Holography Receiver

Real Time Software

1 Introduction

This document has been prepared for the ALMA Holography CDR to take place in Tucson on 2000-Oct-10. It should be read in conjunction with the holography software requirements as described in the ALMA Project Book. This note considers only that software required to implement “single dish” holography. Discussions of interferometric holography are deferred to a later time.

In brief, there are three major software subsystems required to implement holography for ALMA:

- The real-time systems required to scan the beacon (or satellite) appropriately, and to collect and format the data from the holography backend.
- The analysis software to take the raw data, calibrate, grid, and transform it, resulting in a surface residual image.
- Software to take the residual image and produce instructions for adjusting the surface.

The above should work in a nearly-automatic pipeline system, and must be amenable to modification by operations and other staff as the holography techniques required for the ALMA antennae are further refined. If possible, it would clearly be of value to test the hardware and software systems together in advance of delivery of the prototype antenna, for example on the NRAO 12m telescope.

This document addresses only point one above; discussion of points two and three is left to representatives of IRAM who have responsibility for holography analysis software.

2 Requirements

In general, the requirements for single dish holography are similar to those required for on the fly mapping. The antenna rapidly scans (0.5deg/s) the beacon in azimuth and elevation. The entire raster should require about half an hour of observing time. During the raster frequent re-observations at the boresight position may be required for calibration purposes. The ALMA antenna specifications imply that each boresight sample will only cost a few seconds of move time, so they can be taken quite frequently if desired.

During the raster and boresight observations data from the holography backend need to be taken. Integrated auto- and cross-correlation data from the holography backend will be produced every 12 ms. The sampling and integration of this data will be synchronized to the 48 ms array-wide timing pulse. These data will be available over the antenna AMB as standard timing event associated monitor points.

The real-time system (the ABM) shall be responsible for time-tagging the data. The data samples will consist of integrated auto-correlation values for the reference and reflected signals, their quadrature values and several cross-products.

As the data is collected coordinate information will have to be associated with the samples. This will be done by interpolating the encoder readings (effectively sampled at 40Hz according to the antenna contract) to the sample time and applying the pointing model resulting in sky azimuth and elevation.

The data must be written into a data format suitable for data processing and analysis. The time and positioned tagged data will be recorded in a TBD FITS format for presentation to the IRAM analysis software.

Interactive displays should be provided for the benefit of operators and other interested staff – for example a picture showing the fraction of the raster which has been observed and the estimated time to completion.

3 Hardware/Software Partitioning

The holography hardware will consist of two receivers, two mixers, oscillators, A/D converters, a digital signal processor, and supporting electronics (for example, power supply). The data group produced by the hardware consists of six values representing the integrated values of the reference and reflected signals and their various cross-products. Each integration is of 12 ms duration, and so four groups of values will be produced for every 48 ms timing period.

The three analog signals (assuming the quadrature signals are produced prior to digitization) are converted by the A/D converters at a rate of 20 000 samples per second. The digital data is then processed and integrated to produce the six values in the atomic data group. The four integrations per timing period shall begin and end on timing events.

The holography system has a single CAN node on the antenna AMB. The M&C bus carries all control and monitor messages for the device including the holography integrated data contained in the data groups described above.

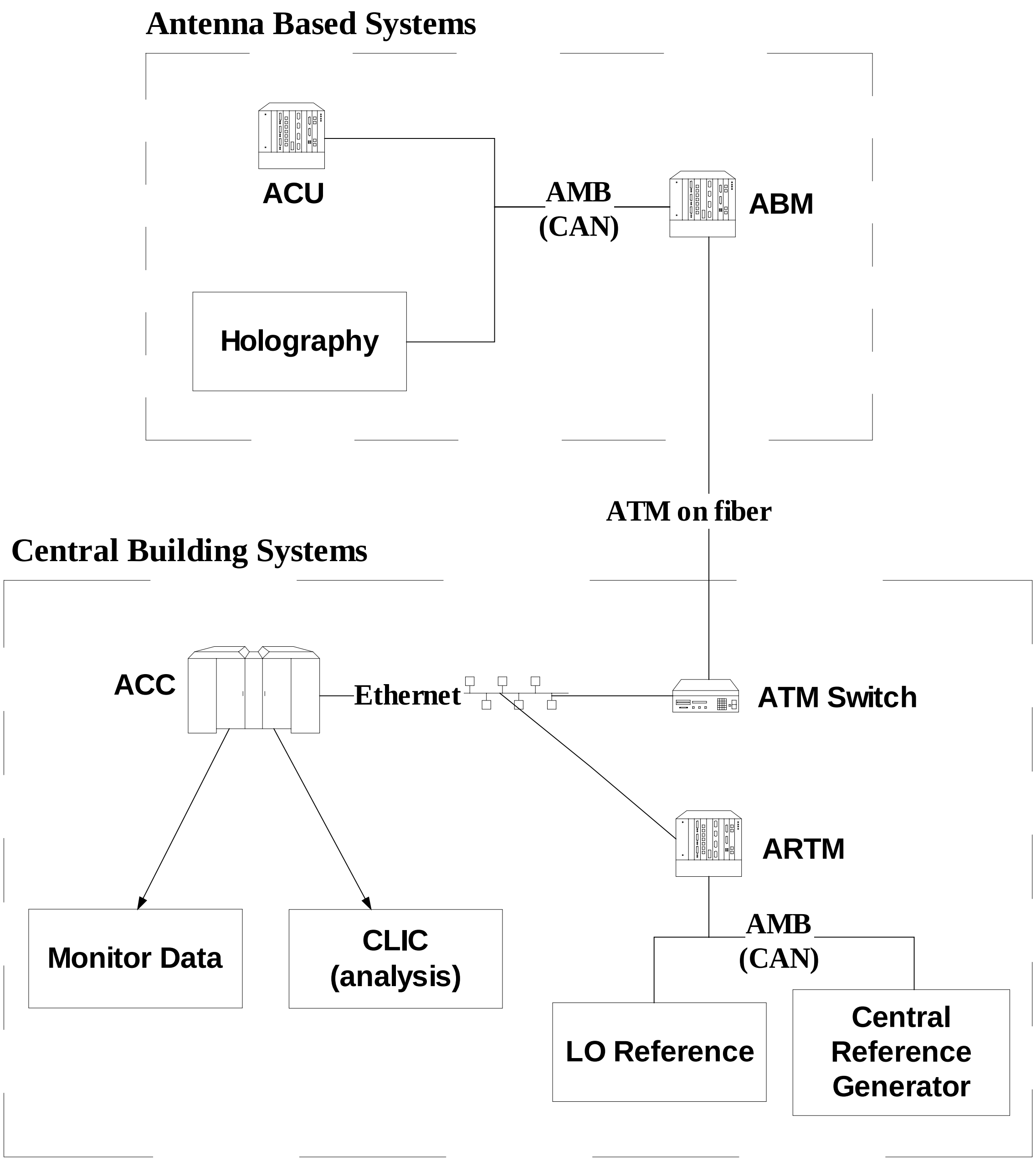

Figure 1: Hardware and Software Systems used in Holography

Figure 1 shows the primary systems involved in a holography measurement. The holography hardware data is sampled in the holography receiver and the ABM collects the 4 sets of values from the previous timing period according to the synchonization specification set out in ALMA Computing Memo #7. The ABM is responsible for time and position tagging this data which is then transmitted via TCP/IP on ATM to the ACC in the central control building. The ACC is also responsible for control of the central building systems which produce the transmitter signal. This control makes use of the ARTM which masters the CAN bus in the central building.

4 Use Cases

Use Case: Perform Holography Observation

CHARACTERISTIC INFORMATION
Description: Move the antenna in a raster scan pattern centered on the source without stopping. Simultaneously collect time-stamped and position-stamped amplitude and phase data. At the end of a scan row be able to stop the observing and perform system calibrations. Be able to start an observation beginning at any scan row.
Actor(s): Operator

PARAMETERS
1. Source Position: This position is tracked (if necessary) to remain at the scan center at all times.
2. Scan Direction: The coordinate in which the map rows will be acquired. It can be either azimuth, elevation, right ascension, declination.
3. Map Row Size: The map dimension of the coordinate given by Scan Direction. This excludes the antenna movement required to reach the Scan Velocity.
4. Map Column Size: The map dimension orthogonal to the coordinate given by Scan Direction.
5. Number of Rows: Number of passes to be made across the map in the Scan Direction. This must be an odd number typically between 29 and 513, inclusive. An odd number places the center row on the source position.
6. Data Integration Time: This sets the time between each data point, and must be a multiple of 12 ms
7. Scan Starting Row: The row number at which to begin the observation. Rows are numbered beginning with zero.
8. Scan Velocity: The rate at which the antenna is to be moving during data collection (arc-second per second).
9. Rows per Calibration: The number of observation rows between periods spent acquiring calibration data.
10. Calibration Integration Time: The time spent acquiring boresight calibration data per boresight calibration observation.
11. Rows per Pointing: The number of observation rows between periods spent acquiring pointing data.
12. Pointing Integration Time: TBD depending on the pointing calibration method.

Use Case: Collect Holography Data

CHARACTERISTIC INFORMATION
Description: Collect and integrate data to include a time and position stamp. Once setup, the collection can be started and stopped at arbitrary

times.
Actor(s): Operator

PARAMETERS
1. Integration time (in multiples of 12ms)

MAIN SUCCESS SCENARIO
1. Setup a clock routine to interrupt at 24 ms after a timing event.
2. Wait for a clock interrupt.
3. Poll data set from hardware
4. Add new data into accumulation buffers.
5. If integration period complete, transfer data, and time stamp, and zero accumulation buffers.

EXTENSIONS
2a-0. The integration has been cancelled.
2a-1. Exit the integration loop.

OPEN ISSUES (optional)
1. Poll or interrupt
2. Is dump rate a parameter?
3. Do we really care if the integration is interrupted?
4. Where do we want to check for quit an integration?
5. Is blanking required?