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NEW MODE OF OPERATION FOR AVALANCHE DIODES : HIGH RANK, HIGH EFFICIENCY FREQUENCY MULTIPLIERS.

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The utilisation of the non linear properties of the avalanche diode allows frequency multiplication. This mode is operated with low breakdown voltage diodes providing negligibly small power in IMPATT or TRAPATT mode. It is somewhat analogous to frequency multiplication by varactor diodes but the avalanche behaves as a non linear inductor as opposed to the non linear capacitance effect found in varactor diodes. That means that in avalanche diodes the depletion layer width is constant so the series resistance is much smaller than in varactor diodes. Besides, the violent non linearity of the avalanche allows frequency multiplication by any integer n up to very high harmonic ranks, without any idler circuit.

This mode of operation was proposed by E. CONSTANT (1) and some of the first results have been published (2),(3),(4). We give here greatly improved results concerning both output powers and conversion losses and harmonic orders, for high rank frequency multiplication with output frequency in the millimeter wave region.

A complete theoritical and experimental study of output powers, conversion losses, efficiency and impedances in fonction of operating conditions (D.C. bias current and frequency) and semiconductor device parameters (areas, space charge layer width and field profiles) was achieved. We shall give all the representative curves in the paper.

We only present here the most significant results on curves (1) and (2). These results were obtained with Silicon diodes whose basic structure is $P^+ N N^+$ which is close to PIN type, and breakdown voltage ranges from 15 to 20 V. These diodes were made by the Laboratoire d'Electronique et de Physique Appliquée.

Figure 1 shows the possibility of frequency multiplication with harmonic orders ranging from 8 to 35 with the same diode and without idler circuits. The output power obtained with the same diode versus harmonic order n is plotted on solid line, triangular data are maximum power. The dotted line shows the conversion loss and the square data the conversion loss corresponding to the maximum output power. The difference between the curves and the data mainly comes from the package. The curves were obtained with S4 packaged diode, the data with unpackaged diodes.

Typical results are

- Multiplication by 10 : output frequency 35 GHz, diode without package
  output power 620 mW
  D.C. power 2 W
  Conversion loss 8,2 dB
- Multiplication by 35 : output frequency 35 GHz, diode without package
  output power 280 mW
  D.C. power 2 W
  Conversion loss 12,8 dB.

Notice that similar results can be obtained with decreased D.C. power and that the power on other harmonic frequencies is always 10 dB below the output power at the considered frequency.

Figure 2 shows that it is quite possible to drive the output frequency in a bandwidth equal to the input frequency only by a change in the latter without any mechanical tuning.

All these results (among which many are not optimised) show that this new mode of operation is able to provide attractive millimeter sources especially as the noise figure is much better (26 dB) than that of IMPATT oscillators (3),(4). In the paper, we shall discuss the extension of frequency multiplication to higher frequencies and to other type of semiconductor, (AsGa especially) which are theoretically more interesting.

References

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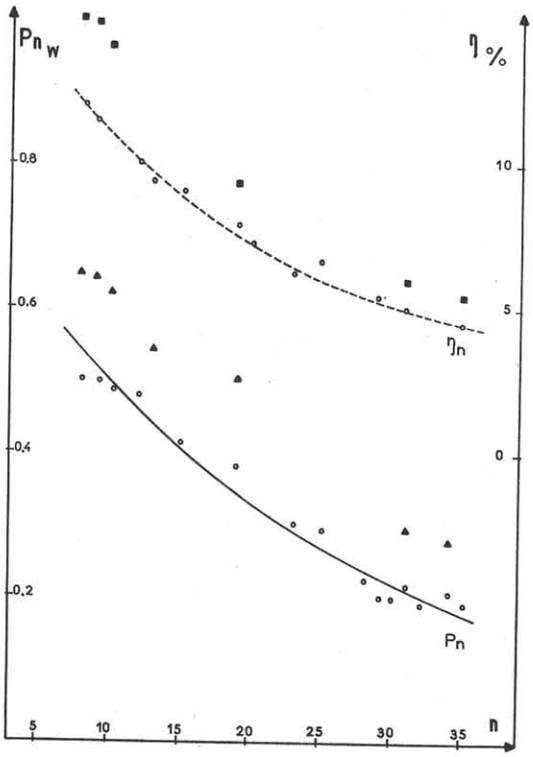

Figure 1 : Output power and conversion loss versus harmonic rank
30 GHz < output frequency < 35 GHz.

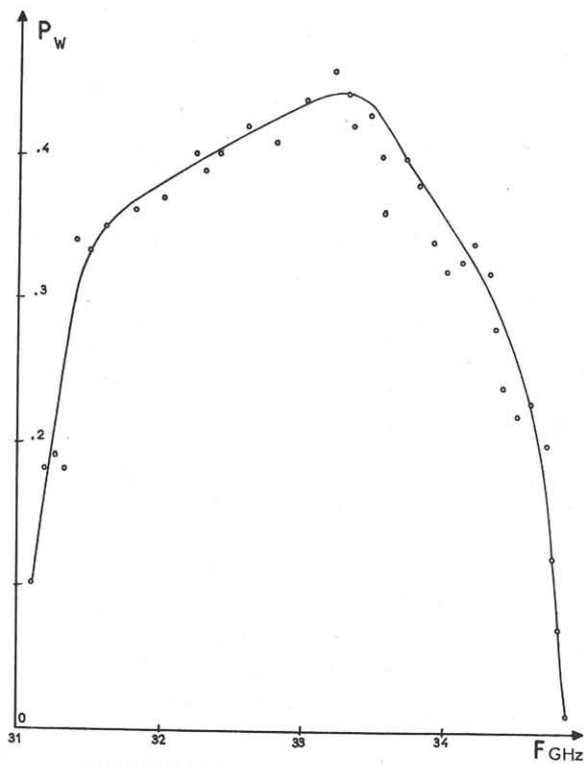

Figure 2 : Output power versus output frequency driven only by input frequency
for multiplication by nine.