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Experiment of Injecting Phase Cal Ahead of the Feed: First Results

Dmitrij Ivanov, Anatolij Maslenikov, Alexander Vytnov

Institute of Applied Astronomy of RAS

Contact author: Dmitrij Ivanov, e-mail: `ltf@ipa.rssi.ru`

Abstract

For developing the Russian VLBI network of new generation, a few experiments of injecting the phase calibration signal ahead of the feed were carried out. In the experiments an external broadband phase calibration signal was emitted through a special feed to a receiver horn directly. Prototypes of the feed for a frequency range of 2–18 GHz were created. The first experiments on injection phase cal ahead of the feed were carried out at Svetloe Observatory of the QUASAR VLBI network. The phase cal signal was emitted by the broadband feed installed on the roof of a mirror cabin, reflected by the sub-reflector, and received by the horn of the receiving system. The results of these experiments are considered.

1. Phase Calibration System

The primary purpose of the phase calibration system is to monitor the instrumental phase delay. For most applications only temporal variations are of interest, but for a few critical applications, such as UT1 measurement and time transfer, knowledge of the absolute delays is also required. For VLBI2010, the specification on the instrumental delay measurement error has been set to < 1 ps, so that it is well below the single-observation stochastic error, which is targeted to be 4 ps [1].

In the current phase calibration system, a spectrally pure reference signal of 5 MHz is transmitted by cable to the mirror room of the radiotelescope, where it synchronizes a generator of very short impulses of about 45 ps duration. The impulses are injected through a direction couple into the input of receiver before the first LNA and passed, with the received signal, through receiver and data acquisition devices to digitization, after which the phases of the tones are extracted.

A similar system has been developed for the Russian VLBI network of new generation. One possible scheme under study is to radiate phase cal impulses from a special broadband feed located ahead of the receiving feed. The main advantage of injecting phase cal ahead of the receiving feed is in putting most of the VLBI signal path into the phase calibration loop; but multipath effects may be a problem.

The phase cal feed is supposed to be mounted on one of the legs supporting the focal box, in a distance from the mirror surface that satisfies the distant-zone condition for radiation. Then the surface will be radiated with a flat front, and radiation of the phase calibration will be focused on the receiving feed of the radiotelescope. Taking into consideration the geometrical sizes of a telescope and other common reasons the following rough characteristics of the phase cal feed are chosen:

Diameter	no more than 30 cm
Pattern width	no more than 40°
Level of side lobes	no more than −15 dB
Frequency band	2–14 GHz
VSWR	no more than 2.0

2. Experimental Research

The possible multipath in telescope has been investigated. The feed for 13 cm band with the demanded pattern width and a side lobe level has been produced. Spiral type of the feed is chosen because of simplicity of calculation and manufacturing. A photo of the manufactured feed is shown in Figure 1.

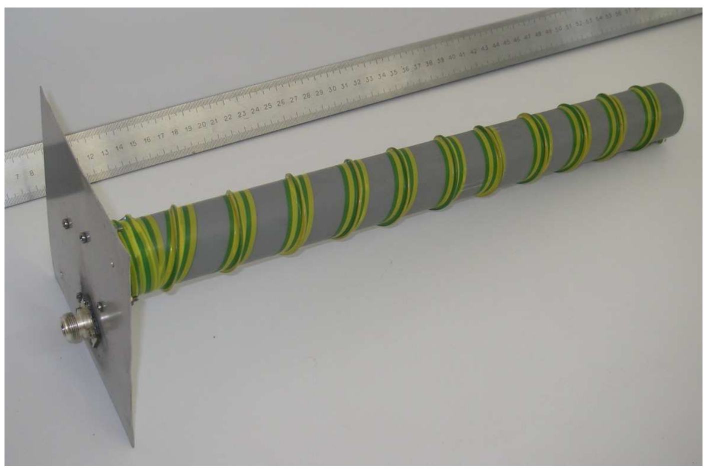

Figure 1. Photo of the manufactured spiral feed.

Measured characteristics of VSWR and radiation pattern of the feed (Figures 2 and 3) are matched with the requirements indicated above.

In mid-2009 a few experiments with the spiral feed were carried out at Svetloe Observatory of the Russian VLBI network Quasar. A feed connects to reserve generator which synchronizes by reference 5 MHz signal. In the output of the S-band receiver, impulses of the phase cal both from the regular generator and radiated from this spiral feed were observed by an oscillograph Agilent DSO 6102A. The output oscillograms are shown in Figures 4 and 5.

As no multipath effect was detected in the experiment, the phase calibration submission described above could be used in the system.

3. Wideband Feed

Transverse electromagnetic (TEM) horn antennas have been used as wideband antennas for various applications. This type of antenna has the advantages of being wideband, lacking dispersion, being unidirectional, and being easily constructed. An exponentially tapered TEM horn antenna with TEM double-ridged transition for the 2–14 GHz frequency band has been described in [2]. At IAA a similar TEM horn feed was built (Figure 6). This feed is now under testing. The

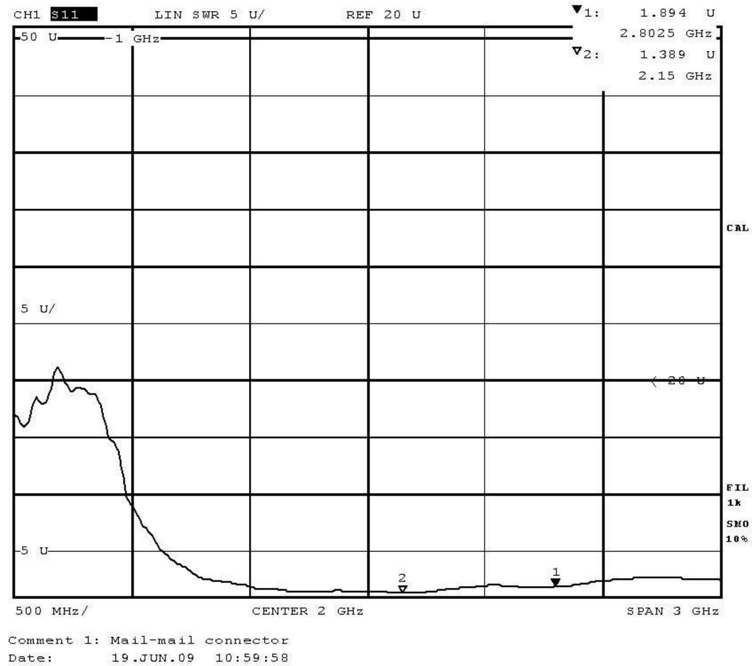

Figure 2. VSWR of spiral feed.

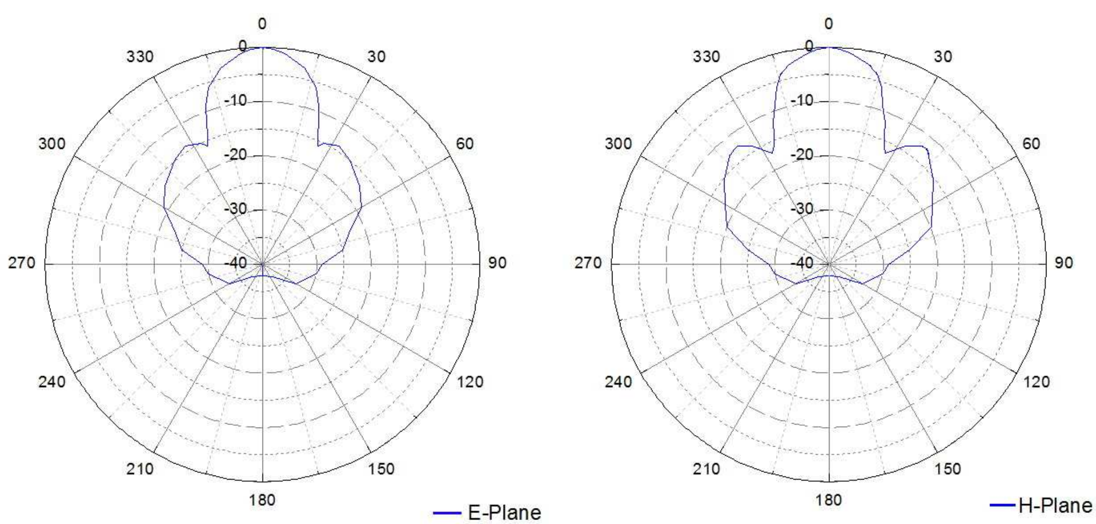

Figure 3. Radiation patterns of the spiral feed.

characteristics of the TEM horn feed indicate that it is feasible to use for emitting the phase cal signal.

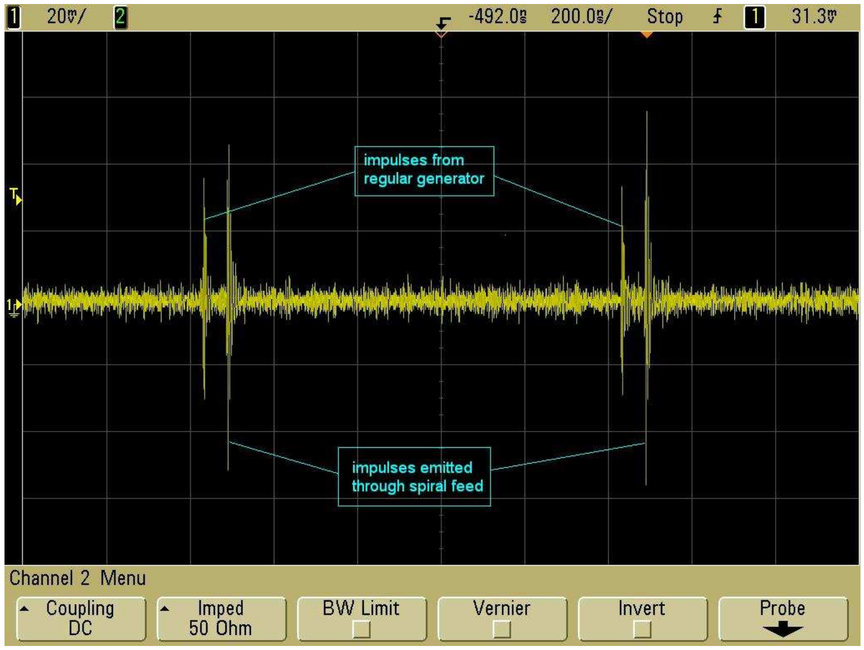

Figure 4. Oscillogram of the output signal from the S-band receiver.

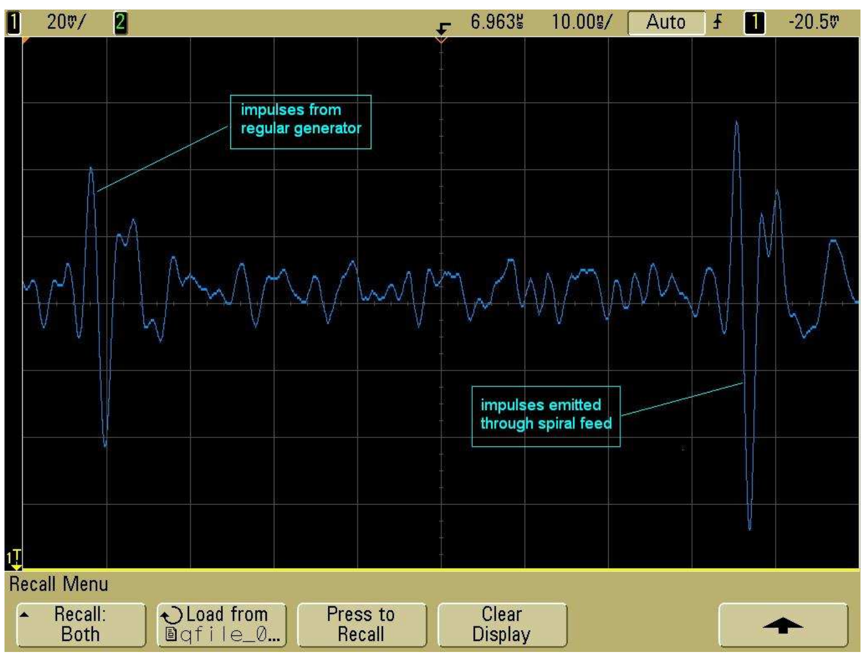

Figure 5. Oscillogram of output signal for S-band receiver.

4. Conclusions

The research carried out showed the absence of multipath effects in the external radiation phase cal signal. A prototype broadband feed for emitting the phase cal signal was made and tested.

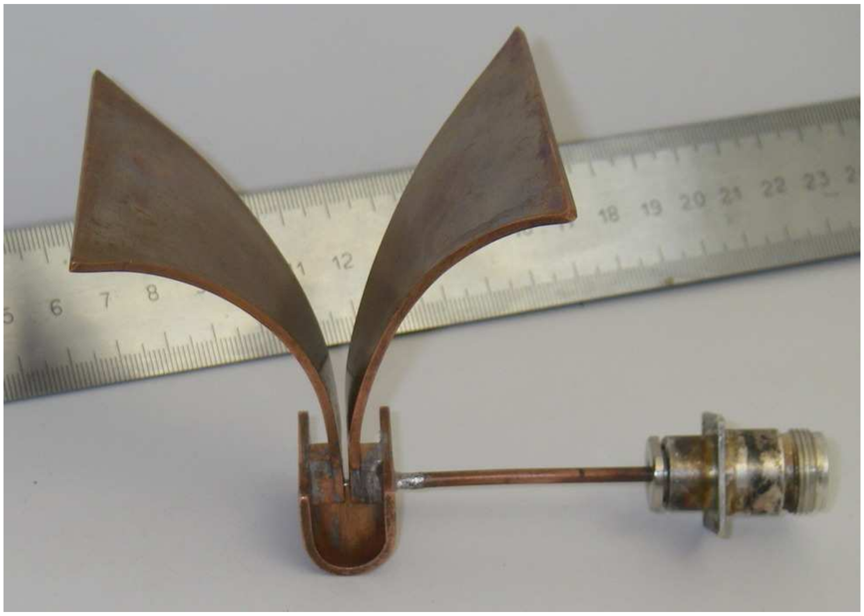

Figure 6. Photo of the manufactured TEM horn feed.

In the near future it is planned to produce a temperature controlled enclosure for the TEM horn feed. Mounting these devices permits us to investigate long-period phase stability and influence of weather conditions.

References

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