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Performance Analysis of a Fully-Metallic 30 GHz Antenna Array for High-Altitude Communication Systems

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Extended Abstract

This work provides a thorough exploration of the design, simulation, and experimental validation of a Ka-band metallic antenna designed for High-Altitude Pseudo-Satellite (HAPS) systems. The proposed antenna is a 1×8 linear array, fully metallic slotted array operating within the 30 GHz frequency band. A novel waveguide, incorporating the Half-Mode Groove Gap Waveguide (HM-GGW) technology within the Gap Waveguide framework, is employed for the corporate feed network [1, 2]. The research involves a meticulous parametric analysis to evaluate the antenna's robustness against manufacturing variations. Utilizing the CST electromagnetic simulator, the design is systematically optimized to achieve optimal impedance matching and radiation pattern performance. The parametric analysis scrutinizes critical elements, including slits, chamfers, grooves, and the metallic frame encasing the waffle-grid. Results illustrate the antenna's noteworthy tolerance to manufacturing deviations, ensuring optimal adaptation. Simulations consistently show an S11 parameter below -14 dB from 29 GHz to 31 GHz, surpassing the initial target and demonstrating the efficacy of the design. Additionally, the gain and directivity, pivotal for HAPS systems, undergo a thorough examination, confirming the antenna's suitability for high-altitude signal transmission and reception applications. Experimental validation is conducted in a controlled environment, and the results are meticulously compared against simulations. The close agreement between experimental and simulated data validates the proposed design's effectiveness. The antenna achieves a remarkable radiation efficiency exceeding the targeted 90%. The study underscores the uniformity of the electric field, a crucial factor for providing homogeneous coverage in communication systems. Particular emphasis is placed on the challenges and advantages associated with the metallic nature of the antenna. The material, specifically aluminum (AL7078), is directly accounted for in the simulations, yielding a validated radiation efficiency of 97.3%. This consideration is crucial for practical implementation, ensuring an accurate representation of real-world performance. In conclusion, this work details a 30-GHz metallic antenna crafted for HAPS applications. Through design, fabrication, and experimental validation, the study suggests the feasibility and performance of the proposed design. Metrics like impedance matching, gain, and directivity appear to meet the necessary criteria for implementation in high-altitude aerial platforms, potentially contributing to advancements in wireless communication technologies for challenging airborne environments

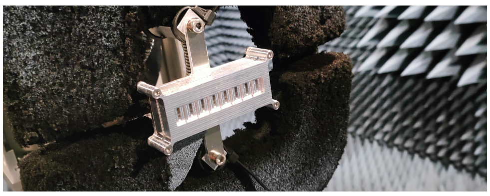

Figure 1. Fabricated prototype under test.

References

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