Low Noise Amplifier MMIC Design for ISAC Using 0.2 um GaN HEMT Technology

YounSub Noh
Photonic/Wireless Convergence Research Department
Electronics and Telecommunications Research Institute
Daejeon, Republic of Korea
nohys@etri.re.kr

HyungSeok Lee
Photonic/Wireless Convergence Research Department
Electronics and Telecommunications Research Institute
Daejeon, Republic of Korea
hyungseok@etri.re.kr

Sung-Bum Bae
Photonic/Wireless Convergence Research Department
Electronics and Telecommunications Research Institute
Daejeon, Republic of Korea
bsb9894@etri.re.kr

ByoungChul Jun
Device Development Team
WAVICE
Hwaseong, Republic of Korea
bcjun@wavice.com

JiHun Kwon
Device Development Team
WAVICE
Hwaseong, Republic of Korea
kjh1364@wavice.com

***Abstract*—This paper describes a 2-stage GaN (Gallium Nitride) LNA (Low Noise Amplifier) MMIC (Monolithic Microwave Integrated Circuit) for integrated sensing and communication (ISAC) applications. The LNA MMIC is fabricated using WAVICE's 0.2 μm GaN HEMT (High Electron Mobility Transistor) technology. With a compact size of 1.31 mm × 1.66 mm, the LNA MMIC exhibits a gain of 17.4 dB ~ 19.4 dB and noise figure of 1.15 dB ~ 1.4 dB from 7.125 GHz to 8.4 GHz frequency range.**

Keywords*—*GaN, ISAC, Low Noise Amplifier, MMIC

I. Introduction

The growing need for more spectrum resources in next-generation wireless networks such as 6G is driving the need for integrated sensing and communications (ISAC) designs that support wide bandwidth, high output power, and high efficiency.

The development of a transceiver architecture that enables circuit block sharing between radar mode and communication mode in the ISAC transceiver has enabled the development of the power amplifier (PA) and LNA, which consume the most power in the front end, using the GaN process [1].

Recent X-band LNA MMICs developed for radar applications had two-stage circuit configurations using source degradation technology [2-4]. In this paper, we present the design, fabrication, and measurement results of a low-noise amplifier MMIC for ISAC applications using WAVICE's 0.2 μm GaN HEMT process.

II. Design

We used WAVICE 0.2 μm GaN HEMT technology on a 100 μm thick SiC substrate for LNA MMIC design. It has a transconductance Gm of 450 mS/mm, threshold voltage V_{TH} of -2.3 V, cutoff frequency f_T of 27.5 GHz, and breakdown voltage V_{BR} above 90 V.

The noise amplifier was designed using a 4F100 (4-fingers, 100 μm gate width) using an s2p model from the S-parameter and noise parameter measurements. To optimize the noise figure and ensure stability, microstrip lines (Ls1 and Ls2) for source-degeneration were applied to all two stages (Fig. 1).

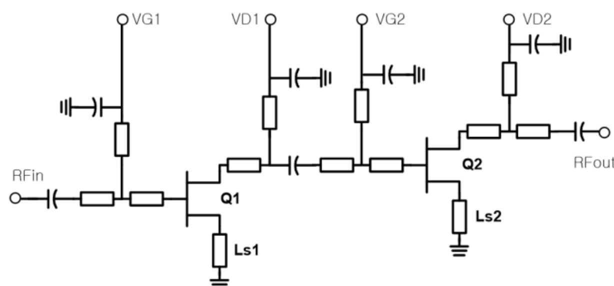

Fig. 1. Schematic of 2-stage low noise amplifier.

The fabricated 2-stage GaN LNA MMIC using WAVICE's 0.2 μm GaN HEMT technology is shown in Fig. 2. The LNA MMIC size is 1.31 mm × 1.66 mm with the substrate thickness of 100 μm.

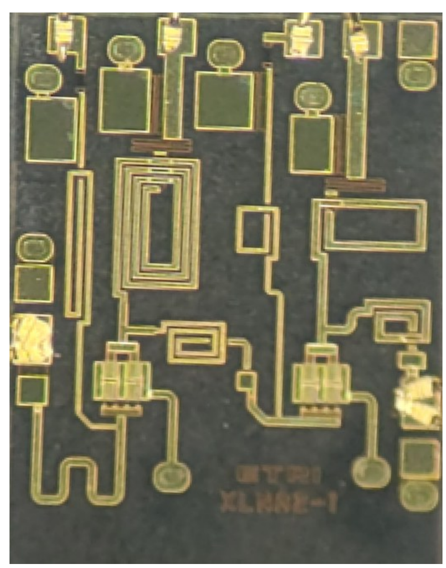

Fig. 2. Photograph of the fabricated 2-stage GaN low noise amplifier MMIC.

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III. MEASUREMENT

The characteristics of the LNA MMIC were evaluated by assembling a test fixture under the conditions of a drain voltage of 20 V and a drain current of 80 mA (Fig. 3).

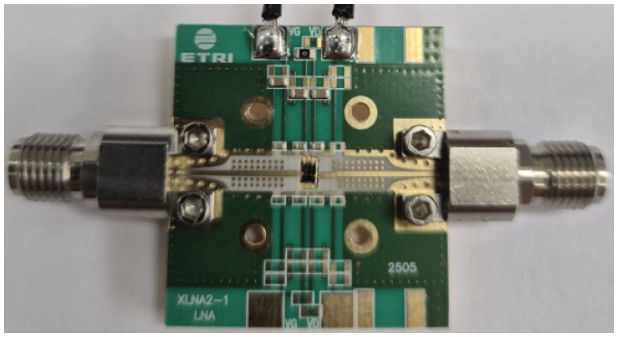

Fig. 3. Photograph of the GaN LNA MMIC test fixture.

The measured gain is 17.4 ~ 19.4 dB, the input return loss is -17 dB ~ -26 dB, and the output return loss is -6.6 dB~ -9 dB (Fig. 4) in the operating frequency band of 7.125 GHz ~ 8.4 GHz. And the measured noise figure is from 1.5 dB to 1.4 dB for the same frequency band.

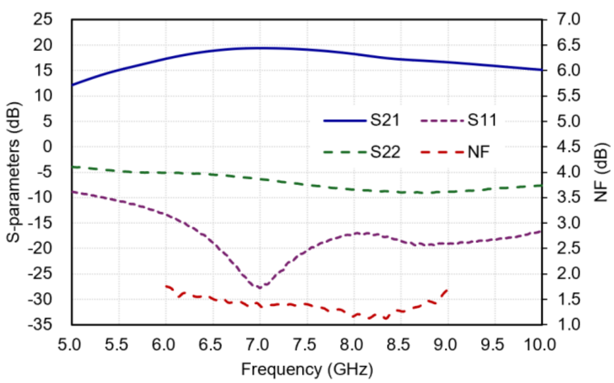

Fig. 4. Measured S-parameters and noise figure of the LNA MMIC.

The P1dB (1dB compression output power) of the GaN LNA MMIC tested at 7.8 GHz was measured to be 23.8 dBm, and the saturation output power (Psat) at the input power of 18.1 dBm was measured to be 31 dBm (Fig. 5).

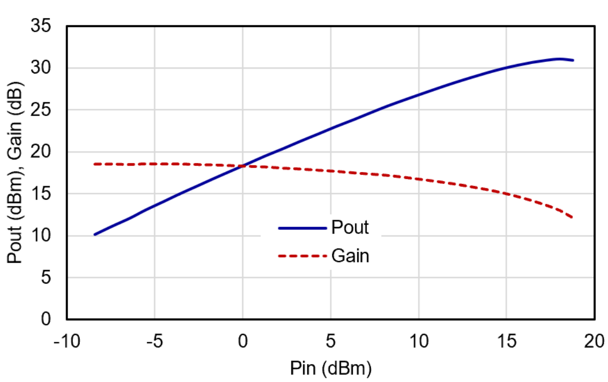

Fig. 5. Measured output power and gain of the LNA MMIC at 7.8 GHz

A performance comparison is provided in Table 1 with previously reported GaN LNA MMICs. This MMIC designed with 0.2 µm GaN technology exhibits the best noise figure and P1dB with the smallest chip size.

TABLE I. PERFORMANCE COMPARISON WITH PREVIOUSLY REPORTED GAN LNA MMICS

Ref.	[2]	[3]	[4]	This work
Technology	0.15 µm GaN	0.25 µm GaN	0.25 µm GaN	0.2 µm GaN
Freq. (GHz)	8-11	9~10	9~10	7.125~8.4
Gain (dB)	>16.8	11.4	18.75	17.4~19.4
NF (dB)	<1.7	<2.1	<1.6	1.15~1.4
P1dB (dBm)	17~19	N/A	20.5	23.8
Chip-size (mm^2)	2.8×2.3	4.3×3.2	2.46×1.79	1.31×1.66

IV. CONCLUSION

A compact GaN LNA MMIC with a small size of 1.31 mm × 1.66 mm has been successfully developed for the ISAC applications using 0.2 µm GaN HEMT technology. Measurement of the MMIC show gain greater than 17.4 dB, noise figure less than 1.4 dB, and P1dB of 23.8 dBm. We believe that this MMIC is the first result for ISAC frequecy band from 7.125 GHz to 8.4 GHz and could be a good candidate for ISAC system designs.

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