Antenna Tuning Units Inside and Out!

Graham Ridgeway M5AAV takes a look at a basic antenna tuning unit suitable for the novice constructor. First he looks at the 'whys and wherefores' before presenting a simple, practical project.

My article is aimed at helping the novice antenna or inexperienced constructor to understand some of the reasons for having and using an antenna tuning unit (a.t.u.). I'll also provide details of an a.t.u. that's simple to construct, won't drain your resources and more importantly - will work! It will also perhaps give you some ideas for future experimentation.

The reason for having an a.t.u., as most of us know, is to match the nominal 50Ω output impedance of the transmitter to whatever impedance the antenna shows. This is of course assuming that the design impedance of the antenna is something other than 50Ω.

The 'Other than 50Ω' category includes not only short and long wires, but also dipoles and G5RV designs, all of which need some form of a.t.u. to allow proper operation. With a single wire type of antenna, the impedance varies not only as a function of element length and frequency in use, there's something else which also needs to be taken into account. That 'something else' is the efficiency of the radio frequency (r.f.) 'earth'. This impedance can range from below 10Ω to well in excess of 2kΩ.

Ignoring The Hype

Ignoring all the 'hype', at the end of the day a.t.u.s fall into one of three categories namely; The Pi, or 'Collins' match, the 'L', or the 'T'. The names given are derived from their configuration (more on this later).

Any of the a.t.u.s I've just mentioned are quite easy to construct. The circuits, **Figs. 1, 2** and **3,** are shown in order for comparison.

The Pi Match, Fig. 1, is normally considered to be the 'standard' format for an a.t.u. It will usually match most random lengths of wire to 50Ω.

In use the Pi Match also has the advantage that it tends (when tuned correctly) to suppress any harmonics that may be present in the transmitter output. Indeed it's still found in many transmitter output circuits.

The L match, Fig. 2, is usually more suited to the shorter lengths of wire. It can be used in a fixed configuration at the base of (for example) a short vertical antenna for single band use.

The T match, Fig. 3, will again match most random wires. However, it seems to be happier when given a reasonable length to 'play' with.

So, now I've listed some basic ideas, the natural question you'll raise is "What type to use"? No doubt you'll be wondering, now that you're faced with three basic choices of a.t.u. and ask "which is the one for me?".

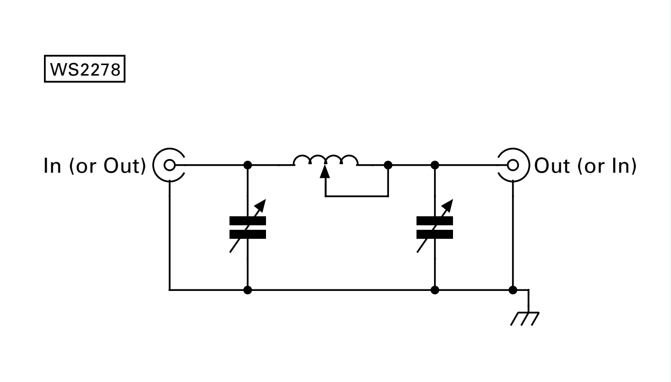

Fig. 1: The Pi Match is normally considered to be the 'standard' format for an a.t.u. It will usually match most random lengths of wire to 50Ω. In use the Pi Match also has the advantage that it tends (when tuned correctly) to suppress any harmonics that may be present in the transmitter output (see text).

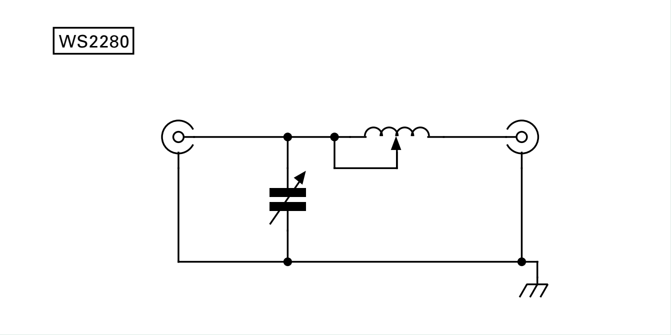

Fig. 2: The L match is usually more suited to the shorter lengths of wire. It can be used in a fixed configuration at the base of (for example) a short vertical antenna for single band use (see text).

General Purposes

For general purposes, as I mentioned earlier, the Pi Match is probably the most versatile. Computer analysis has shown that with modern equipment needing to 'see' 50Ω at the input and anything from 10 to 2kΩ at the output, the coil only needs to be a maximum of some 25μH (micro henries), and neither capacitor needs to be more than 500pF at any frequency from 1.8 to 30MHz.

Although this is not the time to go into definitive figures or detailed calculations, the Pi match type of a.t.u. is the version that will be described

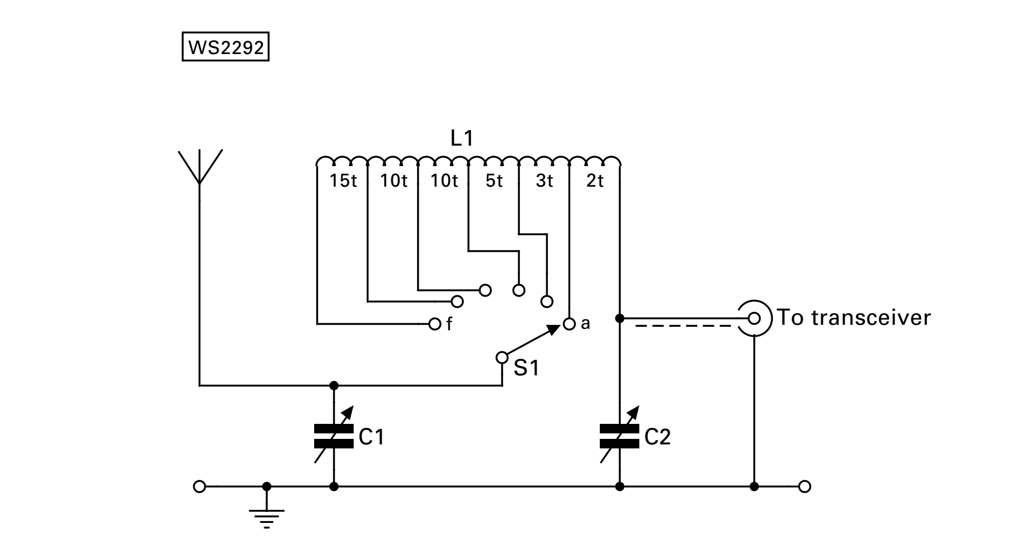

Fig. 3: The Pi match a.t.u. project circuit, the main subject of this article. In the text the author guides the intending constructor through the construction process also suggest how this circuit could form the basis of a more advanced a.t.u. making use of the three basic forms of matching circuits discussed. See the main text for details of the main coil and suitable materials which can be used as the former.

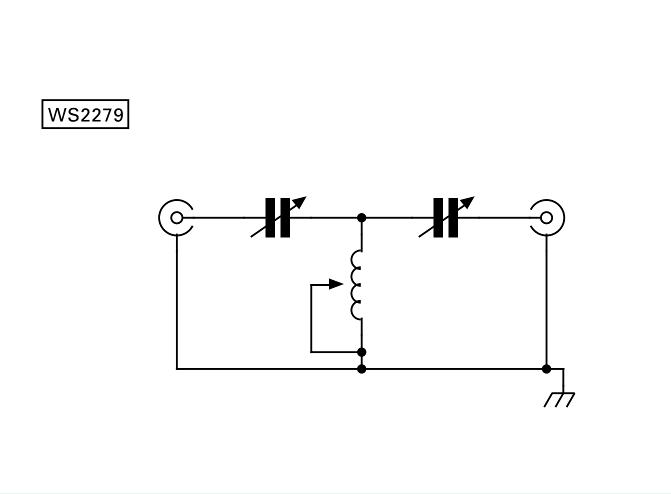

Fig. 4: The T match will match most random wires. However, it seems to be happier when working into a longer length of wire (see text).

here. After all - the idea is to present you with a buildable project to launch you into a.t.u. construction and the circuit we're to use is shown in **Fig. 4**.

For use in the circuit of Fig. 2 the two capacitors (particularly for QRP power levels) need not be wide spaced. In fact ex-broadcast receiver types of around 300 to 500pF will do quite adequately.

The coil consists of some 45 turns on a 50 to 75mm former. When wound the turns are spaced with one wire diameter between each winding. The coil requires to be tapped to allow a range of inductances to be selected.

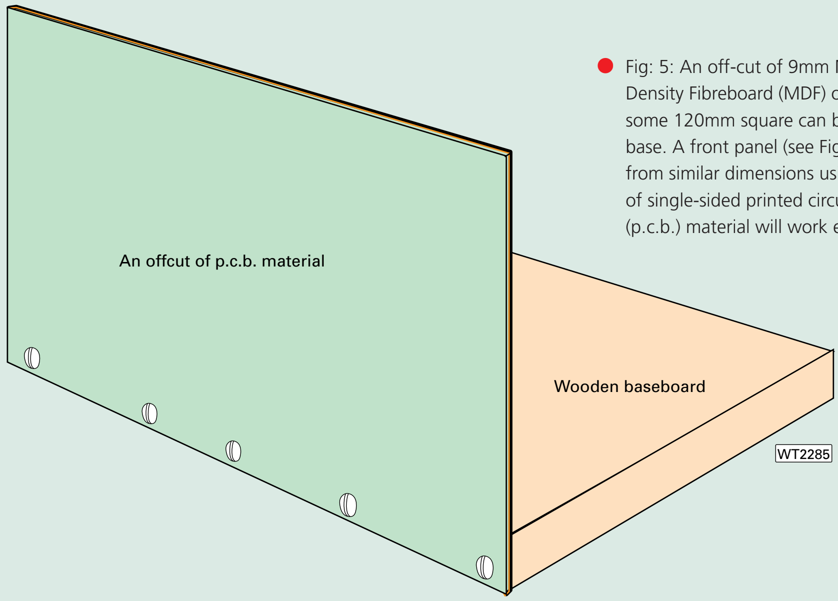

Fig: 5: An off-cut of 9mm Medium Density Fibreboard (MDF) or Plywood some 120mm square can be used as the base. A front panel (see Fig. 6) made up from similar dimensions using an off-cut of single-sided printed circuit board (p.c.b.) material will work equally well.

In practice the necessary tappings can be selected either by means of a rotary switch, or a crocodile clip on a flying lead. **Warning:** To avoid burns don't change coil tappings while r.f. is applied! (even when you're operating at QRP levels!).

Acceptable Former?

When an a.t.u. project is being considered a question often asked is; "What can be used as a former for the main coil". Fortunately, it can be answered quite simply. A quite acceptable former can be fabricated from a washing up liquid bottle. (The BBC's *Blue Peter* children's programme has a lot to answer for!).

So, after you've got the necessary bottle (wait for it to be emptied please!) carefully cut off the top. Leave the bottom in place, as a nut and bolt will secure this to the case or board.

A quick rub over with some emery cloth will give the bottle's surface a slight roughness and assist in holding the wire in place. A suitable alternative is a short length – say 100mm of 50mm plastic pipe, although an alternative method of fixing will have to be used.

Note: You may already be aware that there could be some concerns as to whether certain plastic materials used in items such as drainpipes, etc., are suitable for handling r.f. currents, albeit at low power. Fortunately, there's a fairly quick and easy test that can be done to remove any concerns.

Here's what you have to do; place a sample (use the cut off top' of the proposed 'former' into the microwave oven, along with a cup of water. If after a couple of minutes on high power, the sample has not got hot (be careful, just in case – and watch it the whole time) then it's quite suitable for our purposes.

Spaced Out Problems!

One problem that many constructors encounter when winding a coil that requires spacing onto a former, is how to

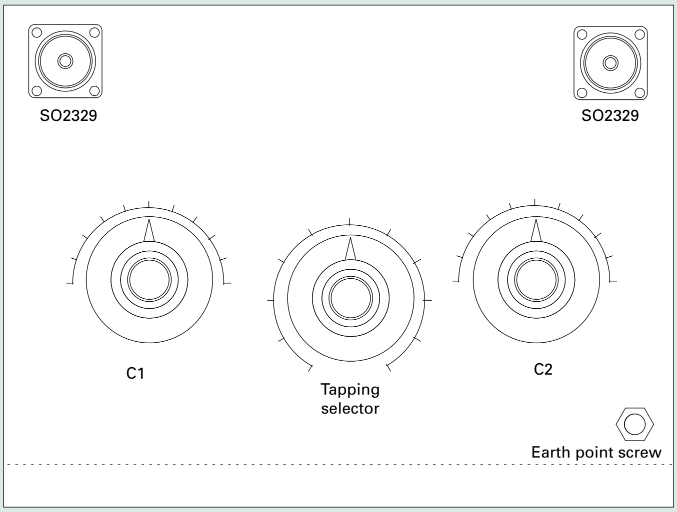

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Fig. 6: The front panel will need to be drilled, as above - to mount the coil tapping switch (if used) along with an input and output socket (SO239s are quite acceptable). Also require are a six x 25mm screws and bolts for connection of the r.f. earth, as well as the two capacitors. The copper surface (the foil) faces inwards and then acts as the common 'ground' for the unit (see text).

get it spaced out correctly. To overcome this common difficulty I find that the best method is to fix one end, and wind the wire alongside a length of thin string.

At each tapping point, form a small loop in the wire before continuing. Don't worry - it's much easier to do than describe! Once both ends of the coil are completed to your satisfaction, (the ends can be fixed in place using hot melt adhesive or an epoxy resin type) remove the string and you're ready to go onto the next stage.

Better In A Box?

Home-brewed equipment does look better in a nice enclosed box and of course they don't trap dust. However, for a basic a.t.u. project of the type we're making here there's no real need to indulge in any serious 'metal bashing'.

You could use an off-cut of 9mm Medium Density Fibreboard (MDF) or Plywood some 120mm square as the base, **Fig. 5**. A front panel, **Fig. 6**, made up from similar dimensions using an off-cut of single sided printed circuit board (p.c.b.) material will work equally well.

The front panel will need to be drilled, see diagram - to mount the coil tapping switch (if used) along with an input and output socket (SO239s are quite acceptable). You'll also require six 25mm screws and bolts for connection of the r.f. earth, as well as the two capacitors. The copper surface (the foil) faces inwards and then acts as the common 'ground' for the unit.

The coil, as previously mentioned above can consist of some 45 turns of 16s.w.g. wire, with tappings at 2, 5, 10, 20, 30 and 45 turns from the 'input' end. If the washing-up bottle former is used after winding it can be screwed directly to the wooden base. **Note:** To ease construction, this need not be enamelled wire – instead try stripping the insulation from some 1mm 'earth lead' wire.

Straightforward Construction

The actual construction of the project is quite straightforward. After winding the coil and preparing the front panel, I suggest that you connect everything up as per the circuit diagram.

Screw the coil down to the baseboard in a suitable position. **Note:** The switch, if used, can then be soldered to the tapping points on the coil **before this is done**. (I've found wiring the switch in this way makes it much easier to handle on the bench, rather than doing it after mounting).

Tune In & Select

To use your basic a.t.u. on the air all you have to do is; tune in a signal and select the tapping point and capacitor settings which provide the greatest signal strength. You should, whenever possible, use the lowest amount of inductance (shortest section of coil selected either by the switch or croc clips) to obtain the best results.

On transmitting a short low power transmission (carried out while you're watching the s.w.r.) meter, and a final adjustment of the variable capacitors will see you tuned up. You'll be 'in business' and achieving the best match possible.

All Three Versions?

At the end of the day, Amateur Radio is all about experimentation, so why not build all three versions? You'll then find out which works best in your situation.

I can imagine readers saying - "Do what ... build all three"? In reply I suggest that you don't panic! Instead, look at the circuits for all three types and a clear similarity can be seen. The coil assembly can be the same for all three. For the Pi and T versions, you'll need two capacitors, and only one for the L match.

For all versions of the basic a.t.u. an input and output socket, which can be of the PL259 variety, or for real QRP the 'phono' sockets, are quite usable. Add in a few 4mm plugs and sockets and you'll have the basics of a really versatile a.t.u., which can be re-configured at will.

The only point which must be watched, is that for the T match, the capacitors are 'floating. i.e. **Not connected to earth** and if this version is constructed, one method is to use either a plain piece of p.c.b. substrate board or even a thin plywood panel. Good luck and I hope enjoy the experience of building your own basic a.t.u.!

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Further Reading

The subjects of antennas and antenna matching could keep you occupied in a library for a life time - it's such a fascinating subject! However, although it can be an extremely academic subject - we're fortunate enough to have some truly excellent books to help us make this branch of our science very enjoyable. One of the very best (although not a commonly seen publication in Europe, it's sometimes available from your local library/reference library) is the well known *Amateur Radio Handbook* by Orr & Cowan. The American produced book contains some of the easiest to understand articles and best presented chapters on antennas, coupling, feeder systems and antennas I've ever discovered in my work. Also to be highly recommended is the ARRL *Antenna Book* (available from the *PW* Book Store). Incidentally, if you're a newcomer to the Amateur radio hobby I thoroughly recommend you have a copy of the ARRL's *Understanding Basics Electronics*. Although not specifically dealing with antennas, this superbly written and presented book is the standard reference work I use and recommend in Radio Basics. It will provide the reader with a thorough grounding in the technical knowledge needed to understand feeders, antennas and the radiation of radio frequency transmissions. I can also recommend the *More Out of Thin Air* reprint (PW Publishing) as a good source of projects and ideas.

Rob Mannion G3XFD, Editor