

Servo Notes Inventory

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Below is a summary table of notes, reports, and technical memoranda that are related to servo development. All of them, plus various graphs, tracking data files, and web-browsable controller diagrams, are available via a public web archive at: www.mmt0.org/~dclark/Reports.

Data from servo testing is likewise available over the web, organized by month at: <http://www.mmt0.org/~dclark/Keith%20Powell/> -- this archive also includes all source code for custom xPC Target hardware i/o boards, custom Simulink library code, data-reduction GUIs, and other miscellaneous files.

Papers

Conference	Title	Subject
American Controls Conference 2005 Portland, OR	Developing Improved Servos for the Multiple Mirror Telescope	Prototyping and testing controllers with xPC Target, support of open-loop data collection, and verification of early versions of the MMT elevation controller.
SPIE Advanced Software and Control for Astronomy 2008 Marseille, France	A Non-linear Disturbance-decoupled Elevation Axis Controller for the Multiple Mirror Telescope	A report on the servo hardware, development process, and operation of the MMT elevation controller as of Spring 2008.

Internal Technical Memoranda

MMTO ITM04-3, “Control System Prototyping – A Case Study” discusses using xPC Target to rapidly develop controller prototypes using the xPC Target machine for open-loop data collection, development of the control law implementation using Simulink, and verification of the controller’s operation with hardware-in-the-loop using an actual *f/9* hexapod actuator.

Progress Reports

A series of memoranda detailing activities related to problem solving and improvements to the controller as the development continued:

Progress Report #1 12/7/06 through 12/13/06

Confirmation of open-loop measurements on the elevation axis.

Progress Report #2 12/22/06

Open-loop data and the newest measurements compared via simulation and the xPC Target results.

Progress Report #3 12/06 through 1/12/07

Commissioning checklist testing, startup issues on the mount computer, and tape versus absolute encoder position.

Progress Report #4 1/15/07 through 1/19/07

New Java GUI to facilitate xPC testing for slewing and tracking the elevation axis. 20Hz modal frequency is noted in testing.

Progress Report #5 1/20/07 through 2/16/07

Work on new notch filters and testing them with xPC Target.

Progress Report #6 2/16/07 through 3/1/07

Verification of new filters and closed-loop tracking with xPC Target.

Progress Report #7 3/2/07 through 3/28/07

Gain optimization on the controller and model fit issues. Wind tracking error versus wind velocity (e.g. relaxation of tracking specifications as a function of wind load). Introduction of disturbance decoupling for improved wind rejection. Startup oscillations encountered by Tom in the mount implementation.

Progress Report #8 3/29/07 through 4/18/07

Open-loop measurements for all 3 secondary configurations. Verification of step responses, checking xPC soft-start code. Wind shake on the telescope with brakes set, and with the controller running.

Note: due to the time-consuming nature of these reports, a more informal approach was adopted where emails with appropriate graphs attached were used during the interim between May 2007 and August 2008. Copies of these will be made available upon request.

Progress Report #9 8/20/08 through 8/28/08

Correction of the windup issue between the primary PID position loop and the disturbance decoupling path. Installation of a 65Hz notch filter to bring both elevation tape heads into operation.

Miscellaneous Reports

Interim reports on various issues were generated, not as full progress reports, but focusing on specific topics:

Elevation Controller Commissioning Checklist January 5, 2007

The original checklist for testing the deployed controller.

Supplemental Servo Report: Wind Shake on the LM628 May 11, 2007

A report detailing wind shake with the LM628 servo in different wind conditions (i.e. different velocities and azimuths).

Delays in the MMT Elevation Controller in Simulation May 18, 2007

Discussion on the effect of time delays in the encoder feedback path on the control loop's stability.

DAC Testing Using xPC Target July 13, 2007

Verification of the DAC output hardware using both the original xPC Target IP-230 unit and the mount PC's PCI-DAC6703, including checks of signal integrity through the servo bridge connector panel.

Slewing Elevation with xPC Target July 18, 2007

Slews of $\pm 10^\circ$ with the xPC Target test controller for reference plots.

Results of Wind-disturbed Tracking October 1, 2007

Comparisons of the LM628 controller and xPC Target test controller tracking during the same M&E night.

Improving Elevation Axis Disturbance Rejection October 5, 2007

Discussion of tracking performance with the linear PID controller, and introduction of a Luenberger Observer and disturbance decoupling as a way to improve the wind rejection.

CodeGenerationCheck May 2, 2008

A semi-autogenerated html report discussing the differences between the two available Windows Simulink hosts and the resulting code that runs on the xPC Target machine.

Results of Testing xPC Target on the Mount Computer May 23, 2008

Checking hardware on the mount computer via migration of the xPC Target controller to the mount PC's hardware to rule out hardware issues as a source of deployment issues with the elevation controller.

El collision 73108 servo August 28, 2008

A discussion of the data from the collision of the telescope and building on 7/31 from an email, with detailed graphs of the controller signals during the incident.

Development Timeline

An html timeline in the */Reports* archive lists milestones and various development issues over the course of the controller upgrade project at: <http://www.mmt0.org/~dclark/Reports/Servo%20Timeline.htm>.