Academia Sinica, Institute of Astronomy & Astrophysics
AMiBA Project

Subject:
Correlator Module Responsivity Test Setup, 13-Element Expansion

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References: Correlator Module SNR Tests (memo 2007-DK003, May 1, 2007), Correlator Responsivity Tests (Correlator_Tests_2007may11)

1. Introduction

The AMiBA project is currently operating with 7-elements but will be upgrading to 13-elements within several months of this writing. The 7-element system requires 42 correlator modules (21 in each correlator frame), along with 7 calibration modules (1 in each 1^{st} section electronics box), plus 6 spares for a total of 55 modules. The expansion to 13-elements will require 156 correlator modules (78 in each correlator frame), along with 13 calibration modules, plus 21 spares for a total of 190 modules. Since we currently have 55 modules we will need to assemble and test 135 more modules for the upcoming expansion.

The original 49 correlator modules in the present system were not tested prior to installation. Rather they were tested in-situ as part of the overall telescope integration test effort. Bad or poorly performing modules were subsequently replaced after the fact. The correlator frame for the 13-element system will be fully populated thus replacing correlator modules will be significantly more labor intensive in terms of disassembly and reassembly. I am therefore recommending that we test the modules prior to installation for the expansion effort.

The intent of this memo is to capture the test methodology used to validate the functionality of each of the deliverable correlator modules prior to installation into the correlator system.

2. Initial Assembly and DC Alignment

The correlator module is composed of three separate pieces that include the Marki correlator module, the DC amplifier board, and the DC amplifier housing (see Figure 1). The interface between correlator module and the DC amplifier board is via 4 small sockets that protrude from the DC amplifier board. These sockets are not initially installed onto the board because they require precise alignment with the correlator module. Insert the 4 sockets into the correlator module ports labeled I1 through I4 and push down until they bottom out. Mount the DC amplifier board into the housing and align the sockets with the holes in the board. Ports I1 through I4 of the correlator module should mate with J1 through J4 of the board, respectively. Solder the 4 sockets in place. Firmly secure the DC amplifier assembly to the correlator module using 4 screws. Measure the DC resistance of J1 through J4 to ground. The resistance should be approximately 50 kOhms.

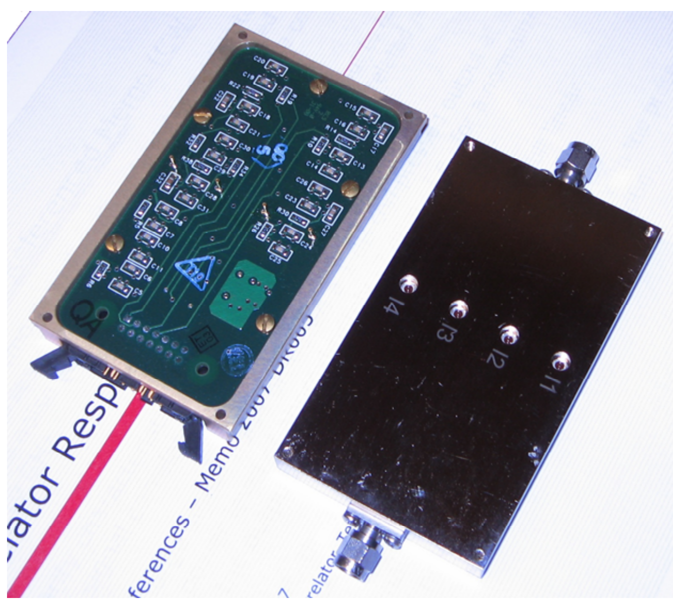

Figure 1 DC amplifier assembly on left, Marki correlator module on right. The 4 sockets protruding from the board align with the 4 pins in the correlator module.

Power up the module using the correlator module test box (gray box just to right of Tek oscilloscope in Figure 4). Use a voltmeter to monitor the voltage at U9-1 and adjust R7 to produce -2.20 V (note negative sign). This is the common or global DC offset presented to each of the 4 lag channels. Next monitor the Lag 1 (L1) output on the test fixture box and adjust R21 to produce +2.20 V (note positive sign). Repeat adjustment for Lag 2 (R37), Lag 3 (R13) and Lag 4 (R29). Figure 2 provides the locations of each of the 5 potentiometers.

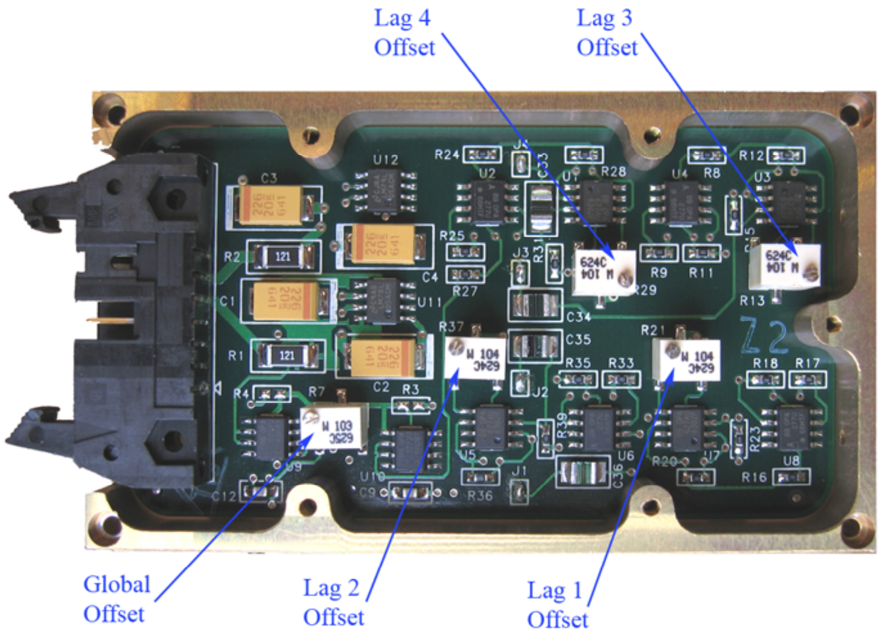

Figure 2 DC offset potentiometers. Adjust global pot for -2.20V at U9-1 first, followed by adjustment of individual lag pots to achieve +2.20V.

3. Test Configuration

Figures 3 and 4 provide the block diagram and photograph for the test setup. The upper "Noise Source Unit 1" (2 to 18 GHz) is split using a power divider and de-correlated using two unequal cable lengths (~5.5 feet disparity ~8.2 nsec). These two uncorrelated noise signals represent the noise output from a pair of receivers. The uncorrelated noise power levels were profiled using AT1 and AT2 to be -6.1 dBm (left input) and -6.6 dBm (right input). The uncorrelated noise can be easily be turned off by removing the DC power supply from the upper noise source unit.

The lower "Noise Source Unit 2" is split using a power divider. Each noise signal is fed to a double balanced mixer. The left mixer is driven into saturation using a 1 kHz square wave with amplitude of 1 Vpp (peak to peak) to produce 0 and 180 degree phase shifts of the 2 to 18 GHz noise signal. For alignment purposes the phase switch frequency was temporarily slowed down to < 1 Hz and a power meter was used to check the power balance between the two phase states. The DC offset of the square wave was fine adjusted to produce an imbalance of < 0.1 dB[1]. The final phase switched noise signal entering the left port of the correlator module under test was -25.7 dBm. The right mixer exists for delay and S21 symmetry to match the left channel. It was driven with a static voltage from a DC power supply and resulted in a level of -25.9 dBm entering the right port of the correlator module under test (goal is to have balance levels into the correlator module).

4. Responsivity Tests

Connect the synch output port of the Wavetek function generator to channel B of the oscilloscope and trigger off of this signal. Using a 10x probe on channel A, connect to the Lag 1 output of the gray test box. Configure channel A to AC coupled mode to remove the +2.2V DC offset. Adjust either one or both blue PV-18 phase shifters using a small Phillips screwdriver until the resultant 1 kHz square wave is maximized and record the RMS amplitude. Figure 5 represents typical responsivity results for a working correlator module with the uncorrelated noise source turned off. Move the 10x probe to the Lag 2 output and repeat adjustment of PV-18 phase shifters for maximum output. Each of the 4 lags is offset in delay by 25 psec and require a different PV-18 delay solution. Note the in-phase relationship between the synch signal and the lag outputs. It is possible to adjust the phase shifters to produce an out-of-phase signal but this will result in smaller output amplitudes.

[1] Final left mixer drive level: +450 mV high state, -550 mV low state. Right mixer: +700 mV (static)

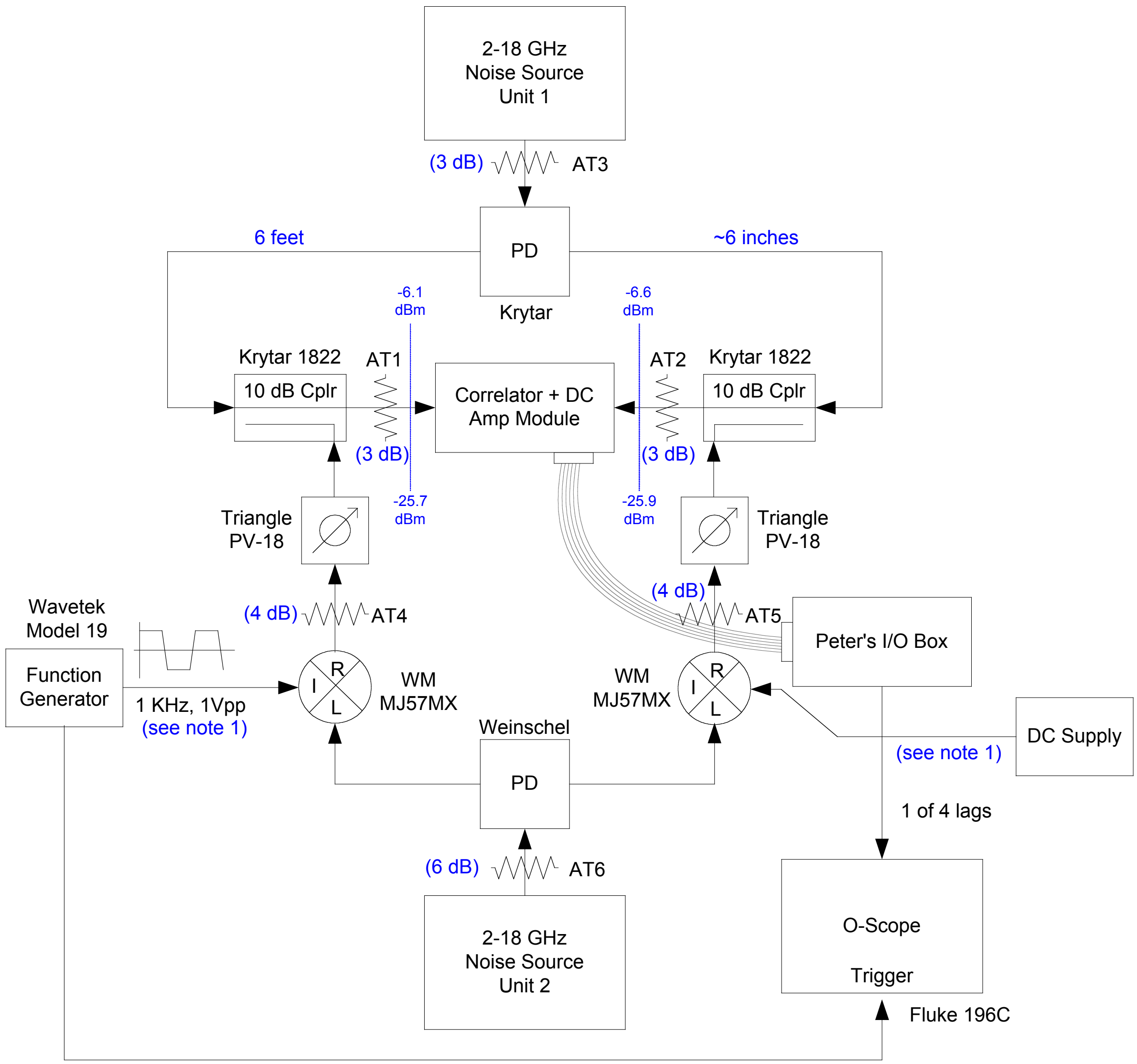

Figure 3 Test setup block diagram. Upper noise source unit 1 produces non-coherent noise while lower noise source unit 2 produces coherent noise into the correlator module under test. 1 kHz phase switching is accomplished by left mixer. Right mixer is present for symmetry and is operated in a static mode.

The specified minimum Marki module responsivity is 80 V_{RMS}/W, and the DC amplifier provides a gain of approximately 1000 V/V. This results in an overall minimum correlator module responsivity of 80 kV_{RMS}/W. The actual input levels going into the module for the example shown in Figure 3 is -25.7 and -25.9 dBm, with the average input power being -25.8 dBm (2.63 uW). Solving for x in the relation below:

$$80\ kV_{RMS}/1\ W = x\ V_{RMS}/2.63\ uW$$

we get x = 210 mV_{RMS}. Thus the minimum output we should expect from a working correlator module should be 210 mV_{RMS}. Note that the four lag responsivity values obtained for serial number 178 in Figure 5 are 456, 418, 431 and 431 mV_{RMS}, which are nearly a factor of two over the specified value.

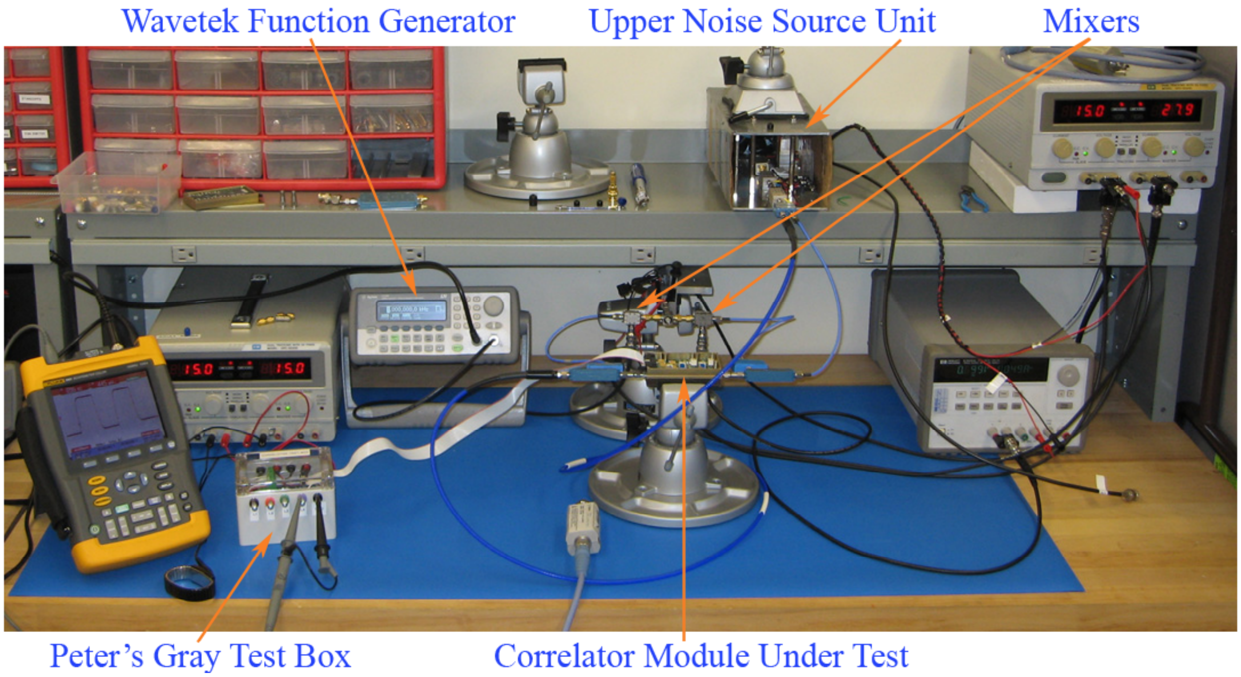

Figure 4 Photo of correlator test station in Hilo lab. The lower noise source unit is barely visible behind the mixers.

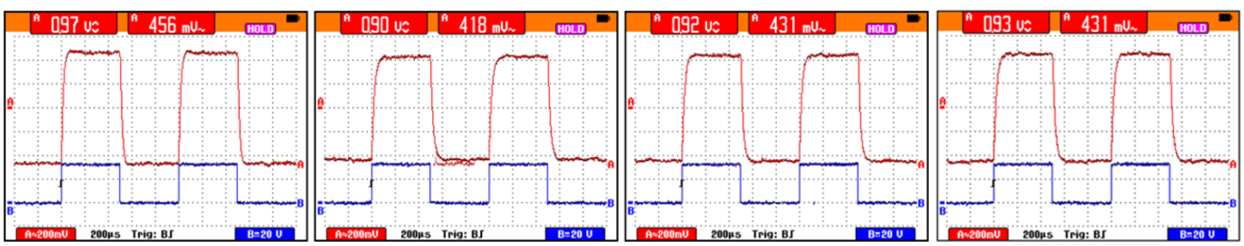

Figure 5 Responsivity results for correlator module serial number 178. From left to right are Lags 1 to 4. Blue trace is synch waveform from Wavetek, red trace is the measured responsivity. Note good consistency of RMS amplitudes: 456, 418, 431 and 431 mV_{RMS}.

5. Recommendations

There are approximately 135 modules to be assembled and tested as of this writing. The 13-element expansion has been delayed due to a structural issue in the platform. Nevertheless, I recommend that we complete the assembly and test of all remaining modules by late summer of 2008.