Ultra-wideband Dielectric Resonator Antenna with Circular Patch Feed

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***Abstract*—A novel dielectric resonator antenna with an ultra-wideband (UWB) bandwidth and great time-domain performances has been proposed. The proposed feed for cone dielectric resonator antenna is a circular patch, which has the potential to achieve ultra-wideband characteristic. The operating frequency range of the antenna is 2.77-11.63GHz. The design provides constant group delay, consistent omni-directional characteristics and high efficiency. The overall dimension of the proposed antenna is 24.3mm×32.6mm with 6.08mm thickness. The proposed antenna provides the valuable dielectric resonator antenna design and shows great value in the fields of breast cancer detection systems.**

Keywords—Dielectric resonator antenna(DRA); circular patch feed; ultrawideband antenna; cancer detection

I. INTRODUCTION

Since the Federal Communication Commission(FCC) prescribed the frequency spectrum from 3.1 to 10.6GHz for ultra-wideband(UWB) applications, UWB antenna has drawn much attention due to its advantages such as simple structure, low cost, high data rate and easy fabrication. However, the feasible UWB antenna design exists some challenges, including sufficient impedance matching bandwidth, high radiation efficiency and avoiding the interference problem, especially for breast cancer detection. The dielectric resonator antenna(DRA) is one of the promising candidate antennas for UWB application owning to some striking characteristics such as low dissipation loss, high radiation, light weight and easy to match targets with different permittivity. However, it is hard for DRA to get a wide band under a high value dielectric constant. Some enhancement techniques are on the way.

In this paper, we propose a novel UWB dielectric resonator antenna integrated with circular patch. It combines the wide band characteristic of disk and the similar permittivity as breast fatter tissue of dielectric resonator, which achieves wide bandwidth enhancements and can be used for breast detection. Moreover, the antenna provides an omni-directional radiation pattern in the horizontal plane, high radiation efficiency and stable time-domain characteristic.

II. ANTENNA CONFIGURATION

Fig.1 shows the proposed UWB dielectric resonator antenna configuration and parameters, which composed by two parts: circular patch with a radius of $2r$ fed by coaxial line and 2 $m \times n$ floors, and cone dielectric resonator whose thickness is 5.08mm and dielectric constant is 10.2.

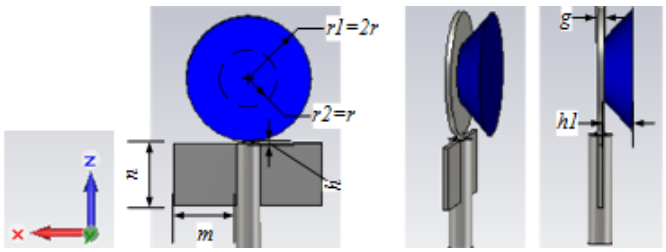

Fig.1. Configuration of the Proposed UWB DRA Antenna. r=5.5, m=n=11, g=l, h=0.6, h1=5.08, Unit(mm)

The type of DRA can be used for the cancer detection. Compared with other sensors, they have lots of advantages such as compact size, high efficiency and, most of the important, the simplicity without a need for matching medium between antenna and patient's breast. The dielectric resonator we used has a similar dielectric constant of 10.2 to the permittivity of the fatty issue. Therefore, there is no need extra matching medium for getting well reflection characteristic.

III. SIMULATION RESULTS AND DISCUSSION

Fig.2 presents the simulated reflection coefficients S11 with different r. The best impedance performance within the UWB frequency range can be achieved when r=5.5mm, which also indicates the variation of r has impact on the lowest operating frequency and resonance frequency of the antenna.

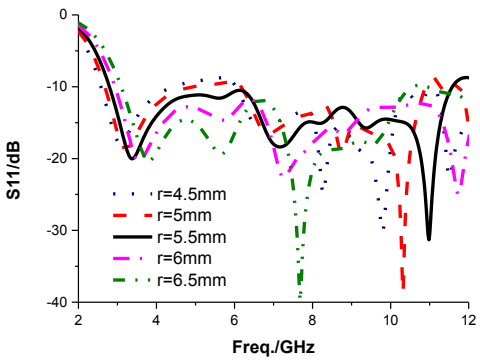

Fig.2. Simulated S11 versus Frequency of Antennas with Different r.

Group delay can be used test the phase center stability, which is a key parameter for antenna, especially for antenna applied in UWB communication and detection systems. If the variation of group delay exceeds 1ns, distortion of impulse waveform will happen as a result of phase nonlinear in the far field. Fig.3 shows the simulation group delay of the proposed antenna has stable phase center over the operation bandwidth with a tinily fluctuation(<1ns).

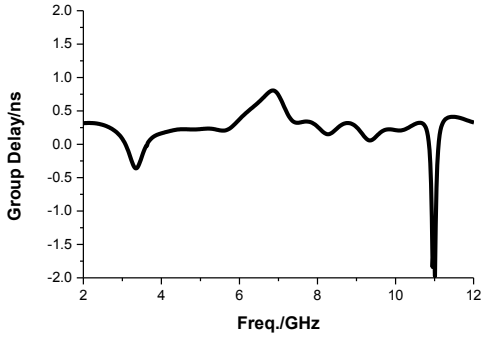

Fig.3. Group Delay over 2-12 GHz

Fig.4 plots the simulated radiation patterns at three different frequencies (3.1, 6.85 and 10GHz), where stable omni-directional xoy-plane radiation patterns are achieved in the frequency range concerned. The antenna radiates in a broadside direction. Moreover, we can observe the maximum radiation directions of xoz-plane and yoz-plane change from two directions to four directions or more with the increase of frequency. The antenna demonstrates a near omni-directional behaviour all the time in horizontal plane.

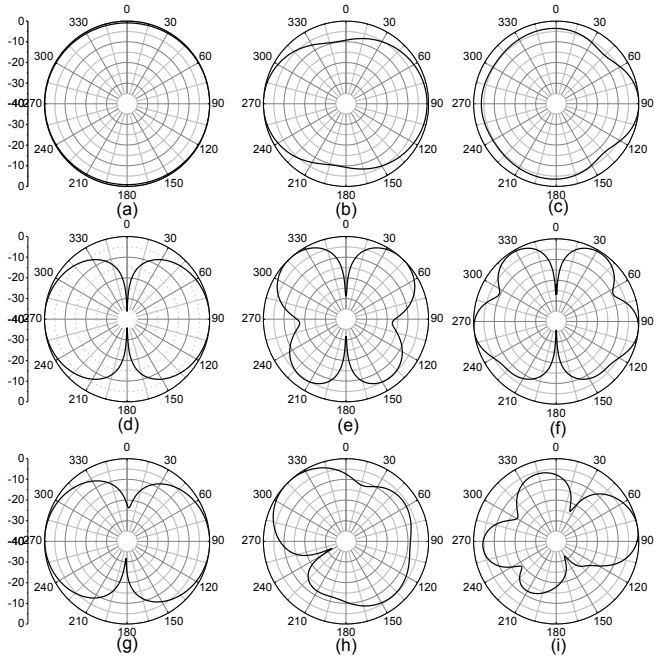

Fig.4. Normalized radiation patterns. (a) xoy-plane at 3.1GHz. (b) xoy-plane at 6.85 GHz. (c) xoy-plane at 10.6 GHz. (d) xoz-plane at 3.1 GHz. (e) xoz-plane at 6.85 GHz. (f) xoz-plane at 10.6 GHz. (g) yoz-plane at 3.1 GHz. (h) yoz-plane at 6.85 GHz. (i) yoz-plane at 10.6 GHz

Fig.5 shows the gain and efficiency of the antenna versus frequency for the proposed UWB-DRA. The antenna reaches higher than 92 percent radiation within all the operation frequency band. Referring to the gain performance, the gain in the operation band improves along with the increase of the frequency gradually from 3.1 to 10.6GHz except the point at 9GHz. The similar gain varying trend of antenna both with DR and without DR can be seen in the simulation results, and the average gains are far more than 3dB. Moreover, the gain in the maximum radiation direction is increased by adding the dielectric resonator as a result of the effect of coupling between disk and cone dielectric resonator.

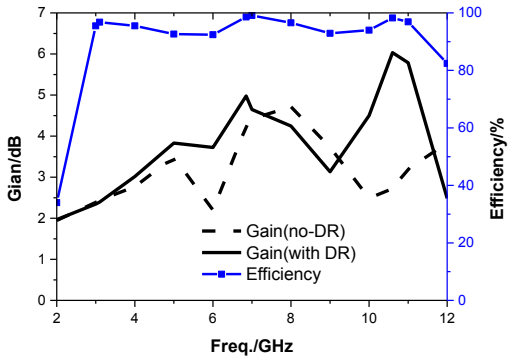

Fig.5. Antenna efficiency and gain versus frequency

IV. CONCLUSION

In this paper, a circular patch feed is present, which has been used to excite a hybrid mode in cone dielectric resonator antenna. The proposed antenna achieves excellent radiation characteristics within the frequency spectrum used for UWB applications. Moreover, dielectric resonators are used for match the human issue perfectly, which makes the proposed antenna to be promising in the breast cancer detection systems.

REFERENCES

[1] K.S. Ryu, and A.A. Kishk, "UWB Dielectric Resonator Antenna Having Consistent Omnidirectional Pattern and Low Cross-Polarization Characteristics," IEEE Transactions on Antennas and Propagation, vol. 59, no. 4, 2011, pp. 1403-1408.

[2] A.K. Gautam, S. Yadav, and B.K. Kanaujia, "A CPW-Fed Compact UWB Microstrip Antenna", IEEE Antennas and Wireless Propagation Letters, vol. 12, 2013, pp. 151-154.

[3] Khalily, M.K.A. Rahim, and A.A. Kishk, "Bandwidth Enhancement and Radiation Characteristics Improvement of Rectangular Dielectric Resonator Antenna," IEEE Antennas and Wireless Propagation Letters, vol. 10, 2011, pp. 393-395.

[4] A.H. Majeed, A.S. Abdullah, F. Elmegri, K.H. Sayidmarie, R.A. Abd-Alhameed, and J.M. Noras, "Aperture-Coupled Asymmetric Dielectric Resonators Antenna for Wideband Applications," IEEE Antennas and Wireless Propagation Letters, vol. 13, 2014, pp. 927-930.

[5] R.K. Chaudhary, R. Kumar, and K.V. Srivastava, "Wideband Ring Dielectric Resonator Antenna With Annular-Shaped Microstrip Feed," IEEE Antennas and Wireless Propagation Letters, vol. 12, 2013, pp. 595-598.

[6] G.S. Reddy, A. Kamma, S. Kharche, J. Mukherjee, and S.K. Mishra, "Cross-Configured Directional UWB Antennas for Multidirectional Pattern Diversity Characteristics, " IEEE Transactions on Antennas and Propagation, vol. 63, no. 2, 2015, pp. 853-858.

[7] David Gibbins, and Maciej Klemn, "A Comparison of a Wide-Slot and a Stacked Patch Antenna for the Purpose of Breast Cancer Detection", IEEE Transactions on Antennas and Propagation, vol. 58, no. 3, 2010, pp. 665-674.