Pekka Sjöman, Petri Jukkala, Nestori Fabritius, Pekka Eskelinen, and Seppo Urpo. 2002. 43 GHz cryogenic LNAs for radio astronomic VLBI-receiver. In: Sergei Tretyakov and Jussi Säily (editors). Digest of Technical Papers of the URSI/IEEE XXVII Convention on Radio Science. Espoo, Finland. 17-18 October 2002. Helsinki University of Technology Radio Laboratory Publications, Report S 257, pages 81-83.

43 GHz Cryogenic LNAs for Radio Astronomic VLBI-receiver

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Abstract

A Q-band INP-HEMT MMIC based amplifier was designed for astronomical purposes. 20K minimum noise temperature at 25K physical temperature was reached at 43 GHz center frequency. About 40 dB average gain was measured from 40 GHz to 50 GHz at 25 K physical temperature.

Introduction

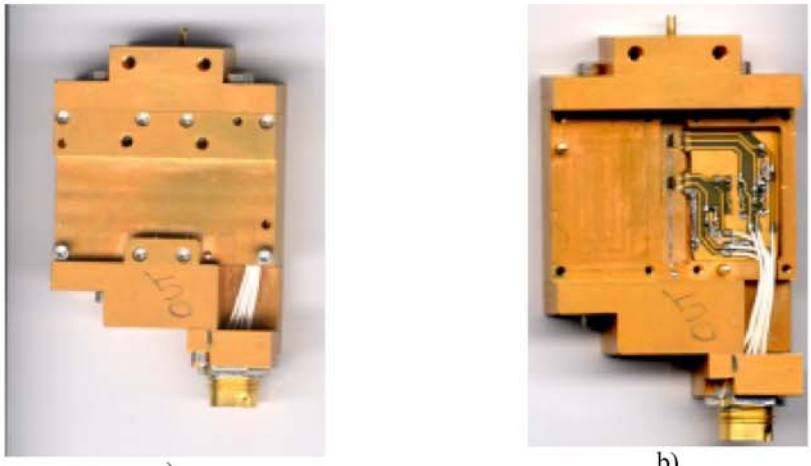
Because of upcoming launch of Planck satellite at year 2007, a pre-measured information of 40 GHz GPS-sources (Gigahertz Peaked Spectrum radio sources) is needed before hand to make a long time burst amplitude behavior predictions. Metsähovi radio observatory is one of the radio astronomic stations to measure 40 GHz GPS-sources before the Planck launch and during the satellite's flight. More about Planck satellite can be found [1], [2].

At the same time the use of 43 GHz receiver as VLBI-receiver demand certain specs for the receiver e.g. the noise should be minimized and the gain should be maximized around 43 GHz VLBI frequency.[3]

Design

The INP-MMIC-HEMTs are from HRL 0.1 µm INP-process. The MMIC design was done for the 60 GHz Planck receiver but because of the good low frequency behavior the same design was selected to the 43 GHz amplifiers. The four-stage design was selected for the 43 GHz amplifier. [4],[5] Because of high gain requirement two four stage MMIC were mounted in series.

The K-connector center pea was selected to be the transmission from WR-22 waveguide to 0.1 mm alumina microstrip. A circular beryllium copper stub was soldered to the K-pea inside waveguide to improve the match from the waveguide to the K-pea. The mechanical dimensions were frozen because of the previous 43 GHz amplifier. A picture of the LNA is shown in figure 1.



a) b)

Figure 1. The LNA with a) and without b) a lid.

Measurements

The system noise temperature was measured in cryogenic chamber with temperature variable load (TVL). A scalar network analyzer HP 8757A was used to measure the gain of the DUT. A block diagram of the test setup is shown in figure 2.

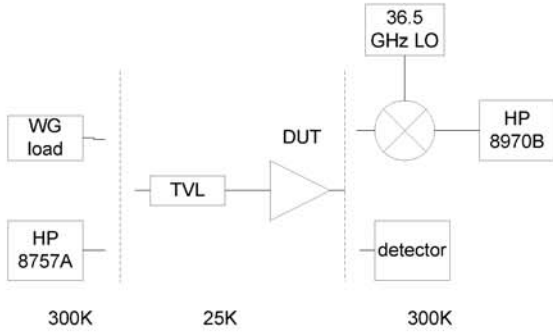


Figure 2. The test setup for the 43 GHz noise and gain measurements.

The temperature variable load was heated up to 53 K to get adequate 1.8 dB Y-factor over the measured frequency range. Measured room temperature and cryogenic gains are shown in figure 3.

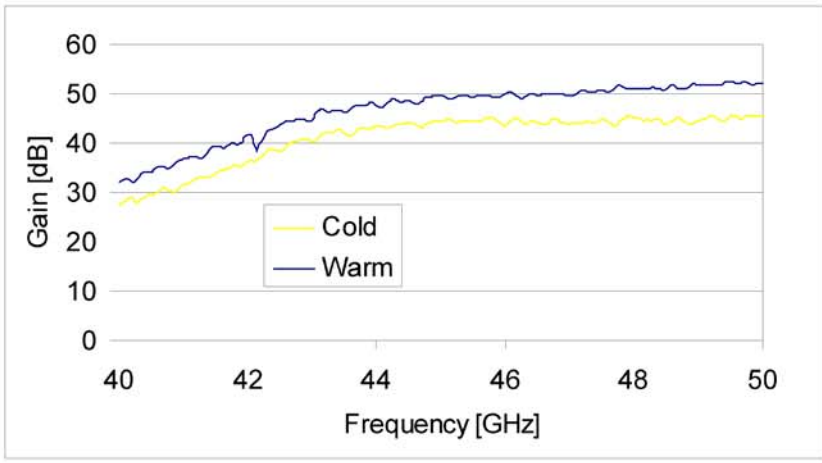


Figure 3. LNA3 Room temperature and cryogenic 25K temperature gains.

The slope at lower frequency range is the feature of the used MMIC-chips. The difference between warm and cold gains is due to the different bias points. The cold temperature bias point (V_d=0.5V, I_d=23 mA) was optimized to minimum noise. and the warm bias point (V_d = 0.7 V, I_d =30 mA) was optimized to maximum gain. The noise response of cooled LNA3 is shown in figure 4.

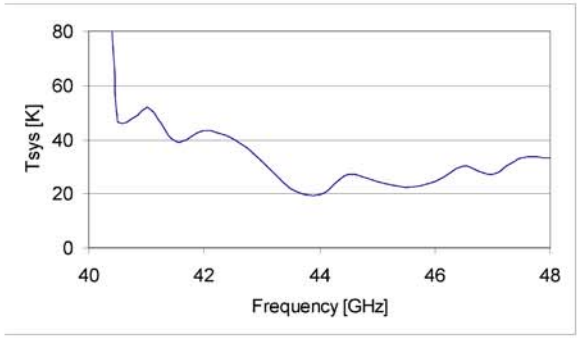


Figure 4. LNA3 noise temperature at 25 K physical temperature.

The noise response shows good performance between 41-48 GHz. At the lower frequency band the chip is not is not in the optimum noise region. Higher frequencies system noise temperature was not measured but there is no reason, why the amplifier does not work up to 50 GHz.

Conclusion

A good INP HEMT based 43 GHz cryogenic amplifier was designed and measured. Minimum 20K noise temperature at 25 K operation temperature was measured. Over 45

dB gain was reached over 43-50 GHz frequency band. At lower frequency band, 40-43 GHz, the selected MMIC chip has about 10 dB slope in the gain.

/1/ http://kurp.hut.fi/quasar/planck/

/2/ http://astro.estec.esa.nl/SA-general/Projects/Planck/

/3/ http://www.jive.nl/

/4/ Tanskanen, J.M., Kangaslahti, P.; Ahtola, H.; Jukkala, P.; Karttaavi, T.; Lahdes, M.; Varis, J.; Tuovinen, J.:"*Cryogenic indium-phosphide HEMT low-noise amplifiers at V-band*", MTT, IEEE Transactions on, 2000. Vol. 48, nro 7, 1283-1286.

/5/ Kangaslahti, P., Gaier, T., Dawson, D., Tuovinen, J., Karttaavi, T., Hughes, N.J., Cong, T.L., Sjöman, P., Weinreb, S.:"*Low noise amplifiers in InP Technology for Pseudo Correlating Millimeter Wave Radiometer", IEEE IMS, Poenix Arizona, May 20-25, 2001* .