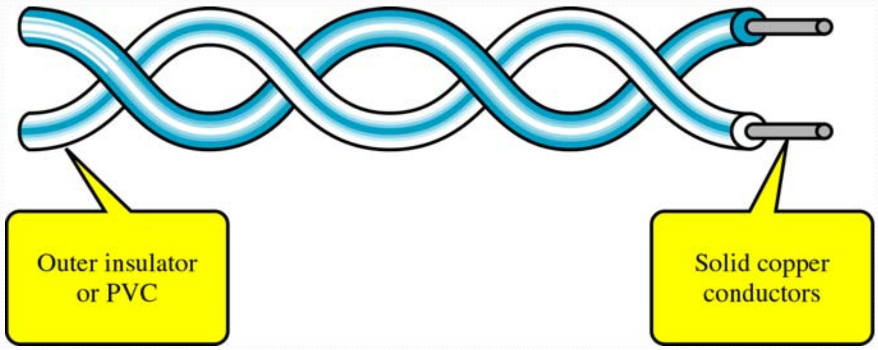
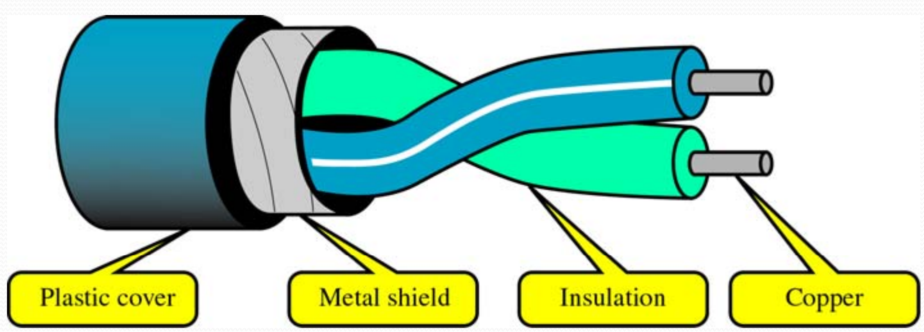


Figure 4-5

Shielded Twisted-Pair Cable



6 **Data transmission media**
a. Guided transmission media: cables, coaxial, waveguide, and fiber optics

Twisted-pair cable

- ***Analog transmission signals***
  - Voice signals can be transmitted to a distance of 6 kilometer, without repeaters.
  - The reason is that the loss at voice level is 1 dB/km.
  - To transmit point-to-point analog signals, a bandwidth of up to 1.1 MHz can be used.

6 **Data transmission media**
a. Guided media: cables, coaxial, waveguide, and fiber optics

Twisted-pair cable

- ***Digital signal transmission***
  - For point-to-point digital lines, it is possible to transmit up to 4 Mbps of data, and even more, depending on the length of the pair.
  - Susceptible to noise and interference because it can easily couple to electromagnetic loads.
  - Easily affected by impact noise. For example, a pair laid in parallel to a 60-Hz power line will be easily induced.

6 **Data transmission media**
a. Guided media: cables, coaxial, waveguide, and fiber optics

Twisted pair cable applications

- It is the most widely used medium for sending both analog and digital signals.
- Used in the telephone system (*backbone)* and in the telephone subscriber loop.
- The human voice frequency range is between 20 Hz and 20 KHz; only a 300 to 3400 Hz standard bandwidth is required to transmit intelligible voice.

6 **Data transmission media**
a. Guided media: cables, coaxial, waveguide, and fiber optics

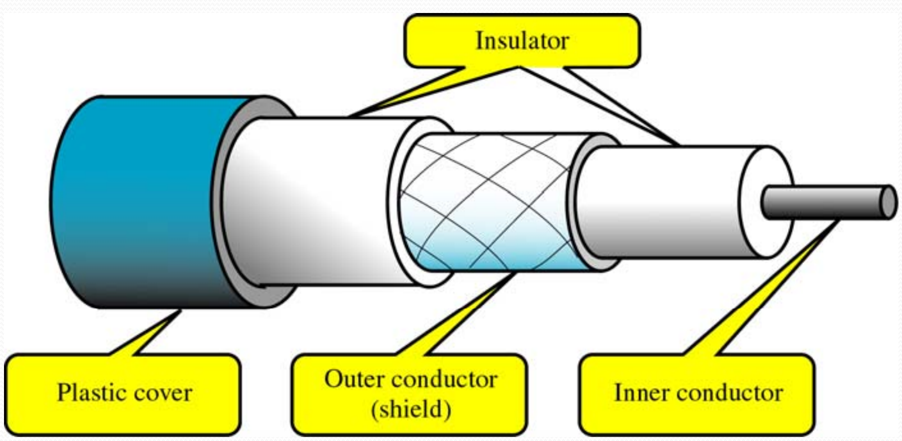
Twisted pair cable applications

- Digital data can be sent to moderate distances. For local links, typically a 28,8-Kbps modem is needed.
- It is possible to transmit signals on base or digital band. For example, it is possible to transmit a T1 circuit (USA) with 24 PCM voice channels which make up an aggregate of 1.544 Mbps or an E1 (ITU-T) circuit with 30 PCM voice channels making up a 2.048-Mbps link.

6 **Data transmission media**
a. Guided media: cables, coaxial, waveguide, and fiber optics

- **Coaxial cable**
  - Coaxial cable consists of two conductors, but built differently from the twisted pair and has a broader frequency range.
  - It is a hollow cylindrical outer conductor that surrounds an inner one-wire conductor.
  - The internal conductor can be solid or have multiple wires, and is kept in its position by regularly-spaced insulating rings or by solid dielectric material.

Coaxial Cable



6 **Data transmission media**
a. Guided media: cables, coaxial, waveguide, and fiber optics

- **Coaxial cable transmission characteristics**
  - Analog and digital signals can be transmitted. Long distance systems can be analog or digital.
  - The 50-ohm cable is used only for digital transmission (in base band), for which Manchester band base coding is used. It reaches speeds over 10 Mbps.
  - For these signals, repeaters are needed approximately every kilometer; a smaller spacing permits higher speeds. Experimental systems permit speeds of up to 800 Mbps with a 1,6-Km spacing.

6 **Data transmission media**
a. Guided media: cables, coaxial, waveguide, and fiber optics

- **Coaxial cable transmission characteristics**
  - The 75-ohm cable is used for both analog and digital transmission. For analog transmission, the frequency range is 300 to 400 MHz. For CATV, television channels are placed on a 6-MHz bandwidth.
  - The 75-ohm cable is used for cable television or CATV (*Community Antenna TeleVision)*. In this case, analog signals are transmitted using frequency-division multiplexing, called **broadband transmission.**

6 **Data transmission media**

a. Guided media: cables, coaxial, waveguide, and fiber optics

- **Coaxial cable transmission characteristics**
  - Digital high-speed transmission can also be achieved by modulating analog signals; in this case, it is known as **single-channel broadband.**

6 **Data transmission media**

a. Guided media: cables, coaxial, waveguide, and fiber optics

- **Coaxial cable transmission characteristics**
  - The coaxial cable provides a response at a frequency higher than the twisted pair; this is why it is used to carry higher frequencies and faster data speeds.
  - It is less susceptible to interference and diaphone than the twisted pair.

6 **Data transmission media**
a. Guided media: cables, coaxial, waveguide, and fiber optics

- **Coaxial cable transmission characteristics**
  - Major performance limitations: abatement, thermal noise, and inter-modulation noise.
  - The latter is present only when several FDM channels or frequency bands are transmitted.

6 **Data transmission media**
a. Guided media: cables, coaxial, waveguide, and fiber optics

- Coaxial cable
  - To achieve a suitable signal quality, a given S/N relation must be maintained. There are two commitment variables:
    - *a) the strength of the signal, and*
    - *b) the spacing between amplifiers.*
  - S/N relation can be increased by placing amplifiers closer to each other to amplify the signal with higher frequency.

6 **Data transmission media**

a. Guided media: cables, coaxial, waveguide, and fiber optics

- Coaxial cable applications
  - It is the most versatile media and is used as *LAN network backbone for long distance telephony* and for television distribution.
  - Uses the frequency-division multiplexing technique (FDM) and can carry more than 10.000 voice channels simultaneously.

Data transmission media

Guided media: cables, coaxial, waveguide, and fiber optics

Waveguide

- At high frequencies, transmission lines and coaxial cables show high attenuation.
- **Waveguides** reduce the attenuation of high frequency signals.

Data transmission media
a. Guided media: cables, coaxial, waveguide, and fiber optics

Waveguide

- Waveguides are generally pipe-shaped structures made of rectangular-, circular- or elliptic-sectioned material, in which the electromagnetic energy is conducted along the guide and is bound to its limits.

- The conducting walls of the pipe confine the wave inside by reflection due to the Snell Law on the surface, where the pipe can be empty or full with a dielectric. The dielectric gives the pipe mechanical support (walls can be thin), bur reduces propagation speed.

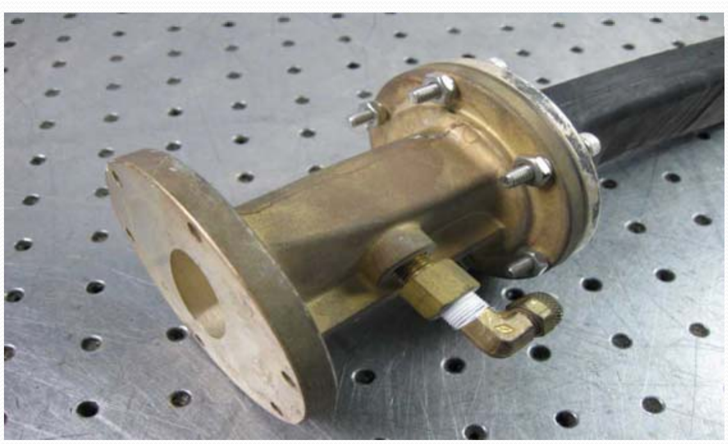
Data transmission media
a. Guided media: cables, coaxial, waveguide, and fiber optics

- There are many types of waveguides. The most important ones are the following:
  - Rectangular (circular, elliptic) waveguide: The one whose cross-section is rectangular (circular, elliptic).
  - Beam waveguide: It consists of a succession of lenses or mirrors capable of guiding an electromagnetic wave.
  - Ridge waveguide: Made up by two coaxial metal cylinders joined along their entire length by a metal radial ridge.

Data transmission media
a. Guided media: cables, coaxial, waveguide, and fiber optics

- There are many types of waveguides. The most important ones are the following:
  - Grooved waveguide, V-guided; H-guided: Rectangular waveguide that includes inner conducting ribs along each of the bigger walls.
  - Periodically-loaded waveguide: Waveguide in which the propagation is determined by regularly-spaced variations of the properties of the medium, the dimensions of the medium, or the contour surfaces.
  - Dielectric waveguide: Consisting wholly of one or several dielectric materials, with no conducting wall.

Data transmission media
a. Guided media: cables, coaxial, waveguide, and fiber optics



Data transmission media
a. Guided media: cables, coaxial, waveguide, and fiber optics

6 Data transmission media
a. Guided media: cables, coaxial, waveguide, and fiber optics

Fiber optics

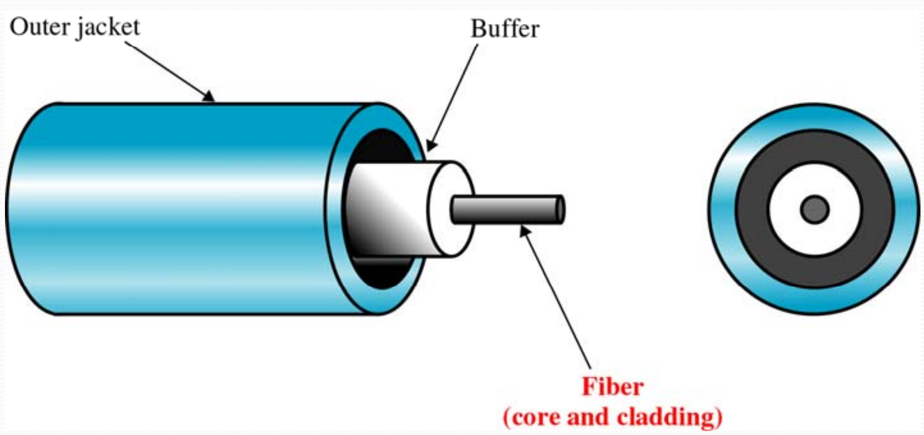
- Fiber optics is a transmission medium made of glass or plastic, thin and flexible (2 to 125 μm) capable of carrying an optical beam.
- A fiber optic cable is cylindric and consists of three concentric sections:
  - core,
  - cladding, and
  - jacket.

6 **Data transmission media**
a. Guided media: cables, coaxial, waveguide, and fiber optics

Fiber optics

- *The* ***core, which is the innermost part***, consists of one or more very thin threads (or fibers) made of glass or plastic.
- Each fiber is covered by **cladding, made of glass or plastic too, but with optical properties** that differ from those of the core.
- The outer layer, called **jacket**, is made of plastic and other materials to protect it from humidity, abrasion, rupture and the environment.

Fiber Optics Construction

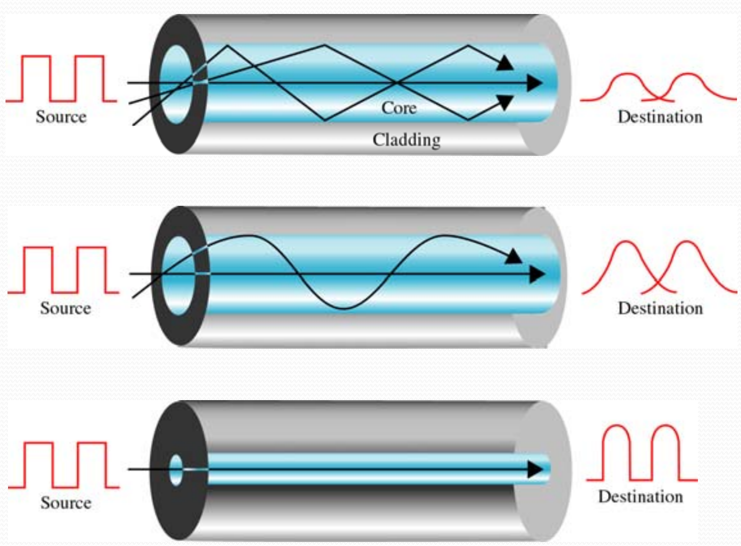


6 **Data transmission media**

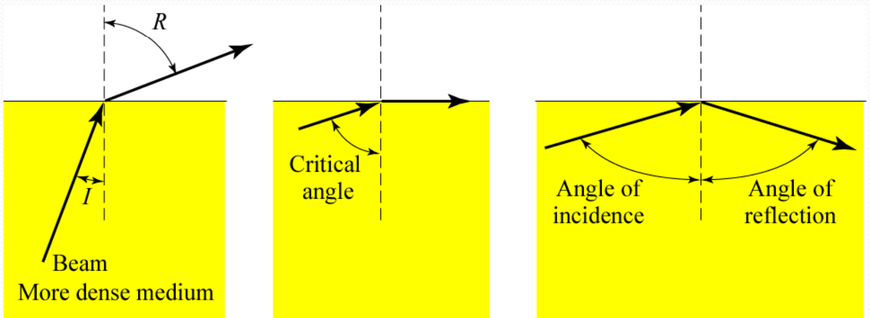
a. Guided media: cables, coaxial, waveguide, and fiber optics

- Fiber optics
  - In **multimode** propagation, the light from the source comes in through the glass core. The low-angle beams are reflected and propagated through the fiber, while other beams are absorbed by the cladding that surrounds the core.
  - If we reduce the radius of the core, few light beams are reflected; and if we reduce the radius to the order of the wavelength, only one angle of mode will pass. This propagation mode is known as **mono-mode.**

Propagation Modes



Refraction and Reflection



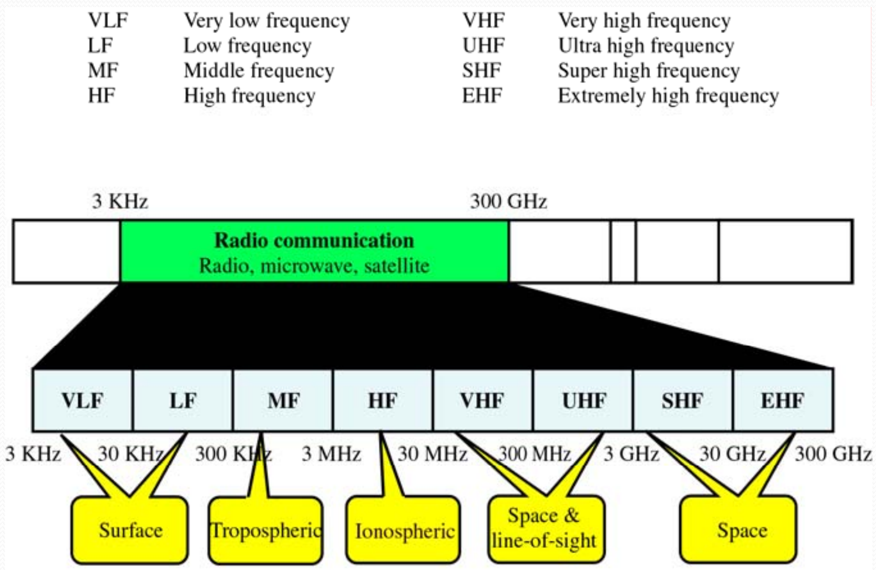
a. Refraction   b. Critical angle   c. Reflection

6 Data transmission media

b. Non-guided media: broadcast, microwaves, satellite.

- **Non-Guided Media**
  - These media include ground microwaves, satellite microwaves, and radio. For these media, unlike the guided media, the bandwidth of the signal produced by the transmitting antenna is more important than the medium for determining the transmission characteristics.
  - Hence, the higher the central frequency of the signal, the greater the potential bandwidth, and thus the faster the digital transmission.

Radio communication Bands



Electromagnetic Spectrum

Frequency	λ	Application
10 KHz	30 Km.	Low frequencies for underwater communications
100 KHz	3 Km.	Long-wave broadcast
1 MHz	300 m	AM broadcast
10 MHz	30 m	Short radio waves (ionosphere)
100 MHz	3 m	FM transmission
150 MHz	2 m	Mobile radio
300 MHz	1 m	Microwave links for point-to-point UHF and UHF TV boadcast
3-60 GHz	10 cm - 0.5 cm	Microwave links

Microwave electromagnetic spectrum

Band	Range in GHz
L	1-2
S	2-4
C	4-8
X	8-12
Ku	12-18
K	18-26
Ka	26-40
U	40-60
V	50-75
E	60-90

Frequency bands for microwave links

Band	Range	Comments
2 GHz	1.7 - 2.7 GHz	Now designated as mobile bands for PCS and DECT
4 GHz	3.8 - 4.2 GHz	Typical operator's bands, high capacity
6 GHz	5.9 - 7.1 GHz	Typical operator's bands, high capacity
7/8 GHz	7.1-8.5 GHz	Average lengths for high capacities
11 GHz	10.7-11.7 GHz	Operator's traditional public bands, high capacity

6 **Data transmission media**
b. Non-guided media: broadcast, microwaves, satellite.

- **Non-guided media**
  - Another property of the signals transmitted by antennae is directionality. In general, at lower frequencies, signals are omnidirectional, and at higher frequencies, the signal can be focused on a directional beam
  - There are 2 frequency ranges of these media that are relevant for this topic:
    - Microwave frequencies in a range from 2 to 40 GHz. At these frequencies, highly directional beams are possible and easily adjustable for point-to-point transmissions.
    - 30-MHz to 1-GHz range frequencies are used for omnidirectional transmission and are appropriate for broadcasting

6 **Data transmission media**
b. Non-guided media: broadcast, microwaves, satellite.

Broadcast

- The main difference between radio and microwaves is that radio is generally omnidirectional and microwaves are very focused. No disk-type antenna required.
- The 30-MHz to 1-GHz range is very useful for broadcast communications. Radial waves are less sensitive to rain attenuation than microwave signals.

6 **Data transmission media**

b. Non-guided media: broadcast, microwaves, satellite.

Broadcast

- However, for data transmission, its low speed is a disadvantage (in Kbps instead of Mbps).
- One of the main reasons for radio wave degradation is interference by multiple paths. These are created by the reflection of land, water or natural or man-made objects. This effect is manifest when the television set shows many images when an aeroplane passes by.

6 **Data transmission media**

b. Non-guided media: broadcast, microwaves, satellite

- **Broadcast**

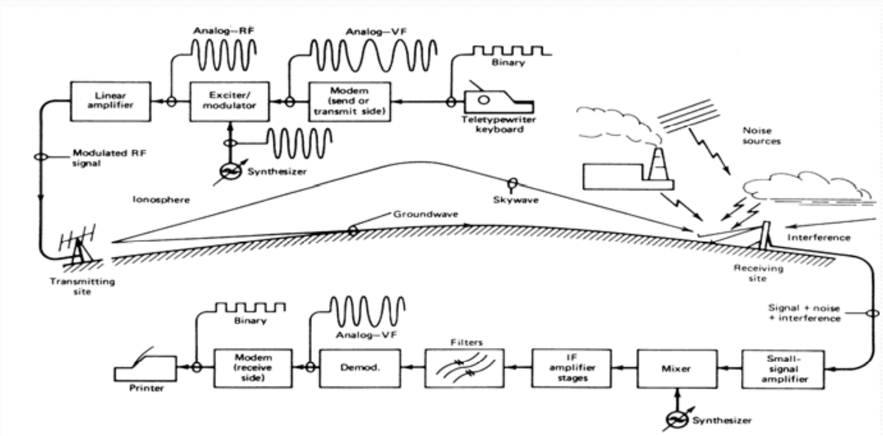


Figure 12.1. A typical HF radiolink providing teleprinter service. (Courtesy of Radio General Company.)

6 **Data transmission media**

b. Non-guided media: broadcast, microwaves, satellite

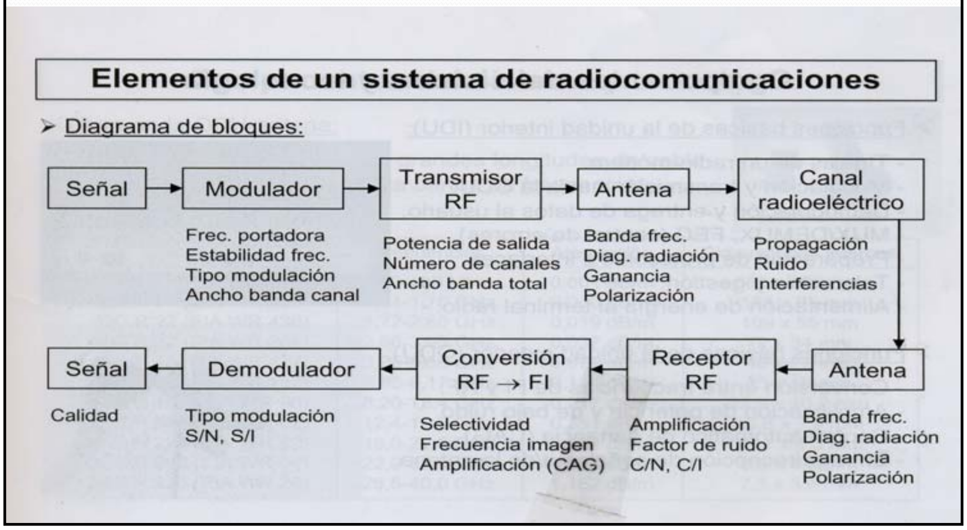
- **Non-guided media**
  - A digital microwave radio is defined as a radio equipment in which one or more properties (amplitude, frequency and phase) of the radiofrequency signal is quantified by a modulating signal.
  - The term **digital** implies a **discrete set of levels of** *amplitude, frequency or phase* as a result of a ***modulating sign***. Let us assume that the modulating signal is a serial stream of synchronous bits.

Frequency bands for microwave links

Band	Range	Comments
13 GHz	12.7 - 13.3 GHz	Typically low to medium capacities
15 GHz	14.4 - 15.4 GHz	All capacities
18 GHz	17.7-19.7 GHz	Operator's traditional public band for medium capacities
23 GHz	21.2 - 23.6 GHz	All capacities
26 GHz	24.5 - 26.5 GHz	All capacities
38 GHz	37 - 39.5 GHz	All capacities

6 **Data transmission media**

b. Non-guided media: broadcast, microwaves, satellite



6 **Data transmission media**

b. Non-guided media: broadcast, microwaves, satellite

- **Non-guided media**
  - There are three generic modulation techniques:
    - Amplitude Modulation - AM,
    - Frequency Modulation – FM, and
    - Phase Modulation – PM.
  - In industry terminology, the letters “SK” are usually added to the first letter of the modulation type, such as ASK meaning Amplitude Shift Keying; FSK, Frequency Shift Keying, and PSK, Phase Shift Keying

6 **Data transmission media**

b. Non-guided media: broadcast, microwaves, satellite

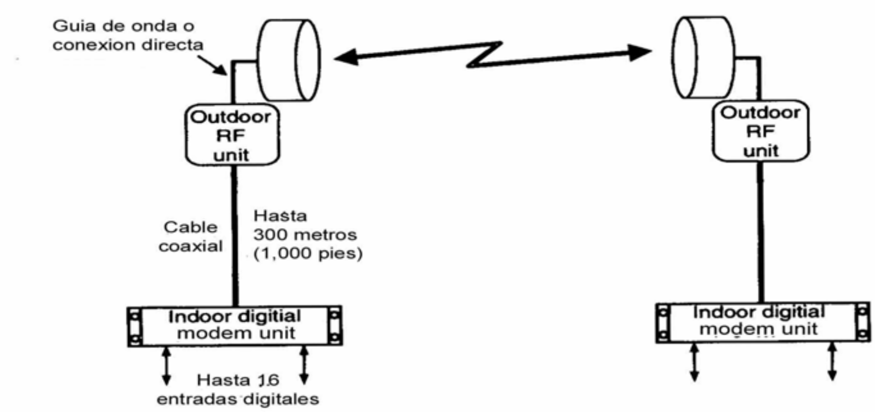
Componentes del sistema y tecnología

- Funciones básicas de la unidad interior (IDU):
  - Típicas de un radio-módem.
  - Modulación y transmisión hacia la ODU.
  - Demodulación y entrega de datos al usuario.
  - MUX/DEMUX, FEC (control de errores).
  - Preparación de protocolos e interfaces.
  - Telemetría y gestión.
  - Alimentación de energía al terminal radio.
- Funciones básicas de la unidad exterior (ODU):
  - Conversión entre frecuencias de FI y RF.
  - Amplificación de potencia y de bajo ruido.
  - Control automático de ganancia (CAG).
  - Entrega/recepción de señales a/de la antena.

6 **Data transmission media**

b. Non-guided media: broadcast, microwaves, satellite

- **Non-guided media**



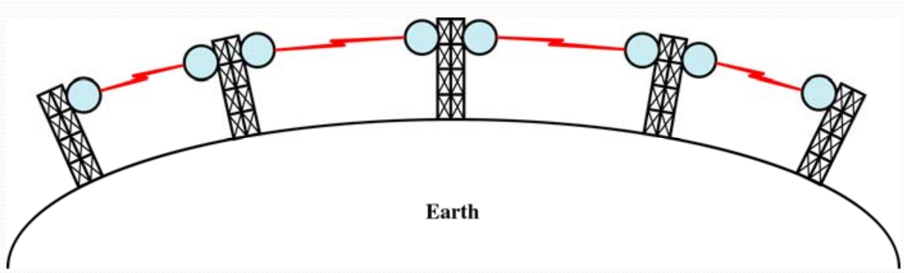
6 **Data transmission media**

b. Non-guided media: broadcast, microwaves, satellite

- **Satellite**
  - A communications satellite is in essence a microwave repeater station. Essentially, a satellite is a radio repeater in the sky (transponder).
  - The satellite is used to link two or more microwave transmitters/receivers, known as earth stations.
  - The satellite receives transmissions over a frequency band (uplink), amplifies (analog transmissions) or repeats (digital transmissions) the signal, and then retransmits it on another frequency (downlink).
  - Only one system will operate on a given number of frequency bands called transponder channels or simply transponders.

Figure 4-20

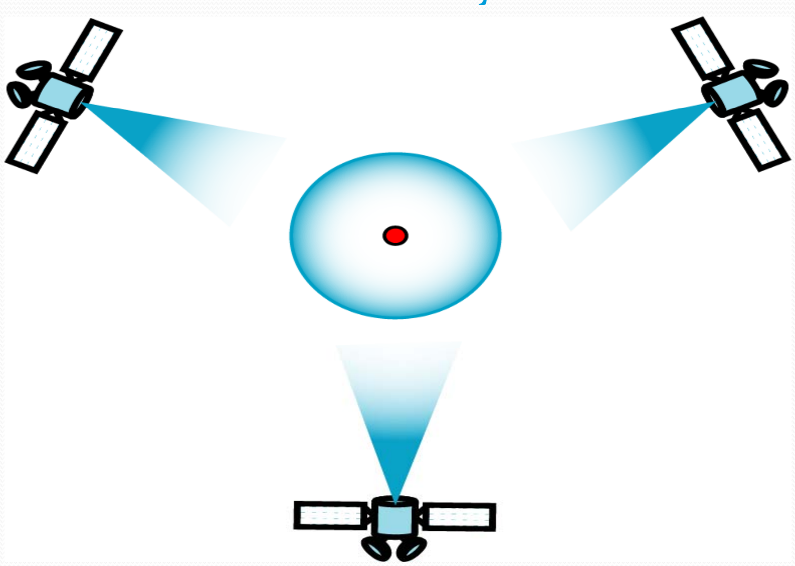
Terrestrial Microwave



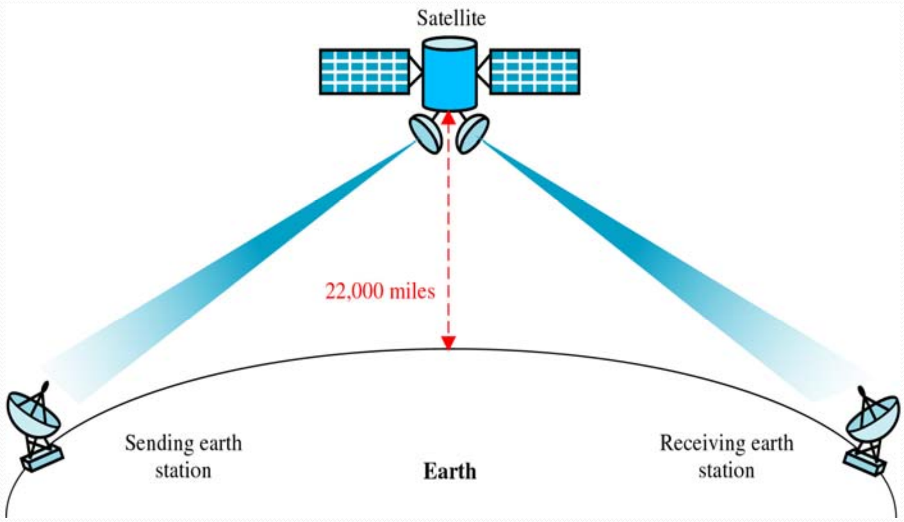
6 **Data transmission media**
b. Non-guided media: broadcast, microwaves, satellite.

- **Satellite**
  - Easy and low-cost access are advantages of the satellite telecommunication services.
  - Adaptability to the specific needs of each user (allowing for asymmetric links and different bandwidths depending on each station).
  - In its most widely used topology (*star*), the network can be very dense (up to 1.000 stations), and is controlled by a central station called HUB, which organizes the traffic between terminals and optimizes access to satellite capacity
  - Can run over C, Ku, or Ka bands, and the higher the carrier frequency the more sensitive they are to meteorological conditions.

Satellite in Geostationary Orbit



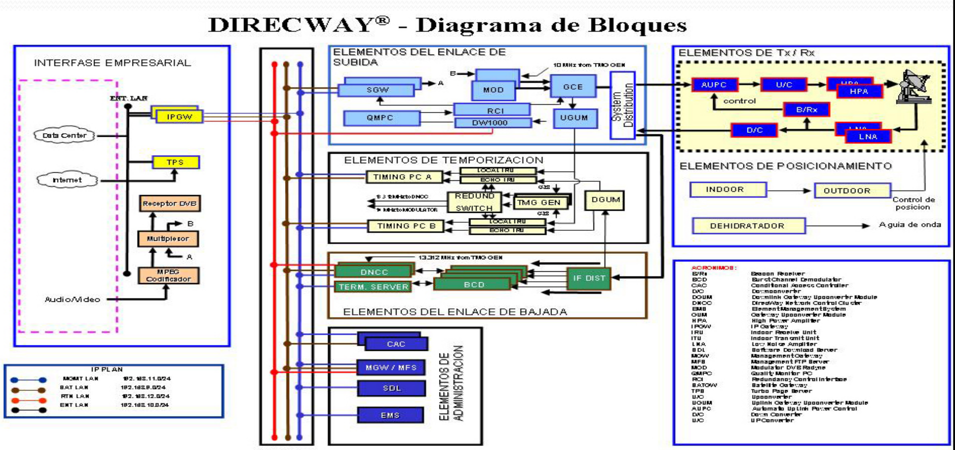
Satellite Communication



6 **Data transmission media**

b. Non-guided media: broadcast, microwaves, satellite

- **Satellite**



6 **Data transmission media**
b. Non-guided media: broadcast, microwaves, satellite

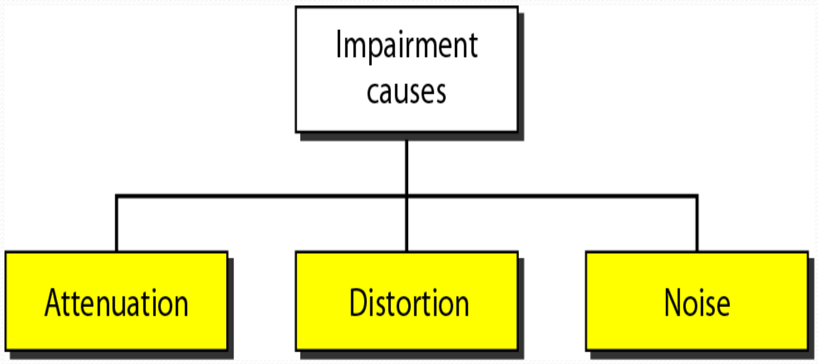
- **Satellite**
  - Communication satellites are used for telephony, data, internet, video, and television transmission over long distances and is the optimum medium for extensively-used international trunk circuits.
  - Competes with terrestrial microwaves and coaxial cable for many long-distance links between countries.
  - They provide fixed telephone and data carrier circuits, point-to-point cable television (CATV); television distribution, music broadcast, mobile phone service, and private networks for companies, government agencies, and military applications.
  - Satellite segment providers are: INTELSAT, TELESAT, HISPASAT, SATMEX, etc.

6 **Data transmission media**
c. Transmission impairment

The different communication media have the capacity to send telecommunication signals, from twisted pair cable to fiber optic links, microwave links, and satellite communication links.

6 Data transmission media

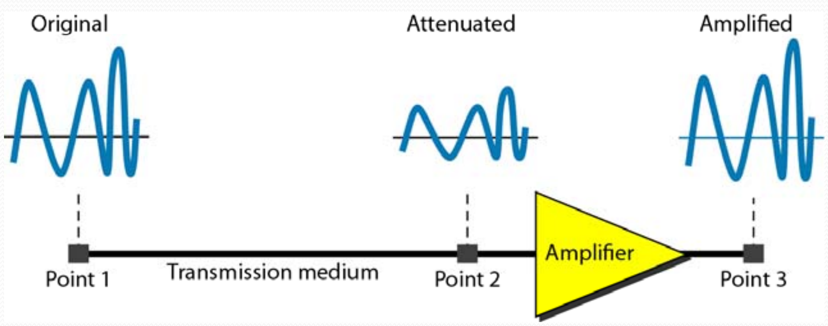
b. Non-guided media: broadcast, microwaves, satellite



Data transmission media

c. Transmission impairment

Attenuation



3.94

Data transmission media

c. Transmission impairment

Let us assume that a signal crosses a transmission medium and its strength drop to half. This means that P2 is (1/2)P1. In this case, attenuation (loss of strength) can be calculated as follows:

$$10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{0.5 P_1}{P_1} = 10 \log_{10} 0.5 = 10(-0.3) = -3 \text{ dB}$$

A loss of 3 dB (–3 dB) is equal to a loss of half the strength.

Data transmission media

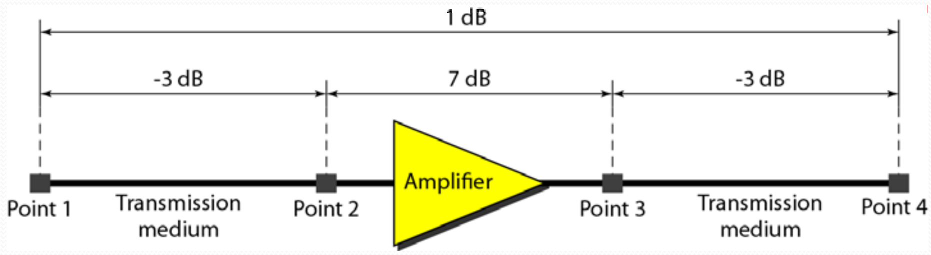
c. Transmission impairment

The power of a signal increases 10 times when passing through an amplifier. This means that $P_2 = 10P_1$. In this case, the amplifying factor (power gain) can be calculated as :

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

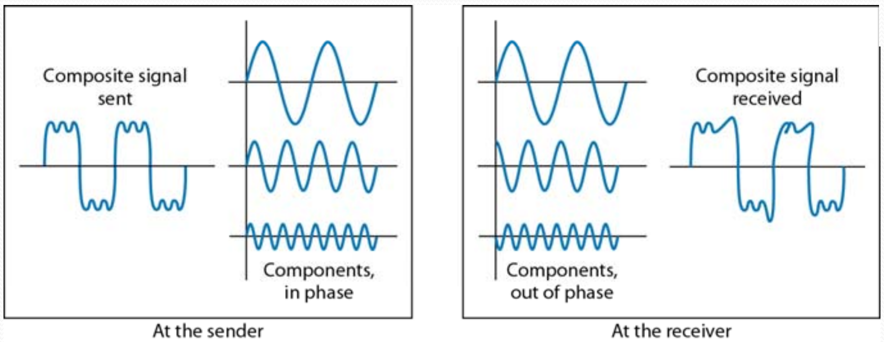
$$= 10 \log_{10} 10 = 10(1) = 10 \text{ dB}$$

Data transmission media
c. Transmission impairment



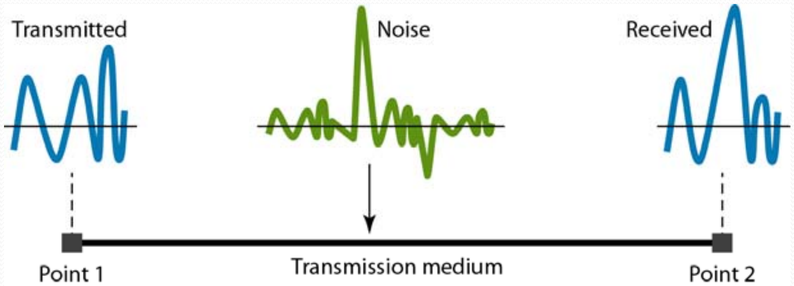
Data transmission media
c. Transmission impairment

Distorsion



Data transmission media
c. Transmission impairment

Noise



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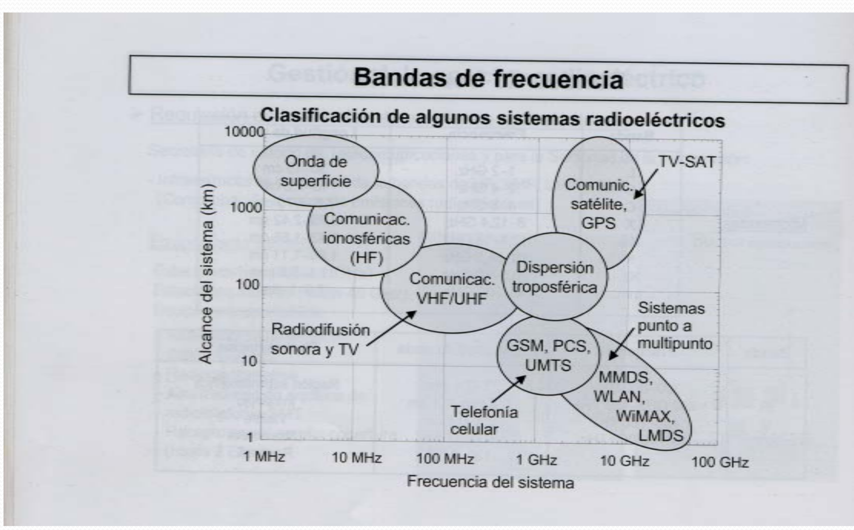
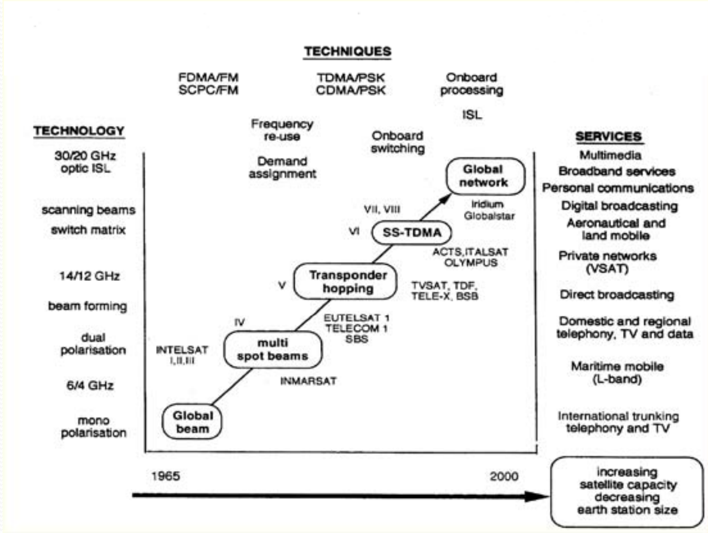
6 **Data transmission media**
d. Comparison of media



6 **Data transmission media**

d. Comparison of media



6 **Data transmission media**

d. Comparison of media

Advantages of Optical Communications

- Enormous potential bandwidth
- Light and small components
- Electrically insulated system
- Immune to interference
- Very secure
- Low transmission loss
- Robust and flexible systems
- Easy maintenance of the system
- Low maintenance cost

6 **Data transmission media**
d. Comparison of media

Fiber optics

The following characteristics are advantages over the twisted pair and the coaxial cable :

- a) Greater bandwidth: 2 Gbps over tens of kilometers. This value is much greater than the hundreds of Mbps/Km for the coaxial cable and the few Mbps/Km for the twisted pair.
- b) Smaller and lighter : It is much thinner than coaxial cable or twisted pair multi-pair cables. It is installed in the troughs inside buildings, and underground, with the additional advantage of its small size. Since it is lighter, support requirements are reduced.

6 **Data transmission media**
d. Comparison of media

- **Fiber optics**
  - c) Less attenuation (0,2 dB/km.): attenuation is significantly lower than for coaxial cable or twisted pair, and remains constant over a long range.
  - d) Electromagnetic insulation: External electromagnetic fields do not affect fiber optics; it is not vulnerable to interference, impact noise, or flutter. Also, since it does not radiate energy, it does not interfere with other equipment and provides a high level of security against intrusion (monitoring) since it is inherently hard to be intercepted.
  - e) Greater spacing between repeaters (60 - 100 kilometers): The cost of the system is less because it has fewer repeaters.
  - f) Low error probability: Its minimum VER is 3x10-10

6 **Data transmission media**
d. Comparison of media

Comparativa cable - radio

- Ventajas del acceso inalámbrico:
  - No se necesita obra civil
  - Adecuado para zonas aisladas o de difícil acceso
  - Rápido despliegue
  - Implantación y crecimiento progresivo
  - Menor coste de mantenimiento
  - Posibilidad de servicios digitales bidireccionales de banda ancha

- Limitaciones frente al cable:
  - Medio compartido: interferencias
  - Fiabilidad y disponibilidad: desvanecimientos
  - Privacidad → encriptación
  - Radiaciones electromagnéticas (¿efecto sobre la salud?)

6 **Data transmission media**
d. Comparison of media

Comparativa cable - radio

- Viabilidad económica de los sistemas de acceso fijo inalámbrico:

Factores críticos a tener en cuenta en relación con una red de cable:
- Cantidad de espectro radioeléctrico disponible: capacidad final del sistema.
- Coste por uso del espectro: licencias de operación.
- Área de cobertura y densidad de clientes → cantidad de equipos necesarios.
- Alcance del sistema: depende de la banda de frecuencias y de la zona climática.
- Coste de una estación base y coste marginal de los terminales de usuario.
- Costes iniciales de instalación y esfuerzos para planificar todo el sistema.