

Design of C-Shaped Patch Antenna for Multiband Applications

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Abstract— In this article, a completely unique design of multiband microstrip patch antenna has been presented for multiband applications. The C-shape antenna is meant on FR-4 substrate and is fed through 50 ohm microstrip feed line. Three I-shape slots are introduced in antenna for size reduction and to supply multiband characteristics to realize bandwidth enhancement. The simulated results show that the antenna operates in two different frequency bands having resonance frequencies at 4.4GHz, 6.6GHz. The antenna exhibits good return loss of -21.0dB @4.4GHz, -12.9467dB @6.2GHz. The proposed antenna has stable radiation patterns and gain values which are 6.29db at 4.4GHz, 4.45dB at 6.2GHz. The VSWR is less than 2. The C-shape microstrip patch antenna finds its applications in commercial WLAN, Wi-MAX and in Radar application

Key-words: *Multiband, Patch Antenna, Radar, VSWR, Wi-MAX, WLAN.*

I. INTRODUCTION

In the era of wireless communication, the necessity of compact and miniaturized multi-band antenna is flourishing rapidly. to satisfy this requirement a microstrip patch antenna is that the available possible solution. Microstrip patch antenna has patch mounted on substrate and ground plane on the opposite side. Microstrip patch antenna are often utilized in mobile and aerospace applications thanks to light weight and low power consumption during transmission and reception [1]. Although microstrip patch antenna has some limitations like narrow bandwidth and low gain but it's several advantages [2] like low profile, lightweight, compact size, financial feasibility, and characteristics of covering multi bands with one structure. to beat these nominated problems various techniques like increasing the peak of dielectric substrate, decreasing dielectric constant [3], and using parasitic patches [4] are wont to enhance the BW of the planar antennas. Antennas play an important role in communication system design in terms of operational frequencies, cost, weight, and size. Allocating one antenna for each communication waveband would make the entire design of mobile terminal bulky not only in terms of size but also in terms of its weight. this is able to also pose questions on the financial feasibility of the system design. the simplest possible solution to the present problem is to style one microstrip antenna with compact size for various communication bands at an equivalent time [5].

II. CATEROGIES OF MULTIBAND ANTENNA

The research study of multiband antennas are often categorized into: PIFAs, wire Antennas and defected patch and ground antennas [6]. Authors of [7,8] have suggests few designs for PIFA with multi communication bands. Introduction of parasitic patches to the traditional microstrip patch antenna is

additionally one among the technique for getting multiband characteristics, where within the main radiating patch works at lower waveband while the parasitic patches are introduced to figure at higher frequencies [9]. Authors of [10] have achieved quadruple bands is single planer monopole radiator with low substrate height achieving four communication frequencies which of [11] have proposed a loop structure mixed with monopole to realize multi bands for communications

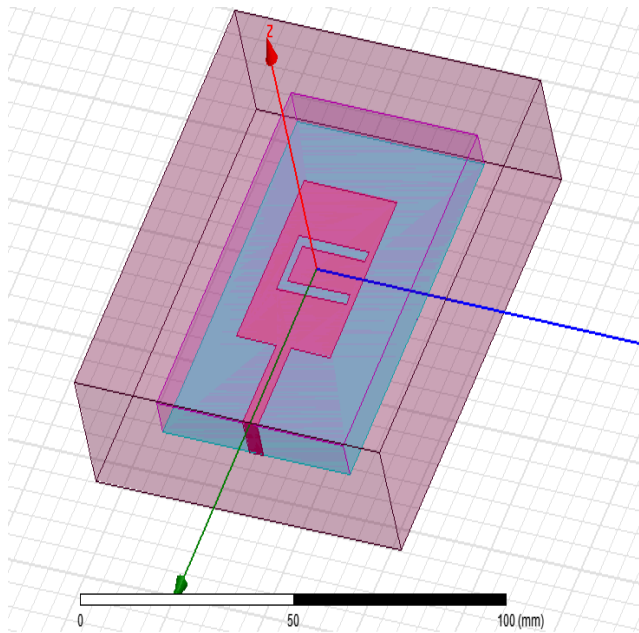
III. RELATED WORK

Looking at simple microstrip patch antenna for single band operation, Numerous microstrip patch antennas are proposed by various authors during this literature review. In [13] microstrip patch antenna has been presented which features a peak gain of three.5db with return loss -30db while in [14] the proposed patch antenna features a gain value of 1.4dB and reciprocally loss of -25dB and in [15] the height achieved gain is 3.4db during this article a completely unique design of triple band microstrip shirt-shape patch antenna has been presented during which the most radiating structure is mounted on FR-4 substrate having dielectric permittivity $\epsilon_r=4.4$. Three L-shape slots are etched within the rectangular patch which increases the inductance of the patch, resultantly increasing the electrical length of the antenna which produces multiband characteristic. therefore, the intent behind this work is to supply a replacement shirt shape design for the patch antenna having the capabilities of covering multi bands of wireless and radar applications. The proposed C-shape microstrip patch antenna during this work provides multiband characteristics with small size and wide bandwidth ($VSWR < 2$). The operating frequencies find its application in C Band. The presented antenna design is additionally compared with another works in term if their sizes, frequency bands, return loss and gain values and therefore the results are tabulated in Table I

TABLE I. Comparison with Different literature

| REF | SIZE (mm) | FREQUENC Y (GHz) | RETURN LOSS (dB) | GAIN (dB) |
|-----------|-------------|------------------|------------------|----------------|
| [16] | 60x40x1.5 | 2.4,5.2 | -20,-18 | 3,2,7 |
| [17] | 60x83.5x1.6 | 1.53,3.27,2.89 | -16,-12,-13 | 1.96,1.96,1.84 |
| [18] | 32x50x1.6 | 2.06,10.92,15.3 | -13,-28,-18 | 1.8,2.3,4.5 |
| This work | 30x40x1.6 | 4.4,6.6 | -21.049,-12.9467 | 6.29,4.45 |

IV. DESIGN OF C-SHAPED ANTENNA



V.

Fig. 1. Design of C-shaped Microstrip Patch Antenna

As shown in Figure 1., the rectangular patch is of dimensions (L x W) on Fr4-epoxy sheet whose loss tangent is 0.02 and height is 1.6mm. The length and width is taken as 30mm x 40mm. The patch antenna is excited using a 50Ω at feed line for impedance matching. The dimension od antenna are calculated using a well-known transmission line theory from electromagnetic theory and antenna and wave propagation.

The steps for calculating the dimensions are as follow:

Step 1: Determine the width of the patch:

$$W = c f_o \sqrt{2\epsilon_r + 1} \quad (1)$$

Step 2: Calculate the length of the patch:

$$L = L_{eff} - 2\Delta L \quad (2)$$

$$\text{Where, } L_{eff} = c f_o \sqrt{\epsilon_{reff}} \quad (3)$$

Where, c is the velocity of light = 3×10^8 m/s
 And ϵ_r is the Dielectric constant of the substrate

$$\epsilon_{reff} = (\epsilon_r + 1.2) + (\epsilon_r - 1.2) \times \sqrt{\frac{1 + (h/w)}{4}} \quad (4)$$

Step 3: the extension of length of ΔL can be calculated as:

$$\Delta L = 0.412 \times h \times \frac{((\epsilon_{reff} + 0.3) \left(\frac{w}{h}\right) + 0.26)}{((\epsilon_{reff} + 0.253) \left(\frac{w}{h}\right) + 0.8)} \quad (5)$$

The flow of these construction of patch antenna is like:

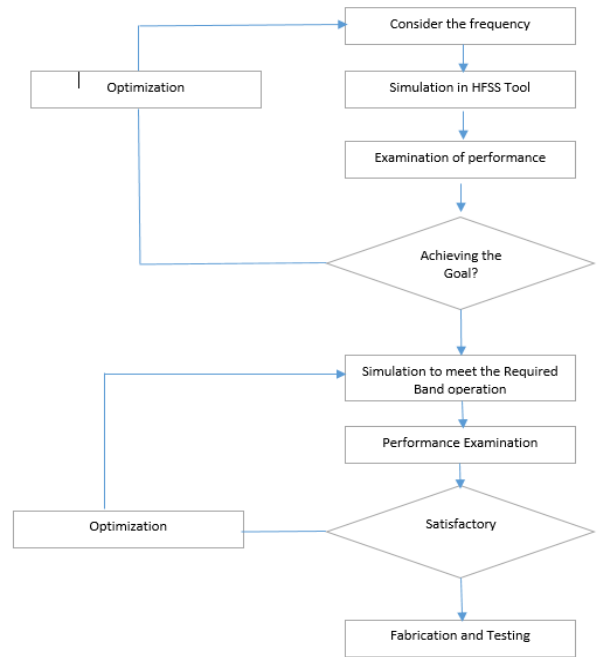


TABLE II. Parameters for C-shaped Antenna

| | |
|-----------------------------|-----------|
| Frequency (GHz) | 4.4, 6.6 |
| Dielectric Substrate | FR4_Epoxy |
| Dielectric Constant | 4.4 |
| Loss Tangent | 0.02 |
| Dimensions(mm x mm) | 30 x 40 |
| Height of the substrate(mm) | 1.6 |
| Impedance | 50 Ω |

VI. PARAMETERS

A) Return Loss:

Antenna's Return loss is the amount of the power reflected from the input of an antenna. Return loss is a quantity often used within RF circuits where the most important thing is impedance matching. Moreover, the winding reception apparatus' radiation design ordinarily has a pinnacle radiation course opposite to the plane of the winding. An antenna's Return Loss may be a figure that indicates the proportion of radio waves arriving at the antenna input that is rejected as a ratio against people who are accepted.

It's laid out in decibels (dB) relative to a brief circuit (100 percent rejection). Consider the antenna getting used in transmit mode.

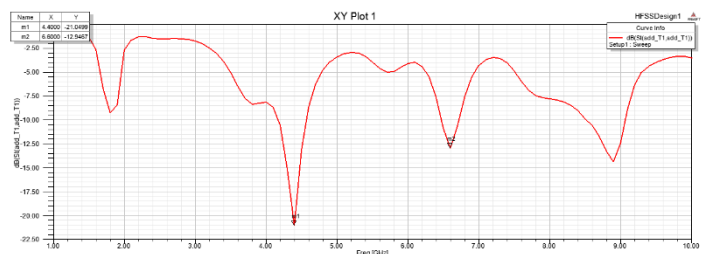


Fig 2. Return loss

B) Gain:

In electromagnetics, the ability gains of antenna or just gain could even be a key performance number that mixes the antenna's directivity and electrical efficiency. During a transmission of antenna, the gain describes how well the antenna converts input power into radio waves headed during a specified direction. Whereas, during a receiving antenna, the gain describes how well the antenna converts radio waves returning from a specified direction into electrical power. Antenna gain is usually defined as the ratio of the power produced by the antenna from a far-field source on the antenna's beam axis to the power produced by a hypothetical lossless isotropic antenna, which is almost equally sensitive to signals from all directions



Fig. 3: Gain of the antenna

C) Frequency, Gain and Power relationship:

- The dependency of Power is on both frequency and gain.
- Gain is defined at a specific frequency.
- Frequency is independent of power or gain.

D) Radiation Pattern:

The radiation pattern of an antenna is the geometric pattern of the relative strengths of the field emitted by the antenna. The radiation pattern reflects the 'sensitivity' of the antenna in all different directions.

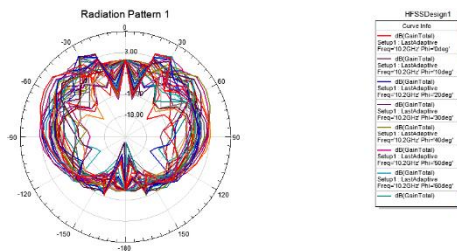


Fig. 4: Radiation Pattern

E) VSWR:

VSWR stands for Voltage Standing Wave Ratio and is also referred to Standing Wave Ratio (SWR). It is a function of the reflection coefficient, which describes the power reflected from the antenna. If the reflection coefficient is T, then VSWR is given by:

$$VSWR = ((1+T)/(1-T)).$$

The reflection coefficient is also known as the s11 parameter or return loss. The range of VSWR should be from 0 to 2 as a VSWR value under 2 is considered suitable for most antenna applications. The VSWR is frequency-dependent. Frequency dependency means the VSWR for the carrier signal could also be different than for the harmonic signal. Generally, the VSWR is specified as a maximum value for the frequency range of a component.

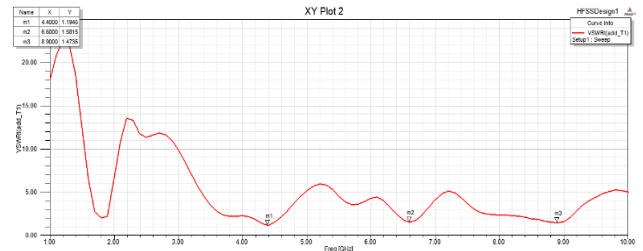


Fig. 5: VSWR

VII. CONFIGURATION OF C-SHAPED PATCH ANTENNA

In Fig.1 the configuration of C-shaped Microstrip Patch antenna is shown. We have placed a sheet of FR4_epoxy there as Fig 1 shows the patch antenna with the ground plane which is designed in High-Frequency Structural Simulator (HFSS). This antenna was aimed to center frequency at 4.4 & 6.6 GHz, in order to evaluate performance. Moreover, the patch antenna is made from eq. (1), eq. (2) and eq. (3) in the software. During the simulation process, the center is kept on changing from 4.4 GHz to 6.6GHz to verify the results that were obtained.

V. SIMULATION & RESULTS

The experimental setup of the whole structure of the spiral antenna is simulated in High-Frequency Structural Simulator (HFSS). With Substrate of FR4_epoxy having effective permeability 4.4 and loss tangent 0.02 and mass density, 1900 is taken. As it is frequency independent here it ranges from 4.4GHz and 6.6 GHz. The spiral antenna is simulated in HFSS in Fig 1 and Fig 2 shows the result of return loss. The spiral antenna with center frequency at 4.4 GHz at first and then 6.6GHz and has a gain of 6.29dB at 4.4GHz frequency as shown in Fig3, the gain of 4.4538 dB at 6.6GHz frequency as shown in Fig.3. The Radiation Pattern is also presented in Fig 4. The VSWR is also shown over here which is greater than 0 and less than 2 which satisfies the condition in Fig.5.

CONCLUSION

The constructed and simulated the C-shaped Patch antenna having substrate FR4_epoxy in HFSS software. The effective permeability is 4.4. Here, step-by-step procedures for designing the antennas were presented in this paper. The height of the antenna is 1.6mm and the width of the antenna is taken as 40mm for impedance matching at 50 Ω. Moreover, the Patch antenna satisfies the condition of gain and return loss as shown in the above figures as it is multiband frequency that it can work at frequency of 4.4GHz and 6.6GHz. So, this antenna presents polarization with the wideband frequency range.

REFERENCES

- [1] Garg, Ramesh. Microstrip antenna design handbook. Artech house, 2001.
- [2] Targonski, S. D., and David M. Pozar. "Dual-band dual polarised printed antenna element." Electronics Letters 34.23 (1998): 2193-2194.
- [3] Manohar, Murli, S. K. Behera, and P. K. Sahu. "Bandwidth enhancement with multi-band & multipolarized rectangular microstrip patch antenna." A Workshop on Advanced Antenna Technology, 2010 Indian Antenna Week. IEEE, 2010.
- [4] Pozar, David M. "Microstrip antenna aperture-coupled to a microstripline." Electronics letters 21.2 (1985): 4950.

- [5] Zhang, Ting, et al. "A novel multiband planar antenna for GSM/UMTS/LTE/Zigbee/Rfid mobile devices." *IEEE Transactions on Antennas and Propagation* 59.11 (2011): 4209-4214.
- [6] Liao, Wen-Jiao, Shih-Hsun Chang, and Long-Kun Li. "A compact planar multiband antenna for integrated mobile devices." *Progress In Electromagnetics Research* 109 (2010): 1-16.
- [7] Falade, Oluyemi P., et al. "Single feed stacked patch circular polarized antenna for triple band GPS receivers." *IEEE transactions on antennas and propagation* 60.10 (2012): 4479-4484.
- [8] Ur-Rehman, Masood, and Ben Allen. "A compact multi-band slotting microstrip patch antenna for wireless applications." *Antennas and Propagation Conference (LAPC), 2013 Loughborough.* IEEE, 2013.
- [9] Rowell, Corbett R., and Ross David Murch. "A compact PIFA suitable for dual-frequency 900/1800-MHz operation." *IEEE Transactions on Antennas and Propagation* 46.4 (1998): 596-598.
- [10] Usman, M., Jan, M.A., He, X. and Nanda, P., 2016, August. Data Sharing in Secure Multimedia Wireless Sensor Networks. In *Trustcom/BigDataSE/I SPA, 2016 IEEE* (pp. 590-597).
- [11] Wong, Kin-Lu, Gwo-Yun Lee, and Tzung-Wern Chiou. "A low-profile planar monopole antenna for multiband operation of mobile handsets." *IEEE Transactions on Antennas and Propagation* 51.1 (2003): 121-125.
- [12] Hsieh, Hsuan-Wei, et al. "Design of a multiband antenna for mobile handset operations." *IEEE Antennas and Wireless Propagation Letters* 8 (2009): 200-203.
- [13] Martinez-Vazquez, Marta, et al. "Integrated planar multiband antennas for personal communication handsets." *IEEE Transactions on Antennas and Propagation* 54.2 (2006): 384-391.
- [14] Mukandatimana, MARIE CHANTAL, and Tayeb A. Denidni. "A multi-resonator microstrip-fed patch antenna for broadband dual-band operation." *Antennas and Propagation Society International Symposium, 2004. IEEE. Vol. 4. IEEE, 2004.*
- [15] AbuTarboush, H. F., H. S. Al-Raweshidy, and R. Nilavalan. "Triple band double U-slots patch antenna for WiMAX mobile applications." *Communications, IEEE, 2008.*
- [16] Werfelli, Houda, et al. "Design of rectangular microstrip patch antenna." *Advanced Technologies for Signal and Image Processing (ATSIP) IEEE, 2016.*
- [17] Karade, Abha R., and P. L. Zade. "A miniaturized rectangular microstrip patch antenna using SSRR for WLAN applications." *Communications and Signal Processing (ICCSP), IEEE, 2015.*
- [18] Subahir, S., et al. "Rectangular spiral microstrip patch antenna integrated with LED for Wifi application." *Telecommunication Technologies (ISTT), IEEE 2014 Shanmuganatham, T., and Deepanshu Kaushal. "Design of multi utility multi band microstrip calculator shaped patch antenna using coaxial feed." Computer, Communication and Signal Processing (ICCCSP), IEEE, 2017.*