Triple Band Compact Broadband Antenna for S-C-X Band Application

Mrigendra sharma[1]
TRUBA Institute of Engineering and Information Technology, Bhopal, India.

Neelesh Gupta[2]
TRUBA Institute of Engineering and Information Technology, Bhopal, India.

Vibhanshu shrivastava[3]
TRUBA Institute of Engineering and Information Technology, Bhopal, India.

Abstract : In this paper a triple band compact broad band Patch antenna is presented using one U-Slot, one square slot with two orthogonal shorting pin,. Low profile coaxial fed Rectangular patch antenna is design, with the FR-4 substrate with a dielectric constant of 4.3 and loss tangent of .019. for generating compactness using two shorting pin contacted orthogonally, this design save 55% design area at 2.75GHz, In this paper a U-Slot, Square-Slot, and two shorting is used for enhancement of impedance bandwidth and return loss. Different parameters like impedance bandwidth $S_{11} \leq$ -10dB is 10% of S-band, 34% of C-Band and 19% of X-Band. Proposed antenna provided linear and circular polarized. Gain along θ, Ø directions, radiation pattern in 2D & 3D E & H field distributions, current distributions are simulated using IE3D^{TM}. The proposed antenna suitable for S-Band, C-Band and X-Band Applications, radar, Bluetooth, GSM and satellite applications.

Keyword Terms—Slotting technique, Shorting Pin, Orthogonal contact, microstrip patch antenna, S-C-X Band

I. INTRODUCTION

Compact broad band antenna has versatile features sustain compactness, high bandwidth, high gain, least loss, multiple polarization and flexible installation with number of system. Recently in modern wireless communication compactness with versatile features is highly recommended, so that raising the demand of Compact Broad band antenna. but in day to day technologies demand is change and enhance with more enhancement in features of device, so that further modification is also required for compact broadband antenna, In recent years mobile communication systems units required least antenna size in order to meet the miniaturization requirements of mobile units. Thus, size reduction and bandwidth enhancement are becoming major design considerations for modern application. . For this reason, to achieve compact and broadband operations of microstrip antennas have greatly demanded. In the last 40 years, the Compact Broad band microstrip antenna has been developed for many Communication systems like Mobile System, Radars, Military, Ultra-Wideband Application, Radio Frequency Identifications application, and reader devices, WiMAX, WLAN and GSM etc.

With the rapid growth of the wireless mobile communication technology, greater demands in future technologies are very small size wide band antennas. For this Microstrip patch antenna is the better part. The Microstrip patch antenna becomes very popular nowadays because of its ease of analysis and Fabrication, low cost, light weight, easy to feed and their attractive radiation characteristics. Although microstrip patch antenna has numerous advantages, it has inherent limitations of narrow bandwidth, low gain. To overcome its inherent limitation of narrow impedance bandwidth and low gain, many techniques have been suggested and investigated for MSA. We can mention multilayer structures [2], broad folded flat dipoles [3], curved lines and spiral antennas [4], impedance matched resonator antennas [5], resonator antennas with capacitive coupled parasitic patch element [6], log periodic structures

[7, 8], modified shaped patch antenna (H-shaped [9]). In the present paper Parasitic patches along main patch type microstrip patch antenna analyzed and compared to the rectangular patch antenna. Microstrip patch antenna in its basic form consists of a metallic radiating patch on one side of the dielectric substrate, which has a ground plane on the other side. The radiating elements and feed lines are usually photo etched on the dielectric substrate [1].

II. DESIGN CONSIDERATIONS

The pertinent design parameters are given together with their relevant equations to allow basic ‗hand' calculations before simulation is attempted. By using this flow of design, simple microstrip patch antenna can implement. Designed for the 6 GHz resonant frequency using the transmission line model (step 1, 2, 3, 4, 5, 6).

In the design procedure of the microstrip antenna using the transmission line model, the desired resonant frequency, thickness and dielectric constant of the substrate are known or selected initially. In this design of rectangular microstrip antenna, FR-4 dielectric material are then; a patch antenna that operates at the specified resonant frequency (6GHz) can be designed by using the transmission line model equations [1].

As shown in figure 1, coaxial probe type feeding mechanism used. The rectangular microstrip patch antenna parameters are:

- Resonating frequency fr = 6 GHz
- Patch width W = 22mm
- Patch length L = 17.7mm
- Total height of antenna h = 1.5mm

The proposed structure of the antenna is shown in Fig. (1). the antenna is simulated on an FR-4 substrate with a dielectric constant of 4.3 and loss tangent of .019. The thickness of the substrate is 1.5mm. Patch .IE3D^{TM} Simulator generated antenna model the patch can also be fed with a probe through ground plane. The probe position can be inset in matching the patch impedance with the input impedance. This insetting minimizes probe radiation

Step 1: Calculation of equivalent dielectric constant:

The equivalent dielectric constant Microstrip patch

antenna is given as:

Where εr = 4.3, h = 1.5mm

Step 2: Calculation of the Width (W):

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}}$$

Step 3: Calculation of Effective dielectric constant (εreff):

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1+12\frac{h}{w}]^{\frac{1}{2}}$$

Step 4: Calculation of the length extension (ΔL):

$$\Delta L = \frac{0.412h(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{w}$$

Step 5: Calculation of the Effective length (Leff):

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$$

Substituting c = 3.00e+008 m/s and f = 6 GHz,

Step 6: Calculation of actual length of patch (L):

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

Design Model

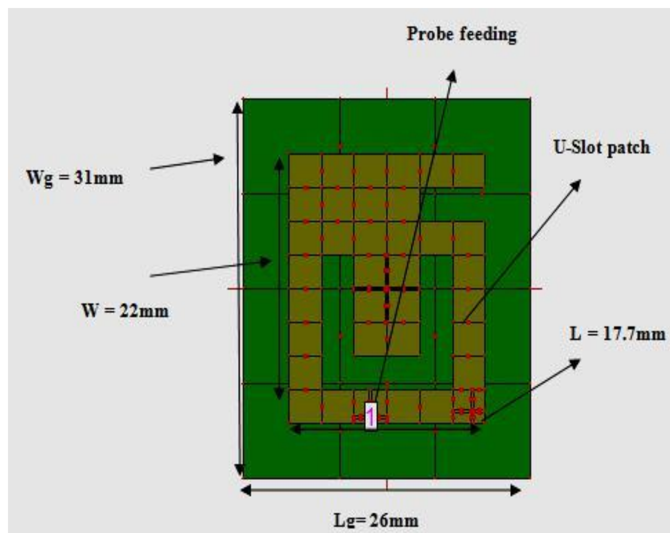

Figure **1 Proposed Antenna**

Lg= 26mm, Wg = 31mm
L =17.7mm W=22mm

Where
Lg and Wg are length and width of ground plan. L and W are the length and width of the meander shape patch

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III. SIMULATION RESULTS

1. Return loss vs. Frequency

We achieved Impedance bandwidth $S_{11} \leq$ -10dB is 10% of S-band, 34% of C-Band and 19% of X-Band. At 2.75GHz return losses is -16.4dB and at 4GHz return loss is -20dB. At 9.75GHz return losses is -16dB, is achieved shown in figure 2.

$S_{11} \leq$ -10dB is 10% of S-band, 34% of C-Band and 19% of X-Band.

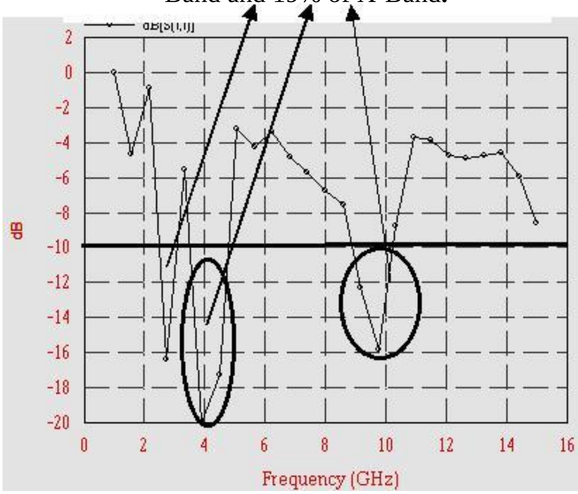

Figure 2 Return loss vs. Frequency

2. VSWR vs. Frequency

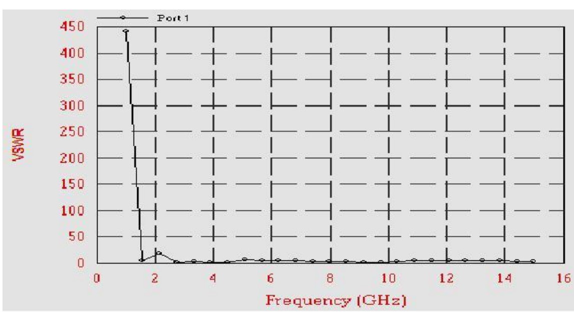

Figure **3. VSWR vs. Frequency**

The value of VSWR is shown in figure 3.We obtained VSWR at 2.75GHz is 1.357, VSWR at 4GHz is 1.382 and VSWR≤ 2 is 10% of S-band, 34% of C-Band and 19% of X-Band

3. Axial Ratio vs. Frequency

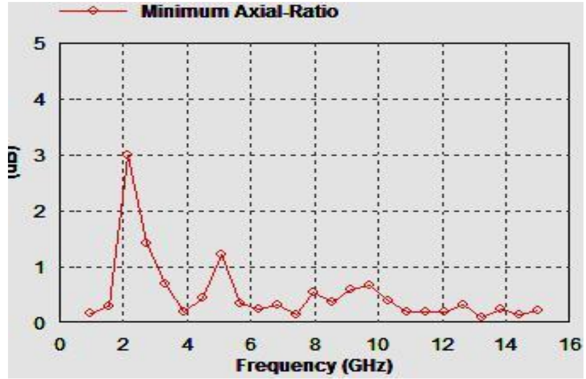

Figure 4. Axial Ratio vs. Frequency

3. Directivity vs. Frequency

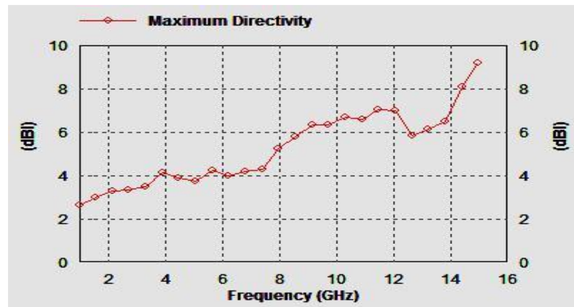

Figure 5. Directivity vs. Frequency

Directivity of antenna varies from 3.7dBi to 6.3dBi shown in figure 8

4. Antenna and Radiating Efficiency vs. Frequency

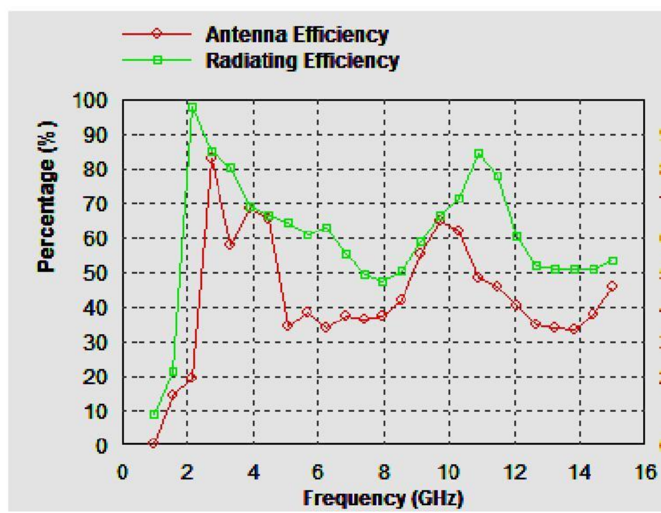

Figure 6. Antenna and Radiating Efficiency vs. Frequency

We have achieved antenna efficiency up to 85%and radiating efficiency 99%

6. Radiation Pattern

We have analyzed elevation and azimuth pattern at 14GHz and 11GHz frequency for different values of θ and φ

6.1 Elevation Pattern at 2.75GHz

The radiation pattern is at 2.75GHz in Maximum gain obtained at 0 and 180 degrees. 3dB Beam Width of the radiation pattern is 71.92 degrees

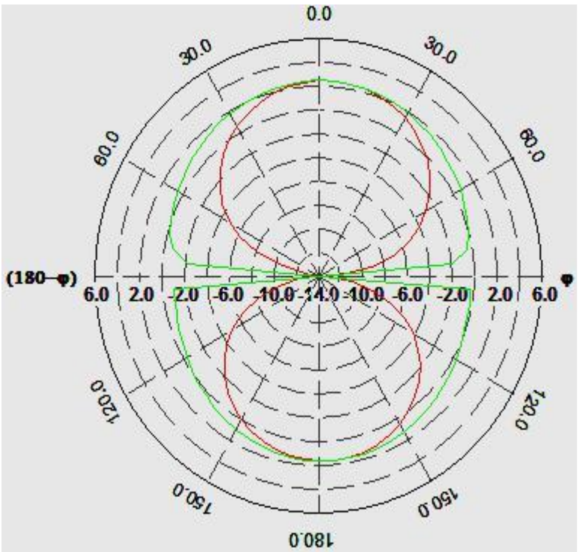

Figure 6.1 Elevation Pattern at 2.75GHz

6.2 Azimuth Pattern at 2.75GHz

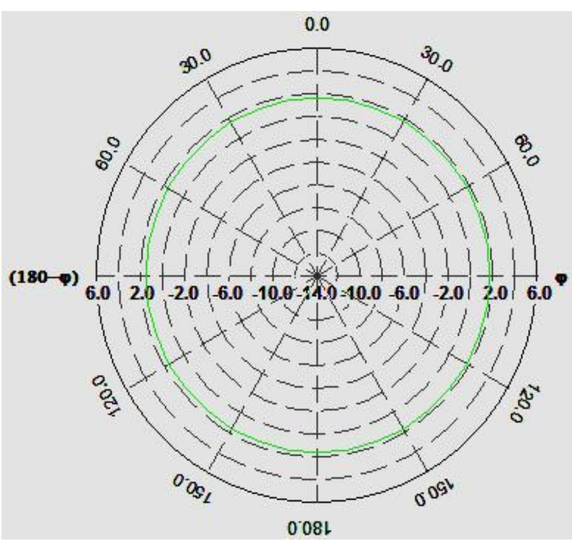

Figure 6.2 Elevation Pattern at 2.75GHz

The Azimuth radiation pattern is at 2.75 GHz in radiation pattern only one side lobe occurs. Maximum gain obtained at 90 and 270degrees. 3dB Beam Width of the radiation pattern is **-2.31238 degrees**.

IV RESULS AND DISCUSSION

In this Paper we analyzed geometries with U-Slot, Square Slot and shorting pin, using FR-4, observed improvement in return losses shown in Table – and fig 2. -Slots generate multiple resonance frequency all are redefine near to each other so that we obtained a broad bandwidth slot and triple band using single geometry. Whole Geometry is Circular andPolarized So that Applicable as a **Radar and Satellite Antenna.** In each antenna type, a design accounted according to the bandwidth. Bandwidth can be increased by increasing the height of the antenna. However, there are some limitations on how high the antenna can be. Current applications require the antenna volume to be small. Therefore, increasing the height of the antenna may not satisfy the size specifications for the required bandwidth. However, performance can be degraded when the height is increased. If a substrate is used in the microstrip antenna, one can increase the bandwidth by lowering its dielectric constant value. For achieving three band we used U-Slot and square slot , these slots generate resonate frequencies for C-Band and X-Band and provided impedance matching for C-Band and X-Band , for generating compactness connected two shorting pins orthogonally, these shorting pins improve surface current in patch towards lower edge of frequency so that the designing used at low frequency of application and generate compactness, the proposed design provided 55% compactness at 2.75GHz, result summary shown in Table-1 and Table-2.

Table 2 Result Summary

Antenna parameters at 2.75GHz	For proposed antenna
3dB Beam Width	(71.792, 163.007) deg.
Directivity:	**3.69343 (dB)**
Mismatch Loss	-0.100654 (dB)
Circular Polarization Loss	-2.25567 (dB)
Input Power at Ports	0.0097709 (W)
Total Radiated Power:	0.0097709 (W)
VSWR	1.357
Return losses	-16.4dB,

Table 1 Return loss vs. Frequency

Frequency	Return losses dB
2.75	-16.4 dB
4	-20 dB
4.5	-17.32dB
9.16	-12.35 dB
9.75	-16 dB

IV. CONCLUSION:

Finally, triple band compact broad band Patch antenna is presented using one U-Slot, one square slot with two orthogonal shorting pin has been investigated. We achieved Impedance $S_{11} \leq$ -10dB is 10% of S-band, 34% of C-Band and 19% of X-Band. At 2.75GHz return losses is -16.4dB and at 4GHz return loss is -20dB. At 9.75GHz return losses is -16dB, is achieved shown in figure 2.. Axial ratio bandwidth is 3dBi at 4GHz so that this linear polarized, this proposed antenna used for linear as well as circular polarization. Directivity of antenna varies from 3.8dBi to 3.7dBi. The proposed design provided 55% compactness at 2.75GHz; the proposed antenna has been presented with orthogonal shorting pins for reducing cross polarization loss of geometry. IE3D^{TM} Simulator used for validation of proposed antenna. The measured parameters satisfy required limits hence making the proposed antenna suitable for S-C-X Band Applications, GSM, WiMAX, Satellite communication, radar applications.

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Author`s Profile

Mrigendra sharma[1] has received the **B.E.** degree in electronics and communication engineering from Technocrates Institute of Technology Bhopal (R.G.P.V. University),India, in 2007.He is pursuing his **M.Tech.** in Digital Communication from Truba Institute of Engineering and Information Technology Bhopal India. His research interest includes compact Broadband microstrip patch antenna, wireless communication (**WiFi,WiMax**),Mobile communication, satellite communication.

Neelesh Gupta[2] is working as A.P. electronics and communication engineering in Truba Institute of Engineering and Information Technology Bhopal India. He is also H.O.D. in dept. of electronics and communication engineering. He guided me through this entire thesis wherein he gave his insights on varying aspects of this topic.

Vibhanshu shrivastava[3] is working as A.P. electronics and communication engineering in Truba Institute of Engineering and Information Technology Bhopal India. He also guided me in collecting various knowledge and data about thesis topic.