A Low-Cost L-Band Line Amplifier (Rev. 1)

Steven W. Ellingson*

October 9, 2002

This report documents the design of a low-cost L-band line amplifier. The description presented here is complete, although the design is a minor revision to a design previous reported in [1]. The change is a reduction in size and a modification to the enclosure to reduce cost. The cost of the new design is about $44 each in small quantities.

Although this unit is intended to be used in conjunction with the LNA described in [2], it may also be useful in other applications. Specifically, this unit provides a 9 VDC bias through the RF input jack which can be used to power the LNA described in [2]. The intended configuration is for the line amplifier to be located within a few feet of the LNA, and used to drive a long section (e.g., 100 ft.) of coaxial cable. The completed line amplifier is shown in Figure 1 and its specifications are summarized in Figures 2, 3, and 4.

Figure 5 shows a schematic of the line amplifier, with a parts list given in Figure 6. Components L1 and C1 form a bias-tee, setting the DC voltage at the input jack to 9 VDC, thereby powering the connected LNA. This part of the circuit also forms a high-pass filter with cutoff at about 200 MHz, which contibutes to the suppression of strong VHF-band interference, such as FM broadcast radio. MMIC amplifiers U1 and U2 provide gain and also serve to buffer the stripline bandpass filter, FL1. Figure 7 shows the assembled circuit on its printed circuit board (PCB).

FL1 is a 3-finger interdigital bandpass filter which was designed through a process of trial-and-error using the "Sonnet" electromagnetic modeling software by Sonnet

*The Ohio State University, ElectroScience Laboratory, 1320 Kinnear Road, Columbus, OH 43210, USA. Email: ellingson.1@osu.edu.

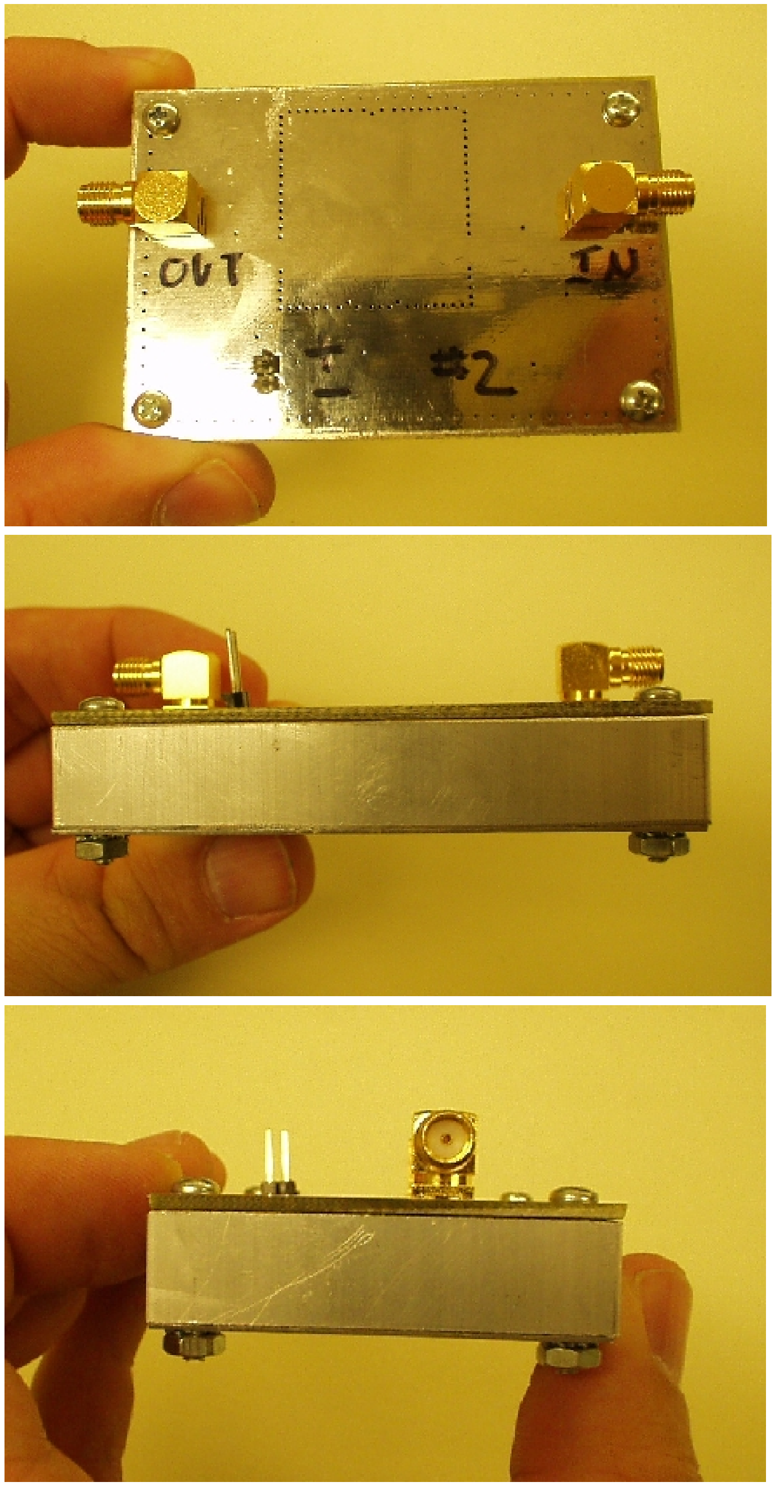

Figure 1: The line amplifier, as tested.

Peak Gain	18 dB @ 1500 MHz
3 dB Passband	1250 MHz to 1750 MHz
Dimensions	83 mm $\times$ 51 mm $\times$ 28 mm
Connectors	SMA female
Power	100 mA @ 12 VDC (12–15 VDC accepted)

Figure 2: Specifications

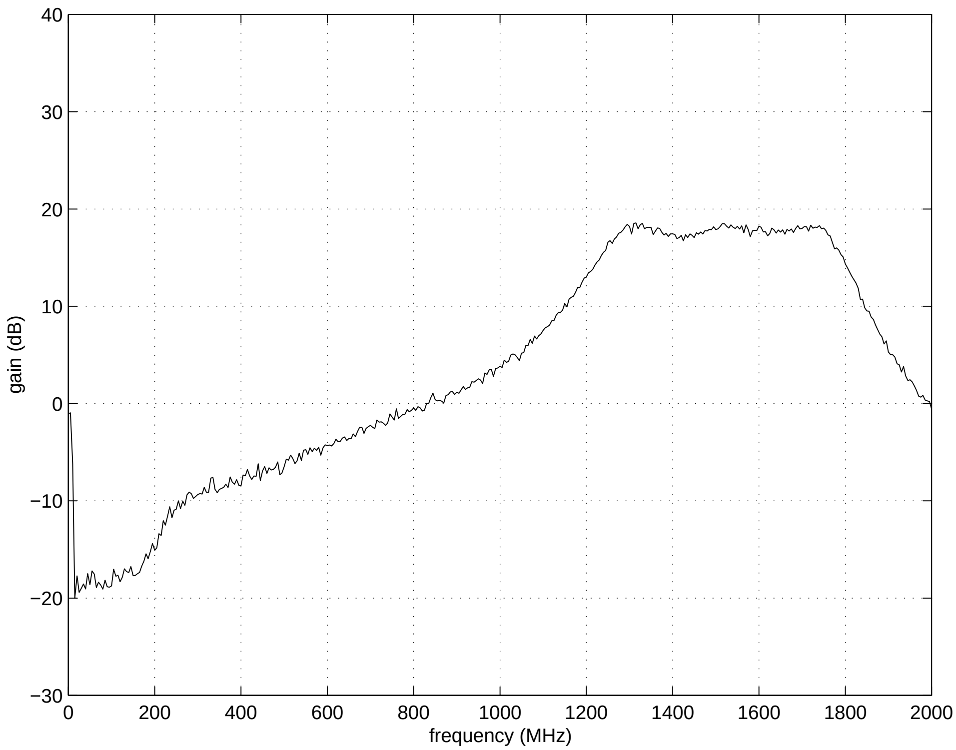

Figure 3: Measured frequency response of line amplifier.

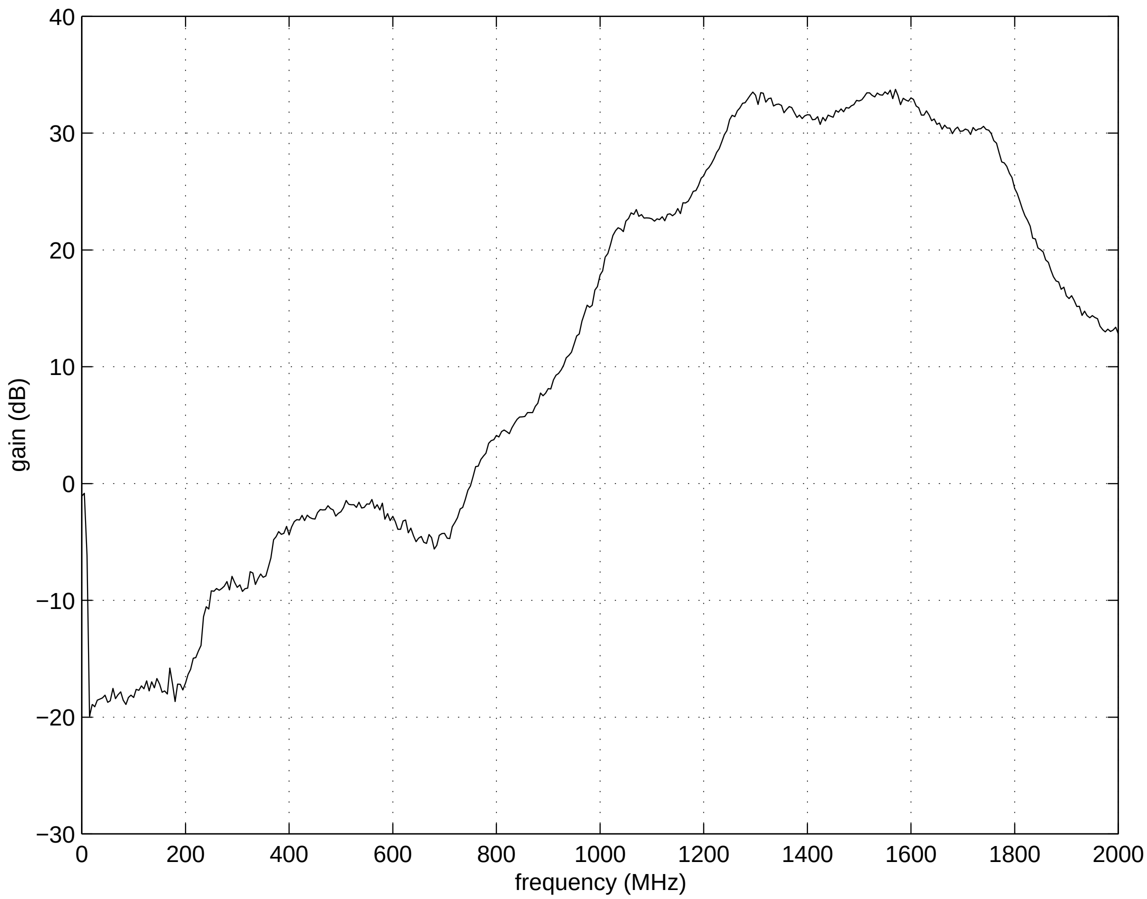

Figure 4: Measured frequency response of LNA described in [2] plus the line amplifier described in this report.

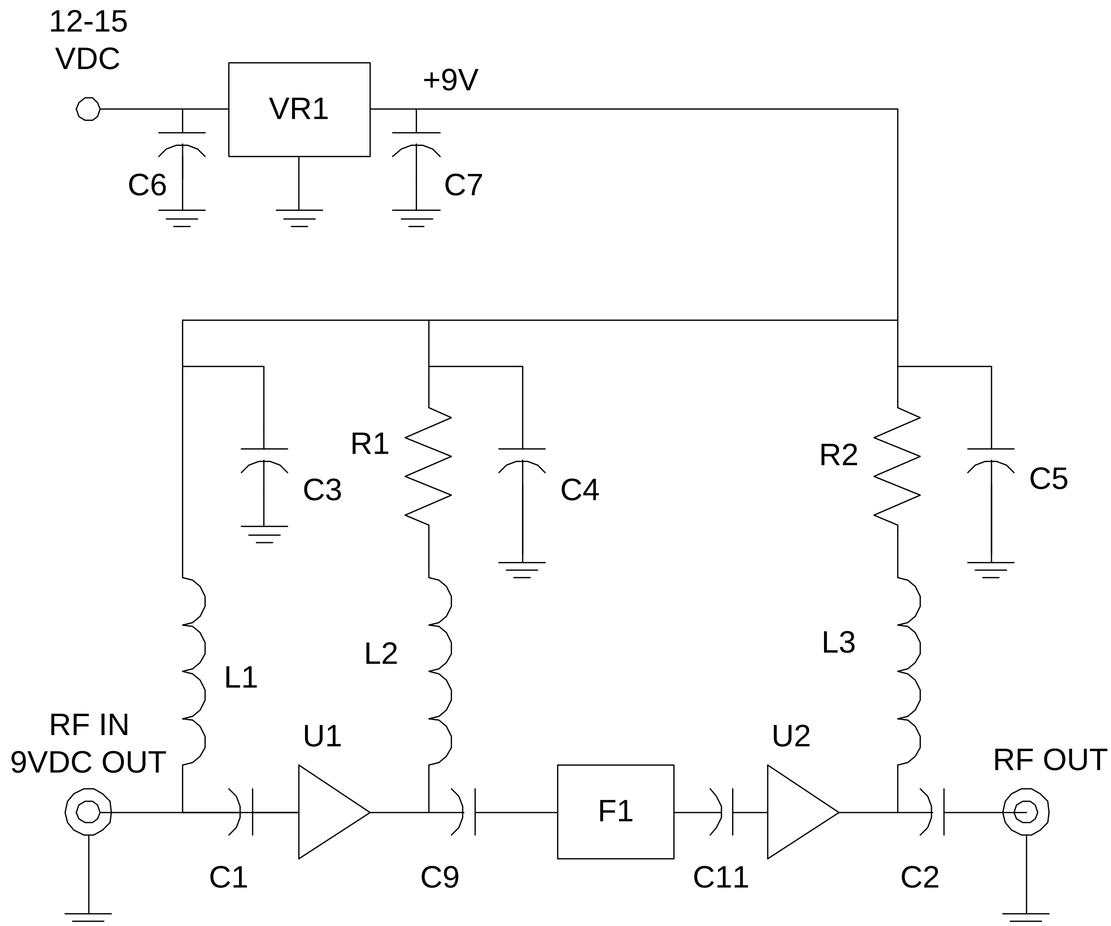

Figure 5: Schematic.

Value	Unit	Description	Qty	ID	Distributor	Part Number	Unit Cost (Qty)
360	Ω	Res, 1W, 5%, 2512	1	R1	Digikey	P360XCT-ND	\$0.88 (10)
51	Ω	Res, 1W, 5%, 2512	1	R2	Digikey	P51XCT-ND	
39	nH	Ind, 0805, 5%	1	L1	Digikey	PCD1167CT-ND	\$0.76 (10)
220	nH	Ind, 1210 (3225)	2	L2,L3	Digikey	PCD1123CT-ND	\$0.58 (10)
10	pF	Cap, 1206, 50V	4	C1,C2,C9,C11	Digikey	PCC100CCT-ND	
0.1	μF	Cap, 0805, X7R	3	C3,C4,C5	Digikey	PCC1812CT-ND	\$0.11 (10)
10	μF	Cap, tant, 35V	1	C6	Digikey	PCS6106CT-ND	\$1.58 (10)
10	μF	Cap, tant, 16V	1	C7	Digikey	PCS3106CT-ND	\$0.62 (10)
		MMIC Amp	1	U1	Mini-Circuits	RAM-6	\$4.95 (30)
		MMIC Amp	1	U2	Mini-Circuits	ERA-6SM	\$3.90 (30)
9	V	Volt. Reg., 7809	1	VR1	Digikey		\$0.48 (25)
		Bandpass Filter	1	FL1		p/o PCB	(p/o PCB)
		PCB	1		ExpressPCB	rfbch3.pcb	\$62.00 (3)
		Connector, SMA(F)	2		Digikey	ARFX1232-ND	\$4.40 (1)
		4-40 screws	4		Digikey	H150-ND	\$0.02 (100)
		4-40 nuts	4		Digikey	H216-ND	\$0.01 (100)
		Aluminum tube	1				
		Aluminum plate	1				

Figure 6: Parts List.

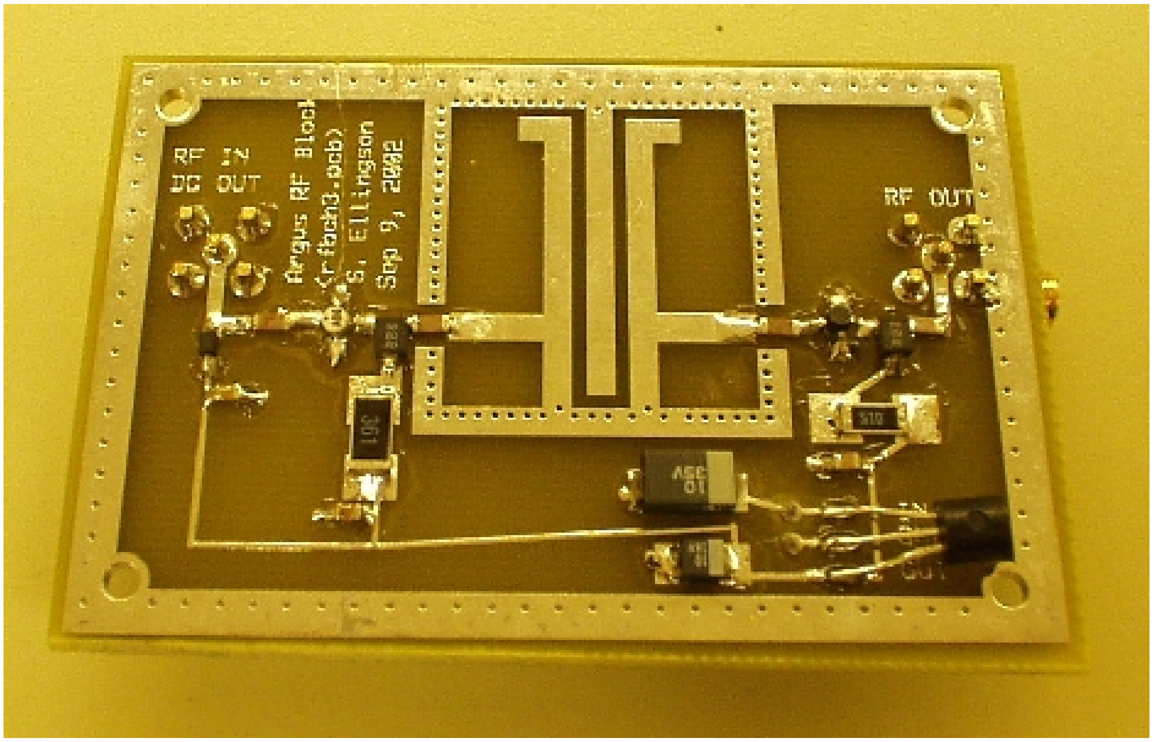

Figure 7: Circuit assembled on PCB.

Software, Inc. The selected design was as shown in Figure 8. The predicted response of the filter is shown in Figure 9.

The enclosure consists of the PCB itself (Figures 10 and 11) with an aluminum spacer and plate to enclose the opposite side. The PCB was obtained from ExpressPCB*. The PCB was designed using ExpressPCB's proprietary PCB layout software. The PCB layout is shown in Figures 10 and 11. The dimensions of the dimensions of the PCB are 3-in by 2-in, which allows ExpressPCB's low-cost "Mini-Board" 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. The unit is held together with 4-40 screws and nuts.

Acknowledgments

The author is grateful for the assistance of Keith Hampson and Grant Hampson in creating the enclosure described in this memo.

*http://www.expresspcb.com

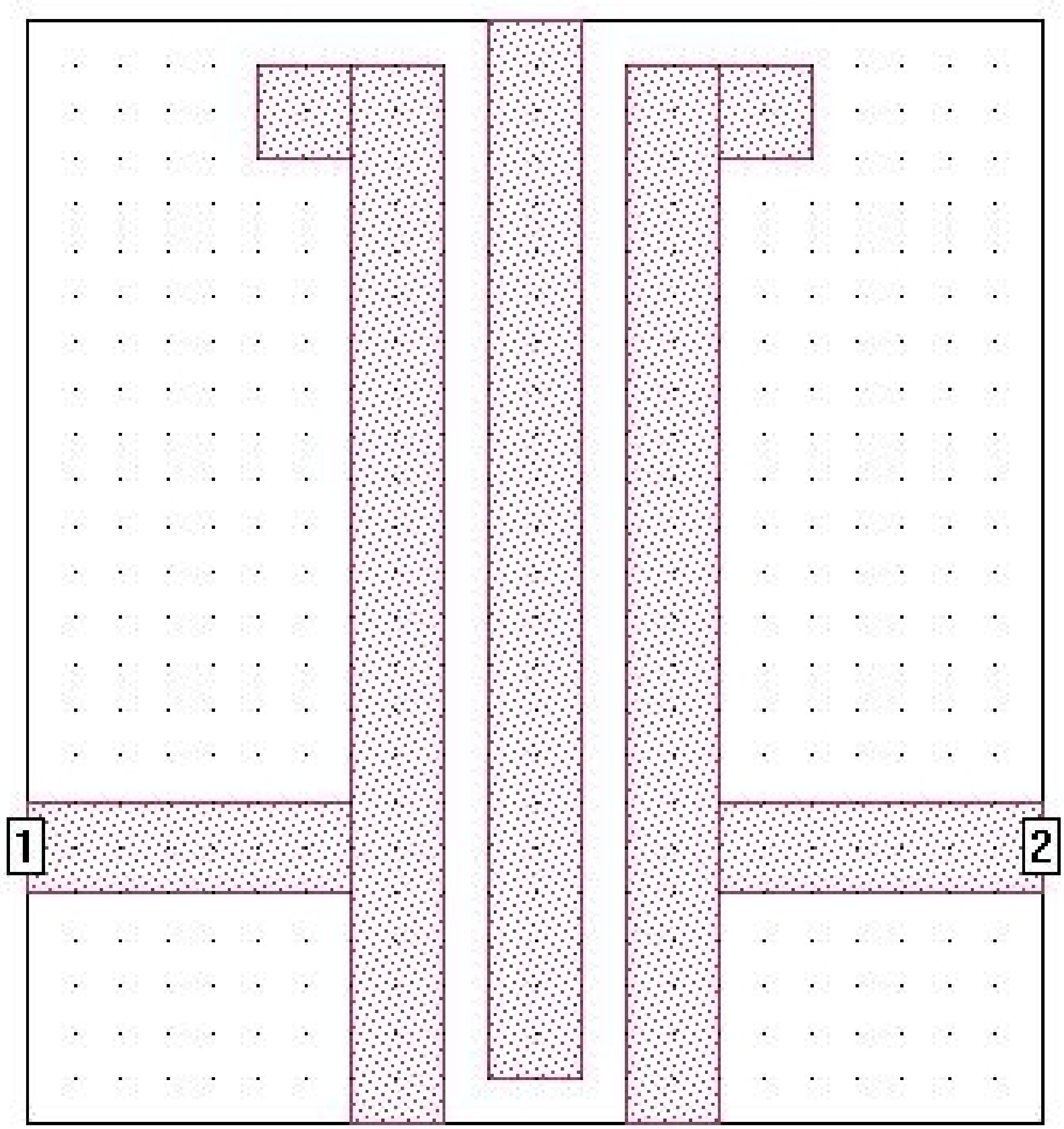

Figure 8: Sonnet model of FL1 used for performance prediction. Shading indicates metalization. The outer box is assumed to be a perfectly-conducting ground. The spacing between grid points is 0.045 in. The substrate is assumed to be 0.062-in thick FR-4 with $\epsilon_r = 4.6$. The substrate is sandwiched between a ground plane and a layer of air ($\epsilon_r = 1$), 1-in thick. Above the air is a continuation of the ground plane, such that the entire filter (except for the input and output ports) is enclosed in perfectly-conducting box.

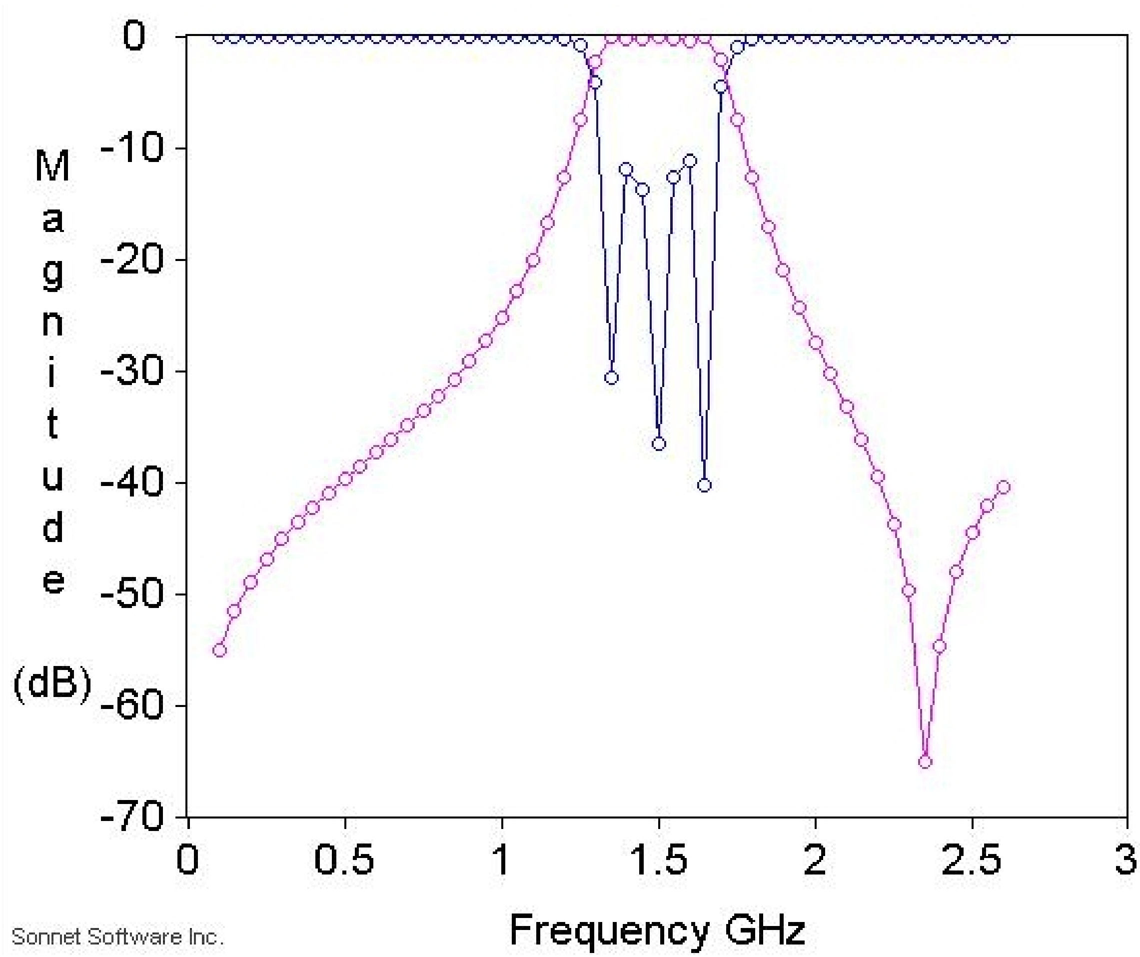

Figure 9: Frequency response of FL1 predicted by Sonnet.

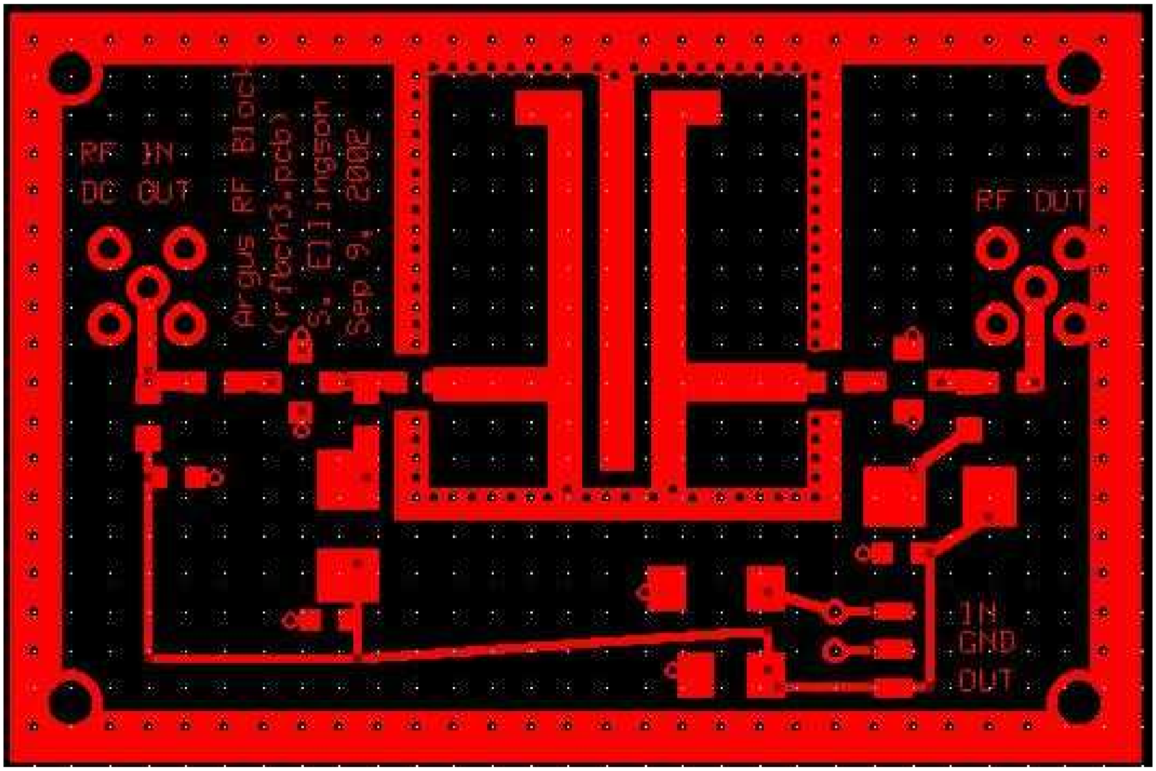

Figure 10: PCB “top” side (screen dump from layout software).

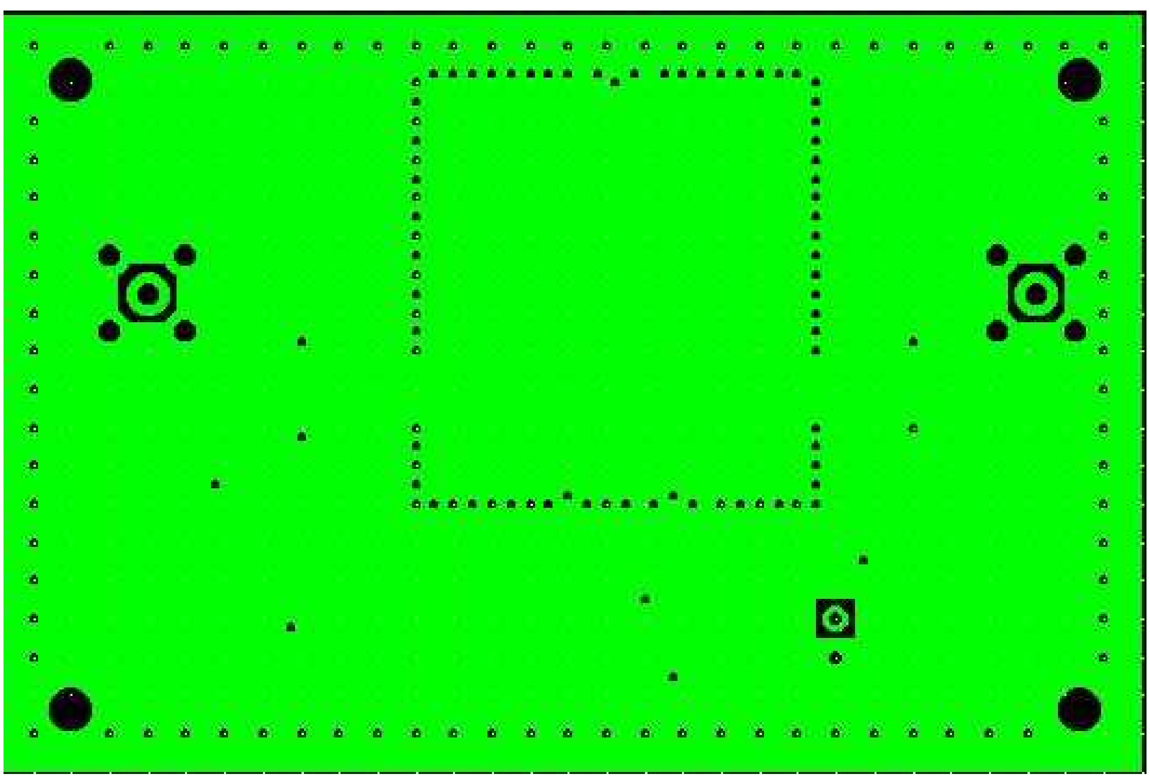

Figure 11: PCB “bottom” side (screen dump from layout software).

References

[1] S.W. Ellingson, "A Low-Cost L-Band Line Amplifier," Design Report, September 9, 2002.

[2] S.W. Ellingson, "A 1-GHz Highpass PHEMT Low-Noise Amplifier", Design Report, July 26, 2002.