Quasi-Optical Solid-State Microwave Sources

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Abstract

Quasi-optical power-combining offers the most promising method for extracting large amounts of power from solid-state devices in the microwave and millimeter-wave range. This technique can be applied to a variety of devices. The difficulties associated with traditional waveguides power-combiners such as skin-effect losses are eliminated because the signals are combined in free-space. The solid-state devices are embedded in a two-dimensional grid configuration and placed in a Fabry-Perot cavity. In this respect, the quasi-optical power-combiner is analogous to a laser oscillator in which the active medium of the laser is replaced with an array of active devices. The grid presents a reflection coefficient to an incident plane wave which is larger than unity and the resonator provides feedback to couple the devices together. The two-dimensional structure of the grid is amenable to modern photolithographic processing and potentially allows thousands of devices to be integrated monolithically.

1. Grid Oscillators

Grid oscillators are periodic planar arrays embedded with active solid-state devices. The elements making up an oscillator grid are not themselves free-running oscillators, but rely on mutual interaction for oscillation to occur. Consequently, the oscillation frequency and output power are strongly affected by the device spacing and the grid configuration. Each device in the array is presented with an embedding impedance which is determined by the grid structure. This embedding impedance, together with the device impedance, determines the grid's overall behaviour as an oscillator. Simple transmission line circuit models have been developed to model the embedding impedances to allow optimization of the grid design.

Although any solid-state device can be used in an oscillator grid, transistors are preferred because of their higher DC-to-RF conversion efficiencies and because they provide a separate control terminal. This allows the devices to be more easily stabilized, permitting oscillations to be controlled through an appropriately designed feedback circuit.

A variety of transistor grid configurations have been investigated[1]. These configurations include MESFET hybrid grids and, more recently, monolithic HEMT grids. The

MESFET grid oscillators were built with either packaged or chip type transistors wire bonded into a grid etched on a microwave circuit board and oscillate at frequencies up to 17 GHz. Hybrid grids with up to 100 elements have been built and tested with maximum effective radiated powers (ERP) of up to 37 Watts and DC-to-RF efficiencies of up to 22%. The monolithic HEMT grids were built on GaAs substrates and were designed to oscillate at 60 to 94 GHz. Individual grids with as many as 400 transistor elements have been constructed. In addition, monolithic grids of HBT transistors are being investigated.

2. Acknowledgments

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3. References

1. R.M. Weikle, M. Kim, J.B. Hacker, M.P. De Lisio, Z.B. Popović, D.B. Rutledge, "Transistor Oscillator and Amplifier Grids," to be published in the *Proceeding of the IEEE*, Sept. 1992.