



ZM-2

Z MATCH

ATU (Antenna Tuning Unit)

The **ZM-2** ATU is unique in that it does not need a tapped coil to accomplish an antenna match. Basically, a Z Match tunes 2 frequency ranges 3.5 to 11mhz, and 12 to 30 mhz at the same time. This is approximate for this version, but it will be able to match most antennas in this range to a 1 to 1 SWR. Many believe the Z Match is far superior to the popular "T" match tuner, and claim a higher call to contact ratio!

An excellent article on how and why the Z Match works is in the "HF ANTENNA HANDBOOK" by Bill Orr W6SAI. Also, an excellent article on a Z Match is in the July 1995 issue of QRP Quarterly by Charlie Lofgren W6JJZ.

The ZM-2 may just be the best ATU you have ever used because of its simplicity and ease of tuning. Remember though it is rated at only **15 watts maximum**.

The ZM-2 does not require an external SWR meter. The built-in SWR visual indicator was designed by N7VE with modifications by WGJJZ and W7LS. It is incorporated in the ZM-2 by special permission of N7VE. It appears to make tuning even faster than normal. SW3 switches the indicator out of the circuit after tuning, because there is a power loss from the resistors. You will note from listening to signals with the SWR indicator in the circuit, the signals will be a little weaker.

PARTS LIST

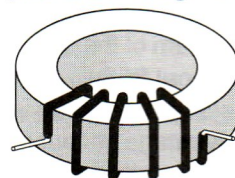
Wire-

- | | |
|----------------------------------|---|
| 15" Green single conductor | () 1 - 1N4148 diode |
| 45" Red | () 1 - Radio-Shack box P/N 270-233 |
| 55" Black | () 2 - Knobs |
| 25" 28 gauge wire | () 1 - Red Terminal Jack |
| () 1 - T130-2 Toroid core | () 1 - Black Terminal Jack |
| () 1 - FT37-43 Toroid core | () 1 - DPDT on-on switch SW3 |
| () 6 - 100 ohm 2 watt resistors | () 1 - DPDT on-off-on switch SW1 |
| () 1 - 1k ohm resistor | () 1 - SPST switch SW2 |
| () 1 - Clear Red LED | () 1 - 500pF capacitor |
| () 2 - Coax or BNC Connectors | () 2 - Dual section 266pF Poly-Variable Capacitors with hardware |
| () 1 - Rubber Grommet | |

Building The ZM-2

Let's start by winding the toroid T1 and getting it out of the way. If you have wound toroids before, sometimes they can be a problem, but this one is easy. Per the drawings, we will need to wind a total of 27 turns plus a 7 turn link onto the T-130 toroid This is easy to do on the ZM-2 toroid. **A turn is counted each time the wire passes through the core center.**

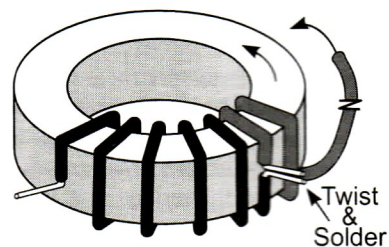
Note the drawing on stripping the insulation. This should make winding the toroid and making the tap connections easy. Simply squeeze the wire Insulation with the flat area of needle nosed pliers hard enough to cut through the insulation. Then trim off the insulation ends.



STEP 1 Select the 15" length of Green wire, and strip away about 1" of insulation from one end. We will start winding the center section first by forming the wire as shown in the cross section drawing. NOTE, winding clockwise or counterclockwise makes no difference but which ever way you chose to use, keep the same

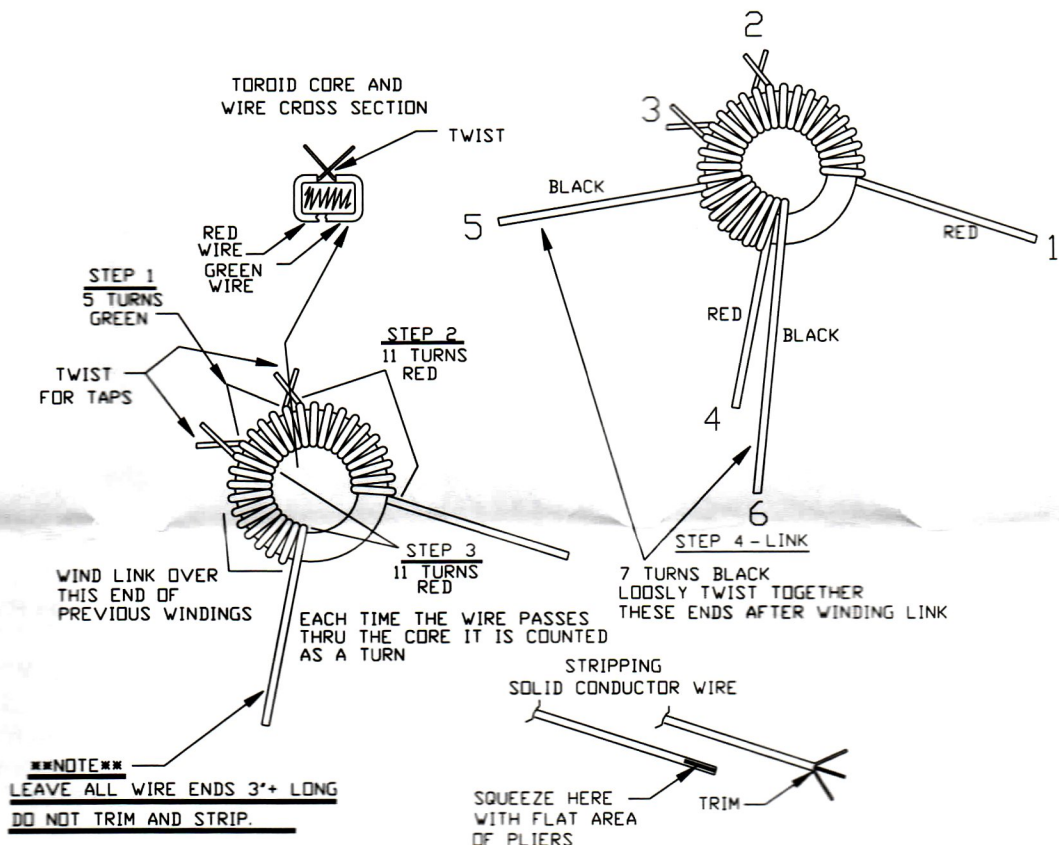
direction on the whole toroid. Wind 5 turns and end it as shown in the cross section drawing by forming around the toroid core and trimming and stripping as shown.

STEP 2 Cut a 19½" length of Red wire and prepare one end as you did for start of Green wire as above. Form on core as shown on cross section drawing. Twist together with the Green wire and wind 11 turns in same direction as if it were a continuation of the green wire. Again wind snug on the core. Leave the end long, 3" or more, do not strip at this time.



STEP 3 Repeat the above process as in STEP 2 with another 19½" length Red wire connecting to the other end of the Green wire. You now have a toroid wound with the necessary taps. Note that it is symmetrical in the windings. 11 turns, 5 turns and 11 turns with long wire ends

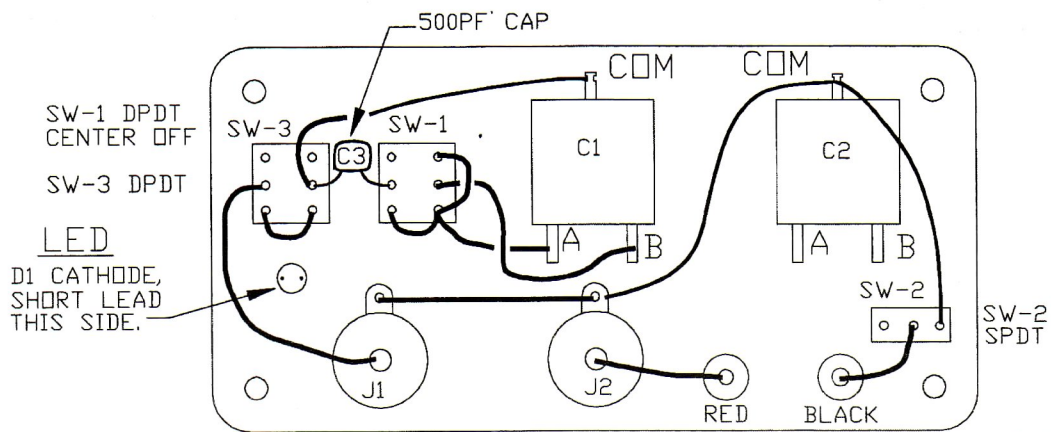
STEP 4 Cut a 20" length of Black wire. With 3 to 4 inches of free wire, hold it alongside of one of the Red wires (either end is OK) and start winding over the existing Red winding going backwards this time, but following the red wire as if the Red and Black wires are in parallel wind 7 turns. Keep the turns snug against the Red winding, note that on the inside of the core, the Black wire will lay on top of the Red wires, and on the core outside, the Black wire will tend to lay between the Red wires. Bring the Black ends together and twist lightly together. This will



hold the link winding in place. Set T1 aside for now.

STEP 5 Wind the SWR indicator toroid core. Prepare the #28 gage wire as shown below the schematic This is a heat stripable type of wire, so no need to scrape off the varnish, just heat and tin with your soldering iron. Hold the tap wire at point XX on the T2 core as shown and wind the 5 turns. Then finish winding the 20 turns on the other side of the tap. Leave the wire ends long for routing for now.

Note the modified Poly Capacitors. The modification consisted of adding a tuning shaft for a knob, and trimming off the unused connections. The poly cap is somewhat fragile. If you force it against it's built-in stop, it will become a little rough to the feel. What has happened is that a few of the rotor plates have become wrinkled and will short during use. With normal use though you will find that the capacitor will remain smooth feeling. Note from the diagram of the cap that there are 2 connections marked "A" and "B". These are the 2 sections of the capacitor, each is about 266pF. The connection along the side by itself is the common connection. The 2 small metric mounting screws provide an insulated mounting, there is no internal connection to any other part of the capacitor. This is an advantage because the Z Match input capacitor is not grounded and needs to be floating. **Make sure to use both of the supplied washers on each screw when mounting the Poly Capacitors - this will keep the screws from damaging the rotor plates.**



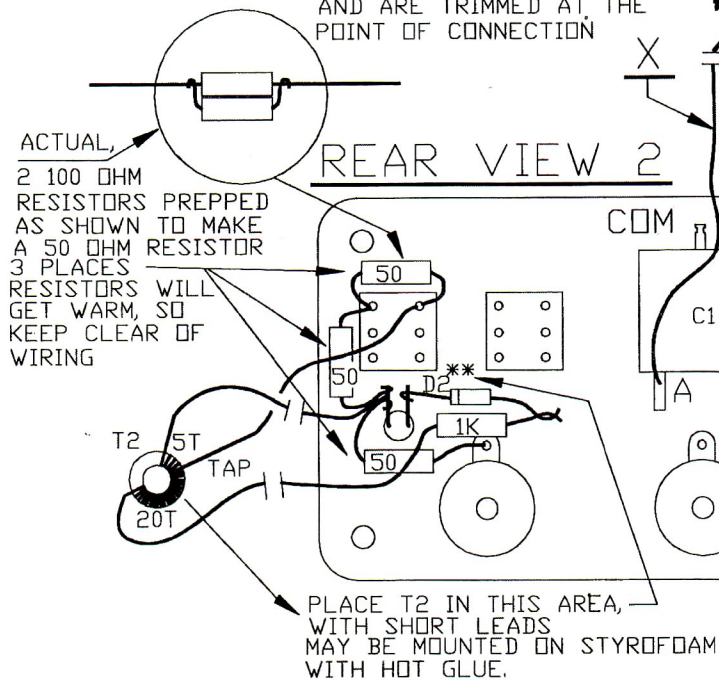
REAR VIEW 1

NOTE**WIRES SHOWN ABOVE
ARE INSULATED WIRES STRIPPED
AT BOTH ENDS

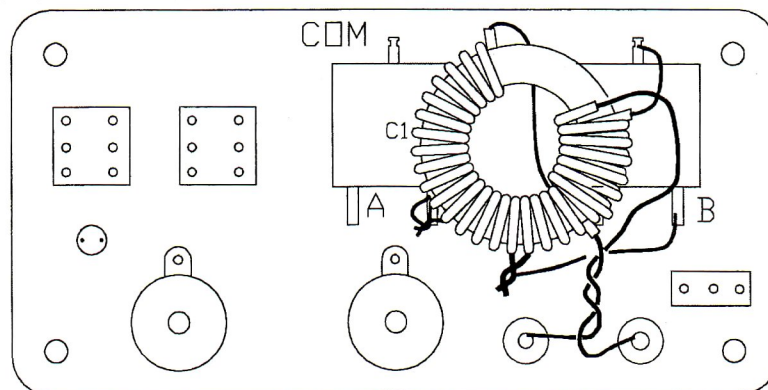
T1 WIRES EXCEPT FOR TAPS
2 & 3 ARE THE EXTRA LONG
WIRES FROM WINDING T1
AND ARE TRIMMED AT THE
POINT OF CONNECTION

THIS IS ACTUALLY A
CONTINUATION OF
THIS WIRE TO THE POINT
OF CONNECTION
THEN STRIPPED

BE SURE TO TWIST
SEVERAL TIMES



REAR VIEW 3



Attaching the Decal And Mounting Parts Attach the decal to the panel, carefully positioning over the holes. Wetting the panel slightly may help. The only critical positioning would be the tuning caps so the dial marks are aligned. Mount the parts to the panel as shown, **tightening from the panel rear when possible. This will keep the decal from twisting or tearing.** The DPDT center off switch SW1 is mounted near capacitor C1. The other DPDT switch SW3 is mounted next to SW1. The red antenna terminal is mounted next to the coax connector J2, then the black terminal next to the SPST "LINK" switch. The terminals will take the popular banana jacks and the 3/4" spacing allows the use of a "Double Bodied" banana jack such as the Radio Shack P/N 274-717 on your open wire or TV twin lead feedline. Secure the LED in place using hot glue or epoxy, or the rubber grommet. **Make sure to use both of the supplied washers on each screw when mounting the Poly Capacitors - this will keep the screws from damaging the rotor plates.**

Wiring The ZM-2 There's nothing critical about wiring the ZM-2 other than keeping the connections short, and avoid any shorts. Keep wires clear of the resistors because they may get very warm during tuning. From the pictorial, "Rear View 1", you should find it easy to follow the connections. Use the excess Black wire for all the connections as shown. No certain order is required for the connections. Marking each wire on the pictorial with a Hi-Liter as connected will assure no wire is missed. Prepare the 100 ohm 2 watt resistors as shown on the pictorial to make three 50 ohm 4 watt resistors. They will take higher power than 4 watts for a short time, but will get very warm. The tuning usually goes so fast that this is a minor problem.

T1 and T2 connections. For clarity, the previous connections from Rear View 1 are not shown in Rear View 2. Connect T2 and SWR components as shown. T2 may be mounted on scrap styro-foam using hot glue to secure in place. Route the resistor leads so that the resistors are clear of other components. T1, keep the toroid leads short, as an example, the wire marked "X" is only 1" long. The toroid wire connections are shown long only for clarity. Keep the Black link wires loosely twisted together to the point of connection on the terminals. The toroid is not mounted, but supported by the connections. If you expect to be backpacking, it may be a good idea to fill the extra space in the box with packing foam. This should not cause any problems since there are no moving parts in the box.

The ZM-2 may be mounted in an enclosure of your choice. Just be sure to keep the wiring as short as possible, and if the new enclosure is deeper from front to back, extending the twisted link wires to rear panel connectors has been successful.

The link is not tolerable of a connection to one side only. You cannot leave the link floating on one side. An antenna needs a reflector whether it is the rest of the radio and wiring or a ground connection or ground plane. That is why the link switch is used. You may connect a ground plane wire, a ground connection, or another antenna wire like in a "V" antenna.

The ZM-2 allows experimenting with antennas. There may be times that you cannot put up a measured to length antenna. Using the ZM-2, you can throw a line up into a tree, run a long wire of unknown length, connect a vertical wire, and know the ZM-2 will tune it. Of course the ground plane makes it all work better. Remember the ground plane is a part of the antenna. Consider it an antenna system. It all works together. The ZM-2 tunes the antenna and the ground or reflector as a part of the overall system. If you change the ground wire length it is the same as changing the antenna length. Also keep in mind that even though the SWR may be zero, (LED out) the antenna may not be a good radiator.

After using the ZM-2 for a while, you'll note that no matter what kind of antenna you have, the ZM-2 dial pointers will usually tune at about the same part of the dial for each band. A faster way of tuning is to first peak on noise, key the transmitter and adjust C2 for a dimming of the LED. While adjusting C2 back and forth across the dimming point, adjust C1 for a further dimming of the LED. Takes two hands but goes very fast. This is an easy way to find the tuning points for C1 and C2.

Sometimes the LED will light when keying the radio even when switched out of the circuit. This is normal and is from stray RF pick-up. A quick check of the schematic will show that the circuit is not connected to the tuner when in the operate position.

ZM-2 CONSTRUCTION HINTS!

Note that the outline of the front panel label and the actual aluminum panel is larger. This is so that when the label is affixed, the outline line will not show. Using a backlight, align the panel so that there is about 1/16" clearance all around the aluminum panel from the label outline. Be sure that the "12" on the far right side of the label is on the panel. Peel away part of the label backing to expose the sticky backing, and carefully apply to the panel, **DO NOT PERMANENTLY PRESS IN PLACE AT THIS TIME!** Just lightly stick in a few places and recheck the alignment. You can remove and realign if necessary. When it all looks good, press in place, remove the rest of the protective backing and press it in place too.

Trimming with a sharp knife works good, but better is to use a fine grain sandpaper like 150 grit to sand at an angle around the label against the aluminum to trim the excess label. If you have a "Smooth" file you can use it to trim the edges.

Apply several coats of clear lacquer spray to protect the label from dirt with general use. When it is completely dry, mark the holes with a center punch to prepare for drilling or punching. Some have used a clear contact material that does a good job too.

WIRING HINTS: Using wire with the insulation removed for the ground connections from the coax connectors to C2 common, to SW2, and from the black jack to SW2, and from the red jack to the coax connector. And it is much easier to wire the short jumpers on SW1, and SW3 using wire without insulation. Just be careful in routing to avoid shorts. Leave the insulation on for the remaining wiring.

The main inductor T1 is laid horizontally on top of the tuning caps held in place with its wiring.

Several customers have designed their own cabinets for the ZM-2 or modified the one supplied as shown on the web page of the Colorado QRP Club at <http://www.mtechnologies.com/cqc/gallery>. Use your imagination! Your feedback is welcome! We have posted detailed photographs on our web site at <http://emtech.steadynet.com>. These photographs may help you in assembling the kit.

Using the ZM-2

****NOTE**, only 1 antenna may be connected at a time. Connect a short coax from your radio to the coax connector J1. If you are using 450 ohm ladder line, 300 window line, or 300 ohm TV line, connect to the **"BAL ANTENNA"** terminals. Be sure to remove any balun in the line. It is not only unnecessary because the ZM-2 is a balanced tuner, but **the balun will cause some losses, and tuning problems**. If you are using a Long-wire, connect to the RED terminal, and a ground wire or ground plane to the BLACK terminal. If you are using the ZM-2 to tune the mismatch from a coax fed antenna, **Disconnect any other antenna from the "BAL ANTENNA" terminals**. Switch the link switch to the "GND" position, and connect the coax from the antenna to the "Antenna" connector on the ZM-2. If you have ever used an antenna tuner, the Z Match is different in that there is no inductance to switch and it is faster, easier, and there are only 2 tuning controls. Switch S1 selects additional parallel input capacity of 250pF (actually 266pF) or 250pF and 500pF in parallel. This may be required for 80 meters with a short antenna, but probably not often used on other bands. Another difference is that it tunes very, very sharp, so sharp in fact that it is easy to miss the resonance point. A good way is to first tune for maximum receiver noise. With SW3 in the TUNE position, tune for lowest SWR, indicated by the LED going OUT! Noting that the controls interact, go back and forth between the two controls. **NOTE, do not stay in the tune position too long as the resistors will get very hot with transmitter keyed.** It is normal for the Z Match to tune an antenna system to zero reflected power where a previous tuner would not do the job. You can throw a wire up in a tree and tune it with a conventional tuner. Eventually you'll get a match. With the ZM-2, it happens so fast you won't want to believe it at first. The end result, less time spent tuning the antenna system, more time spent making contacts, will leave no doubt that it not only works, but does an excellent job.



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