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STi²Fuse for Automotive Power Distribution

STMicroelectronics

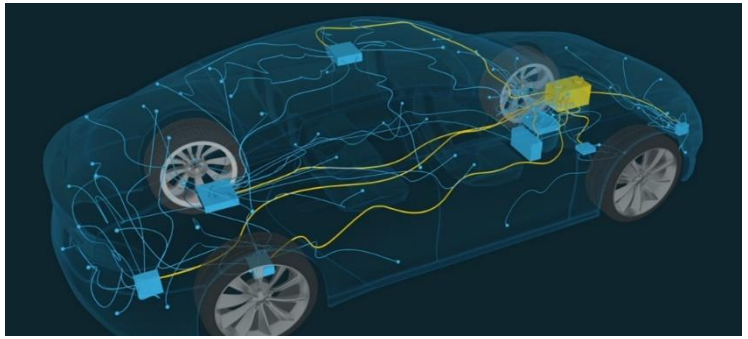
최영민 차장

Low Voltage Integrated Power Division
Automotive Strategic Markets and enabling technologies

Making driving Greener, Safer and more Connected

Smart Power distribution

Migration to zonal architecture and BEV range extension requiring electronic fuses usage in vehicles



VIPower M0-9, M0-11 and BCD
LV MOSFET STripFET F8

Electronic fuse with advanced diagnostic and enhanced functional safety replacing both standard fuses and relays

Automotive Body Electronics

Car body and convenience applications are evolving to increase the comfort of both drivers and passengers

All VIPower technology node and BCD
LV MOSFET STripFET F7 and F8

VIPower and MOSFET serving legacy applications such as lighting, seat module control & heating and other conveniences

Energy efficient Power conversion

Car Electrification and Autonomous Driving processors supply rise the need of energy efficient power conversion

VIPower M0-11 and BCD
LV MOSFET: STripFET F7 and F8

Efficient ADAS Power supply and DC/DC Converters combined with electronic fuses enable weight saving and range extension

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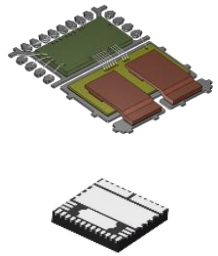
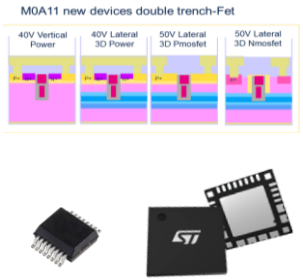
Low Voltage Integrated Power Division
VIPower Technology for High Side Driver

M0-7 / M0-7E	M0-9 / SPI	M0S-11 (ready in 2024)	M0-A11 (ready in 2027)
24 + 5 products in full production	16 products in full production 1 products in pipeline	6 products in development	18 products forecasted
• Rdson from 1.3mΩ to 140mΩ • 1, 2, 4 Channel • Packages: PSSO-16, PSSO-36, Octapak, SO-8	• Rdson from 4mΩ to 100mΩ • 1, 2, 4, 6 Channel • Packages: PSSO-16, QFN 6x6 • Full digital diagnostic, AUTOSAR software device drivers, pin-to-pin compatibility • Higher Power Density thanks to the lower RDSon x Area - 60% less than previous generation	• Rdson from 0.6mΩ to 3mΩ • 1, 2 Channel • Packages: PQFN 7x8.5 • Support the migration to solid-state based on Power Distribution for nominal current up to 40A 	• Rdson from 1mΩ to 20mΩ • 1, 2, 4, 6 Channel • Packages: PSSO-16, QFN 6x6 • Enabling extra features on Power Distribution ,HSDs & MC products 
Planar Power technology	U-MOSFET trench Power technology	Charges coupled trench Power (Double Poly)	
Simple basic analog functions	Added HV lateral - 40V elementary components (driving, diagnostic, protection)	Lateral power n-channel trench integration (low side for integrated bridge in monolithic configuration)	
R_{ON} x mm² : 40mΩ	R_{ON} x mm² : 14mΩ	R_{ON} x mm² : 7mΩ	
	Complex digital functions: 25 kgate/mm² (interfaces, ADC/DAC, OTP)		Complex digital functions: 35 kgate/mm² (interfaces, ADC/DAC, OTP)

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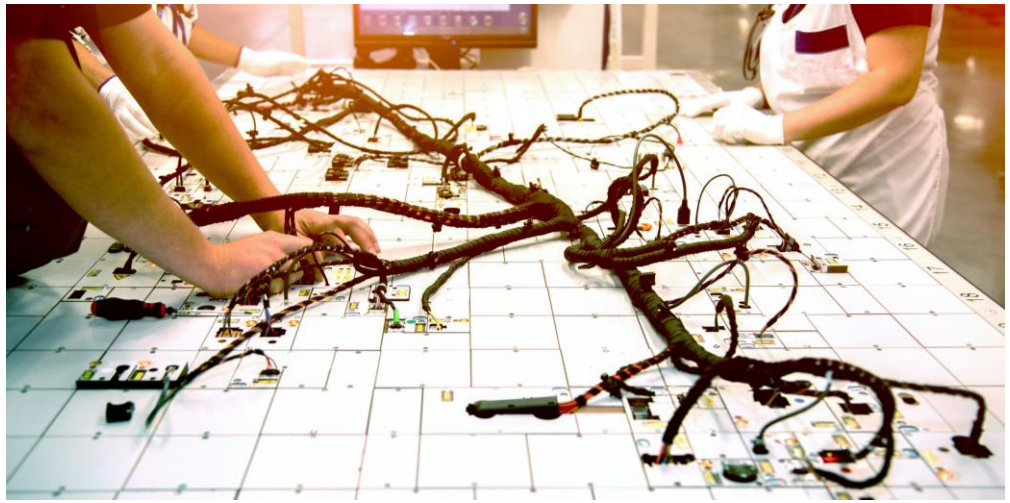
Low Voltage Integrated Power Division
Energy Efficiency

Market	Advanced fuse management: STi²Fuse	Power Optimization: 48V HSDs
Power Distribution		
	• replacing both standard fuses and relays with **advanced diagnostic** and enhanced functional safety • Significant overall weight reduction, up to 20%, due to **cable size optimization** • Power Distribution Box equipped with Electronic fuses is **25%** lighter than mechanical one	• Up to **4x wiring harness** reduction to supply the same power • motors running off 48V are significantly **lighter** than with the conventional 12V system • Increased **power capability** for heavier loads

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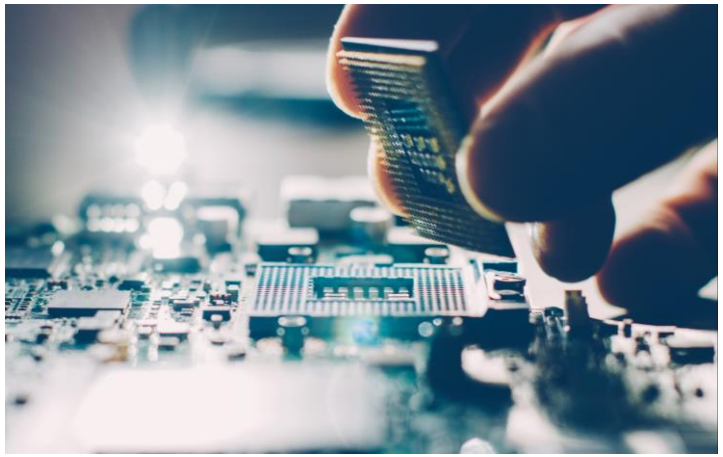
New Technology Challenges

Automated Drive



Reliable electronics
From Level 0 to Level 5

In Vehicle Networking

Zonal architecture with central computing
SDV → Security

Wire harness

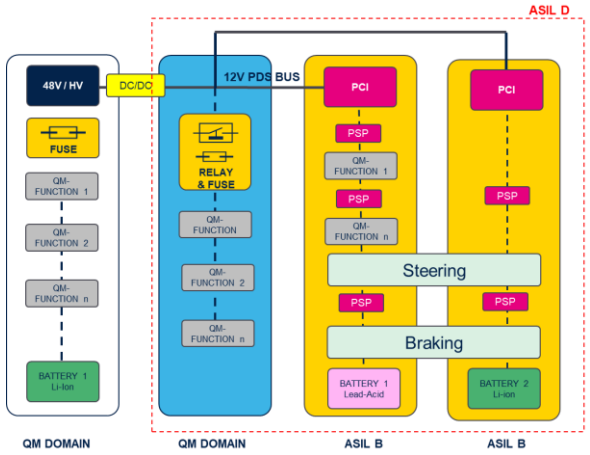
Complexity explosion

Power Distribution

Driving Factors for PD architecture transformation

Automated Drive

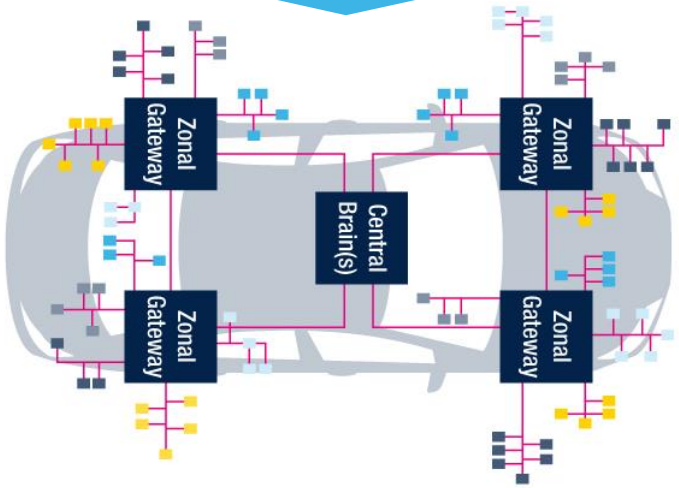
Reliable electronics



- Robustness against failure and interferences propagation is the major driving factor for new power distribution architectures

In Vehicle Networking

Zonal architecture with central computing

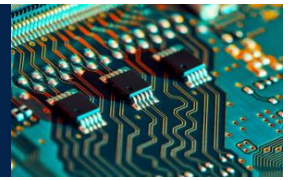


- High performance Central Unit (MPU)
- Functions, loads and sensors are grouped by phisical domains

Wire harness

Wire Complexity explosion

SmartFuse New Function



- Cable protection in any vehicle operating mode including failsafe and parking modes.
- Capable of Switching loads without interruption
- Optimizing the cable diameter for a given load
- Flexible to suit with different cables and loads
- Compatible with new system safety requirements
- Enable health monitoring and preventive maintenance

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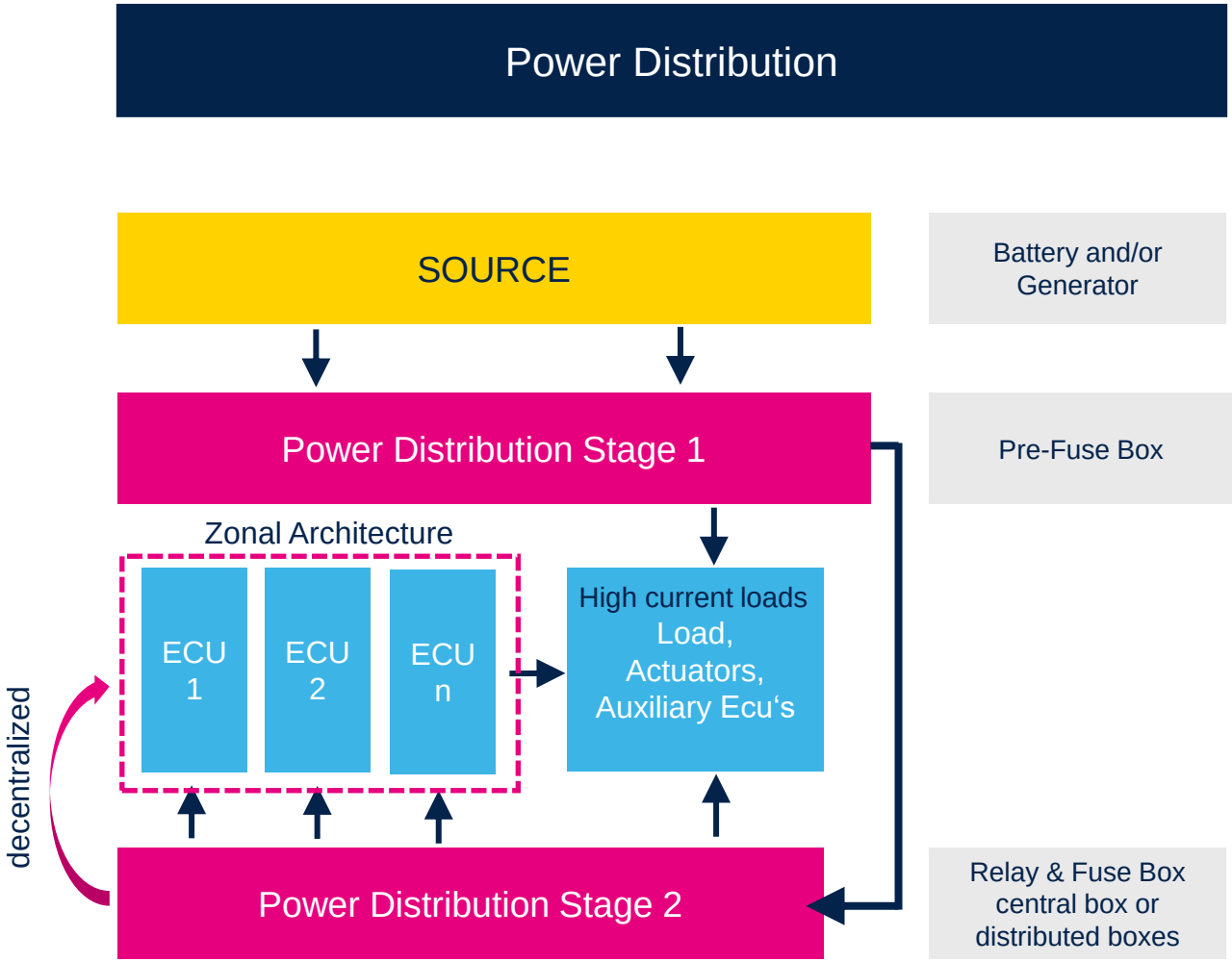
Vehicle E/E Architecture



Centralized Power Distribution

Solution with fuses & electro-mechanical relays for the stage 1 and the stage 2 power distribution.

Partially Decentralized Power Distribution

Partly or up to fully electrification of both stage 1 & stage 2 power distribution. Increasing flexibility for decentralization / wire harness reduction

Decentralized Power Distribution

The stage 2 power distribution is transferred into the zone controller. Zone controller becomes the stage 2 and it is fully electrified

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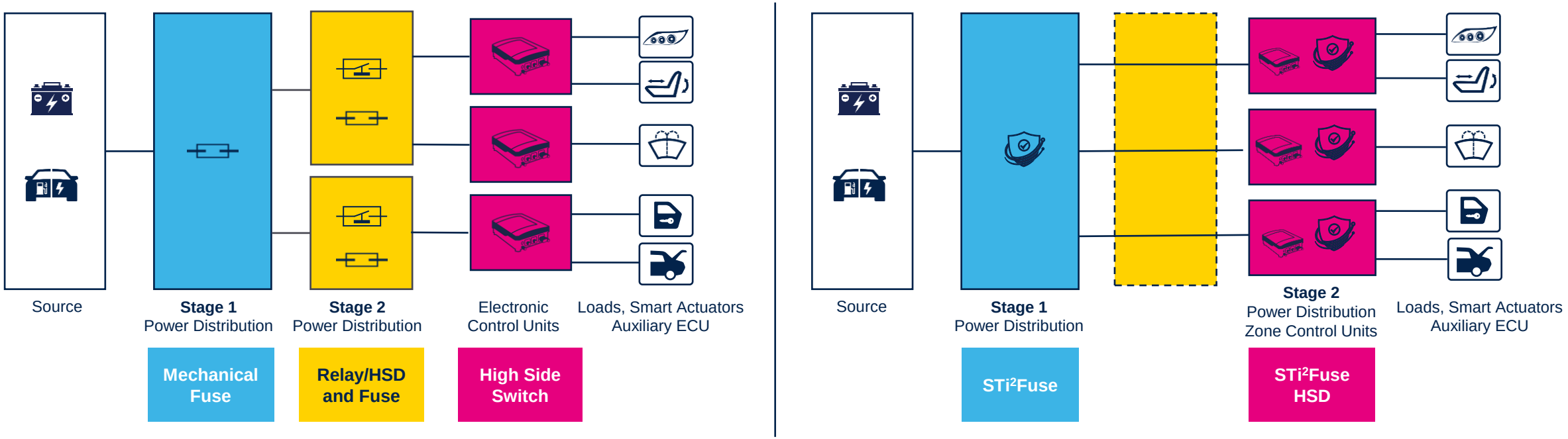
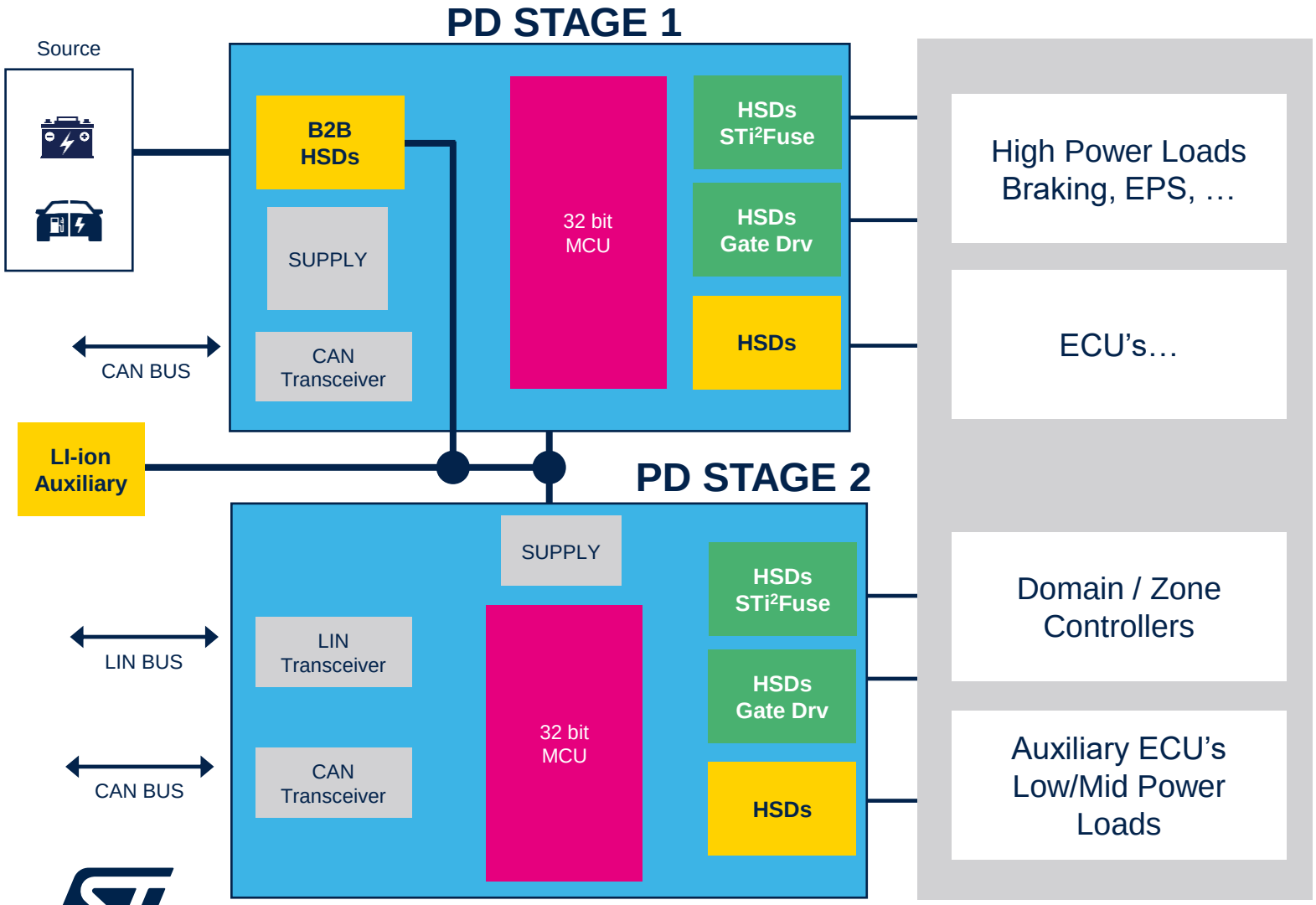
Driving the Transformation of E/E Architecture

Evolution in Automotive Power Distribution…



Power Distribution Concept
ST Proposal



POWER DISTRIBUTION STAGE 1 / STAGE 2 ST PRODUCTS	
STi²Fuse M0-9 + M0S11	• 5 Products (Single / Double) • RDS_{ON}: 0.7mΩ to 3mΩ • Package: PQFN 7x8.5
STi²Fuse M0-9	• 3 Products (Double / Quad) • RDS_{ON}: 5mΩ to 20mΩ • Package: QFN 6x6
HSDs GATE_DRV BCD9 + F8	• 2 Products (Single) • RDS_{ON}: LV MOS F8 Tech • Package: QFN 5x5 + Ext MOS
HSDs M0-9 PARALLEL	• 11 Products (single / double / quad) • RDS_{ON}: 4mΩ to 80mΩ • Package: PSSO-16
HSDs M0-9 SPI	• 6 Products (double / quad / hexa) • RDS_{ON}: 5mΩ to 100mΩ • Package: QFN 6x6

Scalable solution for different current/energy requirements

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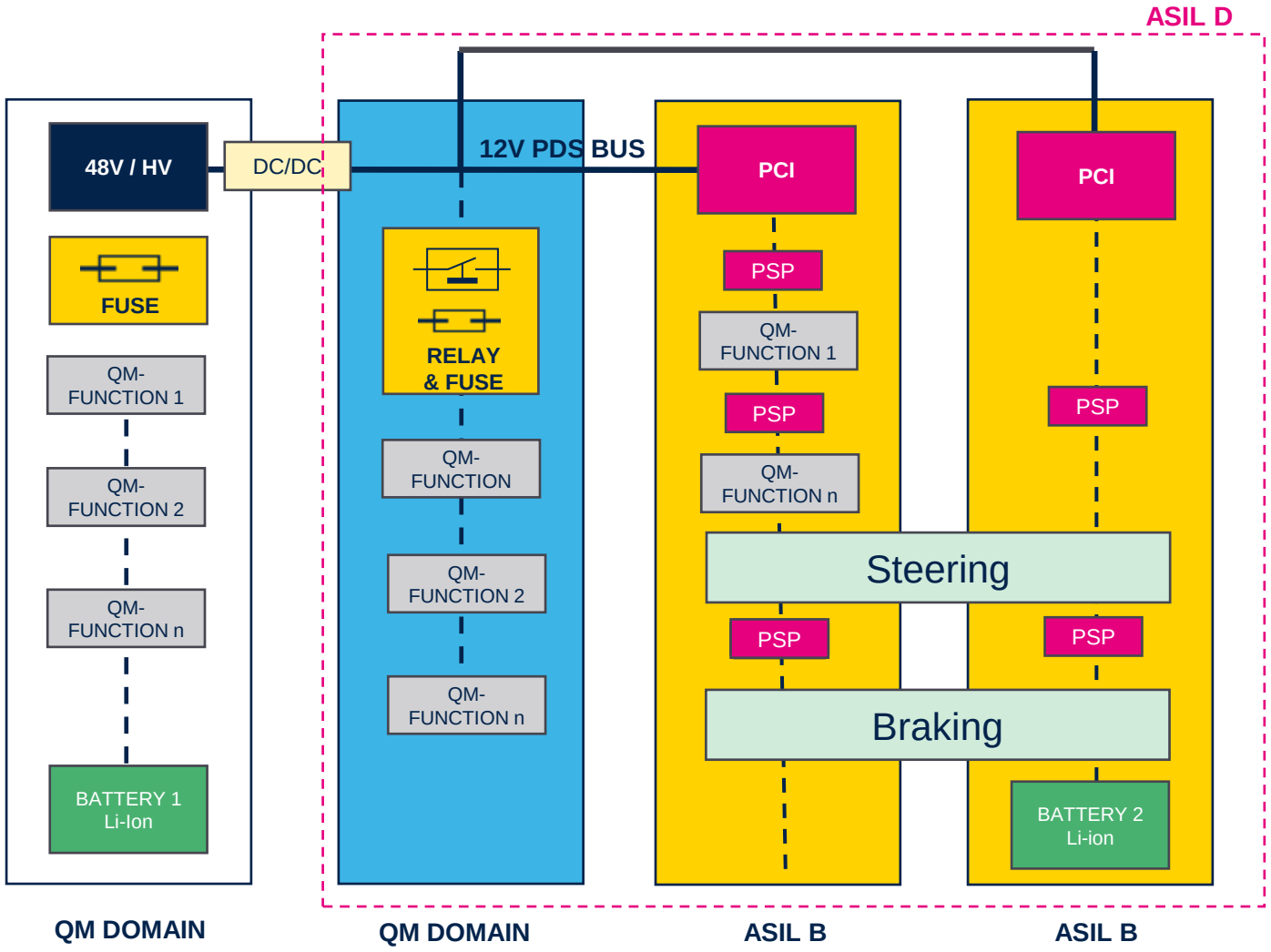
Power Distribution Safety Requirements



Robustness against failure and interferences propagation is the major driving factor for the new power distribution architectures

Critical Functions like Steering & Braking need to be always supplied:

- 12V Power Distribution BUS (PDS) must be always available;
- UV or OV must be filtered

Power supply 48V / HV

- Provide and Ensure the energy needed by the system in normal conditions
- Causing OV or UV to be prevented

Power storage (Li-ion Batteries)

- Ensure the availability of energy and power
- Monitors state of charge, state of health and power prediction

Power distribution safety elements

› **PCI**: Power Connect & Isolation between two PDS

› **PSP:** Power Supply Protection between PDS and Function

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Specific Requirements for eFuse device

New Requirements	What does it mean for the “power distribution switch*„
Load Compatibility	The switch shall supply a direct load or a module having large entry capacitance without interruption due to intrinsic protection and for any ambient temperature. Loads ranging from 0.1A to >50A.
Network stability	The switch shall react against a short circuit within 100µs to prevent the power network to collapse
Wire protection	The switch shall embed a I^2t protection to protect the downstream wire from any abnormal heating
Failsafe mgt	The switch shall be fully operational during SW update, after POR, or in failsafe condition.
ASIL B requirements	The switch shall have a current sense measurement chain for diagnostic and wire protection at ASILB and be compliant with Stuck ON /Stuck OFF requirements
ASIL>B requirements	The switch must guarantee a system protection against thermal incident at ASIL>B
Diagnostic availability	The switch must allow a I,V,T measurement for all outputs for health monitoring
Permanent Vpwr supply	The switch must supply few load in parking mode at 10s of µA standby current and wake up by itself if requested

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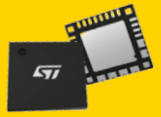
Low Voltage Integrated Power Division
STi²Fuse Tailored for Power Distribution

Monolithic devices

2x Dual channel
1x Quad channel
Production starting from Q4 '23



QFN 6x6

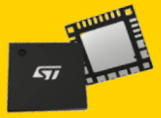
System in Package

3x Single channel
3x Dual channel
Production starting from Q3 '24

PowerQFN 7x8.5

Driver + Ext. MOSFET

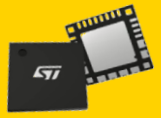
2x Single channel
1x Dual channel
1st product in full production



QFN 5x5

Companion Chip
(Implementing Active Stand-by functionality)

1 product with 8 ch.
supporting stby-on
Production by Q2 '25



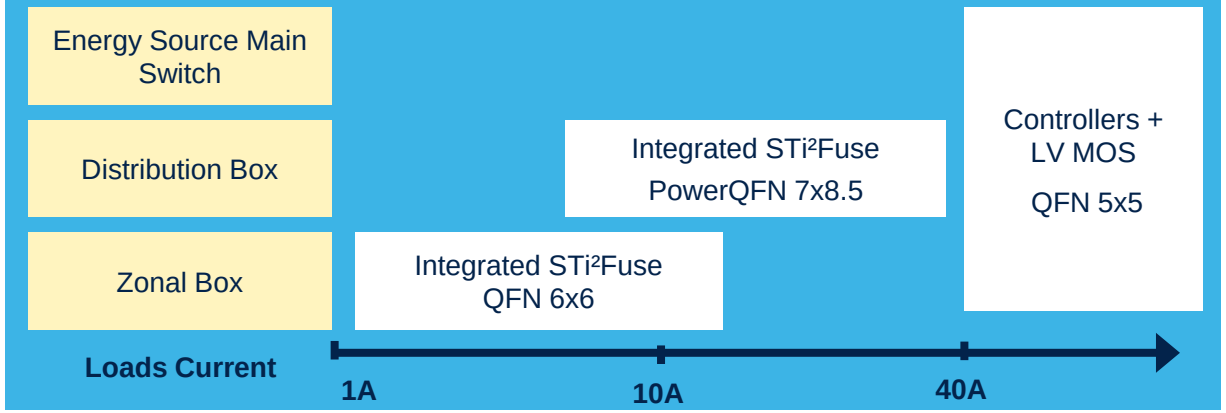
QFN 5x5

STi²Fuse: Electronic fuse with advanced diagnostic and enhanced functional safety replacing both standard fuses and relays

Zonal Architecture Advantages

- Reduced number of ECUs and easy integration / weight and CO2 reduction
- Modular platform management / Safe and fault tolerant
- Multi energy source compatible / Ready for health monitoring & predictive maintenance

LVIP product offer and application coverage



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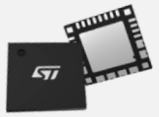
Low Voltage Integrated Power Division
STi²Fuse Tailored for Power Distribution

Monolithic STi²Fuse

M0-9 SPI

- VNF9D5F (2x 5mΩ)
- VNF9D10F (2x 10mΩ)
- VNF9Q20F (4x 20mΩ)



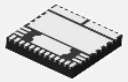
QFN 6x6

- Dual/Quad outputs ST-SPI interface, p2p compatible
- Programmable I²t x ch by OTP in F.S. & SPI in Normal
- 8 steps for both INOM and TNOM
- Capacitive Charging Mode in both Normal & Fail Safe
- ADC & i2t Self Test at POR
- Failsafe state if Backup Logic is present
- Failsafe state if Backup Logic is NOT present

Hybrid STi²Fuse

M0-9 SPI + M0-S11

- VNF9S0M7Q (1x 0.7mΩ)
- VNF9S1M5Q (1x 1.5mΩ)
- VNF9D1M5Q (2x 1.5mΩ)
- VNF9D1M2Q (2x 1.2mΩ)
- VNF9D3Q (2x 3mΩ)
- VNF9D2Q (2x 2mΩ)



PowerQFN 7x8.5

- Single/Dual outputs ST-SPI interface, p2p compatible
- Current, Temperature, Vcc, Vout monitoring
- Temperature and Vout available in OFF
- Prg i²t per channel: 8 steps for both INOM and TNOM
- Emergency stop per Output (EMx): Redundant turn OFF path for safety <100us (in Normal Mode)
- CCM available in both Normal & Fail Safe
- Self Switch On in Reverse Battery
- Supporting Standby-On Functionality coupled with Smart P-Channel for KL30 applications

Driver + Ext. MOSFET

BCD9

- VNF1048F
- VNF1248F

QFN 5x5

- VNFD1248F

Dual Channel

- Gate DRV with i2t protection for 12V, 24V and 48V
- Integrated P-channel to manage the Stby_ON – typ out current is 200mA – 600mA in VNF1248
- Input for a NTC to monitor the external MOSFET temp.
- Digital TJ, VNTC, VOUT and VDS monitoring
- Hard short circuit latch-off configurable via SPI
- I2-t curve configurable via SPI
- Possibility to drive it through DI (also in Normal)
- LH management: NVM for failsafe state and Direct Input
- Capacitive Charging Mode (CCM) in VNF1248
- Bi-Directional current sense in VNDF1248F

Companion Chip

(Implementing Active Stand-by functionality)

BCD9

- L99SP08 (8x 0.85Ω)

QFN 5x5

- 8x P_channel in QFN 5x5
- Current consumption in standby-on: < 10µAx channel
- Typical Ron (@room temp): 850 mΩ.
- Pgr current threshold (NVM) to automatically exit the STBY_ON generating the EN for the main switch.
- Capacitive charging mode in normal operation
- Limp home mode set by dedicated LH pin.
- 5mA current sense accuracy
- Protections triggering generates main switch EN
- ADC Self Test.

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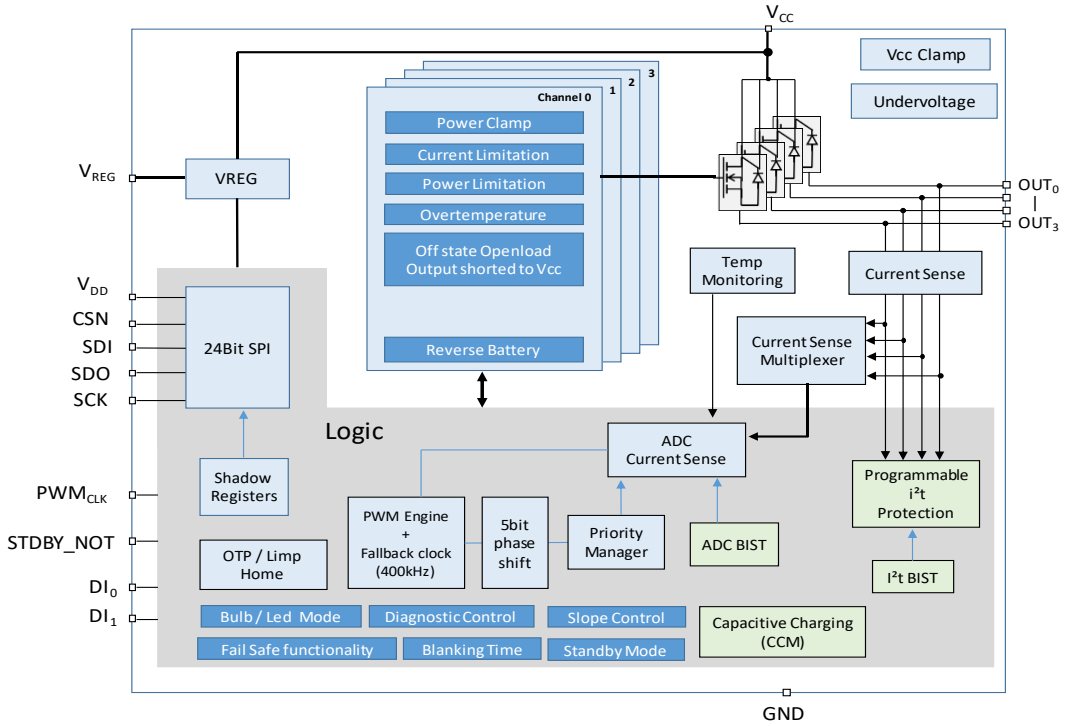
STi²Fuse Monolithic HSDs - Single Die Main Features



DEVICE	RDSON	INOM	TNOM	ILIM
VNF9D5F	2x 5mΩ	4A….15A	300s…1s	75 A
VNF9D10F	2x 10mΩ	2.5A….10A	300s…1s	55 A
VNF9Q20F	4x 20mΩ	1.5A….6A	300s…1s	34 A

- Dual/Quad outputs with 4 wires ST-SPI interface, pin to pin compatible
  - Possibility to drive the device through Direct Input (also in Normal)
- M09 SPI SW-HW compatible
- Programmable I²t per channel
  - 8 steps for both INOM and TNOM
  - Programmable by both OTP in Fail Safe and SPI in Normal
- Diagnostic of overload, short to GND, Output shorted to Vcc and OFF-state open load
- Overtemperature pre-warning (3 thresholds)
- Capacitive Charging Mode available in both Normal & Fail Safe
- ADC & i2t Self Test at POR
- Failsafe state if Backup Logic is present
  - Two Direct Inputs driving outputs (programmable assignment)
- Failsafe state if Backup Logic is NOT present
  - Outputs state set ON or OFF by OTP
  - Direct Inputs are assigned to "i²t status" and “i²t unlatch“ pin
- ISO26262 READY: FMEDA and Safety Manual

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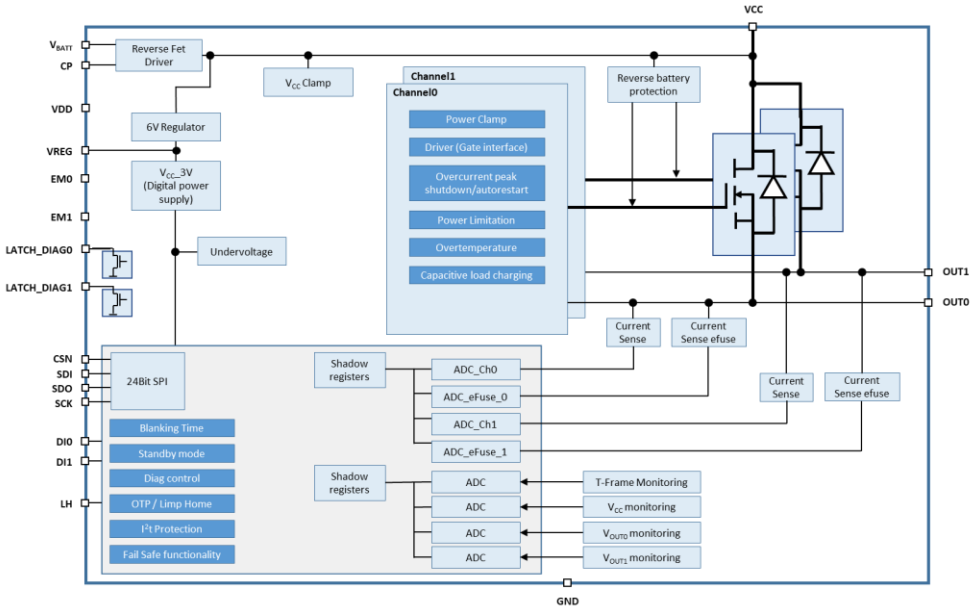
STi²Fuse Hybrid HSDs – Mid To High Currents Main Features



DEVICE	RDSON	INOM	TNOM	IPEAK
VNF9S0M7Q	1x 0.7mΩ	13A….45A	300s…1s	200 A
VNF9D1M5Q	2x 1.5mΩ	9A….32A	300s…1s	140 A
VN9S1M5Q	1x 1.5mΩ	9A….32A	300s…1s	140 A
VNF9D2Q	2x 2mΩ	7.5A….27A	300s…1s	110 A
VNF9D3Q	2x 3mΩ	6A….23A	300s…1s	90 A

- Single/Dual outputs with 4 wires ST-SPI interface, pin to pin compatible
  - Possibility to drive the device through Direct Input (DIx) - also in Normal Mode
- Digital monitoring
  - Current, Temperature, Vcc, Vout
  - Temperature and Vout also accessible when Outputs are OFF
  - Configurable Latched Diagnostic pin for Interrupt
- Programmable overtemperature pre-warning
- Programmable i²t per channel
  - 8 steps for both INOM and TNOM
  - Programmable by both OTP in Fail Safe and SPI in Normal
- Emergency stop per Output (EMx): Redundant turn OFF path for safety <100us (in Normal Mode)
- Capacitive Charging Mode available in both Normal & Fail Safe
- Reverse Protection:
  - Self Switch On in Reverse Battery
  - Dedicated pin (CP) driving the gate of optional external N-MOSFET to block the reverse battery current
- Supporting Standby-On Functionality coupled with Smart P-Channel for KL30 applications
- Limp home management: OTP for failsafe state and Direct Inputs
- ISO26262 READY: FMEDA and Safety Manual

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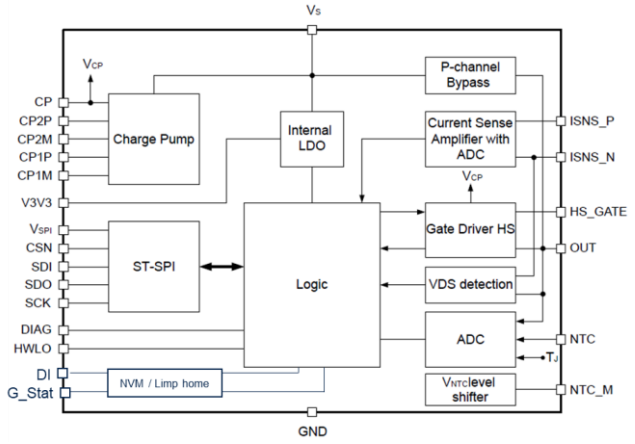
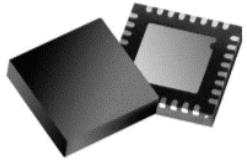
STi²Fuse Controller – VNF1048F / VNF1248F Main Features

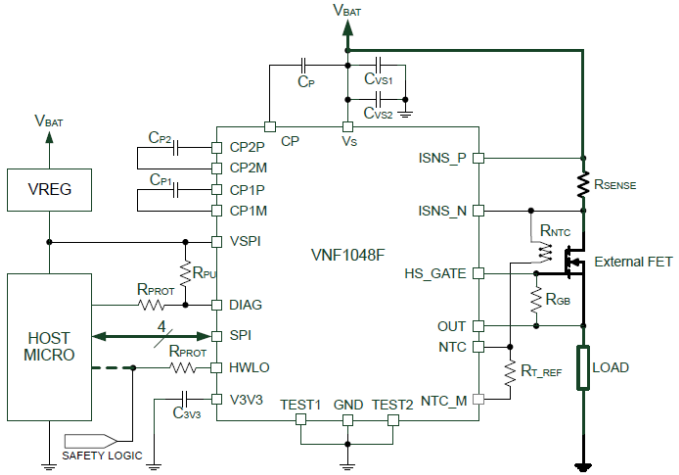
Block Diagram





QFN32L 5x5

Typical Application Schematic



C_{VS1} = 20 µF
C_{VS2} = 100 nF
C_{P1} = 470 nF
C_{P2} = 470 nF
C_P = 470 nF
R_{PROT} = 1 kΩ
R_{PU} = 4.7 kΩ
C_{3V3} = 1 µF
R_{GB} = 47 kΩ
R_{T_REF} = 10 kΩ
R_{SENSE} = 1 mΩ

VNF1048F - Main Features

- High Side Switch Control IC with i2t protection for Automotive 12V, 24V and 48V applications
- Gate driver for an external MOSFET in High Side configuration
- Interfaced to a host microcontroller through a 3.3V and 5V CMOS compatible SPI interface
- Integrated P-channel to manage the Stby_ON – typ out current is 200mA
- High accuracy (3%) Digital Current sense through an external high side shunt resistor
- Input for a NTC resistor to monitor the external MOSFET temperature
- Digital TJ, VNTC, VOUT and VDS monitoring through dedicated ADC

Protections:

- Battery under-voltage shut down
- External MOSFET desaturation shutdown configurable via SPI
- Hard short circuit latch-off configurable via SPI
- I2-t curve configurable via SPI
- Device Over-Temperature shutdown
- External MOSFET Over-Temperature shutdown

VNF1248F - Extra Features

- Possibility to drive the device through Direct Input (also in Normal)
- Stby_ON: P-channel 3 times bigger to achieve 600mA as typ out current vs 200mA
- Limp home management: NVM for failsafe state and Direct Input
- Capacitive Charging Mode (CCM)
- Battery u-cut LV124 compatible

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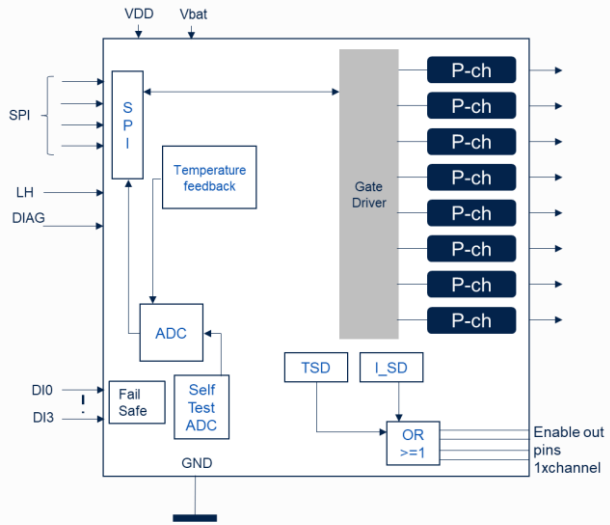
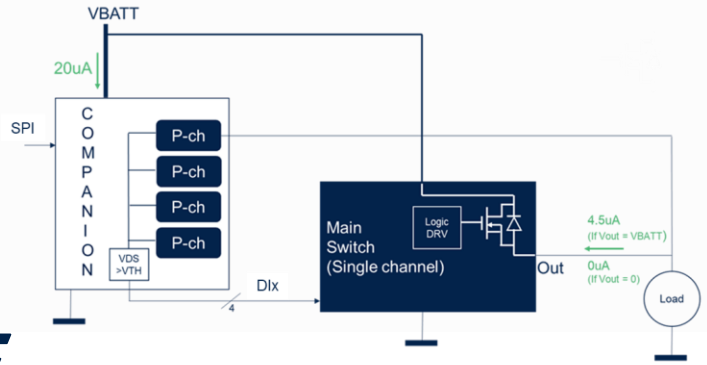
Smart P-Channel - L99SP08 Product ID card

Block Diagram

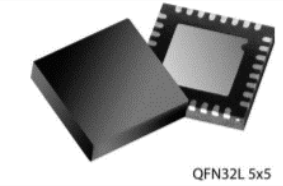


Simplified Application Schematic

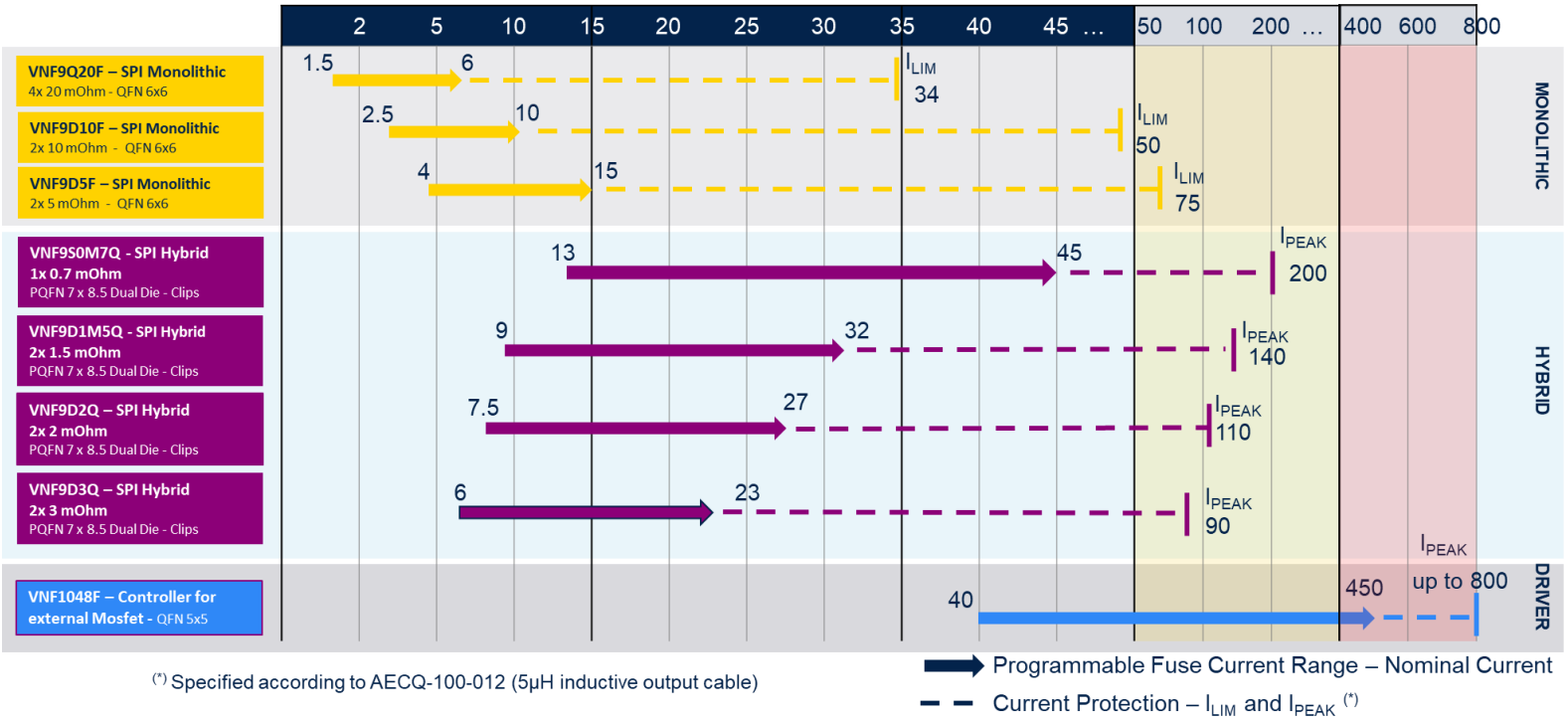


Main Features

- Current consumption in standby-on: < 10µA (x channel, including main switch leakage).
- Typical Ron (@room temp): 850 mΩ.
- Programmable current threshold (NVM) to automatically exit the standby-on state generating the EN signal for the main switch.
- Capacitive charging mode in normal operation through current generator: target is 330uF charged in 200ms.
- Limp home mode set by dedicated LH pin.
- 5mA current sense accuracy and case temperature sensing.
- Protections: current & overtempt shutdown, whose triggering generates main switch EN.
- Diagnostic: available on demand.
- ADC Self Test.
- QFN32L 5x5 package.
- Eco-Sustainability Label: Planet-friendly application.



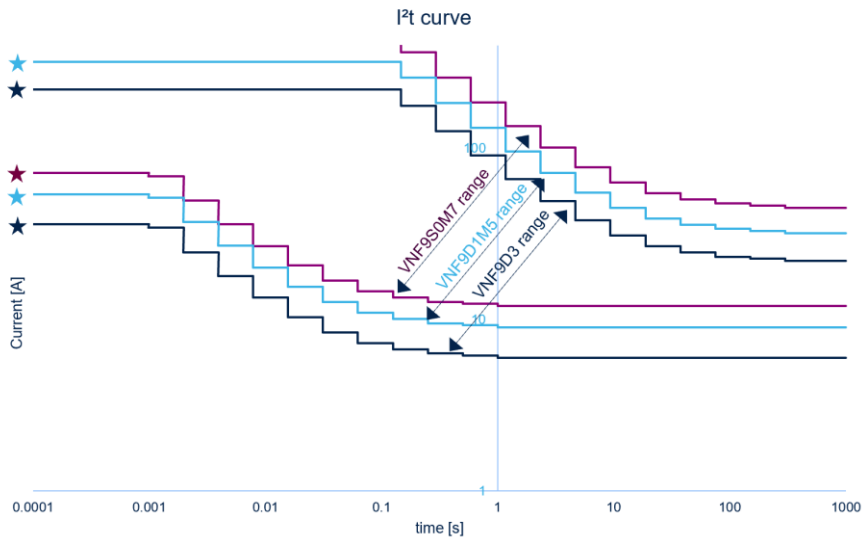
VIPower STi²Fuse
Fuse function: Nominal current programmability



(*) Specified according to AECQ-100-012 (5µH inductive output cable)

I²t - flexible protection feature

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



- p2p HW & SW compatible drop in replacement
- Configurable I²t curves by SPI
- Efficient cable protection from 0.22mm² to ~ 10mm²
- Capacitor pre-charge Mode - Fast turn off (< 100µs) - Functional safety

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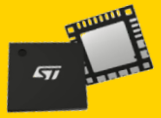
Low Voltage Integrated Power Division
STi²Fuse Tailored for Power Distribution

Monolithic STi²Fuse
VIPower M0-9 SPI

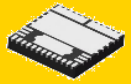
- VNF9D5F (2x 5mΩ)
- VNF9D10F (2x 10mΩ)
- VNF9Q20F (4x 20mΩ)



QFN 6x6

Hybrid STi²Fuse
VIPower M0-9 SPI + M0-S11

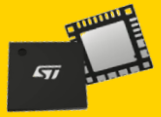
- VNF9S0M7Q (1x 0.7mΩ)
- VNF9S1M5Q (1x 1.5mΩ)
- VNF9D1M5Q (2x 1.5mΩ)
- VNF9D1M2Q (2x 1.2mΩ)
- VNF9D3Q (2x 2mΩ)
- VNF9D2Q (2x 2mΩ)



PowerQFN 7x8.5

Driver + Ext. MOSFET
BCD9

- VNF1048F
- VNF1248F
- VNFD1248F



QFN 5x5

Companion Chip
(Implementing Active Stand-by functionality)
BCD9

- L99SP08 (8x 0.85Ω)

QFN 5x5

STi²Fuse development schedule

	ES	FS	MC30
VNF9D5F	●	Sep/23	Dec/23
VNF9D10F	Q1/24	Q4/24	Q1/25
VNF9Q20F	●	Sep/23	Jan/24

	ES	FS	MC30
VNF9S0M7Q	Q1/24	Q1/25	Q2/25
VNF9S1M5Q	Q4/24	Q3/25	Q4/25
VNF9D1M5Q	●	Jun/24	Dec/24
VNF9D1M2Q	Q4/23	Jun/24	Dec/24
VNF9D3Q	Q4/23	Q3/24	Q1/25
VNF9D2Q	Q4/24	Q3/25	Q4/25

	ES	FS	MC30
VNF1048F	In production		
VNF1248F	Q4/23	Q2/24	Q4/24
VNFD1248F	Q4/24	Q2/25	Q4/25

	ES	FS	MC30
L99SP08	Q4/23	Q3/24	Q2/25

● Available

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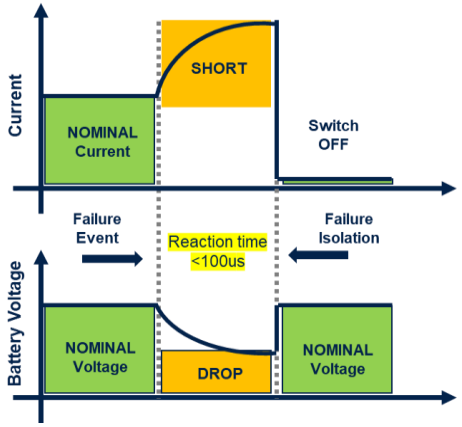
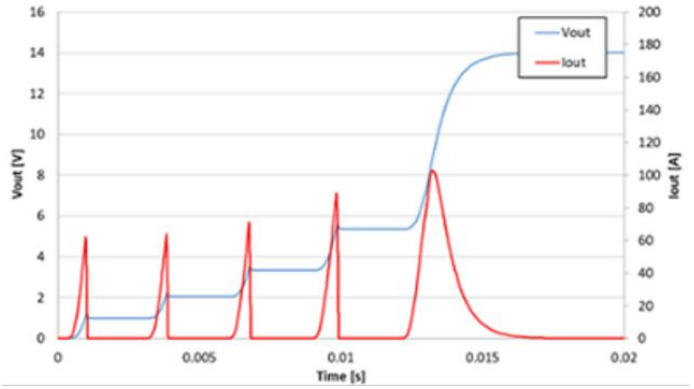
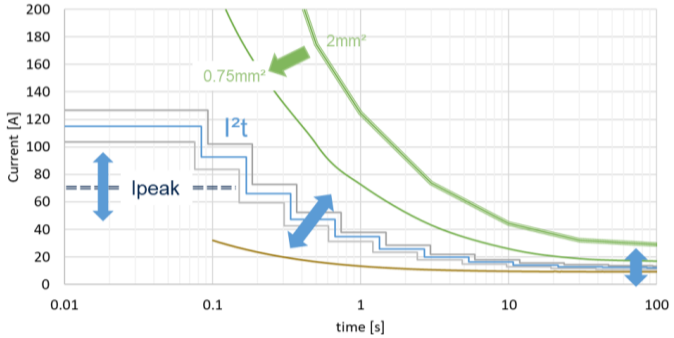
STi²Fuse – Smart Fuses for Automotive Power Distribution With Smart Digital Interface

Boosting Performance





Adding Robustness and Functional Safety



Digital Wire Isotherm Processing

- I²t protection selectable to match the max Ipeak can be adjusted to the load profile.
- I²t protection can be modified by SW during operation

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

Capa 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

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

I²t Functionality

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

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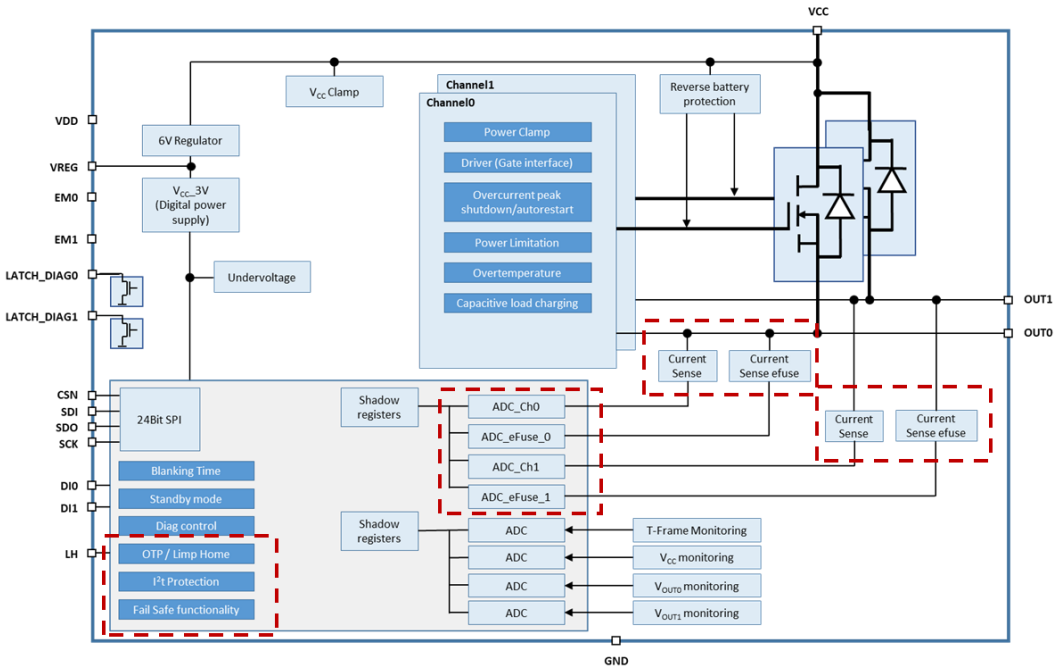
STi²Fuses vs uC + standard HSD



STi²Fuse strengths:

- **uC not Available:** Thanks to the embedded configurable failsafe mode, devices are fully operating, granting the cable protection, even when uC is not available (due to start up POR or during OTA upgrading);
- **Fault:** In case of fault, <100us reaction time granted thanks to the 16kHz current sampling frequency, able to detect fast output current change then, accurate cable temperature;
- **Cascade behavior:** Frequency range and independent output current sampling guarantee synchronization among cascaded devices on different modules – In case of fault, the eFuse switched off is the one closer to the failure point, preventing the battery line to collapse.
- **Sense Accuracy**: Extended sense accuracy in the whole output current range (preventing current saturation), allows optimization with no need of additional margin on cable section sizing.
- **ASIL Level**: ASIL B cable protection is granted due to the embedded redundancy and BIST on current sense chain.

STI²Fuses: more than an HSD with embedded I2t algorithm

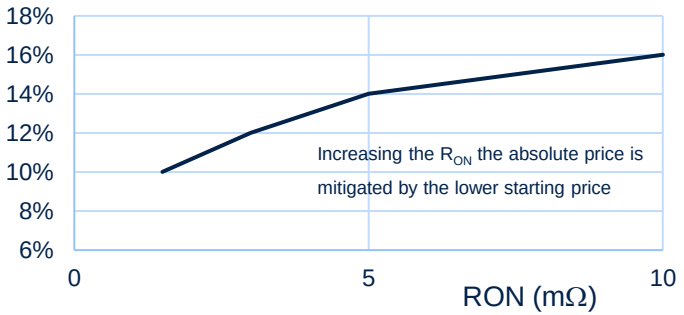
- Redundancy and BIST circuit to ensure safety – ASIL B at device level
- Independent Failsafe mode configurability with NVM programmable I2t curve
- Advanced (I, V, T) Diagnostic in both ON and OFF state
- Very low current consumption in standby to support the parking / Idle mode

STi²Fuses: The best chip solution

Generic considerations

STI²Fuses price adder in % vs the standard HSDs same RON

Delta price mainly impacted by safety redundancies and digital features



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Predictive Maintenance

Product Self Diagnostic and Health monitoring

Devices ready for State of Health - Predictive Maintenance

- State of the art diagnostic embedded in the new product families enables advanced algorithm for system state of health supervision

Benefits

- Avoid “safety critical” failures
- Reduce circuit redundancy extra costs
- Achieve and enable high safety goals (ASIL C)

Applications

- Vehicle Diagnostic and Monitoring Systems
- Multiple & Backup Power Systems
- High safety redundant Systems (i.e. braking)

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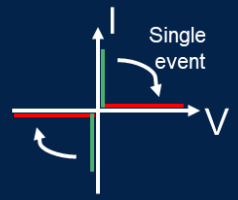
SmartFuse versus Fuse not the same functions

STANDARD FUSES

Widely used for decades in automotive

Able to protect the wire harness at the price of imprecise reaction and manual handling when melted



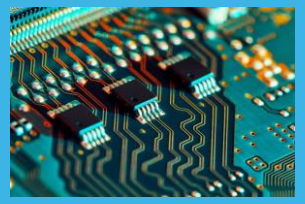
- Cable protection in any vehicle operating mode

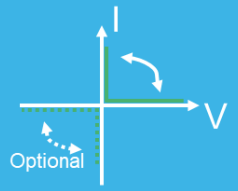
END

SMART FUSES

Are the answer to new electrical topologies and requirements

The Fuse function is now just a part of the overall functions of these SmartFuses





- Cable protection in any vehicle operating mode
  including failsafe and parking modes.

AND

- Capable of Switching loads without interruption in normal operation
- Able of optimizing the cable diameter for a given load
- Flexible to suit with different cables and loads
- Able to decouple the boardnet from hazardous high current transient in few us
- Compatible with new system safety requirements
- Enables health monitoring and preventive maintenance

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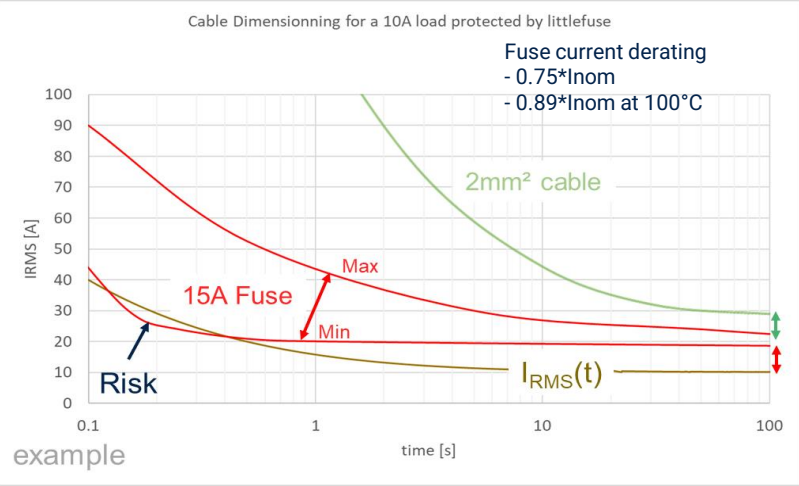
Fuse and Wire selection – Use case Margins to overcome inaccuracies..

Standard Fuses

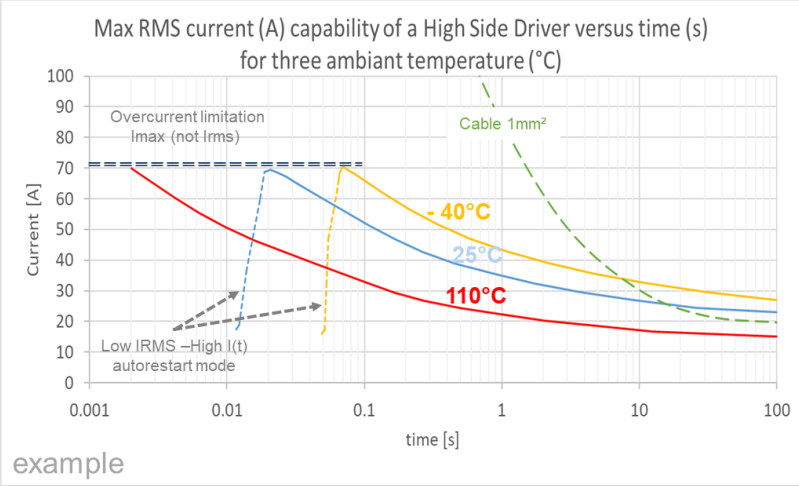
- The fuse must be selected accordingly to the load I_{RMS} and considering necessary margins for the current derating, then proceed with the cable diameter selection.
- In this example, the cable selected has a 3x higher current capability than what the load needs.



- 50ms reaction time
- High Transient then medium voltage drop during few 100ms affecting other load supplies
- Wire has to be sized accordingly, is protected but Fuse has to be changed afterward

Standard HSDs

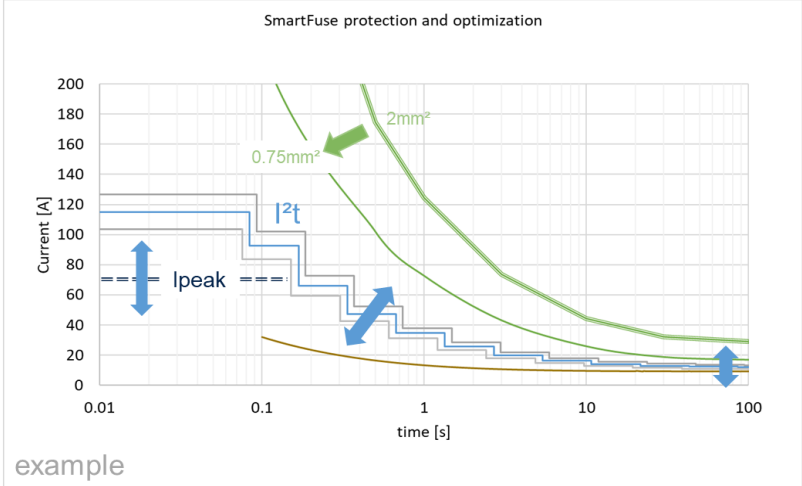
- The cable has to be sized accordingly to the High Side Driver characteristics and not to the load.
- For short time / high current pulses a cyclic behavior is not compliant with the „Load supply switch“ requirement.



- 10ms reaction time (for the MCU to react)
- Voltage unstability which may affect other loads
- Wire harness might be protected unless HSD is more robust than the Wire – Unpredictable in many cases unless over-dimensioning the wire

New STI²Fuse

- A wire diameter can then be selected fitting with the load and not anymore to the fuse
- I²t protection selectable to match the max Ipeak can be adjusted to the load profile.
- I²t protection can be modified by SW during operation



- 100us reaction time without uC intervention
- Voltage drop short transient disturbance not impacting boardnet integrity
- Wire harness protected with possible diameter optimization

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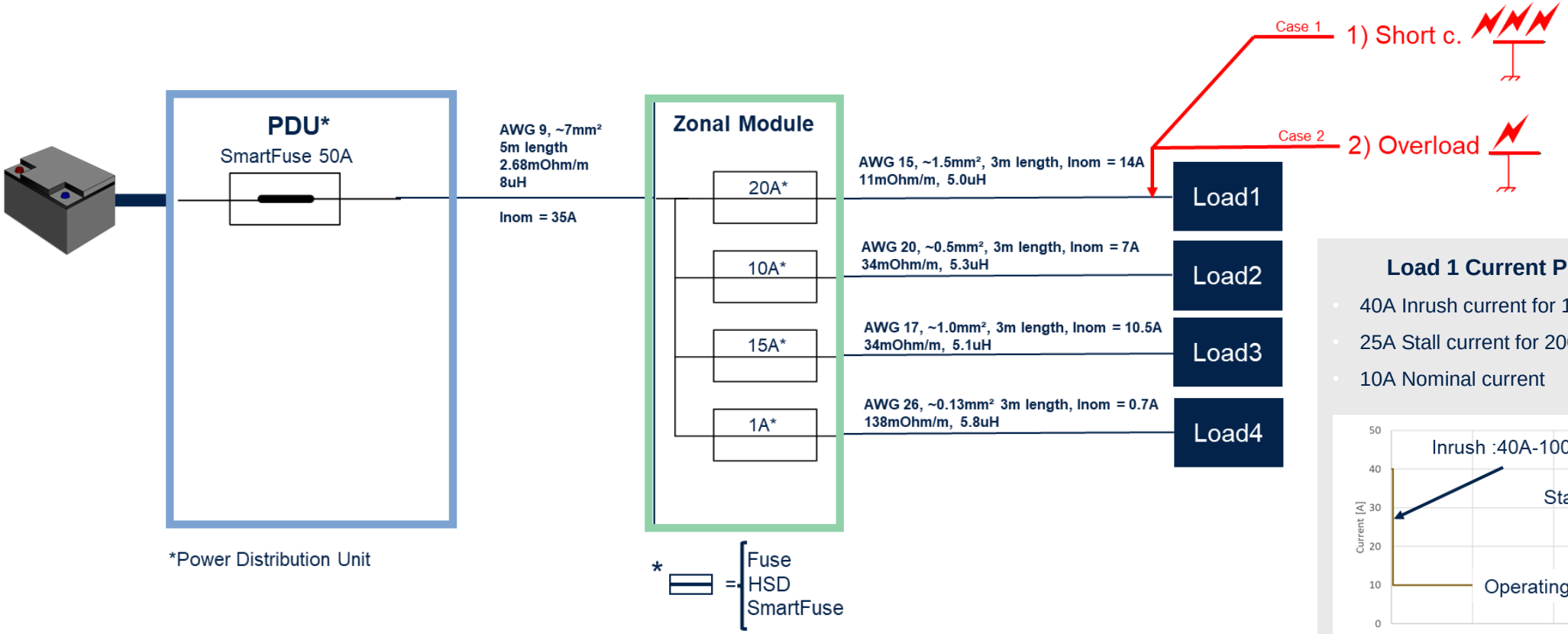
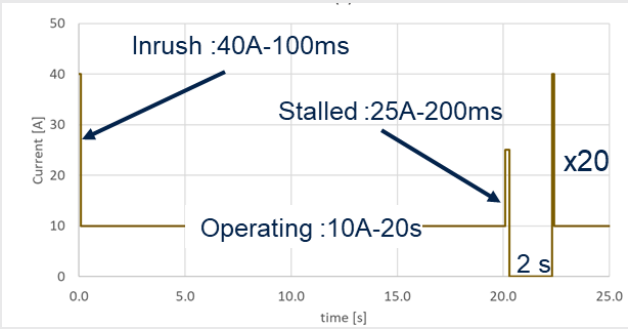
Typical example
Short circuit and overload

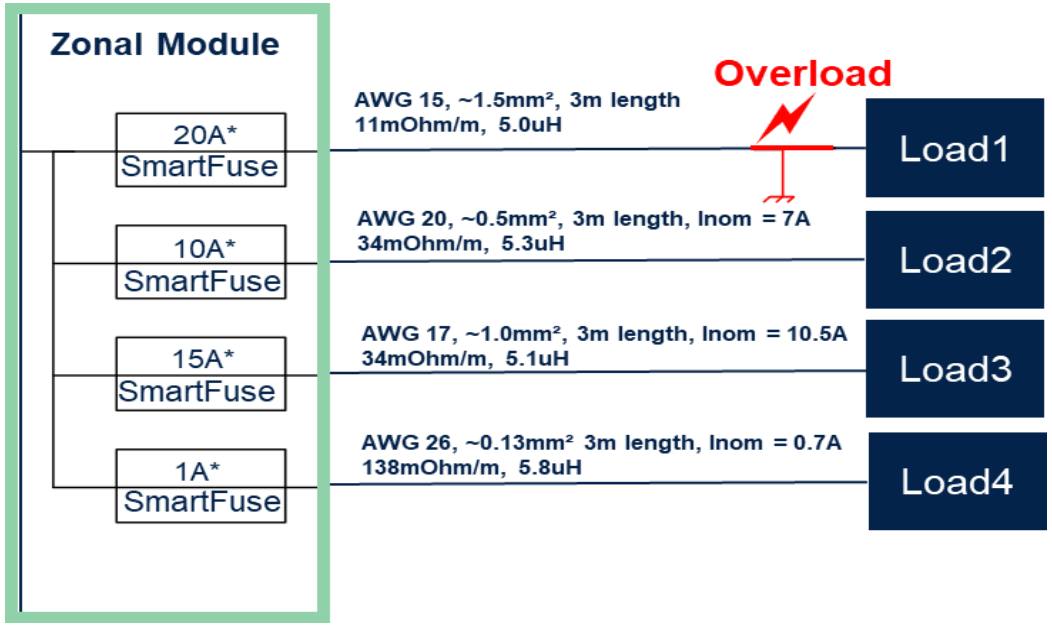


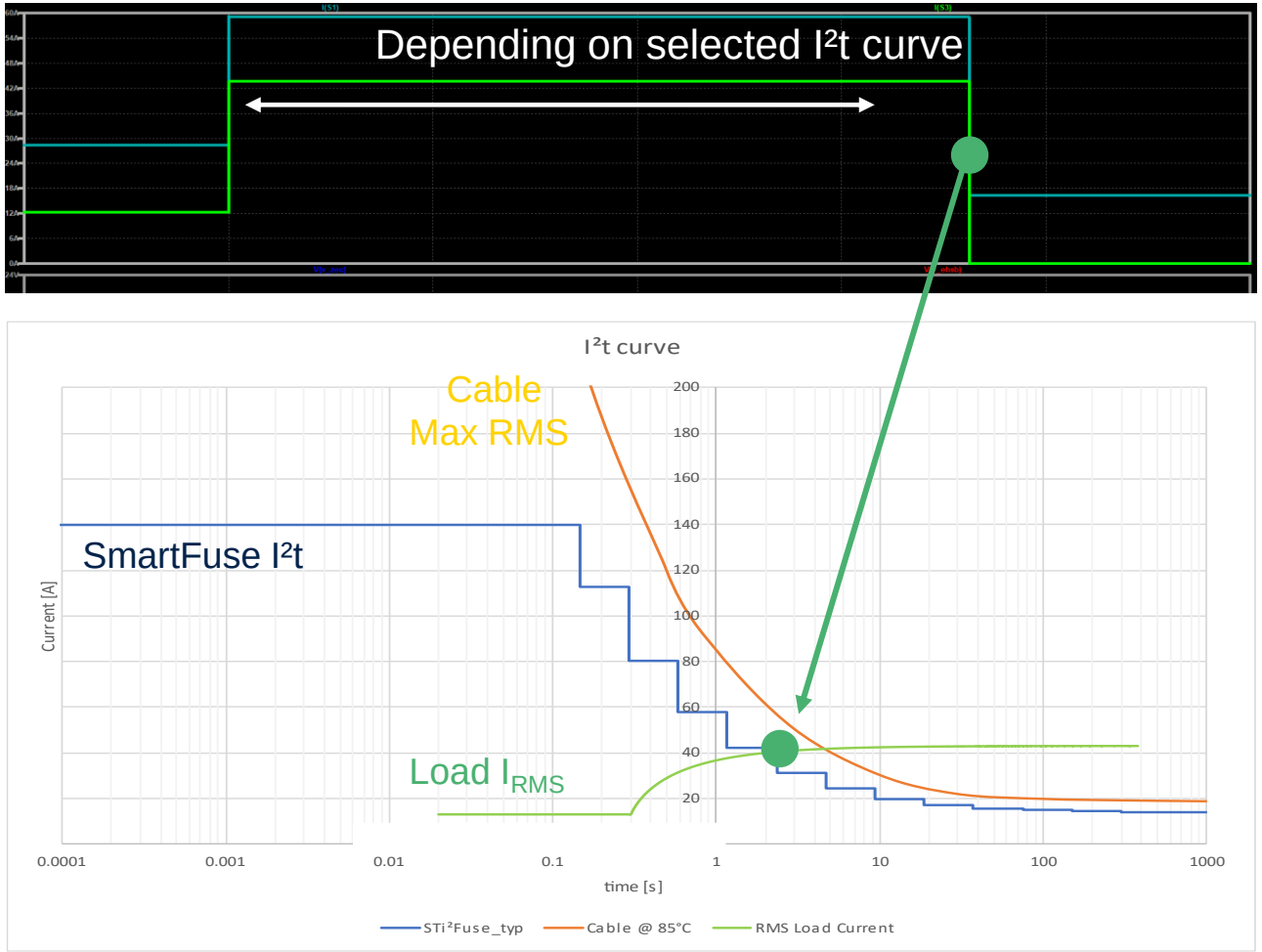
Load 1 Current Profile: DC MOTOR

- 40A Inrush current for 100ms
- 25A Stall current for 200ms
- 10A Nominal current



Case 2 : Overload
Benefit of a SmartFuse





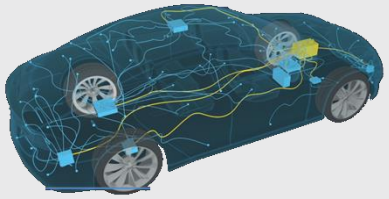
- Time for the SmartFuse to switch off due to the overload condition depends on the I_{RMS} profile accordingly to the selected I²t curve
- The cable diameter can then be optimized to the load.

Conclusions

A new smart energy distribution architecture is emerging to better fit with market trends and regulations

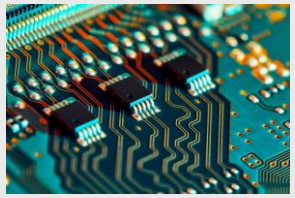
The development of a new function "**SmartFuse**„ is a necessary path to enable this revolution, combining the flexibility of SW with the safety and integration given by HW-based solutions

New Power Distribution Motivations



- Modular Mega platform – Scalable & Digital
- Harness Production cost saving - Automatable
- C02 saving - Wire harness size reduction
- Energy Management – Multi source
- Autonomous Car ready - Safe and fault tolerant
- Predictive Maintenance - Health monitoring

SmartFuse New Function



- Cable protection in any vehicle operating mode including failsafe and parking modes.
- Capable of Switching loads without interruption in normal operation
- Able of optimizing the cable diameter for a given load
- Flexible to suit with different cables and loads
- Compatible with new system safety requirements
- Enable health monitoring and preventive maintenance

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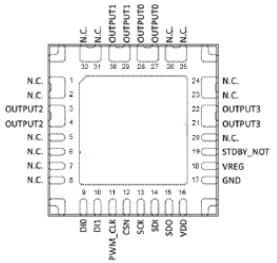
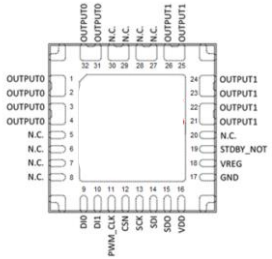
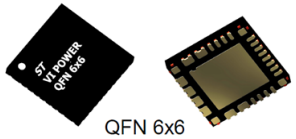
I^2t Characteristics and Tools

VNF9Q20F and VNF9D5F – M0-9SPI I²t

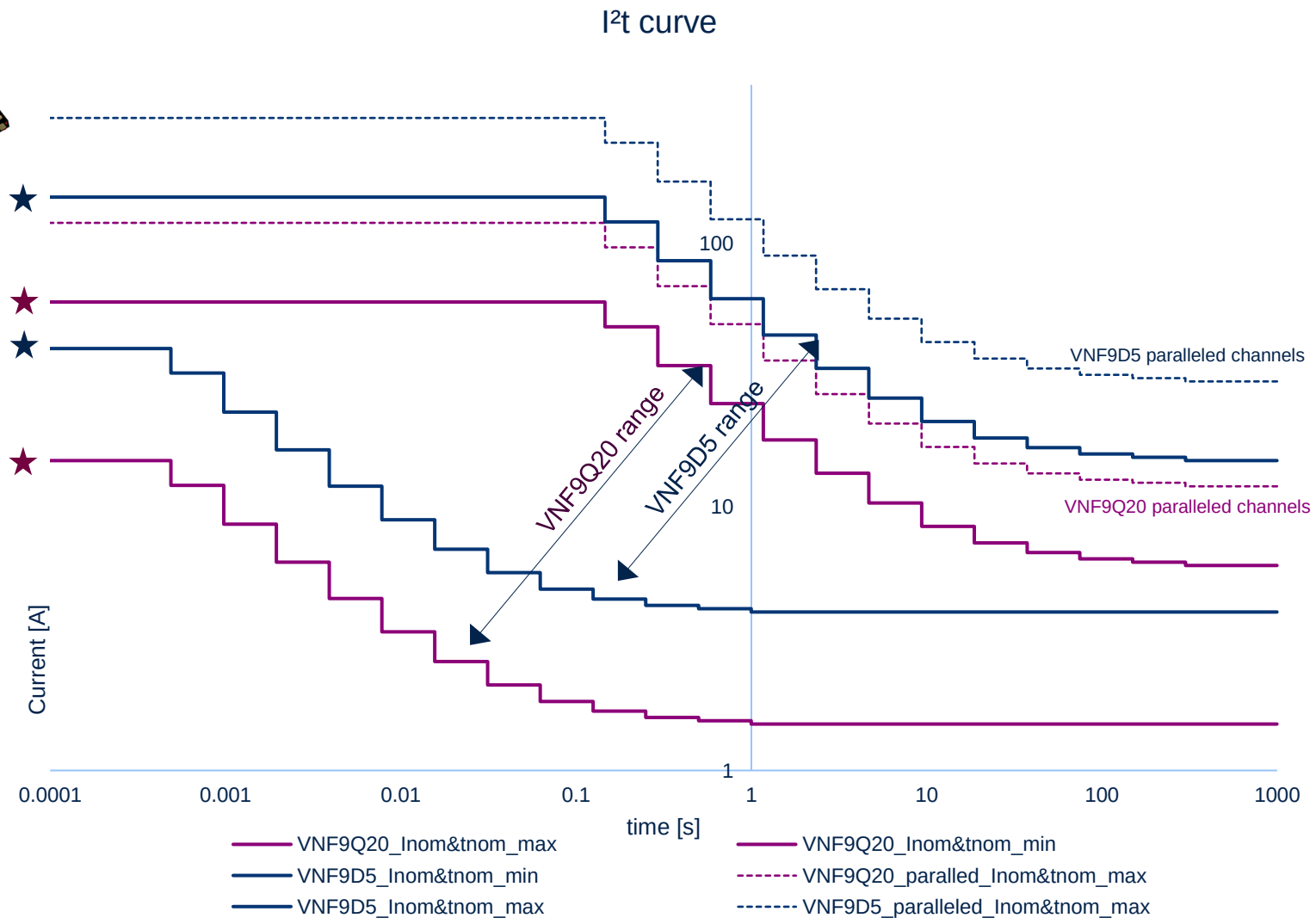






QFN 6x6

- Pin2Pin HW & SW compatible drop in replacement
- Pin2Pin compatible drop in replacement with M0-9SPI
- 128 different, **through SPI SW configurable**, I²t autonomous protection curves with fast (100us) protection against overcurrent
- Efficient cable protection from 0.13mm² to ~1.5mm²
- Capacitor precharge Mode
- ★ Fast turn off (<100us) when exceeding this threshold



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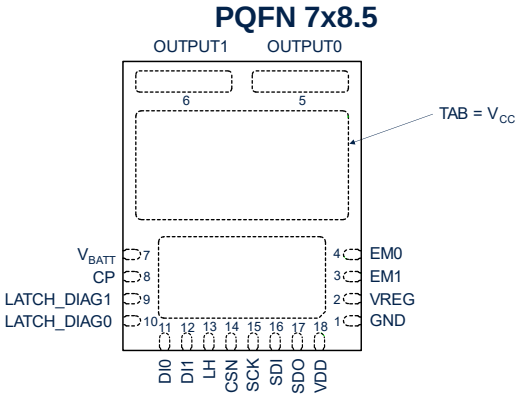
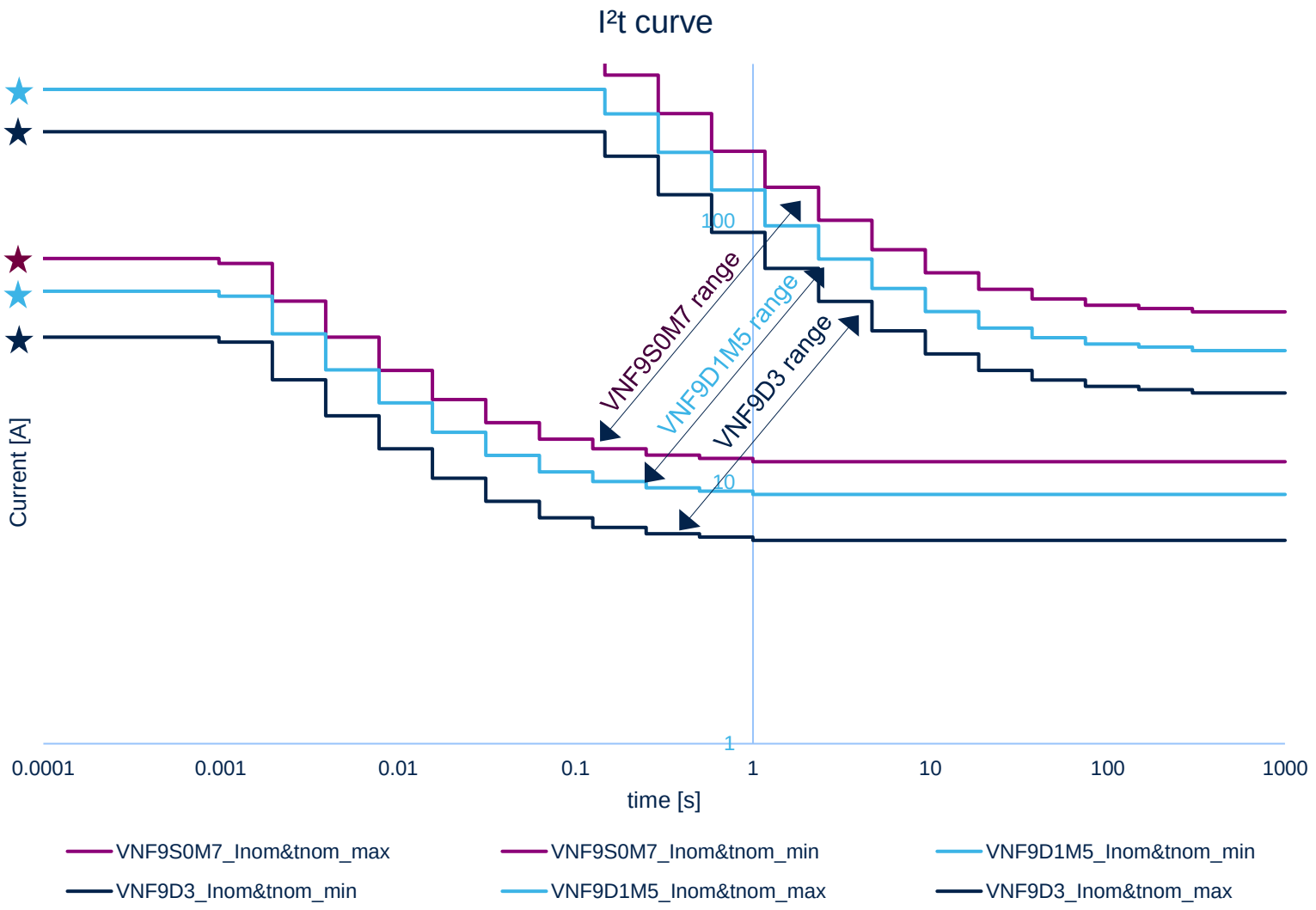
VNF9D1M5, VNF9D3 and VNF9S0M7 – M0-S11SPI I²t

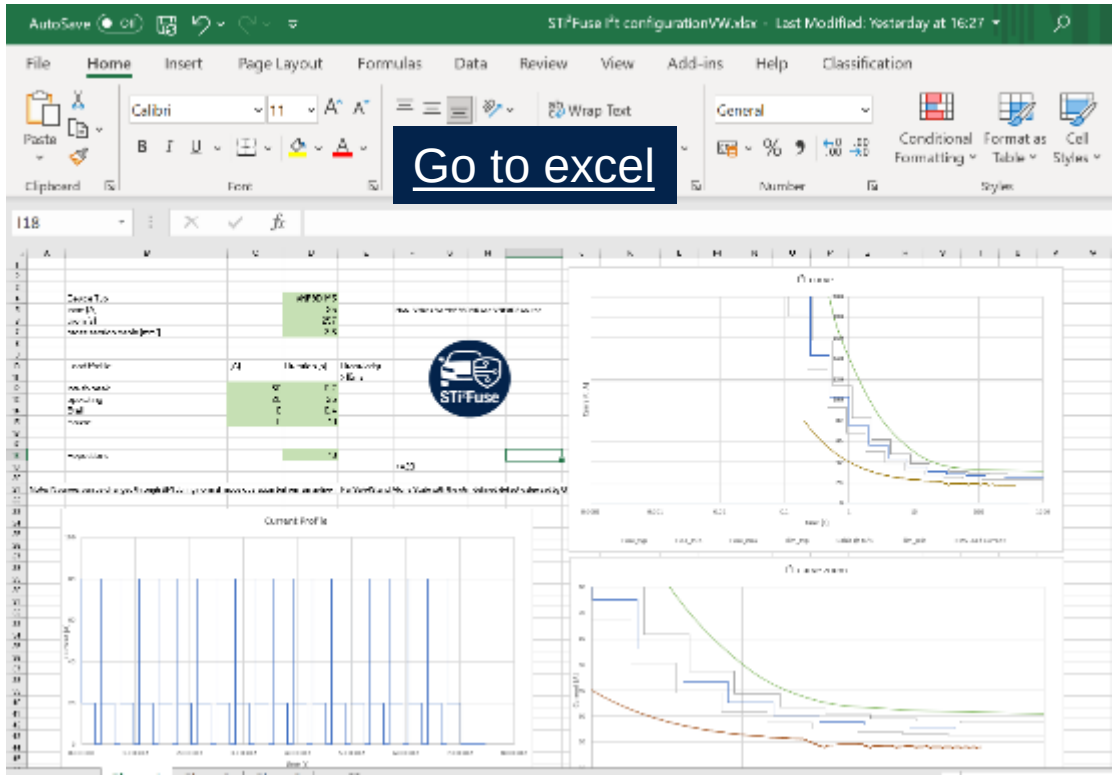


- Pin2Pin HW & SW compatible drop in replacement
- 256 different, **through SPI SW configurable**, I²t autonomous protection curves with fast (100us) protection against overcurrent
- Efficient cable protection from 0.22mm² to ~ 10mm²
- Capacitor precharge Mode
- ★ Fast turn off (<100us) when exceeding this threshold

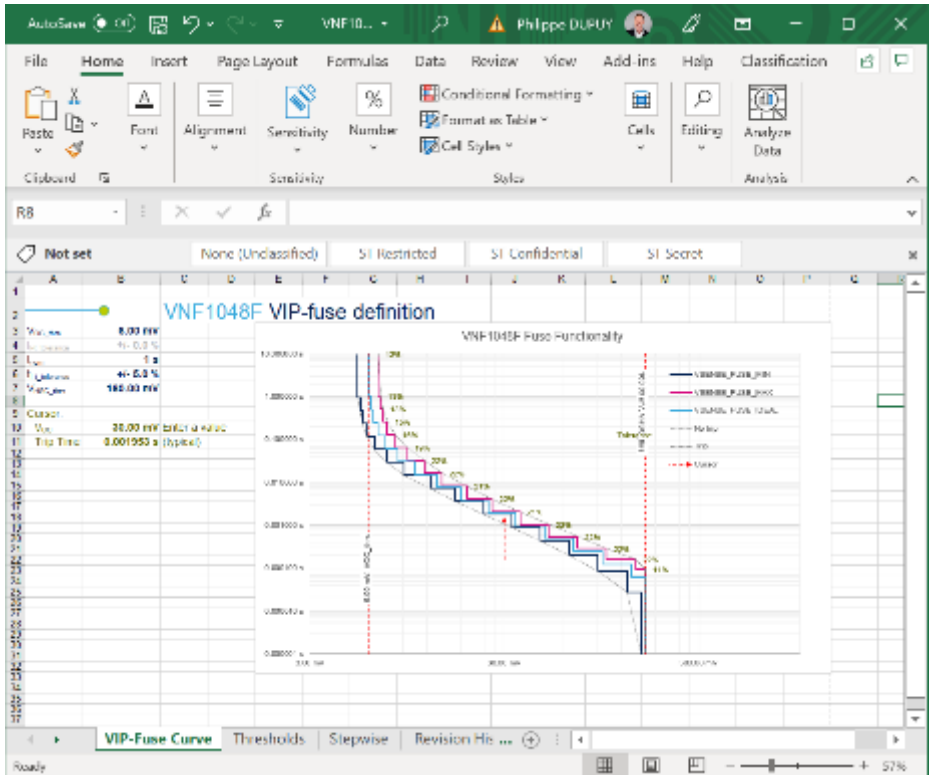


Tools

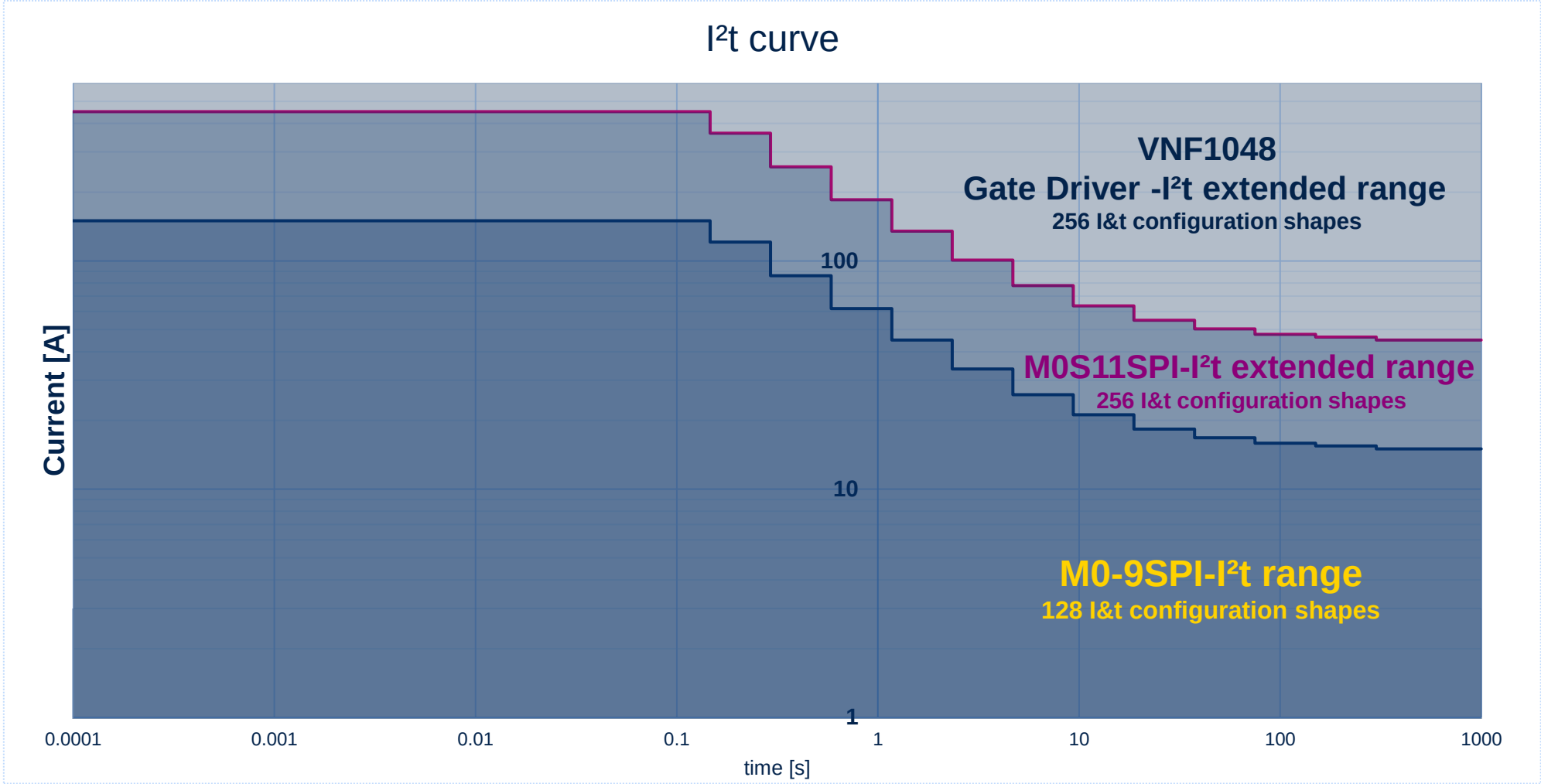
Integrated Solutions



Gate Driver



STi²Fuse: A complete Product Portfolio - SW configurable I²t wire protection for all automotive wires



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