Status and Outlook of WP QPS

R. Denz, S. Mundra, J. Spasic, J. Steckert

Outline

- Radiation tolerant developments for QPS
- QPS & R2E – the 2018 experience
- Upgrades LS2
- Upgrades beyond LS2
- QPS & R2E – tests
- Resources
  - Person power
  - Material

Radiation tolerant developments for QPS - motivation

- LHC QDS & DAQ systems are safety critical and must be highly dependable!
  ~14000 possibilities to stop LHC at any time
- Application is very specific to LHC and its constraints → system is fully custom made (no “black boxes”, neither in hardware nor in firmware)

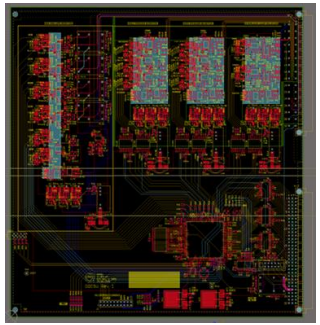
  - Regular arc ~ 1 Gy/year → ok
- Obsolescence of electronic components & useful lifetime
  - Major upgrades only feasible during long shutdowns
- New requirements, features, enhanced performance
  - New requirements for quench detection e.g. for Nb_3Sn magnets

QPS & R2E – the 2018 experience

- The somewhat arbitrary decision to change the TCL settings in 2018 increased the radiation load for QPS equipment especially in half-cells 8 around IP1&5, while the R2E induced failure rate in the RRs dropped
  - Note: ~50% of QDS downtime in 2018 due to changed TCL settings
- R2E problems affected the QPS DAQ systems using the notorious MicroFIP™ and the splice protection systems type DQQBS
  - Both systems nevertheless performed better than expected
  - Mitigation measures implemented during TS#2 have been successful but cover only the problem of false positive
  - Exercise can be regarded as a good test for the HL-LHC

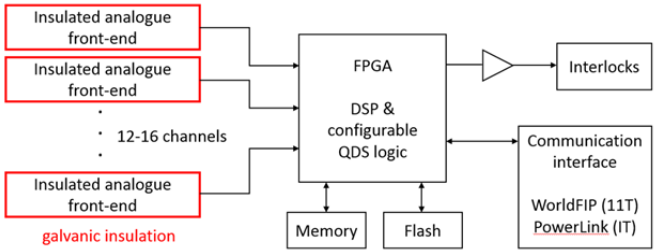
QPS & R2E – upgrades LS2

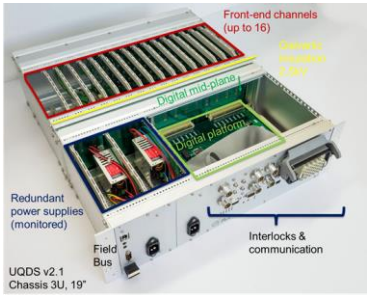
- Upgrade of main quadrupole protection systems: DQLPU type B
  - QPS product lifecycle management
  - Radiation tolerant quench detector and crate controller
  - Field-bus coupler will be recuperated from existing crate
  - 392 units to be installed
  - Prototype including the external power supplies successfully tested in CHARM



QPS & R2E – upgrades LS2

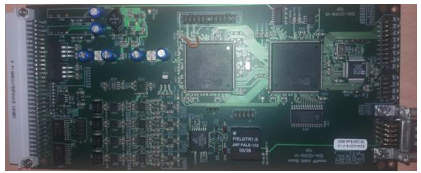
- HL-LHC: Quench detection systems for 11 T Nb_3Sn dipoles
  - Versatile system easily adaptable to various tasks reaching from sophisticated quench detection systems to high performance DAQ
  - Core of the radiation tolerant version is the IGLOO2™ FPGA
  - First deployment of UQDS systems in LHC
    - To be installed in RR73/RR77
    - Successfully tested in CHARM (large margin for RR operation)





QPS & R2E – upgrades LS2

- Upgrade of MicroFip™ based field-bus couplers type DQAMC and DQAMGS in DS areas
  - New development using NanoFIP IP core
  - Implementation requires as well a modification of the QPS supervision software stack
  - Expected to be ready for LHC run 3
- Splice protection systems type DQQBS (nQPS)
  - Patched version already used in LHC
    - Revised version to be produced and tested in PSI
  - Should cover the needs for run 3 but HL-LHC may require a fully new development



QPS & R2E – upgrades beyond LS2

- Universal three channel quench detection board
  - For IPQ and 600 A corrector circuit protection combination with current derivative sensors
  - Radiation tolerant version for the RR
- PowerLink™ based field-bus couplers
  - Providing significantly higher data transmission rates for systems currently installed in the UA, UJ, UL and RR underground
  - Hardware interface must be compatible with existing systems
  - Radiation tolerant version for the RR
- In addition there will be the usual known & unknown unknowns

QPS & R2E – tests

- Continuous demand for testing of components and assemblies
  - 2-3 slots / year for component testing @ PSI
    - Focusing on SEU immunity
  - TID tests using ^{60}Co sources
    - @CERN or outsourced (e.g. to Fraunhofer institute); coordinated by R2E project
  - CHARM tests to be resumed after LS2
- Results from recent tests → see presentation by Surbhi Mundra tomorrow

QPS & R2E resources – person power

Status	Contract start/end	Job description
TECH	02/2019 – 01/2020	Development of radiation tolerant field-bus couplers specific to QPS applications
FELL	03/2018 – 02/2020	Component and system qualification, i.e. management of radiation test campaigns in close collaboration with R2E
PJAS	33% for another 3 years → new addendum with AGH Krakow in preparation	Verification, test and development of safety critical firmware for quench detection and data acquisition systems (emphasis on radiation exposed systems)

QPS & R2E resources – material

Table includes only those items, for which R2E is the principal reason for the upgrade!

RUN 3	nQPS DQQBS	Splice protection system in DS[1] areas 1 & 5 & 7 (pp) and 2 & 8 (ions)	190	300 CHF	57 kCHF (2019 - 2020)
HL-LHC	nQPS DQQBS	Splice protection system in DS areas 1 & 5 & 7	130	400 CHF	52 kCHF (2022 -2023)
HL-LHC	nQPS DQQDS	Symmetric quench detection systems in DS areas 1 & 5 & 7	120	400 CHF	48 kCHF (2022 -2023)
HL-LHC	nQPS crate	DS areas 1 & 5 (motherboard only)	30	300 CHF	9 kCHF (2022 -2023)
RUN3 & HL-LHC	DQAMC	Field-bus coupler DS 1 & 5 & 7 (pp) and 2 & 8 (ions)	140	500 CHF	70 kCHF (2019 - 2023)
	DQAMG		60	500 CHF	30 kCHF (2019 - 2023)
	TEST	Test systems for radiation tests (PSI/CHARM)	N/A	20 kCHF/y	100 kCHF (2019 - 2023)
	Σ				**366 kCHF**

[1]: DS ≡ half-cells 8 - 12

Summary

- All major QPS R2E developments have been completed and production
  - Some additional developments reflecting the 2018 operational experience

Many thanks to the R2E project and its predecessors for providing support and expertise since more than two decades!

- R2E will remain an important design constraint for most of the QPS equipment
  - Major upg HC-CONS a support still needed fo urces!), test measures e.g. for fie