74 MHZ OBSERVING WITH THE VLA-PT LINK*

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ABSTRACT

NRAO, with the assistance of engineers and astronomers from the Naval Research Laboratory, has installed a 74 MHz receiver and a removable dipole on the Pie Town VLBA antenna (Pt). Recent brief tests of this system show the VLA+Pt link appears to work as expected at a frequency of 74 MHz. The major importance of the link for scientific observations is the factor-of-two improvement in angular resolution for sources with declinations north of about +40 degrees (12 arcseconds at 74 MHz), while maintaining the full sensitivity of the VLA (about 50 mJy/beam for a full track at 74 MHz).

INTRODUCTION

Under the direction of William Erickson, a complete 74 MHz system was developed and constructed during the summer of 1997 at NRL. This system consists of deployable crossed-dipole antenna feeds and receiver units to provide necessary gain, conversion to circular polarization, interface to the VLA IF structure, and an integral noise calibration source. This system has proven to be a valuable asset both scientifically, and as a means to test a wide variety of calibration and RFI excision algorithms.

In the fall of 1997, NRAO initiated a plan to link the VLBA Pie Town dish to the VLA site via a fiber-optic link. First fringes with a subarray were observed in December 1998, and a full test with the Pt antenna replacing the 27th VLA antenna was successfully completed in September 1999. Routine observations on this facility began in October 2000, and the first scientific results were published in the journal *Science* in May 2001[1]. The 105 kilometer VLA+Pt link (~70 km baseline) is one of the longest fiber-optic links operating in radio astronomy.

Based on the success of both of these systems, the Naval Research Laboratory and NRAO began an aggressive collaborative program to add 74 MHz capability to the Pt antenna. Initially, in September 2001, it was possible to replace the 327 MHz receiver at Pt with a 74 MHz channel. It is now possible to operate both the 74 and 327 MHz receivers simultaneously over the fiber-optic link (4-p mode).

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HARDWARE

Crossed-dipole Antennas

Both the VLA and the VLBA-Pt antennas were fitted with the same crossed dipoles, as shown in Figure 1. These antennas consist of two half-wave dipoles, arranged orthogonally and bolted to small a weatherproof enclosure containing matching baluns. Because the dipoles contribute to an increase in system temperature (6% at 1.4 GHz), they are only mounted for a fraction of the time in each VLA configuration. To accommodate this scheduling, the dipoles were designed to be mounted and un-mounted using a simple rope and eyebolt scheme. By properly tensioning ropes connected to the end of each element through eyebolts attached to the quadrupod legs the dipoles are held at the appropriate height. Signal cables for the two linear polarizations of the crossed-dipole drop approximately 7 meters and pass through the surface of the antenna and into the vertex room where they are connected to the 74 MHz receivers.

Figure 1. Crossed-dipole antenna being deployed at the Pie-Town VLBA antenna

74 MHz Receivers for the VLA/VLBA

The receivers used at both the VLA and VLBA-Pt locations differ only in the final section responsible for interfacing with the signal distribution chain at each type of site (VLA or VLBA). To produce serviceable receivers (Figure 2) on such a short timescale, they were constructed almost entirely from commercial components (e.g. Minicircuits parts).

Figure 2. 74 MHz receiver being installed in VLBA-Pt vertex room.

The receiver performs several important functions:

(1) The two orthogonal linear feeds are converted by a full quad hybrid (MCL PSQC-2-70N) into right and left circular polarizations (RCP, LCP).

(2) An onboard source (NoiseCom NC302L) injects a noise calibration signal into both the RCP/LCP chains via directional couplers (MCL PDC-20-3). This source is directly powered by a ‘Cal’ signal provided by the site.

(3) Out-of-band rejection filtering is provided by high-Q cavity filters (Lorch 6CP-73.9/1.7-S) with a center frequency of 73.9 MHz and a 1.7 MHz bandwidth. Such a narrow bandwidth is necessitated by the close proximity of local television stations.

(4) The signal is upcoverted to the required 573.9 MHz slot by mixing the RCP / LCP channels with a 500 MHz reference L.O. provided by VLBA IF hardware. The resulting signal is further processed by the VLBA electronics for transport via fiber-optic link. In the case of the VLA receivers, this mixer stage is omitted and the final section consists of two power combiners to consolidate the 74 and 327 MHz channels for transport to the correlator.

Figure 4 presents a complete block diagram of the receiver installed at the Pt location. A detailed discussion of this design, including an account of the effect of the gain distribution on the receiver noise temperature, is available upon request.

GOALS AND RESULTS

It is our goal to provide a platform to perform many of the essential first experiments needed to establish the practicality and usefulness of very long baseline low-frequency interferometry. The first fringes of the VLA+Pt interferometer at 74 MHz are shown in Figure 5. Figure 6 illustrates the low-frequency, high resolution mapping of the quasar 3C123 with the 74 MHz VLA+Pt interferometer. This system has generated great interest in both the astrophysical and ionospheric science communities, already leading to exciting developments in each of these fields.

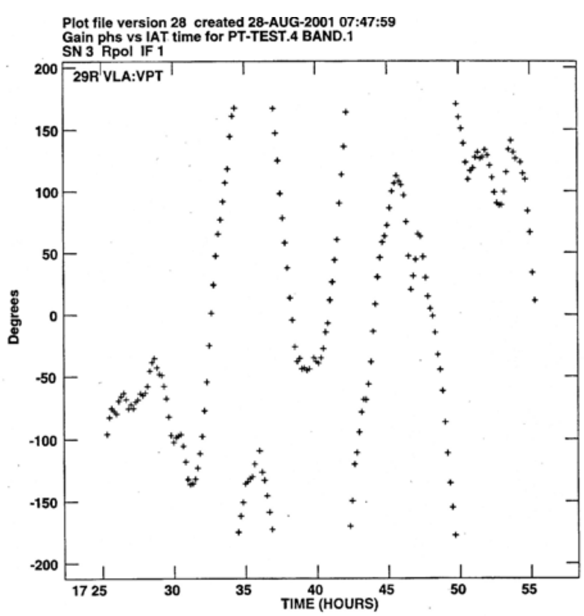

Figure 5. First Fringes using Pt Link at 74 MHz ~50 km baseline on 3C123, August 2001

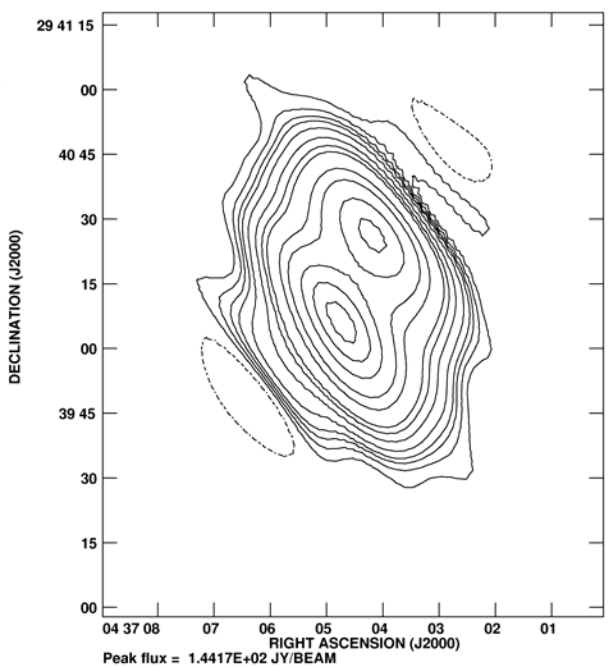

Figure 6. Image of 3C123 at 74 MHz using the VLA+Pt link with a resolution of 9 x 21 arcseconds

[1] Evidence for a Solar System Size Accretion Disk Around the Massive Protostar G192.16-3.82; D. S. Shepherd, M. J. Claussen, S. E. Kurtz, 2001; Science Magazine, Volume 292, Number 5521, Issue of May 25, 2001, pp. 1513-1518.

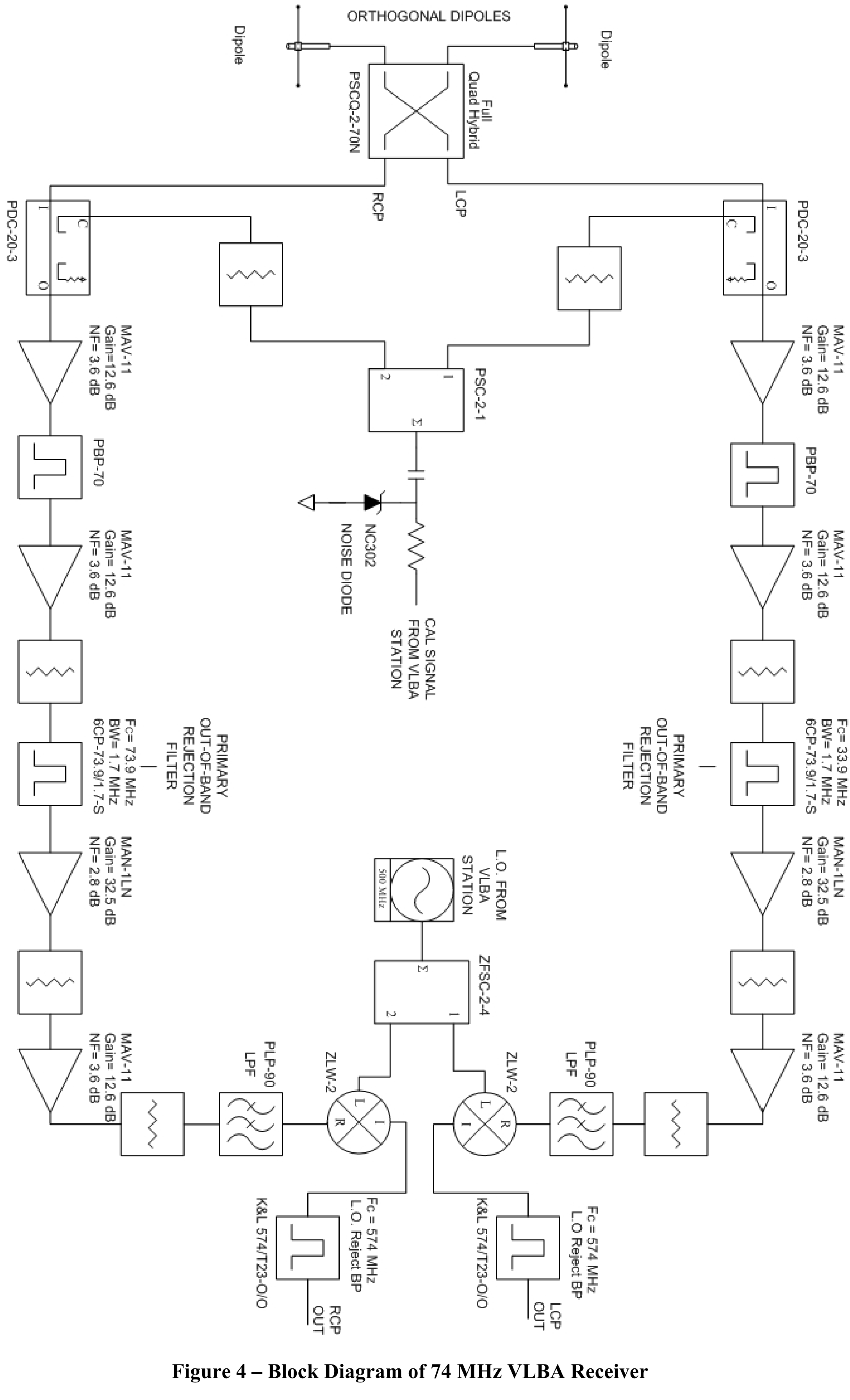

Figure 4 – Block Diagram of 74 MHz VLBA Receiver