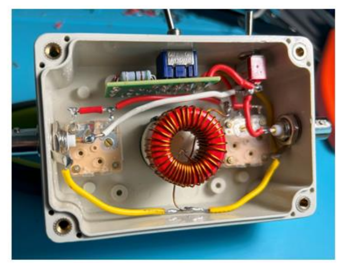
Cowtown Amateur Radio Club

Buildathon Project #3 – QRP Antenna Tuning Unit (ATU)

QRP ATU Construction and Operating Manual



By Richard W5ARH / VK2ARH

Version 1.3 15th October 2023 Updated template with imperial measures

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Introduction

The QRP ATU is the third kit in our Buildathon series and has been chosen to complement the previous builds which involved an EFHW Antenna and the ADX Digital Transceiver. As with the previous builds the ATU kit provides an inexpensive but practical piece of equipment that can be used either in the 'Shack' or out in the field, whilst providing a learning experience during the Buildathon for the participants.

The original kit on which this project is based has been quite rightly criticized for its errors, lack of build and operating instructions, inaccurate drilling template, an inadequate panel overlay and the quality and connection options for the capacitance tuning knobs. These problems have been overcome by the Cowtown build by the provision of additional hardware, new overlay panels and modifications which incorporates all the corrections identified by Carol KP4MD in her excellent video on the topic: https://youtu.be/JceLhTV28oI?si=10w3uxhJedoQut1m .

The kit provides a HF Antenna Tuning Unit (ATU) capable of supporting QRP radio's – up to 10w max and is a practical piece of equipment and works well for its intended purpose.

This ATU utilizes a 'T' matching network consisting of a switched inductor and two variable capacitors and has a built in SWR indicator which can be used when tuning the antenna.

The Cowtown Kit incorporates:

- An ATU bypass switch.
- Templates to facilitate the correct drilling and placement of components.
- An upgraded panel overlay.
- Additional shafts and knobs to enable smooth and reliable operation of the variable tuning capacitors.
- Replacement magnet wire for the toroid, as the original kit magnet wire was 'hard to work'.
- Corrections to overcome the errors with the original 'Chinese kit', ensuing a good working ATU.
- Detailed construction manual (similar in detail to the Cowtown ADX manual) see: https://github.com/VK2ARH/Cowtown-ADX-Project

It would appear as though the kit implements the ATU design originally published in Amateur Radio Today in October 1995 – however the 'T' Match is a widely published and used design. The principles of which can be found in many commercial ATU's.

This kit requires intermediate skills to build, although a beginner with support could easily complete the project. The kit is not electrically complicated but introduces the Buildathon participants to drilling enclosures and mounting electronics hardware in the enclosure, a skill often used in the construction of Amateur Radio projects, and the development and use of custom overlays or decals to support electronics projects. Perhaps the most challenging component is to wind the 36 turn, 12 tap inductor and attach it to the 12 position switch. This is a little tedious but not complicated and anyone who has successfully wound a toroid for the LPF's as part of the ADX or an EFHW Antenna UnUn, has the capability of winding this inductor. It just requires a little more patience.

Remember the Buildathon is designed to enable club members irrespective of experience or ability to come together and with guidance and support from others, enjoy a mutual learning and fun environment in which to build their project. The manual was written with a novice constructor in mind and is focused on a step-by-step instructional build process. Seasoned kit builders please ignore/excuse the detail in parts, or feel free to adopt your own solutions to the various construction elements required to complete the ATU.

I recommend that you read the manual cover to cover before you commence construction to gain an understanding of the process to be followed, the contents of this manual and familiarize yourself with the journey ahead.

Step by Step Kit Assembly

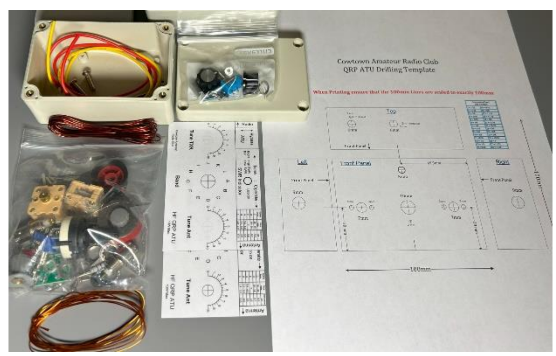
Equipment Needed:

The following equipment is recommended to build the kit:

- Soldering Iron / Station (There are no ‘static sensitive’ components in this project so an ESD protected iron is not required. The project does, however required soldering for larger ‘heat absorbing’ components so at least a 45-65w soldering iron is recommended together with a method of venting fumes away from the soldering area.
- Solder: General utility solder approx. 1.0 – 1.5 mm diameter 63% Sn / 37% Pb with ‘no clean’ flux is recommended, if you are comfortable soldering with Pb based solder.
- Wire cutters (fine precision type) and long nose pliers
- Multimeter
- Phillips head screwdriver
- Small spanner or long nose pliers for tightening nuts on the switches
- Modeling knife and scissors
- Double sided tape (thin)
- Drill and drill bits (see drill template for size of drills required)
- Dremel Tool if available and / or sandpaper
- Solder sucker or solder wick if needed.
- A magnifying glass or higher power reading glasses can assist with checking the quality of your soldering.

The kit uses all through hole components, or general wiring.

Take the time to prepare your work area and layout your tools, keep it free of clutter. An organized work area helps you to focus on the build and not distracted searching for tools and components.



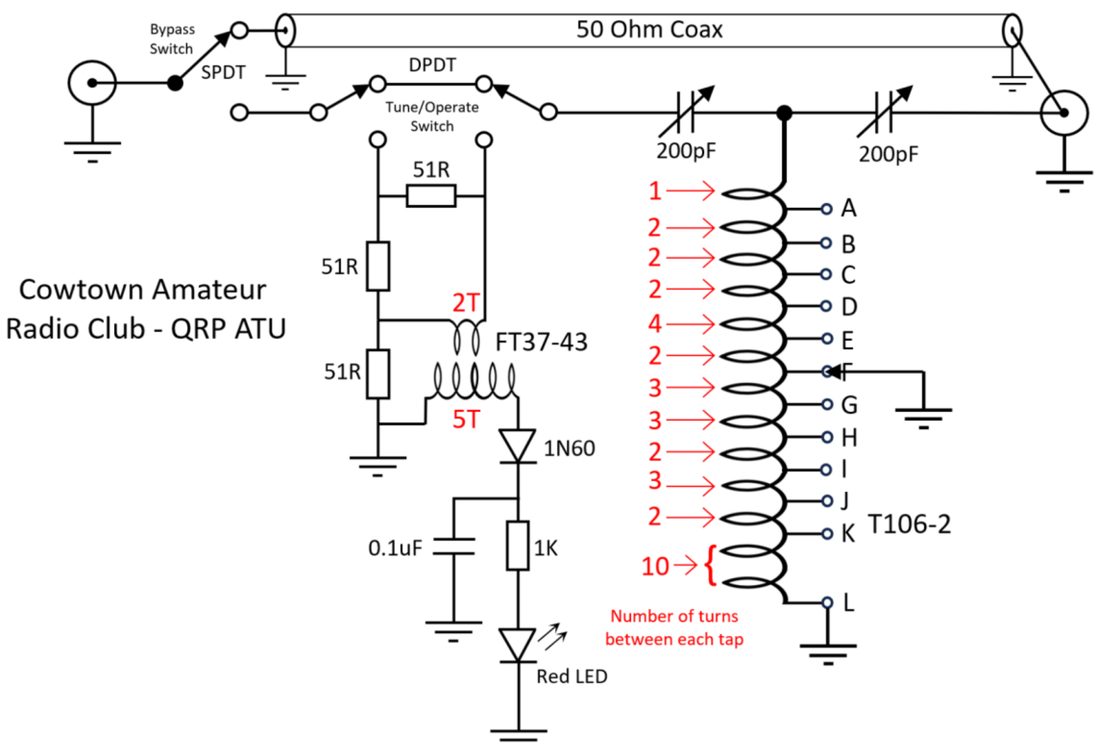
The component list is small so this can easily be checked against a bill of materials or circuit diagram. The Cowtown kit (Shown on the right above) has an additional SPDT switch for the bypass switch, additional knobs and mounting shafts for the variable capacitors, a length of 22 AWG magnet wire, panel overlays and drilling templates. The magnet wire supplied with the original kit is 18 AWG and this is difficult to wind the 36 turn 12 tap inductor hence the replacement with 22 AWG wire which is more than adequate at QRP power levels.

Save the 18 AWG wire and use it on another project eg: winding a higher power UnUn for an EFHW antenna 😉.

Circuit Diagram

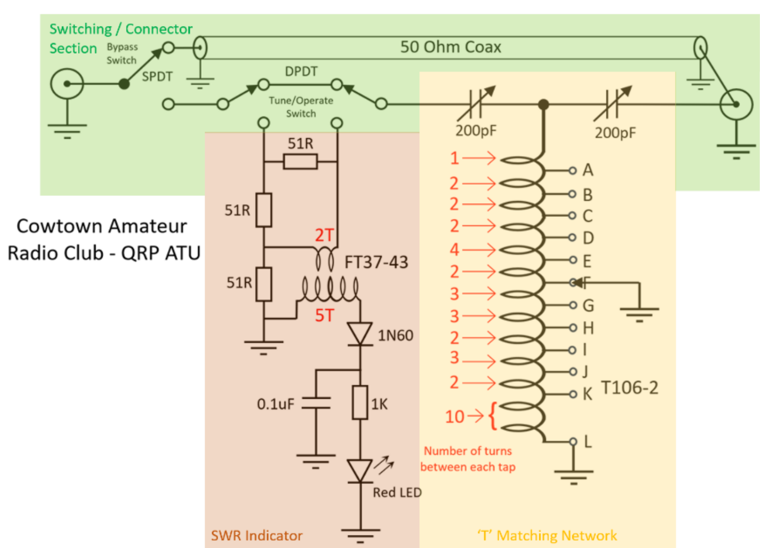
The circuit diagram for the ATU is shown below.

I have redrawn the circuit to include all the necessary corrections to remove the errors with the original 'Chinese Kit' and incorporate the antenna bypass switch. The windings shown on the inductors are the correct ones to be used in the project.

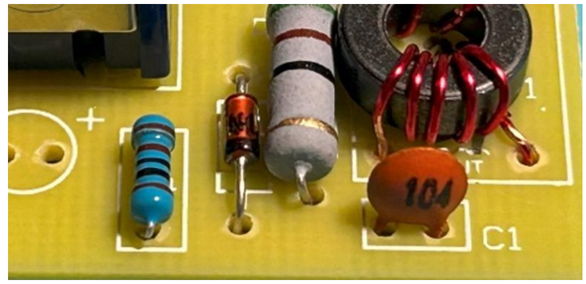


The circuit has basically three components to it:

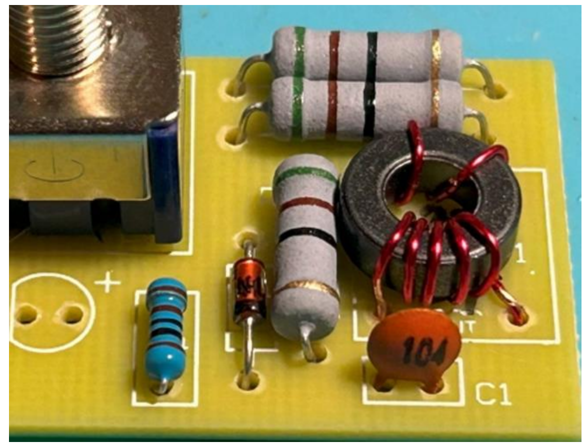
1. The Switching / Connector section
2. SWR Indicator section; and
3. The T Network ATU section.



Construction Tips



The PCB supplied with this Kit has not been well designed or constructed (by comparison to the PCB we used in earlier projects) so the hole sizes on the PCB are generally too large for the component leads. This does not present a problem that cannot be overcome during construction, we simply need to 'fill' the holes with more solder to secure the component onto the board.



Whilst it makes no difference electronically which way resistors and ceramic capacitors are mounted, good practice is to mount each device with the same orientation. By doing so it makes checking the value of components much easier.

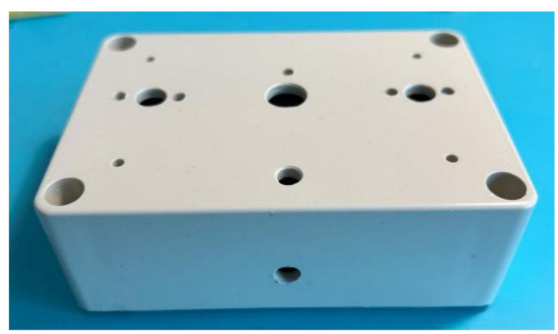
For capacitors or devices with identification marks on them, I try to orient them all in the same direction unless their view is being obstructed by another component. When this happens, I orient them where possible, in a direction that enables them to be read easily. *(Can you pick up my divergence from this guideline in the photo ?)*

For diodes ensure that they are aligned in the correct polarity required for installation. In this project there are only two diodes the 1N60 and the Red LED.

Flux or flux paste is not usually needed if you are using a good quality solder with incorporated flux. Choose a 'no clean' flux if you have the opportunity as this makes for a cleaner result. If necessary, boards can be cleaned with an old toothbrush and isopropyl alcohol. Don't go buying the expensive stuff, 99% isopropyl alcohol can be purchased from the pharmacy section at Walmart for less than $5 for a 16oz bottle and is more than adequate for the cleaning task.

Ensure that you scrape off the enamel from the magnet wire used in the inductors before soldering. This wire is 22AWG wire and is a little too thick to rely upon the heat from the soldering iron to melt the enamel and secure a good solder joint.

When drilling holes into a housing to mount electronic components, take your time to ensure correct alignment of the drilling template and accurate marking of the holes to be drilled. **Measure & Check TWO to THREE times – drill ONCE** should be ringing in your ears as you undertake this phase of the project.



In this manual each time a component is to be identified and soldered to the PCB, installed into the housing or a task is to be performed, it is listed separately proceeded with a square check box. You can 'tick' off the components/tasks as you progress, and this keeps a record of your progress through the build. You can also check off each page as you complete the activity listed on that page in the check box located next to the page number:

- ☑ Component 1
- ☑ Component 2 etc.

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Building the ATU in Stages

The VSWR PCB

The small PCB provided with the kit is used to construct the VSWR section of the ATU.

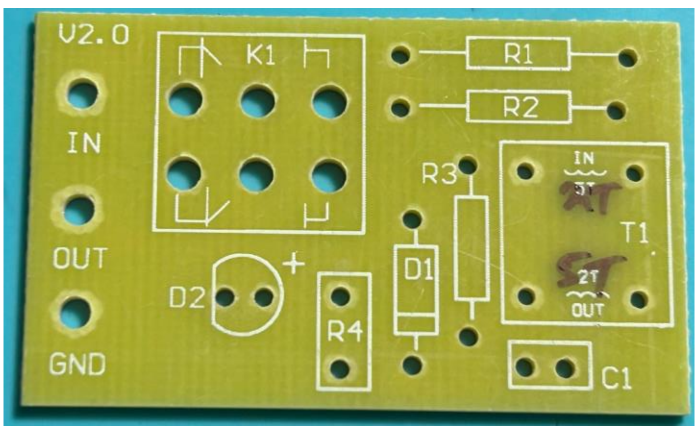
Start out and build the T1 transformer which consists of:

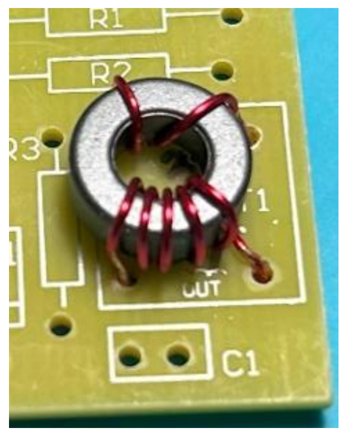
- ☐ FT36-43 (Small Grey Toroid)
- ☐ Two small sections of Magnetic Wire (About 2" and 3" is plenty) – cut these from the original magnet wire supplied with the kit.

This is a step-up transformer with a 2:5 ratio to increase the return voltage from the Antenna to a level sufficient to illuminate the LED to indicate other than a perfect match.

Wind the smaller length of wire twice around the toroid and the longer length of wire 5 times around the toroid. Remember with toroid's the number of turns is counted by the number of times the wire passes through the center of the toroid.

NOTE: The print screen on the PCB incorrectly shows the position of the windings. I have corrected the PCB markings with a 'sharpie' and the photo shows the correct installation of the transformer. The 5-turn side is the output, and the 2-turn side is the input.



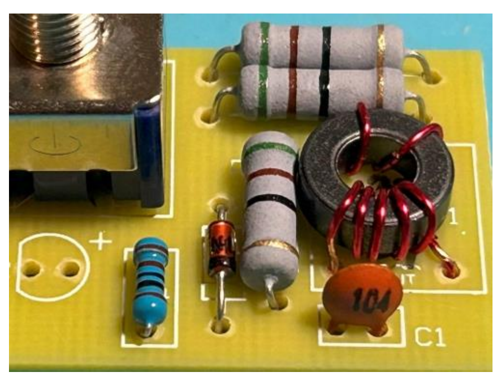


Scrape off the enamel coating from the wire before soldering to the board.

Identify and solder the remaining component to the PCB but **DO NOT solder the LED or the switch to the PCB** at this stage:

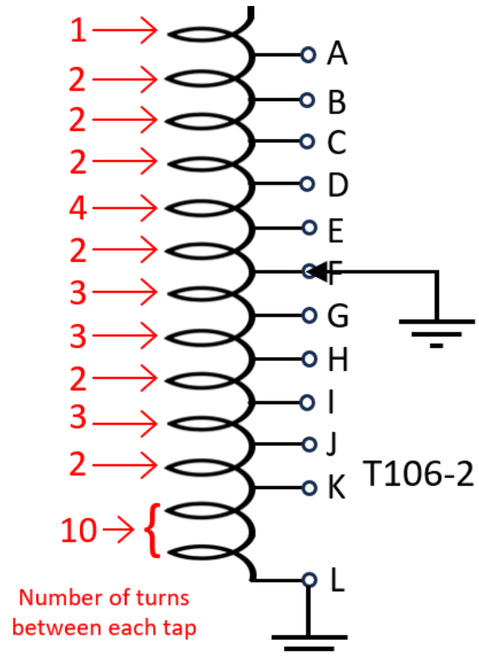
- ☐ R1, R2, R3 all 51R resistors
- ☐ R4 1K Resistor
- ☐ 1N60 Diode
- ☐ 0.1uF Capacitor (104)

In the photo to the right, the switch is shown only for fitment and is not soldered to the board at this stage. It is quite tricky to fit the PCB into the housing if the switch and LED are soldered to the board. These are soldered after the LED, switch and PCB have been positioned in the housing.



Winding the Main Inductor

Winding the main 36 turn, 12 tap inductor and then soldering it to the 12-position switch is probably the most demanding element of the ATU build, it's a little tedious but not complicated. Anyone who has successfully wound a toroid for the LPF's as part of the ADX project or an EFHW Antenna UnUn, has the capability of winding this inductor. It just requires a little more patience.

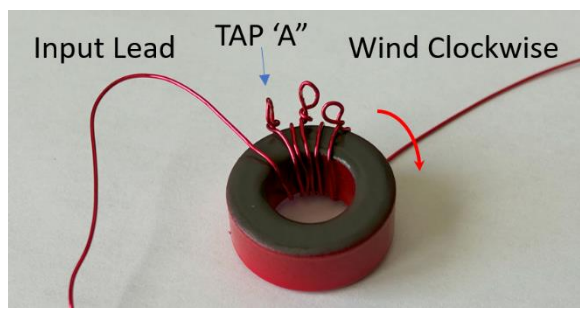


There are a couple of techniques to consider for winding the inductor. The first is to start in the middle of the inductor, and work in one direction and then the other, effectively reducing the amount of wire to be pulled through the toroid with each turn.

If this is your chosen method, there are 17 turns after the 'H' tap and 19 turns before it. You will require approx. 1.7m (67") of wire, so you would need to fold this wire into an 800mm (~31.5") and 900mm (~36") length insert the wire at the 'fold' and wind the longer piece of wire in one direction starting with the fold as the tap at position 'H' and then work in reverse 3T to position G make a tap, 3T to position F make a tap etc. until you finish the windings in the 'upward' direction and then using the shorter section of wire work downward through positions I, J, K and L adding the required number of turns and taps as you go.

I decided that the loose piece of wire not being wound was more likely to snag the wire being wound so I simply started at the top and worked my way down carefully winding the inductor and inserting the taps as I went.

It is a good idea to cross off the number of turns you have completed on the diagram as you go to keep track and avoid any mistakes.



Start by inserting the end through the center of the toroid, fold the main wire back to form a loop (this becomes tap A) which you then twist and then continue to wind the wire twice through the toroid and form another loop which you twist to become tap B. Continue winding the toroid in a clockwise direction (this will ensure correct alignment with the switch lugs). The number of turns between each tap shown in red on the diagram above until you have completed all 12 taps. The finished inductor will look something like the middle photo:

NOTE:

- The position of the tap is on the outer edge of the toroid.
- Twisting the tap also pulls any loose winding tighter.
- Make every effort to pull the wire tight against the toroid when winding to make a nice tightly wound inductor.
- <u>Ensure the wire is not crossed at any stage</u>.
- Spread the taps evenly around the toroid to ensure that they align with the lugs on the 12 position switch, this will 'resolve and you mount the inductor to the switch.
- Leave at least 2-3 inches of wire on the first and last turn to enable connection to the rest of the ATU in the housing.

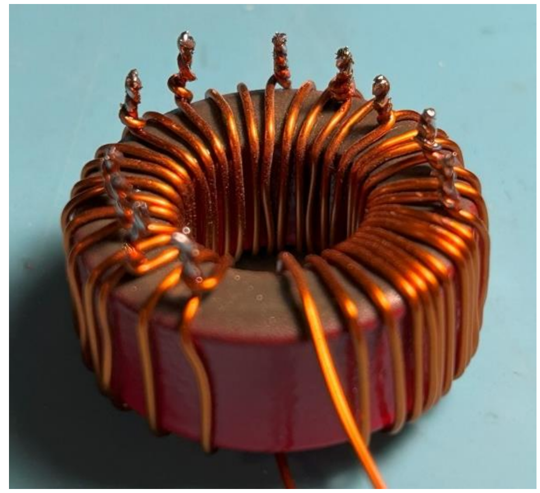
We are aiming to end up with an inductor switch that looks something like this, so keep this in mind when winding the inductor and mounting the inductor on the switch in the next step:

Mounting the Inductor on the 12 Position Switch

The next task is to mount the tapped inductor onto the 12-position rotary switch.

Start by tinning each tap to enable easy soldering to the lugs on the 12-position switch. There are two techniques you can choose here:

- The first is to unwind each lug in turn, scrape off the enamel, then twist it again and tin the lug. The problem with this method is that it is very time consuming and difficult to scrape off the enamel from the now deformed wire, and unless you have been super fastidious when winding the inductor, each of your taps are likely to be different lengths – this will complicate aligning and soldering the inductor to the switch lugs but will ensure continuity through the entire inductor.

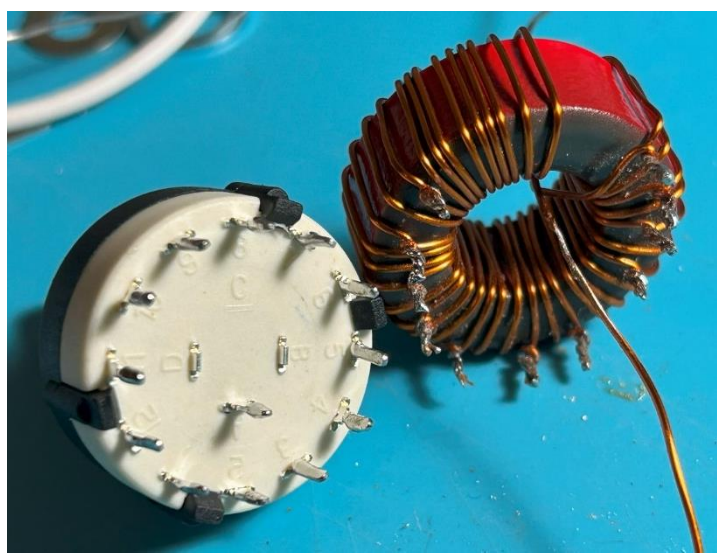


- The second (shown in the photo) is to cut each of the taps at approximately the same length and then scrape and clean off the enamel and then tin the tap. I cheated a little and **lightly** sanded the taps with a sandpaper disk on the Dremel making sure that I did not completely sand away the soft copper tap as this can easily be done if you apply too much pressure when sanding with the disk.

This second technique using the Dremel to sand the enamel away from the tap will still leave enamel in the twist crevasses and although the inductor wire that is exposed will be tinned, you are likely to end up with insulated gaps between either end of the tap in some instances – HOWEVER this is overcome when you solder the tap to the tinned switch lug in the next step – so don't panic if you find breaks in the inductor continuity when testing the continuity through your inductor taps after tinning.

NOTE: When tinning the inductor taps, the wire of the inductor is a good conductor and draws heat away from the solder joint, so ensure you have a suitably rated soldering iron that can deliver the required heat to achieve a good 'tin'.

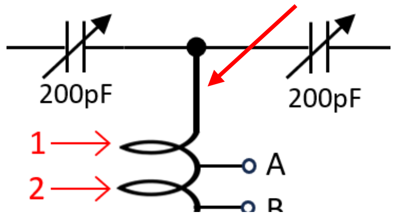
The 12-position rotary switch can easily be damaged if you apply too much heat to the 'position lugs' on the switch when soldering, so act quickly and tin each of the lugs in advance of mounting the inductor on the back of the switch.

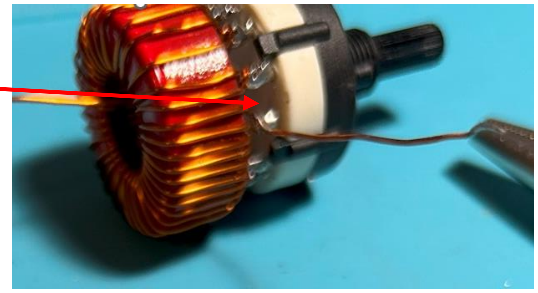


- ☐ Carefully adjust the position of the taps on the inductor so that they align as best you can with each of the lugs on the 12-position switch. **See page 11 for connection details.**
- ☐ Position the inductor and align the taps with the lugs on the switch. Working one at a time apply the soldering iron to the tinned lug on the switch and the tinned inductor tap soldering them together allow to cool, adjust the position if necessary for correct alignment and then move onto the next lug. DO NOT APPLY TOO MUCH HEAT THAT YOU DAMAGE THE SWITCH – ACT QUICKLY if necessary, coming back a second time when things have cooled to make further adjustments.

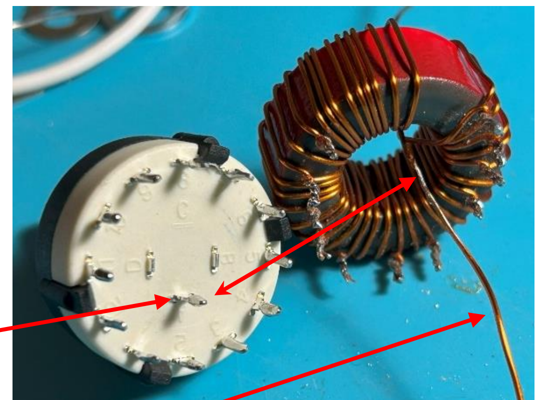
It is important that the inductor remains aligned after soldering each tap to the switch, it is too difficult to go back and try and adjust later.

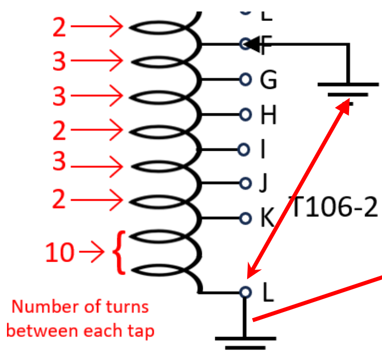
The start of the inductor connects between the two variable capacitors, and this is best achieved by bringing the lead through the gap between switch position 5 and 6 as shown in this photograph.





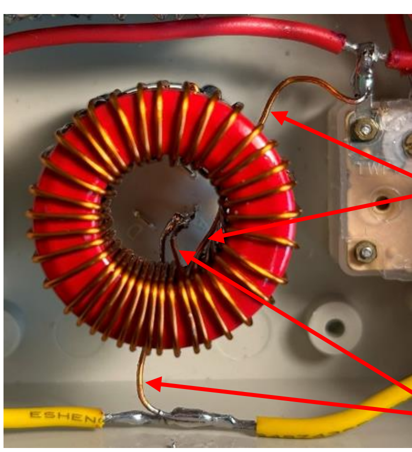
The end of the inductor lead shown emerging from the center of the toroid is also best brought out of the switch between position 12 and 1, in the same manner as the ‘start lead’ shown above. The end lead effectively joins the switch ‘wiper’ lug (position A) to switch position 12 (the L tap) ‘en route’ to being terminated to the ground rail (see p18 for final installation). Scraping the enamel off the magnet wire before you start to affix the inductor to the switch will make it easier to solder these connections.





The finished item should look something like this:

<u>NOTE:</u> This picture (on the right) was taken before the end lead was pulled back through the toroid to exit is the same manner as the ‘start inductor lead’.



The photo to the left gives a good view of the final connections for the two ends of the inductor leads:

‘Start Lead’

‘End Lead’

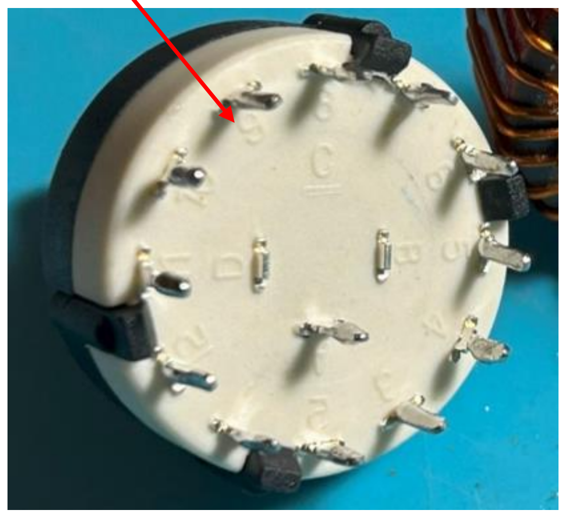
Inductor Tap and Switch Connections

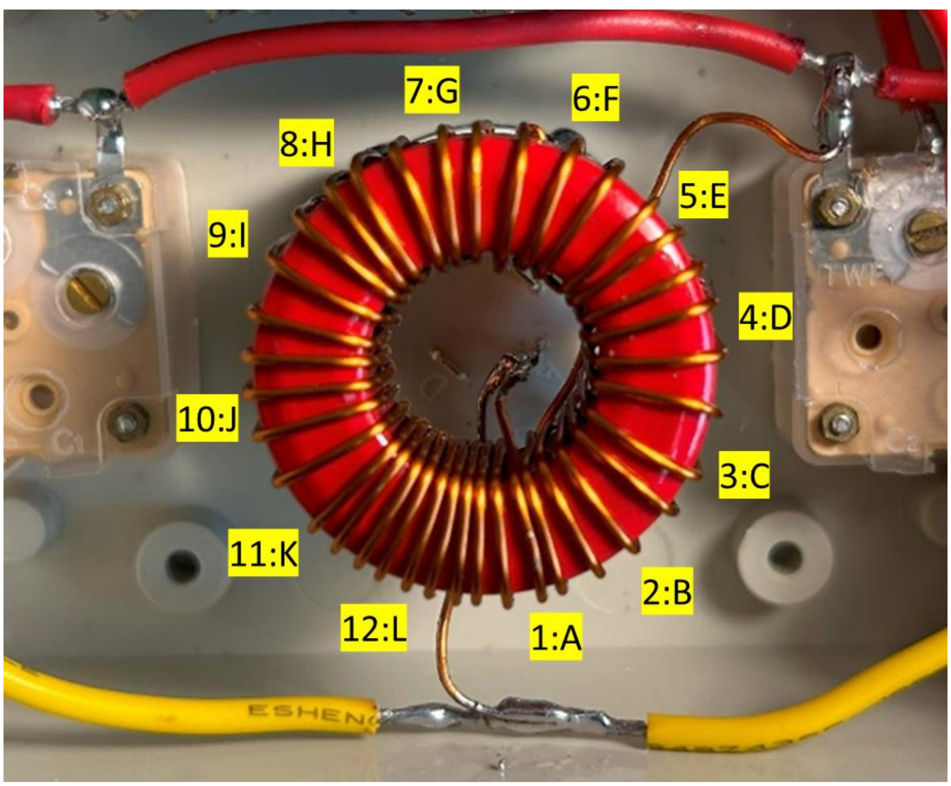
One of the most confusing elements of this stage of the build is knowing which tap to connect to which lug on the 12-position rotary switch. The lugs (switch positions) are identified from A to L as shown in the circuit diagram (p5) and the switch lugs are identified as position 1 – 12 on the back of the switch.

The switch alignment in the housing and the switch connections are shown in the table and photographs below:

Inductor Tap	Switch Position	Freq MHz	Inductance uH
A	1		0.1
B	2	50	0.1
C	3	18-30	0.3
D	4	10 - 14	0.7
E	5	7	1.6
F	6	5	2.3
G	7	3.6 - 4.0	3.5
H	8	3.5 - 3.6	4.9
I	9		6.0
J	10		7.8
K	11		9.1
L - Gnd	12	1.8 - 2.0	17.5

Inductor Values courtesy KP4MD



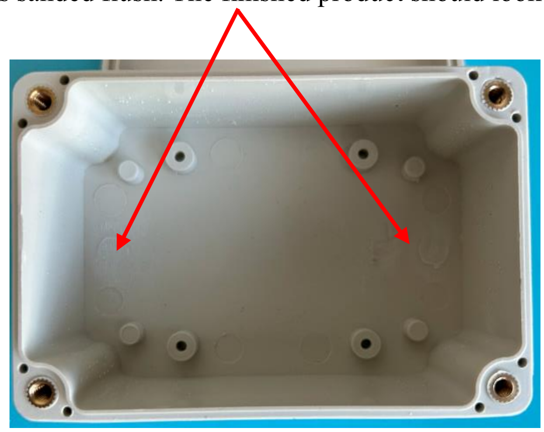


Preparing and Drilling the Enclosure

Before drilling the enclosure, it is necessary to remove two of the screw attachment fittings inside the enclosure to avoid interference with the variable capacitors and allow installation with a little more space between the capacitors.

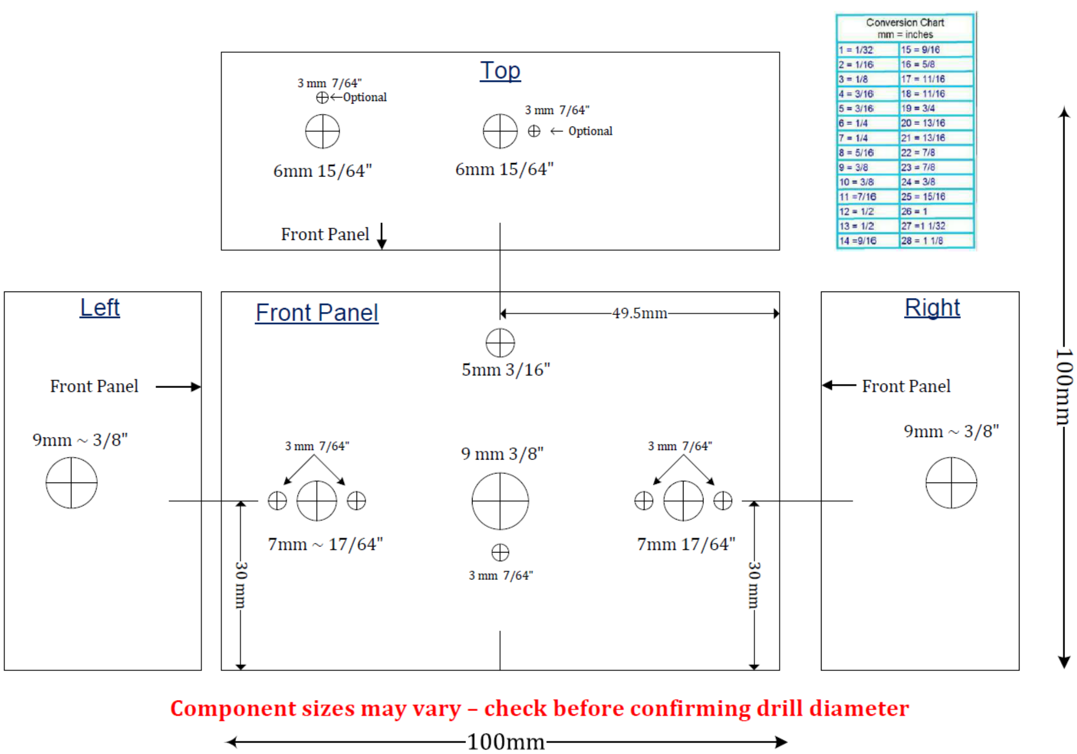
- ☐ Remove the two attachment fittings (identified with circle below) by using a Dremel tool or a combination of wire cutters and sandpaper so that the bottom of the enclosure is sanded flush. The finished product should look something like this:

→

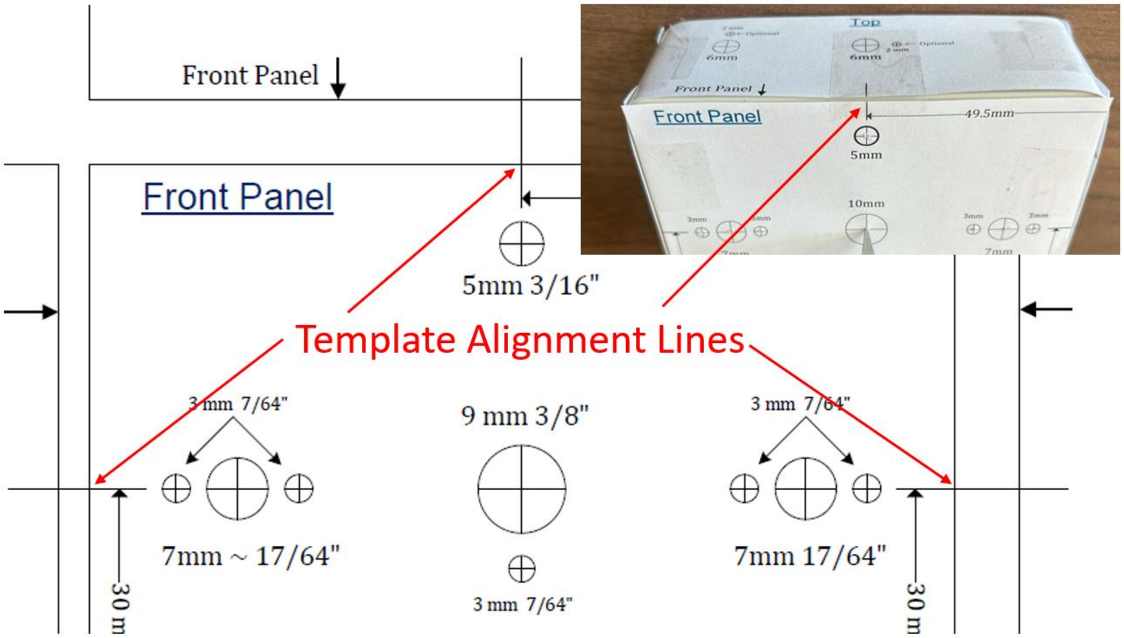


Preparing the Drilling Templates

The Cowtown ATU Kit comes with a drilling template to help ensure the correct mounting of the components in the enclosure. If you have downloaded the template from the GitHub site and printed the template, it is important to check that the printing has been scaled to the correct size. To aid in this process there is a horizontal and vertical 100mm line which is drawn to scale and you should check the measurement of your template to ensure that these lines are exactly 100mm long (measured from point to point of each arrow). The table on the template provides an approximate imperial conversion for the metric measurements, but the template shows the closest imperial measurement. As components may vary between kits it would be wise the check the diameter of the required holes with the components before drilling

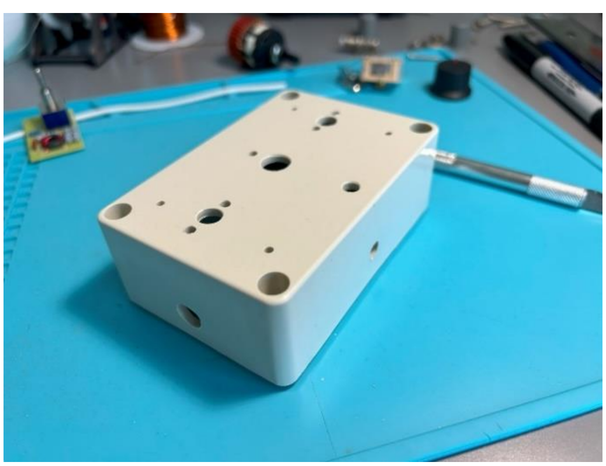


- ☐ Carefully align the front panel template on the outer bottom of the enclosure securing it down with a piece of masking tape or similar.
- ☐ Then align the top, left and right templates on their respective sides of the housing, using the alignment marks to ensure correct alignment with the Front Panel template. Once aligned stick these templates down with tape. NOTE: The BNC connectors are placed slightly forward of the alignment line by design. This is not a mistake.



Drilling the Enclosure

- ☐ Using a sharp object eg: the point of a modelling knife or similar, mark the center position of each drill hole, by pressing through the center of each hole - marking the center position for each hole on the enclosure.
- ☐ When all positions have been marked (double check) remove the drilling templates and drill the housing with the required drill bit sizes. Take particular care to ensure the accurate drilling of the 3mm holes relative to the 7mm and 10mm ‘parent’ holes on the front panel. This will ensure correct fitting of the variable capacitors and the rotary switch locking lug to ensure they remain fixed in location when rotating the knobs.

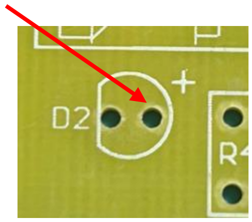


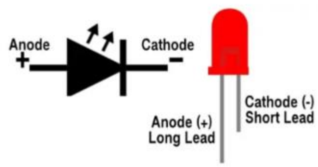
There may be slight variations between the supplied enclosures with the ‘Chinese’ kits these photos show two different enclosures that were supplied with the Cowtown ‘buy’. Whilst obviously from different manufactures, they were almost identical in size, but wall thickness and material used was different, but made no difference to the final product and build process.

Mounting the Components in the Enclosure

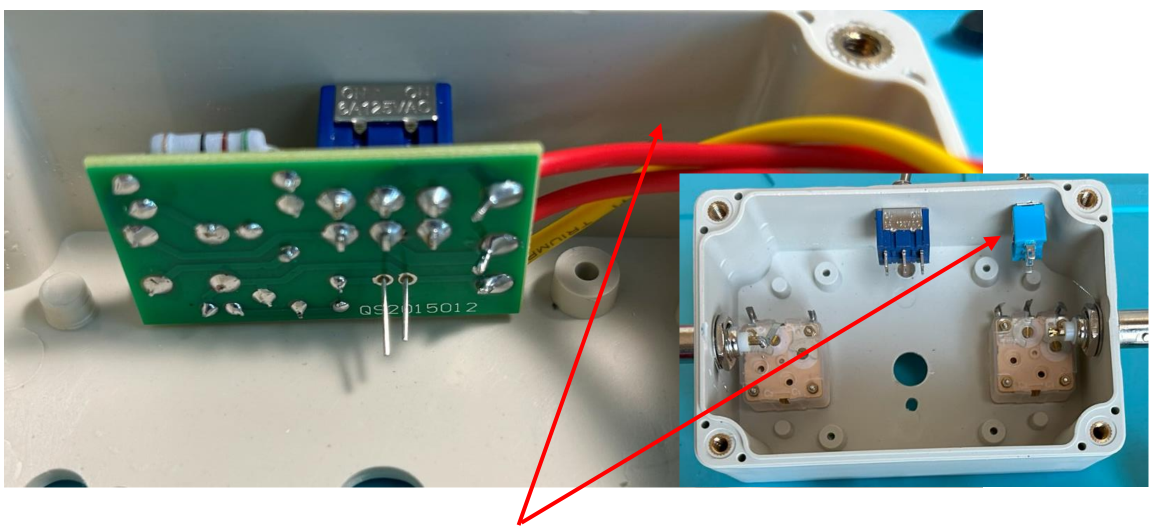
The trickiest component to mount in the enclosure is the PCB due to the need to fit the DPDT switch and the LED on two different sides of the enclosure. If you solder the switch and the LED onto the PCB before fitting it will be virtually impossible to fit the PCB so assemble in the following order:

- ☐ Cut two lengths of the red wire and one of the yellow wire each approximately 75mm (3”) in length and solder to the PCB’ In, Out and Ground Connection. Use Yellow for the ground connection.
- ☐ Fit the LED into the PCB ensuring the correct orientation of the LED. The long +ve lead goes through the hole closest to the + sign marked on the PCB as shown below:





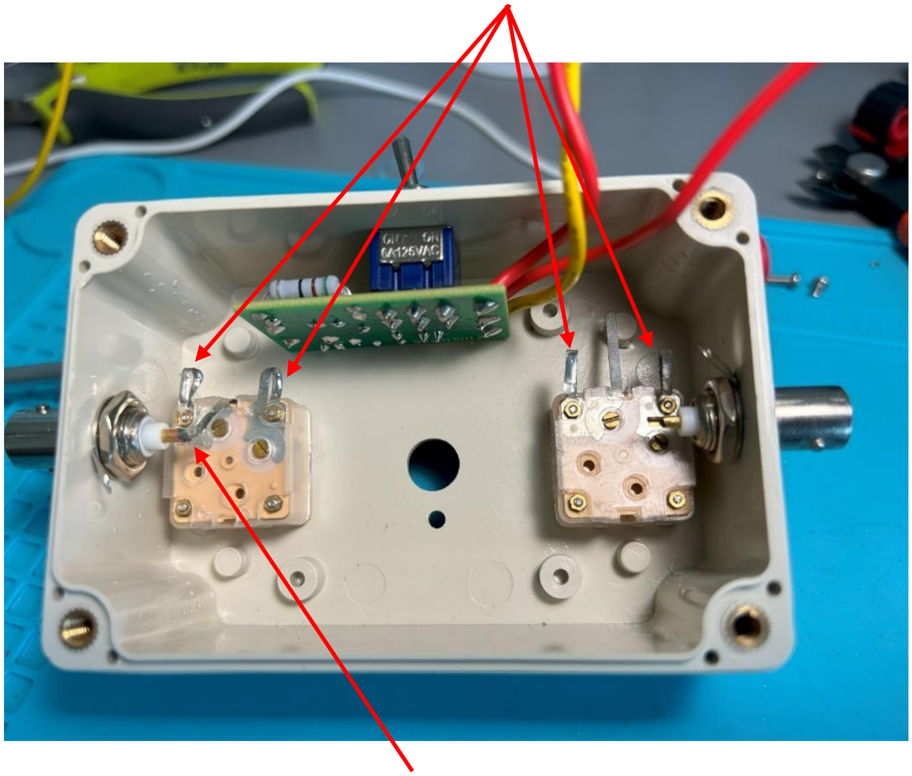
- ☐ Bend the LED though 90º so that it can protrude through the hole on the front panel. DO NOT SOLDER THE LED at this stage.
- ☐ Attach the DPDT switch to the top of the housing and fit the PCB.
- ☐ With the PCB in position attach the PCB to the DPDT switch and align the LED to protrude through the front panel hole solder the board to the switch, and then ensuring that the LED is in the correct position, solder the LED to the board. This is a little tricky, but I found this to be the most practical way of fitting the PCB, switch, and LED.



The SPDT by-pass switch is installed in this location, even though the hole is not shown in the first illustration.

<u>NOTE:</u> In some of the following installation photographs the SPDT bypass switch is not shown as I fitted this at a later stage after building the initial prototype used for the photographs to illustrate this construction manual. Where the wiring for the bypass switch is illustrated you will also see that the other components are installed in the ATU – sorry for the confusion, but the right-hand photograph above shows the installation of components to the enclosure before installing the remaining components.

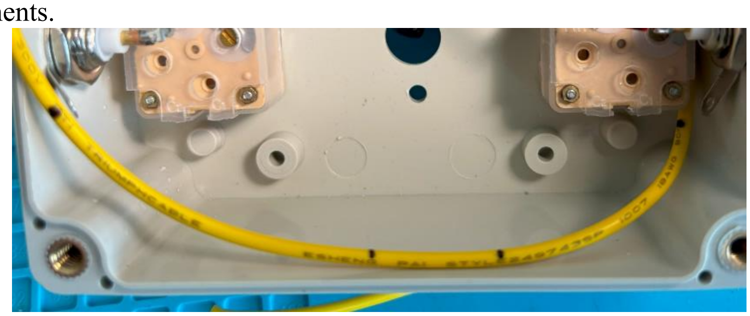
Install the two variable capacitors and the panel mount BNC connectors. NOTE that the two outer leads on the variable capacitors have been folded back and tinned before installation.



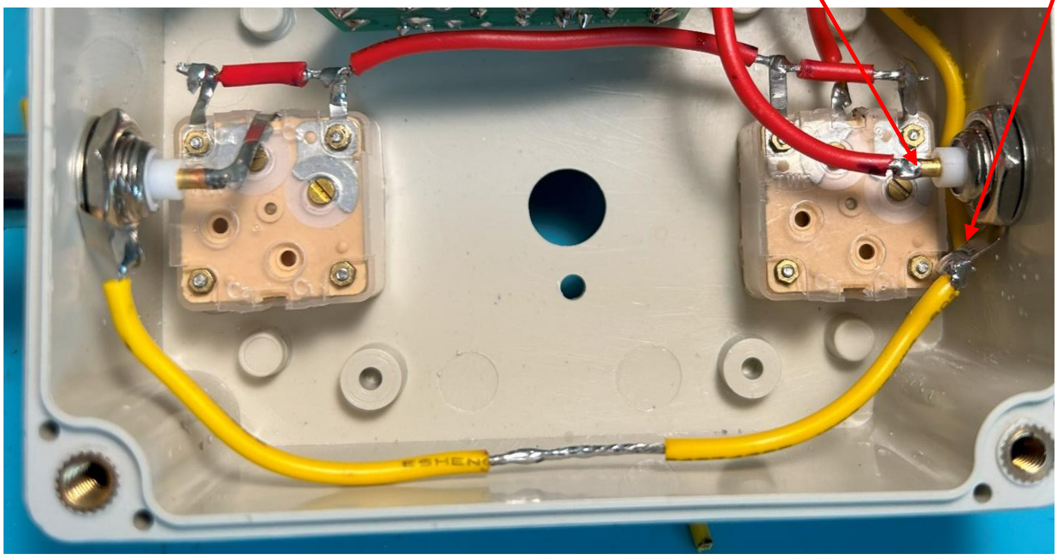
- ☐ Solder the center lead of the left-hand capacitor directly to the inner connector of the output BNC.

- ☐ Prepare a couple of ‘bus’ wires to connect the capacitors and the ground plane of the ATU. The final product is shown below:

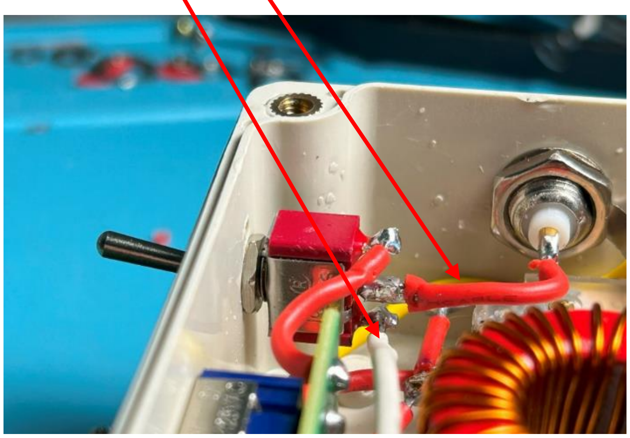
The easiest way to manufacture these cables is to lay the wire in the enclosure and measure/mark the wire in the housing for size and position, remove the outer insulation with a modelling knife and then tin the exposed wire before soldering to the components.



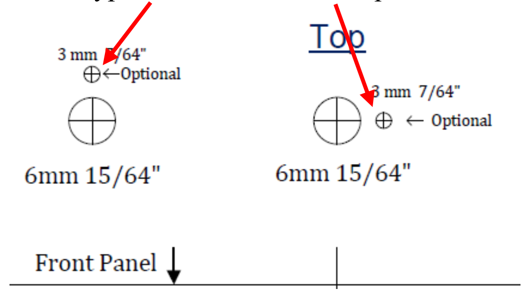
- ☐ Solder the yellow 'ground' wire to the ground lugs on the BNC connectors and the red wire to the capacitors as shown in the photograph below.
- ☐ Solder the 'GND' connector on the PCB to the Ground Lug on the BNC connector with a yellow wire.
- ☐ Solder the 'OUT' connector on the PCB to the center lead on the capacitor



- ☐ If you have not already installed the SPDT switch, install the SPDT by-pass switch and solder/wire the connections as follows:
    - The bottom terminal is wired to the center connector of the output BNC connector.
        - The center terminal is wired to the center of the input BNC connector.
            - The top terminal of the switch is wired to 'IN' connection on the PCB.

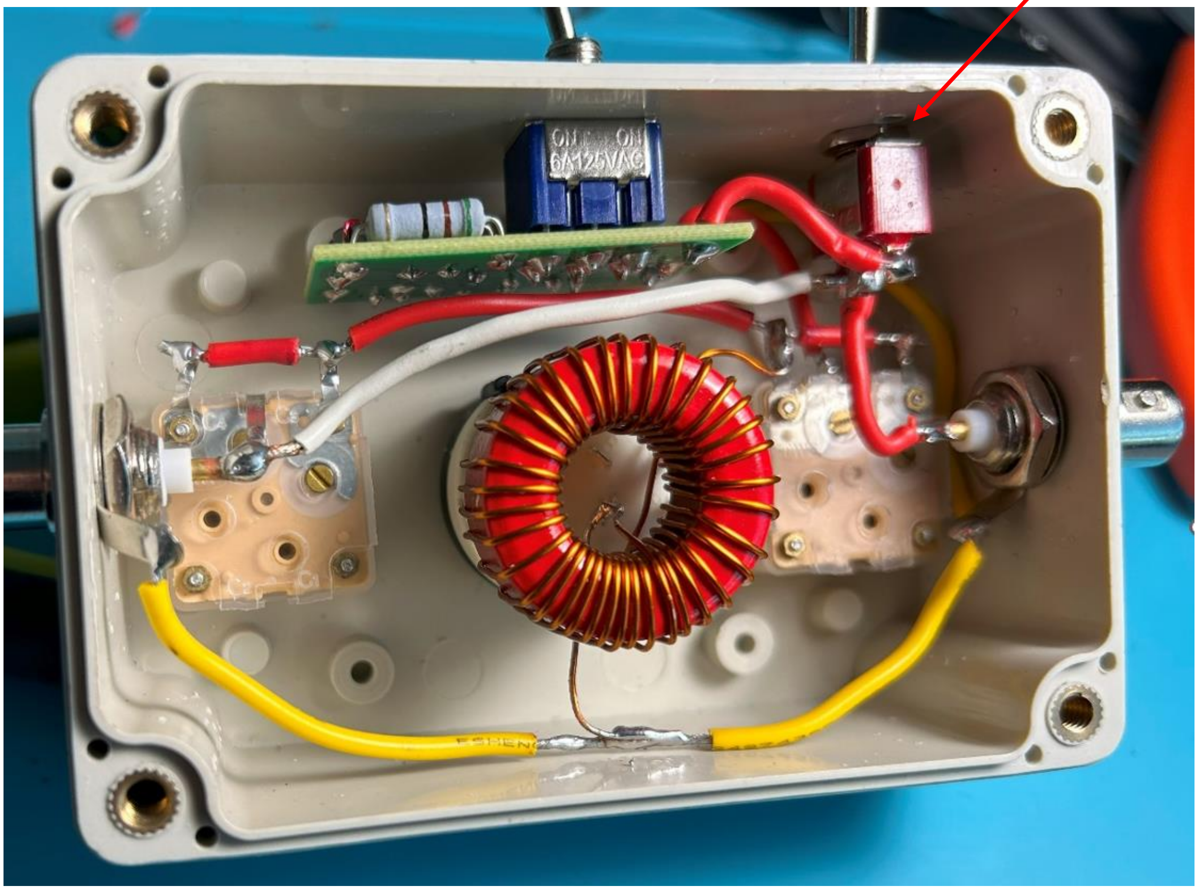


The 2 or 3mm hole (depending on your hardware's requirements) next to the Bypass switch and Tune/Operate switch enables the installation of the rotation 'lock' washer, which will hold the switch in the 'North / South' or East / West orientation to prevent rotation during operation. You may need to bend the lug carefully so that it is bent down approx. 90 degrees in order 'seat' in the hole.

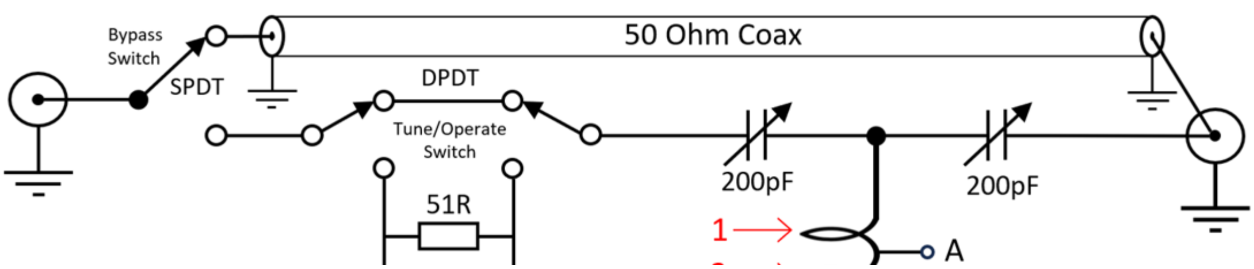


These holes are a matter of personal preference. If the switches are installed with a lock washer and tightened sufficiently these rotational lock washers are not often used, but it is good practice.

The by-pass wire shown in white in this build should be wired in such a way that it avoids the switched inductor once that has been mounted. The following photo shows the completed installation, and shows the Bypass Switch rotational lock washer installed.



The switch wiring is shown below for reference.

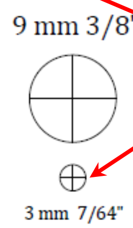


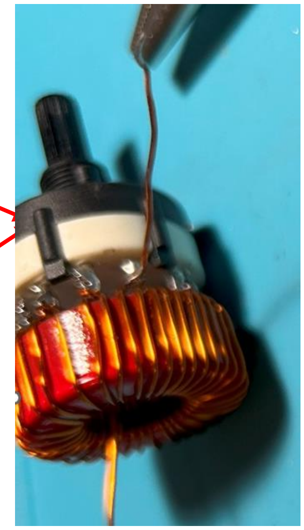
The connection between the Bypass switch and the output BNC connector is shown as a section of 50 Ohm Coax – which I substituted with the 'white' wire shown in the illustration. You can just as easily use a spare length of the red wire supplied with the kit (I didn't have any suitable coax with me at the time of the build). The use of small sized coax is likely to provide a better 'shielded' path for bypass and if you wish to use coax install a length of small diameter coax (eg: RG316, RG174 etc.) and replace the white wire in the illustration, stripping back the outer sheath/shield of the coax and soldering it to the ground lugs on the BNC connectors, and the center coax lead to the lower terminal on the SPDT switch and the other end to the center of the output BNC connector.

Installing the Switched Inductor

☐ Mount the 12-position switch in the enclosure and lightly tighten the shaft nut (we will be removing it a little later when installing the front panel decal).

Align the locator shaft in the 3mm hole so that the switch housing does not rotate during operation.



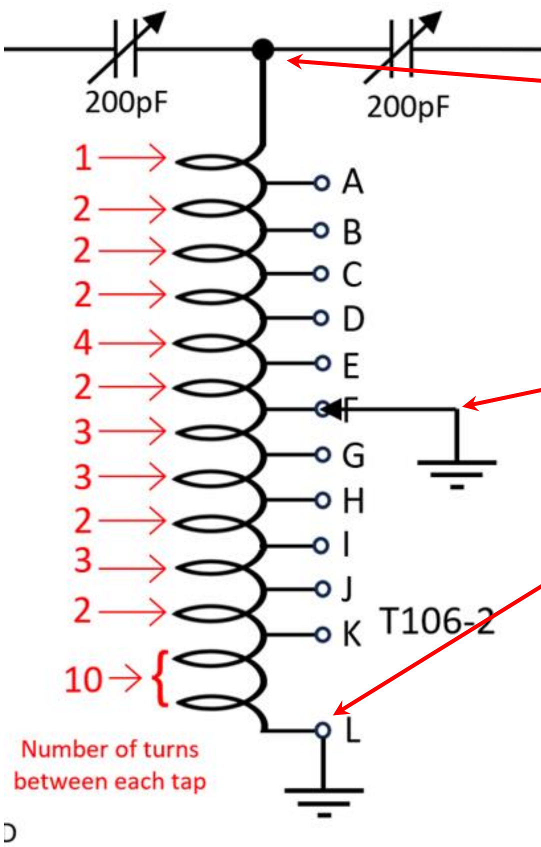


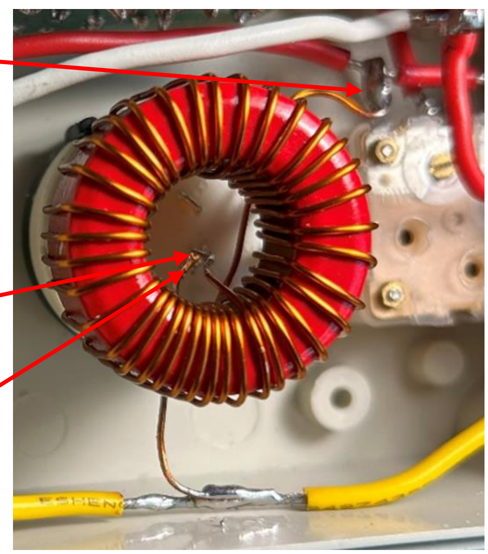
☐ Solder the inductor leads as shown on the diagram below.

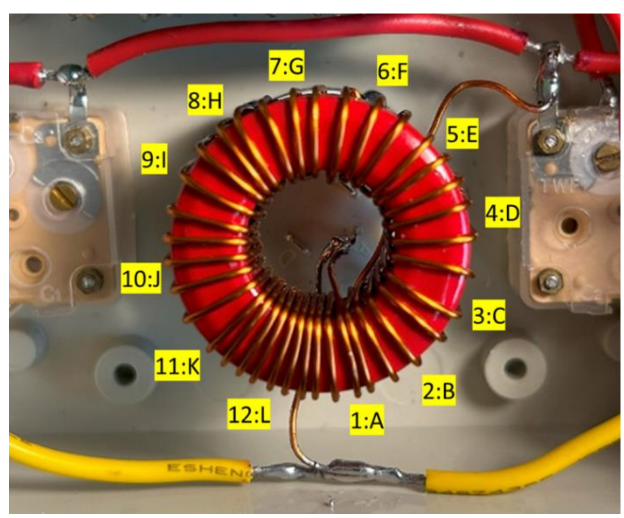
- The input wire to the inductor is connected to the left hand lead of the variable capacitor on the right. This is fed under the inductor, passing between postion 5 and 6 of the rotary switch, and travelling down to the lower end of the inductor before doing one loop around the toroid and is then tapped at A.
- The output wire from the inductor goes from the last turn on the '10' turn section and forms a common ground connection with the A terminal on the 12-position switch, the L tap position soldered to terminal 12 on the 12 position rotary switch and then travels down to the yellow cable ground 'bus' running along the bottom of the enclosure.

☐

☐





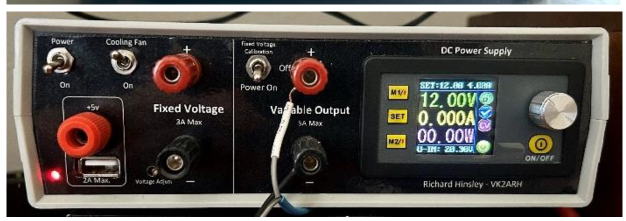


Installing the Front Panel Decal

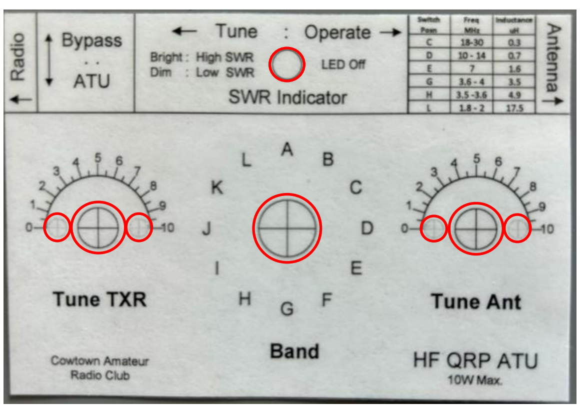
There are as many techniques for labeling front panels and you are free to use whichever technique you prefer, even the panel sticker supplied with the 'Chinese Kit'. However, for the purpose of the Buildathon we have supplied a front panel decal using one of my favorite techniques which I have used in recent years to good effect.

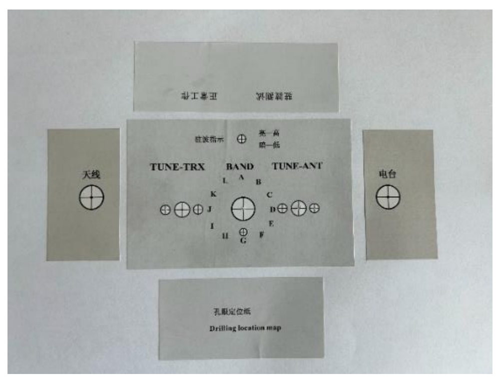
This technique basically involves designing your front panel using CAD software, printing it out on a laser printer, laminating the print, cutting out the decal and then affixing it to the enclosure using a combination of double-sided tape and support from the affixing method used to attach components to the panel.

Here are some examples of where I have used this technique which include a DCC++ model train controller, bench power supply, fox hunt attenuator and the ATU shown below:



The Cowtown panel overlay is a little more illustrative and practical than the decal provided with the original kit shown on the right below. A PDF of Cowtown decal which includes two variants to suit different sized tune knobs can be downloaded from: https://github.com/VK2ARH/Cowtown-ATU-Project





To install the decal on the front panel:

- ☐ Using a sharp modelling knife, or hole punch cut out the holes for the panel components which have been circled in red, and round the four corners of the decal with a pair of scissors:

- ☐ After removing the 12 position switch nut and washer, cover the top of the enclosure with thin double-sided tape without conflicting with installed components and stick the panel onto the enclosure.

- ☐ Fit the 12-position switch back onto the enclosure. The washer and nut on the switch should hold down the center of the front panel overlay.

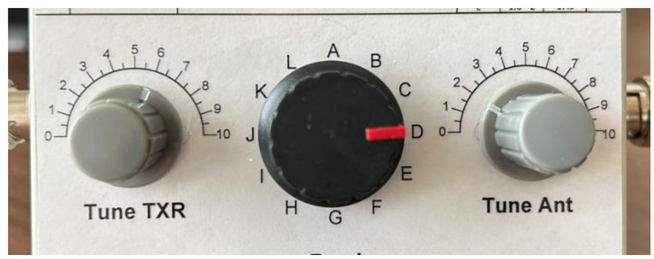
Fitting the Front Panel Knobs

Band Selector Switch

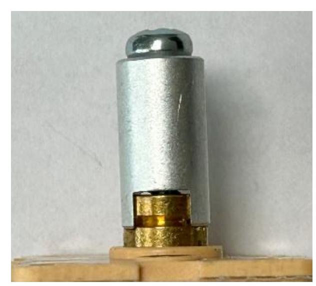
- ☐ Rotate the 12-position switch fully anticlockwise, then place the band select knob onto the switch shaft aligning the position market with switch position A. This is a ‘press fit’ knob.
- ☐ The 12-position switch should now be correctly aligned. Check by ensuring that the switch is able to rotate in a clockwise direction from position A to position L.

Tuning Capacitor Shafts and Knob

The original ‘grey’ knobs and hardware supplied with the ‘Chinese Kit’ for operation of the variable capacitors (see right hand photo below) has many shortcomings, and it is difficult to adequately secure the tuning knob to the capacitor to withstand regular operation. Attempts to fabricate a 3D printed shaft adaptor have not proven to be ‘rugged’ enough, so in the end we sourced a custom-made shaft and knobs to enable reliable operation of the variable capacitors. These items are included in the Cowtown Kit.



The capacitor has an M2 thread for securing a shaft to it. In the Cowtown Kit and the aluminum shaft is 6.4mm (1/4”) in diameter and approx. 12mm in length. The knobs are 20mm diameter at the base and are secured to the shaft with the grub screw.



- ☐ Secure the aluminum shafts to the variable capacitors by placing the shaft over the capacitor shaft collar and tighten the M2 12mm machine screw as shown:
- ☐ Rotating the ‘Tune Ant’ variable capacitor shaft fully counterclockwise, place the knob over the shaft and secure the know to the shaft after aligning the indicator to the 0 position.
- ☐ Rotate the ‘’Tune TXR’ variable capacitor shaft fully clockwise, place the knob over the shaft and secure the know to the shaft after aligning the indicator to the 10 position.

The finished product should look similar to this →

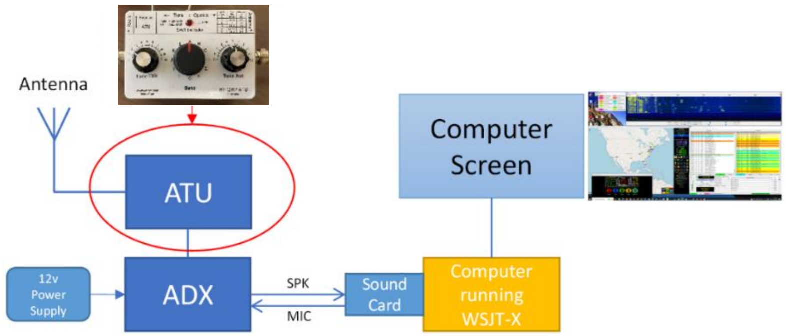
The variable capacitor tune knobs should move through 180^{o} from the 9 O’Clock to the 3 O’Clock position represented by 0 through 10 on the scale.

Using the QPR ATU – Operating Guidelines

The video promoting this Buildathon project also shows the operation of this ATU and can be found here:

https://youtu.be/RU0_GjSdMsE

The ATU is inserted in the antenna feed line as close as practical to a QRP transmitter. The ATU is capable of supporting a 10w power input, if you exceed this you will 'burn' though the dialectic between the plates in the 'polyvaricon' capacitors. In this example the connection is shown working with the ADX which we built in an earlier Buildathon project.



Inductor Tap	Switch Position	Freq MHz
C	3	18-30
D	4	10 - 14
E	5	7
F	6	5
G	7	3.6 - 4.0
H	8	3.5 - 3.6
L	12	1.8 - 2.0

With the ATU inserted into the antenna feedline, if the Bypass switch is set to 'Bypass" the signal path is routed around the ATU directly to the output effectively bypassing the ATU and providing a direct connection to the antenna.

With the Bypass switch set to 'ATU' the signal path is routed to the ATU for antenna tuning.

The basic procedure for tuning an antenna is as follows:

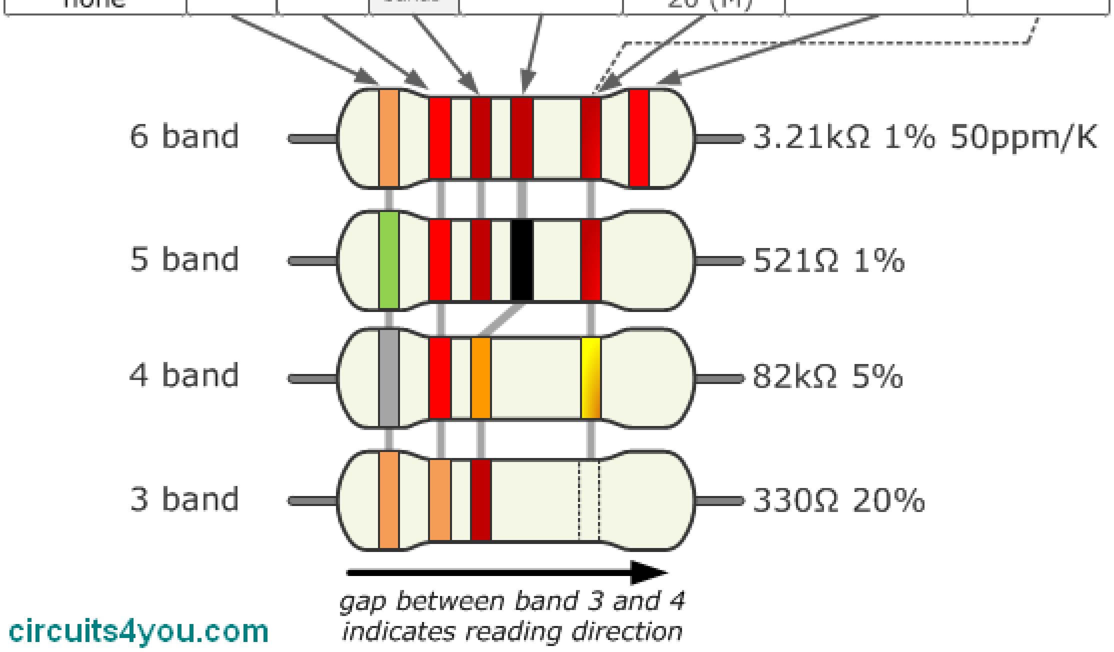
1. Set both TXR and ANT tuning capacitors to position 0 (No Capacitance).
2. Review the table on the front panel (shown above right) and turn the band switch to the position indicated for the frequency you wish to tune. This will be the starting position for the band switch.
3. Listen to or observe the input signal strength and adjust the band switch to confirm that you are in the position that provides the strongest input signal. Now adjust the two tune capacitors to the position at which listening or observing the received input signal produces the strongest result.
4. Switch the TUNE/OPERATE switch to the TUNE position.
5. Activate a carrier on your transmitter at LOW power and observe the intensity of the LED. The LED will illuminate indicating the presence of a reflected signal – the greater the intensity of the LED the higher the SWR.
6. Adjust the two TUNE knobs looking for a 'dip' in the LED intensity – and once identified adjust each Tune knob to achieve the lowest possible level of illumination. A good match will see the LED extinguish.
7. Note the interaction of the two Tune knobs – adjusting one will impact the setting of the other.
8. If you are not able to detect a dip in the LED intensity – try selecting another position on the band switch.
9. **DO NOT** 'key down' your transmitter for a long period of time if you are not able to obtain a match as this has the potential to overhead and damage the PA section of your transmitter. Instead tune for a short period of time, seeking to find a match and then pause to allow the PA section to cool a little before trying again.
10. Once you have identified the best match (lowest possible SWR), switch the TUNE/OPERATE switch to OPERATE – and enjoy. NOTE: The LED indicator does not display when in OPERATE mode, only when in TUNE mode.

It is good practice to record the ATU setting for a particular antenna/frequency/installation – the scales on the front panel overall have been provided to facilitate this. Knowing where to start the tuning process can significantly speed up the tuning process and keeping this information eg: Dipole at home QTH: 20m, 3, D, 6.5 in a notebook or in a table stuck to the back of the ATU can be a great help.

Useful Information

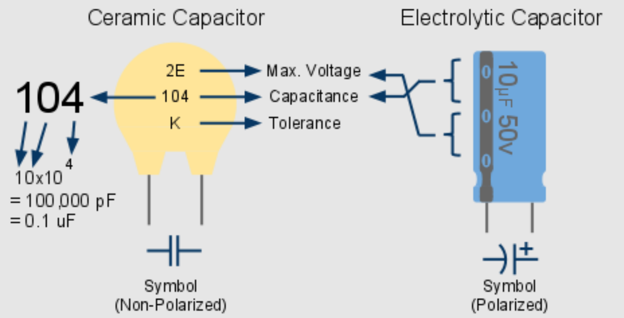
Resistor Color Code Chart

Color	Signficant figures			Multiply	Tolerance (%)	Temp. Coeff. (ppm/K)	Fail Rate (%)
black	0	0	0	x 1		250 (U)	
brown	1	1	1	x 10	1 (F)	100 (S)	1
red	2	2	2	x 100	2 (G)	50 (R)	0.1
orange	3	3	3	x 1K		15 (P)	0.01
yellow	4	4	4	x 10K		25 (Q)	0.001
green	5	5	5	x 100K	0.5 (D)	20 (Z)	
blue	6	6	6	x 1M	0.25 (C)	10 (Z)	
violet	7	7	7	x 10M	0.1 (B)	5 (M)	
grey	8	8	8	x 100M	0.05 (A)	1(K)	
white	9	9	9	x 1G			
gold			3th digit only for 5 and 6 bands	x 0.1	5 (J)		
silver				x 0.01	10 (K)		
none					20 (M)		



Capacitor Identification Chart

Capacitors



Capacitance Conversion Values

Microfarads (µF)		Nanofarads (nF)		Picofarads (pF)
0.000001 µF	↔	0.001 nF	↔	1 pF
0.00001 µF	↔	0.01 nF	↔	10 pF
0.0001 µF	↔	0.1 nF	↔	100 pF
0.001 µF	↔	1 nF	↔	1,000 pF
0.01 µF	↔	10 nf	↔	10,000 pF
0.1 µF	↔	100 nF	↔	100,000 pF
1 µF	↔	1,000 nF	↔	1,000,000 pF
10 µF	↔	10,000 nF	↔	10,000,000 pF
100 µF	↔	100,000 nF	↔	100,000,000 pF

Max. Operating Voltage

Code	Max. Voltage
1H	50V
2A	100V
2T	150V
2D	200V
2E	250V
2G	400V
2J	630V

Tolerance

Code	Percentage
B	± 0.1 pF
C	±0.25 pF
D	±0.5 pF
F	±1%
G	±2%
H	±3%
J	±5%
K	±10%
M	±20%
Z	+80%, -20%

Diode and LED Lead Identification