

## X. MICROWAVE AND MILLIMETER WAVE TECHNIQUES

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#### 1. MICROWAVE DEVICE AND NOISE STUDY

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The objective of these studies is to develop improved signal and noise models for solid-state microwave devices. These models are useful for accurate prediction of device characteristics, optimization of design, and improvement of performance in circuit applications. The three devices of interest at present are silicon BARITT diodes, GaAs microwave FETs, and high-efficiency IMPATT diodes.

##### a. BARITT Diodes

We have fabricated BARITT diodes and made a detailed characterization of their nonlinear properties at microwave frequencies. The measured parameters include small-signal and large-signal device impedance, frequency-modulation sensitivity, and linearity of modulation. We report the following achievements:

(i) An improved method of measurement of large-signal impedance for nonlinear diodes. In this method the sensitivity of measurement is high even when the device impedance is small (VSWR high), and the RF voltage across the device can be measured independently.

(ii) We have devised a lumped-circuit model for BARITT diodes. This model has shown better agreement with experimentally measured devices; improvement has been found over a wider frequency range than in previous models and its elements can be given physical interpretation.

(iii) An extensive set of large-signal measurements for a device with known parameters has provided a data base for evaluating the theoretical nonlinear models of the BARITT diode. This work is reported in the Ph.D. thesis of Gary K. Montress,<sup>1</sup> and a paper is being prepared for publication.

##### b. GaAs Microwave FETs

In the past, work on GaAs FETs has been the experimental characterization of a

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device in order to relate it to its model.<sup>2</sup> This model was used to design an optimum low-noise microwave amplifier with the device under low-temperature operating conditions.<sup>3</sup> An attempt has been made to construct this optimized amplifier.<sup>4</sup> Measurements on the amplifier have suggested that the biasing of the device can be modified to improve the stability, with a small sacrifice of amplifier performance.

### c. High-Efficiency IMPATT Diodes

Our research on high-efficiency IMPATT diodes is directed toward measuring oscillator noise spectra. Quantitative agreement between experimentally measured and theoretically calculated noise spectra has not been achieved for high-efficiency IMPATT diodes. Recent theoretical analyses<sup>5</sup> show that the FM noise measure can be calculated reasonably well if the effect of signal power level upon temperature, and of temperature upon the reverse saturation current, is accounted for. We are attempting to measure both AM and FM noise spectra, as well as the correlation coefficient. These measurements will be used for comparison with theoretical results.

### References

1. G. K. Montress, "Fabrication and Large-Signal Characterization of BARITT Diodes," Ph.D. Thesis, Department of Electrical Engineering and Computer Science, M. I. T., October 1976.
2. J. F. Cooper and M. S. Gupta, "Microwave Characterization of GaAs FETs and the Verification of Device Model" (to appear in IEEE J. Solid-State Circuits).
3. J. F. Cooper, "Characterization of a Microwave GaAs FET at Low Temperature," S.B. and S.M. Thesis, Department of Electrical Engineering and Computer Science, M. I. T., June 1976.
4. J. C. Carrick, "Construction and Measurement of High-Frequency Amplifier with GaAs FETs," S.B. Thesis, Department of Electrical Engineering and Computer Science, M. I. T., August 1976.
5. H. Statz, R. A. Pucel, J. E. Simpson, and H. A. Haus, "Noise in Gallium Arsenide Avalanche Read Diodes," IEEE Trans. on Electron Devices, Vol. ED-23, No. 9, pp. 1075-1085, September 1976.

## 2. ATMOSPHERIC REFRACTION AT MILLIMETER WAVELENGTHS

Joint Services Electronics Program (Contract DAAB07-76-C-1400)

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The microwave aperture synthesis interferometer (described in Section XIII-6 and in previous RLE Progress Reports) will be used to study refraction and absorption in the Earth's atmosphere. The initial measurements will be made at 13 mm. In January 1977, we shall begin to make measurements at high and low angles of elevation, under a variety of weather conditions. The system will be converted to operation at 7 mm

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during 1977.

Interference fringes have been detected at 13 mm by the entire digital system. The 150-MHz correlator works well, and the measurement phase of the project awaits only the interfacing of the digital delay system with the computer, and the completion of the 3-element correlator and phase reference controls.

