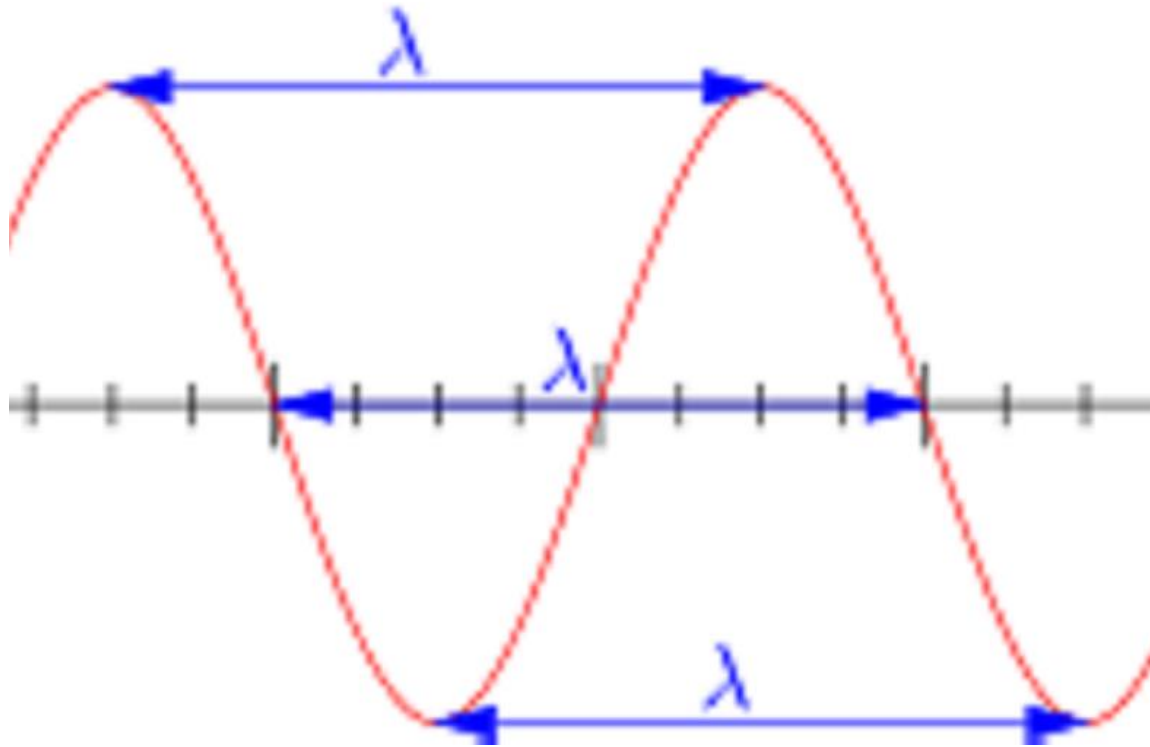
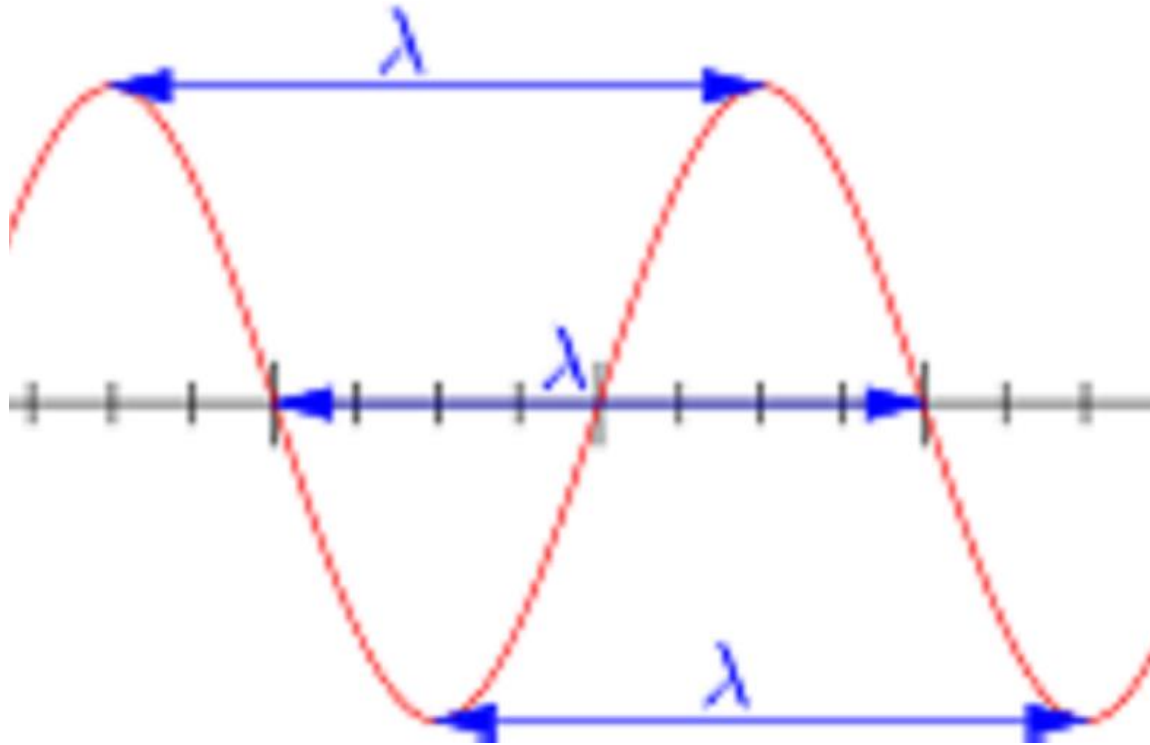


Key Antenna Terms and Numbers

- Wavelength
 - Reflected Energy
 - SWR
 - Ohms Law
 - Resonance
 - Radiation Resistance
 - Impedance
 - Transmission Line
 - Matching
 - Reactance
 - Smith Chart
 - Dipole
 - Pattern
 - Gain
 - Decibel
-
- One
 - 468
 - 300,000,000

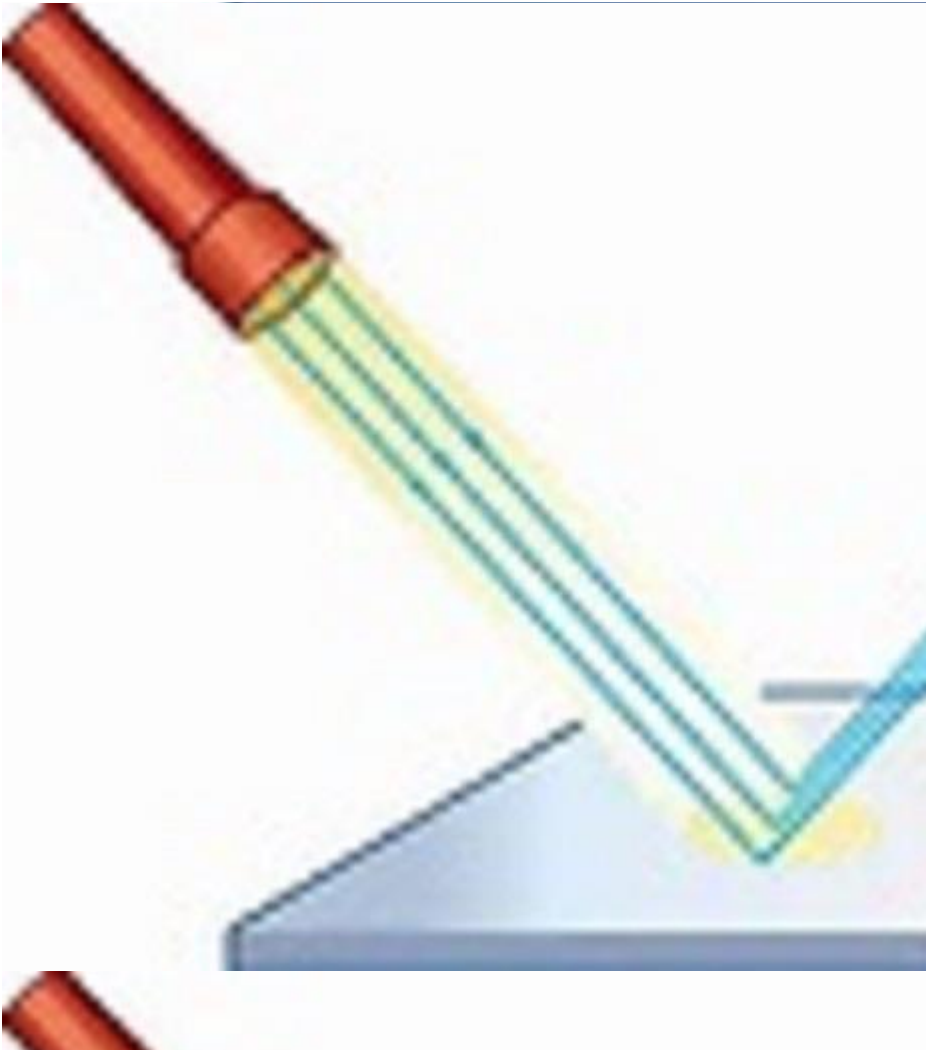


- Electromagnetic waves travel at a velocity of 300,000,000 meters per second
- So the length of a wave is $300,000,000/\text{frequency}$ in Hertz
- Let's use a 30 Mhz signal as an example
- $300,000,000$ Meters per Second
30,000,000 Hertz per Second



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- Let's use a 30 Mhz signal as an example
- 300,000,000 Meters per Second
30,000,000 Hertz per Second
- = 300 Meters or 10 Meters long
30 Hertz

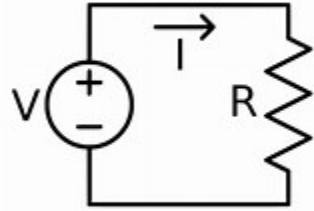
Reflected Energy



- A flashlight shining on a mirror will reflect almost 100% of the energy
- The same flashlight shining on a sheet of glass will reflect some, perhaps 10%, with the balance passing through the glass

Reflected RF Energy is SWR

- Why does SWR Matter?
- When large amounts of energy are reflected back to the transmitter the voltage on the output devices increases. Most transmitters are designed to handle a maximum SWR of 2:1
- Here's the resulting voltages for a 100 watt transmitter
 - SWR 2:1 an increase of 33% to 94 volts
 - SWR 10:1, 316% increase, 223 volts
 - SWR 25:1, 500% increase, 353 volts
- Damage will definitely result

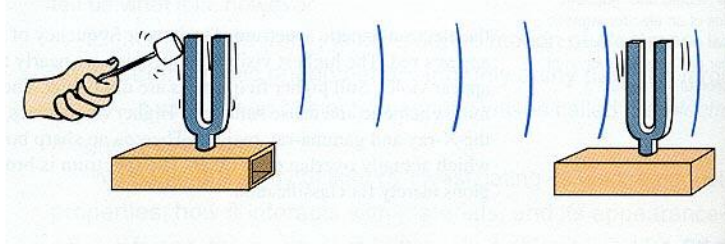


Ohms Law

- Ohms law states that if 1 volt is applied to 1 ohm of resistance, then 1 amp of current will flow
- If the voltage is 2 volts and the resistance is 1 ohm how much current will flow?
- If the voltage is 5 volts and the resistance is 1 ohm how much current will flow?

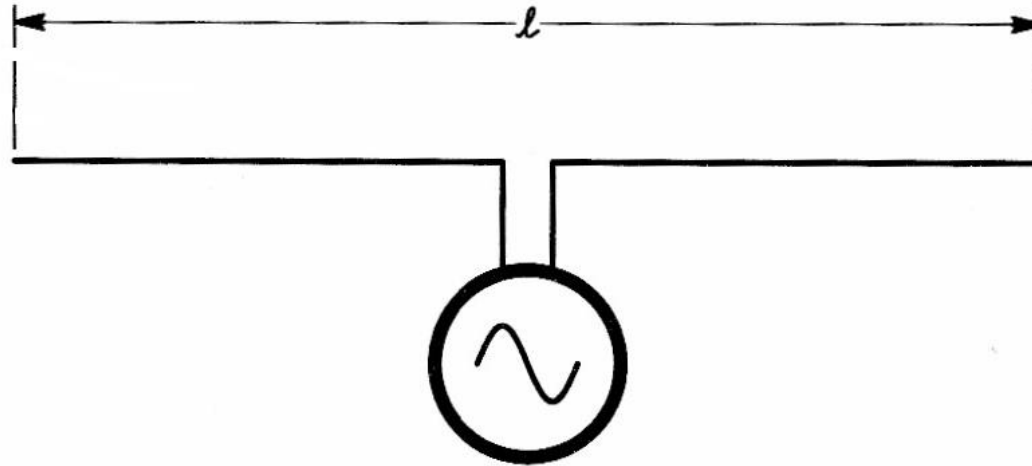
Other Ohms Law Equations

- To find voltage $E=I \times R$
- To find resistance $R=E/I$
- To find power $P=I^2 \times R$
- To find power $P=E^2/R$



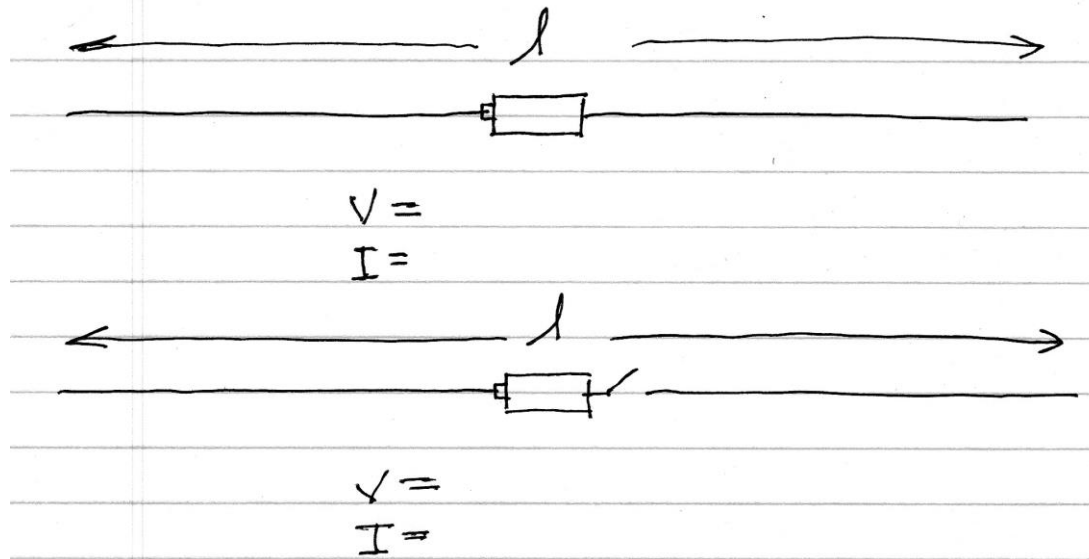
Resonance

- The frequency at which a mechanical device will absorb the most energy
- The electrical equivalent is called a “tuned” circuit
- A length of wire also has an electrical resonance
- The shortest length of wire that will resonate is one that is a half wavelength long
- Most amateur radio antennas are “resonant” types
- The others are “non-resonant” types



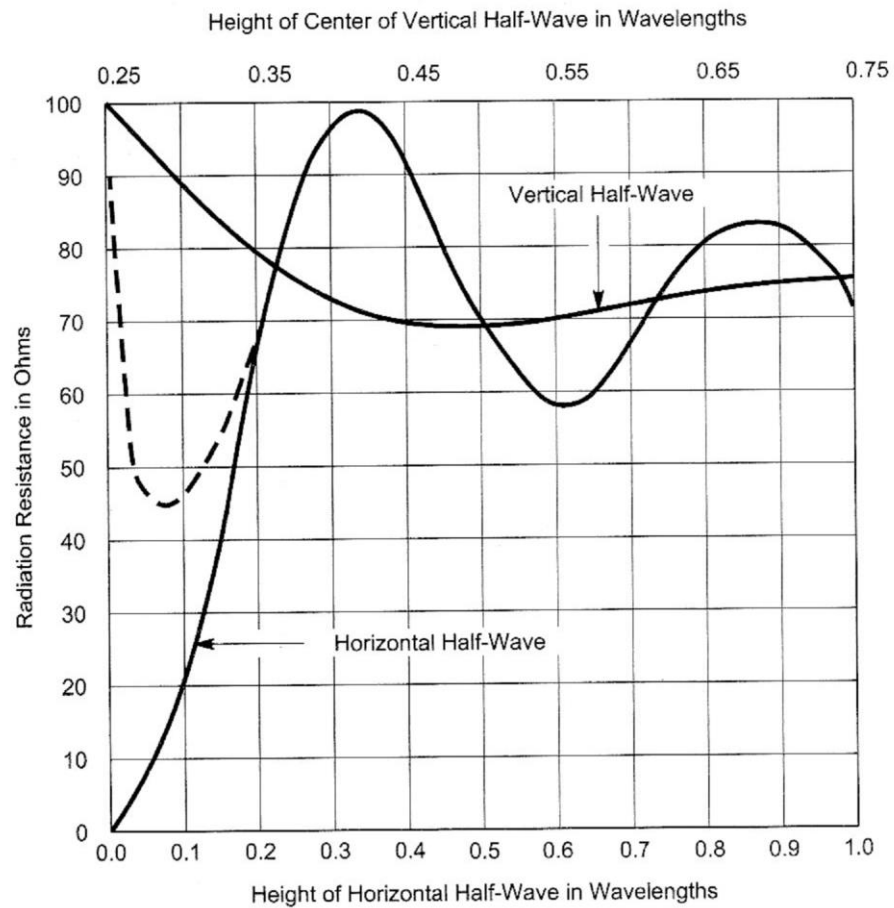
Dipole Antenna

- The “Workhorse” antenna
- Radiates off the sides of the element
- Length of the dipole is approximately $468/F$ mhz
- At $1/2$ wavelength above ground impedance is approximately 72 ohms
- When configured as an inverted v the impedance is lower, around 50 ohms
- Can be built as a “vertical dipole” for low radiation angles
- Is the basis for most beams, J-poles, and ground plane antenna types

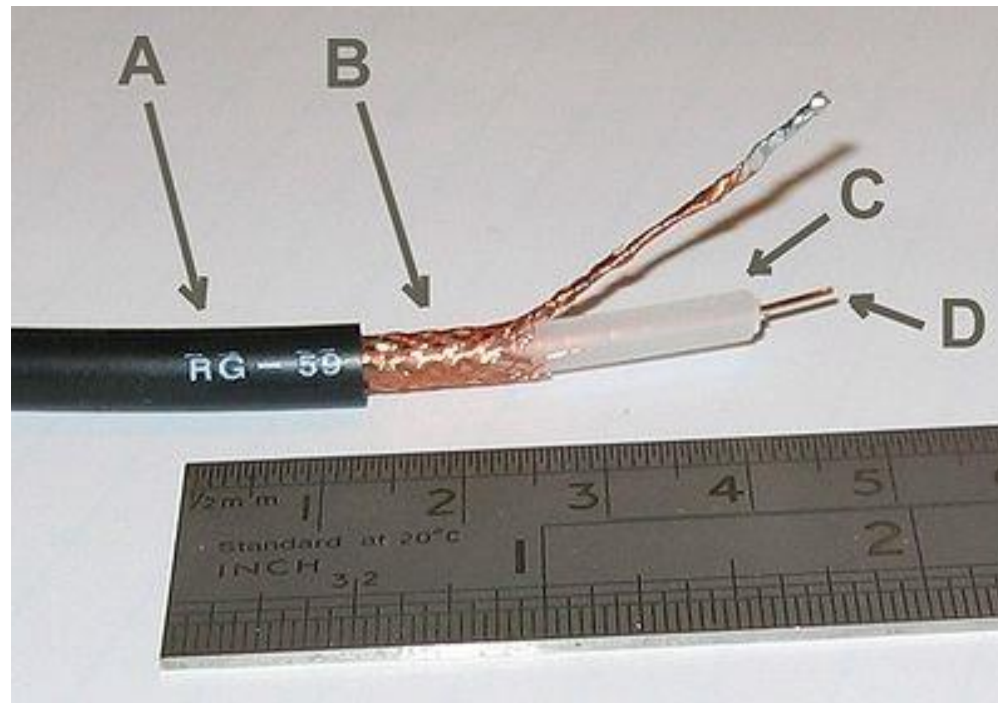


Antenna Radiation Resistance

- Upper drawing-If we measure the current flowing from the battery we find none. The resistance is infinite.
- Lower drawing-We now measure the current flowing from the switched battery and find a real value. The amount of resistance equals the battery voltage divided by the measured current. This calculated resistance is called “radiation resistance”. The energy has been converted into electro-magnetic, or radio, waves.
- This “magic” was discovered by Michael Faraday in 1821, described in math by James Clerk Maxwell in 1864 and the equations simplified by Oliver Heaviside in 1885.



- Other influences include adjacent objects, soil type, soil moisture, wire size, foliage
- Sway and vehicle motion also have an effect



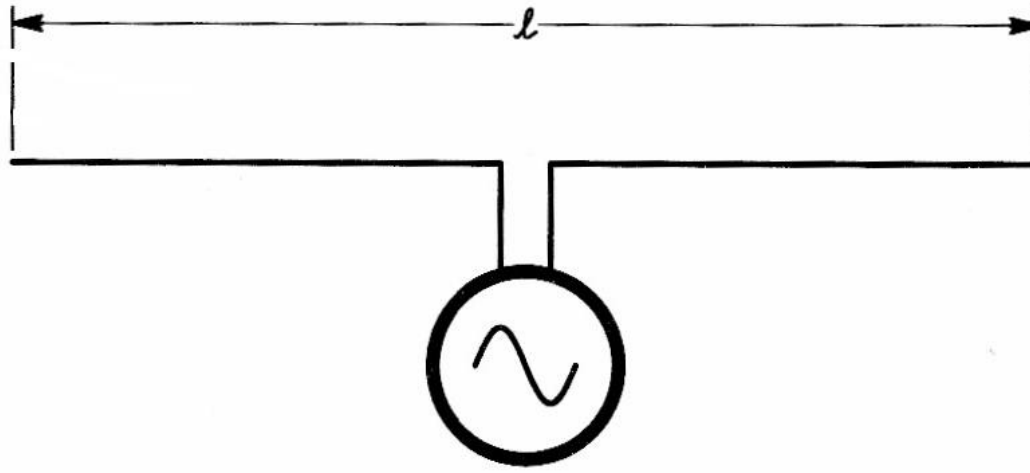
Transmission Lines

- Connect between transmitter and antenna
- For minimum SWR must match antenna impedance and transmitter impedance
- All transmission lines have losses that are frequency dependent
- Most common type is coax, but also ladder line, twin lead and wave guides



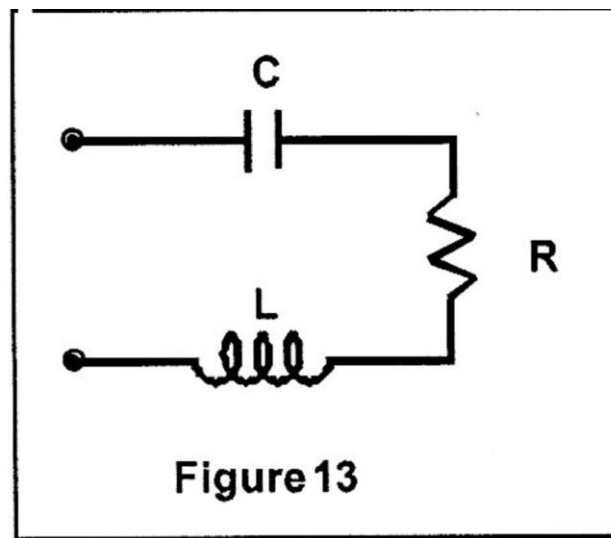
Antenna Matching

- Generally done with a matching network called an antenna tuner that's located in the shack
- The tuner adds an appropriate amount of inductance and capacitance to make the load appear to be a perfect resistance that matches the transmitter output impedance
- Matching can also be done at the antenna, which greatly reduces feedline losses. The type of matching devices for use at the antenna include, gamma, delta, hairpin, omega, beta, L-C networks, stubs and many others



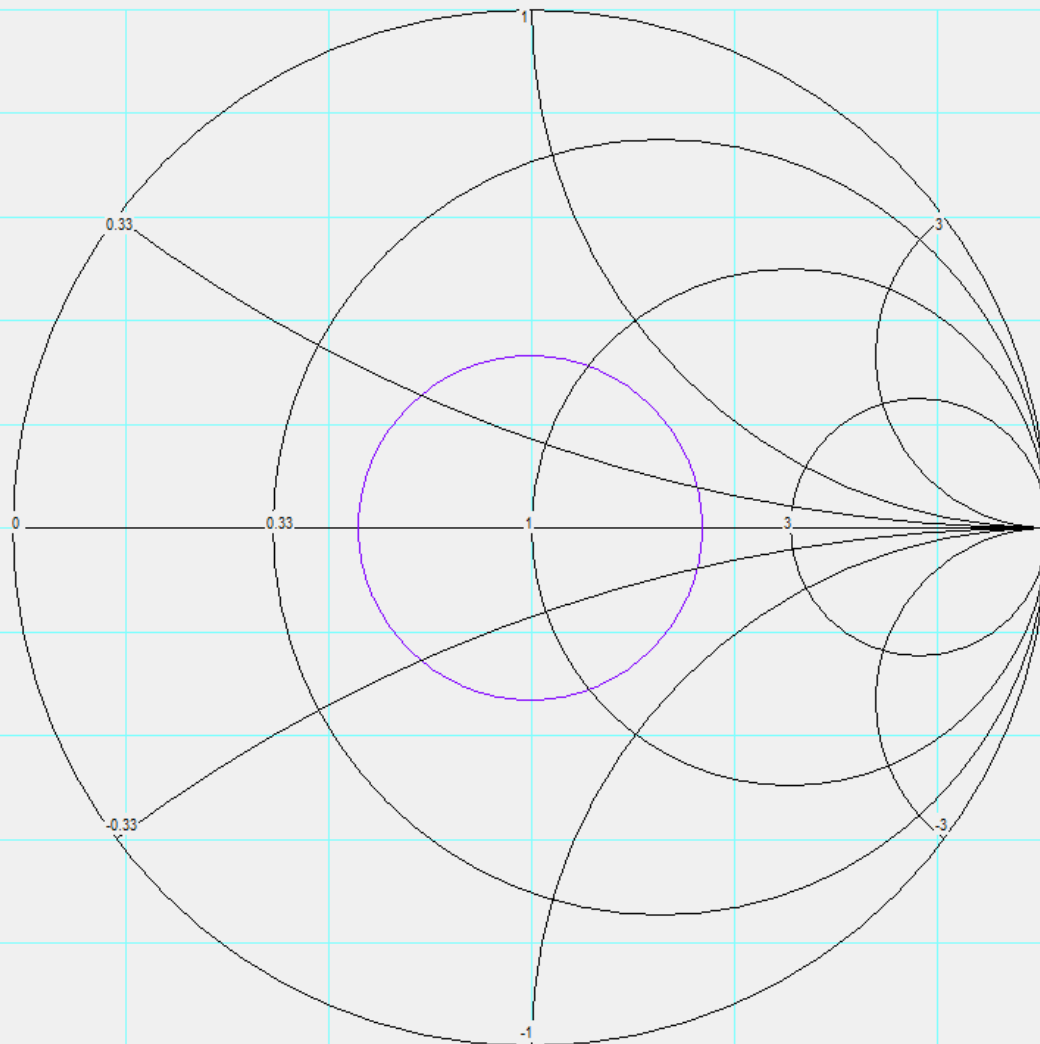
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Dipole Equivalent Circuit

- A dipole antenna can be modeled as a series circuit consisting of a capacitor 'C', and inductor 'L', and a resistor 'R'. The resistor is the value of the radiation resistance we spoke of earlier. The capacitor and inductor provide equal and opposite reactances at the frequency for which the antenna is designed.
- Reactance is AC resistance. Inductive reactance increases with frequency, capacitive reactance decreases with frequency.



Cal

Start = 5 MHz

Center = 7.5 MHz
Span = 5 MHz

Stop = 10 MHz

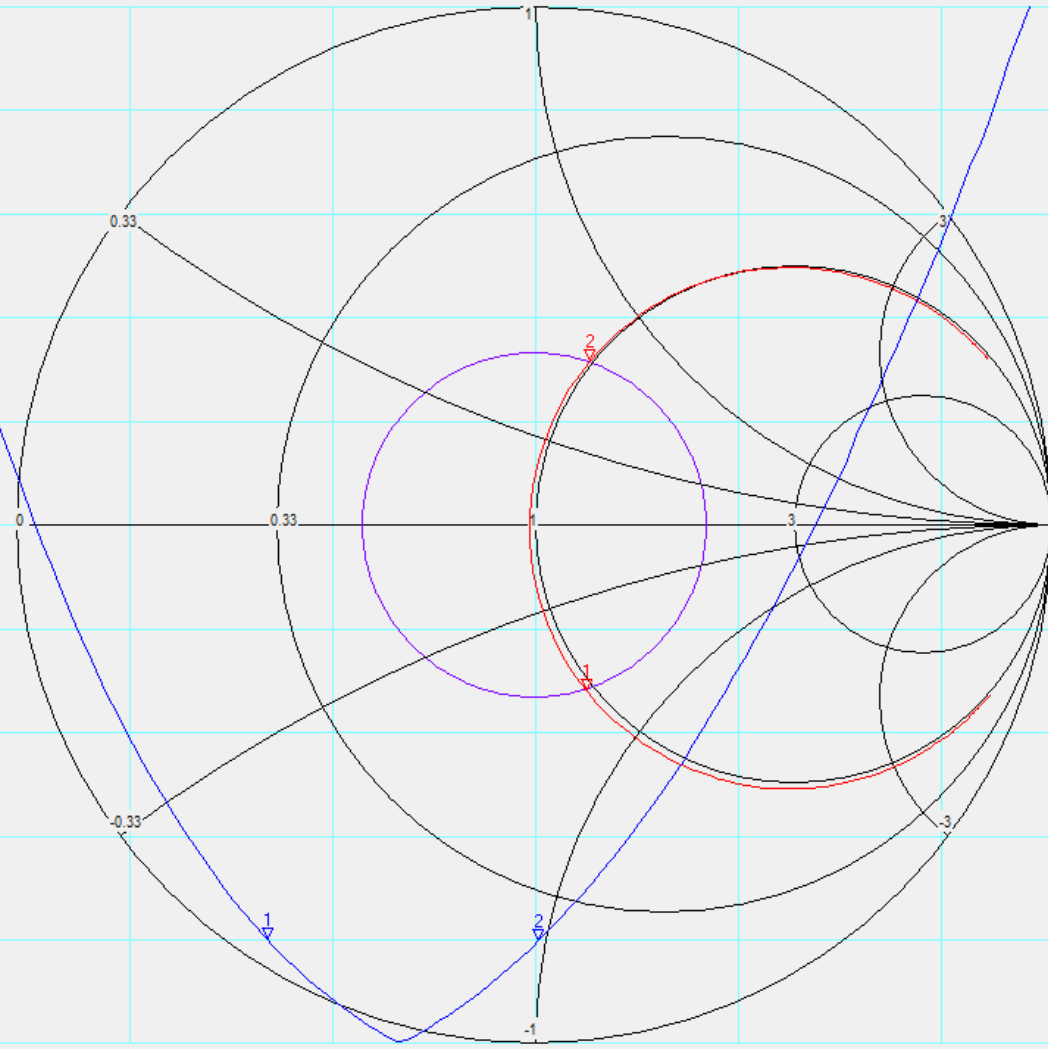
=>
TX Att. = 0 dB

S11 VSWR

S11 Smith

<Ref

1/ 1: 6.84MHz 2.01 0.10-i0.32
2: 7.51MHz 2.00 0.11+i0.32



Start = 5 MHz

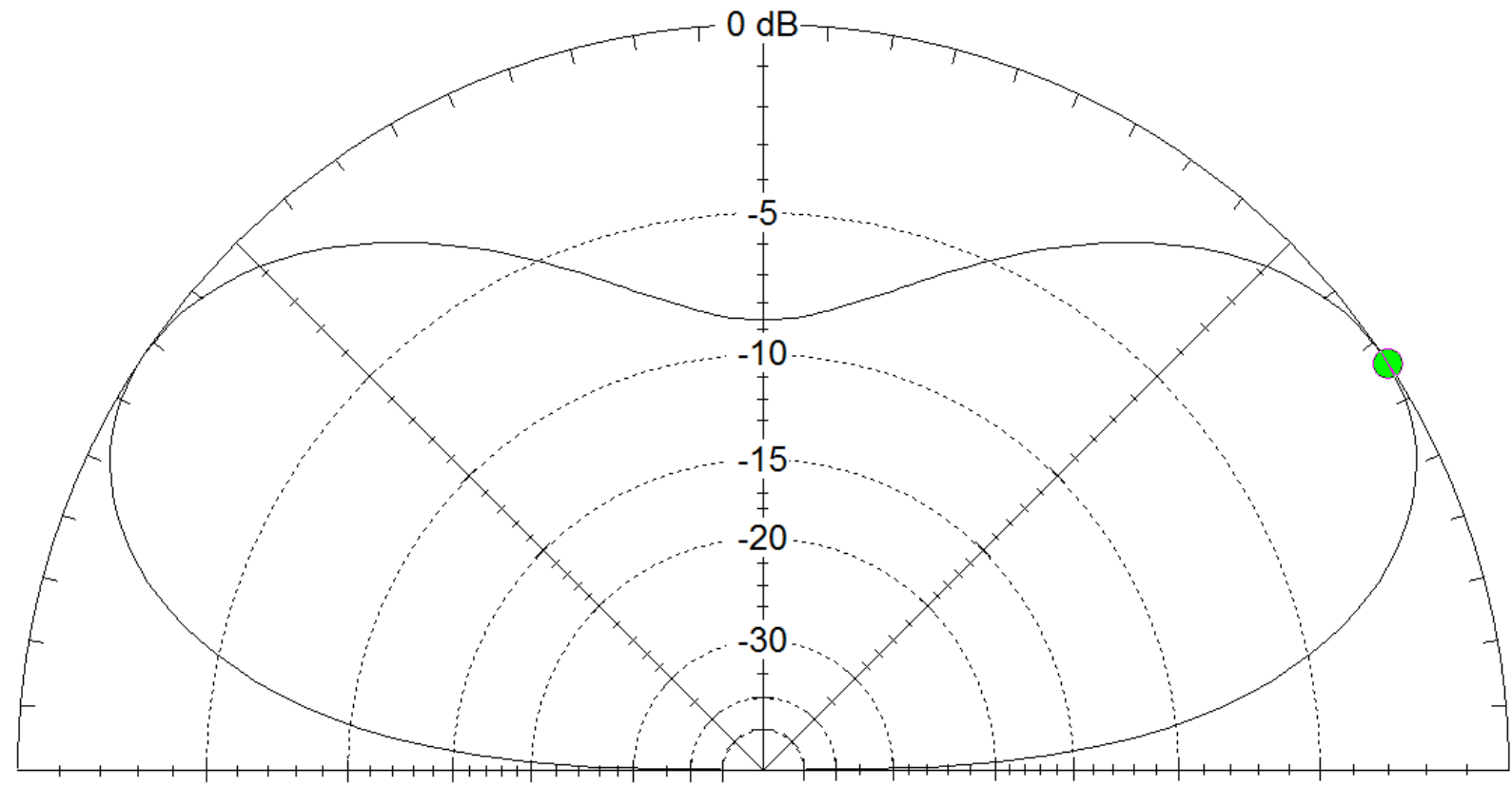
Center = 7.5 MHz
Span = 5 MHz

Stop = 10 MHz

=>
TX Att. = 0 dB

S11 VSWR
S11 Smith

Total Field



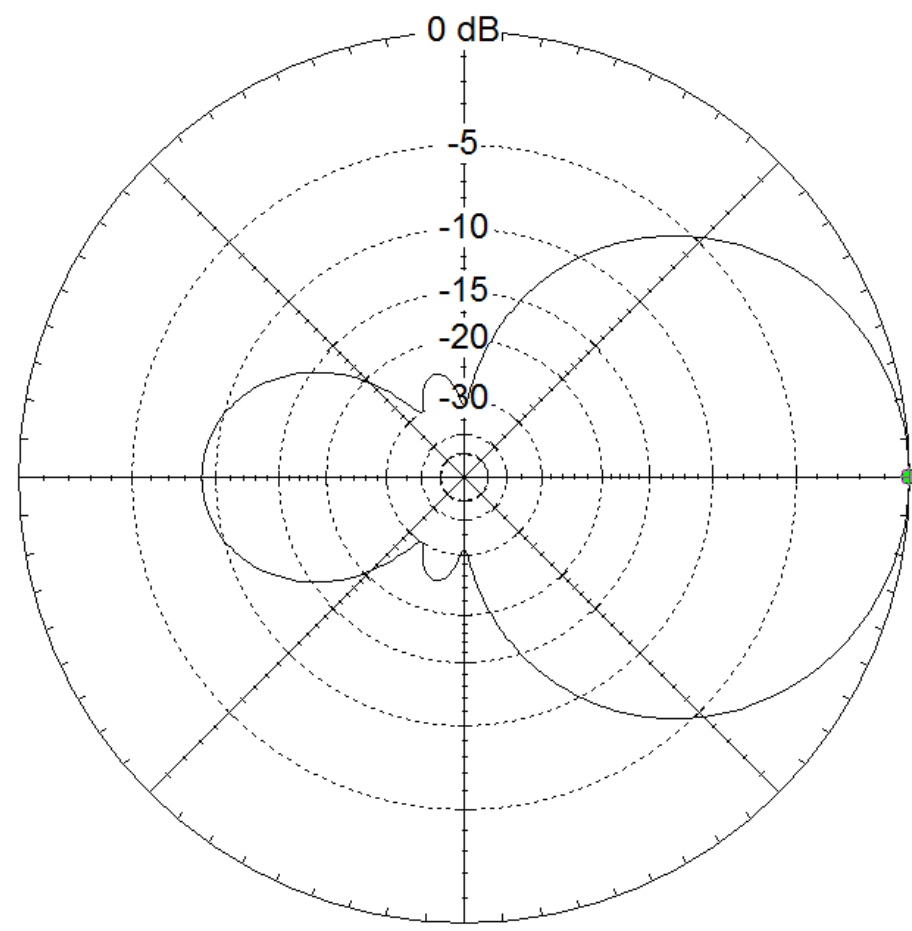
14 MHz

Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 6.82 dBi

Cursor Elev 33.0 deg.
Gain 6.82 dBi
0.0 dBmax

Slice Max Gain 6.82 dBi @ Elev Angle = 33.0 deg.
Beamwidth 41.5 deg.; -3dB @ 15.8, 57.3 deg.
Sidelobe Gain 6.82 dBi @ Elev Angle = 146.0 deg.
Front/Sidelobe 0.0 dB

Total Field



21.2 MHz

Azimuth Plot
Elevation Angle 0.0 deg.
Outer Ring 7.55 dBi

Slice Max Gain 7.55 dBi @ Az Angle = 0.0 deg.
Front/Back 9.06 dB
Beamwidth 73.2 deg.; -3dB @ 323.4, 36.6 deg.
Sidelobe Gain -1.51 dBi @ Az Angle = 180.0 deg.
Front/Sidelobe 9.06 dB

Cursor Az 0.0 deg.
Gain 7.55 dBi
0.0 dBmax

Decibel

- Specifies a power (or voltage) ratio
- For power $10 \times \log (P2/P1)$ (log to base 10)
- Examples:

3dB	2 times as large
10dB	10 times as large
20dB	10 x 10 times as large (100x)
30dB	10 x 10 x 10 times as large (1000x)
40dB	10 x 10 x 10 x 10 times as large (10,000x)

- dBm Ratio relative to 1 milliwatt
- dBi Ratio to isotropic antenna
- dBw Ratio to watts
- dBSPL Ratio to Sound Pressure Level