Fourth prizewinner of the EA-Parameters project competition

Antenna tuning unit covers all HF bands

To the mobile amateur HF operation has always presented a serious challenge and, while modern equipment is much more compact and reliable than that of a few years ago, there remains the major problem of providing an efficient aerial. Here is a simple aerial tuning unit having a wide range of adjustment.

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Just about any mobile antenna which may be required to operate on more than one frequency becomes a compromise in terms of best performance and acceptable standing wave ratio. In mobile activities, where every watt of power counts in a naturally adverse situation, experienced mobile operators have found that the performance of even "top-of-the-line" commercial mobile antennas can be noticeably improved by the use of an antenna tuning unit (ATU) between the transceiver and the antenna. Furthermore, the unit acts as a filter to reduce the possibility of interference to television sets. In addition, all amateur HF bands can be tuned with one whip, thus saving the cost of a series of whips.

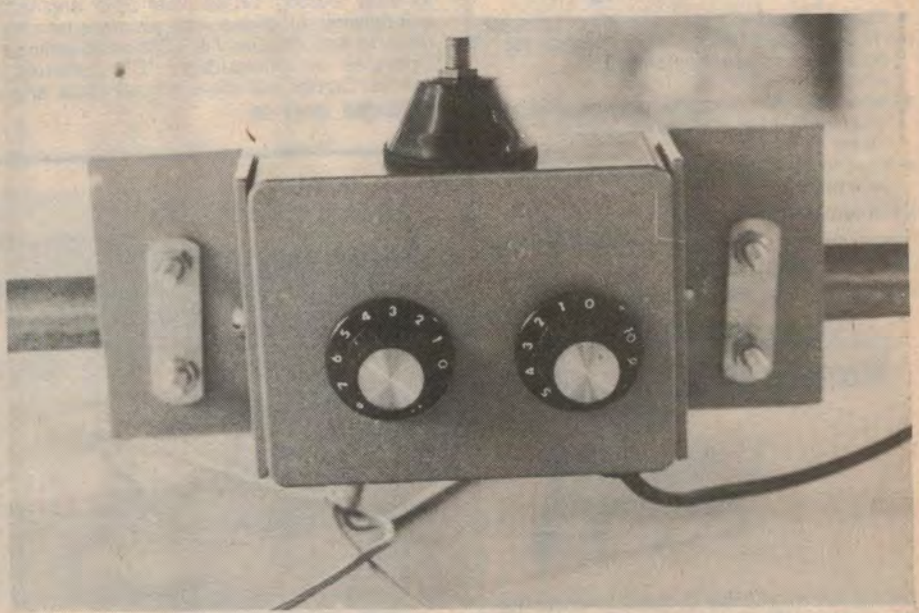
One approach is to put the ATU between the output of the transceiver and the coaxial cable to the antenna. Although this technique provides a distinct improvement in both radiated power and received signal strength it has the disadvantage that standing waves can still exist on the coaxial cable with an associated loss of performance.

Given then that the use of an ATU can provide the advantages outlined above, it follows that it should logically be inserted right at the base of the radiating element itself. As there are, to date, no commercially available units with this feature the author looked into the possibility of making his own and found it to be well within the abilities of any home constructor.

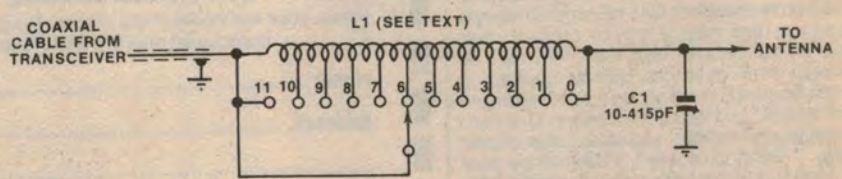
The unit to be described is designed to mount on a ski bar, but this is a mechanical option which could readily be adapted to other forms of mounting to suit the needs of the user, such as bumper, gutter or trunk lid mount. One advantage of some form of roof mounted antenna is that the relatively flat vehicle acts as a ground plane with a corresponding improvement in antenna performance. In addition, the author used four radial wires across the roof as described below, but this is completely optional.

As implied earlier, mobile HF antennas, at least below the 28MHz band, are essentially compromise devices. It is just not practical to accommodate a resonant (quarter wavelength) aerial on a car, for amateur bands below 28MHz.

The shortened aerial no longer presents a purely resistive load to the transmitter; it now has capacitive reactance, looking like a resistor in series



The aerial tuning unit mounted on a ski bar above the car. The left hand knob controls the variable capacitor and the right hand one selects the inductor taps. Note the four "radials" used to improve the ground plane.



The basic circuit as used for the unit in the photograph above, and which puts the variable capacitor at the antenna end of the inductor. Subsequently the author modified the circuit, as shown elsewhere, and improved its performance.

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with a capacitor. As the frequency is made progressively lower, relative to the natural resonant length, this capacitance increases and the resistance decreases.

Such a situation is undesirable for two reasons. Firstly, the aerial is not very efficient as a radiating device and, secondly, the load which it presents to the transmitter may be a long way from the value for which the transmitter is designed. This latter condition prevents the transmitter from generating its rated power.

It is not usually possible to do much about the radiating efficiency of a short aerial but, regardless of this, it is very important to make the aerial look like a correct load for the transmitter. This at least allows the transmitter to develop its rated power.

The capacitive reactance of the shortened aerial can be cancelled by adding an appropriate amount of inductive reactance (a coil) in series with it. This coil may be at the base of the aerial (bottom loading) or part way up the aerial (centre loading).

But such a coil will serve only one frequency. If a single loaded whip is to be used on all bands, it would be selected for the highest band, and additional inductance inserted for the lower frequencies.

In simple terms, this is the job performed by the aerial tuning unit. For practical reasons a tapped coil is used and the fine adjustment provided by the variable capacitor.

Another way of visualising the situation is that the addition of the inductance takes the whole aerial system resonant, as it would be naturally if it was of the correct length. This enables it to present a more reasonable value of load, and one which is essentially resistive to the transmitter.

The completed unit is shown in the photograph, mounted on the ski bar with the radials running away below. The darker wire is, of course, the coaxial cable.

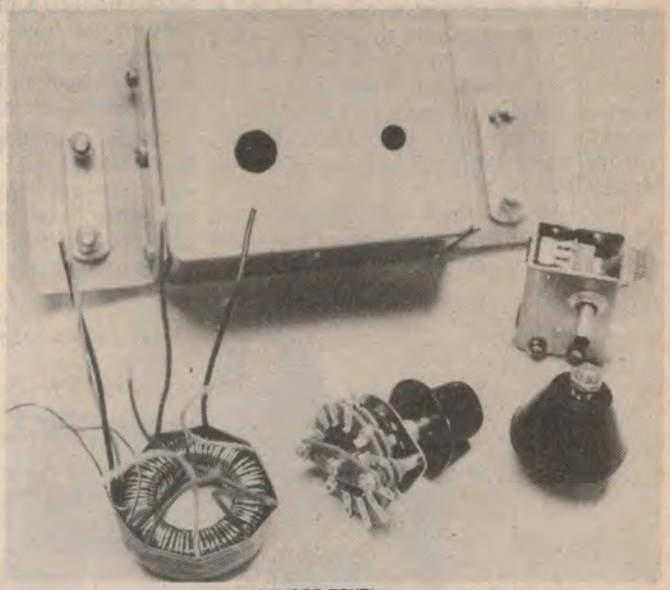
The left hand knob is for tuning the variable capacitor and the right hand knob for selecting the appropriate tap on the inductor, both shown on the schematic diagram.

As detailed below the inductor switch is wired to give no series inductance at position "0", to a maximum series inductance at position "11".

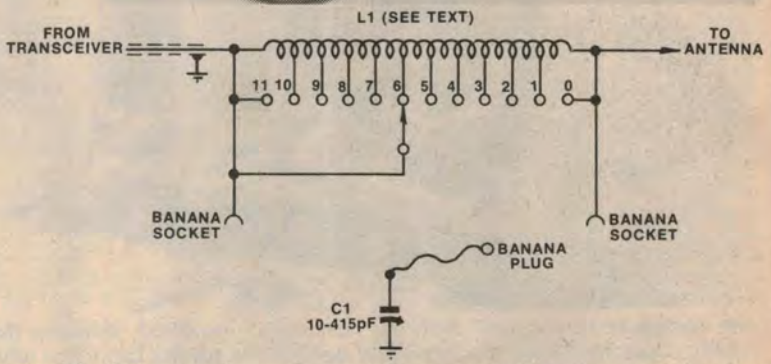
The coil consists of as many turns of 18SWG enamelled copper wire as can be conveniently wound on a two inch toroidal former. The toroidal former is an Amidon T200-2 which is available as part of a "balun kit" from Dick Smith stores. They are also advertised occasionally in "Amateur Radio." The coil depicted has about 65 turns. If a 12 position rotary switch is used, 10 taps are required. These were atached simply by baring the wire on the outside face of the toroid with fine emery paper at the required positions and then soldering on flexible leads about four inches long. The taps can be connected to every sixth turn, but it is probably better to make the first three taps at, say, 1,3 and 5 turns to allow a finer adjustment at the minimum inductance end. Finally, the coil was wrapped with plastic insulation tape.

The tuning capacitor is a standard 10-415pF single gang receiving type which is quite OK at powers up to about 200 watts. When mounting the capacitor make sure that sufficient of the shaft protrudes through the panel to enable the knob to clear the front surface. The larger hole in the panel is used for the tuning capacitor. A suitable rubber grommet in the hole both restricts the entry of water and acts as a friction brake to prevent rotation of the shaft due to road vibration.

The interior photograph shows the general assembly of the unit. The coaxial feeder enters through a grommet in the base of the box left, under the coil



The main components used in the tuning unit. The inductor, left, is wound on a toroid and details are given in the text. The box is supported on two aluminium brackets drilled to take "U" bolts, but conduit saddles can be used.



The author's modified circuit allows the variable capacitor to be connected to either end of the inductor and makes possible a greater tuning range. A good quality switch could be used in place of the plug and sockets.

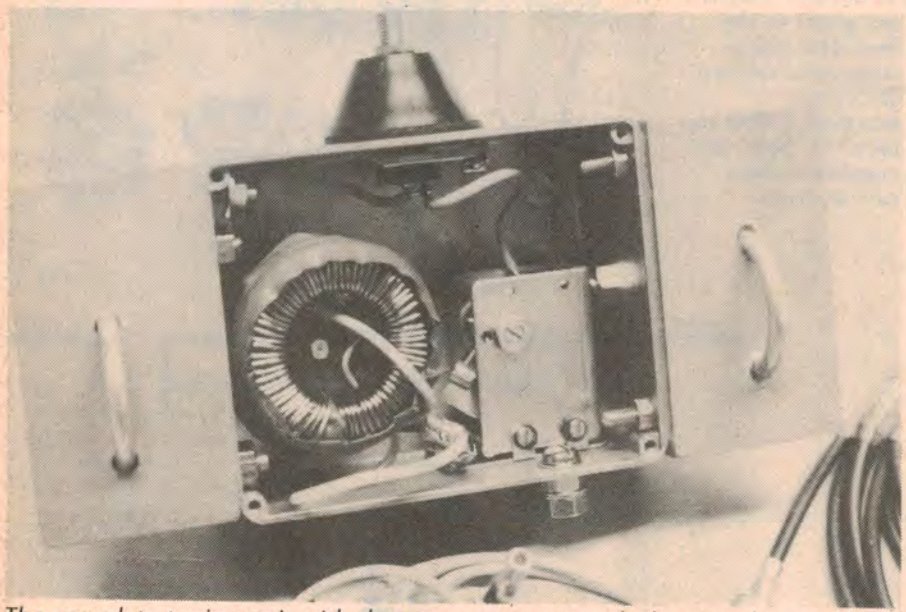
PARTS LIST

1 Toroid, 2 inch AMIDON T200-2
1 Eddystone box, or similar, 120 x 85 x 52mm
1 Roblan single gang variable capacitor, 10-415uF
1 1 x 12 rotary switch, Oak, Paton or similar
2 Knobs
20 feet 18SWG enamelled copper wire
1 Antenna mounting base, single hole roof mount
2 pieces aluminium angle 50 x 50 x 30, each 90mm long.
2 U-bolts 6mm (¼in) x 35mm centres
7 metal thread screw ¼in whitworth x ½in round head with nuts and washers
25 feet PVC insulated hookup wire 23/.0076
9 feet RG58U or RG59U coaxial cable
1 PL259 plug
Grommets, plastic self adhesive insulating tape, solder lugs.

Antenna tuning unit

while the four earth radials are attached to the terminal shown just behind the tuning capacitor. This terminal is made from a ¼" whitworth screw and nuts. Wiring inside the box is heavy duty hookup wire, such as 23/.0076. There can be quite large circulating currents inside the ATU.

The radials, which are designed to improve the earth coupling of the unit into the car body are simply four lengths of hookup wire with alligator clips on the end to clip to the guttering at the four corners of the roof. These radials could be omitted, but in view of the relative inefficiency of mobile HF antennas any move such as this to improve the general efficiency should be adopted. The antenna base is any suitable type. Several are readily available through the trade.



The complete tuning unit with the rear cover removed, showing the toroid and tuning capacitor. Note the large bolt behind the tuning capacitor which is used to terminate the "radials" which clip to the car guttering.

The mounting brackets in this version are scrap pieces of aluminium angle which are screwed to the ends of the box and attached to the ski bar by U-bolts. As mentioned previously, any suitable type of mounting can be used. In a second and later version of this ATU the box was attached to the ski bar by a plastic conduit saddle which cost 5 cents. The box was spray painted before assembly, but after drilling, with the aid of a can of bronze hammertone spray.

In operation, with the antenna mounted on the base, the tuning capacitor is set to its approximate mid-point with a suitable monitoring device such as a field strength detector, SWR meter or, in the case of a solid state transceiver, the final collector current meter, the 12 position switch is rotated until maximum power output or minimum SWR is indicated. Then the tuning capacitor is varied slowly as a fine adjustment.

The unit will need to be retuned for each amateur band but, in most cases, it should be possible to find a compromise setting for any one band which will remain effective across that band or the portion of interest.

Since I submitted my original design I have found that the simple modification of arranging for the tuning capacitor to be connected either on the antenna OR the transmitter side of the inductor greatly extends the range of antenna impedances which can be matched to the transmitter. I did this simply by incorporating two banana sockets on the front panel towards top centre and connecting these inside the box to the transmitter and antenna ends of the coil. The non-earthed side of the capacitor was lifted off the antenna side of the coil and brought out by hook-up wire through a grommet to a banana plug.

The much greater range of impedance match available allows me to use the coupling unit with shorter whips, if desired, and also to use the equipment in the "stationary mobile" mode when I connect a wire antenna from a tree or similar support to the antenna base in place of the whip.

The all-up cost, depending upon how much the junk box yields, should not exceed about thirty dollars. The writer ventures to suggest that this unit will give a greater benefit per dollar in terms of station performance that any other accessory. Since the prototype was put into service the author has logged amateur HF contacts with several United States stations, one each in Germany and Denmark, plus many Australian and New Zealand stations.