

# Efficient Directivity Enhancement Process Applied in Planar Type of Antenna

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**ABSTRACT:** The directivity of a planar type of antenna is highly dependent upon the fringing fields. Also the substrate material gives high impact on the directivity of the patch antenna. This paper provides a way of controlling the emission of fringing fields from undesired direction and increase the directivity by forcing all the fringing fields through the observed direction. Also the performance of antenna using different substrate material is observed.

**KEYWORDS:** Fringing field, Directivity, Bandwidth.

## I. INTRODUCTION

The microstrip patch antenna is a resonant antenna for narrow band microwave links. Basically it has a sandwich-like structure with a dielectric material, i.e. substrate, sandwiched between metal plates from both sides, metal plate on the lower side acting as ground plane and the upper one as radiating patch. Commonly configured microstrip antenna shapes are square, rectangular, circular and elliptical. The concept of microstrip antenna first provided by Deschamps [1], Gutten and Baissinot [2]. Mathematical model of initial microstrip radiator is first applied to design rectangular microstrip patch antenna [3]. When the frequency increased, the effective dielectric constant gradually climbs towards the substrate, therefore phase velocity decreases accordingly [4] [5]. Depending on the definition, the impedance of microstrip rises or falls then rises with increasing frequency [6]. Patch antennas are used in many types of communication. The antenna is designed with a dielectric material as its substrate, the length of the antenna decreases increasing the relative dielectric constant of the substrate.

## II. THEORY

The rectangular microstrip antenna is made up of a metalized pattern over a thin dielectric substrate. The lower surface of substrate is the ground plane. The patch length (L) is about  $\lambda_g/2$  ( $\lambda_g$  = effective wavelength) and substrate height (h) is in order of  $\lambda_g/20$ . As there is very small space between radiating element and ground plane most of the power is radiated in the broadside. The fringing field effectively increases the length of the patch ( $\Delta L$ ) in determining resonance frequency.

The most commonly used design equations of antenna found from [7]

a) Effective dielectric constant

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ 1 + 12 \frac{h}{w} \right]^{-\frac{1}{2}} \quad (1)$$

b) Length extension is

$$\Delta L = 0.412h \frac{(\epsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\epsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (2)$$

c) Effective Length

$$L_{reff} = \frac{C}{2f_0 \sqrt{\epsilon_{reff}}} \quad (3)$$

d) Actual length of patch

$$L = L_{reff} - 2\Delta L \quad (4)$$

e) Actual width of patch

$$W = \frac{C}{2f_0 \sqrt{\frac{\epsilon_r + 1}{2}}} \quad (5)$$

f) Ground plane dimension

$$L_g = 6h + L \quad (6)$$

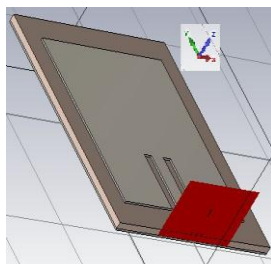
$$W_g = 6h + W \quad (7)$$

### III. SIMULATION

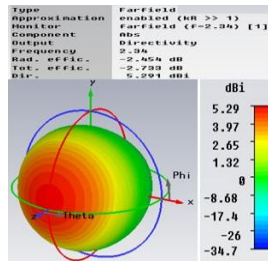
The rectangular microstrip antenna with a co-axial feed is operating for 2.345GHz ISM band having physical parameters as found from the equations from(1) to (7) is given as below:

Parameter	Dimensions	Units
Thickness(h)	1.06	mm
Operating frequency	2.345, 2.585, 2.82	GHz
Length(L)	36.2822	mm
Width(w)	29.8656	mm
Cut width	8	mm
Cut depth	10	mm
Feed width	3.6	mm
Patch length	28.1411	mm
Length of substrate(Lg)	45.8822	mm
Width of substrate(Wg)	38.0656	mm
Width of substrate(Wg)	38.0656	mm

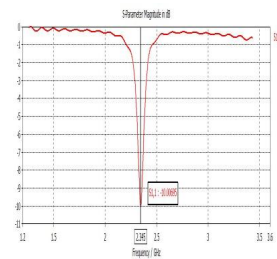
**1. DIRECTIVITY IMPROVEMENT USING COVERED STRUCTURE**



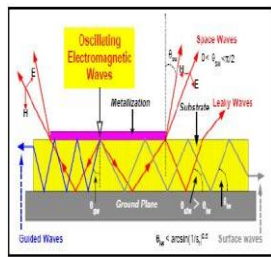
(a)



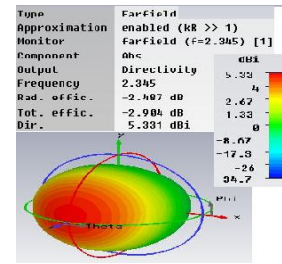
(b)



(c)



(d)

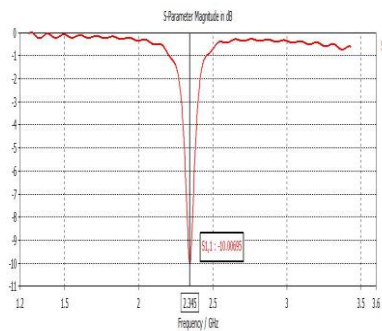


(e)

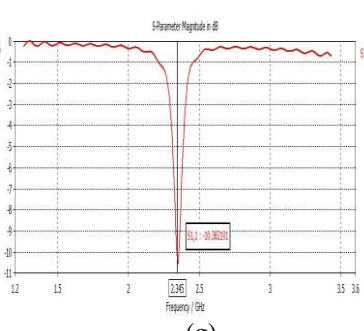
Due to the fringing fields, some amount of radiations are lost through dielectric medium, due to which decrease of the directivity of the antenna takes place and hence the gain of the antenna. Therefore to reduce this loss we covered the antenna by a thin metal plate of height same as the ground plane from the three sides, excepting the side from which port excitation is given and again the parameters are observed. The radiations that are lost in the medium due to fringing field can be limited and hence the antenna's directivity and the gain can be increased. The Fig f is given below shows the change in the parameters from the previous figures, i.e. Fig c.

**2. DIRECTIVITY ANALYSIS USING DIFFERENT SUBSTRATE**

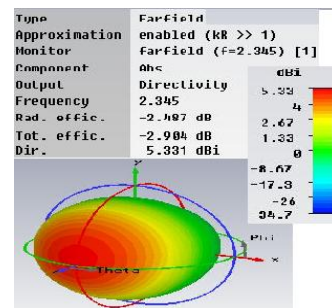
**(A) USING FR-4(LOSSY) AS SUBSTRATE**



(f)



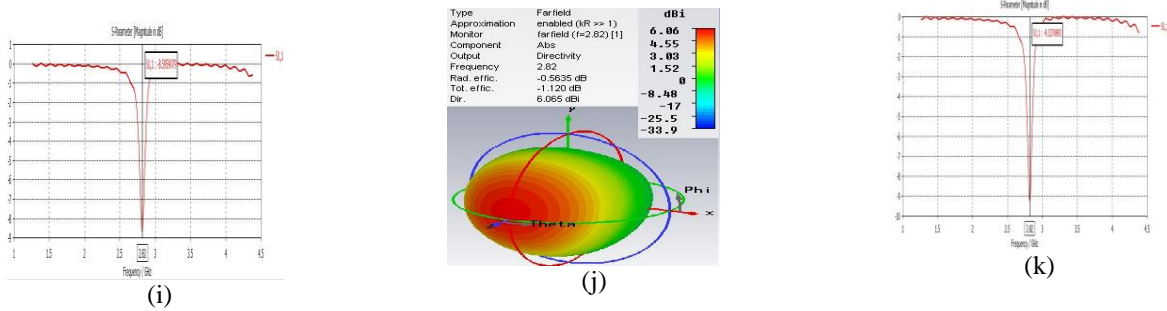
(g)



(h)

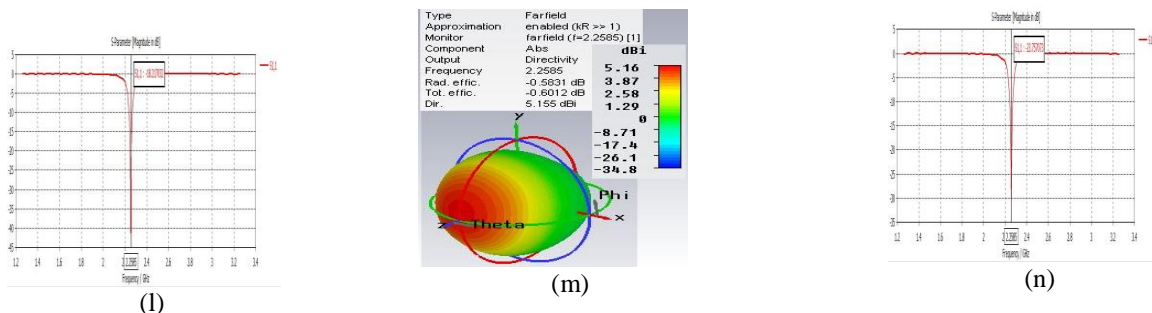
The substrate is FR-4(lossy) and the operating frequency is 2.345GHz. By doing so we find that the s-parameter shows -10.00695dBi, its directivity is 5.291dBi. When the same antenna is covered from three sides to reduce the fringing field effect the s-parameter shows -10.382101dBi and the directivity is 5.331dBi.

(B) USING RUBBER AS SUBSTRATE



The substrate is changed from FR-4(lossy) to rubber and the operating frequency is changed from 2.345GHz to 2.82GHz and all the other parameters are kept constant. By doing so we find that the s-parameter shows -8.4453339dBi shown in fig i, its directivity is 5.994dBi. When the same antenna is covered from three sides to reduce the fringing field effect the s-parameter shows -9.2270892dBi and the directivity is 6.065dBi.

(C) USING GLASS(PYREX)(LOSSY) AS SUBSTRATE



The substrate is changed from rubber to glass (pyrex) (lossy) and the operating frequency is changed from 2.82GHz to 2.585GHz and all the other parameters are kept constant. By doing so we find that the s-parameter shows -18.217032dBi shown in fig l, its directivity is 5.071dBi. When the same antenna is covered from the three sides to reduce the effect of fringing field the s-parameter changes and it gives -23.757073dBi and the directivity becomes 5.16dBi, the representation is shown in figure m and figure n respectively.

**IV. RESULTS AND DISCUSSION**

This table shows the specific frequencies in which the substrates rubber, FR-4(Lossy) and Glass (Pyrex)(Lossy) which are observed provides good observed values of Directivity and S-parameter.

FEATURES	SUBSTRATE					
	FR-4 (LOSSY)		RUBBER		GLASS(PYREX)(LOSSY)	
	NORMAL	WHEN COVERED	NORMAL	WHEN COVERED	NORMAL	WHEN COVERED
Frequency(GHz)	2.345		2.82		2.585	
Permittivity(ε)	4.3		3		4.82	
Bandwidth(MHz)	13	9	7	4	30	28
Directivity(dBi)	5.291	5.331	5.994	6.065	5.071	5.16
Gain(dBi)	4.302	4.386	5.417	5.501	4.510	4.572

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**V. CONCLUSION**

We can conclude that the directivity of the antenna has increased after covering the substrate with metallic strip from all three sides along with the ground plane. Because of that loss from dielectric medium can be reduced and effective radiation from the Z direction can be increased. It is also observed that the directivity of different dielectric materials are different depending on their operating frequency.

**REFERENCES**

- [1] G.A. Deschamps, "Microstrip microwave antenna," presented at 3rd USAF Symp. on Antennas, 1953.
- [2] H. Guttan and G. Baissinot, "Flat arial for ultra high frequencies," French Patent No. 703113, 1955.
- [3] R.E. Munson, "Conformal microstrip antennas and microstrip phased arrays," *ZEEE Trans. Antennas Propagation*, Vol. AP-22 No. 1, pp.74-77, Jan 1974.
- [4] Denlinger, E. J. (January 1971). "A frequency dependent solution for microstrip transmission lines". *IEEE Trans. Microwave Theory Tech.* MTT-19: 30–39.
- [5] Cory, H. (January 1981). "Dispersion characteristics of microstrip lines". *IEEE Trans. Microwave Theory Tech.* MTT-29: 59–61.
- [6] Bianco, B.; Panini, L.; Parodi, M.; Ridetlaj, S. (March 1978). "Some considerations about the frequency dependence of the characteristic impedance of uniform microstrips". *IEEE Trans. Microwave Theory Tech.* MTT-26: 182–185.
- [7] David M. Pozar, "Microwave Engineering" John Wiely and Sons, 2<sup>nd</sup> Edition, Singapore, 1989.
- [8] Steve Jensen, (December 14,2010) ; "Microstrip patch antenna" NAUID : 2931095
- [9] Dr. Sunandan Bhunia, "Microstrip Patch Antenna's Limitation and Some Remedies". IJECT Vol. 4, Issue Spl - 1, Jan - March 2013