



AMATEUR ANTENNAS

THEORY, DESIGN, AND FABRICATION

WHAT IS AN ANTENNA?

- An electronic device that is used either for radiating electromagnetic energy into space or for collecting electromagnetic energy for space
- Any wire carrying AC current will radiate electromagnetic waves and an electromagnetic wave will induce a voltage in a length of wire

THE BASICS RIPPLES IN A POND

Ripples on a pond

- The waves radiate out from where the water was struck
- The algae on the pond only bobs up and down
- The water is only moving up and down.
- The part that raises the algae is called the crest
- The part that lowers the algae is called the trough
- The waves take a certain amount of time to travel across the pond
 - The velocity of the wave can be calculated by:

$$\text{Velocity} = \frac{\text{distance traveled}}{\text{required to travel the distance}}$$

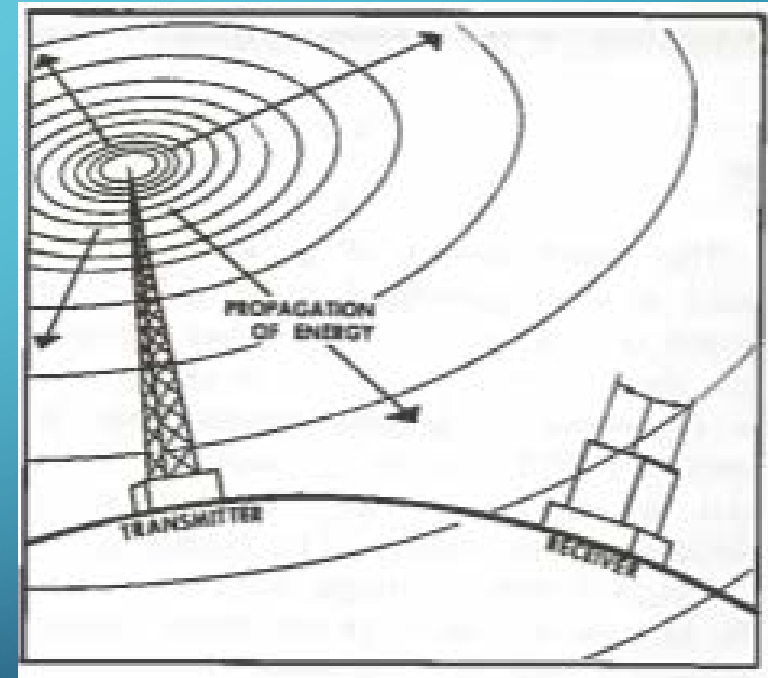
OR

$$v = \frac{d}{t}$$



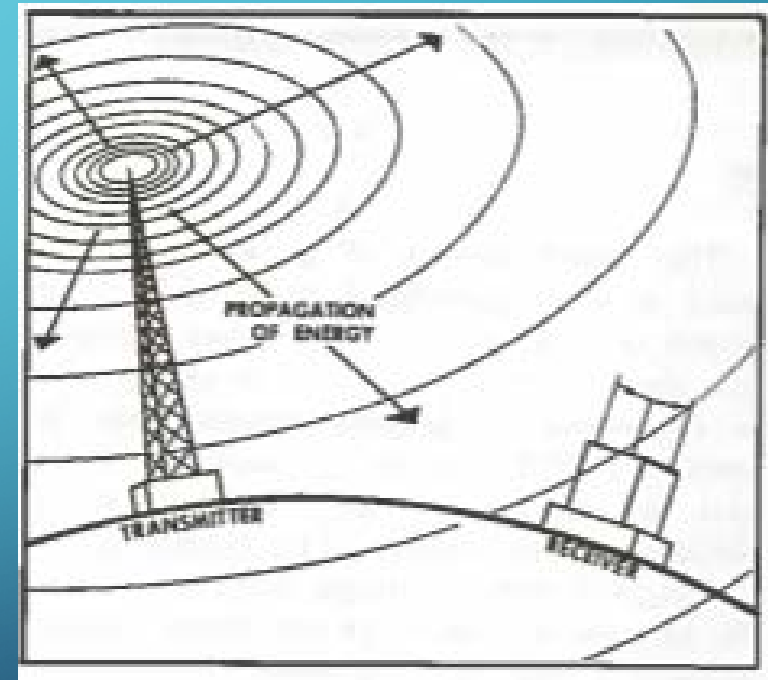
THE BASICS WAVES IN SPACE

- Electromagnetic waves are similar to the waves on the pond
- When the radio waves encounters something that it can act on it gives some of its energy to that device
- The velocity can also be measured and calculated
- Instead of total distance we measure from one crest to the next waves' crest—the wavelength
 - Measured in meters
 - The Greek letter lambda λ
 - SO: $V = \frac{\lambda}{T}$



THE BASICS WAVES IN SPACE

- The number of complete waves every second is the frequency
- The frequency is therefore the reciprocal of the period $T = \frac{1}{f}$
- So, $V = \frac{\lambda}{\frac{1}{f}}$ OR $V = f\lambda$
- V is a constant at 300,000,000 meters per second also known as the speed of light



THE BASICS

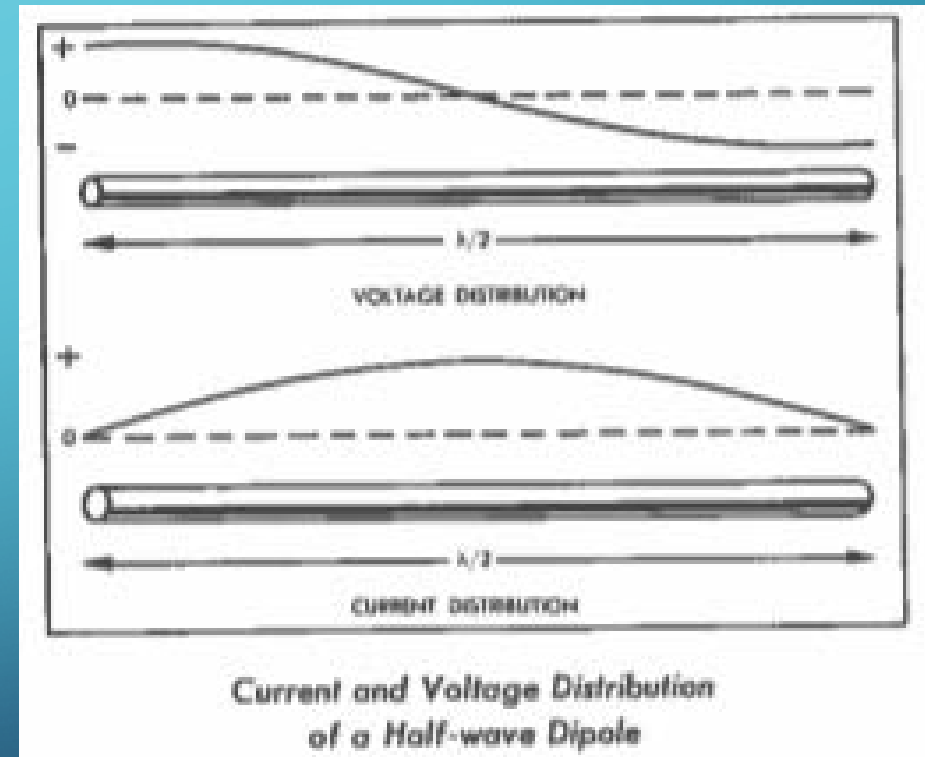
WHY DO WE CARE

- The equation $V = f\lambda$ can be rearranged to determine frequency and meters, or band.
- This is needed to construct a dipole.

THE DIPOLE

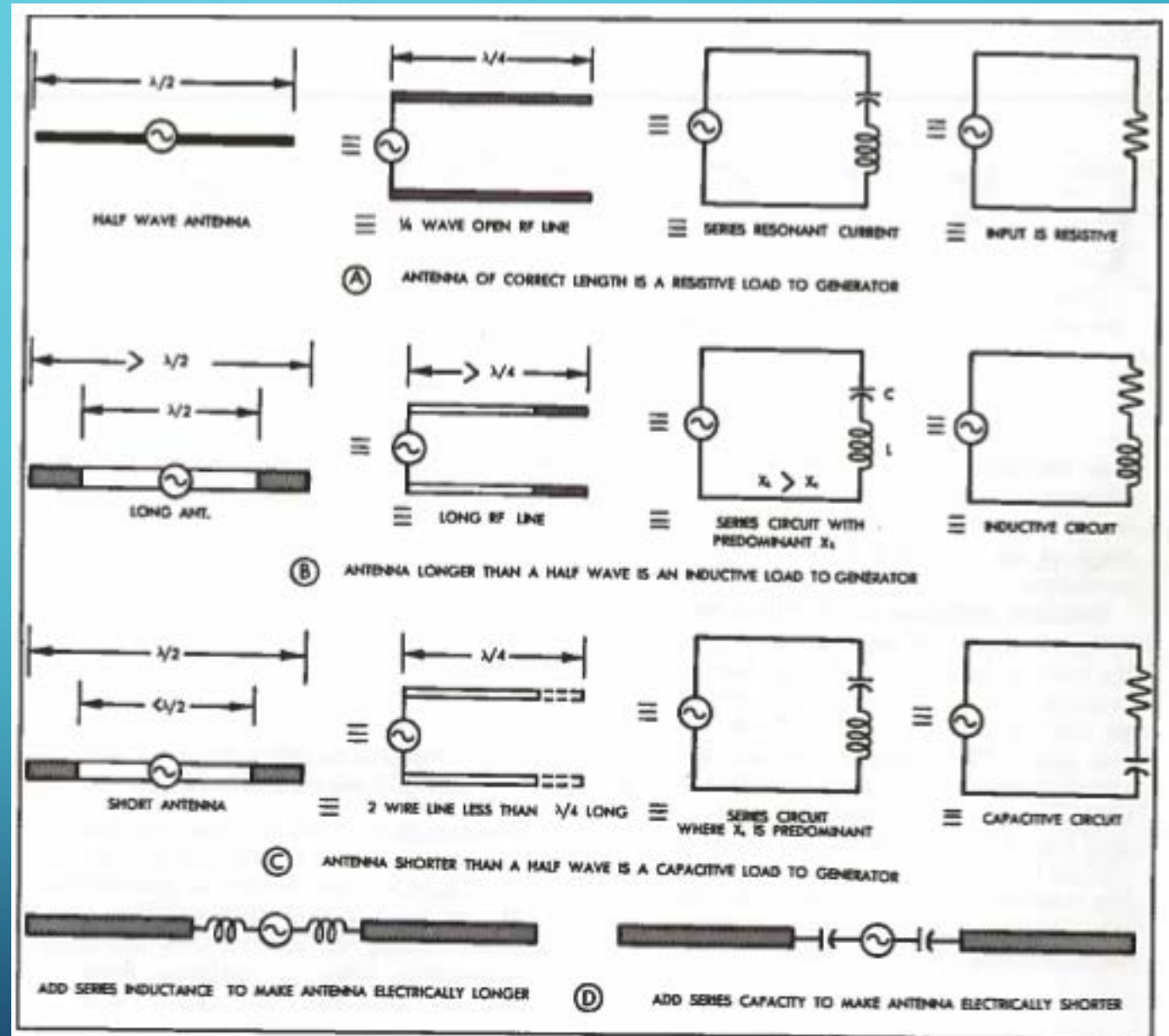
The key to a dipole is the endpoints. The voltage standing wave is high at the endpoints and low at the center whereas the current is low at the endpoints and high in the center.

The important thing to note is that the current and voltage peak $\frac{1}{4}$ wave off of each other.



IMPEDANCE AND CAPACITANCE

- An antenna of the correct length presents pure resistance to the source Line A
- A longer than $\frac{1}{2}$ wave presents an inductive load to the source Line B
- A shorter than $\frac{1}{2}$ wave presents a capacitive load to the source Line C



Effect of Length of Antenna on Impedance

TIME TO DESIGN AND BUILD!

- Questions:
 - What does the antenna need to do?
 - Is this for a permanent installation, mobile, or portable?
 - Do I need just one frequency or multiple?
 - What are the space constraints?
 - Where is it going to be installed?
 - Aesthetic requirements

“IMITATE UNTIL YOU CAN INNOVATE”

-KEVIN SMITH

- Has someone built an antenna that will work for your needs?
- Is there a guide that can walk you through the build?
 - RSGB Stealth Antennas
 - RSGB HF Antennas for Everyone
 - ARRL Antenna Book
 - ARRL Basic Antennas
 - ARRL Wire Antenna Classics
 - And many others
- Look around at what fellow hams have in the area
- Pictures on QRZ or the internet in general.

DESIGN

Whether you are designing your own from a blank page, following instructions from the ARRL Antenna Book, or duplicating a picture that you saw somewhere, start by drawing a diagram.

- It doesn't have to be to scale
- It doesn't have to use technically accurate symbols
- Its purpose is to help you understand what you are setting out to do.

PARTS

- Key Factors
 - What components do you have access to?
 - What tools are at your disposal?
 - What fabrication techniques are you comfortable with?

HELPFUL TOOLS

- PVC cutters
- Miter saw
- Drill press
- Torch and solder
- Wire strippers
- Drill (Cordless or corded)
- Drill Press
- Multimeter
- Antenna analyzer

COMPONENTS

- The plumbing section is your friend.
- Copper pipe makes for great antennas.
- PVC is a fantastic form for coils.
- The strange looks from the Menard's plumbing department when you tell them that you're building an antenna are priceless!
- Stick to copper, brass, aluminum, and stainless steel for hardware and radiators.
 - Steel has a high internal resistance that is less than ideal.

THE INVERTED V



- Simplest of my antennas
- It's a $\frac{1}{2}$ wave dipole supported in the center with the other ends anchored near the ground.
- The radiation pattern is Near Vertical. Which is why it is a Near Vertical Incident Skywave (NVIS) antenna
- These are good for communication with “nearby” stations.
- Mine is used for Indiana QSO Party (INQP) and Indiana State Parks on the Air (ISPOTA)
- Furthest contact on mine was near Rome, Italy on 40 meters.

MONOPOLE

- Nearly as simple as the Inverted V
- $\frac{3}{4}$ copper pipe cut into 4 foot sections with various length end pieces to allow it to be a $\frac{1}{4}$ wave on 40-10 meter bands (1 band at a time)
- A portable ground plane was constructed from toilet ring repair gaskets and tape measures
- Used mostly for INQP and INSPOTA due to high takeoff angles.



MICRO-VERT

- Components

- Capacitive Radiator

- Length (mm) calculated by $l_s = \frac{4700}{f}$
 - Capacitance calculated by $C_{pF} = 19.1 * l_s * \frac{1}{\log 0.575 * (\frac{l_s}{d})}$

- Reactance Coil (Loading Coil)

- Inductive reactance to compensate for the capacitive reactance
 - Inductance calculated by $L_{\mu H} = \frac{(\frac{159}{f})^2}{C_{pF}}$
 - More on that in a minute

- Counterpoise

- Acts as the “ground plane” for the antenna
 - Uses the antenna feed line in conjunction with an RF choke balun
 - Length (m) calculated by $l_r = \frac{58}{f}$



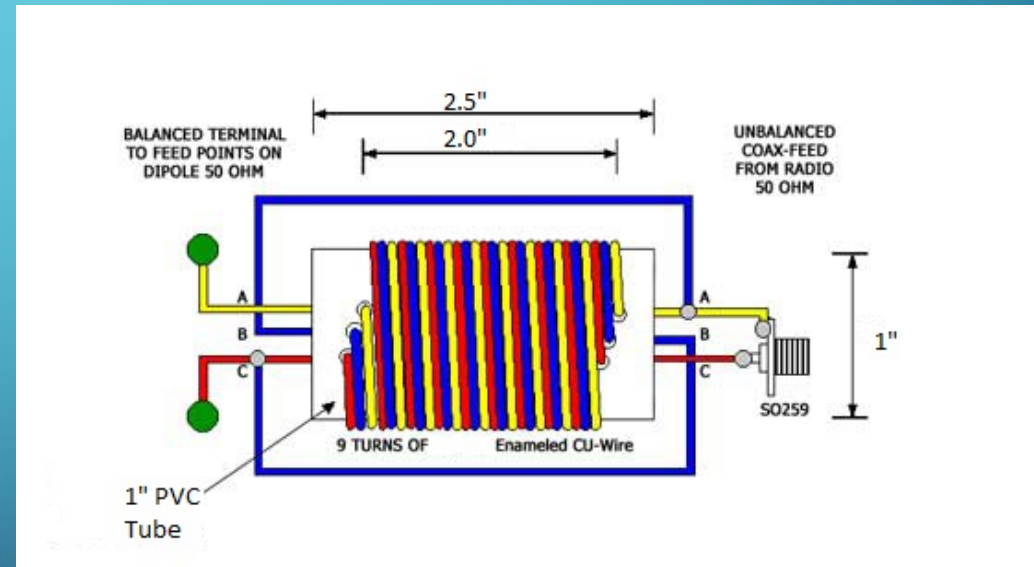
ISOTRON

- Components
 - Inductive coil
 - Large “Capture Area”
 - Large “Capture Area” as a counterpoise
- How to build it
 - Copy the commercially produced version
 - I’m still working on figuring out the math
 - According to isotronantennas.com
 - For an antenna to work, it should be electrically resonant. The ISOTRONS are electrically resonant by using only two components - the large coil in series with the capacitive plates of the antennas. (Match comes automatically with the right combination of the two components at resonance). There is more that is necessary for an efficient antenna. An antenna needs a certain amount of area to couple radiation to the atmosphere. Some call this the "Capture Area". However, this is an "AREA". This "area" can be any shape or form. The laws of physics for this phenomenon do not specify its appearance. THE ISOTRONS HAVE THIS RADIATION "AREA". The ISOTRONS exceed or equal (depending upon the model) the area of a conventional one-half wavelength dipole (#12 wire). In simple terms, we designed the ISOTRONS into a three dimensional package.



BALUNS

- Purpose
 - To connect a balanced antenna to an unbalanced line
- 1:1 Choke Balun
 - Not actually a Balun
 - Purpose is to eliminate RF currents from flowing on the outside of the coax
 - Presents a high impedance to the RF on the outside of the coax
 - Forces the current on each side of the coax to be equal
 - Simplest is the “ugly balun”
 - ~21 feet of coax coiled around a form
 - Size of form doesn't matter
 - The 1:1 Balun that I use is to the right.



BE MINDFUL OF THE ELEMENTS!



REFERENCES

- Straw, R. D. (ed.). (2009). *The ARRL antenna book* (21st ed.). Newington, CT: ARRL.
- ARRL. (1974). *The ARRL antenna book* (13th ed.). Newington, CT: ARRL.
- Myers, R. (ed.). (1975). *The radio amateurs handbook* (52nd ed.). Newington, CT: ARRL.
- Hallas, J. R. (2009). *Basic antennas: Understanding practical antennas and design*. Newington, CT: ARRL.
- Ford, S. (ed.). (2014). *ARRL's even more wire antenna classics* (vol. 3). Newington, CT: ARRL.
- Silver, H. W., Wilson, M. J. (eds.). (2010). *The ARRL handbook* (87th ed.). Newington, CT: ARRL.
- Dennison, M., Fielding, J. (eds.). (2011). *Radio communication handbook* (11th ed.). Bedford, UK: Radio Society of Great Britain.
- Read, G. (ed.). (2010). *HF antennas for everyone*. Bedford, UK: Radio Society of Great Britain.
- Nichols, S. (2010). *Stealth antennas*. Bedford, UK: Radio Society of Great Britain.
- US Air Force. (1963). *Fundamentals of electronics*. Washington, DC: US Government Printing Office.
- Bilal Company. (n.d.). *How do the isotrons work?* Retrieved from https://isotronantennas.com/index.php?main_page=page&id=3.
- Schaefer, J. (2001) *Progress in design of extremely short transmitting antennas*. AnteneX: Retrieved from <http://download.antennex.com/preview/archive4/Apr601/microvert.pdf>