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DIELECTRIC-RESONATOR-STABILIZED SECOND HARMONIC Ka-BAND MICROSTRIP GUNN OSCILLATOR

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Abstract

In the present paper a Ka-band second harmonic microstrip Gunn oscillator stabilized by a dielectric resonator at its fundamental frequency has been investigated. The stabilized second harmonic output power of more than 10mw at Ka-band is observed. Pushing figure is lower than 300KHz/V. Mechanical tuning range is greater than 500 MHz. This oscillator can be used as a local oscillator in mm-wave integrated system.

Introduction

The advantages of the dielectric resonator used as frequency stabilized element in mm-wave integrated oscillator have been described in (1),(2). The low loss and high stability of the dielectric resonator increase the circuit Q of the integrated oscillator and reduce its phase noise. However, the product of the unloaded Q of the dielectric resonator and its resonant frequency is approximately equal to a constant.(3)

$$fQ = \text{constant}$$

This means that the unloaded Q of a dielectric resonator is inversely proportional to the resonant frequency. It degrades the frequency stabilization of oscillator, especially in mm-wave band. Consequently, the application of the dielectric resonator in mm-wave band is limited.

In the present paper, a novel mm-wave integrated oscillator is studied that is dielectric resonator stabilized at its fundamental frequency and output at its second harmonic frequency. Since the resonant frequency of the dielectric resonator is only half of the output frequency, the unloaded Q of the dielectric resonator becomes higher and the frequency stability better.

The harmonic Gunn oscillator stabilized by a metal resonant cavity at its fundamental frequency and the integrated FET harmonic oscillator have been reported. (4),(5) Their work is of great importance in obtaining stabilized high frequency signal. In the present paper, a Ka-band microstrip harmonic oscillator circuit configuration, its principle of operation and experimental results are given.

Configuration and Principle

Fig.1 shows the circuit configuration of the above mentioned oscillator. Its

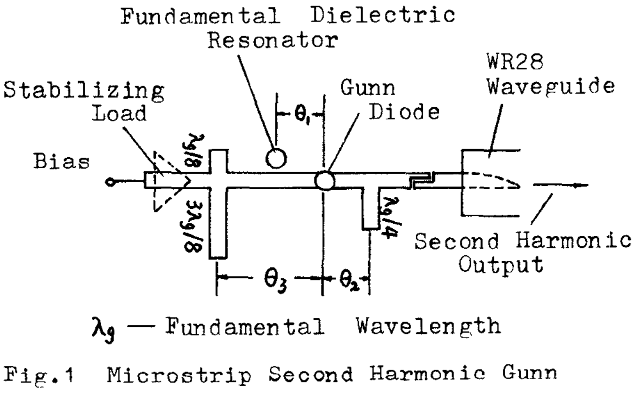
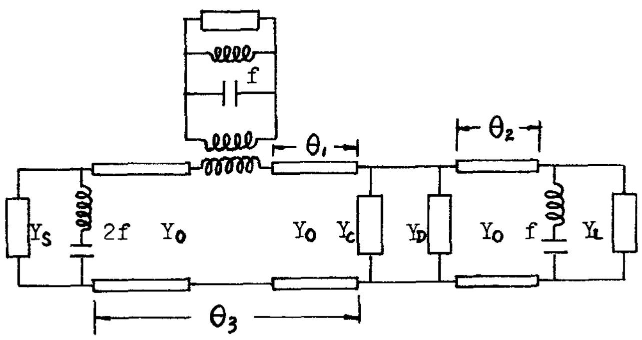


Fig.1 Microstrip Second Harmonic Gunn Oscillator



Y_D -- Equivalent Admittance of Gunn Diode

Y_0 -- Characteristic Admittance of Microstrip

Y_C -- Equivalent Admittance Caused by Mounting Diode

Y_S -- Stabilizing Load Equal to Y_0

Y_L -- Output Load

Fig.2 Equivalent Circuit of the Oscillator

equivalent circuit is shown in figure 2.

The fundamental circuit is a band-reflection type frequency stabilized circuit. Because of the existence of the $\lambda_g/4$ open-circuited stub and the fundamental frequency is below the cut-off frequency of the output waveguide WR28, the fundamental frequency power can not arrive at output port. By arranging appropriately the location of the dielectric resonator with respect to the Gunn diode and microstrip, a best improvement of stabilization can be achieved. When the bias voltage is chosen at the asymmetric operational point on the large signal characteristic curve of the Gunn diode (The bias voltage is slightly higher than the normal value for the ordinary fundamental mode of Gunn diode oscillator), the diode will produce intense second harmonic power while the fundamental circuit is oscillating. The harmonic frequency can be tuned by setting some small metal chips near the microstrip at the right side of the Gunn diode and/or adjusting the metal cap over the dielectric resonator to change the fundamental frequency so that the resonant condition of the second harmonic circuit is satisfied. Additionally, the stub between the stabilizing load and the diode has no effect on fundamental circuit but can completely reflex the harmonic frequency. As a result, the second harmonic power will increase by about 3dB. Since the harmonic frequency and the fundamental frequency have the relation of integer time, the output signal of this oscillator has high stability and low phase noise.

Experimental Results

The photograph of the designed microstrip second harmonic Gunn oscillator stabilized by a dielectric resonator at its fundamental frequency is shown in figure 3. The whole circuit (including the transition from microstrip to waveguide) is fabricated on a Duroid substrate($50x25x0.254mm^3$; ϵ_r=2.22). The Gunn diode is WT-55 from Nanjing Solid-State Devices Research Institute, China. The parameters of the dielectric resonators are listed in Table I.

Figure 4 shows bias characteristics of the output power and frequency of the oscillator. Linearity of the output power with respect to bias can be achieved and variation of frequency is not sensitive to bias when the bias is between 6.5volt and 7.5 volt. Figure 5 shows the characteristic curve of mechanical tuning which can be implemented with the tunable metal cap over the dielectric resonator. The photograph of the frequency spectrum of the designed oscillator is shown in figure 6. Table II summarizes the performance of the oscillator.

Conclusion

The dielectric resonator is used to stabilize the fundamental frequency of the oscillator. Its resonant frequency is only one half of the output frequency of the oscillator, so the unloaded Q is high. It overcomes the weak point caused by the decreasing of the Q value with the increasing of the oscillating frequency in ordinary dielectric resonator oscillator. From this point of view, the present method extends the dielectric resonator application in mm-wave. It is expected that the third harmonic frequency output can be obtained by the same method. Consequently it provides a new way to obtain high stability short mm-wave integrated oscillator.

Acknowledgement

The authors would like to express appreciation to Prof. Li Si-Fan for his help in preparing the paper.

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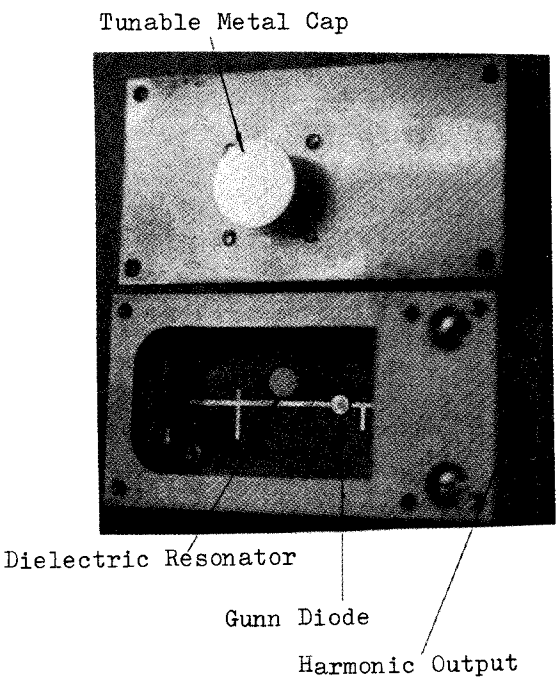

Fig.3 Photograph of Dielectric Resonator Stabilized Microstrip Harmonic Mode Gunn Oscillator

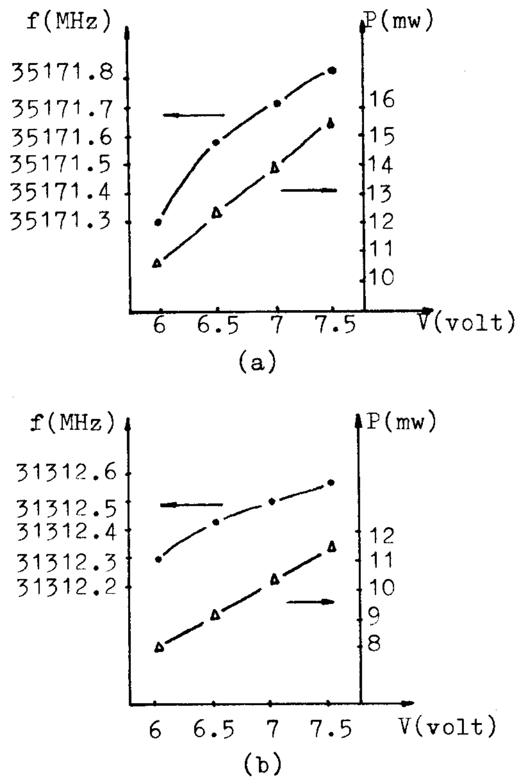

Fig.4 Bias Characteristics of Output Power and Frequency of the Oscillator

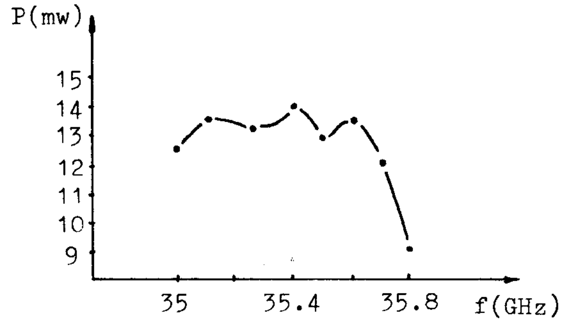

Fig.5 Characteristic of Mechanical Tuning

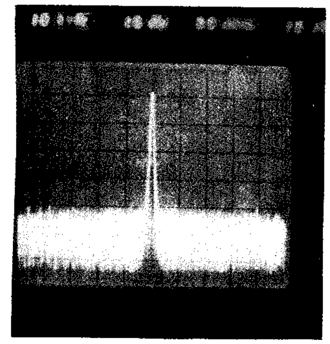

Fig.6 Photograph of Spectrum of Oscillator

Table I

Parameters of Cylindrical Dielectric Resonators

	(a)	(b)
Diameter (mm)	3.55	4.5
Height (mm)	1.32	1.5
Relative Dielectric Constant	36	29
Resonant Frequency (GHz)	17.6	15.6
Temperature Coefficient (ppm/c)	1.2	2
Unloaded Q	4000	6000
Materia	$(ArSn)TiO_4$	$Ba(Zn_{1/3}Nb_{2/3})O_3$ $-Ba(Zn_{1/3}Ta_{2/3})O_3$

Table II

Performance of the Oscillator

	(a)	(b)
Frequency	35.17GHz	31.31GHz
Output Power	14mw	10mw
Pushing Figure	300KHz/V	200KHz/V
Mechanical Tuning	500MHz	500MHz