DL-QRP-AG

ZM-4 ATU for symmetrical and asymmetrical antennas

Please read the manual completely for better understanding before you start assembling

Manual Version 1.3UK

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The Z-Match

Unlike most ATUs the Z-Match is not based on a High Pass or a Low Pass but due to its parallel circuit it´s a bandpass. The benefit of the Z-Match principle is that there is no need for tapped coils. Due to its bandpass characteristic it also attenuates off frequency signals, a fact that helps if your RX tends to have intermodulation problems. If you use the ZM, you do not need a separate SWR meter because during tuning, the Z-Match uses a 50 Ohm Wheatstone-Bridge. This is another great help because your TX-PA always has a real resistive load. The SWR never can exceed 2.0 because if the antenna port is shorted, the bridge resistance is 25 Ohms and if the antenna port is open, the bridge resistance is 100 Ohms. Over the years the Z-Match has become one of the most used ATUs in the QRP community. Lots of us have been happy with the ZM-2 kit of EMTECH USA. Some time ago I started developing the ZM-4. The reason was not dissatisfaction with the ZM-2, but there were 2 problems which I wanted to solve:

1. The ZM-2 “did not like” antennas with a very low feed impedance
2. The ZM-2 could not handle the 160m band

Another idea was to use a PCB to make it easier to build a Z-Match for HAMs with less expierience. Using a lot of papers I found on the internet, in the end I got a design which solved all my problems. Mainly I used the really good papers of Charlie Lofgren, W6JJZ, and Lloyd Butler, VK5BR. The complete ZM-4 can be realized on one PCB. Stability and useability are improved compared to the old design which helps a lot for hard outdoor useage. The new ZM-4 easily tunes my 2x20m doublet between 28 and 1.8 MHz. The two different coupling windings help to tune antennas with very low impedance as well as antennas with very high impedance. The resonant coil compared to the old ZM-2 coil has some extra windings. This extra inductivity together with switchable capacitors adds in the 160m band.

We wish you a lot of fun building and using your ZM-4.
Peter, DL2FI QRPproject.

Assembling the ZM-4

Please take the time to read the manual before you start soldering. It contains some information that will be helpful for success.

If you find something that can be written better, please contact Peter, DL2FI. He will be happy if you help him to make a manual better. Use the email address support@qrpproject.de.

The same email address is good if you need any help!

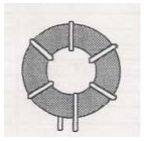
Because the big toroid coil is the heart of our ZM, we start the project by winding it. To make it easy for you we use wires of different colours for each part of the complete winding. Those who are not familiar with toroids should at least read the following introduction. A very helpful article in English language about winding toroids can be found on W8DIZ homepage:
http://kitsandparts.com/wtoroids.html

Toroid winding tips:

Count the turns while you are winding them. ATTENTION: every time the wire is fed through the toroid counts as 1 turn, so always count INSIDE the core!!!

Every time you start a new turn, pull the old turn tight to the toroids body. The turns should lay as near to the toroids body as possible. Never cross an old turn with a new turn, each turn must be parallel to the others.

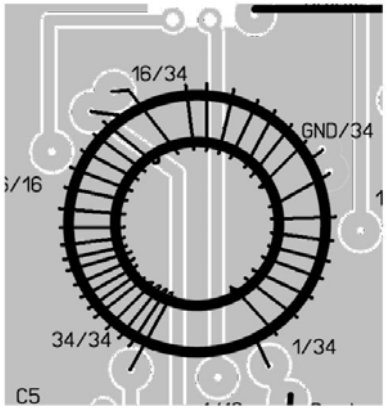
When you have finished a particular winding count the turns again. Use a small screwdriver or your fingernail to help counting. Again, always count INSIDE the core!

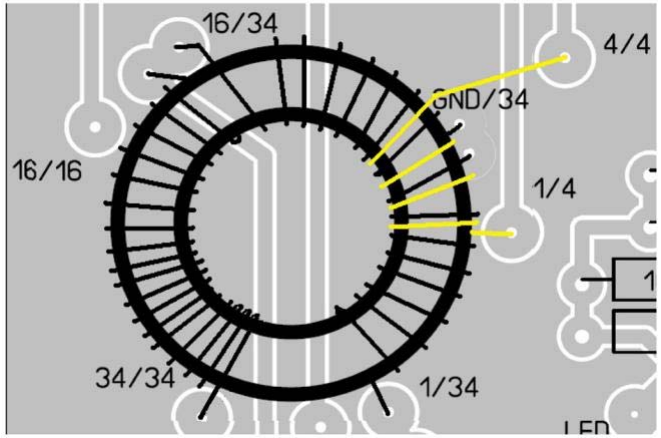


Example: this core has 6 turns

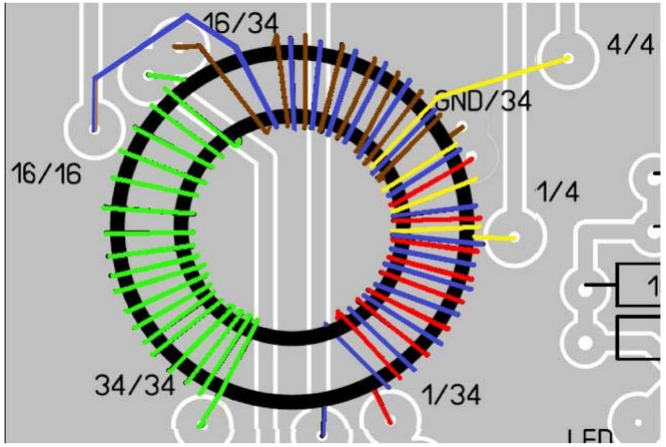
The ZM-4 main toroid needs 1 main winding (the resonant winding) with 2 taps plus two different coupling windings for the low and high impedance outputs. To make it easier to distinguish them we use coloured wires. Start with the red wire. Feed it from the backside of the core through the centre This is the first turn. A short end (about 2-3cm of the wire remains at the back side, the longer end is in front of you. Feed the long end around the core to the back and again from back to front through the core which gives the second turn (remember, count inside the core). The long end of wire must be to the RIGHT side of the first turn now. Pull the long wire tight to the core body. Now wind the remaining 6 turns of the first winding (for a total of 8 turns INSIDE).

Later on the 8 windings will be soldered to the PCB. They are the first part of the main winding which has a total of 34. The PCB is marked with 1/34 which means 1 of 34 at the beginning and GND/34 which means Ground of 34. Lay the toroid on the PCB and cut the wire at both ends. Leave the ends long enough to fit them through the holes named 1/34 and GND/34. Remove the insulation but do not solder yet. The next part of the 34 turn winding of course must start where the first part ends. So that is the reason to have two holes in the PCB here. Use the brown wire and wind the next 8 turns following the same way: from back to front; new turn always to the right side of previous turn. Count 8 turns and cut and remove insulation so the ends fit into hole GND/34 and 16/34 (16 of 34).
Now the remaining part of the main winding. This is 18 turns. They start at the second hole of 16/34 and end at 34/34.
Use green wire, count inside, shorten the wires and remove the insulation at both ends to make them fit into the PCB holes. Do not solder yet, you must wind the couplings first.





Let´s start with the shorter coupling winding. It consists of 4 turns. The coupling must be as symmetrical around the ground point of the main winding as possible. Remember, the grounding point is named GND, and is actually the connection between the red and the brown wire. Symmetrically means, the ground point must be exactly in the middle of the four coupling turns, two before and two after. Use the yellow wire and wind two turns between the last 2 of the red and two more between the first two of the brown wire. Pay attention to the fact the the holes for the coupling on the PCB are a little bit away from the toroid, so do not cut the wires too short.



So, we are not far away from our goal, it is only the longer coupling winding missing. Use the blue wire to make it. This must also be symmetrical around the ground point so we need 8 turns before and 8 turns after it. Start left of the first red turn and wind from back to front. Every blue turn lies between two red turns. Turns number 7 and 8 just before you come to ground point must lay between the red and yellow wires. Yes, there is not much space left, but you will see they all fit together. After the ground point wind the remaining 8 turns.

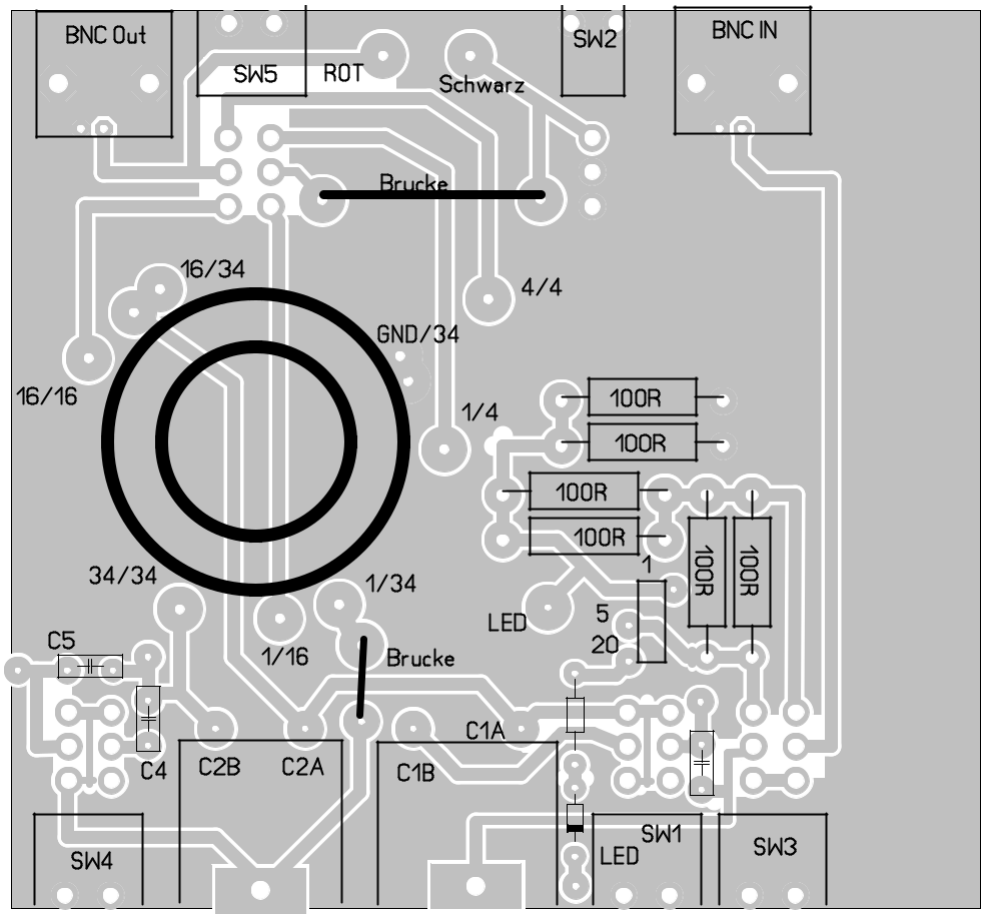
If you are ready, shorten the ends corresponding to the holes and remove the insulation at both ends. Now put the complete toroid onto the PCB and fit all wire ends in the corresponding holes. Tighten the ends, they should hold the toroid flat on the PCB. Bend them at the solder side of the PCB about 45 degrees to hold them in place until you solder them.

Take care to use the correct holes for all wires!!

Start blue = 1/16
Start red = 1/34
Start yellow = 1/4
End red = Gnd/34
Start brown = Gnd/34
End yellow = 4/4
End brown = 16/34
Start green = 16/34
End blue = 16/16
End green = 34/34

To hold the Torroid really flat to the PCB it´s good practise to tighten the wire ends sequentially several times. Go around from wire to wire until all wire ends are tight. If the toroid is placed as it should be, solder all wire ends.

Next place all low profile parts. Start with the two wire jumpers marked as “Brucke” on the PCB (that’s the German for “bridge”). Use two pieces of wire.
[ ] Short jumper at 1/34
[ ] Long jumper above 4/4
Now the “fat” resistors. These are 100 Ohm resistors. By using 2 of them in parallel we have 50 Ohms but less heat problems when tuning at full power.
[ ] 100R pair 1
[ ] 100R pair 2
[ ] 100R pair 3
Go on with the caps. For all caps there is a second hole in the PCB. They are only used if we use caps with bigger spacing. For all caps with 2.5mm spacing use the holes inside the silk screen printing
[ ] C5 lower left side 220pF
[ ] C4 lower left side 270pF
[ ] C3 lower right side 390pF (C3 label missing, there is only the capacitor symbol on the PCB)



Now place and solder:
[ ] 1 kOhm Resistor left of C3 above the Diode marker
[ ] Diode 1N4148, the black band must be placed to the side marked with a band on the PCB

Now the other toroid. This one is much smaller the the main toroid. It´s a grey ferrite FT37-43. We need a total of 25 turns tapped at 5 turns.

Start by winding 5 turns. After 5 turns, twist together a 2-3cm loop, this gives you the tap. Now wind the remaining 20 turns.

Because the 0.2mm wire we use for this toroid is insulated by lacquer, you must destroy the lacquer before you can solder the wire ends to the PCB. If you are not familiar with this technique, again look to the good description written by Papa Diz at http://kitsandparts.com/wtoroids.html.

Now place the toroid onto the PCB. The start turn (the shorter end to the tap) goes to the hole marked 1, the tap to number 5 and the longer end to number 20.
[ ] Transformer FT43-37

Only a few parts to be mounted now. Variable Caps (Polyvaricons), Switches and Jacks. All switches must be connected to the corresponding solder points on the PCB by pieces of the included CuAg wire. The upper row of the switch connectors join to the inner part of the PCB and the lower switch connectors to the holes nearer to the edge of the PCB. Before you can mount the remaining parts you must now drill/prepare the front and back plates of the enclosure. The picture in the appendix is not 100% to scale, you must do your own measurements!!

Start with the BNC jacks at the back side:
[ ] BNC OUT
[ ] BNC IN
[ ] SW2 (only 1 row of pins)
[ ] SW5 (switch with 2 rows of pins but mechanically NO mid point for switching - do NOT confuse this with the other 2 row switches which can be switched up/down/middle!!!)
[ ] Mount the two banana jacks (red and black) corresponding to the “rot” (red) and “schwarz” (black) points on the PCB. Take care to mount them using the isolation parts (so there is no electrical connection to the case)!
[ ] solder a 2-3cm piece of red and black wire into each of the holes marked rot (red) and schwarz (black)

Now the front side:
[ ] SW4 two row switch with middle switch point
[ ] SW1 two row switch with middle switch point
[ ] SW3 two row switch with NO middle switch point!!

Now the variable capacitors (Polyvaricons). They have one lead at the bottom and two at the top. The single bottom lead can be placed directly on the PCB, the 2 top leads are 2cm above the PCB. Solder the single front lead directly to the PCB and each of the two upper leads by using a 2cm piece of bare wire between the leads and the corresponding holes C2B/C2A and C1B/C1A. Use the full length of the leads to solder. Take care not to make a short between the wires and the small nuts on the back of the Polyvaricon.

[ ] Polyvaricon 2, 3 leads
[ ] Polyvaricon 1, 3 leads

In the hole just below the resistors between SW1 and C1 (labelled LED) you must solder a 5cm long piece of wire.

Before you put the PCB into the enclosure check the solder side of the PCB to make sure that all wires have been cut very short directly above the solder! If they are too long they may produce a short between the PCB and enclosure. If OK, set the PCB in the slot. There is only one slot that fits exactly.

At the backside connect the red wire with the red banana jack and the black wire with the black banana jack. Did you mount the banana jacks isolated from the backplane?? You should do, otherwise your feeder will be shorted :-)

Now there is only one part remaining, the LED. Connect the short leg of the LED (cathode) to the wire you have soldered to point marked LED on the PCB and the long leg (anode) end to the connection point at the edge of the PCB immediately between SW1 and C1. You may need a small additional piece of wire to make the latter connection.

Now you can use your ZM-4

Connectors and switches

Front panel, left to right:

SW4 - has 3 positions: up/middle/down. SW4 is used to enable 80 and 160m. Which position is to be used depends on your antenna length, it must be found experimentally. Middle will work with most antennas for 10-40m. If the wire is long enough, it will also be OK for 80m. For 160m and very often for 80m you will have to use up or down, both of which add extra capacitance.

C2 - is the main capacitor. It is used to resonate the ZM-4. C2 and C1 interact so you must tune them both. After some practise, you will be able to tune very quickly. The best way is to pretune in receive mode. Try to find a noise or signal maximum. When you have found it, switch to tune and do fine tuning while you transmit with low power.

C1- is the coupling capacitor. See description of C2

S1 - adds extra capacitance to C1. Normally the middle position is OK. Only if your antenna is very short or its impedance is very low will the upper and lower switch positions help.

S3 - this switches between Operate and Tune. In TUNE a 50 Ohm resistive bridge is switched in. This protects your PA because even with a shorted antenna or a missing antenna your PA will never see a VSWR worse than 2 (25 Ohms if shorted and 100 Ohms if open). At the same time it acts as the measuring device. As long as the antenna is off the 50 Ohm feed match, the LED will light. If you forget to switch to OPERATE for a QSO, your signal will be 6dB down, because only a quarter of the power is coupled to your antenna.

Now the back panel, left to right:

BNC IN - Connect your transceiver here.

S2 - switches between symmetrical and asymetrical feeder. Actually the ZM-4 is a true symmetrical ATU but it can be used for asymmetrical antennas (coax, endfed wire) with the help of this switch. Conect coax to BNC OUT and endfed wires to RED with counterpoise/ground to BLACK.

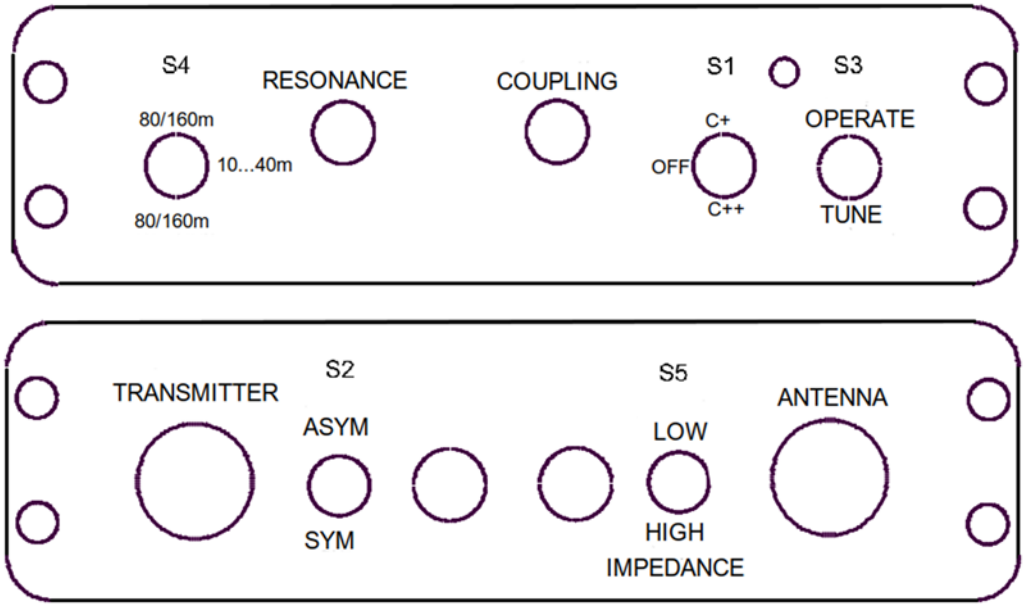
Black Bananajack - one wire of symmetrical feeder or counterpoise

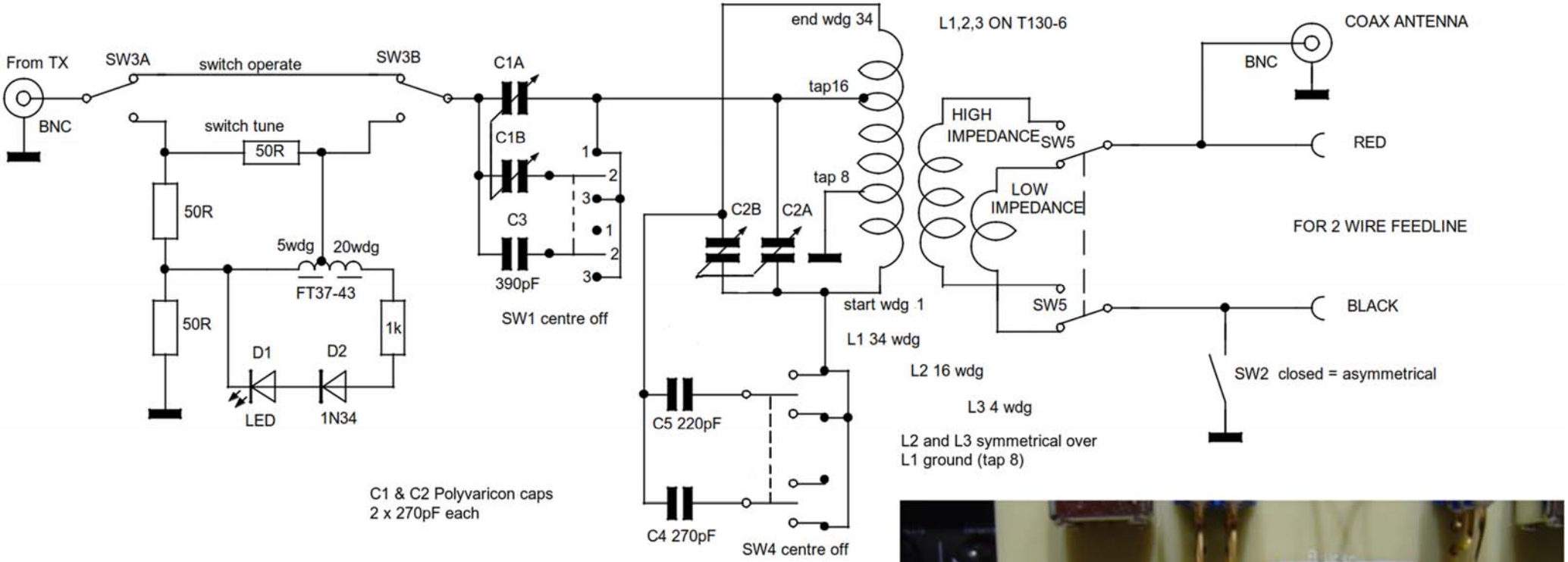
Red Bananajack - one wire of symmetrical feeder or longwire, endfeed

S5 - switches between low and high impedance. Which you need depends on your antenna. Try for best results. Switch upper position is low and lower position is high impedance.

Parts list:

1	Enclosure	1	PCB
6	Resistor 100 Ohm 2 Watt	1	Resistor 1K
2	Polyvaricon capacitor	1	Diode 1N4148
1	LED 3mm red	1	Ferrite toroid FT37-43
2	BNC jack for PCB mounting	1	Cap 390pF
1	Cap 220pF	1	Cap 270pF
1	Toroid T130-6 (yellow)	1	Switch, 1 row, up/down
2	Banana jack	1m	CuAg wire
2	Switch, 2 rows, up/down	2	Switch, up/middle/down
50cm	Red wire	50cm	Brown wire
1m	Yellow wire	30cm	Blue wire
1m	Black wire	1m	Magnet wire, 0.2mm





ZM-4 QRPproject

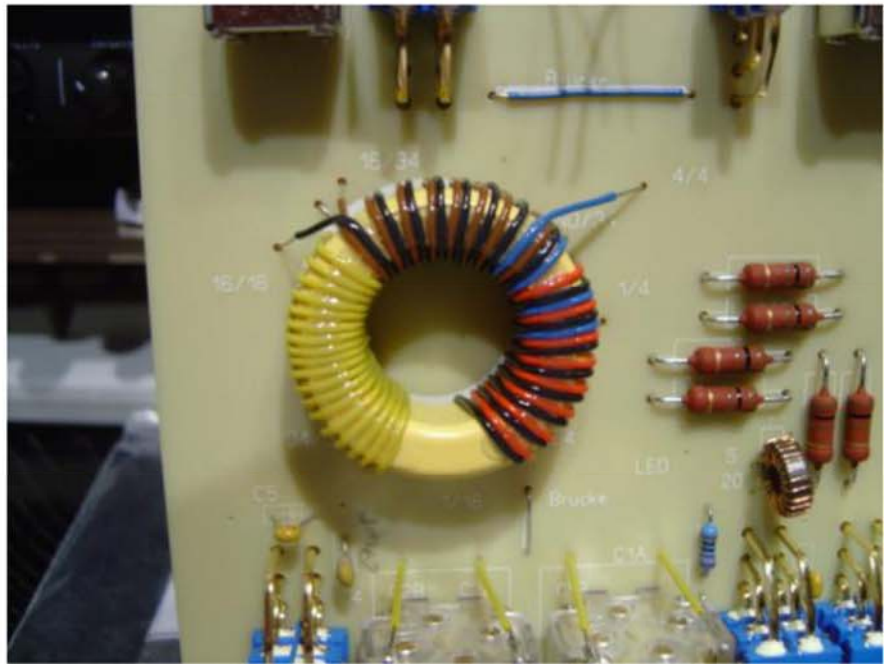


Photo: Fred HB9JCP (note different coloured wires)

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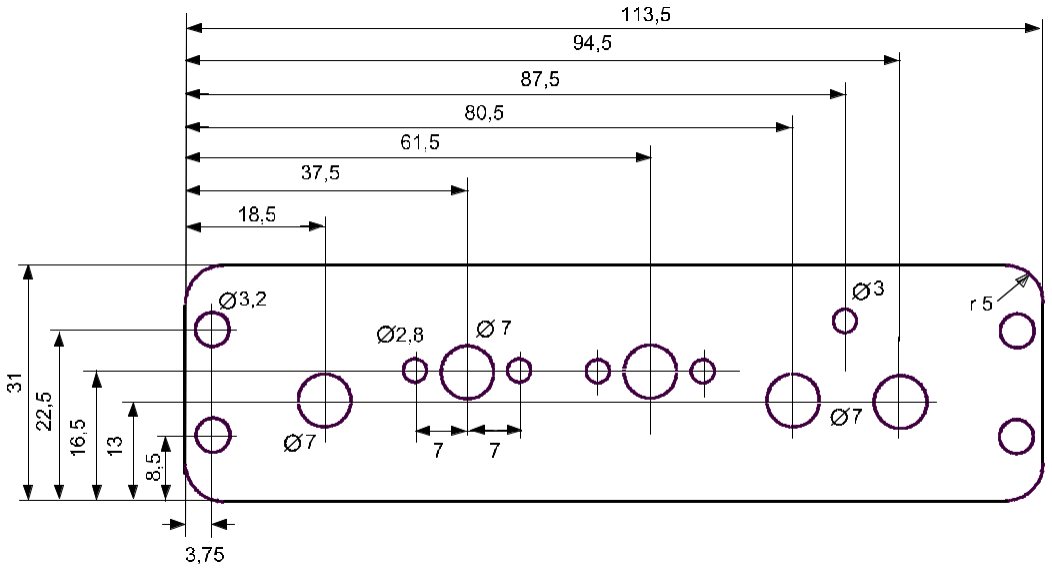
Warning: not to scale!

FRONT



REAR