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Research Article

Spatial Qualification Tests for Highly Selective Compact Micromachined Band Pass Planar Filters

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A highly selective planar band pass filter is proposed for satellite receivers to suppress intermodulation components. The 4-pole filter has a center frequency of 19.825 GHz with a bandwidth of 240 MHz. The measured quality factor is over 600 and the insertion losses are 4.1 dB. The micromachining technological process is used to fabricate this filter. A BCB (benzocyclobutene) thin layer is used as an electrical and mechanical support for the filter. The compatibility of the BCB with the spatial constraints was tested. Various tests were accomplished for this purpose and the results of all these tests are presented in the paper. The tests showed a very small influence of the temperature variation and high temperature storage test and practically no influence of the radiation test on the circuit.

1. Introduction

Today's world is a vast network of global communication. Technology has improved the way in which human beings communicate and transfer information. Although a number of different technical developments have contributed to this improvement, it can be argued that the technology of wireless communications has had a greater impact on modern communications than any other single technology. Wireless industry is the subject of various research works for different applications [1, 2]. The use of satellite systems is one way to achieve wireless communication [3]. In these systems as in all wireless systems, it is very important to achieve very compact and low-cost components. To reach these goals, the choice of the technology is very important. Wireless devices have clearly benefited from the utilization of integrated circuits in many ways, most notably their size and thus portability. The objective of this work is to fabricate compact filters for suppression of intermodulation products in satellite receivers.

Planar circuits are very good candidate in terms of size and cost. But at high frequencies, they suffer from important dielectric and radiation losses. Micromachining [4–8] consists of etching a substrate to form cavities and waveguides. These formed elements could be used to design filters in volumetric [9, 10] or in planar topologies [11, 12]. The micromachining process associated with cavity assembly allows the resolution of planar circuit problems and thus working at higher frequencies [12] which also means better rates of transmission of the system. In this case, the circuit is deposited on a thin dielectric BCB layer [11–13] which is newly used in spatial applications and needs to be tested for compatibility.

2. Filter Topology, Technology, and Measurements

The designed filter has to meet very strict specifications which are center frequency $f_0 = 19.825$ GHz, bandwidth = 240 MHz, and very high rejections equal to 50 dB. To achieve

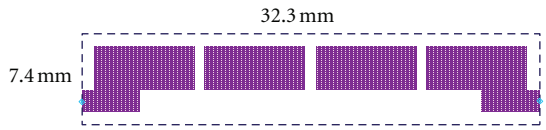

Figure 1: The four-pole filter topology.

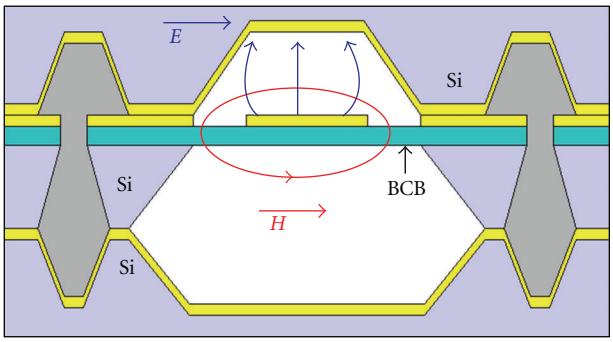

Figure 2: Cross-view of the filter.

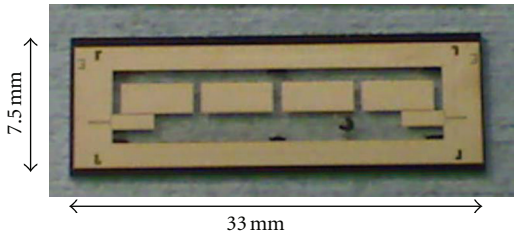

Figure 3: Top view of the membrane suspended filter.

Figure 4: Top view of the shielded 4-pole filter.

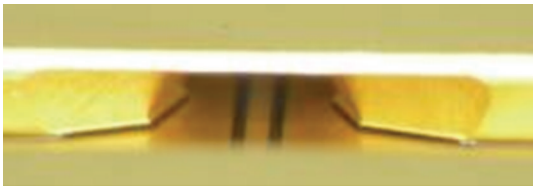

Figure 5: CPW access of the filter.

this narrow band, a high quality factor (over 600) is needed. That is why micromachined planar filter topology is a good option. The width of the resonators and the height of the cavity have been chosen to ensure a high quality factor. Four resonators are needed to obtain a rejection of 50 dB, close to the bandwidth. A top view and the dimensions of the proposed filter are shown in Figure 1.

The filter is composed of a high resistivity silicon substrate, a BCB thin layer (8 μm) with the following characteristics $\varepsilon_r = 2.31$ and $tg\delta = 10^{-3}$. The metallic resonators and feeding lines are in gold (3 μm thick). The filter is composed of 3 silicon wafers which are micromachined using a TMAH solution. The top and bottom wafers are assembled on the central wafer to shield the structure and remove radiation losses. The upper cavity height is 425 μm and the lower one is 760 μm. Propagation is then in air enabling high quality factor which has been measured around 600. Figure 2 shows a cut view of the filter.

Figures 3, 4, and 5 show, respectively, the filter before packaging, the shielded filter, and the CPW accesses (used for the measurements).

Figure 6 shows the comparison between simulations and measurements.

The measurements are very close to the simulations in terms of bandwidth (240 MHz) and central frequency (19.825 GHz). The rejection level required is also verified. The measured insertion losses (4.1 dB) are in coherence with the simulated losses if we add the losses due to the access lines to the simulated ones (1 dB).

3. Spatial Tests

Spatial tests are necessary to check the capability of such filters to be used in geostationary satellite systems. The different performed tests and results are described in the following subsections. The tests are based on applicable standards for integrated components in geostationary satellites.

3.1. Temperature Test. Some of the most interesting features of the filters are its thermal behavior. In Figure 7, the measured S parameters of the filter at 35°C and 65°C are compared. The difference is not very significant; a shift lower than 10 MHz is obtained. The corresponding standard is ESA PSS-01-612/Mil STD 883—Method 1004. The test is also called moisture resistance test.

3.2. Radiation Test. The second test is a radiation test which consists of hitting the circuits with gamma rays of high energy using an accelerator. This test shows that there is no influence on the filter due to radiation as shown in Figure 8.

3.3. High Temperature Storage. The last test is a high temperature storage (HTS) test which means that the device is stored at 125°C during 2000 hours. The corresponding standard is ESA PSS-01-612/Mil STD 883—Method 1008, "B." The HTS test is used to determine the stability of the device in high temperature environment.

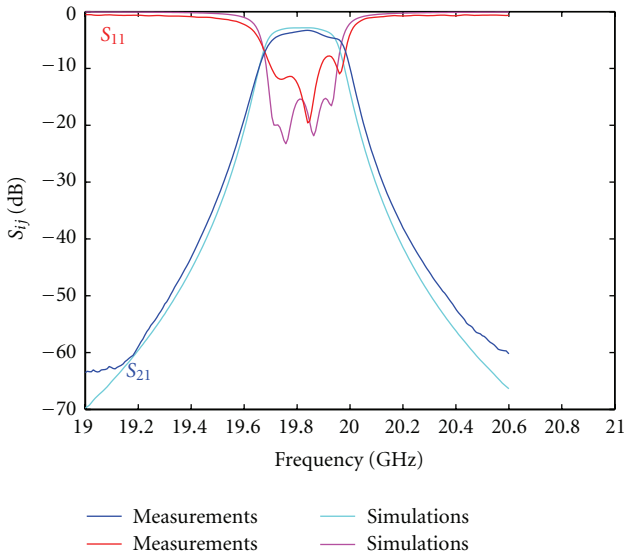

Figure 6: Comparison of the measured and simulated S parameters.

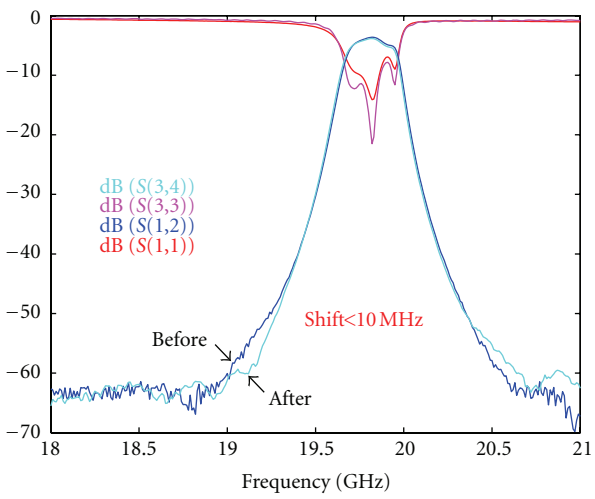

Figure 7: Measured influence of the temperature variation on the S parameters of the filter.

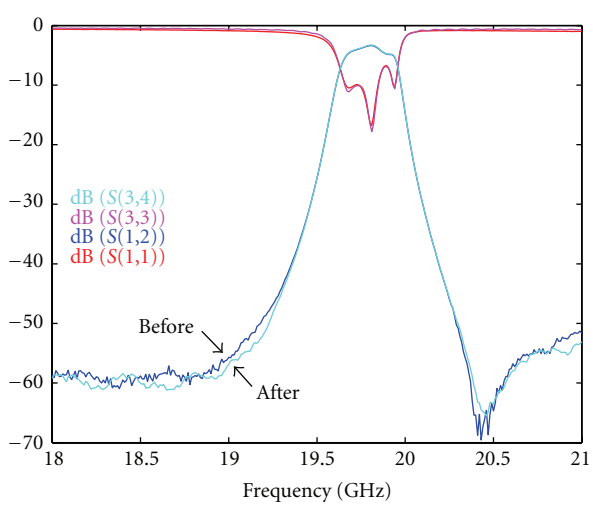

Figure 8: Measured influence of the radiation test on the filter.

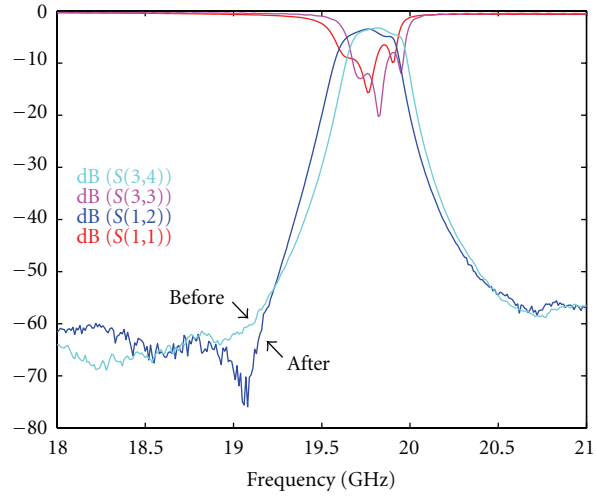

Figure 9: Measured influence of the high temperature storage of the filter.

This test causes a shift of 80 MHz in the filter response as shown in Figure 9. This shift could be taken into account for new fabrications.

4. Conclusion

In this paper, we have presented the design of a four-pole micromachined filter. Measurements and spatial tests have been performed on this filter. Very good measurement results have highlighted the behavior of BCB micromachined band pass filter for wireless applications.

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