ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, *Vol 8(29), DOI: 10.17485/ijst/2015/v8i29/63684, November 2015* ISSN (Online) : 0974-5645

Hybrid Coupled Feed Circularly Polarized Patch Antenna for Military Applications

A. Sahaya Anselin Nisha*

Sathyabama University, Chennai - 600 119, Tamil Nadu, India; nishalawrence.nisha@gmail.com

Abstract

A new configurable circular patch antenna for Military applications fed by 50Ω impedance hybrid coupler feed is examined here. The dual fed circular polarized microstrip antenna is etched on a Rogers with dielectric substrate of 2.2 with the height of 0.16 mm. The effect of hybrid coupling is circular polarization and radiation around 360 degree. The thickness of Circular patch antenna is of 0.381mm. The antenna is designed to achieve high gain of 6dB at the operating frequency of 8GHz. Simulation results and the measured results characteristic are closely matches with each other.

Keywords: Coupler, Directivity, Polarization, Radiation Pattern, Return Loss, Ultra Wide Band

1. Introduction

Planar configurations of microstrip technology is inserting very important role within the field of antenna[1]. Microstrip antenna provides high repeatability of parameters to extend the gain, band width and also the size reduction is achieved by victimization little substrate[2]. Patch will be in any form like rectangular, Circular, Square, Elliptical, Triangular etc[3]. Hybrid coupler implementation with Varactor diode and Pin diode is proposed by S. Cheng, K-OSun[4,5]. Different feeding procedures for UWB antenna are examined and fabricated[6–13]. Dual band microstrip antenna using CSRR and RIS is designed to improve the gain using HFSS software in implemented by Gayathri et al[17]. M. Ghiyasvand et al. in projected microstrip antenna array with the bandwidth from 10.75GHz to 12.75GHz[18]. The circularly polarized properties of 4x4 element planar Microstrip Equilateral Triangular Array Antenna (METAA) printed on Yttrium ferrite substrate with circular polarization are generated by the magnetic bias is applied parallel to the wave propagation in the antenna geometry[19]. Figure 1 shows the fields related with an antenna. The dielectric material is used to couple electromagnetic energy in and around the patch. The electric field is most at one finish of patch and minimum in different finish.This most and minimum finish can depends the applied signal however the electrical field is often zero at the middle of patch. Electric field within the patch is extended outside patch is inflicting radiation in an exceedingly patch and this extended field is thought as fringing field[14–16]. The proposed antenna is in circular shape with 0.381mm and it resonates at 8GHz which includes Military applications and UWB etc. The antenna is fabricated in a thin substrate which shows simulated and measured results are having gain of 6 dB at resonant frequency. The following geometry shows the field distribution of microstrip antenna.

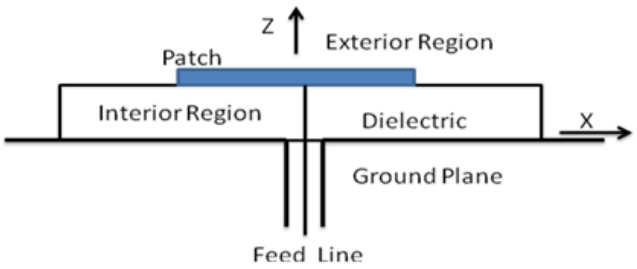

Figure 1. Division of fields is related with an antenna into an interior fields and exterior fields.

* *Author for correspondence*

2. Hybrid Coupler Design

Generally hybrid coupler is a four port device with single input and isolated port and two output port. It divides an input signal into two imbalanced amplitude outputs. At ideal condition input port power is equivalent to sum of two output port power i.e., 90 degree phase shift between these ports. Termination impedance is connected with the isolated port. According to the impedance choice of the series and stub microstrip transmission lines hybrid coupler is designed and shown in Figures 2 and 3. Schematic diagram shows each arm of hybrid coupler having length of 6.838mm and width of 1.157mm. The hybrid coupler is terminated by 50Ω impedance. Magnitude response is calculated theoretically for 8GHz shows coupler is having -30dB return loss at 8.05GHz.

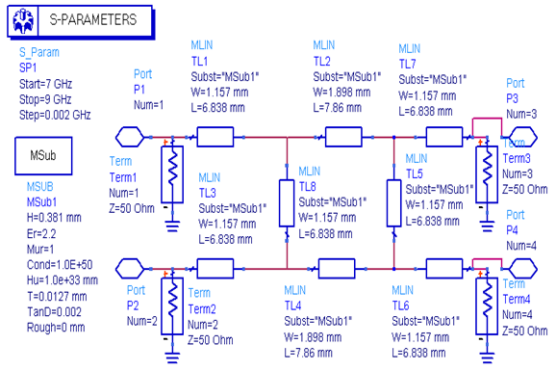

Figure 2. Schematic diagram of hybrid coupler.

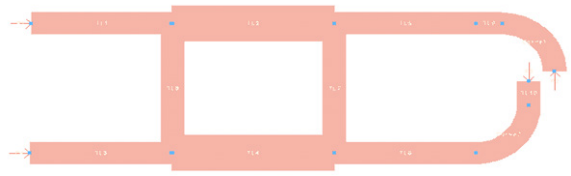

Figure 3. Layout diagramof hybrid coupler.

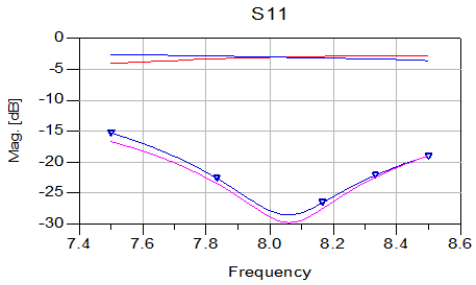

Figure 4. Magnitude response for 0.381 mm thickness for hybrid coupler.

3. Antenna Design and Configuration

The design of proposed antenna is illustrated in Figures 5 and 6. Unlike rectangular patch in this design the material between ground and patch will act as a circular cavity having control on only the radius cannot able to change the order of the modes[16]. The dominant mode in circular patch is 110, so the resonating frequency is given by:

$$f_{r110} = \frac{1.8412}{2\pi a\sqrt{\mu\varepsilon}} \tag{1}$$

$$a_e = \left\{1+\frac{2h}{\pi a\varepsilon_r}\left[l_n\left(\frac{\pi a}{2h}\right)+1.7726\right]\right\}^{\frac{1}{2}} \tag{2}$$

When the patch is excited fringing field will exit, this will make a patch looking larger, to consider this effect corrections is done in the radius of patch. Actual radius a is replaced by effective radius a_e.

$$a = \frac{F}{\left\{1+\frac{2h}{F\pi a\varepsilon_r}\left[l_n\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{\frac{1}{2}}} \tag{3}$$

Where a is the radius of patch

$$F = \frac{8.791\text{x}10^9}{f_r\sqrt{\varepsilon_r}} \tag{4}$$

The proposed radiating element is having radius 7.138mm and it is placed above the substrate. Designed hybrid coupler is connected to radiating element by edging through ground and substrate. The feed point is located at where the 50Ω impedance match is achieved. Figures 5 and 6 show the geometry of proposed antenna structure.

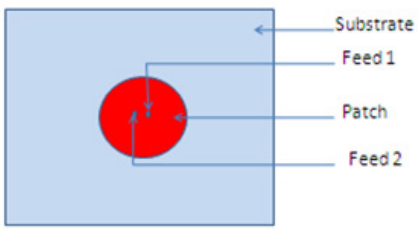

Figure 5. Top view of antenna.

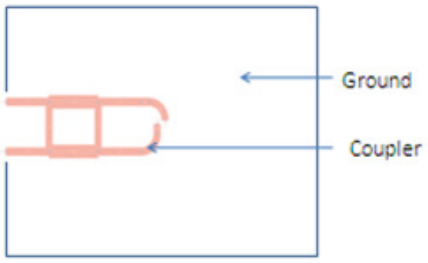

Figure 6. Bottom view of antenna.

4. Results and Discussion

The return loss for the proposed antenna is -28dB at 8.1GHz as shown in Figures 6 and 7. The simulated and measured results are having good agreement. The electric filed distribution of antenna is defined by polarisation, here the proposed antenna is having circular polarization, it is produced by directly connecting the hybrid coupler to radiating element and it is shown in Figure 9. The ratio between maximum radiation intensity in particular direction to power accepted by the antenna is known as gain of the antenna and it is shown in Figures 10 and 11. The maximum gain is obtained 6dB, this is highly suitable for military applications. Figures 11 and 12 shows the far field pattern in 3D and 2D, the effect of hybrid coupler is radiation pattern is around 360 degree.

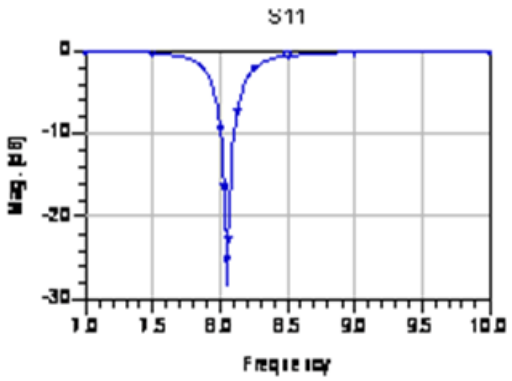

Figure 7. Simulated results of S parameter of the circular patch antenna.

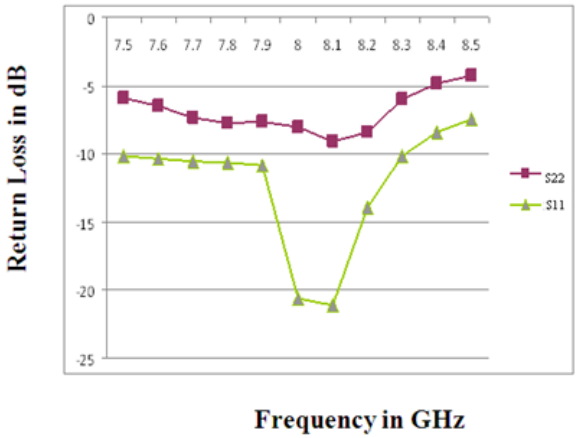

Figure 8. Measured results of S parameter of the circular patch antenna.

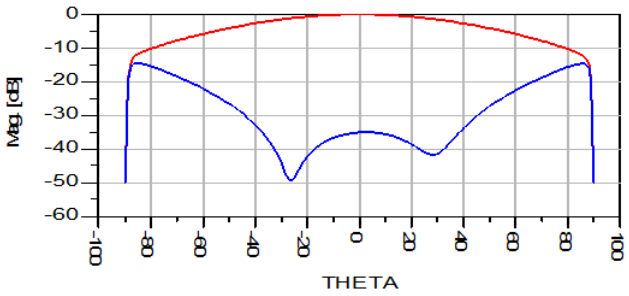

Figure 9. Polarization for a proposed antenna.

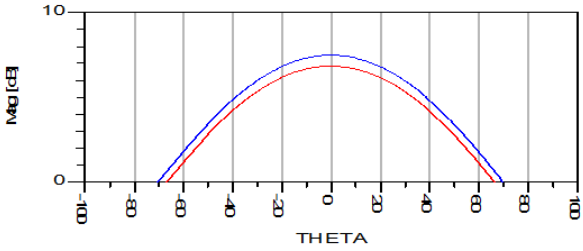

Figure 10. Simulated gain for proposed antenna.

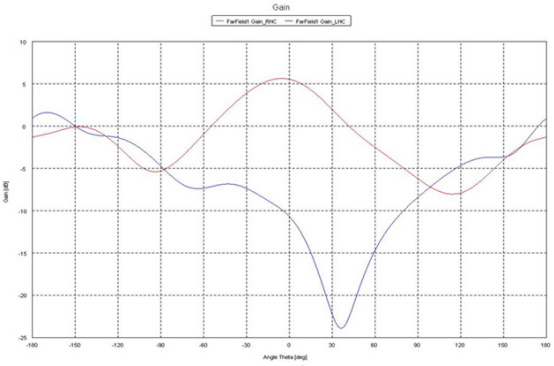

Figure 11. Measured gain for proposed antenna.

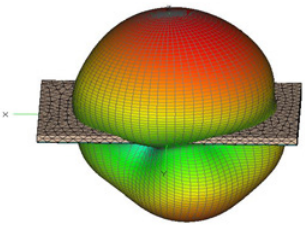

Figure 12. Simulated radiation pattern of proposed antenna.

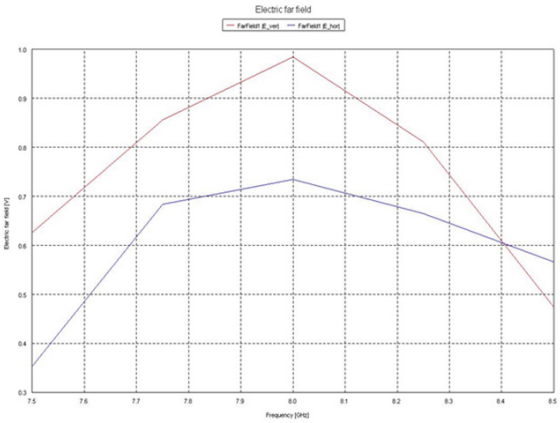

Figure 13. Measured radiation pattern of proposed antenna.

5. Conclusion

A new circular patch with hybrid coupler feeding techniques was designed and parametric studies shows the best structure that can operate at 8.1 GHz frequency. Hybrid coupler feed is producing circular polarization. This antenna having maximum gain of 6dB, return loss of -28dB and the field distribution is around 360 degree. The simulation and measured results are having good agreement between them. The designed antenna is well suited for military applications because of its low profile and mass production possibility. Moreover, the simple and uniplanar structure makes it ease of design. By changing the tapering angle and size the antenna can be made to work for UWB band.

6. References

1. Ong SH, Kishk AA, Glisson AW. Wideband disc-ring dielectric resonator antennas. Microwave and Optical Technology letters. 2002 Dec; 35(6):425–8.
2. James JR, Hall PS, Wood C. Microstrip antenna theory anddesign. London: Peter Perigrinus; 1981.
3. Tokan NT, Gunes F. Support vector characterization of the microstrip antennas based on measurements. Progress in Electromagnetics Research B. 2008; 5:49–61.
4. Cheng S, Ojefors E, Hallbjorner P, Rydberg A. Compact reflective microstrip phase shifter for traveling wave antenna applications. IEEE Microwave and Wireless Components Letters. 2006 Jul; 16(7):431–3.
5. Sun KO, Yen CC, Vander Weide D. A size reduced reflection-mode phase shifter. Mic and Opt Tech Letters. 2005 Dec; 47(5):457–9.
6. Lao J, Jin R, Geng J, Wu Q. An ultra-wideband microstrip elliptical slot antenna exited by a circular patch. Microw Opt Technol Lett. 2008; 50(4):845–6.
7. Azenui AC, Yang HYD. A printed crescent patch antenna for ultrawideband applications. IEEE Antennas Wirel Propag Lett. 2007; 6:113–6.
8. Angelopoulos ES, Anastopoulos AZ, Kaklamani DI, Alexandridis AA, Lazarakis F, Dangakis K. Circular and elliptical CPW-fed slot and microstrip-fed antennas for ultra wideband applications. IEEE Antennas Wirel Propag Lett. 2006 Dec; 5(1):294–7.
9. Ma TM, Tseng CH. An ultra wideband coplanar waveguide-fed tapered ring slot antenna. IEEE Trans Antennas Propag. 2006 Apr; 54(4):1105–10.
10. Qu SW, Ruan C, Wang BZ. Bandwidth enhancement of wide-slot antenna fed by CPW and microstrip line. IEEE Antennas Wirel Propag Letters. 2006; 5(1):15–7.
11. Liang J, Chiau CC, Chen X, Parini CG. Study of a printed circular disc monopole antenna for UWB systems. IEEE Trans Antennas Propag. 2005 Nov; 53(11):3500–4.
12. Azenui NC, Yang HYD. A printed crescent patch antenna for ultrawideband applications. IEEE Antennas Wirel Propag Lett.2007; 6:113–6.
13. Wheeler HA.Transmission-line properties of parallel strips separated by a dielectric sheet. IEEE Trans Microwave Theory Tech. 1965 Mar; 13(2):172–85.
14. David M. Pozar microwave engineering. 3rd ed. NJ: John Wiley and Sons Inc; 2005.
15. Balanis CA. Advanced engineering electromagnetics. New York: JohnWiley and Sons; 1989.
16. Rajaraman G, Anitha M, Mukerjee M, Sood K, Jyoti R. Dual-band, miniaturized, enhanced-gain patch antennas using differentially-loaded metastructures. Indian Journal of Science and Technology. 2015 Jan; 8(1):11–6.
17. Ghiyasvand M, Bakhtiari A, Sadeghzadeh RA. Novel microstrip patch antenna to use in 2×2 sub arrays for DBS reception. Indian Journal of Science and Technology. 2012 Jul; 5(7):2967–71.
18. Kumar D, Pourush PKS.Yttrium ferrite based circularly polarized triangular patch array antenna. Indian Journal of Science and Technology. 2010 Apr; 3(4):447–9.