Development and study of a CW millimeter wave IMPATT diode Power combiner.

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Abstract :

A two-diode power combiner using silicon single drift region Ka-Band IMPATT diodes has been designed, fabricated and its millimeter wave properties has been studied. The diodes have been mounted in a single rectangular millimeter wave cavity fitted with two resonant cap structures placed parallel to each other along the central axis of the wave-guide (Fig.1). With a view to extract large amount of millimeter wave power from a single oscillator mount, a study of the dependence of output millimeter wave power on the mutual separation of the active device within the power combiner cavity has been carried out. The variation of the frequency of the combined millimeter wave signals has also been studied. It has been noticed that for the present circuit level combiner comprising two almost identical active devices, the output frequency of the combiner circuit lie at an intermediate level between the individual frequencies of the two-millimeter wave signal generated within the combiner mount. It has been further found that the combining efficiency of the output power depends on the path difference between the two mm wave signals generated from the IMPATT diodes, which propagate towards the load.

Key words : IMPATT, Ka –Band , Power Combiner.

Introduction :

Power combiner circuits are used to generate larger amount of microwave or millimeter wave power using more than one active device mounted in a single wave-guide cavity. Few reports regarding the chip level power combiner & circuit level combiner are available in current literature (1-3). This type of circuit level combiner circuits are realized by modifying the oscillator cavity mount, which can accommodate more than one active device with proper biasing facility. The millimeter wave and microwave characteristics of the combiner circuit usually depend both on the properties of passive circuits and that of active devices. The passive circuit in turn depends on the cavity dimension, geometry of the mounting circuits and their location within the resonator cavity.

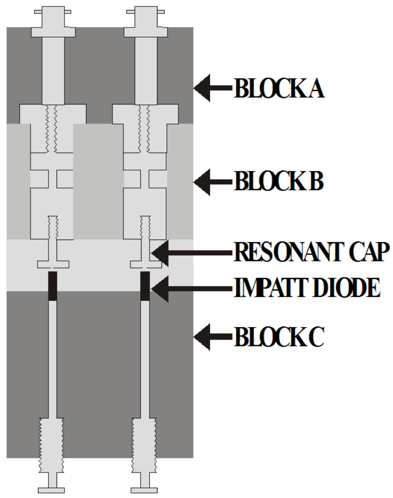

FIG. 1 - SECTIONAL VIEW OF SINGLE CAVITY TWO DIODE RESONANT CAP WAVEGUIDE MOUNT WITH INTEGRETED HEAT SINK.

In the present case, two Ka-Band silicon single drift region IMPATT diodes were procured from ISTOK, Russia and have been utilized in the power combiner circuit. These IMPATT diodes have almost identical characteristics with respect to the breakdown voltage and the millimeter wave properties like frequency and the output power. For this purpose, the diodes were individually tested by putting them in a single diode oscillator cavity fitted with a resonant cap having identical cap diameter and height from the broad face of the wave-guide. Power combiner characteristics have been achieved by putting the two IMPATT diodes into the combiner cavity provided with tw identical resonant cap structures having exactly same diameter and height of the resonant cap.

The present study shows that the millimeter wave power emerging from the combiner cavity depends on the mutual separation of the two resonant cap structures. The frequency of the generated signal also depends on the geometry of the resonant cap and this resultant frequency would lie at an intermediate level between the two frequencies generated by the individual diodes mounted in the same power combiner cavity.

Experimental set up :-

This experimental set up for studying the millimeter wave characteristics of the Ka-Band power combiner has been shown in Fig.1a. The combiner mount is connected to power meter through absorption type frequency meter. The power combiner cavity is fitted with a sliding back short tuner for the adjustment of cavity length and it facilitates the frequency tuning.

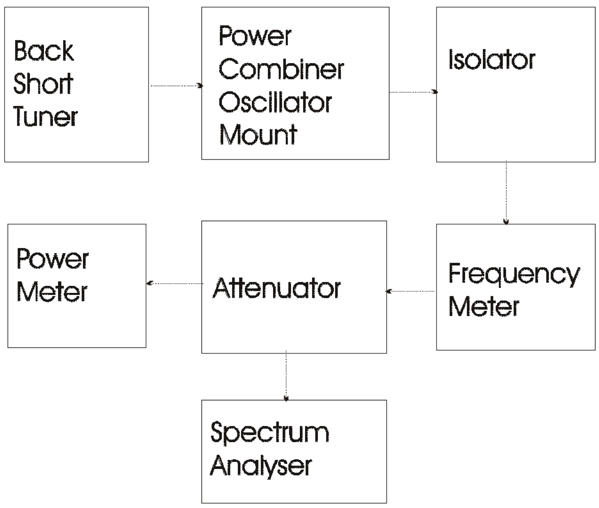

Fig.1a Experimental Set up For Ka-band Power Combiner

Experimental procedure and Results :

Out of the two IMPATT diodes, one diode is first placed under the first resonant cap. The power and frequency response are recorded. This IMPATT diode is then withdrawn from the resonant cap cavity. The second diode is then placed under the second resonant cap. The power and frequency output for the signal generated from the second diode are then noted. Then the two diodes are placed simultaneously under the two resonant cap structures and two diodes are simultaneously fed with dc bias. At this stage, the mount acts as

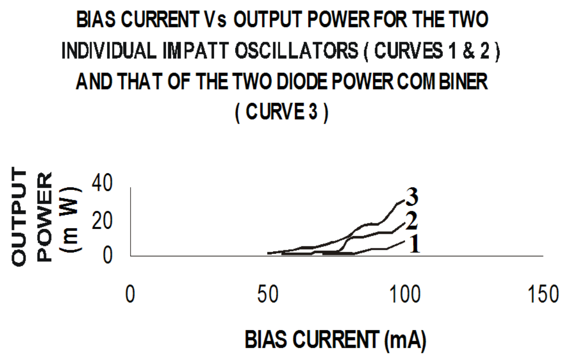

Fig.2

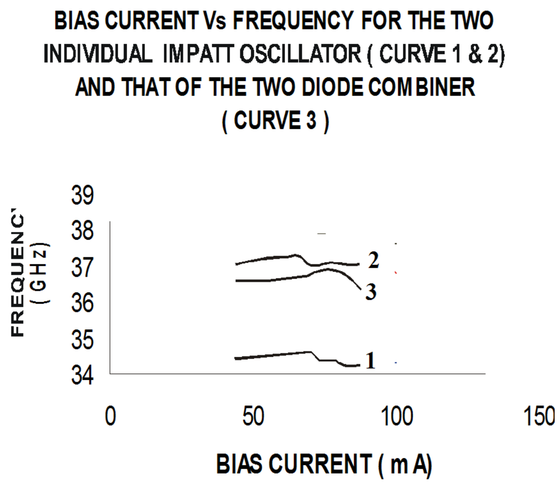

Fig.3

power combiner and the power output and frequency characteristics are obtained for the power combiner. The power output graphs for two individual diodes and the combiner are shown in Fig.2. The corresponding frequency vs bias current graphs for IMPATT diodes oscillating individually and simultaneously are shown in Fig.3.

It has been found from Fig. 2 and 3 that the first IMPATT diode produced 7.9 mW and when combined with the second IMPATT diode with a 20 mW millimeter wave power output the combined output ultimately produced 32.6 mW output power. The frequency variation of the power combiner showed that the frequency of the combiner output was 37.02 GHz wheras the individual diodes produced for the same d.c bias current, frequencies of 34.61 GHz and 37.74 GHz respectively.

Another set of similar study was carried out by changing the mutual separation between the two IMPATT diodes within the power combiner cavity. For this set, the power and frequency variation characteristics against d.c bias current have been shown in Fig.4 and Fig.5, respectively.

In this study, one SDR IMPATT diode individually produced 36.08 mW of power while the second diode individually yielded 38.00 mW of power. The power output for the combiner cavity, in this case was found to be 60 mW. The frequency variation of the power combiner showed that an output frequency of 38.55 GHz could be achieved when the IMPATT diodes, within the combiner mount, individually produced, for the same bias current, frequencies of 36.2 GHz and 38.85 GHz respectively. The oscillation frequency of the power combiner has been found in this case also to occupy an intermediate position between the two frequency characteristics obtained individually from the same mount.

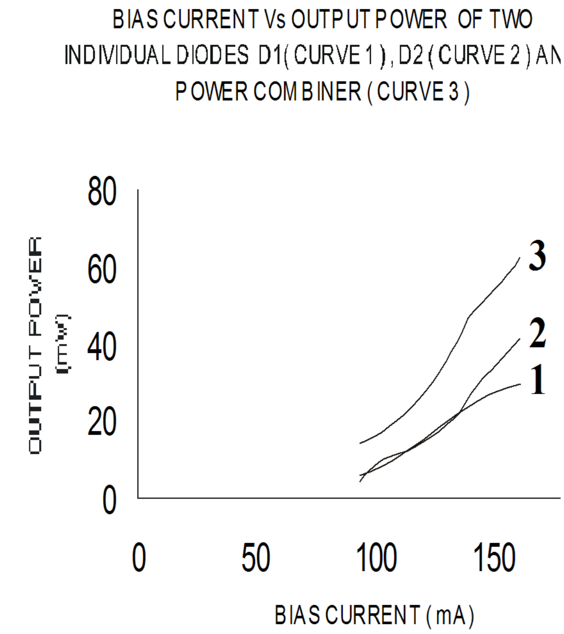

Fig.4

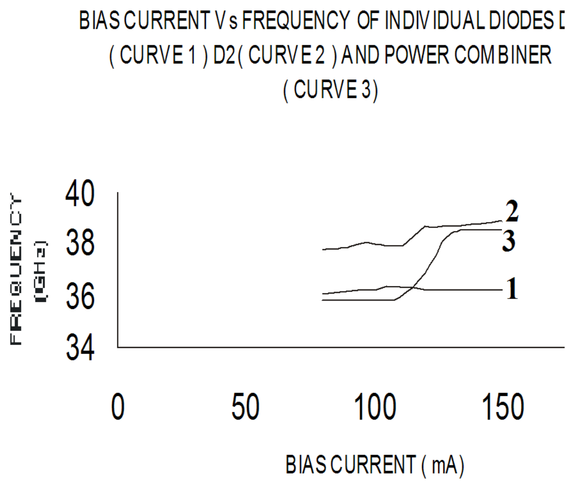

Fig.5

Conclusion :

A two IMPATTT diode power combiner mount for the operation at ka-band has been designed and fabricated. The millimeter wave characteristics of the power combiner circuit has been obtained. The results have shown that the output power from the combiner depends on the separation between the diodes. The frequency of the combined signal has been seen to occupy an intermediate value between the frequencies produced by the diodes when operated individually.

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