

Eco-Friendly Ground Planes for Wireless Devices Using Antenna Booster Technology

Jaume Anguera ^(1,2), Gerard Massana ⁽¹⁾, Inés Ripoll ⁽¹⁾, Aurora Andujar ⁽²⁾, and Joan L. Pijoan ⁽¹⁾

(1) Smart Society Research Group, Universitat Ramon Llull, Barcelona, Spain,
(jaume.anguera@salle.url.edu)

(2) R&D Department, Ignion, Barcelona, Spain, <http://www.ignion.io>

The exponential growth of the Internet of Things (IoT) has sparked an increasing demand for energy-efficient solutions that reduce environmental impact, particularly through the optimization of wireless communication systems. Antennas, as a key component in IoT devices, play a pivotal role in determining energy consumption and overall performance. This research introduces a novel use of Aloe Vera as an organic ground plane to improve antenna efficiency in IoT devices, while simultaneously contributing to a reduction in carbon footprint. The study builds upon Antenna Booster Technology (J. Anguera and A. Andújar “Antenna Booster Technology for Wireless Communications,” Institute of Engineering and Technology, July 2024, ISBN 978-1-83953-300-6), which enables device miniaturization without compromising efficiency, by integrating an Aloe Vera ground plane and evaluating its impact on antenna performance at 900 MHz, a frequency widely used in protocols such as LoRaWAN, Zigbee, and cellular IoT.

Traditionally, ground plane size is crucial for optimal antenna efficiency. A typical metallic ground plane of 0.4λ is required for optimal performance at 900 MHz, corresponding to a large physical size (approximately 130 mm), which limits the miniaturization of IoT devices and increases the environmental cost due to the widespread use of materials like FR4, a common substrate for printed circuit boards. The carbon footprint of FR4-based devices is significant, further exacerbating environmental concerns. This research explores the feasibility of significantly reducing the ground plane size ($<0.1\lambda$) by using Aloe Vera, a natural material with no prior electromagnetic characterization in the microwave domain, as far as we are concerned, as an organic extension to the ground plane.

Through both simulation and experimental validation, the study demonstrates that Aloe Vera can serve as an efficient ground plane substitute. The antenna booster, a non-resonant and electrically small component ($\sim\lambda/30$), is paired with a matching network to ensure optimal impedance matching to 50Ω . With Aloe Vera as an extension of the ground plane, a notable improvement in antenna efficiency is observed, with a 3.1 dB increase in total efficiency compared to a conventional small ground plane made of copper and FR4. These findings underscore the potential of Aloe Vera to replace traditional metallic ground planes in IoT devices, reducing both the device size and environmental impact.

The study also addresses key questions regarding the physical properties of Aloe Vera as a ground plane material, such as its thickness, shape, and the method of connection to the device's printed circuit board (PCB). Though further research is needed to fully optimize the integration of natural materials into antenna systems, the results indicate that Aloe Vera can significantly enhance antenna performance without compromising efficiency.

In conclusion, this work demonstrates the viability of using organic ground planes, such as Aloe Vera, in the design of IoT devices, opening the door to more sustainable wireless communication technologies. By incorporating natural materials into antenna systems, this research sets the stage for a future where eco-friendly solutions can enhance device performance, reduce environmental impact, and contribute to the development of green IoT technologies.