A High Gain Aperture Coupled Cylindrical Dielectric Resonator Antenna with Metamaterial Superstrate

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***Abstract*—This paper presents a design of high gain cylindrical dielectric resonator antenna (CDRA) with the help of metamaterial superstrate. A double layered metamaterial superstrate with unit cell periodicity of 4x4 is designed and suspended above a CDRA. The height of metamaterial superstrate from the ground is optimized to enhance the gain of antenna. The CDRA is fed by microstrip through aperuture at the ground plane. The gain of CDRA with metamaterial superstrates is found to be increased by 4.1 dB and the impedance bandwidth is al so improved.**

Keywords—cylindrical dielectric resonator antenna (CDRA), metamaterial superstrate, high gain.

I. INTRODUCTION

In recent years the demand for wireless mobile communication has led to development of antenna that are low profile and high gain antennas. Dielectric resonator antenna has received much attention in recent years due to high Q-factor, Small size, ease of feeding techniques, high radiation efficiency. The most distinctive advantage of DRA is that it does not have any metallic loss. DRA provides different shapes of antenna such as spherical, hemispherical, cylindrical and rectangular. Cylindrical DRA offers greater design flexibility, where the ratio of radius to height controls the resonant frequency and Q-factor. So for given dielectric constant and resonant frequency, different Q-factor can be obtained by varying DRA dimensions. DRA can be excited by different feeding techniques such as probe, coplanar waveguide, dielectric image guide, aperture coupling and microstrip lines [1]. Various modes can be exited which gives rise to different radiation pattern. DRAs can radiate in both omnidirectional and broadside directions depending on mode of excitations.

Metamaterials are composite material that is purposefully engineered to provide material properties that are not otherwise attainable with ordinary materials. Among different metamaterials, the zero index metamaterials is used as superstrate lense. The electromagnetic waves pass through them which results in concentration of electromagnetic energy normal to metamaterial superstrate [3, 4]. So this uniqueness of metamaterial superstrate can be used to enhance the gain of DRA.

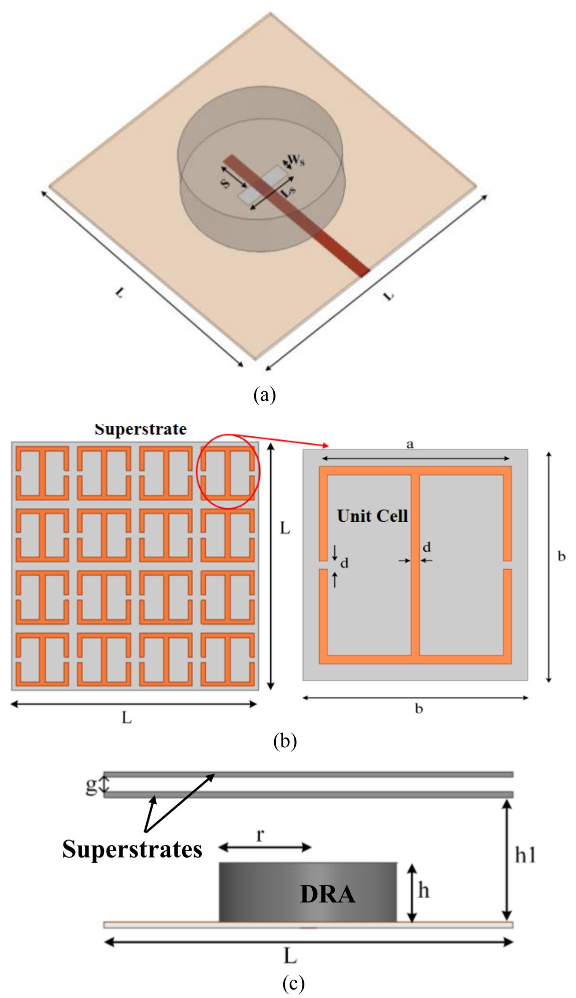

Fig.1 Proposed design (a) Cylindrical DRA without superstrate, L=55, S=6, Ls=6.8, Ws=1.6 (b) superstrate and its unit cell, a=11.75, b=13.75, d=0.5 (c) with superstrate, r=8.6, h= 5, h1=34, g=1. All dimensions are in mm

In this paper an aperture coupled CDRAs antenna is designed and then metamaterial superstrate layers are used to enhance the gain. For this purpose single layer superstrate and then double layer superstrate are used and significant gain improvement is found.

II. Cylindrical Dieectric Resonator Antenna Design

Fig.1 (a) shows the schematic design of CDRA without superstrate. The CDRA is excited by aperture made on the ground plane of the microstrip line. The aperture length (L_S) and stub extension (S) are optimized to excite $HE_{11\delta}$ mode which results in omnidirectional radiation pattern. The designed antenna resonates at 5.7GHz with gain of 5.7 dBi. Rogers RT/duroid 6010 with dielectric constant ε_r=10.2 is used for CDRA and Rogers RT/duriod 5880 substrate with dielectric constant ε_r=2.2 is used for the microstrip line.

III. Metametirial Superstrate Design

Fig.1 (b) shows the metamaterial superstrate and its unit cell. The unit cell [4] consist of a set of metallic lines printed on one side of Rogers RO4350 substrate with a thickness of 0.762mm and dielectric constant ε_r = 3.66. Design parameters of unit cell (a, b, d) are shown in Fig.1 (b). The unit cell parameters are optimized such that, it enhances the gain of CDRA at frequency of 5.7 GHz. A 4x4 array is formed using the unit cells which form the superstraete.

IV. Enhanced Gain CDRA Using Metamaterial Superstrate

Fig.1(c) shows the CDRA with suspended Metamaterial superstrate. The height h1 and gap g are optimized [2, 5] from the ground plane using Ansoft HFSS. The response of the antenna without superstrate, with single layer and double layer supertrates are shown in Fig.2. From the figure we see that the impedance bandwidth is improving with superstrate and there is aslo shift in resonant frequency. The compared E and H-plane radiation pattern of the designed antenna is shown in

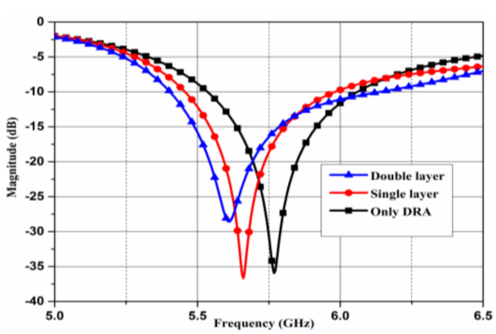

Fig.2 S_{11} comparison of proposed design

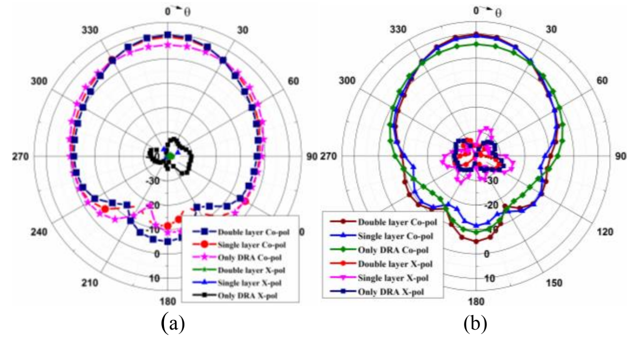

Fig.3 radiation pattern (a) E-plane (b) H-plane

Fig 3. The gain of the CDRA without superstrate, with single layer and with double layer superstrate is 5.7 dBi, 9 dBi and 10 dBi respectively. The cross polar level in both E and H-plane are below 20 dB.

V. Conclusions

We have proposed a CDRA with enhanced gain by making use of metamarerial superstrate. Without superstrate the gain of CDRA is 5.7dBi. With single layer and double layered superstrate the gain increased by 3.3dB and 4.3 dB respectvely. The proposed antenna can find application in many wireless communication systems.

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