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The Design, Optimization and Characterization of 7GHz Ultra Low Noise Figure Amplifier using Hybrid MIC Technique for Satellite Mobile Applications

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ABSTRACT

This article, examines and outlines the configuration of the single operating point 7.2GHz ultra Low Noise Amplifier(LNA). In light of the recreation execution of simulation performance it has been examined the essential trade-offs like Gain, Noise Figure(NF), Return Loss(RL) and stability of the composed LNA. This work shows the LNA configuration of the single stage and took after by two stage cascaded design. This works incorporates the examination of both designs which has distinct only input matching networks and particular just info cascaded configurations and give essential things to embrace the fell arrangements. The LNA design to accomplish ultra NF which is designed using micro strip lines, radial stub series with capacitors. All configuration, investigation and estimations are conveyed in Industrial institutionalize Applied Wave Research(AWR) microwave office tool. Likewise, the simulations result at 7.2GHz NF is 0.28dB, gain 21dB, Input Return Loss(IRL) and Output Return Loss(ORL) are 12.78dB and 20dB correspondingly. The proposed LNA has the applications in Essential military prerequisites for satellite downlinks; the mobile satellite sub-band 7250-7300 MHz is for naval and area portable earth stations. 7250-7300 MHz is for the Mobile-Satellite allotment.

Keywords

Gain; Ultra Noise Figure (NF); Stability analysis; Transistors; Low noise amplifier (LNA); Micro strip lines.

1. INTRODUCTION

A low noise amplifier plays a key part in the general execution of a RF receiver. It is the principal segment in any RF receiver which constitutes and built for low noise figure(NF) and high gain. The general topology of the LNA comprises of three phases: input matching network (IMN), the amplifier itself and the output matching network (OMN) [1][2]. Be that as it may, it is hard for a conventional LNA to accomplish those critical qualities at the same time in which LNA gain and noise will have more effect on the rest of the parts of the receiver [3][4].

Nonetheless, Hybrid Microwave Integrated Circuit(HMIC) based amplifiers are by all account not the only course to LNA. In the course of the most recent two decades there have additionally been advances in the improvement of HMIC LNAs. These amplifiers incorporate the greater part of the transistors, vendor lumped components, transmission lines and matching networks onto an individual circuit board, this combination gives the HMIC a few focal points and its prudent as well. Lamentably, notwithstanding, their coordinated nature implies that it is impractical to completely advance their configuration, accordingly they will never offer as great a noise performance as an amplifier created from discrete devices [5].

2. COLLECTED RESEARCH BACKGROUND

This segment will portray the quantity of late works of the LNA plans which are committed for the great execution at specific focuses. [6] In their article, another coherent penta-band low noise amplifier (CPB-LNA) that works at navigational frequencies viz., 1.2 GHz, 1.5 GHz and wireless Communication frequencies viz., 2.45 GHz, 3.3 GHz and Dedicated Short Range Communication frequency (DSRC), 5.8 GHz for vehicle to vehicle communications is designed and analysed. This circuit has a distinct input matching network which resonates at all desired five frequency bands simultaneously and is achieved by adapting frequency transformation method. The output matching circuit comprises of simple LC matching network designed by using load-pull methodology. The CPB- LNA is simulated using Advance Design System (ADS). The power gain of CPB-LNA is 15.09 dB at 1.2 GHz, 14.368 dB at 1.5 GHz and 14.945 dB at 2.4 GHz, 14.302 dB at 3.3 GHz and 12.075 dB at 5.8 GHz. Noise figure (NF) of 0.48 dB at 1.2 GHz, 1.7 dB at 1.5 GHz and 1.07 dB at 2.4GHz, 0.572 dB at 3.3 GHz and 1.201 dB at 5.8GHz are achieved. Input and output return loss is below −12 dB for all desired frequency bands. [7] In their article, a Multiband LNA for collector framework is intended to work at 950 MHz, GHz, 2.2 GHz, and 2.4 GHz focus frequencies. It was outlined utilizing HJ-FET NE32500 transistor which has self-bias attributes. Through Electronic Design Automation (EDA) reproductions, the outline execution of multiband LNA is dissected and parameters, for example, Gain, return loss, Noise Figure and Stability of the circuit for the above focus frequencies have been assessed. The obtained results, ($S21 > 10$ dB, $S11 < -10$ dB) and low Noise Figure (<1dB) make this LNA a preferred choice for multiband operation.

[8], In their paper it was articulated a LNA with high Gain and minimum noise execution for Global Positioning System (GPS) application. The CMOS LNA execution is planned and mimicked by means of rhythm utilizing UMC 90 nm library. The topology is single finished LNAs outlined which utilizes fell transistor for detachment; the normal source transistor is driven by regular entryway transistor. To have objective for good voltage pick up with least Noise figure, cascoding input matching is done utilizing source degeneration system. Transistors are worked in sub edge locale. At 1.57 GHz recurrence, parameters like force addition, input matching, yield coordinating, detachment, strength are analysed by S-

parameters. The voltage gain of LNA is 31 dB. The noise figure is 0.533 dB, 1dB compression point is -16.95 dBm and IIP3 is 2.91 dBm. The LNA is having power utilization of 8.7 mW for 1.5 V supply. [9], In this paper, a streamlined configuration technique in view of transformative calculations for programmed combination of a current reuse cascode completely coordinated LNA focused on @2.4GHz is talked about. Here genetic Algorithm is proposed to figure the circuit components values and bias levels fit for keeping up the best level of gain, input matching, and power consumption. The circuit recreate utilizing 0.18µm RF CMOS TSMC innovation for to assess execution. Programmed circuit plan utilizing developmental advancement calculation enhanced configuration taking less calculation time contrast with gigantic manual trial. The Simulation comes about demonstrated the power gain (S21) and input matching (S11) are 26dB and -13dB individually @2.4GHz. Simulation results demonstrate output reflection (S12) is less than -35dB and current sink structure 1.8V supply is only 5.6mA.

3. LNA DESIGN METHODOLOGY

The approach of the design is appeared in the flow diagram will investigate the design parameters space of integrated inductively-low noise amplifiers (LNA), under the limitation of coordinated information impedance, is introduced.

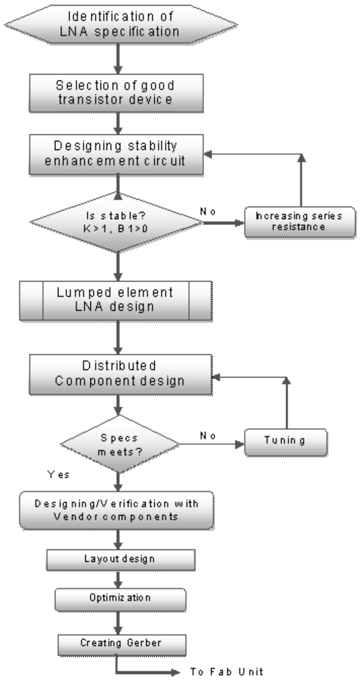

Fig 1. LNA design flow from schematic to implementation

It is based on **AWR** microwave simulation tool and can be easily automated. The optimization to meet the given specification by the vendor is made after transforming the lumped design into Distributed element LNA design. The LNA is expected to show good agreement with AWR simulation and tested in network analyser

3.1 Single Stage Design

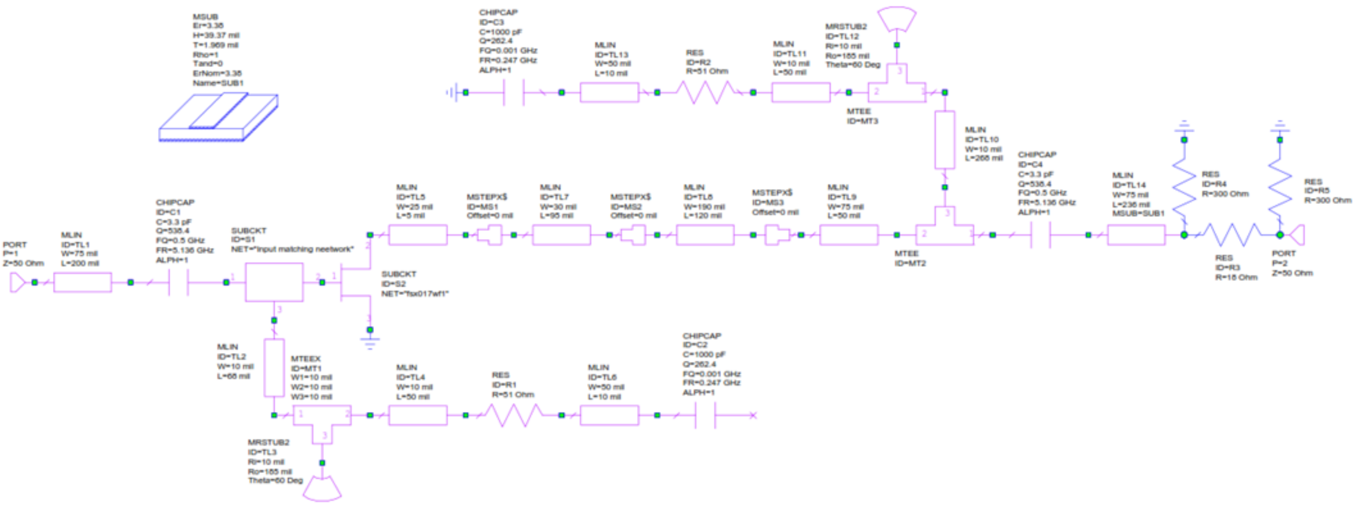

Fig 2. Shows Schematic of single stage LNA design

In the figure 2 arrangement of series gate capacitance C1 is added to the transistors to enhances S11 yet didn't related or influences S22, yet though NF enhances, gain change is less and won't modify stability dependability factors, C2 gives stability to the circuit. Similarly, output side capacitance C4 improves both S11 input return loss and output return loss S22 and improves the performance with respect to Gain and NF but decreases the performances of stability factors.

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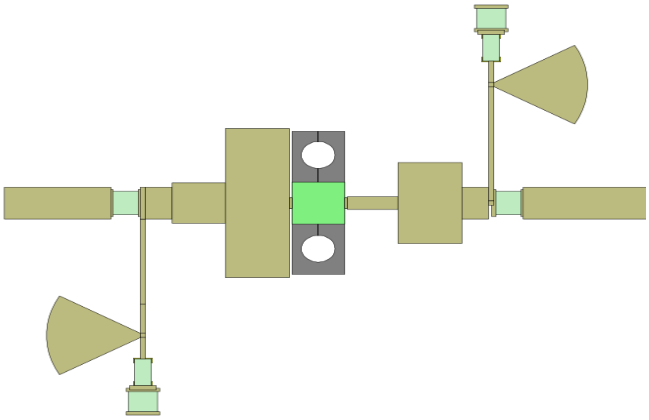

Fig 3. Shows 2D layout of the single stage design.

Layout Design will be set up by taking after certain convention. No two gadgets must be associated consecutive. Utilise MLIN between parts and MTEE$/MCROSS$ at whatever point there is an intersection, Extend the intersection arms utilising MLIN. Establishing must be done utilising through. Soften schematic up to Sub circuits.

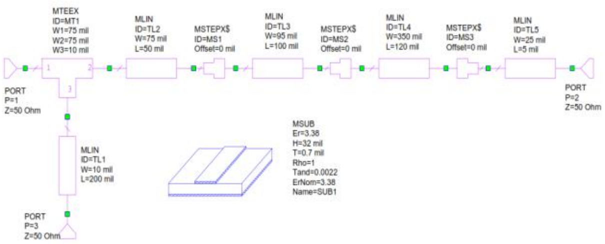

Fig 4. Shows Schematic which contains Microstrip Substrate details

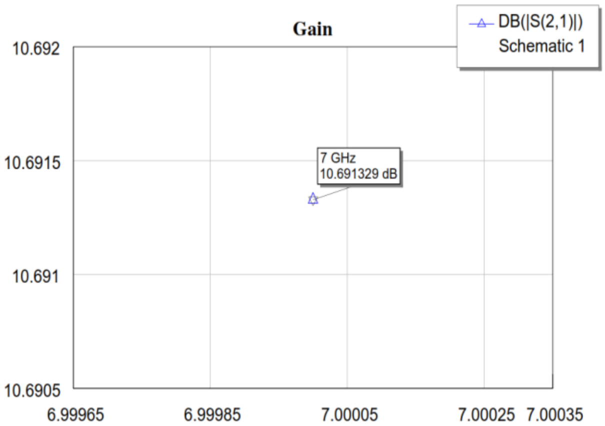

Fig 5. Shows Gain in dB at 7GHz of the single stage design

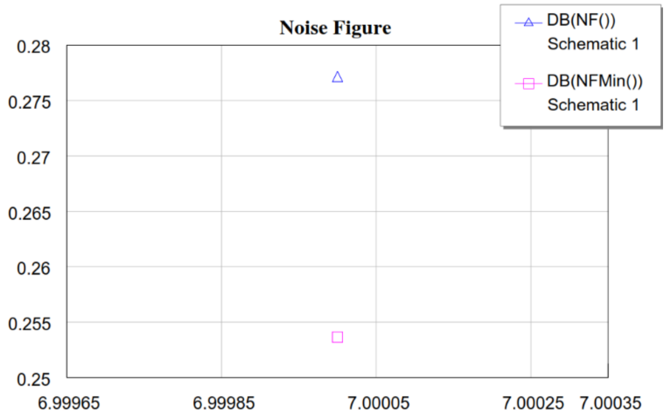

Fig 6. Shows Noise Figure characteristics at 7GHz of single stage LNA

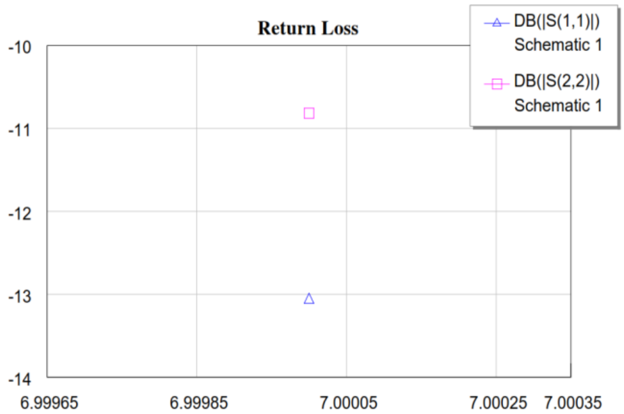

Fig 7. Shows Input Return Loss (S11) and Output Return Loss (S22) in dB at 7GHz of single stage LNA

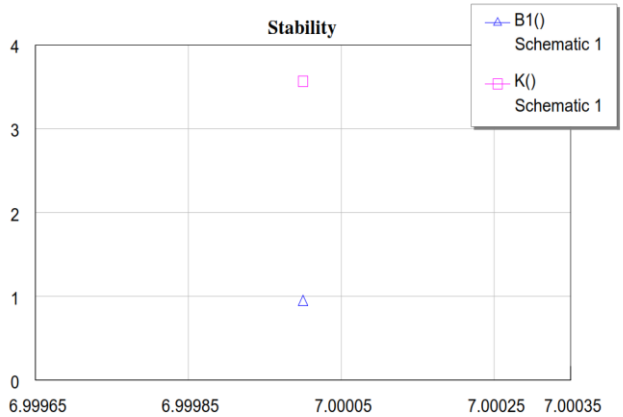

Fig 8. Shows Rollets Factors K and Auxillary Factor B1 of Single stage LNA

$$K = \frac{1-|S_{11}|^2-|S_{22}|^2+|\Delta|^2}{2|S_{12}\cdot S_{21}|} > 1 \qquad (1)$$

$$where\ |\Delta| = |s_{11}\cdot s_{22} - s_{12}\cdot s_{21}| < 1$$

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3.2 Two stage Cascaded LNA

$$F_{total} = F_1 + \frac{F_2-1}{G_1} + \frac{F_3-1}{G_1 G_2} + \frac{F_4-1}{G_1 G_2 G_3} + \cdots \quad (2)$$

where F_n and G_n are the noise factor and available power gain, respectively, of the n-th stage. Note that both magnitudes are expressed as ratios, not in decibels.
Friis's formula can be equivalently expressed in terms of noise temperature:

$$T_{total} = T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} + \cdots \quad (3)$$

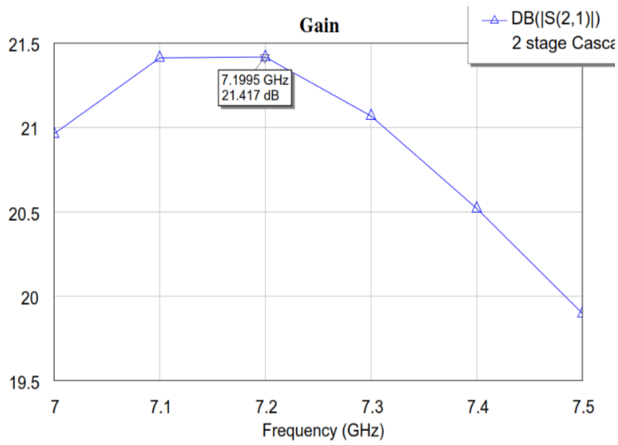

Fig 9. Shows Gain in dB around 7GHz of 2 stage cascaded LNA

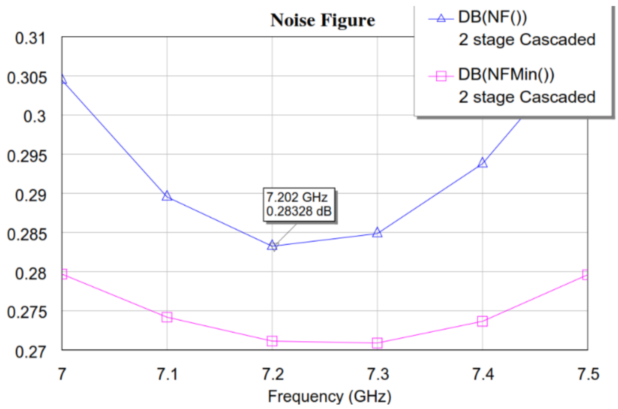

Fig 10. Shows Noise Figure in dB around 7GHz of 2 stage cascaded LNA

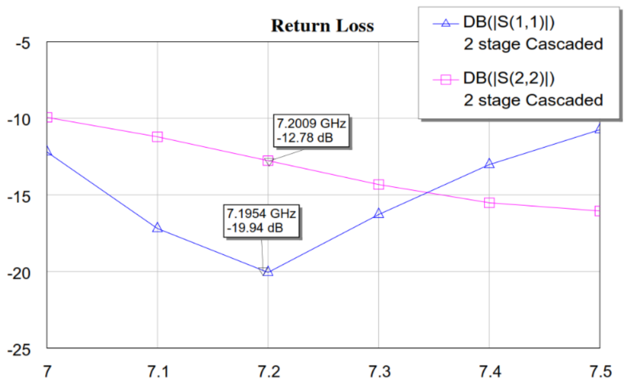

Fig 11. Shows Input Return Loss (S11) and Output Return Loss (S22) in dB at 7GHz of 2 stage cascaded LNA

If the power transmitted by the source is PT and the power reflected is PR, then the return loss in dB is given by

$$RL(db) = 10 \log_{10} \frac{P_T}{P_R} \quad (4)$$

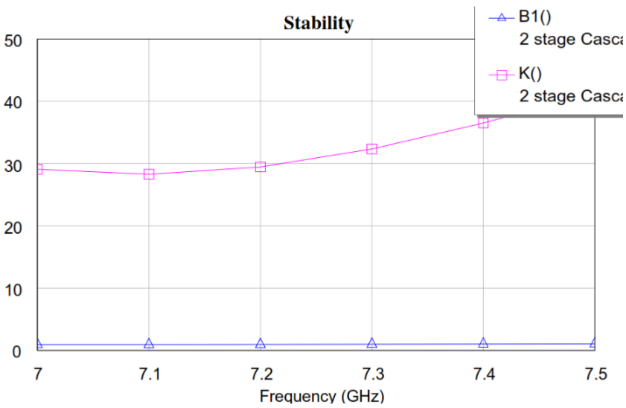

Fig 12. Shows Rollets Factors K and Auxillary Factor B1 of 2 stage cascaded LNA

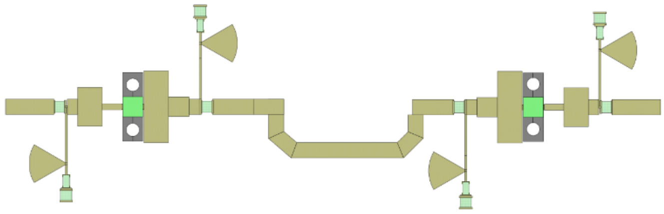

Fig 13. Shows complete 2D layout of 2 stage cascaded LNA

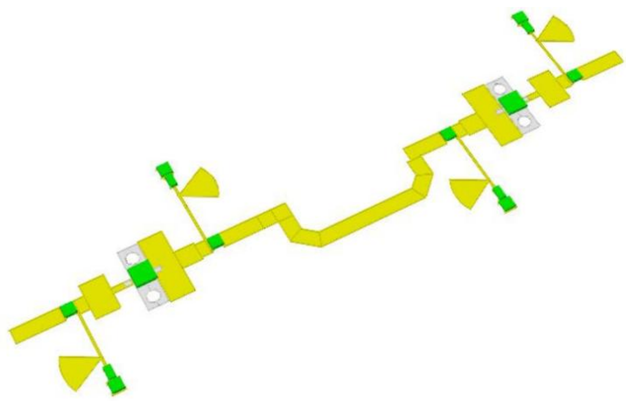

Fig 14. Shows complete 3D layout of 2 stage cascaded LNA

A layout design approach is endeavoured dedicatedly for HMICs (Hybrid microwave integrated circuits), on which prevalent design components are transistors, resistors, capacitors, inductors, coplanar waveguides, T junctions, Micro-strip lines and radial stubs and so forth., shaped by the GaAs manufacture handle. The design arrangement in HMICs comprises of the single layer position of various states of format components under an assortment of separating, orientating, and mounding imperatives with impressions of the vendor components. Every design component is demonstrated to rearrange arrangement errands subject to various position imperatives, and after that an arrangement of the interconnection necessities among components is spoken to by a graphical show in both 2D and 3D viewer, to which a planarization calculation is viably connected. As a consequence of this planarization, a position strategy is built principally by rehashed use of a combining plan. Various exploratory results are additionally appeared to exhibit the practicability of the depicted format approach [10]. A Layout outline preparing framework comprising in the AWR microwave tool for the plan and the other for the examination of HMIC designs utilizing miniaturized scale strip lines is depicted. Two circuit format is demonstrated which is of single stage in figure 4 and 2 stage cascaded circuit layouts 2D viewer in figure 13 and 3D viewer in figure 14.

Ref.	**Frequency (GHz)**	**NF (dB)**	**Gain (dB)**	**Return Loss**	
				S11(dB)	**S22(dB)**
[11]	5	2.8	16	-9.4	<10
[12]	6	2.3	30	<-10	<-10
[6]	5.8	1.20	12	<-12	<-12
[13]	4.1	2.13	19.9	-25.3	-12.6
[14]	5.2	2.8	14.4	<-10	<-10
This work	7.2	0.28	21.8	-19	-12

4. CONCLUSION

In this paper, two stage LNA circuit has been design and simulated for the single point operating frequency of 7GHz and furthermore talked about by the execution examination with single stage and two stage LNA. The paper gives the best possible approach and planning system of the two stage LNA as for fundamental parameters and trade-offs like Bandwidth, Gain, Noise Figure and return loss. These works have been demonstrated analysis and/or simulation of stage wise performance of the LNA design using Industrial Standardise AWR microwave office tool. The proposed LNA can be useful for the applications in military for satellite downlinks; the mobile satellite sub-band 7250-7300 MHz is for naval and area portable earth stations. 7250-7300 MHz is for the Mobile-Satellite allotment and some more.

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