Seminar

Institute for Plasma Research

Title : Design and Analysis of Dielectric Resonator Antenna (DRA) for Wideband Applications

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Venue : Seminar Hall, IPR

Abstract:

In the last few decades, two classes of novel antennas have been explored for wireless communications that are Micro-strip Patch Antenna (MPA) and the Dielectric Resonator Antenna (DRA). Both are highly appropriate for the development of modern wireless communication. DRA do not have any metallic loss, and hence it is highly efficient than its counterpart when operated in microwave and millimeter wave frequencies.

Dielectric Resonator Antennas (DRAs) are open resonating structures made out of high permittivity low-loss dielectric materials. DRA has some interesting characteristics like high radiation efficiency, small size, high power handling capacity, low losses, wide operational bandwidth and ease to integrate with existing technologies as compared to the other resonating antennas. In addition to these interesting characteristics, their resonance frequencies, their excited modes and their radiation characteristics are determined by their dielectric constant, their geometry and their coupling mechanism. This great flexibility of the DRAs in terms of their shape and feeding mechanisms in combination with their other advantageous inherent properties make them suitable candidates for many commercial applications. However, still antenna designers are facing problem of widening bandwidth and improving gain in addition to miniaturization and optimization of radiation. A DRA with rectangular cross section is very adaptable as it provides more degrees of freedom than cylindrical and hemispherical shape.

The talk initially discusses and evaluates detailed development and progress in the design and performance of DRAs taken place within the microwave industry on DRA through a concise review of literature. That deals with fundamental concepts, theory and comprehensive review of the radiation characteristics of DRAs of different possible shapes, such as cylindrical, hemispherical, rectangular and hybrid with choices of different feeding techniques.

Material selection for selecting the dielectric material for a DRA using Ashby's approach is carried out successfully and it was observed that Roger TMM10 (=9.8) material is very promising materials for DRA as DR element. This material is also verified for rectangular DRA and hybrid DRA that provides better bandwidth as compared to other dielectric materials. Thus, this dielectric material is used for the design, simulation and fabrication of proposed DRA mentioned this talk.

Next, comparative study of different rudimentary geometries (rectangular, cylindrical and hemispherical) of DRAs design is carried out for selecting the favorable shape of DRA. These rudimentary geometries of DRA give a better understanding of design parameters of an antenna and their effect on return loss, impedance bandwidth, gain, efficiency and resonant frequency.

Then commonly used feeding techniques such as micro-strip fed, coaxial probe fed; aperture slot fed and coplanar waveguide fed are analyzed using CST Microwave Studio to choose the suitable feeding technique for proposed DRA. It is found that the rectangular DRA fed by coaxial probe provide better resonance level as compared to other geometries. Then a technique for the bandwidth and gain enhancement using air gap-slots is verified for Gammadion Cross DRAs which guarantees larger impedance bandwidth and higher gain with compact shape. Finally, this slot-technique is utilized to widen the impedance bandwidth and to tune the resonant frequency of the antenna for improving and optimization of design parameters.
Following this technique, fabrication and characterization of two novel shapes Asymmetric DRA and Tetraskelion DRA is described. The Rogers copper-clad high-frequency laminates are available in thickness of 0.2 inches (=0.51 cm). Hence, to fabricate the structure, three slabs are joined by applying glue from the edges under high pressure to form 1.5 cm thick slab. The structure of proposed DRA is then fabricated with the help of abrasive jet machine, diamond cutter, diamond filer and diamond drill machine. In the measurements, the reflection coefficients of the DRAs is measured using vector network analyzer (VNA), while the radiation patterns, antenna gains, and efficiencies are measured using a basic antenna measurement setup i.e. Compact Antenna Test Range (CATR) System. These antennas have a simple-interesting structure and relatively reduced volume of 8.24cm3 and 6.48cm3 for Asymmetric DRA and Tetraskelion DRA respectively. The Asymmetric DRA offers an impedance bandwidth of 51% (from 4.1 to 6.7 GHz) at 5.2 GHz resonance while Tetraskelion DRA resonates at 5.25 GHz, and offers an impedance bandwidth of 57.5% (from 3.85 to 6.96 GHz). The measured peak gain of the Asymmetric DRA is 5.3 dBi at the resonant frequency with a high radiation efficiency of 98% while peak gain over the complete bandwidth of operation is 8.2 dBi. However, the peak gain of the Tetraskelion DRA is 4.1 dBi at the resonant frequency with a high radiation efficiency of 95.6%. These types of antennas are very useful for large number of practical applications such as WLAN, WiMax, Vehicular Communication and C-band.
Thus concept of a small DRA with wideband operation in the 4-7 GHz frequency band is presented in this talk. Two new configurations; Asymmetric and Tetraskelion shaped DRA that offer significant enhancements to parameters such as small size, wide operational bandwidth, high gain and high radiation efficiency are fabricated and investigated. In conclusion, this work offers a new, efficient and relatively simple alternative for antennas to be used for multiple requirements in the wireless communication system.