International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 3, March - 2014

Design and Simulation of 4x1 Probe Feed Rectangular Patch Array Antenna for ISM Band Applications

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***Abstract*: In this paper, an effort is made to optimize the gain and return loss to show better performance analysis on the basis of design and simulation results by implementing the 4x1 array of rectangular patch antenna at the operating frequency of 2.45 GHz for ISM band applications. In this proposed antenna, co-axial feeding technique is utilized in order to have a better impedance matching effects. Also the comparative analysis is done with that of the single rectangular patch antenna. The 3D simulation results are carried out by HFSS v13 software which is based on Finite Element Method (FEM) modeling technique.**

Keywords: HFSS, Patch antenna, ISM band

I. INTRODUCTION

Antenna is a vital component in wireless application systems. It is inevitable to avoid the study and design of compact antennas that are used in wireless applications. For the same, the microstrip patch antenna (MPA) can be considered as the promising candidate for future work. The basic patch antenna consist of a dielectric substrate and a ground plane on one side of it and a patch of conducting material on the other side of the substrate. The design and simulations are carried out in HFSS v13 software. In this paper a single rectangular patch antenna is designed and also an 4x1 array of the same is designed and the comparative analysis of both is studied and consequently viewed that array gives better result than single patch antenna.

II. ANTENNA DESIGN, GEOMETRY & CONFIGURATION

Here a four element probe feed antenna is designed & compared with the single patch antenna. By using different design parameter equations appropriate values are selected.[1].

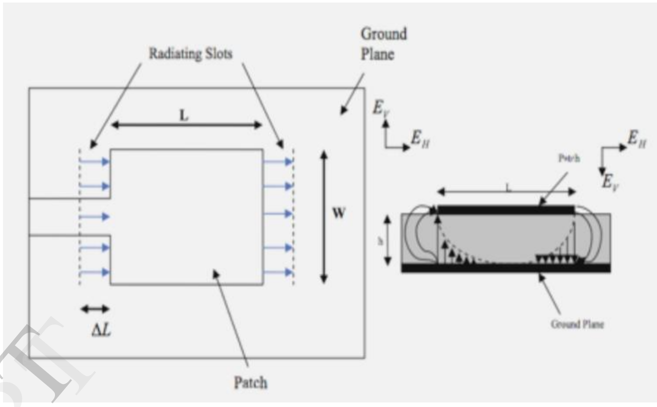

Fig.1. Physical and effective lengths of rectangular microstrip patch[1]

1. For an efficient radiator, a practical width that leads to good radiation of frequencies is

$$W=\frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}}=\frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (1)$$

Where υ_0 is the free-space velocity of light.

2. Determine the effective dielectric constant of the microstrip antenna using

$$\frac{W}{h}<1 \quad (2)$$

$$\varepsilon_{reff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}[1+12\frac{h}{W}]\wedge-\frac{1}{2} \quad (3)$$

3. Determine the extension of the length 3L using

$$\Delta L=0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (4)$$

4. The actual length of the patch can now be determined by solving

$$L = \frac{1}{2 f_r \sqrt{\varepsilon_{reff}} \sqrt{\mu_0 \varepsilon_0}} - 2\Delta L \qquad (5)$$

Variable Description

ΔL = Patch length extension

ε_{eff}= Effective dielectric constant

fr = Resonant frequency

μ_0 = Absolute permeability

ε_r= Dielectric constant of substrate

h = Height of the substrate

W = Width of the patch

L = Length of the patch

The below is the HFSS design of the patch antenna.

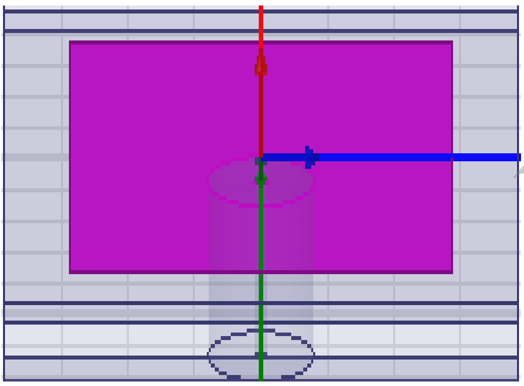

Fig.2. Single patch antenna HFSS design.

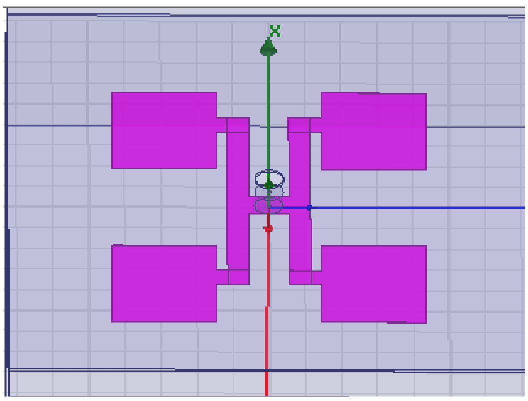

Fig.3. Array of patch antenna HFSS design

Figure.2 shows the single patch antenna & figure.3 shows the array antenna with their probe feed at the center of the substrate. The patch details and the other design specifications are shown in the table below.

Table.1. Design Specifications

PARAMETERS	VALUES
Frequency	ISM band(2.45 GHz)
Substrate material	FR4-epoxy
Substrate dielectric constant	4.4
Substrate height	0.8 mm
Patch length	37 mm
Patch width	29 mm
Patch height	0.035 mm
Ground plane thickness	1 mm

The substrate material is FR4-epoxy with dielectric constant 4.4. The patches are made of copper and the ground plane consists of aluminum. All the four patches are connected via common co-axial feed .

III. RESULTS

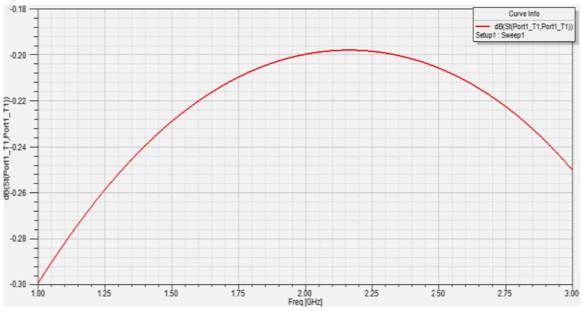

Fig.4. Return loss of single patch antenna

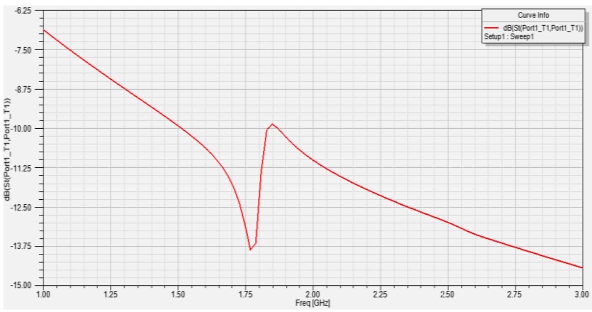

Fig.5. Return loss of array of patch antenna

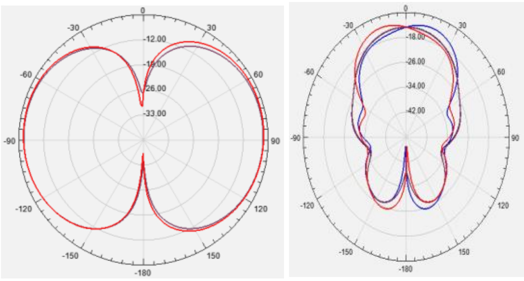

Fig.6. Gain of single patch antenna and array of patch antenna

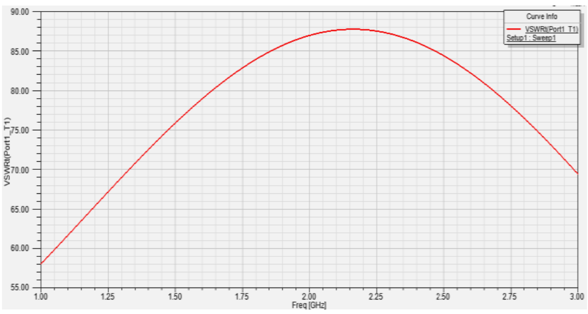

Fig.7. VSWR plot of single patch antenna

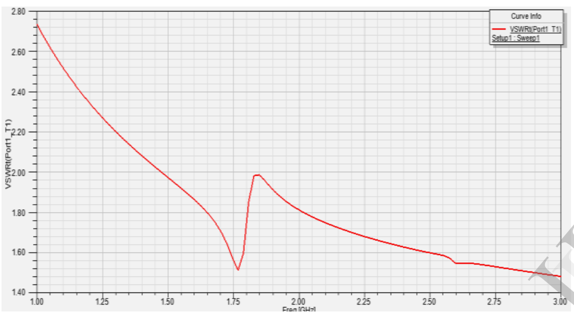

Fig.8. VSWR plot of array of patch antenna

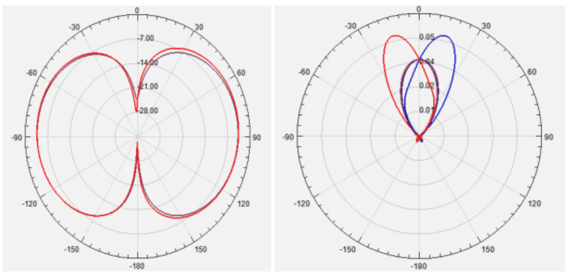

Fig.9. Directivity of single patch antenna and array of patch antenna

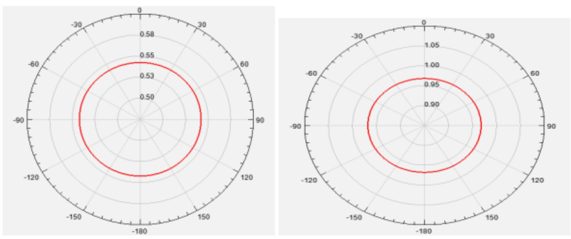

Fig.10. Radiation efficiency of single patch and array of patch antenna

CONCLUSION

The above figure shows the results of the patch array which describes the return loss is decreased by -12 db and hence efficiency of an array antenna is improved. And further the comparative analysis shows that the VSWR value decreases to 1.6 (fig.8) and the radiation efficiency improves from 0.54 to 0.96 in the array antenna (fig.9). Below are the values of the observed results.

Table.2. Result analysis

PARAMETERS	SINGLE PATCH ANTENNA	ARRAY OF PATCH ANTENNA
Return Loss	-0.2 db	-12.80 db
Gain	-26.66 db	-14.42 db
VSWR	85	1.6
Directivity	-26.98 db	-14.27 db
Radiation Efficiency	0.54	0.96

Thus, in this paper we designed an array of rectangular patch antenna and study its comparative results with the single patch antenna which shows that the array of patch antenna gives better results than the single patch antenna. Thus the antenna characteristics can be improved.

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