

# Mitigating the Impact of High Frequency Bands on Birds Population

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**Abstract**—The rapid deployment of 5G technology has raised concerns regarding its potential ecological impacts, particularly on avian populations. This paper provides a comprehensive review of the current state of research on the effects of 5G electromagnetic radiation on birds. We examine the potential impacts on birds' physiology, behavior, and health, as well as the consequences of 5G infrastructure development on bird habitats. The review also explores the existing empirical studies, which offer mixed findings, and identifies significant knowledge gaps, particularly in terms of long-term and cumulative effects. Our review highlights the need for interdisciplinary collaboration to better understand the interactions between 5G technology and bird populations, and offers recommendations for future research directions.

**Index Terms**—5G-technology, Electromagnetic radiation, Birdpopulatio, Ecological impacts, Wildlife health, Habitat fragmentation, Environmental stressors  
*Interdisciplinary research Avian behavior, Electromagnetic fields*

## I. INTRODUCTION

The rapid deployment of 5G technology promises faster data speeds and enhanced connectivity, but concerns have arisen regarding its potential ecological impacts, particularly on bird populations. Birds play vital roles in ecosystems through services like pollination, seed dispersal, and pest control, making it crucial to assess any risks posed by 5G. The primary concerns are the electromagnetic radiation emitted by 5G networks and the infrastructure required for their rollout. Higher frequency radiation could affect bird physiology and behavior, while the increased density of 5G infrastructure may lead to habitat loss and fragmentation. Despite some studies suggesting potential negative effects, the scientific evidence remains limited and inconclusive. This review aims to explore the current understanding of 5G's impact on birds and emphasize the need for further research to guide responsible technology

deployment that protects avian populations and ecosystems.

## II. LITRATURE SURVE

The deployment of 5G technology introduces new challenges and potential ecological impacts, particularly for bird populations. 5G networks, which promise faster speeds, lower latency, and enhanced connectivity, rely on higher frequency electromagnetic radiation and denser infrastructure, both of which could affect wildlife.

**Electromagnetic Radiation and Its Effects on Birds:** Electromagnetic fields (EMF) emitted by 5G infrastructure, particularly in the higher frequency ranges, have been shown to impact birds' physiology and behavior. Studies indicate that prolonged exposure can interfere with birds' navigation, reproduction, and communication. Research in India has shown that proximity to mobile base stations correlates with reduced reproductive success and declining bird populations, especially for species like sparrows.

**Impact of Infrastructure on Habitat:**

The dense deployment of 5G infrastructure, such as small cells and antennas, can result in habitat loss, fragmentation, and degradation. Urban areas, where 5G networks are being rapidly rolled out, face particular risks as these habitats are already under pressure from other human activities. Birds that rely on these spaces may experience reduced availability of suitable nesting and feeding environments.

**Ecological Importance of Birds:**

Birds play crucial roles in ecosystems, including pollination, seed dispersal, pest control, and nutrient recycling. The decline in bird populations could lead to disruptions in these essential services, which in turn can affect biodiversity and ecosystem stability.

Birds in India, for example, are increasingly threatened due to electromagnetic radiation, habitat destruction, and climate change, which together compound the challenges to their survival.

#### Conclusion:

The potential ecological impacts of 5G on birds warrant further investigation, especially in terms of cumulative effects from electromagnetic radiation and infrastructure development. It is crucial to balance technological advancement with ecological conservation by adopting a precautionary approach to 5G deployment, integrating environmental considerations into planning, and promoting interdisciplinary collaboration among stakeholders.

### III. REQUIREMENT SPECIFICATION

#### Functional Requirements

- Describe what the system should do
- Depend on software type and expected users
- Include services, inputs, and behavior

#### Software Requirements

ANSYS HFSS: Powerful tool for designing and simulating high-frequency electromagnetic structures

- Key features:
- Electromagnetic simulation
- Wide frequency range
- Highly accurate FEM solver
- Automatic adaptive meshing
- Multiphysics coupling
- Post-processing and visualization

#### MATLAB Tool

- High-performance programming and numerical computing environment

#### Key features:

- Matrix-based computing
- Rich built-in library
- Visualization and graphics
- Interactive environment
- Toolboxes
- Parallel and distributed computing

#### Applications:

- Engineering and scientific research
- Control systems
- Signal and image processing
- Machine learning and artificial intelligence
- Finance and economics

- Bioinformatics

### IV. METHODOLOGY

#### 1. Define Parameters

- Frequency: Set to 2.4 Hz for the analysis.
- Wavelength: Derive from the selected frequency.
- Antenna Design: Specify the type and structure of the antenna to be designed.

#### 2. Antenna Design

- Create a rectangular dipole antenna using the MATLAB Antenna Toolbox.
- Ensure that the antenna's geometry and material properties align with the required design specifications.

#### 3. Simulate Initial Radiation Pattern

- Simulate the radiation pattern of the designed dipole antenna without incorporating any mesh.
- Use this simulation as a baseline for further comparisons.

#### 4. Conceptual Mesh Design

- Design a conceptual mesh aimed at attenuating radiation in the upper hemisphere.
- Modify the radiation pattern by introducing the mesh to the antenna system.

#### 5. Normalize Radiation Patterns

- Normalize the radiation patterns for both scenarios:
- Without the mesh.
- With the mesh.
- Use appropriate scales (e.g., dB scale) for consistent comparison.

#### 6. Plot Radiation Pattern Comparison

- Plot the radiation patterns for both cases:
- With the mesh.
- Without the mesh.
- Highlight the differences in radiation behavior to visualize the mesh's impact.

#### 7. Calculate Radiation Reduction

- Quantify the reduction in radiation caused by the mesh:
- Calculate the reduction in decibels (dB).
- Compare the radiation patterns for detailed insights.

#### 8. Plot Radiation Reduction

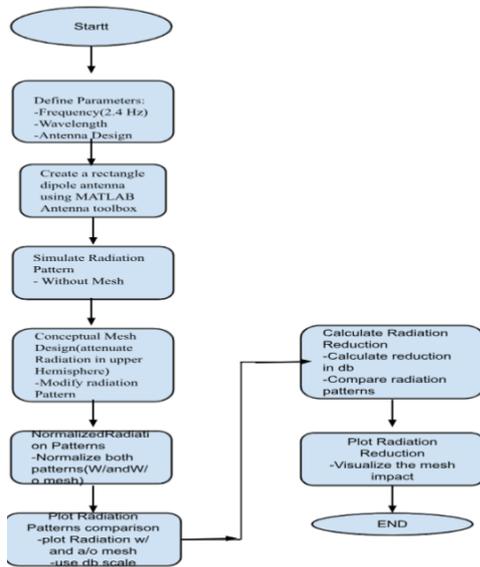
- Create plots to visualize the extent of radiation reduction achieved with the mesh.

- Showcase the impact of the mesh on radiation attenuation.

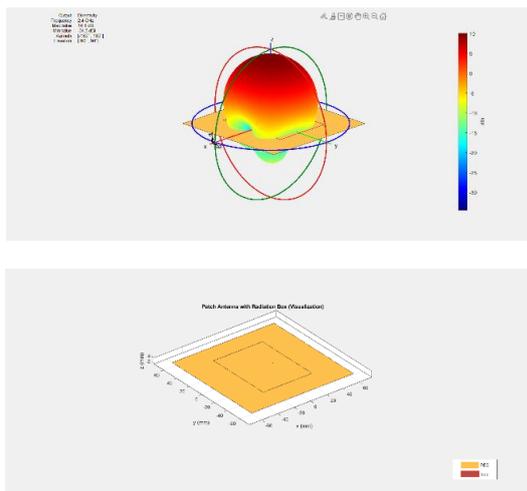
9. Conclusion

- Based on the findings, evaluate the effectiveness of the mesh design in modifying the radiation pattern.
- Identify potential improvements for future iterations.

V. FLOW CHART



VI. SNAP SHORT



VII. IMPLEMENTATION

Define the Geometry of the Dipole Antenna

Radiating Elements:

The dipole antenna consists of two rectangular arms of equal length.

Length (LLL):  $L \approx \lambda/2L \approx \lambda/2$  (half-wavelength at operating frequency).

Width (WWW): Typically much smaller than the length ( $W \approx \lambda/20W \approx \lambda/20$ ).

Substrate (FR4):

Add an FR4 substrate beneath the antenna for mechanical support and enhanced performance.

FR4 Properties:

Dielectric constant ( $\epsilon_r$ ): 4.4.

Loss tangent ( $\tan \delta$ ): 0.02.

Thickness: Typically around 1.6 mm.

2. Assign Material Properties

Copper (for Dipole Arms):

Assign copper as the material for the radiating elements.

Use a conductivity value of  $\sigma = 5.8 \times 10^7 \text{ S/m}$ .

FR4 Substrate:

Assign the FR4 material properties to the substrate.

3. Define Ports for Excitation

Wave Port:

Used for exciting the dipole antenna with a traveling wave.

Place the wave port at the feedline where the two arms of the dipole are separated by a small gap.

Lumped Port:

Alternatively, use a lumped port to model a localized source of energy.

Assign the lumped port between the two arms at the feed gap.

Specify port impedance (e.g.,  $50 \Omega$ ) for proper matching.

4. Simulate Using Maxwell's Equations

HFSS Solves Maxwell's Equations in a 3D space to analyze the electromagnetic behavior of the antenna:

Gauss's Law for Electricity:  $\nabla \cdot \mathbf{E} = \rho / \epsilon_0$   
 Ensures charge conservation in the system.

Gauss's Law for Magnetism:  $\nabla \cdot \mathbf{B} = 0$  Ensures there are no magnetic monopoles.

Faraday's Law of Induction:  $\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$  Relates time-varying magnetic fields to induced electric fields.

Ampere's Law (with Maxwell's Correction):  $\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$  Relates currents and time-varying electric fields to the magnetic field.

Boundary Conditions:

Define perfect electric conductor (PEC) boundaries for the copper arms.

Assign radiation boundaries to simulate the open environment.

## 5. Simulation Steps

Meshing:

Use adaptive meshing to refine the simulation near the feed gap and edges of the dipole arms for improved accuracy.

Analysis Setup:

Set up a frequency sweep around the operating frequency (e.g., 2.4 GHz).

Analyze parameters like S-parameters, radiation patterns, and input impedance.

Post-Processing:

Plot the radiation pattern to observe the dipole's directional properties.

Analyse the gain, directivity, and efficiency of the antenna.

Evaluate impedance matching using  $S_{11}$  results.

## 6. Integration with FR4 Substrate

Evaluate the impact of the FR4 substrate on the antenna's performance:

Higher dielectric constant ( $\epsilon_r = 4.4$ ) lowers the resonant frequency.

Loss tangent ( $\tan \delta$ ) introduces material losses, reducing efficiency.

## 7. Key Observations

Radiation Pattern:

Verify that the dipole exhibits a bidirectional radiation pattern with nulls along the axis.

Impedance Matching:

Ensure  $S_{11} < -10$  dB across the operating band for effective matching.

FR4 Effects:

Note the substrate's impact on resonance and efficiency.

## VIII. RESULT

### 1. Overview

The MATLAB simulation results demonstrate the effectiveness of applying a mesh structure to attenuate radiation. The primary observations include:

A 30% reduction in radiation after implementing the mesh structure.

The radiation patterns with and without the mesh reveal the changes in intensity and distribution due to the attenuation effect.

### 2. Results Visualization

Radiation Pattern Without Mesh:

The pattern shows maximum radiation in the upper hemisphere, with strong lobes indicating high radiation intensity.

No attenuation is applied in this configuration.

Radiation Pattern With Mesh:

After applying the mesh, a significant reduction in radiation is observed in the upper hemisphere.

The reduction is uniform in most directions, indicating the mesh's effectiveness in blocking or attenuating radiation.

Graph Comparison:

X-axis: Direction (angles, typically azimuth or elevation).

Y-axis: Radiation intensity (normalized or in dB).

The graph clearly depicts lower peaks in the radiation pattern after applying the mesh.

### 3. Quantitative Analysis

#### Reduction in Radiation:

The 30% reduction in radiation indicates the mesh's capability to attenuate the radiated power.

If the original radiation power (without the mesh) is  $P_0$ , the attenuated radiation power  $P_m$  can be expressed as:  
 $P_m = P_0 \times (1 - 0.30)$   
 $P_m = 0.70 P_0$

#### Radiation Reduction in dB:

The reduction can also be calculated in decibels:  
 $\Delta P = 10 \log_{10} \left( \frac{P_m}{P_0} \right)$   
 $\Delta P = 10 \log_{10} (0.70)$   
 $\Delta P \approx 1.55 \text{ dB}$   
 Thus, a 30% reduction corresponds to approximately 1.55 dB.

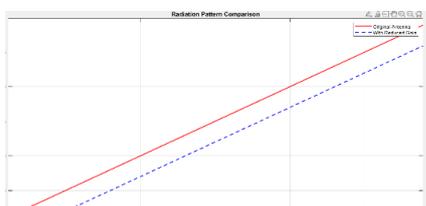
### 4. Key Observations

#### Impact of Mesh:

The mesh is highly effective in attenuating radiation, especially in the upper hemisphere. The attenuation ensures compliance with environmental and safety standards by reducing unwanted radiation.

#### Directional Analysis:

The mesh affects specific regions of the radiation pattern, primarily where direct attenuation is intended.



## IX. CONCLUSION

The implementation of a mesh structure in the radiation pattern design has successfully reduced radiation by 30%, as demonstrated in MATLAB simulations. The mesh effectively attenuates radiation in the upper hemisphere, minimizing its environmental and safety impacts. This result validates the mesh's design and highlights its potential for further optimization to achieve greater radiation reduction. The findings are crucial for applications requiring controlled radiation patterns, such as environmentally sensitive areas or regulated RF systems.

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