Dielectric Resonator Antenna with Wideband Performance In WIMAX/WLAN Bands

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Abstract— The design and optimization of E-shaped Dielectric Resonator Antennas (DRA) working in WiMAX and WLAN bands is presented in this paper. The E-shaped dielectric resonator antenna has been designed with Rogers RO3010 dielectric material (dielectric constant = 10.2). The operating frequency range of the antenna is 3 GHz to 5.845 GHz. The input impedance plot along with the radiation patterns and E-plot at 3.795 GHz, and 5.51 GHz is also presented. The proposed antenna is having a peak realized gain of 5.7 dB at 5 GHz.

Keywords: broad frequency bands, impedance bandwidth, dielectric materials, dielectric resonator antennas, WIMAX/WLAN,

I. INTRODUCTION

Dielectric resonator antennas (DRAs) have received great attention in the last two decades due to their several attractive advantages such as high radiation efficiency, large bandwidth, flexible feed arrangement, wide range of material dielectric constants, ease of excitation, easily controlled characteristics and ease of integration with other active or passive microwave integrated circuit components. DRAs are quite useful in wireless applications and other high frequency applications, where surface wave losses and ohmic losses limits the performance of conventional metallic antennas. Due to these attractive advantages, DRAs have great potential for application in personnel communication devices and wireless portable devices in near future. The idea of using the DR as an antenna had not been widely accepted until the original paper on the cylindrical dielectric resonator antenna (DRA) [1] was published in 1983. Different geometries of the DRA such as rectangular, cylindrical, hemispherical, circular, triangular etc. are possible [2, 3]. The resonant frequency of the DRA is a function of size, shape and material permittivity. A wide range of dielectric constant can be used (from about 8 to over 100), allowing the designer to have control over the physical size of the DRA and its bandwidth.

Systematic experimental investigations on dielectric resonator antennas (DRA's) were first carried out by Long et al. [4]-[5]. Since then, theoretical and experimental investigations have been reported by many investigators on DRA's of various shapes such as spherical, cylindrical (or cylindrical ring), rectangular, etc. (e.g., [6]-[7]). The research of the wide-band DRA was first experimentally carried out in 1989 by Kishk et al. [8]. Since then many wide-band DRAs have been reported [9]-[15].

In this paper a Dielectric Resonator Antennas (DRA) working in WiMAX and WLAN bands is presented. The proposed structure is having an impedance bandwidth ranging from 3 GHz to 5.845 GHz covering all the desired frequency bands. Section 2 of the paper gives the details of the proposed structure. Results and discussion are included in section 3 of this paper.

II. ANTENNA DESIGN

The antenna structure is designed with Ansoft's HFSS [16]. The antenna structure contains a modified ground plane etched on a FR4 substrate of thickness 1.6 mm. The ground Plane is modified by reducing its length to avoid leakage current to flow in the substrate. On the other side of the substrate an E-shaped dielectric resonator of thickness 8.5 mm is developed. The dielectric material used for dielectric resonator is Rogers RO3010 having dielectric constant of 10.2. This dielectric resonator is fed by a microstrip line which consists of two sections. This type of microstrip line is called stepped microstrip line. This stepping is done for proper impedance matching. The top view, back view and side view of the proposed structure is shown in Fig. 1,2, and 3 respectively. The detailed dimensions of the proposed structure are given in Table 1.

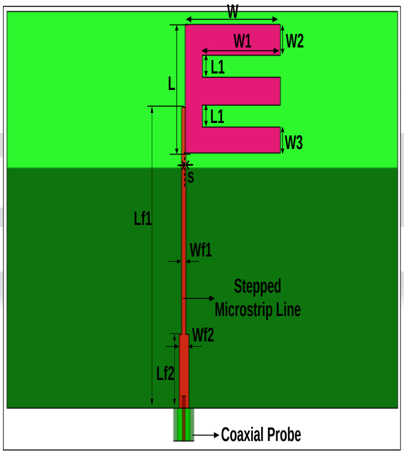


Fig. 1: Top view of the proposed antenna structure.

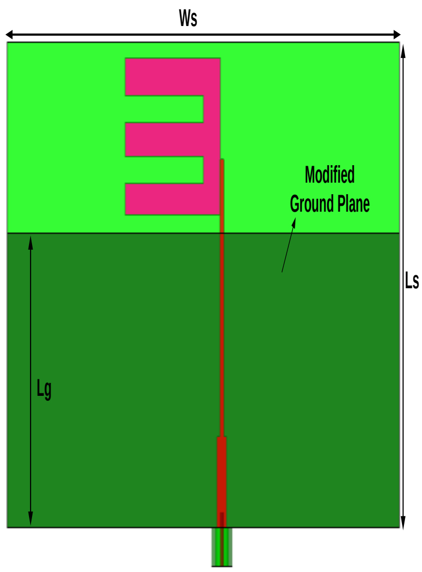


Fig. 2: Back view of the proposed antenna structure.

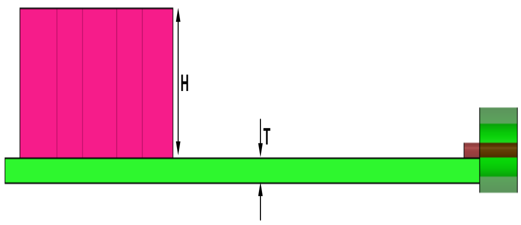


Fig. 3: Side view of the proposed antenna structure.

Table. 1: Optimized antenna dimensions

Parameter	Size (mm)	Parameter	Size (mm)
W	24.4	Wf1	1
L	20	Lf1	47.1
W1	20	Wf2	2.5
L1	3.4	Lf2	11.6
W2	4.8	Ws	100
W3	4	Ls	62
S	0.16	Lg	37.6
H	8.5	T	1.6

III. RESULTS AND DISCUSSION

The simulations are performed in Ansoft's HFSS [16] (considering SMA connector) to optimize the shape parameters of the antenna for the desired operating bands.

A. RETURN LOSS

The return loss results of the proposed antenna are shown in Fig. 4. The impedance bandwidth of the proposed design is from 3 GHz to 5.845 GHz covering WiMAX (3.3- 3.8 GHz) and WLAN Wireless Local Area Network) 5 GHz (5100 - 5800 MHz). At 3.795 GHz and 5.51 GHz frequency, resonance is better. This is because of proper impedance matching at these frequencies. For getting the impedance bandwidth we are taking -10 dB as the reference return loss.

B. INPUT IMPEDANCE (Z_{in})

The input impedance of the proposed structure for the operating frequency range is shown in Fig. 5. It can be seen that the resistive part (real) of the impedance is varying near 50 Ω and the reactive part (imaginary) is varying near 0 Ω. This behaviour is desirable to get proper impedance matching at the port.

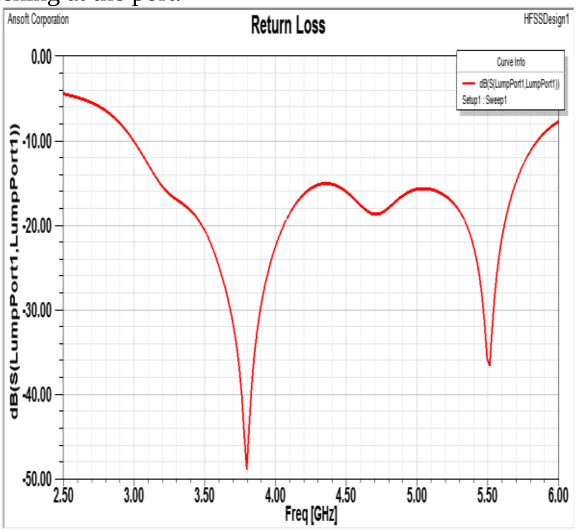


Fig. 4: Return loss characteristics of the proposed antenna.

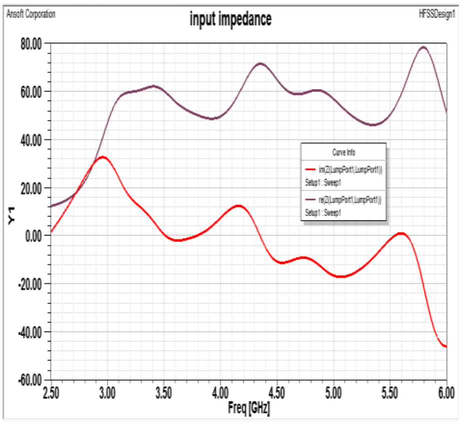


Fig. 5: Input impedance of the proposed antenna.

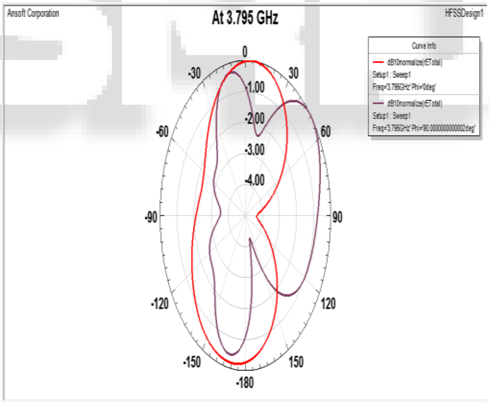
C. RADIATION PATTERN

The radiation patterns of the proposed antenna in XZ plane (phi= 0 degree) and YZ plane (phi=90 degree) at 3.795 GHz, and 5.51 GHz are shown in Fig. 6 (a), and (b).

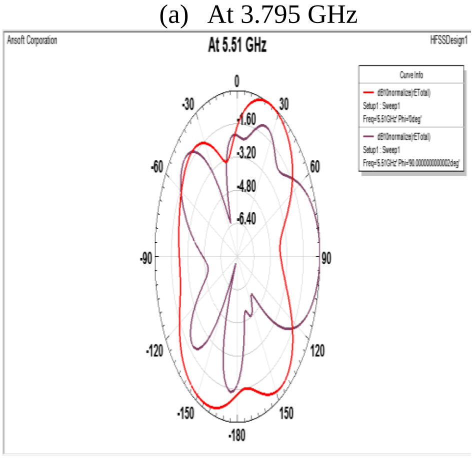
It can be seen from the figure that at 3.795 GHz, there is a null at theta = 90^0 in XZ plane. Wide beamwidth is obtained in YZ plane. At 4.74 GHz, in the XZ plane main beam is towards theta = -120^0. At 5.51 GHz, antenna is capable to receive and transmit the signal in almost all the directions.

D. E-PLOT

The plot of electric field intensity at 3.795 GHz, and 5.51 GHz are shown in Fig. 7. The E variation along the E-shaped DR and microstrip line is presented in the figure.

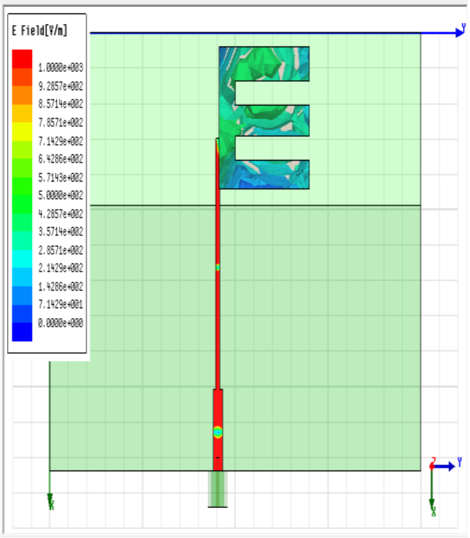


(a) At 3.795 GHz

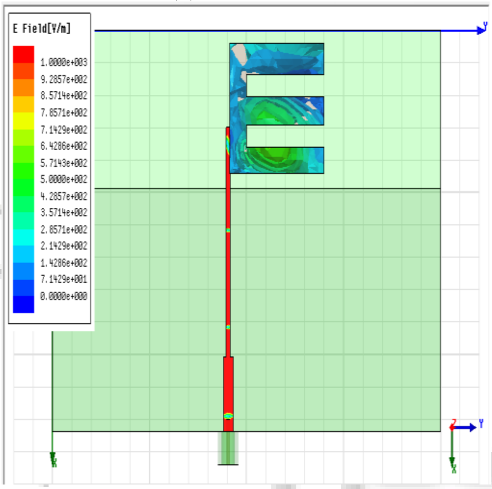


(b) At 5.51 GHz

Fig. 6: Radiation pattern of the proposed antenna.



(a) At 3.795 GHz



(b) At 5.51 GHz

Fig. 7: E-Plot of the proposed antenna.

E. PEAK REALIZED GAIN

The peak realized gain of the proposed antenna varies from 3.21 dB to 5.7 dB in the operating frequency range of 3 to 5.845 GHz. The plot of peak realized gain against frequency is shown in Fig. 8.

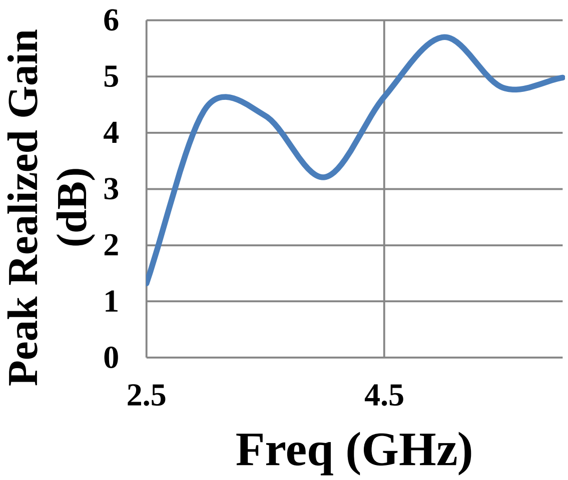


Fig. 8: Plot of Peak Realized Gain.

IV. CONCLUSION

An E-shaped dielectric resonator antenna has been designed and presented with Rogers RO3010 dielectric material (dielectric constant = 10.2). The operating frequency range of the antenna is 3 GHz to 5.845 GHz. The proposed antenna is covering WiMAX and WLAN 5 GHz applications. The radiation patterns, E-plot and peak realized gain of the proposed antenna is presented in this paper. The proposed antenna is having a gain of 5.7 dB at 5 GHz.

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