A Schottky Diode Driven Frequency Doubler at X-band for K-band Vehicle Radar Applications

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Abstract: An applicated integrated schottky diode driver frequency doubler circuit for K-band vehicle radar is presented in this paper. The circuit is mainly composed of an input matching circuit, an output matching circuit and an X-band filter. The simulation show that the conversion loss is 8dB with the input power of 10dBm at 6 GHz by using Agilent Advanced Design System (ADS). Finally the measurements show that a conversion loss is 13.13 dB at the output frequency of 12 GHz. Compared with the traditional frequency doubler, this design provide a low cost design route.
Keywords: Driven frequency doubler, schottky diode, X-band.

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1. INTRODUCTION

With the improvement of living standards, road accident statistics implies strong market demand for improving road traffic safety. High quality performance, low cost radar is crucial for advanced driver assistance and active safety systems [1]. At the same time, as the core of vehicle radar, an increasing number of attention was paid on the study of the frequency source for vehicle radar [2]. At present, 24GHz and 77GHz are the common vehicle radar frequency bands, and the millimeter wave signal source in these bands is mainly obtained by multiplying the stable microwave signal. However, the signal multiplying from microwave signal directly has some problems, such as lower frequency efficiency and lower output power. In contrast, double the output signal by the driver frequency multiplier to achieve the function of four times the input signal has become more popular in millimeter wave signal source acquisition [3].
Ref. [4] introduces a method of connecting a K-band frequency doubler to a 12 GHz frequency source to acquire the 24GHz frequency source. It is an effective way but the 12GHz frequency source is more expensive than the 6 GHz frequency source. In this paper, an X band frequency multiplier is designed based on a 6 GHz frequency source. The cost of obtaining a 24 GHz frequency source by this method is lower than the method of the Ref. [4].

Ref. [5] introduces a high-power Schottky diode frequency multiplier chain at 360 GHz, with a 3 dB bandwidth above 20GHz. Similarly, Ref. [6] introduces a D-band frequency doubler using Schottky diode. Refer to these designs, Schottky diode SMS7621-079LF produced by Skyworks are adopted in this design because of its good features in terms of low cost, high cut-off frequency and good ideality. Tests have been done by a frequency source with about 10 dBm output power at the X-band, and the measured result has a good agreement with simulated result.

2. CIRCUIT DESIGN

2.1 Design of Circuit

The overall schematic diagram of the X-band doubler is shown in Fig. 1. An X-plane microstrip probe is located in the input SMA connector to couple the fundamental wave to the diodes through the input matching networks. The input matching networks is optimised to have strong rejection at the second harmonic, hence it prevents the harmonic waves from leaking into the input port. The desired second harmonic produced by the diodes is coupled outward by an X-plane probe in SMA connector. Between the output port and the diode are an output matching networks and a band pass filter (BPF). The output matching networks is essentially the same with the input one. The only difference is the output matching networks is optimized to have strong rejection at the fundamental band, hence it prevents the fundamental wave from leaking into the output port.

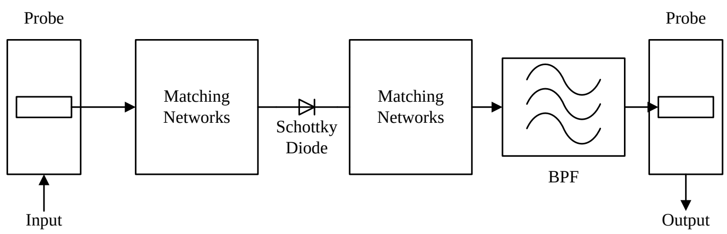


Fig. 1 Schematic diagram of doubler

2.2 Design of Matching Networks

The input and output matching networks model illustrated in ADS is shown in Fig.2. And the simulation results of these parts is shown in Fig.3. As shown in Fig. 3 (a), the input matching networks is matched at 6GHz and the output matching networks is matched at 12GHz.

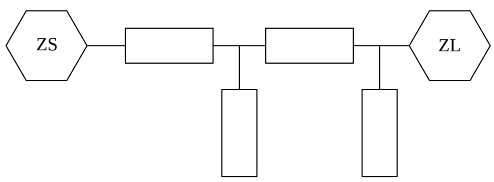
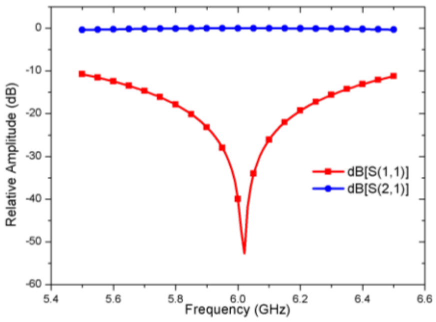
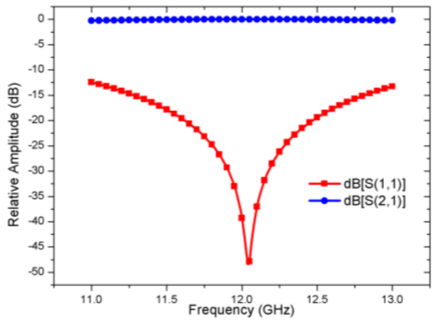


Fig. 2 Schematic diagram of input& output matching networks





(a) Simulation result of input matching networks (b) Simulation result of output matching networks

Fig. 3 Simulation result of input &output matching networks

2.3 Design of BPF

In addition to the output matching networks, the BPF are needed to prevent the fundamental wave from leaking into the output port. In Ref.[7], a quarter wavelength two-finger coupling section has been described featuring octave-bandwidth. Such a structure is well suitable if no ultra-broadband performance is needed. As additional bandwidth is not necessary for the developed attenuator application, a matching structure sketched in Fig.4 is added to improve reflection loss at expense of bandwidth.

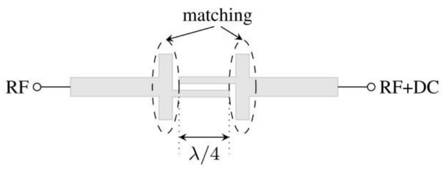


Fig. 4 Quarter wavelength two-finger DC-block with matching structure

2.4 Simulation Results of Frequency Doubler

As shown in Fig. 5, two $\lambda/4$ impedance transformer at the input side of the diodes is used to match the input impendence of the unit, and two section of transmission line at the output side of the diodes is used as an inductor. It is worthwhile to note that all of the passive networks including the input and output matching circuits are solved and optimized in the software ADS.

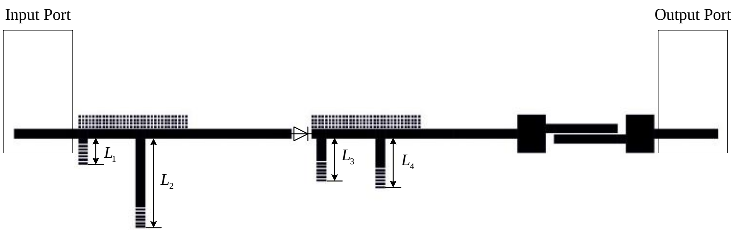


Fig. 5 Model of X-band doubler in ADS

3. RESULTS

A prototype of X-band frequency doubler has been fabricated, as shown in Fig.6. Fig. 7 reveals the simulated and measured results of the doubler. The simulation result is obtained under input power of 10 dBm, and the black curve with squares in Fig. 8 shows the level of output power of the second harmonic.

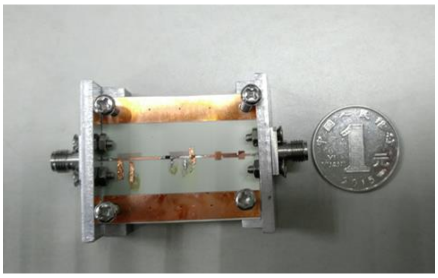


Fig. 6 Photograph of assembled X-band doubler

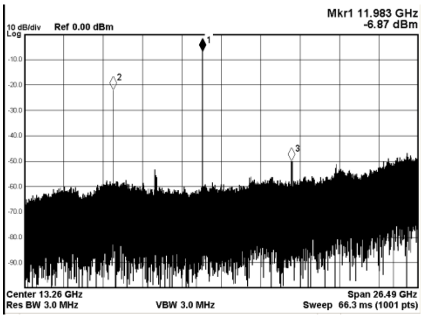


Fig. 7 Measured and simulated output power of X-band doubler at 12GHz

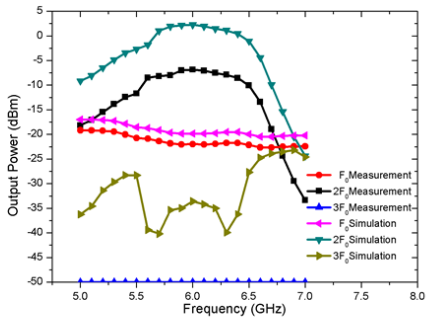


Fig. 8 Measured and simulated output power of X-band doubler

The measured result shows that with an input drive level of about 10 dBm, the fabricated doubler delivers output power level about –6.87 ± 1 dBm over the band of 5.8~6.2 GHz, and –10~ –8 dBm across the bands of 5.6~5.7 and 6.2~6.5 GHz.

4. CONCLUSION

In this paper, a X-band frequency doubler used in the K-band vehicle radar is designed, manufactured and measured. The measured results show that the fabricated doubler delivers output power level about –6.23 ± 1 dBm over the band of 5.8~6.2 GHz, and –10~ –8 dBm across the bands of 5.6~5.7 and 6.2~6.5 GHz with an input drive level of about 10 dBm at 6GHz.

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