UK Radio Astronomy Association

VLF Aerial Tuning Unit

User Manual

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The UK Radio Astronomy Association
A charitable incorporated organisation
Registered Charity No. 1123866

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

Acknowledgements

Design Team

The UKRAA VLF ATU Mk 2 was developed from the original design by Richard Knott.

Testing Team

The VLF Aerial Tuning Unit was tested by Andrew Thomas, Richard Knott.

Contributors

The following authors have contributed to this revision of the VLF ATU User Manual: Andrew Thomas.

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Introduction

The UKRAA VLF Aerial Tuning Unit

The UKRAA ATU was redesigned in 2024 to improve the usability the device when used with the UKRAA VLF Aerial. The electrical design was updated to replace the original variable capacitor which had become obsolete.

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 (0 pF to 6450 pF) of capacitance. 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. Any suggestions or recommendations for improvement of this Manual would be appreciated. Please see the Contacts section for details.

The manual for the Mark 1 ATU is available from the UKRAA website.

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 3mm Allen Key

A small flat-bladed screwdriver

A suitable length of coaxial cable terminated with BNC plugs.
A 1 m length of cable is supplied with the UKRAA ATU.

Quick Start Guide

Switch 1

BNC Connector

Variable Capacitor adjustment

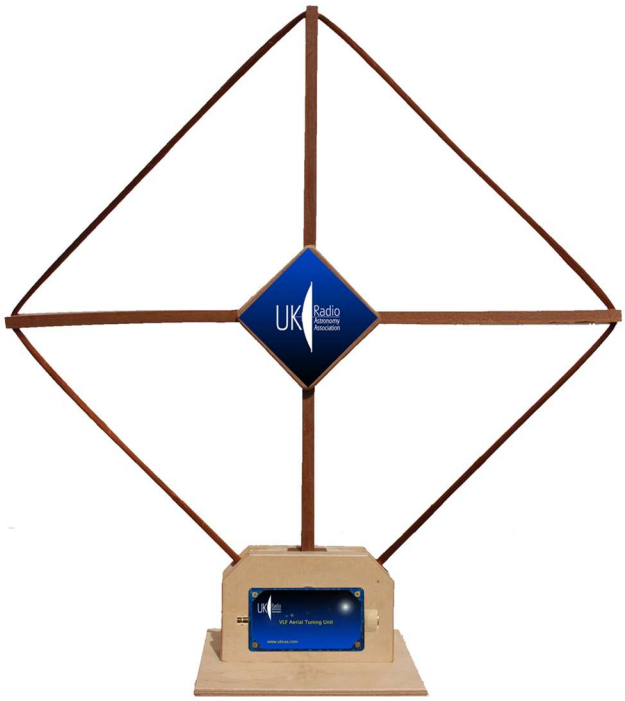
Switch 2

Aerial connection

Aerial connector front view Connected

Aerial connector front view Disconnected

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 allen key, remove the four retaining screws from the ATU lid and remove the lid.
5. Unplug the terminal block from the fixed connector see illustration in the quick start guide.
6. Peel off the paper tabs from the bottom of the four *Sticky Fixers* on the base of the ATU, exposing the adhesive surfaces. (If required to fix to the aerial)
7. Thread the two VLF Aerial wires, including the green sleeve through the hole 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.
8. Using a suitable flat-bladed screwdriver, loosen the two screws in the terminal block. Insert one of the VLF Aerial wires into each of the two terminals and tighten the screws (see the photograph below).
9. Inert the terminal block into the connector.
10. Replace the lid tightening the four retaining screws.

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 1 m length of RG58 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. the high-level output of the UKRAA 23.4 kHz or multi-frequency Signal Generator, via a 100k resistor.
2. Set the tuning wheel on the front of the ATU case to its midway position. This controls the variable tuning capacitor, which has a capacitance range of approximately 0 pF to 200 pF.

3. Initially, check that switch 1 is set to position 0 and switch 2 is set to the 1 position. (See the photograph of the outside of the ATU, above.)
4. Using a suitable flat-bladed screwdriver, rotate the switch 1 (the 16 position switch) on the front of the ATU. The switch should be left in each position for at least 5-10 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 output voltage from the VLF Receiver, measured at the terminals or as displayed on Radio Sky Pipe or a data logger; or other device.
    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 to a maximum, and then decrease as the capacitance is increased further.
7. If necessary, you may need to add additional capacitance using switch 2.
8. Once the Aerial/ATU has been tuned approximately to the required frequency, it can be fine tuned using the variable tuning capacitor.

Glossary

ATU	Aerial Tuning Unit
BCD	Binary Coded Decimal
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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BAA Radio Astronomy Group

Website: https://britastro.org/sections/radio-astronomy

Appendix 1 – VLF Aerial Tuning Unit Specifications

Capacitance range	0 pF to 6450 pF (excluding the connecting cable)

Appendix 2 – Capacitance Settings

Revised VLF – ATU – nominal capacitance values

The variable capacitor is a dual adjustable capacitor, nominally 0-60pF and 0 to 140pF, wired in parallel for nominally 0 to 200pF. All capacitors used are nominal +/-10% value.

Top Switch position	Bottom switch position				
	1	2	3	4	5
0	0 to 200pF	1000 to 1200pF	2200 to 2400pF	3200 to 3400pF	4700 to 4900pF
1	100 to 300pF	1100 to 1300pF	2300 to 2500pF	3300 to 3500pF	4800 to 5000pF
2	220 to 420pF	1220 to 1420pF	2420 to 2620pF	3420 to 3620pF	4920 to 5120pF
3	320 to 520pF	1320 to 1520pF	2520 to 2720pF	3520 to 3720pF	5020 to 5020pF
4	430 to 630pF	1430 to 1630pF	2630 to 2830pF	3630 to 3830pF	5130 to 5330pF
5	530 to 730pF	1530 to 1730pF	2730 to 2930pF	3730 to 3930pF	5230 to 5430pF
6	650 to 850pF	1650 to 1850pF	2850 to 3050pF	3850 to 4050pF	5350 to 5550pF
7	750 to 950pF	1750 to 1950pF	2950 to 3150pF	3950 to 4150pF	5450 to 5650pF
8	800 to 1000pF	1800 to 2000pF	3000 to 3200pF	4000 to 4200pF	5500 to 5700pF
9	900 to 1100pF	1900 to 2100pF	3100 to 3300pF	4100 to 4300pF	5600 to 5800pF
A	1020 to 1220pF	2020 to 2220pF	3220 to 3420pF	4220 to 4420pF	5720 to 5920pF
B	1120 to 1320pF	2120 to 3220pF	3320 to 3520pF	4320 to 4520pF	5820 to 6020pF
C	1230 to 1430pF	2230 to 2430pF	3430 to 3630pF	4430 to 4630pF	5930 to 6130pF
D	1330 to 1530pF	2330 to 2530pF	3530 to 3730pF	4530 to 4730pF	6030 to 6230pF
E	1450 to 1650pF	2450 to 2650pF	3650 to 3850pF	4650 to 4850pF	6150 to 6350pF
F	1550 to 1750pF	2550 to 2750pF	3750 to 3950pF	4750 to 4950pF	6250 to 6450pF

Switch 1

Position	BCD Code	Capacitance
0	0000	no added capacitance
1	0001	+100pF added capacitance
2	0010	+220pF added capacitance
3	0011	+320pF added capacitance
4	0100	+430pF added capacitance
5	0101	+530pF added capacitance
6	0110	+650pF added capacitance
7	0111	+750pF added capacitance
8	1000	+800pF added capacitance
9	1001	+900pF added capacitance
A	1010	+1020pF added capacitance
B	1011	+1120pF added capacitance
C	1100	+1230pF added capacitance
D	1101	+1330pF added capacitance
E	1110	+1450pF added capacitance
F	1111	+1550pF added capacitance

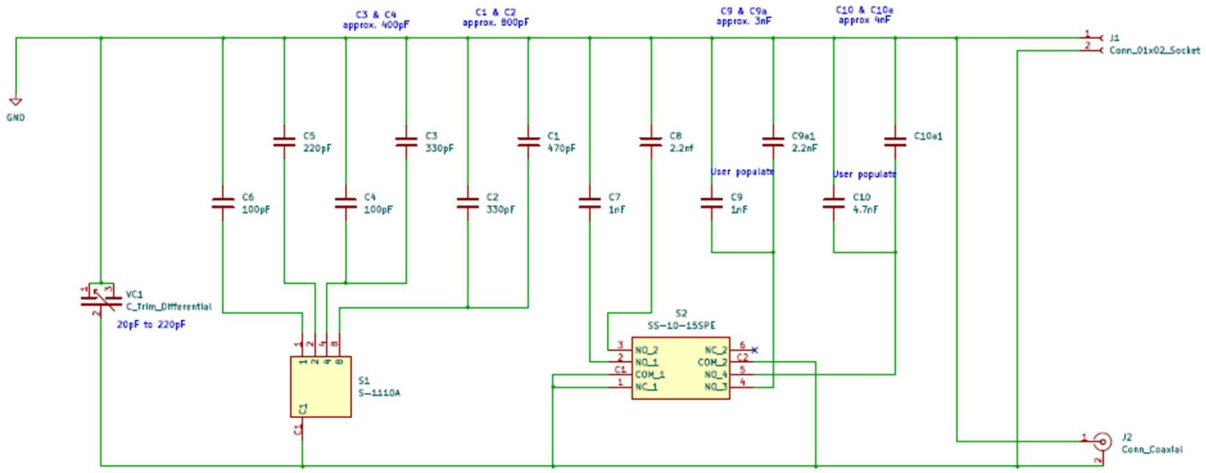
Switch 2 position

- 1 no added capacitance
- 2 +1000pF added capacitance
- 3 +2200pF added capacitance
- 4 +3200pF added capacitance
- 5 +4700pF added capacitance

Appendix 3 – ATU Component Layout

The UKRAA Aerial Tuning Unit Component Layout

Appendix 4 – ATU Circuit Diagram



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
Issue 3	2025-02-18	AR Thomas	Mechanical redesign of enclosure, revised pcb design, new acrylic cover, C9 and C10 installed on pcb

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