# Low noise pre-amplifiers for the 1.3GHz, 2.3GHz and 3.4GHz bands

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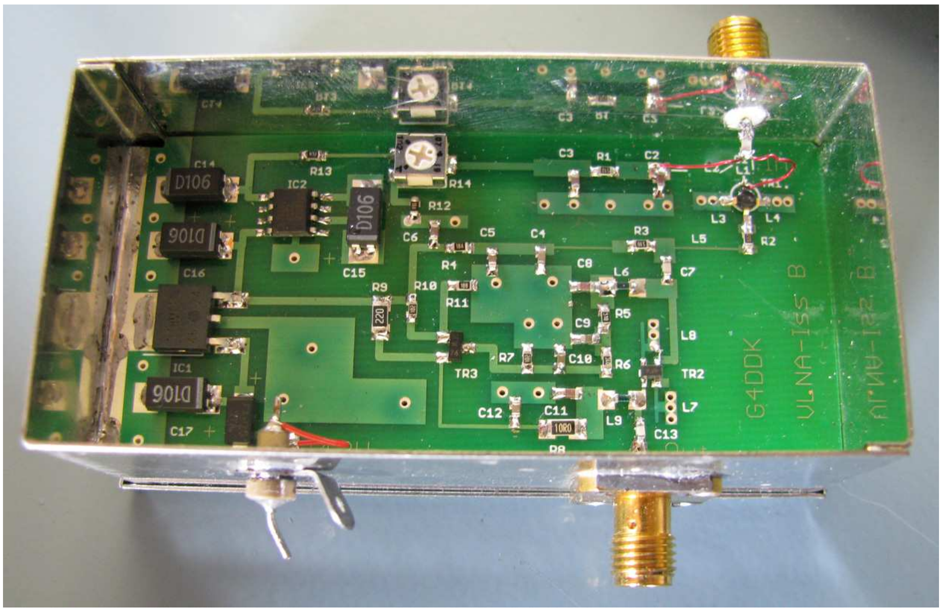


View of the 13cm pre-amplifier

## Introduction

Following my successful use of a small 2.3m diameter TVRO dish for 1.3 and 2.3GHz EME I received a number of requests for details of the pre-ampliers I used. At this time the 1.3GHz pre-amplifier was the well-known WD5AGO, whilst the 2.3GHz one was a modification of a design by W5LUA. I made PCBs for a numbers of amateurs in Europe and in general these worked well, which is a testament to the solid designs from Tommy and Al.

Because of ongoing demand and difficulties obtaining new ATF10135 MESFETs for use in the second stage of the1.3GHz pre-amplifier, I decided to investigate an alternative second stage device. I also decided to house the pre-amplifier in the small (74 x 37 x 30mm), and readily available Schuberth tin plate box.

Noise figure and gain measurements in the UK, The Netherlands, Germany, as well as at Central States VHF Conference 2007 have shown that a stable, repeatable, noise figure of around 0.25 – 0.27dB, with an insertion gain of 36dB, is achievable with the 1296MHz version.

It was immediately apparent that the pre-amplifier board also had the potential to work at 2.3GHz with some component value changes. Installing components with the calculated values (and some empirical substitution!) the result was a noise figure of around 0.35dB and an insertion gain of about 26dB. The reason for less gain at 2.3GHz is partly due to lower gain in the second stage device and the use of a non-optimum microstrip line which is part of the 1.3GHz design.

However, for EME work, even an insertion gain of 26dB may be enough to eliminate the usual second pre-amplifier unit.

Further work showed that the pre-amplifier could also be made to produce an acceptable noise figure and gain in the 3.4GHz amateur band. The initial noise figure achieved at 3.4GHz is between 0.5 and 0.55dB with an insertion gain of around 28dB.

Versions of the preamplifier have been successfully tuned for use at 1090MHz, 1240 - 1296MHz, 1420MHz, 2200 -2290MHz and 2302 – 2320MHz, all with excellent results.

## Circuit description

The circuit schematic is shown in Fig 1

Two different low noise GaAs FETs have been specified for use in the 1.3GHz preamplifier. The NE32584 gives the lowest noise figure, but these are no longer available from NEC. The ATF36077 also works extremely well but has a marginally higher noise figure at 23cm. The NE32584 is therefore the preferred device for 1296MHz EME. The second stage device is an Avago ATF54143.

The input circuit consists of a ‘T’ match with suitable low loss capacitors and inductors. These are mounted in air, rather than soldered to PCB pads, in order to keep parasitic strays to a minimum.

Low noise matching is achieved by careful adjustment of the spacing of the turns of L1. Adjustment is critical if you want to achieve the very lowest NF. This will not coincide with maximum gain. Maximum gain will occur below about 1150MHz when the NF is lowest at 1296MHz.

Input impedance match is improved by the use of first stage source series inductance. This is already designed into the PCB, and results from the inductance of the leads of Tr1, so you don’t need to worry about tuning this parameter. Since the source leads of the ATF36077 are broader than those on the NE325, the inductance is lower and the feedback is consequently less. This results in a slightly worse input return loss. When tuned for lowest noise figure with a 50 R source, the input return loss of the pre-amplifier will not affect the achievable system noise figure as long as the antenna is also a good 50R source. Poor input return loss does lead to a greater uncertainty of the actual noise figure when measurements are made.

Negative bias for Tr1 is provided by an ICL7660 DC-DC inverter. R14 allows a range of adjustment of gate bias voltage which will lead to a consequent change in drain current.

Active bias was chosen for Tr2 as the drain current is set at 65mA to achieve a good dynamic range. At this elevated current I felt that active bias would help to maintain circuit performance.

The pre-amplifier uses a 5 volt, 500mA regulator that uses a surface mount 78M05 regulator soldered to the PCB ground plane 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 preamplifier.

Noise and gain matching of the 2.3GHzand 3.4GHz version of the pre-amplifier necessitates a change of C1, L1 and L2 inductors at the input, L9 in the drain of Tr2 and the coupling capacitors C7 and C13. It also uses the ATF36077 and not the NE32584 in the first stage, although an ATF54143 is still used in the second stage position.

With the very high gain that is achieved in the 1.3GHz version of the pre-amplifier stability can be a problem due to the compact construction that has been used. After a great deal of (largely) unsuccessful testing with screens (to break up waveguide coupling modes) a range of RF absorber materials was then tried. The ARC DD-10017 (2mm thick) silicone magnetic absorber tile material, used in the 1.3GHz and 2.3GHz.pre-amplifier has proven to be very effective at suppressing unwanted coupling and aiding stability. At 3.4GHz it is necessary to use ARC LS-10055 Urethane foam (3.2mm thick) as the coupling mechanism changes considerably between 1.3GHz and 3.4GHz.

## Construction

Full construction details are shown on my web page at www.g4ddk.com

The preamplifier is built on a double sided 1.6mm thick, FR4 printed circuit board. Kits are available from the author.

The PCB is seam-soldered into the tin plate box. The same board is used for the 23, 13cm and 9cm pre-amplifier variants. The only components that need to be changed, when optimizing the band of operation, are Tr1, L1, L2, L9, C1, C7, and C13 (and the absorber tile material for 9cm). See the component list for component details.

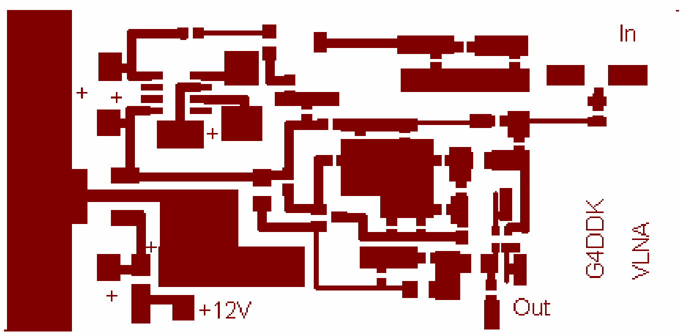

Fig 2 PCB for the LNA. 74 x 37mm FR4 double sided. This board design has now been updated to ‘Issue B’.

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.

Input and output RF connectors are both SMA. EME operators may prefer to use an N type for the input. As long as this has the smaller size flange, it can be fitted within the 30mm height of the box. The connectors can be fixed to the box by drilling holes and using small screws with nuts, or by soldering the connector flange to the tin box.

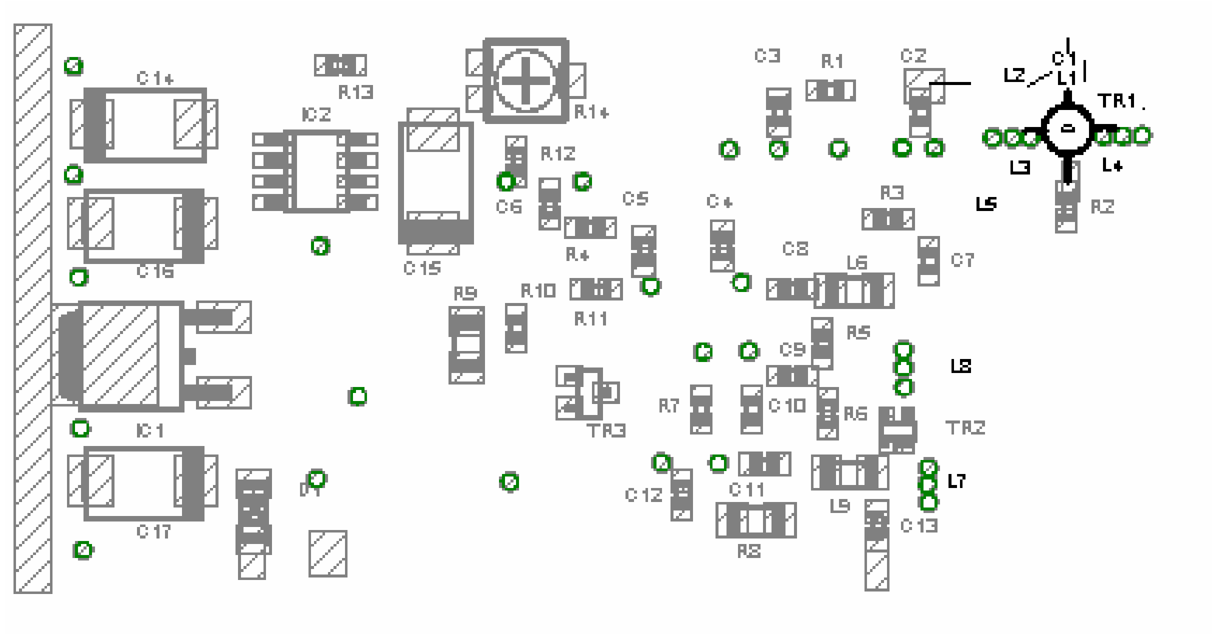


Fig 3. Component overlay for the LNA

The tin plate box needs to be marked as indicated on my web page with holes drilled to accept the input and output sockets as well as the feed-through capacitor.

It is advisable to solder the four 10uF Tantalum capacitors and the 78M05 voltage regulator onto the board before this is soldered into the tinplate box as the capacitors near the 78M05 voltage regulator will be found difficult to solder afterwards due to their proximity to the sides of the box. Take care to observe the correct polarity of the tantalum capacitors.

Use only small gauge solder (UK 28swg size- 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!

Solder C1 onto the spill of the input connector being careful not to overheat the capacitor as it could crack and this is not always obvious. Solder L2 so that one end is on the track pad, as shown, and the other end is carefully soldered to the free end of C1. Solder L1 so that the lower end lead is free to be soldered to Tr1 gate. Winding details for L1 and L2 are shown on the schematic diagram.

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

## Initial Setting up

Check that there is +5v at the output of IC1 and that there is -5v at the output of IC2.

Solder in Tr1 and Tr2 when you are happy that the supply voltages are correct. Disconnect the supply first, of course!

## Alignment

Adjust R14 for 2V on the drain of Tr1.

***23cm details***

With L1 still close wound, measure the noise figure. Now carefully bend the top turn up and away from the remaining turns. The turns should be spaced as shown in figure 2. Re-measure the noise figure. It should now be very low. Now CAREFULLY adjust the spacing of these coil turns for the lowest NF. Care here will be rewarded. There MAY also be some advantage in SLIGHTLY re-adjusting L2 coil spacing. Use only the recommended wire size. Larger gauge wire may crack C1 whilst L1 is being adjusted. Be warned!

Photo 2

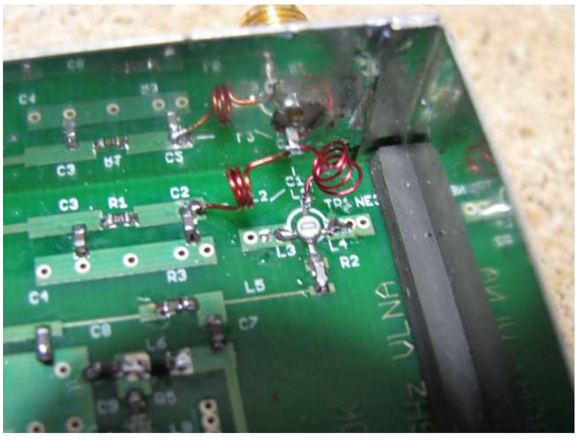

Photo 3

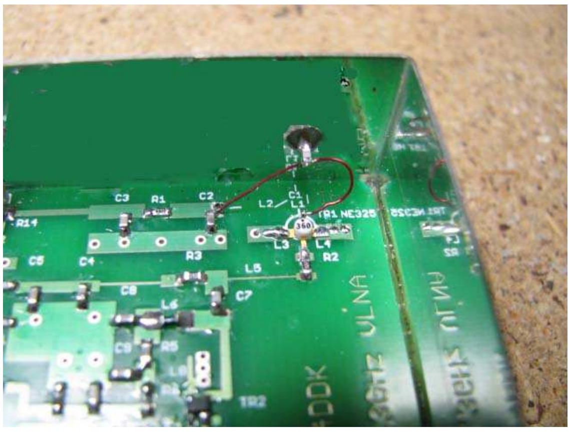

Photo 4

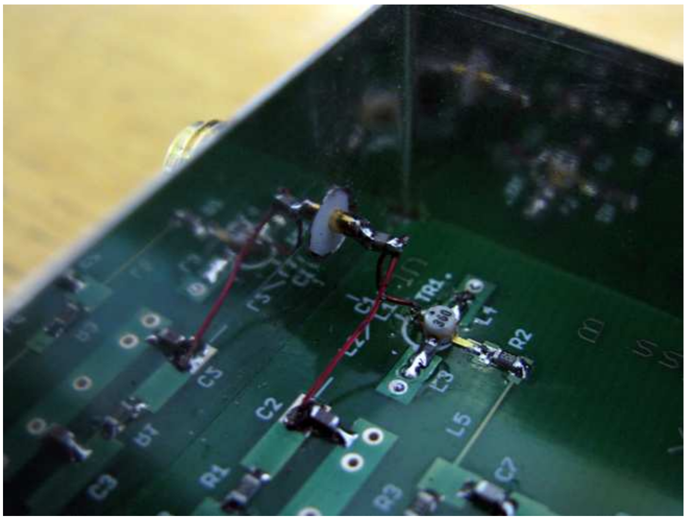

Photo 2  (Right) Input coil details of L1 and L2 for the 23cm version
Photo 3 .(Left) 13cm VLNA L1 and L2 hairpin loop details.
Photo 4 9cm LNA input hairpin loop details.

Stick the RF absorbent material inside the lid of the tin plate box. Putting the lid in place should not result in any increase in noise figure or loss of gain.

The magnetic (electric – 9cm version) field absorber material supplied with the kit has been carefully selected to ensure stability.

***13 and 9cm details***
There should be no need to adjust L1 or L2 in the 2.3 or 3.4GHz version of the pre-amplifier. As long as L1 is the correct length and orientated as shown, it should be as good as it gets. Adjustment of the drain current with R14 is the only variable left!

**Component list for the 23, 13cm and 9cm LNA**

| Part | Value | Package |
|---|---|---|
| C1 - 23cm | 2p7 | C-EUC0805 |
| C1 - 13cm | 3p3 | C-EUC0805 |
| C1 - 9cm | 1pF | C-EUC0805 |
| C2, C8, C11, | 8p2 | C-EUC0603 |
| C7, C13 - 23cm | 8p2 | C-EUC0603 |
| C7 , C13 - 13cm | 4p7 | C-EUC0603 |
| C7 , C13 - 9cm | 4p7 | C-EUC0603 |
| C3, C5, C6, C12 | 220pF | C-EUC0603 |
| C4 | 100pF | C-EUC0603 |
| C9 | 1nF | C-EUC0603 |
| C10 | 10pF | C-EUC0603 |
| C14, C15, C16, 17 | 10uF 20V | Tantalum |
| R1, R3, R5 | 51R | R-EU_R0603 |
| R2 | 22R | R-EU_R0603 |
| R4, R12 | 150R | R-EU_R0603 |
| R6 | 10k | R-EU_R0603 |
| R7, R10 | 1k | R-EU_R0603 |
| R11 | 1k5 | R-EU_R0603 |
| R14 | 1k | R-TRIMM4G/J |
| R8 | 10R | R-EU-R1206 |
| R9 | 22R | R-EU-R1206 |
| R13 | 4k7 | R-EU-R0603 |
| Tr1 | ATF36077/NE32584 | |
| Tr2 | ATF54143 | SOT343 |
| Tr3 | BC807 | SOT23 |
| IC1 | 78M05 | D-Pak |
| IC2 | ICL7660 | SOIC-8 |
| D1 | 1N4001 | SMD |
| L1/l2 | 32swg Enamel covered copper wire | See diagrams |
| L3, L4, L5, L7, L8 | Printed on PCB | |
| L6 | 3n3 | SMD0603 |
| L9 – 23cm | 5n6H | SMD0603 |
| L9 – 13cm | 2n2H | SMD0603 |
| L9 – 9cm | 2n2H | SMD0603 |
| Box | 4 piece tinplate | 74mm x 37mm x 30mm |
| Absorber 23 and 13cm | DD-10017-1 | 30mm x 50mm |
| Absorber (9cm) | | 30mm x 50mm |
| PCB | VLNA Issue B | 72mm x 34mm |

Table 1 Component values for the VLNA. Values in parenthesis are for the 13 and 9cm versions

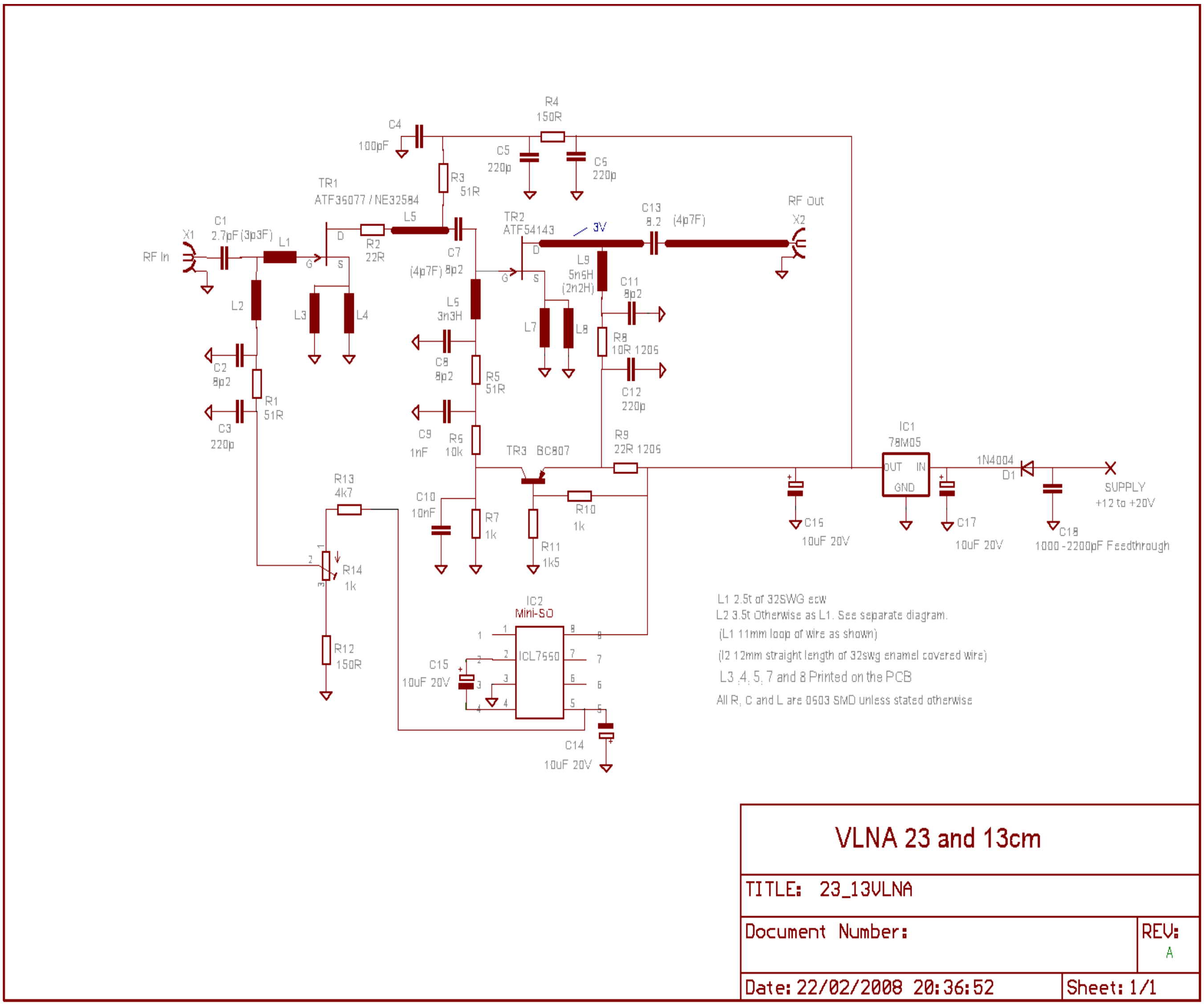


Figure 1 Circuit schematic of the 23, 13cm and 9cm LNA. 13cm band component values are shown in parenthesis. 9cm values are shown on my web page and in the component list.

Always check WWW.G4DDK.COM for the latest build instructions for the LNA.