POWER COMBINING IN A SINGLE MULTIPLE-DIODE CAVITY

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ABSTRACT

This paper describes a simple circuit which can combine several diodes into one resonant cavity. For the particular example cited, over 500 mw is obtained over a 3 GHz bandwidth centered at 33 GHz.

Introduction

Power combining has been used to obtain the higher output powers required for solid state systems by many experimenters.[1-7] The various circuits have utilized 3 dB couplers, injection locking, diodes connected to a central point by coaxial lines, coaxial lines coupling into a single high-Q cavity, and diodes spaced a wavelength apart along a cavity. Some of the limitations associated with these power combining circuits include: narrow tuning range, poor manufacturability, noisy, or large physical size. This paper will describe a simple circuit that overcomes these limitations. In the particular example cited, a minimum of 500 mw at a heat sink temperature of 50°C is obtained over a bandwidth of 3 GHz at 33 GHz. While the FM noise is unaffected by the combining, there does appear to be a 10 dB degradation in the AM noise. A potential application for these units would be as solid state replacements for medium power klystrons. A specific application being as a local oscillator in a multiple stage parametric amplifier.

Circuit Description

The circuit consists of four Gunn diodes coupled into a resonant cavity. The resonant cavity is rectangular and operates in the TE_{101} mode. The diodes are soldered in the cavity corners as shown in Figure 1 and are coupled into the H-fields by means of a post.

The cavity is tuned by means of a ceramic rod that enters the cavity along one of the side walls. Due to the broadband (octave bandwidth) negative resistance of Gunn diodes, the height of the cavity is chosen so as to minimize the TEM mode resonance associated with the post at the second harmonic.

The post also serves to provide dc bias to the Gunn diodes. Figure 2 gives the circuit used to provide dc power to the diodes. As can be seen, the dc power is provided to the diodes in a parallel fashion.

Since this is a multiple diode cavity, the Gunn diodes were matched to each other. The matching consists of initially testing the diodes in a coaxial cavity which was resonant near the frequency of concern. From these tests, the large signal impedance of the diodes could be inferred. The diodes were then matched, based on similarity of the large signal impedance. By using this procedure, when the diodes were mounted into the cavity, no other adjustments were necessary.

DIODE

The design philosophy of the circuit was to use moderate performance and, therefore, easy to obtain Gunn diodes. The Gunn diodes used, were Varian solution grown liquid phase-type epitaxial GaAs. The active layer was typically 2.5μ thick with a doping of around 5×10^{15} carriers/cm^3 grown on a tin doped GaAs substrate. The cathode and anode ohmic contacts consisted of a gold-germainum nickel metal layer alloyed onto the epitaxial and substrate surfaces respectively. The devices used had the cathode ultrasonically compression bonded to the diode package heat sink stud (see Figure 3). The diode package used was a standard Varian N34 package, in which the copper stud was reduced in size, as shown. The equivalent circuit for this package, as measured at 10 GHz, is also shown.

Experimental Results

The tuning curve of a typical unit is shown in Figure 4. As can be seen from the curve, the power varied from 500 to 800 mw (corresponding to a 2 dB variation) over approximately a 10% tuning range. The data was taken at a heat sink temperature of 50°C and the unit was decoupled by approximately 1 dB. The operating voltage and current were 4.7 Vdc and 3.8 Adc respectively which yields a minimum efficiency of 3% for this particular unit. Figure 5 shows the AM and FM noise curves for a typical unit. The AM noise appears to be approximately 10 dB greater than that of a typical single diode cavity of similar design. The FM noise, on the other hand, is the same as that for a single diode cavity whose external Q is approximately 300 (resonant frequency of a single diode cavity was 28.5 GHz). An additional feature of this circuit, is that there appears to be no loss of power due to power combining. This becomes clear when one realizes that all of the individual diodes in this example had power outputs of from 125 to 150 mw when measured in the critically-coupled test cavity at room temperature.

Conclusion

It has been shown that this circuit does provide a relatively simple means of coupling several diodes into a single high-Q cavity. This concept has been used to obtain higher power outputs with RF performance similar to above from 5 GHz to 60 GHz. The concept has also been successfully used for IMPATT diodes.

Acknowledgements

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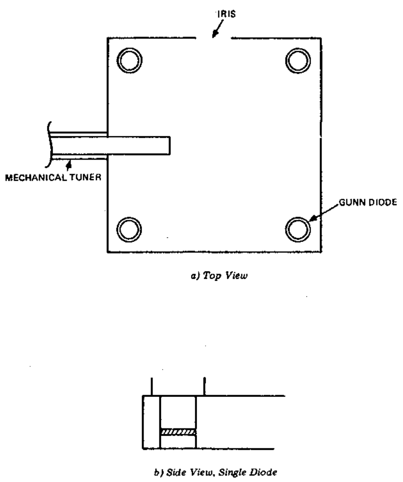

Figure 1: Circuit Configuration

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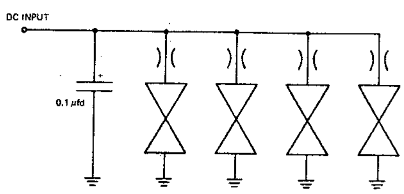

Figure 2: DC Circuit

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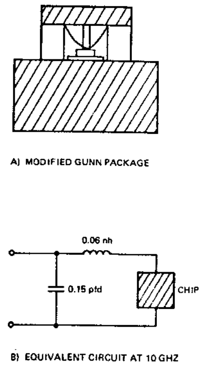

Figure 3: Diode Package

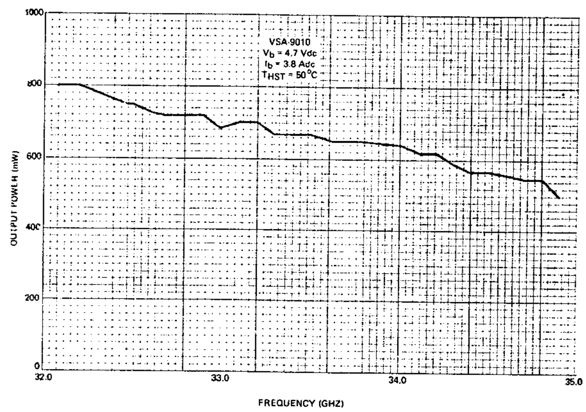

Figure 4: Typical Tuning Curve

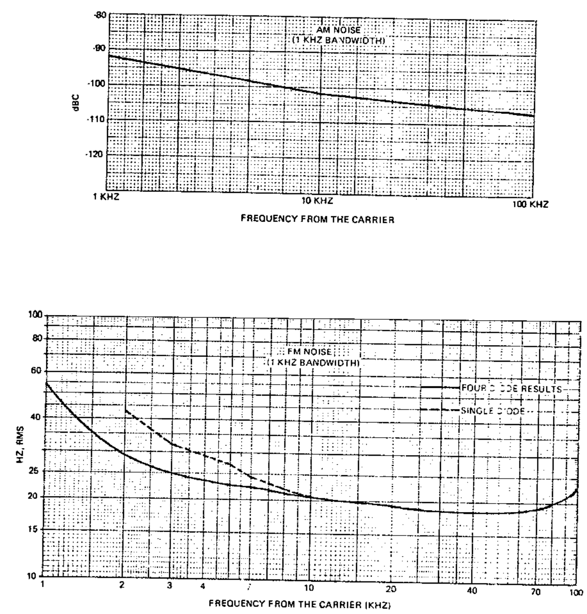

Figure 5: Typical Noise Performance