System Solution Guide - Preview

48V Starter Generator

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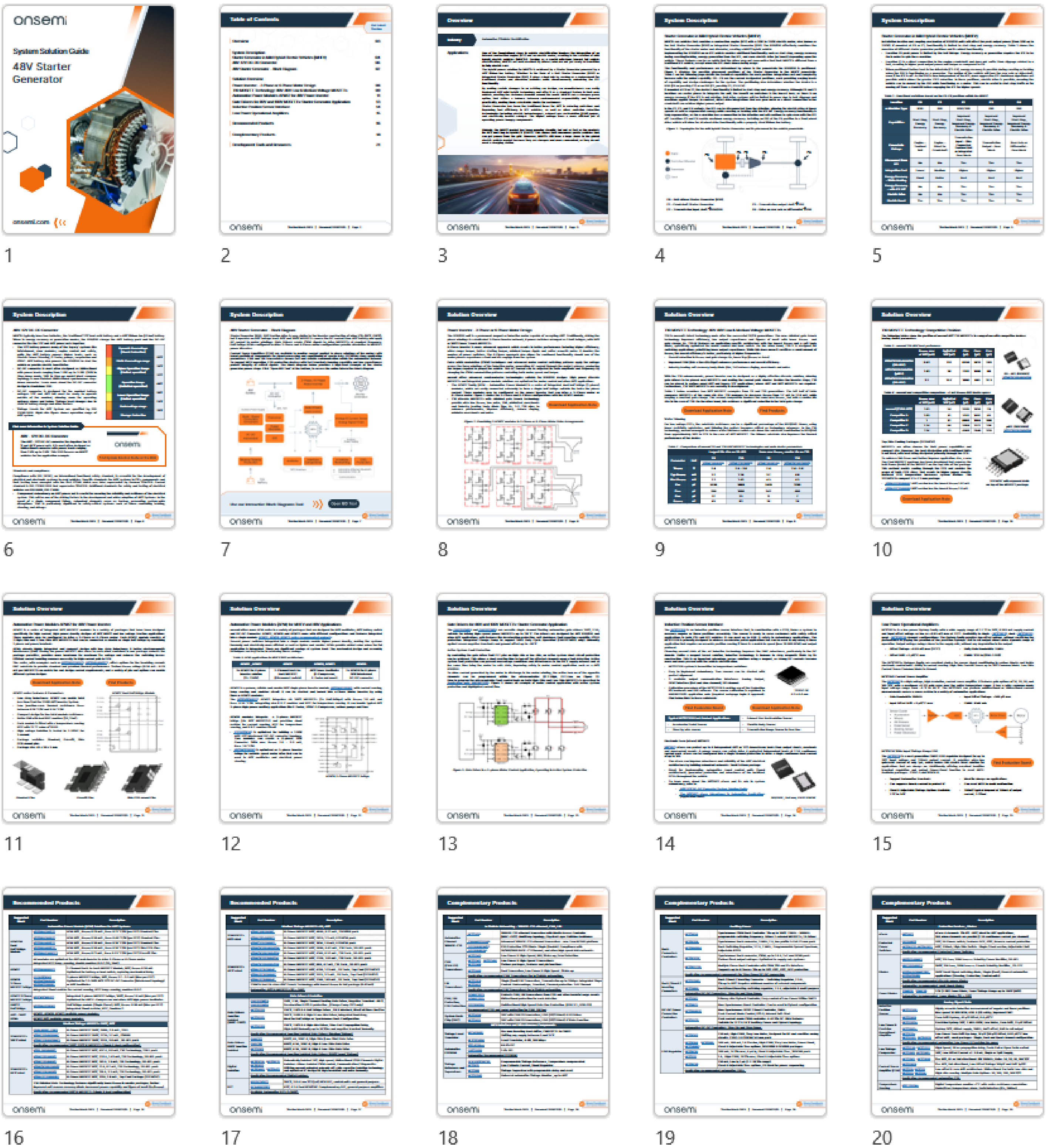


Starter Generator in Mild Hybrid Electric Vehicles (MHEV)

MHEVs are vehicles that combine a combustion engine (ICE) with a 5kW to 25kW electric motor, also known as the Belt Starter Generator (BSG) or Integrated Starter Generator (ISG). The BSG/ISG effectively combines the functionality of the starter motor and alternator, creating a MHEV hybrid vehicle.

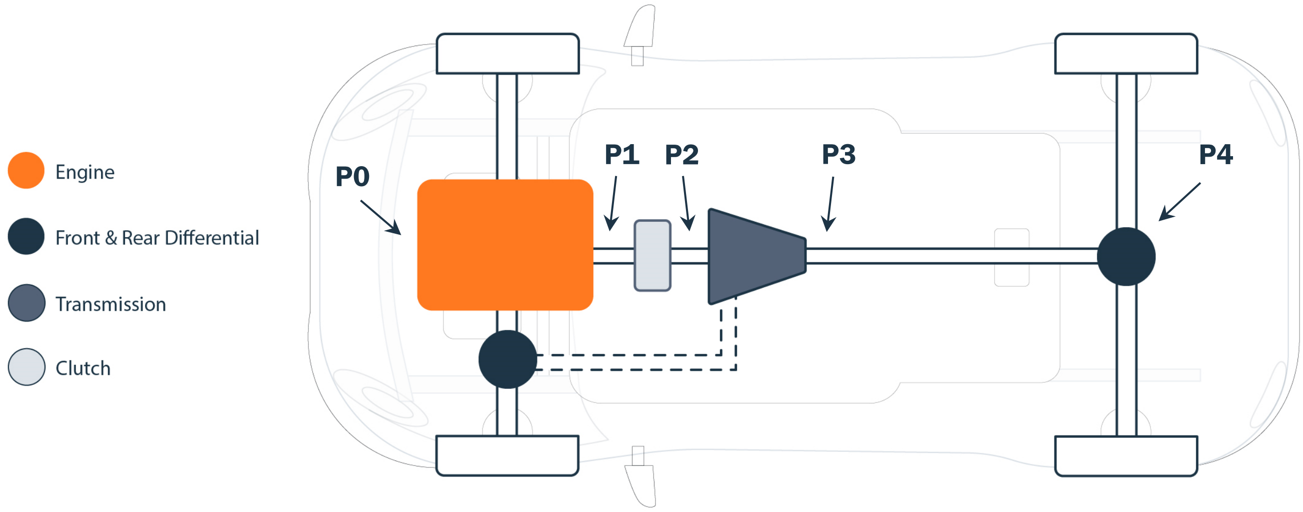
Implementing the BSG/ISG on an ICE vehicle enables additional functionality such as start-stop, energy recovery during coasting/braking, energy generation from the ICE, and even electric drive (or boost) depending upon the vehicle. These features can be so subtle that the driver may not even notice that their MHEV is different from a traditional ICE vehicle, except when the ICE shuts down during usage.

The functionality and performance are determined by where in the powertrain the BSG/ISG is positioned. Figure 1. displays the possible placement positions of the Starter Generator in the MHEV powertrain. Table 1. on the following page details the technical capabilities for each position. Integration cost and complexity increase with the added capability. **P0 – P4 are the current designated positions, each providing varying levels of capability and design challenges for the system.** The positioning also determines whether the device is a BSG (P0 or possibly P2) or an ISG (P1, possibly P2, P3 & P4).

If mounted at P0 or P1, the device's functionality is limited to start-stop and energy recovery. Although P0 and P1 locations are easier places to integrate the unit, the benefit on emissions is the lowest here, as there is no energy recovery if the ICE is not rotating. Belt drive systems will be limited in power due to belt slippage and maximum applied torque. In contrast, direct drive integrations that use gear mesh or a direct connection to the crankshaft can achieve higher power output.

In the P2, P3, and P4 variants, the ICE can be disconnected from the driveline, allowing for electric drive at lower speeds as well as regenerative energy while coasting or braking with the ICE off. Energy recovery functionality is truly regenerative, as the e-machine has a connection to the driveline and will continue to spin even with the ICE off. Locations P3 and P4 enable maximum energy recovery. Installing an ISG at the P4 position in a front wheel drive vehicle will allow for all wheel drive functionality with a properly sized lithium-ion battery.

Figure 1 : Topologies for the mild hybrid Starter Generator and its placement in the vehicle powertrain.



P0 – Belt-driven Starter-Generator (BSG)

P1 – Crankshaft Starter-Generator

P2 – Transmission input shaft →BSG/ISG

P3 – Transmission output shaft → ISG

P4 – Drive on rear axle or differential → ISG

Block Diagram

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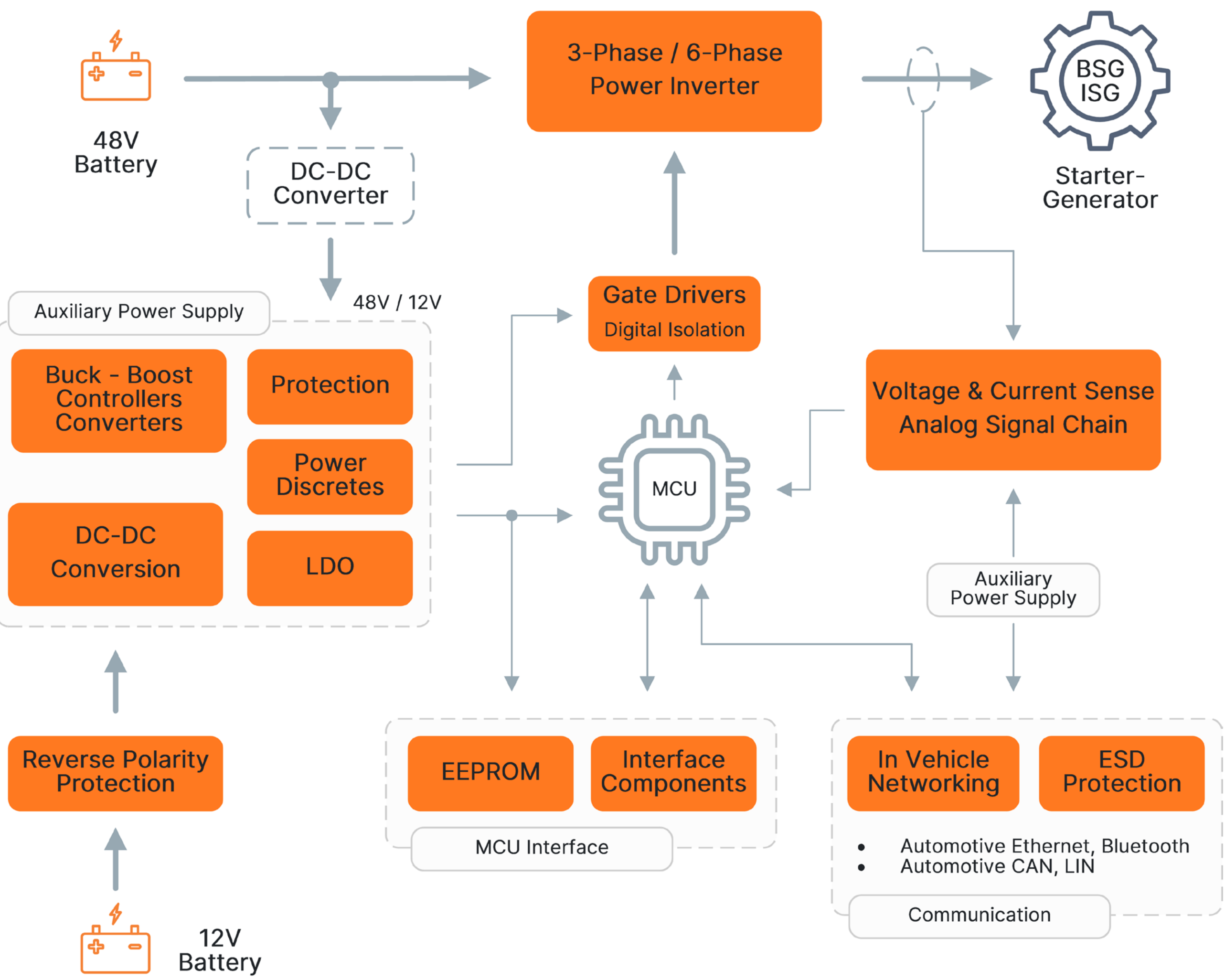
48V Starter Generator – Block Diagram

Starter Generator (BSG, ISG) traction drive is very similar to the inverter construction of other EVs (BEV, PHEV), but it operates on 48V voltage level. 80V and 100V MOSFETs source the DC current from 48V battery and apply AC current to motor windings. Gate Drivers create PWM signals to drive MOSFETs at required frequency. Half-bridge APMs configured to drive 3-Phase and 6-Phase motor configurations provide alternative to MOSFET power discretes.

Current Sense Amplifiers (CSA) are available to monitor current applied to phase windings of the motors with broad portfolio of components for signal processing and conditioning of sensor data. **EEPROMs** store application parameters. **CAN and LIN transceivers** ensure fast and reliable communication within the automotive network. To support MCU operation, **ESD protection devices** with fast transient clamping capability and low capacitances protect integrity of critical signals. The block diagram below provides a high-level example of the starter generator power stage. Click “Open IBD Tool” at the bottom, to access the online interactive block diagram.



Use our Interactive Block Diagrams Tool

Open IBD Tool

Automotive Power Modules APM17 for 48V Power Inverter

APM17 is a series of integrated 80V MOSFET modules in a variety of packages that have been designed specifically for high current, high power density designs of 48V MHEV and low voltage traction applications. **Three modules may be configured to drive a 3–Phase or 6–Phase motor**. Each APM17 module consists of 2 High-Side and 2 Low-Side 80V MOSFETs that can be connected as double or single half-bridge by combining 2 phase-out power terminals.

APMs elevate highly integrated and compact design with low stray inductance & better electromagnetic interference (EMI). Having the power MOSFET dies close to each other contained in one package reduces the package parasitics, provides more headroom for maximum V_{DS} voltage and reduces the switching losses. Efficient current handling removes necessity for high current path in PCB.

The series, with examples such as **NXV08H250DT1**, **NXV08H400XT1**, offers options for the insulating ceramic DBC substrate to provide standard and premium thermal performance. Various $\mathbf{R_{DS(ON)}}$ ratings (0.58 mΩ - 0.76 mΩ per MOSFET) can match the end design current requirements, and a variety of pin–out options can enable different system designs.

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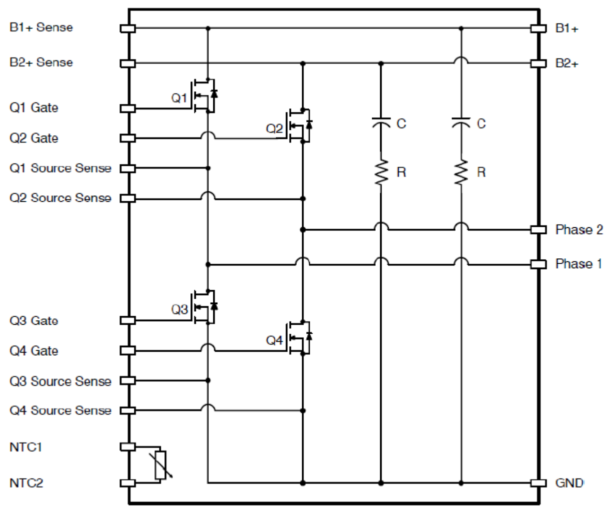
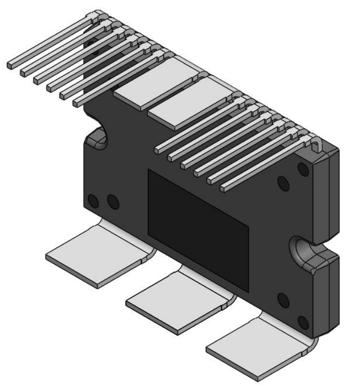
APM17 series Features & Parameters:

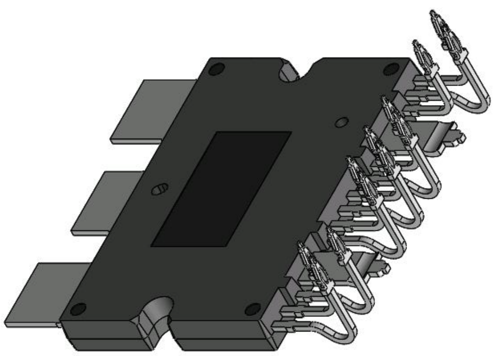
- **Low stray inductance**: APM17 can enable total less than 15nH for 25kW 48V Inverter System.
- **Low junction-case thermal resistance** R_{THJC} between 0.19 °C/W and 0.54 °C/W.
- **Compact design for low total module resistance.**
- Better EMI with dual R&C snubber (1Ω, 15nF).
- Each module is fitted with a temperature sensing NTC with 25 °C value of 10 kΩ.
- High voltage isolation is tested to 3 kVAC for 1 second.
- Package varieties: Standard, Pressfit, Side PCB-mount pins.
- Package size: 45 x 30 x 5 mm

APM17 Dual Half Bridge Module

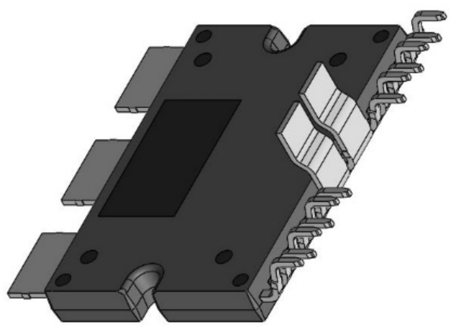




Standard Pins



Pressfit Pins



Side PCB-mount Pins