Modifying the MFJ989C Versatuner-V

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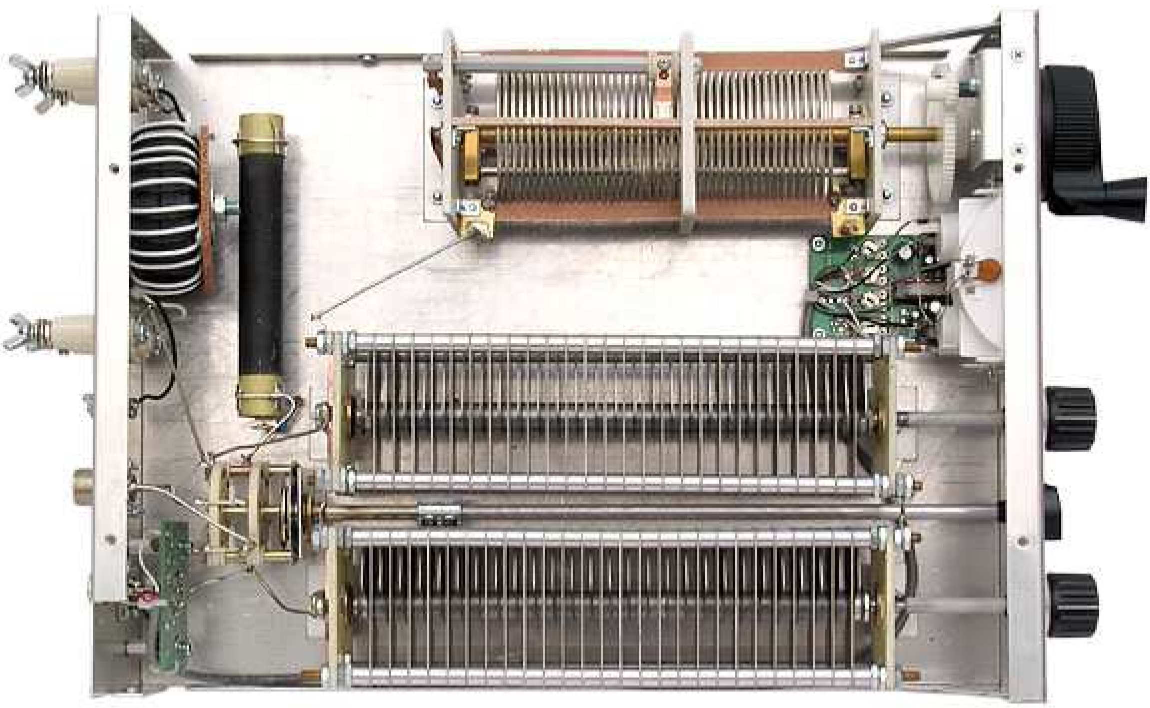
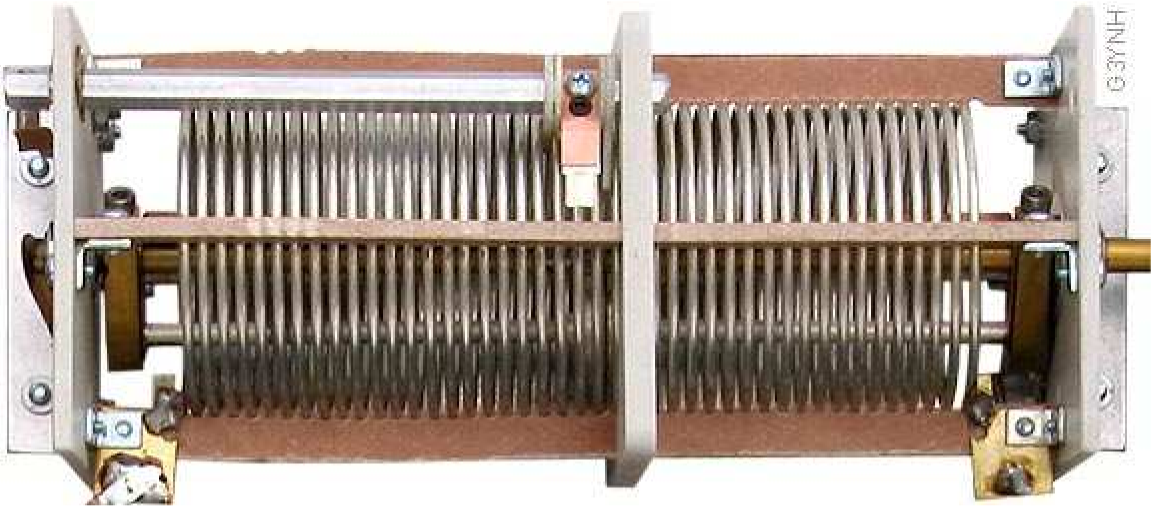
Abstract:
A CLC T-network provides a wide impedance matching range, but is less efficient than an L-network. Provision of capacitor shorting switches allows the T-network to be converted into one of the two L-parallel, C-series L-networks if circumstances permit. Shorting switch modifications carried out on an MFJ989C Versatuner V (**www.mfjenterprises.com**) are described.

MFJ989C description:

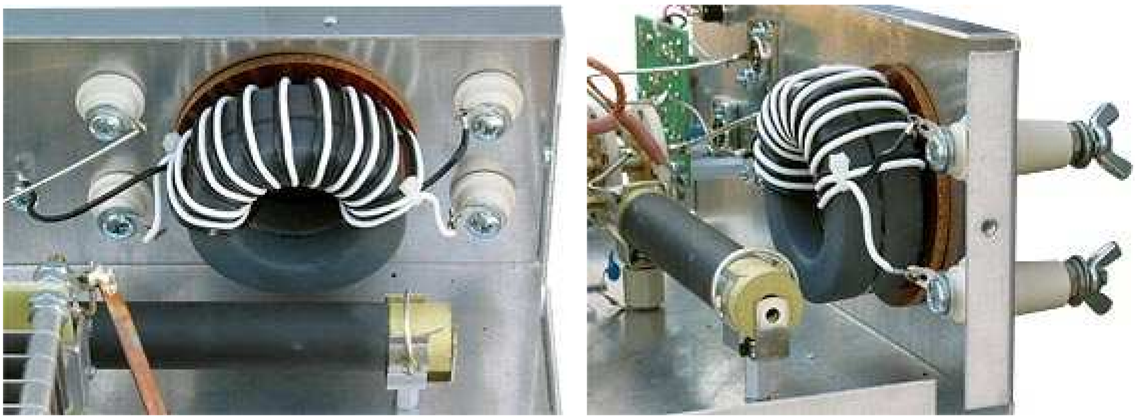
The MFJ989C is a basic T-network antenna matching unit nominally rated for 1.5KW PEP throughput when used with antennas of ≥λ/2 in length. It offers an extremely wide matching range and may be used with electrically short antennas if suitably de-rated. Chassis dimensions are 377 × 275 × 102mm (excluding cover).



The two air-capacitors are variable from 24-240pF, and are rated 6KV RMS. The roller inductor is air-cored and has a nominal maximum inductance of 30µH (neglecting self-capacitance). The unused turns of the coil are shorted to ground, and an additional shorting contact is applied when less than half of the coil is in use (MFJ "Self-Resonance Killer™"). The output-side balun consists of 12 turns of multi-strand silver-plated PTFE covered wire wound on two stacked Amidon FT-240-K cores (A_L, per core, is 4.9µH/turn^2. Total common-mode inductance = 1.4mH). A 50Ω dummy load resistor (next to the balun) is provided so that a linear-amplifier pi-tank can be set-up prior to connection to the antenna matching network.



MFJ variable inductor (30µH). Self-resonance killer contact is top centre, with fibreglass actuator cams passing between the turns of the coil.

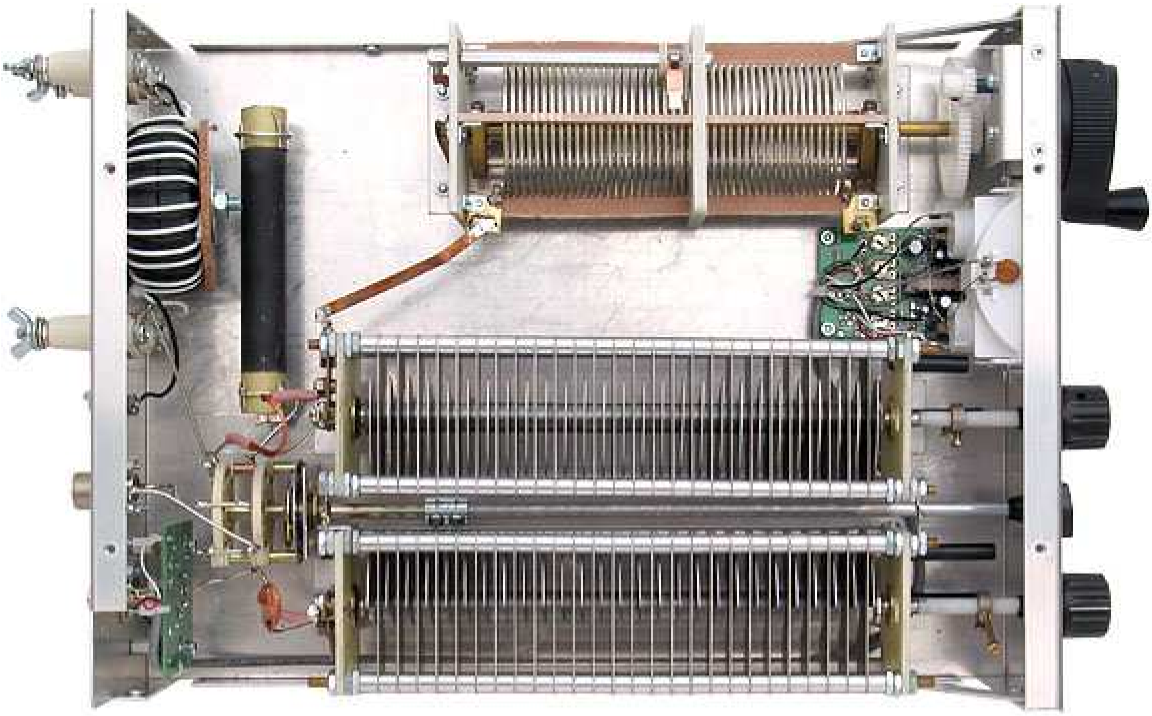


Balun transformer and dummy load resistor.

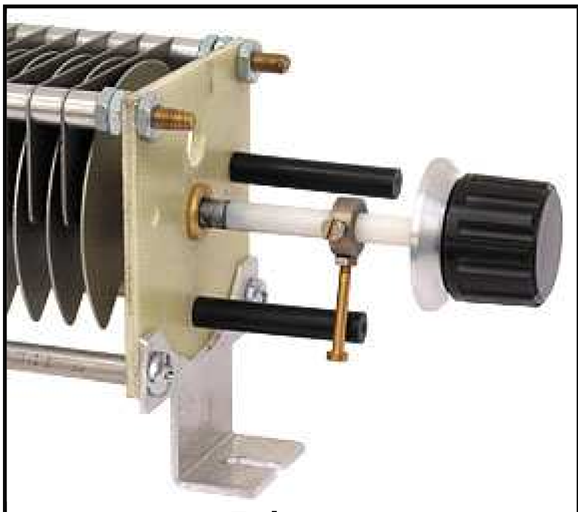
Modifications:
An L network is more efficient than the T-network but has a reduced matching range for given coil and capacitor values. A T-match antenna tuner can be modified to allow its use in one of the two possible C-series, L-parallel, L network configurations by the addition of capacitor shorting switches [**15**][**16**]. This type of modification is particularly easy to implement in cases where the variable capacitors allow 360° of rotation, but only 180° is required, because the shorting switches can be arranged to operate when the capacitor adjustment knobs are rotated to an unused part of the dial. This article relates to the MFJ989C, but the information given may prove useful to those interested in modifying other models.

If the subject of capacitor shorting switches is raised in the company of other radio operators, someone will inevitably offer the helpful advice that: "all you have to do is bend the corner of one of the plates". This however, is exactly how not to do it, as a simple analysis of the problem will show: Firstly, damaging the capacitor plates will encourage field-emission breakdown; and secondly, two pieces of aluminium scraping together is not generally recognised as the basis for a high-current switching system. The MFJ989C is rated for 1.5KW PEP throughput [29], and provides the transmitter with a 50Ω load. Hence, using Joule's law ($P=|\mathbf{I}|^2R$), we may determine that the transmitter-side shorting contact should be rated for at least $|\mathbf{I}|=\sqrt{(P/R)}=5.5A$; and even if we accept that the tuner must be derated when used with electrically short antennas, we should still rate the antenna-side shorting contact for a minimum load impedance of about 10Ω, i.e., $|\mathbf{I}|=\sqrt{(1500/10)}=12.2A$. Thus, presuming that the modification is to be carried out using salvaged parts, we should be looking to recycle old switchgear with high-conductivity contacts rated for at least 20A.

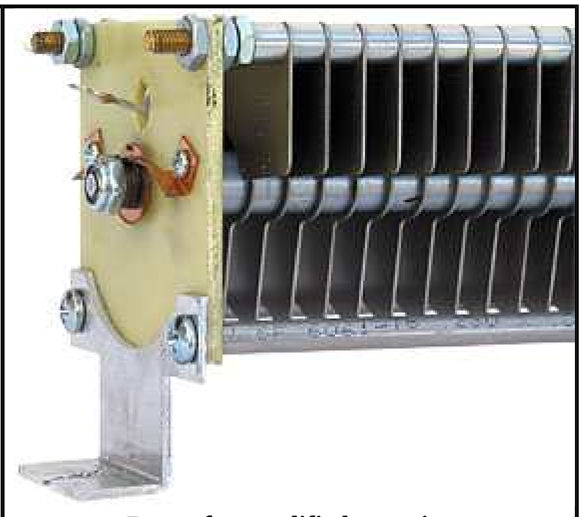
The photograph below gives an overview of the modified MFJ989C.



Shorting switches have been fitted to the rear ends of the capacitors, the object of the exercise being to short directly across the capacitor connections. It would have been easier to fit the switch at the front of the capacitor in each case, but that would have resulted in an unnecessary current path of just over twice the length of the capacitor. The fronts of the capacitors have instead been fitted with end-stops, which restrict rotaton to about 240°. The anti-clockwise end-stop gives a positive registration for the point at which the shorting switch is closed (about 55° past maximum capacitance); and the clockwise end-stop restricts rotation to about 5° past minimum capacitance, thereby preventing the switch rotor from interfering with the connection to the capacitor rotor. The provision of end-stops also allows an additional capacitor rotor connection to be made by means of a flexible copper braid (a direct rotor connection, bypassing the existing wiping contact, generally reduces the ESR of an air-variable capacitor by about a factor of two). The end-stop arrangement is shown below left. Lateral disturbance of the long screw on meeting the stop pillars gave it a tendency to become loose, and so a lock-nut was added and a single drop of shellac varnish (button polish) was applied to the screw threads prior to final adjustment. The right-most pillar on the antenna-side capacitor had to be shortened prior to final assembly, to avoid interference with the power meter, and the collar was moved back accordingly (see overview photograph above).



End stops

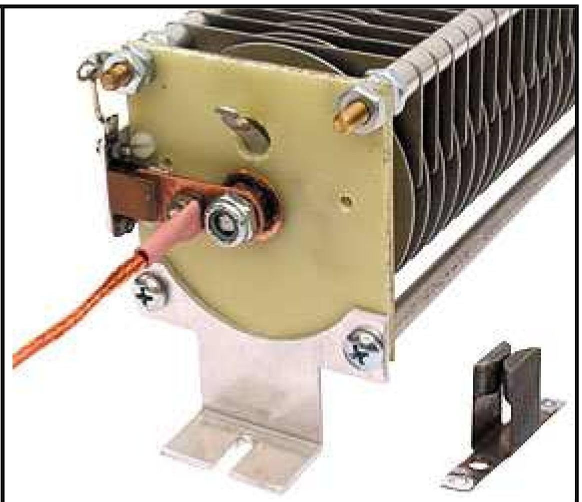


Rear of unmodified capacitor

The rear of an unmodified capacitor is shown above right. Notice that a copper leaf-spring is fitted to apply side-thrust to the rotor bearing. The purpose of this spring is not immediately obvious, especially since no electrical connection is made to it; but since the rotor connection is made via the rear bearing (and its grease), it may be that that the sideways force reduces the capacitor ESR and prevents overheating of the bearing. The rotor connection system is, in any case, non-optimal; and for the modification, the leaf spring is removed to make way for the switch mechanism, and the bearing contact is bypassed by a copper braid attached directly to the rotor.

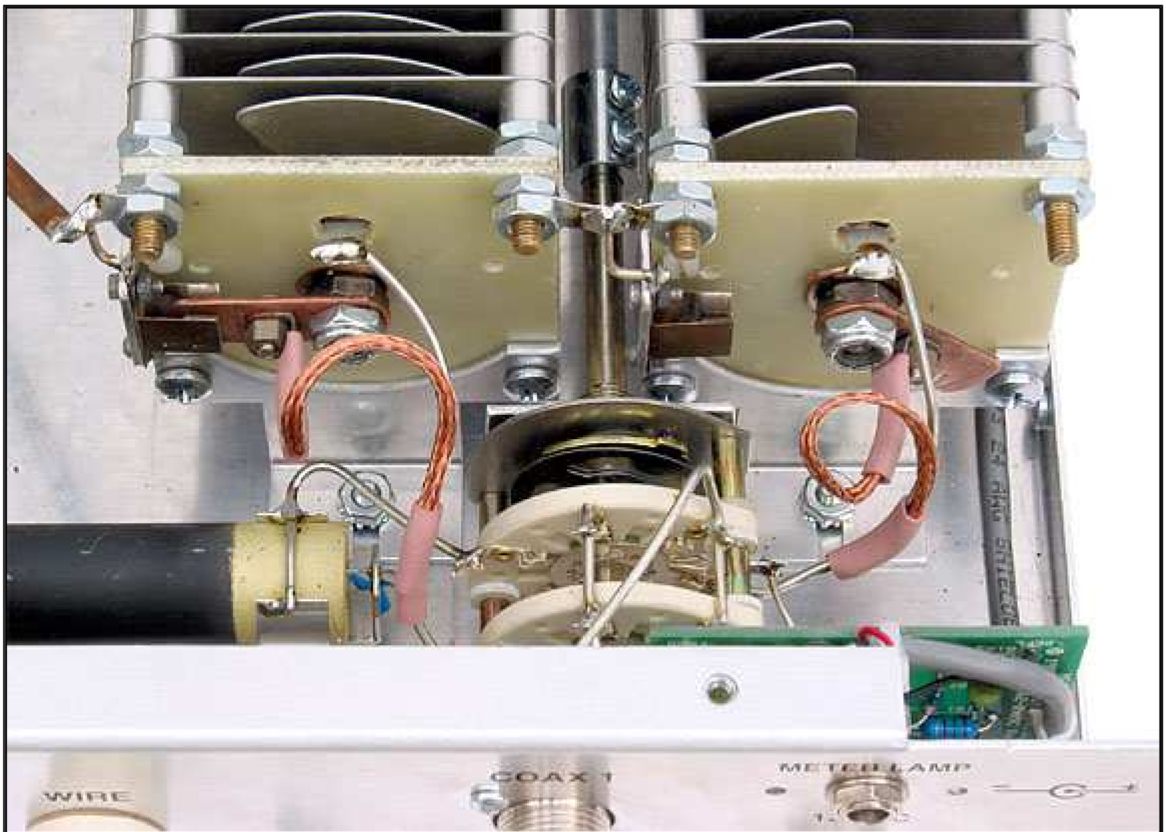
Two views of a capacitor after modification are shown below. The switch rotor is made from a strip of opper about 1.2mm thick, and the stator is a knife-switch contact salvaged from an old transmitter band-changer turret. Other contacts can be salvaged from old circuit-breakers and heavy-duty switchgear, and the mechanical arrangement must obviously depend on the type.

Max. capacitance setting.



Shorted. (Contact shown inset).

In order to fit the switch rotor; the original ¼" UNC stiff-nut (nut with nylon insert) at the back of the capacitor and the slip-collar for the side-thrust spring are removed, the front and rear bearing thrust surfaces are coated with molybdenum-disulphide grease, and a ¼" UNC thin-nut is threaded onto the shaft to restore the rotor-blades of the capacitor to their mid-position. The switch rotor is then locked between the thin-nut and the stiff-nut; the whole assembly being adjusted to gap the capacitor correctly and set the switch rotor to engage with its stator contact when the capacitor is at the anti-clockwise end-stop. The two nuts must be locked together reasonably tightly; and to avoid stressing the end-stops, a thin spanner (wrench) should be used to hold the thin-nut while tightening the outer nut. Since the capacitor main-shaft is aluminium, there is a danger of thread-stripping if excessive force is used. The switch stator contact is mounted on a small aluminium bracket, which is attached to the capacitor back-plate by means of nylon M3 screws and nuts. Electrical connection to the capacitor-rotor is effected by fitting a solder-tag on to the switch-rotor; a Neoprene (Hellerman) sleeve being fitted over the point where the braid is soldered to the tag, in order to provide strain relief. Final assembly is shown below, the original electrical connection to the back bearing being re-made, and the braid being soldered to the connecting wire (joint covered by Neoprene sleeve) in such a way as to allow a short loop which can coil and uncoil as the capacitor is rotated.



Capacitors after re-installation.