A Planar SIS Receiver with Logperiodic Antenna for Submillimeter Wavelengths

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We describe a quasi-optical SIS receiver, which is intended to be part of a combined Schottky/SIS system in the submm wavelength range, for the Kuiper Airborne Observatory. The SIS receiver employs a logperiodic antenna and a diffraction limited substrate-lens to couple to the incoming radiation. The antenna's amplitude and phase characteristics were measured at microwave frequencies with a scaled modell (x47) of the antenna-lens combination in the E, H and two diagonal planes. Fig. 1 shows as a representative result the E- and H-plane data taken at 12.4 GHz. From these measurements we calculate a main beam efficiency better than 85 %.

Currently we use single 1.3 μm^2 Nb-Al/AlO_x-Nb junctions fabricated with standard optical lithography techniques [1] giving an ωRC-product of roughly 10 at 345 GHz and 17 at 584 GHz. A lumped inductor is integrated parallel to the junction to compensate the junction capacitance. It is realized by terminating a short piece of superconducting transmission line with a radial stub. The frequency response of the SIS junction with integrated tuner for 345 GHz was measured using the SIS receiver as video detector in a commercial fourier transform spectrometer. The result of this measurement corresponds to resonances that can be found in the DC IV-curves of tuned junctions [2]. We have observed resonances corresponding to frequencies up to 660 GHz in the DC-IV-curve of tuned junctions with lower current density which indicates that the tuning circuit should still work properly up to that frequency.

As a first verification of the system at a lower frequency a heterodyne measurement at 345 GHz was made. An uncorrected DSB receiver noise temperature of 330 K was achieved. We used a Martin-Puplett Diplexer for injection of the LO power supplied by a solid-state source. No further efforts were taken to improve this noise temperature.

At 584 GHz a DSB receiver noise temperature of 900 +/- 70 K has been obtained recently. The conversion loss was measured to be 15.5 +/- 0.5 dB. The IF amplifier had a noise temperature of 6 +/- 0.5 K at 1.4 Ghz, reflection loss at the output of the mixer was around 1.5 dB. All measurements were taken with 60 MHz IF bandwidth. In Fig. 2 the IV characteristic of the junction with applied magnetic field is shown together with the receiver IF output power for hot/cold loads and laser LO power applied at 584 GHz by means of a 25 μm Mylar beamsplitter. The noise temperature is corrected for the measured loss of 20 % of a fluorogold-sheet provisionally placed in front of the cryostat vacuum window at 300 K to avoid supression of the junctions energy-gap by Near-IR-radiation.

An optically pumped far infrared ringlaser developed for the KAO-Schottky system supplied the local oscillator power at 584 GHz using HCOOH as FIR laser gas [3]. An active stabilization loop controls the CO_2 laser frequency [4]. A stability measurement of the overall system was made in the laboratory and is shown in Fig. 3. The upper trace shows

the DC current flowing through the junction versus time for constant voltage bias at 2 mV. It is a direct measure for the LO-power applied to the junction. The lower trace is the corresponding receiver IF-output power for a 295 K load at the receiver input. The vertical jumps on both traces indicate the points where the LO-power was restored by varying the attenuation in the LO-path. The main effect seen is a slow drift in LO power which is mainly due to a leak in the laboratory version of the ringlaser and could be easily removed with an active stabilization loop maintaining constant DC current through the junction [5]. An additional effect adding to the drift is the slow condensation of water on the cryostat window with the current IR blocking of the cryostat.
The measurement indicates the feasability of using a FIR laser as local oscillator source for SIS receivers which will be an important issue at higher frequencies or for arrays.

Acknowledgements

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References

[1] K.-H. Gundlach, T. Lehnert, D. Billon-Pierron, M. Voss, P. Pasturel, "Preparation and properties of Nb/Al SIS and SIN junctions for mm and submm radioastronomical receivers", Proc. of an ESA Symposium on Photon Detectors for Space Instrumentation, pp. 313-316, ESA/ESTEC, Noordwijk, The Netherlands, Nov. 10-12, 1992

[2] T. Lehnert, F. Schäfer, K.-H. Gundlach, "Resonance effects in Josephson tunnel junctions with integrated tuning structures", submitted to the Journal of Applied Physics

[3] H.K.E. Stadermann, P.B. van der Wal, "Research on an optically pumped FIR Ringlaser", Conf. Dig. 16th Intl. Conf. on Infrared and Millimeter Waves, Lausanne, Switzerland, pp. 112-113, August 26-30, 1991

[4] H. Stuer, diploma-thesis, MPIfR Bonn, 1992

[5] S.K. Pan, M.J. Feldman, A.R. Kerr, E.S. Palmer, J.A. Grange, P. Timbie, "Superconducting tunnel junction receiver for 2.6 mm", Conf. Dig. 8th Intl. Conf. on Infrared and Millimeter Waves, M 6.2, 1983

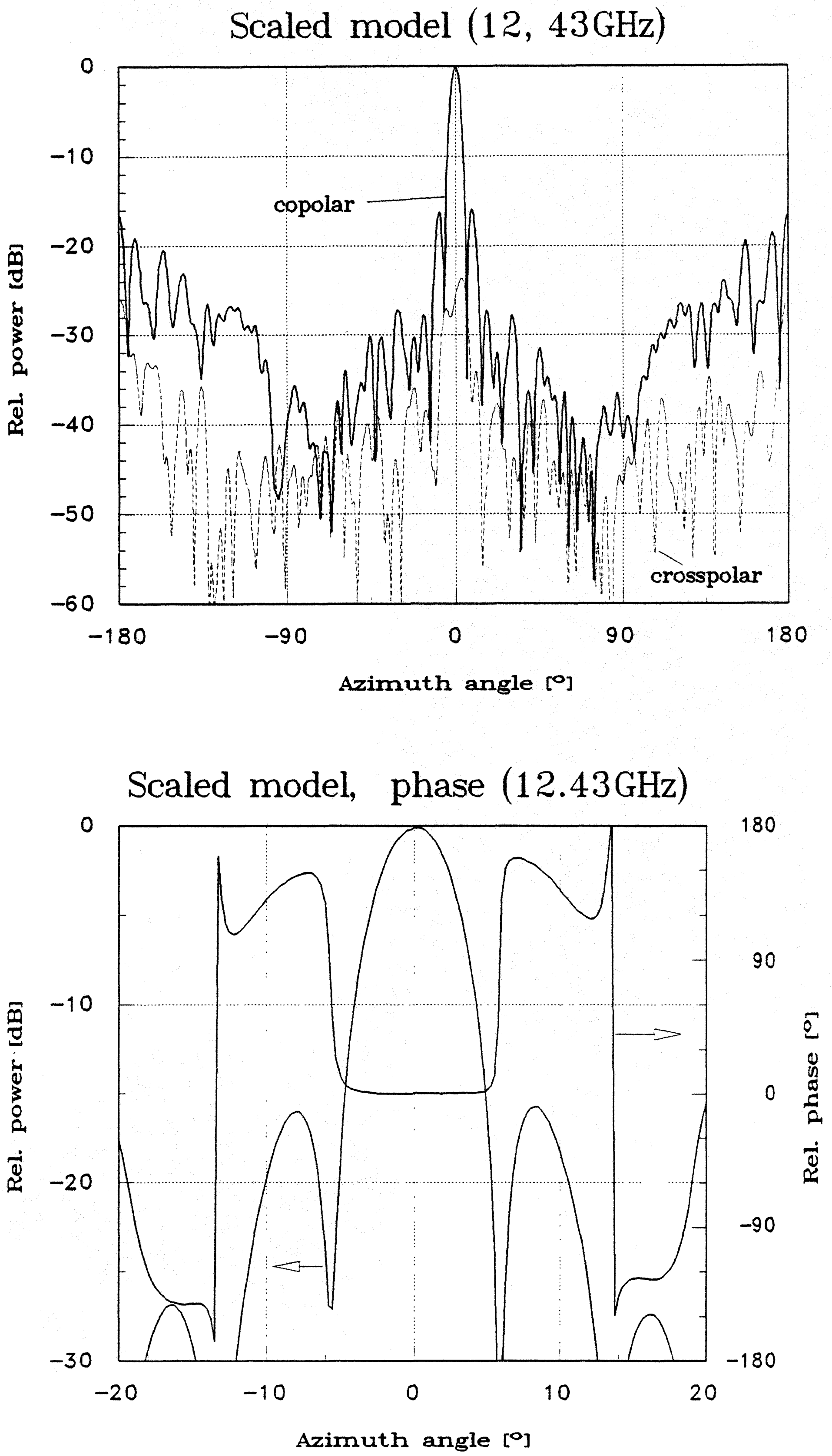
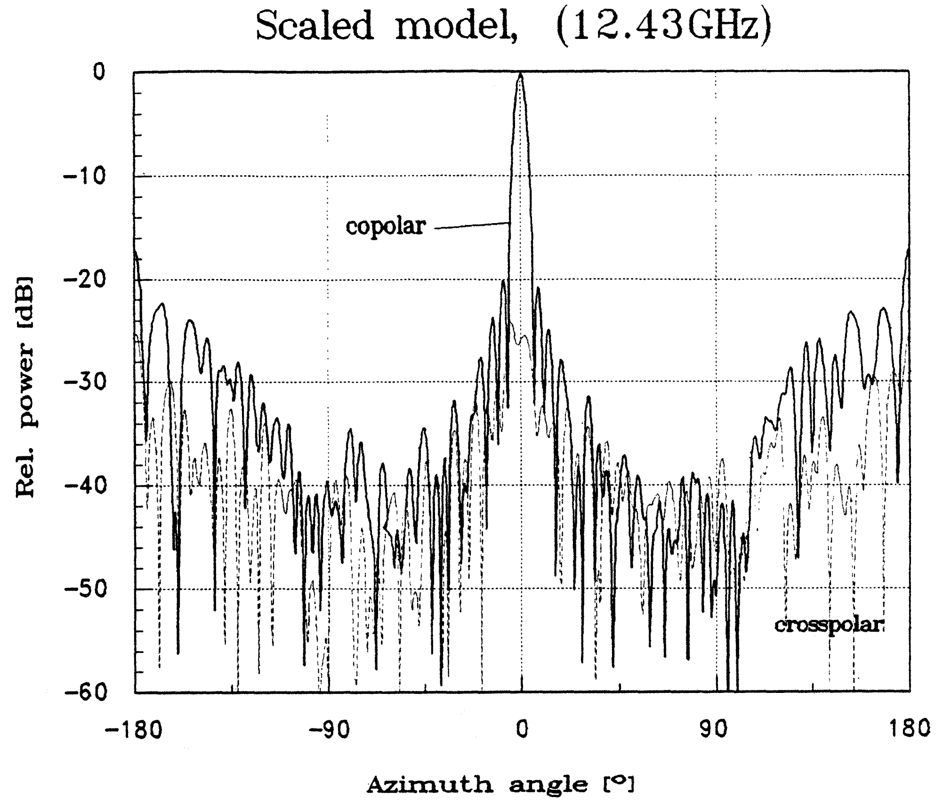


Figure 1a Scaled measurement of the antenna's E-plane characteristic at 584 GHz



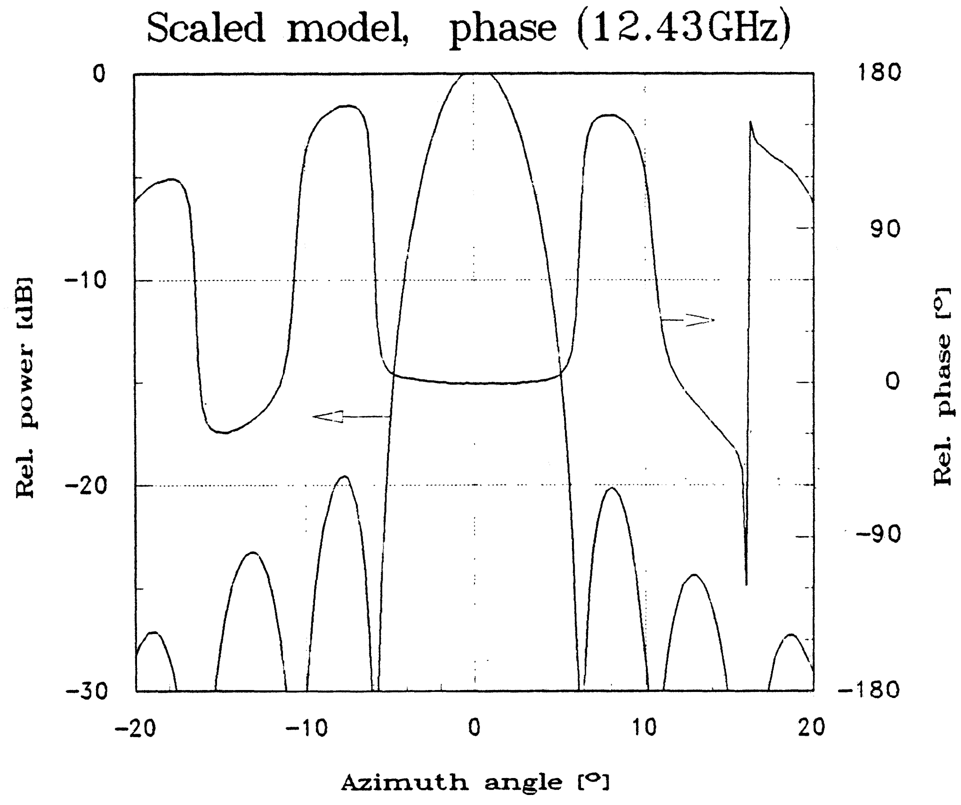


Figure 1b Scaled measurement of the antenna's H-plane characteristic at 584 GHz

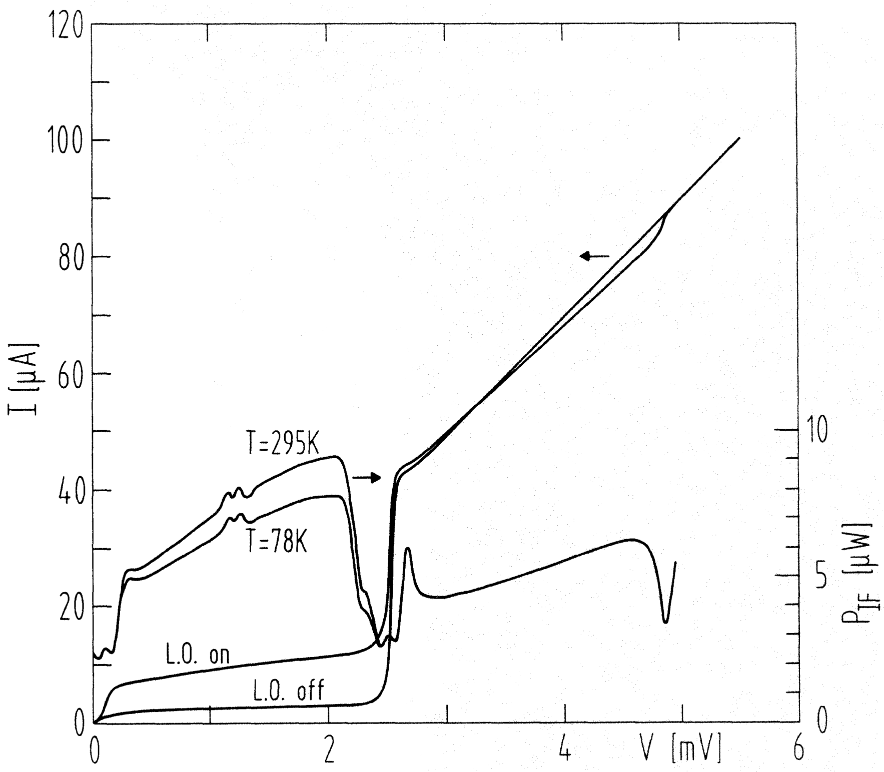


Figure 2 IV characteristic of the junction without and with applied Laser-LO at 584 GHz and receiver IF output for hot and cold loads at the input. A magnetic field is applied.

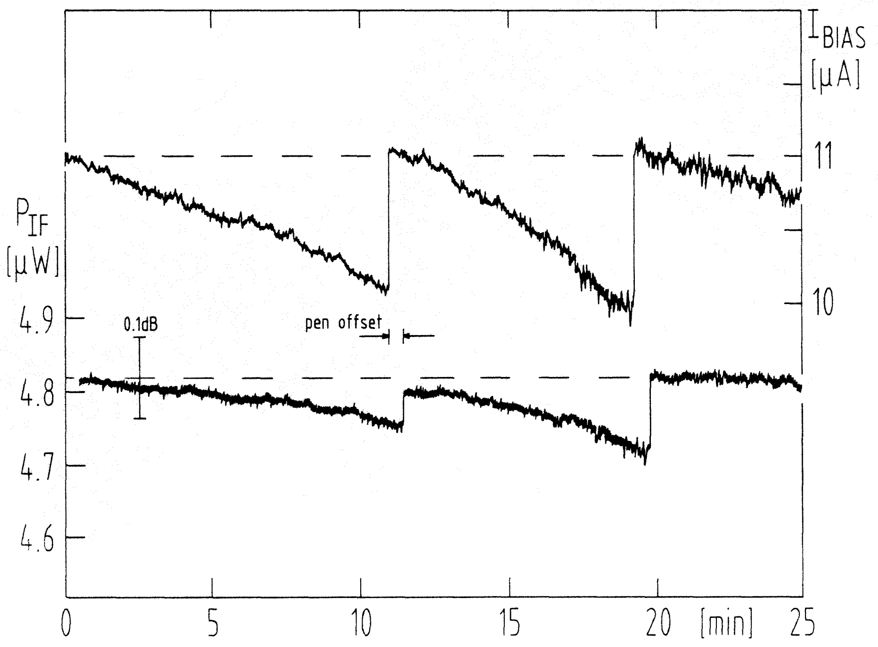


Figure 3 Stability measurement of the overall system with Laser-LO at 584 GHz