

Signal Analysis

- Signals are subject to degradation due to:
 - Attenuation
 - Noise
 - Delay distortion
- Attenuation can be partially overcome with regular amplification.
- The advantage of digital and repeating.

- Noise causes a signal to be modified in the medium.
- It is largely unpredictable.
- Some causes are thermal and impulse activity and crosstalk.
- Noise is bursty.
- Signal-to-noise ratio $SN = 10 \times \log_{10} \frac{S}{N}$
- Delay distortion is caused by the velocity of propagation being different for different frequencies.
- Delay distortion requires longer signal components.

Broadband

- Degradation results in limits on the data rate.
- Issues are:
 - The noise immunity of a medium.
 - The attenuation in the medium.
 - The power used in the signal.
 - The signal bandwidth.
 - The type of signaling used.
 - The type of encoding used.

Nyquist's Theorem

How much data can a signal encode? Nyquist's Theorem gives us some insight.

$$C = 2B \log_2 H$$

where C is the capacity in bits/second

B is the signal bandwidth in Hz

H is the number of signal levels used to represent data.

Example:

$$B = 10,000 \text{ Hz}$$

$$V = 8 \text{ FSK frequencies}$$

$$C = 2 \times 10,000 \log_2 8$$

$$C = 20,000 \times 3$$

$$C = 60,000 \text{ b/s}$$

Shannon's Theorem

$$C = B \log_2 \left(1 + \frac{\text{SignalPower}}{\text{NoisePower}} \right)$$

Example:

$$B = 10,000 \text{ Hz}$$

$$\text{SignalPower} = 3 \text{ W}$$

$$\text{NoisePower} = 0.003 \text{ W}$$

$$C = 10,000 \log_2 \left(1 + \frac{3}{0.003} \right)$$

$$C = 10,000 \times 9.967$$

$$C = 9967 \text{ b/s}$$

Note that the signal-to-noise ratio is $10 \log_{10} \frac{3}{0.003} = 30\text{db}$.

Baud Rate and Bit Rate

- In Nyquist's Theorem, H is the the number of bits per *baud*.
- The baud rate is the number of signal changes in a second.
- The bit-rate is the number of bits per unit time.
- For example, three-bit encoding (8 different signal levels) using FSK with a bit time of 1 ms has a baud rate of 1000 baud and a bit rate of 3000 bits/second.