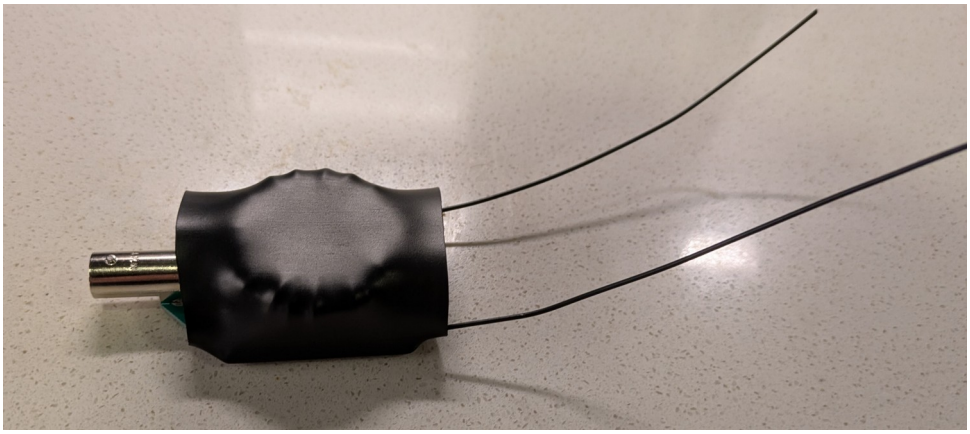
KM4CFT
Technologies LLC

KM4CFT 100W End Fed Antenna Kit

By: Jonathan Kayne, KM4CFT

Thank you for your purchase of your KM4CFT End Fed Antenna kit! This kit is an ultra-portable unun that takes heavy inspiration from the work of Adam, K6ARK. It is designed to be as compact as possible without making assembly too difficult.

This guide will walk you through assembling your KM4CFT End Fed Half Wave or End Fed Random Wire Antenna.



Revision 1, 1/12/2025

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Antenna Types

This antenna kit is designed to be built for one of the two types of end fed antennas described below:

End Fed Half Wave

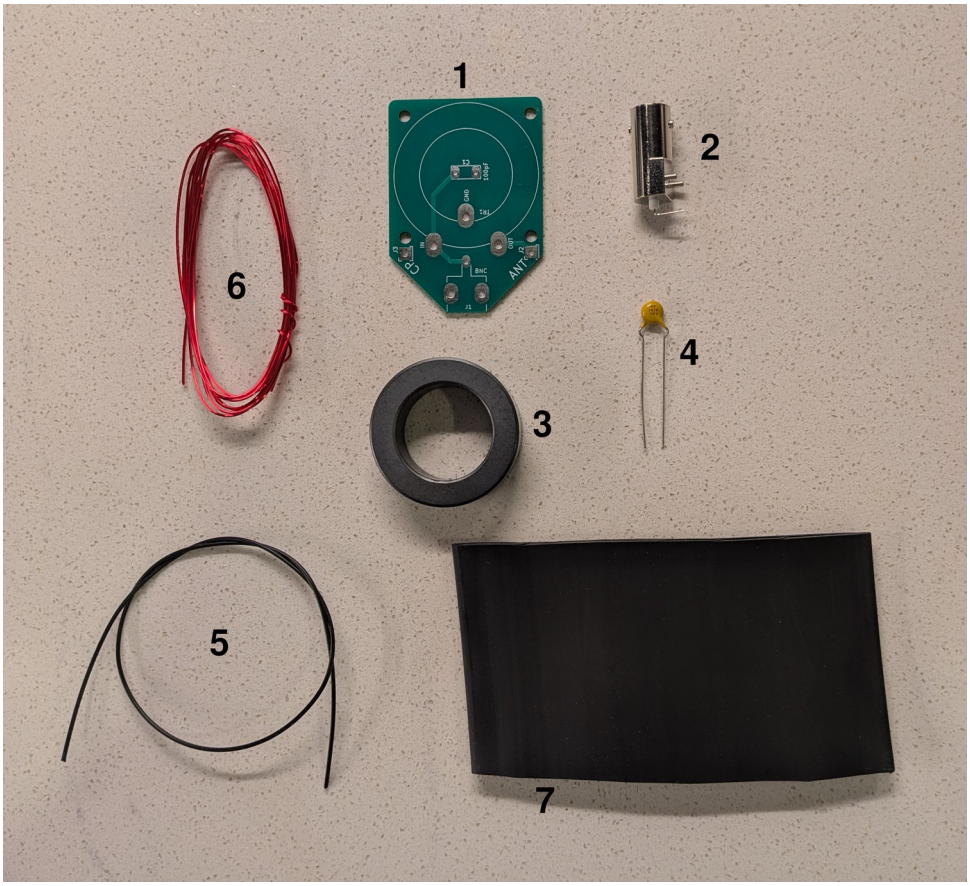
The End Fed Half Wave (EFHW) is known as a *resonant* antenna. This means it is designed to be used without an antenna tuner. They are designed to be resonant on half wave multiples of its resonant frequency. So an 80 meter EFHW is (theoretically) resonant on the 80, 40, 20, and 10 meter bands. This isn't completely true though since the bands aren't exactly multiples of each other. To remedy this, you can use a loading coil along the wire to bring other bands into resonance. These antennas should be deployed in the same fashion as a dipole: sloper, inverted vee, or even vertical if you use a feedline.

End Fed Random Wire

The End Fed Random Wire (EFRW) antenna is *not* resonant and is designed to be used with an antenna tuner. The antenna is essentially designed to be equally "out of tune" on a large range of frequencies, such that a tuner can be used to bring the antenna into a match, and therefore be usable on many bands. This is a great option for radios that have a built-in ATU like the Elecraft KX2, KX3, and the Xiegu X6100 and X5105. With this type of antenna, you want to prevent the antenna from being resonant on any particular band. For finding the length you want, I recommend looking at an article that the University of Delaware posted. It can be easily found by doing an internet search for "*End fed random wire antenna lengths*"

Power Rating

This antenna is designed to be a QRO, or high power antenna. As such, it is rated to operate at 100 watts on CW/SSB and 50 watts on Digital. Antenna power rating has to do with the amount of heat generated by the RF signal. This being said, if you run continuous CW (by holding down the key for an extended period of time) the toroid in the transformer can overheat and will permanently damage it. Depending on the environment and ambient temperature you may be able to push more power through it. If you do this then be sure to monitor the temperature of the matching unit!



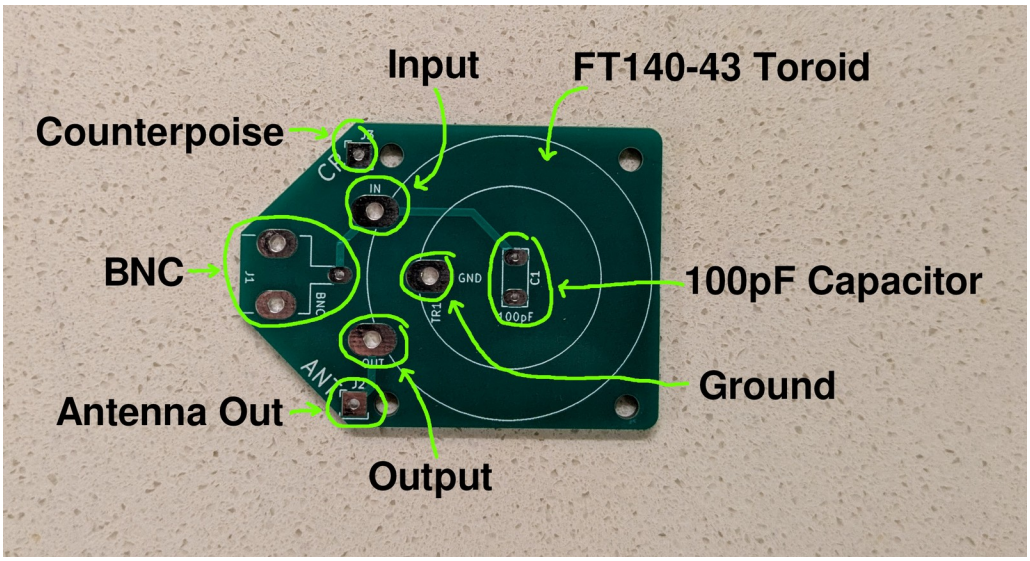
Parts List:

	Item	Qty/Length
1	Printed Circuit Board	1x
2	BNC Connector	1x
3	FT140-43 Toroid	1x
4	100pF 1kV Capacitor	1x
5	26 AWG Polystealth Wire	~ 12”
6	22 AWG Magnet Wire	~ 5’
7	2” Heat Shrink Tubing	~ 2”

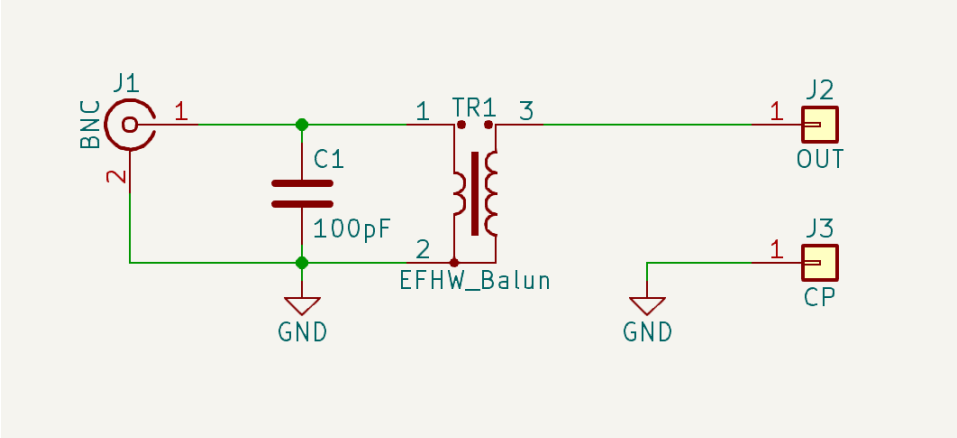
Note: Parts might differ slightly from what is pictured above, namely the capacitor

End Fed Half Wave (EFHW) Build Instructions

Before we begin assembly, lets take a look at the Printed Circuit Board. Note that it might differ slightly in color but will still have the same general layout.



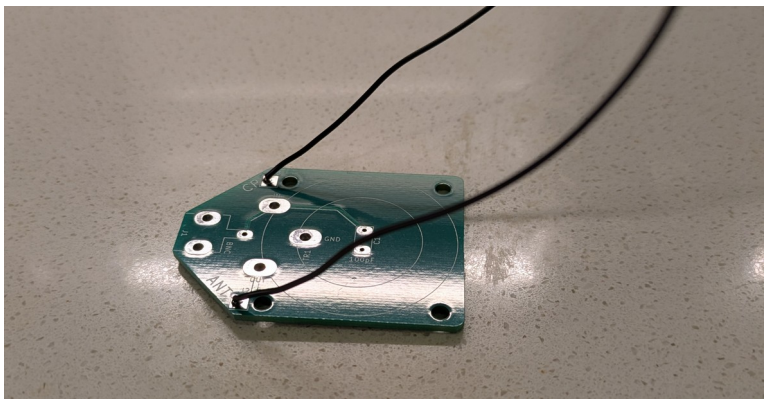
Now that we have a small familiarity with our PCB, lets get to building!



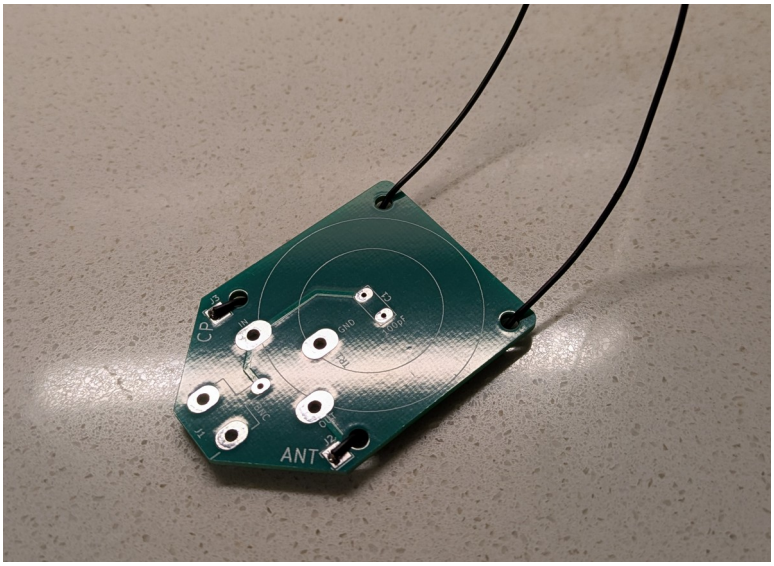
Step 1: Install Radiating Wires

Take your 12 inch length of polystealth wire and cut it in half. Strip a small amount of insulation off the wire and solder them into the holes labeled “CP” and “ANT” as shown in the following photo. Note that the counterpoise wire is completely optional, as you do not technically need a counterpoise for an EFHW antenna.

NOTE: If you choose to *not* install the counterpoise wire then I recommend using a long length of coax when deploying the antenna. I find that a 25 foot length of feedline works great on 20 meters.

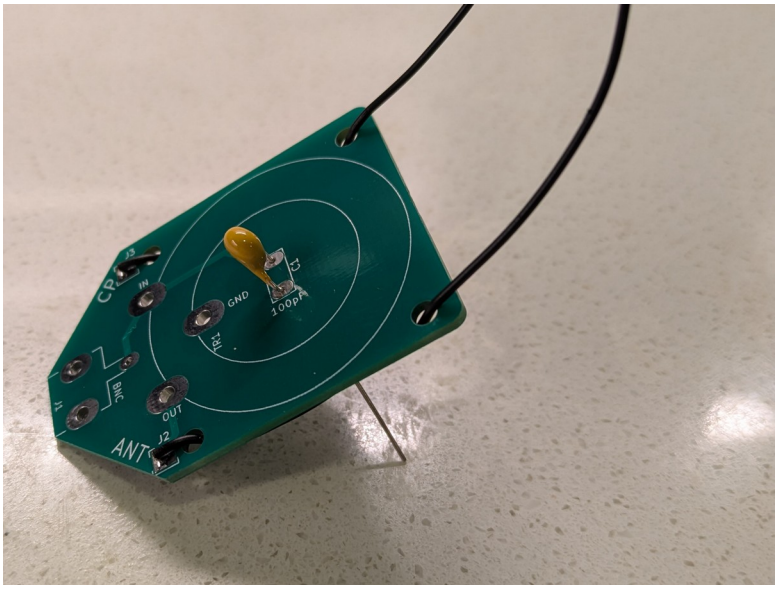


Next, feed the wire through the 4 nonplated holes around TR1 to perform a strain relief.



Step 2: Install the 100pF Capacitor

Take out the 100pF ceramic capacitor and push the leads through the two holes for C1. Bend them outwards to lock the component in place then flip it over and solder it. Trim off the excess leads.

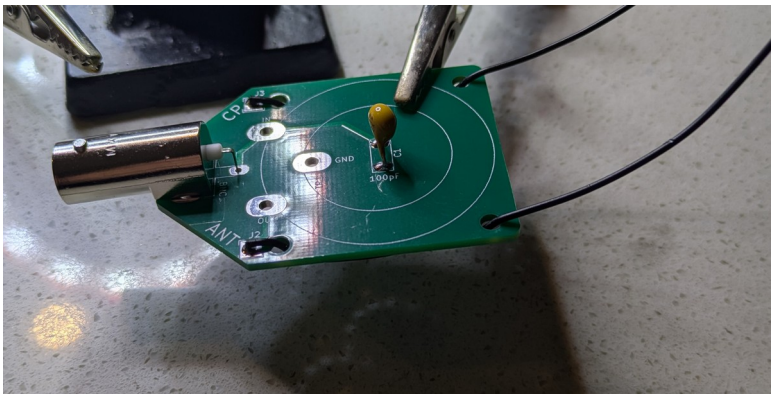


Step 3: Install the BNC Connector

Take out the BNC connector and place it onto J1. For this, I recommend using some helping hands to hold the board. On the top side, solder the center pin so that the connector is “tacked” into place. If you are lucky you might have even properly soldered that pin on the bottom too!

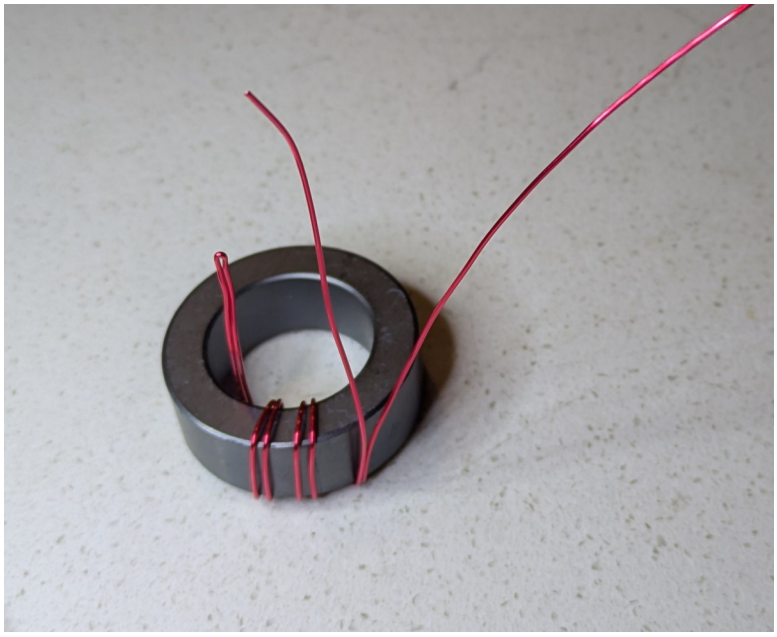
Flip the board over and solder the two ground mounting pins. This might be somewhat difficult since you need to basically heat up the entire component, so higher temperatures and a larger soldering iron tip can make this easy. Be patient though, the solder will flow if you get the connector hot enough.

If the center pin isn’t already good from earlier, use your iron to reflow the solder to ensure the joint is nice is neat.



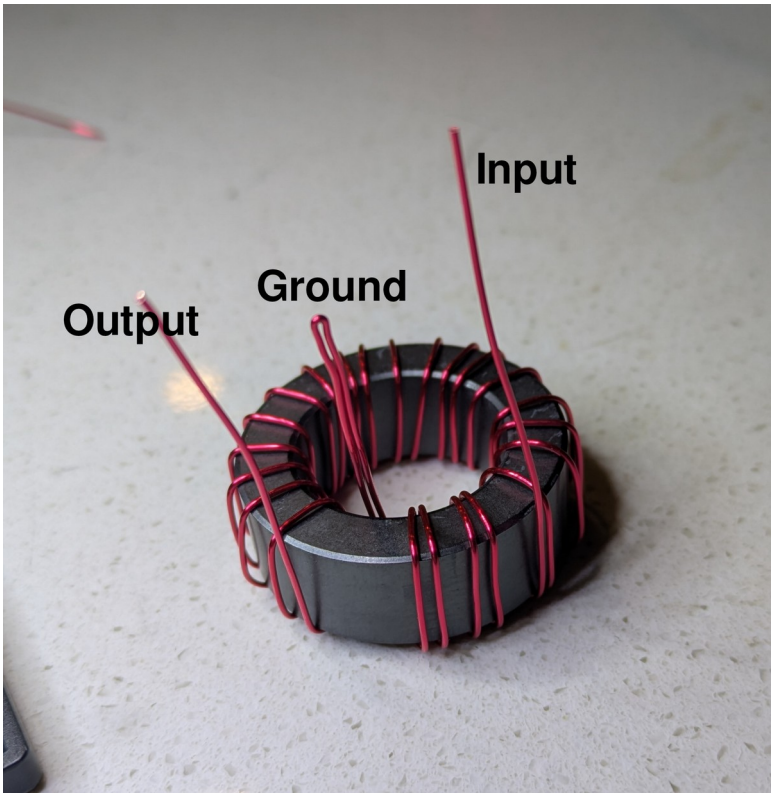
Step 4: Winding the Toroid - Primary

First, take the magnet wire and straighten it out. Next, measure about 8 inches of wire and form a bend. Use some needle nose pliers to squish the bend (otherwise it might not fit through the hole on the circuit board later). Using the bent section of wire, form 3 turns around the toroid. Remember that every time the wire passes through the center of the toroid you count a turn. You should make sure you wind it in the same direction as in the picture so that the wire will line up with the circuit board. This forms the primary and part of the secondary of the transformer.



Step 5: Winding the Toroid – Secondary

Using the remainder of the wire we will finish up the secondary windings of the transformer. The number of turns will depend on what bands you wish to operate on. For 80 meters you want a turns ratio of 3:24, for 40m use 3:21 and for 20m and up use 3:19. In general, I prefer to use the 3:21 ratio. Since we have already wound the first 3 turns of the secondary back in step 2, wind an additional 18 turns to complete the transformer.

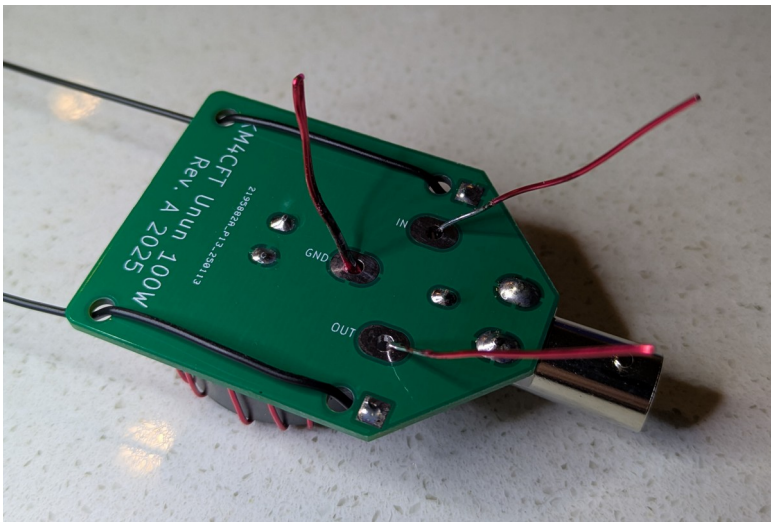


Be sure to double check the number of windings in case you miscounted!

Step 6: Solder on the Transformer

Before we begin this step it should be noted that the enamel on the magnet wire used can be stripped using two methods: mechanical and with heat. You can mechanically strip away the enamel using a hobby knife or with sandpaper. Or, you can use heat via a flame or with molten solder. The most importing thing to know is *all of these methods work*. I personally like to do a combination of a hobby knife and molten solder when doing this.

First, scrape away the enamel on the ends. Next, line up the wires so that they fit into the three holes around TR1. On the other side of the board the holes are labeled so use that to ensure that you are aligned. You might need to use some needle nose pliers to flatten out the bend for the ground.

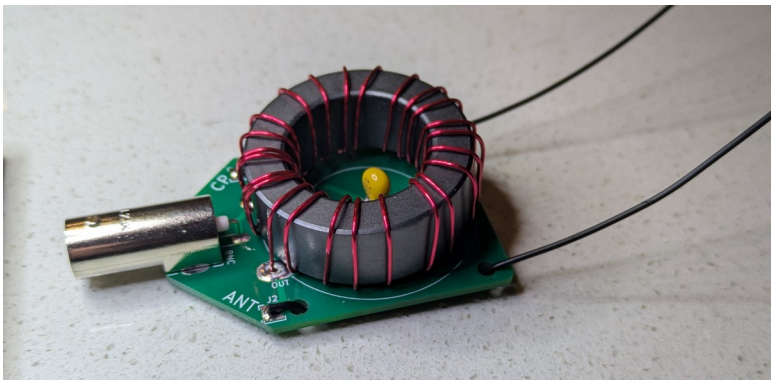


Raise the temperature of your soldering iron and add solder to the three points. To ensure the solder burns away any excess enamel, allow the solder to dwell for at least 10 seconds. The enamel will cause the solder to bubble if there is any remaining.

Inspect the joints and trim off the excess magnet wire!

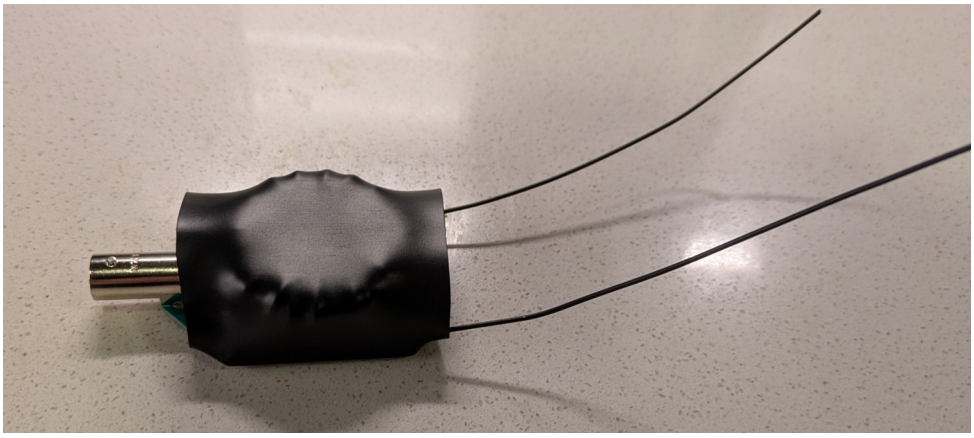
Step 7: Test and Heat Shrink

At this point, you have finished your EFHW Unun. All that is left is to install the heat shrink tubing over the connector. Before that however, I recommend you take it out and test it with a length of wire to make sure it is functioning properly. (see the next section for guidance on how to set up the wire) Once you have verified it works, you can then install the heat shrink.



Before installing the heat shrink you might need to trim the heat shrink slightly so that it fits nicely over the unun. This is cosmetic, so it is not required for you to trim the heat shrink if you don't want to!

With that, you have successfully assembled your 100W KM4CFT EFHW! Congrats!



Additionally, you may want to add some hot glue to the ends if you wish to seal the unun from dust or moisture.

For winders, this is compatible with the K6ARK Winder design that can be 3D printed. You can find the design here: https://www.printables.com/model/320604-wire-antenna-winder-with-female-bnc-clip

End Fed Half Wave Antenna Wire Options

There are two main options you can easily do for your EFHW antenna: single band, or linked multiband. With a single band antenna, you measure and cut the antenna wire so that it is resonant on the band of interest. If you want to make the antenna work on multiple bands you can measure the wire for the highest frequency of operation and then add on additional wire to make the antenna work on lower frequencies.

Single Band:

1. Choose the band you want the antenna to operate on.
2. Calculate the half wavelength for that frequency.
    a) You can calculate it using the following formula: $Half\ Wavelength(m) = \frac{3 \times 10^8}{2 \times f_{Hz}}$
    b) Alternately you can use these lengths. I have made them a bit longer to allow for adjustment:
        - 80m: 142 feet (43.25 meters)
        - 60m: 93 feet (28.3 meters)
        - 40m: 72 feet (22 meters)
        - 30m: 50 feet (15.25 meters)
        - 20m: 36 feet (11 meters)
        - 17m: 28 feet (8.5 meters)
        - 15m: 25 feet (7.6 meters)
        - 10m: 19 feet (5.8 meters)
3. Measure and cut that length of wire and attach it to your antenna line of the unun
4. Using zip ties to form a loop at the end of the wire deploy the antenna in a method similar to how you intend to deploy in the field.
5. Using an antenna analyzer or a calibrated nanoVNA, check the SWR.
    a) If you used the above lengths, the minimum SWR should be *below* the band of interest. Its easier to make the wire too long and shorten it than for it to be too short and need wire added!
6. Adjust the length until the antenna is in tune for your desired band. You don't need to cut the wire, just make sure the excess is folded back on itself to prevent it from affecting the antenna length.

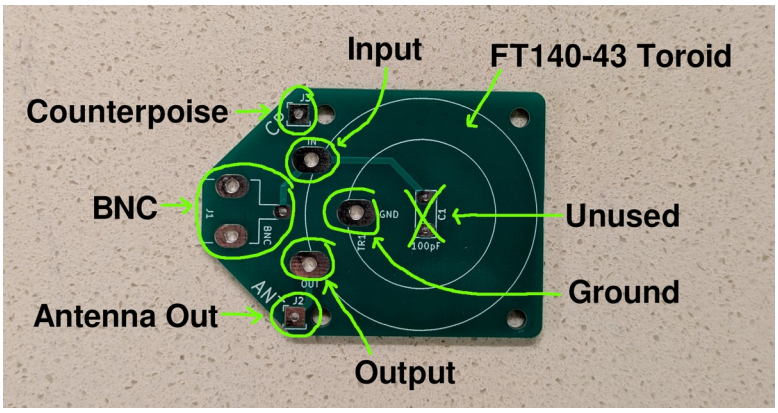
Linked Multiband:

If you want to make the antenna into a linked multiband EFHW, then do this procedure for the *highest* frequency of interest. Add a method to "link" the wires together (such as with spade connectors or mini banana connectors). Then add additional wire and repeat the procedure in order of *decreasing* frequency. Remember to account for the wire length of the higher frequencies when cutting for the next band.

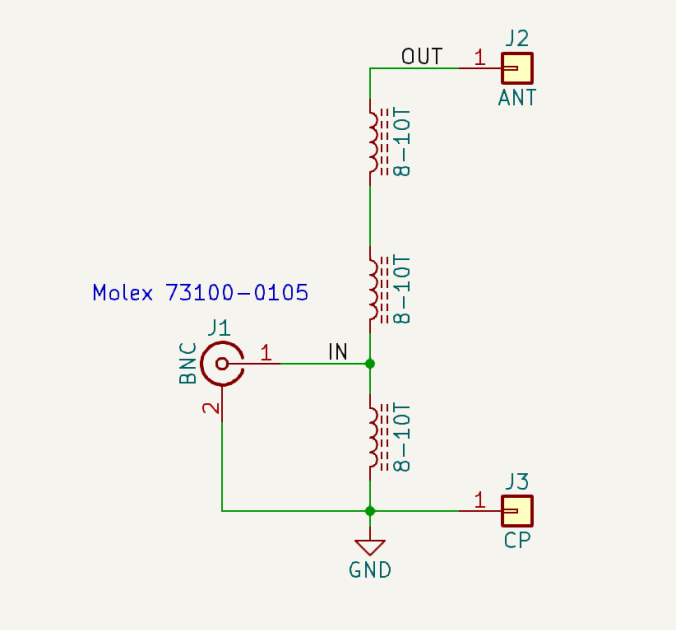
Example: I want my antenna to be resonant on 40 and 20 meters. First I would adjust the wire to be resonant on 20 meters. Lets say after this my wire length ends up being 29 feet. I would then cut another piece of wire to be 43 feet long (72-29=43). I would link this additional piece of wire onto the first link then tune the length for the 40 meter band.

End Fed Random Wire (EFRW) Build Instructions

Before we begin assembly, lets take a look at the Printed Circuit Board. Note that it might differ slightly in color but will still have the same general layout.

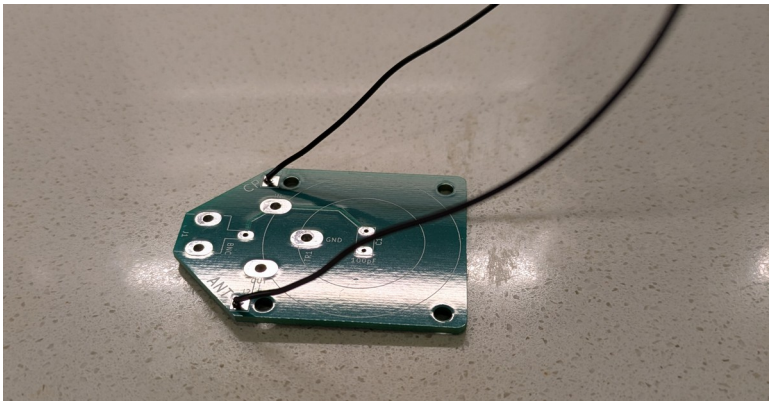


Now that we have a small familiarity with our PCB, lets get to building!

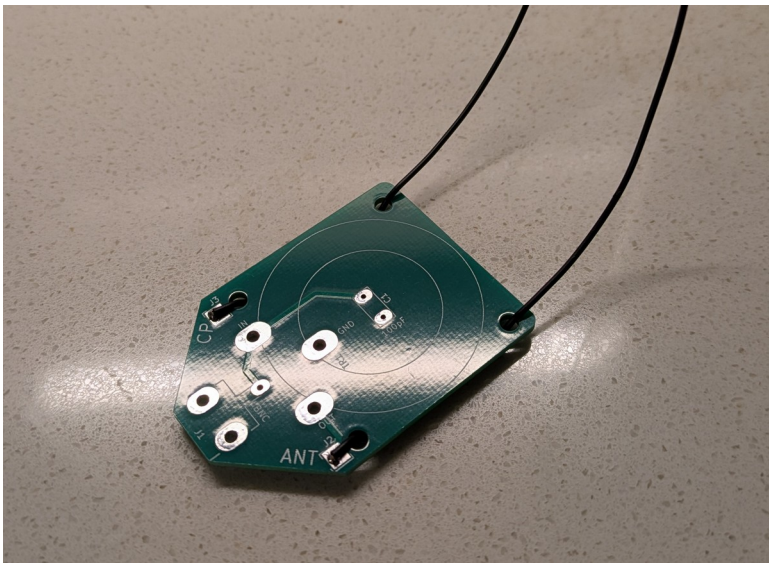


Step 1: Install Radiating Wires

Take your 6 inch length of polystealth wire and cut it in half. Strip a small amount of insulation off the wire and solder them into the holes labeled “CP” and “ANT” as shown in the following photo.



Next, feed the wire through the 4 nonplated holes around TR1 to perform a strain relief.

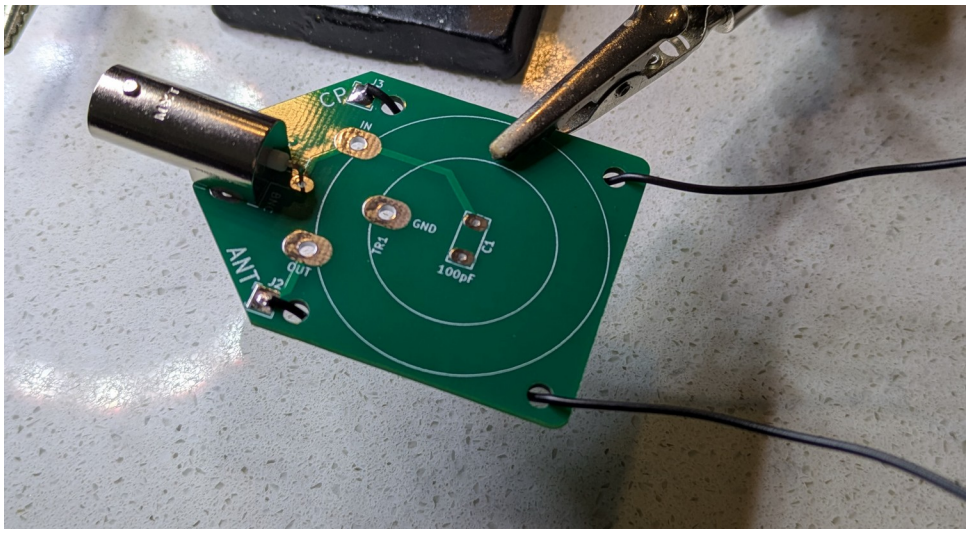


Step 2: Soldering the BNC Connector

Take out the BNC connector and place it onto J1. For this, I recommend using some helping hands to hold the board. On the top side, solder the center pin so that the connector is “tacked” into place. If you are lucky you might have even properly soldered that pin on the bottom too!

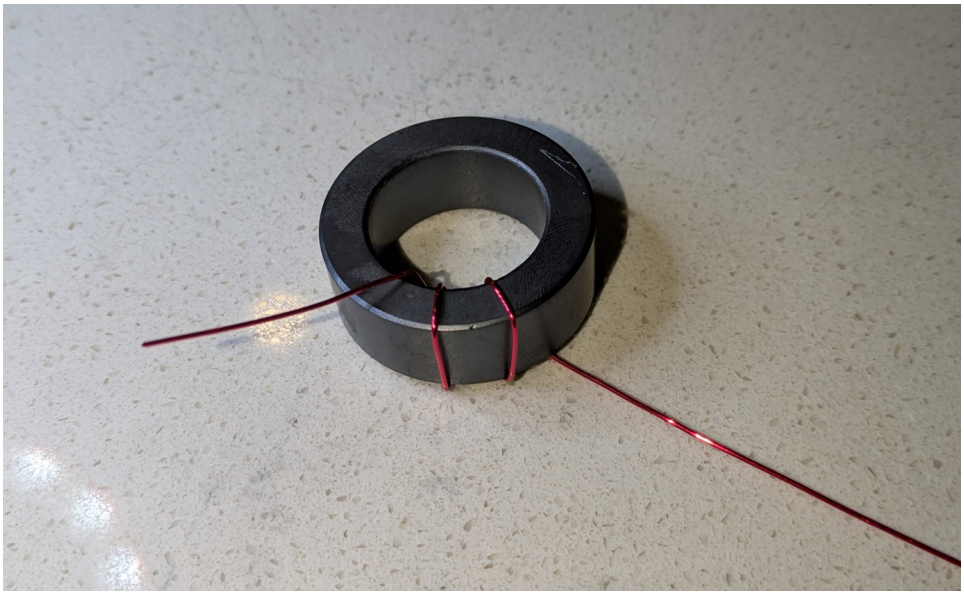
Flip the board over and solder the two ground mounting pins. This might be somewhat difficult since you need to basically heat up the entire component, so higher temperatures and a larger soldering iron tip can make this easy. Be patient though, the solder will flow if you get the connector hot enough.

If the center pin isn’t already good from earlier, use your iron to reflow the solder to ensure the joint is nice is neat.



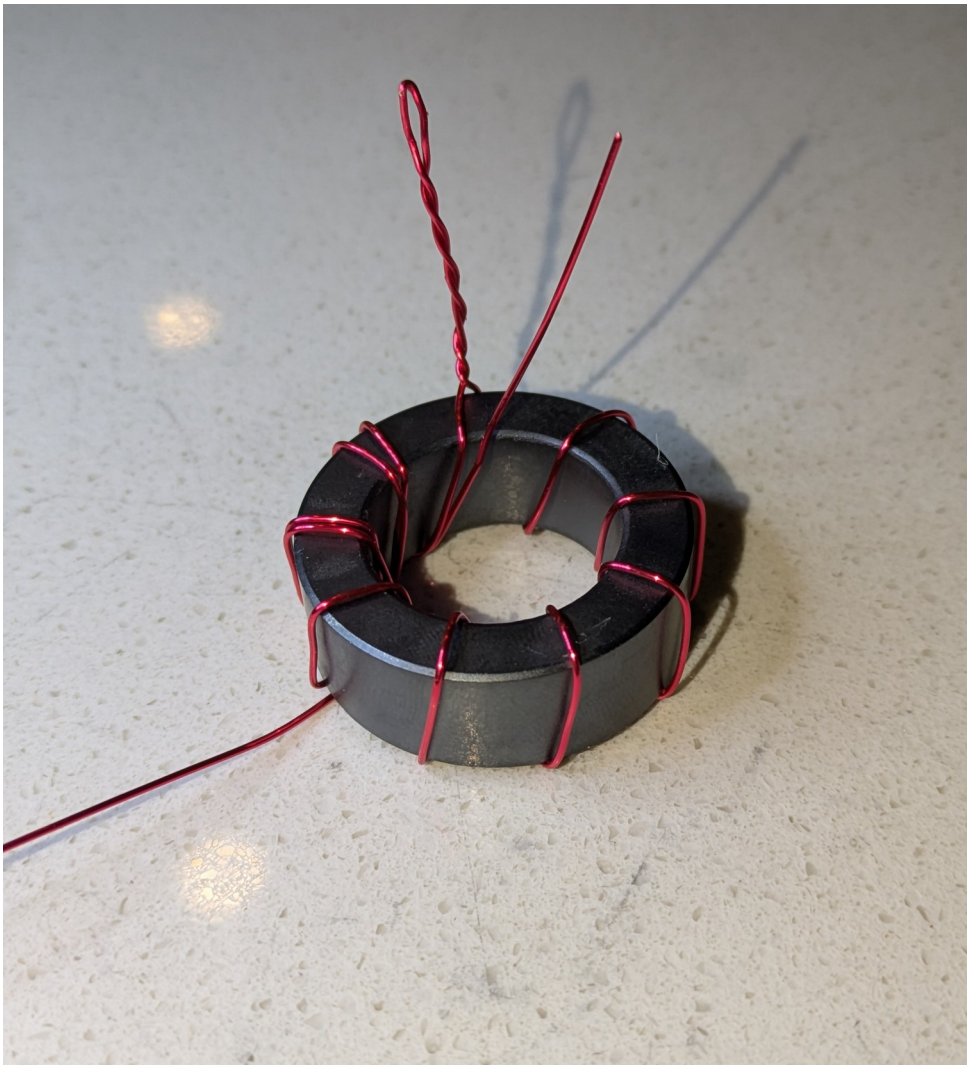
Step 3: Winding the Toroid – Lap 1

Take out your magnet wire and straighten it out. Next we want to wind 8-10 turns around the toroid. Be sure to only leave a small amount of extra wire as a pigtail (about an inch) otherwise you might not have enough to complete the transformer! Remember that every time the wire passes through the center it counts as a turn. Once you have wound your 8-10 turns be sure to spread them evenly around the toroid.



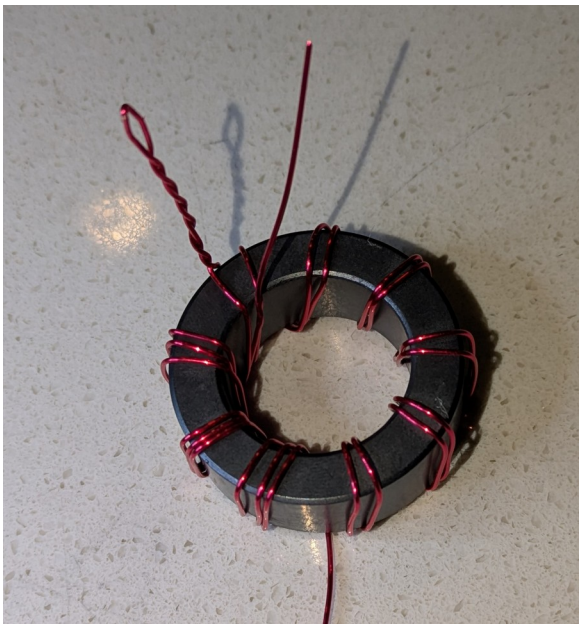
Step 4: Winding the Toroid – Lap 2

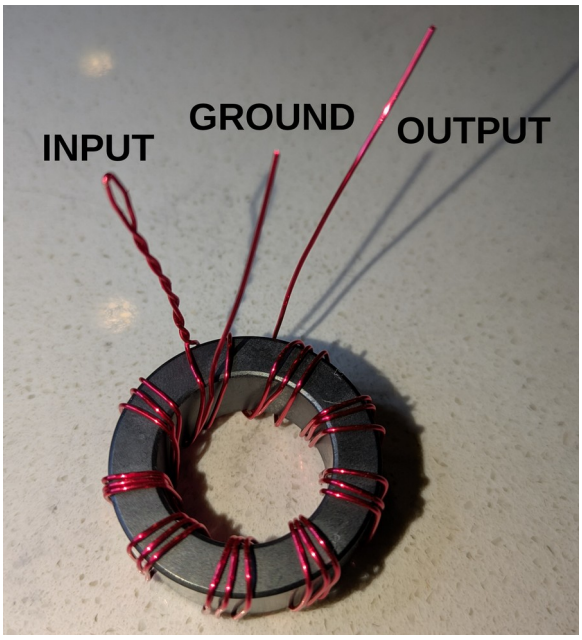
On the long end of your magnet wire form a small loop for the input of the 9:1 unun. You will want to form this loop just after passing the starting loop just like in the picture. Use a pair of needle nose pliers to form a twist on the loop so that you will be able to pull the wire tight as you continue the wind. Take the wire and continue winding. Be sure to follow the first lap of windings like in the image below.



Step 5: Winding the Toroid – Lap 3

Once you have finished your second lap simply continue winding to form the third lap around the toroid. Once you are done you should have 8-10 trifilar windings around the toroid.





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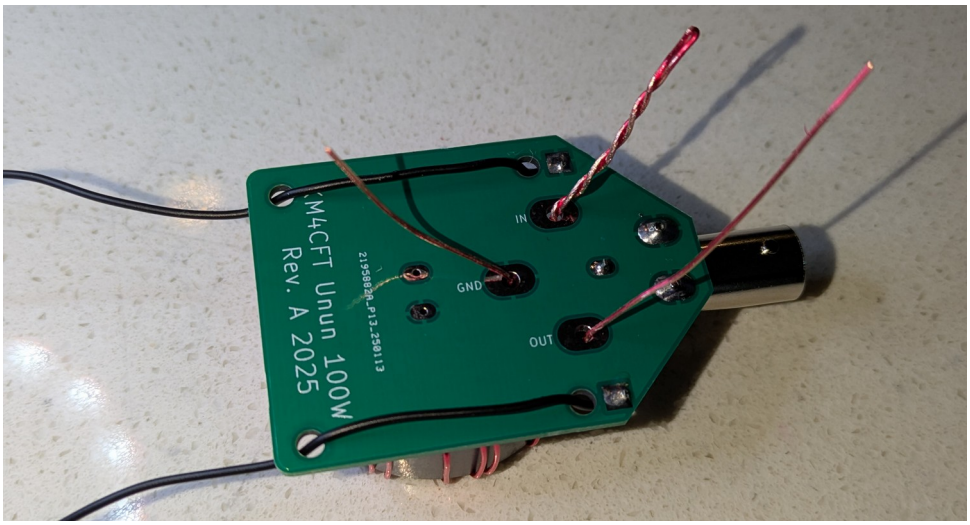
First, scrape away the enamel on the ends. Next, line up the wires so that they fit into the three holes around TR1. On the other side of the board the holes are labeled so use that to ensure that you are aligned. You might need to use some needle nose pliers to flatten out the bend for the input.

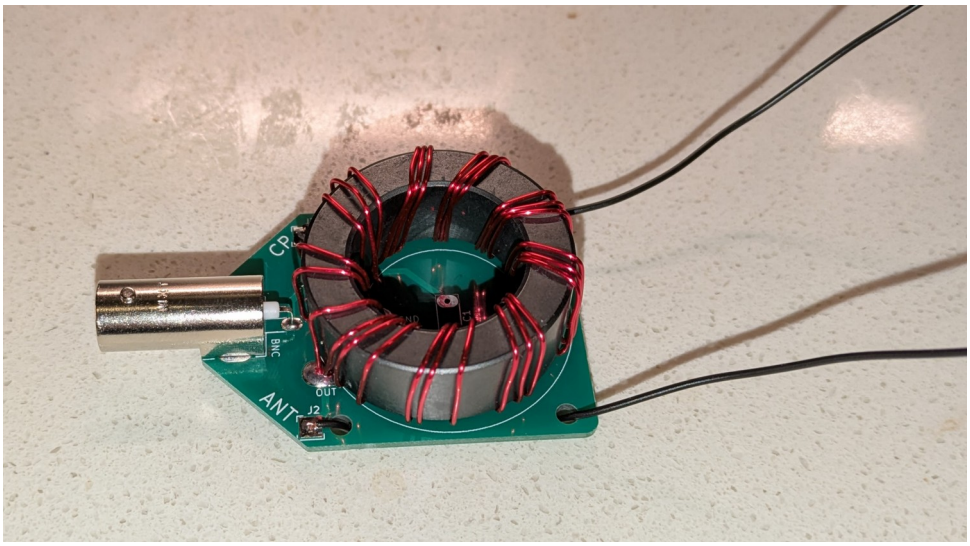


Raise the temperature of your soldering iron and add solder to the three points. To ensure the solder burns away any excess enamel, allow the solder to dwell for at least 10 seconds. The enamel will cause the solder to bubble if there is any remaining.

Inspect the joints and trim off the excess magnet wire!

Step 7: Test and Heat Shrink

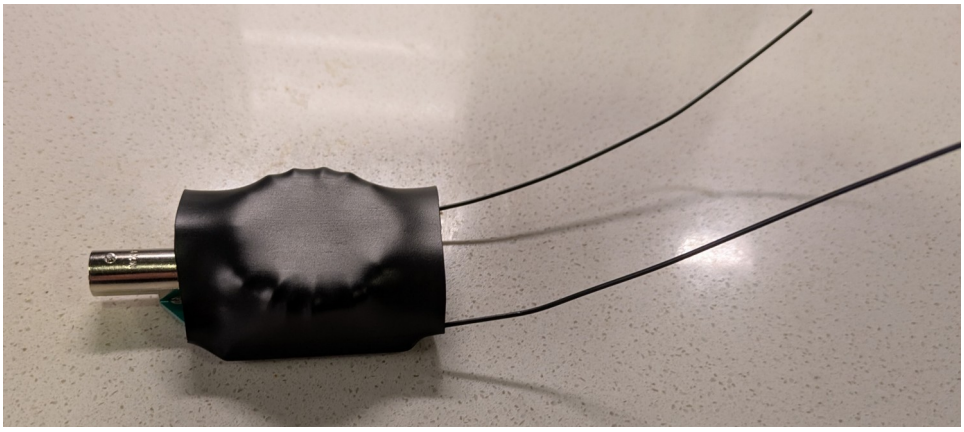
At this point, your EFRW unun is finished. Before installing the heat shrink tubing I recommend you test your EFRW. This can be done by connecting a 450Ω resistor across the two wires and seeing if you get approximately a 1:1 SWR with an antenna analyzer. Once you are happy you may proceed to installing the heat shrink.



Before installing the heat shrink you might need to trim the heat shrink slightly so that it fits nicely over the unun. This is cosmetic, so it is not required for you to trim the heat shrink if you don't want to!

Additionally, you may want to add some hot glue to the ends if you wish to seal the unun from dust or moisture.

With that, you have successfully assembled your 100W KM4CFT EFRW! Congrats!



End Fed Random Wire Antenna Lengths

Ultimately with an end fed random wire antenna there isn't a specific length you need to achieve. What you want to do is make sure the wire length is at least 3/8 of a wavelength of your lowest band you want and that the antenna is *not* resonant on any of the ham bands.

For finding lengths I recommend you read the University of Delaware article on lengths: https://udel.edu/~mm/ham/randomWire/

Typically you will use a 17 foot counterpoise and a radiator length that suits whatever bands you wish to operate.

Another resource comes from HamUniverse which lists some good radiator wire lengths in feet: https://www.hamuniverse.com/randomwireantennalengths.html

29, 35.5, 41, 58, 71, 84, 107, 119, 148, 203, 347, 407, 423