MULTI-PARALLEL OPERATION OF GUNN DIODES FOR HIGH RF POWER

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Twelve diodes are operated to achieve a total output of 920 mW with 80 % "paralleling efficiency" at 12.7 GHz. One oscillator unit consists of four diodes placed in a series-parallel configuration and can be cascaded.

Introduction

A posibility of using several Gunn diodes synchronized at the same frequency in order to get more power is very atractive and was investigated by some workes (1-4).

One of these methods consists in synchronizing oscillators at nearly equal oscillation frequencies into an identical frequency by use of "locking conditions". In this case the mutual coupling may be relatively weak, and the output levels of two oscillators should desirably be equal. For practical oscillators, it is desirable that easy combination of outputs is possible even from diodes having any given outputs.

Principle of Operation

In this paper will be reported the experimental results and their study for the case where diodes are placed at a definite distance from each other for reason of heat dissipation, but with a strong circuit coupling.

In the method to be reported, two (or a plurality of) diodes are mounted in the resonator. With Gunn oscillator diodes, it can be expected, also in case of using diodes having different outputs, 1) that optimum bias voltages are almost equal at ceratin frequencies, 2) and that optimum RF voltages are also almost equal.

Experimental Results

Standard Parallel Operation When two diodes are mounted at positions about 1/4 the width away inward from both sides of the waveguide as shown in Fig. 1, the admittance represented to the waveguide is nearly equal to that obtained when mounting one diode at the center position. Accordingly for the determination of optimum dimensions, it is possible to apply a design parameter for a single diode oscillator.

Output powers from these devices approached, quite closely to the sum of the powers of the diodes.

In this example two diodes produced power output of 320 mW, a "paralleling efficiency" of 100 % and an overall efficiency of 2.8 %.

The reproducibility and stability of oscillation were observed by the Rieke diagram and were confirmed to be at almost the same quality as those for a single diode oscillator.

The tuning waveguide piston was about $\lambda g/2$ behind the diodes, and the frequency band having a 90 % power adding covers a range of 3 GHz, a fairly wide band.

Even with a combination of diodes having different outputs of a ratio as large as 1:4, it was easy to obtain a sum of power outputs. The external Q of a parallel operated oscillator adjusted for maximum output is generally in a range of 50~100. The measured FM noise is almost equivalent to that of a single diode having the same Q value.

Multi-parallel Operation To demonstrate that Gunn diode can be operated in multiparallel, they were placed in a waveguide cavity as shown Fig. 2. The oscillator is constructed of three unit resonators. This series-parallel configuration improves the low RF source impedance. An output from the upper and the lower waveguide resonator is fed into a standard waveguide through a tapered section and 3- stub tuner. Each packaged diode used in the experiment were measured separately as a single oscillator in a waveguide mount. The threshold voltage of diodes is 2~2.5 V, and can be capable of oscillation at 10~15 GHz.

Fig. 3 gives the operating characteristics of each oscillator unit (A, B, C) with four diodes and the performance of the three blocks connected in cascade, where the abscissa is the distance between the movable pistons and the diodes nearest to them. Outputs were optimized by 3-stub tuner at each point. Variation of outputs are rather critical when 12-diodes are coupled. At the operation a number of spectra are observed on a spectrum analyzer until its maximum power with a single spectrum is reached.

Oscillation frequencies for different spacings between the diodes were measured, indicating that the oscillation frequency of the oscillator is substantially decided by the longitudinal distances between diodes which is nearly equal to $\lambda g/2$.

An effect of some failured (opened) diodes on the normal operation in a multi-parallel operation should be known for practical use. The power and frequency characteristics are shown in Fig. 4. In the case of several failured modes for a unit oscillator. It is notable that the frequency shift is very small when a paralled pair is alive.

Conclusions Results of these measurements and measured performance of the multi-parallel operation of Gunn diodes are given in Table 1.

The present investigation of the parallel operation indicate that those methods may be easier way of achieving very high power under certain restrictions.

References

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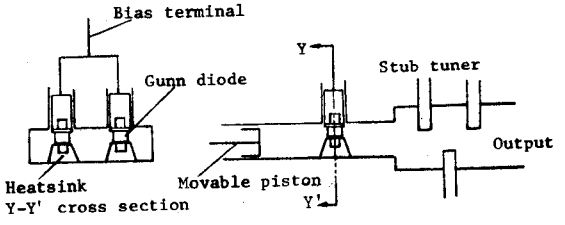

Fig. 1. Schematic of waveguide resonator with parallel connected Gunn Diodes.

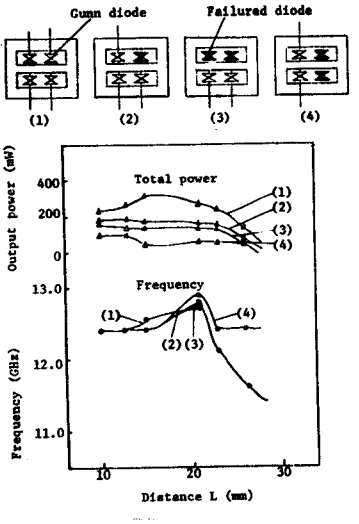

Fig. 4. Failured mode operation of 4-diodes.

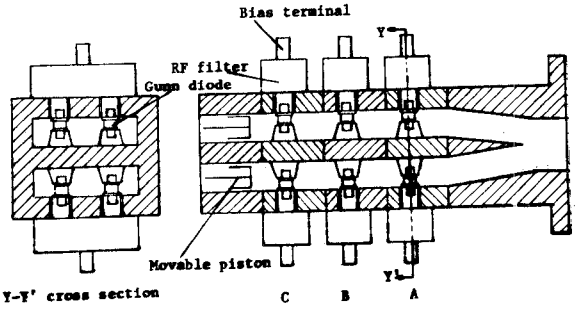

Fig. 2. Diode mount for multi-parallel operation.

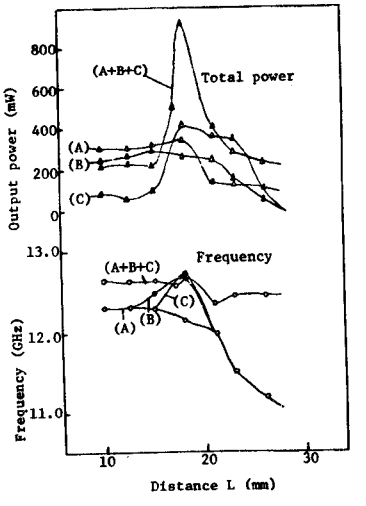

Fig. 3. Output power and prequency vs. distance between the movable piston and diodes for 4-diodes and 12-diodes.

Resonator block	Output power		
	Single diodes	Paralleled diodes	Multi-paralleled diodes
A	105 mW 100	205 mW 100 %	340 mW 97.2 %
	70 75	145 100	
B	65 70	125 92.6	295 93.6
	110 70	180 100	
C	110 100	210 100	440 90.3
	100 155	265 100	
A + B			600 90.3
A + B + C			920 80.0

Table 1. Combined output power and paralleling efficiency.