Regulation and Policy in the Telecommunications Industry
TM 612-WS

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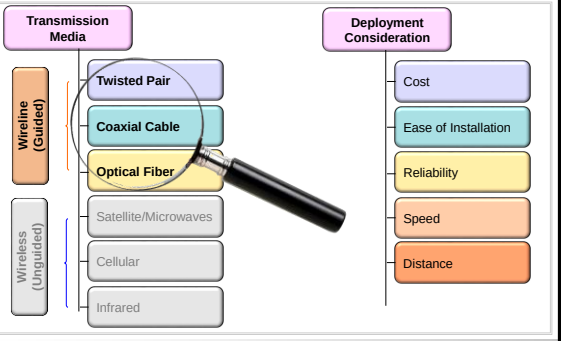
Lecture—09

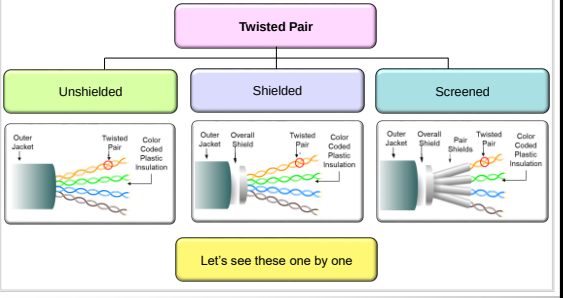
Contents

Transmission Media/Channels



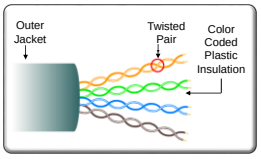
Twisted Pair

Twisted Pair



Unshielded Twisted Pair (UTP)

- **Unshielded Twisted Pair (UTP) is**
  - Four-pair copper wire
  - Each pair is covered by insulation
  - Each pair is twisted around each other
    - Number of twists in the wire pairs varies
    - Twists reduce signal degradation/cross talk caused by EMI and RFI

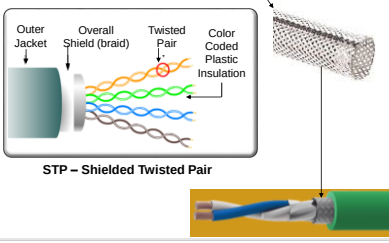


UTP – Unshielded Twisted Pair

EMI = Electromagnetic Interference
RFI = Radio Frequency Interference

Shielded Twisted Pair (STP)

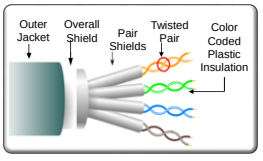
- **Shielded Twisted Pair (STP)**
  - Four pairs of wires are wrapped in an overall **metallic braid**



STP – Shielded Twisted Pair

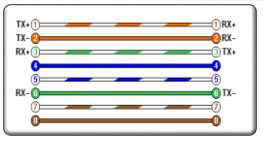
Screened Twisted Pair (ScTP)

- **In ScTP**
  - Each pair of wires is wrapped in metallic foil
  - Four pairs of wires are then wrapped in an overall metallic braid

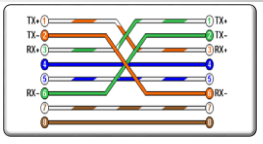


ScTP – Screened Twisted Pair

Straight- or Crossover Twisted Pair



UTP Straight-through Cable



UTP Cross-over Cable

Used for
- Switch to router
- Switch to PC or server
- Hub to PC or server

Used for
- Switch to switch
- Switch to hub
- Hub to hub
- Router to router
- PC to PC
- Router to PC

RJ-45
(Ethernet Cable)

10Base-T
Max segment ~100 meters

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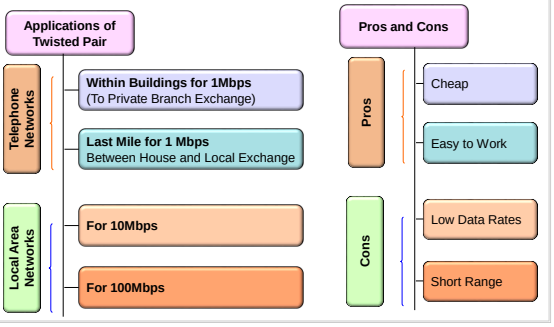
Applications of Twisted Pair Pros & Cons of Twisted Pair



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UTP Categories

UTP Categories - Copper Cable

UTP Category	Data Rate	Max. Length	Cable Type	Application
CAT1	Up to 1Mbps	-	Twisted Pair	Old Telephone Cable
CAT2	Up to 4Mbps	-	Twisted Pair	Token Ring Networks
CAT3	Up to 10Mbps	100m	Twisted Pair	Token Rink & 10BASE-T Ethernet
CAT4	Up to 16Mbps	100m	Twisted Pair	Token Ring Networks
CAT5	Up to 100Mbps	100m	Twisted Pair	Ethernet, FastEthernet, Token Ring
CAT5e	Up to 1 Gbps	100m	Twisted Pair	Ethernet, FastEthernet, Gigabit Ethernet
CAT6	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT6a	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT7	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (100 meters)

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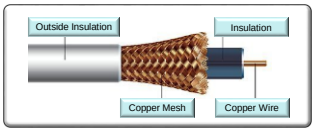
Coaxial Cables

Types of Cabling

- **Coaxial Cable (Coax)**
  - Consists of:
    - Inner conductor wire
    - Insulation (called the dielectric)
    - Copper Mesh
    - Non-conductive jacket (Outside Insulation)



Coaxial Cable Features

- **Compared to Twisted Pair (TP) Coax Cable Provides:**
  - Higher data transmission rate
  - Longer transmission distance
  - Better resistance to interference and attenuation
- **Advantage over TP**
  - Electromagnetic field carrying the signal exists only in the space between the inner and outer conductors. Thus it can be installed next to metal objects (gutters) without the power loss that occur in other copper media
  - It also protects the signal from external electromagnetic interference
  - Carry high-frequency electrical signals with low losses

Coaxial Cable Features

- **Coax Cables Use Following Connectors**
  - BNC (Bayonet Nut Connector)
  - RG6 connectors

Coaxial Cable Applications

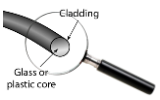
- **Television distribution**
  - Ariel to TV
  - Cable TV
- **Long distance telephone transmission**
  - Can carry 10,000 voice calls simultaneously
  - (Being replaced by fiber optic)
- **Radio Transmitters**
  - Feedlines connecting radio transmitters and receivers to their antennas
- **Local area networks**
  - Short distance computer systems links (e.g., Ethernet)

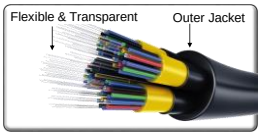
Optical Fiber

Structure

- **Structure**
  - Optical fiber is made by glass or plastic
  - It is very flexible and transparent
  - It is extremely thin (diameter slightly thicker than that of a human hair)
  - Its core is surrounded by a transparent cladding material
  - Cladding has a lower refraction index that keeps light in the core
- **Principle**
  - Total Internal Reflection

How would you define the structure?





Structure

- **Splicing**
  - Process of joining two pieces of fiber
  - Requires precise alignment of the fiber cores

Features/Characteristics

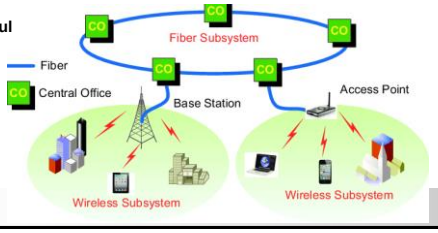
- **Attractive for Communication Signals Transmission**
  - Provide higher bandwidths/capacity (hundreds of Gbps) than Coax or TP
  - Provide longer transmission range
  - Greater repeater spacing (10s of km at least)
  - Lower attenuation
- **Deployment Convenience**
  - Smaller size (take less space)
  - Light weight (13 times lighter than copper)
  - Wider operating temp range
- **Since signal travels in the form of light, it is**
  - Hard to tap into (cyber-secure)
  - Immune to electromagnetic interference
  - Cheaper to operate (cheaper electronics (LEDs))

Optical Fibers Applications

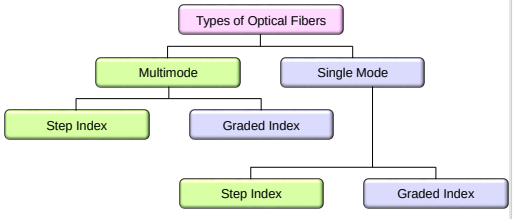
Communication signal Transmission
- Long-haul trunks/Backhaul
- Metropolitan trunks
- Rural exchange trunks
- Subscriber loops

- **Computer Networks**
  - LANs
- **Miscellaneous**
  - Illumination and imaging
  - Fiber optic sensors and lasers

Backhaul

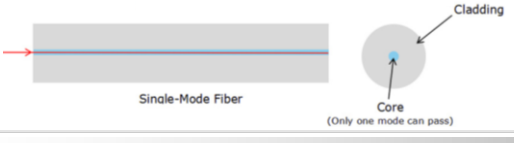


Types



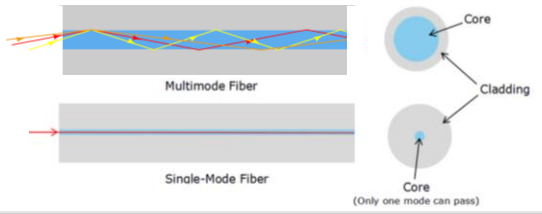
Single Mode Fiber

- **Supports only a single propagation path**
  - They are used for communication links longer than 1,000 meters



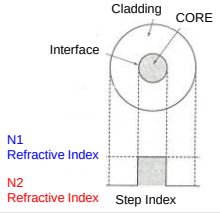
Multimode Fibers

- **Support many propagation paths**
  - Have a wider core diameter
  - Used for short-distance communication links
  - Used where high power must be transmitted



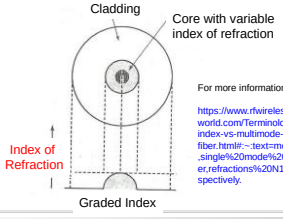
Single Mode Step Index

- Step index means sharp step in the index of refraction between core and cladding interface.
- This indicates that in step index, core and cladding have their own constant index of refractions N1 and N2 respectively.



Multimode Graded Index

- In graded index, index of refraction is not constant but vary smoothly across the diameter of the core.
- Index of refraction is increasing as one goes near the center while decreasing near outer core edges. Index of refraction is maximum at the center of the core. Index of refraction is constant for cladding part of the fiber

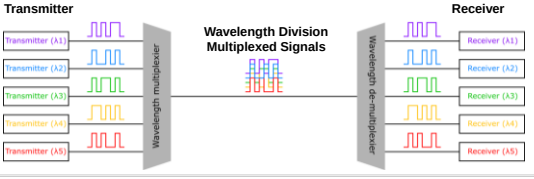


For more information please visit

https://www.rfwireless-world.com/Terminology/single-mode-step-index-vs-multimode-graded-index-fiber.html#:~:text=modes%20of%20fiber.-,single%20mode%20step%20index%20fiber,refractions%20N1%20and%20N2%20respectively.

Optical Fiber - Transmission Characteristics

- **Wavelength Division Multiplexing (WDM)**
  - **Transmitters**: Each transmitter emits at a different wavelength
  - **Receiver**: Each receiver receives de-multiplexed signal
  - **Optical Fiber**: Multiplexed signals are transmitted over optical fiber
  - **Wavelength Multiplexer (MUX):** Multiplex the signals
  - **De-Multiplexer (DEMUX):** Performs reverse operation of MUX



Frequency Utilization for Fiber Applications

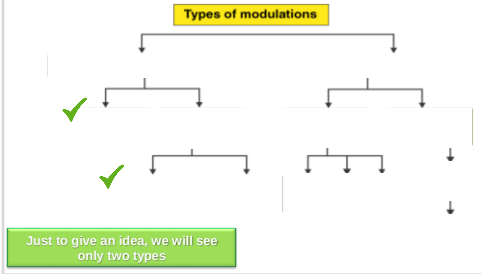
Wavelength (nm) Range (in vacuum)	Frequency range (THz)	Band label	Fiber type	Application
820 to 900	366 to 333		Multimode	LAN
1280 to 1350	234 to 222	S	Single mode	Various
1528 to 1561	196 to 192	C	Single mode	WDM
1561 to 1620	185 to 192	L	Single mode	WDM

Frequency Utilization for Fiber Applications

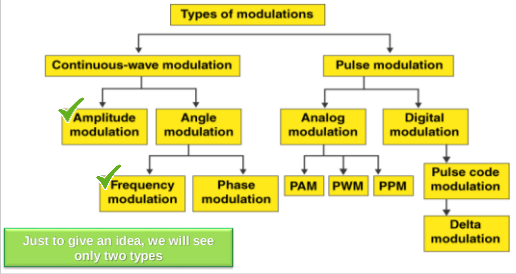
Media Type	Frequency Range	Typical Attenuation	Typical Delay	Repeater Spacing
Twisted pair (with loading)	0 to 3.5 kHz	0.2 dB/km @ 1 kHz	50 μs/km	2 km
Twisted pairs (multi-pair cables)	0 to 1 MHz	0.7 dB/km @ 1 kHz	5 μs/km	2 km
Coaxial cable	0 to 500 MHz	7 dB/km @ 10 MHz	4 μs/km	1 to 9 km
Optical fiber	186 to 370 THz	0.2 to 0.5 dB/km	5 μs/km	40 km

Modulation

Modulation

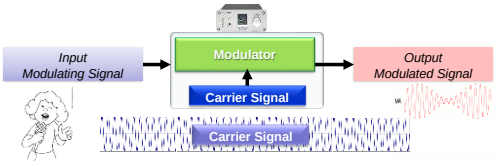


Modulation

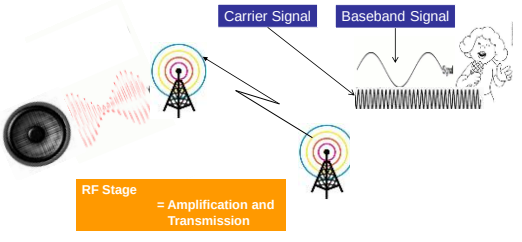


Amplitude Modulation

In AMPLITUDE Modulation
The Amplitude OF A CARRIER WAVE is CHANGED
Based on information **(or MODULATING) SIGNAL, but the Frequency Remains Constant**

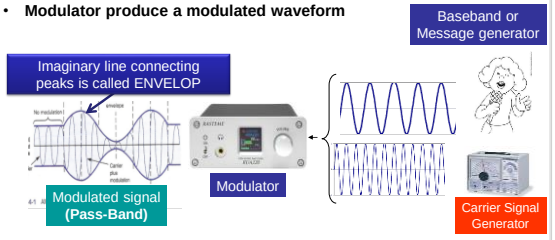


Amplitude Modulation



Principle of AM

- **Two inputs to Modulator (**or modulation devise**)**
  1. **Carrier** (High frequency, constant amplitude)
  2. **Information** (Low frequency)
- **Modulator produce a modulated waveform**



AM Modulation Index

- **The Ratio of Modulating Signal to the Carrier signal**
  - It is represented by "m" $\frac{V_m}{V_c} = m$
  - Since Modulating Signal Voltage Must be Less than the Carrier Voltage
  - Therefore, $m < 1$

If Carrier Voltage = 9 v
Modulating Signal Voltage = 7.5 v
Then Modulation Index = 0.8333 or 83.33%

- "Modulation Index" is also called
- **Modulation Factor, or Coefficient of modulation, or Degree of modulation**
- Multiplying m by 100, gives %age modulation

For Radio Communication
Modulation Index of 100% or less is an FCC Requirement

Frequency Modulation

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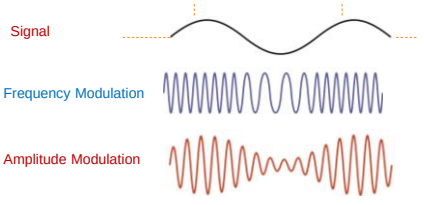
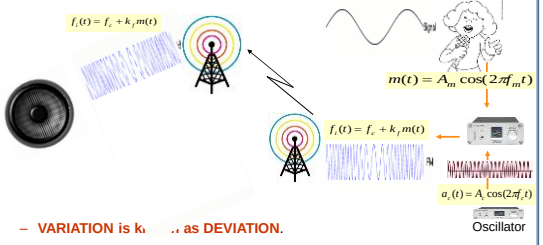
Definition of Frequency Modulation

Instantaneous frequency of **CARRIER** is changed based on **MODULATING SIGNAL**



Frequency Modulation

- In FM Instant Frequency of transmitted signal w.r.t to information is **VARIED**



- **VARIATION is k… …as DEVIATION.**
- E.g. if signal has deviation of ±3 kHz, carrier moves up and down by 3 kHz

Modulation Index (Mathematical Derivation)

Modulation Index $\beta = \frac{\Delta f}{f_m}$

- Δf: **CARRIER FREQUENCY DEVIATION**
- f_m: **Modulating Frequency (Highest component)**

In FM,
Modulation index (β) is the ratio of
CARRIER FREQUENCY DEVIATION to the MODULATING Frequency

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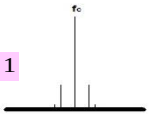
Over Modulation:

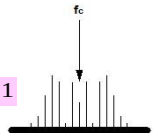
- **Lower the β, lesser the sidebands**
  - Called under modulation

$\beta < 1$



- **Higher the β, more the sidebands**
  - Called over modulation

$\beta > 1$



For Radio Communication
Modulation Index of 100% or less is an FCC Requirement

Carriers and Services

Carriers and Services

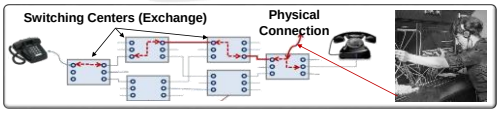
- **Plain Old Telephone Service (POTS)**
  - 56Kbps
- **Integrated Services Digital Network (ISDN)**
  - 128Kbps
- **Digital Subscriber Line (DSL)**
  - 1,544Kbps

POTS
(Plain Old Telephone Service)

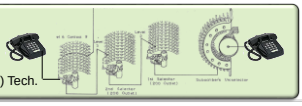
Plain Old Telephone Service (POTS)

POTS is a
- Traditional phone service since 1880s
- It used Copper pair wires
- It was for Analog voice only
- Calls were very **expensive**

POTS Required
- Dedicated circuit between calling parties
- Dedicated operator to connect calls



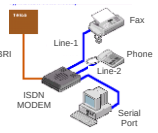
Later POTS
- Operators were replaced by
- automatic switches
- POTS is Circuit Switched (CS) Tech.



ISDN
(Integrated Digital Subscriber Line)

ISDN — Integrated Services Digital Network

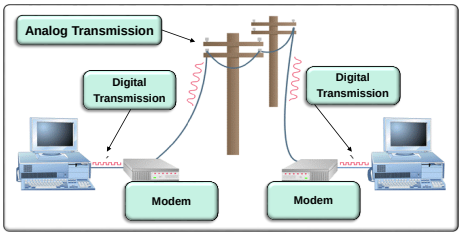
- **ISDN is a Technology or a Standard that**
  - Uses current copper wire infrastructure
  - Uses CS, but also provides access to packet-switched networks
  - Thus integrates voice, video and data on the POTS
  - Transmits voice and data at128 kbit/s (up/downstream)
  - Uses Q.931 signaling protocols (introduced in 1986)
  - Allows users to access the internet through a digital modem



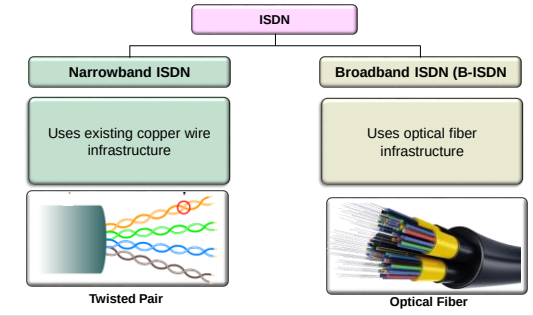
BRI = Basic Rate Interface

What Does a Modem Do?

Modem (Modulation-Demodulation)
MODULATES digital signal into analog signal for transmission over analog medium, and then **DEMODULATES** the signal into digital for receiving



Types of ISDN



Advantages of ISDN

Advantages of ISDN:

- Provides better speeds, higher quality and more reliability
- Alternative to dial-up connection to provide higher internet speeds
- Allow connected devices (e.g., credit card reader, fax machines) to operate over a single line
- ISDN channels have a reliable connection
- ISDN is used to facilitate the user with multiple digital channels
- It has faster data transfer rate

Disadvantages and Future of ISDN

Disadvantages of ISDN

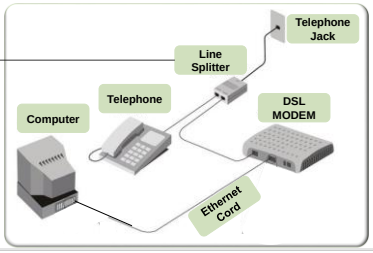
- ISDN lines costlier than the other telephone system
- Require specialized digital devices
- It is less flexible
- ISDN is costlier than traditional broadband options. This has forced to search for alternatives. One popular alternative is VoIP
- ISDN is being replaced by Broadband internet access (e.g., DSL, WAN), however, ISDN is still used as a backup when the main lines fail
- ISDN will be used for high-speed internet access when DSL or cable modem options are not available

DSL
(Digital Subscriber Line)

DSL (Digital Subscriber Line)

- **A technology that**
  - Transmits voice and digital data over the same telephone line
  - Uses higher frequency bands for data, and lower for voice

Line Splitter (Filter)
Used on customer premises
for higher and lower frequency separation



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DSL (Digital Subscriber Line)

DSL

ADSL (Asymmetrical DSL)	SDSL (Symmetrical DSL)
Different Uplink and Downlink Data rates (higher D/L, lower U/L)	Same Uplink and Downlink Data rates (higher D/L, lower U/L)

- **Downlink Data Rate Range**
  - 256 kbit/s to over 100 Mbit/s
  - Currently approaching to 1 Gbit/s
- **Uplink Data Rate Range**
  - Typically 10 times lesser the downlink rate

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Difference Between DSL and ISDN

ISDN	DSL
ISDN is a dial-up connection	DSL is an always-on connection
Cannot offer higher data rates	Offers much higher data rates

Similarities
- **DSL is similar to ISDN as both operate over existing copper telephone lines**
- Both require the short runs to a central telephone office

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Wireline Regulations

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Wireline Competition

- **Alexander Graham Bell patented the telephone on March 7, 1876**
  - 1876-1896 (20 Yrs.) # of daily calls per 1,000 population grew 4 to 37
- **Bell's patent expired in 1894 that created 200 competitors**
  - In next 15 Yrs. # of daily calls per 1,000 population grew 37 to 391
- **Bell rivals gained 51% of market in 1907—AT&T begun buying up rivals**
  - Federal auth.-practiced antitrust–AT&T allowed rivals to interconnect with its NW 1913
- **Telecom rate regulation was in effect by 1925**
  - It discouraged competition and slowed the innovations and efficiencies
- **FCC of 1934 focused on regulation and not on development and promotion**
  - It slowed down new technologies and applications that instead took decades to achieve
  - For details see:
    - Wireline Competition Under the 1996 Act
    - Telecommunications Act of 1996

Dr. Raziq Yaqub

FCC Types and Definition of Voice Services

Type of Voice Service

- **Local Exchange Service**
  Calling within your local exchange, usually encompassing a city, town, or village and its environs
- **Local Toll Service aka InterLATA (Local Access and Transport Area)**.
  Calling outside your local exchange area, but within your area code, or calls to different area codes within your LATA. Per-minute toll charges often apply to these calls
- **Expanded or Extended Local Exchange Service**
  Extends a local exchange calling area and eliminates local toll charges within in the expanded calling area. However, you may see expanded or extended local exchange service as a surcharge on your telephone bill
- **Service Bundles/Service packages**
  These packages often include local toll calling as well as interstate long distance (InterLATA) toll service

Dr. Raziq

FCC Types and Definition of Voice Services (contd.)

Type of Voice Service

Long Distance Toll (interLATA) Service
Calls outside the local exchange and local toll service areas or LATAs. This includes calls that originate in one LATA and terminate in another, and international calls. Interstate toll calling is subject to FCC regulation

Equal Access
It previously allowed customers to select separate local exchange and toll carriers. Later it was eliminated for interstate toll calling due to:
- The increased competitive alternatives available
- The high cost it imposed on traditional telephone companies
- The small number of consumers who chose this service

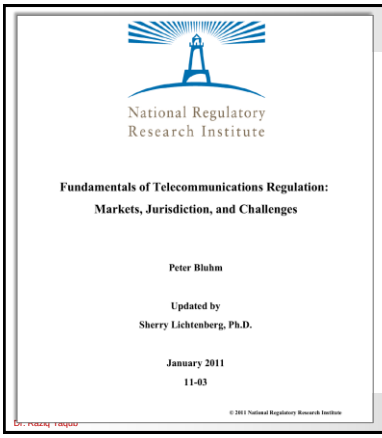
Wireline TSP still must provide this service if the state requires them. Wireless TSP were never subject to equal access requirements.

Dial Around Services:
Allow subscribers to place calls using other TSP by dialing a 1010XXX access code

Key points about Wireline Regulation

Regulations

- The rates for Wireless and Wireline services are not tariffed or regulated in the United States or in most developed countries.
- FCC has radiation safety requirements for wireline service operations
- FCC requires appropriate Framework for Broadband Access to the Internet Over Wireline Facilities (Federal Register Volume 67, Number 40)
- FCC establishes a balance between competition and regulation for the technologies that rapidly evolve and converge
- Preserve the essential public benefits from legacy regulation, even as TSP and their customers move away from traditional regulated, wireline services


National Regulatory Research Institute

Fundamentals of Telecommunications Regulation:
Markets, Jurisdiction, and Challenges

Peter Bluhm

Updated by
Sherry Lichtenberg, Ph.D.

January 2011
11-03

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For in depth review on regulations, please visit https://pubs.naruc.org/pub/FA865BB5-EB2B-0226-8F9A-174F5AAA279A

Chapter Review Questions (CRQ)

Chapter-09

Q1

- **Pick the most accurate statement.**

IN Frequency Modulation, Modulation Index is the:

A. Ratio of Phase Modulation and Frequency Modulation

B. Ratio of Analog Modulation and Digital Modulation

C. Ratio of the frequency deviation to the modulating frequency

D. None of above

Q2

- **Pick the most accurate statement**

In Amplitude Modulation:

A. Message frequency is changed based on CARRIER amplitude

B. Amplitude of a CARRIER is changed

C. Amplitude of modulating, modulated and CARRIER signals all are changed

D. All of above

Q3

- **Pick the most accurate statement about FCC wireline regulations:**

A. FCC has radiation safety requirements for wireline service operations

B. FCC does not have radiation safety requirements for wireline, but for wireless service operations

C. FCC regulates the rates or tariff for wireless and wireline services

D. All the statements are correct

Q4

- **Pick the most accurate statement**

DSL is a technology that:

A.Transmits the digitized voice only over a telephone line, and is not capable of sending data because lines do not have filters to separate voice from data

B.Is not similar to ISDN, as DSL operates over existing copper telephone lines and ISDN over optical fiber.

C.Transmits voice and digital data over the same telephone line, however, it uses higher frequency bands for data, and lower frequency bands for voice

D.None of the statement is correct

Q5

- **Pick the most accurate statement**

Modem (Modulation-Demodulation)

A.MODULATES digital signal into analog signal for transmission over analog medium, and then DEMODULATES the signal into digital for receiving

B.MODULATES analog signal into digital signal for transmission over digital medium, and then DEMODULATES the signal into analog for receiving

C.MODULATES digital signal into analog signal for receiving DEMODULATES the signal into digital for transmition

D.None of the statememts is correct

Answers to CRQ

Q1

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Home Assignment

Chapter-09

Q1. Explain the followings:

- Screened Twisted Pair
- Advantages of Coaxial Cables over TP (Twisted Pair)
- Single Mode Step Index and Multimode Graded Index Optical Fibers
- Amplitude Modulation Index

2. What is the difference between POTS, ISDN and DSL?

3. What are the some of the key points about Wireline Regulations, which Communication act would you refer to for Wireline Competition?