Design of Superconducting On-chip Frequency Multiplexers for a Low-noise Multiband Receiver

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Abstract— **We describe a design of superconducting frequency multiplexers for a wideband heterodyne low-noise receiver.**

I. Introduction

Over the next decade, one of the most important development for radio astronomy in regions of millimeter wave to terahertz wave is ultra-wideband low-noise receivers which can simultaneously observe on a whole atmospheric window. For the current highly-sensitive heterodyne receiver system such as the ALMA, bandwidth for instantaneous observation is below twenty percent of radio frequency (RF) bandwidth Δf_{RF} even for sideband separation and dual polarization modes. In order to realize simultaneous observation close to 100 % of Δf_{RF}, development of wideband low-noise amplifier with bandwidth of several tens of gigahertz will be necessary. However, it is difficult to make wideband amplification keeping the lowest noise temperature.

We propose a concept of a multiband receiver system by dividing the RF band into several number of bands (Fig. 1). In the system, RF signals are divided into several bands by a frequency multiplexer, and then, are input into the individual SIS mixer. Multi-frequency local oscillator (LO) power with an interval corresponding to that of RF bands is injected into the receiver, and then, are divided into individual band by the LO filter bank to operate them simultaneously. Down-converted signals are amplified with individual IF amplifier covering the RF bandwidth.

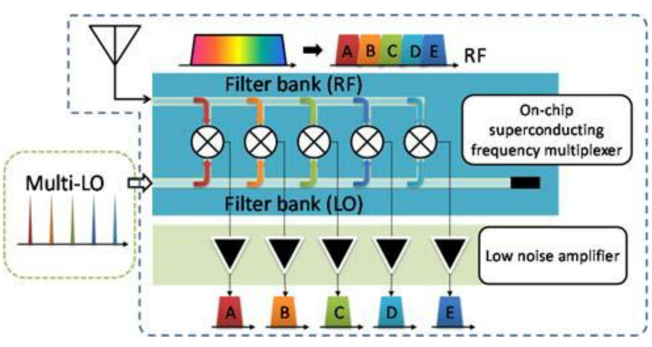

Fig.1 Concept of a multiband receiver system

For the purpose of experimental proof, we are designing a 4-band receiver with 20-GHz bandwidth for each band in RF 380-500 GHz. In this system, key technologies are frequency multiplexer, wideband amplifier, and high power frequency comb generator. In this paper, we focus on a design of the multiplexer. There are various existing designs for the frequency multiplexer based on a quasi-optical or on-chip filter. We chose to use on-chip frequency multiplexers for RF and LO circuit, because compact and simple solution to develop complex system can be achieved. In addition, since the superconducting filters should be able to sharply define the bands because of low loss, the multiplexers are expected to achieve multiband system having few frequency gap between the bands. Figure 2 show the S-parameter of the designed multiplexer based on ideal *L* and *C* elements, and transmission line. The circuit consists of Nowton's frequency divider using low and high pass filters to roughly divide the bands and Chebyshev band pass filters to sharply define the band. The simulation reveals that improper a length of the transmission line among the filters makes the filtering performance degrade due to influence from the out of bands of the other filters. In a practical circuit, careful design will be needed. In this presentation, we will describe the multiplexer design and the capability of the multiband receiver system.

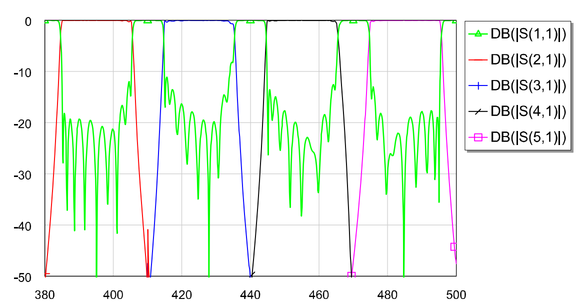

Fig.2 Simulated S-parameters of a multiplexer based on ideal *L* and *C* elements with a two-dimensional circuit simulator.