Design of a Slotted Microstrip Dual Band Patch Antenna

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Abstract— The growth of wireless communication in recent years has made it necessary to develop compact, light weight multiband antennas. Compact antennas can achieve the same performance as large antennas do with low price and with greater system integration. Dual frequency microstrip antennas for transmission and reception represent promising approach for doubling the system capacity. In this work, slotted dual band antennas operate at 4.3 and 6.9 GHz is constructed by modifying the standard microstrip patch antenna geomentry into a fractal structure. In addition to miniaturization and dual band nature, the proposed antenna also removes unwanted harmonics without the use of additional filter components. Using the finite-element-method-based high frequency structural stimulator (HFSS), the antenna is designed and its performance in terms of return loss, impedance matching, radiation pattern, and voltage standing wave ratio (VSWR) is demonstrated. Simulation results are shown to be in close agreement with performance measurement from an actual antenna fabricated on FR4 substrate.

Keywords— *Miniaturized patch antenna, HFSS, FR4.*

I. INTRODUCTION

A Microstrip Patch Antenna (MPA) comprises of metallic patch radiator on an electrically thin dielectric substrate with the ground of metallic material such as copper, gold. Now-a-days the need of wireless communication is in great demand 1][2], and an antenna is the backbone of this system. Among various available antennas, MPA is the major attraction for researchers over the last decades. The microstrip patch structures are probably easy to fabricate. Research on microstrip antenna in the 21st century centered at small sized, increased gain, wide bandwidth, multiple functionality [3][4]. With the wide spread proliferation of wireless communication technology in recent years, the importunity for compact, low profile and broadband antennas has escalated significantly. To meet such features and requirements, the MPA has been proposed because of its low profile, less cost and small size. MPA consists of square patch which is conductor in nature of length "L" and width "W" on one side of dielectric substrate with the thickness of "h" and dielectric constant "εr" with the base named ground. Commonly available shapes of microstrip antenna are circular , elliptical , square, rectangular, but any other shape can also be introduced by using regular shapes. The performance of antenna can be evaluated on the basis of return loss, gain, bandwidth and VSWR. Return loss or reflection loss is the reflection of signal power from the insertion of a device in a transmission line or optical fiber [5]-[8]. Whereas, antenna gain is the ratio of maximum radiation intensity at the peak of main beam to the radiation intensity in the same direction produced by an isotropic radiator or omni - directional antenna having the same input power. Isotropic antenna is standardized to have a gain of unity. Various feeding mechanisms can be used to excite Microstrip patch antennas. These techniques are categorized as contacting and non-contacting technique. The contacting techniques are microstrip line feeding and co-axial plane feeding [9]. On other hand, non- contacting techniques are proximity coupled feeding, aperture coupled feed. In this paper, Slotted MPA with coaxial feed technique has been introduced, the main benefits of this antenna is that it is reliable and easy to fabricate [10]-[12].

II. ANTENNA DESIGN AND CONFIGURATION

A. In order to design slotted antenna, dimensions are chosen on the basis of frequency. Square patch of dimension 28×28 mm^2 is taken. FR-4 epoxy is used as substrate with loss tangent of 0.02 and dielectric constant of 4.4 with ground plane is of 40×40mm^2 size. Length and width of patch is calculated by using following equations:

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_{r+1}}} \tag{1}$$

Where ϵr is relative permittivity, fr is the resonant frequency and c is the velocity of light, and the calculated W is 24mm. The effective dielectric constant of the microstrip antenna is determined using:

$$\varepsilon reff = \frac{\epsilon_{r+1}}{2} + \frac{\epsilon_{r-1}}{2}\,[1+12\frac{h}{w}]^{-1/2} \tag{2}$$

Calculation of the length extension (ΔL)

$$\Delta L = 0.412h\,\frac{(\epsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{reff-0.258})(\frac{w}{h}+0.8)} \tag{3}$$

Calculation of the Effective length (*Leff*)

$$L_{eff} = \frac{c}{2f_{e}\sqrt{\epsilon_{eff}}} \tag{4}$$

Calculation of actual length of patch (L)

$$L = L_{eff} + \Delta L \tag{5}$$

Designing an antenna in wireless application means that the antenna dimensions should be small. Keeping this under consideration, design cogitation was taken from broadband antennas with coaxial feed technique.

B. Methodology

A patch antenna is a type of radio antenna with a low profile mounted on flat surface. It consists of a flat square sheet or patch of metal, mounted over a large sheet of metal called a ground plane. In communication, a metal strip antenna (also known as a printed antenna) usually means an antenna fabricated using microstrip techniques on a printed circuit board(PCB). They are used at microwave frequencies. A patch antenna can be designed in rectangular, circular, square, elliptical, cylindrical etc. Here we are designing a square patch antenna using coaxial feeding. In this technique feed circuitry is shielded from the antenna by a conducting plane with a hole to transmit energy to patch.

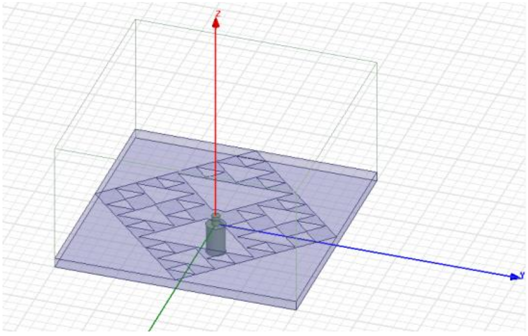


Fig.1. Configuration of patch antenna with slots.

III. FEEDING TECHNIQUES

The patch antennas may be powered with many methods. The processes feeding are categorized in two methods:

In category contacting ,the feeding technique is power by means of a connecting element such as a microstrip line into the radiating patch.

Without conduct category, a transfer of power between the microstrip line and radiating element is performed with the electromagnetic field coupling.

Coaxial probe feeding techniques

The outside conductor of coaxial connector attached at ground plane, while the inside is extends across the dielectric and is welded at the radiating element antenna.

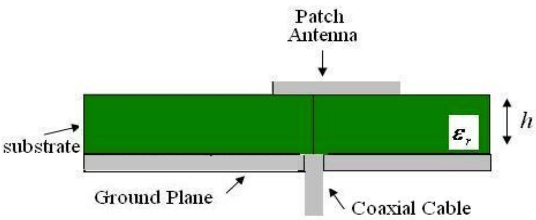
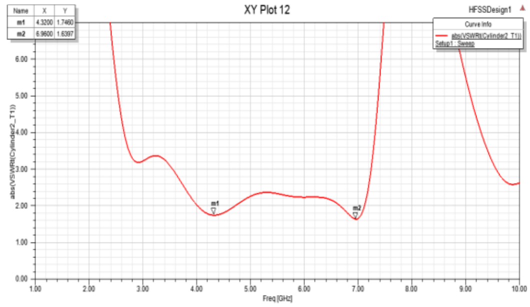


Fig.3.Coaxial probe feed

IV. SIMULATED RESULTS

A. The outcome of simulated results of return loss and gain confirms the optimal performance of the proposed design of antenna.

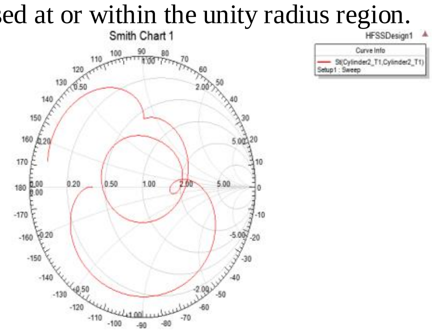


(a)

Voltage Standing Wave Ratio (VSWR) depicts the impedance matching of the antenna. It is the measure of impedance mismatch between the antenna and feed line. For practical use of antenna, it is required that value of VSWR should always be less than or equal to 2. In this design return loss 1.7 dB is achieved at resonant frequency of 4.3 GHz and 1.6 dB for 6.9GHz.

B.SMITH CHART

The smith chart can be used to simultaneously display multiple parameters including impedance, admittance reflection coefficient,S_{nn} scattering parameters noise figure circles constant gain contours and regions for unconditional stability including mechanical vibrations analysis . The smith chart is most frequently used at or within the unity radius region.

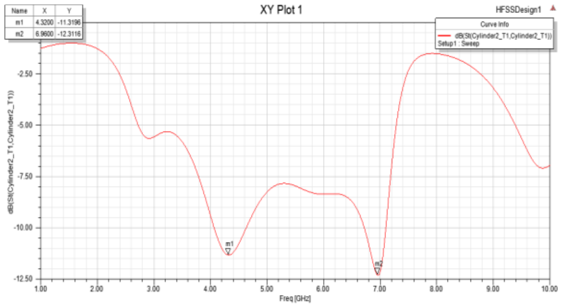


(b)

C. RETURN LOSS

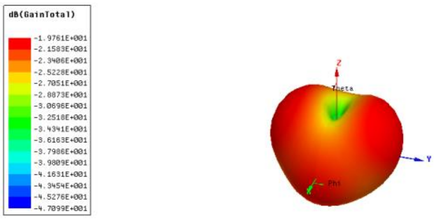
Return loss is related to both standing wave ratio and (SWR)and reflection coefficient (Γ)increasing return loss corresponds to lower SWR .Return loss is measure of how well devices or line are matched .A match is good if the return loss id high .A high return loss desirable and results in a lower insertion loss.

Return loss is used in modern practice in preference to SWR because it has better resolution for small value of reflected wave.



(c)

D . Gain



Antenna gain is usually define as the ratio of the power produced by the antenna by the antenna from a far field source on the antennas's beam axis to the power produced by a hypothetical lossless isotropic antenna which is equally sensitive to signals from all directions.

V. CONCLUSIONS

In this paper, an optimal design of slotted MPA with coaxial feed (used to improve the gain) has been presented, and observed that the designed antenna resonates at two different frequencies and the return loss is less than -10 dB for two frequencies. Gain is also more than 3dB which is also a acceptable value gain for the antenna to work effectively. The proposed antenna can be used for wireless applications for e.g. ultra broadband transceiver which is applicable to GSM ,CDMA ,Bluetooth, GPS, WLAN 802.11a, Transmitter design for 802.16, fixed CPE, Femto BTS,WLAN access point . Simulated and measured results of proposed antenna are in a reasonable agreement with each other, and fabricated antenna resonates at two different frequencies. So, proposed antenna can be declared as better antenna.

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