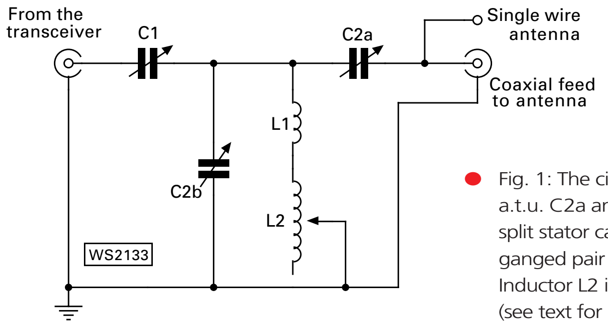
Antenna Workshop

The versatile SPC Antenna Tuner for the h.f. Bands, is described by John Heys G3BDQ this month.

With it's acronym name derived from **S**eries, **P**arallel **C**apacity the SPC matching circuit is a modification of the 'T' matcher and is attributed to the late **Doug de Maw W1FB**. The circuit offers many advantages over other designs and internal matching units. When correctly adjusted, an SPC a.t.u. will efficiently match the 50Ω transmitter output impedance to impedances from under 25Ω to over 1kΩ.

There's now a growing trend to incorporate an internal a.t.u. into many new transceivers. Should the operator of one of these transceivers wish to use an end-fed single wire antenna though, the inboard matcher will be unable to cope with the wide ranging impedances presented by the antenna on different bands.



● Fig. 1: The circuit of the SPC a.t.u. C2a and b may be a split stator capacitor, or a ganged pair of capacitors. Inductor L2 is a rotary unit (see text for details).

● Fig. 2: Front view of the a.t.u. which has a Perspex panel. The turns counter for the rotary inductor allows for quick band changing.

High Impedances

Most internal matching units cannot deal with the high impedances that are often presented by long wire, Windom or other wire antennas. When you employ a linear amplifier, the internal matcher becomes redundant and an external a.t.u. able to handle the higher transmit power becomes essential.

Internal a.t.u.s are really designed to work with antenna systems that present, at the transmitter, impedances not too far removed from a nominal 50Ω. Quite often a multi-band beam antenna, incorporating traps for multi-band operation will show a low s.w.r. only over small sections of each band.

On one of the wider bands, such as 21 or 28MHz, an internal a.t.u. can 'tune out' any small mismatches created by the antenna's limited bandwidth. So, the transceiver will always be presented with a 50Ω load and full output power is maintained. But these internal matching units are engineered to cope with quite a low range of impedances

Due mainly to space limitations, inbuilt matchers tend to use quite small toroidal inductors and fixed capacitors. Though these components take up little space, they generally result in a power through-loss of ten per cent.

Air spaced variable capacitors and cylindrical inductors when used in a matching circuit, as shown in **Fig. 1**, will allow the construction of an a.t.u. which has virtually no loss of power and which can be designed to safely handle transmitter powers ranging from QRP levels up to our legal limits and beyond.

There will always has some capacitance across the inductances L1 and L2, which helps to reduce unwanted h.f. harmonics. This feature although, is perhaps not quite so important, as modern transceivers tend to have very little unwanted harmonic output.

Ganged together

The variable capacitors C2a and C2b (Fig. 1) are ganged together and may be either a split stator item or a pair of capacitors, one of which must have both front and rear spindles to allow coupling. The maximum capacitance of each capacitor should be at least 150pF.

The values for C2a and b, are not critical and higher value capacitances may be employed. My SPC matcher uses 356pF capacitors for C2a and C2b. Values for capacitor C1 can have a maximum capacitance anywhere between 175 and 360pF.

The vane spacing of the variable capacitors used determines the power handling capability of the a.t.u. and wide spaced variable capacitors are now becoming scarce and expensive. Fortunately, they can still turn up at Rallies and Club 'Junk' sales.

I find that variable capacitors from old aircraft transmitters are ideal buys, and many capacitors used in my a.t.u. designs were from this source. Often they have spent many years in the junk box before being used.

However, capacitor 'flashover' **is not just a product of close vane spacing**. Flashover can also arise when the a.t.u. inductance is set incorrectly. To allow fine setting of the inductance value, the inductance L2 should preferably be a rotary unit, often known as a 'Roller coaster' or 'Mangle'. If you're unsure what one of those is, ask grandma!

A multi-tapped coil may be used, but it can often be difficult to find the correct tap point for each band. You would also need a high quality ceramic rotary multi-way switch, to be able to handle high transmitter power. These rotary inductors are becoming scarce too, but they sometimes turn up at club sales, or surplus flea markets.

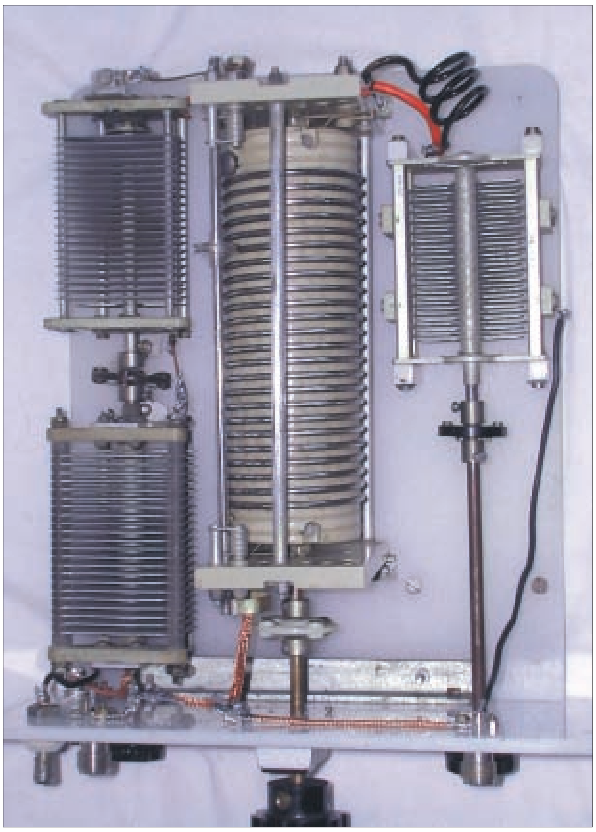


Fig. 3: Top view of the SPC antenna matcher. The layout is arranged to allow short wiring, minimise stray inductance and unwanted capacitance.

Not Grounded

Please note, that in Fig. 1 the earthy end of the L2 is not grounded. Although you may see some published SPC circuits where this point of the the coil is grounded, I've found that when this is linked, there's always a possibility that unwanted resonances can occur at some settings.

Unwanted resonances in the coil will cause power loss and coil heating. If the matcher is to be used on all the h.f. bands, L2 must have a maximum inductance of at least 20µH. As the inductor used in my prototype version has a maximum inductance of only 11µH, it cannot tune the 1.8 and 3.5MHz bands.

Conversely on the 28MHz band, L2 is at a minimal value, and would only use less than one turn. So, its efficiency would be low. To obviate this, a small fixed coil L1 is used in series with the variable inductor L2. This small inductor has an inductance of about 1µH and should be made with heavy gauge (three or four millimetre - 8/10s.w.g.) copper wire.

Old starter motors have some really thick wire. But wherever you get it from, form it into three turns with an internal diameter of 25mm stretched over a 38mm length.

Real Hardware

Translating the circuit diagram (Fig. 1) of the SPC a.t.u. into real hardware can invite certain problems. The connections to C1 and C2a are all above earth potential and the inductor L2 will only have its designed high *Q* (efficiency) when positioned at least its diameter, or more, from any earthed or metallic surface.

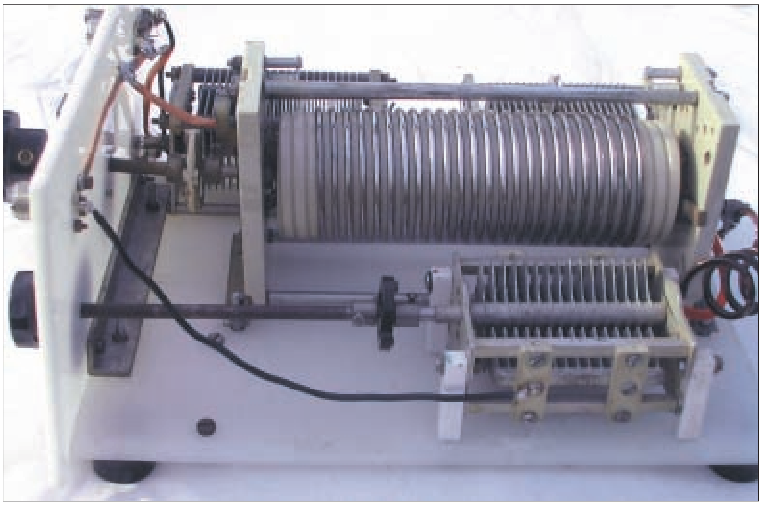


Fig. 4: Side view of the a.t.u. with C1 in the foreground. This capacitor came from a wartime aircraft transmitter. Inductor L1 is wound with enamelled heavy gauge wire.

A metal base and panel would invite insulation and spacing problems so, I made mine from plastic materials. The base, a slab of Polypropylene material, measures 305×40mm. Fortunately, the new cutting boards for kitchen use are made from this and are available quite cheaply.

My local discount store had large 480×320mm boards for a little over £3. This plastic can be sawn and drilled easily and is fine for self-tapping screws. It has a smooth waxy feel and superb insulating properties.

The front panel is a piece of white Perspex bought as an 'off-cut' from the scrapbox of my local glass works. It is held securely to the baseboard by a short length of stout non-ferrous (aluminium) angle shape. The photograph of **Fig. 2** illustrates the panel layout.

It may look rather unusual, but the antennas enter my shack from the left so the antenna connectors are positioned to the left, whilst the input SO-239 coaxial socket is on the right. Normally, coaxial connectors are located at the back of an a.t.u., but my table top and shelf arrangements would make this awkward.

Top View

The top view of the completed unit, **Fig. 3**, shows C2a and b on the left of the baseboard, with C1 is on the right hand side towards the back. The connections to the fixed vanes of C2a and C2b go to L1 as do the moving vanes of C1.

If a split stator variable capacitor unit is used for C2, then the combined moving vanes will connect to L1. Earth loops are avoided by having a length of copper braid run along the panel to which all earth connections are made.

The layout used makes for very short r.f. wiring, as you can see in **Fig. 4**, which gives a side view of the a.t.u. and two of its four 'feet' are just visible at the front and back edges of the baseboard. These feet raise the board away from any earthy surface.

Operation

In operation on 7MHz, the variable inductor (L2) only needs nine turns in circuit. This setting reduces to five turns on 10MHz, two turns on 14MHz, one and a half turns on 18MHz. On trying the 21MHz, just one turn was needed , dropping to just half a turn for the 24MHz band. As I mentioned before, on 28MHz just L1 is in use.

The initial setting up on each band can be done by using a low transmit power and a resistive dummy load. This can be in the range 100 to 600Ω to simulate an actually antenna connection.

The capacitor controls may be set to between a third and half maximum value, then the variable inductor, L2 is rotated until the lowest s.w.r. is found. All the capacitors then should be adjusted to bring down the s.w.r. to unity. Now you're ready to go with higher power. Do not adjust L2 with full transmit power applied.

I've found that the tuning is fairly sharp on 7MHz and ideally, reduction drives for the variable capacitors would be useful. A turns counter for L2 is obligatory, to make repeated settings easily, and I obtained a suitable one from **Mainline Surplus Sales**.

Works Well

This SPC design works well and shows almost no power loss. My unit can easily handle 1.2kW without capacitor flashover and 'loafs' along at the UK legal power levels. Using a rotary inductor with an inductance of 20µH or more will allow operational additionally on the 1.8 and 3.5MHz bands.

Finally, I am indebted to **Bill Staples G0AKY** for taking the pictures to illustrate this article.