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A DUAL DIODE TM_{020} CAVITY FOR IMPATT DIODE POWER COMBINING

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ABSTRACT

A unique design for doubling the number of IMPATT diodes combined in a TM_{020} mode cavity combiner is described. Resulting performance exhibits improved combining efficiency and bandwidth over conventional TM_{ono} mode cavities.

INTRODUCTION

The continuing demand for higher power in limited volume from solid state transmitters has led to microwave cavity designs which combine the power of increasing numbers of IMPATT diodes in a single compact structure. Circular cylindrical cavities are among the most compact of these designs, however, the number of diodes which can be accommodated in a single combiner is limited by the cavity diameter, which is determined by the cavity mode and operating frequency, and the diode package diameter. At X-band a conventional TM_{010} mode cavity can accommodate approximately 15 IMPATT diodes in commercially available packages whereas approximately 30 diodes can be placed around the periphery of an X-band TM_{020} cavity. Higher order TM_{ono} mode cavities accommodate larger numbers of diodes but the microwave design is complicated by the necessity to suppress many unwanted modes existing near the resonant frequency. A patented[1] concept, shown in Figure 1, which doubles the number of diodes that can be combined in a single TM_{ono} cavity, places diodes opposite each other on the top and the bottom of the cavity and is therefore referred to as a dual diode combiner. Diamond[2] has designed and operated a Ku-band dual diode combiner in which each of three diode pairs shares a single bias/coupling line and stabilizing load. This paper describes a unique implementation of the dual diode concept at X-band which, in addition to doubling the quantity of combined devices, isolates each diode's bias circuitry and also exhibits improved combining efficiency and bandwidth over conventional designs.

DUAL DIODE DESIGN

A TM_{020} mode dual diode cavity has been developed, fabricated and evaluated at X-band. Figure 2 shows a

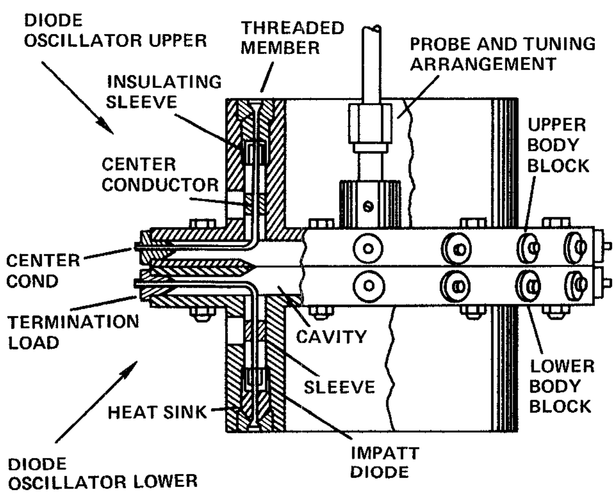

Figure 1 - Patented Dual Diode Circular Cylindrical IMPATT Diode Power Combining Structure

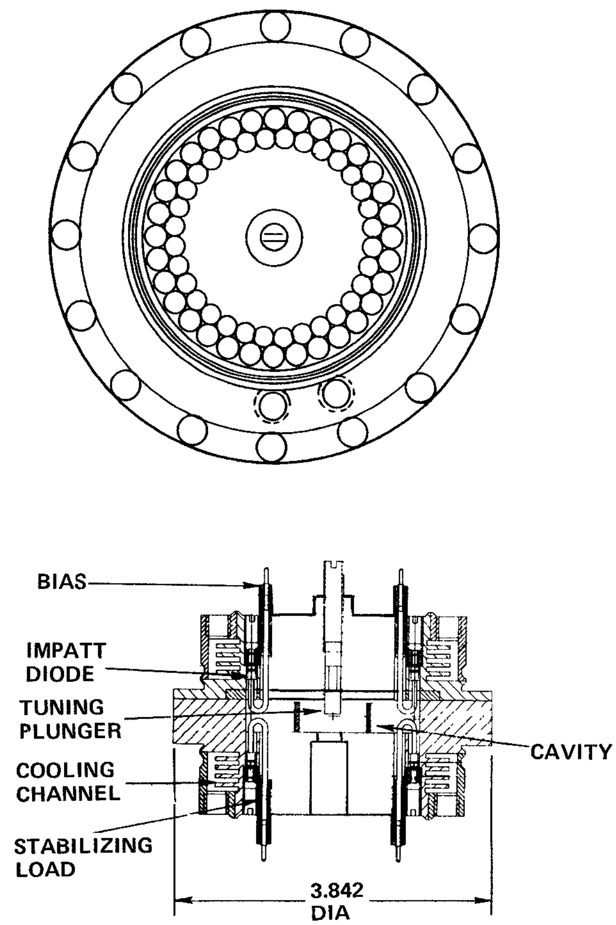

Figure 2 - Improved Dual Diode Design in TM_{020} Mode Cavity Combiner

schematic of the design which is capable of accommodating 64 diodes. In this circuit, as in conventional cavity combiner designs, the cavity presents a high impedance which is matched to the diode at resonance and a low impedance off resonance such that the diode sees a stable termination provided by a microwave absorber, referred to as the stabilizing load. The location of the stabilizing load is the unique feature separating this design from either conventional TM_{ono} cavity circuits, the patented dual diode circuit or Diamond's Ku-band dual diode combiner. Conventional cavity circuits have the load positioned opposite the diode, as shown in Figure 3, thus eliminating half the potential diode locations. The patented dual diode circuit as well as the Ku-band circuit locate the loads radially outward from the periphery thus increasing combiner volume and weight.

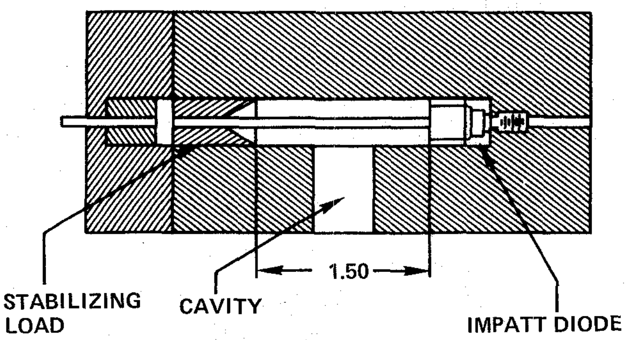

Figure 3 - Conventional Cavity Design with Diode and Stabilizing Load on Opposite Side of the Cavity

For testing and development purposes the dual diode combiner described here has been fabricated to accommodate eight diodes, four on the top and four opposing on the bottom of the cavity. The combiner has been measured passively using an Automatic Network Analyzer programmed to compute combiner efficiency and cavity impedance from reflection measurements at the output port with adjustable shorts installed in the diode ports. The program determines the 2-port equivalent S-matrix.

$$S = \begin{bmatrix} S_o & NS_t^2 \\ S_t^2 & S_E \end{bmatrix} \quad (1)$$

for an N diode combiner where S_o is the output probe scattering parameter, S_E is the even mode diode port scattering parameter and S_t is the output port to diode port scattering parameter. From these parameters the efficiency and normalized cavity impedance are computed.

$$EFF = \frac{N\left|S_t\right|^2}{1 - \left|S_E\right|^2} \quad (2)$$

$$Z = \frac{1 + S_E}{1 - S_E} \quad (3)$$

The impedance information has been used to design a coaxial matching network which provides a good diode impedance match at the design frequency and a stable termination at other cavity mode frequencies and off-resonance.

RESULTS

Figure 4 shows the efficiency versus frequency simulating eight diode operation at an optimum output probe coupling. The 83 percent maximum combining efficiency represents approximately 8 percent improvement over conventional TM_{020} cavity power combiner circuits. No degradation in efficiency is expected as the number of diodes is increased to 64.

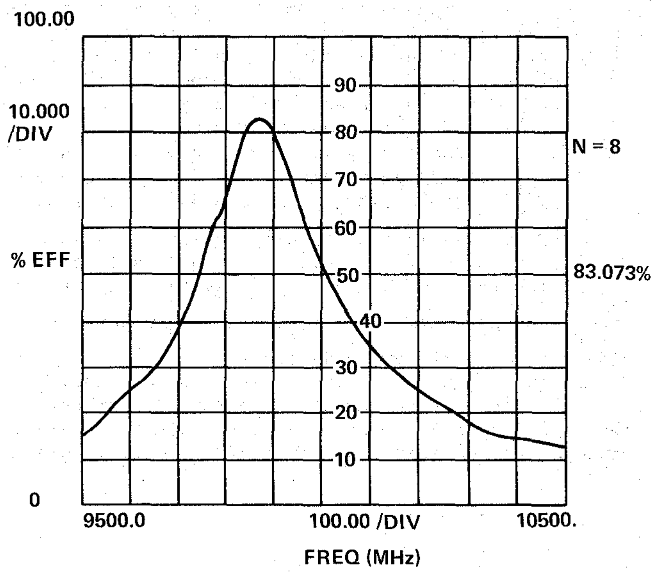

Figure 4 - Efficiency versus Frequency Measured on Eight Diode TM_{020} Dual Diode Cavity Combiner

Diodes which have been operated in the dual diode TM_{020} combiner have been pretested for power capabilities in a single diode conventional TM_{010} cavity circuit. The output power of the dual diode combiner operating with eight diodes is 33 watts average at 30 percent duty cycle, corresponding to a 3 percent increase over the sum of the individual diode output power in the conventional circuit. At 8 dB maximum injection locking gain, the dual diode combiner exhibits 220 MHz of bandwidth at 10 GHz, approximately double the instantaneous injection locking bandwidth of comparable conventional combiners.

Additional data and design information has been excluded here because of space limitations but will be provided at the conference.

CONCLUSIONS

An X-band IMPATT dual diode TM_{020} cavity combiner capable of doubling the number of diodes which can be accommodated and therefore the output power has been developed and operated successfully with up to eight diodes. The design incorporates a bias/coupling line configuration which improves combining efficiency and injection locking bandwidth over conventional designs. A 60 diode version is in the process of being evaluated.

ACKNOWLEGEMENT

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