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Research Article

Parametric Study of Cylindrical Dielectric Resonator Antenna (CDRA) Feeder with Symmetric Parabolic Reflector

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Abstract: In this study a parabolic reflector antenna is designed and fabricated for IEEE 802.11a WLAN application. Initially, a single element circular tuning slot coupled Cylindrical Dielectric Resonator Antenna (CDRA) feeder is designed and fabricated for a symmetric parabolic reflector. Subsequently, the designed feeder is integrated at the focal point of the parabolic reflector to provide unidirectional radiation pattern with improved gain and sidelobe levels. The measured fractional impedance bandwidth achieved for the proposed antenna is 1.8% for S_{11}<-10 dB from 5.32 to 5.52 GHz. A radiation pattern with broadside radiation and low back radiation has been obtained. A good measurement gain of approximately 13 dB is achieved over the bandwidth by placing CDRA feeder at the focal point of the parabolic reflector. In addition, a comprehensive parametric study has been conducted to realize the effect of slot size and position on the resonance frequency of the designed feeder. Furthermore, a parametric study of various reflector parameters has also been performed to study the effect of size, depth and focal point of the parabolic reflector on gain of the antenna. Important design factors have been identified from the parametric study of the antenna. The experimental and measured results show that the designed antenna is suitable for IEEE WLAN 802.11a wireless application.

Keywords: Aperture coupling, circular slot, Cylindrical Dielectric Resonator Antenna (CDRA) feeder, parabolic reflector antenna

INTRODUCTION

An extensive, fast and explosive expansion in wireless communication technology and communication systems has prompted the broad use of high gain, low profile, easy to manufacture and low cost antennas. Although, micro strip patch antennas provide a good solution to the modern requirement of the wireless communication, however the performance of the microstrip patch antennas decreases at the higher frequencies such as millimetre wave frequencies. The Dielectric Resonator Antenna (DRA) has better performance over the microstrip patch antennas since it has lower conductor and surface wave losses at millimetre wave frequencies (Bijumon *et al*., 2007; Baba *et al*., 2013). Dielectric resonator antenna also has several advantages which include its small size, light weight, low loss, ease of fabrication, low production cost, high radiation efficiency (>98%) and high dielectric constant. Furthermore, the benefits of DRA also include that it is available in various sizes, shapes resonance frequency. The impedance bandwidth of DRA can be controlled by its permittivity. For compact size of antenna design, high permittivity of dielectric is used, meanwhile for achieving the wide bandwidth operation a low permittivity of dielectric resonator is commonly utilised (Antar and Fan, 1996; Petosa *et al*., 1998; Nasimuddin and Esselle, 2007; Petosa, 2007; Aras *et al*., 2008). DRAs can be excited by different feeding techniques such as probes (Yuehe and Esselle, 2009; Huynh *et al*., 2011), slot (Denidni and Xian-Ling, 2009; Ohlsson *et al*., 2013), microstrip lines (Trabarov, 2011; Rashidian *et al*., 2012), dielectric image lines (Song *et al*., 2006; Al-Zoubi *et al*., 2009; Omar and Al-Hasan, 2009; Abeesh and Jayakumar, 2011) and co-planar waveguides (Omar and Al-Hasan, 2009; Abeesh and Jayakumar, 2011).

Different implementation of feeding techniques provides different advantages and disadvantages of DRA design. Aperture coupled technique provides

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design advantages that can be favorable in wireless communication. The main advantage of aperture coupling is that it provides feed network under the ground plane which isolates the radiating aperture slot from useless coupling or spurious radiation signals from the feeder structure (Petosa, 2007).

Generally, a single element dielectric resonator antenna exhibits gain of about 5 dBi (Luk and Leung, 2003). Therefore, various gain enhancement techniques of DRA have been presented to achieve high gain of DRA design. A nine element array of DR excited by a microstrip feeder with an aperture slot was designed to enhance the gain of DRA to 10 dBi at 5.84 GHz (Al-Zoubi *et al*., 2010). A gain of 12.31 dBi at 10.5 GHz has also been achieved using 15 elements DRA array by feeding DRA array with Dielectric Image Guide (DIG) technique (Al-Zoubi *et al*., 2010). In some cases, multi-segment DR method is also used to enhance the gain of DRA (Luk *et al*., 1997; Ho Sang and Mun Soo, 2010). Other efforts to enhance the gain of DRA include; integrating DRA with a surface mounted short horn (Nasimuddin and Esselle, 2007) and using Dielectric Image Line (DIL) as feeder (Dashti *et al*., 2009, 2011). In case of DRA array, the arrays are required to have a specific phase and amplitude distribution in order to maximize the gain or to reduce the sidelobe levels. A good gain was achieved in the above cases by using a large number of elements. The fabrication of such large number of elements is difficult and the calculations of phase and amplitude for such a large number of elements are complicated. The DIL technique is an effective solution in obtaining high gain with reduced losses but its design structure is complicated.

In microwave communication field, reflector antennas are widely used for high gain applications mainly in radar and satellite communication (Chair *et al*., 2006; Ito *et al*., 2008; Ali *et al*., 2012). The structure of reflector antennas is designed with several geometrical configurations, but the famous types are plane corner and parabolic reflectors (Kraus, 1988). In high gain antennas the parabolic reflector antenna is commonly used for several applications of wireless terrestrial communications, satellite communications and radar communications. This is due to its ability to lower the cross-polarization, providing very high gain over wide band and ease of design and fabrication. There are different types of parabolic reflector antennas which include symmetric parabolic reflectors, front-fed parabolic reflectors, offset parabolic reflectors and dual offset reflectors.

A reflector antenna consists of two components; a feeder and a parabolic reflecting surface. The main constraint in these antennas is their feed design and size. An appropriate feed design for these reflectors can achieve a good gain. In symmetric parabolic reflector, the central region is usually blocked by the feeder which is placed at its focal point which affects the aperture efficiency and gain of the antenna and causes increase in the sidelobe level. Hence the radiation efficiency of the antenna is reduced. The aperture blockage caused by the feeder structure is greater for reflectors with small aperture size as compared to the reflectors with larger aperture size. A larger feed blocks a larger portion of the reflector central region and also requires heavier support structures. The heavier support structures further blocks the aperture and hence causes further reduction in the performance of the reflector antenna.

Moreover, in symmetric parabolic reflector antenna, the system performance is mainly controlled by the feed (Ludwig, 1973; Clarricoats and David Olver, 1984). The designed feed must illuminate the reflector efficiently and cause small spillover. Therefore, the designed feed must have a broad radiation pattern within the cone of the reflector (James and Hall, 1989). Since the dielectric resonator antenna exhibits the property of having broad radiation pattern, therefore it offers a good potential as a feed for symmetric parabolic reflector.

In this study a circular aperture coupled Cylindrical Dielectric Resonator Antenna (CDRA) feed is designed and fabricated with the symmetric parabolic reflector. The designed CDRA feed is placed at the focal point of the symmetric parabolic reflector to illuminate reflector efficiently with minimum spillover radiation. The simulation of the antenna is carried out using CST Microwave Studio 2009. A comprehensive parametric study has been carried out to study the effect of changing various parameters of the designed CDRA feed on the resistance, inductance and capacitance and resonance frequency of the CDRA. In addition, a parametric study on the variation of the reflector parameters on the peak gain of the antenna has also been performed. The important design factors have been identified from the detailed parametric study of the designed antenna. Over all the focus of the parametric study is on the performance characteristics of the antenna such as its resonance frequency, radiation pattern and gain.

MATERIALS AND METHODS

Design of CDRA feeder: The geometry of the CDRA is illustrated in Fig. 1a and b while the fabricated CDRA is depicted in Fig. 1c and d. The proposed CDRA is designed on an FR4 substrate with thickness 1.565 mm and permittivity 4.9. A 50 Ω microstrip line of width 2 mm and length 60 mm is used to excite the circular slot. The circular slot with radius 4.5 mm is etched on the ground plane at a distance 33 mm away from the feed point along vertical axis or along microstip line. The circular slot is introduced in the design as tuning mechanism to the CDRA. The dimensions of the circular slot are selected to tune the resonance frequency at 5.4 GHz. A Cylindrical Dielectric Resonator (CDR) of CCTO ($CaCu_3Ti_4O_{12}$) dielectric material with

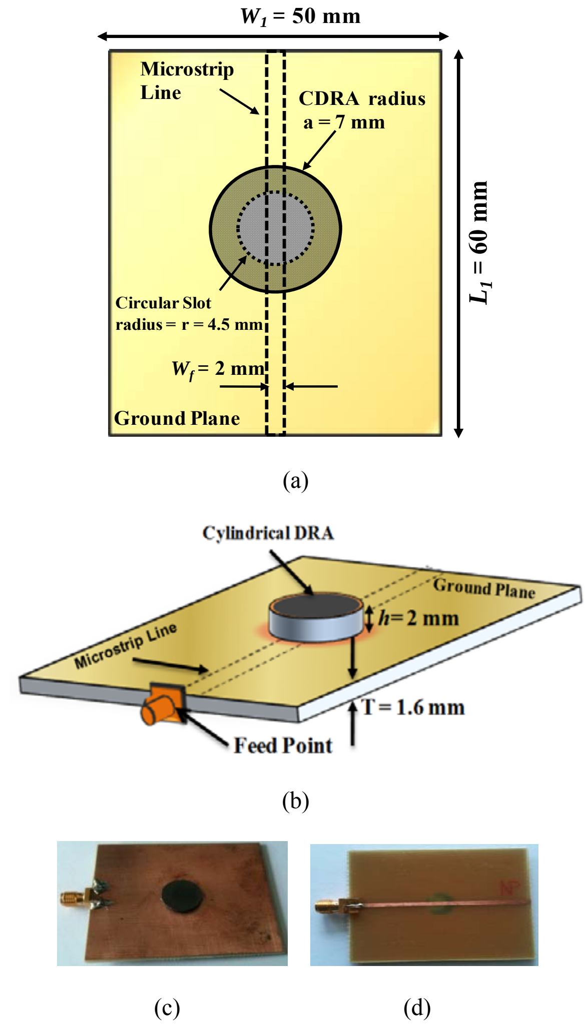


Fig. 1: (a) Geometry of CDRA, (b) perspective view of CDRA, (c) front view of fabricated CDRA, (d) back view of fabricated

Table 1: The dimensions of CDRA feeder

Label	Value (mm)
Radius of CDRA a	7.0
Height of CDRA h	2.0
Radius of the slot r	4.5
Position of the slot from feed p	30.0
Length of the substrate L_1	60.0
Width of the substrate W_1	50.0
Thickness of substrate T_1	1.6

permittivity ε = 55, radius a = 7 mm and height h = 2 mm is placed on the centre of the slot and it acts as a radiating element. This mechanism of feeding and coupling CDR is known as microstrip fed aperture coupling. This technique is extensively used in DRAs and microstrip patch antenna (Ain *et al*., 2012). The dimensions of the CDRA feeder at this optimum frequency is tabulated in Table 1. Furthermore, in the design process of the CDRA, the resonance frequency of the HEM_{11} mode is determined by the following equation (O'Keefe *et al*., 2002):

$$f_o = \frac{c6.324}{2\pi a\sqrt{\varepsilon_r + 2}}[0.27 + 0.36\left(\frac{a}{h}\right) + 0.02\left(\frac{a}{h}\right)^2] \quad (1)$$

where,
f_o = Resonance Frequency
c = Speed of light
h = Height of DR
a = Radius of DR
ε_r = Dielectric constant of DR

The resonance frequency is mostly affected by the value of dielectric constant ε_r and radius to height ratio (*a/h*) of the CDRA. The resonance frequency is inversly proportional to the ε_r i.e., as the values of the ε_r increases, the resonance frequency of the CDRA decreases and vice versa.

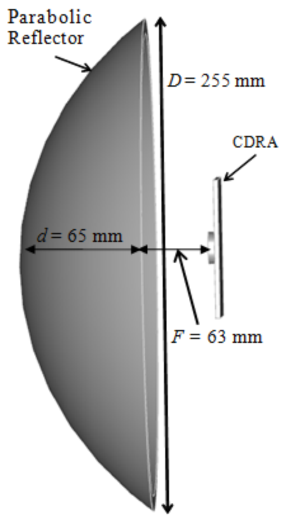
However the resonance frequency increases with the increase in the value of (a/h) which can be achieved by increasing the size of the CDRA or by decreasing its height. Hence, to obtain a desired resonance frequency for a particula r operating mode, the dielectric constant and the dimensions of the CDRA are selected accordingly.

Design of parabolic reflector: Figure 2a shows the geometry of CDRA feeder with symmetric parabolic reflector. The CDRA, with the dimensions 50×60 mm^2 is placed at the center of an aluminum parabolic reflector at its focal point to illuminate the reflector efficiently with minimum leakage through the edges of the reflector. The parabolic reflector with diameter of 245 mm and depth of 65 mm is used in the simulation and fabrication work. The CDRA is placed at the focal point as a feed for the parabolic reflector to obtain a good gain over a frequency band for the designed antenna. The focal point of the reflector is calculated from the equation:

$$F_p = \frac{D^2}{16d} \quad (2)$$

where,
D = Diameter of parabola in mm
d = Depth of parabola in mm
F = Focal point in mm

In practical application of parabolic reflector, it is necessary for the source to be placed at the focal point of the parabolic reflector and illuminate the signal to the parabolic dish efficiently with a small leakage of radiation through the directrix or edges of the parabolic reflector. Consequently the diameter and the depth of the parabolic reflector are selected in such a way that it illuminates the signals efficiently with minimum



(a)

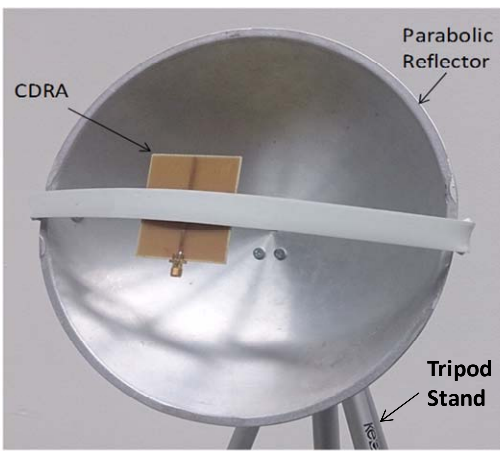


Fig. 2: (a) Geometry of CDRA with parabolic reflector, (b) fabricated CDRA with parabolic reflector

leakage of the radiations arriving from the source. Therefore, in this proposed design, the selection of the parabolic reflector parameters generates optimum gain with the defined dimensions.

The fabricated parabolic reflector with CDRA is depicted in Fig. 2b. To accommodate the CDRA in front of the parabolic reflector at its focal point $F_p = 63$ mm, a Polyvinyl Chloride (PVC) strip is used, which avoids the metallic effect on the radiation of the antenna. The CDRA feeder is glued to supportive PVC strip at the center of the parabolic reflector. A tripod stand is used to hold reflector antenna as shown in Fig. 2b.

RESULTS AND DISCUSSION

Results and discussion of CDRA with parabolic reflector: The fabricated antenna described in Fig. 2b is constructed on the basis of the dimensions and geometrical design shown in Fig. 2a and then it is measured using Agilent E8363C PNA network analyzer. The simulated and measured return loss of the designed prototype is depicted in Fig. 3. It is recorded that the simulated bandwidth, determined at -10 dB reference level is 100 MHz (5.35-5.45 GHz) while the measurement produces a bandwidth of 200 MHz (5.32-5.52 GHz). The measured results produces 100 MHz (100%) more bandwidth as compared to simulated result. This deviation is due to the air gap that exists between the Cylindrical Dielectric Resonator (CDR) and the ground plane for the fabrication unit. This air gap reduces the coupling efficiency between the CDR and the microstrip line. As a result the bandwidth of the antenna increases (O'Keefe *et al*., 2002). It is also observed that the simulated and the measured result generate resonant frequency at 5.4 GHz. It is shown that the measured result shows good agreement with the simulated result. The depth of the measured return loss magnitude (-40 dB) is greater than the simulated return loss (-28 dB). It is found that the measured result produces better impedance matching. The resonance frequency of the parabolic antenna with CDRA remains same as the CDRA without reflector at 5.4 GHz, which is due to large distance between CDRA and parabolic reflector. As a result of this large distance, there is a weak magnetic coupling effect between the feeder and the reflector. Therefore, the resonance frequency with and without reflector remains the same.

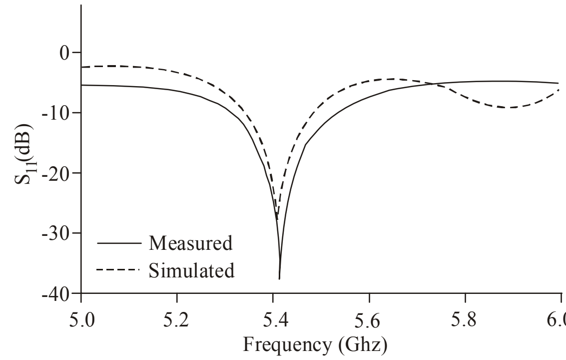
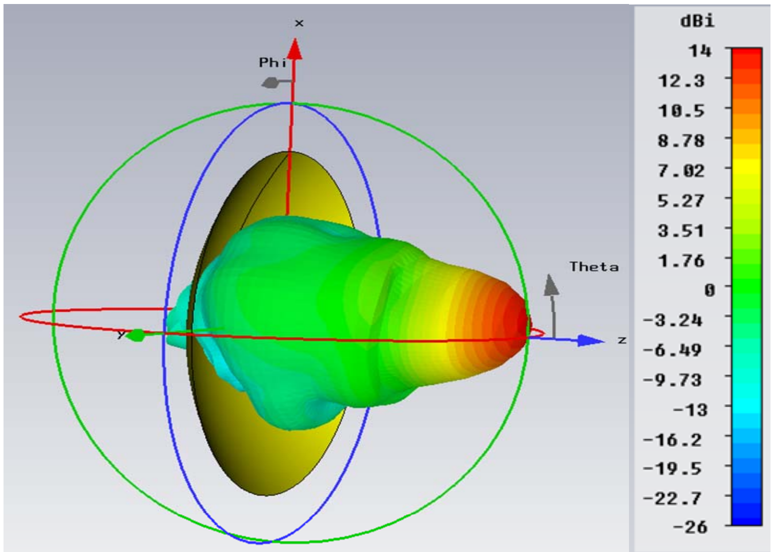


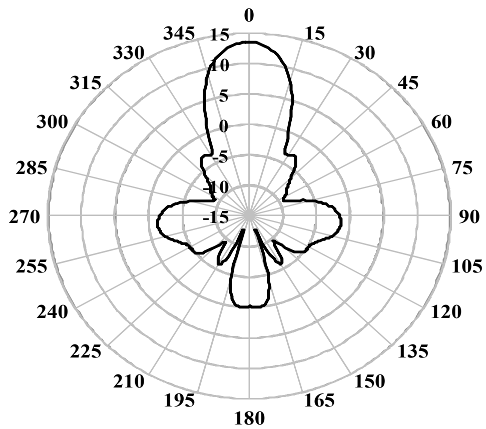
Fig. 3: Simulated and measured return loss (S_{11})

The simulated and the measured *E*-field radiation patterns of the proposed design at 5.4 GHz are depicted in Fig. 4a and b respectively. It is observed that the reflector antenna produces peak gain magnitude of 14.0 dB at 5.48 GHz in the direction of 0°. The measurement result produces a peak gain at 5.4 GHz with reduction gain of 13.5 dB as illustrated in Fig. 4b. In addition, it is also observed that the simulated antenna produces back lobe level of -13 dB in the direction of -180° while the measurement result generate a back lobe level of -10 dB at 5.4 GHz.

From the simulated and the measured results, it is shown that the antenna produces focused beam along



(a)



(b)

Fig. 4: (a) Simulated far-field radiation pattern, (b) measured radiation pattern

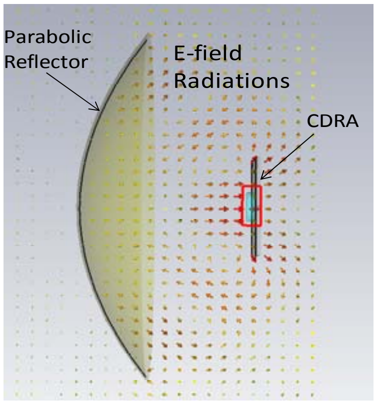


Fig. 5: Simulated E-field radiations

z-axis (Cartesian coordinates) or in the direction of 0^o (polar coordinates) with minimum leakage through the directrix of the reflector and it is suitable for point to point wireless communication.

Figure 5 shows simulated *E*-field radiation signals travelling between the CDRA feeder and the parabolic reflector at resonance frequency of 5.4 GHz. It is observed that the *E*-field radiations from the CDRA strike the parabolic reflector and reflect back parallel to the axis of the reflector which verifies the basic theory of the parabolic reflector antenna. It can also be observed that the magnitude of the radiation is higher within the centre region of the reflector (shown in red colour) and the magnitude of the *E*-field decreases towards the edges of the reflector. It is also noted that the CDRA feeder efficiently illuminates the signals to the parabolic reflector and a small amount of radiations are escaped from the edges of the reflector.

The simulated peak gain of the single element CDRA with reflector is compared with the peak gain of

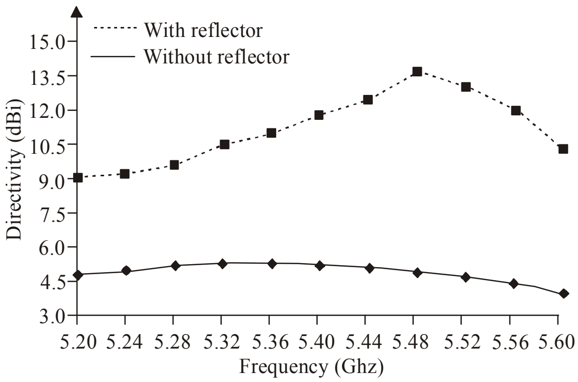


Fig. 6: Simulated peak directivity gain of the CDRA with and without reflector

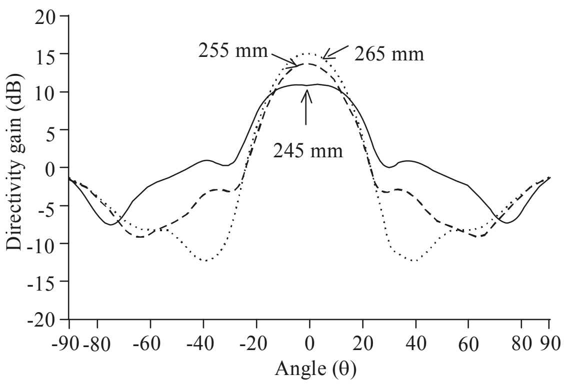


Fig. 7: Effect of diameter of the reflector on the directivity gain of the antenna

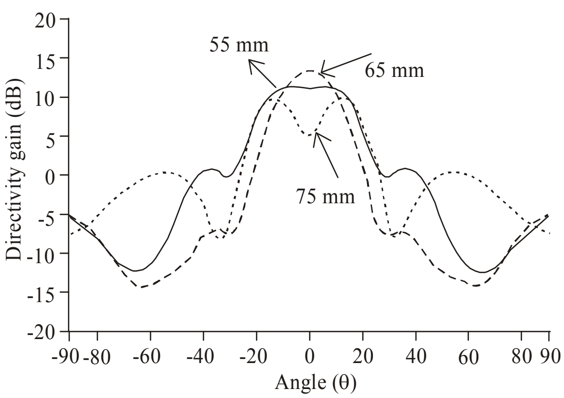


Fig. 8: Effect of reflector depths on the directivity gain of the antenna

the CDRA without reflector from 5.2 to 5.6 GHz as depicted in Fig. 6. It is observed that within the described frequency band, the peak directivity gain of the CDRA with reflector ranges between 9 to 14 dBi with the maximum directivity gain of 14 dBi at 5.48 GHz. Whereas, the peak directivity gain of the CDRA without reflector ranges between 4.8 to 5.5 dBi. The highest directivity gain without reflector is 5.5 dBi which occurs at 5.4 GHz. It is also observed that the peak directivity gain of the CDRA with reflector increases from 9 to 14 dBi as the frequency increases from 5.2 to 5.48 GHz. As the frequency is decreased from 5.48 to 5.6 GHz, the directivity gain of the CDRA with reflector is decreased from 14 to 10.3 dBi.

Similarly, the directivity gain of the CDRA without reflector increases from 4.8 to 5.5 dBi with the increase in the frequency from 5.2 to 5.4 GHz. It is also observed that the directivity gain of the CDRA without reflector decreases from 5.5 to 4 dBi as the frequency is further increased from 5.4 to 5.6 GHz. The variation in the directivity over the frequency band (5.2 to 5.6 GHz) is due to the variation in the impedance matching. The impedance matching of the antenna increase as the frequency increases till the resonance frequency. As a result, more power is radiated from the antenna which increases the directivity gain of the antenna. As the frequency increases further from the resonance frequency, the impedance matching decreases. Consequently, the radiated power decreases, which causes decrement in the antenna gain. Therefore, in both the cases (CDRA with and without reflector), there is significant increment in the peak directivity gain from 5.2 to 5.4 GHz and it is followed by the degradation of the gain for the frequency between 5.4 to 5.6 GHz.

Effect of reflector diameter on the peak gain of the antenna: Figure 7 shows the effect of various diameters of the parabolic reflector on the directivity gain of the proposed antenna at 5.4 GHz. The dish diameter is varied from 245 to 265 mm while the other parameters i.e., focal point and depth are kept constant at 63 and 65 mm, respectively. From the simulation results, it is observed that the directivity gain increases from 10.5 to 14 dBi when the diameter of the parabolic reflector is varied from 245 to 255 mm. This is equivalent to the 40% increment in the gain of the antenna. It is recorded that the antenna gain is increased from 14 to 15 dBi (increment of 17%) as the parabolic dish diameter is varied from 255 to 256 mm. As the dish diameter is varied from 255 to 265 mm, there is slight increase in the directivity gain of the antenna as compared to the change when it is varied from 245 to 255 mm. Therefore, it is observed that, increment of the dish diameter increases the reception of radiations from the source increases and more radiations are reflected from the reflector. Consequently, the antenna directivity gain is increased. Therefore, it is concluded that the optimum size of the reflector can be selected to be 255 mm as further increase in the size will not have much effect on the directivity gain of the antenna but it will increase the reflector size which will cause in the bulkiness of the antenna system.

Effect of depth of parabolic reflector on the gain of the antenna: The variation of the magnitude of

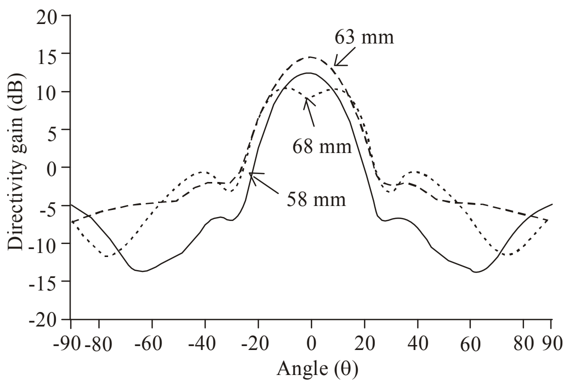


Fig. 9: Effect of focal point of the reflector on the directivity gain of the antenna

directivity gain due to variation of parabolic depth is depicted in Fig. 8. The depth of the parabolic reflector is varied at 55, 65 and 75 mm and the antenna operates at resonance frequency of 5.4 GHz. It is observed that by varying the depth of the parabolic reflector from 55 to 65mm, the directivity gain varies from 12.3 to 13.7 dB i.e., the improvement in gain of over 11%. Similarly when the depth of the parabolic reflector is further increased from 65 to 75 mm, there is degradation in the peak gain of the antenna from 13.7 to 11 dB. It is observed that, the increment in the depth of the reflector increases the receiving area and allow more radiations signals from the feeder at the specific dimension of depth. Further increment to the depth dimension will cause in the leakage of radiation through sidelobes. It is also noted that the symmetric radiation pattern is achieved at all the dimensions of d. However, the maximum directivity gain is achieved with depth of 65 mm. Therefore, it is concluded that the directivity gain of the antenna is significantly affected by the variation in the depths of the parabolic reflector. As the depth of the parabolic reflector is varied from the optimum value of depth d = 65 mm, the radiation energy is not focussed towards the main beam direction (at 0^o) and produces broad radiation pattern. As a result the magnitude of the main beam is reduced.

Effect of focal points of parabolic reflector on the gain of the antenna: Figure 9 shows the effect of various focal points of the parabolic reflector on the directivity gain of the proposed antenna with the parameters of diameter and depth of the parabola fixed at 245 and 65 mm, respectively. The focal point of the antenna is increased from 58 to 68 mm with the increment of 5 mm. The critical analysis results at 58, 63 and 68 mm are depicted in Fig. 9. The results indicate that the antenna achieved a directivity gain of 12 dB at focal point of F_p = 58 mm with operating frequency of 5.4 GHz. It is observed that the antenna achieved directivity of gain of 14 dB at focal point of 63 mm. Further increment to the focal point from F_p = 63 mm to F_p = 68 mm caused decrement in the directivity gain of the antenna from 14 to 10.5 dB. From these variations in the focal point, it is observed that variation in the focal point of the reflector from the optimal value of focal point of 63 mm causes decrement in the directivity gain of the antenna. This variation in the directivity gain is due destructive interference between the incident and reflected radiations. Commonly, feeder is placed at the focal point of the parabolic reflector and reflected waves from the reflector are forwarded along the cantered axis of the reflector and construct a symmetric radiation pattern. Therefore, variation in the position of the feeder from the focal point varies the pattern of the radiations striking the aperture of the reflector which results in a destructive interference between the incident and reflected radiations. As a result the directivity gain of the antenna is lowered.

The results for determination of the focal points of the parabolic reflector are compared with the focal point calculated from equation 4 which is used for dipole feed. The size of dipole feeder is smaller as compared to the CDRA feeder. From the results, it is found that the focal point of the proposed antenna is 63 mm while the focal point calculated from equation 4 is approximately 67.5 mm which is 4.5 mm greater than the optimum focal point of the parabolic reflector with CDRA feeder. There is deviation of 6.7% between the

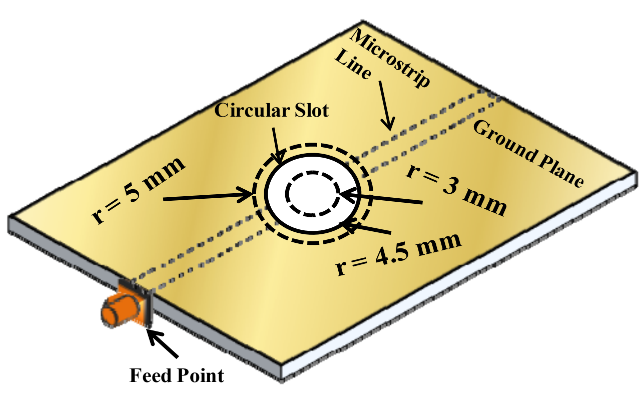


Fig. 10: Geometry of CDRA with different slot radii

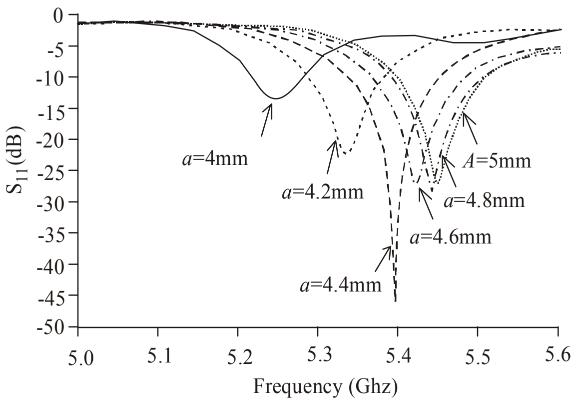


Fig. 11: Effect of different slot radii on the resonance frequency of the CDRA feeder

calculated and actual focal point. Therefore it is found that the parabolic design with CDRA feeder can be implemented with smaller distance of focal point as compared to dipole feeder.

Effect of slot size on the resonance frequency of the antenna: The effect of slot size is examined with CDR height h = 2 mm, radius a = 7 mm and permittivity ε = 55 with slot position if fixed at p = 30 mm from the feed point and varying the radius of the slot.

The radius of the slot is varied from $r = 4$ mm to $r = 5$ mm with the step of 0.2 mm. The geometry of the CDRA with different slot radii is depicted in Fig. 10. The CDRA is omitted from Fig. 10 in order to observe the different sizes of the slot clearly.

Figure 11 shows the resonance frequency as a function of slot radii. It is observed from Fig. 11 that the resonance frequency varies within the range of 5.248 to 5.76 GHz as the radius of the slot is varied from 4 to 5 mm. The results indicate that for radius of the slot 4 mm, the resonance frequency of the CDRA is 5.248 GHz. From the obtained results, it is observed that as the radius of the slot is further increased from the 4 to 5 mm, the resonance frequency is shifted towards the higher frequency and ranges between 5.248 to 5.448 GHz as depicted in Fig. 11. The optimum resonance frequency in this design is selected as 5.4 GHz which can be achieved with the slot radius of 4.5 mm. Therefore, it is concluded that, as the radius of the slot increases, the coupling of the signal from the microstip line through the aperture slot to the dielectric pallet is also increased. Subsequently the resonance frequency is increased. Hence the resonance frequency of the aperture coupled antenna can be tuned to the optimum value by varying the radius of the slot.

The obtained results of resonance frequency vs. slot radius is plotted in Fig. 4. The general equation of the frequency variation as a function of slot radius (a) is derived using MATLAB 2009a curve fitting tool as shown by solid line in Fig. 12. The mathematical equation for the resonance frequency is given as:

$$f(a)_{GHz} = 55.47e^{0.3291a} - 52.65e^{0.3357a} \tag{3}$$

where,
a = Radius of the slot in mm for $4 \leq a \leq 5$

The constant values 55.47, 0.3291, -52.65 and 0.3357, respectively of the above equation are determined by curve fitting method using polynomial equation with an accuracy of 98.8% of obtained results. From the above derived equation, the resonance frequency of the proposed CDRA can be calculated by substituting the values of radius a, of the slot (at which the resonance frequency is to be calculated) and the obtained constant values.

Effect of slot position on the resonance frequency of the antenna: To study the effect of the slot position on the resistance and the resonant frequency, a DRA with height h = 2 mm, radius a = 7 mm and slot radius r = 4.5 mm with slot centered at the DRA axis to excite DRA is considered. The position p of the slot is varied along the microstrip feed line axis with slot positions varying from p = 29 to p = 32 mm with the step of 0.5 mm measured from the feed point along the microstip line axis. Geometry of the CDRA with different

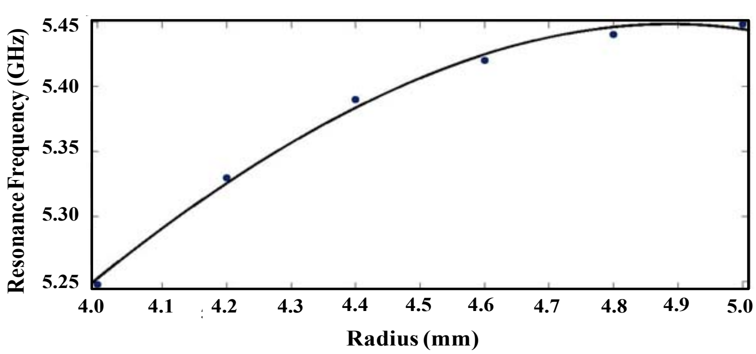


Fig. 12: Plot of resonance frequency versus radius of the slot using curve fitting tool

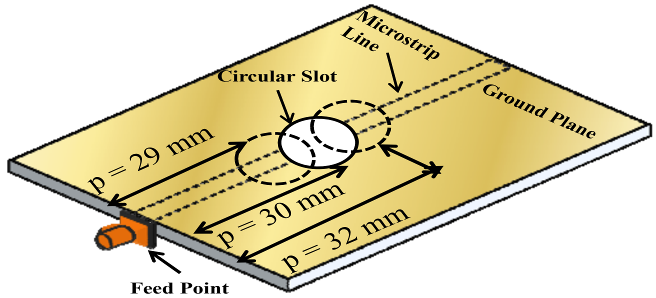


Fig. 13: Geometry of the CDRA showing different positions of the slot

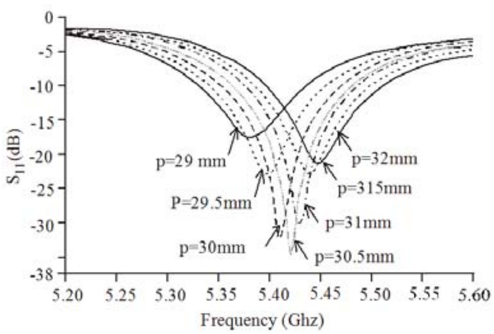


Fig. 14: Effect of different slot positions on the resonance frequency of the CDRA feeder

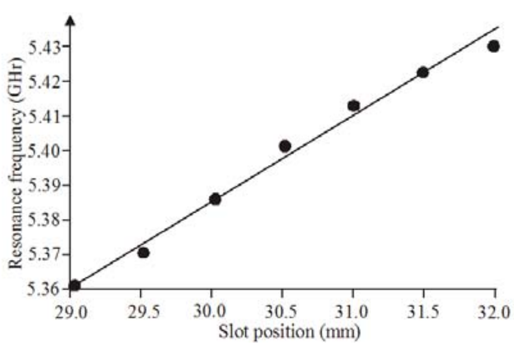


Fig. 15: Plot of resonance frequency versus radius of the slot using curve fitting tool

positions of the slot is depicted in Fig. 13. The CDR is omitted in Fig. 13 in order to create a clear view of the positions of the slot.

The effect of varying the position of the slot on the resonance frequency is illustrated in Fig. 14. It is observed that the resonace frequency of the CDRA feeder is approximately 5.382 GHz when the slot is etched 29 mm from the feed point. As the position of the slot is increased from 29 to 32 mm the values of the resonance frequency increases from 5.382 to 5.438 GHz. The optimum resonance frequency which is 5.4 GHz in this design occurs at a distance 30 mm from the feed point. Therefore the slot is etched 30 mm away from the feed point along the microstrip line axis. From the results it is also observed that the good return loss values of -30, -34 and -38 dB are obtained for p = 30, 30.5 and 31 respectively. For other values of the slot postions the obtaiend return loss values are less than -25 dB. Therefore, it is found that the variation in the position of the circular slot from the feed point along the microstip line axis, varies the impedance matching, which resutls in the shifting of the resonance frequency. However, it is noted that the tuning is not significant in case of variation in the position of the slot as compared to variation in the size of the slot.

In addition a generalized equation for the resonance frequency as a function of slot position is also derived by using similar method as in case of slot radius as shown in Fig. 15. The obtained equation for the resonance frequency as a function of slot postion is given as:

$$f(p)_{GHz} = 0.02514p + 4.653 \tag{4}$$

where:
p_{mm} = Position of the slot for 29≤p≤32

Therefore, by using Eq. (4), the resonance frequency of the CDRA can be obtained within the range 29≤p≤32 by substititing the values of position of the slot at which the resonance frequency is to be calculated. The constant values 0.02514 and 5.653 of the above equation are determined by curve fitting method using linear equation with an accuracy of 99.8% of obtained results.

CONCLUSION

A cylindrical circular aperture Coupled Dielectric Resonator Antenna (CDRA) feeder is designed and fabricated for symmetric parabolic reflector to achieve high gain. A good measured directivity gain of approximately 14 dB is achieved over the bandwidth from 5.32 to -5.52 GHz by placing CDRA at the focal point of the parabolic reflector. A parametric study has been performed to investigate the effects of size and position of the tuning slot on the resonance frequency of the antenna. It is observed that the resonance frequency of the antenna can be varied by varying the slot position and size. In addition, a parametric study of the different reflector parameters has also been conducted to observe the effect of variation in the reflector size, depth and focal point on the directivity gain of the antenna. From the parametric study, it is observed that the variation of the reflector parameters significantly affect the directivity gain of the antenna. The variations in the dimensions of the reflector parameters are analyzed to achieve the optimum performance in the proposed design. A good directivity gain of parabolic reflector with CDRA feeder is achieved at the optimum values of diameter, depth and focal point. The fabricated antenna covers 5.34 to 5.51 GHz band and is suitable for IEEE 802.11a WLAN applications.

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