Onsala Space Observatory – IVS Technology Development Center

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Abstract

The present report describes in brief the technical development done during 2011 at the Onsala Space Observatory in relation to geodetic/astrometric VLBI. The activities focussed on the development of a front-end for VLBI2010 and the integration of a digital back end in the VLBI system.

1. A Front-end for VLBI2010

During 2011 the activities related to the improvement of the performance of an Eleven feed for VLBI2010 can be summarized as follows:

- design of passive balun
- design of new feed petals
- cryogenic tests and noise model

This work was done as a collaboration with the Antenna Group at the Department of Signals and Systems at Chalmers University of Technology. The integration of the Eleven feed into a cryogenic front-end suitable for VLBI2010 was done in collaboration with Omnisys AB.

1.1. Design of a Passive Balun

Two designs for passive feeding networks were developed at the Antenna Group during 2011. At the Onsala Space Observatory (OSO) we made the mechanical design suitable for cryogenic operation and produced two prototypes, see Figure 1.

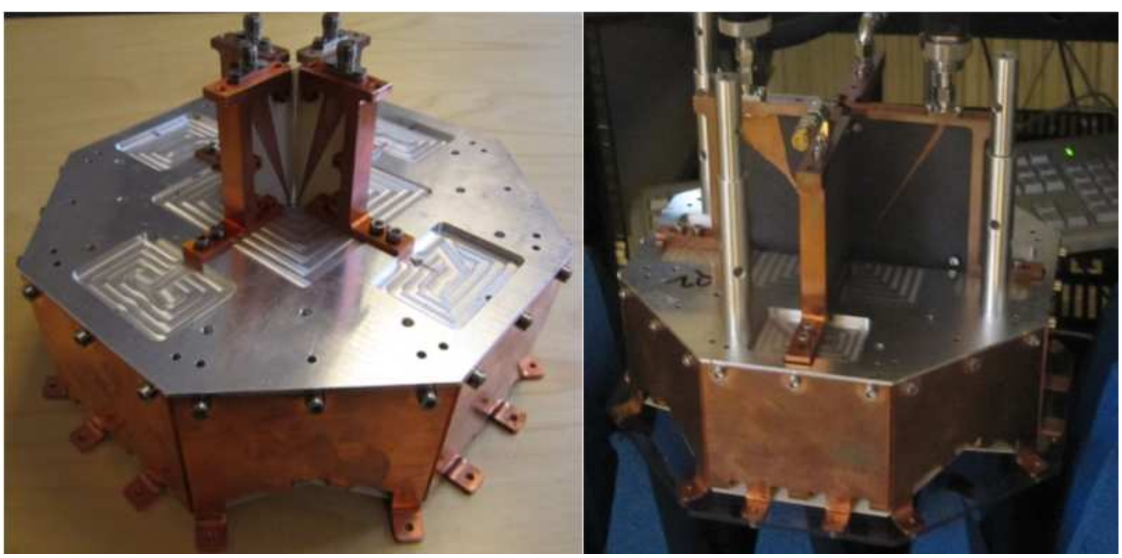

Figure 1. Balun-fed Eleven feeds with linear taper (left) and with Klopfenstein taper (right).

The design of the passive feeding solution to the Eleven feed consists of two passive ultra wideband (UWB) baluns and two UWB power dividers [1]. This feeding solution transforms the four differential ports of the feed to two single ended ports, one for each polarization. Therefore, four differential low noise amplifiers (LNAs) can be replaced by two single ended LNAs, which leads to a much simpler and lower cost system. Two versions of UWB baluns have been developed: a liner taper and a Klopfenstein taper one. Figure 2 shows the measured performance. The prototype with the Klopfenstein taper balun has an improved performance compared to the one with the linear taper balun.

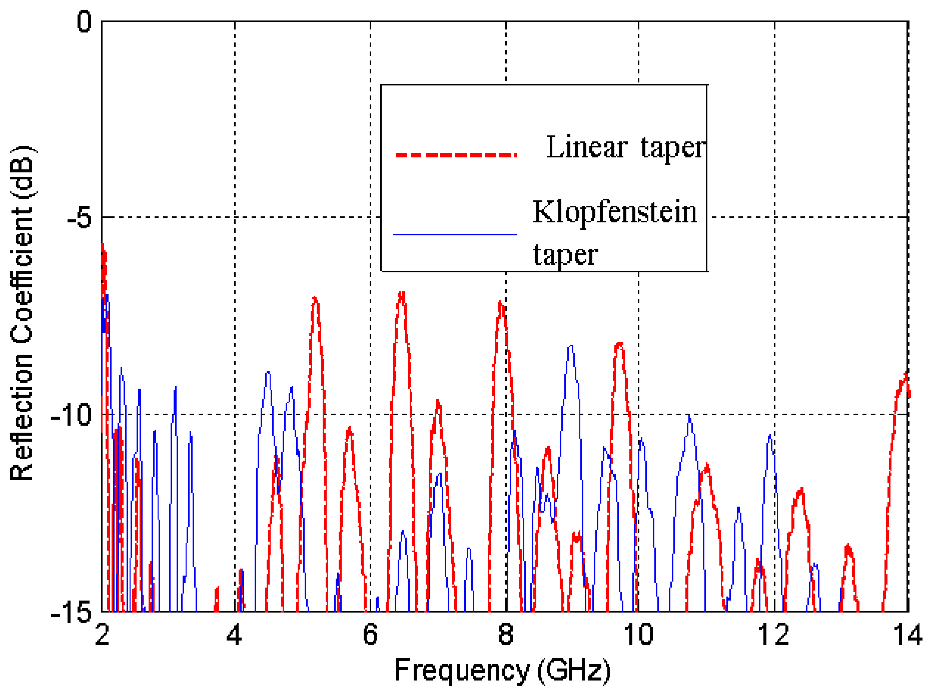

Figure 2. Measured reflection coefficient for the two balun-fed Eleven feed prototypes: linear taper (dashed line, red) and Klopfenstein taper (solid line, blue).

1.2. Design of New Feed Petals

During the last months of 2011 we were working with the mechanical implementation and prototype fabrication of a new circular Eleven feed that was designed by the Antenna Group at Chalmers. Figure 3 shows the CAD model of the production prototype. The circular Eleven feed is constructed of "circularly" curved folded dipoles on a flat printed circuit board (PCB), with the aim of making this antenna structure more rotationally symmetric at a very low manufacturing cost. According to the simulations, it is expected that the circular Eleven feed achieves a BOR1 (body of revolution type 1) efficiency of better than −1 dB over a decade bandwidth of 1.3–14.0 GHz. This is a significant progress for decade-bandwidth feed technology.

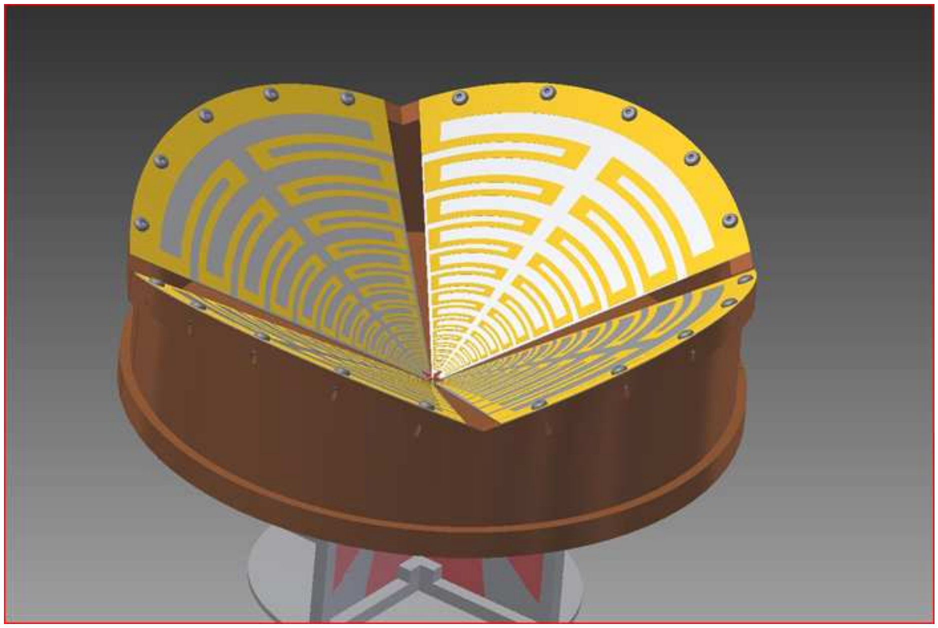

Figure 3. Drawing of the new circular Eleven feed.

1.3. Cryogenic Tests and Noise Model

To characterize the system noise, the 2–13 GHz Eleven feed prototype was integrated with a 20 K cryostat. The feed prototype has eight 50 Ω ports, four for each polarization. Since only four LNAs were available for the tests, the ports for one polarization were terminated with 50 Ω loads. The LNAs are CITCRY01-12 wideband cryogenic 50 Ω amplifiers, purchased from Caltech. The feed system including the cryostat was placed outdoors, with the feed window pointing upwards. The receiver noise was measured by the Y-factor method using hot and cold loads. An absorber at ambient temperature is used as the hot load and the sky as the cold load. A metal pyramid is used as a shielding for the cryostat, in order to reduce the noise pick-up from the ground and the surroundings.

Although the tests were done at the observatory, which is a radio-quiet zone, a strong RFI was observed in the cold spectra from 2 to 3 GHz. Since the system was shielded with the absorber for the hot load measurement when measuring the hot load, the RFI cannot be calibrated out, and the measured Y-factor is not representative for the frequency range 2–3 GHz. A new algorithm for improving the data analysis in the 2–3 GHz band is under development.

The measured system noise temperature was compared with the one predicted by our noise model, shown in Figure 4. The model predictions agree well with the measurements.

2. Integration of a Digital Backend

In 2011 the observatory purchased a digital backend of type DBBC (Digital Base Band Converter) [2], and the work to adapt it to the observatory's instruments was initiated. For geodetic S/X-observations we use coaxial cables to carry the IF-signals from the 20-m telescope down to

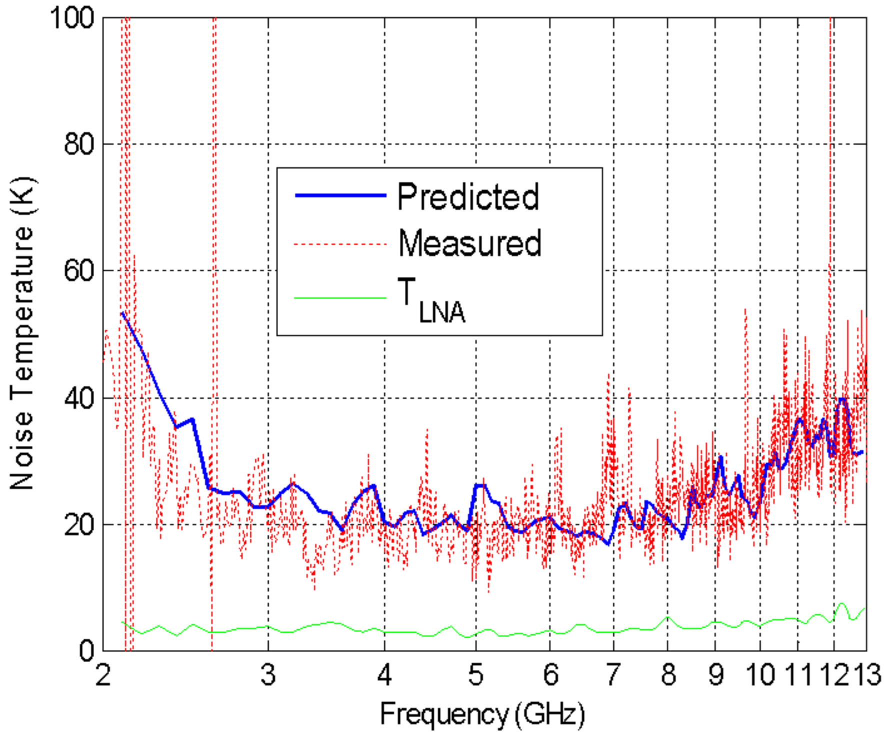

Figure 4. Measured (dashed line, red) and predicted system noise temperature (solid line, blue). The noise temperature of the LNAs is shown as thin solid line in green.

the VLBI backends (Mark IV and DBBC). This implies that the band pass has a slope, with attenuation increasing with increasing frequency. Since the dynamic range of the DBBC is limited, such a band pass slope will degrade the usable signal range of the digital system. We thus decided to introduce equalizers for the IF-signals, and the work to implement these is ongoing.

3. Outlook and Future Plans

We will continue to work on the development of an Eleven feed for VLBI2010. We also aim at preparing the 20-m telescope to become fully compatible with VLBI2010 within the next few years.

References

[1] Raza H, Yang J, Pantaleev M (2011) A compact UWB passive balun solution for cryogenic 2–13 GHz Eleven feed for future wideband radio telescopes. *5th Eur. Conf. on Antennas Propagat. (EuCAP2011)*, Rome, Italy, 11-15 April 2011.

[2] Tuccari G (2004) DBBC - a wide band digital base band convertor, In: *International VLBI Service for Geodesy and Astrometry 2004 General Meeting Proceedings*, edited by Nancy R. Vandenberg and Karen D. Baver, NASA/CP-2004-212255, 234–237.