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Design of Hairpin Resonator Using Advanced Design System

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Abstract

Hairpin resonator is an essential component in Radio Frequency (RF) communication systems. In this paper, a microstrip hairpin resonator is designed using the Advanced Design System (ADS). The hairpin resonator is optimized to operate at a center frequency of 5.8GHz and matched with 50Ohm impedance. The simulation results show that the designed hairpin resonator has an insertion loss of 20dB and a return loss of 1.6dB at the center frequency. The Q factor of the designed resonator is 22.8, indicating good performance. This resonator can be applied to 5.8GHz communication system applications. The proposed design provides a low-cost and small size as well.

Keywords: Hairpin resonator; RF resonator; 5.8GHz resonator

Introduction

As we know that in the RF system, we need RF filters, amplifiers, oscillators, resonators and so on. Among them, the resonator is the one of the devices of the RF system that plays to enhance the selectivity of the channel. Among various types of resonators such as cross-coupled resonator, coaxial resonators, cavity resonators, dielectric resonators, microstrip resonators, surface acoustic wave resonators, quartz crystal resonators, helical resonators waveguide resonators and so on, the hairpin resonator is chosen for design due to its compact size and high quality (Q) factor. This resonator structure consists of two parallel arms that are folded back on themselves, forming a hairpin shape. The hairpin resonator can be used as a bandpass filter or as a resonant element in microwave circuits [1-5].

This paper presents the design of a 5.8GHz hairpin resonator using Advanced Design System (ADS). The ADS software is widely used for the design and simulation of microwave circuits due to its powerful simulation capabilities and user-friendly interface. In the process of design, we performed design and optimization for the given frequency band and achieved the simulation results mainly in terms of insertion loss and return loss. During the design process, the terminals are terminated with 50Ohm impedance for the system [6-10]. When the optimization process is finished, it is planned to fabricate on a printed circuit board (PCB) and test for its performance characteristics using a Vector Network Analyzer (VNA). However, in this work, the design and simulation of hairpin resonator is presented.

Design method

A microstrip hairpin resonator is designed and simulated using Advanced Design System and it consists of a pair of parallel transmission lines that are connected by two U-shaped bends to form a hairpin shape. The U-shaped bends in the hairpin resonator introduce additional capacitance and inductance into the circuit, which can be used to adjust the resonant frequency and bandwidth of the resonator. The U-shaped resonator is shown in Figure 1(a) in which the Z0 is the impedance and W is the width and L is the length of the hairpin resonator whereas S is the gap of the resonator. The equivalent circuit of it is shown in Figure 1(b).

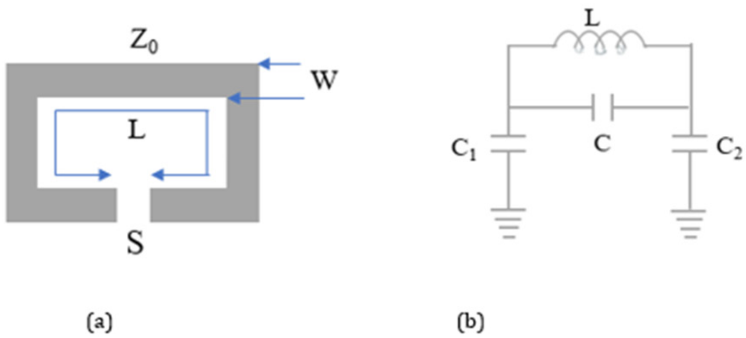

Figure 1: (a) U-shaped microstrip resonator and (b) it's equivalent circuit.

The overall circuit of U-shaped resonator with microstrip lines is shown in Figure 2. The circuit shows the optimized length and width of the microstrip lines, gap of the capacitor loading, and the terminals are terminated by 50Ohm for the RF system.

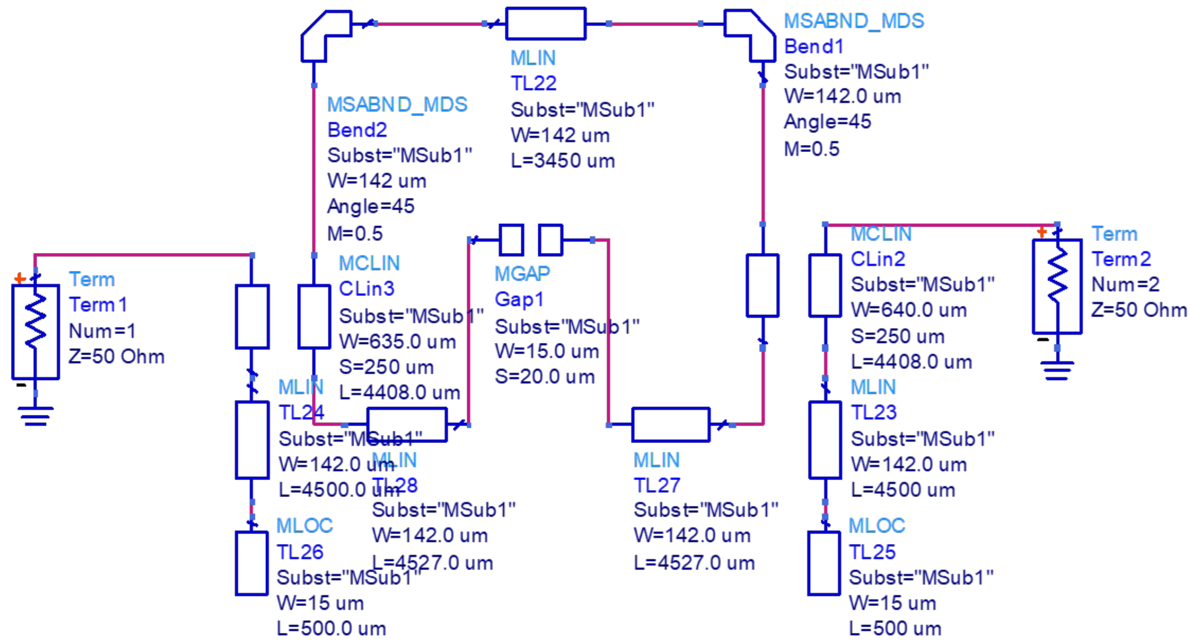

Figure 2: The simulated and optimized circuit of the U-shaped hairpin resonator.

Results and Discussions

The simulation results show that the designed hairpin resonator has an insertion loss (S21) of 20dB and a return loss (S11) of 1.6dB at the center frequency of 5.8GHz. The insertion loss and the return loss are shown in Figure 3 & 4 respectively. The value of the Q-factor of the resonator is found to be 22.8. These results demonstrate that the designed resonator performs effectively in RF communication systems and has a high-Q factor, which allows for narrow bandwidth and low signal loss. The simulation results are analyzed to understand the performance of the hairpin resonator. The insertion loss and return loss are used to evaluate the resonator's ability to pass and reflect signals, respectively. The Q-factor is used to measure the resonator's energy storage capacity, which is related to its bandwidth. The simulated and optimized insertion loss and output reflection coefficient (S11 and S22) on the smith chart is shown in Figure 5.

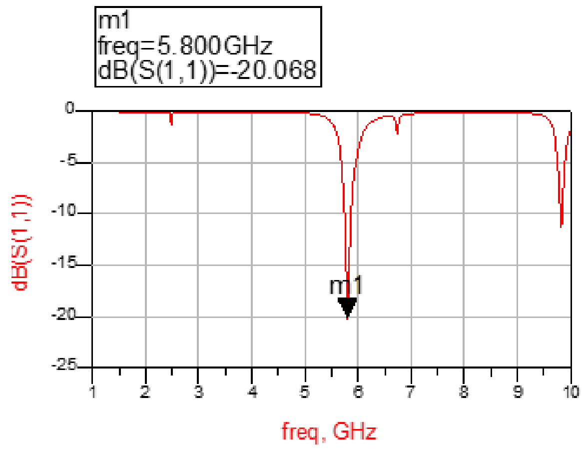

Figure 3: The simulated and optimized S11 and S22 on smith chart.

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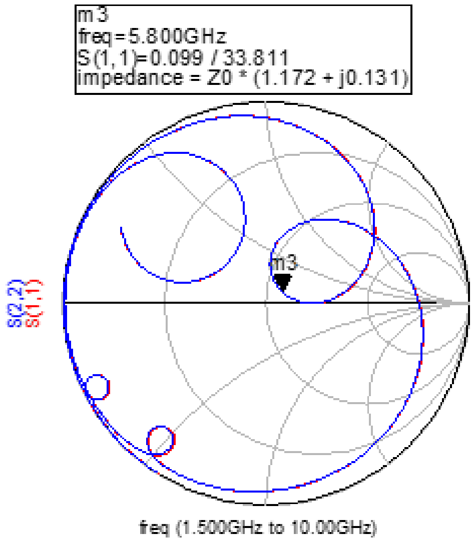

Figure 4: The simulated and optimized return loss (S21).

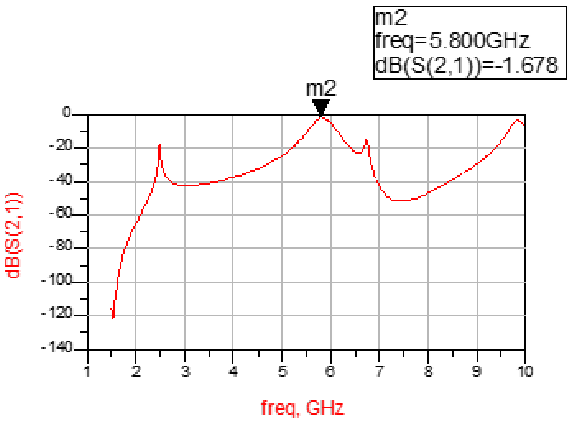

Figure 5: The simulated and optimized insertion loss (S11).

The overall device performance of the designed microstrip hairpin resonator is shown in Table 1.

Table 1:

Parameters	Simulation Results		
	Simulated Values	Unit	Remarks
Insertion Loss (S21)	20.06	dB	-
Return Loss (S11)	1.6	dB	-
Q-factor	22.8	-	-
Center Frequency	5.8	GHz	-

Conclusion

In this work, the microstrip hairpin resonator has been designed and simulated using Advanced Design System (ADS) to have excellent performance for the RF system applications. The simulation results show an insertion loss (S21) and return loss (S11) of 20dB and 1.6dB, respectively at the center frequency of 5.8GHz. The advantage of this design is low cost and compact size which is very important to the RF system. It also characterizes the Q-factor of the resonator that enhances the selectivity of the frequency for the system.

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