IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735. Volume 6, Issue 1 (May. - Jun. 2013), PP 30-33
www.iosrjournals.org

Design of Rectangular Dielectric Resonant Antenna for ku-band Applications

Arigela Nagaraju, R Ramesh
(Department of Communication Systems, SRM UNIVERSITY, India)
(Dept. of Electronics and Communication Engineering, SRM UNIVERSITY, India)

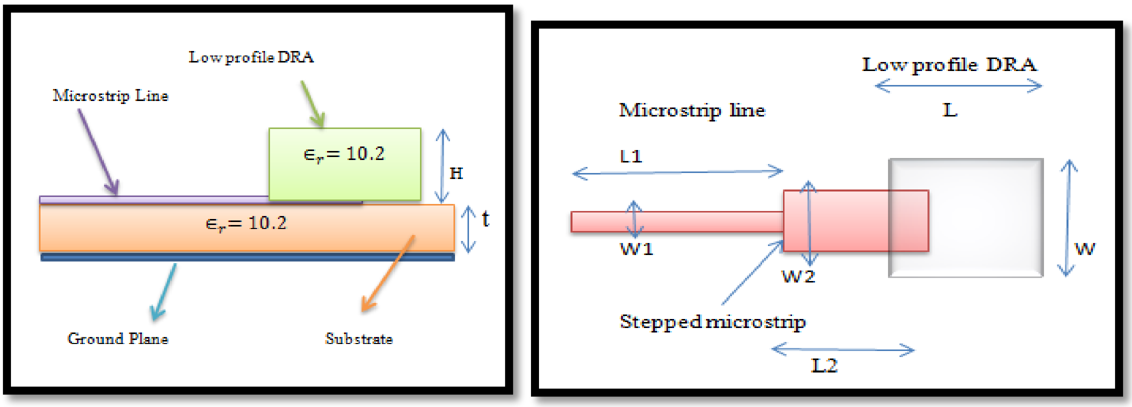
Abstract: *in this paper, a novel broadband, low-profile dielectric resonator antenna using relatively low dielectric constant substrate material .The rectangular DRA is fed with a modified stepped micro strip feed to ensure efficient coupling between the feeder and the RDR. By introducing the RDR with two narrow conducting metallic strips of suitable width the performance of the proposed antenna has been significantly improved, the result leads to a wider operating bandwidth. Parametric investigations for different geometrical variables have been presented. The return loss and radiation performance of the proposed antenna and the related prototypes are successfully optimized with numerical experimentation techniques using Ansoft HFSS software.*
Keywords: *Broadband, Dielectric resonator, Loading strips, Rectangular dielectric resonator antenna, stepped micro strip*

I. Introduction

In recent years, the demand for wideband antennas for wireless mobile communications has led to the development of antennas that are low profile and small in size. In the last two decades, micro strip patch antennas [1] and DRAs [2] have been extensively investigated as suitable antennas for wireless communication applications. The DRA offers attractive features such as low ohmic loss, low profile, small size, wide impedance bandwidth as compared to the micro strip antenna. The DRA can be used at millimeter frequency bands and is compatible with existing excitation methods such as coaxial probe, micro strip transmission line, coplanar waveguide feed or aperture coupling. DRAs are available in basic shapes such as rectangular, cylindrical, spherical and hemispherical geometries. RDRAs offer more design flexibility since two of the three of its dimensions can be varied independently for a fixed resonant frequency and known dielectric constant of the material [3]. Hence, the RDRAs for the current investigations is chosen. Feeding mechanisms that are generally used for DRAs include using micro strip lines [5], coaxial probes [6], coplanar waveguide feeds and aperture coupling. Coupling techniques that have appeared in the literature [3] require high of the permittivity (usually greater than 10) to ensure efficient coupling. Even though high permittivity results in a small DRA, it also narrows the bandwidth. If efficient coupling for relatively low-permittivity, low profile DRAs can be realized, much wider bandwidth can be obtained. Furthermore, inexpensive widely available microwave substrates can be used to make the DRA, rather than commonly used DRAs using high permittivity ceramic resonators. This is precisely the focus of this research. In this paper, a novel, simple, and efficient coupling technique of low permittivity, low profile DRAs, resulting in very broadband performance is presented. Techniques published in the literature for high dielectric constant DRAs include two or more stacked DRAs [7], coplanar parasitic DRAs, and inclusion of air gaps inside DRAs . Such techniques require additional DRA elements increasing the size of the overall antenna or involve a more complicated geometry. The bandwidth of DRA can also be extended by attaching additional parasitic elements to incur another resonance. In this paper, a metallic strip is attached to the top of a DR to incur additional resonance close to that of the DRA resonance. The inductance of the metallic strip and the capacitance between the strip and the ground plane form an LC tank circuit which can be coupled to the DR resonant mode to exhibit a wider bandwidth. Also, the impedance bandwidth of DRA can be further increased by modifying their feeding structures. In this paper a stepped microstrip feed is used to ensure an efficient coupling. The paper first introduces an optimized RDRA, its EM simulated and measured S-parameters then the simulations and measurements of the single and double metallic loading strip RDRA.

II. Antenna Design

The proposed geometry of the low profile DRA fed with a stepped micro strip line is shown in Fig. 1. Through simulations using a commercial full wave analysis software package (Ansoft HFSS), we observed that the width of a metallic strip under the DRA affects drastically its input impedance. A narrow strip width resulted in a high input impedance, much higher than 50 Ω, whereas a wide strip lowered the input impedance of the DRA; hence the proposed geometry.



(a) Stepped micro strip feed RDRA (side view) **(b) Stepped microstrip feed RDRA (top view)**

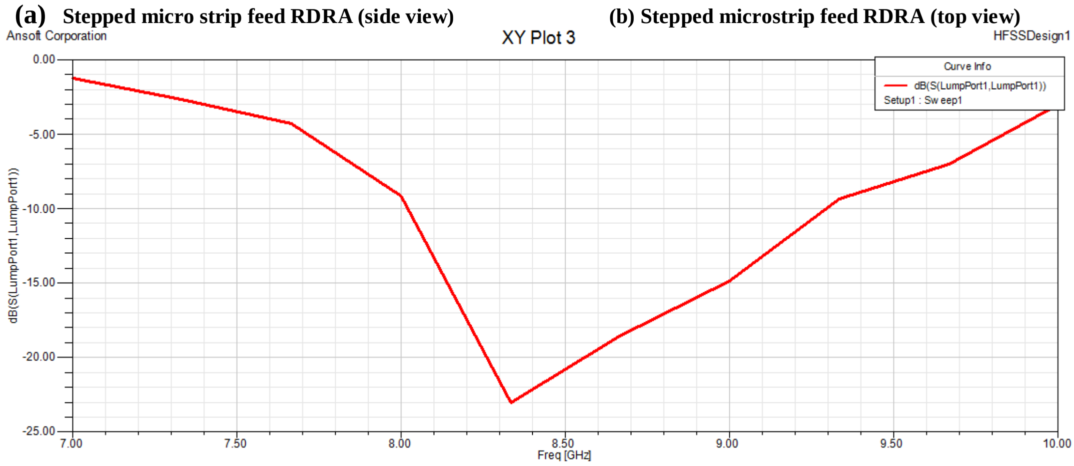


Fig. 2:Stepped microstrip RDRA and simulated |S11|.

The wide strip in essence provides the necessary impedance matching, if its dimensions (width and length) are optimized. The DRA has a dielectric constant ϵ_r and dimensions of length l, width w and height h. whereas the width and length of the stepped section are w2 and l2, respectively as shown in Fig. 1(b). The dielectric constants for both the DRA and the feed substrate are chosen to be the same. The dielectric constant of the resonator material should be $\epsilon_r = 10 - 100$,the size of the DRA can be significantly reduced. Figure 1(b) shows the schematic diagram and the photograph of the designed antenna by stepped micro strip with dimensions W = 10 mm, L = 10 mm, and H = 2.5 mm. A Rogers RT/Duroid 3010 substrate with the thickness t of 1.27 mm and a dielectric constant ϵ_r of 10.2 is used in this study. Figure 2 demonstrates the simulated S-parameters of the optimized antenna versus frequency. The HFSS simulated results show that the relative bandwidth achieved with optimal parameters is about 13 % ranging from 8.0 to 9.3 GHz. The measured and simulated results are shown in Fig. 2. A good agreement is indicated. A 10 dB return loss bandwidth of 16 % (8.0-9.3 GHz).The fractional bandwidth of 16 % represents a very good result for this antenna construction. Simulation results of the optimized stepped micro strip feed RDRA with gain up to 5.8 dB, efficiency up to 89.7 %, and directivity up to 6.34dB.

The TE111 mode of the resonator is excited. In this mode the resonator radiates like a magnetic dipole. The resonance frequency of the TE111 mode of this antenna can be determined using the following equations:

$$k_x^2 + k_y^2 + k_z^2 = \epsilon_r\, k_0^2 \quad (1)$$

$$k_z \tan\left(\frac{k_z H}{2}\right) = \sqrt{(\epsilon_r - 1)k_0^2 - k_z^2} \quad (2)$$

$$\text{Where } k_x = \frac{\pi}{w} \text{ and } k_y = \frac{\pi}{w} \quad (3)$$

By solving these equations for k_z and k_0, the resonant frequency can be obtained from:

$$f_0 = \frac{c}{2\pi} k_0 \quad (4)$$

Where f_0 = 12.52 GHz theoretically while the simulated value is 12.16 GHz with percentage error of 4 %. As the DR permittivity increased the resonant frequency decreased, which results in a high quality factor. As a result the antenna bandwidth is reduced so a low permittivity substrate is used to overcome such problem. It should be noticed that for electrically small antennas there is a trade-off between the size, bandwidth and efficiency.

Every geometrical parameter has different effects on the overall performances of the proposed antenna. It is observed that the width of the metallic strip under the DR affects extremely its input impedance. While wide strip provides the necessary impedance matching, if its dimensions, width and length are optimized. the height of the RDR affects fairly the resonant frequency which decreases as the RDR height increases

III. Proposed Double Metallic Strip Rdra

Figure 3 shows the schematic diagram of the proposed low profile RDRA fed with a stepped micro strip line and loaded with metallic strip. With intensive EM simulations, the antenna is designed and optimized using a commercial 3D full-wave analysis software package. The metallic strip over the RDR affects significantly its gain and bandwidth. A metal strip on the RDR disturbs the shield current and it can change the effective inductance and capacitance of the DRA. A narrow stepped micro strip width resulted in a high input impedance, much higher than 50 Ω, whereas a wide strip lowered the input impedance of the DRA, hence the proposed geometry. The wide strip in essence provides the necessary impedance matching, if other dimensions like width and length are optimized. The DRA is built on Rogers RT/Duroid 3010 substrate with thickness of t = 1.27 mm and dielectric constant $\in_r$ of 10.2. The antenna length L = 10 mm, width W = 10 mm and height H = 2.5 mm. The feed microstrip line has 50 Ω characteristic impedance whereas the width and length of the stepped section are W2 and L2, respectively as shown in Fig. 4. The metallic strip width on the RDR is SW = 2 mm. The dielectric constants of substrate for both the RDR and the feed line are chosen to be the same. The two metallic strips on the RDR will disturb the shield current and it can change the effective inductance and capacitance of the DRA.

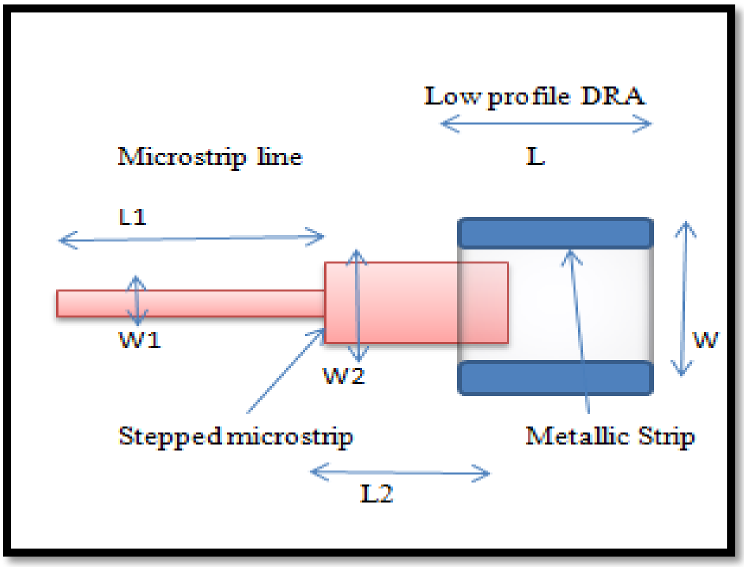
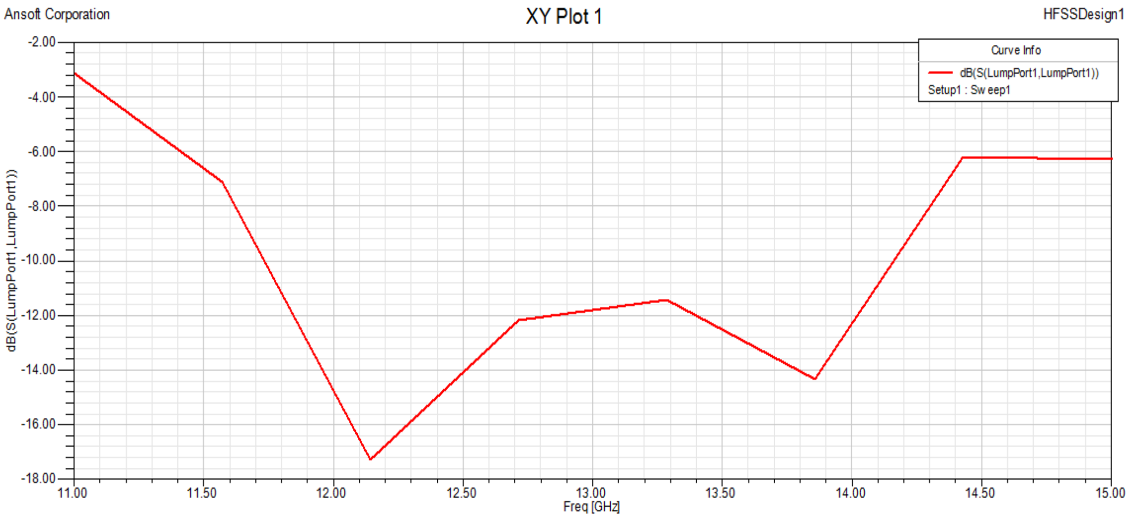
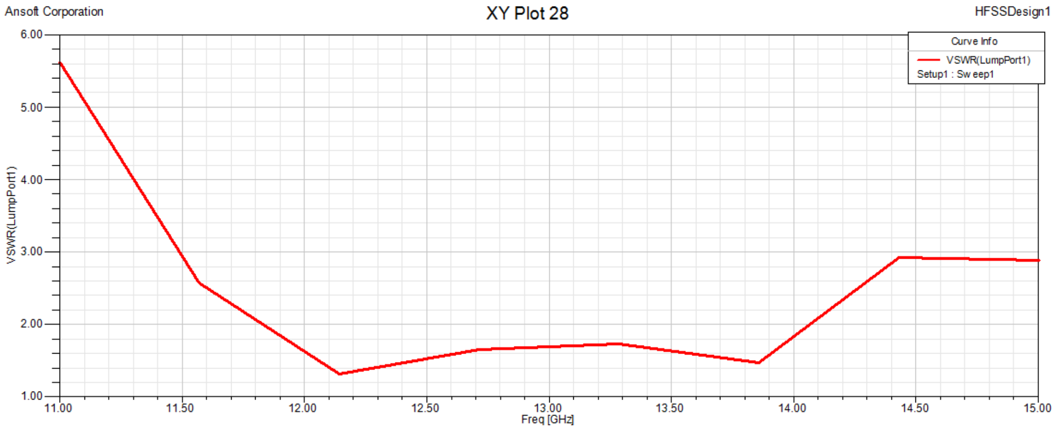


Fig 3: Double metallic Strip RDRA (top view)



(a) Simulated |S11| parameter frequency vs. Return loss

Figure 4(a) illustrates the antenna simulation results of the optimized broadband single metallic strip RDRA which produces a bandwidth 2.4 GHz from 11.75 to 14.15 GHz suitable for wideband wireless communication applications at KU-band



(b) Simulated VSWR Parameter frequency vs. Return loss

Fig.4: Simulation results for proposed double metallic strip RDRA

Figure 4(b) shows the VSWR is below than 2 from the 11.75 to 14.15 GHz frequency range and gain improvement up to 8.27 dB, efficiency up to 87.5 %, and directivity up to 8.78 dB.

It is obvious from Fig. 4 that both simulated and measured S-parameters are in good agreement within the frequency band. A 10 dB return loss bandwidth of 26 % (11.75- 14.15 GHz) with a Centre frequency f_0 = 12.52 GHz is obtained. The difference between the computed and measured central frequencies is only about 4 % (100 MHz). The fractional bandwidth of 26 % represents a very good result for this antenna construction.The proposedantenna offers a peak gain of 8.27 dB, a peak directivity of 8.78 dB.

IV. Conclusion

In this paper, a design of a novel broadband rectangular DRA has been presentedIn this design, a bandwidth enhancement has been obtained by adding a double metallic strips above the RDR and by using stepped microstrip feed. The obtained results show a bandwidth of 26 %.The radiation patterns are found to be stable over the operating frequency range. With these features, the proposed RDRA is suitable for wideband wireless communication systems in the Ku-band.

References

[1] A. Khidre, K. F. Lee, F. Yang, and A. Elsherbeni, "Wideband Circularly Polarized E-Shaped Patch Antenna for Wireless Applications," *IEEE Antennas and Propagation Magazine*, vol. 52, no. 5, pp. 219-229, October 2010.

[2] K. M. Luk and K. W. Leung, "Dielectric Resonator Antennas", *Research Studies Press Ltd Press*, Baldock, Herfordshire, UK, 2002.

[3] Mohsen Khalily, Mohamad Kamal Abdul Rahim, and Ahmed A.Kishk, "Bandwidth Enhancement and Radiation characteristics Improvement of Dielectric Resonator antenna," *IEEE antennas and wireless propagation letters*, vol.10, pp.393-395, 2011.

[4] M. Saed and R. Yadla, "Microstrip-Fed Low Profile and Compact Dielectric Resonator Antennas," *Progress In Electromagnetics Research*, PIER 56, 151–162, 2006.

[5] R.A.Kranenburg and S.A. Long, "Microstrip Transmission Line Excitation of Dielectric Resonator Antennas," *Electronics Letters*,vol.24, no. 18,pp.1156-1157,setember 1988.

[6] Hany A.Atallah and Ehab K.I.Hamad, "Radiation Pattern Improvement of RDRA Using LHM Flat Lens Composed of CSRR," *IEEE-APS Middle East Conference on Antennas and Propagation*, Cairo, Egypt, 2010.

[7] Y. F.Ruan, Y. X. Guo, and X. Q. Shil, "Wideband Dielectric Resonator Antenna," *Microwave and Optical Technology Letters*, vol. 48, no. 2, February 2006.

[8] Y. F. Ruan,Y. X. Guo, and X. Q. Shi1, "Equivalent Circuit Model of Tri-Resonance Wideband Dielectric Resonator Antenna," *Microwave and Optical Technology Letter*, vol. 49, no. 6, June 2007.