ZM-4 ATU for symmetrical and unsymmetrical Antennas

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

Manual Version 1.3UK
The Z-Match
Other than most ATU the Z-match is not based on a High Pass or a Low Pass but due to it’s parallel circuit it’s a Bandpass. The benefit of the Z-Match principle is that there is no need for tapped coils. Due to it’s 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 everytime has a real resistive load. The SWR never can exceed 2,0 because if the antenna port is shorted, the bridge resistance is 25 Ohm and of the antenna port is open, the bridge resistance is 100 Ohm.
During years the Z-Match has become one of the most used ATU for the QRP Community. Lot’s of us have been happy with the ZM-2 kit of EMTECH USA. Some time ago I started the development of ZM-4. The reason was not that I have not been satisfied with the ZM-2, but during time I had found 2 problems which I tried to solve:
1. The ZM-2 „did not like“ Antennas with a very low feed impedance
2. The ZM-2 could not handle 160m Band

Another idea was to use a PCB to make it easier to build a Z-Match for HAMs with less experience.
Using a lot of papers I found in the internet, at the end I got a design which solved all my problems. Mainly I used the really good papers of Charlie Lofgren, W6JJZ, und Llloyd Butler, VK5BR. The complete ZM-4 could be realizes on one PCB. Stability and useability compared to the old design could be improved which helps a lot for hard outdoor useage.

The new ZM 4 easily tune my 2x20m doublett between 28 and 28 MHz. The two different coupling windings help to tune Antennas with very low impedance as Antennas with very high impedance. The resonate coil compared to the old ZM-2 coil has some extra windings. This extra inductivity together with switchable capacitors add the 160m Band.

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

Assembling the ZM4

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

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

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

Because the big Torroid 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 Torroids should at least read the following introduction. A very helpful article in english language about winding torroids can be found on W8DIZ homepage:
http://kitsandparts.com/wtoroids.html

Torroid winding tips:

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

Every time you start a new turn, pull the old turn tight to the torroids body. The turns should lay as near to the torroids body as possible. Never cross an old turn with a new turn, each turn must be parallel to the other.
If you 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 counts 6 Turns

The ZM4 main Torroit needs 1 main winding (the resonate winding) with 2 taps plus two different coupling windings for the low and high impedance outputs. To make it easier to difference them we use coloured wires. Start wit the red wire. Put it from the backside of the core through the core, this is the first turn. A short end (about 2-3 cm 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 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 (complete part 1 is 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 Torroid 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 right side of old 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 are 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 contains of 4 turns. The coupling must be as symmetrical around the ground point of the main winding as possible. Remember, grounding point is named GND, actually it is 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 behind.

Use the yellow wire and wind two turns between the last 2 of the red and the first two of the brown wire.

Pay attention to the fact the the holes for the coupling at the PCB are a little bit away from the torroid, so do not shorten the wire ends 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 one also must be symmetrical around the ground point so we need 8 turns before and 8 turns after the ground point. Start left of the red number one and wind again from back to front. every blue turn is laying between two red turns. Turn number 7 and 8 just before you come to ground point must lay between the red and the yellow wire. Yes, there is not too much space left, but you will see they fit all together. Behind the ground point wind the remaining 8 turns.
If you are ready, shorten the ends corresponding to the holes and remove the isolation at both ends. Now put the complete torroid to the PCB and fit all wire ends in the corresponding holes. Tighten the ends, they should hold the Torroid 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 practice to tighten the wire ends sequential several times. Go around from wire to wire until all wire ends are tight. If the Torroid 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“ at the PCB (that’s the German name for „bridge“) Use two pieces of wire.
  [ ] Short jumper at 1/34
  [ ] long Jumper above 4/4
Now the „fat“ Resistors. This are 100Ohm resistors because by using 2 of them parallel we also have 50 Ohm but less heat problems when tuning with full gallon QRP.
  [ ] 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

Now place and solder
  [ ] 1 kOhm Resistore left C3 above the Diode marker
  [ ] Diode 1N4148, The black band must be placed to the side marked with a band on the BCB

Now the other torroid. This one is much smaller than the main torroid. It’s a gray ferrite FT37-43. We need a total of 25 turns tapped at 5 turns.
Start by winding 5 turns. After 5 turns leave about 2-3cm, twist them together, this gives you the tap. Now the remaining 20 turns.
Because the 0,2mm wire we use for this torroid 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 torroid to the PCB. The start turn (the shorter end to the tap) goes to
the marked with 1, the tap to number 5 and the longer end to number 20.

[ ] Transformer FT43-37

Only a few parts to be mounted now. Variables, Switches and Jacks. All switches must be connected to the corresponding solder points at the PCB by pieces of the shipped CuAg wire. The upper row of the switch connectors belong to the inner part of the PCB, the lower switch connectors to the holes placed more to the edge of the PCB. Before you can mount the remaining parts now you must prepare the enclosure. The picture in the appendix is not 100% on 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 wit 2 rows of Pins but mechanically NO Mid Point for switching. Do NOT interchange the switches with the other 2 row switch 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!
[ ] solder a piece of red and black wire 2-3cm each into 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 NO!! middle switch point

Now the variable Polyvaricons) The use 1 solder tap at the front side and two at the back side. The single solder tap in front must be placed directly to the PCB, the 2 taps are 2cm above the PCB. Solder the single front tap directly to the PCB and each of the two upper solder taps by using a 2cm piece of bare wire between the Taps and the corresponding holes C2B/C2A und C1B/C1A. Take the full length of the taps to solder. Take care not to make a short between the wires and the small nuts at the backside of the Polyvaricon.

[ ] Drehko 2, 3 taps
[ ] Drehko 1, 3 Taps

In the hole just below the resistors between SW1 and C1 (labeled 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 if all wires have been cut very short directly above the solder! If they are too long they may produce a short between PCB and enclosure. If ok, set the PCB in the slot, there is only one slot fitting exactly.

At the backside connect the red wire with the red banana jack and the black wire with the red banana jack. (Did you mount the banana jacks isolated from the backplane?? You should do, otherwise your feeder would 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 effect the latter connection.

Now you can use your ZM4

Connectors and switches

Front left to right:

SW4
SW4 has 3 position: Up middle down. SW 4 is used to enable 80 and 40m. Which position is to be used depends on your antenna length, it must be found experimental. Middle will work with most antennas for 10-40m If the wire is long enough, it will also be ok for 80m. In any case of 160m and very often for 80m you will have to use up or down, both of them add extra capacity.

C2
C2 ist the main capacitor. It is used to resonate ZM4. C2 and C1 interact so you must tune then both. After some training, you will be find it to be very fast tuning. Best way is to pretune in receive mode. Try to find noise or signal maximum. If you have found it switch to tune and do fine tuning while you transmit with little power.

C1
C1 ist is the coupling capacitor. See description of C2

S1
S1 Adds extra capacity to C1 Normaly Middle is ok, only if your antenna is very short or it’s impedence is very low the upper and lower switch position will help.

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

Now the backplane, left to right:

BNC IN
Connect your transceiver here.

S2
S2 switches between symmetrical and unsymmetrical feeder. Actually the ZM4 is a real symmetrically ATU but it can used for unsymmetrical antennas (Coax, endfeed) with the help of this switch. Conect Koax to out and endfeed wires to RED with counterpoise do black

Bananajack SCHWARZ (black)
one wire of symmetrical feeder or counterpoise

Buchse ROT
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 high and lower position is low impedance

Part List:
1 Enclosure 1 PCB
6 Resistor 100 Ohm 2 Watt 1 Resistor 1k
2 Polyvaricon Variable Cap 1 Diode 1N4148
1 LED 3mm red 1 Ferrit Torroid FT37-43
2 BNC Jack for PCB mounting 1 Cap 390pF
1 Cap 220pF 1 Cap 270pF
1 Torroid T130-6 (yellow) 1 Switch 1 row
2 Banana Jack
2 switch up down
2 Switch up down middle
50cm Draht red
50cm Draht brown
100cm Draht yellow
30 cm Draht blue
100 cm Draht bleck
100cm Magnetwire 0,2mm CuL
L1,2,3auf T130-6

Vom TX

Schalterstellung Operate

SW3A

50R

5Wdg 20 Wdg

FT37-43

SW 1 Center off

Doppeldrehköcher 270 pF

C1 A1

1

2

3

C1 B1

C3

390pF

SW 1 Center off

Doppeldrehköcher 270 pF

C2

2

220pF

2

L1 und L3 symmetrisch um Masseanzapfl

C4

270pF

SW4

ZM-4 QRPproject

Foto: Fred, HB9JCP (only demonstration, different wire colours)