A Homebrew Antenna Tuning Unit – Steven VK2STG

Recently I was given a present. A big one. With lots of wires in it. And knobs. And a neon bulb!

Sounds exciting? So, it is… in a way. It's an ATU, antenna tuning unit, aka coupler, matchbox, or whatever your preferred term is for an impedance matching unit. It was given to me by Graham, VK2DIG, on the condition that I work out how it works. This article describes my findings.

First impressions… it's homebrew, made evident by hand written labels on the front panel, but well built. On the front panel, the controls consist of two Vernier-type knobs and a rotary switch selecting between 160m, 15/20m, 40m, 80m, 10m DIP, 20m QUAD and 10m/15m QUAD. The original constructor obviously had a good antenna system!

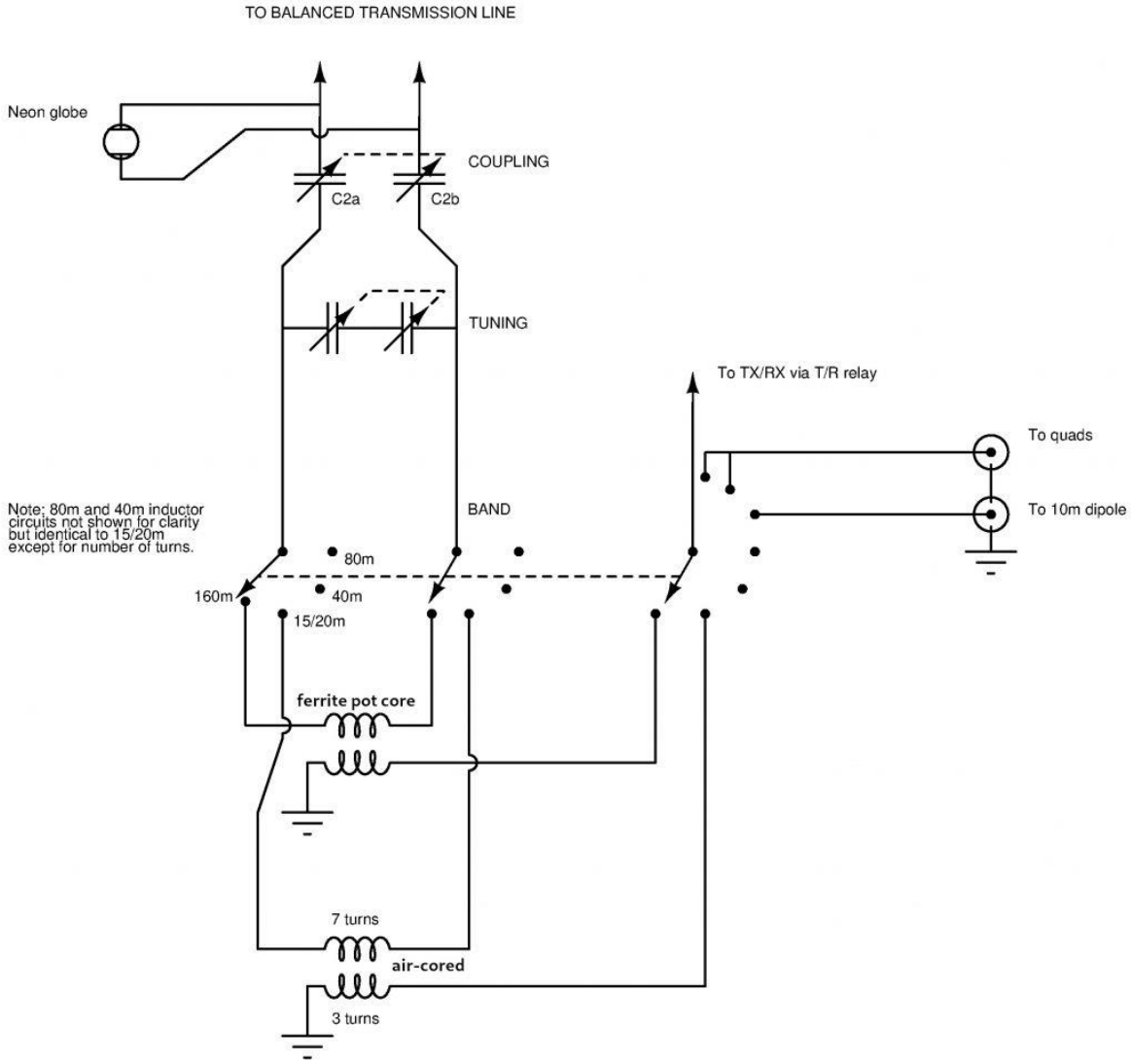
Inside, a mass of wires, variable capacitors, inductors, a large four-ganged switch and several unidentified components are obvious but, to my initial surprise, no tapped or roller inductor. Generally, when "ATU" is mentioned, I tend to think of the typical T-match circuit, as used in many MFJ tuners, but this is not one of those.

It was somewhat dusty, after its long storage, but in mostly sound condition and I think most parts were probably recycled from other equipment. After a clean-up, I settled down to work out the circuit configuration.

The unit turns out to be more or less a classic balanced link-coupled design, a parallel resonant, or tuned, a circuit consisting of a variable capacitor (C1) and a primary inductor, inductively coupled to a smaller secondary inductor, (the "link") which forms the 50 Ω feed to the transceiver. In this example the antenna feed line (balanced open-wire or ladder line, probably connected to a dipole or loop) is coupled to the resonant tuned circuit by a pair of mechanically linked variable capacitors (C2) in series with each side of the feed line.

I won't attempt to properly explain the actual working of this type of impedance matching circuit, but basically the coupled inductors form a transformer to convert the low, 50 Ω input impedance to the high impedance of the parallel tuned circuit, which is tuned to resonance on the frequency in use using C1. This is then coupled to the high impedance transmission line output by C2.

It's probably easier to understand on the circuit diagram below.



For anyone interested in link-coupled tuners, this website: http://www.antentop.org/w4rnl.001/link0.html has a very detailed set of articles by well-known amateur radio L.B. Cebik, W4RNL.

C2 has a specific position marked on the dial for 160m – closer examination showed that at this position the two sets of plates are shorted out by a pair of bent plates, so the transmission line is connected directly to the tuned circuit, bypassing C2. The inductor pair for 160m is in an enclosed ferrite pot core – whereas all the others are air-cored.

The first four switch positions (see above) switch between 4 pairs of primary/secondary inductors using 3 of the 4 stacked rotary switches. Two connect the selected primary inductor into the tuned circuit while the third connects the un-grounded side of the selected link inductor to the transceiver but not directly.

This ATU must have been built for use with a separate receiver/transmitter, as there's a fairly massive relay to switch the ATU's 50 Ω input between an "RX" connector on the rear panel, and either of two transmitter inputs on the front panel, the latter selected with a small rotary switch adjacent to the SO239 sockets. The relay is in the RX position at rest, with the relay coils connected to a valve-type socket on the rear panel. While in the RX position the TX input is grounded. Applying 12VDC switches the relay to TX with a smooth click.

The latter three switch positions completely bypass the ATU circuitry and connect the TX/RX via the T/R relay to one of two more SO239s on the rear of the unit for the 10m dipole and the quads.

Hang on, 3 switch positions, 2 connectors? Why?

What happens here is that the final position on the switch connects to the same SO239 as the previous position, but switches DC power (using the fourth rotary switch) to another valve socket labelled “QUAD RELAY” on the rear, evidently to switch a remote antenna switch, so that two antennas could “share” a run of coax.

On the front panel is what looks (at first) like a normal light bulb, labelled TUNE INDICATOR. This is actually a very large neon globe, connected across the balanced feed output. This should light up with RF voltage, giving a simple means of tuning for maximum output, although I’d expect it to vary between bands, due to the standing waves on the feed line in most conditions.

The wiring is all done point-to-point, with; it seems to me, more attention paid to neatness than to good RF practice. But, it probably causes little extra loss on HF frequencies, and any added reactance will simply be tuned out in use – except for the wiring to the bypass connectors.

No coax is used inside the unit.

The last bit to mention is a small variable capacitor, controlled from the rear, “CRO COUPLING” and a connector next to the RX connector, “CRO”. This is connected, via the capacitor, to the TX input to give a lower level output for connection to an oscilloscope, for monitoring the transmitter’s waveform, probably a good idea especially with the classic valve equipment I suspect this unit was used with.

That just about covers it. I’ve roughly drawn out the circuit diagram, but have omitted the T/R switching and oscilloscope monitoring circuit, also the inductors for 40m and 80m are left out to make it easier to follow – and to draw!

The connectors for the receiver and CRO are an unusual design – I don’t know what they’re called. Please refer to the images below for reference.

It would be interesting to know what radios this tuner was used with – presumably a separate transmitter and receiver, as the switching is incorporated. Graham tells me he bought it from VK2IH, but he (Graham) has another homebrew unit that came with it, labeled VK2TK, so maybe VK2IH bought it from VK2TK.

Both may be silent keys now, but if anyone knows, or knew, either of them I’d be interested in any history to this unit.

Finally, does it work?

One of the variable capacitors had some loose plates, but this was cured very easily, as the problem was nothing more than a loose nut.

I have a 160m dipole at about 15-20 m above ground, fed with a homemade 500 Ω ladder line, so I hooked it up to the output, and an Icom transceiver to the TX input. I lightly wedged the relay contacts in the transmit position, as I’m not using a separate receiver.

It works! Mostly anyway… the contacts on the relay were tarnished, and not reliably making contact, but a moment of work with some fine sandpaper did the trick.

I tried 40m first, initially tuning for maximum signals on receive, then transmitting at low power to check the SWR, and had no trouble at all getting a 1:1 SWR. The Tune Indicator lights up nicely at around 50W or less, and the peak in brightness coincided with low SWR at the rig. Judging by the signal strength on receive it was operating efficiently as well.

Next, I tried 80m. This needed a little more fiddling to get a good match, but it worked fine.

However, on the remaining bands, 160, 20, and 15 metres I was not able to get a match to my antenna. I’m not really surprised! It was always unlikely that my antenna and feedline would match that of VK2TK, or whoever used and constructed this unit. This type of tuner is often built for a specific antenna and can need the number of turns on the inductors changing to use with a different antenna so probably a little experimentation with different inductors would do the trick.

The capacitor plates are widely spaced, and the rotary switch has ceramic insulators with wide spacing between the contacts, so I think this tuner would probably handle a kilowatt or so. (Not tested!)

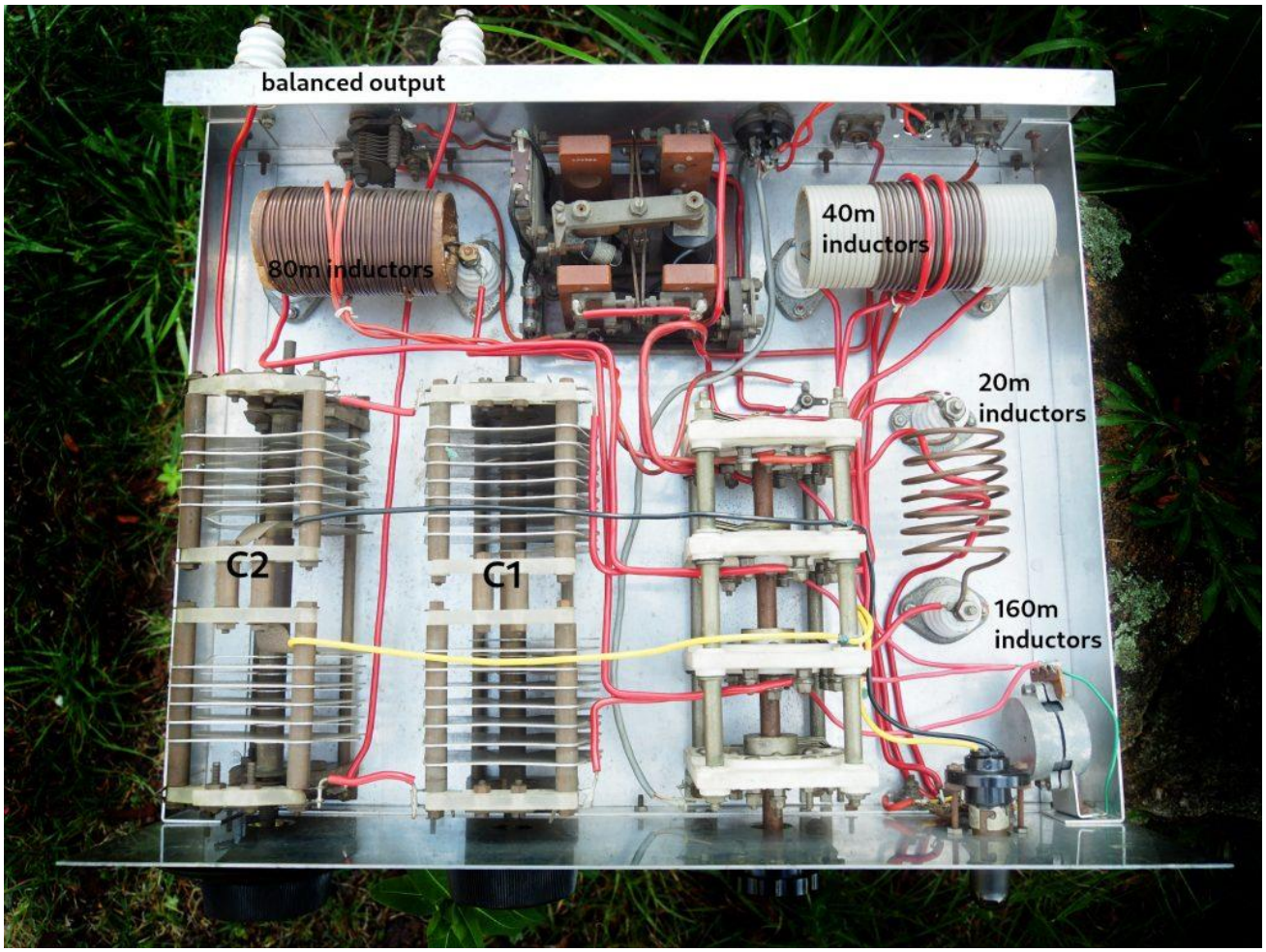
In summary, this unit is in the best traditions of homebrew amateur radio equipment, and with a little work will be perfectly usable with modern equipment as well.

Thanks Graham!

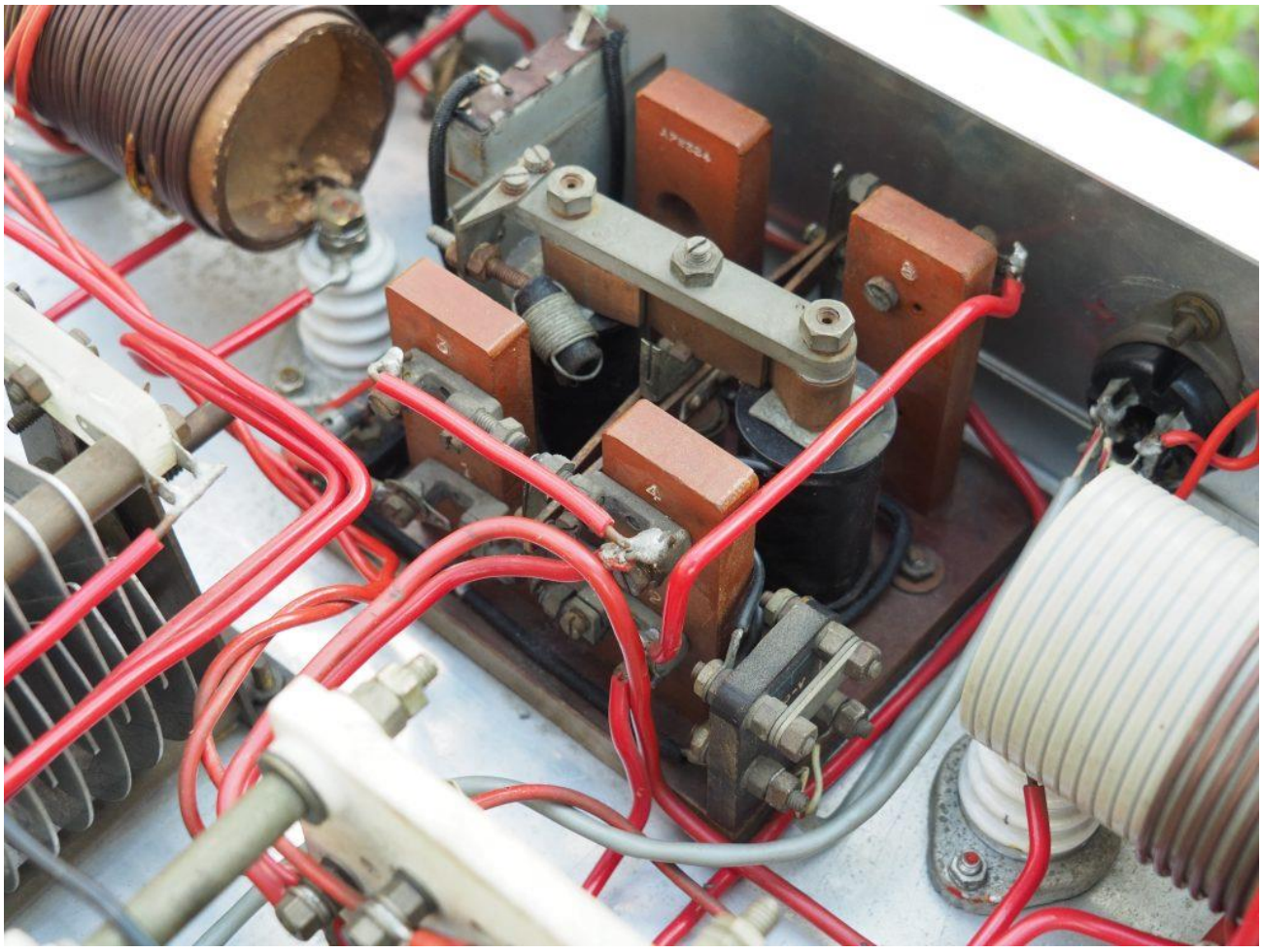
73, Steven VK2STG

Front View

Rear View



Top Overview



Relay

Rear Connections

Tuning Lamp