KIET IJCE KIET International Journal of Communications &Electronics
Volume. No. 3, Issue No. 2, July-December 2015, ISSN: 2320 - 8996

Directional Cavity Back Shell Monopole Antenna for X and Ku bands Application

Ferdows B.Zarrabi[1], Zahra Mansouri[2], Rahele Ahmadian[3], Maryam Rahimi[4]
[1,2]Department of Electrical engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran
[3,4]Department of Electrical engineering, Imam Khomeini international University, Qazvin, Iran

***Abstract*— compact , high gain directive antenna is necessary in microwave imaging and radar application so in this article a directional high gain cavity back shell monopole antenna for X and Ku band application is presented. The prototype antenna is containing monopole structure radiator and semi spherical cavity back for the goals of high gain and directive pattern. The effect of cavity back structure is investigated on four different models of monopole structure such as Discone antenna and slant structure for improving of the cross polarization. All these structures are modified for 8-12 or 10-12 GHz with VSWR less than 2 (more than 40%). At last a shielded antenna is presented to improve antenna radiation characteristic and gain despite of reduction in bandwidth it help to increase the gain of antenna more than 1.3 dBi at 9 GHz . The total sizes of antennas are 30mm×30mm×20mm, so it is compact than Horn antenna.**

***Keywords*— monopole, polarization, cavity back, X-band, shell , shield , Ku band**

I. Introduction

Because of wide bandwidth and economics advantages of UWB systems, they have been used in communication systems, medical imaging, radio communication and biomedical system such as brain struck and breast cancer detection system [1-3]. FCC (Federal Communication Commission) determined some laws and limitation for UWB systems such as frequency band of 3.1- 10.6 GHz for wireless communication or Spectral density of -41.3 dBm per MHz for UWB frequency band [4-5].Monopole antennas are known as a conventional UWB antenna with more than 120% bandwidth. Discone is celebrated type of monopole antenna with Omni directional pattern [6-7]. In last decade, difference model of monopole antenna have been presented for UWB application with some similar characteristics such wide bandwidth, linear polarization and Omni directional pattern with low gain. [2] Circular Disc Monopole (CDM) antenna is famous because of easy design calculation and fabrication for UWB application. Also in some studies have been tried to stabilize the radiation pattern of CDM antenna by changing in ground structure [8-9]. Another type is taper rectangular monopole antenna that has been studied for notch application with slot design and corner ground. It is used for directional application [10-11]. Dipole antenna with new balun and Radome is used for designing antenna with directional pattern in 7.4-10.5GHz. For achieving high gain, cavity back has been used in here to improve antenna gain and directivity [12]. Folded UWB Antenna is modified for Wireless Body Area Network (WBAN) and Specific Absorption Rate (SAR) for body tissue [13].Metal shields and cavity backs are known as conventional way for designing directional antenna or reduce F/B ratio in antenna and improve antenna efficiency [14-15] Metallic Stacked Fabry–Perot Cavity Antennas with FSS and other kind of metamaterial have been considered because of their quality for limiting or improving the wave propagation in some side of antenna. They are used to improve gain and reduce the F/B ratio [16-17]. Antennas with shield are noticed in many experimental research for reduce size or making high directivity antenna for GPR radar or other navigation and detection system with narrow band characteristic [18-20].

II. Antenna Design

Mono pole antenna are known for them UWB characteristic and easy fabrication but these antenna has some weakness such as Omni-directional radiation pattern and low gain despite of weakness , these antennas has good impedance matching and low profile. In other hand shell and cavity back techniques is common way for achieve directive pattern so in here a combination of monopole antenna and shell is used for design UWB antenna at X-band with compact size and directive high gain pattern. Fig 1 shows four different models for prototype antenna. Obviously, antenna divided to two essential parts of radiator and spherical cavity by copper shell. The radiator is a monopole structure and it is connected to SMA 50 Ω feed line. The radius of ground is 15mm and total size of antenna is 30mm×30mm×20mm and these size are more compact than conventional pyramidal horn antenna . For this frequency range the horn antenna dimensions are 45 mm × 35 mm × 100 mm .So the prototype antenna has low profile and low weight than horn antenna . The first antenna is contained a V shape radiator with 5mm height. Discone height for second model is around 11.2 mm. In third and fourth model we used slant

Volume. No. 3, Issue No. 2, July-December 2015, ISSN: 2320 - 8996

radiator and the total height in both structures are 5mm. In all designed antenna the feed gap is 0.3m.

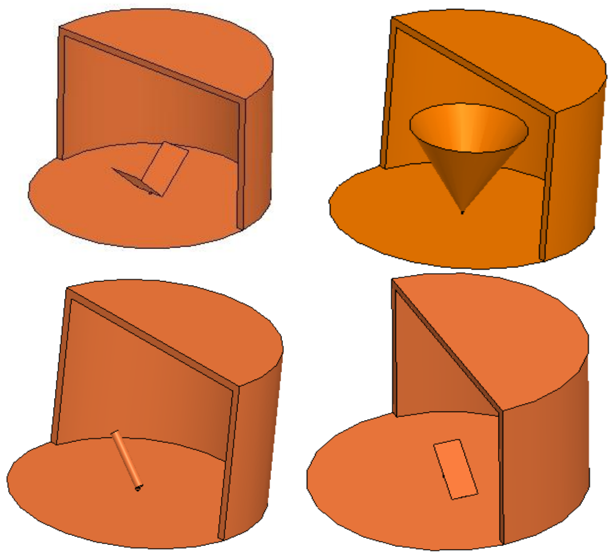
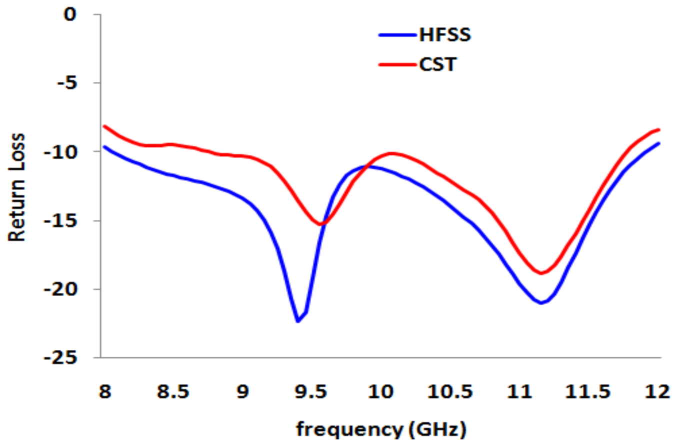


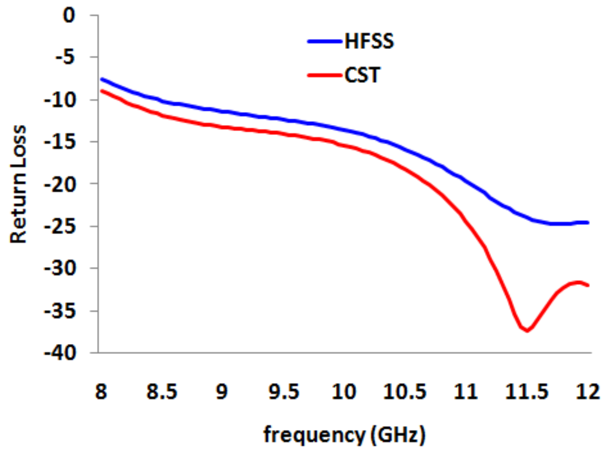
Fig.1 The prototype antenna

III. SIMULATION RESULT

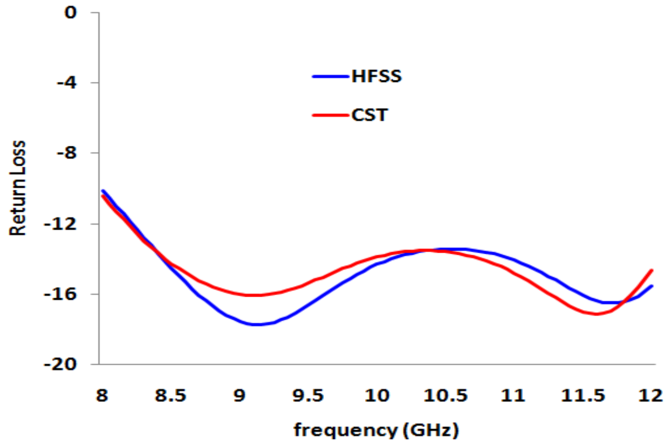
In this paper has been shown the simulation of all prototype antennas with HFSS 11 and CST microwave studio 2009 by different full wave method and the results have been compared together .The antenna parameters have been studied for X-band and Ku-band at 8-12 GHz . Fig.2 a, b, c, d shows the return loss comparison in HFSS and CST for first to fourth antenna, respectively. As presented in Fig 2, all antennas have wide impedance bandwidth in the range of 8-12 GHz which is important for radar application and satellite Ku-band communication for TV satellite communication. The antennas return loss are less than -10 dB at working frequency range.



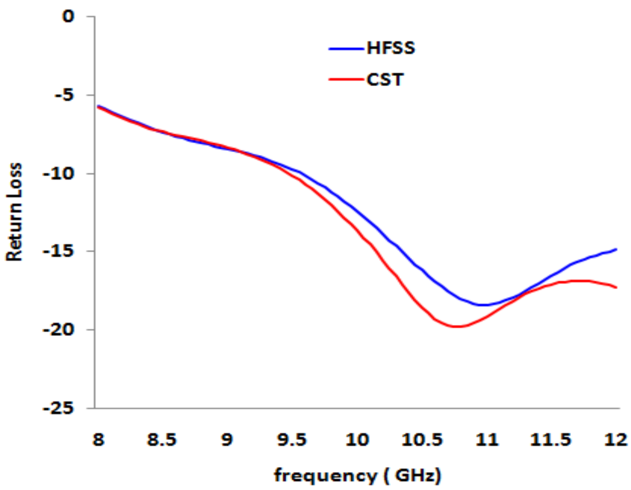
(a)



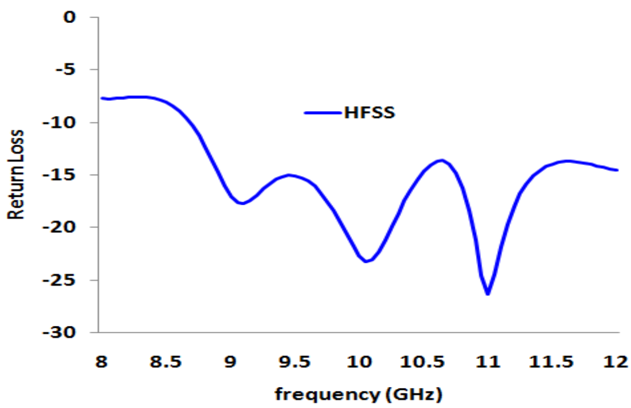
(b)



(c)



(d)

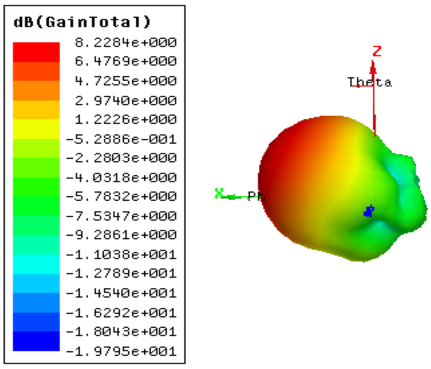


(e)

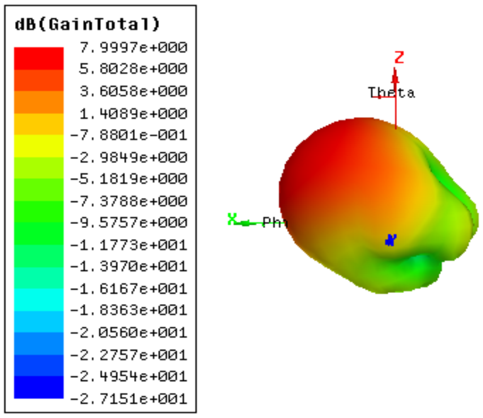
Fig.2 Antennas return loss in HFSS and CST a)V-shape radiator b)Discone radiator c)Slant wire structure d)slant Plane structure e) Pyramidal horn antenna

By comparison return loss of prototype antenna with conventional horn antenna ,despite of large scale of horn antenna , the horn antenna has limited bandwidth and matching design process is too dramatic . But in novel prototype antenna impedance match easy controllable by monopole structure. Fig 2.e shows the horn antenna return loss for this frequency range in HFSS simulator .

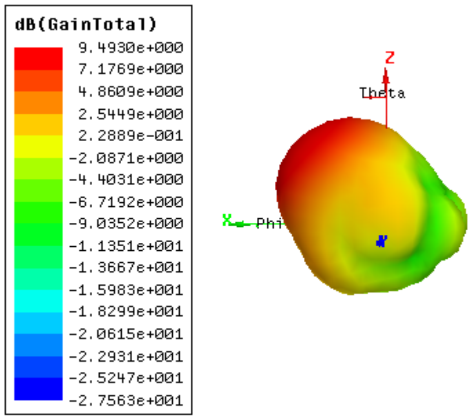
Fig 3 shows the pattern at 9, 10 and 11 GHz for first antenna (V-shape radiator). The antenna presented a directional characteristic at all frequencies and typically the gain for this structure is around 8-10dBi and antenna F/B ratio is more than 18 db .Antenna gain is around 8.22dBi for 9 GHs as shows in Fig 3.a and it is around 8 and 9.5dBi respectively for 10 and 11 GHz. All the prototype antennas have vertical polarization but slant structure in radiator is applied to improve the cross polarization. The pattern of horn antenna 10 GHz is presented in Fig. 3.d . With comparison between pattern , Obviously horn has more gain and better F/B ratio to prototype antenna so here shield is suggested to improve the prototype antenna radiation attribute ..



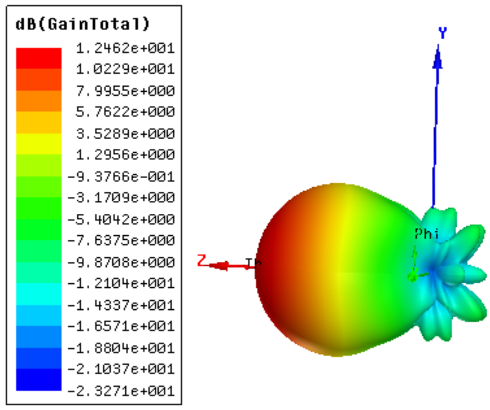
(a)



(b)



(c)



(d)

Fig. 3. Antennas gain for first model a) 9GHz b) 10 GHz c) 11 GHz d) horn antenna 9 GHz

IV. Metamaterial Shield

Metamaterial frequency selective surface (FSS) are known as periodic structure that usually are used in antenna for increase the gain . So in here a shield is added in front of antenna by using thin wire . Apparently, the

KIET IJCE KIET International Journal of Communications &Electronics
Volume. No. 3, Issue No. 2, July-December 2015, ISSN: 2320 - 8996

shield fens will effect on antenna bandwidth and gain. Fig 4 shows prototype antenna with shield fens and the return loss is presented at Fig 5. As shows in Fig 5 the antenna bandwidth is reduced. The bandwidth is 8-9.5 GHz for return loss less than -10dB.

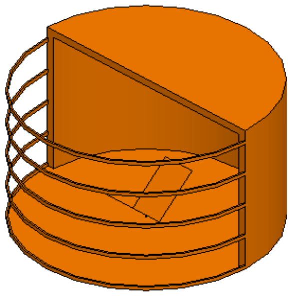


Fig. 4. Antenna with shield

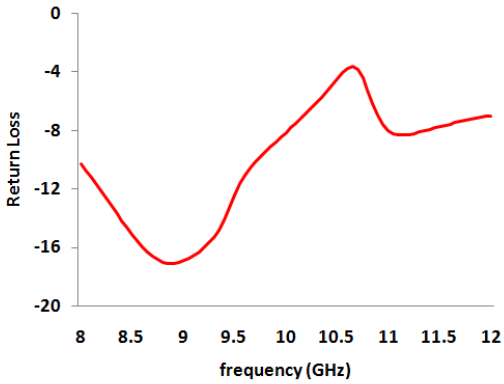


Fig. 5. Return loss of antenna with shield

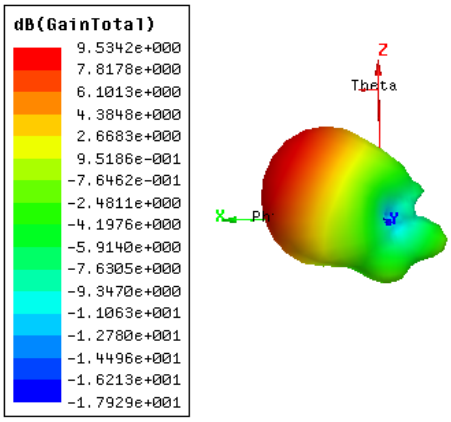


Fig. 6. The pattern of antenna with shield

Fig 6 shows the 3D pattern of antenna for antenna with shield at 9 GHz .The gain in antenna with shield is increased to 9.53dBi, so it shows more than 1.3dBi increment in comparison to conventional model. Fig 7 shows the comparison of cross polarization for Discone structure and slant form .The cross polarization has been increased to 3.17dBi at 10 GHz.

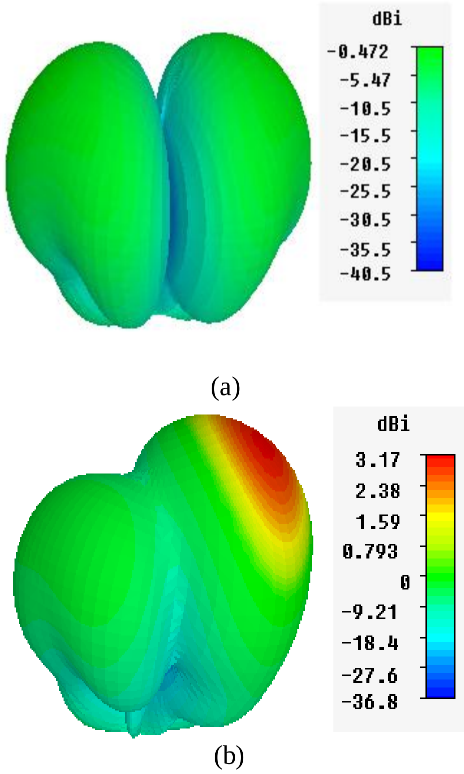


Fig. 7. The cross polarization for 10 GHz a) for Discone model b) for slant structure

V. Conclusion

In this paper, a novel compact antenna with UWB and high gain for X and Ku Bands application is presented. Here shows that with combination of monopole antenna with cavity back shell , we able to achieve high gain and directive radiation pattern . The prototype antenna has low profile and low weight than horn antenna and its shows more impedance matching and lower gain . So by using FSS shield we are tried to improve the antenna gain more than 1.3 dBi at 9 GHz. In other hand we shows difference model of radiator for our monopole antenna and cross polarization have been checked for slant and Discone model . So for high X-Pol application with easy change in monopole structure we able to achieve antenna with high cross polarization .

References

[1] J. Zhang , X. L. Sun, S. W. Cheung, T. I. Yuk, and Z. B. Ni. "CPW-coupled-fed elliptical monopole antenna for UWB applications." In Radio and Wireless Symposium (RWS), 2012 IEEE, pp. 295-298. IEEE, 2012

[2] Z. N.Chen, , M. J. Ammann, X. Qing, X. H. Wu, T. SP See, and A. Cat. "Planar antennas." Microwave Magazine, IEEE 7, no. 6: 63-73. 2006

[3] Abu Bakar, D. Ireland, A. M. Abbosh, and Y. Wang, "Experimental assessment of microwave diagnostic tool for ultra-wideband breast cancer detection," Progress In Electromagnetics Research M, Vol. 23, 109-121, 2012.

[4] D. Ghosh, , A. De, M. C. Taylor, T. K. Sarkar, M. C. Wicks, and E. L. Mokole. "Transmission and reception by ultra-wideband (UWB) antennas." Antennas and Propagation Magazine, IEEE 48, no. 5: 67-99, 2006.

[5] J.Powell, and A. Chandrakasan. "Differential and single ended elliptical antennas for 3.1-10.6 GHz ultra wideband communication." In Antennas and Propagation Society International Symposium, 2004. IEEE, vol. 3, pp. 2935-2938. IEEE, 2004.

[6] F.Keshmiri, , R. Chandra, and C. Craeye. "Design of a UWB antenna with stabilized radiation pattern." In Antennas and Propagation Society International Symposium, 2008. AP-S 2008. IEEE, pp. 1-4. IEEE, 2008.

[7] M.Dionigi, M. Mongiardo, and C. Tomassoni. "Investigation on the phase center of ultra wideband Discone antennas." In German Microwave Conference, 2010, pp. 59-62. IEEE, 2010.

[8] S. A.Hamzah, S. H. Dahlan, R. M. Talib, S. M. Shah, and A. Ubin. "Vertical UWB CDM antenna with integrated band notched filtering." In Applied Electromagnetics, 2007. APACE 2007. Asia-Pacific Conference on, pp. 1-4. IEEE, 2007.

[9] S. Ghosh, "Band-notched modified circular ring monopole antenna for ultrawideband applications." Antennas and Wireless Propagation Letters, IEEE 9: 276-279. 2010

[10] E.Antonino-Daviu, M. Fabres, M. Ferrando-Bataller, and V. M. Rodrigo Penarrocha. "Modal analysis and design of band-notched UWB planar monopole antennas." Antennas and Propagation, IEEE Transactions on 58, no. 5: 1457-1467. 2010

[11] M.A. Peyrot-Solis, G. M. Galvan-Tejada, and H. Jardon-Aguilar, "Proposal and development of two directional UWB monopole antennas," Progress In Electromagnetics Research C, Vol. 21, 129-141, 2011.

[12] M.Guo, and S.-S. Zhong. "Broadband wide beam width printed dipole antenna." In Antenna Technology (iWAT), 2012 IEEE International Workshop on, pp. 72-75. IEEE, 2012.

[13] C. H.Kang, S.J.Wu, and J..H. Tarng. "A novel folded UWB antenna for wireless body area network." Antennas and Propagation, IEEE Transactions on 60, no. 2: 1139-1142. 2012

[14] R. A.Alhalabi, , Y.C. Chiou, and G. M. Rebeiz. "Self-Shielded High-Efficiency Yagi-Uda Antennas for 60 GHz Communications." Antennas and Propagation, IEEE Transactions on 59, no. 3 : 742-750. 2011

[15] S.Yun, D. Kim, S. Nam "Bandwidth and efficiency enhancement of cavity backed slot antenna using a substrate removal," IEEE Antennas and Wireless Propagation Letters, Vol. 11, 1458-1461, 2012

[16] M.Padilla, , and J. Vardaxoglou. "Analysis of a metamaterial based leaky wave antenna with laterally shielded planar technology.": 287-287. 2007

[17] S. A. Muhammad, , R. Sauleau, and H. Legay. "Small-size shielded metallic stacked Fabry–Perot cavity antennas with large bandwidth for space applications." Antennas and Propagation, IEEE Transactions on 60, no. 2: 792-802. 2012

[18] W.Hong, and K. Sarabandi. "Platform embedded slot antenna backed by shielded parallel plate resonator." Antennas and Propagation, IEEE Transactions on 58, no. 9: 2850-2857. 2010

[19] C. H. E. N. Guo, and R. C. Liu. "Design of a shielded antenna system for ground penetrating radar applications." In Antennas and Propagation Society International Symposium, 2009. APSURSI'09. IEEE, pp. 1-4. IEEE, 2009.

[20] P. Y. Chen, and A. Alu. "Dual-Mode Miniaturized Elliptical Patch Antenna With µ-Negative Metamaterials." Antennas and Wireless Propagation Letters, IEEE 9: 351-354. 2010