General License Class

Chapter 7

Antennas

Antenna Basics

- Review
  - Elements
    - Conducting portion of an antenna.
      - Radiate or receive signal.
    - Driven element.
      - Element(s) to which power is applied.

Antenna Basics

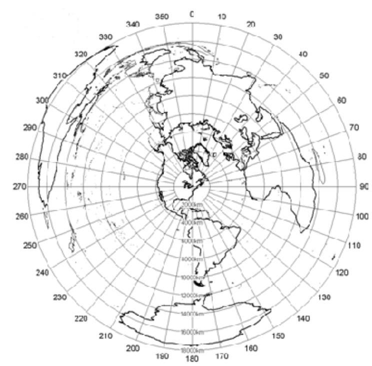
- Review
  - Polarization
    - Orientation of electric field with respect to the earth.
      - Horizontal polarization.
        - Electric field parallel to surface of the earth.
      - Vertical polarization.
        - Electric field perpendicular to surface of the earth.
    - Same as orientation of driven element.

Antenna Basics

- Review
  - Feed-Point Impedance
    - Ratio of RF voltage to RF current at antenna feedpoint.
    - Antenna is resonant if impedance is purely resistive.

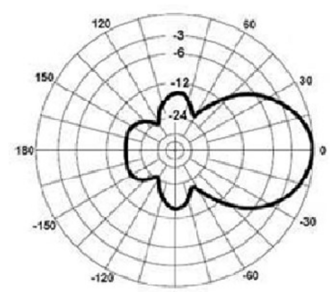
Antenna Basics

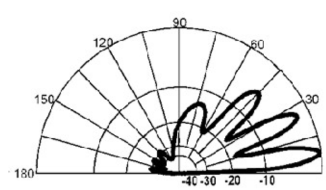
- Review
  - Azimuthal.
    - Azimuth is from the Arabic “al-sumut” meaning “the direction”.
    - “Azimuthal” therefore refers to directions: north, south, east, west, etc.
    - Azimuthal map projection is a map centered on a specified point.



Antenna Basics

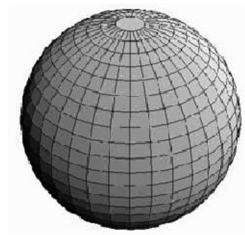
- Review
  - Radiation Pattern
    - Azimuthal pattern.
      - Graph of relative signal strength in horizontal directions.
    - Elevation pattern.
      - Graph of relative signal strength in vertical directions.
    - Lobes & nulls.
      - Regions where radiated signal is a maximum or a minimum.





Antenna Basics

- Review
  - Isotropic Antenna.
    - Theoretical point radiator.
      - Impossible to construct.
    - Radiates equally in **ALL** directions.
      - Radiation pattern is a perfect sphere.



Antenna Basics

- Review
  - Antenna gain references.
    - Gain referenced to an isotropic radiator is expressed as dBi.
    - Gain referenced to a half-wave dipole is expressed as dBd.
    - A half-wave dipole has 2.15 dB gain over an isotropic radiator.
      - 0 dBd = 2.15 dBi.

Antenna Basics

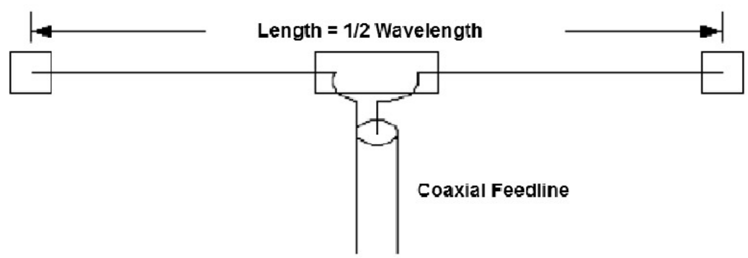
- Review
  - Directional Antenna.
    - Gain.
      - Antennas are passive.
        - $P_{OUT} \leq P_{IN}$
      - "Gain" is accomplished by concentrating radiated energy in one direction at the expense of another.

Antenna Basics

- Review
  - Directional Antenna.
    - Front-to-back ratio (F/B).
      - Ratio of signal strength in forward direction (largest lobe) to signal strength 180° from forward direction.
    - Front-to-side ratio (F/S).
      - Ratio of signal strength in forward direction to signal strength 90° from forward direction.

Dipoles, Ground-Planes, & Random Wires

- Dipoles
  - Most basic real-world antenna.
    - Most other antenna designs are based on the dipole.

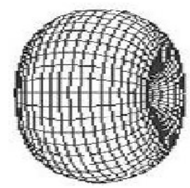


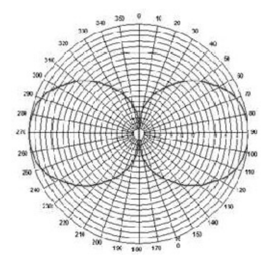
Dipoles, Ground-Planes, & Random Wires

- Dipoles
  - Easily constructed.
    - Actual length shorter than free-space length.
      - Physical thickness of wire.
        - Thicker = shorter.
        - Thicker = wider bandwidth.
      - Proximity to nearby objects.
        - Closer = shorter.
    - Start with Length(ft) = 492 / f_{MHz} & trim for resonance.

Dipoles, Ground-Planes, & Random Wires

- Dipoles
  - Radiation pattern.
    - Toroidal (donut-shaped).
  - Gain = 2.15 dBi.
  - Also used as a reference for antenna gain.
    - Gain referenced to a dipole is expressed as dBd.
    - 0 dBd = 2.15 dBi



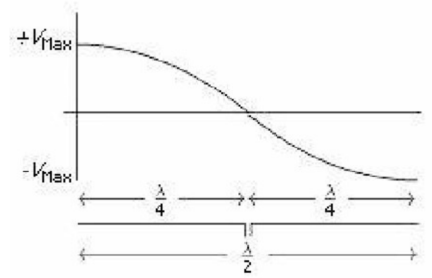


Dipoles, Ground-Planes, & Random Wires

- Dipoles
  - Feedpoint Impedance.
    - Approximately 72Ω in free space.
      - Varies with height above ground.
      - Varies with proximity to nearby objects.
      - Typically closer to 50Ω in real-world installations.
    - Feedpoint impedance at odd harmonics will be about the same as the impedance at fundamental frequency.
      - A 40m dipole (7 MHz) will work well on 15m (21 MHz).

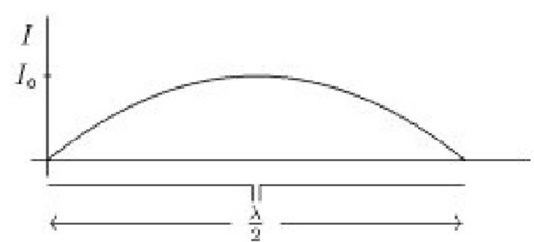
Dipoles, Ground-Planes, & Random Wires

- Dipoles
  - Voltage distribution.
    - Minimum at feedpoint.
    - Maximum at ends.



Dipoles, Ground-Planes, & Random Wires

- Dipoles
  - Current distribution.
    - Maximum at feedpoint.
    - Zero at ends.

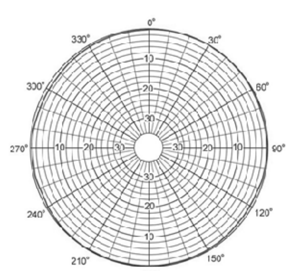


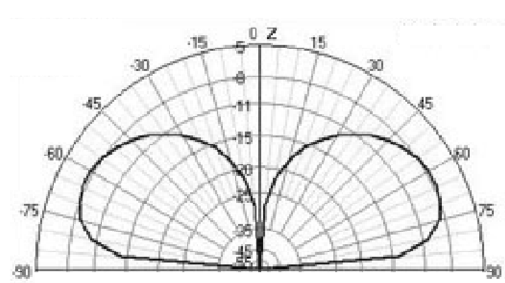
Dipoles, Ground-Planes, & Random Wires

- Ground-Planes (Verticals)
  - One half of a dipole with other half replaced with an electrical "mirror" called a ground plane.
    - Ground plane.
      - Earth -- metal screen, mesh, or plate -- radials.
    - 1/4λ long.
      - Length(ft) = 246 / f_{MHz} (trim for resonance).
    - Feedpoint at junction of radiator & ground plane.

Dipoles, Ground-Planes, & Random Wires

- Ground-Planes (Verticals)
  - Radiation pattern.
    - Omni-directional.





Dipoles, Ground-Planes, & Random Wires

- Ground-Planes (Verticals)
  - Feedpoint impedance.
    - 35Ω with horizontal radials.
    - Angling radials downward (drooping) raises impedance.
      - At between 30° & 45° impedance equals 50Ω.
      - Increasing droop angle to 90° results in a half-wave dipole with an impedance of 72Ω.

Dipoles, Ground-Planes, & Random Wires

- Ground-Planes (Verticals)
  - Mobile HF antennas.
    - Usually some variation of a ground-plane antenna.
      - Thin steel whip mounted vertically.
      - Vehicle body serves as ground plane.
    - Full-size vertical not practical on HF bands.
      - Exception: 10m & 12m.
    - Some type of “loading” is used to make short antenna resonant on desired band.

Dipoles, Ground-Planes, & Random Wires

- Ground-Planes (Verticals)
  - Mobile HF antennas.
    - Loading techniques.
      - Loading coil.
        - Adds inductance to lower resonant frequency.
        - Narrows bandwidth.
        - Adds loss.
        - Can be placed at bottom, middle, or top of radiator.
        - Can be adjustable to cover different bands.

Dipoles, Ground-Planes, & Random Wires

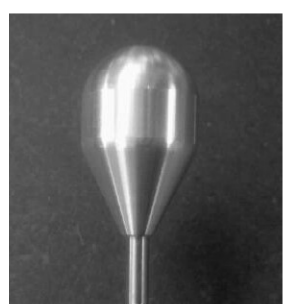
- Ground-Planes (Verticals)
  - Mobile HF antennas.
    - Loading techniques.
      - Capacitive hat.
        - Adds capacitance to lower resonant frequency.
        - Increases bandwidth.
        - Reduces loss.
        - Usually placed near the top of the radiator.

Dipoles, Ground-Planes, & Random Wires

- Ground-Planes (Verticals)
  - Mobile HF antennas.
    - Loading techniques.
      - Linear loading.
        - Part of antenna folded back on itself.
        - Not commonly used in mobile applications.

Dipoles, Ground-Planes, & Random Wires

- Ground-Planes (Verticals)
  - Mobile HF antennas.
    - Corona ball.
      - Small metal sphere at tip of whip.
      - Prevents static discharge from sharp tip of antenna.



Dipoles, Ground-Planes, & Random Wires

- Ground-Planes (Verticals)
  - Mobile HF antennas.
    - Screwdriver antenna.
      - Bottom-mounted loading coil.
      - Motor runs tap up & down coil to adjust for different bands.
        - High Sierra (160m to 6m).
        - Little Tarheel II (80m to 6m).
        - Yaesu ATAS-100 (40m to 70cm).
      - Good compromise between performance & convenience.

Dipoles, Ground-Planes, & Random Wires

- Random Wires
  - Random length of wire put up any way you can.
    - Feedpoint impedance unpredictable.
    - Radiation pattern unpredictable.
    - Connected directly to transmitter or antenna tuner.
      - Station equipment part of antenna system.
      - RF burns from contacting equipment possible.
    - Can yield good results on any band where impedance match can be achieved.

Dipoles, Ground-Planes, & Random Wires

- Effects of Height Above Ground
  - Feedpoint impedance affected by height above ground.
    - Below 1/2λ above ground, impedance steadily decreases as height decreases.
    - Above 1/2λ above ground, impedance repeatedly increases then decreases as height increases.
      - Impedance variations decrease in amplitude until settling on free-space value (72Ω) several wavelengths above the ground.

Dipoles, Ground-Planes, & Random Wires

- Effects of Height Above Ground
  - Radiation pattern affected by height above ground.
    - Signals reflects off ground and combines with direct signal to change pattern.
    - Below 1/2λ above ground, dipole is nearly omni-directional with maximum radiation straight up.
      - Near Vertical Incidence Skywave (NVIS).
        - Useful on 80m & 40m for communicating with close-in stations.

Dipoles, Ground-Planes, & Random Wires

- Effects of Polarization
  - Radiation pattern affected by height above ground.
    - Reflection of signal off of the ground results in signal loss.
      - Loss is less if wave is horizontally polarized.
    - Vertical antennas have lower angle of radiation than horizontal antennas mounted near the ground.
      - Vertical antennas preferred for DX on lower frequency bands.

G4E01 -- What is the purpose of a capacitance hat on a mobile antenna?

A. To increase the power handling capacity of a whip antenna
B. To allow automatic band changing
C. To electrically lengthen a physically short antenna
D. To allow remote tuning

G4E02 -- What is the purpose of a "corona ball" on a HF mobile antenna?

A. To narrow the operating bandwidth of the antenna
B. To increase the "Q" of the antenna
C. To reduce the chance of damage if the antenna should strike an object
D. To reduce high voltage discharge from the tip of the antenna

G4E06 -- What is one disadvantage of using a shortened mobile antenna as opposed to a full size antenna?

A. Short antennas are more likely to cause distortion of transmitted signals
B. Short antennas can only receive vertically polarized signals
C. Operating bandwidth may be very limited
D. Harmonic radiation may increase

G9B01 -- What is one disadvantage of a directly fed random-wire HF antenna?

A. It must be longer than 1 wavelength
B. You may experience RF burns when touching metal objects in your station
C. It produces only vertically polarized radiation
D. It is more effective on the lower HF bands than on the higher bands

G9B02 -- Which of the following is a common way to adjust the feed point impedance of a quarter wave ground plane vertical antenna to be approximately 50 ohms?

A. Slope the radials upward
B. Slope the radials downward
C. Lengthen the radials
D. Shorten the radials

G9B03 -- What happens to the feed-point impedance of a ground-plane antenna when its radials are changed from horizontal to downward-sloping?

A. It decreases
B. It increases
C. It stays the same
D. It reaches a maximum at an angle of 45 degrees

G9B04 -- What is the radiation pattern of a dipole antenna in free space in the plane of the conductor?

A. It is a figure-eight at right angles to the antenna
B. It is a figure-eight off both ends of the antenna
C. It is a circle (equal radiation in all directions)
D. It has a pair of lobes on one side of the antenna and a single lobe on the other side

G9B05 -- How does antenna height affect the horizontal (azimuthal) radiation pattern of a horizontal dipole HF antenna?

A. If the antenna is too high, the pattern becomes unpredictable
B. Antenna height has no effect on the pattern
C. If the antenna is less than 1/2 wavelength high, the azimuthal pattern is almost omnidirectional
D. If the antenna is less than 1/2 wavelength high, radiation off the ends of the wire is eliminated

G9B06 -- Where should the radial wires of a ground-mounted vertical antenna system be placed?

A. As high as possible above the ground
B. Parallel to the antenna element
C. On the surface or buried a few inches below the ground
D. At the center of the antenna

G9B07 -- How does the feed-point impedance of a 1/2 wave dipole antenna change as the antenna is lowered from 1/4 wave above ground?

A. It steadily increases
B. It steadily decreases
C. It peaks at about 1/8 wavelength above ground
D. It is unaffected by the height above ground

G9B08 -- How does the feed-point impedance of a 1/2 wave dipole change as the feed-point location is moved from the center toward the ends?

A. It steadily increases
B. It steadily decreases
C. It peaks at about 1/8 wavelength from the end
D. It is unaffected by the location of the feed point

G9B09 -- Which of the following is an advantage of a horizontally polarized as compared to vertically polarized HF antenna?

A. Lower ground reflection losses
B. Lower feed-point impedance
C. Shorter Radials
D. Lower radiation

G9B10 -- What is the approximate length for a 1/2-wave dipole antenna cut for 14.250 MHz?

A. 8 feet
B. 16 feet
C. 24 feet
D. 32 feet

G9B11 -- What is the approximate length for a 1/2-wave dipole antenna cut for 3.550 MHz?

A. 42 feet
B. 84 feet
C. 131 feet
D. 263 feet

G9B12 -- What is the approximate length for a 1/4-wave vertical antenna cut for 28.5 MHz?

A. 8 feet
B. 11 feet
C. 16 feet
D. 21 feet

G9C19 -- How does antenna gain stated in dBi compare to gain stated in dBd for the same antenna?

A. dBi gain figures are 2.15 dB lower then dBd gain figures

B. dBi gain figures are 2.15 dB higher than dBd gain figures

C. dBi gain figures are the same as the square root of dBd gain figures multiplied by 2.15

D. dBi gain figures are the reciprocal of dBd gain figures + 2.15 dB

G9C20 -- What is meant by the terms dBi and dBd when referring to antenna gain?

A. dBi refers to an isotropic antenna, dBd refers to a dipole antenna

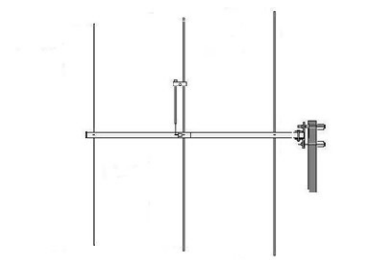
B. dBi refers to an ionospheric reflecting antenna, dBd refers to a dissipative antenna

C. dBi refers to an inverted-vee antenna, dBd refers to a downward reflecting antenna

D. dBi refers to an isometric antenna, dBd refers to a discone antenna

Yagi Antennas

- How Yagis Work
  - Most popular directional antenna.
    - Simple to construct.
    - Provides gain.
    - Rejects interference.



Yagi Antennas

- How Yagis Work
  - Dipoles, ground-planes, & random wire antennas have a single element.

Yagi Antennas

- How Yagis Work
  - An array antenna has more than one element.
    - Driven array.
      - Power fed to all elements.
    - Parasitic array.
      - Power fed to one element (driven element).
      - Remaining elements radiate power coupled from the driven element.

Yagi Antennas

- How Yagis Work
  - Array antenna.
    - Radiation from the elements combine constructively & destructively to create a directional radiation pattern.
      - If in phase, constructive interference increases signal strength.
      - If out of phase, destructive interference decreases signal strength.

Yagi Antennas

- Yagi Structure & Function
  - Yagi antennas are parasitic array antennas with 2 or more elements.
  - Yagi antennas have one driven element.
  - Yagi antennas have one or more parasitic elements called reflectors & directors.

Yagi Antennas

- Yagi Structure & Function
  - Reflectors.
    - One.
      - Additional reflectors make little difference in either gain or front-to-back ratio.
    - About 0.15λ behind driven element.
    - About 5% longer than driven element.

Yagi Antennas

- Yagi Structure & Function
  - Directors.
    - One or more (if any).
      - Additional directors have little effect on front-to-back ratio.
      - Additional directors increase gain.
    - About 0.15λ in front of driven element.
    - About 5% shorter than driven element.

Yagi Antennas

- Yagi Structure & Function
  - 2-element Yagi (1 reflector & 0 directors).
    - Gain is approximately 7 dBi (5 dBd).
    - Front-to-back ratio is approximately 10-15 dB.
  - 3-element Yagi (1 reflector & 1 director).
    - Theoretical maximum gain is 9.7 dBi (7.55 dBd).
    - Front-to-back ratio is approximately 30-35 dB.

Yagi Antennas

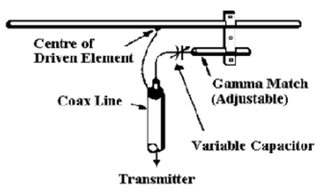
- Design Tradeoffs
  - Adding directors increases gain.
  - Increasing spacing between directors increases gain.
    - At some point, gain starts to decrease with increased spacing.
  - Larger diameter elements decreases change of impedance with frequency (increases bandwidth).
  - Changing spacing & length of elements changes gain, front-to-back ratio, & feedpoint impedance.

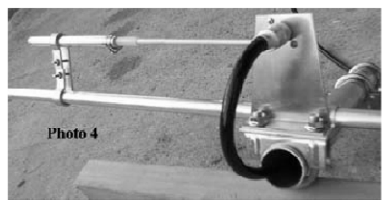
Yagi Antennas

- Impedance Matching
  - Most Yagi designs have a feedpoint impedance of 20-25Ω.
    - SWR >2:1 if fed with 50Ω transmission line.
    - Impedance matching network required to match antenna to feedline.

Yagi Antennas

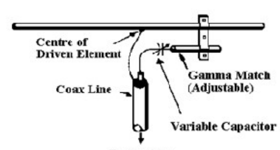
- Impedance Matching
  - Gamma match.
    - Most commonly used matching network.
    - Easy to construct.
    - Easy to adjust.

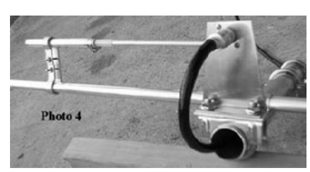




Yagi Antennas

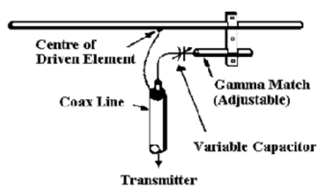
- Impedance Matching
  - Gamma match.
    - Short section of parallel-line transmission line.
      - Driven element is one side of transmission line.
      - Transmission line transforms relatively low impedance of antenna to higher impedance of transmission line.

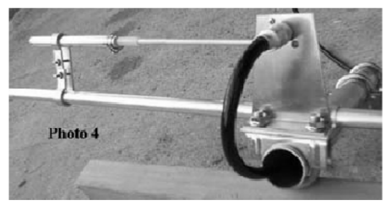




Yagi Antennas

- Impedance Matching
  - Gamma match.
    - Adjustment capacitor.
      - Can be actual capacitor.
      - Usually a metal rod or wire placed inside a metal tube.
    - Adjust capacitor & position of strap for 1:1 SWR.





G2D04 -- Which of the following describes an azimuthal projection map?

A. A map that shows accurate land masses

B. A map that shows true bearings and distances from a particular location

C. A map that shows the angle at which an amateur satellite crosses the equator

D. A map that shows the number of degrees longitude that an amateur satellite appears to move westward at the equator with each orbit

G2D11 -- Which HF antenna would be the best to use for minimizing interference?

A. A quarter-wave vertical antenna
B. An isotropic antenna
C. A directional antenna
D. An omnidirectional antenna

G9C01 -- Which of the following would increase the bandwidth of a Yagi antenna?

A. Larger diameter elements
B. Closer element spacing
C. Loading coils in series with the element
D. Tapered-diameter elements

G9C02 -- What is the approximate length of the driven element of a Yagi antenna?

A. 1/4 wavelength
B. 1/2 wavelength
C. 3/4 wavelength
D. 1 wavelength

G9C03 -- Which statement about a three-element, single-band Yagi antenna is true?

A. The reflector is normally the shortest element
B. The director is normally the shortest element
C. The driven element is the longest element
D. Low feed point impedance increases bandwidth

G9C04 -- Which statement about a three-element; single-band Yagi antenna is true?

A. The reflector is normally the longest element
B. The director is normally the longest element
C. The reflector is normally the shortest element
D. All of the elements must be the same length

G9C05 -- How does increasing boom length and adding directors affect a Yagi antenna?

A. Gain increases
B. Beamwidth increases
C. Front to back ratio decreases
D. Front to side ratio decreases

G9C07 -- What does "front-to-back ratio" mean in reference to a Yagi antenna?

A. The number of directors versus the number of reflectors
B. The relative position of the driven element with respect to the reflectors and directors
C. The power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction
D. The ratio of forward gain to dipole gain

G9C08 -- What is meant by the "main lobe" of a directive antenna?

A. The magnitude of the maximum vertical angle of radiation
B. The point of maximum current in a radiating antenna element
C. The maximum voltage standing wave point on a radiating element
D. The direction of maximum radiated field strength from the antenna

G9C10 -- Which of the following is a Yagi antenna design variable that could be adjusted to optimize forward gain, front-to-back ratio, or SWR bandwidth?

A. The physical length of the boom
B. The number of elements on the boom
C. The spacing of each element along the boom
D. All of these choices are correct

G9C11 -- What is the purpose of a gamma match used with Yagi antennas?

A. To match the relatively low feed-point impedance to 50 ohms
B. To match the relatively high feed-point impedance to 50 ohms
C. To increase the front to back ratio
D. To increase the main lobe gain

G9C12 -- Which of the following is an advantage of using a gamma match for impedance matching of a Yagi antenna to 50-ohm coax feed line?

A. It does not require that the elements be insulated from the boom
B. It does not require any inductors or capacitors
C. It is useful for matching multiband antennas
D. All of these choices are correct

Break

Loop Antennas

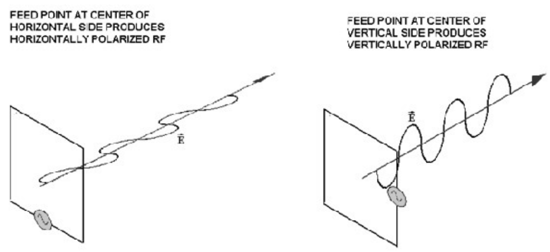
- Loop of wire that completely encloses an area.
  - Normally 1λ or greater in circumference.
  - Can be square, circle, or triangle.
  - Major lobe is perpendicular to plane of the loop.
  - Null is in plane of the loop.

Loop Antennas

- Loop of wire that completely encloses an area.
  - Quad loop.
    - Square loop with each side 1/4λ long.
  - Delta loop.
    - Triangular loop with each side 1/3λ long.

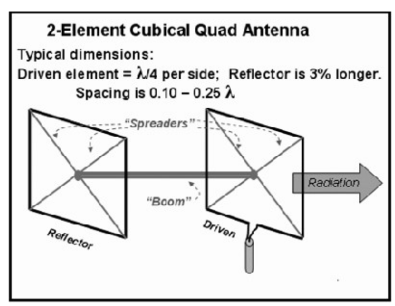
Loop Antennas

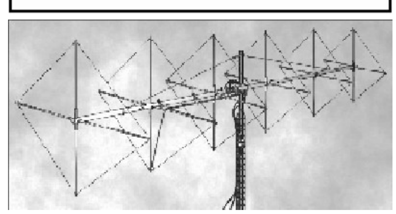
- Polarization.
  - Horizontally polarized if horizontal side is fed.
  - Vertically polarized if vertical side is fed.



Loop Antennas

- Loop Arrays.
  - Cubical quad antenna.
    - Variation of the Yagi.
    - 2 or more quad loops mounted on a boom.
    - 2-element quad has about the same gain as a 3-element Yagi.



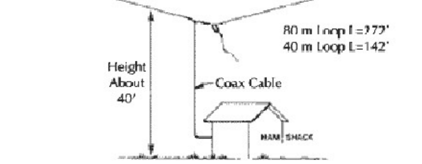


Loop Antennas

- Loop Arrays.
  - Cubical quad antenna vs. Yagi.
    - Quad more mechanically complex.
      - Cross arms required to hold wire.
    - Quad has more surface area.
      - Higher wind loading.
    - Quad more susceptible to ice damage.
    - 2-element quad has about the same gain as a 3-element Yagi.

Loop Antennas

- Polarization of a horizontally-mounted loop.
  - Always horizontally polarized regardless of shape of loop or location of feedpoint.



G9C06 -- What configuration of the loops of a two-element quad antenna must be used for the antenna to operate as a beam antenna, assuming one of the elements is used as a reflector?

A. The driven element must be fed with a balun transformer
B. There must be an open circuit in the driven element at the point opposite the feed point
C. The reflector element must be approximately 5 percent shorter than the driven element
D. The reflector element must be approximately 5 percent longer than the driven element

G9C13 -- Approximately how long is each side of the driven element of a quad antenna?

A. 1/4 wavelength
B. 1/2 wavelength
C. 3/4 wavelength
D. 1 wavelength

G9C14 -- How does the forward gain of a two-element quad antenna compare to the forward gain of a three-element Yagi antenna?

A. About 2/3 as much
B. About the same
C. About 1.5 times as much
D. About twice as much

G9C15 -- Approximately how long is each side of a quad antenna reflector element?

A. Slightly less than 1/4 wavelength
B. Slightly more than 1/4 wavelength
C. Slightly less than 1/2 wavelength
D. Slightly more than 1/2 wavelength

G9C16 -- How does the gain of a two-element delta-loop beam compare to the gain of a two-element quad antenna?

A. 3 dB higher
B. 3 dB lower
C. 2.54 dB higher
D. About the same

G9C17 -- Approximately how long is each leg of a symmetrical delta-loop antenna?

A. 1/4 wavelength
B. 1/3 wavelength
C. 1/2 wavelength
D. 2/3 wavelength

G9C18 -- What happens when the feed point of a quad antenna is changed from the center of either horizontal wire to the center of either vertical wire?

A. The polarization of the radiated signal changes from horizontal to vertical

B. The polarization of the radiated signal changes from vertical to horizontal

C. There is no change in polarization

D. The radiated signal becomes circularly polarized

Specialized Antennas

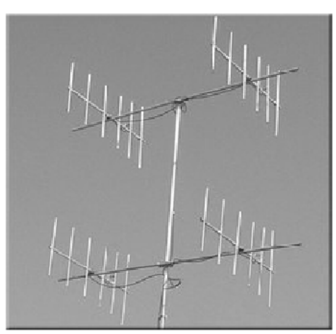
- NVIS
  - Near Vertical Incidence Skywave.
    - Below 1/2λ above ground, dipole is nearly omni-directional with maximum radiation straight up.
  - Horizontally-polarized antenna mounted 1/10λ to 1/4λ above ground.
    - Wire on ground below antenna increases efficiency.

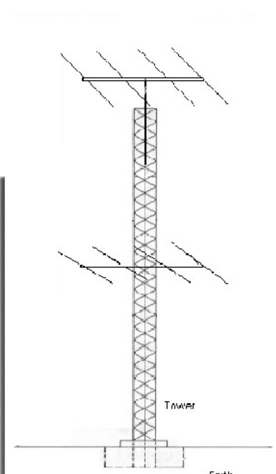
Specialized Antennas

- NVIS
  - High angle of radiation.
  - Useful for communicating with close-in stations.
    - Up to a few hundred kilometers.
    - Popular on 80m & 40m.
      - Especially useful for state-wide emergency communications.

Specialized Antennas

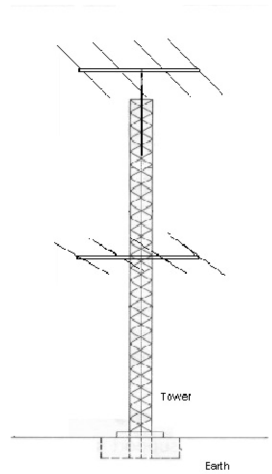
- Stacked Antennas
  - Mounting 2 or more Yagis side-by-side or one above the other.





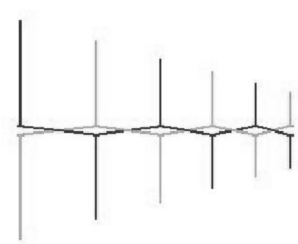
Specialized Antennas

- Stacked Antennas
  - Vertically stacked antennas.
    - Mounted 1/2λ to 1 λ apart.
      - 1/2λ most common.
      - About 3dB gain for 2 antennas.
    - Narrows elevation beamwidth.



Specialized Antennas

- Log Periodics
  - Length & spacing of elements increase logarithmically.
  - Extremely wide bandwidth.
    - Up to 10:1.
  - Widely used for TV antennas.

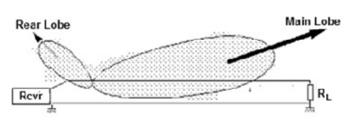


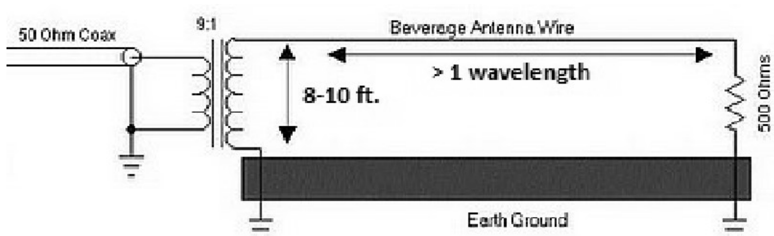
Specialized Antennas

- Log Periodics
  - Less gain than Yagi.
  - Less front-to-back ratio then Yagi.

Specialized Antennas

- Beverage antenna.
  - Traveling-Wave antenna.
  - 1λ or more long.
  - Uni-directional.





Specialized Antennas

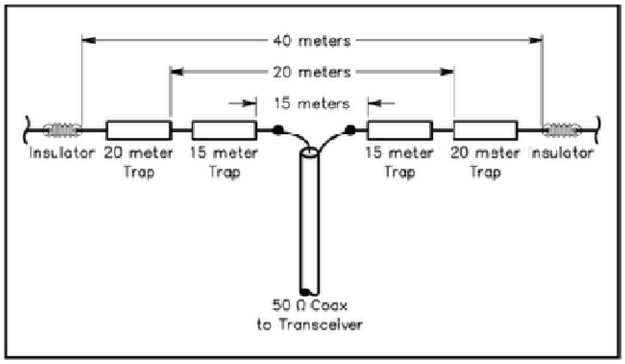
- Beverage Antennas
  - Very inefficient.
    - Low gain.
    - Receive only.
  - Rejects noise.
    - Greatly improves receive performance on low bands.
      - 160m, 80m, & 40m.

Specialized Antennas

- Multiband Antennas
  - Few can put up separate antenna for each band.
    - Dipole works well on odd harmonics.
    - Random wire is multi-band by definition.
  - Mutiband usually refers to an antenna that reconfigures itself for 2 or more bands.

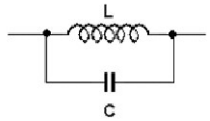
Specialized Antennas

- Multiband Antennas
  - Trapped dipole.



Specialized Antennas

- Multiband Antennas
  - Traps.
    - At resonance a parallel L-C circuit looks like an open circuit.
      - Can be used as an RF switch.
      - Permit multi-band operation.



Specialized Antennas

- Multiband Antennas
  - Trapped dipole.
    - Wire between each pair of traps is a 1/2λ dipole.
      - Outer dipoles are shortened because inductors in traps act like loading coils below the trap resonant frequency.

Specialized Antennas

- Multiband Antennas
  - Tri-band beam.
    - 3 or 4 element Yagi with traps in each element.
    - Typically provides 20m, 15m, & 10m operation.
    - Most popular HF directional antenna.

Specialized Antennas

- Multiband Antennas
  - Disadvantages.
    - Will not reject radiation of harmonics.
    - Traps have losses.
    - Traps narrow bandwidth.
    - On lower frequency bands, antenna is shortened.
      - Less efficient than full-sized antenna.

G9C09 -- How does the gain of two 3-element horizontally polarized Yagi antennas spaced vertically 1/2 wavelength apart typically compare to the gain of a single 3-element Yagi?

A. Approximately 1.5 dB higher

B. Approximately 3 dB higher

C. Approximately 6 dB higher

D. Approximately 9 dB higher

G9D01 -- What does the term "NVIS" mean as related to antennas?

A. Nearly Vertical Inductance System
B. Non-Varying Indicated SWR
C. Non-Varying Impedance Smoothing
D. Near Vertical Incidence Sky-wave

G9D02 -- Which of the following is an advantage of an NVIS antenna?

A. Low vertical angle radiation for working stations out to ranges of several thousand kilometers
B. High vertical angle radiation for working stations within a radius of a few hundred kilometers
C. High forward gain
D. All of these choices are correct

G9D03 -- At what height above ground is an NVIS antenna typically installed?

A. As close to 1/2f wave as possible
B. As close to one wavelength as possible
C. Height is not critical as long as it is significantly more than 1/2 wavelength
D. Between 1/10 and 1/4 wavelength

G9D04 -- What is the primary purpose of antenna traps?

A. To permit multiband operation
B. To notch spurious frequencies
C. To provide balanced feed point impedance
D. To prevent out of band operation

G9D05 -- What is the advantage of vertical stacking of horizontally polarized Yagi antennas?

A. Allows quick selection of vertical or horizontal polarization
B. Allows simultaneous vertical and horizontal polarization
C. Narrows the main lobe in azimuth
D. Narrows the main lobe in elevation

G9D06 -- Which of the following is an advantage of a log periodic antenna?

A. Wide bandwidth
B. Higher gain per element than a Yagi antenna
C. Harmonic suppression
D. Polarization diversity

G9D07 -- Which of the following describes a log periodic antenna?

A. Length and spacing of the elements increases logarithmically from one end of the boom to the other
B. Impedance varies periodically as a function of frequency
C. Gain varies logarithmically as a function of frequency
D. SWR varies periodically as a function of boom length

G9D08 -- Why is a Beverage antenna not used for transmitting?

A. Its impedance is too low for effective matching
B. It has high losses compared to other types of antennas
C. It has poor directivity
D. All of these choices are correct

G9D09 -- Which of the following is an application for a Beverage antenna?

A. Directional transmitting for low HF bands
B. Directional receiving for low HF bands
C. Portable direction finding at higher HF frequencies
D. Portable direction finding at lower HF frequencies

G9D10 -- Which of the following describes a Beverage antenna?

A. A vertical antenna constructed from beverage cans
B. A broad-band mobile antenna
C. A helical antenna for space reception
D. A very long and low directional receiving antenna

G9D11 -- Which of the following is a disadvantage of multiband antennas?

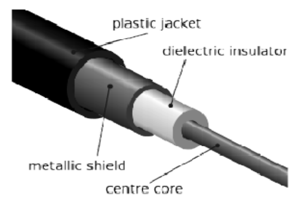
A. They present low impedance on all design frequencies
B. They must be used with an antenna tuner
C. They must be fed with open wire line
D. They have poor harmonic rejection

Feed Lines

- Characteristic Impedance
  - All feedlines have 2 conductors.
  - Impedance determined by geometry of conductors & electrical properties of insulation material.
    - Insulating material has more effect on feedline loss than impedance.

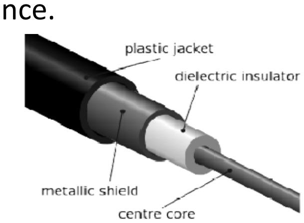
Feed Lines

- Characteristic Impedance
  - Coaxial cable.
    - Center conductor surrounded by cylindrical conductor (sleeve or braid).
    - Conductors insulated from each other by a dielectric material.



Feed Lines

- Characteristic Impedance
  - Coaxial cable.
    - Characteristic impedance determined by ratio of diameter of shield to diameter of center conductor.
      - Larger ratio → higher impedance.
      - 50Ω – RG-58, RG-8X, RG-8.
      - 75Ω – RG-59, RG-6, RG-11.

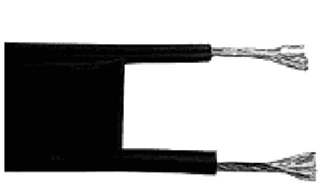


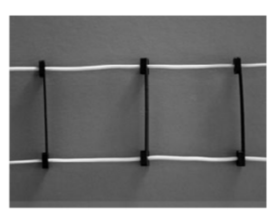
Feed Lines

- Characteristic Impedance
  - Balanced line.
    - Two parallel wires separated by an insulator.
    - Characteristic impedance determined by ratio of diameter of conductors to distance between them.
      - Larger distance → higher impedance.
      - Smaller diameter → higher impedance.

Feed Lines

- Characteristic Impedance
  - Balanced line.
    - 300 Ω – TV TwinLead.
    - 450 Ω – Window line.
    - 600 Ω – Open-wire or ladder line.



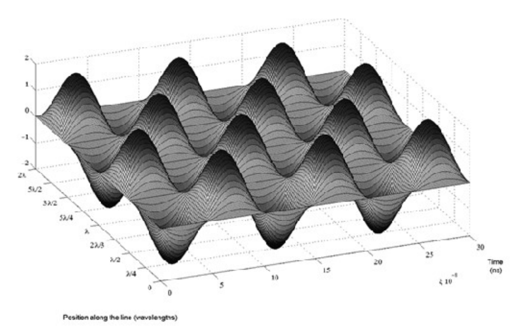


Feed Lines

- Forward & Reflected Power & SWR
  - All power is transferred from feedline to antenna only if impedances are matched.
  - If impedances do not match, some power is reflected back to transmitter.
    - Reflection can occur at:
      - Feedline-to-antenna connection.
      - Connector.
      - Connection between one type of feedline & another.

Feed Lines

- Forward & Reflected Power & SWR
  - Reflected power combines with forward power to form an interference pattern.



Feed Lines

- Forward & Reflected Power & SWR
  - Interference pattern results in standing waves on transmission line.
    - At one point along the line, voltage will be a maximum (V_{Max}).
    - At another point along the line, voltage will be a minimum (V_{Min}).

Feed Lines

- Forward & Reflected Power & SWR
  - Voltage standing wave ratio (VSWR).
    - $VSWR = V_{Max} / V_{Min}$
    - $VSWR = Z_{Load} / Z_{Line}$ or Z_{Line} / Z_{Load}
      - VSWR always > 1.
  - Most amateur equipment designed to work into a 50Ω load.
    - SWR > 2:1 may cause transmitter to shut down.
      - $Z_{Load} < 25\Omega$ or $Z_{Load} > 100\Omega$

Feed Lines

- Impedance Matching
  - To eliminate SWR on the transmission line, the antenna feedpoint impedance must be matched to the transmission line impedance.
    - Matching network MUST be located at antenna.
    - Not always practical.
      - Matching often done between transmitter & transmission line.
        - **Does NOT reduce SWR on transmission line!**

Feed Lines

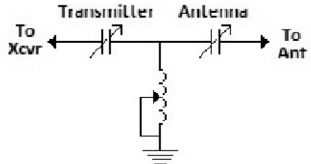
- Impedance Matching
  - Device used to match impedances is called:
    - Impedance matcher,
    - Transmatch,
    - Antenna Coupler, or
    - Antenna tuner.
      - Antenna tunes does NOT tune the antenna. It merely transforms the imepdance of the antenna system to 50Ω.

Feed Lines

- Impedance Matching
  - Sections of transmission lines called “stubs” can also be used to match impedances.
    - Single frequency & not adjustable.
    - Military often used specified lengths of transmission line to match antenna to transmitter.

Feed Lines

- Impedance Matching.
  - Antenna Tuners
    - T-Network.



Feed Lines

- Feed Line Loss
  - All feedlines dissipate some of the power as heat.
    - Resistance of conductors.
    - Absorption by insulating material.
      - Air or vacuum has lowest loss.
      - Teflon has extremely low loss.
      - Polyethylene has higher loss.
      - Solid materials have highest loss.

Feed Lines

- Feed Line Loss
  - All feedlines dissipate some of the power as heat.
    - Loss expressed in dB/100ft at specific frequency.
      - Loss increases as frequency increases.
      - Smaller cables generally have higher loss.

Feed Lines

Cable Type	Impedance	dB/100' @ 30 MHz	dB/100' @ 150 MHz
RG-174	50Ω	4.4 dB	10.2 dB
RG-58	50Ω	2.4 dB	5.6 dB
RG-8x	50Ω	1.9 dB	4.5 dB
RG-213	50Ω	1.2 dB	2.8 dB
9913	50Ω	0.64 dB	1.6 dB
LMR-400	50Ω	0.65 dB	1.5 dB
LMR-600	50Ω	0.41 dB	0.94 dB
RG-6	75Ω	1.0 dB	2.5 dB
CATV ½" Hard-line	75Ω	0.26 dB	0.62 dB

Feed Lines

- Feed Line Loss & SWR
  - As SWR increases, effective line loss is increased.
    - As SWR increases, more power is reflected back to be dissipated as heat in the line.
  - As line loss increases, apparent SWR decreases.
    - If infinite line loss, no power reflected, so apparent SWR is 1:1.

G4A06 -- What type of device is often used to match transmitter output impedance to an impedance not equal to 50 ohms?

A. Balanced modulator
B. SWR Bridge
C. Antenna coupler or antenna tuner
D. Q Multiplier

G9A01 -- Which of the following factors determine the characteristic impedance of a parallel conductor antenna feed line?

A. The distance between the centers of the conductors and the radius of the conductors
B. The distance between the centers of the conductors and the length of the line
C. The radius of the conductors and the frequency of the signal
D. The frequency of the signal and the length of the line

G9A02 -- What are the typical characteristic impedances of coaxial cables used for antenna feed lines at amateur stations?

A. 25 and 30 ohms
B. 50 and 75 ohms
C. 80 and 100 ohms
D. 500 and 750 ohms

G9A03 -- What is the characteristic impedance of flat ribbon TV type twinlead?

A. 50 ohms
B. 75 ohms
C. 100 ohms
D. 300 ohms

G9A04 -- What might cause reflected power at the point where a feed line connects to an antenna?

A. Operating an antenna at its resonant frequency
B. Using more transmitter power than the antenna can handle
C. A difference between feed line impedance and antenna feed point impedance
D. Feeding the antenna with unbalanced feed line

G9A05 -- How does the attenuation of coaxial cable change as the frequency of the signal it is carrying increases?

A. Attenuation is independent of frequency
B. Attenuation increases
C. Attenuation decreases
D. Attenuation reaches a maximum at approximately 18 MHz

G9A06 -- In what units is RF feed line loss usually expressed?

A. ohms per 1000 ft
B. dB per 1000 ft
C. ohms per 100 ft
D. dB per 100 ft

G9A07 -- What must be done to prevent standing waves on an antenna feed line?

A. The antenna feed point must be at DC ground potential
B. The feed line must be cut to an odd number of electrical quarter wavelengths
C. The feed line must be cut to an even number of physical half wavelengths
D. The antenna feed point impedance must be matched to the characteristic impedance of the feed line

G9A08 -- If the SWR on an antenna feed line is 5 to 1, and a matching network at the transmitter end of the feed line is adjusted to 1 to 1 SWR, what is the resulting SWR on the feed line?

A. 1 to 1
B. 5 to 1
C. Between 1 to 1 and 5 to 1 depending on the characteristic impedance of the line
D. Between 1 to 1 and 5 to 1 depending on the reflected power at the transmitter

G9A09 -- What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having a 200 ohm impedance?

A. 4:1
B. 1:4
C. 2:1
D. 1:2

G9A10 -- What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 10 ohm impedance?

A. 2:1
B. 50:1
C. 1:5
D. 5:1

G9A11 -- What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 50 ohm impedance?

A. 2:1
B. 1:1
C. 50:50
D. 0:0

G9A12 -- What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 25 ohm impedance?

A. 2:1
B. 2.5:1
C. 1.25:1
D. You cannot determine SWR from impedance values

G9A13 -- What standing wave ratio will result when connecting a 50 ohm feed line to an antenna that has a purely resistive 300 ohm feed point impedance?

A. 1.5:1
B. 3:1
C. 6:1
D. You cannot determine SWR from impedance values

G9A14 -- What is the interaction between high standing wave ratio (SWR) and transmission line loss?

A. There is no interaction between transmission line loss and SWR
B. If a transmission line is lossy, high SWR will increase the loss
C. High SWR makes it difficult to measure transmission line loss
D. High SWR reduces the relative effect of transmission line loss

G9A15 -- What is the effect of transmission line loss on SWR measured at the input to the line?

A. The higher the transmission line loss, the more the SWR will read artificially low
B. The higher the transmission line loss, the more the SWR will read artificially high
C. The higher the transmission line loss, the more accurate the SWR measurement will be
D. Transmission line loss does not affect the SWR measurement

Questions?

Next Week

Chapter 8

Propagation