Tunable metasurfaces antennas

Context

This PhD topic is part of the PERSEUS project ((**P**ower-**E**fficient **R**adio interface for **S**ub-7GHz distribut**E**d massive MIMO infrastruct**U**re**S**) of the France 2030 Réseau du futur research program, and focuses on the development of tunable metasurfaces antennas.

A new generation of materials known as metamaterials has been the focus of a great amount of research in recent years, because of the extraordinary applications they offer. Metamaterials are usually defined as artificial materials with original properties not readily available in nature. One of the main fields of application is telecommunications, in the fields of optics and microwaves.

The subject of this thesis is the development of antennas using these metamaterials. Metamaterials have proved useful for improving antenna performance. They are frequently used in their two-dimensional form, also known as metasurfaces. Combined with traditional antennas, these metasurfaces can improve radiation properties. There are several types of metasurfaces with exotic properties that are impossible to obtain with conventional materials. However, metamaterials often exhibit their novel properties within a limited frequency range. This narrow frequency band characteristic is a real problem, as many practical applications are broadband and/or multiband.

Therefore, it is necessary to design tunable metamaterials that can be reconfigured in frequency. With appropriate control, the metamaterial can be tuned to achieve the desired property at the working frequency. Tunable metamaterials can also be used for adaptive antennas to control their radiation pattern to take the environment into account, for example.

Thesis objectives

In this context, we demonstrated in Rafael G. L. Melo's thesis [1] that it was possible to place two metasurfaces on either side of a broadband (bow-tie) antenna to obtain a low profile multiband directional antenna compatible with European 4G/5G and Wi-Fi 2.4/5/6E standards and operating in the following bands: 2.40-2.70 GHz, 3.40-3.80 GHz, 5.17-5.83 GHz, and 5.93-6.45 GHz.

The first metasurface exploits both the perfect electrical conductor (PEC) and perfect magnetic conductor (PMC) characteristics of a dual-band artificial magnetic conductor (AMC). The second metasurface, known as the Huygens metasurface, enables the beam to be pointed in one of the operating frequency bands. By controlling the polarization voltages on four varactor columns in the reconfigurable, multiband Huygens metasurface, the beam can be dynamically pointed to ±51°, continuously, within the European 5G frequency range (3.50 to 3.65 GHz) [2].

The aim of this thesis is to further develop this concept along several axes:

- Evolve the Huygens metasurface into a planar structure,
- Add control elements to the artificial magnetic conductor to increase the antenna's number of degrees of freedom,
- Develop a compact power feeding system integrated into the antenna.

Team

To develop the proposed work, the researcher will be hosted in the RFM² team of Télécom Paris at COMELEC department. Télécom Paris is now well known in this field of research, and the successful candidate will benefit from an environment where several researchers are working on related applications, and have set up numerous tools for characterizing and simulating such materials, to which he or she will have access. Seminars within the team and department are also regularly offered. The host team has established numerous international contacts, both through contracts and projects, and through informal cooperation. There will therefore be opportunities to work with recognized academic and industrial laboratories.
Most of the work will be published in the open literature, preferably in journals.

References

[1] R. G. L. Mello, "Active and passive metasurfaces : methodology for the design of a low profile, beam-steerable, multiband, and wideband antenna", PhD, Paris, June 2022.

[2] R. G. L. Mello, A. C. Lepage, X. Begaud, "Taming Fabry-Pérot resonances in a dual-metasurface multiband antenna with beam-steering in one of the bands", Sci Rep 13, 9871 (2023), doi: 10.1038/s41598-023-36828-4

How to apply

PhD profile: The recruited PhD student should have a Master 2 degree (or an engineering degree) with a specialization in Electromagnetism, Antennas, Microwaves, and High Frequency Electronics. Strong knowledge in antenna design, electromagnetism, circuit theory, as well as in the use of commercial electromagnetic software will be required. A good level of spoken and written English is required.

Candidates should send a CV, their academic transcripts, and the contacts of two referees to**:**

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