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Gain Enhancement of Microstrip Antenna By The Insertion of Air Gap Between Layers

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Abstract
With the advancement of wireless technology, microstrip patch antenna becomes very popular due to its attractive features. But main disadvantage of microstrip antenna is its gain is very low. This paper proposed a multilayer patch antenna with an air gap insertion between radiating patch and ground plane. The gain of the proposed antenna in enhanced to 5.41dBi and bandwidth is 350 MHz. The structure of the antenna is very simple and cost effective. The antenna is simulated using Ansoft Designer software version 2.
Keywords: Microstrip, Multilayer, Patch, Gain.

1. Introduction

Microstrip patch antenna is widely popular now a days due to its attractive features. It is good choice for the wireless communication due to light weight, low profile, simple structure easy fabrication and integration [1]. But such antenna has few disadvantages. The disadvantages are narrow bandwidth, low gain, Low efficiency that limits their various applications. Several methods are used to remove these disadvantages.

Microstrip antenna consists of a radiating patch on the one side of a dielectric substrate which has a ground plane in another side. When the antenna in energized, it radiates electromagnetic wave in all directions. The electromagnetic wave that travels in the substrate is known as surface wave and loss due to this surface wave is called surface wave losses. This is the main loss associated with the microstrip antenna that reduces the gain of the antenna [2, 3]. Other different losses such as conductor on dielectric loss can be minimised using better quality conducting material and substrate. Surface wave losses can be reduced by using high impedance surfaces such as electromagnetic [4] and photonic band gap structures[5] that allow and forbid electromagnetic wave is wave in a certain frequency band. Some other methods that reduces the surface wave losses are by using hybrid structure [6], using superstrates [7] and surface mounted horn [8] etc. But disadvantages of these techniques are there are very difficult to fabricate.

The performance of microstrip antenna are greatly depends on substrates parameters such as dielectric constant .That is efficiency and gain becomes low when the dielectric constants are high. Further to increase the efficiency and gain and to decrease substrate loss, an air gap is inserted between radiating elements and ground plane. This air gap reduces the electric field concentration on the substrate and the effective dielectric constant of the radiating plane.

In this paper a simple rectangular patch antenna is proposed to fabricate on FR4 subsrate.An air gap is inserted between radiating element and ground plane to obtain high gain and high efficiency.50 ohm Probe feed technique is used to excite the antenna .The advantage of that feed can be placed anywhere on the patch. The antenna shows almost 5.56 dBi swift gain in the operation region which is good for microstrip antenna.

2. Design of the antenna:

There are several parameter needed to consider which will affect the resonant frequency, bandwidth, and gain of a rectangular patch antenna.
The shape of the patch is the main parameter that affects the antenna characterictics.The patch length L for TM0 mode is given by the equation:
L=C/2fr [€r]1/2
Where, fr is the resonant frequency.

The effective dielectric constant is defined as the dielectric constant of the uniform dielectric material so that:
€reff= [€r+1]/2+ [€r-1]/2 (1+12h/W)-1/2
The following equation is used to calculate the width W:
W=C/2fr { [€r+1]/2}1/2
Where, C is the free space velocity of light.
To determine the length L of the patch, the following equation is used:
L=C/2fr [€reff]1/2 - 2ΔL
The normalised expression of the length ΔL is given by:
ΔL=0.412h [€reff + 0.3][W/h +0.264] / [€reff +0.258][W/h+0.8]
In this paper a rectangular patch antenna is proposed with ground plane dimension 22mmx20mm and patch dimension is 15mmx14mm. The dielectric substrate is FR4 epoxy of relative dielectric constant 4.4 and thickness 1.6 mm. An air gap of thickness 1 mm is inserted between radiating plane and the ground plane. This antenna is fed by a microstrip line with characteristic impedance of 50 ohm. The top view of the proposed antenna is shown in reference figure 1.

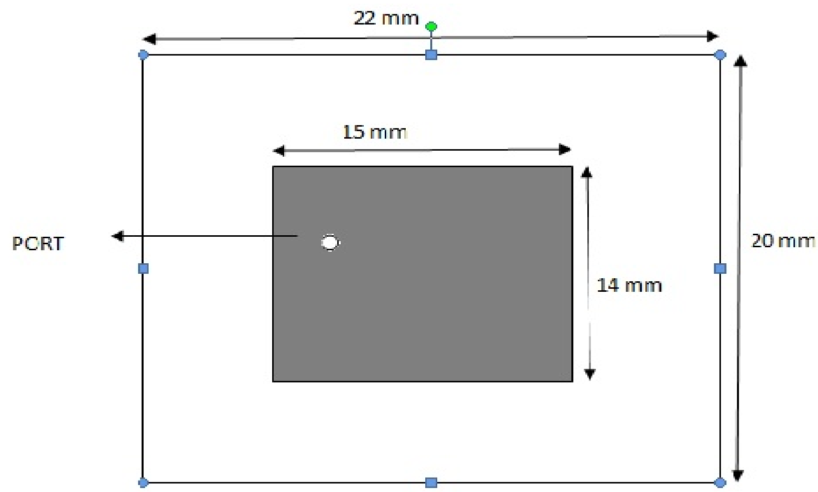

Fig 1: Top view of the proposed antenna.

3. Parametric study:

Resonant frequency and gain of the proposed antenna have been changed by changing the thickness of the dielectric substrate and the thickness of the inserted air gap. A parametric study has done by changing these two parameters which is given below.

	Ant1	Ant 2	Ant 3	Ant4	Ant 5	Ant 6	Ant7	Ant 8
Air gap thickness	1.6mm	1.6mm	1.6mm	1.6mm	.05mm	1.0mm	2.0mm	2.5mm
Dielectric layer thickness	1.6mm	0.5mm	1.0mm	2.0mm	1.0mm	1.0mm	1.0mm	1.0mm
Resonatn frequency(GHz)	7.11	7.16	7.74	7.08	7.29	7.23	7.00	6.85
Reflection coefficient(dB)	-20.34	-25.38	-19.48	-19.34	-23.65	-26.57	-13.65	-10.1
Gain(dBi)	5.94	5.56	5.41	6.05	2.34	4.96	5.64	5.56

4. Results:

The proposed antenna is simulated by Ansoft designer software version 2 whose numerical analysis is based on the finite element method. The effect of change in gain and the resonant frequency as well as corresponding reflection coefficient is studied by changing the thickness if the dielectric layer and the thickness of the air gap. From the parametric table, it is observed that the antenna 6 has maximum swift gain is 4.93dBi and it achieved at the resonant frequency of 7.23GHz (-23.57dB). Again antenna 4 has maximum gain of 6.05dBi at 7.03 GHz resonant frequency. But this gain is sharply decreases on the either side of the resonant frequency. Antenna 3 provides a comparative stable gain of 5.5 dBi to the either side of the frequency of 7.14 GHz. Bandwidth of the antenna 3 is 350 MHz

Fig 2 shows the variation of reflection coefficient with frequency of the proposed antenna. The resonant frequency of the proposed antenna is 7.14 GHz and corresponding reflection coefficient is -19.48dB. Fig 3 shows the variation of gain with frequency. Fig 4 shows the radiation pattern of the proposed antenna that radiates more power in a broadside direction and less in the other direction.

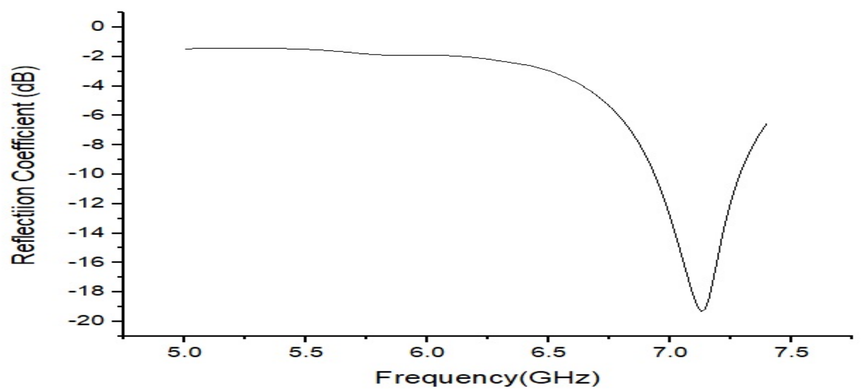

Fig 2: Variation of reflection coefficient with frequency

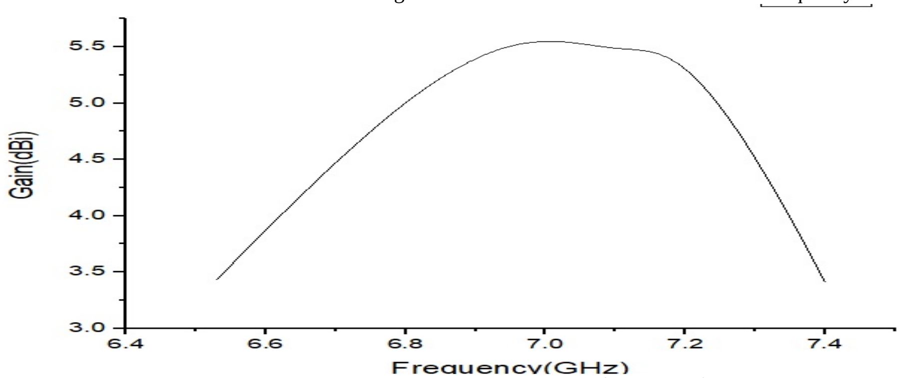

Fig 3: Variation of gain with frequency

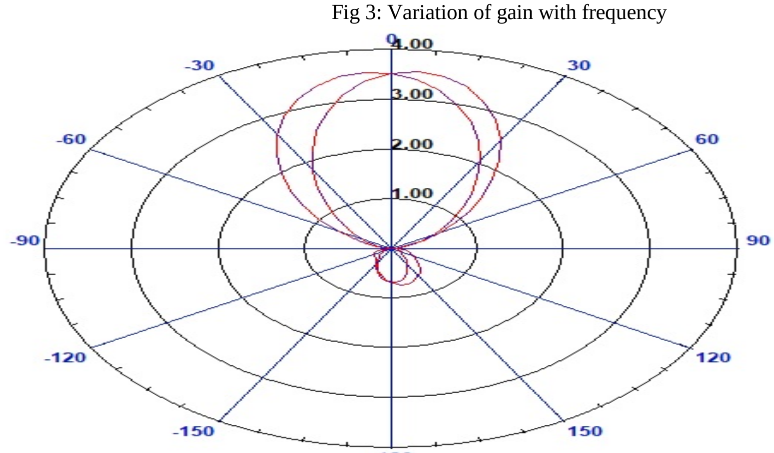

Fig 4: Radiation pattern of the proposed antenna at 7.14 GHz

5. Conclusions:

In this paper an attempt is to make a MSA with double layer and with insertion of an air gap between radiating patch and ground plane. This air gap provides high gain as observed in the simulated result. The proposed antenna has been resonated at 7.14GHzand the band width is good and the gain is truly satisfactory. This antenna is useful in satellite communication. The method can be easily revised and extended for the design of the other types of high gain antenna.

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