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Slot-Fed Dielectric Resonator Antenna for Multi-Frequency Operation

R G Madhuri[1], S L Mallikarjun[2]
[1]*Asst. Professor, Department of Electronics, Kuvempu University, Karnataka, INDIA*
[2]*Asst. Professor, Department of Physics and Electronics, Maharashtra Udayagiri Mahavidyalaya, Udgir, Maharashtra, INDIA*

Abstract: A novel dielectric resonator antenna (DRA) composed of a cross-slot excited by a microstrip line feed and rectangular dielectric resonator is studied experimentally. The dielectric resonator is centered over unequal lengths of a cross-slot. The slot represents the coupling mechanism between resonator and the microstrip line. Dielectric resonator of two different thicknesses is studied, providing multiple resonances. The return loss and radiation patterns are measured and presented.

Introduction

A recent advance in wireless communication has resulted in development of antennas that can embed into wireless products. Since the last two decades DRAs have been under investigation for modern wireless applications. DRA is an excellent radiator as it has negligible metallic loss. It offers advantages such as small size, large bandwidth, low cost and compatibility with the existing feeding techniques such as coaxial probe, slot coupling and microstrip line etc. Different geometries of DRA such as rectangular, cylindrical, hemispherical, circular, triangular etc are possible. Generally, all resonant antennas will have limited bandwidth of operation, due to their resonant nature [1]. Extensive research has been done to increase bandwidth of DRAs by using various configurations [2]. Many investigations have been reported on multi-frequency operations using an arrangement of resonators with different shapes [3, 4]. Multi-frequencies using annular slot antenna and planar antenna were also reported [5-7].

In this paper, an antenna comprising of a rectangular dielectric resonator fed through unequal cross-slot is presented. The study is carried out by using two different thicknesses of dielectric resonator, which exhibits multi-frequency behavior. A slot feed is used to simplify fabrication and improve matching to a 50Ω microstrip line [8]. Low cross-polarization levels are also maintained by using slot feed. The return loss, radiation patterns are measured and presented.

Antenna Geometry

Figure 1 shows the geometry of DRA. The antenna comprises of rectangular dielectric resonator of dielectric constant $\varepsilon_{dr} = 15$. We have studied two antennas DRA_1, with dimensions (L_{dr} = 3cm, W_{dr} = 2.64cm, h_{dr} = 0.3cm) and DRA_2, with dimensions (L_{dr} = 3cm, W_{dr} = 2.64cm, h_{dr} = 0.6cm) fed by a cross-slot of dimension L_{s1} = 2cm, L_{s2} = 0.5cm, W_s = 0.2cm etched on the ground plane of low cost glass epoxy substrate material having dielectric constant, $\varepsilon_r = 4.2$ and thickness, h = 0.16cm. The slot dimensions are taken in terms of λ_0, where λ_0 is free space wavelength in cm. A 50Ω microstrip feedline of length L_f = 3cm from centre of the slot with stub of 1.5cm taken in terms of $\lambda_0/4$ and width, W_f = 0.157cm is used for impedance matching. At the tip of microstrip feed line a 50Ω coaxial SMA connector is connected for feeding microwave power

Experimental Results

The impedance bandwidth over return loss less than -10dB for the proposed antennas is measured. The measurements are taken using Vector Network Analyzer (Rohde & Schwarz, German make ZVK model 1127.8651). Figure 2 shows the return loss versus frequency graph. From the figure it is clear that DRA_1 (h_{dr} = 0.3cm) is resonating for multi-frequency, with 120MHz (1.54%) at 7.78GHz, 570MHz (5.4%) at 10.6GHz, 810MHz (6.6%) at 12.2GHz, 570MHz (4%) at 14.2GHz and 540 MHz (3.44%) at 15.8GHz. DRA_2 (h_{dr} = 0.6cm) is also resonating for multi-frequency, with 1860MHz (26.23 %) at 7.78GHz, 660MHz (6.24 %) at 10.6GHz, 840MHz (6.87 %) at 12.2GHz, 660MHz (4.63 %) at 14.2GHz and 480MHz (3.05%) at 15.8 GHz. In both the cases the multi-frequency behavior is due to independent resonance of slot and dielectric resonator placed at the centre of the slot at which most of the power is coupled to dielectric resonator [9].

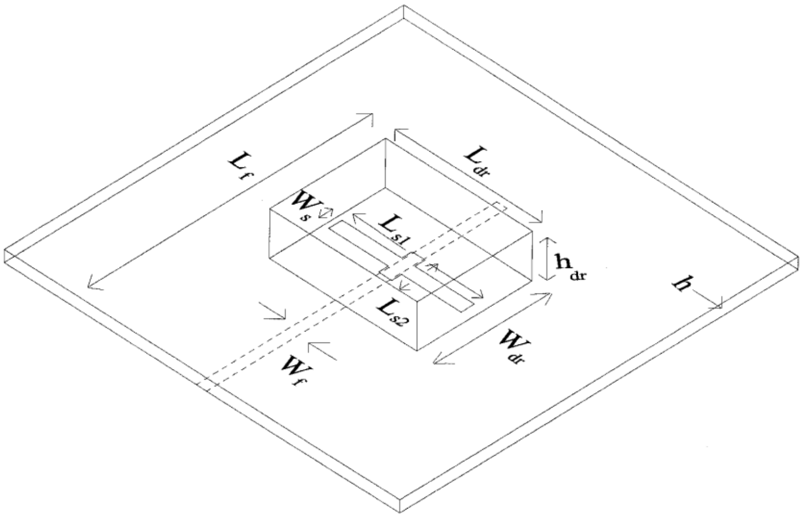

Fig. 1 Geometry of DRA

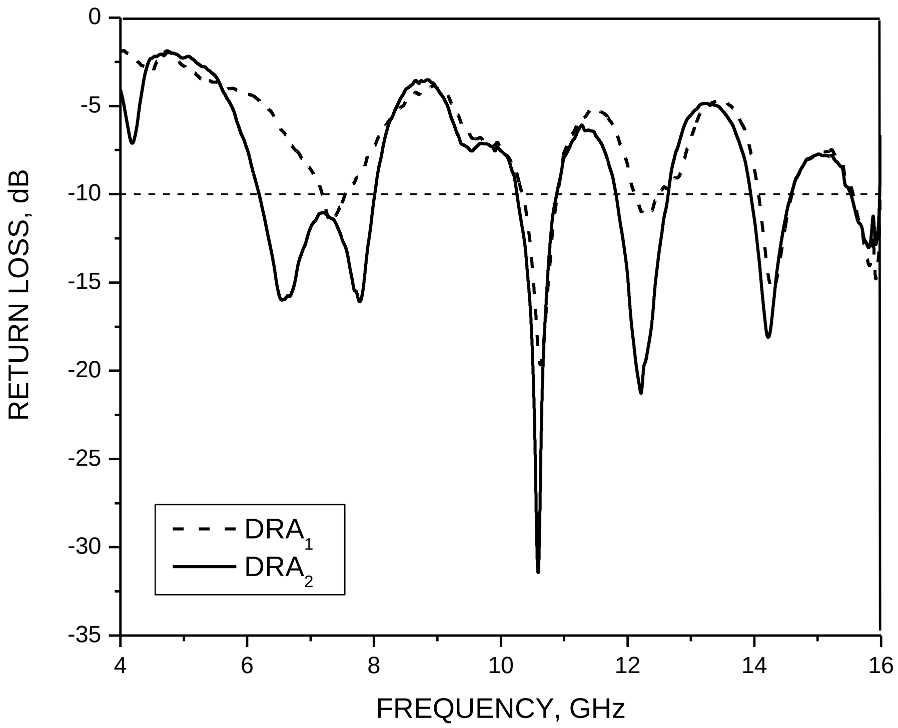

Fig. 2 Variation of return loss frequency versus of DRA_1 and DRA_2

The *X-Y* plane co-polar and cross-polar radiation patterns of DRA_1 and DRA_2 are measured at their resonating frequencies and are shown in Figure 3 to Figure 7. The half power beam width (HPBW) of the proposed antennas are calculated and shown in Table 1.

Table. 1 Measured HPBW of DRA_1 and DRA_2.

Frequency (GHz)	HPBW of DRA_1	HPBW of DRA_2
7.78	67^0	44^0
10.6	18^0	18^0
12.2	16^0	54^0
14.2	49^0	20^0
15.8	44^0	54^0

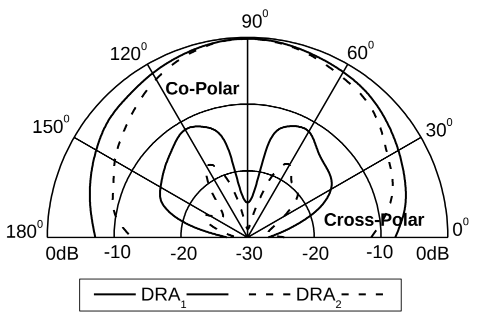

Fig. 3 Radiation pattern of DRA_1 and DRA_2 at 7.78GHz

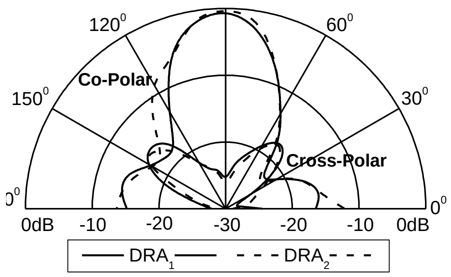

Fig. 4 Radiation pattern DRA_1 and DRA_2 at 10.6GHz

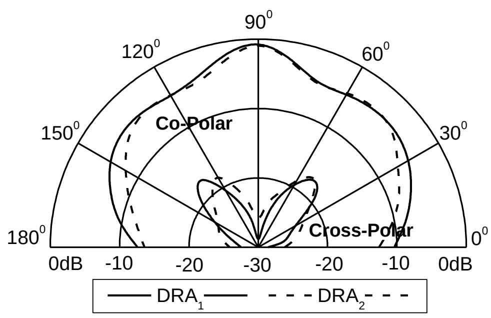

Fig. 5 Radiation pattern of DRA_1 and DRA_2 at 12.2GHz

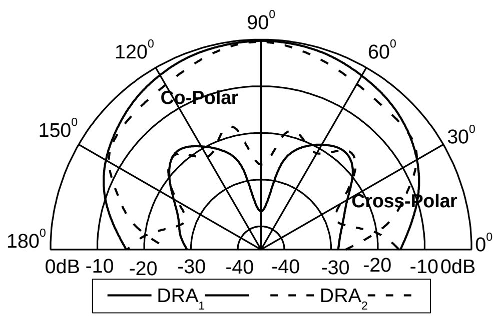

Fig. 6 Radiation pattern of DRA_1 and DRA_2 at 14.2GHz

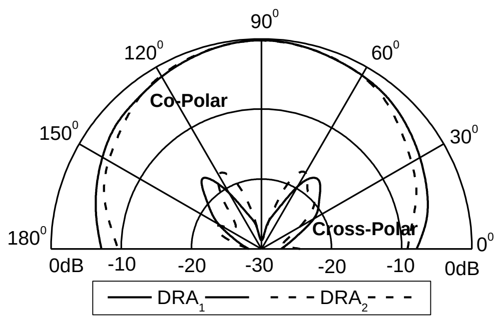

Fig. 7 Radiation pattern of DRA_1 and DRA_2 at 15.8GHz

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It is clear that the measured radiation patterns are broad sided and linear with low cross-polar levels. As DRA_2 gives maximum bandwidth among the proposed antennas, its variation of input impedance is shown in Figure 8. It is seen that the input impedance has multiple loops at the center of Smith chart that validates its wide band and multiple frequency operation.

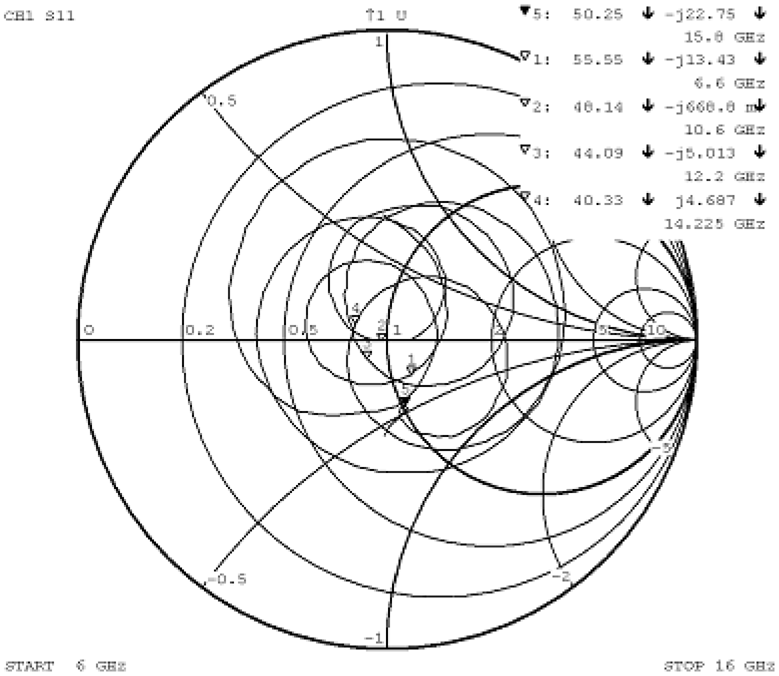

Fig. 8 Variation of input impedance of DRA_2

Conclusion

From the experimental study it is clear that, the proposed antennas are quite simple in fabrication and quite good in enhancing the impedance bandwidth and give broadside radiation pattern. These antennas may find applications in modern communication system.

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