A MILLIMETER-WAVE MONOLITHIC MATRIX DISTRIBUTED AMPLIFIER

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ABSTRACT

A millimeter-wave monolithic two-stage matrix distributed amplifier with greater than 11 dB gain from 16-38 GHz has been demonstrated. This is the first reported two-stage millimeter-wave matrix distributed amplifier. The matrix amplifier topology yields a compact circuit with higher gain per unit area than a conventional distributed amplifier.

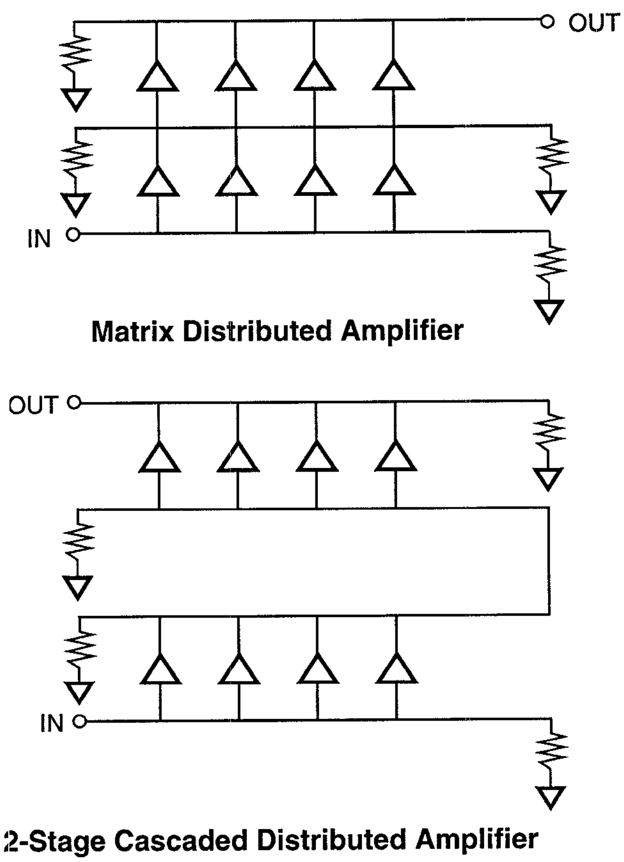

Figure 1. Matrix and Distributed Amplifier Block Diagrams.

INTRODUCTION

Matrix distributed amplifiers are composed of chains of conventional distributed amplifiers. In the matrix amplifier, the distributed amplifiers are stacked such that the output artificial transmission line of one amplifier chain is shared with the input line of the second amplifier chain.[1] This shared idle line is RF terminated. Figure 1 compares the block diagrams of a single stage matrix amplifier with a conventional two-stage distributed amplifier. The matrix amplifier topology yields a compact circuit with higher gain per unit area than cascaded stages of conventional distributed amplifiers. Previously, single stage matrix amplifiers have been demonstrated up to 20 GHz.[1,2] The two-stage matrix amplifier described herein extends the matrix amplifier to millimeter-wave frequencies.

DESIGN

A two-stage matrix distributed amplifier was designed to operate at millimeter-wave frequencies. Each amplifier stage contains four pairs of FETs. The FET

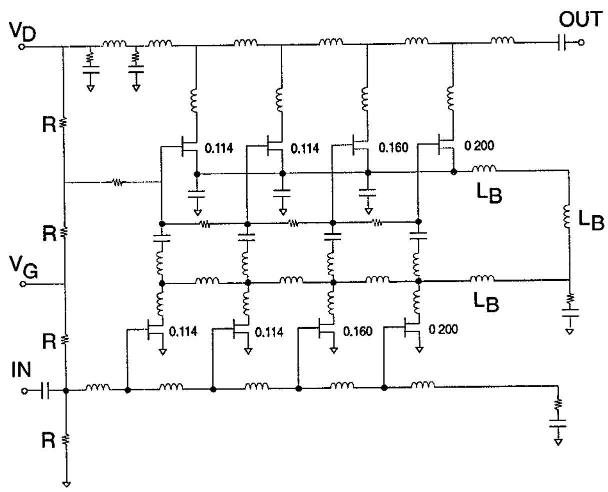

Figure 2. One Stage Millimeter-Wave Matrix Amplifier.

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periphery varies along the amplifier but each paired FET has the same gate periphery. Two identical matrix amplifier stages were cascaded to form the complete two-stage amplifier. Figure 2 shows a schematic of one of the stages. The matrix amplifier total gate periphery is 2.352 mm. The amplifier is biased with a single positive and negative supply. The amplifier FET bias scheme is shown in Figure 3. This bias scheme, demonstrated previously at 18 GHz, has been scaled to 40 GHz.[2] The FETs in each stage are cascode connected at dc through a bias inductor (L_B). This inductor also provides RF isolation between the

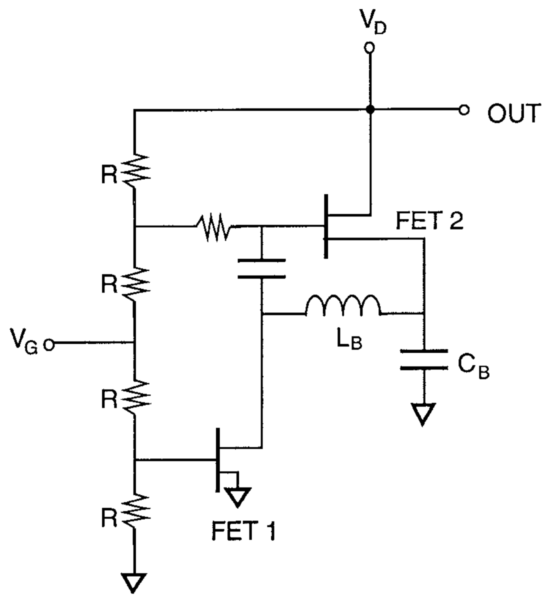

Figure 3. Matrix Amplifier Bias Scheme.

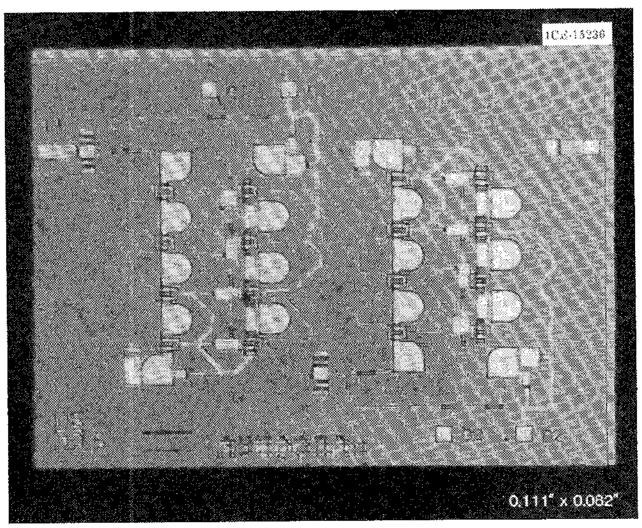

Figure 4. A Photograph of a Two-Stage Matrix Amplifier Chip.

two FETs. A voltage divider is employed to derive identical drain and gate voltage levels for both stages of FETs. For a fixed drain bias, this amplifier draws half the current of comparable multistage distributed amplifiers.

FABRICATION

The two-stage matrix distributed amplifier was fabricated as a monolithic circuit on a semi-insulating GaAs substrate. In the semi-insulating GaAs, an active layer with a carrier concentration of 4.5×10^{17} cm^{-3}, and a contact layer with a carrier concentration of 2×10^{18} cm^{-3} were formed using Molecular Beam Epitaxy (MBE). The FET gate length is 0.25 µm and individual gate peripheries range from 0.100 to 0.200 mm. The circuit is passivated with 2000Å of silicon nitride which also serves as the MIM capacitor dielectric. The complete circuit, measuring 2.81 x 2.08 mm is shown in Figure 4.

MEASURED PERFORMANCE

The small signal measured performance of the amplifier biased at V_D = 6.5 V and V_G = -1.2 V is shown in Figures 5 and 6. From 16 to 38 GHz, minimum input return loss is 6.5 dB and minimum output return loss is 8 dB. Measured gain is 13 dB $\pm$ 1.5 dB from 16 to 38 GHz. The gain control of the matrix amplifier when biased at V_D = 6.5 V and V_G biased at -1.2, -2.75, and -3 V is shown in Figure 7. Greater than 5 dB dynamic range was obtained.

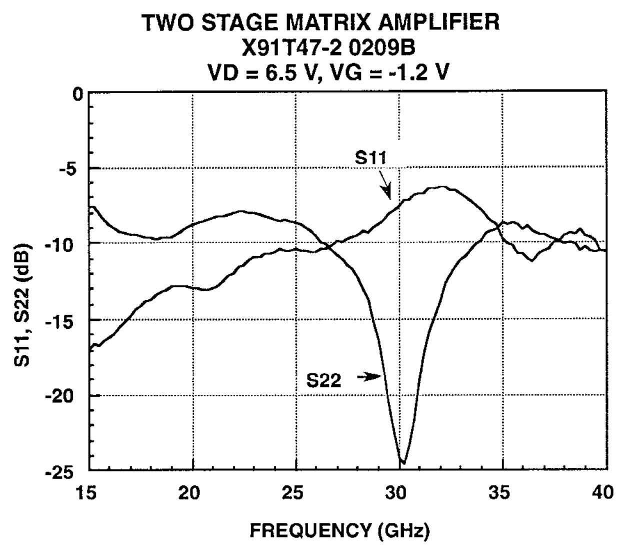

Figure 5. Matrix Amplifier Measured Input and Output Return Loss.

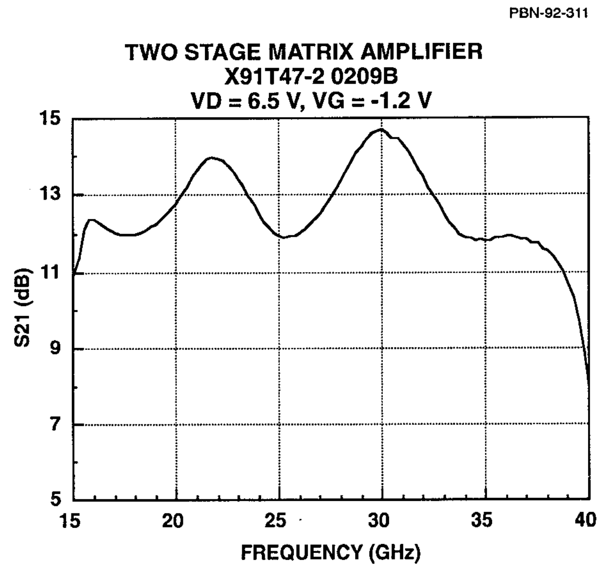

Figure 6. Matrix Amplifier Measured Gain.

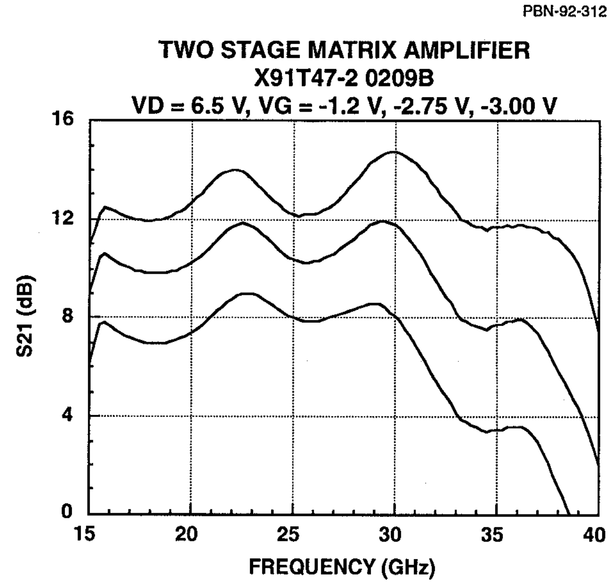

Figure 7. Matrix Amplifier Measured Gain Control.

CONCLUSION

For the first time, a millimeter-wave two-stage matrix distributed amplifier has been demonstrated. From 16 to 38 GHz, measured gain of the amplifier is 13.5 dB $\pm$ 1.5 dB. This demonstration shows that the matrix amplifier topology can be readily extended to millimeter-wave frequencies to design broadband, high gain, compact amplifiers.

ACKNOWLEDGMENTS

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