High Power Wideband AlGaN/GaN HEMT Feedback Amplifier Module with Drain and Feedback Loop Inductances

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Abstract

A high power wideband feedback amplifier module using AlGaN/GaN high electron mobility transistor (HEMT) has been developed that covers the frequency range of DC to 5GHz with small signal gain of 9 dB. Shunt feedback topology is introduced by adding inductances to increase the bandwidth. At midband frequency, power added efficiency (PAE) of 20 % and saturation power level of 29.5 dBm were obtained at a drain voltage of 12 V (V_{ds}) and a gate voltage of -3 V (V_{gs}).

I. Introduction

High power amplifiers with broad bandwidth are key components in phased array radars and communications systems. GaN-based HEMT's for high power applications at microwave frequencies are now possible. This is due to the high breakdown field, high carrier density, and high electron saturation velocity demonstrated by these devices [1-3] To improve the bandwidth of the amplifier, feedback topologies have been used in microwave integrated circuits (MIC's) and monolithic microwave integrated circuits. By inserting inductances in the drain and feedback loop (L_D and L_{FB}), the bandwidth of the amplifier is increased due to compensation of the capacitive portion of the output impedance and a decrease in the effective feedback in the upper band [4].

In this paper, we report an AlGaN/GaN HEMT feedback amplifier module with saturation power level of 29.5 dBm and PAE of 20 %. This amplifier employs L_D and L_{FB} in the drain and feedback loop, thereby extending the 3-dB bandwidth up to 5 GHz.

II. Circuit Design and Fabrication

The schematic of a shunt feedback amplifier with L_D and L_{FB} is shown in Fig. 1. First, the feedback resistance of 150 ohms was chosen by optimizing both the signal gain and gain flatness. Au bonding wires are used in practice in MIC's to connect the active devices and passive components and are modeled here with an equivalent lumped element circuit. Using an established inductance model, L_D and L_{FB} were chosen to improve bandwidth performance. L_D compensates for the capacitive portion of the output impedance at the upper band edge and L_{FB} reduces the effectiveness of the negative feedback with increasing frequency [4]. Alumina with dielectric constant of 9.8 and thickness of 15 mils was used as a substrate material for the matching networks. Using the improved ohmic process reported in [3], AlGaN/GaN HEMT's with gate width of 1.2 mm and gate length of 1 μm were fabricated on SiC substrate with thermal conductivity of 4 W/cm ^{o}C. The fabricated feedback amplifier is mounted on a jig as shown in Fig. 2. The jig efficiently dissipates heat generated from AlGaN/GaN HEMT, so that accurate power performance measurements can be made.

III. Experimental Results

The bias voltages were set to V_{gs}= -3 V and V_{ds}= 12 V for testing small signal and power performances of the feedback amplifier module. Measured small signal gain and return loss with simulated gain are shown in Fig. 3. A gain of 9 dB at center frequency with a 3-dB bandwidth of DC to 5 GHz was achieved. The difference between measurement and simulation can be contributed to processing variations due to the immature GaN-based device processing technology and imperfections in connections.

Power measurement was performed using a RF signal generator in conjunction with a microwave amplifier as the power source. Fig. 4 shows the measured output power, PAE, and power gain as a function of input power at mid-band frequency. A peak PAE of 20 % at an input power level of 22 dBm, saturation power level of 29.5 dBm, and power gain of 9 dB were obtained.

IV. Conclusion

A high power and wideband AlGaN/GaN HEMT feedback amplifier module covering the frequency range of DC to 5 GHz has been developed. Frequency dependent feedback components, inductances modeled from the

Au bonding wires in the drain line and feedback loop, were employed to improve amplifier performance at high frequency range. From the power module with a feedback amplifier, a power gain of 9 dB, output power of 29.5 dBm, and PAE of 20 % were achieved in class-A operation.

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References

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FIGURE CAPTIONS

Fig. 1 *Schematic of a shunt feedback amplifier with* L_D *and* L_{FB}

Fig. 2 *Photograph of the AlGaN/GaN feedback power amplifier module*

Fig. 3 *Measured and simulated small signal characteristics of the amplifier*

Fig. 4 *Measured power characteristics of the amplifier*

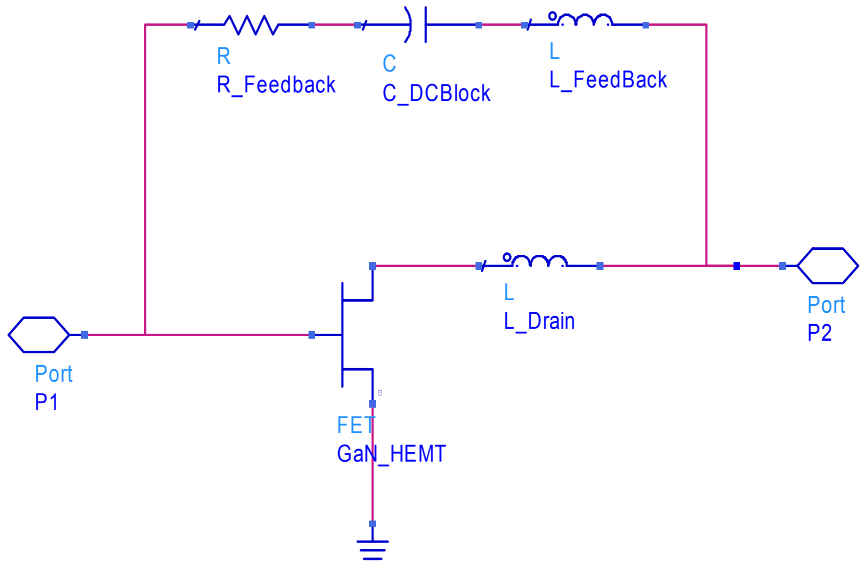

Fig. 1 Schematic of a shunt feedback amplifier with L_D and L_{FB}

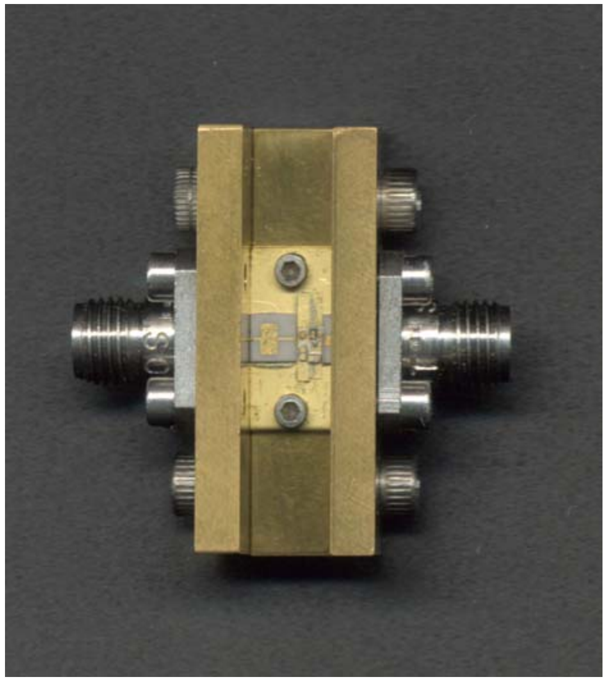

Fig. 2 Photograph of the AlGaN/GaN feedback power amplifier module

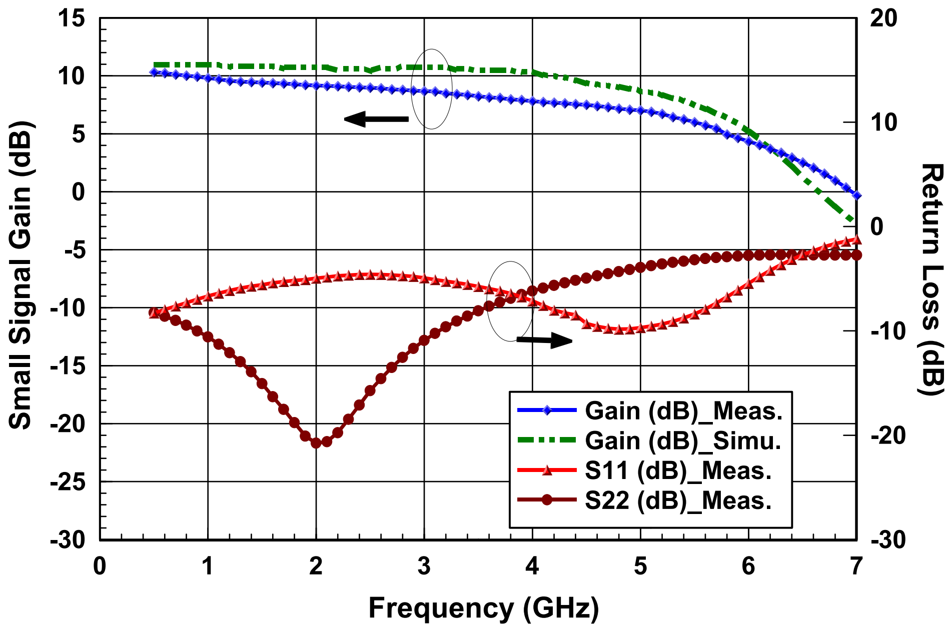

Fig. 3 Measured and simulated small signal characteristics of the amplifier

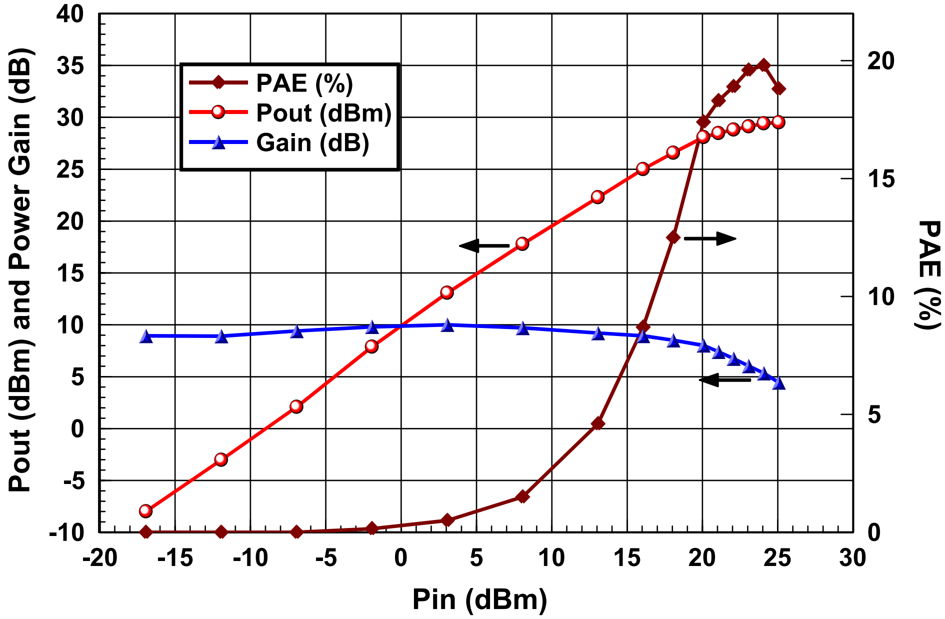

Fig. 4 Measured power characteristics of the amplifier