Antenna? What's That?

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WA3I

Space: The Final Frontier

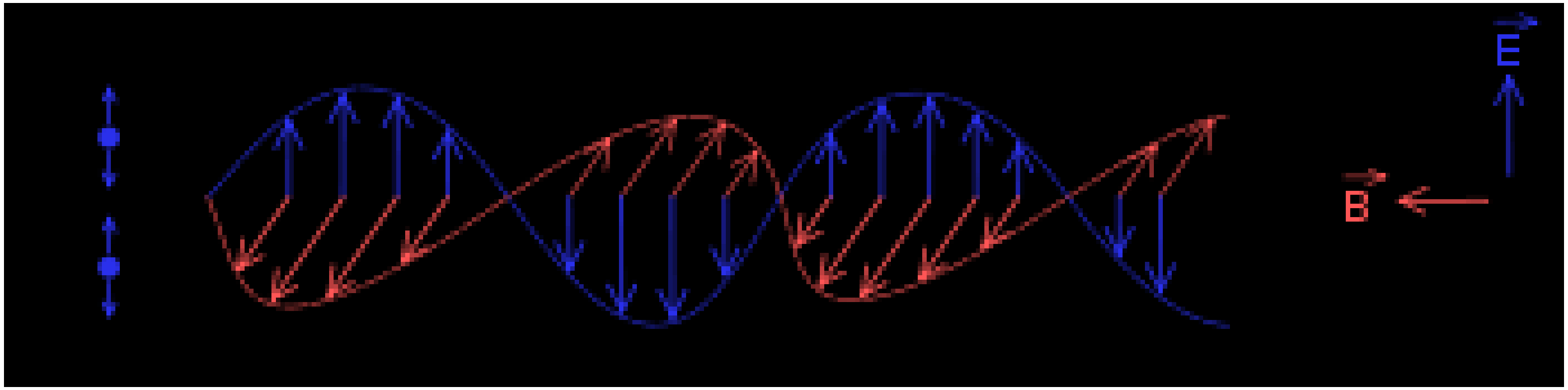
- Empty Space (-Time)
  - Four dimensional region that holds "everything"
  - Is "Permeable": It requires energy to set up a magnetic field within it.
  - An oscillating magnetic field dissipates energy, i.e. "radiates"
  - Light propagates through it.

Magnetic Field

- Relativistic force created by an electric current
- An oscillating electric current creates an oscillating electric and magnetic field
- Under the right conditions, an oscillating electric current will “radiate” electromagnetic energy

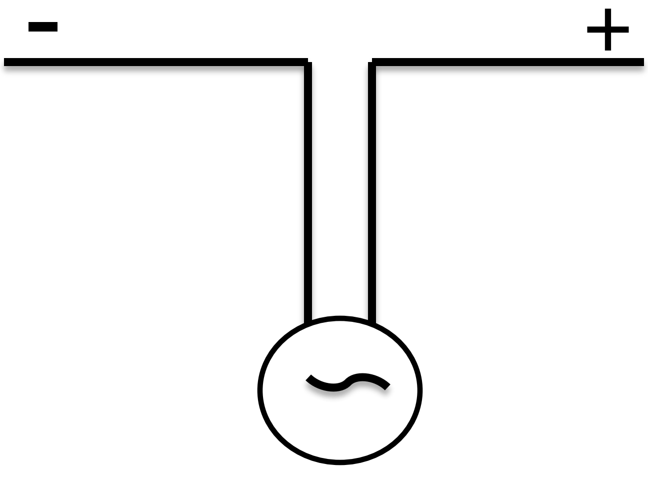
Light – Electromagnetic Radiation

- Light is a magnetic (B) and an electric field (E) propagating together
- $\lambda \times f = c$ where
  - λ is wavelength
  - f is frequency
  - c is speed of light



Antenna

- An electrical conductor
- Usually of a specific length
- An oscillating electric current is fed to it:

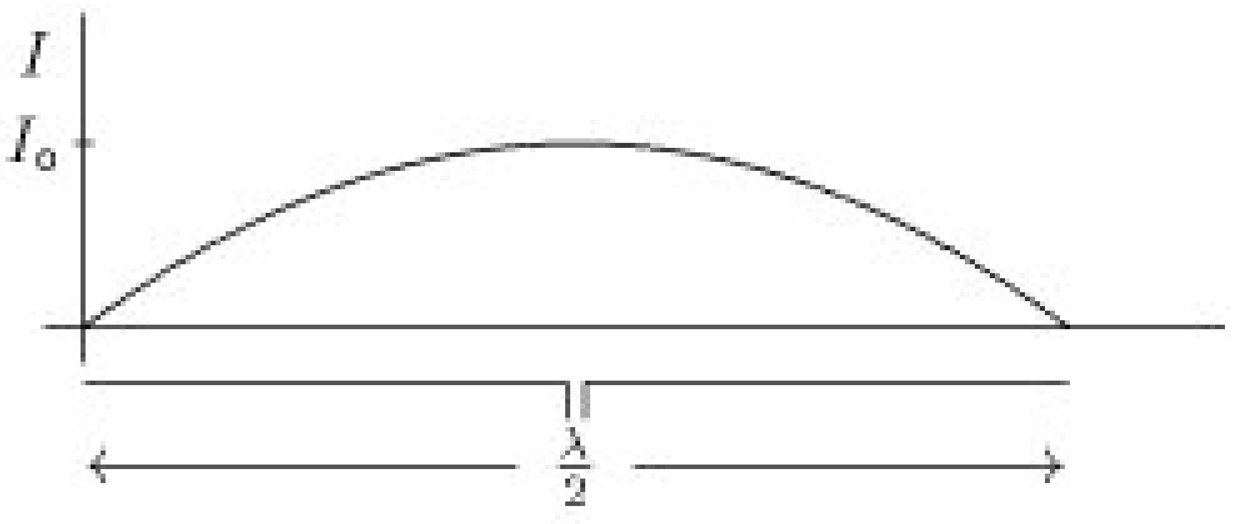


Resonant Antenna

- If the conductor is ½ a wavelength long, the current will resonate
- Like a water sloshing in a trough, the electric current will flow back and forth along the conductor in synchrony with the applied electric current.

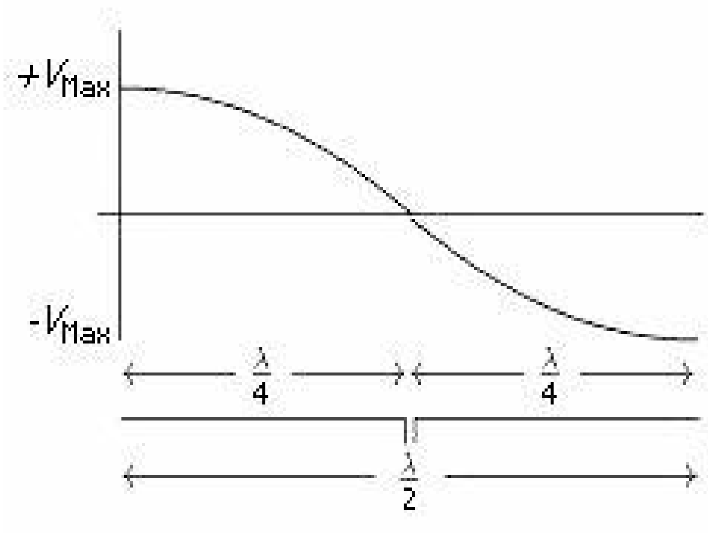
Current in a ½ Wavelength Antenna

- Like the flow of water in a sloshing trough, the current in a λ/2 antenna is highest in the center and lowest at the ends:



Voltage in a ½ Wavelength Antenna

- Like the accumulation of water at the ends of a sloshing trough, the voltage in an antenna is highest at the ends and lowest in the middle:



Voltage on the Antenna

- Measured voltage between any point on the antenna and “ground” will vary sinusoidally
- Measured current at any point in the antenna will also vary sinusoidally

What is Ground?

- Ground is an object large enough to absorb a reasonable amount of electrical charge and not become measurably charged itself. For example: the Earth.
- DC Ground has low resistance to the Earth.
- AC (or RF) Ground has low impedance (both inductive and capacitive) to the Earth.

Grounded?

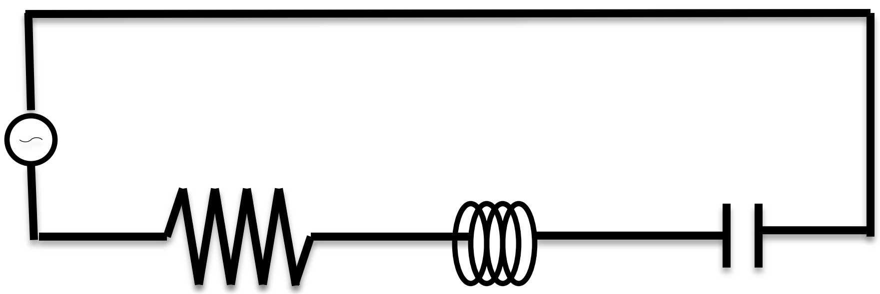
- Anything connected by a low resistance conductor to a ground rod will be at DC ground.
- However, a length of wire will have inductive reactance. To be an AC (RF) ground, the wire should be less than 5% of a wavelength.

Distance to RF (AC) Ground

Frequency	5% of Wavelength
60 Hz	820,000 Feet
3.5 MHz	14.1 Feet
28 MHz	1.8 Feet

Antenna Electrical Equivalent

- All antennas appear electrically to be equivalent to a resistor, inductor, and capacitor in series:



Antenna Electrical Characteristics

- Because charge is accumulating at the ends of the antenna, there is capacitance at the feed point:
- $$C = \frac{1}{2 \pi f X_c}$$

where: C is the capacitance in Farads

f is the frequency

X_c is the capacitive reactance in ohms

Antenna Electrical Characteristics

- Because the electrical current creates a magnetic field, there is inductance at the feed point:
- $L = 2 \pi f X_L$

where: L is the inductance in Henrys

f is the frequency

X_L is the inductive reactance in ohms

Antenna Electrical Characteristics

- At resonance, $X_c = X_L$

- $$f = \frac{1}{2\pi\sqrt{LC}}$$

Antenna Electrical Characteristics

- Because the antenna is radiating energy, (and because the inductive reactance and capacitive reactance “cancel” each other), the antenna looks like a resistor at the feed point
- In free space, the value of that resistor is approximately 50 ohms

Power Dissipation

- Power Dissipation = I^2 x R
- Since I is highest in the center of the antenna, that is where most of the radiation is emitted
- An inverted Vee antenna puts the highest current portion high in the air (a ground mounted vertical puts the highest current at ground level!)

Resonant Antenna Length

- Formulas can be used to calculate the length of a half wave resonant antenna:

$$\text{Length in feet} = \frac{492}{f\ (\text{MHz})}$$

$$\text{Length in inches} = \frac{5904}{f\ (\text{MHz})}$$

Antenna "Modeling"

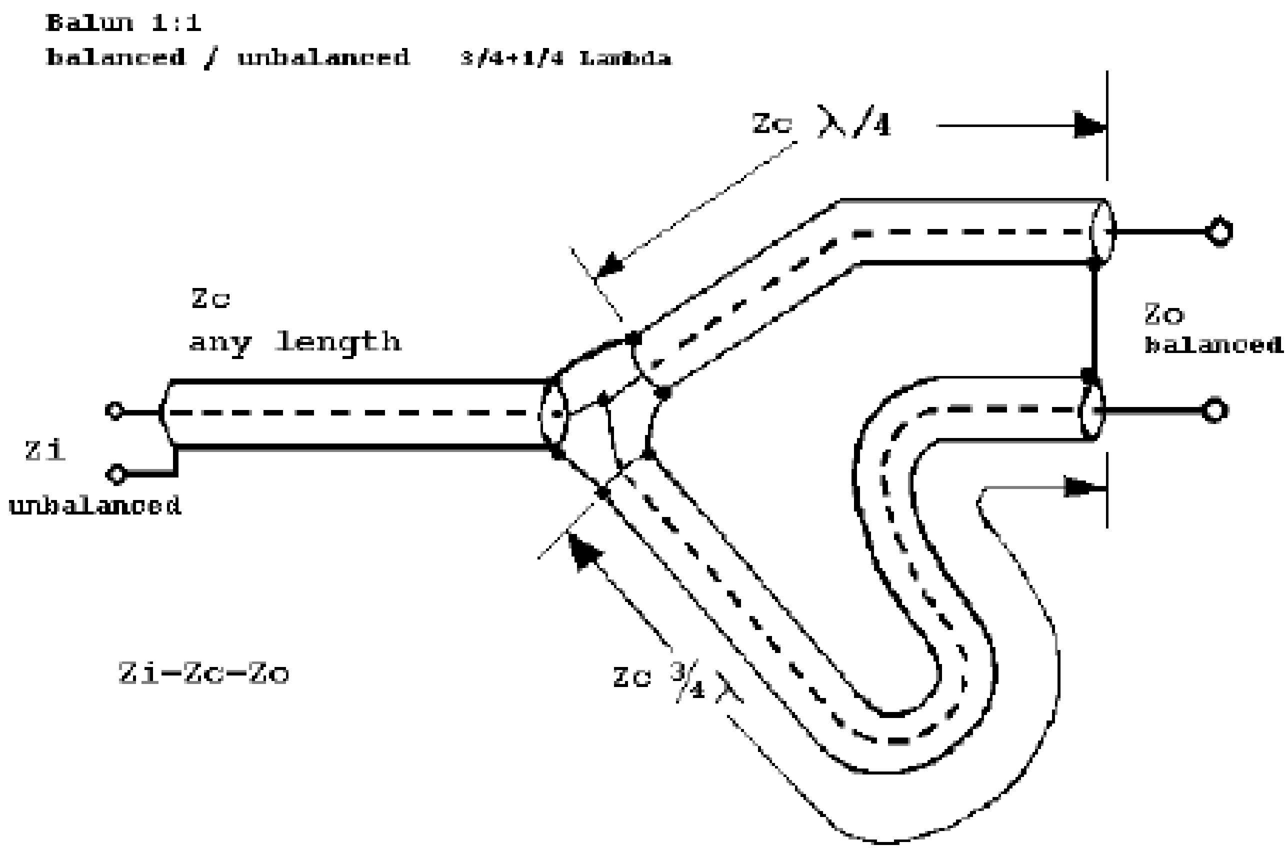
- X_L, X_C, Length, and 1/f are all directly proportional so they scale
- For example, take the dimensions of a 3 element 6m beam and multiply them by 5.
  - The new antenna will resonate at

    50 MHz/5 = 10 MHz
  - X_L will be 5 times higher
  - X_C will be 5 times higher
  - R will be about 50 ohms

Dipole Demonstration

- Experiments will be done at 146 MHz
  - $\lambda/4$ = 19 inches
  - Feed line is electrically $\lambda/2$ long = 31.9 inches
    (length = $\lambda/2$ * Velocity Factor (0.84))
  - Chosen so measured impedance equals antenna impedance
  - Using MFJ-269 Pro Antenna Analyzer
    - Giving SWR, Resonant Frequency, Reactance, and Resistance of the Antenna

1 to 1 Balun Design



Antenna Demonstrations

1. Demonstrate resistors (@ 14 MHz and 146 MHz)
   - 51 Ohms
   - 100 Ohms
   - 27 Ohms
2. Demonstrate R/L/C circuit
3. Demonstrate ¼ λ Vertical
   - Without balun
   - With balun
   - With Inductors on feed line

Antenna Demonstrations

4. Demonstrate ½ λ horizontal dipole

   (and Measurement of C and L)

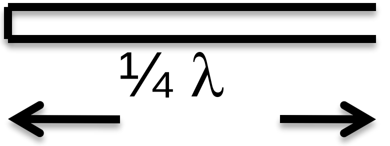
5. Demonstrate "top hat" horizontal dipole (2 hats)
   - Where is the high current?
   - Where is the radiation coming from?
6. Demonstrate "top hat" – ¼ λ horizontal monopole (1 hat)
   - Like a 2 meter HT?

Antenna Demonstrations

7. Demonstrate short ¼ λ vertical with "top hat"
8. Demonstrate ¾ λ – ¼ λ Dipole
9. Demonstrate ¾ λ – "top hat"

The ¼ Wave Stub

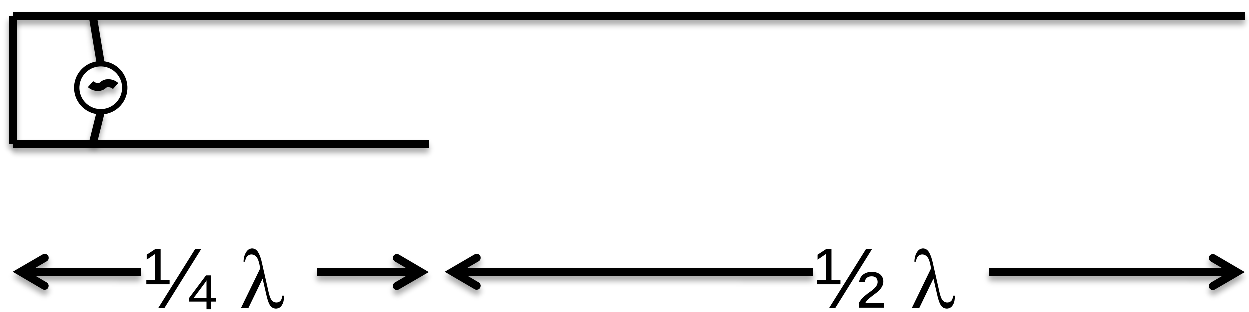
- ¼ λ Stub
  - Two parallel wires, shorted at one end
  - Looks like:



  - Electrically: It presents an open circuit (high impedance) for RF at frequency f (=c/λ) at the open end.
  - (Students: If the stub is open, what impedance does it present at the open end?)

Time to Think Outside the ☐ .

- Take the full wave antenna and fold it at the feed point:



- This is a half-wave antenna fed with a quarter wave stub.

Vertical Demonstration

10. Demonstrate ½ λ vertical (“J” pole)
11. Demonstrate non-resonant vertical
12. Demonstrate non-resonant vertical with a stub.
13. Demonstrate resonant 1 λ J-pole antenna with both ends grounded!
14. Demonstrate resonant ¾ λ J-pole antenna with both ends grounded!

Common Antennas

- One ¼ λ monopole fed against ground
- Two ¼ λ monopoles connected together (a ½ λ dipole, center fed)

Less Common Antennas

- Two ¼ λ monopoles connected together where one or both are shortened with (a) capacitive hat(s)
- One ¼ λ monopole with a capacitive hat fed against ground
- ¾ λ conductor with one end at ground potential (End fed ½ λ “J”-pole)
- A full wave conductor with both ends at ground potential!

Where's Waldo?

- Find the antennas in the following pictures

Light Pole

- 40 ft high
- Small capacitive hat
- Approximately ¾ λ on 20m
- Would probably also work on 17m, 15m, 12m and 10m
- Feed two poles for a phased array?


95 NORTH
Chester
Philadelphia
3/4 MILE
SOUTH

Light Pole on 202

- Maybe 25 ft including horizontal section
- Approximately ¾ λ on 12m
- Would probably also work on 10m

Traffic Sign + Supports

- Total length base to base: 300 ft
- Full wavelength on 80 m
- Would probably also work on 40m and 20m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Light Standard at Frawley Stadium

- Total height 130 ft
- Approximately ¾ λ on 40m (longish)
- Would probably also work on 30m and 20m

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21st.com
EXIT 6
M.L. King Jr Blvd
Fourth St
MUST EXIT
Delaware's bank.
Always has been. Always will be.
WSFS Bank

Billboard at Frawley Stadium

- Total height 60 ft, Great “top hat”
- Approximately ¾ λ on 40m (top hat would compensate for short length)
- Would probably also work on 30m and 20m

Power Poles Along Tracks

- Total length base to base: 300 ft
- Full wavelength on 80 m
- Would probably also work on 40m and 20m

So, What’s an Antenna?

Many things you never considered!!!