Co-design and co-integration of multiband active antenna arrays for satellite radionavigation systems

F.Fezai, J.Sence, S.Bila
F.Torrès, T.Monédière, B.Jarry
XLIM UMR7252 Université de Limoges/CNRS
123 av. Albert Thomas, 87060 Limoges, FRANCE

F.Seyfert, M.Olivi
INRIA Sophia-Antipolis Méditerranée
2004 rte des Lucioles, 06902 Sophia Antipolis, FRANCE

B.Frigui, R.Chantalat
CISTEME
12 rue Gémini, 87068 Limoges, FRANCE

P.Pouliguen, P.Potier
DGA/DS/MRIS
7, rue des Mathurins, 92221 Bagneux, FRANCE

***Abstract*— This paper presents the structuration and the first results of a research program dedicated to the co-design and the co-integration of a multiband antenna array for a GPS/Galileo receiver. The objective is to develop a novel design approach taking into account all parts of the RF system simultaneously. By this way, the aim is to improve the performances of the RF front-end compared to a traditional approach where RF circuits would be designed separately.**

I. INTRODUCTION

COCORAM is a 3-year research project, begun in January 2014, and funded by the DGA (French Defense Agency) and the ANR (French Research Agency). The project evolves in the context of a strong increase of integration density for electronic systems devoted to communication, localization, or supervision. The deployment of such systems also has to answer an increasing demand of flexibility in terms of frequency, power or coverage. The flexibility in frequency can be simultaneous with multi-band devices or selective by reconfiguration of the frequency band. The flexibility in terms of power allows minimizing the consumption of the system and the flexibility of coverage directing the beam through the target in order to optimize the link budget or on the contrary to protect itself from a noise source.

The increase of both efficiency and compactness requires grouping elementary functions (antenna, filter, amplifier…), which allows to reduce interconnection stages and to take into account the interactions between individual elements [1]-[3]. In the frame of COCORAM, the demonstration will be given with the design of a receiver network made of 4 elements for GNSS (Global Satellite Navigation System) radio navigation systems

II. OBJECTIVES

The main objective of this project is to develop a methodology for co-designing the antenna and the associated circuits (filters and low-noise amplifier – LNA) in order to reach optimal performances (radiation, efficiency) with an integrated and compact device.

Several issues have to be considered in the frame of COCORAM:

- The capacity to develop a generic tool for the co-design of multifunction systems, in particular the matching of a circuit on complex and frequency variable impedances at its input and output ports,
- The design of a radiation element with multiband circular polarizations, large angular opening, and the minimization of couplings during the network assembly,
- The design of multiband filters in a context of a mutual design (co-design) and the distribution of the filtering function within the system, between the antenna and the LNA, and after the LNA,
- The design of sub-circuits in heterogeneous technologies,
- The realization of a part of the filtering function with the low quality factor elements used for the LNA MMIC,
- The compromise between power and noise matching during the co-design for which the impedances of reference are different from 50 ohms.

III. PROJECT ORGANIZATION

The project is organized in 4 tasks. The first task (T1) concerns the specifications and the system analyses. The second task consists in designing the antenna, the filter and the LNA separately, following the classical design approach based on a 50-Ω impedance matching for all circuits. The receiver system designed in this task will serve as a reference in terms of performance and volume occupation.

The third task (T3) is the core part of the project. The synthesis approach for co-designing the circuits on optimized impedance and the appropriate CAD tools will be developed first. Then, based on the system analysis (T1) and the initial receiver design (T2), a co-design of the system will be performed. The last task (T4) concerns the manufacturing and

the experimental characterizations of the GNSS front-end receiver.

IV. Specifications and First Results

The system to be designed consists in a 4 active antenna array as presented in Fig. 1. Each antenna generates a right circular polarization (RHCP) [4]-[6] and covers two passbands centered at 1255 and 1575 MHz respectively, with a nominal gain of 20 dB. One can note that the antenna array is very compact for the working frequencies.

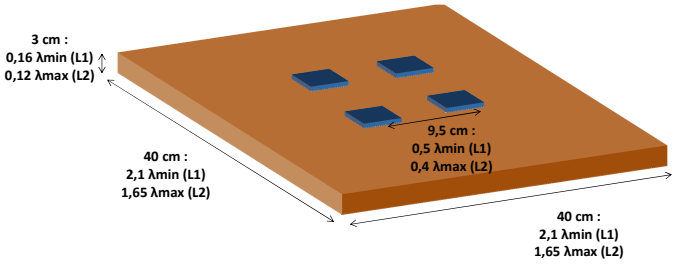

Fig. 1. Specified footprint of the 4 active antenna array

For the reference system (T1), an initial radiating element has been designed first. The antenna consists in a patch antenna with optimized tuning slots and two orthogonal feeds. On the other hand, a dual-band bandpass filter [7] with 5 poles and 3 transmission zeroes has been synthesized and a commercial LNA has been identified to fulfil the specifications.

The current step involves finalizing the antenna and the circuits designs in order to evaluate the performances of the system including the array of 4 elements [8].

V. Conclusion

A research program dedicated to the co-design and the co-integration of a GNSS front-end receiver is presented. The objectives, the structuration, the specifications and the first results have been given.

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