System Solution Guide - Preview

48V-12V DC-DC Converter

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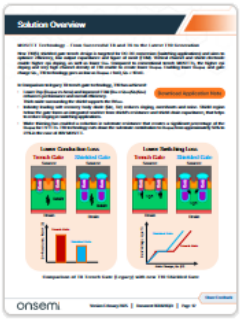

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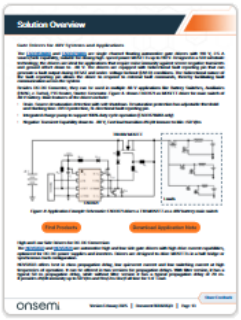

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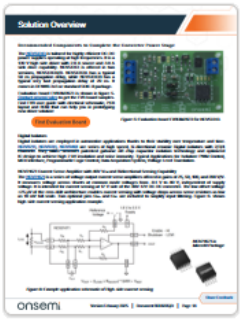

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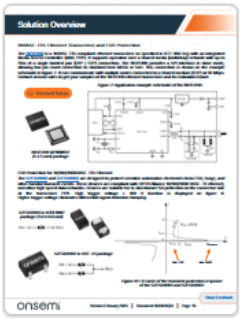

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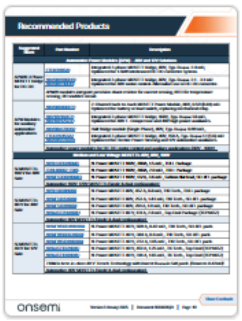

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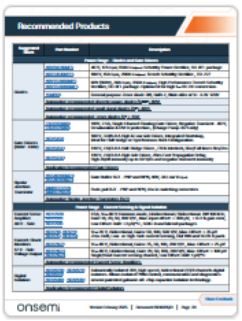

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Block Diagram

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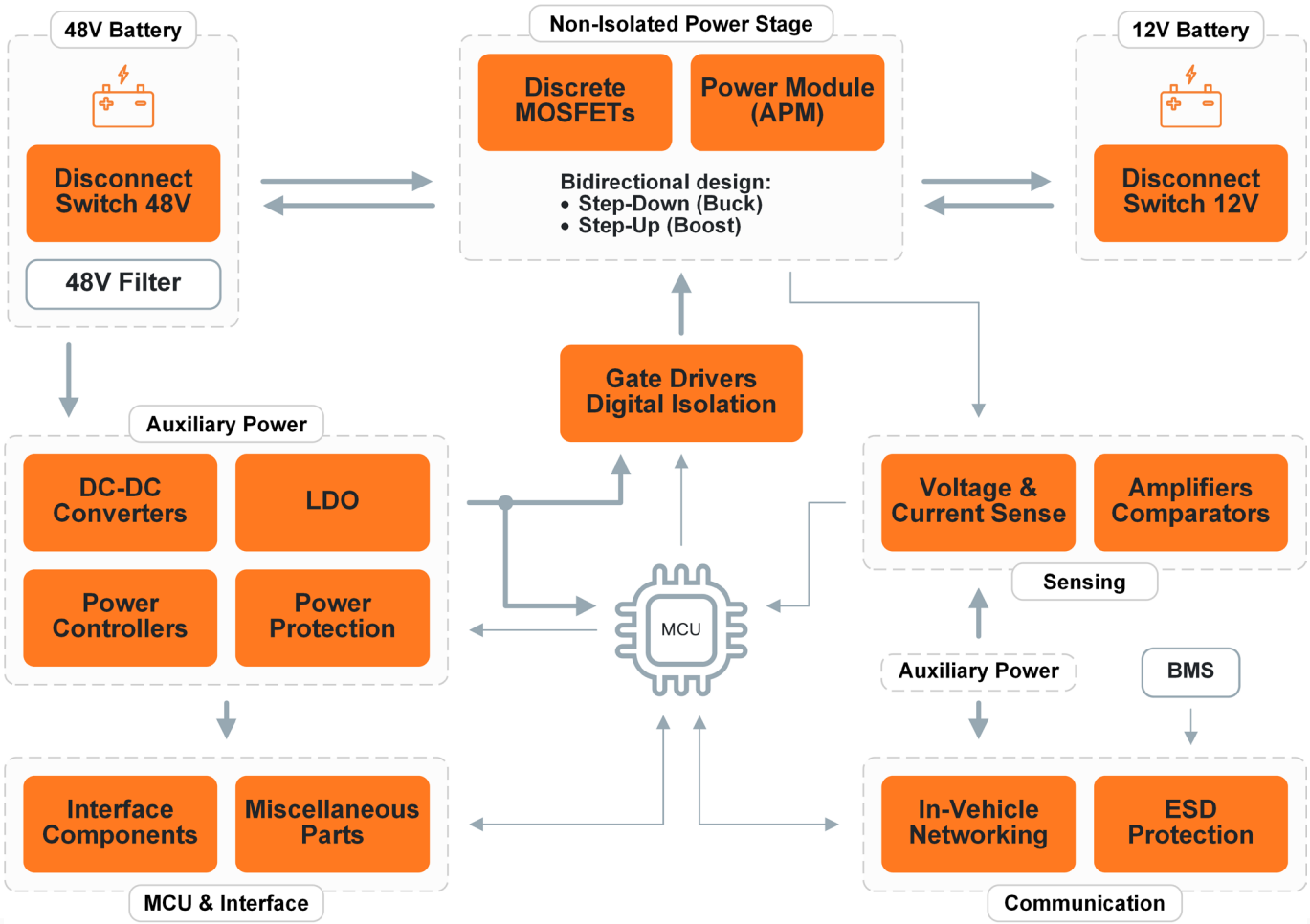
48V-12V DC-DC Converter - Block Diagram

The prevalent power stage topology in this application is the **non-isolated synchronous step-down converter**. Synchronous switches facilitate bidirectional current flow to allow boost mode. When observed from the 48 V side, the configuration functions as a synchronous step-down converter, while from the 12 V side, it transforms into a synchronous step-up converter.

Power stage can be designed with discrete MOSFETs or integrated automotive power modules (APM). **onsemi** offers variety of components to scale the design up or down in terms of power level and optimize the sum of conduction and switching losses. Choosing key and complementary components such as gate drivers, digital isolators and auxiliary power supplies completes the design. Find **onsemi's** components offer in the **Recommended & Complementary Products** sections of the full System Solution Guide.

LC filter can be placed on the 48 V side to mitigate output voltage ripple in boost mode. Spreading power over more interleaved phases also reduces output voltage ripple. The bidirectional capability significantly influences the choice of passive components. To allow bidirectional operation, capacitors inside the power stage dynamically shift their function. Passive components choice becomes a tradeoff between reducing output voltage ripple, overshoots, and system cost.



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Automotive Power Modules

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Automotive Power Modules (APM) in 48V DC-DC Converter

onsemi offers multiple series of integrated automotive power modules (APM) in a variety of packages that are designed for power applications in 48V systems, MHEV and low voltage traction systems. APMs elevate highly integrated and compact design with low stray inductance and better electromagnetic interference (EMI). The module's efficient current handling simplifies the high current path on the PCB. APMs integrate a shunt resistor, NTC and snubber circuit.

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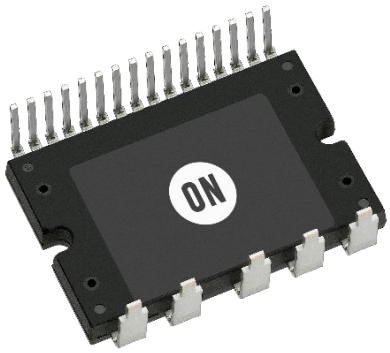
Table 1: APM modules offering for multiple 48V applications

APM19	APM19, APM21	APM17	APM12 , APM17
2x APM19 for 6-phase 3 kW interleaved DC-DC converter	48V Power Auxiliaries (E-Compressor, E-Turbo and more)	2-Channel back-to-back MOSFET (Disconnect switch)	3x APM17 for 6 phase Inverter solution (15- 25 kW)

The APM19 module FTC03V85A1 is 80 V low $R_{DS(ON)}$ module, featuring a 3−phase MOSFET bridge optimized for building a 1.5 kW 48V−12V interleaved DC−DC converter. The APM19 can be used in the synchronous step-down converter topology, where one module handles 3 phases in the converter (2 MOSFET switches per phase) that account for up to 1.5 kW. Two modules can scale up this design to a 3 kW converter (6 phases). Synchronous switches in each phase allow bidirectional current flow in the boost mode. The multiphase interleaved approach for the DC-DC converter reduces output ripple current and thus allows designers to use smaller capacitors with less capacitance and achieve faster transient response. The NXV08V110DB1 is an alternative module for building the same DC-DC converter topology, but it is better optimized for motor control applications.

- MOSFET dies integrated in the APM19 are selected to balance the sum of conduction and switching losses that result from MOSFETs $R_{DS(ON)}$, gate charge Q_G and other parasitics.
- An RC snubber circuit is already integrated in APM19 module that is ready for damping the parasitic inductances and capacitances on the switch node during switching transitions.
- Integrated precision shunt resistor for current sensing is optimized for low parasitic inductance and good stability across the entire temperature range.



44 x 29 x 5 mm

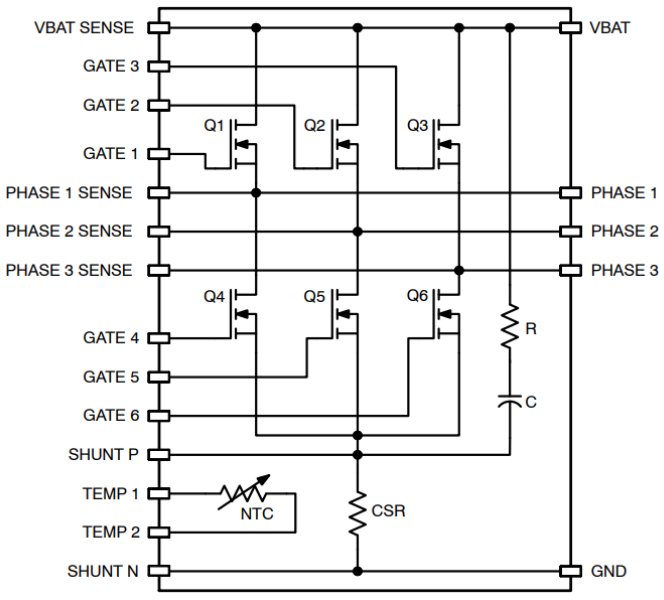


Figure: APM19 3-Phase Module internal layout: MOSFET bridge, NTC, current shunt resistor and RC snubber.

Product Value Propositions

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Gate Drivers for 48V Systems and Applications

The FAD3151MXA and FAD3171MXA are **single channel floating automotive gate drivers with 110 V, 2.5 A source/sink capability**, suitable for driving high−speed power MOSFETs up to 110 V. Designed in a SOI substrate technology, the drivers are ideal for applications that require noise immunity against severe **negative transients and ground offset down to −80 V**. The drivers are equipped with bidirectional fault reporting pin that can generate a fault output during DESAT and under−voltage lockout (UVLO) conditions. The bidirectional nature of the fault−reporting pin allows the driver to respond to external fault commands, thereby facilitating fault communication across the system

Besides DC-DC Converter, they can be used in multiple 48 V applications like Battery Switches, Auxiliaries (HVAC, e-Turbo), PTC heater, Starter-Generator. Driver features include:

- Drain−Source desaturation detection with soft shutdown. Desaturation protection has adjustable threshold and blanking time. UVLO protection, Bi-directional fault reporting pin.
- Integrated charge pump to support 100% duty cycle operation (FAD3171MXA only)

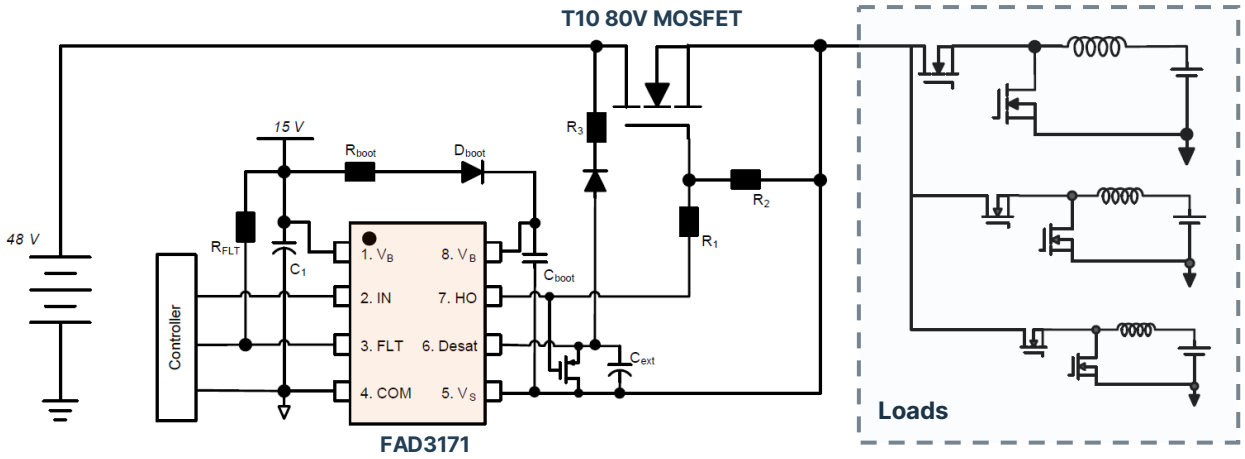

Figure: Application Example Schematic: FAD3171 drives a T10 MOSFET as a 48V battery main switch

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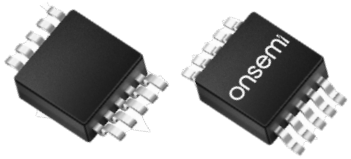
NCV21671 Current Sense Amplifier with 40V V_{CM} and Bidirectional Sensing Capability

The NCV21671 is a series of voltage output current sense amplifiers offered in gains of 25, 50, 100, and 200 V/V. It measures voltage across shunts at common mode voltages from -0.1 V to 40 V, independent of supply voltage. It is intended for current sensing at 12 V side of the 48V-12V DC-DC converter.

The low offset voltage ±25 μV of the zero-drift architecture enables current sensing with voltage drops across sense resistors as low as 10 mV full-scale. Two optional pins C_{IN+} and C_{IN-} are included to simplify input filtering. Example figure shows high-side current sensing application example.



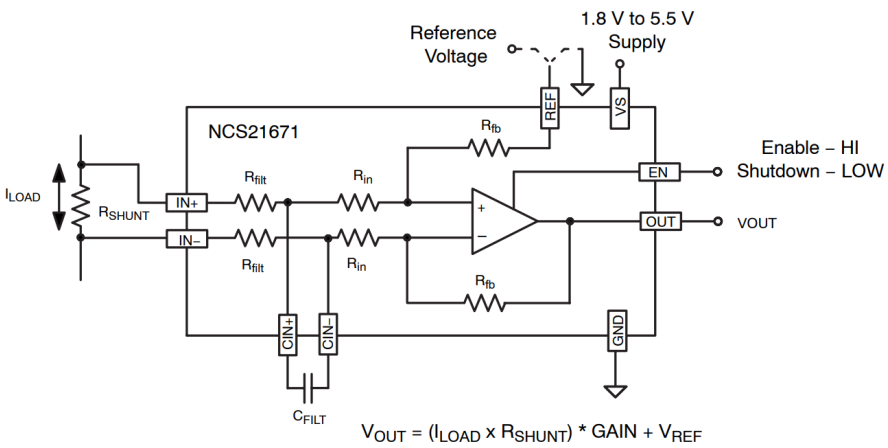


Figure: Example application schematic of High-side current sensing

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