Millimeter-Wave WideBand Dielectric Resonator Antenna

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***Abstract*—A millimeter-wave wideband cylindrical dielectric resonator antenna (DRA) excited in its HEM_{113} and HEM_{115} modes is presented. The two modes are combined to widen the bandwidth, giving a wide 10-dB impedance bandwidth of more than 25%. The variation of the antenna gain is less than 3 dB across the impedance passband ($|S_{11}|$ < -10 dB).**

I. INTRODUCTION

TE dielectric resonator antenna (DRA) is suitable for millimeter-wave applications because of its low loss and high efficiency. Conventional DRAs are operated in their fundamental modes [1]–[2], and they may be too small to be fabricated precisely at millimeter-wave frequencies. Recently, it was found that using higher-order modes can increase the DRA size and make the DRA more tolerant to fabrication errors [3]. A drawback of the higher-order mode approach is that the DRA has a narrower bandwidth due to an increase in the effective dielectric constant. To widen the bandwidth, the higher-order HEM_{113} and HEM_{115} modes are merged in this paper to give a wideband millimeter-wave DRA.

II. ANTENNA DESIGN RESULTS

Fig. 1 shows the configuration of the proposed cylindrical DRA. The DRA has a diameter of Φ_D, height of H_D, and dielectric constant of ε_r. It rests on a ground plane which has a side length of L_G and thickness of H_G. To excite the DRA, a SMA probe with a diameter of Φ_P and height of H_D is placed against the surface of the antenna.

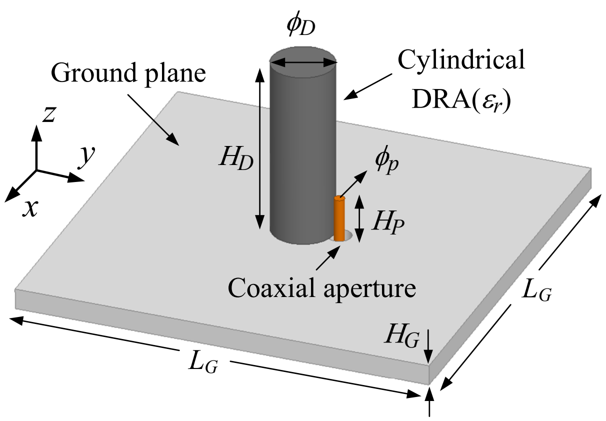


Fig. 1. Configuration of the proposed DRA: Φ_D = 3 mm, H_D = 8.5 mm, Φ_P = 0.25 mm, H_P = 1.9 mm, L_G = 30 mm, H_G = 4 mm, and ε_r = 7.

The proposed DRA was simulated with ANSYS HFSS and measurements were done to verify the simulations. Fig. 2 shows the reflection coefficient and antenna gain of the proposed DRA. With reference to the figure, reasonable agreement between the measurement and simulation is obtained. The measured and simulated impedance bandwidths ($|S_{11}|$ < -10 dB) of the proposed DRA are 25.1 % (22.6–29.1 GHz) and 26.4 % (22.4–29.2 GHz), respectively. The result is similar to that of a previous wideband design, which combines the fundamental HEM_{111} mode and higher-order HEM_{113} mode [4]. Fig. 2 also shows the measured and simulated antenna gains of the proposed DRA. As can be observed from the figure, across their impedance passbands ($|S_{11}|$ < -10 dB), the measured and simulated maximum gains of the DRA are 8.32 dBi (28.5 GHz) and 8.62 dBi (29.15 GHz), respectively. The gain variations in the measurement and simulation are less than 2.9 dB and 2.8 dB, respectively. This result is much better than that of the previous wideband DRA [4], in which the measured gain variation is more than 4.5 dB across its impedance passband ($|S_{11}|$ < -10 dB).

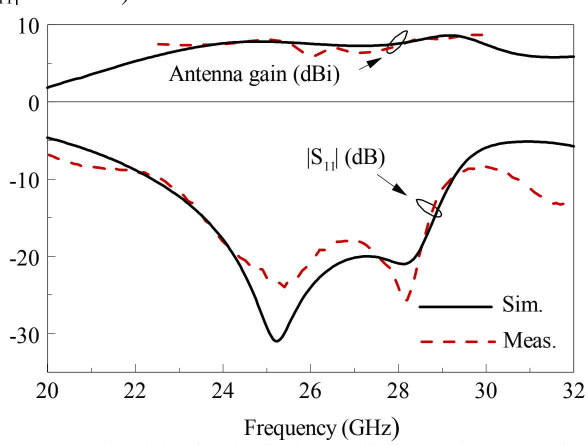
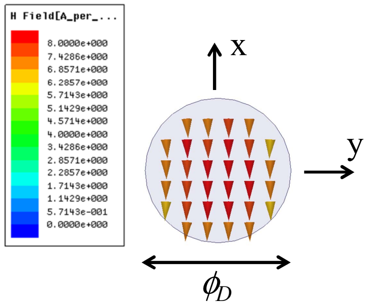


Fig. 2. Measured and simulated reflection coefficients and antenna gains of the proposed DRA. The parameters are the same as in Fig. 1.

Figs. 3 and 4 show the simulated resonant H- and E-fields inside the proposed DRA in the first (25 GHz) and second (28 GHz) resonant modes, respectively. With reference to the figures, the field distributions at 25 GHz and 28 GHz are found to be consistent with those of the HEM_{111} and HEM_{113} modes of the DRA, respectively.

Fig. 5 shows the measured and simulated radiation patterns of the proposed DRA at 25 GHz and 28 GHz. As canbe observed from the figure, the measurement agrees reasonably well with the simulation. It can be seen from the figure that broadside radiation patterns are obtained for both resonant modes, which are expected for the HEM_{113} and HEM_{115} modes.



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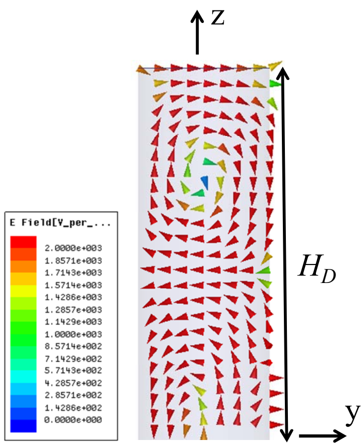
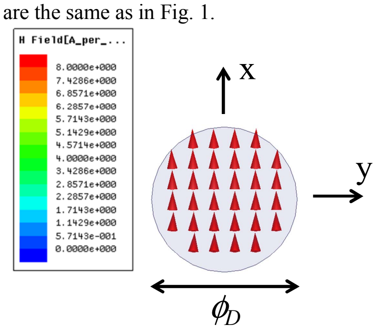


(b)

Fig. 3. Simulated resonant fields inside DRA at 25 GHz. (a) H-field (b) E-field. The parameters are the same as in Fig. 1.



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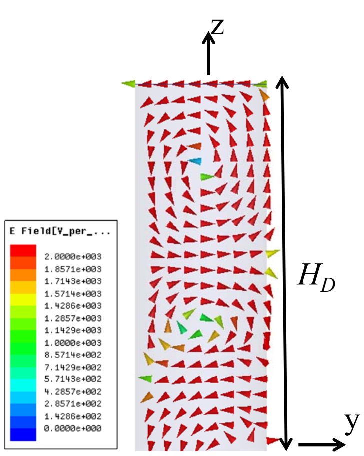
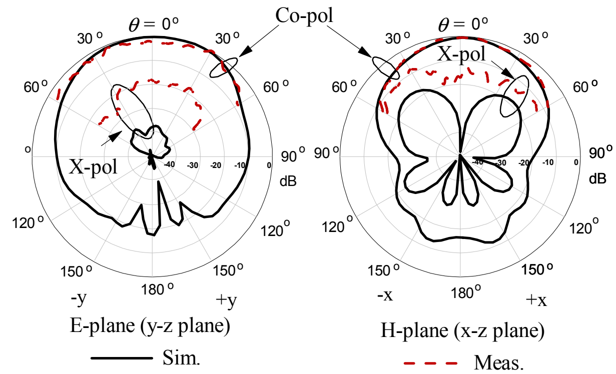


(b)

Fig. 4. Simulated resonant fields inside DRA at 28 GHz. (a) H-field (b) E-field. The parameters are the same as in Fig. 1.



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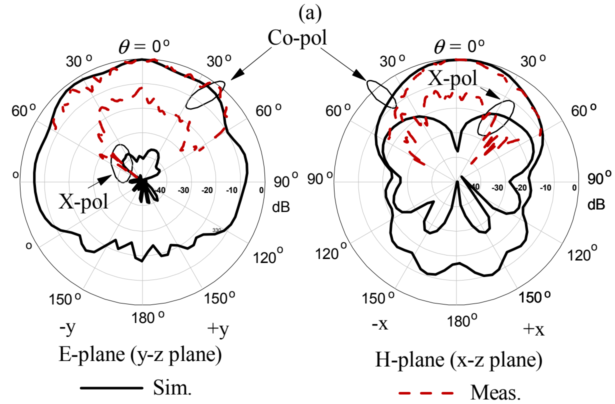

(b)

Fig. 5. Measured and simulated radiation patterns of the proposed DRA at (a) 25 GHz and (b) 28 GHz. The parameters are the same as in Fig. 1.

III. CONCLUSION

A wideband cylindrical DRA has been investigated for millimeter-wave applications. The wide bandwidth has been obtained by merging the higher-order HEM_{113} and HEM_{115} modes. Ansoft HFSS was used to simulate the DRA and the simulations have been verified with measurements. Reasonable agreement between the simulated and measured results has been observed. It has been found that the performance of the proposed DRA is similar to that of the conventional wideband DRA which makes use of the fundamental HEM_{111} mode and higher-order HEM_{113} mode.

Acknowledgements

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