

Professional Development Short Course On:
Fundamentals of Telecommunications

Instructor:

Dr. Charles Alexander

ATI Course Schedule:

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ATI's Fundamentals of Telecommunications:

http://www.aticourses.com/fundamentals_telecommunications.htm

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TOPICS COVERED

- Introduction to Telecommunications
- Transmission Channel Characteristics
- Open Systems Interface (ISO) Model
- Signal Formatting & Data Communications
- Modulation & Multiplexing
- Digital Signal Processing Concepts
- Principles of Speech & Video Compression

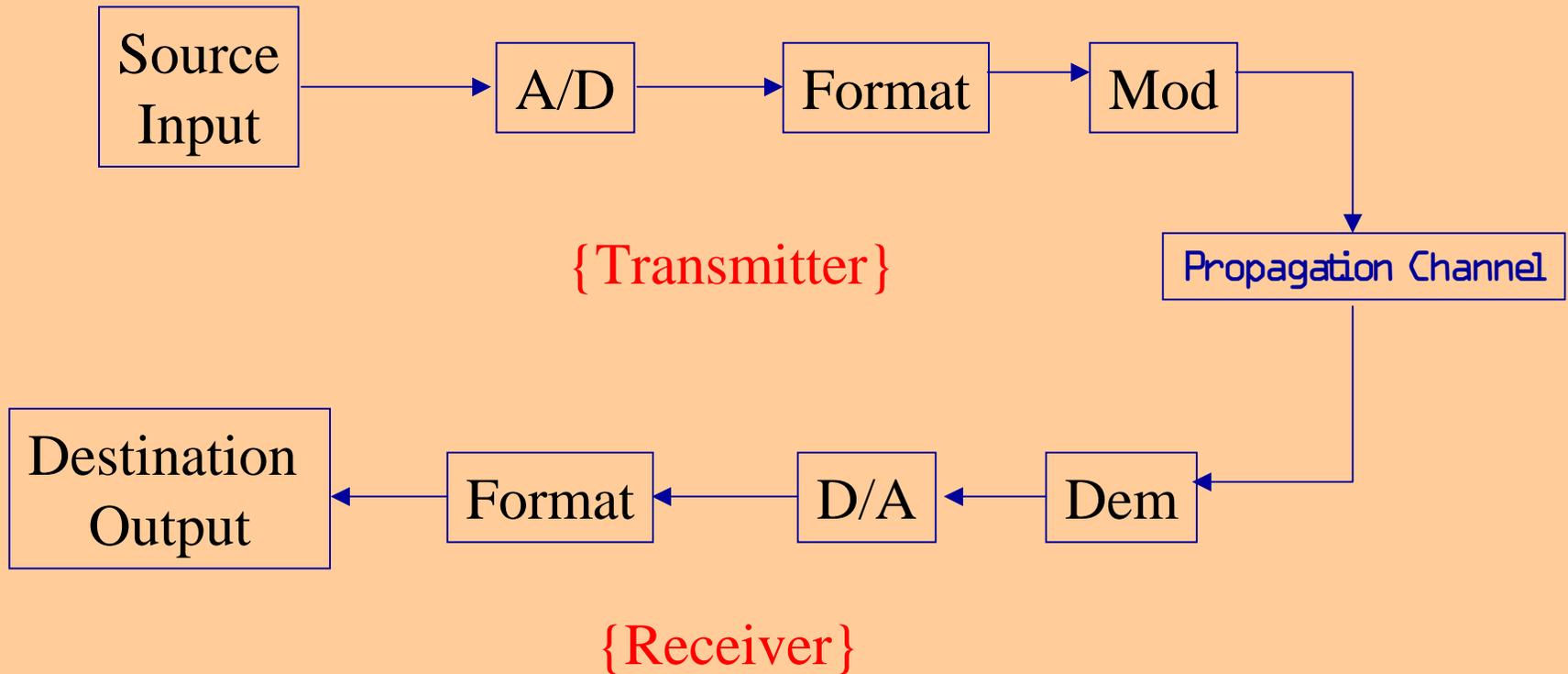
APPLICATIONS & TRENDS

- Satellite Communications (Past & Present)
- Digital Telephony, PSTN & CPE
- LAN, WLAN, WiFi, Bluetooth
- SONET & Optical Communications
- Wireless Technologies (GSM, TDMA, 3G)
- Multimedia Data Compression Techniques
- Echo Cancellation (LMS Vs Adaptive)

CASE STUDIES/ TRADE-OFFS

- Wired Vs Wireless Communications
- Satellite Vs Microwave Vs Optical
- Circuit Vs Packet Switching
- Multiple Access (TDMA, FDMA, CDMA)
- ISDN Vs ATM Vs SS7
- Cellular (TDMA Vs CDMA Vs GSM)
- Echo Cancellation (LMS Vs Adaptive)

Basic Communications Model



Telecommunication Signal Types

- Signals Classifications (Analog or Digital)
 - Deterministic (Periodic or Aperiodic)
 - Follows some analytic or graphical form
 - Predictable (Amplitude, Frequency & Phase)
 - Time Averaging (Fourier Transforms)
 - Nondeterministic (Periodic or Aperiodic)
 - Stochastic or Random Processes
 - Random events or occurrences
 - Statistical Averaging (Auto-Correlation)

Signal Classifications

Name	Digital?	Type of Signals
Fourier Series	Analog signals	Periodic signals
Fourier Transform	Analog signals	Arbitrary functions including realizable transients
Discrete Time Fourier Transform	Continuous in ω	Finite length or exponentially decaying infinite length
Discrete Fourier Transform	Digital	Finite duration and periodic signals
Z-Transform	Digital	Arbitrary functions including realizable transients

Noise & Interference

- In the real world (practical systems) there is not only signals but noise (both internal such as thermal and external such as man-made interference, multipath and galactic)
- Noise is a random or stochastic process (amplitude, phase and/or frequency not deterministic or known for all time)

Analog-To Digital (A/D)

- Three Steps In A/D Conversion
 - Continuous Time to Discrete Time Sampling (C/D)
(Also Called Time Quantization – Nyquist Criteria)
 - Amplitude Quantization (Quantization Noise)
(Uniform/Linear or Nonuniform/Nonlinear - Voice)
 - Encoding or Bit Stream Time Representation
(PCM, DM, ADM, ADPCM)

Modulation and Demodulation

- Need some type of methodology for transmission over long distances (Modulation)
- Need to modulate the signal at one end- (transmitter) demodulate at other (receiver)
- Basic Modulation Types (Analog/Digital):
Amplitude (AM/ASK), Frequency (FM/FSK),
and Phase (PM/PSK)

Propagation Channel

- Wires, Satellite, Microwave, Optical
 - Could be through sets of exchanges (PBXs)
 - Channel Restricts Signal Characteristics
 - Matching
 - Electromagnetic transmission will support high frequencies
 - Speech is low frequency
- process of matching signal to medium:
(modulation, multiplexing, multiple access)

Public Switched Telephone Network (PSTN)

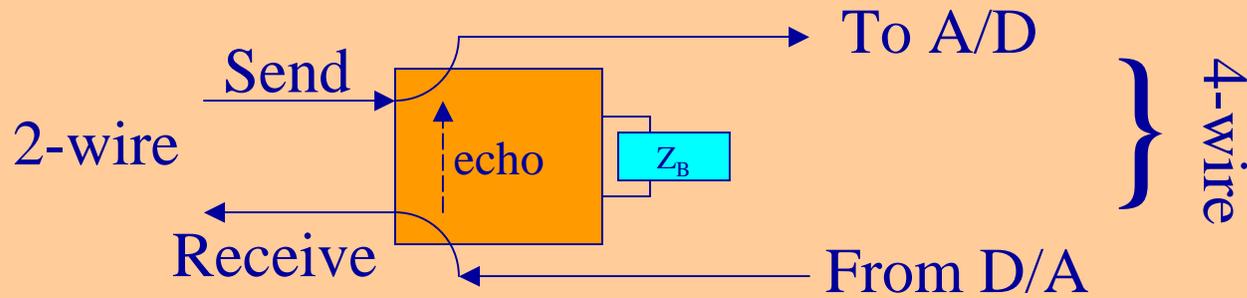
- Telephones, facsimile machines, and computer systems are ubiquitous
 - More computers sold than TV sets
 - More telephones than people
- Basic communications model (PSTN)
 - Information flows from source to destination over a channel (wire/fiber/microwave/satellite)

PSTN Network Limitations

- Subscriber connected to network: local loop
 - Terminates in central office in line circuit
 - Signals between line circuits are trunks
- On demand links
- Two-wire: to CPE
- Four-wire: from line circuit (Echos)
- CPE is analog
- Switching likes digital signals
 - A/D, D/A, anti-aliasing, replicate, amplify

Echo Cancellation Problem

- A typical hybrid is depicted as



- Some of the Receive signal leaks into the Send path \Rightarrow echo
- If all Receive power coupled into subscriber loop, there would be no echo
 - Governed by Balance Impedance, Z_B

Hybrid Circuits

- If the impedance into the subscriber loop is Z_{in} (depends on number of devices hung, current, and distances [hundreds of feet to a few miles]), the transfer function

– US: less than 12 kft

$$H(f) = \frac{1}{2} \frac{Z_{in}(f) - Z_B(f)}{Z_{in}(f) + Z_B(f)}$$

- Matching the impedance of the input and the subscriber loop

Solutions To PSTN Echo

- Time & Frequency Compression
- Round Trip Attenuation (small delays)
- Echo Suppressors (medium delays)
- Echo Cancelors (large delays-satellite)
- Adaptive Algorithms (Digital Filters)

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- Communications & Computer Programming
- Radar/EW/Combat Systems
- Signal Processing & Information Technology
- Sonar & Acoustic Engineering
- Spacecraft & Satellite Engineering

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