Transmission Lines

Part 12a of
"Electronics and Telecommunications"
A Fairfield University E-Course
Powered by LearnLinc

Module: Digital Systems (in two parts)

- Texts:
  - "Computers," Capron, Benjamin Cummings, 1996, ISBN 0-10053-0662-5
  - "Telecommunications," Blyth, McGraw-Hill, 1990, ISBN 0-02-61001041-2
  - "Understanding Telephone Electronics," Bigelow, Newnes, 1997, ISBN 0-7506-9944
- References:
  - Electronics Tutorial (Thanks to Alex Pounds)
  - Electronics Tutorial (Thanks to Mark Sokos)
- Part 9 – Computers
  - 5 on-line sessions plus one lab
- Part 10 – Digital Communications
  - 5 on-line sessions plus one lab
- Mastery Test part 5 follows this Module

Section 11: Broadcast Systems

- Frequency Division Multiplexing
- AM
  - Modulation
  - Demodulation (The Envelope Detector)
- FM
  - Modulation
  - Demodulation (The Phase-Locked-Loop)
- Super Heterodyne Receivers
- Television
- Sampling

Section 12: Transmission and Networks

- Transmission Lines
  - Twisted pair
  - Coaxial Cable
  - Optical Fiber
- Microwave Systems
- Satellite Links
- Telephone Systems
- Local Area Networks
- Cellular Phone Systems

Section 12 Schedule

Session 12a	**09/24**	**Transmission Lines, Radio, Microwave & Satellites**	**Bigelow: 36-42; WWW, notes**
Session 12b	09/29	POTS	Bigelow: 1-36, 47-78, WWW, notes
Session 12c (No Class 10/06)	10/01	Telephone Systems & the CO	Bigelow: 79-106, 211-251
Session 12d (No class 10/13)	10/08	LANs	WWW, notes
Session 12e	10/15	Cell Phone Systems	Bigelow: 332-341; WWW, notes
Session 12f (Lab - 10/25, Sat.) (Quiz 12 due 10/26)	10/20	Review for Quiz 12	
Session 12g	10/27	Quiz 12 Results	
Session 12h	10/29	MT 6 Q&A	
MT6 (Sat, Cheshire)	11/01	MT 6	
MT6 Results	11/03	MT 6 Results	

Transmission Media: Get signals from here to there

- Copper
  - Unbalanced, open wire line
  - Pair
    - Untwisted or Twisted
    - Unbalanced or Balanced
  - Coaxial cable
- Radio
  - Free Space: Antennas
  - Microwave:
    - Free Space
    - Wave Guides
  - Satellite
- Optical
  - Free Space
  - Fiber

A Transmission Line

- Signal goes in: voltage, current, characteristic impedance (Z_0)
- Signal propagates as an electromagnetic wave (speed of light)
- Signal comes out and is absorbed in the termination impedance
  - Attenuation (loss)
  - Reflection (impedance mismatch)

Open Wire Line

- Signal travels on a copper wire; Use "Ground" as a return
  - Good
    - Low cost
  - Bad
    - Susceptible to interference and "crosstalk"
      - Induced signals due to open "loop" structure
      - Common impedance in ground path
    - High loss in the ground return

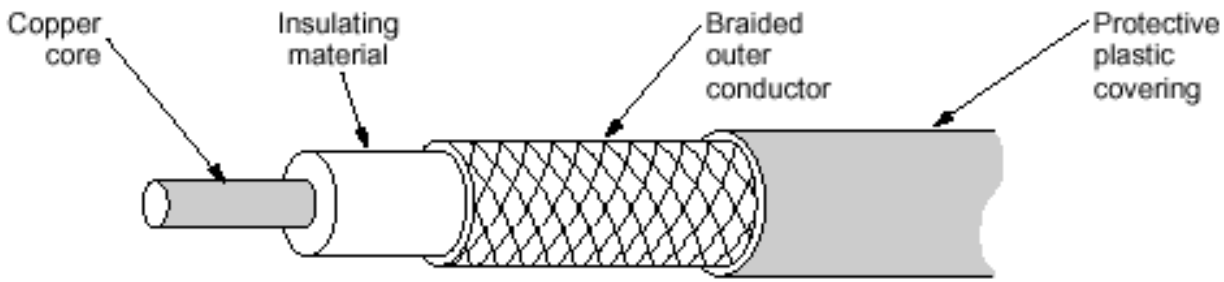
Unbalanced Pair

- Add a copper return (neutral) wire
  - Good
    - Lower loss in the return path for the current
    - Independent return path
      - no common coupling impedance
  - Bad
    - Open structure still allows induced signals
      - Reduced by keeping signal and return lines close
      - Further reduced by twisting
    - Adds cost

Balanced Pair

- Put signal on one line and minus the signal on the other line
  - Good
    - Coupled signals tend to cancel each other out
    - “Common mode” rejection
    - Twisting very effective (Method used today)
  - Bad
    - Adds cost
    - Balance maintenance requires care
      - Audio transformers, center tapped
      - Differential operational amplifiers

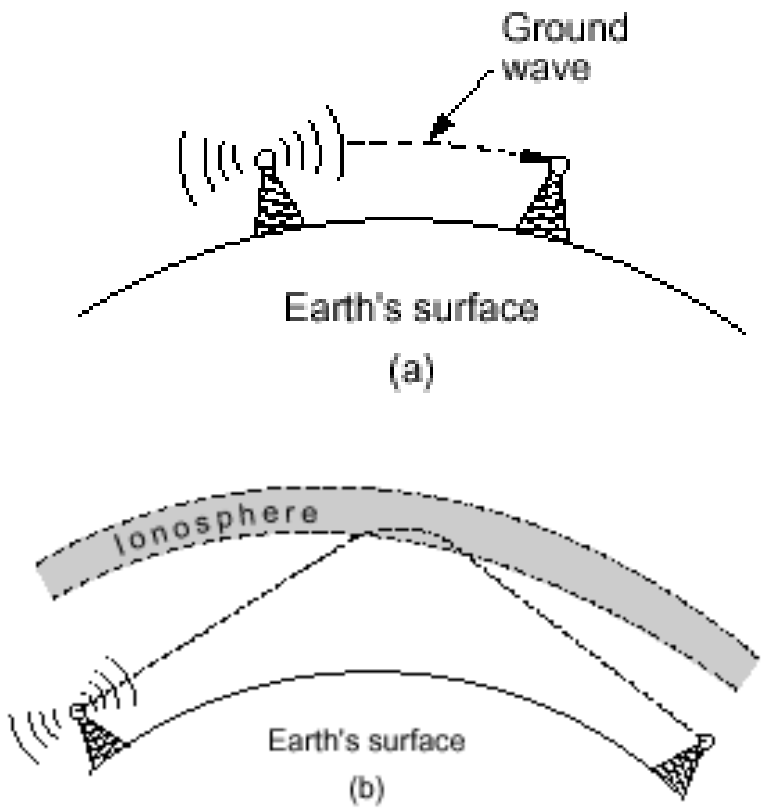
Coaxial Cable



- Signal travels down the inner conductor and returns via the shield (outer conductor)
  - Good
    - Isolated from the rest of the world by the shield
    - Consistent impedance, large bandwidth (1 GHz)
  - Bad
    - Cost and connectors

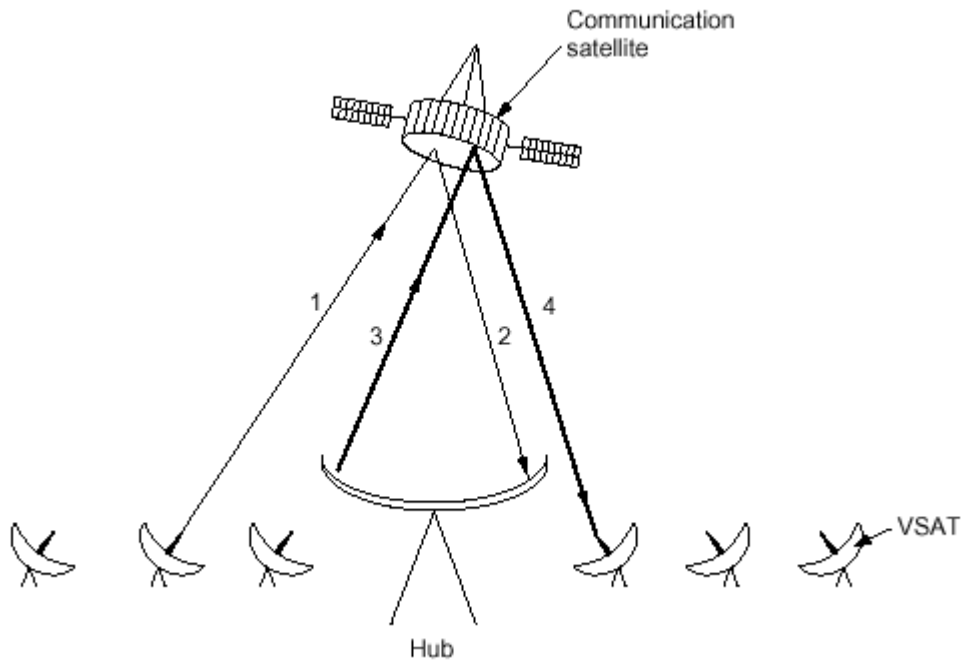
Line of Sight Radio

- Radio waves tend to go in a straight line (especially at high frequencies)
- The earth (and other obstacles) can get in the way
- Signals can bounce off surfaces



Satellite

- Uplink
  - Earth station
- Downlink
  - Satellite transmits a "footprint"
  - Received by microwave "dish"
- Geo-stationary
  - 22,000 miles high
  - Remains fixed over a spot on the equator.
  - Allows a fixed receiving antenna



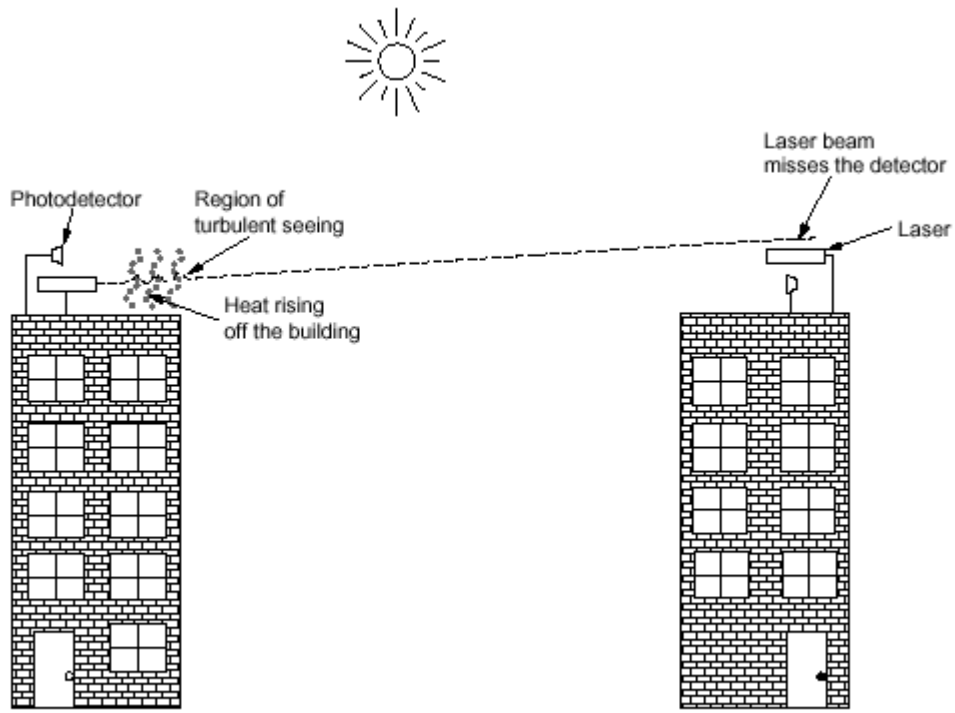
Satellite Systems

Band	Frequencies	Downlink (GHz)	Uplink (GHz)	Problems
C	4/6	3.7–4.2	5.925–6.425	Terrestrial interference
Ku	11/14	11.7–12.2	14.0–14.5	Rain
Ka	20/30	17.7–21.7	27.5–30.5	Rain; equipment cost

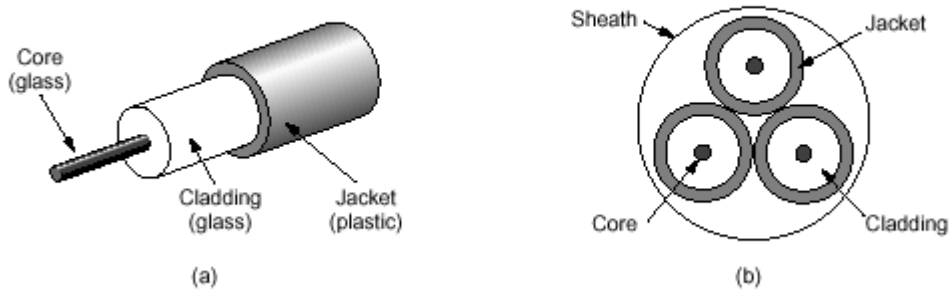
- Higher frequency – shorter wavelength – smaller dish
- Satellite TV uses high frequencies and a high power satellite transmitter to allow 18” receiving dish.

Free Space Optical

- Use lasers and photo-detectors
- Fog, rain, snow, and leaves can cause problems

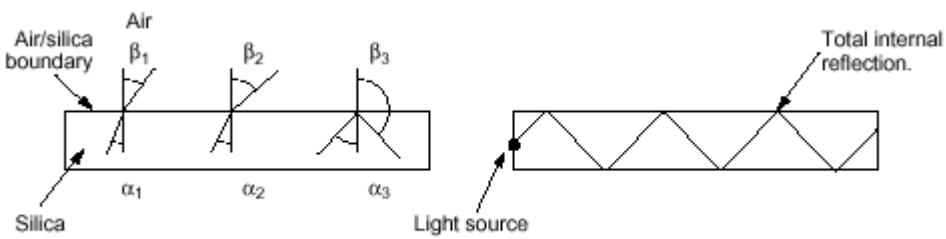


Optical Fiber



- Light travel down a thin Glass Fiber
- What keeps it in?

  hint: the speed of light is slower in high index glass



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