Evaluation of a 640 GHz Cryo-Receiver for Limb Emission Sounder JEM/SMILES

Masumichi Seta and Takeshi Manabe
National Institute of Information and Communications Technology, Tokyo184-8795, Japan

Ken'ichi Kikuchi, Seikoh Arimura, Yasunori Fujii, Ryouta Sato, Toshiyuki Nishibori, Hiroyuki Ozeki, Akinobu Okabayashi, and Junji Inatani
Japan Aerospace Exploration Agency,Tsukuba, Ibaraki 305-8505 Japan

We are developing a 640 GHz SIS receiver for JEM/SMILES. SMILES is an instrument to observe ozone layer in limb sounding method from the International Space Station. SMILES aims to realize the most sensitive 640 GHz heterodyne receiver for space use. The design goal of the receiver noise was 500 K in SSB. The sensitivity is dominated by the noise of a mixer, the noise of a first low noise amplifier, and the loss in input optics. We had developed a SIS mixer with a DSB noise temperature of 65 K. We also had developed a cooled 20 dB amplifier for 11-14 GHz IF band with a noise of 16 K. The mechanical 4 K cooler for SMILES has cooling capability of 20 mW at 4.5 K stage. It was one of the difficulties for a receiver for space use to integrate the mixers and amplifiers into such a limited cooling capability cryo-receiver while keeping low noise requirement of 500 K. Strict specifications of heat load for the cooler restrict freedom in design for optics and IF output cable from the mixer. A diameter of window for RF signal is limited to be 25 mm and three IR filters are inserted on the RF path. Zitex is selected for the IR filters to minimize dielectric loss for less than 0.15 dB. We developed a beryllium-copper IF cables for connection between the SIS mixer and the 20 K cooled amplifier for satisfying thermal load requirement of 1.6 mW into the 4 K stage. The loss of IF signal is 0.4 dB that is much smaller than conversion loss 6.5 dB of the mixer. The SSB system noise of the receiver is designed to be 480 K evaluated at input port of the ambient temperature optics.

The engineering model of the 640 GHz receiver has been manufactured. The noise temperature of the cryo-receiver was evaluated to be 200 K in DSB by the Y-factor method. The noise is now mainly determined by the noise for the SIS mixer of 65 K, the conversion gain of -6.5 dB of the mixer, and the noise for the cooled amplifiers of 16 K. The DSB 200 K noise is upper limit for realizing SSB noise of 480 K after assembling the ambient temperature optics with 0.7 dB loss on the cryo-receiver. It may be possible to reduce the noise further by decreasing physical stage temperature for the SIS mixer and a modification of IF circuit of the SIS mixer.

The effect of vibrations during launch on the cryo-receiver was examined by comparing frequency characteristics of the noise before and after random vibration test. There was no significant change in the frequency characteristics of the noise.

We concluded that our design and the EM for the cryo-receiver fulfilled requirement in noise for the space qualified 500 K noise 640 GHz heterodyne receiver.