Antennas 101

The Basics

Ward Silver NØAX

The Basics - 1

- Antennas radiate (or receive) because electrons are accelerated (or are caused to accelerate) in the antenna's *elements*
- Radio or *electromagnetic* waves are both an E- (electric) and H- (magnetic) field
- Electrons move parallel to E-fields
- Strongest radiation from accelerating electrons linearly (back and forth)

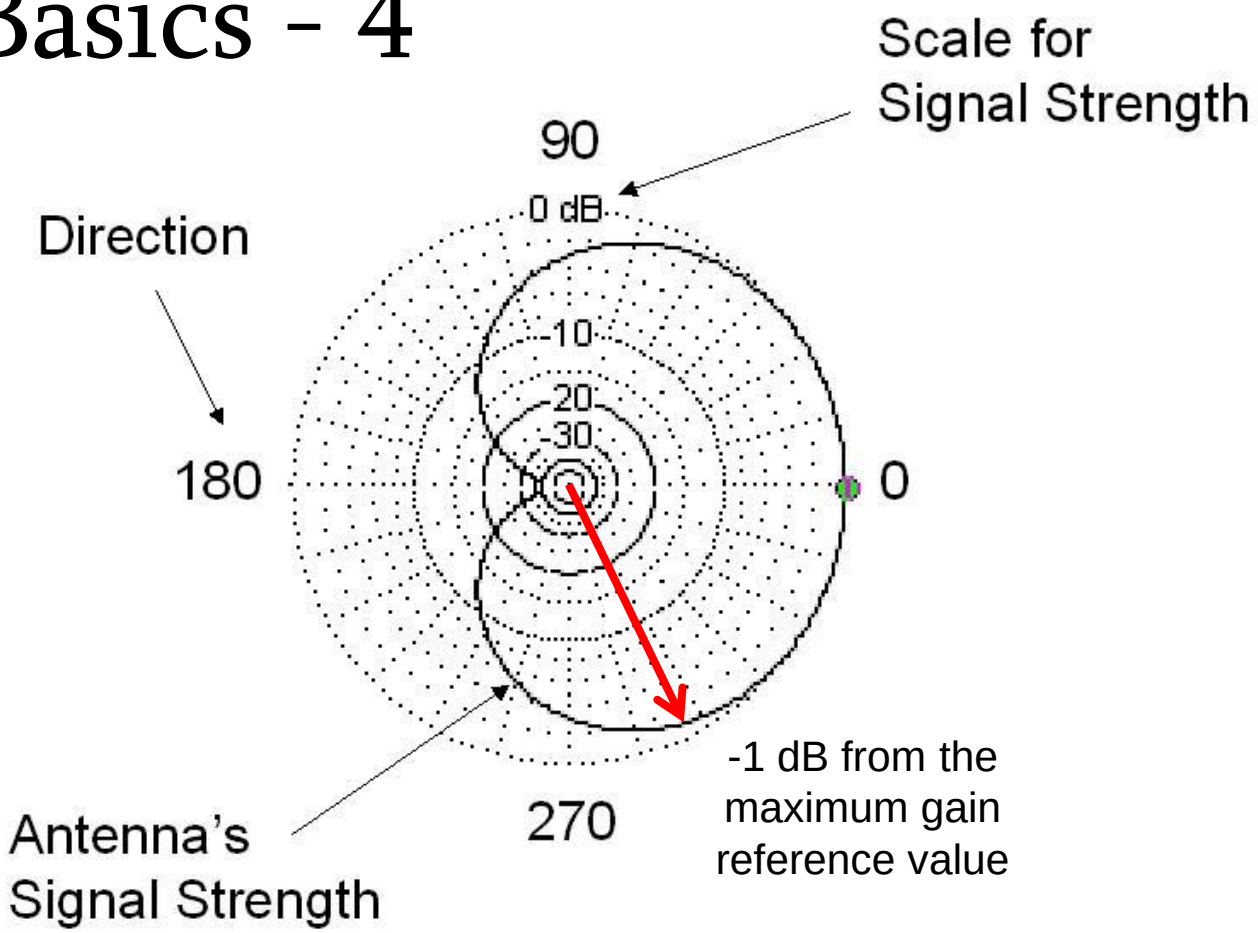
The Basics - 2

- The orientation of the E-field determines the *polarization* of the wave because that's what makes the electrons move (current)
- Antennas transmit & receive radio waves in the same way
- The *radiation pattern* shows how antennas distribute energy in space

The Basics - 3

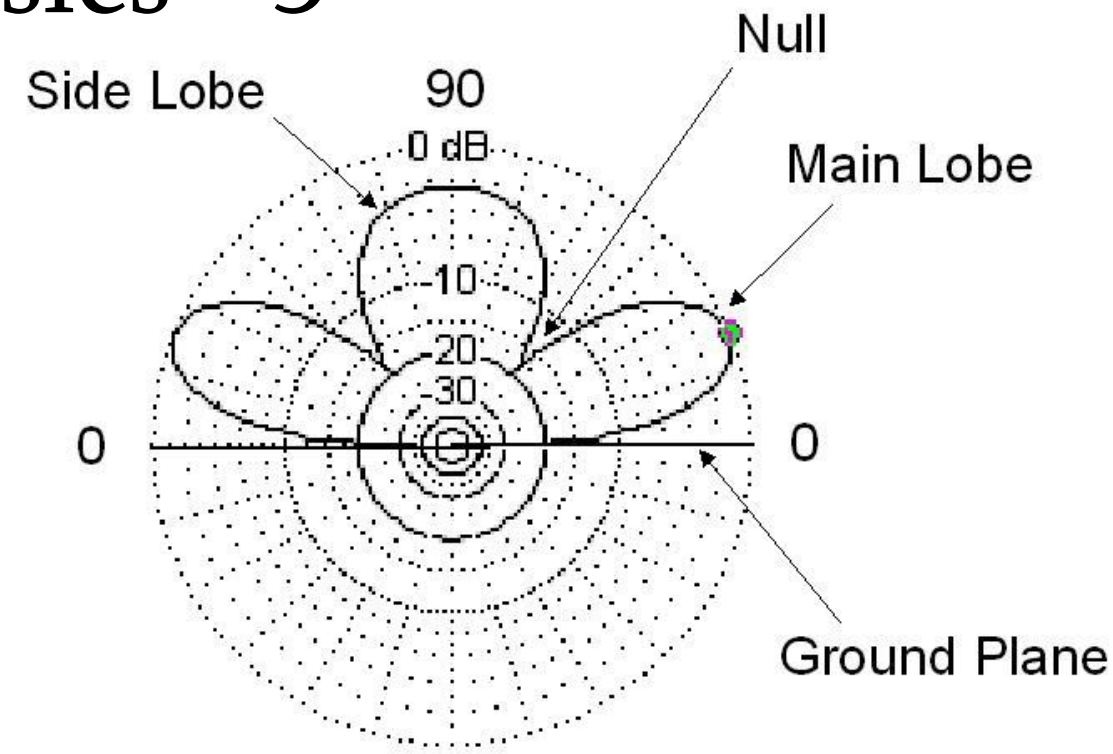
- deciBels (dB) = 10 log (power ratio)
- Impedance = ratio of Voltage to Current
- Feed point - place where power is applied

The Basics - 4



Azimuthal Pattern

The Basics - 5

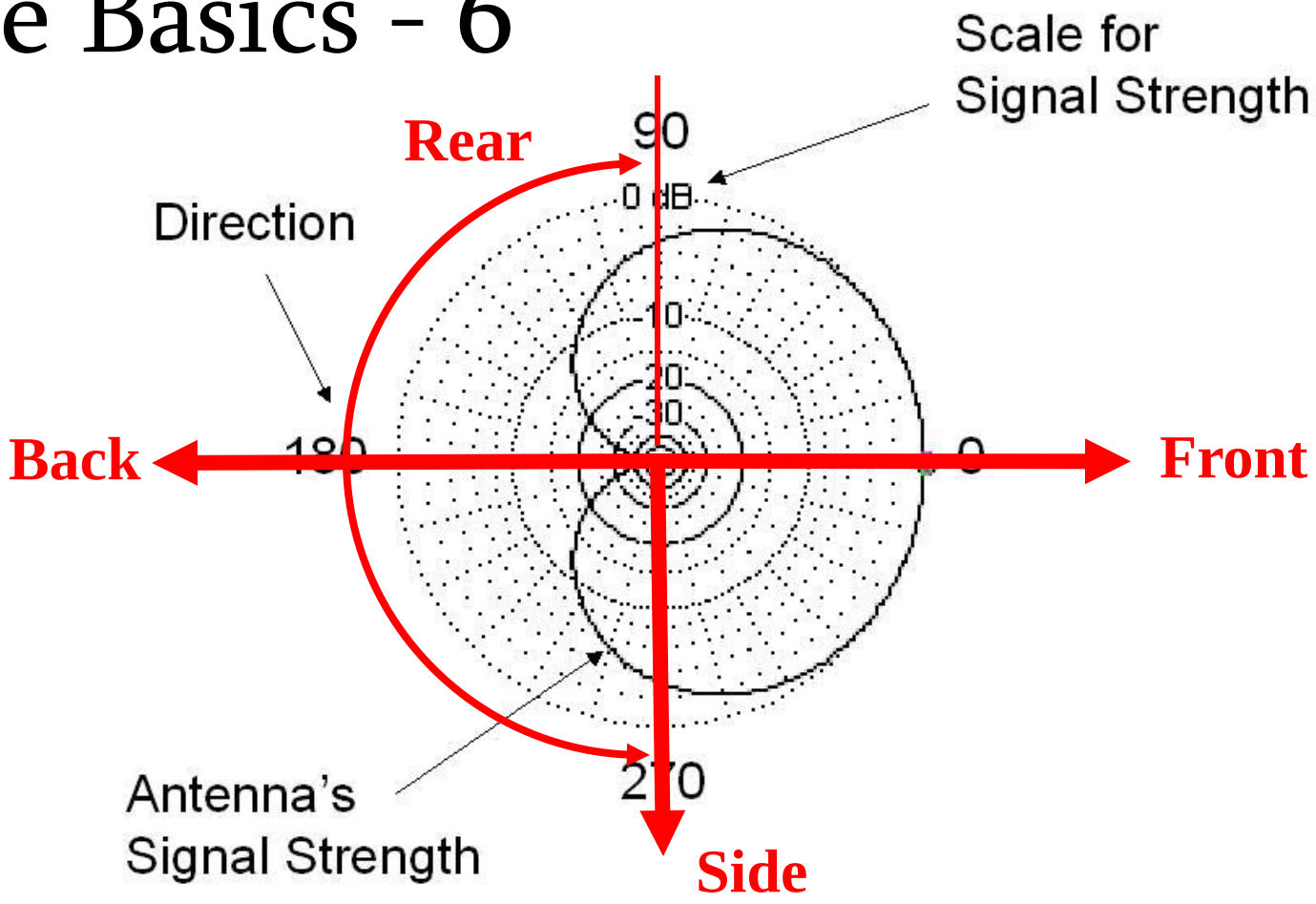


Elevation Pattern

The Basics - 6

- *Front-to-Back*, *Front-to-Side*, and *Front-to-Rear* ratios
  - Front-to-Rear ratio based on an average across 90 or 180 degrees “behind” the antenna in the pattern’s rear quadrant(s)

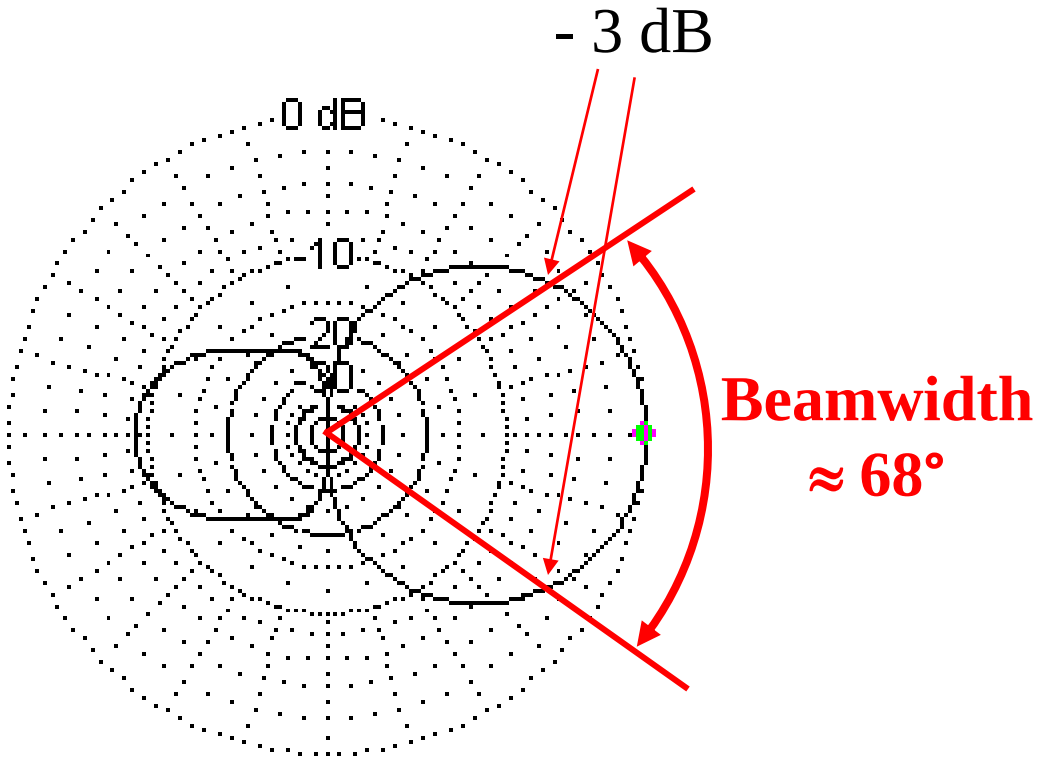
The Basics - 6


Scale for
Signal Strength
Rear
90
0 dB
10
20
30
Direction
Back
180
0
Front
270
Antenna's
Signal Strength
Side

The Basics - 6

- *Beamwidth* - angular width of main lobe
  - Angle between the two points at which power is ½ that at the peak (-3 dB points)

The Basics - 6



The Basics - 7

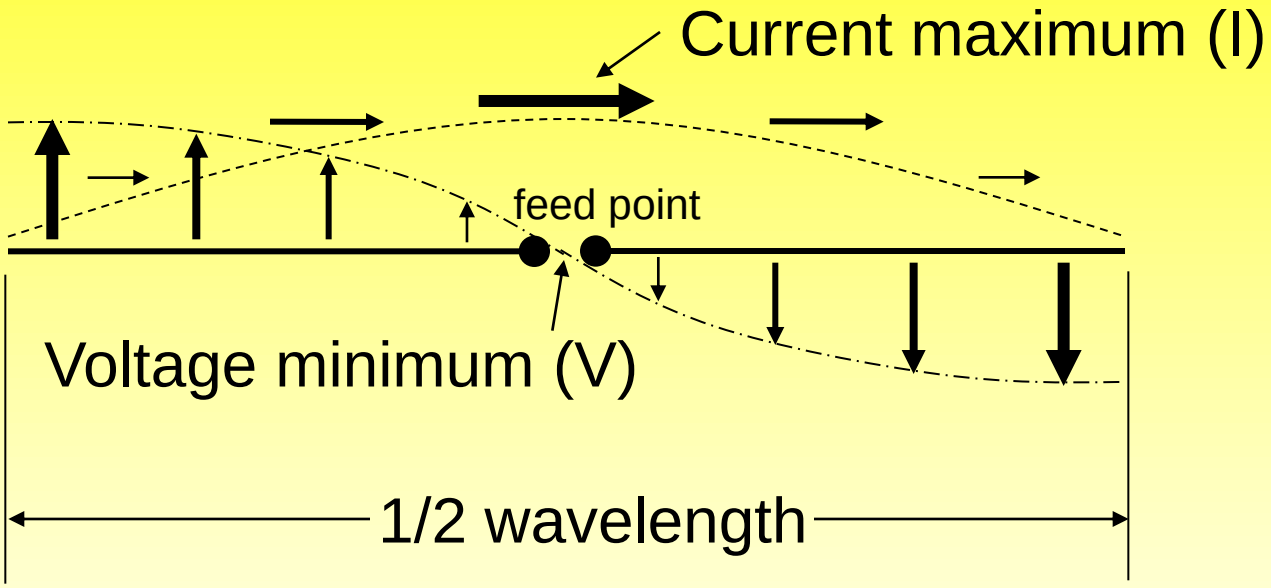
- *Gain* measures re-distribution of energy
- *Gain* is a comparison of antennas
- Gain is always ***with respect to a reference***
  - dBi (*isotropic*), dBd (*free-space* λ/2 dipole)
  - λ/2 dipole has 2.15 dBi gain
  - Ground-plane gain equivalent to λ/2 dipole
  - 3-element Yagi may have up to 5 dBd gain

QUESTIONS??

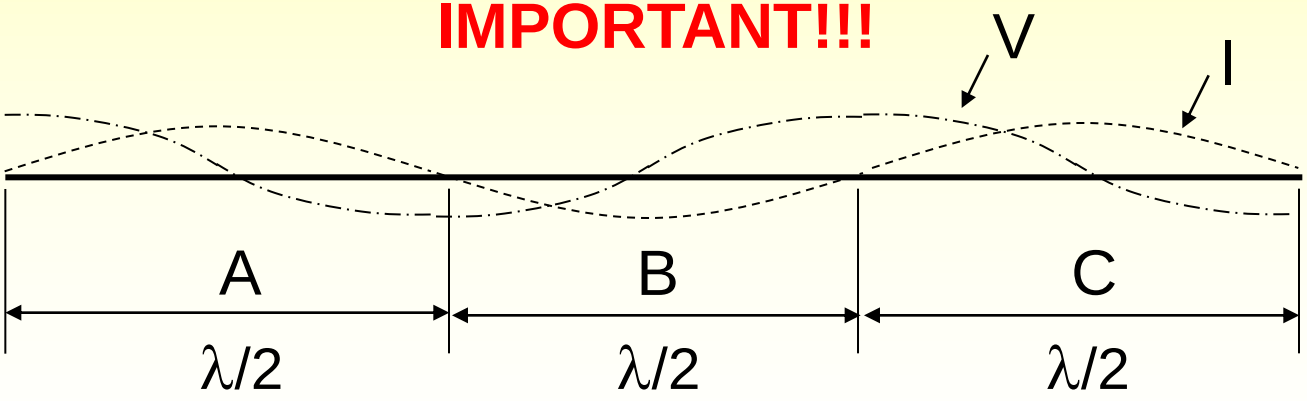
The Dipole - 1

- Oldest and simplest form of antenna
  - "Di" (two) "Pole" (voltage polarity)
  - Usually 1/2-wavelength long
- Similar to a vibrating string's fundamental
  - *Current maximum* in the middle
  - *Voltage maximum* at the ends
- Pattern repeats every 1/2-wavelength
  - Direction or amplitude is reversed

The Dipole - 2



IMPORTANT!!!



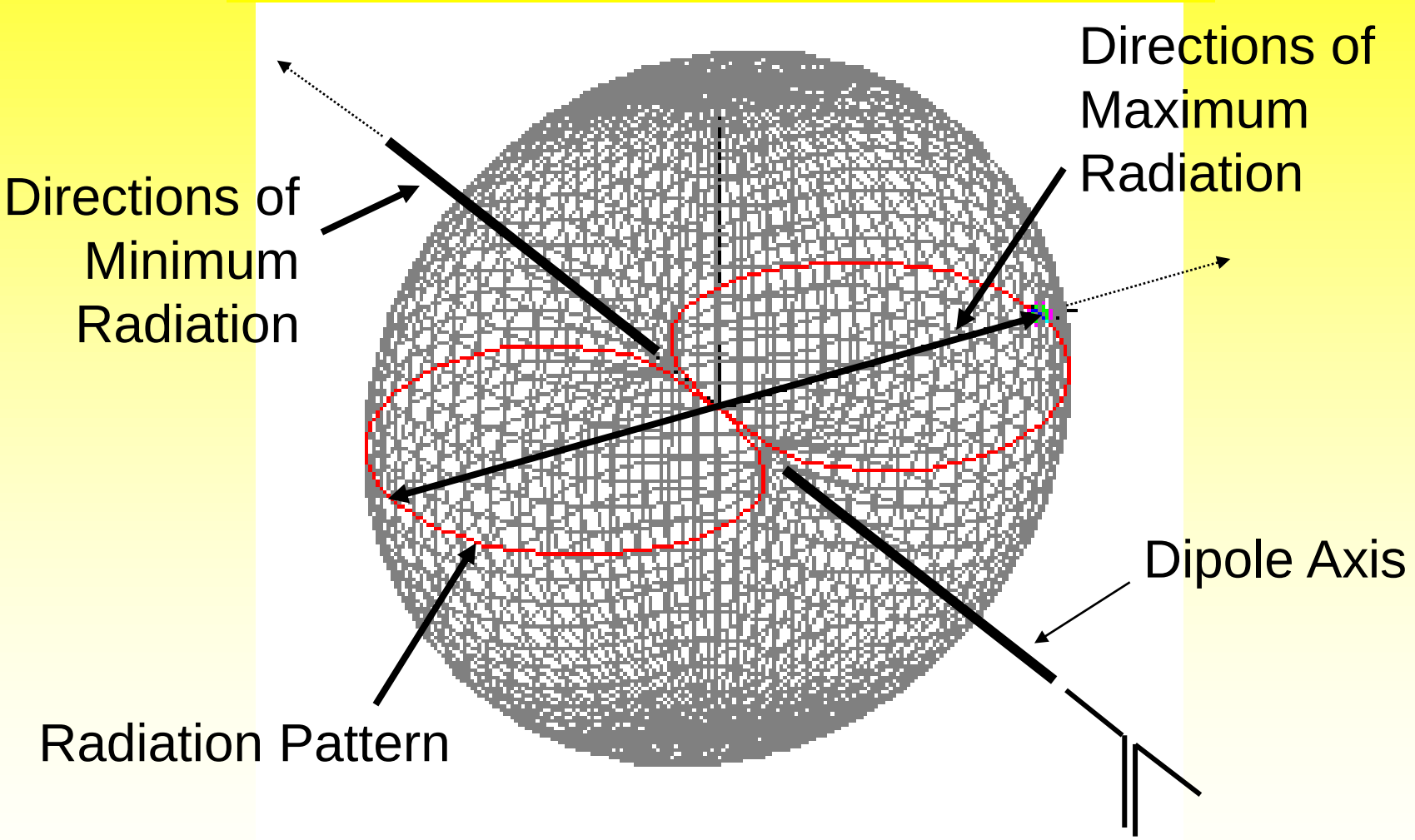
The Dipole - 3

- *Free-space* wavelength (λ)
  - λ = c / f or 300 / f in MHz (in meters)
  - λ/2 = 492 / f in MHz (in feet)
- *Length-to-diameter effect*
  - Makes the antenna a little longer *electrically*
  - Thicker conductors are longer electrically
- *Effect of height* on electrical length
  - 460/f to 490/f (rarely 468/f)

The Dipole - 4

- Radiated energy is strongest *perpendicular* to an electron's motion
  - electrons move along the length of a dipole
  - radiation strongest broadside to the dipole

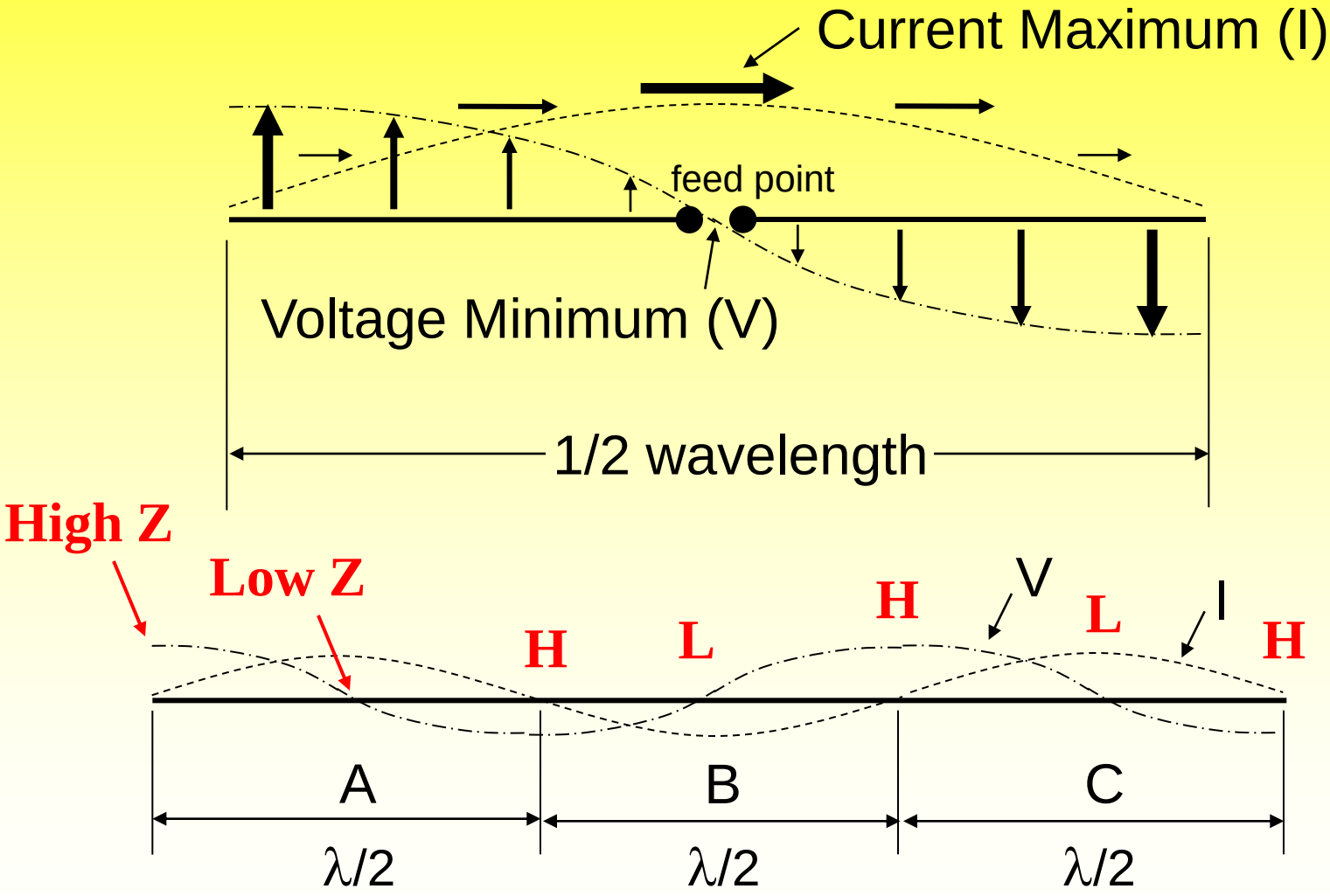
The Dipole - 4


Directions of Maximum Radiation
Directions of Minimum Radiation
Dipole Axis
Radiation Pattern

The Dipole - 5

- Feed point impedance varies with position
  - High at the ends and low in the middle
  - Resonance – feed point impedance all resistive, no reactance
    - Z = R + *j* 0 ohms
    - Doesn't matter what R is (*any* value, not just 50 Ω)

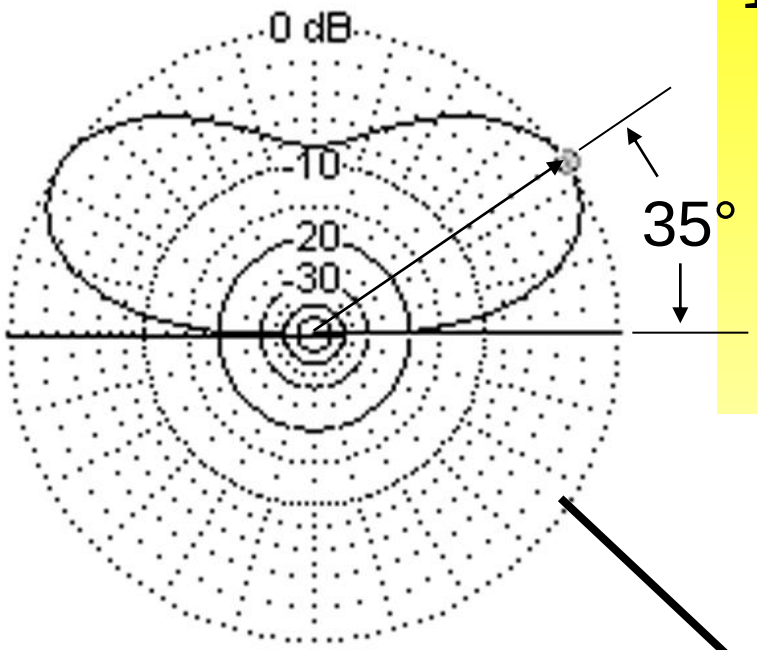
The Dipole - 5

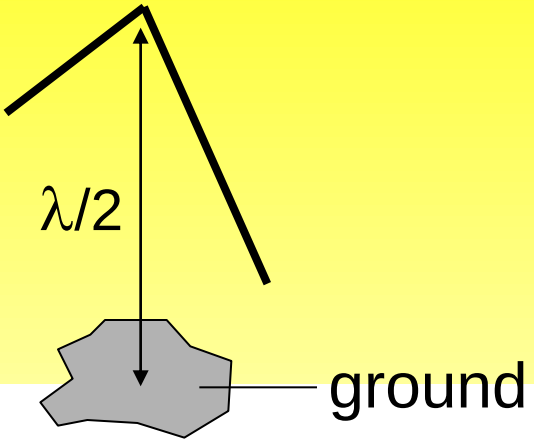

Current Maximum (I)
feed point
Voltage Minimum (V)
1/2 wavelength
High Z
Low Z
H
L
H
V
L
I
H
A
B
C
λ/2
λ/2
λ/2

The Dipole - 6

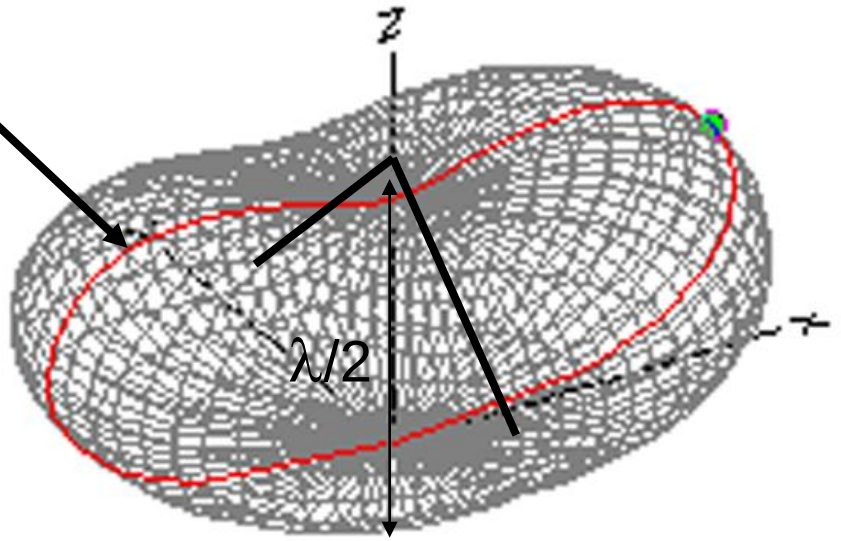
- Inverted-Vee is a “bent” dipole
- Radiation pattern adds the effect of *ground gain* from reflections
  - Can add as much as 6 dB over free space
  - Free-space gain best comparative measure
- Ground gain varies with height and with ground conductivity

The Dipole - 6





Inverted-Vee
Radiation Pattern

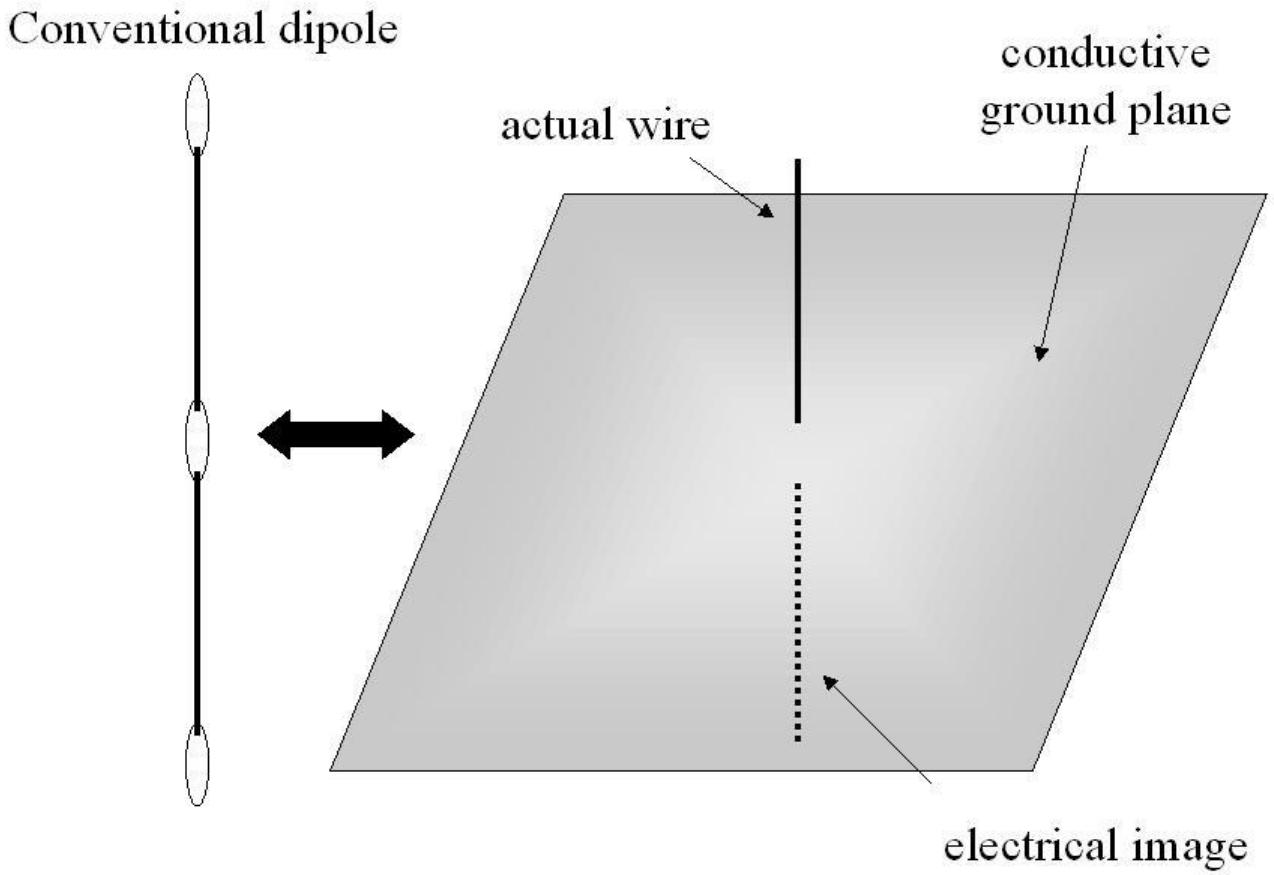


QUESTIONS??

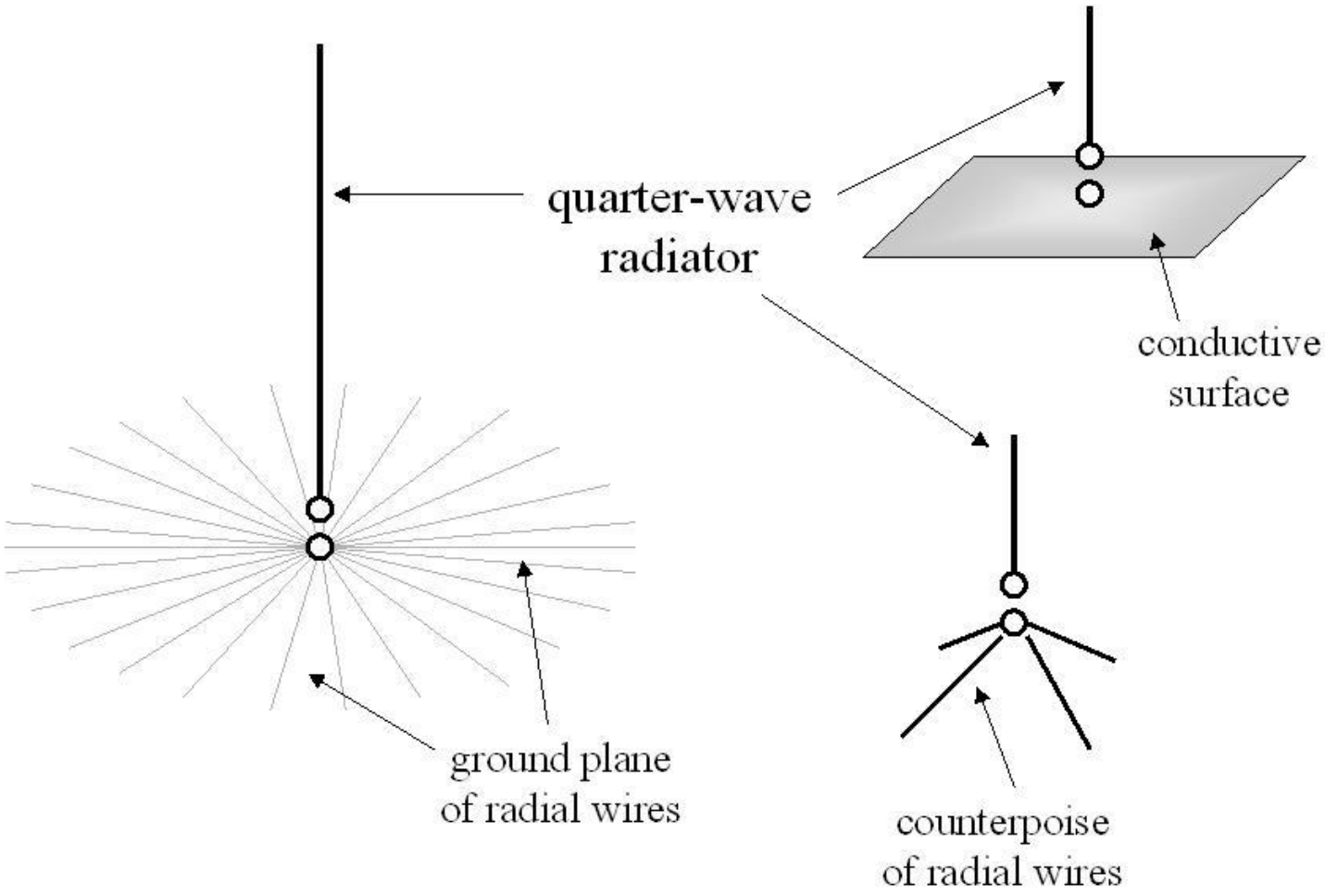
The Ground Plane - 1

- Start with a vertical dipole in free-space
- Cut off one half of the dipole
- Replace the missing half with a *ground plane* or *counterpoise*
- *Omnidirectional* if oriented vertically
- Also called a *monopole*

The Ground Plane - 2

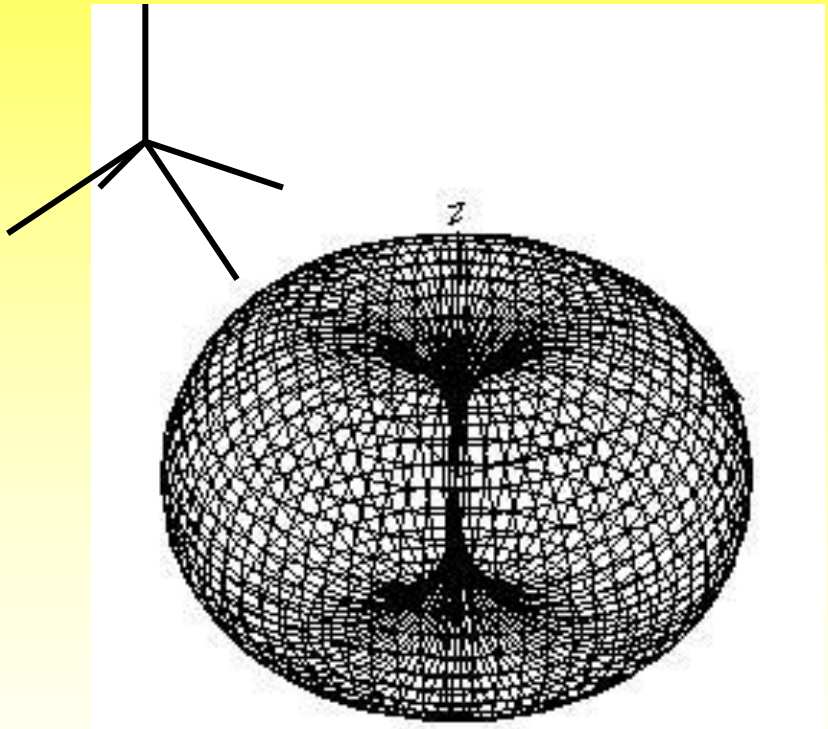


The Ground Plane - 3



The Ground Plane - 4

- Equal radiation broadside
- Nulls along the axis



The Ground Plane - 5

- Length (ft) ≈ 234 / f (MHz)
  - 231 / f if #14 wire used, - 221 if 5/8" tubing
- Feed point impedance ≈ 35 Ω
  - if radials used, sloping increases feed point impedance
  - approximately 45° of droop gives best match
  - halfway between dipole (72 Ω) and ground plane (35 Ω)

Useful References and Books

- ARRL Publications
  - *Antenna Book, Basic Antennas*
  - *Compendium* and *Classics* series
- RSGB Publications
  - *Practical Wire Antennas* and *HF Antennas for all Locations*
- CQ Communications
  - Sevick's and Maxwell's books on xmsn lines, baluns
  - *Vertical Handbook*, *All About Quads*

Useful On-Line References

- ARRL Technical Information Service
- AC6V.com and Dxzone.com
- L.B. Cebik's web site - www.cebik.com
  - Part of the Antennex.com site (subscription)
- Antennas and TowerTalk reflectors at www.contesting.com

Thank You!