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ULTRA-WIDEBAND METAMATERIAL FILTER BASED ON ELECTROINDUCTIVE-WAVE COUPLING BETWEEN MICROSTRIPS

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Abstract—In this work, we analyse the frequency response of microstrip lines coupled by complementary split ring resonators (CSRRs) etched on the ground plane supporting electroinductive waves (EIWs). The single-particle configurations demonstrate the principle of operation whose bandwidths reach 67% of the central frequency. A double configuration is afterwards investigated as a further improvement of the filtering response, such as the level of the spurious lower frequency band. Finally, an ultimate prototype comprising different CSRRs along the access line, together with the aforementioned EIW-coupling is proposed for filtering undesired higher bands. Experimental results confirm numerical analysis.

1. INTRODUCTION

The design of microwave planar filters and couplers has taken a great advantage of the new perspective brought along by the advent of metamaterials [1]. In particular, Split Ring Resonators (SRRs) [2] and CSRRs [3] have become powerful elements in planar technology as a result of their tailored frequency response as well as their subwavelength dimensions [4].

Recently, the underlying physics of an isolated SRR or CSRR and the interaction between SRRs or CSRRs and other elements, such as series interdigitated capacitive gaps [5] and electromagnetic bandgaps [6], have been deeply studied in planar technology leading to exotic electromagnetic behaviors such as left-handed propagation [4].

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Among other consequences, EIWs are supported by CSRRs because of the close interaction between neighbor elements [7, 8]. Therefore, in a discontinuous microstrip that otherwise exhibits stop-band at certain frequencies, a passband can be achieved at those frequencies if CSRRs are etched on the ground plane, being propagation supported by the existence of the CSRRs [7]. This approach is employed in this paper in order to design coupled microstrip filters.

Subsequently, we further investigate the viability of coupling microstrip lines within an enhanced ultra-wide bandwidth with filtering response. The strategy used to improve the coupling bandwidth and minimize the spurious bands arising at lower and higher frequencies is to combine two electro-inductive coupling branches, i.e., two stages in cascade. This leads to 70% measured bandwidth of the central frequency and the spurious lower frequency lobe of −30 dB. Finally, chains of CSRRs are designed to be placed underneath the access microstrip lines in order to remove the undesired higher frequency spurious band, taking advantage of the frequency selective nature of the CSRR elements.

2. DESIGN AND FABRICATION OF THE ELECTRO-INDUCTIVE PARTICLE

A schematic with the relevant dimensions of the single-CSRR configuration, as well as the fabricated prototypes, is presented in Fig. 1. They consist of two microstrip lines with a separation between line of $d_x = 1$ mm to each other and an overlap region $2d_z$. Within the overlap area, that is, at the end of each microstrip, a CSRR is etched on the ground plane. The relevant dimensions of the microstrip lines and CSRRs are summarized in Table 1.

Table 1. Parameters of the single scheme (in mm).

Parameters	Prototype 1	Prototype 2
L_x	5	6
L_z	4	6
w	1.2	1.2
c	0.5	0.3
d	0.1	0.3
d_x	1	1
d_z	2	3.25