High Power Wideband AlGaN/GaN HEMT Feedback Amplifier Module

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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 5 GHz with small signal gain of 9 dB. Shunt feedback topology is employed by adding inductive components 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}).

A feedback amplifier with AlGaN/GaN HEMT

GaN-based HEMT's for high power applications at microwave frequencies are now possible due to the high breakdown voltage, high carrier density, and high electron saturation velocity. For wider bandwidth characteristic, feedback topologies have been used in microwave integrated circuits (MIC's) and monolithic microwave integrated circuits. By inserting inductive components in the drain line and feedback loop (L_D and L_{FB}), the bandwidth of the amplifier is increased. This is due to compensation of the capacitive portion of the output impedance at the upper band edge and a decrease in the effectiveness of the negative feedback with increasing frequency [1].

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. Alumina with dielectric constant of 9.8 and thickness of 15 mils was used as a substrate material for input and output matching networks. AlGaN/GaN HEMT's with gate width of 1.2 mm and gate length of 1 μm were fabricated on SiC substrate. 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.

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.

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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Reference

[1] Niclas, K. B, Wilser, W. T., Gold, R. B., Hitchens, W. R., "The matched feedback amplifier: ultra wide-band microwave amplification with GaAs MESFET's", *IEEE Trans. Microwave Theory Tech.*, vol. **MTT-28**, No. 4, pp. 285-294, 1980.

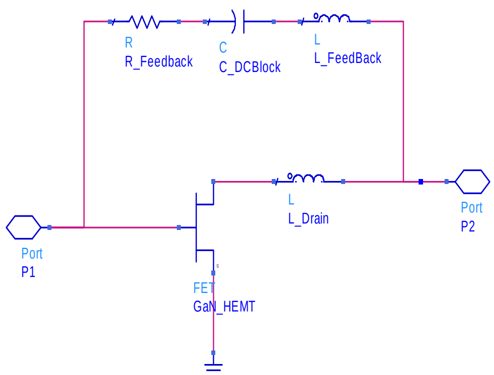

Fig. 1 Schematic of a shunt feedback amplifier with L_D and L_{FB}

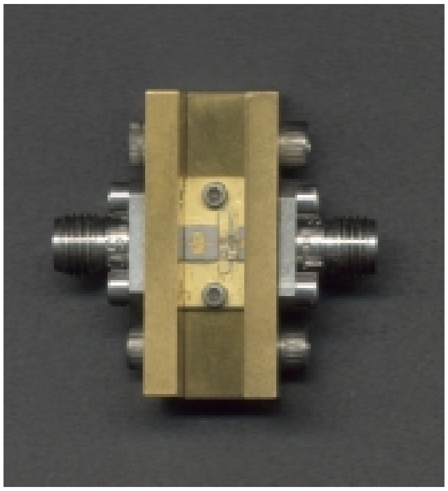

Fig. 2 Photograph of the AlGaN/GaN feedback power amplifier module

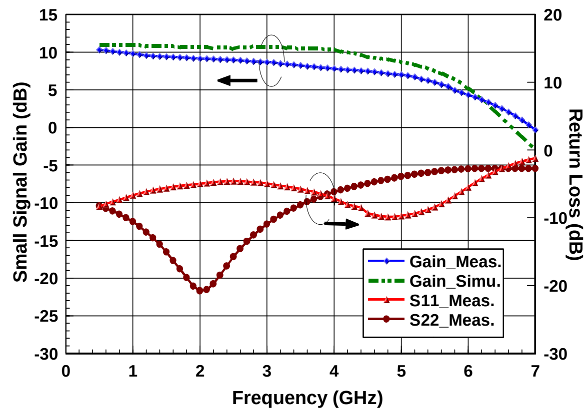

Fig. 3 Measured and simulated small signal characteristics

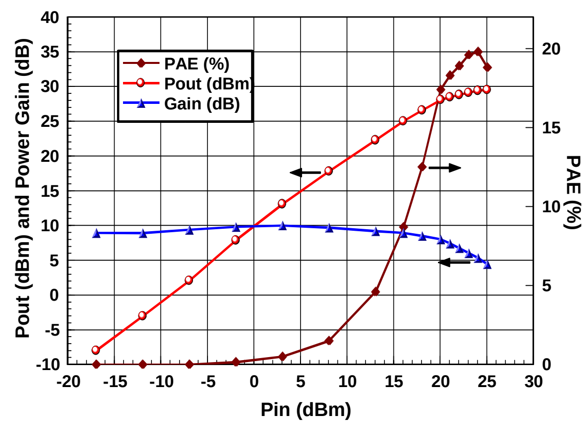

Fig. 4 Measured power characteristics