OPTIMIZATION OF A PRINTED LOG-PERIODIC ANTENNA POSITION ON A UAV

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Abstract

As wireless networks continue to advance and the need for low-latency communication links increases, calibrating antennas installed in the field is essential. In this context, Unmanned Aerial Vehicles (UAVs) are very useful for applications such as UAV-based measurements. Given its light weight, wide bandwidth makes Printed Log-Periodic antenna (PLPDA) an ideal solution as UAV probe. Our study examines the performance of a PLPDA mounted on a UAV. Extensive simulations are performed to determine the optimal position for the PLPDA on a UAV. Simulations are carried out in CST Studio Suite 2022 using the time domain Finite Integration Technique (FIT) with appropriate mesh settings. At the optimized location PLPDA achieves a -10 dB bandwidth of 6.2 GHz.

1 Introduction

In recent years, several Unmanned Aerial Vehicle (UAV) applications have been made possible with the development of portable devices such as portable spectrum analysers, portable signal generators, and Software Defined Radios (SDR). For in-situ measurements, one of the most important steps is identifying the optimal trajectory of the UAV and selecting the probe antenna [1]. Vivaldi, Helix, and quasi-Yagi antennas are commonly used for UAV applications. These antennas are designed to be integrated [2] as a part of the UAV body. The antenna mounted on a UAV should be light [3], exhibit a small aerodynamic profile, wide bandwidth, and have the least amount of Electromagnetic (EM) coupling with the UAV body. In this paper, we present an analysis of the performance of a Printed Log-Periodic antenna (PLPDA) mounted on a UAV. An antenna optimization is proposed, in terms of where PLPDA can be mounted on the UAV. Unlike conventional methods of overcoming the EM coupling [4] with the UAV which involve design changes [5] at the antenna level, we propose to find an optimized location for the PLPDA. The proposed PLPDA is a printed version of a log-periodic antenna with dimensions: 262 mm × 170 mm ×1 mm. The PLPDA, consisting of 25 dipoles, with the smallest dipole measuring 6.5 mm in length and the longest measuring 74.5 mm, and has a -10 dB bandwidth of 6.2 GHz.

2 Design

The proposed PLPDA is used as a receiving probe on drone to measure RF systems installed in the field for various applications. Our approach proposes an optimized location for the PLPDA on the UAV through simulation. The proposed PLPDA is mounted on a custom-built UAV, which has a maximum dimension of 405 mm, motors with 35 mm diameter, and a base metallic plate of maximum dimension 0.4λ at 700 MHz.

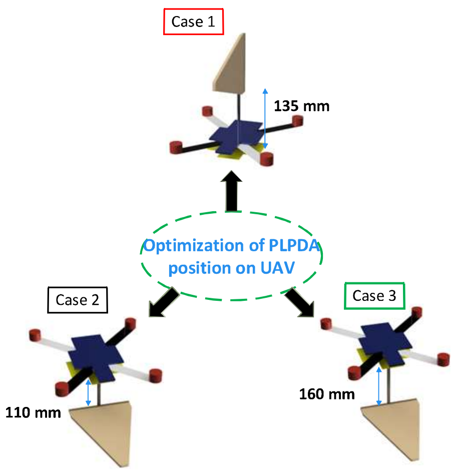

Fig. 1. Optimization of PLPDA position on UAV

Fig. 1. illustrates three scenarios where the PLPDA could be mounted on a UAV. To prevent EM coupling of the probe with the metallic components of the UAV in case 1, the distance from the metallic plate has been increased to 135 mm. In this case, the antenna is vertically polarized. It is necessary to perform further optimization steps, and in case 2, the probe is positioned below the drone at 110 mm from the base plate. In case 3, the probe performance is further optimized by maintaining

160 mm from the base plate. An extensive optimization has been carried out to fine-tune the mesh settings. With 43 million mesh cells, it took about 49 minutes to simulate the complete structure. We have compared the simulation results with the mesh size [6] of 80 million mesh cells and 43 million mesh cells, and the results indicate good agreement. Simulations have been performed using an Intel(R) Core (TM) i9-12900K processor @3.2 GHz (16-cores) and 128 GB of RAM, accelerated by a 24 GB NVIDIA RTX A5000 GPU with a CST acceleration token.

2.1 Simulation Results

Here, we present the simulation results for determining the optimal location for a PLPDA on a UAV. As shown in Fig. 2, the S11 parameters for the three PLPDA locations on the UAV are compared to a standalone PLPDA, which is not enclosed in the radome. In all three cases, when the PLPDA is enclosed in the radome and is mounted on the UAV, there is a shift in resonance by 310 MHz towards the lower frequencies.

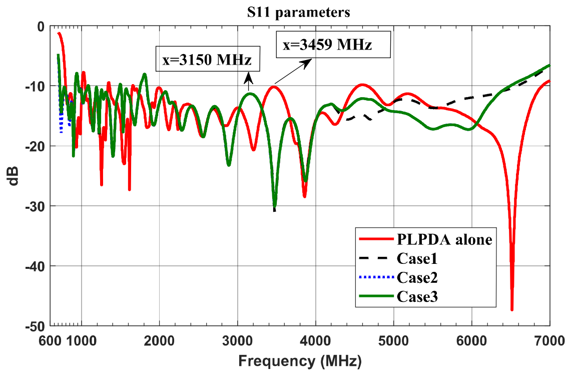

Fig. 2. S11 parameters

Fig. 3. illustrates the polar plots of the radiation patterns at 0.7 GHz and 7 GHz. It can be observed from the plots that when the PLPDA is placed on top of the UAV, patterns are distorted due to the base plate of 0.4λ at 700 MHz.

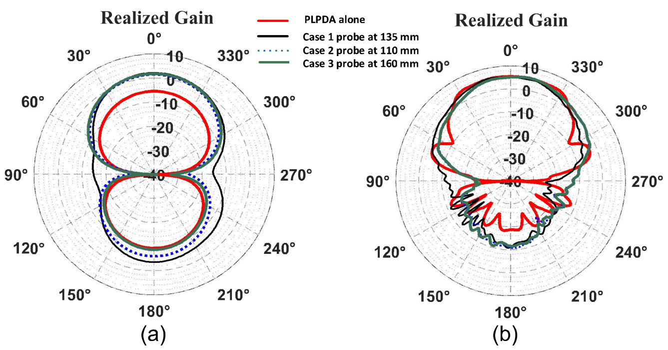

Fig. 3. Radiation patterns in the elevation plane at (a) 0.7 GHz, (b) 7 GHz

To overcome the EM coupling, we tried moving the PLPDA to several positions at the top of the UAV, however, distortions in the radiation pattern were still seen at lower frequencies. Therefore, we have moved the PLPDA to the bottom of the UAV in case 2. As we can see from the polar plots for case 2, there are no longer distortions in radiation patterns at lower frequencies. This case was further optimized in case 3 by moving the PLPDA to 160 mm from the base metallic plate.

3 Conclusions

In this paper, a wide band printed log-periodic antenna operating between 0.7 to 7 GHz is selected as a probe for a UAV. To avoid EM coupling between UAV components and the PLPDA, optimization of PLPDA is done in terms of its position on the UAV. Among the three cases studied, case 3 is the optimized one. In this position, we were able to maintain PLPDA patterns undistorted at lower frequencies.

Acknowledgements

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