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Analysis of Variation in Parameters of Lna Due to Ideal Lumped and With Vendor Components

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Abstract: - **This paper examines the simulation of a Low Noise Amplifier with lumped components in output and intermediate matching networks in frequency range of 3-5.1 GHz. The paper shows that due to unavailability of exact values of ideal lumped components in form of vendor components designed LNA parameters will change accordingly due behavioral change in values of components. Small change in values of components causes large changes in S-parameters of device which will cause respective change in parameters since all parameters are related with S-parameters at microwave regions. This proposed Low Noise Amplifier has been designed and simulated in AWR Microwave Office. The designed amplifier provides noise figure <1.5 dB, gain >23 dB, Input Return Loss < -10 dB and Output Return Loss <-10.4 dB with unconditional stability in frequency range of 3 – 5.1 GHz with both ideal lumped component design and vendor lumped component.**

Keywords: - **ATF36163, Ideal Lumped elements, PHEMT, Noise Figure, Return Loss.**

I. INTRODUCTION

Low Noise Amplifier is a typical component used regularly in wireless circuit. It amplifies the signal while introducing a minimum amount of noise. The first stage of a receiver is typically a low-noise amplifier (LNA), whose main function is to provide enough gain to overcome the noise of subsequent stages (for example, in the mixer or IF amplifier). Aside from providing enough gain while adding as little noise as possible, an LNA should accommodate large signals without distortion, offer a large dynamic range, and present good matching to its input and output, which is extremely important if a passive band select filter and image-reject filter precedes and succeeds the LNA, since the transfer characteristics of many filters are quite sensitive to the quality of the termination.

An LNA combines a low noise figure, reasonable gain, and stability without oscillation over entire useful frequency range. There is a requirement of high sensitivity and broadband Amplifier designs necessitate selection of transistors with very low minimum noise figure (NFmin) and noise resistance (Rn) values.In general the important characteristics of LNA are: high Gain, low Noise figure, Stability, Linearity and good input output matching.

In this paper, parameters of two-stage low-noise-amplifier (LNA) are compared by utilising ideal lumped components and vendor lumped components. In the design process, the Pseudomorphic High Electron Mobility Transistor (PHEMT) ATF36163 is used as active device at first and second stage. In the design process, The AWR software is used to determine Linear parameters Noise Figure, Gain, Return Loss and Stability [4]. The high electron mobility transistor (HEMT) or Psuedomorphic HEMT (pHEMT) has been widely utilized for LNA designs owing to its inherently low-noise characteristics [5]-[6], and the GaAs-based pHEMT has become a well-established commercial process technology in microwave and millimeter-wave electronics [8].The fundamental component of pHEMT innovation is signal to noise ratio for higher frequency range making them a preferred device as compared to its counterparts [7].

II. THEORETICAL DESCRIPTION

In this section, we will introduce basic theory of two stage LNA lumped matching network. Using optimum noise matching, minimum achievable noise figure of an LNA (NFmin) is obtained. On the other hand, power gain (conjugate impedance matching) yields the maximum available power gain for a circuit. Unfortunately these two matchings are contradictory and hence both of maximum available gain and minimum noise figure are not simultaneously possible. Good input and output matching can be obtained by using proper matching networks by utilising ideal lumped components but on the other hand availability of exact values of ideal components is not guaranteed. This paper is comparing results by utilising both ideal and nearest possible vendor components of Panasonic LNA design.Input and output port taken as standard 50 Ω.

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III. DESIGN OF LNA

Low noise amplifier designed according to flowchart given below,

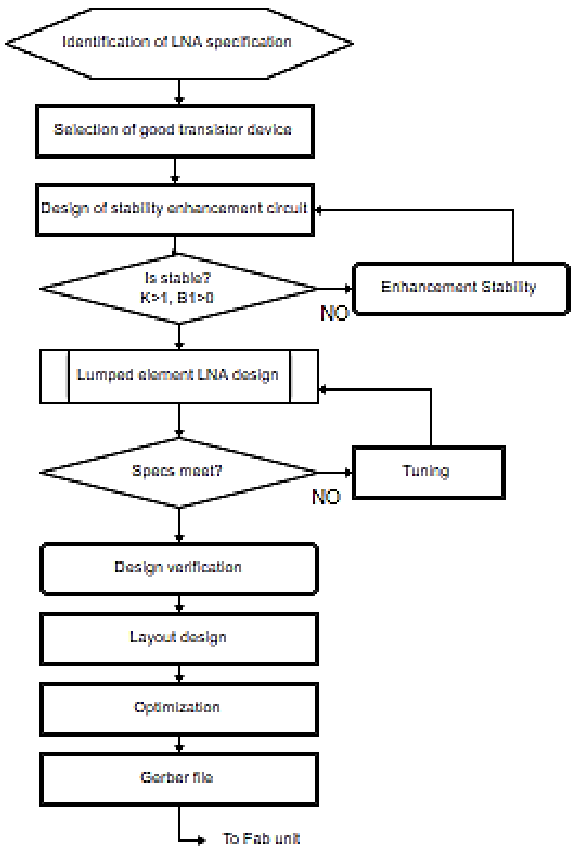

Fig 1: Design procedure of LNA

LNA is designed using AWR Microwave Office SimulationTool utilising ATF36163 PHEMT operating at 1.5 V, 20 mA.

IV. DESIGN OF PROPOSED LNA

FirstlyLNA is designed using ideal lumped component, Figure 2 shows design with ideal lumped components.

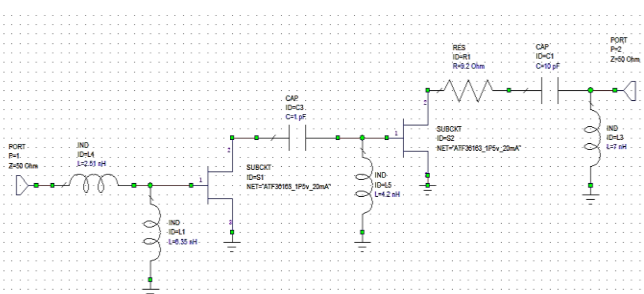

Fig 2: Designed LNA with ideal lumped components

Input Matching Network consist of L-type network utilisingof L-L combination having values L1=2.51nH, L2=6.35nH.
Intermediate Matching Network consist of L-type network utilising of C-L combination having values C1=1pf, L1=4.2nH.
Output Matching Network consist of L-type network utilizing R-C-L combination having valuesR1=9.2Ω, C1=10pf, and L1=7nH.All the Matching Networks designed using Smith chart analysis method (Complex Conjugate Matching).
Secondly lumped elements are replaced by vendor elements library components of panasonic. Figure 3 shows design with vendor lumped components.
Due to availability of fixed values of vendor lumped components exact values will not be same of ideal components.

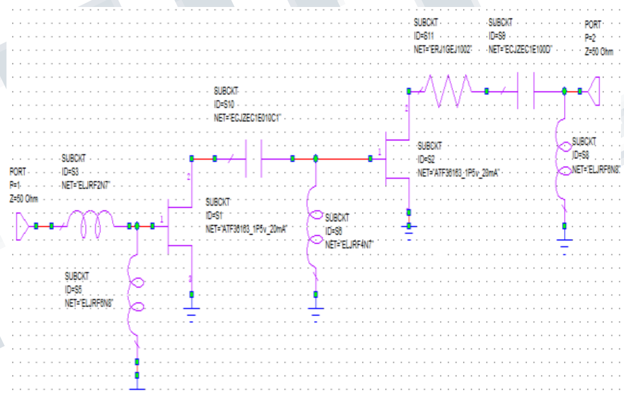

Fig 3: Designed LNA with vendor lumped components

Input Matching Network consist of L-type network utilising of L-L combination having values L1=2.7nH, L2=6.8nH.
Intermediate Matching Network consist of L-type network utilising of C-L combination having values C1=1pf, L1=4.7nH.
Output Matching Network consist of L-type network utilizing R-C-L combination having valuesR1=10Ω, C1=10pf, and L1=6.8nH.

V. RESULTS OF PROPOSED DESIGN

Please The Noise Figure for cascaded LNA will be given by,

$$F_{total} = F_1 + (F_2-1)/G1 + (F_3-1)/G_1G_2 + \ldots \quad (1)$$

where,
Fn and Gn 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.

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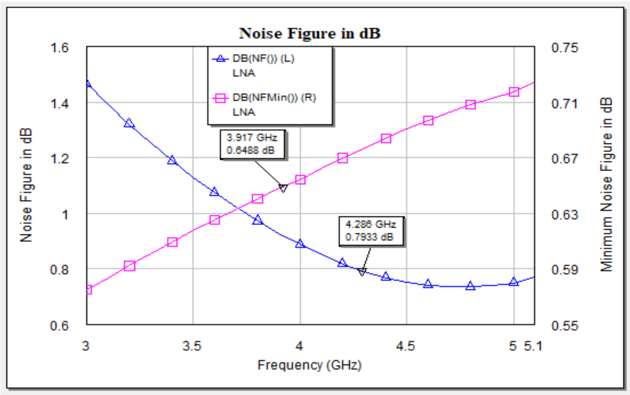

Fig 4: Noise Figure of the LNA with ideal lumped components

Figure 4 Shows variation of Noise Figure of the LNA with respect to frequency and is controlled within 1.5 dB for two stage cascaded design.

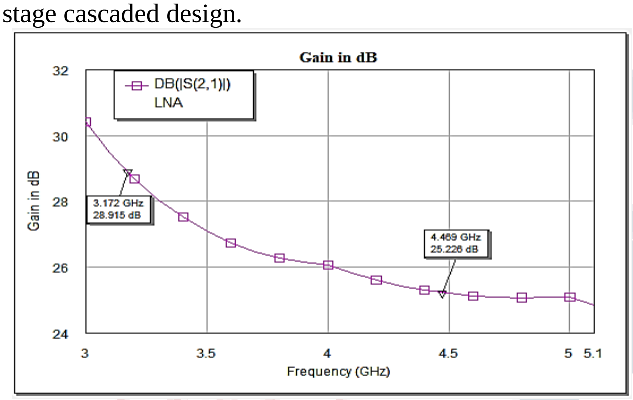

Fig 5: Gain of the LNA with ideal lumped components

Figure 5 Shows variation Gain of the LNA with respect to frequency and is varying within 25 – 30.5 dB for two stage cascaded design.

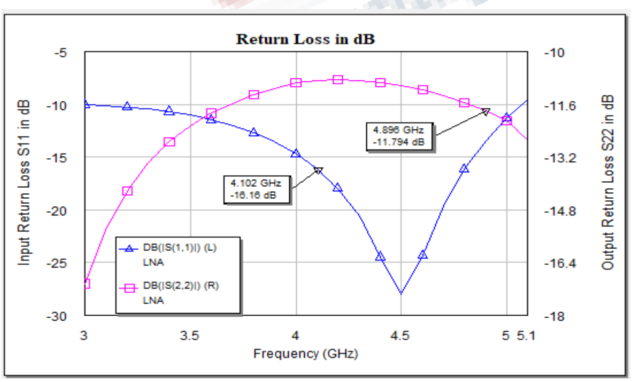

Fig 6: Return Loss of the LNA with ideal lumped components

For transmission power PT from the source and the reflected power PR the return loss in dB is given by,

$$RL\ (dB) = 10 \log_{10} (Pt/Pr) \qquad (2)$$

Figure 6 Shows variation Return Loss of the LNA with respect to frequency and is varying within -10 to -27.5 dB (IRL) and -11 to -27 dB (ORL) for two stage cascaded design.

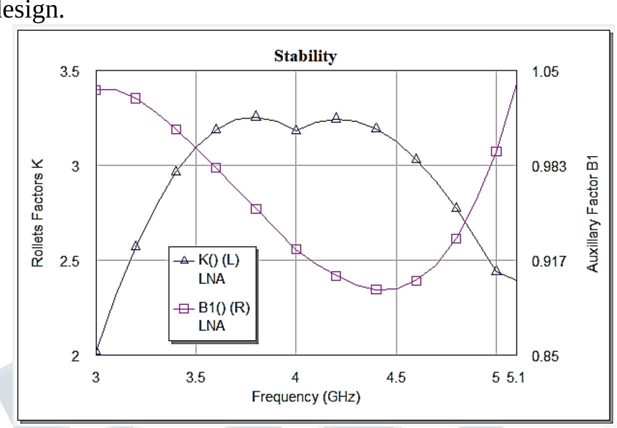

Fig 7: Stability of the LNA with ideal lumped components

For unconditionally stability,

$K = (1-|S11|2-|S22|2+|\Delta|2)/2*(S12*S21) > 1$ (3)

And

$|\Delta| = | S11* S22 - S12\ S21| < 1$ (4)

Figure 7 Shows Designed LNA is unconditionally stable over entire range 3 -5.1 GHz over Bandwidth of 2.1 GHz.

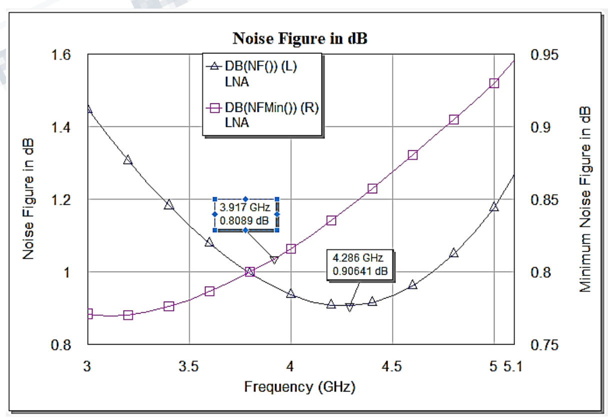

Fig 8: Noise Figure of the LNA with vendor lumped components

Figure 8 Shows variation of Noise Figure of the LNA (with vendor components) with respect to frequency and is controlled within 1.5 dB for two stage cascaded design.

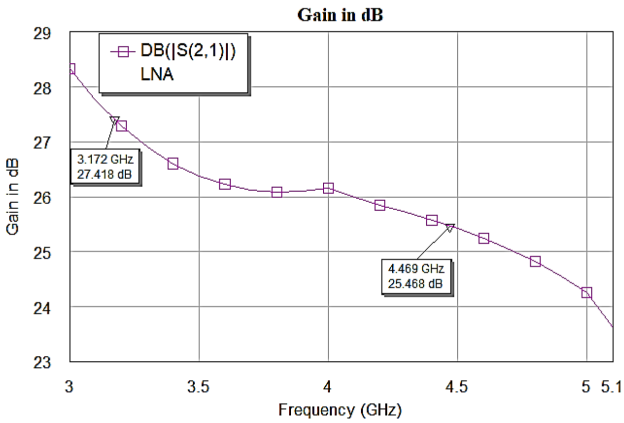

Fig 9: Gain of the LNA with vendor lumped components

Figure 9 Shows variation Gain of the LNA(with vendor components) with respect to frequency and is varying within 23.5 – 28.5 dB for two stage cascaded design.

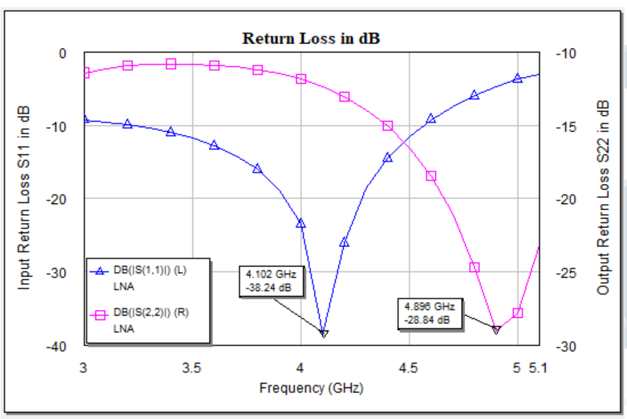

Fig 10: Return loss of the LNA with vendor lumped components

Figure 10 Shows variation Return Loss of the LNA(with vendor components) with respect to frequency and is varying within -10 to -38 dB (IRL) and -10.4 to -28.84 dB (ORL) for two stage cascaded design.

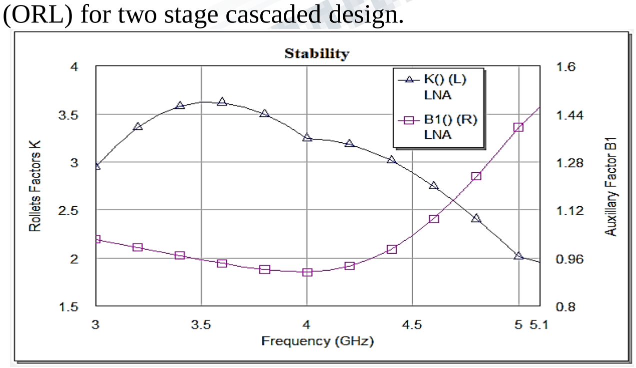

Fig 11: Stability of the LNA with vendor lumped component

Figure 11 Shows Designed LNA(with vendor components) is unconditionally stable over same range 3 -5.1 GHz over Bandwidth of 2.1 GHz.

Table 1. Comparision of Results

Parameters	Gain in dB	Noise Figure in dB	S11 in dB	S22 in dB
Withideal component	25 to30.5	.59 to 1.5	-10to -27.5	-11 to -27
With vendor component (Panasonic)	23.5 to 28.5	0.9 to 1.5	-10 to -38	-10.4 to -28.84

VI. CONCLUSION

A low noise amplifier has been designed by utilising ideal and practical lumped components for 3-5.1 GHzand simulated using AWR Microwave office industrial tool. Results shows that there will be variation in recorded results due to unavailability of exact values of lumped components. Bandwidth achieved for LNA is 2.1 GHz. Additional advantages of this design is higher Gain and lower noise figure with lower Return Loss over entire operating range.

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