Modular Analysis Software for the ALMA Front End Test and Measurement System

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Introduction: The Atacama Large Millimeter/ Submillimeter Array (ALMA) is a radio interferometer that is located in the Atacama Desert in Chile (altitude ~16,400 ft.). It consists of 66 antennae, creating a synthesized aperture with a diameter of up to 16 km. There are 59 12-m antennae and seven 7-m antennae, each of which has a parabolic dish (cannont deviate from a perfect parabola by more than 20 microns), sub-reflector, and receiver. The structure of the interferometer can be seen in Figure 1.

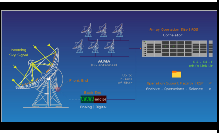

Fig 1: This diagram shows the structure of ALMA interferometer. Each antenna consists of a dish, a front end, a back end system which connect to a correlator which combines the signal from every antenna.

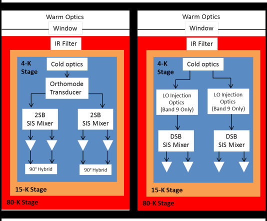

Fig 2: These are diagrams of the Cold Cartridge Assembly, which processes the sky signal to be sent to the back end of the antenna. (*Left*) Bands 3-7. (*Right*) Bands 8-10.

New Modular Library: This library is written in PHP and is used to accept, analyze, and display test data from the Front Ends. This upgrade features a more structured interface that allows flexible database retrieval, universal data structures that allows for simple data manipulation, and an adaptable plotting algorithm.

The Front End: Each front end is a cryogenically cooled system that has 10 receiver bands that allow a frequency coverage from 31.3 GHz to 962 GHz. Each band, except bands 1 & 2, is cooled to 4 K and consists of an orthomode transducer (OMT) and either a pair of SIS mixers (bands 3-7) or a single SIS mixer (bands 8-10) that are fed by a 90° hybrid RF coupler and LO couplers. This structure can be seen in Figure 2. This system essentially takes a sky signal and 1) mixes it with a reference frequency generated by a local oscillator (LO), 2) lowers the signal to an intermediate frequency (IF), 3) splits it between it's polarizations (using the OMT), then splits it again into an upper and lower sideband (using the SIS mixers), and 4) sends these signals to the back end.

The Test System: The test system compares system outputs to pre-determined specifications for minimal noise in the observations made by the receivers. This system tests noise temperature (noise added to the output from the receiver) and the IF output spectrum (checks for spikes in power over the IF window and the maximimum power variation a specified IF range), along with other attributes in the Warm Cartridge Assembly (WCA).

Results: These new upgrades decreased the computation time of the testing algorithms and allows for ease in developing new upgrades and performing maintenance. This new software is integrated into the server at the NRAO Technology Center and will be integrated into the server in Chile. Examples of the test outputs can be seen in Figure 3.

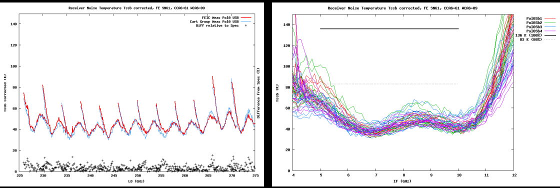

Fig 3: (*Left*) The plot shows the LO frequency (GHz) vs. the corrected noise temperature for the receiver (red), for the cartridge (blue), and the difference (black). For optimization, the black needs to be as close to 0 as possible. (*Right*) The plot shows IF signal (GHz) vs. corrected noise temperature (K), for each sideband for each polarization, which must be below the 100% (black) and 80% (dotted) specification.

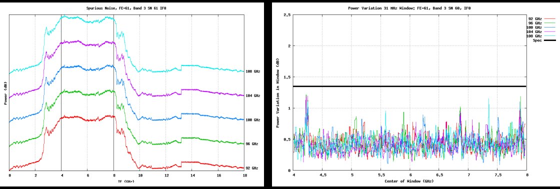

Fig 4: (*Left*) The plot shows IF frequency (GHz) vs. power (dB) for band 3, and is looking for spikes and large variations between the desired IF window (4 – 8 GHz). Each LO frequency for the band is represented. (*Right*) The plot shows the power variation (dB) over a 31 MHz window at the center frequency of the window (GHz). Each LO frequency for the band is represented, along with the specification line. at 1.35 dB.