Study of the LSR-MTM antenna: Dual-band and dual-polarized approaches

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Abstract

Microstrip patch antenna loaded with a series gap discontinuity and a 4-arm logarithmic spiral resonator (LSR) is investigated. Two structures are given, one is a dual-polarized metamaterial antenna (MTM). The other one is a dual-band MTM antenna. Both antennas are based on the LSR-MTM transmission line (TL) approach [1]. It is shown by comparison that a big reduction in antenna's size, compared to conventional patch antenna, could be achieved. Furthermore, simplicity of fabrication will turn out to be an advantage of such antennas. CST Microwave studio is used to simulate and optimize the proposed antennas. Measurement results are finally presented to verify functionality.

1. Introduction

An artificial material with negative permittivity and permeability is able to transmit electromagnetic waves (Left-Handed Transmission line) [2]. Planar metamaterial antennas are based on left-handed TLs. This causes a reduction of antenna's size. One type of such antennas is the LSR-MTM antenna. The metamaterial effect is realized with a logarithmic spiral resonator etched on the ground plane of the antenna. On the top side, a patch with a gap in its middle is etched. This is shown in Fig.1a and Fig.3a (for more details see [3]). In this paper a 4-arm LSR-MTM antenna is presented. The use of the 4 arms makes the antenna symmetrical and consequently a dual-polarized LSR antenna is achieved (section 3). Using two different spirals makes it possible to have a dual-band planar MTM antenna (section 2).

2. Dual-Band MTM antenna

As seen in Fig.1a two spirals of different lengths are used to achieve the dual-band approach. Fig.1b shows the simulated and measured reflection parameter (S_{11}) of the antenna under test (AUT). The measured resonance frequencies of the antenna are observed to be $f_r = 1.22$ GHz and 1.55 GHz. The measured and simulated S-parameters show a good agreement. However, at $f_r = 1.55$ GHz an S_{11} of approximately $-8dB$ is observed. An important figure of merit of this antenna is the amount of reduction in size which is aproximately 70% [4]. This is due to the fact that a larger ϵ_{r-eff} is achieved, which could be shown as follows: [3]

$$L = \frac{\lambda_{guided}}{2} = \frac{c_0}{2 \cdot f_r \cdot \sqrt{\epsilon_{r-eff}}} = 26.6\,mm \tag{1}$$

$$\epsilon_{r-eff} = (\frac{c_0}{2 \cdot f_r \cdot 26.6\,mm})^2 = 21.36 \tag{2}$$

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in which L denotes the length of the patch, c_0 denotes the light velocity and f_r is the operational frequency of the antenna (Dual-Band) which is equal to 1.22 GHz. Fig.2 shows the radiation patterns of this antenna. It's clear that radiation takes place in both direction, i.e. the patch and the spiral side. Good agreement between measurements and simulations are noticed.

(a) (b)

Fig. 1: Dual-Band MTM antenna: a) Front and Back faces. b) Reflection parameter (S_{11})

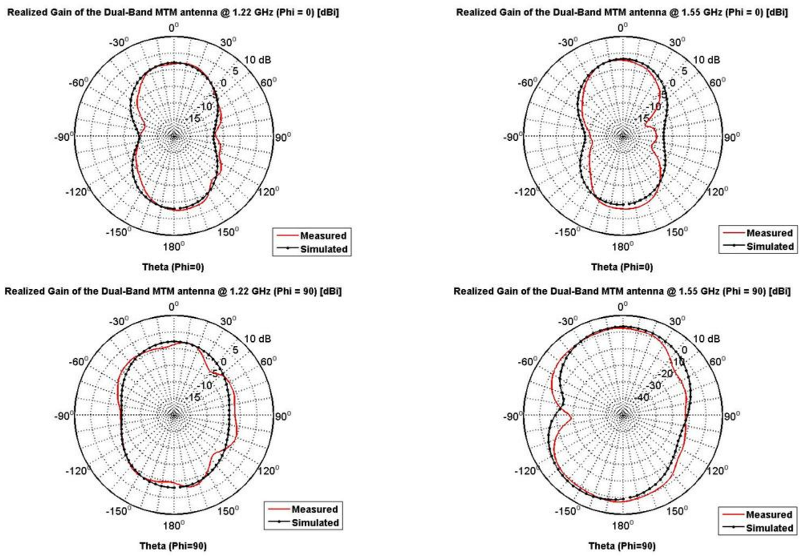


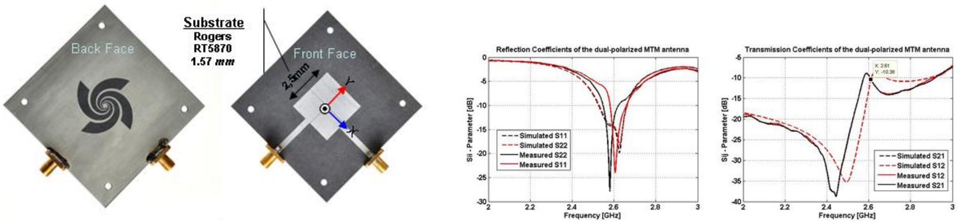
Fig. 2: Realized Gain of the Dual-Band MTM antenna

3. Dual-polarized MTM antenna

Due to the symmetrical structure of the 4-arm LSR (Fig.3a); the dual-polarized approach is achieved. Fig.3b shows the complete scattering parameters of the antenna both simulated and measured. The measured resonance frequency of the antenna is observed to be $f_r = 2.6$ GHz. The difference between simulations and measurements are due to fabrication inaccuracies which would only be seen using a microscope. It's worth noting here that the correlation coefficient of this antenna is about 0.07, which implies that such antenna could even be a good candidate for MIMO applications [5]. Measurement and simulation results of the radiation patterns of this antenna are shown in Fig.4.

4. Conclusion

In this paper a dual-band and a dual-polarized MTM antennas based on LSR-TL technology have been investigated. Simulation and measurement results show a good agreement. The main important figures



(a) (b)

Fig. 3: Dual-Polarized MTM antenna: a) Front and Back faces. b) S_{ii} and S_{ij}.

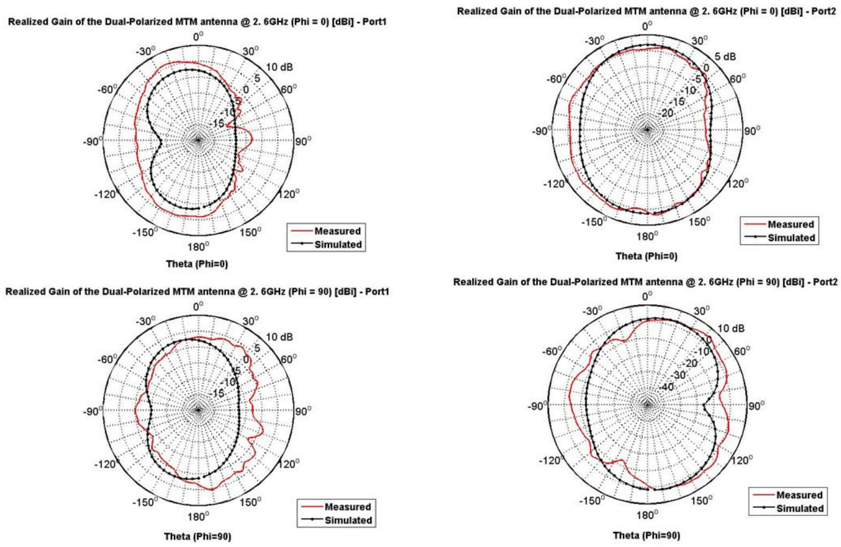


Fig. 4: Realized Gain of the Dual-Polarized MTM antenna

of merit of such antennas are: simplicity of fabrication; since no vias are required compared to other technologies like Epsilon negative (ENG) metamaterials, reduction of antenna size compared to conventional patch antennas and ability of being candidates in MIMO applications. A main feature of the used LSR is the ability to shift the operational frequency by simply rotating the spiral. A feature that could optimize the antenna even further [3]. However in this paper this effect ain't been taken into account. As a future work a comparison between a 2-arm and a 4-arm LSR, which are a main backbone in MTM antenna structures, could be done to point out the advantages that could be gained.

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