

A Reconfigurable Multiband CPW-Fed Antenna Based on a Quad-Mode Slot-Line Resonator

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Abstract—This paper presents the design and realisation of a compact reconfigurable quad-/dual-band microwave antenna, which has been implemented based on a novel quad-mode slot-line resonator (SLR). The coplanar waveguide (CPW) feeding structure has also been designed in detail in order to be able to optionally function under both the weakly- or strongly-coupling conditions. Under the weakly-coupling condition, the antenna has four narrow operating bands relating to the four resonant modes, while under the strongly-coupling condition, another resonance arises. As a result, a dual-band antenna is produced with a very wide second band. The fabricated antenna has then been thoroughly measured under both the intended conditions, which show good agreement with the conducted simulations.

Index Terms—Multiband antenna, multimode component, slot-line resonator, reconfigurable microwave antenna.

1. Introduction

The SLRs have been widely used to design multiband and wideband microwave components during the recent decade, e.g., dual-band CPW-fed slot antennas had been shown in [1] and [2]. The SLRs exhibit special advantages since they can be effectively folded within a relatively smaller size, because the current distribution on SLRs mainly concentrated around the slot [3]. As a result, the tri-band components in [4] and [5] could be designed with very compact sizes by fully folding and combining three different length SLRs. A single-slot can be specifically bent to generate more than one resonance, which makes the multimode SLRs even more competitive in designing components with more compact size. In [6], based on a dual-mode SLR, a two-port antenna was designed not only with compact size, but also with very high isolation due to the two resonances. As demonstrated in [7], the compact quad-mode SLR-based wideband bandpass microwave filter had also an extremely high selectivity.

In this investigation, a compact quad-mode SLR has been obtained based on the dual-mode SLR proposed in [8]. The CPW feeding structure has also been designed to be able to optionally work under both the weakly- or strongly-coupling conditions. The weakly-coupling is realised using a single-sided metallic tape (i.e., only conductive on the top), and the strongly-coupling is implemented using two 20-pF ceramic capacitors. Under the weakly-coupling condition, the antenna has four narrow operating bands, while under the strongly-coupling condition, a newly generated resonance arises to combine the 3rd and 4th bands into a wide operating band.

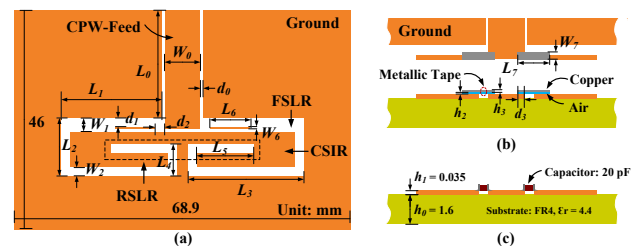


Fig. 1. (a) Layout of the proposed microwave antenna; (b) feeding structure under the weakly-coupling condition; (c) feeding structure under the strongly-coupling condition; $W_0 = 4.6$, $W_1 = 2.2$, $W_2 = 1.2$, $W_6 = 0.5$, $W_7 = 0.8$, $L_0 = 22$, $L_1 = 17.55$, $L_2 = 9.0$, $L_3 = 18.45$, $L_4 = 4.6$, $L_5 = 8.85$, $L_6 = 6.8$, $L_7 = 3.0$, $d_0 = 0.4$, $d_1 = 1.2$, $d_2 = 1.0$, $d_3 = 0.88$, $h_2 = 0.02$, and $h_3 = 0.05$.

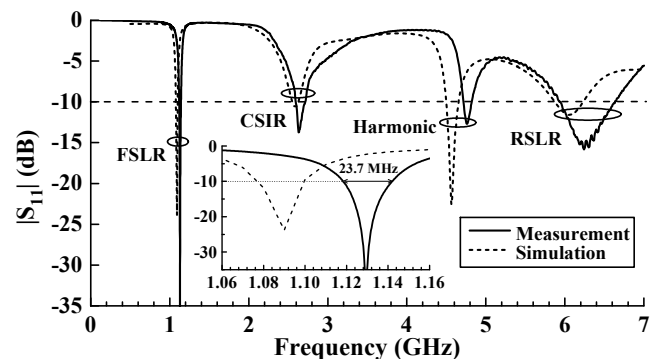


Fig. 2. Simulated and measured S_{11} under the weakly-coupling condition.

2. Microwave Antenna Design and Measurement

(1) Weakly-Coupled Quad-Band Antenna

The layout of the proposed antenna is shown in Fig. 1 (a), and the topology of the CPW-based feeding structure under the weakly-coupling condition is also presented in Fig. 1 (b), which is realised using the two top-only conductive metallic tapes (i.e., Fig. 3). To simplify the design, the metallic tape is modelled by a copper over the air-gap. The simulations have been carried out using the HFSS software. As Fig. 2 presents, the simulated and measured S_{11} are in good agreement. There are four resonances around 1.13, 2.64, 4.78, and 6.32 GHz with 10-dB fractional bandwidth (FBW) of 2.1%, 4.8%, 2.3%, and 10.8%, respectively. The 1st and 4th microwave resonances are produced by the folded- and rectangular-SLR

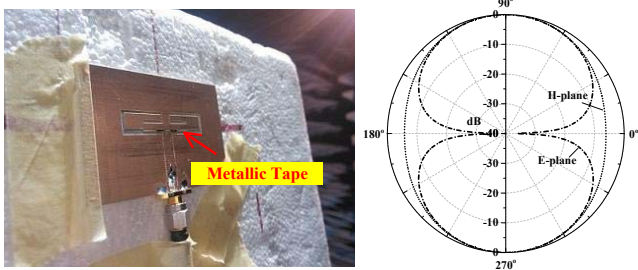


Fig. 3. Implementation of the feeding structure under the weakly-coupling condition; the simulated radiation pattern of the 1st operating frequency.

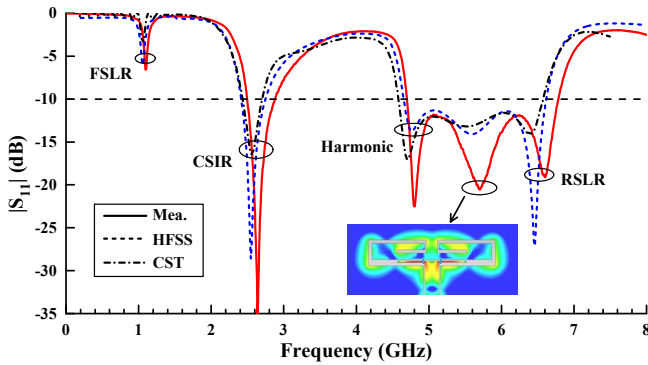


Fig. 4. Simulated and measured S_{11} under the strongly-coupling condition.

(FSLR and RSLR), respectively. The 2nd and 3rd resonances are due to the fundamental and 1st harmonic resonance of the coplanar stepped impedance resonator (CSIR) [7].

(2) Strongly-Coupled Dual-Band Antenna

The topology of the feeding under the strongly-coupling condition is shown in Fig. 1 (c); which is implemented using two 20-pF ceramic capacitors with the size of 0402. Also, as Fig. 4 presents, the simulated and measured S_{11} are in good agreement, confirming the two operating bands from 2.50 to 2.88 GHz, and 4.70 to 6.78 GHz, respectively. In fact, a new resonance is generated between the 3rd and 4th resonances; which is due to the T-shaped resonator (TR) at the end of the CPW feeding line. The length of the metallic strip (i.e., L_6) can also be well employed in order to control the frequency of this resonance (i.e., f_{TR}), which is depicted in Fig. 5, and is validated through the surface current distribution as in Fig. 4. It is worth mentioning that the FSLR does not function under the strongly-coupling condition, because of the high quality factor of the FSLR. The simulated far-field radiation patterns under the strongly-coupling condition are presented in Fig. 6.

3. Conclusion

In this paper, a novel quad-mode SLR is proposed as the radiation part of a reconfigurable multiband antenna. Two types of CPW-based structures have been designed in order to feed the resonator under the weakly- or strongly-coupling conditions. Under the weakly-coupling condition, it works as a quad-band antenna with four narrow bands. Also, under the strongly-coupling condition, this structure operates as a dual-band microwave antenna with a very wide second band. The proposed design also shows competitive advantages such as compact component size, flexible multiband, and low cost.

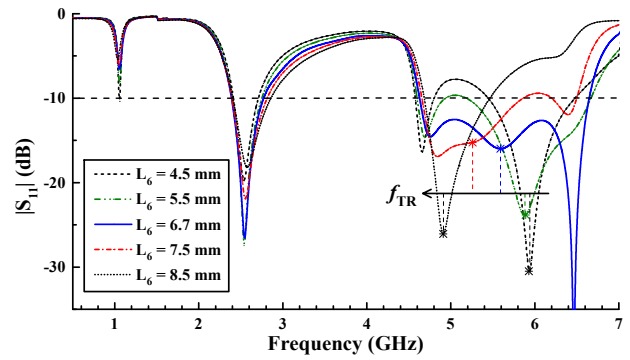


Fig. 5. Simulated S_{11} of the proposed antenna under the strongly-coupling condition with different L_6 as the parameter.

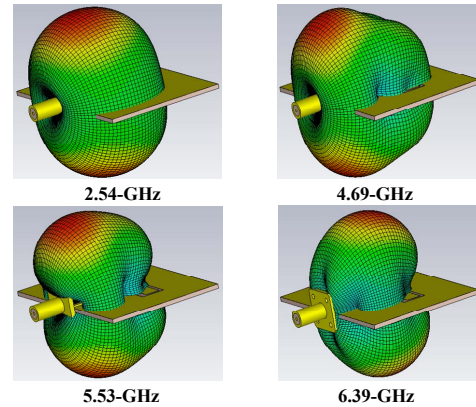


Fig. 6. Simulated 3D far-field radiation patterns (i.e., based on the CST Microwave Studio software) under the strongly-coupling condition.

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