

Memorandum

To: Eric Tollestrup
From: Dan Clemens
Date: December 19, 2002
re: *Mimir* I/O Board Functionality (V5)

Scope: This memo describes the purpose and functionality of the eight *Mimir* I/O boards to be located in the electronics box mounted with the cryostat at the telescope. This memo should be consulted when designing and debugging software for driving *Mimir*'s electromechanical units within the cryostat using the STP100 stepper motor controller cards.

Assumptions: A fundamental assumption is that each stepper motor in the cryostat is associated with up to five electrical switches and may have an electrically powered brake or other similar device. This allows each filter wheel or similar device to be treated as a distinct "unit" and to be cabled to one I/O board using a standard cable. The same I/O board could be connected to a filter wheel or to a camera positioner or to a slit belt unit. All boards are interchangeable. All cables are interchangeable. Every board must be capable of discovering which motor unit it is attached to and be able to report that information back to the host computer. Every board must be uniquely identified back to the host computer.

Purpose: The I/O board serves to augment one STP100 stepper motor card for applications involving stepper motor motion and mechanical unit position sensing. In *Mimir*, these include the polarimeter (half-wave plate rotation unit), filter wheels, camera slit belt unit, and camera selection unit. The I/O board enhances the number of signals the STP100 can return to the host computer. The I/O board returns a unique cable identifier to the STP100 allowing the host computer to know which mechanical unit within the cryostat is attached to the board. The I/O board also returns a unique board identifier to the STP100 to allow checking for a match of I/O board with connected cable and STP100 internal board identification. The I/O board also handles hardware limit condition processing, by halting the flow of stepper motor power and setting any brake present in the motor unit. Finally, the I/O board displays a wide range of diagnostic signals to a 10-LED stack and to the 7-segment LED display.

Communication: The I/O board is accessed via the RS-232/485 channel of the piggyback STP100 card. The STP100 provides four signal lines that can be accessed via the PR ("pin read"), PS ("pin set"), PC ("pin clear"), and AD ("read A/D line") commands of the STP100. Two of the four STP100 lines are used as control lines from the STP100 to the I/O board to select one of four operating modes for the I/O board.

The control lines are the STP100 "Pin 5" and "Pin 6" connections of the STP100's J7 connector. The I/O board considers "Pin 5" the more significant of the two

control lines. In the I/O board schematic, the lines are called “STPOut1” and “STPOut0”, for pin 5 and 6, respectively.

The other two STP100 lines, “Pin 3” and “Pin 8”, are used to send information from the I/O board to the STP100. In three of the I/O board modes, this information is in the form of TTL signals and can be read using the RP (“read pin”) digital mode of the STP100. In one mode of the I/O board, the signals are analog voltages (in the 0-5V range) and are read by the STP100 using the AD1 (“read analog voltage on pin 3”) and AD2 (“read analog voltage on pin 8”) commands.

Signals Captured: The following signals are collected by the I/O board and presented to the STP100:

Table 1: I/O Board Signals		
Name	Type	Description
Cable ID	Analog	Unique identifier for the motor unit at the end of the cable (that is, inside the cryostat) – See Table 3 below
Board ID	Analog	Unique identifier for the I/O board being used – See Table 4 below
Panic/Home	TTL	Depending on the nature of the motor unit, returns either a “home” signal, or a “panic” signal. Panic is the logical OR of the four limits below. If any of the limits is reached, the panic line is asserted. This allows the STP100 to monitor this bit while moving the stepper motor.
Detent	TTL	Returns status of detent signal line to motor unit.
E1/SR	TTL	In Filter wheels, E1 is the LSB of the 4-bit filter position encoder. In slits and camera positioners, SR is the Software Right limit switch signal.
E2/SL	TTL	Similar to E1/SR, but for the second bit of the filter position sensor and/or the Software Left limit switch.
E3/HR	TTL	Third filter position sensor and/or the Hardware Right limit switch. “Hardware” limit switches have higher priority than “Software” limit switches on the I/O board and when asserted cause the motor power to disengage.
E4/HL	TTL	Similar to E3/HR, but MSB of filter position sensor and Hardware Left limit switch.

I/O Board Mode Selection: The two output lines of the STP100 are used to select the mode of the I/O board. The following table summarizes the modes and the signals returned to the STP100 in each mode.

Table 2: I/O Board Operating Modes						
Out 1 “Pin 5”	Out 0 “Pin 6”	Mode Name	In 0 “Pin 8”	In 1 “Pin 3”	Signal Type	Actions
Set (“1”)	Set	GETID	Cable ID	Board ID	Analog	Reads Cable ID; Can reset motor off condition; Brake set
Set	Clear (“0”)	MOVE	Panic/ Home	Detent	TTL	Brake Released; HL/HR limits cause motor off
Clear	Clear	READ A	E2/SR	E1/SL	TTL	Brake set
Clear	Set	READ B	E4/HR	E3/HL	TTL	Brake set

Cable ID: The Cable ID consists of a resistor-based voltage divider for which one of the resistors is located at the end of the wiring harness with its associated motor within the cryostat. By selecting particular resistors for each motor unit, a unique voltage from the voltage divider is generated. This voltage is fed back to pin 8 of the STP100 and read using the **AD2** command. An on-board ADC on the I/O board also samples the voltage divider and resolves the information to a single digit cable ID number and presents this information on the 7-segment LED on the front panel of the I/O board. The encoding scheme is as shown in the following table:

Note that the Cable ID must be read multiple times, using several AD2 calls. The returned values should be averaged (perhaps with outlier removal). The deviation of the measured average from the averages listed in the table below should be less than the uncertainty listed in the table below to be able to claim a valid unit identification.

Table 3: Cable ID Encoding on I/O Board					
ID #	Unit Name in <i>Mimir</i>	Resistors in cryostat	I/O Board 7-seg LED	STP100 AD2 Count Values	
				Average	Uncertainty
0	Fail	short	0	<66	
1	HWP	6.0k	1	73	3
2	Polar	7.9k	2	86	3
3	FW1	10.4k	3	102	3
4	FW2	13.7k	4	120	3
5	FW3	17.7k	5	136	3
6	...	22.6k	6	150	3
7	...	29.9k	7	167	3
8	Camera	41.4k	8	183	3
9	Slit Unit A	59.3k	9	198	3
c	Slit Unit B	94k	“c”	215	3
d	...	230k	“d”	231	3
>9	Fail	open	“u”	>236	

Board ID: A resistor-based voltage divider is also used to identify the I/O board back to the STP100 and then on to the host computer. The voltage output is selected by a DIP switch (one of eight switches) that also gives a visual identification to the individual I/O board. In the Get ID mode, the voltage divider returns an analog voltage that is digitized by the STP100 via the **AD1** command. The encoding is as shown in the following table:

Table 4: Board ID Encoding on I/O Board			
Board Number	DIP Switch Selection	STP 100 AD1 Count Values	
		Average	Uncertainty
0	Do Not Use – This Activates all boards		
1	1	68	2
2	2	89	2
3	3	102	2
4	4	113	2
5	5	128	2
6	6	153	2
7	7	165	2
8	8	178	2

Actions: The I/O board controls the stepper motor power being sent to the STP100 card as well as the power to any brake in the motor unit in the cryostat. In the MOVE or READ modes of the I/O board, if either the HR or HL signal is true (a hardware limit switch is closed), stepper motor power is removed and the brake is set.

Motor power reset is accomplished either by pressing a front panel push button switch, or if the jumper is present, the driving computer may also reset motor power by issuing a GETID mode selection.

Front Panel Switches: There are two push buttons and one toggle switch on the front panel. The toggle switch enables the LED displays or extinguishes them. The top push button switch issues a GETID signal, independent of the STP100, which latches the cable ID onto the 7-segment LED display. This is useful for debugging cables when a computer is not present to communicate with the STP100 board. The lower push button resets stepper motor power after a hardware limit has been reached.

Front Panel LEDs: There is a 10-element LED stack and a 7-segment LED display. The 7-segment LED shows the most recent Cable ID value. The 10 element LED stack shows that status of the following signals:

Table 5: Front Panel 10 Element LED Stack	
LED Number (from top)	Signal Name, Description
<i>Motor/Brake Information Group</i>	
1 (red)	Brake Released – power is being sent to the brake unit
2 (red)	Motor Power Fail – the stepper motor power has been turned off because a hardware limit condition was sensed.
<i>Command Group</i>	
3 (red)	STP Out 1 = “Pin 5”
4 (yellow)	STP Out 0 = “Pin 6”
<i>High Level Information Group</i>	
5 (yellow)	Panic/Home
6 (yellow)	Detent
<i>Low Level Information Group</i>	
7 (yellow)	E4/HR
8 (green)	E3/HL
9 (green)	E2/SR
10 (green)	E1/SL

Commanding Considerations: Because the brake release is tied directly to the MOVE mode condition, care must be exercised in designing the commanding sequences to the I/O board or a potentially dangerous condition could occur. This is particularly the case for the *Mimir* camera positioning unit, where stepper motor power is normally turned off after a move and the brake is set. If the I/O board is given a MOVE mode selection before stepper motor power is turned on by the STP100, the brake will be released and the camera block could hit a hardware limit (at which time the brake will be set).

Useful programming sequences would be something like the following:

Table 6: Model STP100 & I/O Board Commanding Sequences			
Desired Action	STP100 Commands	I/O Board Mode	Actions, Notes
Get Motor Unit ID	PS6		NOTE: set pin 6 BEFORE pin 5 to avoid passing through MOVE mode!!!
	PS5	GETID	Loads ID for Cable
	AD2		Read Cable ID
	AD1		Read I/O Board ID
	PC5	READ B	NOTE: clear pin 5 BEFORE pin 6 to avoid MOVE mode
	PC6	READ A	Safe place to leave I/O board
Move Unit	PS6		
	PS5	GETID	Clear any motor off condition
	SP		turn on stepper motor power
	PC6	MOVE	Brake off, ready to move
	RP8		read panic/home bit
	RP3		read detent bit
	TC3		set STP test condition on detent
	II350		move 350 more steps
	RP3		check detent bit
	RP8		check panic/home bit
	PS6	READA	set brake
	SO		turn off motor power
Read Limits	PS6		
	PC5	READB	
	RP8		read E2/SR bit
	RP3		read E1/SL bit
	PC6	READA	
	RP8		read E4/HL bit
	RP3		read E3/HR bit