A broadband down-conversion module for the extended W-Band

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***Abstract*—We have developed a broad band receiver module in the extended W-band (70 - 116 GHz). The module is a sideband separation receiver based on a high-frequency amplification stage followed by a broadband downconverter. A general description of the architecture will be presented describing its most important components. Some of its more important figures of merit will be discussed.**

***Index Terms*—Microwave integrated circuits, Multichip modules, Frequency conversion, Microwave mixers, Low-noise amplifiers, Focal plane arrays, Multi-beam systems.**

I. Introduction

Interest in constructing focal plane arrays (FPAs) has been growing over the last years. The potential of synchronous/ simultaneous detection using a large number of receiver elements make them very interesting for applications such as radio-astronomy, millimeter wave imaging systems, satellite communications and Earth remote sensing [1].

We have focused our work in the design and construction of compact down-converters modules in the band from 67 to 116 GHz, equivalent to a fractional bandwidth of 53%. This frequency range is motivated by several astronomical projects, including the Atacama Large Millimeter Array (ALMA) [2] but multiple non-astronomical systems can benefit from such large bandwidth and feasibility of integration in large imaging systems. These modules are designed with a scalable and compact architecture and good input return loss that allows easy integration into large systems.

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II. Module Design and Construction

The general design of the module is shown in figure 1. The input stage of the module is a quadrature hybrid implemented in WR10 waveguide with the isolated port terminated in a waveguide load. Each signal is amplified by a commercial MMIC low noise amplifier (CGY2190 of OMMIC) with a gain of 20dB and a noise of 2.8 dB. The signal is then down-converted using sub-harmonic mixers which were designed by us and built in MMIC technology using the GaAs Schottky diodes process from UMS, this process has shown good performance in W-band [3]. Previous measurements of the mixers show conversion loss lower than 15 dB when driven by a 5 dBm local oscillator (LO) source. The output IF signal have a broadband IF range of 0-12GHz. The LO signal required by the down-converter is delivered by a Wilkinson divider followed by a lowpass filter that acts as controlled termination for RF signals leaking into the LO path.

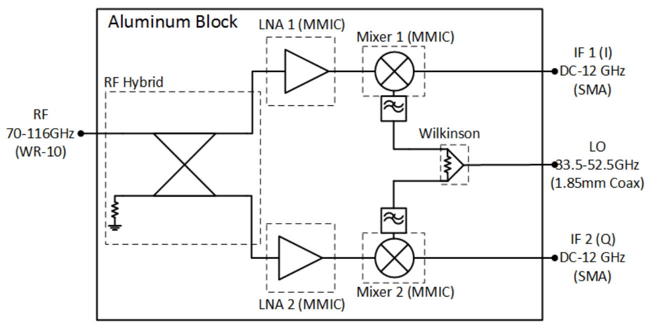

Fig. 1. Proposed broadband downconverter architecture. The input quadrature coupler allows the module to be used as sideband separation mixer. The first amplification stage is a 20 dB MMIC from OMMIC. The second stage is the downconverter itself which is implemented as a subharmonic mixer. The LO is distributed using a Wilkinson coupler followed by a LO filter.

The module was built and assembled at our workshop. A picture of the complete module is shown in figure 2. The housing, including the waveguide structures was fabricating by CNC milling on Aluminum 6061. The complete block size is 50mm x 25mm x 20mm. The input RF connector is a rectangular waveguide (WR10) with a standard flange UG387/U. The LO is fed by a 1.85mm connector and the IF outputs corresponds to SMA connectors. The module uses a

15 pin bias connector for the amplifiers.

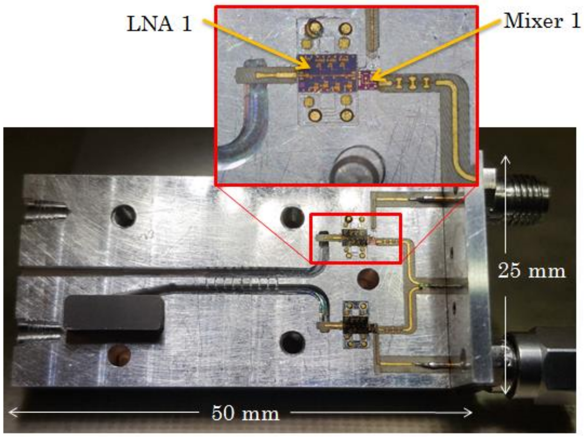

Fig. 9. Picture of the interior of the assembled module. An amplification of the picture shows the LNA and mixer MMICs.

III. Module Measurements

The input return loss for the module was measured and shown in figure 3. The measurements show return loss above 10 dB in the complete band above 70 GHz. Several measurements with different Bias setting for the amplifiers where made showing similar performance. This good return loss allows the module to operate without an isolator.

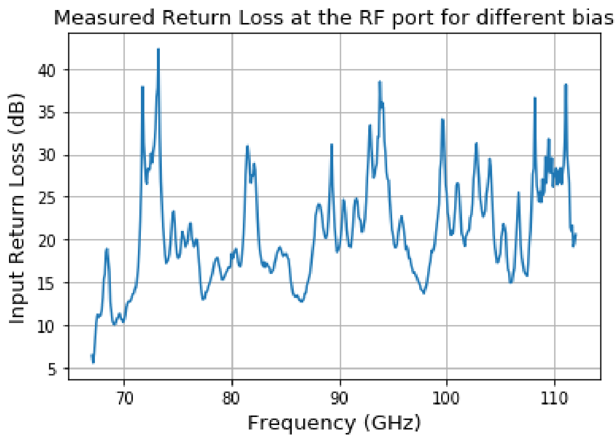

Fig. 3. Measured input return loss of the module for a LO of 40 GHz with and equal bias setting for the two amplifiers.

The block requires an external IF coupler to accomplish with sideband separation. During testing we use a 0.8-4.2GHz unit which limit our IF bandwidth. The operating points of the amplifiers were chosen in order to maximize Side-band Rejection Ratio (SRR), effectively cancelling small amplitude imbalances in the system. SRR > 10 dB has been archived in over 70% of the band. This value could be improved using digital techniques [3]. Figure 4 shows the measured conversion gain in a 2SB configuration. I/Q conversion gain were also measured with the removal of the IF Hybrid.

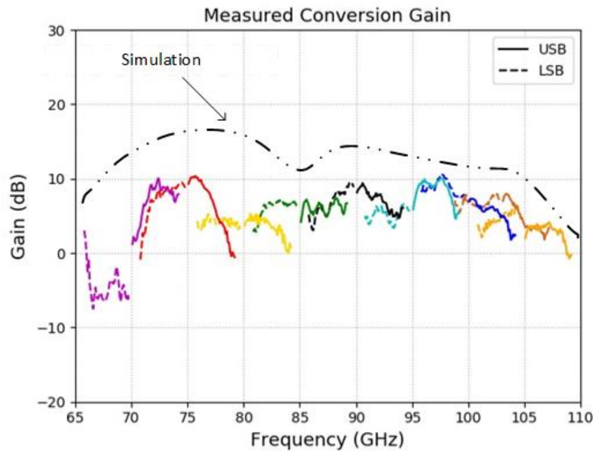

Fig. 4. Measured conversion gain with sideband separation, for a LO frequencies of 35, 37.5, 40, 42.5, 45, 47.5, 50 and 52.5 GHz with an average power of 12 dBm and comparison with the simulation in NI AWR Microwave office.

The results show good performance in the majority of the band. The decrease in conversion gain and return losses at the beginning of the band is due to mechanical constrains in the RF hybrid. Additional measurements of noise have also been made showing an average of ~1500K at room temperature. Additionally, all components of the module had been measured separately at cryogenic temperatures showing no downgrade in performance, so the module should work at cryogenics if necessary.

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