UK Radio Astronomy Association

VLF Aerial Tuning Unit

User Manual

www.ukraa.com

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Acknowledgements

Design Team

The UKRAA VLF ATU was designed and developed by
Andrew Lutley, Alan Melia and Norman Pomfret.

Testing Team

The VLF Aerial Tuning Unit was tested by
Andrew Lutley and Alan Melia.

Production Team

The initial batch of the VLF ATUs was produced by Andrew Lutley.

Contributors

The following authors have contributed to the VLF ATU User Manual:
Andrew Lutley, Alan Melia, Dr Laurence Newell, Whitham Reeve.

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Introduction

UKRAA

The UK Radio Astronomy Association (UKRAA) is a non-profit-making charitable company limited by guarantee. It was established by the Radio Astronomy Group of the British Astronomical Association (BAA) to facilitate the production and sale of radio astronomy products.

This Manual describes how to connect and use the UKRAA VLF Aerial Tuning Unit. Any suggestions or recommendations for improvement of this Manual would be appreciated. See the Contacts page for further details.

The UKRAA VLF Aerial Tuning Unit

The UKRAA VLF Aerial Tuning Unit

The VLF Aerial Tuning Unit (ATU) is designed to provide a means of tuning a VLF loop aerial over a wide range (50 pF to 3500 pF) of capacitances. The ATU uses a switchable bank of fixed value capacitors and a variable tuning capacitor.

When used in conjunction with the UKRAA VLF Aerial, it will form a 'parallel tuned circuit' to provide an input signal to the VLF Receiver in the frequency range 15-35 kHz, enabling the latter to receive VLF radio transmissions at suitable frequencies.

The ATU is a passive device and does not require a power supply.

Using the ATU to Tune a VLF Aerial

A VLF Aerial needs to be tuned via the ATU to the required VLF frequency. Tuning a VLF Aerial to the required frequency is achieved by adjusting the switches and then turning the tuning knob on the ATU to obtain the maximum output signal amplitude, as described in more detail below.

Support

All users of the UKRAA VLF Receiver system are encouraged to make use of the support available from UKRAA for setting up and operation. Please see the Contacts section for details.

Tools Required

You will need the following tools to connect the ATU to the UKRAA VLF Aerial and the UKRAA VLF Receiver:

Wire cutters

A modelling knife

Fine sandpaper

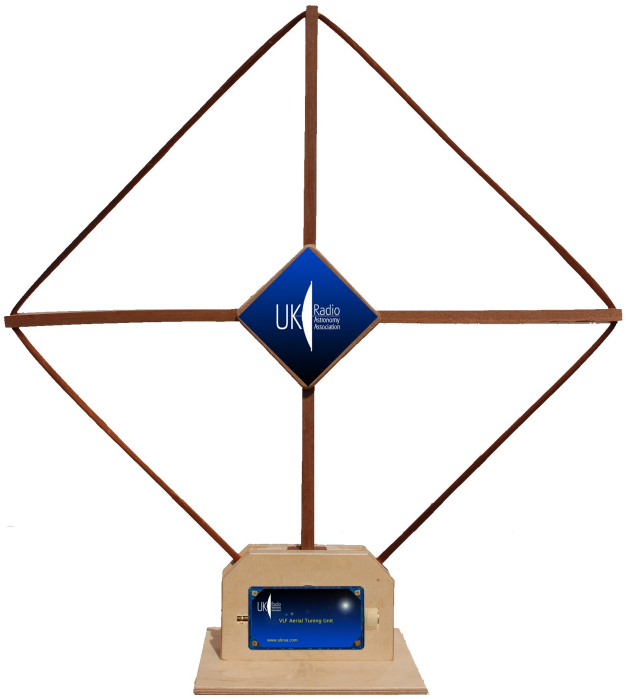
A small cross-headed screwdriver

A small flat-bladed screwdriver

A suitable length of coaxial cable terminated with BNC plugs.
A 60 cm length of cable is supplied with the UKRAA ATU.

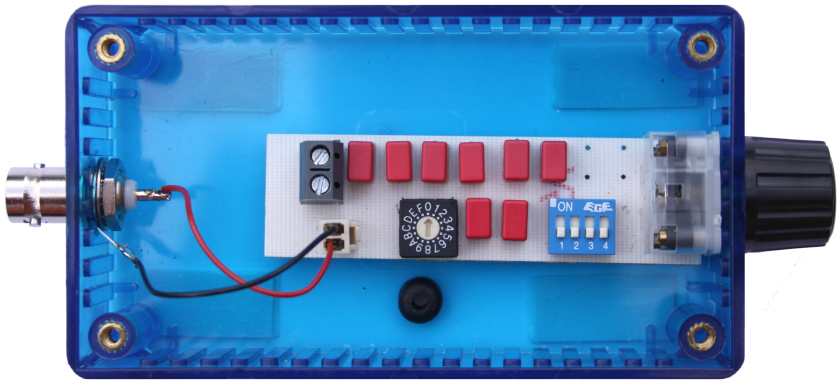
You will also require a soldering iron and solder.

Connecting the ATU to the UKRAA VLF Aerial



The UKRAA VLF Loop Aerial with ATU fitted

1. Using wire cutters, cut the two UKRAA VLF Aerial copper wires leaving a length of about 10 cm exposed, measured from the outside of the clamp side plate.
2. Using a modelling knife, scrape the insulating coating from the last 10 mm of the two VLF Aerial wires to expose the copper core.
3. Using a small strip of fine sandpaper, sand the last 10 mm of the two VLF Aerial wires to ensure that the copper core is fully exposed.
4. Using a suitable cross-headed screwdriver, remove the four retaining screws from the ATU lid and remove the lid.
5. Peel off the paper tabs from the bottom of the four *Sticky Fixers* on the base of the ATU, exposing the adhesive surfaces.
6. Thread the two VLF Aerial wires through the grommet in the base of the ATU and press the ATU firmly against the side of the VLF Aerial, positioning it centrally on the Aerial clamp side plate.
7. Using a suitable flat-bladed screwdriver, loosen the two screws in the terminal blocks at the end of the ATU printed circuit board. Insert one of the VLF Aerial wires into each of the two terminal blocks and tighten the screws (see the photograph below).



ATU Aerial Connection Terminals and Capacitor Switch

Connecting the ATU to the VLF Receiver

Connect a convenient length of coaxial cable terminated with BNC plugs to the BNC socket on the ATU and the BNC socket on the VLF Aerial. A 60 cm length of RG59 cable is supplied with the UKRAA ATU.

If using cables of different lengths, or of different characteristic impedance, you will need to take account of variations in the capacitance added by the cable, which will necessitate re-tuning a previously tuned Aerial/ATU. For instance, each metre of 50 Ohm coaxial cable adds about 100 pF to the capacitance of the system, which will significantly alter the receiver tuning, and hence its sensitivity. See the table below for some examples of the capacitance per metre of commonly-used cables.

Cable Type	Nominal Impedance (Ohms)	Nominal Capacitance (pF/m)
RG58/A/CU	50	80 - 101
RG59/U/BU	75	53 - 67
RG8/U	50	79
RG8/X	50	75
RG213	50	101
RG6/U	75	53 - 56
RG11	75	53 - 57
LMR400	50	78

Variations of Cable Capacitance with Impedance

Tuning the VLF Aerial

1. Connect the VLF Aerial/ATU either to:

   a. a VLF Receiver, as described above, which has been tuned to the required VLF frequency; or

   b. an audio signal generator, as described in the VLF Receiver User manual; or

   c. if tuning the VLF Aerial/ATU to the Ramsloh (23.4 kHz) frequency, the high-level output of the UKRAA 23.4 kHz Signal Generator, via a 100k resistor.

2. Set the brushed aluminium knob on the right hand side of the ATU case to its midway position. This controls the variable tuning capacitor, which has a capacitance range of approximately 15 pF to 150 pF.

3. Initially, check that the 4 DIP switches (the bank of four numbered switches, numbered 1, 2, 3 and 4 in a blue rectangular enclosure) on the ATU printed circuit board are all set in the OFF (lower) position. (See the photograph of the inside of the box, above.)

4. Using a suitable flat-bladed screwdriver, rotate the hex switch (the 16 position switch in a grey rectangular enclosure to the left hand side of the DIP switches) on the ATU printed circuit board starting from position 0 through to position F. The switch should be left in each position for at least five seconds to take account of the VLF Receiver integration time.

5. Either:

   a. If using a VLF Receiver to tune the Aerial/ATU as described in 1 a above, note the signal strength from the VLF Receiver, as displayed on Starbase, Radio Sky Pipe or a data logger; or

   b. If using a signal generator to tune the Aerial/ATU as described in 1 b or c above, monitor the voltage across the Aerial with an oscilloscope or AC voltmeter as described in the 'Tuning the Aerial' section of the VLF Receiver User Manual.

6. As the resonance of the Aerial/ATU approaches the desired frequency, the signal strength should increase, and should then decrease as the capacitance is increased further.

7. If necessary, you may need to add additional capacitance using one or both of the DIP switches 1 and 2.

8. Once the Aerial/ATU have been tuned approximately to the required frequency, they can be fine tuned using the variable tuning capacitor.

9. Replace the ATU lid and replace the four retaining screws.

Glossary

ATU	Aerial Tuning Unit
DIP	Dual In-line Package (in relation to a switch)
RoHS	Restriction of Hazardous Substances
UKRAA	The UK Radio Astronomy Association
VLF	Very Low Frequency
WEEE	Waste Electrical and Electronic Equipment

Contacts

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Starbase Information

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BAA Radio Astronomy Group

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Appendix 1 – VLF Aerial Tuning Unit Specifications

Capacitance range	50 pF to 3500 pF (excluding the connecting cable)

Note that a connecting cable of 50 Ohm characteristic impedance will have a capacitance of approximately 100pF per metre; cables of other impedances may be used.

Appendix 2 – Capacitance Settings

A. With switch 2 DIP switches all set to the **off** position:

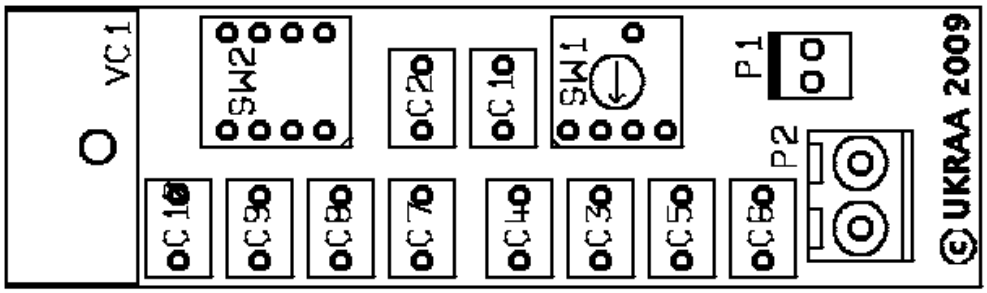
Switch 1 position	Switch 1 binary	Capacitance (approximate)
0	0000	30–165 pF
1	0001	130–265 pF
2	0010	240–375 pF
3	0011	335–475 pF
4	0100	445–580 pF
5	0101	545–680 pF
6	0110	655–790 pF
7	0111	750–890 pF
8	1000	800–940 pF
9	1001	900–1040 pF
A	1010	1010–1150 pF
B	1011	1110–1250 pF
C	1100	1215–1360 pF
D	1101	1315–1460 pF
E	1110	1430–1567 pF
F	1111	1525–1665 pF

B. When using the switch 2 DIP switches, add the following capacitance values to the values set out in A above:

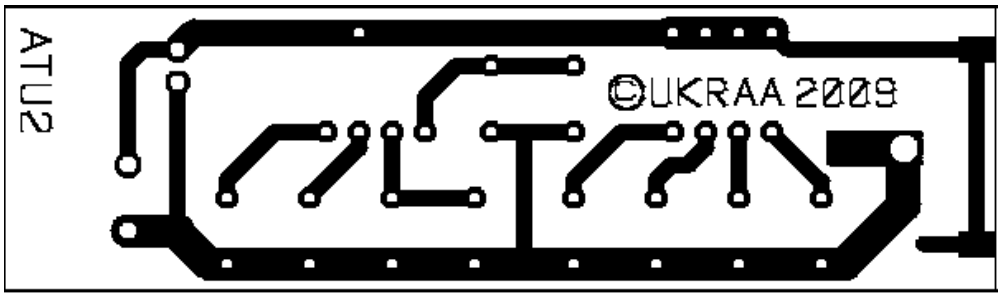
DIP Switch 1	DIP Switch 2	DIP Switch 3	DIP Switch 4	Additional capacitance (approximate)
Off	Off	Off	Off	0 pF
On	Off	Off	Off	1000 pF
Off	**On**	Off	Off	1000 pF
On	**On**	Off	Off	2000 pF

NB The switch 2 DIP Switches 3 and 4 are not used in the ATU as supplied.

Appendix 3 – ATU Component Layout

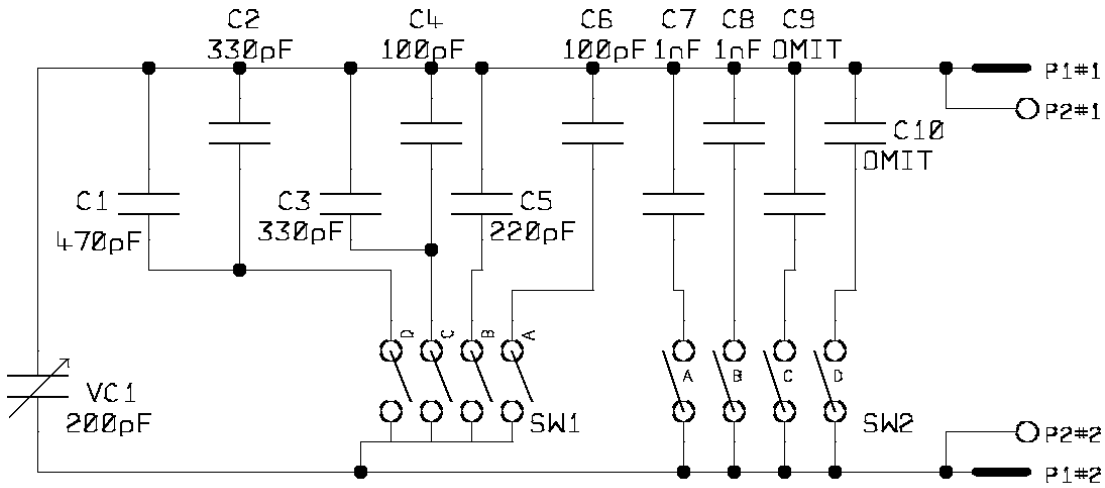


The UKRAA Aerial Tuning Unit Component Layout



The UKRAA Aerial Tuning Unit Circuit Board Tracking

Appendix 4 – ATU Circuit Diagram



The Circuit Diagram of the UKRAA Aerial Tuning Unit

Appendix 5 - Regulatory Compliance

RoHS

The Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC, (commonly referred to as the Restriction of Hazardous Substances Directive or RoHS) was adopted in February 2003 by the European Union. The RoHS directive took effect on 2006 July 1, and is required to be enforced and become law in each member state. This directive restricts the use of six hazardous materials in the manufacture of various types of electronic and electrical equipment. In speech, RoHS is often spelled out, or pronounced "rosh".

The above paragraph was taken from the Wikipedia essay on RoHS.

The RoHS Directive restricts the use of the following six hazardous substances in electronic and electrical equipment products falling within the Directive:

- Lead
- Mercury
- Cadmium
- Hexavalent chromium
- Polybrominated biphenyls
- Polybrominated diphenyl ethers

UKRAA confirms that the suppliers of the components and materials used in the UKRAA VLF Aerial Tuning Unit have stated that such components and materials are RoHS compliant and that reasonable steps have been taken to confirm these statements.

WEEE

RoHS is closely linked with the Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC that sets collection, recycling and recovery targets for electrical goods and is part of a legislative initiative to solve the problem of huge amounts of toxic e-waste.

The Waste Electrical and Electronic Equipment (WEEE) Directive is designed to ensure the efficient collection and recycling of electrical and electronic equipment at end-of-life. If a customer purchases a new product from UKRAA which falls within the WEEE Directive to replace an existing one (of similar function to the one that has been sold) and intends to dispose of the existing one, then the customer can request that we take back the existing product and deal with the costs and logistics of recycling it. Any customer wishing to take advantage of this facility should contact us. Provided that the existing product comes within the scope of the WEEE Directive, we will make arrangements for its return or collection and will deal with its disposal.

Revision History

Revision	Date	Author	Status
Draft A	2009-09-09	A J Lutley	Internal draft for peer review
Draft B	2009-09-14	A J Lutley	Amended internal draft for peer review
Issue 1	2010-01-12	L M Newell	Incorporated reviewer's comments
Issue 2	2011-03-10	A J Lutley	Updated images

Outstanding Work

None, document is at Issue status