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Parametric Effect for Improvement of Microstrip Patch Antenna Performance

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Abstract:-The quality factor is a figure-of-merit that is representative of the antenna losses. Typically there are radiation, conduction (ohmic), dielectric and surface wave losses present in planar antennas. Planar antennas are high-Q devices with Qs sometimes exceeding 100 for the thinner elements. But, high-Q elements have small bandwidths. Also, the higher the Q of an element, the lower is its efficiency. Increasing the thickness of the dielectric substrate will reduce the Q of the planar element and thereby increase its bandwidth and its efficiency. There is a need to analyse individual quality factors also and optimize them to achieve a significant trade-off between gain and losses. When the losses are low but not lowest the radiation efficiency is also found to be optimum .In this Paper I have analyse two different planner antenna using two different materials such as FR4 and Teflon (PTFE). I have designed planner antenna using computer simulation technology (CST).After analysing the result of two different materials of planner antenna will the different types of Quality factor losses. I can conclude that the Teflon (PTFE) material is best with the compare FR4. I have analysing two different planner antenna using two different feeding techniques such as coaxial feed and microstrip feed line. After analysing the result of two different feeding techniques of planner antenna I can conclude that the microstrip feed line with using Teflon (PTFE) material achieve high gain and directivity compare to coaxial feed techniques. After I have analyse two different planner antenna using Teflon (PTFE)
Material with and without slit. I can conclude that with slit design of planner antenna is better than
Without slit design because in with slit design of MPA achieve dual band BW.

Keywords: Antenna Losses, Bandwidth, Planar antennas, Quality Factor (Q), Radiation Efficiency.

I.INTRODUCTION

Microstrip antennas (MSA) offer many attractive features such as low weight, small size, ease of fabrication, ease of integration with Microwave

Integrated Circuits (MIC) and can be made conformal to host surface. However, they suffer

From low gain, narrow bandwidth, low efficiency, and low power handling capability [1-3].With using C band range 4-8GHZ application of satellite

Communication I have used 4.0 GHZ frequency. The proposed microstrip antenna is design and simulated using CST Microwave Studio.

II.FUDENTAMEL AND FOOTPRINT EQUATION

As a measure of antenna performance, the quality factor can generally be defined in three ways: (i) as a relation between the stored reactive energy and the radiated power of the antenna, (ii) as a function of its impedance or admittance, and (iii) as a function of its bandwidth. Every approach has its own physical meaning and yields different operational limits.[6]
The quality factor is a figure-of-merit that is representative of the antenna losses. Typically there are radiations, conduction (ohmic), dielectric and surface wave losses. Therefore the total quality factor Qt is influenced by all of these losses and is, in general, written as,

$$\frac{1}{Qt} = \frac{1}{Qrad} + \frac{1}{Qc} + \frac{1}{Qd} + \frac{1}{Qsw} \qquad (1)$$

Where, Qt = total quality factor

Qrad= Quality factor due to the radiation (space wave) losses

Qc= Quality factor due to the conducting (omics) losses

Qd= Quality factor due to the dielectric losses

Qsw= Quality factor due to the surface waves

For very thin substrates, the losses due to surface waves are very small and can be neglected. However, for thicker substrates they need to be taken into account. These losses can also be eliminated by using cavities. There are approximate formulas to represent the quality factors of the various Losses can be expressed as,

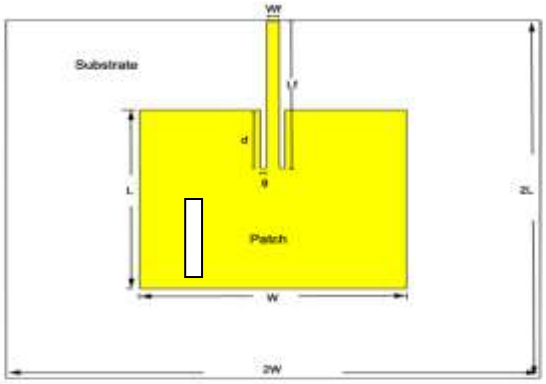
$$Qc = h\sqrt{\pi f \mu \sigma} \qquad (2)$$

$$Qd = \frac{1}{\tan\delta} \qquad (3)$$

$$Qrad = \frac{2\omega\varepsilon r}{hGt/l} K \qquad (4)$$

Where, **tan δ** is the loss tangent of the substrate material, **σ** is the conductivity of the conductors associated with the patch and ground plane, **Gt/l** is the total conductance per unit length of the radiating aperture.[2]

III. Antenna design geometry



L	7.5mm
W	2.7mm

The rectangular patch antenna is approximately a one-half wavelength long section of rectangular Microstrip transmission line. When air is the antenna substrate, the length of the rectangular Microstrip antenna is approximately one-half of a free-space wavelength. The length of the antenna decreases as the relative dielectric constant of the substrate increases.
The resonant length of the antenna is slightly shorter because of the extended electric "fringing fields" which increases the electrical length of the antenna slightly.

Frequency of operation (fr): The Resonant frequency of the antenna must be selected appropriately. The C- Band Systems uses the frequency band 4-8 GHZ .The resonant frequency selected for my design is 4.0 GHz. [1]
Dielectric constant of the substrate (εr): The dielectric constant of substrate material plays an important role in the patch antenna design. A substrate with a high dielectric constant reduces the dimensions of the antenna but it also affects the antenna performance. So, there is a trade-off between size and performance of patch antenna. The Dielectric constant of the substrate selected for my Design is **εr** = 4.3, 2.1. [1]

Height of dielectric substrate (h): For the Microstrip patch antenna to be used in communication systems, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate should be less. The height of the substrate selected for my design is 1.6 mm. After the proper selection of above three parameters, the next step is to calculate the radiating patch width and length.[1]

Step 1: Calculation of Width (W) [1]
For an efficient radiator, practical width that leads to good radiation efficiencies is,

$$W = \frac{c}{2f0\sqrt{\frac{\varepsilon r+1}{2}}} \qquad (5)$$

Where c is the free space velocity of light.

Step 2: Calculation of Effective Dielectric Coefficient (εreff)[1]

The effective dielectric constant is

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (6)$$

Step-3:- Calculation of Effective Length (Leff)[1]

$$Leff = \frac{c}{2f0\sqrt{\varepsilon reff}} \qquad (7)$$

Step 4: Calculation of the Length extension (ΔL) [1]

$$\Delta L = 0.412h\,\frac{(\varepsilon reff+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon reff-0.258)\left(\frac{W}{h}+0.8\right)} \qquad (8)$$

Step 5: Calculation of actual Length of Patch (L) [1]

$$L = Leff - 2\Delta L \qquad (9)$$

The actual length of radiating patch is obtained by

Design Rectangular Micrstrip Patch antenna using three different subtracting materials with using different length, width, height and tangent losses as shown in table 1.

Table: 1 Input Parameter for MPA design

Material Name	Dielectric Constant	Loss tangent	Height Of the Substrate(mm)	Length Of the Patch (mm)	Width Of the Patch (mm)
FR4	4.3	0.025	0.8	17.4	22.4
Teflon (PTFE)	2.1	0.0002	0.8	25	29

Table 2: output Parameter for MPA design

Material Name	**Return Loss**	**VSWR**	**BW (MHZ)**	**BW (%)**	**Gain (db)**	**Directivity (dbi)**
FR4	-25.7	1.1	0.1	2.5	3.3	7.5
Teflon (PTFE)	-24.0	1.1	0.05	1.3	7.5	8.1

Table: 3: Quality Factor, Q in terms of different substrate

Material Name	**Qc**	**Qd**	**Qsp**	**Qsw**	**Qt**
FR4	7.15	39.99	4.4×10^-13	4.4×10^-12	55.6×10^-23
Teflon	7.15	999.9	1.0×10^-13	2.9×10^-11	101.1×10^-18

Table 4: Parameter comparison using with and without slot MPA design

Parameters	Without slot	With Slot	
Return Loss(db)	-24.0	-19.6	
VSWR	1.1	1.2	
		fr=4 GHZ	fr=6GHz
BW (%)	1.39	1.01	0.49
Gain(db)	7.5	8.0	3.0
Directivity (dbi)	8.1	8.2	4.7

IV.Simulation Result

Without Slot	**With Slot**

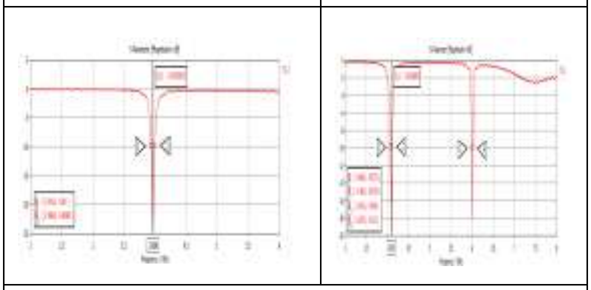
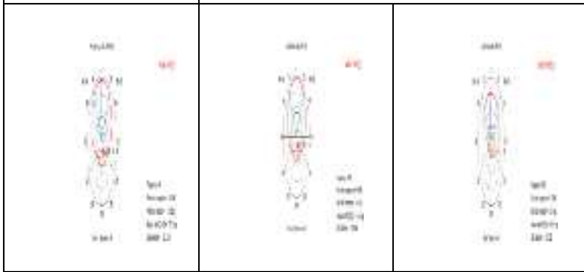


Fig 1. Return Loss Plot

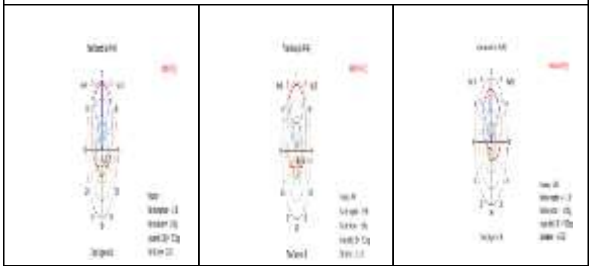
Fig 2. VSWR Plot

Without Slot	**With Slot**	



	Fr=4GHZ	Fr=6GHZ

Fig.3 Gain Plot



	Fr=4GHZ	Fr=6GHZ

Fig.4 Directivity Plot

V. Conclusion

Here I have presented the design of rectangular microstrip patch antenna using different materials like FR4, Teflon (PTFE), and their various results obtained such as return loss, VSWR, bandwidth, radiation pattern in polar plot.

Using Teflon (PTFE) material I got better gain, directivity, and Quality factor comparing to FR4.By, using Teflon (PTFE) material Bandwidth decreases to comparing FR4 but radiation power increases and thus, efficiency is also increased.

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