

Design of Microstrip Patch Antenna on Cylindrical Surface

V Santosh Kumar, C Dharmaraj

Abstract—Easy fabrications and low cost makes microstrip patch radiators more necessary for many applications. In this paper, some observations are made on microstrip patch mounted on a cylindrical curved surface with variation in radius. Considered patch antenna placed on a planar surface operating at a frequency of 5GHz. The same patch was placed on a cylindrical surface with radius of 15mm and 20mm and different properties of the antenna are measured. Here the cylinder will act as substrate and the material used for Substrate is FR4 epoxy with relative permittivity 4.4 and Dielectric loss tangent of 0.02. The antenna design and simulations are carried by High Frequency Structural Simulation (HFSS) tool.

Keywords — Microstrip antenna, conformal antenna, cylindrical, WLAN.

I. INTRODUCTION

According to IEEE slandered (IEEE Std 145-1993), an antenna which conforms to the particular shape is known as conformal antenna [1]. Now days, the size of the device decreased drastically to improve the functionality. The antennas required for various applications in the field of communication side should be of small size, light weight and low profile [2]. When a non-planar surface is considered for mounting an antenna, it inherently improves the characteristics compared to traditional microstrip antenna mounted on planar surface [3].

Conformal antennas are mainly used for several applications like military, aerodynamics, surveillance and civilian. In civilian applications, cylindrical surfaces are more preferable than sectorial antennas. The conformal antennas are also promptly used in fast moving vehicles as a collision warning.

The conformal antenna or arrays are widely used in the applications of military, long distance communications and moving vehicle tracking etc. In civilian applications like base station communication, conformal antenna or arrays are used.

The design of conformal antennas is of two types. i) The defined patch is wrapped on cylindrical substrate. ii) The substrate is also wrapped to the defined shape. In general the body of the object on which the antenna was placed acts as one conducting surface, and the wrapped patch acts as another conducting sheet. In this paper, the design of conformal antenna using wrapped patch on cylindrical substrate. The characteristics of antenna changes with the change in radius of the substrate.

The conformal microstrip antenna consists of two parts i) microstrip feed network ii) microstrip radiator [4].

Microstrip feed networks are used in case of array configuration. Generally microstrip patch radiators are used.

II. ANTENNA DESIGN& RESULTS

A. Basic equations used for patch dimensions

Width and length of patch is given by [5],

$$\text{Width} = \frac{c}{2f_0\sqrt{\frac{\epsilon_R+1}{2}}}; \quad \epsilon_{eff} = \frac{\epsilon_R+1}{2} + \frac{\epsilon_R-1}{2} \left[\frac{1}{\sqrt{1+12\left(\frac{h}{W}\right)}} \right]$$

$$\text{Length} = \frac{c}{2f_0\sqrt{\epsilon_{eff}}} - 0.824h \left(\frac{(\epsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} \right)$$



Fig. 1: Patch Dimensions

B. Microstrip patch on planar surface

A rectangular microstrip patch is considered with multiple changes on the patch. Geometry of the considered rectangular patch is [6],

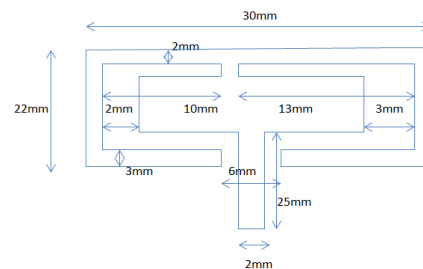


Fig. 2: Geometry of the patch

Table 1: Antenna Measurements

Parameter	value
Substrate length	40mm
Substrate width	40mm
Substrate height	1.6mm
Patch length	22mm
Patch width	30mm
Stripline length	25mm
Stripline width	2mm

Revised Manuscript Received on April 12, 2019.

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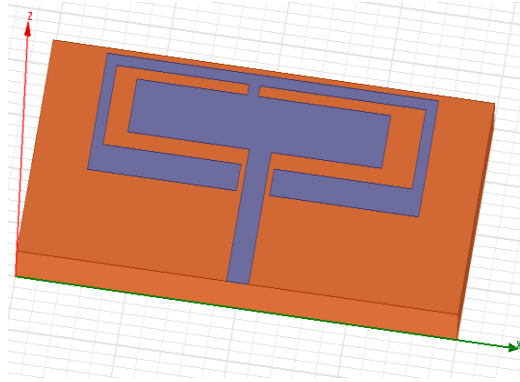
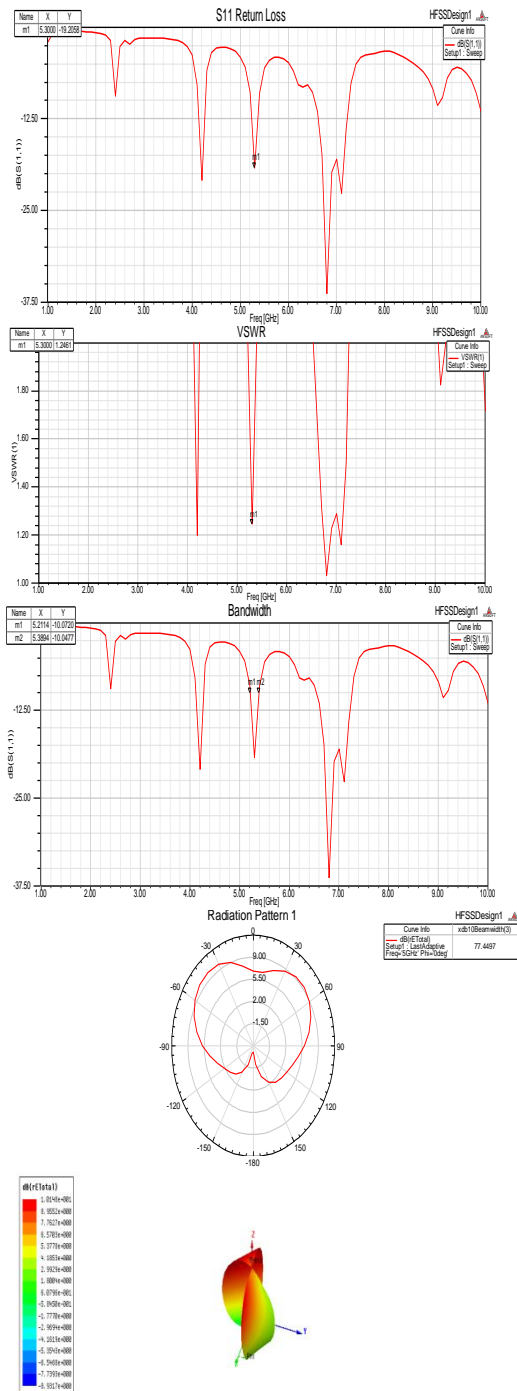


Fig. 3: HFSS Design of Microstrip patch placed on planar Surface

C. Simulation Results



D. Microstrip patch on cylindrical surface

The same patch which was used for planar surface is now mounted on a cylindrical surface with a radius of 15mm and 20mm. The shape of the patch changes as the radius of the substrate changes. The radius dimensions are user defined values. For this case, if the radius is less than 15mm or greater than 20mm, the patch or ground are not perfectly conformed to that shape. Generally conformal antennas are used for controlled gain (depending on shape of the substrate), low return loss, and change in operating frequency, increased bandwidth and beamwidth [1].

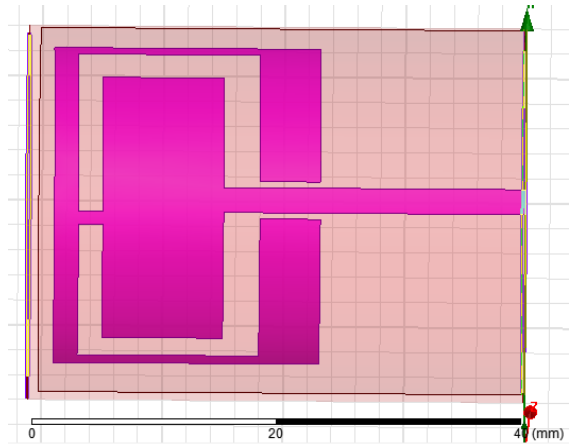


Fig 4: HFSS Design of Microstrip patch placed on cylindrical Surface (Radius:15mm)

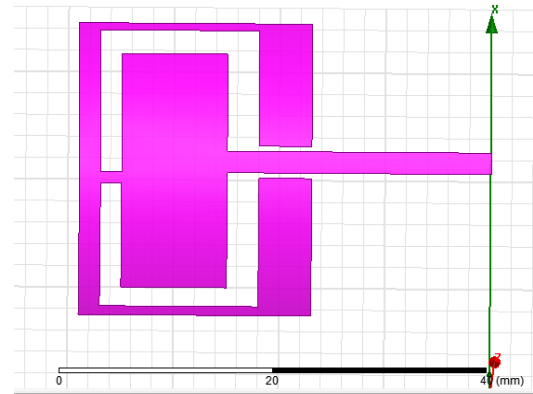
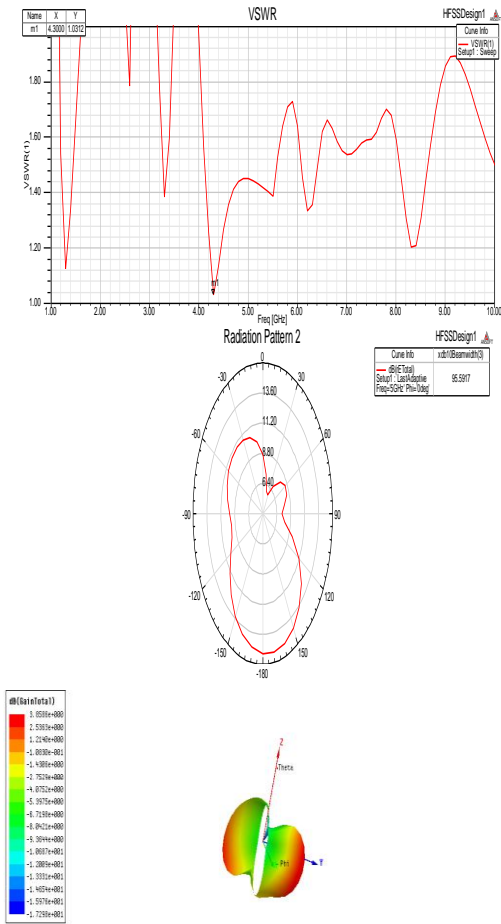


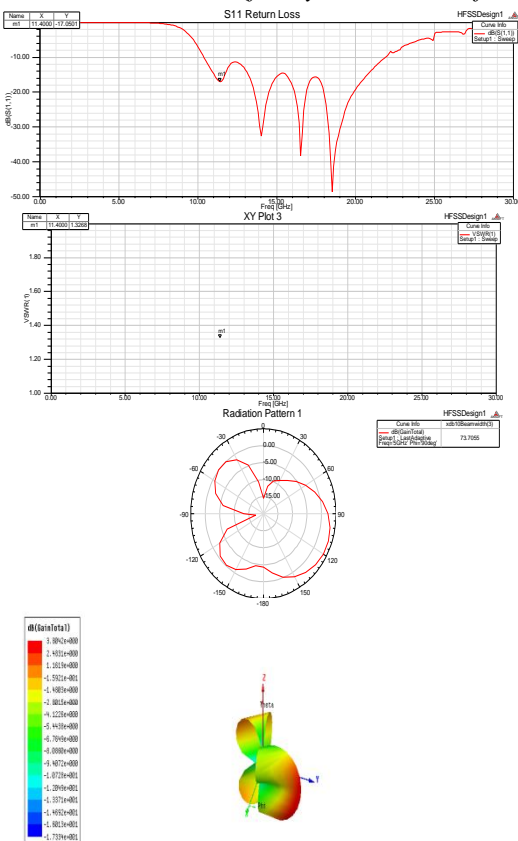
Fig 5: HFSS Design of Microstrip patch placed on cylindrical Surface (Radius:20mm)

E. HFSS Simulation Results (for Cylinder radius of 15mm)





F. HFSS Simulation Results (for Cylinder radius of 20mm)



G. Comparisons of simulation results

Parameter	Planar Surface	Cylindrical Surface (15mm Radius)	Cylindrical Surface (20mm Radius)
S11 Return Loss (dB)	-19.2	-36.27	-48.55
Operating Frequency (GHz)	5.3	4.34	18.5(12to 21)
VSWR	1.246	1.032	1.017
Bandwidth (GHz)	0.178	1.8	12
Gain (dB)	1.4	3.85	3.842

III. CONCLUSION

Characteristics of antenna parameters with cylindrical structured substrate have studied on comparison with antenna on a planar surface. A microstrip patch antenna was mounted on a cylindrical substrate with variation in radius. It is observed that with the conformal structure of antenna, the gain and bandwidth enhancement was observed. Return loss (S11) reduces drastically. Also the operating frequency varies from 4.34GHz to 18.5GHz.

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