13cm LNA

Low Noise Amplifier for the 2.3GHz band

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Advance information.....this will change!

Introduction

I have successfully modified the components in my 23cm VLNA to allow it to work on the 13cm (2320MHz) band. The results of my testing are that the prototype pre-amplifier is providing a measured noise figure of about 0.30 - 0.33dB with 25 - 26dB of insertion gain.

Note. *This is NOT a claim that this pre-amplifier will achieve this noise figure. Accurate NF measurement is notoriously difficult to do and there are lots of pit-falls for the unwary. The picture above shows a spot measurement I made whilst developing this LNA. But you must agree that it looks impressive!*

The pre-amplifier uses the 23cm VLNA PCB with an Avago ATF36077 GaAs FET first stage into an ATF54143 second stage. It was necessary to re-calculate the noise match for the 36077 at 2320MHz as well as the interstage matching into the 54143 in order to achieve acceptable gain and overall noise figure. Only the ATF36077, followed by an ATF54341 should be used in this pre-amplifier.

If there is sufficient interest then I will offer 13cm LNA kits. These will contain the necessary components to make the 13cm version of the existing 23cm VLNA. Commercial, silver-plated, plated-through-hole (PTH) PCBs and parts kits for the

13VLNA will be available from the author. No connectors or feedthrough capacitors will be offered, as with the existing 23cm VLNA.

These pre-amplifiers will be offered with the same tinplate box housing as for the 23cm VLNA. When used with the supplied RF absorber tile, these amplifiers will be unconditionally stable.

Circuit description

The circuit schematic is shown in Fig 1 below.

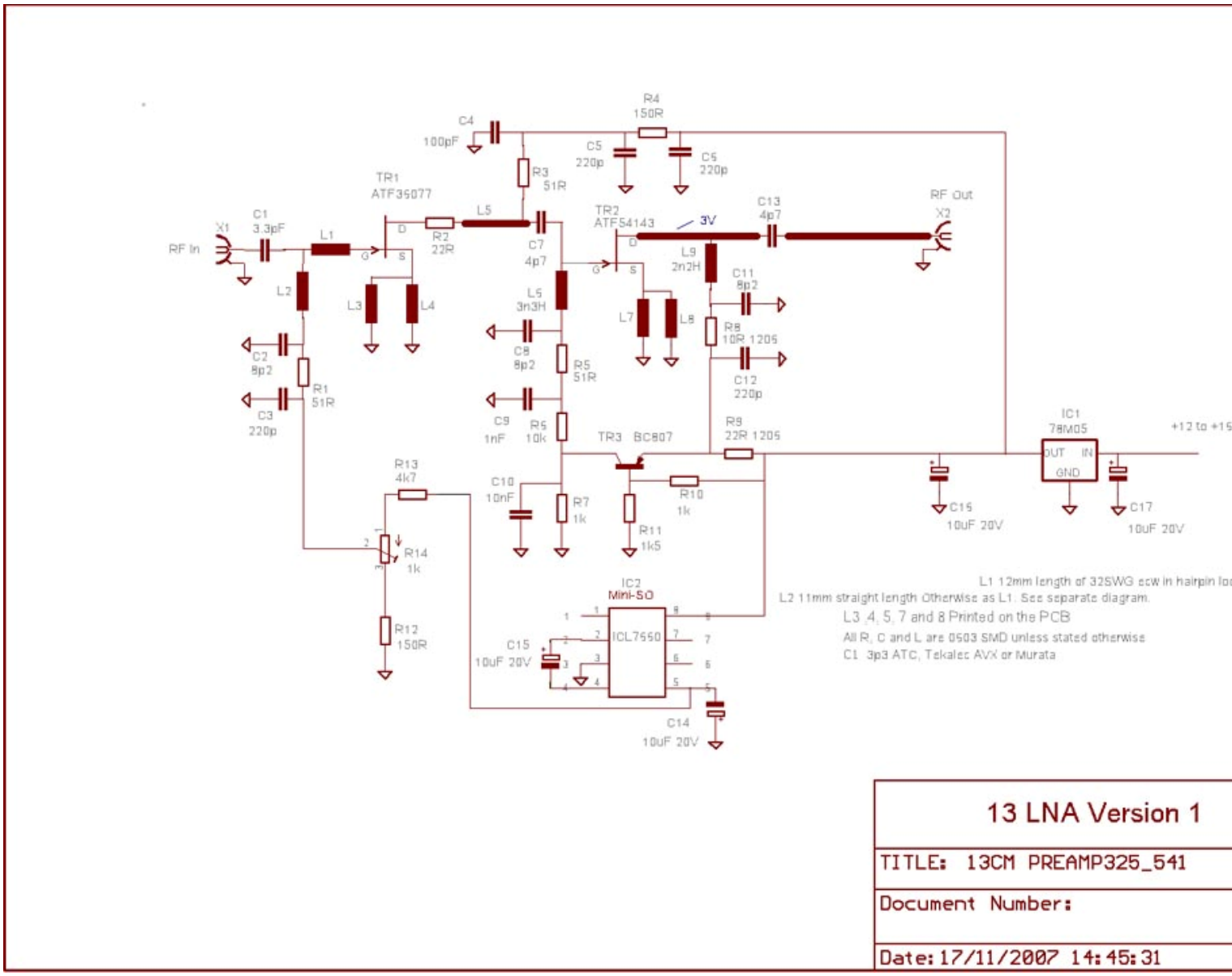


Fig 1 circuit schematic of the 13cm LNA.

The input circuit consists of a ‘T’ match with suitable low loss capacitor and inductors. Photo 2 shows the input arrangement. Low noise matching is achieved by adjusting the position of the hair-pin inductor, L1. The lowest noise figure occurs when L1 is at right angles to the FET.

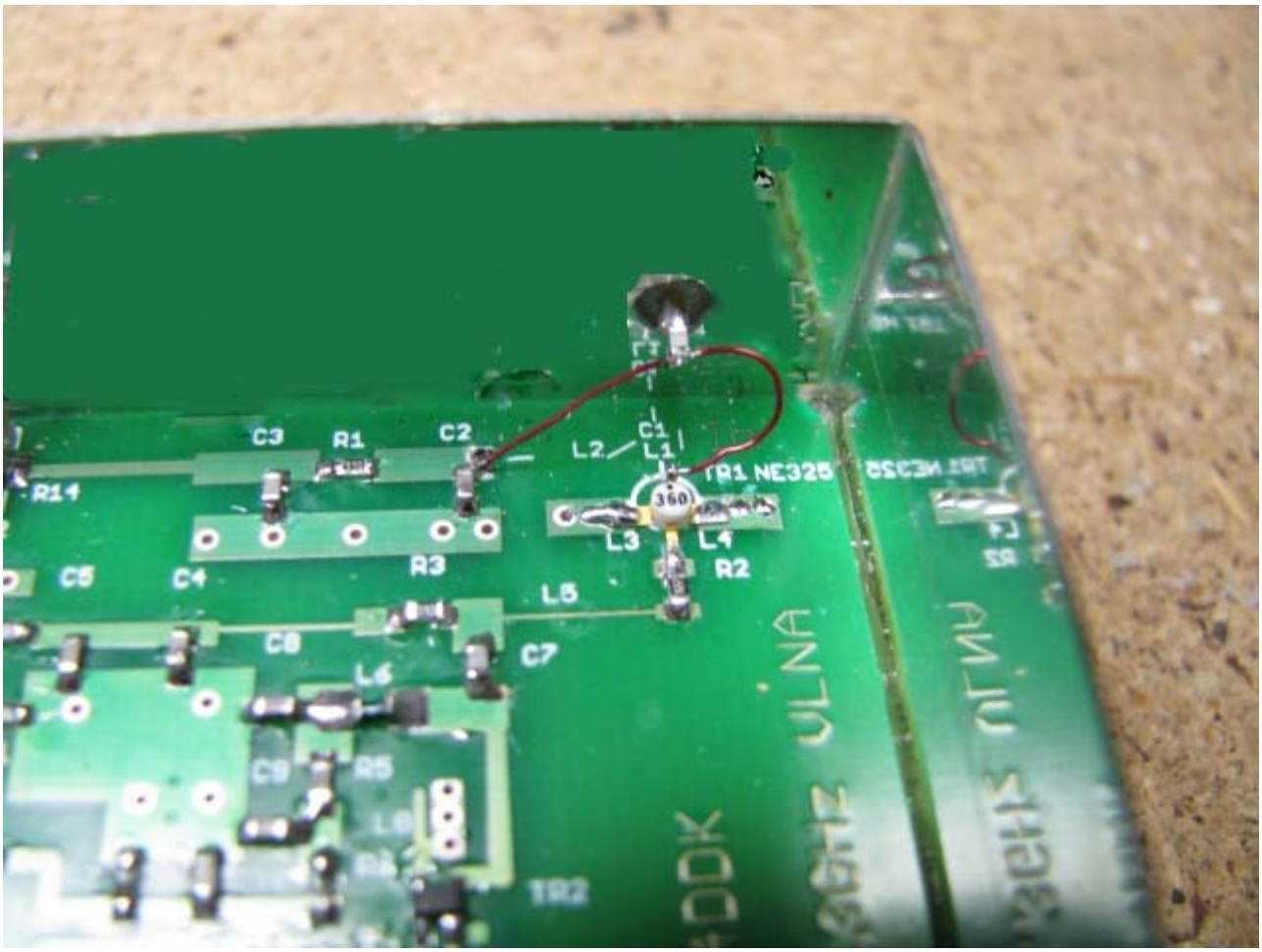


Photo2
Shows the input hairpin loop, L1, and the bias decouple, L2. The series input capacitor is 3.3pF.

Except where indicated, 0603 size surface mount components are used on the board in order to minimize component parasitics. This has proven most successful and it is a genuinely good reason to move towards 0603 or even 0402 size parts in all designs above 1GHz.

Negative bias for the ATF36077 is provided by an 7660 DC-DC inverter IC. R14 allows a range of adjustment, from approximately -0.4 to -1.2V. The bias adjustment range has been modified from the original 23cm VLNA. R13 has been changed to 4.7k and R12 has been decreased to 150R.
R4, in the drain supply to Tr1, has been increased to 150R.

Active bias was chosen for Tr2 as the drain current is set quite high, at 60mA, to achieve a good dynamic range. At this elevated current I felt that active bias would help to maintain circuit performance. This is provided by Tr3, a BC807 PNP transistor .

The whole unit runs from a 5 volt, 500mA regulator IC that uses a surface mount (D-Pak) 78M05 regulator soldered to the PCB ground plane to act as the heat sink. A TO92 packaged 78L05 will not supply enough current without over-dissipating.

D1 is there to ensure that an accidental reversal of the supply doesn't destroy the pre-amplifier. The Trucap tantalum capacitors, especially C17, seem to be very sensitive to even small reverse voltages. If you do accidently connect up the supply with reveresed polarity, the preamp should survive, although C17 may need to be changed to ensure longer term reliability. This is probably true for many tantalum capacitor manufacturers.

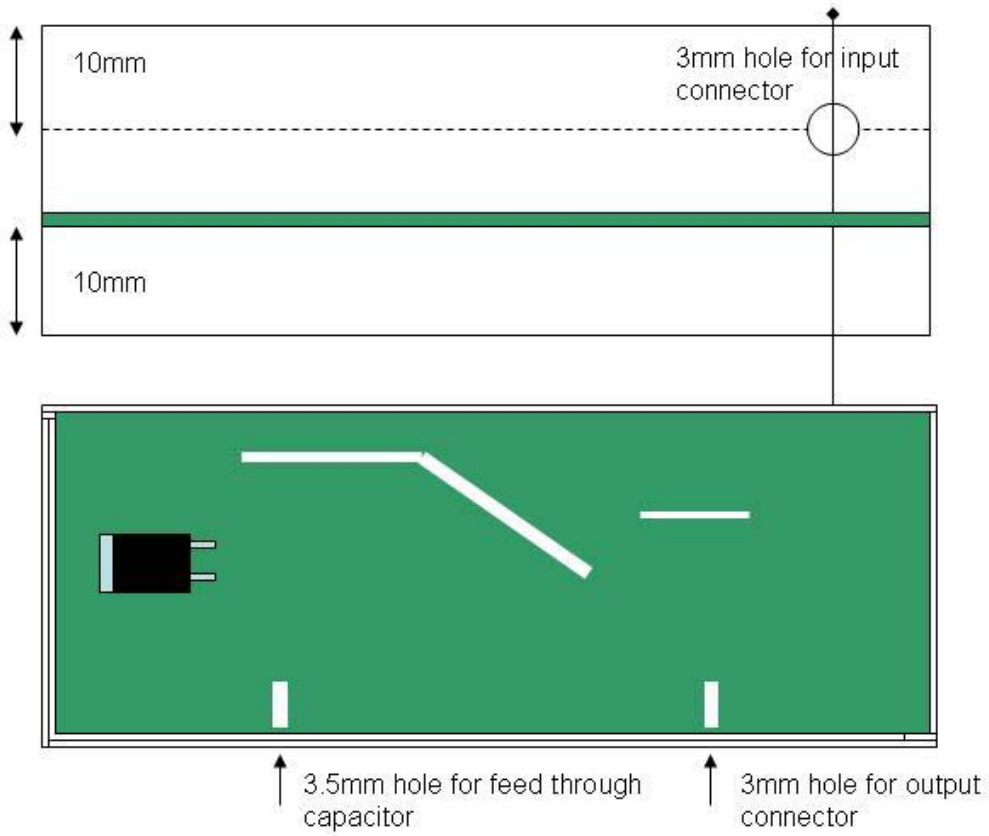
The RF absorber material IS PART OF THE DESIGN and must be used if the full performance of the pre-amplifier is to be achieved.

Construction

The PCB is designed to fit into a popular 74 x 37 x 30mm tin plate box. A revised PCB will be offered in the kit.

It is advisable to solder the four 10uF Tantalum capacitors, R14 and 78M05 voltage regulator to the board before this is soldered into the tinplate box as the capacitors near the 78M05 and R14 will be found difficult to solder afterwards. Do watch the polarity of the tantalum capacitors.

Prepare the tinplate box, drilling holes for the SMA RF connectors and the DC feed-through capacitor.



Board in the box information.

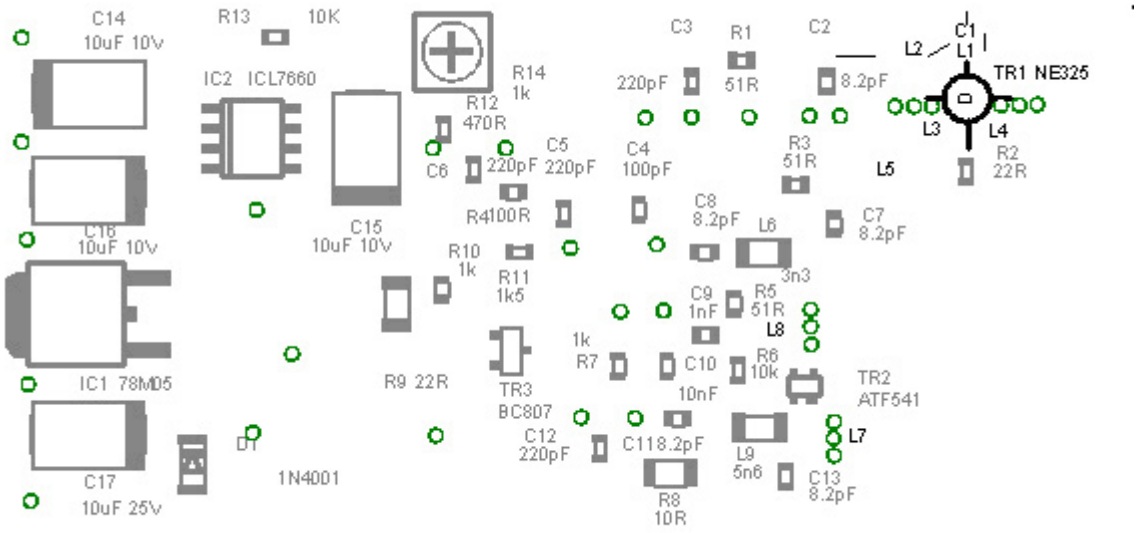


Fig 3 layout. This is for the 23VLNA. Tr1 is an ATF36077. C7 and 13 are now 4.7pF. L9 is 2n2H.

The input connector hole should be 10mm below the top rim of the box. The output connector hole should be level with the pre-amplifier output track. The feedthrough capacitor hole should be 10mm below the rim of the box and on the same box wall as the output connector. Both RF connectors can be drilled 3mm diameter, although the hole for the feedthrough capacitor should obviously be drilled to accomodate the actual capacitor used.

Mark a line 10mm below one rim of the box (a vernier caliper is ideal for this). This is the ground-plane position. Seam-solder the PCB into the box, taking care to ensure it is level and then soldered all the way round including on the component side at the regulator end of the box. It will be necessary to file small cut-outs in two corners of the PCB in order to clear the seam overlaps in the box.

Use small gauge solder (28swg - nothing larger) and a fine-pointed small soldering iron to solder all the components onto the board. Regular 22swg solder is GUARANTEED TO MAKE A MESS OF THE BOARD! Suitable solder can be obtained from Rapid Electronics of Colchester as a SMD rework kit. Regular 22SWG solder is probably best used only to assemble the box and for seam soldering the PCB.

Solder C1 onto the spill of the input connector. Solder L2 so that one end is on the track pad, as shown, and the other end is soldered carefully to the free end of C1. Solder L1 so that the **bottom** of the loop is free to be soldered to Tr1 gate. The spill of the input connector must be cut down so that it protrudes no more than 1mm inside the box.

D1 can be soldered direct between the feedthrough capacitor and the (cathode - bar) PCB land or soldered onto the board in the place indicated, with a wire connection

between the diode anode and the feedthrough. An SMD style diode will probably be offered in the kit.

Solder in the two GaAs FETs after the initial setting up.

Initial Setting up

Connect +12v to +16v to the feed through capacitor. Check IC1 for +5 +/-0.2V at its output.

Check that the output of IC2 is -5 +/-0.2V

Check that the variable resistor R14 adjusts the output voltage at the free end of L1 over the range -1.2 to -0.4V. Initially set it at -0.8V

If any of these tests fail, check for incorrect component values or bad joints.

Solder the GaAs FETS into place, ensuring correct lead orientation, especially the leads of Tr2. It is best to use a small insulated soldering iron to prevent static damage. Touch the soldering iron TIP to the tin plate box before soldering the GaAs FET leads.

Correct the power supply to the box and adjust R14 so that Tr1 drain voltage is 2.0v. Also check that Tr2 drain voltage is about 3.0V.
Measure the noise figure. Now carefully bend the hairpin loop as shown in photo 2. Re-measure the noise figure. It should now be very low. Now CAREFULLY re-adjust the position of THE HAIRPIN for the lowest NF. Care here will be rewarded. Now go back and adjust R14 to obtain the lowest noise figure.

RF absorbent material should be stuck to the inside of the lid of the tin plate box. If using the supplied piece of ARC material, remove the protective paper from the rear of the absorber. Stick the absorber towards the end of the lid nearest the amplifier section. Putting the lid in place should not result in any increase in noise figure or loss of gain. This stuff is MAGIC!

The magnetic field absorber material supplied with the kit has been carefully selected to ensure stability.

Results

The pre-amplifier has had only limited testing at this time. The results are about in-line with expectations. An additional 3dB MIGHT be squeezed from the amplifier with some further circuit changes. Please remember that the PCB is FR4, not PTFE.

Expect <0.4dB noise figure and >25dB gain.

The prototype was tested between 2300MHz and 2350MHz with almost identical results and NO further adjustment. It is to be expected that the noise figure will remain sensibly constant across the entire amateur 13cm band (2300 to 2450MHz).

Caveat Emptor

The pre-amplifier is offered as a kit, the noise figure and gain achieved will depend on the individual constructor's ability with the soldering iron and patience in setting up the pre-amplifier.

The pre-amplifier should only be operated with the lid in place. This will keep out unwanted WiFi and other signals in the S band range.
However, without the high quality commercial magnetic field absorber material inside the tin plate box lid, putting the lid in place is guaranteed to degrade performance. Foam absorber, such as 'CMOS' foam, will not work very well in this application. Please use the right material. It is as much a part of the design as the FETs used!

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