ROF 1 - 2m ARDF receiver

Date: September 24, 2006

Ed: 10

Author: Jon Sletvold

1. ARDF 2M RECEIVER

The radio is designed to improve the functionality from my current receivers.

Keywords are lightweight, easy but strong mechanical design and water-resistant. Easy replication and assembly is also an important design property of the receiver.

The Swedish 3-element ARDF receiver is a slim and lightweight design, but has limited room for the electronics and is not waterproof as is. The electronics is based on the ROX-1 receiver, which has worked satisfactory, and a new and improved design ROX-2 design has incorporates some of the changes I have been thinking of. Unfortunately I can't use the board as it is because of the physical size doesn't fit the compartment of the molded aluminum box I'm using.

1.1 Disclaimer and copyright

This receiver is designed for the radioorienteering sport (amateur radio direction finding) only. It's possible to modify the receiver for other frequencies, but I have not tested the receiver outside the 144MHz to 145MHz range.

Any desire to copy, modify or use this design for the benefit of the radioorienteering sport is allowed and encouraged. Please note that the design is based on tools with a non-commercial license and that other people have contributed to the design and should be granted for their job.

Commercial use of this construction is not allowed without permission from the designer.

1.2 Contact information

Norwegian ARDF association WEB: www.ardf.no

Designer email: jonaasle -@- online.no

My phone: +47 91179562

Print board and top marking will be produced for the receiver. Contact the designer for further information.

2. ANTENNA AND HOUSING

The antenna is made of flexible measuring bands that are flexible and stiff enough to be self contained even with large movement of the radio. They are tapered with four elements at the root of the antenna.

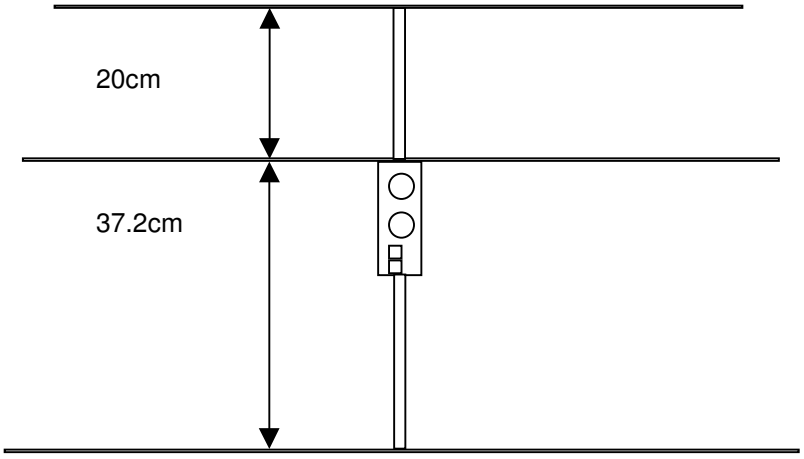
The antenna boom is made of glass enforced nylon bolts 15mm in diameter. They are fastened with screws to the centre box that is an ALUBOS 600 prefabricated enclosure that has very good water proof capabilities. The size of the profile is 57mm x 32mm x 150mm (W x H x L)

2.1 Antenna data

Reflector 108cm

Driver 100cm

Director 88cm

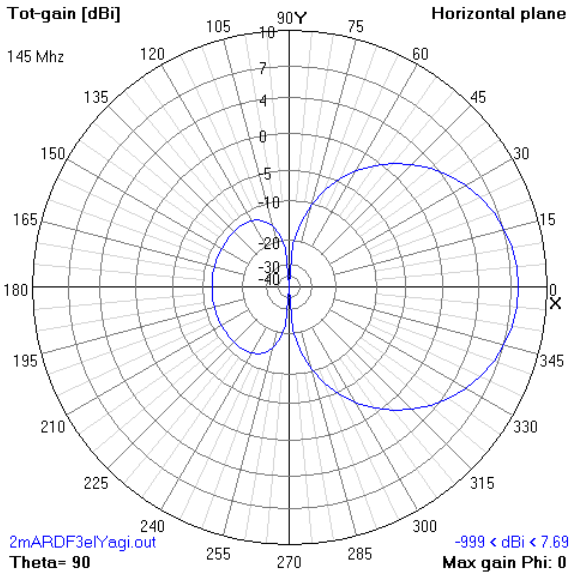


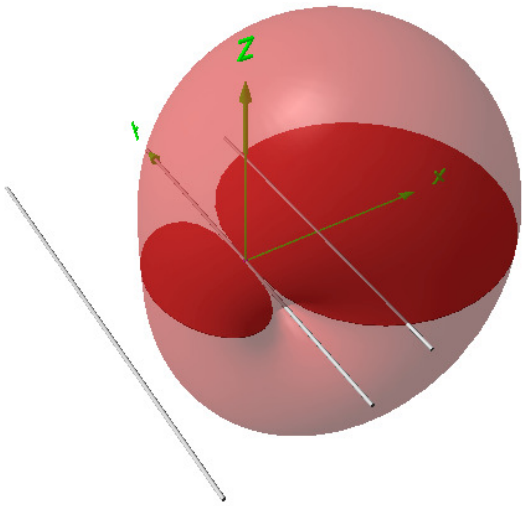
2.2 Antenna pattern

The antenna is simulated using 4nec2 by Arie Voors.

NEC input file:

```
CE
GW  1   13  0       0.5     1.5  0       7.5e-3  1.5  5.e-3
GW  2   13  0       -7.5e-3 1.5  0       -0.5    1.5  5.e-3
GW  5   1   0       -7.5e-3 1.5  0       7.5e-3  1.5  5.e-3
GW  6   27  -0.372  0.54    1.5  -0.372  -0.54   1.5  5.e-3
GW  7   23  0.2     0.44    1.5  0.2     -0.44   1.5  5.e-3
GE  0
EK
EX  0   5   1   0   1   0
GN  -1
FR  0   1   0   0   145 0
EN
```

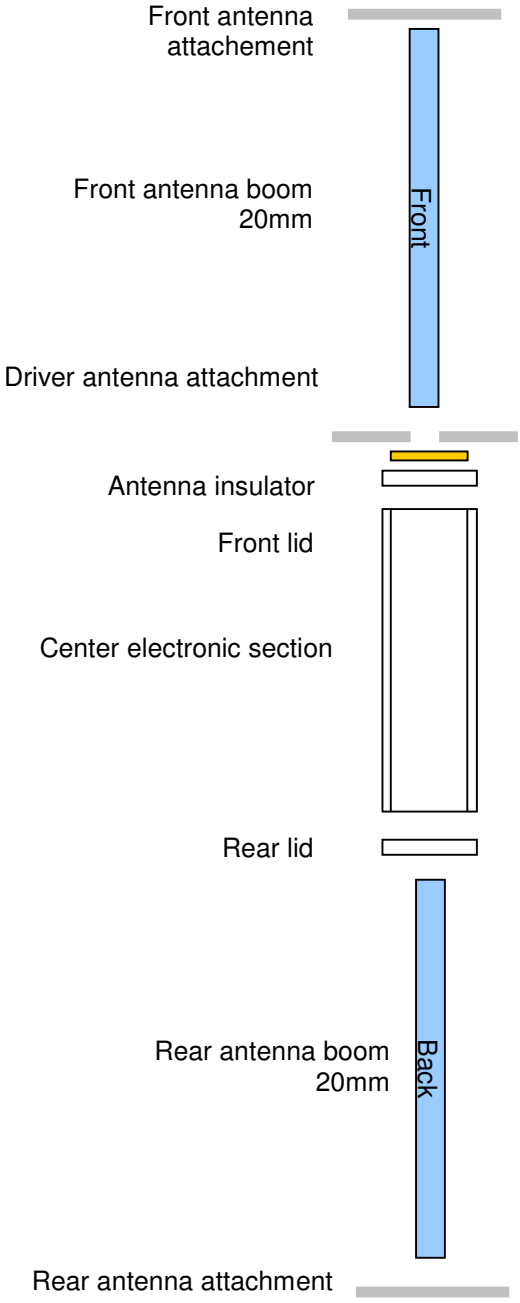




The elements used in the simulation are 5mm wires that don't match exactly the steel antenna, but this is not a critical issue. Antenna impedance is resistive and about 44ohm at 145MHz. This is a broadband antenna and not optimized for gain and will not be affected too much by how the runner holds the antenna.

2.3 Antenna boom

The antenna booms are cut as shown and drilled in the centre for M4 treads. The antenna booms are fastened into the centre electronic section and to the antenna attachments at each side.



Antenna elements

Reflector 53.25cm

Driver 49.00cm

Director 43.25cm

Antenna elements bulid-up

Primary element

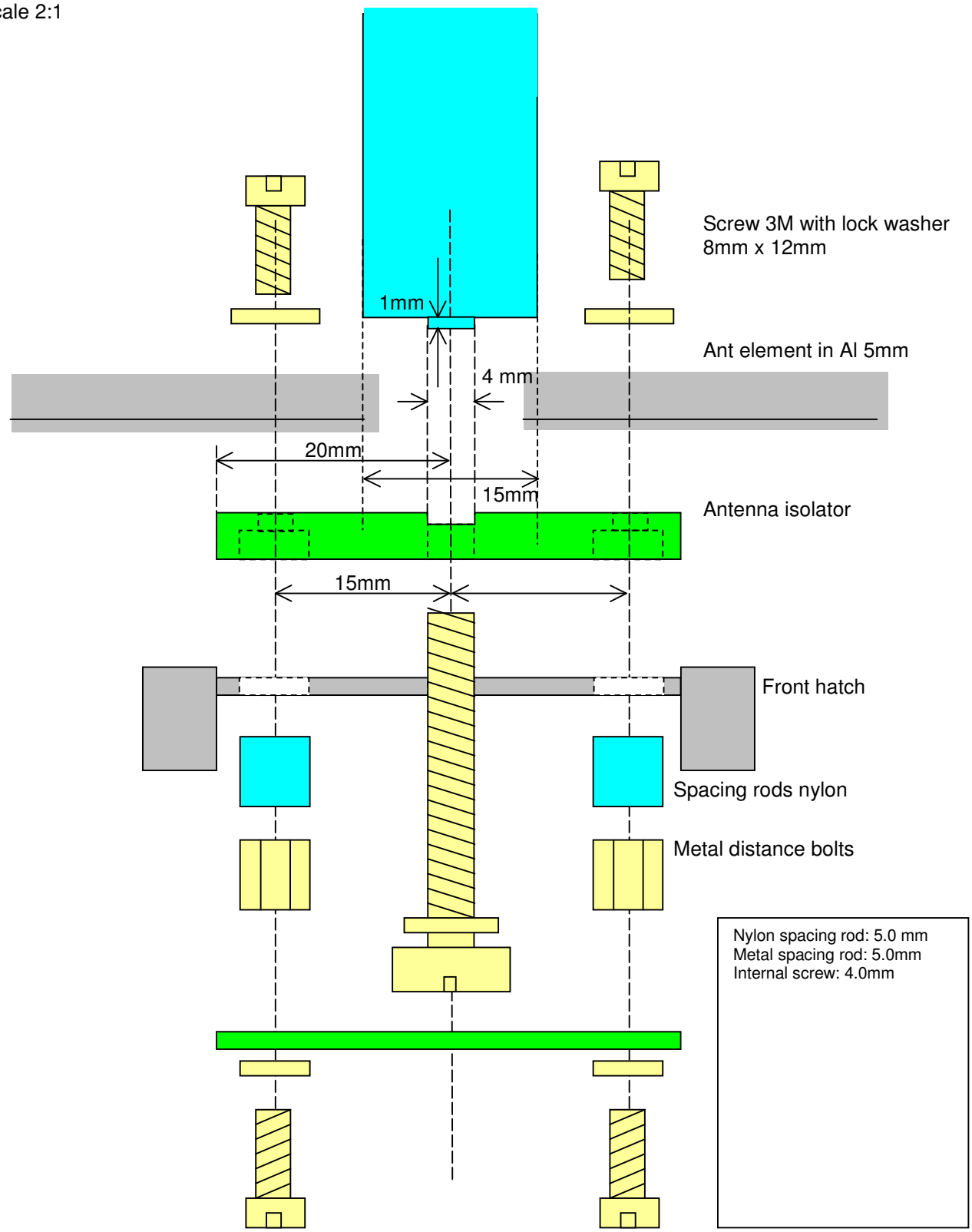
El 1. 30cm

El 2. 20cm

El 3. 10cm

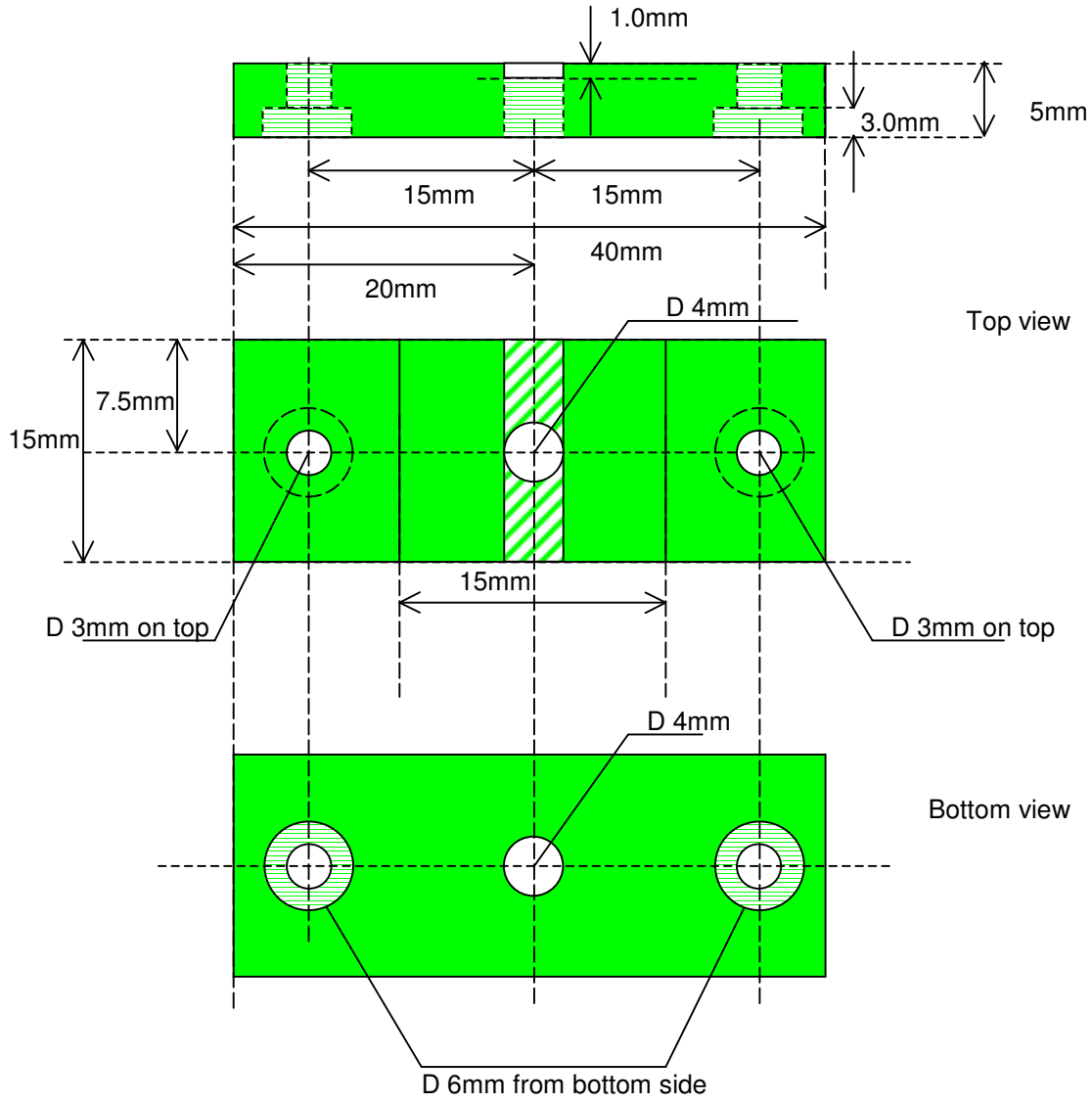
2.4 Antenna details

Scale 2:1



2.5 Antenna isolator

The antenna isolator can be made from any isolating material. A 5mm print board (epoxy fibre boar) has been used in the current receivers.



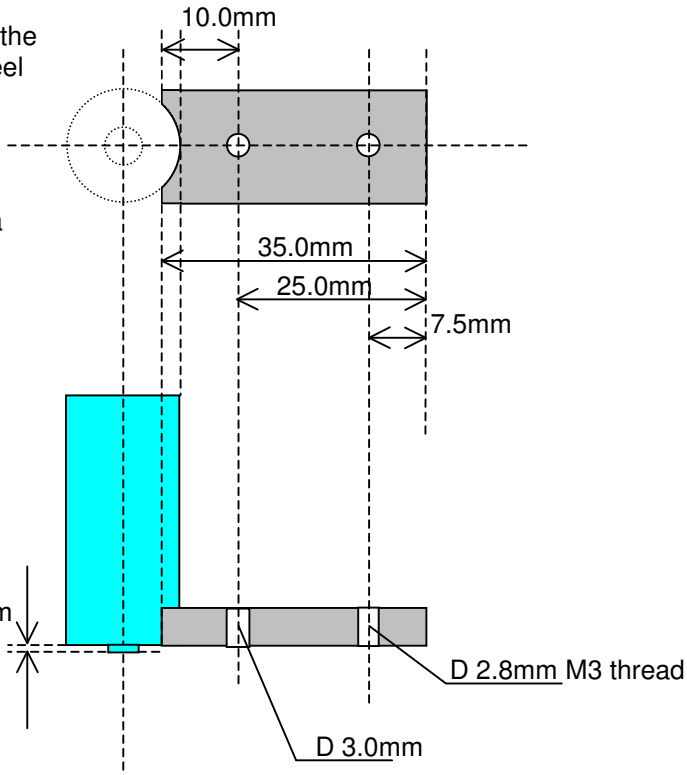
Scale 2:1

2.6 Driver attachment detail

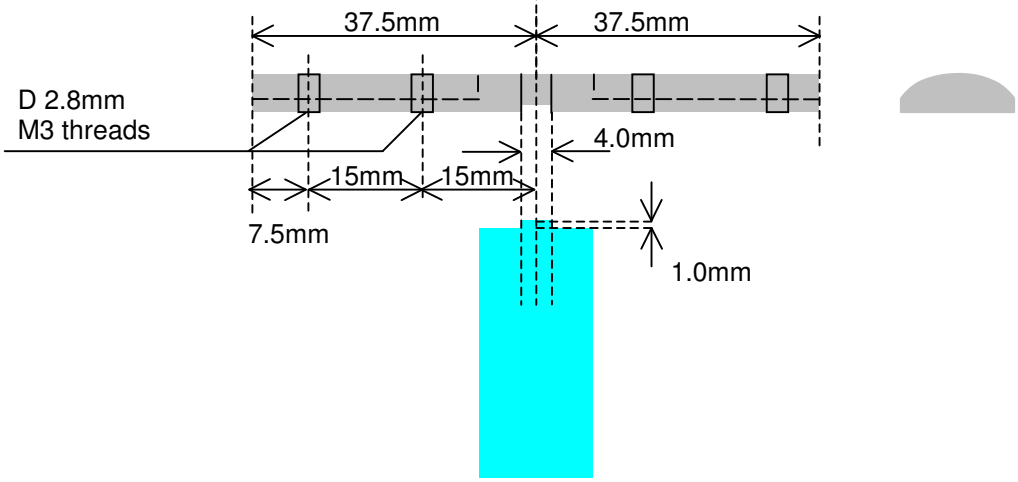
The driver attachment element is made out of a piece of aluminum size 5x15x75mm.

Use a hacksaw to cut the profile and shape the profile to match the curve of the antenna steel bands.

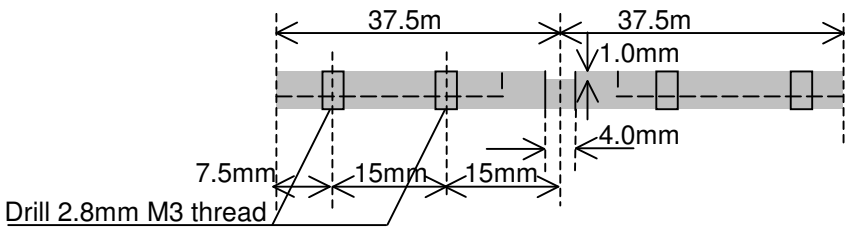
The front and rear part is used to fasten the antenna with 3mm screws. The center antenna attachment detail is fastened with a 3mm screw going into the internal PCB.



Director element attachment detail

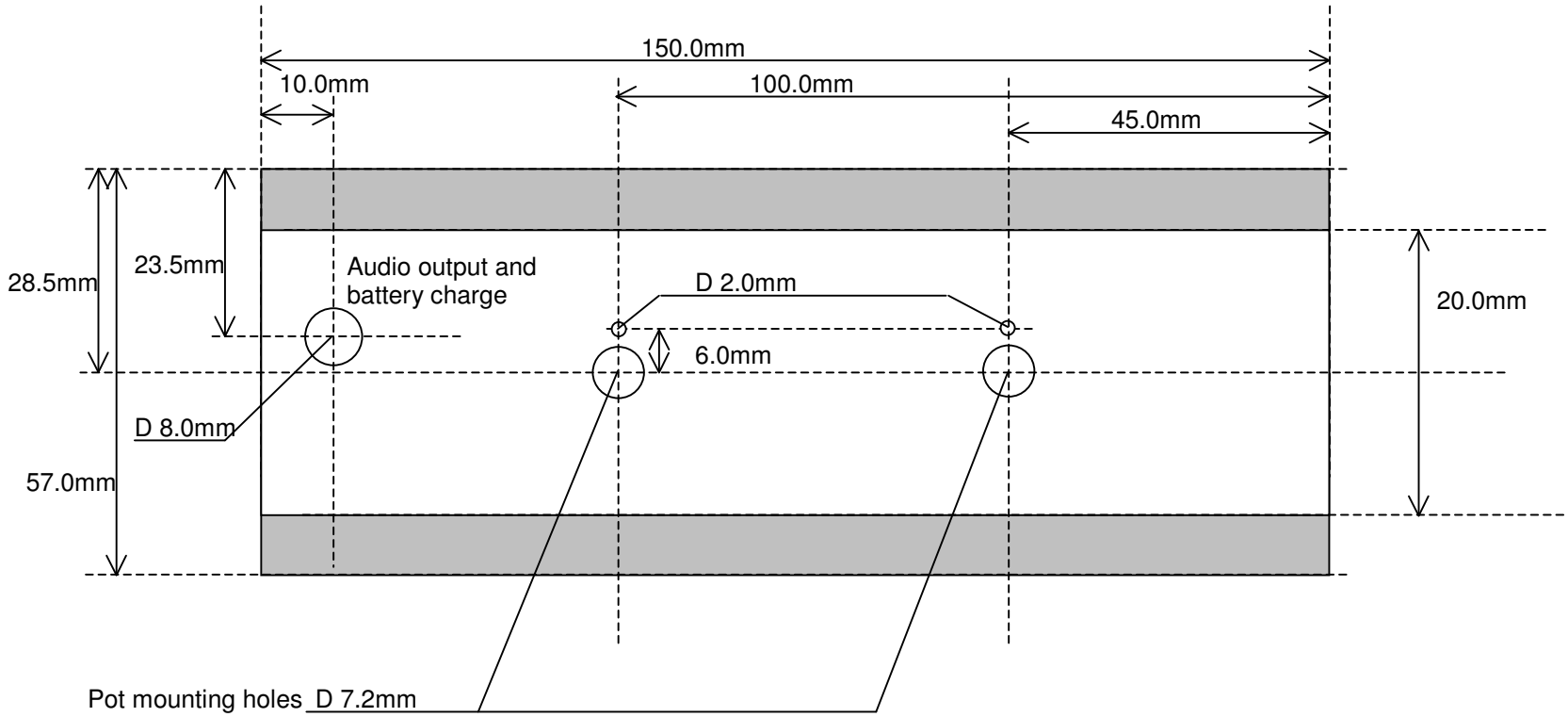


Reflector antenna attachment detail

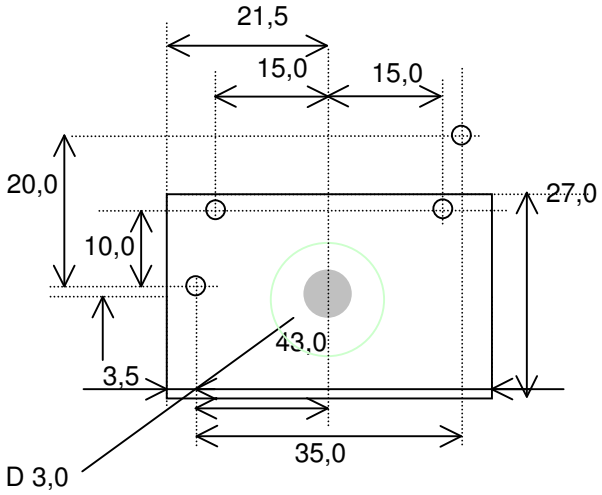


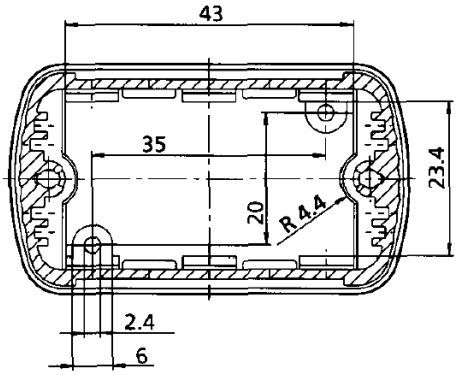
2.7 Audio and power control

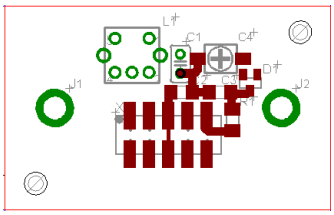
An internal PCB is mounted and attached to the top pot-meters that controls gain and frequency. This PCB is attached to the main bottom PCB through a vertical mounted PCB soldered to the bottom PCB. Battery, switch and audio are connected to the top PCB.

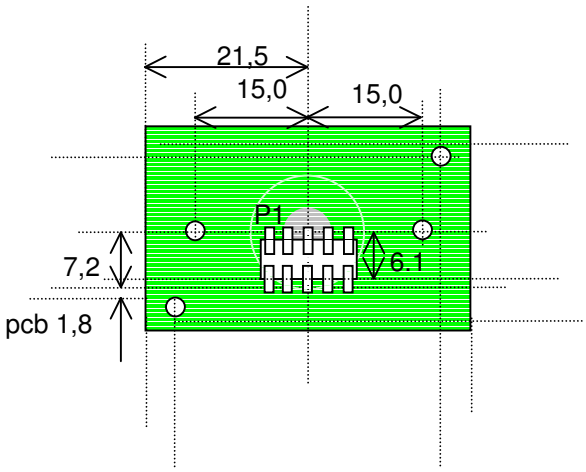


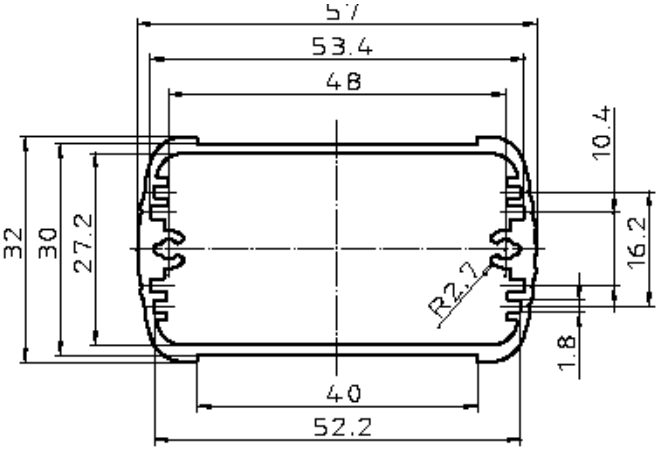
2.8 Antenna connection, internal PCB

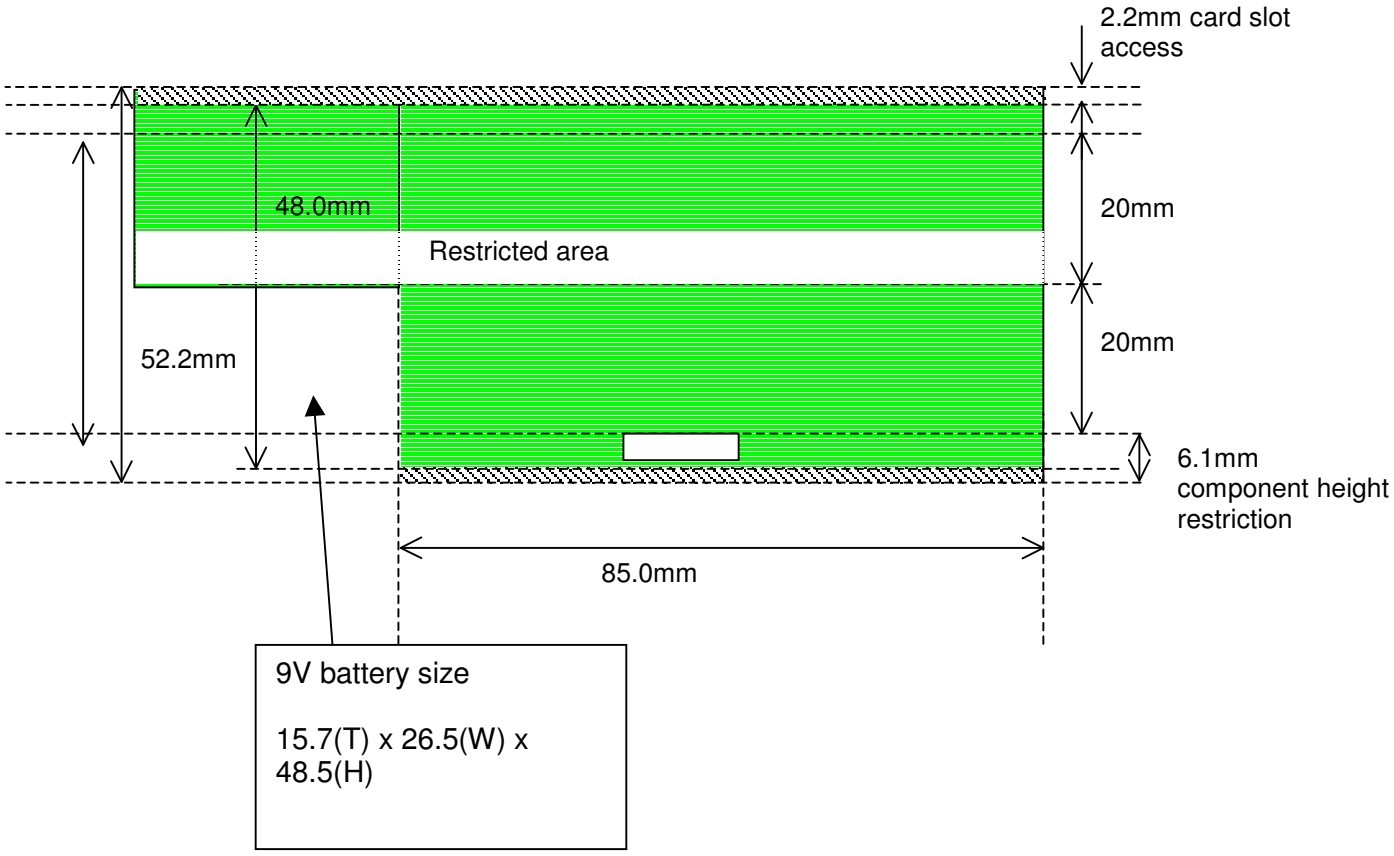












3. ELECTRONIC CONSTRUCTION DETAILS

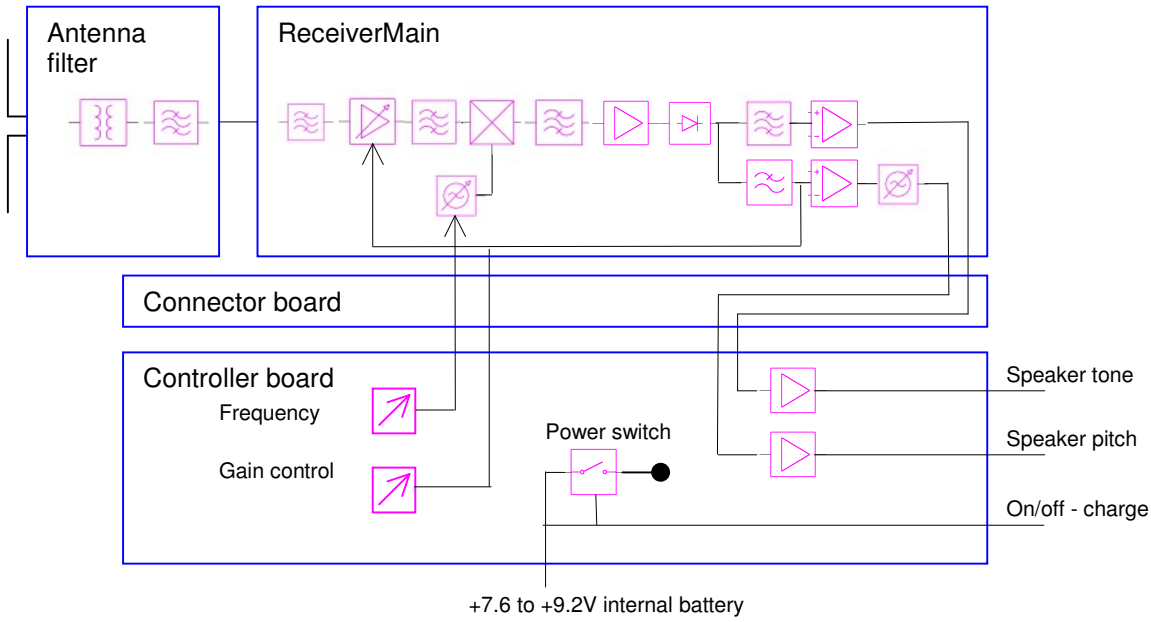
3.1 Internal units

The receiver consists of 4 boards. The schematics shown in this document are for reference only. The current schematic revisions are

Main board with RF front-end, the SA626/SA636 down converter and the audio filter and audio pitch signal strength indicator. The control board contains the frequency and gain control pot, and audio power amplifier and a charge and MOS-FET on-off switch. The connection board connects the control board to the main board, and also acts as a shield between the dual gate FET amplifier and the SA636 circuit. The antenna filter is part of the connection of the external antenna and the main board. This board also contains a transformer and a filter section.

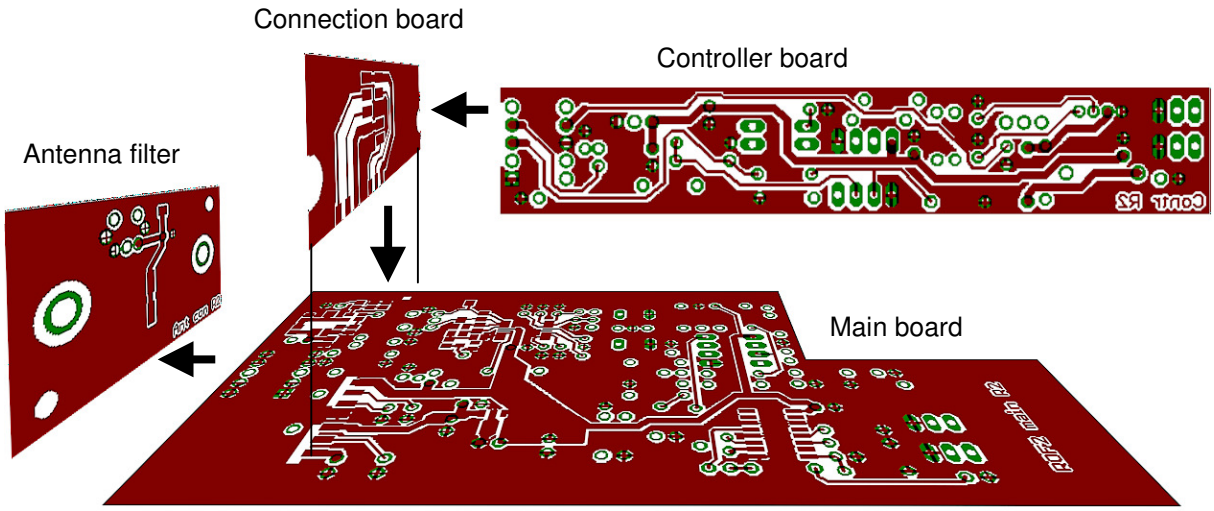
3.2 Block diagram

The block diagram shows the basic functions of the receiver. Some details as trim and level control are not shown.



3.3 Unit assembly

The illustration shows an exploded view of the board position. The boards are connected together with pin headers, except for the connection board that is soldered directly to the main board.



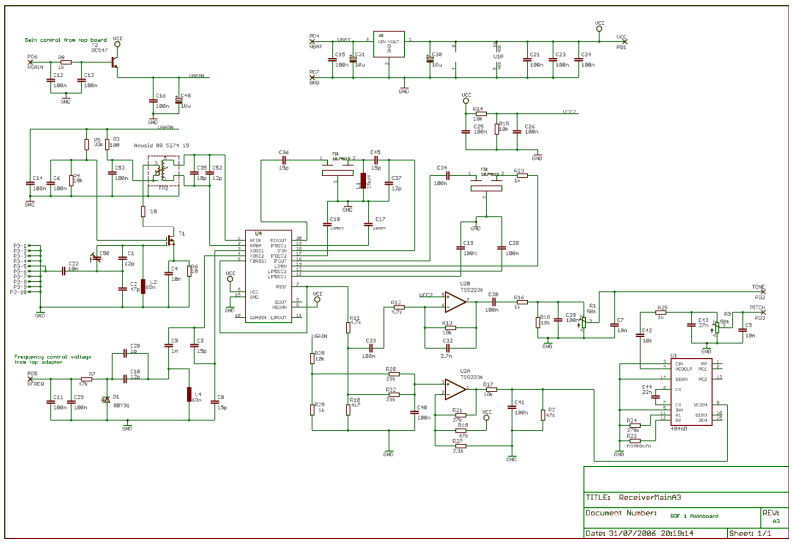
3.4 The main board

The main board is built around a SA636 (or SA626). The input uses a dual gate FET BF991 as a gain reduction element. The gain voltage is buffered in a transistor and is used for to control the input gain and to adjust the pitch tone.

A MF of 10.7MHz is used. The filter is a 25kHz channel spacing crystal filter. The filter needs impedance adjustment from 330 ohm to 3kohm. This is done on the first filter only, while the second filter uses a resistor as it's recommended with 12dB attenuation on the second IF amplifier section according to manufacturer application note. The impedance matching is not perfect, but adequate for the receiver performance.

The RSSI output is filtered and used to drive the pitch oscillator. The high sensitivity of the pitch oscillator requires compensation and a summation gain block is used by summing the RSSI and the gain setting. The audio filter is centred on 1kHz.

The VCO uses SMD components only and the adjustment of the VCO is done by regulating the frequency control voltage on the controller board.



The LC oscillator uses a varicap diode and a chip inductor of 68nH to generate the internal oscillator frequency. The frequency range is quite large and the voltage is controlled in the controlled board by two trim-potentiometer, thus the upper and lower frequency range can be adjusted.

The C10 and C28 are also used to pull the oscillator to the correct range, and some value tuning might be required.

Varicap properties:

Max 20pF Min 8pF

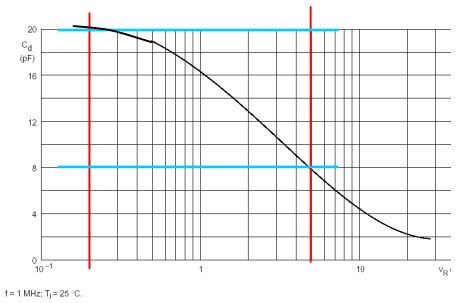
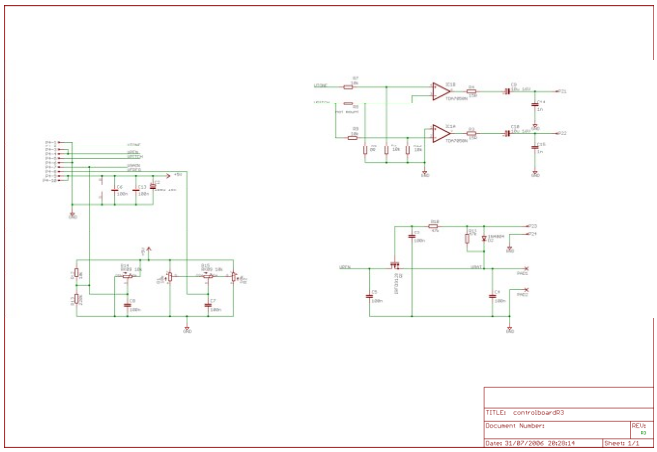


Fig.2 Diode capacitance as a function of reverse voltage; typical values.

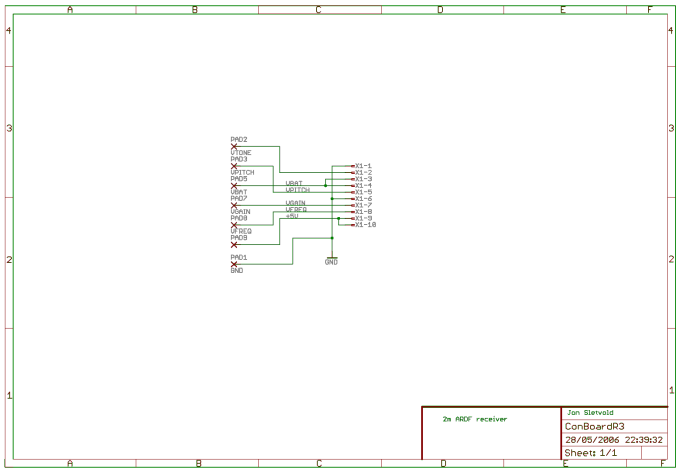
3.5 The controller board

The controller board has a stereo power amplifier. The signal from the main board can be mixed to one channel, but normal operation is to use stereo headset. The output serial resistors are used to avoid short-cut of the signal when using mono jack, and will also minimise the level difference when high impedance hearing plug is used.



3.6 The connection board

The connection board is soldered to the main board and acts as both an interconnection between the main board and the controller board, but also as a shield between the low level antenna signal and the internal high level signals.

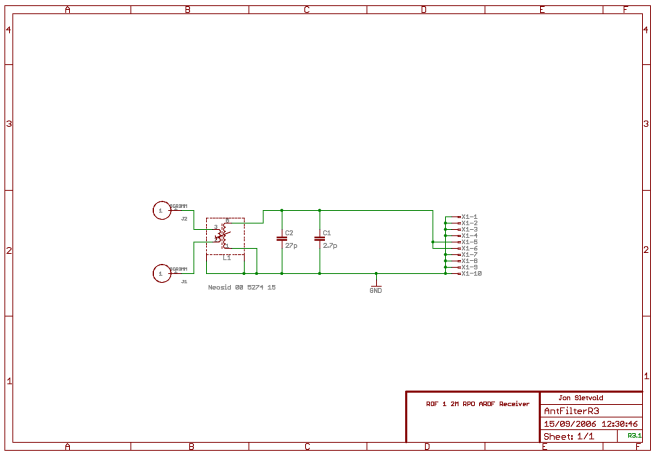


3.7 Antenna filter

The antenna filter board both filters and converts the balanced antenna to an unbalanced signal.

The transformer will also increase the impedance to the dual gate-fet input, and act as a band pass filter.

The filter is tuned together with the input capacitor C50 on the main board.



3.8 Audio connection and charger

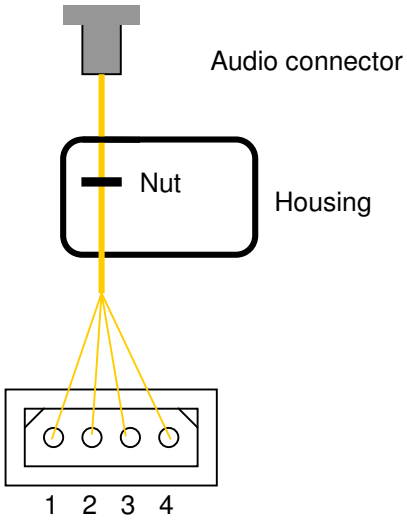
The audio connection uses a 4-pole connector from Marushin, MJ-064H. The connector is mounted to the chassis with a connector for easy attachment to the controller board. Water proofing can be applied by using proper glue/silicon over the soldering and in the chassis hole.

The connector is installed into the mechanical housing prior to the installation of the PCB. The wires are soldered to the audio connector and to the 4 pole McMuro connector (type 201F4C03U 4) as shown below. Remember to put the wires though the audio connector hole before soldering. Also remember to put the nut on the correct side of the housing.

The radio is switched on when a stereo jack with three poles is used and the connection pin 3 is short cut to the GND pin 3.

Charging of the internal battery is done by connecting a current limited voltage source between pin 3 (+) and 4 (0V). An internal diode is used to connect the charge voltage to the battery. A prefabricated cable from Marushin, type MC-4350 can be used.

Pin	Function
1	Right audio – pitch
2	Left audio – tone
3	Charge or on-switch.
4	Common GND



3.9 Battery

A NiMh battery is recommended for the radio. The charger must be capable of delivering 12-15V and with the current limitation of 15mA to 30mA, depending of the battery charging requirements.

A battery connector (Elfa number 42-041-78) is soldered to the ControllerBoard PAD1 (+) and PAD2 (GND).

3.10 Soldering

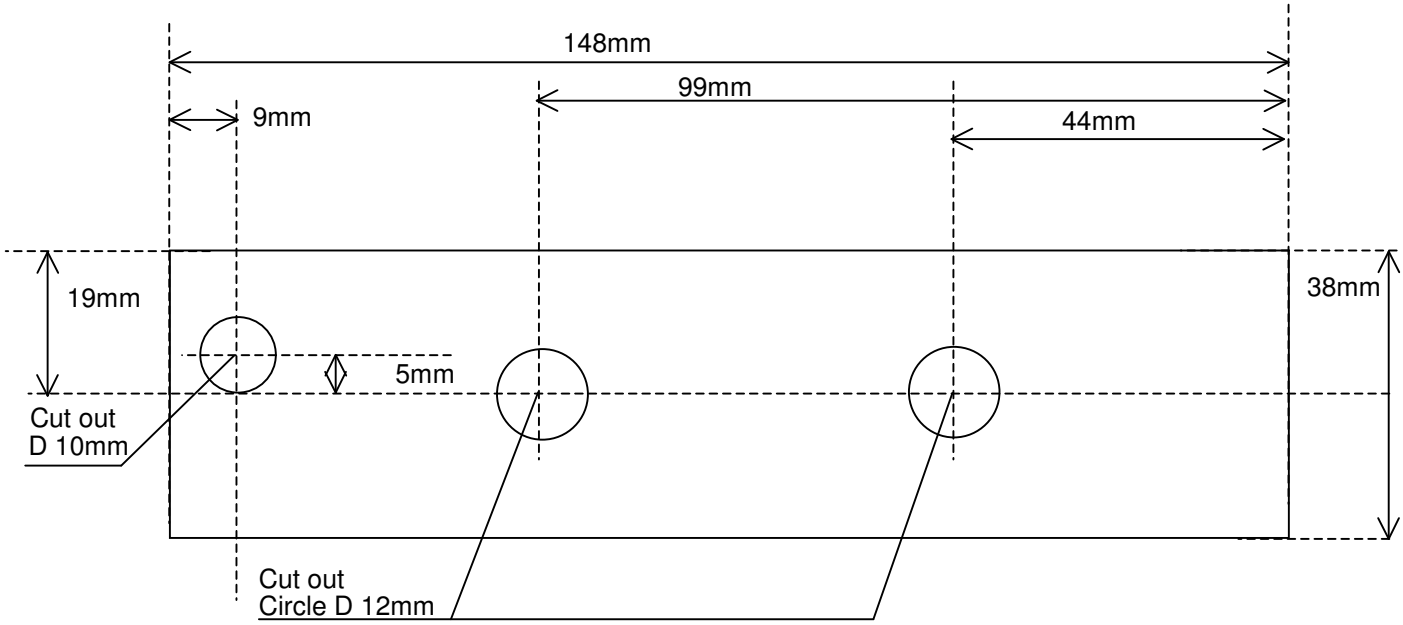
Test the position of ConBoard X1 connector in the mechanical housing before soldering all pins. Install the ControllerBoard in the housing and solder the ConBoard to the ReceiverMain board. Slide the ReceiverMain board into the housing and verify from the front that the connectors on the ConBoard fits the ControllerBoard.

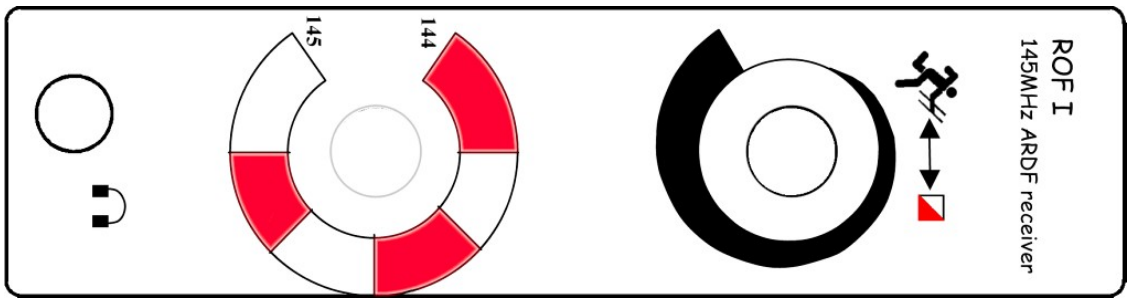
Perform the same alignment with the AntFilter connector X1.

4. TOP AND BOTTOM STICKER

The sticker is printed on a waterproof material with the size and marking as shown.

Contact the author about premade marking.





ROF-1 ARDF receiver
144-145MHz

Rev:

Ser #:

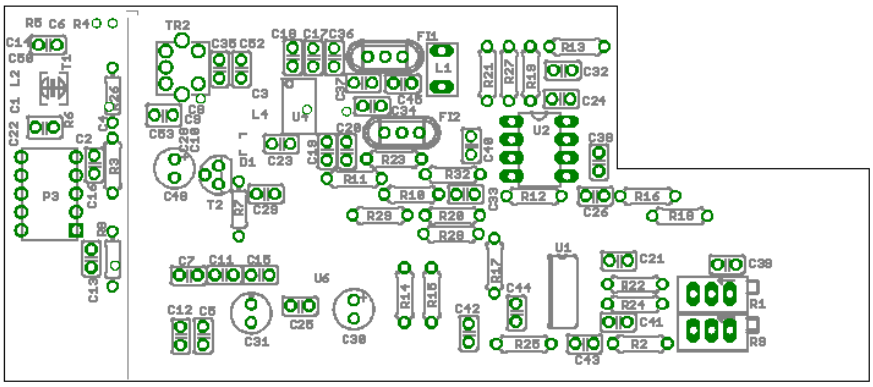
Name:

Country:

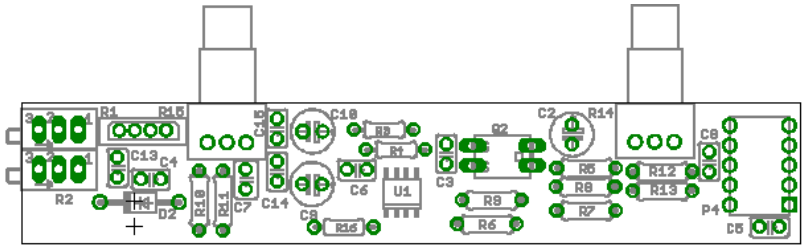
Tel:

5. COMPONENT PLACEMENT

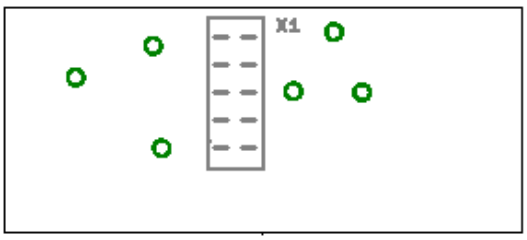
Main board components



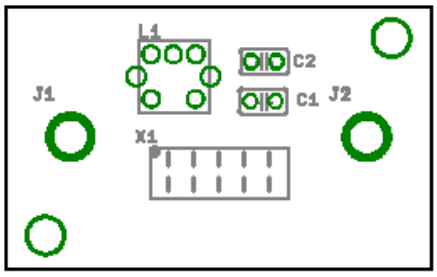
Controller board component placement



Connection board component placement



Antenna filter component placement



6. TUNING AND TESTING

The receiver is tested prior to installation into the mechanical housing.

Attach all boards, power and audio connection. Test for any short cuts on the +9V and +5V power supply before connecting the battery.

Connect the +9V battery. Test the internal +2.5V reference on the ReceiverMain board VCC2 to be within +/- 10%.

Adjust gain to max and verify voltage VGAIN to be about 4.6V.

The gain pitch tone should now be in one of the earphones. Adjust ReceiverMain R9 to get a reasonable level.

Adjust R1 on the controlboard to about 1V on themid tap and R2 mid tap voltage to about 3V. Apply a signal of 145.500MHz and –10dBm to the receiver antenna input and adjust the frequency control R15 until the pitch tone increases as the correct internal VCO frequency is found. R1 and R2 set the frequency range by tuning the top and bottom voltage of the VCO control range. Typical frequency range is 144 to 145MHz.

Decrease the input signal and adjust the variable inductors TR2 and capacitor C50 to peak the signal strength pitch. Also adjust the AntFilter L1 to increase the pitch. This inductor is a little bit difficult to adjust, but turning the AntFilter board upside down and attaching to the ReceiverMain board is a way to do this.

Tune the receiver both the upper and lower end of the frequency range. Adjust the signal generator gain as the tuning is peaked. A correctly tuned receiver should be able to detect a carrier signal as low as –110dBm. It's possible to tune the receiver filters a little bit up and down on each side to get a broader frequency response on the cost of reducing the peek performance on a small frequency area. This is not a broad range receiver, but adequate performance should be possible within a 2MHz bandwidth.

Install the electronics in the housing with the antennas and retest the receiver. Some adjustment to L1 and C50 might be required

Test the receiver with ARDF transmitters. Peek the signal with the frequency control first. Adjust the gain to verify that the receiver is not saturated. The receiver should be able to detect direction to a transmitter within the range of 5m when the gain is set to low. Some training is necessary to learn how the receiver behaves.

The current consumption is about 18mA at max gain, and down to 11 mA at the low gain. A 180mA/h 9V battery should make the receiver work for at least 10h.

7. REFERENCE SOURCES

This project would not have been accomplished without available software and information made available on the internett:

Development:

Eagle CAD Schematic and layout software: http://www.cadsoftusa.com/

SwCADIII Spice simulator from LinearTech, LTSpice/SwitcherCAD III: www.linear.com

4nec2 Antenna simulation software: http://home.ict.nl/~arivoors/

Design sources:

Audio pitch:
http://www.users.bigpond.net.au/vk3yng/foxhunt/80m_sniffer/80m_mk2/80m_sniffer_text.html

ROX-2: http://www.open-circuit.co.uk/home.php