

New Product Update

Decrease factory downtime with the TPS274C65 and its advanced load diagnostics.

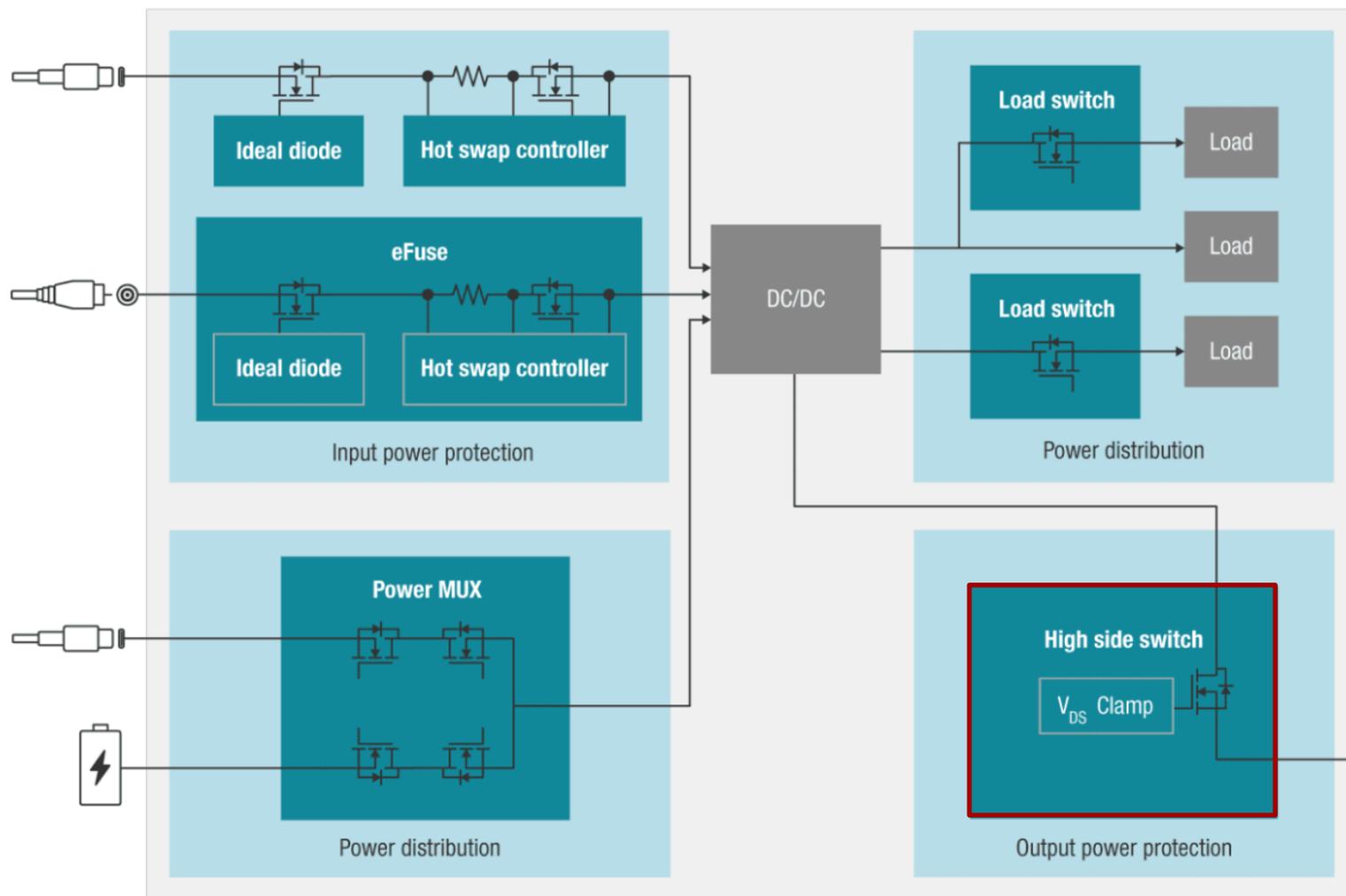
Paul Kundmueller

Product marketing engineer

Agenda

- Power switches overview
- High-side switch overview
- TPS274C65 overview
 - Serial protocol interface (SPI)
 - Integrated ADC
 - Increased power density
 - Reverse current blocking
 - LED module
- Industrial applications
 - Factory automation
 - Building automation
 - Grid infrastructure
- EVM overview

Power switches | use cases



Common design challenges

Input power protection

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

Power distribution

- Power sequencing
- Inrush current control
- Power muxing /power oring

Output power protection

- Current limiting
- Inductive load driving

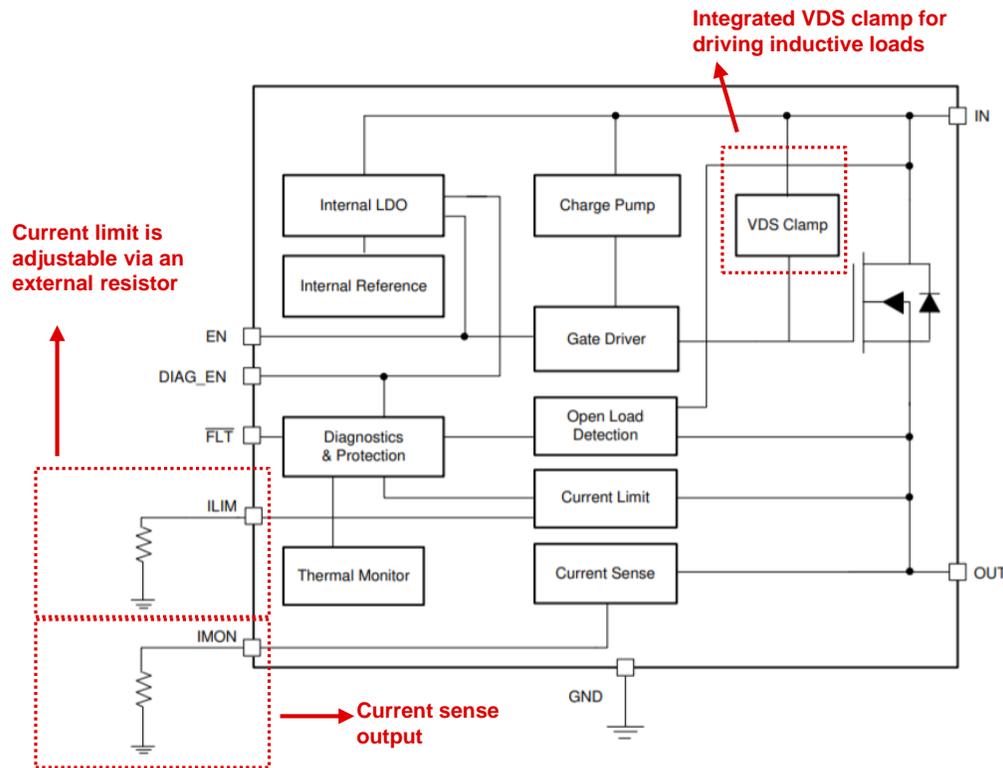
High-side controllers

Isolated switches

Low-side switches

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.



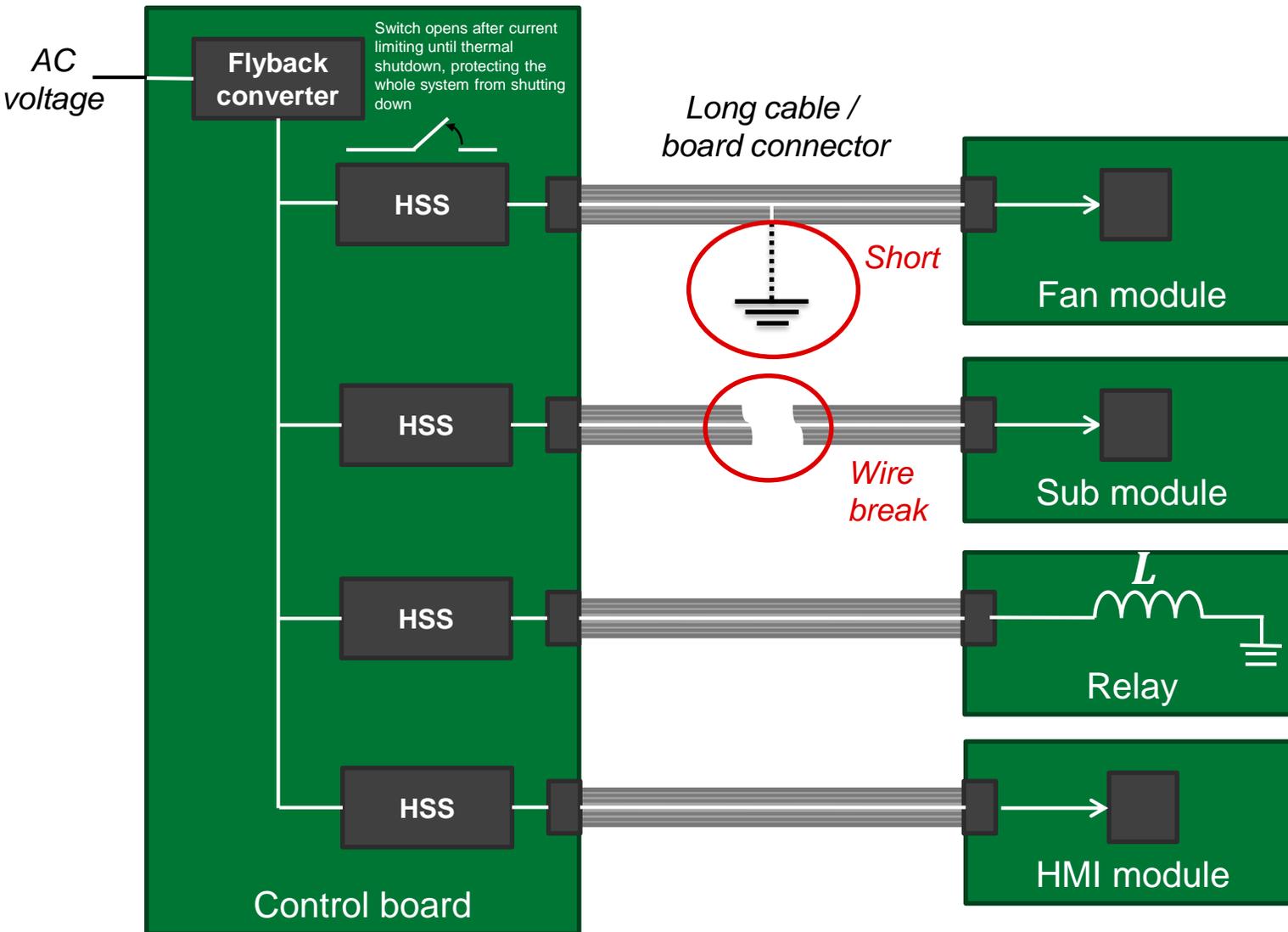
Adjustable **current limiting** enables application scalability and capacitive load driving

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 ($8\text{ m}\Omega$ - $1\ \Omega$).

Power distribution | use cases



Fast short circuit protection and current limiting of **high-side switches (HSS)** prevents the flyback converter from collapsing all the voltage rails

HSS offer current monitoring and open load detection can be used to alert the MCU when there is a wire break or short-circuit which helps to reduce downtime

HSS have integrated VDS clamps to handle inductive kickback of inductive loads such as relays, fans, and pumps

HSS can limit inrush current for modules which have large bulk capacitors such as HMIs

TPS274C65xx SPI, Quad, 1.65 A, high side switch

Features

- Operating voltage range: 10 V to 36 V, transient protection to 48 V
- Low R_{ON} : 65 m Ω typ 25°C, 115 m Ω max, 125°C, $V_S = 24$ V
- 10 MHz, 4-wire, **SPI Interface**:
 - Addressed and daisy chain mode, CRC for SPI communication failure

Diagnostics:

- 8-bit ADC for accurate current sensing ($\pm 6\%$ @ 1 A across temp)
- FAULT pin to interrupt host processor
- Fault reporting over SPI
- Input supply and output voltage monitoring
- Status registers: PGOOD, short and open-circuit, thermal alarm

Integrated Protection

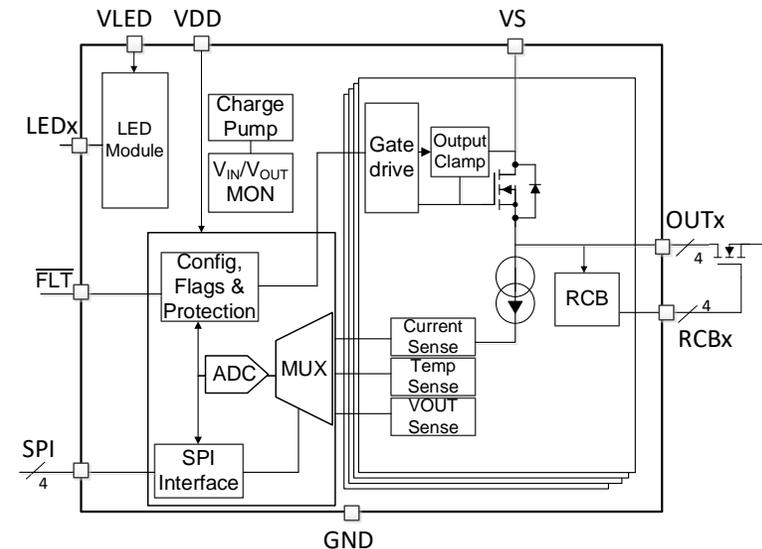
- Over-temperature shutdown
- SPI programmable current limit: 300 mA – 2.6 A
- SPI configurable current limiting for inrush current handling
- Reverse Current Blocking Control: Drive external FET
- LED drive from 3.3 V or 5 V supply (8-LEDs for Fault/Status)
- Industrial temperature range: -40°C to $+125^\circ\text{C}$
- Package: QFN40 (6 x 6), 0.5 mm pitch

Benefits

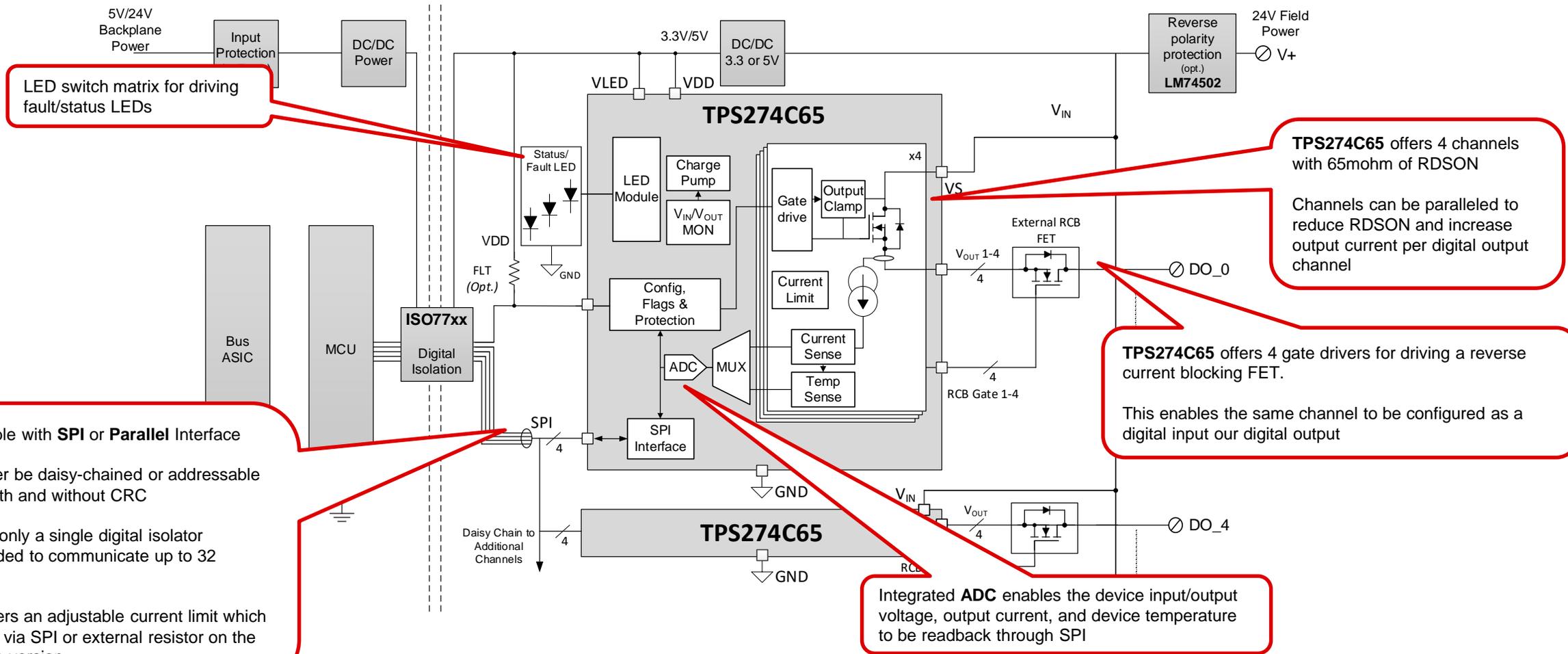
- Low Power Dissipation: 65m Ω RON and low quiescent current draw from 24 V supply minimize module power dissipation
- SPI programmable current limit enables low fault current for safety applications and reduces the impact on power supply
- Daisy Chainable and addressable SPI saves I/O pins on the MCU by allowing single SPI interface for multiple separate switch channels
- Integrated digital diagnostics and accurate current sensing enable precise load protection/monitoring
- Reverse current blocking control enables use in universal I/O application and protects against output mis-wiring

Applications

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



TPS274C65 | overview



LED switch matrix for driving fault/status LEDs

TPS274C65 offers 4 channels with 65mohm of RDSON
Channels can be paralleled to reduce RDSON and increase output current per digital output channel

TPS274C65 offers 4 gate drivers for driving a reverse current blocking FET.
This enables the same channel to be configured as a digital input or digital output

Integrated ADC enables the device input/output voltage, output current, and device temperature to be readback through SPI

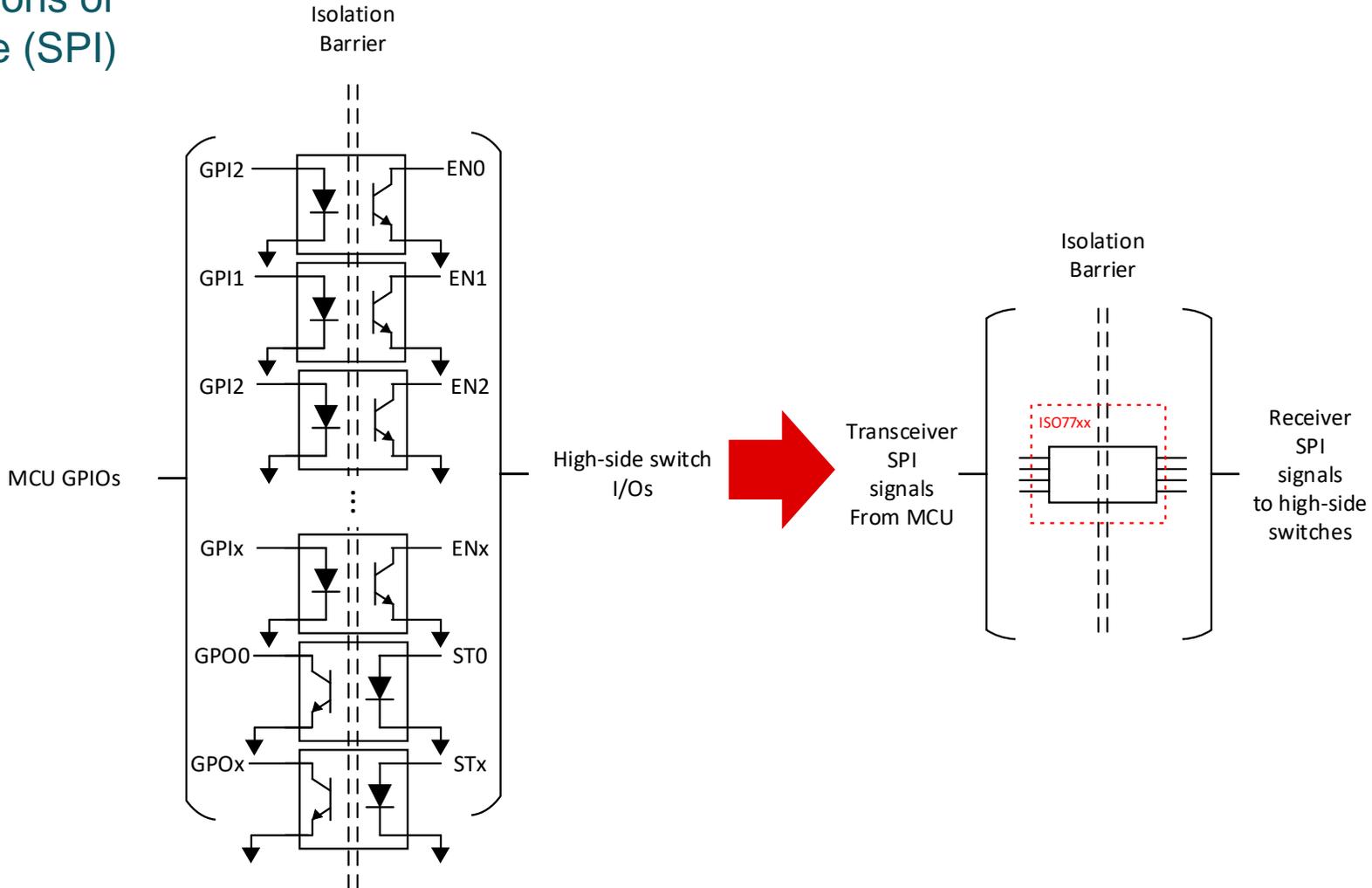
Versions available with **SPI** or **Parallel** Interface
SPI can be either be daisy-chained or addressable
SPI available with and without CRC
Benefit of SPI, only a single digital isolator ISO7741 is needed to communicate up to 32 channels
TPS274C65 offers an adjustable current limit which can be adjusted via SPI or external resistor on the parallel interface version

TPS274C65xS | serial protocol interface (SPI)

TPS274C65AS and TPS274C65BS versions of the device enable serial protocol Interface (SPI) communication

SPI communication

- Reduces the amount of GPIOs required to control the high-side switches
- In isolated systems, SPI reduces the number of signals which need to cross an isolation barrier which reduces the size and cost of the solution



TPS274C65xS | SPI configurations

SPI configurations

- TPS274C65xS offers two different SPI configurations:
 - Addressable SPI configuration
 - Daisy chain configuration
- The TPS274C65xS offers either a 16/24/32 bit frames with and without CRC functionality.
- CRC ensures data communication integrity.
- The state of each channel can be updated on each frame enabling simultaneously during each read or write cycle enabling simultaneously channel update and register access.

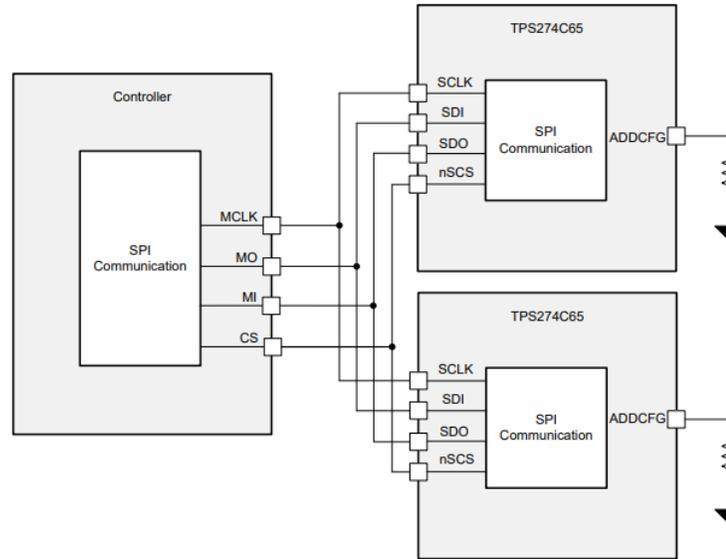


Figure 9-6. Addressable SPI Configuration

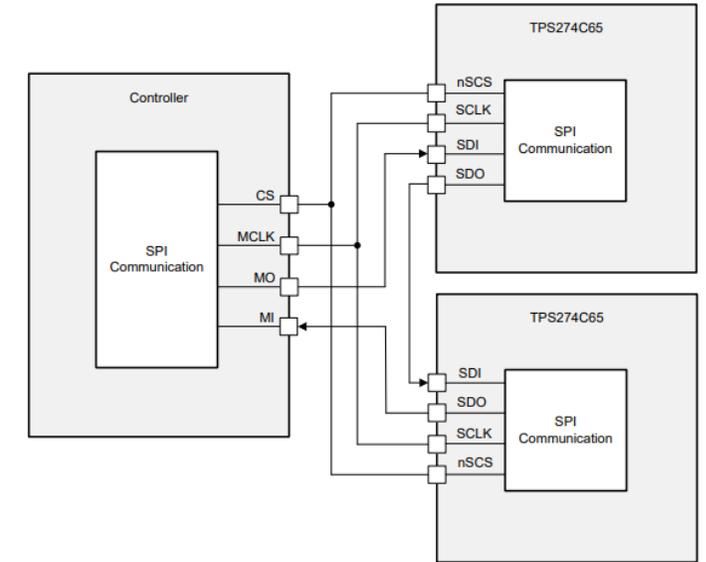
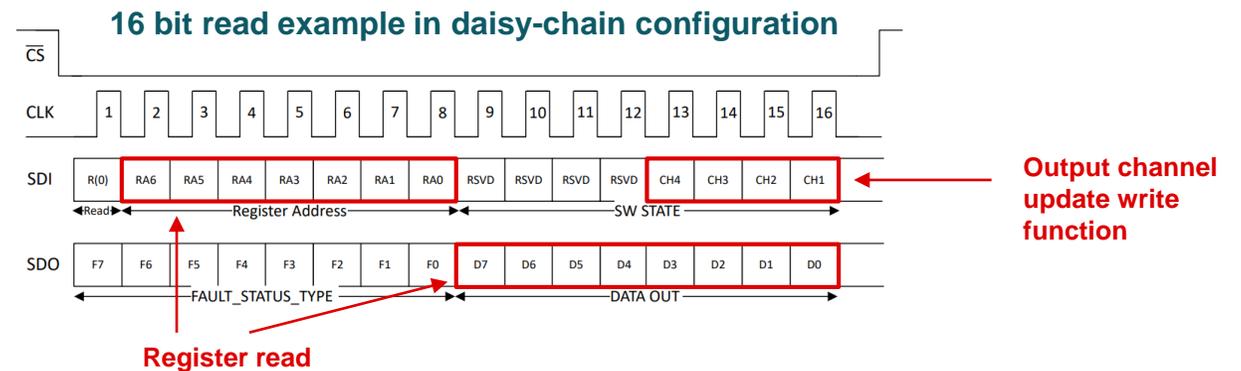


Figure 9-7. Daisy Chain Configuration



TPS274C65AS | integrated ADC

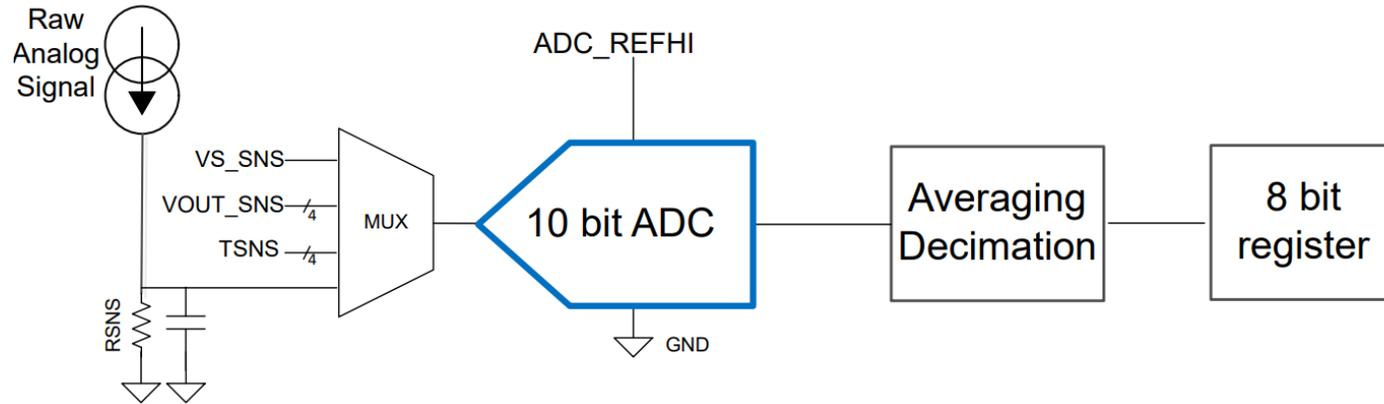
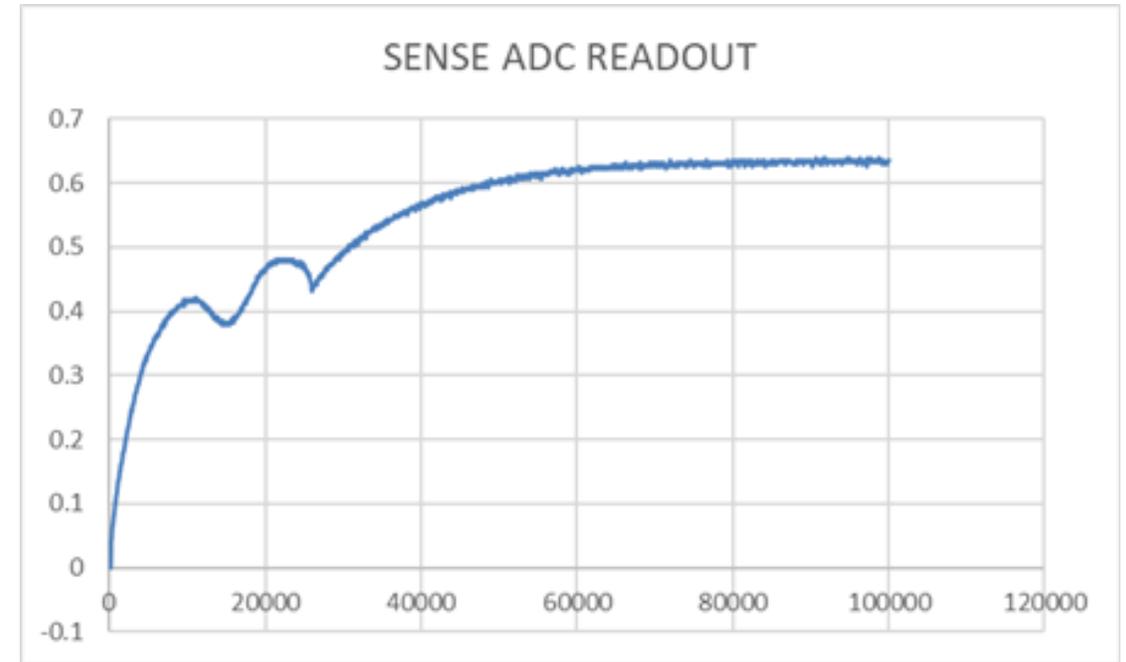
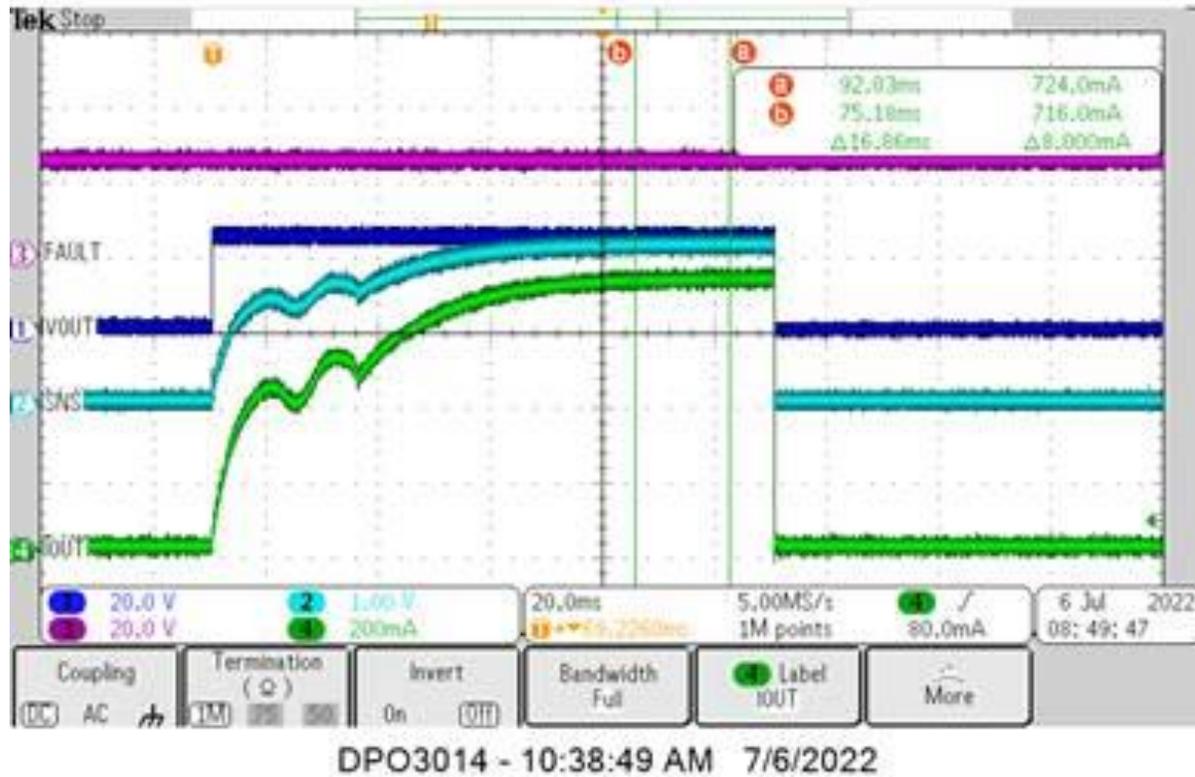


Figure 9-36. ADC Block Diagram

- Refresh rate of the integrated ADC is 65 us typical.
- The ADC function can be deactivated through SPI.
- Any ADC measurement can be deactivated through SPI.
- The ADC scheduling is round robin with the following order:
 1. ISNS
 2. TSNS
 3. VOUT_SNS
 4. VSNS

- TPS274C65AS enables *current sensing*, *temperature sensing* and *VOUT sensing* per channel
- The *integrated ADC* enables the above analog sensing information to be converted to digital and then sent through *SPI*
- The *integrated ADC* helps to reduce system cost, routing, and enables analog signal information to be sent over isolation barriers through SPI
- *Current sensing* measures the current flow each of the internal MOSFETs
- *Temperature sensing* measures the temperature of the internal MOSFET to record the junction temperature of the MOSFET
- *VS sensing* measures the voltage at the input of the TPS274C65 and *VOUT sensing* measures the voltage at the output of each channel

TPS274C65AS | ADC current sense readout example

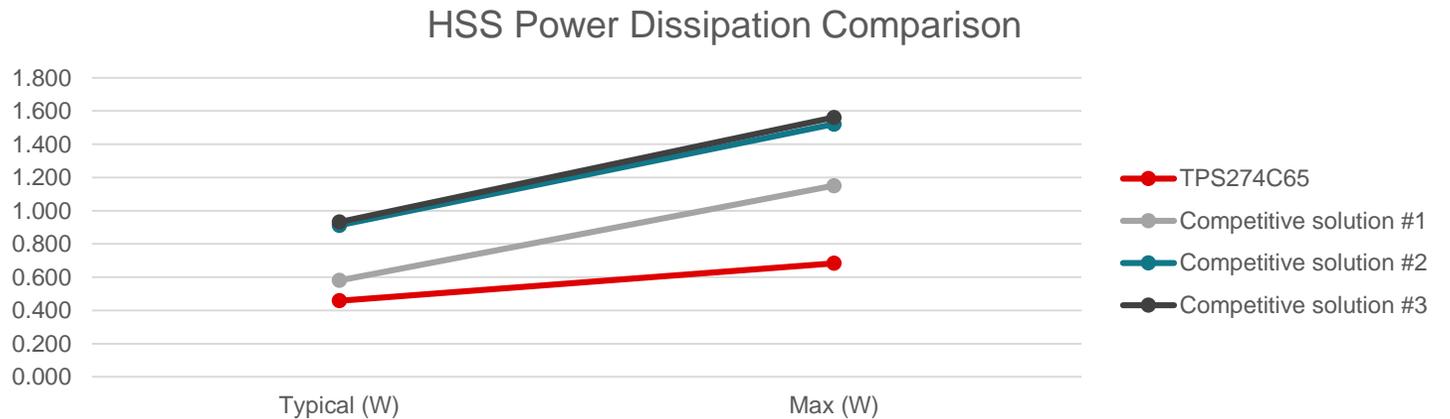


Refresh rate ~65 us

TPS274C65 | increased power density

- **TPS274C65** enables lower power dissipation through its four **65-mΩ** channels and an optional low voltage supply which can be used with an external buck converter to increase system efficiency
- Compared to other competitive solutions in the market, the **TPS274C65** can offers reduce power dissipation by **40%** for a **16CH/500 mA** digital output module
- This can enable higher power modules or smaller module sizes
- Below shows a power dissipation comparison for a **16CH/500 mA** digital output module between **TPS274C65** and other competitive solutions in the market

System Configuration		
Parameter	Value	Unit
V_Supply	24	V
VDD	3.3	V
IOUT/CH	0.5	A
# of CHs	16	
# of LEDs	32	
LED current	0	A
Buck converter Eff	80%	
Solutions		
	High-side switch	Isolation
Solution #1	TPS274C65	ISO7762
Solution #2	Competitive solution #1	ISO7762
Solution #3	Competitive solution #2	
Solution #4	Competitive solution #3	

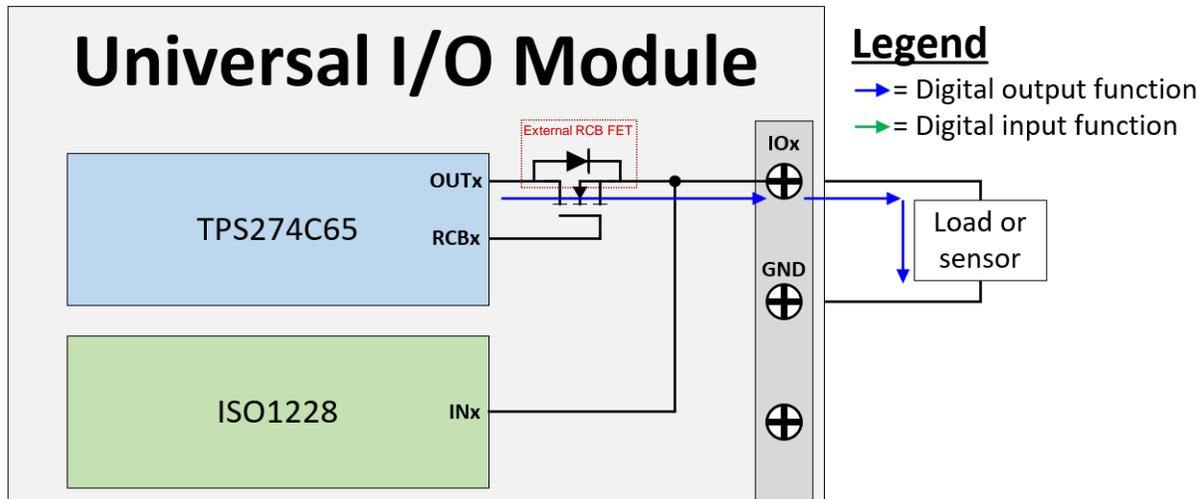


Solution		CHs per device	Isolation		Buck Converter		High-side switch						Total System	
High-side switch	Isolation		IQ (A)		P_Buck_Diss (W)		Typical			Max			Typical (W)	Max (W)
			Typ	Max	Typ	Max	P_Device_IQ (W)	P_FET (W)	P_Total (W)	P_Device_IQ (W)	P_FET MAX (W)	P_Total (W)		
TPS274C65	ISO7762	4	0.0054	0.0075	0.007	0.009	0.192	0.260	0.452	0.235	0.440	0.675	0.459	0.684
Competitive solution #1	ISO7762	8	0.0054	0.0075	0.005	0.007	0.096	0.480	0.576	0.144	1.000	1.144	0.581	1.151
Competitive solution #2	0	8	0	0	0.000	0.000	0.432	0.480	0.912	0.562	0.960	1.522	0.912	1.522
Competitive solution #3	0	8	0	0	0.000	0.000	0.432	0.500	0.932	0.562	1.000	1.562	0.932	1.562

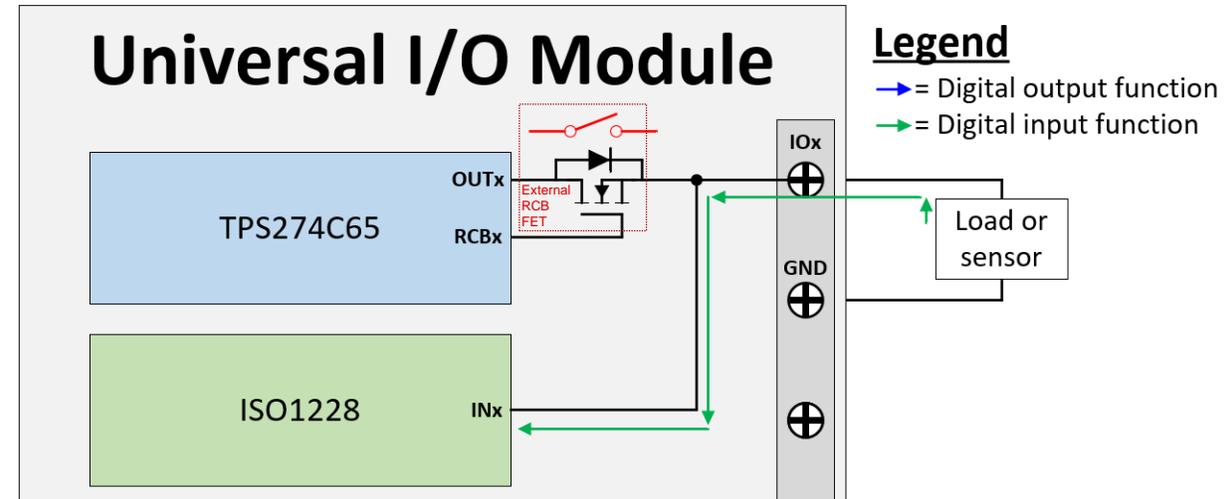
TPS274C65AS | Optional reverse current blocking drivers

- TPS274C65 offers optional gate drivers (RCBx) to drive external reverse current blocking (RCB) MOSFET
- This can provide protection against output mis-wiring or higher output voltage transients affecting the VS supply for the other channels
- This enables the device to be used in universal I/O application where a single channel can be either configured as a digital output or a digital input as shown below

Channel configured as digital output



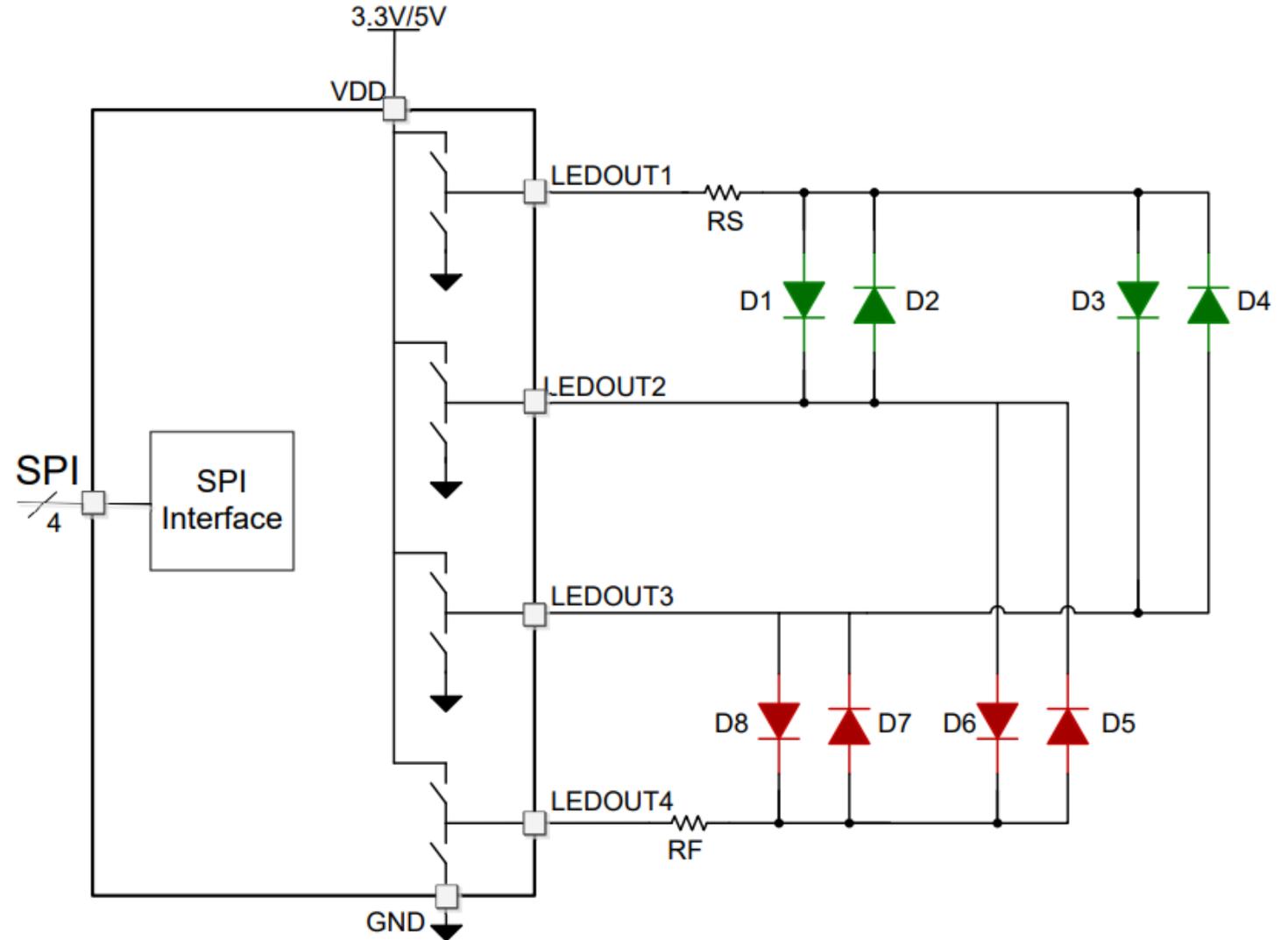
Channel configured as digital input



TPS274C65AS

LED switch matrix

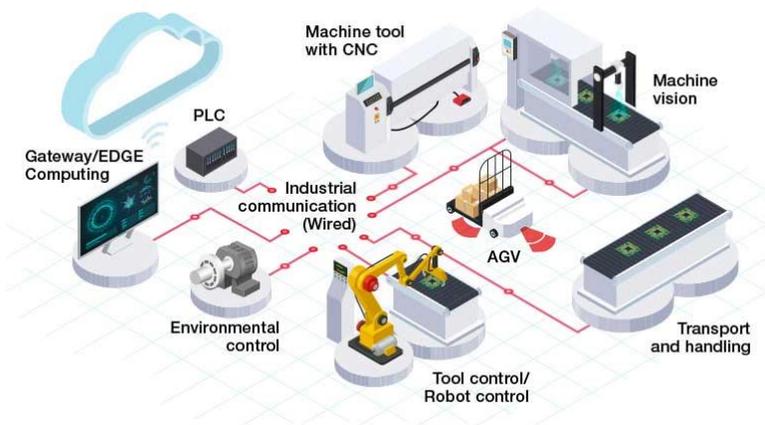
- The LED driver is designed to control each LED with independent clock signals with ON phases offset from each other.
- The LED driver PWM frequency is 1 kHz.
- A total of 8 LEDs can be driven.
- Green, Red, and Yellow can be created through the LED driver.
- LED driving decision **controlled only through SPI** register setting. TPS274C65S does not determine FAULT LED drive state.



TPS274C65 | industrial use cases

Factory Automation

- **High-side switches** are used to provide a digital output function in many factory automation applications like **PLC** along with power distribution in larger systems like **robotics, linear transport systems, and CNC machines**



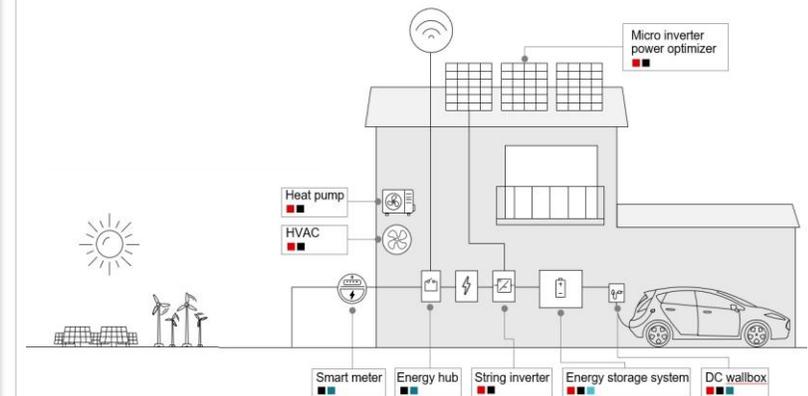
Building Automation

- **High-side switches** are used as output switches in **fire alarm control panels, building security systems, and HVAC controllers** to distribute power across buildings along with providing protection from short-circuits



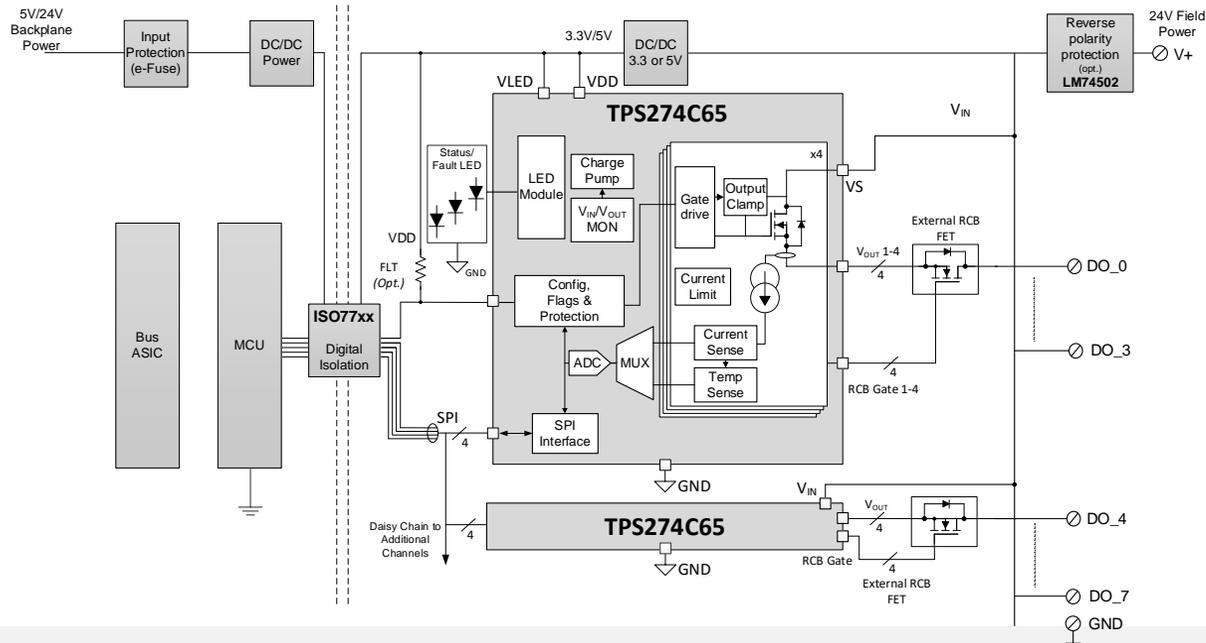
Grid Infrastructure

- **High-side switches** are used in **EV charging stations, string inverters, and energy storage systems** to distribute power to different sub systems and to ensure the systems are protected against short-circuits

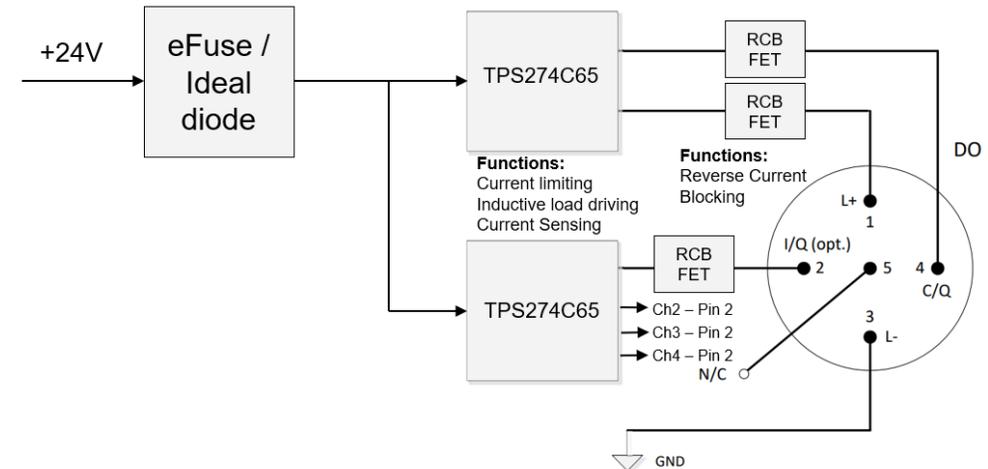


Factory automation | PLC modules

Digital output module block diagram



I/O link class a port example

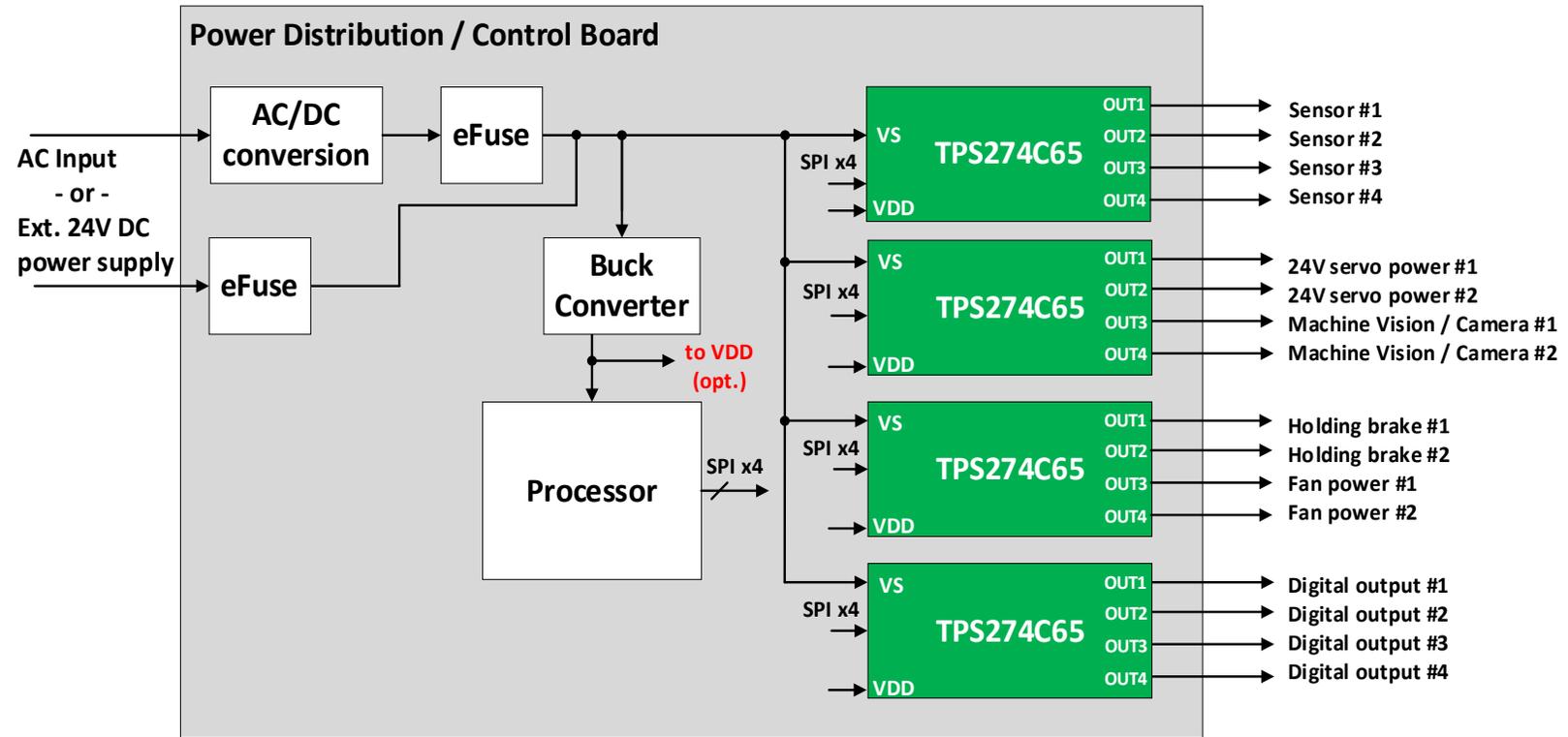


- TPS274C65 was designed for use in PLC digital output modules and universal I/O modules
- The integrated ADC of the TPS274C65 allows for the information to be easily sent over the isolation barrier back to the CPU module for data processing
- This can help to enable predictive maintenance
- The low RDSON of the TPS274C65 can also help to decrease modules sizes or increase the number of channels in IP67 type modules with little to no air flow
- The TPS274C65 is also designed to operate in I/O link controllers and provide load diagnostics to the cloud for data processing and predictive maintenance

Factory automation | power distribution in large machines

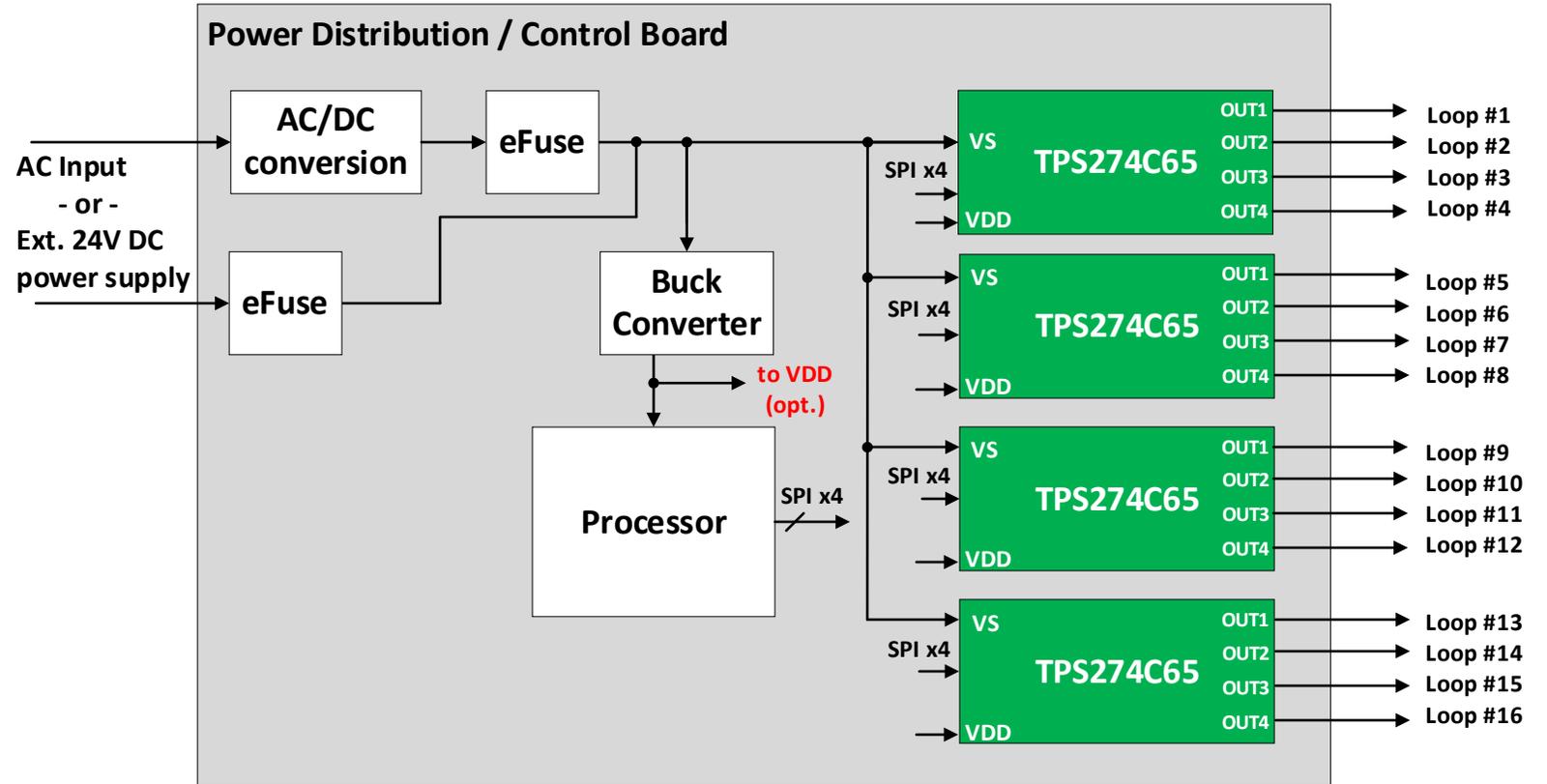
In large machines such as robotics, CNC machines, and linear transport systems, high-side switches can be used to distribute power and provide advanced load diagnostics through its integrated ADC to:

- 1) provide predictive maintenance to increase efficiency
- 2) to get the system back online faster when it stops by providing diagnostic information on the 24 V power distribution



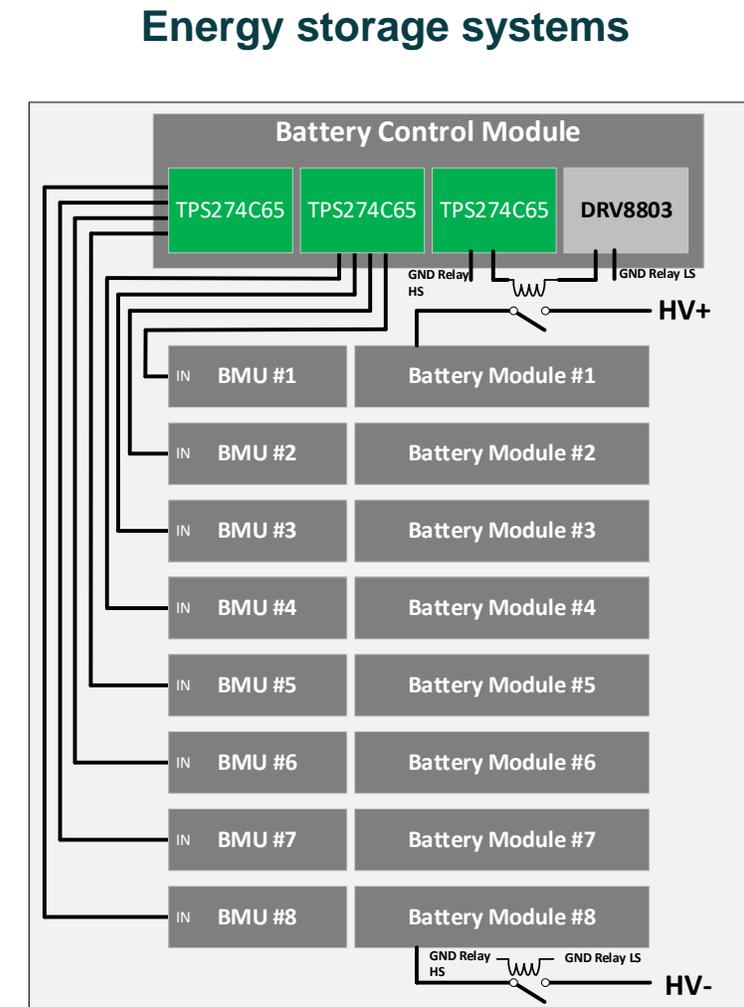
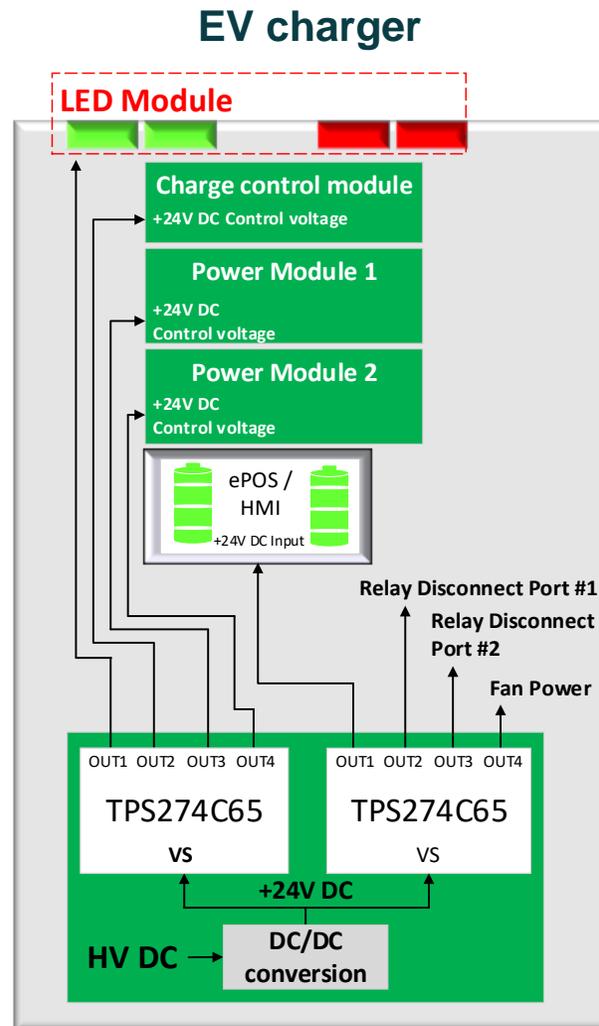
Building automation | power distribution

- High-side switches can be used to provide power distribution in building automation applications such as:
 - Fire alarm control panels
 - Building security systems
 - HVAC controllers
- The high-side switches can be used to provide short-circuit protection for the loop outputs which can have multiple devices connected to them



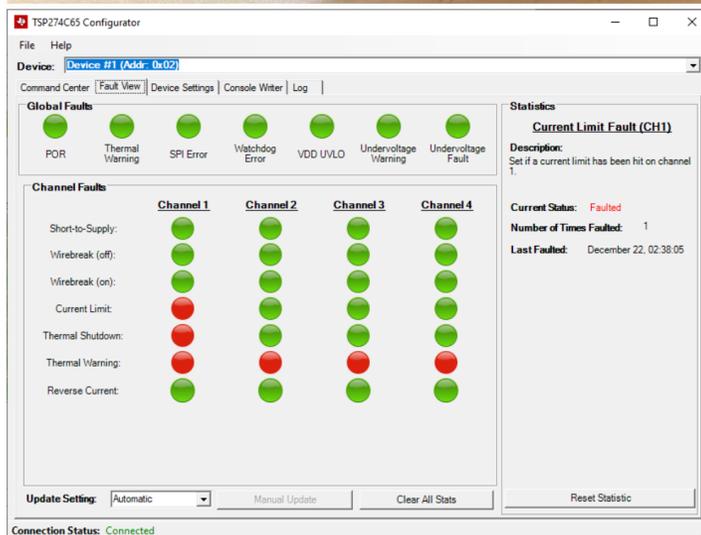
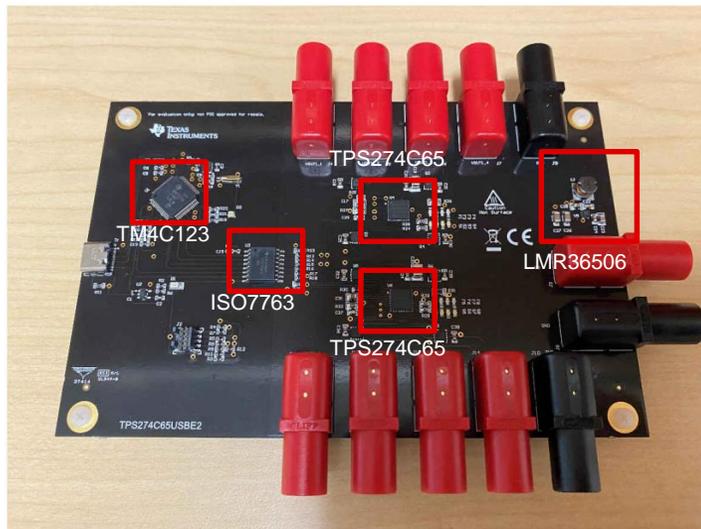
Grid infrastructure | power distribution

- High-side switches can be used to provide power distribution in grid infrastructure applications such as:
 - EV chargers
 - Energy Storage Systems
 - String Inverters
- Many of these systems are often in remote areas or spread across many locations so the ability to perform *remote diagnostics* is important
- **TPS274C65** can help to provide these load diagnostics to enable remote debug to help determine the source of the issue



TPS274C65USBEM | enables an out-of-box experience

With a USB connection and a small GUI download, starting the evaluation of the TPS274C65 can happen in less than 5 minutes!



Features

- Two TPS274C65 65-mΩ quad-channel industrial high-side switches placed in an addressable SPI configuration
- Complete digital isolation from digital and high-current rails using the ISO7763DWR reinforced isolation device
- Integrated TM4C123 ARM® Cortex®-M4F microcontroller with USB host interface
- Full-featured and lightweight Windows host GUI for device configuration and monitoring

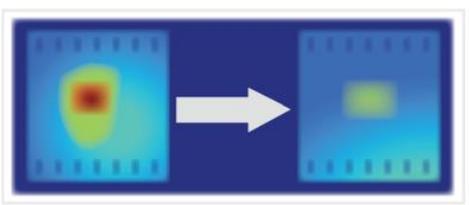
TPS274C65 | summary

Achieve lower power dissipation, real time diagnostics, higher configurability, and integration at a lower system cost

Reduced power dissipation

Enables higher power density and smaller modules

- TPS274C65 integrated four 65 mΩ RDS(on) channels in a small 6mm x 6mm package
- The channels of the device can be paralleled to provide lower RDS(on) and higher output current per channel
- The device also provides an optional VDD supply to further reduce system power dissipation



Real time diagnostics

Enables smarter power distribution to reduce factory downtime

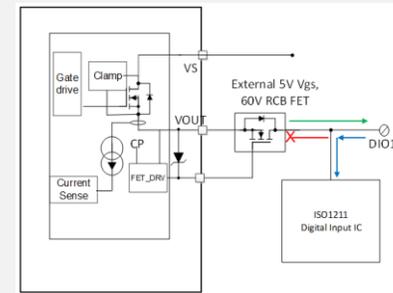
- TPS274C65 integrates an ADC which enables the output current & voltage, and temperature per channel to be read through SPI
- Detect wire breaks accurately down to 320uA
- High accuracy current and voltage sense can enable smart power distribution and predictive maintenance



High configurability & Integration

Optimized performance

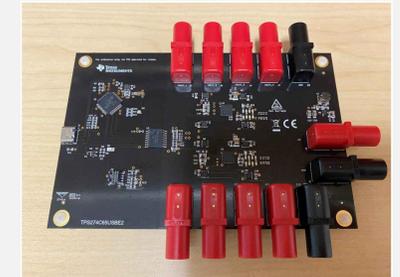
- TPS274C65 offers a serial protocol interface (SPI) to configure and control itself
- Multiple devices can be connected in daisy-chain mode or addressable SPI to enable use in 32CH+ modules
- A reverse current blocking (RCB) gate drive is available per channel to enable the use in universal digital I/O modules
- An LED switch matrix is available to drive up to 8 LEDs per device



Reduce system cost

Lowest system cost with an enhanced feature set

- SPI communication enables a lower system cost by reducing the number of isolation channels required
- High configurability enables the device to be used across multiple module types to reduce total development cost
- Developed in the latest process node enables the high integration and lowest cost



TPS274C65 | variants

Part Number	Interface	Current Limit	Current Sensing	Open Load Detect	RCB Gate Driver	LED Matrix	Package	Samples	Release to market
TPS274C65AS	SPI	Adjst. by SPI	Via integrated ADC	ON and OFF state	Yes	Yes	40-QFN	On ti.com	Mid-Sept'23
TPS274C65BS	SPI	Adjst. by SPI	No	OFF state	No	No	40-QFN	On request	Mid-Sept'23
TPS274C65CP	Parallel	Adjst. by ext PIN	No	OFF state	No	No	40-QFN	On request	Mid-Sept'23

Visit www.ti.com/npu

For more information on the New Product Update series, calendar and archived recordings



© Copyright 2023 Texas Instruments Incorporated. All rights reserved.

This material is provided strictly “as-is,” for informational purposes only, and without any warranty.
Use of this material is subject to TI’s **Terms of Use**, viewable at [TI.com](https://www.ti.com)

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated