Experiment Evaluation of a Multiport Harmonic Gunn Oscillator With Fundamental Signal Suppression

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Abstract In this paper, a multiport harmonic Gunn oscillator for oscillator arrays is proposed. The proposed oscillator consists of Gunn diodes, a slot-ring resonator and microstrip lines. The circuit has two ports. One of the ports is an output port for the second harmonic frequency and the other is a synchronization port for the fundamental frequency. The second harmonic output port has a band elimination filter to suppress the undesired fundamental signal. The oscillator is expected to be robust against its load fluctuation due to the filter. In this study, the proposed oscillator is experimentally evaluated. The oscillation frequencies were 10.1 GHz and 20.2 GHz at the fundamental and the second harmonic frequencies, respectively. The output powers at the second harmonic port were -6.0 dBm at the second harmonic frequency and -22.0 dBm at the fundamental frequency. The output powers at the fundamental port is 9.9 dBm at the fundamental frequency and -13.0 dBm at the second harmonic frequency. Undesired signals are suppressed at each port.

Keyword Multiport, Gunn Diode, Slot-Ring Resonator, Oscillator

1. Introduction

Recently, demands of radars such as an on-vehicle radar have been increased. In these consumer applications, downsizing and cost reduction are essential.

Phased array systems are usually used to realize radars. The phased array effectively steers the beam by controlling the phase of each antenna element. However, the structure is complicated and the circuit size becomes large because large phase shift is required. To solve the issue, oscillator arrays are proposed. Quasi-optical power combining using mutually synchronized oscillator arrays [1], a phase-shifterless oscillator array [2], and a Push-Push oscillator array using resonator type coupling circuits [3] have been studied to simplify the configuration and improve the performance. In the oscillator arrays, the phase differences between adjacent oscillators are controlled by a variable phase coupling circuit connected between the oscillators. The phase shift required for the oscillator arrays is smaller than that of the phased array system, and it achieves a low cost and simple circuit configuration. The authors have studied oscillator arrays using the second harmonic Push-Push oscillators [4]-[6]. The Push-Push oscillator array provides a large phase shift because the phase shift at the second harmonic frequency is twice phase shift of the fundamental frequency used in the variable phase coupling circuits.

In this paper, we propose a harmonic Gunn oscillator with two port for output signal and synchronization. A band elimination filter is employed at the second harmonic output port to suppress the undesired fundamental signal. As the circuit configuration is simple, multiport oscillator more than two ports are available.

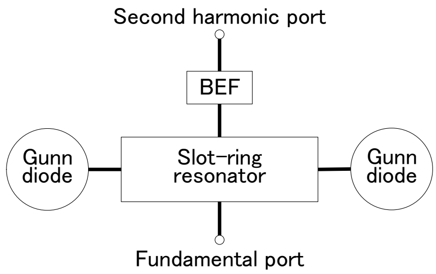


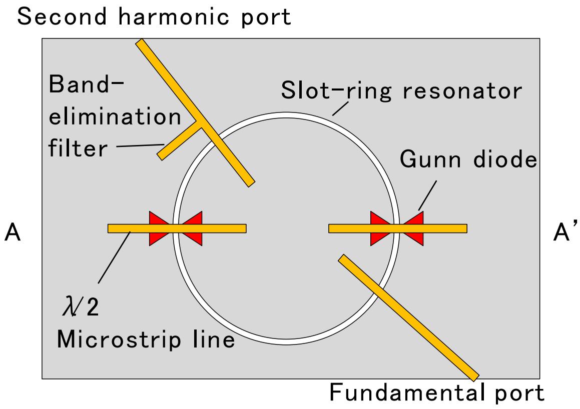
Fig. 1. Basic configuration of the proposed multiport harmonic Gunn oscillator.

2. Basic Concept

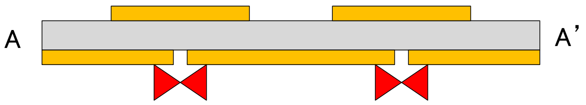
Fig. 1 shows a basic concept of the proposed multiport harmonic Gunn oscillator. The oscillator has two ports for the output of the second harmonic signal and synchronization using a fundamental signal. Two Gunn diodes are used as an oscillation device and a slot-ring resonator determines the oscillation frequency. The second harmonic output port employs a band-elimination filter (BEF) to suppress the undesired fundamental signal.

3. Structure and Operating Principle

Fig. 2 shows the structure of the proposed multiport harmonic Gunn oscillator. A slot-ring resonator whose circumference is two wavelengths at the fundamental frequency is formed on the bottom of the substrate. The slot width is 0.2 mm. Two Gunn diodes are mounted on the slot-ring resonator bisecting the slot



(a) Top view



(b) Cross sectional view (A-A')

Fig. 2. Basic configuration of the multiport oscillator

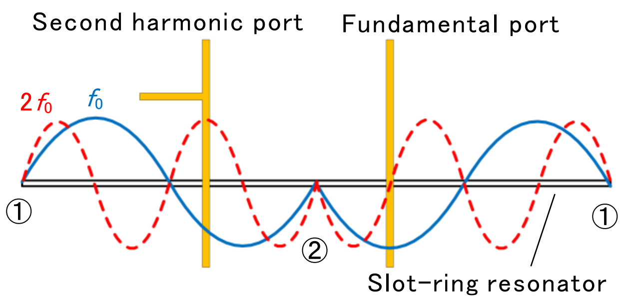
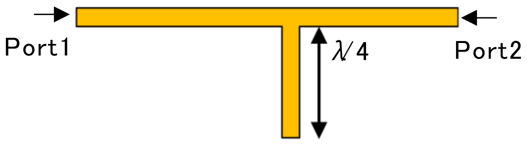


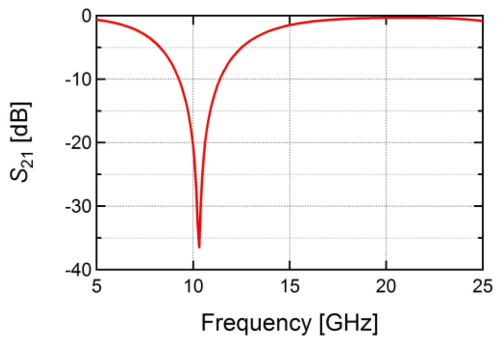
Fig. 3. Output ports and standing waves on slot-ring resonator

ring. Hence, applying bias voltage to the Gunn diode is easy because the slot ring separates the anode and cathode of the Gunn diodes. Microstrip lines are formed on the top of the substrate. The second harmonic port and the fundamental port are connected to the resonator using the microstrip lines. A 1/4-wavelength open stub at the fundamental frequency is attached to the second harmonic port to suppress the fundamental signal. Two 1/2-wavelength open-end microstrip lines at the fundamental frequency are formed just above the Gunn diodes. Although the Gunn diode is a low impedance device, the impedance is not zero. The 1/2-wavelength microstrip lines are used to stabilize the resonant field by reducing the impedance.

Fig. 3 shows the voltage standing wave distribution in the slot-ring resonator. The straight line corresponds the slog-ring resonator and ① and ② show the position where the Gunn diodes are mounted. At ① and ②, the voltage standing wave has a null



(a) Structure of the band elimination filter



(b) Simulation result

Fig. 4. Design of the band elimination filter attached to the second harmonic port.

due to the 1/2-wavelength microstrip lines.

The fundamental signal port is located at the position where the fundamental standing wave becomes maximum and the second harmonic becomes zero. The second harmonic port is located at the position where the second harmonic standing wave becomes maximum. However, the fundamental standing wave is not zero at this position. Then the band elimination filter to suppress the fundamental signal is required.

4. Filter Design

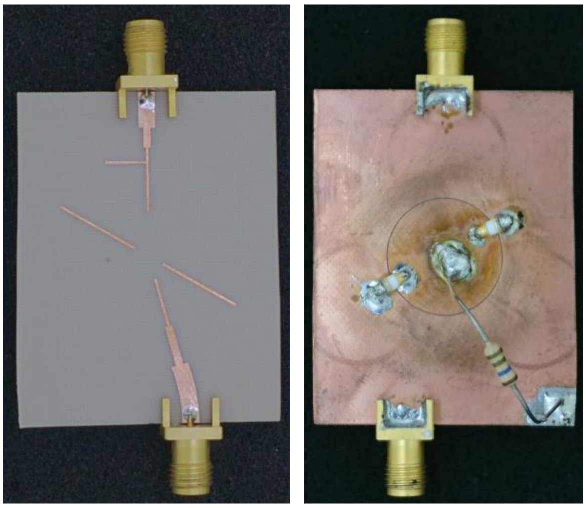
Fig. 4 shows the structure and simulated performance of the band elimination filter using 1/4-wavelength open stub at the fundamental frequency. The characteristic impedance of the microstrip lines is 135 Ω at 10 GHz (the fundamental frequency). The fundamental signal is suppressed -20.7 dB at 10 GHz as shown in Fig. 2(b).

5. Measurement Results

Fig. 5 shows photographs of a prototype multiport harmonic Gunn oscillator. The bias voltage is applied via a 1.6-Ω resistor as shown in Fig. 5 (b). The design frequency of the oscillator is 20 GHz at the second harmonic frequency. The lower port is the fundamental port and the upper port is the second harmonic port in Figs. 5 (a) and 5 (b). The substrate is a Teflon substrate with a relative dielectric constant of 2.15 and a thickness of 0.8 mm. The size is 36 mm × 46 mm. The Gunn diodes are Microsemi's MG1052-30.

Fig. 6 shows the measured output power spectrum of the prototype oscillator. The oscillation

Second harmonic port Second harmonic port

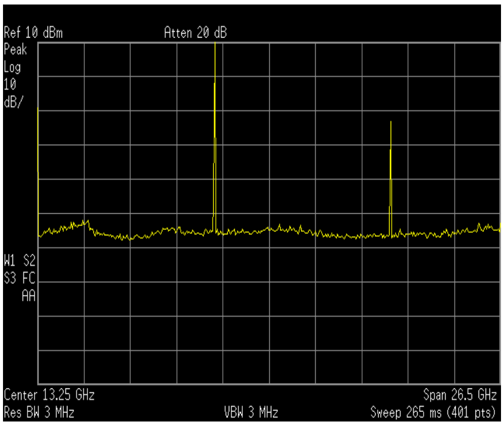


Fundamental port Fundamental port

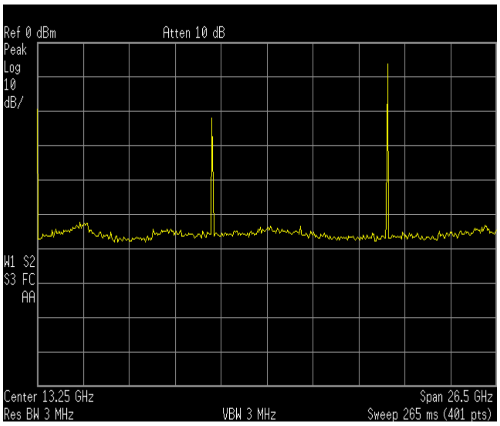
(a) Top view (b) Bottom view

Fig. 5. Photographs of a prototype 20-GHz oscillator (36 mm × 46 mm).

frequencies are 10.1 GHz and 20.2 GHz at the fundamental and the second harmonic frequencies, respectively. The output powers at the second harmonic port are -6.0 dBm at the second harmonic frequency and -22.0 dBm at the fundamental frequency. The output powers at the fundamental port are 9.9 dBm at the fundamental frequency and -13.0 dBm at the second harmonic frequency. Undesired signals are suppressed by 16 dB at the second harmonic port and 22.9 dB at the fundamental port. The bias voltage is 8.5 V and the bias current is 0.23 A.



(a) At the fundamental port



(b) At the second harmonic port

Fig. 6. Measured output power spectrum.

6. Conclusion

In this paper, evaluation results of a multiport harmonic Gunn oscillator with a fundamental signal filter has been reported. The second harmonic signal of -6 dBm was obtained with the fundamental suppression of 16 dB. The fundamental output power at the fundamental port was 9.9 dBm

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