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A New Microstrip Antenna for Today's Needs

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Abstract

In this framework, a new wideband miniature microstrip antenna based on the composite right-left handed transmission line (CRLH-TL) structure with enhancement gain is proposed and investigated. This microstrip antenna is constructed of the two unit cells, also presented antenna is designed from 3.35 GHz to 4.75 GHz which corresponding to 34.56% bandwidth. The overall size of the presented antenna is 13.2 mm x 6.4 mm x 0.8 mm or $0.17\lambda_0$ $0.08\lambda_0$ x $0.01\lambda_0$ at the operating frequency f = 4.05 GHz (where λ_0 is free space wavelength). The radiation peak gain and the maximum efficiency which occurs at 4.75 GHz, are 2.6 dBi and 38.2%, respectively.

Keywords

Microstrip antenna, Composite right/left-handed transmission line (CRLH-TL), Microwave implementation.

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Introduction

In present years, the printed antennas have received great attention in wideband applications due to their advantages of minimized, planar, low cost, light weight, broadband, compatibility and easy integration with other microstrip circuits. Applications in present-day communication systems usually require smaller antenna size in order to meet the miniaturization requirements of microwave units. Thus, size reduction and bandwidth enhancement are becoming major design considerations for practical applications of microstrip antennas [1].

In this work, we using of the MTM and the simple techniques for reduction in size, extension of bandwidth and increment of gain of the antenna, which consist of applying of the printed planar mushroom structure based on CRLH-TL and appropriate structural parameters. Diverse implementations of MTM structures have been reported and demonstrated [2]. In this paper a MTM CRLH antenna with two unit cells which each unit cell embrace of two printed L-shaped gaps capacitors and the spiral inductor accompanying a metallic via connected to ground plane is presented. The printed L-shaped structure exhibit wide bandwidth, miniature and improvement gain property which useful for wideband and miniature antennas.

This paper is organized in the following way. A broadband and small antenna prototype with high gain and efficiency employing the proposed concept will be depicted in Section II. Followed by section III where various performance including dimension, impedance bandwidth and radiation patterns characteristics of the recommended antenna are demonstrated. Further discussion and conclusion are raised at last.

Modelling of the Proposed Antenna

Various implementations can be utilized to implement the CRLH-TL unit cell including surface mount technology (SMT) chip components and distributed lines. However, lumped elements are not suitable in antenna design because of their lossy properties and discrete amounts. We have applied printed planar way for our microstrip antenna design, since printed planar topologies are good candidate for antenna design because of their benefits which consist reduction in dimension, loss less and non-discrete amounts. A new wideband and miniature microstrip antenna with improvement gain based on CRLH-TL presented in here, which consists of two unit cells while each unit cell will be

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designed by two rectangular radiation patches with printed L-shaped gaps into patches, and the spiral inductor accompanying metallic via connected to the ground plane. Figure 1 shows geometry of the proposed antenna and figure 2 display equivalent circuit model of each cell as CRLH unit cell. In the topology, port 1 is stimulated with an input signal and port 2 is matched to 20 Ω load impedance. The antenna topology is based on a CRLH-TL model employed as a periodic structure. Because the lowest mode of operation is a left-handed mode, the propagation constant approaches negative infinity at the cut-off frequency, and decrease its magnitude as frequency is incremented. Making usage of the event, electrically great but physically compact antenna can be developed.

By means of the L-shaped gaps and spiral inductors with shorting via-hole

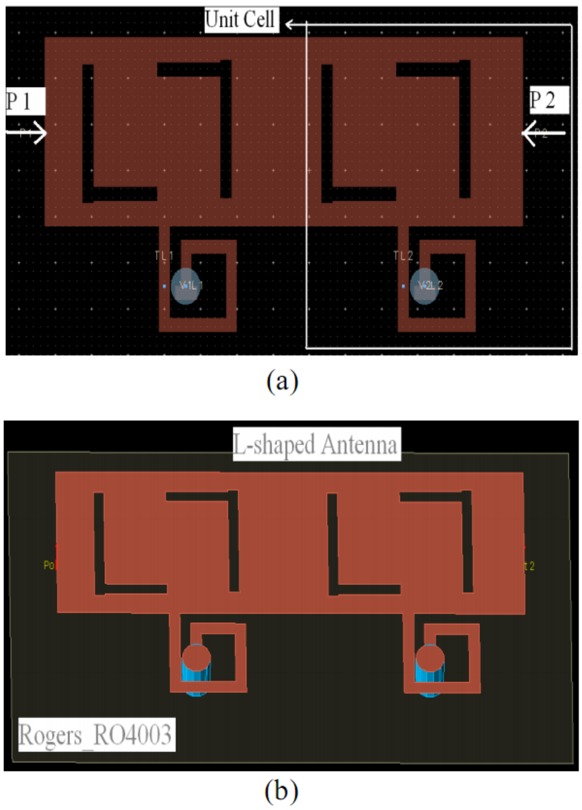

Figure 1: *Configuration of the presented microstrip antenna composed of the two unit cells based on CRLH MTM-TL. a) Top view, b) Isometric view.*

connecting to ground plane, the series capacitance (C_L) and shunt inductance

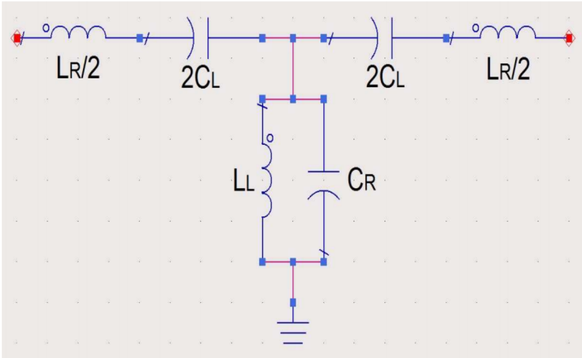

Figure 2: *Proposed microstrip Antenna: Equivalent circuit model of the CRLH MTM antenna for one unit cell.*

(L_L) can be easily implemented in a compact fashion. The host TL possess the right-handed parasitic effects that can be seen as shunt capacitance (C_R) and series inductance (L_R).

In this paper, we employing of MTM technology and the printed planar approach which results to foot print area reduction of the proposed microstrip antenna. Overall size of this antenna is $0.17\lambda_0$ x $0.08\lambda_0$ x $0.01\lambda_0$ at the operating frequency f = 4.05 GHz where 0 is the free space wavelength and also with choosing smaller distance between printed L-shaped gaps edges, we will be obtained wide bandwidth from 3.25 GHz to 4.75 GHz which corresponding to 1.4 GHz bandwidth. Furthermore, with acceptable selecting of the number unit cells (N) constructing antenna structure and structural parameters of the spiral inductors such as number of turns (N), inner radius measured to the center of the conductor (R_i), conductor width (W) and conductor spacing (S) we will be achieved good radiation performances. The gain and efficiency of the proposed antenna are changed from -1.3 dBi to 2.6 dBi and 9.41% to 38.2%, respectively, into frequency band 3.35 - 4.75 GHz, that shown very good radiation characteristics. Therefore, the MTM antenna designed is small and ultra-wideband with high gain and efficiency. The proposed antenna based on CRLH-TL made very small size and wide bandwidth to support today's multi-band modern wireless applications and microwave devices.

Figure 1 shows configuration of the recommended microstrip antenna constructed of the two unit cells based on CRLH-TL structure that was designed on a *Rogers_RO*4003 substrate, with a dielectric constant of 3.38, a thickness

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of 0.8 mm and TanD = 0.0022. This mushroom type unit cell consisted of 6.6 mm x 6.4 mm or $0.085\lambda_0$ x $0.08\lambda_0$ patch, printed on top of the Substrate which in each unit cell, the series capacitance (CL) is developed by two the printed L-shaped gaps into radiation patches, and the shunt inductance (LL) is resulted from the spiral inductor shorted to the ground plane through the metallic via. The topology possess the RH parasitic effects that can be view as shunt RH capacitance (C_R) and series RH inductance (L_R). The C_R is mostly come from the empty spaces between the patch and the ground, and the unwanted currents which flow on the patch raise L_R, that indicates that these C_R and L_R cannot be ignored. The recommended modeling keeps the overall dimension of the single cell small while aims at reducing the ohmic loss to improve radiation characteristics. The microstrip antenna patronages all cellular frequency bands from 3.35 - 4.75 GHz, applying single or multiple feed designs, which removes the demand for antenna switches. All of these attributes make the suggested microstrip antenna is well suitable for today's needs such as wireless components, RF circuits and microwave implementation [3, 4].

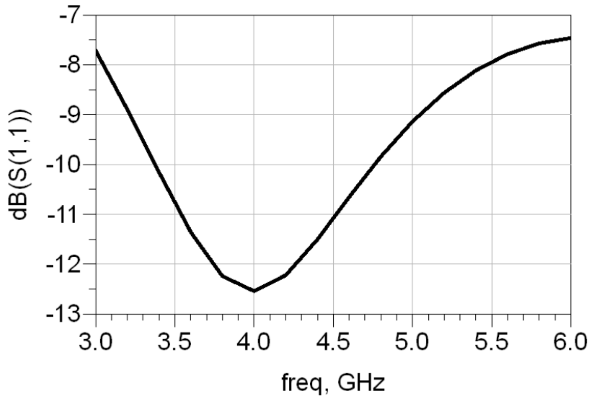

Figure 3: *Simulated reflection coefficient S_{11} of the suggested microstrip antenna.*

Simulation Results and Discussions

The proposed microstrip antenna based on metamaterial is designed as a CRLH antenna where the substrate has dielectric constant $\epsilon_r = 3.38$, thickness h = 0.8 mm and TanD = 0.0022. Broadband and small recommended antenna is simulated by using the full-wave simulator (ADS). The simulated reflection coefficient (S11 parameter) displayed in figure 3, and simulated radiation gain pattern in 3.4, 4 and 4.6 GHz are plotted in figure 4. The simulated gains at

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3.4, 4, 4.6 GHz are -1.26, 0.76, and 2.4 dBi, respectively. The radiation patterns have unidirectional characteristics. The simulated radiation efficiency is 19.84% at 3.4 GHz, 11.69% at 3.4 GHz, and 35.98% at 4.6 GHz. To validate the design procedure the proposed microstrip antenna was compared with some of the antennas and their dimension and radiation characteristics were summarized in Table 1.

The two unit cells of the wideband and small antenna is designed from 3.35 GHz to 4.75 GHz and this antenna exhibit good matching between this frequency band for 20Ω impedance port. The physical length, width and height of the suggested antenna are 13.2 mm, 6.4 mm and 0.8 mm ($0.17\lambda_0$ x $0.08\lambda_0$ x $0.01\lambda_0$), respectively. The gain and the radiation efficiency of this antenna are varies from -1.3 dBi to 2.6 dBi and from 9.41% to 38.2%, respectively, into the frequency range 3.35 GHz to 4.75 GHz.

Table 1: *Dimension and Radiation Characteristics of some of the Antennas in Comparison of the proposed Microstrip Antenna*

Papers	[4]	[5]	Microstrip Antenna
Gain	0.45 dBi	0.6 dBi	2.6 dBi
Bandwidth	0.8-2.5 GHz	1-2 GHz	3.35-4.75 GHz
Efficiency	53.6%	26%	38.2%
Dimension	$0.4\lambda_0$ x $0.03\lambda_0$ x $0.03\lambda_0$	$0.07\lambda_0$ x $0.07\lambda_0$ x $0.03\lambda_0$	$0.17\lambda_0$ x $0.08\lambda_0$ x $0.01\lambda_0$

Conclusion

In this paper, we introduced a new concept of antenna size reduction with broad bandwidth accompanying enhancement gain based on a MTM design methodology. A practical wideband, miniature and high gain microstrip antenna with a simple feed structure and planar circuit integration possibilities has been demonstrated. Overall size of the recommended antenna is 13.2 mm x 6.4 mm x 0.8 mm or $0.17\lambda_0$ x $0.08\lambda_0$ x $0.01\lambda_0$ at the operating frequency f = 4.05 GHz where λ_0 is free space wavelength. A return loss below -10dB from 3.35 GHz - 4.75 GHz was obtained which corresponding to 34.56% bandwidth. The peak gain and the maximum efficiency of the proposed antenna which occurs at f = 4.75 GHz, are 2.6 dBi and 38.2%, respectively. This antenna has the

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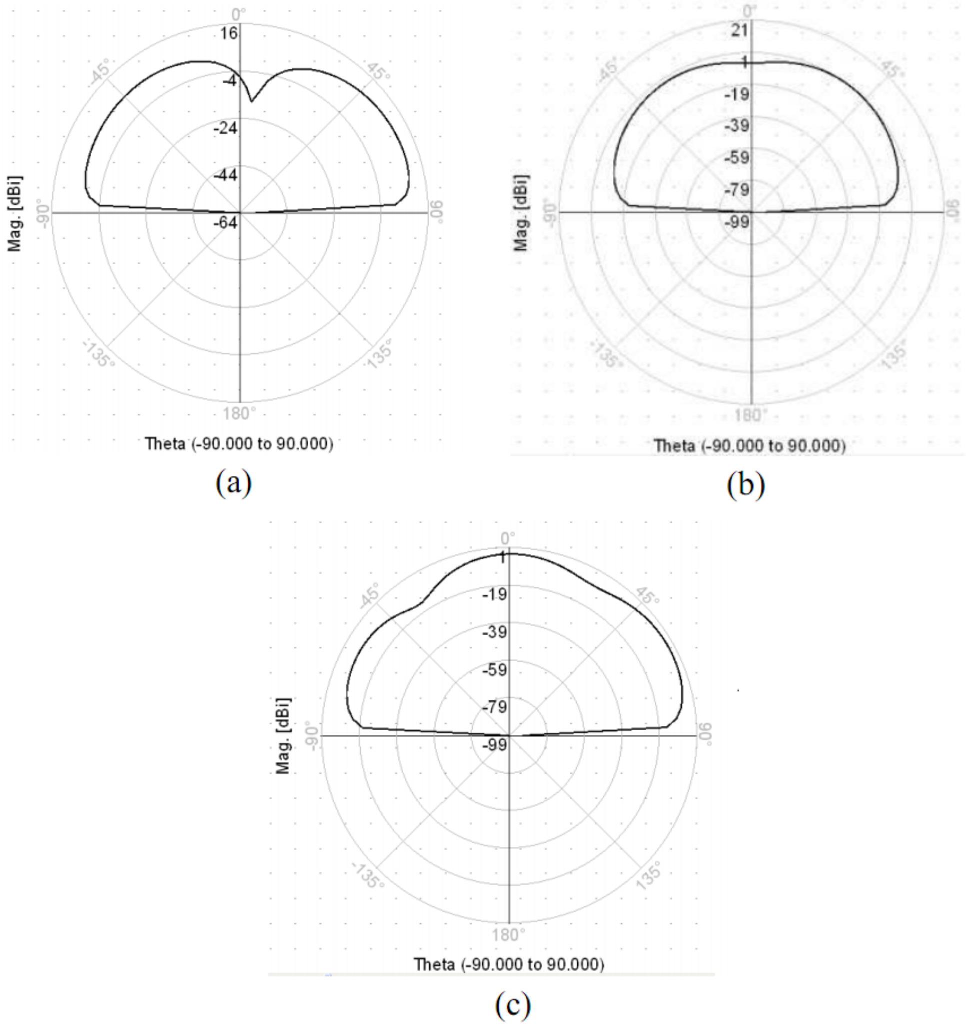

Figure 4: *Radiation gain pattern of the microstrip antenna in elevation ($\phi = 0^o$), a) at 3.4 GHz, b) at 4 GHz and c) 4.6 GHz.*

advantages of ultra-wideband, compact size, high gain, unidirectional radiation patterns and simple implementation. The recommended microstrip antenna can be used for Today's needs such as microwave apparatus, wireless components, transceivers and so on.

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