PROCEEDINGS OF SCIENCE

"Octave" Project: Application of Superwide-Band Technologies for the RATAN-600 Continuum radiometers

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The "Octave" project seeks to modernize the RATAN-600 continuum radiometers. The implementation of the first stage was started for the 13, 31 and 49 cm wavelength of the decimeter range. The second stage concentrates on the rest of the centimeter range. Using the method presented in this report, it is possible to produce radiometers hat have the ability to react quickly to the changing interference environment (and to retune the receivers to an adjacent band).

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1. Introduction

Summarizing the reports presented in these proceedings, there are several ways of doing RFI mitigation:

- selection of remote and radio quiet site for the telescope away from possible RFIs sources,
- administrative tools,
- hardware tools, and
- using software tools.

From this point of view there are differences between old and new generation telescopes. As an example, for our radio telescope RATAN-600 the last two points (hard-and software protection) were not done. In addition, some of the operational frequencies used available industrial LNAs mostly used for military and space applications. As a result, we have RFI at satellite downlink frequencies (3.9 and 11 GHz). For the first 10-15 years of operation there were no real problems with interference but now the situation has changed. The first point of good natural shielding is still applicable for RATAN-600. However, the administrative approach to clean the environment is very complicated and in some times even tricky because:

- when the Soviet period passed away the protection zone was also dissolved,
- the local TV stations do not use filters to stay in their allocated bands,
- there are illegal transmitters operating in the area (GSM, WiFi, radio links, etc.).

Further development of the Octave project is impossible without addressing the following issues:

- creating a noise immunity to combat the fast urbanization,
- minimizing service operations and operational expenses,
- making place for new primary feeds in the compact focal box,
- introducing operation in two linear (or circular) polarizations.

The solution of these problems is to develop a super wide band front-end for several decimeter radiometers inputs. This is possible using a new multioctave primary feed with a weak frequency dependence for the phase center position. In the following, I we will present how we can take into account RFI issues in developing these new receivers.

2. The stage of decimeter wavelength

The basis for the project is a new development of a broadband antenna of the type Eleven developed at Chalmers University of Technology (Fig. 1 and Fig.2) [1], [2]. The Eleven antenna is intended for be use as a primary feed of many radio telescopes (Green Bank, SKA). With the Eleven antenna as a primary feed for the RATAN-600, a transition will be made from the use of primary feeds with combined phase centers to a wide-band feed. The use of this feed 1) removes the restrictions or the choice of operating frequency of a partial radiometric channel, 2) allows moving to an interference-free frequency range, 3) allows the implementation of comprehensive analysis of all decimeter frequency ranges accessible with the RATAN-600, and 4) extends the capabilities of pulsar studies and of multi-frequency monitoring modes.

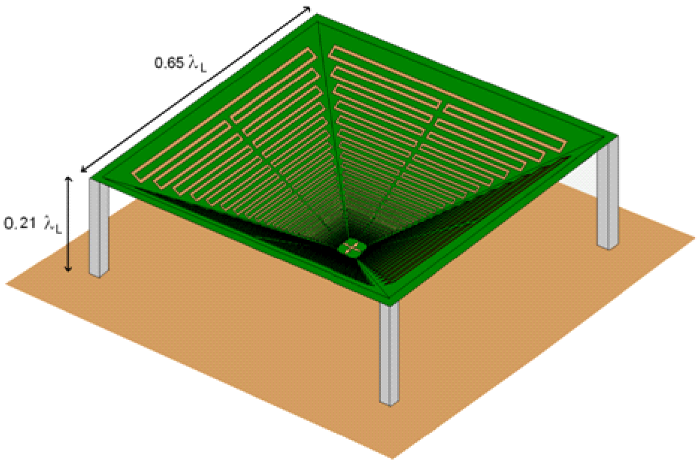

Figure 1: The Eleven antenna lab model (left) and real antenna (right) designed for RATAN-600

The general properties of the Eleven antenna are:

- the reception of two linearly polarized signal components (simultaneous registration of the Stokes parameters I, U and Q),
- a polarization isolation of order of 20dB,
- a stable beam across more than a decade bandwidth (Fig.2),
- a low noise temperature, and
- a phase center position independent of frequency.

For and efficient application, we plan to develop an equally wide-band low-noise amplifying block with two-channel input (for two polarizations) (Fig. 3). The frequency selected radiometric channels are connected to the block output through anti-interference filters. A modified radiometric noise-adding radiometer (NAR) is used. An additional modulated noise signal from a common noise generator is supplied to the input of the first amplifier. Synchronous alteration of the transition factor and precise balancing are implemented independently at the input of every partial frequency channel (Fig. 4). The input of the low-noise wide-band block can be improved afterwards by inserting input amplifiers between the primary feeds and the 180° hybrid coupler by using "active hybrids" with two amplifiers with balanced inputs. The full block diagram of the front-end unit is presented in Figure 5.

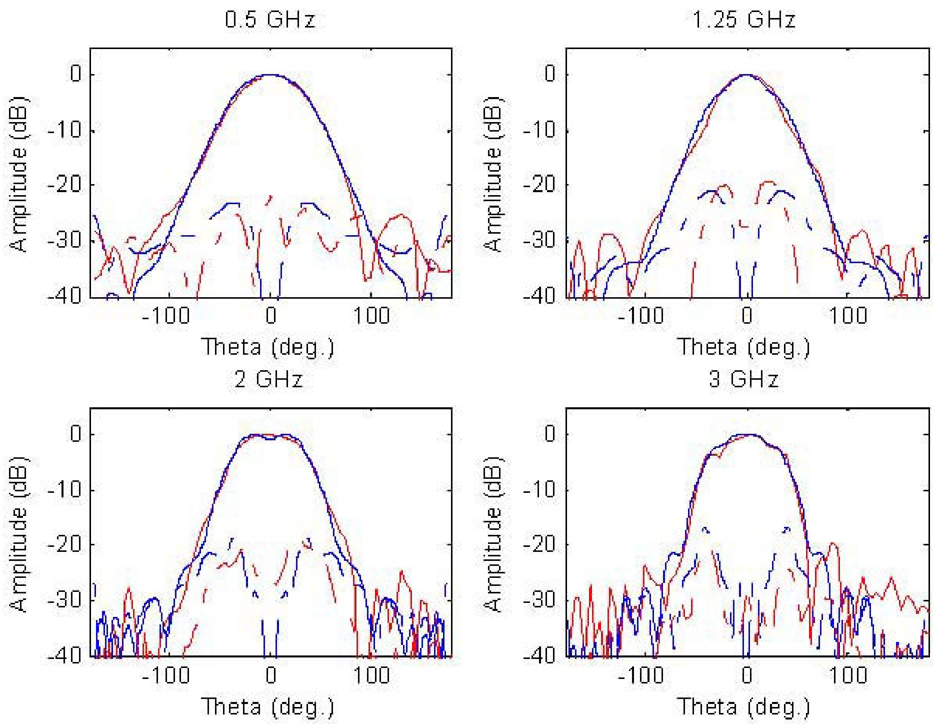

Figure 2: RATAN-600 Eleven Feed far-field patterns.

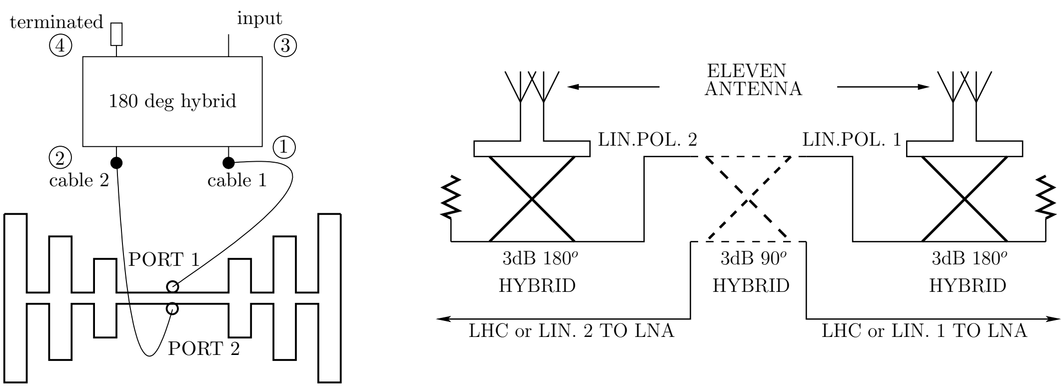

Figure 3: The Eleven feed and LNB interconnection. 90^o hybrid coupler is inserted only for the registration of circular polarization

3. The second development stage for centimeter wavelengths

The next development stage of the project is to apply the described approach for the modernization of the 6.25, 3.9 and 2.7 cm radiometers (Fig. 7) . The input sections of these radiometers are cooled to 15K by means of three complicated (and expensive) closed-cycle cryogenic systems. The combined Eleven primary feed for the mentioned frequency range may be placed in a cryostat

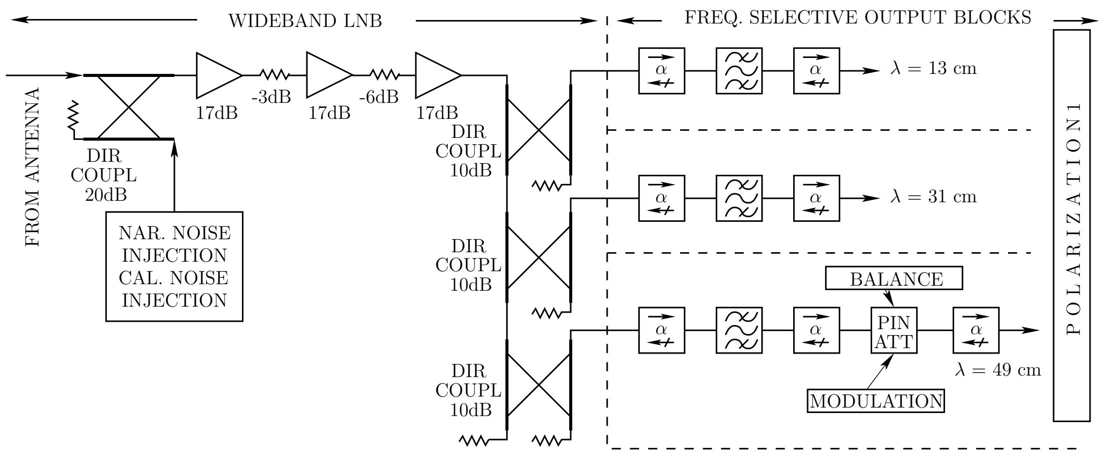

Figure 4: One polarization channel structure (49 cm output bloc shown expanded to demonstrate NAR mode of operation)

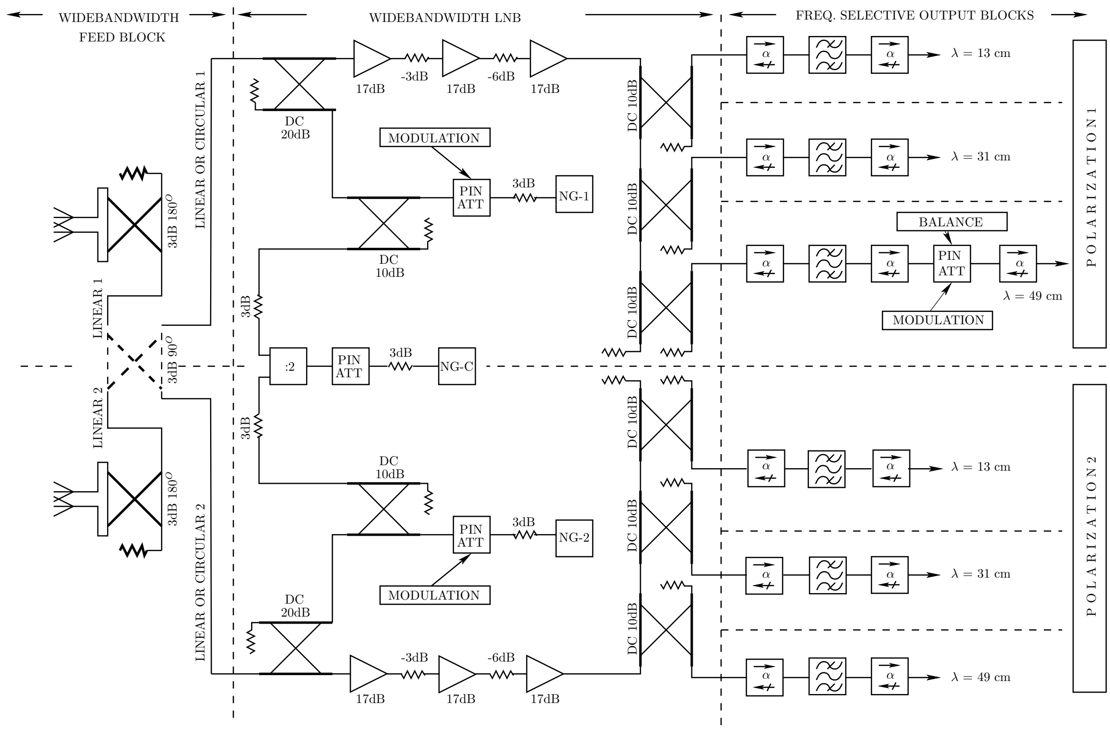

Figure 5: The full block diagram of the front-end unit

(Fig. 8) with a vacuum window. In doing so, the input block, which is common for three (or more) radiometers, can be cooled by one cryogenic system instead of three. Using the above method, it

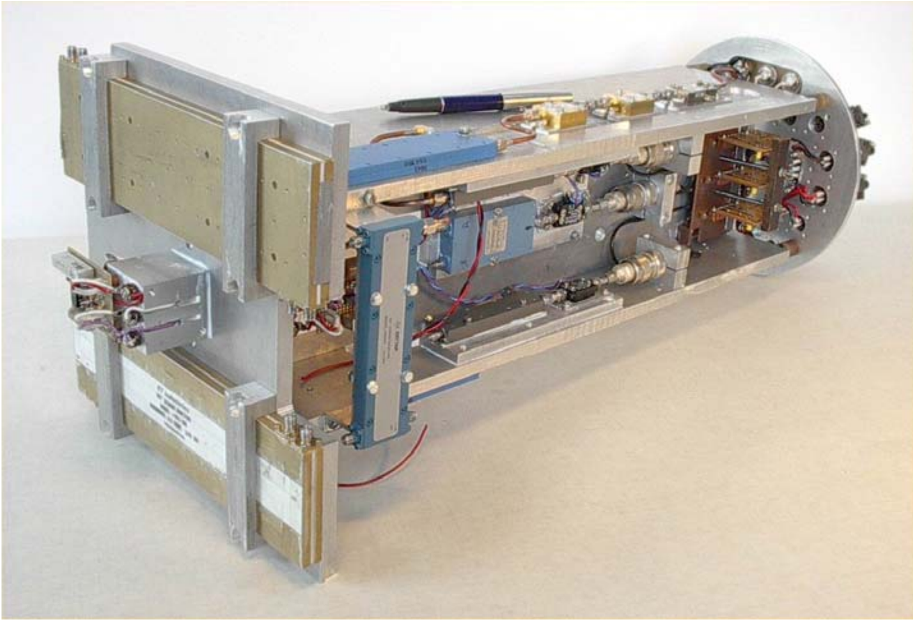

Figure 6: The construction of the front-end unit

is possible to build radiometers with the ability to quickly react to a changing interference environment and to retune the receivers to adjacent bands.

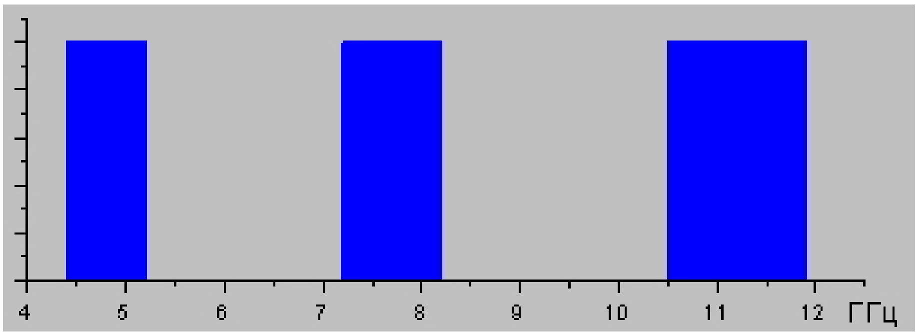

Figure 7: The bands of the 6.25, 3.9 and 2.7 cm RATAN-600 radiometers

4. Conclusions

As a product of using the Eleven feed with wide-band radiometers we can:

- reduce the construction and operational expenses for the new radiometers,
- operate in two linear (or circular) polarizations,
- obtain extra space in the focal box for the new receivers, and
- develop a fully cooled radiometric input that makes an important step towards an "ideal radiometer".

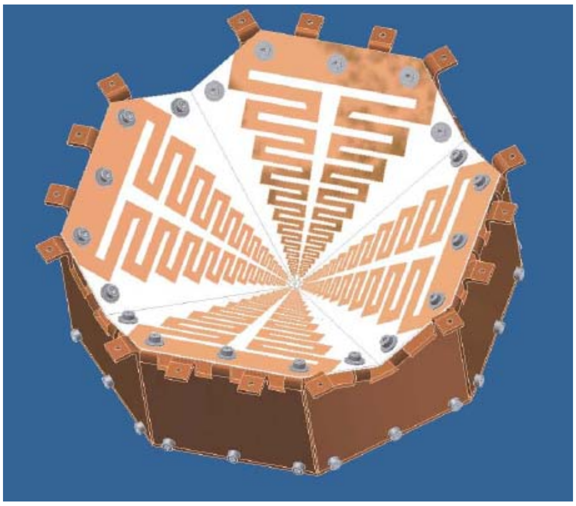

Figure 8: The cooled Eleven feed design. [4]

The new system makes it possible for the radiometers to quickly react to a changing interference environment and to retune the receivers to adjacent bands.

References

[1] http://www.sao.ru/hq/lrk/OCTAVE_09_2008.ppt (in Russian)

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[3] Per-Simon Kildar at al., Development of a Cooled 1-14GHz Eleven antenna for VLBI, 2010, Chalmers Univ. of Technol., Sweden www.fs.wetzell.de/veranstaltungen/vlbi/frff2009/frff2009.html

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