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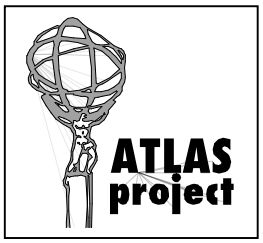

Date: 23 March 2023

Functional Specification and Test Report

THE ATLAS ROMAN POTS INTERLOCK LOGIC IN 2023: TEST RESULTS

Abstract

This document summarizes the Beam Interlock System (BIS) tests performed on the ATLAS-ALFA and ATLAS-AFP interlock system in March 2023. After the March's validation, both detectors were ready to take part (be inserted) during the pilot beam (April 2023). A full set of tests was done to qualify ALFA and AFP movement system to be ready for LHC Run 3 data-taking in 2023.

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History of Changes

Version	***Date***	***Comments or Description of Changes***
0.1	23-03-2023	First version containing March tests prepared by M. Trzebinski and B. Dziedzic

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1. INTRODUCTION

ATLAS-AFP interlock logic is based on ATLAS-ALFA (see [1], [2] and [3]). During LS2 the logic was not changed, thus its validation remained the same as during Run 2 (see [4], [5] and [6]). AFP movement system is kept the same as during Run 2. Due to update to newer LabView version, minor changes were done to PXI software (S. Ravat). Motors and switches were tested during survey in September 2021 and February 2023. Station was tested to retract via springs ("emergency retraction") to HOME position in a full range between "just outside HOME switch" to ~1 mm from the beam center. Mechanical switches and electrical stoppers were tested as well.

In this report the following naming condition will be used:

- A FAR: 12-217-F-H, XRPH.B6L1.B2,
- A NEAR: 12-205-N-H, XRPH.A6L1.B2,
- C NEAR: 12-205-N-H, XRPH.A6R1.B1,
- C FAR: 12-217-F-H, XRPH.B6R1.B1.

ATLAS-ALFA movement system was not changed during LS2. Due to update to newer LabView version, minor changes were done to PXI software (S. Ravat). Motors and switches were tested during the survey in November 2021 and February 2023. Stations were tested to retract via springs ("emergency retraction") to HOME position in a full range between "just outside HOME switch" to ~1 mm from the beam center. Mechanical switches and electrical stoppers were tested as well.

In this report the following naming condition will be used:

- RP1: XRPV.B7L1.B2 LU
- RP2: XRPV.B7L1.B2 RU
- RP3: XRPV.A7L1.B2 LU
- RP4: XRPV.A7L1.B2 RU
- RP5: XRPV.A7R1.B1 LU
- RP6: XRPV.A7R1.B1 RU
- RP7: XRPV.B7R1.B1 LU
- RP8: XRPV.B7R1.B1 RU

Interlock system was validated based on set of tests described in details in [5].

2. TEST OF THE INJECTION PERMIT

It was checked that 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). Test is described in details in Ref. [5] section 2.

For AFP tests were done on 08/03/2023.

- A FAR at 14:44,
- A NEAR at 14:43,
- C NEAR at 14:45,
- C FAR at 14:53.

Tests for ALFA were done on 08/03/2023:

- RP1 at 15:00,
- RP2 at 15:01,
- RP3 at 15:02,
- RP4 at 15:03,

- RP5 at 15:04, - RP6 at 15:05,
- RP7 at 15:06, - RP8 at 15:08.

Due to the latter LVDT calibration of the B7L1, the test was repeated on 18/03/2023:

- RP1 at 18:40, - RP2 at 18:41,

For each pot it was checked that ATLAS INJECTION_PERMIT is lost when pot is moved outside HOME position and restored once HOME is reached.

Loss and restoration of user permit was also randomly checked during other tests described in this document. **No failure was observed.**

3. TEST OF THE RESPONSE TO THE LVDT-TO-LIMITS COMPARISON

In this test the proper reaction of pot (retraction in case of validation of warning and/or dump limit) and change of USER_PERMIT (going false in case of violation of dump limit, staying true otherwise) was tested. Following Ref. [5] section 3, test was composed of 2 parts:

a) test of inner dump limit,

b) test of inner warning limit.

For both ALFA and AFP the Test was done on 18/03/2023. Results are summarized in Table 1 and Table 2 for ALFA and AFP, respectively.

a. Test of inner dump limits for upper ALFA Roman Pots:

- set outer dump limit > outer warning limit > OUT switch, typically:
  outer dump = 50 mm,
  outer warning = 49 mm
- set inner dump = -5 mm,
  inner warning = -4 mm
- move pot to 30 mm
- set inner limits > 30 mm:
  inner dump = 31 mm,
  inner warning = 32 mm

Observe the immediate interlock reaction ("permit lost/restored" 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.

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.

b. Test of warning limits for upper ALFA Roman Pots:

- set outer dump limit > outer warning limit > OUT switch, typically:
  outer dump = 50 mm,
  outer warning = 49 mm
- set inner dump = -5 mm,
  inner warning = -4 mm
- move pot to 30 mm
- set inner warning = 32 mm

Observe the immediate interlock does not react ("permit lost/restored" in the table): USER_PERMIT(Bi)=1 for the beam concerned while USER_PERMIT(Bi')=1 for the other beam.

Verify that the Roman Pot is automatically extracted and that the USER_PERMIT stays at 1.

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 inner dump limits for upper AFP Roman Pots:

- set outer dump limit > outer warning limit > OUT switch, typically:
  outer dump = 49 mm,
  outer warning = 44 mm
- set inner dump = -5 mm,
  inner warning = -3.5 mm
- move pot to 30 mm
- set inner limits > 30 mm:
  inner dump = 35 mm,
  inner warning = 36 mm

Observe the immediate interlock reaction ("permit lost/restored" 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.

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.

b. Test of inner warning limits for AFP Roman Pots:

- set outer dump limit > outer warning limit > OUT switch, typically:
  outer dump = 49 mm,
  outer warning = 44 mm
- set inner dump = -5 mm,
  inner warning = -3.5 mm
- move pot to 30 mm
- set inner limits > 30 mm:
  inner dump = 32 mm,
  inner warning = 31 mm

Observe the immediate interlock does not react ("permit lost/restored" in the table): USER_PERMIT(Bi)=1 for the beam concerned while USER_PERMIT(Bi')=1 for the other beam.

Verify that the Roman Pot is automatically extracted and that the USER_PERMIT stays at 1.

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.

Table 4. Result of ALFA LVDT-to-limits comparison test done on 18/03/2023.

	part a)			**part b)**		
	time	extraction to HOME	permit lost/restored	time	extraction to HOME	permit lost
RP 1&2	18:59	yes	yes/yes	19:15	yes	no
RP 3&4	19:20	yes	yes/yes	19:24	yes	no
RP 5&6	19:27	yes	yes/yes	19:30	yes	no
RP 7&8	19:33	yes	yes/yes	19:36	yes	No

Table 2. Result of AFP LVDT-to-limits comparison test done on 18/03/2023. Each time warning and/or dump limit is violated pot should be extracted to HOME position. USER_PERMIT loss (resulting in a beam dump) should only be observed in case of dump limit violation.

	part a)			**part b)**		
	time	extraction to HOME	permit lost/restored	time	extraction to HOME	permit lost
A FAR	20:17	yes	yes/yes	20:22	yes	no
A NEAR	20:29	yes	yes/yes	20:34	yes	no
C NEAR	20:40	yes	yes/yes	20:48	yes	no
C FAR	20:51	yes	yes/yes	20:54	yes	no

Observation of USER_PERMIT changing from true to false (and vice versa) was done using BIS history file. For each pot it was checked that USER_PERMIT on the other beam is not affected. It was also checked that each time pot is extracted to HOME position and after reaching it the USER_PERMIT is restored. Similarly to previous tests (cf. Ref. [4-6]), the effect of "ringing" was observed.

No unexpected behavior was observed.

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

Correct behavior of pots (extraction, loss/no loss of USER_PERMIT) was also tested as a function of various beam modes and state of override key. The test is based on the one described in Ref. [5] section 4, with exception of UNSTABLE_BEAMS mode (state deprecated for Run 3). As there were no changes in the LHC interlock system concerning input flags in comparison to the previous BIS test [7] **the test was omitted.**

5. TEST OF THE LVDT BYPASS BOX

As described in Ref. [5] section 5, 4 tests for AFP were performed 8th of March:

1) *failure during the AFP run* at 15:34,
2) *the forbidden use case* at 16:20,
3) *the holiday mode* at 16:48,
4) *failure when AFP is in STANDBY* at 16:57.

Tests for ALFA were performed 8th of March:

1) *failure during the ALFA run* at 16:15,
2) *the forbidden use case* at 16:33,
3) *the holiday mode* at 16:43,
4) *failure when ALFA is in STANDBY* at 17:04.

In all cases system reacted as expected. **No failure was observed.**

6. TEST OF HARDWARE AND SOFTWARE BUTTONS

This part contains two tests (see Ref. [5] section 6 for details):

a) *extraction by DCS* tested:

- for AFP on 08/03/2023:
    - A FAR at 17:41,
    - A NEAR at 17:42,
    - C NEAR at 17:43,
    - C FAR at 17:44.
- for **ALFA failed** due to lack of communication with older type of PXI crate.

b) *emergency extraction by hardware button* tested:

- for AFP at 17:56,
- for ALFA at 17:52.

Extraction by DCS for **AFP reacted as expected**, for **ALFA failed**.

In case of emergency extraction by hardware button both systems reacted as expected. **No failure was observed.**

7. CONCLUSION

For all tested situations and input combinations, behavior of the ATLAS-AFP and ATLAS-ALFA interlocks was as expected. Therefore, both AFP and ALFA are ready to take part (be inserted) during the LHC Run 3 data taking. These tests are valid as long as there are no hardware nor software changes in the movement systems.

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] Functional Specification and Test Report THE ATLAS-ALFA INTERLOCK LOGIC IN 2016: SPECIFICATION AND TEST RESULTS, EDMS 1607453.

[4] Specification and Validation of the Motion Control System of the ATLAS Forward Proton Roman Pots, EDMS 1608103.

[5] Functional Specification and Test Report THE ATLAS-AFP INTERLOCK LOGIC IN 2017: SPECIFICATION AND TEST RESULTS, EDMS 1808750.

[6] ATLAS-AFP Interlock Logic in 2018: Additional Test Results after TS1-2018, EDMS 1996432.

[7] The ATLAS Roman Pots Interlock Logic in 2022: Test results, EDMS 2729054.