MPS E-Fuse and E-Fuse +

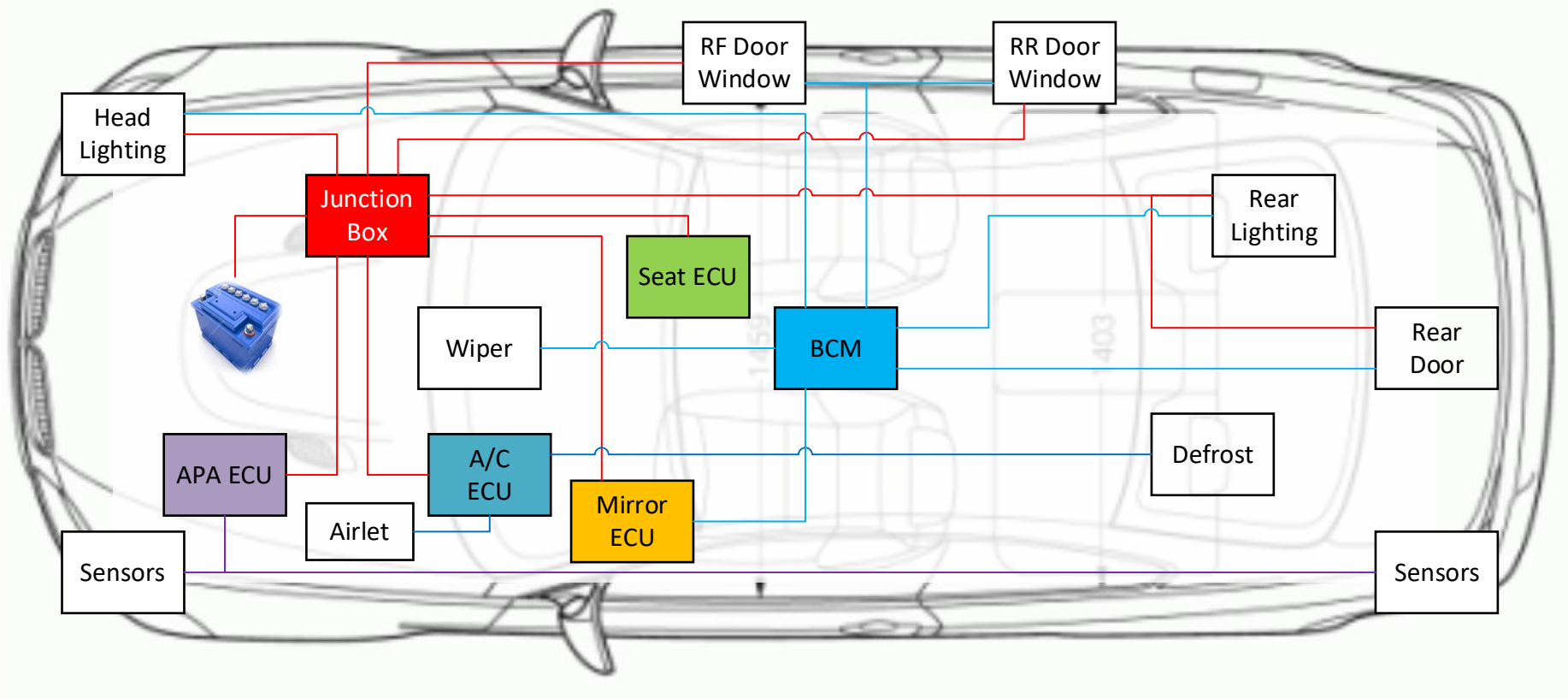
The world first fail-safe E-Fuse

August 2025

Agenda

1. MPS E-Fuse
2. MPS E-Fuse +

Traditional E/E Architecture (EEA)

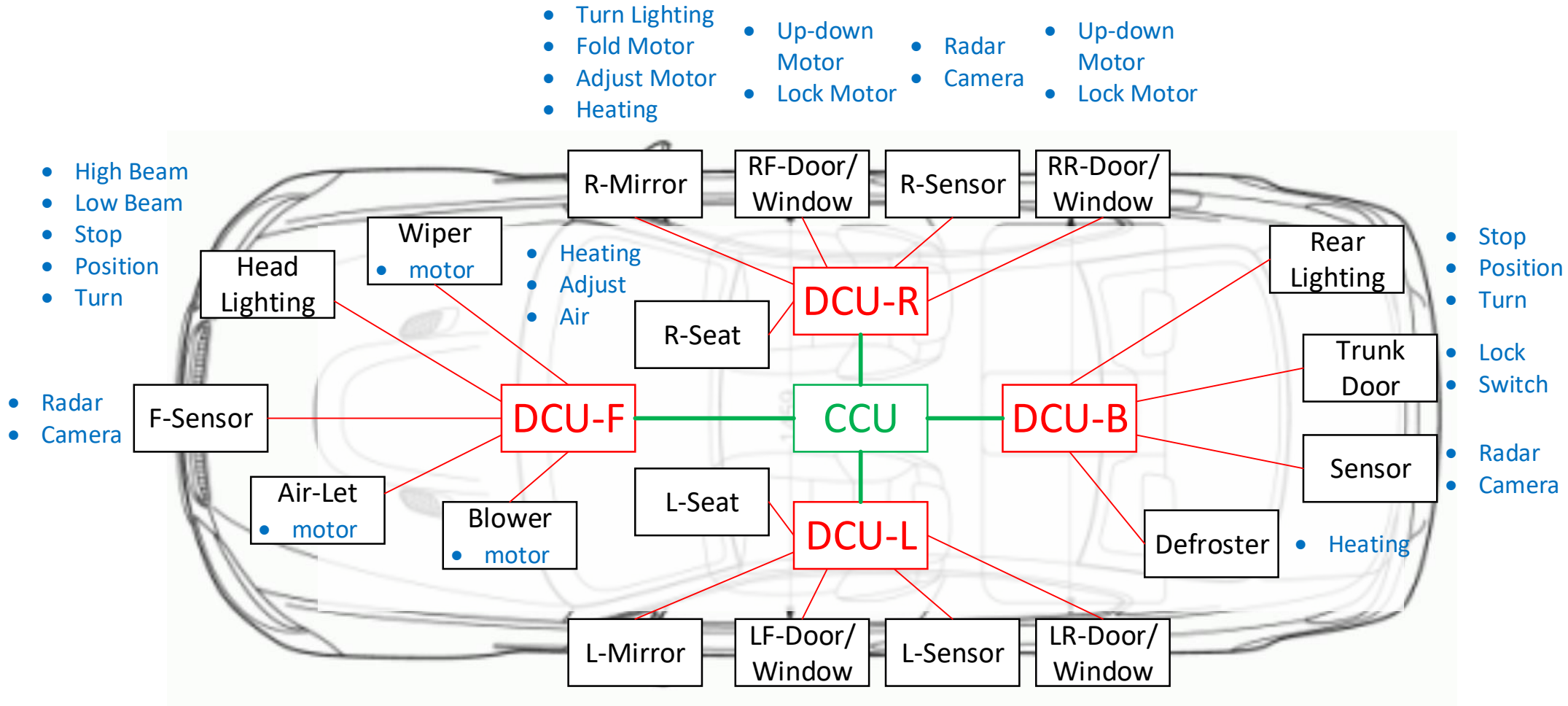


- Many ECUs; ECUs are classified by function
- Dedicated junction box to supply and protection battery

Drawbacks

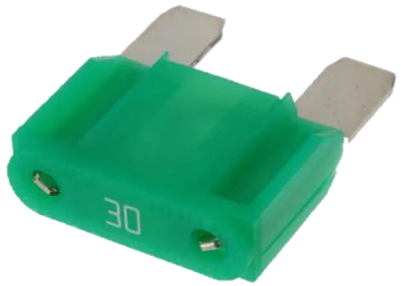
- Long wire: high cost, complex vehicle assembly and low production efficiency.
- Traditional passive fuses in junction box need professional maintenance.
- Hardware-defined system.

New EEA (Body): Zonal Domain Control Unit



Zonal DCU may also be called Vehicle Integration Unit (VIU).
Central Computing Unit (CCU) may also be called Vehicle Computing Unit (VCU).

Automotive Fuse and E-Fuse

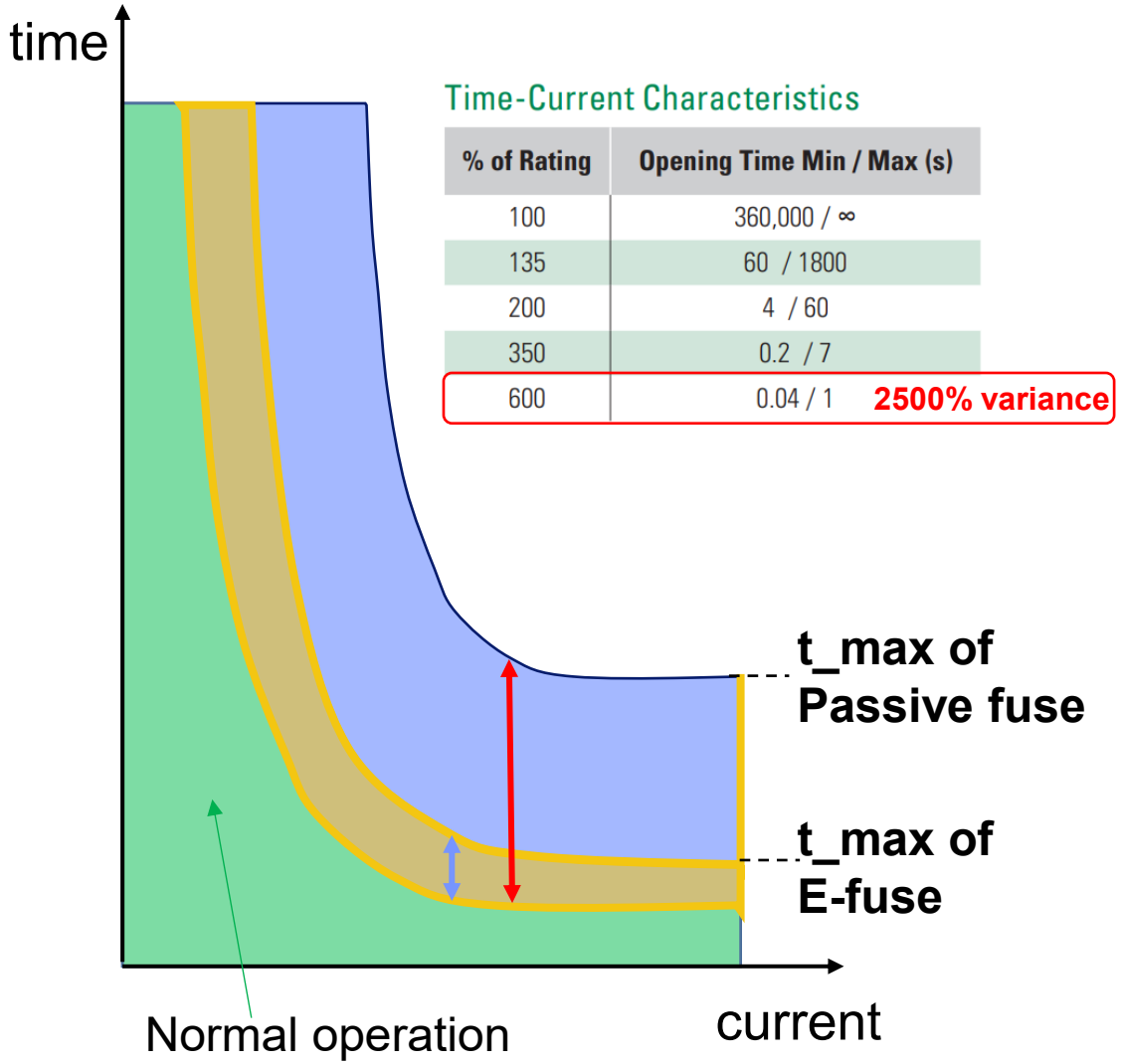


Maxi Fuse
(29x34mm)

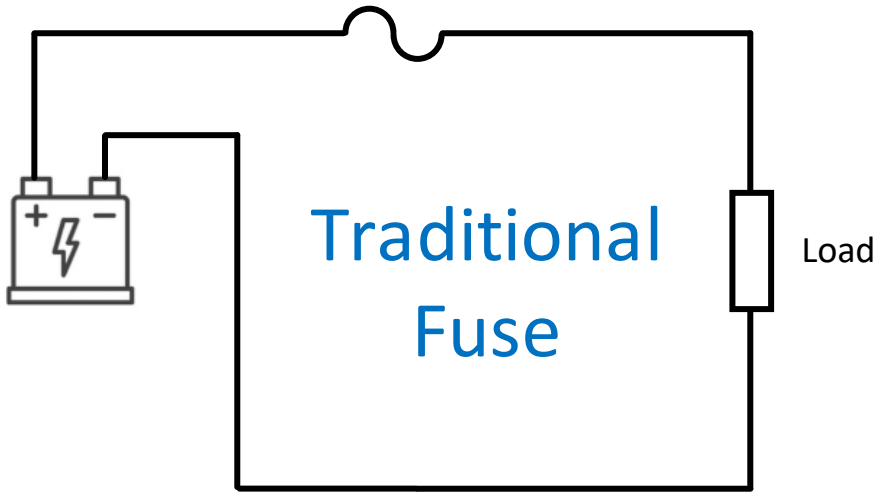
Mini Fuse
(29x34mm)

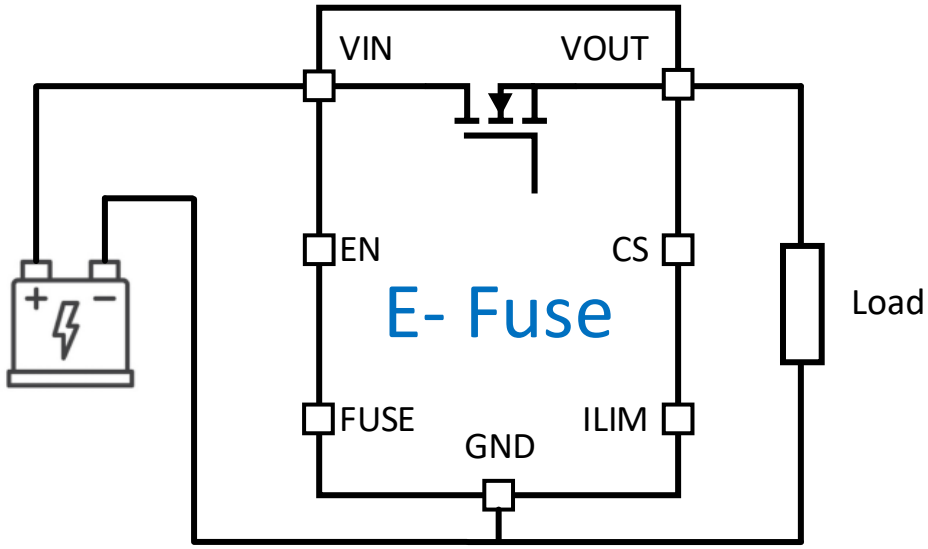
E-Fuse
(6x8mm)

- E-Fuse' Time-Current Char is much more accurate than traditional Fuse
  - 20% vs. 2500%
  - Save wire harness
- E-Fuse combines the switch function
  - Single device replace relay and fuse
- E-Fuse can program different Fuse current and Fuse type
- E-Fuse has much smaller size



Traditional Fuse and Integrated E – Fuse

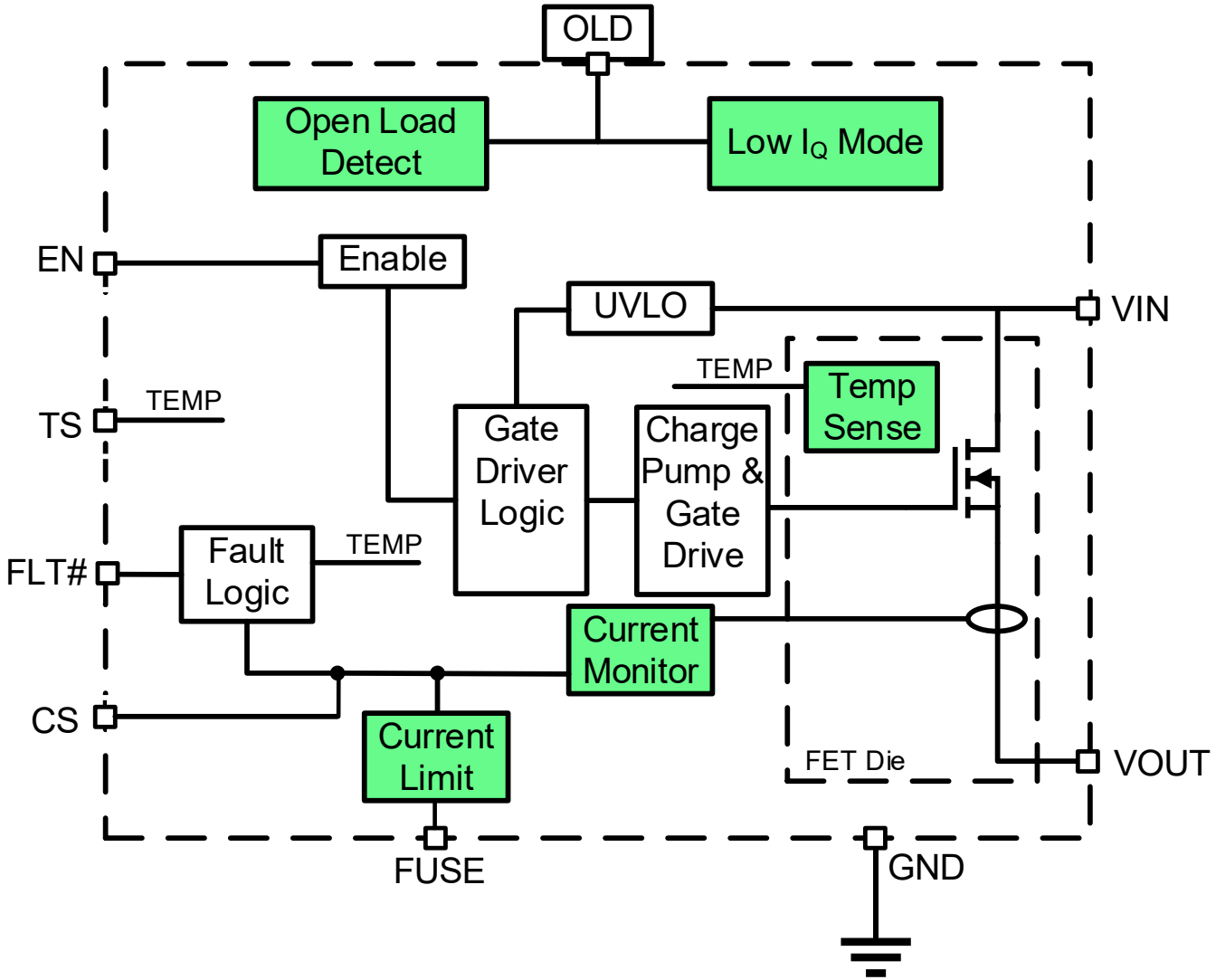




- Slower Response
- Bigger Size
- Unstable Protection
- Only Over Current Protection
- Not reusable
- More Maintenance Cost

- Faster Response
- Smaller Size
- More Accurate Protection
- Full Monitoring and Protection
- Resettable
- Less Maintenance Cost

MPS E-Fuse Functional Diagram



- **Low I_Q Mode**
- **Programmable Current Limit**
- **Programmable Fuse Time**
- **Open Load Detection**
- **Current Sensing**
- **Temperature Sensing**

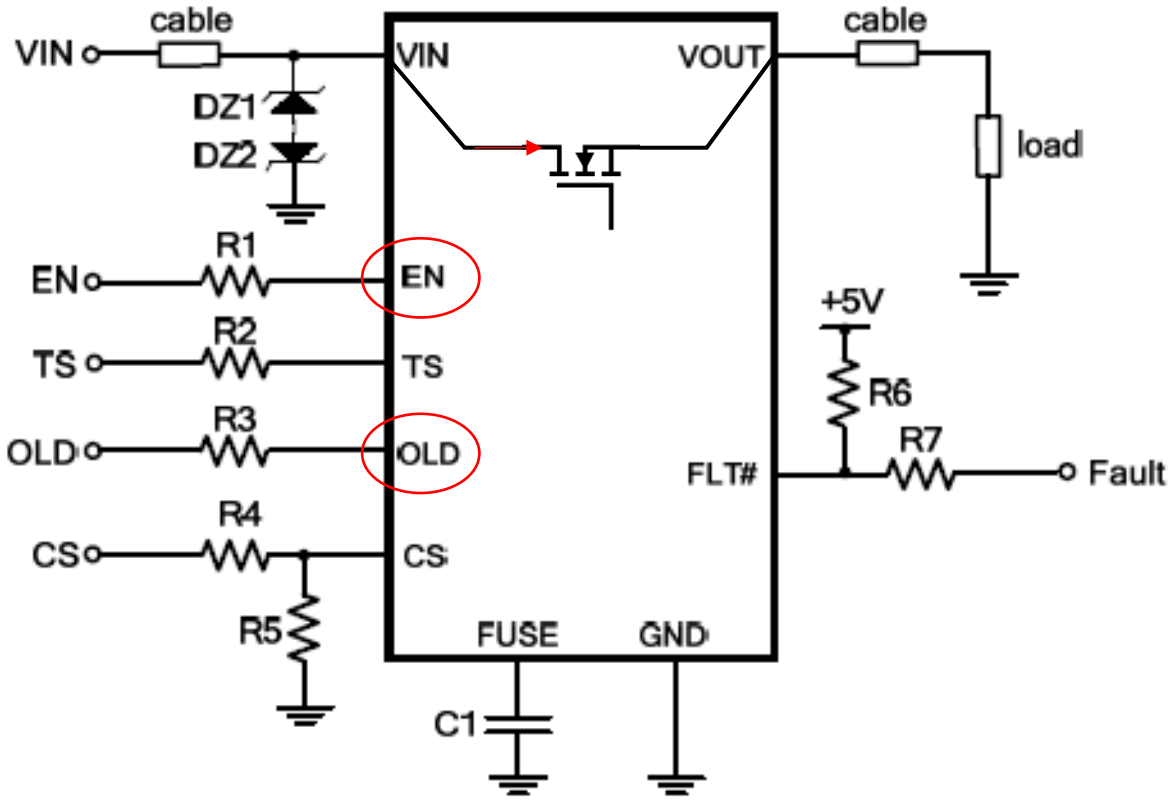
Low Operation I_Q Mode

When **EN is high**, by **pulling up the OLD pin**, the device enters a low I_Q mode. In this mode, the output current needs to be less than $I_{NOM,SLP}$.

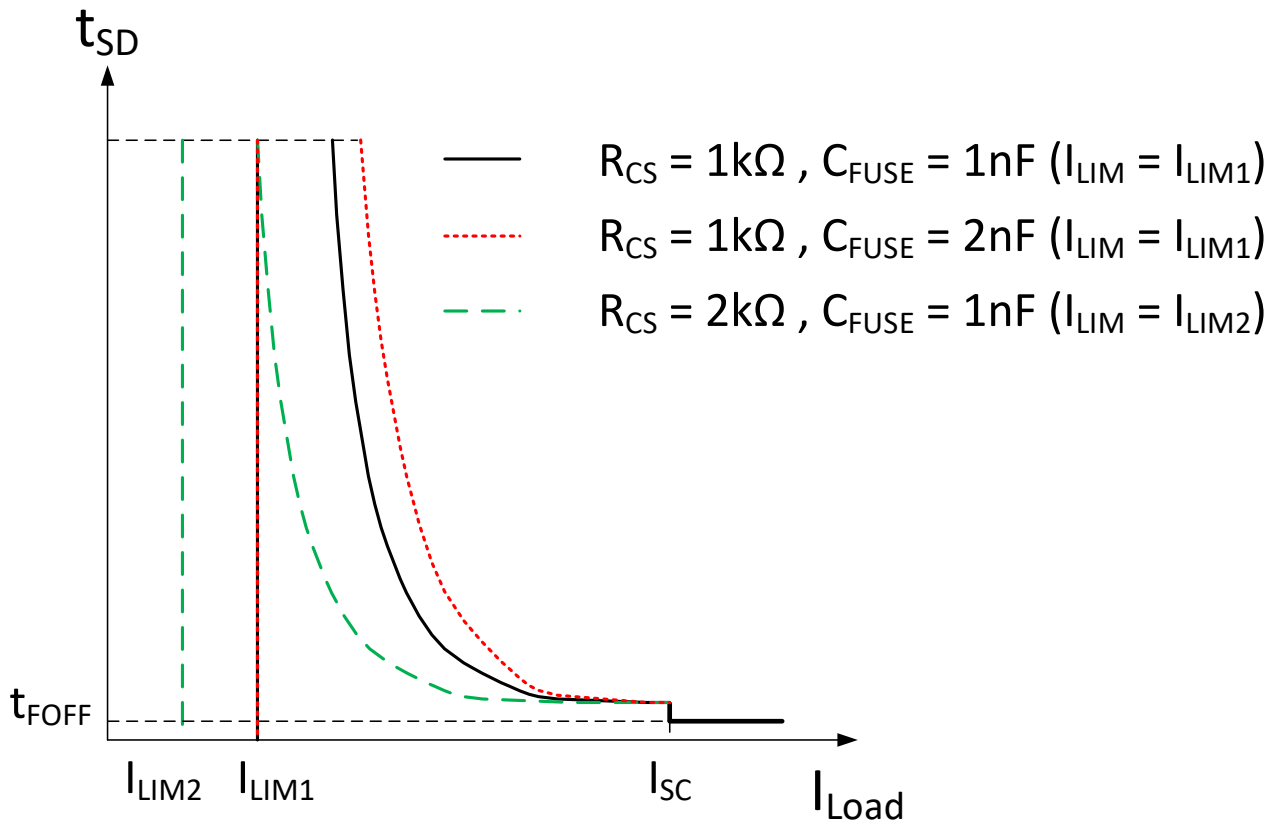
In low I_Q mode, the I_Q will be lower to 20μA to save the battery's life.

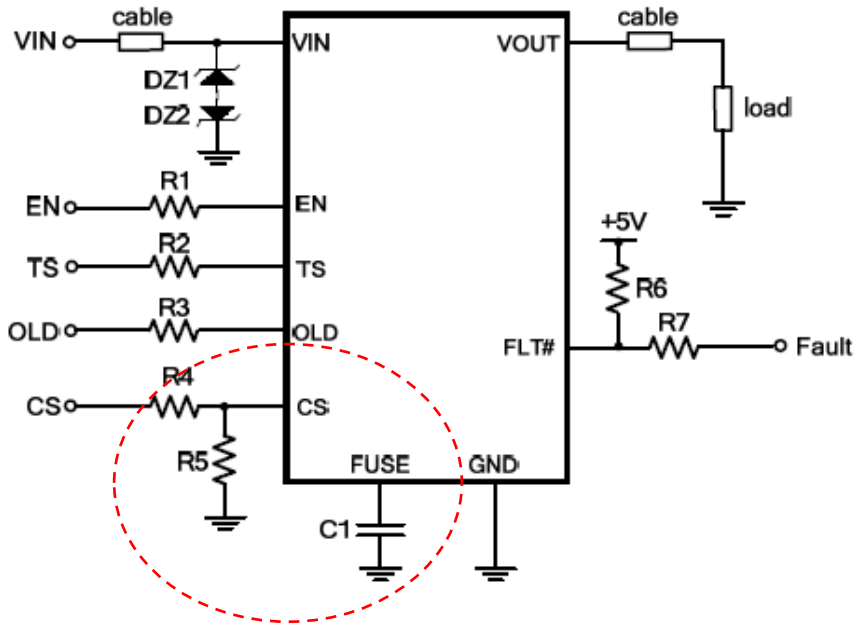
When **Iout > $I_{NOM,SLP}$** , the device turns on the main FET and **goes back to the normal mode automatically**. Need to toggle OLD to reset.

Note: $I_{NOM,SLP}$ varies from 0.1A to 1A on different parts.



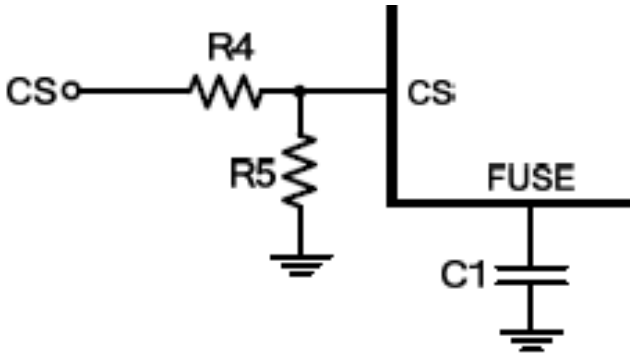
Fuse-like Over Current and Short Circuit Protection





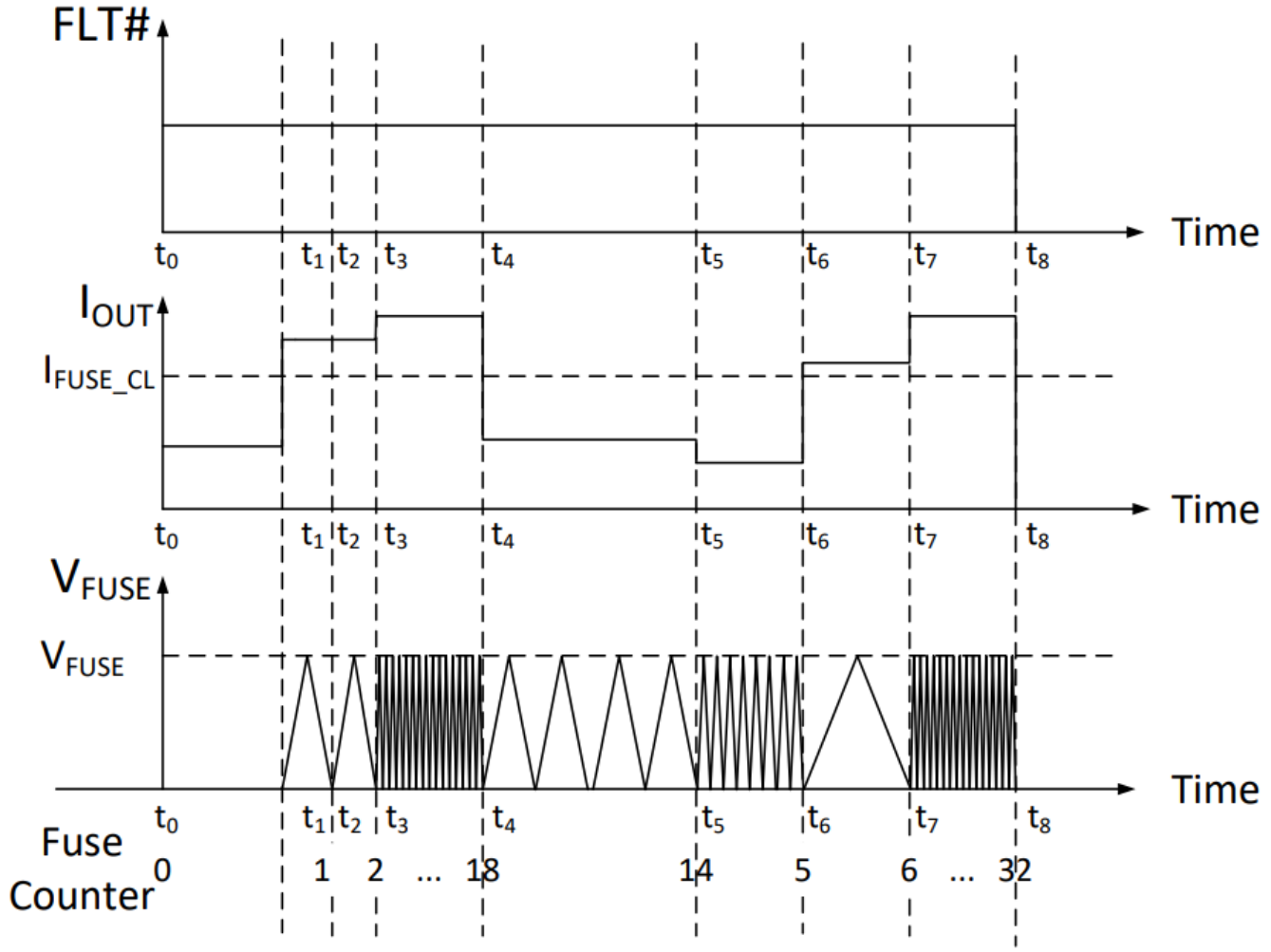
When over-current occurs, a portion of the sensed current charges CS pin to 3V. The rest charges FUSE to 3V and then the FUSE is discharged. After several cycles, the device shuts down. If the sensed current reaches I_{SC} (Typ 200A), the device turns off immediately.

Fuse-like Over Current



$$I_{LIM} = \frac{f_{(CS\ gain)}}{R_{CS}}$$

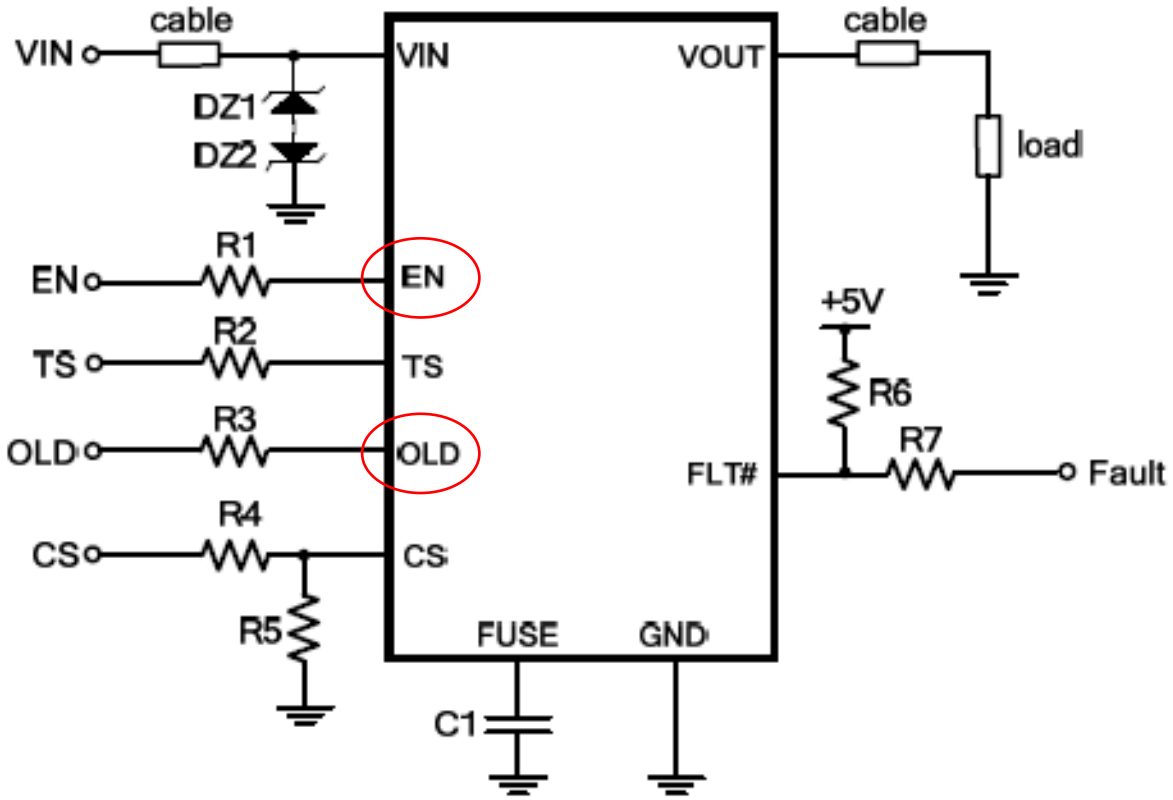
$$t_{SD} = \frac{f_{(I_{Load}-I_{LIM})}}{C_{FUSE}}$$



Open Load Detection

When **EN is low**, by **pulling up the OLD pin**, the device starts open load detection.

If open load condition is detected, the FLT# pin will be pulled to low to remind MCU the fault condition.



CS and TS sense

CS Function (Current Sense Monitor)

The CS pin outputs a current proportional to the VIN to VOUT current of the power device. Typically, the CS pin current is k_I of main FET current. The CS pin is clamped to 3V as the additional current is used for the Fuse current limit.

TS Function (Temperature Sense Monitor)

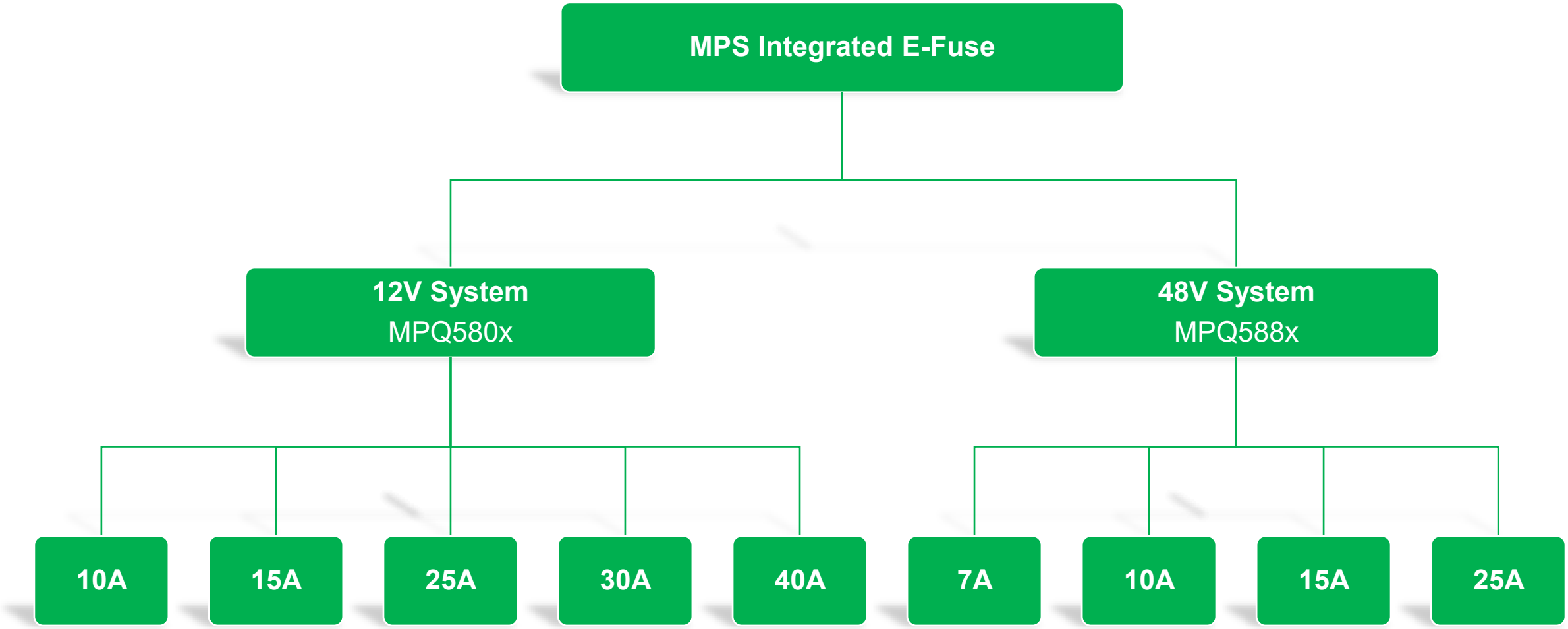
The temperature sensor outputs a voltage that indicates the current MPQ58xx power switch junction temperature. The temperature sensor voltage is:

$$V_{TS}=1V+k_{TS}*(T_J-25°C)$$

Example:

Parameter	Symbol	Condition	Min	Typ	Max	Units
Current Sense						
Current Sense Gain	k_I			50		μA/A
Thermal Sense						
Temperature Monitor Gain	k_{TS}			13		mV/k

MPS Integrated E-Fuse



Agenda

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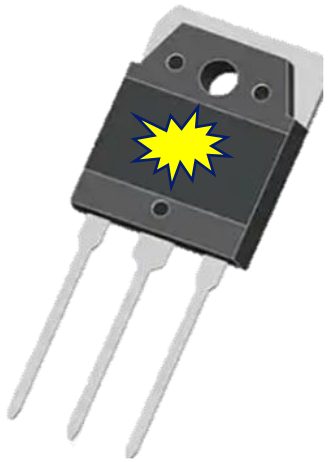
MOSFET Fail Reasons

SOA (Safe Operating Area)

UIS (Unclamped Inductive Switching)

BV (Breakdown Voltage)

Heating



Fail Open

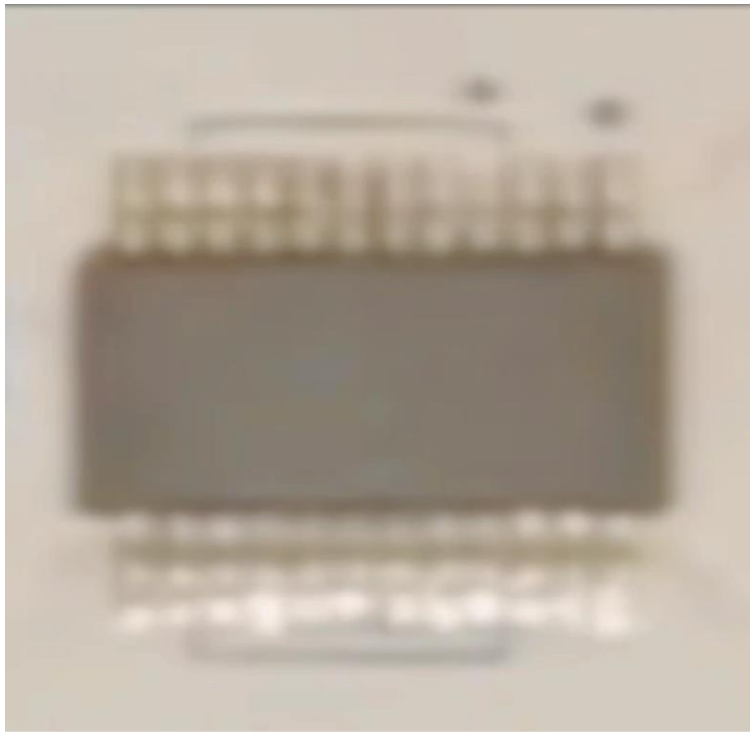
or

Fail Short

Fail Short of E-Fuse and E-Fuse +

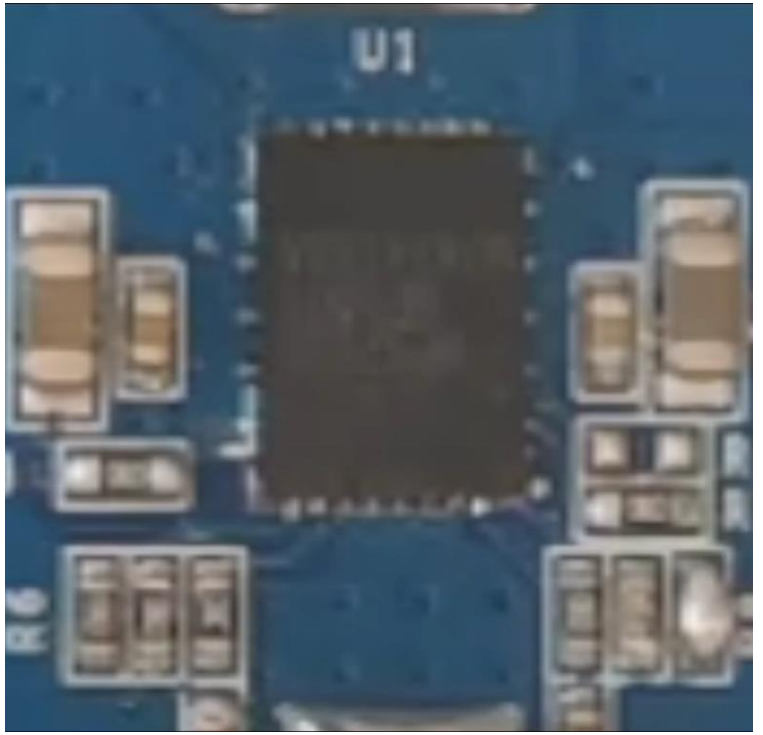
Most of time, E-fuse will protect against over current. But what if when the IC failed due to aging and other effect? By physics, MOSFET has chance to fail short, and is possible to cause fire.

Traditional E-Fuse Fail Short



IC on fire. Can cause hazards

MPS E-Fuse+ Fail Short

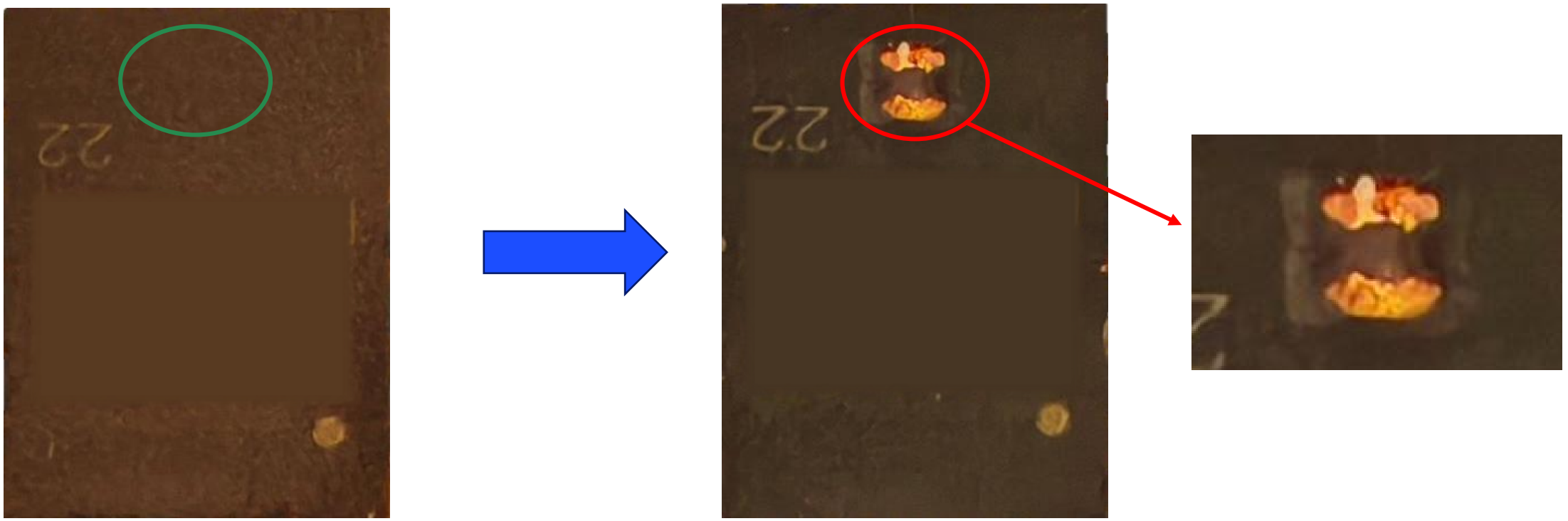


Build in metal fuse melt, no fire.

MPS E-Fuse+ is fail safe !

What is E-Fuse + ?

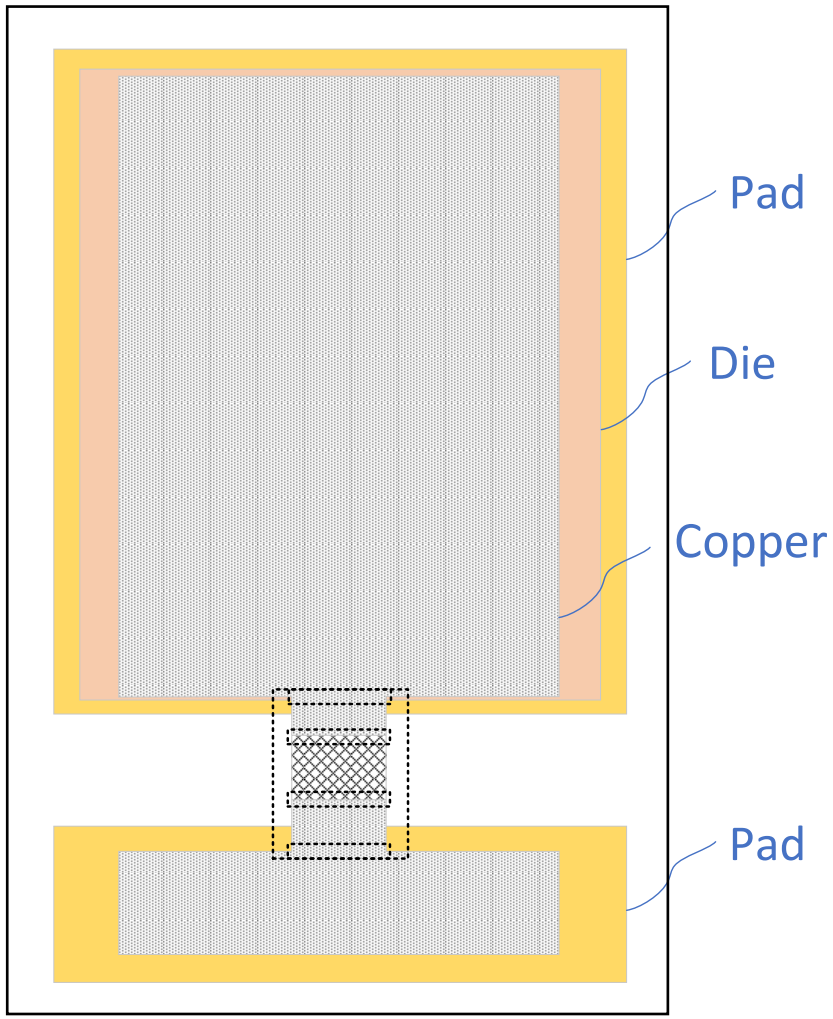
MPS E-Fuse + Fail Safe



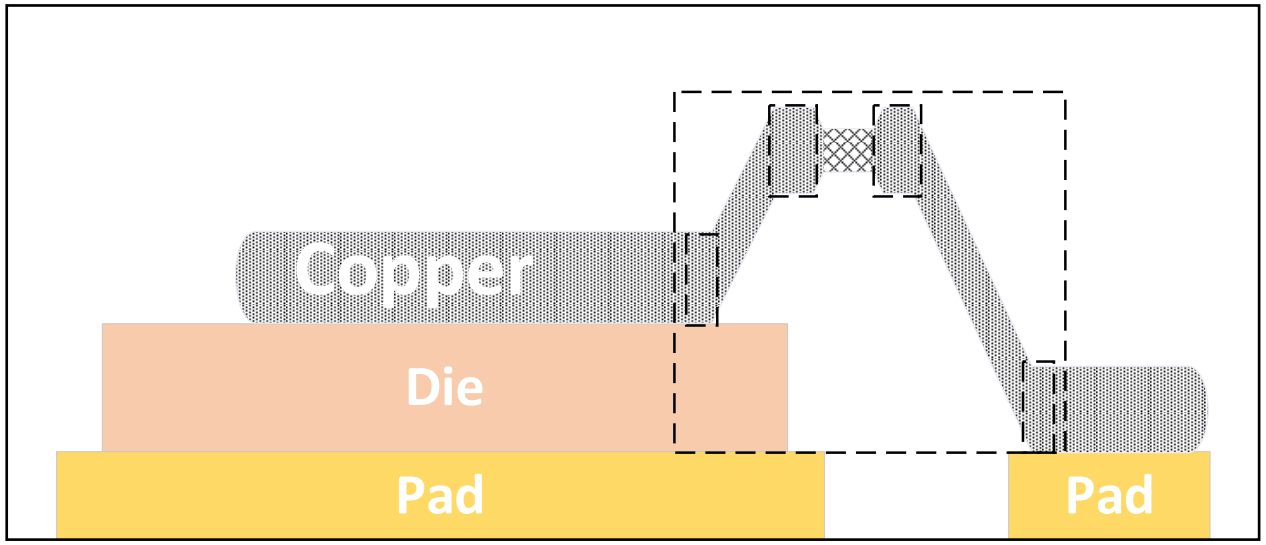
Fail Safe without any critical side damage !

What is E-Fuse + ?

Top View



Side View



Package level passive fuse integrated! - MPS Patent

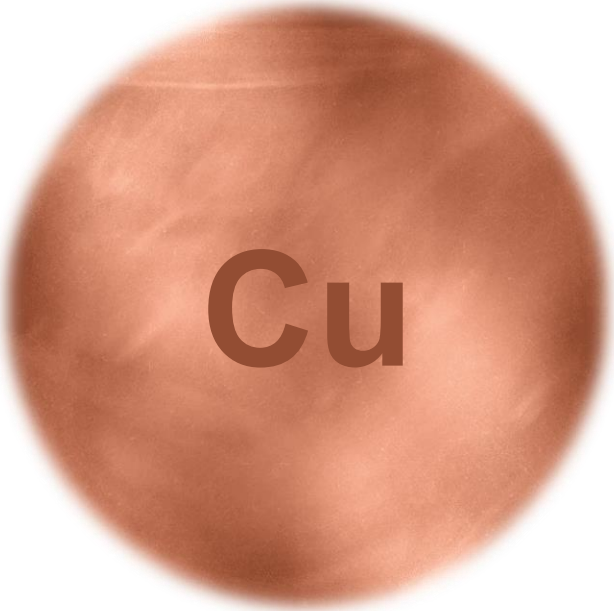
How to E-Fuse + ?

How to E-Fuse + ?

1064.43°C melting

Material

How to E-Fuse + ?



1083.4°C melting

Material

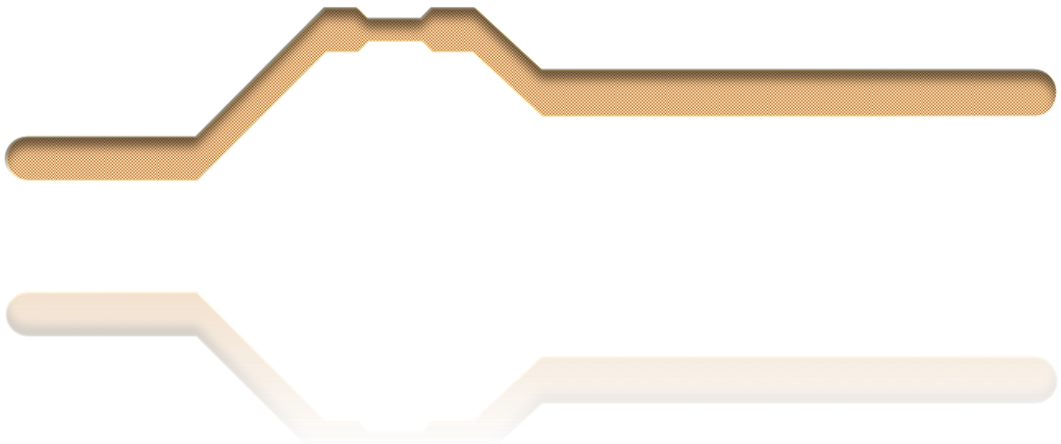
How to E-Fuse + ?

Thickness

Width

Length

Package

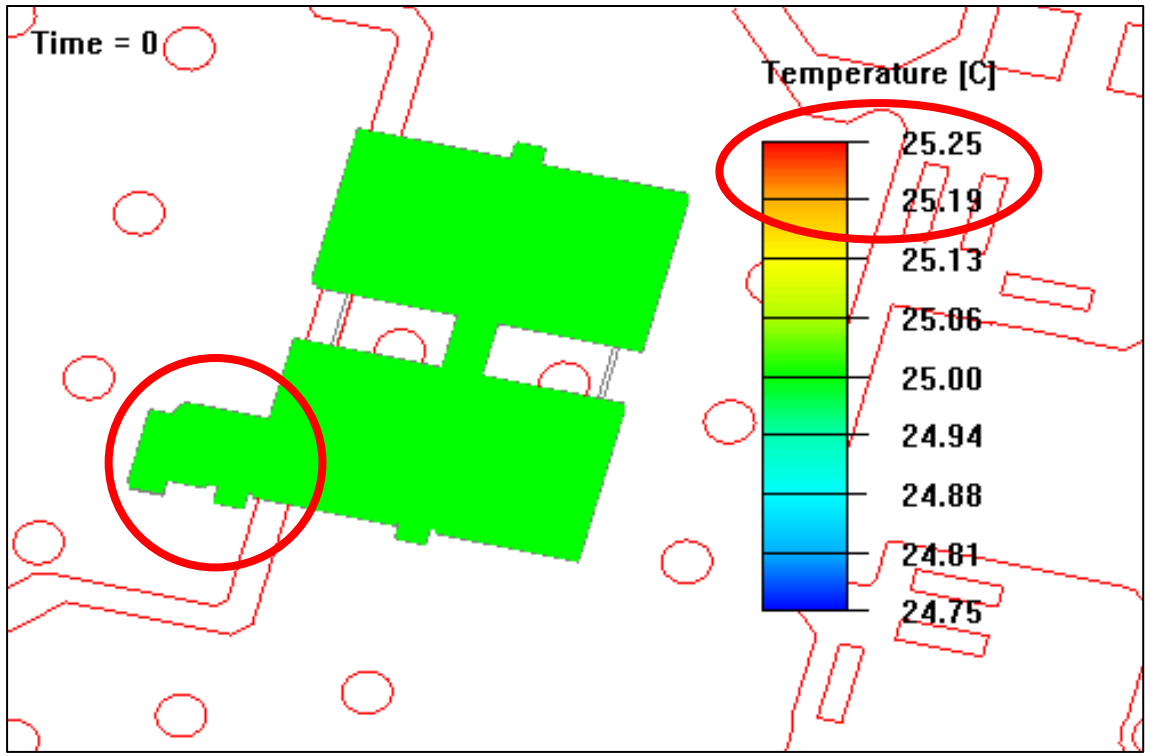


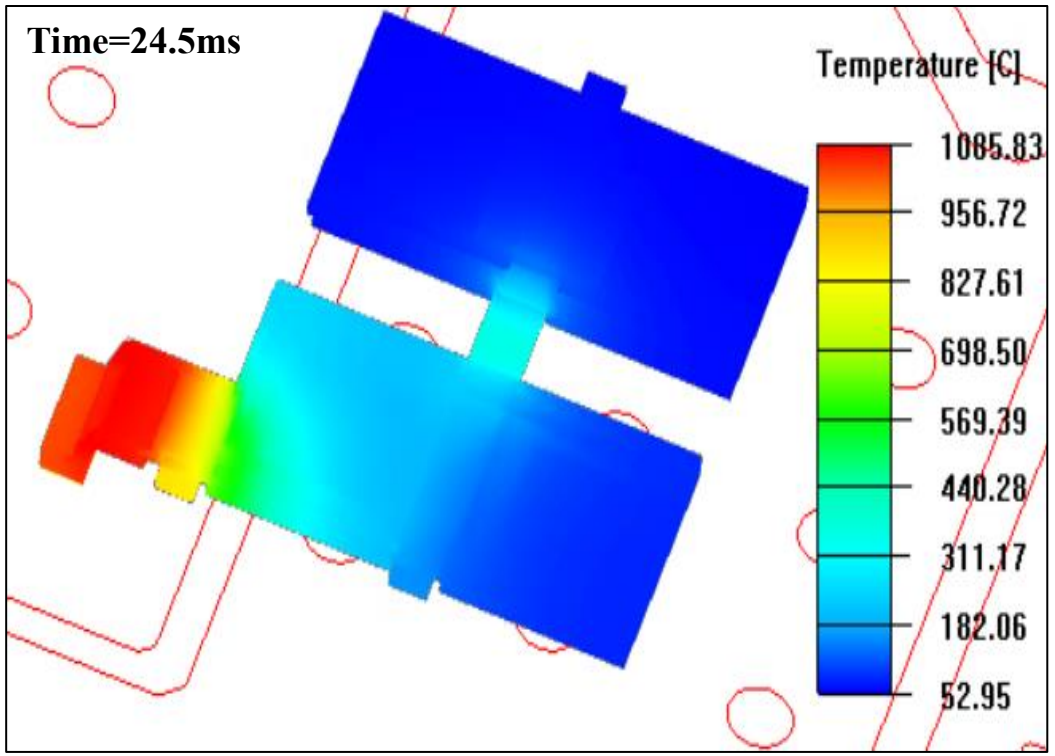
Only 0.15mΩ
Ron Increasing

Melting at
Target Current

Structure

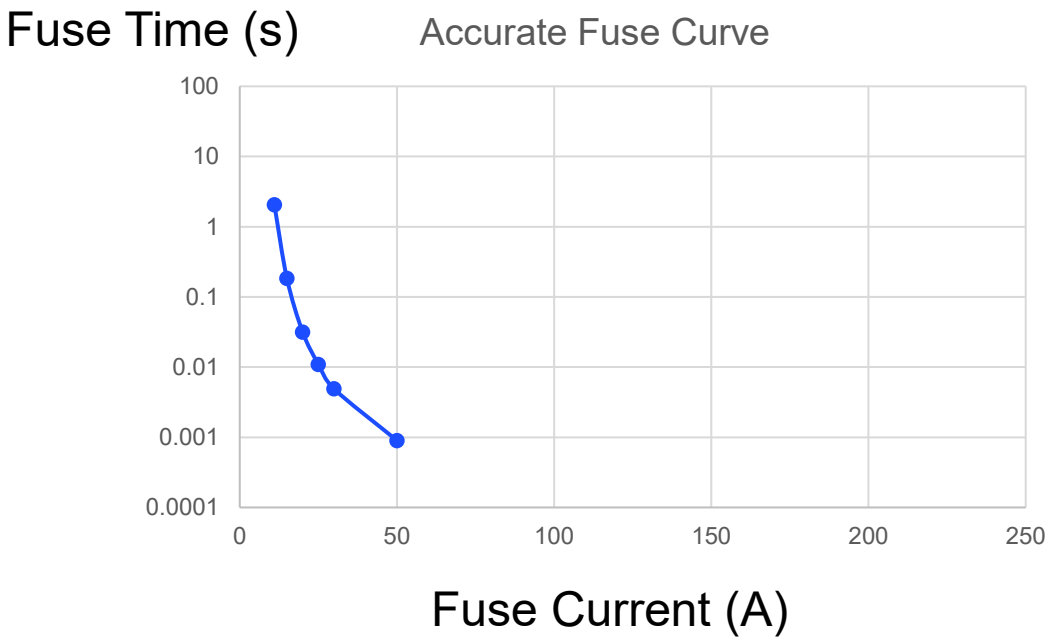
How to E-Fuse + ?


Time = 0
Temperature [C]
25.25
25.19
25.13
25.06
25.00
24.94
24.88
24.81
24.75


Time=24.5ms
Temperature [C]
1085.83
956.72
827.61
698.50
569.39
440.28
311.17
182.06
52.95

Fuse Curve – With Metal Fuse Version

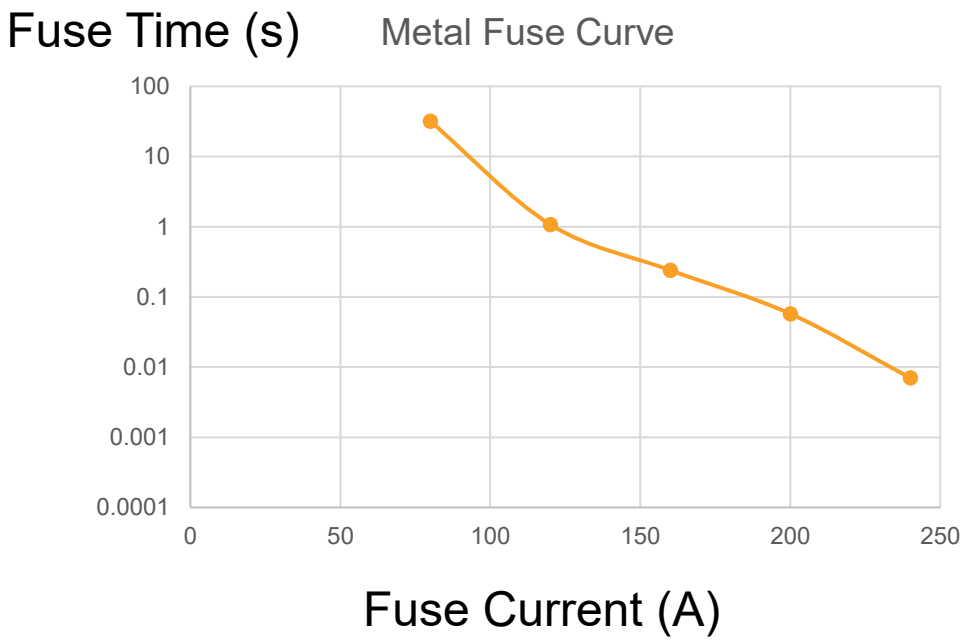
E-Fuse Current Limit and OTP Enabled:



E-Fuse is working:

- Accurate fuse curve

E-Fuse Current Limit and OTP Disabled:



Emulate E-Fuse fail:

- Fuse current and time is a combination of FET and metal fuse blow up.
- Higher fuse current

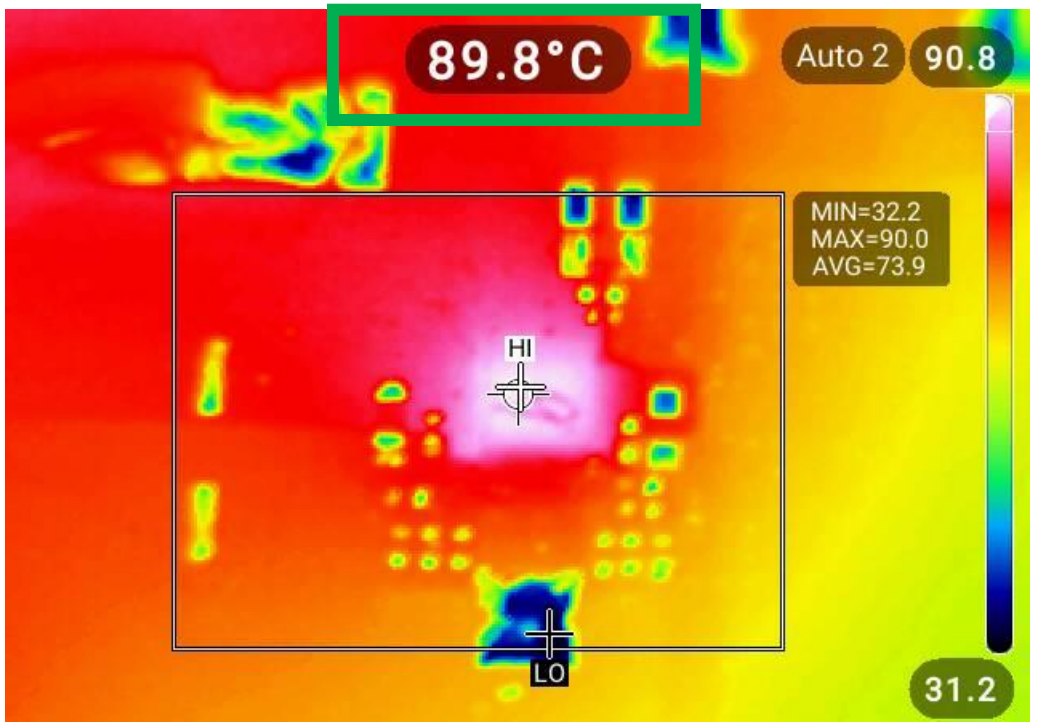
Case Thermal Rise

Test Condition: Vin=12V, Io=40A

MPS E-Fuse

Tc=87.8oC, Ta=25.0oC, **Δ=62.8 °C**

MPS E-Fuse +

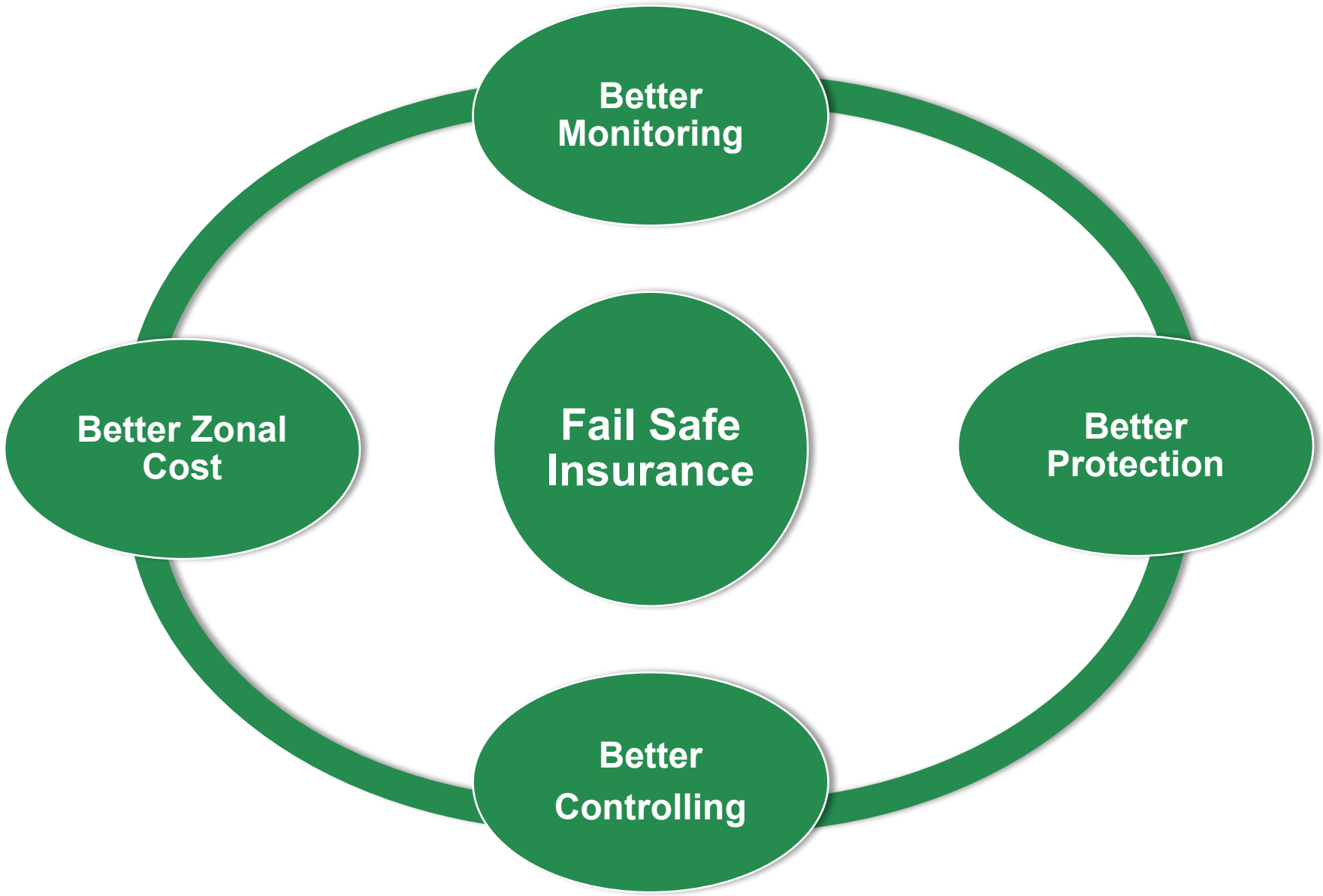


Tc=89.8oC, Ta=24.3oC, **Δ=65.5°C**

Only 0.15mΩ R_{ON} increasing, 2.7°C T_C rising !

Why E-Fuse and E-Fuse + ?

Why E-Fuse and E-Fuse + ?



Why E-Fuse and E-Fuse + ?

SAFE

Thanks for Listening !