Novel Safe-Life concept for circuit protection devices

5th Space Passive Component Days (SPCD), International Symposium, 15-18 October 2024, ESA ESTEC

Bruno Zemp, Elmehdi Moradi

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Agenda

> Motivation & Goal

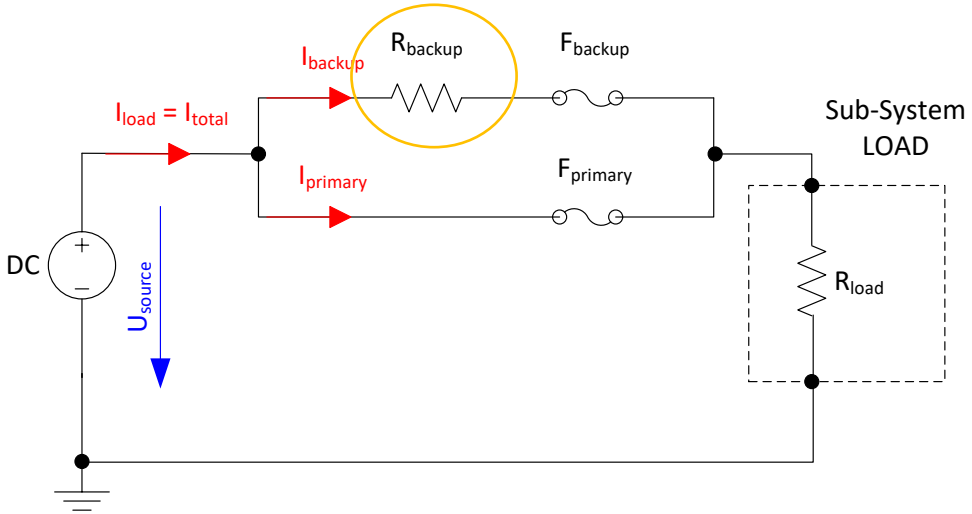
> Novel Safe-Life Module – Concept and Function Model

> Results and next steps

Motivation

A degraded or faulty component can lead to an unexpected system failure.
⇒ Therefore, redundancy concepts are applied.

Common warm-redundancy circuit with fuses:



REQ:
$P_{max\_R\_backup} = I^2 * R = 1.2\ W$

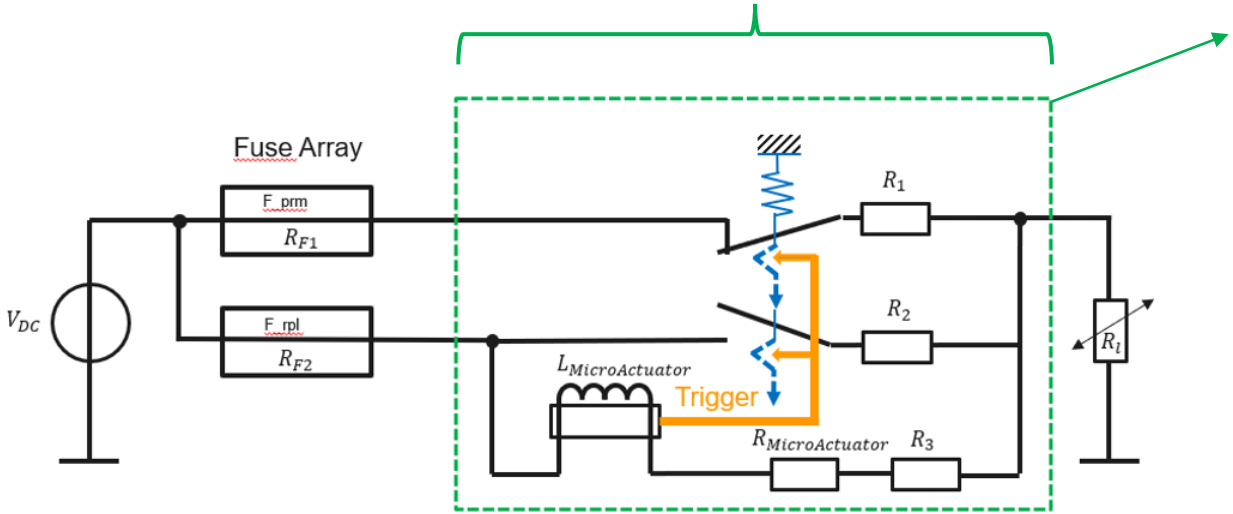
Not feasible for currents above 3 A
(violation of criteria above)

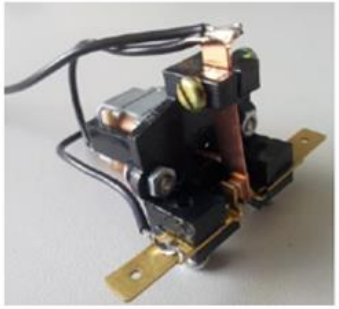
GOAL:
Solution for high current applications (> 3A) with low ohmic-losses

Goal	REQ	Comments
Low ohmic losses	Electric resistance < 5.3mOhm	Resistance similar to HCSF 15 A (max. 5.3mOhm)
	Total Power Dissipation <= 1.2 W	10-times smaller than with series resistor!
Compatibility for rated components up to 15 A	15 A (continuously)	e.g. SCHURTER space fuse range goes up to 15 A
Safe isolation of a fault circuit	Galvanic isolation	
Small Size	<= 1cm^3	

Safe-Life Module

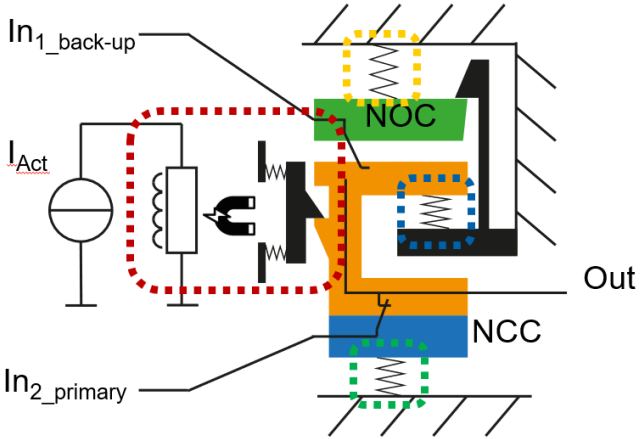
A three-terminal device





Very first function model

Safe-Life Module: Si-based irreversible (MEMS) Microswitch



Travel Springs

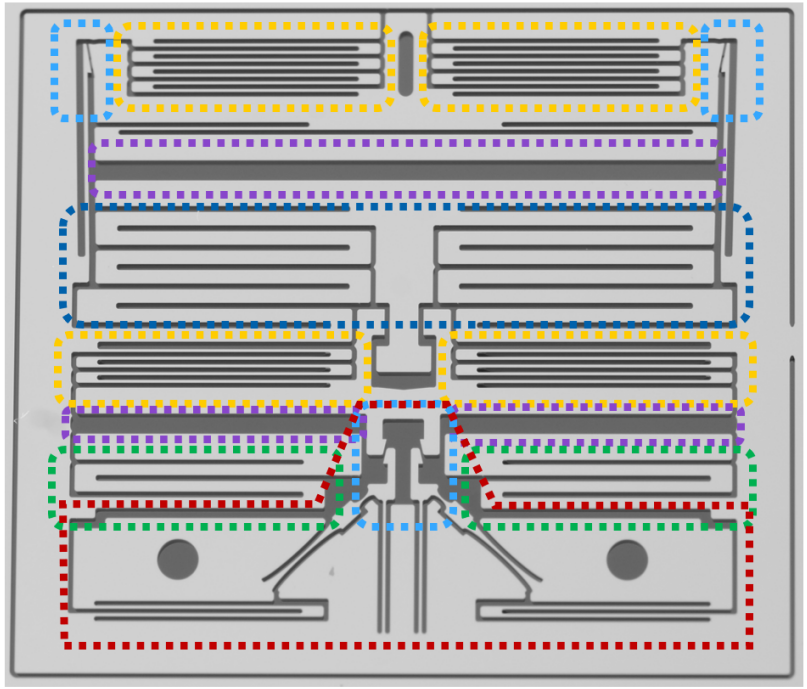
NOC

Main Spring

NCC

Split Spring

Mechanical Locking



Release Mechanism

Size = 14 x 14 x 0.5 mm

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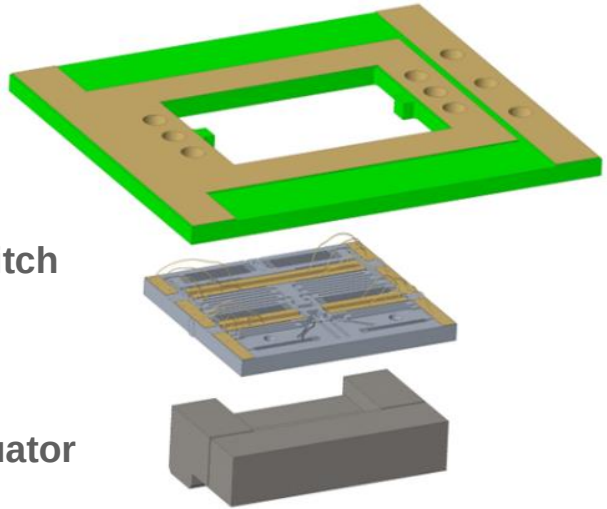
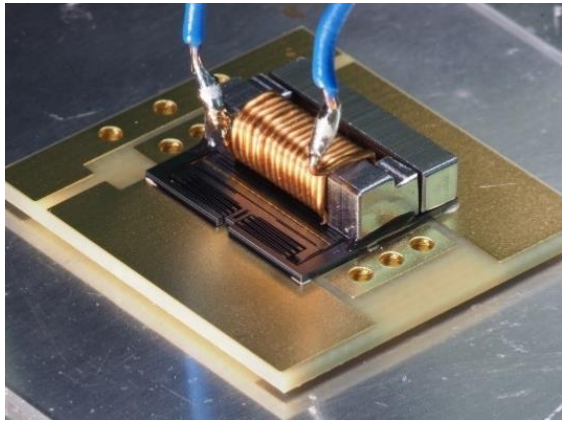
CONCEPT

PCB

Irreversible microswitch system on a Si-chip

Electromagnetic actuator





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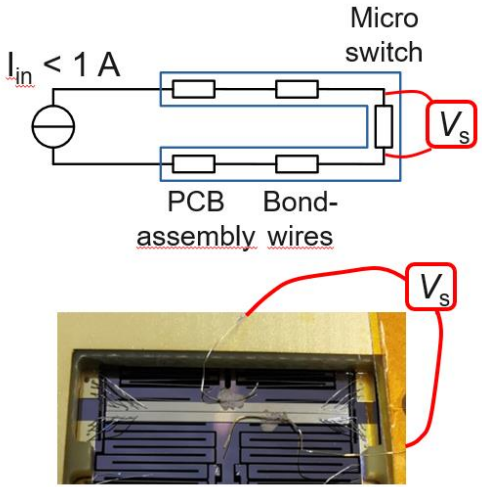
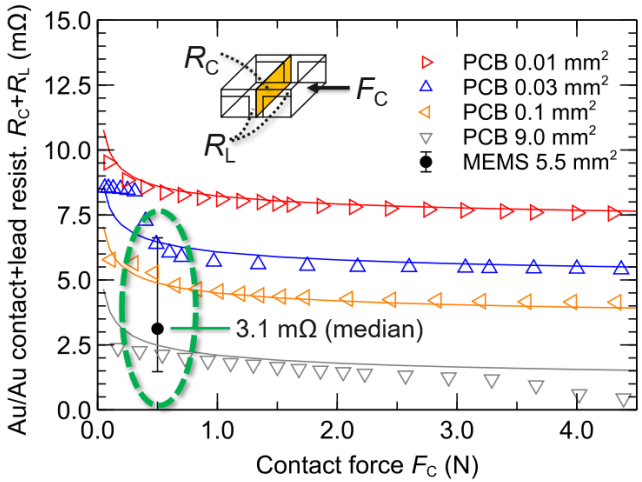
Cold Resistance Measurement



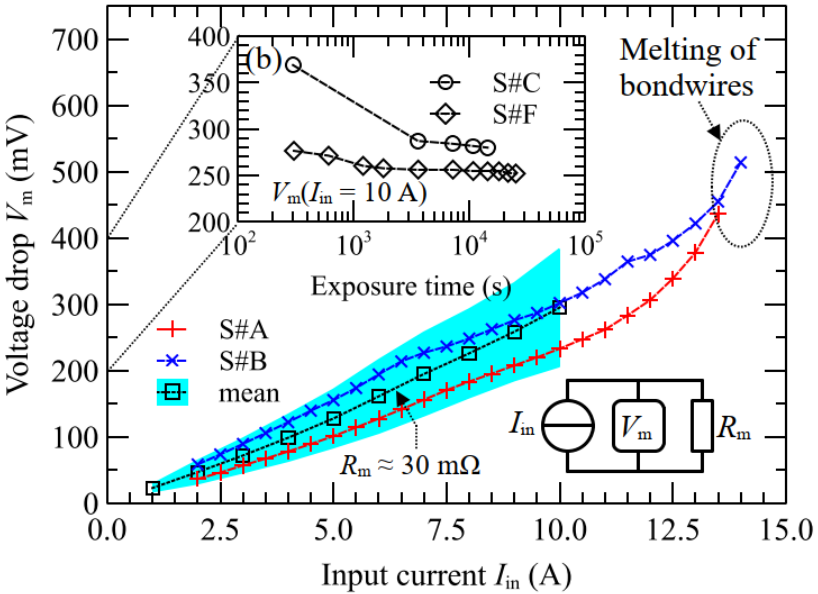


Sample size = 8

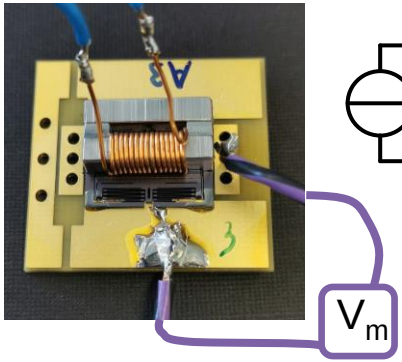
Observation

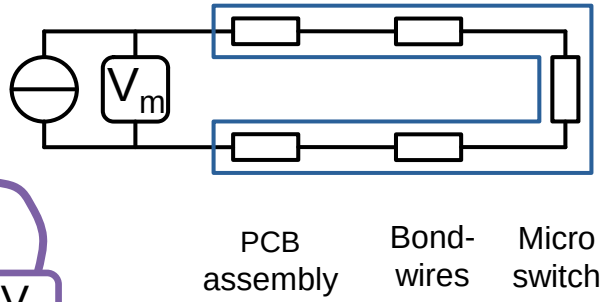
Contact resistance NCC: 3.1 mOhm (median)

Design limit test -> current step test (voltage drop as function of input current)



Sample size = 5





Observations:

Linear function U = f(I) up to 10 A:

⇒ warm resistance: ~30 mOhm
⇒ Power dissipation: ~3 W (approx. 3-times higher than SCHURTER HCSF 10A)

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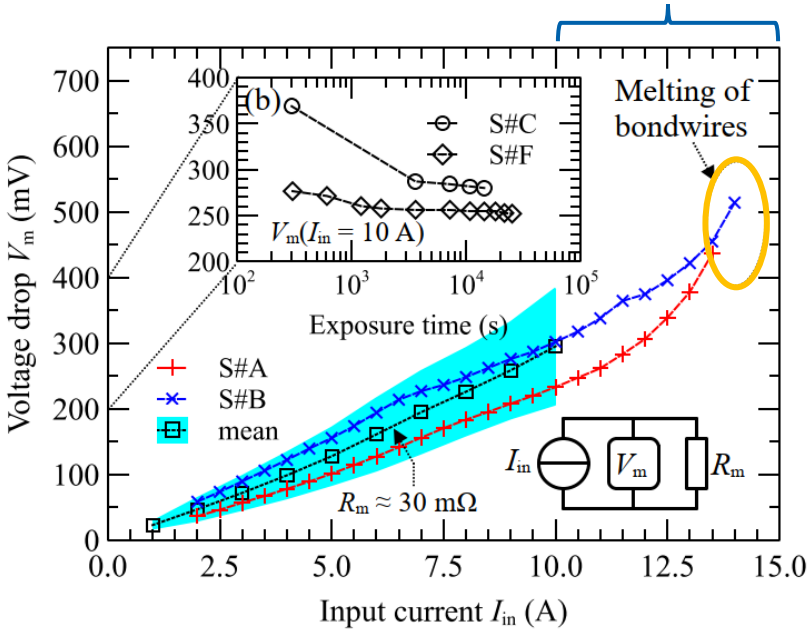
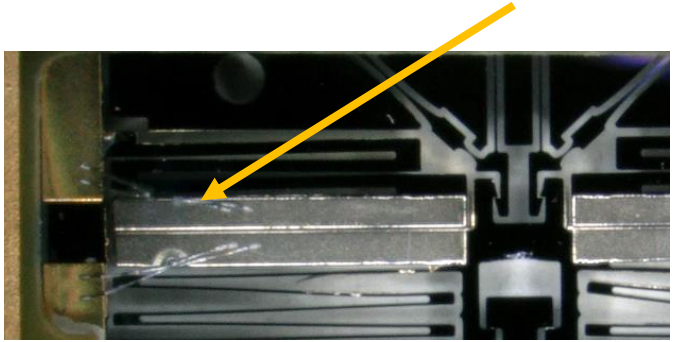
Design limit test: Currents above 10 A



Observation

Max. surface temperature:

10 A:	65°C
12 A:	> 100°C (at contact area and wire-bonds)
>13.5 A:	damage -> wire bond melt-down!

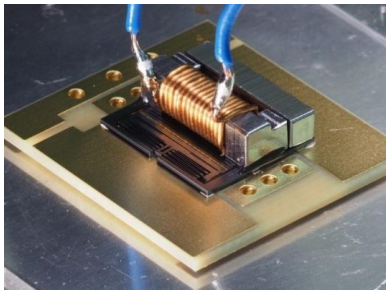


Sample size = 2

Summary and next steps

Goal	REQ	Concept – Function Model
Low ohmic losses	Electric resistance < 5.3mOhm	Contact resistance 3.1mOhm Total electric (warm) resistance 30mOhm
	Total Power Dissipation <= 1.2 W	3 W at 10 A
Compatibility for rated components up to 15 A	15 A (continuously)	10 A (continuously)
Safe isolation of a fault circuit	Galvanic isolation	yes
Small Size	<= $1cm^3$	yes

First function model demonstrates feasibility.



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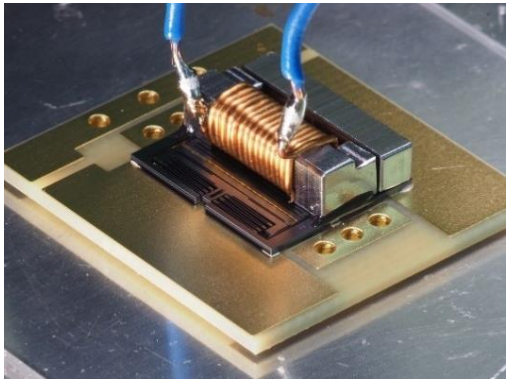
Next steps



Design improvements and challenges to be approached in a next step:

1.) Electrical resistance to be reduced (contact force, tolerances, contact area, surface)
2.) Massy electro-magnetic actuator to be replaced
3.) Design focus on mechanical robustness/immunity against mechanical shock/vibration (not yet addressed)
4.) Desing simplification to reduce manufacturing costs

Thank you for your attention

Elmehdi Moradi
Electrical Engineer
elmehdi.moradi@schurter.com

Bruno Zemp
CTO
bruno.zemp@schurter.com

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