Progress In Electromagnetics Research, PIER 76, 201–210, 2007

2.5 GHZ BATIO$_3$ DIELECTRIC RESONATOR ANTENNA

M. F. Ain, S. I. S. Hassan, J. S. Mandeep, M. A. Othman and B. M. Nawang

School of Electrical and Electronic Engineering
Universiti Sains Malaysia
Nibong Tebal, 14300, Pulau Pinang, Malaysia

S. Sreekantan, S. D. Hutagalung, and Z. A. Ahmad

School of Materials and Mineral Resources Engineering
Universiti Sains Malaysia
Nibong Tebal, 14300, Pulau Pinang, Malaysia

Abstract—Experimental study on a cylindrical Dielectric Resonator Antenna (DRA) using barium titanate ($BaTiO_3$) is presented in this paper. The antenna is fed with a $50\,\Omega$ microstrip transmission line at frequency around 2.5 GHz. High dielectric constant ($\varepsilon_r = 1000$) resonator samples with different thickness are employed. The return loss, input impedance and radiation patterns are studied. Design simulation results using CST software also presented.

1. INTRODUCTION

Recently, the dielectric resonator antenna has been proposed as an alternative to the popular microstrip patch parallel with rapid progress in microwave communication that demands miniaturization of microwave circuits. Dielectric antenna have proved themselves to be ideal candidates for antenna application by offer several advantages including mechanical simplicity, large impedance bandwidth [6], simple coupling schemes to all commonly used transmission line [9, 10], very high radiation efficiency, can be made smaller than conventional metal antennas and more resistant to proximity detuning when placed close to another object. DRA can be easily varied by suitably choosing the dielectric constant of the resonator material and its dimensions [1, 7]. Dielectric Resonators (DR's) are preferred because they are easy to fabricate and offer more degree of freedom to control the resonant frequency and quality factor [11]. However, the high Q factor restricts the bandwidth, which limits its usefulness as an antenna [8, 12]. Therefore, high permittivity DR's are preferred in the design of antenna.

2. ANTENNA CONFIGURATION

The configuration of proposed cylindrical DRA is shown in Fig. 1. It comprises a DR of diameter $D = 14\,\text{mm}$ fabricated by using $BaTiO_3$ dielectric materials with relative permittivity $\varepsilon_r = 1000$ through conventional ceramic processing. The DR is fed energy by a $50\,\Omega$ microstrip line of width $= 2.18\,\text{mm}$ and length $= 40.13\,\text{mm}$ by putting on the top of substrate. The substrate is duroid with dielectric constant is, $\varepsilon_{rs} = 2.5$. SMA connector is soldered to the microstrip line to provide better matching as shown in Fig. 2. DR's are varied with different thickness to get different operating frequency.

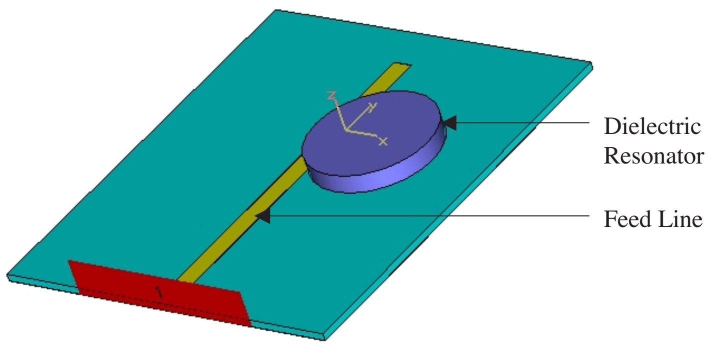


Figure 1. Geometry of dielectric resonator antenna fed by microstrip transmission line.

3. RESULTS AND DISCUSSION

Fig. 3 show the antenna characteristic for DRA when height $H = 2\,\text{mm}$, Fig. 4 show the antenna characteristic for DRA when height $H = 2.5\,\text{mm}$ and Fig. 5 show antenna characteristic for DRA when height $H = 3\,\text{mm}$ for proposed antenna. From the results, it is clearly shows that the antenna operates at different resonant frequencies when the heights of DR are varied. Resonant frequencies for height $= 2\,\text{mm} \sim 2.787\,\text{GHz}$, height $= 2.5\,\text{mm} \sim 2.496\,\text{GHz}$ and height $= 3\,\text{mm} \sim 2.294\,\text{GHz}$.

The measurement of DRA's were done by using HP 8720B Network Analyzer to see reflection and radiation characteristic of the proposed antenna. Their results are shown in Fig. 6, Fig. 7 and

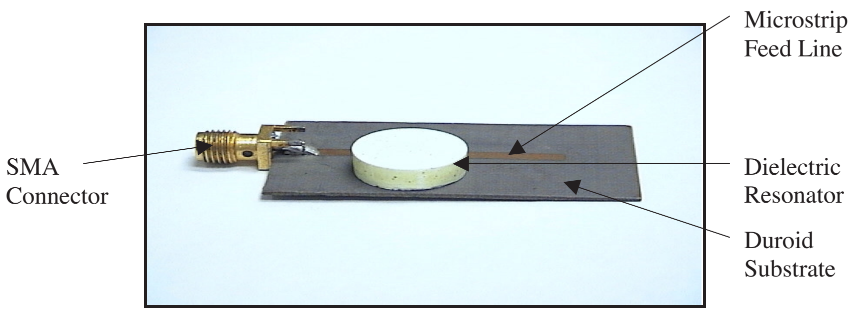
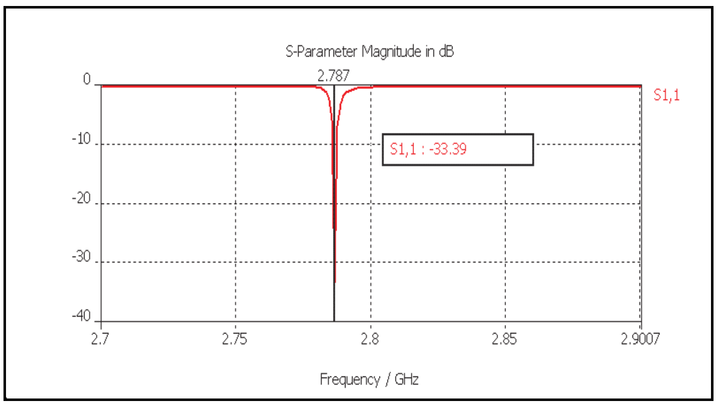
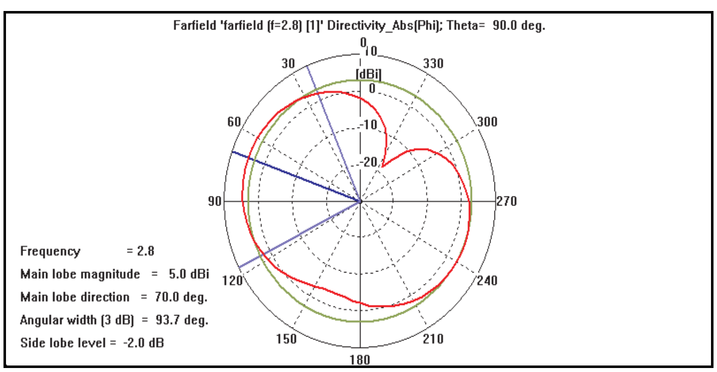


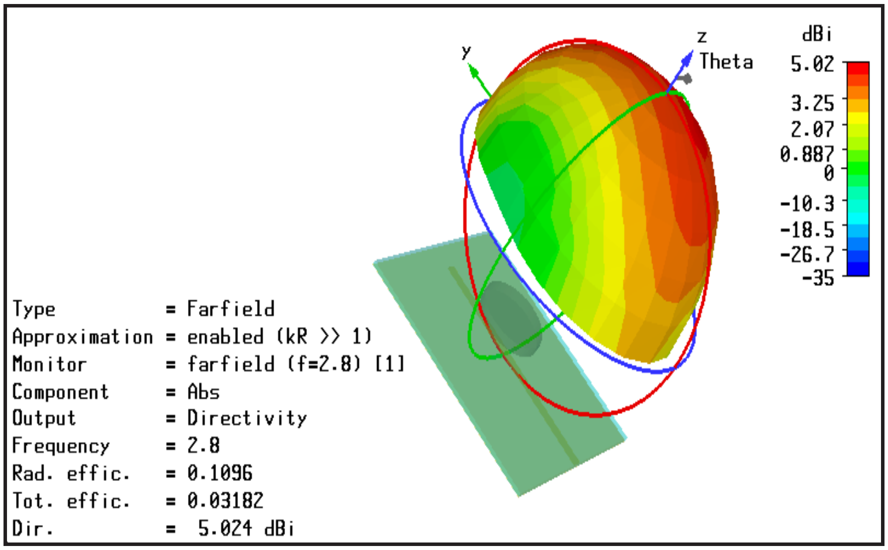
Figure 2. Dielectric antenna with SMA connector.



(a)

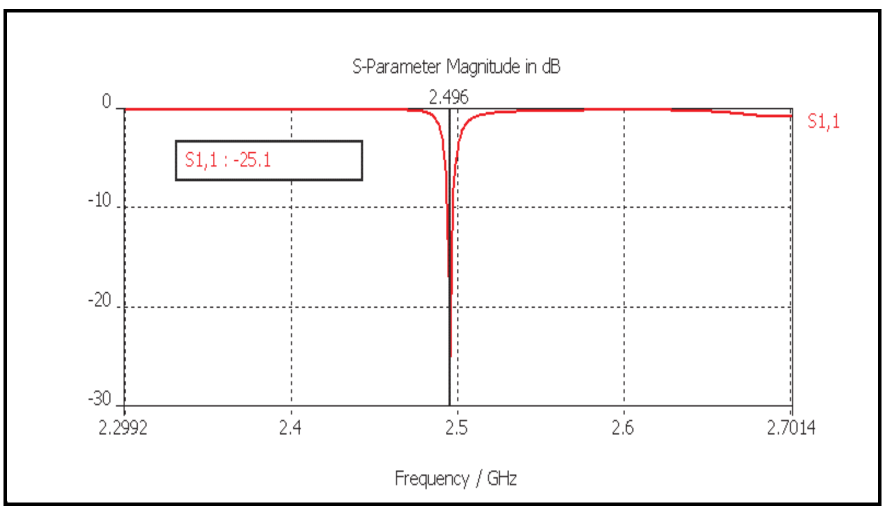


(b)

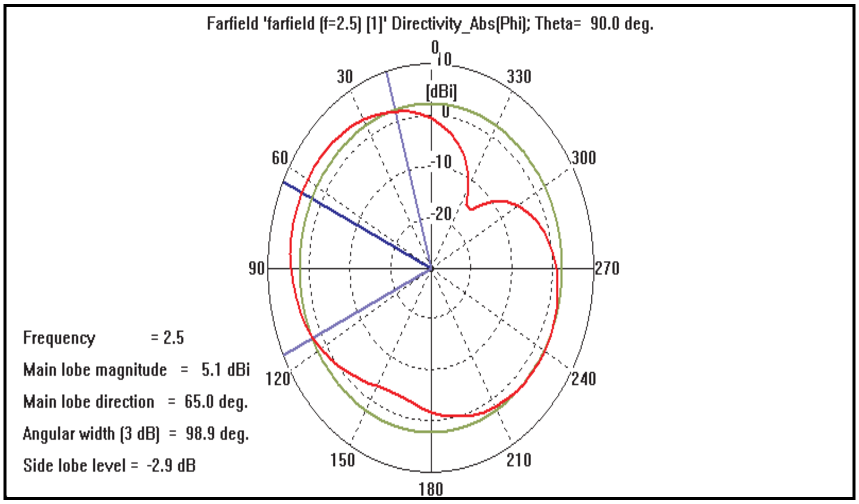


(c)

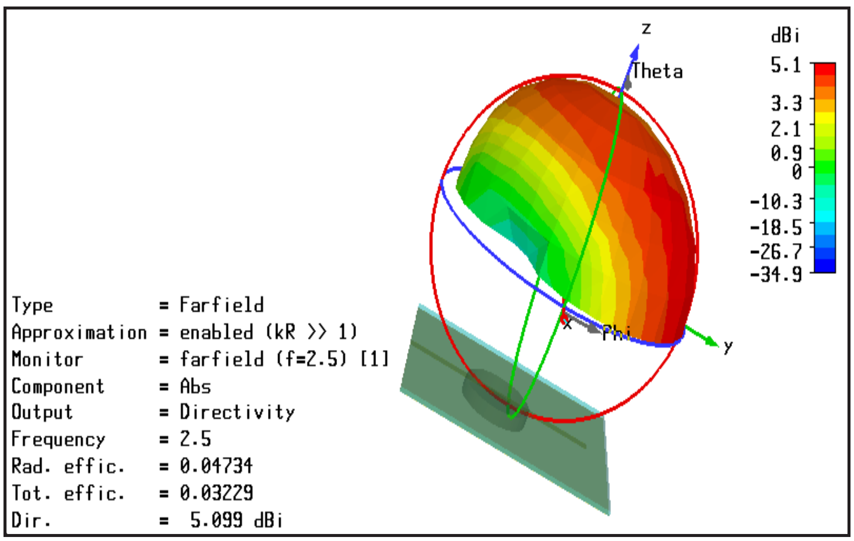
Figure 3. Characteristic simulation for $H = 2\,\mathrm{mm}$ (a) S_{11} (b) Radiation pattern (c) 3-D radiation pattern.



(a)



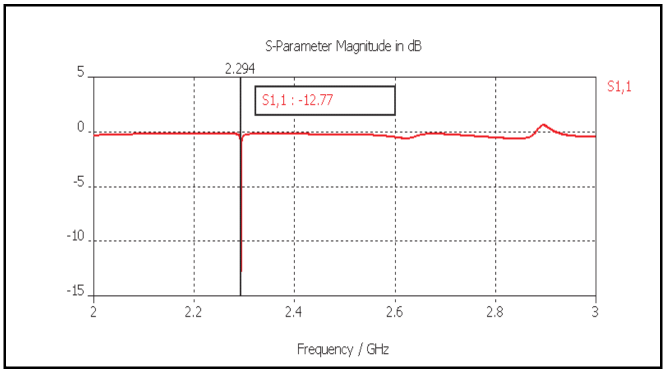
(b)



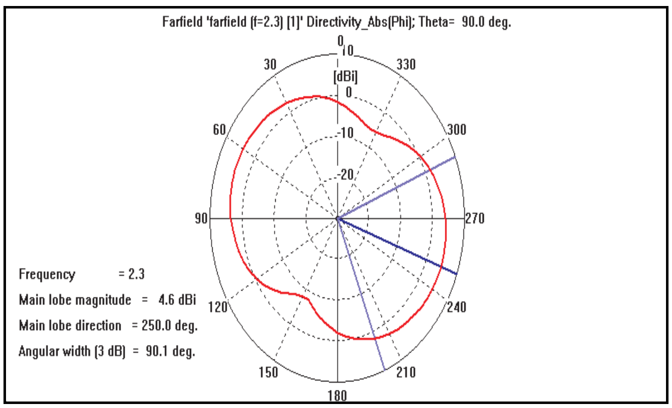
(c)

Figure 4. Characteristic simulation for $H = 2.5\,\mathrm{mm}$ (a) S_{11} (b) Radiation pattern (c) 3-D radiation pattern.

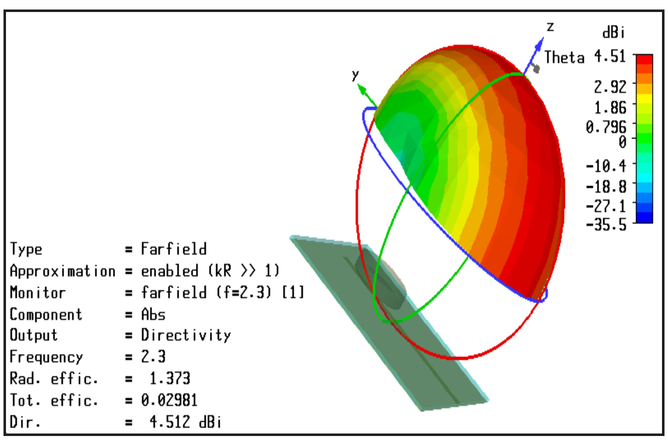
Fig. 8. From the results, it also shows that each height give a different operation point. Resonant frequencies for height $= 2\,\mathrm{mm} \sim 2.786\,\mathrm{GHz}$, height $= 2.5\,\mathrm{mm} \sim 2.546\,\mathrm{GHz}$ and height $= 3\,\mathrm{mm} \sim 2.231\,\mathrm{GHz}$. Both simulation and measured results almost same.



(a)

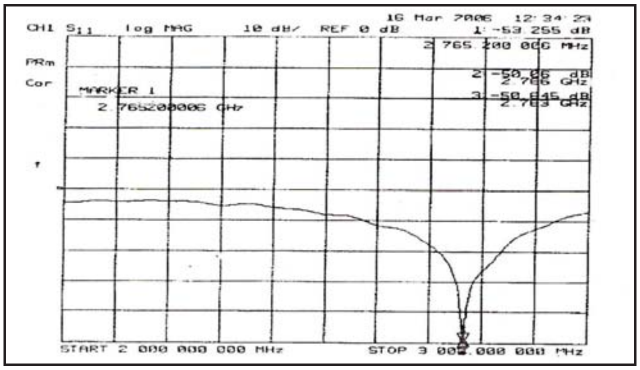


(b)

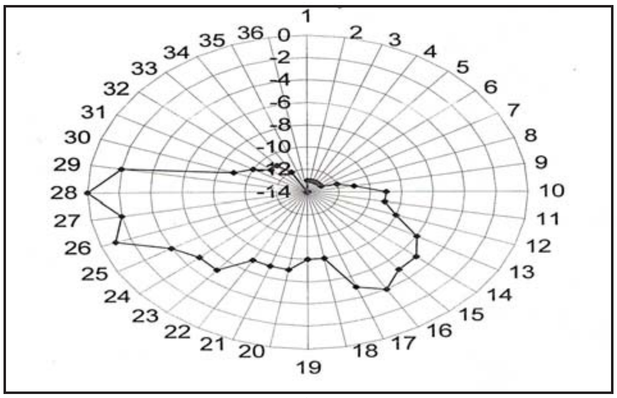


(c)

Figure 5. Characteristic simulation for $H = 3\,\text{mm}$ (a) S_{11} (b) Radiation pattern (c) 3-D radiation pattern.

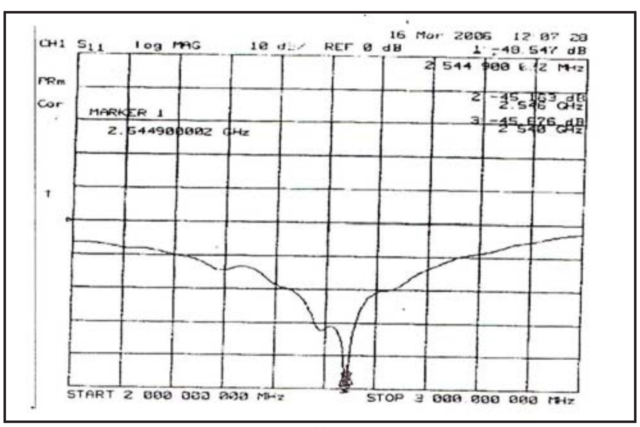


(a)

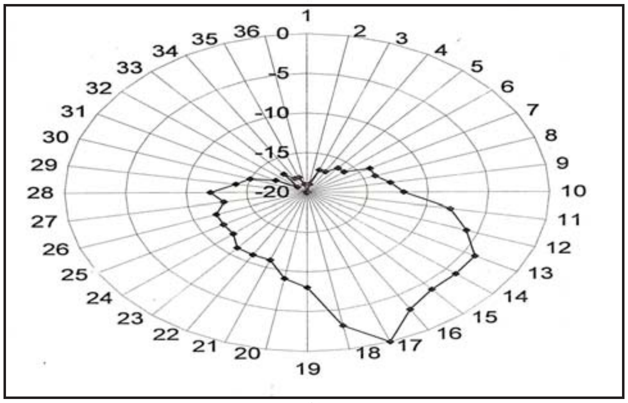


(b)

Figure 6. Characteristic simulation for $H = 3\,\mathrm{mm}$ (a) S_{11} (b) Radiation pattern.

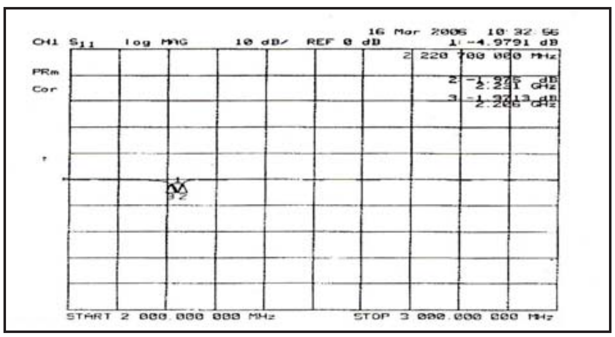


(a)

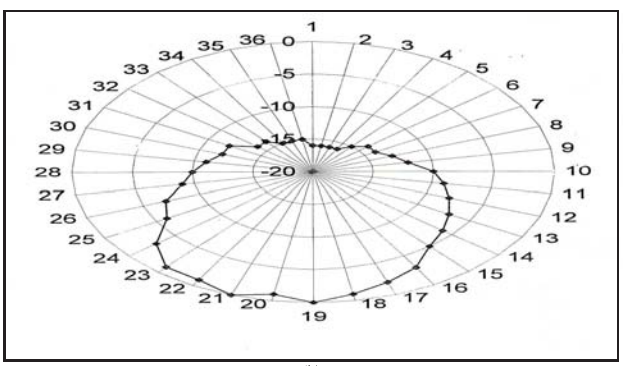


(b)

Figure 7. Characteristic simulation for $H = 3\,\mathrm{mm}$ (a) S_{11} (b) Radiation pattern.



(a)



(b)

Figure 8. Characteristic simulation for $H = 3\,\mathrm{mm}$ (a) S_{11} (b) Radiation pattern.

4. CONCLUSIONS

Experimental study on different height of cylindrical DR excited by a $50\,\Omega$ microstrip transmission line has been carried out and presented. The simulations result closely matching with experiment results. The different thickness of DR gives different resonant frequency. Therefore, it can be scaled to the desired operating frequency by varying a thickness of the dielectric resonator. This type of antenna has a big potential in wireless application such as cellular phone, MIMO wireless system, WLAN and GPS system. The future works aim at using new DR materials with different feeder and different position to excite wider and useful frequency bands.

ACKNOWLEDGMENT

Authors would like to thank Universiti Sains Malaysia and FRGS for supporting the project.

REFERENCES

1. Bujimon, P. V., S. K. Menon, M. N. Suma, M. T. Sebastian, and P. Mohanan, "Broadband cylindrical dielectric resonator antenna excited by modified microstrip line," *Electronics Letters*, Vol. 41, Issue 7, 385–387, March 31, 2005.
2. Long, S. A., M. McAllister, and L. C. Shen, "The resonant cylindrical dielectric cavity antenna," *IEEE Transactions on Antennas and Propagation*, Vol. 31, No. 3, 406–412, 1983.
3. Petosa, A., A. Ittipiboon, Y. M. M Antar, D. Roscoe, and M. Cuchaci, "Recent advances in dielectric resonator antenna technology," *IEEE Antennas and Propagation Magazine*, Vol. 40, No. 3, 35–47, 1998.
4. Kranenberg, R. A. and S. A. Long, "Microstrip transmission line excitation of dielectric resonator antennas," *Electronics Letters*, Vol. 24, No. 18, 1156–1157, 1988
5. Mongia, R. K., A. Ittipiboon, Y. M. M. Antar, P. Bhartia, and M. Cuhaci, "A half-split cylindrical dielectric resonator antenna using slot-coupling," *IEEE Microwave and Guided Wave Letters*, Vol. 3, No. 2, 38–39, 1993.
6. Denidni, T. A., Y. Coulibaly, and L. Talbi, "Design of a broadband hybrid dielectric resonator antenna for x-band applications," *J. of Electromagn. Waves and Appl.*, Vol. 20, No. 12, 1629–1642, 2006.

7. Xiao, J.-K., S.-P. Li, and Y. Li, "Novel planar bandpass filters using one single patch resonators with corner cuts," *J. of Electromagn. Waves and Appl.*, Vol. 20, No. 11, 1481–1493, 2006.
8. Bao, X. L. and M. J. Ammann, "Comparison of several novel annular-ring microstrip patch antennas for circular polarization," *J. of Electrom. Waves and Appl.*, Vol. 20, No. 11, 1427–1438, 2006.
9. Yang, R., Y.-J. Xie, P. Wang, and L. Li, "Microstrip antennas with left-handed materials substrates," *J. of Electromagn. Waves and Appl.*, Vol. 20, No. 9, 1221–1233, 2006.
10. Tadjalli, A., A. R. Sebak, and T. A. Denidni, "Resonance frequencies and far field patterns of elliptical dielectric resonator antenna: analytical approach," *Progress In Electromagnetics Research*, PIER 64, 81–98, 2006.
11. Kishk, A. A., A. W. Glisson, and G. P. Junker, "Bandwidth enhancement for split cylindrical dielectric resonator antennas," *Progress In Electromagnetics Research*, PIER 33, 97–118, 2001.
12. Song, Y. and A. R. Sebak, "Radiation pattern of aperture coupled prolate hemispheroidal dielectric resonator antenna," *Progress In ElectromagneticsResearch*, PIER 58, 115–133, 2006.