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Routing with Classical Corrugated Waveguide Low-Pass Filters with Embedded Bends

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Abstract—A very simple design method to embed routing capabilities in classical corrugated filters is presented in this paper. The method is based on the calculation of the heights and lengths of the so-called filters design building blocks, by means of a consecutive and separate extraction of their local reflection coefficients along the device. The proposed technique is proved with a 17th-order Zolotarev-filter whose topology is bent twice so that the input and output ports are in the same plane while preserving the in-line filters behaviour. This new filter allows the possibility of eliminating subsequent bending structures, reducing the insertion loss, weight, and PIM.

1. INTRODUCTION

The physical configuration of numerous applications such as ground terminals or multi-beam satellite payloads has become very intricate in order to allocate different RF/microwave components which are put together trying to make the best use of the volume available. In ground terminals, it is easy to find complex structures with low-pass filters and bends which are conveniently allocated to obtain a more compact terminal [1–3]. Multi-beam payloads are triggering the need of very compact output sections because up to hundreds of waveguide filters and bends are used to accomplish different functions [4]. In fact, once a signal has been amplified, it needs to be filtered and channelized/combined depending on the terminal/payload configuration [5]. Nowadays, when the physical configuration of the terminal/payload needs a bend before or after the low-pass filter, two different structures are utilized. This issue produces a negative impact in terms of insertion loss, volume/mass, and passive intermodulation (PIM) if we compare it with the solution presented in this paper. Therefore, developing a novel design technique for waveguide filters with adaptable physical layout will improve the industry's freedom to trade-off all these variables, and it will also boost the flexibility to design more complex and compact terminals and payloads.

The classical corrugated low-pass filters in rectangular waveguide technology have been widely employed in previous applications. Indeed, its design method is very well explained in [6] and available in commercial software tools. Very recently, an analytical approach has been proposed to accurately obtain their final physical dimensions using exclusively closed-form expressions [7]. As far as the authors' knowledge, all efforts to fold waveguide filters have kept focused on band-pass filters [8, 9]. In the case of low-pass filters, all of them follow the same in-line topology as in [7], and, typically, if a classical corrugated low-pass filter with embedded bends is required, its frequency response is retrieved by brute-force optimization of the constituent physical parameters, using only the optimizer tool of an electromagnetic software (i.e., FEST3D for instance). However, this paper goes beyond that and presents a very simple design technique that could be easily implemented in a software tool (i.e.,

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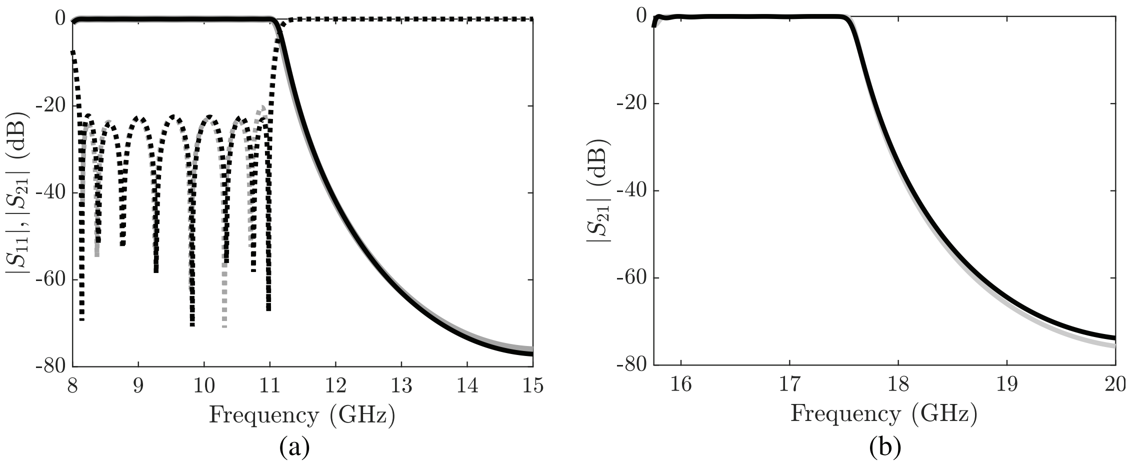

Figure 5. FEST3D simulated frequency response comparison for the in-line design (grey line) and the novel filter in this paper (black line) for the (a) fundamental TE_{10} mode and (b) TE_{20} mode (the rest of the higher-order modes up to 20 GHz are below −150 dB). $|S_{11}|$ in dotted line and $|S_{21}|$ in solid line.

its in-line counterpart.

The novel filter has been fabricated in aluminium in two halves in clam-shell configuration to reduce also the PIM of the structure (Fig. 6). The measurement results shown in Fig. 7 are very close to the simulated ones, and the filter fulfils not only the required frequency specifications but also the physical restrictions imposed.

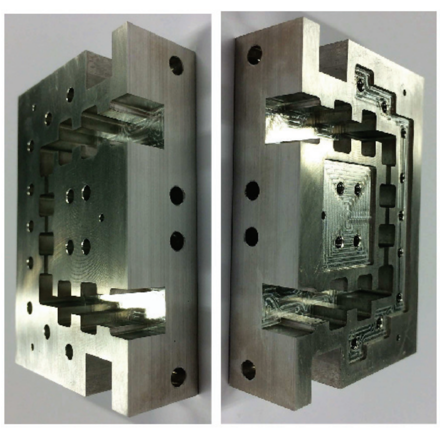

Figure 6. Photograph of the unassembled fabricated prototype.

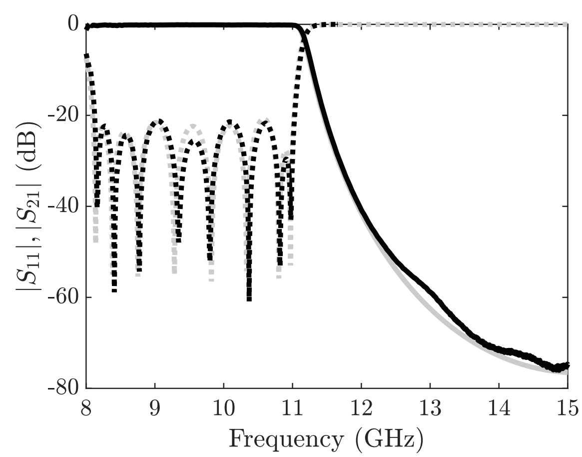

Figure 7. Frequency response measurements of the novel filter (black line) and CST MWS simulation of the novel filter with rounded corners (grey line). $|S_{11}|$ in dotted line and $|S_{21}|$ in solid line.

4. CONCLUSIONS

In this paper, a new easy and quick design technique to embed bends in classical corrugated waveguide low-pass filters has been proposed. This avoids cumbersome sub-assemblies reducing the insertion loss, weight, and PIM in ground terminals and multi-beam payloads. The proposed technique has been proved with a 17th-order Zolotarev bent filter whose frequency response measurements are very close to the simulated and targeted ones.

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