TCI

Telescope Control Interface

Specification of an OpenTCI based interface to the control software of Astelco Company telescopes

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01.03.2006	Updated for RA-DEC, ZD-ZD(ALT-ALT) (dp,mr)

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Contents

1 Preface

This document describes the interface to all Astelco GmbH telescopes. For the communication the TPL2 protocol will be used (refer to [2] for protocol specifications). The TCI interface implements the OpenTCI standard (refer to [1]). Unless otherwise noted this interface complies with the OpenTCI standard. Therefore only the hardware specific parts will be described as well as some extensions.

In addition to the OpenTCI basic modules there may be one or more additional modules covering your individual specifications and ordered software. These modules will also be described in this document.

2 Module CABINET

This module allows direct access to the control cabinet and provides functions for turning on and off main power as well as a lot of diagnostic functions. The hardware independent functions are provided as specified by the OpenTCI standard.

2.1 Hardware event numbers and texts

The `CABINET.STATUS` module allows the client to access the telescope system status and log files. The hardware dependent event numbers and texts will be described in appendix B.

2.2 Hardware dependent functions

According to the OpenTCI standard, the TCI provides several other structures and variables mostly for debugging and maintenance tasks. These are situated in the `CABINET.CORE` sub-module.

Note: These structures are only described here for completeness and serve primarily internal testing purpose. You must not try to use them and their structure and meaning can be changed at any time without notice.

Name	Type	Access	Description
`EXECUTE`	STRING	RW	Execute custom functions.
`TRACE`	MODULE		Low-level debugging interface.
`SETTING[]`	STRUCT		Access to all internal parameter variables.
`STATE`	INT	RO	Internal state of the system.
`UPTIME`	FLOAT	RO	Uptime of the telescope system.
`BITS`	BINARY	RO	Internal data.

The CABINET.CORE.TRACE sub-module:

Name	Type	Access	Description
AVAILABLE	INT	RO	Available trace time.
CHANNEL[]	STRUCT		Trace channels.

The CABINET.CORE.TRACE.CHANNEL[] sub-structure:

Name	Type	Access	Description
NAME	STRING	RO	Name of trace channel.
BASE	STRING	RW	Base name for trace files.
COUNT	INT	RW	Number of trace runs.
TIME	INT	RW	Trace duration [ms].
STEP	INT	RW	Trace granularity [ms].
RUN	INT	RW	Start or stop tracing.
CYCLIC	INT	RW	Trace cyclic.
RESULT	BINARY	RO	Trace result.

The CABINET.CORE.SETTING[] sub-structure:

Name	Type	Access	Description
NAME	STRING	RO	Name of the parameter.
VALUE	STRING	RO	Value of the parameter.
UNIT	STRING	RO	Unit of the parameter.
DESCRIPTION	STRING	RO	Description of the parameter

3 Module SENSOR[] and SWITCH[]

Since the hardware design will provide no switchable components that should be controlled by anyone other than the telescope control software the SWITCH module may be empty or missing at all. The SENSOR[] module will provide temperatures at several locations at the telescope. Usually, at least one sensor at the main mirror M1 and another inside the control cabinet is available. The name and unit of the sensors should make it easy to find out where each sensor is located.

A List of custom TPL2 Event numbers

Name	Value	Module	Description
maxsample	5	Pointing	Cannot sample more points.
calcfail	6	Pointing	Calculation of pointing parameters failed.

B List of hardware error numbers and texts

A list of all possible errors and their meaning is given in this section. For most errors there is a classification of the severity, as well as a recommendation of what to do, if the error occurs:

Class	Description
[I]	Information message, usually no user intervention necessary.
[W]	Warning message, usually the system will continue to operate, but with some limitations, especially for the device that generated the error.
[E]	Error message, the whole system is halted and put in a safe condition.
[P]	Panic message, the whole system is halted and put in a safe condition.

Short	Recommendation
(C)	Clear the error, after the reason for the error (e.g. the too large coordinate in case of a soft limit condition) has been resolved.
(R)	If possible, resolve the reason for the error and restart the entire system afterwards. If the error occurs again, ask for support.
(S)	Ask for support, as this error is not supposed to occur in a release version.

Some errors (like the limit switch errors for azimuth and elevation) should never occur during normal operation, and have therefore a "(R)" recommendation. However, when the telescope is moved by hand while the power is off, this error can be cleared without a system reboot.

No	Text	Description
0	TBD	(S) TBD

C Module POINTING

This module provides simple functions to point the telescope to RA/DEC positions. This interface is limited by design in the sense that:

- it can only track extra-solar objects;
- it cannot take proper motions, radial velocities etc. into account;

- it will only accept J2000.0 coordinates;

Note: This module uses the `TRAJECTORY` sub-modules of the axes internally, the client must never use this module's functionality mixed with direct axis functions.

In addition to the OpenTCI `POINTING` module the `DUMPFILE` will be appended a number (starting with 0) which is automatically incremented on writing of `RECORDCOUNT`.

C.1 Calculation of model coefficients

The `POINTING` module provides an easy way of calculating incrementally pointing model coefficients. Depending on the number of taken samples the internal fit core will fit the appropriate number of terms and will also take into account the existing model, refining it step by step.

C.2 Model for AZ-ZD mounted telescopes

The used pointing correction model is the standard geometrical model with 6 coefficients for mounting errors and one for accounting the tube flexure.
Note: If the number of samples is 1, only `AOFF` and `ZOFF` will be fitted, below 7, only `AOFF`, `ZOFF` and `CA` will be calculated.

The following coefficients will be used:

Name	Type	Access	Description
`AOFF`	FLOAT	RW	Absolute azimuth encoder offset.
`ZOFF`	FLOAT	RW	Absolute zenith distance encoder offset.
`AE`	FLOAT	RW	Azimuth axis tilt of vertical to NORTH.
`AN`	FLOAT	RW	Azimuth axis tilt of vertical to EAST.
`NPAE`	FLOAT	RW	Zenith distance axis not perpendicular to azimuth axis.
`CA`	FLOAT	RW	Collimation axis not perpendicular to zenith distance axis.
`FLEX`	FLOAT	RW	Tube flexure term.

The following equations are used to calculate correction for azimuth and zenith axis:

$$\begin{aligned} d_{\mathrm{A}} &= c_{\mathrm{AN}} \cdot \sin A \cdot \cot Z \\ &- c_{\mathrm{AE}} \cdot \cos A \cdot \cot Z \\ &+ c_{\mathrm{NPAE}} \cdot \cot Z \\ &- c_{\mathrm{CA}} \cdot \csc Z \end{aligned}$$

$$
\begin{aligned}
& + \; c_{\mathrm{AOFF}} \\
d_{\mathrm{Z}} \; = \; & \cos A \cdot c_{\mathrm{AN}} \\
& + \; \sin A \cdot c_{\mathrm{AE}} \\
& + \; \sin Z \cdot c_{\mathrm{FLEX}} \\
& + \; c_{\mathrm{ZOFF}}
\end{aligned}
$$

C.3 Model for RA-DEC mounted telescopes

The used pointing correction model is the standard geometrical model with 6 coefficients for mounting errors plus one for tube flexure.
Note: If the number of samples is 1, only `HOFF` and `DOFF` will be fitted, below 7, `HOFF`, `DOFF`, `ME` and `MA` will be calculated.

The following coefficients will be used:

Name	Type	Access	Description
`HOFF`	FLOAT	RW	Absolute hour angle encoder offset.
`DOFF`	FLOAT	RW	Absolute declination encoder offset.
`NPHD`	FLOAT	RW	Hour angle axis not perpendicular to declination axis.
`ME`	FLOAT	RW	Polar axis misalignment in elevation.
`MA`	FLOAT	RW	Polar axis misalignment in azimuth (towards EAST).
`CH`	FLOAT	RW	Collimation axis not perpendicular to hour angle.
`FLEX`	FLOAT	RW	Tube flexure term.

The following equations are used to calculate correction for azimuth and zenith axis:

$$
\begin{aligned}
d_{\mathrm{H}} \; = \; & c_{\mathrm{NPHD}} \cdot \tan D \\
& - \; c_{\mathrm{CH}} \cdot \sec D \\
& + \; c_{\mathrm{ME}} \cdot \sin H \cdot \tan D \\
& - \; c_{\mathrm{MA}} \cdot \cos H \cdot \tan D \\
& - \; c_{\mathrm{FLEX}} \cdot \cos \Phi \cdot \sin H \cdot \sec D \\
& + \; c_{\mathrm{HOFF}} \\
d_{\mathrm{D}} \; = \; & c_{\mathrm{ME}} \cdot \cos H \\
& + \; c_{\mathrm{MA}} \cdot \sin H \\
& + \; c_{\mathrm{FLEX}} \cdot (\cos \Phi \cdot \cos H \cdot sinD - \sin \Phi \cdot \cos D)
\end{aligned}
$$

$$+ \; c_{\mathrm{DOFF}}$$

Where Φ is the telescope's latitude.

C.4 Model for ALT-ALT mounted telescopes

The used pointing correction model is a standard geometrical model with 6 coefficients for mounting errors and one for tube flexure.
Note: If the number of samples is 1, only `ZOFF[0]` and `ZOFF[1]` will be fitted.

The following coefficients will be used:

Name	Type	Access	Description
`ZOFF[0]`	FLOAT	RW	Absolute ZD[0] encoder offset.
`ZOFF[1]`	FLOAT	RW	Absolute ZD[1] encoder offset.
`NPZZ`	FLOAT	RW	ZD[0] not perpendicular to ZD[1] axis.
`ZA`	FLOAT	RW	Mount misalignment in azimuth (towards east).
`ZE`	FLOAT	RW	Mount misalignment in elevation.
`CZ`	FLOAT	RW	Telescope beam not perpendicular to ZD.
`FLEX`	FLOAT	RW	Tube flexure term.

The following equations are used to calculate correction for azimuth and zenith axis:

C.5 Refraction parameters

The following values can be modified to control the refraction compensation:

Name	Type	Access	Description
`MODE`	INT	RW	0 - no refraction correction, 1 - use defaults for refraction (10 °C, 1010 mbar, corrected by height), 2 - use customized settings
`TEMPERATURE`	FLOAT	RW	Outside temperature in Celsius (only for mode 2).
`PRESSURE`	FLOAT	RW	Air pressure in mbar (only for mode 2).
`HEIGHT`	FLOAT	RW	Height above sea level in meters (only for mode 1).

References

[1] M. Ruder and D. Plasa. *OpenTCI, Open Telescope Control Interface — An open specification of a TPL2 based interface to control a telescope*. 4pi systeme GmbH. 4PI-DOC-03-008-02.

[2] M. Ruder and D. Plasa. *TPL2, Transfer Protocol Language, V2 — A protocol for client-server based exchange of data and commands over a TCP/IP network connection*. 4pi systeme GmbH. 4PI-DOC-03-008-01.