The Green Bank Telescope K-Band Focal Plane Array

Monitor and Control System Hardware Description for the Critical Design Review of January, 2009

Introduction

The receiver Monitor and Control system does just that: monitors various parameters that indicate the operational status of the receiver, provides a way to alter some parameters to optimize the receiver function and provides an interface between the monitor and control functions and the rest of the telescope system. For GBT receivers and related systems this has been done with a descendent of the VLBA Standard Interface Board (SIB). The requirements of a multi pixel array exceed the capacity of the GBT version of the SIB by a large factor, and system communication needs would overwhelm the capabilities of the existing GBT Monitor and Control Bus (MCB), also based on a VLBA standard using an RS-485 serial bus.

Needs

For a multiple pixel array the complexity of the monitor and control system increases by a factor roughly equal to the number of pixels. For a small number of pixels the additional hardware and wiring aren't too cumbersome, but when the number of pixels starts reaching ten, twenty, or in the sixties as in the long term plans for the KFPA it becomes a major effort to fabricate a wiring harness to connect thousands of monitor and control points to a central location. It also adds significant weight when a couple thousand meters of wire are added to a receiver, and if something malfunctions and creates a need for repair it can lead to significant time lost from observing to sort out the problem, find the related wiring and correct it. Since an array receiver is already built in a physically distributed architecture it was decided that also distributing the monitor and control system was the best approach.

Distributed System

The single pixel KFPA prototype uses a monitor and control system built on small circuit boards placed near their related functions and communications is done with the Inter-Integrated Circuit bus (IIc or I-squared-C). The IIc bus is overseen by a microcontroller which communicates with the rest of the telescope system by 100 Mbit Ethernet. The microcontroller also has firmware that creates a web browser based GUI that affords the user monitor and control capabilities from any computer allowed access by the Green Bank network without any other software. The IIc bus is deactivated during observing scans to reduce the possibility of RFI.

LNA Bias

Each polarization of each pixel has a cryogenically cooled, four stage amplifier. Each stage of these amplifiers requires a drain bias and a gate bias. The amplifier as a whole requires an LED bias and a ground. Each of these bias voltages must be provided separately for each stage and carefully regulated. Using traditional NRAO bias supply cards would result in each bias voltage requiring an individual, insulated feed-through into the vacuum dewar, resulting in twenty DC feed-throughs for the single pixel prototype but over 1,200 DC feed-throughs, each with the potential to leak, for a 61 pixel system. Using the distributed idea a bias card was made using IIc-controlled potentiometers to adjust the bias voltages and IIc A/D converters to monitor the bias voltages. This bias card was located inside the vacuum dewar and required only six feed-throughs for eight amplifier stages in two amplifiers, those six including two for the bipolar power supply.

Prototype Performance

The monitor and control system used on the prototype receiver is built to mimic what would be on later multi-pixel receivers. A bias card for the two cryogenic amplifiers and an eight channel temperature sensing card are placed inside the dewar, a power supply monitoring and regulation card, a two channel vacuum sensor card and a 16 channel I/O expander card to provide digital control bits are placed outside the dewar and all cards are connected to power and IIc busses.

After a few minor difficulties due to our inexperience with IIc the system operated as expected. The web page feature became the primary interface between the users and the receiver and additional software was created to log some of the monitor points. When the Ethernet network was not available an interface with a standard PC running Labview was able to perform, all necessary monitor and control functions. An additional monitor point was added to monitor the noise calibration voltage inside the dewar by using an unused channel on the temperature sensing card.

Determinations

From the experience gained from the prototype we feel a distributed monitor and control system served by an IIc bus is fully capable of meeting the monitor and control needs of an array receiver.