The W5JCK Portable 80m/75m/SWL Helical Antenna Project

My latest antenna project is a portable 80m helical "broomstick" loosely based on a design by Arnie Coro, CO2KK, of Radio Havana Cuba. This makes a good SWL antenna. However, I designed my version to be resonant around 3.800 MHz. I also designed it to be quickly assembled and disassembled for easier transportation. Estimated cost of this project is less than $75. This project should take no more than a few hours to build.

Photos of the antenna

Indoor floor mount (SWL only)

Outside mast mount (for DXing, I hope)

Connector Box in horizontal position for floor/ground mounting.

Connector Box in vertical position for mounting to a mast.

Instructions

These instructions will allow you to build the antenna exactly as I did. You can adapt the instructions to fit your needs and materials.

Step 1: Obtain the necessary materials

- One 10-ft piece of 1" dia. schedule 40 PVC pipe cut to lengths of 78-in and 42-in
- One "T" style plastic conduit box with three couplings to accommodate 1" PVC pipe
- 2 plugs (1-in dia.) for conduit box
- 1 PVC rounded cap to fit over 1-in dia. PVC pipe
- 14 gauge plastic covered, stranded wire (at least 135 feet, not including radials)
- One SO-239 chassis female connector (4 hole)
- Several fully insulated, crimp "quick disconnects" for 14 gauge wire
- 2 brass welding rods 1/8-in dia. by 36-in length, cut into six 12-in lengths
- Large roll of clear packaging tape
- Optionally, a few small alligator clips

Step 2: Measure and cut the wire

Measure and cut two lengths each of **at least 135' (41.15 meters)** of 14 gauge wire. Yes cut two lengths because one will be used as the antenna wire and one will be used as a 1/2 wavelength ground radial.

You need about 130' of wire to be resonant on 3.8 MHz. The rule of thumb is 1/2 wavelength of wire for the resonant frequency. However, always start out with a much longer piece of wire than you need so that you can trim the excess off as you tune the antenna. Remember that shortening the wire increases the resonant frequency.

English formula for 1/2 wavelength

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492 ÷ freq (MHz) = length (feet)
492 ÷ 3.8        = 129.47 feet
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Metric formula for 1/2 wavelength

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150 ÷ freq (MHz) = length (meters)
150 ÷ 3.8        = 39.4736 meters
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Step 3: Calculate the number and placement of turns

Calculate the minimum number of required turns

Each turn around the 1 inch (2.54 cm) PVC pipe requires approximately **4.445 inches (11.29 cm)** of wire. Since we need about 130 feet (39.74 meters), we will need **351 minimum turns**. (The formulas to determine these amounts are illustrated below.)

English formula for length of each turn

```
turn diameter = O.D. of PVC pipe (inches) + wire dia. (inches) =
                1.315"                    + 0.1"               = 1.415"

PI      x turn diameter = length per turn

3.14159 x 1.415"        = 4.445" appx.
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English formula for minimum number of turns required

```
1/2 wavelength (inches) = length in feet x 12 = 130' x 12 = 1560 inches

1/2 wavelength (inches) ÷ turn length (inches) = min. number of turns

1560"                   ÷ 4.445"               = 351 turns
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Metric formula for length of each turn

```
turn diameter = O.D. of PVC pipe (cm) + wire dia. (cm) =
                3.34 cm               + 0.254 cm       = 3.5941 cm

PI      x turn diameter = length per turn

3.14159 x 3.5941 cm     = 11.2912 cm appx.
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Metric formula for minimum number of turns required

```
1/2 wavelength (cm) = length in meters x 100 = 39.4736 x 100 = 3947.36 cm

1/2 wavelength (cm) ÷ turn length (cm) = min. number of turns

3947.36 cm          ÷ 11.2912 cm       = 351 turns
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Calculate the placement of turns on the PVC pipe

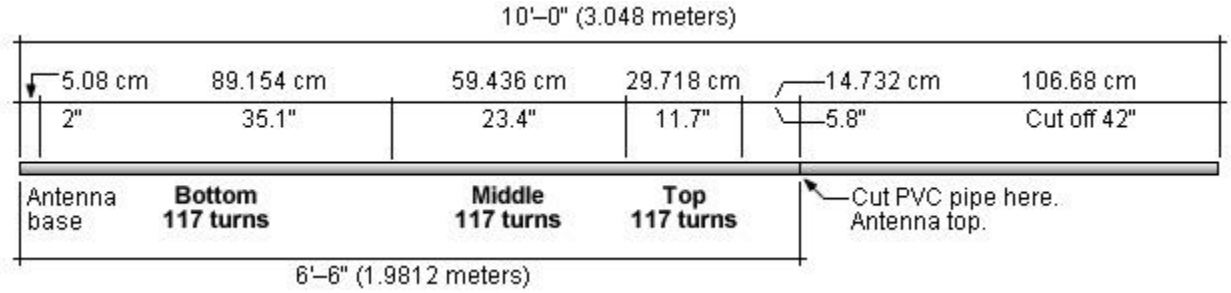
Although you can use a single pitch (distance between turns of wire), varying the pitch optimizes the helical distributed loading thereby resulting in improved performance. The easiest way I found to do this is to vary the pitch for each 1/3 length of the wire. We already determined the wire length to be 130 feet (39.74 meters), so each 1/3 length is 43'–4" (13.25 meters). We also determined that we need 351 turns of wire, so each 1/3 of that is 117 turns.

The recommended pitches for each 1/3 length of wire are as follow:

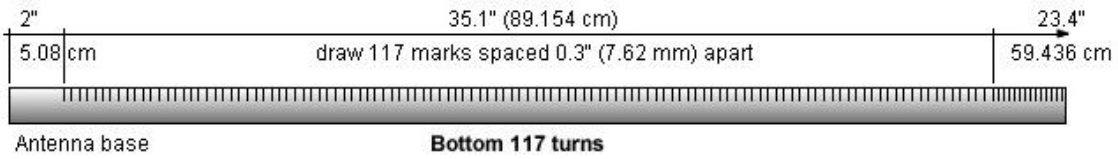
- **Pitch for Bottom 117 turns—0.3 inch (7.62 mm)** per turn and **35.1 inches (89.154 cm)** for all 117 turns.
  Each turn should be separated by a distance equal to two diameters of the wire. We determined the wire to be appx. 0.1 inch (2.54 mm) diameter. If you lay out the wire then add the separation distance, the centerline distance between the wire in any turn to the wire in the next turn is three times the diameter of a wire. So three times the wire diameter is 0.3 inch (7.62 mm) and is the distance required for each turn in the bottom 117 turns. Thus the total space required for the bottom 117 turns is 117 times 0.3 inch (7.62 mm), which equals 35.1 inches (89.154 cm).
- **Pitch for Middle 117 turns—0.2 inch (5.08 mm)** per turn and **23.4 inches (59.436 cm)** for all 117 turns.
  Each turn should be separated by a distance equal to one diameter of the wire. If you lay out the wire then add the separation distance, the centerline distance between the wire in any turn to the wire in the next turn is two times the diameter of a wire. So two times the wire diameter is 0.2 inch (5.08 mm) and is the distance required for each turn in the middle 117 turns. Thus the total space required for the middle 117 turns is 117 times 0.2 inch (5.08 mm), which equals 23.4 inches (59.436 cm).
- **Pitch for Top 117 turns——0.1 inch (0.254 mm)** per turn and **11.7 inches (29.718 cm)** for all 117 turns.
  Each turn should be tightly wound. That means each turn requires appx. 0.1 inch (2.54 mm). Thus the total space required for the top 117 turns is 117 times 0.1 inch (2.54 mm), which equals 11.7 inches (29.718 cm).

Step: 4: Mark the PVC pipe

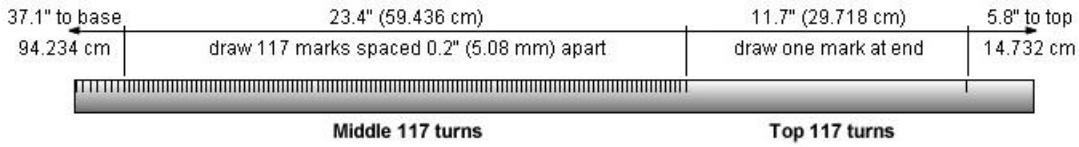
Now that we have determined the space required for the bottom, middle, and top groups of turns, we can layout our dimensions on the PVC pipe using the diagrams below.



a. As shown in the diagram above, measure up 2 inches (5.08 cm) from the bottom of the PVC pipe and draw a mark.
b. From the previous mark, measure up 35.1 inches (89.154 cm) and draw a mark. This space will contain the bottom group of turns.
c. From the previous mark, measure up 23.4 inches (59.436 cm) and draw a mark. This space will contain the middle group of turns.
d. From the previous mark, measure up 11.7 inches (29.718 cm) and draw a mark. This space will contain the top group of turns.
e. From the previous mark, measure up 5.8 inches (14.732 cm) and draw a mark. This is the approximate place where you will cut off the PVC pipe, but do NOT cut it off yet. Wait until you finish wrapping the wire to verify that you have enough space, and only then cut off the extra.
f. In the space for the bottom group of turns, draw 117 marks each spaced 0.3 inches (7.62 mm) apart. (See the following diagram.) *HINT: I used and engineering ruler that divides inches into tens. I first drew off a group of 30 marks on the long edges of a piece of letter size paper, numbered every 10th mark, then used this guide to transfer all my marks to the PVC pipe.*



g. In the space for the middle group of turns, draw 117 marks each spaced 0.2 inches (5.08 mm) apart. (See the following diagram.) *HINT: Use the hint discussed in step f.*

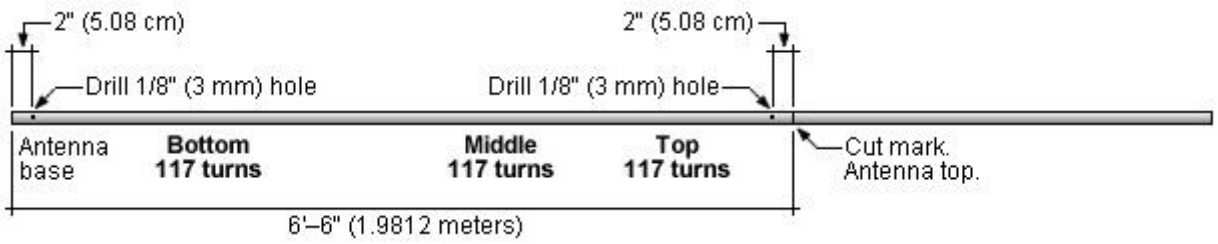


h. There is no need to draw each mark in the space for the top group of turns. (See the previous diagram.)
i. Optionally, you can use a long piece of clear packaging tape to cover the marks you drew on the PVC pipe. This will prevent the marks from rubbing off while still allowing you to see them.

Step: 5: Drill holes in the PVC pipe

For this step you will need a drill with a 1/8 inch (3 mm) bit to drill holes into the PVC that are just big enough to allow the 14 gauge wire to pass through but still be a tight fit.

a. Drill a 1/8" (3 mm) hole 2 inches (5.08 cm) from the bottom of the PVC pipe. This hole will be at the first mark you made for the bottom group of turns near the base of the antenna. You only need to drill through one side of the PVC pipe. (See diagram below.)
b. Drill a 1/8" (3 mm) hole 2 inches (5.08 cm) below the cut mark you drew. You only need to drill through one side of the PVC pipe. This hole will be 76 inches (193.04 cm) above the base of the antenna. (See diagram below.)

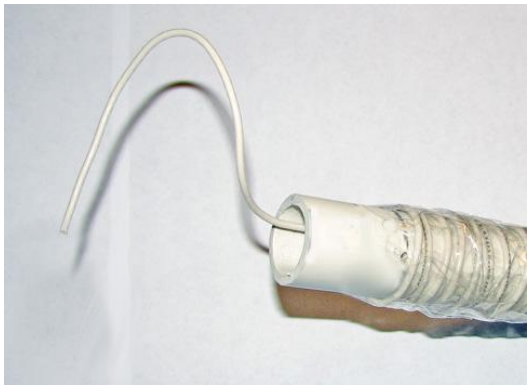


Step: 6: Turn the wire around the PVC pipe

You measured and cut two lengths of wire in step 2 above that are half-wavelength (plus) in length. Now you will wind one of those wires around the PVC pipe starting near the base of the antenna and ending near the cut mark.

To help with this tedious and labor intensive task, I recommend getting someone to help you. I also recommend using spooled wire so that you can run a dowel (or some kind of rod) through the center of the spool and suspend the spool between two chairs (or your helper's hands. Being able to unwind the wire from the spool on to PVC pipe by turning the pipe was a major time and labor saver.

a. Push about 8" (20 cm) of one end of the wire into the hole you drilled near the base of the antenna in step 5 a above, and pull it out the bottom of the pipe as shown below. Tape the wire at the hole to keep it from accidently moving.

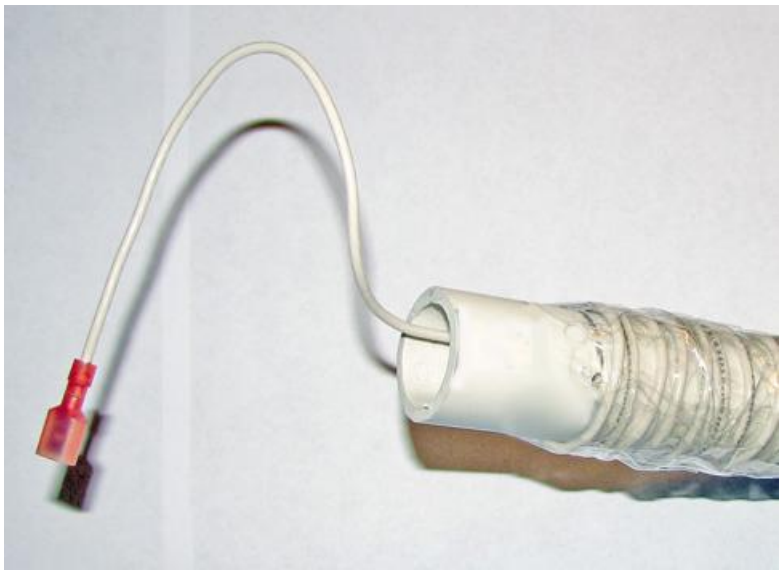


b. Begin turning the wire around the PVC pipe taking care to align the center of the wire with a mark you drew on the pipe in steps 4 f and 4 g above. The direction of the turns (clockwise or counterclockwise) does not matter as long as you make all the turns in the same direction. *HINT: I recommend that you place a small piece of packaging tape over your turnings at least every 2 inches (5 cm) to ensure the wire doesn't move. This will also allow you to take a break ever so often without having to worry about the wire unwinding itself. About every 12 inches (30 cm) you should tightly wrap your turnings with the packaging tape to keep them permanently in place.*
c. When you reach the start of the top group of turns, begin turning the wire tightly, that is, do not leave any space between the remaining turns.
d. When you reach the end of the top group of turns, mark your wire so you can see where the approximate half-wavelength is located. (*HINT: I used a bit of electrical tape to mark this point.*) Continue to turn the wire around the PVC pipe until it is near the hole you drilled in step 5 b above. Be sure to tape the wire up to the last turn to permanently secure it, but leave about 12 inches (30 cm) of loose wire after the last turn.
e. When you are certain that you have more than enough wire for a half-wavelength turned around the PVC pipe, then you can cut off the excess pipe at the cut mark you drew in step 4 e above. *NOTE: If you had to turn the wire beyond (above) the cut mark, then measure up 2 inches (5 cm) above the last turn of wire and draw a new cut mark then cut off the pipe at that point. then drill a 1/8" (3 mm) hole just above the last turn of wire.*
f. Push the remaining wire into the hole you drilled near the cut mark in step 5 b above, and pull it out the top of the pipe like you did in step 6 a above. Tape the wire at the hole to keep it from accidently moving.

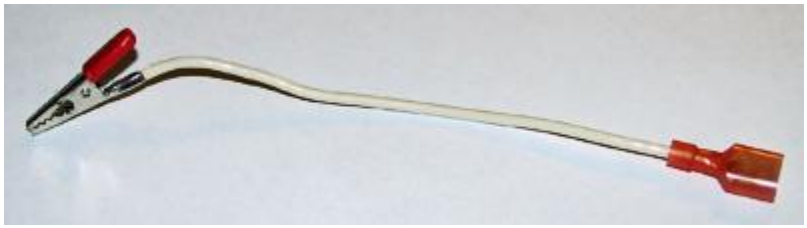
Step: 7: Attach the quick disconnectors

You do not have to use quick disconnectors, but they really come in handy for quickly assembling/disassembling the antenna to either work on it, change its configuration, or to transport it to another location.

a. Attach a male quick disconnector to the end of the wire coming out of the base of the antenna as shown below.



b. Attach a male quick disconnector to the end of the wire coming out of the top of the antenna as shown above.
c. **Ground/radial connection wire:** Attach a male quick disconnector to one end of an 8" (20 cm) piece wire and an alligator clip to the other end as shown below.

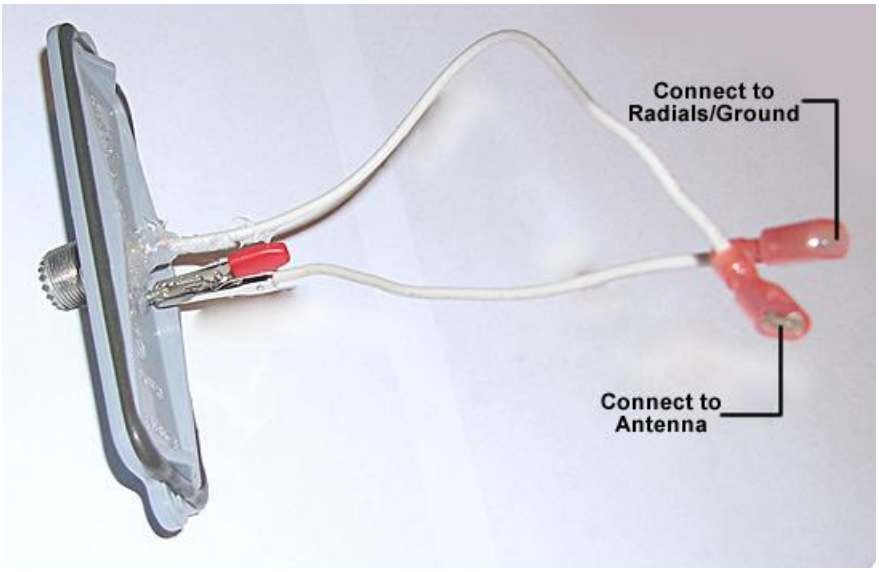


d. **Ground/radial wire:** Attach a female quick disconnector to one end of the half-wavelength radial wire you cut in step 2 above. This will plug into the male quick disconnector on the connector for the ground radial wire you made in step 7 c above.
e. **SO-239 connection wire:** Attach a female quick disconnector to one end of an 8" (20 cm) piece wire. You will connect the other end of this wire to the SO-239 chassis female connector later. This will plug into the male quick disconnector on the wire protruding from the base of the antenna.
f. **Capacitance hat connection wire:** Attach a female quick disconnector to one end of an 8" (20 cm) piece wire. You will connect the other end of this wire to the capacitance hat later. This will plug into the male quick disconnector on the wire protruding from the top of the antenna.

Step: 8: Assemble the coax/radial connector box

For this step you will need a drill with a 1/8 inch (3 mm) and a 1/2 inch (13 mm) bits to assemble the connector box that handles the coax feedline connection and the ground/radial wire connection. This box also provides a base to sit the antenna on the floor or ground or to attach it to a mast.

a. Remove the cover and drill a 1/2 inch (13 mm) hole in the center.
b. Place the SO-239 chassis female connector over the hole you drilled in step 8 a above. Mark where the four holes in the SO-239 are located, then drill four 1/8" (3 mm) holes.
c. Attach the SO-239 by inserting four small, self-tapping screws through the SO-239 chassis and into the four holes you drilled in step 8 b above.
d. Solder the unattached end of the SO-239 connection wire you made in step 7 e above to the center connector on the back of the SO-239 chassis female connector, as shown below.

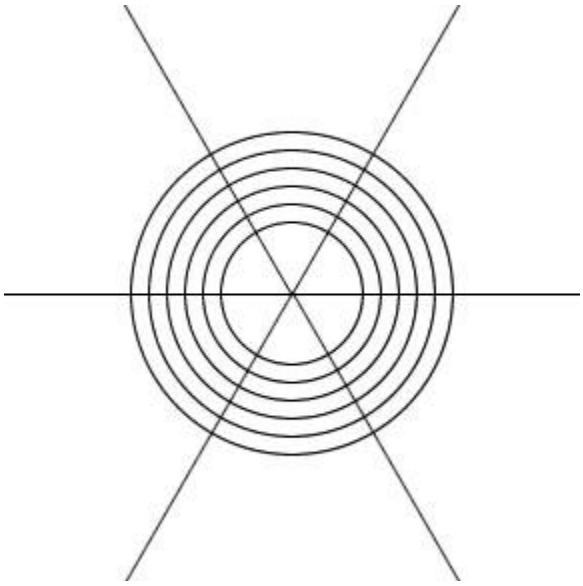


e. Apply a liberal amount of silicone caulk over the back of the SO-239 chassis female connector to seal it from water as well as to prevent shorting across it with the ground/radial wire. Be sure not to cover the ends of the four protruding screws with the silicone caulk as you will need them exposed.
f. Attach the Ground/radial connection wire you made in step 7 c above to one of the exposed screws using the alligator clip. Or you could just solder it on, but I prefer the alligator clip.

Step: 9: Build the capacitance hat

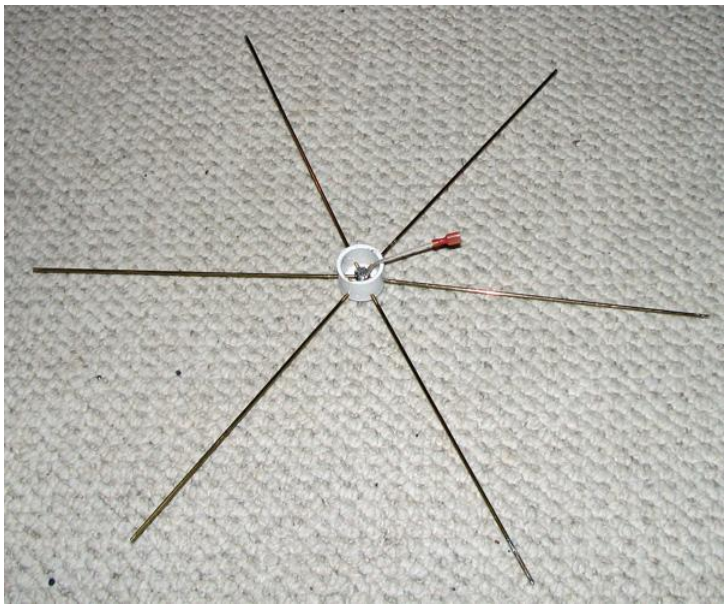
You now need to build the capacitance hat to sit on top of the antenna. This provides capacity hat termination and reduces the noise level. The capacitance hat should be at least 6 inches (15.24 cm) in diameter. This one is 24 inches (60.96 cm) in diameter.

a. Cut two 1/8 inch (3 mm) dia. by 36 inch (91.44 cm) long brass welding rods into six 12 inch (30.48 cm) lengths.
b. Drill six 1/8 inch (3 mm) holes in the side of the PVC rounded cap. The holes should be drilled about 1/4 inch (6.35 mm) down from the top of the cap and equally spaced around the circumference. Yes, this is a bit difficult to get right. The idea is to have the holes placed where the rods, when inserted into the cap, will protrude out of the cap at 60 degree intervals thus forming a hexagonal capacitance cap. To help you align and mark the PVC rounded cap for drilling, copy the image below and print it out, then center the PVC rounded cap over the image an mark the edge where each line intersects the circumference. Then transfer each mark up the side of the PVC rounded cap to about 1/4 inch (6.35 mm) down from the top and drill the hole there. A drill press is best, but I did mine with a handheld drill.

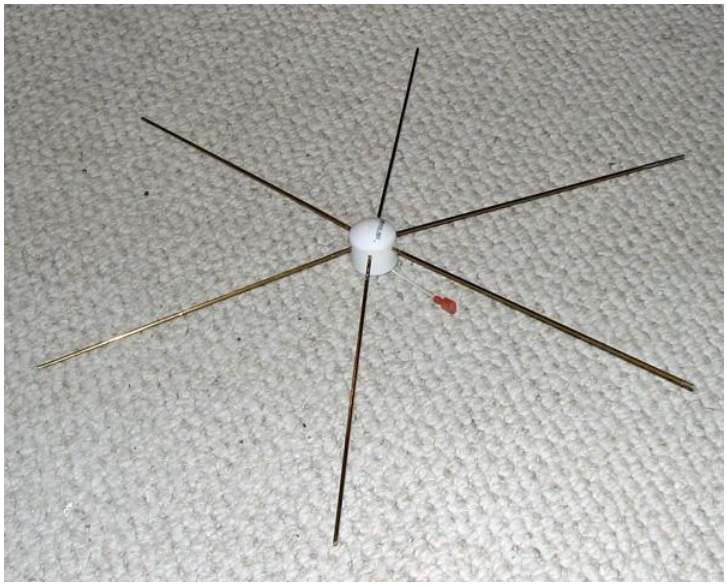


c. Push each of the six 12 inch (30.48 cm) lengths of welding rod through one of the six holes you drilled in step 9 b above. Make sure they meet in the center of the PVC rounded cap. You might need to use a pair of pliers as they will be a tight fit, which is what you want.

d. Solder the unattached end of the capacitance hat connection wire you made in step 7 f above to the point where the six welding rod pieces meet as shown below. Be sure to the bare wire and solder makes a good contact with all six pieces.



e. For extra security, you can place a bead of epoxy glue on the inside of PVC rounded cap where each welding rod piece goes through a hole.



Step: 10: Optional, Build an RF Choke Balun

This is optional, but recommended. Using an easy to build RF Choke 1:1 Balun will help keep RFI from traveling down the coax feedline and back into your shack.

- Obtain a piece of 4 inch (10 cm) diameter PVC pipe. Or you can use a plastic container like I did. I found a small Gatorade container and used it.
- Make 12 winds of your coax cable around the pipe/container and tape into place, as shown below.

I used a short 10 foot (3 meter) piece of RG-58 coax to make my RF Choke Balun. I hooked one end of the RF Choke Balun into the SO-239 on my antenna, and the other end was connected to a 50 foot (15 meter) RG-8 coax cable that runs to the tuner in my shack. This method allows me to use the RF Choke Balun with any coax cable for when I want to take it to another location.

Step: 11: Assemble the antenna

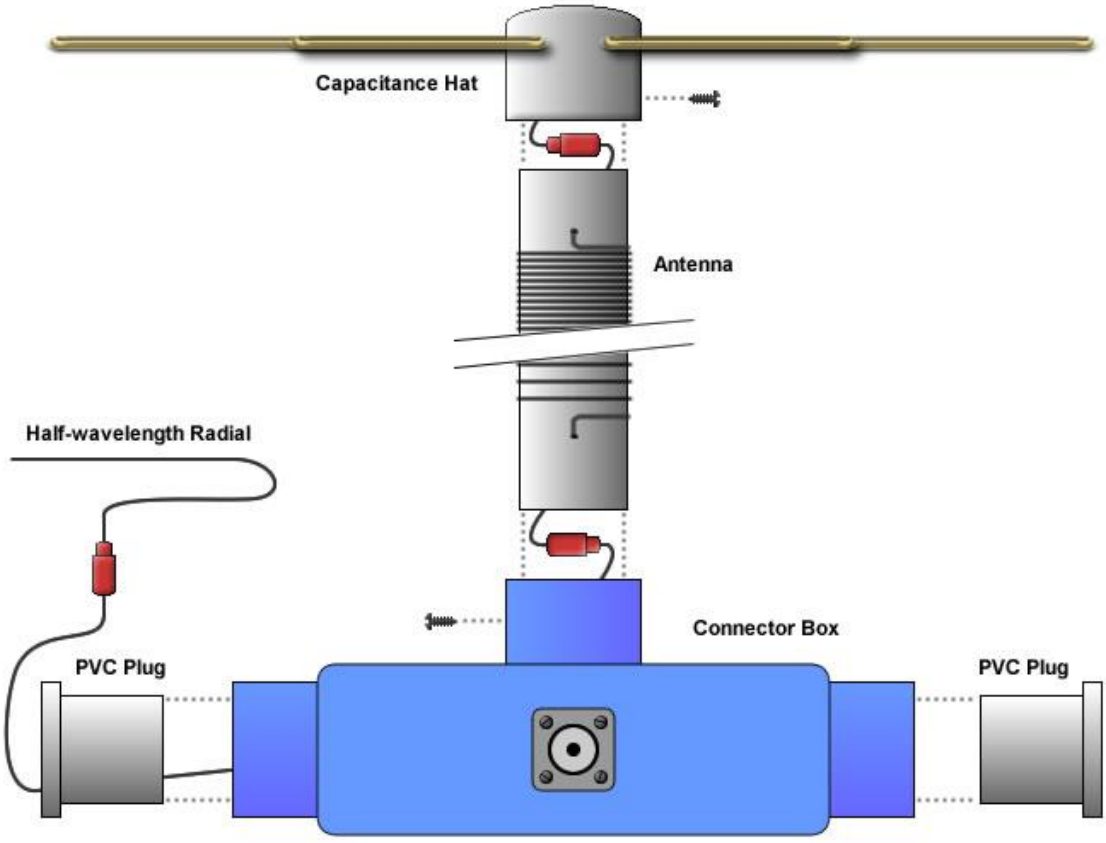
The only thing left to do now is assemble the antenna from the pieces you have made.

Assemble for mounting on the ground or floor

To assemble for mounting on the ground or floor, use the following diagram.

- Drill a hole in the bottom of one of the PVC plugs large enough to allow the ground/radial connection wire and it's quick disconnector to pass through.
- After inserting, wrap electrical tape around both PVC plugs and the connector box couplings to make the connections watertight.
- After inserting the antenna into the connector box coupling, drill a 1/8 inch (3 mm) hole through one side of the coupling and PVC pipe and insert a small, self-tapping screw to secure them together. Then wrap electrical tape around the connector box coupling to make the connection watertight.

- After inserting the antenna into the capacitance hat, drill a 1/8 inch (3 mm) hole through one side of the hat and PVC pipe and insert a small, self-tapping screw to secure them together. You do not need to tape this connection.

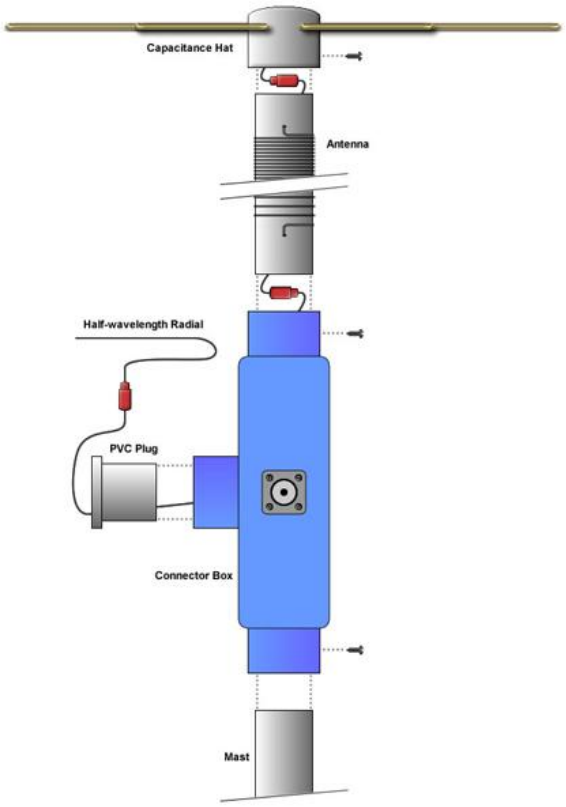


Assemble for mounting on a mast or tripod

To assemble for mounting on a mast or tripod, use the following diagram.

- Drill a hole in the bottom of one of the PVC plug large enough to allow the ground/radial connection wire and it's quick disconnector to pass through.
- After inserting, wrap electrical tape around the PVC plug and the connector box coupling to make the connections watertight.
- After inserting the antenna into the connector box coupling, drill a 1/8 inch (3 mm) hole through one side of the coupling and PVC pipe and insert a small, self-tapping screw to secure them together. Then wrap electrical tape around the connector box coupling to make the connection watertight.

- After inserting the antenna into the capacitance hat, drill a 1/8 inch (3 mm) hole through one side of the hat and PVC pipe and insert a small, self-tapping screw to secure them together. You do not need to tape this connection.
- After inserting the bottom connector box coupling over the mast, drill a 1/8 inch (3 mm) hole through one side of the coupling and mast and insert a small, self-tapping screw to secure them together. Then wrap electrical tape around the connector box coupling to make the connection watertight.



The only caveat to mounting this antenna to a mast is that the connector box is plastic and might not withstand the stresses of strong winds which cause the antenna to sway. So if you mount it to permanently to a mast, be sure to use at least three non-conducting guide cables to secure it.

All Done

I hope you enjoy your new homebrew antenna. Don't forget to tune it or at least use a tuner if you will be transmitting. I would keep the output power to 100 watts or less, but transmit only if it is mounted safely away from your shack. If the antenna is too close to you, either do not transmit, or at the very least lower the output power down to a safe level.

Please let me know how this antenna worked out for you. You can email your comments to me.

Enjoy!

73 de W5JCK

Visit the W5JCK Website