# Motor Technologies 3: Protection Features

## TI Precision Labs – Motor Drivers

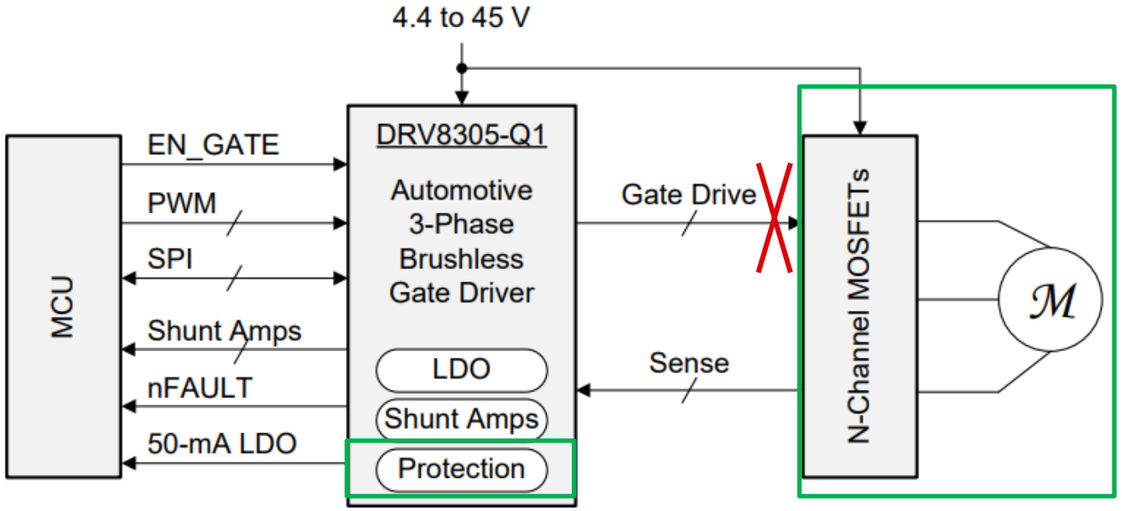
**Presented and prepared by Aaron Barrera**

# Overview

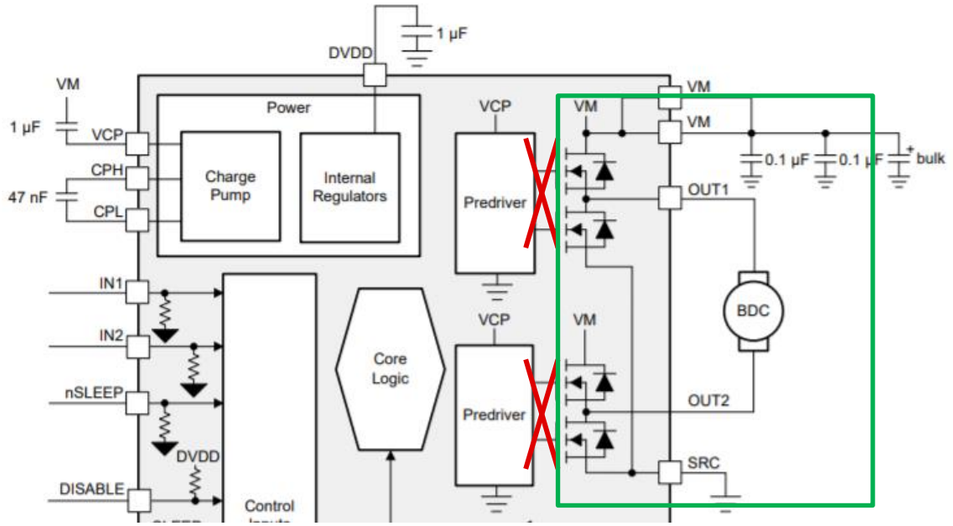
- Protection Features Summary
- Common Protection Features
  - VM undervoltage (UVLO)
  - Charge pump undervoltage (CPUV)
  - Overcurrent Protection (OCP)
  - Thermal warning / shutdown (OTW/ OTSD)
- Other Protection Features
- Examples:
  - DRV8872
  - DRV8343S-Q1

# Protection Features Summary

- TI's Motor Drivers come equipped with a variety of smart protection circuits that protects the motor and power MOSFETs when an unsafe condition is detected
  - Action(s) taken: disable MOSFETs and/or charge pump, report a fault condition




**<u>Smartly</u> turning off the FETs protects the motor!**



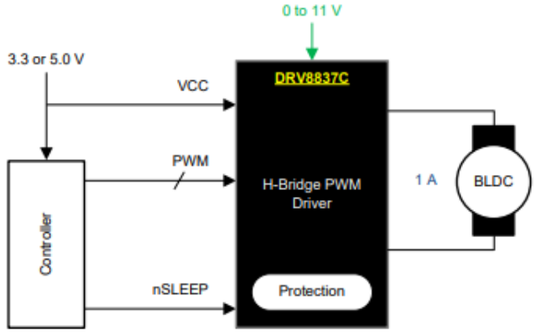

**DRV8842 – DC Motor Driver IC**

# Protection Features Summary (cont.)

Protection Features can vary by:

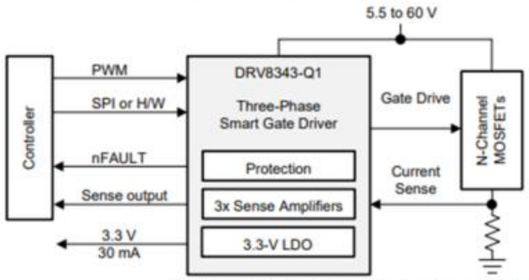
| Motor Type | Family | Interface |
|---|---|---|
| • Brushed-DC<br>• Brushless-DC<br>• Stepper | • DRV8x<br>• DRV10x<br>• DRV3x | • Hardware<br>• Serial Peripheral Interface (SPI) |

**DRV8837C Simplified Diagram**



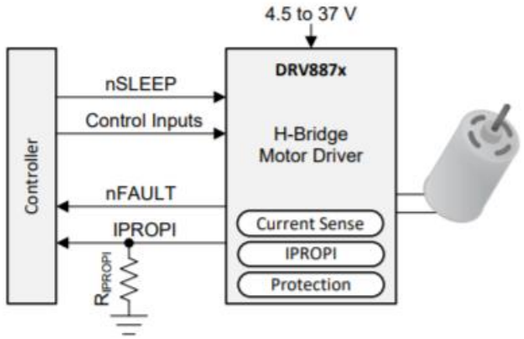



**DRV8343-Q1 Simplified Schematic**






**Simplified Schematic**



# Protection Features Summary (cont.)

## Fault Reporting / Actions Taken

### Hardware

- **nFAULT** driven low
- Default configurations
- No indication of which fault occurred
- Often automatic retry until fault condition is cleared

### Serial Peripheral Interface (SPI)

- **nFAULT** driven low
- Set operating parameters
- Reads out fault diagnostic information
- Configurable fault response

***8.6.1.1 FAULT Status Register (Address = 0x00) [reset = 0x00]***

FAULT Status is shown in Figure 45 and described in Table 16.

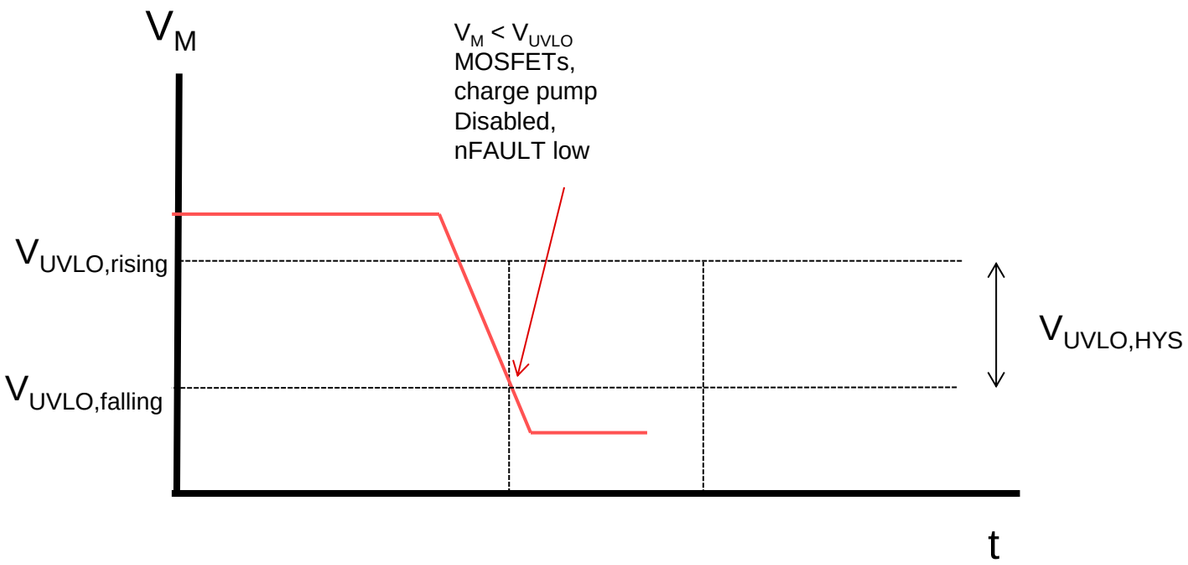
**Figure 45. FAULT Status Register**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| FAULT | GDF | CPUV | UVLO | OCP | OTW | OTSD | OL_SHT |
| R-0b | R-0b | R-0b | R-0b | R-0b | R-0b | R-0b | R-0b |

# Common Protection Features

# Supply Undervoltage Lockout (UVLO)

- Supply voltage falls lower than the $V_{UVLO}$ falling threshold
  - Determined by $V_{UVLO}$ and $V_{UVLO\_HYS}$
  - Re-enable drivers after supply > $V_{UVLO,rising}$



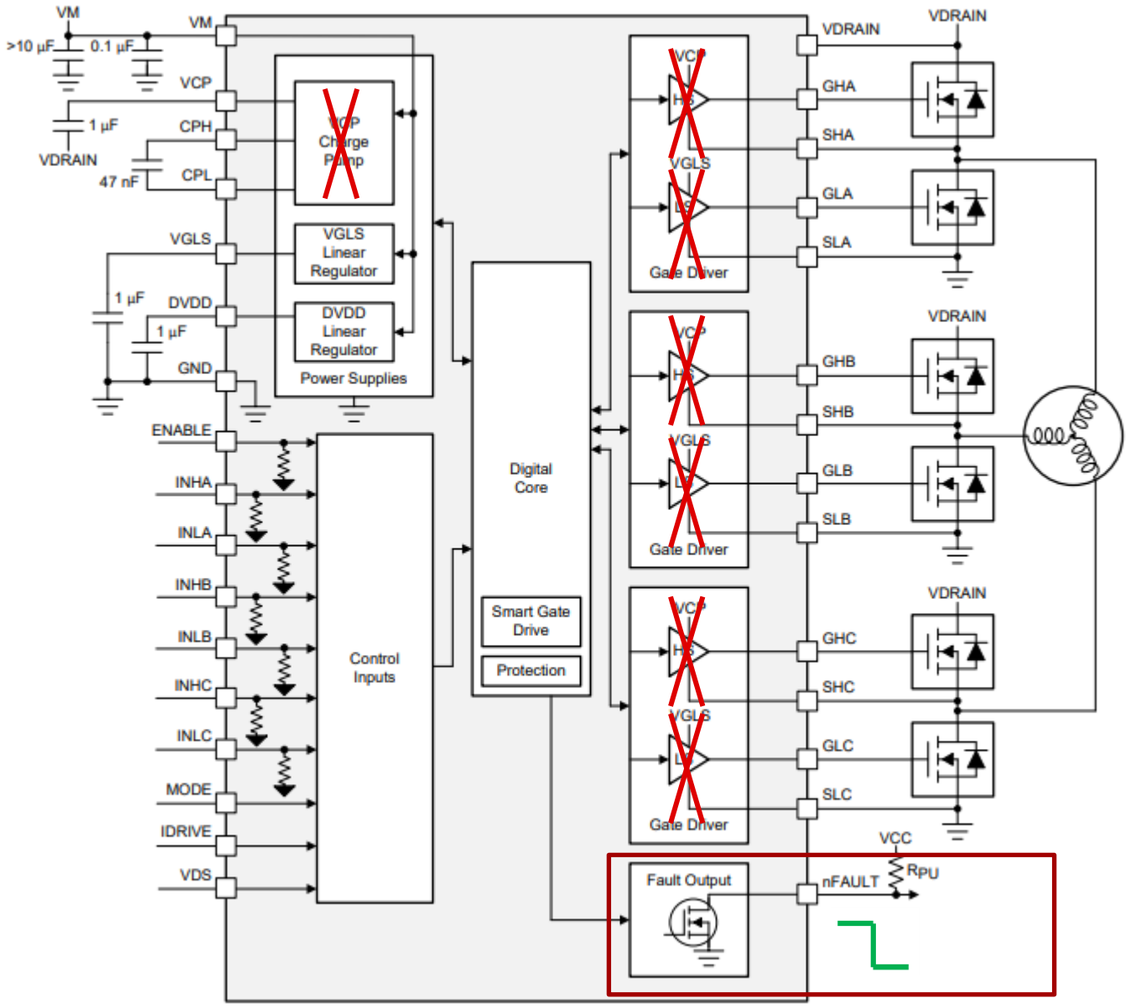




**Figure 14. Block Diagram for DRV8350H**

# Supply Undervoltage Lockout (UVLO)

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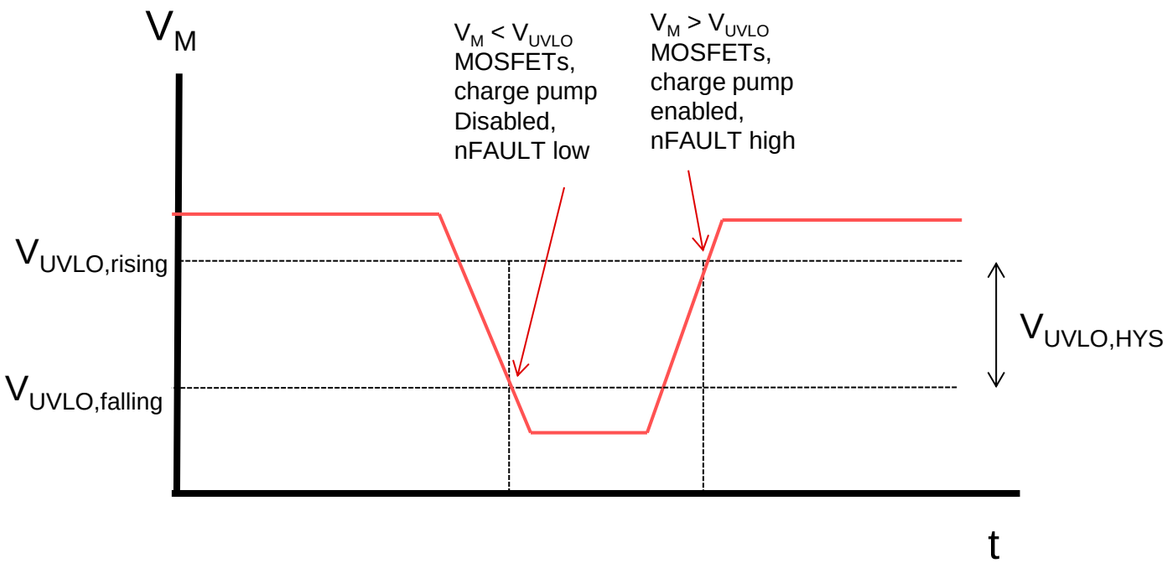


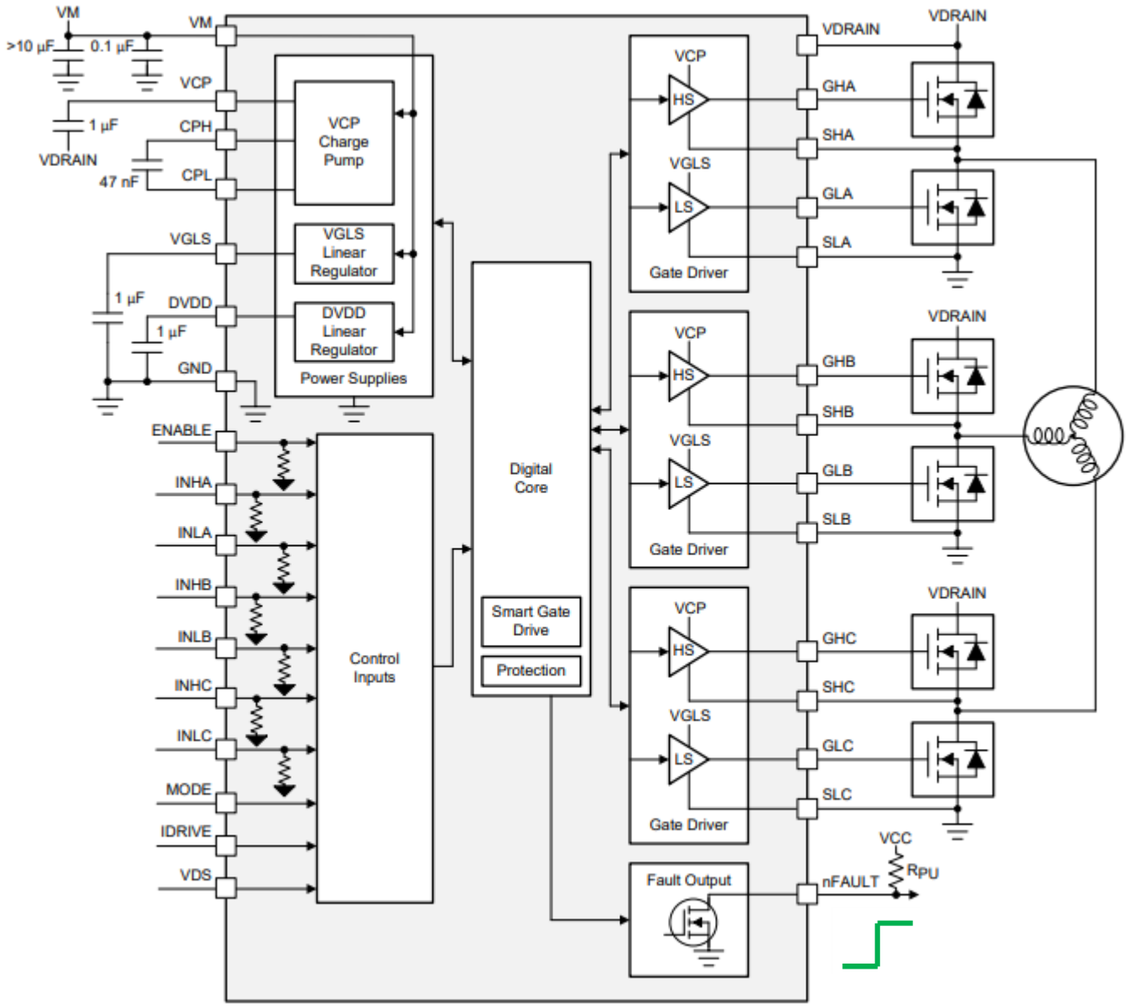
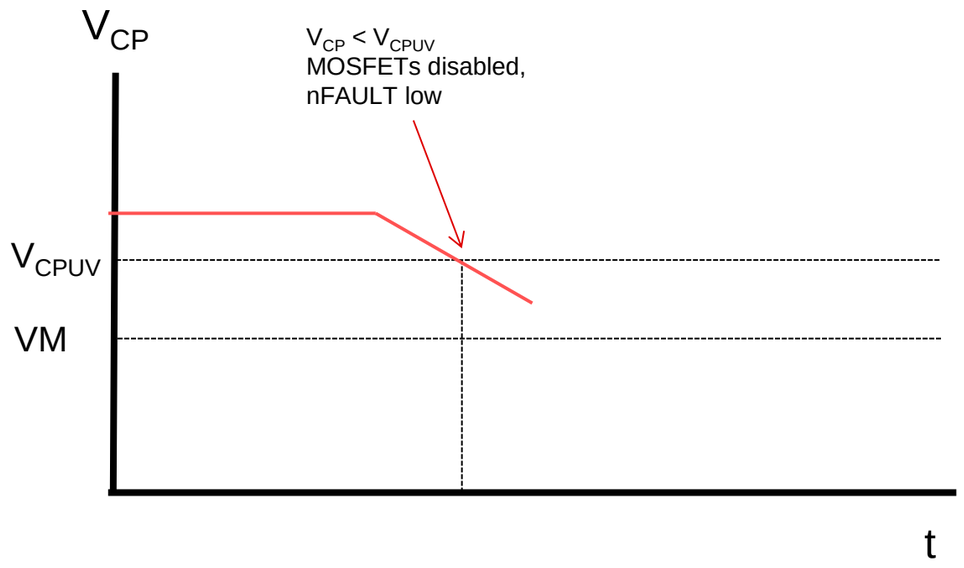
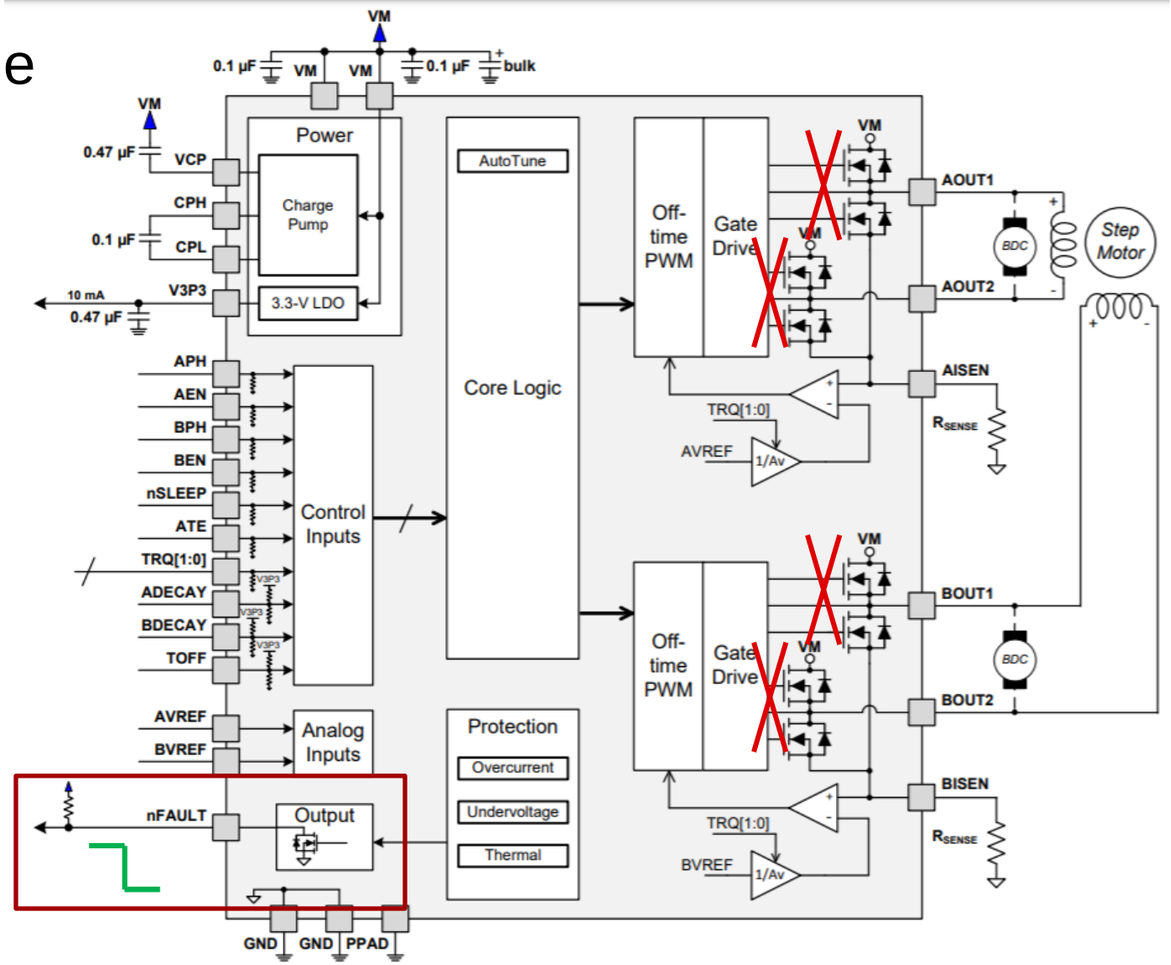




**Figure 14. Block Diagram for DRV8350H**

# Charge pump undervoltage (CPUV)

- Charge pump voltage (VCP) falls lower than the CPUV threshold voltage of the charge pump
  - MOSFETs are disabled, nFAULT is driven low
  - Waits until CPUV condition is cleared




**DRV8881 – 2A Dual H-Bridge Stepper Motor Driver**

# Charge pump undervoltage (CPUV)

- Charge pump voltage (VCP) falls lower than the CPUV threshold voltage of the charge pump
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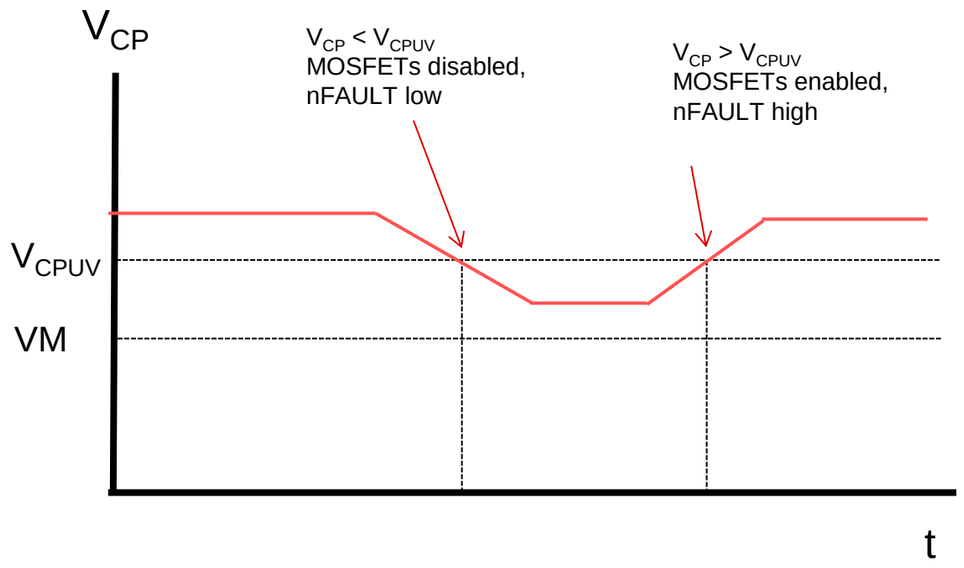
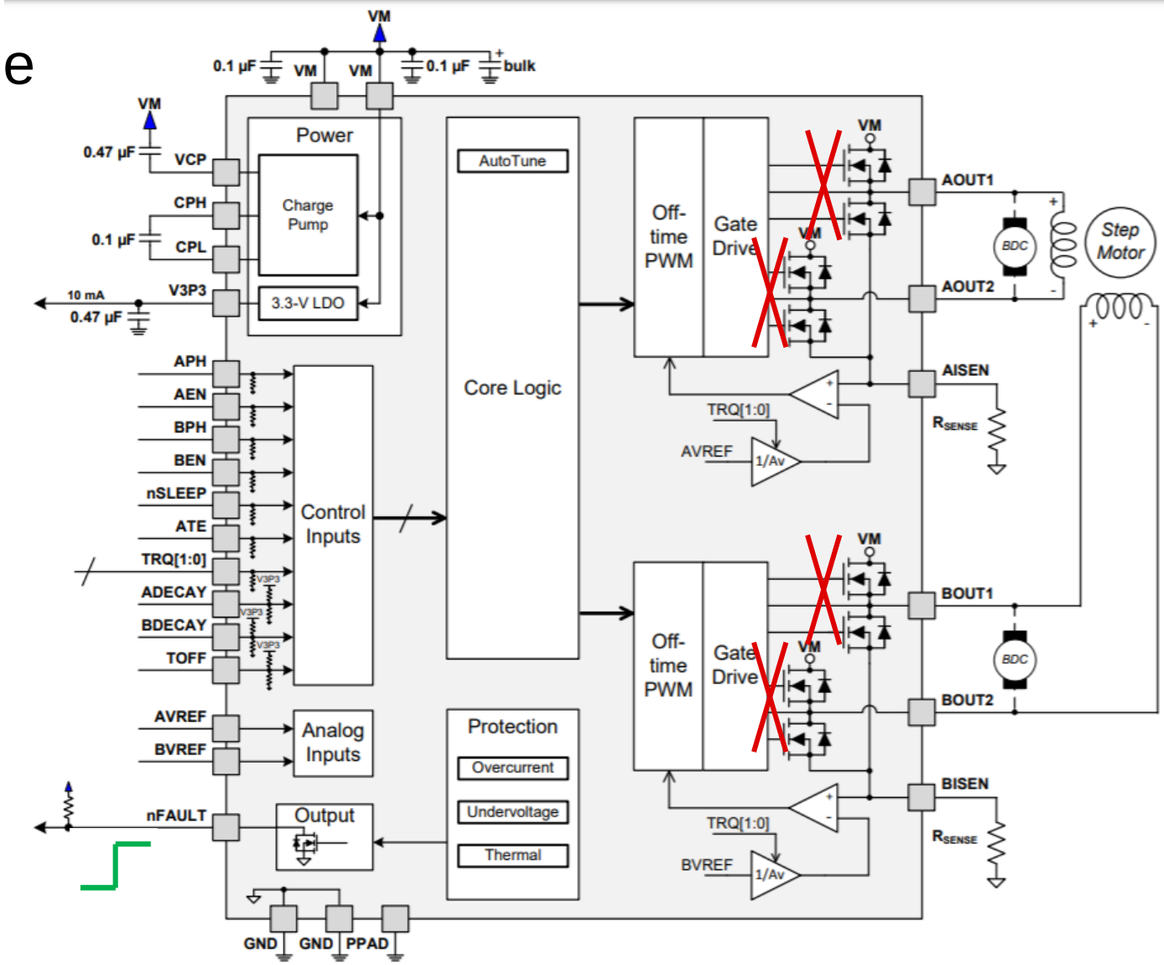
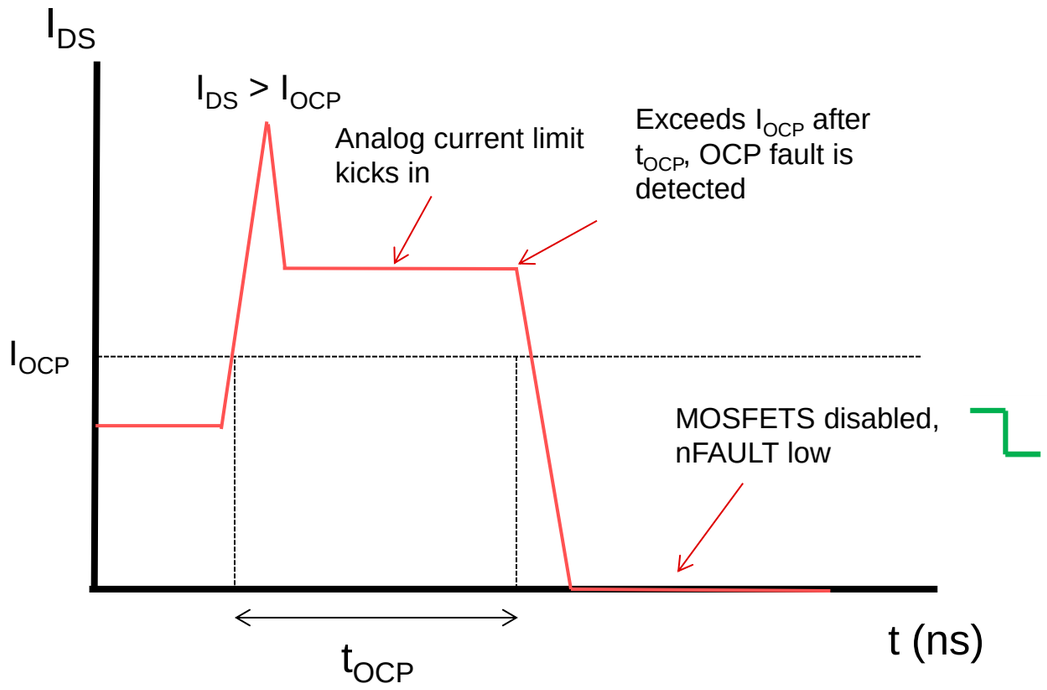


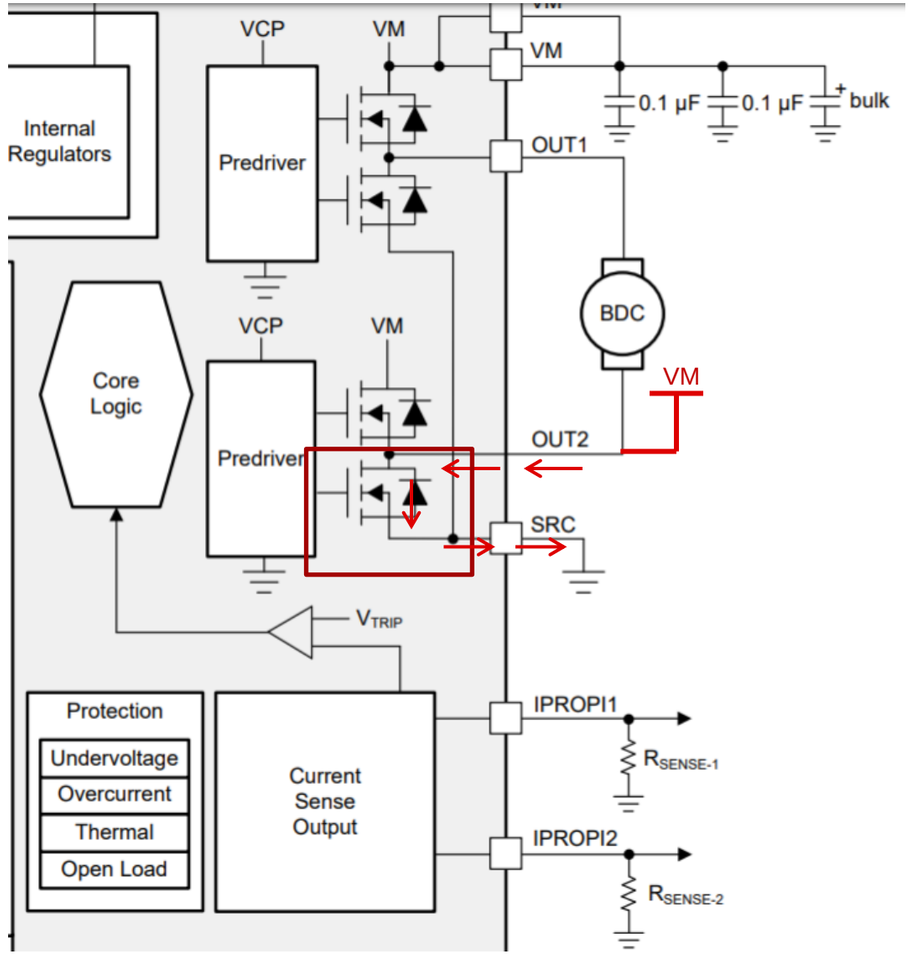




**DRV8881 – 2A Dual H-Bridge Stepper Motor Driver**

# Overcurrent Protection (OCP)

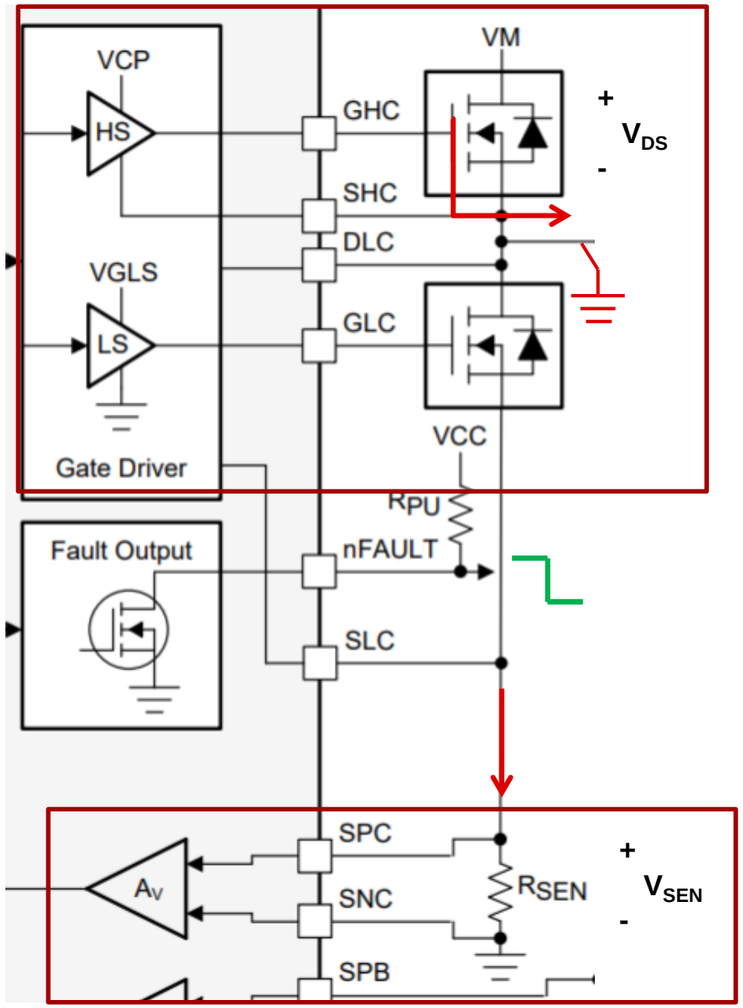
- Detects motor short conditions and protects system from damage
  - Analog current limit
  - Digital threshold and deglitch
  - Sense pin overvoltage



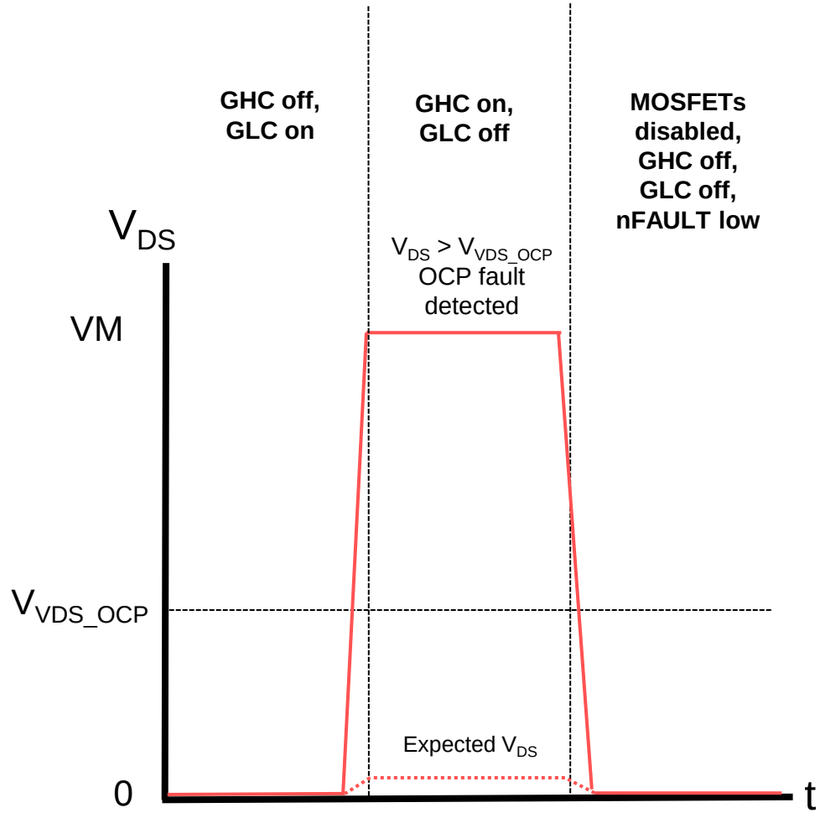

**DRV8873-Q1 – Automotive H-Bridge Motor Driver**

# OCP on a Gate Driver



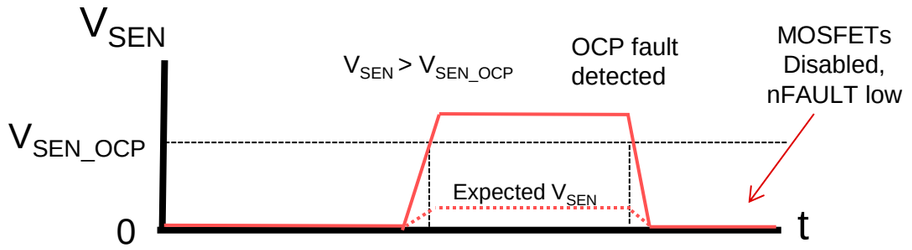

## $V_{DS}$ Overcurrent Protection (VDS_OCP)

Source-drain voltage monitored by dedicated pins, compared to threshold for OCP



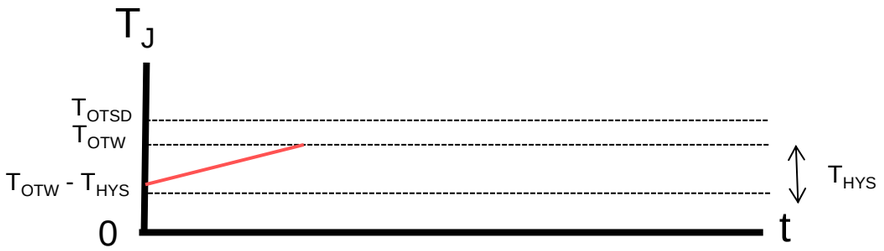

## $V_{SEN}$ Overcurrent Protection (VSEN_OCP)

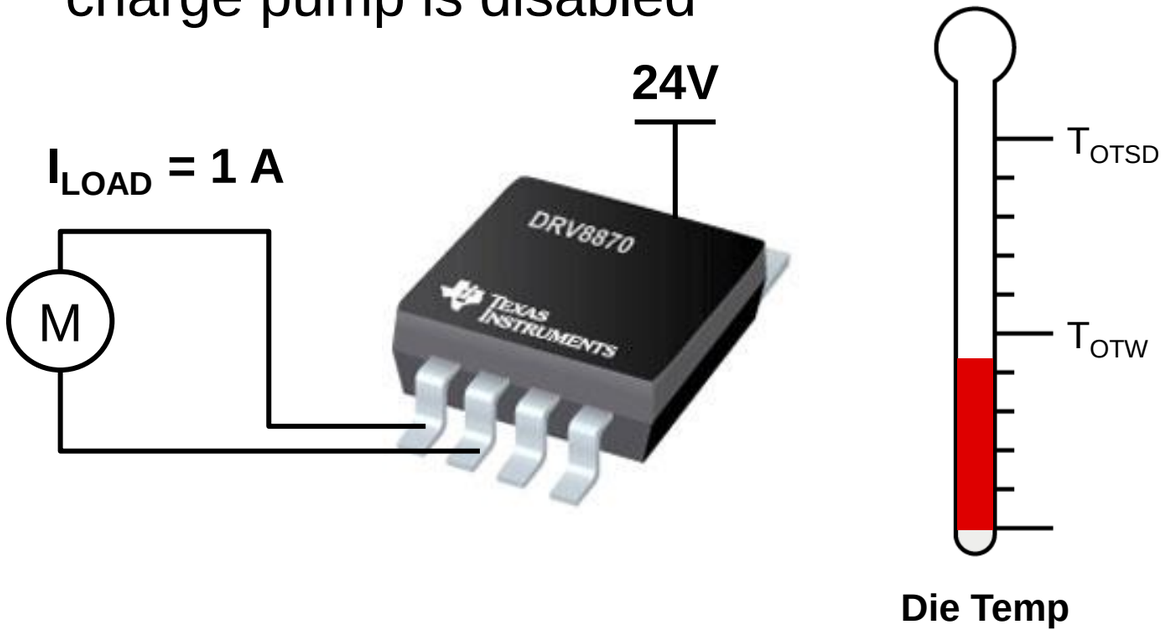
Internal CSAs can compare voltage across shunt resistor to threshold for OCP



# Thermal warning / shutdown (OTW/OTSD)

- **Overtemperature Warning** (OTW)
  - Devices continues to function
  - Only featured on some devices
- **Overtemperature Shutdown** (OTSD)
  - nFAULT driven low, MOSFETs and charge pump is disabled



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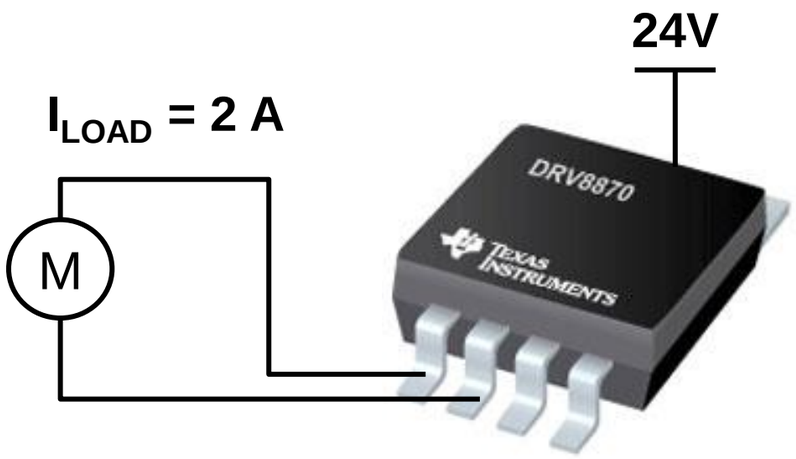
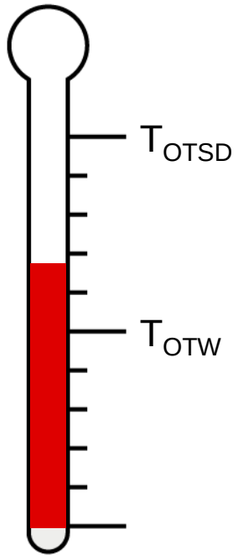
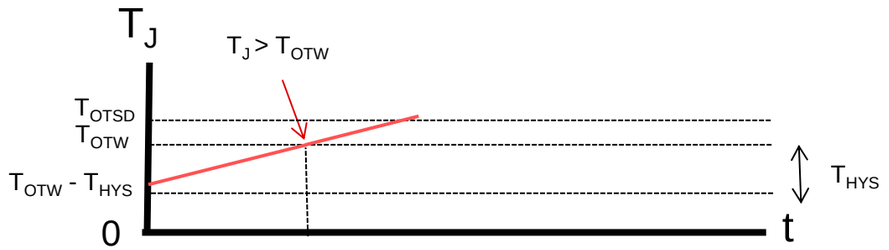



Die Temp



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| R-0b | R-0b | R-0b | R-0b | R-0b | R-0b | R-0b | R-0b |

**Table 16. FAULT Status Register Field Descriptions**

| Bit | Field | Type | Default | Description |
|---|---|---|---|---|
| 7 | FAULT | R | 0b | Logic OR of FAULT status registers |
| 6 | GDF | R | 0b | Indicates gate drive fault condition |
| 5 | CPUV | R | 0b | Indicates charge pump undervoltage fault condition |
| 4 | UVLO | R | 0b | Indicates undervoltage lockout fault condition |
| 3 | OCP | R | 0b | Indicated overcurrent fault condition either by VDS or SEN_OCP |
| 2 | OTW | R | 0b | Indicates overtemperature warning |
| 1 | OTSD | R | 0b | Indicates overtemperature shutdown |
| 0 | OL_SHT | R | 0b | Indicates open load detection, or offline short-to-supply or GND detection |

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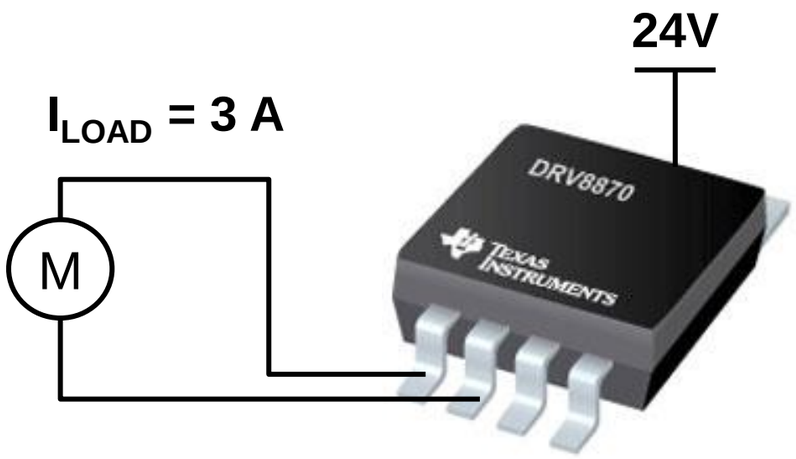


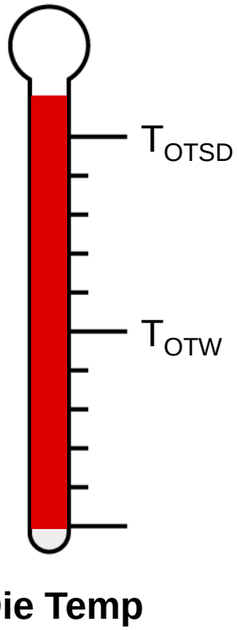


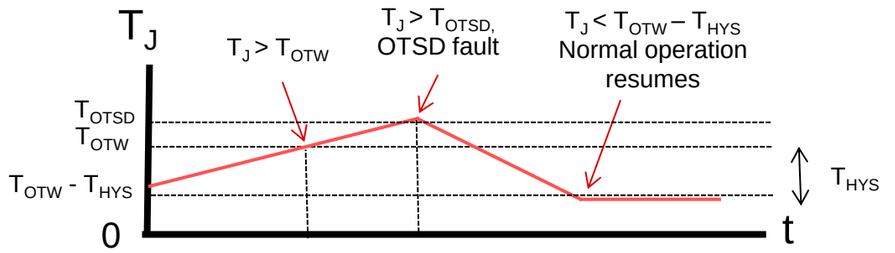


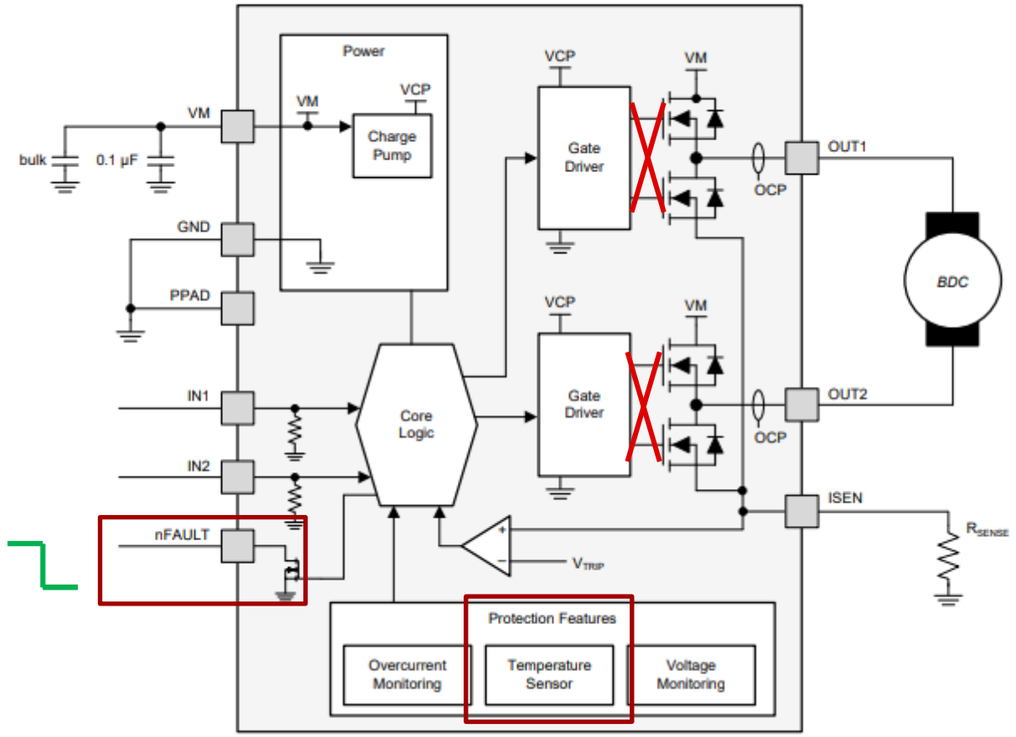

# Other Protection Features

- Overvoltage Protection
- Gate driver fault
- Open Load Detection
- Short-to-battery / short-to-ground
- Dead Time
- MOSFET dV/dt Turn On Protection

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