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Reconfigurable frequency discriminator with uniform 2-bit frequency band using slow wave structure

Sung-min Sim(1), Yeonsu Lee(1), Hye-lim Kang(1), Ignacio Llamas-Garro*(2), Marcos T. de Melo(3), Minho Song(1), and Jung-Mu Kim(1)

(1) Department of Electronic Engineering, Chonbuk National University, South Korea, e-mail: jungmukim@jbnu.ac.kr

(2) Centro Tecnològic de Telecomunicacions de Catalunya, Spain, e-mail: Ignacio.llamas@cttc.es

(3) Universidade Federal de Pernambuco, Brazil

Abstract

In this paper, we conducted a design and simulation for a reconfigurable frequency discriminator (RFD) with a slow wave structure and a 180º silicon MEMS phase shifter. The proposed RFD circuit has lower power consumption and smaller size than conventional RFD circuit using PIN diodes at high frequency bands. The RFD shows that 2-bit identification is possible in the 30-40 GHz frequency band. We obtain a uniform frequency division between 32 GHz and 40 GHz by tuning the impedance of reference line.

1. Introduction

The reconfigurable frequency discriminator (RFD), which can obtain radio information used by enemy forces, is a key device in electronic warfare [1]. Typically, the RFD is composed of power divider, reference line, delay lines, and power combiner [1]. An RF input signal is split into two signals of equal magnitude by a power divider. The signals of the reference line and delay line are delayed and recombined at the circuit output to extract bits for unknown frequency identification. The recombined signal is divided into frequency sub-bands, used for frequency identification. PIN diodes are typically used to select the delay line in RFD, however it consumes high power and has limited application at high frequencies [2].

Electronic warfare applications frequently use high frequency bands, requiring accurate frequency discrimination from the RFD. However, it is necessary to study the RFD design for precise and uniform frequency discrimination to be applied at high frequency bands, because PIN diodes have limitations at high frequencies. In order to solve the limitation of PIN diodes, the reconfigurable delay line was designed and simulated using a MEMS 180º phase shifter, actuated by electrostatic force replacing the PIN diodes. A slow wave structure is used to increase group delay and electrically reduce the long transmission line. Therefore, the reference line of the RFD is designed using a slow wave structure that can be fabricated shorter than a typical transmission line and is used to tune the frequency response of the device.

2. Design

Figure 1 shows a schematic diagram of the proposed 2-bit RFD based on CPW transmission lines. The input and output port impedances were matched to 50 Ω and a 2-stage power divider is used operating at 30-40 GHz. The length of the reference line has one-half of the guided wavelength at 35 GHz. The silicon MEMS phase shifter changes the capacitance of the reconfigurable delay line to achieve a 180º phase difference between its two states, ON and OFF at 35 GHz.

3. Results

Figure 2 shows the HFSS simulation results of the proposed device. A threshold of –9 dB is defined for the circuit, the RFD design using a typical CPW transmission line had a non-uniform 2-bit distribution of the frequency sub-bands (see Fig. 2). The characteristic impedance of the reference line was adjusted through the slow wave structure to obtain uniform frequency sub-bands for frequency identification, as shown in Fig. 3. The frequency sub-bands of the RFD can be uniformly discriminated in range from 32 GHz to 40 GHz, when the characteristic impedance of the reference line is tuned 71.9 Ω and a threshold is -7.5 dB (see Fig. 4). As a result, we verified that the slow wave structure can be used to obtain uniform frequency sub-bands for frequency identification in the 32-40 GHz band.

4. Conclusion

An RFD was designed and simulated using the slow wave structure and a 180º silicon MEMS phase shifter. The proposed RFD was simulated by using HFSS simulator. The RFD with the typical CPW transmission line was tuned to achieve uniform frequency division in the 32-40 GHz through the slow wave structure.

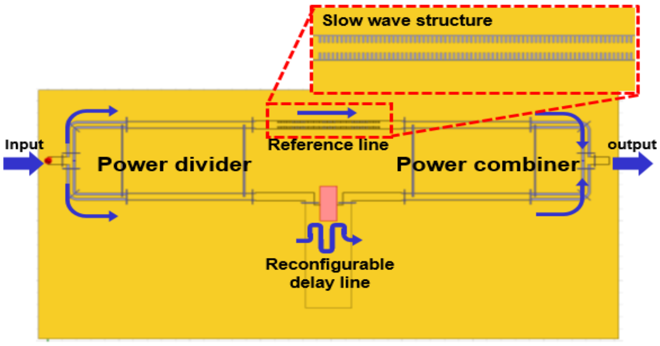
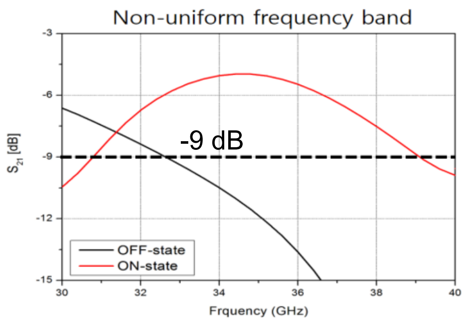


Figure 1. Schematic diagram of RFD



OFF-state	1	1	0	0
ON-state	0	1	1	0

Figure 2. RF simulation result of the RFD without slow wave structure

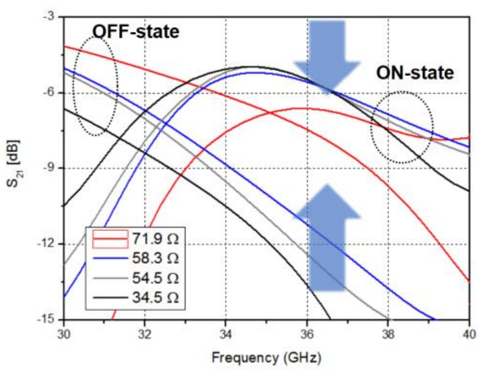
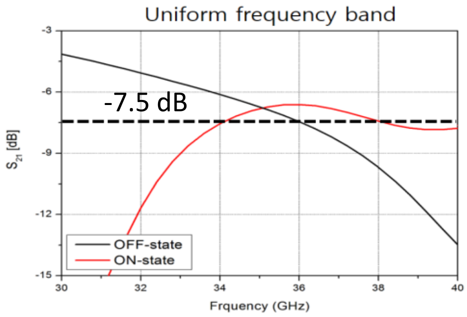


Figure 3. RF simulation results of slow wave structure tuning for uniform frequency division



OFF-state	1	1	0	0
ON-state	0	1	1	0

Figure 4. RF simulation result of the RFD with slow wave structure.

Acknowledgements

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