An L-band Cryogenic Phased Array for the Green Bank Telescope: Instrumentation Upgrades and Expanded Field-of-View

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A new low-noise cryogenic phased array feed (PAF) receiver optimized for the Green Bank Telescope (GBT) optics has been developed as part of the focal L-band array for the GBT (FLAG) project. In this work, the dipole spacing has been increased to expand the instantaneous field-of-view of the receiver and the instrumentation has been upgraded to improve the system temperature and reliability. The PAF is a 19-element hexagonal array of crossed dipole radiating elements, in which the near-half-wave coaxially-fed dipoles are tuned to operate near 1.4 GHz. These dipole elements are designed optimally for active impedance matching to cooled low-noise-amplifiers (LNAs). The transition between the dipoles and the LNAs consists of a custom balun and thermal transition to minimize electrical loss and heat transfer between the warm dipoles and the cold (~20 deg K) LNAs. The LNAs are custom-designed for low-noise cryogenic operation between 1-2 GHz, with 36 dB of gain and noise temperature of ~5K. Integrated with the front end receiver package is a 38-channel customized electronics assembly with each channel consisting of an I/Q mixer-downconverter and an 8-bit analog-to-digital converter (ADC) with a digitizing bandwidth of 150 MHz. Also integrated with the assembly is a serial multiplexer and fiber optic transmitter for each of the 38 channels, which is used to transport the data over ~2km through fiber optic links. A unique feature of the digital links is that the data is streamed with no formatting and bit and byte alignment functions are implemented in the far end digital signal processing. After the data is aligned, the 150 MHz bandwidth is channelized using a 512-bin polyphase filter bank (PFB), implemented on a Casper ROACH II based FPGA system. Following the filter bank, calibration coefficients are applied to transform the I and Q channels into the upper and lower sidebands. A streaming data acquisition system is initially used to record one of the PFB channels to disk for commissioning testing. The data are then processed offline. We will present preliminary results from a recent test observation campaign with the GBT. In a coordinated development program, a wideband (150 MHz) real-time phased array beamforming backend was developed for use with this PAF system for the study of diffuse hydrogen, pulsars, and fast transients on the GBT.