The Physical Layer

COMP312

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Lecture Outline

- Analogue Signals and Transmission Terminology.
- Transmission Media.

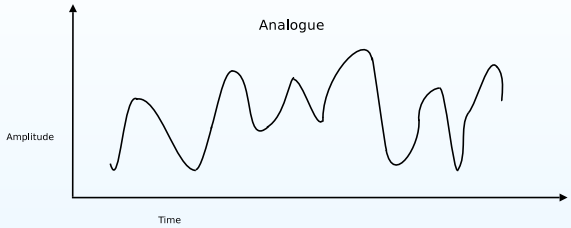
OSI Protocol Model

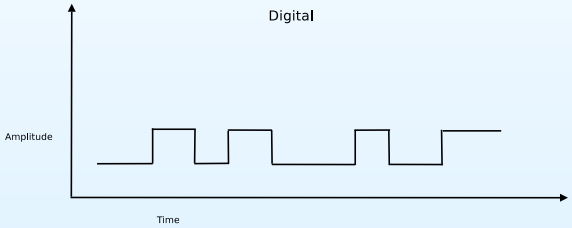
Working Here

Analogue Signals and Transmission Terminology

- Basic Properties
- Spectrum
- Terminology
- Transmission Impairments

Analogue Signals





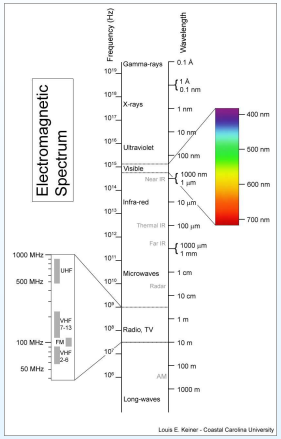
Signal Components

Electromagnetic waves

$$c = f\lambda$$
$$c = 2.998 \times 10^8 m/s$$

$f(Hz)$	λ
10^5	$3000m$
10^6	$300m$
10^7	$30m$
10^8	$3m$
10^9	$30cm$
10^10	$3cm$
10^11	$3mm$

Spectrum



Terminology 1

- Transmitter
- Receiver
- Medium
  - guided
  - unguided

Terminology 2

- Point to Point
- Point to Multipoint
- Multiple Access

Terminology 3

- Simplex
- Half Dulplex
- (Full) Duplex

Signal Impairments

- Attenuation
- Noise
- Delay Distortion

Attenuation

- Attenuation is the reduction of signal strength with distance.
- The loss function is a property of the media, but tends to be multiplicative with distance.
- The received signal needs to be large enough for the receiver to interpret it and to stand out from any noise
- To maintain signal strength amplifiers or repeaters are used.

Noise

Noise is the addition of unwanted signals. There are four main categories of noise

- Thermal noise is a physical property of any conductor due to the movement of electrons. This produces noise that is uniform across the spectrum which is known as white noise.
- Intermodulation noise is mixing of different frequencies in a signal due to non-linearities in the medium.
- Crosstalk or interference is the addition of other signals due to them being fed in from another channel. e.g. from a parallel wire.
- Impulse noise is caused by sudden electromagnetic disturbances such as lightning or arcing of an electrical switch. It is very wideband but short in duration.

Delay Distortion

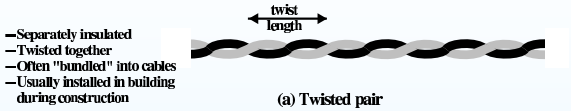
- In guided media different frequencies may travel at slightly different speeds.
- This results in a blurring of the signals

Return to ToC

Transmission Media

- Guided Media
  - Twisted Pair
  - Coax
  - Fibre Optics
- Unguided
  - Radio
  - Other

Guided Media 1 -Unsheilded Twisted Pair

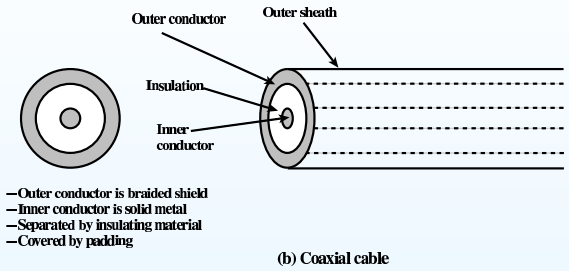


Cat 5 attenuation (per 100m) 1MHz: 2.0dB, 10MHz:6.5dB 100MHz: 22dB

UTP

- Cheap
- Common
  - Telephone Subscribers
  - Building wiring (LANs, phones)
- Fast over short distances
  - 10, 100 Mbps
  - less than 100m
- Susceptible to interference
- Sheilded twisted pair may reduce interference

Guided Media 2 - Co-Axial Cable



Thin (ethernet) Coax attenuation (per 100m) 1MHz: 1.4dB, 10MHz:4.2dB 100MHz: 13.7dB

Coax

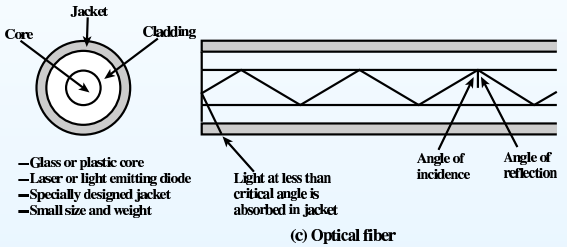
- Highest bandwidth electrical medium
- Common in RF Applications
  - Television and Radio
  - Cable distribution
- Used to be choice for high end applications
  - LANs
  - Telephone trunks
- Now UTP is cheaper for LANs
- Fibre is faster for Long Haul.

Characteristic Impedence

$$Z_0 = \sqrt{\frac{L}{C}}$$

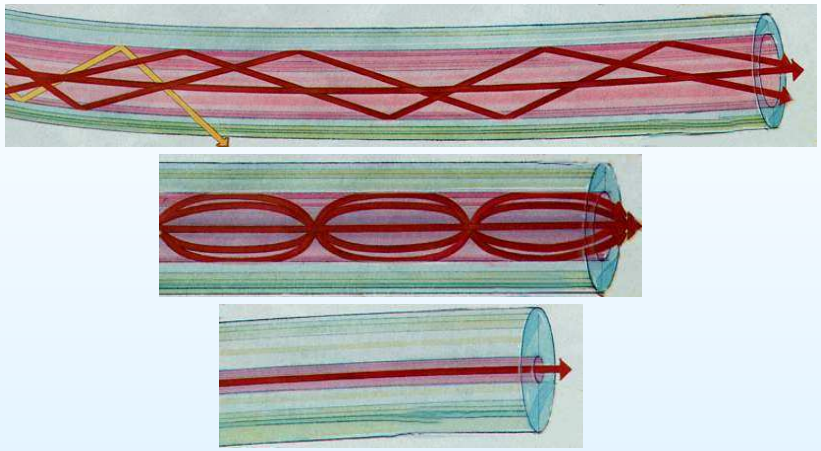
Ethernet thin coax 50Ω
Television antennae 75Ω

Guided Media 3 - Fibre Optics

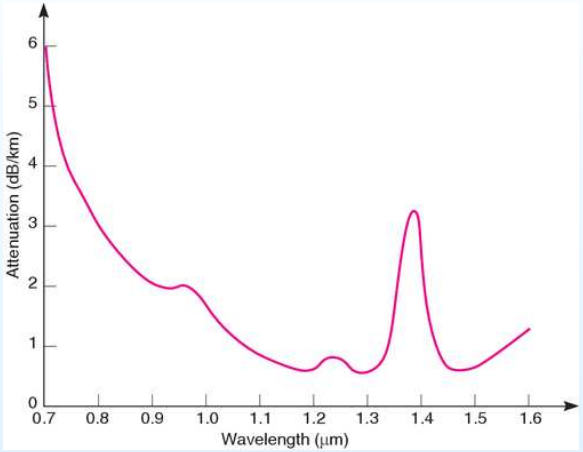


(c) Optical fiber

Fibre Optic Modes



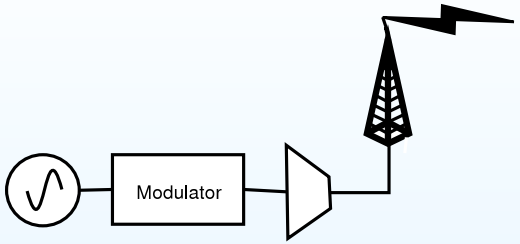
Fibre Optic Attenuation



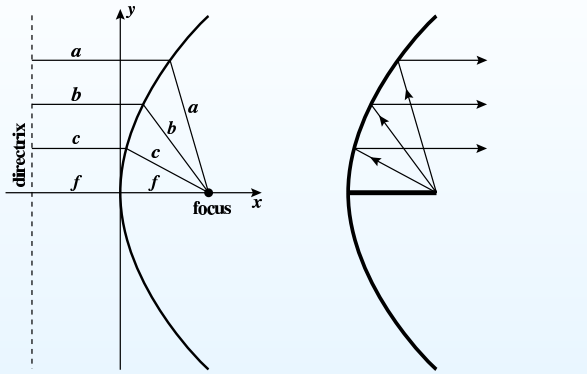
Fibre Optics

- Greatest Capacity - Terabits
- Greatest Distances - 1000 km
- Small size and weight
- Electromagnetic Isolation
  - Long Haul Trunks
  - Metropolitan Networks
  - Campus Backbone Networks
  - High bandwidth connections (>1Gb/s)
- Anywhere the cost of a cable can be justified if UTP cannot do the job!

Unguided Media Radio



Radio - Antenna

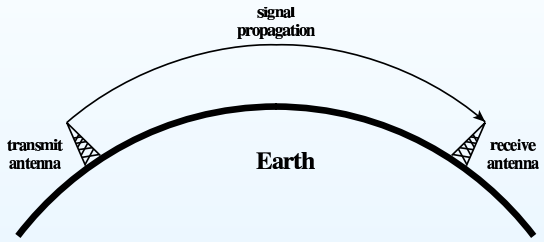


(a) Parabola

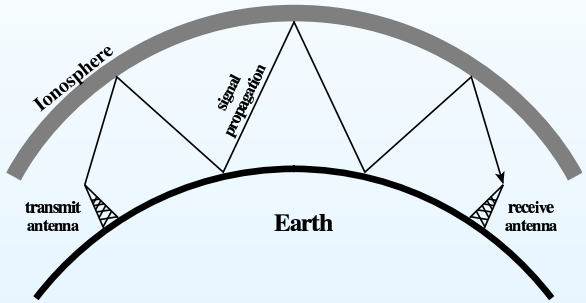
(b) Cross-section of parabolic antenna showing reflective property

Antenna Gain

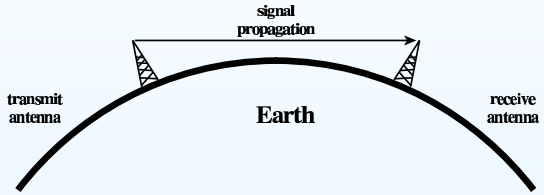
Radio - Groundwave Propagation



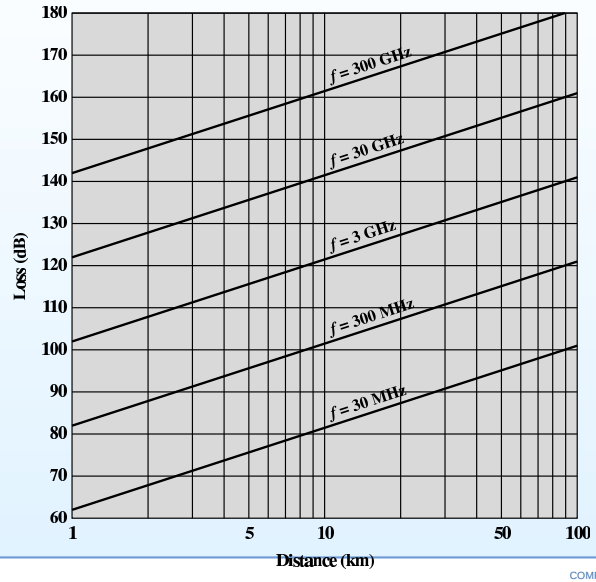
Radio - Skywave Propagation



Radio - Line Of Sight Propagation



Propagation Loss

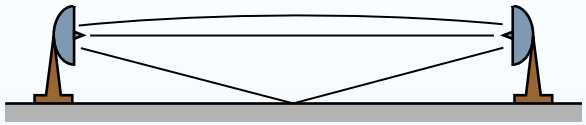


Path Loss Equation

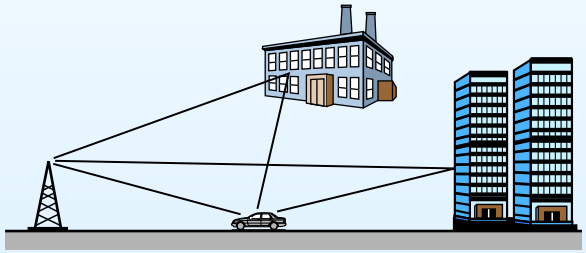
$$P_{receive} = P_{transmit} + G_{transmit} + G_{receive} - (L_D \times D) - Fade$$

$$P_{receive} \geq ReceiverSensitivity$$

Multipath



(a) Microwave line of sight



(b) Mobile radio

Other Unguided Media - Free Space Optics

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