SCHURTER ELECTRONIC COMPONENTS

SCHURTER Fuses for Space

“Circuit Protection Solutions for future space applications”

Space Passive Components Days
12.-14. October 2016, ESA / ESTEC

Bruno Zemp

2016-10-14

V1

Overview

SCHURTER ELECTRONIC COMPONENTS

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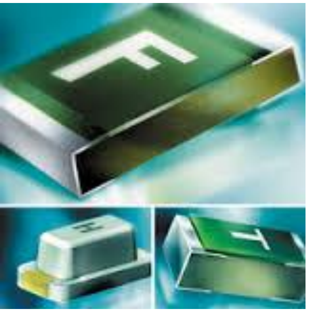
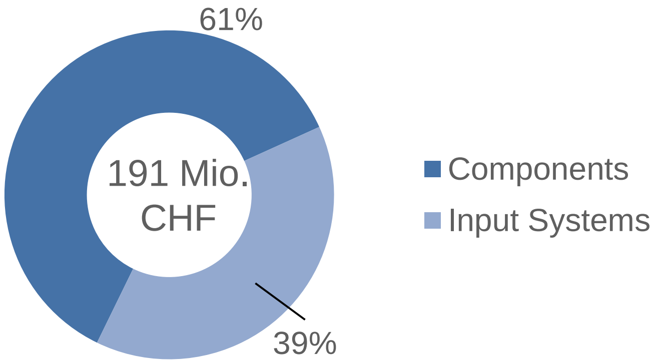
SCHURTER Electronic Components

«SCHURTER Electronic Components operates successfully as a Swiss technology company worldwide. We offer solutions to our business partners, also for the most demanding requirements. In a dynamic market, we are growing thanks to high technical expertise, financial independence and extraordinary innovation.»

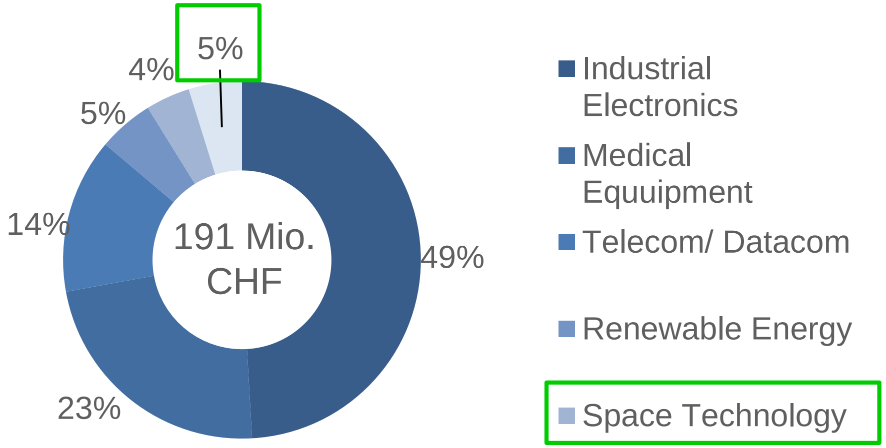


Components

SCHURTER is a leading innovator, manufacturer and distributor of fuses, connectors, circuit breakers, input systems and EMC products – and an important service provider for the PCB assembly and electronics industries.



Segmentation



Input Systems

SCHURTER develops, manufactures and markets input systems, touch screens and touch panels, capacitive sensor keypads, membrane keypads and housing systems in close cooperation with the customers.

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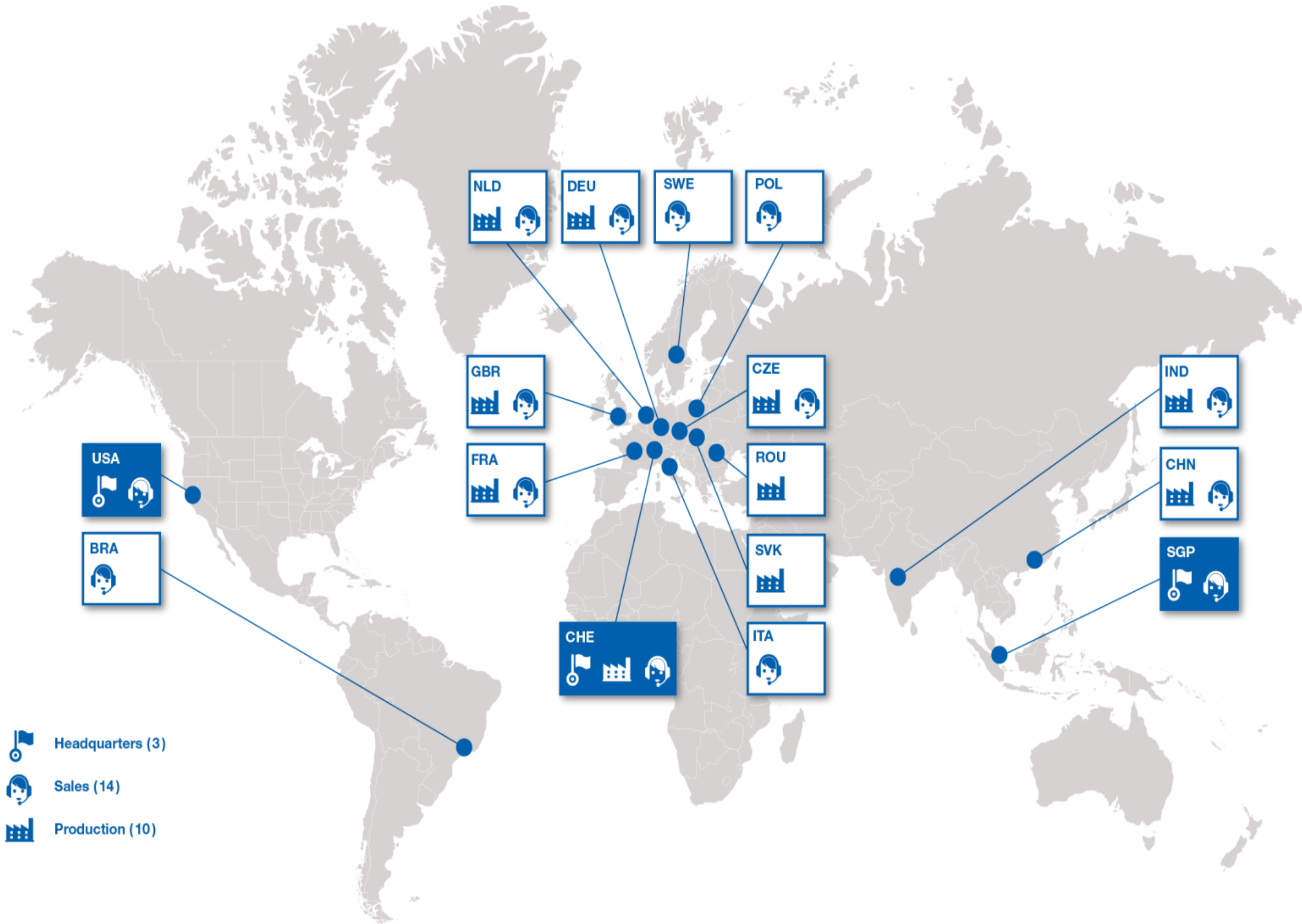


SCHURTER Space fuses at a glance

The SCHURTER MGA-S & HCSF fuses are the exclusive ESA ESCC qualified and listed parts.

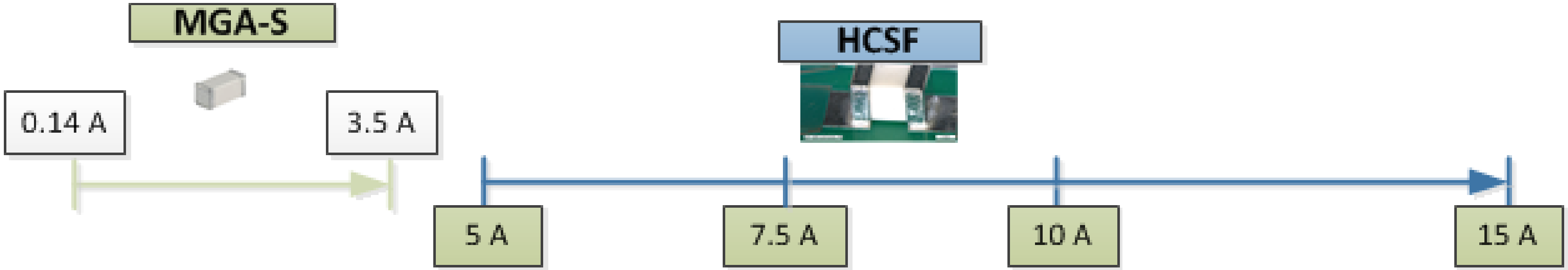
With the established and ESA ESCC qualified space fuse called MGA-S (MGA Space) and the new qualified space fuse called HCSF (High Current Space Fuse), SCHURTER AG covers nominal current protection requirements for space application from 0.14 A up to 15 A or even more, if they are set in parallel. Both fuse types are sealed, based on solid state thin film technology and comply with the strict requirements of space.

How many fuses have SCHURTER served to space customers since 2008?
Indeed more than 180’000 fuses!!!

ESA ESCC qualified fuse families:

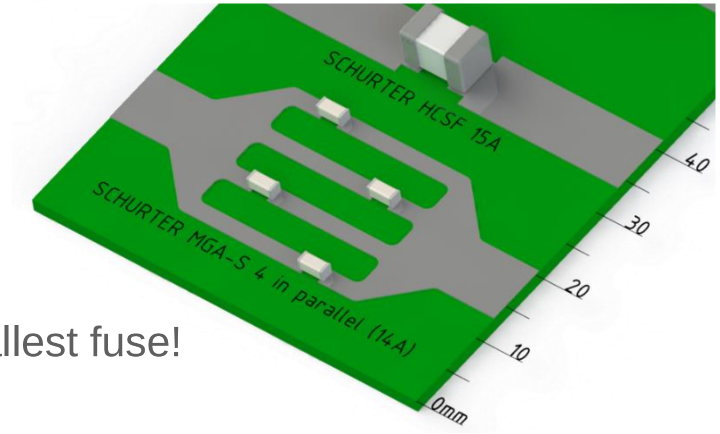
MGA-S: Small SMD fuse (1206)
Rated current range: 0.14 A up to 3.5 A
Application: Overcurrent protection in “Low Power” module
Qualified since 2008

HCSF: SMD fuse (3220)
Rated current range: 5 A up to 15 A
Application: Overcurrent protection in “Low Power” and “High Power” module
Qualified since 2016



Key Figures MGA-S and HCSF

HCSF



- > ESA ESCC qualified (4008, 4008/001, 4008/002)
- > Established fuse (MGA-S) for space application
- > Sealed fuse body
- > Solid state thin film fuse technology – no wire!
- > SMD 1206 (MGA-S) and SMD 3220 HCSF) - very compact size, smallest fuse!
- > Very quick (MGA-S) or fast acting (HCSF)
- > DC and AC rated (125 V)
- > Rated current from 0.14 A up to 15 A
- > High breaking capacity – 300 A at 125 VDC (MGA-S), 1kA at 125 VDC (HCSF full rated current range)
- > Terminal metal finish – effective whisker growing barrier
- > Each fuse undergoes extensive control and screening procedures during production processes according to ESCC 4008
- > Reliability Report (Screening, Burn-In) available

An application example

Why fuses are used in space applications?

E.g. in telecom satellites the electrical energy from solar arrays and batteries are joined together via Power Supply Regulator and Power Distribution Unit. On the other hand the energy is distributed to different sub-systems (modules).

«Important» Modules like SM (Service) or CM (Communication) have to be protected.

The main job of the fuse:

- ⇒ A fuse protect sub-systems from component damage if an **critical overcurrent** occurs.
- ⇒ Due to of sub-system redundancy a fuse **have to disconnect** the energy flux of the failed module or sub-system in a **fast, reliable and safe** manner.
- ⇒ Always available during entire mission => **high availability!**
- ⇒ No impact on system performance or functionality => **high reliability!**

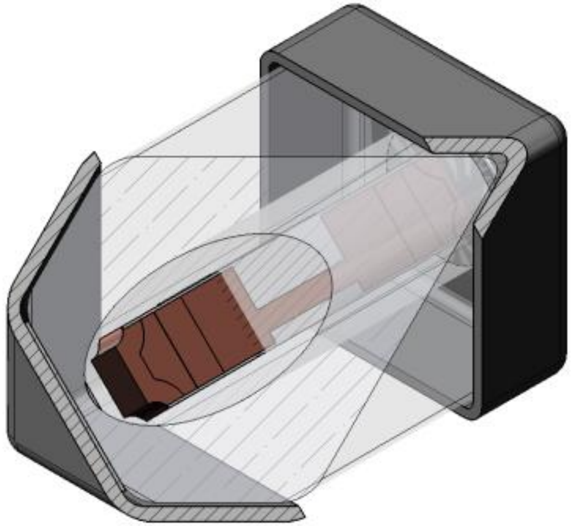
Construction

Main Components

Fuse Element: Solid state thin film technology

Body: High performance, pure ceramic housing

Filler: Silicone filler, conditioned and performed



The constructions of the space fuses from SCHURTER are strong inherited.

HCSF 7.5 A

≈

What does this mean?

- Main production processes taken over from MGA-S for HCSF
- The fuse element technology of HCSF is based on the MGA-S
- All materials are similar (housing, plating finish, filler, solder, substrate)

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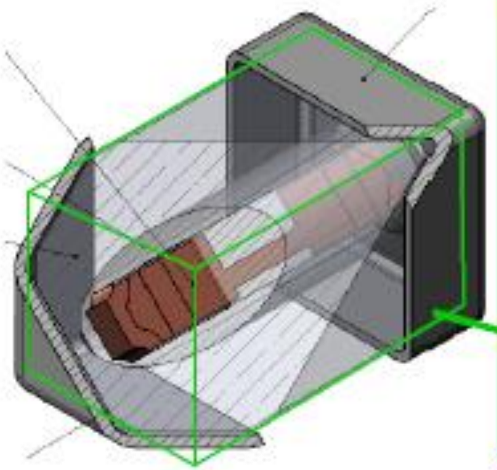
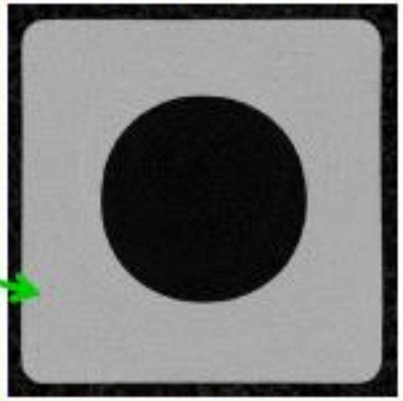
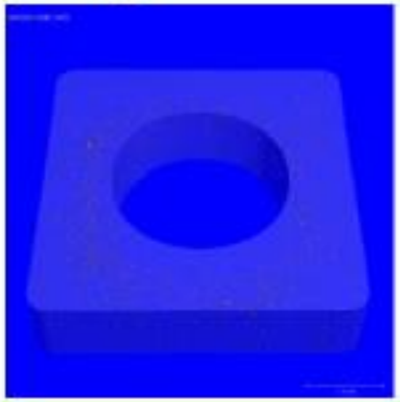
HCSF / HCF Ceramic Housing versus Commercial Fuse Housing



HCSF / HCF Ceramic housing



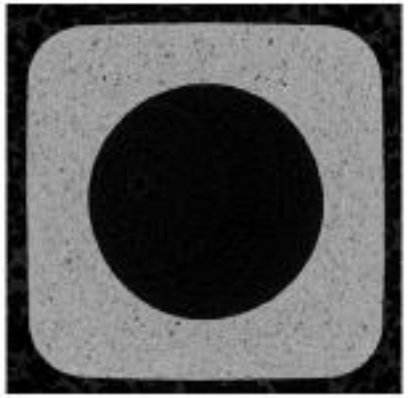


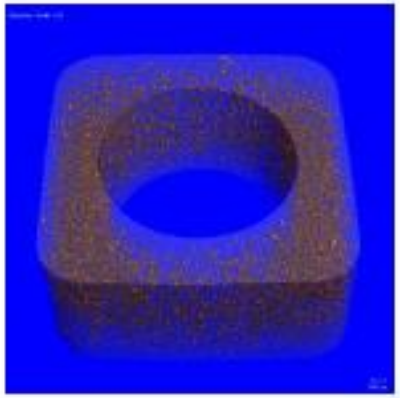
Advantage

- High density
- Homogeneous
- Pure material
- Imporous
- Thick-walled

=> Very robust!

Ceramic housing of a commercial SMD fuse (UMT-H)





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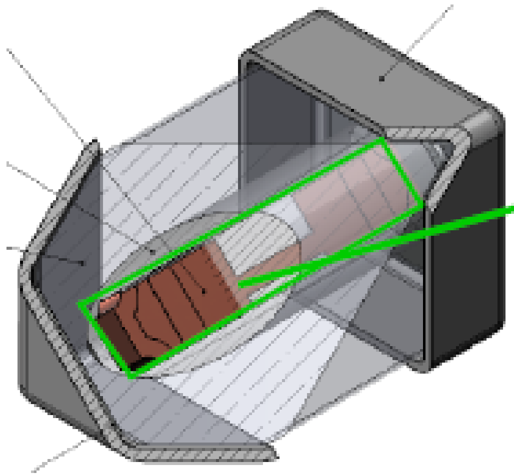
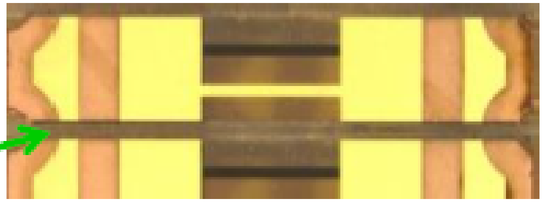
HCSF / HCF Fuse Element: Solid State Technology



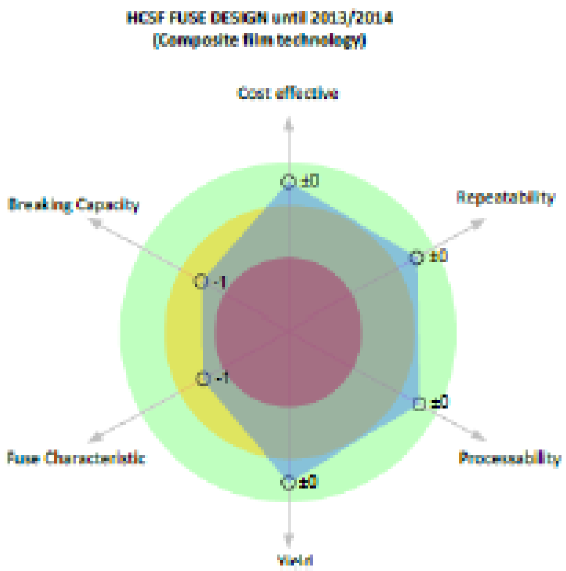
Substrate of the QM HCSF 10 A (2015)

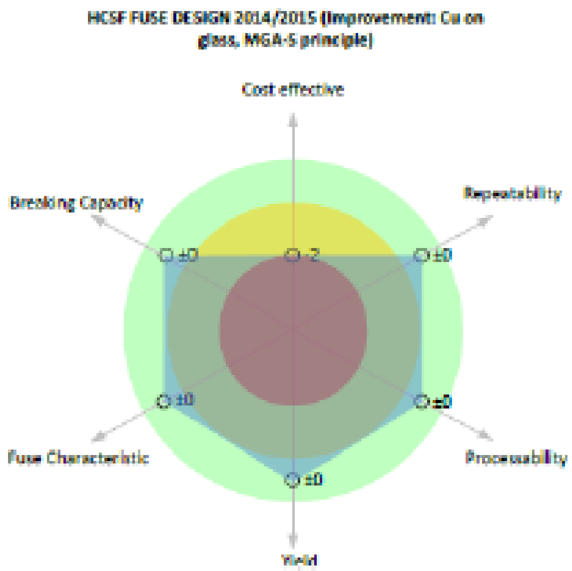


Advantage

- No carbon
- High insulation resistance
- High breaking capacity
- Save interrupting at low overcurrent operating (< 250 % In)

=> Robust fuse design!





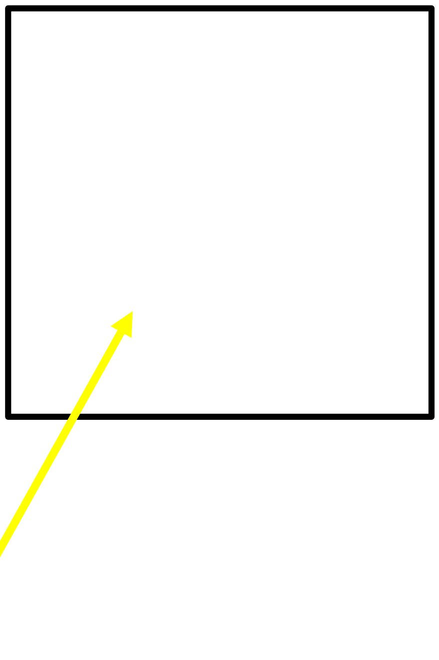
Initial conditions

Before we started the evaluation the fuse was like a partly black box – the limitations of the fuse were not well-known at all!

Four key requirements:

Behaviour under space related conditions (Thermal Vacuum)

Long term behaviour (4'168 h Life Test)



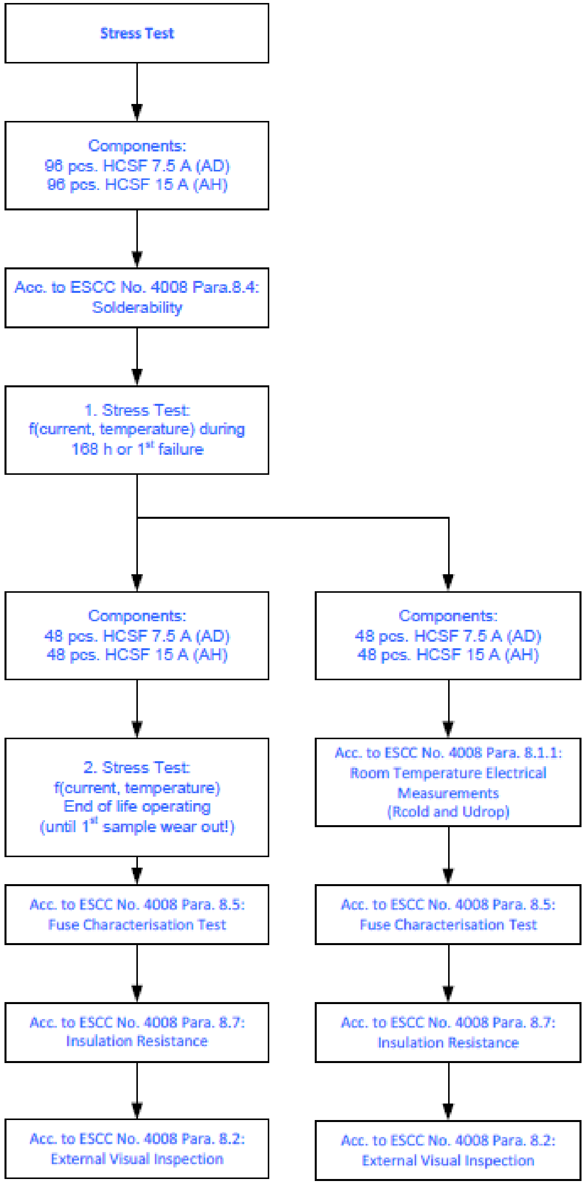
Resistivity against high short current pulses

Breaking Capacity depends on supplied voltage

Main Goal

> **Bring light into the darkness!**
> Know the real performance and limitations of the fuse (e.g. design limits)
> Figuring out the compatibility for the strict space requirements

Evaluation Test: 4’168 h Stress Test at 125 °C and 85 °C



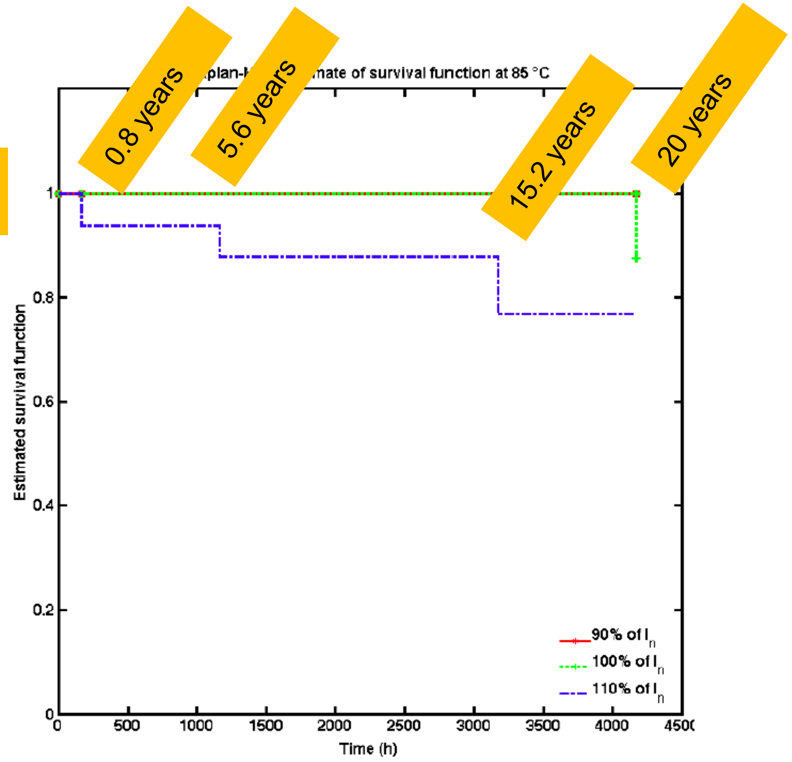
Overview of the test at 85 °C

I_n	Test Current	168 h	1168 h	2168 h	3168 h	4168 h
7.5 A	110 % of I_n	14/16 (-2)	7/8 (-1)	7/7	7/7	7/7
	100 % of I_n	16/16	8/8	8/8	8/8	7/8 (-1)
	90 % of I_n	16/16	8/8	8/8	8/8	8/8
15 A	110 % of I_n	16/16	8/8	8/8	7/8 (-1)	7/7
	100 % of I_n	16/16	8/8	8/8	8/8	7/8 (-1)
	90 % of I_n	16/16	8/8	8/8	8/8	8/8

The blue coloured figures describes the removed samples based on at least one failure criteria.

Survival Function

Corresponding calculated life time (Arrhenius life-stress model)



Key Figure: Behaviour in space related conditions

ESCC 4008 Para. 8.15 Thermal Vacuum Test (125 °C, p < 10 E-5 mbar, min. 48 h, Load current = 80 % of IR)

Electrical measurements – investigation of potential aging effects

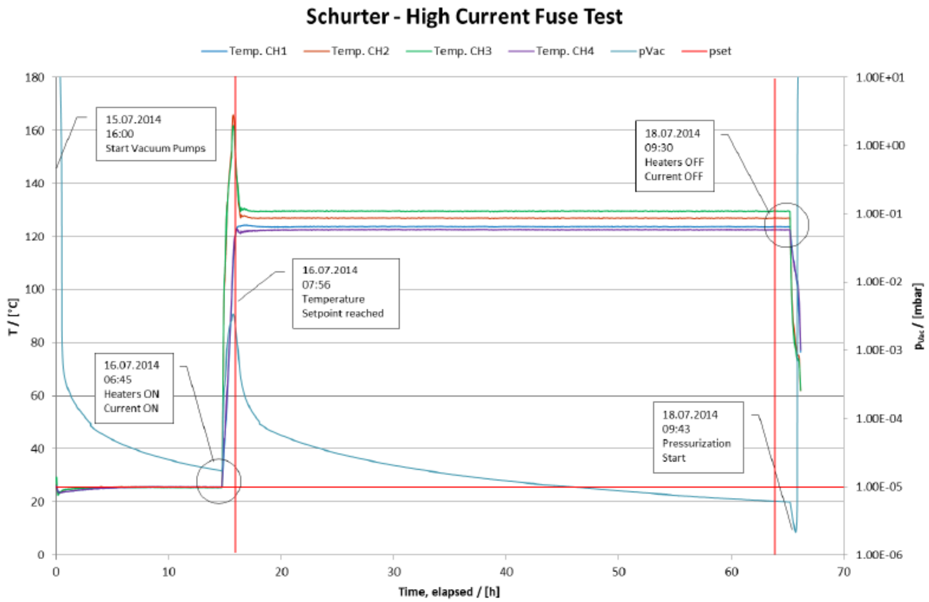
4.1 Electrical measurement: Deviation of the R_{cold} and U_{drop}

	R_{cold} deviation			U_{drop} deviation			Result
	Min	Max	AVG	Min	Max	AVG	
HCSF 7.5 A	0.86 %	1.37 %	**1.15 %**	-3.22 %	1.79 %	**-0.13 %**	**Pass**
HCSF 15 A	0.72 %	1.44 %	**1.09 %**	-0.34 %	2.17 %	**0.56 %**	**Pass**

Table 2: Deviation of the electrical values

Totally 3 test campaign have been performed during the evaluation and qualification phase. Each test campaign included minimum 3 of the 4 fuse types (rated current).

All samples passed! No indication of aging observed!



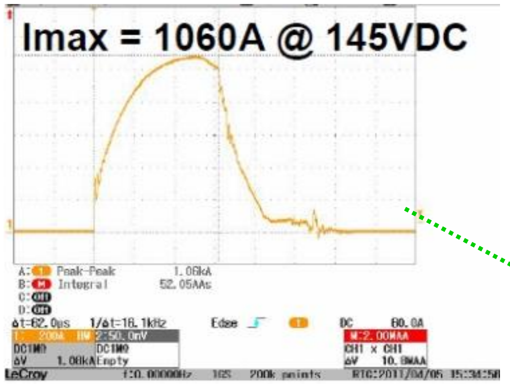
HCSF Key Figure: Breaking Capacity

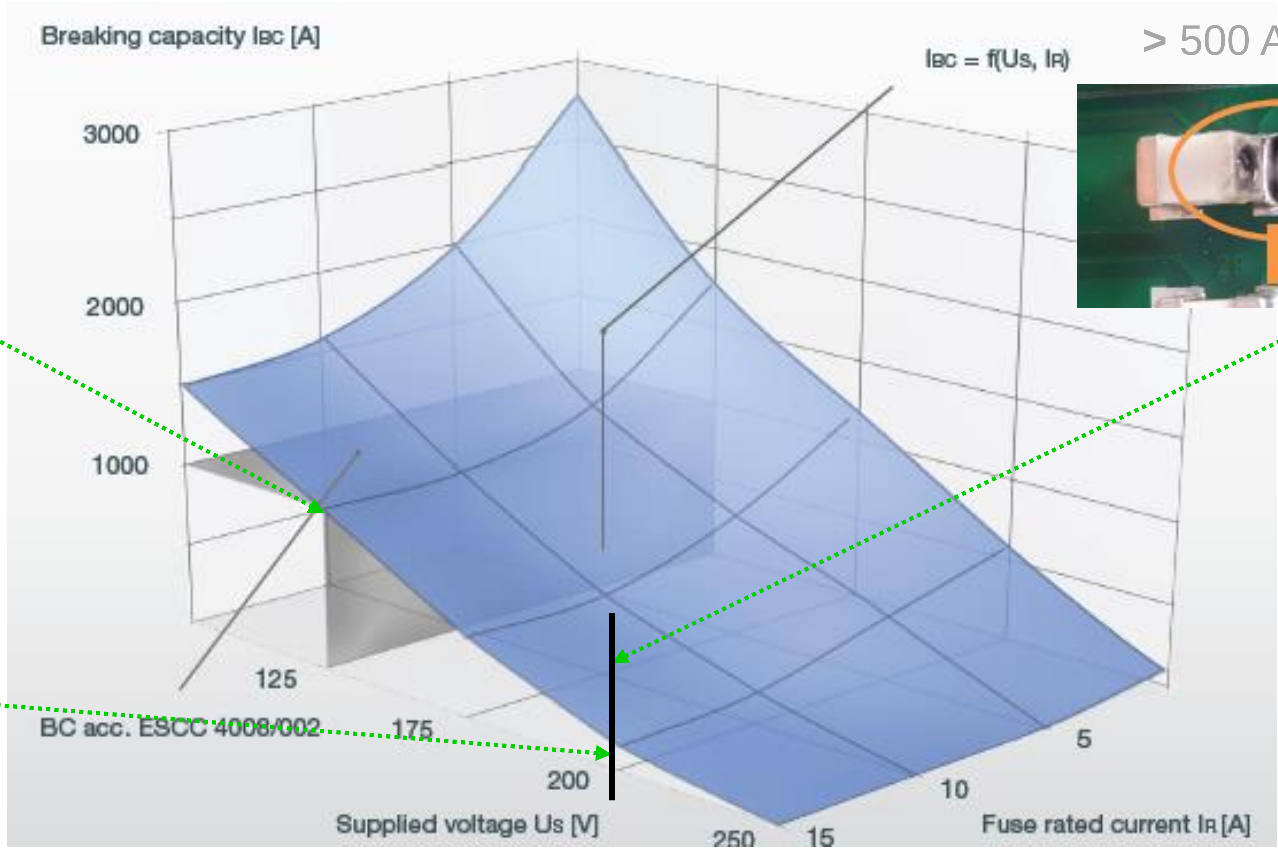
Breaking Capacity: Is the ability of a fuse to interrupt without being destroyed or causing an electric arc with unacceptable duration.

Big safety margin - the true breaking capacity of the HCSF is beyond the qualified rating!!!

ESCC 4008/002:

- BC at DC according to the data sheet is 1000 A at 125 VAC





> 500 A at 200 VDC

200 A at 200 VDC

HCSF Key Figure: Current Pulse Resistivity

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Fundamental behavior: The current pulse resistivity of fuses mainly depends on the pulse energy (I^2t) and the repetition time – caused by the thermal constant of the fuse.

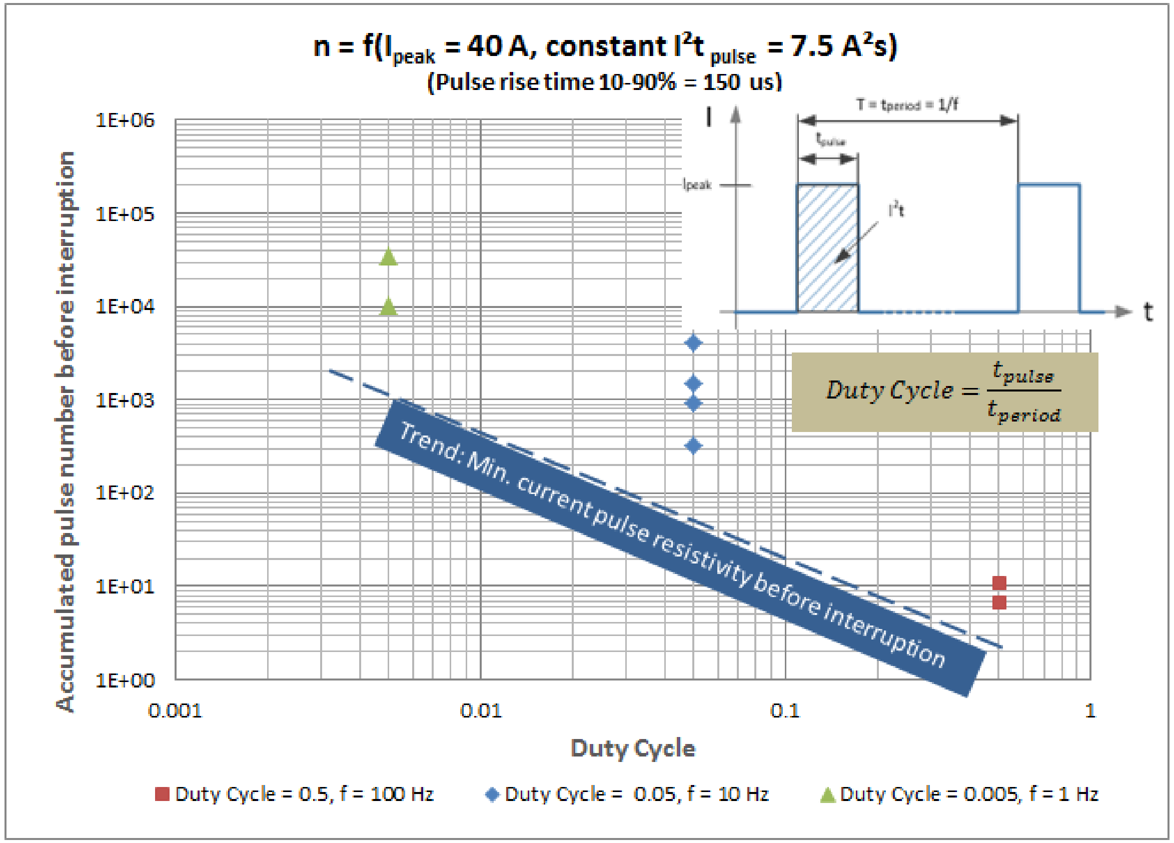

Chart: Current pulse resistivity at 23 °C of HCSF 10 A

SCHURTER is performing extended current pulse tests.

The aim of this effort is to outline the fundamental behaviour at common current pulse conditions and offers customers a useful guide line!

The design rules (derating factor for current pulse operating) are going to be a part of the HCSF Engineering Handbook 0105.2216.

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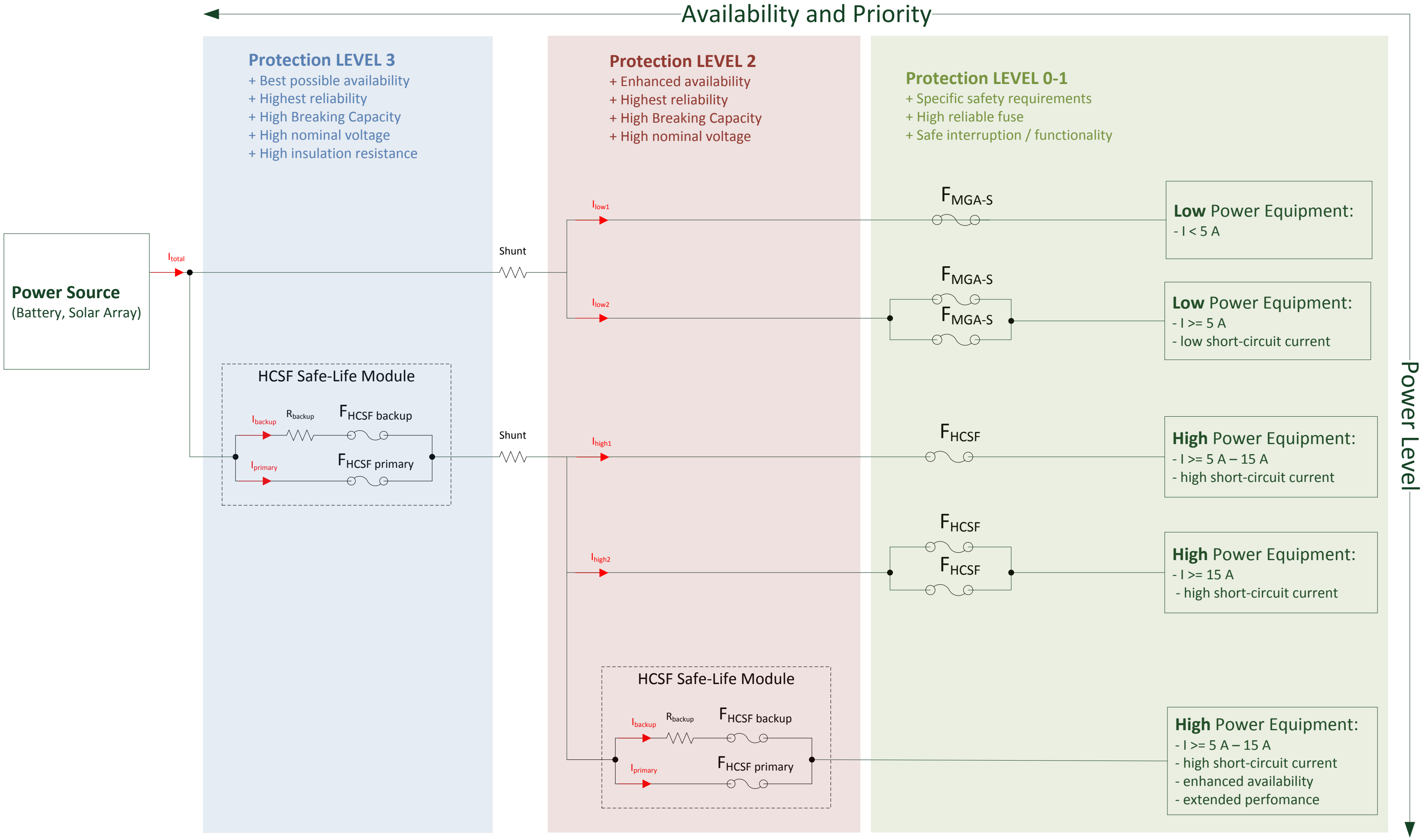
Fuse Selection for Application Specific Circuit Protection

The criteria on fuses for effective circuit protection varies depending on the application requirements like protection functionality level. In particular for space application, the remarkable environment conditions, the high reliability and availability of safety requirements of the system need additional dimensioning actions to get the best fitting fuse.

The most important design parameters for fuses and their related performance data are listed below:

Application Requirements / Parameter	Relation	Fuse performance data	SCHURTER Fuses for Space	
			MGA-S	**HCSF**
Safety requirements (electrical protection reaction sensitivity – fail safe)	←→	Fuse tripping characteristic - quick acting F, very fast acting FF	FF	F
Safety requirements (reliability, availability)	←→	Design / technology – e.g solid state, qualification and reliability data, safe-life concept	Solid state ESCC QPL Rel. data available	Solid state ESCC QPL Rel. data available
Environment requirements (space, ground, etc.)	←→	Qualification and approval as in [1], ESCC-Q-ST-30-11C as in [4]	ESCC 4008001	ESCC 4008002
Supplied voltage	←→	Rated voltage	125 VDC	125 VDC
Average load current	←→	Rated current	0.14 – 3.5 A	5 – 15 A
Short inrush current	←→	Breaking capacity (e.g. HCSF safe-operating area)	Max 300 A	Min 1000 A See Safe-Operating Area data in E-HB, as in [7]
Current pulse profile (duty cycle, peak current, amount of pulses during mission time)	←→	I^2t, current pulse derating factor	See MGA-S Data Sheet as in [5] and SCHURTER guide to fuse selection	See HCSF Data Sheet, as in [6]and E-HB, as in [7]
Ambient temperature	←→	Temperature derating	See MGA-S Data Sheet	See HCSF Data Sheet or E-HB
Size and mounting	←→	E.g. SMD	SMD 1206	SMD 3220

Fuses are broadly used in telecom spacecraft and other application where safety requirements are needed. Depending on system level (availability, priority, etc.) the best suitable type of protection device has to be chosen.



MGA-S

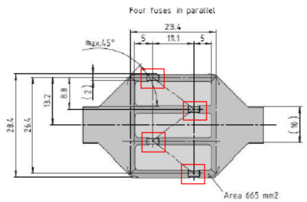


Figure 14: Four fuses in parallel

MGA-S in parallel

HCSF

Protection Level 4: Fully redundant protection device / module

Future Work – how we deal with the trends

Market Trends

Trend	Consequence on circuit protection requirements
High electrical power	Circuit protection device deal with even higher currents and high voltages – higher rated current and rated voltage, high breaking capacity
High integrated electronic system	SMD, small in size, low power dissipation
New functionalities	Customer specific fuse characteristic, current pulse resistivity
Non-functional requirements	Availability, high reliability, space qualified (ESCC 4008), additional long term data requested
Decreasing development time	Accurate and easy applicable Spice Model of the fuses

How SCHURTER and ECI keep up the trends with innovative products and solutions

Trend: High electrical power

Potential solution: HCSF 20 A or even higher current ratings to deal with increasing load currents

Goal: No sets of fuses in parallel – less PCB space needed

Trend: Non-functional requirements like availability and reliability

Potential solution: Investigation of extended design-in parameter like current pulse derating of the fuses or Safe-Life Solutions

Goal: Customer use the best fitting fuse => highest availability

Trend: Fast Engineering – decreasing development time

Potential solution: More accurate and easy applicable Spice Model of the fuses

Goal: Economics - Cost and Time reduction in Engineering

The way to the ESCC qualification of the HCSF

HCSF 7.5 A

Project Review

“Long way to the final destination”

> The qualification test campaign lasted 9 month.
> The evaluation test campaign took 20 month.
> The design and construction phase (Prototype 1 and 2) took more than two years.

Unique fuse:

> The HCSF is the first space fuse for rated currents up to 15 A holds an ESA ESCC certificate
> The HCSF is the smallest SMD fuse for rated currents up to 15 A and with a breaking capacity of 1000 A at rated voltage (125 VDC).

Thank you for your attention