Design and Analysis of Half-Split Cylindrical DRA for FPV Applications

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Abstract : In this paper, a half-split cylindrical dielectric resonator antenna (HSCDRA) is designed for first person view (FPV) application. Proposed antenna is designed with characteristics including a wideband bandwidth and circular polarization nature. As for the structural information, antenna consist half split cylindrical dielectric resonator (HSCDRA) with two different layers of permittivity while considering radial direction of projection. The circular polarization is achieved by exciting the purposed antenna through a modified CPW (co-planar waveguide) with slotted patch. For the confirmation of rotation of electric field, a TM11$\boldsymbol{\delta}$ mode is used to excite inside the DRA structure. Proposed antenna radiates predominantly in right hand circular polarization field with -12dB over the working band. Center frequency of 5.5 GHz is used which results in 850 MHz usable bandwidth where both S11< -10dB and Axial Ratio (AR) < 3 dB, with bandwidth falls in the range of 5.15 - 6.00 GHz, also radiation efficiency is found to be 90%

Index Terms **- Wideband, Circularly polarization, Half split cylindrical dielectric resonator antenna, slotted patch CPW feed.**

I. INTRODUCTION

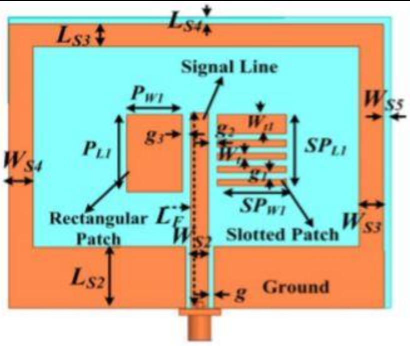
In the modern world of wireless electronics there is an important application on the basis of WLAN technology based on specific frequency of 5.8 GHz which is First Person View (FPV) also known as video piloting. It is a duplex system which is used in unmanned aerial vehicle (UAV) or drones with machine to man interfacing done by using a simple feedback of live video signals from the camera on board, using this info ground-based pilot can control the flights of UAVs. (Fig.1)

Fig. 1. First person view in UAV

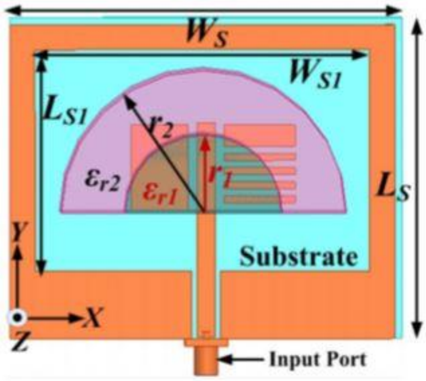
FPV is a perfect example of mm wave antenna usage in modern world. A conventional FPV kit associated with a whip/ dipole antenna which will be used in transmission and reception of video signals. This will be leading to main 3 problems associated with a dipole antenna usage low power situation those are

- Orientation offsets which will be decreasing gain and range.
- Due to the linear polarization of dipole antenna, it is susceptible to multipathing effects.
- Conventional FPV antenna may lag high radiation efficiency which is crucial for low power devices.

Here the above-mentioned difficulties are mainly appeared due to the linear polarization nature of dipole antenna, to overcome this a clover leaf model antenna was designed where multiple dipole antenna was wrapped together to form a structure like a clover leaf like the name suggests. Where the linear polarization problem was addressed by using SDMA (space division multiple accesses) nature of multiple antenna usage but still the conducting material losses remains and it decreases the overall gain of the setup. Circularly polarized (CP) antenna are used for the reliability of video signal on receiving as well as the transmitting side of communications (B. Gupta and C. Kumar,2012). Due to the high degree of flexibility and versatility of DRAs over wide frequency range allow them in becoming perfect candidate for UAV antenna designing (S. Gao, Q. Luo and F. Zhu,2014) (R. Kumar,2014). DRA setup allows antenna engineers to choose from a wide verity of feeding mechanisms as well as the particular characteristics of antenna in terms of its working bandwidth and polarization nature (R. K. Chaudhary,2016).



(a)



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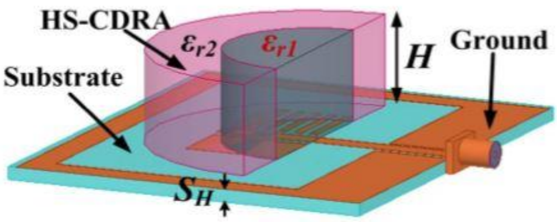


(c)

Fig. 2. Geometry of proposed antenna (a) & (b) top view, (c) 3D view [all dimension are in mm: r1 = 11, r2 = 20, H = 12.5, SH = 2, LS = 49.25, LS1 = 32, LS2 = 8.5, LS3 = 5, LS4 = 0.25, WS = 54.25, WS1 = 48, WS2 = 2.5, WS3 = 2.7, WS4 = 3.25, WS5 = 0.25, PW1 = 8.5, PL1 = 12, SPW1 = 9, SPL1 = 12, Wt = 1, Wt1 = 3, g = 1 = g1, g2= 1.4, g3 = 1.2 and LF = 31.5].

In this paper, HSCDRA is used with a modified CPW fed which will enhance the chance of getting a circular polarization. A modified CPW consist of signal line and rectangular slotted patch which will assisting in the excitation of orthogonal mode in HSCDRA (K. X. Wang and H. Wong,2015) (S. Fakhte, H. Oraizi and R. Karimian,2014). Proposed Antenna shows RHCP mode with usable bandwidth is observed when S11< -10 dB input impedance and AR < 3dB with center frequency at 5.50 GHz. Ansoft-HFSS 15.0.3 software has been utilized for carry out simulation.

II. Antenna Configuration

Fig.2. explain the geometrical structure of proposed wideband HSCDRA with CP. As per the figure mentioned above this antenna structure is made of two HSCDRAs which is have different permittivity value, those are Polyflon Polyguide ($\epsilon_2 = 2.32, r_2 = 20mm$) and Arlon AD430 ($\epsilon_1 = 4.3, r_1 = 11\ mm$) . In case of excitation a CPW feeding mechanism is deployed with rectangular slatted patch is etched on the top surface of FR4 epoxy substrate ($\epsilon = 4.4, S_H = 2mm$). Additional to this a SMA port is being connected to signal line to complete the structural design of purposed antenna.

III. Evolution Of Antenna And Parametric Study

3.1Design Mechanism

In case of justifying final design structure, following antenna figures (Fig.3.) are used as a trace of evolution process through which the final HSCDRA structure is obtained. As per the figures (Fig.3.) there are mainly four major steps involved in the designing, named as Antenna I to Antenna IV. In the case of Antenna, I (Fig.3. (a)), which is consist of a single feed line (signal line) and HSCDRA structure, it will be having 650 MHz of input impedance bandwidth, but its axial ratio value is far from desired limit (Fig.4.). Next structure is created by using an insertion of extra patch on left side of feeding line and also extending this procedure by the addition of another patch on the right side of feeding line will result in Antenna III (Fig.3. (a) and Fig.3. (b)). In simulation result there isn't a large improvement in the axial ratio value also the input impedance measurement is show in the figure (Fig.4.). As a final modification the right-side patch is slotted to specific dimension (Antenna IV). Due to this CPW feed is referred as modified CPW feed which results in significant improvement in impedance and axial ratio bandwidth (Fig.4. and Fig.5.).

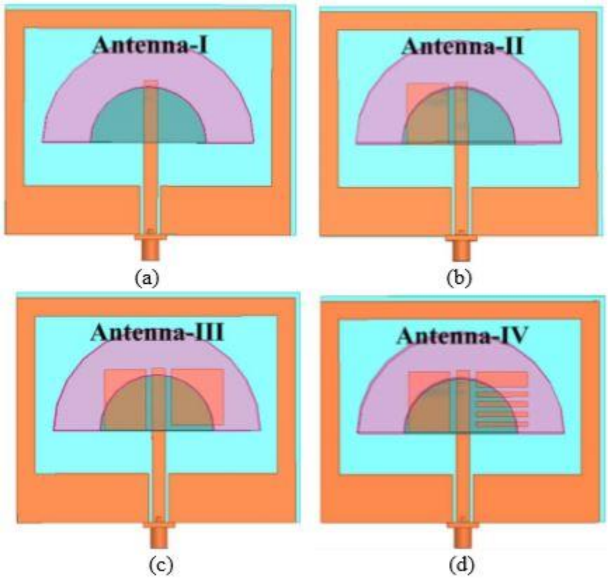


Fig. 3. Geometry of evolution of proposed antenna (a) Antenna-1 (b) Antenna-II (c) Antenna-III (d) Antenna-IV

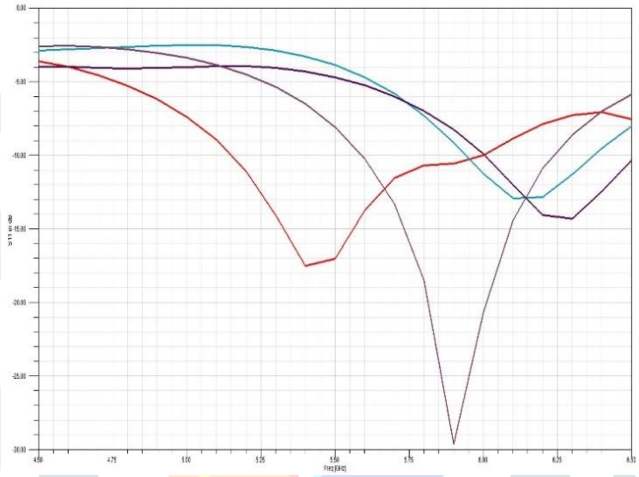


Fig. 4. Input reflection coefficient of evolution of proposed HS-CDRA. (a) Antenna-1 (b) Antenna-II (c) Antenna-III (d) Antenna-IV.

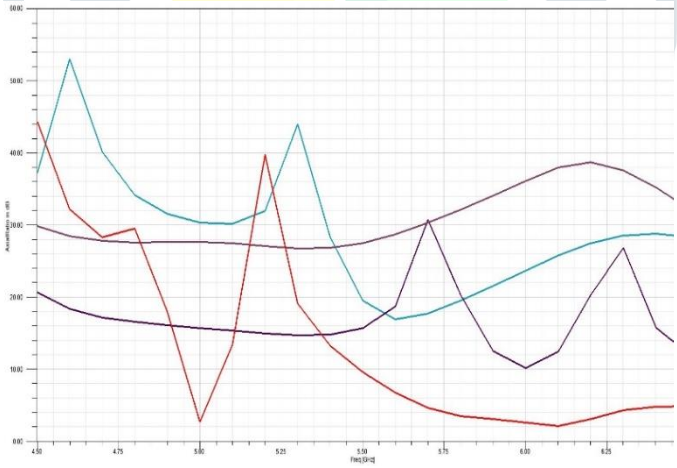


Fig. 5. Input reflection coefficient of evolution of proposed HS-CDRA. (a) Antenna-1 (b) Antenna-II (c) Antenna-III (d) Antenna-IV.

3.2 Realization of Circular Polarization

To realize the circular polarization, E-field distribution of proposed antenna is performed at $0^0, 90^0, 180^0$ & 270^0 phase angles. The observations are plotted in following figures, also it is noted that at an angle of 0^0 & 90^0 E-field have direction are opposite such that orthogonality concept is justified. The mode inside of HSCDRA is recognized as $TM_{11}\delta$.

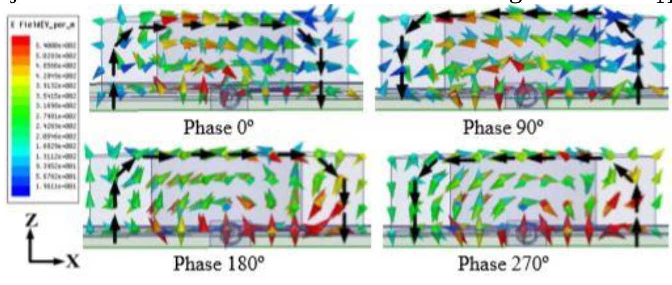
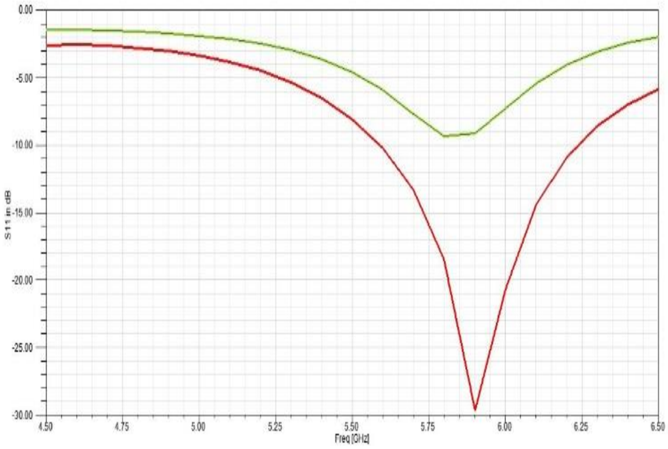


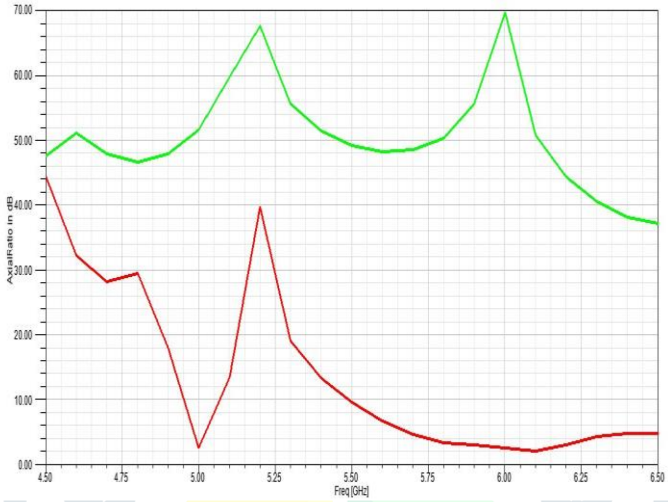
Fig. 6. Distribution of E-field inside the antenna at 5.50 GHz.

3.3 Use of HSCDR

As per the above figure suggests the effects of DRA on input reflection coefficient and axial ratio bandwidth, from the figures it is clear that with out DR structures improvements in axial ratio is not significant. Simulation are also carried out by interchange the dielectric material that were used in two DRA structure, which resulted in no improvement in input impedance and axial ratio bandwidth (Fig .7.).



(a) Input reflection coefficient with DRA--------, without DRA-------.

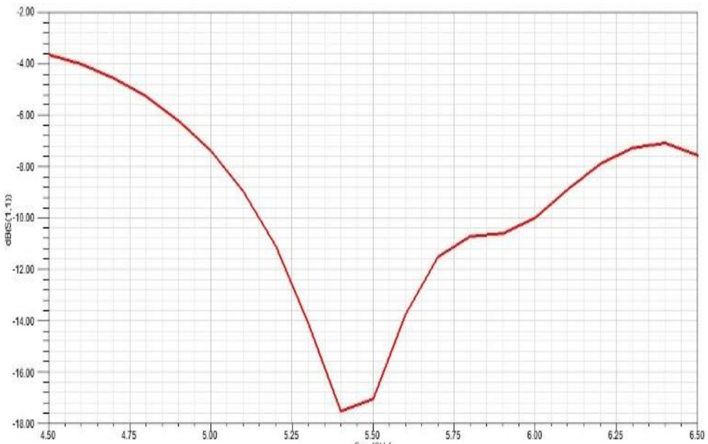


(b) Axial ratio bandwidth with DRA-------, without DRA-------

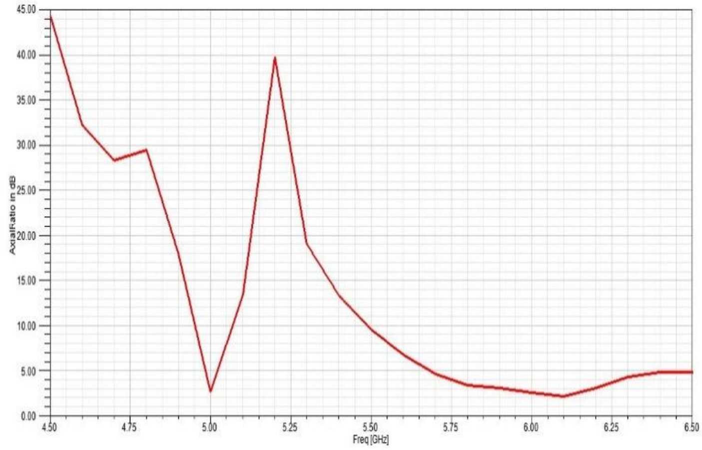
Fig.7. Effects of HSCDRA

IV. RESULTS AND DISCUSSION

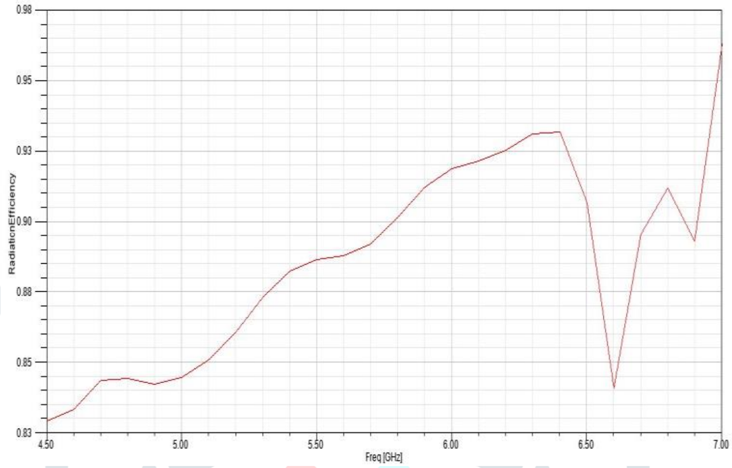
After designing the proposed DRA structure, verification of near and far-field simulations are carried out on Ansoft HFSS 15.0.3. With simulation carried out on discreate option, simulation results must find good agreement with real life physical conditions. Figures (Fig.8.) show measurement of input reflection coefficient where value of S11<-10 dB has been found out as 850 MHz (5.15-6.00 GHz). Axial Ratio measurements are plotted on succeeding figure with desired AR value for CP is below 3dB, which results in 500MHz of bandwidth (5.75-6.25 GHz). Simulations are proceeded by setting centre frequency at 5.50 GHz. Succeeding fig show total gain in dB and can be used to map out the working bandwidth of antenna and next fig represents the plotting of radiation efficiency of DRA structure, which hold evident to the former argument that DRA holds higher than normal radiation efficiencies.



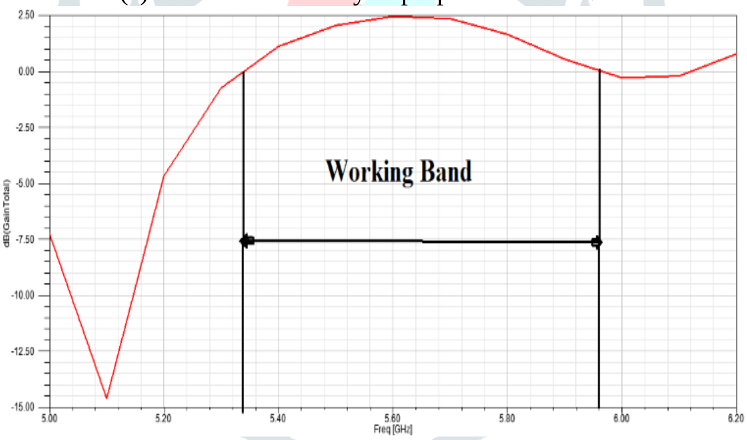
(a)Input reflection coefficient of proposed HS-CDRA.



(b) Axial Ratio of proposed HS-CDRA.



(c)Radiation efficiency of proposed antenna.



(d)Total gain of proposed antenna.
Fig .8. Antenna parameters.

V. Conclusion

A wideband circularly polarized half split cylindrical DRA has been designed and simulated. Proposed antenna is excited by using modified CPW feed which consist of a signal line and a slotted patch structure. Results from simulation suggests that HSCDRA is capable of containing orthogonal mode ($TM_{11}\delta$) when excited by the CPW feed. Designed antenna can obtain an input impedance bandwidth of 850MHz (centered on 5.55GHz) and AR bandwidth of 500MHz (centered on 6.00GHz). Overall proposed antenna provides stable gain, improved radiation efficiency and a Right-hand circular polarization profile to perfectly fit in FPV applications.

VI. Acknowledgment

Firstly, authors spare a thought for late Mr. SADASIVAN J who guide us throughout this project. We would also especially grateful to Dr. Hari R, HOD of ECE, GECWYD for providing necessary facilities to incorporate this work.

VII. References

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