PhD position

Design of 3D-printed multiband electrically small dielectric resonator antennas for nanosatellite applications

Laboratories:

ISAE-SUPAERO
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Context:

Reducing the size of platforms and payloads is a major challenge for the deployment of nanosatellites. This constraint also applies to on-board antennas, which must have a small footprint and low weight. The use of multi-band antennas represents an interesting solution to minimize the number of on-board antennas while covering the various frequency channels useful for the mission (TM/TC, data links, …).

To reduce the dimensions of an antenna it is common to use dielectric materials with high permittivity in which the wavelength is decreased [1]. This solution has been successfully applied to the miniaturization of printed antennas, dielectric resonator antennas (DRA), …

Recently, ISAE-SUPAERO, ENAC, and ANYWAVES have shown the potential of additive manufacturing (AM) of ceramics in the engineering of high dielectric constant materials. For example, a 2.45 GHz DRA made of a 3D-printed anisotropic ceramic has been designed [2]. Here, the permittivity tensor of the ceramic is controlled by repeating in space a unit cell with a spatial period much smaller than the wavelength in the material. The structured material finally behaves as a homogeneous dielectric medium whose permittivity depends on the unit cell.

If one now considers a larger spatial period according to the wavelength, the structured material may behave totally differently. Indeed, at specific frequencies the electromagnetic wave propagation may be forbidden due to an electromagnetic band gap (EBG) in the material [3] which can be used for example to improve antenna radiation properties [4]. Such properties may also be obtained using metasurfaces that is often used to reduce antenna dimensions [4-5]. This frequency dependence of shaped materials and metasurfaces properties opens up interesting prospects, particularly for the design of low-profile multiband antennas.

The main objective of this Ph.D. is to evaluate the potential of engineered periodic structures, namely 3D-printed ceramics and metasurfaces, in order to design multiband electrically small antennas. The challenge is thus to reduce the volume occupied by on-board size of the antennas in nanosatellites while preserving the bandwidth, the radiation pattern, and the polarization purity. Such antennas could be applied to the needs of space industry, for the L, S and X-band.

[1] J. L. Volakis, C.-C. Chen, and K. Fujimoto, *Small Antennas: Miniaturization Techniques & Applications*, McGraw-Hill, 2010.

[2] C. Morales, C. Morlaas, A. Chabory, R. Pascaud, M. Grzeskowiak, and G. Mazingue, *Single-Fed Circularly Polarized Dielectric Resonator Antenna using an Anisotropic Material*, IET Antennas and

Propagation Conference, Birmingham, UK, 2019.
[3] F. Castles, D. Isakov, A. Lui, Q. Lei, C. E. J. Dancer, Y. Wang, J. M. Janurudin, S. C. Speller, C. R. M. Grovenor, and P. S. Grant, *Microwave dielectric characterisation of 3D-printed BaTiO3/ABS polymer composites*, Scientific Reports, vol. 6, 22714, 2016.
[4] C. Morlaas, B. Souny, and A. Chabory, *Slot planar antenna on metallic support with large bandwidth*, Proceedings of the 5th European Conference on Antennas and Propagation (EuCAP 2011), Rome, Italy, Apr. 2011.
[5] Wei E. I. Liu , Zhi Ning Chen, Xianming Qing , Jin Shi , and Feng Han Lin, *Miniaturized Wideband Metasurface Antennas*, IEEE Transactions on Antennas and Propagation, vol. 65, n. 12, pp. 7345-7349, Dec. 2017.

Qualifications:
The successful applicant is expected to hold or to be about to receive an engineering or master 2 degree in Electrical Engineering.
Candidates should demonstrate skills in antenna and microwave engineering. A good English level and good writing skills are also requested.

Application:
Interested candidates should send their CV via e-mail, accompanied by a cover letter.
The application should be done through the CNES website
https://recrutement.cnes.fr/en/annonce/1101107-159-3d-printed-multiband-electrically-small-antennas-for-small-satellites-31400-toulouse

Location:
ISAE-SUPAERO, Toulouse, France.

First day of employment:
Between September and December 2021.

Duration of the contract:
Up to 36 months.

Contact:

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