Design of Miniaturised Microstrip Patch Antenna Using Slots

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Abstract. This paper presents a performance analysis of rectangular microstrip patch antenna at frequency of an ISM band. The resonant frequency is set at 2.5 GHz to match a range of ISM Band applications. The software environment HFSS is used to design and compare antenna performance. The proposed antenna uses rectangular slot/notch loading with a strip line inserted to create an E-antenna. The antenna was presented with denim substrate of dielectric constant 1.6mm.In this coaxial feed is used. The built antenna output was evaluated for terms of bandwidth, gain, return, vswr and radiation pattern.

1.INTRODUCTION

Microstrip patch antenna plays an important role in the demands of wireless service in this rapidly evolving world of wireless communication systems. The latest trend in commercial and government communication systems was to build low-cost, low-weight, low-profile antennas capable of maintaining high performance over a large frequency spectrum. Over the years, the configuration of microstrip patch antennas is the most common choice used to realize microwave, radar, and networking purposes in millimeter wave monolithic integrated circuits. Within this frequency operating range the antenna should have stable gain, radiation pattern, polarization, etc.It should be of small scale, conformal, low cost at the same time and should be easily integrated into the RF circuits. The Microstrip patch antenna is printed directly onto the circuit board. Since the slotted microstrip patch antenna needs few components, it is low cost, simple to fabricate, and light weight. Such features make slotted patch microstrip antennas suitable for use on mobile phones and other small electronic devices. Microstrip patch antenna consists of a dielectric substrate on the other side, with a ground plane. The microstrip patch antenna is very well suited for applications such as wireless communication systems, cellular phones, pagers, radar systems and satellite communication systems due to its advantages such as low weight, low profile planar configuration and integration capability with micro wave integrated circuit technology.

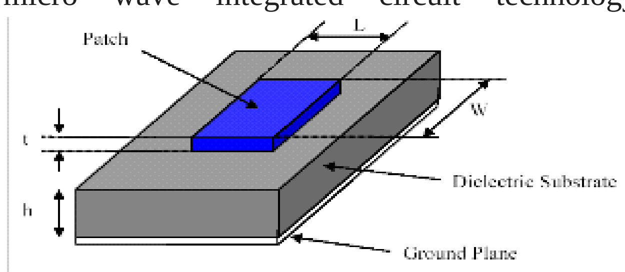

Fig.1.Microstrip Antenna

2. ANTENNA DESIGN

The geometry of proposed E-shape antenna is shown in Fig.2. It consists of an E-shaped patch antenna, a rectangular patch, partial grounding and a microstrip feeding the substrate heights are 3.5 mm.

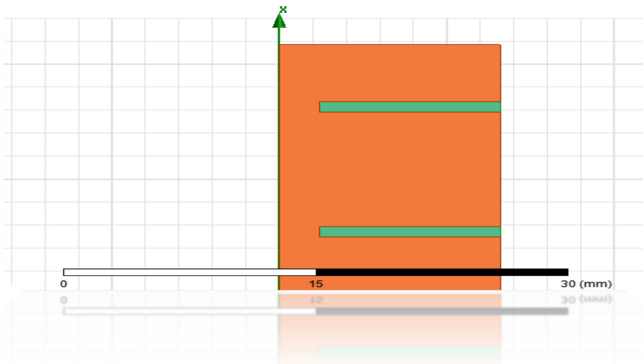

Fig.2. Actual HFSS model (top view)

The design process was start with HFSS'13, aiming a bandwidth at 2.5 GHz for ISM band applications. The parameters involved in the design process are dimension of rectangular patch, two parallel slots of E-shaped patch, feed point position and the separation between patches.

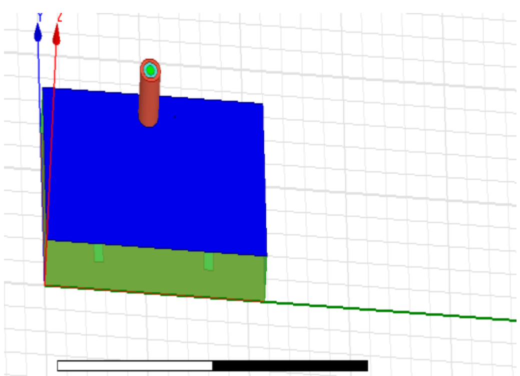

Fig.3 Actual HFSS model (elevated side view)

The above figure shows that having patches and the feed. The feed given is coaxial feed.

Table.1.Material used for patch antenna

	Material
Patch	Copper
Substrate	Denim(ε_r=1.6)

2.1 DESIGN CONSIDERATIONS

The three important parameters which are to be considered for designing a rectangular microstrip patch antennae are:

1) **Operation Frequency (f_o):** The antenna's resonant frequency must be correctly chosen. The defined frequency range for ISM band service is from 2.4-24 GHz. Thus the built antenna must be able to function within this high frequency range. The selected resonant frequency for the design is 2.5 GHz.

2) **Dielectric constant of the substrate (ε_r):** The dielectric material choosen for this design is Denim which has dielectric constant of 1.6.

3) **Height of the dielectric substrate (h):** For the Microstrip patch antennae to be used in ISM band, it is essential that the antennae are kept light and compact. Hence, the height of the dielectric substrate is chosen as 3.5 mm. Hence, the essential parameters for the above explained design are chosen as f0 = 2.5 GHz, Denim = 1.6 and h = 3.5 mm.

2.2DESIGN PROCEDURE

Step 1: Determination of the Width (w): The width is given by,

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r+1)}{2}}}$$

By substituting c = 3 × 10^8 m/s, ε_r = 1.6 and f_0= 2.5 GHz, it can be easily determined that w = 54.82 mm.

Step 2: Determination of effective dielectric constant (ε_{reff}): The effective dielectric constant is represented by,

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}}$$

By substituting ε_r = 1.6, w = 54.82 mm and h =3.5 mm, it can be determined that ε_{reff} = 1.581.

Step3: Determination of the effective length (L_{eff}):

The effective length is given by,

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}}$$

By substituting ε_{reff} = 1.581, c = 3 × 10^8 m/s and f_0 = 2.4GHz, it can determined that L_{eff} =0.049706 m=49.706 mm.

Step 4: Determination of the length extension (ΔL): The length extension may be represented by,

$$\Delta L = 0.412h\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

By substituting ε_{reff} = 1.581, w = 54.82 mm and h = 3.5 mm, it can be determined that ΔL = 0.85342 mm.

Step 5: Determination of actual length of patch (L): The actual length is obtained by the expression,

$$L = L_{eff} - 2\Delta L$$

By substituting L_{eff} = 49.706mm and ΔL = 0.85342 mm, the actual length can determined as L = 48.85168 mm. In the foregoing mathematical computations, the patch parameters have been designed for the substrate Denim with dielectric constant 1.6.

3. SIMULATION RESULTS AND DISCUSSIONS:

3.1RETURN LOSS

For simulation we used HFSS'13 of ansoft, which is very good for microstroip antennas. After simulating the design, the results obtained are,

The equation for return loss calculated from the reflection coefficient,

$$R = 20\log10(\Gamma) = 20\log_{10}(S11).$$

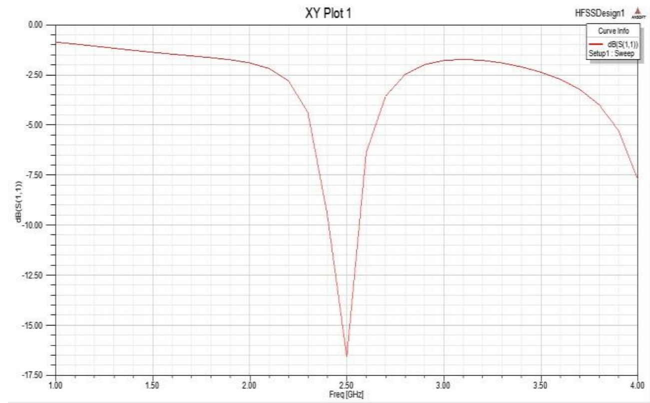

Fig.4 Return loss (S_{11}) parameter of the E-shape microstrip patch antenna

The above figure shows the return loss of -16.50dB at 2.5 GHz.

3.2 VSWR(VOLTAGE STANDING WAVE RATIO)

The voltage standing wave ratio equation is,

$$s = v_{max}/v_{in} = (1+r) / (1-r).$$

The allowable standard VSWR for fabricating the antenna <1 in which r=reflection co-efficient.

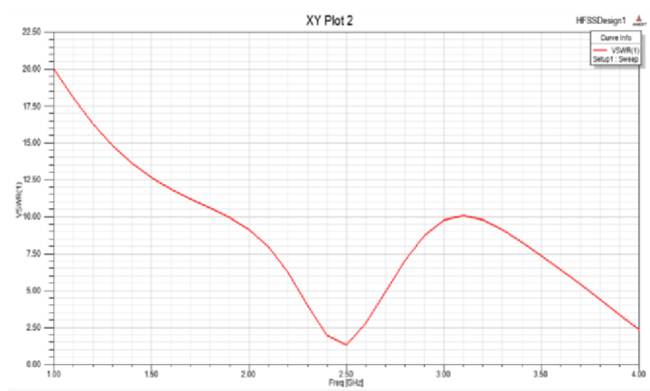

Fig.5 VSWR of the E-shape antenna

The above Fig.5 shows the VSWR value 1.50 which we required.

3.3 RADIATION PATTERN

The designed antenna is radiating all its power in one direction therefore optimized antenna has unidirectional radiation pattern.

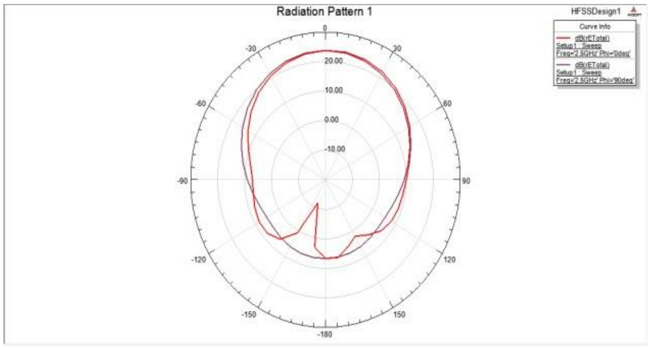

Fig.6 Radiation pattern of the E-shape antenna

The Fig.6 shows the radiation pattern of the E-shape antenna with slots. The radiation pattern gives us a gain of the antenna. The Fig.7 shows the gain of the antenna in dB with Phi, Theta and Gain total. The gain of the E-shape microstrip patch antenna is obtained as 6 dB.

Fig.7 Gain of the E-shape antenna

The Table.1 shows us the convenient view of the resonant frequency, return loss, VSWR, and gain of the E-shaped microstrip patch antenna.

Patch shape	Resonant Frequency (GHz)	Return Loss (dB)	VSWR	Gain (dB)
E-shape antenna	2.5	-16.50	1.50	6.00

Table.1 Obtained results

The dimension of rectangular patch as well as the shift of coaxial feed point location has been optimized to achieve this gain and it can be used for ISM band applications.

4. CONCLUSION

A microstrip E-shaped patch has been presented in this paper. Simulations and results of the patch have been provided a useful design for an antenna operating at a frequency of 2.5 GHz for ISM band applications. The return loss of the proposed antenna is less than -16.50 dB and increase in the gain. The voltage ratio of the signal in transmission line obtained is 1.5. Thus it is concluded that the proposed E-shape microstrip patch antenna enhanced the gain of the antenna and VSWR of the antenna.

5. REFERENCE

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