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SOLID-STATE TRAVELLING WAVE AMPLIFIERS BASED ON MULTI-STREAM INSTABILITY

FINAL REPORT

BY

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A method for the amplification of microwaves, based on the space-charge interaction of electron streaming sheets with different velocities in a semiconductor is obtained. A maximum of 18 dB gain in the 3-90 GHz band is predicted. Comparisons of MESFET, bipolar transistor, and state induction transistor Class C amplifiers show that silicon bipolar type is preferred. A completely new approach to the phenomenological quantal dissipation problem has been formulated and solved by Dirac's constrained dynamics. Boson operator, generalized to dissipative oscillator is also obtained.

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STATEMENT OF THE PROBLEM STUDIES

A method for the amplification of microwaves, based on the space-charge interaction of electron streaming sheets with different velocities in a semiconductor, is obtained. A theory of an n^+ - n - n^+ GaAs diode is formulated. We consider electron-charged sheets, each of which has a different average velocity due to the doping concentration gradient along the thickness direction. A dispersion relation is obtained for space-charge waves in the semiconductor, and a numerical analysis is used to claculate the propagation constant.

Comparisons of MESFET, bipolar transistor and static induction transistor class C amplifiers have been presented. Simplified modelliing of the I-V charcteristics and input circuits is employed.

In view of the importance of damped harmonic oscillators as a model in ultrasmall solid state devices, Boson operators for generalized quantal harmonic oscillators with time-dependent mass, frequency, damping and driving forces have been presented. A constrained dynamical formulation of the dampled harmonic oscillator system has been obtained. Then generalized classical Hamiltonian based on the Dirac theory and its quantal counterpart are given.

Underline of the Most Important Results

1. In a solid-state travelling-wave amplkifier a maximum of 18dB gain in the 3-90 GHz band can be achieved.

2. The silicon bipolar transistor leads among the three divices (bipolar, MESFET and static indiction transistor) in output power, gain and efficiency. The InP MESFET followed by the GaAs can give power comparable to thie bipolar type with slightly lower gain and efficiency. The static induction transistor has higher power potential but its gain and efficiency are both moderate.

3. A completely new approach to the phenomenological quantal dissipation problem has been formulated and solved based on Dirac's constrained dynamics.

List of All Publications Published

1. Y. Wang, "Constrained Dynamics of Dampled Harmonic Oscillaotor, J. Phys. A: Math. Gen. 20 (1987) 4745-4755.

2. Y. Wang, "Boson Operators for Generalized Harmonic Oscillators", J. Phys. JA: Math Gen 20 (1987) 4739-4744.

3. Y. Wang and H. Jahandoost, "Solid-State Travelling Wave Amplifiers based on Multi-Stream Instability", Int. J. Electronics, 1985, 58, 4, 571-585.

4. Y. Wang, (Invited paper), Comparison of MESFET, Bipolar Transistor and Induction Transistor Class C Amplifiers", Int. J. Electronics, 1985, 59, 1, 1-17.

5. Y. Wang, "Fundamental Performance Limitations for Transit-Tme Devices", Int. J. Electronics, 1985, 58, 6, 1037-1040.

6. Y. Wang, "Singular Perturbation Applied to the Relaxation Oscillations of the Van der Pol Oscillator", Int. J. Electronics, 1987, 62, 3.

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Miss Mitra Pejman (Master of Engineering in E.E. June 1987).

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1. Y. Wang, "Applications of Lagrange Expansion to the Problem of Shielded Surface Waves", IEEE Trans. on Microwave Theory & Techniques, April, 1969.

2. Y. Wang, "Review of Some Mathematical Models of Nonlinear Domain Dynamics in Bulk Effect Semiconductors", Journal of Institute of Mathematics and its Applications, 11, 251-280, 1973.

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14. Y. Wang & M. Bahrami, "Leakage Effects in n-GaAs MESFET with n-GaAs Buffer Layer", Int. Journal of Electronics, 57, 5, 647-663 (1984).

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