Session 8 – What we’ll do for beam preparation in 2009

Powering Interlocks

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on behalf and with many contributions of colleagues from TE-MPE-MI
Quick status after HWC and first operation of powering interlock systems in 2008

Modifications during the Shut-down

What needs to be re-commissioned/checked in 2009

Tools available to speed-up the interlock system validation

Pre-requisites

Hoch much time does it take?

Staged approach vs. energy, intensity
Powering Interlocks (+FMCM) in the LHC

**Powering Interlock for sc circuits (PIC)**
- Interfacing with QPS, converters, UPS, AUG, and cryogenics
- 820 electrical circuits (+752 60A orbit correctors)
- >10,000 magnets
- 36 controllers SIEMENS 319
- Cycle time 1ms

**Warm Magnet Interlocks for nc circuits (WIC)**
- Interfacing with converters and magnets
- 45 electrical circuits
- 149 nc magnets
- 8 controllers SIEMENS 300 Safety
- Cycle time ~ 100ms

**Fast Magnet Current Change Monitors (FMCM)**
- Detection of fast current changes (10E-4 @ 1ms) for 12 critical nc circuits through V measurement
- D1, MSD, RD34 & Q4/5 in IR3 and IR7, Alice comp

Note: FMCM and WIC also exist in SPS-LHC Transfer Lines
Powering Interlocks vs Beam Interlock

Beam Interlock System

- LHC Devices
- Movable Devices
- BCM Beam Loss
- Experimental Magnets
- Collimator Positions
- Environmental parameters
- BTV screens
- Mirrors

- SMP
- Software Interlocks
- SEQ via GMT
- CCC Operator Buttons
- Experiments
- Transverse Feedback
- Beam Aperture Kickers
- Collimation System
- FBCM Lifetime
- BTV
- MKI

- Beam Dumping System
- Injection BIS
- Timing System (PM)

- PIC essential + auxiliary circuits
- WIC
- FMCM
- RF System
- BLM
- BPM in IR6
- Access System
- Vacuum System
- Access Safety Blocks
- RF/e-Stoppers

- Magnets
- Power Converters
- Monitors aperture limits (some 100)
- Monitors in arcs (several 1000)
- Doors
- EIS
- Vacuum Valves (~300)

- QPS (several 1000)
- Power Converters ~1500
- AUG
- UPS
- Cryo
- OK

- 32
- 8
- 12

1/4 of LHC BIS user connections for powering interlocks, collecting a large inventory of interlock channels
Fast Magnet Current Change Monitors (FMCM) in 2008

- For startup 2008 11 oo 12 FMCM units installed
- Fully commissioned in TL (for previous CNGS runs and injection tests), partially commissioned in LHC (no priority during startup 08 as maskable inputs to BIC)
- With operational systems (once commissioned) very satisfactory functional performance

- ‘Modifications’ during shut-down:
  - Completion of installations (missing device on ALICE compensator)
  - Resolved and improved multiple pending issues on LHC devices (cross-talk on MSD, optimized settings for injection and nominal energy)
  - Completion of controls and PM interface (mainly transfer line issue with target dependent timing signals)
FMCM re-commissioning in 2009

- As never quite done and due to many changes in LHC devices, propose a systematic re-commissioning of all monitors and final validation of all thresholds.
- For 2009 still manual commissioning, possibilities for automation will be addressed for next shut-down (lower priority due to few channels & fast commissioning).
- All 12 LHC devices can be commissioned remotely from the CCC in ~ half a day, through two current cycles + fault trigger @ injection and nominal.
- Commissioning can take place immediately after circuit is HWC to nominal to be ready for first beam (FMCM functionality independent of energy & intensity).
- All FMCMs are maskable inputs to the BIC, thus absolutely required ‘only’ for unsafe beam.
- Before unsafe beam, final validation of thresholds with dedicated beam tests, ie provoking powering failure on eg D1 and measuring beam excursion until beam dump.
  - Can be combined with other tests but vital to validate the redundancy wrt BLM for such failure cases.

MPS procedure: LHC-OP-MPS-0008
Warm Magnet Interlock System (WIC) in 2008

- All 8 systems installed and operational, driven almost exclusively by operations/HWC
- After HWC 08, WIC fully commissioned, except for the FM352 (=fast module for beam dump)
- WIC Commissioning in 08 done manually, 'only' 45 circuits powering 149 magnets in LHC; commissioning takes couple of hours / point, IR3 and IR7 ~ half a day
WIC modifications during shut-down

- No modifications to WIC hardware nor connections, with exception of temporary removal of WIC in TZ76
- Inclusion and test of FM352 (redundant path to PLC for beam dump requests from power converters)
  - To assure fast transmission of beam dump request following internal PC faults (due to inherently longer cycle time of safety PLCs)
- Modules were already installed in 2008
- Will be connected into logic through new electronic card and tested during re-commissioning phase
- SCADA representation & diagnostic for module will be added
WIC re-commissioning in 2009

- Systematic re-commissioning of all systems (required for full validation of FM352)
- For 2009 still manual commissioning, possibilities for automation will be addressed for next shut-down (identical principle as PIC – see later)
- Pre-requisites: Commissioning can take place at zero current, before powering tests start
- All devices are to be commissioned locally with magnet and converter experts in ~ half a day per insertion region.
- Commissioning already during HWC period to be ready for first beam (WIC functionality independent of energy & intensity)
- All WICs are unmaskable inputs to the BIC, thus required for any beam operation
- No dedicated beam tests required, final validation of redundancy and reaction times can be done in parallel with other equipment tests

MPS procedure: LHC-OP-MPS-00010
All 36 systems installed and operational, again to large extent driven by operations

Hardwired Interlocks of 11 circuits (out of >900) not fully commissioned (due to NC in circuits/magnets...)

Few ‘real’ interlock issues found in Powering Interlock System during HWC, mostly configuration issues or cabling/connector issues

Good news: So far exceeded reliability/availability predictions (overall MTBF expected to be ~ 9 months) as no critical component failure or ‘blind failure’ observed in large installation during 2 years of ‘operation’

Profited a lot from automated commissioning tools, clear need to continue in this direction to allow for systematic & regular re-testing of interlocks during operational periods

Couple of first use-cases where powering system performed emergency dump (1st Emergency beam dump provoked on 11th Sept. after water fault in DC cable)

   Worked well (redundancy towards BIC, <1ms until completion of beam dump
What would have happened with beam on 19th Sep 08?

11:18:36:845 Internal failure of PC received by PIC

+1ms                 Beam Dump request to BIC UA43
+100us              Beam dump request in IR6 @ LBDS+ 200us             Completion of beam dump

E2:11:18:36.798 Imeas not following Iref by 300 mA

300 mA

E1:11:18:36.260 first abnormal value of U_res from RB.A34 @11:18:37.361

Protection WG, 50ms
Revision of functionality of Global Powering Subsector OFF for corrector circuits

Functionality anticipates a shut-down of circuits in the same powering subsector / cryogenic volume in case of main magnet quenches and consequent risk of quench propagation

Currently performing a Fast Power Abort, resulting in a quench-back of numerous 600A corrector magnets (and activation of EE systems)

New proposal for SPA summarised in ECR and tested in laboratory, impact on all 36 installations

Installation of QPS upgrade

No impact on HW installations (new interlocks included in existing channels on QPS side), but on PVSS SCADA system (additional agents to be included)

Relocation of equipment UJ76/TZ76

Interlock racks already previously located in TZ76, but temporary removal due to civil works (PIC for arc 67 and 78)

Connection Access – Powering Interlocks (under discussion)

Temperature interlocks on top part of HTS current lead (under discussion)
Several operational improvements & new functionalities in SCADA system (EN-ICE)

- Uniform framework as for QPS/Cryo SCADA
- ‘Super’-lock for circuits with NC
- UPS start-up interlock (+additional diagnostics via TIM/DIP) operational in addition to hardwired interlock
- ‘masking’ of SW channels during HWC and early beam operation

Proven vital for efficiency, but difficult to keep track despite procedures
From interlock point of view, no need to systematically re-test internal functionality (except for S34 and not yet commissioned circuits from HWC08)

For all other sectors, need to test that no (unwanted) modifications of cabling have taken place, ie between PIC and QPS/PC

Systematically re-test all links with Cryogenics

Systematically re-test all links with UPS and AUG system

Repeat Power Permit test (link with PC) and Circuit Quench (link with QPS), tbc with other system experts, MPP/HWC

Working on full automation of test sequences and analysis of HWC tests with EN-ICE for start-up 2009 and future shut-downs (except main circuits)
PIC re-commissioning in 2009 – Cold Checkout

- Powering Interlock System provides 32 inputs to the BIS, 16 maskable and 16 unmaskable.
- Configuration defines which circuits are mandatory for beam operation (unmaskable) or ‘auxiliary’ (maskable).
- As ‘guinea pig’ for 2008, automated procedure to test and validate the interfaces and configuration before beam operation.
- Takes around 1 hour/sector, due to topology of connections PIC-BIC needs 2 adjacent sectors reserved for test.
- Around 1500 logical tests per sector, test results stored in LSA and MTF.
- Staged approach for PIC vs energy/intensity: When to activate the full redundancy and safety of the system?

No Powering Subsector OFF
Only maskable BIS inputs

Injection / first circulating beam

Powering Subsector OFF
Only maskable BIS inputs

Circulating, safe beam = MPS-1

Powering Subsector OFF
Full redundancy, maskable & unmaskable BIS inputs

Unsafe beam = MPS-2 and >

LHC-OP-MPS-00005 + next talk of J.Wenninger
Conclusions

- Majority of powering interlock systems operational for most of 2008 (except FMCMs), resulting in valuable experience and feedback
- Based on extensive 2008 experience, don’t expect major surprises in 09 and confident to comply with schedule
  - One doubt: CPLD XC95144 used in PIC vs SEE?
- Main priorities 2009 further automation of interlock tests (in view of regular automated tests with BIS) + traceability of masking
- No dedicated tests with beam with any of the systems, some few ‘emergency dumps’ demonstrated functionality of beam dumps from powering interlocks
- Need to agree on proposal for common staged approach (ie when to transit from flexible state to rigid & full system functionality)
  - Needs time for implementation and commissioning
- Encouraging experience with systems availability (MTBF) in view of the very complex MPS
THANKS FOR YOUR ATTENTION