Water Dense Dielectric Patch Antenna

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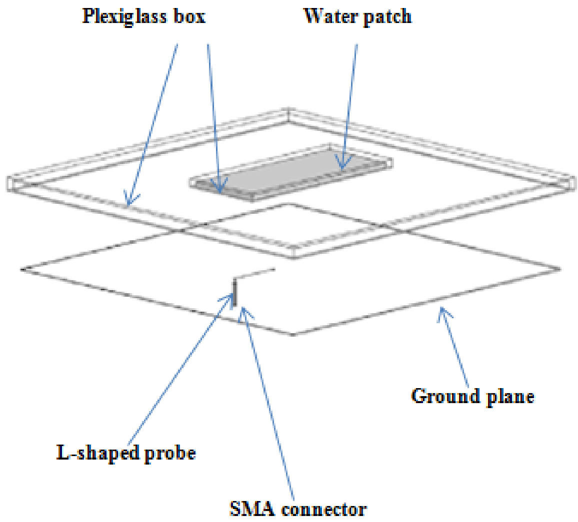
ABSTRACT
An innovative water dense dielectric patch antenna fed by L-probe is proposed and investigated. The operation mechanism of the water DDPA perform similar to the conventional rectangular metallic patch antenna operated in the fundamental TM 10 mode. An L-shape probe is used to excite water DDPA in order to observe bandwidth performance of antenna by selecting the thick high relative permittivity supporting substrate in between the ground plane and the water patch. The water DDPA operated at 1.025 GHz exhibit maximum impedance bandwidth of 11.38%, maximum gain of 7.76 dBi, radiation efficiency up to 70% and symmetrically unidirectional radiation pattern with low backlobe and low cross polarization level. Performance of this DDPA is observed with different dimensions and patch material (normal and distilled water), simulated results are investigated.

Keywords
L-probe, water patch, dense dielectric patch antenna

1. INTRODUCTION
Different liquid materials, such as mercury [1], [2], eutectic gallium indium (EGaIn) [3], liquid crystal [4], [5], and water [6], [7], have been utilized for realization of antennas owing to their many interesting properties, such as liquidity, transparency, and so on. Among these materials, water has become the most popular one recently because of low cost, easy access, and safety. Generally, the use of water for designing antennas can be divided into two kinds-the salt water and the pure water. The salt water is usually used as a conductor to support current flow .Different water monopoles have been designed based on this idea [8], [9]. On the other hand, the pure water is commonly applied as a dielectric to construct dielectric resonator (DR) antennas [10]–[11]. However, the high dielectric loss of the water degrades the radiation efficiency of these antennas.

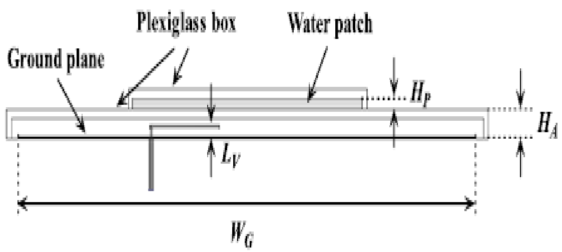
Now days the dense dielectric patch antenna is designed [12], as compare to conventional metallic patch antenna the metallic patch is replace with water patch with high dielectric constant. The waves can be trapped between the dielectric water patch and ground plane because of high permittivity of dielectric patch as compare to supporting ground plane. The result [12] shows that the cavity mode is excited between dielectric patch and ground plane.

2. ANTENNA DESIGN

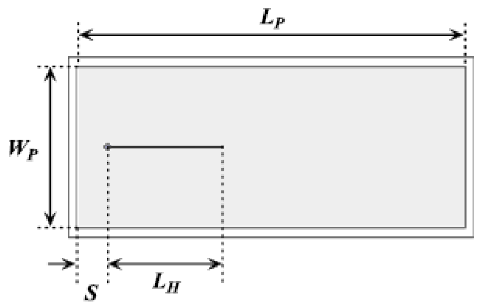


(a)

The geometry of proposed water dense dielectric patch antenna as shown in Fig.1. It consists of two plexiglass box stacked together, the thickness of plexglass is 0.4 mm and dielectric constant is 3.4.The top box having a length of Lp , width of Wp and height Hp is filled with pure water, while bottom larger box is empty and its act as a supporting to the structure. The substrate between the water patch and theground plane is air. The square metallic ground plane having length Wg placed at the bottom of larger plexiglass box where the L-shape probe is mounted. The height and length of L-shaped probe is Lv and LH respectively. S is the spacing between the edge of water patch and position of L-shaped probe. [14]



(b)



(c)

Fig 1: Geometry of the L-probe fed water dielectric patch antenna (a) Overall geometry (b) Side view (c) Top view [14]

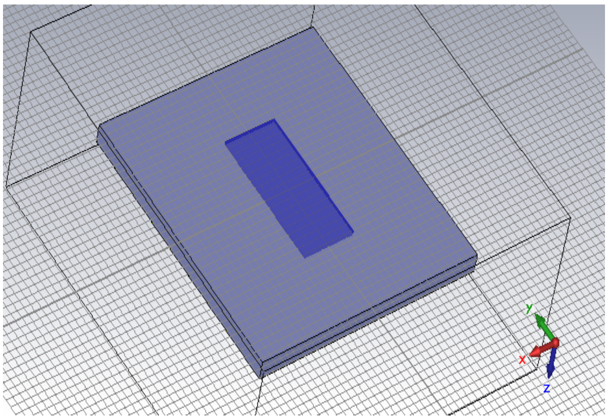


Fig 2. Model design in CST studio

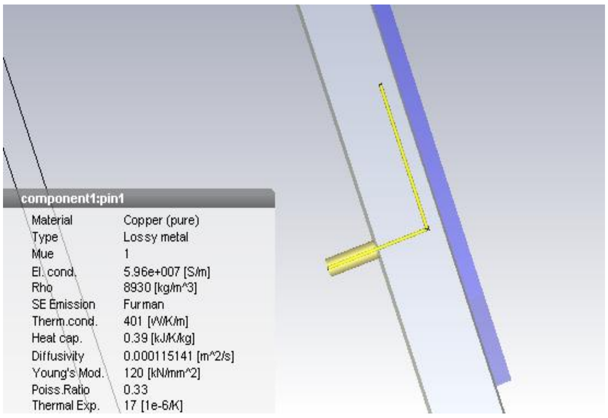


Fig 3. Side view of model design in CST studio

The proposed antenna model is design in CST Studio 2015 as shown in Fig. 2. It consist of water patch, air substrate and metallic ground plane having L-shape probe with SMA connector for feeding the antenna. For design of SMA connector consist of pin is pure copper coated with dielectric material Teflon. The L-shape probe is design to the intersection of two pure copper pin. For design antenna model select the appropriate material from library to the different component used in the antenna. According to result [13] the aperture coupled DDPA with a thin substrate has a narrow bandwidth of 1%. However, it is well known that the L-probe fed patch antenna [13] is a wideband antenna structure. Therefore, it is worthwhile to investigate the bandwidth performance of the novel water dielectric patch antenna.

Table 1. Dimension and performance of antenna

Dimensions	**Design I**	**Design II**
HA	10	20
LP	180	170
WP	80	80
LV	7.4	15.9
LH	57	44
S	35	35
HP	5	5
WG	350	350
Fo (Ghz)	0.95 Ghz	1.01 Ghz
B.W.(S11<-10 dB)	7.32 %	11.38 %
Max. Gain(dbi)	9.46 dbi	7.76 dbi

The bandwidth performance of antenna mainly depend on the height of the substrate, here the height HA for the three designs is 10, 20mm respectively. The center frequency of the operating band is set at 1.02 GHz in this study. The permittivity and the loss tangent of the pure water are set as 81 and 0.04. The performances of the designs are simulated with the assistance of a full-wave electromagnetic solver – CST STUDIO. The dimension and performance of antenna are shown in table 1. The impedance bandwidth significantly increases with the height of the air substrate. For Ha=10 mm the bandwidth is 7.32%, HA=20mm the bandwidth is 11.38% and for From this result, it can be concluded that L-probe feeding is effective method to widen the bandwidth of antenna and gain of antenna is increase with thick substrate as compare to thin substrate. Therefore, it can be seen from the above analysis that for any requirement of practical applications, a proper height of substrate may be selected to achieve the desirable bandwidth.

3. RESULT

The simulated |S11| and gain of WDDPA is as shown in fig. The simulated bandwidth is 7.32 % (0.85 GHz to 1.2 GHz), 11.38% for antenna design of I, II respectively with |S11|< -10 db. The simulated gain is 9.46 dB, 7.76dB for antenna design of I, II respectively as shown in Table 1.

The S-parameter curve for design I as shown in fig. showing the operating band of 085 GHz to 1.2 GHz with the centre frequency of 0.95 GHz and impedance bandwidth of 7.32 %.

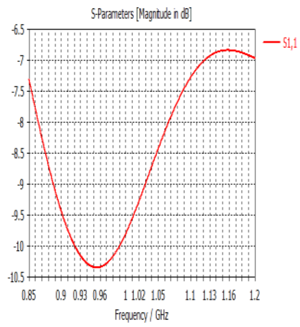


Fig. 4. Simulated |S11| parameter of proposed water dielectric patch antenna

The radiation pattern of design I as shown in fig showing the symmetrically unidirectional pattern with main lobe magnitude is 9.46 dBi at 1.025 GHz.

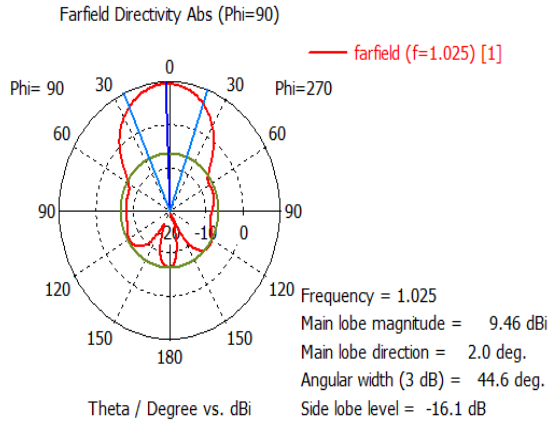


Fig 5. Simulated radiation pattern of the proposed water dense dielectric patch antenna at center frequency of the operating band

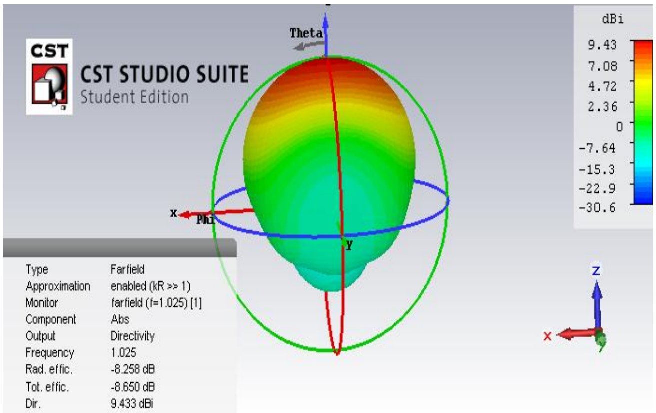


Fig 6. Simulated 3D view far field directivity of water dense dielectric patch antenna

Distilled water patch

By changing the normal water patch to distilled water patch the antenna performance was investigated. The dielectric constant of distilled water is 78.4. The simulated bandwidth is 5.32% and simulated gain is 9.68 dBi.

The simulated bandwidth of distilled water patch is somewhat lower than the normal water patch and gain is more as compare to normal water patch in WDDP antenna. For design I

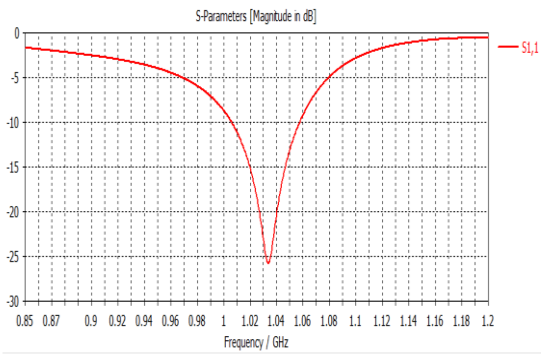


Fig 7. Simulated |S11| parameter of proposed water dielectric patch antenna

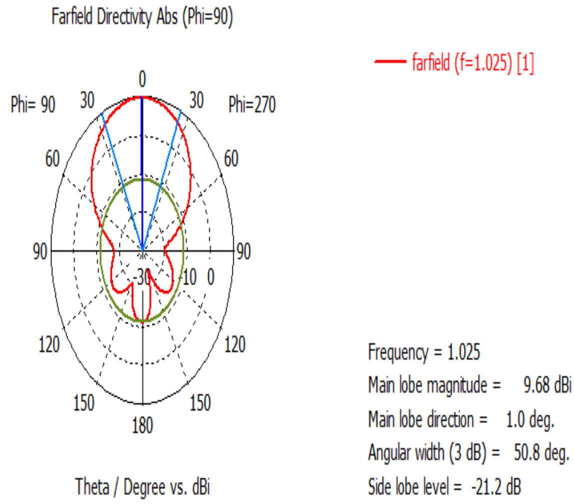


Fig. 8. Simulated radiation pattern of the proposed water dense dielectric patch antenna at center frequency of the operating

Fig.7 shows the S11 parameter of distilled water patch antenna which shows the lower the bandwidth i.e. 5.32 % than normal water patch antenna. Fig. 8 shows the radiation pattern of distilled water patch antenna having max. gain is 9.68 dBi

band.

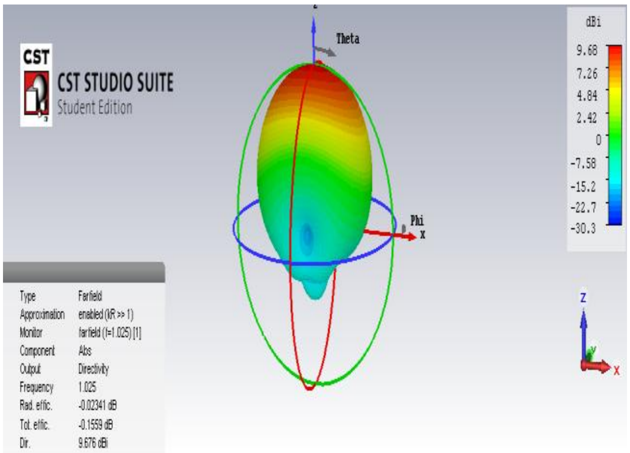


Fig 9. Simulated 3D view far field directivity of Water dense dielectric patch antenna

Table 2. Performance of antenna for design I

	Design I
F0 (Ghz)	0.95 Ghz
BW(S11<-10 db)	5.32 %
Max. Gain(dbi)	9.68 dbi

4. CONCLUSION

An innovative water dense dielectric patch antenna fed by L-probe is proposed and investigated. The purposed water dielectric patch antennas constructed by using pure water same as a basic principle of conventional metallic patch antenna. The L-probe feeding is applied to the water patch antenna similar to L-probe feed metallic patch antenna. The bandwidth of the antenna is improved by increasing the thickness of supporting substrate between water patch and ground plane. The impedance bandwidth is 11.38 % with the maximum gain of 7.76dbi. The radiation pattern of the prototype is symmetrical with low backlobe and low cross polarization level.

5. FUTURE SCOPE

Antenna will be integrated with solar cell because of transparent water patch used in satellite application.Antenna will be worked in dual band application.

6. REFERENCES

[1] Y.Kosta and S.Kosta, ''Liquid antenna systems,'' in Proc. IEEE AP-SInt.Symp. , Jun. 2004, pp. 2392–2395.

[2] Y. Kosta and S. Kosta, ''Realization of a microstrip-aperture-coupled-passive-liquid patch antenna,'' in Proc. IEEE Int. RF Microw. Conf., Dec. 2008, pp. 135–138.

[3] G.J.Hayes,J.-H.So,A.Qusba,M.D.Dickey,and G. Lazzi, ''Flexible liquid metal alloy (EGaIn) microstrip patch antenna,'' IEEE Trans. Antennas Propag., vol. AP-60, no. 5, pp. 2151–2156, May 2012.

[4] O.H.Karabey,S.Bildik,S.Bausch,S.Strunck,Gaebler,and R.Jakoby, ''Continuously polarization agile antenna by using liquid crystal-based tunable variable delay lines,'' IEEE Trans. Antennas opag.,vol.61,no.1,pp. 70–76, Jan. 2013.

[5] J.-C.S.Chieh and A.-V.Pham, ''A bidirectional microstrip X-band antenna array on liquid crystal polymer for beamforming applications,'' IEEE Trans. Antennas Propag., vol. 61, no. 6, pp. 3364–3368, Jun. 2013.

[6] S. S. Alja' a freh, Y. Huang, and L. Xing, ''A compact dual-feed water based diversity antenna, '' in Proc. Loughborough Antennas Propag. Conf., Nov. 2013, pp. 182–185.

[7] L. Xing, Y. Huang, Y. Shen, S. Al Ja'afreh, Q. Xu, and R. Alrawashdeh, ''Broadband U-shaped water antenna for DVB-H applications,'' in Proc. IEEE AP-S Int. Symp., Jul. 2014, pp. 1930–1931.

[8] E. Paraschakis, H. Fayad and P. Record, ''Ionic liquid antenna,'' in Proc. IEEE Int. Workshop Antenna Technol., Small Antennas Novel Metamater, Mar. 2005, pp. 552-554

[9] H. Fayad and P. Record, ''Broadband liquid antenna,'' Electron. Lett., vol. 42, no. 3, pp. 133–134, Feb. 2006.

[10] S.G.O'KeefeandS.P.Kingsley,''Tunability of liquid dielectric resonator antennas,'' IEEE Antennas Wireless Propag. Lett., vol. 6, pp. 533–536, 2007.

[11] R.Zhou, H.Zhang,and H.Xin,''Liquid-based dielectric resonator antenna and its application for measuring liquid real permittivities,'' IET Microw., Antennas Propag., vol. 8, no. 4, pp. 255–262, Mar. 2014.

[12] H.W.Lai, K.-M.Luk, and K.W.Leung, ''Dense dielectric patch antenna— A new kind of low-profile antenna element for wireless communications,'' IEEE Trans. Antennas Propag., vol. 61, no. 8, pp. 4239–4245, Aug. 2013.

[13] K. M. Luk, C. L. Mak, Y. L. Chow, and K. F. Lee, ''Broadband microstrip patch antenna,'' Electron. Lett., vol. 34, no. 15, pp. 1442– 1443, 1998.

[14] Yujian Li and Kwai-Man Luk, " A water dense dielectric patch antennas" IEEE access., Vol 3, pp. 274-280, March 2015.