Haystack Observatory Technology Development Center

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Abstract

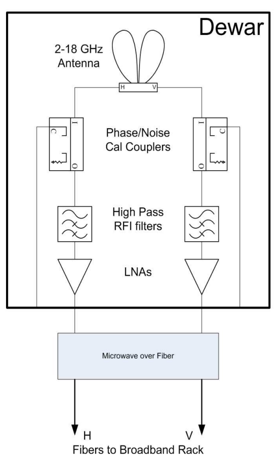
Technology development at MIT Haystack Observatory focused on three areas in 2009:

- a broadband, high-sensitivity receiver and data acquisition system to support VLBI2010 broadband delay observations
- the VLBI2010 prototype 12-m antenna system to be installed at GGAO
- improvement of data transfer over high speed fiber

1. The Broadband Delay Signal Chain

A proof-of-concept broadband signal chain has been designed and implemented by Haystack, with significant contributions from Honeywell Technology Solutions, Inc. The main components comprising the receiver front-end are displayed in Figure 1:

- Feed/LNAs in 20K Dewar
- Broadband phase and noise calibration
- RF over fiber transmitter



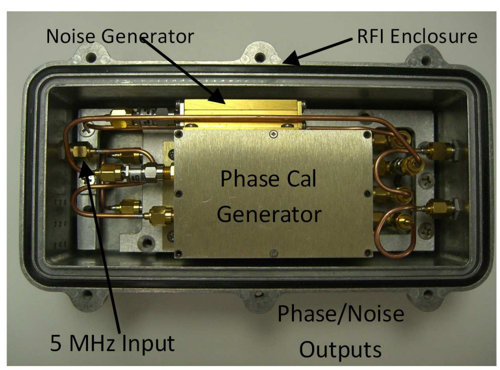


Figure 1. Main components of the receiver front-end: block diagram on the left; phase and noise calibration hardware on the right.

Many parts of the prototype front-end signal chain received attention this past year. Activities included:

- measurement of the antenna pattern of the Lindgren quadridge feed in the Dewar
- receipt and testing of a broadband Eleven feed from Chalmers
- enhancement of the new digital phase cal generator enclosure to reduce leakage to -180 dBm and to mitigate phase cal self-interference

The main components in the back-end are displayed in Figure 2 and Figure 3:

- Fiber receiver, amplifiers, and splitters (ORCA box)
- UpDown Converter (UDC) to select frequency bands
- Digital back-end (DBE) for digitization and filtering
- Mark 5B+ recorder

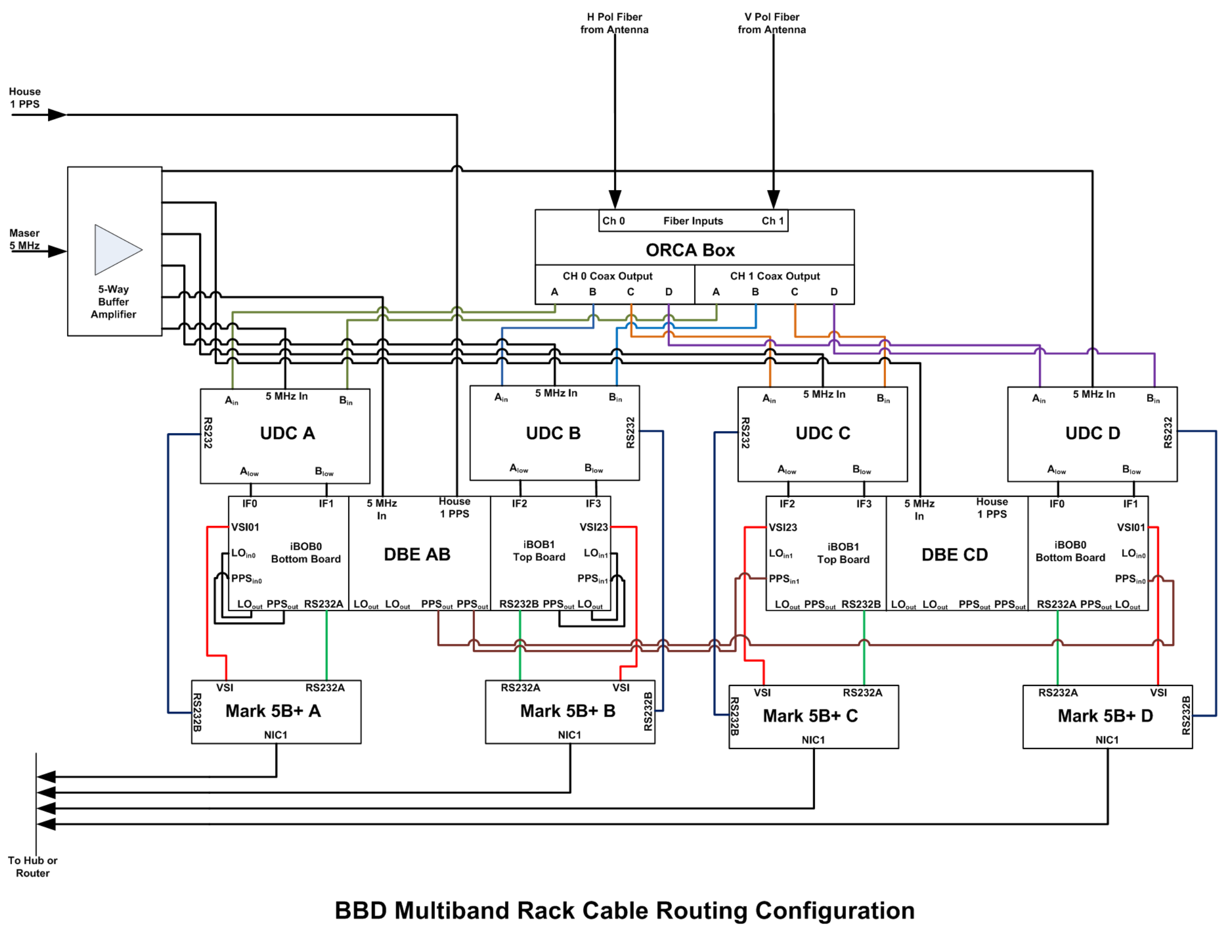


Figure 2. Schematic of the receiver back-end

Progress has been made in the development of upgrades for the DBE and the Mark 5B+ recorder. The new DBE, designated RDBE, is being developed jointly with NRAO, while the Mark 5B+ recorder is being upgraded to Mark 5C with hardware modifications from Conduant Corp. The RDBE will have adjustable analog level control, automated digital channel gain, selection of output channels, and 10 GigE output. The Mark 5C will support 4 gigabit per second recording via 10 GigE input. In 2009 the polyphase filter bank was implemented in the FPGA code of the RDBE, data were transferred from the RDBE to the Mark 5C over the 10 GigE path, and auto-correlations were made of the data recorded on Mark 5 disk modules.

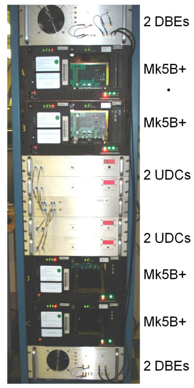


Figure 3. Photo of the receiver back-end hardware

2. Patriot 12-m Installation at GGAO

After implementing broadband proof-of-concept data acquisition systems on the Westford 18-m and GGAO 5-m antennas, a 12-m antenna was ordered with NASA funding and was delivered to GGAO. It is awaiting completion of the pad before assembly can continue.

3. Monitor and Control Infrastructure

Haystack began developing new monitor and control infrastructure (MCI) for the NASA Patriot 12-m antenna to be installed at GGAO, and a Google group has been established to centralize the development efforts. This MCI is being designed to meet the needs of the next generation VLBI2010 system and to further the initiative to enable remote, mostly unattended station operation. The GGAO 12-m MCI system initially will be composed of five separate nodes which will each collect data and provide control of the various components of the stations, as indicated in Figure 4. Data collected from each node will reside on a local backup repository.

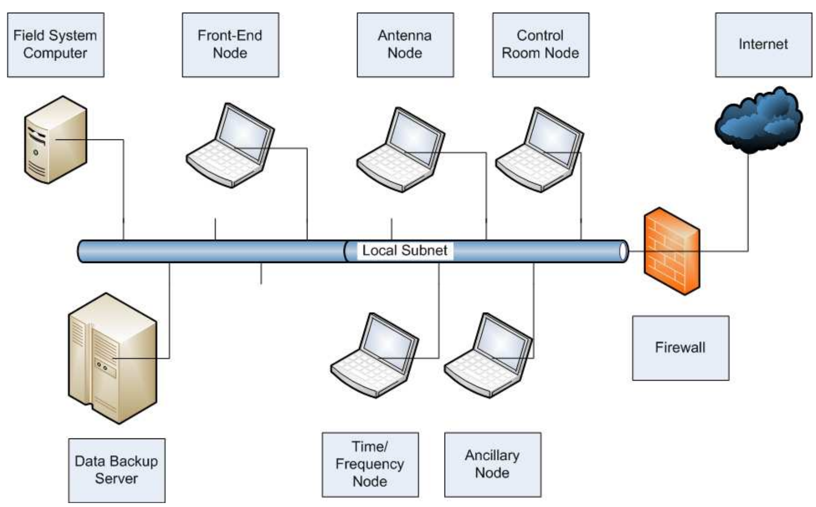


Figure 4. Network diagram of the 12-m monitor/control infrastructure

4. GGOS Station Self-introduced RFI

In an effort to understand what problems might exist when co-locating instruments at a GGOS site, effective isotropic radiated power (EIRP) levels were measured from the SLR 9.4 GHz aircraft radar and from the 2 GHz DORIS beacon at GGAO. These levels are being compared to that which will introduce unacceptable RFI into the VLBI2010 system. A recommendation regarding the acceptable EIRP levels as observed by the VLBI2010 front-end from the DORIS beacon and the SLR radar transmitters is pending.

5. e-VLBI Development

Haystack Observatory continues to support development for real-time e-VLBI and for e-VLBI data transfers. The main activities in 2009 were in e-transfer improvements.

- Improvements have been made in the automated transfer of VLBI data from Wettzell to USNO for the weekday Intensives.
- New connections: Haystack has been very active in helping to specify, support, and test new e-VLBI connections. Connection to the USNO correlator was implemented, but initially at a very low rate due to administrative problems. Work continues on completing the connection from the Kokee, Hawaii site to the DREN network which will provide access to the U.S. Testing has begun on the new connection to Fortaleza.
- Haystack has also been working with GSI and NICT personnel to improve e-transfers from Japanese K5-equipped sites. Data from all K5 sites are e-transferred and translated to Mark 5A or Mark 5B format. Recently the choice of format has been made at the destination correlator, after transfer of the data from GSI, in order to most closely match the complement of Mark 5A and Mark 5B playback systems at the correlator. The K5 e-transfers have been implemented and improved jointly with personnel at GSI and at Kashima.

6. Acknowledgements

The broadband demonstration system is funded by NASA's Earth Surface and Interior Focus Area through the efforts of John LaBrecque, Chopo Ma, and Herb Frey.

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Sandy Weinreb and Hamdi Mani of Caltech have also continually supported developments of the broadband receiver through direct and e-mail correspondence on various topics regarding cryogenic microwave receiver front-ends. They have also provided hardware and test support through network measurements of the Eleven antenna received by Haystack and through custom modification of their LNAs to protect the broadband front-end from the high power transmitters at the Millstone Hill Observatory.