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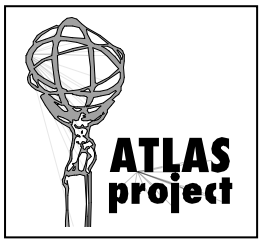

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Functional Specification and Test Report

THE ATLAS-ALFA INTERLOCK LOGIC IN 2015: SPECIFICATION AND TEST RESULTS

Abstract

This document summarizes the re-commissioning tests performed on the ATLAS-ALFA interlock system March 2015.

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History of Changes

Version	*Date*	*Comments or Description of Changes*
0.1	04-06-2015	Copy/paste of doc. 1503866 with some updating on who checks/approves.
0.2	30-06-2015	Comments by S. Wenig implemented
0.3	02-07-2015	Updated the interlock logic with the 3 tick comparison and the section of LVDT-to-LIMIT validation.
0.4	09.09.2015	Taking comments by Markus and Daniel. Then release

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1. THE ATLAS-ALFA INTERLOCK LOGIC IN 2015

The block diagram of the interlock logic for 2015 is shown in Figure 1. The diagram has not been changed since 2012 and is documented in [1] and [2]. The LVDT-to-limit comparison has however been changed: Instead of comparing once every 10 ms and acting based on one comparison (like in Run1), a comparison is made every 6 ms and if and only if 3 consecutive LVDT-to-limit comparisons fail, the system reacts by extracting ALL the pots (for warning limit) or by extracting the pots and changing the USER_PERMIT from T to F (for dump limits). This solution was approved at the 110th MPP meeting for operation in 2015, provided that in the long term the implementations of ALFA/TOTEM and the COLL team converge towards a standard solution.

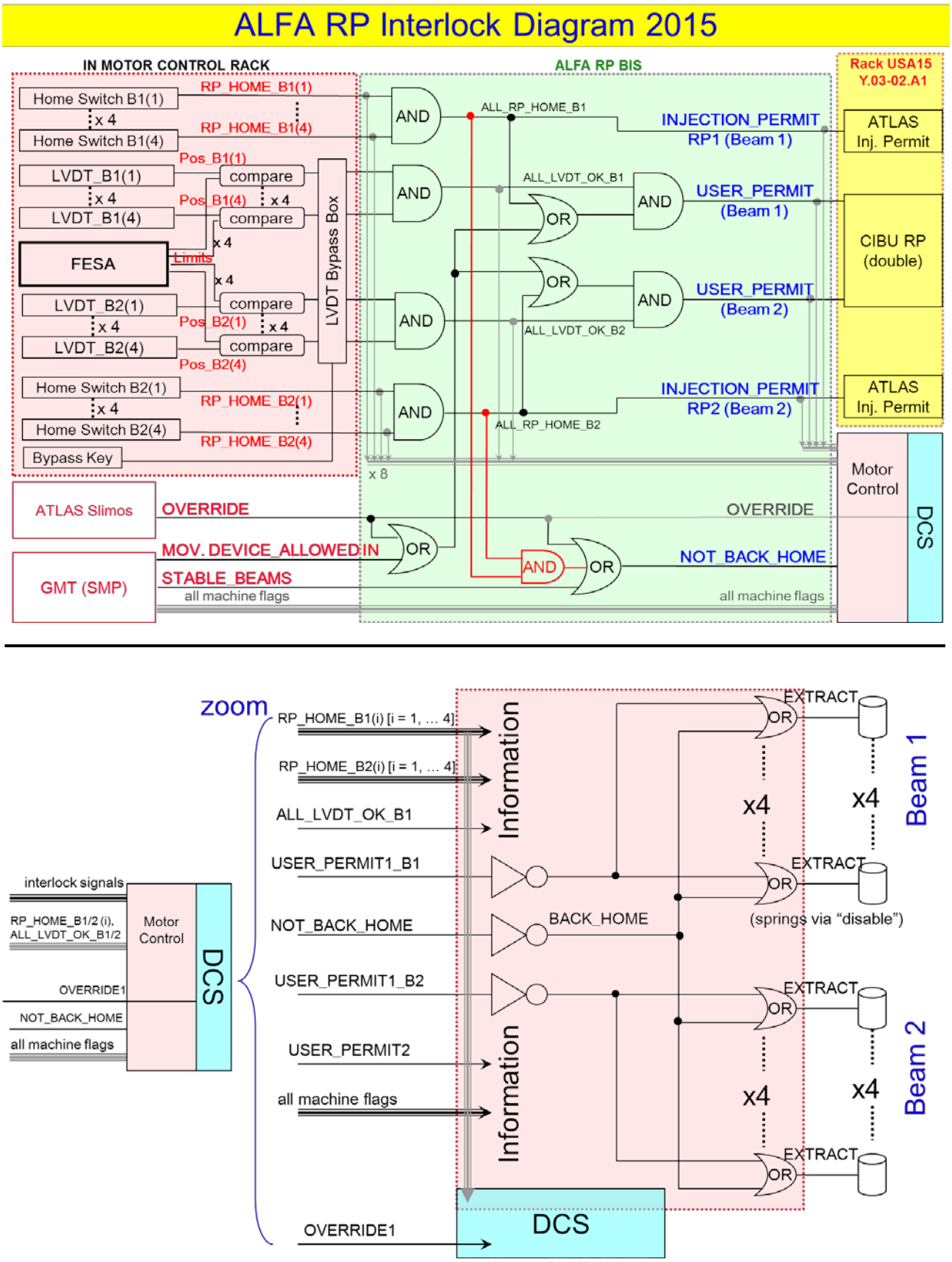


Figure 1: Interlock logic used in 2012. Top part: global view of the logic. Bottom part: zoom on the internal logic in the PXI computer (motor control rack).

2. TEST OF THE INJECTION PERMITS

2.1 REMOVAL OF THE INJECTION_PERMIT BY A POT LEAVING *HOME*

Any single Roman Pot not within the ON-range of the HOME switch withholds the RP INJECTION_PERMIT for its respective beam (B1 or B2):

ALL_RP_HOME_B1 = RP_HOME_B1(1) x … x RP_HOME_B1(4) ,

ALL_RP_HOME_B2 = RP_HOME_B2(1) x … x RP_HOME_B2(4) ,

where the index (1, … 4) runs over the 4 RPs in each beam.

When the RP returns to the HOME position, the INJECTION_PERMIT is restored.

RP INJECTION_PERMIT here represents two inputs to the global ATLAS INJECTION_PERMIT as illustrated in Figure 1 Top.

In ATLAS DCS the current state of the ATLAS injection permit matrix is displayed. For the Roman Pots there are one for Beam 1 (RP1) and one for Beam 2 (RP2) as shown in ATLAS DCS Figure 2.

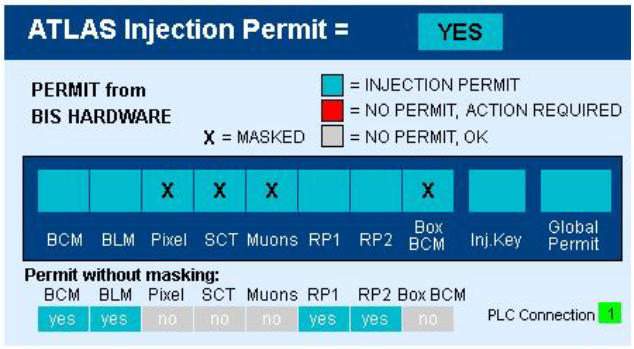


Figure 2. ATLAS injection permit DCS view before stating the injection permit test.

Removing the injection permit of ALFA breaks the INJECTION_PERMIT of ATLAS to the LHC. As ALFA does not have its own injection permit line to the LHC Beam Interlock System there are two options for validating the injection permit:

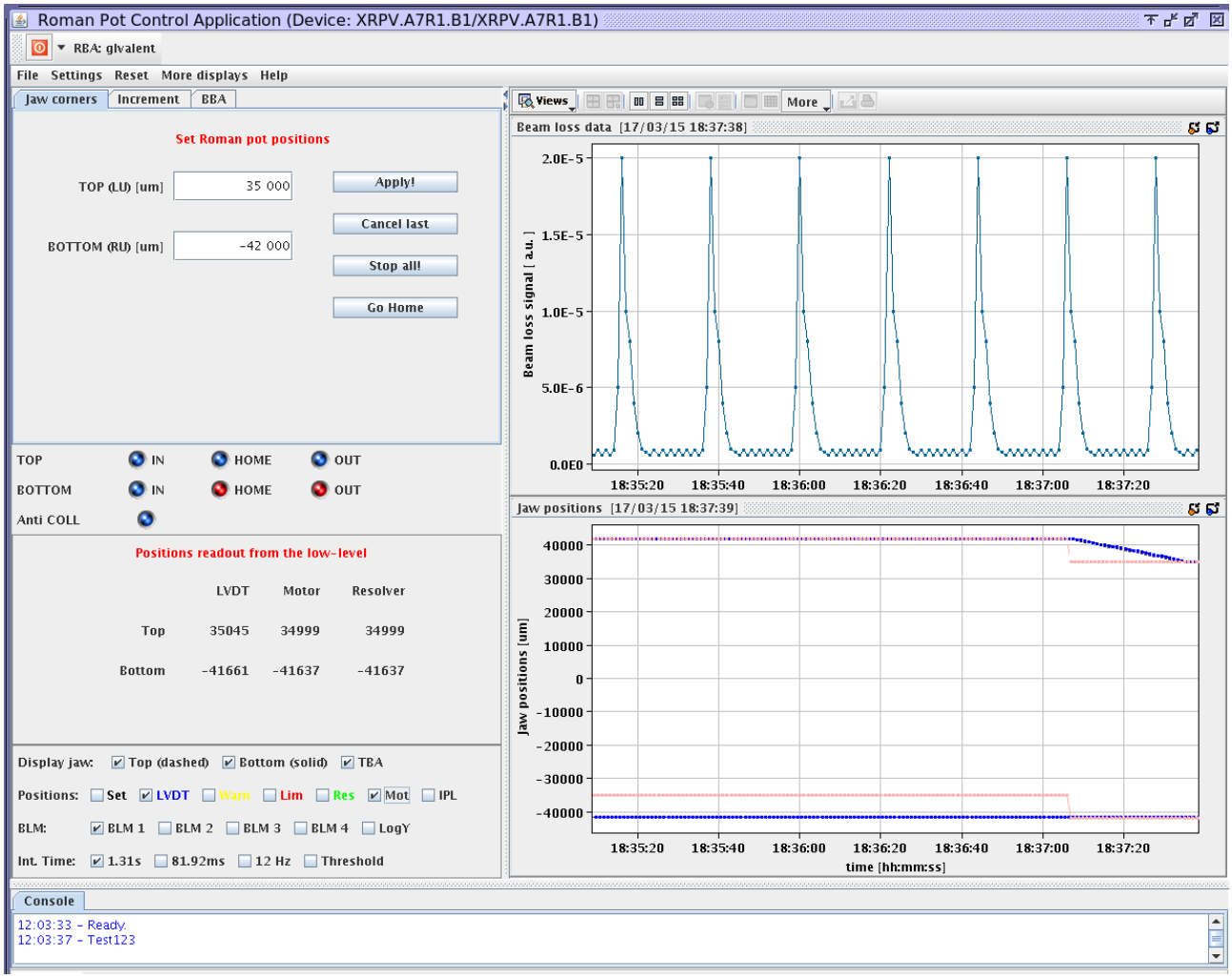
1. Direct: Make sure that all other ATLAS sub-detectors injection permits are given (or if not, were masked) and that the ATLAS injection key was turned ON. Then test that any Roman Pot leaving HOME breaks the ATLAS INJECTION_PERMIT.
2. Factorized: Test that a break for the ATLAS injection permit is propagated to LHC. Then test that if any Roman Pot leaves HOME it is seen by the ATLAS interlock logic.

In 2012 the factorized option 2 was used as the interlock test in 2012 was done during an ATLAS access where the injection key could not be turned ON (due to safety). In 2015 all other ATLAs sub-detectors were either masked or providing injection permit and the ATLAS injection key was turned (see Figure 2), so the direct method 1 was used.

Test sequence for each Roman Pot:

1. All Roman Pots at HOME.
2. Check in BIS that the INJECTION_PERMIT is present for both beams (documented with screenshot with time stamp included in the LHC OP logbook [3]).
3. Move in one Roman Pot.
4. Check in ATLAS DCS that the INJECTION_PERMIT is broken for the beam of the Roman Pot (documented with screenshot with time stamp included [3]).
5. Move the Roman Pot back at HOME.
6. Check in ATLAS DCS that the INJECTION_PERMIT is given for both beams (documented with screenshot with time stamp included [3]).

An example of the movement and resulting break of the injection permit for beam 1 is shown in Figure 3.



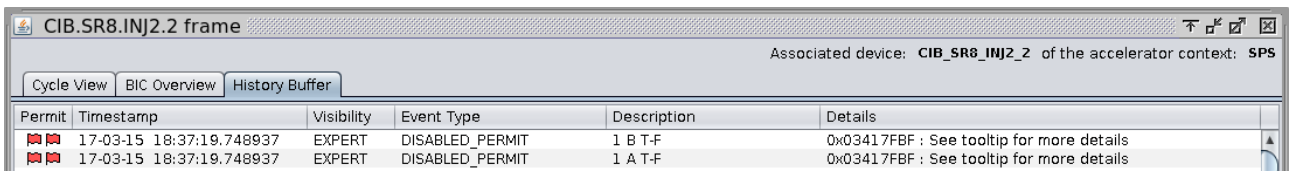


Figure 3. *TOP:* Collimator application used to move Roman Pot A7R1 Upper out of garage. *BOTTOM:* Corresponding loss of INJECTION_PERMIT seen in the BIS history buffer.

The sequence was successfully tested for all 8 Roman Pots. All worked as they are supposed to.
The time stamps when each Roman Pot was tested are shown in Table 1 for beam 1 and in Table 2 for beam 2. They are documented in [3].

Beam 1 (Sector 1-2)

Short name	Station name	INJECTION_PERMIT lost [elog]	INJECTION_PERMIT recovered [elog]	INJECTION_PERMIT affected
A7R1U	XRPV.A7R1.B1	18:37	18:39	Beam1
A7R1L	XRPV.A7R1.B1	18:40	18:41	Beam1
B7R1U	XRPV.B7R1.B1	18:43	18:44	Beam1
B7R1L	XRPV.B7R1.B1	18:45	18:47	Beam1

Table 1: elog time on the 17/03-2015 when the INJECTION_PERMIT lost/recovered for each Roman Pot for beam 1.

Beam 2 (Sector 8-1)

Short name	Station name	INJECTION_PERMIT lost [elog]	INJECTION_PERMIT recovered [elog]	INJECTION_PERMIT affected
B7L1U	XRPV.B7L1.B2	18:18	18:23	Beam2
B7L1L	XRPV.B7L1.B2	18:28	18:30	Beam2
A7L1U	XRPV.A7L1.B2	18:31	18:33	Beam2
A7L1L	XRPV.A7L1.B2	18:34	18:35	Beam2

Table 2: elog time on the 17/03-2015 when the INJECTION_PERMIT lost/recovered for each Roman Pot for beam 2.

3. TEST OF THE RESPONSE TO THE LVDT-TO-LIMITS COMPARISON (ALL_LVDT_OK)

The user permits of beam 1 and beam 2 are defined by the logic:

$$\text{USER\_PERMIT(B1)} = \text{ALL\_LVDT\_OK\_B1} \times (\text{ALL\_RP\_HOME\_B1} + \text{DEVICE\_ALLOWED} + \text{OVERRIDE1})$$

$$\text{USER\_PERMIT(B2)} = \text{ALL\_LVDT\_OK\_B2} \times (\text{ALL\_RP\_HOME\_B2} + \text{DEVICE\_ALLOWED} + \text{OVERRIDE1})$$

where

$$\text{ALL\_LVDT\_OK\_B1} = \text{LVDT\_OK\_B1(1)} \times \ldots \times \text{LVDT\_OK\_B1(4)}$$

$$\text{ALL\_LVDT\_OK\_B2} = \text{LVDT\_OK\_B2(1)} \times \ldots \times \text{LVDT\_OK\_B2(4)}$$

(note: x holds for “AND” and + holds for “OR”)

Since the movement system does not allow to move a Roman Pot into an illegal position, the Roman Pots have to be first put into a legal position and then the critical limits modified *a posteriori*, such that the Roman Pot ends up in an illegal position.

This is done for each Roman Pot and for each limit (old inner warning, old inner dump and new inner dump) separately.

a. Test of old and new inner dump limits for upper Roman Pots:

- set outer dump limit > outer warning limit > OUT switch, typically:
  outer dump = 45 mm,
  outer warning = 44 mm
- set inner dump = 5 mm,
  inner warning = 6 mm
- move pot to 20 mm
- set inner dump = 25 mm,
  inner warning = 26 mm

Observe the immediate interlock reaction ("react." in the table): USER_PERMIT(Bi)=0 for the beam concerned while USER_PERMIT(Bi')=1 for the other beam.

Verify that the Roman Pot is automatically extracted and the USER_PERMIT goes back to 1 (column "final").

Since the last step (retraction via springs) happens very fast, the transitions of the USER_PERMIT to 0 and back to 1 have to be found in the BIS history file.

An example of the movement and resulting removal of the injection permit for beam 1 is shown in Figure 4 and Figure 5.

Figure 4. Collimator application used to move Roman Pot B7L1 Upper.

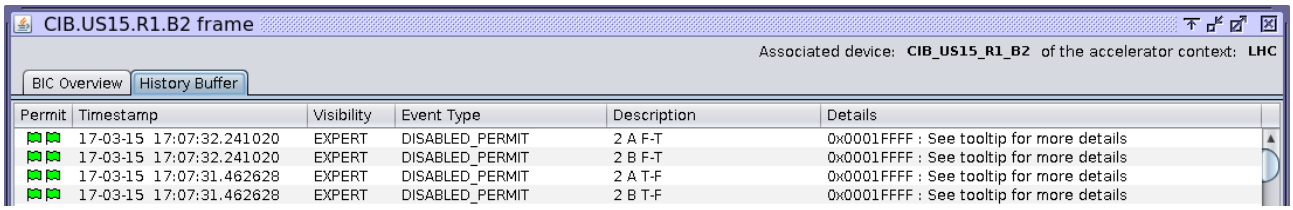


Figure 5. Corresponding loss of INJECTION_PERMIT seen in the BIS history buffer.

b. Test of old inner warning limits for upper Roman Pots:

- set outer dump limit > outer warning limit > OUT switch, typically:
  outer dump = 45 mm,
  outer warning = 44 mm
- set inner dump = 5 mm,
  inner warning = 6 mm
- move pot to 20 mm
- set inner warning = 26 mm

Observe the immediate interlock ("react." in the table) does not change; ie USER_PERMIT(Bi) stays equal to 1 for the beam concerned and USER_PERMIT(Bi')=1 for the other beam.

Verify that the Roman Pot is automatically extracted and that the USER_PERMIT stays at 1 (column "final").

Since the last step (retraction via springs) happens very fast, the check of any transitions of the USER_PERMIT to 0 and back to 1 have to be found in the BIS history file.

c. Test of inner limits for lower Roman Pots:

Same procedure as for top pots, but with all position and limit signs inverted.

d. Test of outer limits:

Not relevant for Roman Pots.

The test results are summarized in Table 3 and Table 4.

Beam 1 (Sector 1-2)			Old Inner warning				Old inner Dump				New inner Dump			
			USER_PERMIT (B1, B2)				USER_PERMIT (B1, B2)				USER_PERMIT (B1, B2)			
Name	#RP	Station name	React	Extraction?	Final	Time	React	Extraction?	Final	Time	React	Extraction?	Final	Time
A7R1U	5	XRPV.A7R1.B2	1,1	Yes	1,1	17:52	0,1	Yes	1,1	18:06	0,1	Yes	1,1	18:09
A7R1L	6	XRPV.A7R1.B2	1,1	Yes	1,1	17:42	0,1	Yes	1,1	17:45	0,1	Yes	1,1	17:48
B7R1U	7	XRPV.B7R1.B2	1,1	Yes	1,1	18:24	0,1	Yes	1,1	18:28	0,1	Yes	1,1	18:31
B7R1L	8	XRPV.A7L1.B2	1,1	Yes	1,1	18:13	0,1	Yes	1,1	18:16	0,1	Yes	1,1	18:19

Table 3: Reactions of the USER_PERMIT on the 18/06-2015 for beam 1 and the RP extraction signals by violations of the different limits. All worked as expected. e-log references: [3]

Beam 2 (Sector 8-1)			Old Inner warning				Old Inner Dump				New Inner Dump			
			USER_PERMIT (B1, B2)				USER_PERMIT (B1, B2)				USER_PERMIT (B1, B2)			
Name	#RP	Station name	React	Extraction?	Final	Time	React	Extraction?	Final	Time	React	Extraction?	Final	Time
B7L1U	1	XRPV.B7L1.B2	1,1	Yes	1,1	17:05	1,0	Yes	1,1	17:08	1,0	Yes	1,1	17:12
B7L1L	2	XRPV.B7L1.B2	1,1	Yes	1,1	16:43	1,0	Yes	1,1	16:48	1,0	Yes	1,1	16:51
A7L1U	3	XRPV.A7L1.B2	1,1	Yes	1,1	17:30	1,0	Yes	1,1	17:34	1,0	Yes	1,1	17:37
A7L1L	4	XRPV.A7L1.B2	1,1	Yes	1,1	17:18	1,0	Yes	1,1	17:21	1,0	Yes	1,1	17:24

Table 4: Reactions of the USER_PERMIT on the 18/06-2015 for beam 2 and the RP extraction signals by violations of the different limits. All worked as expected. e-log references: [3].

4. TEST OF USER_PERMIT1 AND AUTOMATIC POT EXTRACTION AS A FUNCTION OF ALL INPUT FLAGS

In the context of Sections 2 and 3, the correct behavior of the states ALL_RP_HOME_Bi and ALL_LVDT_OK_Bi [i = 1, 2] has been tested as a function of the individual Roman Pot states. In particular, it has been verified that each Roman Pot is able to dump its beam by violating any of the 3 existing dump limits (old inner, new inner, old outer).

It remains to be shown that all the logical combinations of ALL_RP_HOME_Bi and ALL_LVDT_OK_Bi with all the relevant beam flags and the override signal produce the correct reaction of the user permits and the spring extraction system:

USER_PERMIT1(Bi) =
ALL_LVDT_OK_Bi x (ALL_RP_HOME_Bi + DEVICE_ALLOWED + OVERRIDE1) [i = 1, 2]

NOT_BACK_HOME =
STABLE_BEAMS + OVERRIDE1 + (ALL_RP_HOME_B1 x ALL_RP_HOME_B2)

In addition, all Roman Pots are extracted when the USER_PERMITs = 0. Hence:

EXTRACT = [¬(NOT_BACK_HOME)] + [¬(USER_PERMIT1(B1))] + [¬(USER_PERMIT1(B2))]

Since for this test it is irrelevant in which way ALL_RP_HOME_Bi and ALL_LVDT_OK_Bi are brought to FALSE (i.e. which Roman Pot violates which limit), it is enough to perform it for one example Roman Pot per beam and the old inner limit.

Table 5 shows all combinations of the input conditions of the interlock logic, along with the reactions of the RP spring extraction system and the USER_PERMIT1 of the beam under test.

To reach all these combinations, a few sequences were followed (Table 6). Note that the states #22 and #24 are unreachable; they would require too many simultaneous violations of protected movement rules. The states #13 – 18 (except 17) were also skipped. They have the common property that the HOME position is made illegal by the critical limits. Such a choice of limits are without any practical meaning and hence of purely academic value.

Inputs	Combinations to be tested (labelled by the small blue numbers) 1	2	3	4			5	6
ALL_LVDT_OK_Bi	1	1	1	1	1	1	1	1
ALL_RP_HOME_Bi	1	1	1	1	1	1	1	1
DEVICE_ALLOWED	1	1	1	1	0	0	0	0
STABLE_BEAMS	1	1	0	0	1	1	0	0
OVERRIDE1	1	0	1	0	1	0	1	0
USER_PERMIT1(Bi)	1	1	1	1	N/A	N/A	1	1
EXTRACT	0	0	0	0	N/A	N/A	0	0

Inputs	7	8	9	10			11	12
ALL_LVDT_OK_Bi	1	1	1	1	1	1	1	1
ALL_RP_HOME_Bi	0	0	0	0	0	0	0	0
DEVICE_ALLOWED	1	1	1	1	0	0	0	0
STABLE_BEAM	1	1	0	0	1	1	0	0
OVERRIDE1	1	0	1	0	1	0	1	0
USER_PERMIT1(Bi)	1	1	1	1	N/A	N/A	1	0
EXTRACT	0	0	0	1	N/A	N/A	0	1

Inputs	13	14	15	16			17	18
ALL_LVDT_OK_Bi	0	0	0	0	0	0	0	0
ALL_RP_HOME_Bi	1	1	1	1	1	1	1	1
DEVICE_ALLOWED	1	1	1	1	0	0	0	0
STABLE_BEAM	1	1	0	0	1	1	0	0
OVERRIDE1	1	0	1	0	1	0	1	0
USER_PERMIT1(Bi)	0	0	0	0	N/A	N/A	0	0
EXTRACT	1	1	1	1	N/A	N/A	1	1

Inputs	19	20	21	22			23	24
ALL_LVDT_OK_Bi	0	0	0	0	0	0	0	0
ALL_RP_HOME_Bi	0	0	0	0	0	0	0	0
DEVICE_ALLOWED	1	1	1	1	0	0	0	0
STABLE_BEAM	1	1	0	0	1	1	0	0
OVERRIDE1	1	0	1	0	1	0	1	0
USER_PERMIT1(Bi)	0	0	0	0	N/A	N/A	0	0
EXTRACT	1	1	1	1	N/A	N/A	1	1

Impossible modes
(STABLE_BEAMS without DEVICE_ALLOWED)

Table 5: All combinations of input signals to the interlock logic and the expected reaction of the USER_PERMIT and the RP spring extraction system. Both beams (Bi = B1, B2) have to be tested independently. The combinations with orange background have not been tested: #22 and #24 are unreachable, #13 – 18 are irrelevant (HOME position out of critical limits).

State Transition	Beam Mode	OVERRIDE1	Pot Position	Action on Limits ('old' set of limits)	Interlock Reaction	Date B1	Date B2
						17.03.	
6 to 2	to STABLE_BEAMS			open limits: inner warning = 29 mm, inner dump = 28 mm	USER_PERMIT = 1	14:06	15:28
2 to 1		0 to 1			USER_PERMIT = 1	14:10	15:29
1			motor reset		USER_PERMIT = 1		
1 to 7			move pot to 35 mm		USER_PERMIT = 1	14:14	15:32
7 to 9	to UNSTABLE_BEAMS				USER_PERMIT = 1	14:23	15:35
9 to 21				illegal limits: inner warning = 37 mm, inner dump = 36 mm	USER_PERMIT = 0	14:23	15:36
21 to 3			automatic extraction		USER_PERMIT = 1	14:27	18:03
3				open limits: inner warning = 29 mm, inner dump = 28 mm	USER_PERMIT = 1	14:30	15:39
			motor reset				
3 to 1	to STABLE_BEAMS				USER_PERMIT = 1	14:35	15:41
1 to 7			move pot to 35 mm		USER_PERMIT = 1	14:36	15:43
7 to 19				illegal limits: inner warning = 37 mm, inner dump = 36 mm	USER_PERMIT = 0	14:38	15:44
19 to 1			automatic extraction		USER_PERMIT = 1	14:38	15:46
1				open limits: inner warning = 29 mm, inner dump = 28 mm	USER_PERMIT = 1	14:41	15:46
			motor reset				
1 to 7			move pot to 35 mm		USER_PERMIT = 1	14:42	15:48
7 to 11	to ADJUST				USER_PERMIT = 1	14:45	15:48
11 to 12		1 to 0			USER_PERMIT = 0	14:47	15:49
12 to 6			automatic extraction		USER_PERMIT = 1	14:47	15:49
2	STABLE_BEAMS	0	all pots at home			14:52	15:53
			motor reset		USER_PERMIT = 1	14:53	15:54
2 to 8			move pot to 35 mm		USER_PERMIT = 1	14:53	15:55
8 to 10	to UNSTABLE_BEAMS				USER_PERMIT = 1	15:07	15:57
10 to 4			automatic extraction		USER_PERMIT = 1	15:07	15:59
4 to 2	to STABLE_BEAMS				USER_PERMIT = 1	15:09	16:00
			motor reset				
2 to 8			move pot to 35 mm		USER_PERMIT = 1	15:10	16:00
8 to 20				illegal limits: inner warning = 37 mm, inner dump = 36 mm	USER_PERMIT = 0	15:10	16:02
20 to 2			automatic extraction		USER_PERMIT = 1	15:10	16:02
2				open limits: inner warning = 29 mm, inner dump = 28 mm	USER_PERMIT = 1	15:14	16:03
			motor reset				16:03
2 to 8			move pot to 35 mm		USER_PERMIT = 1	15:15	16:05
8 to 12	to ADJUST				USER_PERMIT = 0	15:18	16:07
12 to 6			automatic extraction		USER_PERMIT = 1	15:18	16:07

Table 6: Test sequences followed to reach all interlock input combinations labeled in Table 5. The main sequence (4th block) was executed with the pots XRPV.B7R1.B1 and XRPV.B7L1.B2. The test was performed on 17-03-2017 [4]

5. TEST OF THE LVDT BYPASS BOX

The LVDT bypass box has been tested on the 16/03-2015 [5].
Four scenarios were considered with the following test sequences.

5.1 TEST 1 (FAILURE DURING ALFA RUN)

1) Move some RPs towards the beam.
2) ***Simulate failure***: switch PXI crate with FPGAs off.
   → The USER_PERMITs of both beams become FALSE (beam dump)
   → All RPs are extracted with the springs. This is visible via the INJECTION_PERMITs which become TRUE.
   → The collimator application and the DCS are blind to RP status and positions.
3) ***Remedy to enable beam operation (without RPs)***: Turn BYPASS on.
   → The USER_PERMITs are re-established.
   → The motors are disabled; all attempts to reset or move RPs fail.
   → The collimator application and the DCS stay blind to RP status and positions because the PXI is still off.
4) ***Recovery after repairs***: restart PXI and FPGA processes.
   → The collimator application and the DCS see RP status (*Unconfigured*) and positions (HOME position).
   → The USER_PERMITs stay TRUE (bypass still on).
5) ***Back to normal***: Turn BYPASS off and re-enable the pots.
   → The DCS sees that the power is re-enabled.
   → The USER_PERMITs stay TRUE.
6) Reset motors and move some RPs towards the beam.
7) Check normal position interlock functionality: make pot position illegal by changing the limits.

5.2 TEST 2 (THE FORBIDDEN USE CASE)

This use case will not be operationally applied but was tested for completeness.

1) Move some RPs towards the beam.
2) [Assume that the PXI needs to be rebooted for some reason]
3) Turn BYPASS on.
   → This does not remove the USER_PERMITs but extracts and disables all RP motors.
   → The collimator application and the DCS see the RP status and positions.
   → The motors cannot be reset or moved.
4) Switch PXI crate with FPGAs off.
   → The USER_PERMITs stay TRUE.
   → The collimator application and the DCS are blind to RP status and positions.
   → The RPs are known to be at HOME due to the INJECTION_PERMITs (TRUE).
5) Restart PXI and FPGA processes.
   → The USER_PERMITs stay TRUE.
   → The collimator application and the DCS see the RP status and positions.
   → The motors can still not be reset or moved since motor power is still off.
6) Turn BYPASS off and re-enable the motors.
   → The USER_PERMITs stay TRUE.
7) Reset motors and move some RPs towards the beam.

5.3 TEST 3 (THE HOLIDAY MODE)

1) All pots are in garage (at the HOME switch), i.e. INJECTION_PERMIT is TRUE.
2) ***Before leaving for holidays***: Turn BYPASS on.
   → The USER_PERMITs stay TRUE.
   → The RP motors are disabled; the springs pull the RPs further out to the stopper (which is within the HOME range, i.e. INJECTION_PERMIT = TRUE).
   → The collimator application and the DCS see the RP status (*Unconfigured*) and positions.
   → Attempts to reset the motors or to move pots fail.
3) ***Upon returning from holidays***: Turn BYPASS off and re-enable the motors.
   → The USER_PERMITs stay TRUE.
   → The RPs can be reset and moved again.

5.4 TEST 4 (WHEN THE CCC CALLS IN THE NIGHT – FAILURE WHILE ALFA IS IN STANDBY)

1) All pots are in garage (at the HOME switch), i.e. INJECTION_PERMIT is TRUE.
2) ***Simulate failure***: switch the PXI crate with the FPGAs off.
   → This removes the USER_PERMITs for both beams.
   → The collimator application is blind to RP status and positions.
   → The DCS is blind to RP status and positions.
   → The RPs are known to be at HOME because INJECTION_PERMIT stays TRUE.
3) ***Remedy to re-enable beam operation***: Turn BYPASS on.
   → This re-establishes the USER_PERMITs and disables the RP motors.
   → The collimator application and the DCS are still blind to RP status and positions.
   → All attempts to reset the motors or to move pots fail.
4) ***Recovery after repairs***: Restart PXI crate and FPGA processes.
   → No interlock reaction because bypass is active.
   → The collimator application and the DCS see RP status and positions.
   → All attempts to reset the motors or to move pots still fail because motor power is still forced off.
5) ***Back to normal***: Turn BYPASS off and re-enable the motors.
   → The USER_PERMITs stay TRUE.
   → The RPs can be reset and moved again.

6. TEST OF HARDWARE AND SOFTWARE BUTTONS

6.1 EXTRACTION BY DCS

Each Roman Pot was moved out of HOME position and then extracted by ATLAS DCS. This test was successfully performed on 16 March 2015 [5]. ALFA also has a global "Extract all" bottom which also was tested successfully.

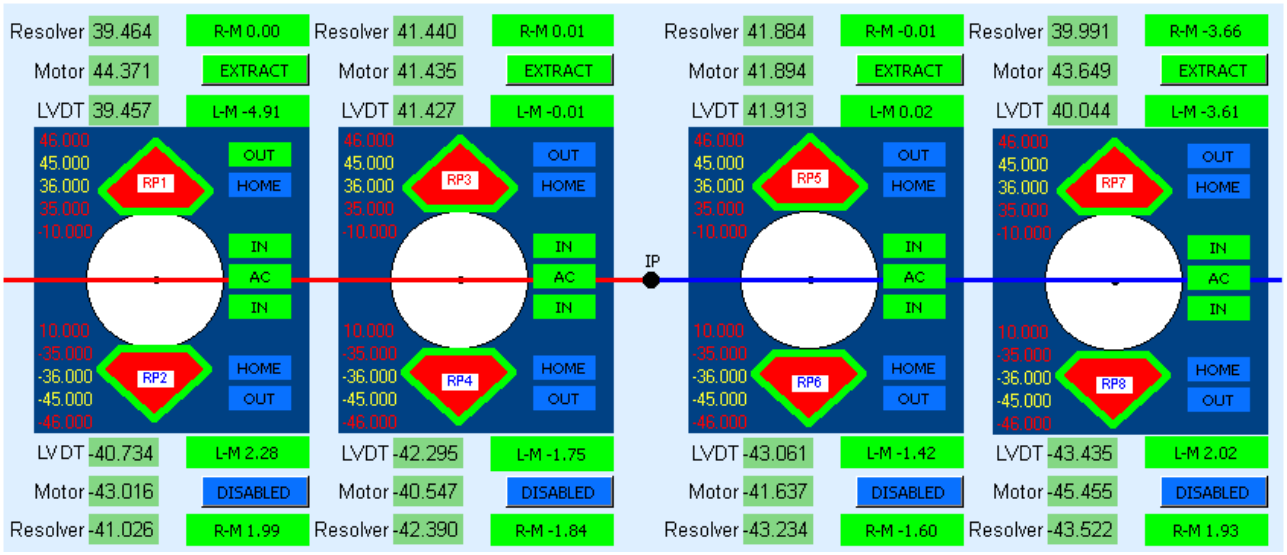


Figure 6. ATLAS DCS for ALFA Roman Pots showing the extraction and disabling buttons.

6.2 DISABLING BY DCS

When a Roman Pot station is in state “Unconfigured”, it is possible to disable the station from DCS. This is done by excluding the Roman Pot from communication from the top level. The feature was successfully tested on 22/05-2015 [6]. Figure 7 shows the collimator status display. The turquoise color indicates that the ALFA Roman Pots are disabled.

Figure 7. Collimator status display for Roman Pots with the ALFA Roman Pots disabled.

6.3 EMERGENCY EXTRACTION BY HARDWARE BUTTON

This test was done on 16 March 2015 at 17:42 [5]:

1) Move some RPs towards the beam.
2) Push the emergency extraction hardware button in the ATLAS control room.
   → All RPs are extracted and their motors disabled.
   → This is visible in the collimator application and in the DCS.
   → The USER_PERMITs stay TRUE.
   → The INJECTION_PERMIT becomes TRUE due to the extraction.
3) Before resetting or moving RPs the motor power has to be re-enabled at a panel in the ATLAS control room.

7. CONCLUSION

For all tested situations and input combinations, the output signals of the ATLAS-ALFA interlock card correspond to the specifications.

The tests were factorised in two stages:

- Each individual Roman Pot was shown to remove the INJECTION_PERMITs (Section 2) and the USER_PERMITs (Section 3) when it was either in a state or in a position incompatible with these permits.
- All combinations of external situations and flags (SMP flags, OVERRIDE1) and the global Roman Pot situation (ALL_LVDT_OK, ALL_RP_HOME) were tested in a sample Roman Pot per beam (Section 4).

The functionalities of the LVDT bypass box (Section 5) and the hardware emergency extraction button (Section 6.3) have been shown to be according to the specifications.

The emergency extraction of Roman Pots by DCS software was shown to be functional (Section 6.1).

REFERENCES

[1] Functional Specification and Test Report THE ATLAS-ALFA INTERLOCK LOGIC IN 2012: SPECIFICATION AND TEST RESULTS, EDMS 1205861 v.1, ATLAS Project Document Number ATL-UR-ER-0002 14 June 2012.

[2] The Movement Control of the TOTEM and ALFA Roman Pots – Revision 2012, EDMS 1203969.

[3] LHC OP e-log entry: 18-06-2015 Afternoon.

[4] LHC OP e-log entry: 17-03-2015 Morning.

[5] LHC OP e-log entry: 16-03-2013 Afternoon.

[6] LHC OP e-log entry: 22-05-2013 Afternoon.