67-116 GHz receiver development for ALMA Band 2+3

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Abstract— The ALMA telescope is already a functional instrument delivering great science. However, it is not equipped with all receiver bands, and particularly band 2 has not been approved for construction yet. Recent technological developments in cryogenic MMICs open an opportunity to extend the originally planned bandwidth of this receiver (67-90 GHz), and potentially combine the two ALMA bands 2 and 3 (84-116 GHz) within a single receiver.

In this paper we report the design and first test results of the ALMA system compatible wideband 67-116 GHz receiver. Two types of the optics, feed horns and OMTs, have been designed to couple to the ALMA telescope beam using a modified Fresnel lens. Both types of hardware have been manufactured and tested in a near field beam scanner. The measured beam patterns and optical efficiencies are compliant to ALMA specifications and in good agreement with simulations.

The receiver system uses cryogenic low noise amplifier (LNA) at its input, developed using the state-of-art 35 nm gate length InP HEMP process of NGC. The MMIC design process was performed with individual simulation of the different matching networks using the electromagnetic (EM) simulator Momentum; a tool included with the Keysight ADS package. The best LNAs tested so far show a noise temperature less than 28 K from 70 GHz to 110 GHz at cryogenic ambient temperature of 20 K.

The amplified by the LNA signal is frequency translated (down converted) to the ALMA intermediate frequency (IF) range of 4-12GHz. The down-convertor comprises a Schottky barrier based subharmonic sideband separating mixer, local oscillator (LO) and IF amplifier chain. Design simulations indicate the expected mixer noise and conversion loss performance to be approximately 1000K (SSB) and -8dB respectively for a typical LO power level of +8dBm.

A fully compatible to ALMA electrical and mechanical interfaces, cartridge type cold receiver has been designed and built to accommodate receiver optics and LNAs, while the downconverter is located in the warm cartridge assembly at room temperature. The system has been assembled and its characterization is currently underway, results of the measurements will be reported at the Conference.