General License Class

1

General Class

Chapter 7

Antennas

2

Antenna Basics

Review

- Elements
  - The conducting parts of an antenna.
    - Elements radiate or receive signals.
  - Driven element.
    - The element(s) to which power is applied.

3

Antenna Basics

Review

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

4

Antenna Basics

Review

- Feed-Point Impedance
  - The ratio of RF voltage to RF current at the antenna feedpoint.
  - The antenna is resonant if the impedance is purely resistive.

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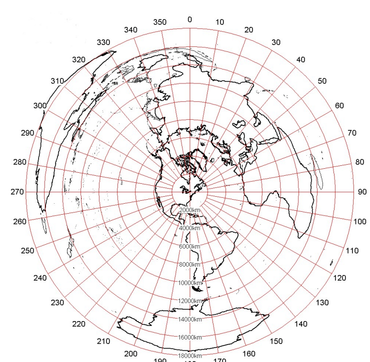
Antenna Basics

Review

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



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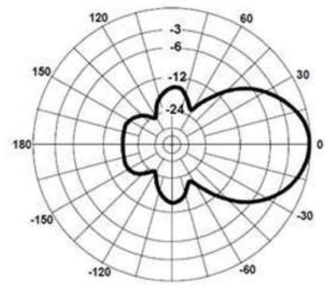
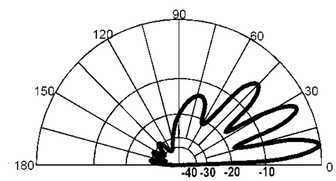
Antenna Basics

Review

- Radiation Pattern
  - Azimuthal pattern.
    - A graph of the relative signal strength in horizontal directions.
  - Elevation pattern.
    - A graph of the relative signal strength in vertical directions.





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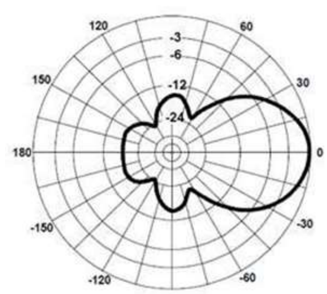
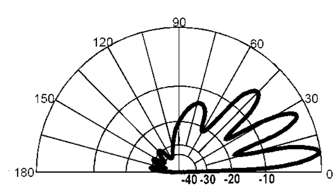
Antenna Basics

Review

- Radiation Pattern
  - Lobes.
    - Regions where the radiated signal strength is a maximum.
  - Nulls.
    - Regions where the radiated signal strength is a minimum.





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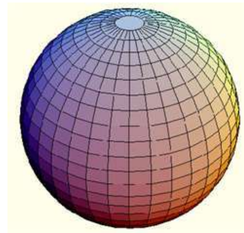
Antenna Basics

Review

- Isotropic Antenna.
  - A theoretical point radiator.
    - Impossible to construct.
  - Radiates equally in ALL directions.
    - Radiation pattern is perfect sphere.
  - Used as a reference for antenna gain.
    - Gain referenced to an isotropic radiator is expressed as dBi.



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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.

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Antenna Basics

Review

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

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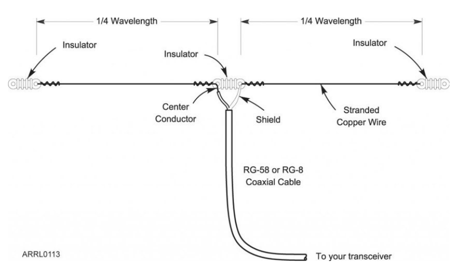
Dipoles and Ground-Planes

Dipoles

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



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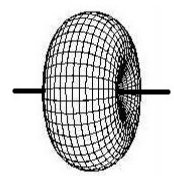
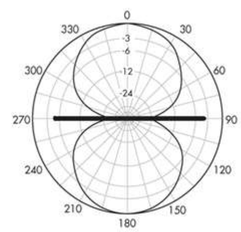
Dipoles and Ground-Planes

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





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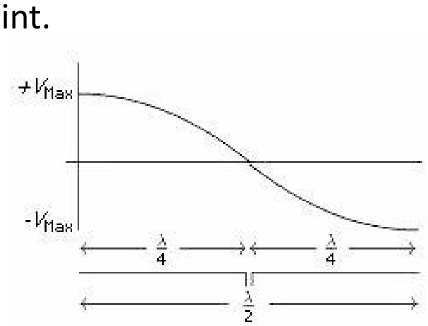
Dipoles and Ground-Planes

Dipoles

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



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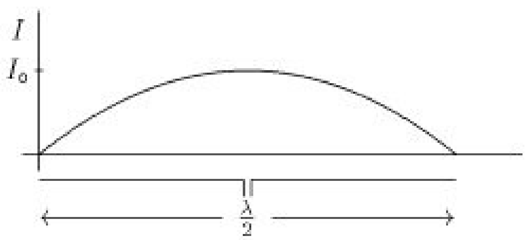
Dipoles and Ground-Planes

Dipoles

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



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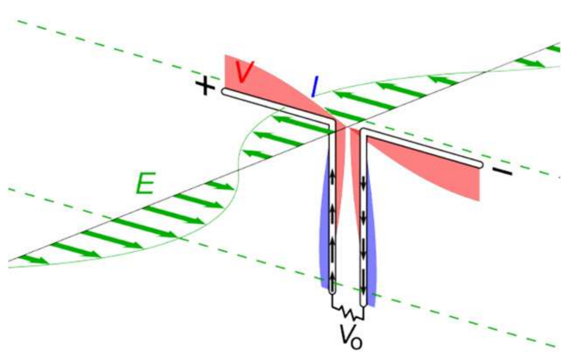
Dipoles and Ground-Planes

Dipoles



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Dipoles and Ground-Planes

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.

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Dipoles and Ground-Planes

Dipoles

- Feedpoint Impedance.
  - The feedpoint impedance increases as the feedpoint is moved away from the center of the antenna.
    - Off-center fed dipole (OCF).
      - Often incorrectly called a “windom” antenna.
    - End-fed half-wave (EFHW).
      - The feedpoint impedance is very high.

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Dipoles and Ground-Planes

Dipoles

- Feedpoint Impedance.
  - The feedpoint impedance at the odd harmonics will be about the same as the impedance at the fundamental frequency.
    - A 40m dipole (7 MHz) will also work well on 15m (21 MHz).
  - The feedpoint impedance at the even harmonics will be very high.
    - About the same as an end-fed dipole.

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Dipoles and Ground-Planes

- Dipoles
  - Dipoles are easily constructed.
    - The actual length is shorter than the free-space length.
      - The length varies with the thickness of the wire.
        - Thicker → Shorter.
        - Thicker → Wider Bandwidth.
      - The length varies with proximity to nearby objects.
        - Closer → Shorter.

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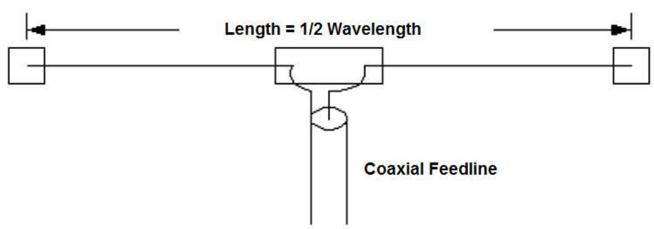
Dipoles and Ground-Planes

- Dipoles
  - Easily constructed.
    - Start with Length(ft) = 492 / f_{MHz} & trim for resonance.



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Dipoles and Ground-Planes

- Dipoles
  - Dipoles can be mounted is just about any configuration.
    - They do **NOT** have to be straight & level.
    - Often mounted with a single support point at the center.
      - Inverted-V.
    - Often mounted with a single support point at the end
      - Sloper.

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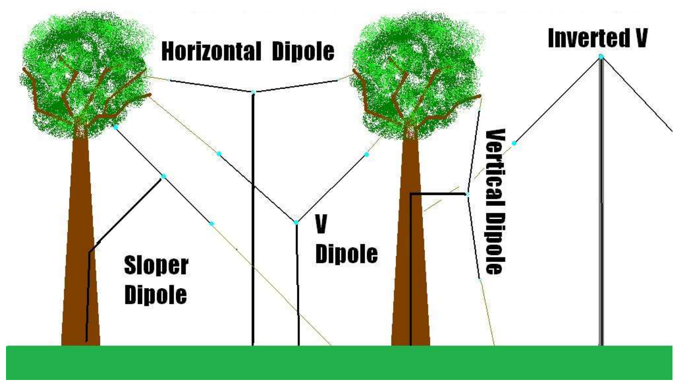
Dipoles and Ground-Planes

- Dipoles



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Dipoles and Ground-Planes

Ground-Planes (Verticals)

- One half of a dipole with the other half replaced with an electrical "mirror" called a ground plane.
  - Vertical element is 1/4λ long.
    - Length(ft) = 246 / f_{MHz} (trim for resonance).
  - Feedpoint is at the junction of the radiator & the ground plane.

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Dipoles and Ground-Planes

Ground-Planes (Verticals)

- The ground plane should extend at least 1/4λ from the driven element in all directions.
- The ground plane can be:
  - The earth.
  - A metal screen, mesh, or plate.
  - Radials.
    - Radials are placed on the ground or buried a few inches below the surface

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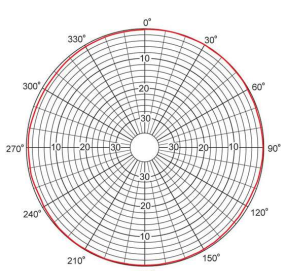
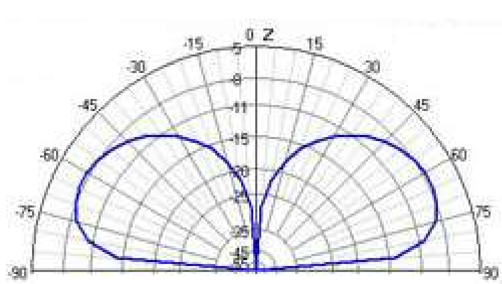
Dipoles and Ground-Planes

Ground-Planes (Verticals)

- Radiation pattern.
  - Omni-directional.





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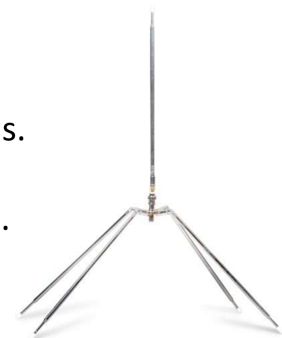
Dipoles and Ground-Planes

Ground-Planes (Verticals)

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



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Dipoles and Ground-Planes

Ground-Planes (Verticals)

- Mobile HF antennas.
  - Mobile HF antennas are usually some variation of a ground-plane antenna.
    - A thin steel whip mounted vertically.
    - The vehicle body serves as the ground plane.
  - A full-size vertical is not practical on HF bands.
    - Exception: 10m & 12m.
  - Some type of “loading” is used to make a short antenna resonant on the desired band.

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Dipoles and Ground-Planes

Ground-Planes (Verticals)

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

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Dipoles and Ground-Planes

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.

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Dipoles and Ground-Planes

Ground-Planes (Verticals)

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

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Dipoles and Ground-Planes

Ground-Planes (Verticals)

- Mobile HF antennas.
  - Loading techniques.
    - Linear loading.
      - Part of the antenna is folded back on itself.
      - Not commonly used in mobile applications.

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Dipoles and Ground-Planes

Ground-Planes (Verticals)

- Mobile HF antennas.
  - Corona ball.
    - Prevents static discharge from the sharp tip of the antenna while receiving.
    - Prevents RF voltage discharge from the sharp tip of the antenna while transmitting.

33

Dipoles and Ground-Planes

Effects of Ground

- The feedpoint impedance of a dipole is affected by the height above the ground.

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Dipoles and Ground-Planes

Effects of Ground

- Below 1/2λ above the ground, the impedance steadily decreases as the height decreases.
    - The impedance approaches 0Ω at ground level.

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Dipoles and Ground-Planes

Effects of Ground

- Above 1/2λ above ground, the impedance repeatedly increases and decreases as the height increases.
    - The impedance variations decrease in amplitude until settling on the free-space value of 72Ω several wavelengths above the ground.

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Dipoles and Ground-Planes

Effects of Ground

- The radiation pattern is affected by the height of the antenna above the ground.
  - The signal reflects off the ground and the reflections combine with the direct signal to change the pattern.

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Dipoles and Ground-Planes

Effects of Ground

- Below 1/2λ above the ground, a dipole is nearly omni-directional with its maximum radiation straight up.
  - Near Vertical Incidence Skywave (NVIS).
    - NVIS is useful on 80m & 40m for communicating with close-in stations.
    - A dipole mounted 1/10λ to 1/4λ above the ground is a good NVIS antenna.

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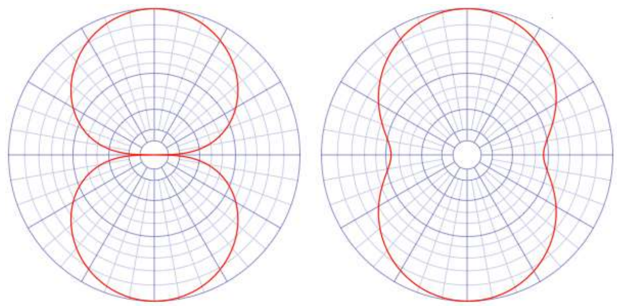
Dipoles and Ground-Planes

Effects of Ground



Radiation Pattern in Free Space

Radiation Pattern Close to the Ground

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Dipoles and Ground-Planes

Effects of Ground

- Antenna polarization affects the signal loss.
  - The reflection of the signal off the ground results in signal loss.
    - The loss is less if the wave is horizontally polarized.
  - Vertical antennas have a lower angle of radiation than horizontal antennas mounted near the ground.
    - Vertical antennas are preferred for DX on the lower frequency bands.

40

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 reduce radiation resistance
C. To electrically lengthen a physically short antenna
D. To lower the radiation angle

41

G4E02 -- What is the purpose of a corona ball on an 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 RF voltage discharge from the tip of the antenna while transmitting

42

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. Q of the antenna will be very low
C. Operating bandwidth may be very limited
D. Harmonic radiation may increase

43

G9B02 -- Which of the following is a common way to adjust the feed point impedance of an elevated 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 beyond one wavelength
D. Coil the radials

44

G9B03 -- Which of the following best describes the radiation pattern of a quarter-wave, ground-plane vertical antenna?

A. Bi-directional in azimuth
B. Isotropic
C. Hemispherical
D. Omnidirectional in azimuth

45

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

46

G9B05 -- How does antenna height affect the azimuthal radiation pattern of a horizontal dipole HF antenna at elevation angles higher than about 45 degrees?

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

47

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

48

G9B07 -- How does the feed point impedance of a horizontal 1/2 wave dipole antenna change as the antenna height is reduced to 1/10 wavelength 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

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G9B08 -- How does the feed point impedance of a 1/2 wave dipole change as the feed point 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

50

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

A. Lower ground losses
B. Lower feed point impedance
C. Shorter radials
D. Lower radiation resistance

51

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. 33 feet

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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. 132 feet
D. 263 feet

53

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

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G9C04 -- How does antenna gain in dBi compare to gain stated in dBd for the same antenna?

A. Gain in dBi is 2.15 dB lower
B. Gain in dBi is 2.15 dB higher
C. Gain in dBd is 1.25 dBd lower
D. Gain in dBd is 1.25 dBd higher

55

G9D01 -- Which of the following antenna types will be most effective as a near vertical incidence skywave (NVIS) antenna for short-skip communications on 40 meters during the day?

A. A horizontal dipole placed between 1/10 and 1/4 wavelength above the ground
B. A vertical antenna placed between 1/4 and 1/2 wavelength above the ground
C. A horizontal dipole placed at approximately 1/2 wavelength above the ground
D. A vertical dipole placed at approximately 1/2 wavelength above the ground

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G9D02 -- What is the feed point impedance of an end-fed half-wave antenna?

A. Very low
B. Approximately 50 ohms
C. Approximately 300 ohms
D. Very high

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G9D08 -- How does a “screwdriver” mobile antenna adjust its feed point impedance?

A. By varying its body capacitance
B. By varying the base loading inductance
C. By extending and retracting the whip
D. By deploying a capacitance hat

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G9D12 -- What is the common name of a dipole with a single central support?

A. Inverted V
B. Inverted L
C. Sloper
D. Lazy H

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Yagi Antennas

Directional Antenna Basics

- Directional antennas are desirable for 2 reasons:
  - They create gain in a specific direction.
    - Improve reception by making the desired signal stronger.
    - Make your signal stronger for the receiving station.
  - They reduce gain in certain directions.
    - Reject interference by making an interfering signal weaker.

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Yagi Antennas

Directional Antenna Basics

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

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Yagi Antennas

Directional Antenna Basics

- An array antenna has more than one element.
  - Driven array.
    - Power is fed to all elements.
  - Parasitic array.
    - Power is fed to one element (driven element).
    - The remaining elements radiate power that is coupled from the driven element.

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Yagi Antennas

Directional Antenna Basics

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

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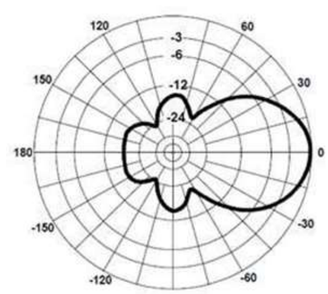
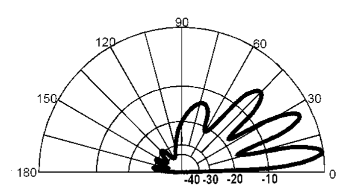
Antenna Basics

Directional Antenna Basics

- Radiation Patterns
  - Azimuthal pattern.
    - A graph of the relative signal strength in horizontal directions.
  - Elevation pattern.
    - A graph of the relative signal strength in vertical directions.





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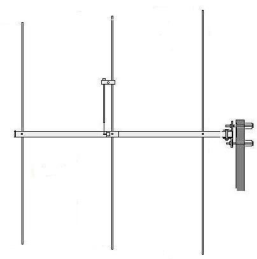
Yagi Antennas

Yagi Structure

- Most popular directional antenna.
  - Simple & inexpensive to construct.
  - Provides gain.
  - Rejects interference.



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Yagi Antennas

Yagi Structure

- 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.

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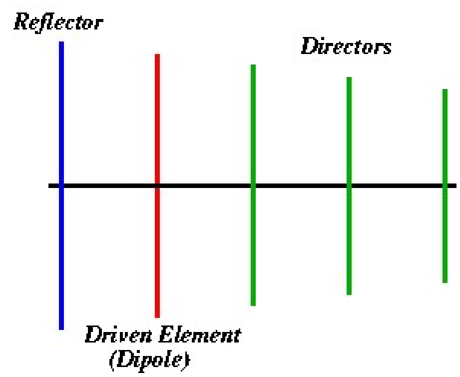
Yagi Antennas

Yagi Structure



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Yagi Antennas

Yagi Structure

- 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.

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Yagi Antennas

Yagi Structure

- 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.

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Yagi Antennas

Yagi Structure

- 2-element Yagi (1 reflector & no 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.

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Yagi Antennas

Design Tradeoffs

- Adding directors increases gain.
- Increasing spacing between directors (longer boom) 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.

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Yagi Antennas

Impedance Matching

- Most Yagi designs have a feed point impedance of 20-25Ω.
  - SWR >2:1 if fed with 50Ω transmission line.
  - An impedance matching network is required to match the antenna to the feedline.

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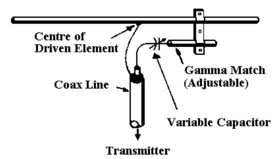
Yagi Antennas

Impedance Matching

- Gamma match.
  - Most commonly used matching network.
  - The driven element does not have to be insulated from the boom.
  - Easy to construct.
  - Easy to adjust.



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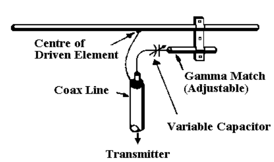
Yagi Antennas

Impedance Matching

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



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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.

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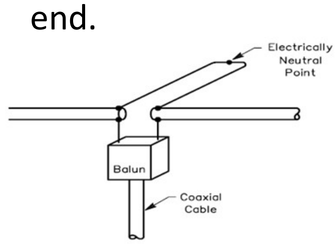
Yagi Antennas

Impedance Matching

- Beta match.
  - a.k.a. – Hairpin match.
  - Short section of transmission line shorted at the end.



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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 specific 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

77

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

78

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

79

G9C03 -- How do the lengths of a three-element Yagi reflector and director compare to that of the driven element?

A. The reflector is longer, and the director is shorter
B. The reflector is shorter, and the director is longer
C. They are all the same length
D. Relative length depends on the frequency of operation

80

G9C05 -- What is the primary effect of increasing boom length and adding directors to a Yagi antenna?

A. Gain increases
B. Beamwidth increases
C. Front-to-back ratio decreases
D. Resonant frequency is lower

81

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 that in the opposite direction
D. The ratio of forward gain to dipole gain

82

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

83

G9C10 -- Which of the following can be adjusted to optimize forward gain, front-to-back ratio, or SWR bandwidth of a Yagi antenna?

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 these choices are correct

84

G9C11 -- What is a beta or hairpin match?

A. A shorted transmission line stub placed at the feed point of a Yagi antenna to provide impedance matching
B. A 1/4 wavelength section of 75-ohm coax in series with the feed point of a Yagi to provide impedance matching
C. A series capacitor selected to cancel the inductive reactance of a folded dipole antenna
D. A section of 300-ohm twin-lead transmission line used to match a folded dipole antenna

85

G9C12 -- Which of the following is a characteristic of using a gamma match with a Yagi antenna?

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

86

Break

87

Loop Antennas

Large Loops

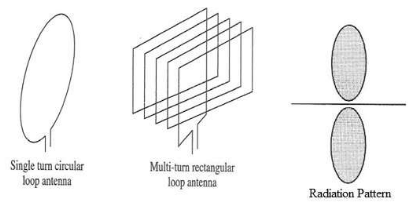
- A loop of wire that completely encloses an area.
- Normally 1λ or greater in circumference.
  - Quad loop.
    - Square loop with each side 1/4λ long.
  - Delta loop.
    - Triangular loop with each side 1/3λ long.

88

Loop Antennas

Large Loops

- The major lobes are broadside (perpendicular) to the plane of the loop.
- There is a null is in the plane of the loop.



89

Loop Antennas

Large Loops

- A loop that is mounted horizontally has a high angle of radiation.
  - A good NVIS antenna.
- A loop that is mounted vertically has a low angle of radiation.
  - A good DX antenna.

90

Loop Antennas

Large Loops

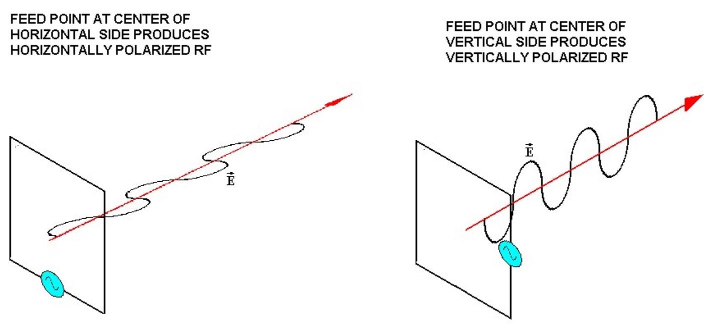
- A loop that is multiple wavelengths long and is mounted horizontally:
  - Is nearly omnidirectional.
  - Has a lower angle of radiation than a dipole mounted at the same height.

91

Loop Antennas

Large Loops

- Polarization of a vertically-mounted loop.

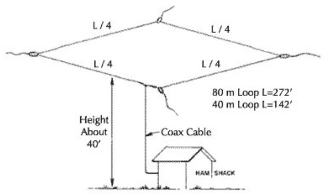


92

Loop Antennas

Large Loops

- Polarization of a horizontally-mounted loop.
  - A horizontally-mounted loop is always horizontally polarized regardless of the shape of the loop or the location of the feedpoint.

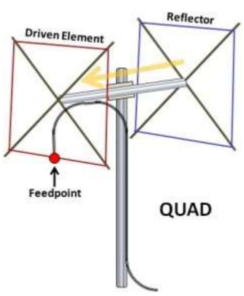


93

Loop Antennas

Large Loops

- Quad and delta loop beams.
  - Quad loop beam.
    - a.k.a. - Cubical quad antenna.
    - Variation of the Yagi.
    - 2 or more quad loops mounted on a boom.

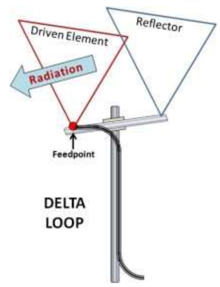


94

Loop Antennas

Large Loops

- Quad and delta loop beams.
  - Delta loop beam.
    - Variation of the Yagi.
    - 2 or more delta loops mounted on a boom.



95

Loop Antennas

Large Loops

- Quad and delta loop beams.
  - The circumference of the driven element is 1λ.
  - The circumference of the reflector is about 5% more than the driven element.
  - The circumference of each director is about 5% less than the driven element.

96

Loop Antennas

Large Loops

- Quad and delta loop beams.
  - Loop beam antennas are more mechanically complex than a Yagi.
    - Insulating supports are required to hold the wire.
  - Loop beam antennas have more surface area.
    - Higher wind loading.
  - Loop beam antennas are more susceptible to ice damage.

97

Loop Antennas

Large Loops

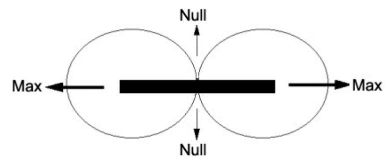
- Quad and delta loop beams.
  - A 2-element loop beam antenna has about the same forward gain as a 3-element Yagi.
  - A 2-element loop beam antenna typically has a greater front-to-back ratio than a 3-element Yagi.
  - Quad and delta loop antennas with the same number of elements have about the same gain.

98

Loop Antennas

Small Loops

- If the circumference of the loop is less than 1/3λ, the radiation pattern changes:
  - The major lobes are in the plane of the loop.
  - There are nulls broadside (perpendicular) to the plane of the loop.



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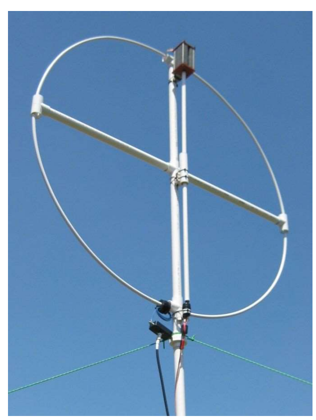
Loop Antennas

Small Loops

- Small loops are usually mounted vertically.
- Small loops are inefficient due to their small size.



100

Loop Antennas

Halo Antennas

- A dipole bent into a circle or square.
  - If a square, often called a "squalo".
- Maximum radiation is in the plane of the antenna.
- Usually mounted horizontally to provide a horizontally-polarized, omnidirectional antenna for VHF.

101

Loop Antennas

Halo Antennas

102

G9D03 -- In which direction is the maximum radiation from a VHF/UHF “halo” antenna?

A. Broadside to the plane of the halo
B. Opposite the feed point
C. Omnidirectional in the plane of the halo
D. On the same side as the feed point

103

G9D10 -- In which direction or directions does an electrically small loop (less than 1/10 wavelength in circumference) have nulls in its radiation pattern?

A. In the plane of the loop
B. Broadside to the loop
C. Broadside and in the plane of the loop
D. Electrically small loops are omnidirectional

104

Specialized Antennas

Random Wires

- A random length of wire put up any way that you can.
  - The feed point impedance is unpredictable.
  - The radiation pattern is unpredictable.
    - May have several lobes at different angles

105

Specialized Antennas

Random Wires

- Random wires are typically connected directly to the transmitter or antenna tuner.
  - The station equipment becomes part of the antenna system.
  - RF burns are possible if the station RF ground is not adequate and you touch the equipment while transmitting.

106

Specialized Antennas

Random Wires

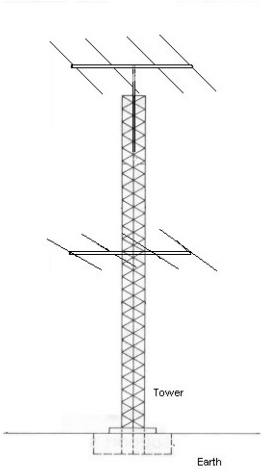
- Random wires can yield good results on any band where an impedance match can be achieved.

107

Specialized Antennas

Stacked Antennas

- Mounting 2 or more Yagi antennas side-by-side or one above the other.



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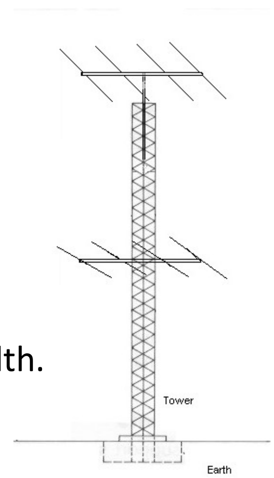
Specialized Antennas

Stacked Antennas

- Vertically stacked antennas.
  - Mount the antennas 1/2λ to 1λ apart.
    - 1/2λ is the most common.
    - About 3dB gain for 2 antennas.
  - Narrows the elevation beamwidth.

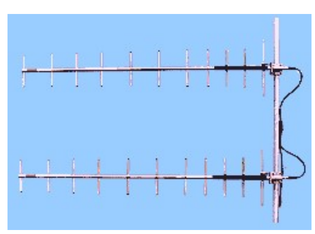


109

Specialized Antennas

Stacked Antennas

- Horizontally stacked antennas.
  - Antennas are mounted side-by-side.
  - Spacing is wider to prevent interaction.

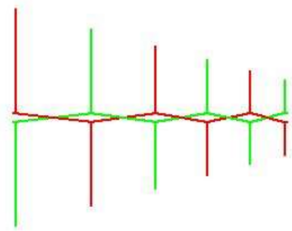


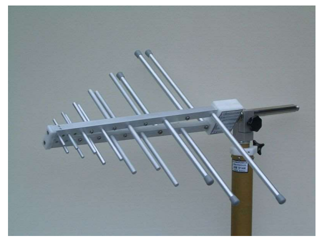
110

Specialized Antennas

Log Periodics

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





111

Specialized Antennas

Log Periodics

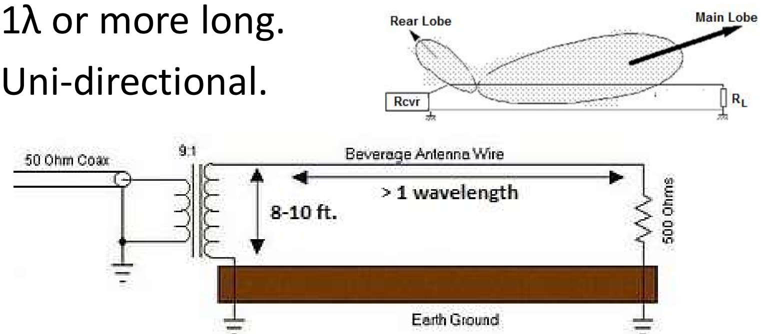
- Less gain than Yagi.
- Less front-to-back ratio than Yagi.

112

Specialized Antennas

Beverage Antennas

- Traveling-wave antenna.
- 1λ or more long.
- Uni-directional.



113

Specialized Antennas

Beverage Antennas

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

114

Specialized Antennas

Multiband Antennas

- Few amateurs have room to put up a separate antenna for each band.
- Few amateurs can afford to put up a separate antenna for each band.
- The use of multiband antennas is a common way to work around these limitations.

115

Specialized Antennas

Multiband Antennas

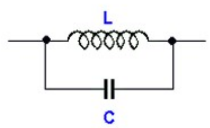
- A mutiband antenna is an antenna that is designed to work on 2 or more bands.
- A common way to make a multiband antenna is by using traps.

116

Specialized Antennas

Multiband Antennas

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



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Specialized Antennas

Multiband Antennas

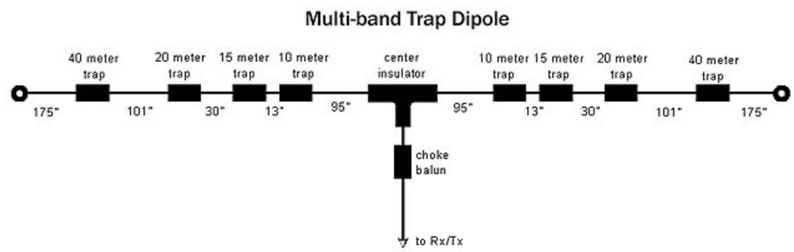
- Trapped dipole.
  - The wire between each pair of traps is a 1/2λ dipole.
    - The outer dipoles are shortened because the inductors in the traps act like loading coils below the trap's resonant frequency.

118

Specialized Antennas

Multiband Antennas

- A 3-band trapped dipole.



119

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.

120

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.

121

G9B01 -- What is a characteristic of a random-wire HF antenna connected directly to the transmitter?

A. It must be longer than 1 wavelength
B. Station equipment may carry significant RF current
C. It produces only vertically polarized radiation
D. It is more effective on the lower HF bands than on the higher bands

122

G9C09 -- In free space, how does the gain of two three-element, horizontally polarized Yagi antennas spaced vertically 1/2 wavelength apart typically compare to the gain of a single three-element Yagi?

A. Approximately 1.5 dB higher
B. Approximately 3 dB higher
C. Approximately 6 dB higher
D. Approximately 9 dB higher

123

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

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

124

G9D05 -- What is an advantage of vertically stacking horizontally polarized Yagi antennas?

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

125

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

126

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

A. Element length and spacing vary logarithmically along the boom
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

127

G9D09 -- What is the primary use of a Beverage antenna?

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

128

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

129

Feed Lines

Characteristic Impedance

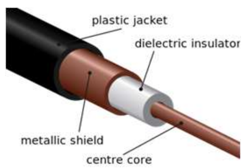
- All feedlines have 2 conductors.
- Feedline impedance is determined by the geometry of the conductors & the electrical properties of the insulation material.
  - The insulating material has more effect on the feedline loss than on the impedance.

130

Feed Lines

Characteristic Impedance

- Coaxial cable.
  - A center conductor surrounded by a cylindrical outer conductor (sleeve or braid).
  - The conductors are insulated from each other by a dielectric material.

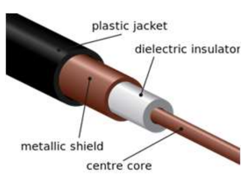


131

Feed Lines

Characteristic Impedance

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



132

Feed Lines

Characteristic Impedance

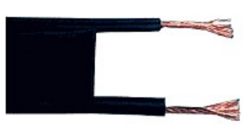
- Balanced line.
  - Two parallel wires separated by an insulator.
  - The characteristic impedance is determined by the ratio of the diameter of the conductors to the distance between them.
    - Larger distance → higher impedance.
    - Smaller diameter → higher impedance.

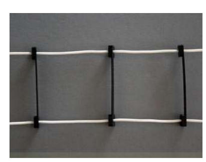
133

Feed Lines

Characteristic Impedance

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





134

Feed Lines

Forward and Reflected Power and SWR

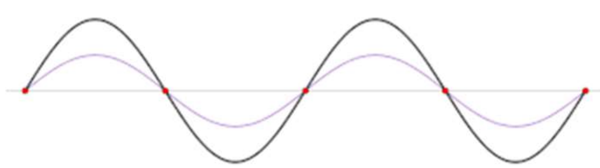
- All power is transferred from feed line to antenna only if impedances are matched.
- If impedances do not match, some power is reflected back to transmitter.
  - Reflection can occur at:
    - Feedline-to-antenna connection.
    - Connector.
    - Connection between one type of feedline & another.

135

Feed Lines

Forward and Reflected Power and SWR

- Reflected power combines with forward power to form a stationary interference pattern.



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Feed Lines

Forward and Reflected Power and SWR

- The 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}).

137

Feed Lines

Forward and Reflected Power and SWR

- Voltage standing wave ratio (VSWR).
  - $VSWR = V_{Max} / V_{Min}$
  - $VSWR = Z_{Load} / Z_{Line}$ or Z_{Line} / Z_{Load}
    - VSWR always > 1.

138

Feed Lines

Forward and Reflected Power and SWR

- Most amateur equipment is designed to work into a 50Ω load.
  - An SWR > 2:1 may cause protective circuitry in the transmitter to reduce the output power or to shut the transmitter down completely.
    - $Z_{Load} < 25\Omega$ or $Z_{Load} > 100\Omega$

139

Feed Lines

- Impedance Matching
  - To eliminate SWR on the transmission line, the antenna feed point impedance must be matched to the transmission line impedance.

140

Feed Lines

- Impedance Matching
  - To eliminate SWR on the transmission line, the matching network **MUST** be located at antenna.
    - The impedance matching is often done between the transmitter & the transmission line.
      - **This causes the transmitter to see a matched load, but does NOT reduce SWR on the transmission line!**

141

Feed Lines

Impedance Matching

- A device used to match impedances is called:
  - Matching network,
  - Transmatch,
  - Antenna coupler, or
  - Antenna tuner.
    - An antenna tuner does **NOT** tune the antenna. It merely transforms the impedance of the antenna system to 50Ω.

142

Feed Lines

Impedance Matching

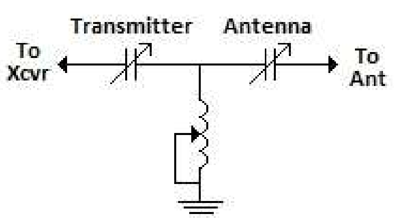
- Sections of transmission lines called “stubs” can also be used to match impedances.
  - Stubs only match the impedances at a single frequency & are not adjustable.
  - The military often uses specified lengths of transmission line to match the antenna to the transmitter.

143

Feed Lines

Impedance Matching.

- Antenna Tuners
  - Almost all antenna tuners use a T-network.



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Feed Lines

Feed Line Loss

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

145

Feed Lines

Feed Line Loss

- Feed line loss is specified in dB/100ft at a given frequency.
  - The loss increases as the frequency increases.
  - Smaller cables generally have higher loss.

146

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

147

Feed Lines

Feed Line Loss & SWR

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

148

G4A06 -- What is the purpose of an antenna tuner?

A. Reduce the SWR in the feed line to the antenna
B. Reduce the power dissipation in the feedline to the antenna
C. Increase power transfer from the transmitter to the feed line
D. All these choices are correct

149

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

150

G9A02 -- What is the relationship between high standing wave ratio (SWR) and transmission line loss?

A. There is no relationship between transmission line loss and SWR
B. High SWR increases loss in a lossy transmission line
C. High SWR makes it difficult to measure transmission line loss
D. High SWR reduces the relative effect of transmission line loss

151

G9A03 -- What is the nominal characteristic impedance of "window line" transmission line?

A. 50 ohms
B. 75 ohms
C. 100 ohms
D. 450 ohms

152

G9A04 -- What causes reflected power at an antenna's feed point?

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

153

G9A05 -- How does the attenuation of coaxial cable change with increasing frequency?

A. Attenuation is independent of frequency
B. Attenuation increases
C. Attenuation decreases
D. Attenuation follows Marconi's Law of Attenuation

154

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

A. Ohms per 1,000 feet
B. Decibels per 1,000 feet
C. Ohms per 100 feet
D. Decibels per 100 feet

155

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 an odd number of electrical quarter wavelengths long
C. The feed line must be an even number of physical half wavelengths long
D. The antenna feed point impedance must be matched to the characteristic impedance of the feed line

156

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

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

157

G9A09 -- What standing wave ratio results from connecting a 50-ohm feed line to a 200-ohm resistive load?

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

158

G9A10 -- What standing wave ratio results from connecting a 50-ohm feed line to a 10-ohm resistive load?

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

159

G9A11 -- What is the effect of transmission line loss on SWR measured at the input to the line?

A. Higher loss reduces SWR measured at the input to the line
B. Higher loss increases SWR measured at the input to the line
C. Higher loss increases the accuracy of SWR measured at the input to the line
D. Transmission line loss does not affect the SWR measurement

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Questions?

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Next Week
Chapter 8

Propagation

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