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Design of A Dual Band Split Ring Slotted Square Patch Antenna for Wimax Applications

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Abstract

In this article the authors have proposed a single coaxial square complementary split ring antenna with high directivity. The analysis of dual resonance frequencies with respect to the key parameters of square complementary split ring antenna is well matched to industry based IE3D software as well as experimental results. The proposed antenna resonated at frequencies 2.25-3.1Ghz which is quite close to the WiMAX range in India. Thus, the proposed antenna can be optimized for WiMAX applications.

1. Introduction

With the increase of demand for data usage, internet connectivity and networking, new methods have emerged out making older methods obsolete. One such emerging technology that we are going to focus here is Wi-Max (Worldwide Interoperability for Microwave Access), a wireless communication standard (IEEE 802.16 family of network standards)[1], designed to provide a data rate of 30-270 Mbps[2][3]. There is no uniform global licensed spectrum for WiMAX however the WiMAX forum has published three licensed spectrum profiles: 2.3 GHz, 2.5 GHz and 3.5 GHz, in an effort to drive standardization and decrease cost. The various frequency ranges of WiMAX application in various parts of the world are as follows. In USA, the biggest segment available is around 2.5 GHz,[22] . Elsewhere in the world, the most-likely bands are 2.3 GHz in Asia, countries like India and Indonesia will use a mix of 2.5 GHz, 3.3 GHz and other frequencies [4]. Pakistan's Wateen Telecom uses 3.5 GHz. In this paper the authors have described the design and implementation of one such antenna that can possibly be used for Wi-Max accessed in Asia and India at a freq range of 2.2-3.0 GHz with good directivity.

2. The proposed antenna model

The proposed antenna model has been inspired form the concept of metamaterial, where the SRR has been etched out from the top part of the patch (fig-1). Interestingly the antenna worked at dual frequencies and also showed good radiation pattern at these frequencies. The frequencies at which the antenna resonated are 2.25 GHz and 3.3 GHz which is the application range for Wi-Max in India [4] and hence the proposed model can be used for Wi-Max application in East Asia. Generally a square patch antenna gives more spurious radiations and to reduce these spurious radiations loaded split ring, slot ring and notches are generally used [5][6-9]. The SRR is a resonator and not a radiator, to study its use as an antenna SRR have been etched from the top part of the patch antenna and its effect by varying various parameters like ‘a’, ‘b’, ‘g’ , ‘k’ and ‘t’ as shown in fig1.

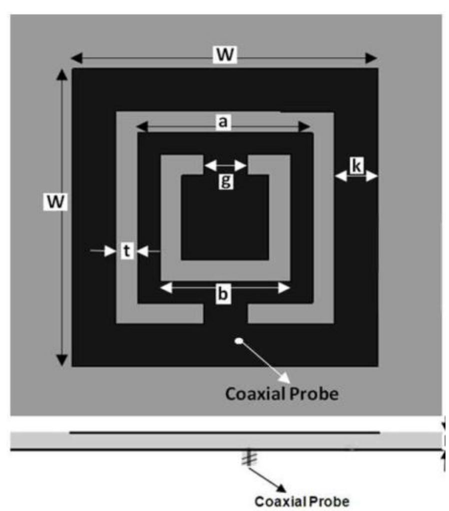

Figure-1: Prototype of square complementary Split Ring Antenna (CSRA)

3. Analysis

The proposed square complementary split ring antenna (SCSRA), gives dual narrow band with maintaining high gain. In this paper the authors, proposed formulae for dual resonate frequencies of SCSRA could be determined on the basis of some key parameters of SCSRA, like ‘a’, ‘b’, ‘g’, ‘k’ and ‘t’ as shown in fig1. The first resonant frequency f_1 and second resonant frequency f_2 can be determined as [5].

$$f_1 = \frac{c(a+b)}{a^2 + 2ab} \qquad (1)$$

$$f_2 = \frac{c}{a} \qquad (2)$$

Where the dimensions of ‘a’ and ‘b’ could be defined from equation (1), (2) and (3) as

$$a = \lambda_2 \qquad (3)$$

$$b = \frac{\lambda_2(\lambda_1 - \lambda_2)}{(2\lambda_2 - \lambda_1)} \qquad (4)$$

Under the constraints that.

$2f_1 > f_2$ and $(f_2 - f_1) < 1.5$ GHz,

Where, ‘c’ is equal to velocity of light in free space.

‘k’ = ‘g’=’2*t’..

‘$\frac{t}{k}$’ and ‘$\frac{t}{g}$’ should be = 0.5 and,

The above formulas can be used to design antenna working at some other different resonant frequencies. But, certain constraints as mentioned above have to be kept in mind.

4. Dimension of the proposed antenna

The dimensions and specification of the proposed antenna are as follows. Refer fig-1.

W =14 cm
a =10cm
b =6cm
t =1cm
k =2 cm
g =2cm
Name of substrate = ECCOSTOCK HT0003
Permittivity of substrate (ε)=2.2
Loss Tangent of substrate =0.0003
Thickness of substrate =3.2mm
Ground plane substrate dimensions =20x20cm

5. Results and Explanations

Fig. 1 shows the prototype of fabricated SCSRA made by ECCOSTOCK HT0003 substrate where the dimensions are defined as ‘W’=14cm, ‘W/a’ is equal to 1.4, ‘b/a’=0.6, ‘t/a’=0.1 and the value of ‘k’=‘g’=2*t. Both the length and width of ground plane is 20 cm. The dielectric constant ‘ε’ is equal to 2.2 and the loss tangent is 0.0003. The thickness ‘h’ of this dielectric sheet is 3.2mm. The comparison of reflection coefficient (S_{11}) between IE3D software and experimental result is shown in fig-2 in decibel scale. The experimental setup for reflection coefficient is taken place by N5230A-Vector Network Analyzer. According to proposed theory as mentioned in equation number 1 and 2, are well matched with both IE3D and experimental results and these data are given in table-1. The fig-3 shows the comparison of well matched radiation patterns of both simulated and experimental one. In elevation plane at 2.22 GHz, the high gain occurred at $\varphi=0^0$ and the pattern shape maintains according to fig-3. Similarly in same elevation plane at second resonance frequency i,e 3.06GHz high gain occurred at $\varphi=50^0$ and the pattern looks as shown in fig3. During measurement of radiation pattern inside the anechoic chamber, the distance between source-antenna to Antenna under Test (AUT) which is nothing but SCSRA, are kept at distance (1meter) greater than $2\frac{D^2}{\lambda}$ for all frequencies. The experimental data and IE3D data of radiation pattern is compared in Fig. 3. From Fig. 3 it is been concluded that in 1st resonant frequency (f_1) at $\varphi = 0^0$, the effective communication takes place at $\theta = 60^0$ and $\theta = 0^0$ and $\theta = -60$ whereas at 2nd resonant frequency (f_2) the effective communication takes place at $\varphi = 50^0$ *and* $\theta = 30^0$,-30^0.

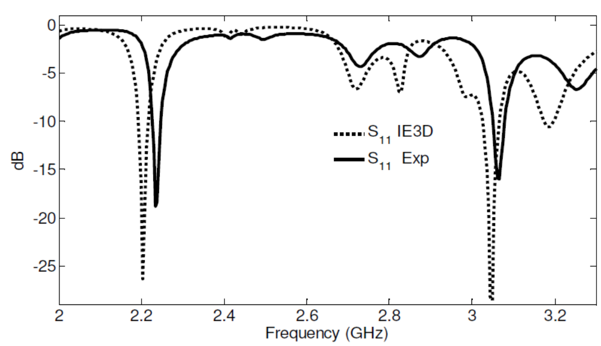

Figure-2: Comparison of reflection coefficient at port number-1 in dB scale in IE3D and Experimental.

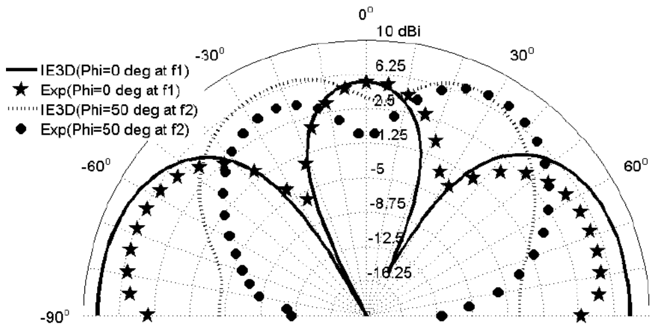

Figure-3: comparison of radiation pattern at phi(ϕ)=0^0 in f_1 and phi(ϕ)=50^0 in f_2.

Table-1

1st Resonant frequency(f_1) / 2nd resonant freq(f_2)	IE3D		Expt	
	f_1(GHz)	f_2(GHz)	f_1(GHz)	f_2(GHz)
Resonant frequency	2.2	3.1	2.24	3.06
Error in frequency w.r.t theory	0.4%	2.5%	2.2%	2%
Phi(ϕ)	0^0	50^0	0^0	50^0
Gain(dBi)	8.19	9.37	8.19	9.37

6. Conclusion

The authors presented a simple probe feed of square complementary split ring antenna producing dual resonance frequencies with enhanced frequency diversity. The proposed formulae of resonance frequencies are well matched to industry based IE3D simulation software as well as experiment also. The square CSRA gives dual operating frequency with robust diversity pattern. The error in frequency w.r.t thoeroy was relatively low and teh antenna resonated at frequencies of 2.25-3.1 GHz which can possibly used for Wi-Max applicaions in Asia.

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