An S-Band EBG Antenna for Mini-UAV

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1. Introduction

UAV (Unmanned Aerial Vehicle) systems are generally used in gathering intelligence and for surveillance purposes [1]. The concept of sending an unmanned vehicle to perform a mission which can be usually characterized with one or more of the three D's; Dull, Dirty and Dangerous, is gaining popularity with both civil authorities and in military use. The possibility to have the UAV operator in a safe place while the needed information can be extracted from the operation zone, whether it is the local chemical factory fire that is been observed by the firefighters or tactical data from the battlefield, is of course tempting [2] – [5].

The missions UAV's perform usually produce large information flows from the UAV's sensors to the Ground Control Station (CGS) which furthermore generates a need to establish radio communication links between the UAV and GCS for telemetry and command & control purposes. And as always with radio links, the antenna design has a paramount role when determining the performance of a radio communication system.

In this project the goal was to design a 3.5kg and ca. 1.5m wingspan mini-UAV using EPP (Expanded PolyPropylene) as the material for the mini-UAV's fuselage. When designing a mini-UAV system of this size there are a few important restrictions to be taken into consideration. These are mainly the minimization of size and weight of the UAV subsystems without compromising the overall system performance. The used system design concept in which the UAV subsystems and antennas were integrated into the structure of the UAV brought enhancements for both the design phase and for the actual end-usability of the mini-UAV. In design phase the antennas could be designed as a load bearing parts of the mini-UAV, which gave savings in weight. And for the end-user viewpoint the embedded antennas are service free and virtually unbreakable

This paper will address the development of an EBG antenna [6] for Patria mini-UAV, Fig. 1. The operation frequency of the antenna is centered at 2.35 GHz with 80 MHz input-match bandwidth for transmitting video data from the mini-UAV to the Ground Control Station. The designed antenna is attached to the mini-UAV's wing, and the antenna is looking down to the ground.

2. Antenna Design

Ansoft HFSS has been used to model and optimize an EBG patch antenna for the mini UAV. The geometry is shown in Fig. 2. The antenna is made out of Rogers RO4350 high frequency laminate whose dielectric constant is 3.48 and loss tangent 0.004. The substrate thickness is 1.6 mm. The high-impedance ground plane size is 70 mm by 50 mm. The high-impedance ground plane is employed in order to obtain wider impedance bandwidth. The EBG lattice is composed of cut out discs whose diameter is 12 mm. The discs have 4 mm distance from each other. The optimized patch dimensions for the length and width are 31 mm by 34 mm, respectively. In addition, an extra solid ground plane can be included to improve the gain performance. This additional ground plane functions as a cavity-backing plate. Its distance from the high-impedance ground plane is 20 mm.

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Fig. 3. shows the simulated input-match performance. It can be seen that over 80 MHz input-matching bandwidth is obtained with and without cavity-backing with center frequency of 2.35 GHz. Fig. 4. shows the simulated radiation patterns for both principal planes, i.e., E- (xz) and H-planes (yz), respectively for center frequency.. The simulated directivity for cavity-backed antenna is 6.0 dBi, whereas without cavity-backing the directivity is 4.5 dBi.

3. Experimental Results

Return loss was measured with Agilent technologies E8362B PNA series network analyzer. The limit for input-match bandwidth was defined as VSWR is less than 2:1. Fig. 5. shows the measured S11 for antenna alone, antenna attached to the UAV's wing, and antenna attached to the wing with cavity-backing. The results show that the center frequency remains nearly fixed, as well as the input-match bandwidth. The measured input-match bandwidth is 100 MHz centered at 2.35 GHz. The results are in good agreement with the simulations. Radiation patterns were measured at 2.35 GHz in an electromagnetically anechoic chamber in VTT (Technical Research Centre of Finland). Figs. 6 and 7 show the measured Co- and Cross polarized patterns for xz- and yz-planes respectively. The measured maximum gain is 5.0 dBi. Measured results are again in good agreement with the predictions.

4. Conclusions

Future utilization of mini-UAVs payload systems will necessitate thorough antenna design process to improve the performance of the application. This paper has addressed the development of the EBG-antenna for Patria mini-UAV. In this research, we have considered a wing attached antenna which is buried inside the wing structure, such that the antenna is looking down to the ground. The antenna operates at the center frequency of 2.35 GHz, and it has input-match bandwidth of 100 MHz. Here, the antenna input match and radiation characteristics have been optimized with Ansoft HFSS simulations and measurements. It has been shown that the measured results are in good agreement with simulations.

References

[1] www.uavforum.com, cited 01/13/06.

[2] J. F. Vesecky, J. M. Cornwall, Integrated design of Synthetic Aperture Radars for Unmanned Aircraft, IEEE Geoscience and Remote Sensing Symposium, IGARSS '96 Remote Sensing for a Sustainable Future, Vol. 4, pp. 2347 – 2348, 1996.

[3] M. Chaohua, L. Yimin, Y. Guangzheng, A 3mm-Wave Battle Field Surveillance Radar for the Mini-UAV, 2001 CIE Conference on Radars, 154 – 157, 2001.

[4] F. Pinkney, D. Hampel, S. DiPierro, B. S. Abbe, M. Sheha, UAV Communications Payload Development, IEEE MILCOM -97, Vol. 1, pp. 403 – 407, 1997.

[5] H. Hellsten, L. M. H. Ulander, Airborne Array Aperture UWB UHF Radar – Motivation and System Considerations, IEEE Radar Conference, pp. 47 – 53, 1999.

[6] P. Salonen, M. Keskilammi, L. Sydänheimo, A Low-Cost 2.45 GHz Photonic Band-Gap Patch Antenna for Wearable Systems, IEE 11th International Conference on Antennas and Propagation (ICAP 2001), No. 480, Vol. 2, pp. 719 – 723, Manchester, UK, 2001.

Fig. 1. UAV flight test.

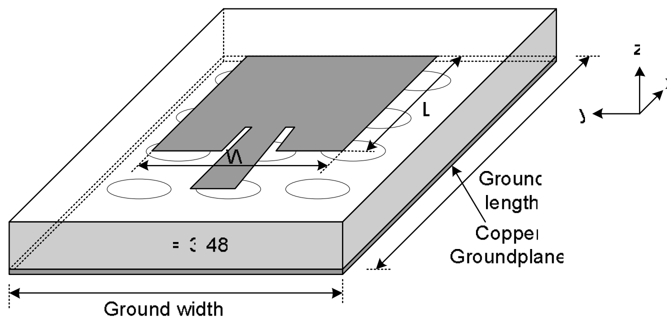

Fig. 2. Antenna Geometry.

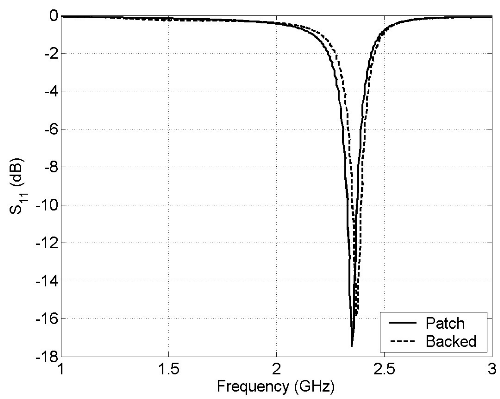

Fig. 3. Simulated return loss.

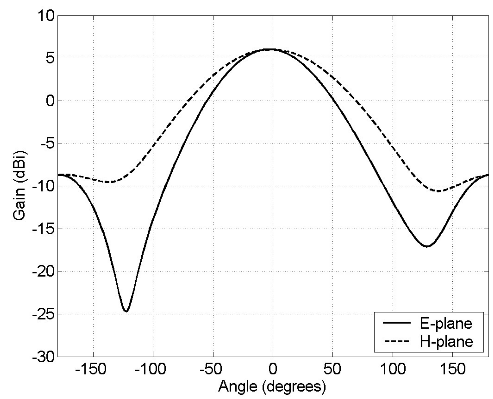

Fig. 4. Simulated E- and H-plane radiation patterns at 2.35 GHz.

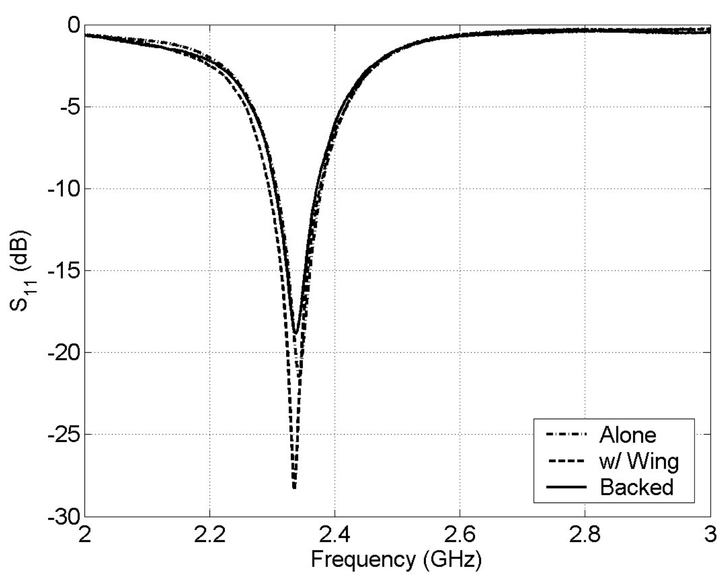

Fig. 5. Measured return loss.

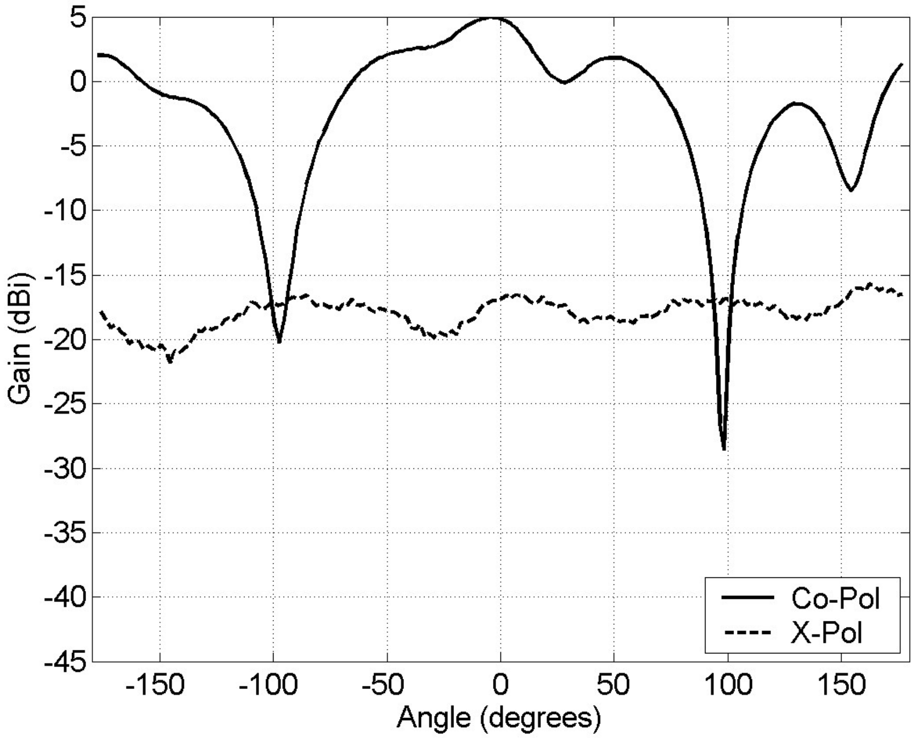

Fig. 6. Measured xz-plane radiation pattern at 2.35 GHz.

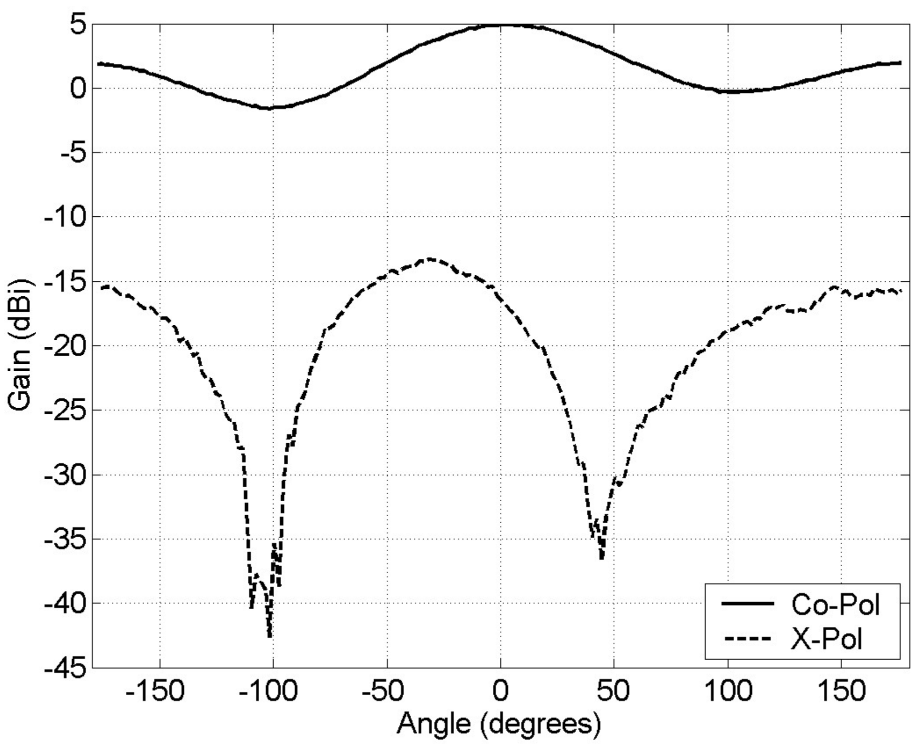

Fig. 7. Measured xz-plane radiation pattern at 2.35 GHz.