Building A 2 Meter Antenna

The Three Element Yagi-Uda

ABSTRACT
A Yagi-Uda antenna, or Yagi antenna, is a simple antenna designed to focus radio waves in a specific direction offering both high gain and selectivity. It consists of a Driven Element (commonly a dipole, J Pole or folded dipole) and parasitic elements – any number of Directors in front and a single Reflector in back, all of which are mounted on a central boom.

A favorite pastime of many amateur radio operators is building antennas. A vast field, exotic materials, and piles of expensive gear are not required. See the 1976 NIST NBS Tech Note 688 for everything there is on the subject of Yagi antennas.

The 2 meter Yagi antenna provides highly improved performance over a "rubber ducky" or mobile mag mount antenna. Mounting and testing the antenna are easy with common tools. Building the antenna helps the operator develop the skills necessary for building more advanced antennas.

In this document, the required materials are listed, the steps for building are described, and the testing of the final product is demonstrated. Components are inexpensive and readily available from several sources.

MATERIALS
Experimenting with antennas shouldn’t break the bank. Many common household items are easy to work with and radiate just fine. A common radiator is the wire clothes hanger. Typically hangers are made of of 12 to 14 gauge wire, with no real preference for this project.

PVC plumbing parts are strong, cheap, and readily available. The 1/2 inch PVC ‘cross’ connector will serve as the foundation of this antenna. 1/2 inch ‘tee’ connectors are used to mount the Director and Reflector. PVC is used for the boom and mast. A modified 1/2 ‘tee’ connector is used to attach the antenna boom to the mast.

Construction will be press-fit for the PVC and #10 1-1/2 inch pan head bolts to bind the wire to the PVC.

A ten foot length of ¾, or 1 inch schedule 40 PVC pipe will be used for the mast. (Cut it at 6 feet if needed to get it home.) Two boom sections, 16 inches each, are needed for this design. A four-foot section of iron rebar is used to stabilize the mast at home, in the field, or on the road.

All of these materials are available at Home Depot or Lowe’s.

DESIGN
The Internet offers many Yagi designs. The dusty, old, 1976 NIST document NBS 688 on Yagi-Uda antenna design boils down to a few simple rules:

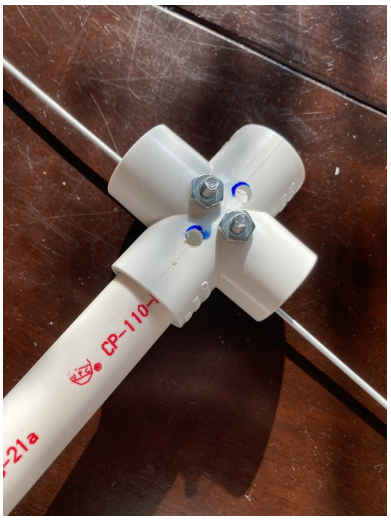
For our target of 146.94 mHz, we get a wavelength of 80.3 inches.

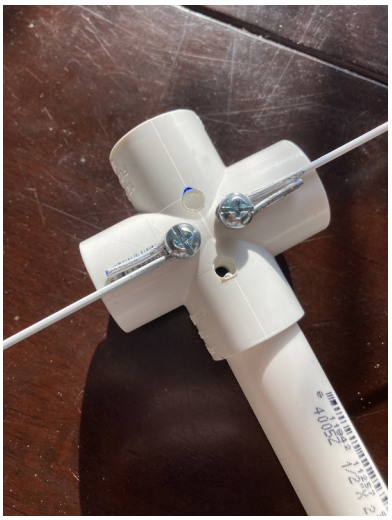
- All elements are 0.2 wavelengths apart, so 80.3 * 0.2 = 16 inches
- The Driven Element is ½ wavelength, so 80.3 * 0.5 = 40.15 inches
- The Reflector is +5% of the driven element, so 40.15 * 1.05 = 42.16 inches
- The Directors are -5% of the driven element, 40.15 * 0.95 = 38.14 inches
- Any extra Directors, as many as you want, are all equal length and spacing

CONSTRUCTION
The first step is to deconstruct the hanger. Clip just below the twisted area, as this is too hard to straighten. Unfold the hanger and straighten as best you can. This can result in a section over 40 inches long – enough for the elements. Cut the Driven Element in half to allow for tuning.

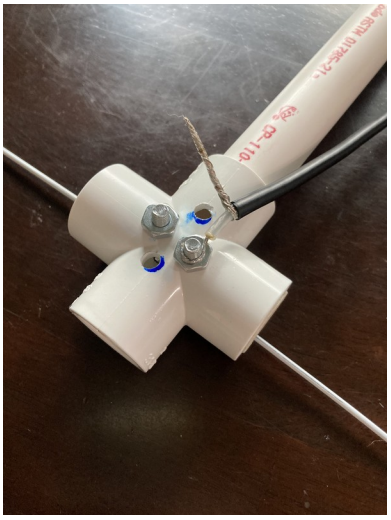
Loops are made at the ends of the wire. Bend back and then loop around. Wrap around a #10 bolt and form the loop with needle nose pliers. Be sure the remaining length is over 19 inches.

The wire sections will be attached to the PVC tee using #10 bolts and washers. Drill holes to fit the bolts. Be sure to sand or scrape the paint or lacquer off the wire to allow for a clean contact.



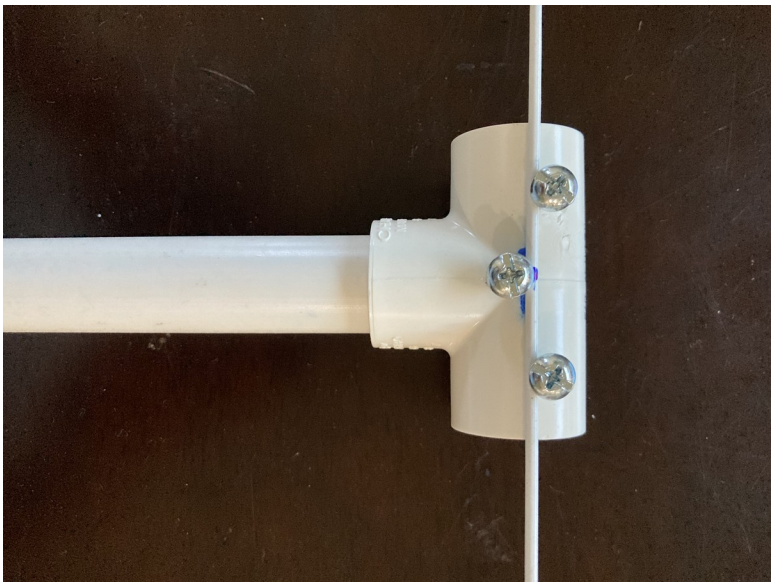


The feed line will be attached with a second pair of nuts. Strip and solder tin 1 inch from the end. Loop around the bolts and secure with nuts. Be sure to keep the two sections of the feed line from touching. Larger #10 ring terminals (to fit the bolts) may be attached to allow for reuse, easy break down, and storage.



The wire sections of the Director and Reflector will be attached to the PVC tee using #10 bolts. Drill holes in this clever offset pattern to fit the bolts. The tee will be a simple press fit onto the PVC boom.

Make one for the Reflector and one for the Director. These lengths are left long until the final tuning steps.



A simple vertical dipole is used as the core of the design. Remaining sections of the PVC pipe are used as boom elements. 1/2 inch tee connectors are used for both the Director and Reflector, and are mounted in the same manner as in the vertical dipole antenna.

Start the boom with the 1/2 inch tee with the Reflector at the end. Add 16 inches of PVC and add the Driven Element cross. Add 16 inches of PVC and add the tee with the Director element. Leave the PVC long until the final tuning steps.

MOUNT THE ANTENNA

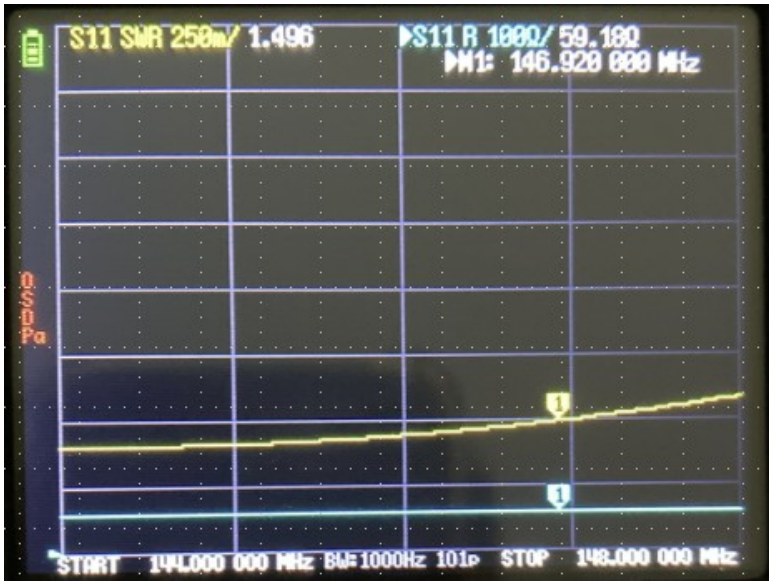
A 1/2 inch tee connector will be used to clip on to the horizontal mast.

Using a hacksaw, remove the ‘top’ of the long side as shown below. The goal is to remove less than half of the section. Not enough, and it is too hard to clip on. Too much and it won’t stay on. Trial and error is fine. The tee is then fitted to the mast for a finished mount.

Drive the rebar a foot or so into the ground (or a five-gallon bucket of sand for apartment dwellers). This will provide stability and height in a light-weight and easy-to-set-up and take-down solution. Slide the mast over the rebar and pull the feed coax back to the radio.

TESTING RESULTS

The length of the radiating element affects the SWR. We shall start with the match of the dipole Driven Element by itself. (Both elements of the dipole should be cut to the same length.)



The first reading shows SWR of 1:1.496 and impedance of 59 Ohms. Not bad. We see the SWR minimum is to the left of the markers. The driven element is too long.

Transforming a dipole into a Yagi antenna significantly affects its Standing Wave Ratio (SWR). The presence of these closely spaced conductors alters the electromagnetic fields, changing the antenna's impedance from the desired 50 ohms and necessitating tuning steps, such as adjusting element lengths, spacing, or adding an additional match structure to improve the match and reduce SWR.

Checking the SWR of the complete assembly shows values wildly different from the dipole alone.

A “hairpin” or “beta” match may be made from an 8 inch piece of insulated wire, folded into a ‘U’ shape, attached to the feed point. The hairpin's shape provides inductance, while shortening the driven element introduces capacitance. Together, they form a balanced matching network.

Good SWR for a Yagi antenna is generally considered to be below 2:1, with a target of 1.5:1 or lower for optimal performance. This is achieved by tuning the antenna's driven element length and the proportional element lengths.

Important note! Check the match of the dipole separately. Once you get the best match, measure the dipole. The Reflector is 1.05 times this amount, and the Director is 0.95 times this amount! The spacing of elements is (0.2 times (twice this amount)). (because, math)

FINAL THOUGHTS

The three element Yagi is an easy-to-build antenna with some quirks with tuning. Commonly available parts and simple construction techniques make this a good starter project. This antenna can provide significantly improved performance on handhelds and mobile radios over supplied antennas.

Differences in materials and feed line may influence SWR and impedance. Lengths of different antennas, as built, may be different. It is important to learn and use antenna tuning skills.