A NOVEL W-BAND SUSPENDED SUBSTRATE MICROSTRIPLINE SECOND HARMONIC GaAs GUNN OSCILLATOR

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ABSTRACT

A novel w-band suspended substrate microstripline second harmonic GaAs Gunn oscillator has been developed. The output power of 4 mW at 94 GHz, 5.8 mW at 88.3 GHz and 15 mW at 75 GHz has been achieved with different Gunn devices and circuit parameters, respectively.

INTRODUCTION

In low noise applications, such as receiver local oscillators, Transferred Electron Oscillators (TED'S), or Gunn sources, exhibit superior behavior compared with IMPATT sources. With GaAs Gunn devices, a fundamental mode operation up to about 65 GHz is possible. Above this frequency, the second harmonic mode is required. On the other hand, InP Gunn devices are able to perform in a fundamental mode up to at least 100 GHz [1]. Currently available GaAs Gunn diode oscillator with second harmonic mode and InP Gunn diode with fundamental mode routinely produce 20-30 mW and 60-80 mW output power at 94 GHz in standard radial disk waveguide geometrics, respectively [2]. However, waveguide oscillators are inherently difficult to be made in low cost and small size. The use of millimeterwave integrated circuits has the advantage of small size, light weight and low cost. The most successful integrated oscillators for w-band applications are microstripline design, which use InP Gunn devices and work with fundamental mode. At present, however, InP Gunn devices provide problems concerning availability, maturity of technology and price. Therefore, for most practical application purposes, the GaAs second harmonic Gunn oscillator is still first candidate. Unforturnately, there is only one paper contributing to MIC second harmonic Gunn oscillators with output power of 0.5 mW at w-band [2]. In authors' opinion, this situation may be caused by larger circuit loss and critical circuit design or fabrication tolerance of microstripline as well as difficult adjustment (or optimization) of circuit parameters and Gunn device position, mostly.

The suspended substrate microstripline is the modified version of microstripline. Compared with normal microstripline, it has some attractive features, such as lower attenuation and larger tolerance of fabrication. Therefore, it has been extensively used in millimeterwave mixers, multipliers and so on. This paper describes a novel w-band suspended substrate microstripline second harmonic GaAs Gunn oscillator. The output power of 4 mW at 94 GHz, 5.8 mW at 88.3 GHz and 15 mW at 75 GHz have been achieved with different Gunn devices and circuit parameters, respectively. The oscillator can be easily integrated with other suspended substrate microstripline circuits for applications, such as with a mixer to form a fully integrated suspended substrate microstripline front-end of receiver. This novel configuration can be easily modified to form VCO and power combiner.

CIRCUIT DESCRIPTION

The configuration of suspended substrate microstripline second harmonic GaAs Gunn oscillator is shown in Fig.1,a. It consists of Gunn devices, radial-disk-like transformer, printed circuit board, WR-10, WR-19 rectangular waveguides and

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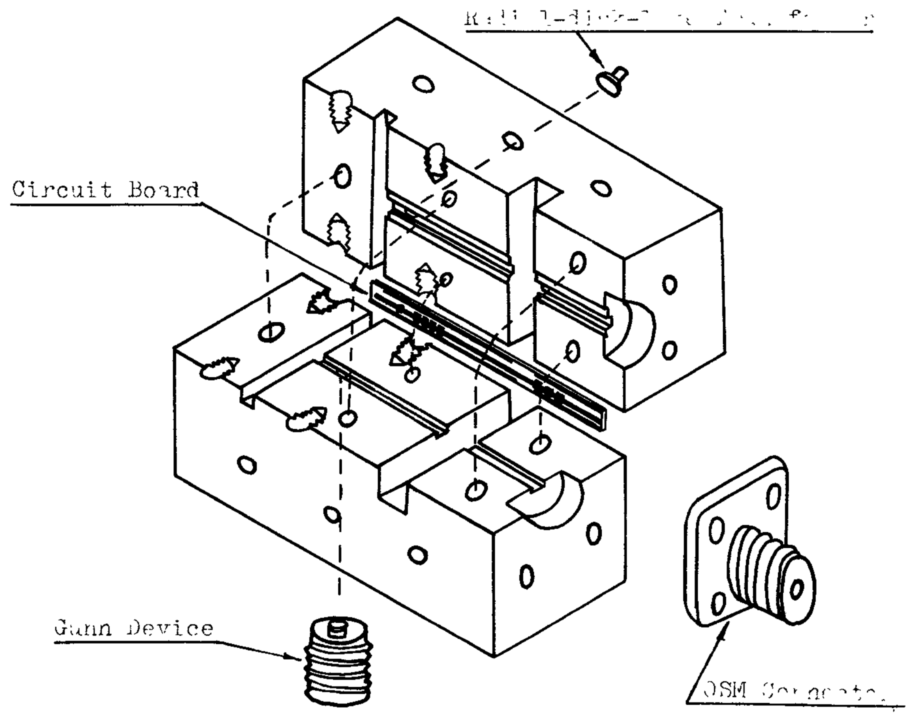
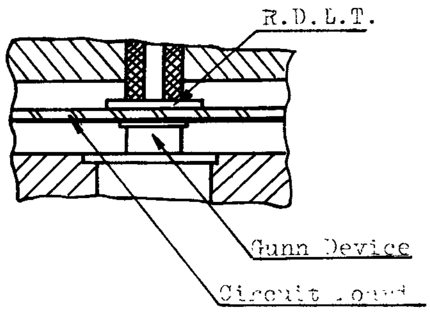
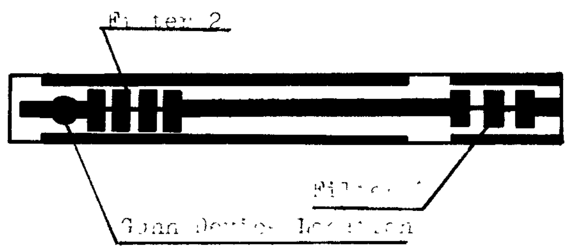


a. Disassembled View (with backshort Removed)



b. Assembly of Gunn Device and Radial-disk-like Transformer



c. Circuit Board

Fig. 1 Configuration of Developed oscillator

sliding backshorts. The Gunn device used is GaAs packaged type, commercially available from Nanjing Electronic Devices Research Institute (Type WT-57) with a typical output power of 60-90 mW in Q-band (40-60 GHz). The radial-disk-like transformer is used to match the impedance of Gunn devices with circuit and determine the frequency of oscillator. By changing the thickness and diameter of the radial-disk-like transformer, the frequency and output power of the oscillator can be adjusted. Furthermore, this radial-disk-like transformer can be served to prevent deformation of the printed circuit board when the packaged Gunn device is installed on the circuits, as shown in Fig.1,b. The integrated circuits are fabricated on a 0.127 mm (0.005 in.) Duroid 5880 substrate. The circuit board is enclosed in a channel with a cross-section of 1.27x 0.65 mm (0.05 x 0.025 in.). This cross-section dimension can guarantee a single quasi-TEM mode of operation at w-band. On the circuit board, two low-pass filters are required to separate the fundamental frequency, second harmonic frequency and

DC bias, as shown in Fig.1,c. Design of the second harmonic filter adjacent to the Gunn device (Filter 2) is based upon the 7-element L-C ladder, low-pass prototype approximation with a cutoff frequency of 60 GHz to reject the second harmonic frequency and pass the fundamental frequency and DC bias. The other one (Filter 1) is a 5-element L-C ladder low-pass filter to prevent fundamental frequency from leakage into DC bias port. Both of filters are optimized using SUPER COMPACT/PC and their frequency responses are given in Fig.2. Gunn device

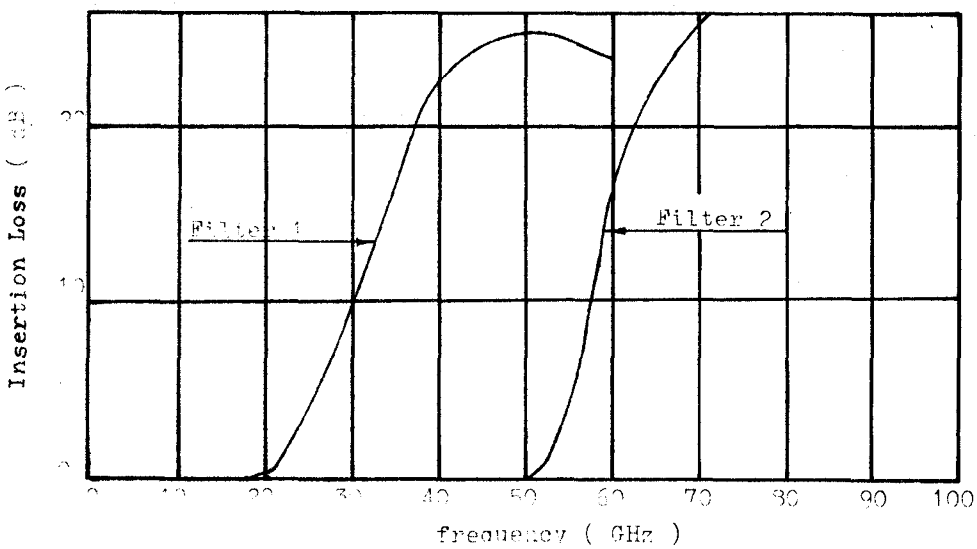


Fig.2 Frequency Responses of the Filters

is located at approximately a quarter wavelenghth of second harmonic frequency away from the 7-element filter. The distance between Gunn device and output waveguide (WR-10), which is experimentally determined for the best output power, is approximately a half wavelength of second harmonic frequency. An electric probe type transition is used to couple the output power to standard WR-10 waveguide and a sliding backshort is used to adjust output power. The fundamental frequency through filter 2 is coupled into fundamental resonance cavity which is formed with standard WR-19 waveguide and two sliding backshorts. This resonance cavity can raise the oscillator's frequency stability and provides fine mechanical frequency tuning. The DC bias is fed into the Gunn device through an OSM conector and two low-pass filters.

PERFORMANCE

Fig.3 shows a photograph of the suspended substrate microstripline second harmonic Gunn oscillator with backshorts removed. By changing the thickness and diameter of the radial-disk-like transformer and using different Gunn devices, the frequency can be adjusted anywhere between 75-98.5 GHz. Some remarkable frequencies with recognized output power have been selected and shown in Table 1. The output power of 4 mW at 94 GHz, 5.8 mW at 88.3 GHz and 15.0 mW at 75 GHz have been achieved. The fine mechanical tuning range is approximately 1 GHz.

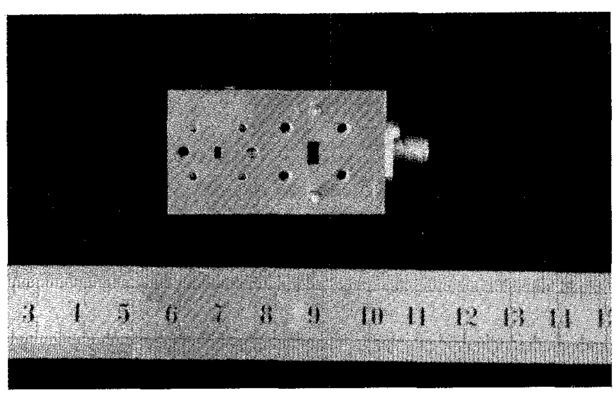


Fig. 3 Photograph of Developed Oscillator

Table 1. Oscillator Performance

Frequency (GHz)	75.0	88.3	94.0
Output Power (mW)	15.0	5.8	4.0

CONCLUSION

A novel w-band suspended substrate microstripline second harmonic GaAs Gunn oscillator has been developed. The output power of 4 mW at 94 GHz, 5.8 mW at 88.3 GHz and 15 mW at 75 GHz have been achieved with different Gunn devices and circuit parameters. The oscillator can be easily integrated with other suspended substrate microstripline circuits, such as with a w-band cross-bar mixer to form a full integrated suspended substrate microstripline front-end of receiver. This integrated Gunn oscillator has tremendously reduced cost, size and weight compared with conventional waveguide ones.

REFERENCES

[1] H.Barth, et al,"GaAs Gunn Oscillators Reach the 140 GHz Range," IEEE MTT-S, Digest, pp.367-369, 1985.

[2] J.Ondria, "Quartz Microstrip Radial Disk Fundamental and Second Harmonic MMW Gunn Oscillators," Proc. of 18th European Microwave Conference, No.0900-1040-1, 1988.