

Implementation of The PLC Controlled Instrument-Change Interlocks

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This document describes the present interaction of the PLC system with the LATCHES and the LIFT. This initial document does not contain the correct PLC names for the described logic functions. It is simply my initial attempt to document the installed interlock system before leaving the site. The document is intended to follow section III of "A Specification For PLC Implementation of Instrument-Change Interlocks" Connie Rockosi, Jim Gunn, 2001/01/31 (draft), SDSS Controls Archive Mail Message 409.

The following are the signals derived from the mechanical switches on the telescope used in the logic implementation.

Instrument ID Switches

This has been the most problematic part of the instrument change interlocks. The lift is not capable of raising the imaging camera high enough to actuate the ID switches or the saddle in place switches. There has been intermittent problems with one of the cartridges we used during the testing not actuating the ID switches with the lift up as well. In the latch logic below (section 5), the requirement that the instrument ID switches indicate the imaging camera in place and saddle in place had to be removed from the latch permit logic for the imaging camera to get the auto mode to work. The instrument ID switches read reliably when the instrument has been latched to the telescope. The present implementation of the logic code requires all 12 switches to be in the correct state to assert an instrument in place signal.

Instrument ID Switch Codes	Instrument
1111 1111 1111	No instrument on the telescope
0000 0000 0000	Disconnected Cable
0001 0001 0001	Imaging Camera
0101 0101 0101	Engineering Camera
1110 1110 1110	Fiber Cartridge #1
1101 1101 1101	Fiber Cartridge #2
1100 1100 1100	Fiber Cartridge #3
1011 1011 1011	Fiber Cartridge #4
1010 1010 1010	Fiber Cartridge #5
1001 1001 1001	Fiber Cartridge #6
1000 1000 1000	Fiber Cartridge #7
0111 0111 0111	Fiber Cartridge #8
0110 0110 0110	Fiber Cartridge #9
0100 0100 0100	Undefined
0011 0011 0011	Undefined
0010 0010 0010	Undefined

Corrector ID Switches

01 Corrector not in place
10 Corrector in place

Lift plate ID Switches

0001 Imager without J-hook
1001 Imager with J-hook
1011 Cartridge
1111 Cartridge, springs compressed
1010 Eng. Camera
1110 Eng. Camera, springs compressed
0010 SC lens cart

1. Protect the camera Tbar kinematics.

The MCP or PLC are only allowed to move the camera Tbar latches when the telescope is at the zenith.

An audio alarm will sound when either safety latch is opened AND the Tbar latches are not in the transport position.

An audio alarm will also sound if the imaging camera is not on the telescope AND the Ops. cart is in the dog house AND the doghouse door is opened.

2. Disallow activity unless the telescope is pinned at the zenith, and the telescope is at the instrument change position.

Auto mode enable requires:

The instrument latch control box mode switch to be in the auto mode AND
the Altitude locking pin in place AND
the instrument lift pendant to be in the auto port AND
the rotator at the instrument change position AND
the Azimuth at the stow position AND
the Altitude at the zenith AND
no errors in the Flex I/O links.

3. Protect the lens if mounted.

The instrument lift is allowed to move up the first 2". The lift plate will contact and identify any of the instruments within this distance.

At a lift height of 2" the lift up will be inhibited if
(the imaging camera is on the lift OR
the engineering camera is on the lift) AND
the corrector lens is on the telescope.

4. Protect the instruments / latches / doors against lift collisions.

The instrument lift up motion has been implemented in a state machine fashion as a function of lift height. By enforcing an up permit, illegal up motions are inhibited from non known lift states. Up motion is permitted under the following conditions:

Auto mode enabled (Item 2 above) AND
Lift pump switch on AND
Dead man switch depressed AND

lift height = 0 - 2" AND
Ops. cart in position OR
Ops. cart in dog house OR
Imaging camera on lift w J hook in place OR
Imaging camera on lift w/o J hook in place

lift height = 2" - 18" AND
Empty plate on lift OR

(Corrector on lift AND
Primary latches open) AND
Corrector on telescope OR
Corrector not on telescope AND
Secondary latches open OR

Imaging camera on lift w/o J hook in place AND
Imaging camera on telescope AND
Corrector not on telescope OR

Imaging camera on lift w J hook in place AND
No instrument on the telescope AND
Primary latches open AND
Secondary Latches open AND
Saddle latches open AND
Corrector not on telescope OR

(Cartridge on lift OR
Cartridge on lift compressed OR
Empty plate on lift) AND
(Cartridge on telescope OR
No instrument on the telescope AND
Primary latches open AND
Slit head door 1 open AND
Slit head door 2 open AND
Slit head latch 1 open AND
Slit head latch 2 open) OR

(Engineering Camera on lift OR
Engineering Camera on lift compressed OR
Empty plate on lift) AND
(Engineering Camera on telescope AND
Corrector not on the telescope) OR
(No instrument on the telescope AND
Primary latches open AND

Secondary latches open AND
Corrector not on the telescope)

lift height >18"

Lift is allowed to continue up to the instrument change positions

5. Allow only appropriate latch activity when instrument is being installed / removed.

Imaging camera up in place =

(Imaging camera on lift w J hook in place OR
Imaging camera on lift w/o J hook in place) AND
Lift height = 21.80 - 22.15" AND
Lift force > 1400 lbs.

Cartridge up in place =

Cartridge on lift compressed AND
Cartridge on the telescope AND
Lift height = 22.85 - 23.05 AND
Lift Force > 950 lbs.

Eng. Cam up in place =

Eng. Cam on lift compressed AND
Eng. Cam on the telescope AND
Lift height = 22.89 - 23.09 AND
Lift Force > 950 lbs.

Corrector up in place =

Corrector on lift AND
Corrector on the telescope AND
Lift height = 23.04 - 23.24 AND
Lift Force > 750 lbs.

Primary Latch Permit =

Auto Mode AND
(Instrument install OR
Instrument Remove) AND
Imaging camera up in place OR
Cartridge up in place OR
Eng. Cam up in place OR
Corrector up in place

Secondary Latch Permit =

Auto Mode AND
(Instrument install OR
Instrument Remove) AND
Imaging camera up in place OR
Corrector up in place

Saddle Latch Permit =

Auto Mode AND
(Instrument install OR
Instrument Remove) AND
Imaging camera up in place

6. Allow latch activity as necessary to properly configure telescope to receive instruments or to do biases in doghouse.

The instrument lift up motion will be inhibited at a lift height of 2" for latches in an incorrect state to allow for installation of the instrument. The primary, secondary, and saddle latches are allowed to be opened or closed as necessary to correct the problem if no instruments are connected to the telescope that use the latches. The primary, secondary, and saddle latches are blocked from activation after the lift height exceeds 6". The following logic is used

Primary Latch Permit =

Lift height < 6" AND
No Instrument on the telescope AND
Saddle not on the telescope AND
(Imaging camera on lift w J hook in place OR
Imaging camera on lift w/o J hook in place OR
Cartridge on lift OR
Eng. Camera on lift OR
Corrector on lift)

Secondary Latch Permit =

Lift height < 6" AND
No Instrument on the telescope AND
Saddle not on the telescope AND
(Imaging camera on lift w J hook in place OR
Imaging camera on lift w/o J hook in place OR
Eng. Camera on lift OR
Corrector on lift)

Saddle Latch Permit =

Lift height < 6" AND
No Instrument on the telescope AND
Saddle not on the telescope AND
(Imaging camera on lift w J hook in place OR
Imaging camera on lift w/o J hook in place)

7. Prevent lowering the lift when up with an instrument unless latches are safely configured.

The instrument lift down motion again has been implemented in a state machine fashion as a function of lift height. By enforcing an down permit, illegal down motions are inhibited from non known lift states. Down motion is permitted under the following conditions:

Lift hand pendant in the auto port AND
Lift pump switch on AND
Dead man switch depressed AND

lift height > 23.1" AND

(Corrector on lift AND
Primary latches open) AND
(Secondary latches open OR
Secondary latches closed)

lift height = 22.3 - 23.1" AND
(Corrector on lift AND
Primary latches open) AND
(Secondary latches open OR
Secondary latches closed) OR
(Cartridge on lift OR
Cartridge on lift compressed) AND
((Primary latches closed AND
Slit head latch 1 closed AND
Slit head latch 2 closed) OR
(Primary latches open AND
Slit head door 1 open AND
Slit head door 2 open AND
Slit head latch 1 open AND
Slit head latch 2 open)) OR

Cartridge on telescope AND
Primary latches closed AND
Slit head latch 1 closed AND
Slit head latch 2 closed OR

(Engineering Camera on lift OR
Engineering Camera on lift compressed) AND
(Engineering Camera on telescope AND
Corrector not on the telescope) AND
(Primary latches open OR
Primary latches closed) OR

(Engineering Camera on telescope AND
Primary latches closed)

lift height = 18 -22.3 AND

(Corrector on lift AND
Primary latches open) AND
(Secondary latches open OR
Secondary latches closed) OR

Imaging camera on lift w J hook in place AND
((Primary latches open AND
Secondary Latches open AND
Saddle latches open) OR
(Primary latches closed AND
Secondary Latches closed AND
Saddle latches closed)) OR

(Cartridge on lift OR
Cartridge on lift compressed) AND
((Primary latches closed AND
Slit head latch 1 closed AND
Slit head latch 2 closed) OR
(Primary latches open AND
Slit head door 1 open AND
Slit head door 2 open AND

Slit head latch 1 open AND
Slit head latch 2 open)) OR

(Engineering Camera on lift OR
Engineering Camera on lift compressed) AND
(Primary latches open OR
Primary latches closed) OR

Empty plate on lift AND
(Primary latches open OR
Primary latches closed)

lift height <18"

Lift is allowed to continue down to the bottom of the lift travel

8. Protect the telescope / instruments from collision with the lift plate.

Altitude motions are inhibited unless the lift plate is down. This was implemented in previous versions of the PLC code. To help eliminate possible catch 22 conditions, the instrument lift down permit, only requires the correct instrument / latch combinations and the lift pendant to be in the auto port. This should allow the instrument lift to be moved completely down under less stringent conditions.

9. (Added Interlock) Protect the instruments from excessive lift contact and instrument mounting shocks.

A series of lift speeds enforce slowly contacting an instrument when initially raising the lift and enforcing slow seating of the instrument to the telescope. The following table lists the instrument and maximum speeds allowed at various lift heights. The manual speed control on the lift pendant will allow the lift speed to be decreased below the maximum enforced speed at any time in the lift range.

<u>Instrument</u>	<u>Seating Height</u>
Imaging Cam	21.97 - 22.10
Cartage	22.97 - 23.01
Eng. Cam	22.98 - 23.01
Empty Plate	N/A
Corrector	23.12 - 23.16

<u>Instrument</u>	<u>speed 1</u>	<u>speed 2</u>	<u>speed 3</u>	<u>speed 4</u>
Imaging Cam	Any Height	< 21.89"	2.2" - 21.74"	2.5" - 20.99"
Cartage	Any Height	< 22.80"	2.2" - 22.50"	2.5" - 22.00"
Eng. Cam	Any Height	< 22.80"	2.2" - 22.50"	2.5" - 22.00"
Empty Plate	Any Height	< 22.80"	2.2" - 22.50"	2.5" - 22.00"
Corrector	Any Height	< 23.00"	2.2" - 22.75"	2.5" - 22.20"

10. (Added Interlock) Protect the instruments from excessive forces while installing or removing.

To help protect the instruments from inadvertent contact with unknown objects, the lift force for each instrument is monitored during the lift process. Excessive up force or too little down force will stop the instrument lift. The following table lists the forces allowed for both up and down motions for the various instruments.

Lift up force limits (Lift force less than value shown in the table.)

<u>Height</u>	<u>Cartg</u>	<u>Eng. Cam</u>	<u>Empty Plate</u>	<u>Corr</u>	<u>Empty Turtle</u>
0-0.75	500	500	500	500	500
0.75-2.0	None	None	None	None	None
2.0-20.0	450	350	200	350	150
20.0-21.89	500	350	200	350	150
21.89-22.3	500	400	200	400	150
22.0-23.1	1100	1100	1100	N/A	N/A
23.1-23.3	N/A	N/A	N/A	800	800

<u>Height</u>	<u>Imaging Turtle</u>	<u>Empty Cart</u>
0-0.75	500	500
0.75-2.0	None	None
2.0-20.0	1400	350
20.0-21.89	1650	350
21.89-22.3	1700	1700
22.0-23.1	1100	1100
23.1-23.3	N/A	N/A

Lift down force limits (Lift force greater than value shown in the table.)

<u>Height</u>	<u>Cartg</u>	<u>Eng. Cam</u>	<u>Empty Plate</u>	<u>Corr</u>	<u>Empty Turtle</u>
0-0.75	-125	-125	-125	-125	-125
0.75-2.0	None	None	None	None	None
2.0-20.0	310	220	0	125	0
20.0-21.89	310	220	0	125	0
21.89-22.3	310	220	0	125	0
22.3-24.0	None	None	None	None	None

<u>Height</u>	<u>Imaging Turtle</u>	<u>Empty Cart</u>
0-0.75	-125	-125
0.75-2.0	None	None
2.0-20.0	1100	150
20.0-21.89	150	150
21.89-22.3	N/A	N/A
22.3 - 24.0	None	None

11. (Added Function) Purge cell timer.

The purge cell timer will activate for automatically 30 seconds when the imaging camera or a cartridge are latched to the telescope.