

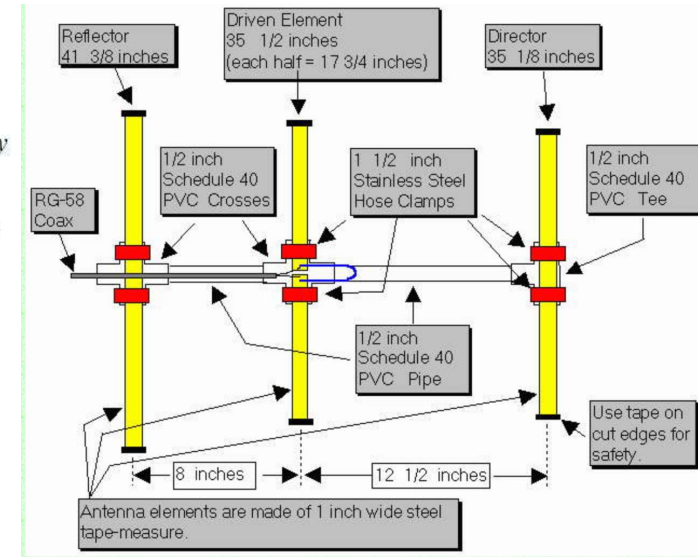
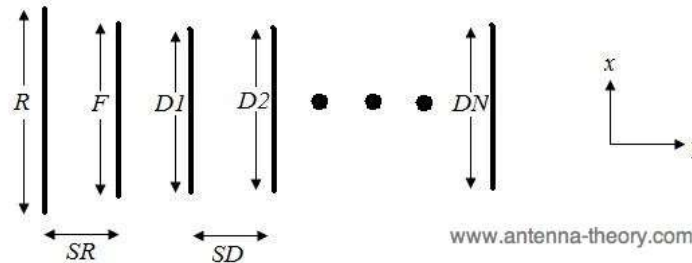
Stuff about Uda and Yagi



Things I've recently learned that hopefully will shed waves on YAGI antennas

Why use a Yagi-Uda (or not)

- Lightweight
- Simple to build
- Low-cost
- Unidirectional beam
 - (Front to back ratio measures this)
- Maybe nots...
 - Narrow bandwidth (narrower than a ham band)
 - Needs to be pointed
 - More complex than a dipole or vertical or other wire or loop antennas



History

- Prof S. Uda in Japan developed the concept by experimenting with different antenna spacings.
 - When? Early 1920s. Published 1926 Journal of I.E.E.
 - What frequency? 4.4m or 68Mhz
- Prof H. Yagi was a colleague of Uda and translated his work into English in 1928. Although acknowledging UDA, history often assigns credit to the last person to rediscover something.
- The work was recognized in the US as ground breaking in 1928
- Common TV antenna with a folded dipole
- Later, some folks thought YAGI was a code word

Yagi's seminal paper 1928

At that time
Ultra Short Waves
were
less than 10 m

BEAM TRANSMISSION OF ULTRA SHORT WAVES*

BY
HIDETSUGU YAGI

(College of Engineering, Tohoku Imperial University, Sendai, Japan)

Summary—Part I of this paper is devoted to a description of various experiments performed at wavelengths below 200 cm. Curves are given to show the effect of the earth and various types of inductively excited antennas called "wave directors." Part I is concluded with a discussion of beam and horizontally polarized radiation.

Part II is devoted chiefly to the magnetron tubes used for the production of very short wavelengths (as low as 12 cm.) and the circuit arrangements employed. It is shown that the geometry of the tube and its external connections are of great importance.

The effect of variation of plate voltage, magnetic field strength and other factors on the high-frequency output, is described.

INTRODUCTION

The general term "short wave" loses much of its lucidness when the range of frequency involved is considered. For this reason, the term "ultra short waves" will apply to only those electro-magnetic waves whose length is less than ten meters.

One of the simplest ways of generating short waves by means of vacuum tubes is to use the push-pull circuit developed by M. Mesny. This connection has been fully described by Mr. Englund in the PROCEEDINGS of the Institute.

Waves shorter than ten meters may be produced with stability, but it is difficult to make ordinary tubes operate

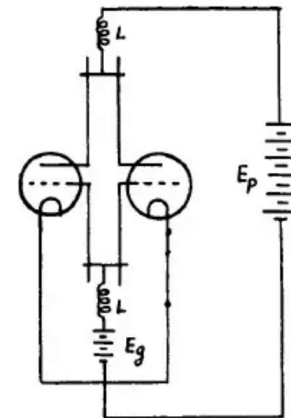


Fig. 1—Circuit Diagram of Oscillator; 60-200 cm.

Scheibe has reported a stable minimum of 30 cm. With somewhat less stability, he has produced waves 24 cm. long.

Yagi's seminal paper 1928 cont'd

satisfactorily below two meters. While electro-magnetic coupling is successfully used in the method referred to above, it seems much better to resort to electrostatic coupling in circuits used for the generation of waves of the length described in this paper. Fig. 1 shows a circuit which has been used in the generation of waves shorter than 100 cm.

Stable oscillations were successfully produced using ordinary tubes in this circuit. Such waves have been utilized to determine the natural frequencies of the various forms of metallic bodies. The characteristics of "wave directors," which will be fully described later in the paper, were thoroughly studied with the short waves produced using this type of generator. However, it was impossible to generate waves shorter than 60 cm. even with this circuit using electrostatic coupling within the tubes.

The method of Barkhausen and Kurz enables one to obtain much shorter waves. By this method, it was possible to reduce the minimum wavelength to 36 cm. using plate voltages in the order of 300 volts. Schafer and Merzkirch obtained waves of the order of 34 cm. with a plate voltage of 350 volts, and when the range of frequency involved is considered. For this

*Original Manuscript Received by the Institute, January 30, 1928; Revised Manuscript Received by the Institute, March 29, 1928. Presented before meetings of the Institute in New York, Washington and Hartford.

Reprinted from the *Proceedings of the Institute of Radio Engineers*, vol. 16, no. 6, pp. 715-741, June 1928. Copyright, 1928, by the Institute of Radio Engineers.

Mr. K. Okabe, assistant professor at the Tohoku Imperial University, has succeeded in generating exceedingly short, sustained waves by introducing certain modifications in the so-called magnetron. These waves are the shortest which it has been possible to generate so far as the author is aware. He was able to produce fairly strong radiation at a wavelength of 12 cm. and, by the use of harmonics, was able to obtain a minimum of 8 cm. The practical application of these ultra short waves will be dealt with in Part II of the paper.

PART I BEAM RADIATION FOR 4-METER WAVES

Mr. S. Uda, assistant professor at the Tohoku Imperial University, has published nine papers in the *Journal* of the I.E.E. of Japan on beam radiation at a wavelength of 4.4 meters. Several papers by Mr. Uda and the author have been presented at the Imperial Academy of Japan and the Third Pan-Pacific Science Congress held in Tokyo in 1926. In the following description, some of the much more notable points of the beam system used in this work will be explained. The photographs show some of the actual apparatus used.

Fig. WAVE REFLECTORS AND DIRECTORS

Suppose that a vertical antenna is radiating electro-magnetic waves in all directions. If a straight oscillating system, whether it be a metal rod of finite length or an antenna with capacities at both ends and an inductance at the middle, is

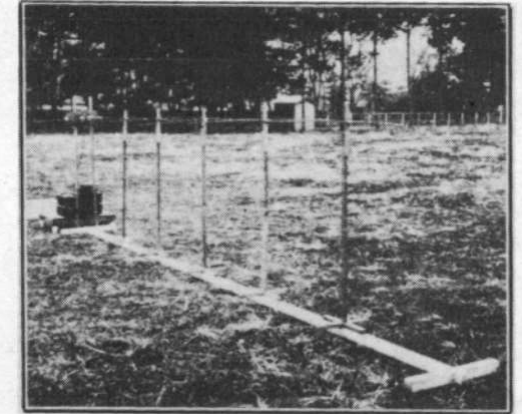
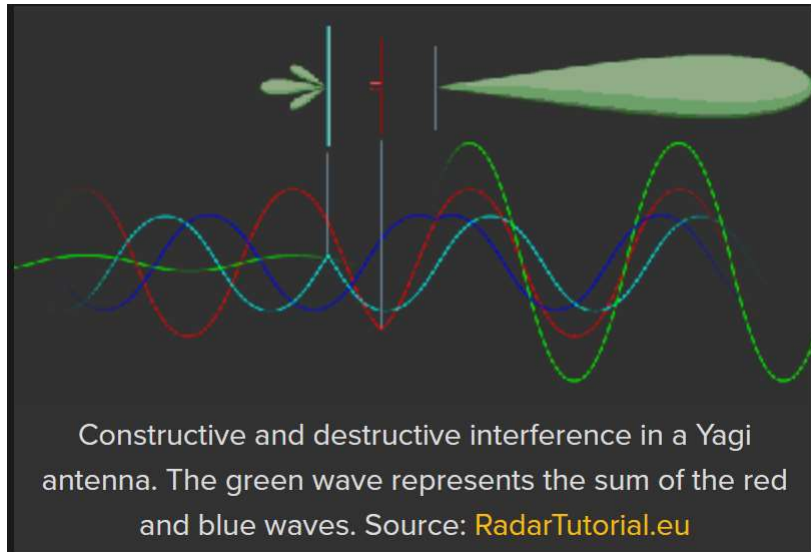


Fig. 19—Projector Horizontally Polarized Wave; 260 cm.

Uda's contributions

Wave action

- This site has a nice description on the Yagi-Uda
 - <https://hackaday.com/2017/05/24/on-point-the-yagi-antenna/>
- And a nice dynamic graphic from RadarTutorial.eu
 - https://hackaday.com/wp-content/uploads/2017/04/yagiexplanation_gesamt.gif



Summary of element effects

- Another link <http://jtecheng.com/?p=957>
 - Building a Yagi Antenna for UHF 42
 - 13 Jul, 2015 in Expertise / Sidetracks by lj
- *“The diameter of the elements is important. Larger diameters produce an antenna with a wider bandwidth; for a broadband receiving antenna this is a good thing. It makes the antenna less sensitive to one specific frequency and more able to see a broader range. Choosing bigger diameter material will also mean slightly shorter element lengths; also a good thing, as less overall length of material is required.”*
- Null in back is not discussed.

Summary of element effects (1)

- Reflector
 - Longer than driven element
 - One is enough
 - Spacing to the driven element has
 - little effect on forward gain BUT
 - a large effect on Front-to-Back ratio and input impedance
 - Useful for adjusting all but forward gain
 - Wavelength /4 or a bit longer than half the driven element length
 - For $f = 146.535$ MHz, this is 20.15"

Summary of element effects (2)

- Driven element
 - Really just a dipole ($\text{Wavelength} / 2 = 150 / (f \text{ in MHz})$)
 - $\text{Length in inches} = 5905.5 / (f \text{ in MHz})$
 - $\text{Length in feet} = 492.125 / (f \text{ in MHz})$
 - Typically made resonant (Resistive without Reactance)
 - **About 5% shorter or $5616 / (f \text{ in MHz})$**
 - Length and element radius has
 - a large effect backward gain and input impedance
 - small effect on forward gain
- Example for 146.535 MHz Wavelength or $80 \frac{3}{4}'' = 2.051\text{m}$
 - $\text{Wavelength} / 2 = 40 \frac{3}{8}''$ Typically resonant at about 5% shorter
 - $5616 / 146.535 = 38.325''$ or $38 + 5/16''$

Summary of element effects (3)

- Directors
 - Shorter than driven element by about 10% (0.4λ to 0.45λ)
 - Length and Spacing have
 - A large effect on everything: forward gain, backward gain and impedance
 - Are most critical to overall performance
 - Spacing typically 0.3λ to 0.4λ (about 25% less than length)
 - Spacing can be uniform but this is not optimal
 - NATIONAL BUREAU OF STANDARDS TECHNICAL NOTE 688 (December 1976)
 - Page 7 TABLE 1. OPTIMIZED LENGTHS OF PARASITIC ELEMENTS FOR YAGI ANTENNAS OF SIX DIFFERENT LENGTHS
 - <https://tf.nist.gov/general/pdf/451.pdf>

DESIGN Using YagiCAD

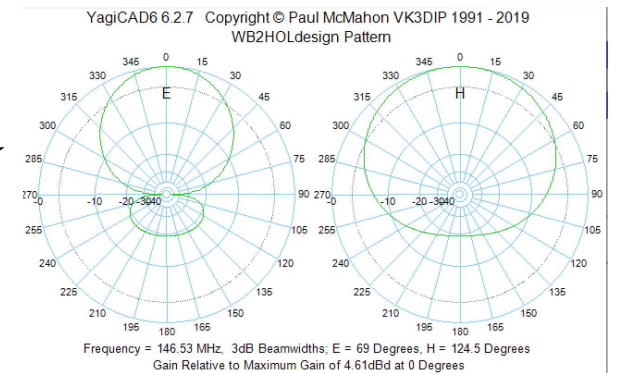
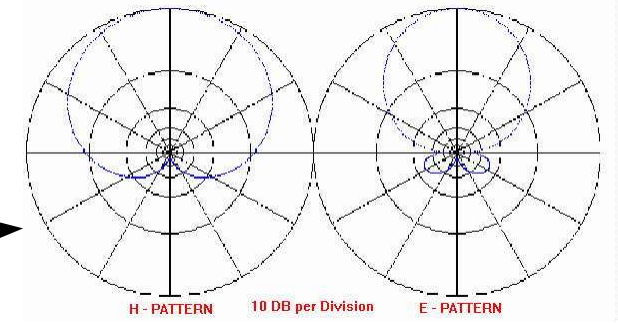
- YagiCAD by Paul McMahon VK3DIP
- <http://www.yagiacad.com/yagiacad/YagiCAD.htm>

- News and Releases – *USE ver 6.2.7 not 4.1*
- What is YagiCAD
 - -Yagiacad is a fully integrated analysis and design package primarily intended for VHF yagi aerials.
- WHAT YAGICAD WILL NOT DO - **WORTH READING**
- YagiCAD is FREEWARE
- History - *Really interesting stuff about version 4.1*
- Installing and Removing YagiCAD
- Screenshots
- Genetic Optimization In YagiCAD
- YagiCAD Tips, Tricks, and Examples
- Downloads

“Back in 1987 I wrote the first version of YagiCAD based on some earlier programs I had done for one of the pre IBM PC machines called a Microbee.. As this was pre-internet days I released YagiCAD via the medium that was available at the time which was Compuserve. There were several versions, up to the last one I did in 1991 which was YagiCAD version 4.2 (yes not 4.1).”

Null in the back discussion

- My analysis
 - A Null in the back is not guaranteed but possible
 - A Null is needed to get the desired fox hunt value
 - Many questions surface on the WB2HOL design that has been copied and documented in many places
 - http://theleggios.net/wb2hol/projects/rdf/tape_bm.htm
 - Yagi 4.1 is really old and not even an official release
 - Experimental data is sketchy
 - Yagi CAD 6.2.7 does not show a null. Even out of band. Impedance is capacitive though
 - A new design based on VK3DIP emails is being built and tested.



WB2HOL Yagi Cad 6.2.7 Setup

YagiCAD6 6.2.7 Copyright © Paul McMahon VK3DIP 1991 - 2019

File Edit Calculate Toolbox Help

Title: WB2HOLdesign Source: Web link

FILE: C:\Users\pfred\AppData\Local\YagiCAD6\WB2HOLdesign.YC6 LAST SAVED: 1/24/2020

Comments: As built in inches

Frequency: 146.525 MHz Gain: 4.61 dBd (cf 2.63) Z IN: 29.03 - J 92.56 OHMS Total NEC2 segs. = 63
F/B: 19.39 dB Eff: 100.0 % Total Loads = 0

All Dimensions in Inches

	Elem.	Position	Length	Diam.	Material	Type	Segs.
▶	R1	0	41.375	0.03937008	Lossless	Dipole	21
	Drv.	8	35.50008	0.03937008	Lossless	Dipole	21
	D1	20.50004	35.12504	0.03937008	Lossless	Dipole	21

YagiCAD6 VK3DIP Hairpin Match

Zline = 50.0 (Ohms)
Freq = 146.525 (MHz)
Diam = 0.0394

Diam rod
Za = 29.03 - J 92.56 OHMS

Space S = 1.575
Length L = 2.39
VSWR = 6.483
Suggested Antenna Reactance: -24.67288

Enter Required Values

Z in (Ohms): 50
Diam: 0.0393
Spacing: 1.5748

☐ Auto Adjust Driver

Adjust Driver for desired value

Match Type

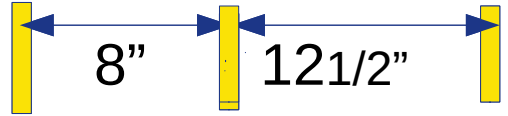
☐ Capacitor ☒ Hairpin ☐ Tee ☐ Omega ☐ Tee (No C)
☐ Inductor ☐ Folded ☐ Gamma ☐ Direct(None) ☐ Gamma (No C)

Hairpin Match - Hairpin LENGTH 2.39 SPACING 1.575 DIAM. 0.0394

New Design for 146.535 MHz with 5 foxes 30 KHz apart

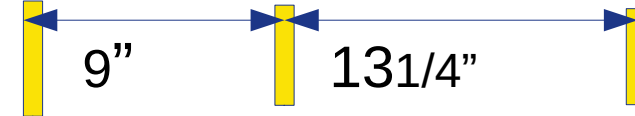
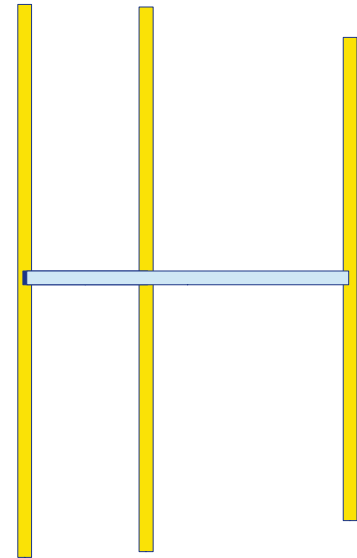
- VK3DIP redesigned it for 146Mhz with a null
- 5 numbers : 3 element lengths and 2 spacings

– WB2HOL : $41\frac{3}{8}"$ $35\frac{1}{2}"$ $35\frac{1}{8}"$
 – $8"$ $12\frac{1}{2}"$



- The null is narrow so I scaled it to 146.535

– K1YBE : $39\frac{3}{4}"$ $39\frac{1}{4}"$ $34\frac{3}{4}"$
 – $9"$ $13\frac{1}{4}"$
 – F/B 43.76 dB, $Z_{in} = 22.52 + j 29.24$ ohms

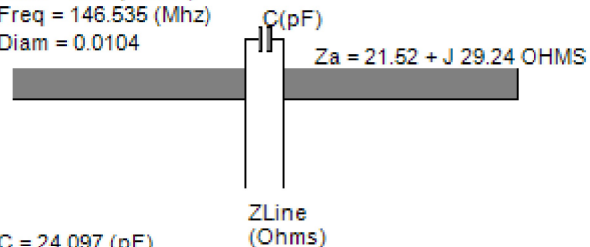
K1YBE design

YagiCAD6 VK3DIP Capacitor Match

Zline = 50.0 (Ohms)

Freq = 146.535 (Mhz)

Diam = 0.0104



C = 24.097 (pF)

VSWR = 1.225

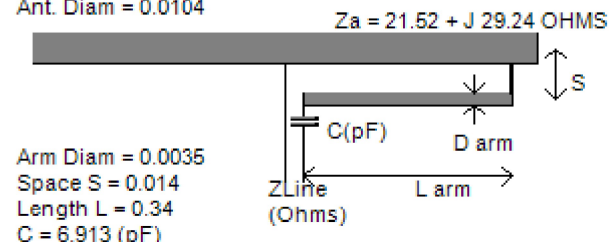
Suggested Antenna Reactance: 24.75619

YagiCAD6 VK3DIP Gamma Match

Zline = 50.0 (Ohms)

Freq = 146.535 (Mhz)

Ant. Diam = 0.0104



Arm Diam = 0.0035

Space S = 0.014

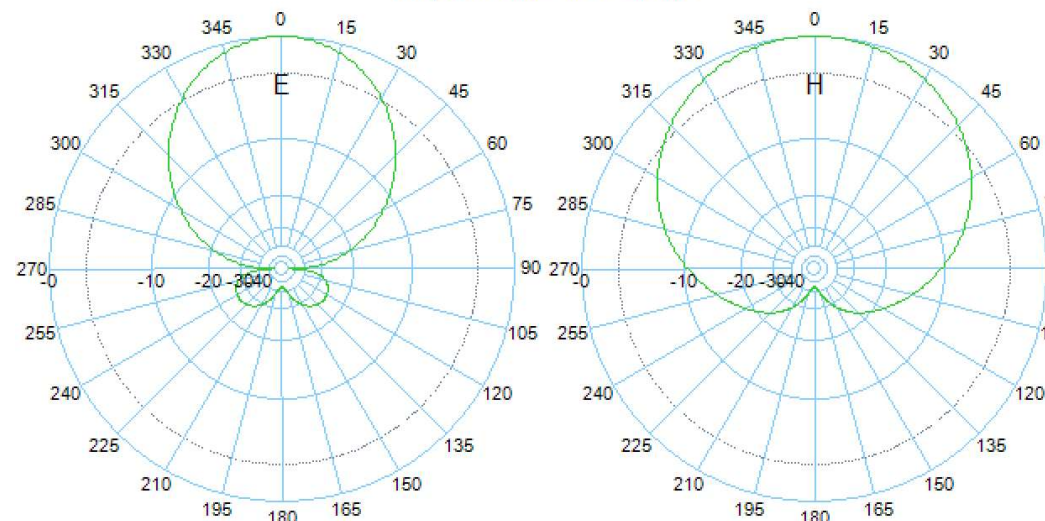
Length L = 0.34

C = 6.913 (pF)

<http://www.iw5edi.com/ham-radio/2925/the-gamma-match>

YagiCAD6 6.2.7 Copyright © Paul McMahon VK3DIP 1991 - 2019

Adjusted146545 Pattern

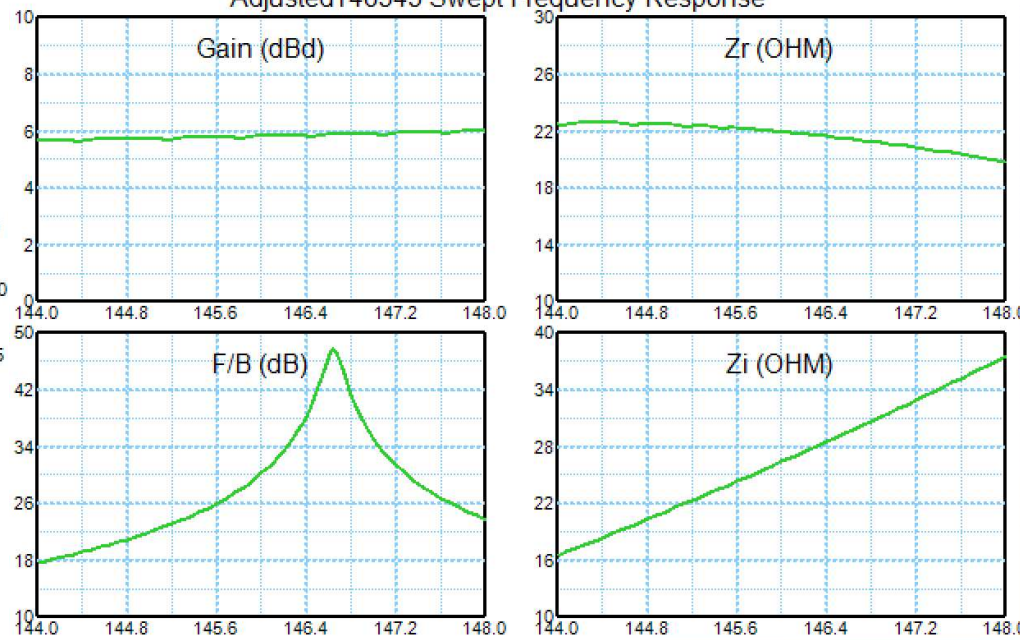


Frequency = 146.54 MHz, 3dB Beamwidths; E = 63 Degrees, H = 103.5 Degrees

Gain Relative to Maximum Gain of 5.86dBd at 0 Degrees

YagiCAD6 6.2.7 Copyright © Paul McMahon VK3DIP 1991 - 2019

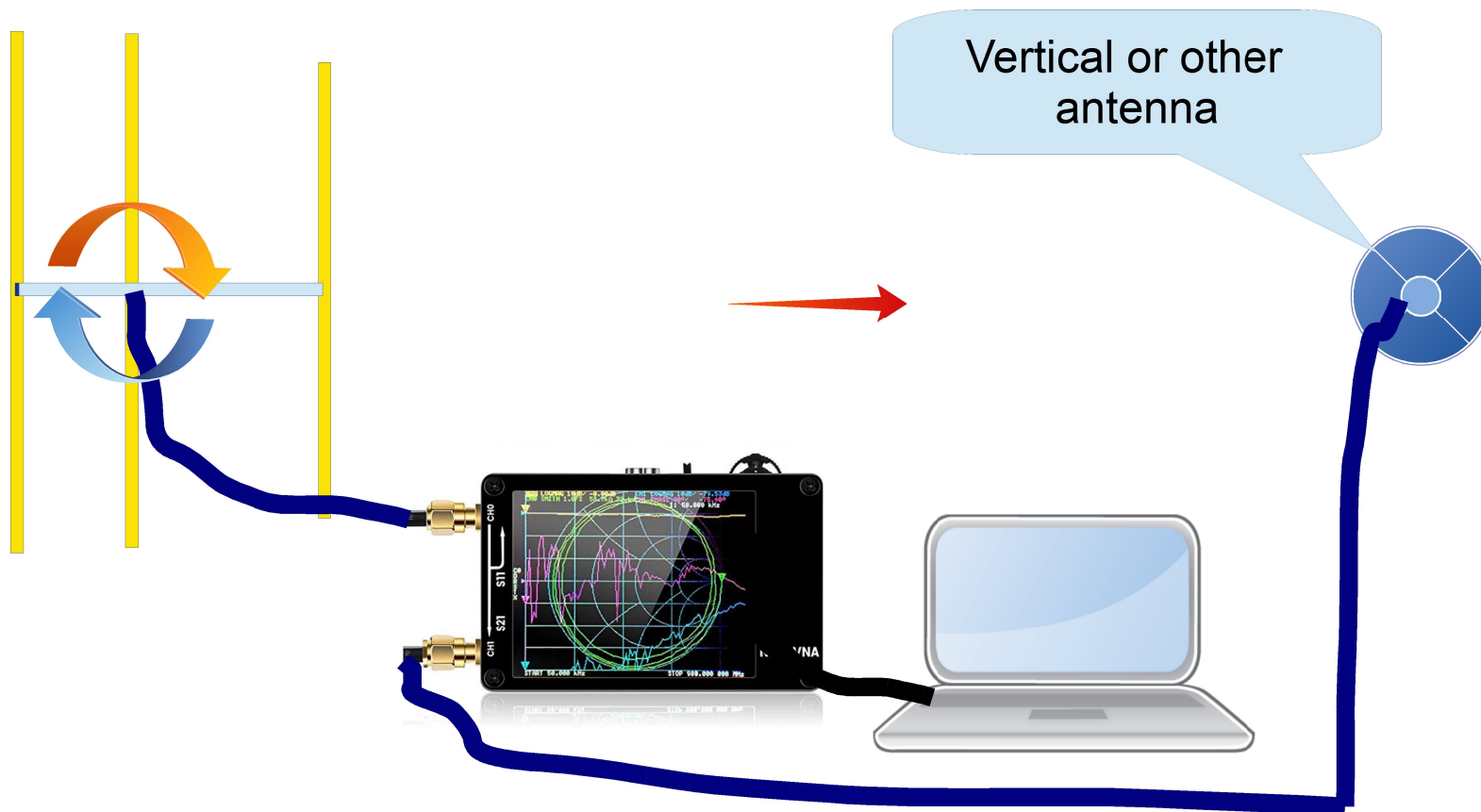
Adjusted146545 Swept Frequency Response



Gamma match issues

- Hairpin match won't work since $Z=21.52 + j29.24$ is inductive.
 - $R + jX$ (inductive) vs $R - jX$ (capacitive)
- Gamma match complicates folding the arm but gets Z to 50 ohms or $SWR = 1$ with a capacitor and inductor
- Capacitor only match gets to $SWR = 1.225$ and very simple to implement. e.g. a couple twisted insulated wires.
- An RG8 coax based Gamma match is intriguing and instructive. Video at <https://www.youtube.com/watch?v=fYrvEnshSzE> shows how starting at 8 min 30 sec.
- Next step. BUILD AND TEST IT

Measurement Demo with NanoVNA



Have fun.. It's a hobby



By the way..

***The forward end of a
tape-measure Yagi-Uda makes a great
2m antenna.***

For Fox hunting ..

don't forget to watch your back end.

K1YBE@yahoo.com