International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.01, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Design of Wide Band Patch Antenna Backed by a Planer Electric-LC Resonator

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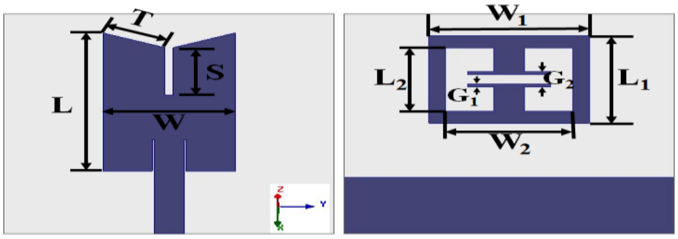
ABSTRACT

An omnidirectional low cost wideband microstrip antenna, backed by an electric-LC resonator, applicable for WiMAX and WLAN applications is presented in this paper. In the given design, a simple patch printed over the substrate is main component used for the radiation and a planer electric-LC resonator is printed on the back side of the antenna. An electric-LC resonatoris consists of inductive walls and capacitive gap, and the resonant frequency depends on its physical dimensions. This resonator is used to enhance the bandwidth and to design the antenna having small size. By utilizing this structure a wide band, from 2.5-GHz to 6.5-GHz, is obtained which covers 2.5/3.5/5.5-GHz for WiMAX and 5.2/5.8-GHz for WLAN. The presented antenna in this paper is advantageous because of having easy design, low cost of fabrication, smaller size and ease of fabrication which is suitable for WiMAX and WLAN communication systems.

Key-words-Electric-LC(ELC), omnidirectional.

I. INTRODUCTION

RINTED antennas have an important role and plenty of applications in the fast developing wireless industry, military, aircraft, missile, satellite and in the many other commercial tools. The increasing use of Worldwide Interoperability for Microwave Access (WiMAX), Personal Area Network (PAN) and Wireless Local Area Network (WAN) leads to the design and development of wideband microstrip antennas having low profile, compact size, light weight and low cost of fabrication. Compactness of these small size antennas leads to high integration level in the microwave devices and communication systems. In this paper, great emphasis is given in designing electrically small microstrip antenna having wideband that covers 2.5-GHz to 6.5-GHz range. In [1-4], a number of monopole and slotted antennas are reported for WiMAX and WLAN applications but, all of them have very large size and complex structures.Number of multiband antennas are presented in [5-8]. In [5], a simple structure of T- shaped antenna having dual band is reported but it has only two narrow operational bands like antenna used in [6]. In [7], the configuration consists of a



(a) (b)

Fig.1. Antenna configuration: (a) Patch (b) ground

monopole radiator and a trapezoid conductor printed on the ground plane excellently covering upper/lower bands of WiMAX and WLAN but dimensions are not suitable for the limited space. In [8], a small size CPW fed antenna is projected and it is suitable for various tri-band uses but it shows different radiation patterns for all the three bands i.e. E –field and H- field patterns are not stable. Configuration used in paper [9] is integrated with EBG (electromagnetic band gap) structures and an Electric-LC resonator which produces dual band and covers required bands for WiMAX and WLAN. The EBG structure used in this antenna increases the complexity in fabrication and makes it bulky and also EBG structures have some disadvantages like surface wave losses and cavity losses. CSRR(Complementary splinted resonating rings) and ELC (Electric-LC) configurations have property of containing a static resonating frequency at smaller wavelength than guided wavelength. So these structures are helpful in miniaturization of the structure [10],[11].An ELC resonator consist of parallel metallic walls and capacitive slits forms a circuit analogous to the LC circuit whose frequency of resonance is restricted by the size and dimensions of the walls. ELC resonators are utilized to design many important devices, e.g., absorber [12], [13], modulators [14], [15] etc. Some
-reconfigurable ELC resonators have the property of frequency tuning are reported in [16]. In this paper a simple planer electric-LC resonator is proposed.Like usual LC circuits, the electric-LC resonator makes the structure resonating when the energy restricted in capacitive gaps in the form of electric field becomes equal to energy restricted in inductive walls in the form of magnetic field.

II. ANTENNA DESIGN

Configuration of the projected antenna is shown in fig. 1. The design consists of a dielectric substrate, having dimensions 1x35x35 mm^3 and relative permittivity 2.08, sandwiched between a simple patch and ELC resonator. After observing the current distribution in the patch a bilateral triangle, having length of two sides equal to 7 mm and that of third side is equal to 14 mm, is etched from the patch. A rectangular slot, having dimensions 7.5mm x .9mm with one side touches one vertex of the triangle, is also etched from the patch. An electric-LC resonator and a rectangular slot having length 35 mm and width 9 mmis printed on the back side of the antenna as shown in fig. 1(b). Remaining dimensions of the antenna is shown in the table 1. Power is supplied to the antenna through a microstrip feed line printed on the same side of patch. Length and width of the microstrip line is optimized by performing parametric analysis. Operational band of antenna covers a wide band ranging from 2.5-GHz to 6.5-GHz which contains 2.5/3.5/5.5-GHz required for WiMAX and 5.2/5.8-GHz required for WLAN.

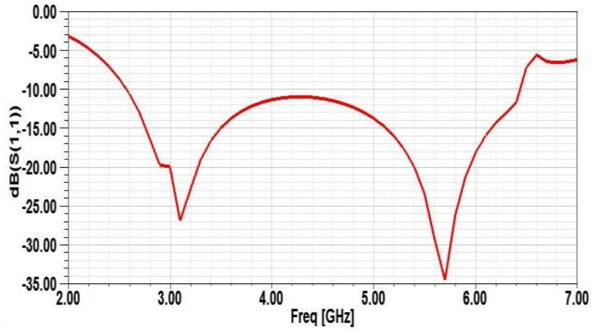


Fig. 2 : Return loss of the antenna.

TABLE 1:*Antenna Dimensions*

L	22 mm	W	14 mm
T	7 mm	S	7.5 mm
L_1	14 mm	L_2	10.1 mm
W_1	17 mm	W_2	13.6 mm
G_1	0.5 mm	G_2	2.5 mm

The graph of return loss, with respect to frequency, is shown in fig. 2 which shows the fraction of power reflected back to the same port through which the power is supplied. It shows a good impedance matching between 2.5-GHz to 6.5-GHz.

Because resonating frequency depends mainly on dimensions of the ELC element so a parametric analysis is carried out to see the effect of change in W_2 and $L_{2.}$ Effect of variation in L_2 is shown in fig. 3(a) by keeping all the other parameters constant. As value of L_2increases from 10.1mm to 10.5mm the bandwidth reduces slightly and two upward spikes occurred at 3.6-GHz and 3.9-GHz for L_2 = 10.3mm and L_2 =10.5mm respectively. So, there is a small effect is observed of varying the parameter L_2.

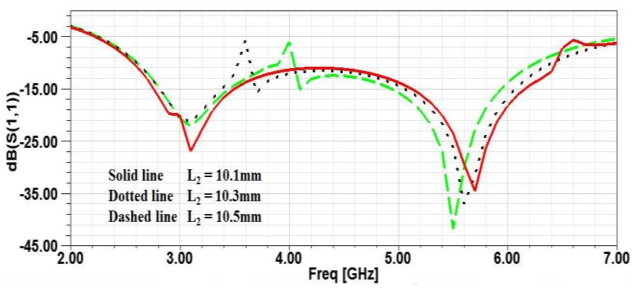


Fig. 3(a): Effect of change in L2 of ELC element

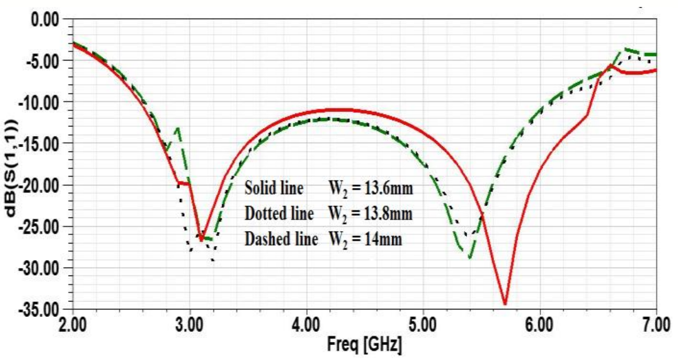


Fig. 3(b): Effect of change in W_2 of ELC element

In fig. 3(b) variation of W2is shown. As W_2 increases from 13.6mm to 14mm upper cut-off frequency reduce to 6.05 GHz from 6.5 GHz due to which bandwidth reduces slightly. So, L_2 is kept at 10.1mm and W_2 is at 13.6mm.

III. RADIATION PATTERN

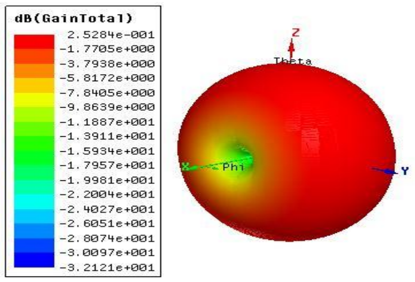
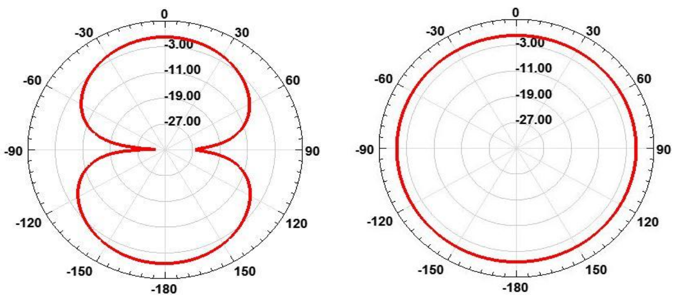


Fig. 4: 3-D Polar plot



(a) (b)

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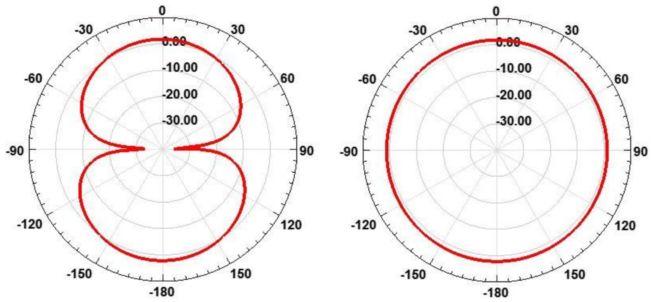
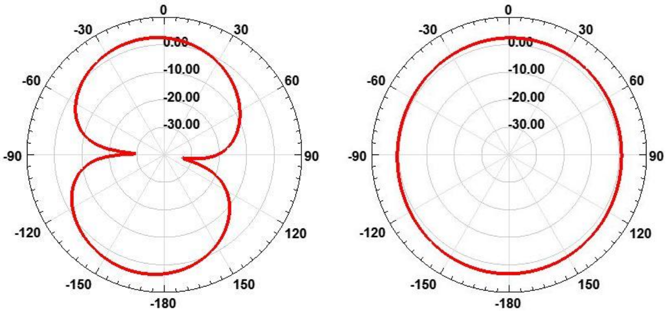
ISSN: 2319-8354



(a) (b)



(c) (d)

Fig 5: Simulated radiation pattern of antenna at (a) 2.5-GHz, (b) 3.5-GHz
And (c) 5.5-GHz

Dissemination of power with respect to space is shown in fig. (4). 3-D polar plot of the antenna is donut-shaped or toroidal which validates the polar plot of an omnidirectional antenna. Cross-sectional view of the 3-D polar plot is shown in fig. (5), which demonstrate the E-field and H-field plot of the antenna at all the three resonant frequencies 2.5-GHz, 3.5-GHz and 5.5-GHz.The radiation pattern shown in fig. (5), shows a stable radiation pattern for all the three resonant frequencies which overcomes the drawback of the antenna used in [8].

IV. CONCLUSION

A wideband omnidirectional antenna integrated with an electric-LC element is shown in this paper. The proposed antenna covers a wideband from 2.5-GHz to 6.5-GHz, this operational band consists of 2.5/3.5/5.5-GHz bands for WiMAX and 5.2/5.8-GHz bands for the WLAN. The proposed antenna has a stable radiation pattern for WiMAX and WLAN frequency bands with 99% efficiency. The reported antenna has an easy configuration and electrically small size which can be applied for different wireless systems and microwave devices.

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