Amateur Radio Antennas

Some Selected Introductory Topics

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NIARA Tech Session

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My 1st rig was a Heathkit Twoer

- It was an AM 2 meter transceiver
- Crystal controlled
- 5 watts
- This was a good way for a Novice class license holder to get started with voice communications

My 1st rig was a Heathkit Twoer

Quarter wave whip antenna

- Used for base station
- Whip was bent at about 60 degrees just above the connector
- Very basic and very cheap. One could be made from a coat hangar and connector with a little soldering

Quarter wave whip

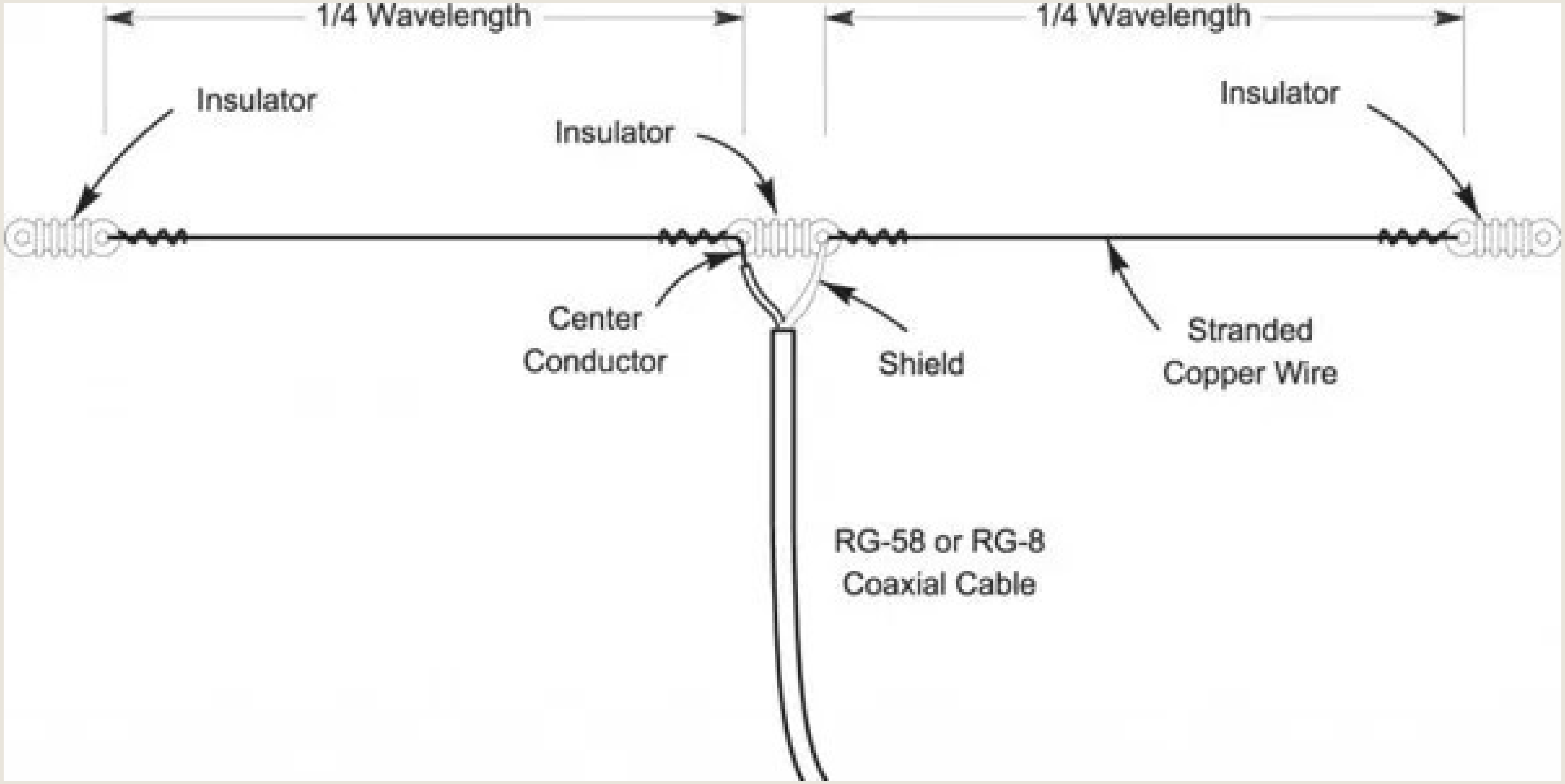
This type of antenna was used when I was at home.

Halo or horizontal loop for mobile

- The halo was mounted on a short pole with a bracket on the bottom edge which could be wedged into place with the car door closed.
- I threw it in the back seat of the car when not in use.

Halo or horizontal loop used mobile

I made and put up a 40 M dipole



WAVELENGTH

Wavelength = 300 / frequency in MHz

ƛ = wavelength

300 is a factor based on the speed of light (radio waves)

f = frequency in MHz

Speed of light (and radio waves) is:

299,792,458 M/s

Let's calculate the wavelength of 7.150 MHz

ƛ = 300 / f

300 / 7.150 = 41.96 M

From the drawing earlier, the branches of the dipole are ¼ wavelength

¼ X 41.96 = 10.49 M or 31.42 ft

Dipoles can be cut to a particular frequency by this approach

While the calculation is theoretically correct, in actual application the antenna would be a little long

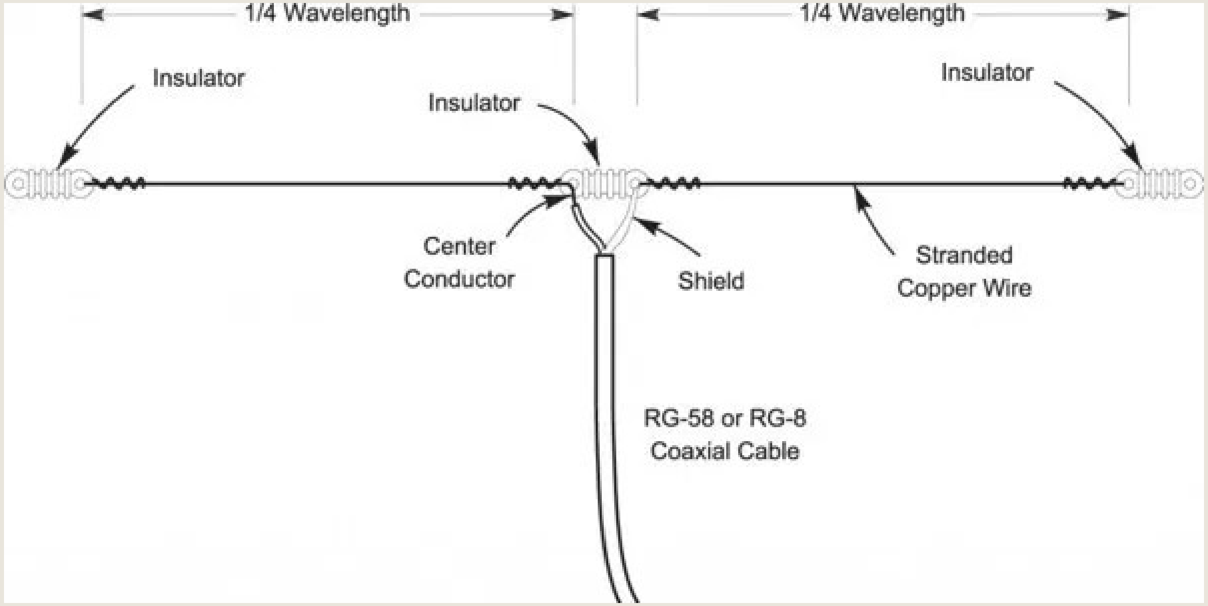
An actual antenna cut to frequency would be around 5% shorter

This 5% takes into account capacitive end effects and other factors

$$\lambda = 300 / f$$

As the frequency goes up, the wavelength goes down

Also as the frequency goes up the size of the antenna goes down as antenna designs are related to wavelength



A 40 M dipole will also work for 15 M (it is approximately 3/2 wavelength)

Solid or stranded wire will work

Typically #16 wire or larger is used (will handle high power)

Insulated wire can be used

SKIN EFFECT

The maximum power allowed a amateur operator is 1500 watts pep.

The signal rides on the surface of the conductor (AC).

The bigger the conductor the larger the surface area (and the lower the resistance)

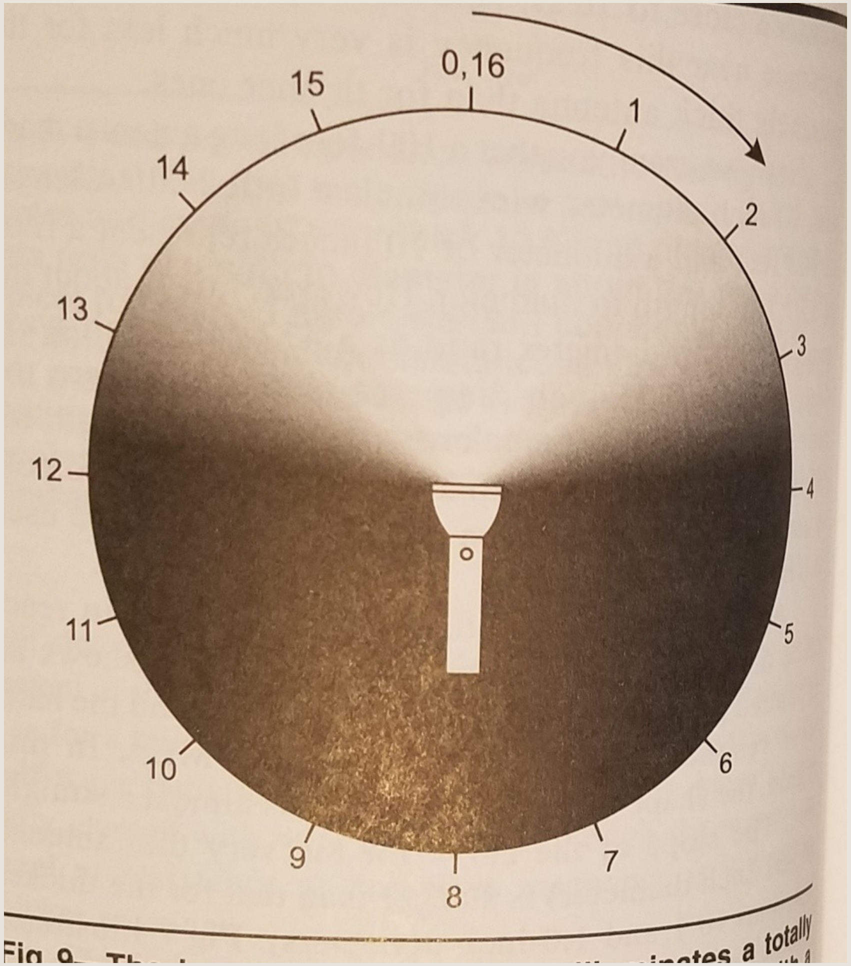
The skin depth decreases with with increasing frequency

SKIN EFFECT

The skin effect does not occur in direct current applications

In DC, the current is distributed throughout the cross section of the conductor

Flashlight illumination pattern



From The ARRL Antenna Handbook, 20th Edition

Flashlight pattern plotted on polar graph

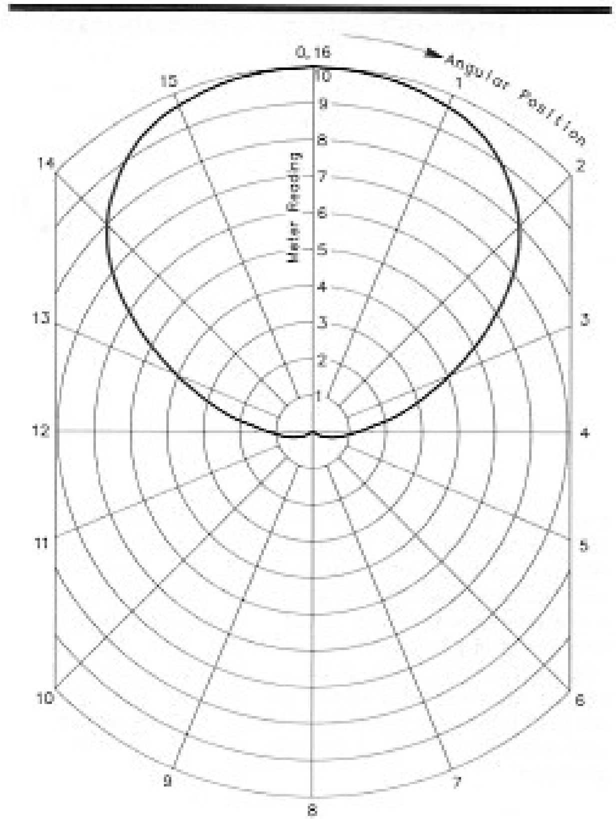
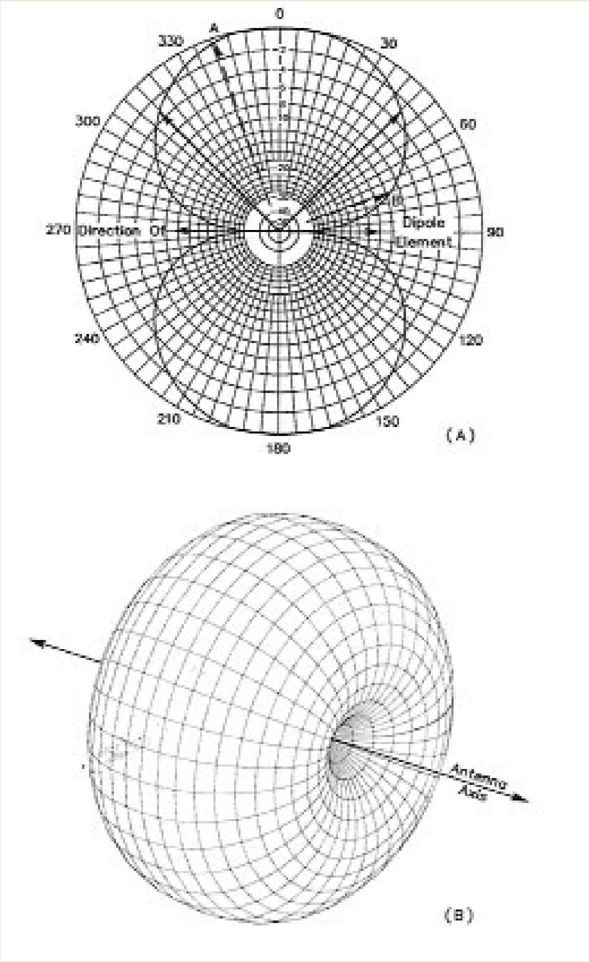


Fig 10—The radiation pattern of the flashlight in Fig 9. The measured values are plotted and connected with a smooth curve.

From The ARRL Antenna Handbook, 20th Edition

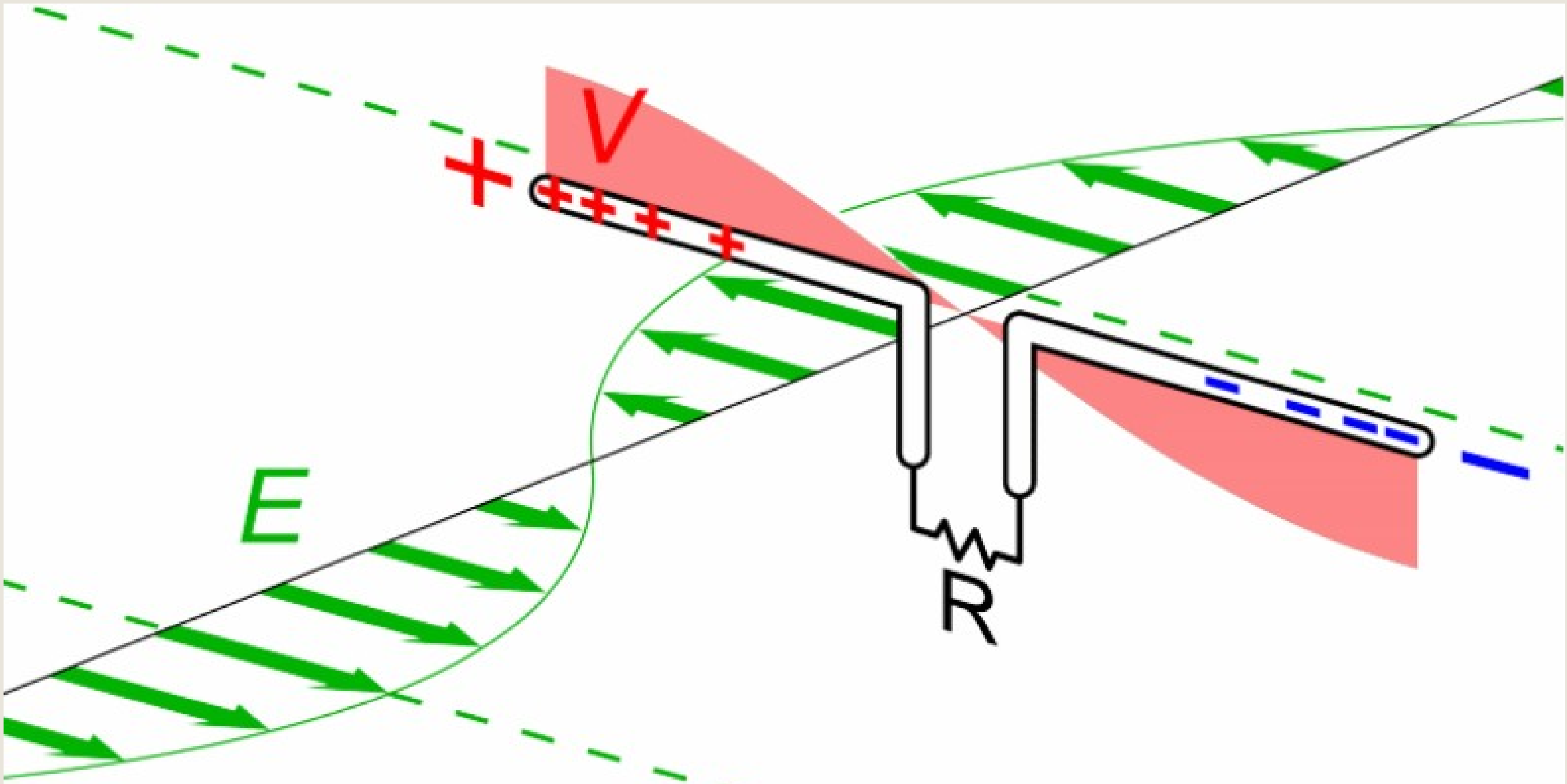
Theoretical dipole freespace radiation pattern



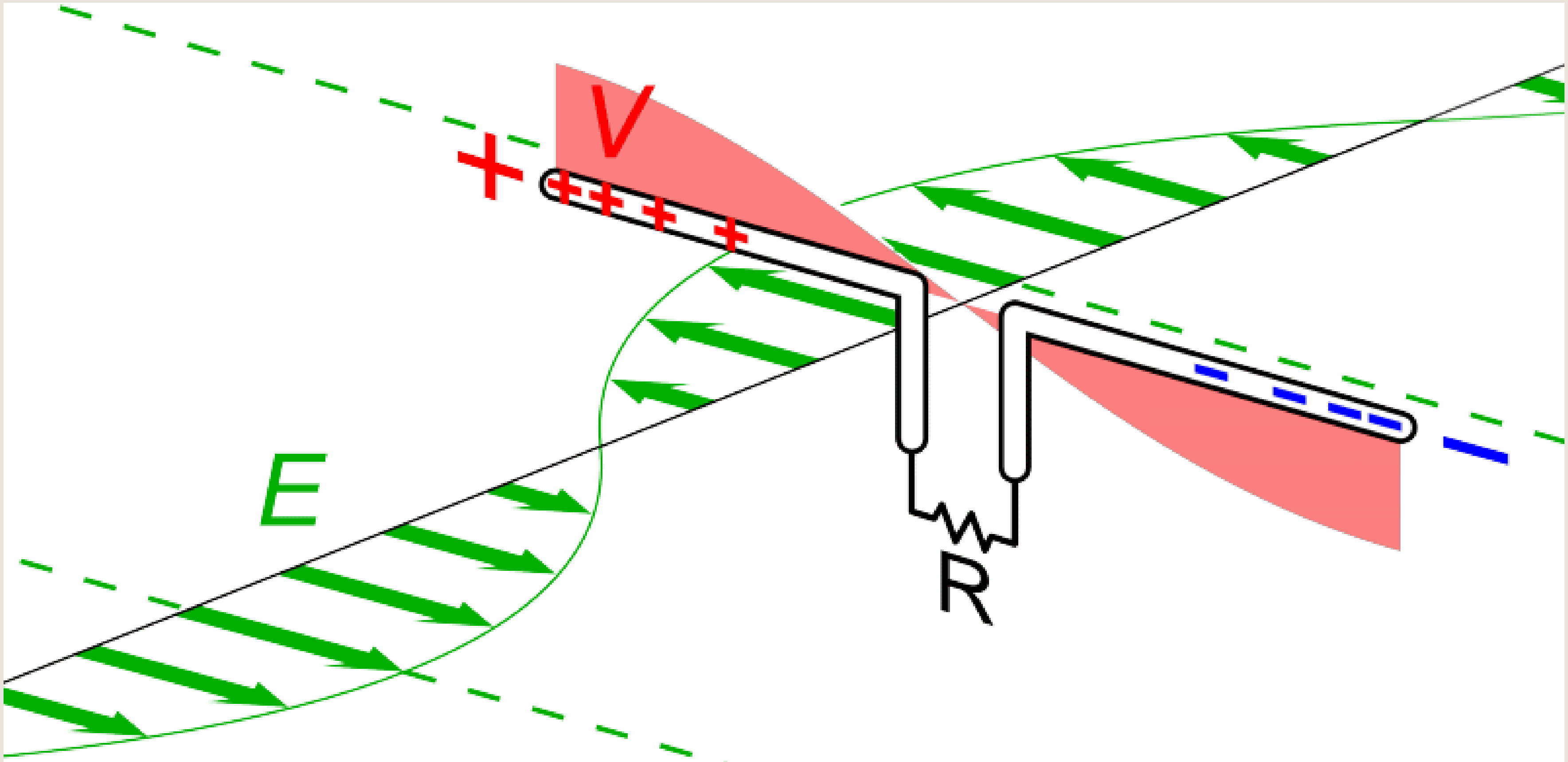
Greatest signal strength perpendicular to the dipole direction
Don’t forget the signal is 3-dimensional

- **The radiation pattern of the dipole varies with the height above the ground of the antenna**
- **Generally the higher the better for antennas**
- **The impedance of a dipole can change depending on its height**

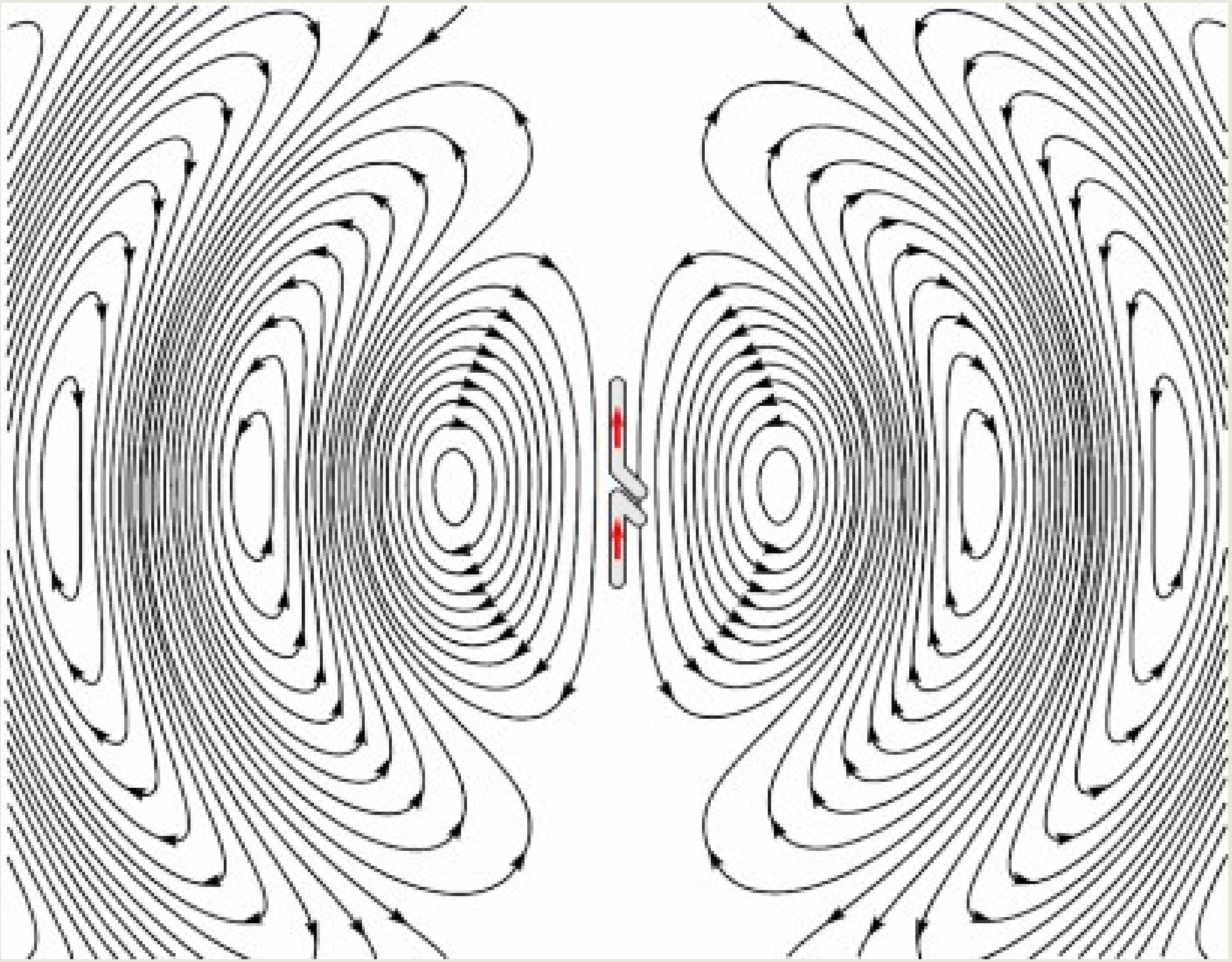
Dipole Receiving Signals



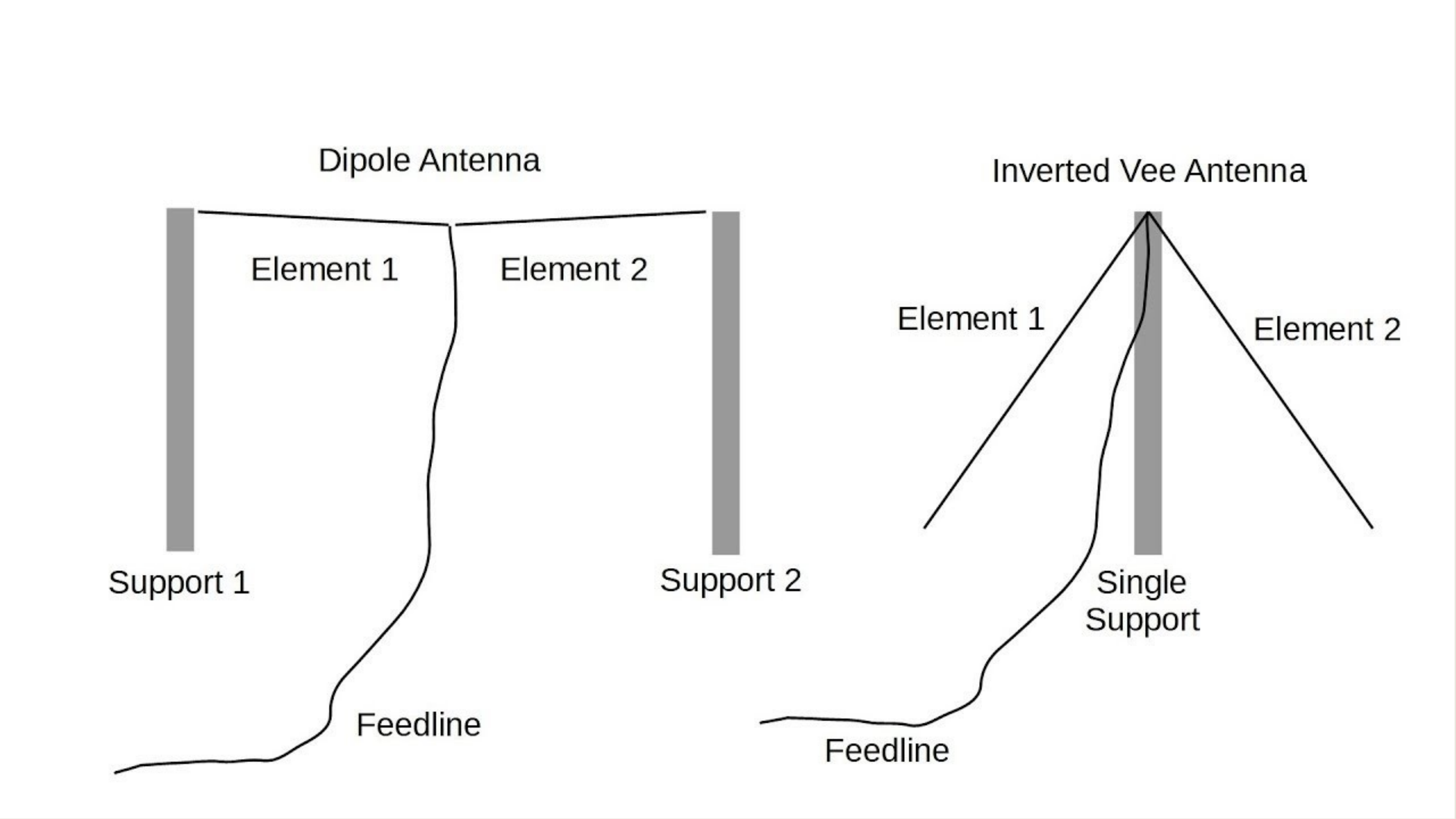
Dipole Receiving Signals Animation



Transmit Signals Through Dipole



Inverted V antenna



Biggest difference from a dipole is the way it is supported
Angle between Element 1 & 2 minimum is 60 degrees

Antenna Reciprocity

The electrical characteristics of an antenna such as radiation pattern (directionality) and resonant frequency are the same for an antenna sending signals or receiving signals.

Antenna Gain

- An antenna takes the power of the signal received from the transmitter through the transmission line and converts to radio waves

- Gain describes how well an antenna converts its inputs into radio waves in a particular direction

- Higher gains are associated with more directionality

Understanding the term deciBel

The term Bel is derived from the name of Alexander Graham Bell, inventor of the telephone. The unit deciBel (1/10 Bel) is used because a one decibel difference in loudness between two sounds is the smallest difference detectable by human hearing..

The deciBel (dB) originates from methods used to quantify signal loss in telegraph and telephone circuits.

Let’s get into antenna gain

To start, we need to some logarithm basics (base 10).

$10^{0.2}$=-3 (log of -3 is 0.2)

$10^{0.1}$=-1 (log of -1 is 0.1)

10^{0}=1 (log of 1 is 0)

10^{1}=10 (log of 10 is 1)

10^{2} =100 (log of 100 is 2)

10^{3}=1000 (log of 1000 is 3)

The Log can be calculated on many calculators by putting a number in and pushing the Log button.

Gain

Antenna gain is usually defined as the ratio of the power produced by an antenna in its strongest direction or main lobe compared to a reference antenna.

Two common reference antennas are the isotropic radiator and the dipole

dB gain and Gain are different

Isotropic Radiator

Isotropic radiator: theoretical point source of radiation which radiates equally in all directions

Isotropic radiators do not exist, only a theoretical concept

Antenna gain dB = 10 x $\log_{10}(G)$

Gain of Isotropic Antenna

Since the isotropic antenna is only theoretical, it is assigned a base value a follows:

The Gain “G” is 1

$$dB_i = 10 \times \log_{10}(G) = 10 \times \log_{10}(1) = 0$$

$$dB_i = 0$$

Calculate dB gain of an antenna compared to isotropic radiator

Antenna gain dBi = 10 x $\log_{10}(G)$

An antenna with a peak power gain of 5 over the isotropic radiator would have G (or Gain)=5

dBi = 10 x $\text{Log}_{10}(G)$ = 10 x 0.6989 = 6.989

Rounding off would take it to 7

The Log can be calculated on many calculators by putting a number in and pushing the Log button

Gain of ½ Wave Dipole

The dipole has some directionality, so the gain of a diplole is greater than that of the theoretical isotropic antenna

Dipole gain dB or $dB_d = 10 \times \log_{10}(G)$

The Gain of a diplole compared to the theoretical antenna is 1.64

Dipole dB_d – $10 \times \mathrm{Log}_{10}(1.64) = 2.15$

Dipole dB is often presented as dB but sometimes it is presented as dB_d

It is important when reviewing antennas to note do the specs say dB (dB_d) or dB_i.

The dB_d or dB of a dipole is 2.15

dB_i = 0

People selling antennas often use dB_i as it results in a bigger number making the antenna look better

If an antenna has a dBi gain of 5

It has a dB or dB_d gain of 2.85 (5 - 2.15)

Be careful when reviewing antennas to watch what “dB” is used in the specs

Example: Hy-Gain TH-3MK4

HF Beam Antenna Type: Yagi
HF Beam Antenna Band Coverage: 20, 15, 10 meters
HF Beam Antenna Elements: 3
HF Beam Element Material: Aluminum tubing
Antenna Power Rating: 1,500 W
Beam Antenna Boom Length: 14.00 ft.
HF Beam Antenna Boom Diameter (in.): 2.000 in.
HF Beam Antenna Longest Element: 27.42 ft.
Beam Antenna Turning Radius: 15.30 ft.
Effective Moment (approximate): 536 ft. lbs.
Mast Mounting Clamp Minimum: 1.875 in.
Mast Mounting Clamp Maximum: 2.500 in.
Wind Surface Area: 4.600 sq. ft.
Feedpoint Impedance: 50 ohm
Antenna Feedline Connection Type: Terminal studs, #10
Antenna Weight: 35.00 lbs.

Beam Antenna Gain: 8.0 dBi
Beam Antenna F/B (dB): 25.0 dB

Yagi Antenna

Also known as the Yagi-Uda antenna was developed in 1926 by Shintaro Uda and Hidetsuga Yagi

It is highly directional so its dBi and dB numbers will be relatively high

Yagi Antenna Example

My Hustler 5BTV

(omnidirectional) antenna)

5BTV – 80/40/20/15/10

60 radials connected to a base plate

The radials can be buried or just laid on the ground

Radials form a ground plane for the antenna

A ground plane is a conducting surface, connected to transmitters ground and serves as a reflecting surface for radio waves

Traps

Hustler 5BTV uses “traps”

Traps enable an antenna to cover multiple bands without changing the antenna mechanically

Traps pass all frequencies except the frequency it is designed to block or “trap”

Traps

Multiple traps in an antenna enable the antenna length to be changed based on the frequency input to the antenna

W9GOO’s station set up for digital modes

Since last October I have been using my station to make digital mode contacts using mostly psk31 and FT8 on 40 M, 20 M, 15 M, and 10 M using my vertical antenna

FT8 mode is accomplished by all operators using the same software, WSJT.

Signal reports are given in dB.

FT8 Signals

The WSJT software was developed originally for EME (earth-moon-earth) communications.

It is set up to detect weak signals

Each transmit/receive cycle is 15 seconds

There is a limit of 13 characters per cycle

FT8 signal occupies 50 hz

FT8 Signal Reports

FT8 signals range typically from -26 dB to +16 dB

The -dB signals are signals that are below the noise level

The + dB signals are above the noise

FT8 Signal Reports

Taking a sample of 100 actual contacts:

Received signals averaged: -3.32 dB

Sent signals averaged= -12.47 dB

My deficit on the average is -9.17 dB

I would really like to level the playing field

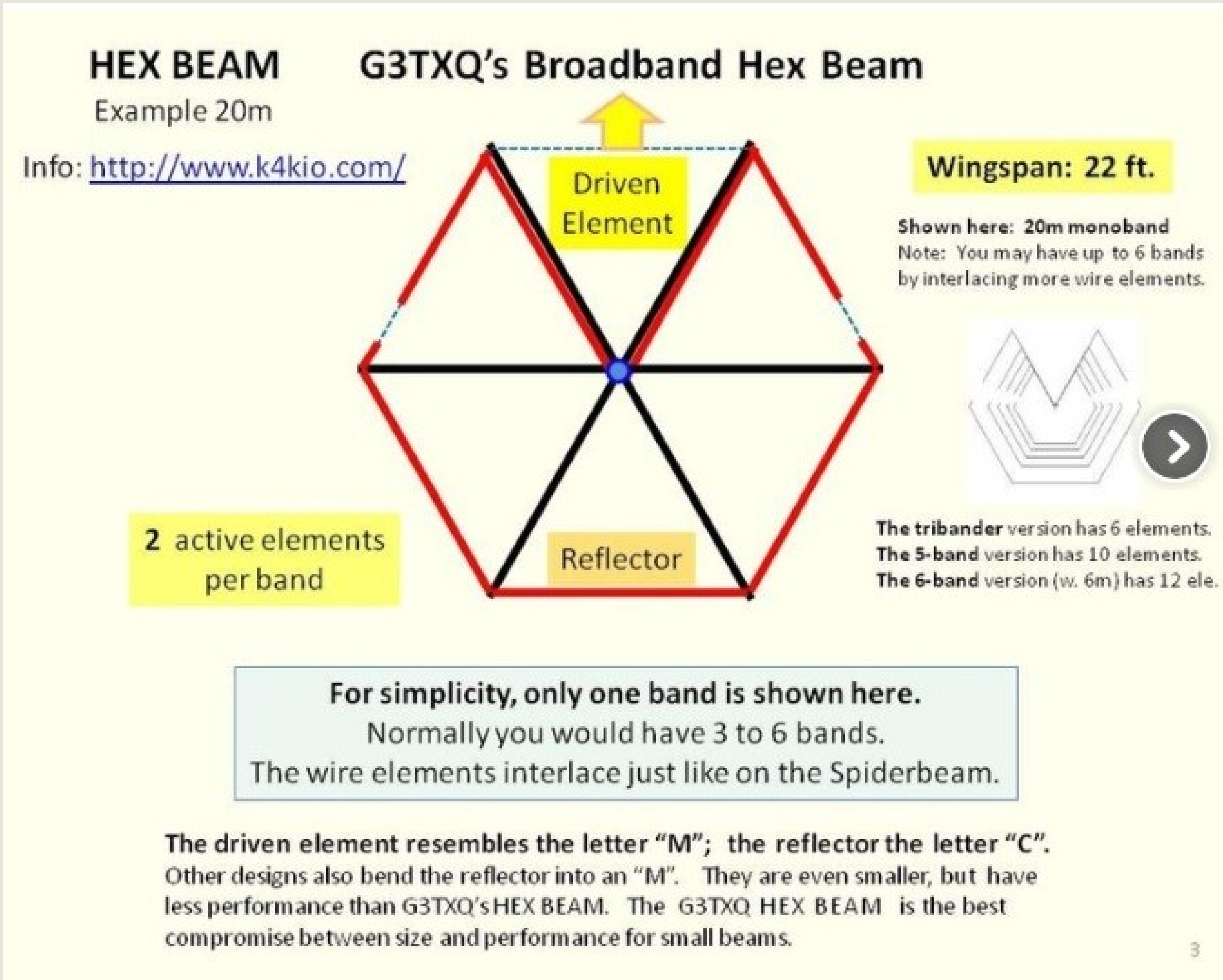
Using PSK31, many stations were contacted who exhibit strong signals and are using hexbeams

My Hustler vertical is a popular antenna of that style

I started to look into hexbeams

Hexbeam

From DJ0IP website



From DJ0IP website

PERFORMANCE	SPIDERBEAM			HEX BEAM		
BAND	# of Ele.	Gain dBi*	F/B	# of Ele.	Gain dBi*	Pk F/B
20m	3	6.7	14 - 20	2	5.5	26
17m	2	5.4	20 - 25	2	5.3	21
15m	3	6.9	20 - 25	2	4.7	17
12m	2	5.2	10 - 12	2	4.3	14
10m	4	7.1	18 - 22	2	4.9	14
6m	N/A	N/A	N/A	2	4.8	11
Comments	*Manufacturer's Published Gain Figures, Antenna in Free Space					
FEATURES	SPIDERBEAM			HEX BEAM		
Wingspan	10m / 33 ft.			6.6m / 21.6 ft.		
Turning Radius	5m / 16.5 ft.			3.3m / 10.8 ft.		
Wind Area	3.8 sq. ft.			6 sq. ft.		
Weight	Portable: 14 lbs. / HD: 23 lbs.			24 lbs. / Lightweight*: 13 lbs.		
Comments				* Using Spiderbeam Poles		

I have a 6 band K4KIO hexbeam in the garage to install

I plan to compare with the Hustler 5BTV

With the improved directionality I am expecting better results

ANTENNA TUNING

Today’s amateur transmitters are looking to see a resistive load of 50 ohms. The load being the combination of feedline and antenna.

When I started in amateur radio, we frequently started learning how to tune the tube technology transmitters with a dummy load. It is used today as a piece of testing equipment.

A dummy load is often a 50 ohm resistor immersed in oil or air cooled and designed for a range of frequencies and a maximum power level.

As the impedance from the feedline and antenna departs from the nominal 50 ohms, the greater this discrepancy, power loss of antenna output and the brick of transmitter damage increased.

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My Icom 746 Pro has a built in tuner. It will tune a VSWR of 3 or less.

Anything more than 3 it will not allow the transmitter to operate.

VSWR or SWR

VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio (SWR).

The minimum VSWR is 1.0

The closer to 1.0 the better

VSWR	Reflected Power %
1.0	0.0
2.0	4.0
3.0	25.0
4.0	30.9
5.0	36.0
10.0	66.9

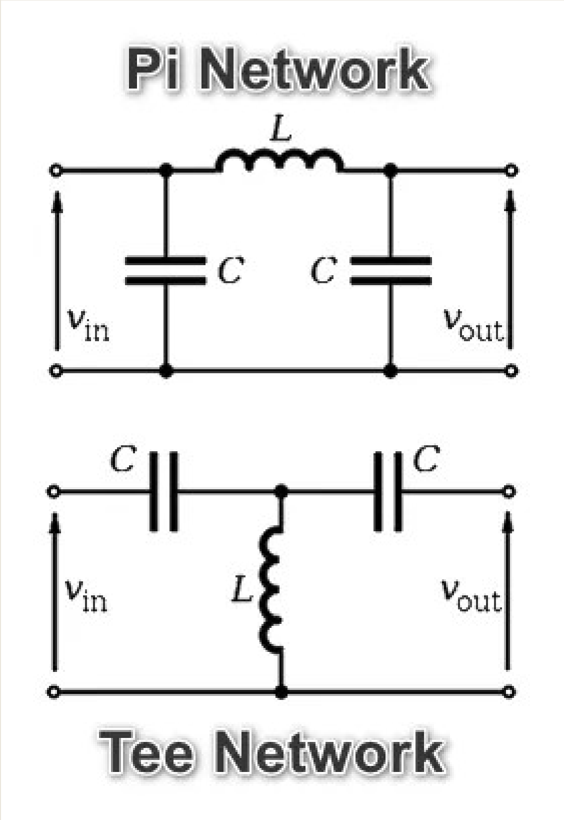
Antenna Tuning

Antenna tuners do not tune antennas

Antenna tuners match the impedance of feedline and antenna combinations when the antenna tuner is located at or near the transmitter

The ideal antenna tuner location is at the antenna.

Example antenna tuner circuits



These components would be variable in nature

Whenever possible it is better to have an antenna set up for the frequency that is to be used.

A dipole for 160 M would be about 260 ft long

Theoretically an antenna tuner could tune a 10 ft antenna to work for 160 M (make it look like 50 ohms)

Unfortunately the antenna would not be effective, it is still 10 ft

This is the 1st it what can be a series of presentations on antennas

This presentation was intended to be a starting point

Let us know the topics which there is interest in learning more about

Thank you