LOW NOISE AMPLIFIER USING ELECTROMAGNETIC SIMULATOR AT U-NII FREQUENCY BAND

Hak-Sung Kim, Cheol-Su Kim, Jong-Hun Kim, Byung-Jae Lee
Jong-Chul Lee and Nam-Young Kim
School of Electronic Eng. Kwangwoon Univ.
RFIC Research & Education Center, Mission Technology Research Ce
E-mail : tank@explore.kwangwoon.ac.kr

In this paper, the design for a low noise amplifier with the EM simulation is presented. The ATF36077 pHEMT device is applied to design LNA for U-NII frequency band (5 GHz ~ 6 GHz). The matching networks have been designed by the only open ended stub in order to reduce parasitic effects generated from a via structure. Through EM simulator, the simulation result shows that the linear gain (@5.5 GHz) is over 10 dB, input return loss and output return loss (@ 5.5 GHz) are a below 10 dB respectively, and the 3rd order intercept point is about 17 dBm.

I. Introduction

The U-NII frequency band is an ideal solution for short-haul applications. The U-NII band is divided into three sub bands at 5.15 GHz ~5.25 GHz , 5.25 GHz ~ 5.35 GHz and 5.725 GHz ~ 5.825 GHz. The first band is strictly allocated for indoor use and is consistent with the European High Performance Local Area Network (HIPERLAN). The second and third bands are intended for high-speed digital local access products for campus and short-haul microwave applications. In this paper, a LNA with a low noise pHEMT device (ATF36077) has been designed for such a system. In order to design of practical radio frequency and microwave circuits some information of the limitations and the parasitic associated with practical components such as (R, L, and C) are essential. Because of the constrained properties, it is difficult to design with lumped components in required frequency band. Therefore, the distributed element such as a microstrip transmission line has been used for a choke and matching network. The Agilent Momentum CAD tool as an EM simulator has been used for the analysis of 2.5D structure. Momentum CAD tool takes into account real-world design geometries to simulate coupling and parasitic effects, which overcomes the limitations of general circuit simulators. The general circuit simulators must explicitly account for signal coupling and are also limited to designs that can be constructed from available circuit models, while this is implicitly account for signal coupling and is not constrained by available models.

II. Circut Design of LNA

For required frequency range, distributed elements are available for the blocking circuit, and also can be designed without the additional parasitic elements. Figure 1 shows the DC block circuit with microstrip transmission line and equivalent circuit.

In practical microstrip, coupled transmission line of DC block has the two mode; even mode and odd mode due to dielectric inhomogenuity. Figure 2 shows the characteristic curve of designed DC blocking circuit.

The bias circuit of Fig. 3 is utilized to provide DC bias. A high impedance transmission line, which is one - quarter wavelength transmission line, transforms a short circuit into an open circuit at input and output of the transistor. The RF short-circuit can be obtained from a chip capacitor or a microstrip radial stub, which is shown in Fig. 4. By selecting the length of the radial stub with a quarter-wavelength, a short circuit is obtained at input of the stub. The distributed nature of the circuit also makes it susceptible for low frequency and high frequency as shown in Fig. 3. The inclusion of a small (0.5pF) and a big capacitor (100pF or more) and a resistor can help reduce these oscillations.

The stability of an amplifier should be considered. In the all frequency band without required band, the stability is improved through shunt capacitor of bias networks. Also resistive loading at the output and adjusting length of the radial stub keeps to stabilize the transistor at all frequency. Figure. 5 represents the improved stability factor.

The matching circuit is composed of only distributed element in order to reduce the parasitic effects generated from a via structure. This matching networks have been designed by the only open ended stub. Figure. 6 represents the layout of the designed low noise amplifier.

In this paper, the entire circuits are analysed using circuit EM simulator takes into account most of practical design geometries. Figure 7 shows the characteristic curve of the designed LNA circuit.

III. Conclusion

In this paper, the LNA as a single stage with a ATF-36077 pHEMT device at the U_NII frequency band (5 GHz ~ 6 GHz) has been designed. Through EM simulator such as Agilent Momentum CAD tool, it can be expected to get a good simulation results comforted with those of commercial device. From the simulation results, the linear gain (@5.5GHz) is an over 10 dB, input return loss and output return loss (@ 5.5 GHz) are a below 10 dB respectively, and the IP3 is about 17dBm. The size of the designed LNA is 30 x 32 mm.

Acknowledgement

We greatly appreciate the support of RFIC Research and Education center of Kwangwoon University, Agilent Technologies, and Mission Technology Research Center,

References

[1] G. Gonzalez, Microwave Transistor Amplifier Analysis and Design, Prentice Hall 1996.
[2] F. GARDIOL, Microstrip Circuits, John Wiley & Suns, 1994
[3] D. M. Pozar, Microwave Engineering Addison-Wesley, 1993.
[4] K.G. Gupta, R. Garg, and I. J. Bahl, Microstrip Lines and Slotlines, Artech House, 1979.
[5] Agilent Momentum manual

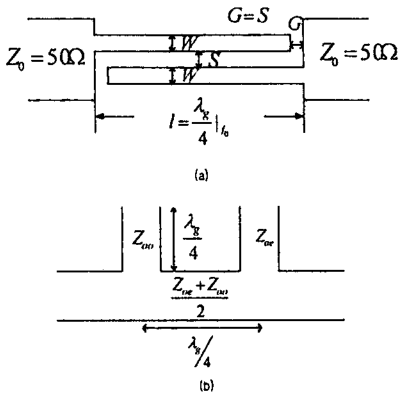


Fig. 1. The DC block circuit
a) Microstrip Line
b) Equivalent impedanc

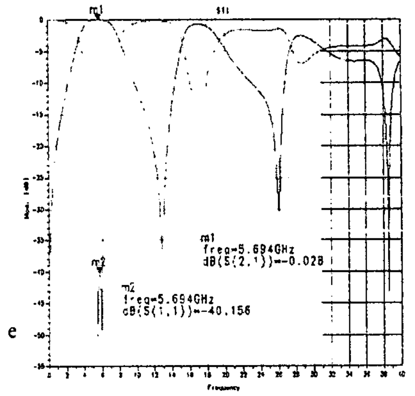


Fig. 2. The characteristic curve of DC blocking circuit using coupled microstrip transmission line

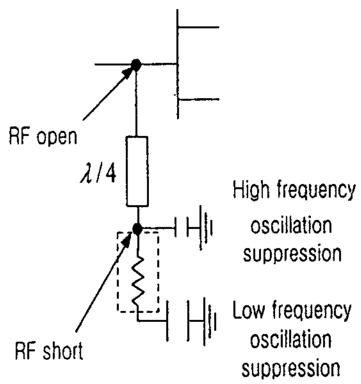


Fig. 3. DC bias circuit without inductors

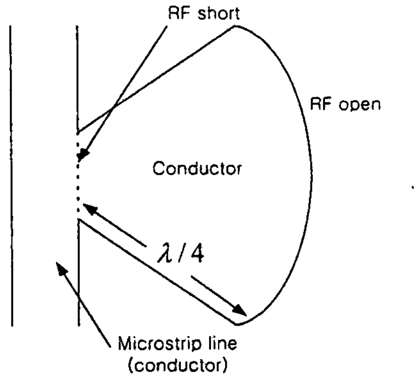


Fig. 4. Microstrip radial short circuit (top view)

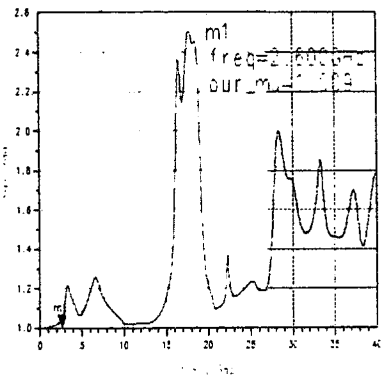


Fig. 5. The improved stability factor

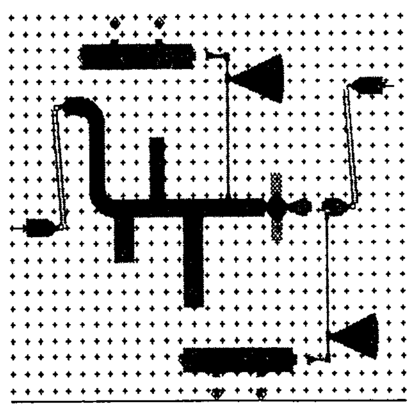
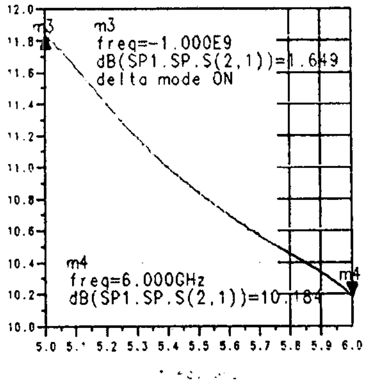
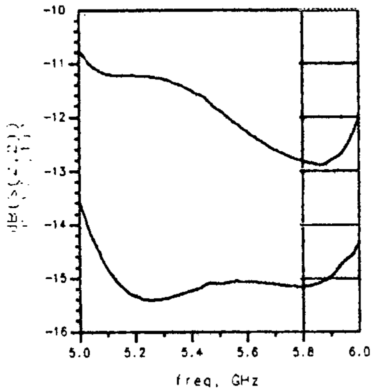


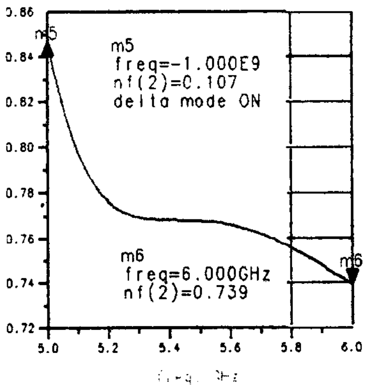
Fig. 6. The layout of low noise amplifier



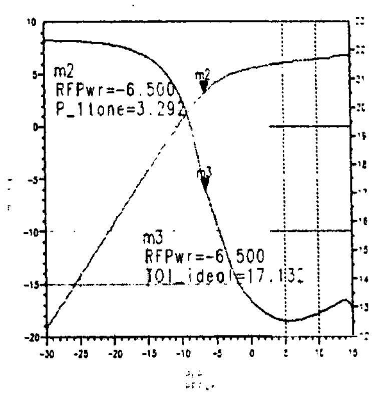
(a) Linear gain



(b) Return Loss



(c) Noise Figure



(d) 3rd order intercept point

Fig. 7. The characteristic curve of the designed LNA circuit (a) linear gain (b) return loss (c) noise figure (d) 3rd order intercept point (@1dB gain compression point)