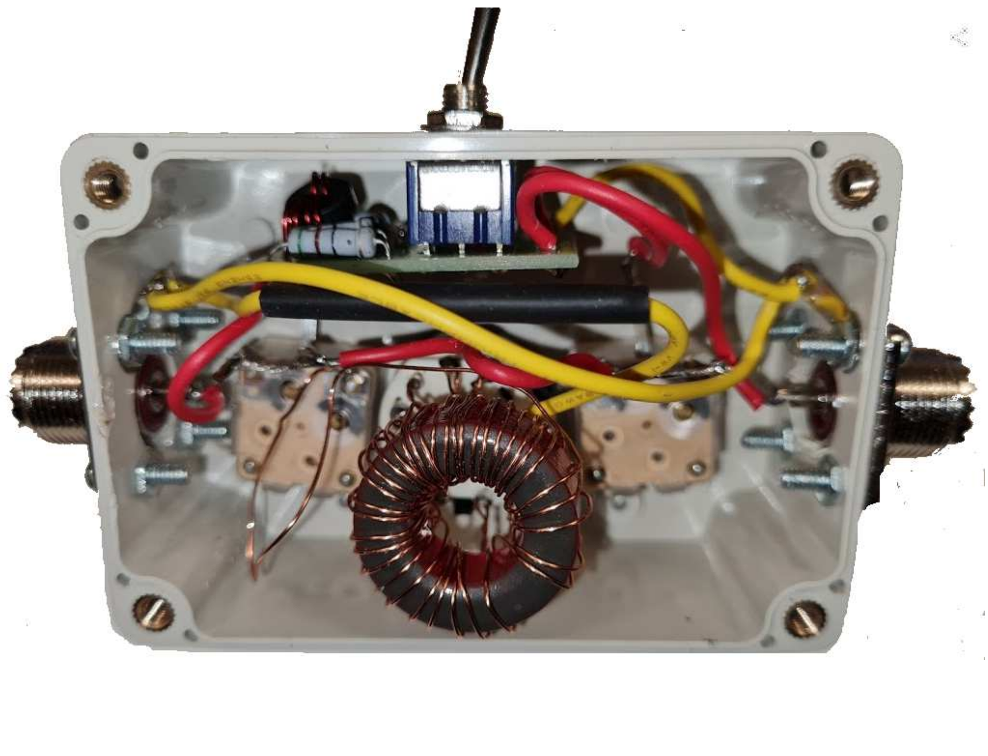
QRP - Manual
Antenna Tuner

Otherwise known as

QRP Manual Days Antenna Tune Tuner DIY Kit 1-30Mhz or

QRP Manual DIY Antenna Tuner Kit 1 -30Mhz



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This document was re-written and added to by Bob Fryer - VK1ERF
Additional review by Rod Channon – VK1CBR

Attribution

I feel it is only fair that attribution should always be given where original published work has been used for the basis of a project or design. This should have been given on the original instructions. Whilst I do not have the exact history of who released it first, I always believe an attempt should be made to provide some detail as part of the project or design.

The QRP Manual Tuner appears to be the combination a few pieces of work, some that are possible to locate on the Internet.

SWR Indicator Circuit - Dan Tayloe N7VE LED SWR indicator
T-NetworkTuner - http://www.arrl.org/files/file/Technology/tis/info/pdf/9501046.pdf
QST article: "A QRP Console" Doug DeMaw, QST, Sept. 1970 – No link – have not read it

Whilst there is no one definitive article, like most things, ideas are improved on through the years. However, I think it is important to provide known attribution, as this also allows the reader to understand and confirm the foundations that the project or article are based on.

Caveats – Before you move on

The information provided is based on the original translated instructions which may have faults. I have added much more detail and instruction which may also have its faults. You should perform your own research and calculations, particularly as your use of this kit may differ from my use, but rest assured, the release of these instructions means that my unit worked based on these instructions and that I am using it for QRP work in the HF Spectrum working on 5 Watts or less (generally less). If there are some limitations or further concerns, I will list them in this document.

This "kit" is not overly complex, but it is frustratingly fiddly, and there are opportunities for "dry joints" particularly with the enameled copper wire provided.

I have no affiliation with the product designer or original documentation author, and I have no affiliation with the companies that sell this product.

Introduction

To start with, this kit is available from several suppliers, particularly generally Chinese suppliers under the umbrellas of Aliexpress, Amazon, Ebay and Banggood etc. Whilst it has been around for quite a few years, it is still a popular kit. Some suppliers provide extremely poor instructions, whilst most other suppliers provide no instructions at all. This is a extensive rewrite to make it easier to follow due to the poor translation of the original instructions.

I bought this as a quick and simple tuner for QRP CW operation and I suspect that once working it will do exactly what I am after. However, longevity, reliability, quality are different issues, but again this is part of the journey in **learning**, **upgrading**, **rebuilding**, making it better. Even whilst reviewing the instructions and the circuit diagram, I already noticed some areas that were inconsistent with general reference designs.

Let us be very clear, there is nothing overly unique about this design. There are several reference designs similar in the years gone past, and in fairness, this design is not overly complex either. It basically combines two main types of circuits.

1) Tuner
2) SWR Indicator

However, to give the suppliers their dues, they put the parts needed into a bag, so that we don't have to go looking for them, but don't expect this kit to be a precision kit. Based on the price, the parts are basically scooped up and put in bags with no consideration of component changes. So, you will most likely have to make changes to mountings on the fly. Typical issues I found were,

- PCB Markings for SWR Indicator Toroid are incorrect.
- 0.8mm enamelled wire supplied instead of the stated 0.5mm wire.
- Variable capacitor component dimensions larger than the original design
- Variable Capacitor mount holes oversized on sticker.
- Wrong nuts supplied for required screw for Variable Capacitor knobs

These are not insurmountable issues, but if you paid your money, expecting a perfect run in your build, it Is unlikely.

My serious advice on building this kit is to work on the basis that nothing should be assumed as being correct, check, recheck and once built check again…however hopefully these revised instructions will make your life a little easier.

Kit Parts Issues/Faults

As this kit is sold by a number or "shops" via Aliexpress, Banggood, Ebay, to name a few, they each provide the parts from their suppliers and/or stock. This means that the kit that was bought a year go (or even a few months ago) may not have the same parts provided. Likewise for a less than $10 project, they are not going to take the time to make sure the replacement parts that they have provided, will make any difference to the project.

It is up to you to check and test the parts, and in some cases ascertain the correct values of the parts sold to you. So lets look at the faults or issues I found on the build.

Issue 1 : Enamelled wire supplied was 0.8mm instead of the stated 0.5mm wire – This made it hard to work with, particular when you make multiple taps on a toroid that then must be soldered at multiple points on a switch. It also placed undue stress on the "plastic" switch which eventually failed.

Issue 1 Remedy : Replaced the 0.8mm with 0.5mm enamelled wire. With the small number of winds, the difference between 0.8mm and 0.5mm is negligible, but the ability to work with it (malleability) is quite a bit. It is fair to say that a couple of hours are saved working with the 0.5mm wire.

Issue 2 : Enamelled wire coating is the deep red coating which is hard to remove. This type of enamelled wire is something I prefer to avoid, especially for winding on toroids. This enamel can only really be removed by sandpaper/emery paper which can still lead to dry joints.

Issue 2 Remedy : Replaced the deep red enamelled wire with a "gold coloured" enamelled wire. This can have the enamel removed with a soldering iron and tinned at the same time. I recommend reading the following section on Enamelled wire.

Issue 3 : Following the stickers for hole dimensions and placement is not recommended. First issue is that the hole sizes for mounting screws for the variable capacitors are too large, which then forces you to use washers. As they have been made too large, when you go to drill the hole for the centre shaft, it is too close, especially if you need to enlarge the whole slightly to provide clearance.

Issue 3 Remedy : Avoid the stickers if you can, planning out your own layout and labelling if possible.

Issue 4: As per issue 3 – following the stickers will force you to place the variable capacitors at angles due to the existing stubs inside the case. You can see this in figure 15, where the variable capacitors need to be set at an angle.

Issue 4 Remedy : Avoid the stickers if you can, planning out your own layout and labelling if possible, possibly building into your own case with more space.

Issue 5 : Knobs and screw hardware was not suitable or missing nuts. I looked at the pieces provided, and it was not going to be reliable or long wearing.

Issue 5 Remedy : Due to the missing nuts, I already had to take a trip to the local electronics store, so I re-thought the knobs and detailed the changes in this document. This included picking up some new variable capacitors with large dials (I did not use the variable capacitors, but modified the dials to make new bases to which I glued the knobs.

Enamelled Wire & Winding Toroids (some quick thoughts)

I was doing a quick bit of research on this enameled wire (looking for the different types of enamel being used in the last 10 years) and even in the last few years, I noticed that there is a lot of forum chatter on best ways, quickest ways, best methods in dealing with removal of insulation from enamelled wire.

So, I thought for others that do not have experience with toroids and enamelled wire, that I would put my thoughts down (or even for others that find toroids frustrating because of these issues). Please note, I do not claim to be an expert.

Now there are two main types (there are more) of insulation used on enamelled wire that the general consumer can purchase. This is PUR1 (Polyurethane Grade1) and PEI (Polyester-imide). PUR1 can be melted by a reasonable quality soldering iron (as I mention below), but PEI-S (Solderable) can also be melted but at a higher temperature. There are many grades of PEI such as PEI-S, PEI-AI, PEI-B, which may require stripping/cleaning with abrasive.

When winding toroids, I have always shied away from the deep red enameled wire as I have always associated it with the PEI enamels. I might be wrong on whether it is PEI and I might be wrong on assuming that these deep reds are not easy to melt the insulation away, but in almost all cases, my assumption has been right. The other issue is that unless you are buying from a specialist supplier (e.g. RS Components, Element 14, etc.) they usually do not have the insulation material listed, and generally they don't have data sheets available. Specialist suppliers like the ones mentioned above will have data sheets or they will have the words in their descriptions such as "solderable PUR insulation", "Insulation Material PUR"," Insulation Coatings : Polyurethane 180" and "Solderable PU Enamelled Copper"

I prefer to use the enamelled wire that I get from a local electronics shop which is more of a gold colored enamel (and I am assuming that it is PUR). When you present a tap (toroidal tap) or the ends of the gold coloured enamel wire with a blob of solder, the enamel melts/burns away (under a good magnifying glass you can actually see it bubble away), and tins the copper wire at the same time. I find I have a less likelihood of dry joints when using this wire.

For those in Australia, this can be found at Jaycar Electronics with the following URL https://www.jaycar.com.au/0-5mm-enamel-copper-wire-spool/p/WW4016. They also sell it via Ebay as well.

If you look at the following picture in figure 1 (which I have left large to make it easier to see), the tinning of this enamelled copper wire was completed in roughly 7 seconds with no sandpaper or emery board. It required a temperature-controlled soldering iron at 350 degrees Celsius (for the taps I turn it up to 370 degrees), and a blob of fresh solder. With the iron on the end of the copper wire, let it build a ball until you see the enamel coating disappear (bubble), and the copper being tinned. It is a little bit of an artform, but it is achievable with a good soldering iron, and believe me it is a lot more reliable than using emery paper or scraping the wire.

Figure 1

I can't tell you what enamel coating this is exactly (I am assuming PUR1) but I am pleased that it appears to have a melting point around the 370 degree Celsius mark (at least that's what the Soldering iron was set at).

So in summary, if you have some simple toroids, its not going to make too much difference what enameled wire you use, but if you are doing some complex toroids with multiple taps, you will find that your choice of enamelled wire could save you a few hours of work, or possibly even throwing your project out the window in frustration.

Finally, one more thing. You may find others talking about wrapping PTFE tape (plumbers thread tape) around the toroid. I generally use the PINK tape (still called plumbers tape) which is thicker than the general plumbers tape. I don't always use it, and may depend on the likelihood of the toroid scraping the insulation on the Enamelled wire (packed windings), or if it is going to be outside (balun etc), then I normally use it. If unsure whether to use it, just use it, you won't be worse off and actually adds a bit of movement resistance to the windings moving round the toroid.

Tools

I tossed up whether to mention it, but I think it is necessary. Using the right tools to do the job will make your life a lot easier. Note, I say the right tools, and not necessarily the most expensive or the best tools.

For most of us it is a hobby with a finite end to the finances, so you need to be prudent on the gear that you purchase. It would be nice to go out and spend $1000+ on all the tools that you want, but for many this is not possible. But the following are important;

- **Temperature Controlled Soldering Iron (and or station)** - In Amateur Radio, you are going to work with a variety of components, particularly items such as SO239 Sockets or Enamelled Copper wire, and then back down to heat sensitive semiconductors. A good temperature-controlled iron just makes a lot of sense.

- **Multimeter** – Just put a little bit of money into this, as a good multimeter will last you years, and may be one of the most useful tools you will own.

- **Good set of pliers and Diag pliers/Diagonal Cutters/Side Cutters** - Just don't go for the cheapest, put a little bit of money into some decent ones, you will learn to appreciate them.

Other useful tools that reduce frustration.

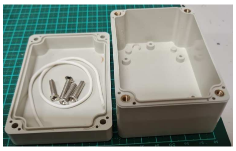
- **Soldering Helping Hand with Magnifier and LED Lighting** - Now I will be honest and state that my eyesight is nothing like it used to be, so I find the magnifier really helpful, and the ability for this thing to hold a board or even just a wire, just makes it easier. Whether you are old or young, good eyesight or not, a good light source and a good magnifying glass will make identifying issues or faults that so much easier.

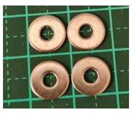
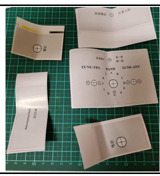
- **Powered Rotary Tool with flexible Shaft (e.g. Dremel or similar) -** There is nothing I have found that has been more useful in the workshop than the Rotary tool. Originally purchased as a useful tool for the garage, it was moved in the workshop many years ago, and has never left. With a range of engraving, polishing, cutting, cleaning, sanding, carving and drilling tools, it becomes indispensable in the workshop now. With the ability to control the speed, even delicate work whilst parts are in place, can be completed without applying too much force.

Bill of Materials (BOM)

This kit comes with the following parts :

Table 1

Qty	Part	Picture	Comment
1	Weatherproof Sealed Box		Box includes seal and 4 Countersunk Screws
1	T-106-2 Toroid		Red in Colour – I describe it as the Tuner Toroid
1	FT37-43 Toroid		Black in Colour - I describe it as the SWR Toroid
1	2.5m Length of 0.5mm enamelled wire		SEE IMPORTANT NOTE ON THIS COMPONENT IN THIS GUIDE
1	12 Pole Rotary Switch		
1	Large Knob		
2	Variable Capacitors		The ones I was provided with appear to be 80/160pf on my measurements – in other words 20pf-240pf when paralleled (per each Variable Capacitor)
2	Small Knobs		
1	Circuit Board		Standing Wave Indicator (PCB Marked V2.0)
1	Double Pole Double Throw Switch (DPDT)		

1	Red light emitting diode		
3	51 ohm 2W resistor		
1	1K Resistor		
1	1N60 Diode		
1	0.1uF Ceramic Capacitor		
2	Pieces of insulated wire		
2	BNC Sockets		And the relevant mounting pieces
4	Countersunk Screw for Variable Capacitors		Not actually countersunk screws
2	M2 Bolts (20mm Long)		
2	M2 Nut		
4	M2 Washer		
1	Set of Stickers		For hole positioning SEE IMPORTANT NOTE ON THIS COMPONENT IN THIS GUIDE

What is an Antenna Tuner?

An antenna tuner has been known by many names over the years, but the most popular names are Antenna Tuning Unit (ATU), Antenna Tuner, Antenna Matching Unit, etc.

Antenna tuning, in simple terms, is the process of matching the antenna impedance with source impedance. If you do not provide a close match, you are at risk of damaging the finals on your transmitter as the transmission is reflected back at your transmitter.

Antennas can be best described as an RLC (Resistance, Capacitance, and Induction) network,. Its values can be affected by the antenna's physical properties which are the shape, size, material, height above ground, and other environmental factors.

Probably the most effective and the most energy efficient way to tune an antenna is by trimming (or lengthening the antenna to the correct wavelength) to bring it into resonance. For many of us, where an end fed dipole is the only option, or a single dipole tuned to the 15m band is the longest antenna you can install (planning laws / HOA / etc), then an antenna tuner is probably the next best thing.

The most common term you will hear in relation to antenna tuning is SWR which stands for Standing Wave Ratio which is the ratio of forward to reflected power.

An antenna tuner uses a combination or inductive and capacitive components (ala the QRP Manual Tuner), to match and bring the Antenna into resonance. It should be noted that just because you reduced your SWR and your impedance matches, does not necessarily mean that the full amount of power is propagated, but it does mean that you have less chance of your transmitter being damaged, and you can use that antenna to broadcast even if it is not necessarily efficient.

The QRP Antenna Tuner uses a T-Network design and is best suited to the 1-30MHz frequency range and can withstand the transmit power of 15W (when the switch is switched to normal operation mode. The original instructions states "The tuning range of this tuner is approximately 40-300 ohms, which is very convenient for QRP communications, to ensure high efficiency radio transceiver in communication, but also allows you to fully enjoy the fun of building this tuner yourself".

NOTE : I have added a lot of the above has general background to provide a springboard for more research if any one is interested. Ultimately, antennas, SWR, antenna matching, resonance, impedance, capacitance and resistance form part of a very complex and vast subject that you could devote a lifetime to (and some do). This discussion is intended to provide a general background, not a definitive discussion.

Circuit Diagram

Let's take some time to look at the circuit diagram, as it will help us understand the process as we build the device.

As mentioned earlier, this QRP Antenna Tuner, in its simplest form is based on a T-Network design. In current times, this type of design accounts for many of the commercial designs as they are reasonably simple to design and build. However, each design type, has its drawbacks and in this case it is a high pass design, which provides for no harmonic attenuation.

Let's look quickly at a basic layout of a T-Network (Figure 2) and compare it to the network diagram of the QRP Antenna Tuner (Figure 3)

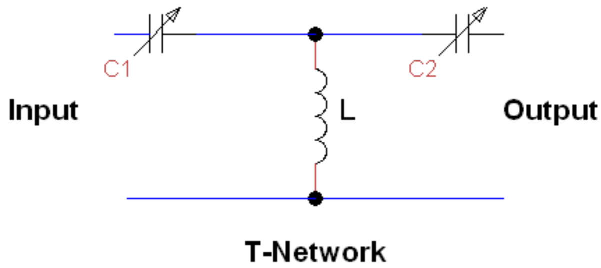


Figure 2

As you can see, if we look at the circuit diagram in Figure 3, you will see very clearly the T-Network component like figure 2 above. The only difference in the complete network diagram is that the inductor is tapped, so that we can use the 12 Pole Switch to change the inductor value.

So, if you are new to antenna tuners, you are probably wondering what the rest of the circuit is for. Well, the Double Pole Double Throw (DPDT) switch provides a very clear separation (with the switch in in normal operation mode) of the two circuits.

In effect we have two main circuits

1) **a T-Network design to provide the tuning/impedance matching**
2) **A resistive bridge circuit to provide an indication of SWR**

You will find plenty of information on the T-Network and the effect of the inductance and variable capacitors on the Internet and the many publications. Basically, the resistors and the "tuned" impedance of your Output form a balanced bridge (when it is correctly balanced), with the LED showing no voltage or very little when the SWR is close to 1:1

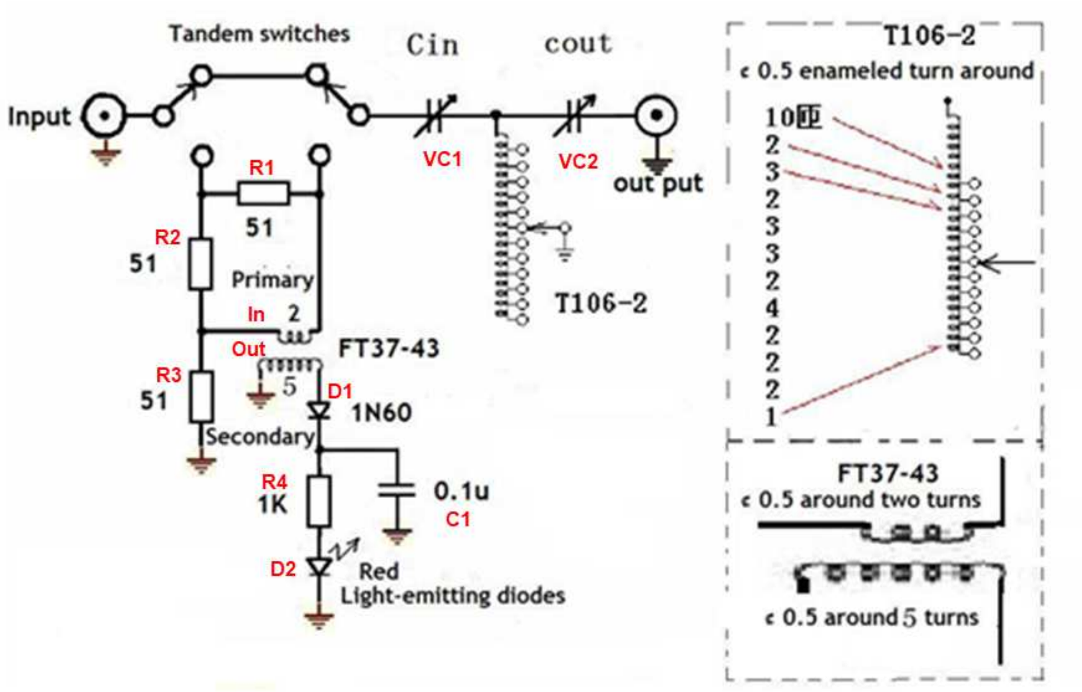


Figure 3 – Original supplied Circuit Diagram

Honestly, if the kit becomes all too much, there is nothing stopping you mounting the two capacitors on the board, build your toroid, mount it, and use a alligator lead to select the toroid tap instead of a switch and ignore the SWR LED and use an external SWR meter. I was close to doing this until I realised the fault with the PCB markings for the LED SWR. Just remember you are dealing with RF, so take normal precautions.

Build Instructions

1) First, make sure your workspace is clean and organized. There is nothing worse than trying to start with the remnants of your last project sitting on the bench.

2) Next make sure you have the time to concentrate and start on this project. There are parts of this project that require some concentration (particularly the toroid winding and tapping) and they require the time. So, plan your time, and be prepared to do a really good job on the toroids. It is true to say that the tuning toroid, in particular, is the heart of this project, and you should take the time to wind it correctly, tightly, making sure that the taps are done well, and that the taps have had the enamel removed, and taking an interest in pre-tinning the taps and the 12 pole switch to make your life easier.

3) Now the original instructions are unclear on what to start with, but my recommendation is to start with the two toroids, which is what we will start with. Please note however, if you become frustrated with the toroids, you can take a break by preparing the case by drilling and checking parts fit (it can be very therapeutic!!)

4) So let's ease into it and start with the simpler SWR Indicator toroid first. Locate the 0.5mm enamelled wire. You should have one length of it in your parts, and the same wire is used for both toroids. As I mentioned, mine came with 0.8mm enamelled wire. For the purpose of this project, considering the power levels and the length of the windings, the slightly larger diameter wire will have negligible effect other than proving a little harder to wind on the smaller toroid. (but as I mention further on, the 0.8mm made it harder as it took longer to complete the toroids, and in the end did some damage to the switch (placing it under stress).

Hint : for those that have not wound toroids before, a turn is counted as it passes through the middle of the toroid. So passing a wire straight through the middle (and not wrapping on the core) is actually called one winding. I personally, as many others probably do., count the number of windings I can see on the inside diameter of the toroid.

The length of Enamelled Wire provided should be at least 2500mm (2.5m)

SWR indicator toroid

Table 2

Total turns : 7	Length per turn : 15mm	Total : 105mm
Taps : 0		
Toroid Tails : 4	Length per tail : 20mm	Total : 80mm
Total Wire Required		**185mm (0.185m)**

As I mentioned, we will start with the SWR Indicator toroid first, so the best thing is to cut the enamelled wire to the size that we really need. Just for interest, I cut off a 250mm piece for the smaller toroid (which is more than we need), leaving 2250mm piece for the tuning toroid (again more than we need).

The SWR Indicator Toroid – Primary Winding (2 turns)

Figure 4

The SWR Indicator Toroid – Secondary Winding (5 turns) + Primary

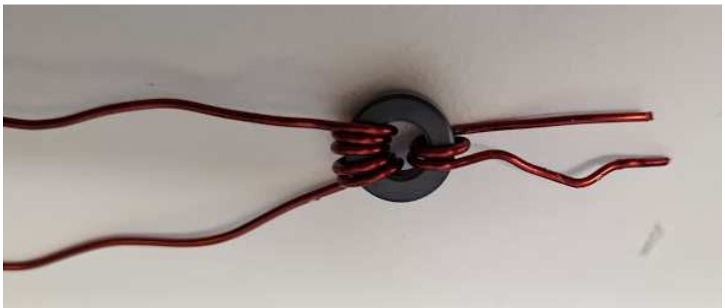


Figure 5

You will notice that I have left the secondary winding tails a little longer. The reason for this is that to sit nicely (space wise) on the PCB, the toroid needs to sit up (e.g not flat).

As you can see, count the windings in the hole, to confirm your winding count, in this case 5 windings on the left hand side and 2 windings on the right hand side.

Now once again I will state that the markings on the PCB are WRONG in respect of showing the number of turns, the "OUT" should have 5 Turns, and "IN" 2 Turns. Fit this toroid to the board now. Hopefully you have not jumped ahead and put the parts on the board, as it just makes it harder, particularly as the wires of the toroid are stiffer and harder to place.

Now, perform a test placement on the board and remove the excess tails. We need to do this so that we can scrape the enamel off the ends (unless you heeded my previous advice on enamelled wire) before we can solder them onto the board.

Once fitted, it should look like the following picture (which shows the correct way to install against the markings on the PCB). As previously mentioned, note that the toroid needs to sit up to enable a correct fit.

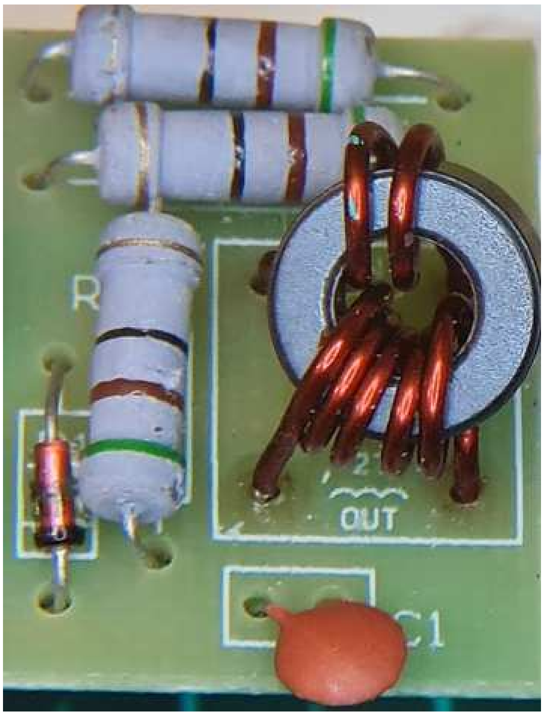


Figure 6

Now I will be honest, and state that all the work on the SWR Indicator toroid took about 1.25 hours. This is the sort of time (unless you make toroids every few days), that it will take you, and this includes cleaning the enamel off the ends, and when soldered, testing continuity to make sure we have no dry joints. If you are going to have dry joints, it will be on the toroid connections to the board, so it is worth the extra time to get it right.

If you have successfully completed this toroid, then well done, one more to go, and then it gets easier.

5) Now we will build the tuning toroid. Take the piece of remaining enamel wire (which should be about 2250mm long)

Tuning toroid

Table 3

Total turns : 35	Length per turn : 50mm	Total : 1750mm
Taps : 12	Length per tap : 20mm	Total : 240mm
Toroid Tails : 2	Length per tail : 50mm	Total : 100mm
Total Wire Required		**2090mm (2.09m)**

Let's ease into it by performing the initial 10 turns before we need to do our first tap.

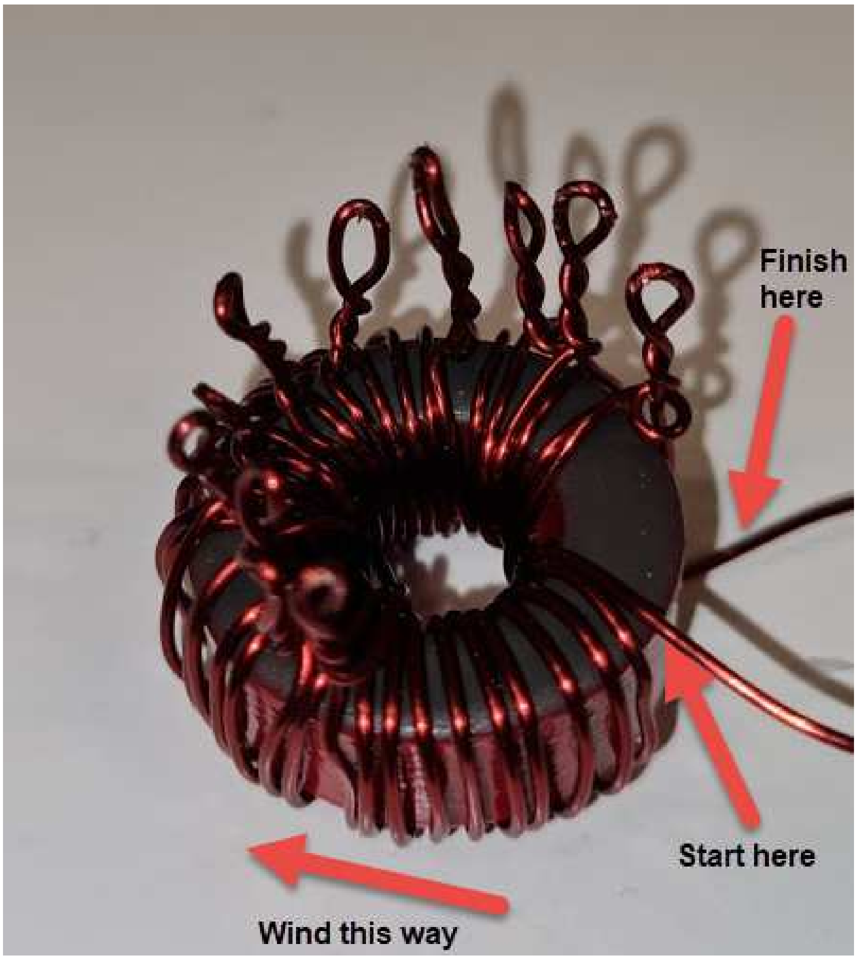


Figure 7 – Tuning Toroid – wire direction

So on the 10th turn, we need to make a tap, and then so on as per the table. Just clarifying, for instance, the 12th Turn has the twist on it, not two turns and then a twist.

Start Tail		Leave about 100mm (connects to variable capacitor later)
Tap 1	10th Turn	Tap (+10)
Tap 2	12th Turn	Tap (+2)
Tap 3	15th Turn	Tap (+3)
Tap 4	17th Turn	Tap (+2)
Tap 5	20th Turn	Tap (+3)
Tap 6	23rd Turn	Tap (+3)
Tap 7	25th Turn	Tap (+2)
Tap 8	29th Turn	Tap (+4)
Tap 9	31st Turn	Tap (+2)
Tap 10	33rd Turn	Tap (+2)
Tap 11	35th Turn	Tap (+2)
Tap 12		Tail (+1) This is the End tail which connects to 12 on rotary switch

Once finished it should look like the following,

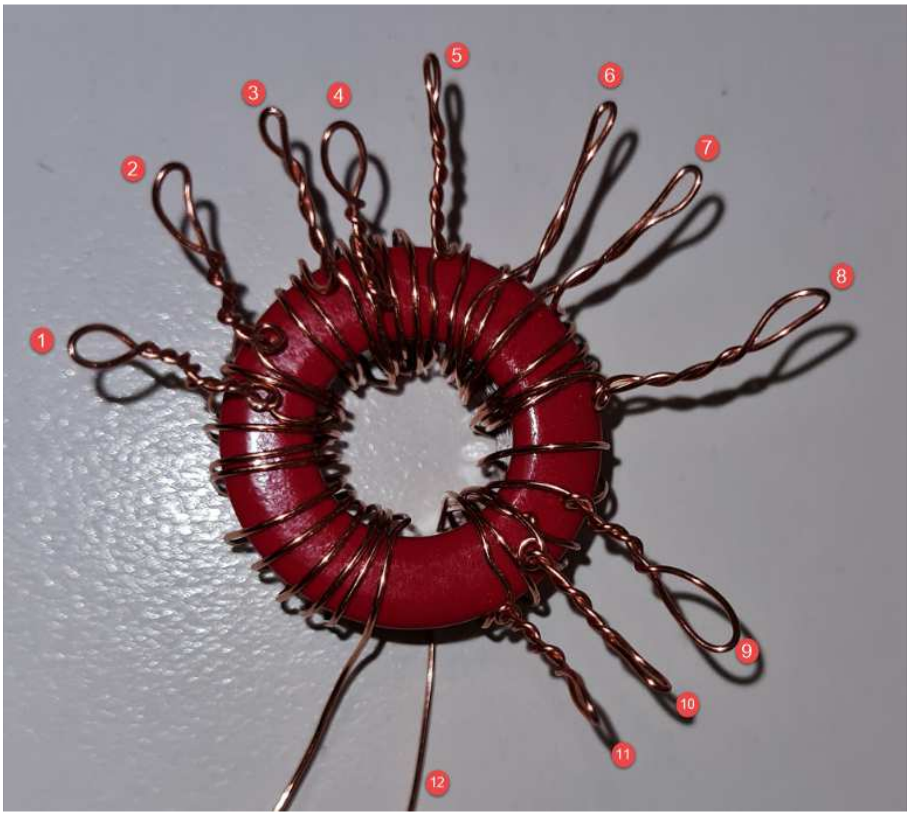


Figure 8 – Completed Tuning Toroid

And once you have the taps tinned, they should look very similar to the following:

Figure 9 – Taps Tinned

Each one should have a healthy tin to it. As mentioned, if you obtain the correct Enamelled wire, you will find that, you will have them all correctly tinned without any sanding or scraping. You will also find that you have less chance of damaging your rotary switch with too much heat and too long trying to get the solder to take.

Now we are ready to work on the Rotary Switch. Before you start connecting the taps to the switch, cut a piece of hook up wire provided (about 80mm) and solder one end to the lug in the middle of the switch (normally marked “A”)

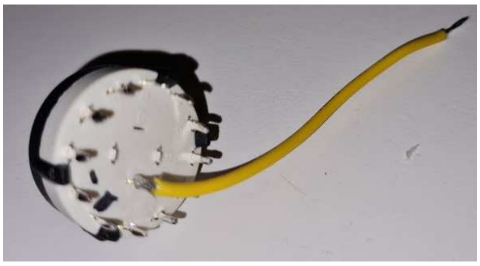


Figure 10 – Rotary Switch

If you don’t do this now, you will have trouble soldering once the toroid is connected. You might also notice that I have pre-tinned each of the lugs on the switch, and have also pre-tinned the tap points on the toroid. This can save you some frustration.

When you have completed all your taps, you then need to add your 12 position switch and solder each of the taps to the positions on the switch. In the table above, you will see that Tap 1 is on the 10th turn, and this corresponds to position (connection) 1 on the switch.

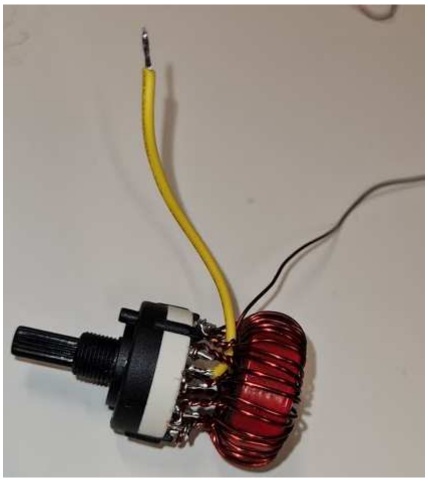


Figure 11 – Rotary Switch Completed with Soldered Toroid

As I mentioned, I paid the price of staying with the supplied 0.8mm enamelled wire, as it made it harder to wrestle the taps into place, and the turns were not as tight as I would have liked. I would have to say even the solder joints were a little harder due to the larger wire diameter. Ultimately, I was not happy with the solder joints either.

I ended up restarting with new switch, and 0.5mm enamelled wire and what a difference it made. Instead of 2.5 hours with the toroid and switch assembly, it came down to 1.5 hours. For those with keen eyes, you might also note that some of the included pictures show the toroid with 0.5mm enameled wire as I took the opportunity to take them as I re-built the toroid.

However, that said, this is the most likely area for dry joints, so take the extra time and test it. Connect your multimeter up to the wire from the switch (yellow in my case), and the other end of copper tail (take the enamel off so you can get a reading). Once these are connected, put you multimeter on the continuity tester (beeps when a connection is made), and turn to each position on the switch, and you should hear the beep stop as you change position (as it is a break before make switch), and the beep should be heard again when the switch is in the next position. If you get a position that does not beep, it is highly likely that you have a dry joint in that position (you may have a faulty switch or it might have been damaged whilst soldering), but the dry joint is the most likely, so a touch up with the soldering iron will confirm whether this is the issue. Just one thing, if you test checks out, put a little pressure on the toroid whilst holding the rotary switch assembly (not too much), and perform the test again. If all ok, you are ready to proceed.

6) Complete the installation of components on the SWR indicator PCB.

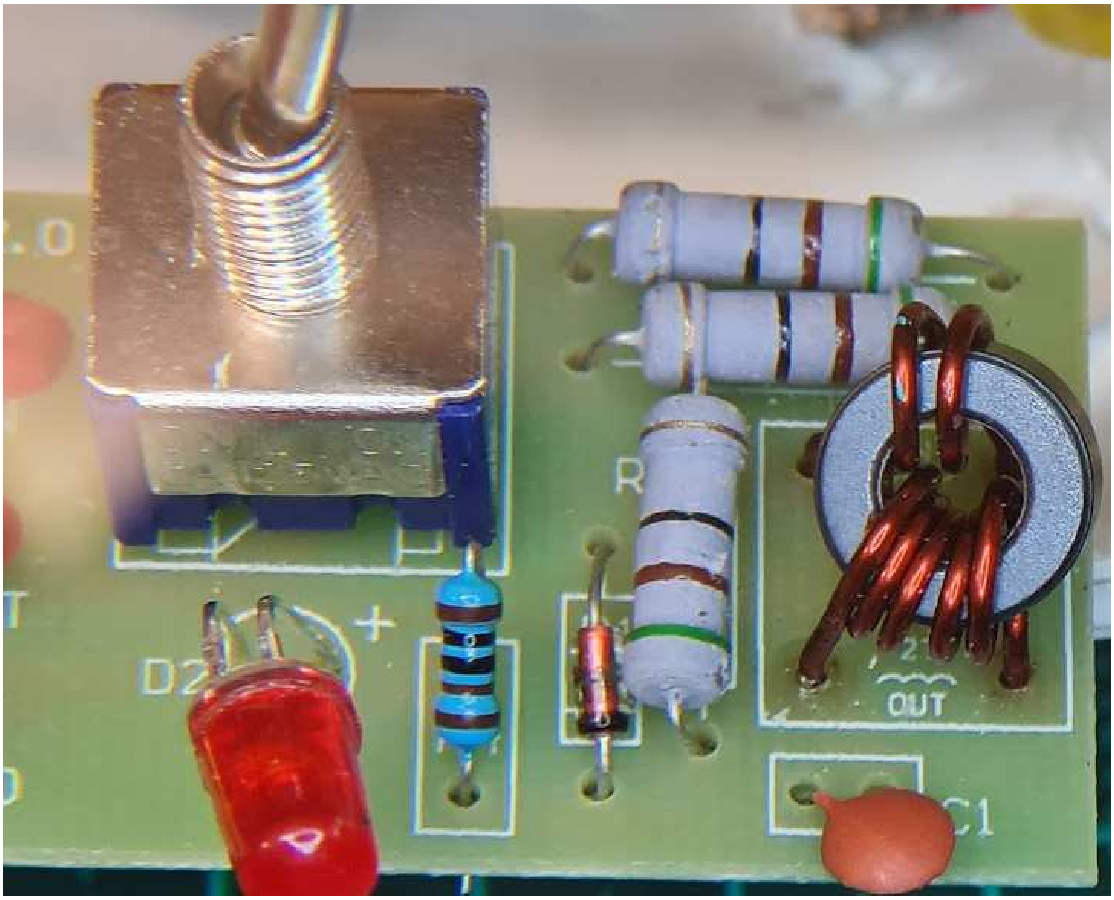


Figure 12 – PCB with all components installed

Just in case you missed it, the PCB Is incorrectly marked in terms of the number of turns. Where it says "OUT 2T", it should read "OUT 5T", and where it says "IN 5T", it should read "IN 2T"

Other than the major correction above, there was nothing special about mounting the components, but make sure you mount the 1N60 Diode and the red LED the correct way with respect to polarity. Also when installing the red LED, solder the LED with the legs at full length, as this LED will mount into the case, and may need to be moved. Its much easier to shorten the legs should you need to.

Also while we are at it, solder a few pieces of hook up wire to the connections on the PCB marked IN / OUT & GND. Look at the following photo for where the wires from the board go so that you can gauge the lengths you need.

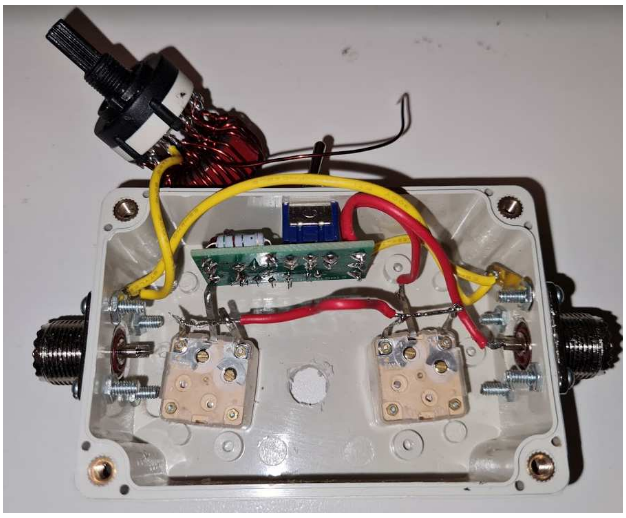


Figure 13 – Showing the cabling

7) We are now going to prepare and drill the case. The case is also the mounting structure for all the components, so to complete the work further we need to start mounting the parts in the case.

As I mentioned in the "Kit Parts Issues/Faults section at the start of this document, you can use the stickers, but do not put blind faith on where to drill, and how big to drill. I will be honest and say that if I did this kit from start again, I would use another slightly larger case, and make my own holes and measurements

If you proceed with the stickers, make sure you line up the LED hole and Switch hole as the switch comes out of the top, and the LED out of the front.

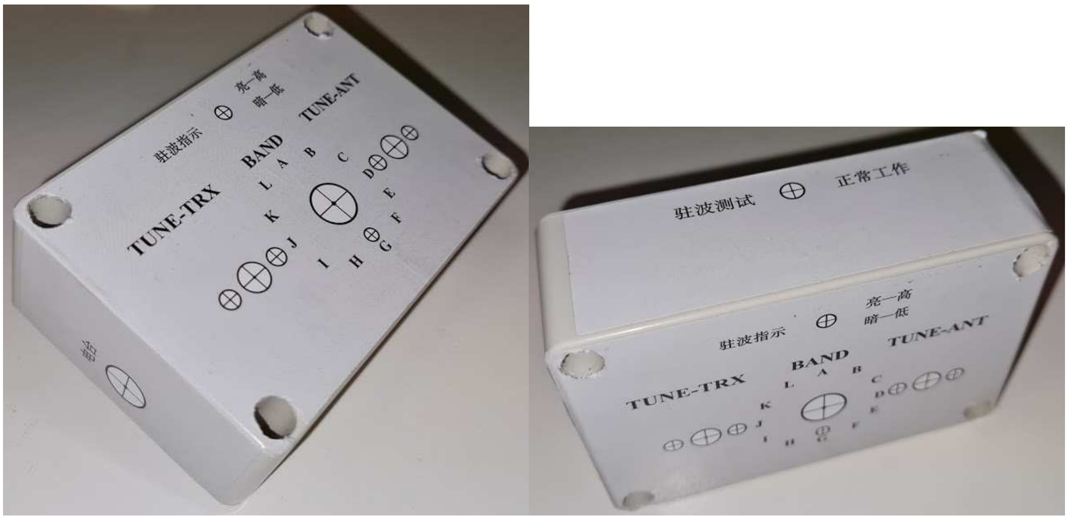


Figure 14 – Installing the Stickers

Now finally attach the BNC socket sticker on the sides. Again taking note that the socket is mounted back towards the Lid of the case.

I ended up not using the stickers for sides (BNC connections), as I have elected to install a SO239 Sockets (whereas all my antennas – including QRP – utilise a PL259 plug), but this is just my own personal preference. For my QRP gear, I have a PL259 to BNC adaptor.

> Hint : Particularly for these plastic cases, drilling is the best way to make your holes. However I use tapered reamer (https://en.wikipedia.org/wiki/Reamer), once the hole is drilled, especially as I test fit the component. It's quicker than changing the bit on the drill (especially if you do it a few times), and probably safer than using a utility knife. And it's a great deburrer as well.

Just a couple of pointers to save you some trouble and frustration (however it may depend on what the supplier has provided).

1) Drill the middle hole for the Variable capacitors and see if they sit straight. If you look at the picture of my partial construction, you will see that the capacitors will not sit straight, as the supplier provided variable capacitors that are larger than the original design (only by a few millimeters), so they don't mount straight and you may need to drill the mounting holes slighly off perpendicular.

2) Do not drill the holes to mount the variable capacitors at the size shown on the sticker. The holes are way too large, and you will be forced to use the washers provided. The washers themselves, are way too large, partially covering the rotating part of the variable capacitor. The washers are too thick, meaning that the screw does not meet the thread, or least enough of it to secure the variable capacitor. Make the hole size just big enough for the screw, and if possible avoid the use of the washer.

3) If you do put in SO239 sockets, you can still use the BNC Stickers as a guide. Just remember that the SO239 needs a little more mounting room from the edge of the case, but you need to make sure you don't come into far, as it will get very tight in case. In other words, check your sizing before you drill.

Now to complete the assembly and final wiring

Lets look at the photo (figure 15) again….

We need to place a wire between the two variable capacitors. Strip off the ends leaving about 10mm more than you normally would, and tin it. Make sure you tin the variable capacitor connections as well, as you will be soldering in a tight space, and it just makes it a lot easier.

Make sure that you have bridged the the two outside connections of the variable capacitor, as shown by the arrows. The middle connection is naturally not to be joined to this bridge.

I leave that middle connection standing up until I complete the correct connection to it, and then push it down moving it away from the other two (as you can see on the right hand side, where I have already connected the wire coming from the "OUT" (on the PCB) to the middle connection, and have then pushed that connection away from the other two connections.

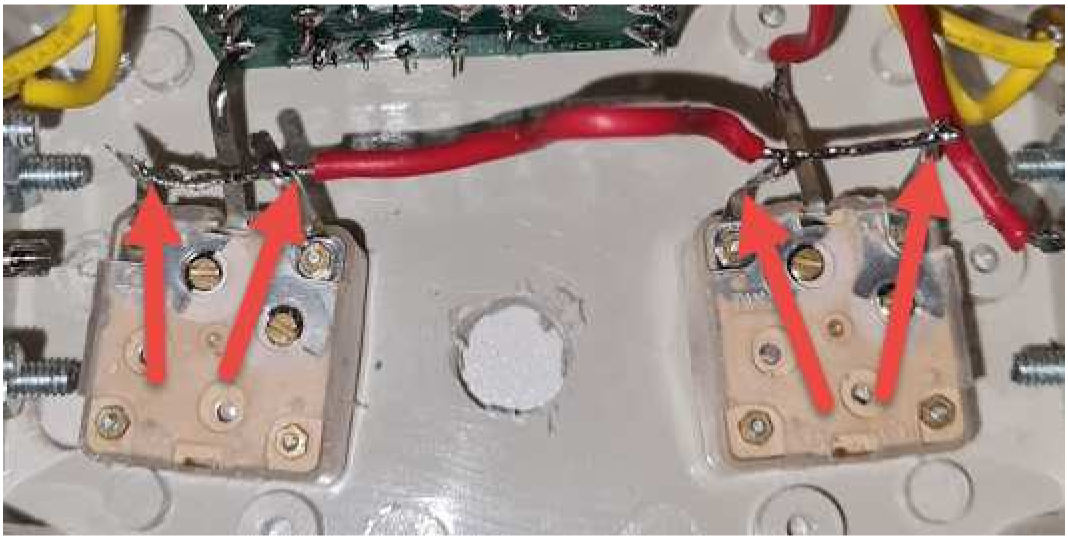


Figure 15 – Close up of the variable capacitor connections

Try to get as much of the fiddly wiring done before you mount and complete the final solder points on the rotary switch

It is a bit hard to show you all the wiring, but from the pictures, as well as the circuit diagram, you should find it easy to follow.

If you are wondering why the big piece of heatshrink tubing. This is just where I joined the wires (after re-doing the toroid as mentioned earlier). Your wire can be one continuous piece.

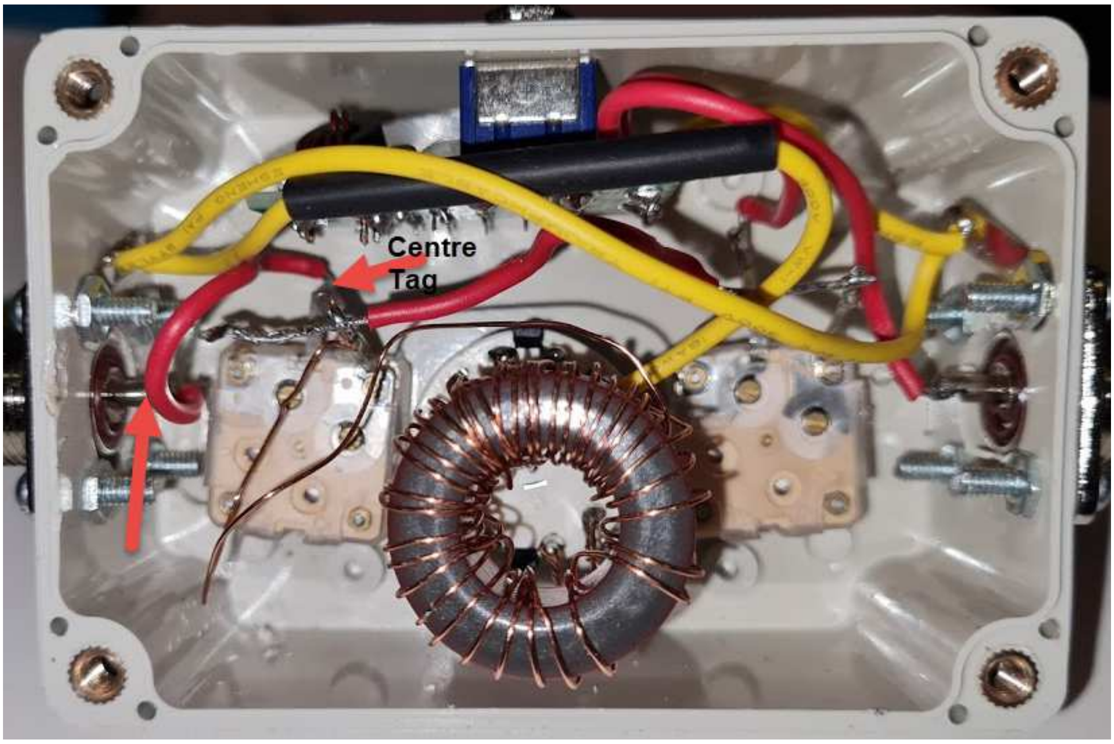


Figure 16 – Completed QRP Antenna Tuner with lid removed.

Completing the Build

Now we are down to placing the knobs on the unit to complete the build

Adding the knob to the rotary switch is straight forward, so no issues there.

The knobs supplied for the variable capacitors, were next to useless. First of all, the nut provided with the bolt, was incorrect, and secondly, the method of attachment to the shaft, was tenuous at best.

So, I went out and purchased the following parts

2 x variable capacitors with dials
2 x small knobs that had a clear hollow at the bottom.

In simple words, I am going to going to use the dials as the base of the knobs after I cut them to the size of the base of the knob and glue them. I will place the variable capacitors in the parts box for another day as I don't need them, just could not get purchase the dial without them

The knobs as per the picture, have a cap on top that comes off, and a hole in the top of the main knob itself, which will allow me to screw the knob securely onto the variable capacitor.

You might be lucky and have been provided something different or the correct size nuts. If that is the case, then keep going with that. However, if you have the same issue as I did, this is an alternative.

Figure 17 – Modified washers, and replacement knobs and modified dial.

The above is a picture of the parts, to correct the knobs for the variable capacitors. I just cut the large dial with snips close to the size of the base of the knob. Took the top of the knob, and placed the screw down the middle so that it comes out of the bottoms and screwed it in. Not the most glamorous, but it is solid and works.

The washers that I was forced to use as the holes in the box were too large, I had to snip the sides off, so that they did not interfere with the dial.

Now it's time to dress it up a little, and you might want to add some English Translations. I didn't, but I plan to redo the stickers.

Figure 18 – Correct English wording for the Switch

Figure 19 – Antenna Connection

Figure 20 – Transceiver/Transmitted Connection

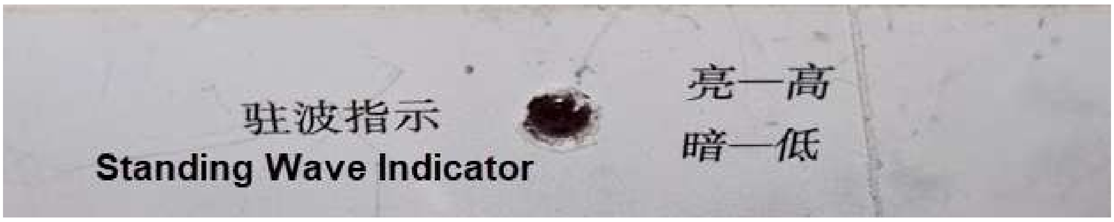


Figure 21 – Standing Wave Indicator (LED)

Offline Testing of your Build

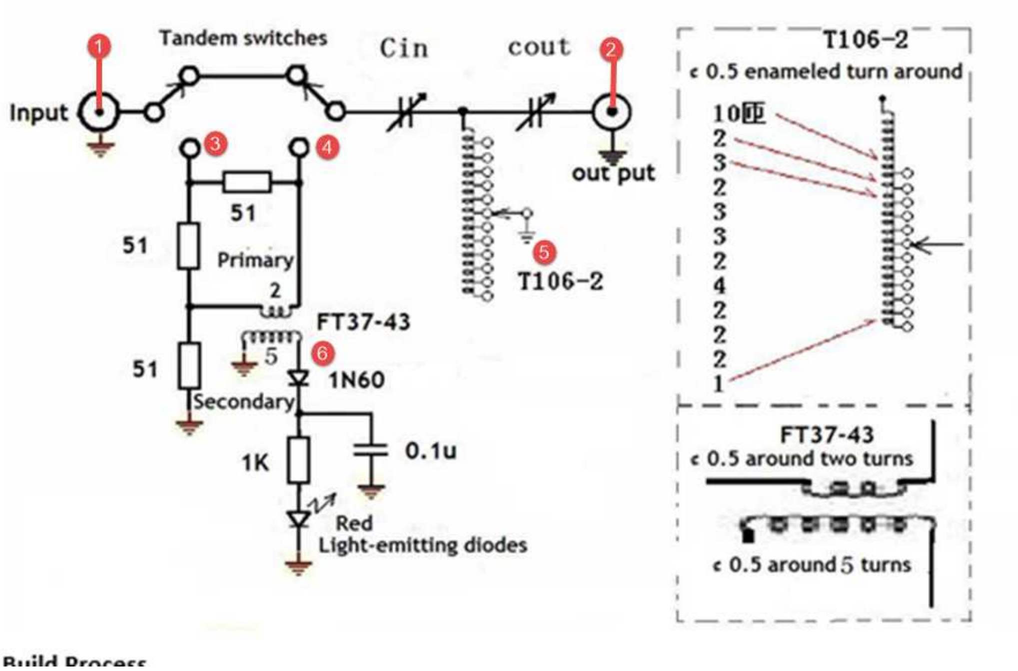


Figure 22 – Test Points

1) You should have already performed one check, being to check the connection of the switch to all your taps. This is best done before you install the switch and toroid into the case. If you have already installed these, you can test it by removing the end of the toroid winding from the variable capacitors to perform your tests and then re-solder quite easily.

2) Another check, if you have the tool (either an expensive capacitance checker or a low cost component checker - Geekcreit® LCR-T4 12864 LCD Graphical Transistor Tester Resistance Capacitance or its many other names and makers, is checking from TX input centre conductor (1) to RX output centre conductor (2), and confirm you can see about 20 - 120pf (remember you have two 240pf capacitors in series, so the you expect to see half the capacitance. It's a good way of checking both variable capacitors are working, and you haven't inadvertently put a screw through the plates. Just remember these devices are no good for below 20pf, (but far better than multimeters that measure capacitance as many cannot get in to the picofarad range).

3) Now putting the switch into "SWR indicator" mode (so we are switching the SWR Indicator in), put one probe on earth, and the other probe on the point marked (3) in figure 22 – Test Points and you should get a reading

somewhere in the vicinity of 76-77 ohms, which would be correct. All this is checking is that the resistors are soldered correctly. Otherwise, any SWR indication is going to be wrong, if the resistive bridge is not providing the right values.

Now these tests are not definitive, but may provide some direction using some basic tool such as the multimeter, or capacitance meter. In effect there are three critical components

1) variable capacitors
2) Toroid winding and its taps
3) Resistive bridge.

A problem with any of these components is likely to cause a failed project, so the extra time, tests, checks are really worthwhile. This is why I checked everything once delivered, this included checking that the variable capacitor values matched some of the other reference designs I had seen.

While some of these checks of components and parts pre-build and some of the checks post build, may seem like overkill, I identified three issues through those checks

1) Before starting, I found the enamelled wire supplied was 0.8mm instead of 0.5mm, using low cost digital calipers.

2) After the build, when performing basic point to point tests between components and relating it back to the circuit diagram, I found that the SWR indicator toroid was not making sense, and indeed was incorrectly marked on the PCB

3) And finally located an issue with one of the Resistors being a dry joint on one end, which showed up when I did the “sanity” checks reviewing the circuit diagram and confirming what resistances I could see and one was not correct.

How to use:

1) Connected to the transmitter to the transmitter connection and the antenna to the antenna connection. Turn the switch to Standing Wave Indicator.

2) Set your transmitter power to no more than 5W

3) Select an Unused Frequency (so listen before you commence the next step)

4) Using CW or AM, key the transmitter.

5) Keeping the transmit time as short as possible, repeatedly adjust the inductance knob starting at “Position A” and adjusting the two capacitors knob, until the red LED is set to minimum brightness (note this is minimum brightness)

6) Once you have the setting providing the dimmest possible LED, switch back to normal operation.

7) Ideally you should have a proper SWR / power meter to provide confidence that your SWR is within parameters, as indeed is your power output.

Figure 23 – Showing a match of 1:1.3 on 15m dipole at 40m – Dim LED

Figure 24 – Inductor deliberately changed – SWR way off – Bright LED

Diagram showing where the Antenna Tuner placement.

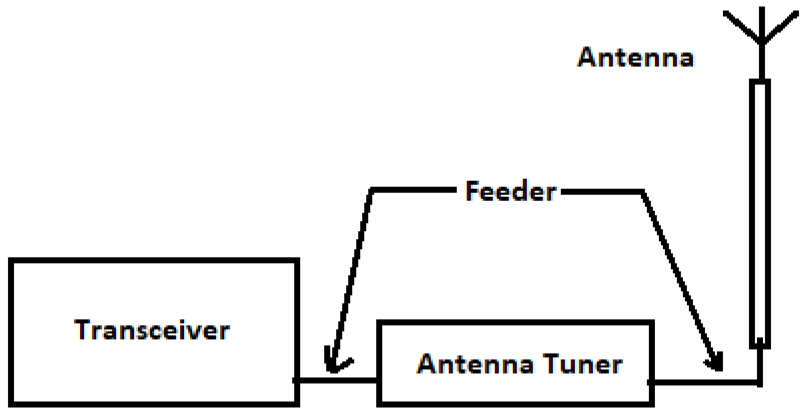


Figure 25 – Block Diagram showing where the Antenna Tuner is located.

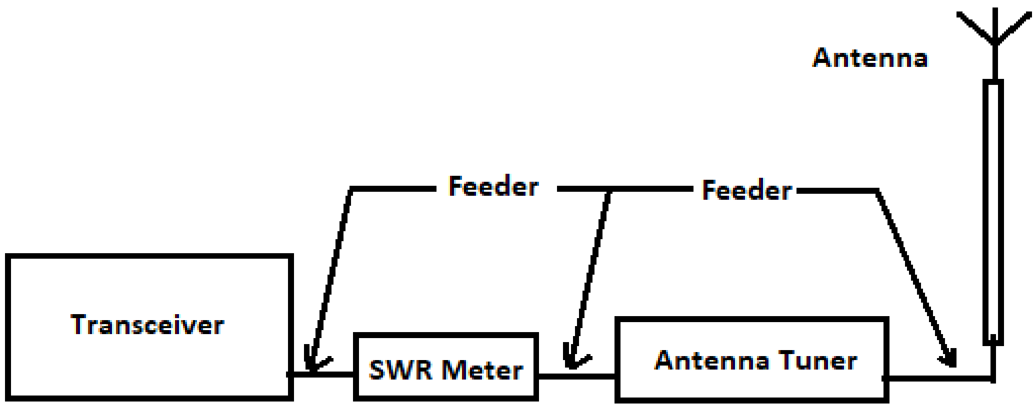


Figure 26 – Block Diagram showing where the Antenna Tuner is in relation to the SWR Meter

Chinese Authors Original Notes:

This antenna tuner can be adjusted to within the tuning range of about 40-300 ohms. If other parameters, are necessary, change the number of turns of T106-2 to adjust.

Again, whilst the switch is switched to "Standing Wave Indicator", the input power should not exceed 5W, and the test should be kept as short as possible

Comments on this kit

Realistically, this kit costs no more than $AU10.00 (about $US7.00), so when I ordered it, I looked at making sure that I got some value out of it. So, the ease of access to the Toroids, as well as the kit coming with a couple of variable capacitors. If I tried to obtain the parts locally, it would have cost more than that. If you notice, I haven't mentioned the case or the switch as I have concentrated just on parts I can re-purpose in other projects.

Secondly, I looked at the educational value out of dealing with this project. I would not have got as much out of this project if the project worked first time, but I would still have learnt something. However, as expected, there were some issues, and it forced me to bring my theory back up to speed. In fact, I have enjoyed getting back to inductors and impedance.

Now, what I will say is that if you are going to build antennas or antenna matchers or antenna baluns / ununs is that you should invest in some test equipment. Paricularly in the last few years the NanoVNA units sold on Ebay, Banggood and Aliexpress are only around $AUS70-80 and are quite popular. Alternatively, a reasonable PWR/SWR meter should be in every shack (even if you just deal with resonant antenna's)

Using a NANOVNA, I was able to quickly confirm that this QRP Antenna Tuner was actually tuning (even though originally the LED did not light up). Again, with the right test tools, I was able to determine what part was working, and what I needed to concentrate on.

So, whilst on the Internet, I see a lot of comments on this kit (and I will agree with some of the comments), I think it is worth looking at what you did learn, or if you revisit the project, what you could learn.

I confirmed that indeed the antenna tuner component was working as I could clearly see the impact of the inductance selection and the varying the capacitance had on the SWR (confirmed via the NanoVNA). Using a 21m resonant dipole, and tuning it for 40m use, with the antenna tuner was able to achieve 1:1.3. Good enough for what I was trying to do.

Musings on this kit and reference Designs

As I was working through the design of this kit and "filling in the gaps" of this kit, I wanted to match it up with the reference designs

What I found was intriguing, particularly when I looked at the information provided by http://www.arrl.org/files/file/Technology/tis/info/pdf/9501046.pdf particularly around T-Network tuners. If I can summarise, it is expecting the following values

C1 – 20 to 240pf (Variable)
C2 – 20 to 240pf (Variable)
L – adjustable from 0.1 to 35uH

The supplied capacitors supplied appear to meet the criteria. So the Inductor is the unknown in this case (although we know the number of winds and the toroid type).

So I looked up one of the many online toroid winding calculators and used the following https://www.66pacific.com/calculators/toroid-coil-winding-calculator.aspx
This is what this calculator churned out, based on the number of windings that we are using.

INDUCTANCE
Desired: 16 uH
Calculated: 15.6 uH (98% of desired) **Turns required:** 34

CORE
Part number: T-106-2 (Red)
Frequency Range: 1 to 30 MHz
u: 10
A_L: 135 uH/100 turns

Figure 27

As you can see, the inductance falls short of what the ARRL article is mentioning. But based on review of many other designs as well as passing the parameters through a T-Network Tuner Simulator, I found that 80m to 10m, the inductance required appears to be in the range of 0uH thrrough to 18.5uh (using typical values for R and X)

Some Useful links relating to the T106-2 Toroid.
http://www.amidoncorp.com/t106-2/
https://toroids.info/T106-2.php
https://www.66pacific.com/calculators/toroid-coil-winding-calculator.aspx

Who am I??

My name is Bob Fryer, callsign VK1ERF from Australia, a guy that took almost 35 years to get his basic Ham licence. Well, it reads bad, but it is not that bad. I had a strong interest in Electronics and Radio in my teenage years, I did my initial Ham exams 35 years ago and failed on the CW portion and never completed the process (as life changed). In 2021 as part of the Covid-19 pastimes, working on Lora-WAN devices, I found it interweaved with Amateur Radio, so I decided it was time to get my Ham Licence, which I did.

Whilst I have only just obtained my Basic Ham licence, I started my journey in Electronics in the late 1970's and was heavily involved until the late 1980's. My career direction changed and I took a break until 2010, when I became involved in Digital Electronics again and marveling at the changes since the 80's. In the last year or so, I have re-ignited my interest in RF, and all that I learnt back in the 80's, is coming back in droves, with primary interests in Antenna's, and a renewed interest in QRP & CW (funny how they take CW out of the exam and now people are interested in it)

I hope these instructions are useful to someone else.

73's
Bob