APPLICATION NOTE

AN1037
Optimizing a Silicon Bipolar LNA Performance for Blue Tooth Applications

Abstract

The NE662M04 is NEC's latest generation of Silicon Bipolar junction RF-transistor, using a state-of-the-art UHSO 25 GHz f_T wafer process. It provides excellent low voltage/low current performance and is ideally suited for low noise mobile applications. This application note describes a low-noise amplifier designed for the Blue Tooth RF standard specifications per ***Table 1****. The emphasis is set on achieving a low noise, high gain performance while keeping current consumption at a minimum and a fairly good input and output match.*

General information, test results, circuit schematic, board layout and Billing of Material is enclosed as a reference. ***California Eastern Laboratories*** *also provides this circuit as an evaluation board to its customers for quick turn around design cycles.*

LNA Design and Matching Network

In order to achieve the specification and provide the appropriate matching, the design uses an inductive emitter feedback through a high impedance printed transmission line and all other matching elements are lumped components. The approximately 0.7 nH emitter inductance provides a few advantages: It allows for matching the device for minimum noise figure performance while keeping an acceptable input matching, it enhances the in-band stability performance of the LNA and to some lesser extent, it improves the linearity of the device. However, the trade-off is reduced gain and the potential for high frequency oscillations. The latter can easily be negated by carefully choosing the out of band matching.

The bias network is a simple base resistor that will fix the current to 5 mA. In circuits where temperature stability or reduced sensibility to manufacturing variations is more of an issue, an active stabilization bias can be used with commonly available electronic bipolar transistors.

The input matching network comprises only C_1 and L_1 and is set to achieve Γ_{OPT} from a 50Ω input load. L_1 is also used as the choke that brings the base current to the transistor and is RF grounded by C_2. The long transmissions line to and from C_3 are only additional DC chokes to bias the device. The output matching is a simple capacitive match through C_7 that provides better than 1.5:1 match. L_2 is the RF choke grounded through C_5 and further choking is provided by the printed inductive transmission line. The circuit schematic, layout and assembly drawing are available in **Figures 1, 2, 3** and the Billing of Material is displayed in **Table 2**.

The matching has been optimized for the particular Blue Tooth receiving band. However, the PCB board can be used in a wide range of applications, from 460 MHz to about 3 GHz for a number of devices, providing that an appropriate matching network is synthesized.

The 2.4 GHz LNA results are available in **Figure 4-6** and **Table 3**.

Item	Parameters LNA Section	Specifications	Test Results	Units	Notes
1	Voltage	3	3	V	Low Voltage
2	Current	5	5	mA	Low Current
3	Operating Frequency	2400-2483.5	1930-1990	GHz	US/European Bands
4	Gain	10	12	dB	
5	NF	1.5	1.3	dB	Low Noise
6	Input IP3	0	3	dBm	High IP3
7	1 dB Compression Point	-5.0	0	dBm	
8	Input VSWR (50 Ohms)	2.5:1 (-9.5 dB)	-10	-	
9	Output VSWR (50 Ohms)	1.5:1 (-14 dB)	-15	-	
10	Stability at all Frequencies	Unconditionally Stable	Unconditionally Stable	-	
11	Operating Temperature	-40 to +80	-40 to +80	°C	

Table 1. Bluetooth Low Noise Amplifier: Specifications and Test Results.

EVALUATION BOARD PARTS LIST

QTY	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.
1	TF-100413		NE34018-EVAL TEST FIXTURE BLOCK	14
1	LL 1608-FH5N6S	L1	5.6 nH INDUCTOR TOKO	13
1	LL 1608-FH15NJ	L2	15 nH INDUCTOR TOKO	12
1	LL 1608-FH2N7S	L3	2.7 nH INDUCTOR TOKO	11
1	MCR03J303JK	R1	0603 30 K OHM RES ROHM	10
2	MCH185A121JK	C2, C5	0603 120 pF CAP ROHM	9
1	MCH185A4R7CK	C1	0603 4.7 pF CAP ROHM	8
2	MCH185A102JK	C3, C4	0603 1000 pF CAP ROHM	7
1	MCH185C300JK	C7	0603 30 pF CAP ROHM	6
1	881-6116	C6	4.7 μF CAP AVX	5
1	NE662M04	U1	IC NEC	4
2	2340-6111 TG	P1	PIN HEADER 3M	3
2	2052-1215-00	J1, J2	OSM JACK OMNI SPECTRA	2
1	FD-100722	PCB	NE622M04-EVAL FAB. DRAWING	1

Table 2. LNA Billing of Material

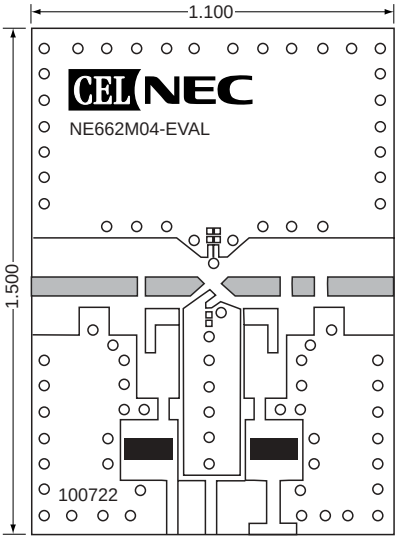

Figure 2. Printed Circuit Board Layout

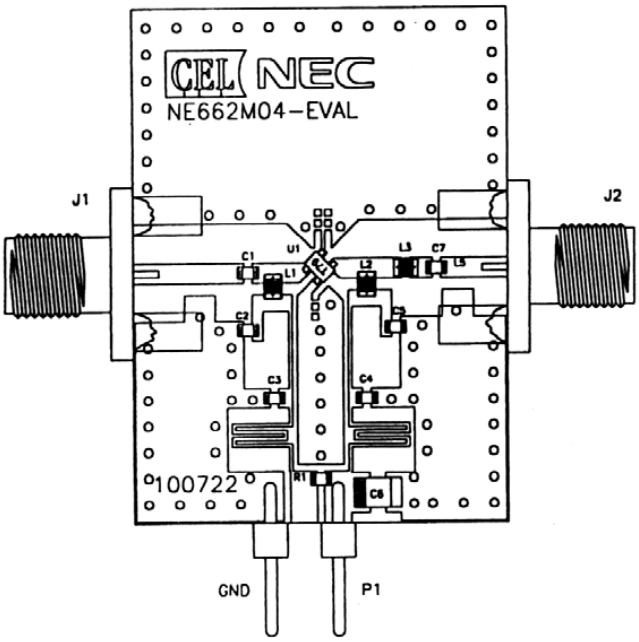

Figure 3. LNA Assembly Drawing

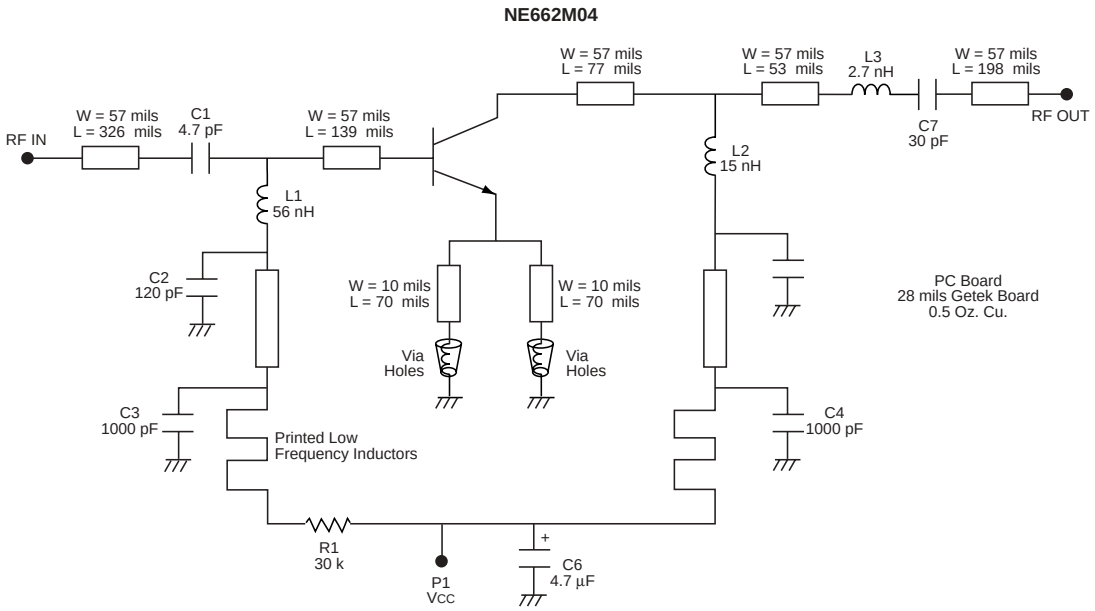

Figure 1. NE662M04 Blue Tooth LNA Schematic

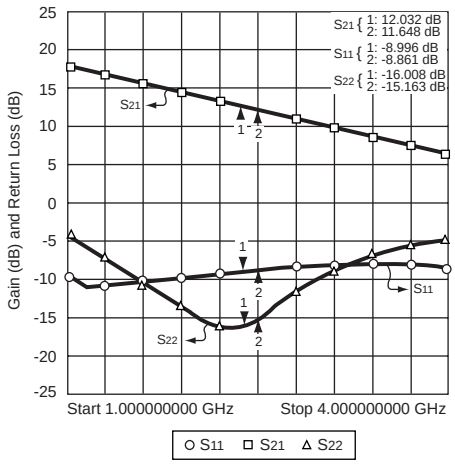

Figure 4. Measured Small Signal Performance

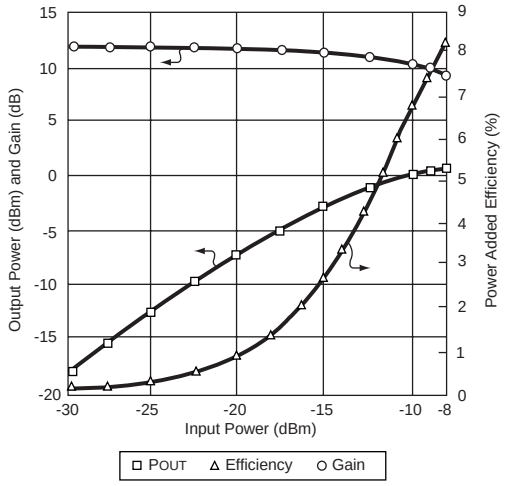

Figure 5. Output Power Performance

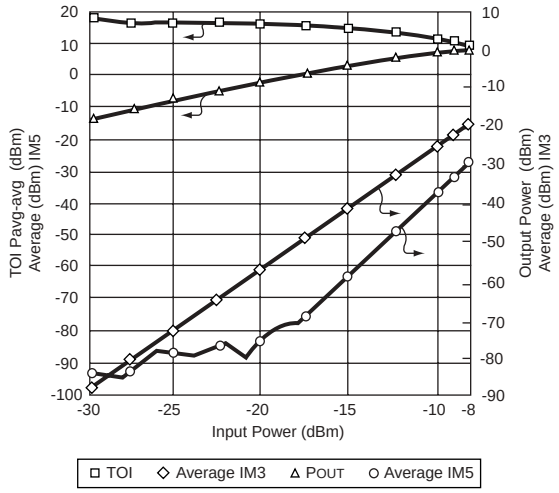

Figure 6. Linearity Performance

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Input Power (dBm)	Output Power (dBm)	Gain (dB)	Average (dBm) IM3	C / IM3 (dBc) Pavg-avg	TOI (dBm) Pavg-avg
-30.00	-18.15	11.85	-88.57	70.50	17.18
-29.00	-17.20	11.80	-87.54	70.42	18.09
-28.00	-16.29	11.71	-80.97	64.59	15.91
-27.00	-15.22	11.78	-78.80	63.50	16.45
-26.00	-14.20	11.80	-75.87	61.58	16.50
-25.00	-13.23	11.77	-72.48	59.16	16.27
-24.00	-12.24	11.76	-69.83	57.67	16.68
-23.00	-11.25	11.75	-66.67	55.33	16.33
-22.00	-10.25	11.75	-63.08	52.75	16.04
-21.00	-9.26	11.74	-60.93	51.66	16.57
-20.00	-8.28	11.72	-57.28	48.91	16.09
-19.00	-7.29	11.71	-54.46	47.09	16.17
-18.00	-6.34	11.66	-51.67	45.16	16.07
-17.00	-5.36	11.64	-48.44	42.83	15.80
-16.00	-4.40	11.60	-45.41	40.67	15.60
-15.00	-3.46	11.54	-42.37	38.59	15.51
-14.00	-2.57	11.43	-39.48	36.34	15.02
-13.00	-1.69	11.31	-35.86	33.58	14.52
-12.00	-0.86	11.14	-31.86	30.25	13.51
-11.00	-0.14	10.86	-27.81	26.83	12.45
-10.00	0.51	10.51	-24.15	23.66	11.34
-9.00	1.04	10.04	-21.04	21.00	10.46

Frequency: 2.400 GHz
V_D: 2.999 V, I_D = 5 mA
P_{OUT} at 1 dB: .168 dBm
Gain at 1 dB: 10.744 dB
Efficiency at 1 dB: 6.39 %
IIP3 at P_{IN} = -21 dBm = +4.77 dBm
Noise Figure at 2.4 GHz = 1.15 dB

Table 3. Summary of Power Performance.

California Eastern Laboratories

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