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GREGOR: M2M3M5M6M7 INTERFACE

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Signatures & Approval

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1	2023-02-06	O. Grassin	New Document	
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1 Scope

This document describes the M2M3M5M6M7 interface software, which is used at GREGOR telescope during optical setups and observations.

It is integrated in the GREGOR Control System, respecting the infrastructure and communication protocols.

2 Reference and applicable documents

GCS - GREGOR Control System

ICS - Instrument Control System

DCP - Device Communication Protocol

CoSM - Communication of Short Messages system

BTF3 - Beam Tracker system at focus F3

VI - Virtual Instrument

- M2M2M3M5M6M7 - DCP Commands Rev4.pdf
- BeamTracker Interface documentation.pdf

3 Overview

The M2M3M5M6M7 interface controls the small motorization related with the main beam of the telescope, the M2 mirror, M3 mirror and the M5, M6, M7 mirrors in the Coudé part. It manages a group of 7 Faulhaber motors in 4 motorization subsystems, and also controls the PI Hexapod that holds the M2 mirror.

- M2 mirror 6 struts: 3 translations + 2 rotations PI Hexapod M850
- M3 mirror 1 motor: linear Faulhaber motorization
- M5 mirror 2 motors: elevation and azimuth Faulhaber motorization
- M6 mirror 2 motors: elevation and azimuth Faulhaber motorization
- M7 mirror 2 motors: elevation and azimuth Faulhaber motorization

This motorization provides several essential functions for the telescope, for the alignment and observations:

- Telescope beam alignment.
- Focusing.
- Beam tracking at focus F3 (wobbling compensation).

The telescope alignment, up to the output window of the optical laboratory, is performed by the M2, M3, M4, M5, M6 and M7 mirrors.

The focusing is adjusted by:

- M2 mirror, for the daily variation due to temperature and elevation)
- M3 mirror, for the In/Out Derotator position.

The active beam stabilization is related to the M11 mirror motorization on the AO bench and a controlled loop at the F3 focal plane by the M5 mirror, as a part of the Beam Tracker system.

The M2M3M5M6M7 interface controls all the motorization, driven by a PI Hexapod controller for M2 mirror and Faulhaber driver modules for M3, M5, M6, M7 mirrors, through the network (Xport/CoSM) to the motorization, at their serial communication port.

4 Features

The M2M3M5M6M7 has evolved over the years to fulfill the science specifications of the telescope. Its goal is to provide an optimal tuning for the optical beam, from mirror M2 until the mirror M11, giving a tool to the user to control and optimize the telescope for observations.

It integrates all the functionality for manual or remote control performing:

- Ergonomic control for device positioning and setup
- Smart homing
- M2 cover safety and security
- DCP commands
- dcpAggregator communication
- Error and position log to files
- Communication status display
- Remote panel

Last version: Version 2023-04

5 Motorization location

All motorization is located at the dome level, on the telescope itself. The driver system parts are distributed over the AZ-Box2, the East telescope pillar and under the azimuth plate (azimuth encoders room).

The beam path is going from the M1 mirror to the output window at the optical laboratory on GREGOR's 5th floor.

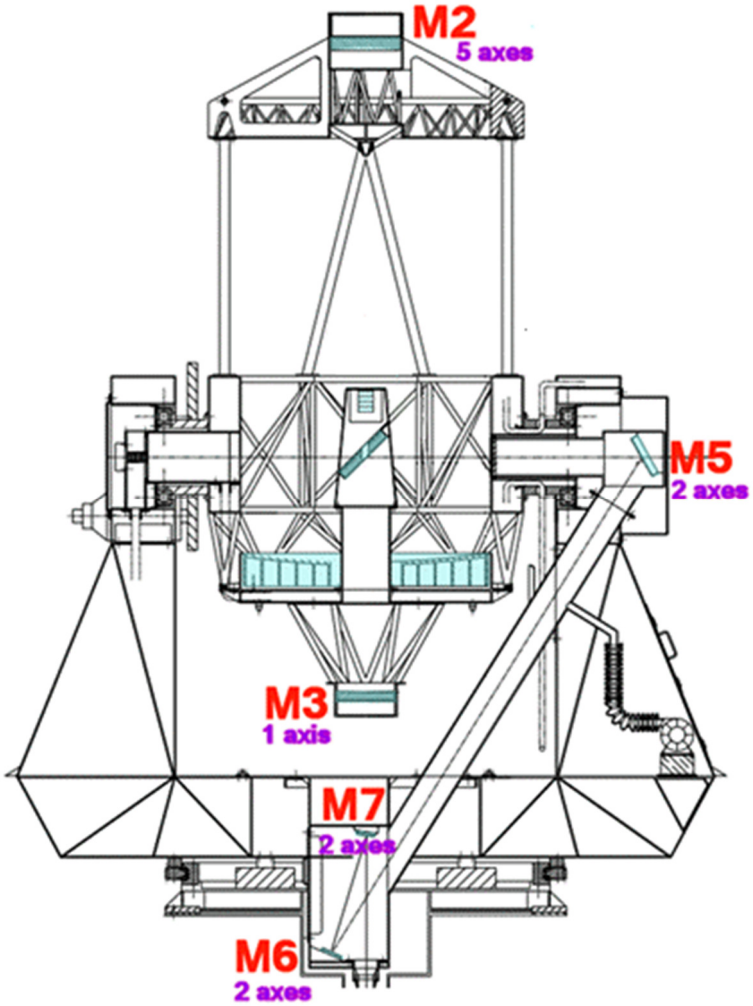


Figure 1 - The GREGOR telescope with the relevant mirrors marked

Name	*Type*	*Actuator*	*Function*
• M2	Mirror	6 struts	3 translations + 2 rotations
• M3	Mirror	1 motors	linear
• M5	Mirror	2 motors	elevation, azimuth
• M6	Mirror	2 motors	elevation, azimuth
• M7	Mirror	2 motors	elevation, azimuth

6 Software

The M2M3M5M6M7 interface (VI) has been developed in the LabVIEW15/64bits environment, on the CentOS7 Linux operating system.

The software has to manage events coming from the user GUI and remote commands through the DCP protocol from client instruments, Conductor, BTF3, etc.

It also allows to use "LabVIEW remote panel" connections, from a remote computer, such as GREGOR Flight Stations.

6.1 Installation

The LabVIEW15/64bits IDE is used to compile the source as an executable application.

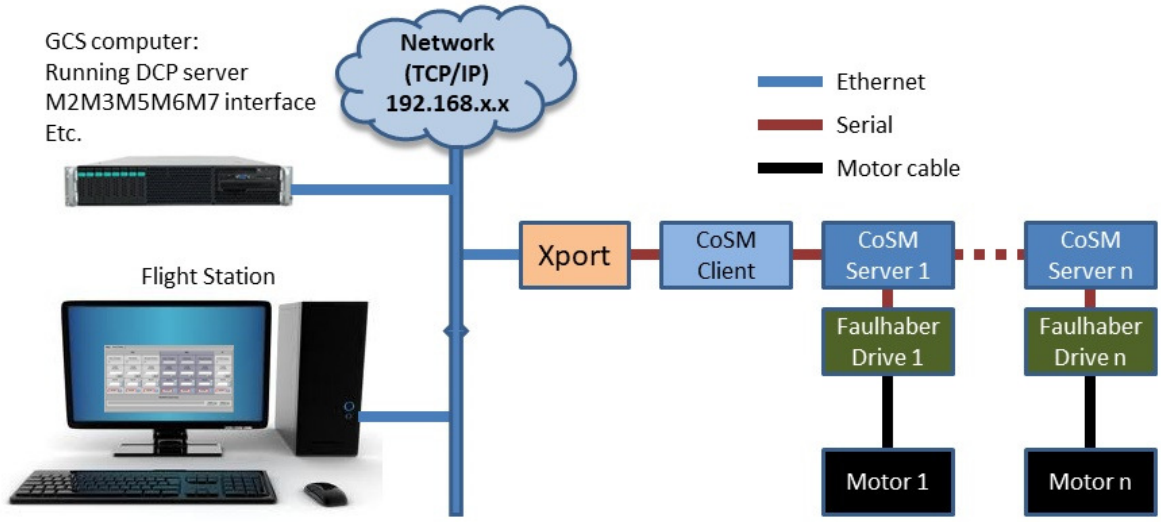


Figure 2 - Complete system diagram

It should be installed on the GCS computer, at the "/opt/G_Control/M2M3M5M6M7/" directory, with two folders:

- "log" for errors and position storage (in the "motors" subfolder).
- "config" containing the configuration file for the communication, motorization and general setting.

The last source version is periodically updated after modifications and available at the KIS-GitLab site (https://gitlab.leibniz-kis.de/ot/labview/).

6.2 Smart homing

This feature is integrated in the motor referencing function. It offers a quick referencing sequence (software only) when a motor is already powered & referenced, …after a restart of the interface, for example. (Thanks to a trick that detects if the Faulhaber driver had a power loss).

To validate the state of a motor driver, it is needed to click on its respective "Home" button. The "Smart Homing" is now available in all motorization interfaces, as it gives the freedom to close and restart the interface without the need of referencing with movements all the controlled motors. The resulting advantages are a gain of time (instantaneous validation), no loss of the current position, reliability and no stress!

If the referencing with movement is required, for example when a drive has been powered down (power voltage << 24V), or if the "Force Homing" option is checked,
the motorization will do the referencing,
by running the stage to find its "zero" end-switch position.

This can last for various tens of seconds to minutes, depending of the travel range of the motor axis.

A repositioning of the motor after a hard referencing
(setting back its former position),
may not bring it to the precise position as before,
even if the position numbers are the same!

Please, refer to the Optical Lab responsible,
before referencing any critical motorization with movement.

6.3 Startup and close.

The interface software is normally in a running state, on the GCS computer. In rare cases, it is needed to restart the interface; if a new version is implemented, the configuration file has been modified, OS failure, computer shut down, etc.

To avoid any problem, it is advised to start and stop the interfaces properly.

Figure 3 - Loading the interface...

Startup

Verify that the M2M3M5M6M7 interface is not currently running on the system.

On the ICS interface (Gregor Instrument Control) of the GCS computer, double-click on the M2M3M5M6M7 item in the explorer menu on the left side…

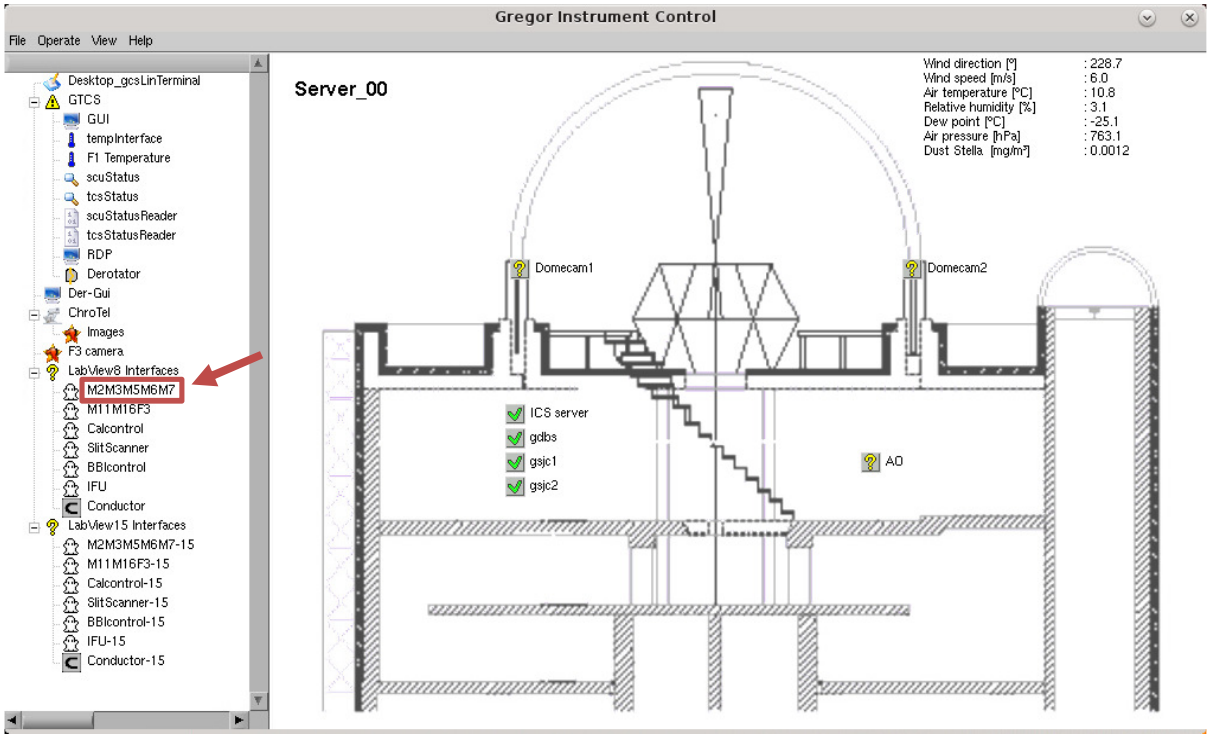


Figure 4 - ICS interface – Starting the M2M3M5M6M7 interface

Only one instance of the interface can be running; any attempt to start more will generate an error message, as the communication ports for remote panel, the DCP client name at the GCS DCP server is already used and the motorization Xport are already opened by the first one.

At startup, the GUI appears, loads the parameters and shows the main panel;
verify that the DCP and Xport indicators are connected (green).

The motorization is now ready to be referenced.
In a normal use, if all the motorization of the interface has to be referenced, after a restart for example, go to the "MAIN" panel, verify that the "Force homing" is **not checked**, then click the "Home All" button. => All the motorization is then "Soft" referenced instantly.

The motorization is then ready for use. For more details, refer to the "Smart homing" section.

A remote panel of the interface is also available on the Flight Station (FS).
The following steps are required to use the M2M3M5M6M7 interface remotely:

- Be sure that the M2M3M5M6M7 interface is correctly running on the GCS computer.
- Verify that the M2M3M5M6M7 interface is not running on the FS; otherwise, use it.
- On the FS, access the ICS interface (similar to the GCS ICS interface).
- Double-click on the M2M3M5M6M7 item, left side explorer menu, then the front panel opens.
- Use the interface.

Close

Depending of which interface instance is used, the closing procedure differs, creating a difference between the main instance and the remote panel instance:

- Main (on GCS computer): Always use the "Stop" button, that will start the closing sequence step by step, to properly quit all connections of the interface with the external world.

  Do not use the "X" button, on normal closing. In some case of irresponsive or frozen interface, this option can be tried. In any case, it may take a few seconds.

Figure 5 - Closing screen

- Remote panel (on Flight Stations): The case is different as it is only a virtual window that can be closed by the "X" button. On the remote panel, the "Stop" button is inactive. The window closes immediately.

6.4 Configuration file

The configuration file is located in the "**/opt/G_Control/M2M3M5M6M7/config/**" directory. It contains all the needed parameters for the interface, as communication, motorization drivers, default positions, and internal settings. It is recommended not to modify any parameter of configuration file, without the express clearance of the responsible person.

6.5 Errors/Positions log

All errors that occur and all movements of the motorization are registered by the interface on the GCS computer.

If some error occurs, the interface registers it in a log file, on the GCS computer; the file is named "**M2M3M5M6M7_[YYYYMMDD]_[hhmmss].txt**", in the following directory: "**//opt/G_Control/M2M3M5M6M7/log/**"

Motor position log: After each movement of a motor, the new position is stored in a log file, on the GCS computer; the file is named "**M2M3M5M6M7_PosLog_[YYYY-MM-DD].txt**", in the following directory: "**//opt/G_Control/M2M3M5M6M7/log/ motors/"**

Stored parameters: Date, Time, M2x, M2y, M2z, M2u, M2v, M3, M5-1, M5-2, M6-1, M6-2, M7-1, M7-2, Cmd.

6.6 dcpAggregator

With the introduction of a new GUI for the observations (GREGOR GUI), the heavy traffic querying motorization position information, status and remote control, has led to a communications bottleneck.

The dcpAggregator, as a DCP compliant client from one side and MQTT information broadcast server from the other, makes the link between the two systems.

The M2M3M5M6M7 interface has been upgraded to solve the issue.

The position and status of a motorization are sent to the dcpAggregator after a movement. Then, the information is automatically distributed as an event, to all subscribers (mainly the GREGOR GUI). This way, the information does not have to be requested every few seconds over the DCP protocol from the M2M3M5M6M7 interface, interfering with other events. There is a parameter in the configuration file to set the dcpAggregator name and a parameter ¨SendToAggregator = true/false" to enable or disable the function.

The M2 status is sent after Hexapod movements to the dcpAggregator in the format of:
set update M2/1/abs:0.0000 M2/2/abs:0.0000 M2/3/abs:-3.2800 M2/4/abs:-0.0959 M2/5/abs:-0.0210 M2/0/sta:1
where: sta=0 (Not aligned), sta=1 (Operational), sta=2 (Default position)

6.7 BTF3

The Beam Tracker at F3 system uses the M5 motorization to perform the beam correction in a feedback loop, using the AXIS Q1604 Network Camera, in front of the F3 filter wheel. Commands are passed through the DCP server to send the calculated displacements of the M5 axes. When the M5 motorization is moved manually from the interface for a specific use, verify

that the position is not altered in the background by remote control commands. In such case, disable the BTF3.

7 Using the interface

To startup or close, please refer to the "Startup and close" paragraph. All default motor positions are setup in the configuration file.
(A tooltip will appear, to remind the min/max value of the "Absolute Movement" indicator for each motor, if the mouse cursor is set over the display box)

7.1 Main panel

This panel gathers various functions for the telescope setup.

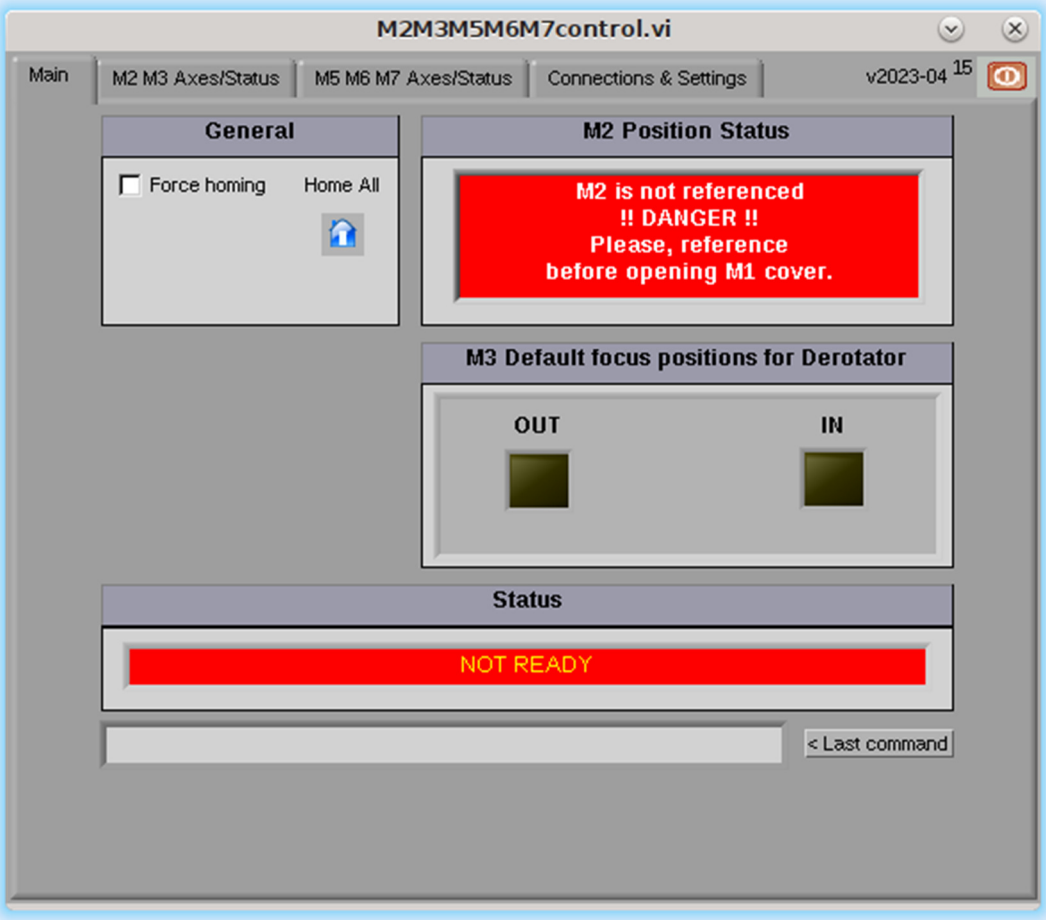


Figure 6 - Main panel

7.1.1 General

- **Force homing** 

If checked and a "Home" is sent, a referencing movement will be executed to find the zero position. Each motor can be also referenced separately.
(See "Smart Homing" and "AXES/STATUS" chapter for more information).

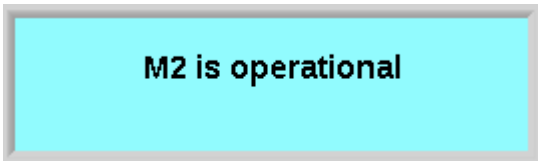
- **Home All** 

Click on this button to reference the whole motorization. A smart homing is done, unless the "Force homing" option is checked, which leads to **real referencing movements**.
Access the "AXES/STATUS" panel and check that the indicator turns to "Referenced" (green) for every referenced motor, which confirms that the motor is ready for manual positioning or remote control through DCP commands.

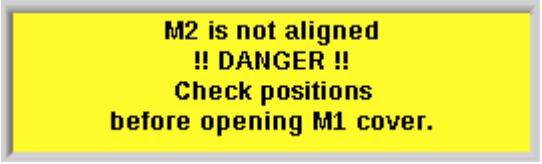
7.1.2 M2 position status

This indicator shows the current status of the M2. It can be one of the three following states:

The M2/Hexapod needs to be referenced.



The X, Y, U, V value are in range.
The V (focus) can be changed as needed.



One or more of the X, Y, U, V value is out of range.

The tolerance is fixed to ±0.001 in position or angle, to notify a misalignment.

7.1.3 M3 Default focus positions for Derotator

It provides a quick positioning of M3 mirror, according to the Derotator position (IN/OUT of the beam).

7.1.4 Status

Message indicator: It gives a quick information about the interface events.
(Idle/No error/Busy/Error)

Last Command: Command events information. Only last message is shown.

7.2 M2 M3 Axes/Status panel

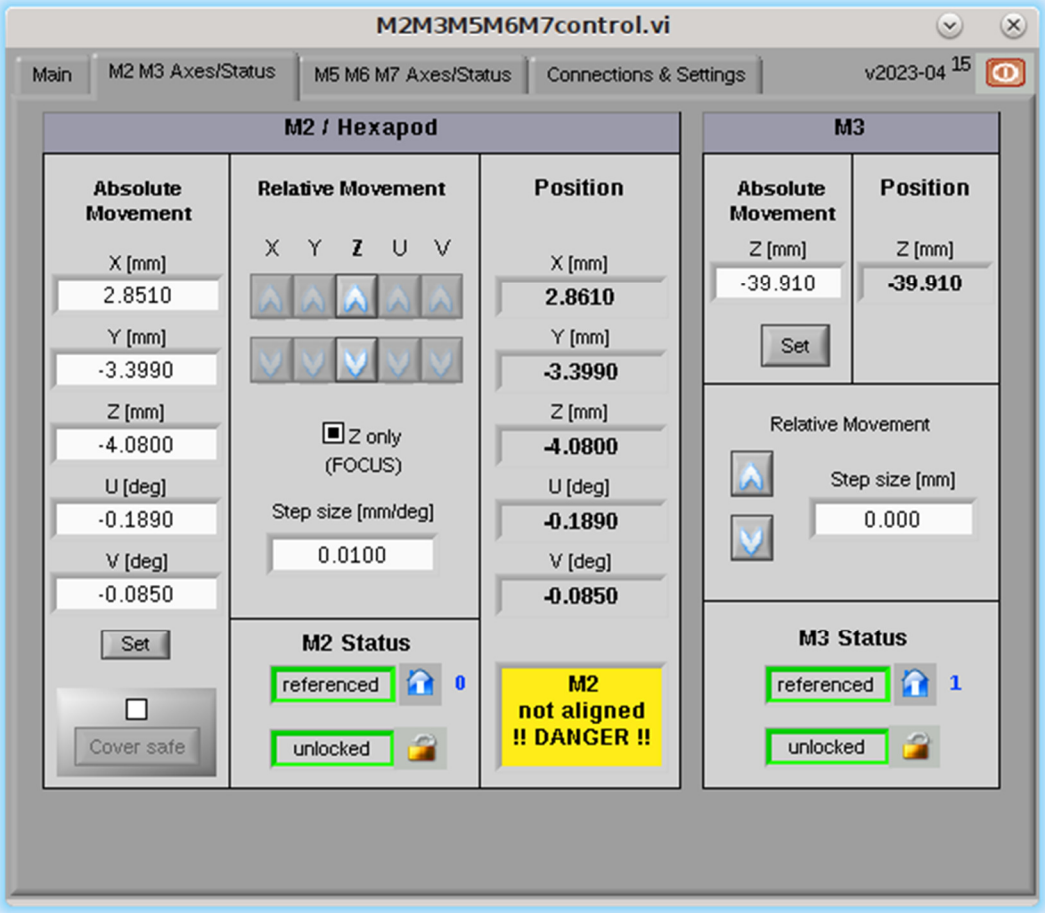


Figure 7 – M2 M3 Axes/Status panel

7.2.1 M2 / Hexapod

This panel manually controls the M2 positioning.

7.2.1.1 Absolute Movement

Position controls

These parameters can be edited to set a position for a defined axis.

Be extremely careful of moving any axes different from the "z" (Focus).

Set

This button sends the motorization to the corresponding position. After moving, the position value can be confirmed by the position indicators

Cover safe

Use this feature to start the procedure to protect M2 with its cover.
Refer to the dedicated section below.

7.2.1.2 Relative Movement

Arrows

Click on the desired arrow to perform a step movement of the axis. The step size can be adjusted in the control, below. The upper arrow increases the position and the lower arrow decreases it.

Z only (FOCUS) 

Select this option to disable other axes than the "z" for focus movement. This feature protects the user from axes mistakes, that could lead to a bad alignment of the beam and burn some telescope part.

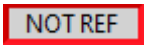
Step size

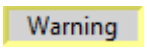
Enter the desired step for the axis movement here. The value is expressed in mm or degree, according to the axis type.

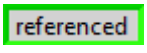
7.2.1.3 M2 Status

Motorization status

This indicator has 3 states as:

- 

When the motorization state is unknown at start up or when an error happened. Motorization needs to perform a "Home".
- 

The motorization is moving to the referenced "0″ position.
- 

The motorization has referenced and is ready for position movements.

Home

Button for referencing and to validate the Hexapod motorization.
The "Referenced" indicator must be green, to allow movements.

Special M2 referencing behavior:
At the first referencing after opening the interface, all axes (x, y, z, u, v) will be moved to the reference position from the configuration file.
To keep the telescope focused with M2, all following M2 references will not move the Z axis; but only (x, y, u, v).
For a complete reference, use the "Force homing" option.
Without this option, the smart referencing will verify if the Hexapod has been referenced previously. If so, it will only do a movement to the default position. Otherwise, it will execute a real referencing (zero switch search), then move to the default position.

For security reason and to avoid burning telescope parts when referencing the M2/Hexapod, follow the instructions in the pop-up window:

Figure 8 - M2 security

By clicking the "DONE" button, the user agrees to move the M2/Hexapod device.

It is recommended to perform the M2 reference always at the same telescope elevation:

ele = 5 deg.

Lock/Unlock

The "Lock" feature allows the user to keep the control of the motorization, in this case M2. Any remote-control command sent to the interface, will be denied. It is not commonly used and the recommended state is "Unlocked".

7.2.1.4 Position

The current motorization position is shown for each hexapod axis.
If a misalignment is detected after a movement, an indicator will pop-up under the position values, to notify the user about the issue and the status is sent to the dcpAggregator.
If the hexapod is not referenced, this indicator is also shown with the "not referenced" warning.

The misalignment detection is based on the M2 default positions, stored in the configuration file. After a telescope alignment tuning, the new (x,y,z,u,v) default values must be updated in the section [Axes Default Positions], key "M2defPosition".

7.2.2 M3

This panel manually controls the M3 positioning.

7.2.2.1 Absolute Movement

Position control

The parameter can be edited to set a position for a M3 axis.

Set

This button sends the motorization to the corresponding position. After moving, the position value can be confirmed by the position indicators

7.2.2.2 Relative Movement

Arrows

Click on the desired arrow to perform a step movement of the axis. The step size can be adjusted in the control, at the right. The upper arrow increases the position and the lower arrow decreases it.

Step size

Enter here, the desired step for the M3 axis movement. The value is expressed in mm.

7.2.2.3 M3 Status

Motorization status

This indicator has 3 states as:

- NOT REF When the motorization state is unknown at start up or when an error happened. Motorization needs to perform a "Home".
- Warning The motorization is moving to the referenced "0″ position.
- referenced The motorization has referenced and is ready for position movements.

Home

Button for referencing and to validate the motor.
The "Referenced" indicator must be green, to allow movements.

Lock/Unlock

The "Lock" feature allows the user to keep the control of the motorization, in this case M3. Any remote-control command sent to the interface, will be denied. It is not commonly used and the recommended state is "Unlocked".

7.3 M5 M6 M7Axes/Status panel

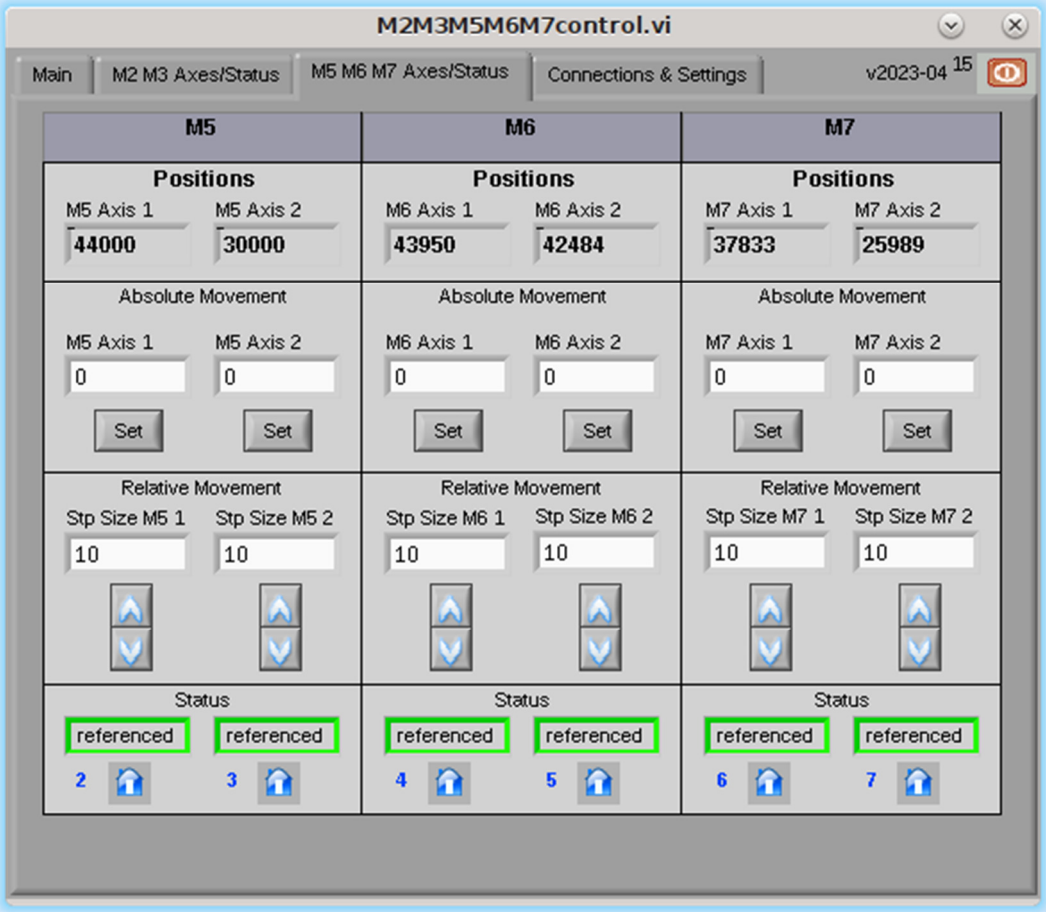


Figure 9 – M5 M6 M7Axes/Status panel

7.3.1 M5 M6 M7

It is sometimes needed to manually adjust the position of a motor. This panel helps the user to reference, set the desired position or send steps increments/decrements, of a specific motor. The panel is a compound of 3 motorizations of 2 axes. As there are identical, only one section will be described.

Positions

Display of respective motors position

Absolute Movement

The control box can be edited to set a position for any axes.

Set

This button sends the motorization to the corresponding position. After moving, the position value can be confirmed by the position indicators

7.3.1.1 Relative Movement

Step size

Enter here, the desired step for any axis movement. The value is expressed in encoder steps.

Arrows

Click on the desired arrow to perform a step movement of the axis. The step size can be adjusted in the control, at the right. The upper arrow increases the position and the lower arrow decreases it.

Status

Motorization status

This indicator has 3 states as:

- NOT REF When the motorization state is unknown at start up or when an error happened. Motorization needs to perform a "Home".
- Warning The motorization is moving to the referenced "0″ position.
- referenced The motorization has referenced and is ready for position movements.

Home

Button for referencing and to validate the motor.
The "Referenced" indicator must be green, to allow movements. 

7.4 Connections & Settings panel

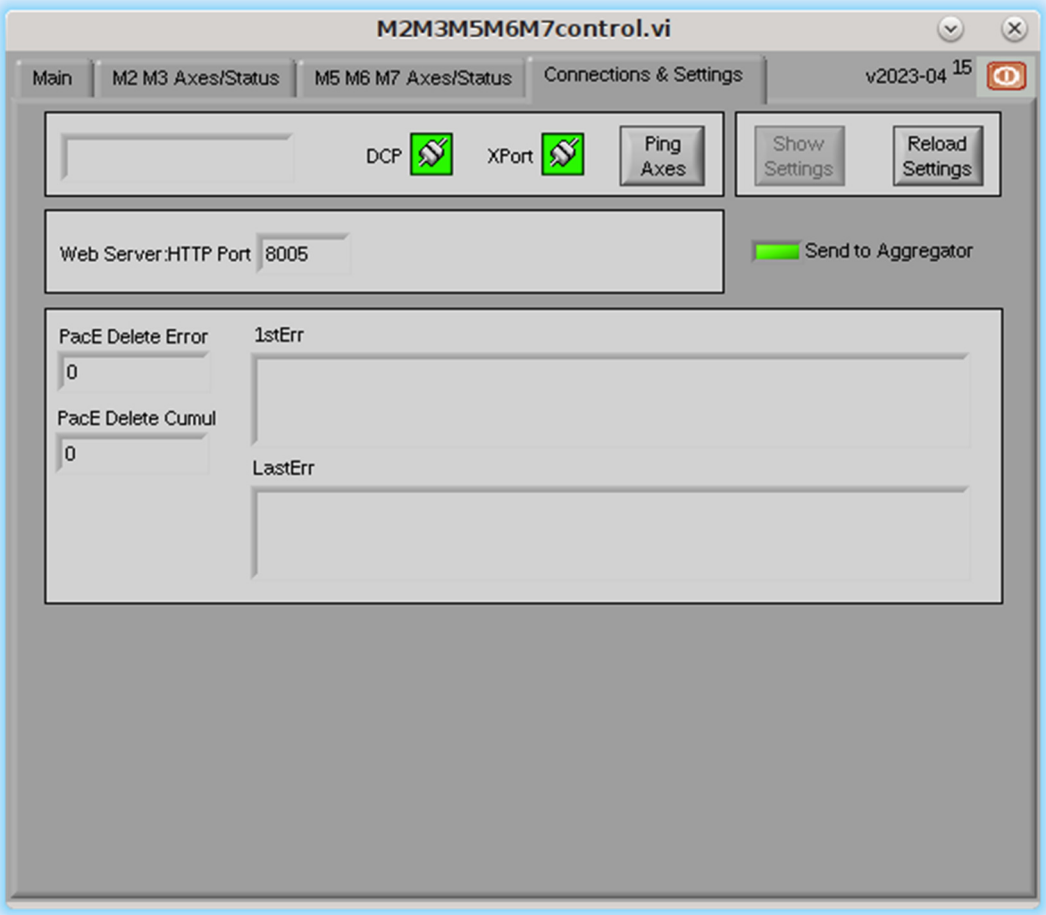


Figure 10 - INFO panel

The "Show Settings" button is not currently functional and remains disabled.

The "Reload Setting" button performs a reloading of the setting written in the configuration file and updates the required indicators of the GUI.

The "Ping Axes" button ask to all motor drivers the respective position values.

The DCP and Xport indicators display the status of the communication lines (connected or broken). Always check first these indicators, if an error occurs in communication or motion.

The Web Server indicator shows the used port for Remote panel feature.

The Send to indicator LED status, shows if a dcpAggregator communication is running. (light on: working)

The middle panel "Pace_Delete_Error" was added to show possible issues generating big error files in the last years, related to a communication loss between the interface and the DCP server. The reason could be a network issue, or the DCP server was stopped, frozen or not started. The M2M3M5M6M7 software is now able to detect the cases and skip the subsequent errors from the log file, just keeping the first one, showing the current error event and the total number of occurrences. The only action to take if the error is detected, is to solve the problem and

reestablish the connection with the DCP server. Meanwhile, it is not possible to move the motorization remotely.

7.5 Motorization limits

The motors cannot be moved by manual or remote control over their limits; at a first step, it is the software limits, setup in the configuration file, that prevent to move beyond.

There are also hardware limits, fixed into the motor driver parameters, placed just after the software limit range, to definitively block the positioning further.

Any unauthorized modification of these limit parameters could lead to serious damages of the motorization, optics and mechanical devices of the bench.

Please, ask a responsible person before any change.

7.6 M2 Cover safe procedure

In the case that the M2 mirror has to be protected by its cover, it is convenient to perform **before**, the "Cover safe" procedure, in order to re-center the mirror to its parked position and disconnect its control system, to avoid any damage. The procedure is integrated into the interface; just follow the provided instructions…

To start the procedure, the user has to activate the "Cover safe" option box, then click on its button. A warning message box appears:

Figure 11 - Cover safe 1

The operation must be performed at the telescope parking position to avoid potential reflections of the Sun on M2. If the user agrees to continue, a second message box pops-up and he/she has to strictly follow the instructions:

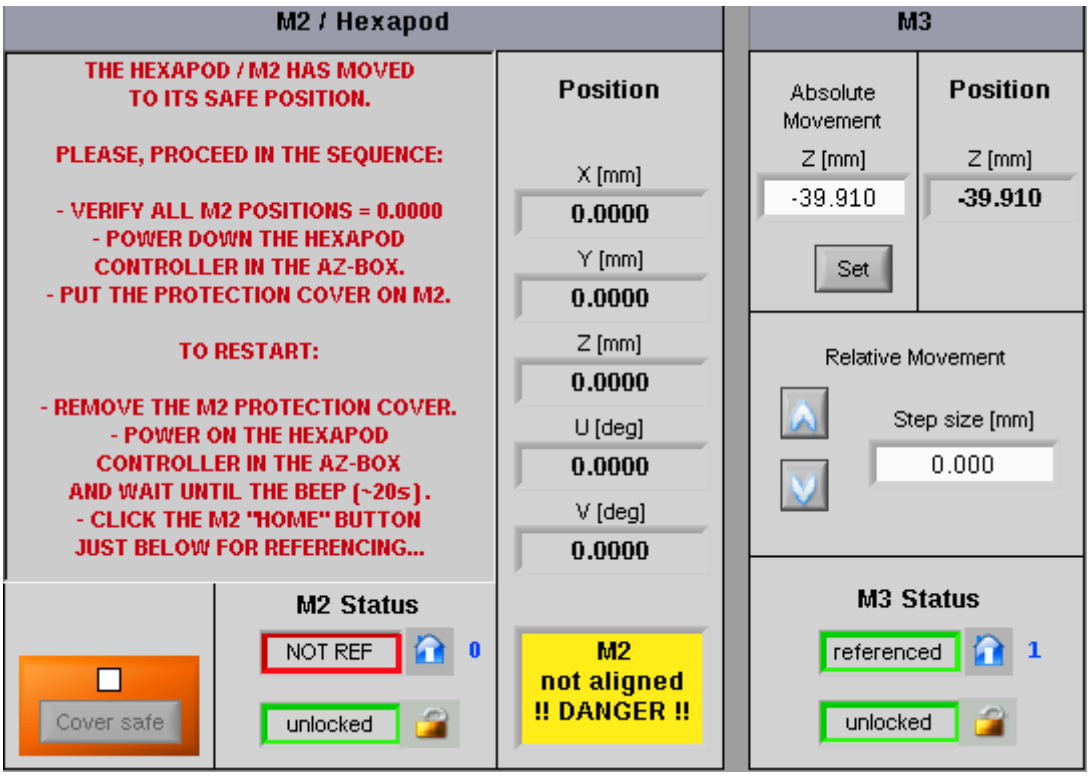


Figure 12 - Cover safe 2

It is advised to keep this panel open on the M2M3M5M6M7 interface, to be able to perform the steps to restart. That will also inform other users that an operation is in progress…

The figure shows that M2 has gone to its mechanical centered position, its motorization has been deactivated. After the power down of the Hexapod controller inside the AZ-Box2, the cover can be placed to protect the mirror.

!!!Do not perform any M2 referencing while its cover is ON,

to avoid any irreversible damage!!!

Follow carefully the "Restart" instructions step by step (Figure 12 - Cover safe 2), and ensure the previous task is completely executed, before continuing… The final step is a full Hexapod referencing, to return to the operational mode.

8 Technical data

8.1 Hexapod controller

Hexapod manufacturer : PI (www.pi.ws)
Hexapod type : H-850K096
Hexapod controller type : C-887.52

The controller is fixed in the upper part of the AZ-Box2 at the dome floor. Open the first door to access it.

Figure 13 - Hexapod controller

Pivot point (mm) : R 0 S 0 T 109

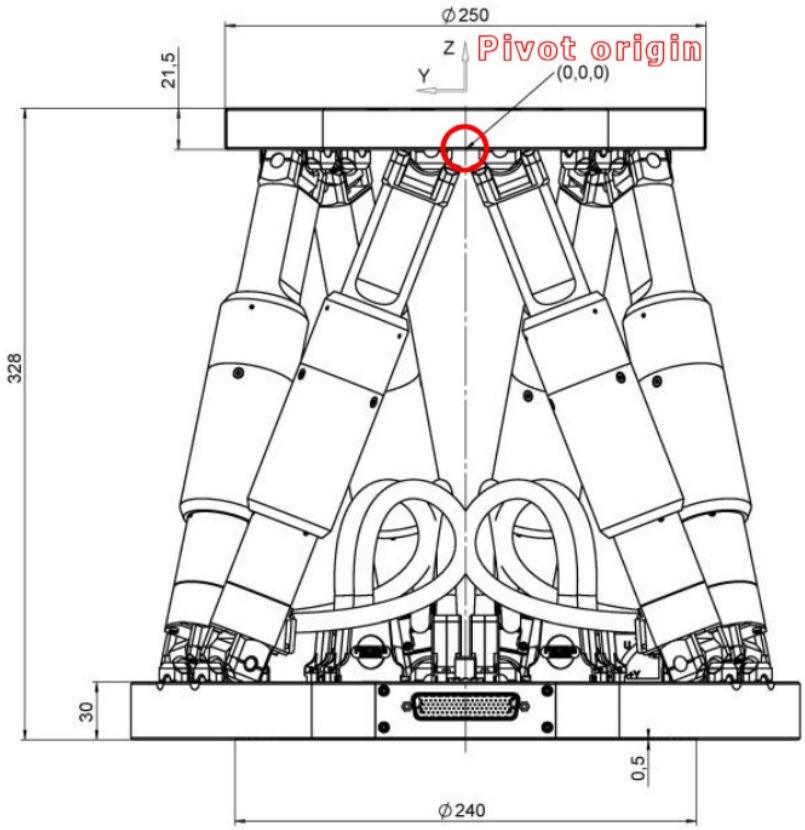


Figure 14 - Hexapod Pivot point origin

8.2 Faulhaber

Other motorization : Faulhaber drivers
Drivers types : MCDC3006S for M3; MCDC2805 for M5, M6 & M7

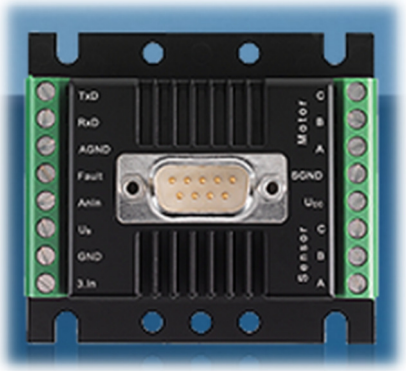


Figure 15 - MCDC Faulhaber driver module

8.3 CoSM modules – daisy chain configuration

IP: 192.168.90.81

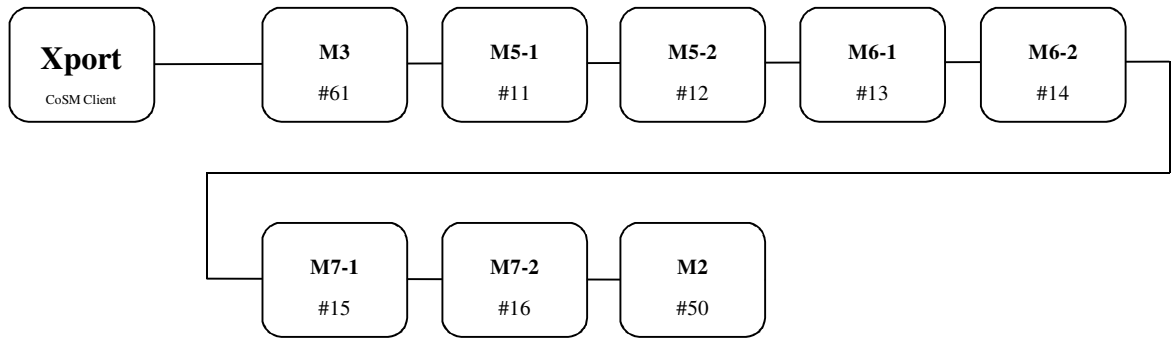


Figure 16 - CoSM modules - daisy chain configuration

9 DCP commands

To use the DCP functions, this interface name is: **M2M3control**

The current command list, for the remote use of the interface and its motorization:

- "**set nop**" for communication test
- "**set position abs**" for axis absolute position
- "**set position rel**" for relative movement
- "**get position abs**" for reading the axis position
- "**set position def**" for sending axes to the default position
- "**get position def**" for reading axes default positions
- "**get status secu**" for reading the motorization status

For detailed information and parameters, please refer to the specific lastly updated documentation, available in the blog:

https://blog.tt.iac.es/wp-content/uploads/2023/05/M2M3M5M6M7-DCP-Commands-Rev4.pdf

10 What's new?

(2023-03-26)

- Deep cleaning of unused functions:
  Removed GTCS communication.
  Removed M2 and M3 internal configuration offsets (for AO/Image-Derotator, not used).
  Configuration file cleaning.
  Disabled "Show settings" button.
- New M2 security messages added:
  "M2 is operational", "Not Referenced", "M2 not aligned" in GUI panels.
- Standardized M3 driver communication layer, as same as all SMS motors.
- Added "Reload Configuration file" functionality.
- Added new DCP command for M2 status.
- Added new Aggregator message for M2 status.
- Added the "Home All" button.
- Speed up the interface shut down.

(2022-11-08 …)

- Added: Error filtering.
  The filtering prevents the generation of huge error files on the GCS server, when trigged. (Errors occurred when the DCP server was not connected.)
- Added: dcpAggregator position communication for GREGOR GUI / MQTT.
- Added: cover protection security feature for M2 (in the M2 & M3 panel):
  - "Cover safe" button and option box
  - Message box (abort/continue)
  - Procedure information message
- Renewed the commands for the Hexapod, because of its replacement.
  (New Hexapod, controller and cabling 2022-02)
- Added: local position log in file.
- Added: new pane for M3 default position in function of the Derotator (IN/OUT). In the Main panel.
- M3 minor bug corrections at referencing.
- New DCP commands

(2015-09-15)

- M3 referencing with M2 synchronization to home positions: For a former reason when M3 was referenced, M2 was moved to the home reference positions, making it to lose the current positions. After Dirk Soltau agreement, this behavior has been removed and the referencing of both motors is totally independent.

(2015-06-18) Bugs correction and DCP commands implementation:

- Some M2 DCP commands were missing in the list to retrieve independent M2 axes and have been added to the software. So now the "get position abs M2 p" where "p" parameter can be from 1 to 5 will return the axis position of x, y, z, u and v respectively.
- An erratum for the "get position abs M3 0" axis value has been corrected in software and DCP documentation to fit standard. (Now: get position abs M3 1). Client interface developers have to be aware if M3 position is used.
- The common motorization interface "timing issue" has been corrected too.
  No answer extra delay will occur randomly.
- DCP commands documentation has been updated with new functions and correction as Rev.2
- Interface version number is now (v2015-06), indicated at the upper right corner.

(2013-2014)

- Smart Homing
- Security feature
- New DCP commands & bug corrections
- Other improvements & cosmetics