General License Course

Chapter 7
Antennas

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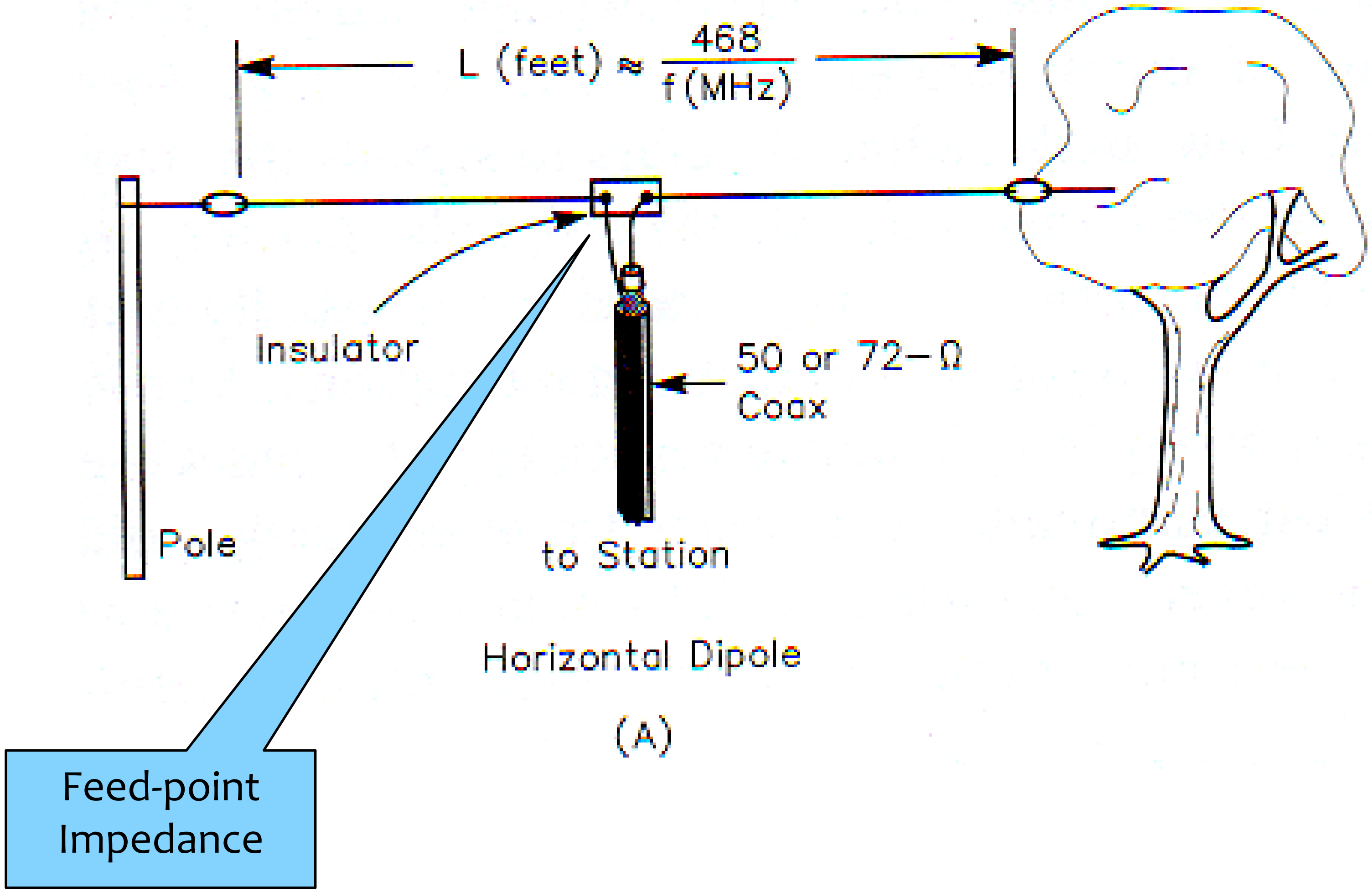
A Look at Antennas

- ***The time, effort and money invested in your antenna system generally will provide more improvement to your station than an equal investment to any other part of the station.***

Black Text: Regular information
Blue Text: Information related to a Question-Pool question
Bold text: Key words

Antenna Review: The Dipole



What is Impedance?

Impedance is resistance to movement

- When I ride a bicycle on dirt or gravel trails, I encounter resistance; moderate resistance makes for good exercise
- Power is transferred from my legs to the bicycle's wheels allowing me to push forward

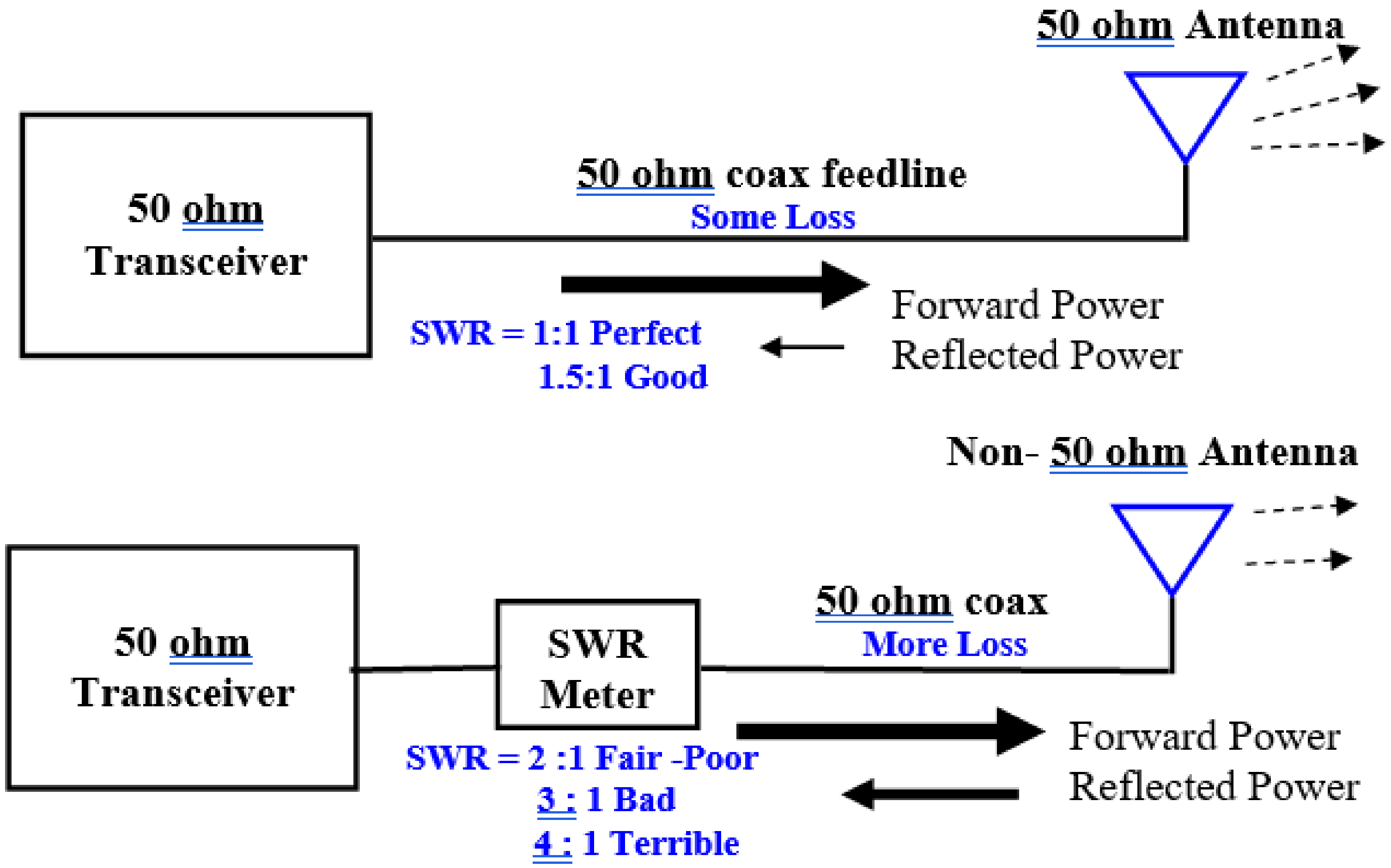
- Similarly, a transmitter is able to deliver power into an antenna if it has some impedance to push into.

Efficient Power Transfer

I will be able to **most efficiently deliver power** from my legs to the pedals if the size of the bicycle **matches** my body size

Your radio station will be **most efficient when the transmitter, feedline and antenna are matched** (have the same impedance).

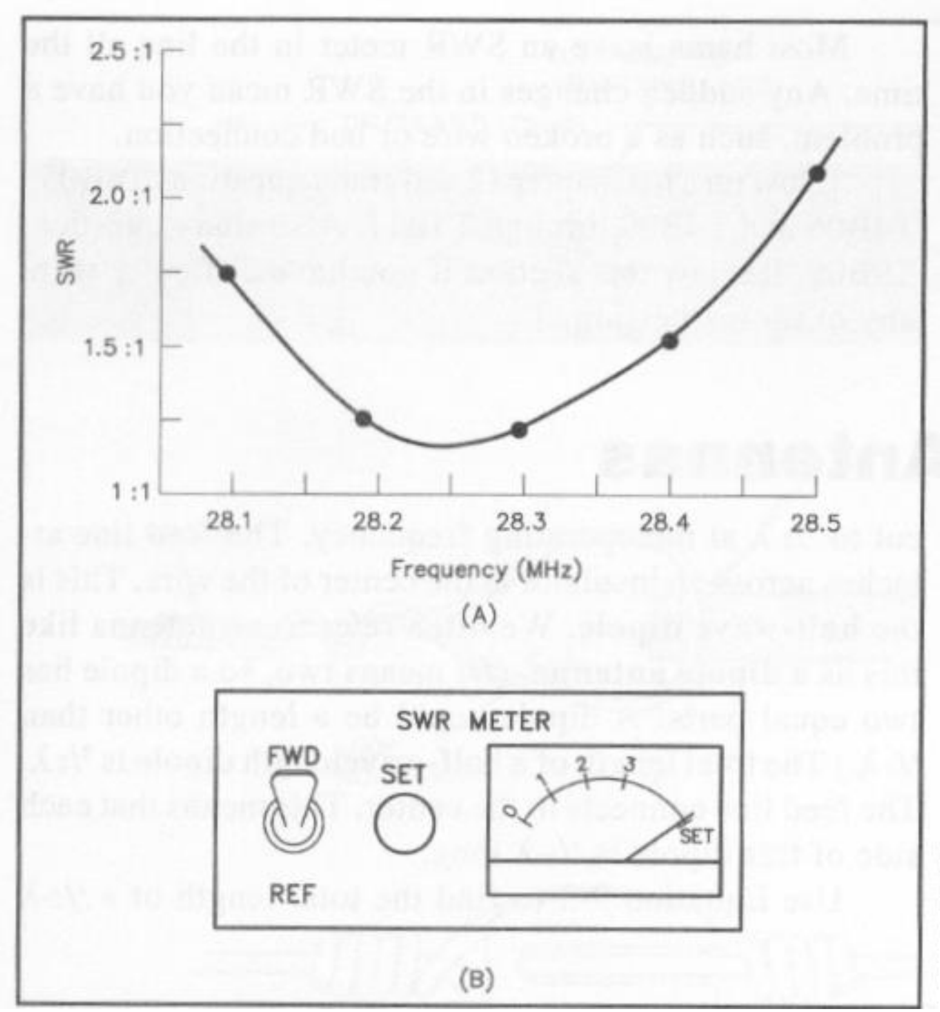
Review: Standing Wave Ratio (SWR)



Standing Wave Ratio (SWR)

SWR	% of Power Being Reflected Back	What it Means to Operation
1 : 1	0%	Perfect match / Very good operation
1.5 : 1	4%	Good match / Good operation
2 : 1	11%	Fair-poor match / Reduced performance
3 : 1	25%	Bad match / Poor performance
4 : 1 or higher	38% or higher	Terrible match / Bad performance

SWR Measurements



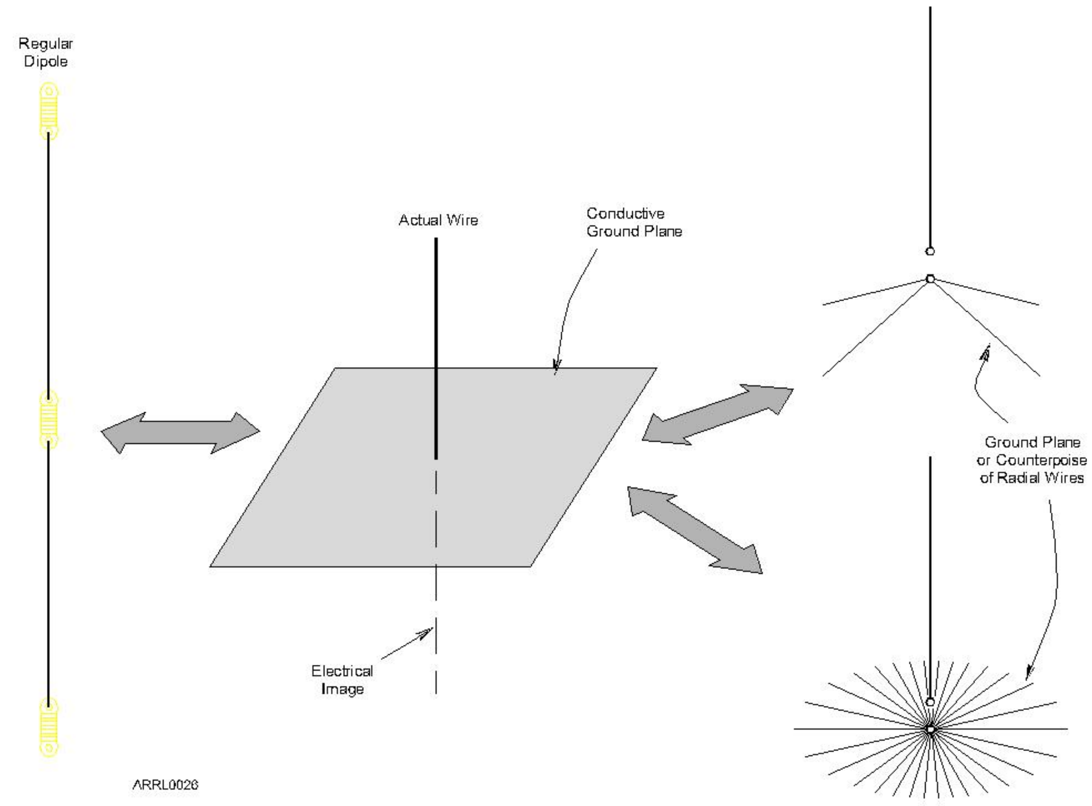
SWR Meter / Directional Wattmeter

Antenna Review: Ground-Plane

Also called a
Vertical Antenna

One half of a
dipole is replaced
with a
"ground plane"

The ground plane
can be a metal
sheet or wires
(called radials)



Decibel (dB)

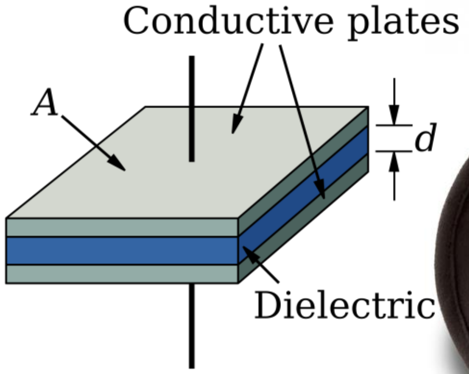
- The Decibel is a measure of *change* in the power of a signal.
- Abbreviated: dB
- Somewhat like percent of change—but dBs are non-linear

Decibel	Change in Power	Observed Effect	Example
1 dB	About 20%	Hardly perceivable	1 W → 1.2 W
3 dB	Factor of 2	Just noticeable	1 W → 2 W
6 dB	Factor of 4	Significant	1 W → 4 W
10 dB	Factor of 10	Quite significant	1 W → 10 W
15 dB	Factor of 32	Very significant	1 W → 32 W
20 dB	Factor of 100	Huge difference	1 W → 100 W
30 dB	Factor of 1000	Extreme difference	1 W → 1000 W

Section 7:1 Dipoles and Ground Planes

19 Questions

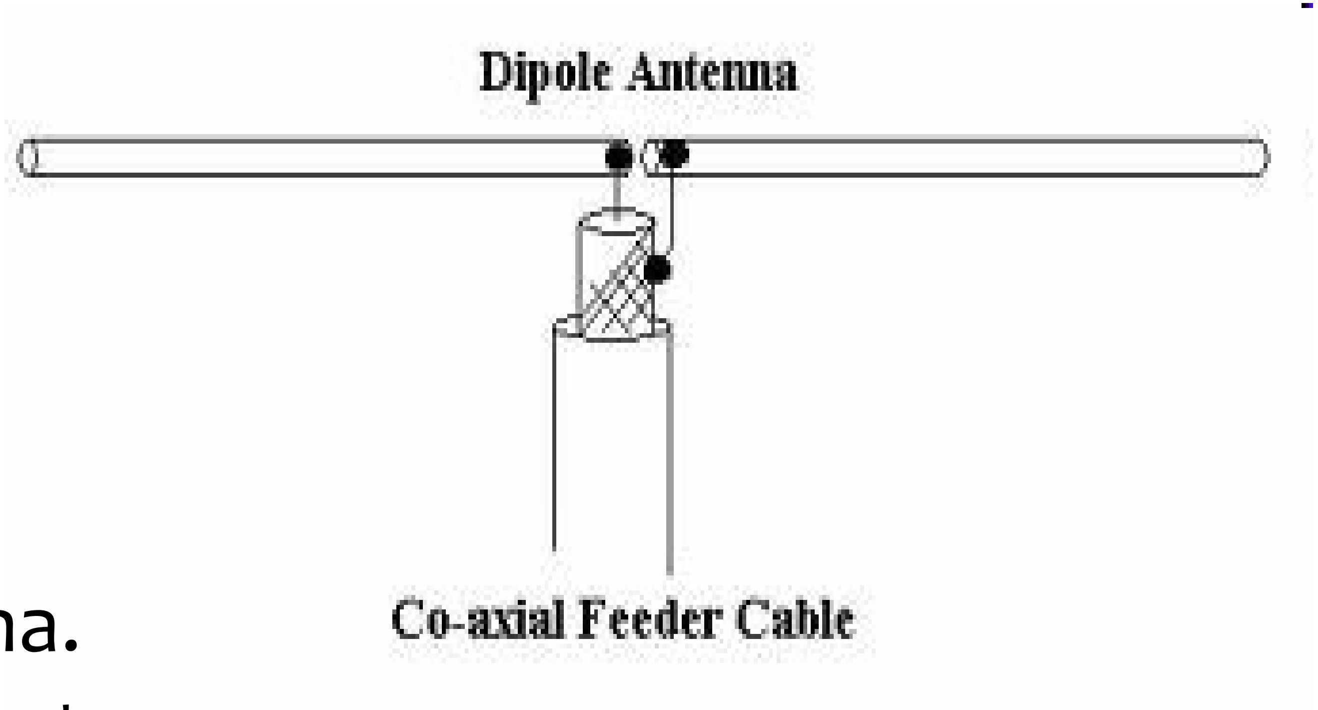
- Mobile HF Antennas
  - Capacitance hat
  - Corona ball
  - Limited Bandwidth
  - Screwdriver coil



- Antenna's impedance & radiation patterns
  - Verticals – radials
  - Dipoles – height above ground; fed at the center, off-center or end
  - Inverted "V" configuration of a dipole
  - Dipole height
- Antenna length and gain

Section 7:1 Dipoles and Ground Planes

The Dipole

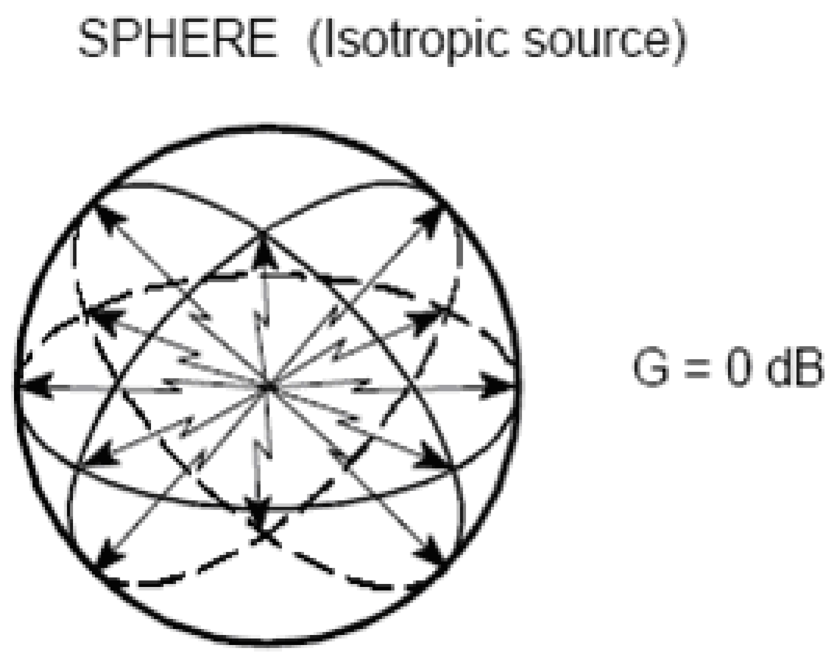


- The most basic antenna.
  - Two conductors, equal length parts.
  - Feed line connected in the middle.

Isotropic Radiator

* Isotropic radiators are used as reference radiators

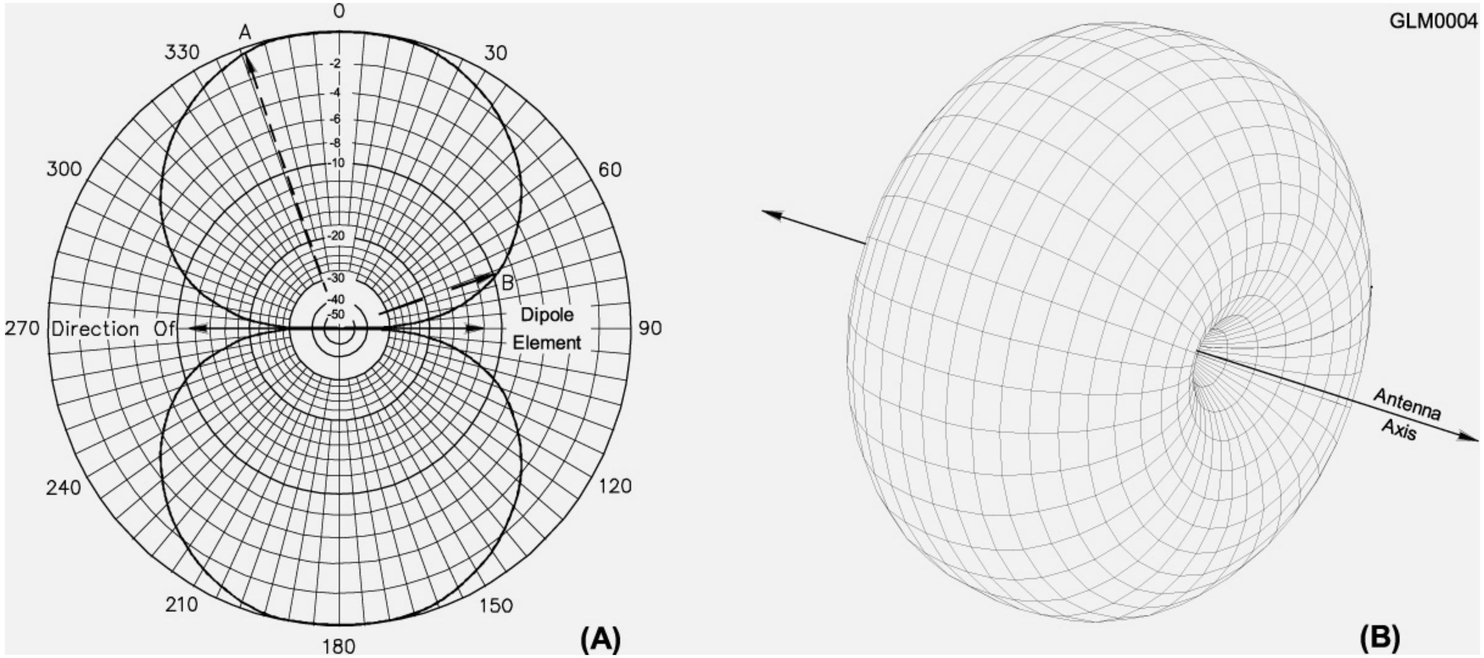
* An **isotropic radiator** is a theoretical point source of electromagnetic or sound waves.



Broadside Radiation Pattern

This "**figure-eight pattern is the shape of the azimuth pattern for a dipole antenna in free space**. (G9B04)

What is the radiation patten of a dipole antenna in free space in a plane containing the conductor?



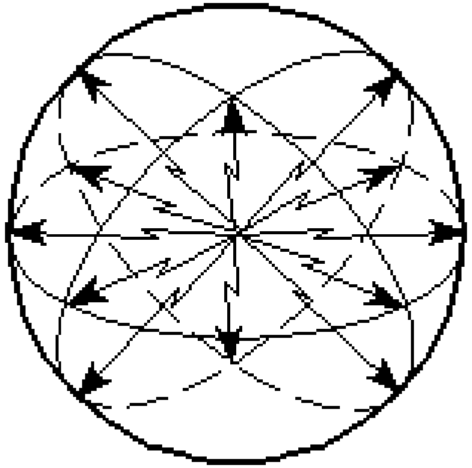
Azimuthal Pattern

Computer Generated Sketch

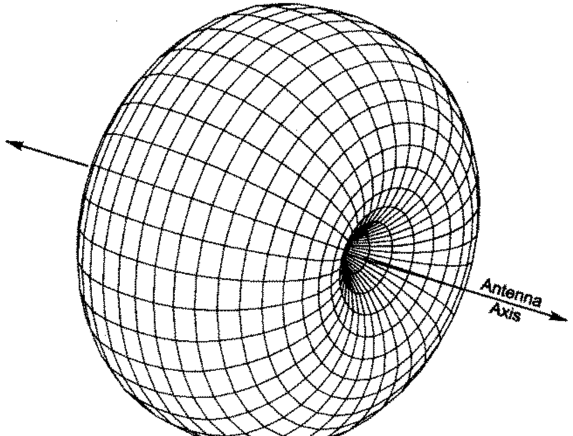
A Look at Gain

When we talk about the gain of other antennas

- The Isotropic radiator has no gain in any direction.
- The Radiation of the main lobe of a dipole is 2.15 dB greater than would be expected from an Isotopic antenna.



… we can reference the gain to an **isotropic** radiator (**dBi**)



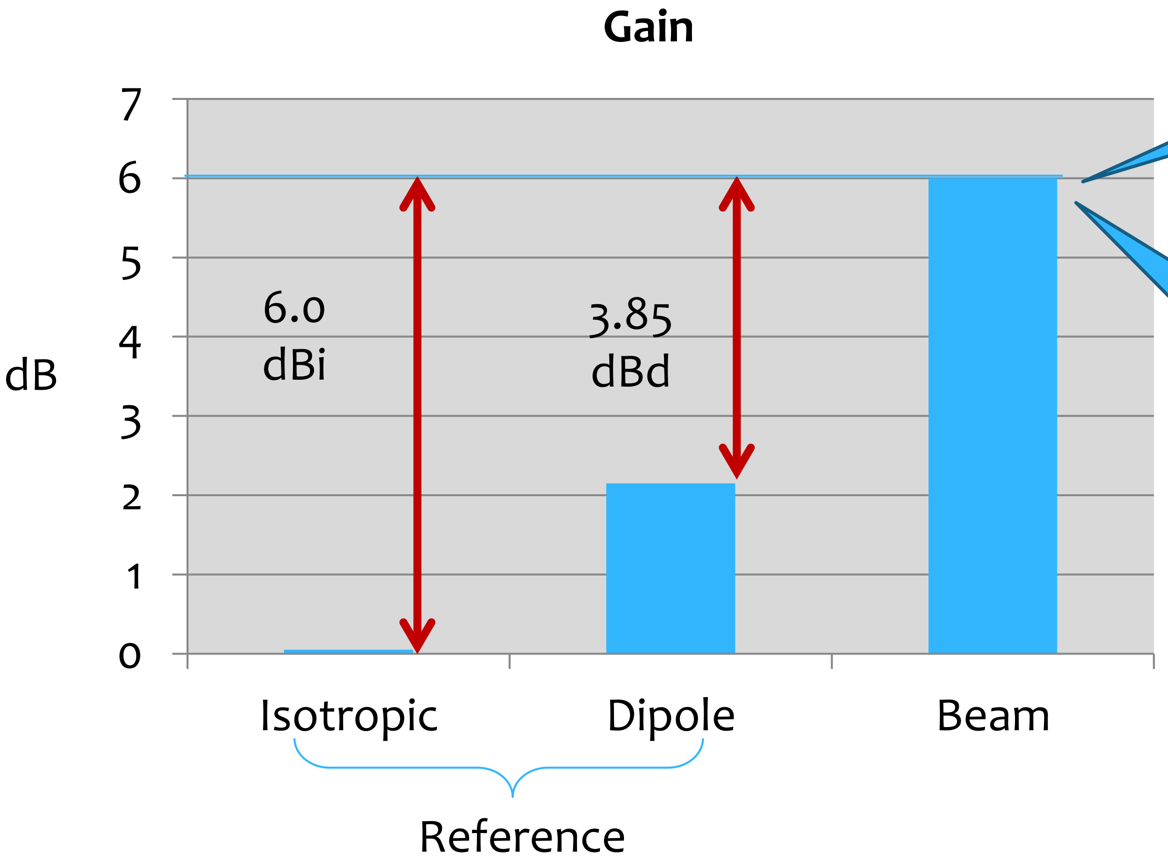
(B)

… or we can reference the gain to a **dipole** antenna (**dBd**)

To Convert:

- **dBi to dBd, subtract 2.15 dB**
- **dBd to dBi add 2.15 dB**

dBi and dBd



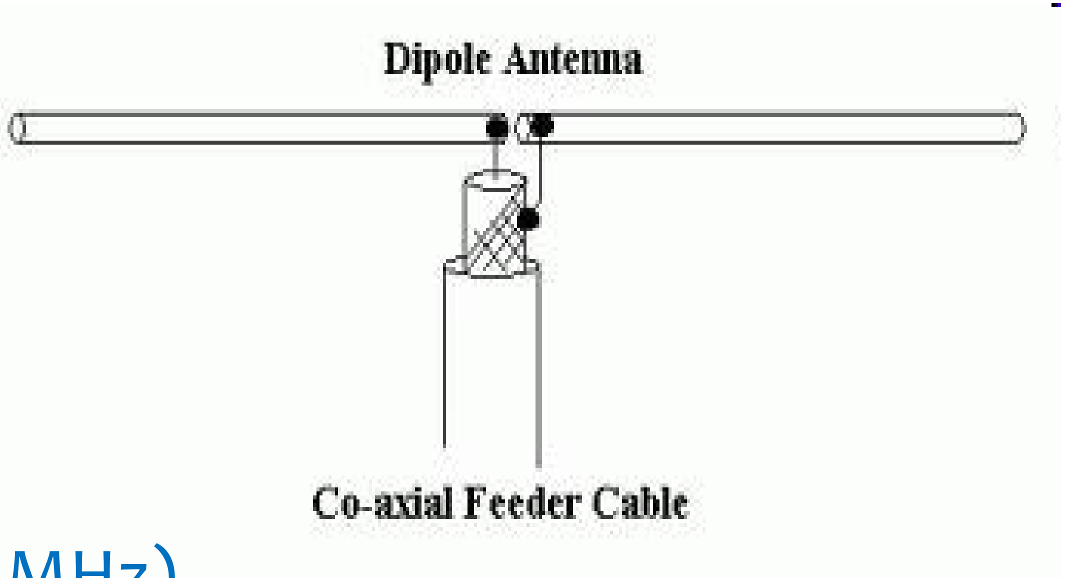
The beam antenna we want to buy advertises a gain of **6 dBi**

Or the same antenna could be advertised as having a gain of **3.85 dBd**

Example 9-1

Dipole Length

Pg 7-4



- Total length is ½ wavelength.
- Length (in feet) = 492 / Frequency (in MHz).
  - For 146 MHz: 492 / 146 = 3.4 ft = 40.8 inches
  - For 28.5 MHz: 492 / 28.5 = 17.3 ft G9B12
- Many factors alter the exact length

Other books say

468/f

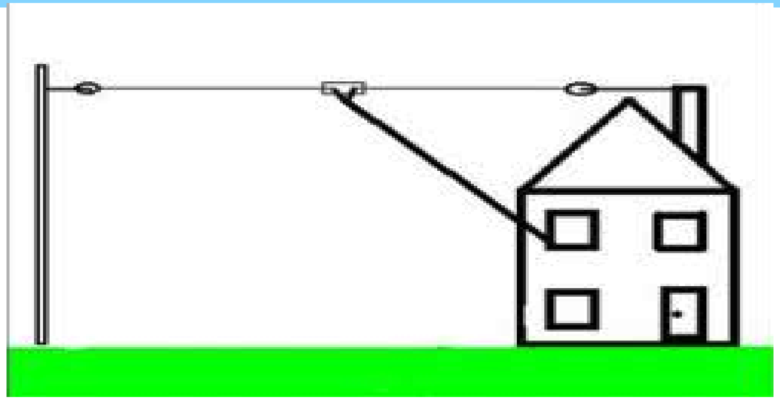
Dipole Antennas

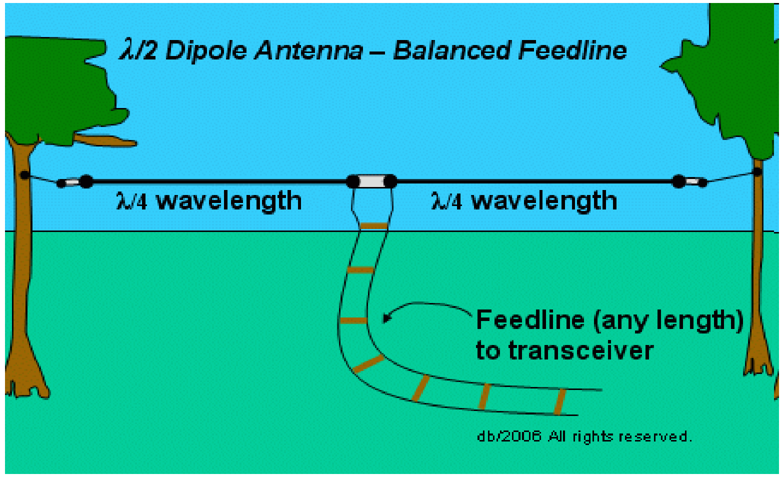
Pg 7-4

- The approximate length for a 1/2-wave dipole antenna cut for 3.550 MHz is **132 feet.** (G9B11)
  - *Calculate ½ wavelength in feet by dividing 492 by the frequency in MHz.*
  - *492 / 3.550 = **138.5 Feet***
- **33 feet** is the approximate length for a 1/2-wave dipole antenna cut for 14.250 MHz. (G9B10)
  - *Calculate ½ wavelength in feet by dividing 492 by the frequency in MHz.*
  - *492 / 14.250 = **34.5 Feet***

468/f =

- 131.8ft
- 32.9 ft





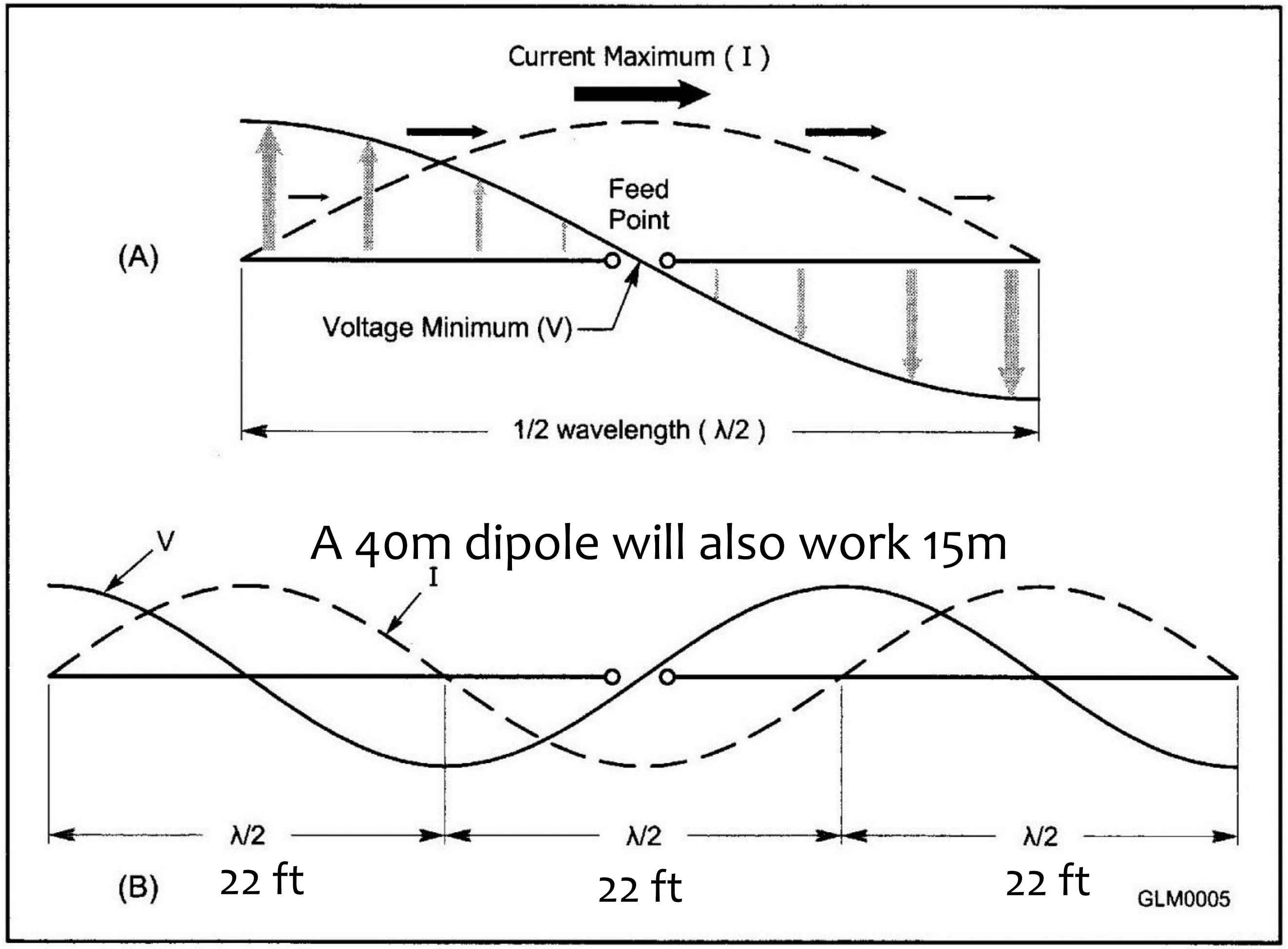
Half-wave Dipole with 450 ohm feedline (not coax).

Practical Information – Dipole Lengths

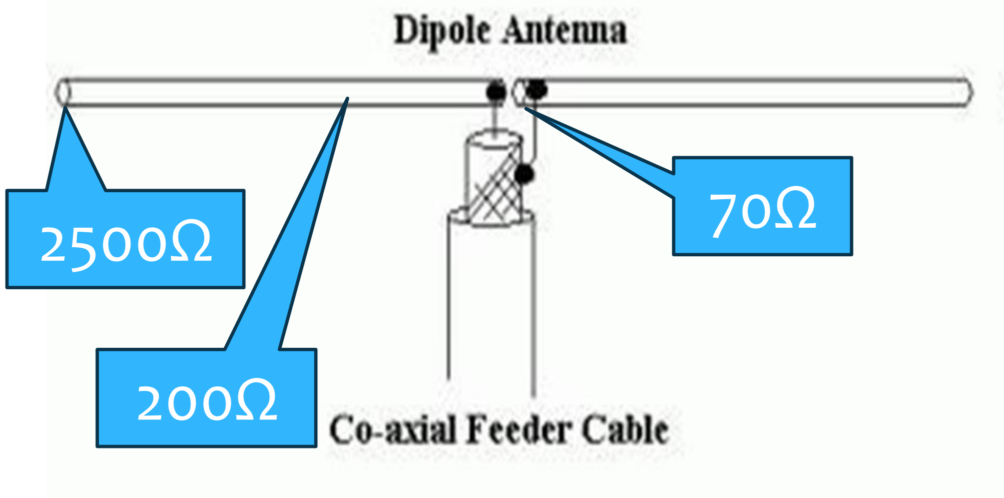
Wavelength	*Frequency*	*Length*
80 meters	3.725 MHz	125.6 feet
40 meters	7.125 MHz	66 feet
15 meters	21.125 MHz	22 feet
10 meters	28.150 MHz	16.6 feet
10 meters	28.475 MHz	16.4 feet
2 meters	146.0 MHz	3.25 feet
1.25 meters	223 MHz	2.1 feet = 25 inches

Half-Wave Dipole Antenna

7-3



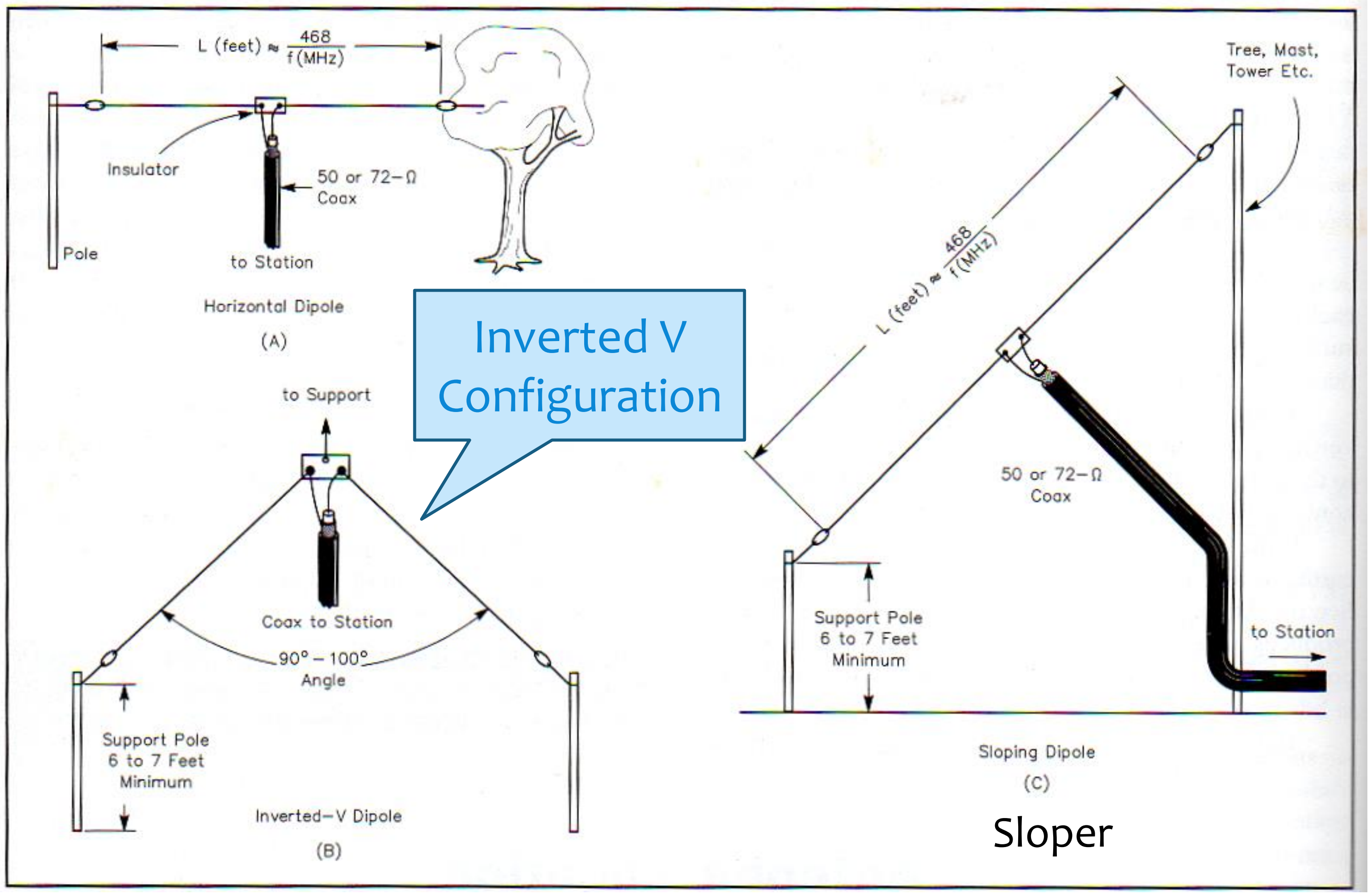
Impedance vs. Feedpoint



As we move the feedpoint of the antenna further away from the center, the feedpoint impedance **increases.** G9B08

There are Many Dipole Variations

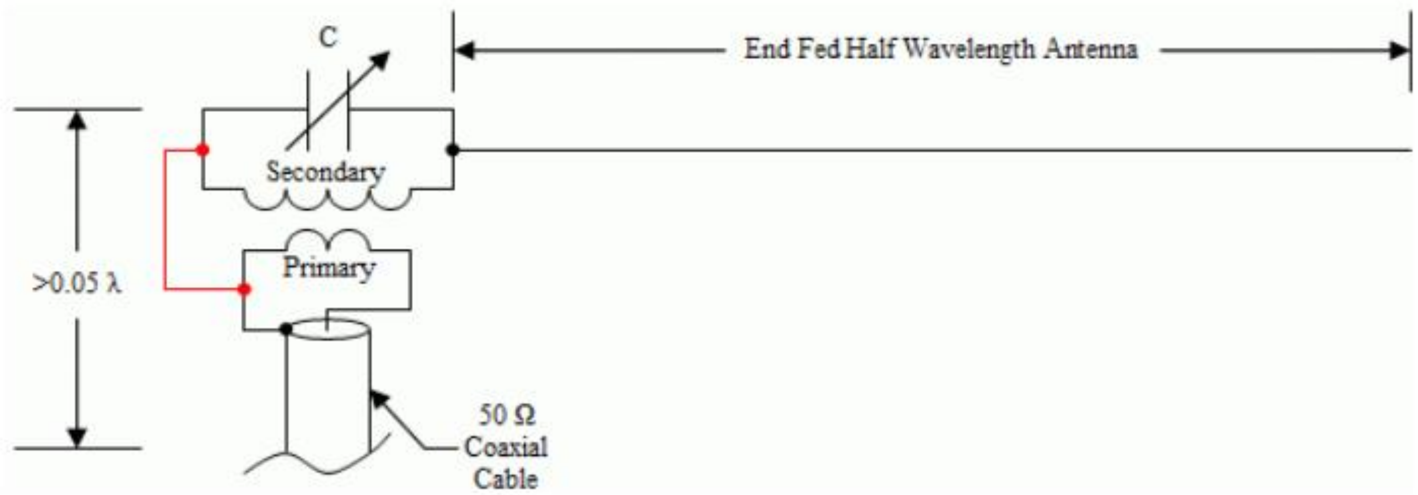
- **The efficiency of a simple dipole is hard to beat.**
- **Most simple dipoles work only one band**, however a 40m dipole will tend to also work on 15m.
- Dipoles are **simple to build and a great learning experience**.

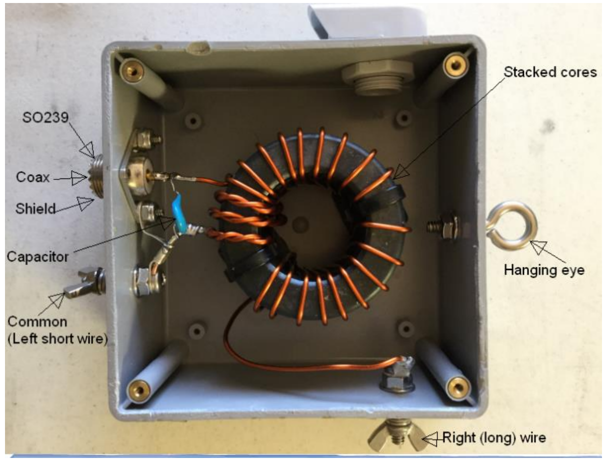


End Fed Halfwave (EFHW)

7-4

G0KYA's HF End Fed Half Wave (EFHW) antenna – construction details





49:1 Impedance Ratio

- An end-fed half wave antenna can be thought of as being like a dipole, only fed at one end.
- The impedance at the end of the antenna is **very high** (several thousand ohms).

G9D02

The Ground-Plane (Vertical)

7-4

- A vertical is like a dipole that is oriented perpendicular (**vertical** to the Earth’s surface).
- One half of the dipole is replaced by the ground-plane.
  - Earth
  - Car roof or trunk lid or other metal surface.
  - Radial wires.
- Length (in feet) = 246 / Frequency (in MHz).
  - For 146 MHz: 246 / 146 = 1.7 ft = 20.2 inches

Some books say

234/f

Vertical Antennas

7-4

- The approximate length for a 1/4-wave vertical antenna cut for 28.5 MHz is **8 feet.** (G9B12)

Calculate 1/4 wavelength in feet by dividing 246 by the frequency in MHz.

246/28.5 = 8.6 Feet

Or Using the alternate formula

234/28.5 = 8.2 Feet

Practical Information: Vertical Lengths

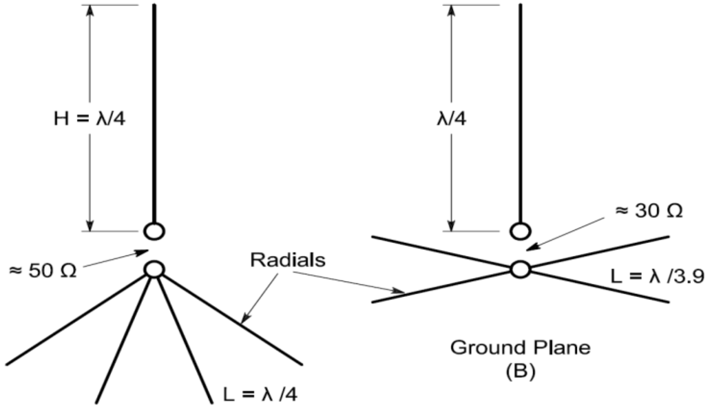
Wavelength	*Frequency*	*Length*
80 meters	3.700 MHz	63.24 feet
40 meters	7.125 MHz	32.8 feet
15 meters	21.125 MHz	11.1 feet
10 meters	28.150 MHz	8.3 feet
10 meters	28.4 MHz	8.2 feet
6 meters	52.5 MHz	4.5 feet
2 meters	146.0 MHz	1.6 feet (19.25 inches)
1.25 meters	223.0 MHz	1.05 feet (12.6 inches)
70 cm	440.0 MHz	0.53 feet (6.4 inches)
23 cm	1282.5 MHz	0.18 feet (2.2 inches)

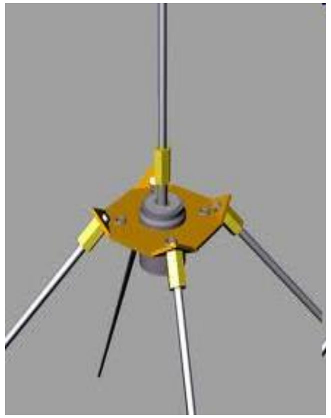
Elevated Vertical Antennas

7-5

- An advantage of downward sloping radials on a quarter wave ground-plane antenna is that **they bring the feed-point impedance closer to 50 ohms*.** (G9B02)
- The radiation pattern of the vertical is **omnidirectional in azimuth.** (G9B03)

* Bending the radials changes the impedance from about 30 ohms up towards 50 ohms.





Notice ground plane elements are angled downwards.

Ground-Mounted Vertical Antennas

7-5

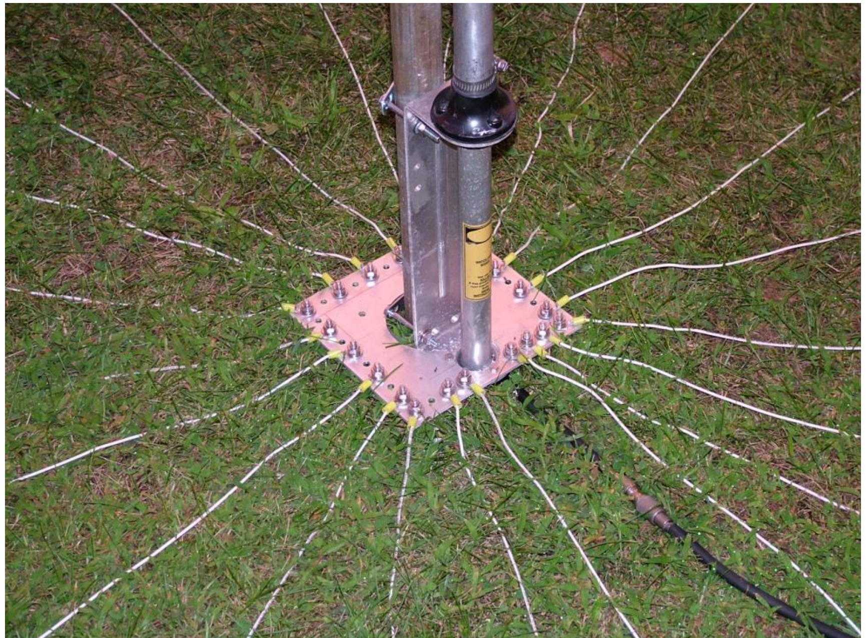
- The radial wires of a ground-mounted vertical antenna system should be placed **on the surface or buried a few inches below the ground.** (G9B06)

A common length for radials is ¼ wavelength.

Although, on ground-mounted verticals the length of the radials is not that critical.

Ground wire kit.

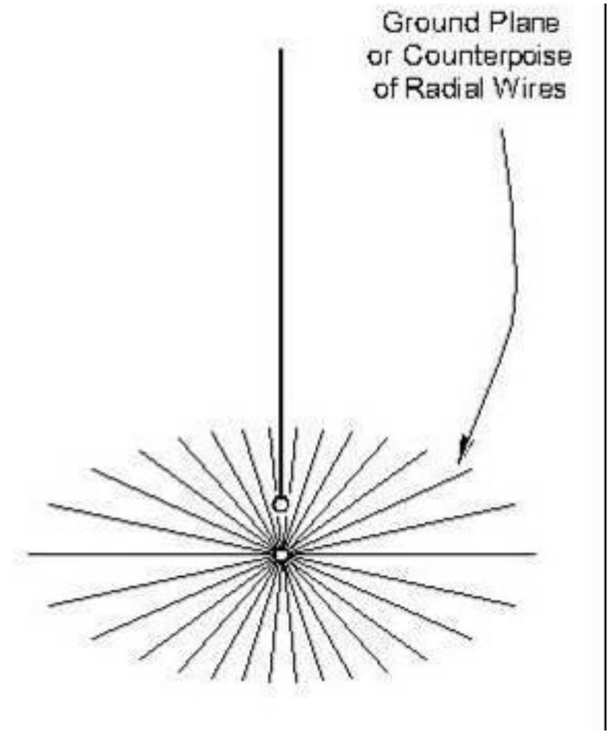
Surface mounted ground wires.



Verticals are Omnidirectional

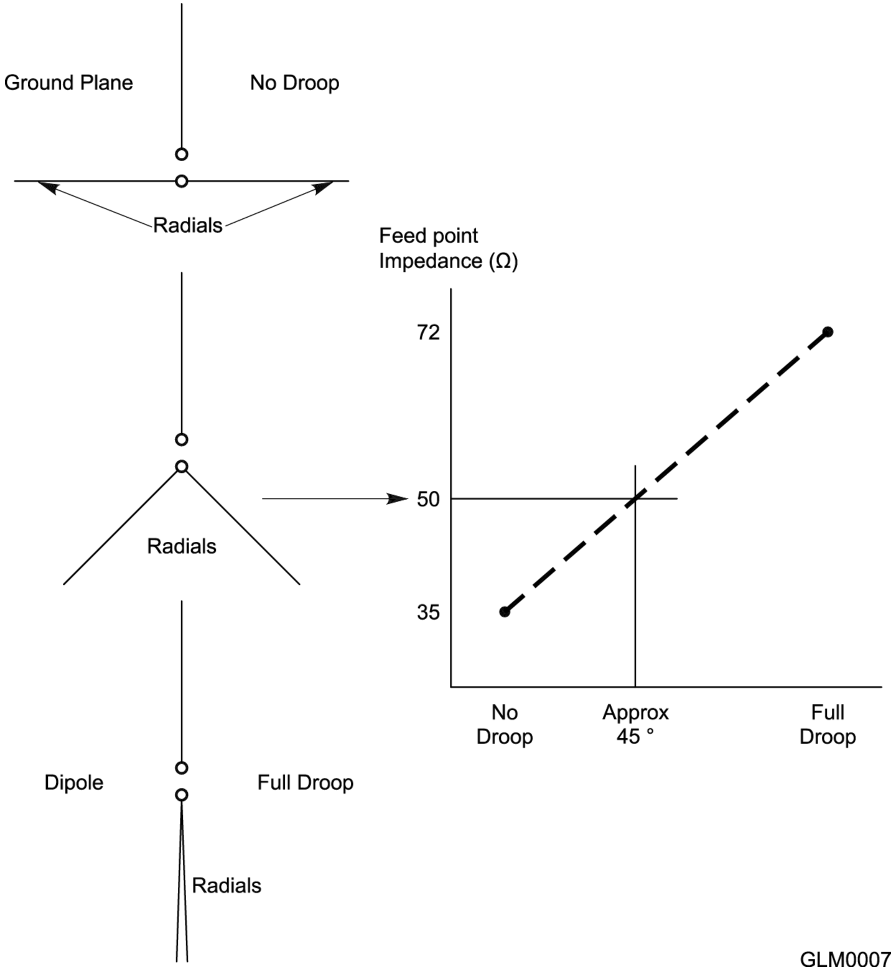
7-5

* The ground plane antenna's pattern is omnidirectional in azimuth. G9B03
  * More simply stated, it radiates the same signal strength in all directions.



Elevated Vertical - Sloping Radials

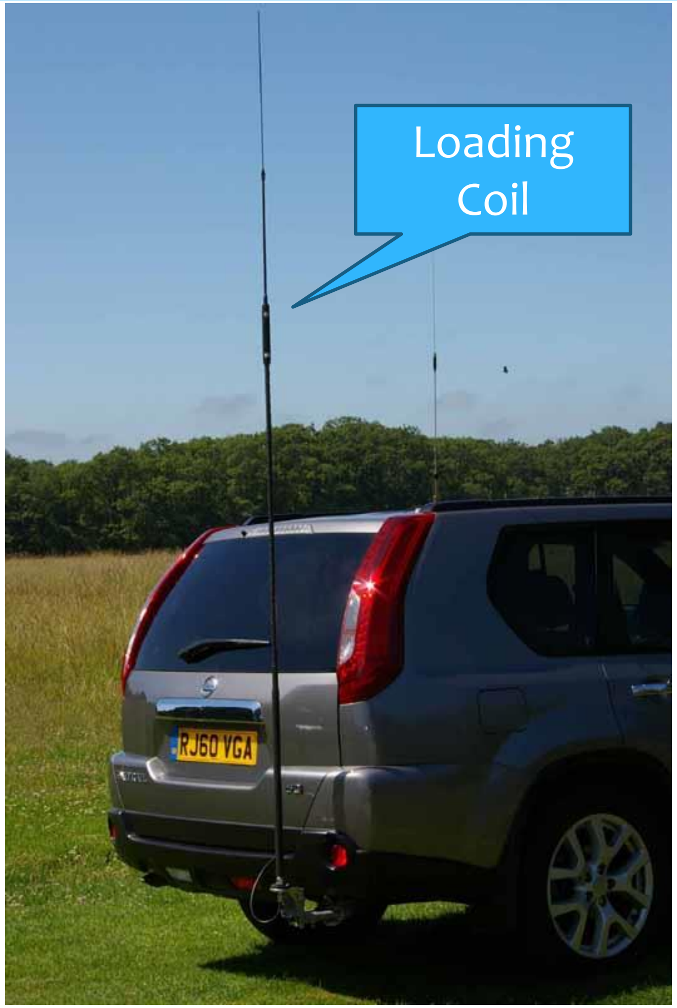
As the radials droop downward, the impedance is increased.

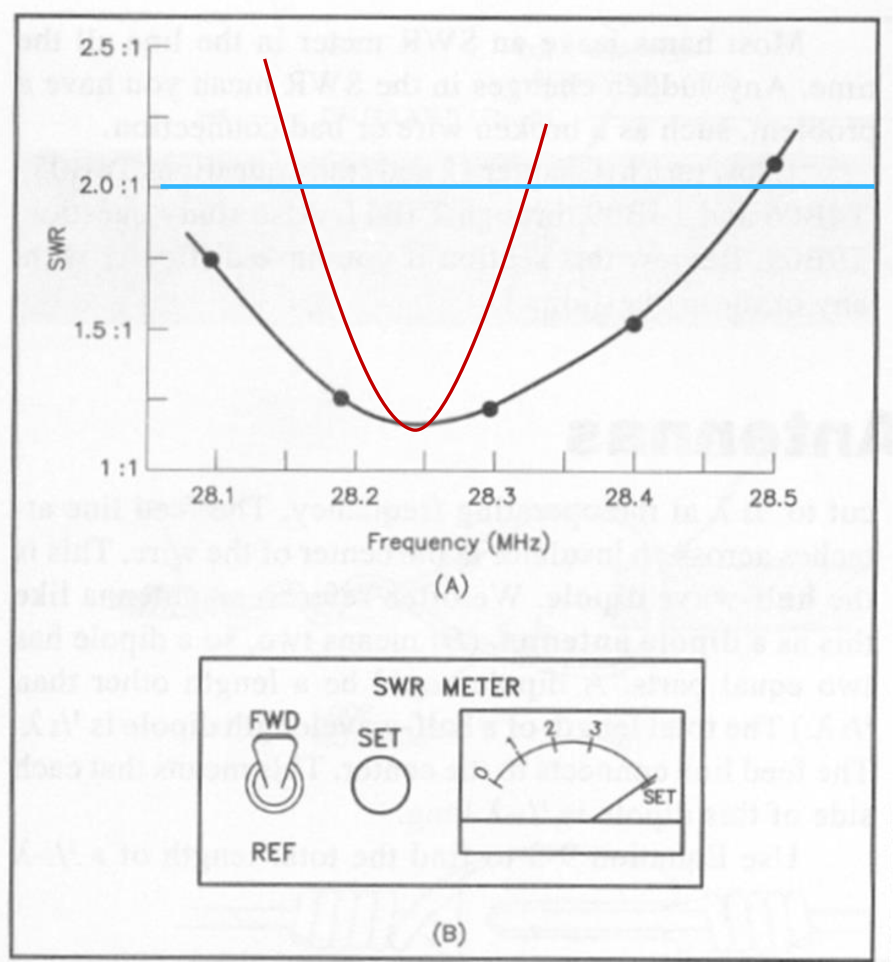


Mobile Antennas are Verticals

7-5, 6

* Loading Coil
  * Allows for physically shorter antennas
  * **Results in a reduced operating bandwidth** (G4E06)
* Corona Ball
  * Is attached to the tip of the antenna
    * **Prevent high-voltage discharge** (G4E02)



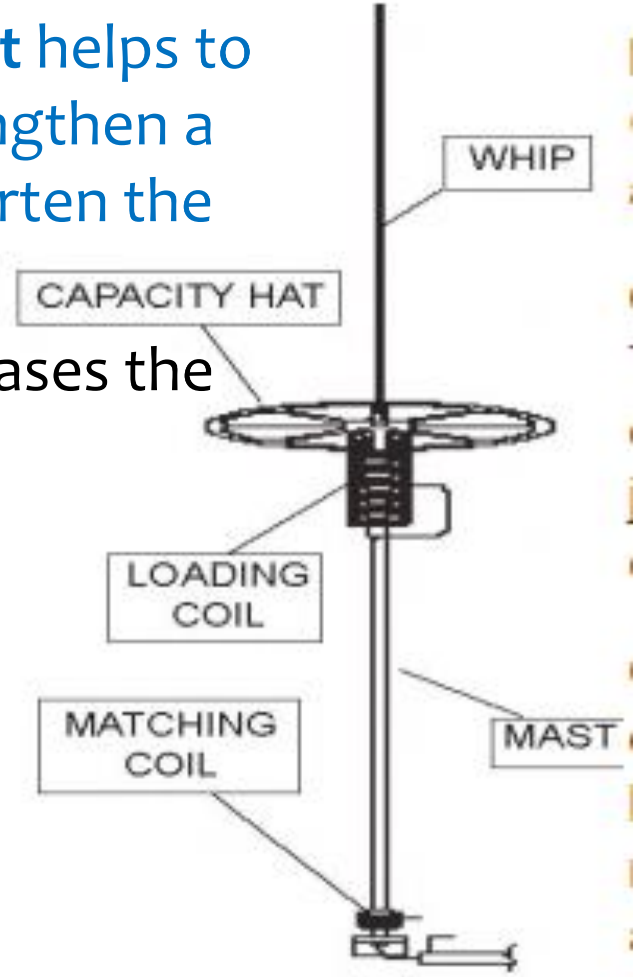


Mobile Antenna Enhancements

7-5, 6

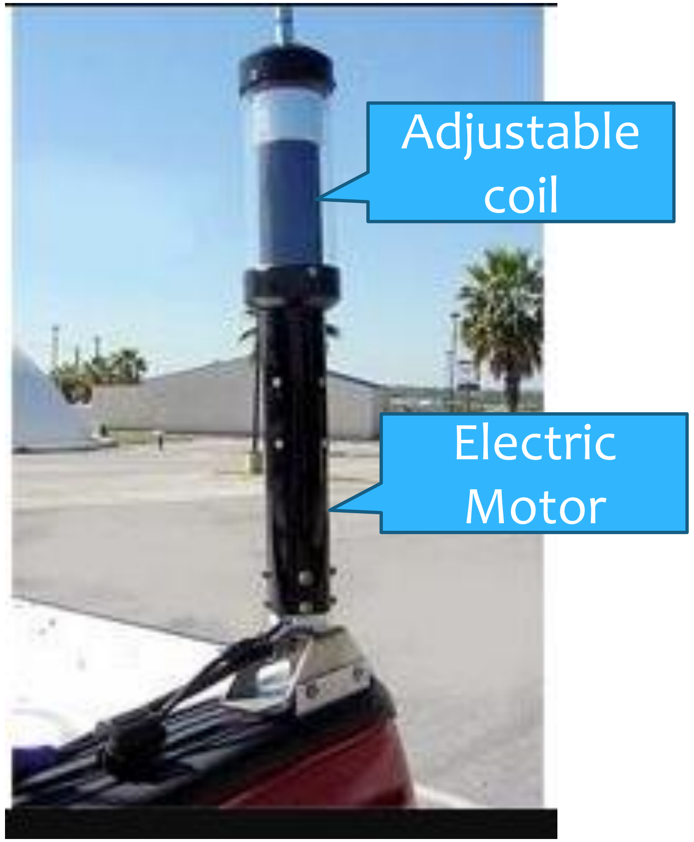
A **Capacity Hat** helps to electrically lengthen a physically shorten the antenna G4E01

* It also increases the bandwidth

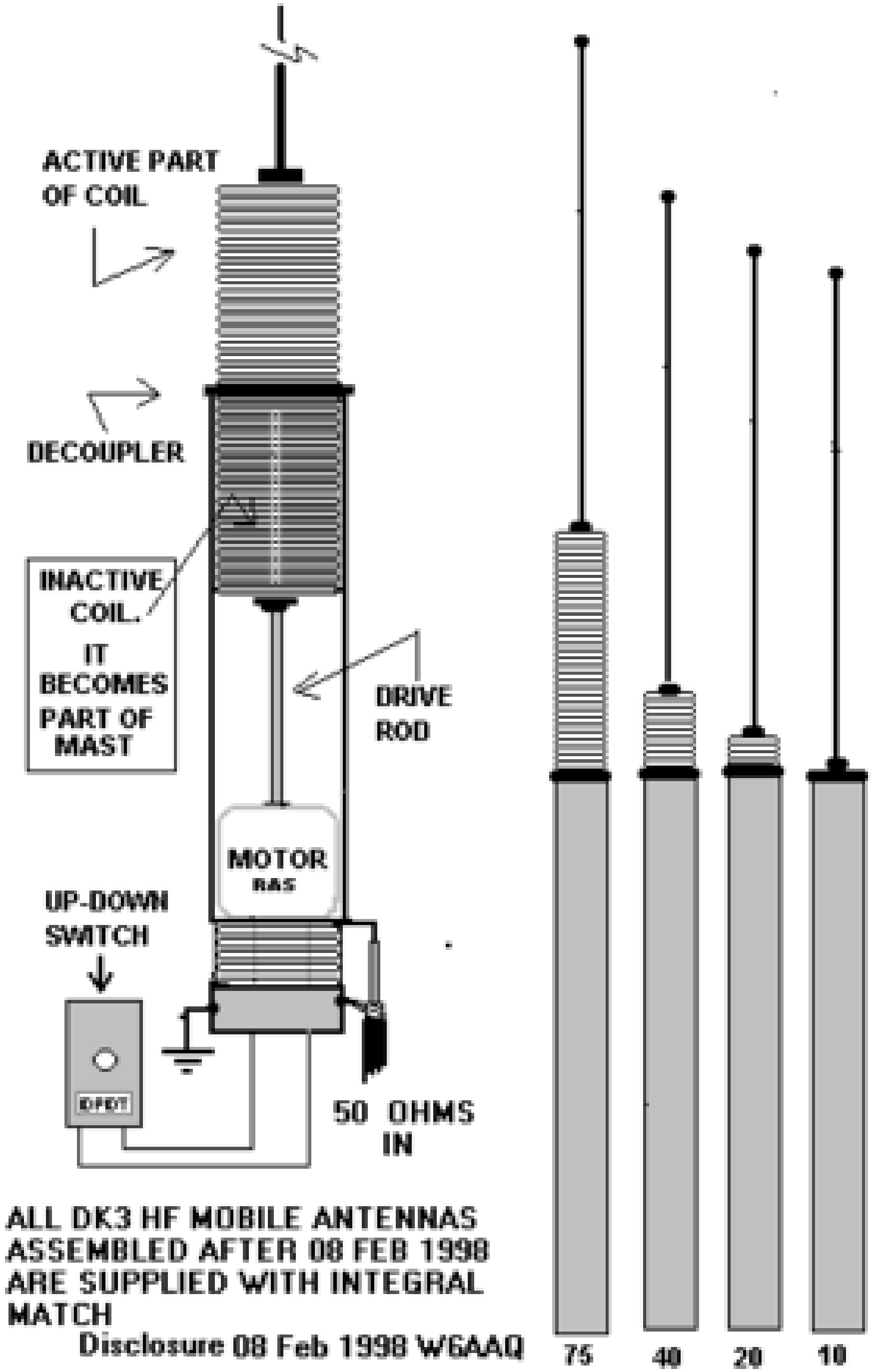


A **Screwdriver Antenna** uses an adjustable inductor for the loading coil, making the antenna tunable.

- The adjustment is made with an electric motor turning a threaded rod, somewhat resembling an electric screwdriver



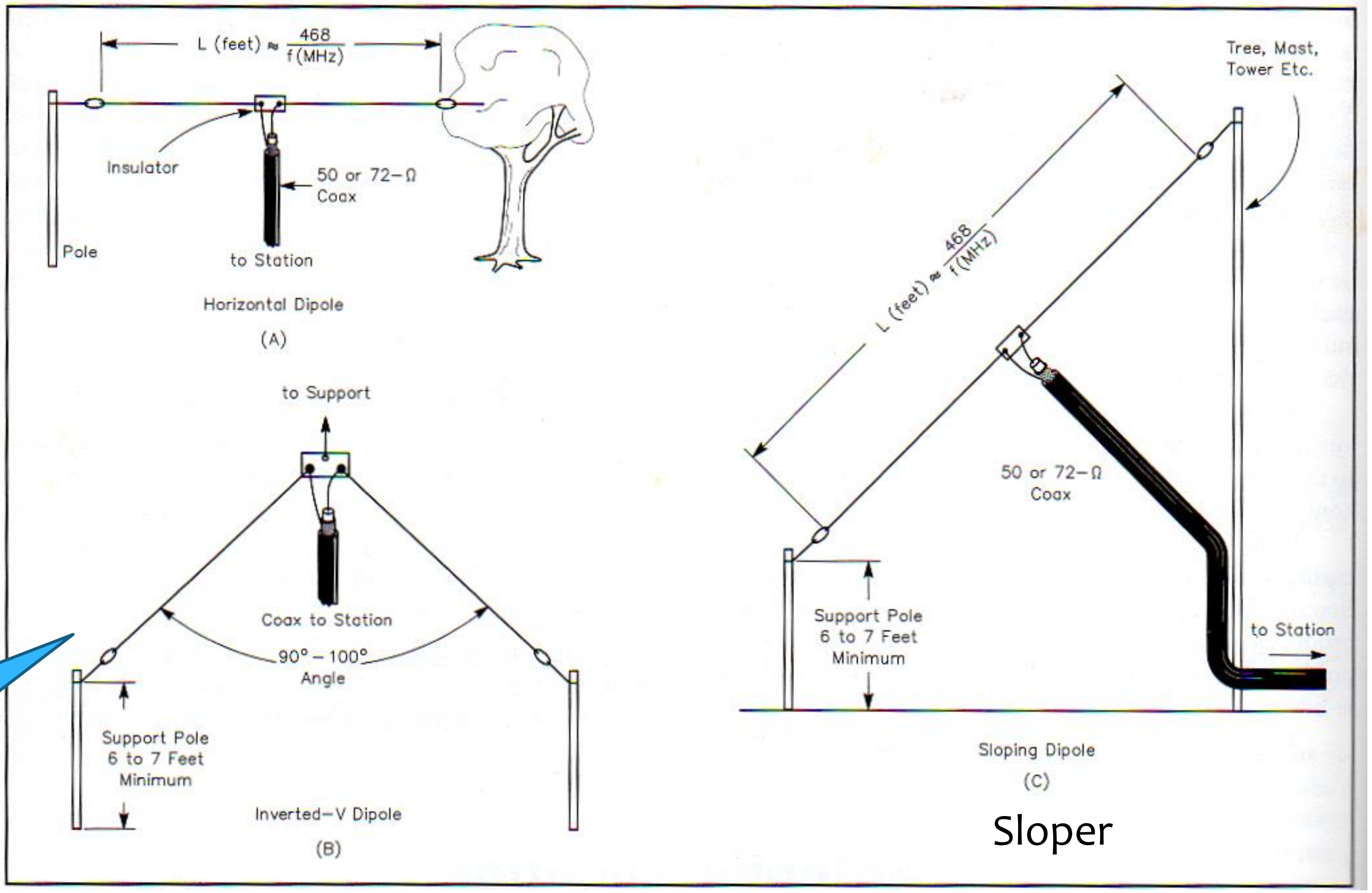
Inside the Screwdriver Antenna



Back to the Dipole
There are Many Dipole Variations

- **The efficiency of a simple dipole is hard to beat.**
- **Most simple dipoles work only one band**, however a 40m dipole will tend to also work on 15m.

Inverted V Configuration

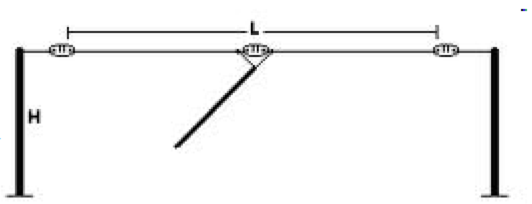


Back to the Dipole

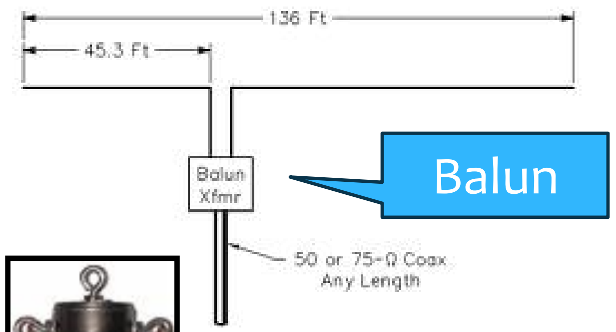
Dipole Antenna Impedance

7-6

- As the antenna is **lowered from 1/4 wave above ground, the feed-point impedance** of a 1/2 wave dipole antenna **steadily decreases.** (G9B07)
  - Antenna height affects the feed point impedance.



- The feed-point impedance of a 1/2 wave dipole **steadily increases** as the feed-point location is moved **from the center toward the ends.** (G9B08)



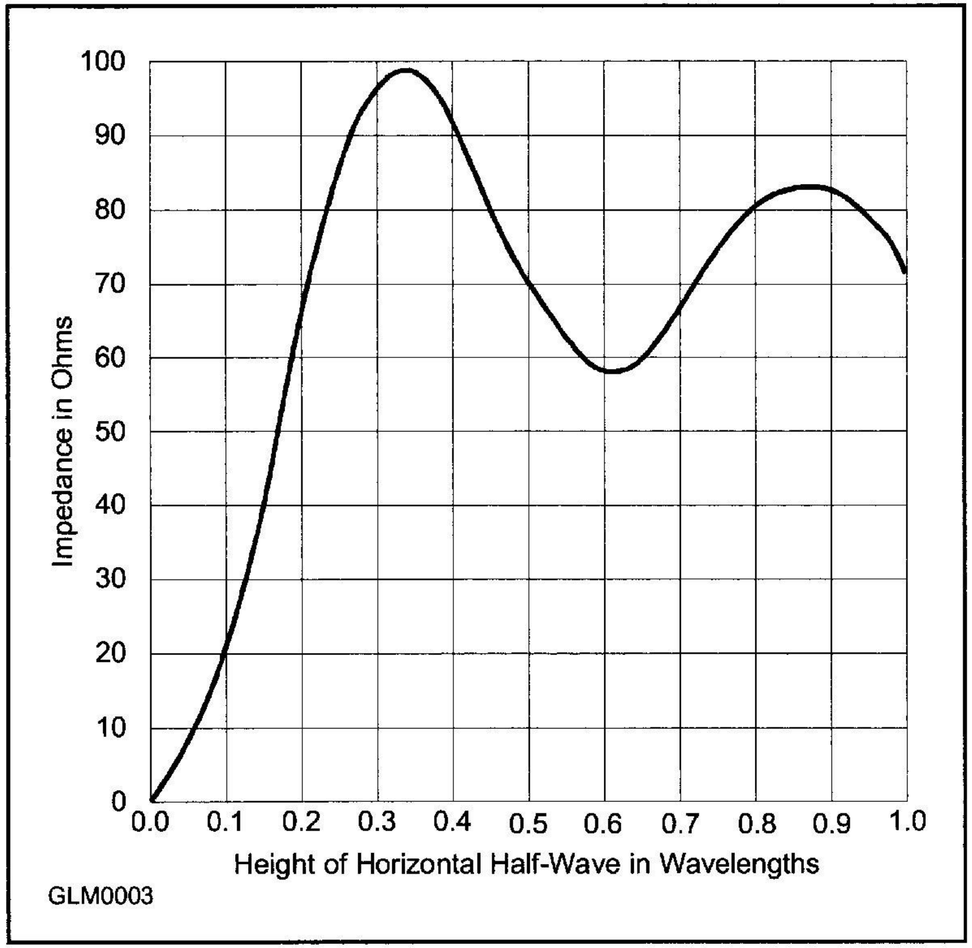
A Balun can match the 200-ohm impedance of the antenna to the 50-ohm impedance of the coax cable

Dipole Antenna Impedance

7-7

Center Fed Dipole

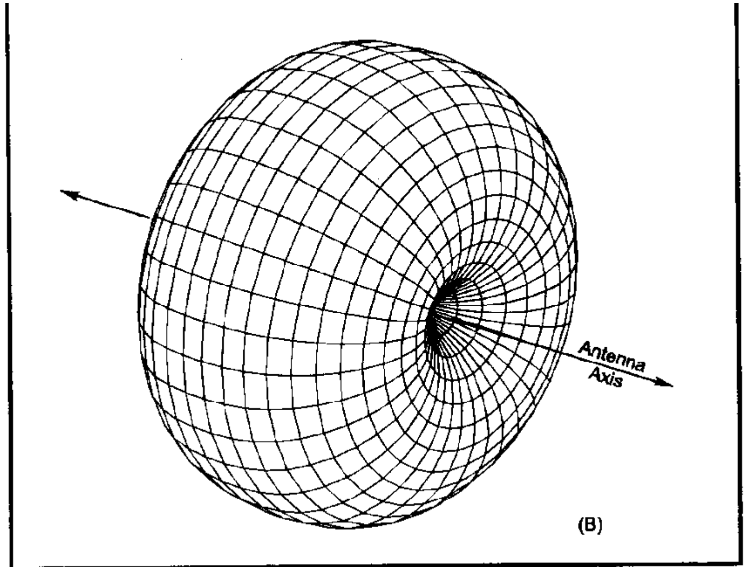
The height of the dipole antenna above the ground affects the impedance of the antenna.



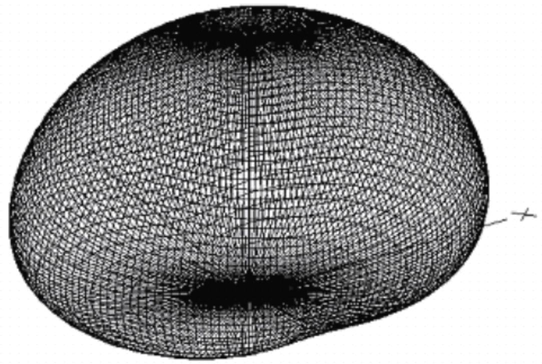
Dipole Antennas Pattern

Pg 7-7

- **If the antenna is less than 1/2 wavelength high, the azimuthal pattern is almost omnidirectional and directed upward.** (G9B05)



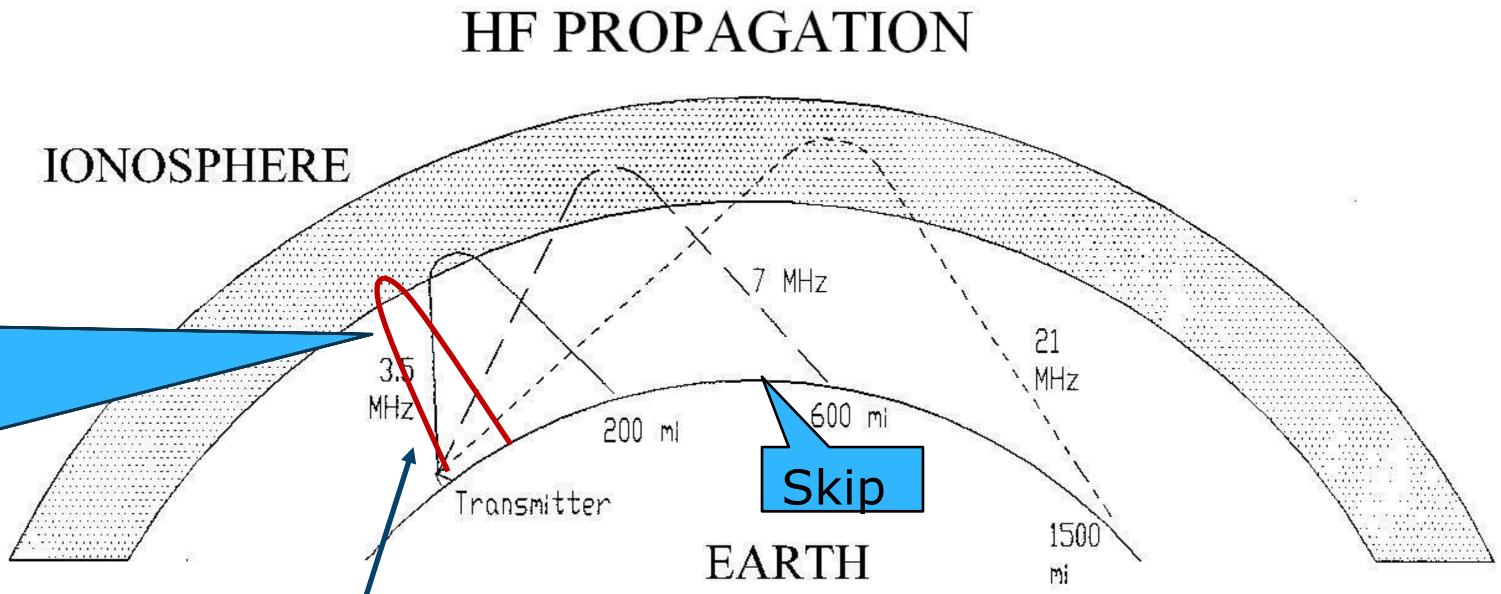
Free-space directional pattern



Omni-directional pattern

HF Propagation

* The ionosphere reflects the radio waves



A NVIS signal goes almost straight up, then comes almost straight down, providing communications with in a few hundred miles

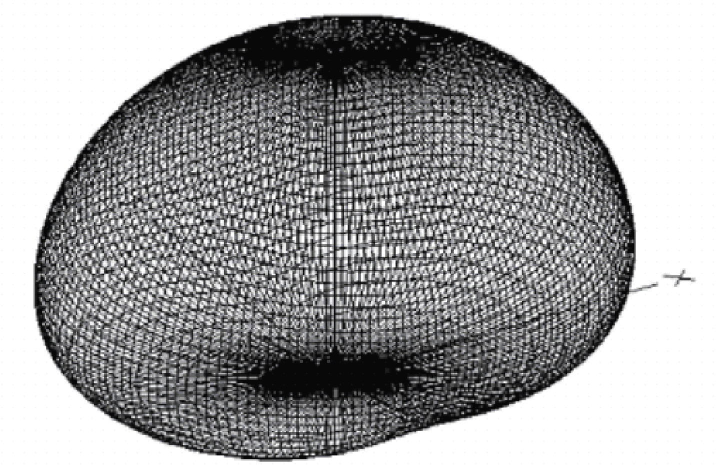
Near Vertical Incidence Skywave (NVIS)

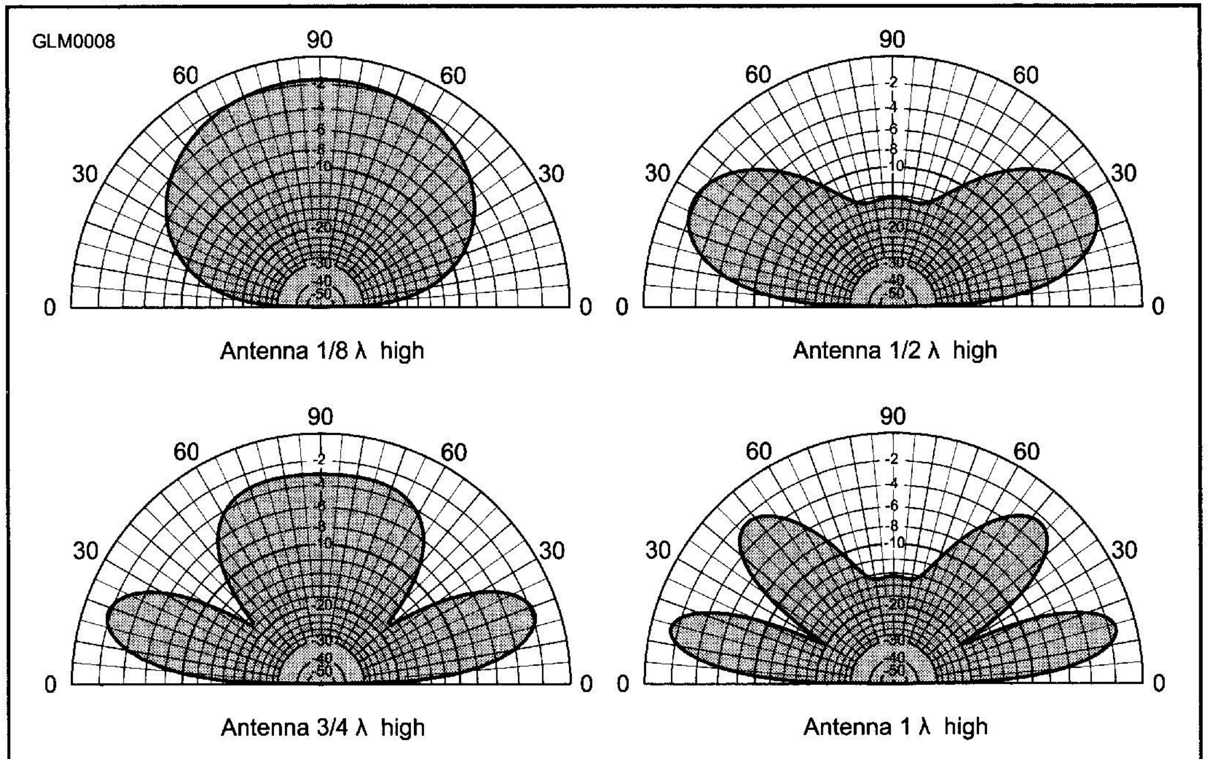
80m & 40m are common NVIS bands

Dipole Radiation Pattern - Elevation

7-7

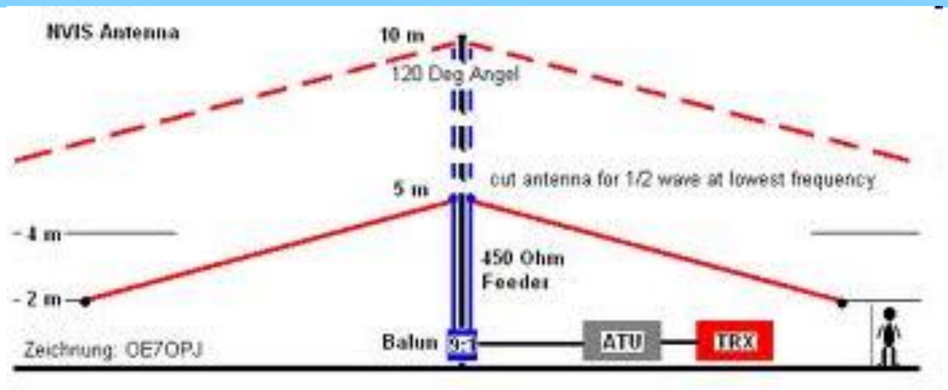
- The dipole antenna's height significantly affects the radiation pattern



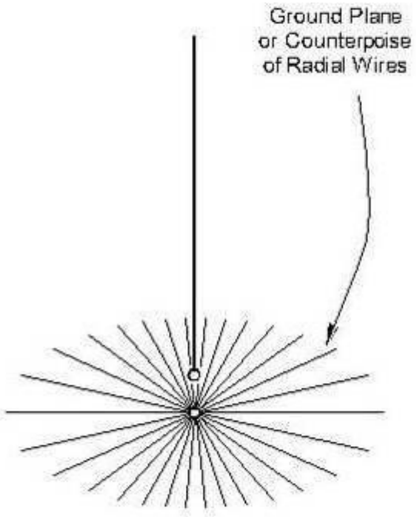


NVIS Antennas

- An NVIS antenna typically installed **between 1/10 and 1/4 wavelength** above ground. (G9D01)

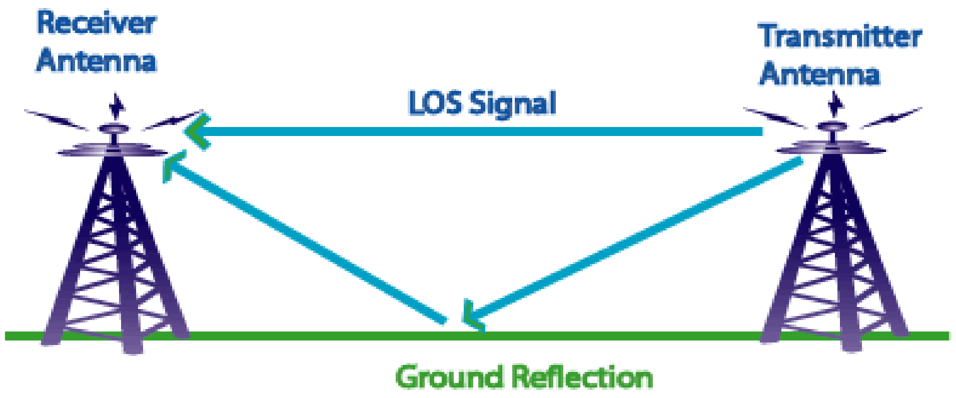


- **Practical information: Vertical antennas make <u>very poor</u> NVIS antennas.**



Antenna Polarizations

- Antennas emit polarized signals
  - Horizontal antennas emit horizontally polarized signals
  - Vertical antennas emit vertically polarized signals.
- An advantage of a horizontally polarized as compared to vertically polarized HF antenna is **lower ground reflection losses.** (G9B09)
  - The received signal is a combination of the direct (line of sight) waves, thus horizontal polarization results in stronger signals



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

G9C04

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

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

G9C04

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

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

G9B03

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

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

G9B11

$L = 492 / f$

$L = 492 / 3.55$

$L = 138.59$

$L = 139$ feet

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

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

G9B08

Section 7.2 Yagi (Directional) Antennas

10 Questions

- Azimuthal projection map
  - The world from a different view
- Yagi Directional Antenna
  - Driven element, reflector and director
  - Element lengths
  - Forward gain, main lobe and front-to-back ratio
- Antenna's impedance Matching
  - Hairpin
  - Gama

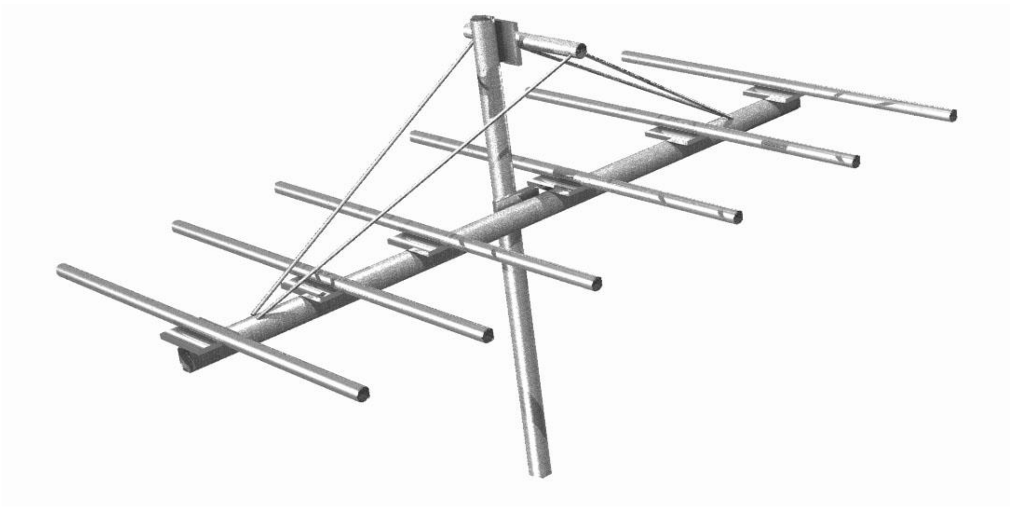
Section 7.2 Yagi Antennas
Directional (Beam) Antennas

- Directional antennas focus or direct RF energy in one direction.
    - Gain: An apparent increase in power in the desired direction (both transmit and receive).
    - Directional antennas minimize signals in other directions, potentially reducing interference

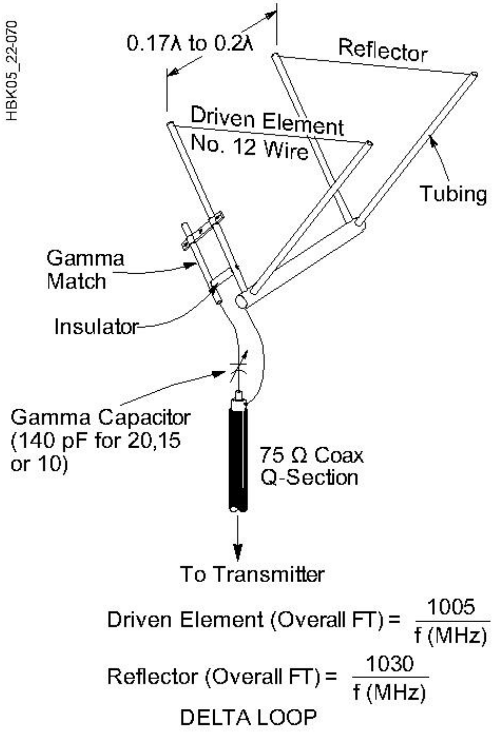
- Yagi (rod-like elements – TV antennas).
- Quad (square wire loop elements).
- Delta (triangle wire loop elements).

Directional (Beam) Antennas

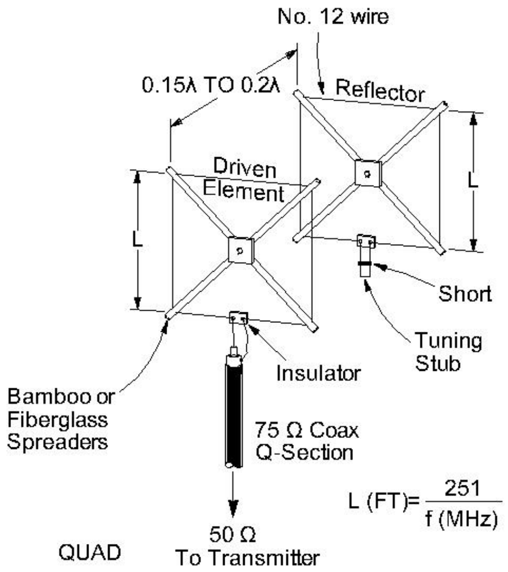
FYI



Yagi



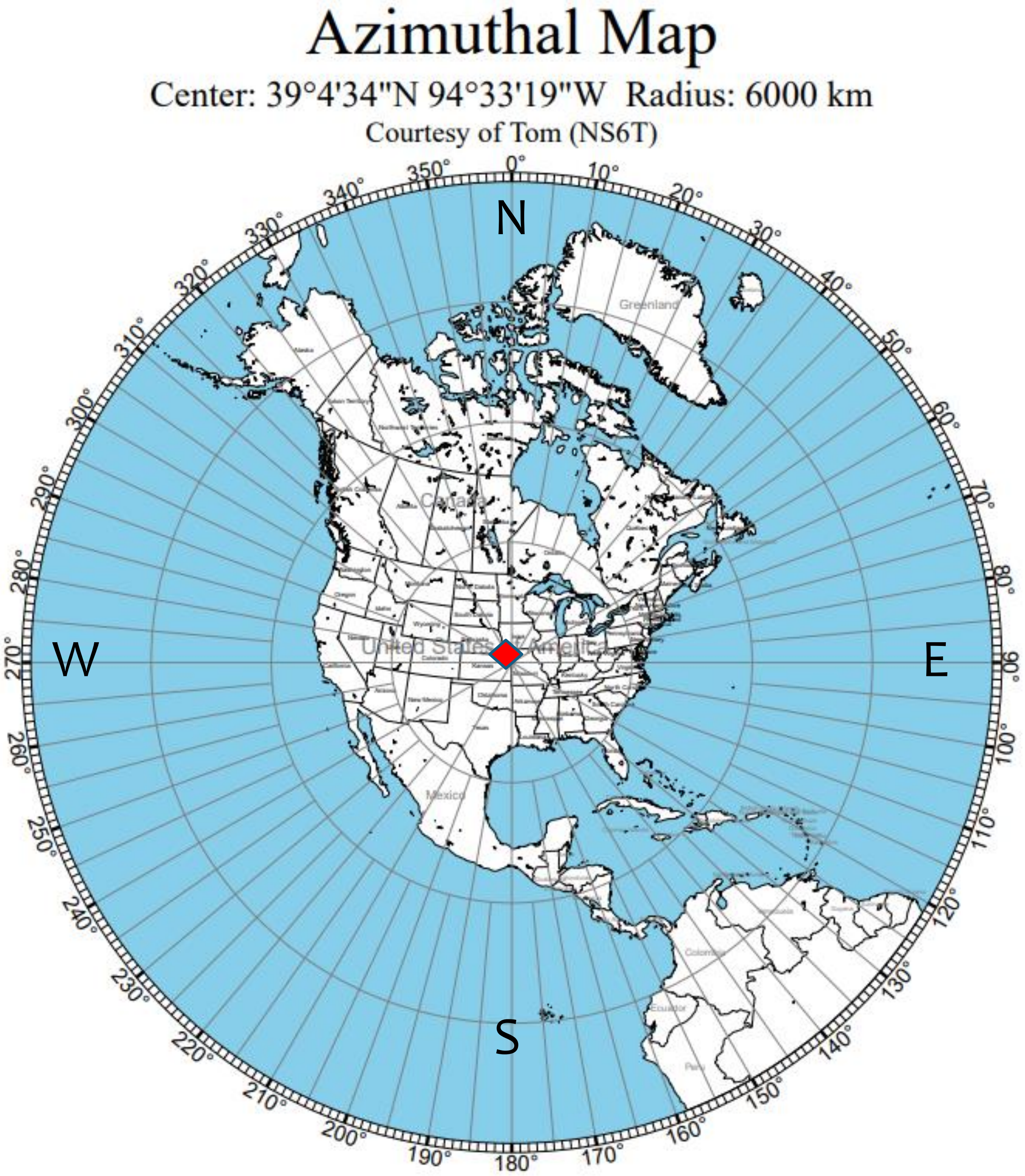
Delta



Quad

Azimuthal Projection North America 7-9

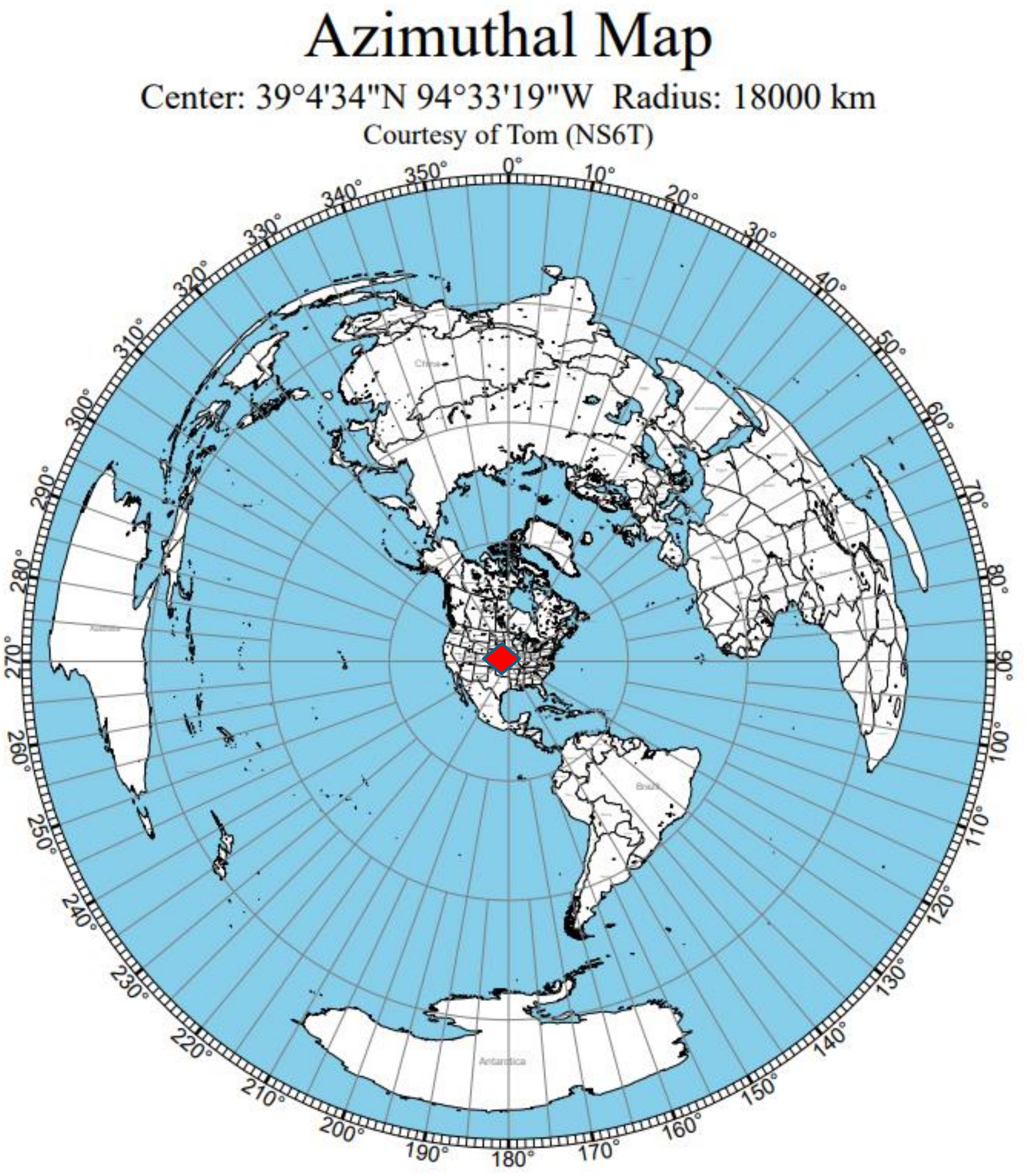
- An azimuthal projection map can show the true bearing (and shortest distance) to a distant station
- This projection is centered on Kansas City and shows North America +



Azimuthal Projection

7-9

- An azimuthal projection map can show the true bearing and distance from a specific location
- This projection is centered on Kansas City and shows most of the world.
- Courtesy of Tom, NS6T
- https://ns6t.net/azimuth/azimuth.html



Radiation Pattern

7-9 to 7-11

- Looking down from above the antenna:
  - The direction of the maximum signal is the **Main Lobe** **G9C08**
- When the **Main Lobe** is pointed at the distant station we want to talk to:
  - We will hear that station better
  - That station will hear us better

Main Lobe

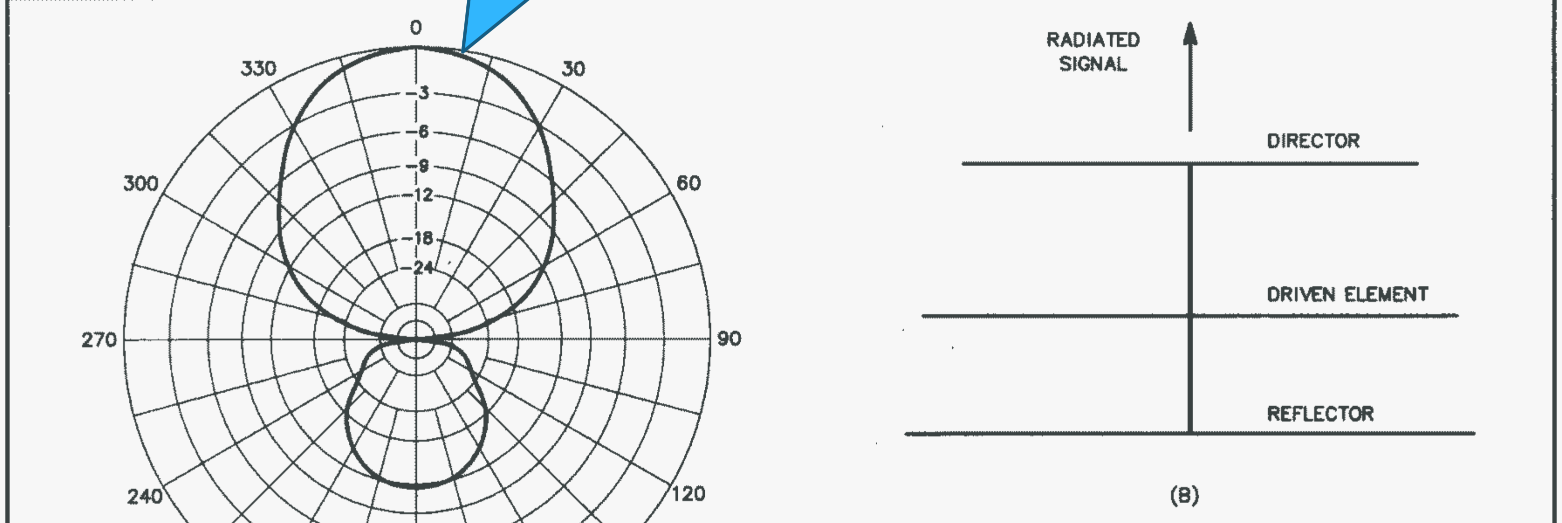
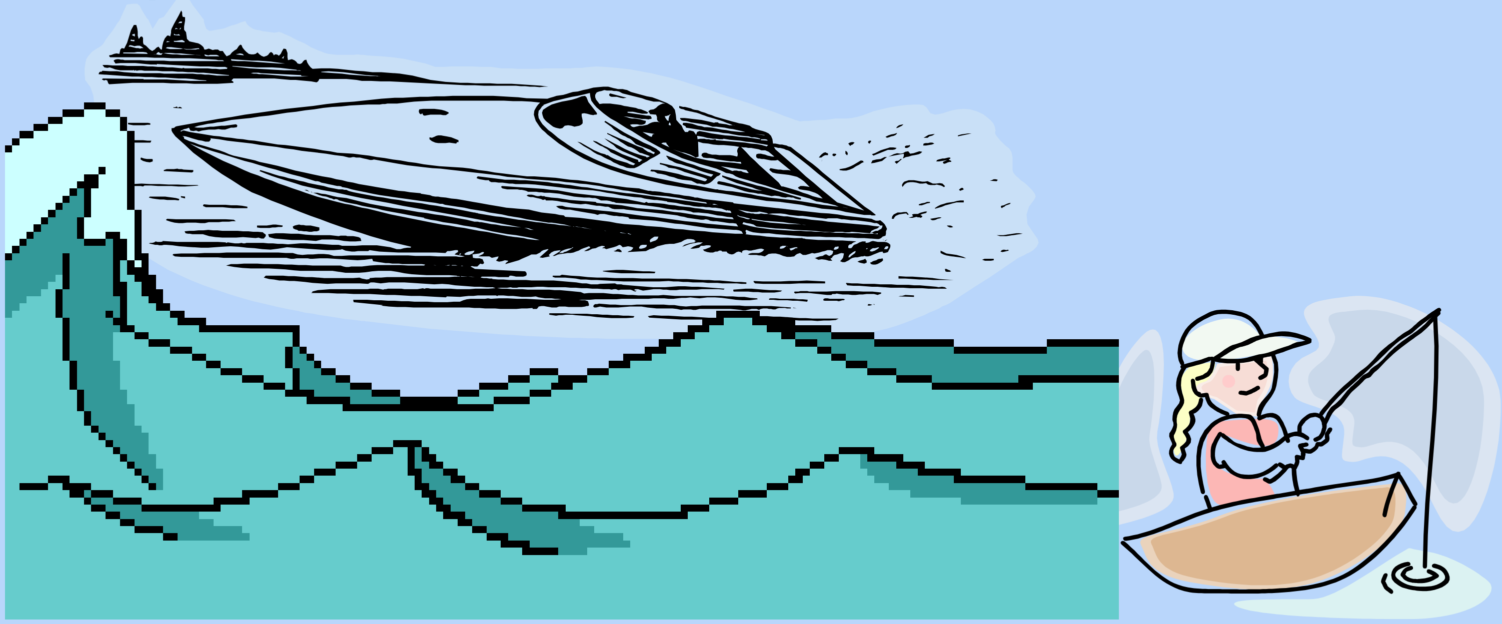


Figure 9-32 — Part A shows a typical radiation pattern for a Yagi beam antenna. Part B shows the direction the beam is pointing. The transmitted signal is stronger in the forward direction than in others.

Parasitic Energy

* Energy is coupled from one boat into the other.



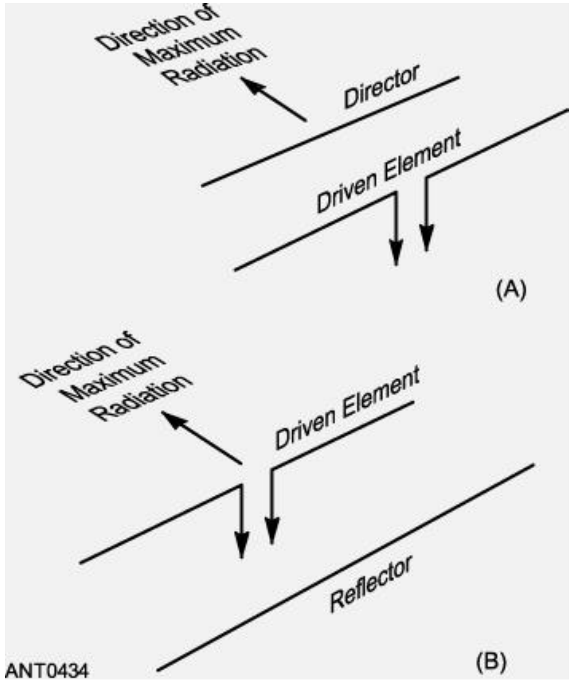
No Wake Zone

Directional (Beam) Antennas

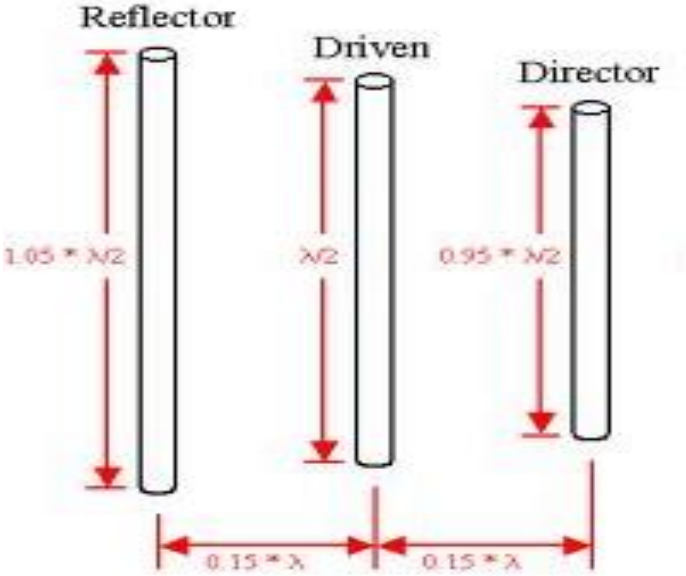
- A Beam antennas have parts called elements.
  - A **Driven** element is connected to the radio by the feed line.
  - A **Reflector** element is on the back side.
  - A **Director** element is on the front side toward the desired direction.

The Director and Reflector are called parasitic elements

Simple 2-element Yagi

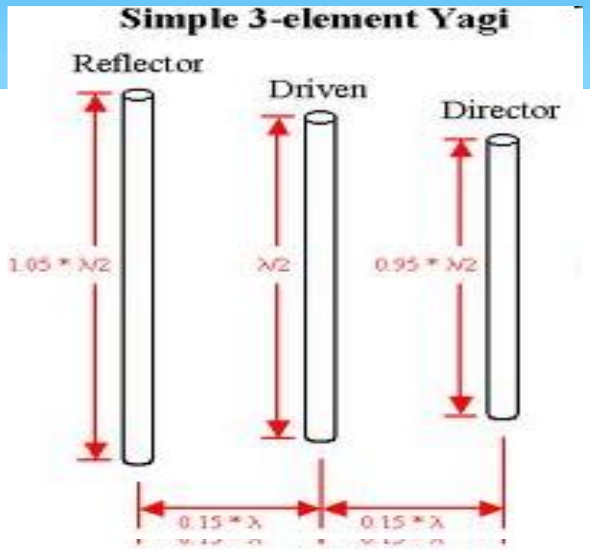


Simple 3-element Yagi



Antennas

- The approximate length of the driven element of a Yagi antenna is **1/2 wavelength.** (G9C02)
- In a three-element, single-band Yagi antenna,
  - **The director is shorter than the driven element.** (G9C03)
  - **The reflector is longer than the driven element** of. (G9C043)*9200
- **Larger diameter elements** increase the bandwidth of a Yagi antenna. (G9C01)



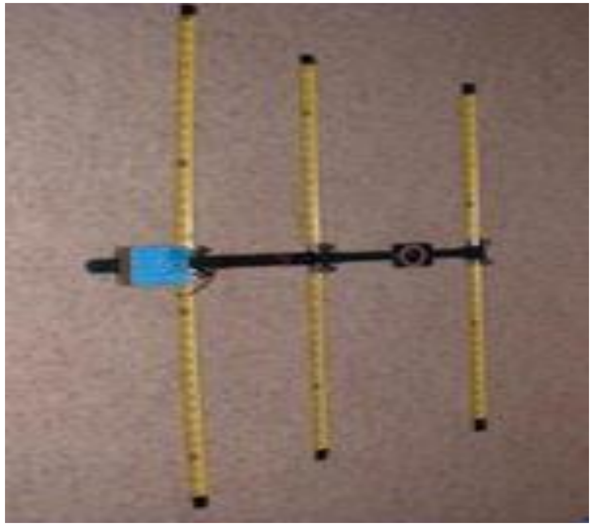
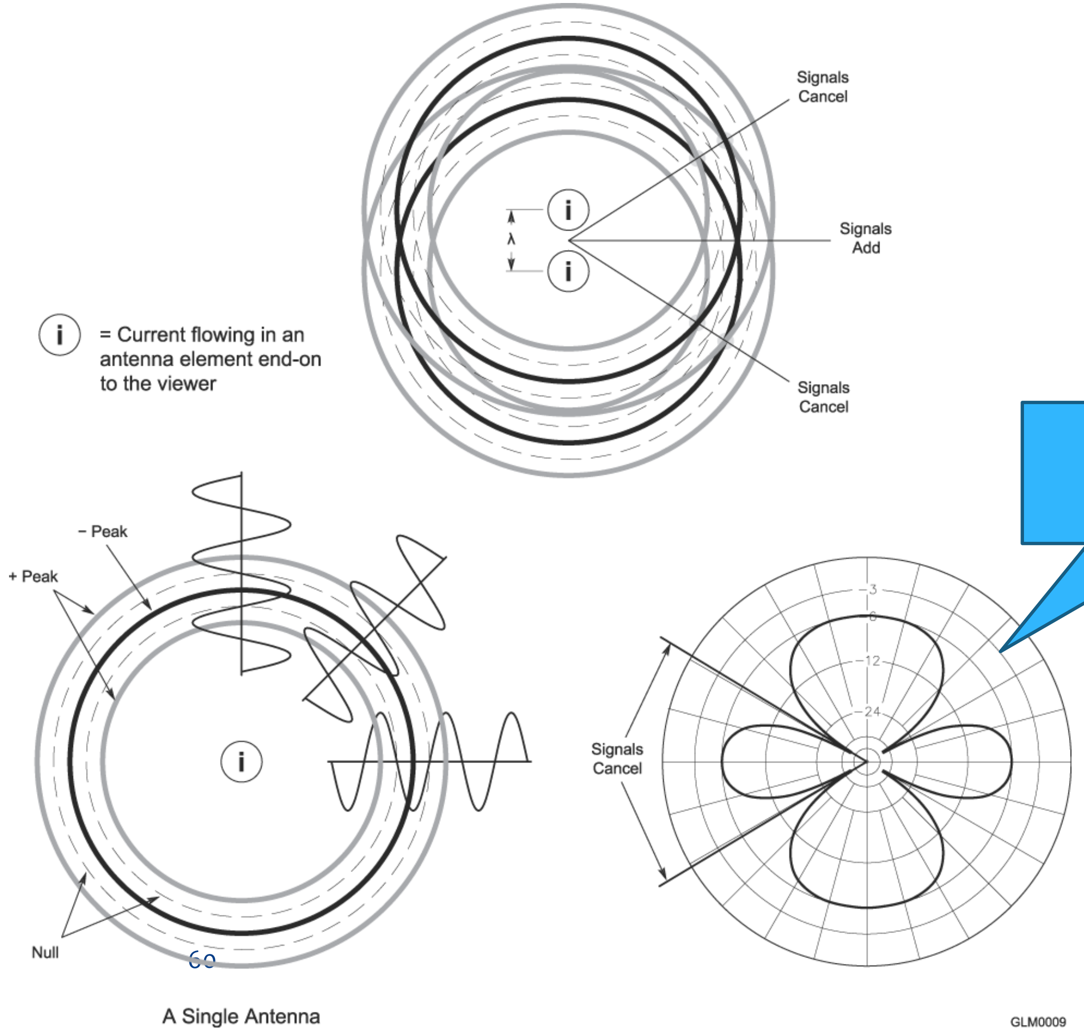


Figure 7-7

7-10

* Illustration of how the radiated signals add in some direction and cancel in other directions with two elements.



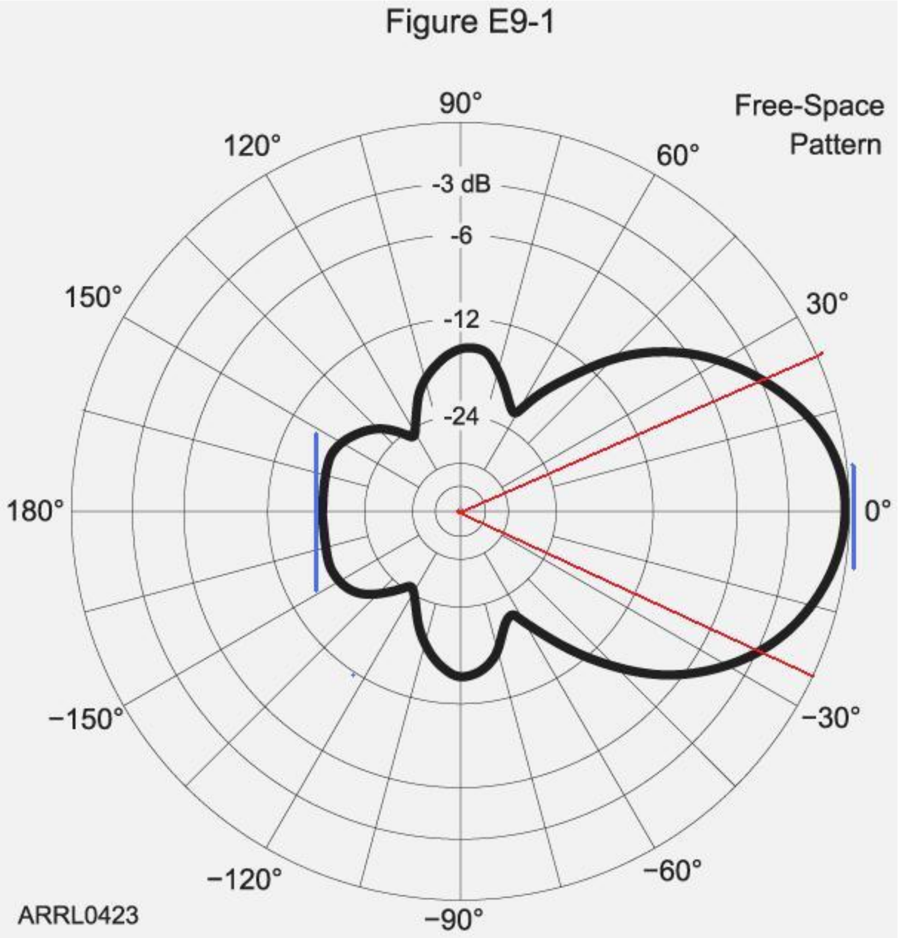
Radiation Pattern

Yagi Antennas

- The “major lobe” or **"main lobe"** of a directive antenna is **the direction of maximum radiated field strength from the antenna.** (G9C08)

- The **"front-to-back ratio"** of a Yagi antenna is **the power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction.** (G9C07)

The red lines show **Beamwidth**

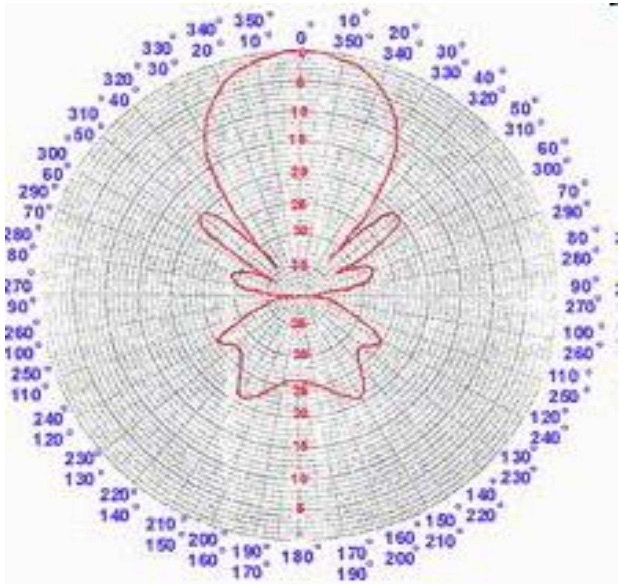


Yagi Antennas

- A Yagi antenna is often used for radio communications on the 20-meter band because it helps **reduce interference from other stations to the side or behind the antenna.**

- The **gain increases** when **you increase boom length** and add directors to a Yagi antenna. (G9C05)

- Many common Yagi HF antennas are triband. They cover 10-15-20 meters

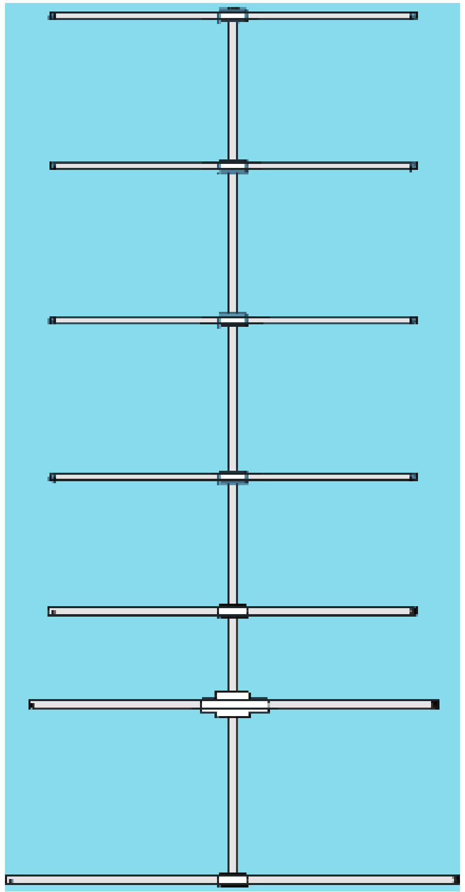


Yagi Antennas

- In a Yagi antenna design, the following variables can be adjusted to optimize forward gain, front-to-back ratio, or SWR bandwidth (G9C10)

  - The physical length of the boom
  - The number of elements on the boom
  - The spacing of each element along the boom

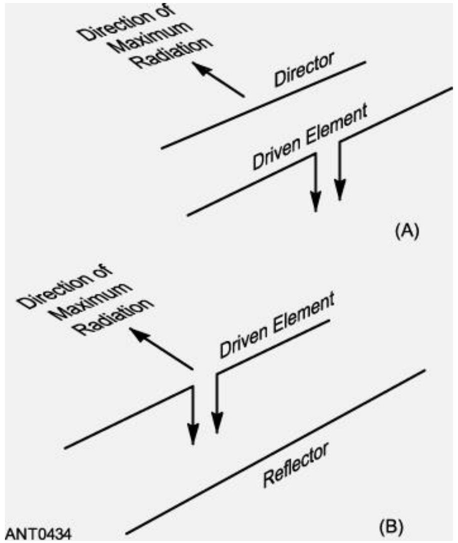
All of these choices are correct

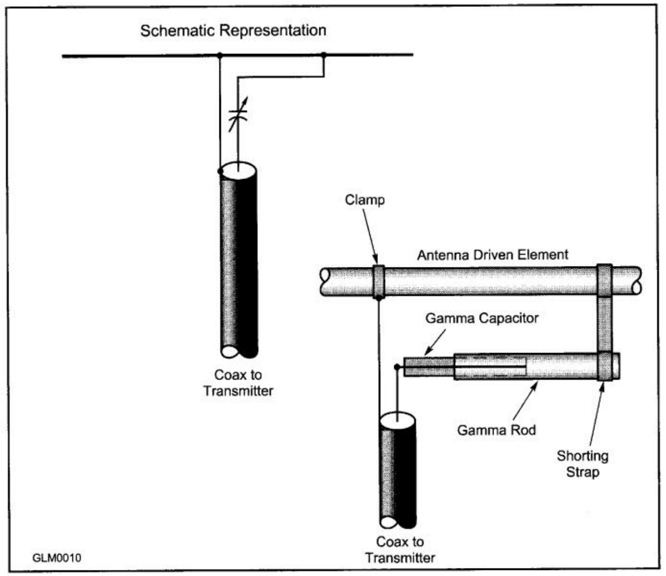


Antennas – Gama Match

7-11 & 12

- The purpose of a **gamma match** used with Yagi antennas is **to match the relatively low feed-point impedance to 50 ohms.**



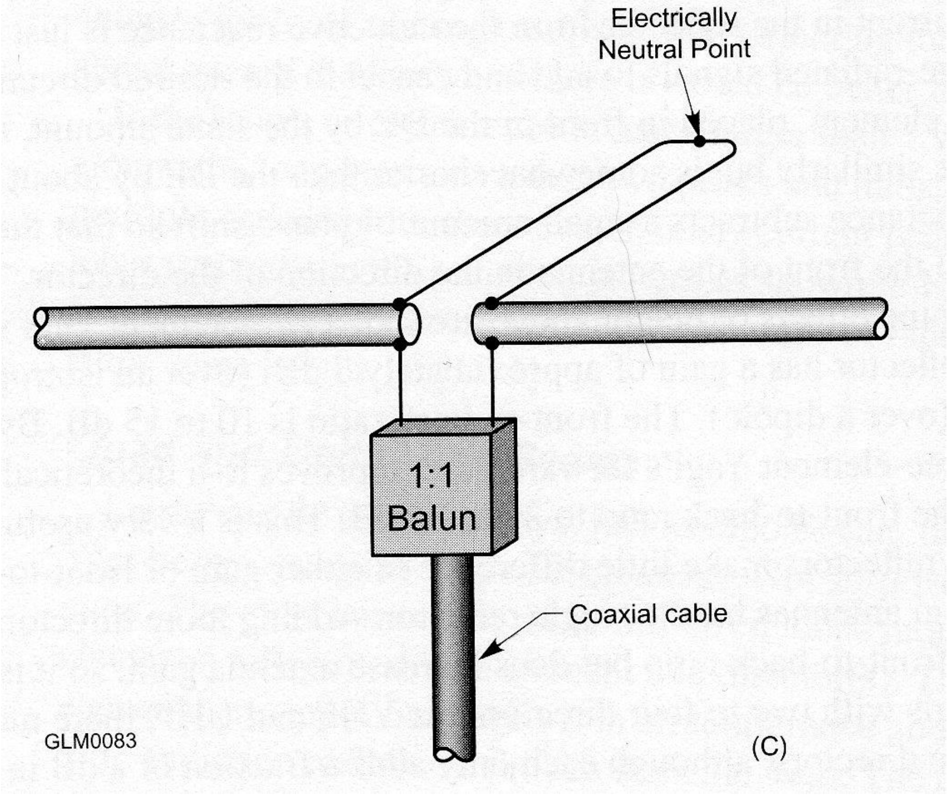


- An advantage of using a **gamma match** for impedance matching of a Yagi antenna to 50-ohm coax feed line is that **it does not require that the elements be insulated from the boom.** (G9C12)

Antennas – Hairpin Match

7-11 & 12

- A **beta or hairpin match is a shorted transmission stub** placed at the feed point of a Yagi antennas **to provide impedance matching.** (G9C16)
  - It provides inductance to cancel out any stray capacitance
  - Used only on single-band antennas



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 G9C15

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 G9C15

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 lobe compared to that in the opposite direction

D. The ratio of forward gain to dipole gain

G9C15

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 lobe compared to that in the opposite direction**

D. The ratio of forward gain to dipole gain

G9C15

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

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

G9C05

Section 7.3 Loop Antennas

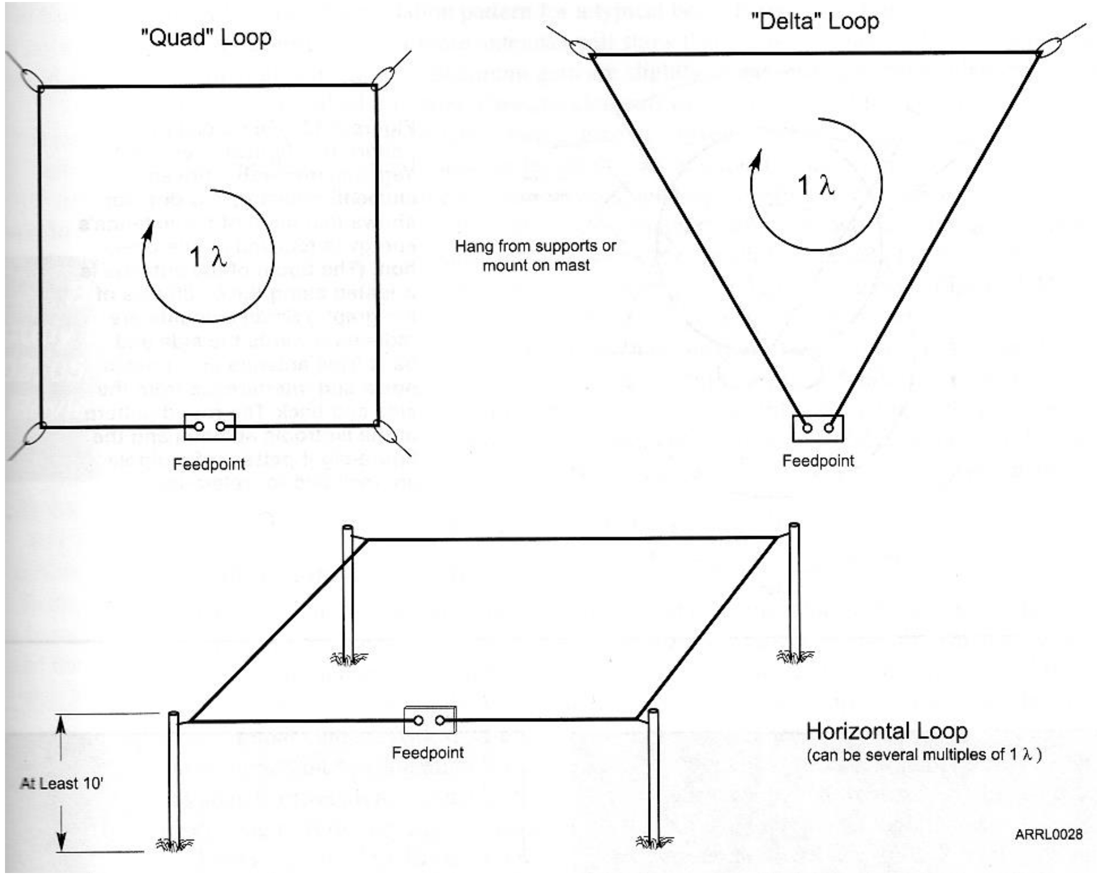
2 Questions

- Loop Antennas
  - Maximum radiation with a VHF/UHF halo
  - Radiation pattern of a small loop

Section 7.3 Loop Antennas
Variations of the Loop Antennas

FYI

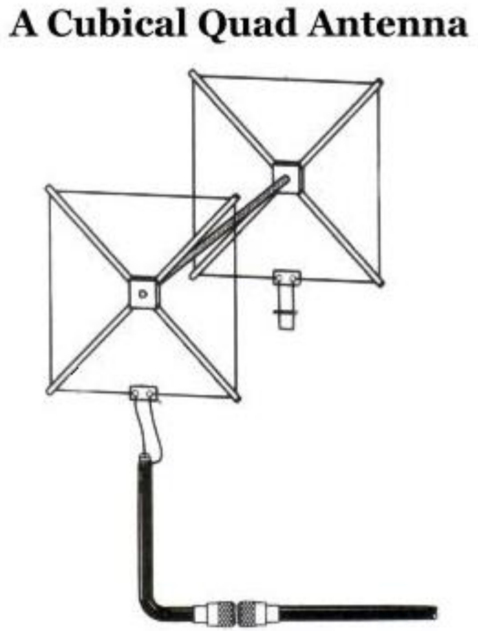
- Quad
- Delta
- Horizontal

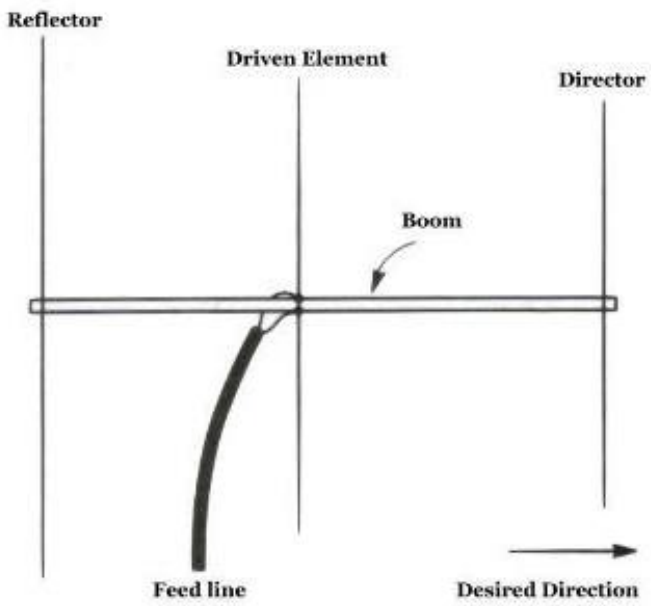


Quad Antennas

FYI

- The forward gain of a two-element quad antenna is about the same as the forward gain of a three-element Yagi antenna.





- Each side of a quad antenna driven element is **approximately 1/4 wavelength.**

Large Horizontal Loop

7-14

- An 80-meter loop will use about 530 feet of wire in the air.
- Can provide multi-band performance when used with an antenna tuner

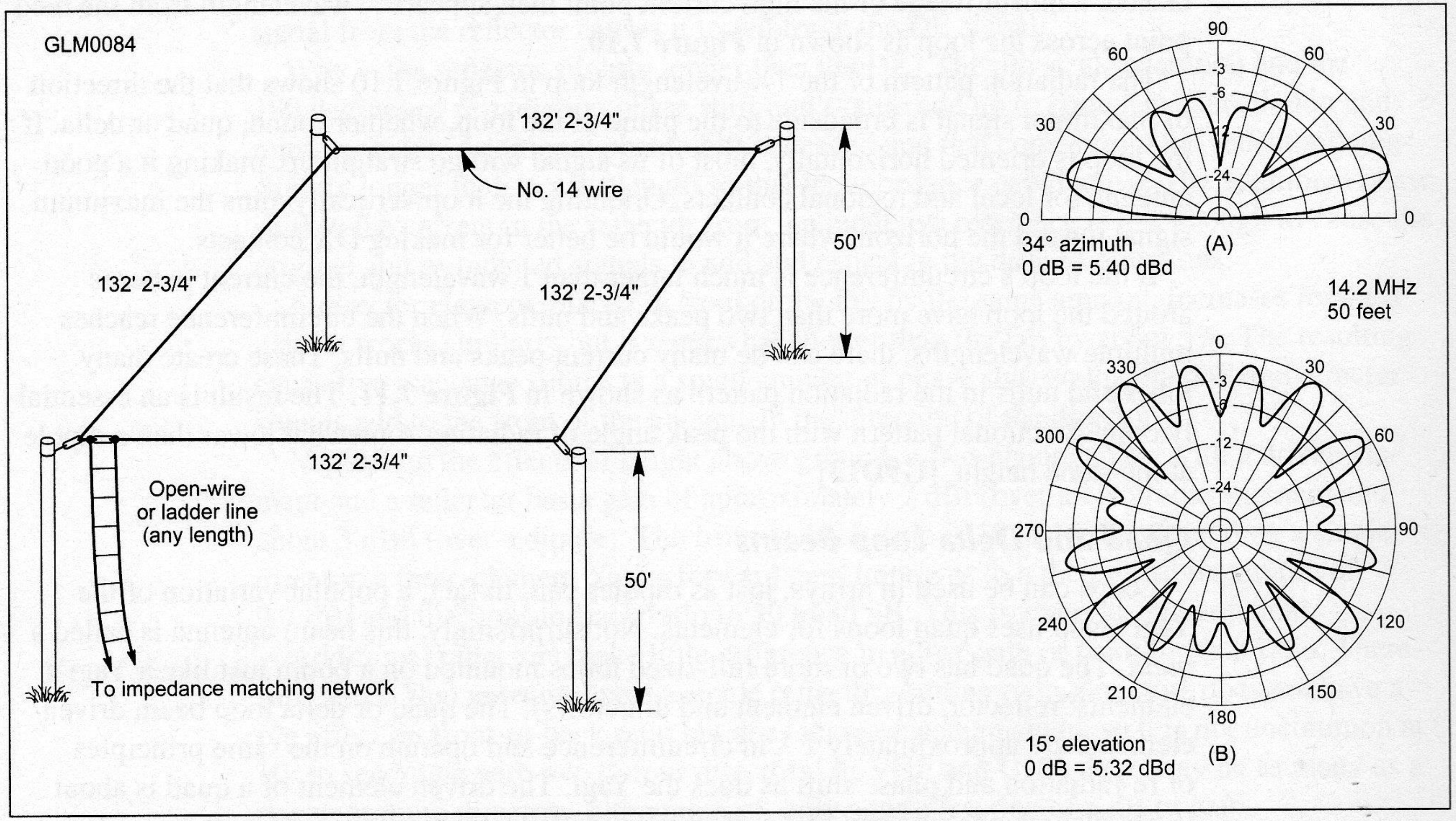


Fig. 7.10

Direction of maximum signal is broadside to the plane of the loop, whether round, quad or delta. Orienting the loop vertically aims the maximum signal toward the horizon (*good for DX*).

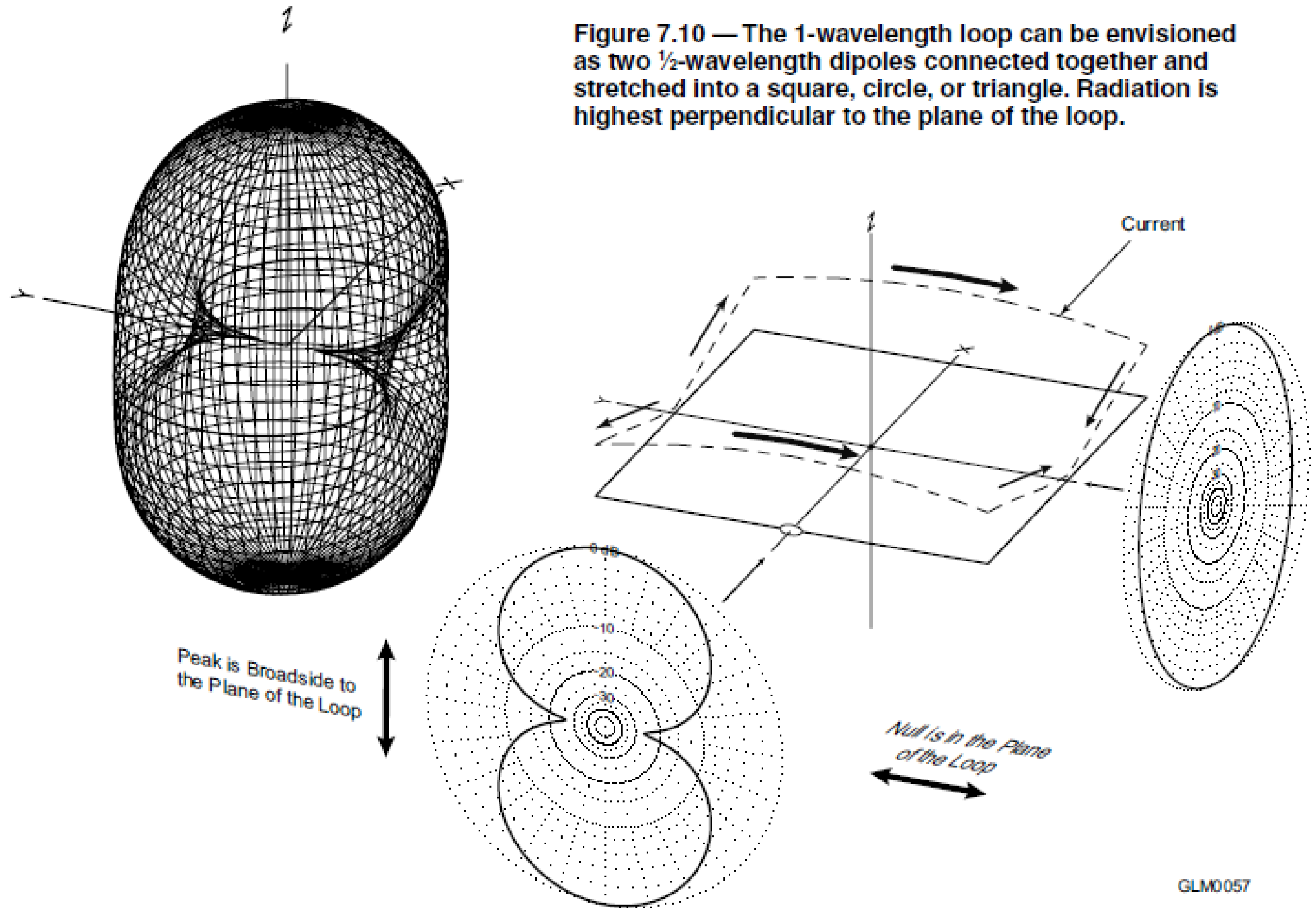


Figure 7.10 — The 1-wavelength loop can be envisioned as two ½-wavelength dipoles connected together and stretched into a square, circle, or triangle. Radiation is highest perpendicular to the plane of the loop.

Small Loop Antennas

7-15

* Often called a magnetic loop antenna
* Total circumference is less than 1/3 wavelength.
* Will exhibit sharp nulls broadside to the plane of the antenna G9D10
* Popular **very-small** space antenna, but not very efficient
* Very narrow bandwidth with limited power capability

Halo Loop

7-15/16

* The halo antenna is omnidirectional in the plane of the antenna.
* ½ wavelength dipole antenna, which has been bent into a circle or square
* Popular on 2m and 6 m

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

G9C06

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

G9C06

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   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

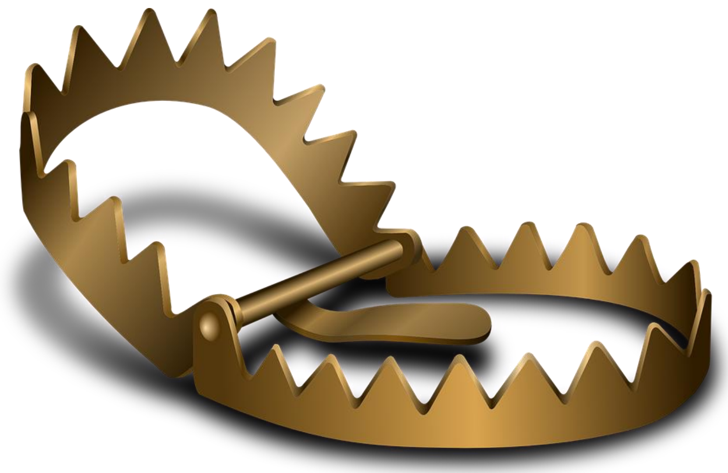
C. Broadside and in the plane of the loop

D. Electrically small loops are omnidirectional G9D10

Section 7.4 Specialized Antennas

8 Questions

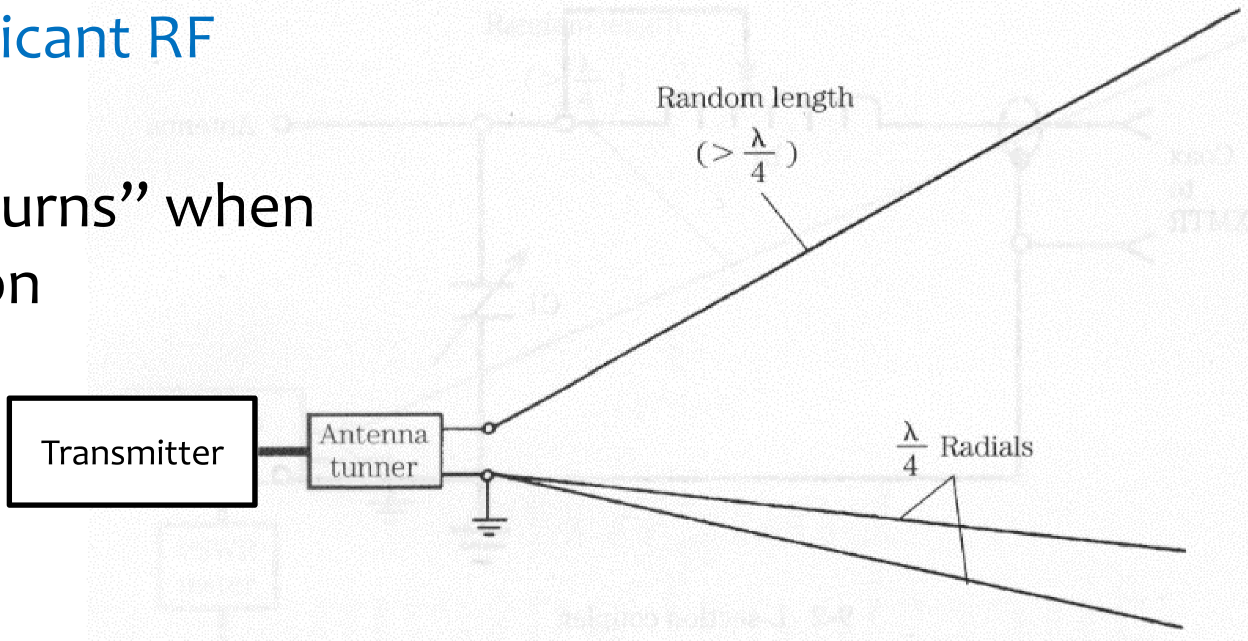
7-16



- Random wire
- Stacked Yagi antennas
- Trapped antennas - multiband
- Multi-band antennas
  - Poor harmonic rejection
- Log periodic antenna
- Beverage antenna

Section 7.4 Specialized Antennas
Random Wire Antenna

* Random wire antennas with an antenna tuner can cover many bands
* The station equipment becomes part of the antenna system and can carry significant RF currents G9B01
* The operator may experience "RF burns" when touching metal objects in the station
* ¼ wavelength radials will help establish an RF ground to reduce the undesired voltages



9-3 Radials improves the "ground" of random length antenna.

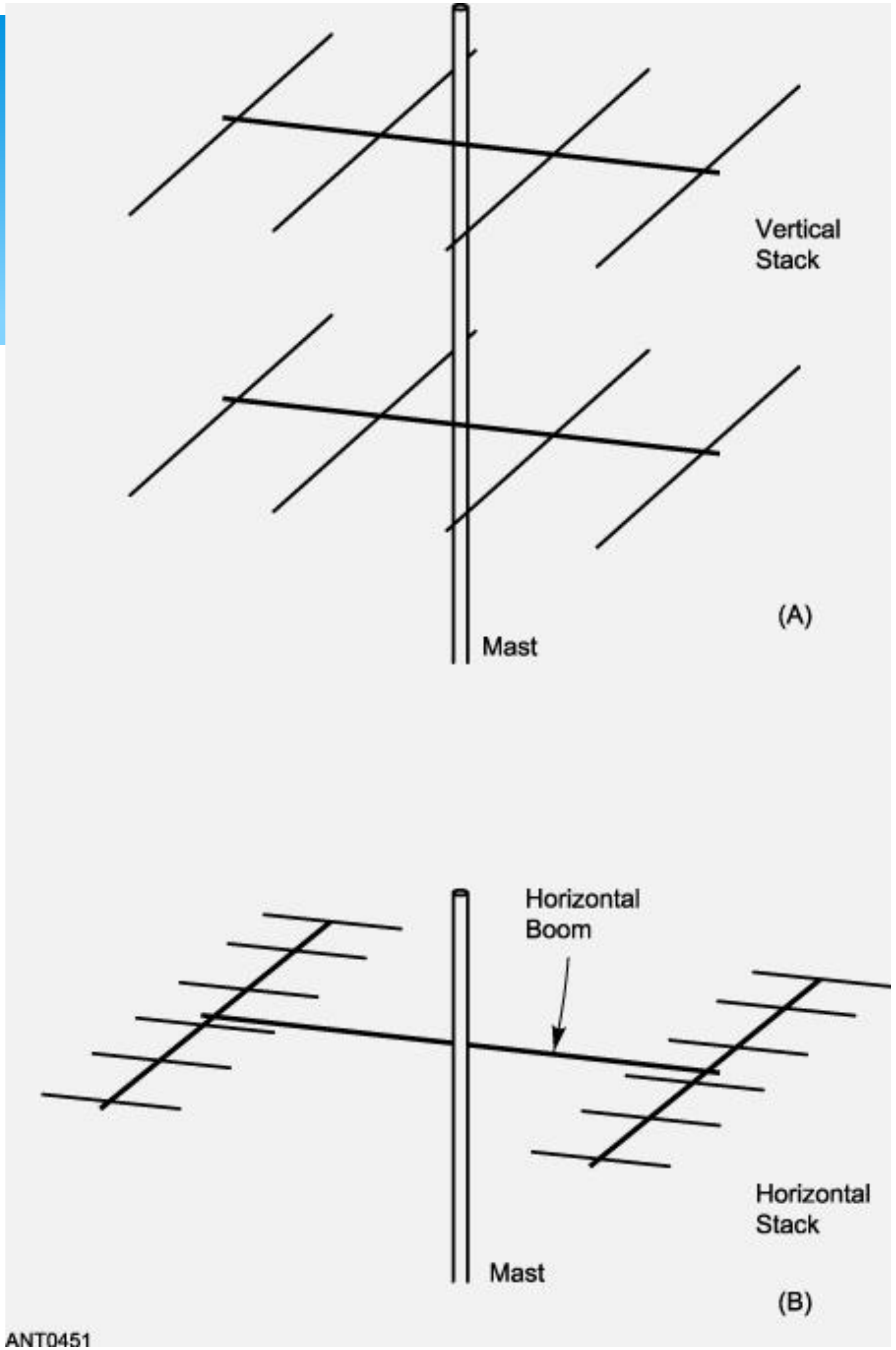
Stacked Antennas

7-16

Stacking antennas results in more gain

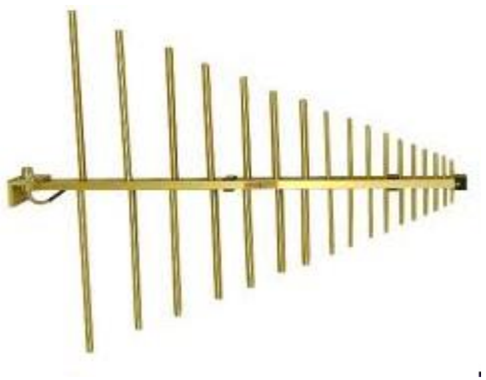
- Vertical stacking
- Horizontal stacking

- One advantage is vertically stacking horizontal Yagi antennas is that it **narrows the main lobe in elevation** G9D05
  - More of the signal is directed at the horizon rather than at high angles
- If two horizontally polarized Yagi antennas are vertically stacked and spaced ½ wavelength apart, it results in about 3 dB of gain G9C09



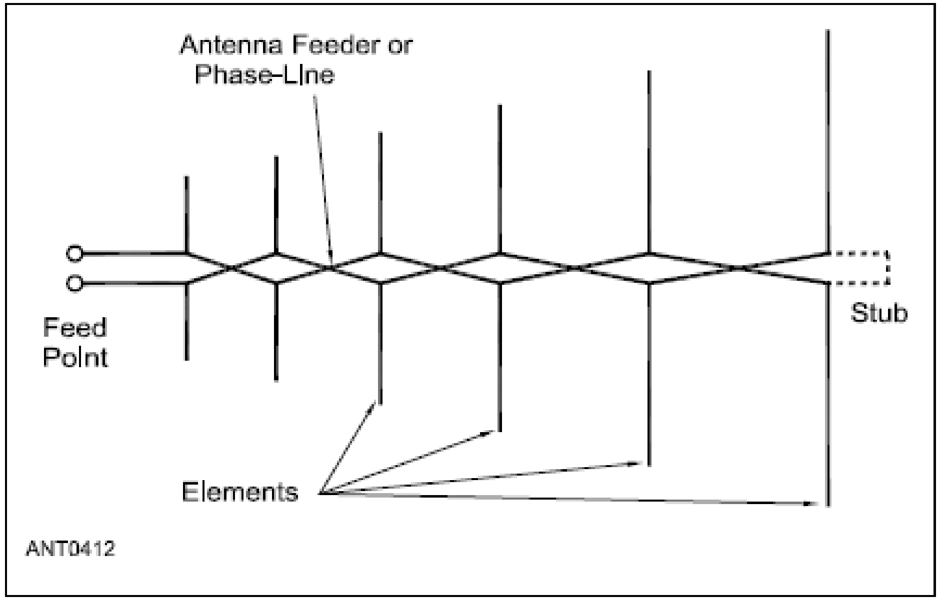
Log Periodic Antennas

- The gain of a log periodic antenna is less than that of a Yagi, but an advantage of a log periodic antenna is **wide bandwidth.** (G9D06)
- For a log periodic antenna, the **length and spacing of the elements increases logarithmically from one end of the boom to the other.** (G9D07)

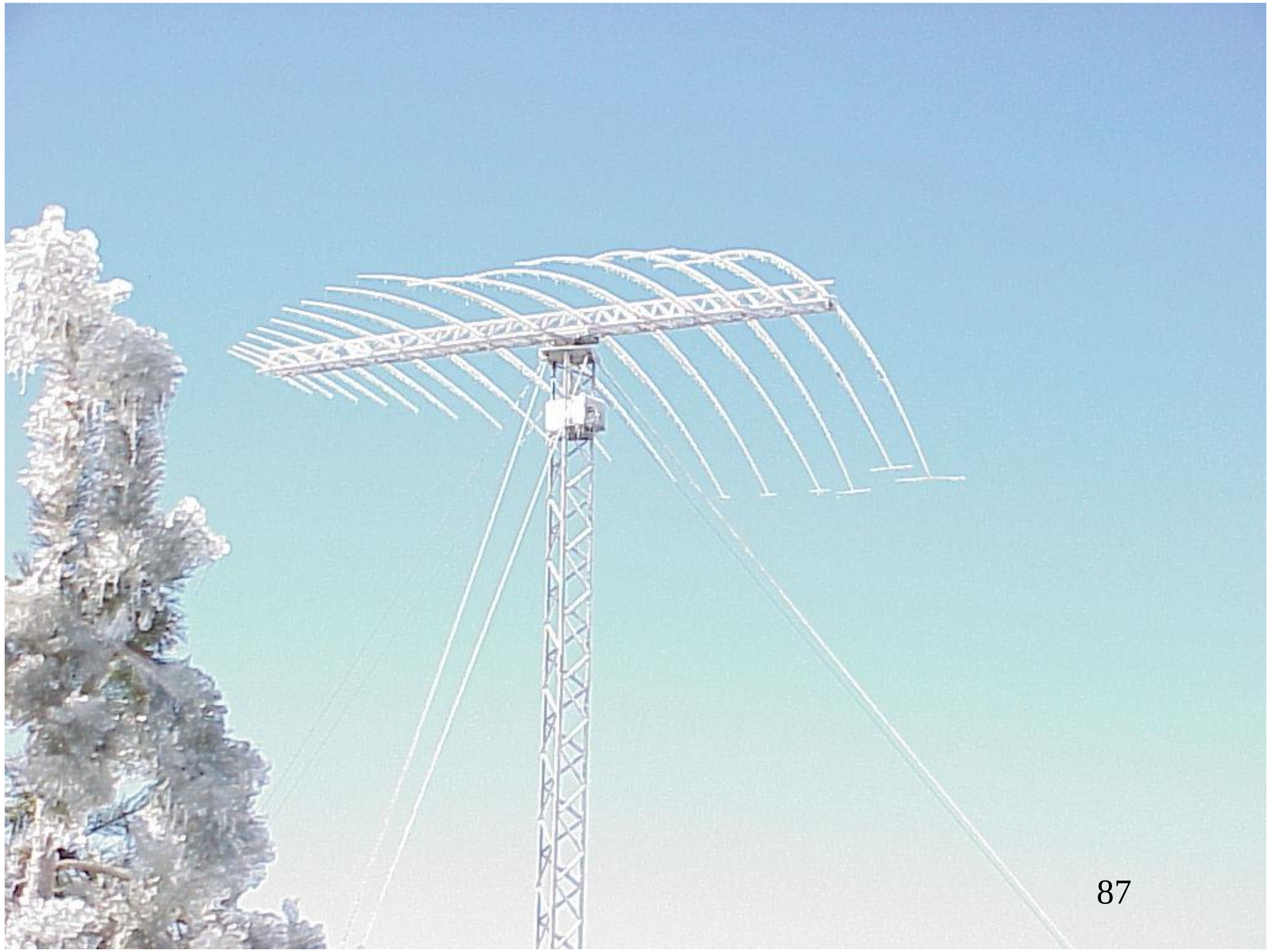


290 – 2000 MHz

EW8DQ, and his rotatable HF log-periodic beam antenna in Belarus



Log Periodic Antenna

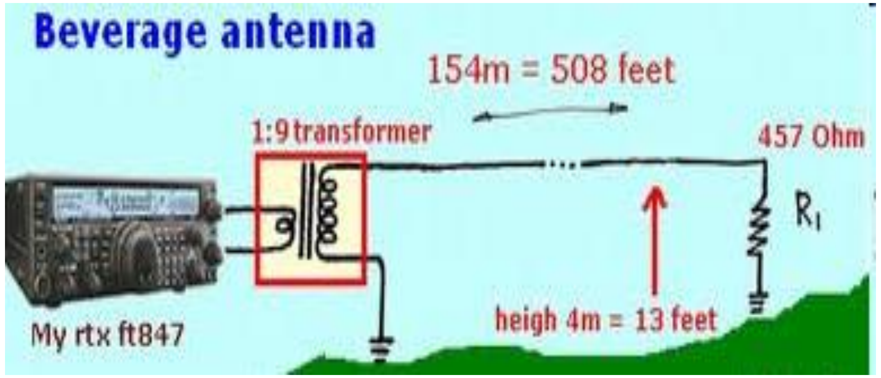


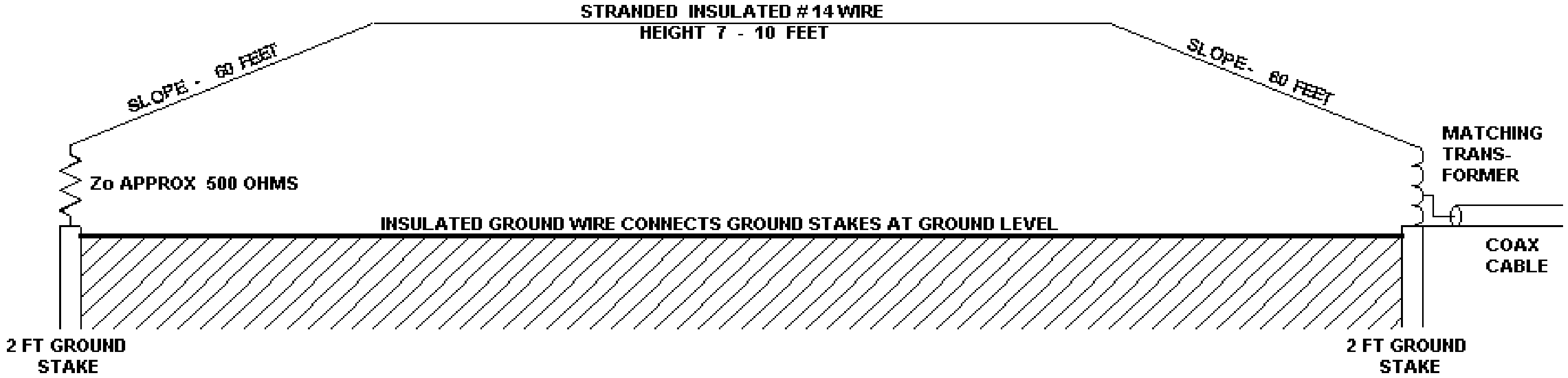
- 6.5 – 30 MHz continuous coverage
- 40 ft long boom
- Up to 52 ft element length
- Weigh: 330 lbs (without ice)

Beverage Antenna

7-11/18

- A Beverage antenna is primarily a directional receiving antenna for MF and low HF bands (G9D08)
- An application for a Beverage antenna is as a **directional low-noise receiving for low HF bands.**
  - The main lobe is off the terminated end
- A Beverage antenna is **very long and mounted at a low height.**



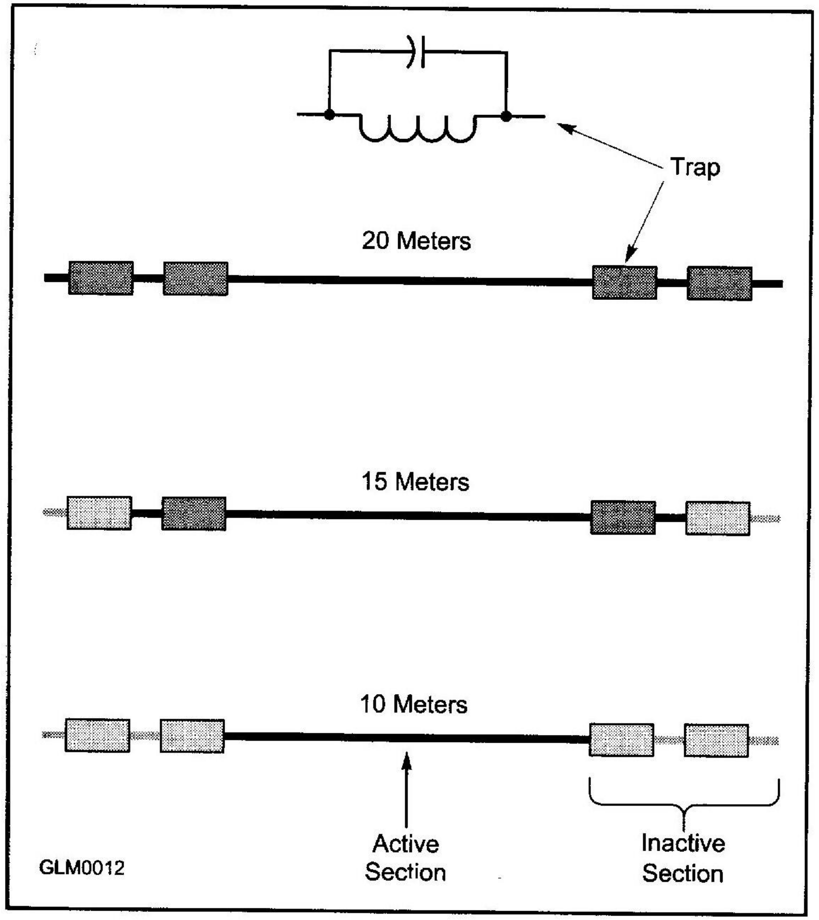


Multiband Antennas

7-18/19

- It is common, convenient and cost effective to have amateur radio antennas that operate on multiple bands.

- One such antenna uses traps to electrically isolate portions of the antenna, as in this trap dipole. Traps permit multiband operation (G9D04)



TRAP DIPOLE

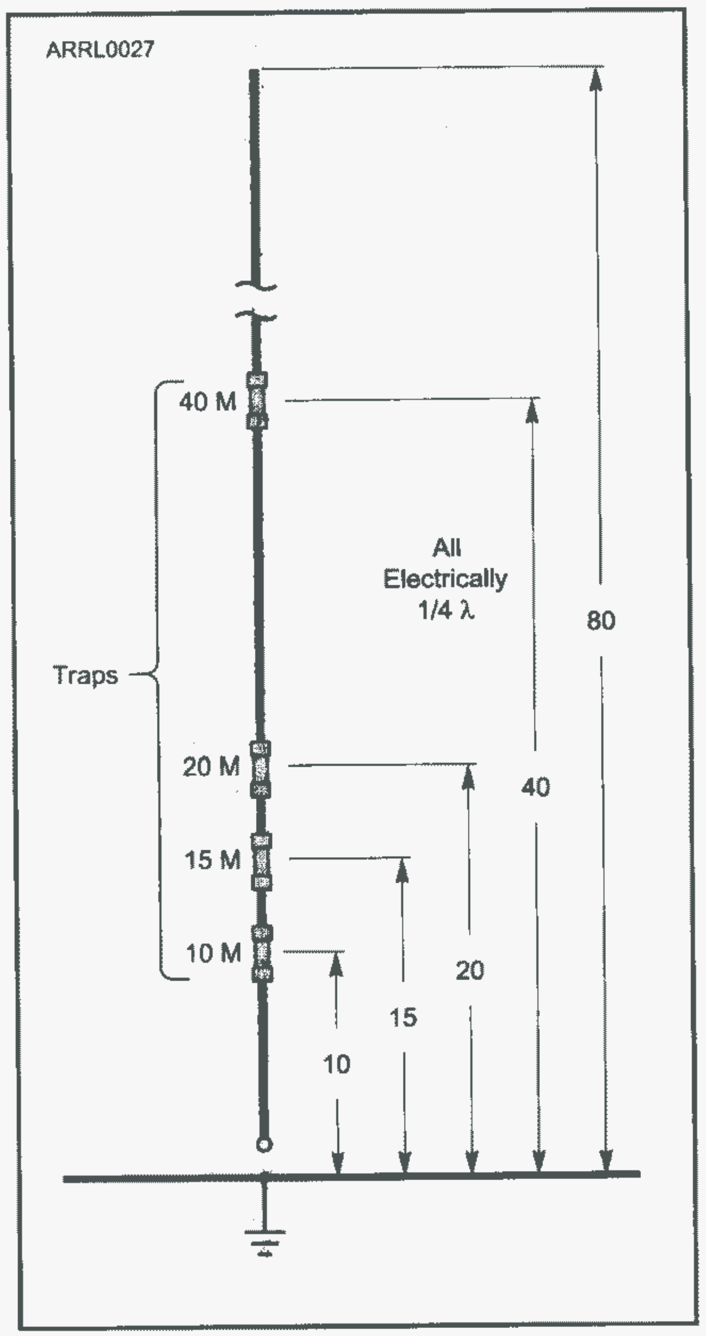
Multi-band Beam with Traps

* The primary purpose of antenna traps is **to permit multiband operation.** (G9D04)

Multiband Antennas

7-19

- Trap verticals are very common antennas that operate on multiple bands.
- A disadvantage of multiband antennas is that **they have poor harmonic rejection.** G9D11
- A vertical Antenna has an **omnidirectional** azimuthal radiation pattern.



TRAP
VERTICAL

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

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

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

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

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 G9D07

Which of the following describes a log-periodic antenna?

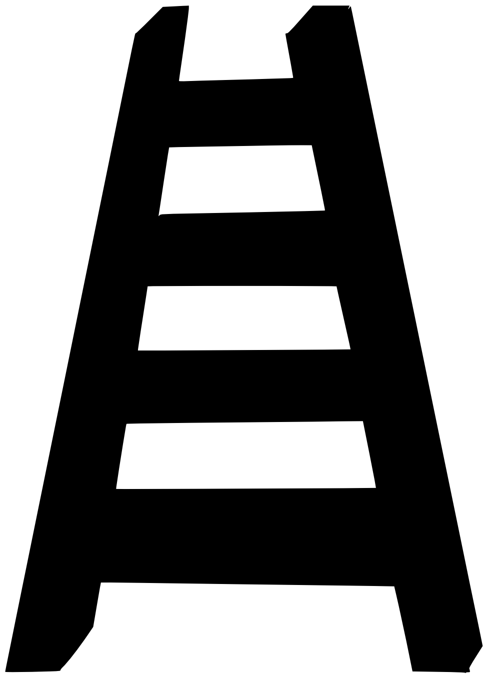
A. **Element length and spacing vary logarithmically along the boom**
B. Impedance varies periodically as a function of frequency
C. Gain varies logarithmically as a function of frequency
D. SWR varies periodically as a function of boom length G9D07

Section 7.5 Feed Lines

12 Questions

7-19

- Characteristic Impedance
  - Parallel conductor line
  - Window line (Ladder line)
- Antenna tuners
- SWR – reflected power
  - Calculating SWR
- Loss in coaxial cable
  - Affect on SWR

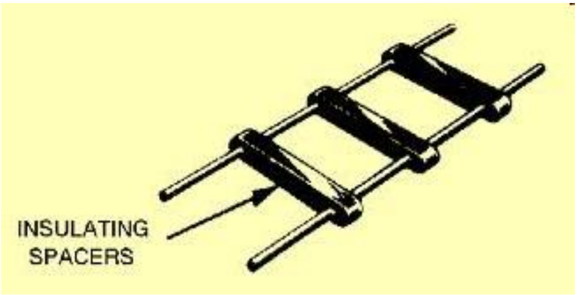


Section 7.5 Feed Lines

7-20

Parallel Conductor

- **300 ohms** is the characteristic impedance of flat ribbon TV type twinlead.



450 ohms is the characteristic impedance of most ladder line, also called "window line." (G9A03)

Coax

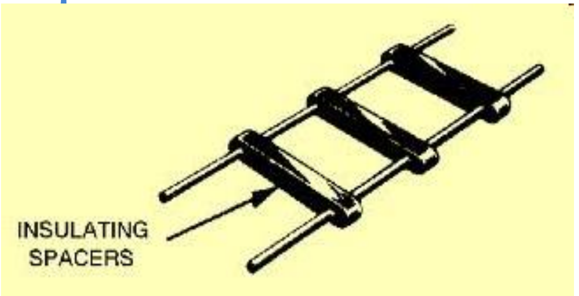
- The attenuation of coaxial cable **increases** as the frequency of the signal it is carrying increases. (G9A05)

- RF feed line losses usually expressed in **dB per 100 ft.** (G9A06)

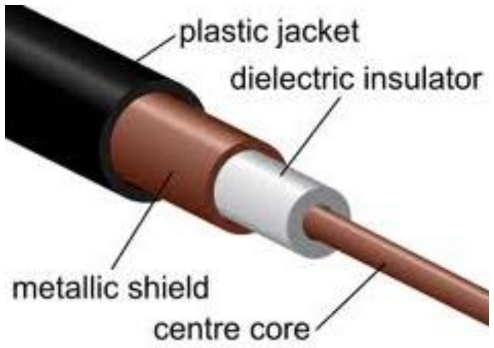
Feed Lines

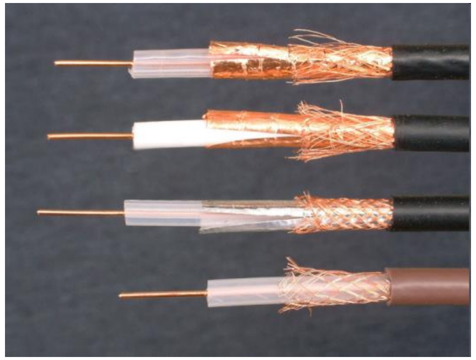
- **The distance between the centers of the conductors and the radius of the conductors** determine the characteristic impedance of a parallel conductor antenna feed line. (G9A01)

300 Ohm Twin Lead



Parallel two-wire line





Air Dielectric Coaxial Cable

- **50 and 75 ohms** are the typical characteristic impedances of coaxial cables used for antenna feed lines at amateur stations.

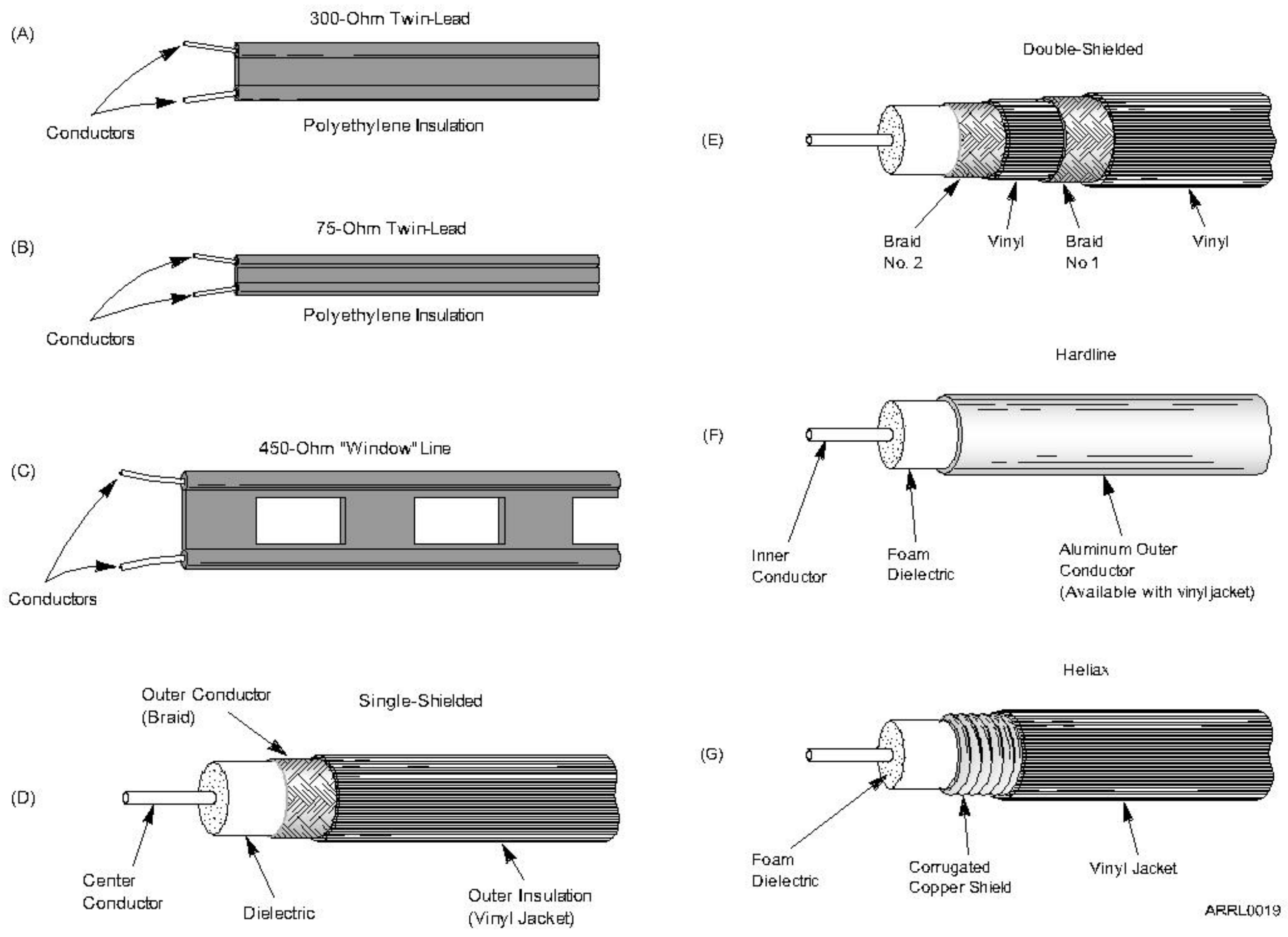
Fig 7.18

Parallel-Conductor feedlines:

* Have very low loss compared to coax.
* Typical impedances are 300 or 450 ohms
* Must be spaced away from metal or earth

Coax cables:

* Can be single shielded or double shielded, 50 or 75 Ω
* Flexible or rigid



Standing Wave Ratio (SWR)

- If the antenna and feed line impedances are not perfectly matched, some RF energy is not radiated into space and is returned (reflected) back to the source.
  - Something has to happen to this reflected energy – generally converted into heat or unwanted radio energy (bad).

- **A difference between feed-line impedance and antenna feed-point impedance** is the reason for the occurrence of reflected power at the point where a feed line connects to an antenna. (G9A04)

Standing Wave Ratio (SWR)

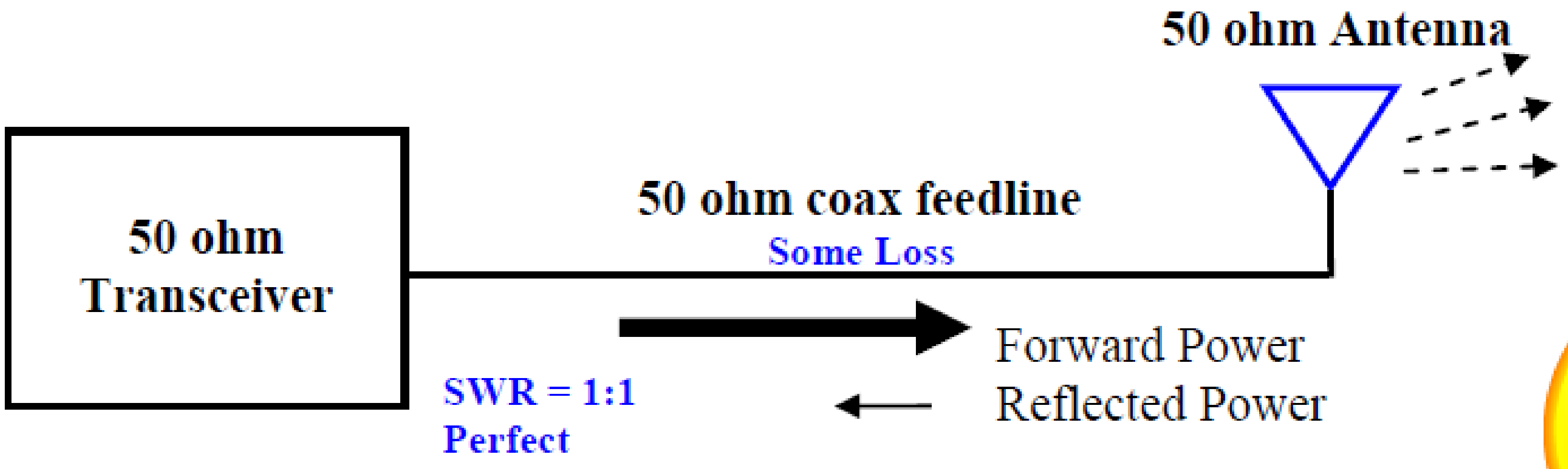
More disadvantages of high SWR:

- **The higher the SWR, the more feedline loss you will experience, especially if the feedline is lossy.** (G9A02)
- **With high feedline loss, the SWR measured at the radio end will be artificially lowered.** (G9A11)
- **High SWR increases the risk of high-voltage breakdown of the coax.**

Antenna SWR

- A standing wave ratio of **1:1** will result from the connection of a 50-ohm feed line to a non-reactive load having a 50-ohm impedance.

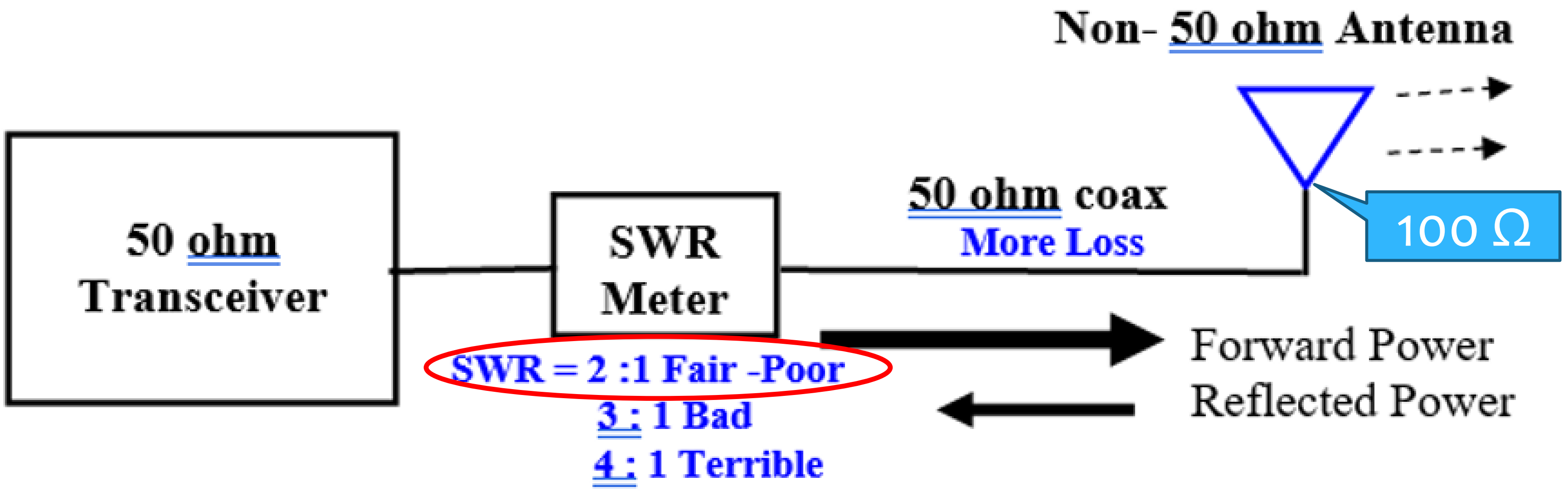
$SWR = Z_1 / Z_2$ 50 / 50 1 : 1 VSWR



Antenna SWR

- A standing wave ratio of **1:1** will result from the connection of a 50-ohm feed line to a non-reactive load having a 50-ohm impedance.

$SWR = Z_1 / Z_2$ 100 / 50 2 : 1 VSWR



Antenna SWR

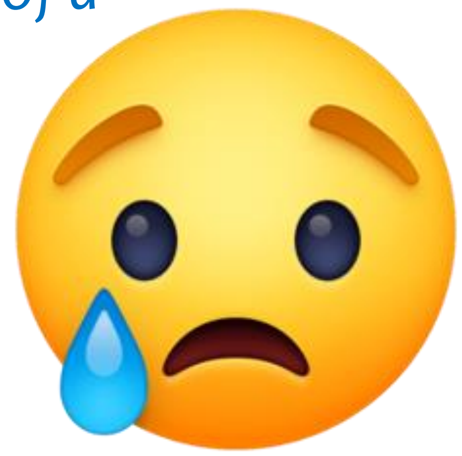
7-22

- A **4:1** standing wave ratio will result from the connection of a 50-ohm feed line to a non-reactive load having a 200-ohm impedance. (G9A09)

$SWR = Z_1 / Z_2$ *200/ 50* *4:1 VSWR*

- A standing wave ratio of **5:1** will result from the connection of a 50-ohm feed line to a non-reactive load having a 10-ohm impedance. (G9A10)

$SWR = Z_1 / Z_2$ *50/ 10* *5:1 VSWR*



Antenna Couplers

- An **antenna coupler** is often used to enable matching the transmitter output to an impedance other than 50 ohms.

Manual Coupler

Antenna Couplers go by many different names:

- Transmatch
- Antenna Tuner
- Impedance Matcher

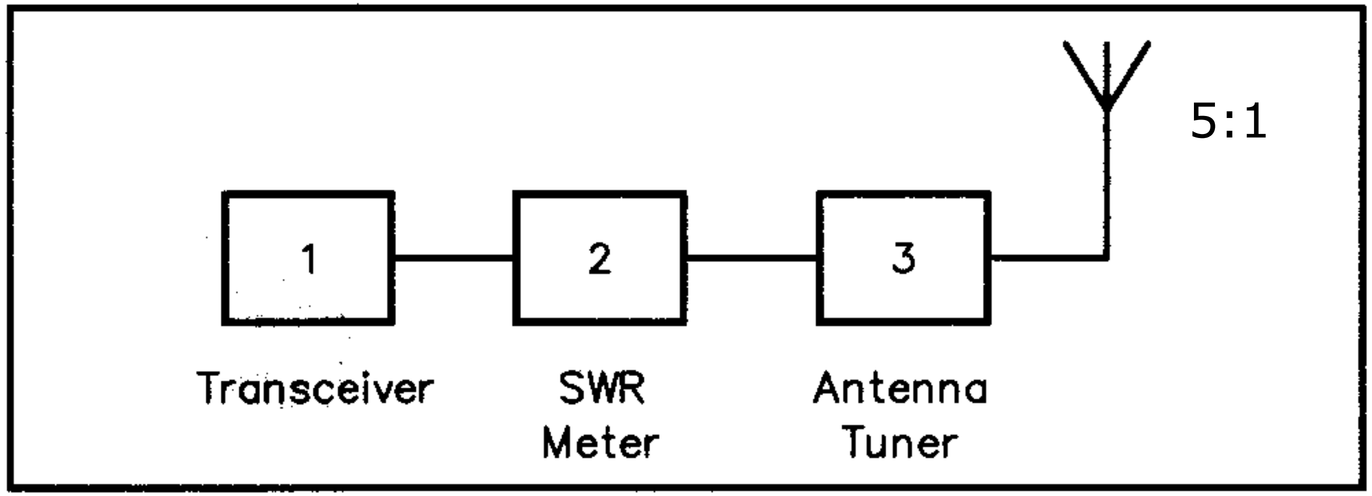
An automatic coupler can be placed directly at the feed-point of the antenna, providing good efficiency.

Automatic Coupler

Antenna Tuners

7-22 & 23

- To prevent standing waves on an antenna feed line, **the antenna feed-point impedance must be matched to the characteristic impedance of the feed line.** (G9A07)
- 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, the resulting SWR on the feed line is still **5 to 1.** (G9A08)

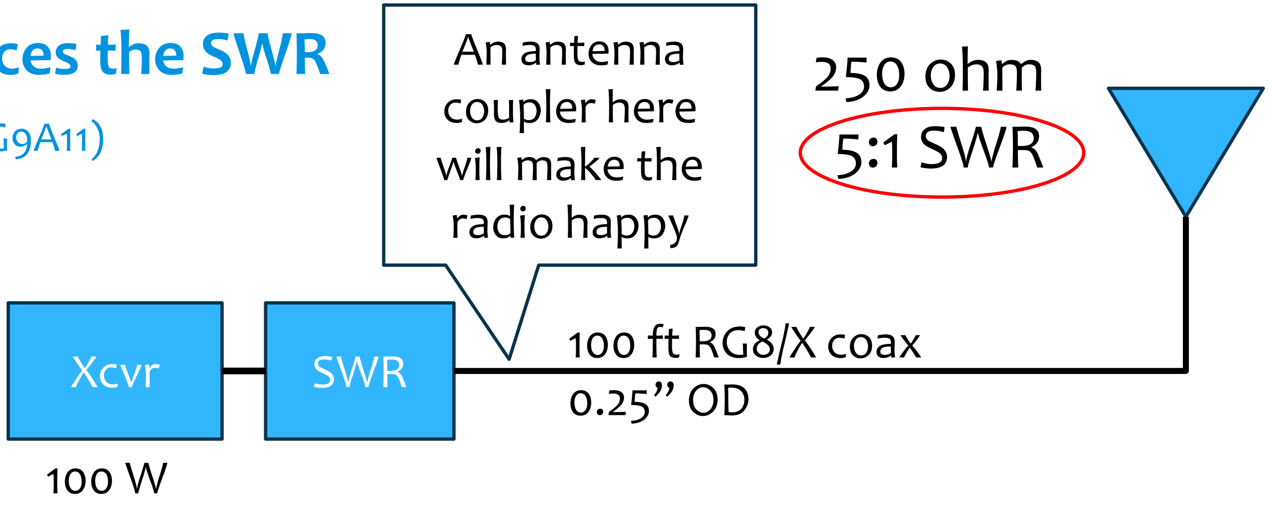


Feedline Loss Masks Bad SWR

Higher **transmission line loss reduces the SWR** measured at the input to the line (G9A11)

The Loss in the Coax will:

* Mask a high SWR
* Add additional loss



Frequency	50Ω Loss	Measured SWR	Actual Loss	Power @ Ant
3.8 MHz	0.5 dB	3.6:1	1.2 dB	75W
28 MHz	1.5 dB	2.6:1	3.1 dB	49W
146 MHz	4.1 dB	1.4:1	6.3 dB	23W

Feed Lines - Loss

7-23

Coax Cable Signal Loss (Attenuation) in dB per 100ft							
Loss	RG-174	RG-58	RG-8X	RG-213	RG-6	RG-11	9913
USE	HF	HF/VHF	HF	HF/VHF	VHF/UHF	HF/VHF	VHF/UHF
1MHz	1.9dB	0.4dB	0.5dB	0.2dB	0.2dB	0.2dB	0.2dB
10MHz	3.3dB	1.4dB	1.0dB	0.6dB	0.6dB	0.4dB	0.4dB
50MHz	6.6dB	3.3dB	2.5dB	1.6dB	1.4dB	1.0dB	0.9dB
100MHz	8.9dB	4.9dB	3.6dB	2.2dB	2.0dB	1.6dB	1.4dB
200MHz	11.9dB	7.3dB	5.4dB	3.3dB	2.8dB	2.3dB	1.8dB
400MHz	17.3dB	11.2dB	7.9dB	4.8dB	4.3dB	3.5dB	2.6dB
Imped	50ohm	50ohm	50ohm	50ohm	75ohm	75ohm	50ohm

Similar to **LMR400**

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

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

G9A04

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

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

G9A10

$SWR = Z_1 / Z_2$

$SWR = 50 / 10$

$SWR = 5$

$SWR = 5:1$

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

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

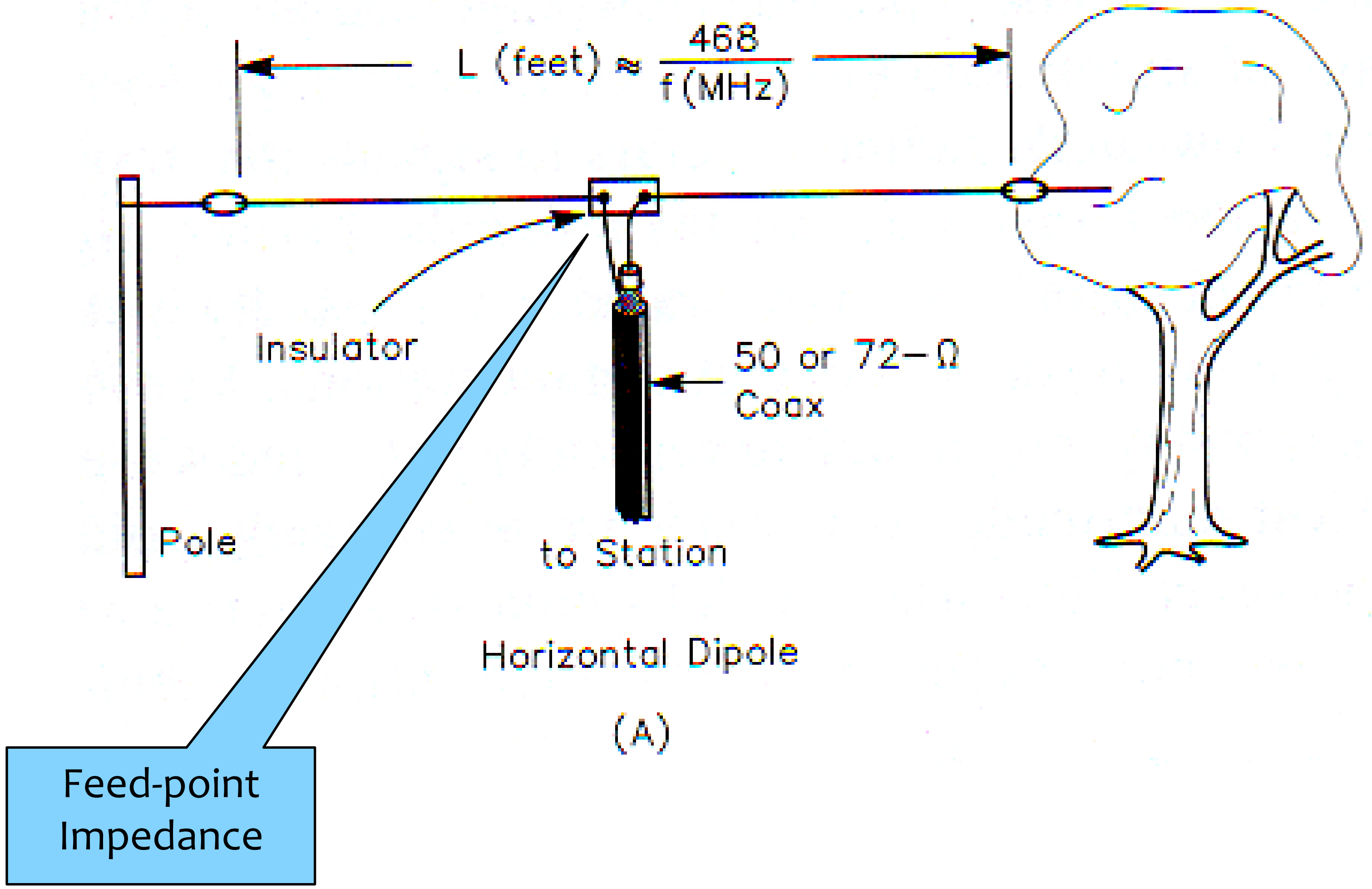
(G9A07)

Appendix

Practical Info

-- Antennas --

The Most Basic Antenna: The Dipole

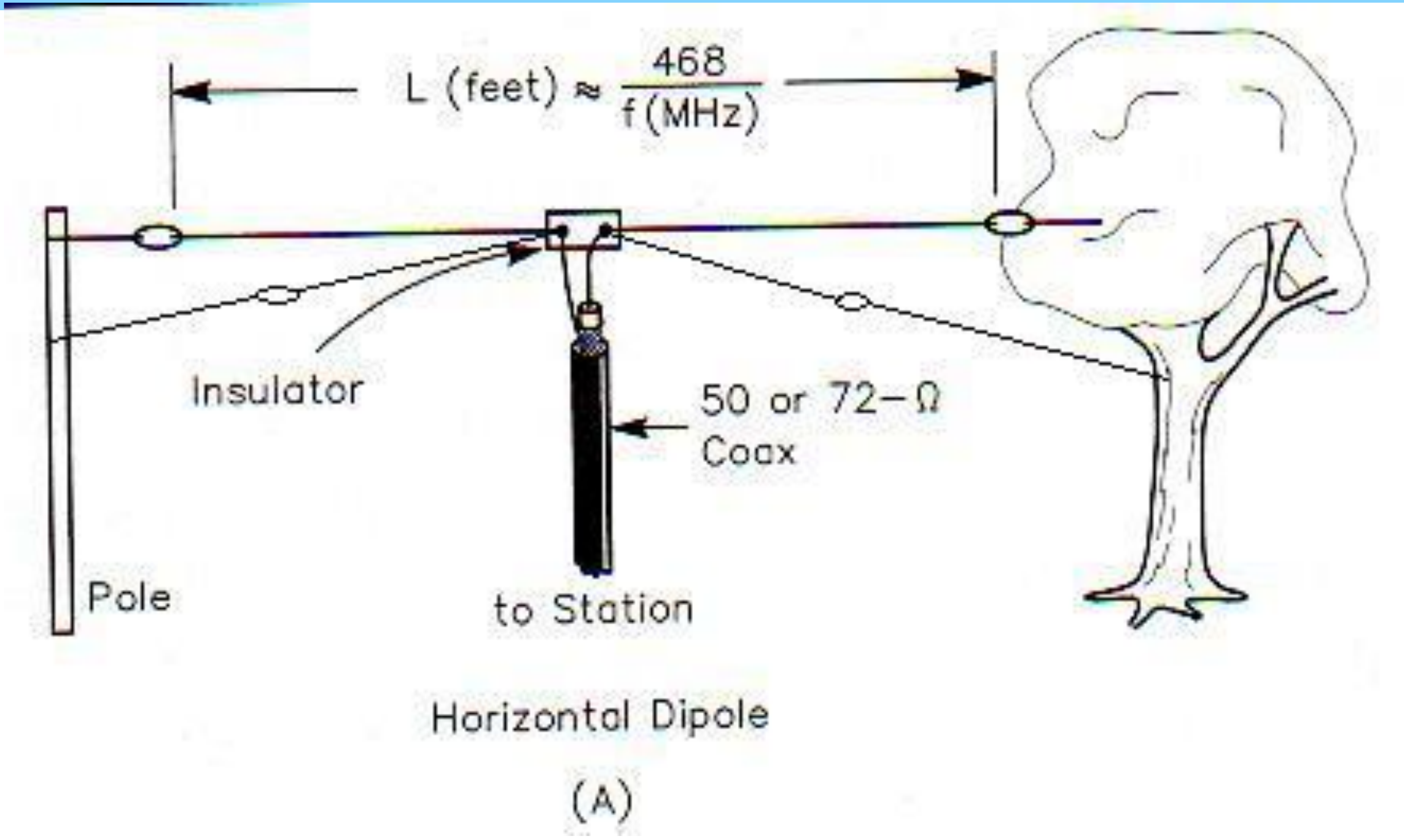


Practical Information: Fan Dipole

A Fan Dipole, with elements cut for **40m and 20m**, may also work fairly well on 15m.

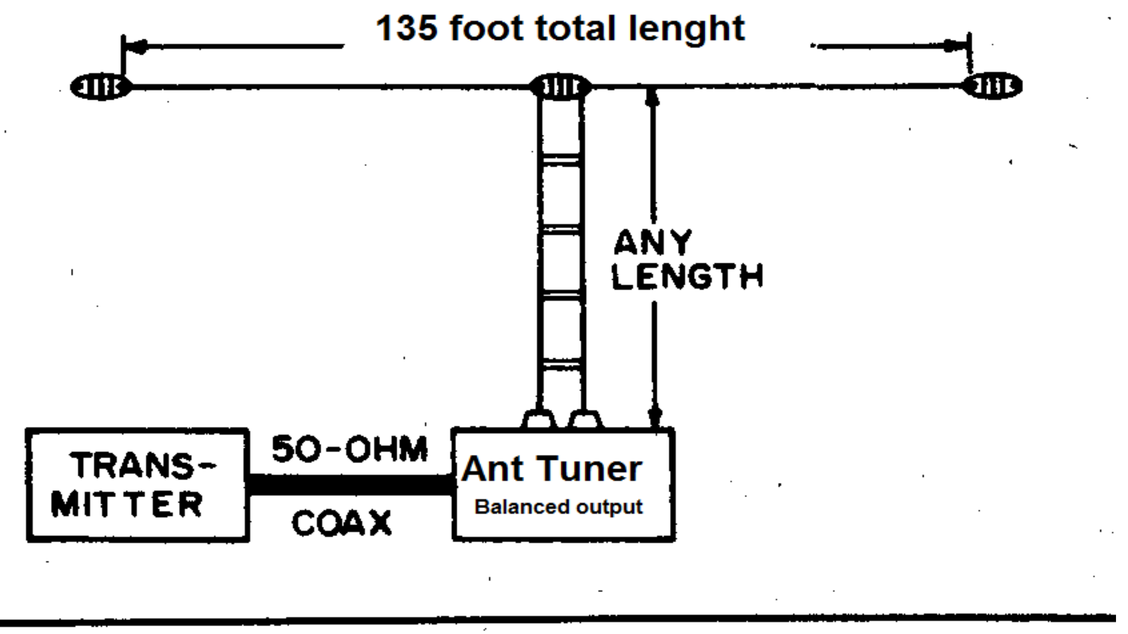
The longest element will be about 66 ft long.

It can be configured flat top or as an inverted-V



Practical Information: My Favorite!

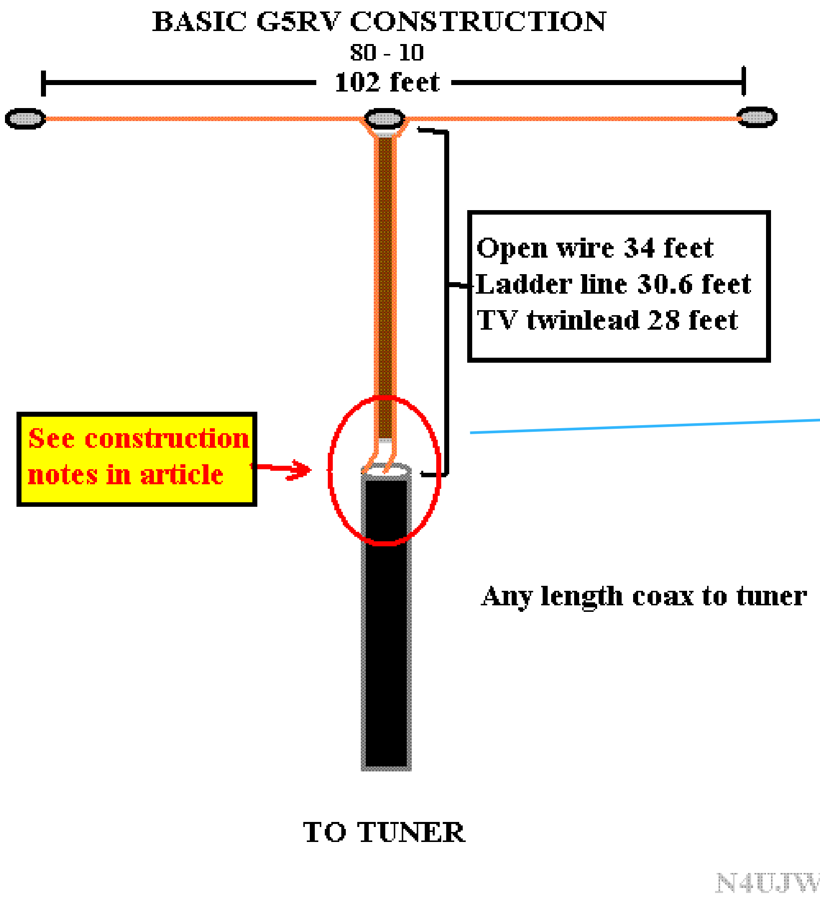
* 80 m Dipole fed with ladder line and an antenna tuner
* It is sometimes called a double-zepp antenna; 80 – 10m coverage



—A center-fed antenna system for multiband use.

Practical Information: The G5RV

* 102 ft Dipole fed with ladder line and an antenna tuner



The mismatch between the ladder line and the coax can contribute to significant loss

End Fed Halfwave (EFHW)

FYI

- EFHW antennas can be "homebrew," built from kits or purchased fully assembled
  - ARRL 40m EFHW kit, 100w power rating, $80
  - myantennas.com 80m EFHW assembled, 1kW power rating, < $300

EFHW-8010-1K

Table 2
EFHW-8010-1K SWR Measurements

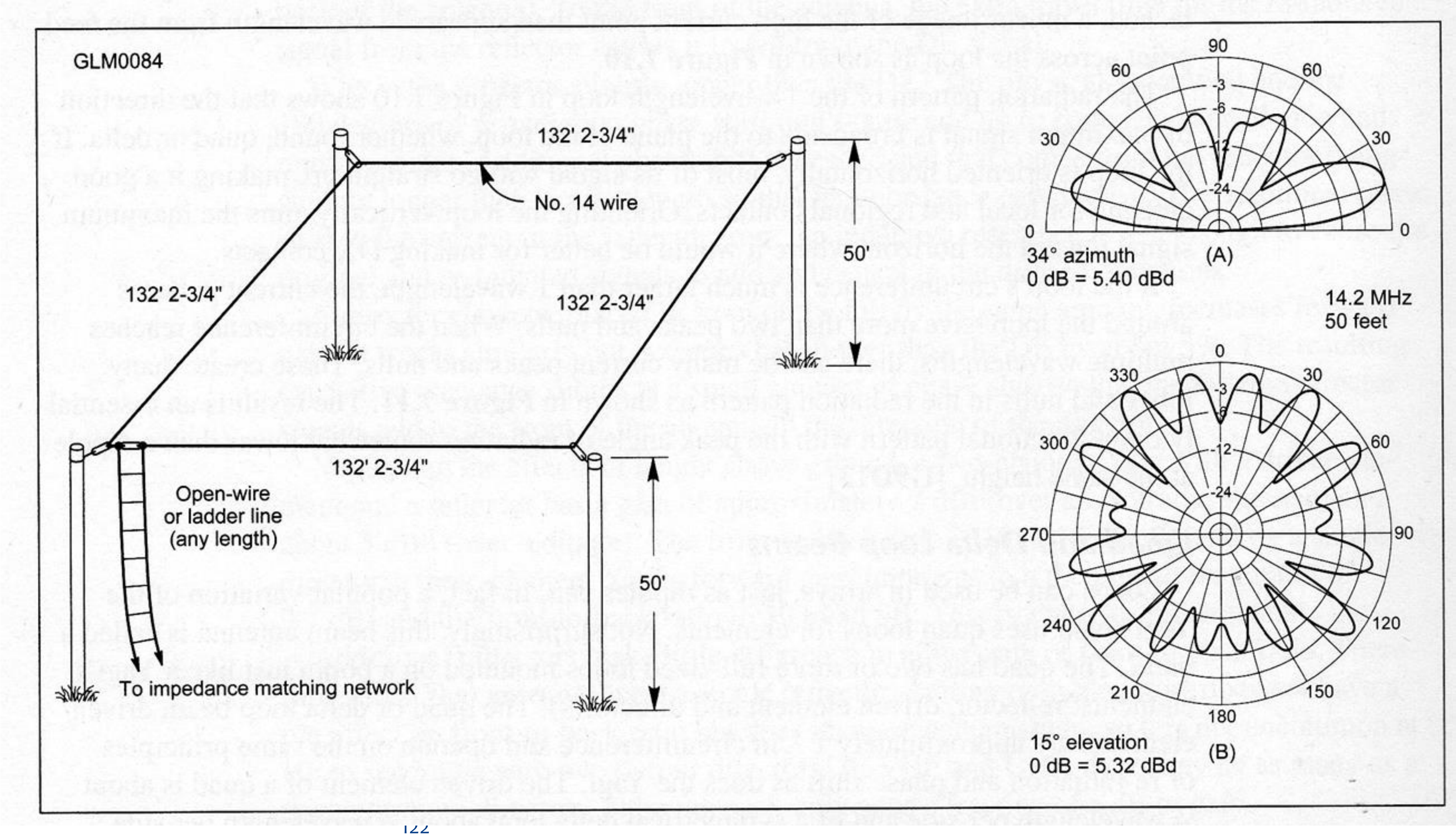
Frequency (MHz)	Manufacturer's "Typical SWR"	SWR Measured At Entrance Panel	SWR Measured At Station
3.60	1.5:1	2.0:1	2.0:1
7.05	1.2:1	1.3:1	1.3:1
10.1	1.5:1	4.0:1	3.3:1
14.2	1.1:1	1.4:1	1.4:1
18.1	1.5:1	2.0:1	1.8:1
21.2	1.3:1	1.2:1	1.1:1
24.9	1.2:1	1.1:1	1.1:1
28.5	1.4:1	2.3:1	2.0:1

40m EFHW, 65 ft long: 40, 20, 15 & 10m bands
80m EFHW, 130 ft long: 80, 40, 30, 20, 17, 15, 12 & 10m

Ref: March 2016 QST
The article suggests the SWR at 4 MHz is > 5:1

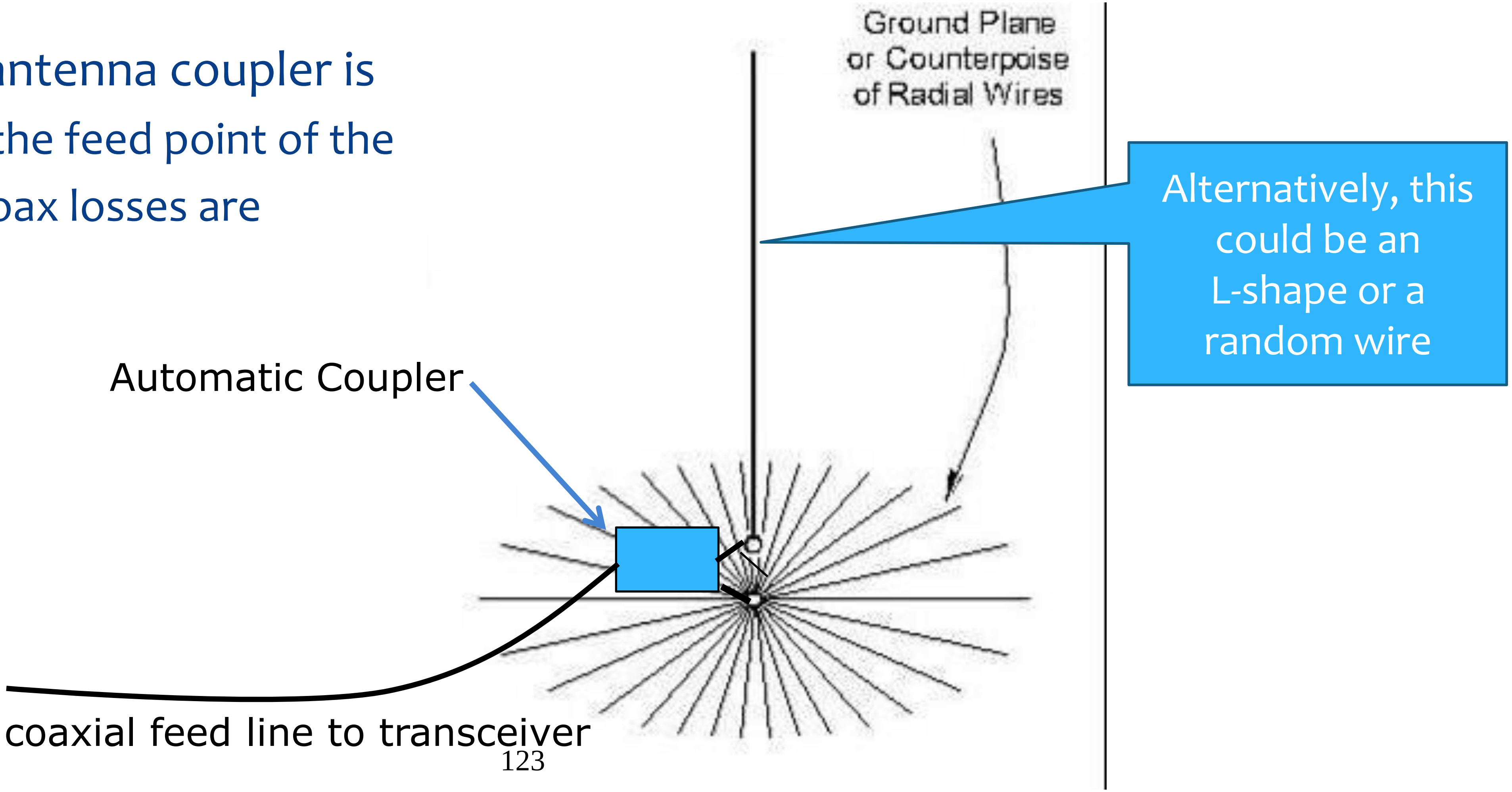
Large Horizontal Loop

* For the 80 m band, each side is about 132 ft long, for a total length of 529 ft.



Practical Information: Automatic Antenna Coupler

* When the antenna coupler is located at the feed point of the antenna, coax losses are minimized.



Practical Information: Trapped Verticals and Dipoles

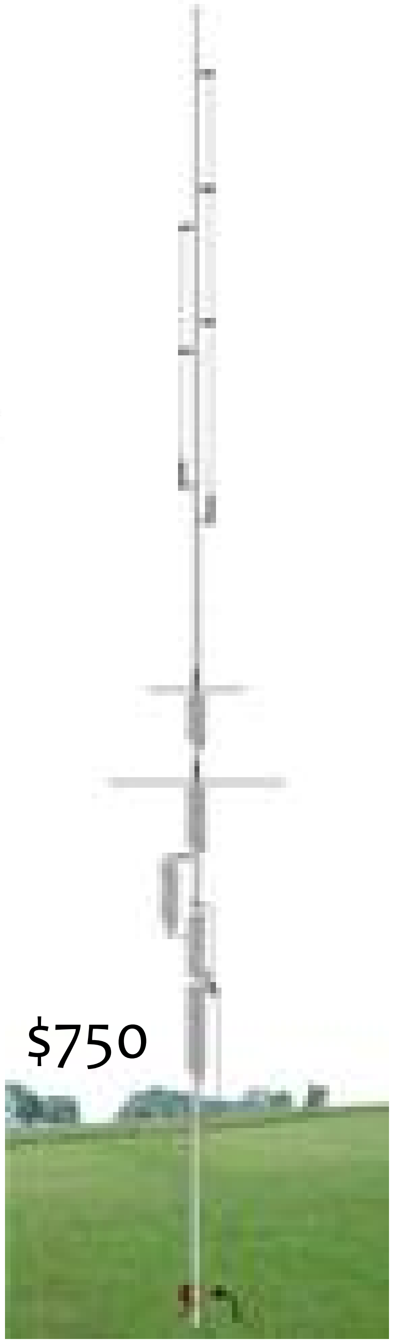
* Traps provide for multi-band performance.

* Common trapped antennas are:
* Verticals
* Dipoles
* Yagis

$190

Radials Required

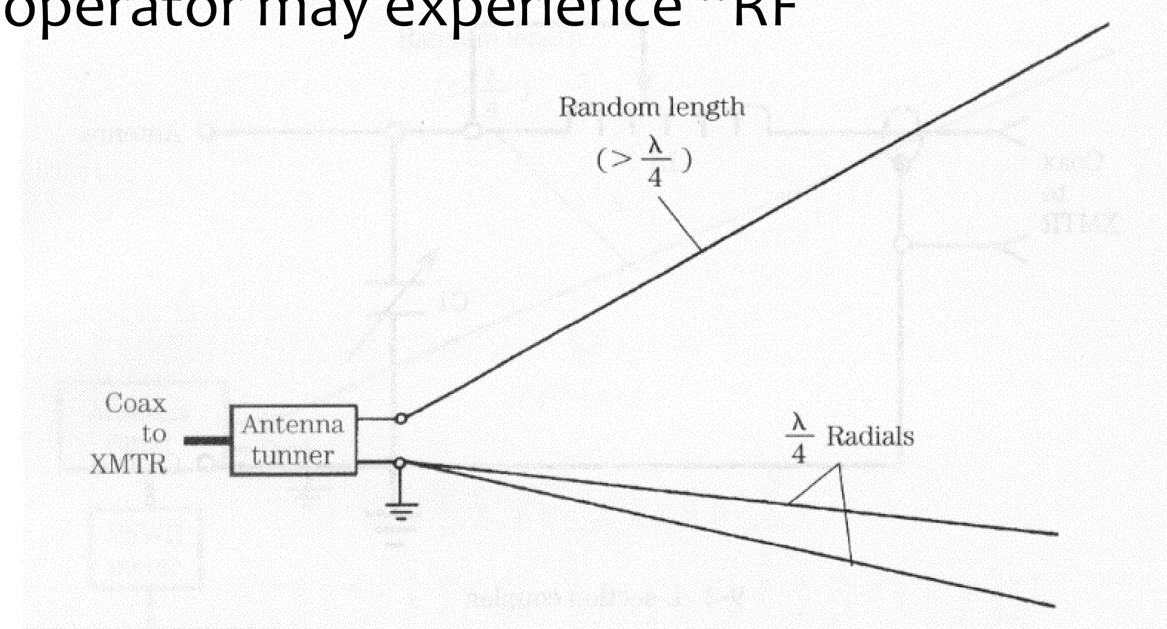
$230



$750

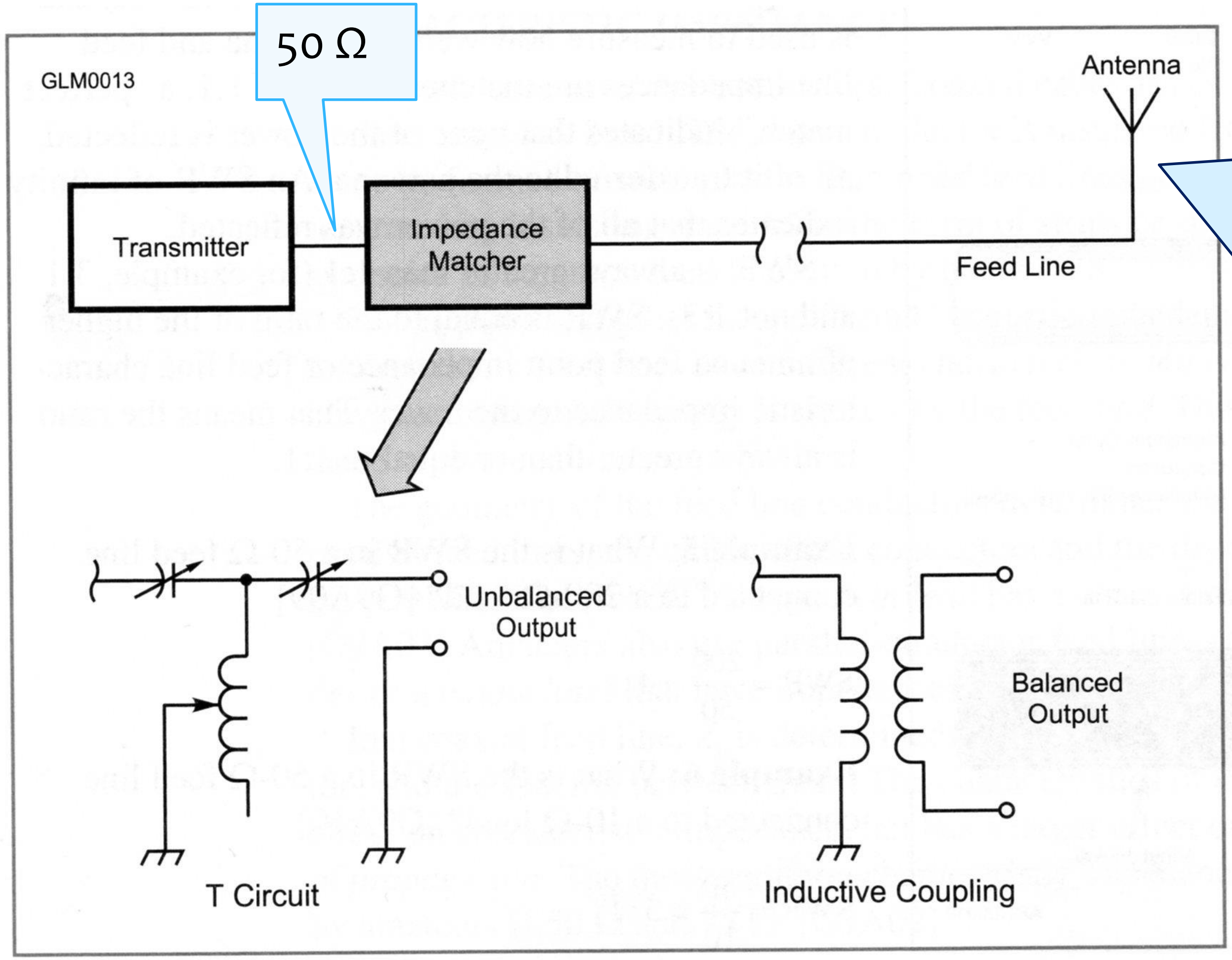
Practical Information: Random Wire

* Random wire antennas with an antenna tuner can cover many bands. If the antenna tuner is in the shack, the "antenna" starts in the shack.
* A good ground is required or the operator may experience "RF burns"



9-3 Radials improves the "ground" of random length antenna.

Practical Information: Multiband Antennas



<u>Practical Info:</u>
Coax may be used if the SWR is 3:1 or less.
(Risks:

- Excessive loss
- High voltage)

If the SWR is much above 3:1, use ladder line.

Practical Information: Feedlines

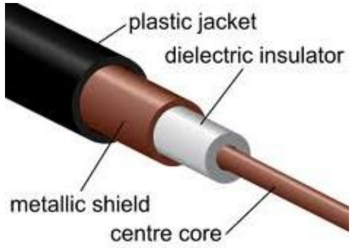
7-21

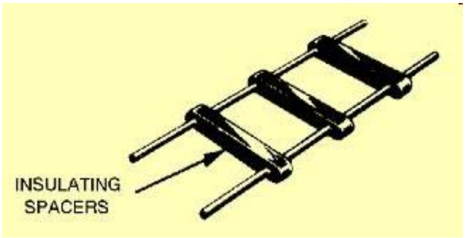
Coax (50 or 75 Ω)

* Is very Convenient
  * May be bundled with other coax or routed next to metal objects
  * Excess coax can be coiled up
* Good if used with low SWRs

Parallel Conductor

  * Twin Lead (300 Ω)
  * Ladder Line (450 Ω)
* Must be spaced away from other conductors or metal objects
* May not be coiled
* Tolerant of high SWRs





Antenna Options