Amateur Radio Technician License Training

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Topics on Exam

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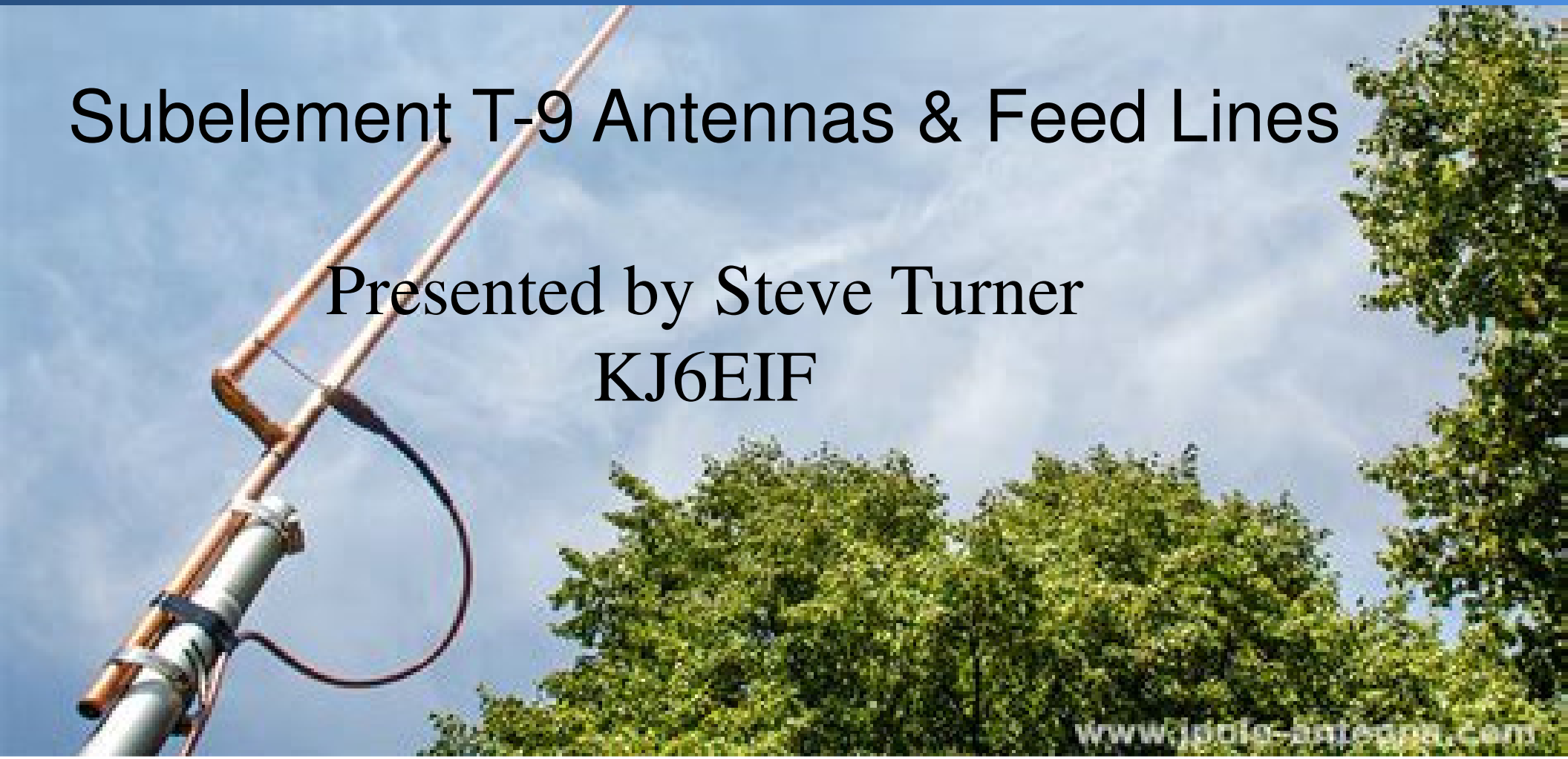
2023 Amateur Radio Technician License Training



Subelement T-9 Antennas & Feed Lines

Presented by Steve Turner
KJ6EIF

Antenna System Fundamentals

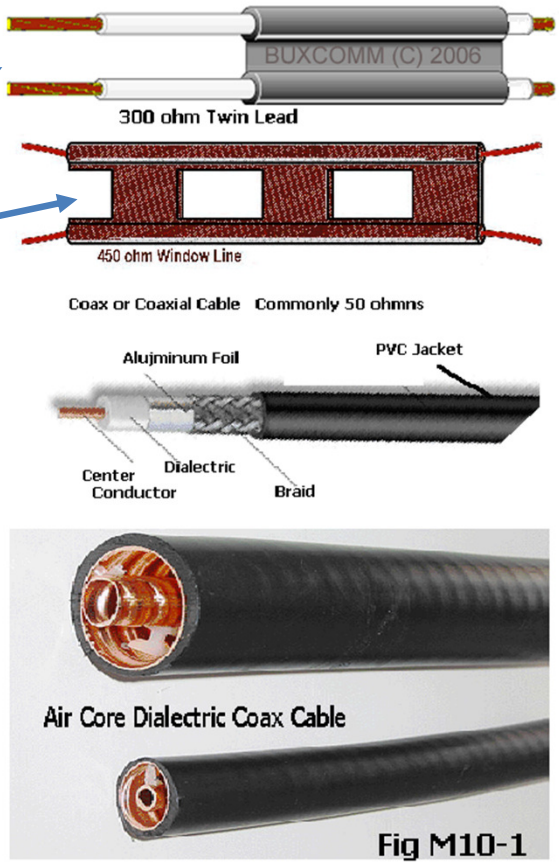
The Antenna System

- **Connector**: Connects radio to the feed line.
- **Feed line**: Connects your radio to the antenna.
- **Antenna**: Transforms current into radio waves (transmit) and vice versa (receive).
- **Test and matching equipment**: Allows you to monitor and optimize antenna system performance.

Feed Lines

Feed Lines

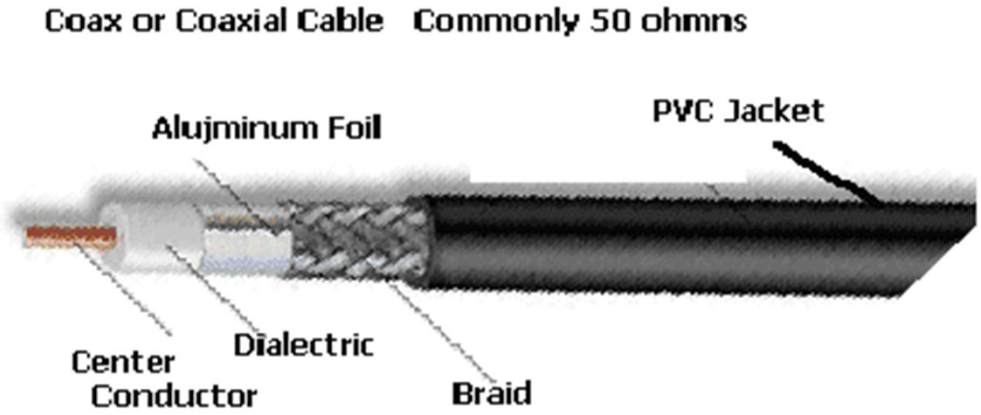
- Feed line carries RF power from your station to the antenna.
  - Open wire or twin lead
  - **50 ohm Coaxial** or **Coax Cable most commonly used in amateur radio**
  - **Air insulated Hard Line lowest loss at VHF and UHF frequencies**



Feed Lines

Coax Cable Anatomy

- **Center conductor**: Central wire
- **Dielectric**: Insulation surrounding center conductor
- **Shield**: Braid and often foil surrounding dielectric
- **Jacket**: Protective outer plastic coating



Coaxial Feed Lines

Coaxial Cable

- **50 ohm Coax most common feed line**
- **Easy to use, requires few special installation considerations (not affected by nearby materials)**
- **Loss increases with frequency**
- **Air-insulated "hard line" has lowest loss at VHF and UHF frequencies**

Coaxial Feed Line Connectors

- **PL-259 connectors are commonly used on HF & VHF frequencies.**
- **Above 400mHz, N connectors are the most suitable**
- SMA common on handhelds
- **Coax connectors MUST be sealed against water when exposed to weather to avoid or prevent an increase in feel line loss**

- **UHF**

PL-259

SMA---------->

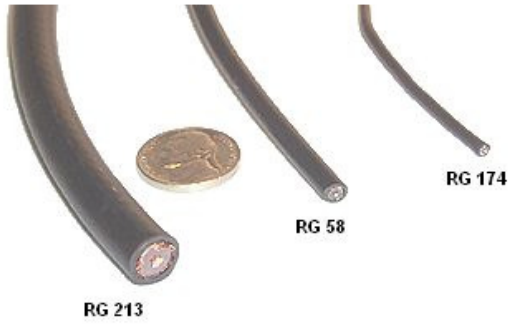
- **N**

Coaxial Feedline Losses

As length and/or frequency increases, coax signal loss increases

Attenuation in dB per 100 feet							
Cable Group	30 MHZ	50 MHZ	100 MHZ	150 MHZ	450 MHZ	1000 MHZ	2400 MHZ
RG-58A/U	2.5	4.1	5.3	6.1	10.6	24	38.9
RG-213	1	1.5	2.1	2.8	4.4	7.1	12

What is the electrical difference between RG-58 & RG-213?



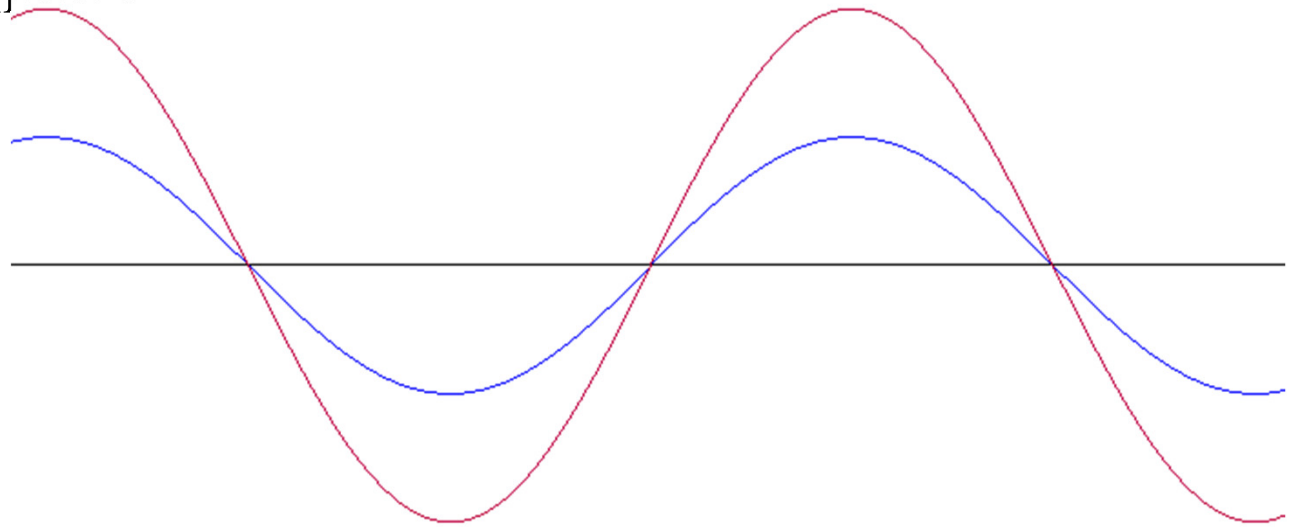
Smaller the coax, the greater the loss

Sources of Feed Line Signal Loss

- **Water intrusion into Coax Connectors**
- **Multiple connectors in the feed line**
- **Using too long a feed line**
- **Using wrong feedline for frequency**
- **High Standing Wave Ratio (SWR) due to poor antenna match**

Standing Wave Ratio (SWR)

If the antenna feed point & feed line impedances are not identical, some *RF forward power* is *reflected* back toward the transmitter



In Ham Radio SWR is expressed as a voltage ratio often written VSWR

creating a pattern of *standing waves* of voltage & current in the feed line

Feed Line Standing Wave Ratio (SWR)

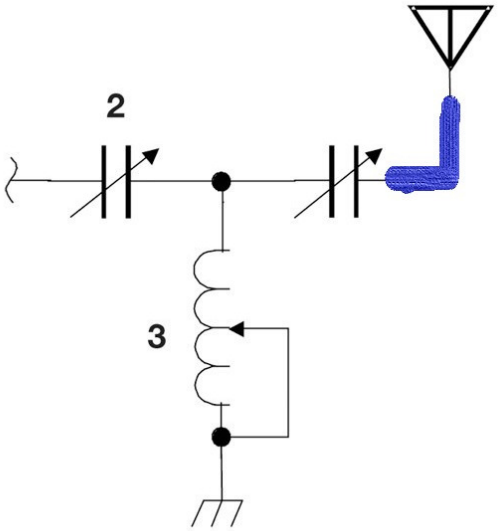
- **SWR is a measure of how well a load** (antenna) **is matched to the transmission line** (Coax)

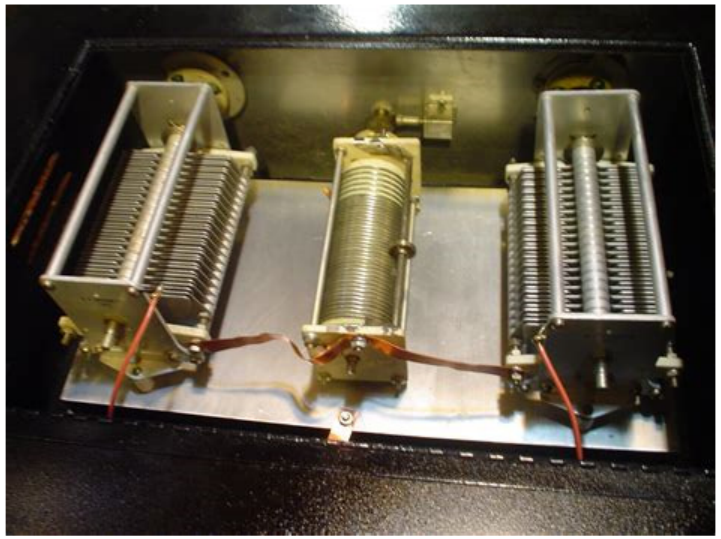
- **A high SWR causes signal loss** because less power is transferred to or from the antenna.
  - 1:1 SWR is perfect – no power reflected
  - 1.5:1 SWR is 4% loss of power
  - 2:1 SWR is >11% loss (max acceptable most equipment)
  - 3:1 SWR is 25%

A loose connection in an antenna or a feed line can cause erratic changes in SWR readings

Antenna Tuner (Antenna Coupler)

The major function of an antenna tuner (antenna coupler) is to match the antenna system impedance to the transceiver's output impedance.





Antenna Fundamentals

The Antenna Vocabulary

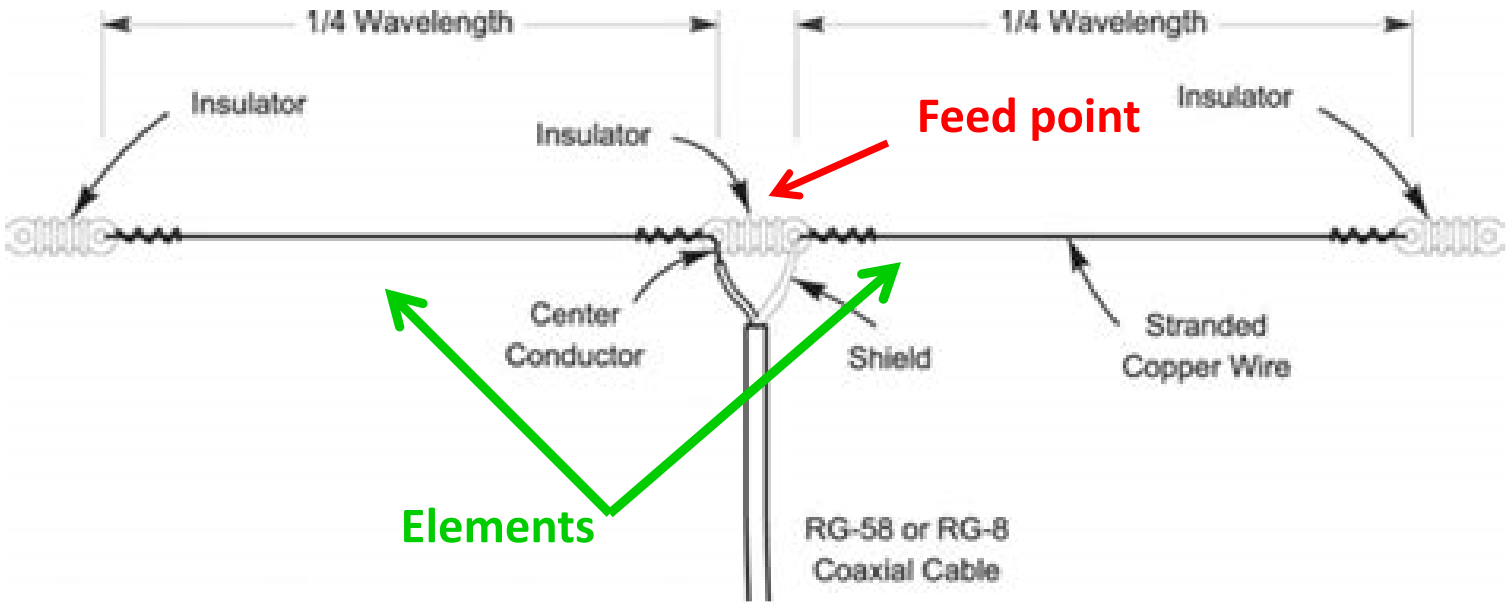
- **Element**: The conducting part or parts of an antenna designed to radiate or receive radio waves.

- **Feed point**: Where the transmitted energy enters the antenna.

- **Radiation Pattern:** Direction(s) of strongest radiation and reception of energy by the antenna.

½ λ Dipole Antenna

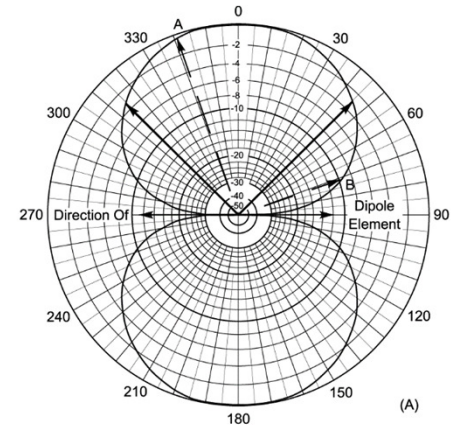
- Total length is ½ wavelength (½ λ)
- Simple and complete antenna with a nominal impedance 50-75 ohms Ω. Good match for 50 Ω coax

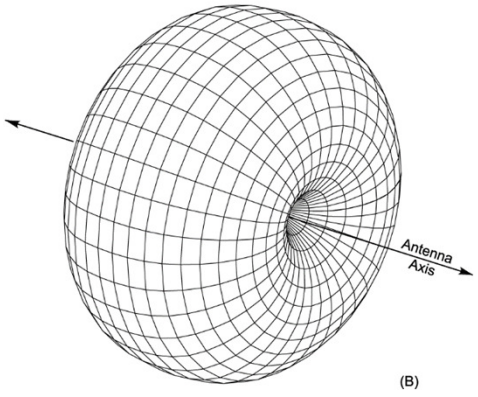


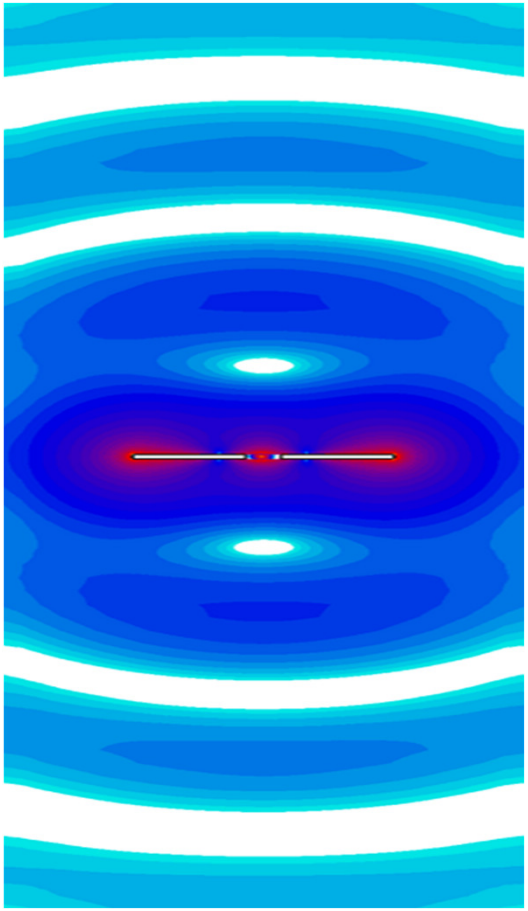
½ λ Dipole Antennas

- **Half wave dipole radiates the strongest signal broadside to the antenna,** weakest off the ends

- 3D radiation pattern looks like a donut or bagel This is a *free-space* picture







½ λ Dipole Antennas

- Length (in feet) estimated 468 / frequency (in MHz) multiply X12 for inches

EXAMPLE: 6 meter dipole $\frac{468}{50\ \text{mHz}}$ = 9.36 ft X 12 = 112.3 inches

- Shortening a dipole will increase its resonant frequency

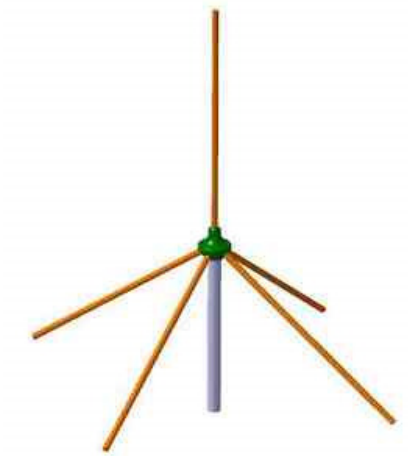
- **A simple dipole oriented parallel to the Earth's surface is horizontally polarized**

¼ Wavelength (¼ λ) Ground-Plane Antenna

- Length (in feet) usually estimated
  - 234 / frequency (in MHz) – often short, start long and trim to length
  - Thickness of whip or rod also affects calculated length
  - Nominal impedance 35-50 ohms Ω

Example:146mHz : $\frac{234}{146\text{mHz}}$ **=1.6 ft X 12 = 19 inches**

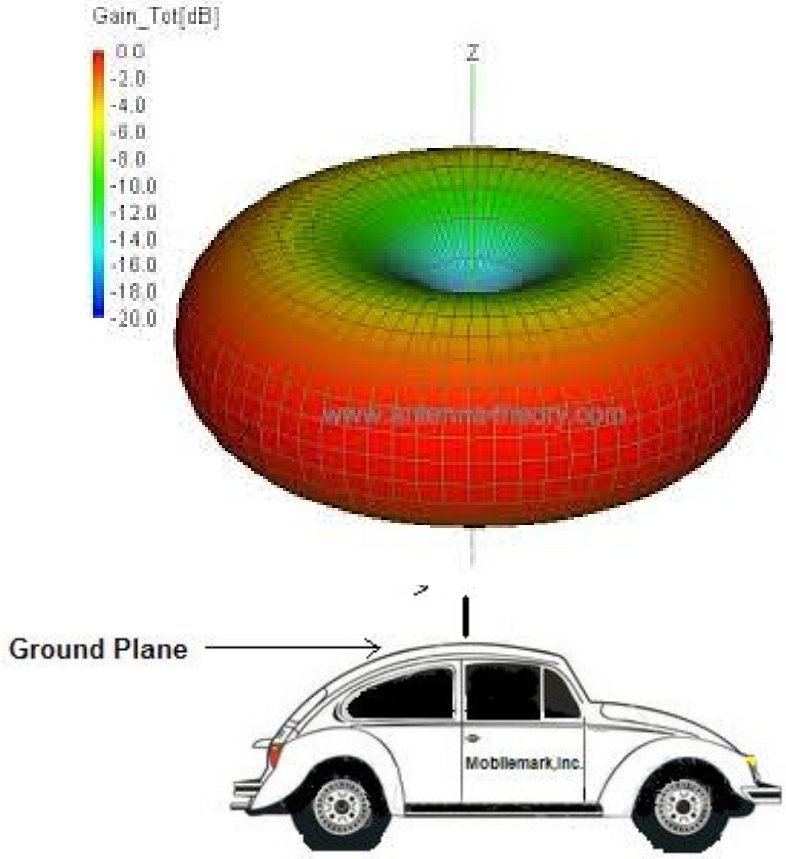
The other half of the dipole must be present either and radials, a reflective surface, or a capacitive connection to earth like your body or a car's body



Vertically Polarized

¼ Wavelength (¼ λ) Ground-Plane Antenna

- Vertical ground-plane antennas are omni-directional
- car surface acts like ground plane replacing radials
- Mount mobile whips in center of roof or trunk for best coverage



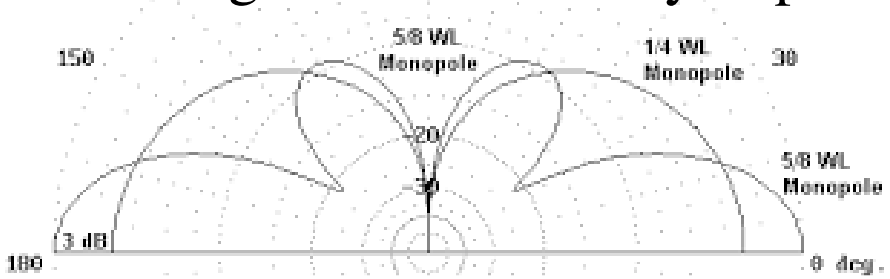
Cross-Polarization Review

- A receiving antenna and the incoming wave polarization must match for maximum reception.
  - **Cross-polarized**: antenna elements and the wave's electric field are at right angles can reduce reception by a factor of 100 (20db)
- For elliptically polarized waves (such as HF sky-wave) any antenna will respond at least partially.

Practical Antennas

Gain Antenna Construction

- Lengthening a ¼-wavelength VHF/UHF ground-plane to $^{5}/_{8}$ wavelengths focuses more signal toward the horizon lower angle of radiation and gain which usually improves range.



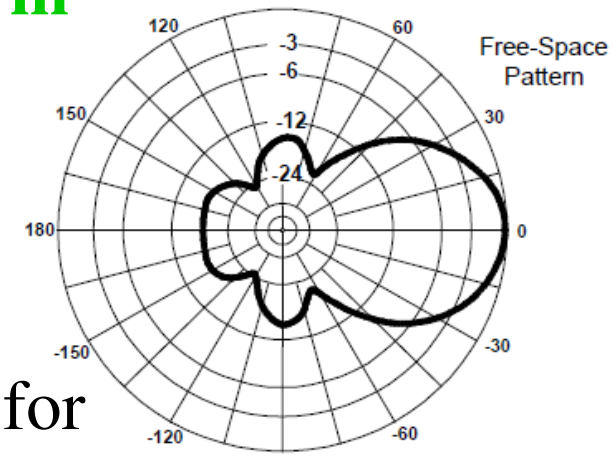
- **Inserting an inductor makes the antenna longer electrically. This is refered to as "Antenna Loading"**

Practical Antennas

Directional (Beam) Antennas

- **A Beam antenna concentrates signals in one direction.**
  - Gain improves range
  - Reduces reception in unwanted directions
  - Reduces interference to and from other stations
- Directional characteristics are the same for receiving as they are for transmitting.

Figure E9-1



Antenna Fundamentals

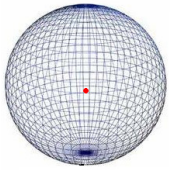
The Antenna (More Vocabulary)

- **Isotropic**: Equal radiation in all directions.
- **Gain**: The increase in signal strength in a specified direction compared to a reference antenna (isotropic). Measured in decibels (dB).
- **Omnidirectional**: No preferred horizontal direction, but can be designed to have gain.
- **Directional**: A beam antenna concentrates signals in one direction.

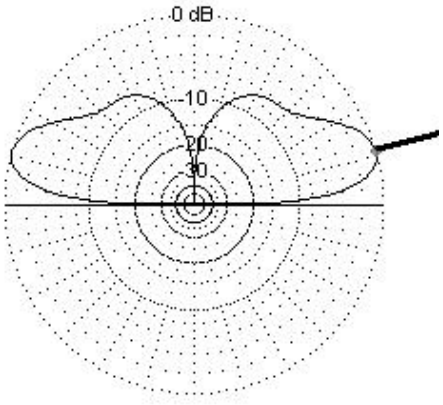
Antenna Gain

*

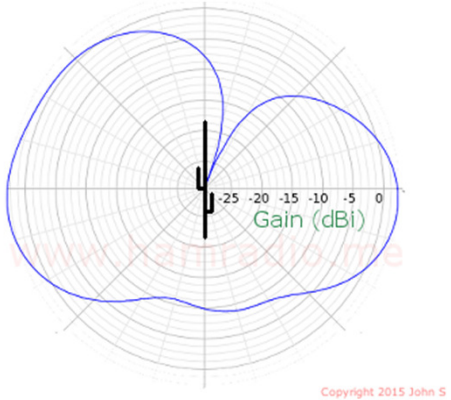
Isotropic point
0 db gain - *reference*



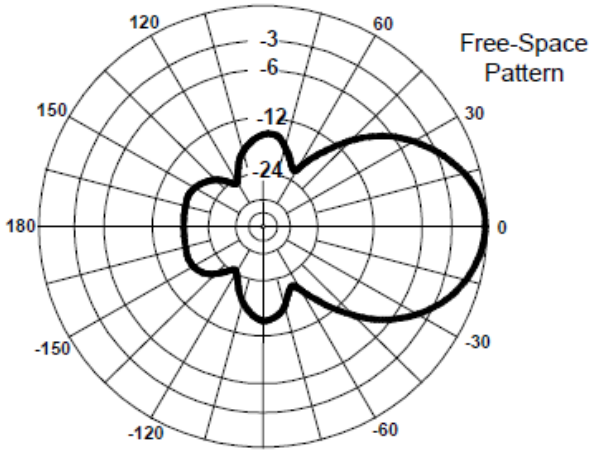
5/8 wave vertical
some gain



J Pole
some gain



Yagi
most gain



Practical Antennas

Short Flexible (Rubber Duck) Handheld Antenna

- Coiled wire (an inductor) coated in tough plastic makes the antenna electrically longer
- Convenient size, rugged enough for handheld use
- The radio and operator make up the ground plane and complete the dipole
- Does not transmit or receive as effectively as ¼ wave antenna due to low efficiency
- Doesn't work well inside vehicles due to metal body shielding signal

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