A new approach to fuse management in modern vehicles

**Electronic Smart Fuses**

- Replacing both standard fuses and relays with advanced diagnostic and enhanced functional safety

**Main Advantages**

<table>
<thead>
<tr>
<th>System</th>
<th>FAST: Reaction time / two orders of magnitude faster</th>
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<tbody>
<tr>
<td></td>
<td>FAULT TOLERANT: Remote reset, no need to access the fuse box for replacement</td>
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<td>TINY: Replacing both fuses and relays with smart fuses reduces fuse box size</td>
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<td>LOAD SHAPED: Cable size can be optimized based on load characteristics</td>
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<table>
<thead>
<tr>
<th>Savings</th>
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<tr>
<td>Wire harness size reduction</td>
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<tr>
<td>- A mid size car has approx. 3km cable - 45kg for power distribution</td>
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<td>- An electronic Box is approx. 0.350kg lighter</td>
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<tr>
<td>Up to 20% overall weight reduction leading to CO2 saving / increased range</td>
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<thead>
<tr>
<th>Enabling</th>
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<tr>
<td>- Zonal Architecture: Manage and distribute multiple sources energy</td>
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<tr>
<td>- Autonomous Driving: Fault tolerances</td>
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<tr>
<td>- Predictive maintenance: Device health monitoring</td>
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</table>

**Mechanical Power Distribution Module PDM**

**Smart Power Distribution Module S-PDM**

**Load Shaped: A flexible protection feature**

The “Fuse” programmable curve features an intelligent circuit breaking aimed to protect PCB traces, connectors and wire harness from overheating.
Smart fuses for power distribution with smart digital interface

**12V Boardnet Stability**

Fast turn-off
STi²Fuse guarantees power network stability reacting autonomously within 100us against overload to prevent the power network to collapse.

**CCM – Large Capacitor Compatibility**

Cap Charging
STi²Fuse offer compatibility with large capacitive loads through a dedicated CCM feature, avoiding SW intervention and avoiding additional parallel switches for charging.

**State of Health - Predictive Maintenance**

Diagnostics
STi²Fuse have a complete I,V,T monitoring for system state of health supervision and predictive maintenance able to detect degradation before failures might occur.

**Adding Robustness and Functional Safety**

**Current Sensing**

ASIL - CSensing
STi²Fuse have a full range, redundant, autonomous current sense with high speed sampling and BIST protection for ASIL applications.

**Battery μ-cut**

Immunity
STi²Fuse keeps operating state at Functional Status A during battery μ-cuts maintaining seamless system operation and wire harness protection.

**Autonomous Wire Harness Protection**

Pt Functionality
STi²Fuse ensures SW independent wire protection fully operational without uC, during POR, in failsafe condition: programmable at Tier1 or OEM assembly line.

- STi²Fuse have a complete I,V,T monitoring for system state of health supervision and predictive maintenance able to detect degradation before failures might occur.
- STi²Fuse guarantees power network stability reacting autonomously within 100us against overload to prevent the power network to collapse.
- STi²Fuse offer compatibility with large capacitive loads through a dedicated CCM feature, avoiding SW intervention and avoiding additional parallel switches for charging.
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- STi²Fuse keeps operating state at Functional Status A during battery μ-cuts maintaining seamless system operation and wire harness protection.
- STi²Fuse ensures SW independent wire protection fully operational without uC, during POR, in failsafe condition; programmable at Tier1 or OEM assembly line.
Melting fuses drawbacks

- Dimensioned on peak current, not on RMS current
  - Tripping much earlier than the cable reaching a critical temperature
  - Oversize cables, connectors and PCB traces
- Unlimited current capability for tens of milliseconds
  - Does not prevent fault propagation to the upstream power bus and other systems

- Service
  - Non resettable
  - Requires access
  - Prone to user error
An ST invention for an absolute protection $I^2t$ programmable curve

Whatever the electrification level or power train architecture

<table>
<thead>
<tr>
<th>The concept</th>
<th>The advantages</th>
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<tbody>
<tr>
<td>VIP-FUSE IT curve</td>
<td>• Smaller and fault tolerant</td>
</tr>
<tr>
<td>FUSE current unlimited</td>
<td>• Dimensioned on RMS load current and current limited</td>
</tr>
<tr>
<td>VIP-FUSE Current limited</td>
<td>• Simplified, lighter and cheaper wire harness</td>
</tr>
<tr>
<td>VIP-FUSE I-$t$ adaptive curve</td>
<td>• Reduced stand-by consumption</td>
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<tr>
<td>VIP-FUSE IT curve</td>
<td>• Helps increasing the overall safety and reliability level with benefits for autonomous driving too:</td>
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<tr>
<td>VIP Fuse</td>
<td>• SW Reset of HW fault</td>
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<tr>
<td>Cable @ TAMB=85°C</td>
<td>• Faster Fault reaction time (&lt;100us)</td>
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<tr>
<td>Fuse 10 Amp</td>
<td>• Real time diagnostic of critical modules and switch itself</td>
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- $I^2t$: $I^2t$ programmable curve
- VIP-FUSE: VIP FUSE
- CO2: CO2
- EV Range: EV Range
- ASIL: ASIL
Active stand-by ON

- Reduced stand-by consumption in sleeping modules (e.g. parking functions)
- Standby Switch Normally-ON with low quiescent current
- Up to 600mA current capability
- Fast self wake up
- Device configuration saved during standby
Focus Applications:
1. Power Distribution
2. Fuses replacement
3. High current loads

Unique ST patented I2t programmable curve (eFuse) and Active Standby ON

Unique broad range of operating voltage (6 to 60V)

Full programmability and diagnostics via SPI

Enhanced protections and failsafe features (ASIL B)

Small QFN package (5 x 5 mm)
Controller with eFuse functionality for 12/24/48V applications
- Operating supply voltage range 6V – 60V (AMR 70V)
- Gate drive for an external MOSFET(s) in high side configuration
- 2 stage Charge Pump for low-voltage operation
- Active standby ON (200mA current capability), low standby current (<70uA)
- 32-bit ST-SPI interface compatible with 3V/5V CMOS level
- Input for a NTC resistor for external MOSFET temperature monitoring
- External MOSFET desaturation detection (V_{DS} monitoring)
- High accuracy unidirectional digital current sense via SPI through an external high side shunt resistor
- Integrated ADC for T_j, V_{NTC}, V_{OUT} and V_{DS} conversion
- Small QFN 5x5

Protctions:
- I^2t curve configurable via SPI (eFuse functionality)
- Hard short circuit latch-off configurable via SPI
- Battery under-voltage shut down
- Device Over-Temperature shutdown
- External MOSFET Over-Temperature shutdown
- External MOSFET desaturation shutdown configurable via SPI
- Advanced fail-safe features (built in self test, registers lock), ISO26262 ASILB ready
VNF1048F eFuse functionality

eFuse simulator tool and evaluation kit with GUI available

Nominal Trip time (T_NOM) 1-511 sec

Nominal Overcurrent Threshold (OVC_THR) 6-90 mV
STi2Fuse Portfolio & Roadmap
Qualification Schedule

Quad
- Power SSO-36 "AY" 10.3x10.3mm
- QFN"F" 6x6mm
- PQFN"Q" 7x8.5mm

Notes:
(*) will be available with and without Standby ON, different part numbers
(**) standby ON not supported
(***) external Smart P-Channel IC L99SP08 to support standby ON mode

Qualified
Date: December 2022
Timeline Information can be subject to variations without advance notification
**VIPower for Power Distribution**

**STi²Fuse roadmap**

<table>
<thead>
<tr>
<th>Application Segment</th>
<th>Products Roadmap</th>
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<tbody>
<tr>
<td><strong>Electronic Smart Fuses</strong></td>
<td><strong>Monolithic devices in QFN 6x6</strong></td>
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<tr>
<td>- replacing both standard fuses and relays with advanced diagnostic and enhanced functional safety</td>
<td>- M0-9 SPI technology</td>
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<td></td>
<td>- First two products qualified in 2024</td>
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<td></td>
<td>- VNF9D5Q</td>
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<td>- VNF9Q20F</td>
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<td>- Qualified by: H2 2023</td>
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<tr>
<td></td>
<td>- Controller + Ext. MOSFET – 12V, 24V, 48V</td>
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<td>- 1st release in production</td>
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<td>- 2nd release in development</td>
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<td>- Double ch</td>
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<td>- VNF9D1M5Q</td>
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<td>- VNF9D3Q</td>
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<td>- VNF9D2Q</td>
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**A flexible protection feature**

The “Fuse” programmable curve features an intelligent circuit breaking aimed to protect PCB traces, connectors and wire harness from overheating.