Digital vs. Analog Transmission
Nyquist and Shannon Laws

Required reading:
Forouzan 3.4 to 3.6
Garcia 3.3 to 3.5

CSE 3213, Fall 2015
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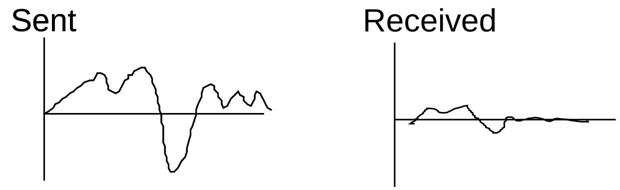
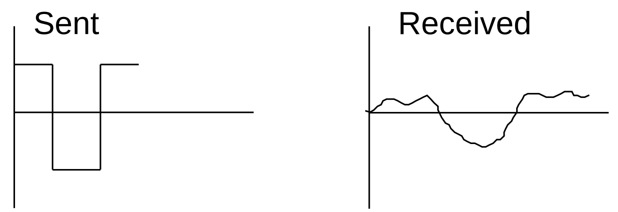
Transmission Impairments

Transmission / Signal Impairments – **caused by imperfections of transmission media**

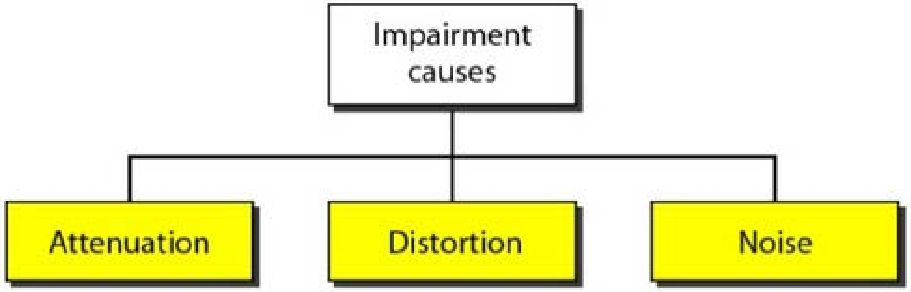
- **for analog signals, impairments can degrade signal quality**



- **for digital signals, impairments can cause bit errors**



- **main types of transmission impairments:**



Transmission Impairments: Attenuation

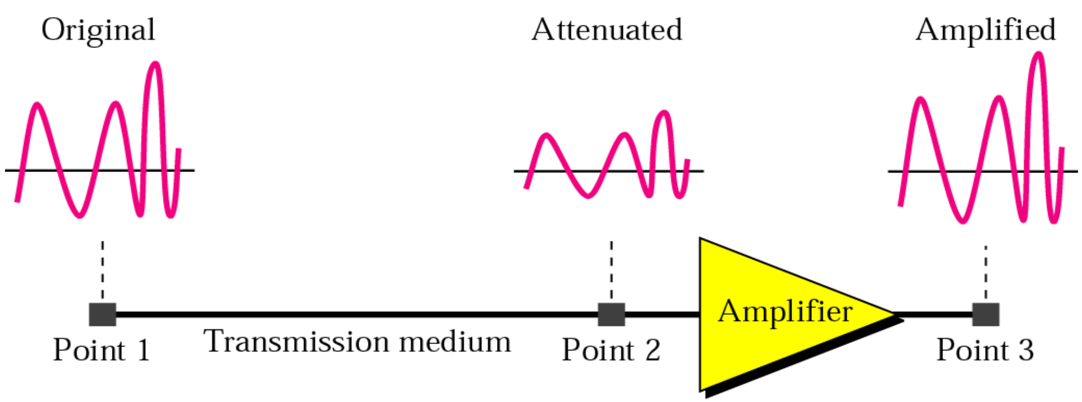
Attenuation – **reduction / loss in signal power**

- **when a signal travels through a medium it loses some of its energy so that it can overcome the resistance of the medium**
- **main challenges in combating attenuation:**

  (1) received signal must have sufficient strength so that receiver can detect signal, but not too strong to overload transmitter/ receiver circuitry

  Less of a problem for digital signal !!! → **(2) signal must maintain a level sufficiently higher than noise, at all times, to be received without error**

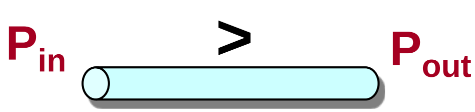
- **to compensate for loss, analog amplifiers / digital repeaters are used to boost the signal at regular intervals**



Transmission Impairments: Attenuation (cont.)

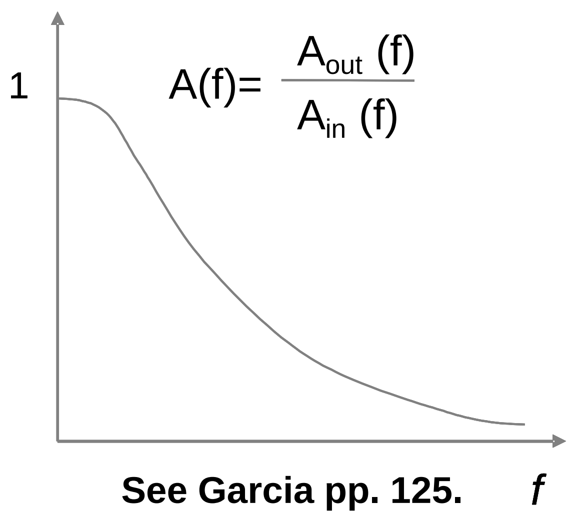
Attenuation (cont.) – **def. loss in signal power as it is transferred across a system (medium)**

- **typically determined for each individual frequency**
- **apply sinwave of frequency f and power P_{in} to channel input and observe signal power P_{out} at channel output**



$$\text{Attenuation}(f) = L(f) = 10 \cdot \log_{10} \frac{P_{in}(f)}{P_{out}(f)} \ [dB]$$

Amplitude Response



$$A(f) = \frac{A_{out}(f)}{A_{in}(f)}$$

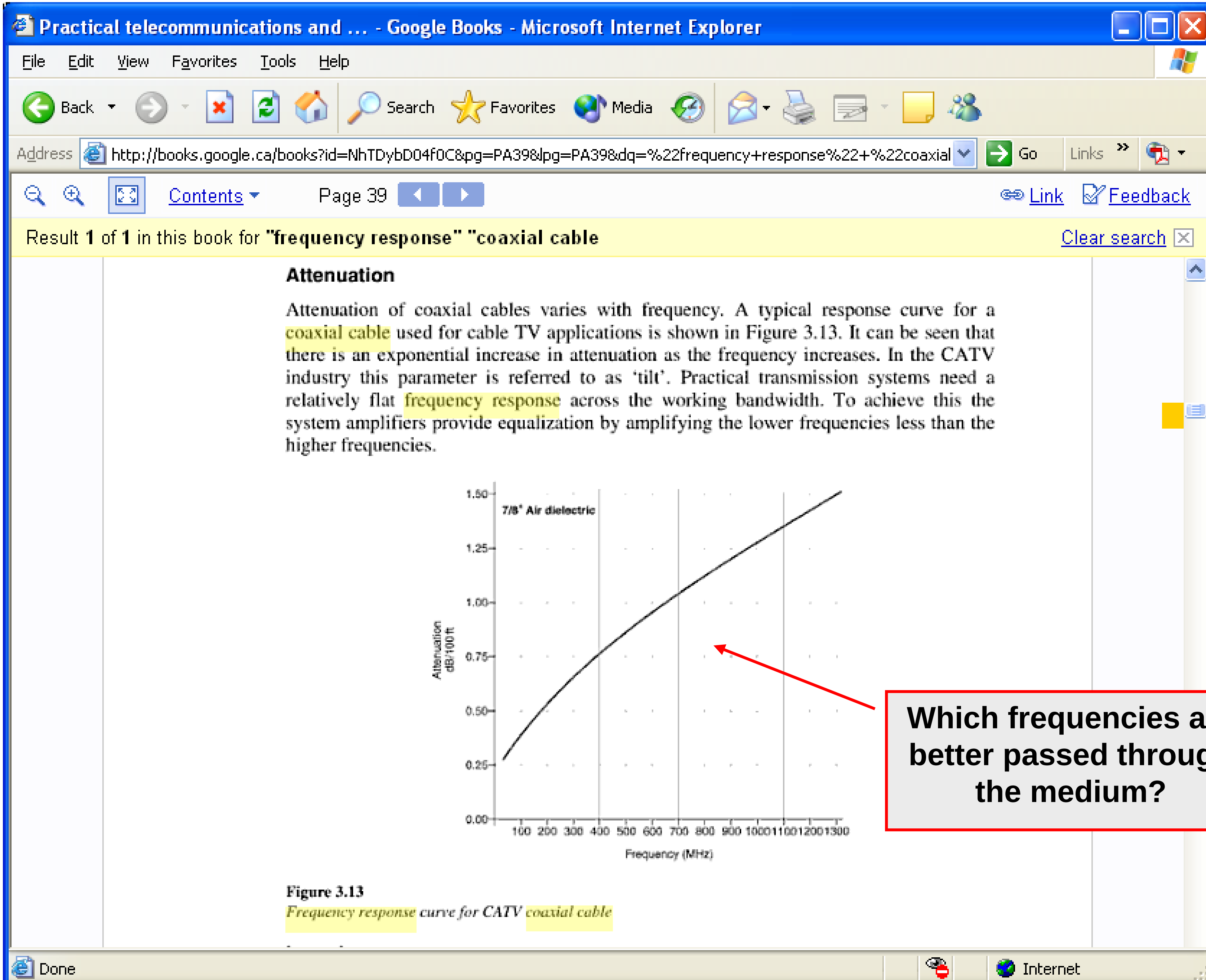
- aka **'magnitude of frequency response'**

$$L(f) = \frac{P_{in}(f)}{P_{out}(f)} = \frac{A_{in}(f)^2}{A_{out}(f)^2} = \frac{1}{A(f)^2}$$

$$\text{Atten.}(f) = L(f) = 20 \cdot \log_{10} \frac{1}{A(f)} \ [dB]$$

channel's amplitude response function A(f)

See Garcia pp. 125.



Attenuation

Attenuation of coaxial cables varies with frequency. A typical response curve for a coaxial cable used for cable TV applications is shown in Figure 3.13. It can be seen that there is an exponential increase in attenuation as the frequency increases. In the CATV industry this parameter is referred to as 'tilt'. Practical transmission systems need a relatively flat frequency response across the working bandwidth. To achieve this the system amplifiers provide equalization by amplifying the lower frequencies less than the higher frequencies.

Figure 3.13
Frequency response curve for CATV coaxial cable

Which frequencies are better passed through the medium?

Transmission Impairments: Attenuation (cont.)

Why decibel (log function)?

1. **Signal strength often falls off exponentially** (e.g., with distance $P_{out} = P_{in} / d^k$)**, so loss is easily expressed in terms of decibels – linear function in log-plot.**

2. **The net gain or loss in a <u>cascaded</u> transmission path can be calculated with simple addition and subtraction.**

   In figure below, a signal travels a long distance from point 1 to point 4. The signal is attenuated by the time it reaches point 2. Between points 2 and 3, the signal is amplified. Again, between points 3 and 4, the signal is attenuated. We can find the resultant attenuation for the signal just by adding the decibel measurements between each set of points.