Microstrip Patch Antenna with Metallic Ground Plane Using Nano-Composite

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Abstract

This paper has been focused on the dimensional parameter of the microstrip antenna structure namely; the height of the microstrip antenna with slot substrate and the width of the patch microstrip antenna, by using nano- composite materials which are composed of RT Duriod 5880 and silicon with nanofillers. In this research paper, it has been innovate nano-composite materials as a substrate for the microstrip antenna by adding nano-fillers. Also, it has been demonstrated that the height and width of the suggested model for the microstrip antenna smaller than the conventional rectangular microstrip antenna. The suggested nano-composite material has been investigated efficient and compact microstrip antenna, compact size, simple fabrication and increase radiation, bandwidth and surface wave power of microstrip antenna with and without slot.

Keywords: Microstrip antenna, Nano filler, Rectangular Microstrp, slot antenna

Introduction

Antenna is a device that is used to transfer the electromagnetic waves radiating in an unbounded medium, usually free space, and vice versa and each antenna is designed for a specific frequency or frequency band. Microstrip antennas consist of a metallic patch on a dielectric substrate, which has a grounded metallic plane at the opposite side and the patch has great variety of geometries such as square, rectangular, circular, triangular or elliptical. Microstrip patch antennas have various advantages such as low profile, light weight; easy fabrication and conformability to mounting in addition size reduction and bandwidth enhancement are major design considerations for practical applications of microstrip antennas, but the major disadvantages of this type of antenna are low efficiency, low power, high Quality factor (Q), poor polarization purity, poor scan performance, and narrow frequency bandwidth [1,2].

In communication applications patch antennas have attracted much interest due to their compactness and dual-frequency efficient operation with some difficulties, as relatively low gain, narrow bandwidth, and sensitivity to fabrication. Rectangular and circular microstrip resonant patches have been used extensively in a variety of array configurations[3]. As conventional antennas are often bulky and costly part of an electronic system, microstrip antennas based on photolithographic technology are seen as an engineering breakthrough [3, 4].

The antenna performance of microstrip patch antennas varies with different patch configurations and feeding methods. The most popular feed point mechanisum are the line, coaxial probe, aperture coupling and proximity coupling feed.. In basic aperture coupled patch antenna the radiating microstrip patch element is etched on the top of the antenna substrate (PCB, polyanaline, plastic film,Si substarte), and the microstrip feed line is etched on the bottom of the feed substrate. Microstrip line-fed structures are more suitable due to ease of fabrication and lower costs, but this feed structure is the strong parasitic radiation as serious drawback [2-5]. The microstrip line feed technique is selected in this paper. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a high dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation. In order to design a compact microstrip patch antenna, substrates with higher dielectric constants is used which are less efficient and result in narrower bandwidth. [5-7].

A microstrip slot antennas have been extensively used in military (aircraft, spacecraft, satellites, and missiles) and commercial (mobile radio and wireless communication systems) applications. These types of slot antennas have numerous features. For instance, they have light weight, small size, and low cost. In addition, they can be easily integrated with planar and nonplanar surfaces and have many degrees of freedom in their design. [13-15].

In the present work, a logical comparison has been carried out for the suggested models with suggested nano-composite materials and conventional rectangular microstrip antenna. Also, this paper has been explained the improvement in height of substrate and width of patch by using novel suggested nano-composite materials which compose of RT Duriod 5880 with nano-filler Fumed Silica, Aluminum Oxide and Graphite.

ANTENNA DESIGN

A microstrip antenna consists of conducting patch on a ground plane separated by dielectric substrate with thickness h and relative permittivity ε_r as shown in Fig. 1. The conducting patch can be taken any shape but rectangular and circular configurations are the most commonly used. The most typical substrates have a dielectric constant in range of 1.2 to12. Thick substrates with high dielectric constant are desirable as they provide better efficiency, larger bandwidth and loosely bound fields for radiation into space and high dielectric constant substrates are generally preferred for maximum radiation [4, 5].

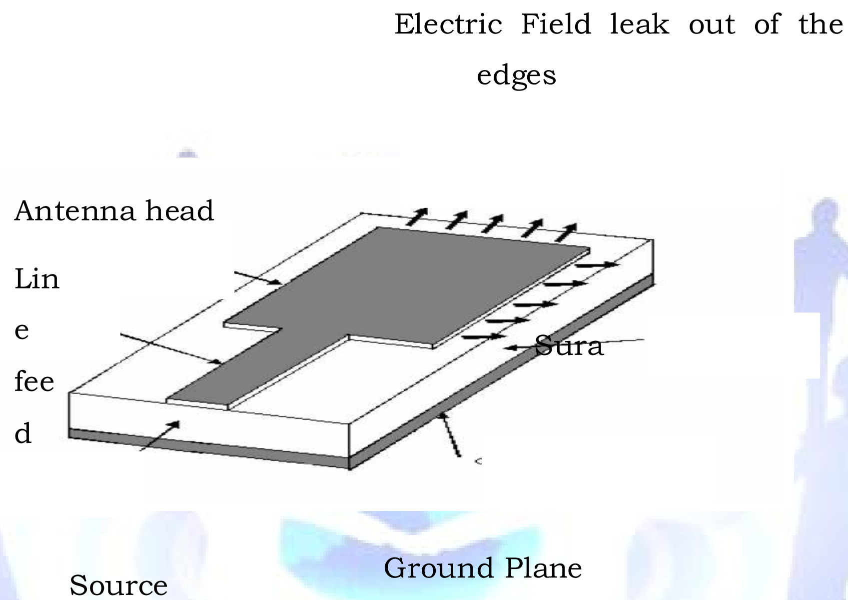

Fig. 1 Microstrip antenna model

Thick substrates with high dielectric constant are selected as they provide better efficiency, larger bandwidth and loosely bound fields for radiation into space and high dielectric constant substrates are generally preferred for maximum radiation whatever, at thin substrates with high dielectric constant (2.2-12) are usually applied in microwave circuitry because of their minimized undesired radiation and coupling, and the smaller sizes of their elements [5].

A larger patch width increases bandwidth, and radiation efficiency. With proper excitation one may choose a patch width W greater than the patch length L without exciting undesired modes. It can be seen that the width can be calculated from [3, 4]:

$$W = \frac{c}{2 f_r}\left(\frac{\varepsilon_r+1}{2}\right)^{-0.5} \qquad (1)$$

Also, the patch length determines the resonant frequency, and is a critical parameter in design because of the inherent narrow bandwidth of the patch. The length is found by calculating the half-wavelength value and then subtracting a small length to present the fringing fields effect. So, the length is given by [3, 4]:

$$l = \frac{c}{2 f_r \sqrt{\varepsilon_{eff}}} 2 \Delta l \quad (2)$$

$$\Delta l = 0.412\, h \frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.813\right)} \quad (3)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} - \frac{\varepsilon_r-1}{2}\left(1+\frac{12r}{W}\right)^{-0.5} \quad (4)$$

An important design step is to choose a suitable dielectric substrate of appropriate thickness h and loss tangent. The substrate dielectric constant ε_r plays a role similar to the substrate thickness. A high value of ε_r for the substrate will increase the fringing field at the patch periphery, and see the radiated power.

SELECTEDNANO-PARTICLES

In this research, it has been selected the following nano-particles for enhancing the performance of microstrip patch antenna: Fumed Silica is one of the most important filler that used in insulating materials, integrated circuits, electric components, conductors, and many other applications. Main advantages of Fumed Silica are costless and have a great effect on properties such as viscosity, stiffness and strength.

Aluminium Oxide is the family of inorganic compounds with an amphoteric oxide and is commonly referred to as alumina, corundum as well as many other names, reflecting its widespread occurrence in nature and industry. Its most significant use is in the production of aluminium metal, although it is used as abrasive due to its hardness and as a refractory material due to its high melting point.

RESULTSANDDISCUSSION

In this paper, all results and performance optimizations have carried out by using the microstripline Studio and FDTD technique. Simulation results with Microwave Studio are verified with FDTD technique. From the simulation of a Patch antenna with FDTD, it has been seen that the 3D FDTD method is a good technique for predicating electric field propagation. The FDTD technique can be used to generate wide frequency responses with no change in modeling. Also it provides a near complete solution of Maxwell's equations in a 3D model.

Table 1. Parameters of suggested models

substrate	Dielectric constant(□)	Radiation efficiency (R□)	Directivity (dBi)	Fre. (Ghz)
RT duriod 5880	2.2	0.6099	7.863	1.805
RT duriod 5880+silica	2.7	0.5867	7.662	1.6
RT duriod 5880+Alumina	3.80	0.8314	7.143	1.44
RT duriod 5880+carbon	4.50	0.9882	7.030	1.3
Silicon substrates				
	11.9	0.993	7.763	1.8
	11.9	0.953	7.543	1.6
	11.9	0.945	7.500	1.3

Effect of New Nano-particle

The graph displays the return loss $S_{1,1}$ of microstrip antenna by using new nano- composite material (RT Duriod 5880 with Fumed Silica, Aluminiup and carbon coumpound), at the same resonant frequency 1800 MHz of microstrip antenna with slot and at the same resonant frequency 750 MHz of microstrip antenna without slot. It is noticed that, using suggested nano-composite materials have been enhanced, the radiation efficiency, bandwidth and surface wave power of microstrip antenna. Also, the dimensions of microstrip antenna have decreased as

Table 2: dimensional detail of design

Substrate	(□)	H (mm)	W (mm)	L (mm)	Z_0 single mode feed	Z_0 differe ntial	Z_0	Radiation efficiency
RT duriod 5880	2.2	10mm	30.8403	119.27	36.3	40.8	50	0.6099
RT duriod 5880+silica	2.7	10mm	27.6855	125.364	38.5	34.9	50	0.5867
RT duriod 5880+Alumin a	3.8	10mm	21.4871	122.366	44.7	48.2	50	0.8314

RT duriod 5880+carbon	4.5	10mm	18.8927	122.926	45.14	50.8	50	0.9882

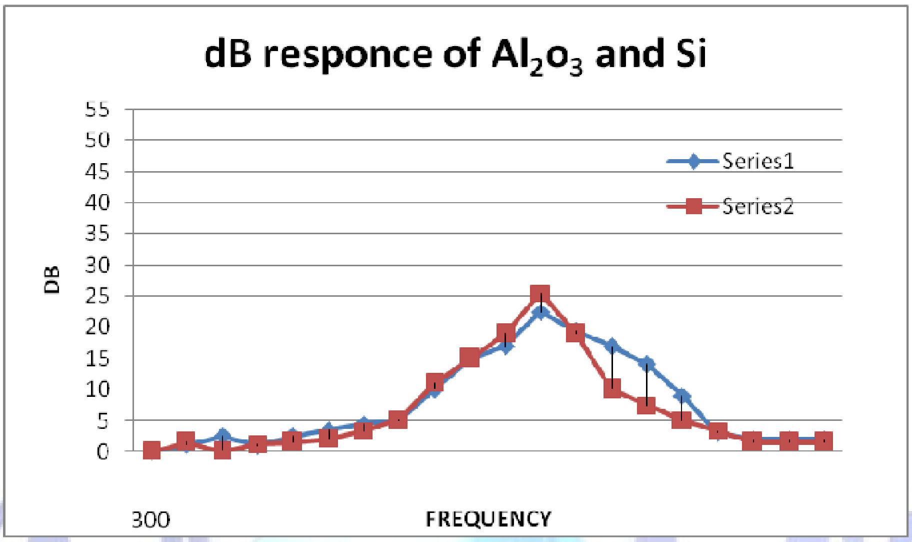

Fig: 2 frequency response

Using nano-composite materials have been enhanced the radiation, bandwidth and surface wave power of microstrip antenna with slot. Nano-composite materials have been enhanced the radiation, bandwidth and surface wave power of microstrip antenna without slot. The sizes of suggested models are lower than conventional model sizes at these frequencies.

Also, it is cleared that, using the suggested material has reduced the height, width and length of the antenna as shown in table.4. The radiation efficiency, bandwidth and surface wave power of microstrip antenna have been increased, and so dimensions of microstrip antenna have been decreased. Compact microstrip antenna has been investigated high performance, light weight, easy fabrication and low cost.

CONCLUSIONS

Novel nano-composite materials which are composed of RT Duriod 5880 with nanofillers Aluminum Oxide and Graphite have been enhanced the design of microstrip antenna with slot. Novel nano-composite materials which are composed of RT Duriod 5880 with nanofillers Fumed Silica , aluminum and Graphite have enhanced the design of microstrip antenna without slot.Height and width of the suggested microstrip antenna models are smaller than these of the conventional rectangular microstrip antenna with and without slot.

The radiation efficiency, bandwidth and surface wave power of microstrip antenna have been enhanced by using suggested new nano-composite materials with easy fabrication, high performance and low cost.

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