CYLINDRICAL DIELECTRIC RESONATOR ANTENNA FED BY A STAIR SLOT IN THE GROUND PLANE OF A MICROSTRIPLINE

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Abstract

A novel coupling scheme to cylindrical dielectric resonator antenna is proposed and investigated. In particular, coupling to the resonator is achieved by simple slot firstly and a stair slot secondly exited by a microstrip line. The objectives of this change are to maximize the coupling, increase the gain and miniaturize the structure antenna, achieve resonance at the desired frequency. An approximate and quick design approach is given followed by more accurate design and analysis using commercial software. The antenna was fabricated and tested. Measurements match well with simulation results..

1. Introduction

Since 1970's, dielectric resonators have brought immense research interest for many research groups world wide due to their attractive features and inherent merit of high quality factor structures, low conducting losses, small size, light weight, compactness, and ease of excitation and relative low costs which made them suitable for many practical applications. First, dielectric resonators were mainly used in the design of active and passive microwave circuits such as microwave filters, discriminators, and stabilized oscillators [1, 2]. Later, Long and al. have proved in early 1980's that certain low-Q radiating modes could be excited from same dielectric resonator when it is placed on a finite ground plane in an open-space environment [3].
This paper suggests a miniaturized antenna at 3.5GHz, themselves well to integration with printed technology. The paper is organized as follows. Section I presents a comparative study between a simple slot antenna and a slot antenna associated to a dielectric resonator (DR) to explain the resonator effect to minimize the size of the antennas. In section II, a new stair slot antenna is proposed to increase the coupling and facilitate the variation of resonance frequency all by keeping the same dimension of the antenna.

2. Antenna Geometry

The proposed antenna geometry is shown in Fig. 2. It comprises a cylindrical DRA of dielectric permittivity ε_{rd} = 37, height h = 8 mm and radius r=*7mm*, which is centered on top of a rectangular slot in ground plane of dimensions 25 mm × 25 mm. The slot, with length Ls=*14mms* and width Ws = 1 mm, is etched in the ground plane of an open-ended microstrip line that serves as the feeding mechanism. The microstrip line of width Wm = 1 mm is a 50 Ω line

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printed on a FR4 substrate of permittivity ε_s= 4.4 and thickness t = 0.8 mm. Finally, the stub length Lm = 7 mm microstrip line under the slot is designed to ensure impedance matching.

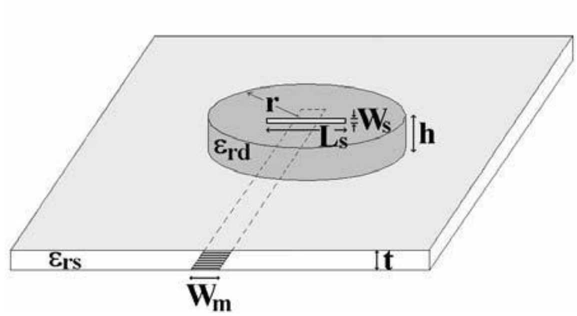

Fig.1. Antenna geometry

With reference to Fig. 1, the parameters that determine the frequency of radiation for the slot are primarily the permittivity ε_{rd} and ε_{rs}, as well as the length of the slot L_s. From the other side, the DRA modes occur at frequencies determined by the permittivity and the dimensions r, h of the DRA .

1.1 Simulation and measurement results

The original cylindrical DRA is studied. Fig. 2 shows the measured and simulated of coefficients of reflection the DRA. With reference to the figure, reasonable agreement between the measured and simulated results is obtained. Fig.3 shows the gain 3D of the DRA.

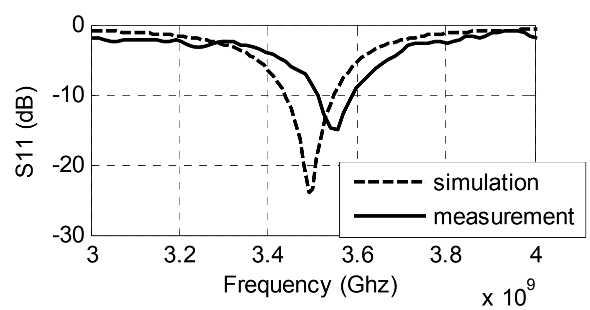

Fig.2.Coefficient of reflection

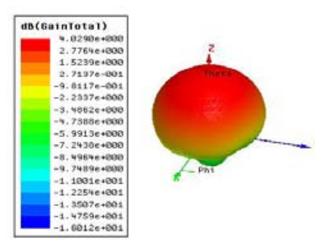

Fig.3. Gain 3D

1.2 Parametric study

The geometry of the antenna is shown in Fig. 1. The cylindrical DRA has a radius a and a height h. The value of h was chosen as 8mm. The DRA is excited by a slot located at the Centre of the ground plane. The dielectric constant of the DRA is steadily decreased from a starting value of 100, with the focus mainly centered on lower permittivity's since these will produce a wider bandwidth. For each value of permittivity the length l of the slot is optimized so that a 50Ω impedance match is obtained, if possible. If a match is not possible, the probe length is optimized to minimize the magnitude of S11. The impedance bandwidth, resonance frequency and radiation pattern are investigated to observe what effects the permittivity has on these two important figures of merit for the DRA. All simulations were carried out using HFSS v12.

Figure.4.5 shows respectively the variation of resonance frequency vs. the length of the slot and the permittivity of dielectric resonator. As the length and the permittivity increases, the resonance frequencies merge

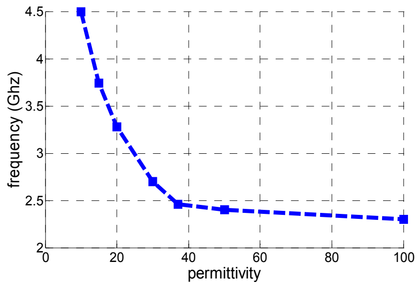

Fig.4. Resonance frequency vs. Relative permittivity

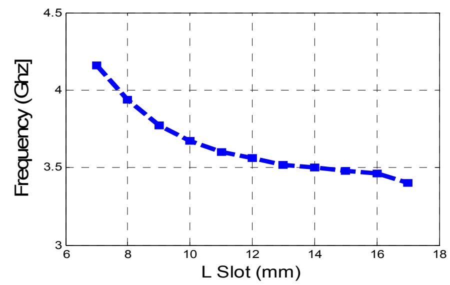

Fig.5. Resonance frequency vs. L_slot

To increase the coupling, widening the bandwidth, varying easily the resonance frequency and miniaturized the antenna structure we propose to change the simple slot by a stair shaped slot.

2. A stair slot dielectric resonator antenna

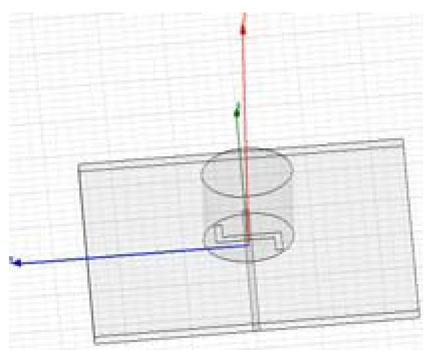

Fig.6. A stair slot antenna geometry

2.1 A stair slot dielectric resonator antenna

The microstrip fed and the stair-slot was fabricated and the resonator was deposed on the stair slot. Measurements were performed to determine the return loss, impedance characteristics, and the radiation in both the E plane and H plane of the antenna. The obtained results show that very good performance has been achieved.

Return Loss: The calculated return loss of the DRA operating in the fundamental mode versus frequency is shown in Fig. 7 along with the measured data. The HFSS computed resonant frequency is 3.53 GHz and the measured resonant frequency is 3.5GHz.The small differences between the measured and predicted values may be attributed to the proximity effects, manufacturing tolerances, and other effects of the connector used for the transition from the coaxial cable to the microstrip line.
Gain: Fig 8 shows the 3D antenna gain. It should be noted a maximum gain of 5.45dBi

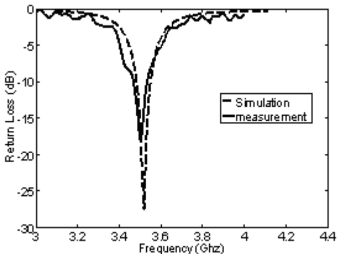

Fig.7.Coefficient of reflection

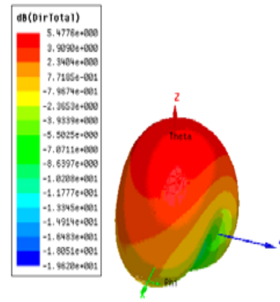

Fig.8. Gain 3D

3. Conclusion

Dielectric resonator antenna fed by microstrip is investigated and a novel coupling scheme is devised and tested. This new structure was fabricated and tested firstly. The predicted simulation results were verified by performing experiments on the fabricated antenna. In second part to minimize the antenna and increase the gain a simple slot is emplaced by a stair slot.

4. References

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