Characterization of a 183 GHz radiometer receiver with heterodyne noise injection calibration system

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***Abstract* — This paper explores the possibility of calibrating a 183 GHz radiometer with noise injection using a heterodyne noise source. The system comprises two mixers with a shared LO source for signal down-conversion and noise up-conversion. A standard 16 dB baseband noise source is used for generating the noise at the IF port before upconversion.**

Keywords—Heterodyne, Noise Source, ENR, Sub-harmonic, Calibration, Sub-millimeter

I. Introduction

Radiometer systems at submillimeter wavelengths usually employ calibration methods with mechanically moving mirrors, switching alternatively the signal to onboard calibration targets and the scene of observation. For space applications where moving parts are always a risk factor, we can use electronically controlled noise injection calibration method as alternative to bulky systems that are sensitive to ageing. Traditional solution to generate noise signals at the RF frequency consists in using noise diodes [1]. In this work, we propose heterodyne noise generation with the advantage of reusing existing mixer designs and frequency scalability, as previously demonstrated in [2].

II. System Description

A block diagram of the radiometer system bench with the integrated heterodyne noise source is shown in the Figure 1 and the implemented test setup in Figure 2. The system is comprised of two sub-harmonic mixers in the 183 GHz band utilizing the United Monolithic Semiconductors (UMS) Schottky diode process [3]. The Sub-Harmonic Mixer (SHM) 2 mixer serves as a down-converter and the SHM 1 as an upconverter of the IF noise signal. A wideband intermediate frequency noise source Agilent 346B with around 16 dB of Excess Noise Ratio (ENR) is used for the IF noise signal. The upconverted noise signal is injected into the receiving system using a 15 dB directional coupler. Due to the same Local Oscillator (LO) feeding both mixers, the noise upconverted by SHM 1 falls into the same frequency band as the receiving band of the SHM 2.

III. Measurement Results

Prior to the noise injection demonstration, the mixers were first individually characterized to determine the optimal LO power levels that yield the best system noise temperature and conversion loss. The LO power levels can be adjusted by the mechanical variable waveguide attenuators. The measured optimum LO power and noise temperature of SHM 1 and SHM 2 are shown in the Figure 3. The SHM 2 was also characterized in a “dual-LO” configuration when the LO signal was split to feed both subharmonic mixers at the same time.

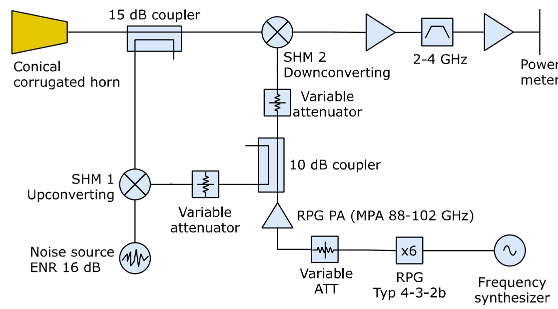

Figure 1 Block diagram of the receiver system

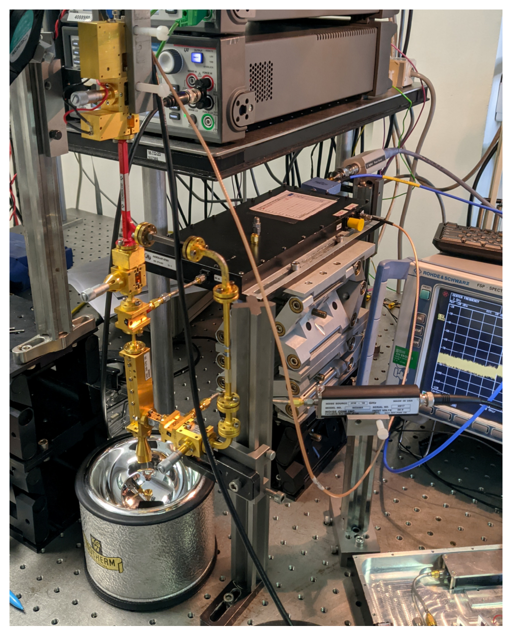

Figure 2 Implemented test setup

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In the subsequent step, we demonstrated a noise injection capability using a heterodyne noise source. For a constant system noise temperature T_{sys} and antenna temperature T_{ant}, injecting the noise can be regarded as if the temperature of the observed target would increase. This manifests as an increase of the detected IF power as well.

Figure 4 shows the measured IF spectra when the heterodyne noise source is ON and OFF at the LO frequency of 183 GHz. The ENR variation of the employed IF noise source in the 2-4 GHz band is 0.09 dB. The measured flatness of the injected noise obtained by subtracting the ON and OFF IF spectra is within the ENR variation of the IF noise source (Figure 5).

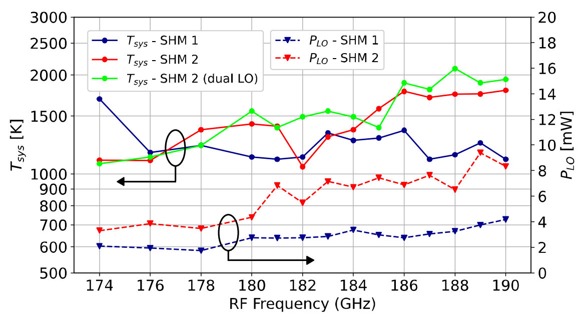

Figure 3 Noise performance of the two subharmonic mixers

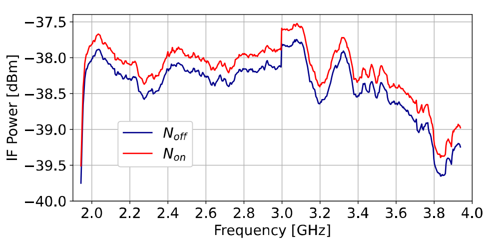

Figure 4 IF frequency spectra with noise source ON and OFF

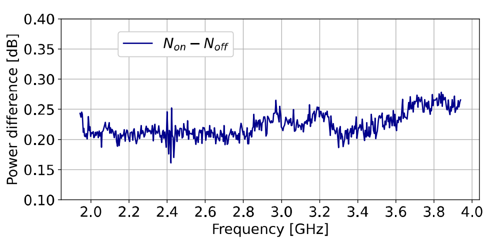

Figure 5 Difference of the ON and OFF IF spectra

IV. CONCLUSION AND FUTURE WORK

We presented measurements of a radiometric receiver in the 183 GHz band with an integrated heterodyne noise source. The employed subharmonic mixers were measured in terms of their noise performance, and we demonstrated a noise injection capability into the receiving system by measuring the IF spectra of the down-converting mixer before and after noise injection. We demonstrated that the flatness of the injected noise was very similar to the flatness of the IF noise source.

In the future, we will focus on characterizing the heterodyne noise source at different RF frequencies and by using IF frequency noise sources with different ENR levels. Furthermore, the stability of the noise source and its adequateness as a calibrator will be determined. Operation at higher millimeter wavelengths will be investigated as well.

ACKNOWLEDGEMENTS

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