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# Design of Dual Frequency Stacked Patch Antenna Array for L-Band Applications

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***Abstract:** A Double Frequency stacked patch antenna array, DESIGNED for the frequencies of 1.348 GHz and 1.575 GHz in L-Band . The array accommodates sixteen antenna elements of 4×4 array fed by individualistic coaxial cable. The Radiation patterns for the two single element and array are studied. Comparison between the radiation patterns of a specific element and array are studied. Dual patch is used for both single element and antenna array, two patches resonates for two different designed frequencies of L-Band the impedance characteristics of both single element and array are studied and gains of single element and array are compared. ANSYS HFSS software is used for the simulation in this proposed work.*

***Keywords-** Miniaturization, Multi Frequency, Passive Array, Stacked Patch.*

## I. INTRODUCTION

The patch antenna is limited band and broad beam antenna. The patch antenna is also called microstrip antenna [1-3]. The microstrip antenna have gained popularity due to its less weight, low cost and small volume [4][5]. By implementing the patch antenna technique the bandwidth is enhanced [6-8].Now in present days compact natue of the antenna is very much desirable and really it is a challenge in the present day senario to design a minitiarized compact size antenna, so the elements of the array should be near to each other and at the same time mutual coupling amidst the elements of the array is also considered. To minimize the coupling effect if we place elements in an array far from each other then the size of the array increases which is not desirable [9].In this work presented a 4×4 array with individual coaxial feeding technique. The spacing between each antenna element is λ/2 which decreases the dimensions of the array exigently[11].

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## II. ANTENNA DESIGN

Single stacked patch antenna element is presented in Fig. 1. The stacked patch technique is used for enhanced band width and two patches resonate for two different designed frequencies of L-Band in this proposed model This proposed antenna consists of 16 elements which are combined in to 4 × 4 array. The dimension is as follows:
Length and width of the substrate are measured as 200 mm [10]. RT Duroid 6010 substrate of thickness $h$ = 3.77mm and relative dielectric constant is $\varepsilon_r$ = 10.2 are considered [11].

The patch width is calculated by using the equation 1

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

Using the equations 2,3 and 4 length can be calculated.

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

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} \quad (3)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad (4)$$

The length (L) of the patch is computed using the equation 5

$$L = L_{eff} - 2\Delta L \quad (5)$$

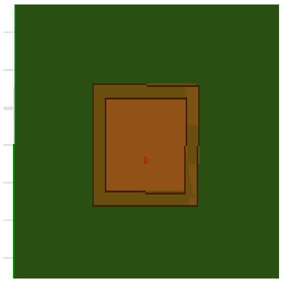


**Fig. 1. The basic Structure of the Antenna Element.**

Fig. 2 shows the 4x4 micro strip patch antenna array with an individual coaxial feed technique.

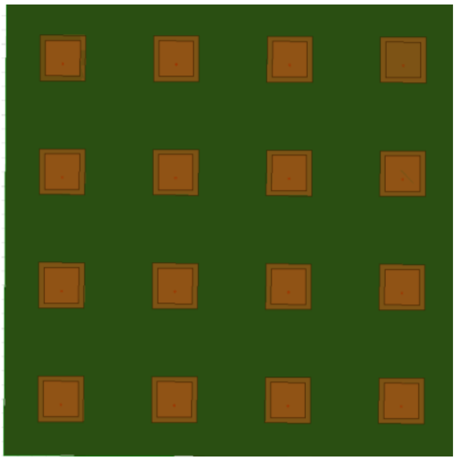


**Fig. 2. The structure of 4×4 Antenna Array**

## II. SIMULATION AND MEASURED RESULTS

The reflection coefficient($S_{11}$) graph of the single element is presented in Fig. 3, from which the antenna is operated at1.348 GHz and 1.575 GHz.

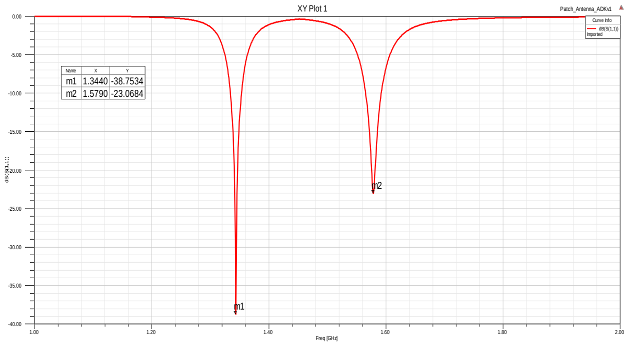



**Fig. 3. The Characteristic impedance of the Single Antenna Element**

Reflection coefficient graph of the 4x4 array is presented in Fig. 4-5, the operating frequencies of the array are 1.348 GHz and 1.575 GHz. In the study of radiation characteristics of the antenna are at these frequencies are observed.

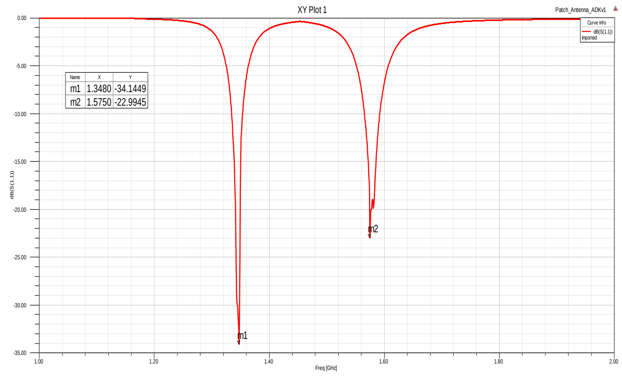
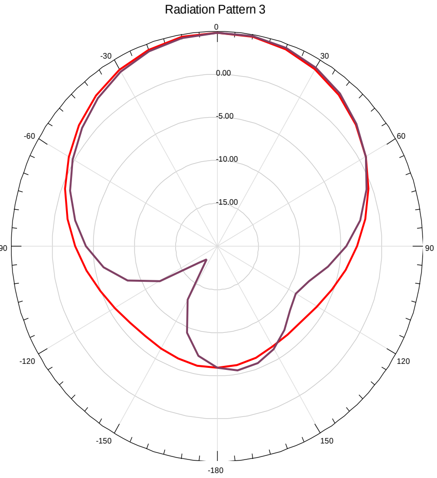
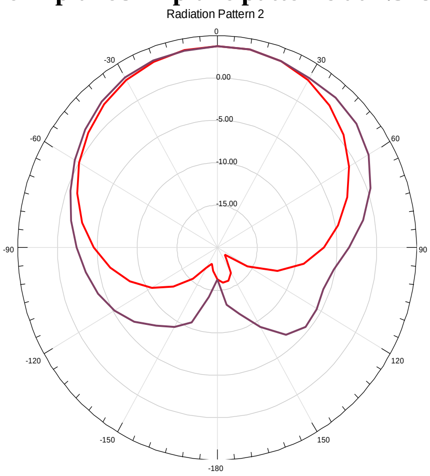



**Fig. 4. The Characteristic Impedance of the 4×4 Antenna Array**

In Fig. 5, The 2D radiation pattern of single element is presented



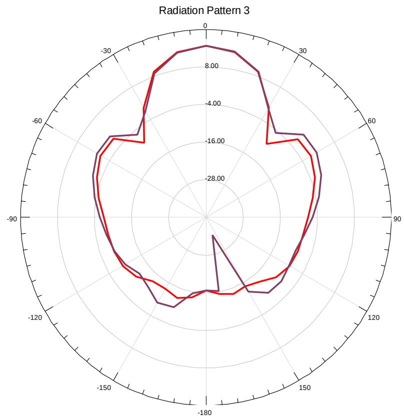

**(a) The H-plane& E-plane patterns at 1.348 GHz**



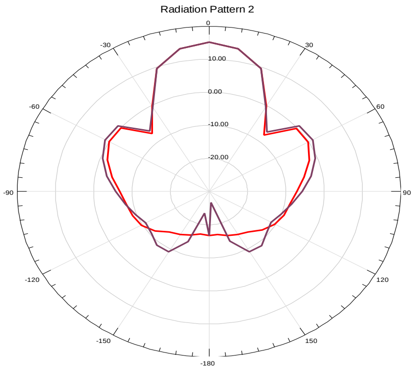

**(b) The H-plane& E-plane patterns at 1.575 GHz**

**Fig. 5. Single Antenna Element Radiation pattern**

In Fig. 6, the 2D radiation pattern of 4x4 stacked array is presented. From the results in Fig. 6 it is determined that the antenna array has major lobe with improved gain and small side lobes.




**(a) H-plane & E-plane patterns at frequency of 1.348 GHz**



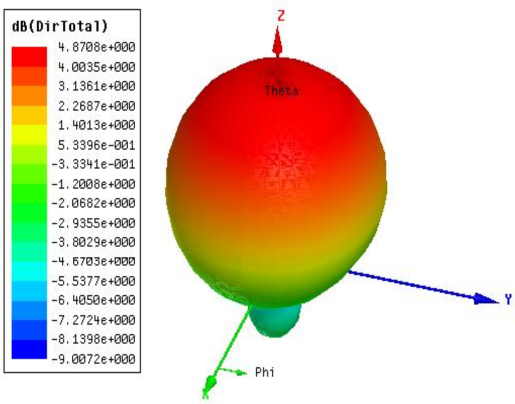

**(b) The H-plane & E-plane patterns at frequency of 1.575GHz**

**Fig. 6. The 4×4 Antenna Array radiation pattern**

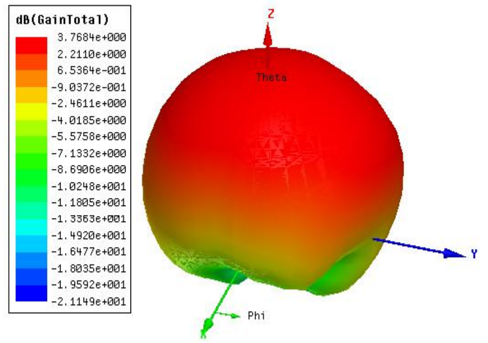
The gain of single a element is shown in the figure 7. A gain of 4.87dB and 3.76dB is obtained for single element at 1.348GHz, and 1.575GHz respectively. The gain of 16 element array is shown in figure 8 and the details are 14.77dB, and 15.10dB is achieved at 1.348GHz, 1.575GHz respectively for 16 element Array. It is observed that the gain of the array has been improved when compared to the single antenna element. This proposed antenna resonates for two L-Band frequencies and stacked patch technique is used for bandwidth enhancement and the two patches resonate for two different designed frequencies of L-Band.

In patch antennas, characteristics such as high gain, beam scanning, or steering capability are possible only when discrete patch elements are combined to form an array. It is inferred that for any planar array configuration, optimized antenna characteristics can be obtained, depending upon the element spacing. The effect of mutual coupling can be minimized by optimizing the inter element spacing in both the planes. The antenna provides frequency close to the designed operating frequency at λ/2 inter element spacing operating at maximum efficiency with an acceptable directivity and gain. When antenna structure is closely spaced, the return loss improves in the H plane. It has been shown that with the increasing array spacing, the power radiated by the antenna array and its efficiency gets reduced significantly.

A defected ground structure when used with micro strip patch antennas leads to the reduction in size and harmonics of the antenna, the cross polarization and mutual coupling are also reduced. Many researchers have worked in the field of stacked Micro strip antenna and incorporated defected ground structures in a stacked Multilayer Micro strip antenna to achieve desired results.

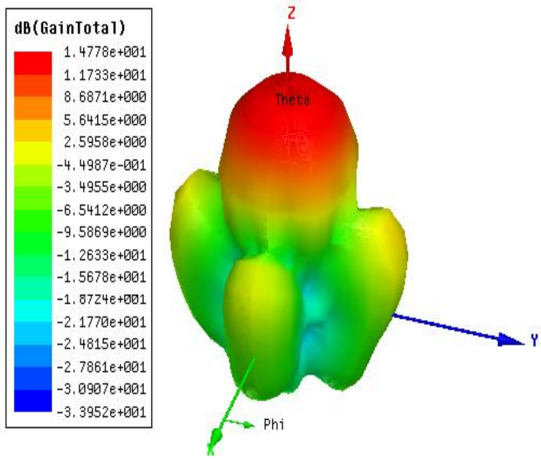



**(a) Gain 4.87dB is obtained at 1.348 GHz**

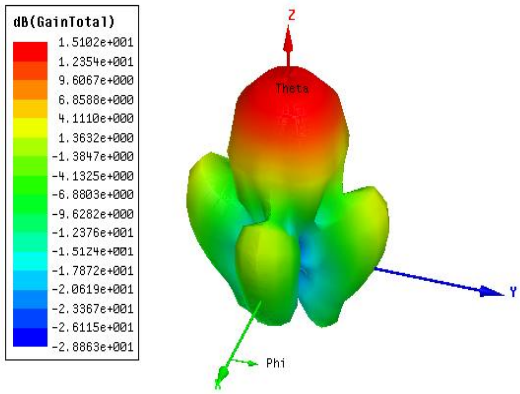



**(b) Gain 3.76dB is obtained at 1.575 GHz**

**Fig. 7. The gain of Single Antenna Element**




**(a) Gain 14.77dB is obtained at 1.348 GHz**




**(b) Gain 15.10 dB is obtained at 1.575 GHz**

**Fig. 8. The gain of 4×4 Antenna Array**

Table 1 below shows the comparison between proposed antenna and other antennas which also resonates for L-Band frequencies. Miniaturization of the array antenna is better, when compared to other antennas. Additionally the gain of the proposed antenna is improved than the other antennas.

| Antenna | Size of Antenna | Frequency of operation | Gain (dB) |
|---|---|---|---|
| [1] | 120mmx120mm | 1.268GHz<br>1.615GHz | 2.3<br>3.1 |

| | | | |
|---|---|---|---|
| [2] | 254mmX254mm | 1.575 | 14.9 |
| [3] | 70mmX80mm | 1.66GHz<br>3.25GHz | 5.6<br>6.3 |
| [4] | 230mmx230mm | 1.7GHz<br>2.3GHz | 6<br>5.4 |
| Proposed | 200mmx200mm | 1.348GHz<br>1.575GHz | 14.7<br>15.1 |

**Table 1: Comparison of antenna proposed with recent works**

## IV. CONCLUSION

In this communication, the antenna which resonates for two different designed frequencies of L-Band is proposed. Stacked patch technique is used in order to achieve enhanced bandwidth and two patches resonate for two different designed frequencies. The simulated results show that gain of stacked patch array antenna is improved when compared to single element and the obtained radiation patterns are satisfactory. Here miniaturization of the antenna array is achieved with satisfactory gain improvement.

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## REFERENCES

1. Shu, Ting, et al. "Design considerations for DBF phased array 3D surveillance radar." Proceedings of 2011 IEEE CIE International Conference on Radar. Vol. 1. IEEE, 2011.
2. Wen-bin, G. O. N. G. "DBF multi-beam transmitting phased array antenna on LEO satellite." Acta Electronica Sinica 12 (2010)
3. band applications." IEEE Antennas and wireless propagation letters 8 (2009): 1014-1016.
4. Ge, Lei, and Kwai Man Luk. "A three-element linear magneto-electric dipole array with beamwidth reconfiguration." IEEE Antennas and Wireless Propagation Letters 14 (2014): 28-31.
5. Sekhar, M., and P. Siddaiah. "Performance of Feed on Dual Frequency Antenna in Ka-Band." International Journal Of Innovative Research In Electrical, Electronics, Instrumentation And Control Engineering (IJIREEICE) 2.5 (2014): 2321-2004.
6. Sekhar, M., & Siddaiah, P. Comparison of Dual Frequency Antenna in Ka-Band with and without Shorting pin. International Journal of Modern Communication Technologies and Research, 2(8)
7. Sekhar, M., and P. Siddaiah. "UWB Antenna For Ka-Band." Global Journal of Advanced Engineering Technologies 4.1 (2015): 2277-6370.
8. Sekhar, M., & Siddaiah, P. (2015). Quad Band Triangular Ring Slot Antenna. International Journal of Scientific & Engineering Research, 6(4), 1637.
9. Brookner, E. (2007, April). Phased-array and radar breakthroughs. In 2007 IEEE Radar Conference (pp. 37-42)IEEE.
10. Sai Vinay Kumar P, Giri Prasad MN. Quad frequency stacked patch planar antenna array for radar and navigational applications. Microwave and Optical Technology Letters. 2019 Oct;61(10):2255-60.
11. M, S., Kusuma Kumari, E., & Kumar, A. N. V. R. (2017). Wideband High-Gain Circularly Polarized Planar Antenna Array for L Band Radar. 2017 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC).

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