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Certified Wireless Network Administrator (CWNA)
PW0-106

Chapter 2
Radio Frequency Fundamentals

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Chapter 2 Overview

- What is a radio frequency signal?
- Radio frequency characteristics
- Radio frequency behaviors

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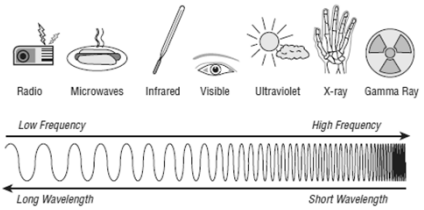
What is a radio frequency signal?

- **Electromagnetic (EM) wave**
- **Operates in electromagnetic spectrum**
- **Can move through matter or space**
- **Types of electromagnet waves include radio waves, gamma rays, X-rays, and visible light**
- **Begins as an alternating current (AC) signal sent through a copper conductor**
- **AC signal is radiated out of an antenna**
- **Travels at the speed of light**



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Radio Frequency Characteristic

- Wavelength
- Frequency
- Amplitude
- Phase

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Wavelength

- Distance between two successive points of a wave pattern
- Represented by the Greek symbol λ (lambda)
- Higher frequency = smaller wavelength
- 2.45 GHz wave = 4.82 inches (12.24 cm)
- 5.775 GHz wave = 2.04 inches (5.19 cm)

Wavelength (inches) = 11.811 / frequency (GHz)

Wavelength (centimeters) = 30/frequency (GHz)

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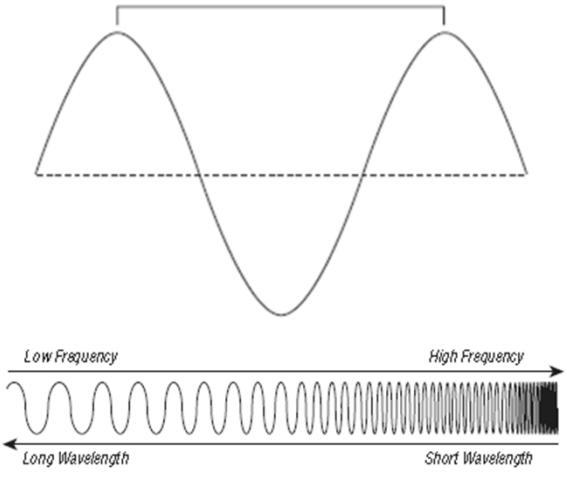
Wavelength (continued)



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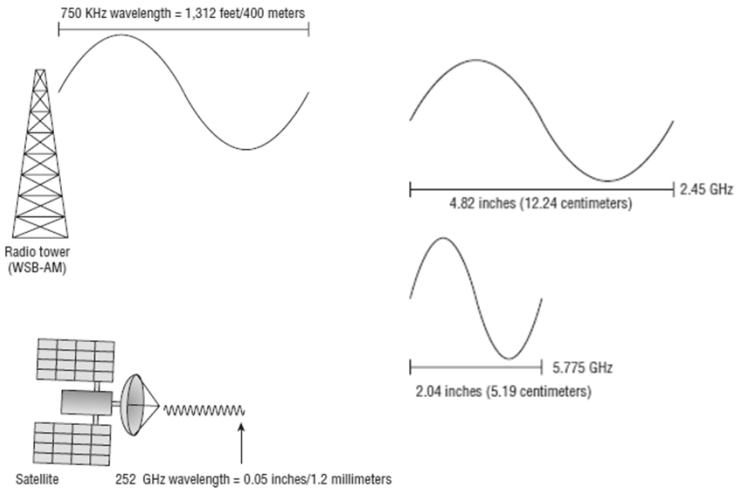
Wavelength (continued)



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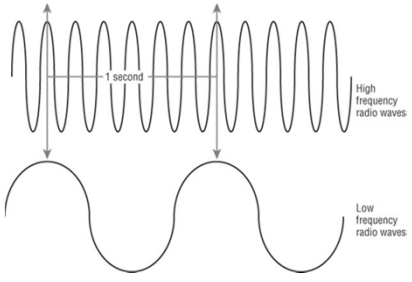
Frequency

- Number of cycles or oscillations within a specified time interval
- Measured in hertz (Hz)
- 1 hertz = 1 cycle per second



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Wavelength & Frequency Relationship

- There is an inverse relationship between wavelength and frequency
- Three components of this relationship
  - Frequency (f), measured in hertz (Hz)
  - Wavelength (λ), measured in meters (m)
  - Speed of light (c), constant value of 300,000,000 meters/sec
- $\lambda = c / f$ and $f = c / \lambda$
- The longer the wavelength, the lower the frequency (and vice versa)

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Amplitude

- Strength or power of the wave
- Defined as the maximum displacement of a continuous wave
- RF amplitude corresponds to the electrical field of the wave
- Transmit amplitude = initial amplitude that leaves the radio transmitter
- Receive amplitude = received signal strength
- Typical 802.11 transmit power (indoor devices)
  - 1 mW to 100 mW

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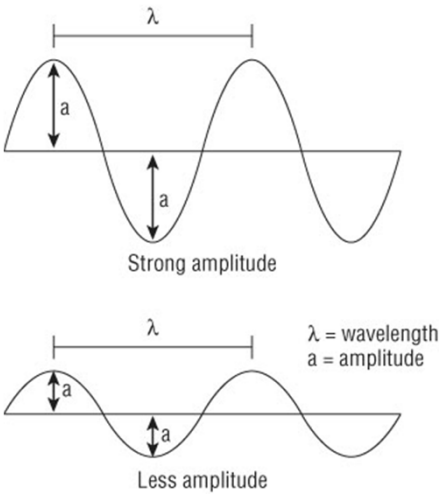
Amplitude (continued)



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Phase

- Involves the relationship between two or more signals that share the same frequency
- Measure in distance, time, or degrees
- Typically measure in degrees when referencing 802.11 waves
- In Phase = two waves with the peaks in exact alignment
- Out of Phase – two waves with the peaks not in exact alignment

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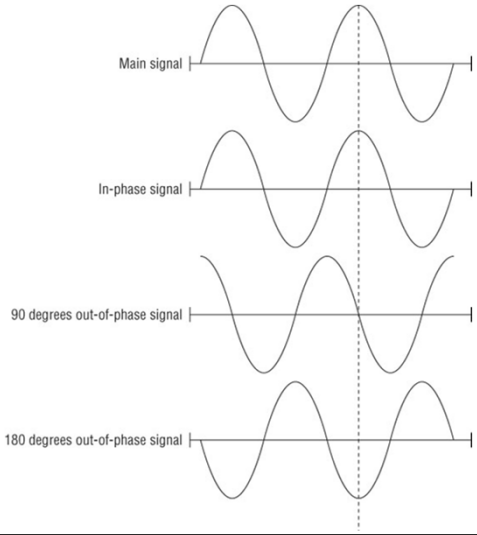
Phase (continued)



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Effects of Phase on Amplitude

- Two in-phase waves (0 degree separation) will combine their amplitude, resulting in a received signal with a greater signal strength
- Two waves 180 degrees out of phase will cancel each other out, resulting in an effective received signal strength of null
- With any other difference in phase, depending upon the amount of phase separation, the resulting signal could increase or decrease

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Radio Frequency Behaviors

- Wave propagation
- Absorption
- Reflection
- Scattering
- Defraction
- Diffraction
- Loss (attenuation)
- Free space path loss
- Multipath
- Gain (amplification)

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Wave Propagation

- Waves move away from the antenna
- As the wave moves away from the antenna, it will broaden or spread
- Wave propagation can be affected by:
  - Absorption - Reflection
  - Scattering - Refraction
  - Diffraction - Free space path
  - Multiplath - Loss (attenuation)
  - Gain (amplification)

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Absorption

- Most common RF behavior
- Most materials will absorb some amount of an RF signal
- Denser materials will absorb more RF signal
- A leading cause of attenuation
- Directly effects the amplitude of the wave

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Reflection

- When a wave bounces off an object instead of traveling through it
- Sky wave reflection can occur in frequencies below 1 GHz (large wavelengths)
- Microwave reflection occur between 1 GHz and 300 GHz (smaller wavelengths)
- Cause of multipath signal

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Scattering

- Multiple reflections
- Occurs when the wavelength is larger than pieces of the medium the signal is hitting
- Can occur as a wave moves through an object, reflecting off minute particles with the medium
- Can also occur when a wave encounters an uneven surface

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Refraction

- The bending of an RF signal as it passes through a medium with a different density
- Most commonly occurs due to atmospheric conditions
- Three most common causes
  - Water vapor
  - Changes in air temperature
  - Changes in air pressure

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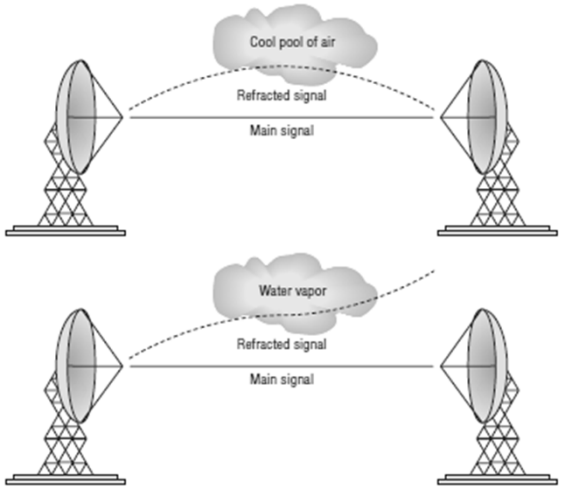
Refraction



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Diffraction

- The bending of an RF signal around an object
- It is the bending and spreading of an RF signal when it encounters an obstruction
- Typically caused by a partial blockage of the RF signal
- Sitting directly behind the obstruction is an area known as the RF shadow

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Loss (Attenuation)

- Decrease of amplitude or signal strength
- Causes include:
  - Absorption
  - Distance
  - Negative effects of multipath
- Water is a major source of absorption

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Free Space Path Loss (FSPL)

- Attenuation of a signal as it travels
- Loss of signal strength caused by the natural broadening of the waves (beam divergence)
- Loss of signal strength is logarithmic, not linear
- 6 dB rule = doubling the distance will result in a loss of amplitude of 6 dB

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Free Space Path Loss (FSPL) (continued)

FSPL = 36.6 + (20log10(f)) + (20log10(D))
FSPL = path loss in dB
f = frequency in MHz
D = distance in miles between antennas

FSPL = 32.44 + (20log10(f)) + (20log10(D))
FSPL = path loss in dB
f = frequency in MHz
D = distance in kilometers between antennas

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Multipath

- When two or more paths of a signal arrive at a receiving antenna at the same time or within nanoseconds of each other
- Caused by
  - Reflection - Scattering
  - Refraction - Diffraction
- Delay Spread = Time differential between multipath signals

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Multipath

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Multipath (continued)

- Four possible results of multipath
  - Upfade – increased signal strength
  - Downfade – decreased signal strength
  - Nulling – signal cancellation
  - Data corruption (most common)
- Intersymbol interference (ISI) = corruption caused by bits overlapping due to delay spread

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Gain (amplification)

- Increase of amplitude or signal strength
- Two types of gain
  - Active gain
  - Passive gain
- Active gain = increase caused by adding additional power
- Passive gain = increase caused by focusing the RF signal, typically by an antenna

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