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A Comparative Analysis of a Circularly Polarized Microstrip Patch Antenna with & Without U-Slot

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Abstract - *In this paper Circularly Polarized (CP) patch antenna at L-band is designed. The antenna contains a U-Slot and designed with DGS technique to reduce the size of antenna. U-slot etched in the antenna allowed the fabrication on a high-dielectric-constant (10.2) substrate that achieves a reasonable axial-ratio bandwidth. Circular Polarization can be generated on a rectangular patch antenna by truncating two opposite corners of patch. In this paper a comparison has been done between a CP Microstrip antenna with and without U-Slot. At the operating frequency of 1.575 GHz with the size of the patch is 25mm X 25mm, while ground plane of 50mm X 50mm and the thickness of the substrate is 10.2 mm.. The parameters of antenna like return loss, axial ratio, RHCP and LHCP, gain are analyzed using CST MSW Software. The operating frequency is 1.521 GHz.*

Key Words: Circularly Polarized (CP), Patch Antenna, U-Slot, Defected Ground Structure (DGS), Multiband, Truncated Corners.

1. INTRODUCTION

CIRCULARLY polarized (CP) antennas have received considerable attention for the applications in the fields of wireless mobile communications, remote sensing, satellite communications, and radar detection as they can not only receive arbitrary polarization electromagnetic waves, but additionally the electromagnetic waves that they radiate can also be received by other arbitrary polarization antennas. CP antennas can provide better mobility and weather penetration than linearly polarized (LP) antennas. Meanwhile, they can reduce the multipath effects and allow more flexible orientation of the transmitting and receiving antennas [1].

In the last decade, the development of modern wireless systems has prompted increased investigation on micro strip radiators, with particular attention paid to improving performance and miniaturization [2].Micro strip patch antennas with U-slots were proposed a decade and a half ago [3,4].These U-slot antennas are simple in structure and are easy to fabricate. It was demonstrated that U-slot patch antennas with linear polarization have good electrical characteristics including wide bandwidth, high gain, and quite stable gain across the operating frequencies [5]. Recently, it was found that U-slot patch antennas can also be operated with circular polarization (CP) [6].

Circularly polarized antenna is well-known for its feature of relative insensitivity to transmitter and receiver orientations. CP radiation is generated when two degenerate orthogonal linearly polarized modes, of equal amplitude and 90 phase difference are independently attractive Patch antenna is one attractive candidate for Parameter producing circular polarization owning to its characteristics of wide bandwidth, high gain, low profile and low cost. For a single feed patch antenna, truncating a pair of corners and cutting a diagonal slot are two conventional ways to generate CP radiation. Recently, it was found that U-slot patch antennas can also be operated with circular polarization (CP).

By cutting a symmetrical U-slot with equal arms in a square patch with truncated corners, an axial-ratio (AR) bandwidth of about 4% can be obtained [6]. Another design is achieved by loading an unsymmetrical u slot on a square patch [7]. The unequal arms of the U-slot produce the orthogonal currents for CP radiation, and an axial-ratio bandwidth of about 4% is also obtained [5]. If the patch shape is like the square or the circle, the bandwidth is the same and proportional to its size. The deviations start when the shape changes drastically and becomes a narrow or wide rectangle. If the radiation edge becomes narrow, decreases the radiation loss and increases the antenna Q, reducing the bandwidth. For a patch with a large radiating edge, the reverse is true [8].

In general, the advantages and drawbacks of patch antennas with high permittivity substrate are a controversial problem and some interesting results. In this paper we have performed an exploration on patch antennas built on a high permittivity substrate [9].To obtain high bandwidth a U-Slot is used. The dimension of the patch as well as the position of the probe feed is optimized leading to a wideband circular polarized behavior [10].

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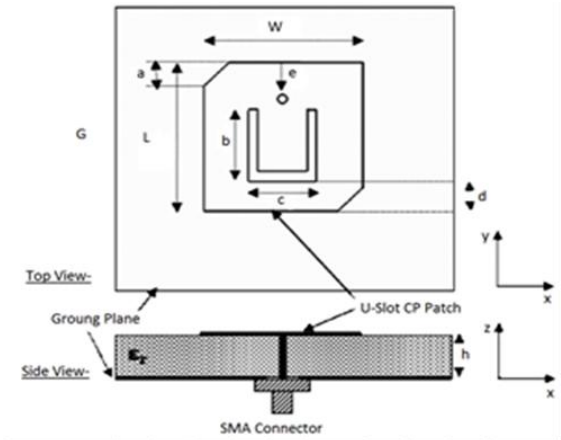
2. ANTENNA DESIGN AND GEOMETRY

The circular polarization is done with truncation of corners mechanism. Defects ground structure is used to improve the various parameters of circularly polarized microstrip patch antenna with U-slot, i.e. bandwidth, return loss. Figure 3.1 shows the proposed design of circularly polarized microstrip patch antenna with U-slot and defected ground structure.



Parameters	a	b	c	d	e	h	G	L	W	ε_r
Unit (mm)	5	10	11	7	6	10.2	50	25	25	10.2

Figure1: Geometry of proposed U-slot Circularly Polarized Microstrip Patch Antenna

The antenna geometry is shown in Figure 1. This antenna is designed to operate at around 1.521 GHz. The truncated square patch of length L and width W is printed on a microwave substrate (with dielectric constant 10.2) for exciting two orthogonal modes for CP radiation. A U-shaped slot (with 1-mm width) is cut in the truncated patch. The function of the U-slot is to introduce a capacitance that can suppress the inductance due to the vertical feeding probe so as to enhance the impedance and axial-ratio bandwidths. The feeding probe is connected to an SMA launcher that is mounted underneath the ground plane. As discussed in [10], the U-slot enables the use of thicker substrates to obtain larger impedance bandwidths. The total height of the dielectric is 10.2mm, and the dielectric is made up of six layers of thin substrates. After optimizing the various antenna parameters with the help of CST Transient solver, a prototype with the parameters listed in Figure 3.1 was designed and simulated.

2.1 Circularly Polarized Patch Antenna without U-Slot:

Truncated corners are used in square patch to generate circular polarization. A patch with single-point feed generally radiates linear polarization, in order to radiate CP, it is necessary for two orthogonal patch modes with equal amplitude an in-phase quadrature to be induced. This can be accomplished by slightly perturbing a patch at appropriate locations with respect to the feed.

Perturbation configurations for generating CP operate on the principle of detuning degenerate modes of a symmetrical patch by perturbation segments as shown in figure 2. Proper perturbation segments will detune the frequency response of mode 2 such that, at the operating frequency, the axial ratio rapidly degrades while the input match remains acceptable. The actual detuning occurs either for one or both modes depending on the placement of perturbation segments.

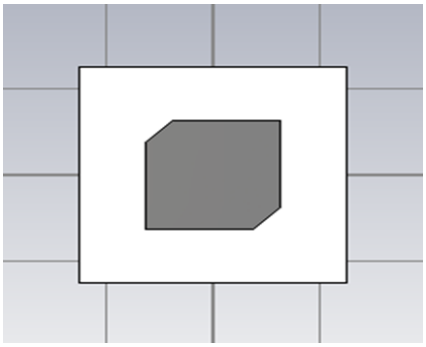


Figure2: CST Design of a rectangular patch with truncation for CP

2.2 Circularly Polarized Patch Antenna with U-Slot:

The single-layer probe-fed U-slot patch antennas have been extended to circularly polarized radiation. A U-shaped slot (with 1-mm width) is cut in the truncated patch. The function of the U-slot is to introduce a capacitance that can suppress the inductance due to the vertical feeding probe so as to enhance the impedance and axial-ratio bandwidths. Moreover, the design has a relatively wider axial ratio bandwidth when compare to other single-fed CP microstrip antennas. Figure 3 shows the front view of proposed U-Slot antenna.

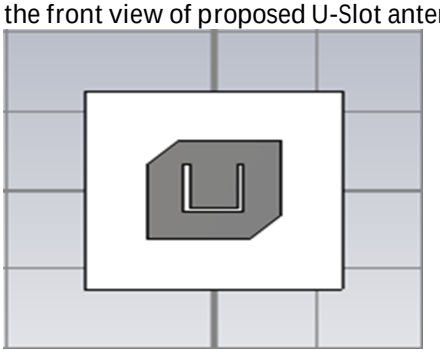


Figure3: CST Design of a rectangular patch with truncation & U-Slot for CP

Defected Ground Technique has been used in this design to enhance the performance of the antenna. With the results it can be seen that DGS improves the antenna performance by improving the results like Return Loss

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and Axial ratio values. Figure 4 shows the back view of proposed U-Slot antenna with DGS.

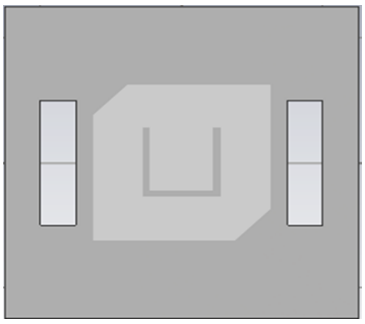

Figure4: CST Design of a rectangular patch with truncation, U-Slot & DGS

3. RESULTS AND DISCUSSION:

This simulation is carried out by using Transient solver method, CST MSW. For small antenna design, the size of the ground plane is a very important parameter to be considered. For this simulation, the size of the ground plane is equal to the substrate size. The square-shaped ground plane with a length G varied from 40 to 50 mm is investigated. The simulation of circularly polarized U-Slot Patch antenna with dielectric constant 10.2 and height of substrate 10.2 mm are used in design. The results obtain after the simulation (CST software) of Circularly Polarized U-Slot Patch Antenna are shown in fig.5 and fig.6. Fig.5 represents the return loss response for truncating corners CP antenna. Fig.6 illustrates return loss response of CP antenna with U-Slot and DGS.

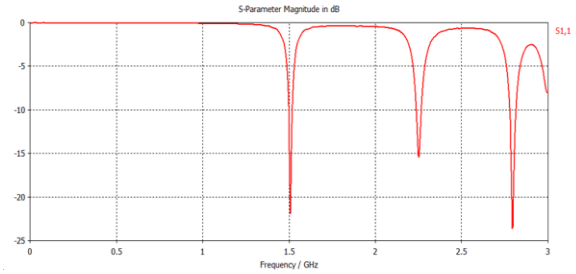

Figure5: CST Result of a rectangular patch with truncation for CP

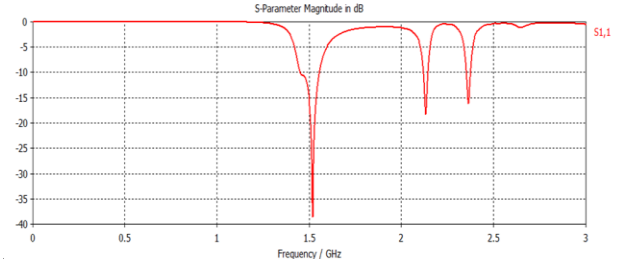

Figure6: CST Result of a rectangular patch with truncation, U-Slot & DGS for CP

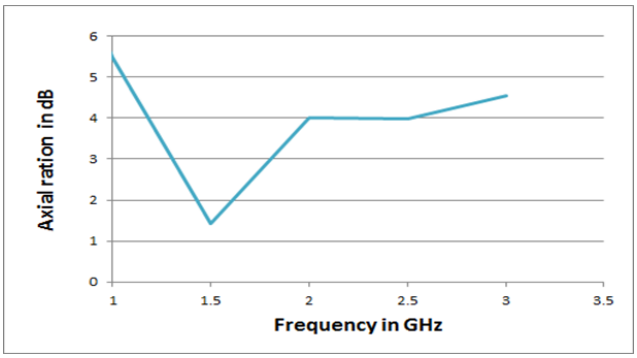

Figure7: Axial Ratio of a rectangular patch with truncation for CP

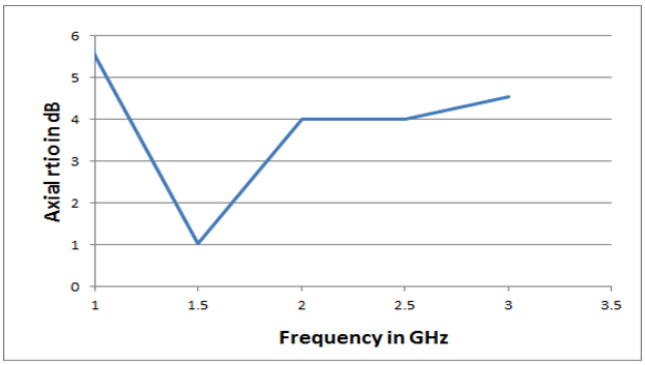

Figure8: Axial Ratio of a rectangular patch with truncation, U-Slot & DGS for CP

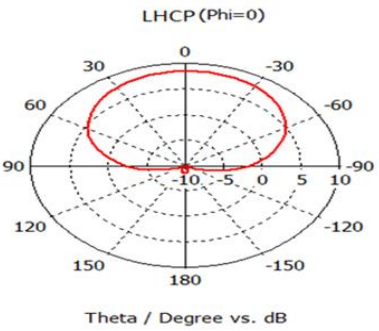

Figure9: LHCP of proposed U-slot patch antenna for phi=0 degree

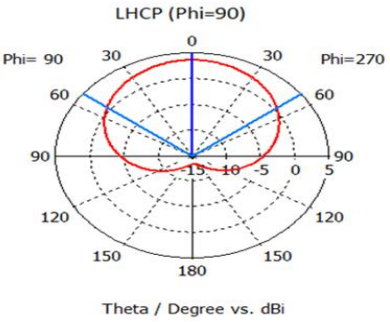

Figure10: LHCP of proposed U-slot patch antenna for phi=90 degree

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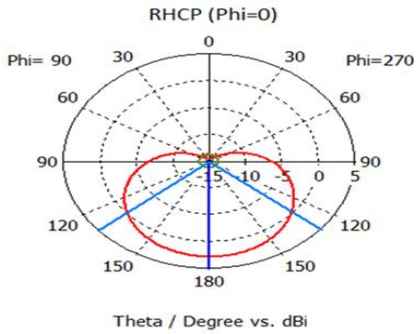

Figure11: RHCP of proposed U-slot patch antenna for phi=0 degree

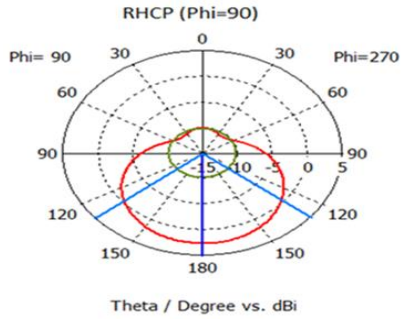

Figure12: RHCP of proposed U-slot patch antenna for phi=90 degree

Figure 7 shows the Axial ratio of a rectangular antenna with truncation while figure 8 shows the Axial Ratio of a u-Slot antenna. Figure 9 and 10 represents the radiation patterns of LHCP for phi equals to 0 and 90 degree. Figure 11 and 12 shows the radiation pattern of RHCP for phi equals to 0 and 90 degree. For real application of GPS, the receiving antenna should be designed as a right-hand circularly polarized (RHCP) antenna. In this design, the antenna is easy to adjust with RHCP operation by changing the truncated corner of the patch to another diagonal axis. Then, the antenna can operate with RHCP [2].

3.1 Comparison:

In this section a comparison of a single feed Circularly Polarized Patch Antenna with Truncation of edges and without U-slot, Truncation of edges and with U-slot and Truncation of edges having U-slot with Defected Ground Structure is done. Figure 13 shows the compared result of S11 of a single feed Circularly Polarized Patch Antenna with and without U-slot and with and without DGS using CST software.

The comparison of Axial Ratio is shown in figure 14. By introducing U-slot we can achieve a good axial ratio bandwidth. The value of Axial Ratio after implementing U-Slot in a single feed circularly polarized microstrip patch antenna is 1.0221 Db.

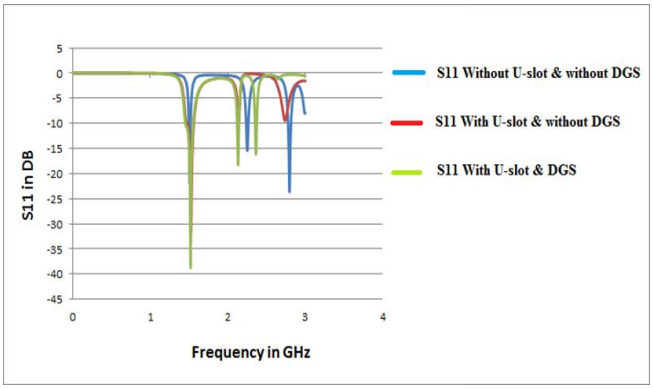

Figure 13: Compared Result of S11 of Circularly Polarized Patch Antenna with U-slot & without U-slot

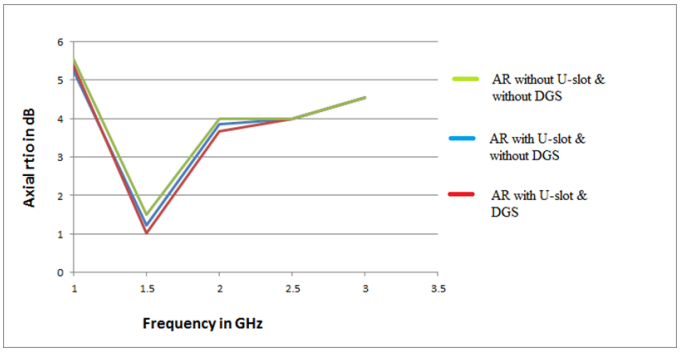

Figure 14: Compared Result of AR of Circularly Polarized Patch Antenna with U-slot & without U-slot

3. CONCLUSIONS

In this paper a single feed Circularly Polarized Patch Antenna has been designed with U-Slot & defected ground structure to obtain efficient design. The proposed design was implemented and analyzed at the cut off frequency1.5 GHz. The circular polarization has been achieved by introducing truncation of corners in the patch. After introducing, U-Slot in the proposed design the better return loss and axial ratio has been obtained. With U-Slot Defected Ground Structure has also been introduced in this design.

In this design it has been seen that U-Slot in a single feed circularly polarized patch antenna improves the circular polarization characteristics. The Axial ratio bandwidth has been improved by introducing U-Slot. It has been seen that the size of antenna can be reduced by introducing Defected Ground Structure in the antenna. The change in return loss has also been seen by introducing Defected Ground Structure.

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REFERENCES

[1] J. R. James and P. S. Hall, Handbook of Microstrip Antennas. London, U.K.: Peregrinus, 1989, pp. 219–253.

[2] X.L. Bao and M.J. Ammann, "Dual-frequency circularly-polarized patch antenna with compact size and small frequency ratio," IEEE Trans. Antennas Propag., vol. 55, no.7,July 2007.

[3] K. F. Lee, K. M. Luk, K. F. Tong, S. M. Shum, T. Huynh, and R. Q.Lee, "Experimental and simulation studies of the coaxially fed U-slot rectangular patch antenna," Inst. Elect. Eng. Proc., Microw. Antennas Propag., vol. 144, pp. 354–358, Oct. 1997.

[4] Y. X. Guo, K. M. Luk, and K. F. Lee, "U-slot circular patch antennas with L-probe feeding," Electron. Lett., vol. 35, no. 20, pp. 1694–1695, Sep. 30, 1999.

[5] Ka Yan Lam, Kwai-Man Luk, Kai Fong Lee, Hang Wong, Kung Bo Ng, (2011), "Small Circularly Polarized U-Slot Wideband Patch Antenna", IEEE Antennas and Wireless Propagation Letters, vol. 10, pp. 87-90,2011.

[6] S. L. S. Yang, K. F. Lee, A. A. Kishk, and K. M. Luk, "Design and study of wideband single feed, circularly polarized microstrip antennas," Prog. Electromagn. Res., vol. 80, pp. 45–61, 2008.

[7] K.F .Tong and T.P .Wong, "circularly polarized U-Slot antenna," IEEE Trans. Antennas propag., vol.55 no.8, pp.3382-2385, Aug.2007.

[8] Zarreen Aijaz1& S.C. Shrivastava, —Effect of the Different Shapes: Aperture Coupled Microstrip Slot Antenna‖ International Journal of Electronics Engineering, 2(1), pp. 103-105,2010

[9] D. D. Sandu, O. Avadanei, A. Ioachim, G. Banciu, P. Gasner, —Microstrip Patch Antenna With Dielectric Substrate‖,Journal of Optoelectronics and Advanced Materials Vol. 5, No. 5, pp. 1381 – 1387, 2003.

[10] M. Pirai and H. R. Hassani, —L-Probe Fed Circular Polarized Wideband Planar Patch Antenna On CylindricalStructure,ProgressIn Electromagnetics Research C, Vol. 3, 161–167, 2008.

[11] D. M. Pozar, Microwave and RF Design of Wireless Systems, John Wiley & Son, Inc, 2010.

[12] CST (computer Simulation Technology) microwave software studio 2010.

BIOGRAPHIES

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