AlGaN/GaN HFET Single-Ended Frequency Doubler

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Abstract - This paper presents the first single-ended AlGaN/GaN heterojunction field effect transistor (HFET) frequency doubler at 8 GHz. Reflector type circuit topology was employed by adding fundamental signal and 2nd harmonic frequency reflectors to the output and input circuits, respectively. For the frequency doubler with 1mm gate periphery AlGaN/GaN HFET, conversion gain of 0.17 dB and output power of 15.34 dBm were achieved in the pinch-off operating region with a drain voltage (V_{DS}) of 12 V.

AlGaN/GaN HFET Frequency Doubler

A single-ended frequency doubler was designed in a conventional way with fundamental and 2nd harmonic frequency reflectors. In the output matching circuit, a fundamental signal reflector was added to the matching network designed at the 2nd harmonic by using a $\lambda/4$ open-circuited microstrip line (at the fundamental frequency) as the reflector. A reflector for the 2nd harmonic in the input side, a $\lambda/4$ open stub (at the 2nd harmonic) was utilized as a part of the matching circuit to enhance the conversion gain [1].

The AlGaN/GaN HFET was fabricated on SiC substrate via device isolation, ohmic metallization, gate metallization, Si_3N_4 passivation, and finally air-bridge processes. The design of frequency doubler was based upon measured S-parameters from an AlGaN/GaN HFET with 1mm gate width and 0.8 μm gate length. The input matching network designed at 4 GHz was built on Alumina substrate with dielectric constant of 9.8 and thickness of 15 mils while the designed output matching circuit at 8 GHz was fabricated on Duroid substrate with dielectric constant of 2.33 and thickness of 31 mils. The photograph of the fabricated frequency doubler is shown in Fig. 1.

For large-signal measurements, the bias voltages were set to V_{DS} = 12 V and V_{GS} = -5 V. The measured conversion gain and output power at the second harmonic frequency with respect to the input power are shown in Fig. 2. A maximum conversion gain of 0.17 dB at 8 dBm input power and saturated output power of 15.34 dBm were observed. Fig. 3 shows the conversion gain versus frequency measured from 3.7 to 4.5 GHz. A conversion gain of up to 0.67 dB was achieved over the measured frequency range. In Fig. 4, the measured suppression characteristic of the fundamental and 3rd harmonic frequencies is shown. Suppression of -27 dBc and -30 dBc for the fundamental and 3rd harmonic frequencies, respectively, was observed.

Conclusion

A 4 to 8 GHz single-ended AlGaN/GaN HFET frequency doubler has been presented. The fundamental frequency signal reflector was used in the output side to suppress the fundamental signal power while the 2nd harmonic reflector was also utilized in the input matching circuits to enhance conversion gain. The saturated output power of 15.34 dBm and maximum conversion gain of 0.17 dB were achieved from the 4 to 8 GHz AlGaN/GaN frequency doubler.

Acknowledgements: The authors would like to thank Prof. K. L. Wang, Dr. C. P. Wen, Dr. S. Cai, and Y. Cheng at University of California, Los Angeles for providing the AlGaN/GaN HFETs

Reference

[1] Y. Iyama, A. Iida, T. Takagi, and S. Urasaki, "Second-harmonic reflector type high-gain FET frequency doubler operating in K-band," *IEEE MTT-S Int. Microwave Symp. Dig.*, pp. 1291-1294, 1989.

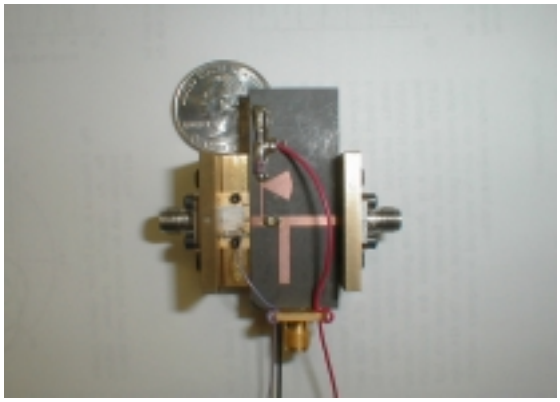

Fig. 1 Photograph of the AlGaN/GaN HFET frequency doubler

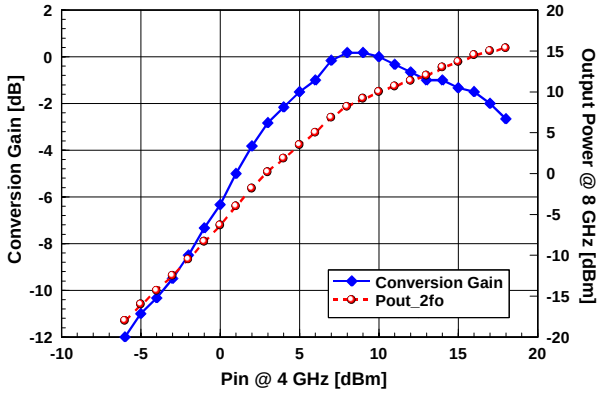

Fig. 2 Measured conversion gain and output power with respect to the input power for the AlGaN/GaN HFET frequency doubler

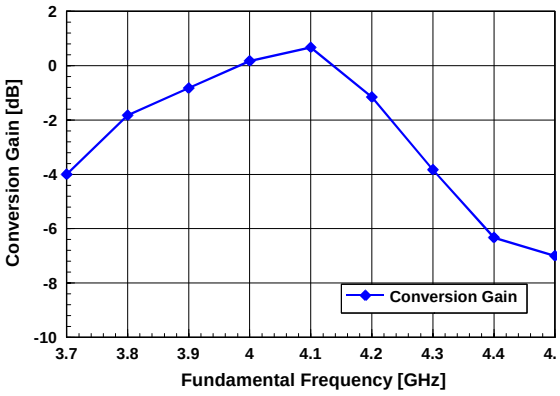

Fig. 3 Measured conversion gain versus frequency for the AlGaN/GaN HFET frequency doubler

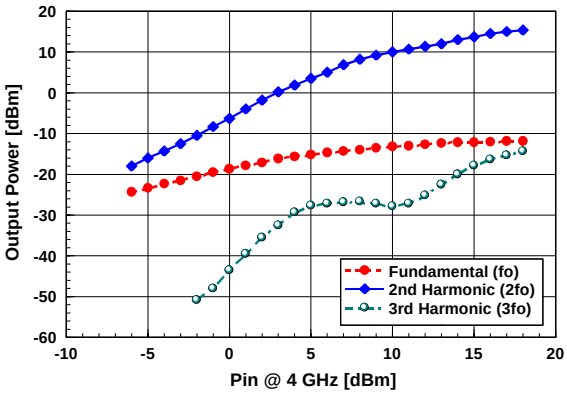

Fig. 4 Measured output power at fundamental, the 2nd, and 3rd harmonics for the AlGaN/GaN HFET frequency doubler