# Welcome!
# Texas Instruments New Product Update

- This webinar will be recorded and available at www.ti.com/npu
- Phone lines will be muted
- Please post questions in the chat or contact your sales person or field applications engineer

# New Product Update Webinar

## Industrial eFuses & High-side switches

**Power Switches**

**1/28/2021**

# Agenda

**Power Switches Overview**

**eFuse**

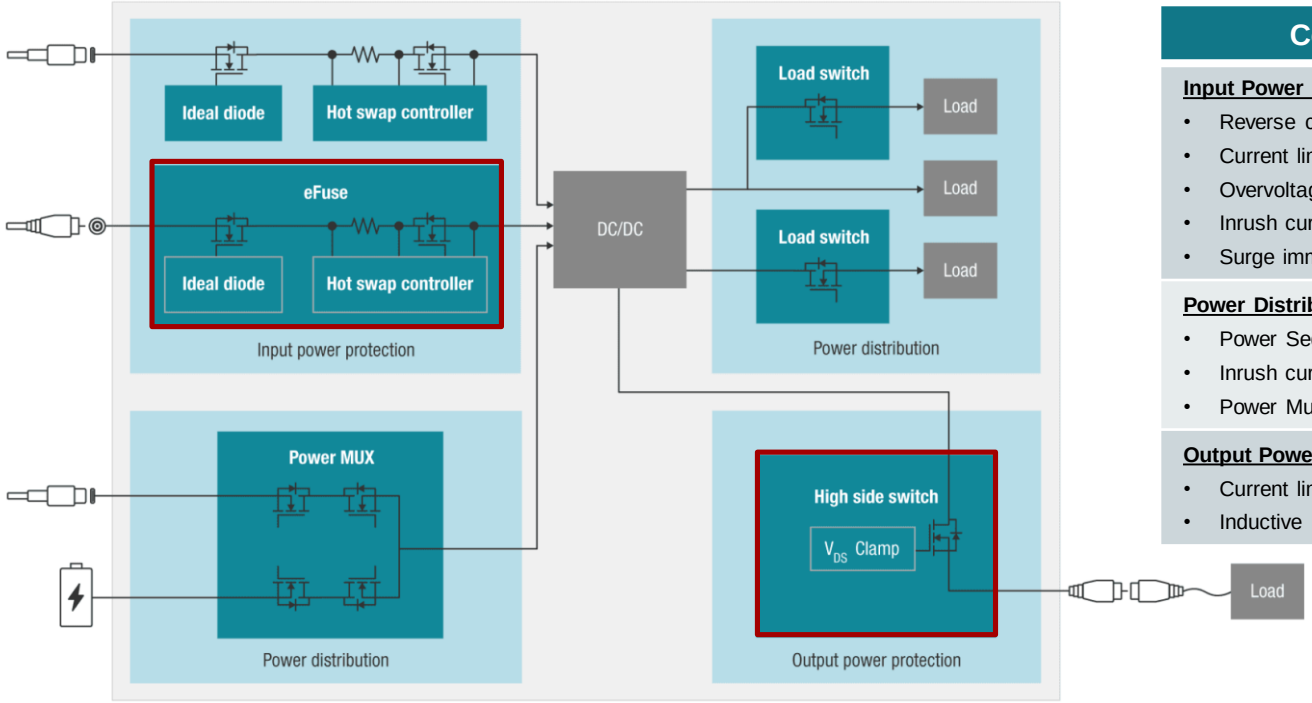
- What is an eFuse?
- TPS25947
- TPS2661
- TPS2640

**High-side switch**

- What is a high-side switch?
- TPS274160
- TPS27SA08
- TPS272C45

**Additional resources available on ti.com**

# Power Switches | Use Cases




## Common Design Challenges

**Input Power Protection**

- Reverse current blocking
- Current limiting
- Overvoltage protection
- Inrush current control
- Surge immunity

**Power Distribution**

- Power Sequencing
- Inrush current control
- Power Muxing/Power Oring

**Output Power Protection**

- Current limiting
- Inductive load driving

# Agenda

**Power Switches Overview**

**eFuse**

- What is an eFuse?
- TPS25947
- TPS2661
- TPS2640

**High-side switch**

- What is a high-side switch?
- TPS274160
- TPS27SA08
- TPS272C45

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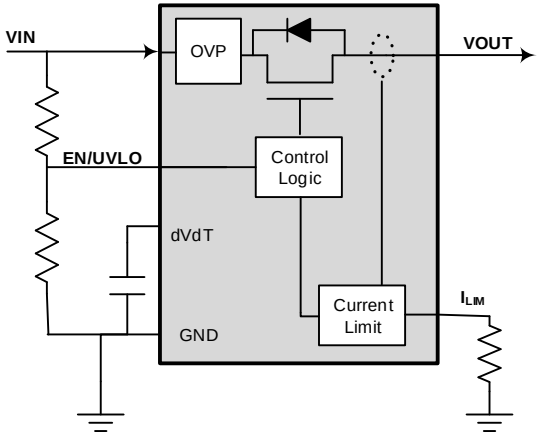
# TI eFuse Overview

**eFuses** are integrated power protection switches that provide overvoltage and overcurrent protection during fault events.

**eFuses** are used at the input of a system.




## Features & Benefits

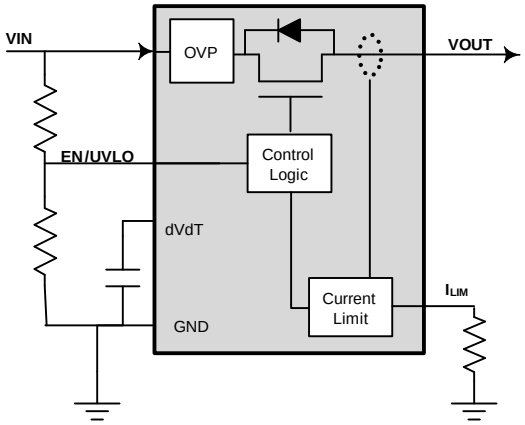
| | |
|---|---|
| Adjustable current limit & Adjustable slew rate control | • More flexibility in system design<br>• Enables the same device to be used across different applications |
| Short circuit protection | • Very fast (<200ns) response time to severe short circuit events |
| Over & under voltage protection | • Programmable OVP & UVLO helps to eliminate supervisory circuits |
| Reverse current & reverse polarity protection | • Protects against mis-wiring<br>• Reserves holdup capacitor charge during power failure (Last Gasp)<br>• Enables Power Muxing |
| Status & power good signals | • PG signal provides sequencing in the application<br>• Fault intelligence provided to the micro controller etc<br>• Real Time Analog Load current monitor |
| UL recognized | • All eFuses are UL recognized, this enables faster certification of the end product since a UL device is being used |

# eFuse Topologies

## Basic Topologies

- eFuses utilize a charge pump to drive internal NMOS FET(s) to act as protection switches
- eFuses are available in two different topologies
  - Single FET
  - Back-to Back FET (B2B)

## Single FET Topology



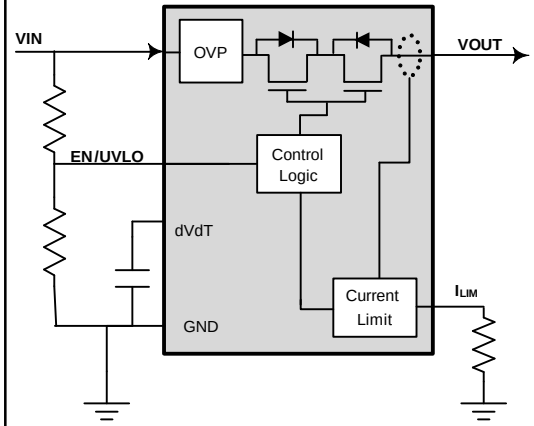

**Consists of a single hot-swap FET to enable:**

- ✓ Overvoltage protection
- ✓ Current limiting
- ✓ Slew rate control

**Features NOT included:**

- × Reverse current blocking
- × Reverse polarity protection

## Back-to-back FET (B2B) Topology




**Consists of two back-to-back FETs to enable the same features and more:**

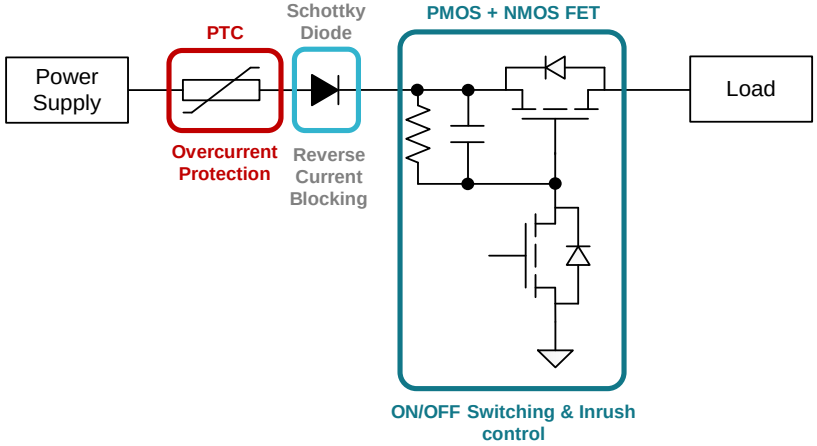
- ✓ Overvoltage protection
- ✓ Current limiting
- ✓ Slew rate control

**Features included:**

- ✓ Reverse current blocking
- ✓ Reverse polarity protection

# Discrete vs. Integrated | eFuse

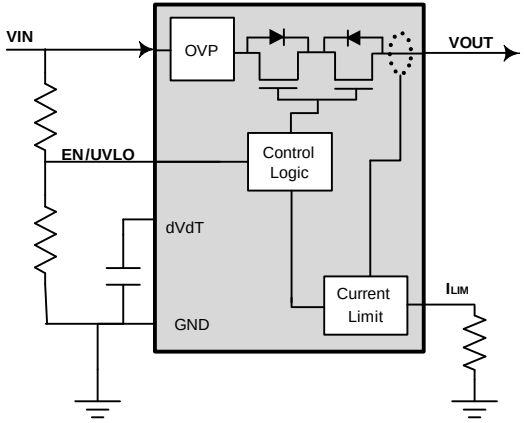
## Discrete Input Protection Circuit




**Features:**

| | | | |
|---|---|---|---|
| ✓ | Overcurrent protection | ➡ | - *Slow reaction time, wide variation, high $P_{DISS}$* |
| ✓ | Slew rate control | ➡ | - *Non-linear rise time, high peak inrush* |
| ✓ | Reverse current blocking | ➡ | - *High power dissipation ($P_{DISS}$)* |
| ✓ | Reverse polarity protection | | |
| ✗ | Overvoltage protection | | |
| ✗ | Fault/PGOOD Indicator | | |

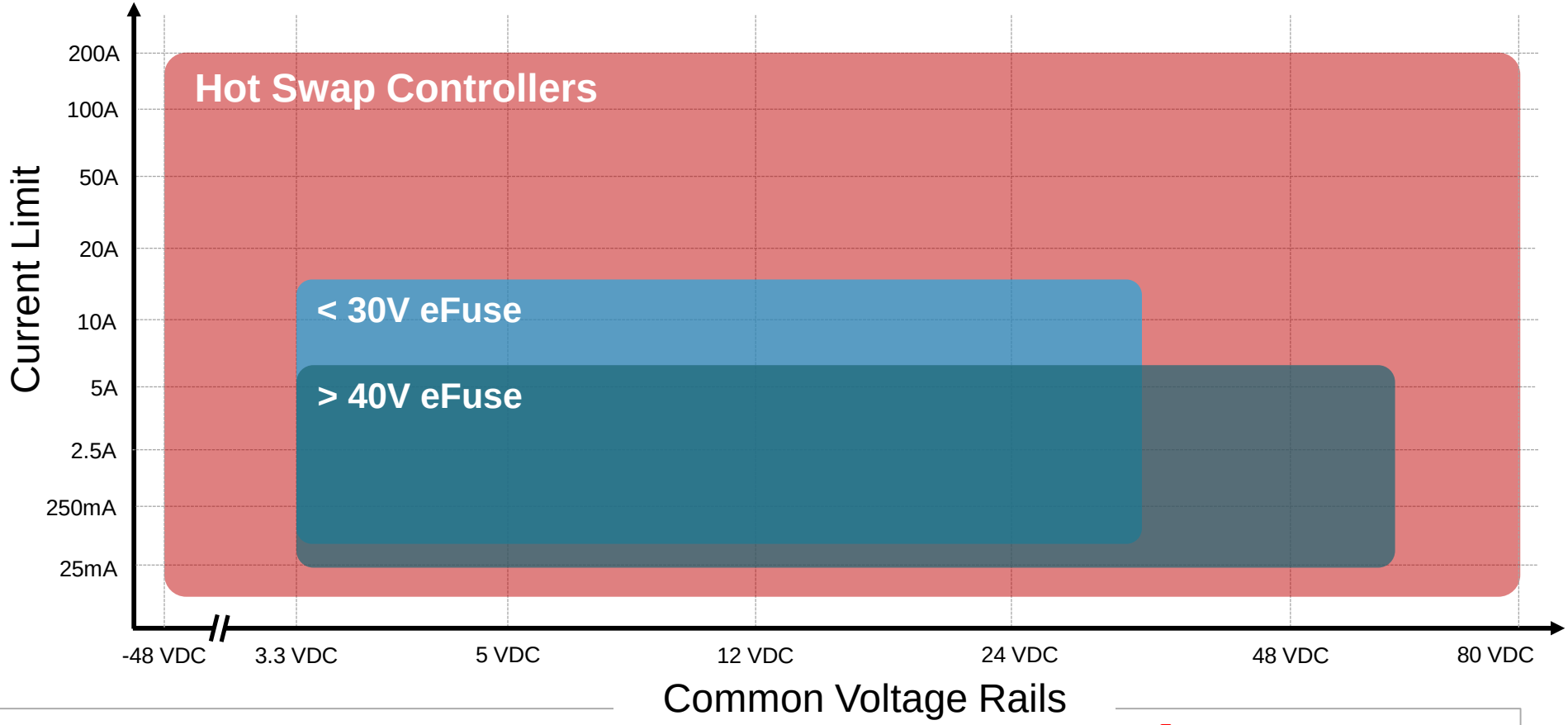
## Integrated eFuse




**Features:**

| | | | |
|---|---|---|---|
| ✓ | Overcurrent protection | ➡ + | *Accurate & fast response, low $P_{DISS}$ due auto-retry & latch off response* |
| ✓ | Slew rate control | ➡ + | *Linear rise time reduces peak inrush current* |
| ✓ | Reverse current blocking | ➡ + | *Integrated blocking FET enables low $P_{DISS}$* |
| ✓ | Reverse polarity protection | | |
| ✓ | Overvoltage protection | ➡ + | *Also provides OVP* |
| ✓ | Fault/PGOOD Indicator | ➡ + | *Enables fault reporting for smarter protection* |

# eFuse & hot-swap controller portfolio | Today



# TPS2640 | 40V, 2-A Industrial eFuse

## Features

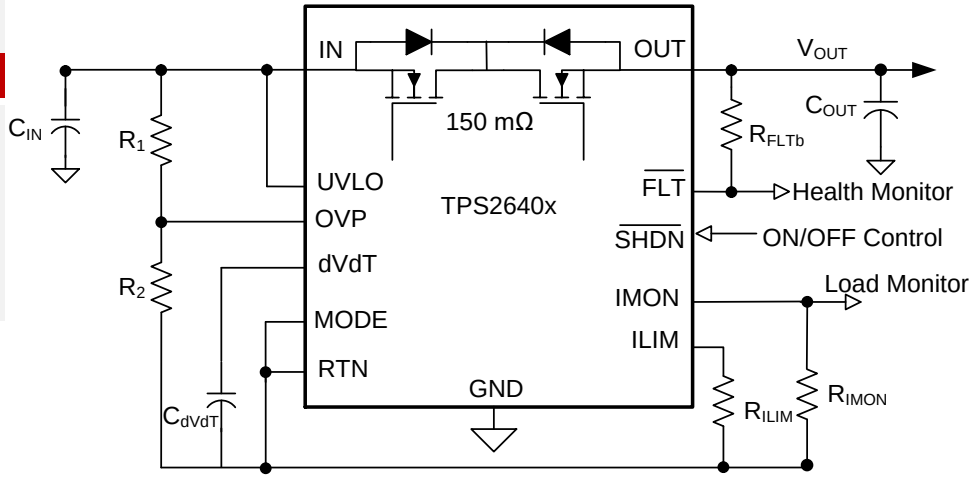
- **4.5V - 40V DC** operation, 45V Abs DC, **55V Abs Max (10ms Transient)**
- Integrated **150mΩ Back-to-back MOSFET**
- **0.1 to 2.2 A** Accurate current limit (±10%)
- Programmable UVLO; OVP Cut-Off
- Programmable Output Slew Rate using dVdT pin
- Input Reverse Polarity Protection
- Pulse current /power support with circuit breaker mode
- Analog current monitor output (IMON)
- **16 PWP Leaded Package [6.4 x 5 mm], 24QFN [5x4 mm]**

## Applications

- HMI Power protection in Factory Automation
- Encoder Power Protection in Servo Drives
- Fire Alarm Control Panel
- Industrial PCs
- ATMs
- Electronic Thermostats
- Elevators

## Benefits

- Small QFN package **saves >60% PCB Area** than Discrete Component Design
- 48V Transient Abs Max for **load protection from Power Surge** (IEC61000-4-5, 500V, 2Ω
- **40% Lower Power Dissipation** than a Schottky Diode (0.5V) + PFET (0.1Ω)



# TPS25947 | 23V, 28mΩ, 5.5A eFuse w/ True RCB

## Features

- 2.7 – 23V operating range
- 28V Abs Max Rating
- Integrated 27 mΩ Pass MOSFET
- Always-On Reverse Current Blocking with zero DC reverse current
- Integrated reverse polarity protection
- Programmable Current limit with Monitor: 0.5-6A
  - ± 10% Current Limit accuracy
  - Programmable fault delay timer
- +/-15% Current Monitor Accuracy
- Programmable $V_{OUT}$ Slew Rate (dVdt)
- Programmable UVLO
- Adjustable OVLO/Selectable OVC
- Fault / Power Good Indication options
- Latch-off and retry versions available
- UL 2367 Recognition (Planned)
- Safe during Single Point Failure Test (Planned)
- 2mm x 2mm, 0.45mm pitch QFN package

## Benefits

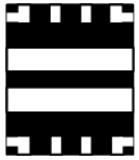
- Supports wide range of supply rail voltages
- Tolerates large VBUS overvoltage/transients
- Lower droop on bus voltage and self-heating
- Fast RCB allows “Last gasp” cap hold-up and Power MUXing
- Protection against mis-wiring or faulty adapters without the need of any external components
- Reduced Power Supply Margin Specs
- Allows transient peak currents without tripping (emulating fuse behavior)
- Enhanced System Monitoring & Diagnostics
- Inrush current management as per system needs
- Protects downstream loads from unsafe voltages

- Easier System Power Sequencing & Control
- Flexible Design Options
- Makes safety certification simpler

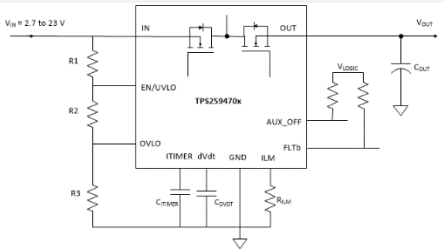
- Small Footprint

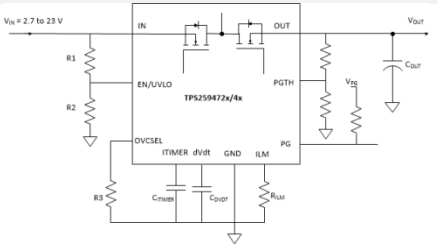
## Applications

- Adapter Input protection
- PowerMUX/ORing
- Server Motherboard/Add-on cards(NIC/HW Accelerator)
- Gaming PC/GraphicsAccelerator cards
- Storage - RAID/HBA/SAN/eSSD/cSSD
- Docking stations/Monitors



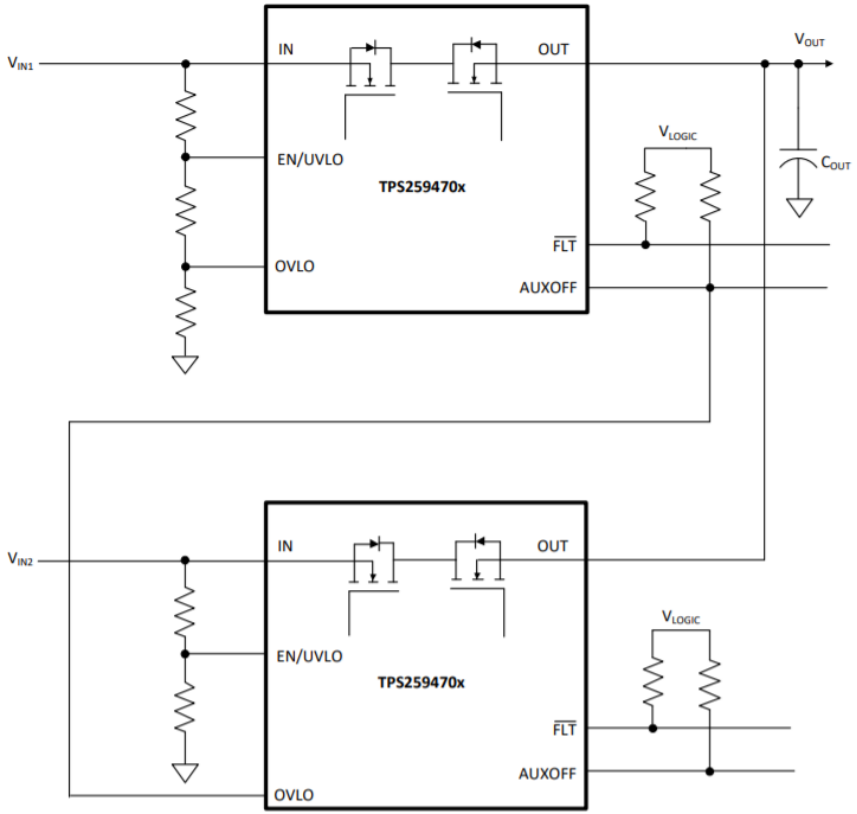
2.0mm x 2.0mm
0.45 mm pitch



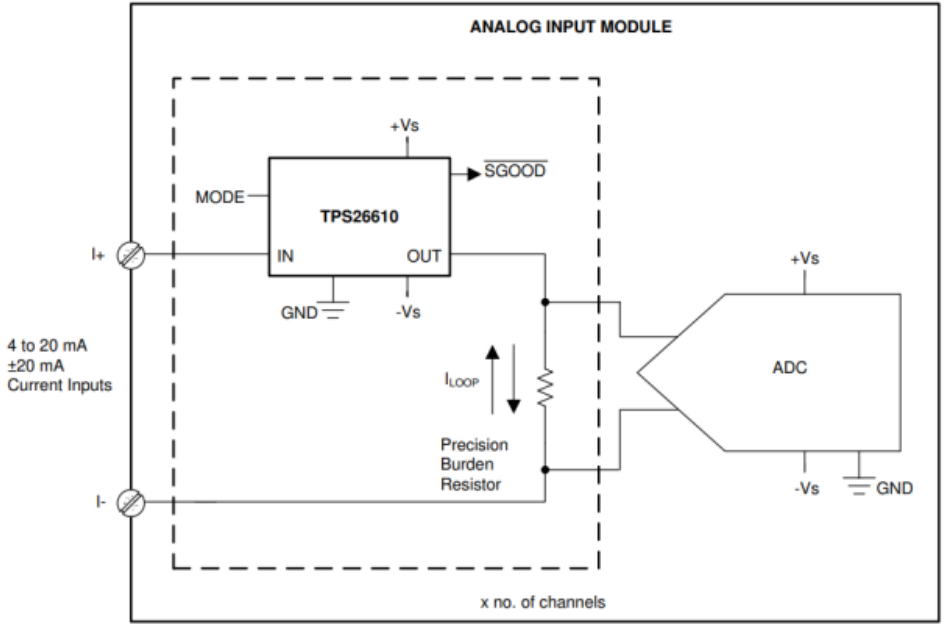




Texas Instruments

# Power Mux example | TPS25947

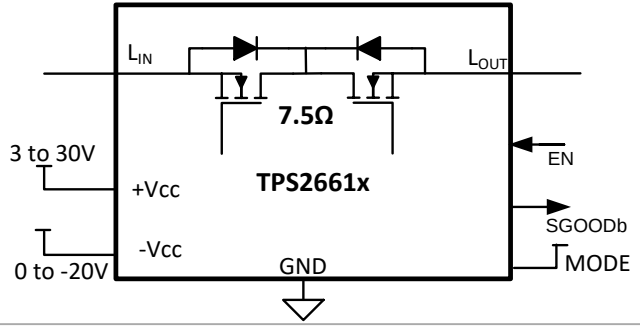


# TPS2661 | Universal 4-20mA, Current loop protector




## Features

- Supports bidirectional current loops with **0V to ±50V operating** range (with external Vs)
- Current drawn from loop $\mathbf{I_Q}$ **< 0.1uA** (external Vs powered)
- Integrated 7.5Ω MOSFET
- Fixed $\mathbf{I_{LIMIT}}$ **= ± 30mA ±15%**
- **EN pin control**
- Device status reporting through SGOODb pin
- Protection against input side miswiring
- Thermal shutdown
- Available in 2.9x1.6mm SOT Package, with 0.65mm pin pitch



# Agenda

**Power Switches Overview**

**eFuse**

- What is an eFuse?
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- TPS2640

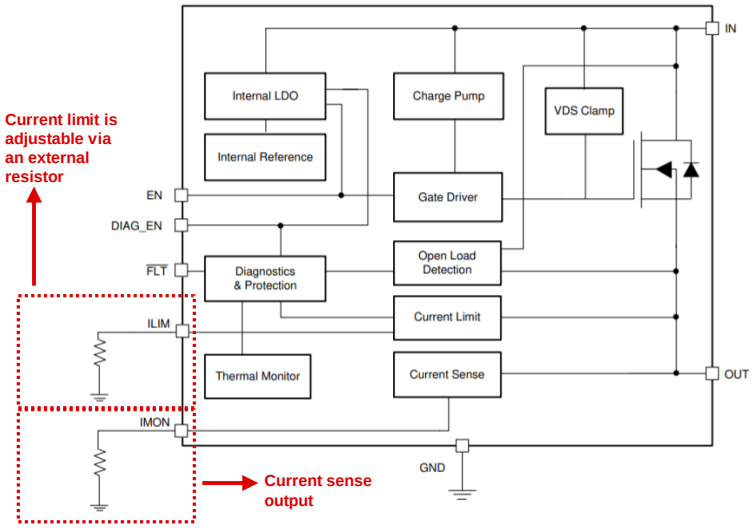
**High-side switch**

- What is a high-side switch?
- TPS274160
- TPS27SA08
- TPS272C45

**Additional resources available on ti.com**

# TI High-side switches | Overview

**High-side switches** are integrated power switches that are used to drive off board resistive, inductive, and capacitive loads. **High-side switches** are generally used at the output of the system.



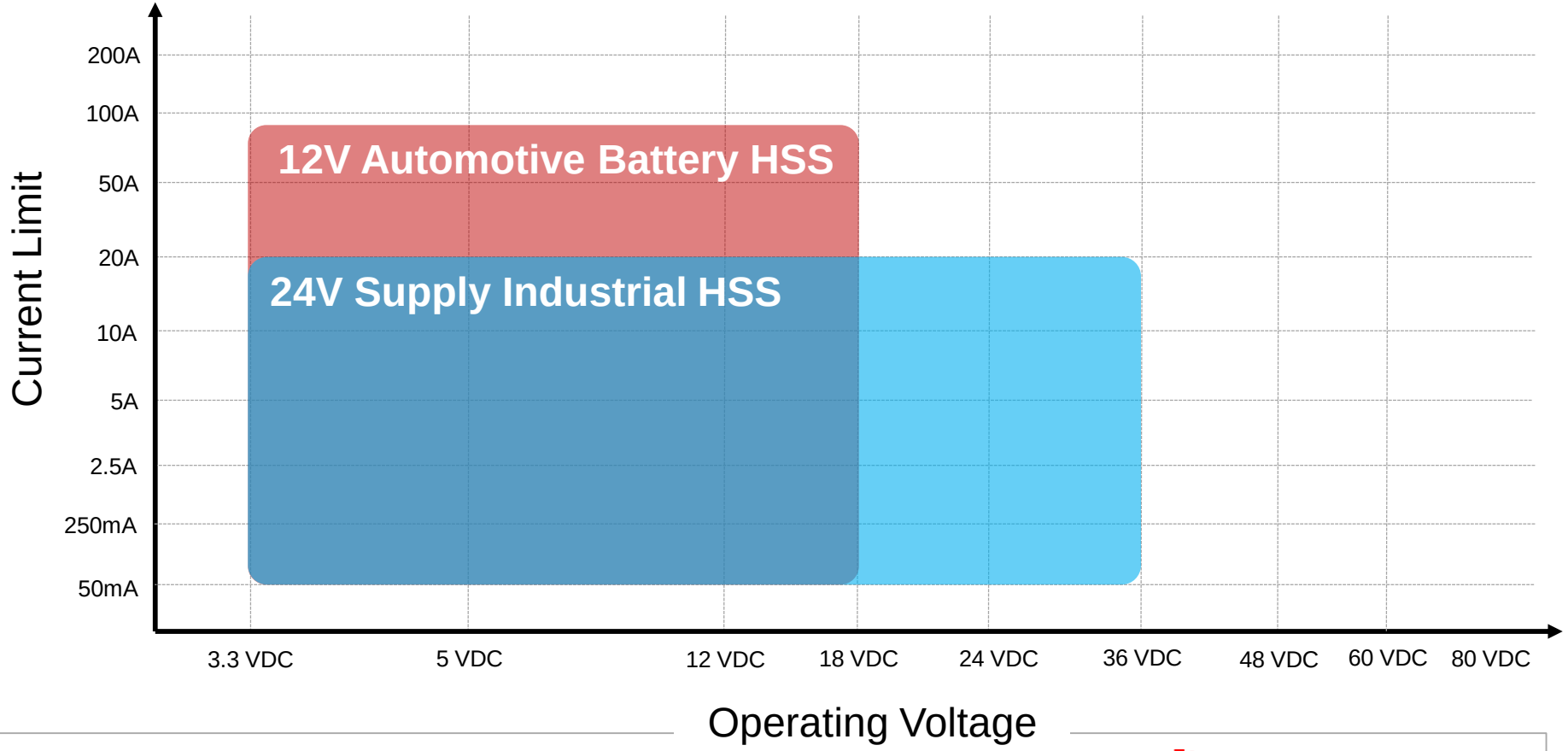

Adjustable **current limiting** enables application scalability and capacitive load driving

Accurate **current limiting** reduces the power requirements of the external power supply

**Current monitoring** enables load diagnostics to detect wire breaks and faults to reduce downtime

*TI's Smart Power Switches portfolio provides a wide range of RDSON value (8mΩ-1Ω).*

# High-side switches portfolio | Today



# Industrial high-side switch portfolio | Key Devices

| Parameter | TPS27S100 | TPS274160 | TPS27SA08 | TPS272C45 |
|---|---|---|---|---|
| Interface | Parallel | Parallel | Parallel | Parallel |
| # of CHs | 1 | 4 | 1 | 2 |
| Operating $V_{IN}$ | 4 to 40V | 4 to 36V | 8 to 36V | 4.5 to 36V |
| Integrated $V_{DS}$ clamp | 50 – 70V | 50 – 70V | 40 – 58V | 49 – 58V (ver A & B)<br>N/A (ver C) |
| # of CHs | 1 | 4 | 1 | 2 |
| $R_{DSON}$, typ | 80 | 160 | 8 | 45 |
| Current limit | Adjst, 0.5 – 4A | Adjst., 0.25 – 4A | Fixed, 12.8 – 27.8A | Adjustable, 0.5 – 4A |
| Features | ✓ OL Detect –ON state<br>✓ OL Detect – OFF state<br>✓ Current SNS (ver B) | ✓ OL Detect –ON state<br>✓ OL Detect – OFF state<br>✓ Current SNS (ver B) | ✓ OL Detect –ON state<br>✓ OL Detect – OFF state<br>✓ Current SNS | ✓ OL Detect –ON state<br>✓ OL Detect – OFF state<br>✓ Current SNS |
| Current SNS acc. @ 1A | +/-3% | +/-2% | +/-5% | +/-4% |
| Status Pin | Yes, ver A | Yes | Yes | Yes |
| Package | QFN-16, 3.5mm x 4mm<br>HTSSOP-14, 5mm x 6mm | QFN-28, 4mm x 5mm | HTSSOP-16, 5mm x 6mm | QFN-24, 4mm x 5mm |
| Status | **Production** | **Production** | **Production** | **APL** |

# TPS274160 | Quad Channel High Side Switch

## Features

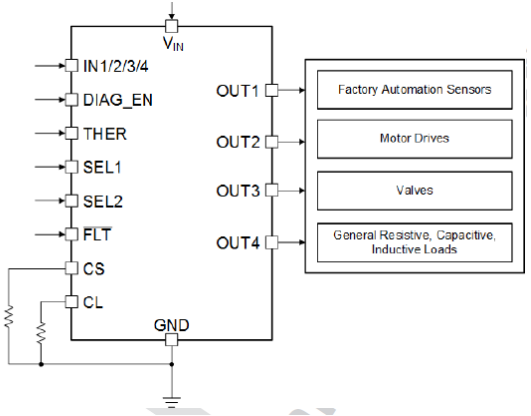
- **Operating Voltage:** 5V - 36V, 48V ABS MAX transient
- **$R_{DSON}$:** 165mΩ typical, 260mΩ max (125ºC)
- Operating Junction Temperature, -40 to 150ºC
- uC Input 3.3V and 5V logic compatible
- **Accurate current sense:** ±3% @ 500 mA, ±15% @ 25mA
- **Adjustable, accurate current limit:** 0.25A – 7A, ±15% when ≥ 500mA
- **A Version:** Individual open-drain status pin per channel
- **B Version:** Current Sense Analog Output
- Protection
  - Short to GND protection by current limit (internal or external)
  - Thermal Shutdown and Thermal Swing
  - Configurable latch-off or auto-retry options
  - **Integrated $V_{DS}$ clamp for inductive load driving (50 – 70V)**
- Diagnostic
  - Overcurrent and short to ground detection
  - **Open load / Short to battery detection during on and off state**
  - Global Fault Report for fast hardware interrupt
- **Package:** QFN-28, 4mm x 5mm, 0.5mm pitch

## Applications

- **Factory Automation**
- **Remote I/O**
- **Digital Output Module**
- **Motor Drives**

## Benefits

- **Open load detection** provides an interrupt to the system when there is a fault (wire break, short-circuit, etc…)
- **Accurate, adjustable current limit reduces the external power supply requirements** and **improves capacitive load driving**
- **Accurate current sense** enables **predictive maintenance (wire break, sensor aging, etc…)**
- **Integrated $V_{DS}$ clamp** enables **inductive load driving**
- QFN package reduces the solution size




QFN-28
4mm x 5mm, 0.5mm pitch
20mm²

# TPS27SA08 | 3-36V, 9mΩ

## Single-Channel High Side Switch in HTSSOP-16 package

## Features

- **Single-channel high-side switch**
- **Operating voltage range:** 3V to **36V**
- **ABS Max voltage:** 40V
- **Low ON-Resistance:**
  - $R_{ON}$ = **9mΩ** typ at $T_J$ = 25ºC, VIN = 24V
  - $R_{ON}$ = 20mΩ max at $T_J$ = 150ºC, VIN = 24V
- **Integrated protection:**
  - Over-temperature shutdown
  - Versions with different current limiting type – cut-off or clamping
  - Under-voltage lockout
  - Automatic switch turn-off with loss of ground
  - VDS clamp for inductive loads or support short circuit protection with cable inductance
  - Configurable fault handling via LATCH pin

## Targeted Applications

- **Power Distribution Switch**
- **Fire Alarm Control Panel**
- **HVAC System Controller**
- **Servo Drives**
- **Factory Automation**

## Features

- **Diagnostic:**
  - Fault indication via open drain output and via analog sense
  - Multiplexed analog sense output for **accurate load current sensing**, voltage and FET temperature sensing
  - Open-load detection
- **Ambient temperature rating:** -40˚C to 125 ˚C
- **Small HTSSOP package:** 16pins, **32mm²** total size

## Benefits

- **Accurate current sense**: improved diagnostics at light load

.

- **Open-drain status pin**: provides fault indication independent of the microcontroller ADC.

| Over current Reaction | Current Limit | Part Number |
|---|---|---|
| Limit/clamp current (switch stays enabled) | 20A | TPS27SA08C |

# TPS272C45 | Dual-Channel 4A, 45 mΩ High Industrial Side Switch

## Features

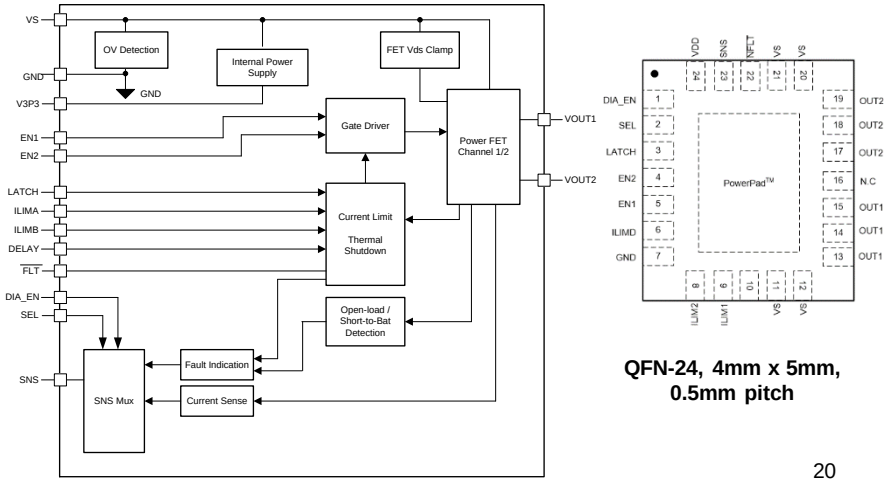
- **Wide Operating voltage range:** **4.5V to 36V**
- **Integrated Inductive Discharge Clamp:** Breakdown above 48V
- **Diagnostic:**
  - Multiplexed analog sense output for accurate (4% @ 1A, 15% @ 100mA, 60% @ 10mA) current sensing
  - Open-load, overcurrent, and short-to-supply detection
- **Low ON Resistance:** $R_{ON}$ : 45 mΩ typ 25˚C, 78 mΩ max, 125˚C, $V_S$ = 24V
  - Integrated 2nd low voltage supply (5/3.3 V) input pin to minimize power dissipation
- **Integrated protection:**
  - Over-temperature shutdown
  - Supply Under-voltage lockout
  - Resistor Adjustable Current Limit, **500 mA – 4 A (adj) / 5.8 A (fixed)**
  - Two-level current limit for fast charging or inrush current handling
  - Fault indication on the sense pin or **with open drain nFLT pin**
  - FET VDS clamp for inductive loads
  - Configurable fault handling via LATCH pin
- **Ambient temperature rating:** -40˚C to 125˚C
- **Small QFN package:** 24 pins QFN, 20 mm², **0.5mm pitch**

## Targeted Applications

- **Factory Automation**
  - **Remote I/O**
  - **Digital Output Module**
- **Motor Drives**

## Benefits

- **Low Power Dissipation:** 45 mΩ RON and low voltage supply input minimize device power dissipation
- **Accurate current sense**: improved diagnostic capabilities without the need for end of line calibration. Accurate open-load or shorted load diagnostics even with light loads.
- **Adjustable current limit**: allows setting based on the application and the use of lower cost components and connectors – lower system cost. Higher threshold on switch initial turn-on allows flexible inrush handling
- **Robust Design:** Tested in accordance to IEC61000-4-2/4/5




**QFN-24, 4mm x 5mm, 0.5mm pitch**

# Low voltage supply | TPS272C45

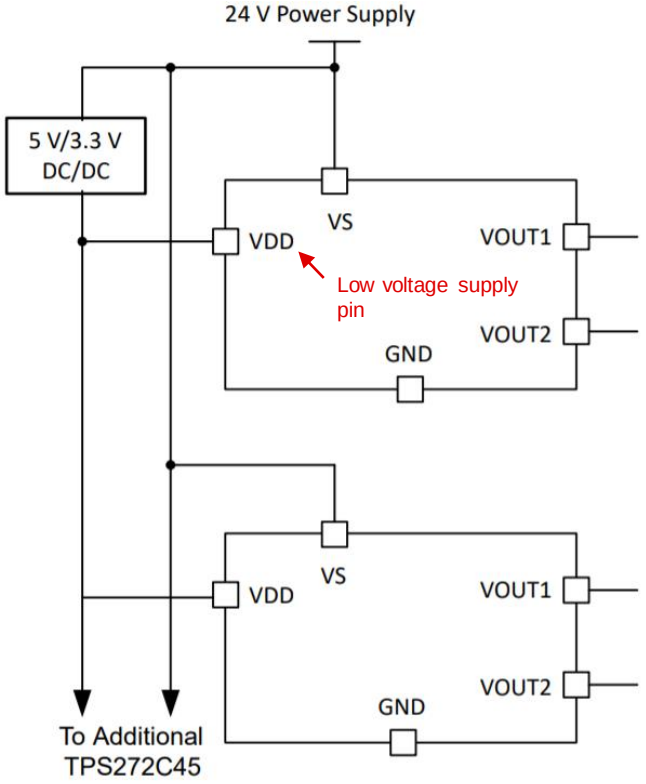
**TPS272C45A** supports a low voltage bias supply through the $V_{DD}$ pin which can help to reduce the power dissipation inside the device.

The $V_{DD}$ pin support either 3.3V or 5V supplies

Below is a comparison between **TPS272C45A** (w/ $V_S$ supply) and **TPS272C45B** (w/o $V_S$ supply):

**Table 9-2. Power Dissipation Calculations**

| $I_{LOAD}$ | Version | Resistive Losses (max, 125°C) | Controller Losses (max, 125°C) | Total $P_{DISS}$ (max, 125°C) |
|---|---|---|---|---|
| 500 mA (both channels) | B | 39 mW | 211 mW | 250 mW |
| | A | 39 mW | 50 mW | 89 mW |
| 2 A (both channels) | B | 624 mW | 211 mW | 735 mW |
| | A | 624 mW | 50 mW | 674 mW |

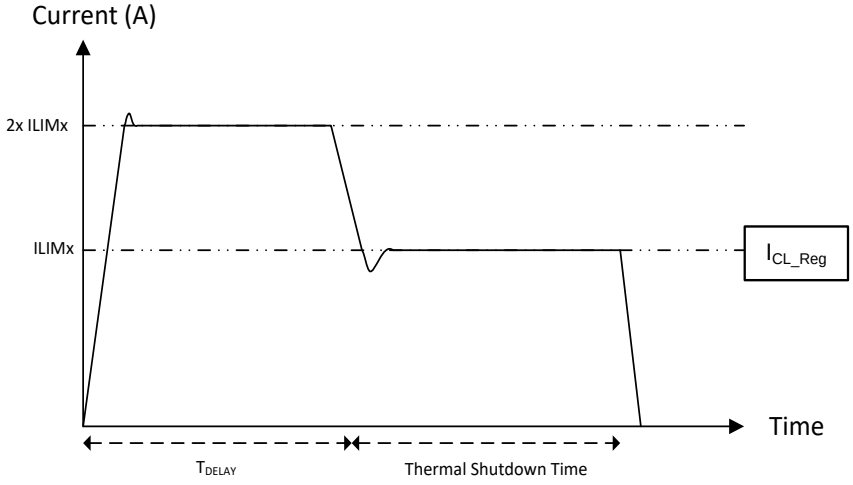


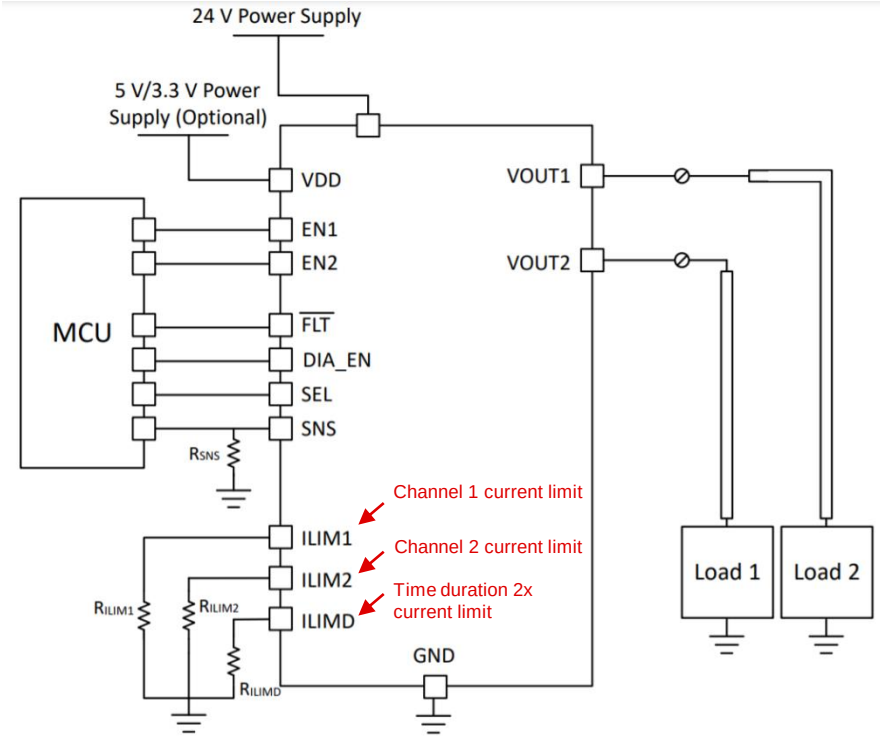
# Inrush current limit functionality | TPS272C45

The current limit can be increased by 2x during startup to:

- increase the charge rate of capacitance
- enable bulb driving

This can be configured through the **ILIMx** which sets the current limit threshold and **ILIMD** which sets the time duration of the 2x current limit.



# TPS272C45 | Variants

## 5 Device Comparison Table

**Table 2. Device Options**

| Device Version | Part Number | Low Voltage Supply? | Current Limit | Integrated Inductive Clamp | Advantage |
|---|---|---|---|---|---|
| A | TPS272C45**A** | Yes | Adjustable by ILIMx resistor | Yes | Lower device power dissipation with most of the quiescent current drawn from the lower voltage supply input - enables reduced total heat dissipation and thus smaller module sizes. |
| B | TPS272C45**B** | No | Adjustable by ILIMx resistor | Yes | Lower system costs with a single power supply (cost of a low voltage regulator is avoided) |
| C | TPS272C45**C** | No | Adjustable by ILIMx resistor | No | Enables usage of external TVS Clamp for high inductive loading |

# Industrial high-side switch portfolio | Key Devices

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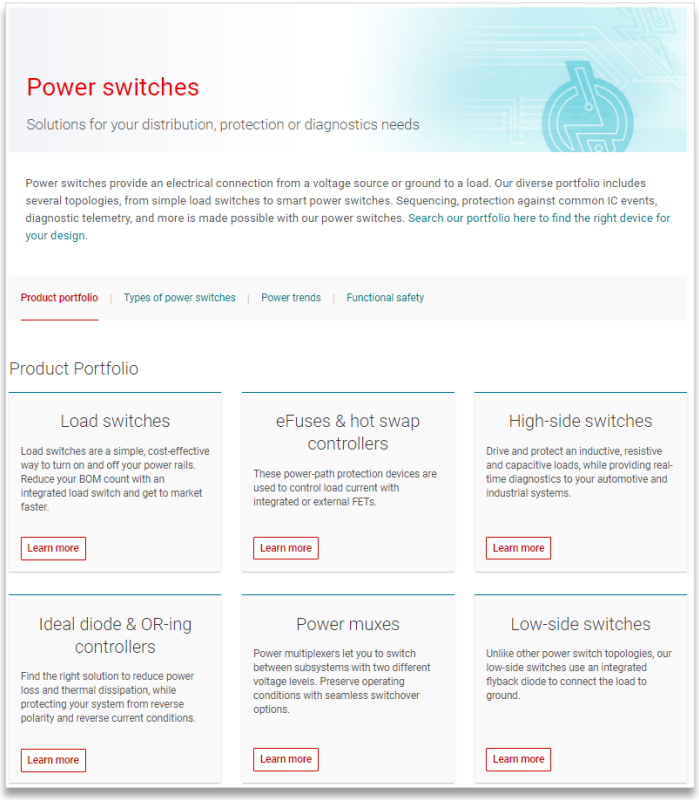
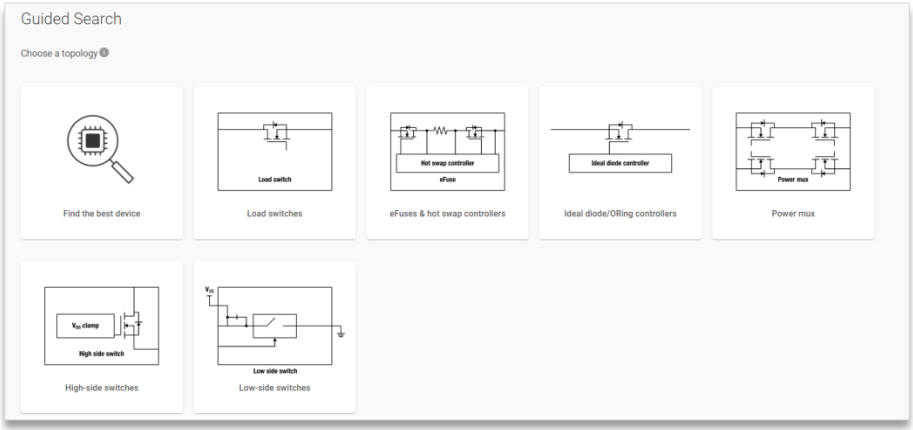
|---|---|---|---|---|
| Interface | Parallel | Parallel | Parallel | Parallel |
| # of CHs | 1 | 4 | 1 | 2 |
| Operating $V_{IN}$ | 4 to 40V | 4 to 36V | 8 to 36V | 4.5 to 36V |
| Integrated $V_{DS}$ clamp | 50 – 70V | 50 – 70V | 40 – 58V | 49 – 58V (ver A & B)<br>N/A (ver C) |
| # of CHs | 1 | 4 | 1 | 2 |
| $R_{DSON}$, typ | 80 | 160 | 8 | 45 |
| Current limit | Adjst, 0.5 – 4A | Adjst., 0.25 – 4A | Fixed, 12.8 – 27.8A | Adjustable, 0.5 – 4A |
| Features | ✓ OL Detect –ON state<br>✓ OL Detect – OFF state<br>✓ Current SNS (ver B) | ✓ OL Detect –ON state<br>✓ OL Detect – OFF state<br>✓ Current SNS (ver B) | ✓ OL Detect –ON state<br>✓ OL Detect – OFF state<br>✓ Current SNS | ✓ OL Detect –ON state<br>✓ OL Detect – OFF state<br>✓ Current SNS |
| Current SNS acc. @ 1A | +/-3% | +/-2% | +/-5% | +/-4% |
| Status Pin | Yes, ver A | Yes | Yes | Yes |
| Package | QFN-16, 3.5mm x 4mm<br>HTSSOP-14, 5mm x 6mm | QFN-28, 4mm x 5mm | HTSSOP-16, 5mm x 6mm | QFN-24, 4mm x 5mm |
| Status | Production | Production | Production | APL |

# More resource for Power Switches on TI.com

## Power Switches Portal Page | ti.com/powerswitches

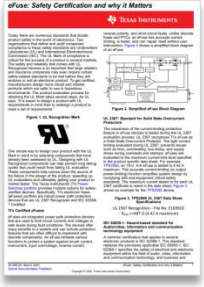



## Power Switches Guided Search Tool | Link

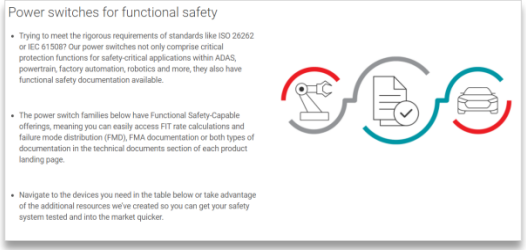



11 Ways to Protect Your Power Path | Power Switches eBook Link


eFuse: Safety certification and why it matters | Technical Note Link




Power switches for functional safety | Power Switches Functional Safety Capable Landing Page Link



# Visit www.ti.com/npu

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