Coupling in multilayer devices

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***Abstract*—Novel design for devices in multilayer stacked is proposed. Split Ring resonators and Complementary Split Ring resonators are used, in microstrip or dual stripline-microstrip configuration to build different devices. A double frequency resonator and a multilayer triplexer are presented among the paper.**

Keywords—coupling, SRR, CSRR, multilayer

I. Introduction

The properties of Split Ring Resonators (SRR), studied at the end of last century by [Pendry], as well as Complementary Split Ring Resonators proposed by [Falcone] established a starting point for the design of novel microwave devices. The operation in sub-lambda operation for these particles made them suitable in the miniaturization of microwave devices such as filters [Bonache], couplers [Jarauta] or antennas [Paul].

In this paper Square Complementary Split ring Resonators (SCSRR) will be used instead. The main dimensions can be seen in Fig.1 They are square side length *l*, width of the rings *c*, and separation between rings *d*.

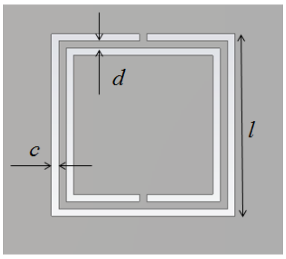
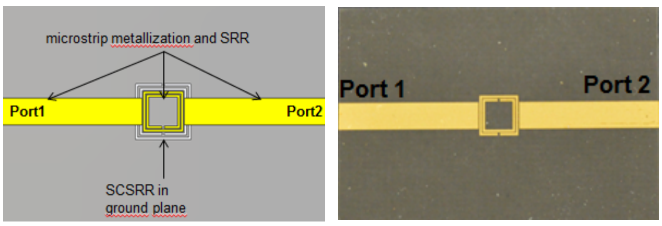


Figure 1. SCSRR main dimensions

II. Double frequency resonator

For the first device, the serial resonator proposed in [Jarauta] is taken as started point. There, a Square SRR (SSRR) in serial resonator is used. The SSRR in the serial configuration is excited because of the electric field perpendicular to the microstrip line, due to the bi-anisotropy of SSR [Marques Iddrisi]. Just below SSRR, a Square CSRR (SCSRR) is etched in the metallization layer. This resonator is excited due to the e-field established from input line to the ground in microstrip line. The layout and the top layer of fabricated prototype are shown in Fig.2.



a) b)

Figure 2. a) Top view overlapped layers. b) Top layer manufactured prototype

This device was designed in the commercial substrate Rogers RO5880 with thickness h=0.79mm. The SSRR on top layer has a side length l_1 = 3,4mm, width of the rings *c* = 0,2mm, separation between rings *d* = 0,1mm and distance between microstrip input and SSRR s_1 = 0,1mm. The SCSRR has a side length l_2 = 5mm, width of the rings c_2 = 0,2mm, separation between rings d_2 = 0,1mm. In the case of SCSRR is also important to consider the length of input metallization line over the SCSRR. In this case defined from the center of the ring to the beginning of the metallization layer as p_1 and p_2 as plotted in Fig 3.

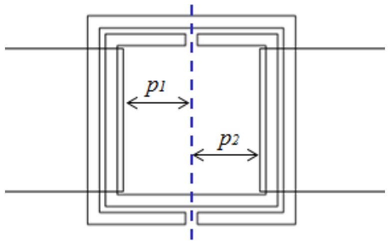


Figure 3. Detailed parameters p1 and p2 over the SCSRR

For the device in Fig. 2, the parameters are p_1 = 1,9mm and p_2 = 1,9mm. With all above dimensions, the simulation results can be seen in Fig.4.

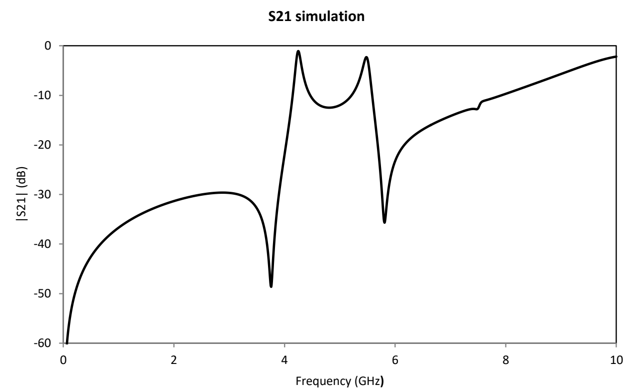
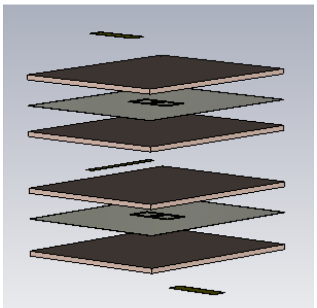


Figure 4. Simulated S_{21}.

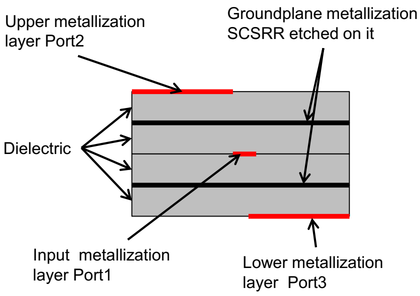
Two resonances are obtained, the first one at f1= 4,24GHz, corresponding to the CSRR resonance with a value S21=1,2dB. The second one at f2=5,51GHz is the resonant frequency of the SSRR. In this case the insertion loss S21=1,1dB.

III. Multilayer stripline diplexer

The second device proposed is a multilayer diplexer. The input line is a stripline. On both metallization layers which builds the stripline groundplane, a couple of SCSRRs are etched. As it is well known, in a stripline a TEM mode Finally, over and below of each metallization layer, a new substrate with a new strip just above the side of the rings is located. They build two microstrip lines that act as output layers. The different layers are schematically displayed in perspective view in Fig. 5a and in front view in picture Fig. 5b.



a)



b)

Figure 5. Multilayer stripline diplexer. a)perspective view. b) front view

The SCSRRs are identical and they are positioned side by side as it can be seen in Fig. 6. The main dimensions are *l*=4mm, *c*=0,2mm, *d*=0,2mm. Separation between rings is *s*=0,2mm. The values of the distance from the center of the SCSRR to the beginning of output line to port 3 is p_1=1,5mm. And to port 4, p_2=1,4mm. The design details can be seen in top view in Fig. 6.

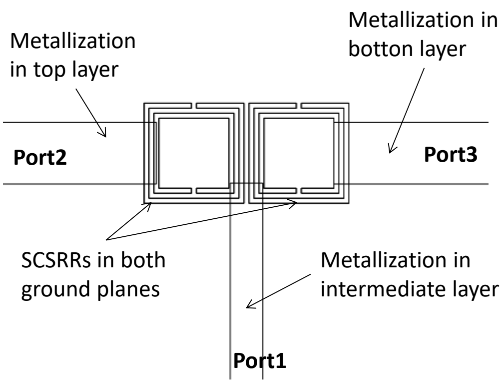


Figure 6. Multilayer stripline diplexer top view

The results of simulation for device presented can be seen in Fig. 7.

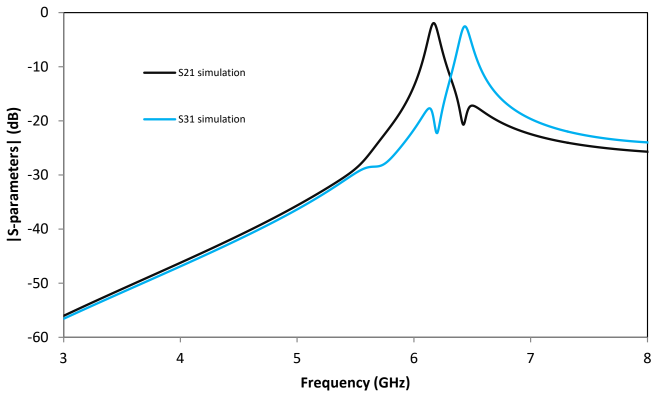


Figure 7. S-parameters response for multilayer diplexer

The S-parameters response for this device presents two resonant frequencies. The first one, to output port 2, f_0=6,176GHz with insertion loss S_{21}=-2,02dB and the second one to output in port 3 is achieve at f_1=6,44GHz with insertion loss S_{31}=-2,56dB. Two remarkable results are obtained for this device. Good insertion losses on each port, but also, that resonant frequencies are really close each other.

IV. Discussion of the results

It is possible the coupling of energy between layers vertically. The effective area for the double resonator is 0,0019 λg^2. For the case of the diplexer apart from the insertion losses, a key figure is the separation between resonant frequencies with a ratio of 1,043.

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