The measured results, however, are seen to perform better than the simulated ones for deflections from 22 to 100 μm. This discrepancy may possibly be due to the membrane possessing a nonuniform deflection as it is pulled down. In our deflection measurements, the membrane deflection was measured at the membrane centre. However, for our corrugated membrane, it is possible that the membrane possessed a greater deflection slightly off centre. If this was the case, then our measured deflection at the membrane centre would be less than the average deflection over the entire membrane surface, which would explain the performance discrepancy between the two curves in Figure 9. Nevertheless, the agreement is surprisingly close.

5. CONCLUSION

A frequency-tunable MPA has been fabricated using a micromachined reconfigurable ground-plane membrane. Electrostatic actuation of the membrane away from the antenna-patch substrate introduced a controllable air-gap thickness between the substrate and the copper ground plane. The resonant frequency of the MPA was controllable between 16.8 and 17.82 GHz for a ground-plane deflection from 0 to 138 μm. This represents an approximately 6% controlled variation in the resonant frequency of the MPA. These measured results are in close agreement with the simulated performance of the MPA using Ensemble 8.0.

ACKNOWLEDGMENTS

This research was funded by the Natural Sciences and Engineering Research Council (NSERC) of Canada and the Canadian Institute of Telecommunication Research (CITR).

REFERENCES


DC TO 6-GHZ HIGH-GAIN LOW-NOISE GaInP/GaAs HBT DIRECT-COUPLED AMPLIFIERS WITH AND WITHOUT EMITTER-CAPACITIVE PEAKING

C. C. Meng, T. H. Wu, and S. S. Lu

1 Department of Communications Engineering
National Chiao Tung University
Taiwan, R.O.C.

2 Department of Electrical Engineering
National Taiwan University
Taiwan, R.O.C.

Received 11 March 2004

ABSTRACT: High-gain shunt-series shunt-shunt wideband amplifiers with and without emitter-peaking capacitors are demonstrated by using GaInP/GaAs HBT technology. Experimental results show that the power gain is 28 dB from DC to 6 GHz for a wideband amplifier without emitter-peaking capacitors. On the other hand, a wideband amplifier with emitter-peaking capacitors can increase the gain bandwidth up to 8 GHz at the cost of lower input/output return loss. Both circuits have similar power and noise performance. The noise figures of both designs are less than 2.8 dB for frequencies below 6 GHz; \( \text{OP}_1\text{db} \) and \( \text{OIP}_3 \) are 7 and 20 dBm at 2 GHz, respectively. Total current consumption is 67 mA at 5-V supply voltage for both wideband amplifiers. © 2004 Wiley Periodicals, Inc. Microwave Opt Technol Lett 43: 67–69, 2004; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20377

Key words: GaInP; HBT; amplifier

1. INTRODUCTION

Wideband amplifiers [1–4] play an important role in modern wireless-communication systems. The essential design approach of a wideband amplifier is dual-feedback-loop technology. A dual-
A feedback-loop configuration (shunt-series shunt-shunt) is used to achieve matched-impedance wideband amplifiers in this paper. The circuit schematic of the designed shunt-series shunt-shunt GaInP/GaAs HBT wideband amplifier is illustrated in Figure 1. Resistors \( R_{g1} \) and \( R_{g2} \) in Figure 1 are the global-feedback and local-feedback resistors, respectively. A Darlington pair is used in the second stage to improve the frequency response. A shunt-series shunt-shunt amplifier has intrinsic over-damped characteristics in gain response under matched-impedance conditions; thus, an emitter-capacitive gain-peaking technique is used to extend the power-gain bandwidth by compensating the intrinsic over-damped frequency response of power gain [2, 5]. In this paper, two nearly identical wideband amplifiers (one with emitter-peaking capacitors and the other without emitter-peaking capacitors) are fabricated in order to compare the performances. \( C_{e1} \) and \( C_{e2} \) are the emitter-peaking capacitors, as shown in Figure 1.

2. PRINCIPLES OF CIRCUIT DESIGN

A photograph of the fabricated GaInP/GaAs HBT wideband feedback amplifiers is shown in Figure 2. There are two designs in the die. The wideband feedback amplifiers in Figure 2 were implemented using 1.4-μm emitter-width GaInP/GaAs HBT technology. The top one is a wideband amplifier with emitter-peaking capacitors and the bottom one is a wideband amplifier without emitter-peaking capacitors. The bottom device layout has been rotated 180° with respect to the top one in order to facilitate on-wafer probing. Both designs have identical transistor sizes for comparison purposes. The size of transistor \( Q_1 \) is 1.4 × 9 × 2 μm, the size of transistor \( Q_2 \) is 1.4 × 6 × 1 μm, and the size of transistor \( Q_3 \) is 1.4 × 9 × 5 μm. The die size is 1 × 1 mm. Most of the die area is not fully utilized in order to facilitate the on-wafer measurement, and the die size of each wideband feedback amplifier can be easily compacted into 0.4 × 0.4 mm.

3. MEASUREMENT RESULTS AND DISCUSSIONS

Total current consumption is 67 mA at 5-V supply voltage for both GaInP/GaAs HBT wideband amplifiers. The first stage consumes 17 mA, whereas the second stage consumes 50 mA. The forward-transmission gain and input-return loss are illustrated in Figure 3, while the reverse-transmission gain and output-return loss are illustrated in Figure 4. The circuit without gain-peaking capacitors has 6-GHz 3-dB gain bandwidth, and \( S_{11} \) is below −15 dB and \( S_{22} \) is below −12 dB for the measurement range from DC to 18 GHz, as illustrated in Figures 3 and 4, respectively. The circuit with emitter-peaking capacitors has a higher gain bandwidth, but suffers from lower input/output return losses for frequencies above 4 GHz when gain peaking starts to appear. Thus, \( S_{11} \) reaches −8 dB, while \( S_{22} \) reaches −9 dB at 8 GHz for the circuit with emitter-peaking capacitors. In other words, some trade-offs exist between power-gain bandwidth and matched-impedance bandwidth when the emitter-peaking capacitors are introduced. Figure 5 illustrates \( Z_T \) (50Ω load transimpedance) and \( Z_{21} \) (open load transimpedance) for both designs calculated from the measured \( S \) parameters. \( Z_T \) is defined as the transimpedance gain with 50Ω load and is calculated according to the following widely used formula:

\[
\sqrt{S_{22} - S_{11}} = Z_T
\]
The circuit using emitter-gain-peaking capacitors has 65-dB gain and 8-GHz 3-dB bandwidth for $Z_T$, but the circuit without emitter-peaking capacitors has the same gain with 4-GHz 3-dB bandwidth for $Z_T$. The $Z_{21}$ data in Figure 5 also shows that the emitter-peaking capacitors have an influence upon the $Z_{21}$ response. Figure 6 illustrates the noise and power performances of both circuits. Both designs have similar noise figures, which are less than 2.8 dB for frequencies below 6 GHz. OP1dB and OIP3 of both circuits as functions of frequency are also illustrated in Figure 6. OP1dB and OIP3 are 7 and 20 dBm at 2 GHz, respectively. Both OP1dB and OIP3 decrease when the frequency increases. There is no apparent power-performance difference between the two designs.

4. CONCLUSION

In this paper, 28-dB gain, DC to 6-GHz GaInP/GaAs shunt-series shunt-shunt feedback wideband amplifiers have been demonstrated. The experimental results show that power gain is 28 dB and input/output return loss is below 12 dB from DC to 6 GHz for the wideband amplifier without emitter-capacitive peaking. An emitter-capacitive peaking technique can extend the 3-dB power-gain bandwidth at the cost of lower input/output return loss. The circuit using peaking capacitors has 8-GHz 3-dB power-gain bandwidth, while $S_{11}$ reaches $-8$ dB and $S_{22}$ reaches $-9$ dB at 8 GHz. Both circuits have similar noise and power performances. The noise figures of both circuits are less than 2.8 dB for frequencies below 6 GHz.

ACKNOWLEDGMENTS

This work was supported by the National Science Council of Republic of China under grant no. NSC 92-2219-E-009-023 and by the Ministry of Education under grant no. 89-E-FA06-2-4.

REFERENCES


© 2004 Wiley Periodicals, Inc.