

III. SOLID-STATE MICROWAVE ELECTRONICS*

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A. MICROWAVE FREQUENCY DOUBLER

The research during this period has been concentrated on the development of theoretical guidelines for frequency doubler design. Based on an imbedding network model suggested by D. H. Steinbrecher, the condition of optimum frequency doubler is derived. Through the use of a Smith chart, criteria of an optimum network, performance, and supplementary observables can be predicted. The results are analytical. Although certain limitations have been assumed at the beginning, they are reasonable in practice. From this, a systematic design approach has been formed. A frequency doubler from 14.4 GHz to 28.8 GHz is under construction and test, at the present time.

A. Y. Chen

B. THEORY OF RESISTIVE MIXERS

This report summarizes a thesis submitted by the author to the Department of Electrical Engineering, M. I. T., in January 1970, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

A theoretical study has been made of mixers employing purely resistive devices. The analysis has two main parts. The first part treats the mixer as a linear periodically time-variant resistance inserted in a passive linear time-invariant imbedding network without paying attention to the method of obtaining the resistance waveform. Different imbedding networks that allow a closed-form solution of the mixer equations are identified and classified. A system of nomenclature introducing names such as Z-, Y-, H- and G-mixers is introduced. These designations are derived from the types of network matrices that have to be used in the analysis. The wealth of knowledge of mixer circuits analyzable in closed form is employed to find the optimum resistance waveforms for various imbedding networks and the optimum imbedding networks for different resistance waveforms, and, in general, to set fundamental limits on the performance

*This work was supported by the National Aeronautics and Space Administration (Grant NGL 22-009-163); and in part by the Joint Services Electronics Programs (U. S. Army, U. S. Navy, and U. S. Air Force) under Contract DA 28-043-AMC-02536(E).

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of resistive mixers.

The second part of the analysis is concerned with mixers employing diodes with exponential characteristics. The problems of the pumping waveform, pump power, and DC bias parameters are treated. The performance of different mixers is obtained and compared for identical pump power and DC bias conditions.

Other topics considered in the analysis are the sensitivity of the mixer performance to variations in the source impedance and shape of the resistance waveform, the problem of incomplete terminations of the undesired out-of-band frequencies, and the noise figure and noise temperature ratio in mixers employing purely exponential diodes.

The results of this research emphasize the importance of the method of pumping and the proper termination of the out-of-band frequencies on the performance of the mixer.

A. A. M. Saleh

C. AVALANCHE DIODE AMPLIFIERS

By using the small-signal experimentally derived model for the avalanche diode junction,¹ negative resistance reflection amplifiers are being designed and constructed. Since the diode impedance is quite frequency-dependent, however, conventional filter design techniques have limited value in the analysis. Also, stability becomes of prime importance when large values of amplifier gain are desired. These two problems complicate the analysis considerably.

A simple amplifier has been built in coaxial transmission line and uses an impedance transformer to bring the magnitude of the diode negative resistance close to 50Ω . The amplifier has a 10-dB gain with a 3.5% fractional bandwidth at 9.5 GHz. We hope to achieve a gain of 15-20 dB over a 10% bandwidth, this being theoretically possible for the small-signal model of the avalanche diode junction.

D. F. Peterson

References

1. D. H. Steinbrecher and D. F. Peterson, "Small-Signal Avalanche Diode Equivalent Circuit Model," Quarterly Progress Report No. 96, Research Laboratory of Electronics, M.I.T., January 15, 1970, pp. 51-53.