Amateur Radio General License Training

Welcome

These presentations are sponsored by:

Mendocino Auxiliary Communications Service (MACS)

Mendocino County Amateur Radio Communications Service (McARCS)

Willits Amateur Radio Society (WARS)

Topics on Exam

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General Class FCC License
Antenna System

Sub-element G9 Antennas and Feed lines

46 Pool Questions, 4 Exam Questions

Antennas and feed line are the most important components of your station!

They affect the signal strength of both the received and transmitted signals, and the amount of received noise and interference from other stations.

Improving your Antenna System offers the greatest potential for improving the range of your signal.

Green Boxed Numbers G9D02 (D) reference the test questions which all follow the presentation

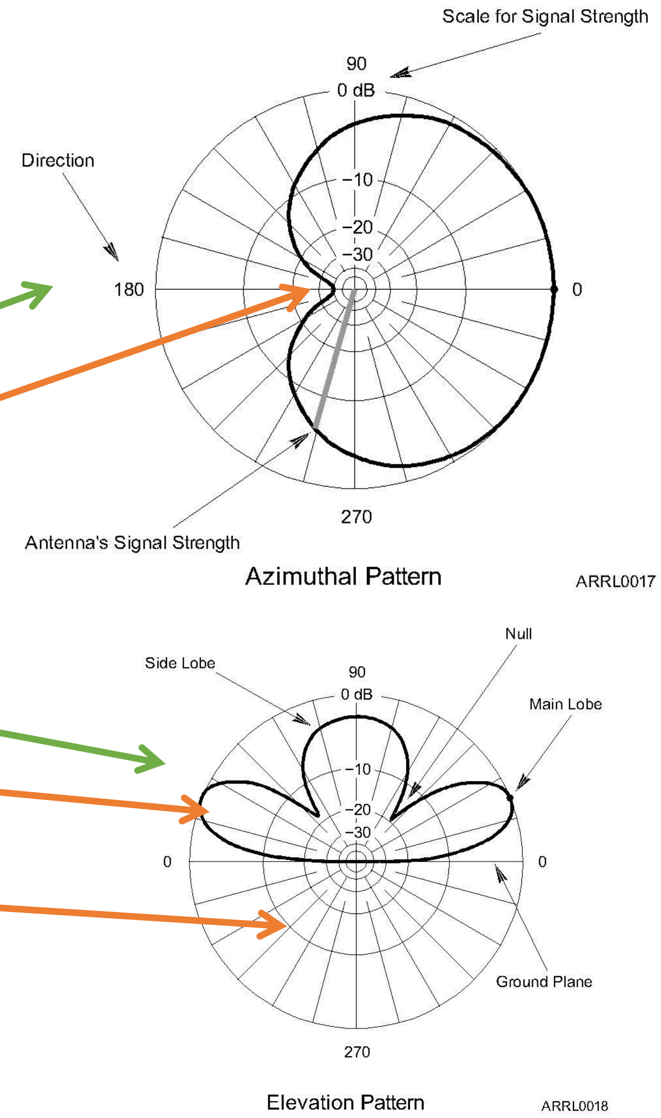
Antenna System Review of Terms

- **Antenna:** transforms current into radio waves (transmit) and vice versa transforms radio waves into current (receive).
- **Element (s):** conducting part or parts of an antenna designed to radiate or receive radio waves.
- **Polarization:** the orientation of the electrical field in relation to ground. If the element is horizontal, the polarization is horizontal.
- **Feed point**: Where the transmitted energy enters the antenna.
- **Feed Point Impedance:** the ratio of RF current to voltage at the feed point
- **Resonance:** The antenna is resonant when the feed point impedance is completely resistive with no reactance

Antenna Radiation Patterns

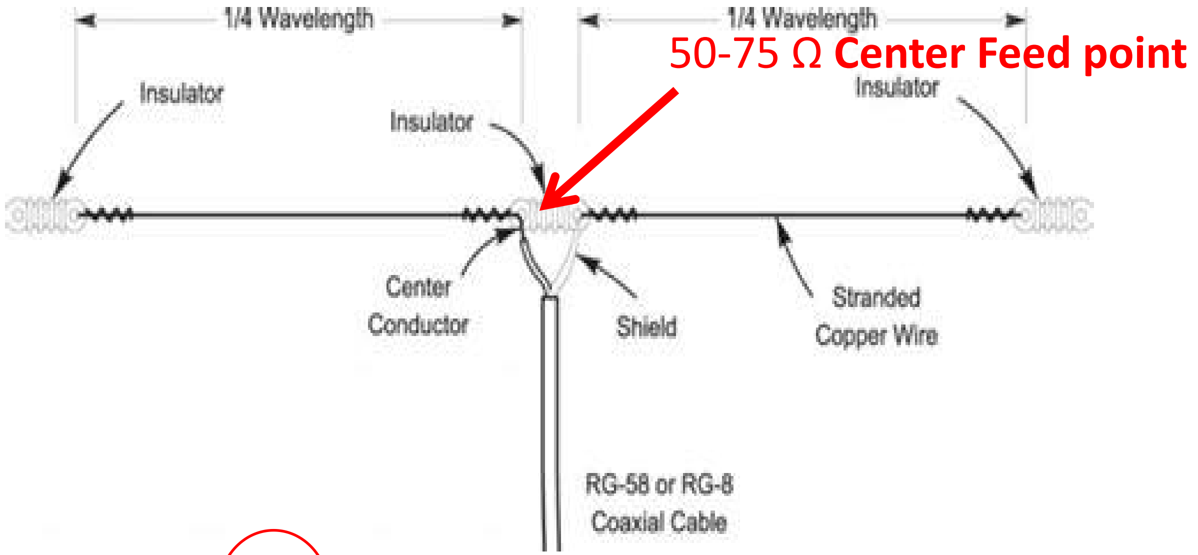
- Radiation patterns: are a way of visualizing antenna performance for both transmit and receive

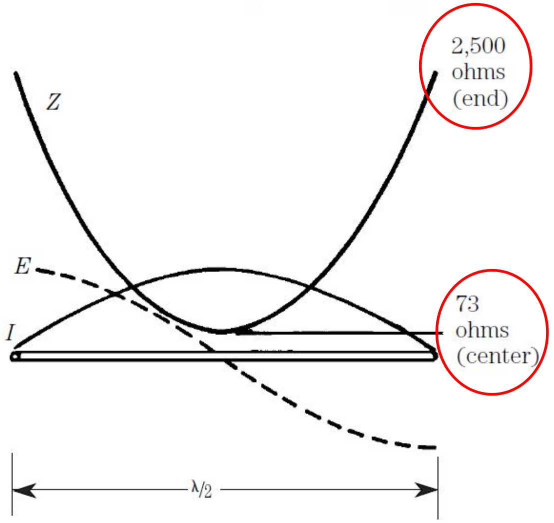
- Azimuth - horizontal directions
- Nulls - radiation at a minimum
- Elevation - vertical directions
- Lobes - direction of radiation
- Decibels scale



1/2 λ (Wavelength) Dipole Antenna

- Simple & complete nominal center feed point impedance 50-75 Ω
- Good match for 50 Ω coax and modern radio equipment
- The feed point impedance of a 1/2 wave dipole increases steadily as the feed point is moved from the center toward the ends G9B08 (A)



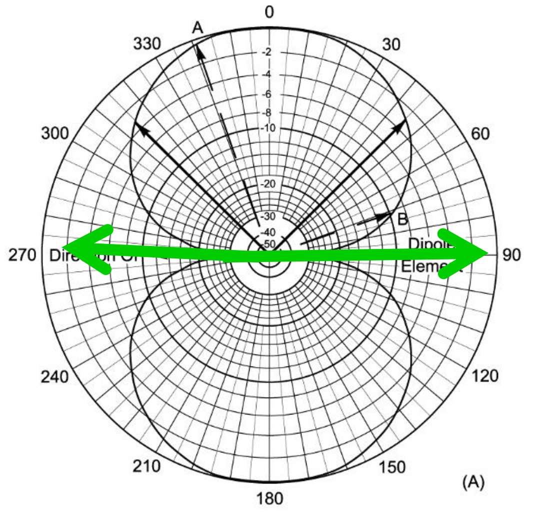


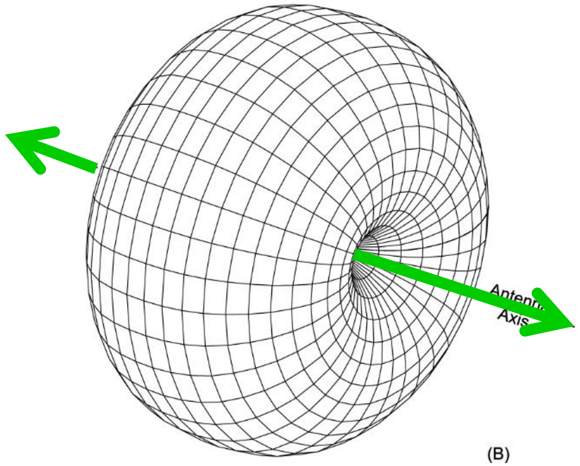
G9D02 (D)
What is the feed point impedance of an end-fed half-wave antenna?
D. Very high

1/2 λ Dipole Antenna

- Radiates strongest broadside to the dipole elements, weakest off the ends
- If elements are oriented horizontally, the radiated waves are horizontally polarized
- 3D radiation pattern looks like a donut or bagel - *a Figure 8 at right angles to the antenna in free space*

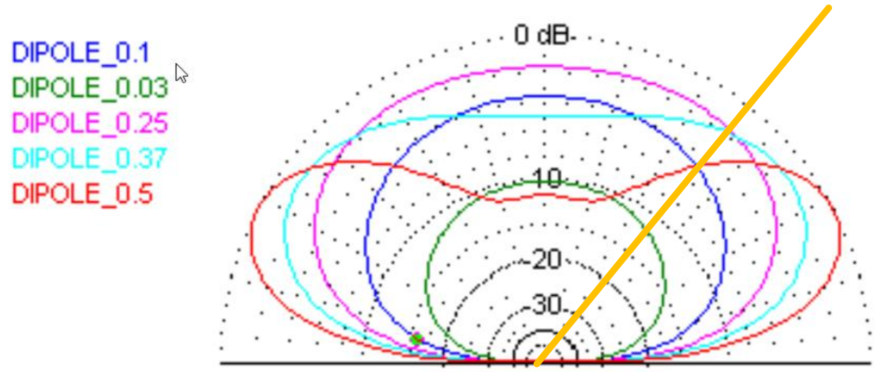
G9B04 (A)

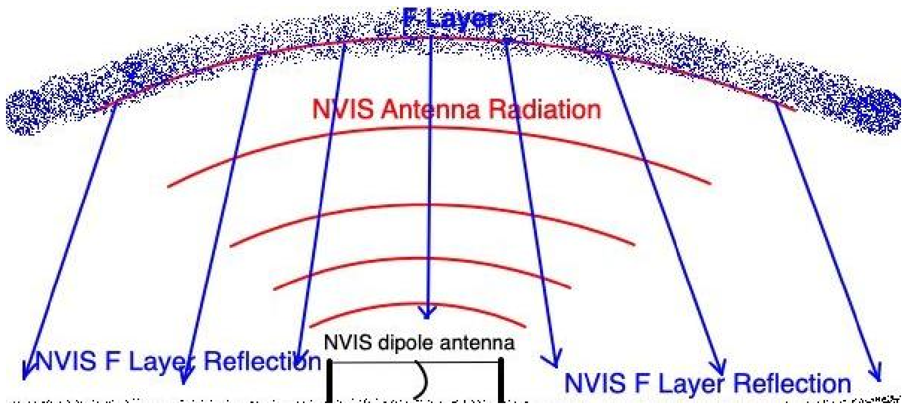




1/2 λ Dipole Antenna

- ***The antenna's proximity to the ground in wavelengths will affect resonance, impedance, and both the azimuth and the elevation angle of radiation!***
- Resonant element length will increase, with increasing height, above ground (gets longer)
- Impedance will decrease by reducing the height, above ground G9B07(B)
- *The azimuth and elevation angle of radiation will change as the height, in wavelengths, above ground changes* G9B05 (C)

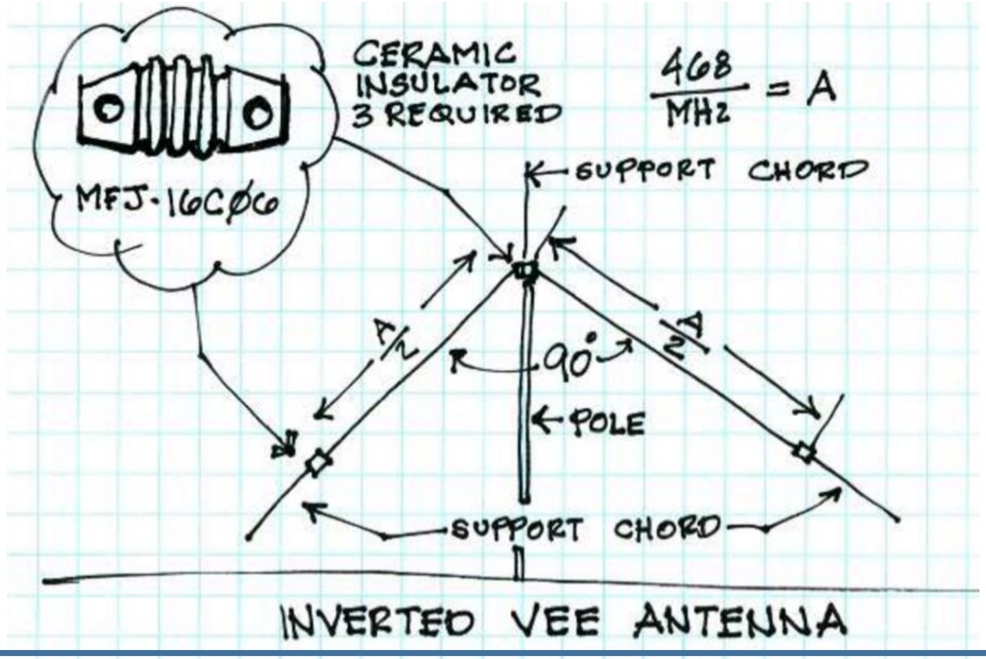




1/2 λ Dipole Antenna

- Lower ground losses is an advantage of using a horizontally polarized as compared to a vertically polarized HF antenna. G9B09 (A)

Inverted V is the common name of a dipole with a single central support. G9D12 (A)



1/2 λ Dipole Antenna

To <u>estimate</u> the length, in feet, of a dipole, divide 468 by the frequency in mHz. (The General handbook recommends 492/*f* since it is the free space length and will provide you extra to cut off or preferably fold back, during tuning)

What is the approximate length for a 1/2 wave dipole antenna cut for 14.250 mHz? G9B10 (D)

468/ 14.250 mHz = 32.84 feet or 33’

What is the approximate length for a 1/2 wave dipole antenna cut for 3.550 mHz? G9B11 (C)

468/ 3.550 mHz = 131.83 feet or 132’

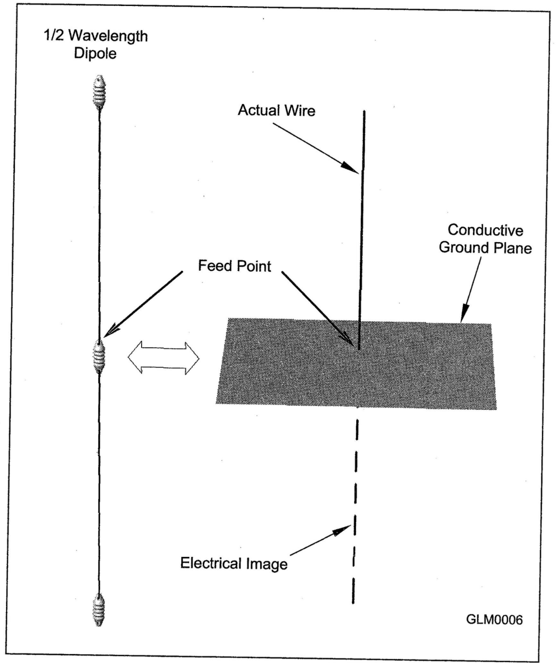
1/4 λ Monopole Antenna

1/4 λ Ground-plane (Vertical Monopole) Antenna

A ground plane is 1/2 of a dipole. The missing 1/2 is replaced by an electrical mirror called a ground plane

- the ground plane can be:
  - wires on the ground or buried a few inches below G9B06 (C)
- a metal plate, auto trunk lid or auto roof
- wires or metal rods elevated radials above the earth

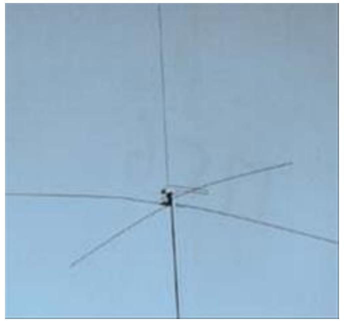
buried 33' wire radials for 40 meter 1/4λ.
Feedline trench in foreground.



ARRL General Handbook p 7-5

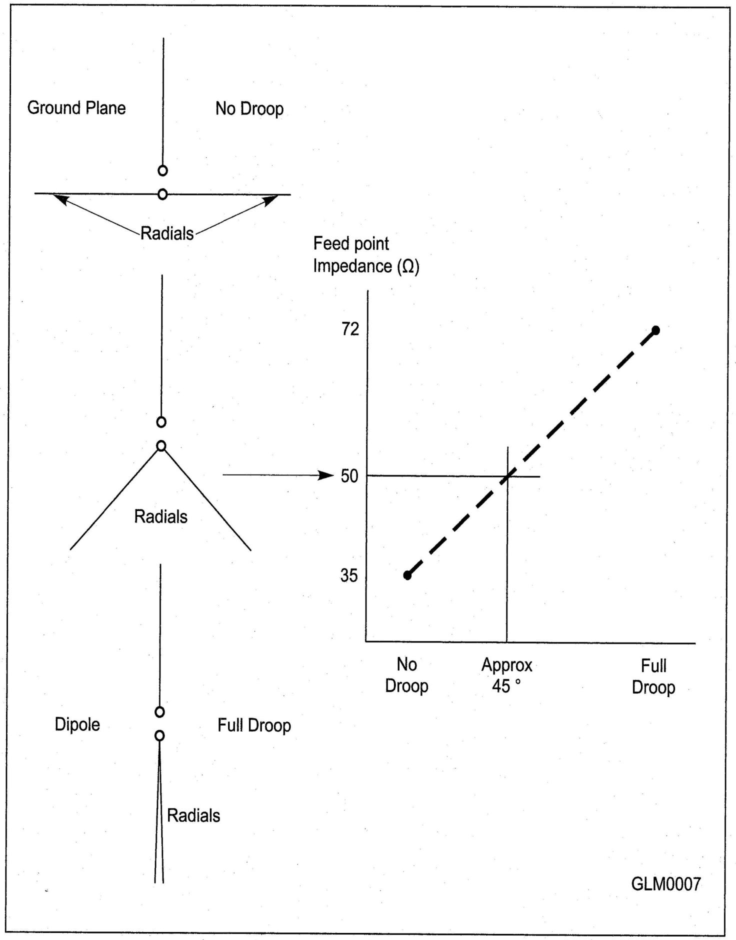
1/4 λ **Elevated radials** Ground-plane Antenna

Impedance matching



- Horizontal radials 35Ω

- Sloping the radials down to a 45 degree angle lowers impedance to 50Ω G9B02 (B)
- a full droop to vertical makes a vertical dipole and 75Ω impedance



ARRL General Handbook p 7-6

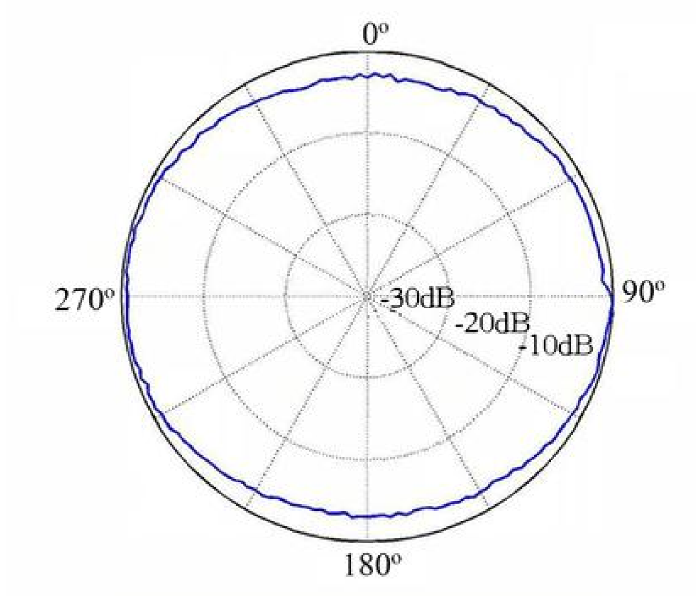
1/4 λ Monopole, Ground-plane Vertical Antenna

To <u>estimate</u> the length, in feet, of a Ground plane, divide 234 by the frequency in mHz.

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

234/ 28.5 mHz = 8.21 feet or 8’
G9B12 (A)

The radiation pattern of a quarter-wave ground-plane vertical antenna is best described as omnidirectional in azimuth.
G9B03 (D)



Directional Array Antennas

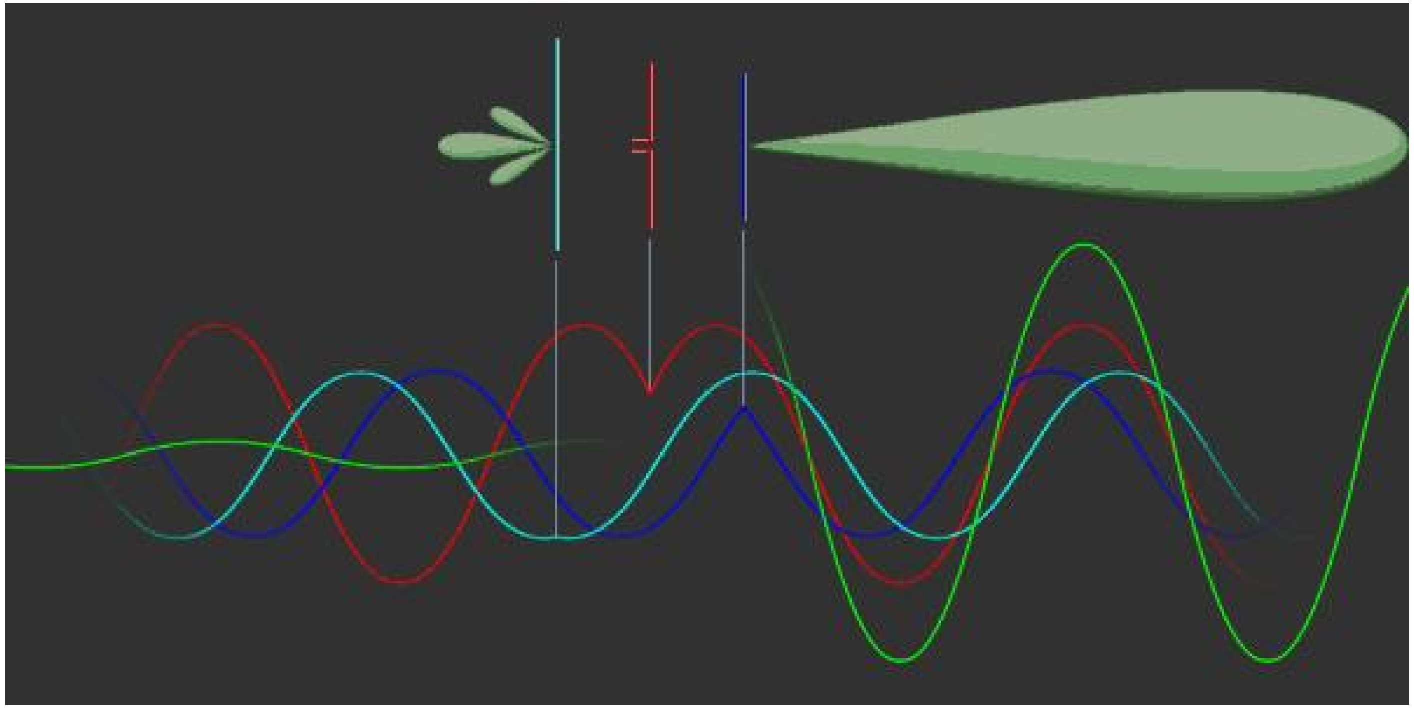
- An Array is two or more elements, designed to focus energy, in a specific direction called the main lobe G9C08 (D)
- Two types of arrays: driven and parasitic
  - Driven element(s) are connected directly to feedline
  - Parasitic element(s) interact with the radiated energy of the driven element(s) without a direct connection
- Both influence the radiation pattern using constructive and destructive interference of the radio waves

Yagi Antenna

Driven Element

Reflector
Parasitic Element

Director
Parasitic Element



Main lobe

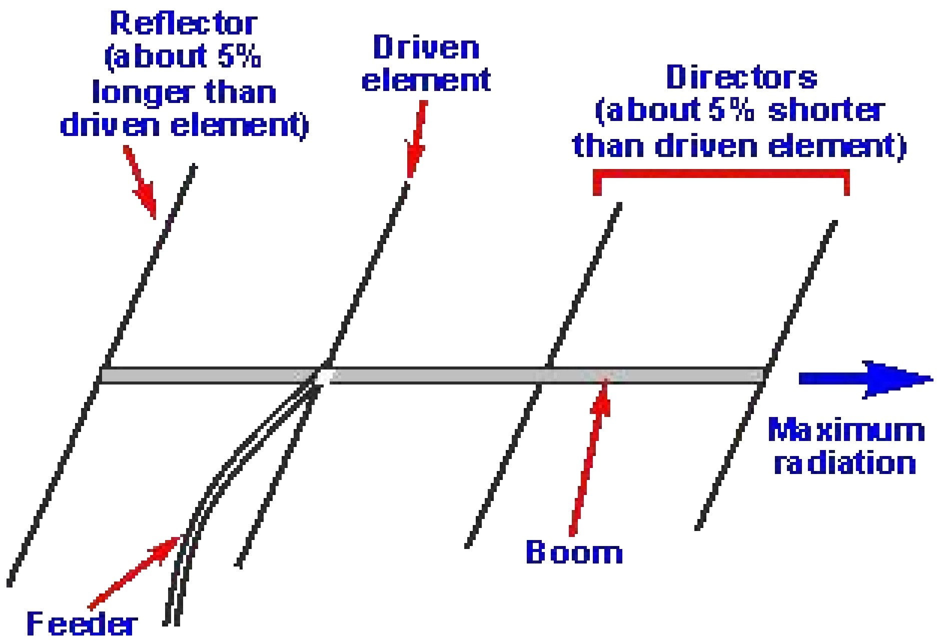
Destructive
Interference

Constructive
Interference

Yagi Antenna

G9C02 (B)
What is the approximate length of the driven element of a Yagi antenna?
B. 1/2 wavelength

G9C03 (A)
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



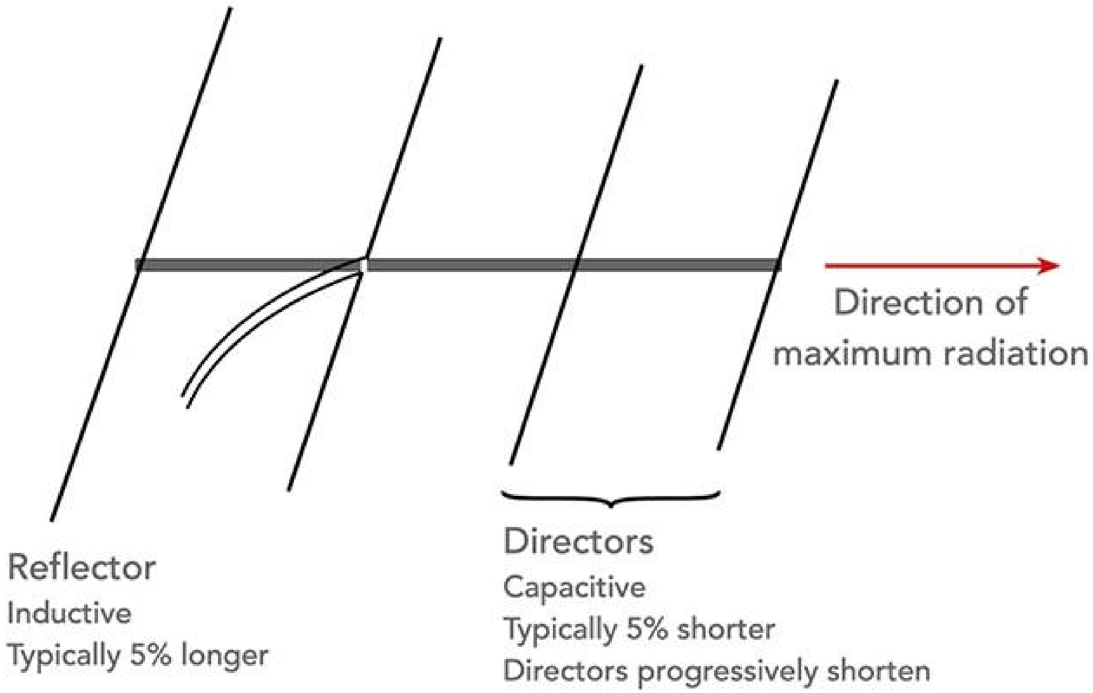
The physical length of the boom, the number of elements on the boom, and the spacing of each element along the boom, can **ALL** be adjusted to optimize forward gain, front-to-back ratio, or SWR bandwidth of a Yagi antenna. G9C10 (D)

Yagi Antenna

G9C05 (A) What is the primary effect of increasing boom length and adding directors to a Yagi antenna?
A. Gain increases

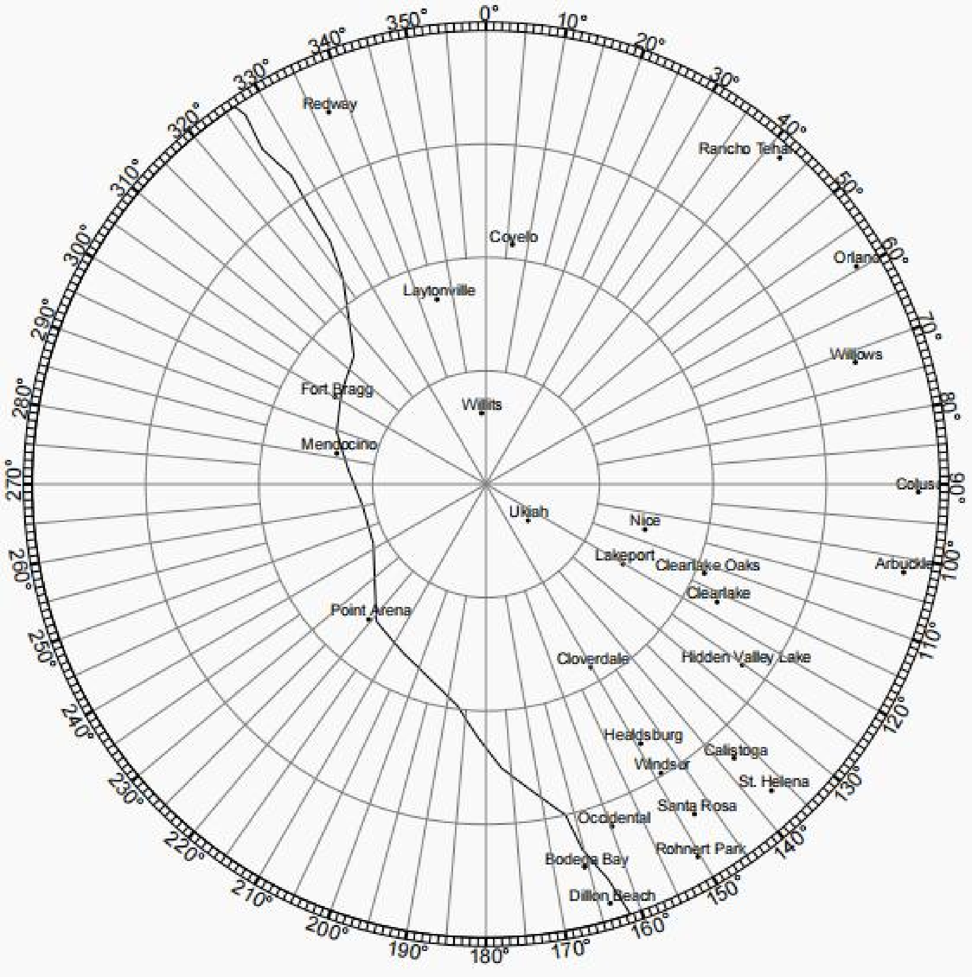
G9C04 (B) How does antenna gain in dBi compare to gain stated in dBd for the same antenna?
B. Gain in dBi is 2.15 dB higher

Example: 8.15 dBi vs. 6.0 dBd forward gain for same antenna

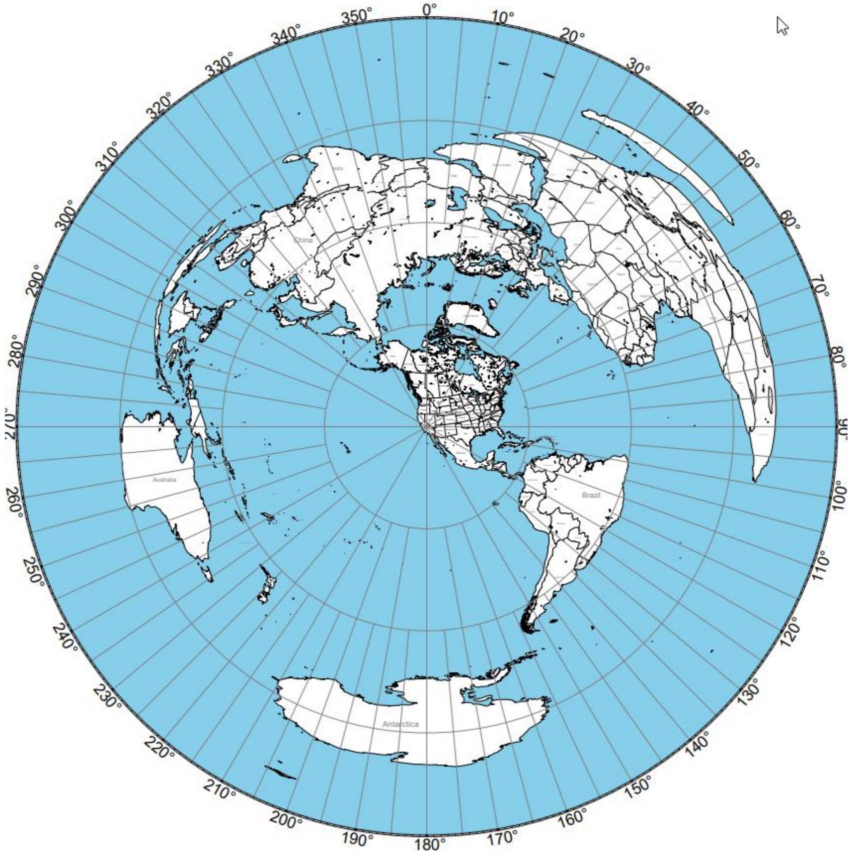


G9C01 (A) Which of the following would increase the bandwidth of a Yagi antenna?
A. Larger-diameter elements

Directional Antennas



A map that shows true bearings and distances from a specific location is an Azimuth Projection Map G2D04



Comparing Gain Antennas

- **Isotropic:** non-existent point in space radiating *equally in all directions.* A theoretic point for reference & comparison only. expressed as dBi
- **Omnidirectional:** radiates a signal equally in all horizontal directions
- **Decibel (dB):** unit of power measurement used to compare antenna gain to a specific reference (isotropic dBi or dipole dBd) G9C04(B)
- **Front to back ratio(F/B):** ratio of preferred direction to reverse G9C07(C)
- **Front to side ratio (F/S):** ratio of preferred direction to right angles

Stacking Yagi Antennas

G9D05 (D)

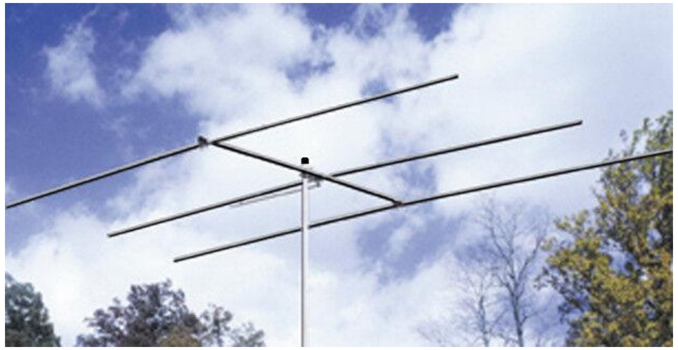
What is an advantage of vertically stacking horizontally polarized Yagi antennas?

D. It narrows the main lobe in <u>elevation</u>

G9C09 (B)

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?

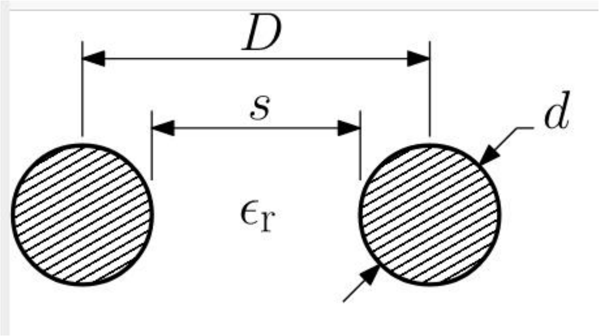
B. Approximately 3 dB higher



Feed lines:

characteristic impedance and attenuation;
standing wave ratio (SWR) calculation,
measurement, and effects;
antenna feed point matching

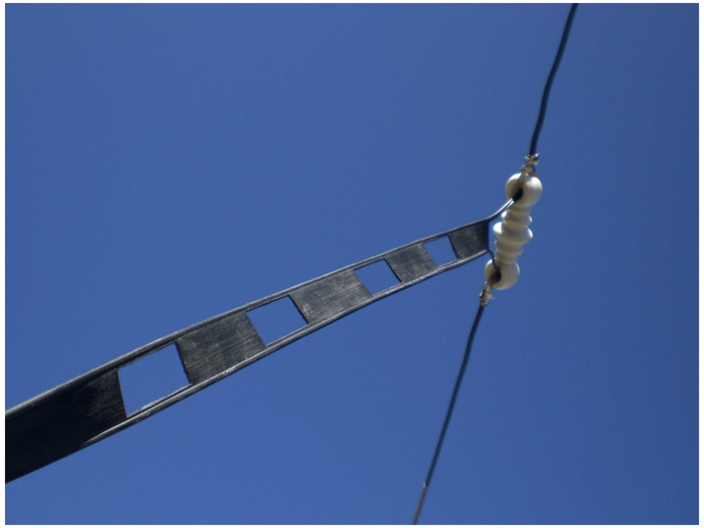
Feed lines: Characteristic Impedance



- The characteristic impedance of a parallel conductor feed line is determined by the distance between the centers of the conductors and the radius of the conductors.

G9A01 (A)

- Nominal characteristic impedance:
  - Coax: 50 Ω and 75 Ω
  - Window Line : 450 Ω G9A03(D)
- Expressed in ohms (Ω), symbolized as Z_0



Feed Lines: attenuation

G9A05 (B)
How does the attenuation of coaxial cable change with increasing frequency?
B. Attenuation increases

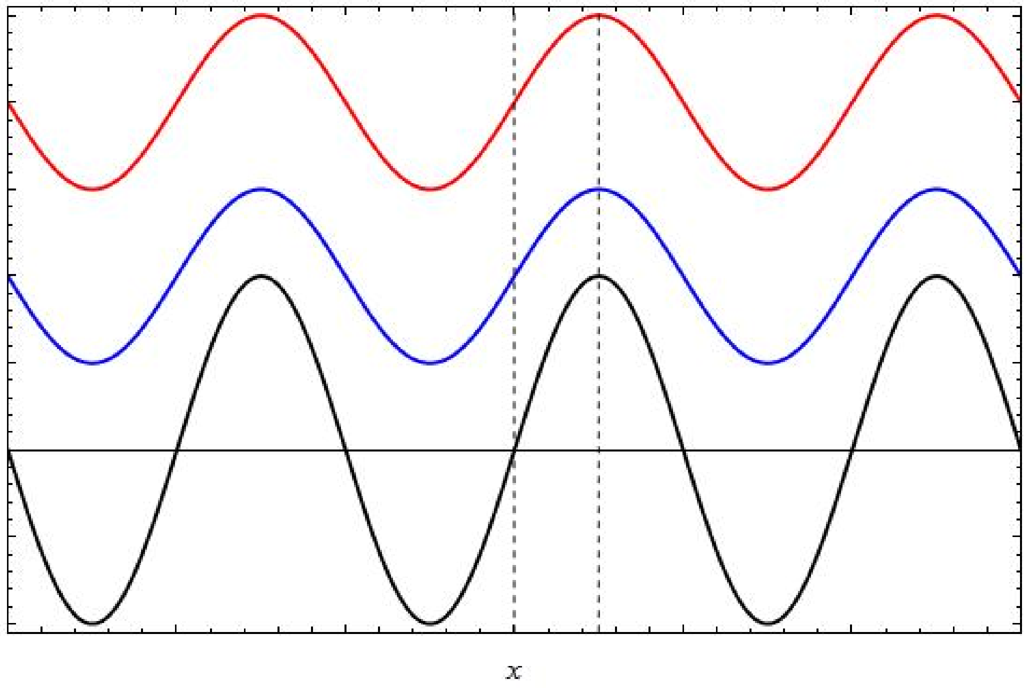
G9A06 (D)
In what units is RF feed line loss usually expressed?
D. Decibels per 100 feet

Type	Impedance	Loss @ 1 MHz	Loss @ 10 MHz	Loss @ 100 MHz	Loss @ 1 GHz
RG-59/U	72 ohms	.6	1.1	3.4	12
RG-6/U	72 ohms	.4	.8	2.7	9.8
RG-11/U	72 ohms	.2	.4	1.3	5.2
RG-58/U	50 ohms	.4	1.3	4.5	18.1
RG-8/U	50 ohms	.2	.5	1.5	4.8
1/2" line	75 ohms	.1	.2	.8	3.2
7/8" line	75 ohms	.03	.1	.6	2.9
Twin lead	300 ohms	.1	.3	1.4	5.9
Open wire	405 ohms	.02	.08	.3	1.1

Feedline attenuation per 100’ expressed in decibels (dB)

Standing Waves

Standing wave from two propagating waves



Standing Wave peak voltages may damage the transmitter

G9A04 (C)

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

C. A difference between feed line impedance and antenna feed point impedance

G9A07 (D)

What must be done to prevent standing waves on a feed line connected to an antenna?

D. The antenna feed point impedance must be matched to the characteristic impedance of the feed line

Calculating Standing Wave Ratio (SWR)

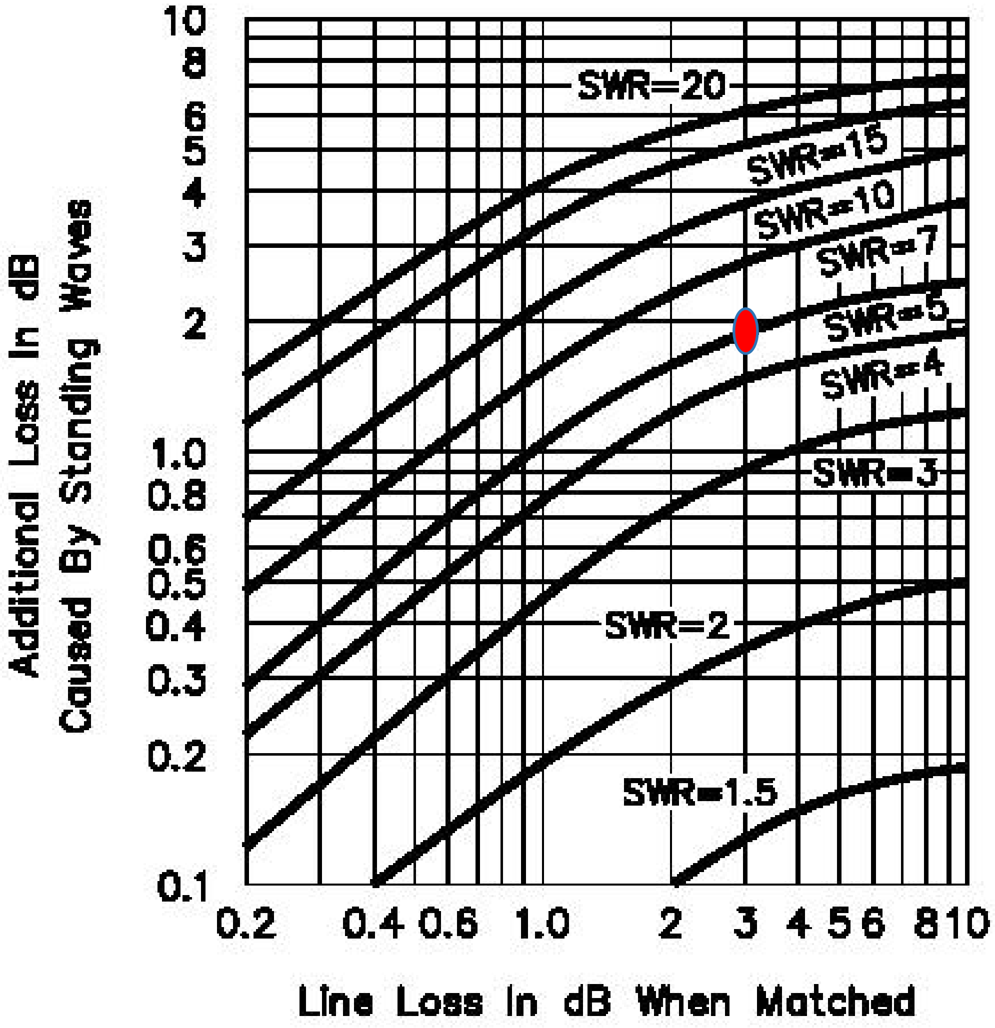
G9A09 (A)
What standing wave ratio results from connecting a 50-ohm feed line to a 200-ohm resistive load?
A. 4:1

SWR = 200/50 = 4:1

G9A10 (D)
What standing wave ratio results from connecting a 50-ohm feed line to a 10-ohm resistive load?
D. 5:1

SWR = 50/10 = 5:1

Feedline Loss + SWR Loss



G9A02 (B)

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

B. High SWR increases loss in a lossy transmission line

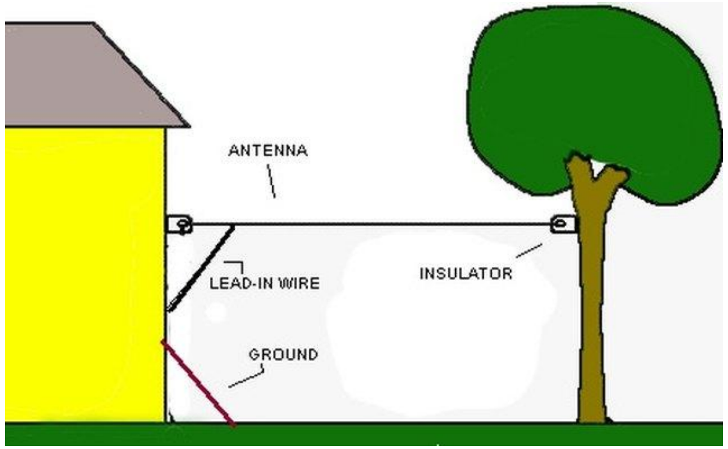
100 watts 3db coax line loss and 2db SWR loss results in 32 watts at Antenna

Antenna Feed Point Matching

G9B01 (B)

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

B. Station equipment may carry significant RF current



Antenna Matching and High Loss Feedline

Antenna Tuners installed between the feedline and radio have no effect on any mis-match between the feedline the antenna impedance G4A06

G9A08 (B)

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? B. 5:1

G9A11 (A)

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

Yagi Antenna Impedence Matching

G9C11 (A)

What is a beta or hairpin match?

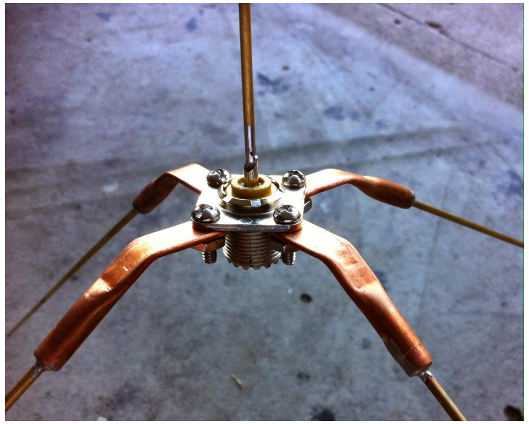
A. A shorted transmission line stub placed at the feed point of a Yagi antenna to provide impedance matching

G9C12 (A)

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

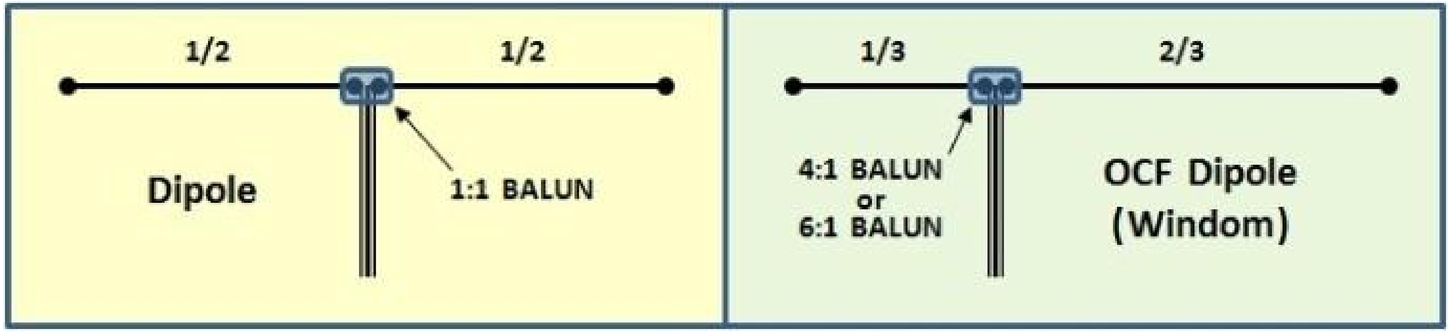
A. It does not require the driven element to be insulated from the boom

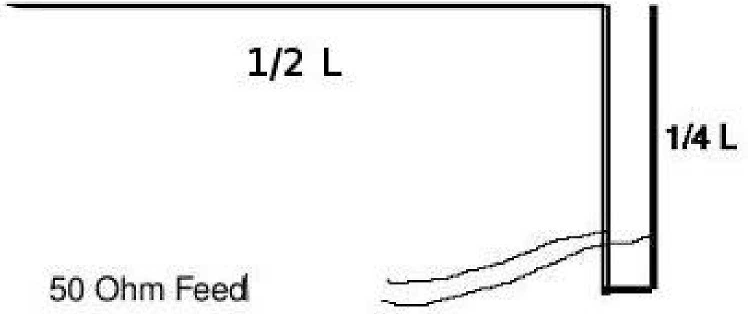
Other Impedence Matching Methods



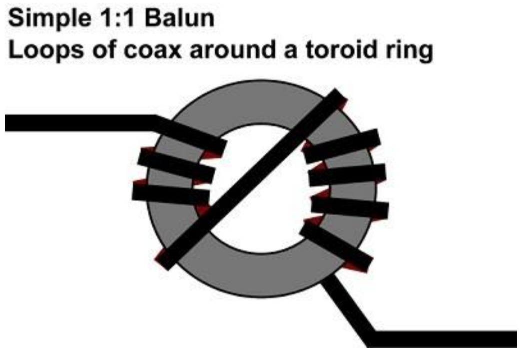
adjust proximity to ground

Moving the feedpoint





1/4 matching stub (J Pole)



Unun Current Choke
50 ohms to 50 ohms

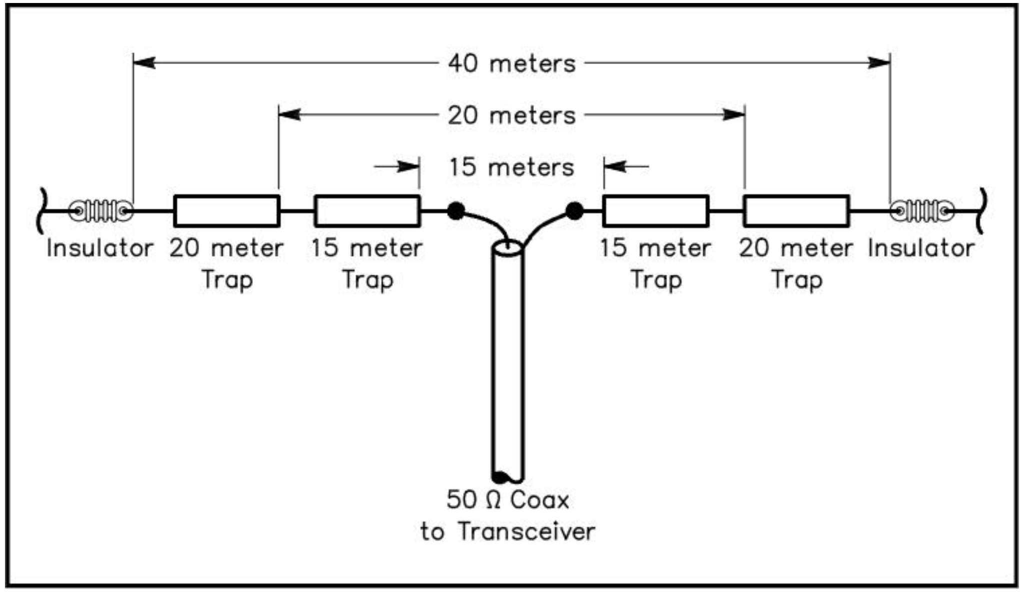
4:1 Voltage Transformer
200 ohms to 50 ohms

G9D – Specialized antenna types and applications

Specialized antennas - Multiband

Log-periodic antenna

The element length and spacing vary logarithmically along the boom to create a wide bandwidth / multiband antenna G9D07 (A) G9D06 (A)



Multiband Trap Dipoles

Traps enable multiband operation G9D04 (A)

Using an LC circuit to:

- Inductive Loading /lengthen element
- open circuit by resonanting
- capacitive shortend element

G9D11 (D) Multiband antennas have poor harmonic rejection

Specialized antennas - Mobile

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

C. Omnidirectional in the plane of the halo

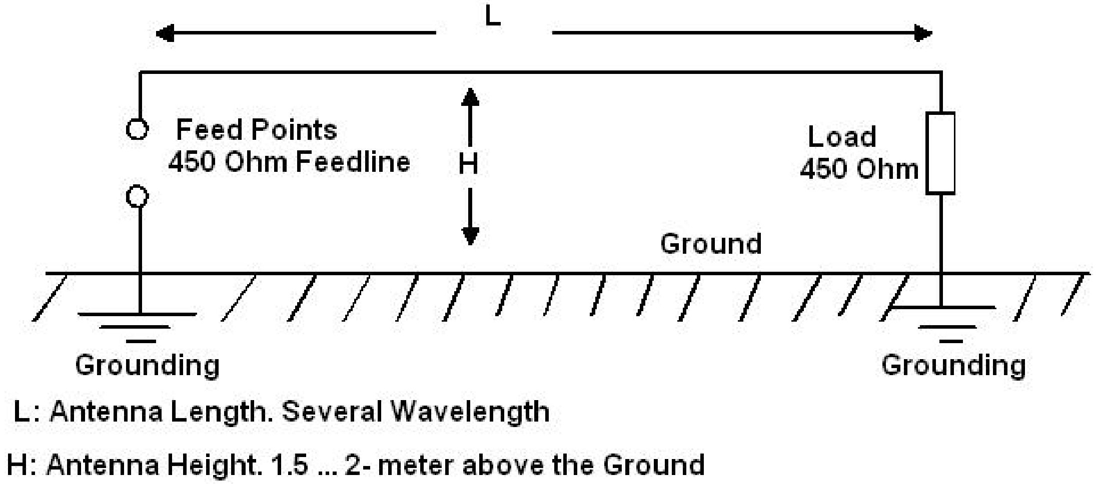
A “screwdriver” mobile antenna adjust its feed point impedance by varying the base loading inductance. G9D08 (B)

Specialized antennas - Low Band Receiving

G9D09 (A)

What is the primary use of a Beverage antenna?

A. Directional receiving for MF and low HF bands



Specialized HF antennas

G9D10 (B)

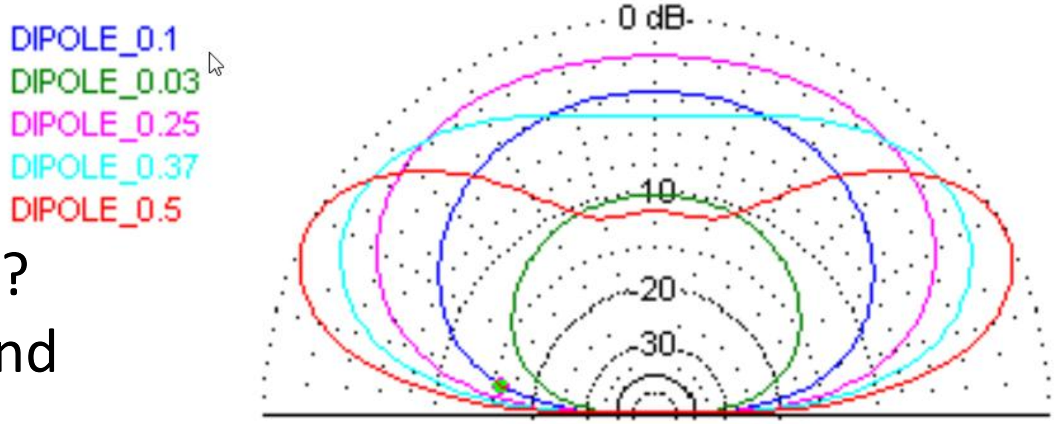
In which direction or directions does an electrically small loop (less than 1/10 wavelength in circumference) have nulls in its radiation pattern?

B. Broadside to the loop

G9D01 (A)

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



Following are all the actual questions with correct answers for your review later.

any questions?

Thank you for your kind attention.

Good luck

73

Steve Turner, KJ6EIF

G9A01 (A)
Which of the following factors determine the characteristic impedance of a parallel conductor feed line?
A. The distance between the centers of the conductors and the radius of the conductors

G9A02 (B)
What is the relationship between high standing wave ratio (SWR) and transmission line loss?
B. High SWR increases loss in a lossy transmission line

G9A03 (D)
What is the nominal characteristic impedance of “window line” transmission line?
D. 450 ohms

G9A05 (B)
How does the attenuation of coaxial cable change with increasing frequency?
B. Attenuation increases

G9A06 (D)
In what units is RF feed line loss usually expressed?
D. Decibels per 100 feet

G9A08 (B)
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?
B. 5:1

G9A04 (C)
What causes reflected power at an antenna's feed point?
C. A difference between feed line impedance and antenna feed point impedance

G9A07 (D)
What must be done to prevent standing waves on a feed line connected to an antenna?
D. The antenna feed point impedance must be matched to the characteristic impedance of the feed line

G9A09 (A)
What standing wave ratio results from connecting a 50-ohm feed line to a 200-ohm resistive load?
A. 4:1

G9A10 (D)
What standing wave ratio results from connecting a 50-ohm feed line to a 10-ohm resistive load?
D. 5:1

G9A11 (A)
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

G9B01 (B)
What is a characteristic of a random-wire HF antenna connected directly to the transmitter?
B. Station equipment may carry significant RF current

G9B02 (B)
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?
B. Slope the radials downward

G9B03 (D)
Which of the following best describes the radiation pattern of a quarter-wave ground-plane vertical antenna?
D. Omnidirectional in azimuth

G9B06 (C)
Where should the radial wires of a ground-mounted vertical antenna system be placed?
C. On the surface or buried a few inches below the ground

G9B12 (A)
What is the approximate length for a 1/4 wave monopole antenna cut for 28.5 MHz?
A. 8 feet

G9B10 (D)
What is the approximate length for a 1/2 wave dipole antenna cut for 14.250 MHz?
D. 33 feet

G9B11 (C)
What is the approximate length for a 1/2 wave dipole antenna cut for 3.550 MHz?
C. 132 feet

G9B04 (A)
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

G9B09 (A)
Which of the following is an advantage of using a horizontally polarized as compared to a vertically polarized HF antenna?
A. Lower ground losses

G9B07 (B)
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?
B. It steadily decreases

G9B08 (A)
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

G9B05 (C)
How does antenna height affect the azimuth radiation pattern of a horizontal dipole HF antenna at elevation angles higher than about 45 degrees?
C. If the antenna is less than 1/2 wavelength high, the azimuth pattern is almost omnidirectional

G9D12 (A)
What is the common name of a dipole with a single central support?
A. Inverted V

G9C01 (A) Which of the following would increase the bandwidth of a Yagi antenna?
A. Larger-diameter elements

G9C02 (B) What is the approximate length of the driven element of a Yagi antenna?
B. 1/2 wavelength

G9C03 (A) 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

G9C04 (B) How does antenna gain in dBi compare to gain stated in dBd for the same antenna?
B. Gain in dBi is 2.15 dB higher

G9C05 (A) What is the primary effect of increasing boom length and adding directors to a Yagi antenna?
A. Gain increases

G9C07 (C) What does "front-to-back ratio" mean in reference to a Yagi antenna?
C. The power radiated in the major lobe compared to that in the opposite direction

G9C08 (D) What is meant by the "main lobe" of a directive antenna?
D. The direction of maximum radiated field strength from the antenna

G9C10 (D)
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

G9D05 (D)
What is an advantage of vertically stacking horizontally polarized Yagi antennas?
D. It narrows the main lobe in elevation

G9C09 (B)
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?
B. Approximately 3 dB higher

G9C11 (A)
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

G9C12 (A)
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

G9D03 (C)
In which direction is the maximum radiation from a VHF/UHF “halo” antenna?
C. Omnidirectional in the plane of the halo

G9D04 (A)
What is the primary function of antenna traps?
A. To enable multiband operation

G9D06 (A)
Which of the following is an advantage of a log-periodic antenna?
A. Wide bandwidth

G9D08 (B)
How does a “screwdriver” mobile antenna adjust its feed point impedance?
A. By varying its body capacitance
B. By varying the base loading inductance

G9D07 (A)
Which of the following describes a log-periodic antenna?
A. Element length and spacing vary logarithmically along the boom

G9D11 (D)
Which of the following is a disadvantage of multiband antennas?
D. They have poor harmonic rejection