Development of an RF Waveguide Frequency Multiplexer for a Multiband Heterodyne System

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The Atacama Large Millimeter/submillimeter Array (ALMA) is the most powerful ground-based radio telescope. The ALMA telescope uses ultra-sensitive cartridge-type heterodyne receivers. The instantaneous bandwidth of the ALMA for Bands 3 to 8 (except for Band 5) is currently 4 GHz per sideband and polarization, which is limited by the amplifiers in principle. Recently, although microwave low-noise cryogenic amplifiers with wide bandwidth exceeding 10 GHz have been developed, the instantaneous bandwidth is still limited if compared with the radio frequency (RF) bandwidth, especially at the higher frequency bands. The purpose of this study is to increase the instantaneous bandwidth, focusing on a front-end receiver system. The system proposed introduces the concept of a multiband receiver which consists of two multiplexers, one for dividing the full RF band into smaller bandwidths, and the other to separate the tones in a multi-frequency local oscillator (LO) signal. Each of the smaller bandwidth RF signals and the corresponding LO tone are injected into individual dedicated SIS mixers. The resulting down-converted signals will be in the same IF bandwidth and can be simultaneously amplified with dedicated similar IF amplifiers. This allows down-converting the full RF bandwidth at once, which translates into ultra-wideband operation.

This paper will describe the concept design of the multiband heterodyne receiver system in the 380-500 GHz band. We will also present the design of a waveguide RF multiplexer with 25 GHz bandwidth for each channel. The 25 GHz bandwidth has been chosen because it corresponds to the state-of-the-art bandwidth of current IF amplifiers. The designed multiplexer has no frequency gap between channels. This is done by using a hybrid-coupled multiplexer, which is composed of two identical 90 degree hybrid couplers and two identical filters. Waveguide iris coupled bandpass filters and 3-dB blanch-line couplers were used for the multiplexer. Full-wave simulation results will be compared with measurements.

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