High Dynamic-Range and Very Low Noise K-Band p-HEMT LNA MMIC for LMDS and Satellite Communication

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Abstract

An excellent noise figure and high linearity, K-band p-HEMT LNA MMIC, that incorporates single-bias configuration and negative feedback circuit, has been developed for LMDS (Local Multi-point Distribution Service) and satellite communication. The third order intercept point (IP3) of this MMIC is 20 dBm, while output power at 1-dB gain compression is 8.5 dBm. The IP3 and noise figure is 19.5 +/- 1 dBm and 1.8 +/- 0.2 dB, respectively, at frequencies between 24 and 32 GHz. The die size of the MMIC is 1.9 mm^2. This MMIC shows a potential reliable application in high-speed wireless access system.

1. INTRODUCTION

The design and manufacturing technologies of K-band low-noise amplifiers (LNAs) MMIC have been matured, and these MMICs are being commercially available. While modulation schemes for LMDS such as quadrature amplitude modulation (QAM), used to handle high capacity data transfer, requires these amplifiers should be high third-order intercept point [1].

This paper demonstrates a high linearity, 24-32 GHz LNA MMIC for LMDS and satellite communication.

2. HEMT STRUCTUER AND MMIC DESIGN

This LNA MMIC consists of 3-stages InGaP/InGaAs pseudomorphic HEMTs (p-HEMTs), which is fabricated on a semi-insulated GaAs substrate with 0.15-µm-long T-shaped gate electrode [2], [3]. A schematic cross section of the HEMT is shown in Figure 1.

By using self-bias scheme, gate-bias circuit can be removed and insertion loss of biasing circuit is 0.2 dB lower than conventional circuits. The die size of the MMIC is reduced to 1.9 mm^2 by means of minimized biasing circuit and high-impedance matching circuit [4], [5].

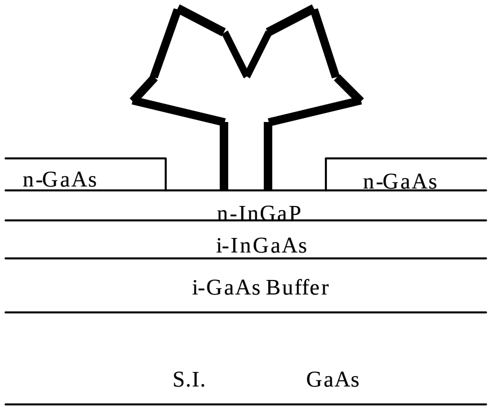

Figure 1 Schematic cross section of a T-shaped 0.15-μm InGaP/InGaAs HEMT

The gate widths of first and second stages are 80μm and to increase output power, gate width of third stage is 160μm. Matching condition of this MMIC, at first and second stage is matched for the minimum noise figure (NF) and that at final stage is matched for the gain and linearity. Microphotograph of the LNA MMIC 1.6 x 1.2 mm^2 in size is shown in Figure 2.

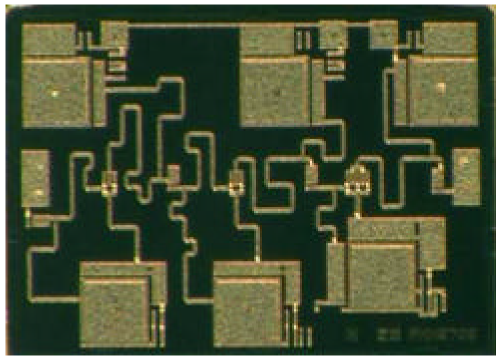

Figure 2 Microphotograph of the LNA MMIC

On the other hand, to achieve high linearity, source inductance was inserted in each p-HEMTs (Figure 3). This is an effective element for linearity using negative feedback, when input power increase.

3. THE PERFORMANCE OF LNA MMIC

The NF and Gain performance of LNA MMIC which was characterized with RF-probe at V_{DD}=3V and I_{DD}=23mA bias condition is shown in Figure 4.

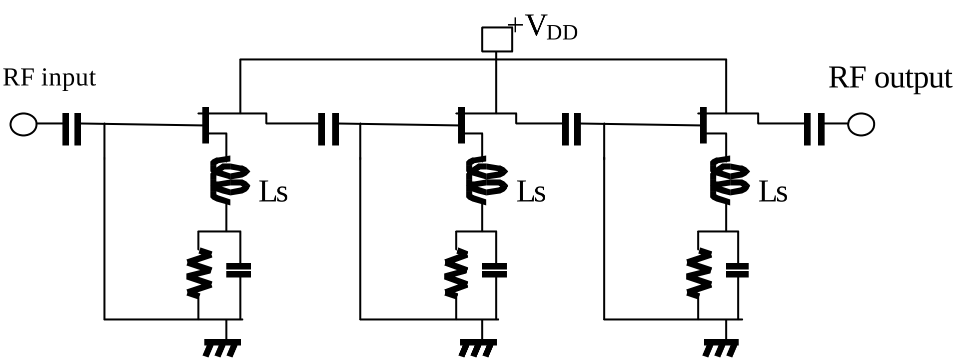

Figure 3. Circuit topology of the LNA MMIC
Ls : Source Inductance

As shown in this graph, noise figure is better than 2 dB from 24 to 32 GHz, and minimum 1.6 dB at 27 GHz. The associated gain is 24 dB at 24 GHz and 18 dB at 32GHz.

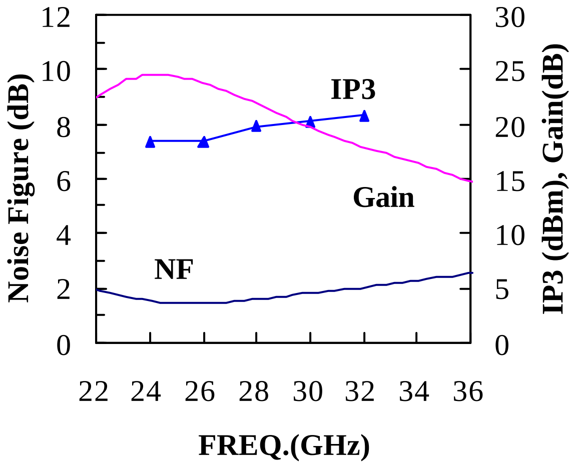

Figure 4. NF, Gain and IP3

Figure 5 shows output third order intercept point (IP3) of 20 dBm with input signals at 30 and 30.01 GHz, at V_{DD}=3V and I_{DD}=23mA bias condition.

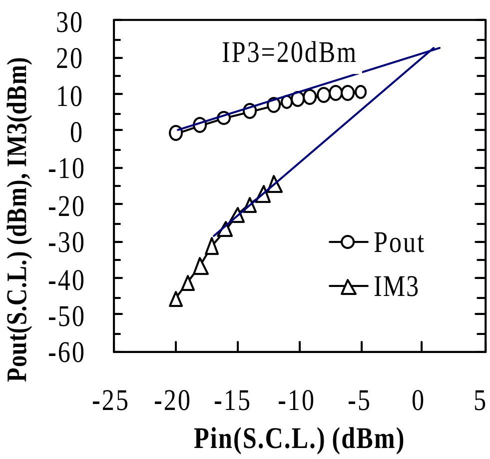

Figure 5. output power and IM3 versus

It was measured with RF-probe under CW RF drive. The third order inter-modulation distortion (IM3) product varies with a slope that remains approximately 3, up to a relatively saturated power level. Here output power at 1-dB compression (P1dB) is 8.5 dBm and small-signal gain is 19.3 dB under single-tone condition. IP3 is higher than 18.5 dBm from 24 to 32 GHz (Figure 4). Figure 6 shows IM3 (in dBc) versus the total output power level at the same bias condition.

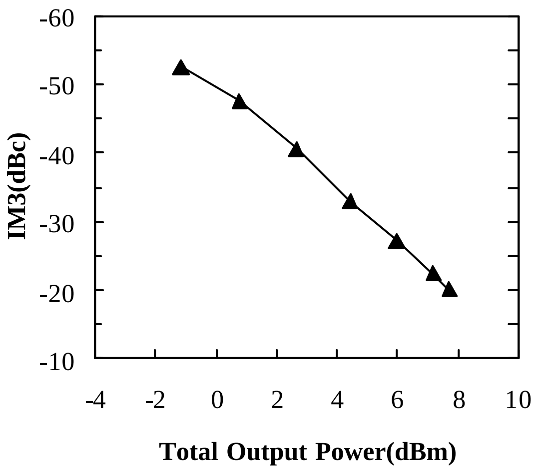

Figure 6. IM3 versus total output

The IM3 is better than -45 dBc at the total output power of 2 dBm. By means of extra source inductance, IM3 is 6 dB better than without source inductance.

4. CONCLUSIONS

We have developed an excellent noise figure and high linearity K-band p-HEMT LNA MMIC. Using single-bias configuration and negative feedback elements, the noise figure is lower than 2 dB and associated gain is more than 18 dB from 24 to 32 GHz. The IM3 is -45 dBc at the total output power of 2 dBm and IP3 is 20 dBm at 30 GHz. From these results, the LNA MMIC is suitable for high-speed wireless access system.

5. ACKNOWLEGMENT

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6. REFERENCES

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