A HIGH POWER 270 GHZ FREQUENCY TRIPLER FEATURING A SCHOTTKY DIODE PARALLEL PAIR.

by J.Thornton, C.M.Mann and P.de Maagt*
Rutherford Appleton Laboratory, Didcot, Oxon, UK,
*ESTEC, Noordwijk, The Nederlands

ABSTRACT

A high output power millimetre wave frequency tripler is reported. Important features of the diode mount include a planar waveguide probe which facilitates the parallel combination of two Schottky varactor diodes and provides them with a more ideal embedding impedance.

This approach allows for higher power production and handling ability than a similar device using a single diode. Maximum output power at 271 GHz is 15 mW with a flange to flange efficiency of ≈5%.

INTRODUCTION

In the development of heterodyne receivers at millimetre and sub-millimetre wave frequencies, the provision of sufficient local oscillator power (LO) is often a limiting factor. Sufficient LO power to drive a Schottky diode receiver operating at 1THz has recently been demonstrated [1]. The LO chain used two cascaded frequency triplers driven by a Gunn oscillator. There is now a requirement for a solid state heterodyne receiver operating at 2.5THz which is to be used for the measurement of the hydroxyl molecule (OH), an important indicator in the ozone depletion process. A system based around a second harmonic mixer would provide an attractive solution but would require LO power levels of ≈1mW at 1.25THz. The highest power reported to date is 250µW from a tripler at 800GHz [2] which was pumped using the doubled output (7.5mW) from a Gunn oscillator at 134GHz.

Multiplication at these frequencies has historically been difficult to achieve, largely due to the dimensions of the components and the associated difficulties in both the design and physical realisation of the circuits. Use of a lithographically produced planar whisker has relaxed the constraints on the circuit's dimensions and assembly. A tripler making use of this approach had been demonstrated [3] but the output power was limited by the power handling capability of a single diode.

With the use of lithography it was possible to pattern a whisker with two tips. This step of allows simultaneous contact of two diode anodes in parallel, effectively doubling their power handling capability. The consequent doubling of diode capacitance makes impedance matching more difficult, however, the use of a planar waveguide launching probe provides better circuit control than the conventional wire whisker approach, without the need for extra waveguide tuning elements such as backshorts.

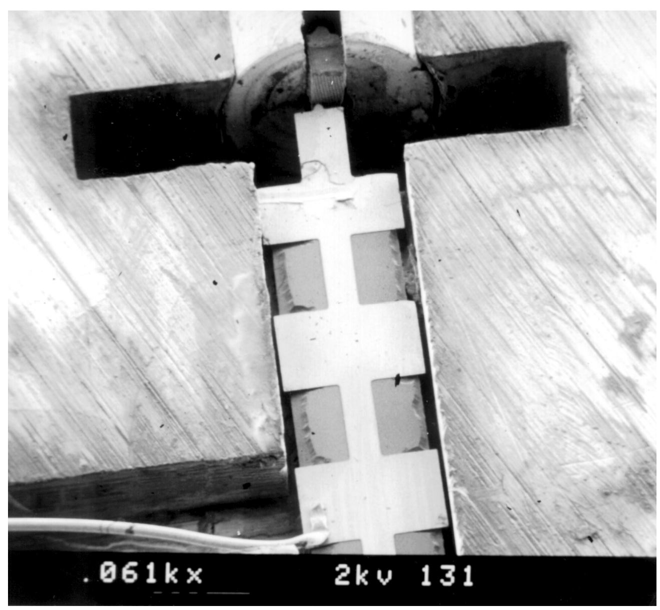

Figure 1: An SEM image of an assembled tripler circuit showing the output waveguide and filter/planar probe

TRIPLER DESIGN APPROACH

The tripler block's geometry was based very closely on [4] and has a nominal operating range of 200 to 290 GHz. The idler waveguide has a cross section of 1.143 x 0.229 mm. The diode used was a Schottky varactor, type 5M4 fabricated at the

0-7803-4603-6/97/$5.00 (c) IEEE

University of Virginia, and has ≈4μm anodes. The original suspended-stripline filter was discarded in favour of a simpler stripline filter in a rectangular enclosure. The filter was designed to present a near short circuit for the second and third harmonic frequencies at the edge of the output waveguide. A scanning electron micrograph of an assembled tripler circuit is shown in figure 1.

TRIPLER PERFORMANCE

Having fabricated a range of filters with contacting probes, a single diode contact was made using a structure designed for optimum performance around 245GHz.

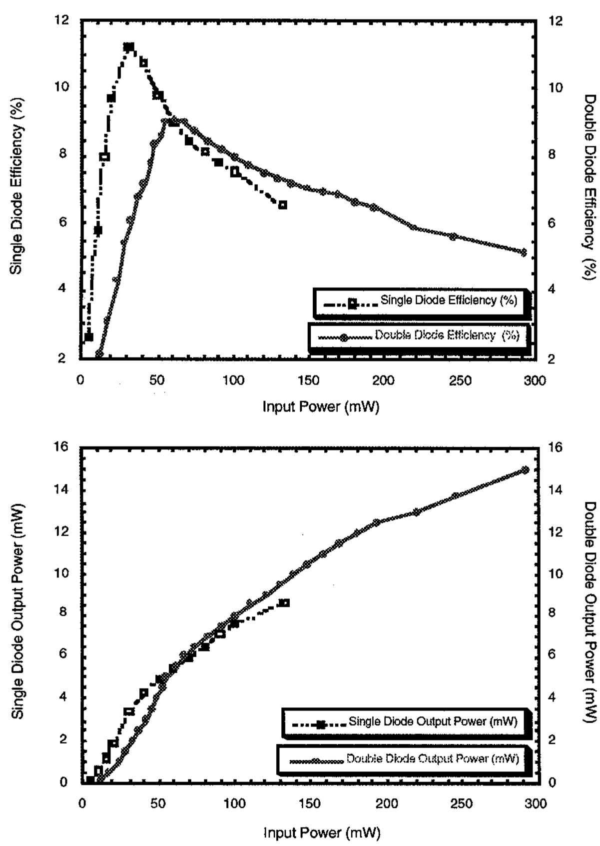

Figure 2: Plots showing the relative efficiencies and output powers for the single and double diode devices

Figure 2 shows efficiency and output power curves for the single diode and two diodes respectively. The single diode device had an efficiency of 11% at 244GHz at an input power of ≈30 mW, whilst the two diode device delivered its best efficiency of 9% at around 60 mW input at 271GHz. This is to be expected for two similar diodes operating in parallel, since each receives half the input power (i.e. 30 mW) and delivers half the output power.

CONCLUSION

The study has demonstrated that a parallel pair of Schottky diodes has a greater power handling and production capability than a single diode.

To a first order the relationship is essentially linear i.e., twice the area provides twice the power, but relies on the ability to provide the correct embedding impedance to the diode pair so as to remove the effect of the larger parasitic capacitance. Future improvements can be expected when the waveguide matching structure is further optimised to facilitate the use of bigger single diodes.

REFERENCES

[1] 'An all-solid state 1THz radiometer for space applications', R. Zimmermann, T. Rose. T. Crowe, T. Grein, Dig. Sixth Int. Sym. on Space THz Technol., Pasadena. CA. Mar.1995.

[2] 'Progress Toward Solid State Local Oscillators at 1THz', T. Crowe, T. Grein, R. Zimmermann, P. Zimmermann.

[3] 'A Design Approach For Planar Waveguide Launching Structures', J. Thornton, C. M. Mann, 7th Int. Symp. Space THz Technology, Charlottesville, March 96.

[4] 'An efficient 200 - 290 GHz Frequency Tripler Incorporating A Novel Stripline Structure'. J.W.Archer. IEEE-MTT, VOL.32 No.4 April 1984