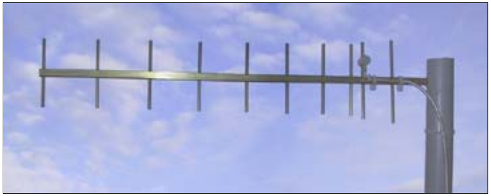
Building a 2.4ghz
10 element brass yagi

for wireless Ethernet application



What started as an experiment has now become an obsession. Like yourself, I also wanted to increase the distance of my 802.11b wireless ethernet. I don't really have any use for doing such a thing, but the curiosity was there. So I began researching this topic and found some very interesting ideas and creations out there. Such as increasing the power of the transceiver and building antennas out of a Pringles can. In fact I have tried to build some of these creations myself and have gotten some interesting results. But for one thing, I never really understood how most of these designs worked. For that matter, how to further increase it's performance.

The Brass Yagi project presented here was my attempt on pursuing that long distance 802.11b wireless ethernet. It is one of probably many more different projects that I will be building in the future, just to satisfy my curiosity. This Brass Yagi is based on an output generated from a GWBASIC software called ANTDL6WU which is based on the workings of Guenter Hock (DL6WU). A copy of which can be downloaded from here or here.

I had originally created this antenna using a coat hanger (see Hanger Yagi). Each of the elements were soldered to the boom that was made out of the same material and diameter as the elements itself. The problem with this is that the elements did not really stay in place. The elements were not fully secure on the boom, that when the antenna was accidentally dropped, the elements would break off. Imagine what a strong gust of wind could do to it. I guess it was the material of the coat hanger or the type of solder used was the cause of the problem. So I redesigned it using different materials. This time I used brass as materials.

Why brass you say? I had thought of using aluminum, like most antennas are made from, but I can only think of one easy way to attach the elements to the boom. That is to spot weld it. I am now in the process of saving money for a good cheap welder. In the mean time I'll use what is available to me.

The brass material was an alternative to aluminum since soldering lead to it was possible. I used a 7/32" hollow Square Brass Tube as the boom and a 3/32" Brass Round Tube as elements. I then inserted and soldered wire solder through the hollow opening of the boom to secure the elements.

A majority of the tools and materials used for this project can easily be obtained from many home improvement stores. Some special tools like a rotary tool and a drill press is suggested and recommended, but I'm sure you'll find a way around this.

Well, enjoy this little project and please let me know how yours went.

Tools Required

Safety Glasses
12” Straight Edge Ruler
Vernier or Dial Caliper (optional)
Drill Press (recommended) or Hand Drill
Rotary Tool with Cutting Disc (recommended) or hacksaw
Propane Torch
Hot Melt Glue Gun
Soldering Iron
Side Cutter or Wire Cutter
Sand Paper/Emery Cloth
Painters Tape (optional)

Parts Required

7/32" x 1' Brass Square Tube
3/32" x 3' Brass Round Tube
Wire Solder
9/32 x 4” Hot Melt Glue Stick
1' RG-172 coaxial cable

Building the Yagi

1. Clean brass pipes.

Clean both brass tubes of any dirt like corrosion or label adhesive. Some paint thinner or varsol may help for this procedure. You may also use some fine sand paper or emery cloth for those hard to remove dirt.

2. Mark the drill points on the boom. (See ANTDL6WU report for detailed information)

Use the following suggested procedure for marking the drill points.

A. Lineup the tip of the 7/32" x 1' Brass Square Tube at 278.11mm on a straight edge ruler (276.11mm for the director 8 element plus 2mm to space it from the tip of the square tube).

B. Mark the following values on the Square Tube.

Director 8	276.11mm
Director 7	235.47mm
Director 6	196.55mm
Director 5	159.47mm
Director 4	124.97mm
Director 3	94.03mm
Director 2	67.51mm
Director 1	45.41mm
Driver (Folded Dipole)	35.71mm
Reflector	13.00mm

This should leave approximately 26.69mm after the reflector element. This should be enough space for a bracket or harness to mount the yagi.


3. Drill the mark points on the boom.

Use a 7/32 drill bit on a drill press and drill through all the mark points on the square tube. Drill all the way through the square tube creating two holes (one on each side of the pipe).

NOTE: I would strongly suggest not to free hand the drill points using a hand drill unless you have a good sturdy hands. The idea is to make the holes precisely right to have the elements tightly fit on the hole. This will make it a lot easier to center the elements during assembly.



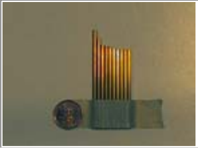
4. Mark and cut the elements. (See ANTDL6WU report for detailed information)

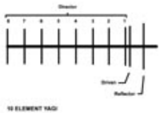
Using the 3/32" x 3' Brass Round Tube and a ruler. Mark and cut the brass pipe using the following values.

Reflector	63.48mm
Driver (Folded Dipole)	58.07mm
Director 1	54.77mm
Director 2	53.87mm
Director 3	52.75mm
Director 4	51.86mm
Director 5	51.42mm
Director 6	50.98mm
Director 7	50.54mm
Director 8	50.54mm

Measure and cut one element at a time. Start from the longest element (reflector) to the smallest (director 8). This ensures that in the event that the element is undercut, the element can still be use for the next element size down.

Use a file or the top side of the rotary tools cutting disc to fine cut the elements to the right size. You can also use a caliper to measure the elements to the precise size or just simply eyeball it using a straight edge

<table>
<tr><td></td><td>ruler.</td></tr>
<tr><td></td><td>5. Arrange the elements for easy assembly (optional).

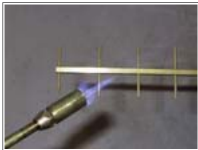
To prevent confusion on which element is which. Arrange all 10 elements on a flat surface and use a painters tape to tape down all the elements. Peel the tape with the elements attached and set it aside for later assembly.</td></tr>
<tr><td> 
</td><td>6. Assemble boom and element.

Starting from the tip of the square brass tube and the shortest element (Director 8). Insert all elements through the square brass tube. Do not worry about centering or straightening the elements for now. It will be dealt with during assembly and bonding.</td></tr>
<tr><td></td><td>7. Insert bonding agent.

Insert 1 or 2 strands of wire solder through the length of the boom. Leave about 5mm on both ends of the boom for slack. Bend the ends to prevent it from slipping through the boom.</td></tr>
<tr><td></td><td>8. Center the elements.

Using a small straight edge ruler, measure both side of the element and center both side to the boom. Do this for all 10 elements.

As explained previously in step 3, if the boom were drilled precisely, the elements should fit tightly to the boom. This should prevent it from moving until the wire solder inside the boom has been melted.</td></tr>
</table>

	**9. Bonding the element s to the boom.** Secure one end of the boom on a metal vise grip or lay the assembled yagi on a concrete floor. Using a propane torch, heat the length of the boom. Concentrate the flame on the boom element joints. Spend at least 2 to 3 seconds per joint. Let the yagi cool down and inspect every element for any loose joints. **WARNING:** Ensure you have waited enough cooling time before handling the yagi.

The Gamma Match

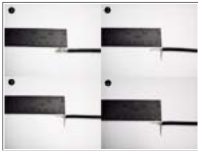
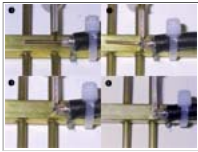
I have chosen to use a gamma matching system for this yagi instead of dealing with baluns and folded dipole. For one thing, the following design makes it a lot easier to tune. This helps a lot when determining the brass yagi's performance.

 	**1. Building the gamma strap holder.** Using the 9/32 x 4" Hot Melt Glue Stick and a drill press with 3/32" bit attached. Drill 2 holes across the glue stick at approximately 5mm apart. Cut the glue stick on both ends of the 2 holes at about 3mm away from either end of the 2 holes.
	**2. Cutting the gamma pipe.** Using the excess 3/32" x 4" Round Brass Tube that was used for building the elements and a straight edge ruler. Measure and cut about 10mm of brass tube. Clean cut both ends with a file and scrape off any sharp edges on the inside circumference of the pipe.

	**3. Cutting the gamma wire and the gamma shorting strap.** (1) Cut off about 35mm of RG-172 coaxial cable; (2) Remove and discard the outer jacket and braided shield leaving the inner jacket and conductor; (3) Remove 15mm of inner jacket revealing the inside conductor; (4) Finish by cutting off 13mm of the conductor. Use the 22mm inner jacket and conductor as the gamma wire and the 13mm conductor as the gamma shorting strap.
	**4. Assembling and mounting the gamma match.** (1) Bend the gamma shorting strap creating a squared off u-shape and insert it through the 2 holes on the gamma strap holder; (2) Insert the gamma pipe through one of the hole on the gamma strap holder making sure that there is contact between the outer part of the gamma pipe and the gamma shorting strap; (3) Insert the other hole of the gamma strap holder onto the driven element of the yagi making sure there is contact between the outer part of the driven element and the gamma shorting strap; (4) Finally, insert the gamma wire through the gamma pipe with the 2mm of conductor on the gamma wire just sitting on top of the boom. The 2mm of conductor on the gamma wire will be used as the feed point for the yagi.

Feed Point

The feed point used on this Brass Yagi project does not use a connector on the yagi itself. Instead, the feed line is directly soldered to the yagi's boom and matching system.

	**1. Drill the shield feed point.** Drill a 3/32" hole on the boom about 5mm behind the driven element.
	**2. Prepare feed line.** (1) Strip off about 15mm of the outer jacket of the coaxial cable; (2) Separate and twist the outer braided shield from the center conductor; (3) Strip off 12mm of the center conductor jacket; and (4) Apply some solder on the twisted outer braid.
 	**3. Attach the feed line.** Insert the twisted braided shield to the 3/32" hole on the boom and solder. Flip the coax cable to the other side of the boom and secure with tie wraps.
	**3. Attach feed line to gamma match.** (1) Align the center conductor of the feed line to the gamma wire; (2) Solder the tips together; (3) Cut off the excess tips of the center conductor; and (4) Apply some hot glue to prevent it from touching the boom.

Tuning the Brass Yagi

Listed below are 3 ways to improve the performance of the Brass Yagi.

1. Ensure that the elements are lined up.

It is assumed that the elements are lined up from each other on the boom. The tips of the elements on the other hand may not. This may be due to the holes on either end of the boom being slightly off. Use a pliers and a straight edge ruler or a caliper to straighten the tips of the element between each other. Make sure to measure both sides.

2. Limit the length of the feed line.

The shorter the feed line the better the signal. Enough said!

3. Adjust the gamma shorting strap.

Slide the gamma shorting assembly along the driven element and gamma wire.

Additional Information

A majority of information used to develop this antenna was acquired through the internet. There are numerous yagi designs out there that influence the creation of this antenna. Some additional books also helped to understand the intricacies of antenna design. Listed below are some good source of information that was used for this project.

Web Sites

http://latorilla.com/vhf/
http://www.signalengineering.com/ultimate/index.html
http://henryfox.net/antennas/
http://www.cebik.com/radio.html
http://xe1mex.gq.nu/antenas/yagi.html
http://www.wirelessanarchy.com
http://www.frars.org.uk
http://www.seattlewireless.net/index.cgi/BuildingYagiAntennas
http://www.esoterraka.com/twcn/

Books

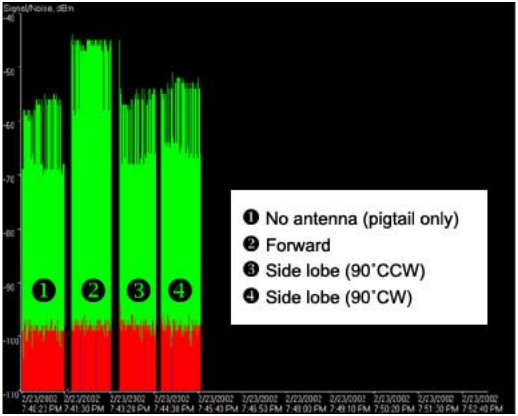
The ARRL Antenna Book - http://www.arrl.org
The ARRL UHF/Microwave Experimenter's Manual - http://www.arrl.org

Source for Materials

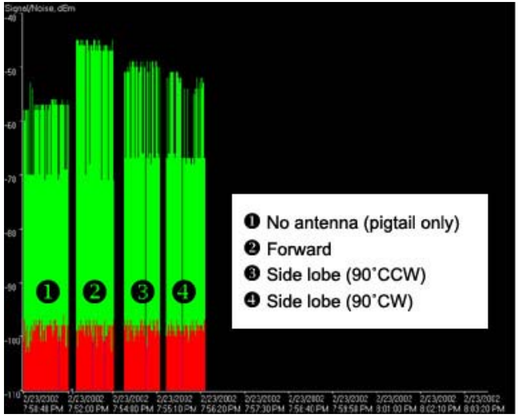
Most materials used for this project can be easily obtained from most home improvement stores. Although I did not find any brass materials of these dimensions at Home Depot, I was able to find some at a nearby Woodbridge, Ontario branch of Rona Lansing. Additional parts like cables and connectors were purchased from a amateur radio store in Concord, Ontario called Radio World.

Benchmark

Any gain? Well, I don't think I could draw any conclusion on this except it's directional properties. There are a lot of factors involve to produce a non-debatable conclusion. For one thing, I don't have the right equipment to produce such results. But what I can tell you are the procedures that I have done to illustrate the following images below.



Antenna 1



Antenna 2

I have notice that most people use [Net Stumbler] by Marius Milner to gauge the performance of most homemade 802.11b antennas. So that is exactly what I have used here. Both yagi antenna's were measured on an Orinoco Silver with a one foot pigtail. The transmission was made with a Linksys WAP11 Access Point set at channel 6 and the power at 0x80. The distance between the Orinoco and the Linksys was spread out at around 25 feet from each other. Both yagi antenna's were identical except for the feed line. Antenna 1 used a 1' RG-58 coax cable while Antenna 2 used a 3' RG-172 coax cable.

The test was done based on the following 4 configurations. (NOTE: I forgot to measure the back)

1. No antennas were used except for the pigtail attached which was laid flat on a table beside the computer.
2. Forward measurement with the yagi elements positioned vertically.
3. Side measurement with the yagi element positioned vertically and the antenna facing 90 degrees counter clockwise from the access point.
4. Side measurement with the yagi element positioned vertically and the antenna facing 90 degrees clockwise from the access point.

In addition to these, the Net Stumbler was set to a scan speed of 5 (fastest) and both gamma match on the antenna's were calibrated to their best possible forward gain.

So you be the judge!

BACK | EMAIL