# Feed Analysis of Tri-Patch Multiband Antenna for Satellite Communication

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***Abstract* - A compact multiband antenna suitable for radar and satellite application operating in S, C, X, Ku and K bands of electromagnetic spectrum is presented. Antenna is compact in size, single-layer and is fed using coaxial probe feed. Feed location has been optimized and an analysis has been presented.**

***Index Terms* — Microstrip patch, Multiband antenna, Tri-Patch, Probe feed, Microwave bands, Optimized feed.**

## I. INTRODUCTION

In high-performance applications like aircraft, radar, satellite and missile systems, low profile antennas are required due to constraints in size, weight, expenditure, performance and ease of installation. Microstrip patch antennas are suitable candidates for these applications due to their compactness, low profile, easy fabrication and light weight features [1]. Various techniques have been reported in literature to achieve compactness, for controlling polarization and bandwidth enhancement [2]. Earlier a coaxilly-fed single layer compact antenna has been reported for IEEE radar band C and X [3]. The antenna radiating patch consists of three rectangular patches which are overlapped along their diagonals. This paper present optimization of antenna feed location analysis. Simulations were carried out using Ansoft HFSS (High Frequency Structure Simulator). Presented antenna operates with-in S, C, X, Ku and K band. Different antenna parameters such as return loss, gain and frequency variations are observed by changing the feeding locations. Rest of the paper is arranged as; antenna design is discussed in Section II, results and analysis is presented in Section III and paper is concluded in Section IV.

## II. ANTENNA DESIGN

Antenna geometry shown in Fig. 1 has overall size of $35.48\times27.48mm^2$ with three rectangular patches overlapped along their diagonals, each having dimensions of $13\times9mm^2$. Roger RT/duroid 5880(tm) with relative permittivity of 2.2 and thickness of 1.58mm has been used as substrate. Coaxial probe feed is used for feeding purpose. Feed location has been varied and an analysis has been carried out to find an optimized feed location. Location of probe feed is along (X, Y) coordinate, at a distance of 4.43mm from the centre of the patch in (-X, Y). Inner and outer radius of probe feed is 0.5mm and 1.6mm respectively.

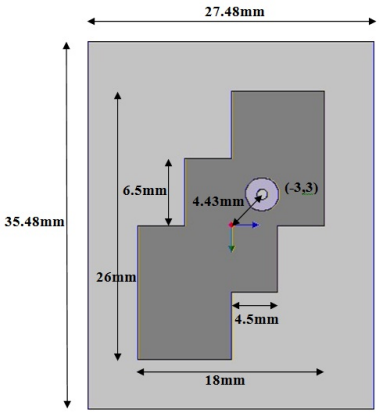


Fig. 1. Antenna geometry with feed location.

## III. RESULTS AND ANALYSIS

Figure 2 illustrates the predicted S-parameters for the presented antenna when feed is located at (-3,3) as shown in Fig. 1. Feed location is varied along the diagonal length of the patch from the origin (center of patch) to its right most edge. The observed results are tabulated in Table I. It is noted that, as the feed point location is moved away from the center of the patch, the lower frequency bands start to decrease and also there is a shift at the higher frequencies.

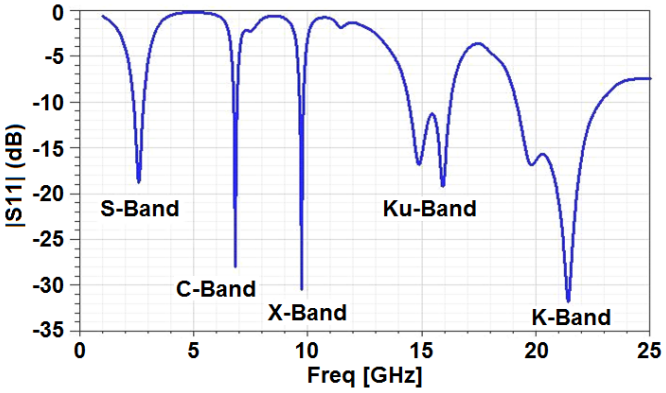


Fig. 2. Predicted |S11|when feed is located at (-3, 3).

The maximum return loss in lower bands (C and X band) is obtain at (-3, 3) but in case of higher bands (Ku and K band) the maximum return loss is obtained at (-3.25, 3.25). As feed point move away from the center, the bandwidth decreases in lower band but increases in higher bands. Furthermore at (-3,3), bandwidth achieved in [3] is enhanced from 154MHz to 160MHz and 209MHz to 220MHz in C-band and X-band, respectively. At this feed location, it also includes two additional bands having bandwidth of 1520MHz and 3890MHz for Ku-band and K-band respectively. At (-3.25, 3.25), bandwidths achieved are less than [3] for C-band and X-band but additional bands having bandwidth of 1520MHz and 4940MHz for Ku-band and K-band are also observed. Return loss at various feed location is shown in Fig. 3.

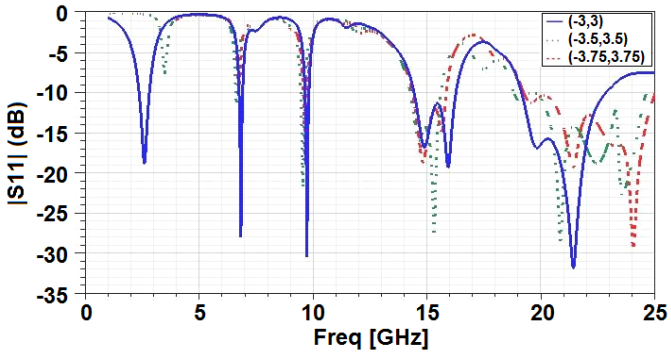


Fig. 3. Predicted |S11| for feed located at different locations.

TABLE I
EFFECTS OF FEED POSITION ON ANTENNA PARAMETERS

| Feed Location (X,Y) | C Band | | |
|---|---|---|---|
| | Central Frequency (GHz) | Return Loss (dB) | Bandwidth (MHz) |
| (-3.25,3.25) | 6.67 | 16.48 | 130 |
| **(-3,3)** | **6.71** | **26.30** | **160** |
| (-3.5,3.5) | 6.64 | 11.49 | 90 |
| (-3.75,3.75) | 6.76 | 9.54 | - |
| | X Band | | |
| (-3.25,3.25) | 9.58 | 24 | 200 |
| **(-3,3)** | **9.58** | **30.58** | **220** |
| (-3.5,3.5) | 9.59 | 21.12 | 200 |
| (-3.75,3.75) | 9.66 | 18.46 | 210 |
| | Ku Band | | |
| (-3.25,3.25) | 15.48 | 33.73 | 1540 |
| **(-3,3)** | **15.47** | **20** | **1520** |
| (-3.5,3.5) | 15.49 | 30 | 1590 |
| (-3.75,3.75) | 16.01 | 18.61 | 1600 |
| | K Band | | |
| (-3.25,3.25) | 20.95 | 40 | 4940 |
| **(-3,3)** | **20.88** | **29** | **3890** |
| (-3.5,3.5) | 21 | 28.44 | 5800 |
| (-3.75,3.75) | 21.50 | 30 | 5740 |

Radiation patterns at various frequencies are shown in Fig. 4. It is noted that antenna has peek gain of 7.3dB, 8.6dB, 7.3dB, 7.2dB and 10.1dB at 6.71GHz, 9.58GHz, 14.72GHz, 15.47GHz and 20.88GHz respectively.

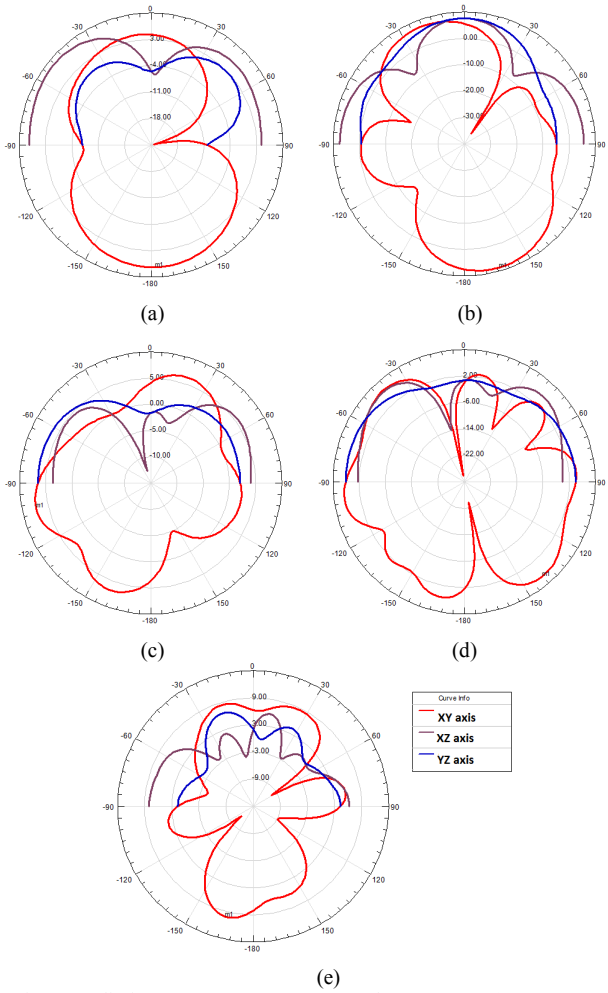


Fig. 4. Radiation Patterns at (a) 6.71GHz (b) 9.58GHz (c) 14.72GHz (d) 15.47GHz (e) 20.88GHz.

## IV. CONCLUSION

Feed analysis of a coaxially-fed single-layer microstrip patch antenna with a compact structure has been presented. The presented antenna with optimized feed has a multiband behavior and has improved bandwidth in comparison to an earlier reported design. It is suitable for application operating with-in S, C, X, Ku and K bands.

## REFERENCES

[1] C. A. Balanis, Antenna Theory: Analysis and Design: John Wiley, 2005.

[2] K.-L. Wong, Compact and Broadband Microstrip Antennas: John Wiley & Sons, 2002.

[3] F. Islam, M. A. M. Ali, B. Y. Majlis, and N. Misran, "Design, simulation and fabrication of a microstrip patch antenna for dual band application," in *International Conference on Electrical and Computer Engineering (ICECE)*, 2008, pp. 799-802.