

IV. SOLID-STATE MICROWAVE ELECTRONICS*

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A. HIGH DYNAMIC RANGE MIXERS

We have continued our studies of high dynamic range mixers. An HF mixer covering 0.5-29.5 MHz, with no input tuning, has been constructed using four MOS FET's in a symmetric bridge circuit. Measurements of the dynamic range show that a +4 dB two-tone signal at the input gives third- and fifth-order intermodulation terms greater than 120 dB down. The mixer has been described in a Master's thesis by M. J. Ward¹ and in a paper by R. P. Rafuse presented at the 1968 International Solid State Circuits Conference.² We are continuing theoretical and experimental work, and hope to have some of the devices operating in the 225-400 MHz band soon.

R. P. Rafuse

References

1. M. J. Ward, "A Wide Dynamic Range Single-Sideband Receiver," S.M. Thesis, Massachusetts Institute of Technology, January 1968.
2. R. P. Rafuse, "Symmetric MOSFET Mixers of High Dynamic Range," Digest of Technical Papers, International Solid State Circuits Conference, February 14-16, 1968.

B. LOW-NOISE SOLID-STATE RECEIVER

We are engaged in developing a low-noise solid-state 60-GHz receiver. Theoretical predictions have been made which indicate an expected single-sideband receiver noise figure less than 6-dB for the system described by the block diagram shown in Fig. IV-1.

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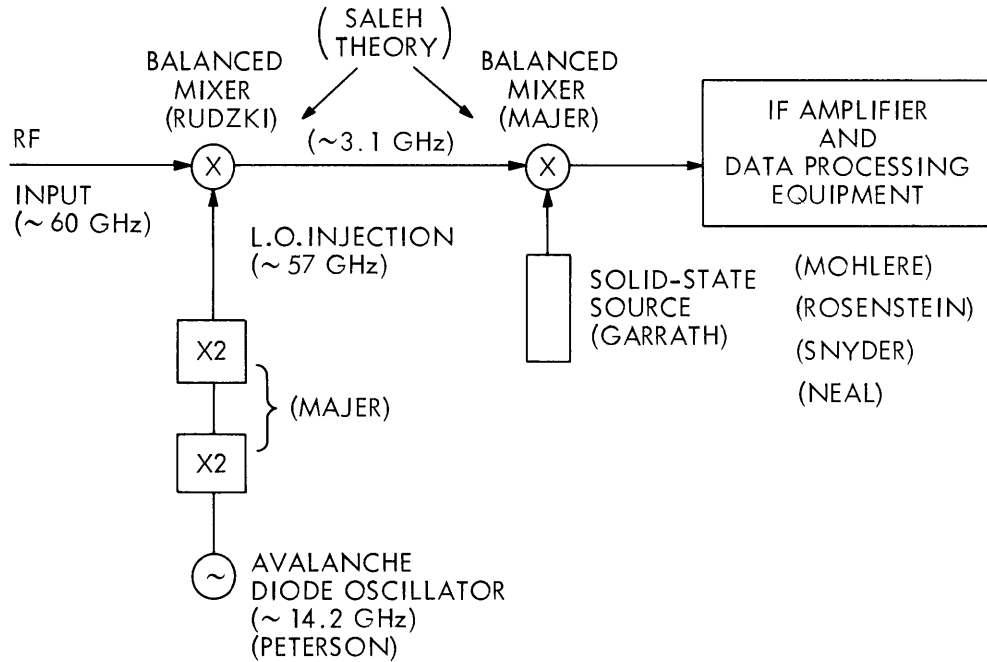


Fig. IV-1. Diagram of 60-GHz receiver.
(Names of those responsible for development are indicated.)

Progress reports on the various system components and some seemingly unrelated investigations follow.

D. H. Steinbrecher

1. 60-GHz MIXER

The 60-GHz mixer program is approximately 15% complete. Theoretical studies have been made on the design parameters of the diode package and diode mount. The mounting studs and IF filters have been completed. Quartz diode sleeves have been obtained, and the assembly of the diode packages has begun. The machining of balanced mixer waveguide hardware with a reduced height is 75% complete. A 60-GHz test bench is 50% assembled. No tests have been made.

J. E. Rudzki

2. S-BAND MIXER

Two coaxial diode holders for a balanced mixer have been designed and fabricated in the machine shop. A special rack-bench has been mounted with devices for

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measurement of impedance and noise figure at S-band. The input impedance of the holder vs diode bias has been measured at 3.1 GHz. In order to find two similar diodes, the impedance measurements are under way.

J. W. Majer

3. FREQUENCY DOUBLERS

Two frequency multipliers have been designed from 15.2 GHz to 30.4 GHz, and from 30.4 GHz to 60.8 GHz. Four such units (two of each) are under construction in the machine shop. These multipliers will be used initially for diode measurements, and then modified to provide a 57-GHz local oscillator for the 60-GHz mixer.

J. W. Majer

4. MIXER THEORY

It has been found that shorting the harmonics at one end while opening them at the other end of a balanced mixer (or vice versa) gives a lower conversion loss than the classical method of shorting (or opening) the harmonics at both ends of the mixer for a square, near square, sinusoidal or near sinusoidal local-oscillator driving voltage.

The effect of incomplete harmonic termination on the conversion loss of a square-driven balanced mixer has also been studied.

A. A. M. Saleh

5. CHARACTERIZATION OF AN AVALANCHE DIODE OSCILLATOR AT X-BAND AND Ku-BAND

The design and construction of the microwave circuit required to hold the diode for measurements have been completed. A search for equipment that is needed for the project is now under way, and a list is being made of necessary pieces.

Certain aspects of the theory associated with the device and measurement techniques that will be used have been studied.

Measurements will begin as soon as most of the equipment is available.

D. F. Peterson

6. L-BAND QUADRUPLER

Most of the research done during the past quarter was concerned with measurements on varactor punch-through diodes for the purpose of getting information upon a more extended equivalent circuit of the diode. Measurements have been made to determine the inductance of the diode in a certain configuration. Other measurements have been made to determine the first series resonant frequency of the diode in a configuration

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similar to that in a multiplier which will be built later.

First attempts have been made to compute the idler network of an L-Band quadrupler.

K. H. Gerrath

7. D-C AMPLIFIER

Our principal area of activity has been the implementation and testing of a circuit designed by D. H. Steinbrecher. The circuit in question is a high input impedance (of the order of $10^{15} \Omega$), low output impedance (of the order of 5Ω) small-signal DC amplifier with unity voltage gain. The circuit employs two FET bridges as chopper and decorrelator, with a random chopping waveform derived from avalanche noise in a silicon junction. The bridges, the noise generator, and bridge driver have been built, and the components mentioned above have been individually tested. The system is in the stage of being assembled.

R. D. Mohlere

8. INTERMODULATION IN TUNING VARACTORS

The theoretical stage of the measurement of intermodulation distortion on a varactor-tuned 200-MHz cavity is just being completed. Two helpful papers on theory of biased diode capacitance have been found. The theoretical analysis of intermodulation is close to completion, and capacitance and intermodulation measurements will follow. A comparison of theoretical results with actual results, and possible explanations for discrepancies, will be included in the final report on the subject.

T. L. Neal

9. WIDEBAND HYBRIDS

Testing and development of wideband hybrids using ferrite beads and coaxial transmission line is progressing. Tests on a simple $50\text{-}\Omega$ inverting transformer indicate that approximately 0.5-dB insertion loss is attainable when using 4 beads strung on 20-mil coaxial cable. This loss will be lower for balanced to unbalanced transformers with 4 beads per line. Bandwidth tests are not complete at the high-frequency limit, but the transformers should be useful beyond 1 GHz. The low-frequency limit is much higher than that computed when using a simple R-L model for the beads. The measured half-power cutoff frequency is approximately 3 MHz, while the computed frequency is 0.3 MHz. This discrepancy is still unresolved. Measurements of input impedance vs frequency for a $50\text{-}\Omega$ balanced to $50\text{-}\Omega$ unbalanced transformer with matched balanced output are now being made.

R. E. Snyder

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10. LOW-FREQUENCY HIGH DYNAMIC RANGE
PHASE DETECTOR

Our problem is to investigate the amplitude-to-phase conversion in a field-effect transistor bridge. The DC output will be plotted against the input drive signal for various phase differences. We expect that the output will remain constant for a wide range of drive signal amplitudes for a constant phase difference.

The variable phase-shift network and amplifier have been set up to drive the phase-splitter and gate-drive circuit. The main problem now is to balance the FET bridge, to eliminate the effect of parasitic capacitances, and so forth. I have encountered some difficulty in doing this.

H. T. Rosenstein

11. 23.8-GHz DEGENERATE PARAMETRIC AMPLIFIER

A 23.8-GHz degenerate parametric amplifier with an effective input noise temperature of 150°K has been built and is being evaluated. It has a bandwidth of 70 MHz with a gain of 20 dB.

P. W. Rosenkranz

