48V-12V DC-DC Converter

Updated: DEC-2023

Industry	• Automotive – Vehicle Electrification
Applications	• Since the introduction of electric lighting on automobiles in 1898, the market demand for increased electrical features and content grows relentlessly. As 12V systems are stretched to their limit, the automotive industry is now migrating to 48V systems. This transition aims to increase available power, reduce wire and connector size, and accommodate additional electrical content and higher power consumption. • The current standard for Mild Hybrid Electric Vehicles (MHEV) is to have two batteries. 48V-12V DC-DC converter interfaces the new 48V battery and the legacy 12V battery which remains to power lighter loads and existing 12V systems like infotainment, engine control and safety modules.

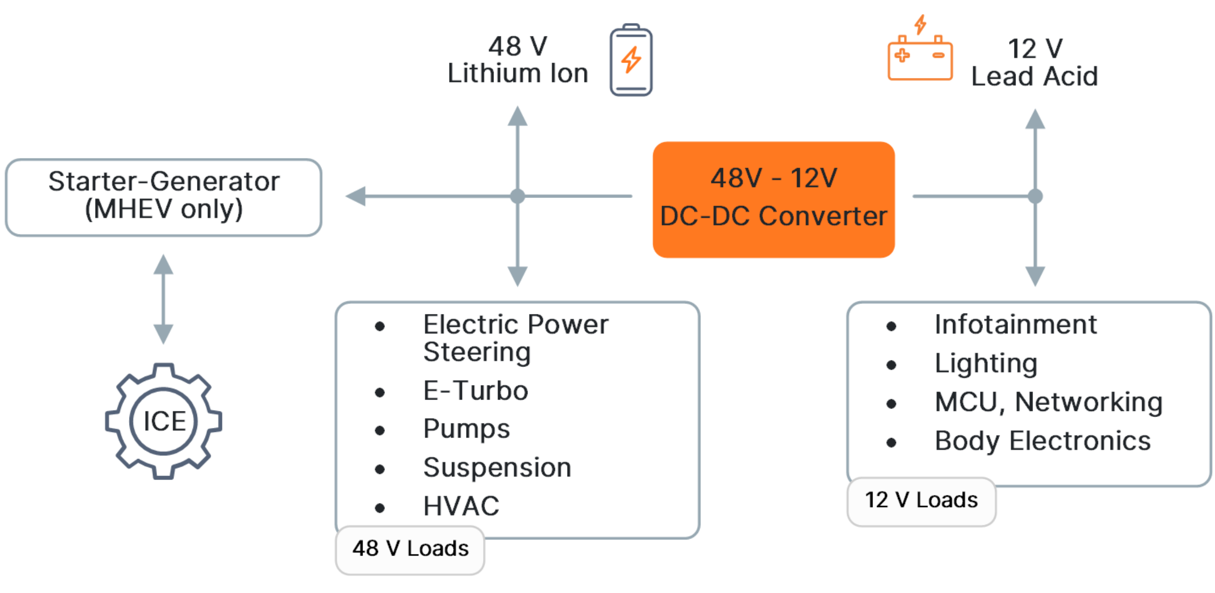
System Purpose

48V has traditionally been focused on internal combustion applications, enabling start-stop functionality in MHEVs, as well as other emission reduction technologies including electric turbochargers, exhaust-gas recirculation (EGR) pumps, and electrically heated catalyst.

MHEVs have improved fuel efficiency and reduced emissions, while maintaining a familiar driving experience. By combining the power of internal combustion engine (ICE) and electric motor, MHEVs provide a practical transition towards full electrification.

One distinguishing feature of 48V systems when compared to high voltage (HV) systems is chassis grounding. 48V systems retain the simplicity, cost savings, and shielding benefits provided by a traditional 12V system while reducing the load currents by 4x. 48V systems maintain higher power quality, given the increased voltage margin, compared to 12V systems.

48V is also an enabler for Advanced Driver Assistance Systems (ADAS) and higher-level autonomous features. **Electric power steering, steer-by-wire and brake-by-wire** (X-by-Wire) are power intensive accessories, but X-by-wire systems also require a high level of reliability, functional safety, and redundancy. Redundant actuation for high-peak load devices, like steer by wire are enabled to be lighter and more cost effective at 48V compared to 12V systems.



Market Information and Trends

Recently, 48V accessories have begun to enter the market in **Battery Electric Vehicle (BEV) applications**. Higher voltage accessories provide the same benefits to BEV accessories – smaller wire harnesses – for existing vehicle loads including cooling and cabin fans, electrically heated seats, and other high-power accessories where high voltage (HV) is impractical.

As 48V systems become more prolific, vehicles will have a mix of 12V, 48V, and HV (400V/800V) power networks. With the availability of 48V power on vehicles, traditional 12V accessories will migrate to the 48V bus, beginning with the highest loads in the system. Traditional 12V loads will continue to be supported thanks to DC-DC converters – either from a HV bus, or from a 48V battery; however, as loads migrate to 48V, the size of the 12V DC-DC converter may decrease over time as 48V becomes mainstream.

With a relatively low barrier to implementation, taking an existing vehicle platform and adding certain modifications allows automakers to launch **48V mild hybrid** as a standard feature in their new vehicle models, fulfilling a large global customer demand. MHEVs remain a cost-effective electric solution making them an attractive customer choice.

The MHEV market globally has been experiencing a steady growth, although it's not as rapid as the growth observed in the Battery Electric Vehicle (BEV) and Plug-in Hybrid Electric Vehicle (PHEV) markets. This trend indicates a shift in consumer preference towards vehicles that can be charged from the grid. Despite this, MHEVs continue to hold a significant share in the global electric vehicle market due to their lower cost and the convenience they offer in terms of not requiring a charging infrastructure.

The global MHEV market was valued at USD 71.19 billion in 2021 and is forecast to reach a value of USD 333.27 billion by 2030, growing at a Compound Annual Growth Rate (CAGR) of 18.5% between 2021 and 2030. 2023 market value is estimated to reach USD 100.35 billion.

Asia-Pacific is capturing the largest share of the market owing to the highest vehicle sales, majorly in China. Expected to grow even faster during forecasted period until 2030. Many automotive companies continue to invest in the Asia-Pacific market to cater to the strong demand for hybrid vehicles.

Source: EV-Volumes: Global EV Sales for 2022, Mordor Intelligence : MHEV Market Size & Share Analysis , Coherent Market Insights : MHEV market analysis

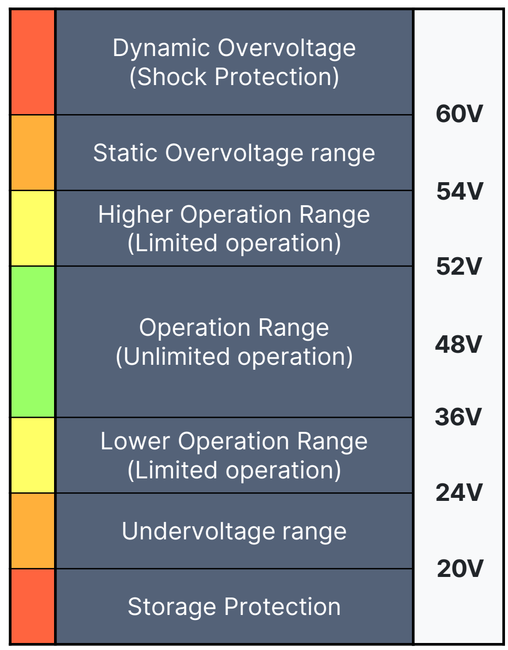
System Description

DC-DC Converter

Among the primary electronic units in the MHEV 48 V system are a three–phase inverter to operate the starter/generator which charges the 48V battery and the **DC–DC converter that ties the 12V and 48V power nets together**.

DC-DC converter can be designed either as unidirectional or bidirectional, where unidirectional function (Step-down) is mandatory. **This System Solution Guide assumes bidirectional converter as go to design. Power levels range from 1 kW up to 3 kW, with 3kW commonly in Step-down mode and usually just 1kW in Step-up mode**.

- Non-Isolated bidirectional synchronous Buck-Boost is the most common topology. Isolated topologies like Dual Active Bridge, CLLC are possible but not adopted as much due to design complexity and lower voltage level requirement. Isolated topologies are prevalent in high voltage to low voltage conversion, where it is mandatory to isolate HV and LV parts of the circuit.
- DC-DC converter is designed for the nominal battery voltages 12V and 48V but must be ready to operate outside of the nominal, allowing room for operating voltages above and below. Voltage level changes due to state of battery charge and other factors.
- To achieve best performance, 48V battery needs low series resistance and flat discharging curve. Cell voltage should not change substantially with battery charge level. Suitable technologies are Lithium-Ion (Li-Ion) or Lithium-Polymer (Li-Pol).
- Traditional 12V lead-acid battery (Pb) is kept inside MHEV also for its electrical advantages like better performance at lower temperatures, lower self-discharge and overall capacity-to-cost ratio.



Voltage Levels for 48V System
Specified by ISO 21780:2020

Starter-Generator in MHEV

Starter and generator are now integrated into a single device, integrated starter-generator (ISG) or belt starter-generator (BSG). **The BSG/ISG unit enables start-stop functionality, energy recovery when coasting or braking, energy generation when the ICE is running**, as well as electric drive or boost depending on system implementation.

- When in energy recovery or generation modes, the BSG/ISG operates as a generator providing reverse power flow back to the 48V battery pack.

The key differences of BSG/ISG lie in their physical placement, connection to the engine, and integration within the vehicle. These positions are marked as P0 to P4. Each level of starter-generator integration (P0 – P4) provides varying levels of capability and design challenges for the system.

- The BSG is typically externally mounted and connected via a belt drive system (P0), making it suitable for retrofitting existing vehicles. Efficiency is lower compared to ISG.
- The ISG is compact and more integrated into the engine and drivetrain (P1-P4), thus providing faster response times and higher efficiency.

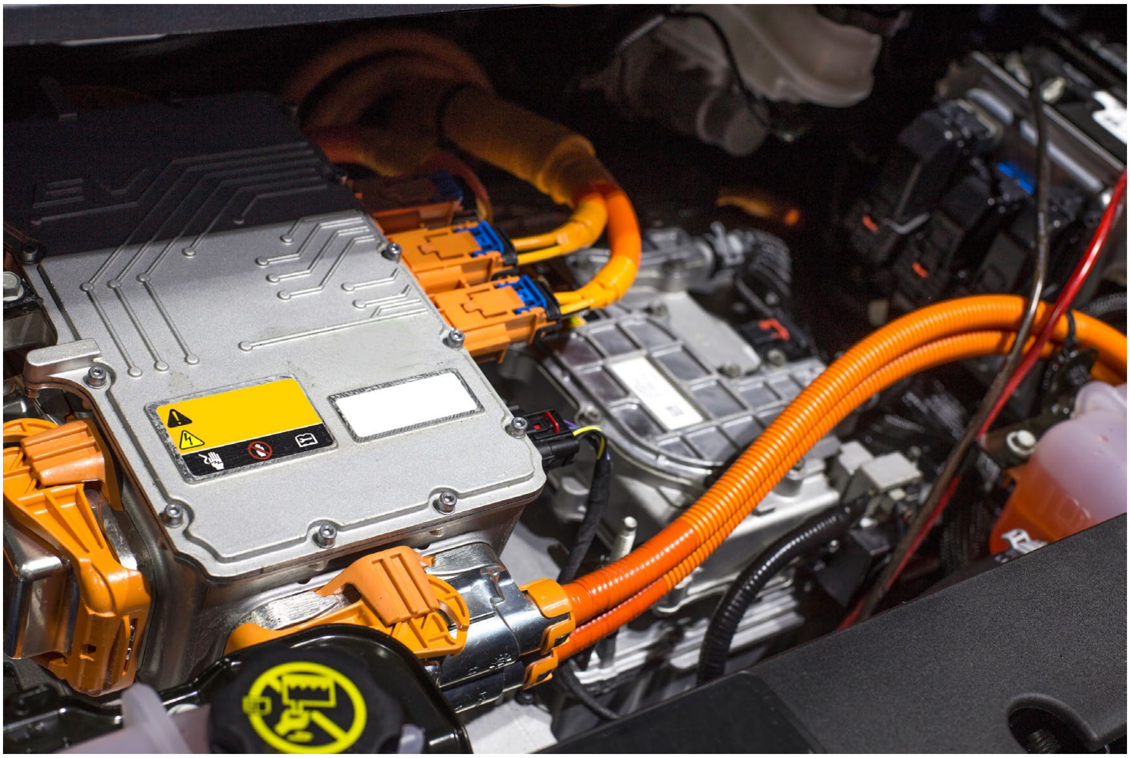
System Description

MCU & Sensing in DC-DC Converter

MCU acts as the brain that controls the DC-DC converter, overseeing the dynamic adjustments necessary for optimal and efficient power transfer. It is continuously monitoring and processing sensor inputs with most important voltage, current and temperature.

Input and output voltages of the DC-DC converter depend on the batteries and their state of charge. MCU is monitoring the input and output voltages in this application instead of regulating them, since the voltages are imposed by the batteries. DC-DC converter must be able to transfer power regardless of the changes in battery voltage, within certain operating range.

- The MCU can dynamically adjust the PWM duty cycle and switching frequency based on current and voltage feedback. It is crucial to maintain a stable output voltage, compensate changes in power delivery, minimize losses and ensure the best conversion efficiency. Current sensing is crucial in controlling the power flow, preventing overcurrent conditions, and keeping within safe operational limits.
- **Digital isolators are commonly employed to safeguard the MCU from potential issues arising from different ground references and to limit noise propagation from power stage to the control stage**. Isolating gate drivers, MCU and power stage helps in managing the noise and voltage spike propagation. Optocouplers are not recommended in DC-DC converter, because of their degradation and drift of key parameters over lifetime, when exposed to higher temperatures. (Compensation of the drift would be necessary)
- The MCU communicates with Battery Management System (BMS) by using vehicle CAN, when battery charging profile should be adjusted. The MCU must be able to disconnect the converter so that it does not consume energy when the vehicle is turned off and wake up in the correct mode according to the state of charge of the 48V and 12V batteries.

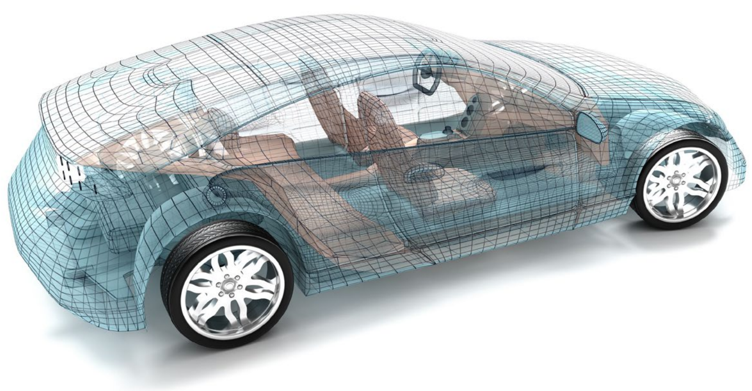


System Description

24V Systems in MHEV large vehicles

The appeal of Mild Hybrid 48V extends beyond just passenger cars, it also holds significance for Commercial and Agricultural Vehicles (CAV) due to a shared commitment in emissions reduction. Mild hybrid buses have gained more popularity in Europe, and we can see their adoption by cities, replacing pure diesel buses in public transportation.

- The length of the vehicle and the power consumption from electronic loads primarily favor 24V as the main voltage network in large vehicles like trucks, busses, and military vehicles. Higher power demands, copper cost of longer cables and associated voltage drops are some of the reasons to use 24V instead of 12V.
- Similar to its application in cars, a crucial requirement for large vehicles is providing power to the lower voltage 24V network. DC-DC converter topology from passenger MHEV cars, operating in buck-mode (step-down 48V to 24V) and boost mode (step-up) can be used for large vehicles, but components choice must consider the needs of higher performance, power consumption and longer cables.



Standards and compliance

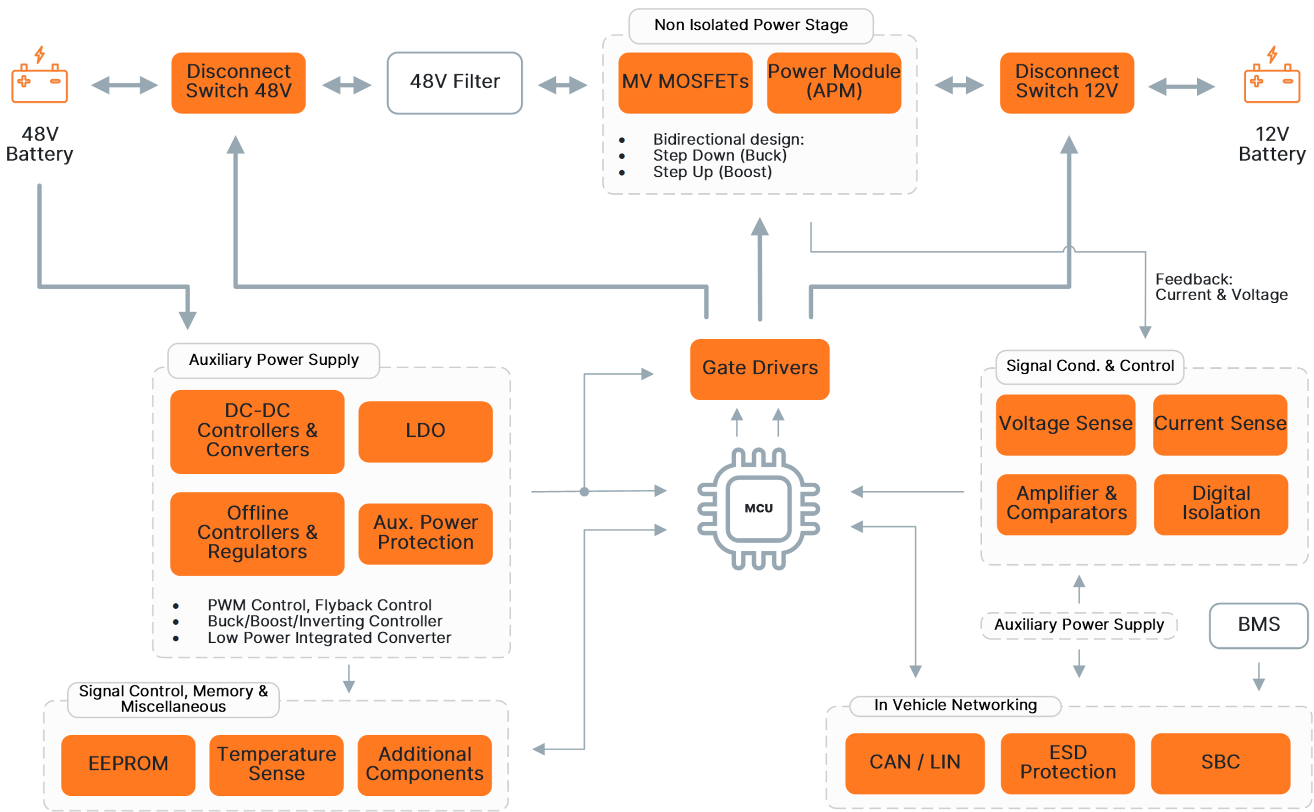
Compliance with ISO 26262, an international functional safety standard, is essential for the development of electrical and electronic systems in road vehicles. Its primary goal is to minimize the risk of hazards caused by system failures in vehicles, addressing potential dangers such as software glitches, sensor errors, and hardware malfunctions.

Specific standards for 48V systems in EVs, components and their testing have emerged with the first LV148 which was later superseded by German **VDA320**. Current standard is **ISO 21780:2020** that supersedes VDA320. Additional standards for safety and testing of electrical vehicles are **ISO 6469**, **ISO 21498.**

- **Component redundancy on 48V power net is crucial** for ensuring the reliability and resilience of the electrical system. This will be one of the driving factors in the development and wider adoption of 48V Systems. In the event of a single component failure, redundant elements serve as backup, preventing system-wide disruptions. This is particularly significant in safety-critical systems such as those controlling braking, steering, and airbags.
- **onsemi**, with its long history as a leading provider of automotive products, understands the challenge to reduce costs, combined with increasing demands on performance and safety. Expertise and Implementation of ISO 26262 at onsemi is a key in providing cost effective solutions to customers, without compromises on safety.
- It enables the company to offer optimal architectures and solutions by identifying safety requirements assigned to integrated circuits and other automotive components. Focusing on the important failure modes and their prevention.

Solution Overview

DC-DC bidirectional converter based on non isolated Buck - Boost topology



Power stage

The prevalent power stage topology in this application is the **non-isolated synchronous step-down converter**. Synchronous switches also 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.

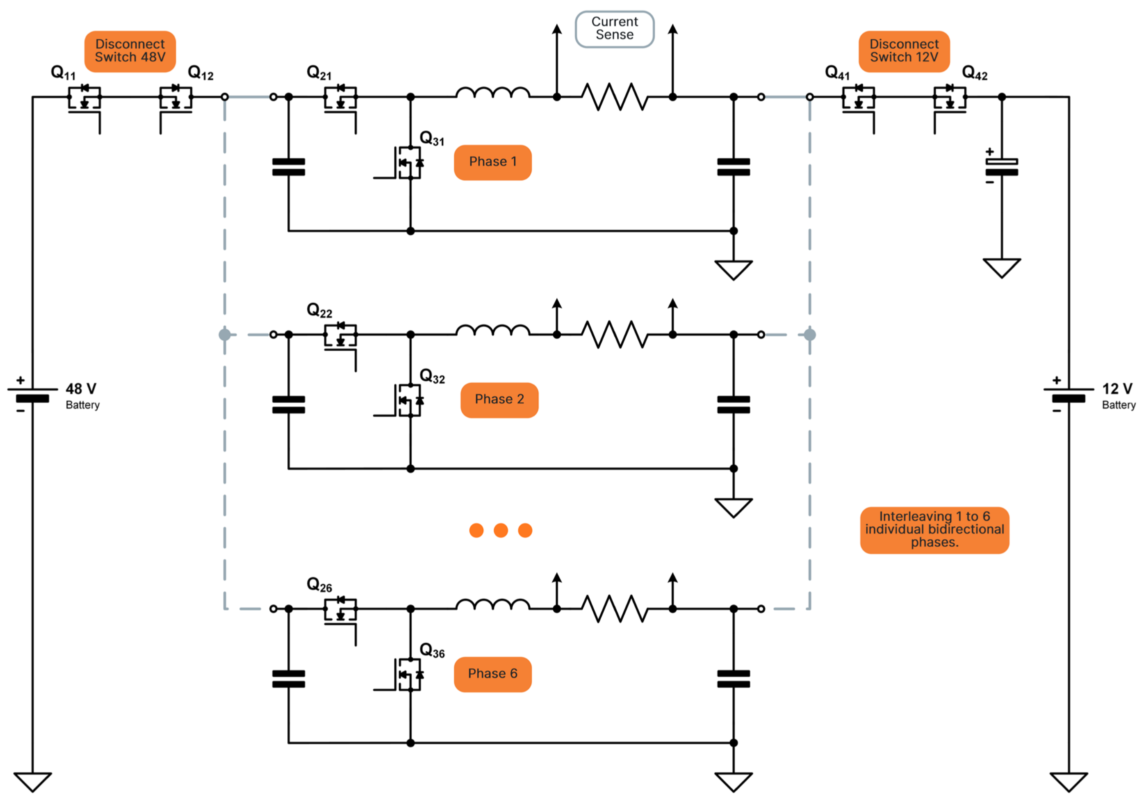
12V-48V automotive systems connect a battery to the DC-DC converter output, which helps in reducing output voltage ripple. **L-C filter** is placed on the 48-V side to further mitigate output voltage ripple in boost mode. Another way of reducing output voltage ripple is spreading power over more interleaved phases. The L-C filter might affect the converter stability for both step-down and step-up modes. Consider that the inductor's saturation current must surpass the average DC current and the capacitors are designed to accommodate the specified ripple current.

The bidirectional capability significantly influences the choice of input and output capacitors. To allow bidirectional operation, capacitors inside the power stage dynamically shift their function. Choosing the amount of output capacitance is a tradeoff between reducing output voltage ripple, overshoots, and system cost. Too much output capacitance will also counterproductively affect transient response time.

Find Interactive Block Diagram on the Web

Solution Overview

Power Stage: Interleaved non-isolated Bi-directional Buck - Boost topology



**Simplified Schematic*

Multiphase Converter

Consider a multiphase DC-DC bidirectional converter employing up to 6 interleaved (parallel) power stages (phases). Multiphase converters are a logical choice for high-power applications, offering advantages such as lower output ripple, enabling the use of smaller capacitors, quicker transient response compared to single-phase counterparts. Additional benefits are reduced inductor size and improved power dissipation distributed across the PCB.

MOSFETs inside the power stage must handle high currents and have significant effect on total system efficiency. Conduction and switching losses make up power dissipation on the transistors. Main parameters to consider are $R_{DS(ON)}$, gate charge and parasitic elements which strike balance between conduction and switching losses.

- Ideal choice becomes the onsemi's new **T10 technology** for LV and MV MOSFETs, which utilizes shielded gate trench design with ultra low Q_G and $R_{DS(ON)} < 1m\Omega$.
- T10 technology reduces ringing, overshoots and noise with its industry leading soft recovery body diode (Qrr, Trr), which strikes perfect balance between good performance and recovery behavior.

Solution Overview

Component redundancy in 48V Systems

Component redundancy on 48V power net is crucial in ensuring the reliability and resilience of the electrical system. **In the event of a single component failure, redundant elements serve as backup**, preventing system-wide disruptions. This is particularly significant in safety-critical systems such as those controlling braking, steering, and airbags. The automotive environment poses various challenges, including vibrations, temperature fluctuations, potential component failures and risk of short circuit.

- Redundancy contributes to the overall robustness of the vehicle's electrical architecture, ensuring continuous and uninterrupted functionality in the case of component failures, accidental damage and mitigating the risks associated with electrical short circuits.
- **Migrating to 48V architecture enables faster adoption of ADAS and higher-level autonomous features like steer-by-wire and brake-by-wire**, where the requirement for redundancy, fault-tolerance and reliability is critical. Redundant actuation for these high-peak load devices becomes lighter and more cost effective at 48V compared to 12V systems.
- 48V redundant power buses with redundant switches can prevent a fault propagation from one power bus to another bus. This ensures that essential functions can be seamlessly transferred to unaffected pathways in the event of a failure affecting one part of the system.

Table 1 showcases some of onsemi parts which can improve robustness and reliability of the 48V electrical architecture by building redundant networks. Individual proposed parts are introduced in the following chapters of this System Solution Guide.

Type	Part Number (PN)	Part's Example Use Case
Discrete T10 MOSFET	NVBLS0D8N08X NVMFS1D9N08X	• 80V MOSFET with low $R_{DS(ON)}$: 0.79 mΩ, 1.9 mΩ variants. • Variable use in 48V Systems: DC-DC converter, Motor Control, Load Switch, Battery Switch, BMS.
Automotive Power Module	NXV08B800DT1	• 80V, 0.58mΩ 2-Channel back-to-back MOSFET module. • 48V battery or load switch with reverse current blocking. • Robust integrated solution with temperature sense.
Electronic Fuse (eFuse)	NIV3071	• Integrated overcurrent, thermal & overvoltage protection solution. • Protection in zonal & domain controllers, body control modules and power distribution units. • Hot plug protection, Fault Reporting.

Table 1 : Parts Proposition for building redundancy in 48V Systems

Electronic fuse (eFuse) NIV3071 can protect up to 4 independent 48V downstream loads from output shorts, overloads and overcurrent events. Power source can safely drive 4 protected independent loads at 2.5A continuous current each. eFuse can be configured into a single channel to drive a single continuous load current of up to 10A.

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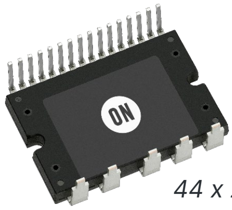
Solution Overview

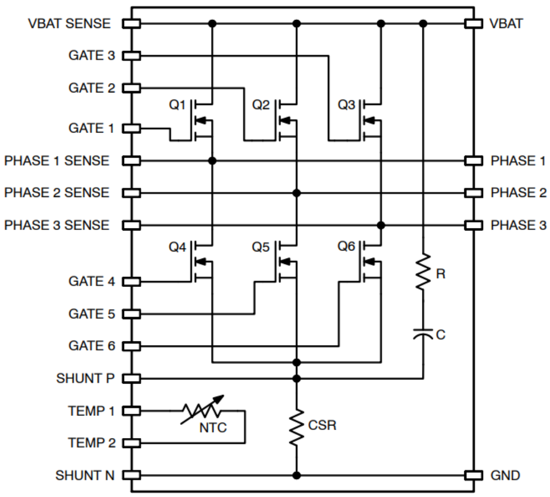
Integrated Automotive Power Modules (APM) for 48V and MHEV Applications

onsemi offers multiple series of automotive MOSFET modules in a variety of packages that are designed for power applications in 48V systems, MHEV and low voltage traction systems. Release of APM21 module further augments onsemi's line of high performance, high reliability transfer–molded modules for automotive applications. APMs elevate highly integrated and compact design with low stray inductance & better electromagnetic interference (EMI). Efficient current handling removes necessity for high current path in PCB.

- The NXV10V160ST1 **APM21** integrates six 100V MOSFETs (3x Half-Bridge) and can handle 3 phases for typical applications like 48 V Inverter, E-Compressor and other high-power auxiliaries.
- **APM19** modules: FTC03V85A1 is an 80 V low $R_{DS(ON)}$ module, featuring a 3–phase MOSFET bridge optimized for building a **1.5kW 48V–12V interleaved DC–DC converter. Two modules can create a 6-phase 3kW Converter.**
- NXV08V110DB1 is an 80 V low $R_{DS(ON)}$ APM19 module optimized as 3–phase inverter bridge for variable speed motor drive.
  APM19 modules include a precision shunt resistor for current sensing, an NTC for temperature sensing, and an RC snubber circuit.



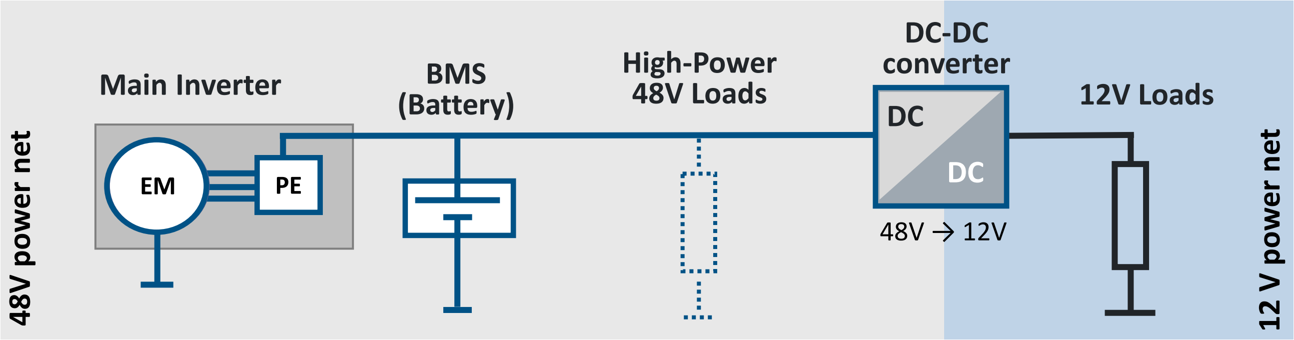
44 x 29 x 5 mm



APM19 3-Phase MOSFET bridge

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

Table 2: APM use in MHEV 48V architecture



Solution Overview

Integrated Automotive Power Modules (APM) for 48V and MHEV Applications

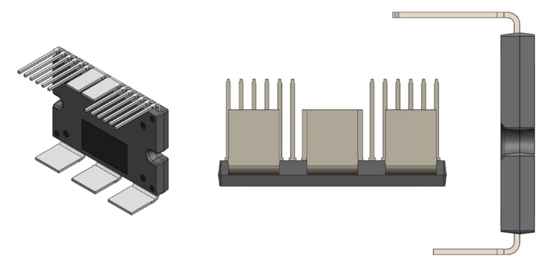
APM12 is a proven and reliable 80V single phase inverter module, NXV08A170DB2, with current sensing, temp sensing and snubber circuit. It can be stacked and turned into n-Phase Motor Inverter by using times n-APM12 modules.

APM17 modules are configured as dual half bridges (2–phase modules), which are easily connected externally to form a single half bridge suitable for twice the phase current.

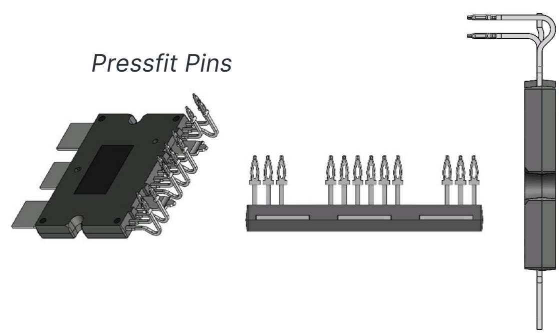
AMP17 examples: NXV08H250DT1, NXV08H400XT1. Three APM17 modules may be configured together to drive a 3–phase motor or 6–phase motor (48V main inverter).

- **Low stray inductance**: APM17 can enable total less than 15nH for 25kW 48V Inverter System.
- **Lowest junction-sink thermal resistance.**
- **Compact design for low total module resistance.**
    - Efficient High current handling without high current path in PCB.
    - For 20~25kW, 24~36 MOSFETs can be reduced to 3 APMs.
- The series offers options for the insulating ceramic DBC substrate to provide standard and premium thermal performance.
- Multiple $R_{DS(ON)}$ ratings can match the end user's current requirements, and a variety of pin–out options to enable different system designs.
    - Package varieties: Standard, Pressfit, Side PCB-mount pins.

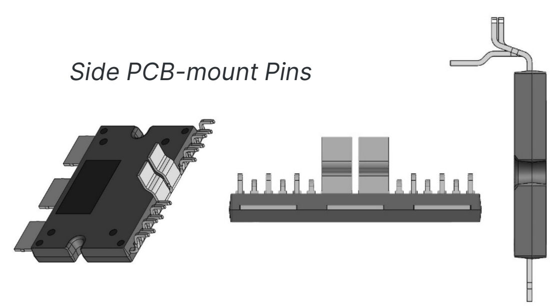
Standard Pins

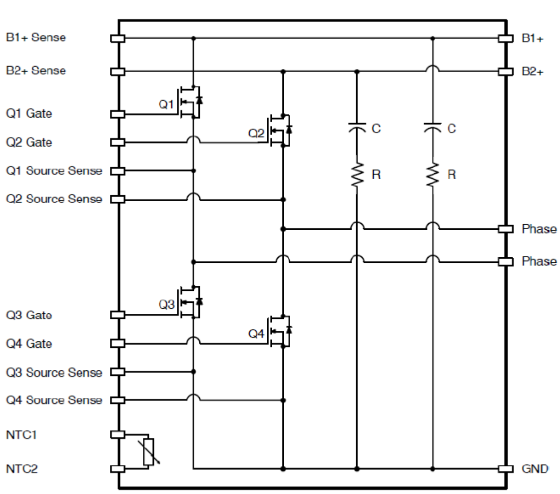


Pressfit Pins



Side PCB-mount Pins





APM17 Dual Half Bridge Module

48V-12V DC-DC Converter

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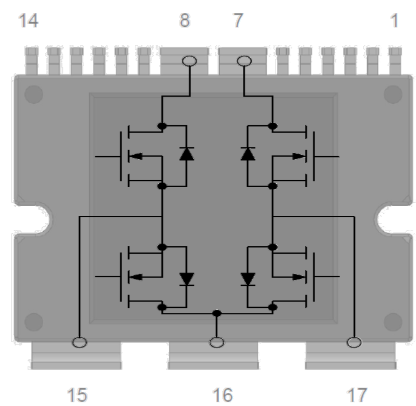
Solution Overview

APM17 – Back-to-Back MOSFET Module as Battery and Load switch

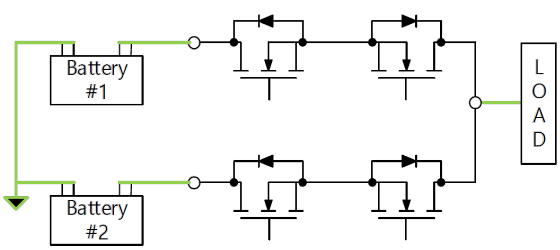
NXV08B800DT1 is automotive 2-Channel back-to-back MOSFET power module, 80V, 0.58mΩ with common source connection. It works excellently in 48V MHEV applications, either as battery or load switch (shown on the concepts below).

Electrically Isolated DBC Substrate for Low Rthjc, integrated temperature sensing.

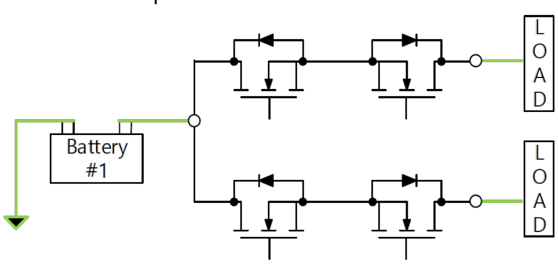
- Low junction-sink thermal resistance.
- Optimized stray L & highly integrated compact design.
- Use in bi-directional system, input path separation.



Use Concept #1 Battery Switch



Use Concept #2 Load Switch



Disconnect Switch inside DC-DC converter

Each side of the DC-DC converter should have the capability to disconnect from the corresponding power rail through a disconnect switch (circuit breaker). The optimal solution is a double back-to-back N-MOSFETs configuration, even though only a single MOSFET is required on the 48V side.

onsemi MOSFETs with low $R_{DS(ON)}$ and a voltage rating ranging from 40V to 100V are suitable, contributing minimally to conduction losses along the power path. The disconnect switch should also protect the converter against overvoltage and overcurrent. The protected side of 48V/12V disconnect switches can serve as a reference point for voltage sensing circuits.

12V Battery Side

Users can commonly access the 12-V battery in a vehicle which places a strict requirement for reverse polarity protection in the event that a user swaps battery terminals. This is why a back-to-back MOSFET configuration is used within the disconnect switch to protect the converter from reversed battery polarity. The DC-DC converter must disconnect from both power rails when the system is off, preventing current consumption during off time.

Solution Overview

MOSFETs : Low & Medium Voltage

onsemi offers wide variety of LV and MV MOSFETs for DC-DC Converter, Motor Control and other 48V automotive applications. Designers can choose from multiple component technologies that offer different features. 80V to 100V MOSFETs are available for the converter power stage, 48V auxiliaries and other applications. 40V LV MOSFETs will be effective within the 12V power rail and 12V legacy applications.

T10 shielded gate trench technology

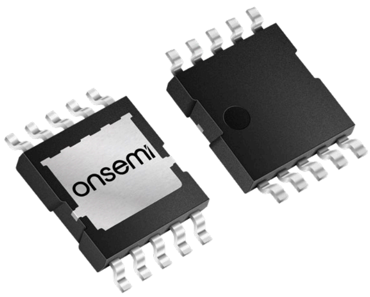
New T10 shielded gate trench technology is targeting DC-DC conversion applications (T10S variant) and motor control, load switch (T10M variant). It aims to optimize efficiency, low output capacitance and figures of merit with lower $R_{DS(ON)}$ and gate charge Q_G. Best-in-class 40V trench technology, NVMFWS0D4N04XM, goes as low as 0.42 mΩ $R_{DS(ON)}$ in small 5x6 package. 80V option NVBLS0D8N08X goes as low as 0.79 mΩ $R_{DS(ON)}$.

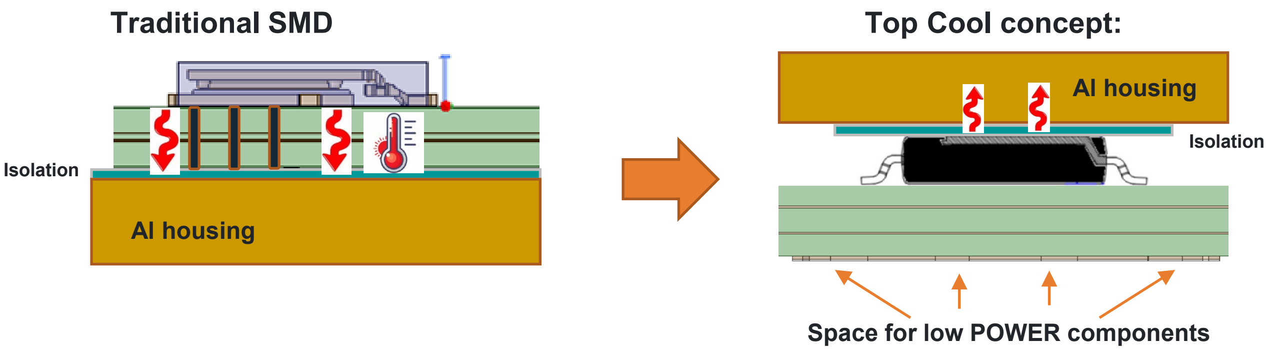
Top Side Cooling Packages (TCPAK)

MOSFETs are commonly chosen for their power capabilities and compact size. However, the heat dissipation with traditional SMDs is not ideal because the heat propagation is mainly through the PCB. To counter this issue and to improve on application size even further, a new Top Cool MOSFET package has been developed which exposes the lead frame (drain) of the MOSFET on the top side of the package. This method avoids cooling through the PCB. TCPAK57 is compact 5.1 x 7.5 mm package. More in Top Cool Application Note.

NVMJST0D9N04C 40V version comes with the lowest $R_{DS(ON)}$ 1.07 mΩ .
NVMJST2D6N08H 80V version comes with the lowest $R_{DS(ON)}$ 2.8 mΩ .

- Top cool enables the usage of both PCB sides, that results in higher power density.
- Reduced PCB temperature increases system lifetime.
- Improved thermal performance with heat path skipping PCB.
- Leaded package (Gullwing leads) boosts board level reliability.
- Cu clip connection to minimize package resistance.





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Solution Overview

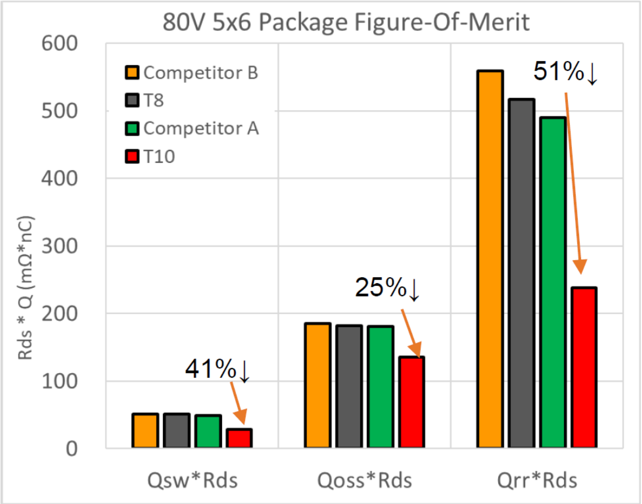
T10 MOSFET Technology: MV 80V and LV 40V

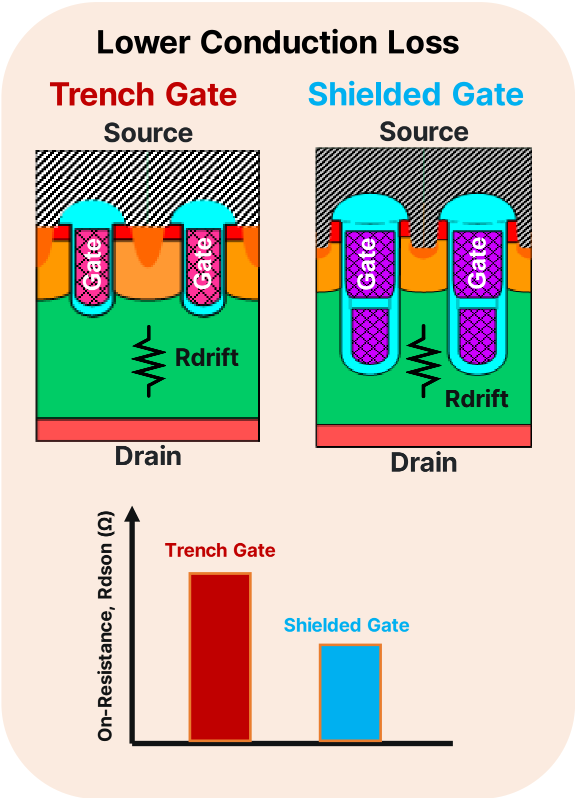
New T10(S) shielded gate trench design is targeted for DC-DC conversion (switching applications) and aims to optimize efficiency, low output capacitance and figure of merit (FOM).

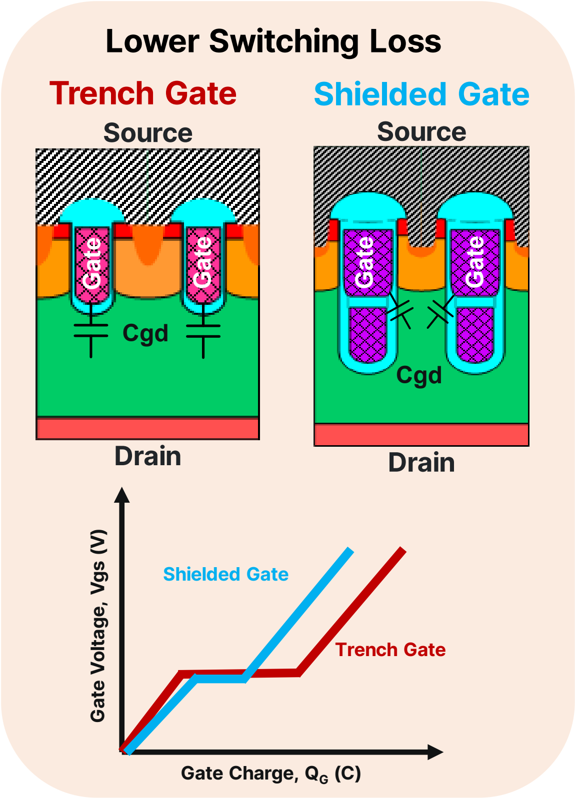
In Comparison to legacy T8 trench gate technology, T10 has achieved:

- Lower $R_{DS(ON)}$ and gate charge Q_G, with $R_{DS(ON)} < 1m\Omega$, $Q_G < 10$ nC.
- Lower Rsp ($R_{DS(ON)}$ vs Area)
- Improved FOM (Rds x Qoss/Q_G/Qgd) enhances performance and overall efficiency.
- Industry leading soft recovery body diode (Qrr, Trr) reduces ringing, overshoots and noise.

FOM Improvement







Comparison of T8 Trench Gate (Legacy) with new T10 Shielded Gate

Solution Overview

Gate Drivers for 80V and 100V MOSFETs and Power Modules

The FAD3151MXA and FAD3171MXA are **single channel floating automotive gate drivers 110V, 2.5A**, suitable for driving high−speed power MOSFETs up to 110 V. Designed in a SOI technology, the drivers are ideal for applications that require noise immunity against severe **negative transients and ground offset up to −80 V**.

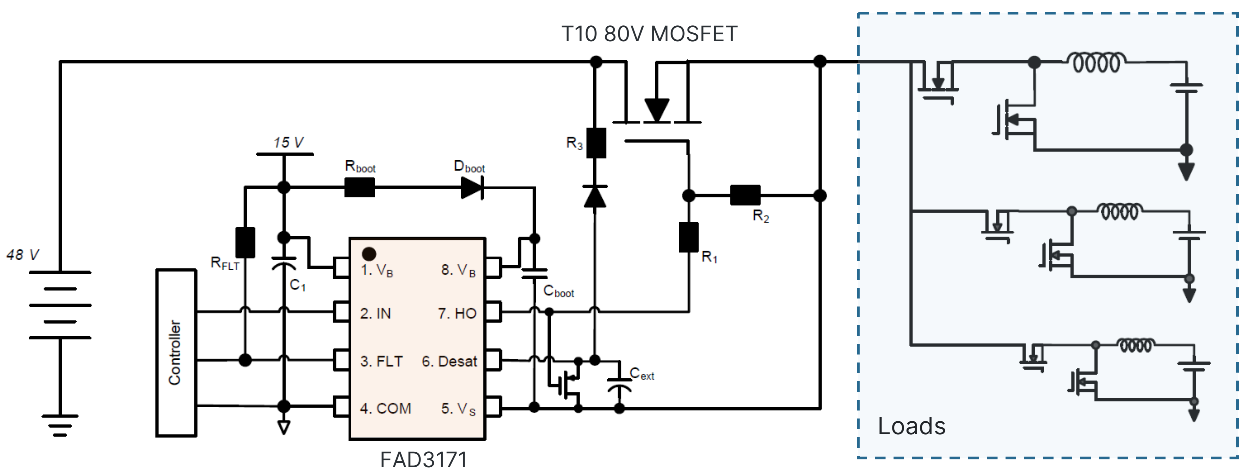
Besides DC-DC Converter, they can be used in multiple 48V applications like Battery Switches, Auxiliaries (HVAC, e-Turbo), PTC heater, Starter-Generator.

Features:

- Drain−Source Desaturation Detection with Soft Shutdown
- Integrated Charge Pump to support 100% Duty Cycle Operation (FAD3171MXA only)
- UVLO protection, Bi-directional Fault Reporting Pin
- Negative Transient Capability up to −80 V, Fast load transition dV_s/dt Immune to Min ±50 V/ns

Design Resources:

- Application note AND90251/D : FAD3151MXA and FAD3171MXA Schematics, Examples and circuit analysis
- Tutorial : General Isolation and Gate Drivers Overview



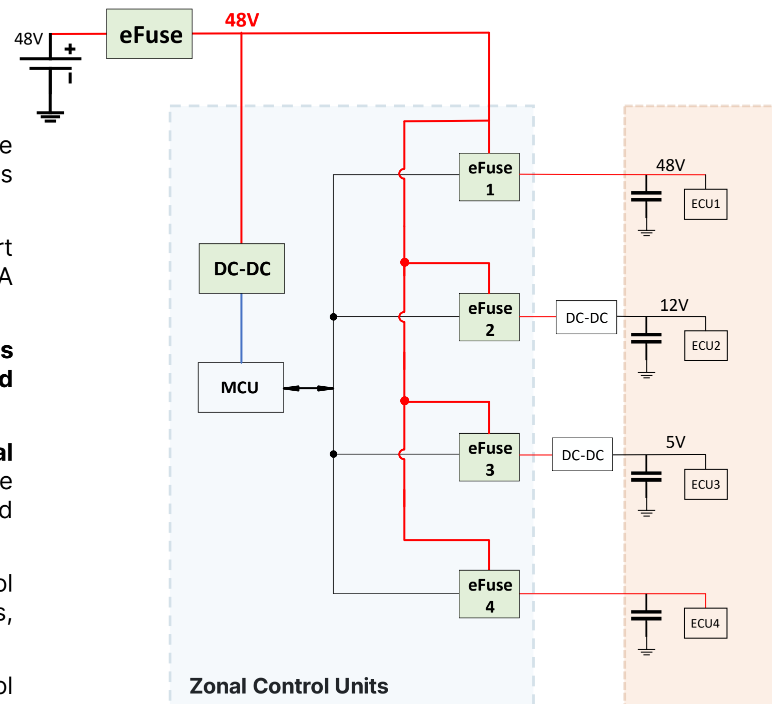
Application Example Schematic: FAD3171 drives a T10 MOSFET as a 48V battery main switch

High and Low Side Drivers for DC-DC Conversion

The NCV51513 and NCV51511 are automotive high and low side gate drivers with high drive current capabilities and options, optimized for DC-DC power supplies and inverters. Drivers are designed to drive MOSFETs in a half bridge or synchronous buck configuration.

NCV51513 offers best in class propagation delay, low quiescent current and low switching current at high frequencies of operation. It can be offered in two versions for propagation delays. With filter version, it has a typical 50 ns propagation delay, while without filter version it has a typical propagation delay of 20 ns. It provides dV/dt immunity up to 50 V/ns and Rise / Fall Time 9 ns / 7 ns for 1 nF Load.

Solution Overview



Electronic Fuse (eFuse) NIV3071

NIV3071 is an 8V to 60V, 10A electronic fuse (eFuse) integrating 4 independent channels (2.5A per channel) in a small 5x6mm package.

- Drive 4 independent 2.5A loads or short eFuse outputs together for single 10A continuous load current under 48V.
- **Protect 12V and 48V downstream loads from output shorts, overloads and overcurrent events.**
- Good for implementing **automotive zonal control units** (zonal architecture), guarantee protection and robustness of the localized ECUs throughout the vehicle.
- Protection for 48V Automotive body control modules, ADAS Domain controllers, Telematics, Harness Protection.
- Soft-start, configurable current limit, control and status monitoring pins.
- Evaluation board NIV3071MTW4GEVB allows design prototyping and testing.

NCV12711 – 12V Auxiliary Power – Peak current PWM controller

The NCV12711 is a fixed−frequency peak−current−mode PWM controller containing all of the features necessary for implementing single−ended power converter topologies (Flyback, Forward converter). With wide 4-45V input range it can work as DC-DC controller for auxiliary power.

- Operating 100kHz to 1MHz with slope compensation (Preventing subharmonic oscillations, improve EMI)
- 1A Source/Sink Gate Driver. No need for auxiliary winding.
- Input voltage UVLO protection, Over-power protection, programable soft-start.
- Evaluation board NCV12711FLOATGEVB : 12V/1A Primary side regulation without AUX winding.

Digital Isolators

Digital isolators are employed in automotive applications thanks to their stability over temperature and time. NCIV9211 , NCIV9311, NCIV9401 are series of high speed, bi-directional ceramic Digital isolators with 2/3/4 channels. They utilize **onsemi's patented galvanic off−chip capacitor isolation technology** and optimized IC design to achieve high 2kV insulation and noise immunity. Off−chip ceramic capacitors serve both as the isolation barrier and as transmission medium for signal switching using On−Off keying (OOK) technique.

Typical Applications for Isolation: PWM Control, MCU interface, Programmable Logic Control, Data Acquisition System, Voltage Level Translation.

48V-12V DC-DC Converter

Recommended Products

Suggested Block	Part Number (PN)	PN Description, Comments
Automotive Power Module (APM) Solutions for 48V Systems		
APM19 3 Phase MOSFET bridge	FTC03V85A1	Integrated 3-phase MOSFET bridge, 80V, 2.1 mΩ, 1.5kW optimized for interleaved DC-DC Converter. Integrated Shunt resistor, NTC, Snubber C
	NXV08V080DB1 NXV08V110DB1	Integrated 3-phase MOSFET bridge, 80V, 2.1 (3.1) mΩ Rds(on). Optimized for 48V Auxiliaries. Integrated precision shunt resistor, NTC for temperature sensing, and an RC snubber circuit.
AMP12 Half Bridge	NXV08A170DB2	Half Bridge module (Single Phase), 80V 0.99 (1.35) mΩ , Integrated Shunt resistor, NTC, Snubber C
APM17	NXV08B800DT1	2-Channel back-to-back MOSFET Power Module, 80V, 0.59 (0.81) mΩ. Optimized for battery or load switch, replacing mechanical Relay.
APM17 Dual Half Bridge	NXV08H250DT1	Dual Half Bridge MOSFET Power Module, 80V, 0.76 mΩ. Optimized for 48V main inverter. Integrated NTC, Snubber R & C.
APM21 3 Phase MOSFET bridge	NXV10V160ST1	Integrated 3-phase MOSFET bridge, 100V, 2.2 mΩ Rds(on). Optimized for 48V E−Compressor and high power Auxiliaries.
40V – 100V APMs	APM12, APM19, APM21 available power modules.	
	APM17 80V available power modules.	
Medium and Low Voltage MOSFETs 40V, 80V, 100V		
Si MOSFETs 100 V for 48V Side	NVBLS1D5N10MC	N-Power MOSFET 100V, 300A, 1.5 mΩ , TOLL Package
	FDBL86062_F085	N-Power MOSFET 100V, 300A, 2.0 mΩ , PowerTrench technology, TOLL
	NVMTS1D6N10MC	N-Power MOSFET 100V, 273A, 1.7 mΩ , 8x8mm flat lead
	NVMFS3D6N10MCL	N-Power MOSFET 100V, 132A, 3.6 mΩ , 5x6mm flat lead
	Application recommended 100V-120V N-MOSFETs (single & dual configuration)	
Si MOSFETs 80 V for 48V Side	NVBLS0D8N08X	N-Power MOSFET 80V, 457 A, 0.8 mΩ, T10 Technology, TOLL package
	NVMFS1D5N08X	N-Power MOSFET 80V, 253 A, 1.43 mΩ, T10 Technology, SO-8FL package
	NVMFS1D9N08X	N-Power MOSFET 80V, 201 A, 1.9 mΩ, T10 Technology, SO-8FL package
	NVBLS1D1N08H	N-Power MOSFET 80V, 351 A, 1.05 mΩ, TOLL Package
	NVMYS003N08LH	N-Power MOSFET 80V, 132 A, 3.3 mΩ, LFPAK-56
	Application recommended 80V N-MOSFETs (single & dual configuration)	
Si MOSFETs 40 V – 80V (Top Cool Package)	NVMJST2D6N08H	N-Power MOSFET 80V, 131A, 2.8 mΩ , Top Cool Package (TCPAK57)
	NVMJST1D2N04C	N-Power MOSFET 40V, 451A, 1.25 mΩ , Top Cool Package (TCPAK57)
	NVMJST3D3N04C	N-Power MOSFET 40V, 157A, 3.3 mΩ , Top Cool Package (TCPAK57)
	NVMJST1D6N04C	N-Power MOSFET 40V, 314A, 1.65 mΩ , Top Cool Package (TCPAK57)
	Application recommended 40V-80V N-MOSFETs (Top Cool Package)	
Si MOSFETs 40 V for 12V Side (T10M SL Technology)	NVMFWS0D4N04XM	N-Power MOSFET 40V, 509A, 0.42 mΩ , DFNW5 5x6 Package
	NVMFWS0D5N04XM	N-Power MOSFET 40V, 414A, 0.52 mΩ , DFNW5 5x6 Package
	NVMFWS1D1N04XM	N-Power MOSFET 40V, 233A, 1.05 mΩ , DFNW5 5x6 Package
	NVMFWS2D3N04XM	N-Power MOSFET 40V, 121A, 2.35 mΩ , DFNW5 5x6 Package
	T10M is best-in-class 40V Trench Technology with lowest Rdson in 5x6 package (Min. 0.42mΩ)	
	All Application usable 40V N-MOSFETs (I_D > 50A)	

48V-12V DC-DC Converter

Recommended Products

Suggested Block	Part Number (PN)	PN Description, Comments
Diodes & Gate Drivers		
Diodes	NRVB1240MFS	40 V, 12A $I_{F(AV)}$, 150A $I_{FSM(max)}$ Schottky Power Rectifier, SO-8FL package
	NRVTSA4100E	100V, 4A $I_{F(AV)}$, 150A $I_{FSM(max)}$ Trench Schottky Rectifier
	NRVTS3060MFS NRVTS30100MFS	60V (100V), 30A $I_{F(AV)}$, 350A $I_{FSM(max)}$, High Performance Trench Schottky Rectifier, SO-8FL package. Optimized for high f_{sw} DC-DC conversion.
	Application recommended discrete power diodes	
	Automotive small signal diodes	
	Automotive zener diodes (Vz > 15V)	
Gate Drivers Junction Isolated (100V -150V)	FAD3151MXA FAD3171MXA	110V, 2.5A, Single Channel Floating Gate Driver, Negative Transient −80 V, Desaturation & UVLO protection , (Charge Pump 3171 only)
	NCV51513	130 V, 2.0/3.0 A Half-Bridge Driver , EN & Interlock, Rise/Fall times 9ns/7ns
	NCV51313	130 V, 2.0/3.0 A High side Driver, 20ns Fast Propagation Delay, High dv/dt immunity up to 50 V/ns and negative transient immunity
	NCV51511	100 V, 3.0/6.0 A High & Low side Driver, Integrated Bootstrap, Ideal for Half bridge or Synchronous Buck Configuration.
	Application Recommended Junction Isolated Gate Drivers (Medium Voltage)	
Gate Drivers 600V Junction Isolated	FAN7171	600V, 4A, SOIC-8, High-Side Gate Drive
	FAD7191	600V, 4.5A, SOIC-8, High & Low-Side Gate Drive
	NCV5183	600V, 4.3A, SOIC-8, High & Low-Side Gate Drive
	Application Recommended Junction Isolated Gate Drivers (600V target Voltage)	
Auxiliary Power		
Buck Converter and Controller (Step down from 48V)	NCV891330	Dual-Mode Step-Down Regulator, 3 A, 2 MHz, Low-Iq
	NCV6324	Synchronous Buck Converter, 3 MHz, 2.0 A
	NCV890104	Buck Switching Regulator, 1.2 A, 2 MHz, Programmable Spread Spectrum, Adjustable RSTB
	NCV6323F	Buck converter, Synchronous, PWM. Up to 1.6 A DC. Various Fixed Output Voltages. Optimized to supply sub-systems.
	Application recommended components for Step-Down DC-DC conversion. Including inverting converter.	
High Power **Buck Controller**	NCV1034	Synchronous PWM Buck Controller. Vin up to 100V. 25kHz - 500kHz programable switching frequency. Drives 2 external N-MOSFETs, 2A Driver.
	NCV8856A	Synchronous Buck Controller with adjustable output. Vin up to 38V. Integrated Gate Driver = 1.5A max , CSP & CSN Voltage = 10V max
	NCV81277A	Multiple Phase Buck Controller with PWM_VID and i2c interface. Supports up to 4 Phases. Vin up to 20V. UVP, OVP, OCP protection.
Buck / Boost / Inverting Converter - Switching Regulator	NCV33163	Buck / Boost / Inverting Converter - Switching Regulator, 2.5 A, Vin up to 60V. Requires minimum number of external components
	NCV3064	Buck / Boost / Inverting Converter - Switching Regulator, 1.5 A, Vin up to 40V. Optimized for high-frequency operation
	NCV33063AV	Buck / Boost / Inverting Converter - Switching Regulator, 1.5 A, Vin up to 40V. Internal compensated reference, comparator, duty cycle control.

48V-12V DC-DC Converter

Recommended Products

Suggested Block	Part Number (PN)	PN Description, Comments
Auxiliary Power		
Offline Controllers: PWM, LLC Control, Flyback	NCV3843B	Current Mode PWM Controller, suited for driving power MOSFETs in DC-DC converter applications.
	NCV4390	Secondary side PFM controller for LLC resonant converters with synchronous rectifier control.
	NCV1362	Primary side Flyback Controller. Integrated features for easy control of Low Power Offline SMPS.
	NCV8871	Non-Synchronous Boost Controller. Can be used in Flyback configuration.
	NCV898031	Non-Synchronous SEPIC / Boost Controller, 2MHz. Peak Current Mode Control, UVLO, Internal Soft-Start.
	NCV12711	Peak current-mode PWM controller: 4-45 Vin DC. Rich features. Suitable for 12 V & 24 V Auxiliary Power and Flyback topology.
High Voltage Switching (Offline) Regulators	NCV1076 NCV1060 NCV1063	Automotive High-Voltage Switching Regulator. Integrated Current mode controller with 670V MOSFET. Provided with different features and packages.
LDO Regulator	NCV8163	250mA, High PSRR, Very Low Noise, 1uF COUT, TSOP-5 & XDFN4
	NCV8164	300mA, High PSRR, Very Low Noise, 1uF COUT 150C Power Good, Fixed & Adjustable output options, WDFNW6 & DFNW8 packages
	NCV8189	500mA, High PSRR, Very Low Noise, 1% accuracy, 150C, Power Good, Fixed & Adjustable output options, WDFNW6 & DFNW8 packages
	NCV59801	1A, High PSRR, Very Low Noise 1% accuracy 150C, Power Good, Fixed & Adjustable output options, WDFNW6 & DFNW8 packages
	NCV8718xx	300mA, 24 Vin max, 4uA Iq, Fixed & Adjustable Vout options WDFN6 package
	NCV1117xx	1A, High PSRR, (up to 20 Vin) Adjustable and fixed output options.
	NCV8730xx	150mA, Low Iq 1uA (2.7-38 Vin range) Adjustable and fixed output options, PG ideal for power sequencing.
	Application recommended automotive LDOs.	
Auxiliary Power : Protection		
eFuse	NIV6150 NIV6350	Resettable fuse 200 mΩ (85 mΩ) $R_{DS(ON)}$ Reverse current protection. Fast response Overvoltage clamp and undervoltage lockout.
	NIV3071	eFuse 4 channels. Vin 8V - 60V, Ideal for 12V up to 48V applications, 10A when channels are parallel (2.5A continuous current per channel)
Protected power switches	FPF2895V	28 V, 5 A rated current limit power switch, Features OCP, OVP, Reverse current protection
	NCV47722	40V, 350mA rated High Side Switch with Adjustable Current Limit and Diagnostic Features
	NCV47822	40V, 350mA rated, **Dual** High Side Switch with Adjustable Current Limit and Diagnostic Features
	Application recommended Protected Power Switches	

Recommended Products

Suggested Block	Part Number (PN)	PN Description, Comments
CAN, LIN Transceivers (In Vehicle Networking)		
CAN (CAN-FD) Transceivers	NCV7343	Low Power & High Speed, INH, Wake-up, Error Detection.
	NCV7342 NCV7344 NCV7349	Low Power & High Speed Transceivers Various packages, features and pin functions.
	NCV7446	Dual Transceiver, Low Power & High Speed . Wake-up
	Application recommended CAN Transceivers for In Vehicle networking.	
LIN Transceivers	NCV7329	Single (Dual) LIN Transceiver, Transmission up to 20kbps. Integrated Slope Control. Undervoltage, Transient, Thermal protection. TxD Timeout
	NCV7422	
	Application recommended LIN Transceivers for In Vehicle networking.	
CAN, LIN Protection, ESD Protection	SZNUP3125	Protects CAN, LIN transceivers from ESD and other harmful surge events. Bidirectional protection for each data line. Options for 32V, 24V Dual Line CAN/CAN-FD/CAN+LIN Bus Protector.
	SZNUP2124	
	SZNUP2125	
	SZESD8704xx	Unidirectional High Speed Data Line Protection.
	Recommended ESD and surge protection for CAN, LIN bus	
System Basis Chip (SBC)		
System Basis Chip (SBC)	NCV7450	SBC with CAN FD transceiver, LDO (5V/250mA) & HS Driver
	NCV7451	SBC with CAN FD transceiver, LDO (5V/250mA) & Wake Function
	NCV7471C	SBC with CAN/CAN-FD + 2 LIN transceivers, Boost-Buck DC-DC (5V/500mA) and LDO (5V/50mA)
Analog Signal Chain		
Low Power & Precision **Operational Amplifier**	NCV21874	Zero-Drift, 45 µV Offset, 0.4 µV/°C
	NCV21911xx	36V, 2 MHz GBW, Low Noise, Zero-Drift, 25 µV Offset
	NCV2007x	36V, 3MHz, Rail-to-rail output
	NCV20231xx	36V, 3 MHz GBW, 0.95 mV Input Offset. Wide supply range 2.7 V to 36 V.
	NCV333xx NCV2333 NCV4333	Low Power Zero-Drift Op-Amp, 10 µV (30 µV) Offset, 0.07 µV/°C low offset drift, space saving packages. Single, Dual and Quad channel configuration.
	Application recommended automotive Low Power & Precision Op-amps	
Low Voltage Comparator	NCV2250	Push-Pull, High Speed, 50 ns propagation delay
	NCV2252	Open Drain, High Speed, 50 ns propagation delay
	NCV2901 NCV2903	36V, Low Offset Current +/- 5.0 nA, Single or Split Supply, Input Common Mode Voltage to GND level
Current Sense Amplifier (CSA)	NCV7041	CSA for high voltages (HV) with high resolution. Best for High-side sensing in HV applications. V_{CM} 80V, Bi-directional. Gains : 14, 20, 50, 100 V/V
	NCV7030	V_{CM} 80V, Uni-directional, 100 kHz BW, Gain Options: 14, 20 V/V 0.3 % gain error over the entire temperature range
	NCV21674	V_{CM} 40V, Uni-directional, Low Offset Voltage 100µV and Drift 1µV/C
	NCV210, NCV211 NCV213, NCV214	Low offset & zero drift architecture. Bidirectional. For both Low-side and High-side sensing. Multiple Gain Options: 50, 100, 200, 500 V/V
	Application recommended automotive CSA	

Recommended Products

Suggested Block	Part Number (PN)	PN Description, Comments
Miscellaneous components		
Temperature Sensing	NVT210CMxx NVT211CMxx	Digital Temperature monitor ±1°C with series resistance cancelation. Under/Over-temperature alarm. Serial Interface (i2c, SMBus)
Voltage Level Translator	MC14504B	Hex non-inverting level shifter, CMOS/TTL to CMOS. Shifting any supply between 5 and 15 V.
	NLVSX5004	Level Translator, 4-Bit, 100 Mbps
Automotive EEPROM	NV24C64xx	64-Kb I2C
	CAV25010	1-Kb SPI
	CAV24C512xx	512-Kb I2C
	NV25320xx	32-Kb SPI
	Automotive Recommended EEPROM	
Voltage Reference and Supervisors	SC432BVSNT1G NCV431	Programmable Voltage Reference, Temperature compensated Low Cathode Current, Shunt Regulator
	NCV308	Voltage Supervisor with programable delay and reset
	NCV33161	Universal automotive Voltage Monitor , up to 40V
	NCV303	Ultra Low current voltage detector with programmable delay
Digital Isolation	NCIV9210 NCIV9211 NCIV9311 NCIV9401 NCIV9411	Galvanically isolated 2kV, high speed, bidirectional 2/3/4 Channels Digital Isolators. Allows Isolated PWM control, Communication / Diagnostics. Utilizing onsemi patented galvanic off−chip capacitor isolation technology and optimized IC design for high insulation and noise immunity.
Zener diodes	1SMB59	3 W Zener Diode, Zener Voltage Range up to 200V, SMB package
	1SMA59	1.5 W Zener Diode, Zener Voltage Range up to 68V, SMA package
	SZMMSZ52	500mW Zener Diode, Zener Voltage Range up to 110V, SOD-123 package

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Technical Documents

Note that reference designs may contain non-automotive parts to support functionality.

Type	Description & Link
Ref Design (Evaluation Board)	100V Synchronous Buck Controller NCP1034 Evaluation Board
Ref Design (Evaluation Board)	12V/1A Primary side regulation without AUX winding (12V Auxiliary power)
Ref Design (Evaluation Board)	NCV8163 LDO Regulator, 250 mA
Ref Design (Evaluation Board)	40W SiC Auxiliary Power Supply
Ref Design (Evaluation Board)	130V Half bridge driver NCP51513
Ref Design (Evaluation Board)	CAN Driver Shield (NCV7342 Transciever) Evaluation Board
Video	48V Automotive Advancements
Video	48V Automotive Systems and Power Modules
Webinar	48V Mild Hybrid Systems
Blog	48-Volt Systems for MHEV and Beyond
Blog	48V Technology for Mild Hybrid Construction and Mining Machinery
Application Note	Introduction High Current Dual Half Bridge Modules for Automotive MHEV Applications [AND90235/D]
Application Note	Top Cool Package for Power Discrete MOSFETs
White Paper	Power Conversion in Mild Hybrid Electric Vehicles [TND6317/D]
White Paper	Optimizing Power Efficiency and Performance for Hybrid and Electric Vehicles [TND6388/D]
White Paper	Engineering Essentials: Choosing Between Digital Isolators or Optocouplers [TND6387/D]
Tutorial	Basics of In-Vehicle Networking (IVN) onsemi products [TND6015]

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