Haystack Observatory Technology Development Center

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Abstract

Technology development at MIT Haystack Observatory focused on four areas in 2010:

- Digital backend recorder development
- Development of VLBI2010 receiver hardware
- RFI compatibility at GGOS stations
- Monitor and control infrastructure

1. Digital Backend Recorder Development

In 2010, the Haystack-NRAO collaboration continued to develop the RDBE subsystem (see Figure 1). In its current state, the RDBE is functional as a polyphase filter bank (PFB) processing eight user-selectable 32-MHz channels from a choice of sixteen uniformly-spaced channels in the 512-MHz IF bandwidth. A PFB personality with 8-MHz frequency channels is also planned, to provide compatibility with older data acquisition systems and to allow joint observations with the operational S/X geodetic network. A digital downconverter (DDC) personality is currently under development and will support flexible tuning of LO frequency and bandwidth for multiple baseband frequency channels.

Currently the RDBE produces data in Mark 5B formatted packets at 2 Gbps over its 10 Gigabit Ethernet interface; a VDIF output data-formatting module is currently under development for the RDBE and will provide more flexibility in the data output format. The RDBE also possesses a timing module which can be programmed to start and stop data packet transmission. This feature allows the RDBE to control the data observation start and stop times, hence shifting the time keeping responsibility from the Mark 5 data recorder to the digital backend. The Mark 5C 10Gbps data packet recorder was also demonstrated to reliably record ethernet data packets produced by the RDBE at a data rate of 2 Gbps; 4 Gbps operation is expected in the near future.

In July 2010 a VLBI fringe test was conducted between the Westford 18-m and GGAO 5-m antennas. In this experiment both sites used an RDBE programmed with the 32-MHz PFB personality and a Mark 5C data packet recorder. A 10-minute recording was made on the source 3C84, and fringes were successfully detected.

2. Development of VLBI2010 Receiver Hardware

Haystack Observatory is engaged in the development of a receiver front-end for the new GGAO Patriot 12-m antenna (see GGAO 2010 network station report). This hardware (see Figure 2a) is based on the cryogenic 2-14 GHz Eleven antenna developed at Chalmers University of Technology. In January 2010, noise temperatures were measured at 2-10 GHz with the new feed [1] and a set of Caltech 1-12 GHz LNAs [2]; the measured values were ~20 K over 3-10 GHz, with somewhat higher values expected above 10 GHz due to higher LNA noise temperatures.

The feed, shown in Figure 2a, is expected to be installed on the Patriot 12-m antenna in early 2011.

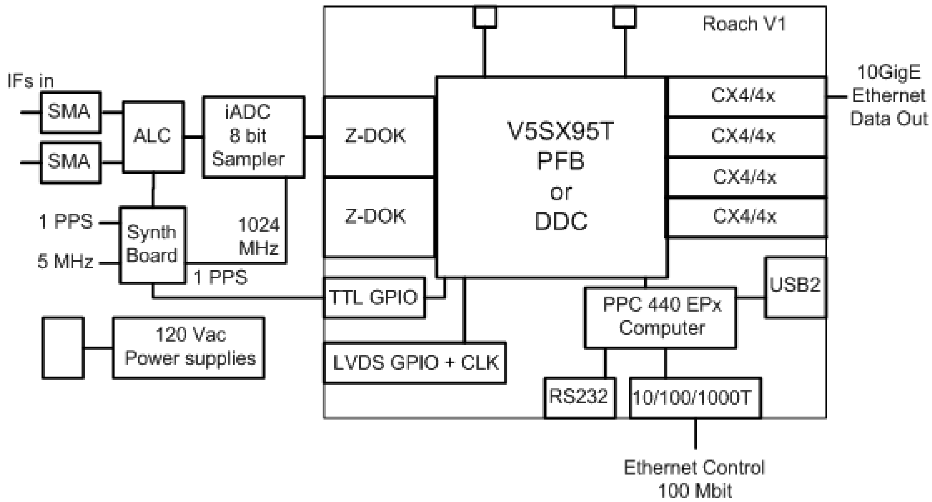

Figure 1. System Block Diagram of RDBE.

In late 2010 Sandy Weinreb and Ahmed Akgiray [3] introduced a new unbalanced broadband QRFH design (see Figure 2b). This feed was designed specifically for the Patriot 12-m antenna and requires only one LNA per polarization. At Caltech a prototype QRFH was constructed, and its radiation patterns were measured; the measurements indicate performance is near the theoretical expectation. This feed is also expected to be evaluated on the Patriot 12-m antenna in 2011.

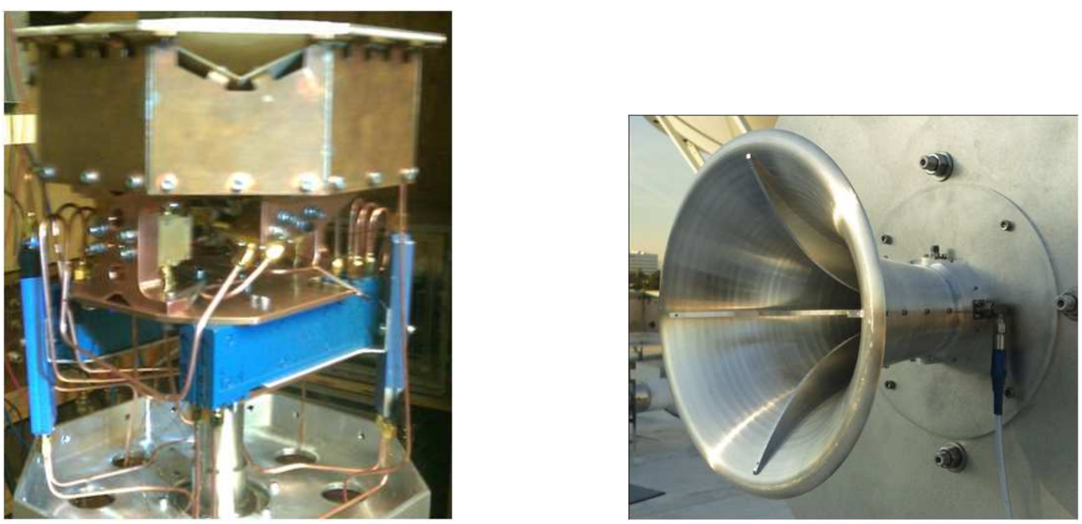

Figure 2. Broadband microwave feeds to be evaluated on the Patriot 12-m antenna at GGAO. (a) Chalmers Eleven Feed, with associated hybrids and LNAs, (b) Caltech QRFH.

A broadband noise-adding radiometer (NAR) system was developed at Haystack to provide VLBI2010 receiver noise temperature diagnostics. The system is based on a MiniCircuits broadband log-detector, which performs an RF power to DC voltage transducer function, and an Arduino microcontroller, which coherently integrates the receiver noise power during on and off states of the calibrated noise source. A block diagram of the NAR system is shown in Figure 3.

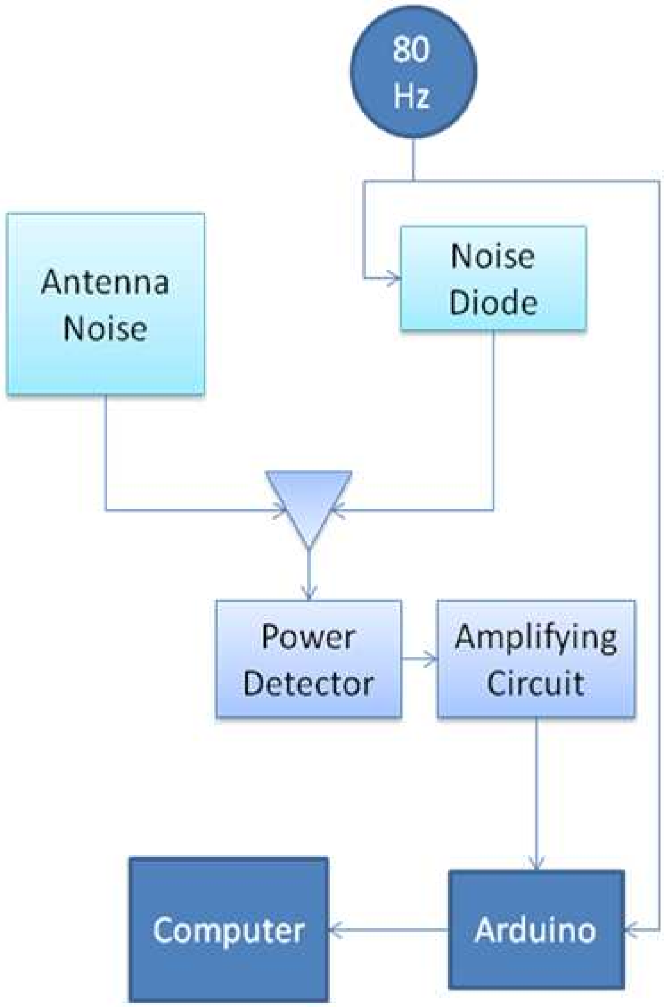

Figure 3. System block diagram of the Arduino-based Noise Adding Radiometer.

3. RFI Compatibility at GGOS Stations

Haystack staff studied the compatibility between a VLBI2010 receiver and both a DORIS ground transmitter and an SLR aircraft radar. The latter two systems have the potential to degrade VLBI data quality and, in the worst case, damage the front-end of the receiver. For a VLBI2010 receiver incorporating LNAs similar to the Caltech LNAs [2], studies [4] concluded that the power received at the feed from a DORIS beacon should be below -80 dBW, and below -70 dBW as received from the SLR radar. Options for inserting an RF barrier between a transmitter and a VLBI antenna are being investigated. The goal is to satisfy these power level restrictions without significantly degrading the DORIS and SLR data products.

4. Monitor and Control Infrastructure (MCI)

MCI collaboration between Wettzell station, NVI, and Haystack continued in 2010. In July 2010, a face-to-face meeting of the VLBI2010 MCI team took place at Wettzell. The main outcome pertinent to the VLBI community was the team sanction of a generalized MCI interface which can be adapted to accommodate arbitrary MCI system architectures. This was deemed necessary in order to accommodate MCI system architectural situations that extend beyond the specific cases encountered at Wettzell, GGAO, and Westford/Haystack. MCI self-identification will be a key feature of this generalization.

Haystack has also outlined a detailed description of the MCI needed for the newly installed Patriot 12-m radio telescope at GGAO. Hardware currently under development jointly by Honeywell-TSI and Haystack will meet the MCI requirements set forth for this system. The SysMon scheduler and IDL2RPC communications interface developed at Wettzell will be incorporated to provide the software backbone for this system.

References

[1] J. Yang, et.al., “Cryogenic 2-13 GHz Eleven feed for reflector antennas in future wideband radio telescopes,” IEEE Trans. on Antennas Propag. Special Issue on Antennas for Next Generation Radio Telescopes, vol. 59, no. 3, March 2011

[2] N. Wadefalk and S. Weinreb, “Data sheet on CITCRYO1-12A, 1-12 GHz Cryogenic HEMT Low Noise Amplifier,” California Institute of Technology

[3] A. Akgiray and S. Weinreb, “Wideband Near-Constant Beamwidth Flared Quad-Ridge Horn Feed for Reflector Antennas in Radio Astronomy.” Presented at the 2011 National Radio Science Meeting, Boulder, Colorado

[4] C. Beaudoin, B.E. Corey, and B. Petrachenko, “Radio frequency compatibility of VLBI, SLR, and DORIS at GGOS stations.” Poster G11B-0638 presented at the 2010 American Geophysical Union Fall meeting, San Francisco, CA