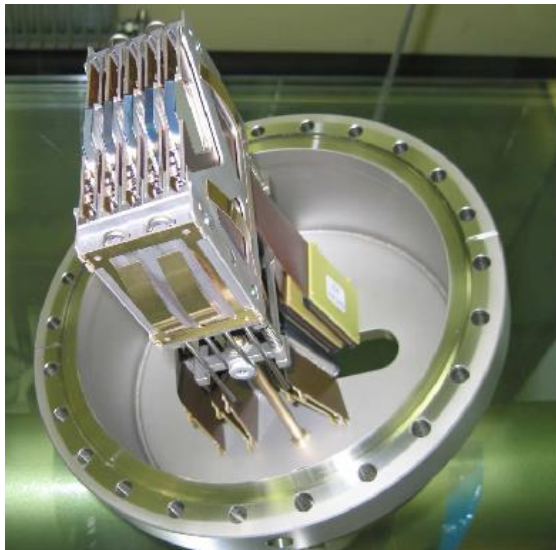


Follow-Up on the ALFA and TOTEM Roman Pot Movement System Review

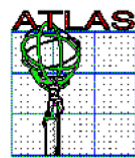
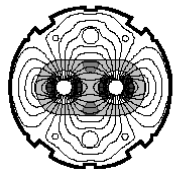


Mario Deile
for the
TOTEM and ALFA Teams
with special thanks to the collimation team

9 March 2012



CERN
CH-1211 Geneva 23
Switzerland



Project Document No.

CERN Div./Group or Supplier/Contractor Document No.

PH/TOT, PH/ADO

EDMS Document No.
1203969 v.0.4a

Date: 2012-03-08

Functional Specification and Test Report

THE MOVEMENT CONTROL OF THE TOTEM AND ALFA ROMAN POTS – REVISION 2012 –

Abstract

This note describes the modifications of the ALFA and TOTEM Roman Pot movement control system and of the related position interlock logic during the winter Technical Stop 2011/2012.
The re-commissioning procedure and test results are also reported.

To be circulated soon.

Prepared by:

**M. Deile
P. Fassnacht
S. Jakobsen
X. Pons
S. Ravat
F. Ravotti**

Checked by:

**R. Assmann
J. Baechler
K. Hiller
F. Lucas Rodriguez
S. Redaelli
D. Wollmann**

Approved by:

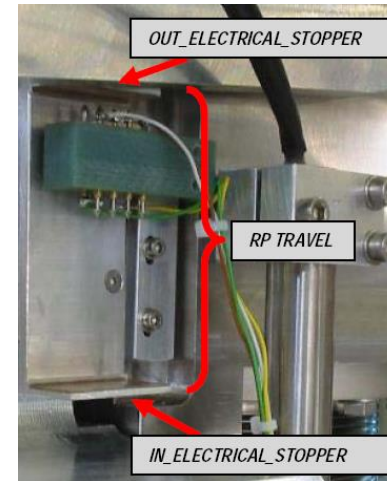
**R. Schmidt
J. Wenninger
M. Zerlauth**

The Problems

1. Failures of the Motor Step Counter Reset Procedure

spontaneous movement stops during the search for the OUT stopper's on-off transition point caused by:

- interference between the OUT and the IN stopper,
- electrical sparks in the on-off transition region giving a fake trigger for stopping the search movement



(mechanical reference)

2. Interlock logic: RP extraction when STABLE_BEAMS = 0 and OVERRIDE = 0 even if pots were already at HOME

- unnecessary for safety
- leads to loss of step counter reference at each injection
- springs pull the pots permanently against the end stoppers → mechanical stress

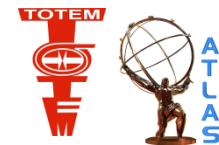
3. Lessons from the November 2011 event (ALFA)

- Spring extraction from HOME position when the OVERRIDE key was turned off (see #2.)
- Execution of a pot movement without valid step counter calibration
- Movement failure of a pot (see #1)
- Reset procedure started from a position other than HOME
- Reset of the step counter although pot not arrived at the OUT stopper

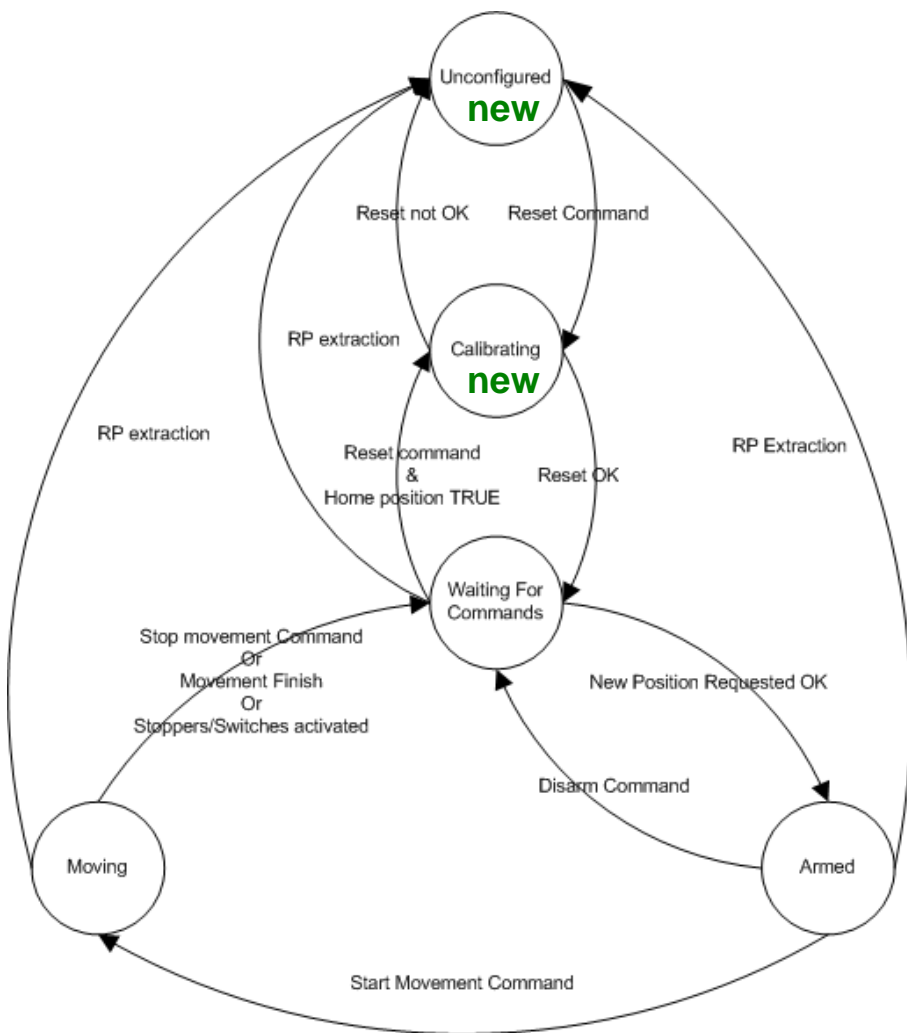
4. Operation Deadlock due to Hardware Fault (TOTEM FESA FEC)

Impossible to give USER_PERMIT when LVDT position evaluation in FPGA cannot be re-established

The Solutions (1)



1. The Modified FSM



Tests on 5 March:

TOTEM:

LHC COLL logbook: <https://ab-dep-op-elogbook.web.cern.ch/ab-dep-op-elogbook/elogbook/secure/eLogbook.php?shiftId=1042132> ,
16:08 - 16:44.

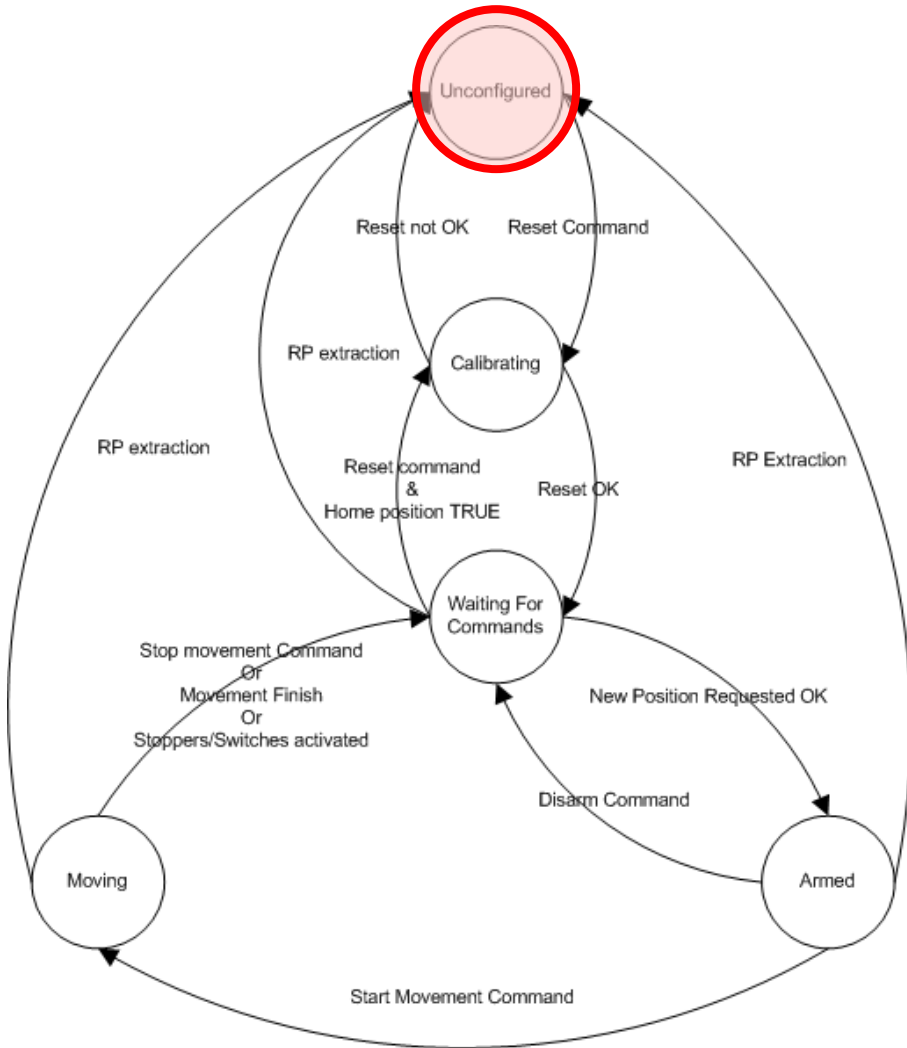
ALFA:

LHC OP logbook: <https://ab-dep-op-elogbook.web.cern.ch/ab-dep-op-elogbook/elogbook/secure/eLogbook.php?shiftId=1042142>

The Solutions (1)



1. The Modified FSM



Test Sequence (TOTEM example)

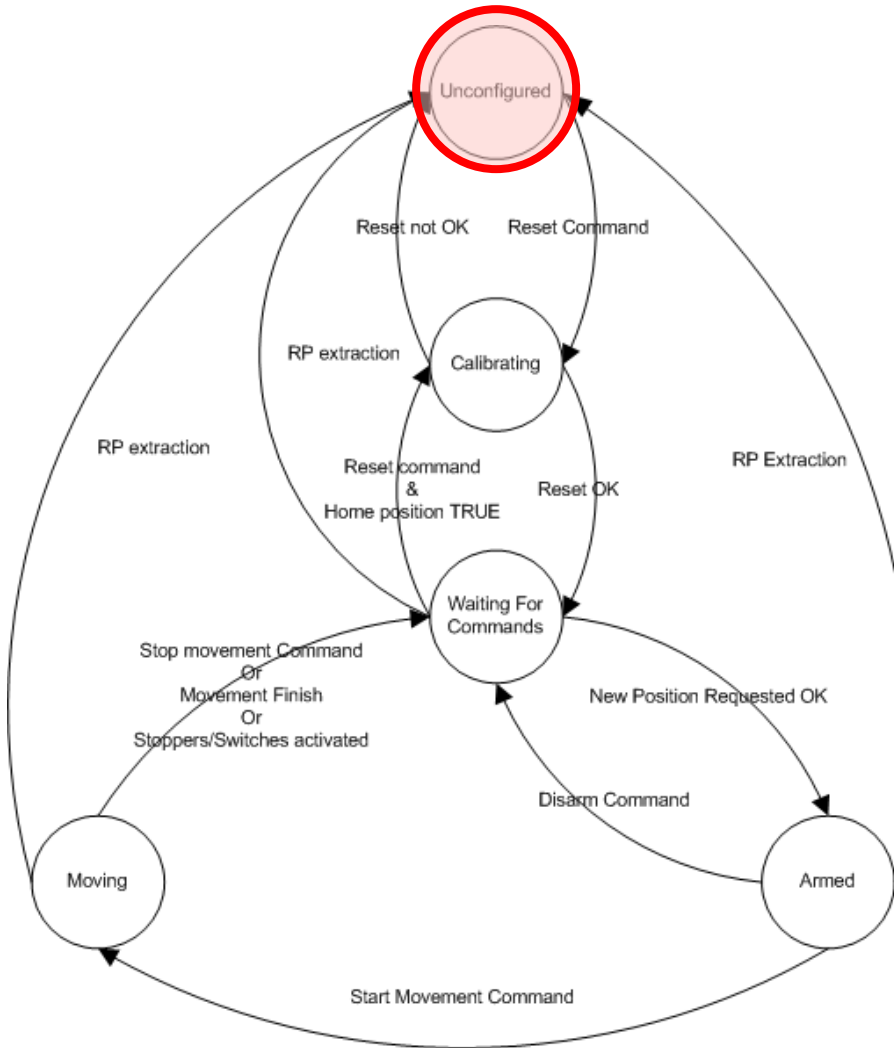
All RPs *Unconfigured*, OUT Stopper warning

Collimator	Status	Collimator	Status
XRPH.B4L5.B2 ->	MDC	XRPV.B4L5.B2 ->	MDC
XRPH.A4L5.B2 ->	MDC	XRPV.A4L5.B2 ->	MDC
XRPH.B6L5.B2 ->	MDC	XRPV.B6L5.B2 ->	MDC
XRPH.A6L5.B2 ->	MDC	XRPV.A6L5.B2 ->	MDC
XRPH.B4R5.B1 ->	MDC	XRPV.B4R5.B1 ->	MDC
XRPH.A4R5.B1 ->	MDC	XRPV.A4R5.B1 ->	MDC
XRPH.B6R5.B1 ->	MDC	XRPV.B6R5.B1 ->	MDC
XRPH.A6R5.B1 ->	MDC	XRPV.A6R5.B1 ->	MDC
RPH.21.TEST ->	MDC PRS	RPV.21.TEST ->	MDC PRS
XRPV.A7L1.B2 ->	MDC	XRPV.A7R1.B1 ->	MDC
XRPV.B7L1.B2 ->	MDC	XRPV.B7R1.B1 ->	MDC

1. The Modified FSM

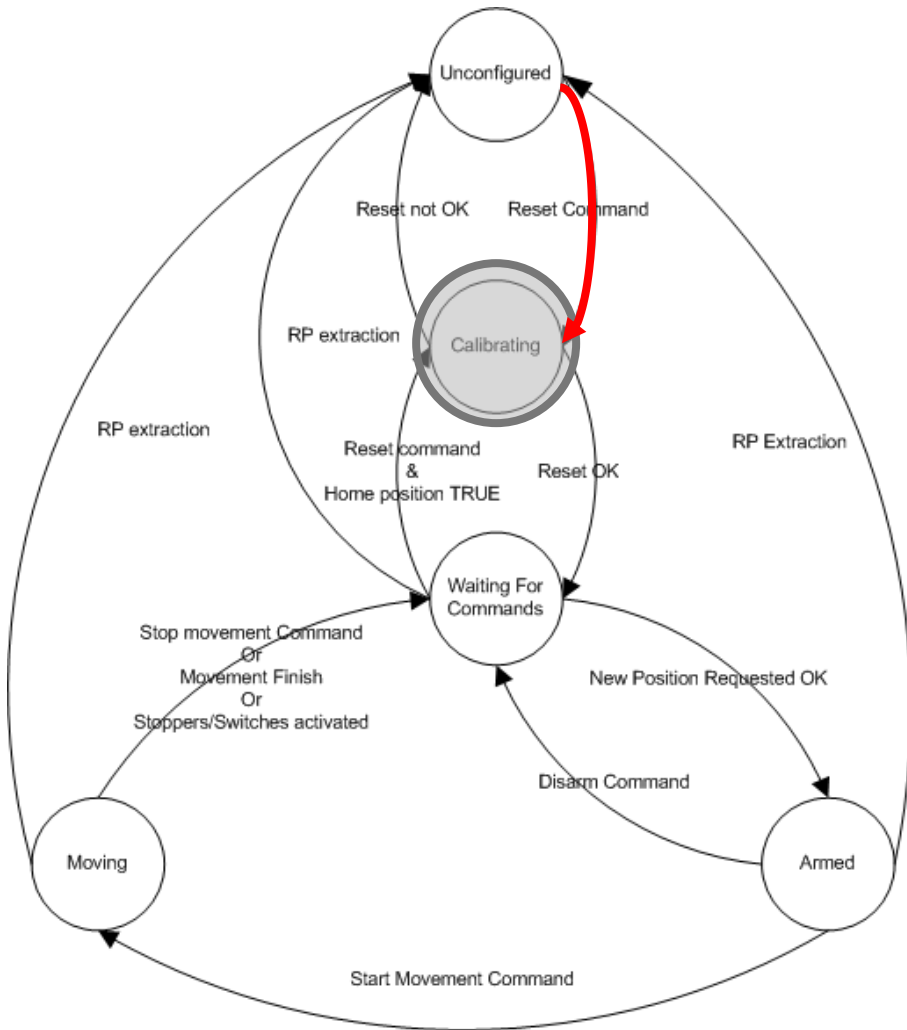
Test Sequence (TOTEM example)

Try to move XRPV.B6R5.B1 without prior step counter reset.
Correctly refused with console output:



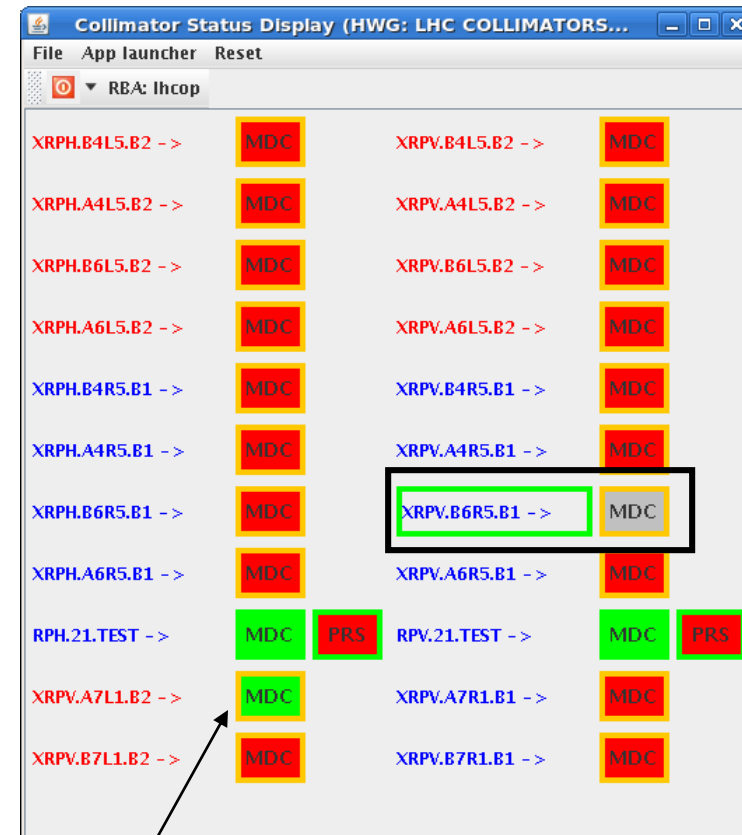
```
16:12:33 - Failed to execute the command; exception:
cern.jpac.ParameterException: The MDC is not WAITING!!
at cern.lhc.app.collimators.setting.jpac.DiscreteAbsolutePositionSettings.setDiscreteAbsPosition(DiscreteAbsolutePositionSettings.java:368)
at cern.lhc.app.collimators.setting.jpac.DiscreteAbsolutePositionSettings.setDiscreteAbsPosition(DiscreteAbsolutePositionSettings.java:327)
at cern.lhc.app.collimators.LHCCollimatorController.sendAbsoluteSettings(LHCCollimatorController.java:2725)
at cern.lhc.app.collimators.LHCCollimatorController.access$3000(LHCCollimatorController.java:100)
at cern.lhc.app.collimators.LHCCollimatorController$ApplyMotor.actionPerformed(LHCCollimatorController.java:1480)
at javax.swing.AbstractButton.fireActionPerformed(AbstractButton.java:1995)
at javax.swing.DefaultButtonModel.fireActionPerformed(DefaultButtonModel.java:2318)
at javax.swing.DefaultButtonModel.setPressed(DefaultButtonModel.java:242)
at javax.swing.plaf.basic.BasicButtonListener.mouseReleased(BasicButtonListener.java:236)
at java.awt.Component.processMouseEvent(Component.java:6290)
at java.awt.swing.JComponent.processMouseEvent(JComponent.java:3267)
at java.awt.Component.processEvent(Component.java:6055)
at java.awt.Container.processEvent(Container.java:2039)
at java.awt.Component.dispatchEventImpl(Component.java:4653)
at java.awt.Container.dispatchEventImpl(Container.java:2097)
at java.awt.Component.dispatchEvent(Component.java:4481)
at java.awt.LightweightDispatcher.retargetMouseEvent(Container.java:4575)
at java.awt.LightweightDispatcher.processMouseEvent(Container.java:4236)
at java.awt.LightweightDispatcher.dispatchEvent(Container.java:4166)
at java.awt.Container.dispatchEventImpl(Container.java:2083)
at java.awt.Window.dispatchEventImpl(Window.java:2482)
at java.awt.Component.dispatchEvent(Component.java:4481)
at java.awt.EventQueue.dispatchEventImpl(EventQueue.java:648)
at java.awt.EventQueue.access$000(EventQueue.java:84)
at java.awt.EventQueue$1.run(EventQueue.java:607)
at java.awt.EventQueue$1.run(EventQueue.java:605)
at java.security.AccessController.doPrivileged(Native Method)
at java.security.AccessControlContext$1.doIntersectionPrivilege(AccessControlContext.java:87)
at java.security.AccessControlContext$1.doIntersectionPrivilege(AccessControlContext.java:98)
at java.awt.EventQueue$2.run(EventQueue.java:621)
at java.awt.EventQueue$2.run(EventQueue.java:619)
at java.security.AccessController.doPrivileged(Native Method)
at java.security.AccessControlContext$1.doIntersectionPrivilege(AccessControlContext.java:87)
at java.awt.EventQueue.dispatchEvent(EventQueue.java:618)
at java.awt.EventDispatchThread.pumpOneEventForFilters(EventDispatchThread.java:269)
at java.awt.EventDispatchThread.pumpEventsForFilter(EventDispatchThread.java:184)
at java.awt.EventDispatchThread.pumpEventsForHierarchy(EventDispatchThread.java:174)
at java.awt.EventDispatchThread.pumpEvents(EventDispatchThread.java:169)
at java.awt.EventDispatchThread.pumpEvents(EventDispatchThread.java:161)
at java.awt.EventDispatchThread.run(EventDispatchThread.java:122)
```

1. The Modified FSM



Test Sequence (TOTEM example)

XRPV.B6R5.B1 *Calibrating*, still **OUT** Stopper warning



ALFA test at the same time

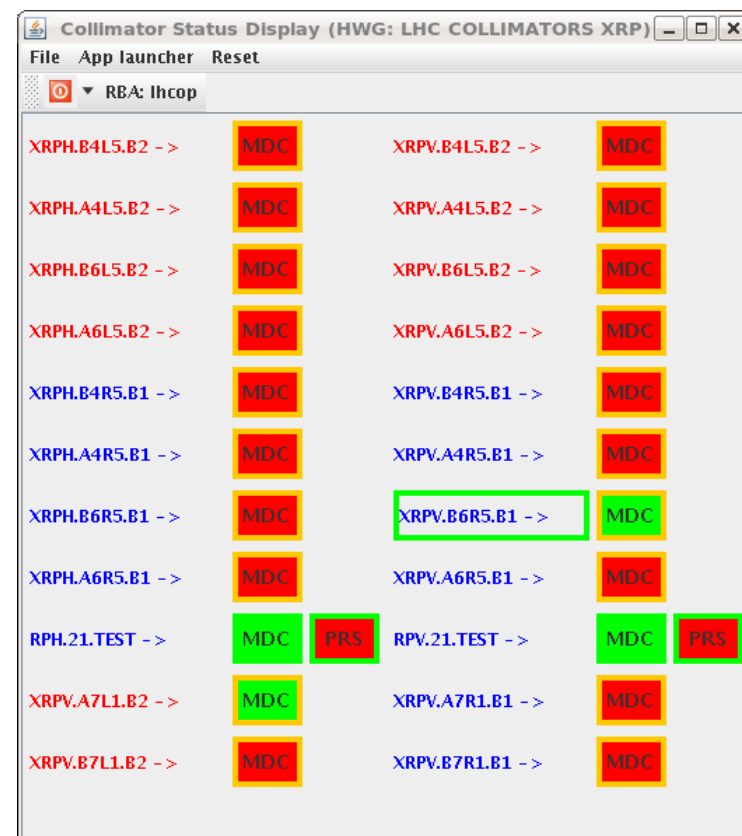
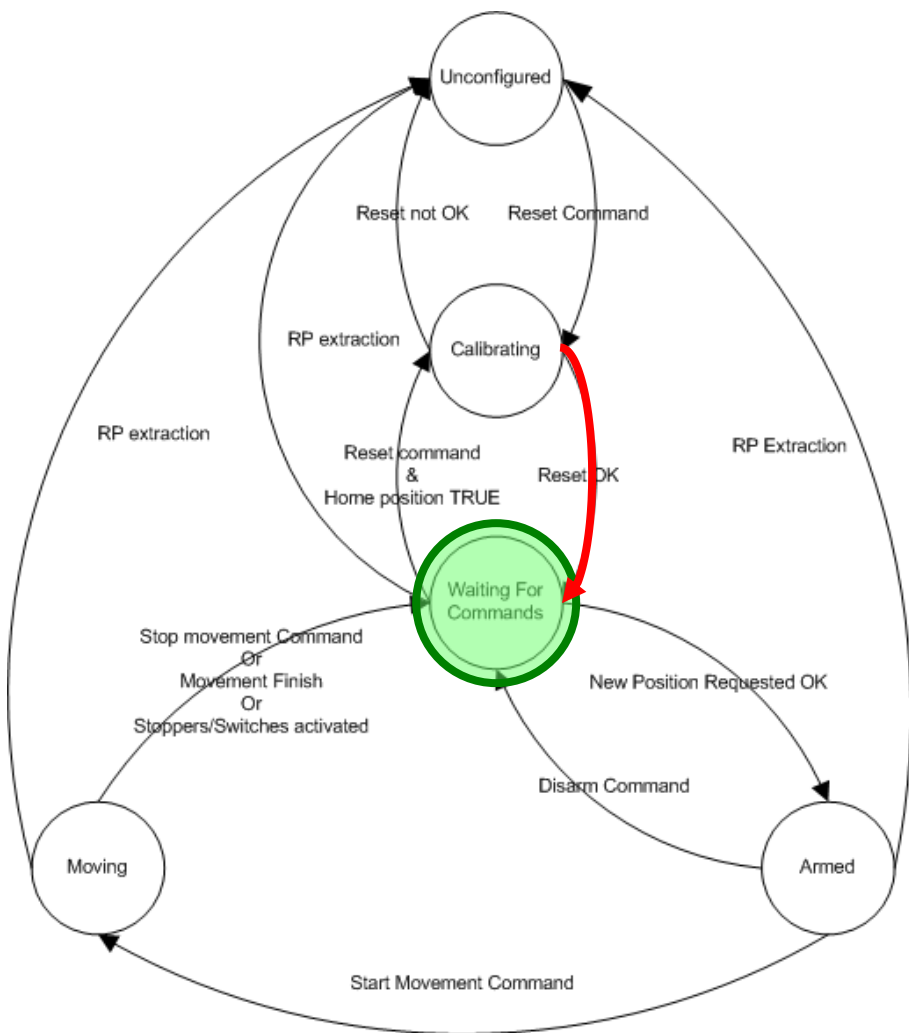
The Solutions (1)



1. The Modified FSM

Test Sequence (TOTEM example)

XRPV.B6R5.B1 *Waiting for Commands*, OUT Stopper warning



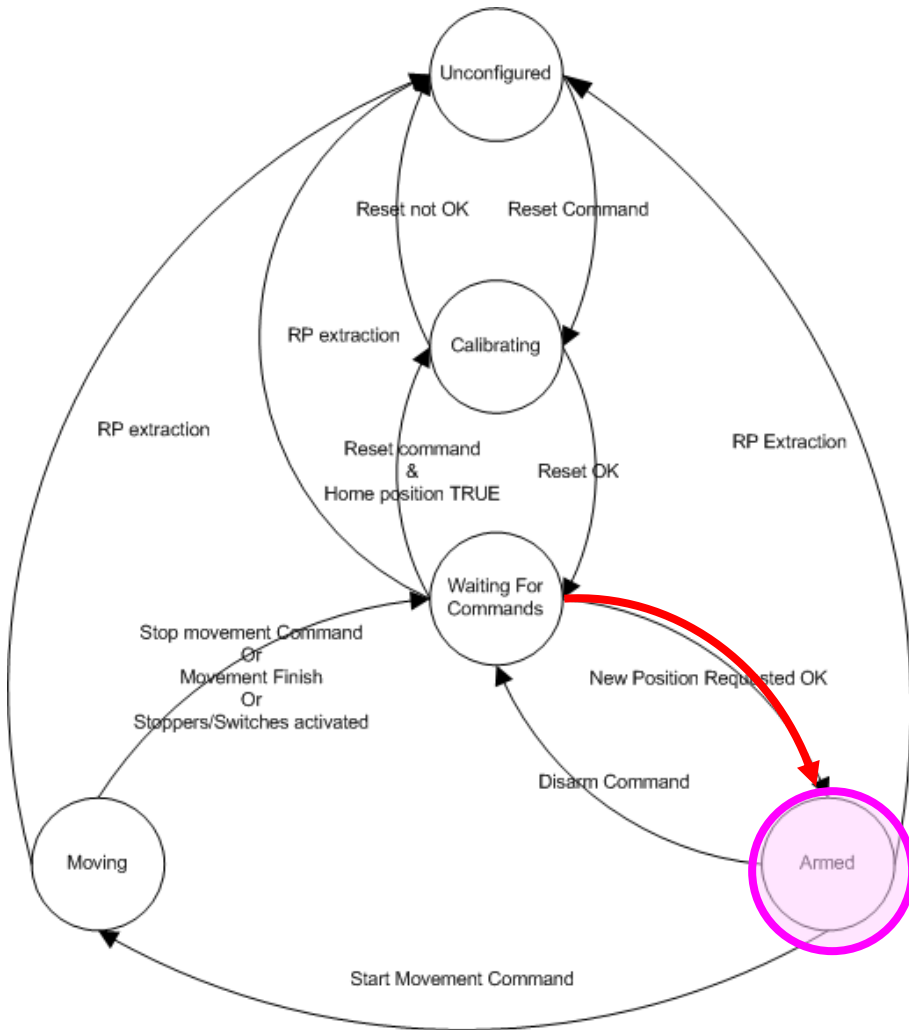
The Solutions (1)



1. The Modified FSM

Test Sequence (TOTEM example)

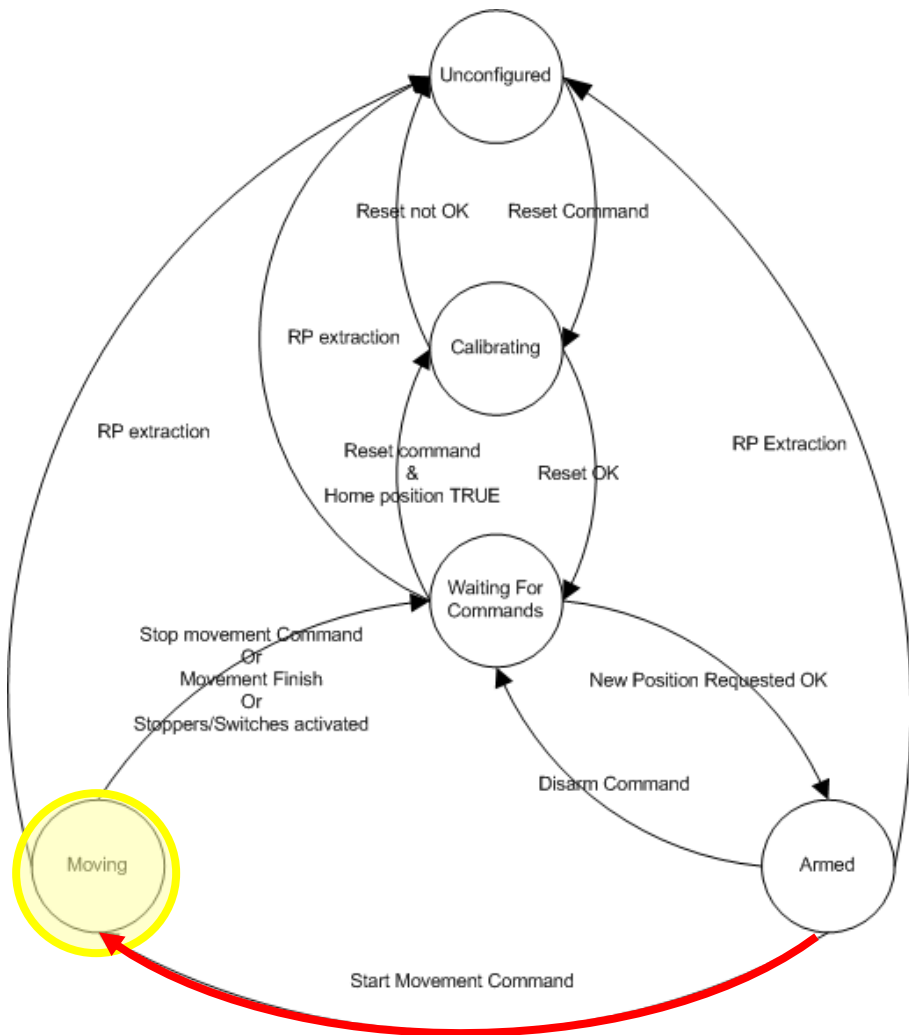
XRPV.B6R5.B1 *Armed*, OUT Stopper warning



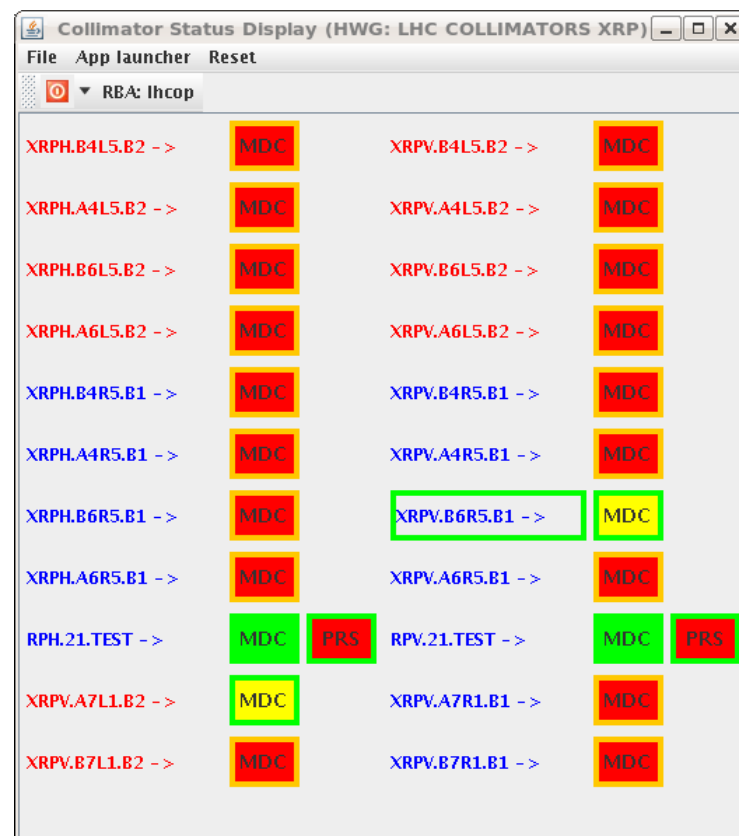
[I am too slow to catch this transitional state.]

1. The Modified FSM

Test Sequence (TOTEM example)



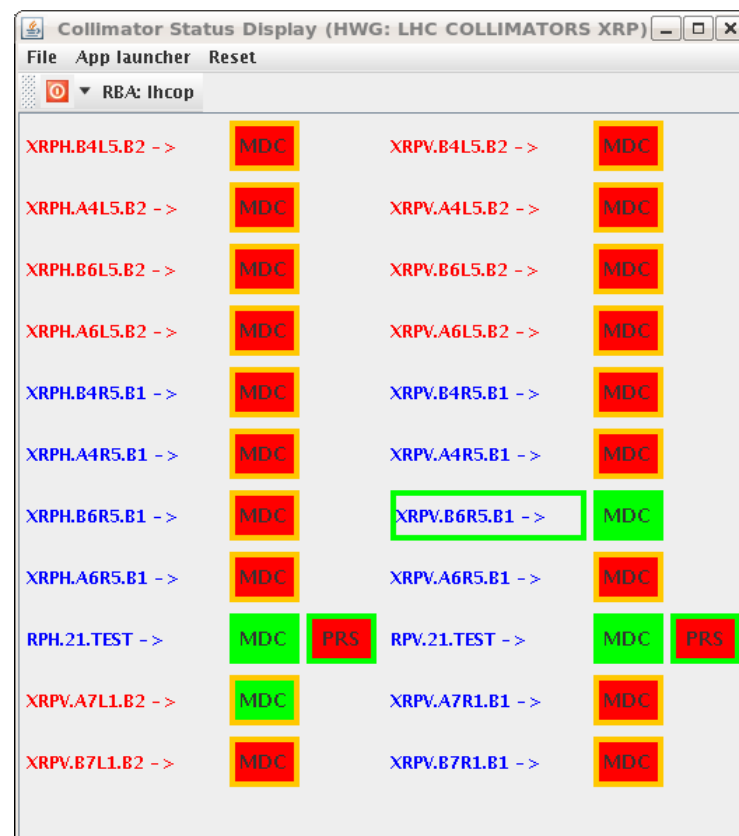
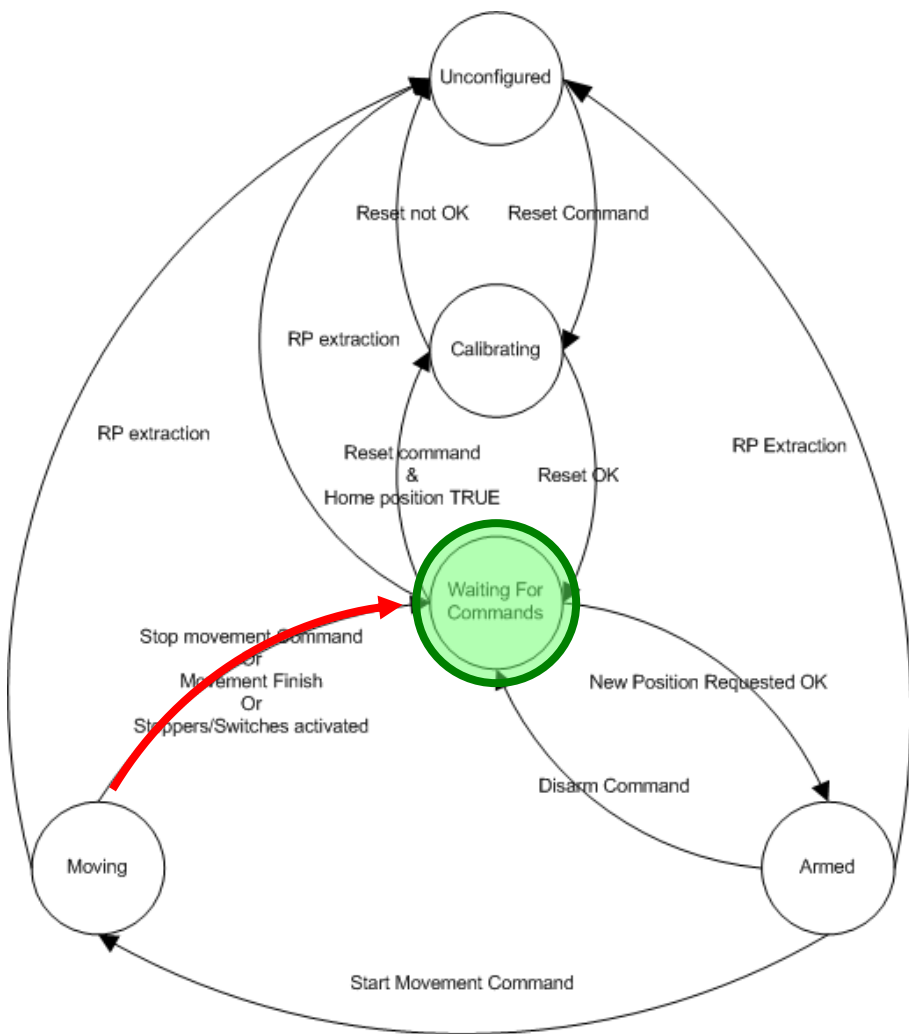
XRPV.B6R5.B1 **Moving**, no warning (OUT Stopper left)



1. The Modified FSM

Test Sequence (TOTEM example)

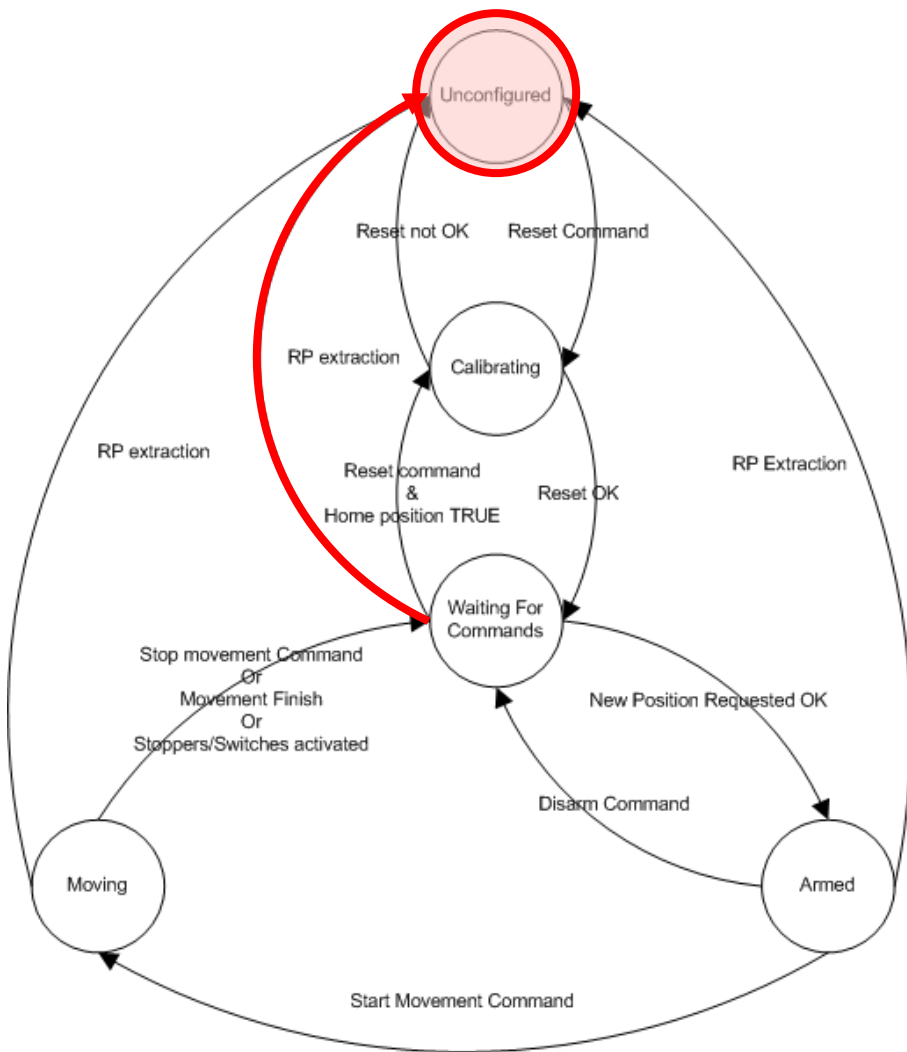
XRPV.B6R5.B1 *Waiting for Commands*, no warning



The Solutions (1)

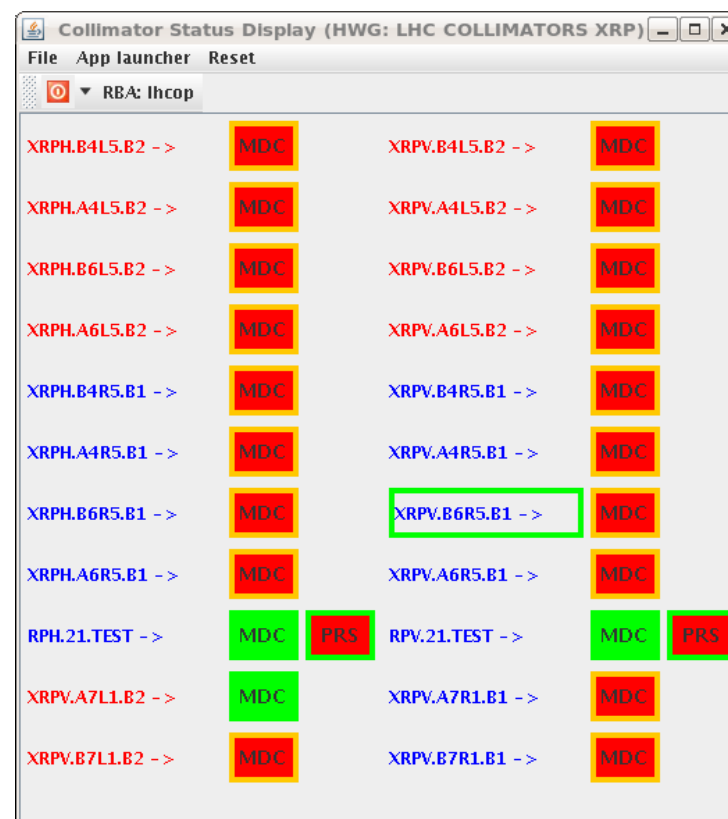


1. The Modified FSM



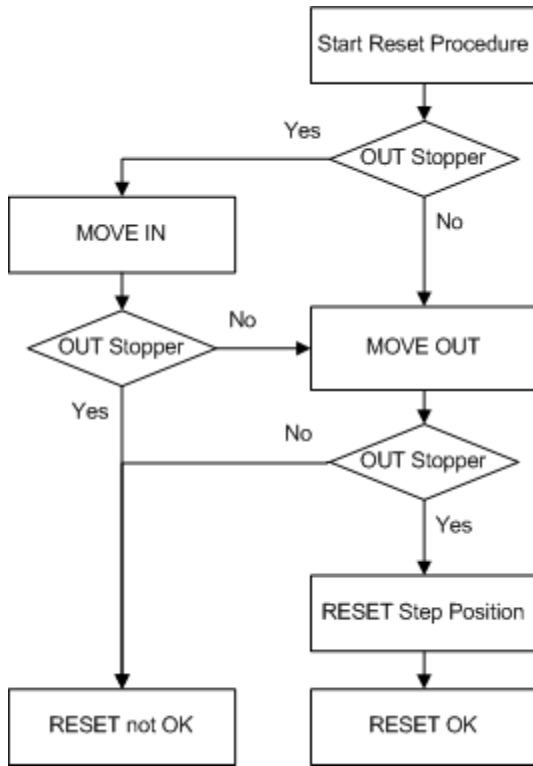
Test Sequence (TOTEM example)

Extract XRPV.B6R5.B1 with the springs
Unconfigured, OUT Stopper warning

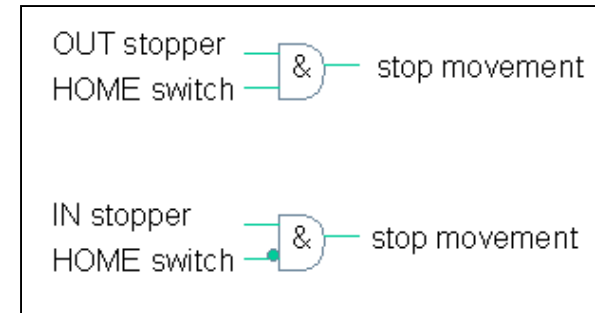


2. Improved Step Counter Reset Procedure and Redefined Electrical Stopper Actions

New flow diagram



New stopper logic to avoid IN / OUT interference



Iterative OUT Stopper search → prevent stops caused by sparks
100 ms after finding the OUT Stopper, its presence is re-verified.

If OUT Stopper not ON any more, resume movement.

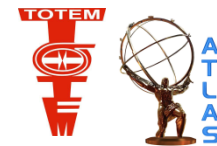
Iterate up to 5 times.

If finally OUT Stopper has been found → reset the counter

If not, go back to *Unconfigured* with error.

Counter is only reset if the OUT Stopper transition point has been found, otherwise back to *Unconfigured* with error (never observed so far)

The Solutions (2)

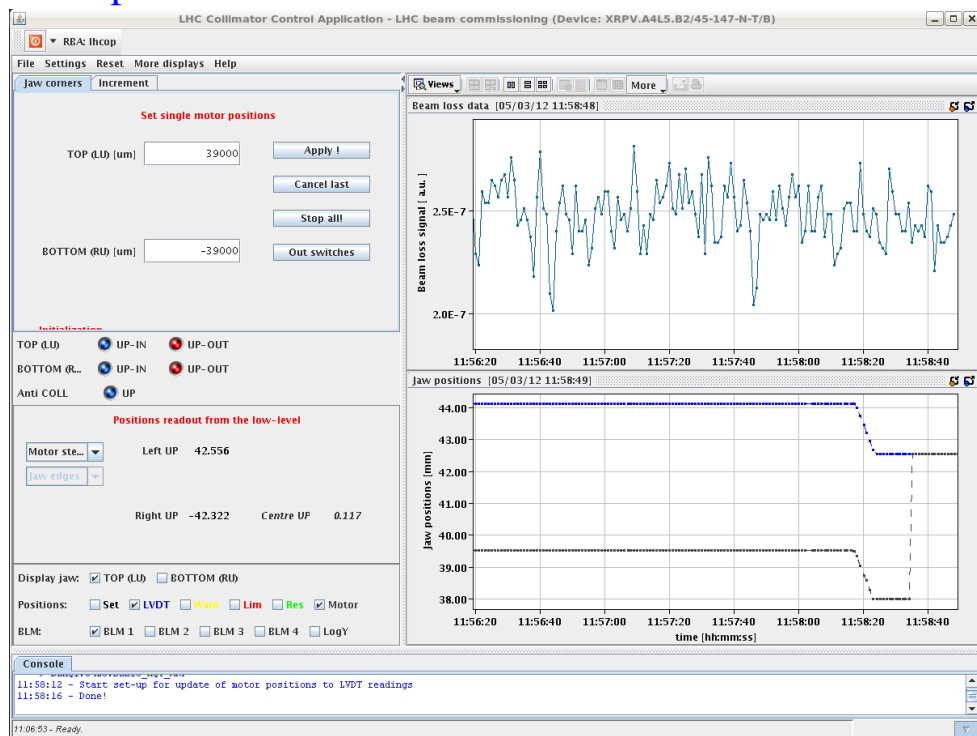


Reset procedure tested and documented:

TOTEM: 5 March

LHC COLL logbook: <https://ab-dep-op-elogbook.web.cern.ch/ab-dep-op-elogbook/elogbook/secure/eLogbook.php?shiftId=1042132>, 11:25 - 12:33.

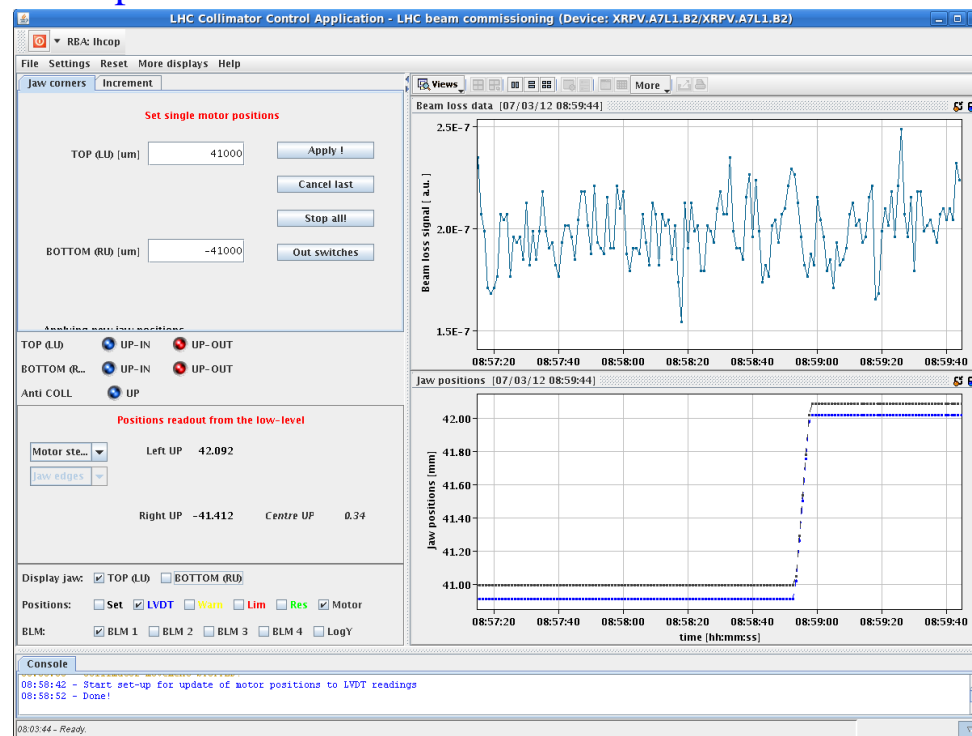
Example:



ALFA: 7 March

LHC OP logbook: <https://ab-dep-op-elogbook.web.cern.ch/ab-dep-op-elogbook/elogbook/secure/eLogbook.php?shiftId=1042191>

Example:



Up to now each TOTEM RP was reset at least 6 times.

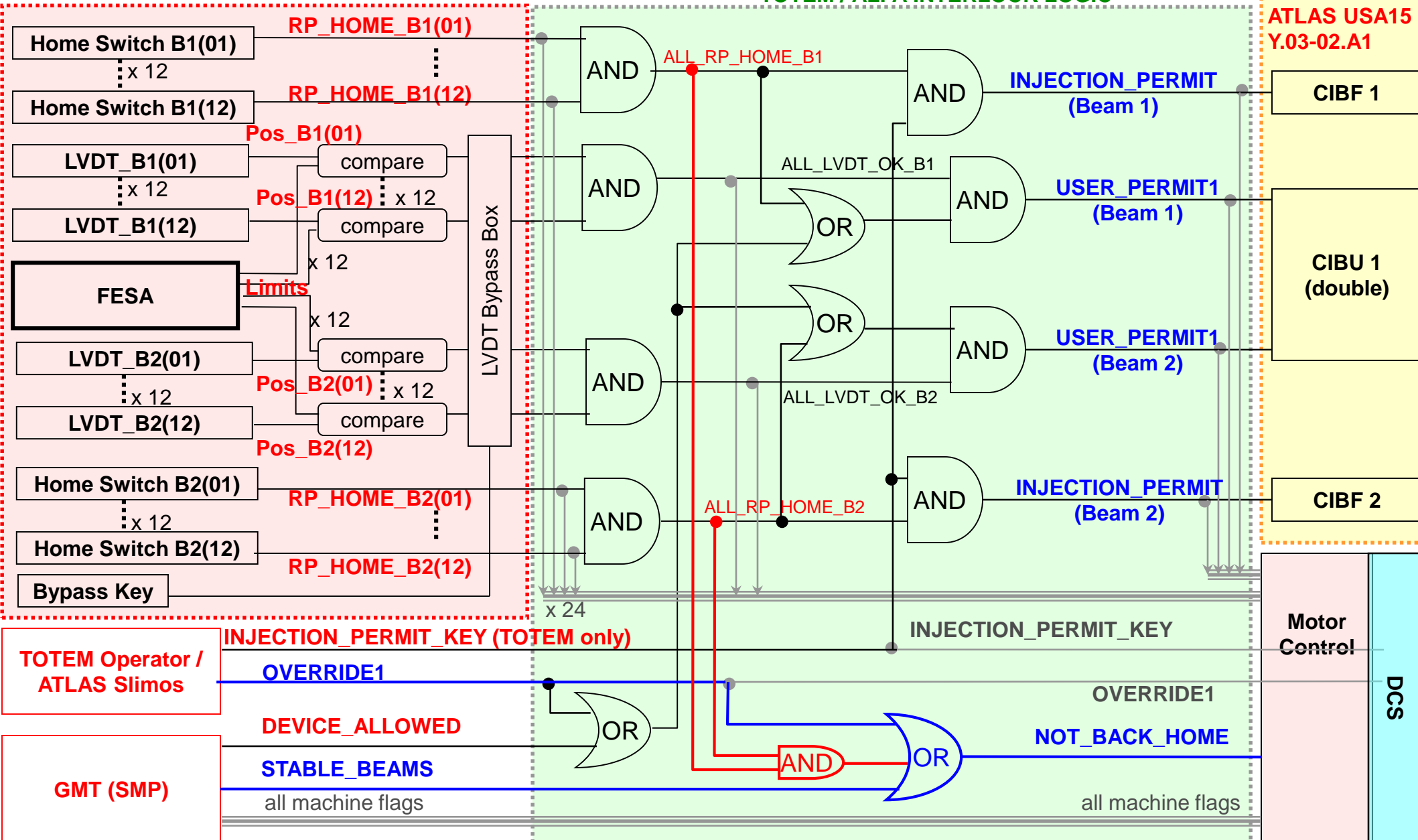
- Reset always worked at the first attempt.
- Always the correct reference position was returned.

The Solutions (3): Interlock Logic 2012

IN MOTOR CONTROL RACK

TOTEM / ALFA INTERLOCK LOGIC

CMS S1E08 /
ATLAS USA15
Y.03-02.A1



TOTEM:

New definition of NOT_BACK_HOME tested successfully on 5 March

LHC COLL logbook: <https://ab-dep-op-elogbook.web.cern.ch/ab-dep-op-elogbook/elogbook/secure/eLogbook.php?shiftId=1042132> , 18:34 – 18:42.

Test sequence:

1. Activate the OVERRIDE key.
2. Step counter reset for all RPs. Leave the pots at the OUT_STOPPER, i.e. within the HOME range.
3. Deactivate the OVERRIDE key.
4. Verify that the displayed motor positions have not changed and still correspond to the OUT stopper positions.

ALFA:

Test done on 25 January.

4. The LVDT Bypass Box

- One key per experiment (ALFA, TOTEM) to
 - bypass LVDT input to interlock
 - and disable all pots at the same time.Key to be kept in the CCC.
- Vertical key position :
 - LVDT Position interlock active,
 - RP motors can be enabled.
- Diagonal key position :
 - LVDT Position interlock bypassed,
 - RP motor power disabled by hardware link
- Failsafe design:
if 24 V power supply of the bypass box fails,
the LVDT position interlock stays active.
- Status of key and motor power transmitted to DCS for information

Circuit diagrams in EDMS 1183242 by Xavier Pons.

TOTEM: box operational. Test will be part of the interlock tests soon.

ALFA: box not yet modified from 2011 version (4 keys)

TOTEM LVDT Bypass Box

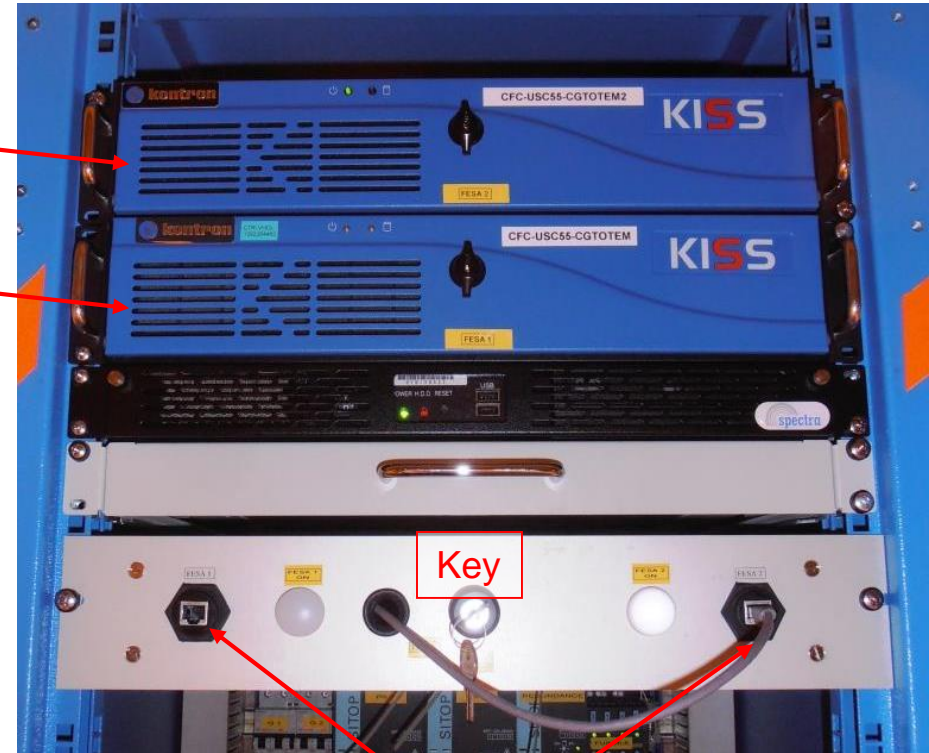


5. The FESA Switch-Over Box (TOTEM only)

→ Fast and easy replacement of a FESA FEC
in case of hardware failure

FESA FEC 1

FESA FEC 2



Key

Alternate Ethernet connections

Tested on 7 March

LHC COLL logbook: <https://ab-dep-op-elogbook.web.cern.ch/ab-dep-op-elogbook/elogbook/secure/eLogbook.php?shiftId=1042208>

- Communication loss to FESA 1 triggers RP extraction but no beam dump.
- After switch-over FESA 2 starts everything automatically and re-establishes communications
- RPs end up *Unconfigured* .

6. FESA Software Updates

- Reflect changes in the PXI FSM
- Proper RBAC maps for ALFA and TOTEM (see appendix or report)

Wish List for the CCC Application



- **Display new inner limits as curves**
- **Human-understandable error messages** (presently “java ...” over ~20 lines)
- **Configure the button “Out Switches” to send the pots to the OUT Stopper positions**
(and call it “Out Stoppers” for consistent nomenclature)
- **Naming conventions for existing button display:**
“ ● UP-IN ● UP-OUT ” → “ ● IN-Stopper ● HOME ”
- **Add another button for the real OUT Stopper**
- **Add the BBA tab to the production version** (for alignment)
- **Display difference between motor and LVDT** (as a number)

RBA: lhcop

File Settings Reset More displays Help

Jaw corners Increment **BBA**

Set single motor positions

TOP (LU) [um]

Apply!

Cancel last

Stop all!

BOTTOM (RU) [um]

Out switches

unreadable

Applying new jaw positions

- TOP (LU) UP-IN UP-OUT X(HOME) OUT Stopper
- BOTTOM (R... UP-IN UP-OUT X(HOME) OUT Stopper
- Anti COLL UP

Positions readout from the low-level

Motor ste...

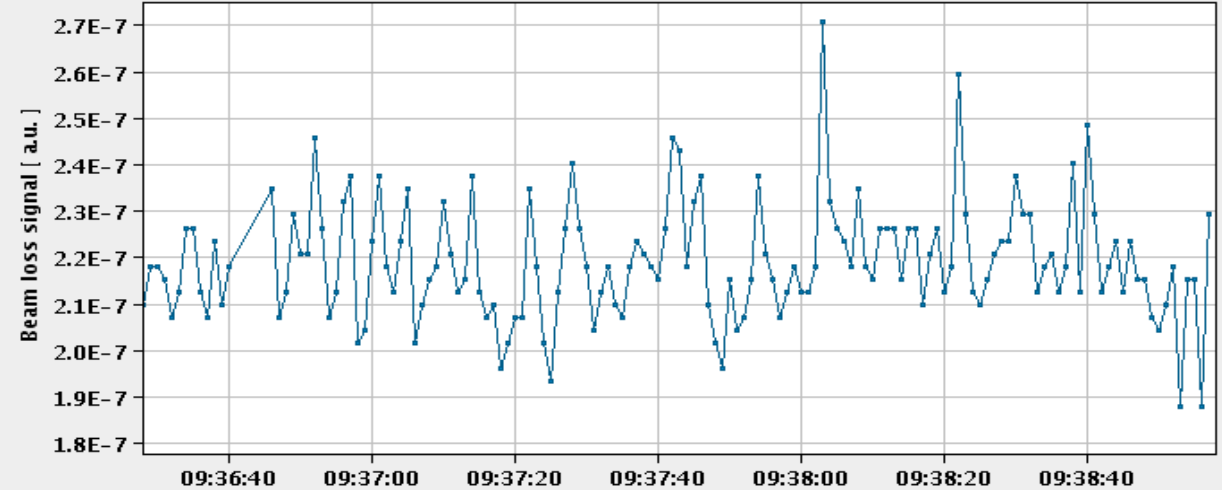
Jaw edges

- Display jaw: TOP (LU) BOTTOM (RU)
- Positions: Set LVDT Warn Lim Res Motor
- BLM: BLM 1 BLM 2 BLM 3 BLM 4 LogY

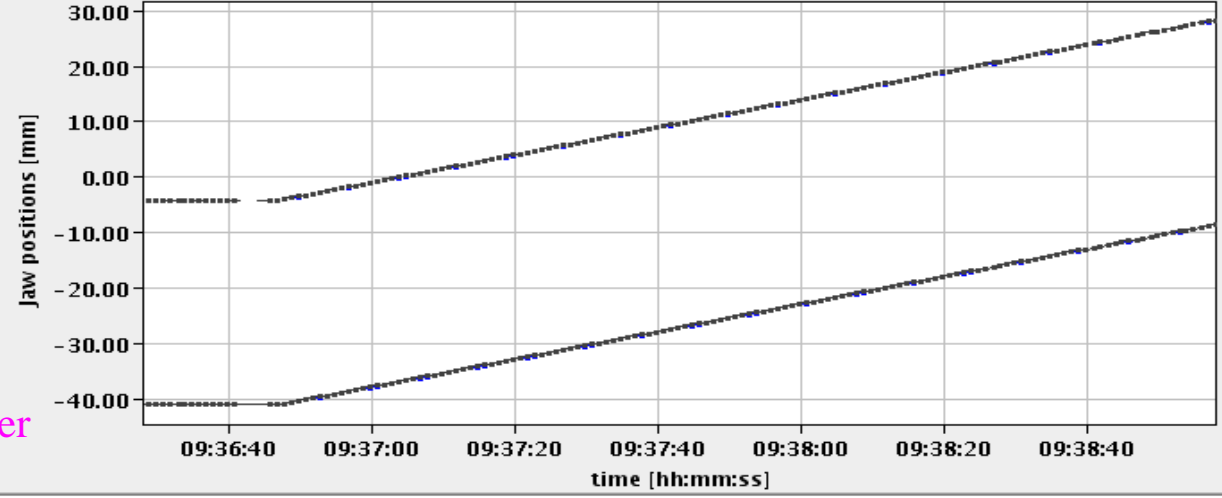
Inner

Views More

Beam loss data [07/03/12 09:38:57]



Jaw positions [07/03/12 09:38:57]



Console

```
09:27:11 - Start set-up for update of motor positions to LVDT readings
09:27:15 - Done!
```

Homework for LS1



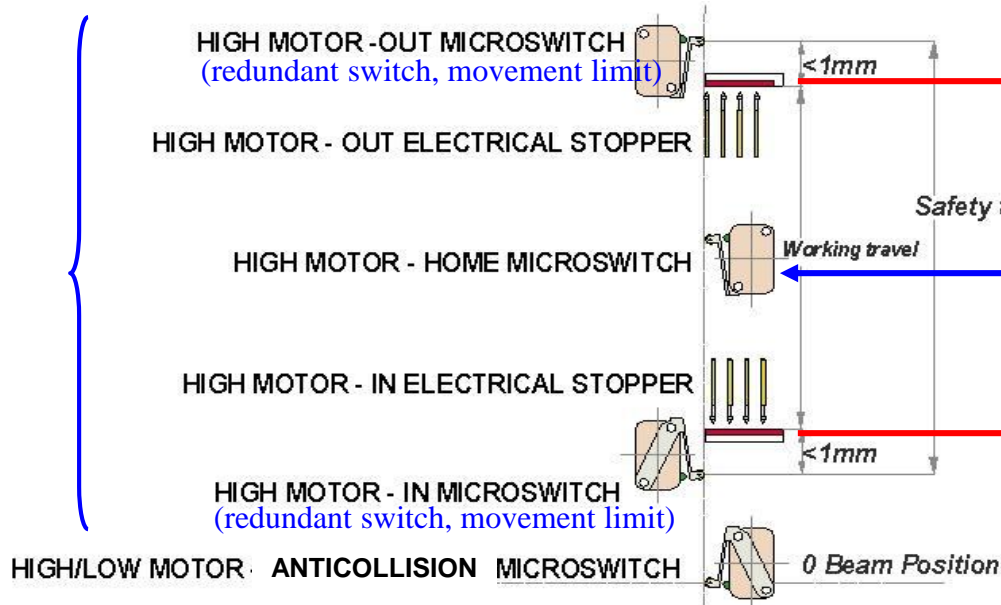
- Commission resolver position measurement
- Add warning level to new inner limits (needs FESA work)
- Add emergency extraction button to CCC application (needs FESA work)

Backup



The Microswitch System

Top Pot

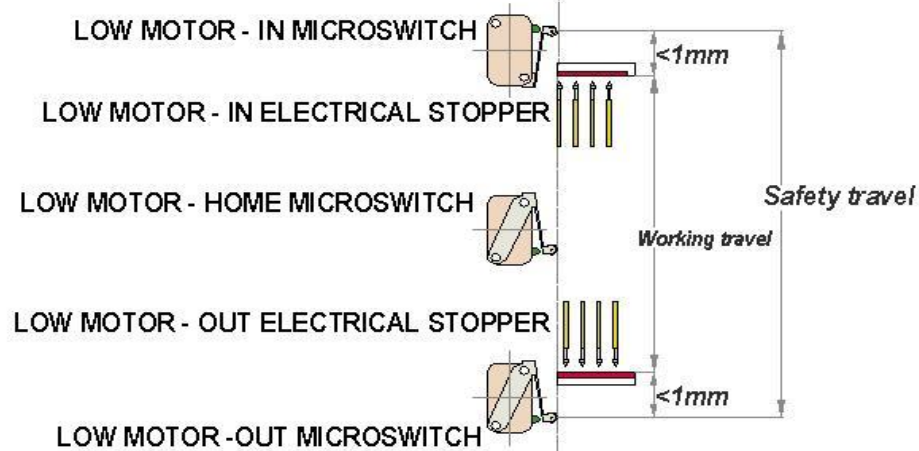


Surveyed mechanical reference

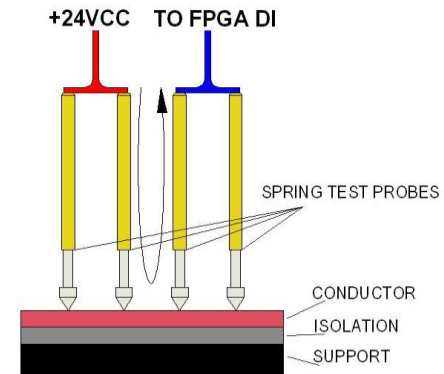
wide "on" range, only used for interlocks

Surveyed mechanical reference

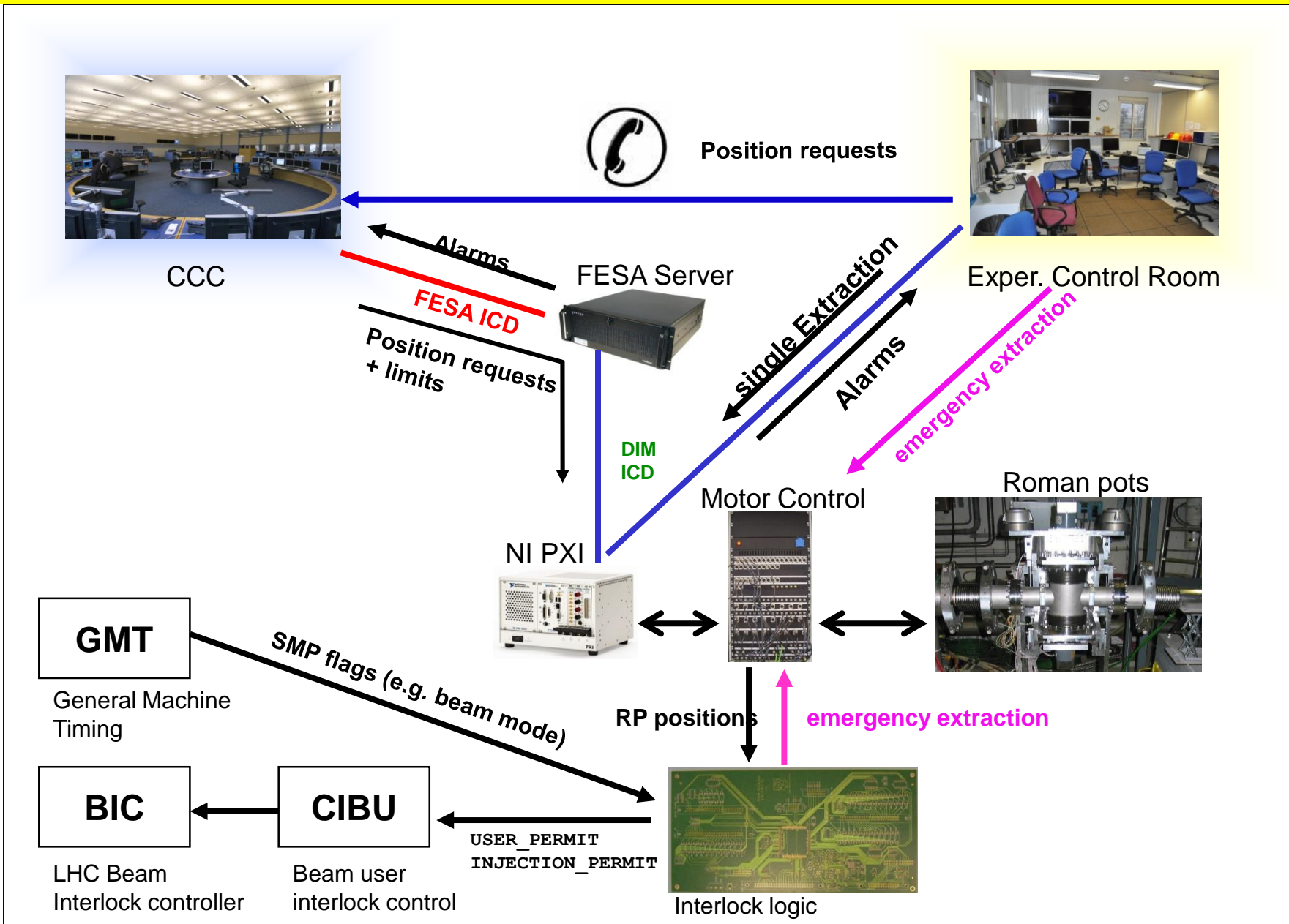
Bottom Pot



Electrical Stopper



Movement System Architecture



The PXI Crate and its Cards



The CPU manages:

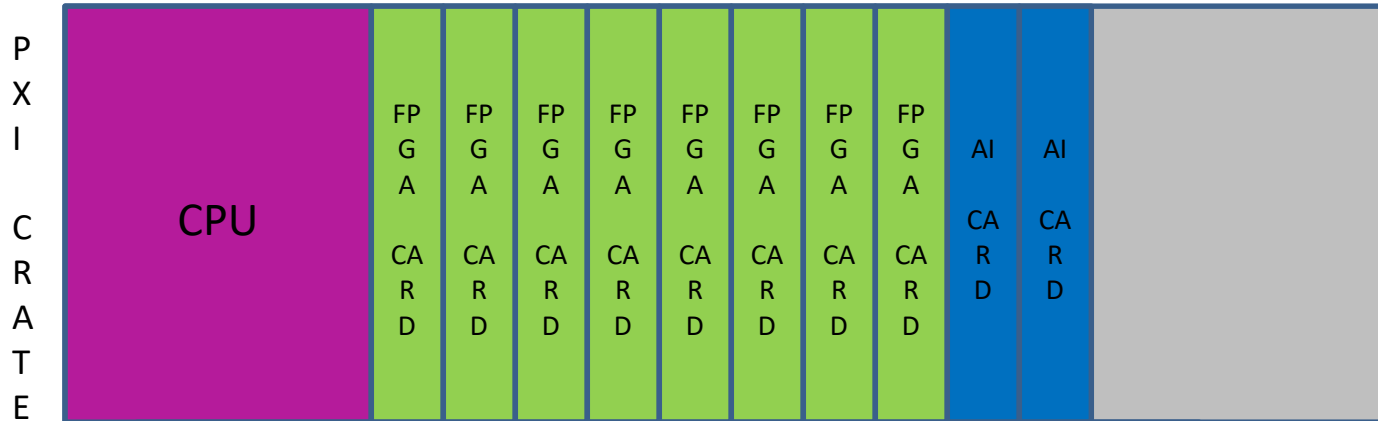
- DIM Communication with FESA and DCS
- Transmit CCC and DCS commands to fpga and read status from FPGA
- Convert ratio LVDT in mm
- Communication with motor drive via RS485. It can read an absolute encoder.

For each RP:

2 Analog Inputs for the resolver

-> It's the CPU which will count motor steps with the measurements.

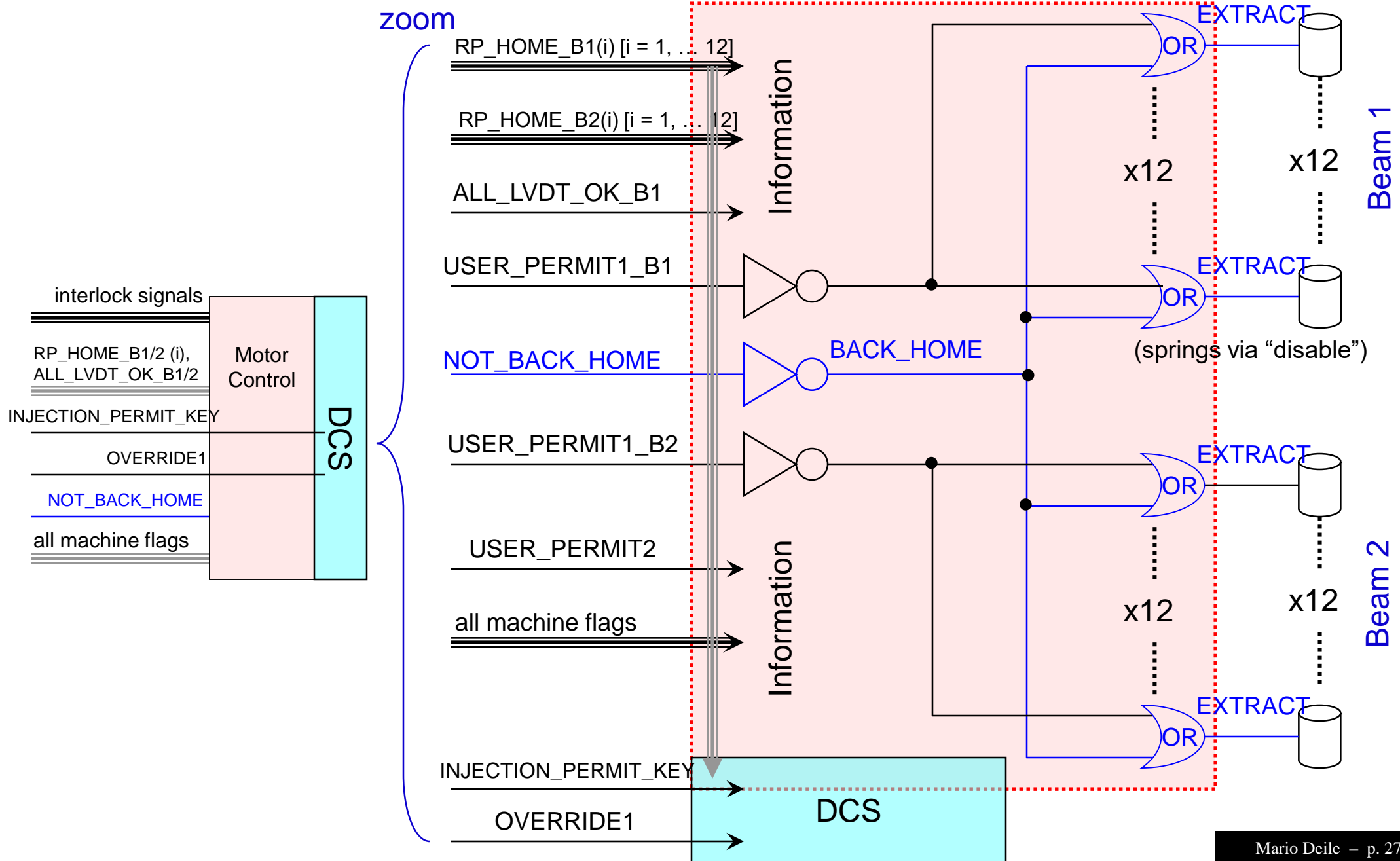
-> to process the data it will take more than 1 second (48 channels to filter)



For each station, one FPGA card manages :

- Digital inputs from interlock box, switches and stoppers
- 1 Analog Output for the resolver and 1 Analog Output for the LVDT
- 2 Analog Inputs to measure one LVDT
- LVDT Ratio calculation
- Check if one RP position is out of limit (warning and critical)
- Motor Control according FESA commands, interlocks, switches and stoppers
- All the processes are independent from the CPU

TOTEM & ALFA Interlock Block Diagram (Part 2)



New RBAC Maps



Device Group: *RomanPots-2009*

Roles → Properties Group ↓	LHC- Operator	MCS- Collimation	TOTEM-XRP- EXPERT	ALFA-XRP- EXPERT
Operator	X	X	X	
Operator_expert	X	X	X	
MCS_properties	X	X	X	

Table 2: RBAC map for the TOTEM RPs.

Device Group: *RomanPots-ALFA*

Roles → Properties Group ↓	LHC- Operator	MCS- Collimation	TOTEM-XRP- EXPERT	ALFA-XRP- EXPERT
Operator	X	X		X
Operator_expert	X	X		X
MCS_properties	X	X		X

Table 3: RBAC map for the ALFA RPs.

Property Group details:

Groups → Assigned Properties ↓	Operator	Operator_expert	MCS_properties
Disarm	X		
ErrorsAcknowledge	X		
InnerPotLimits			X
InterlockThreshold			X
InterlockThresholdFunct			X
RequiredAbsolutePosition	X		
SoftwareTrigger	X		
Stop	X		
UpdateAbsolute Position		X	

Table 4: Properties assigned to the different groups.