Design of Dual Frequency Stacked Patch Antenna for L Band Applications

P Krishna Chaitanya, M. Pachiyannan

Abstract- This article presents a thorough explanation on stacked patch antenna (SPA) for dual frequency applications. The strip antenna operates in L-Band at 1.34GHz and 1.579 GHz. The SPA designed and simulated on a Rogers RT Duroid 5880 substrate using dielectric constant of 2.2 and depth of 3.77mm for each layer. In Finite Element Method the proposed design is based Ansys electromagnetic suit (HFSS version 19.1.0), the proposed antenna simulated results provides good performance for dual band frequency applications in term of return loss and radiation pattern for dual frequency applications.

Key words- Microstrip antenna, Dual Frequency SPA, HFSS, Return Loss.

I. INTRODUCTION

In recent communication system antennas plays vital role in creating the link between transmitter and receiver, for aerospace and mobile applications these microstrip antennas are well suited because is provides light weight, low profile, and small power handling capacity. Patch antennas can be designed in a various shapes in order to obtain improve gain and bandwidth. The proposed model is a stacked rectangular patch antenna Resonate at two frequencies with coaxial feed. It can be operated at L-band.

The utilization of low profile multiband antennas are increased in wireless communication due to its rapid growth the future requirement for Wireless devices are to support more than one network, having different operating frequencies and also increased the transmission of audio, video and data. In this article we proposed such an antenna which meets the requirement of satellite based portable communication devices, particularly weather radar, surface ship radar, and some communications satellites.

II. DESIGN CONSIDERATIONS

Design considerations and formulas for the Micro strip rectangular Patch Antenna are as follows

A. Operating Frequency

In L-band one of the applications is radar system for the basic operations [1]. Hence the frequency of operation selected for the design is 1.34GHz and 1.579 GHz.

B. Substrate Dielectric Constant

The substrate and superstrate dielectric material selected is Rogers RT Duroid 5880 which has a dielectric constant of 2.2. Low dielectric constant is selected since it gives better gain [1].

C. Dielectric Substrate thickness

Surface waves are induced in the substrate as thickness of the substrate increases. Thus results in undesired radiation of surface waves also decreases the efficiency of the antenna and injects the specious coupling between circuits or in elements of Antenna, hence we considered the substrate thickness as 3.77mm [2].

D. width and length of the Dielectric Substrate

Most often and in our article the antenna width and Length are considered as λ [3].

E. Dimensions of the Regular Patch antenna

The length and width of the patch are 16 mm×21 mm, which are calculated using the formulae [1].

$$W = \frac{C}{2f_0\sqrt{\left(\frac{\varepsilon_r + 1}{2}\right)}}$$

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

$$L_{reff} = \frac{C}{2f_o\sqrt{\varepsilon_{reff}}}$$

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

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

III. SPA DESIGN

The Parameters of SPA are examined and used to design the antenna in HFSS simulator, the material perfect electric conductor (PEC) is employed for the patch. To feed this SPA we utilised Coaxial feed, initially with the single patch alone, the antenna is resonating at only one frequency (1.34 GHz) then the second patch is stacked above the first patch, and by optimising the dimensions of both the patches we are able to achieve dual frequency of operation (1.34 GHz and 1.579 GHz) at the optimal position. It is observed that by varying the position of the patch with respect to the position of the coax feed and by varying the dimensions of the patch we can achieve the dual frequency of operation.

Revised Manuscript Received on December 15, 2019.

P Krishna Chaitanya, Asst. Professor, Dept. of Electronics and Communication Engineering, VFSTR, Guntur , India

M. Pachiyannan, Assoc. Professor, Dept. of Electronics and Communication Engineering, VFSTR, Guntur , India

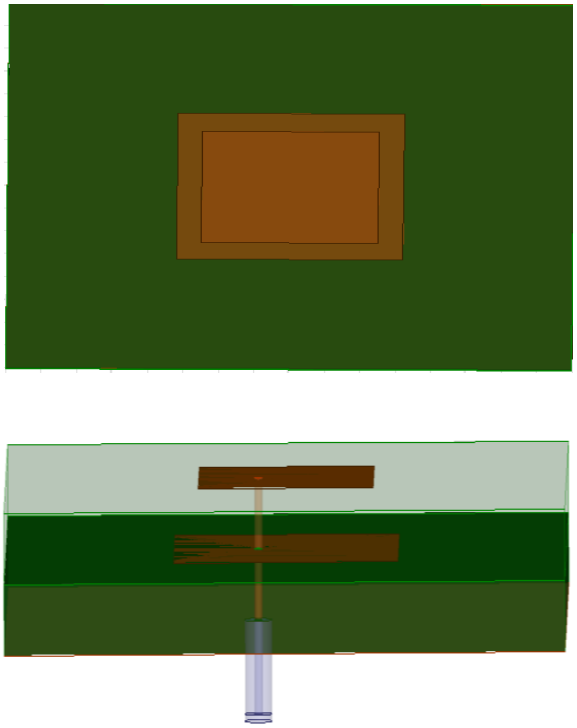


Fig. 1 Stacked Rectangular Patch Antenna

Parameter	Dimension
Each Substrate Dimension	50 mm × 50 mm × 3.77 mm
Patch1 Dimensions	33.5 mm × 33.5 mm
Patch2 Dimensions	28 mm × 28 mm

Tabel 1 Antenna Parameters

IV. RESULTS

Acquired Dual frequency of operation at 1.34 GHz and 1.579GHz with a highest gain of 8.5 dB and 9.42 dB and directivity of 8.26 and 4.15 dB with a good impedance matching respectively.

A. Return Loss

Obtained return loss of -38.75 dB at 1.34 GHz and -23.06 dB at 1.579 GHz.

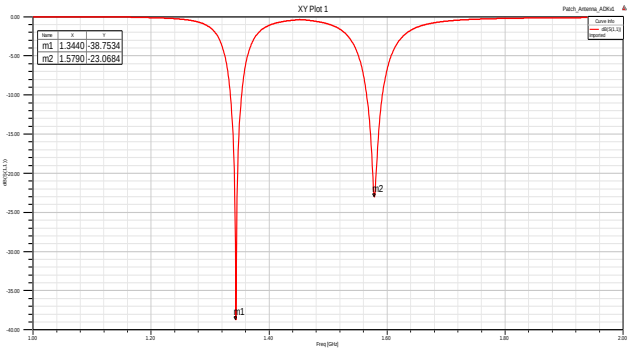
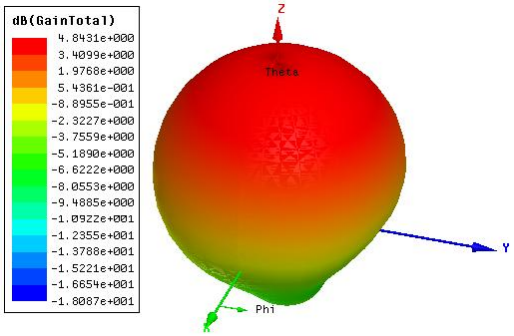


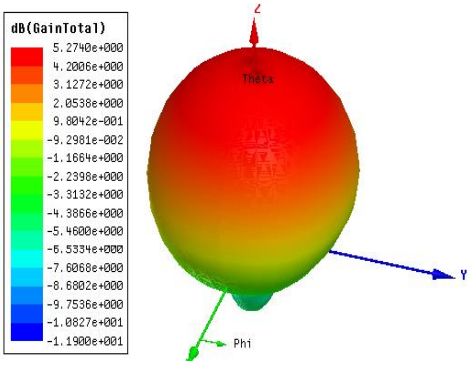
Fig. 2 Return loss

B. 3D Polar plot

The 3D polar plot below shows the gain of the antenna at both the operating frequencies, achieved a gain of 4.84dB at 1.34 GHz and 5.27dB at 1.579 GHz.



At 1.34 GHz

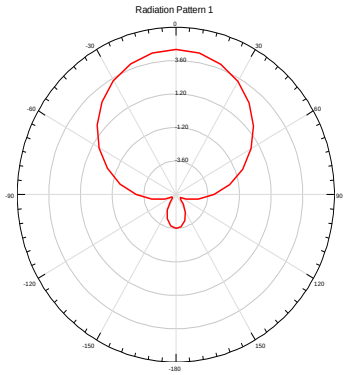


At 1.579 GHz

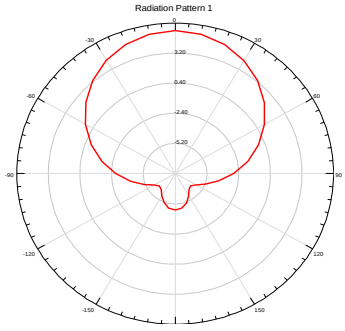
Fig. 3 3D Polar Plot

C. Radiation Pattern

The radiation patter of the antenna at both the operating frequencies are as shown below, it is observed that at both the frequencies proposed antenna have Omni directional radiation pattern.



At 1.34 GHz

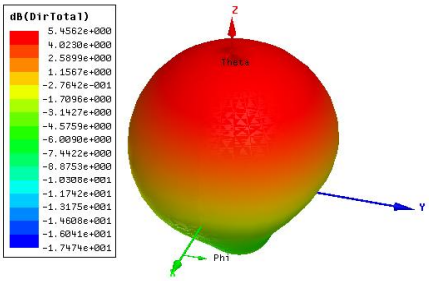


At 1.579 GHz

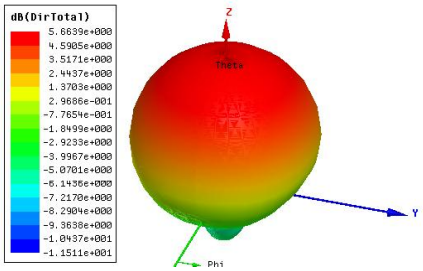
Fig. 4 Radiation Pattern

D. Directivity

The plot below shows the directivity of the antenna at both the operating frequencies, achieved a directivity of 5.45dB at 1.34GHz and 5.66dB at 1.579GHz.



At 1.34 GHz



At 1.579 GHz

Fig. 5 Directivity

V. CONCLUSION

The proposed antenna characteristics are as follows, dual band is obtained at 1,34GHz and 1.579GHz frequency. The gains at achieved frequencies are 4.84dB and 5.27dB and return loss are -38.75dB and -23.06dB, so it is clear this antenna is suitable for L-band dual frequency applications like whether radar, surface ship radar and communication satellites. The impedance matching and resonant frequency depends on position of coax feed, position of microstrip and it's dimensions.

ACKNOWLEDGMENT

We are extending our gratitude to the authorities of VFSTR (Deemed to be university) for extensive support to operate their potentials and backing to compose this article. Also our sincere thanks to KEYSIGHT Technologies.

REFERENCES

1. N. P. Yadav, et al., "High Gain Electromagnetically Coupled Stacked Circular Disk Patch Antenna for Wideband Application," Progress In Electromagnetics Research Symposium Proceedings, Guangzhou, China, Aug. 25–28, 2014.
2. Md. Maruf Ahamed, et al., "Rectangular Microstrip Patch Antenna at 2GHZ on Different Dielectric Constant for Pervasive Wireless Communication," International Journal of Electrical and Computer Engineering, Vol.2, No.3, June 2012, pp. 417 ~ 424.
3. M.I. Jais, et al., " High gain 2.45 GHz 2×2 patch array stacked antenna," Computer, Communications, and Control Technology, 2015 International Conference on 21-23 April 2015.
4. Shiqiang Fu, et al., "Low-cost single-fed circularly polarized stacked patch antenna for UHF RFID reader applications," Progress in Electromagnetic Research Symposium, 8-11 Aug. 2016.
5. R. Mishra, et al., "Effect of Height of the Substrate and Width of the Patch on the Performance Characteristics of Microstrip Antenna," International Journal of Electrical and Computer Engineering, Vol.5, No.6, December 2015, pp. 1441-1445.
6. Sekhar M, Siddaiah P "Performance of Feed on Dual Frequency Antenna in Ka-Band" International Journal Of Innovative Research In Electrical, Electronics, Instrumentation And Control Engineering Vol. 2, Issue 5, May 2014. ISSN 2321 – 2004.
7. Sekhar M, Siddaiah P "Comparison of Dual Frequency Antenna in Ka-Band with and without Shorting pin (IJMCTR), Volume-2, Issue-8, August 2014.
8. Sekhar M, Siddaiah P "UWB ANTENNA FOR KA-BAND" Global Journal of Advanced Engineering Technologies Volume 4, Issue 1-2015.
9. [9] Sekhar M, Siddaiah P "Quad Band Triangular Ring Slot Antenna" International Journal of Scientific & Engineering Research, Volume 6, Issue 4, April-2015 1637.