Transmission Media
Unguided
Impairments

CSE306

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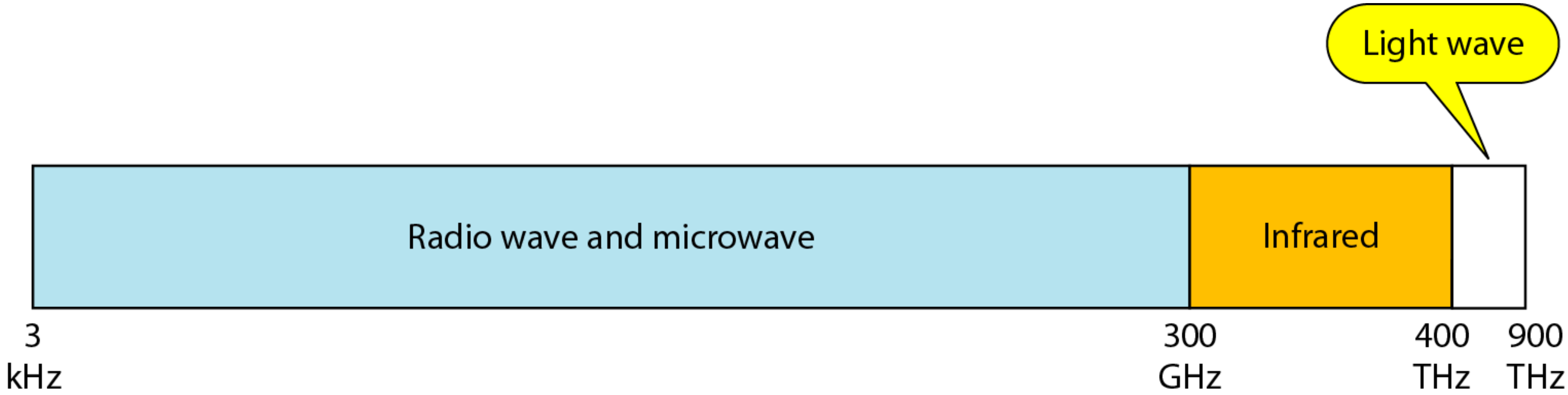
UNGUIDED MEDIA: WIRELESS

Unguided media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication.

Electromagnetic spectrum for wireless communication



Bands

Band	*Range*	*Propagation*	*Application*
VLF (very low frequency)	3–30 kHz	Ground	Long-range radio navigation
LF (low frequency)	30–300 kHz	Ground	Radio beacons and navigational locators
MF (middle frequency)	300 kHz–3 MHz	Sky	AM radio
HF (high frequency)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (very high frequency)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh frequency)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (superhigh frequency)	3–30 GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30–300 GHz	Line-of-sight	Radar, satellite

POLL 1

- Which of the following band is associated with Cellular phones and Pagers

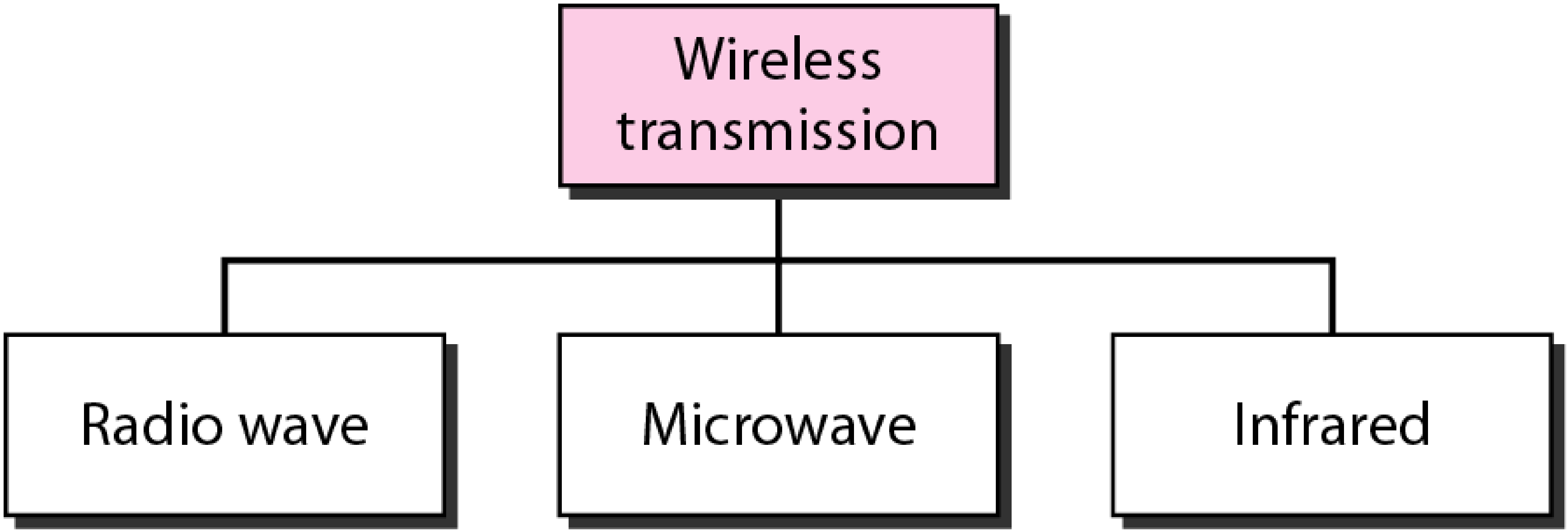
a) UHF

b) VHF

c) SHF

d) EHF

Wireless transmission waves



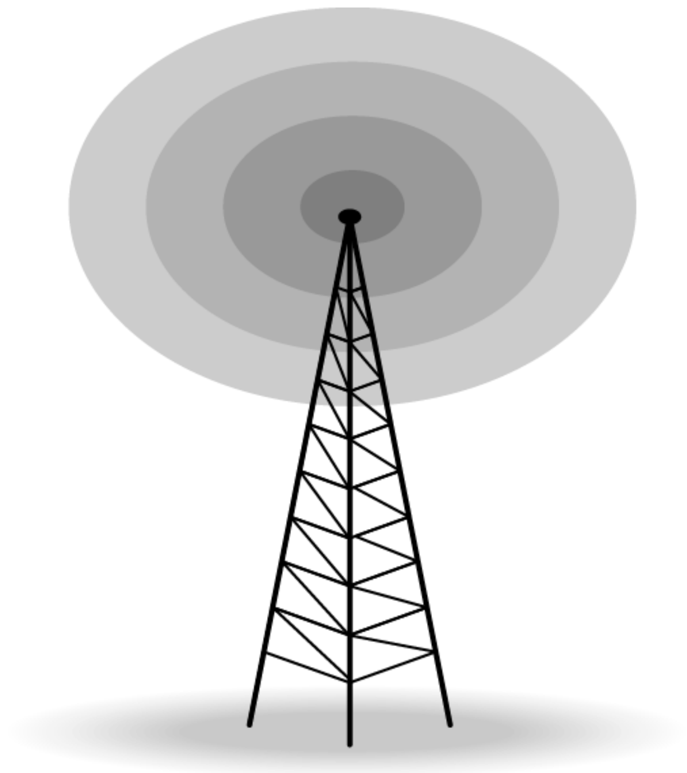
Note

Radio waves are used for multicast communications, such as radio and television.

They can penetrate through walls.

Use Omni directional antennas

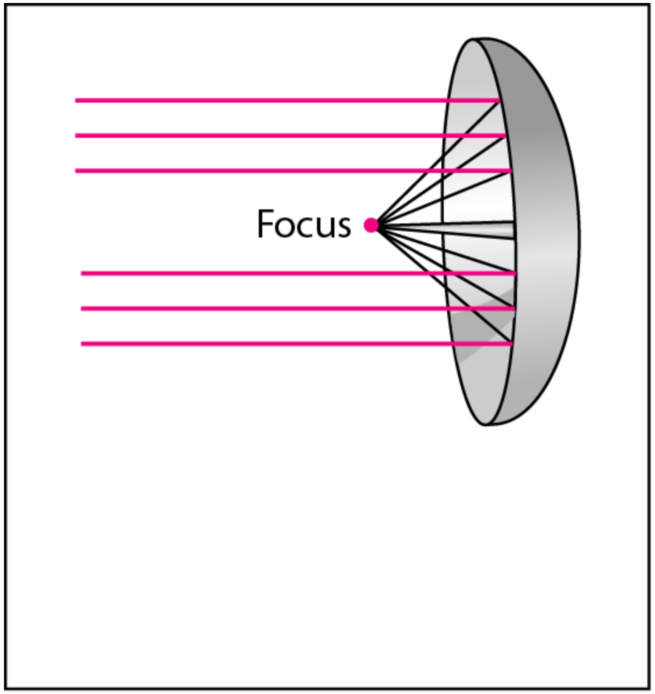
Omnidirectional antenna



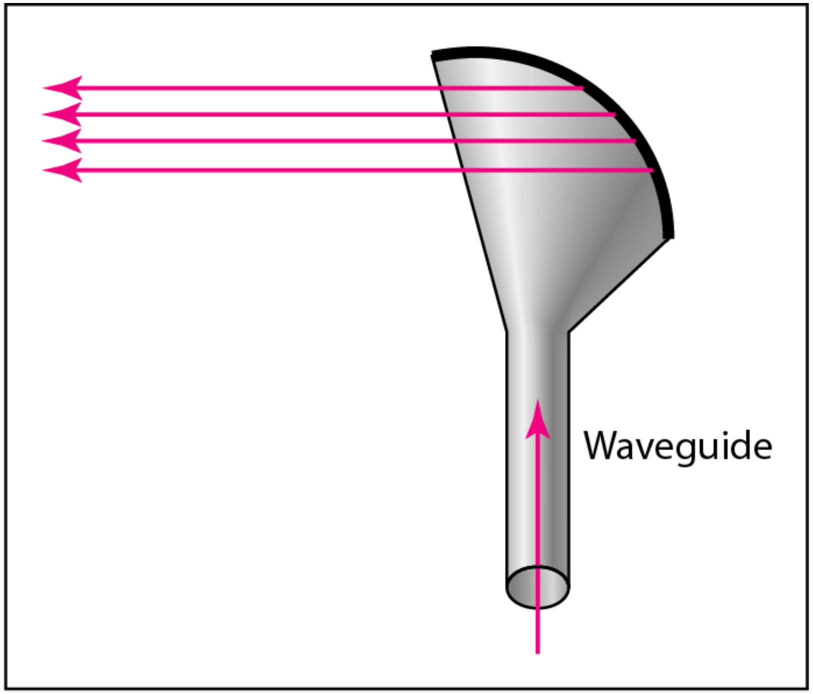
Note

Microwaves are used for unicast communication such as cellular telephones and wireless LANs. Higher frequency ranges cannot penetrate walls. Use directional antennas - point to point line of sight communications.

Unidirectional antennas



a. Dish antenna



b. Horn antenna

Note

Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.

POLL 2

- Which of the following is related to Unicast communication

a) Infrared Signals

b) Microwave Signals

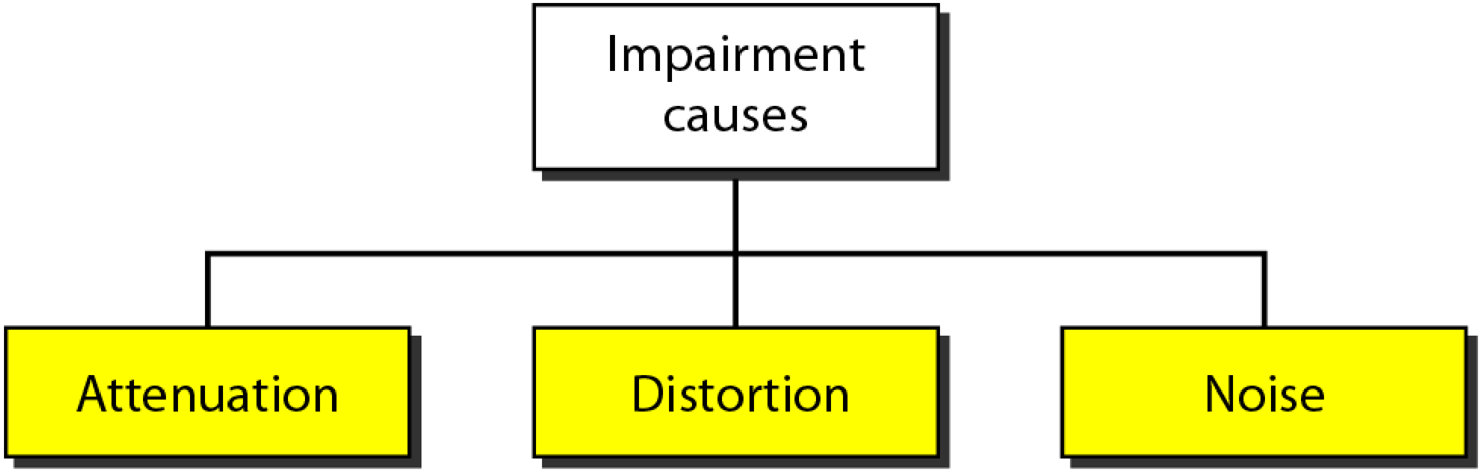
c) Radio Signals

d) None of the above

Transmission Impairment

- Signal transmit through medium that are not perfect.
- This imperfection cause signal impairment.
- What is sent is not received.

Causes of impairment



POLL 3

- Which of the following is **NOT** a type of impairment

a) Distortion

b) Attenuation

c) Noise

d) Amplification

Attenuation

- Means loss of energy => weaker signal
- When a signal travels through a medium it loses energy overcoming the resistance of the medium
- Amplifiers are used to compensate for this loss of energy by amplifying the signal.

Measurement of Attenuation

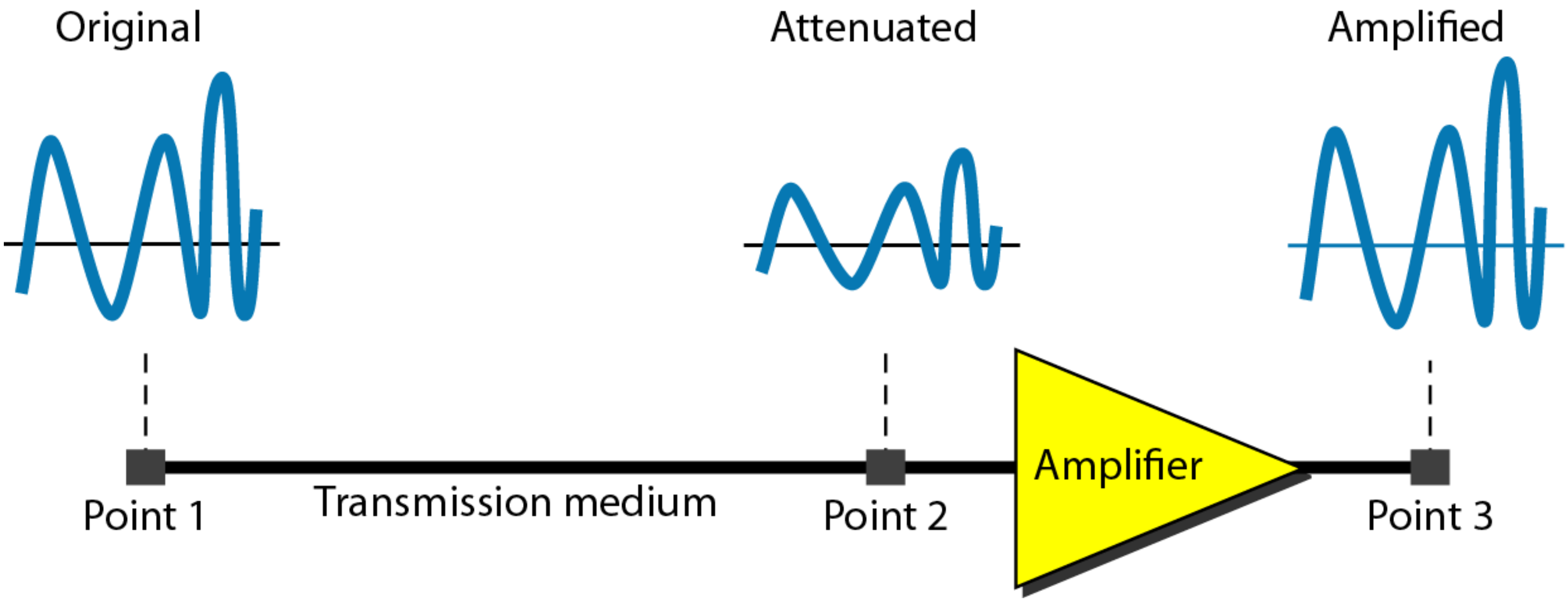
- To show the loss or gain of energy the unit "decibel" is used.

$$dB = 10\log_{10} P_2/P_1$$

P_1 - input signal

P_2 - output signal

Attenuation



Example

Suppose a signal travels through a transmission medium and its power is reduced to one-half. This means that P_2 is (1/2)P_1. In this case, the attenuation (loss of power) can be calculated as

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

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

Question

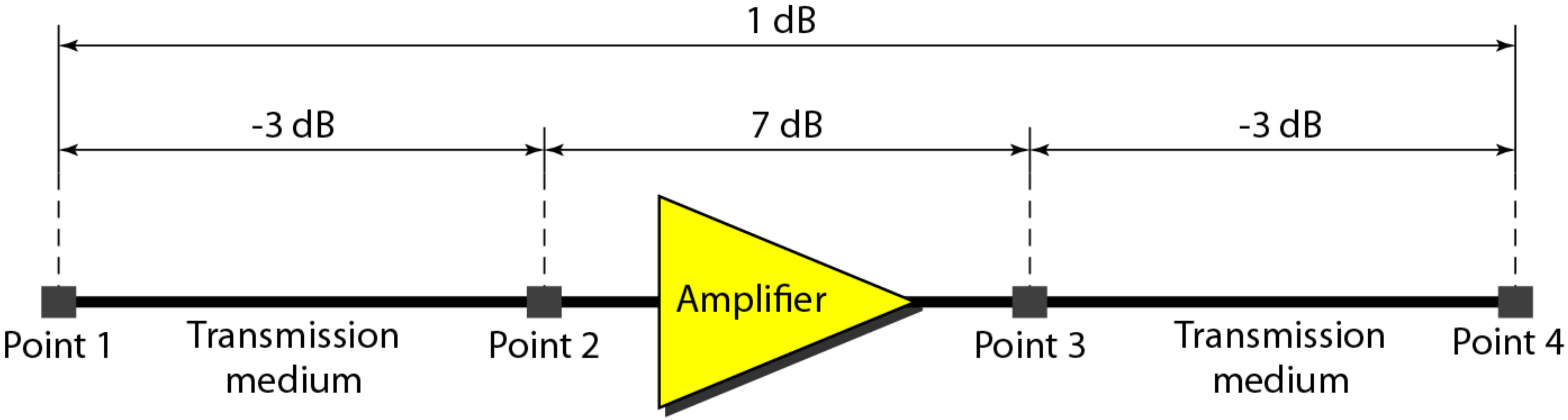
A signal travels through an amplifier, and its power is increased 10 times. This means that $P_2 = 10P_1$. In this case, the amplification (gain of power) will be

a) ***11 dB***
b) ***12 dB***
c) ***20 dB***
d) ***10 dB***

$$\boxed{10\log_{10}\frac{P_2}{P_1} = 10\log_{10}\frac{10P_1}{P_1}}$$

$$\boxed{= 10\log_{10}10 = 10(1) = 10\text{ dB}}$$

Decibels for Example



Example

One reason that engineers use the decibel to measure the changes in the strength of a signal is that decibel numbers can be added (or subtracted) when we are measuring several points (cascading) instead of just two. In Figure 3.27 a signal travels from point 1 to point 4. In this case, the decibel value can be calculated as

$$\boxed{dB = -3 + 7 - 3 = +1}$$

Example

Sometimes the decibel is used to measure signal power in milliwatts. In this case, it is referred to as dB_m and is calculated as $dB_m = 10 \log10 P_m$, where P_m is the power in milliwatts. Calculate the power of a signal with $dB_m = -30$.

Solution

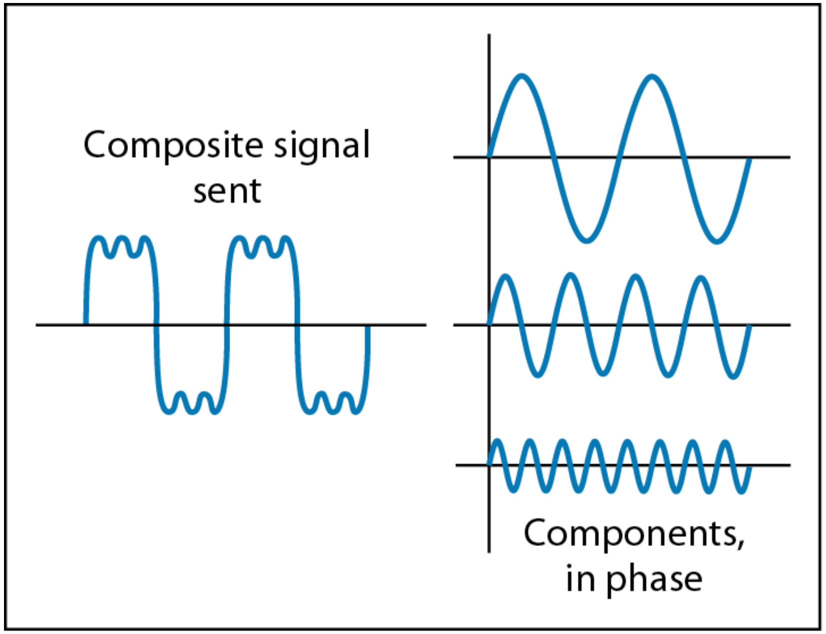
We can calculate the power in the signal as

$$\boxed{\begin{array}{c} \mathrm{dB_m} = 10 \log_{10} P_m = -30 \\ \log_{10} P_m = -3 \qquad P_m = 10^{-3}\ \mathrm{mW} \end{array}}$$

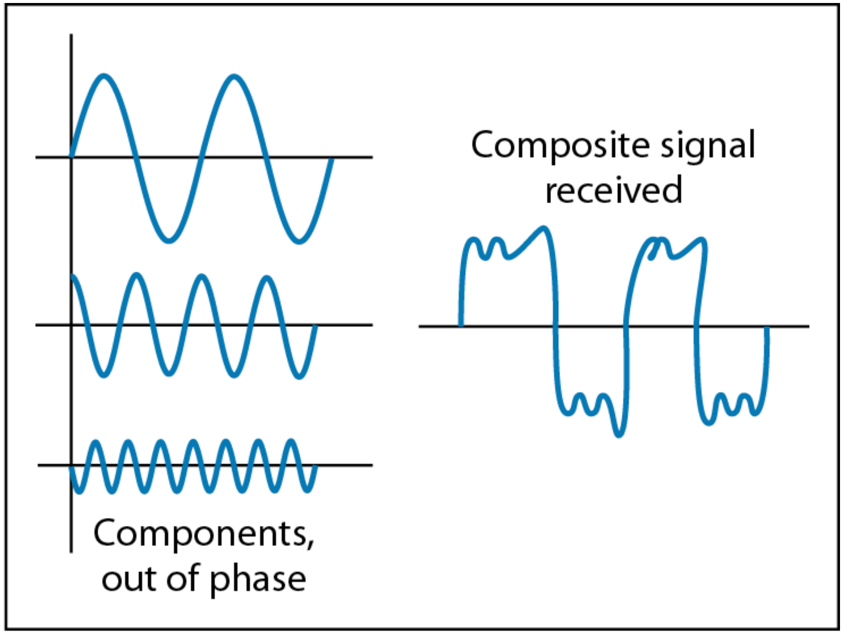
Distortion

- Means that the signal changes its form or shape
- Distortion occurs in composite signals
- Each frequency component has its own propagation speed traveling through a medium.
- The different components therefore arrive with different delays at the receiver.
- That means that the signals have different phases at the receiver than they did at the source.

Distortion



At the sender

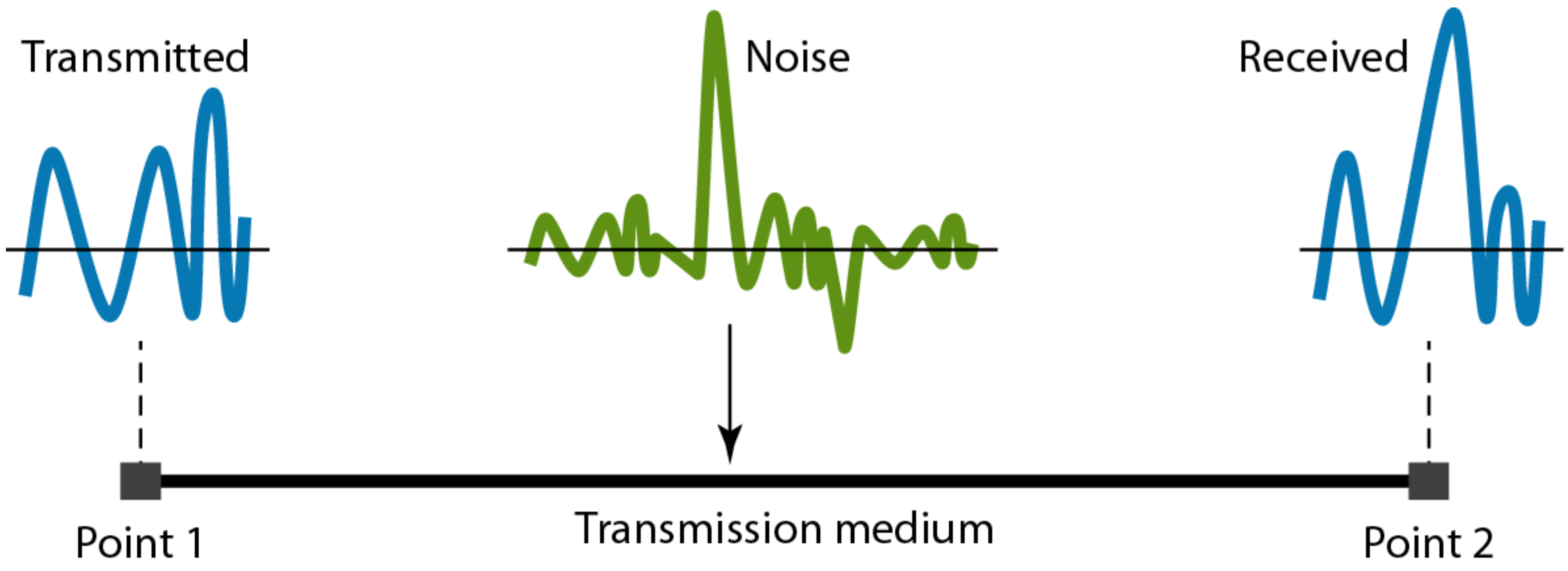


At the receiver

Noise

- There are different types of noise
  - Thermal - random noise of electrons in the wire creates an extra signal
  - Crosstalk - same as above but between two wires.
  - Impulse - Spikes that result from power lines, lightening, etc.
  - Induced

Noise



Transmitted
Noise
Received
Point 1
Transmission medium
Point 2

Signal to Noise Ratio (SNR)

- To measure the quality of a system the SNR is often used. It indicates the strength of the signal wrt the noise power in the system.
- It is the ratio between two powers.
- It is usually given in dB and referred to as SNR_{dB}.

Example

The power of a signal is 10 mW and the power of the noise is 1 μW; what are the values of SNR and SNR_{dB}?

Solution

The values of SNR and SNR_{dB} can be calculated as follows:

$$SNR = \frac{10{,}000\ \mu W}{1\ mW} = 10{,}000$$

$$SNR_{dB} = 10 \log_{10} 10{,}000 = 10 \log_{10} 10^4 = 40$$

Example

The values of SNR and SNR$_{dB}$ for a noiseless channel are

$$\mathrm{SNR} = \frac{\text{signal power}}{0} = \infty$$

$$\mathrm{SNR_{dB}} = 10 \log_{10} \infty = \infty$$

We can never achieve this ratio in real life; it is an ideal.

Figure *Two cases of SNR: a high SNR and a low SNR*