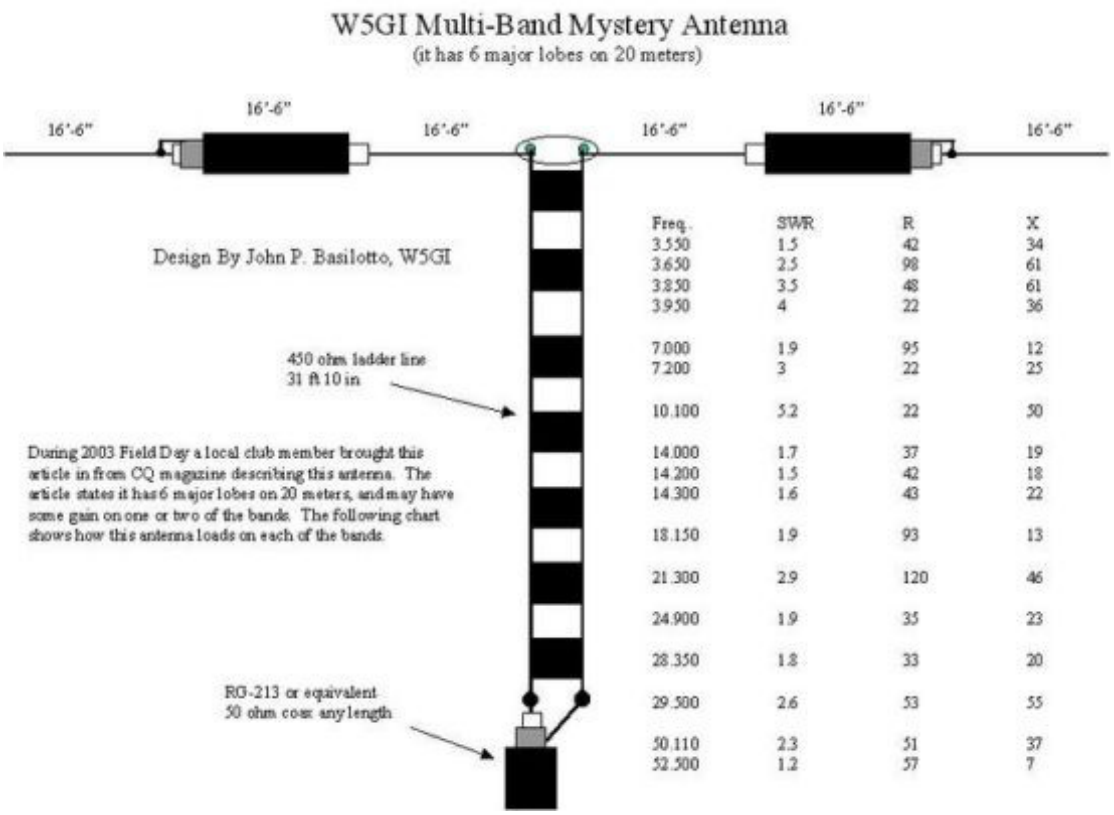
W5GI Mystery Antenna

A multi-band wire antenna that performs exceptionally well even though it confounds antenna modeling software

Article by W5GI (SK)



The design of the Mystery antenna was inspired by an article written by James E. Taylor, W2OZH, in which he described a low profile collinear coaxial array. This antenna covers 80 to 6 meters with low feed point impedance and will work with most radios, with or without an antenna tuner. It is approximately 100 feet long, can handle the legal limit, and is easy and inexpensive to build. It's similar to a G5RV but a much better performer especially on 20 meters.

The W5GI Mystery antenna, erected at various heights and configurations, is currently being used by thousands of amateurs throughout the world. Feedback from users indicates that the antenna has met or exceeded all performance criteria. The "mystery" part of the antenna comes from the fact that it is difficult, if not impossible, to model and explain why the antenna works as well as it does. The antenna is especially well suited to hams who are unable to erect towers and rotating arrays. All that's needed is two vertical supports (trees work well) about 130 feet apart to permit installation of wire antennas at about 25 feet above ground.

The W5GI Multi-band Mystery Antenna is a fundamentally a collinear antenna comprising three half waves in-phase on 20 meters with a half-wave 20 meter line transformer. It may sound and look like a G5RV but it is a substantially different antenna on 20 meters. Louis Varney's antenna, although three half waves long, was an out-of-phase aerial. Mr. Varney had two specific reasons for selecting a 3 half waves on 20… he wanted a four-lobe radiation pattern, at least unity gain and a low feed point impedance. The Mystery antenna, on the other hand, presents a six-lobe pattern on 20 meters, gain broadside to the antenna, and also low feed point impedance to simplify matching the antenna to the rig. Additionally, the Mystery antenna is designed to work at least as well, on the other HF bands as a G5RV. In short, the Mystery antenna is a sky wire that incorporates the advantages of a 3 element collinear and the G5RV antenna.

In its standard configuration, a collinear antenna uses phase reversing stubs added at the ends of a center fed dipole. These stubs put the instantaneous RF current in the end elements in phase with that in the center element. You can make these phase reversing stubs from open wire line or coaxial cable. Normally, a shorted quarter-wave stub is used, but an open-ended half wave stub would also work. The problem is that the dangling stubs are unwieldy and or unsightly.

An article written by James E. Taylor, COCOA- A Collinear Coaxial Array, published in 73 Amateur Radio, August 1989, describes a low profile collinear coaxial array.

According to Taylor, when you apply a RF voltage to the center conductor at the open end, the stub causes a voltage phase lag of 180 degrees at the adjacent coax shield. This happens because the RF is delayed by one quarter-cycle as it passes from left to right, inside the coax to the shorted (opposite) end. There's another quarter-cycle delay as the wave passes back from right to left inside the coax and emerges on the shield at the open end. Add up the delays and you get a total time delay of one-half cycle, or 180 degrees. In essence, the coax section serves two purposes: it provides the necessary delay and provides part of the radiating element in a collinear array.

The first prototypes of the Mystery antenna used the Taylor formulas, which which called for cutting the wires to a quarter wave length using the formula 234/f(Mhz) and the coax, using the same formula, but applying an appropriate velocity factor. The first version of my antenna worked well on 20 meters but failed as a multi-band antenna.

The second antenna was built with constructed with the coax cut to the same length as the wire. This was done with the belief that perhaps the coax didn't behave like coax and therefore the velocity factor wasn't applicable. Surprisingly, the new antenna performed exceptionally well on 20 meters, had low SWR and performed just as well on the other HF bands and 6 meters as my G5RV reference antenna.

Step-by-Step Construction

The W5GI Multi-band Mystery Antenna looks like a plain dipole (see figure1 and photo A below) and is very simple to build.

Photo A – Full view of the W5GI multi-band Mystery Antenna with all sections shortened considerably for illustration purposes.

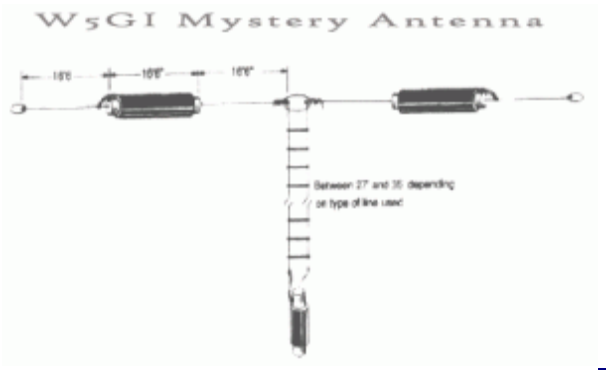


Figure 1 – Schematic drawing of the W5GI Multi-band Mystery Antenna. See text for details on connection of coax sections in center of antenna legs and on length of of twin lead stub.

Builders of the Mystery antenna will need the following materials:

- 3 wish bone insulators
  About 70 feet of wire (14 gauge household electrical wire works well,)
  Sufficient twin lead or open wire to make a half wave section on 20 meters. Window-type 18 gauge 300 ohm ribbon works best. The Wireman is an excellent source for antenna wire and 300 ohm line.

- 34 feet of RG8X mini-coax

- An electrical connector, available from most electrical parts stores, to connect the twin lead and coax

- Shrink tubing to cover the exposed coax joints

The antenna can be built in less than an hour when you have the above materials. When you're ready to proceed, perform the following steps:

1. Cut the electrical wire into four equal lengths of 17 feet.

2. Cut the two lengths of coax to 16'6 each.

3. Cut a 20 meter half-wave section of twin lead. This piece needs to be adjusted by its velocity factor. If 300 ohm window type line is used with a VF of .91, the total length will be 30 ft. Alternatively, 450 ohm, solid 300 ohm or homemade open-wire line can be used provided the electrical length is on-half wave on 20 meters. Actual length will vary, typically between 27 and 35 ft., depending on type and velocity factor.

4. Trim two inches of braid from one end of both lengths of coax (Item A).

5. Trim one inch of braid and center insulator from the opposite end of both coax sections (Item B).

6. Build a 20-meter dipole without end insulators. Note: The next two steps 7 and 8 of the construction process involve connecting only the “inner” end section of the coax section to one end of the dipole; the shield is not connected to anything here. At the other end of the coax section both the coax shield and second wire section are connected to the coax center conductor.

7. Connect one end of the dipole to the center conductor of the coax (Item A) and cover with shrink tubing as shown in photo B below.

8. Connect the opposite end of the coax (Item B) to braid AND quarter wave wire section, cover with shrink tubing, and connect to end insulator as shown in Photo C below.

9. Install the twin lead through the holes of the center insulator (you may have to enlarge the holes) and solder to antenna wire as shown in photo D below.

10. Connect the opposite side of the twin lead to the coax as shown in photo E below. Almost any type of connection will work provided the connection is stable and sealed properly.

11. Install the antenna with the center conductor at least 25 feet high. Mine is installed in a horizontal plane; however, others have installed the W5GI antenna as an inverted-vee and are getting excellent results.

Photo B – Connection of inner end of coax section (closer to center). Note that only the center conductor is connected to the wire.

Photo C – Connection of outer end of coax section (further from center). Note that both center conductor and shield are connected to the wire.

Photo D – Connection of twin lead to inner antenna wires at center of antenna

Photo E – Connection of twin lead to coax. Short length of coax section is for illustration purposes only. All connections should be weatherproofed with shrink-tubing, CoaxSeal, or similar.

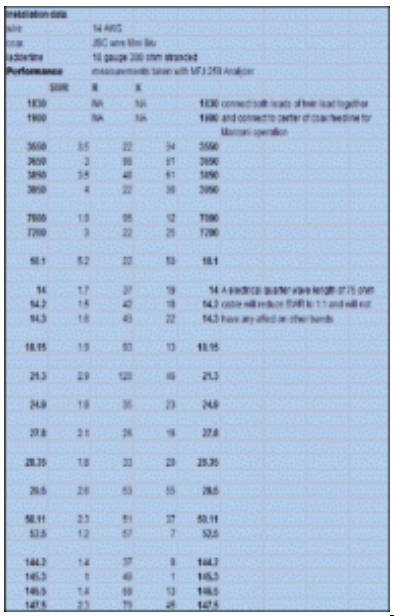


Table 1 – Measured performance of the W5GI Mystery Antenna at various frequencies. Columns list frequency, SWR (all as a ratio to 1), Resistance (R) in ohms, and Reactance (X) in ohms.

On-the-Air Performance

On 20 meters, you should expect 3-6 dB gain over a dipole and a 6-lobe radiation pattern with an elongated figure 8 pattern perpendicular to the plane of the antenna. This is typical of a 3 element collinear array. For a simple explanation of collinear arrays read “Troubleshooting Antennas and Feed lines” by Ralph Tyrrell, W1TF. On all other bands the antenna performs like a G5RV, which is really a random length dipole on all but 20 meters. M. Walter Maxwell, in “Reflections II, Transmission Lines and Antennas”, aptly describes this phenomenon. Several users report it is possible to use the antenna on 160 meters but you will need to connect the twin lead together at the point where it connects to the coax. On 160, the antenna performs like a Marconi. Those who have used the antenna on 160 say the W5GI Mystery antenna is a quieter receiving aerial compared to other 160-meter antennas.

As for the theory of operation, it remains a mystery. At least three experts tried computer modeling the antenna. All three rendered completely different findings.

You will enjoy building a W5GI Multi-band Mystery Antenna! Many hams has done so and find it to have been a fun project and an excellent performer.

Notes:

(1) Information on this page has been taken from an article published in the July, 2003 issue of CQ magazine. You can download a copy of the article in Adobe Acrobat format by clicking HERE.

(2) W5GI will build an antenna for a nominal fee. Discount prices start at $65.00, plus shipping, for the W5Gi multi-bander. Mono band antennas cost more because a 4:1 balun is used.

(3) For additional information, or to order an antenna, please call or send an mail.

(4) Dimensions for the mono-band antenna:

AND		Inside wire	Coax	Outside wire		Overall length	
	10.1		23′ 10″	23′ 4″	23′ 6″		141 ft 4 inches
	14.18		17′ 2″	16′ 8″	16′ 10″		101 ft 4 inches

	18.13		13′ 7″	13′ 1″	13′ 3″		79 ft 10 inches
	21.25		11′ 9″	11′ 3″	11′ 5″		68 ft 10 inches
	24.9		10′ 1″	9′ 7″	9′ 9″		58 ft 10 inches
	28.5		8′ 11″	8′ 5″	8′ 7″		51 ft 10 inches
	50.125		7′ 10 “	7′ 4″	7′ 6″		45 ft 4 inches
	• The above dimensions are for a dipole hung in the horizontal plane. They were calculated by using the formula 234/freq (MHz) plus additional length for attaching to connectors/insulators. • If the antenna is to be installed an Inverted V, increase all lengths by 5%. • Any of the above antennas can easily be used as multi band antennas by eliminating the 4:1 balun and using open wire/twin lead directly to an antenna tuner						

(4) Dimensions for the multi-band antenna:

Inside wire	Coax	Outside wire	Overall length
17′ 2″	16′ 8″	16′ 10″	101 ft 4″

This antenna uses a twin lead matching stub instead of a 4:1 balun.

- Use only 300 ribbon line for the matching stub. Start with 34 ft 7″, trim as necessary to obtain lowest SWR.
- Mono-banders with either a voltage or current (preferred) 4:1 balun.
- This antenna exhibit significant gain only on 20 meters. On all other bands the antenna performs like a G5RV.

FAQ

Can RG-58 [or any other coax] be substituted for RG-8X (mini)?

Theoretically it should work, at least electrically. The main concern is the strength of the smaller wire. A portable Mystery Antenna using RG-174 is in the planning stage. If anyone has tried using different cables, please pass along your thoughts and observations for posting on this website.

[Note: disregard velocity factor (VF) of coax-it is not applicable in my design]

Can I use twin lead or open wire line directly to an antenna tuner in lieu of coax and a twin lead stub?

Absolutely. The twin lead stub is only necessary to give the antenna its multi-band characteristics.

How can I determine the twin lead Velocity Factor?

The best way to determine velocity factor is to ask the distributor or manufacturer. It is very important that the correct VF be used in calculating the length of the twin lead. 300 ohm ribbon is a good choice. There are numerous types available. The VF range from 80 to 90 percent-for 300 ohm line, which means the half wave line could be anywhere from 26.4Ft to 29.7FT. 450 ohm ribbon line typically has a VF of 95%, which means the length should be 31.35 FT. The ARRL Antenna book list VF for different lines.

[Note: Use 33 feet as the 20 m half wavelength for the above calculations.]

Should I use a balun?

A balun is unnecessary and will only degrade performance. A line isolator between the end of the twin lead and the coax is recommended. It helps minimize feed line radiation and stray RF, which can cause problems in the shack.

[Note: The original article recommends the use of a 4:1 balun for a mono-band version of the Mystery Antenna; however, a balun is no longer recommended. Instead, try a quarter wave 75 Ohm matching transformer. RG59 (Beldon 8241) is a good choice. A section of 75 ohm cable cut for 20 meters 10.89 feet can be used with the the multiband antenna. It will lower the SWR on 20 m to close to 1:1 and is transparent on the others bands.]

I get higher SWR readings than appeared in your article, am I doing something wrong?

Probably not. SWR is a function of several variables to include wire and cable type, height above ground, etc. The best measure to ensure the antenna is constructed correctly is the 20m SWR. It should be under 2:1 across the entire 20 m band, and if you use a 75- OHM match transformer (see above) closer to 1:1.

Can I install the Mystery Antenna as an Inverted V?

Absolutely. There are thousands of Mystery Antennas in use in many different configurations. Feedback from builders indicates that the antenna is very forgiving and will work under almost any condition to include indoors and with the ends bend.

Where can I buy a Mystery Antenna?

The W5GI Mystery antenna is available as a kit from the Wireman or, if you prefer, direct from W5GI ready to install for $100 shipped within the U.S. W5GI can also build mono-band antennas for any band 40 to meters. Call or email for a cost estimate.