BISv2 CIBF Reliability Study

Quantitative summary of the FMECA

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Reliability Targets CIBU (indicative)

End Effect	Target reliability FITS
Blind Failure (per channel)	100
Blind Failure (both channels, i.e., A/B)	0.05
False Dump	70

Approach

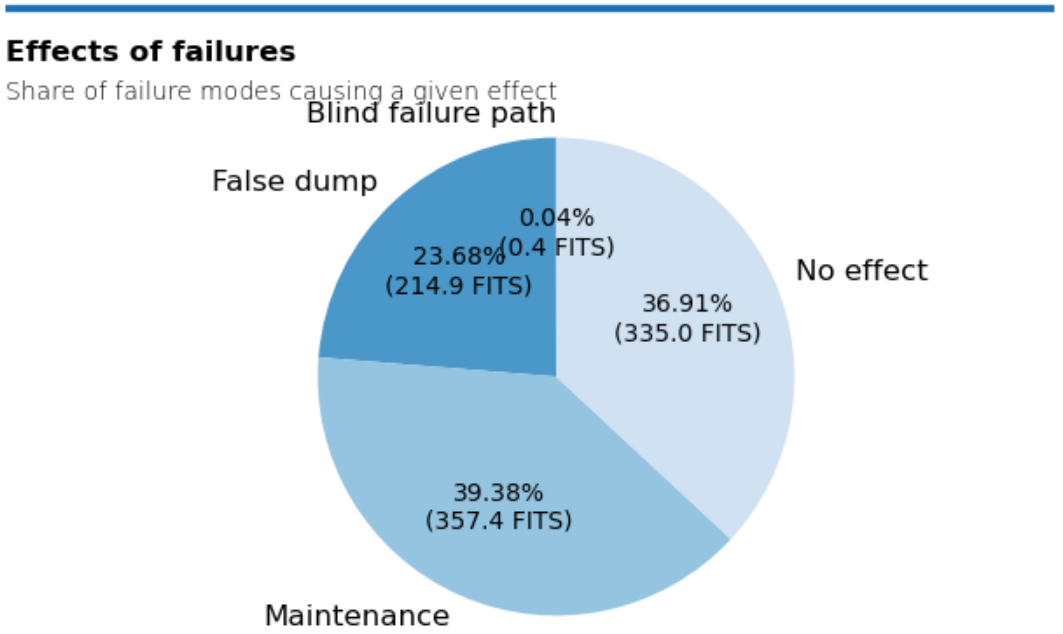
The approach applied for other BISv2 boards was based on a thorough balancing of individual targets for each board type so that **together they meet the overall goal**. The overall target for the entire system is **1 critical failure in 1,000 years** (risk matrix). Based on the:

- **approximate complexity**,
- **number of boards' instances**,

We reach the reliability targets presented above.

Preliminary results

- **Relatively small fraction of blind failures – 0.04%**
  - ✓ 0.4 FITS = 1 failure every 285,388 years
- **False dumps similar to the numbers in other boards – 24%**
  - ✓ 215 FITS = 1 failure every 531 years
  - ✓ Still beyond requirements, but MIL-HDBK-217 estimates generally conservative
- **Maintenance – 39%**
  - ✓ 357 FITS = 1 failure every 320 years
- **37% of failure modes have no impact**
  - ✓ 335 FITS



End Effect	Predicted FITS	Corresponding Reliability
Blind Failure	0.4 FITS	0.9999976
False Dump	219 FITS	0.9986868
Maintenance	357 FITS	0.9978602
No Effect	335 FITS	0.9979920

Blind Failures

- **CIBF – 2 failure modes:**
  - Components **IC2** and **IC19** (FOD060L): **optocouplers stuck low** in **User Permit A/B**;
  - Components **IC3** and **IC21** (74LVT14D): **inverter stuck high** in **User Permit A/B**;
- **CIBU:**
  - Same for user permit optocoupler and inverter (although “stuck high/low” mismatch + an additional “input open” inverter)
  - Additional blind failure on RS-485 transceiver on input open (to CIBM)
    - Fail-safe property of RS-485

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Reliability Monitoring Results

Quarters: Q1/2022 to Q4/2022
Based on structural similarity

Supplier	**User Part Number**
Nexperia B.V.	74LVT14D

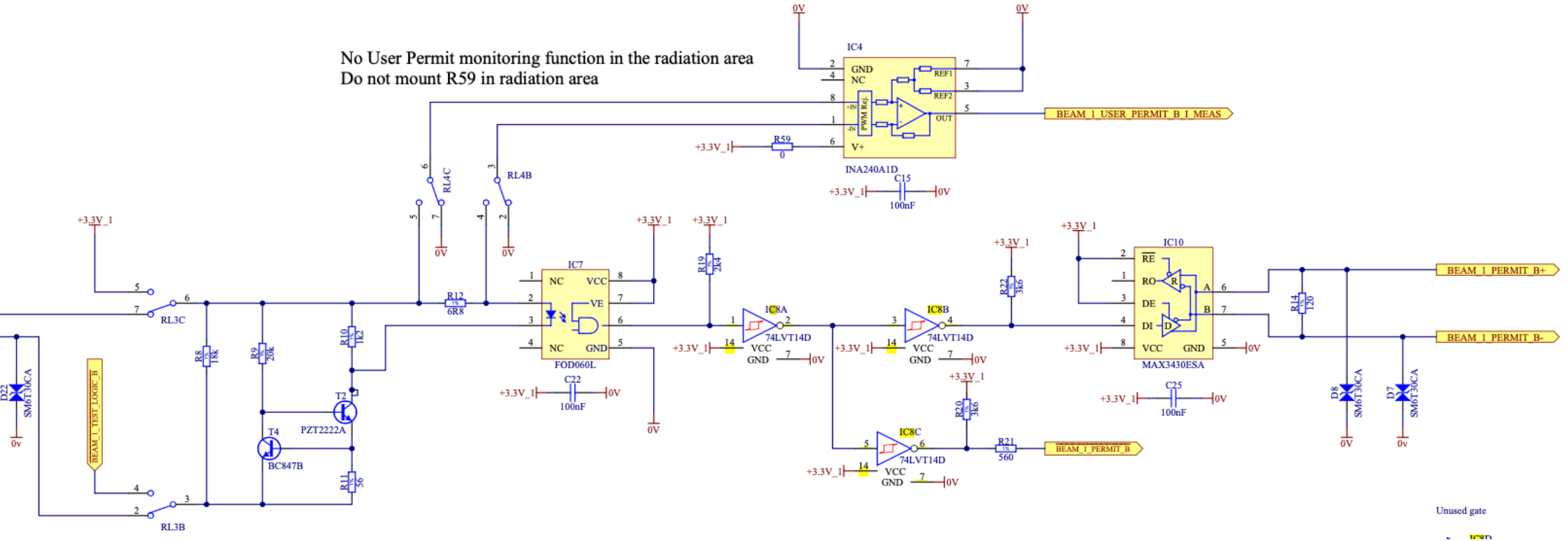
Part Description: Hex inverter Schmitt-trigger

Function Family: LVT
Process family: Sub micron
Package family: SO

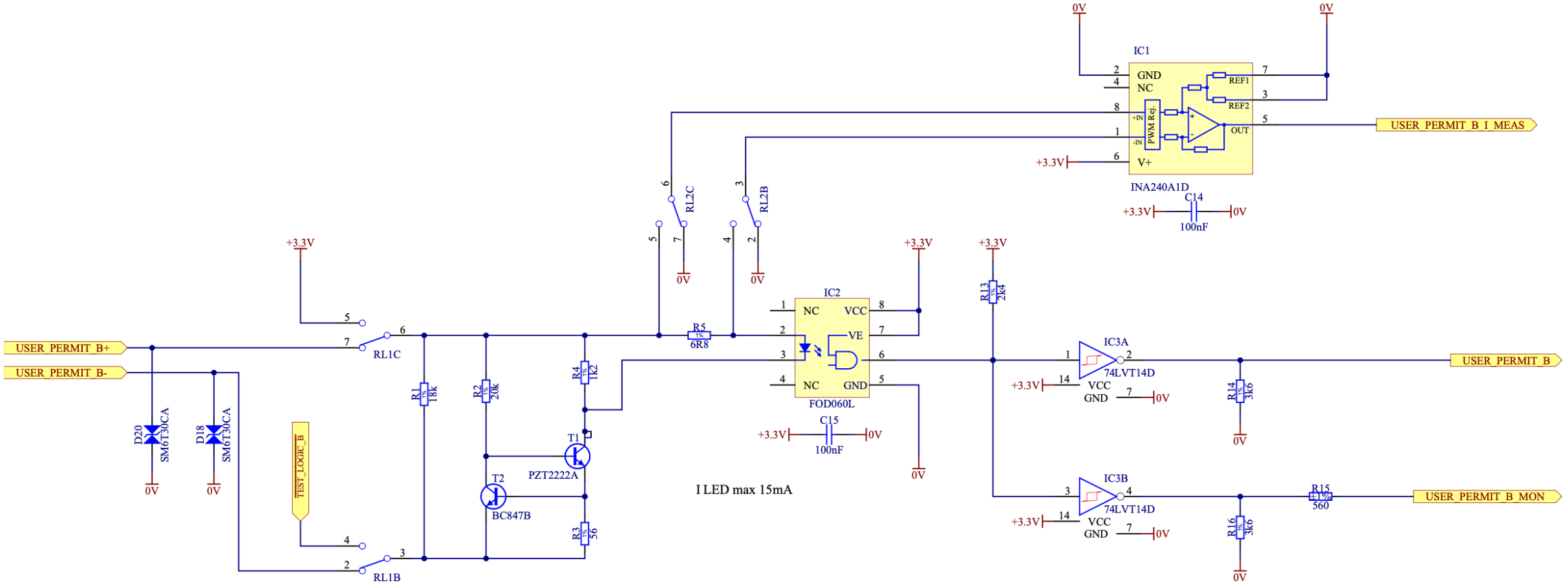
JESD47 Test		**Test Conditions**	**Duration**	**# Lots**	**# Quantity**	**# Rejects**
# 1	**TEST** Pre- and Post-Stress Electrical Test	Tamb = 25 °C	N/A	see below	all parts	see below
# 2	**PC** Preconditioning	JESD22-A113 MSL 1	N/A	460	29380	0
# 5a	**HTOL EFR** High Temperature Operating Life Extrinsic	JESD22-A108 Tj = 150°C $V_{CCMAX} \leq V \leq 1.2*V_{CCMAX}$	48 hours or 168 hours	132	33268	0
# 5b	**HTOL IFR** High Temperature Operating Life Intrinsic	JESD22-A108 Tj = 150°C $V_{CCMAX} \leq V \leq 1.2*V_{CCMAX}$	≥500 hours	89	7065	0
# 7	**TC** Temperature Cycling	JESD22-A104 -65 °C to 150°C	≥500 cycles	69	17630	4
# 9	**uHAST / HAST** unbiased or biased High Accelerated Stress Test	JESD22-A101 Tamb = 130 °C, RH = 85%, V = V_{CCMAX}	96 hours	202	11750	0

https://assets.nexperia.com/documents/quality-document/74LVT14D_Nexperia_Product_Reliability.pdf

CIBU


No User Permit monitoring function in the radiation area
Do not mount R59 in radiation area
IC4
INA240A1D
BEAM_1_USER_PERMIT_B_I_MEAS
R59
C15
100nF
RL4C
RL4B
RL3C
RL3B
R8
R9
R10
R11
R12
6R8
T2
PZT2222A
T4
BC847B
BEAM_1_TEST_LOGIC_B
D22
SM6T30CA
IC7
FOD060L
C22
R19
IC8A
IC8B
IC8C
74LVT14D
R22
R20
R21
560
IC10
MAX3430ESA
C25
R14
120
BEAM_1_PERMIT_B+
BEAM_1_PERMIT_B-
BEAM_1_PERMIT_B
D8
D7
Unused gate

CIBF


IC1
GND
NC
REF1
REF2
PWM Rej.
+IN
-IN
OUT
V+
INA240A1D
C14
100nF
+3.3V
0V
USER_PERMIT_B_I_MEAS
RL2C
RL2B
IC2
NC
VCC
VE
NC
GND
FOD060L
R5
6R8
R13
2k4
IC3A
74LVT14D
VCC
GND
R14
3k6
USER_PERMIT_B
IC3B
R15
560
R16
3k6
USER_PERMIT_B_MON
USER_PERMIT_B+
USER_PERMIT_B-
RL1C
RL1B
R1
18k
R2
20k
R4
1k2
R3
56
T1
PZT2222A
T2
BC847B
D20
SM6T30CA
D18
SM6T30CA
TEST_LOGIC_B
I LED max 15mA
C15
100nF

Blind Failures

- **2 failure modes:**
  - Components **IC2** and **IC19** (FOD060L): **optocouplers stuck low** in **User Permit A/B**;
    - failure rate: 0.13 FITS (10% of total 1.38 FITS assigned to the component from 217Plus standard)
    - Between 8 (35°C, 90% CL) to 39 FITS (55°C, 90% CL)
  - Components **IC3** and **IC21** (74LVT14D): **inverter stuck high** in **User Permit A/B**;
    - failure rate: 0.05 FITS (10% of total 0.5 FITS from the producer).
    - Alternative: up to 8 FIT.

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Reliability Monitoring Results

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Based on structural similarity

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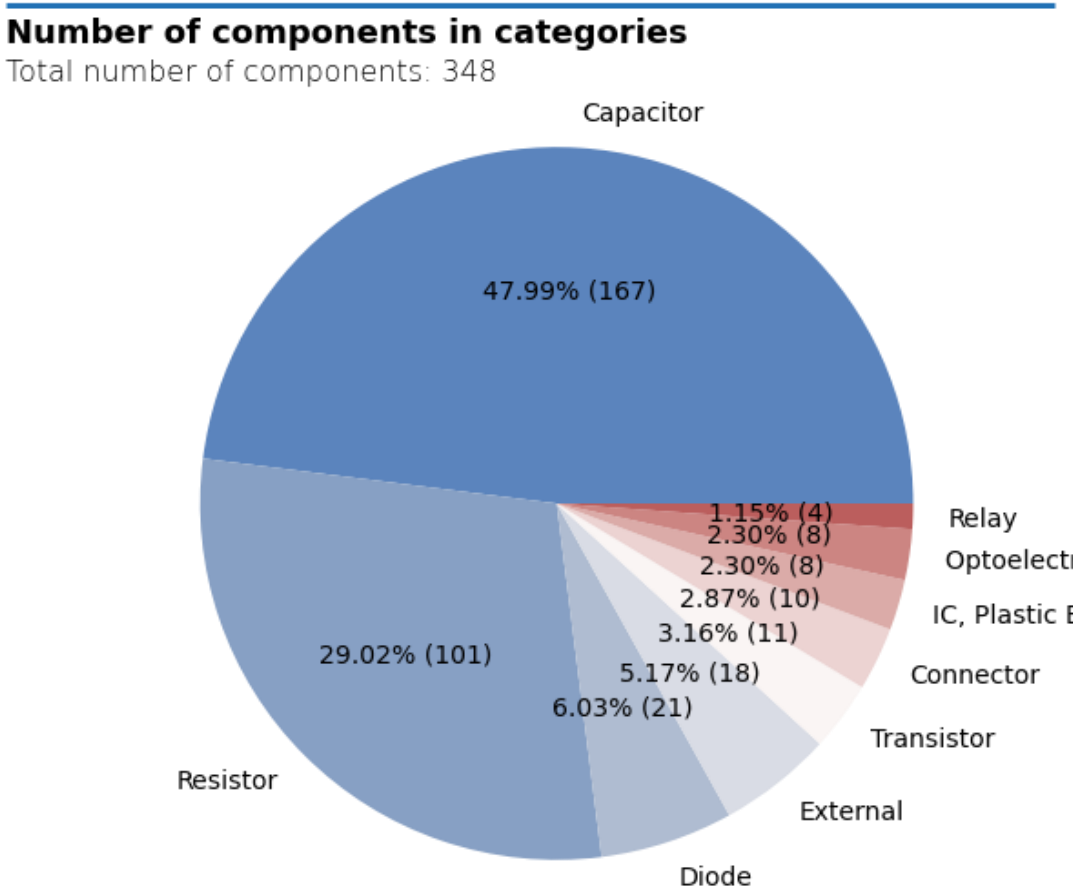
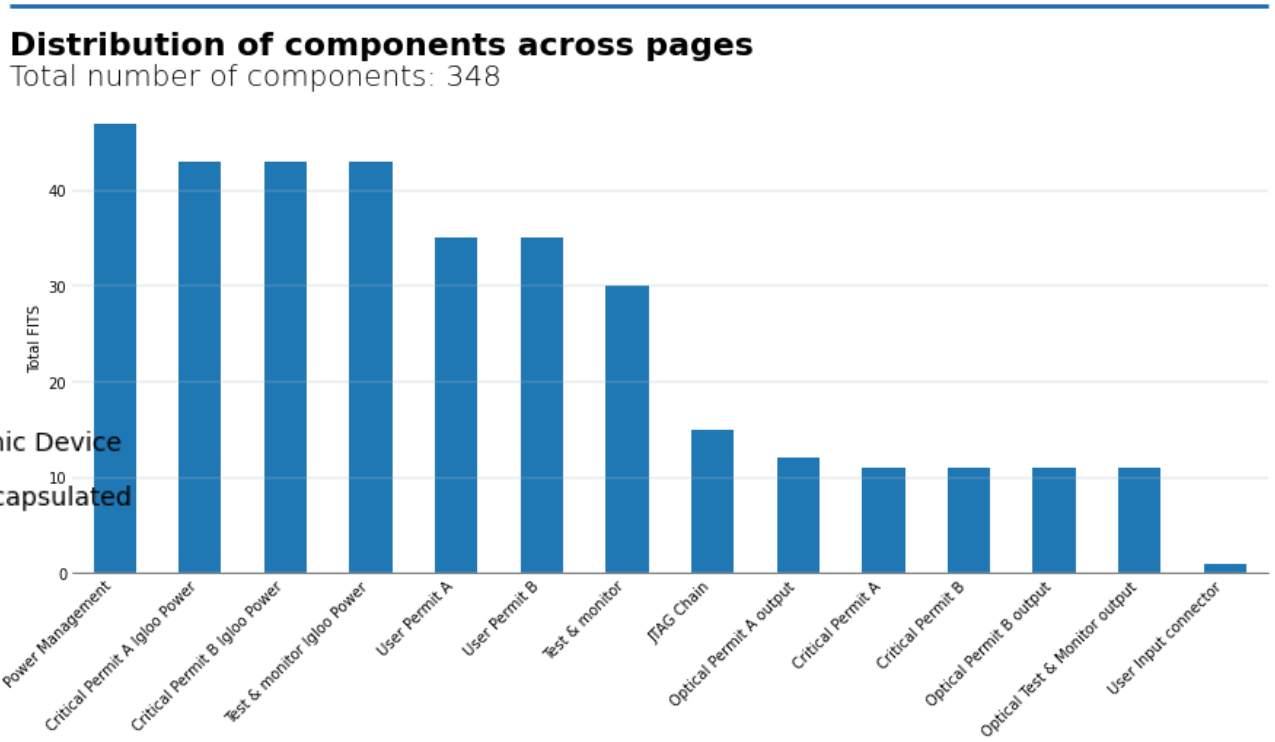
Distribution of component types and locations

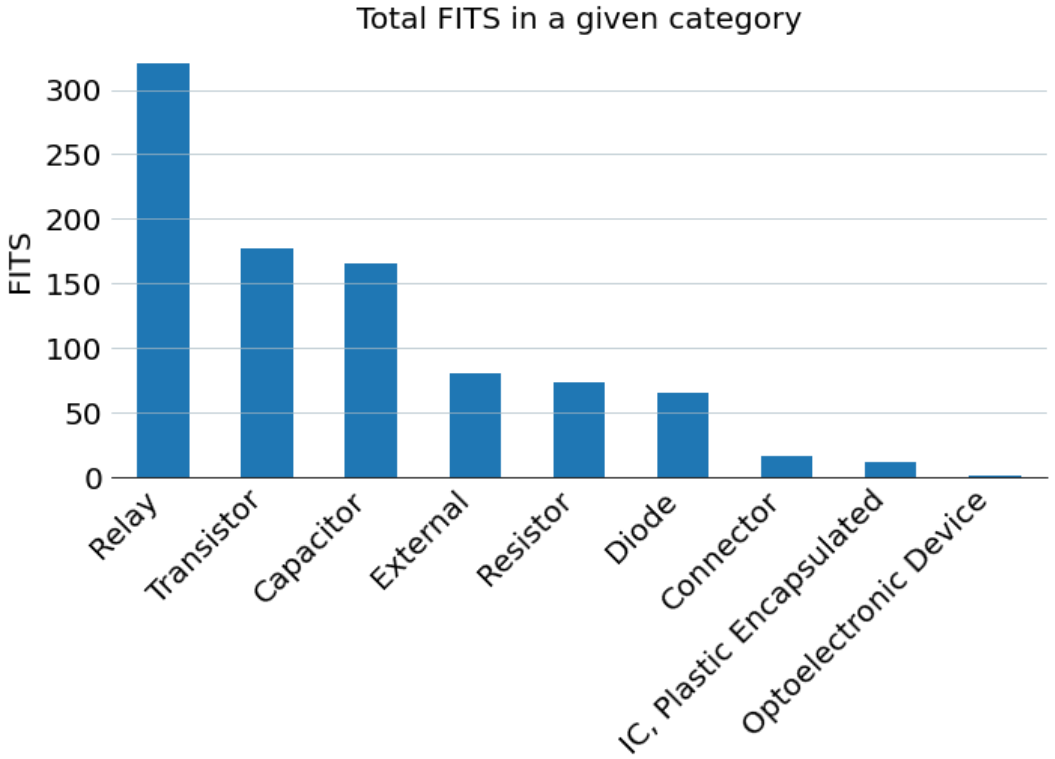


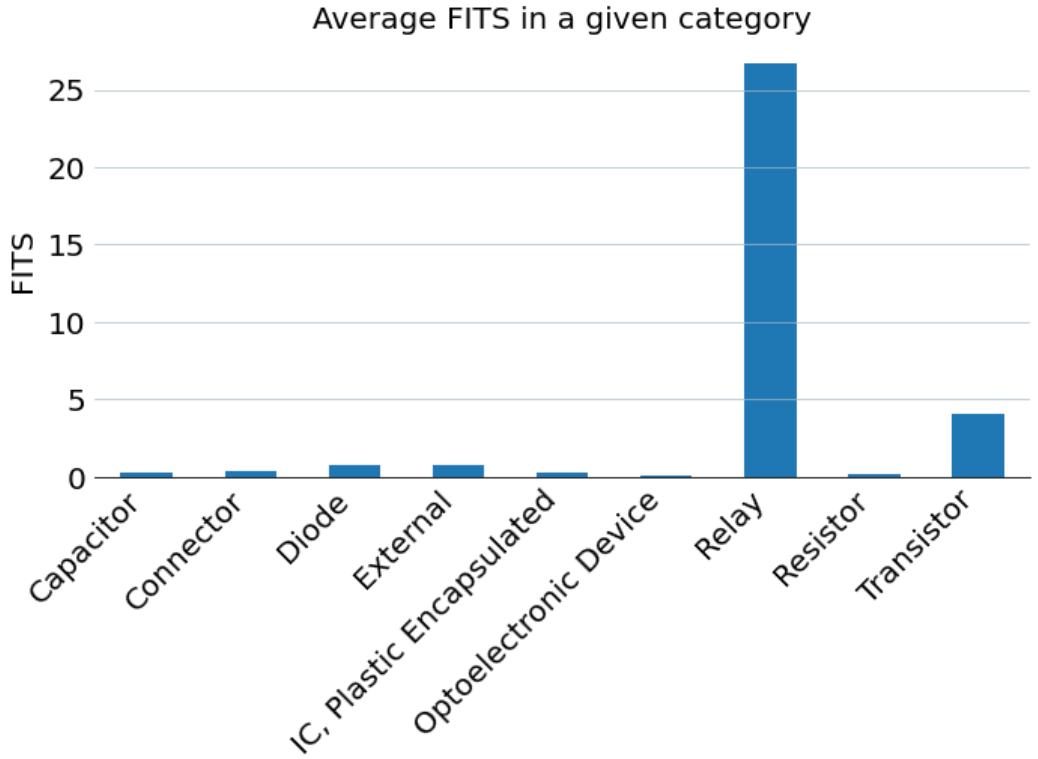


Failure rate prediction - statistics

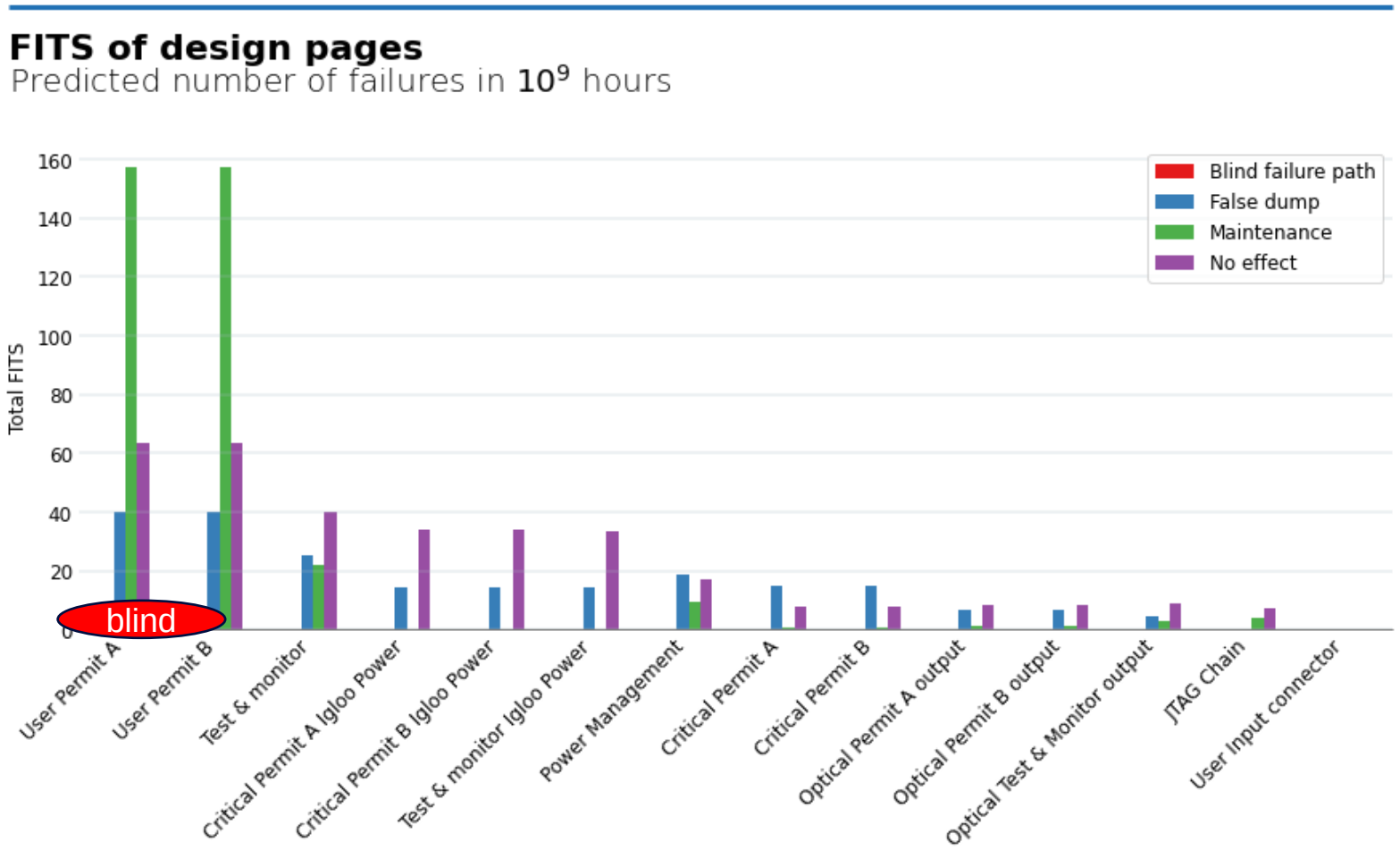
FITS of component categories

Distribution of number of predicted failures in 10^9 hours across categories

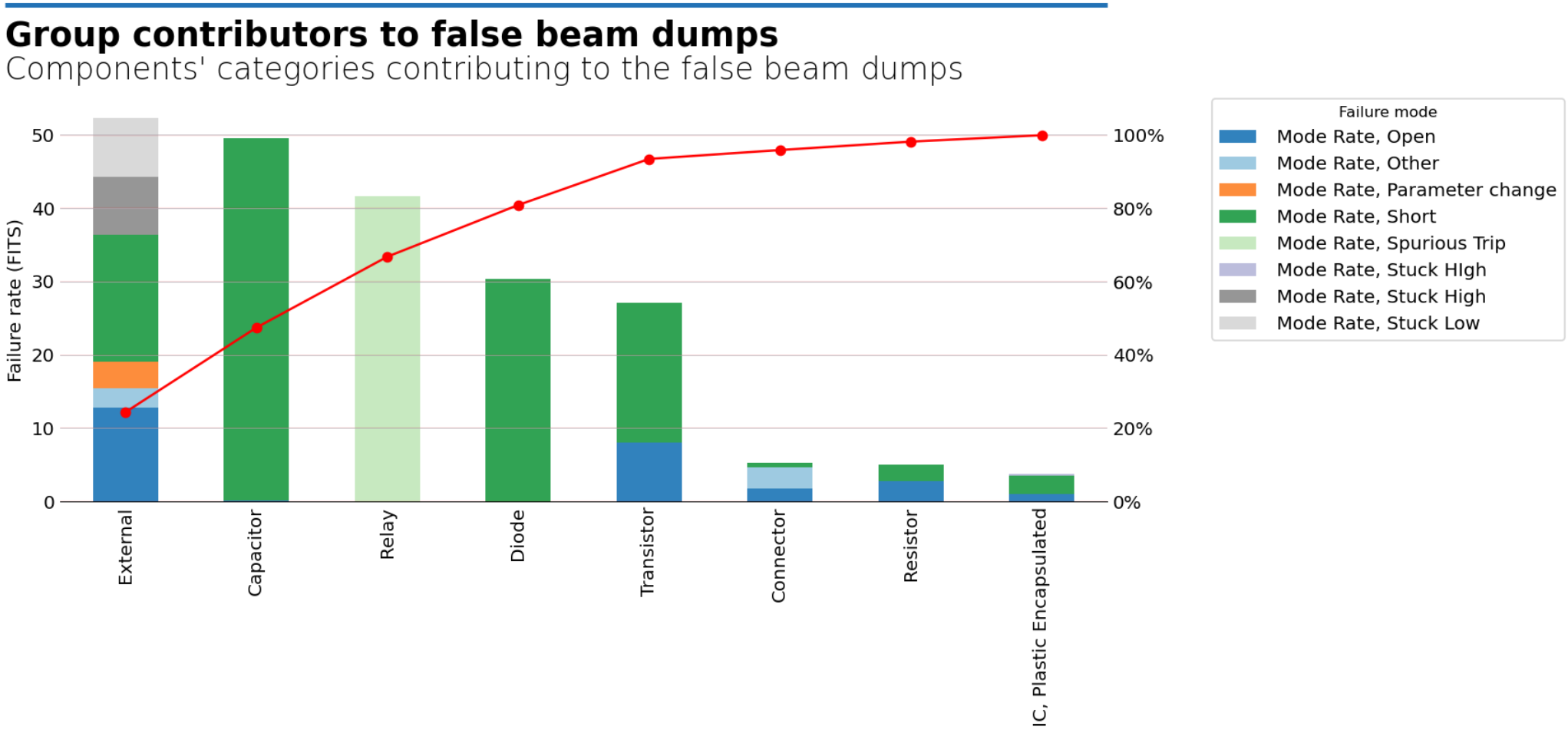




Failure effects per design location



Causes of false dump failures

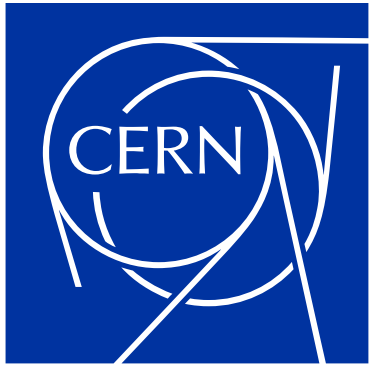


Next steps

- **SFP**
  A “daughter board” to be included in the FMECA. EDA-04670-V1.

- **Global model**
  As the study of the entire BISv2 system nears completion.

- **CIBDS**
  The next board in the BISv2 study



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