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Design of tunable microwave transmission lines using metamaterial cells

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Abstract In this paper, frequency tunable transmission lines are designed using metasurface split ring resonator unit cell. We prove that the tuning principle in metasurface transmission lines is based on the variation of the resonance frequency of the permeability. The frequency-tuning arises by changing the values of two gaps in the inner and outer rings of unit cell ($g1$ and $g2$). The branches of a disconnected gaps type conductor of each unit cell can be joined by switches (PIN diodes, MEMs, etc.). According to switch states ON or OFF, the unit cell has four different commutable behaviors which are 00, 01, 11, and 10. The results show that the resonance frequency of our metasurface transmission line is strongly shifted by about 2.5 GHz between the cases (01) and (11).

1 Introduction

The technologies to implement reconfigurable and tunable metasurface transmission lines have seen significant progress in recent years [1]. The tuning is achieved through electronic actuation where, typically, changes in a capacitance, or local changes in the permittivity of a dielectric layer, are generated by the actuated voltage or applied field. These tunable or reconfigurable structures operate in the lineal regime [2]. Micro-electromechanical systems for radio-frequency applications (RF and MEMS) constitute a key enabling technology for telecommunication systems [3, 4]. The successful integration of RF and MEMS switches in electrically small metamaterial resonators is expected to be an enabling technology for many microwave applications. The tuning principle in most metasurface transmission lines is based on the variation of the resonance frequency of the resonant elements through electronic actuation. This tuning can be achieved by loading the split rings (SRRs, OCSRRs, etc) with varactor diodes or RF-MEMS. The goal of this work is to tune the frequency of metasurface transmission line by changing the resonance frequency of the effective permeability in the SRR unit cell. It can be controlled by an external command system (PIN diodes, MEMs, etc).

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2 Method

2.1 Design of tunable metamaterial unit cell

Our tunable elementary unit cell is composed of split-ring resonator made of disconnected conducting with two gaps (g_1, and g_2) in the inner and outer rings on opposite sides. Each gap can be joined by switches that enable to control over individual metamaterial elements. According to switch states (ON or OFF), the unit cell has four different behaviors that are (00, 01, 11, 10), as shown in Fig. 1b. The actionable behavior of our unit cell allows us to introduce the tuning of metasurface transmission line. The representation of the unit cell with all the geometrical parameters is shown in Fig. 1a. The incident wave in Fig. 1a is a plane wave with its wave vector k in the x-direction and the E-field polarized in the z-direction, while the magnetic field vector H oriented along the y-direction.