Ministry of Higher Education and Scientific Research

Al-Mustaqbal University

College Of Engineering & Technology

Computer Techniques Engineering Department

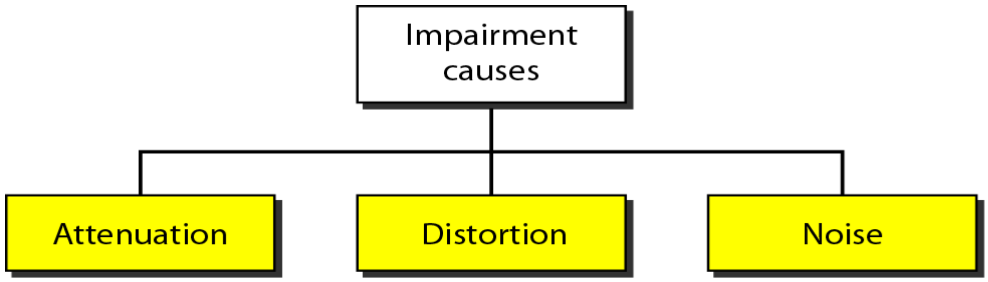
Computer Networks Fundamentals

Lecture 12:

TRANSMISSION IMPAIRMENT

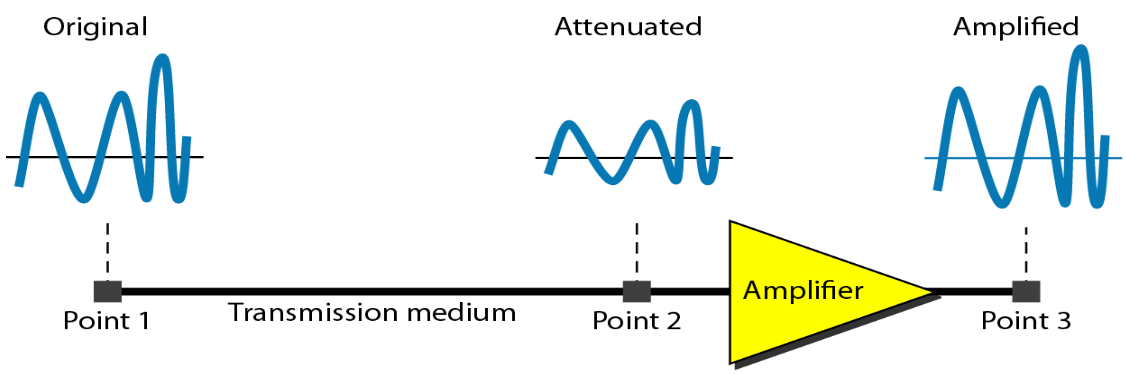
12.1- TRANSMISSION IMPAIRMENT

Signals travel through transmission media, which are not perfect. The imperfection causes signal impairment. This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium. What is sent is not what is received. Three causes of impairment are ***attenuation***, ***distortion***, and ***noise***



12.1.1- Attenuation

Attenuation means a loss of energy. When a signal, simple or composite, travels through a medium, it loses some of its energy in overcoming the resistance of the medium. That is why a wire carrying electric signals gets warm, if not hot, after a while. Some of the electrical energy in the signal is converted to heat. To compensate for this loss, amplifiers are used to amplify the signal.



To show that a signal has lost or gained strength, engineers use the unit of the *decibel*. The **decibel (dB)***measures the relative strengths of two signals or one signal at two different points*. Note that the decibel is negative if a signal is attenuated and positive if a signal is amplified.

$$\boldsymbol{dB = 10 \log_{10}(\frac{P_2}{P_1})}$$

Example 5:

Suppose a signal travels through a transmission medium and its power is reduced to one-half. This means that P2 is (1/2) P1. In this case, the attenuation (loss of power) can be calculated as follows:

$$10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{0.5\ P_1}{P_1} = 10 \log_{10} 0.5 = 10 \times (-0.3) = -3\ dB$$

A loss of 3 dB (–3 dB) is equivalent to losing one-half the power.

Example 6

The loss in a cable is usually defined in decibels per kilometer (dB/km). If the signal at the beginning of a cable with -0.3 dB /km has a power of 2 mW, what is the power of the signal at 5 km?

Solution

The loss in the cable in decibels is $5 \times (-0.3) = -1.5\ dB$. We can calculate the power as

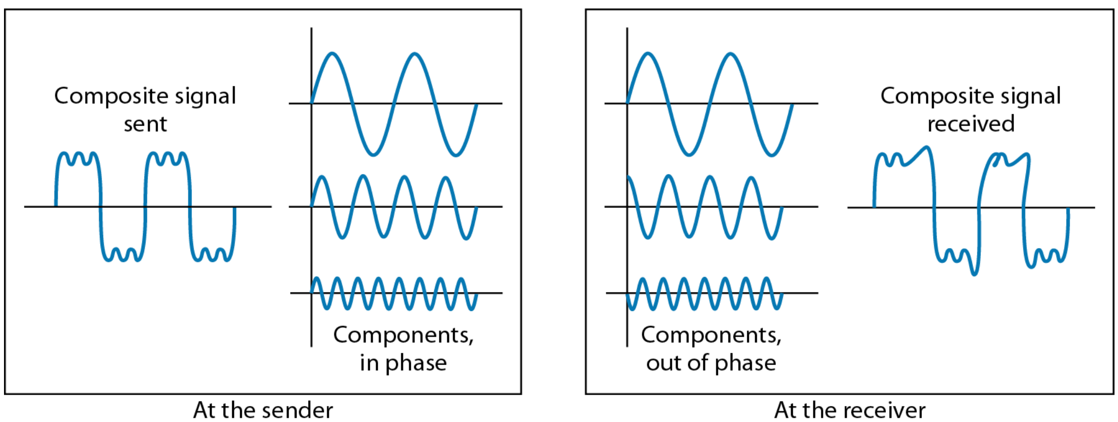
$$dB = 10 \log_{10} \frac{P_2}{P_1} = -1.5 \qquad \log_{10} \frac{P_2}{P_1} = -0.15$$

$$\left(\frac{P_2}{P_1}\right) = 10^{-0.15} = 0.71$$

$$P_2 = 0.71 \times P_1 = 0.71 \times 2 = 1.4 mw$$

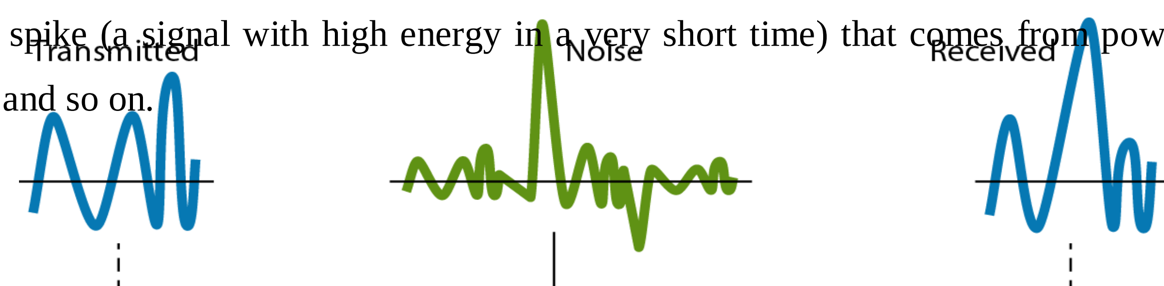
12.1.2-Distortion

Distortion means that the signal changes its form or shape. Distortion can occur in a composite signal made of different frequencies. Each signal component has its own propagation speed (see the next section) through a medium and, therefore, its own delay in arriving at the final destination. Differences in delay may create a difference in phase if the delay is not exactly the same as the period duration. In other words, signal components at the receiver have phases different from what they had at the sender. The shape of the composite signal is therefore not the same.



12.1.3-Noise

Noise is another cause of impairment. Several types of noise, such as ***thermal noise, induced noise, crosstalk, and impulse noise,*** may corrupt the signal. ***Thermal noise*** is the random motion of electrons in a wire which creates an extra signal not originally sent by the transmitter. ***Induced noise*** comes from sources such as motors and appliances. These devices act as a sending antenna, and the transmission medium acts as the receiving antenna. ***Crosstalk*** is the effect of one wire on the other. One wire acts as a sending antenna and the other as the receiving antenna. ***Impulse noise*** is a spike (a signal with high energy in a very short time) that comes from power lines, lightning, and so on.



12.1.4- Signal-to-Noise Ratio (SNR)

It is the term useful to find the bit rate of the signal and it is defined as the ratio of the signal power to the noise power as shown below:

$$\boldsymbol{SNR} = \frac{average\ signal\ power}{average\ noise\ power}$$

Because SNR is the ratio of two powers, it is often described in decibel units, $\boldsymbol{SNR_{dB}}$ and defined as:

$$\boldsymbol{SNR_{dB} = 10\log_{10} SNR}$$

Example 7:

The power of a signal is 10 mW and the power of the noise is 1 μW; what is the value of SNR_{dB}

$$SNR = \frac{(10 \times 10^{-3}\, W)}{(1 \times 10^{-6}\, W)} = \frac{10 \times 10^{3}}{1} = 10000$$

$$SNRdB = 10\ \log_{10}(10000) = 10\log_{10}(10^{4}) = 40\ Db$$

12.1.5- Data Rate Limits

A very important consideration in data communications is how fast we can send data in ***bits per second*** over a channel. Data rate depends on three factors:

1. **The bandwidth available**
2. **The level of the signals we use**
3. **The quality of the channel (the level of noise)**

Two theoretical formulas were developed to calculate the data rate: one by Nyquist for a noiseless channel, another by Shannon for a noisy channel.