Using EZNEC To Compare Antennas Part 1

Bill Leonard N□CU

What is the “Best” antenna?

There is no “Best” antenna!

***For a given set of goals and constraints*, there may be a "Best" antenna!**

Typical Goals & Constraints

- **Directive vs. Omni Directional**
- **Gain**
- **Beam takeoff angle**
- **Beamwidth (Azimuth & Elevation)**
- **Front to Back Ratio**
- **Front to Side Ratio**
- **Efficiency**
- **Bandwidth**
- **Band coverage**
- **Height required**
- **Support structure required**
- **Rotator required**
- **Governmental & HOA restrictions**
- **Obstructions (buildings, mountains, etc)**
- **Cost**
- ***Spouse's restrictions***

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EZNEC can help

- Support structure required
- Rotator required
- Governmental & HOA restrictions
- Obstructions (buildings, mountains, etc)
- Cost
- *Spouse's restrictions*

What Criteria to Use for Comparing Antennas?

- **Distance:**
  - **DX:** >2000 miles
  - **USA:** 200-2000 miles
  - **NVIS:** <200 miles
  - **Ground Wave:** <50 miles
- **Takeoff Angle:**
  - **DX:** 1^{o}-20^{o} (ARRL propagation charts)
  - **USA:** 11^{o}-63^{o} (single hop for F2 layer at 200 miles)
  - **NVIS:** >63^{o}
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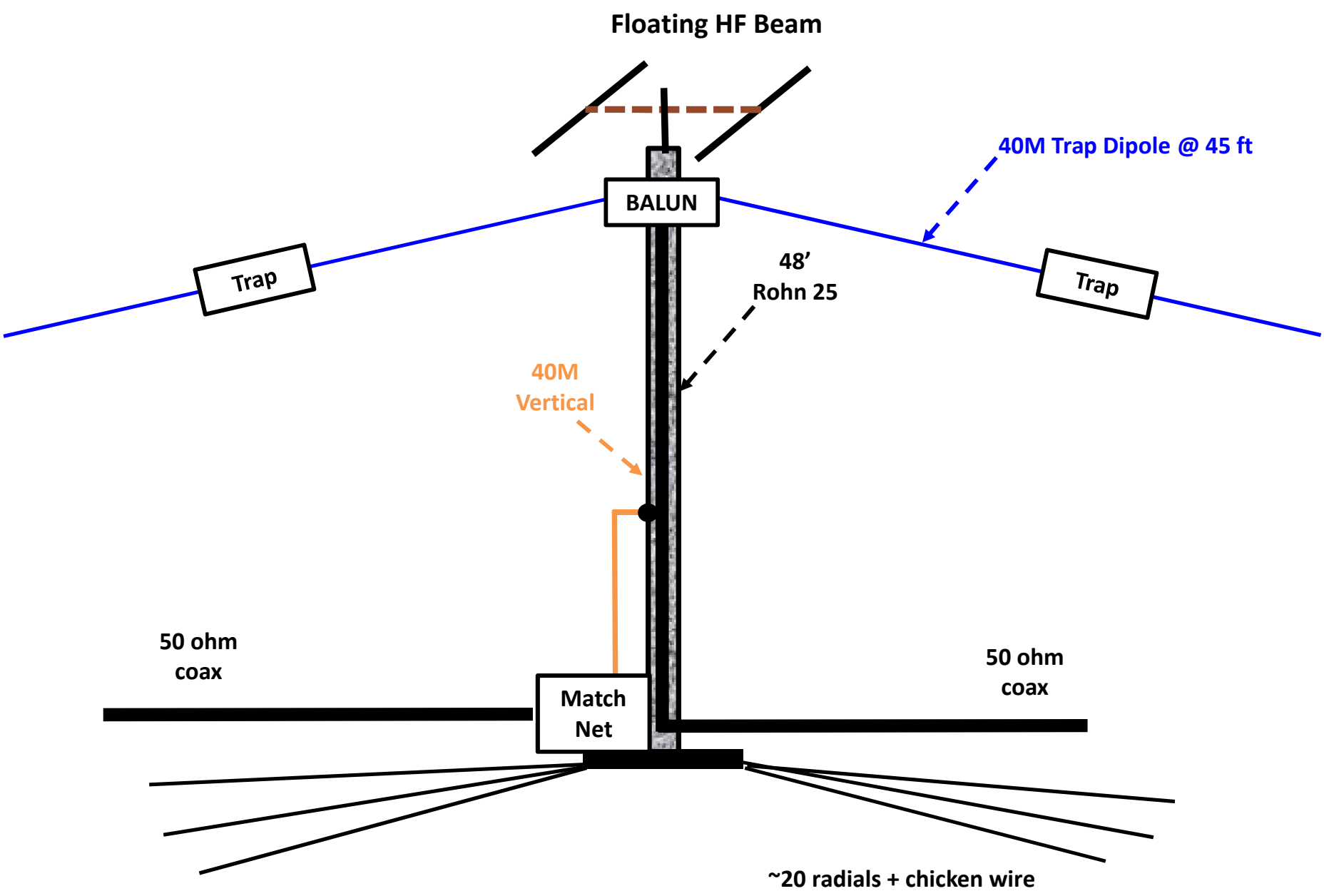
I like to compare gains above real ground at 10^{o} & 30^{o}

Example 1: 48’ Shunt Fed Tower as 40M Vertical



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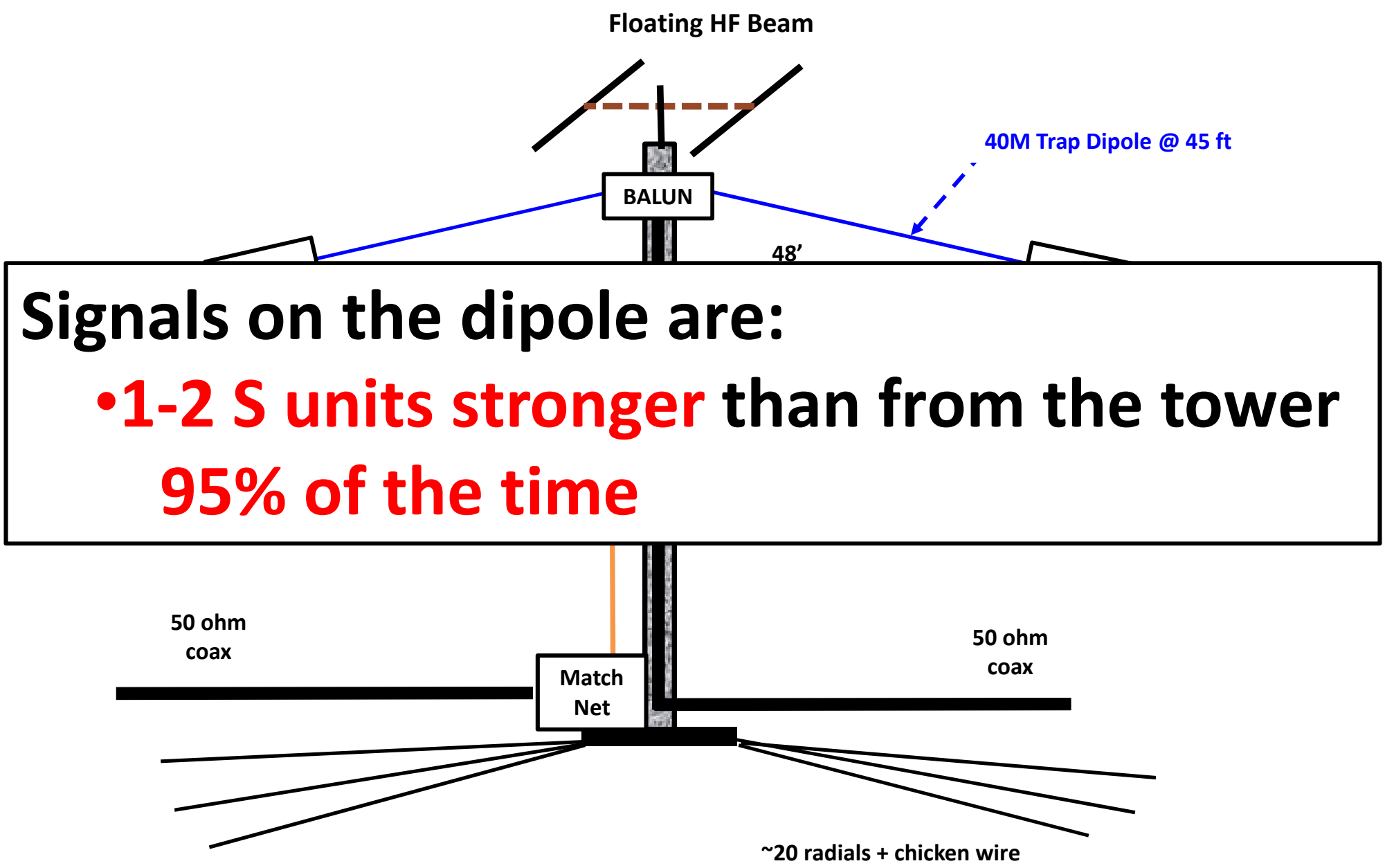

Signals on the dipole are:

- **1-2 S units stronger than from the tower**

  95% of the time

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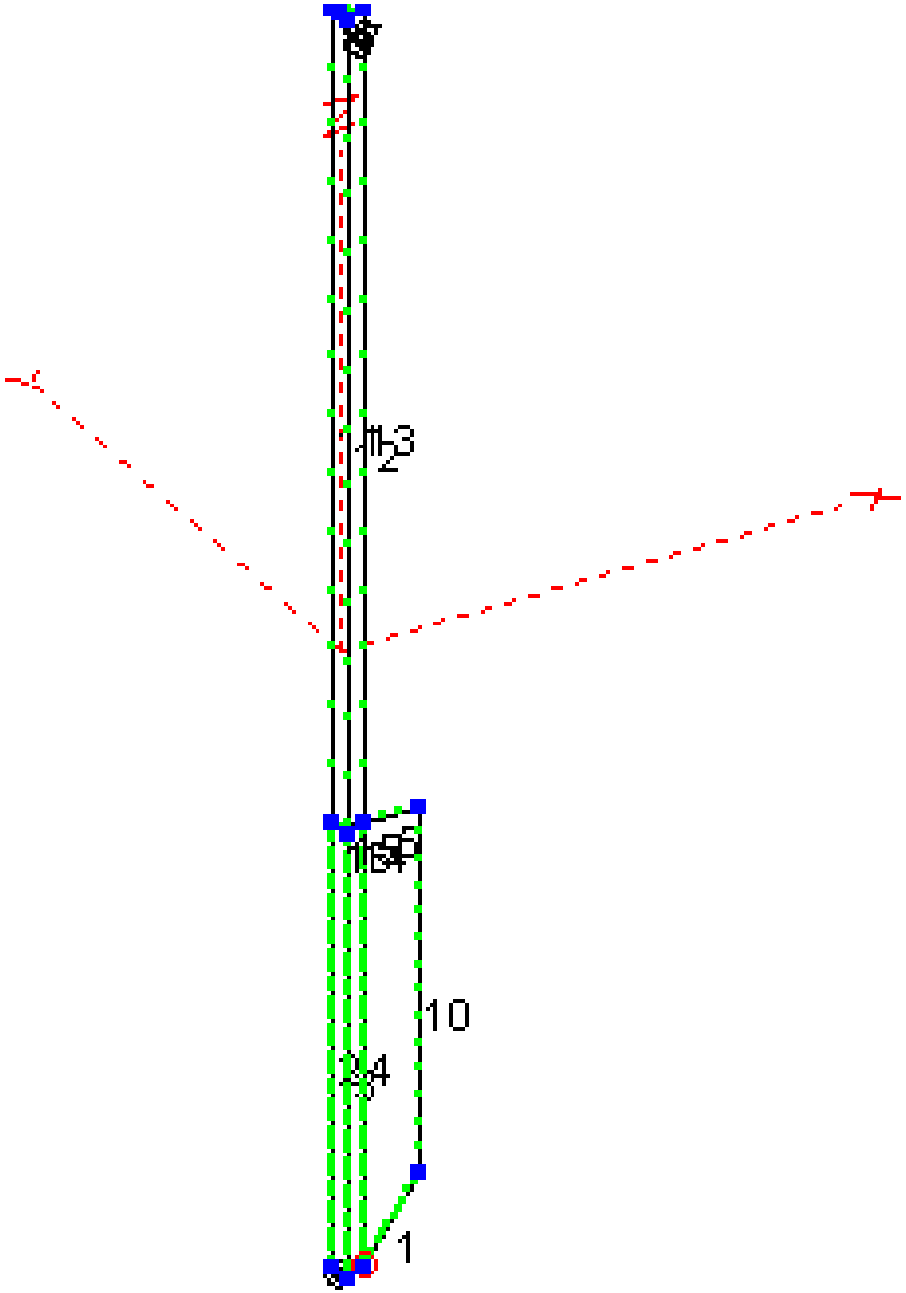
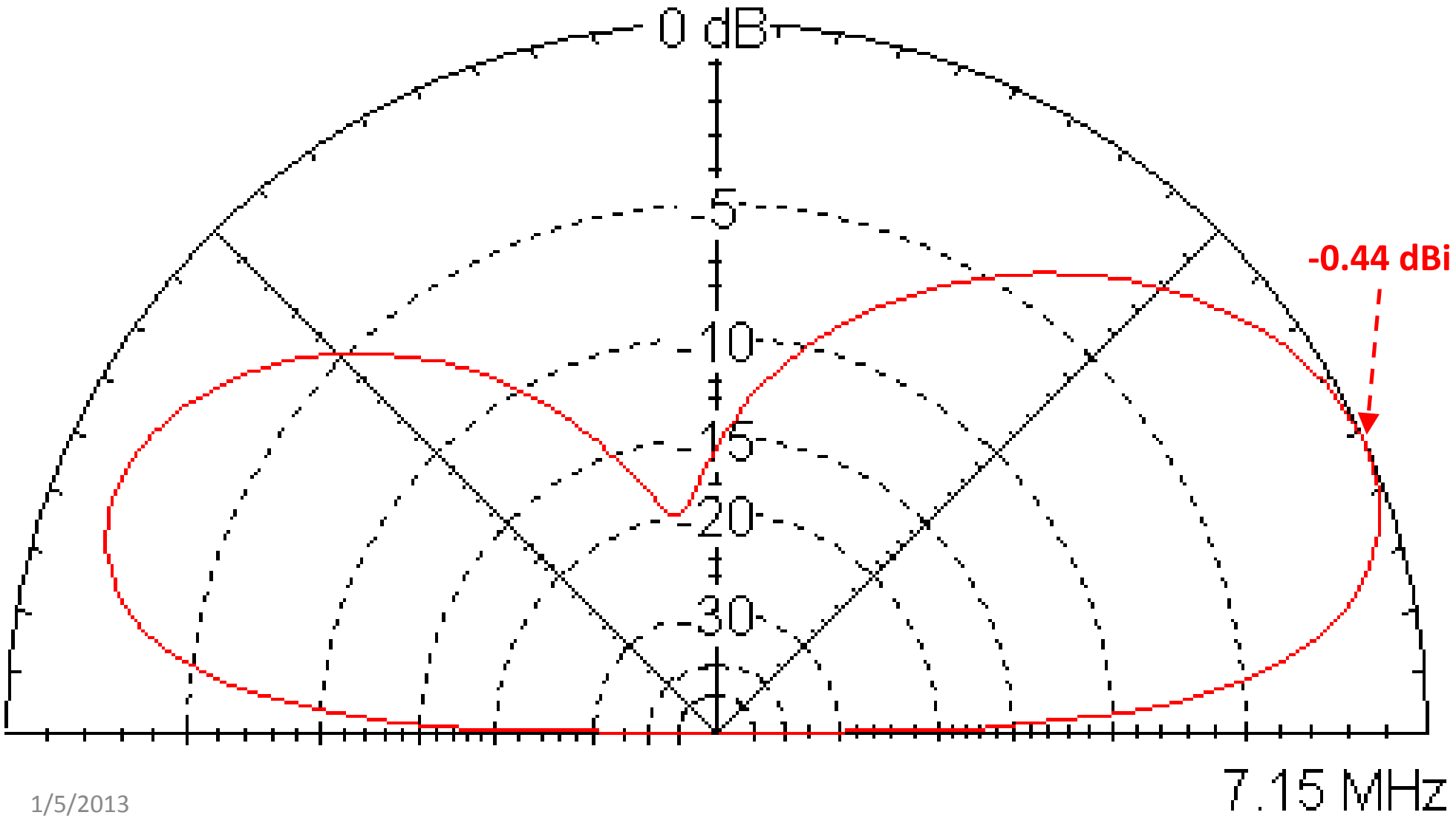


Example 1: 48’ Shunt Fed Tower as 40M Vertical

Tower pattern from EZNEC

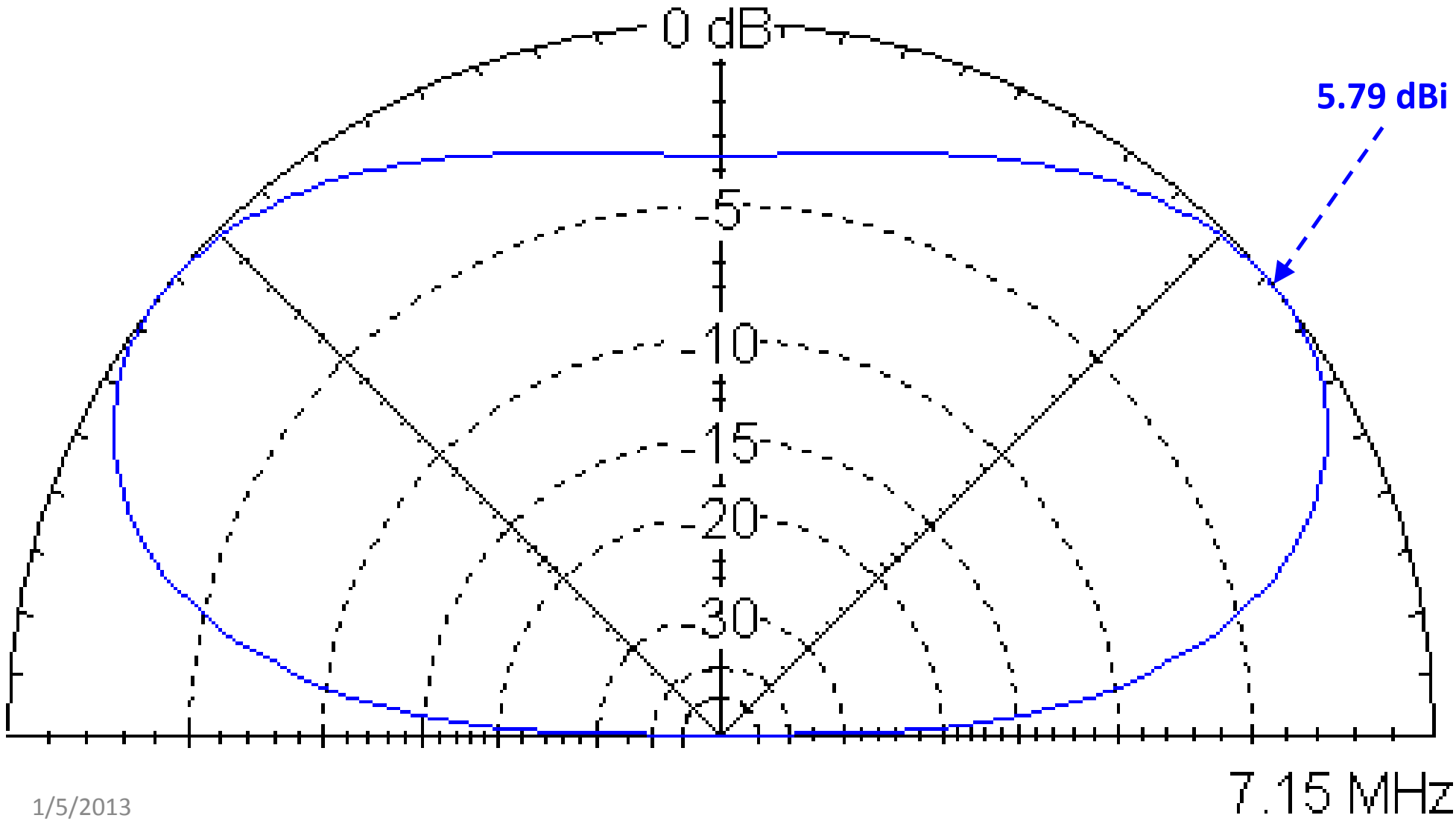
(mountain gnd)



Example 1: 48’ Shunt Fed Tower as 40M Vertical

Dipole pattern from EZNEC

(45 ft above mountain gnd)



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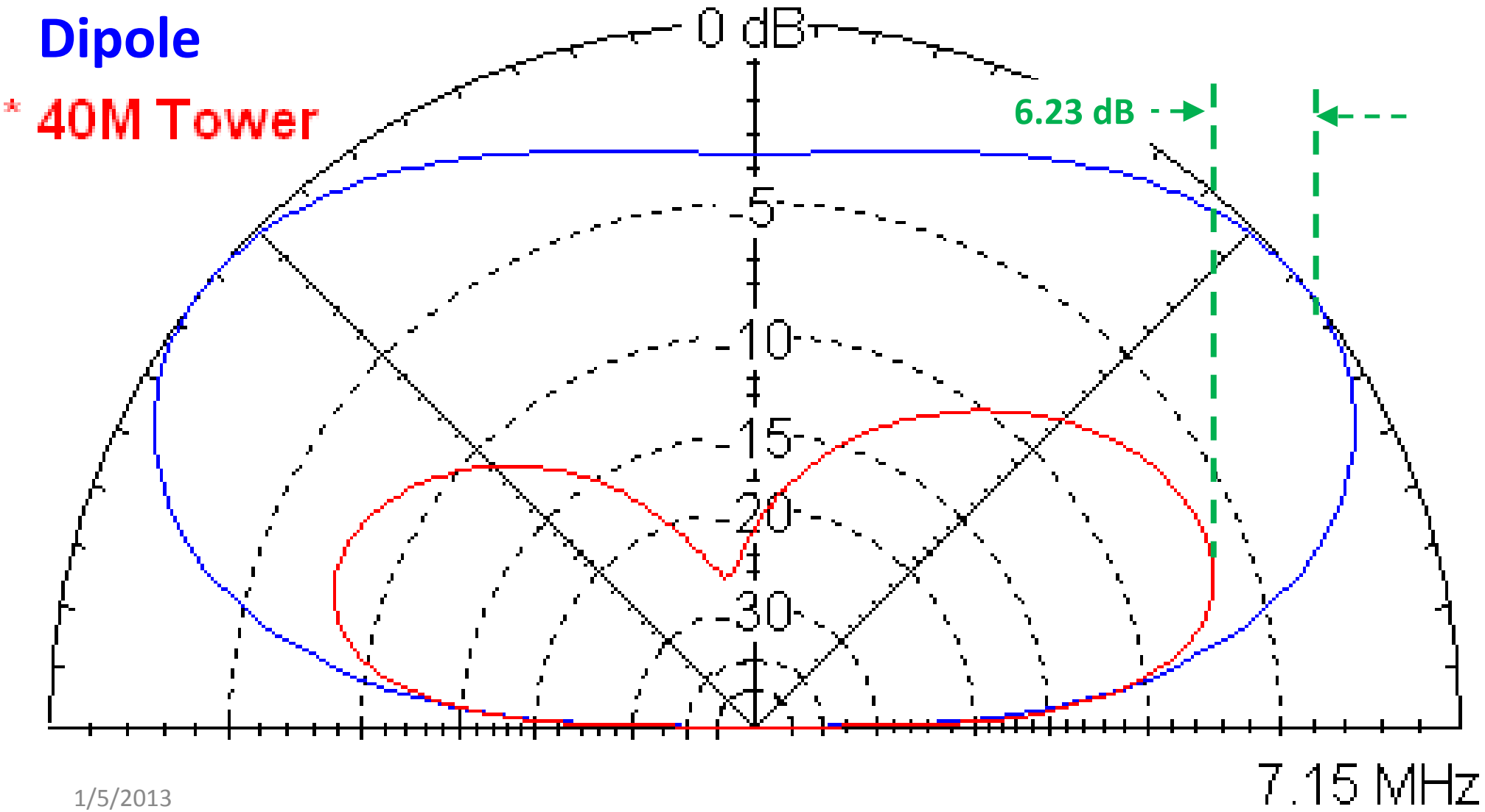
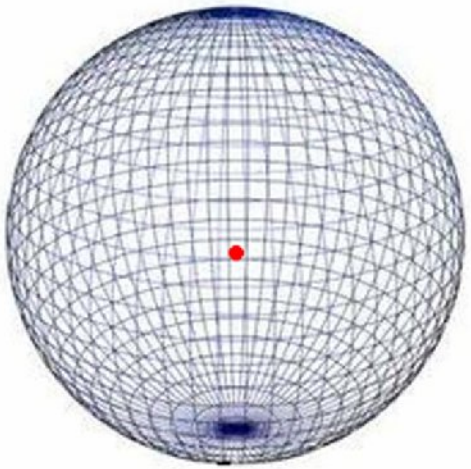
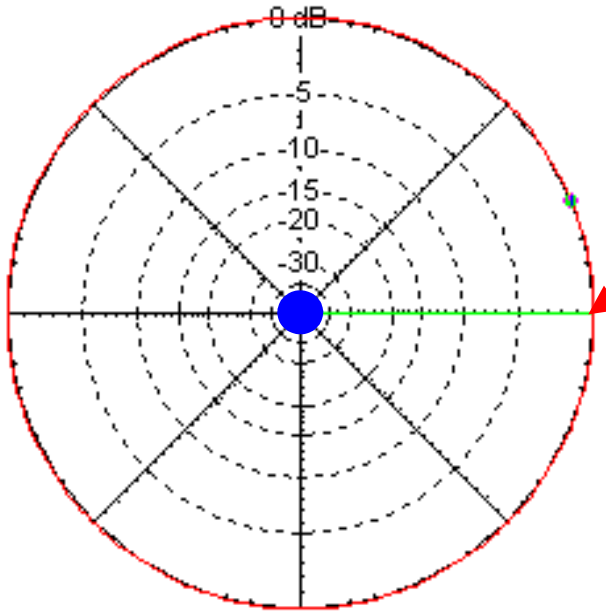


Isotropic Radiator in *Free Space*

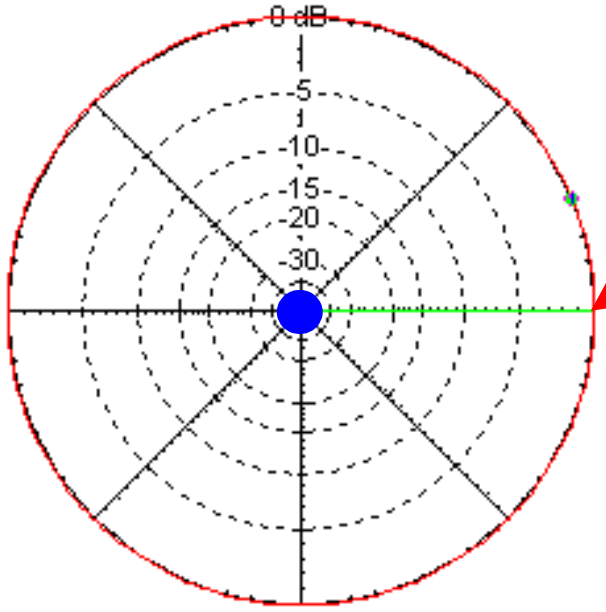


ELEVATION



0 dBi

AZIMUTH



0 dBi

Note: Elevation & Azimuth have no meaning in *Free Space*

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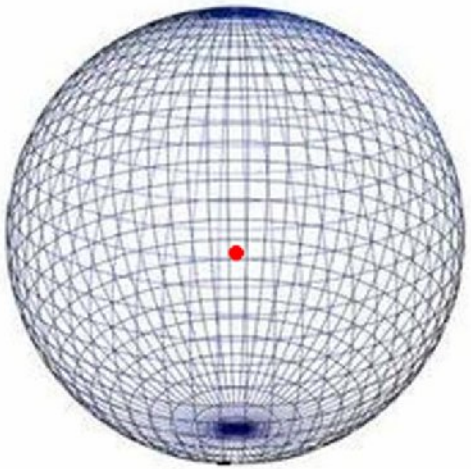

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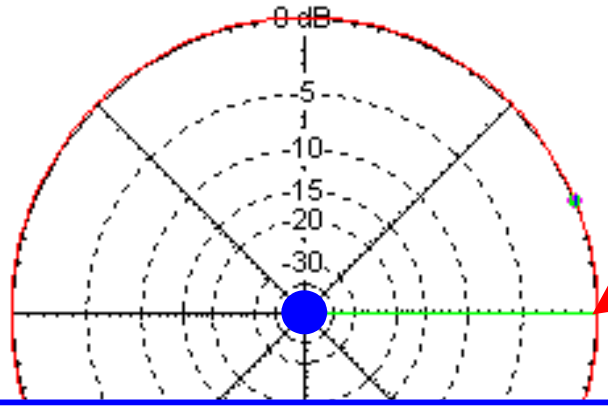
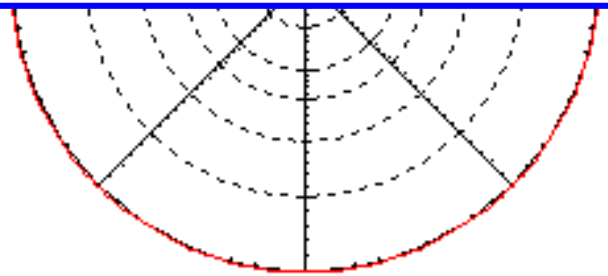
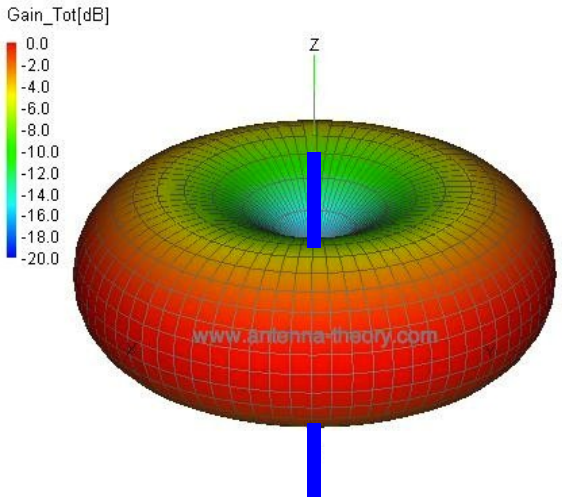


Isotropic Radiators:

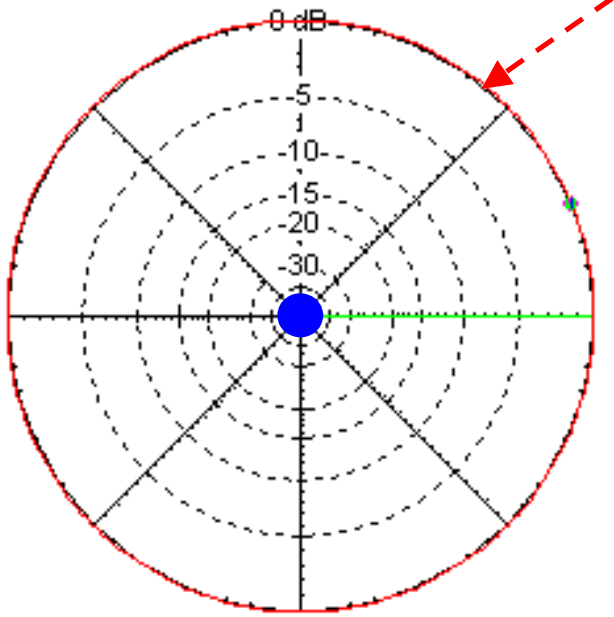
- Only exist in theory
  - "Hertzian Dipole" => 1.76 dBi
- Radiate 0 dBi in all directions
- Assumes ***matched linear polarization***
- Are always in ***free space***



Dipole in *Free Space*



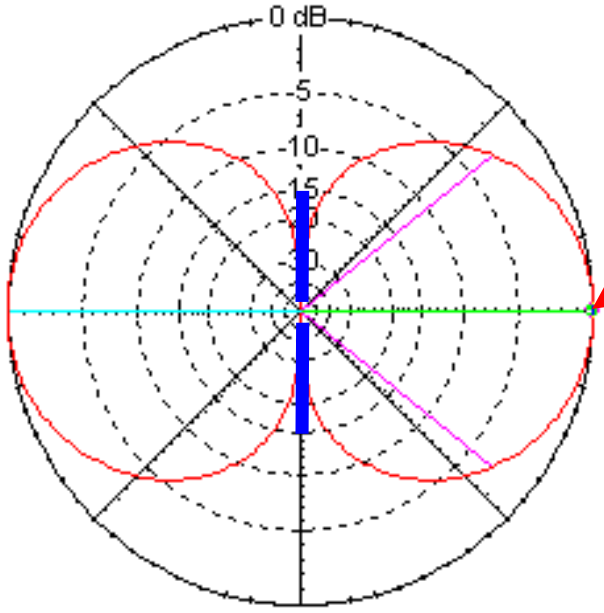
ELEVATION



2.15 dBi for Az = 0°

F_o:	14.15 MHz
Gain:	2.15 dBi
EL Angle:	n/a°
EL BW:	n/a°
AZ BW:	78.2°
R:	72.1 Ω
SWR:	1.44
Length (#12):	33.719 ft

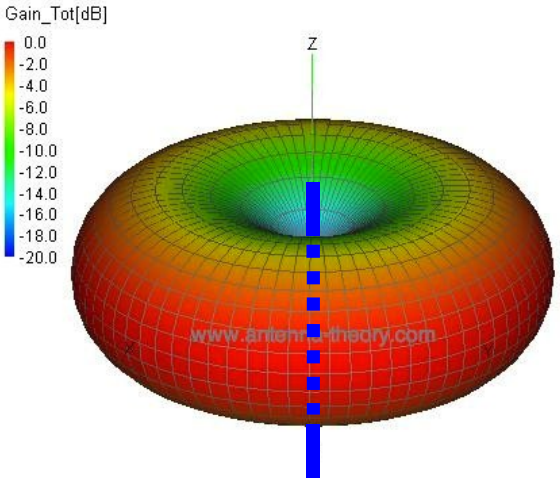
AZIMUTH



2.15 dBi

Note: Elevation & Azimuth have no meaning in *Free Space*

Dipole in *Free Space*



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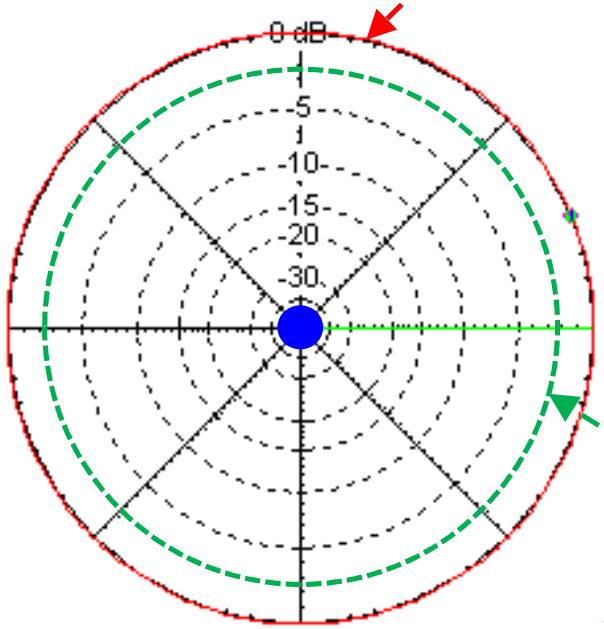

0 dBd = 2.15 dBi for Az = 0°

Isotropic (0 dBi)

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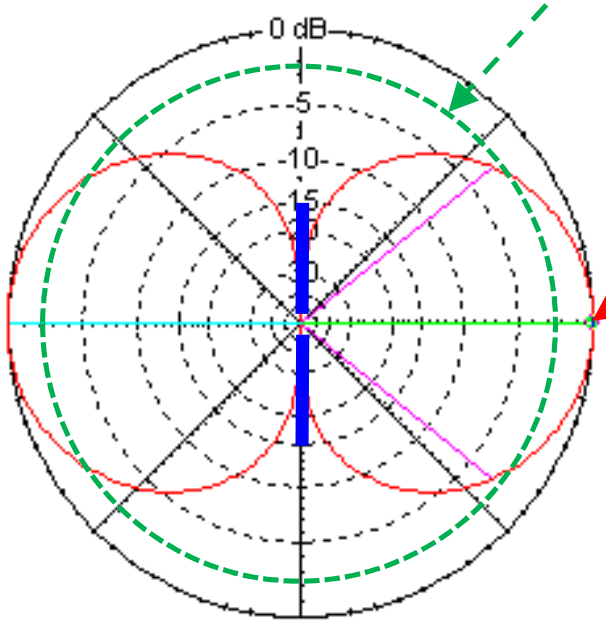

0 dBd

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Horizontal Dipole Above Infinite Loss Ground

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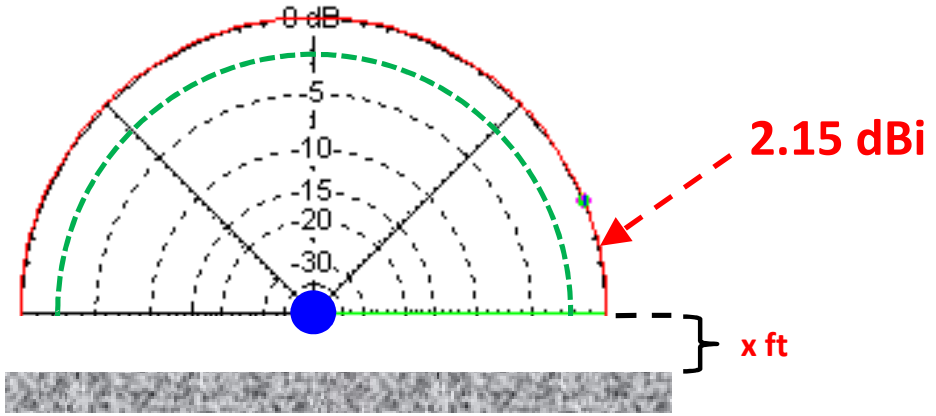
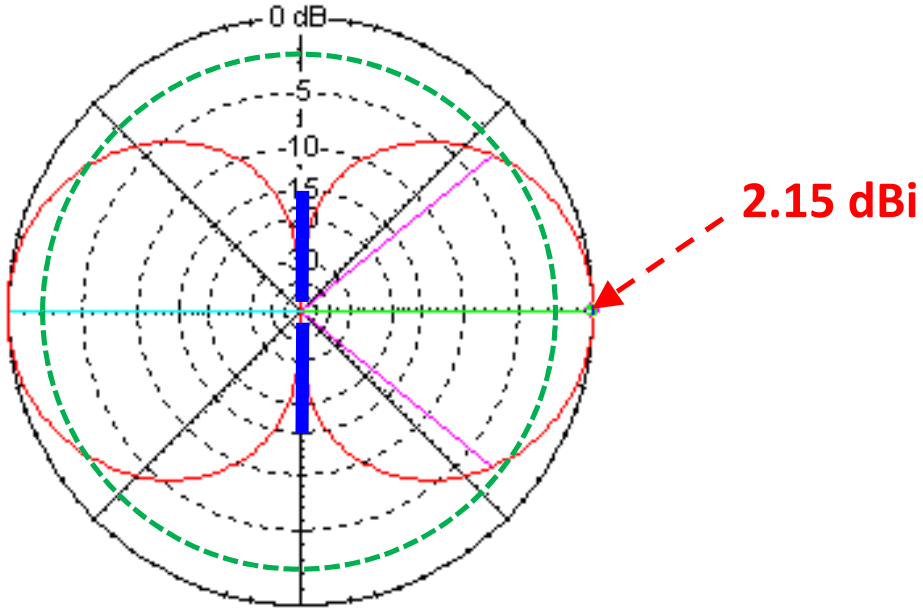
ELEVATION



AZIMUTH



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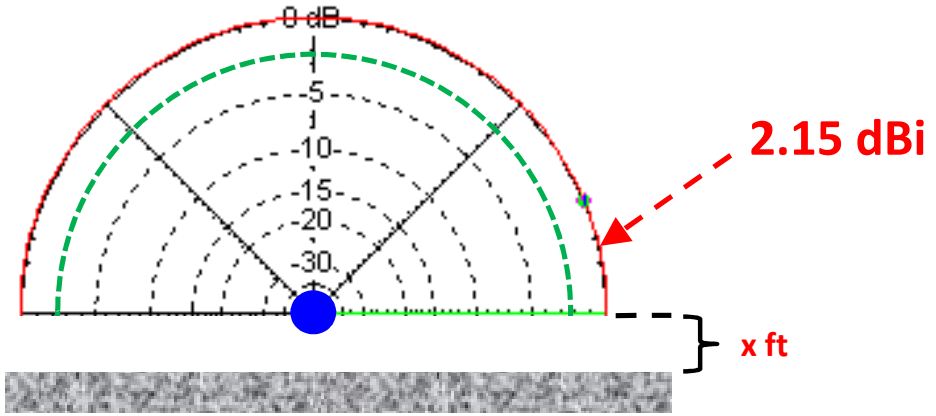

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El	
Az	
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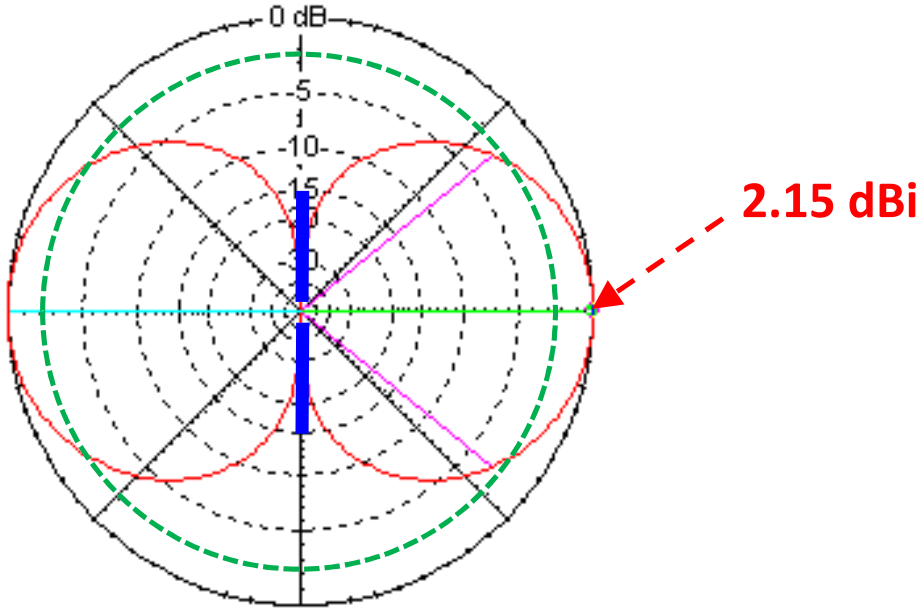
Ground reflection gain = 0 dB



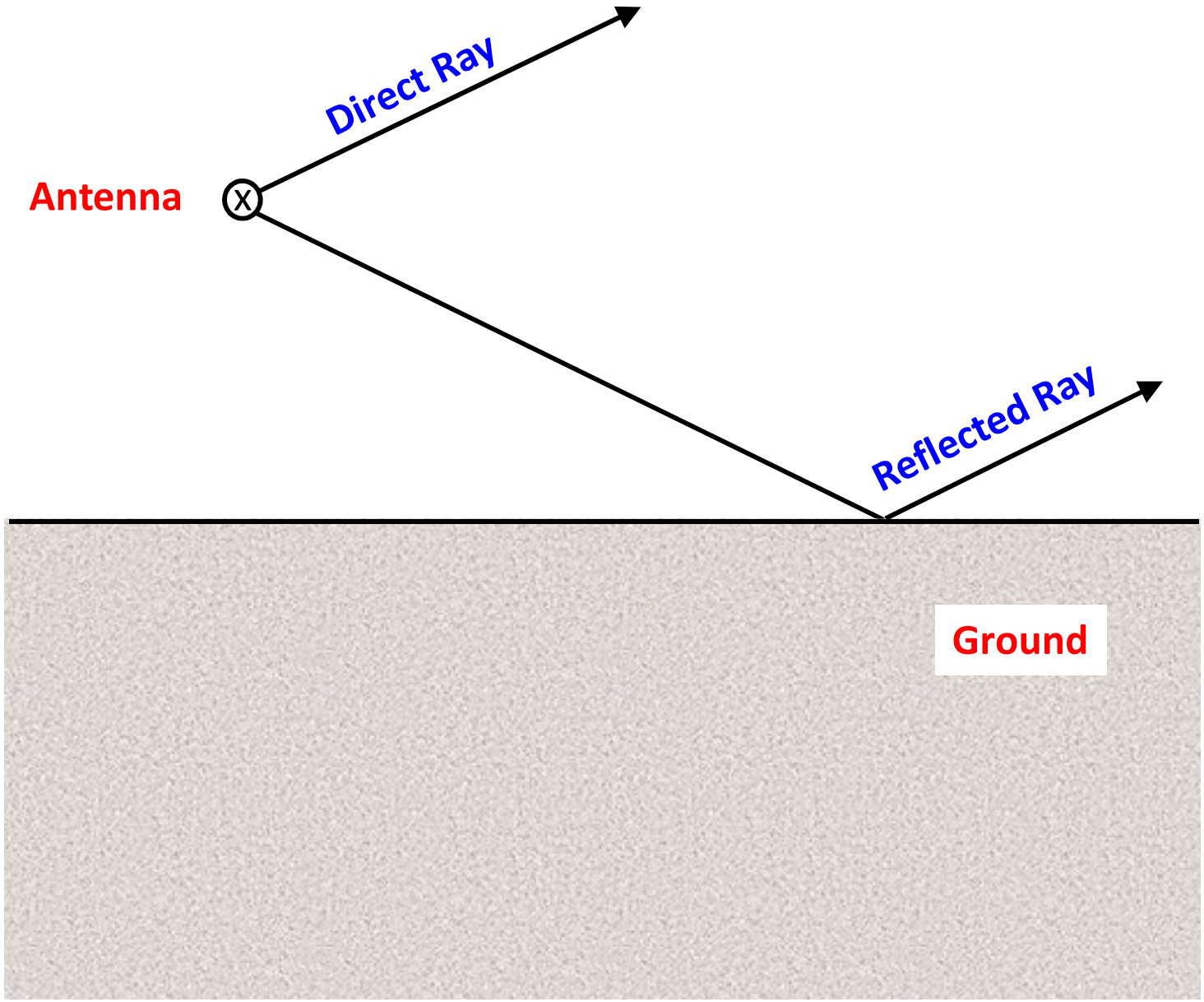
AZIMUTH

Note: Elevation & Azimuth have no meaning in *Free Space*

Real Antennas

- **Any real antenna is always above a *Real Ground*:**
  - Pattern, Gain and Impedance vary with:
    - Height above ground
    - Type of ground
    - Polarization
    - Construction:
      - Size of elements
      - Material used for elements
      - Mounting hardware and technique
      - Insulators

Reflections From Real Ground (Ray Tracing)



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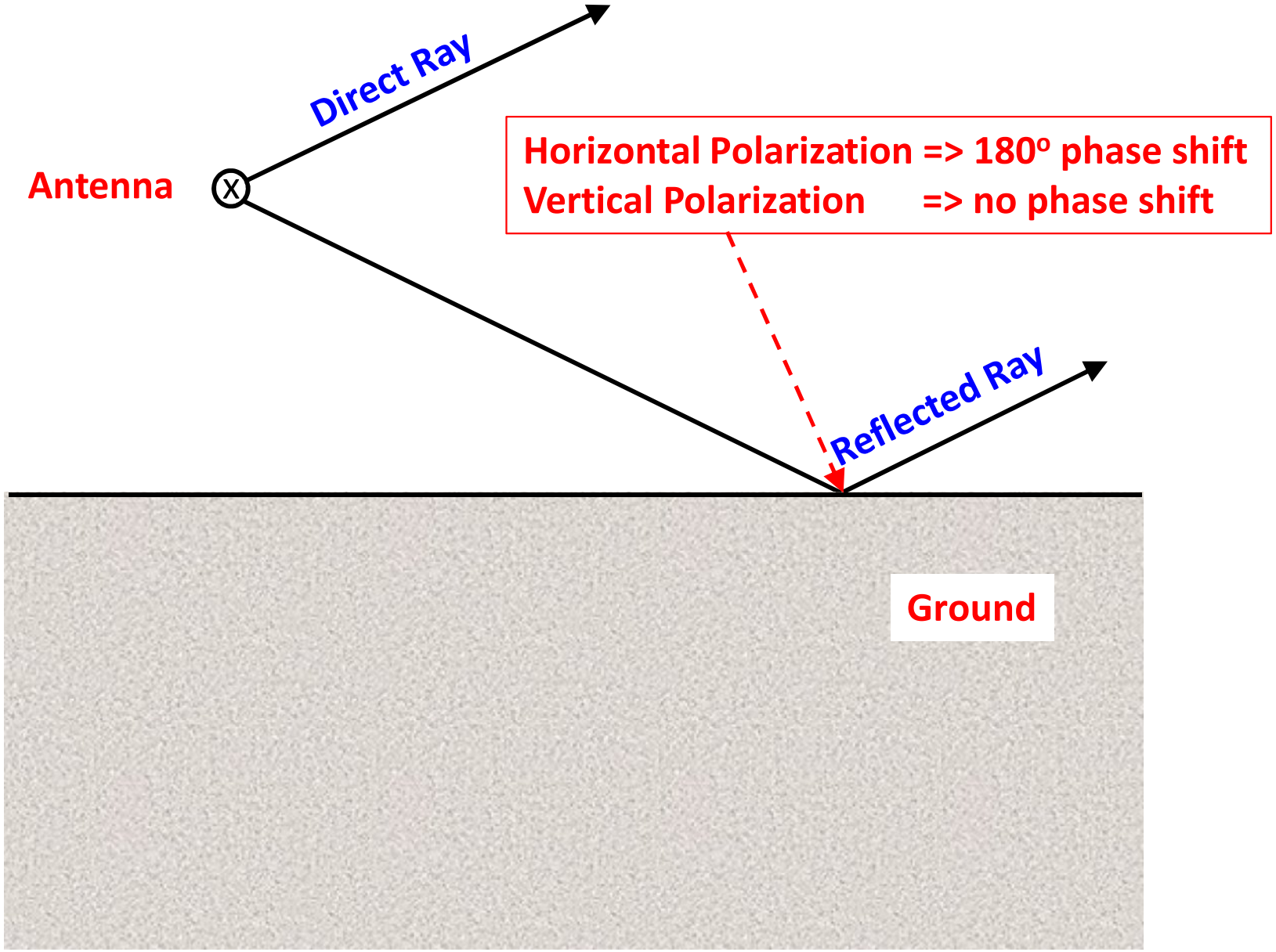

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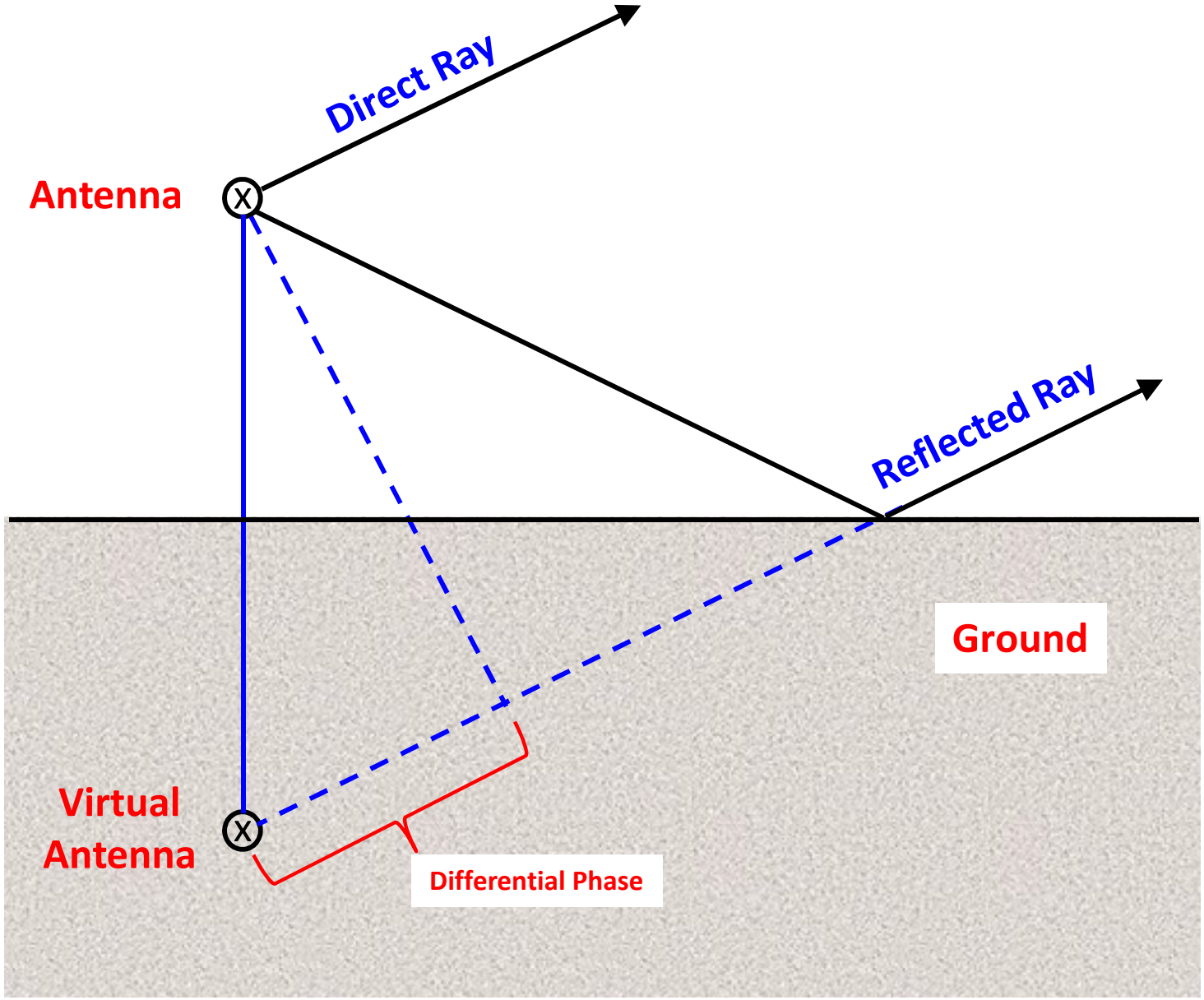

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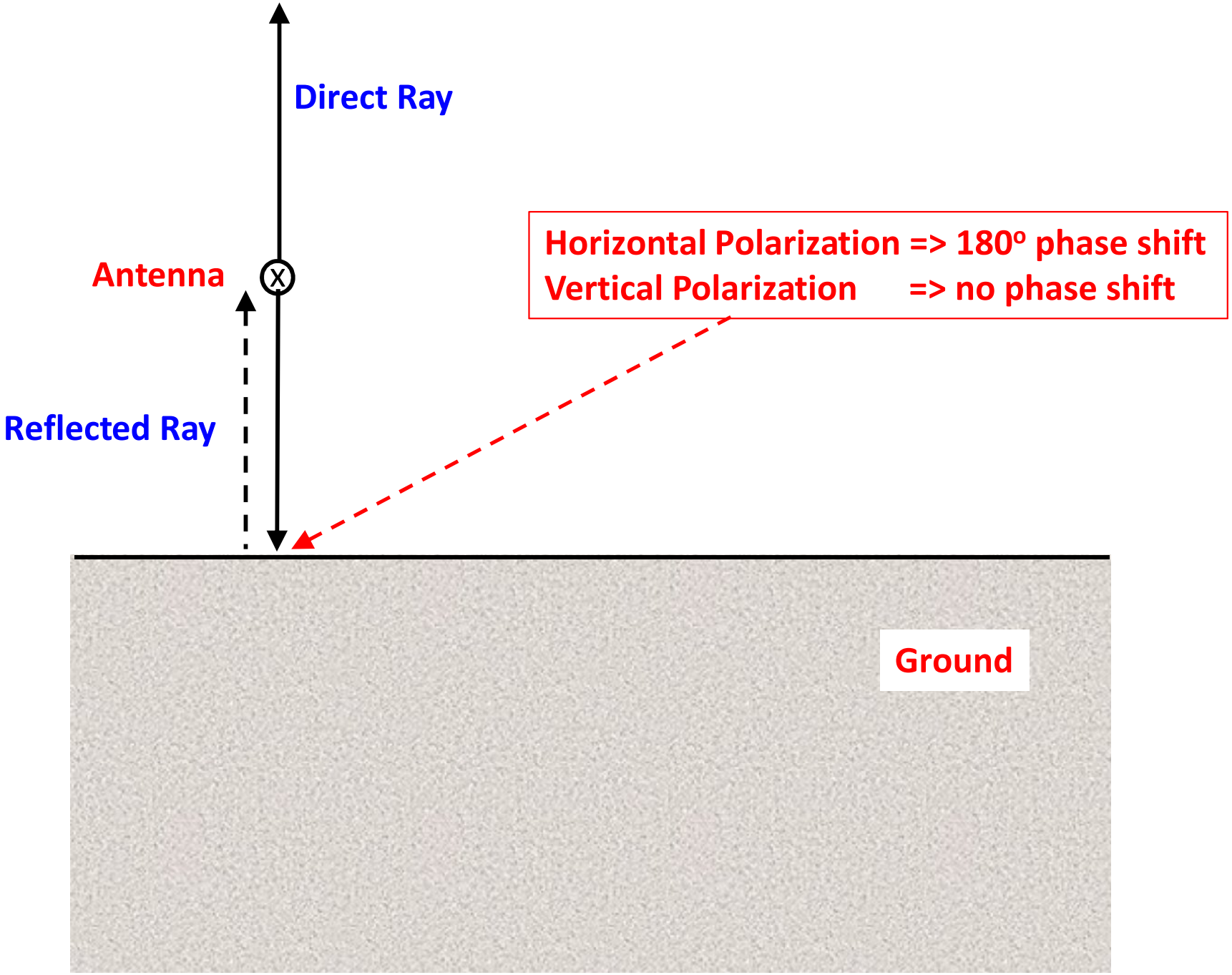
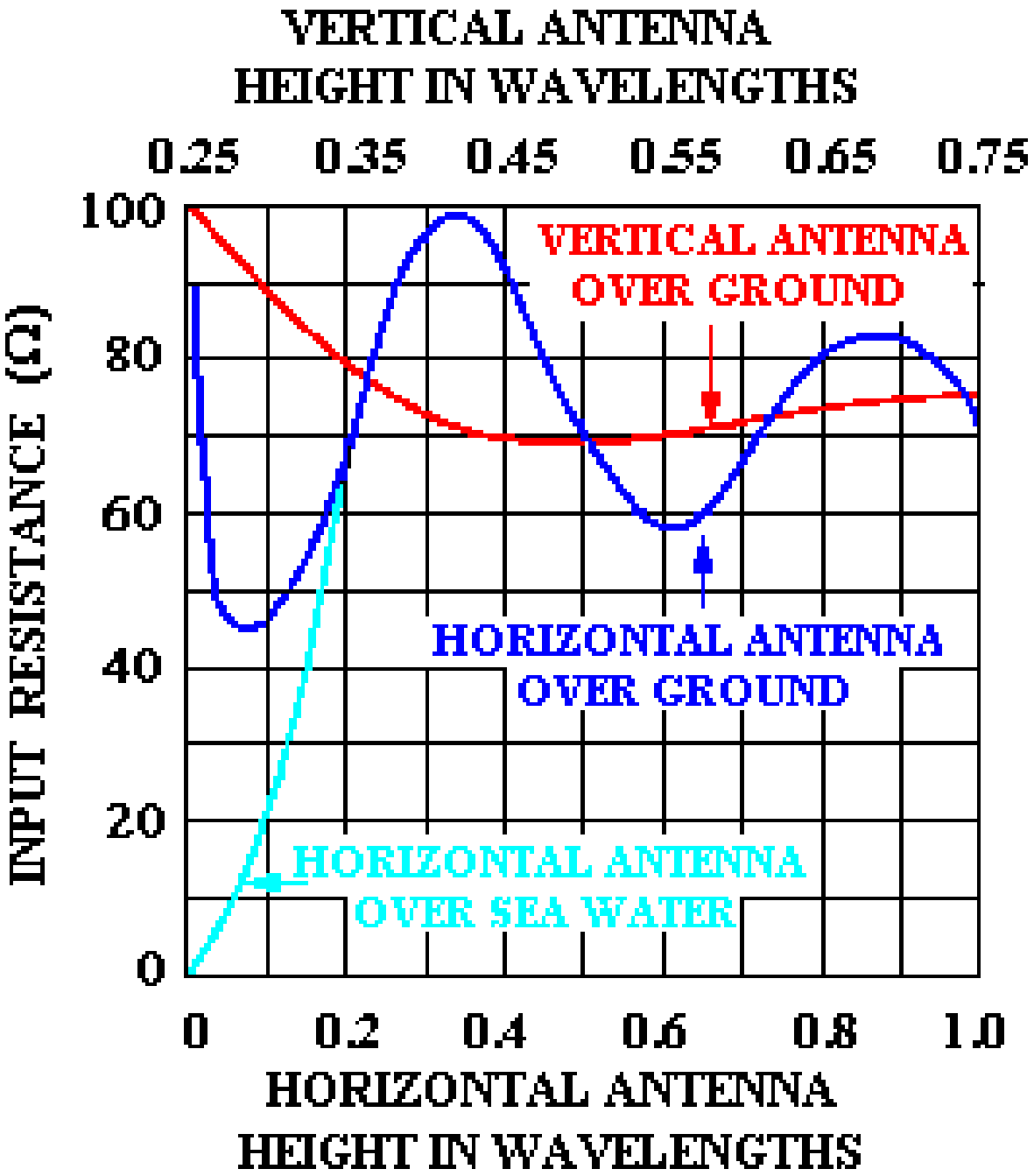


Reflections From Real Ground (Impedance)



Ground Reflection Gain

Horizontal Polarization:

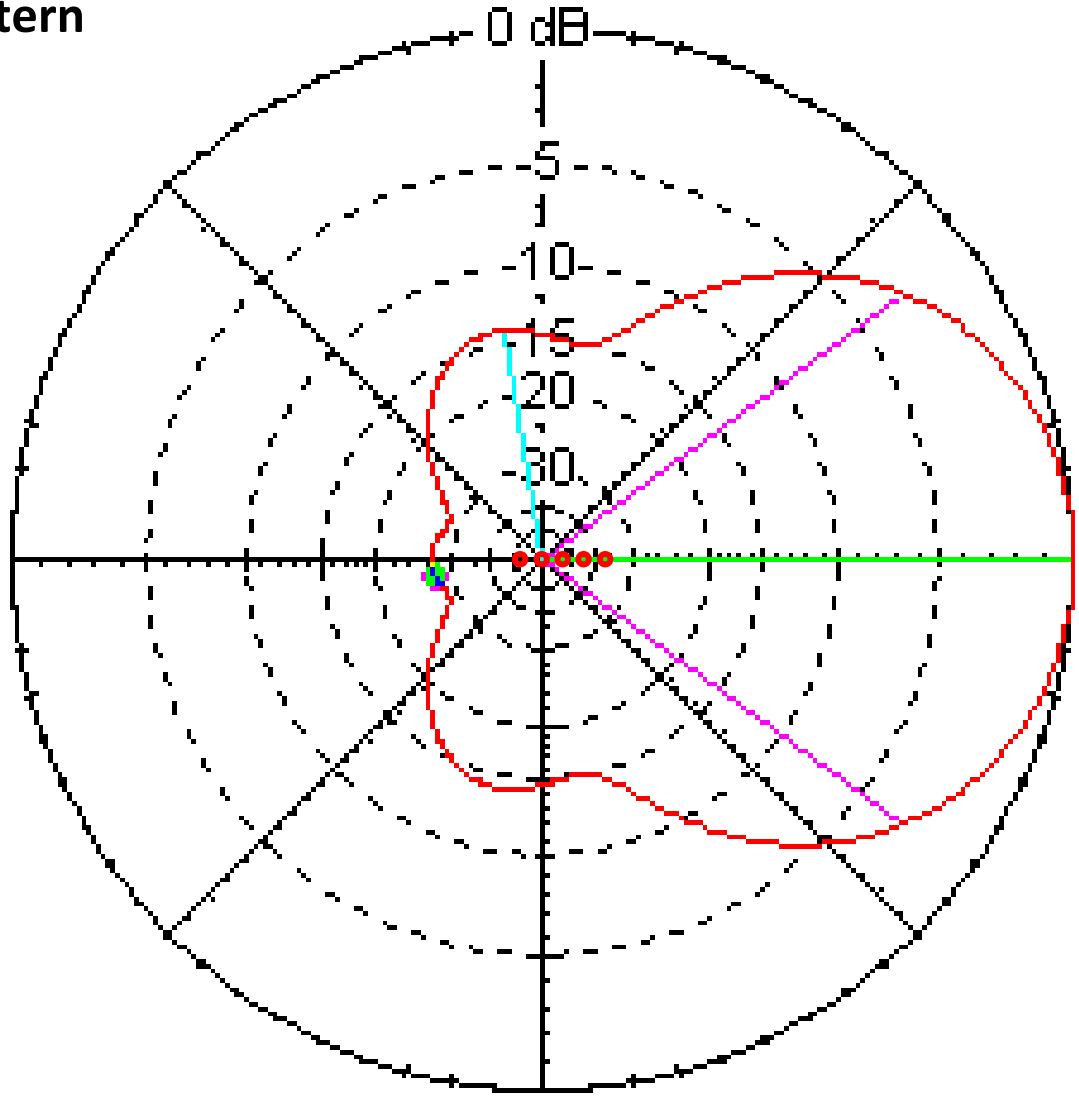
- **Peak gain can be 4.5 – 7.0 dB higher than Free Space gain depending on:**
  - **Ground type**
  - **Height above ground**
  - **Elevation angle**
  - **Azimuth angle**
- **Vertical Polarization: <3dB over real ground**

When comparing different antennas:

- Do not compare a Free Space pattern to a pattern over ground
- Use identical ground conditions
- Use identical polarizations
- Be careful when using dBd

Example 2: 20M 5 Element Wide Spaced Yagi

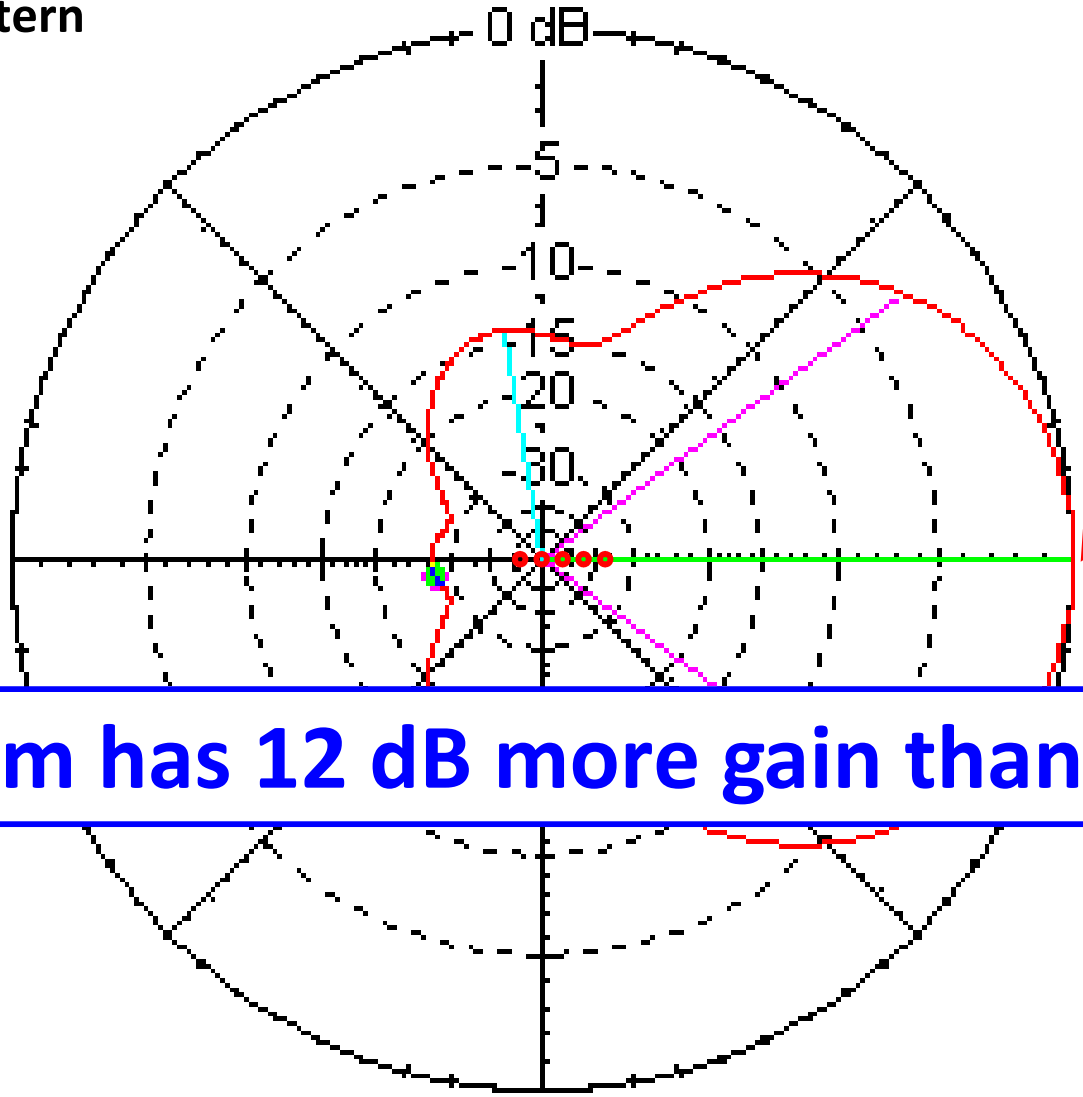
Free Space Pattern



9.84 dBi

Example 2: 20M 5 Element Wide Spaced Yagi

Free Space Pattern



9.84 dBi

“Our beam has 12 dB more gain than a dipole”

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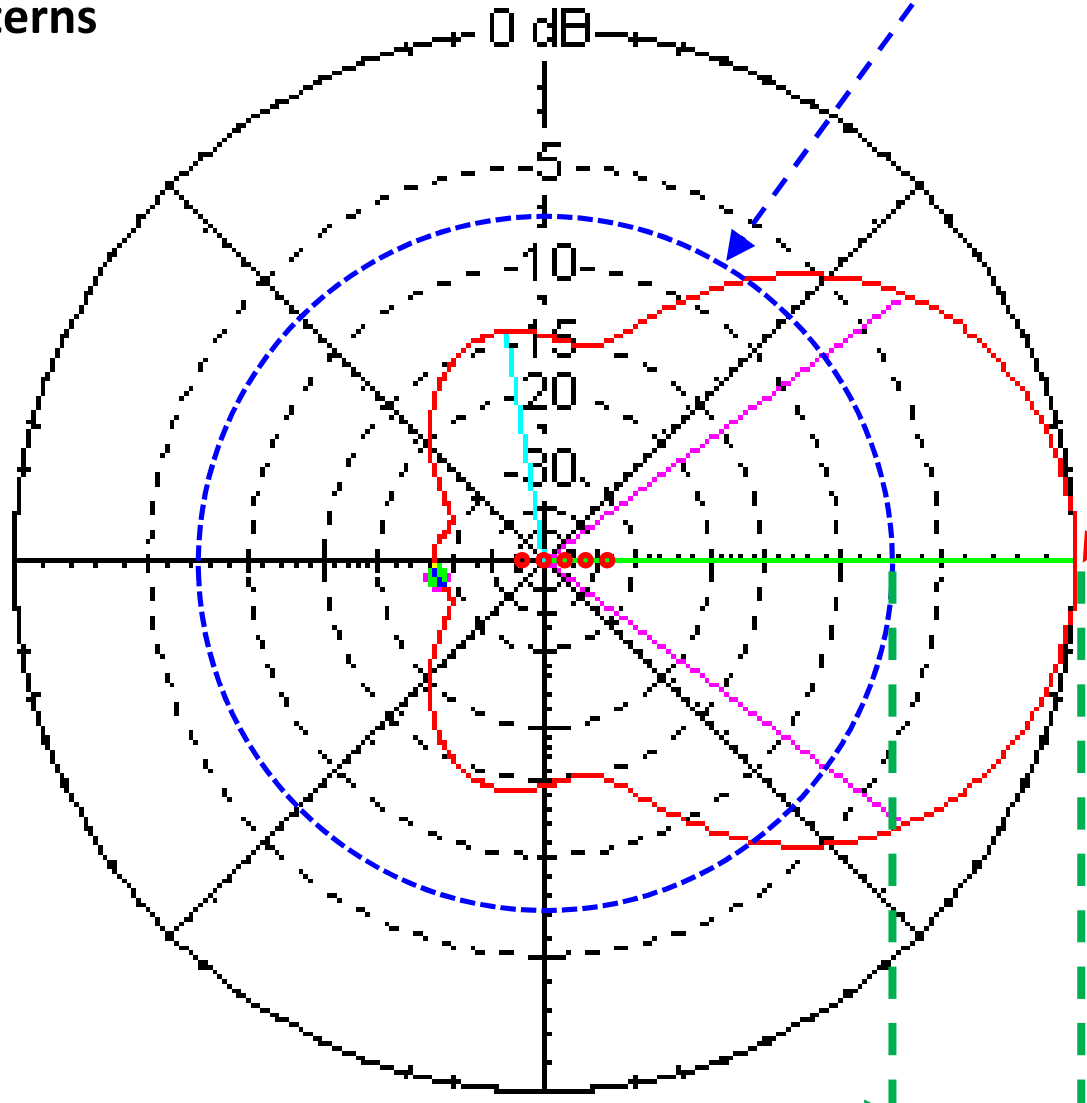
Free Space Patterns



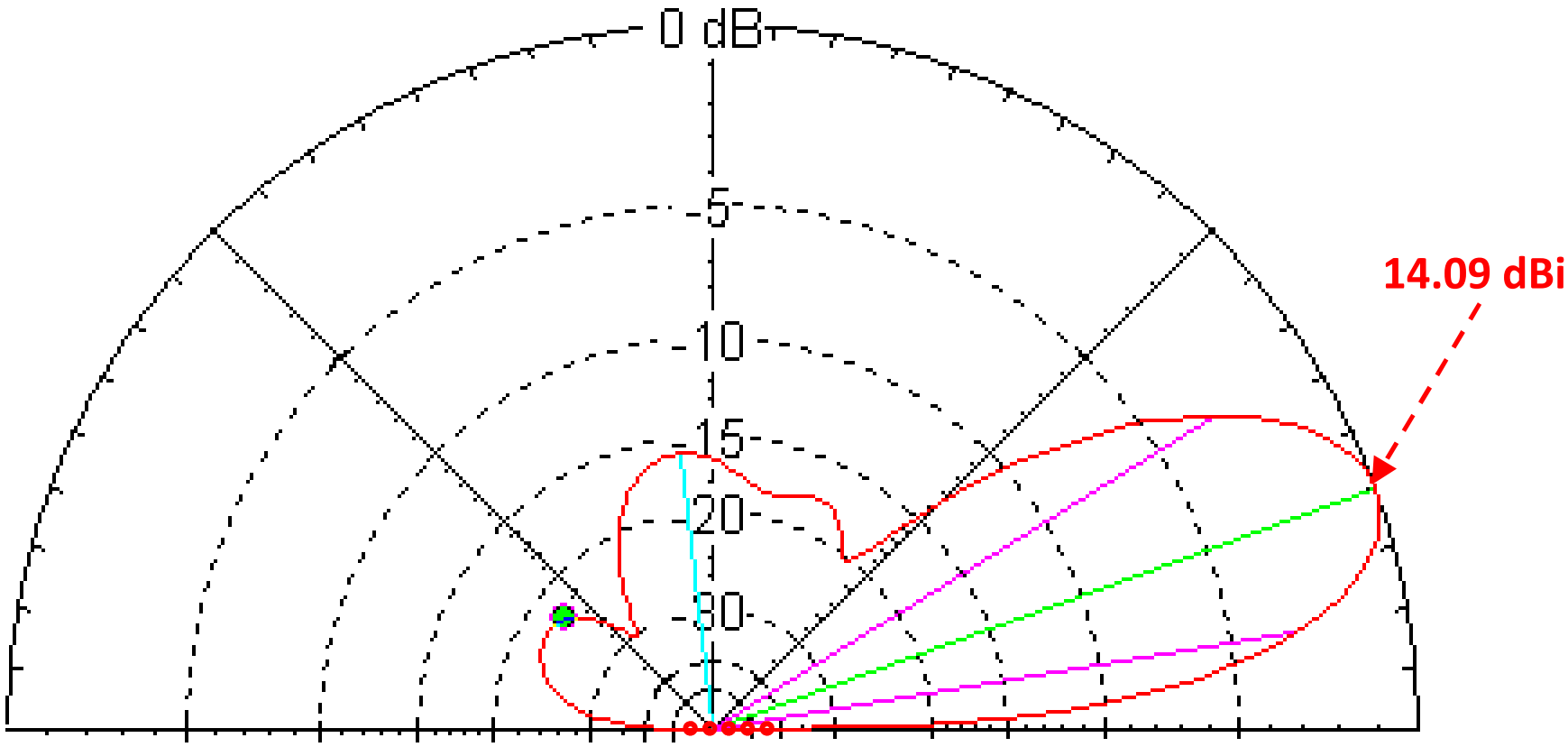
Dipole (2.15 dBi)

9.84 dBi

7.69 dB

Example 2: 20M 5 Element Wide Spaced Yagi

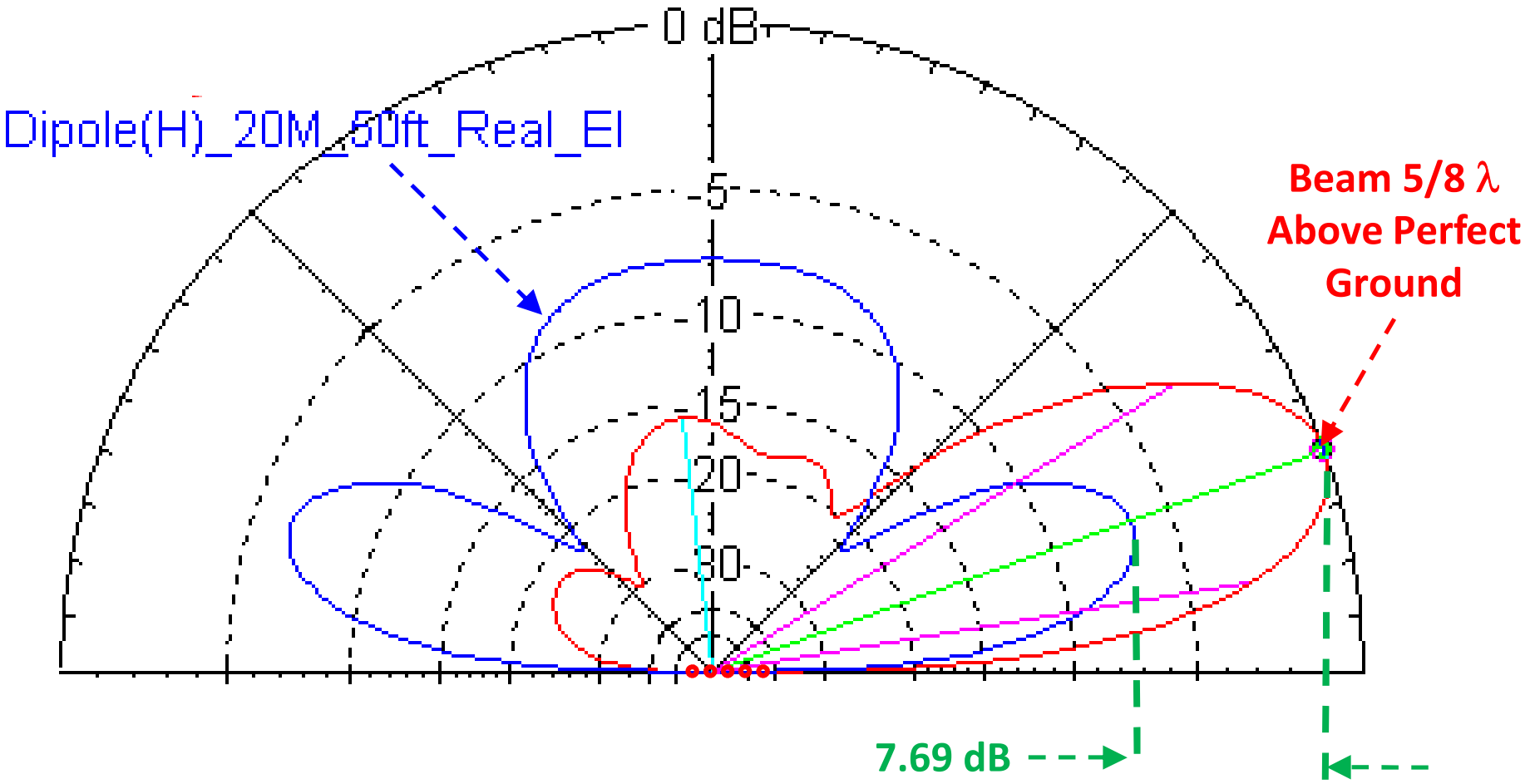
Pattern for Beam 5/8 λ Above Perfect Ground



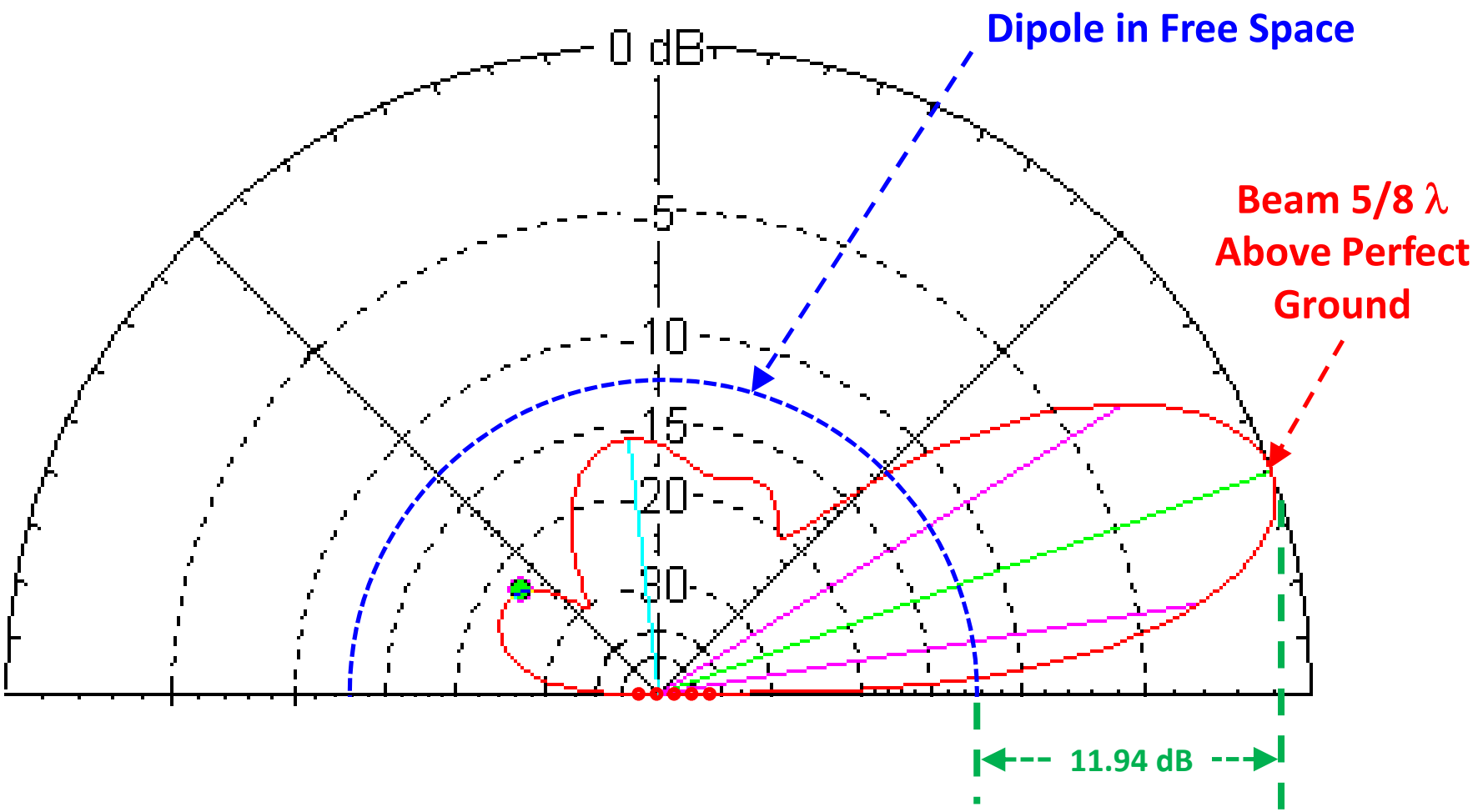
Ground reflection gain = 14.09 – 9.84 = 4.25 dB

Example 2: 20M 5 Element Wide Spaced Yagi

Both Beam & Dipole 5/8 λ Above Perfect Ground

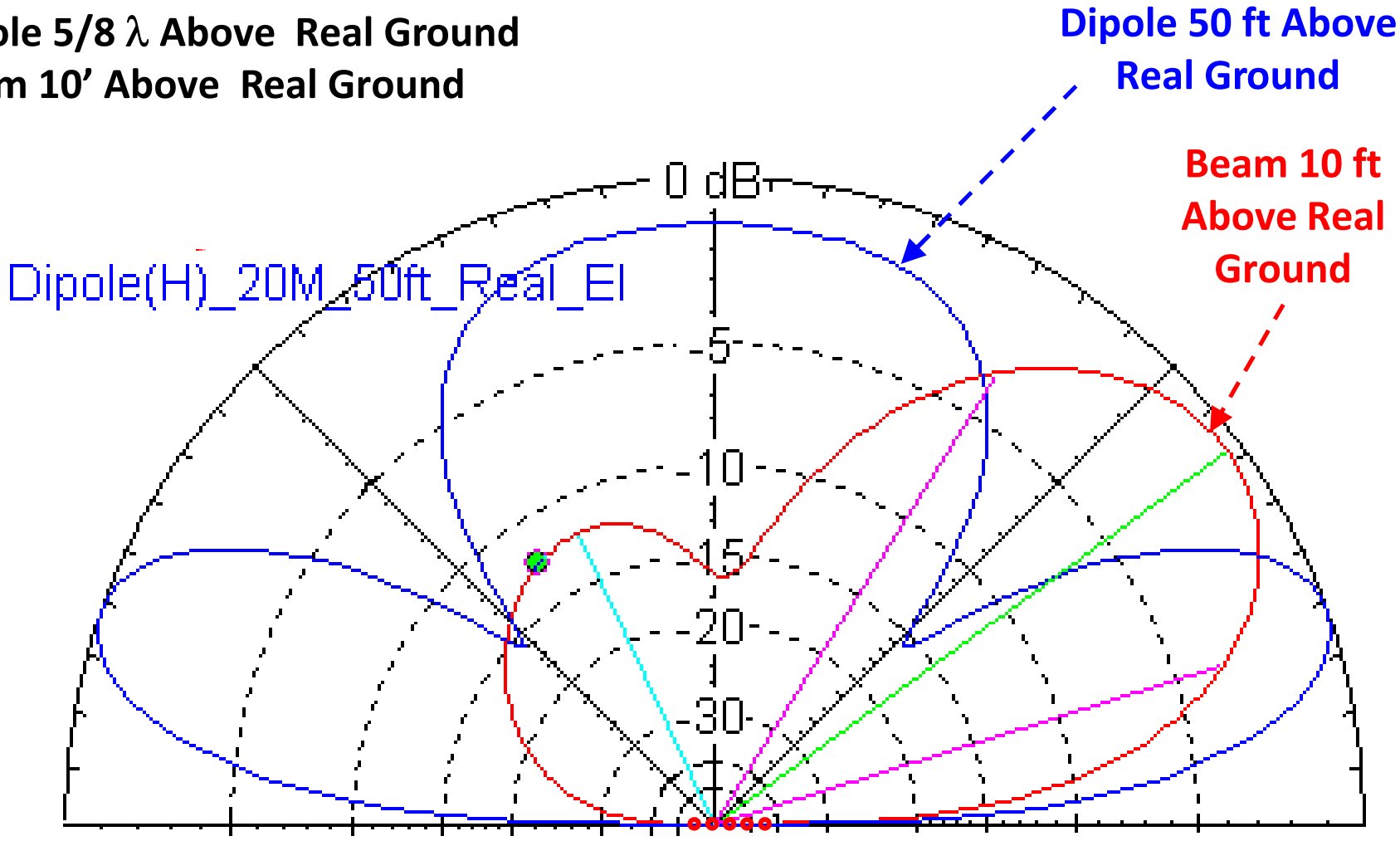


Example 2: 20M 5 Element Wide Spaced Yagi



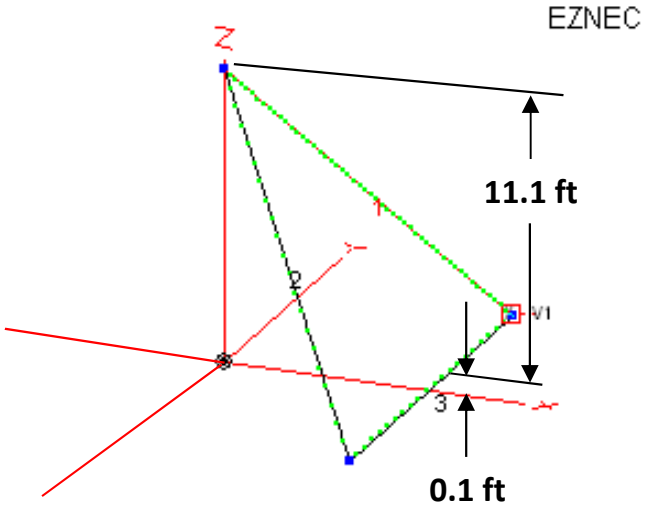
Example 2: 20M 5 Element Wide Spaced Yagi

- Dipole 5/8 λ Above Real Ground
- Beam 10’ Above Real Ground



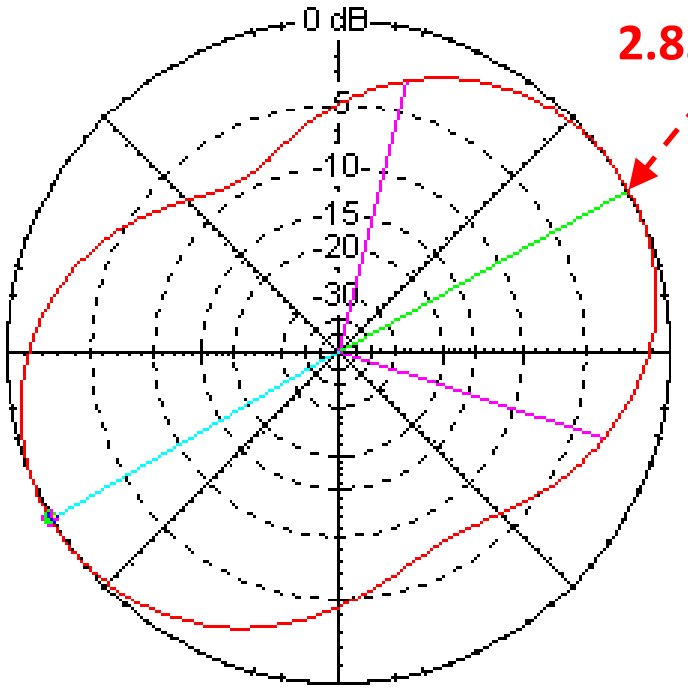
Example 3: January 2013 QST

Full wave delta loop for 15M



The gain of this antenna "...is only 0.25 dB less than if the antenna were in Free Space."

EZNEC Free Space pattern: 2.85 dBi @ 30°

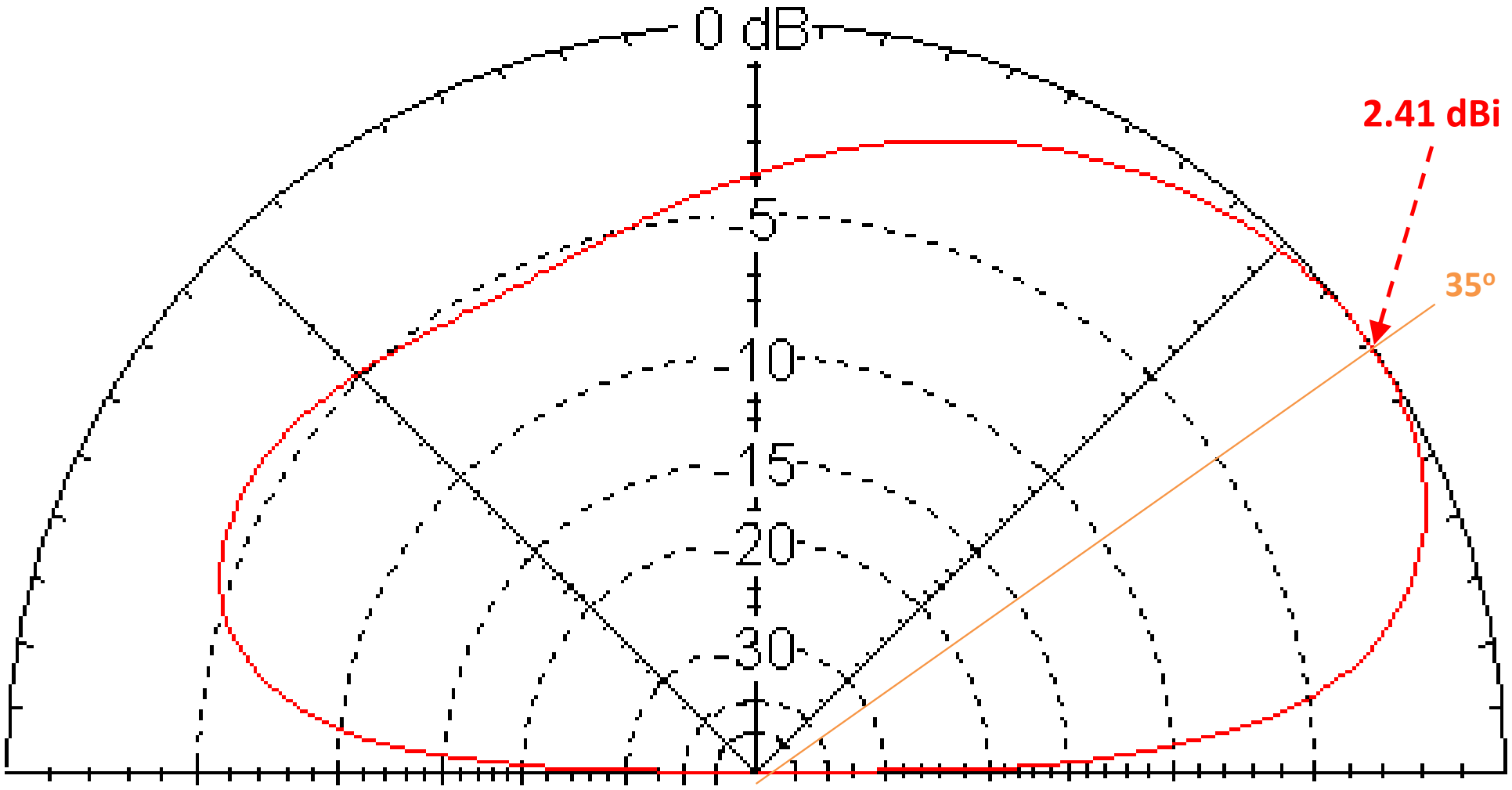


The theoretical maximum gain (free space) = +2.96 dBi = +0.81 dBd

Antennas that don't work off of ground, don't work well close to a lossy ground

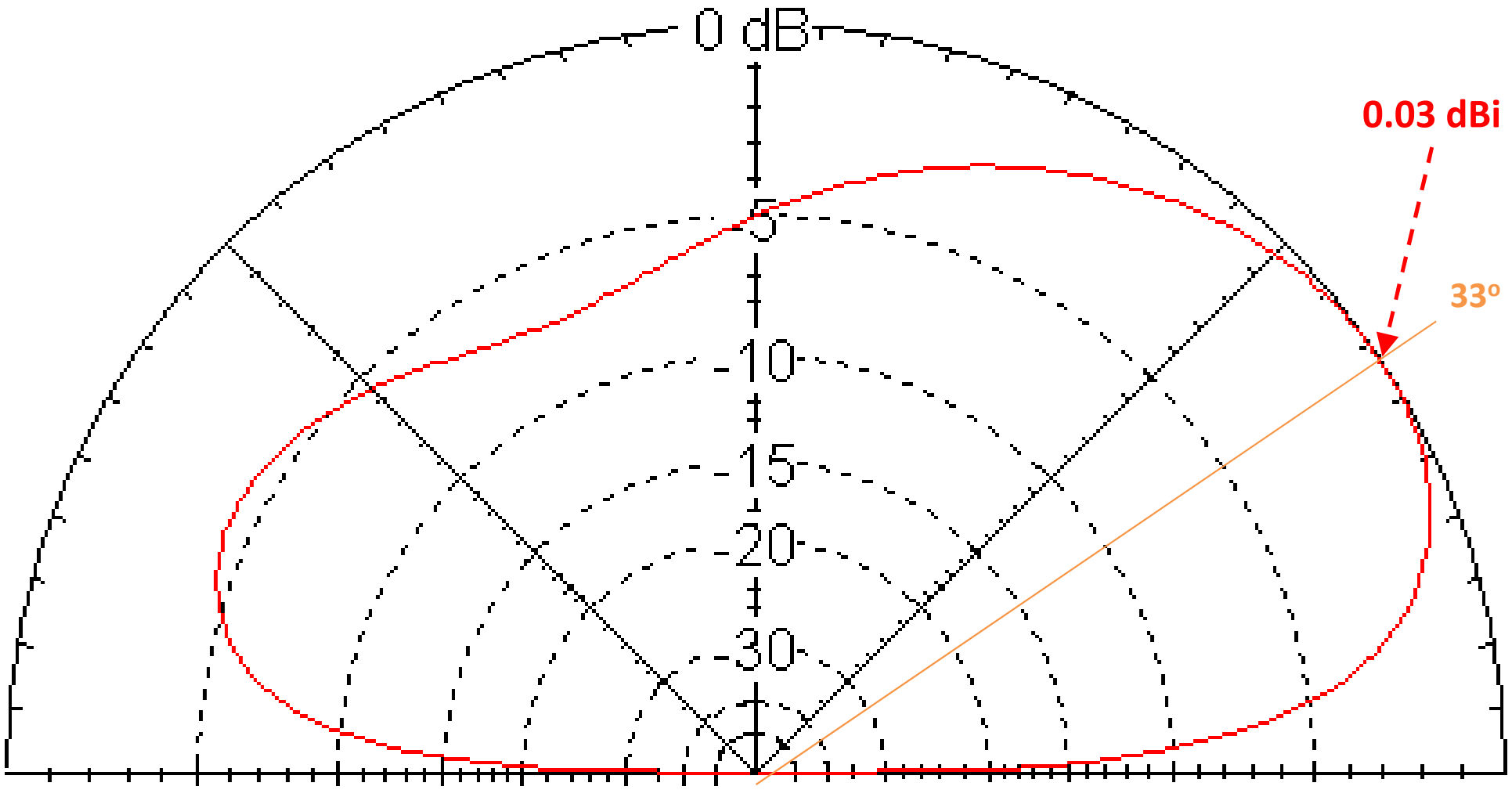
Example 3: January 2013 QST

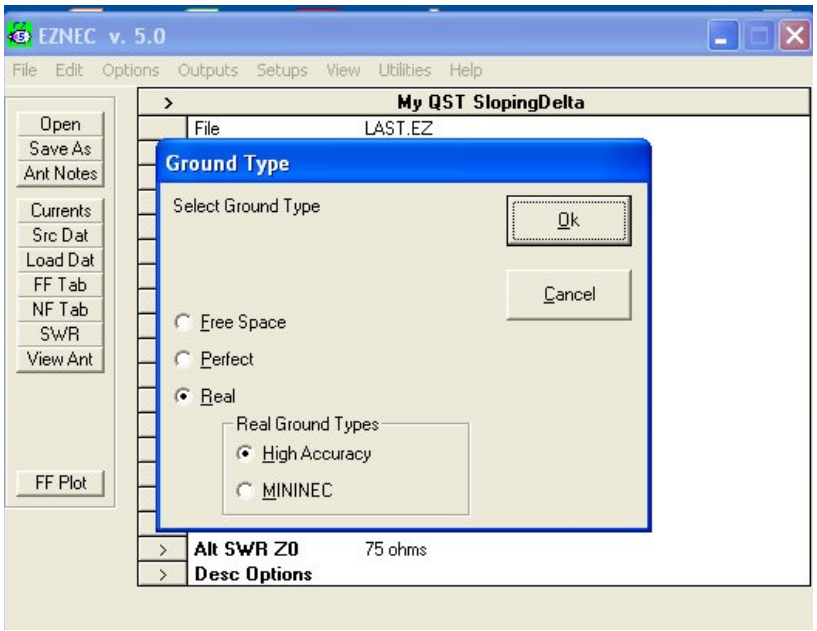
K1QW Pattern in QST article



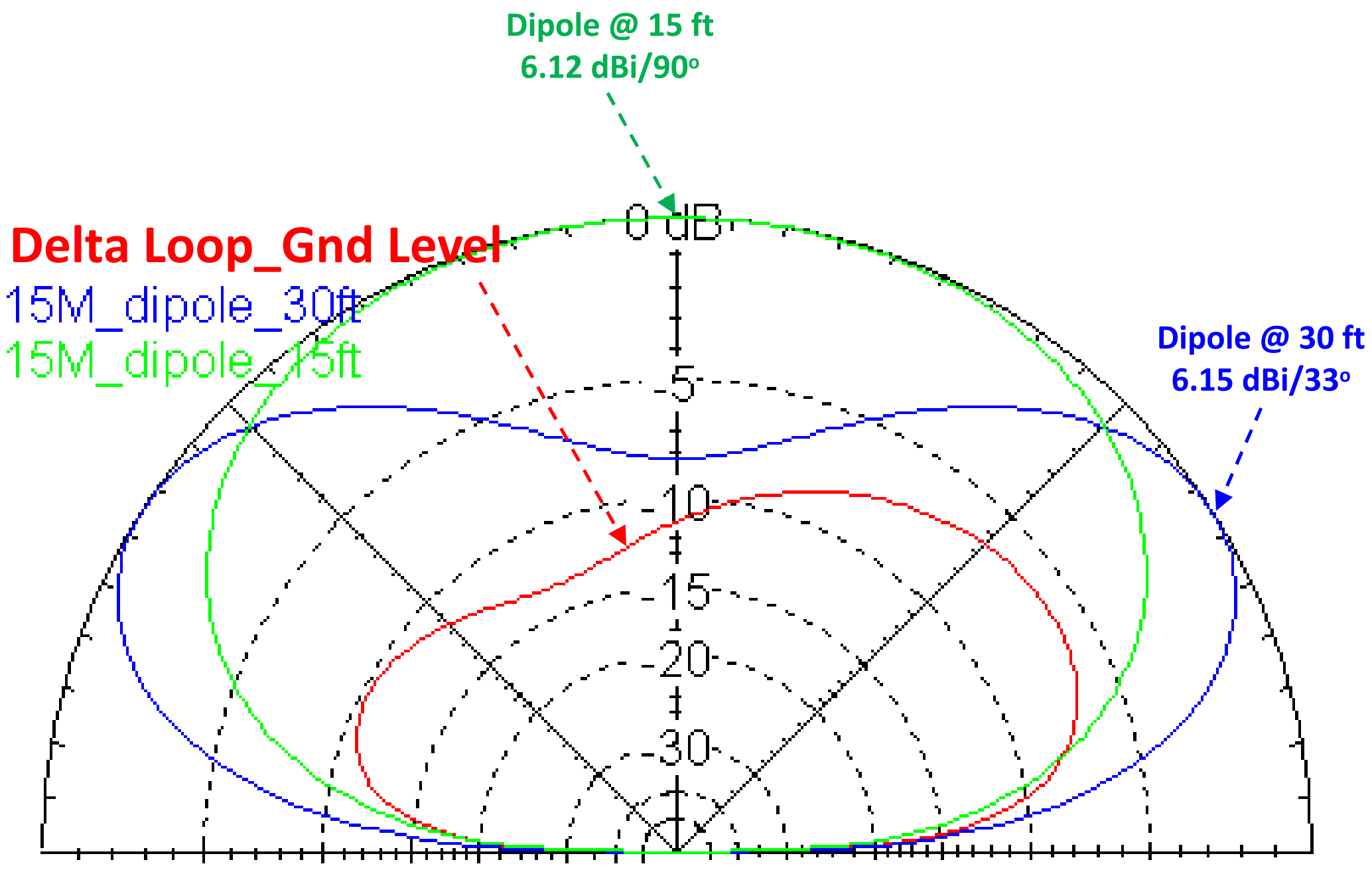
Example 3: January 2013 QST

show both patterns




EZNEC v. 5.0
File Edit Options Outputs Setups View Utilities Help
Open
Save As
Ant Notes
Currents
Src Dat
Load Dat
FF Tab
NF Tab
SWR
View Ant
FF Plot
My QST SlopingDelta
File LAST.EZ
Ground Type
Select Ground Type
Ok
Cancel
Free Space
Perfect
Real
Real Ground Types
High Accuracy
MININEC
Alt SWR Z0 75 ohms
Desc Options

Example 3: January 2013 QST



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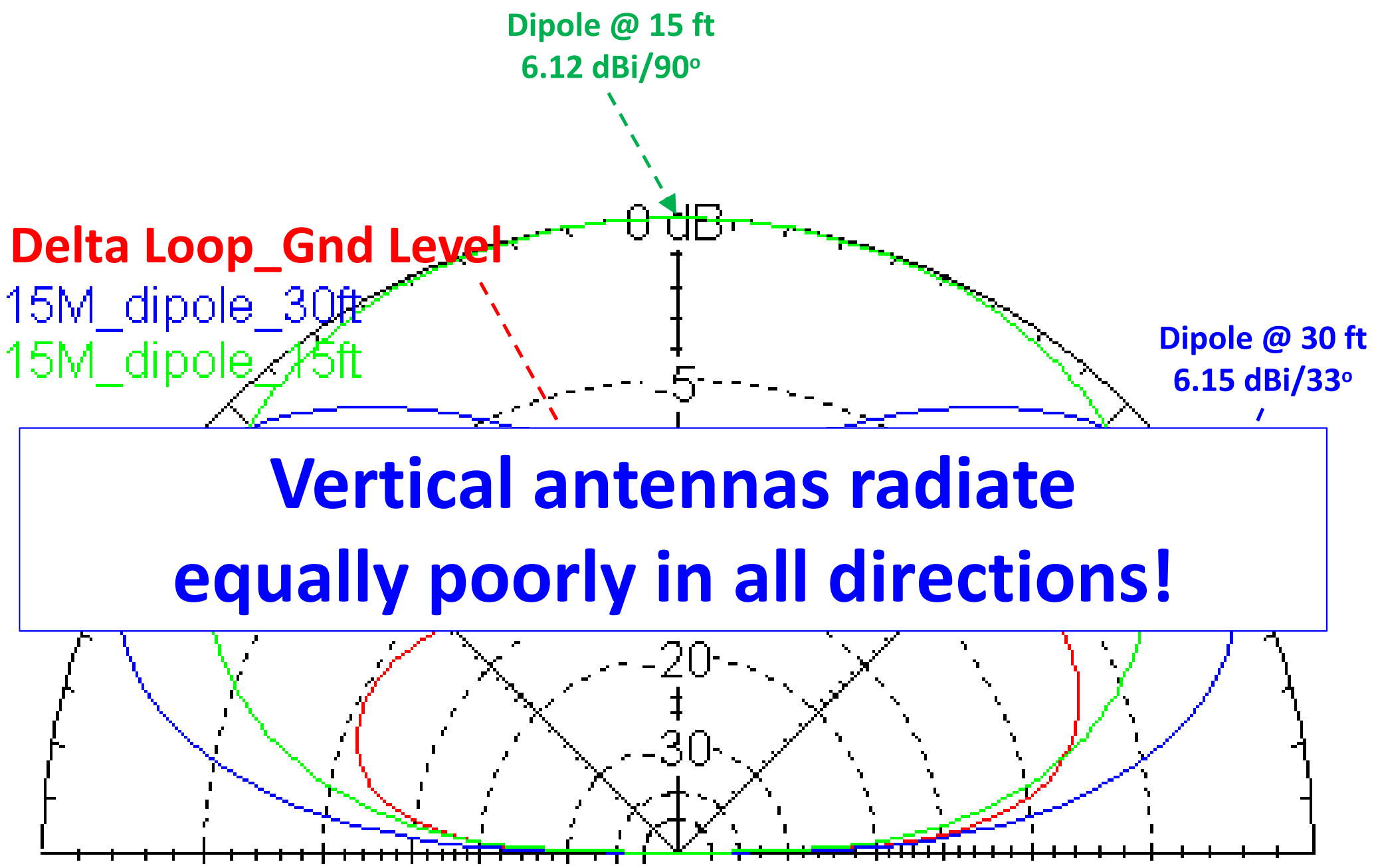

Vertical antennas radiate equally poorly in all directions!

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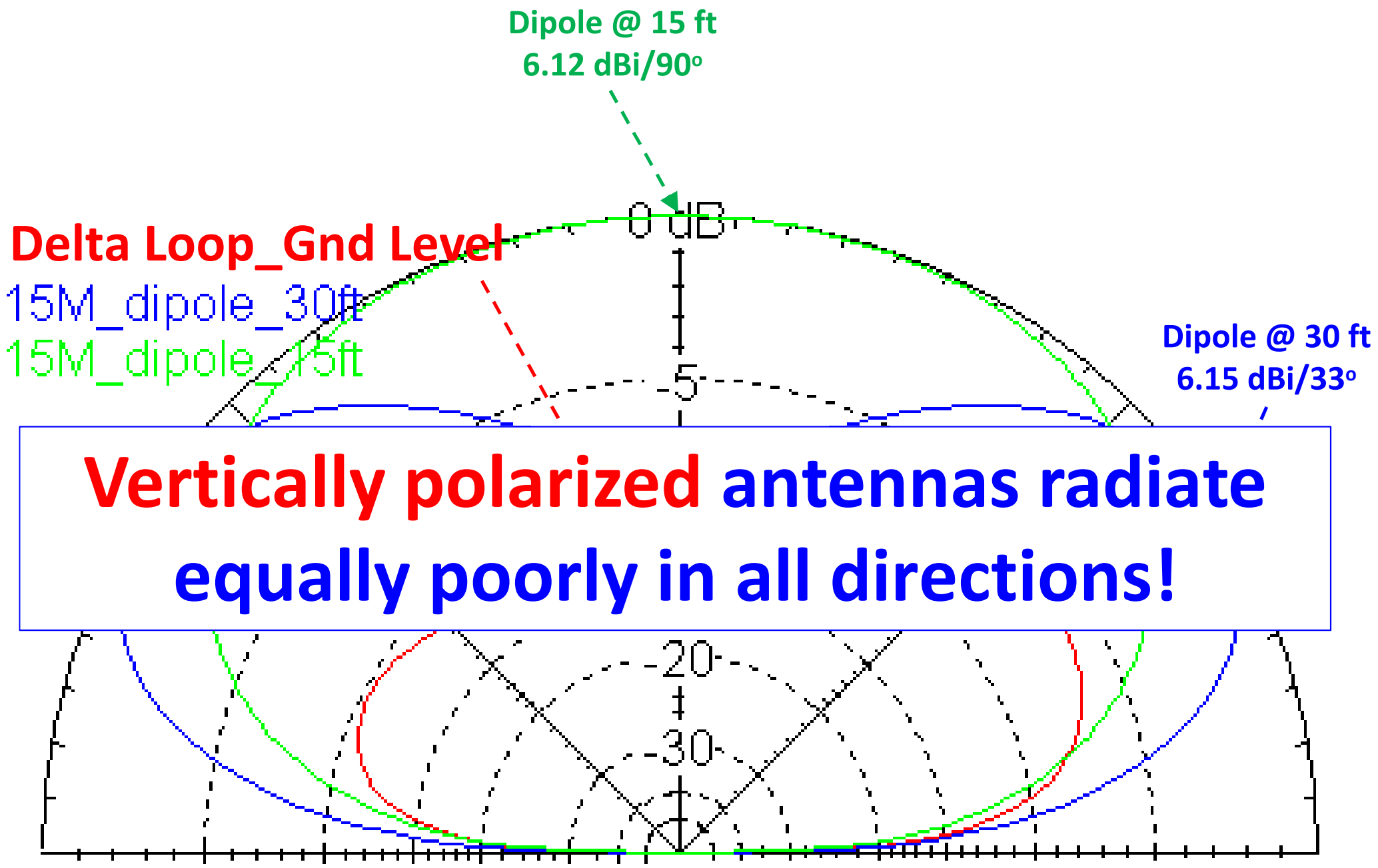

Vertically polarized antennas radiate equally poorly in all directions!

Example 3: January 2013 QST

show both vert & horiz patterns for beam