A New Receiver for Geodesy and Astrometry at the Korean VLBI Network

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Abstract We have been developing a new VLBI receiver, which enables the making of simultaneous observations in C/X- and Ka-bands. It will be used for geodesy and astrometry as a part of the Korean VLBI Network (KVN). A couple of motivations behind this development had sprouted up one after another over the course of several issues. The radio frequency interference (RFI) in S-band has long been an issue and has led to demands for a wide-band or a higher-band receiver. In the meantime, K-band and X/Ka-band catalogs have been included in the latest version of the ICRF. For the East Asia VLBI Network (EAVN), a K-band geodetic experiment has been conducted recently, although an issue about atmospheric correction has remained. GNSS has been considered to be one of the proper independent tools for providing atmospheric corrections to such a single-band VLBI observation. Taking those issues into consideration, KASI made a conceptual design of a KVN-only geodetic campaign, which can observe S/X and X/Ka catalog sources with atmospheric corrections estimated by GNSS. During an experiment campaign in the coming years, the performance of the receiver will be checked in terms of inter-operability.

Keywords KVN, Receiver, Geodesy, Astrometry, GNSS

1 Introduction

A new VLBI receiver has been developed in order to keep up with increasing demands on geodesy, astrometry, and space science. The need for space geodetic research and issues about the national/regional reference frame and spacecraft tracking have been raised sequentially over the past decade. Although legacy VLBI is operating as a key component of the Sejong GGOS site, radio frequency interference at S-band is inevitable. Considering those various needs and situations comprehensively, the development of a new KVN receiver began in 2022. In the early period, we selected the optimal combination of frequencies of the receiver. We focused on possibilities of research availability and interoperability with other networks. As a result, a receiver which enables the making of simultaneous observations in C/X- and Ka-bands became a candidate. It is planned to be used for geodesy, astrometry, and spacecraft tracking experiments as a part of the KVN.

2 Specifications

The specifications of the geodetic/astrometric receiver system for the KVN can be summarized as follows:

- C-band range: 6.2–7.0 GHz
- X-band range: 8.0–8.8 GHz
- Ka-band range: 28–34 GHz
- Dual circular polarization in all bands
- Mean receiver temperature: 40 K at C/X-band and 30 K at Ka-band
- Dewar with the front-end
- Noise/phase cal. injection

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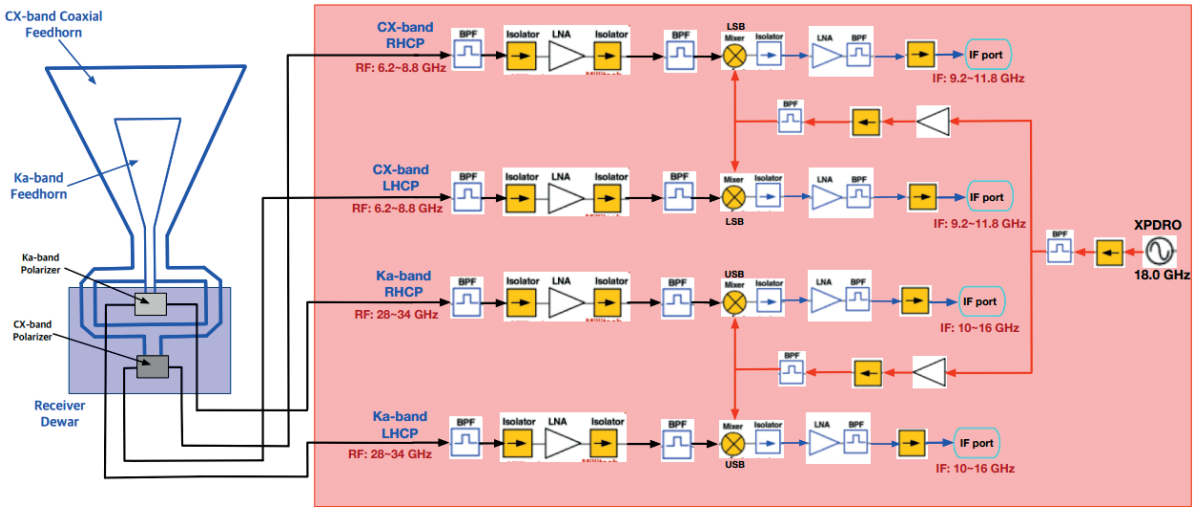

Fig. 1 C/X/Ka-band receiver system.

3 C/X/Ka-band Receiver Layout and Performance Tests

A prototype of a C/X/Ka-band receiver system has been undergoing development with its layout as shown in Figure 1. The coaxial dual feedhorn consists of an external part for C/X-bands and an internal part for Ka-band as shown in Figure 2. The cryostat part consists of a room temperature receiver system and a dewar as shown in Figure 1 and Figure 3, respectively. The feedhorn will be located at the Cassegrain focus as shown in Figure 4. The simulations were performed with an ideal Gaussian beam.

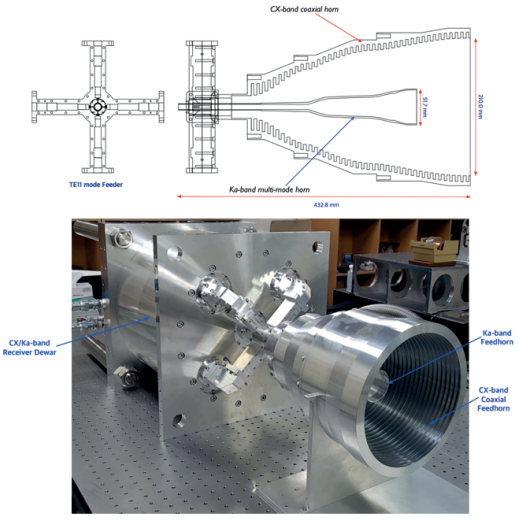

Fig. 2 The coaxial dual feedhorn.

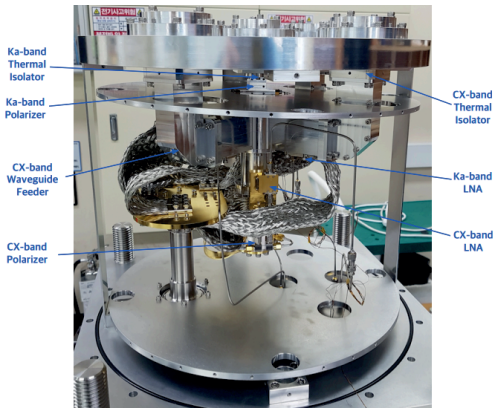

Fig. 3 A dewar of the receiver system.

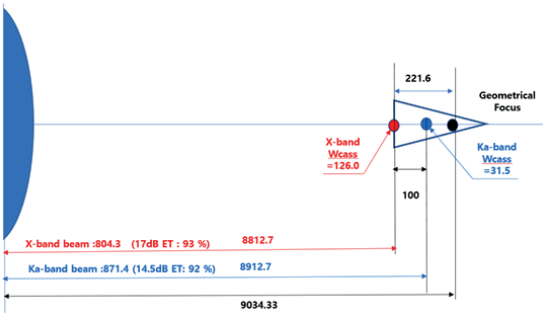

Fig. 4 Quasi-optics of the receiver.

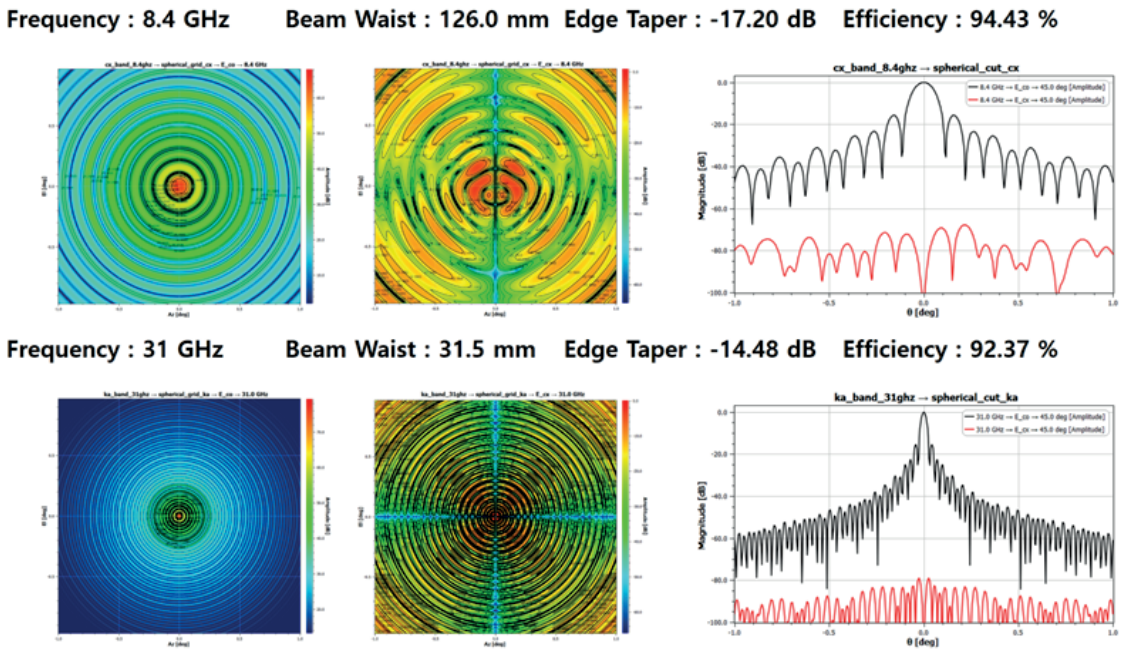

Fig. 5 GRASP simulation results.

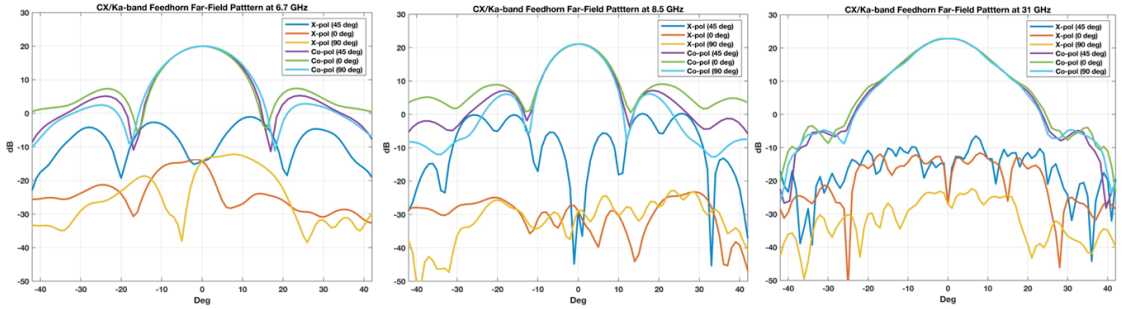

Fig. 6 Far-field patterns by frequency (6.7, 8.5, 31 GHz) of the feedhorn.

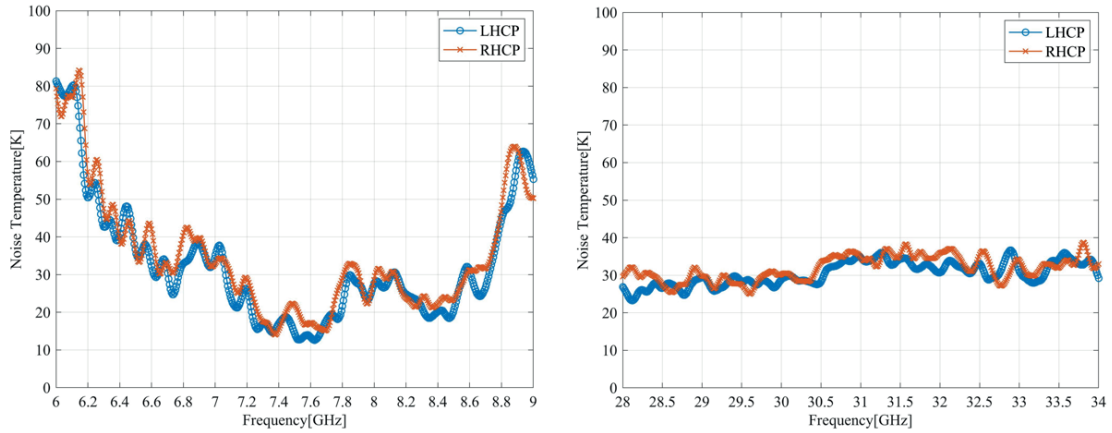

Fig. 7 Receiver noise temperatures of C/X-band (left) and Ka-band (right).

For the C/X-bands, the blockage of the Ka-band feedhorn inside was not considered. Aperture efficiencies at 8.4 GHz and 31 GHz were simulated as shown in Figure 5. The performance of the coaxial dual feedhorn capable of simultaneous observations of C/X-band and Ka-band was measured as shown in Figure 6. The results of the receiver noise temperature measurement are shown in Figure 7.

4 Future Works

The C/X/Ka-band receivers are planned to be installed at the KVN Yonsei and Pyeongchang sites. The first one will be installed at the Pyeongchang site in the first half of 2024, and the second one will be installed at the Yonsei site in 2025. Figure 8 shows a plan for the receiver arrangement of the Pyeongchang receiver room.

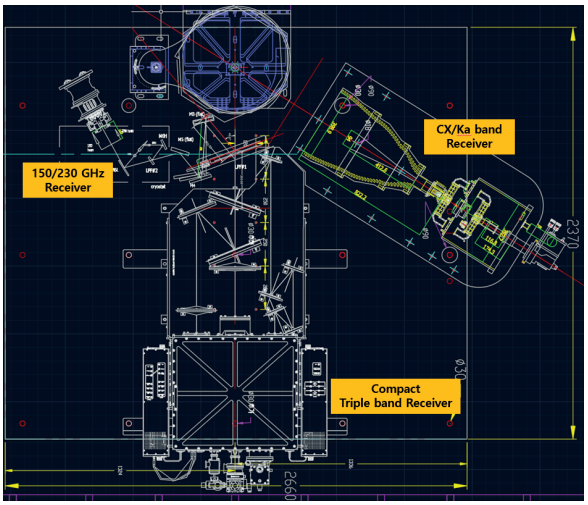

Fig. 8 Receiver room of KVN Pyeongchang.

After performance verification, it will be operated for a geodetic and astrometric experimental campaign in collaboration with the National Geographic Information Institute. In the future, it will also promote test observations and development of ancillary devices for spacecraft tracking.

Acknowledgements

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