Smart Power Supply for FPGA and SoC

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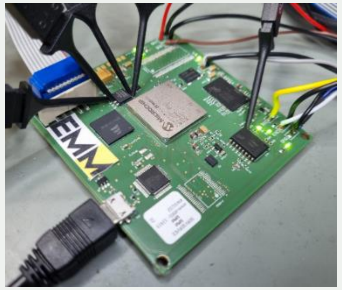
Engineering Minds Munich GmbH – Company Overview

engineering minds munich

2020 incubatee in ESA BIC

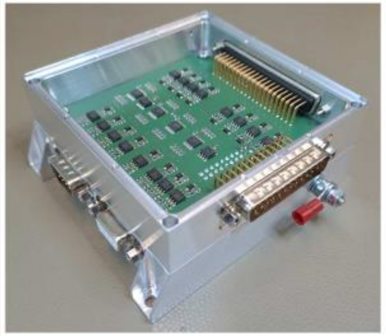


esa

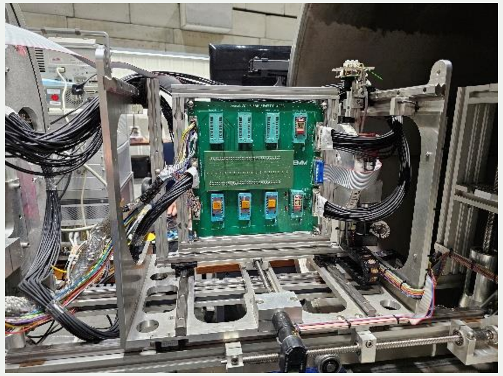
business incubation centre Bavaria

Smart Processing Module

Satellite mixed-signal electronics and data processing



Assessment of Non-Volatile Memories

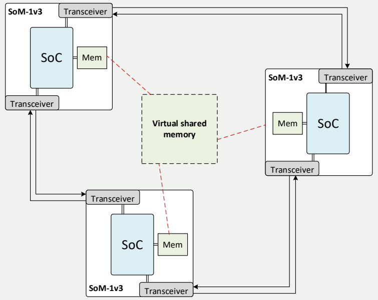


namlab
nanoelectronic materials laboratory

Fraunhofer INT

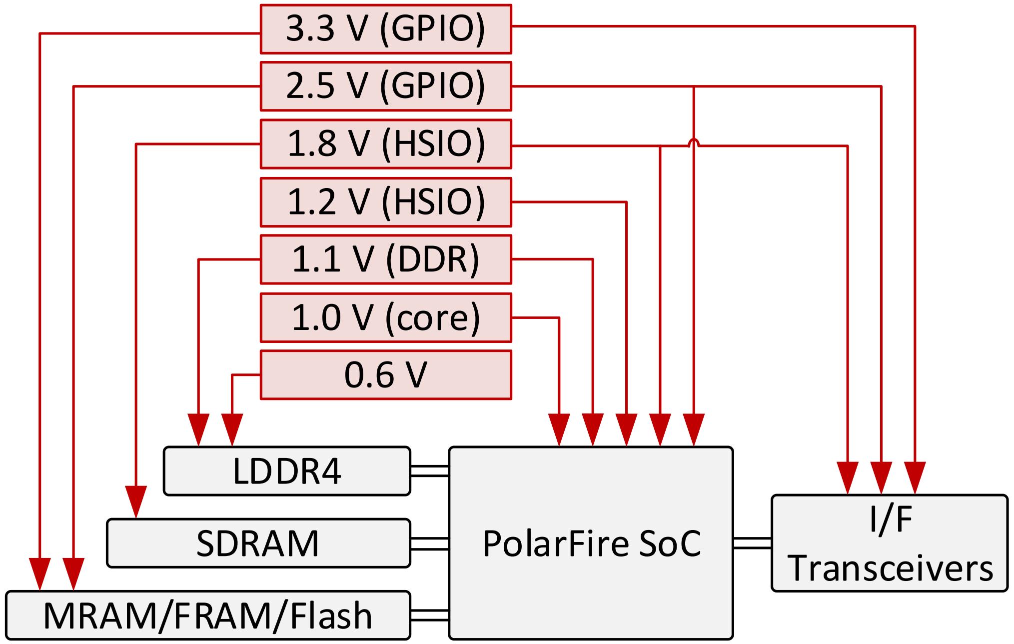
Distributed Multi-OBC

TUM



Bayerisches Staatsministerium für Wirtschaft, Landesentwicklung und Energie

Smart Power Supply – IDEA



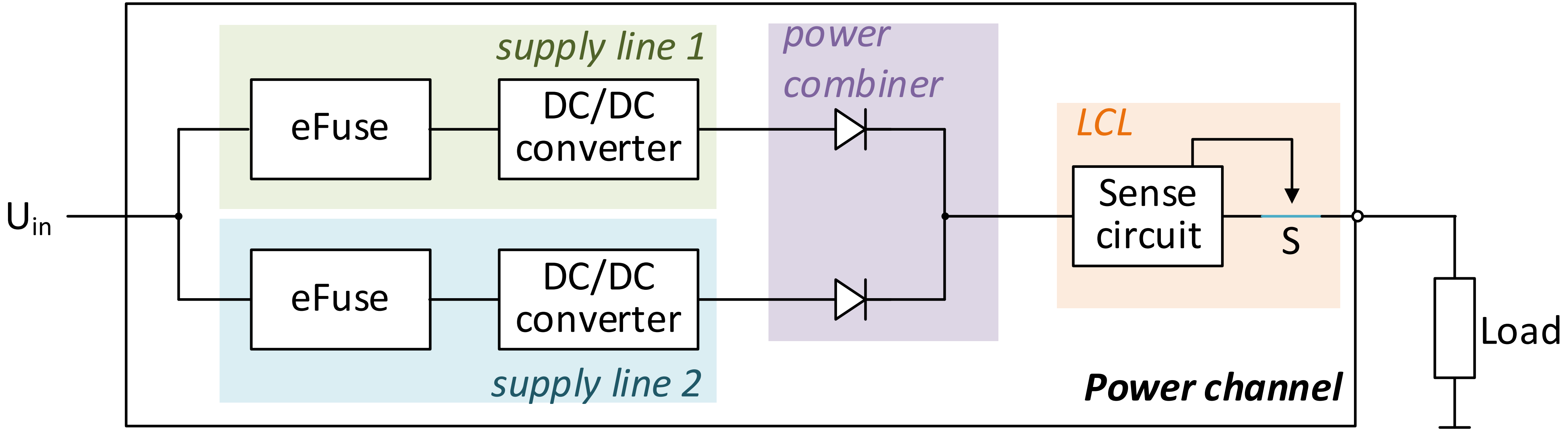
Secondary power supply for NewSpace electronics with low voltages at high currents

High reliability and radiation tolerance with COTS components

Modular, scalable, compact and cost-efficient

Key requirements for SPS

- 8 channels, 1.0V .. 3.3V, max. 3A per channel
- ±2% voltage accuracy
- Latch-up protection of load



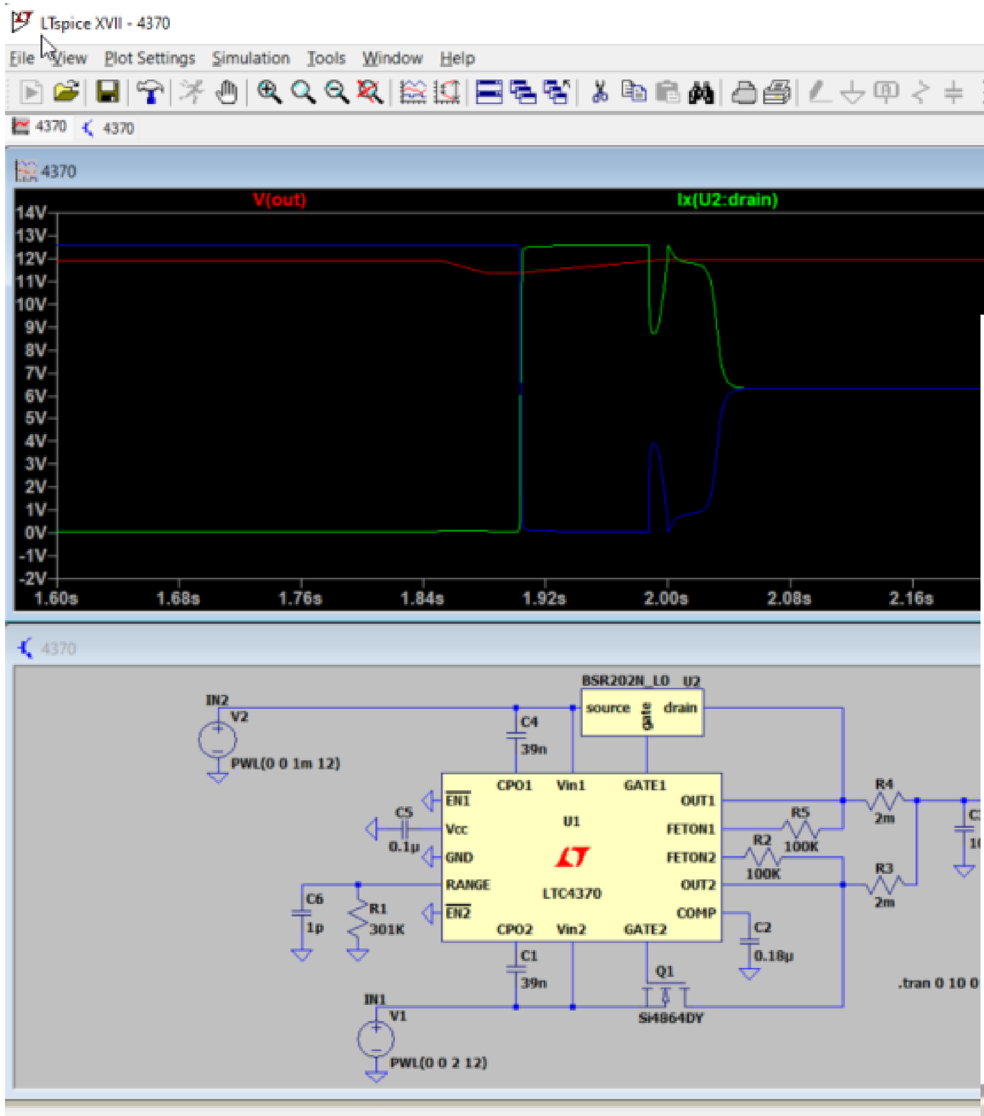
Each channel built with two active redundant supply lines

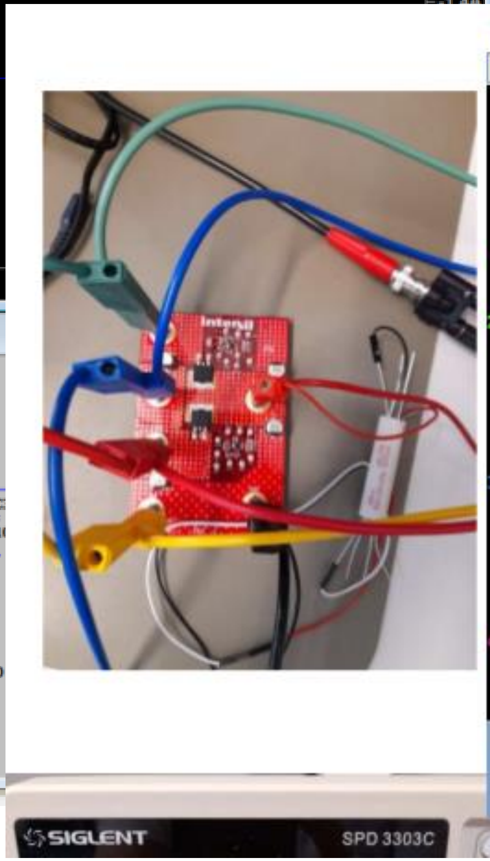
→ When both channels are on, the supply current is shared
→ When one channel is off, the supply current is fully provided by the remaining channel

Buck Converter Selection

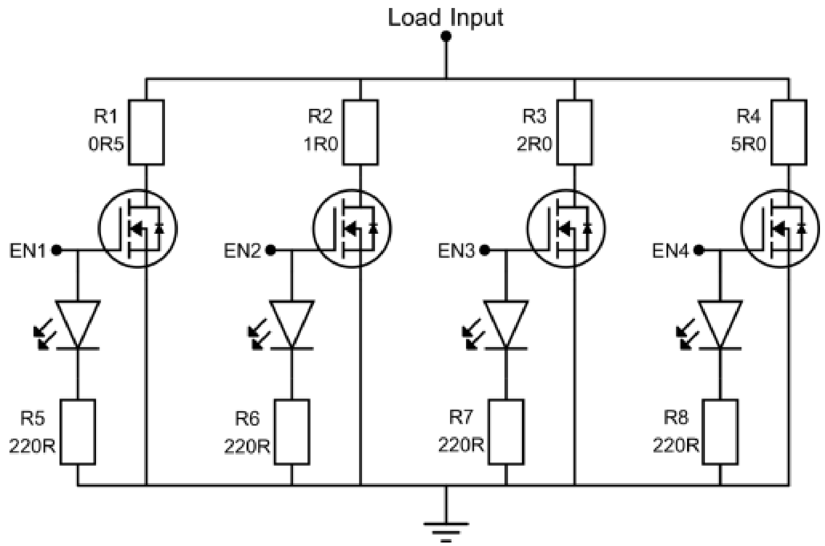
Buck Converters			Key Parameters					
IC	Manufacturer	Evalboard	$V_{IN\ MAX}$ [V]	$V_{IN\ MIN}$ [V]	$V_{OUT\ MAX}$ [V]	$V_{OUT\ MIN}$ [V]	V_{OUT} Accuracy	$I_{CONTINUOUS}$ [A]
L5987A	ST	STEVAL-ISA201V1	18	2.9	V_{IN}	0.6		3
IR3883	Infineon	--	14	4	5	0.5		3
LTC3307B	Analog Devices	DC2990A	5.5	2.25	V_{IN}	0.5	±1%	3
L6983NQTR	ST	STEVAL-ISA209V1	38	3.5	V_{IN}	0.85		
TLVM13630	TI	TLVM13630EVM	36	3	6	1	±1%	3
MagI3C-VDRM	Würth	MagI3C Evalboard 171050601	36	6	6	0.8		5
BD9E303EFJ-LB	Rohm	BD9E303EFJ-EVK-001	36	7	VIN x 0.8	1		3
ST1S50	ST	STEVAL-ISA146V1	18	4	0.88xVin	0.8		4
SC186	Semtech	--	5.5	2.9	3.3	0.8		4
PM8903ATR	ST	--	6	2.8	5.5	2.9	±1%	3

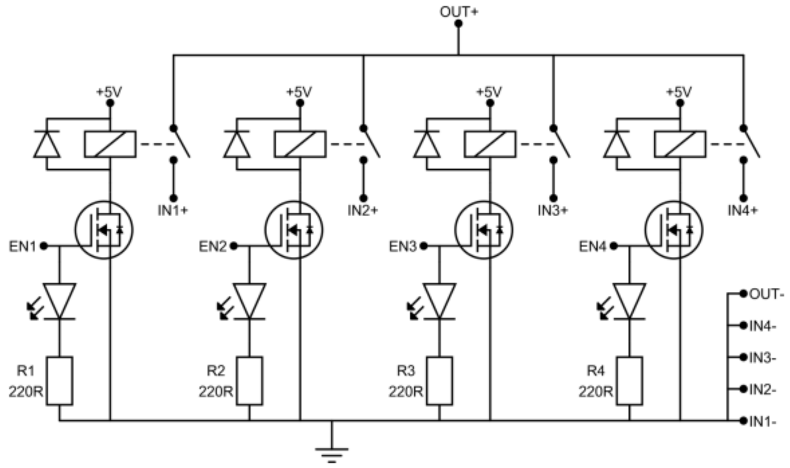
Simulations and Breadboard Tests



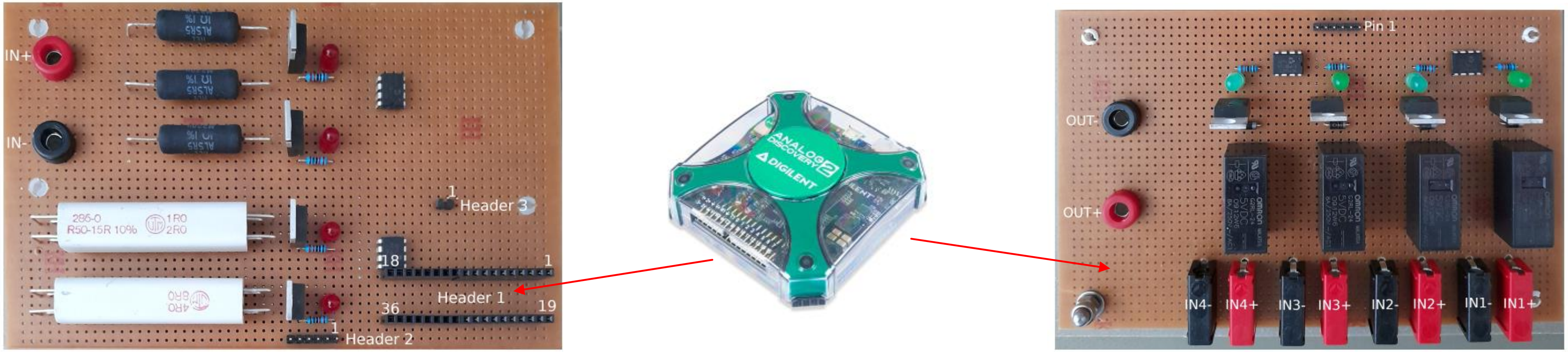


Load Matrix





Load distribution to 4 channels



diation tests with
ring to check
degrade at 1 krad

Component Radiation Test Results

Time	TID [Gy]	SC186-1 [V]	SC186-2 [V]	IR3883-1 [V]	IR3883-2	TCKE805 [V]	STEF033 [V]*
10:46	1.75	1.804	1.804	1.843	1.836 [V]	4.992	4.420
11:56	3.50	1.812	1.804	1.835	1.834	4.920	4.470
13:06	5.25	1.810	1.800	1.862	1.864	4.940	4.460
14:24	7.00	1.804	1.804	1.835	1.852	4.990	4.410
15:31	8.75	1.804	1.804	1.835	1.833	4.940	4.470
16:38	10.50	1.805	1.806	1.836	1.835	4.990	4.470

- Buck outputs are adjusted to 1.8 V
- eFuses are measured without load

* STEF033 is limiting output voltage to 4.5 V

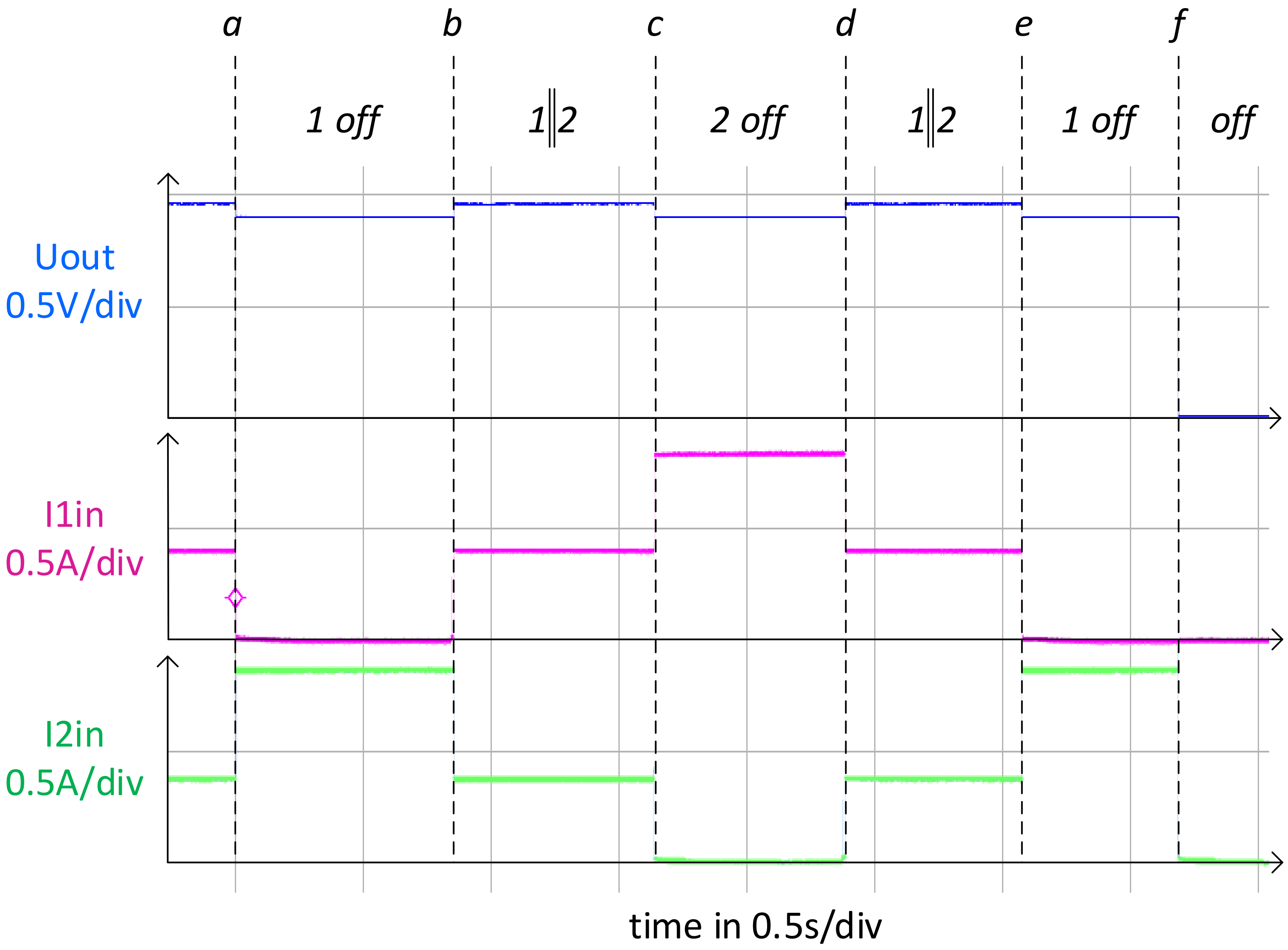
SPS Breadboard

eFuses Bucks CSCs LDO LCL

- Several options can be selected via jumpers (e.g. output with or w/o LDO)
- Test pins are included to measure internal signals and apply error sources

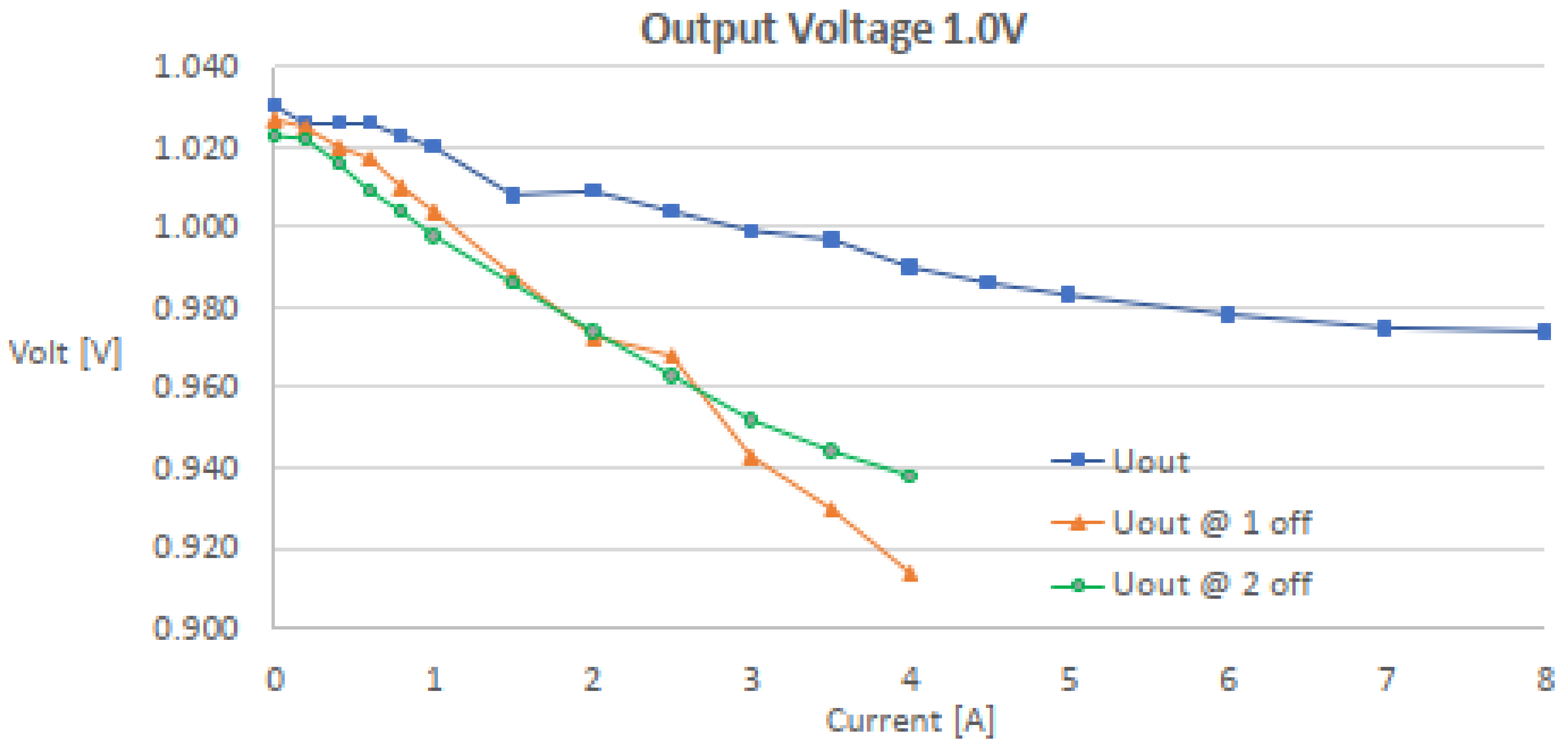
- By removing all of the test parts, a PCB area of 8 cm² is feasible

Load Sharing

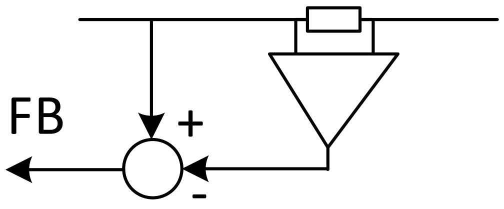


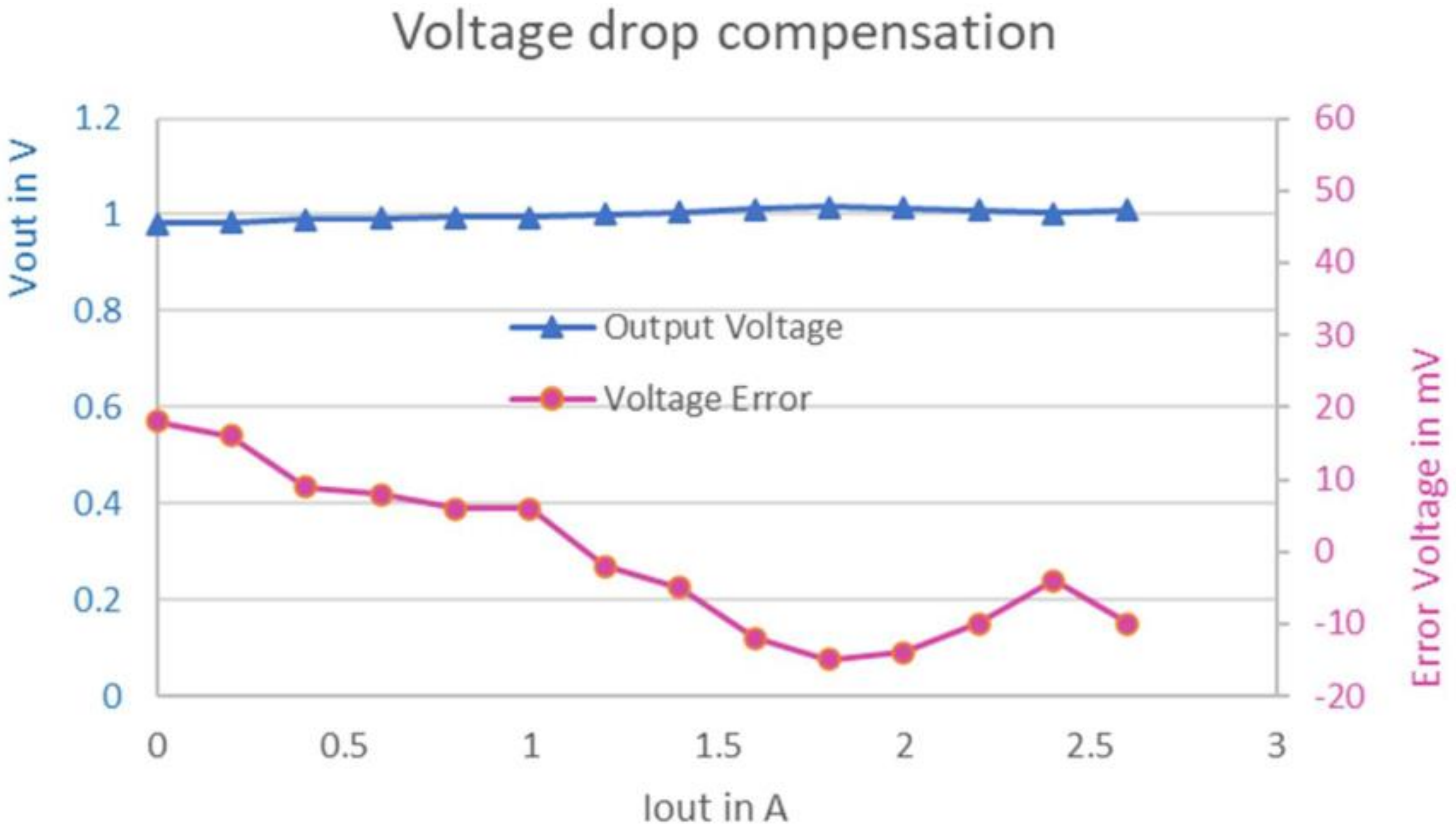
Load sharing performs, but the output voltage has some drops

Output voltage accuracy



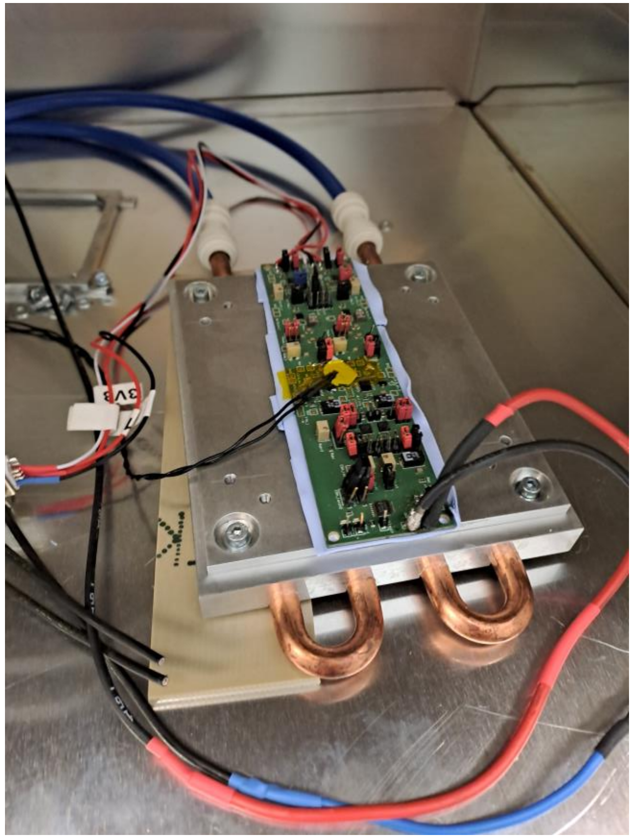
The tolerance of ±2% (0.98 .. 1.02 Volt) is only achieved from ≈ 1.0 .. 1.8 Amp

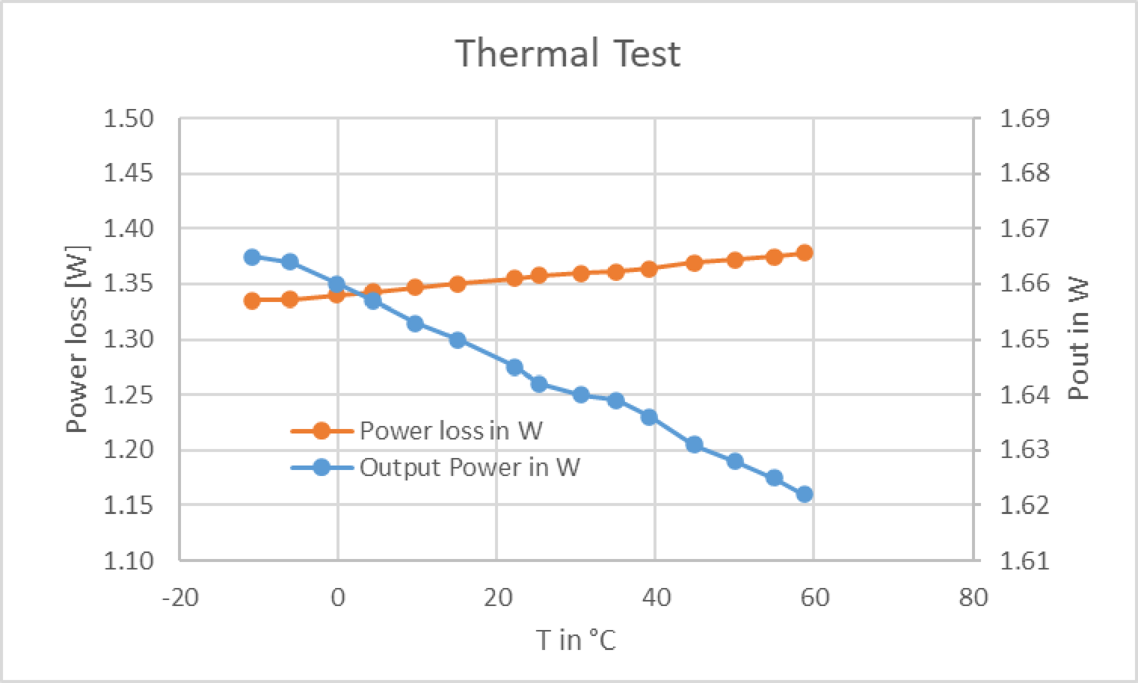




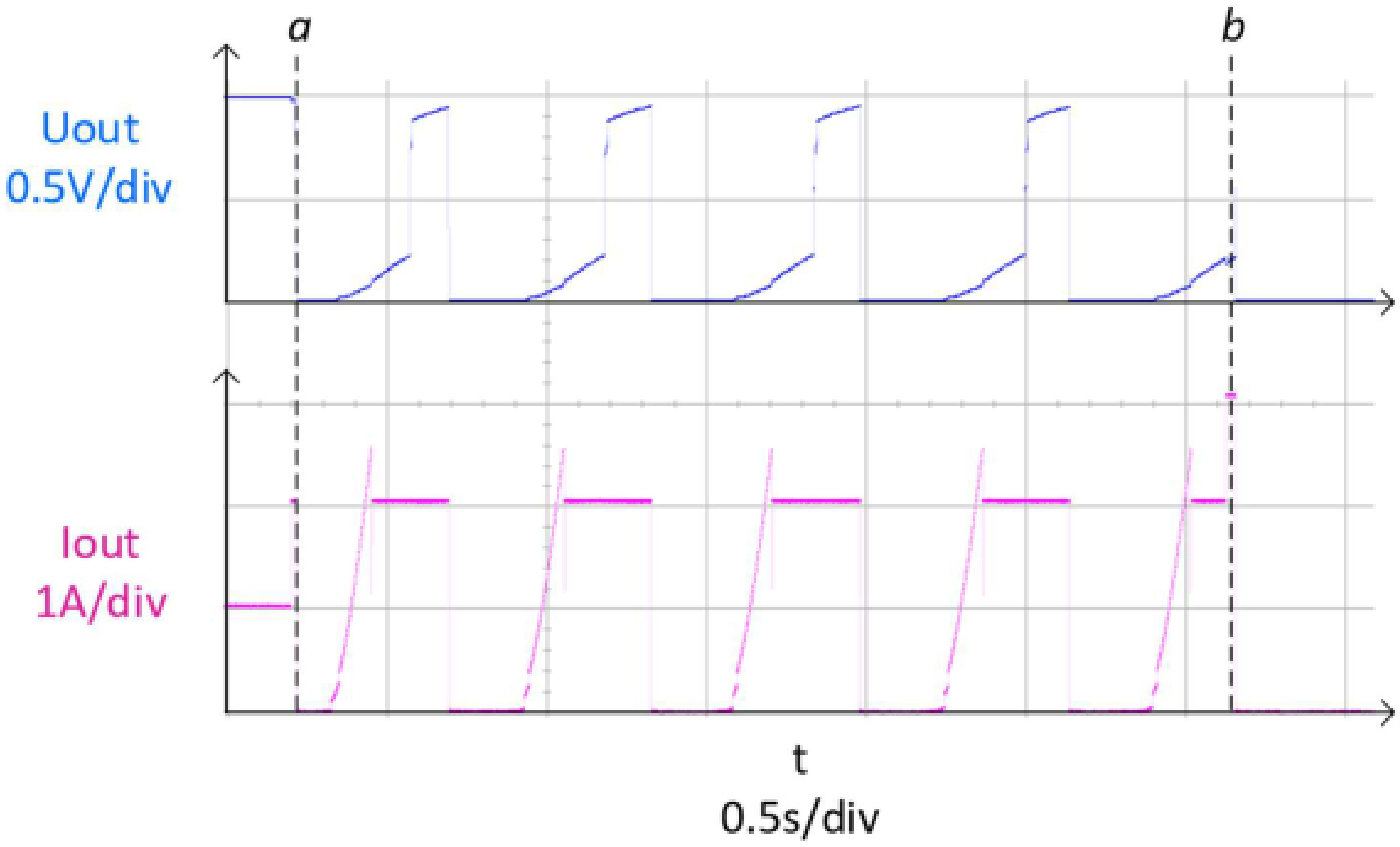
A output current-dependent voltage is subtracted from the Buck feedback (FB) to Compensate for voltage drop across series resistances of CSC and LCL.

Thermal Vacuum Testing





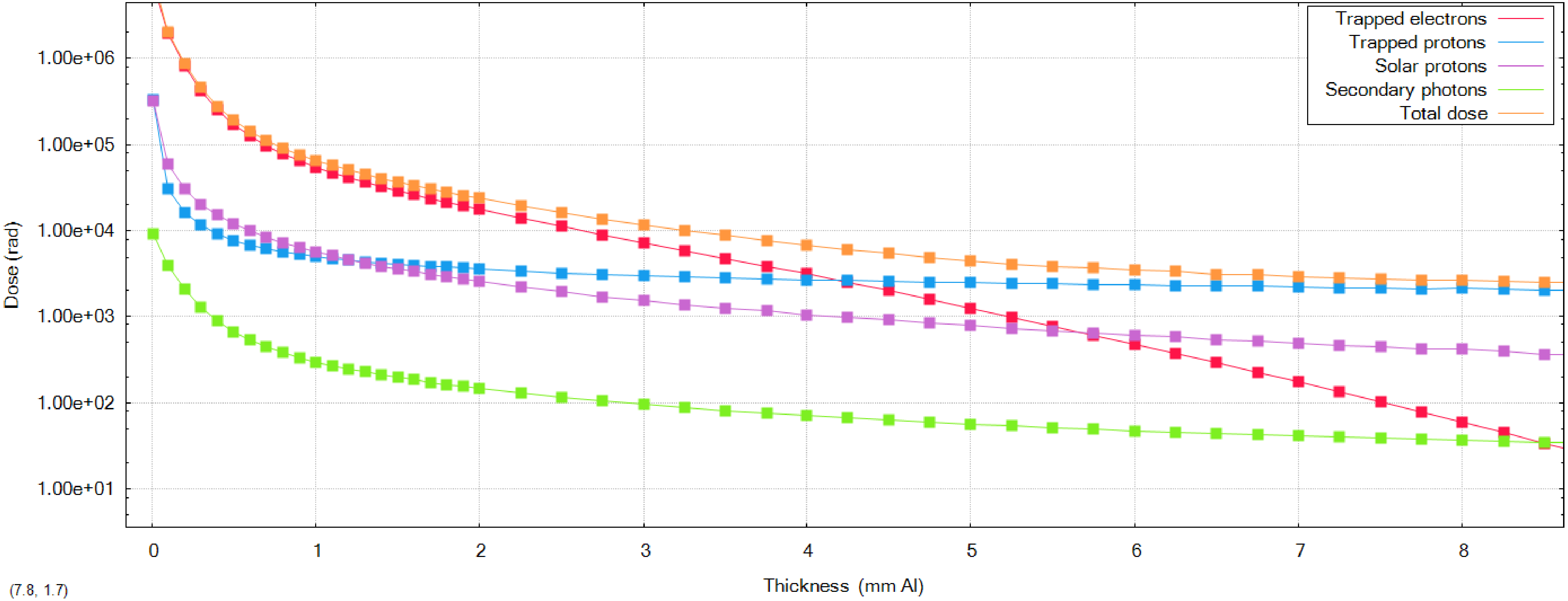
LATCH-CURRENT LIMITATION



Using an electronic load:

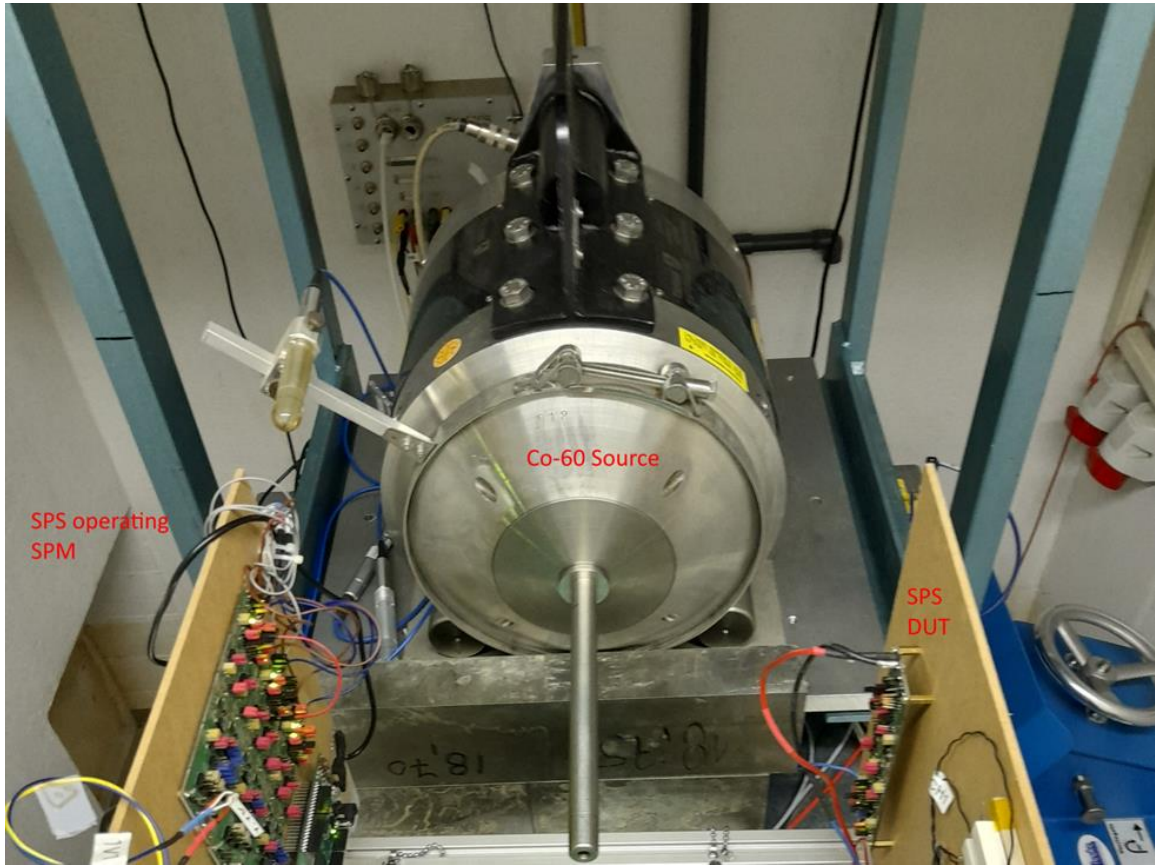
- Nominal current: 1A
- @ a : increased load to 2A
  → hick-up mode

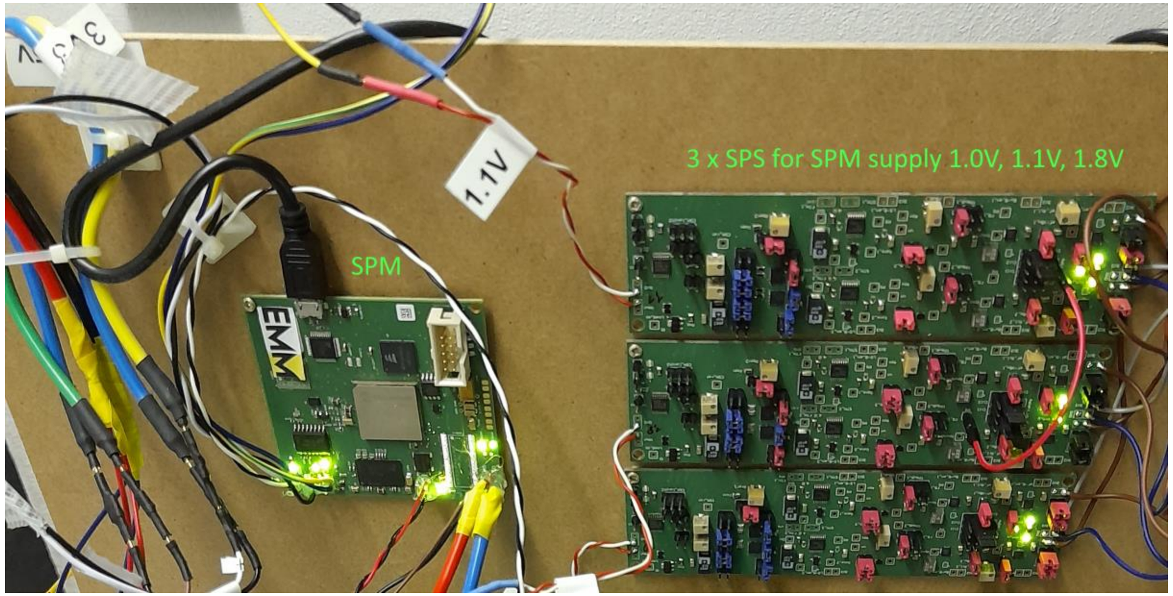
- @ b : increased load to 3A
  → Output switched off



OMERE Software Assuming an aluminum-equivalent shielding thickness of 3mm results in a radiation load of a little bit above 10 krad. With a radiation design margin of 2, any equipment for such a mission would need to be compliant with 20 krad of TID.

https://www.trad.fr/en/space/omere-software/



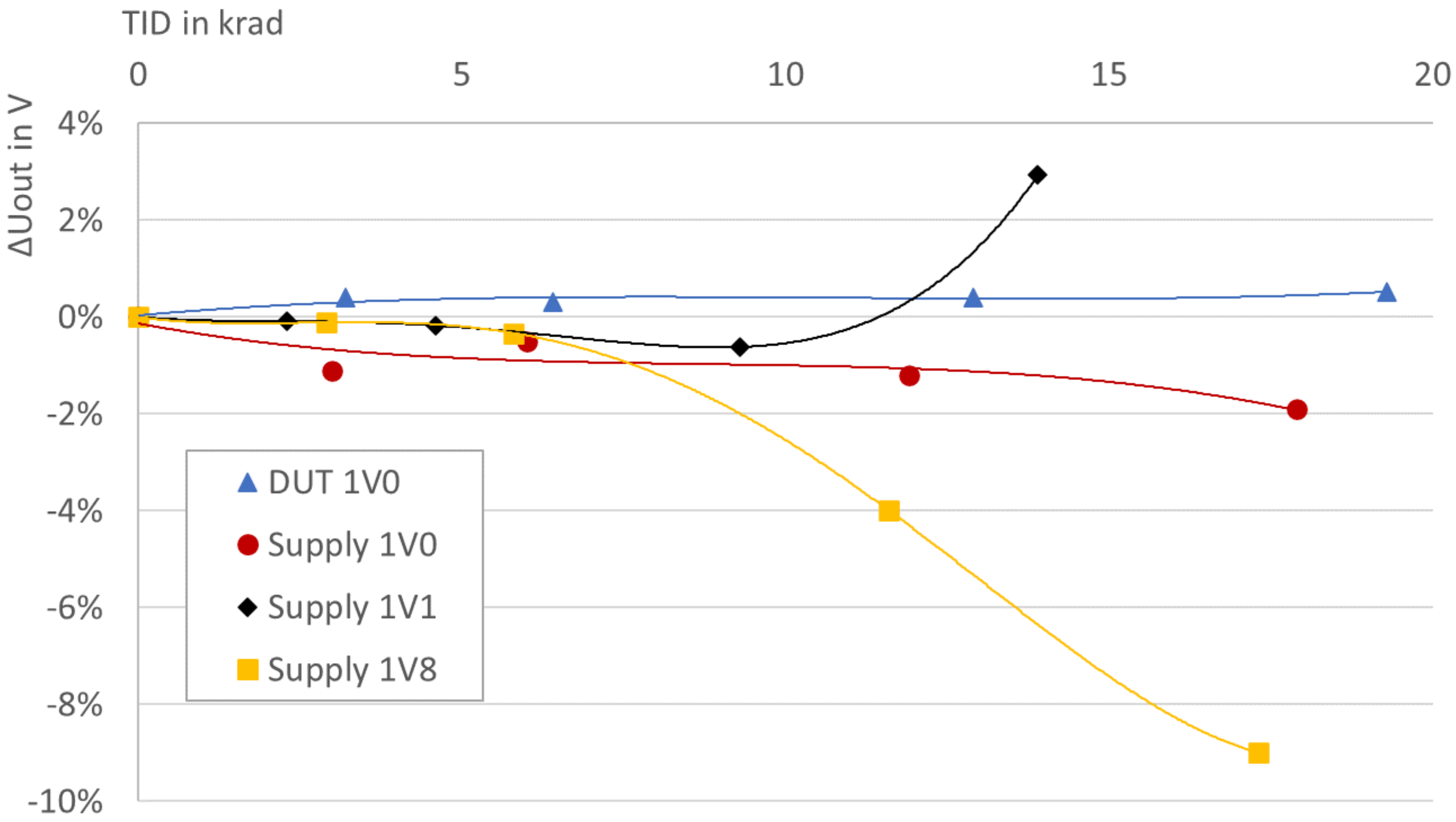


Co-60 source was used to apply TID

4 SPS breadboards have been tested:

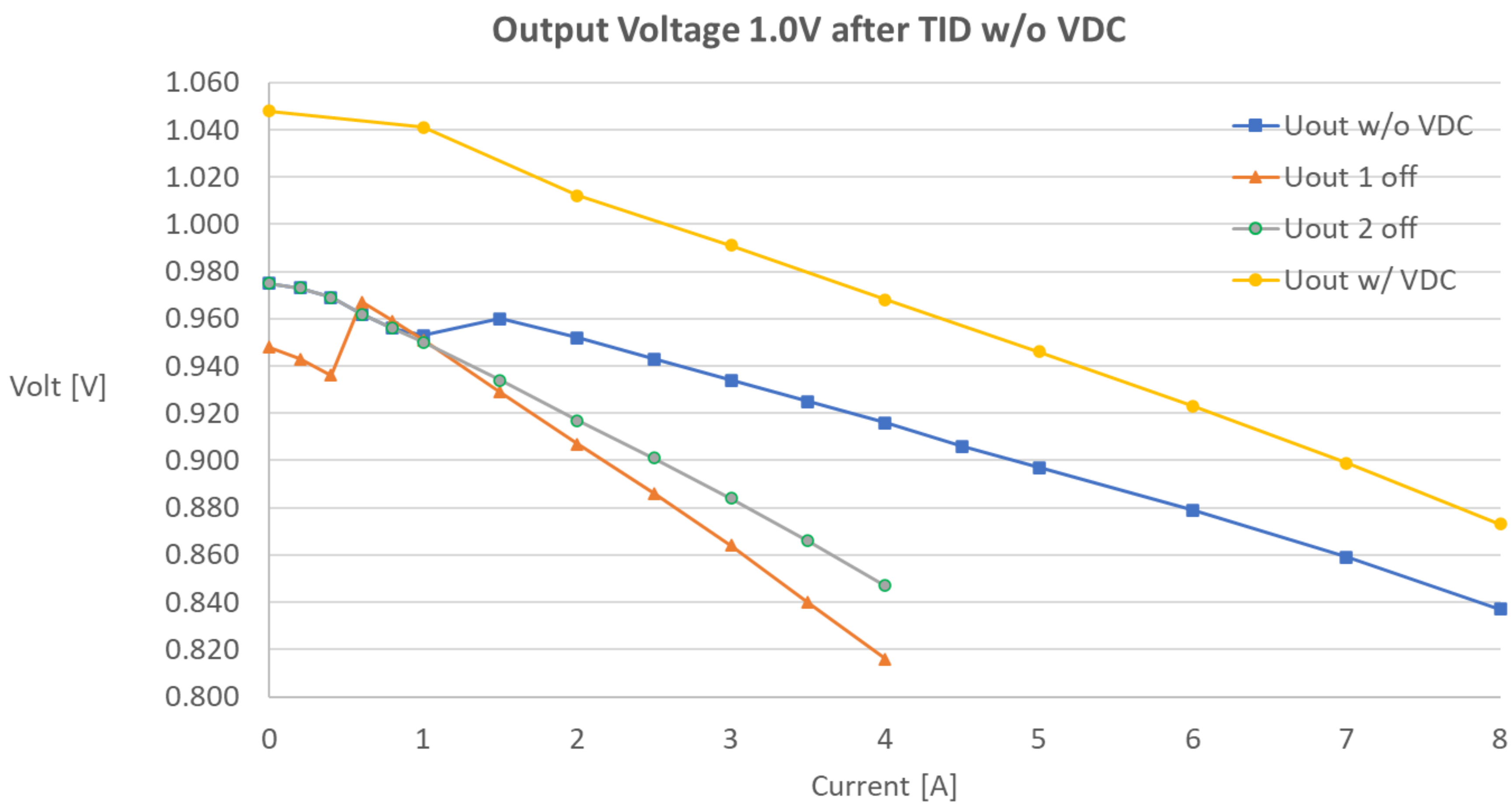
- 1 connected to electronic load
- 3 supplying a processor module

Output Voltage Accuracy

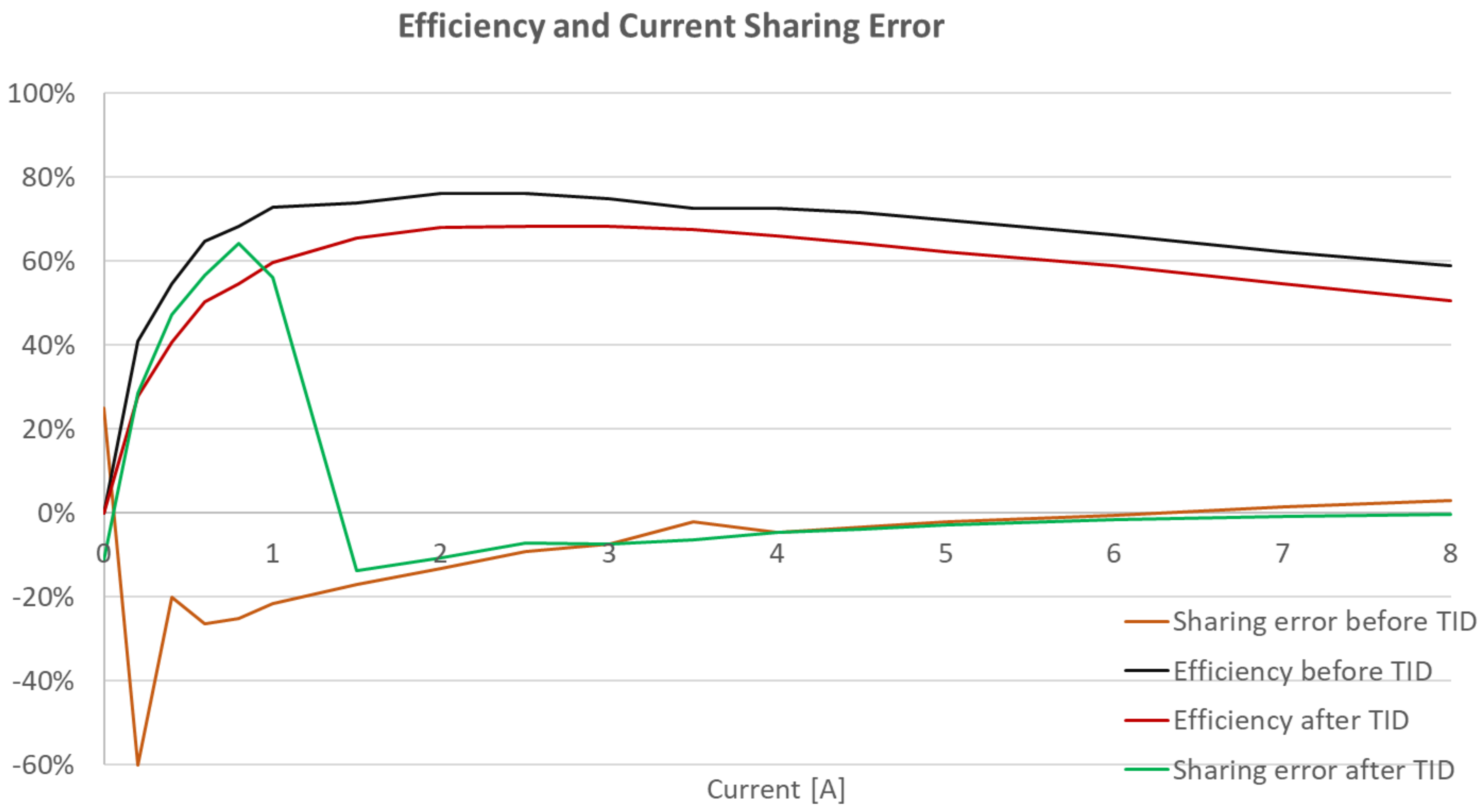


LDO regulators of 1.1V and 1.8V appear to introduce voltage drifts.

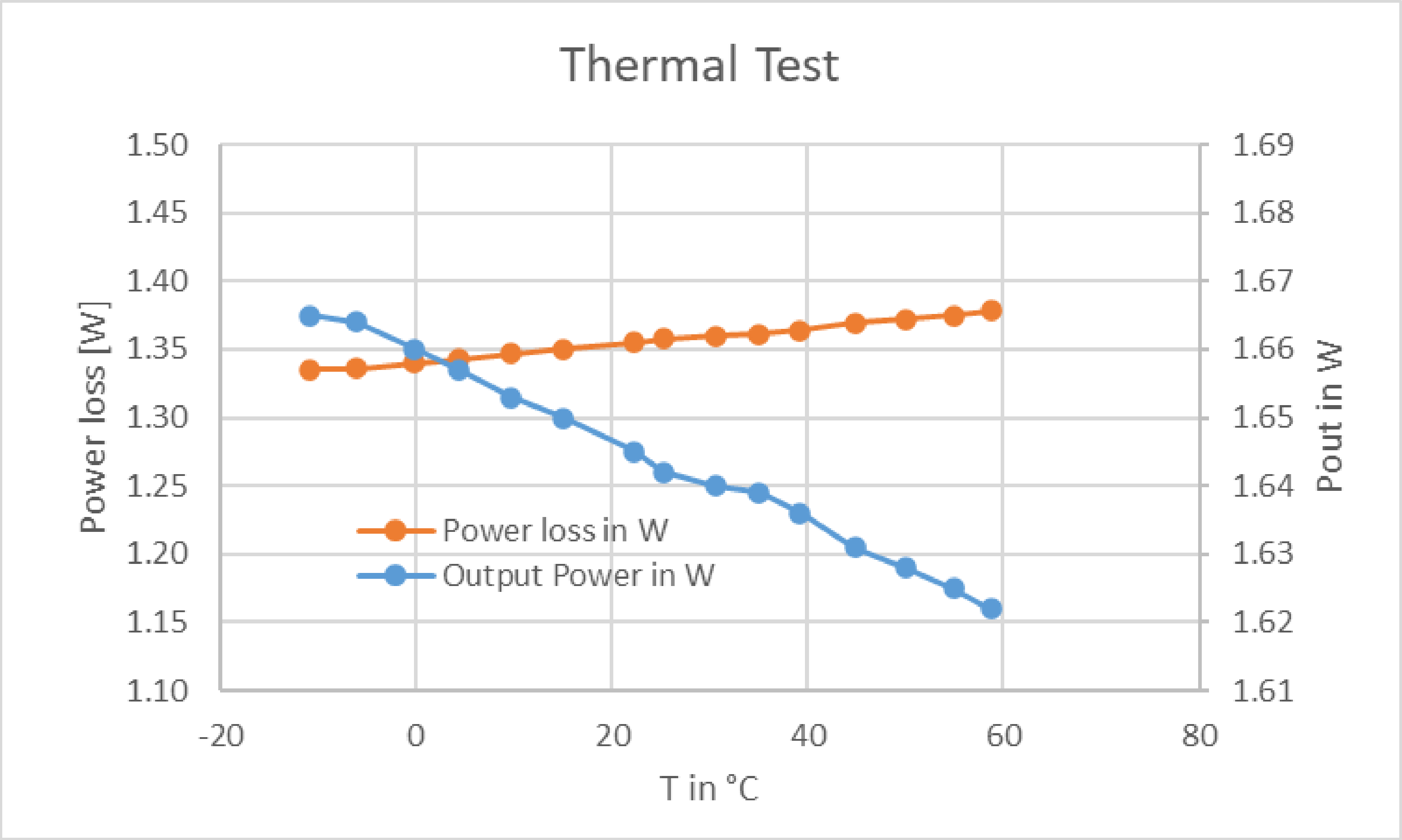
Output Voltage after TID



COMPARISON OF SPS BEFORE AND AFTER TID

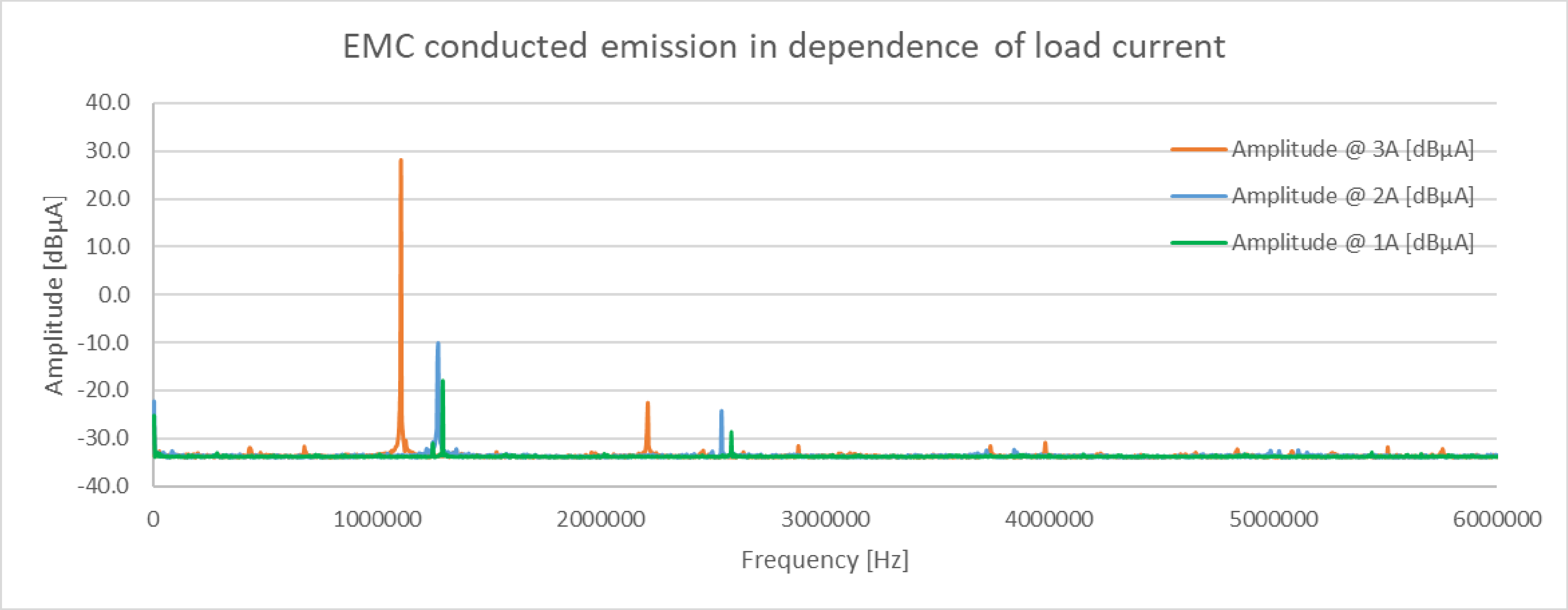


TID introduced a 10% efficiency degradation

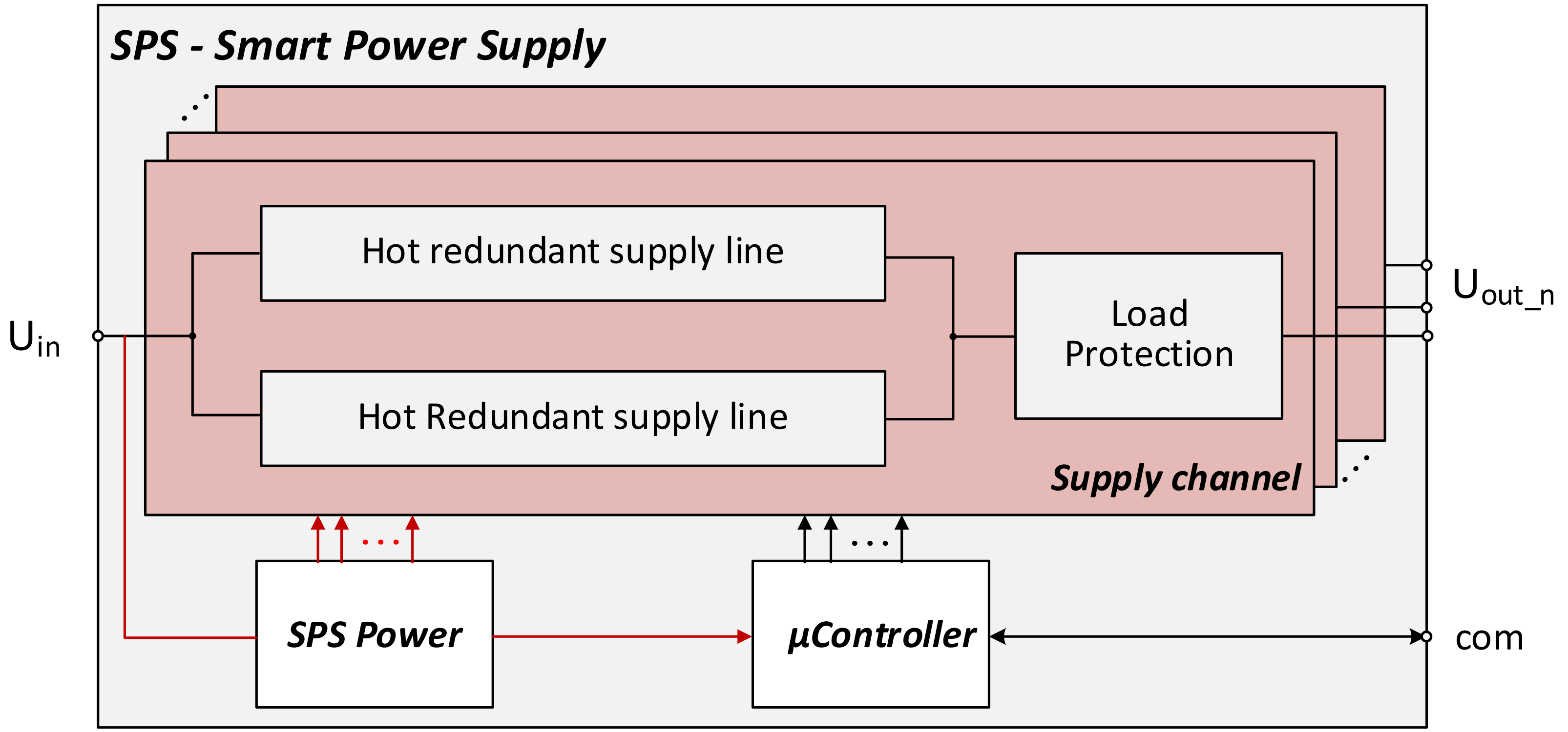


Efficiency is in the order of 55% only, this was performed after TID tests

EMC Test Results



Top-Level Concept



8 supply channels will be combined into one module, each having 2 supply lines

A rad-tolerant Point-of-Load converter will be implemented for SPS power supply

A rad-tolerant µController will be implemented for SPS control and HK DAQ

CONCLUSION

Smart Power Supply will fulfill the needs for low voltage, high current components

The modular concept also allows to combine several supply lines and build 2 out of 3 or other constellations, providing higher currents (6, 9, 12 A).

Many thanks to Nikola Bošković who guided us through this activity !

Thank you for your attention!