UQDS - IT– Reliability Analysis

12/07/2024

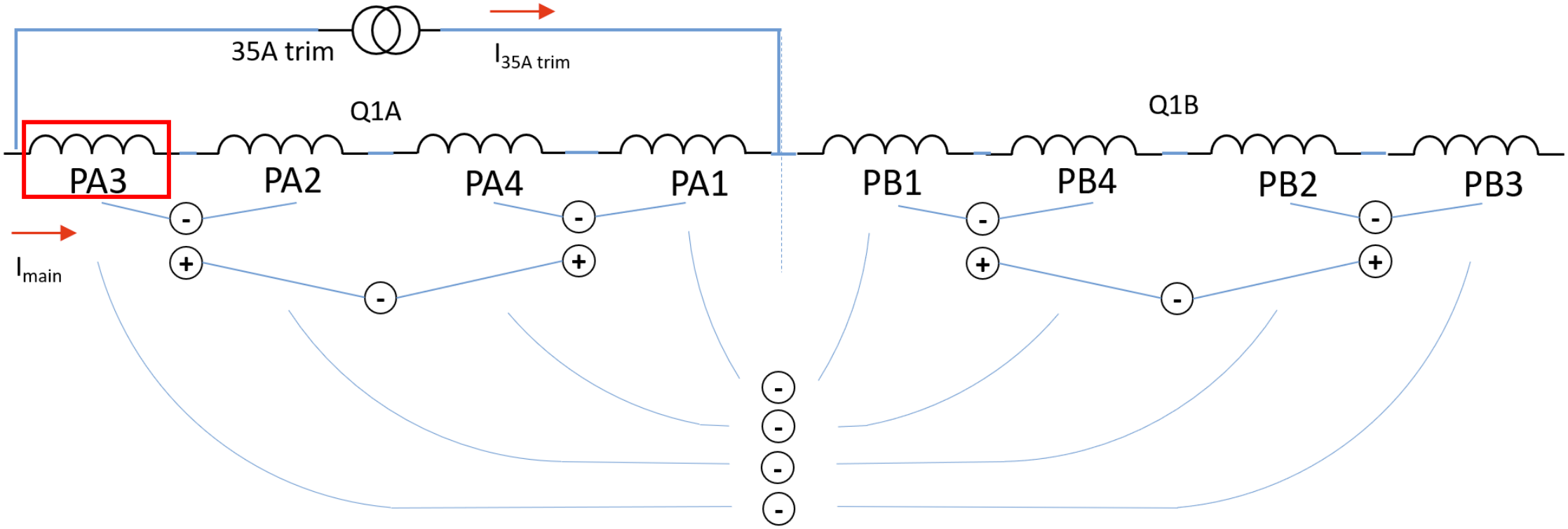
Progress since last meeting

- **Analysis of the failure rate apportionment of the Digital Platform**

- **Continuous demand**
  - Calculation of the failure rate
    - Below 3kA (4oo8 QHDS) and above 3kA (7oo8 QHDS or 1 CLIQ)
    - 1 year and 3 years Inspection interval
  - Sensitivity Analysis
    - Determined for which inspection interval the reliability target can be met

- **No Continuous demand**
  - Determined a model, which can be used for simulations
  - Started to do simulations for different demand rates and inspection intervals

Quench scenario



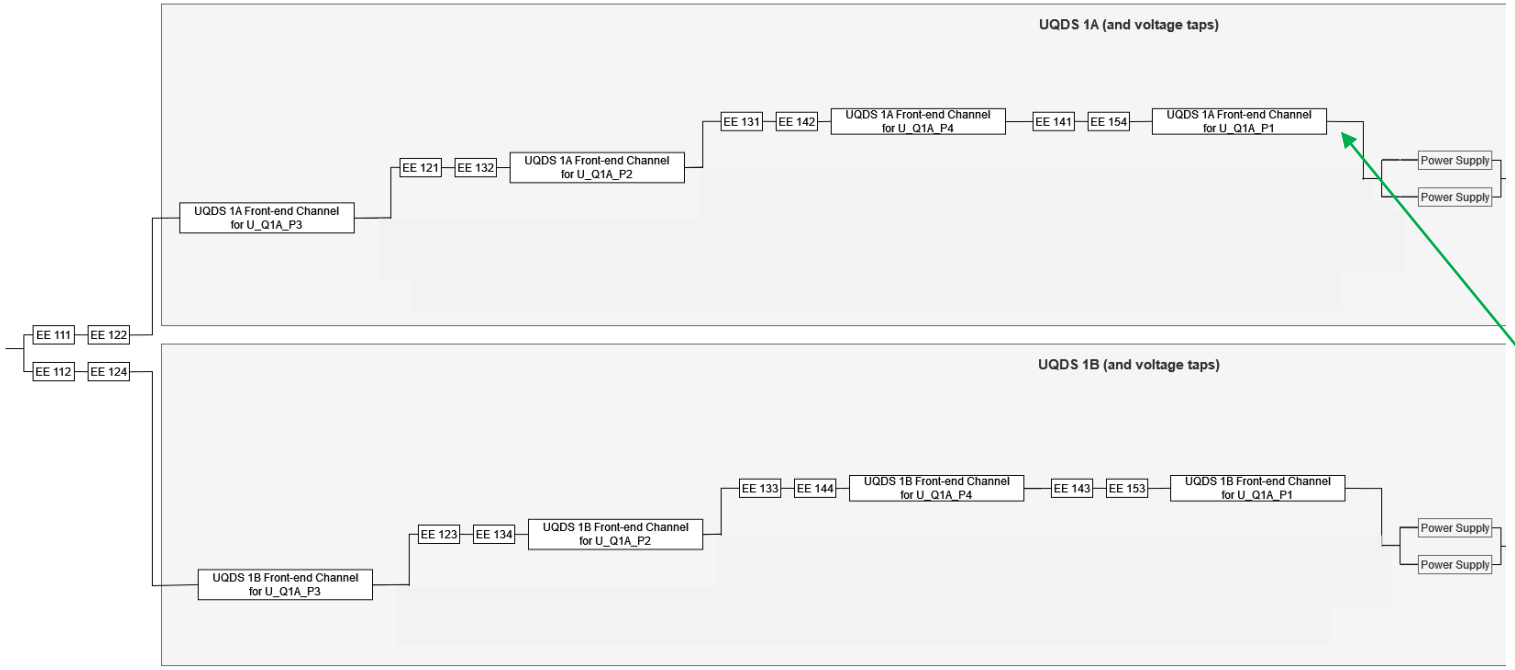
Asymmetric detection: Coil-coil comparison of neighboring coils (PA3 - PA2, PA4 – PA1, PB1 – PB4, PB2 – PB3)

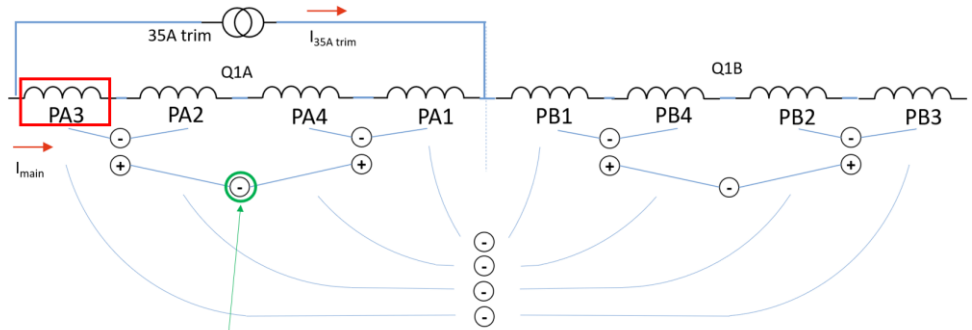
Magnet symmetric detection: Comparison of magnet halves: (PA3 + PA4) – (PA4 + PA1), (PB1 + PB4) – (PB2 + PB3)

Full symmetric detection: Comparison of Coil voltages between Q1A and Q1B

Reliability Block Diagram for a single quench in a magnet (e.g. Quench in Coil PA3)

Pessimistic scenario





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Magnet symmetric detection: Comparison of magnet halves: (PA3 + PA4) – (PA4 + PA1), (PB1 + PB4) – (PB2 + PB3)

Full symmetric detection: Comparison of Coil voltages between Q1A and Q1B

Failure rates

System/Component	Failure rate/FITs
Voltage Tap	13.38
UQDS	
Channel	70.29
PSU	874.70
Midplane	38.42
FPGA	1183.00
Trigger Interface	7.00
PDSU	
PSU	0
FPGA	1183.00
Midplane	46.16
QHDS/CLIQ Trigger Interface	7.00

Failure rates

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Voltage Tap	13.38
UQDS	
Channel	70.29
PSU	0
Midplane	38.42
FPGA (Digital Platform)	1183.00
Trigger Interface	7.00
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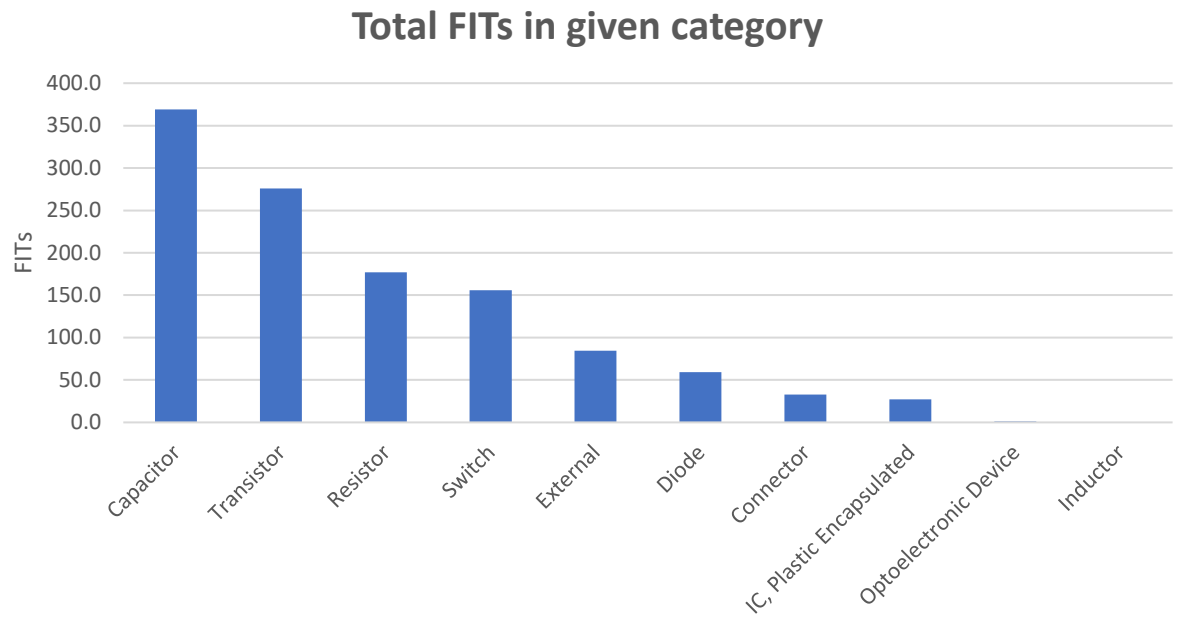
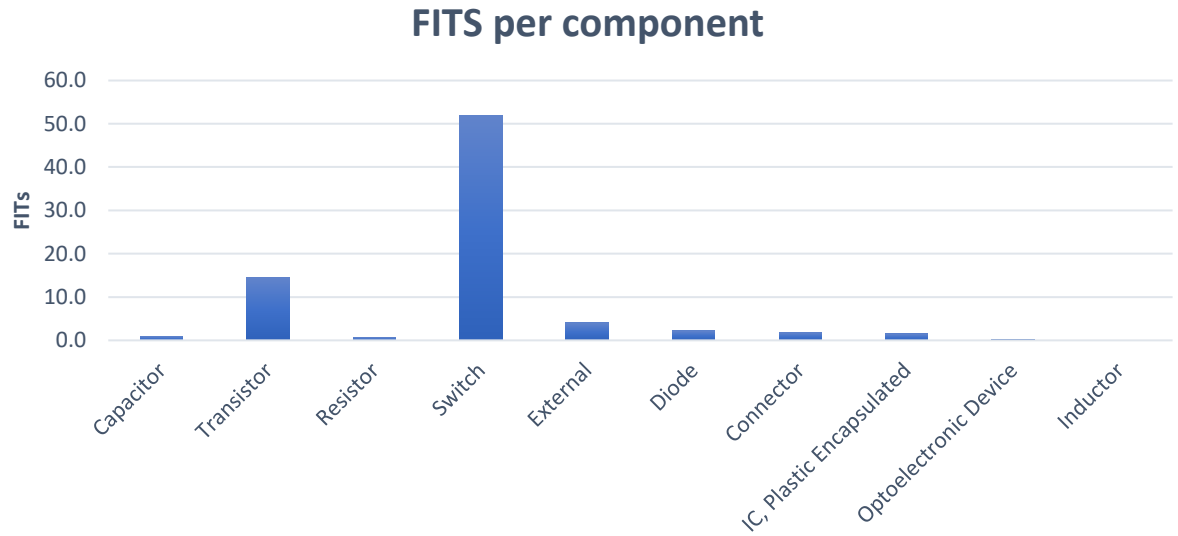
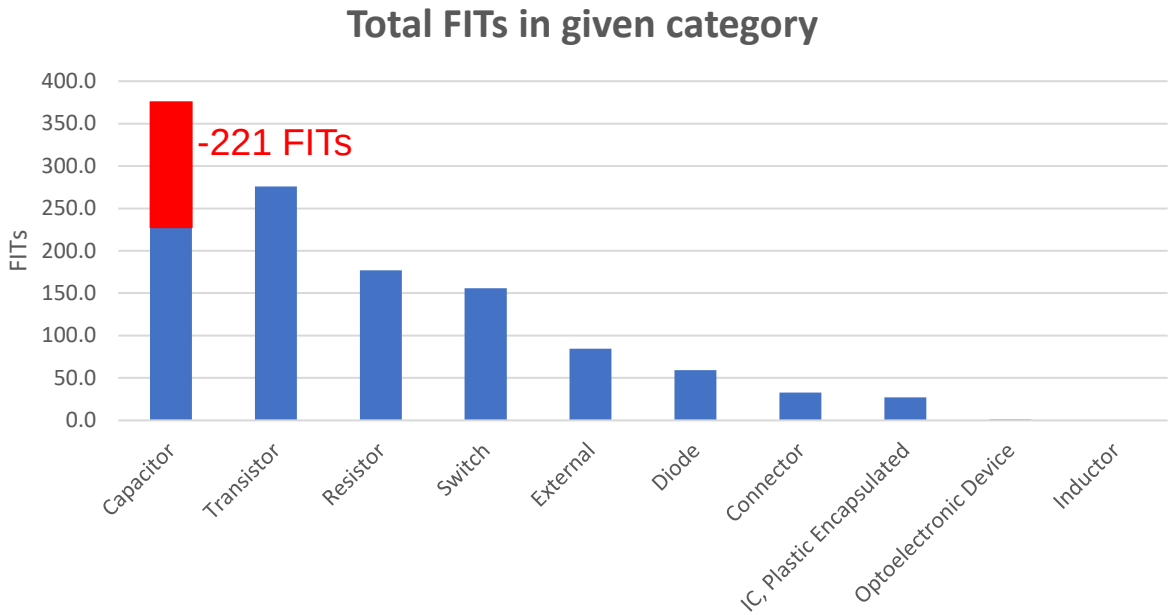
PSU only influences the availability.

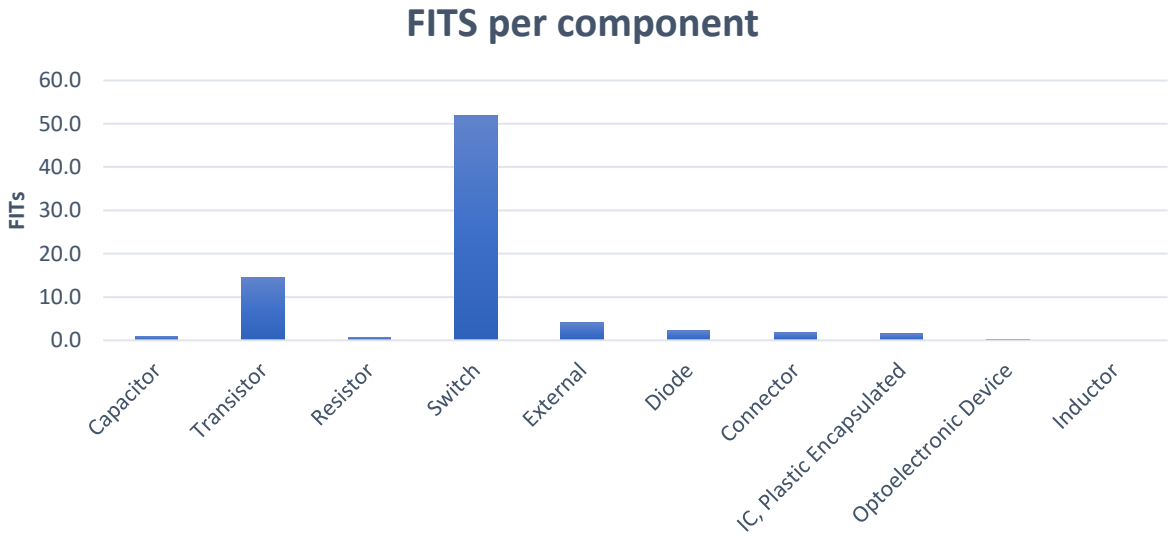




Failure rates

System/Component	Failure rate/FITs
Voltage Tap	13.38
UQDS	
Channel	70.29
PSU	0
Midplane	38.42
FPGA (Digital Platform)	962.00
Trigger Interface	7.00
PDSU	
PSU	0
FPGA (Digital Platform)	1183.00
Midplane	46.16
QHDS/CLIQ Trigger Interface	7.00





Only the failure mode short of the Capacitors of the DSP card – FPGA power delivery can cause blind failures.
-> Is a protection against this failure mode possible?

Failure rates

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Voltage Tap	13.38
UQDS	
Channel	70.29
PSU	0
Midplane	38.42
FPGA (Digital Platform)	962.00
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PDSU	
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Can a safe failure fraction be defined (in particular for the Digital Platform)?

UQDS v3

- When will the new version of the system be released?
- By what Percentage will the number of which components increase?

PDSU

- Can the same assumptions for the Digital Platform of the UQDS also be made for the PDSU?
  - PSU only influences the availability
  - Only the failure mode *short* must be considered for the capacitors of the DSP card – FPGA power delivery

Calculations – Continuous Demand

Assumptions

- **Continuous Demand** (if there is a failure of the system, there is always a quench)
- Reliability Target of maximum **1 allowed failure in 1.000 years**
  - No magnet protection leads to a downtime of months, which leads to a target of max. 1 failure/100 years
  - Multiplied by 10 because of other systems that can cause a similar downtime

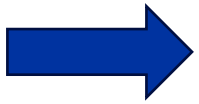
	below 3kA (4oo8 QHDS)		above 3kA (7oo8 QHDS or 1 CLIQ)	
Inspection Interval	1 year	3 years	1 year	3 years
Failures per system in 1000 years	0.3329	1.1916	0.3329	1.1916

We don’t have 1 system but ~5000 QDS systems

Sensitivity Analysis – Continuous Demand

Failures per 1000 years, when considering the 5000 QDS systems:

Inspection Interval	above 3kA (7oo8 QHDS or 1 CLIQ)
1 year	1664.4
1 month (30 days)	167.56
1 week	39.12
5 hours	1.16
4 hours	0.93



The reliability target can be met for an Inspection Interval of ~ 4-5 hours

Comparison with results from QPS Analysis in 2004

2004

Probability of protecting LHC S.C. elements
IN ALL quenches (20 years)

Quench Detectors		Channels	Yearly Test	Monthly Test
	DQQDI,T	180	0.801	0.991
	DQQDG	418	0.932	0.997
	DQQDL	2016	0.412	0.991
	DQQDC	1198	0.619	0.974
		3812	**0.1904**	**0.9536**

Now

Probability of protecting LHC S.C. elements in all quenches (**20 years)** when considering 5000 QDS and a continuous demand.

Inspection Interval	above 3kA (7oo8 QHDS or 1 CLIQ)
1 year	0.0000
1 month	0.0179

Conclusion

- The reliability target can not be met with a continuous demand and an Inspection Interval above ~4-5 hours.

- We have to check whether we can lower the failure rate of the boards by excluding certain components or failure modes which do not cause a blind failure.

- We have to and and also started to check for
  - different inspection intervals,
  - for which demand rate

  the reliability target can be met.

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