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AN HTS FILTER SUBSYSTEM FOR 800MHz MOBILE COMMUNICATION SYSTEM

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In this paper, we present a high temperature superconducting (HTS) Filter subsystem, which consists of a 14-pole HTS filter, a low noise amplifier (LNA), a Stirling Cooler and an electronic control system. The HTS filter has a 2.1% fractional bandwidth at 814MHz. It was fabricated on MgO substrate which was double sides coated with YBCO thin films. The insertion loss of the HTS filter is less than 0.2dB, the gain of the subsystem is 22dB at 60K. In this subsystem, the out-of-band rejection is better than 70dB and the steepness of the band-edges is larger than 25dB/MHz at 60K.

Keywords: HTS filter; LNA; subsystem; mobile communication system.

1. Introduction

Along with the development of Mobile Communication, the existing mobile communication network has limitations in the capacity and its service quality comes down correspondingly.[1] The high temperature superconducting (HTS) filter has lower insertion loss, larger band-edge steepness and higher out-of-band rejection than normal filter.[2,3,4,5]The noise figure of low noise amplifier (LNA) at 77K is much lower than that of normal amplifier. The HTS Filter receive subsystem can significantly improve the sensitivity and the selectivity of the mobile communication base stations. It can benefit Mobile Communication System networks with increased capacity, coverage efficiency and data transmission rates.

In this paper, we describe the design and the measurement of a 14-pole HTS filter for 800MHz Mobile Communication System application. Combining HTS filter with an LNA in a Stiring Cooler, we assembled a receiver subsystem which shows a good performance.

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2. HTS Filter Design and Test

We designed a 14-pole HTS band-pass filter on an MgO substrate with thickness of 0.51mm. The relative dielectric constant ε_r of the substrate is 9.7. The central frequency of the HTS filter is 814MHz and the bandwidth is 17MHz.

The HTS filter which was made up of a parallel array of half-wavelength resonators was designed based on Chebyshev-prototype. In the design process, the resonator configuration, the adjacent resonators gaps and the position of input and output feed-lines should be determined. We used EM software *Sonnet* to simulate the resonant frequency of a single resonator, the coupling coefficients between resonators and external quality factor.

The resonator configuration should be determined first. The corresponding half-wavelength at 814MHz is actually more than 70mm. To keep the filter frame within a 2 inch MgO substrate, we created a resonator named doubly-folded micro-strip line resonator. The resonator has only 1.5mm width and 22mm length, which is less than one third of the half-wavelength. But the configuration of resonator has a problem that we have difficulty to find out the position of the input and output feed lines according to 50Ω characteristic impedance and the external quality factor, so we changed the first and the last resonator configuration to match the external quality factor. The couplings between non-adjacent resonators are very weak, so the layout of the 14-pole filter can be determined based on Chebyshev prototype only considering the couplings between the neighboring resonators.[6] After the initial values of the filter parameters were determined, we had to adjust some parameters to get a satisfactory filter response. This adjustment was necessary because of the parasitic coupling which is quite weak but not zero. The optimized simulated filter response is shown in Fig. 1. As the figure shows, there are transmission zeros at band edges. These transmission zeros are the result of the galvanic couplings of the input and output feed lines to the first and last resonator, respectively.

The filter was fabricated using double-sided YBCO film which was deposited on a 38.2mm × 30.5mm × 0.51mm MgO substrate and packaged in a copper shield box. Its frequency response was measured by Agilent 8720/ES network analyzer as presented in Fig. 1, the solid line shows the measured characteristic of the filter at 60K and the dash line shows the simulated response of the filter. The measured result shows that the pass-band is about from 805.5MHz to 822.5MHz, the insertion loss is less than 0.2dB, the out-of-band rejection is better than 70dB and the steepness of both band edges is larger than 25dB/MHz at 60K. It shows an excellent consistency between the measurement and the design.

3. HTS Subsystem Performance

We manufactured an 800MHz Mobile Communication HTS filter subsystem, which mainly consists of the HTS filter, a 22dB gain LNA and a Stirling Cooler. The filter and LNA were connected and mounted on a cryogenic platform, which were connected to the cold head of a Stirling Cooler and enclosed in a dewar. The subsystem

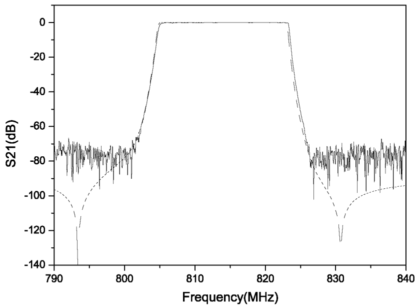

Fig. 1. Responses of the measured and simulated result of the 14-pole HTS filter.

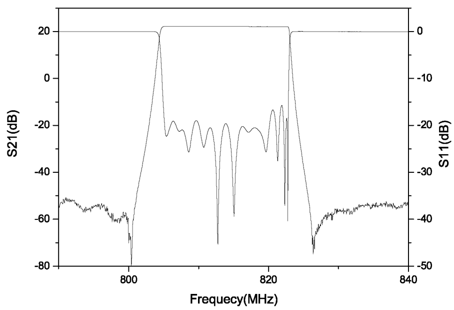

Fig. 2. Measured performance of the HTS subsystem.

was operated at a temperature of 60 K. In order to keep good heat exchange between the HTS filter and the Stirling Cooler, and good thermal isolation between inside and outside of the dewar, we packaged the subsystem as reported in our preview work.[1,7]

We used Agilent 8720/ES to measure the frequency response of the subsystem. Fig. 2 shows that the gain in the pass-band is about 22dB with a good flatness. The parameter of S11 in the pass-band is better than -15.7dB. The out-of-band rejection is better than 70dB, and the steepness of both band edges is larger than 25dB/MHz. The subsystem shows high selectivity at both sides of the band-edge. Fig. 3 shows that the voltage standing wave ratio (VSWR) is less than 1.4 from 805.5MHz to 822.5MHz. We used Agilent N8773A noise figure analyzer to measure the noise figure (NF) of the HTS subsystem. Fig. 4 shows that the noise figure (NF) of the HTS subsystem is about 0.7dB at work frequency, the result shows that the subsystem has a high sensitivity.

4. Conclusion

In this paper, we used doubly-folded micro-strip line resonators to design a 14-pole HTS filter for an 800MHz mobile communications. The central frequency and the fractional of the filter are 814MHz and 2.1% respectively. The measured insertion loss of the filter in the pass-band is less than 0.2dB at 60K. The assembled HTS subsystem including the HTS filter and a LNA shows a flat low noise figure of 0.7dB in the pass-band and high steepness of the band-edges which is larger than 25dB/MHz.

Acknowledgements

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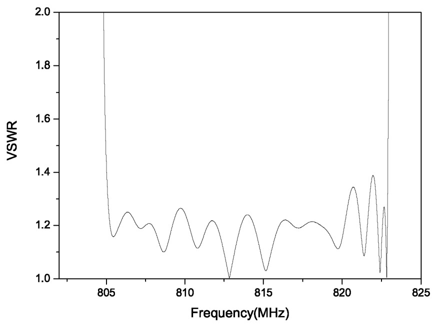

Fig. 3. Measured VSWR of the HTS subsystem.

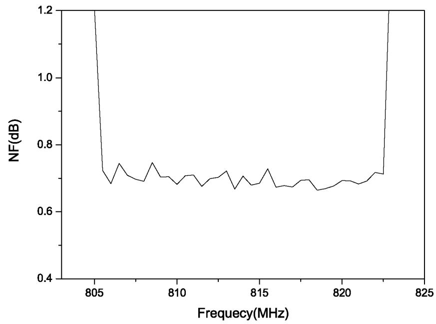

Fig. 4. Measured Noise Figure of the HTS subsystem.

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