WILEY

Certified Wireless Network Administrator (CWNA)
PW0-106

Chapter 4
Radio Frequency Signal and Antenna Concepts

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Chapter 4 Overview

- Active and Passive Gain
- Azimuth and Elevation Charts
- Interpreting Polar Charts
- Beamwidth
- Antenna Types
- Visual Line of Sight
- RF Line of Sight
- Fresnel Zone

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Chapter 4 Overview (continued)

- Earth Bulge
- Antenna Polarization
- Antenna Diversity
- Multiple-Input Multiple-Output (MIMO)
- Antenna Connection and Installation
- Antenna Accessories

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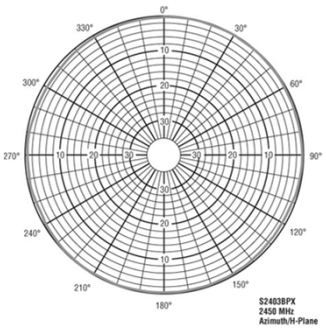
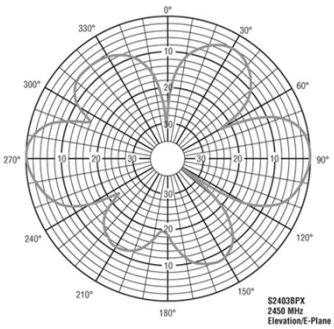
Azimuth and Elevation Charts

- Commonly known as radiation patterns
- Created in controlled environments
- Also known as polar charts





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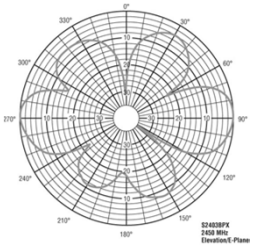
Azimuth and Elevation Charts (continued)

- Azimuth chart = H-plane = top-down view
- Elevation chart = E-plane = side view
- Outer ring usually represents strongest signal
- Scale of chart is in dB from outer ring inward
- Therefor chart is logarithmic not linear



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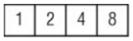
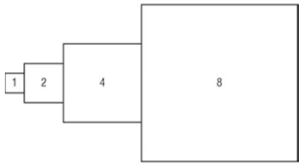
Interpreting Polar Charts

- Often misinterpreted and misread
- dB aspect of chart is often misunderstood
- If you have 4 boxes and each is double the previous, it is simpler to represent them as the first image versus the second





- However many people do not realize that the first image is a logarithmic representation, not the actual linear coverage

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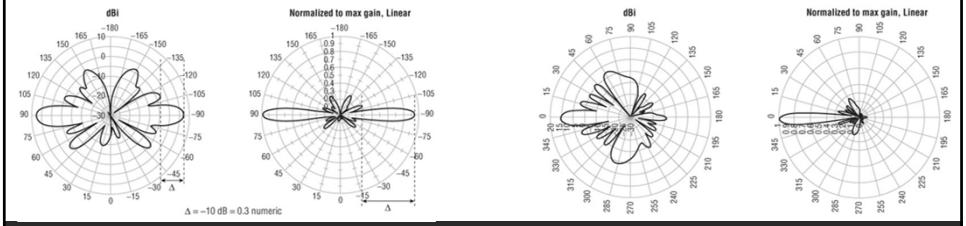
Interpreting Polar Charts (continued)

- Left images show logarithmic and linear representation of an omnidirectional antenna
- Right images show logarithmic and linear representation of a directional antenna
- Remember the 6 dB rule when creating a normalized view of a polar chart



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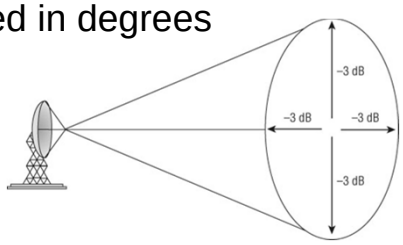
Beamwidth

- Measurement of how broad or narrow the focus of an antenna is
- Measured both horizontally and vertically
- Measurement from the strongest point on polar chart to the half power (-3 dB) points
- Measured in degrees



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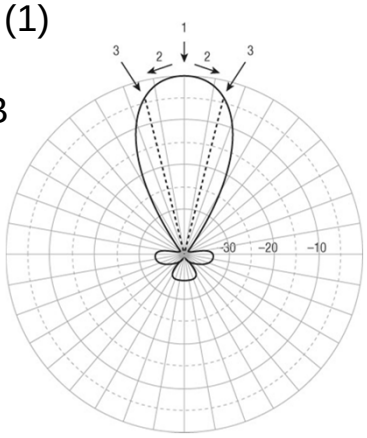
Beamwidth (continued)

- Start at the strongest point (1)
- On each side, move along the antenna pattern to 3 dB closer to center of polar chart (2)
- Draw a line to these points and measure the degrees between the lines (3)



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Beamwidth (continued)

Antenna types	Horizontal beamwidth (in degrees)	Vertical beamwidth (in degrees)
Omnidirectional	360	7 to 80
Patch/panel	30 to 180	6 to 90
Yagi	30 to 78	14 to 64
Sector	60 to 180	7 to 17
Parabolic dish	4 to 25	4 to 21

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Antenna Types

- Omnidirectional – radiates in all directions, provides general coverage
- Semidirectional – wide directional focus
- Highly directional – narrow directional focus
- Antennas focus both transmitted and received signals

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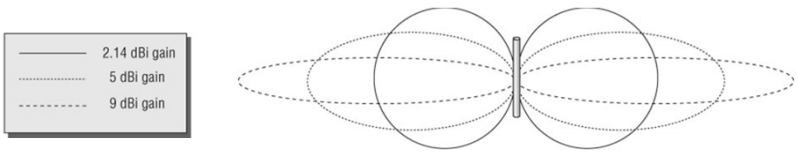
Omnidirectional Antennas

- Dipole antenna is typical
- Coverage pattern is bagel shaped
- Typically used for point-to-multipoint networks
- Top view (azimuth) is circular
- Side view (elevation) is shown below, varies with gain



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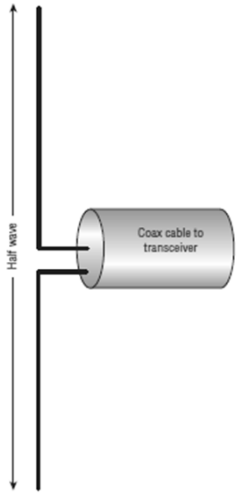
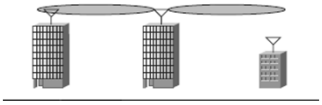
Half-wave dipole antenna



Improperly installed



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Semidirectional Antennas

- Directs signal in a specific direction
- Short to medium distance communications
- Three types of antennas
  - Patch
  - Panel
  - Yagi
- Planar Antennas (Patch & Panel)
- Horizontal beamwidth < 180 degrees


Patch


Yagi

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Highly Directional Antennas

- Most focused, narrow beamwidth
- Strictly point-to-point communications
- Two types of antennas
  - Parabolic Dish
  - Grid
- Grid antenna less susceptible to wind load

Grid

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Sector Antennas

- High-gain, semidirectional
- Generates very little RF signal behind the antenna (back lobe)
- Pie-shaped coverage – 60 to 180 degrees
- Sectorized array – multiple sector antennas installed as a group to provide 360 degrees of horizontal coverage
- Narrow vertical beamwidth – 7 to 17 degrees (slight downtilt)

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Antenna Arrays

- Group of two or more antennas integrated to provide coverage
- Perform beamforming – concentrating RF energy
- Three types of beamforming
- Static
- Transmit
- Dynamic

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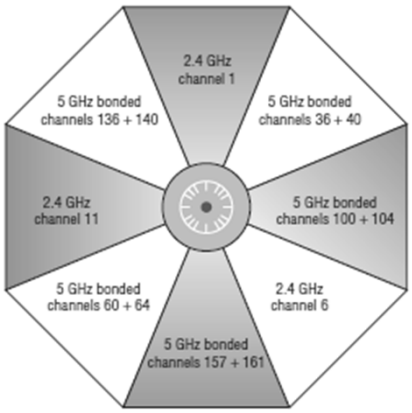
Static Beamforming

- Using directional antennas to provide a fixed radiation pattern
- Another term for sectorized array
- Slight overlap between antenna patterns can improve roaming



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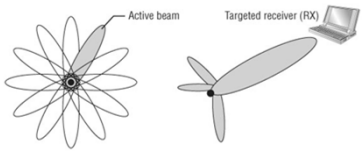
Dynamic Beamforming

- Focuses the RF energy in a specific direction and particular shape in the direction of an individual client
- Broadcast frames are sent omnidirectionally
- Pattern can change on a frame-by-frame basis
- Uses an adaptive antenna array
- Known as *smart antenna technology* or *beamstearing*



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Transmit Beamforming (TxBF)

- Multiple phase-shifted signals are transmitted to arrive in-phase at the location of the receiver
- A digital signal processing technology
- Technically not an antenna technology
- 802.11n amendment defines two types
  - Implicit TxBF
  - Explicit TxBF

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Visual Line of Sight (LOS)

- Perceived straight line that light travels along
- Due to refraction, diffraction, and reflection, there is a slight chance that it is not
- Has no bearing on successful RF transmission

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RF Line of Sight

- Required unobstructed LOS between two antennas
- Additional area needed around the visual LOS
- Additional area = Fresnel zone

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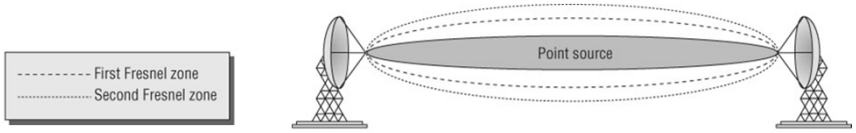
Fresnel Zone

- Imaginary American football-shaped area that surrounds the visual LOS between two point-to-point antennas
- Theoretically an infinite number of zones
- Closest zone is the first Fresnel zone
- First two zones are most relevant
- Only frequency and distance effect size of Fresnel zone (unaffected by antenna gain)



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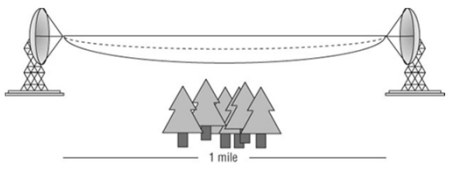
Fresnel Zone (continued)

- Obstruction of first Fresnel zone will negatively influence the integrity of the RF communication
- Obstruction decreases the energy of the received signal
- Ideally no obstructions at all
- > 40 percent obstruction will likely make the link unreliable



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Fresnel Zone Formula (at midpoint)

Radius of first Fresnel Zone

radius = $72.2 \times \sqrt{[D \div (4 \times F)]}$
D = distance of the link in miles
F = transmitting frequency in GHz

Minimum clearance formula (60% unobstructed)

radius (60%) = $43.3 \times \sqrt{[D \div (4 \times F)]}$
D = distance of the link in miles
F = transmitting frequency in GHz

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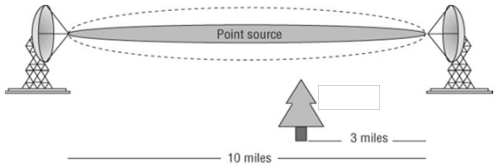
Fresnel Zone Formula (at any point)

Radius of first Fresnel Zone at any point

radius = $72.2 \times \sqrt{[(N \times d1 \times d2) \div (F \times D)]}$

N = which Fresnel zone you are calculating (usually 1 or 2)
d1 = distance from one antenna to the location of the obstacle in miles
d2 = distance from the obstacle to the other antenna in miles
D = total distance between the antennas in miles (D = d1 + d2)
F = frequency in GHz



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Earth Bulge

- Curvature of the earth
- Must be considered if link is > 7 miles

  $H = D^2 \div 8$

  H = height of the earth bulge in feet

  D = distance between the antennas in miles

- Overall antenna height formula

  H = obstacle height + earth bulge + Fresnel zone

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Antenna Polarization

- Orientation of the amplitude of the RF waves
  - Vertical
  - Horizontal
- Transmitting and receiving antennas must have the same orientation
- "Antenna Properties.wmv" from the book's website www.sybex.com/go/cwna3e presents this well

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Antenna Diversity

- Exists when wireless device has two antennas and receivers functioning together
- Pre-802.11n radios use switched diversity
- Listens with multiple antennas but only processes the signal with the best amplitude – known as receive diversity
- When transmitting, the device will the antenna that was last used to receive – known as transmit diversity

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Multiple-Input Multiple-Output (MIMO)

- More sophisticated form of antenna diversity
- Radio architecture that can receive or transmit using multiple antennas concurrently
- Uses complex signal-processing techniques
- Enhances
  - Reliability
  - Range
  - Throughput
- Used by 802.11n and 802.11ac radios

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MIMO Antennas

- Indoor MIMO Antennas
  - Typically not much choice
  - Usually 3 omnidirectional antennas
  - One antenna vertical, other two slightly tilted
- Outdoor MIMO Antennas
  - Usually 2 antennas per radio
  - Multipath is provided by using different polarization
  - Special pairs of omnidirectional antennas provide horizontal and vertical polarization
  - Directional MIMO antennas incorporated two antenna elements within one physical antenna

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Antenna Connection and Installation

- Voltage Standing Wave Ratio (VSWR)
- Signal Loss
- Antenna Mounting
  - Placement
  - Mounting
    - Indoor mounting considerations
    - Outdoor mounting considerations
  - Appropriate use and environment
    - Ingress Protection Rating (IP Code)
    - National Electrical Manufacturers Association (NEMA) Enclosure Rating
    - "Appareils destinés à être utilisés en **AT**mosphères **Ex**plosives" (ATEX) Directives
    - National Electrical Code (NEC) hazardous locations

Antenna Connection and Installation (continued)

- Antenna Mounting (continued)
  - Orientation and alignment
  - Safety
  - Maintenance

Antenna Accessories

- Cables
- Connectors
- Splitters
- Amplifiers
  - Fixed-gain
  - Fixed-output
- Attenuators
- Lightning arrestors
- Grounding rods and wires

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Regulatory Compliance

- For an access point manufacturer to sell its product within a country or region, it must prove that its product operates within the rules of the relevant regulatory domain, such as the FCC.
- The FCC does allow an antenna to be substituted with a different one, providing two key conditions are met:
  - The gain of the new antenna must be the same or lower than the antenna that the system was certified with.
  - The new antenna must be of the same type, which means that the antenna must have the same in-band and out-of-band characteristics.

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- Azimuth and Elevation Charts
- Interpreting Polar Charts
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- RF Line of Sight
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