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20 GHz HIGH POWER IMPATT TRANSMITTER

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ABSTRACT

The development of a 20 GHz proof-of-concept (POC) high power solid state transmitter sponsored by NASA Lewis Research Center and USAF Space Division is described. The transmitter utilizes GaAs IMPATT diodes for high power output and high efficiency, and operates in the constant-voltage injection-locked mode to achieve high dc-to-rf conversion efficiency. The transmitter is a three-stage design consisting of a single-diode driver, a dual-diode intermediate driver, and a twelve-diode rectangular waveguide power combiner in the output stage to achieve 29 dB gain and 16 W power output.

Transmitter Design

The first driver stage consists of a single-drift GaAs IMPATT diode mounted at the bottom of a coaxial line cross-coupled to the reduced-height waveguide as shown in Figure 1. The coaxial line serves to transform the relatively low device impedance to a higher value compatible with the waveguide impedance.[1] At the top end of the coaxial line, a lowpass filter is used in conjunction with a tapered load introduced to isolate the RF from the dc bias and to suppress spurious oscillations.

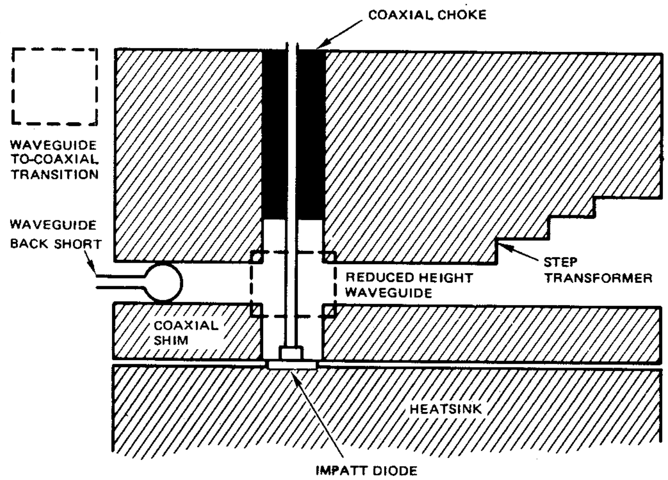

Figure 1. Reduced-Height Waveguide Amplifier Circuit

The second driver stage consists of two IMPATT diodes mounted side-by-side in a reduced height waveguide circuit as shown in Figure 2. By injection-locking the dual-diode module with the first driver stage, between 2.5 W and 3.2 W output power was achieved between 19.3 and 19.7 GHz. Figure 3 shows the output characteristic of the second driver stage.

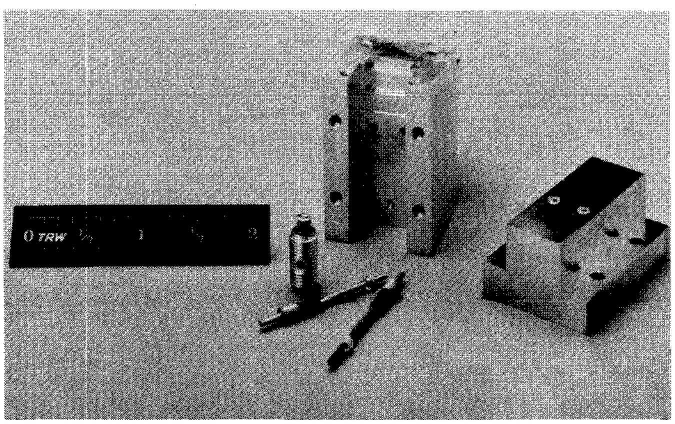

Figure 2. Dual-Diode Injection-Locked Circuit

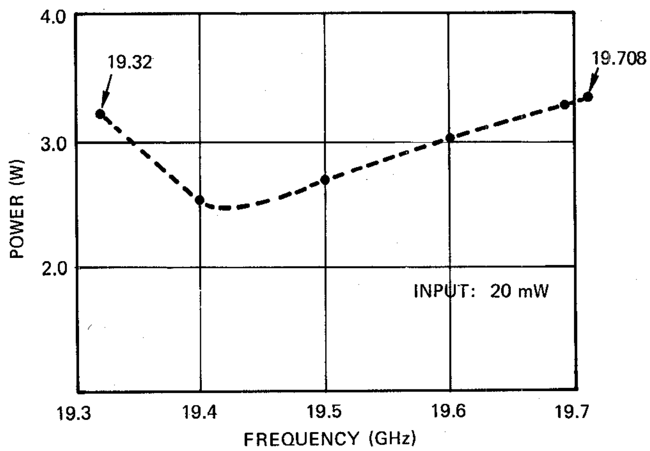

Figure 3. Two-Stage Amplifier Output Performance

The output power stage consists of a twelve-diode rectangular waveguide cavity combiner, more commonly known as the Kurokawa circuit.[2] Twelve 1.6 W single-drift GaAs IMPATT diodes were selected for power combining. The combiner structure is shown schematically in Figure 4. IMPATT diodes mounted inside coaxial modules are placed near the periphery of the waveguide cavity. The magnetic field line interaction between the resonant cavity and the coaxial lines which penetrate the cavity periphery is the vehicle by which power accumulation takes place. At the top end of each coaxial module, a lossy termination in the form of a hollow cylinder made of Eccosorb material is used to suppress unwanted oscillations. Each termination can be manually adjusted up or down a metallic bias post to achieve power phase matching between diodes. A unique feature of this combiner is that all diodes operate in the constant voltage biasing mode. This mode has the advantage that as the temperature of the combiner goes up, the bias currents go down, resulting in the self-regulation of the diode junction temperature.

Low loss, broadband circulators are required to properly isolate the input from the output in any injection locking system. Figure 5 shows the excellent performance of these circulators developed at TRW. A number of ferrite junctions can be integrated into one housing to form a multijunction circulator assembly. This unique mechanical design has been used in the present 20 GHz transmitter to achieve a high degree of mechanical integrity and ruggedness.

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Transmitter Performance

The POC transmitter has been evaluated extensively for rf performance. A maximum output power of 15.85 W was achieved at 19.85 GHz. Figure 6 is a plot of the output characteristics of the POC transmitter. With 20 mW input power, the locking bandwidth over a 3 dB power variation is 300 MHz. By comparing the peak output power with the dc input power, the overall dc-to-RF efficiency of the POC transmitter was found to be 12%. Figure 7 is a photograph of the complete POC transmitter assembly.

Conclusions

The rectangular waveguide power combining technique has been successfully utilized in the development of a high power solid state IMPATT transmitter at 20 GHz capable of 16 watts of CW output power.

Acknowledgments

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References

1. R. L. Eisenhart and P. J. Kahn, "Theoretical and Experimental Analysis of a Waveguide Mounting Structure," IEEE Trans. on Microwave Theory Tech., Vol. MTT-19, August 1971, pp. 706-719.
2. K. Kurokawa and F. M. Magalhaes, "An X-band 10-Watt Multiple IMPATT Oscillator," Proc. IEEE, Vol. 59, January 1971, pp. 102-103.

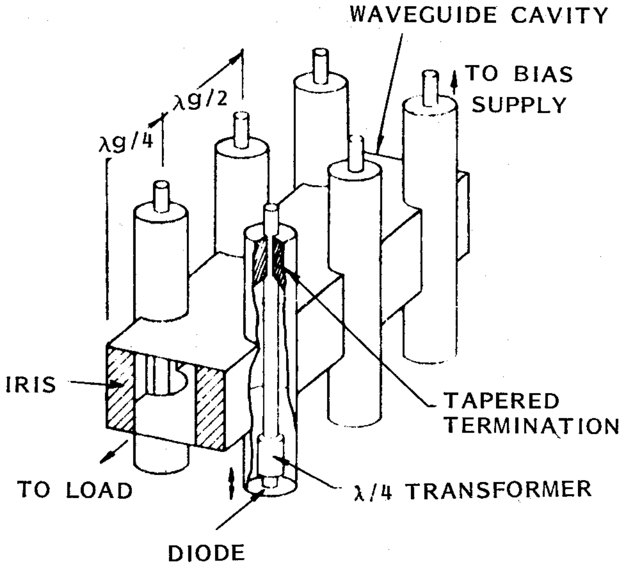

Figure 4. Rectangular Waveguide Power Combiner

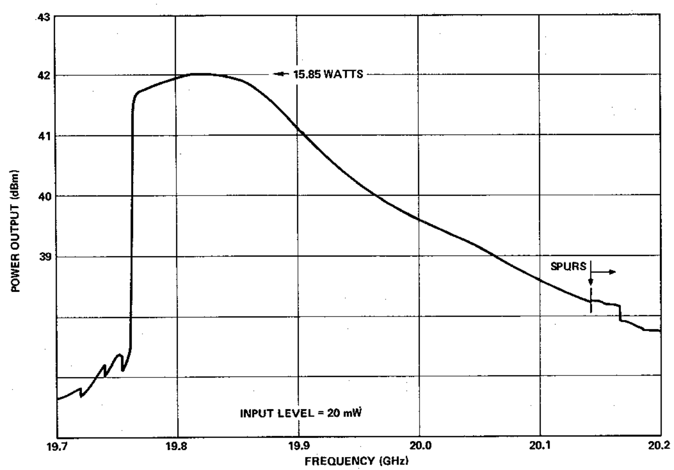

Figure 6. 3-stage POC Amplifier Output Characteristics

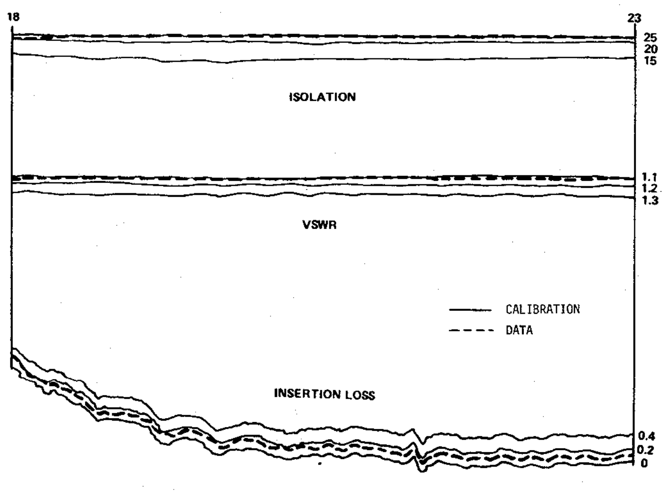

Figure 5. 20 GHz Circulator Performance

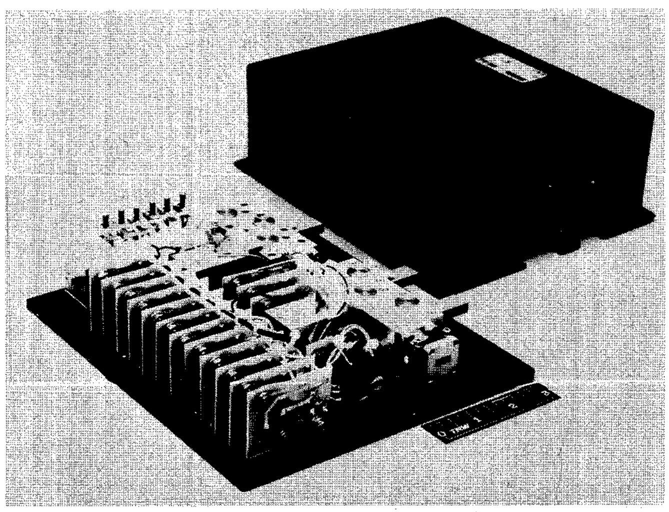

Figure 7. 20 GHz Transmitter Assembly