A Low-Cost 1 GHz Highpass Low-Noise Amplifier

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This report documents the design of a simple, low-cost broadband low-noise amplifier (LNA). This LNA is designed to provide robust performance at L-band and above even in the presence of strong interference from UHF broadcast signals. This is achieved using a 1 GHz highpass filter before amplification. As a result, the noise figure and input VSWR are not as good as other LNA designs. Nevertheless, this LNA is quite useful as a low-cost method to preserve system noise figure when the antenna and receiver must be separated using a long cable, and gain compression due to interference is problem.

The completed LNA is shown in Figure 1 and its specifications are summarized in Figures 2 and 3.

Figure 4 shows a schematic of the LNA electrical design. A parts list is given in Figure 5. Figure 6 shows the assembled circuit on its printed circuit board (PCB).

The enclosure is constructed from PCB material. The PCB was obtained from ExpressPCB*. The PCB was designed using ExpressPCB's proprietary PCB layout software. The completed PCB is shown in Figure 7. Note that the raw PCB consists of four sections: (1) The main PCB for the electronics, which doubles as the top cover, (2) The bottom cover, which is mostly ground plane, and (3) two identical sections which are used as spacers between (1) and (2). The dimensions of the dimensions of the raw PCB are 3.8-in by 2.5-in, which allows ExpressPCB's low-cost "MiniBoard" service to be used. The laminate is 0.062-in FR-4 epoxy glass with a dielectric constant specified to be between 4.2 and 5.0.

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*`http://www.expresspcb.com`

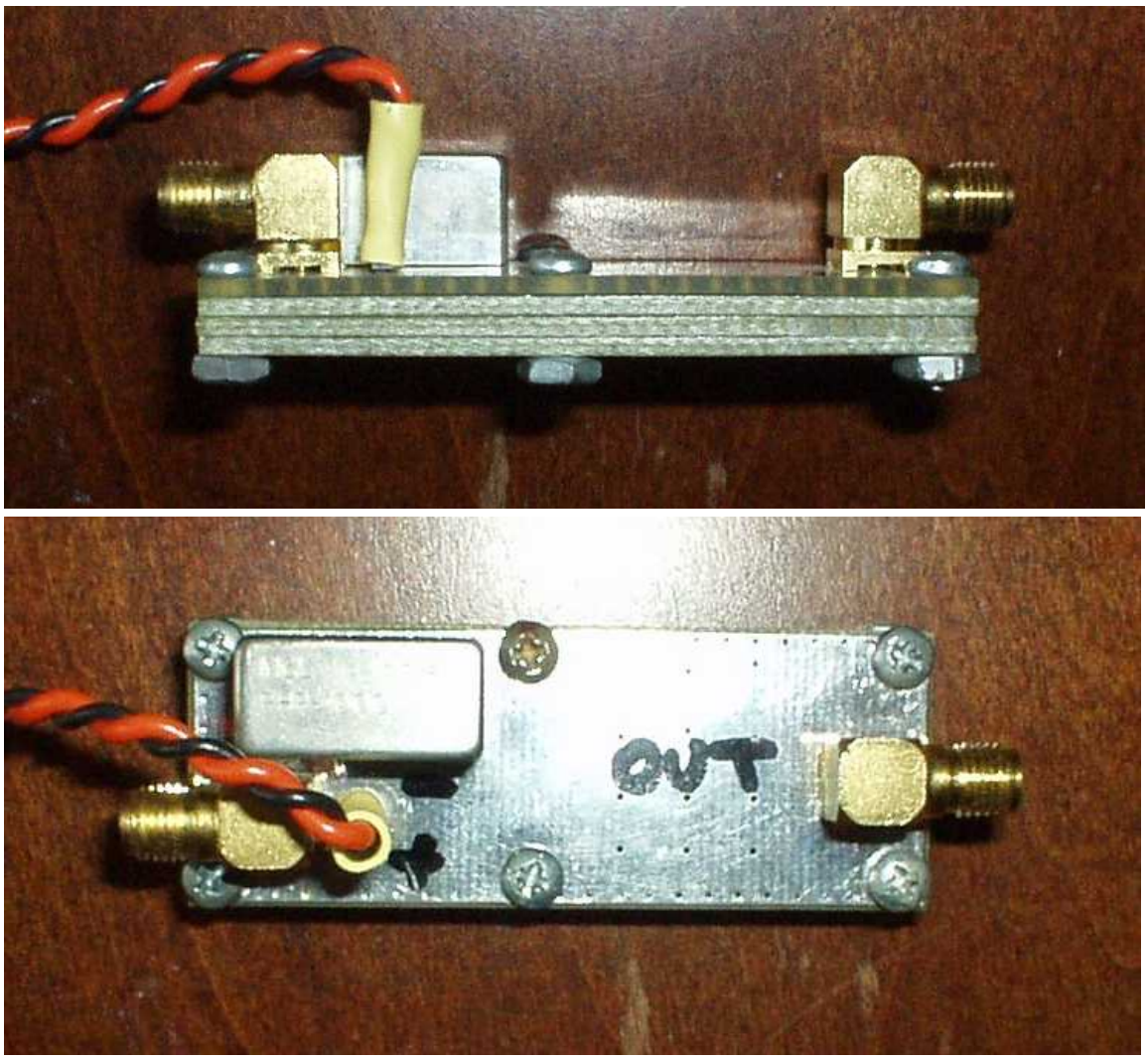

Figure 1: The LNA, as tested.

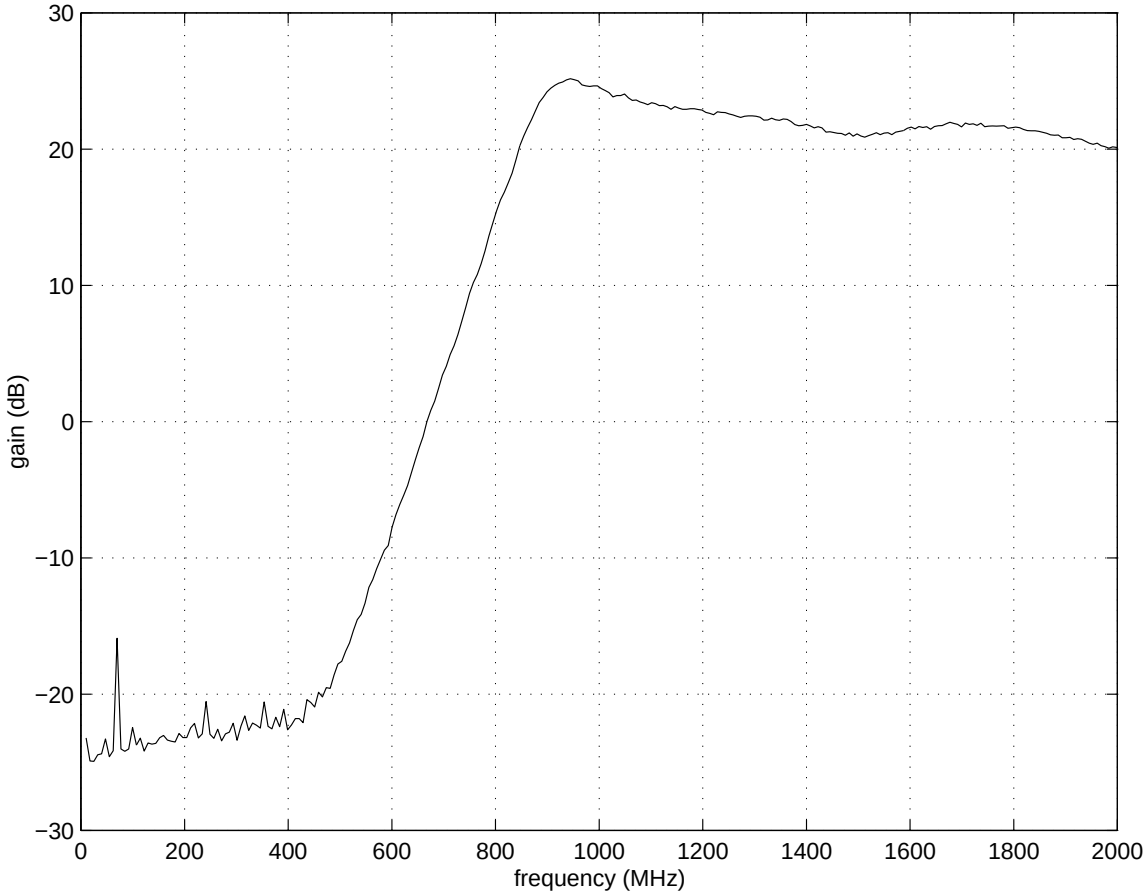

Figure 2: Measured frequency response.

Gain	22 dB @ 1420 MHz
Noise Figure	3.8 dB *
1 dB Compression Point	−26 dBm input @ 1420 MHz
Input VSWR	1.9:1 *
Dimensions	74 mm × 25 mm × 20 mm
Connectors	SMA female
Power	96 mA @ 15 VDC
	(12–15 VDC accepted)

* Estimated from component specifications.

Figure 3: LNA Specifications

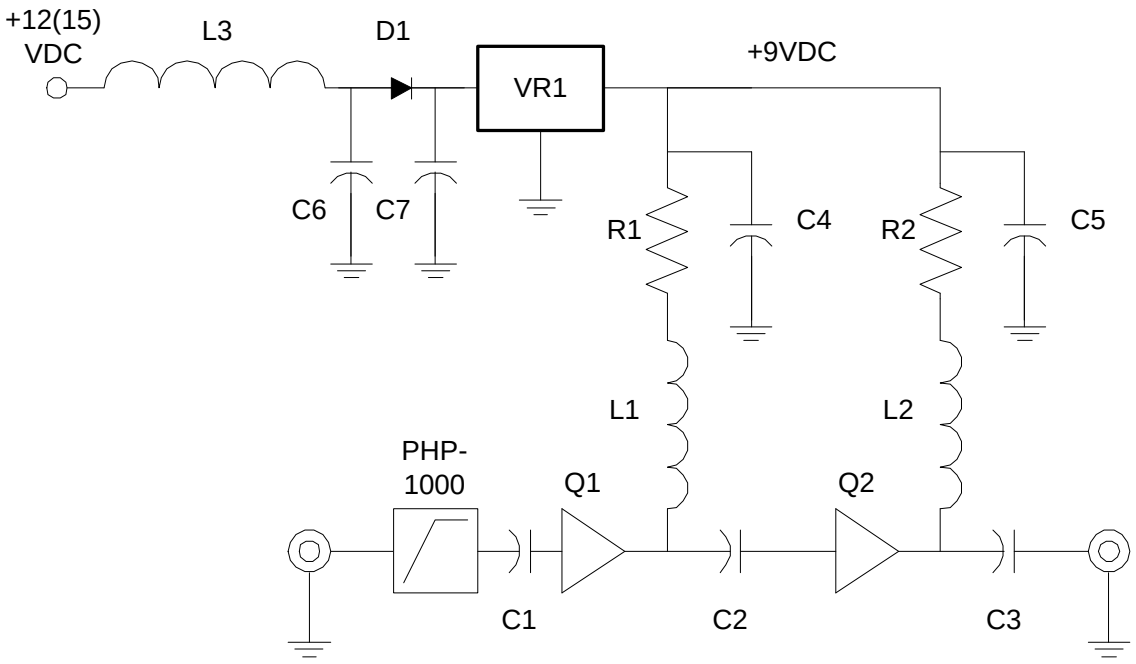

Figure 4: LNA schematic.

Value	Unit	Description	Qty	ID	Distributor	Part Number	Unit Cost
		Connector, SMA(F)	2		Jameco	188525	$4.95
		Highpass filter	1		Mini-Circuits	PHP-1000	$14.95
100	pF	Cap, 1206, ceramic	3	C1–3	Digikey	PCC101CCT-ND	
0.1	μF	Cap, 0805, X7R	2	C4–5	Digikey	PCC1812CT-ND	$0.07
0.001	μF	Cap, 0805	2	C6–7	Digikey		
220	nH	Ind, SMD, 10%	3	L1–3	Digikey	PCD1123CT-ND	
360	Ω	Res, 1/8W	1	R1	Digikey		
51	Ω	Res, 1W, 5%, 2512	1	R2	Digikey	P51XCT-ND	
		MMIC Amp.	1	Q1	Mini-Circuits	RAM-6	$4.95
		MMIC Amp.	1	Q2	Mini-Circuits	ERA-6SM	$3.90
1N4148		Diode, DO35 case	1	D1	Jameco	94908	$0.04
78L09		Reg., TO-92 case	1	VR1	Jameco	192225	$0.19
		PCB	1		ExpressPCB		$59.00
		4-40 screws	6		Digikey		
		4-40 nuts	6				

Figure 5: Parts List.

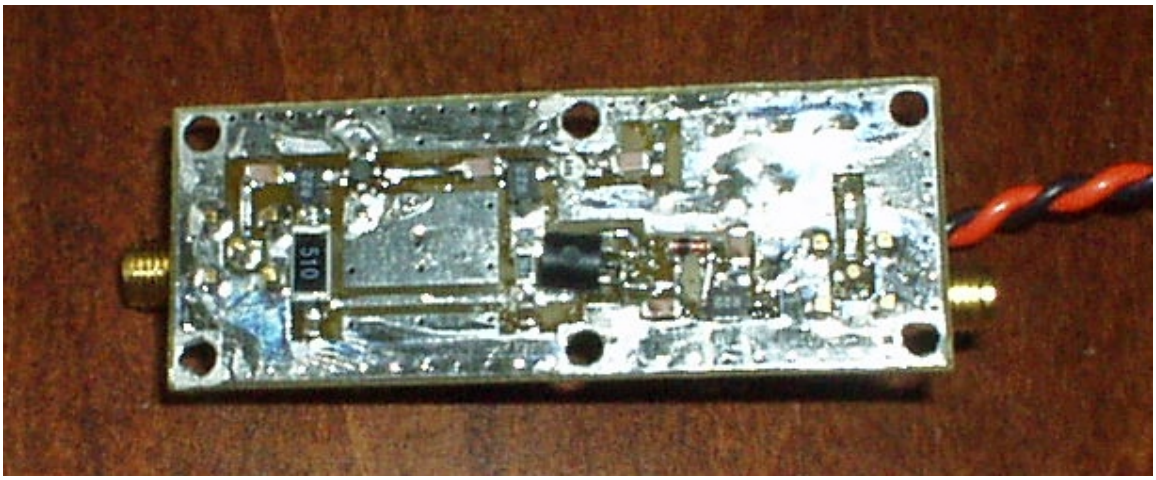

Figure 6: Circuit assembled on PCB.

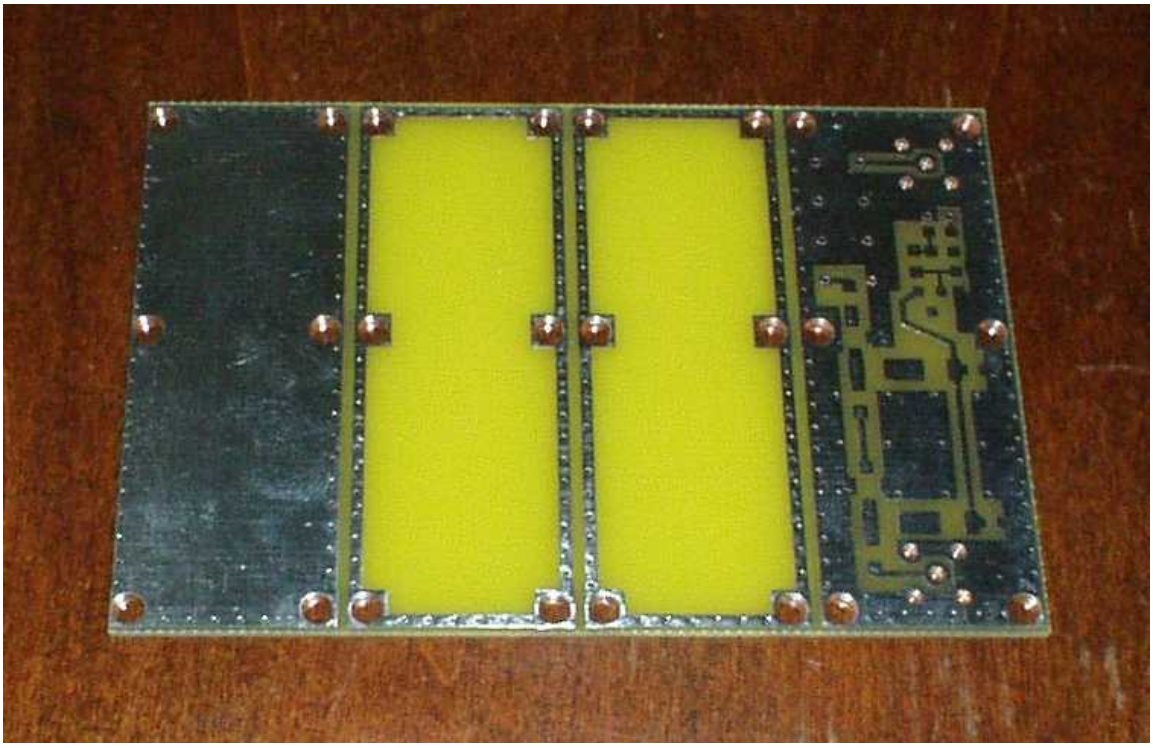

Figure 7: PCB as received from the PCB vendor.

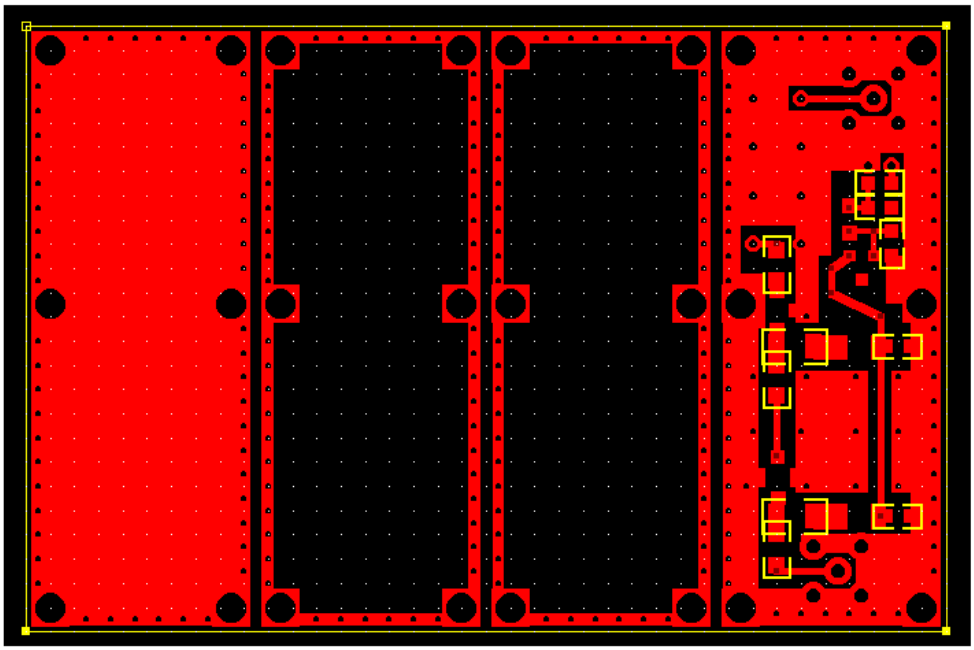

Figure 8: PCB “top” side (screen dump from layout software).

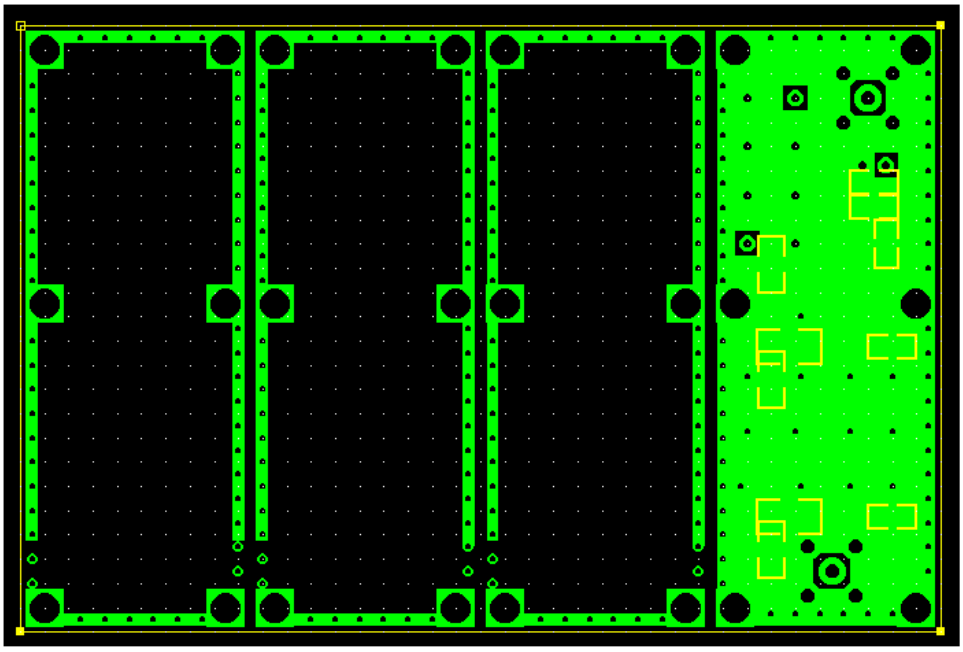

Figure 9: PCB "bottom" side (screen dump from layout software). Note that rim traces are not completed on leftmost 3 panels: This is an error, but has no significant impact on shielding performance.

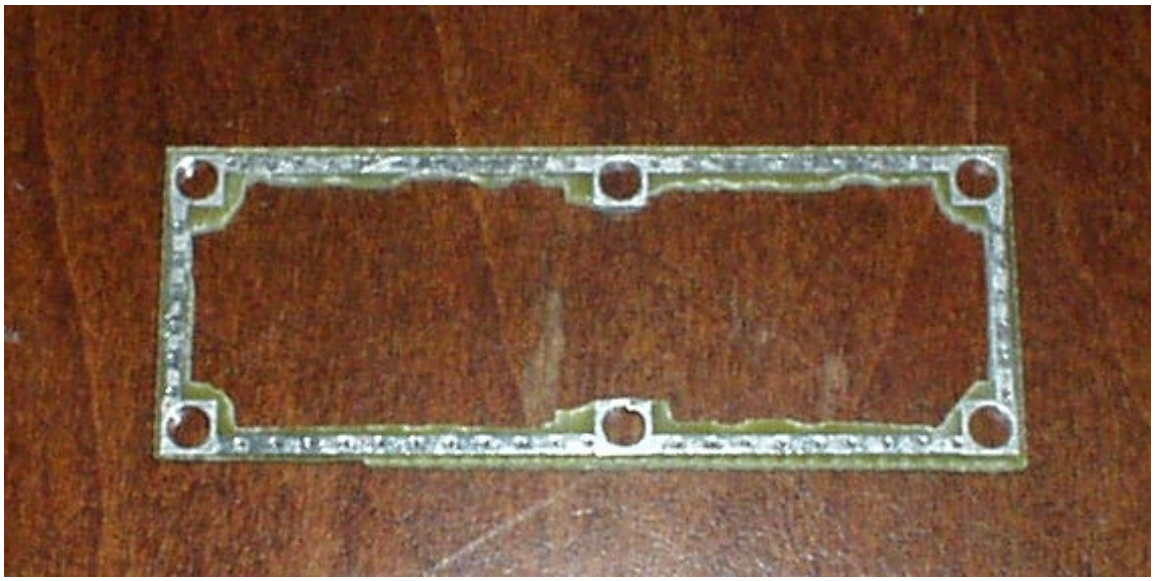

Figure 10: Spacer section, after being cut away from the raw PCB and milled out.

The LNA is assembled as follows:

1. The raw PCB is cut into four sections. The spacer sections are milled out as shown in Figure 10.

2. The SMA connectors, filter, and power leads are installed from the reverse side (relative to the circuit traces) of the main PCB.

3. The electronics are installed on the main PCB.

4. The spacer sections are stacked on the compenent side of the main PCB, followed by the ground plane section. The unit is held together with screws and nuts.