500-650 GHz spectrometer development for TELIS

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***Abstract*- We present design and experimental results of the 500 - 650 GHz Superconducting Integrated Receiver (SIR) channel for the Terahertz Limb Sounder.**

I. Introduction

TELIS (Terahertz Limb Sounder) is a cooperation between DLR (Institute for Remote Sensing Technology, Germany), RAL (Rutherford Appleton Laboratories, UK) and SRON (National Institute for Space Research, the Netherlands), to build a three-channel balloon-borne heterodyne spectrometer for atmospheric research [1]. TELIS will utilise state-of-the-art superconducting heterodyne technology and is designed to be a compact, lightweight instrument capable of providing broad spectral coverage: 500 GHz (RAL), 500-650 GHz (SRON-IREE) and 1.8 THz (DLR), with high spectral resolution. First flight is foreseen in April 2007.

II. SIR Design and Phase Locking

A key element of the 500-650 GHz channel for TELIS is Superconducting Integrated Receiver (SIR) [2], which comprises in one 4 x 4 x 0.5 mm^3 chip a low-noise SIS mixer with quasioptical antenna, superconducting Flux Flow Oscillator (FFO) acting as local oscillator and SIS Harmonic Mixer (HM) for FFO phase locking, Fig. 1. The FFO is a long Josephson tunnel junction in which an applied dc magnetic field and a bias current drive a unidirectional flow of fluxons, each containing one magnetic flux quantum. The velocity and density of the fluxons and thus the power and frequency of the emitted mm-wave signal may be adjusted independently by joint action of bias current and magnetic field. As the free-running linewidth of the FFO can be up to 10 MHz, the

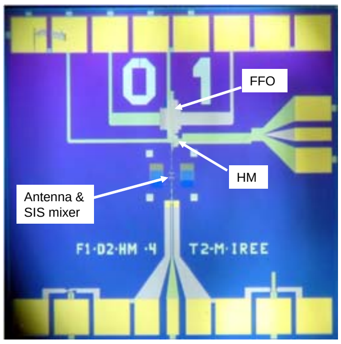

Figure 1. Photo of the SIR chip. Antenna coupled SIS mixer, FFO and HM for FFO phase locking are located on a 4x4 mm^2 chip. FFO, SIS, and HM are connected with microstrip transmission lines, which contain a number of RF-coupling and dc-blocking elements. The SIS mixer and FFO are provided with local magnetic fields via integrated control lines.

FFO is locked to an external reference oscillator, LSU, using a phase lock loop system, Fig. 2. The SIR microcircuits are fabricated on a Si substrate using high quality Nb-AlOx-Nb or Nb-AlN-NbN tri-layer. The receiver chip is placed on the flat back surface of the Si elliptical lens, forming an integrated lens-antenna. A number of off-set reflectors are used to interface the optical beam to the pointing telescope. A 2 GHz wide IF of the SIS mixer is analyzed by a 1000 channel digital autocorrelator.

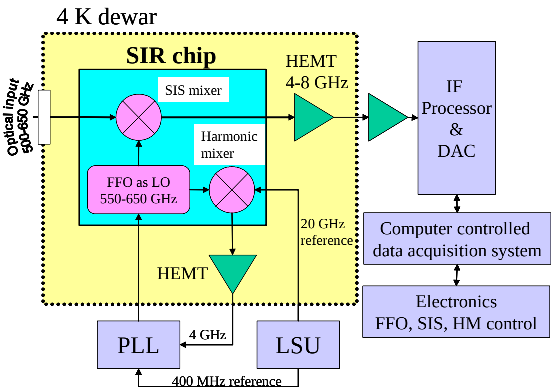

Figure 2. Schematics of the FFO stabilization circuit. FFO frequency is mixed in HM with the harmonic of 19-21 GHz reference. The mixing product is amplified, downconverted and compared with the 400 MHz reference in the PLL. The phase difference signal generated by PLL is used to feedback the FFO control line.

III. SIR Performance

In a representative laboratory setup tests have been conducted on SIR devices. DSB noise temperature below 400 K was obtained in about 100 GHz input bandwidth of the receiver. The IF response is fairly flat in the designed frequency range 5-7 GHz.

To prove capability of the SIR for high resolution spectroscopy we have successfully measured line profiles of OCS gas around 625 GHz. The tests were done in a laboratory gas cell setup at a gas pressure down to 0.2 mBar, corresponding to the FWHM linewidth <5 MHz.

References

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