A S-BAND PUSH-PULL 60-WATT GaAs MESFET FOR MMDS APPLICATIONS

G. Sarkissian and R. Basset
California Eastern Laboratories, 4590 Patrick Henry Drive,
Santa Clara, California 95054-1817
Z. Shingu and F. Ono
NEC Corporation, 1753, Shimonumabe, Nakahara-Ku, Kawasaki,
Kanagawa 211, Japan

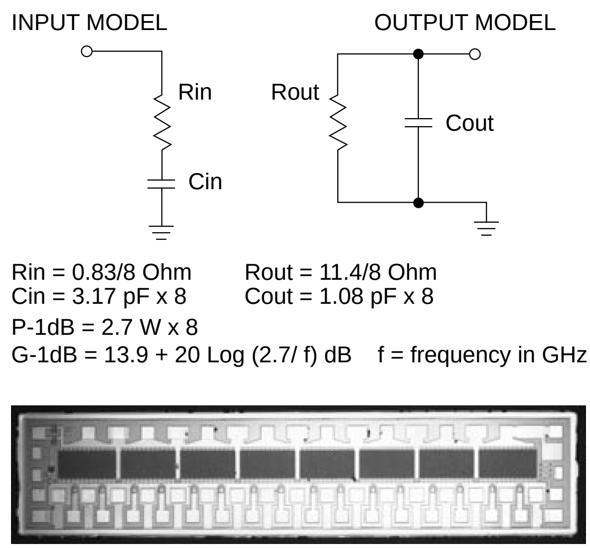
Abstract

A new 2.5 - 2.7 GHz High-Power GaAs FET for the MMDS application is presented. It uses two pairs of pre-matched chips mounted on the same carrier and combined in push-pull configuration with a microstrip balun. This device exhibits 60 W of output power with 11.0 dB of gain. This is the highest power reported for such a device.

Introduction

Higher output power is one of the requirements for the rapidly growing Multi-Point Multi-Channel Distribution Systems (MMDS) wireless cable TV market. Because it is essential to reduce the size and cost, as well as increase the performance of the Solid-State Power Amplifiers (SSPA) used in MMDS transmitters, new innovative devices and matching/combining circuits have to be developed. At present, the highest power device available for this application is a 30 W single-ended GaAs FET device, as presented in [1]. In order to obtain a higher output power for a defined process, the total gate periphery of the device has to be increased. If a classical single-ended solution is used (parallel combining), the result is a decrease in the input and output impedances of the device,

Figure 1



which results in an increase in the loss of the matching circuits. To avoid this problem, it was decided to use the more elegant and efficient push-pull approach. The push-pull configuration allows the designer to obtain an input and output impedance four times higher than that of a parallel approach for the same output power level. The key element for this configuration is the balun which transforms the unbalanced signal at the 50 Ω asymmetric port to a balanced signal between its two symmetric ports. In order to design a push-pull 60 W device at 2.5 - 2.7 GHz, a novel microstrip balun was designed. This balun can be easily incorporated into the

0-7803-4603-6/97/$5.00 (c) IEEE

amplifier circuit. Also, its two balanced ports are D.C. isolated from the ground.

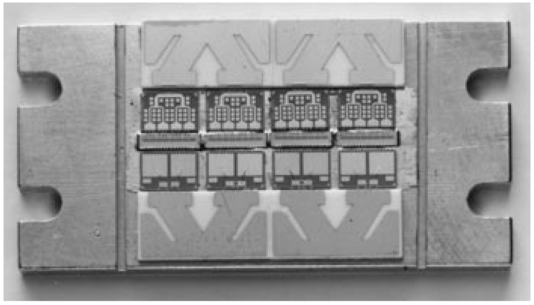
Modeling

One port simplified large signal input and output models of the FET chip were created similar to those presented in [2] and [3]. An elementary FET chip section (a cell with 5.28 mm gate periphery which represents 1/8th of the full chip) was mounted on a carrier and its optimum source and load impedances as well as its P_{-1dB} and gain at 2.7 GHz were measured by a load-pull method. It was then assumed that the power would scale for the full chip and be constant in the 2.5 - 2.7 GHz band. Also, the gain was assumed to have a -6.0 dB slope per octave in the same band. The FET chip and its model are shown in figure 1.

Matching Circuit Design

Each side of the device utilizes a pair of 42 mm gate periphery GaAs FET chips. The input and output impedances of each pair of chips were internally matched to larger impedances using bond wires, localized capacitors, and microstrip lines on high Er materials as shown in figure 2. Then, an external microstrip matching circuit on a plastic substrate was used to complete the matching of the input and output impedances to 25 Ω for each side of the

Figure 2



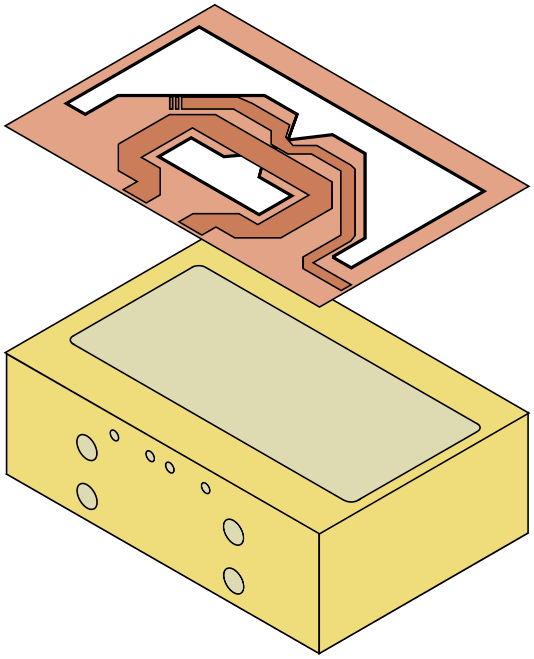
push-pull. The input internal matching network (IMN) was designed such that its dissipative losses would compensate for the -6.0 dB per octave gain slope inherent to the FET chip.

Balun Design

The key element of microwave high power push-pull devices is the balun. The type of balun used has to satisfy several requirements:

- o Its unbalanced port impedance has to be 50 Ω and its balanced port impedances have to be relatively low, 50 Ω or lower.
- o It has to be easily manufactured and integrated with the amplifier circuit.
- o It must have low loss.
- o It must have good amplitude and phase balance.

Figure 3



An original printed microstrip Marchand type balun based on [4] and [5] was designed with an EM simulation software,

Figure 4

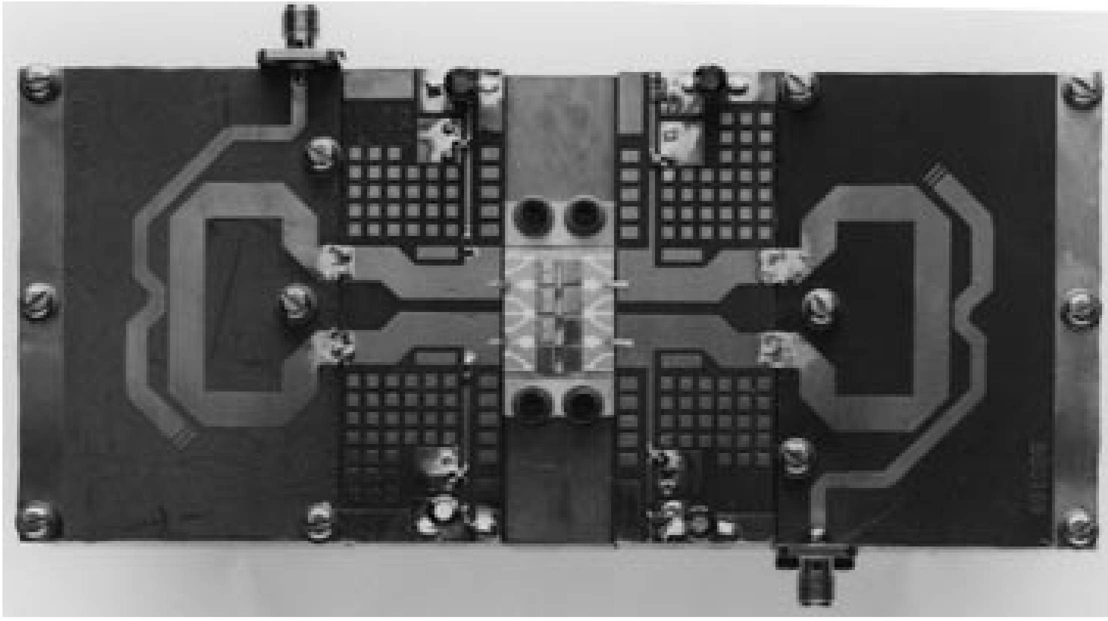
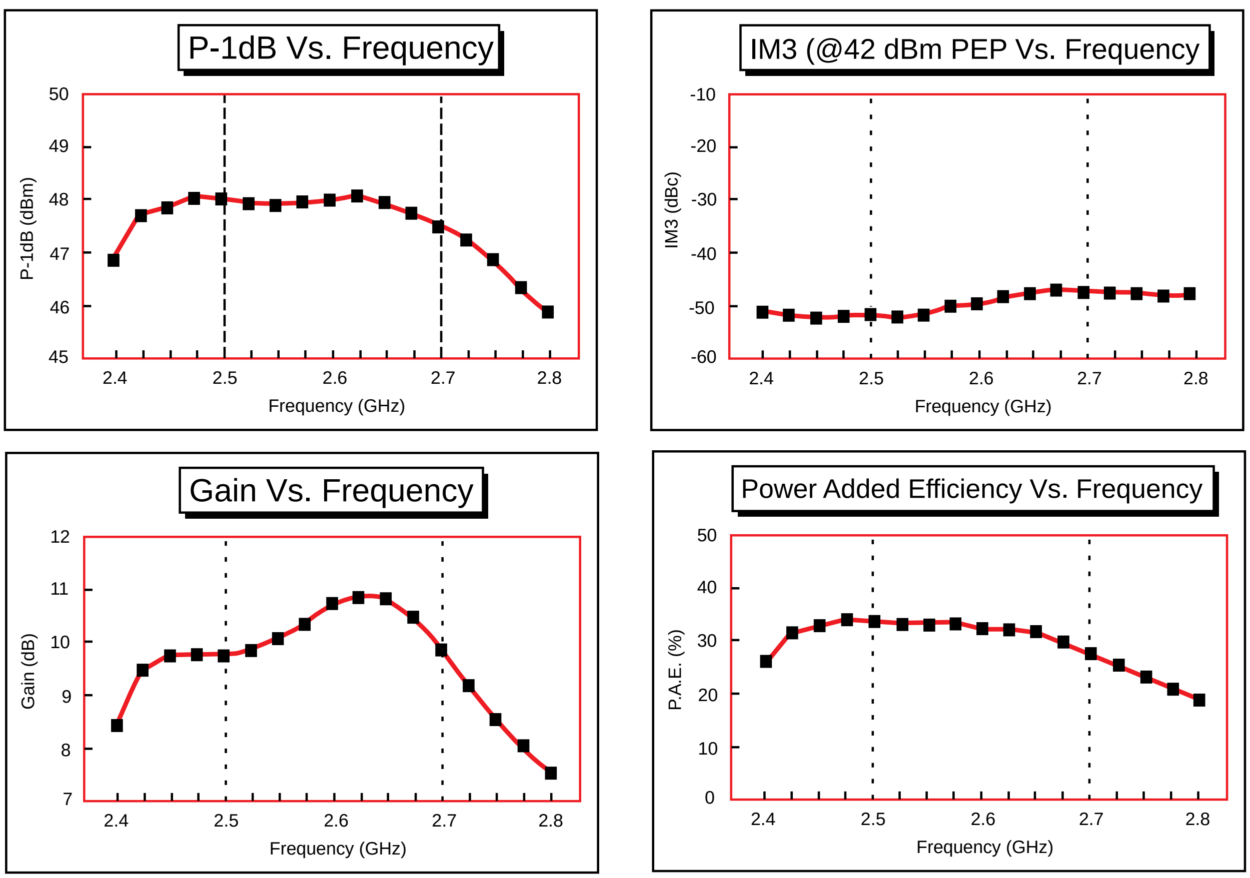


Figure 5



with the unbalanced port impedance of 50 Ω and the balanced ports impedances of 25 Ω each. The bandwidth of interest is 2.5 - 2.7 GHz. This balun was then realized and tested. In the target bandwidth, an input return loss of better than 20.0 dB, and maximum phase and amplitude imbalance of less than 2 degrees, and 0.1 dB were achieved. The insertion loss, which was measured indirectly by connecting two baluns back-to-back, was 0.35 dB for each balun. These numbers are close to the EM simulation results and show that this type of balun has a similar loss to a Lange coupler, and has an excellent balance. It should be noted that the balun was tested as designed with no tuning or modifications done during the test. This demonstrates the power of EM simulation for complex circuits (large junctions & two level substrate with cavity). Figure 3 shows a drawing of this balun. It should be noted that no D.C. blocking capacitors are used.

Push-Pull Amplifier Circuit

Figure 4 shows the complete amplifier circuit. The two microstrip baluns don't require any additional connections to the main circuit and their top substrates can be directly printed on the same substrate as the rest of the amplifier. This makes a very compact and easy to assemble circuit.

RF Performance

Figure 5 shows the Output Power (P-1dB), the Gain (G-1dB), the Power-Added Efficiency (Eadd.) at 1.0 dB Gain Compression and IMD3 at Pout = 42.0 dBm PEP versus frequency. The device was biased in class-A at Vds = 10V and Idsq = 6.0 A per side.

Conclusion

An S-Band 60 W low distortion GaAs MESFET push-pull transistor has been successfully developed by using a push-pull technique with no significant performance degradation in comparison to the existing 30 W power devices. This device will allow the designers of broad band SSPAs to reduce the cost and the size of their systems.

Acknowledgment

The authors are grateful to M. Hart and O. Truong for testing these devices, and to D. Newman for assembling these parts.

References

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