8-POLE SUPERCONDUCTING QUASI-ELLIPTIC FUNCTION FILTER FOR MOBILE COMMUNICATIONS APPLICATION

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ABSTRACT

This paper presents recent developments of an 8-pole planar high temperature superconductor bandpass filter with a quasi-elliptic function response. A novel planar filter configuration that allows a pair of transmission zeros to be placed at the band edges is described. The miniature filter has a bandwidth of 15 MHz at a centre frequency of 1777.5 MHz it is designed for mobile communication base station applications. The filter is fabricated using double sided YBCO thin film on an MgO substrate of size 0.3x22.5x39mm. The preliminary results are presented.

INTRODUCTION

There is currently considerable interest in using high temperature superconducting materials for the construction of high performance filters for mobile communication applications [1]-[7]. However, most of the work has been for systems in the USA, here we present the first report on a filter designed for a European system. The receive filter is designed for the DCS1800 standard, which covers the frequency range 1710 MHz to 1785 MHz. The filter is designed to cover a 15 MHz sub-band of this frequency range as shown in Figure 1. Figure 1 also shows how the use of superconductors benefits the filter; providing low insertion loss and very steep roll-off at the filter band edges. Further discussion of the benefits of HTS to DCS1800 systems can be found in [8]

This filter is designed within a European consortium sponsored by the European Commission. It involves a number of companies (GEC-Marconi, Thomson CSF and Lybold) and two Universities (Birmingham and Wuppertal). The program acronym is *SUCOMS* and it is funded through the Advanced Communications Technologies and Services (ACTS) program. The objective of the program is to construct a HTS based transceiver for mast mounted DCS1800 base stations. The filter described here is one of two designs for front end filtering on the receive side. More details of the program can be found in [8]

8 POLE QUASI-ELLIPTIC FILTER

The majority of the reported HTS filters exhibit chebyshev's response, here we present a elliptic response filter. An 8-pole quasi-elliptic function filter meets the requirements of the filter specification for the base station. Elliptic function filters are particularly interesting because they have steep roll-off's at the passband edge. They are characterised by transmission nulls close to the band edge, the position of which can be adjusted in the design. Figure 2 shows the ideal frequency response of the 8-pole quasi-elliptic function filter. For a resonator Q of 50,000 the minimum insertion loss is predicted to be almost 0.1dB whilst this extends to 0.4dB at the band edges. From the wider band response the first sidelobe appear at a level of –38dB.

The layout of the filter is shown in Figure 4. It consists of eight microstrip meander open-loop resonators. The configuration of the resonators allows both electric and magnetic coupling. To design the filter the coupling coefficient matrix required to obtain the required filter response is calculated analytically [11] and then the coupling coefficients are determined by full-wave analysis software. Figure 3 shows the calculated frequency response of the final filter using full-wave analysis software. Note that because of the complexity of the filter structure that a cell size of only 0.05mm was used. This means that the filter dimensions entered for the simulation were rounded off to a precision of 0.05mm. Nevertheless, the full-wave simulated response does verify the design approach.

The superconducting filter is produced using $YBa_2Cu_3O_7$ thin film HTS material. This is deposited onto a MgO substrate that is 0.3x39x22.5mm and had a dielectric constant of 9.65. The size of the packaged filter is 2”x1.5”x0.5”, considerably smaller than similar filters using any other technology.

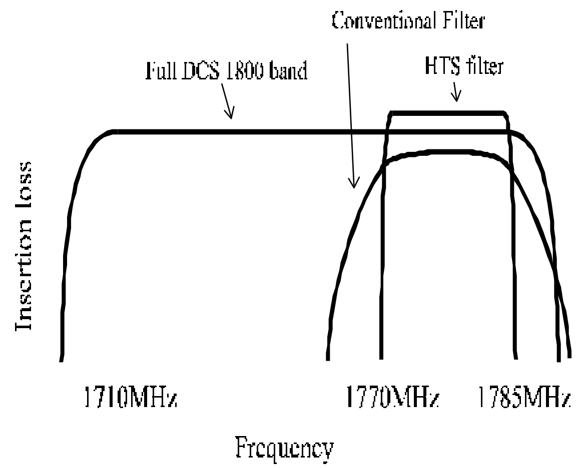

Figure 1: Diagramatic repersentation showing the effect of using an HTS recieve filter in a DCS1800 sub-band.

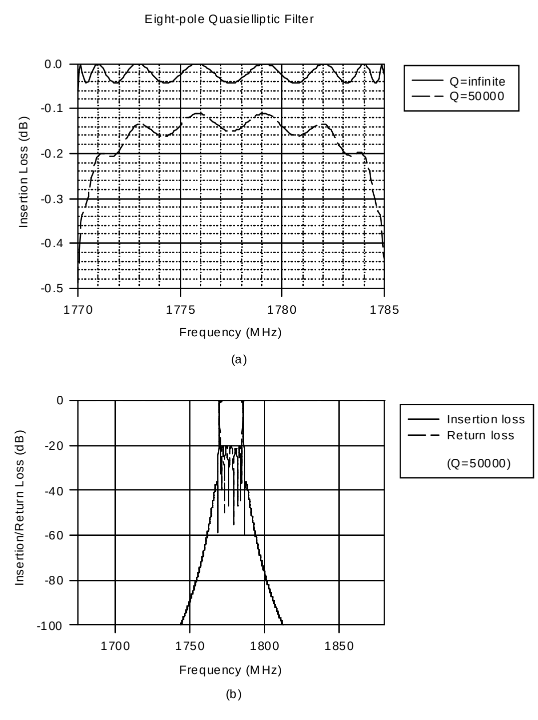

Figure 2: The calculated frequency response of an 8 pole quasi-elliptic function filter. (a) Passband (b) extended band.

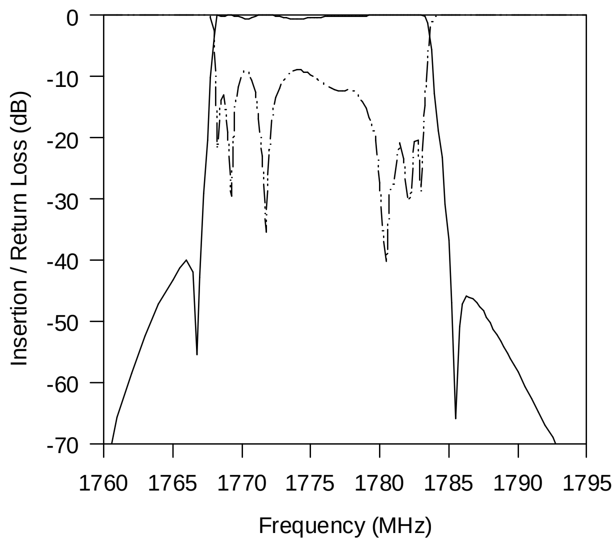

Figure 3: Filter response modelled with full-wave simulator.

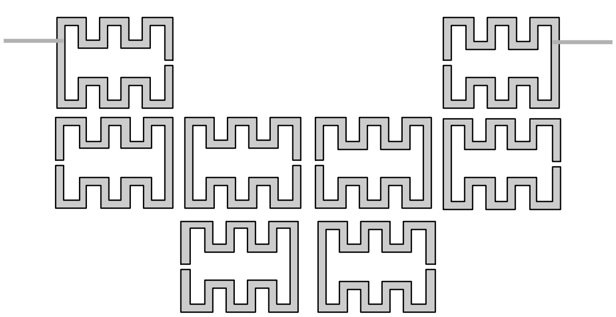

Figure 4: A microstrip 8-pole quasi-elliptic function filter using meander open-loop resonators.

EXPERIMENTAL RESULTS

Figure 5 shows preliminary experimental results of the superconducting filter, which was measured in liquid nitrogen at 77K after tuning. The filter shows the characteristic of the quasi-elliptical response with two diminishing transmission zeros near the passband edges. The two transmission zeros result in a sharper filter shirt so as to improve the selectivity of the filter. The tuning is necessary because of a variation in substrate thickness, which has a considerable impact on the performance of narrow band filters. It can be shown that if the substrate thickness has a variation of ±10um, which is about the tolerance of the substrate used, the resonant frequency shifting of the meander open-loop resonators is about ±7MHz. This makes the resonators asynchronously tuned and results in a weaker coupling between coupled resonators. As a consequence, large ripples in the passband occur. To tune the filter, the package for the filter has sixteen tuning screws appropriately positioned.

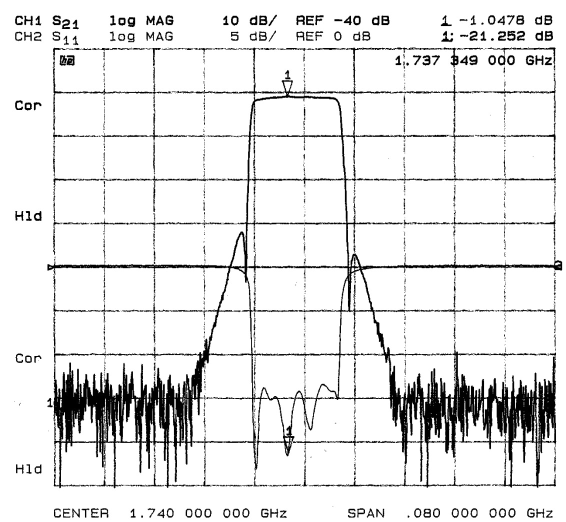

Figure 5 : Frequency response of the superconducting DCS1800 filter in liquid nitrogen at 77K.

The wider band response shown in Figure 6. The latter shows that spurious responses do not occur up until about 3GHz. this stopband range is more than adequate for our applications.

This filter is designed for the receiver and is required to handle a maximum input power of 0dBm. Experimentally, it was found that even for a input power of 5dBm, the frequency responses of the filter do not change.

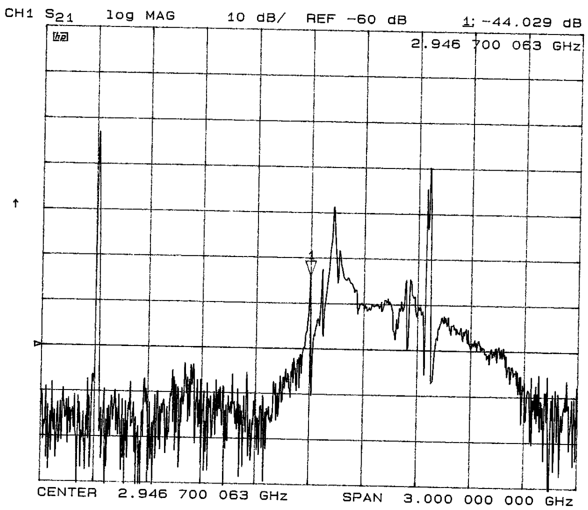

Figure 6: Spurious response of the filter.

CONCLUSION

We have presented recent developments of an 8-pole planar HTS bandpass filter with a quasi-elliptic function response. We have introduced a novel filter configuration that allows a single pair of transmission zeros to be realised and miniatures the size of filter. The preliminary measured responses of the filter have been demonstrated. It is shown that the excellent performance and the small size of the filter presented make it hold promise for mobile communications application.

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