Description of a HEMT 144 MHz Low Noise Amplifier

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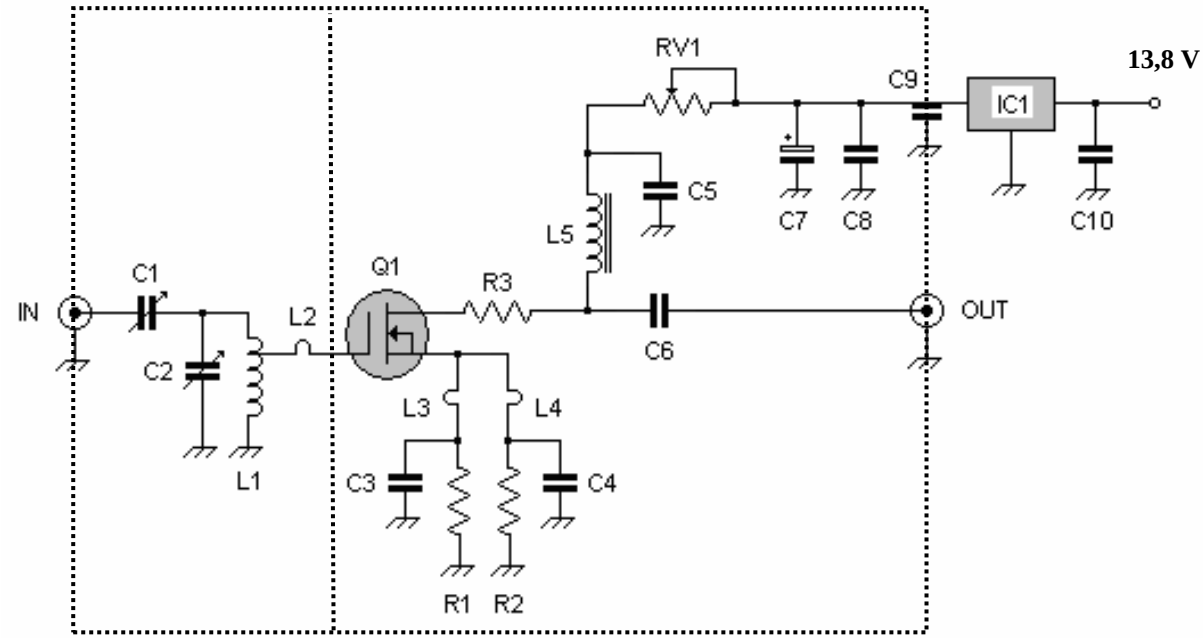
1. Introduction

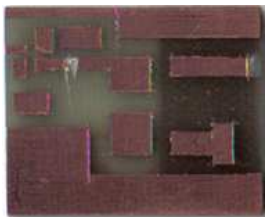
This document provides the description of a 144 MHz Low Noise Amplifier (LNA) using a High Electron Mobility Transistor (HEMT) **ATF33143** from Agilent. Together with exhibiting a low Noise Figure (NF), this preamplifier provides a high IIP3 (Input 3rd order Intermodulation Products) too, answering the strong signals handling demand of nowadays.

2. Schematic

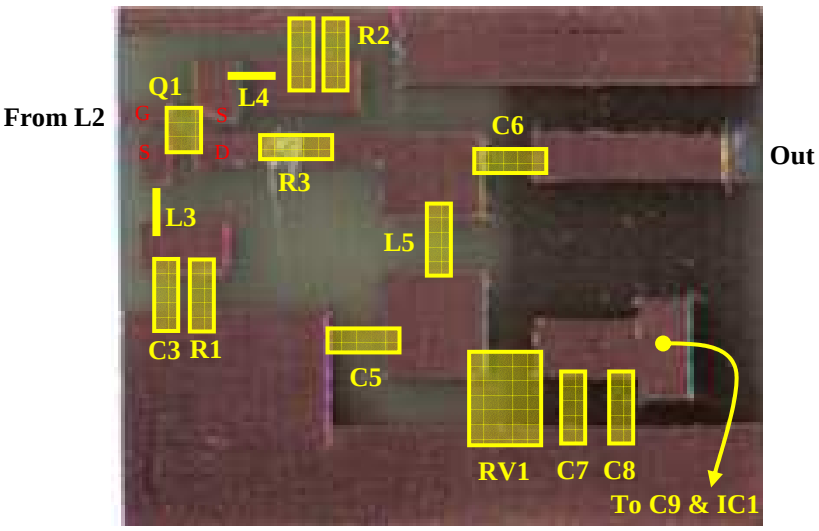


3. Building Details

3.1. Output PCB



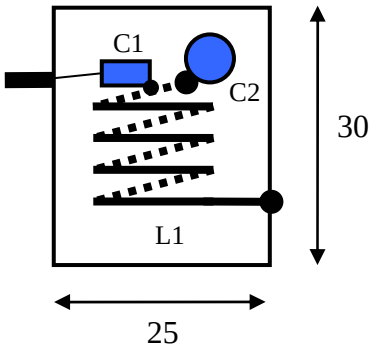
This the Output PCB, hosting all the components but C1, C2, L1 & L2, located in the Input enclosure. This PCB is made of single sided FR4 epoxy board.



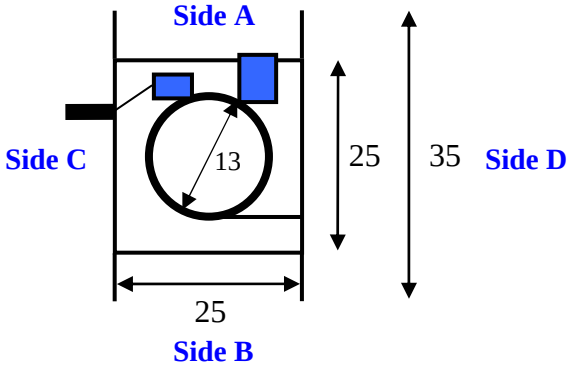
No more PCB layout than what is shown here above is provided. Indeed, for most of my homebrew devices, my PCB design method is not very re-producable i.e. I'm used to use an adhesive film put on the board ; the components are located on top and the film is removed with a cutter where the copper has to leave. The board is then etched. For more elaborated layouts (which is not the case here), I use the same technique but instead of placing the components directly on the board/adhesive film assembly, I use a standard drawing editor, for example "Paint" available in the accessories of MS Windows.
I've drawn several standard component footprints which I copy-paste on my workspace in the drawing editor. Afterwards, I print the resulting sheet and place it on top of the board/adhesive film assembly and proceed the same way than before (removal of the film with a cutter). The difference is that then I have a softcopy of the PCB layout.
For the pinning configuration of the ATF33143, refer to section 8.

3.2. Mechanics

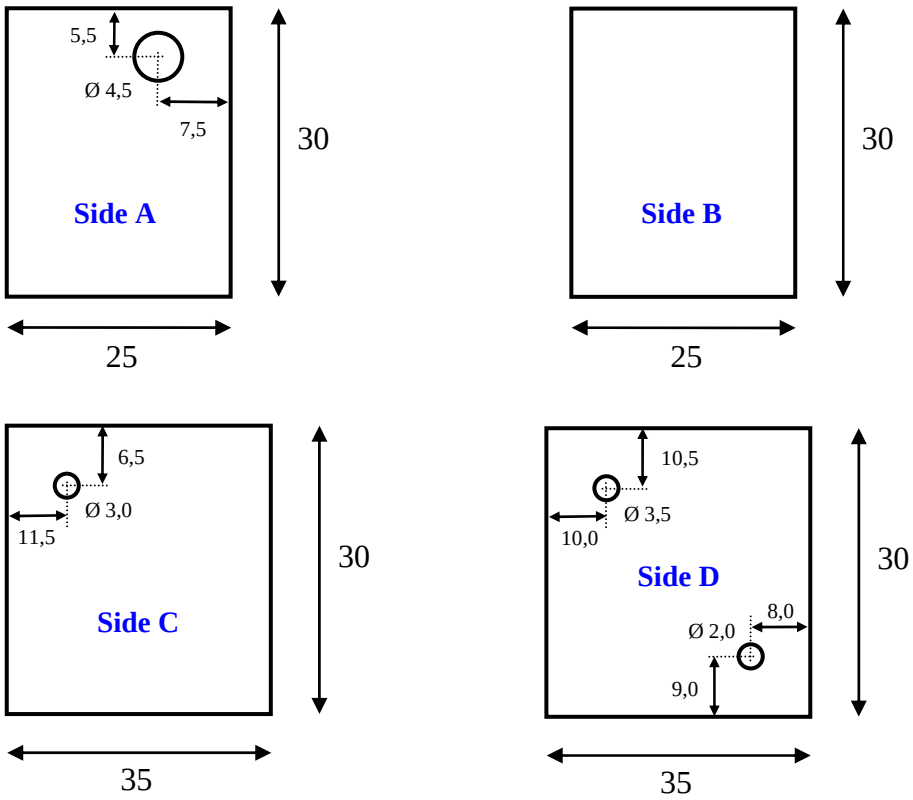
The drawings below show how the Input enclosure is built. It is made of 1,6 mm thick double sided FR4 epoxy boards. Have a look also at the pictures in section 5.
Note that the drawings are not to scale ; all the figures are in expressed in mm.



Side View

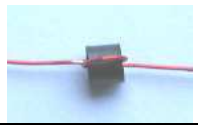


Top View

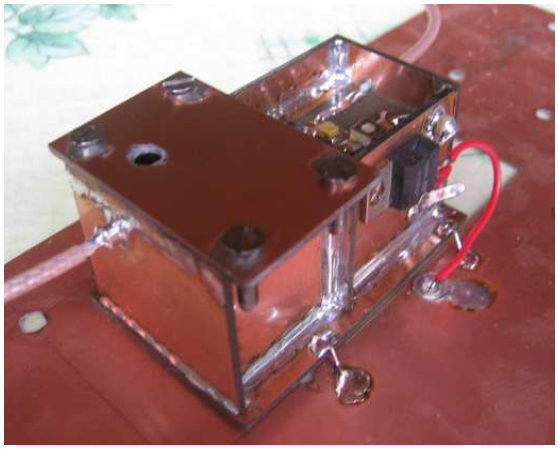


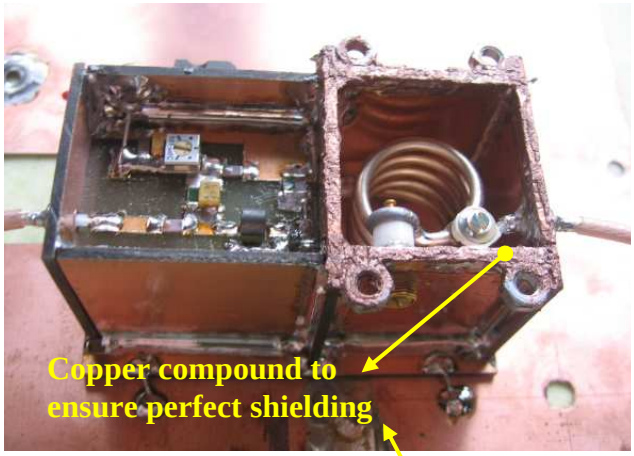
4. Part List

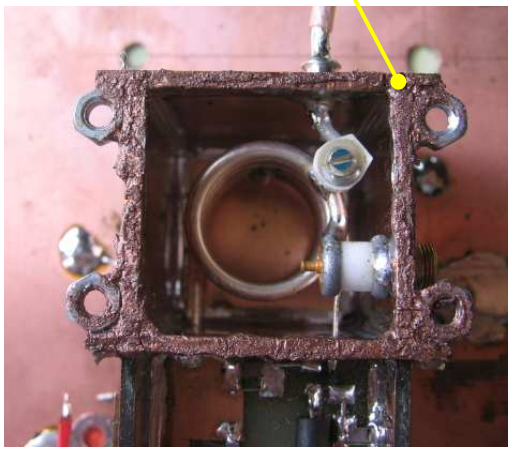
Part list (excl. Inductors, see next page)				
Part ID	**Value**	**Type**	**Supplier**	**Remarks**
R1, R2	12 Ω	¼ W	Various	SMD 1206
R3	27 Ω	¼ W	Various	SMD 1206
RV1	100 Ω	3314 (¼ W)	Bourns	SMD
C1	3,3-20 p	GKU18000	Sprague Goodman	Blue
C2	1-10 p	Var. Hi-Q	Johanson	The higher the Q the better
C3, C4, C5	1 n	NP0	Various	SMD 1206
C6	150 p	NP0	Various	SMD 1206
C7	1 µ	Tantalum 16V	Various	SMD
C8	10 n	X7R	Various	SMD 1206
C9	1 n	Feed-through	Various	
C10	100 n	X7R	Various	Through-Hole
IC1	7805	Voltage Regulator	Various	TO220 case
Q1	ATF33143	HEMT	Agilent Technologies	

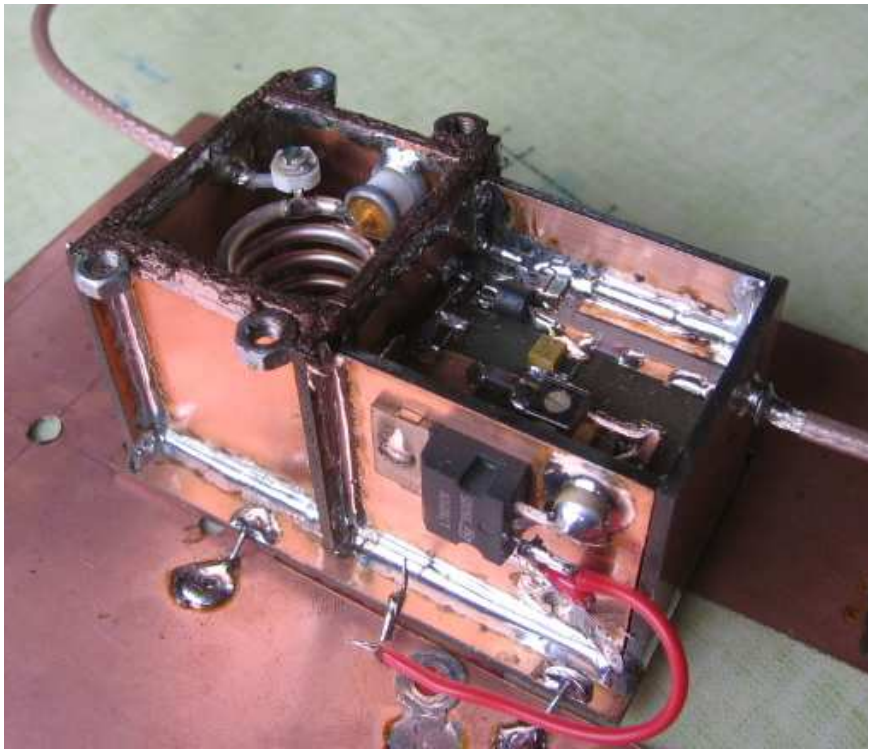
Inductor's part list / building data									
Part ID	**Value**	**Coil former Diam. (mm)**	**Type**	**Wire Diam (mm)**	**Supplier**	**# Turns**	**Winding**	**Core**	**Shielding**
L1	≈ 115 nH	13		2 Cu-Ag	Home	3 ½	Spaced 1 wire diameter	Air	Resonator enclosure
L2		N/A	Straight Wire	0,4 Cu-Ag	L2 is a straight wire of 18 mm length, linking the Gate of Q1 and the inductor L1. L2 is soldered at L1 at 1 turn from the L1 hot end (C2).				
L3, L4		N/A	Straight Wire	Lead Tail of a ¼ W Resistor	L3 & L4 are linking Q1 to the PCB pads hosting R1/C3 & R2/C4				
L5		Ferrite Bead		0,2 enamelled	1 turn through the central hole of the bead :  				

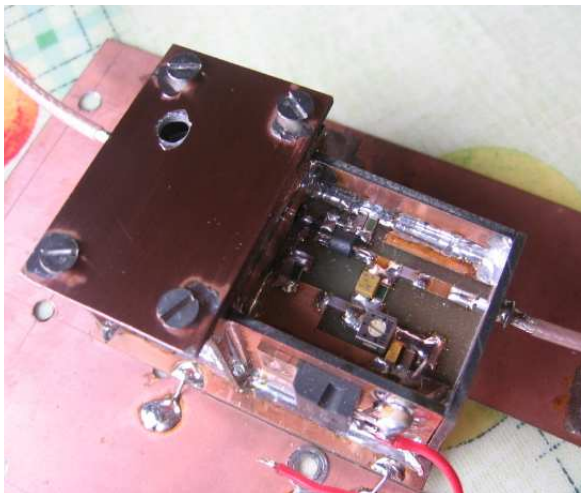
5. Pictures

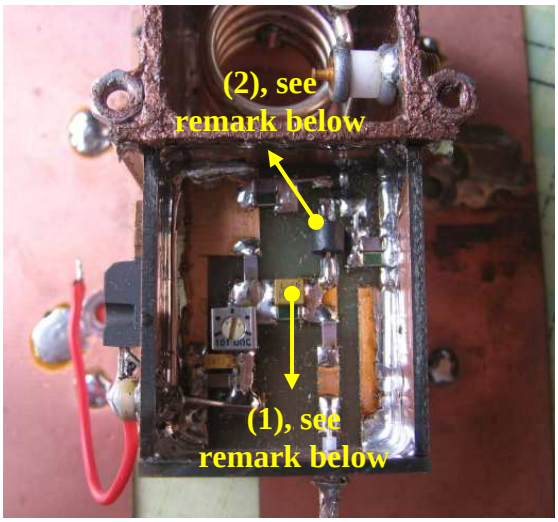












Remarks :

- The pictures show L1 having a 4,5 turns winding but on my prototype this figure turned out to be too much. So, the last winding has been shorted (this can be seen on the right picture here above). **The correct winding is then well 3,5 turns**, as indicated in the part list.
- The **pictures above are from the old version of the preamplifier (oscillating)**. To cure the oscillation problem, (1) on the picture above has now been replaced by a ferrite bead (L5) and (2) has been replaced now by a 27 Ω resistor (R3).

6. Tuning

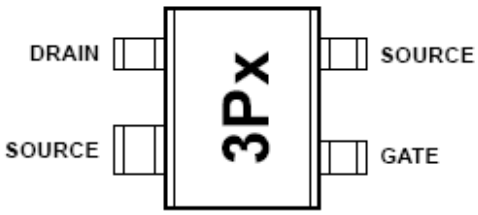
First adjust RV1 so that the (Drain) current is around 60-80 mA. Then, using a weak stable signal at the input, tune C1 and C2 to achieve the best (maximum) S/N ratio. The tuning is not very sharp. For tips about preamp tuning, have a look at the document of WA5VJB "GaAs FET Preamp Cookbook" provided in the compressed (.zip) file, together with the present document. This paper is dating a bit and then not up to date regarding the HEMT input impedances. However, it provides some relevant information.

7. Performance

The measured gain is 27 dB and the IIP3 lies around 0 to +5 dBm. Note that this is is the peak gain, function of the tuning of the input capacitors (C1 & C2) and not necessarily corresponding to the optimum NF. The optimum NF should be in the range 0,25 to 0,4 dB.
No other measurement nor simulation result can be provided here. Given the nature of the Input matching circuit/HEMT transistor input impedance combination, this preamp has a wide bandwidth of its own. Though there is a peak of gain around 144 MHz (depending of the tuning of the input capacitors C1 & C2), this preamp still delivers some gain in the 88-108 MHz broadcast band and also around 10 dB (more or less flat) up to 500 MHz.

8. Appendix

Pin Connections and Package Marking



Note: Top View. Package marking provides orientation and identification.

"3P" = Device code
"x" = Date code character. A new

9. Document History

Date	Device Version	Comment
01/04/2008	1st	Creation of the document
06/09/2008	2nd	Schematic modified to cure oscillations