Design of a Dual-Band SIW Filter for a L-band Receiver

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***Abstract* – This paper presents the design of a dual band filter for the integration of a RF receiver front-end in the L band. The synthesis from the imposed filtering specifications led us to choose the SIW technology that ensures a good trade-off between electrical performances and space requirements.**

I INTRODUCTION

Advanced wireless RF front-ends are required to afford higher performances in always smaller footprints. The receive filter, presented in this paper, answers severe specifications, allowing to handle both GPS and Galileo signals with strong rejections to insure the immunity of the equipment. The specifications for such a dual-band filter are post noted in Figure 1. The trade-off between dimensions and quality factor is then going to lead the choice of the integration technology.

II SYNTHESIS

A 10 order asymmetric transfer function with 4 transmission zeros fits with the specifications [1]. This function is optimized without considering the losses due to the finite quality factor of resonators. The footprint specified for this filter is 60 x 60 mm^2.

The transfert function is afterward drawn according to various values of quality factors. The insertions losses depending on the quality factor are recorded in Table 1. To reach losses lower than 3 dB in every bandwidth a quality factor of 300 is necessary. It involves to use quasi-volume technologies.

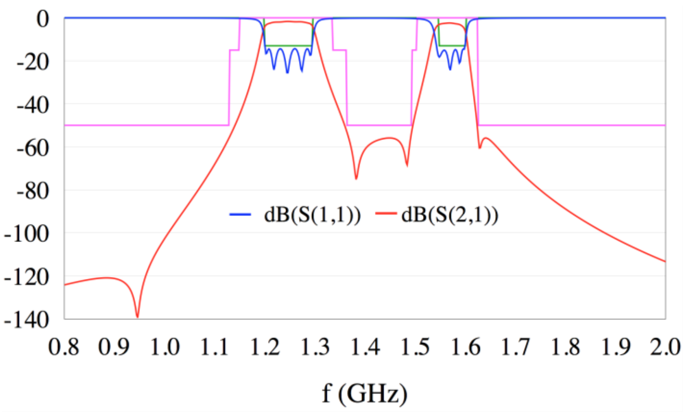


Figure 1. Ideal S Parameters of the filter for a quality factor (Q_0) of 300.

III MANUFACTURING TECHNOLOGY

In terms of quality factor, SIW technology is a solution, which is situated basically between planar and waveguide technologies [2], leading to Q values of some hundreds as expected in this application.

The filter has to be integrated within a receiver front-end, behind a patch antenna, whose footprint is 57 x 57 mm^2. In order to fit with this specified surface, we decided to stack the resonators on two levels. For implementing 5 resonators on each level, the maximum size of a single resonator was estimated to 20 x 20 mm^2.

The selected substrate is a semi-organic from Rogers (RT / Duroid 6010) with relative permittivity ε_r = 10.2 (10.7 for simulation) and loss tangent tanδ = 2.10^{-3}. We selected this substrate because of the high relative permittivity, which allow reducing the resonator size. Substrate with lower loss tangent may be found, but the permittivity would be reduced.

In order to realize a resonator working in the L-band with a maximum size of 20 x 20 mm^2 using the previous substrate, a capacitive effect is required. The capacitive effect is provided by a post placed in the middle of the SIW cavity. The capacitive post will allow reducing the size of the resonator, but the quality factor will be reduced also. A precise dimensioning is performed applying electromagnetic analyses.

The design of the resonator is performed considering 3 stacked layers for each resonator level: two 2.54-mm layers and a 0.635-mm layer. The basic resonator, whose dimensions are presented in Figure 2, provides a quality factor of about 325 at 1.4 GHz, as specified in this study.

	Insertion loss / dB	
Q_0	**First band**	**Second band**
100	5.0	7.0
300	1.7	2.5

Table 1. Insertion losses according to the quality factor.

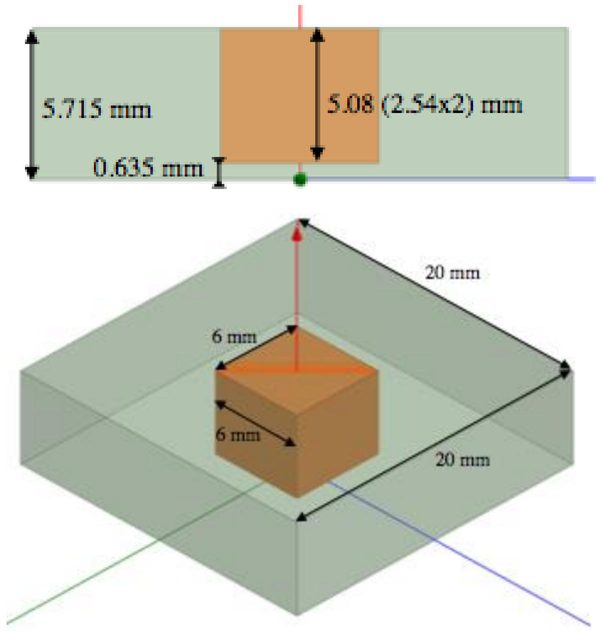


Figure 2. SIW resonator

IV Filter Design

The structure is then dimensioned with an electromagnetic model defined as presented in Figure 3. The structure is excited by short-circuited coplanar waveguide (CPW) lines. The filter is then constructed by arranging positive and negative couplings between resonators, as defined in the synthesized coupling matrix. The initial dimensions are given by dimensioning of individual coupling elements, and the dimensions of the final structure are optimized by identifying the coupling matrix after each electromagnetic simulation.

The filter dimensions are 20 x 93 x 11.52 mm^3. The structure has been dimensioned with aligned resonators and coupling elements; however, in order to fit with the footprint specifications, the filter may be folded in order to form a U-shaped structure.

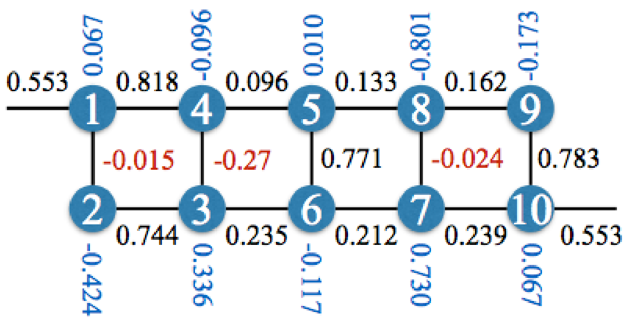
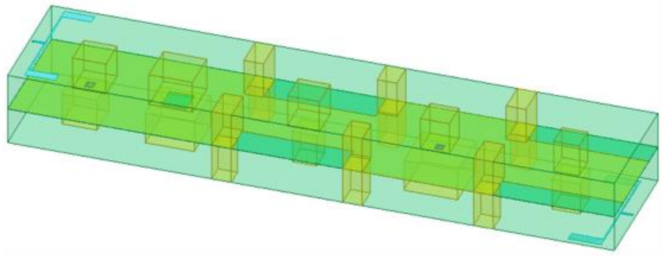
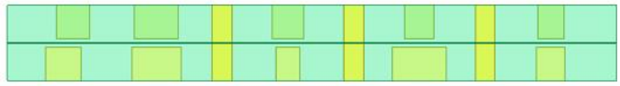


Figure 3. Coupling diagram

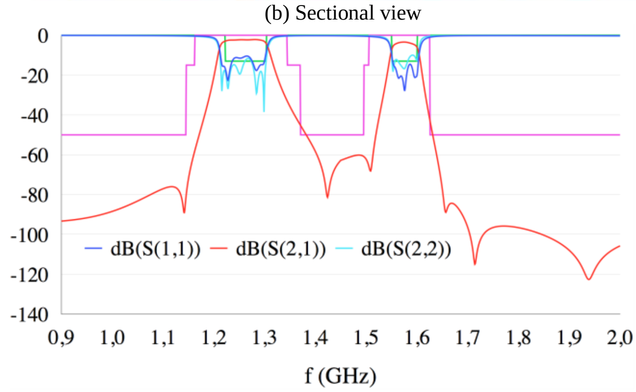
The optimized model complies with the specifications as shown in Figure 4. As expected, the effective quality factor is found between 250 and 300. Moreover, one can note the presence of an additional transmission zero, which does not degrade the performance.



(a) Perspective view



(b) Sectional view



(c) Response

Figure 4. Filter model and simulation (HFSS)

V Conclusion

This paper presents the design of a dual-band filter intended for a L band receiver. The SIW technology is chosen to optimize the compromise between compactness and electrical performances. A first design allowed to demonstrate the filter feasibility. An optimization of the design taking into account manufacturing constraints is currently ongoing. The works presented in this article are financed within the framework of the project ANR ASTRID COCORAM.

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