Ph.D. in Information Technology
Thesis Defense

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Room PT1

Steven Kleber CAICEDO MEJILLONES – XXXIV Cycle

SYNTHESIS OF FILTERS AND FILTERING ANTENNAS FOR MICRO AND MILLIMETER WAVES APPLICATIONS

Supervisor: Prof. **Michele D'Amico**

Abstract:

Filters and antennas are the closest building blocks to the air interface in modern wireless communications systems. Filters allow the transmission of signals in a desired frequency range and eliminate those that operate in the unwanted range. Antennas help radiate signals within their operating range. This thesis focuses on the development of new methods for the synthesis and design of these two blocks and the integration between them.

On the one hand, with the advent of different 5G solutions and the massive deployment of IoT, the need for highly selective filters also arises. With size as a constraint in many applications, the introduction of several transmission zeros at specific frequencies may be necessary. This conversely often leads to intricate topologies and therefore more complicated implementation. Extracted pole and cascaded blocks are modular topologies that can overcome all these issues, allowing to design of even fully canonical filters. This thesis proposes novel, accurate and analytical methods for the synthesis of extracted-pole and cascade-block filters including resonating and non-resonating nodes. These methods are based on the well-known coupling matrix synthesis. Then, suitable matrix operations are applied to transform the circuit into the target topology. Regarding the extracted-pole filters, the new method allows to synthesize filters in a more accurate way compared to the state-of-the-art. Regarding the cascaded-block synthesis, the new methods allow to analytically synthesize filters that previously were only possible through optimization.

On the other hand, filters and antennas are devices that are usually connected between them. This interconnection may increase the filter-antenna footprint as a matching network may be needed. If that is the case, this also adds losses to the link budget. This is particularly critical in the millimeter wave frequency range. That is why the rest of the thesis focuses on the synthesis and design of filtering antennas addressing different use cases. This thesis first proposes planar filtering antenna solutions in PCB for the customer premises equipment of a fixed wireless access system, as well as for a phased array antenna that uses frequency division duplexing. A circularly polarized horn filtenna for space applications is also proposed. For all these works, a design procedure based on filter synthesis is presented. Synthesis-based design works on the premise that an equivalent circuit approximates the real model reasonably well. The main advantage of this type of design is that the expected frequency response of the final prototype is known in advance. Therefore, the selection of the best solution that satisfies the given requirements can be done through fast but accurate circuit simulations. When the best solution is found, the actual full-wave prototype is designed in a modular way. That is, the full-wave prototype is designed by blocks according to the synthesized circuit, then all the blocks are assembled.

Most of the work presented in this dissertation has been published or submitted to international peer-reviewed scientific journals and conferences.

PhD Committee

Prof. **Gian Guido Gentili,** DEIB - Politecnico di Milano
Prof. **Santiago Cogollos Borras**, Universitat Politecnica de Valencia
Prof. **Antonio Morini**, Universita' Politecnica delle Marche