



**Atacama
Large
Millimeter /
submillimeter
Array**

Installation and Test Plan of the Hydrogen Maser ALMA Phasing Project

ALMA-05.11.21.01-0001-A-PLA

2014-04-10

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1. Description

1.1. Purpose

As part of the ALMA Phasing Project (APP), an upgrade of the Master Frequency Standard (MFS) is required, as the current Rubidium based source is inadequate.

This document describes basic framework required for the installation and initial testing of a T4Science Hydrogen Maser (Maser) in the CLOA room at the AOS, as well as a list of required equipment and personnel. A rough timeline is also presented.

1.2. Scope

This plan only covers the Maser installation part, along with a reduced set of PAS (Provisional Acceptance on Site) tests. A preliminary Compliance Matrix will be generated following the work.

It does not address the software and Monitor and Control upgrades that are required.

NOTE: although intended to ultimately replace the current, Rubidium cell based MFS, this Q1 2014 work will only install and functionally test the new HMaser, without changing the CLOA from its current state.

2. Related Documents and Drawings

2.1. Applicable Documents

Ref	Document Title	Document Number
[AD01]	Backend IPT Product Assurance Requirements	BEND-50.00.00.00-079-B-PRO
[AD02]	ALMA Environmental Specification	ALMA-80.05.02.00-001-B-SPE
[AD03]	ALMA System General Safety Design Specification	ALMA-10.08.00.00-003-B-SPE
[AD04]	ALMA Safety Manual	ALMA-10.08.00.00-011-D-MAN

2.2. Interface Control Documents

Ref	Document Title	Document Number
ICD 01	ICD between APP and ALMA Back End	ALMA-05.11.10.00-50.00.00.00-A-ICD

2.3. Test Report Documents

Ref	Document Title	Document Number
PAI	PAI for APP Hydrogen Maser Master Frequency Standard	ALMA-05.11.21.50-001-A-TDR
PAS	PAS for APP Hydrogen Maser Master Frequency Standard	ALMA-05.11.21.50-001-A-TDR

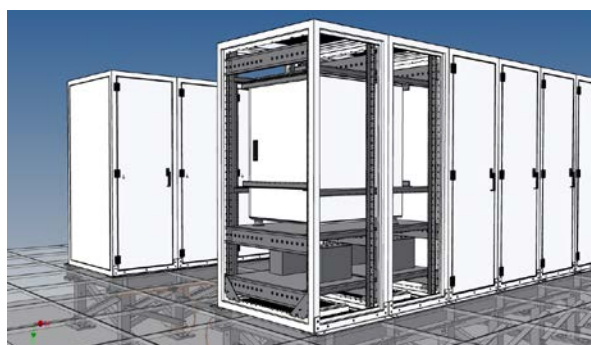
2.4. Abbreviations and Acronyms

AD	Applicable Document
ADE	ALMA Department of Engineering
AIV	Assembly, Integration and Verification
ALMA	Atacama Large Millimeter Array
AOS	ALMA Operation Site

APP	ALMA Phasing Project
BE	Back End
CLOA	Central LO Article
COTS	Commercial Off the Shelf
CRD	Central Reference Distributor
CRG	Central Reference Generator
ICD	Interface Control Document
LO	Local Oscillator
Maser	T4Science Hydrogen Maser
MFS	Master Frequency Standard
MIT	Massachusetts Institute of Technology Haystack Obs.
NRAO	National Radio Astronomy Observatory
OSF	Operations Support Facility
PAI	Preliminary Acceptance In-House
PAS	Product Acceptance On-Site
RD	Reference Document
TBD	To Be Determined
UC	Universidad de Concepcion

3. Installation Drawing (preliminary)

Below is a drawing representing the rack layout and an inside view of what the proposed installation plan hopes to achieve. The completed assembly will have all the doors and panels installed.



4. Bill of Materials

The Article to be installed consists of three major subassemblies, the maser, the battery packs and the racks, as indicated in the table below.

Description	Configuration Item Number
Hydrogen Maser	
Equipto dual 19" rack	
Battery pack	
Temperature Sensor	
Inter rack Cables	
Intra rack cables	

Table 1: Hmaser article

5. Summary of Maser Requirements to be Verified and Accepted

5.1. Technical Requirements

This plan is intended to cover only the installation of the hydrogen maser in the CLOA room. It does not cover the integration of the maser output into the CLOA, which will happen at a later date. For this reason, only two of the APP technical requirements will be addressed through the PAS, and those only partially.

- Maser Allan Standard Deviation shall be $< 1e-13$ at 1 second integration times and $< 2e-14$ at 10 second integration times (APP0120).
- Maser status/health information shall be accessible via a network interface and recorded at least once every 10 minutes (APP0110).

5.2. Project and IPT-level Technical Requirements

- Verification of the temperature monitoring system
- Verification of the M&C interface

6. Verification Process

The following section provides a summary of the process.

6.1. In-House Preliminary Verification and Acceptance (PAI)

The following tests will be performed at MIT Haystack to establish baseline performance:

- The Allan Standard Deviation of the maser signal with a precision quartz crystal oscillator will be measured at Haystack in the 1-10 second range. This test will use a Symmetricom 5115A Phase Noise Test Set. The schematic of the test with photo of the relevant test equipment is shown in Figure 1.

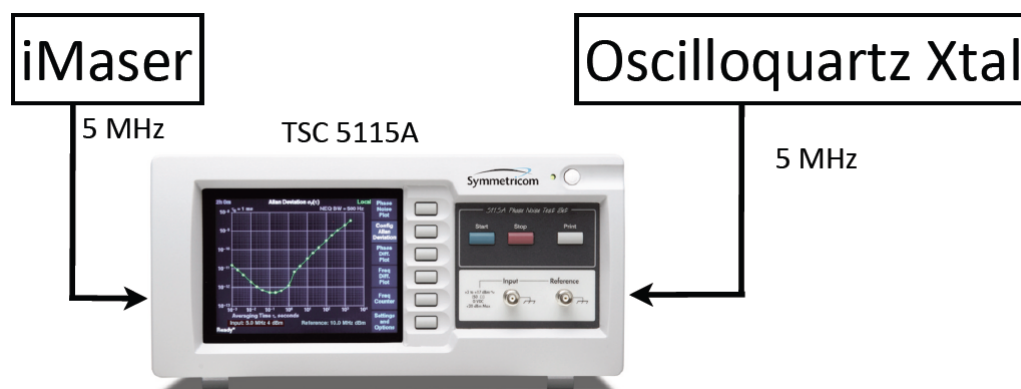


Figure 1: Test setup for ADEV measurement of Maser-Crystal comparison

- The APP Maser diagnostics can be remotely monitored via an internet connection. At MIT Haystack, this connection will be tested and verified. The nominal values of all diagnostics will be noted at MIT Haystack and recorded. The monitoring page can be accessed via a netbook computer directly attached to the maser internet connection (Figure 2).

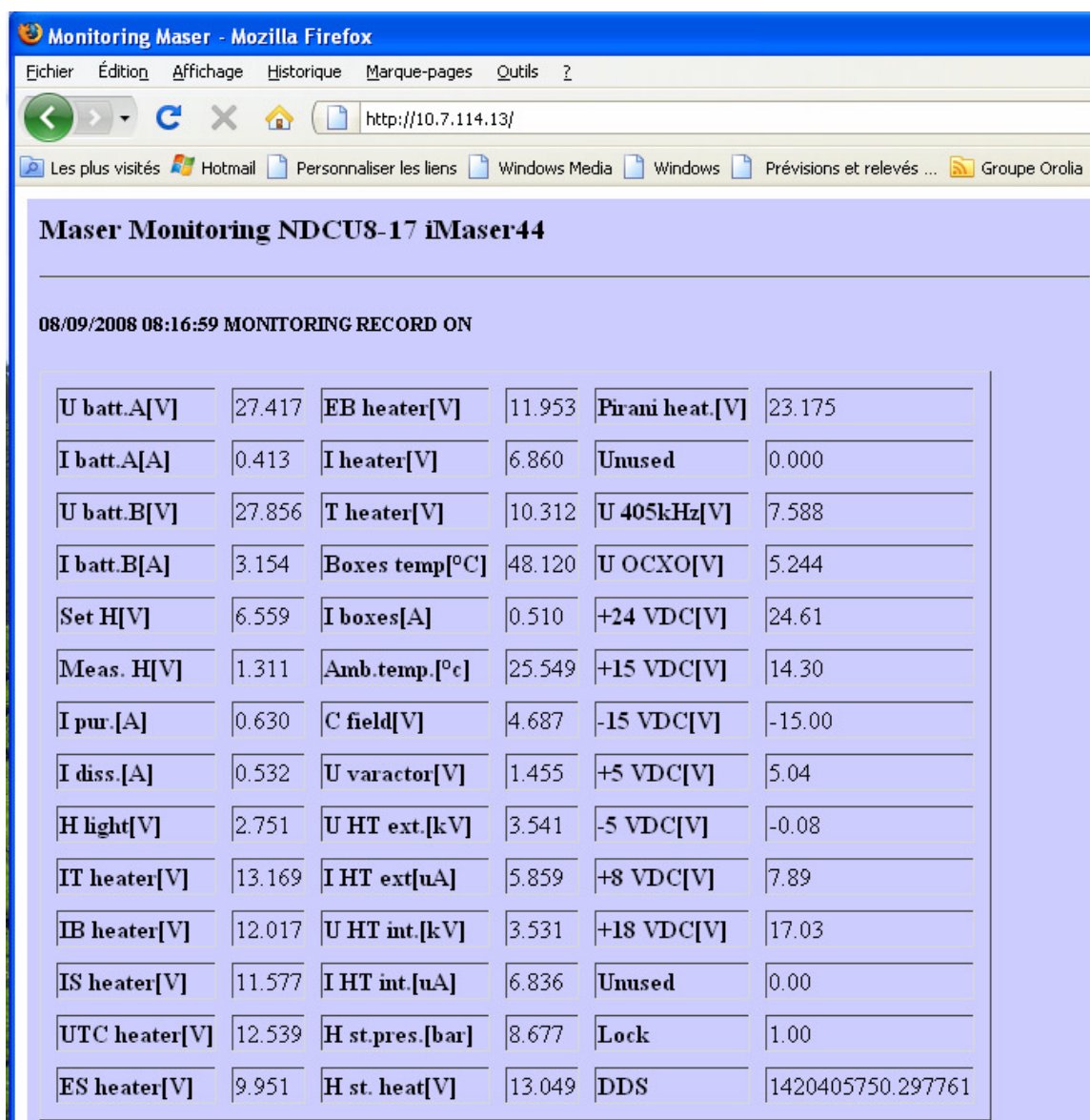


Figure 2: Maser web-interface with diagnostic information (updates with a user-settable cadence)

- In addition, the 1PPS from the Maser will be compared against a GPS 1PPS to measure and verify linearity of offset between these pulses over time. The drift of the maser on time scales of a day will be recorded.

The test results will be compiled in the PAI for APP Hydrogen Maser Master Frequency Standard, document number ALMA-05.11.21.50-0001-A-TDR.

6.2. On-Site Acceptance (PAS)

The following tests will be performed at the AOS and then compared to PAI results. It is envisaged that the PAS of the maser will be carried out in the Correlator Room at the AOS. Once PAS is passed, the maser will be relocated into the racks to be installed in the CLO Room.

- The maser will require at least 24 hours to come to thermal equilibrium. After that has been achieved and verified through stabilization of the diagnostic signals, we will compare all maser diagnostics (Figure 2) with those recorded while at MIT Haystack. This will constitute evidence that the main sub-systems in the maser are operating normally. For this

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test, a netbook computer will be connected directly to the Maser at the AOS, but we will also test connectivity on the ALMA network as available.

- After verification of normal maser diagnostic signals, the comparison ADEV test shown in Figure 1 will be performed and the results compared with identical tests carried out at MIT Haystack.
- A test of the APP GPS vs Maser 1pps will be carried out and compared to results obtained at Haystack. This will be done with the Agilent Counter. At this time, the capability of synching the maser 1PPS to an external 1PPS (in this case the GPS 1PPS) will be performed.
- The Maser will be connected to the Computing network, to enable monitoring and control. All basic remote maser access via internet connection will be tested, including monitoring and control.
- PAS for the maser rack will consist of a visual check that the rack sustained no damage during shipment, and then after installation in the CLO Room, the A/C power from the in-rack supply will be verified.

The following equipment must be on site before the start of PAS. Items indicated by a (*) must be brought to the site 2 weeks (14 days) prior to PAS, and powered up to allow them to stabilize.

- **Oscilloquartz crystal (*)**
- Symmetricom 5115A Phase Noise Test Set
- Netbook computer
- Agilent 53132A Counter
- Connecting cables

6.3. Maser Integration and Test

During the maser PAS, the racks to house the maser will be installed in the CLO Room, and when the racks are ready, the maser will be installed in the HMR and all connections within the HMR established. In addition, all cabling from the HMR to the correlator room (for maser 1PPS output and 1PPS Synch) will be run.

At this point, several additional tests leading to integration of the maser can be carried out:

- Remote monitoring and control of the maser can be re-tested through commands and features available in software release version 10.8.
- Re-establishment of monitoring the comparison of the APP GPS 1PPS with the maser 1PPS; synch testing of the maser 1PPS can also be tested with the maser in place.

The tests above do not require that the 5MHz and 10MHz outputs from the maser be connected to the ALMA CRG/CRD (replacing the rubidium 5MHz). Once these connections are made (ref. ICD with ALMA BE), the remaining integration tests can be carried out. These will also require software version 10.8 to be running:

- Monitor ALMA GPS 1PPS vs. 1PPS derived from maser 5MHz. This is the same comparison that is currently available using the rubidium standard.
- Regression tests to ensure that the maser 5/10MHz references deliver performance identical to that of the Rubidium standard for standard ALMA observations.



7. Preliminary task list

The maser rack will be installed in the LO room, using the two remaining mounts on the seismic structure. Since the raised floor, seismic mount and electrical connections are already in place, no modifications to the HVAC or electrical systems are planned.

The following task list is based on the availability of a certain number of AIV staff, in addition to the staff from MIT, Universidad de Concepcion and NRAO:

- 2 operators, for heavy lifting, including forklift, from ALMA Logistics
- 2 technicians for cabling and installation

Responsible Group	General Tasks
ADE	Prepare Correlator room for maser PAS and prepare CLO room for maser installation (make room for equipment, manage ventilation, power, communications). Prepare space for testing.
Logistics/BE	Transport crates (maser, racks and test equipment) from OSF to AOS
ADE/BE	Uncrate racks.
NRAO/MIT/UC	Uncrate maser and test equipment
MIT/UC	Maser PAS (in Correlator Room)
ADE/BE/NRAO/UC	Install new racks in CLO Room
NRAO/MIT/UC	Maser rack PAS
ADE/BE/MIT/UC	Install batteries and cable harnesses in maser rack.
ADE/BE	Perform intra-rack connections (including connections for 1PPS and 1PPS synch between CLO Room and Correlator Room.
ADE/BE/MIT/NRAO/UC	Install Hydrogen Maser in rack.
ADE/BE/MIT/NRAO/UC	Maser I&T tasks as above (section 6.3)
ADE/BE	Wrap up

In addition, OSF staff will need to arrange:

- Unloading of racks and maser from transport truck (note: do maser and rack require adherence to ALMA pallet standard?)
- Storing of racks and maser until ready to transport to AOS (in the Correlator lab at OSF).
- Transport of racks and maser to AOS (?TBC)
- Uncrate racks and maser, storage of crates.



8. Timeline, Tasks, Responsibilities

Preparation:

Task	Responsible group	Start date	Comment
Determine install date	MIT/NRAO/ BE/ADE	March 1st	Tentatively set for May 10-17
Plane tickets	Various	April	
Request lodging	Various	April 1-15	
Truck rental	??	April 1-15	For transport from Santiago?
Compile export documentation	MIT/NRAO	April 1-15th	
Ship racks	MIT	April 10th	
Ship Maser	MIT	April 15th	
High altitude physical / dispensation	All visitors	April 1 st ~30th	
Racks Arrive at OSF		May 5th	No later than
Transport Racks to AOS	Logistics/BE	May 6th	
Prepare CLO room for Maser installation (make room for equipment, manage ventilation, power, communications). Prepare space for testing.	ADE	May 6-7th	
Prepare Correlator room for Maser tests (to be done prior to re-location in CLO room)	ADE	May 6-7th	
NRAO/UC Staff Arrive OSF		May 7th	
Safety Training, Authorizations(NRAO/UC)		May 7th	
Maser arrives at OSF		May 10 th	No later than.
MIT Staff Arrive OSF		May 11th	
Safety Training, Authorizations (MIT)		May 11th	
Transport Maser to AOS	Logistics/BE	May 11 th	



Installation/Testing

Task	Responsible group	Start date	Comment
Uncrate racks, rack PAS (section 6.3), install rack in CLO Room	ADE/BE/NR AO/UC	May 9-10th	
Signal Cables run for maser signals (1PPS, 1PPS Synch) between CLO Room and Correlator Room.	ADE/BE		
Uncrate maser, setup maser PAS (in Correlator Room)	ADE/BE/MI T/UC	May 11-14	Note, May 14 th is regression testing : no work in CLO Room.
Move Maser to CLO Room, install in rack	ADE/BE/MI T/NRAO/UC	May 15th	Work in CLO Room
Maser Installation & Test (section 6.3)		May 15-17th	
Final testing -> handover		May 17th	
Compile results for TDR		May 31st	