2-18 GHz, HIGH-EFFICIENCY, MEDIUM-POWER GaAs FET AMPLIFIERS*

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ABSTRACT

A GaAs FET amplifier using a 600 μm gate width device has achieved ~ 300 mW output with 20-25% power-added efficiency across 2 to 18 GHz. With a 1350 μm FET, 0.5 W output power was obtained from 7 to 16.5 GHz. Extending its large-signal performance to 2 GHz appears feasible.

Introduction

Wideband operation of power GaAs FET amplifiers was reported by our laboratory in the 1980 International Solid-State Circuits Conference.[1] It was shown that an output power of 200 mW over the 6 to 18 GHz band with 5 dB gain can be obtained. Conventional 600 μm gate width FETs with eight parallel gate fingers and air-bridge interconnected source pads were used. Recently, devices with a single gate stripe and multiple gate pads (π-gate) have been developed and shown to have higher power gain at K-band frequencies.[2] As an amplifier a 1350 μm gatewidth FET had an output power of 675 mW with 5.8 dB gain at 20.5 GHz. As an oscillator a 1350 μm device produced 200 mW output at 25 GHz. In this paper, the implementation of these new (π-gate) devices for wideband operation in the 2-18 GHz range will be described.

Circuit Development and Microwave Performance

S-parameters appropriately modified for large-signal operation were used for computer-aided design of broad-band amplifiers. Figure 1 shows the computed gain-frequency response of a 600 μm gate width FET. The input circuit consists of six short transmission lines of various lengths. The output circuit consists simply of a short section of low-impedance line and an impedance transformer. Even though the amplifier was only optimized for 6 to 18 GHz operation, its bandwidth extended down to 2 GHz. The experimental, 2-18 GHz small-signal gain-frequency response is also shown in Figure 1. Large-signal operation was also obtained for several 600 μm gate width amplifiers. Figure 2 shows the gain-frequency responses of two of the amplifiers. For amplifier #1, a gain of 4 ± 1 dB covering 2-18 GHz was obtained with 20 dBm input. An output power of 320 mW was obtainable at the 5 dB gain points. With the exception of a gain dip (~ 3 dB) near 10 GHz, a better than 4 dB gain (250 mW output) was maintained across the entire 2 to 18 GHz band. Amplifier #2 achieved 5 ± 0.5 dB gain across most of the 2 to 12 GHz band with 320 mW output at the 5 dB gain points. Amplifier #2 has a higher drain inductance which resulted in the high-frequency gain roll-off. It is conceivable that the drain inductance (bondwire) of amplifier #1 can be reoptimized to minimize the gain dip near 10 GHz. The average power-added efficiency of these amplifiers was in the range of 20 to 25%. Note that amplifier #1 achieved 560 mW (27.5 dBm) output with 7.5 dB gain and 57.5% power-added efficiency at 2.5 GHz. Figure 3 shows the gain-frequency response of yet another 600 μm FET over the 7 to 18 GHz band. The device mounting configuration is shown in the inset. At 11.3 GHz, 370 mW was obtained with ~5.7 dB gain and 23% power-added efficiency.

To obtain higher output power, a 1350 μm π-gate FET amplifier was designed for 7-18 GHz operation. Figure 4 shows the computed gain-frequency response. Like the 600 μm gate width FET amplifier described above, the bandwidth extends down to 2 GHz. A small-signal gain-frequency response is shown in the same figure. The circuit topologies used were similar to those of the 600 μm FETs. The measured large-signal gain-frequency response of one amplifier is shown in Figure 5. Across 7 to 16.5 GHz, a nominal output power of 0.5 W with 5 ± 1 dB gain was obtained. A higher than optimum bondwire inductance was responsible for the gain roll-off at the upper bandedge. Even though the large-signal gain-frequency response has not yet been measured for frequencies between 2 and 7 GHz, an output power of at least 500 mW and ~ 5 dB gain are expected.

In addition to the broad-band large gate width amplifiers discussed above, wideband amplifiers using 300 μm gate width devices were also fabricated and tested. An output power of 100 mW with ~ 6 dB gain has been achieved across the 7 to 18 GHz band as shown in Figure 6. Again, the output power and gain performances extend down to 2 GHz.

Conclusions

Ultra-broad-band amplifiers using π-gate FET devices have achieved substantial output powers with reasonable gains and high efficiencies in the 2 to 18 GHz band. Specifically, a state-of-the-art GaAs FET amplifier using a 600 μm gate width device has achieved ~ 300 mW output with 20-25% power-added efficiency across the entire 2 to 18 GHz band. In conjunction with a broad-band 3 dB hybrid coupler[1], various gain blocks can be fabricated for high gain, high power operation across the 2 to 18 GHz band. These amplifiers will find important applications in future EW and ECM systems.

Acknowledgment

The authors with to thank F.H. Doerbeck for supplying the epitaxial GaAs, and L.P. Graff and S.F. Goodman for technical assistance.

References

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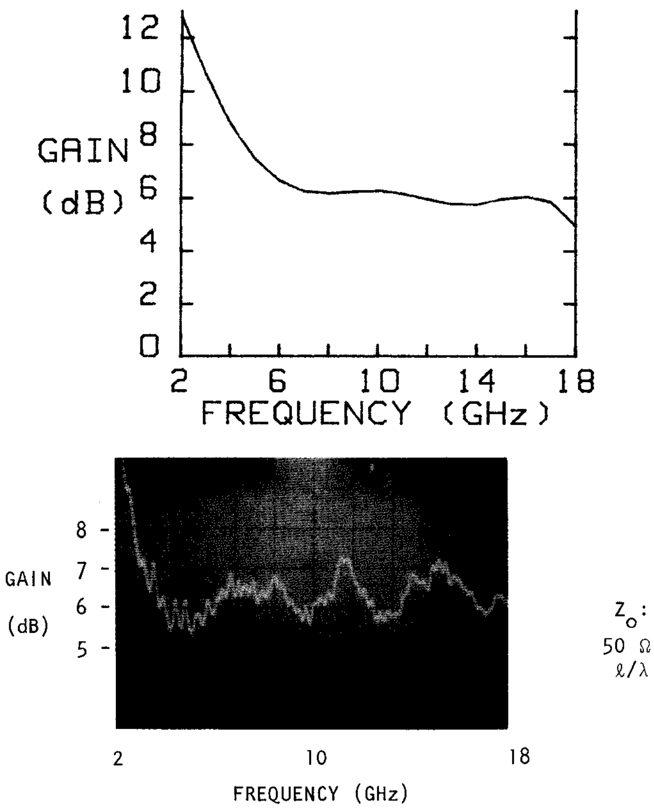
* This project is sponsored by the Naval Air Systems Command under Contract N00173-79-C-0047 administered by the Naval Research Laboratory.



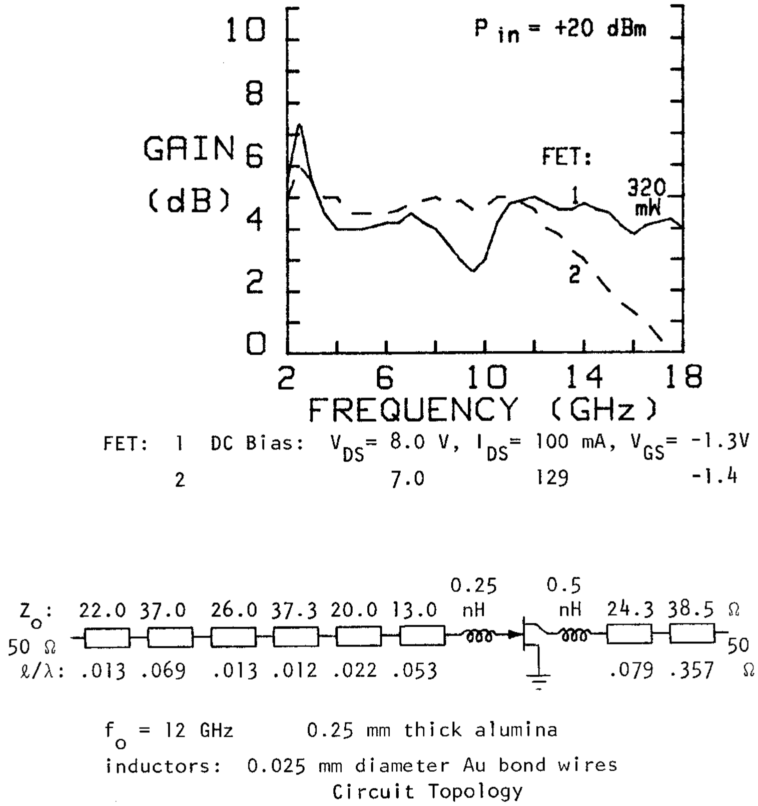
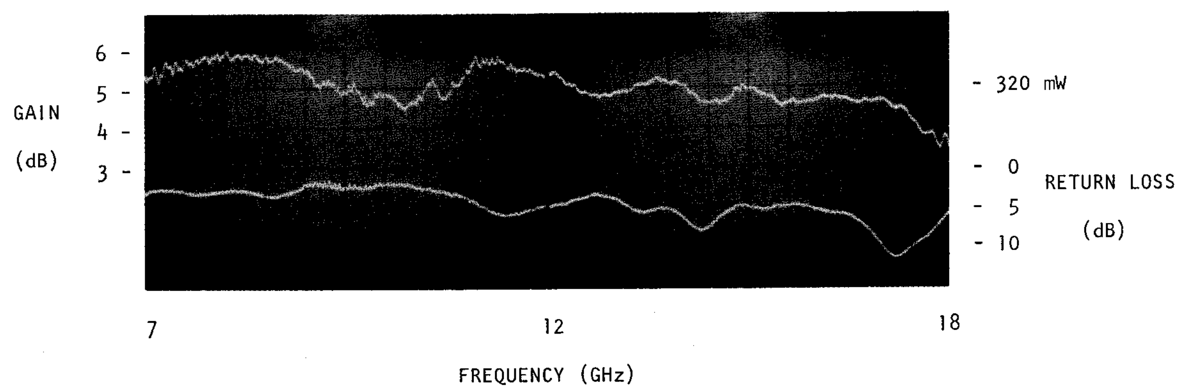


Fig. 1. Computed and Experimental Gain-Frequency Responses of a 2 to 18 GHz GaAs FET Amplifier Using a 600 μm Gate Width π-gate FET.

Fig. 2. Circuit Topology and Large-Signal Performances of Two 600 μm FET Amplifiers Across the 2 to 18 GHz Band.



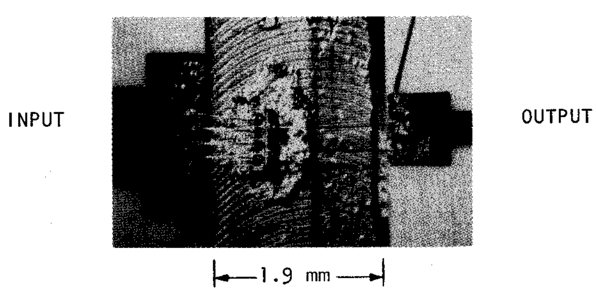


Fig. 3. Performance of a 600 μm Gate Width FET Amplifier Across 7 to 18 GHz.

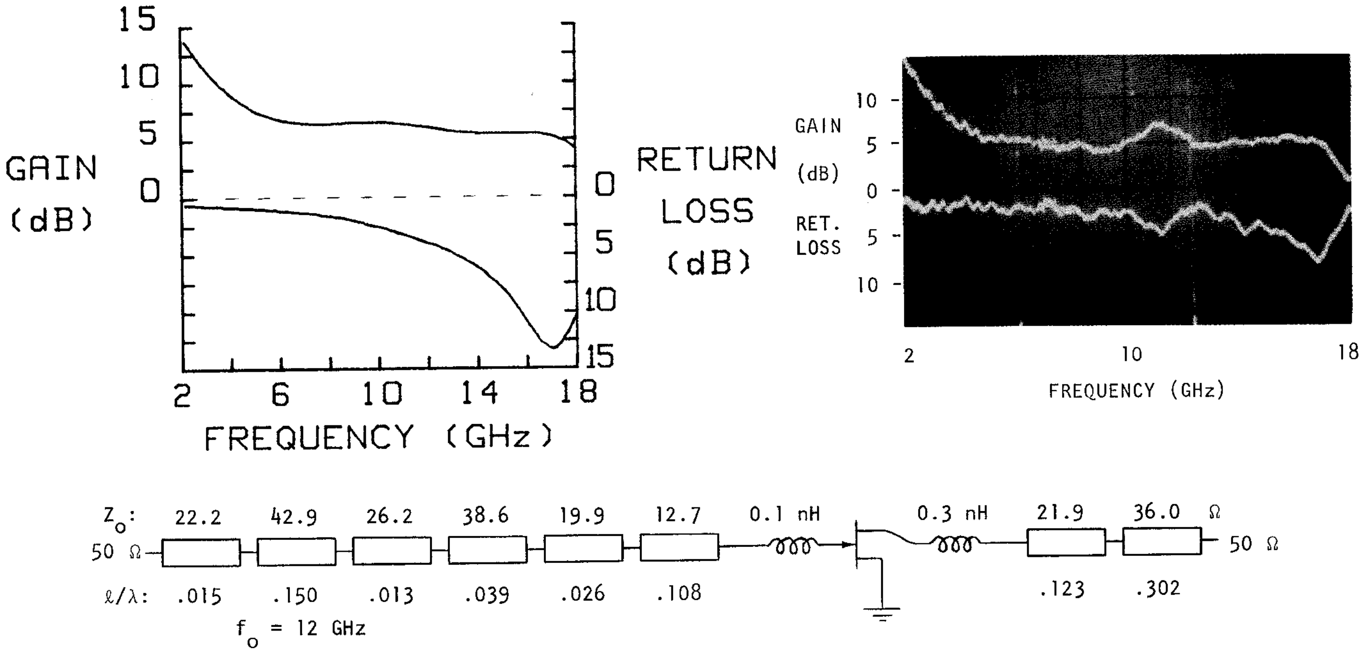
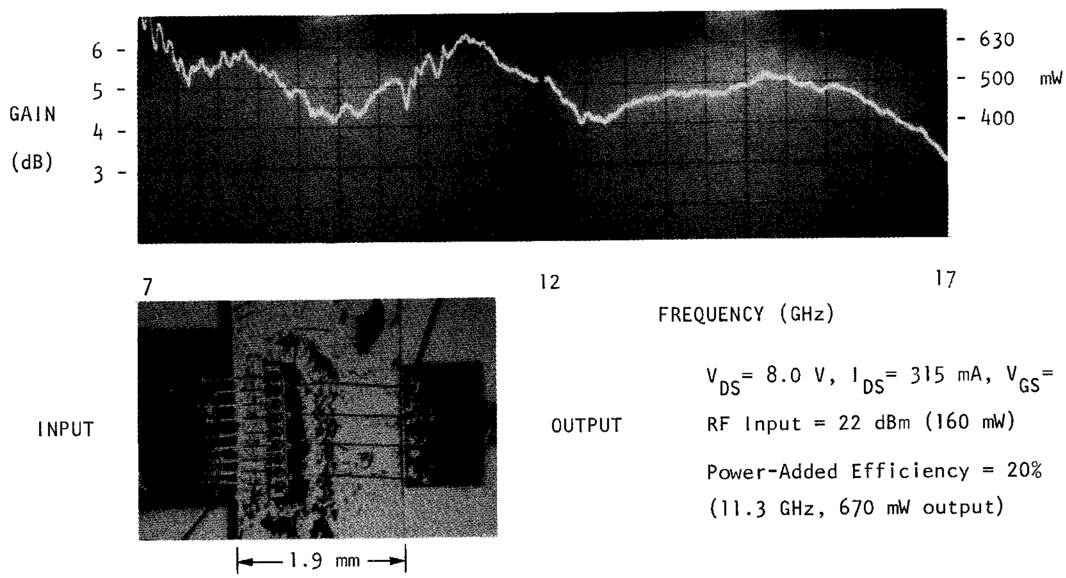


Fig. 4. Circuit Topology and Computed and Experimental Gain-Frequency Responses of a 1350 μm π-gate FET Amplifier.



V_{DS}= 8.0 V, I_{DS}= 315 mA, V_{GS}= -0.5 V

RF Input = 22 dBm (160 mW)

Power-Added Efficiency = 20%

(11.3 GHz, 670 mW output)

Fig. 5. Performance of a 1350 μm Gate Width FET Amplifier Across 7 to 17 GHz.

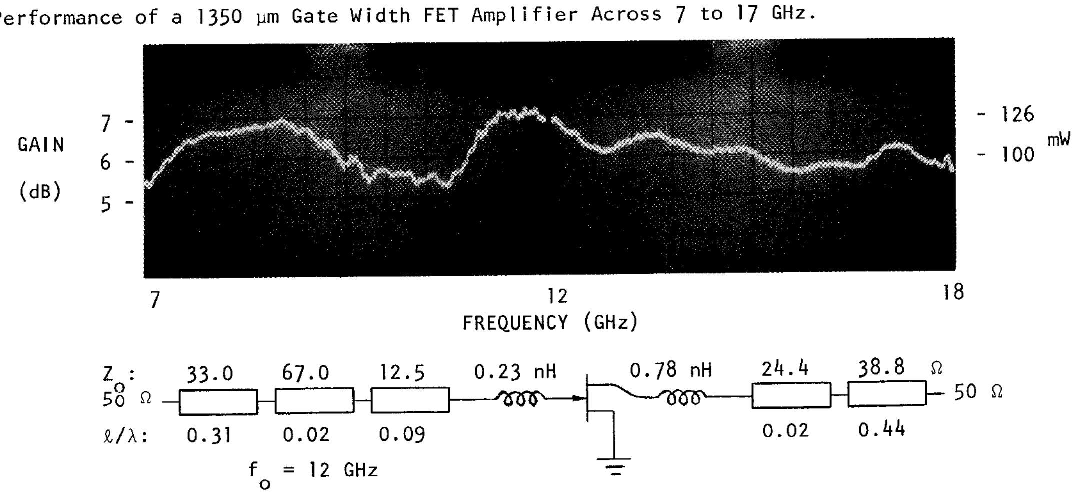


Fig. 6. Circuit Topology and Gain-Frequency Response of a 300 μm Gate Width FET Amplifier.