Garuda Vyuha based Microstrip patch antenna structure with high-gain for dual-band wireless applications

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Abstract: In this paper, a high-gain dual-band planar Microstrip patch antenna is designed to work at two different frequencies namely 5.6GHz and 7.4GHz. The antenna structure is in the form of Garuda Vyuha and has high directivity. The results propose that the Garuda Vyuha based antenna structure has very low profile and good polarization characteristics. The proposed antenna structure is simulated using ADS software and from the simulated results, the return loss is -15.094dB at 5.681GHz and -12.371dB at 7.337GHz. The Antenna operates at a bandwidth of 22MHz at 5.6GHz and 41MHZ at 7.4GHz. The Antenna provides a directivity of 5.921 at 5.6GHz and 6.2 at 7.4GHz. This antenna structure can be used for dual band applications in Wireless systems operating in these bands.

Keywords: Garuda Vyuha, radiation pattern, micro strip patch, dual band, radiation efficiency, directivity.

1. INTRODUCTION

These days, with the fast advancement antenna is planned for 5G and sub-6 GHz (for instance, 3.3–3.6 and 4.8–5.0 GHz) utilization [1], for example, base-station with dual polarized antennas. These require better exhibitions with lower loss, high radiation patterns, and lower cross-polarization levels. Dual-polarized antennas reduces multipath fading and expand channel limit and hence used in base-station [2]–[4].The demand for dual polarized antennas with higher suppression levels in the electromagnetic environments become increasingly complicated [2]–[5]. The reduction in out-of-band suppression characteristics are obtained by the use of filters [6]–[8]. Addition of filters may lead to insertion loss and complicated in structure.

There are developing requirements for double band high-gain receiving wires for some applications, for example, satellite and remote correspondences [9]. In any case, the longing for high-increase, double range activity, planar engineering, and low assembling cost make a few difficulties and different methodologies utilized by every one independently.

Clustering numerous indistinguishable components is a clear strategy to expand the antenna in design [10], [3]. Fabry-Pérot cavity antenna is a viable method to improve the antenna gain without the need to structure a feeding system, in which a transmitting component is inserted inside a cavity with reflecting surface on top and a ground plane at the base [11]. This represents certain drawbacks like higher assembling and mechanical dependability issues [12]. High-gain and low-profile antenna that don't need convoluted feed structures are layered antenna that work dependent on the excitation of flawed waves. This antenna can be an awesome to supplant the traditional high-gain receiving elements [13].

For a specific purpose an antenna that operates at various frequencies is required for double band. Numerous procedures are there to make a transducer element in double band like accomplishing resonating element in the same layer [14] or in a stacked configuration. Two distinct modes in various arrangements, for example, single-layer patch [15-19], slot [16], or dielectric resonator antenna can likewise give multi-band activity. An exceptionally straight forward strategy...
to make extra groups is to utilize parasitic components that reverberate in the ideal frequency [20]. Numerous dual band with high-gain reception apparatus can be found which are created on overlay sheets with simple feeding systems depend on the Fabry-Pérot cavity [21], [22], or met surface layer [23]. A sort of double band high-gain antenna of either multi-layer structures with an air hole in the middle of or a non-planar structure is focused. In [24], double band capacity of folded radio wires is contemplated. It is demonstrated that various folding with various measurements can make diverse resonant frequencies [25].

To accomplish two resonant frequencies, two distinct patches are entertained to form a Garuda Vyuha's (GV) design. For joining, a feeder is coordinated into the focal point of the expected double band antenna. In this approach of designing an antenna, a double band two range polarized patch antenna with better selectivity is expected to satisfy the needs for higher band applications. A five square shape spaces carved at each side of a straightforward rectangular patch, double activity groups and an innate radiation null are produced. Plus, simple feeding structures involve an impedance resonator that gives two additional radiation nulls outside the two bands. Double band pass response is noted. In addition, every polarization is differentially taken care of for a superior association with differential circuits as shown in Figure 1.

![Figure 1. Structure of Garuda Vyuha](image)

The overview of the paper is presented as. The explanation about the antenna element, antenna array and their design approaches are detail focused in section 2. Section 3 is about the results and discussion about the proposed antenna element with final as the conclusion part of the proposed Garuda Vyuha based Micro strip antenna.

2. ANTENNA ELEMENT DESIGN

For an antenna of array configuration, the size of element is important for checking the far field performance. For most cases, spacing between components at not exactly half frequency for the most elevated frequency to avoid side lobes. In an introduced case, working groups are broad separated and tradeoff is required in the choice of unit cell size.

The antenna that is structured focus on the dual band groups. Specific material is used for the fabrication of substrate. The GV structure consists of rectangular patches with a triangular prism structure on the top to cover the entire angle. The patches are adjusted to be operated at various frequency bands. The patches can be configured to improve the transmission area and power.

2.1 Aperture Coupled Antenna Design

Many feeding techniques are compared with coupling concepts at the millimeter range of frequency. As the radiation has to be better for higher range of frequency and the design is also simple to cover the area, coupled configuration is preferred. [11]. Aperture coupling structure is tested with the simulation for gain and directivity. The feed from the proposed structure can be freely fed in to the patches. The exact dimensions of the patches and the feed to the structure are tested with many iterations as better gain as the constraint of design. Coaxial like structure is used between the patches and the ground substrate [13]. At the base layer, a micro strip line type of patches is put to feed antenna.

2.2 Dual-Band Patch Antenna
To have a better understanding on the proposed structure, five patches with feeding structures are appeared in Figure. 1. A traditional rectangular patch antenna with single polarization is Antenna1 while cross polarization is experienced by Antenna 2. Both antennas utilize micro strip lines for input. The calculated S parameter and achieved gain of antennas are outlined in Figure. 2.

From the Figure. 2, it tends to be seen that the first antenna resonates at about 5.68 GHz, and the realized gain diminishes gradually as the impedance matching deteriorates but the second antenna is resonating at 7.337 GHz. All the more critically, a radiation null between the two resonant modes with a roll off at 6.25 GHz as given in Figure.3.

For better clarity in the design, current dispersions on the patches at various frequencies are delineated in Figure. 4. It is very well seen that the fundamental current is longer along the patch edge and shorter than the side length of the patch at resonant frequency.

The rectangular patches at the corners of Vyuha are of 1mm in height and 4 mm in width. To have better radiation another pair of rectangular patches with 0.8mm in height and 3 mm in width is framed at the inner part of antenna. At the middle, a rectangular patch with 1 mm in height and 4 mm in width is designed with the specifications of polygon above the rectangular with 33 mm
pointing edge as depicted in Figure 1. All the patches are connected with a feeder of 0.3 mm in width and 18.3 mm long to have better polarization.

The antenna gain for various estimations of patch periodicity is shown in Figure 5. In this figure, a full-wave simulation of the antenna directivity is achieved by and the simulation of an individual patch is acquired by the susceptance of the folding.

![Gain and Directivity of Proposed antenna](image)

**Figure 5.** Gain and Directivity of Proposed antenna

A feeder is needed to be coordinated in focal point of the corrugated structure to make the general antenna as minimized as could reasonably be expected. A feeder antenna can be a wideband antenna that covers the two groups. In any case, a double band feeder is a superior decision is better to keep the transitional frequencies from engendering and stifle. The feeder should be made out of a focal opening that takes care of the folded structure. Truth be told, a double band open ended waveguide feeder is required.

Various arrangements of slot and patch antennas can be found for the plan of feeder as in [23], these feed structures behave invalid at broadside in the event that they are utilized as feeder for the proposed double band folded structure. The proposed corrugated structure is symmetric and produce TM01 mode around the middle and their coordination creates an invalid at broadside as in Figure 5. Thus, a feeder with TE11-like field dissemination on the focal opening is needed.

![Electric Field Intensity of Proposed antenna](image)

**Figure 6.** Electric Field Intensity of Proposed antenna

### 3. RESULTS AND DISCUSSION

The effective area of the designed antenna component is presented in Figure 7. The antenna is a broadside radiator at both the lower and higher band with an area of around 0.25 cm². The significant and sharp pattern can be seen in the plot that is emphasizing the Garuda Vyuha.
The estimated radiation patterns of the proposed Garuda Antenna component at 5.6 and 7.4 GHz is shown in Figure 8. Low cross-polarization levels are achieved by unidirectional radiation designs. In addition, determined 3 dB beam widths over the two groups are also separately calculated.

A double band pattern is achieved with the blend of the radiator and the feed line for the proposed Vyuha as appeared in Figure 9. The two polarizations show comparative attributes, where 45° linear polarization are shown.

It is observed from Figure 10 that the right and left hand circular polarization with various angle of coverage of antenna and its magnitude are plotted which justifies the name of the proposed design. The deliberate tilt angle for different frequency range between the transmissions of signals is obtained and plotted in Figure 11.
The estimated values in the graph show that the proposed antenna component has double activity groups of 5.2 to 5.5 and 7.15 to 7.45 GHz with VSWR < 1.2. The measuring angle of the designed antenna above a reference plane as phi is projected in Figure.11 which gives a rear view of transmission of signals in the focused view.

**Figure 10. Circular Polarization of Proposed antenna**

Axial ratio of antenna plays a major role in polarization and is nothing but the ratio between the major and minor axis of polarization. If the polarization is in elliptical then the major and minor axis are different. Here for the Garuda Vyuha the axial ratio in broadside array structure is calculated as 2.447 dB, which provides better radiation efficiency as in Figure.12.

**Figure 11. Tilt angle of proposed antenna**

**Figure 12. Axial Ratio of Proposed Antenna**
Table 1 gives a detailed explanation of the proposed antenna with dual band of operation. It also clearly gives the gain and directivity improvement achieved with minimum input power and radiation efficiency.

Table 1. Parameters of the Proposed Antenna

| Parameter                  | Band 1       | Band 2       |
|----------------------------|--------------|--------------|
| Frequency (GHz)            | 5.6 GHz      | 7.5          |
| Input power (w)            | 0.0007       | 0.0008035    |
| Radiated power (w)         | 5.4x10^{-5}  | 2.43x10^{-5} |
| Directivity (dBi)          | 6.02096      | 5.75672      |
| Gain (dB)                  | -5.55399     | -9.436       |
| Radiation efficiency (%)   | 6.95833      | 3.024        |
| Maximum intensity (w/steradian) | 1.721x10^{-5} | 7.28x10^{-6} |
| Effective angle (Steradian)| 3.14133      | 3.3384       |

4. CONCLUSION

The results propose that the antenna array covers the 5G bands and has great polarization isolation. This paper introduced a multilayer, double band double energized antenna for S band. Estimated values of the antenna show that the proposed vyuha has double band of 5.6 GHz and 7.4 GHz for differential VSWR < 1.1. Additionally, a high out-of-band gain-suppression at 25 dB is acquired. A double band high-gain Garuda Vyuha's radio wire is introduced. The resonance conditions for the corrugations are determined logically dependent on a unit-cell examination of the folded structure. It is proved that Garuda antenna gives the better gain, directivity and coverage. In this work, the impact of various configurations of folded structure on the antenna is explored. At that point, a double band reception apparatus is intended for focus frequencies of 5.6 and 7.4 GHz by utilizing two distinct corrugations.

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