System Solution Guide

# Battery-powered Tools

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| | |
|---|---|
| **Industry** | Industrial – Handheld Tools, Industrial Tools and Equipment, Battery-powered Tools |
| **Application** | Battery-powered Tools, also known as cordless tools, offer convenience, portability, and efficiency and now widely used across industries like construction, woodworking, automotive, and do-it-yourself (DIY) projects. These tools rely on rechargeable batteries to operate, eliminating the need for a constant power source and are usually powered by typically between 12 V and 72 V. The innovation of battery technology is leading to lighter and more powerful batteries with faster charging times. This encourages broader adoption of battery-powered tools across various industries and applications. |

## System Purpose

- Battery-powered tools offer several advantages over corded counterparts. They provide greater mobility and flexibility, allowing users to work in remote locations or confined spaces without the restrictions of a cord. Additionally, they are generally quieter by taking advantage of Brushless DC (BLDC) motor, more lightweight, and easier to maneuver, enhancing user comfort and reducing fatigue during extended use.
- Key considerations when choosing battery-powered tools include battery capacity, charging time, compatibility and overall durability. With the ongoing advancements in battery technology, battery-powered tools continue to gain popularity and are becoming indispensable for both professionals and hobbyists alike.
- The most important performance requirements of the power stage driving the motors are small form factor, high efficiency, good thermal performance, reliable protection and peak-current capability. A small form factor enables flexible mounting of the power stage inside the tool, better PCB layout performance and low-cost designs. High efficiency provides maximum battery life and reduces cooling efforts. Reliable operation and protection facilitate long lifetimes, which help with product reputations.
- Integration of smart technologies such as Bluetooth connectivity, mobile app control, and battery monitoring systems with specific-designed semiconductors are becoming more prevalent. There features enhance user experience, improve tool performance, and enable better maintenance and diagnostics.

## Market Information & Trends

### Growing Battery-powered Tools Market

Battery-powered tools are mechanical devices that operate on a battery. These tools include handheld machine drills, nail guns, saws, grinders, impact wrenches, and garden tools, which are used for varied applications such as production, packaging, assembly, and maintenance operations, including drilling, screw driving, chiseling, sanding, and mowing.

The global battery-powered tools market size was valued at USD 29.50 billion in 2022 and reached USD 30.76 billion in 2023. It is projected to reach USD 55.68 billion by 2032, growing at a compound annual growth rate (CAGR) of 7.7% during the forecast period (2024-2032). The growth of the battery-powered tools market is attributed to advancements in battery technology increasing environmental concerns and a desire for eco-friendly solutions. The growth of the global power tools market is driven by rapid industrialization worldwide, a rise in urbanization, and a surge in the adoption of battery-powered tools in the automotive industry. Moreover, there has been a surge demand for household power tools due to the growing popularity of do-it-yourself (DIY) techniques.

### Higher Supply Voltage Tools

The market is witnessing an increasing desire for battery-powered tools with elevated voltage ratings, surpassing the conventional 24 volts and beyond. This surge is primarily driven by the escalating demands of professional users who necessitate enhanced power output and extended operational durations. Such requirements are particularly crucial in rigorous applications such as construction and manufacturing, where heavy-duty tasks demand robust tool performance and prolonged runtime.

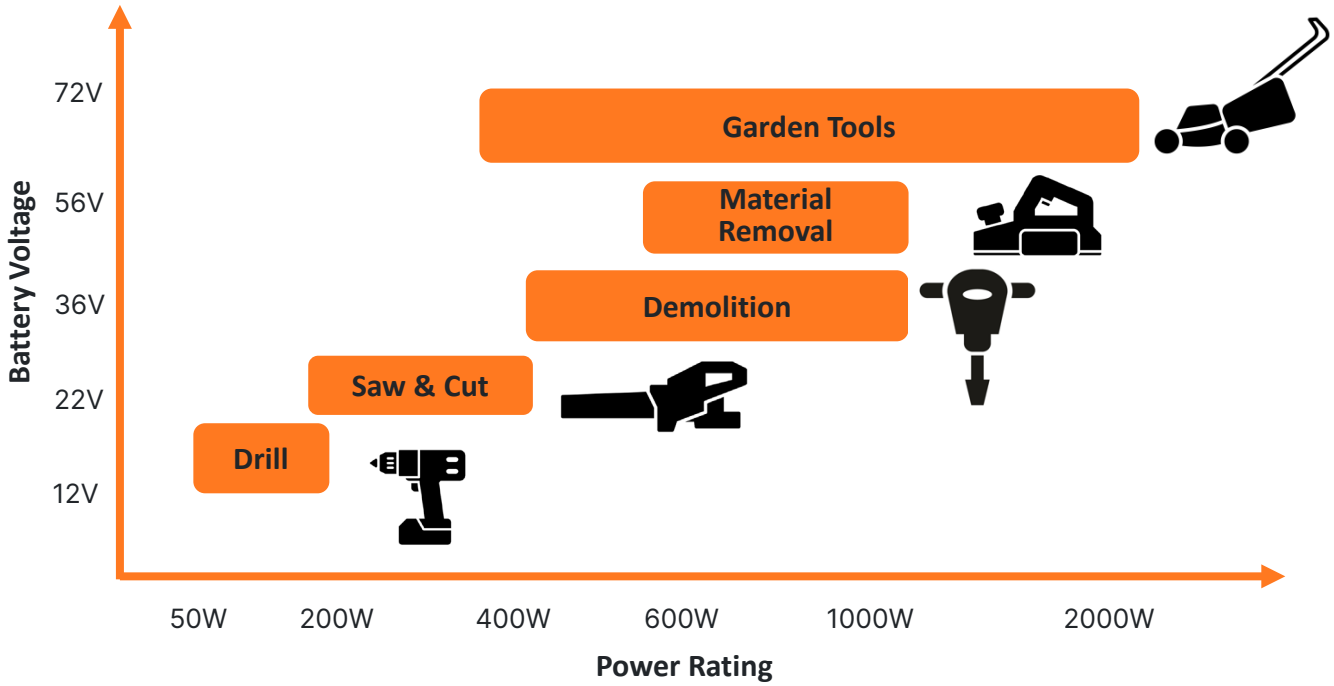



*Figure 1: Battery-powered Tool Types*

Sources: Straitsresearch, Grandviewresearch, Finance.yahoo

## Market Information & Trends

### Battery Technology and Innovation

Most cordless power tools use cylindrical Li-ion batteries in the 18650 form factor, with a nominal voltage ranging from 3.3 to 3.7 volts. Cylindrical cells can be stacked in series to increase voltage, or connected in parallel, to increase capacity, or both. Another Li-ion battery type is prismatic which improves space utilization by allowing flexible design. But this type is more expensive, less efficient thermally and shorter cycle life than cylindrical.

Manufacturers continue to refine Li-ion technology, improving the “maximum continuous discharge” (MCD) performance vs. cost, weight, charge rate, cycle life, capacity and ruggedness.

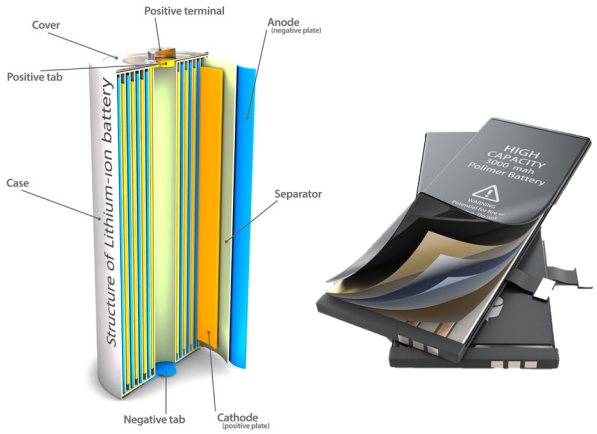



*Figure 2: Cylindrical & Prismatic Cell*

Fast charging capabilities also become a crucial feature for power tool batteries, allowing users to minimize downtime and increase productivity. Companies are investing in fast-charging technologies like lithium-titanate batteries and advanced charging algorithms to reduce charging times while maintaining battery health.

### Brushless DC (BLDC) Motors vs Brushed DC (BDC) Motors

BLDC motors are rapidly becoming the norm in high-end battery-powered tools. BLDC motors represent significant advancements over brushed DC motors as described below:

- Efficiency: BLDC motors are considerably more efficient than BDC motors
- Longevity: They have a longer lifespan due to the absence of brushes, which reduces wear and tear
- Torque: BLDC motors deliver more torque per weight, making them suitable for various applications
- Maintenance: With no brushes to replace, BLDC motors require less maintenance

As a result, tools equipped with BLDC motors boast extended lifespan and enhanced performance, making them the preferred choice for professionals and enthusiasts alike.

*Table 1: Low power BLDC vs BDC motors comparison (< 1kW)*

| Parameter | Brushed DC Motors | Brushless DC Motors (BLDC) |
|---|---|---|
| Power type | DC | DC |
| **Efficiency** | **60-80%** | **80%-95%** |
| Size | Small | Small |
| **Noise** | **Large** | **Small** |
| Speed range | Wide | Wide |
| Response | Intermediate | Intermediate |
| **Service life** | **Short** | **Long** |
| Price | Low | Intermediate or high |
| Applications | Drills<br>Small handheld tools | Garden tools<br>High-end power tools |
| Judgment | Cost focused | Efficiency focused<br>Versatility focused |

*Figure 3: BLDC Motor*

## Market Information & Trends

### LV-MV Si Power MOSFET

Market insights from one global leading manufacturer of battery-powered tools:

- **Battery Packs:** 12V, 18V and 36V variants dominate in handheld drills and screwdrivers
- **Cost Competitiveness:** The previous generations of MOSFETs are being replaced by the new more cost-effective generation
- **Voltage Usage:** 30V and 40V MOSFETs are predominantly utilized for 12V & 18V battery packs, while 60V and 80V MOSFETs are well-suited for 36V battery packs
- **Current Handling:** During stall or braking conditions, the current can increase significantly (up to 5-7 times of the rated current, which can go up to 300A)
- **$V_{th}$ (threshold voltage) Spread Consideration:** Maintaining $V_{th}$ spread tight is crucial for MOSFET paralleling
- **Dual Cool Package:** Dual cool package MOSFETs being evaluated by leading manufacturers are the new trend for higher power density


*Figure 4: Battery-powered Screwdriver*

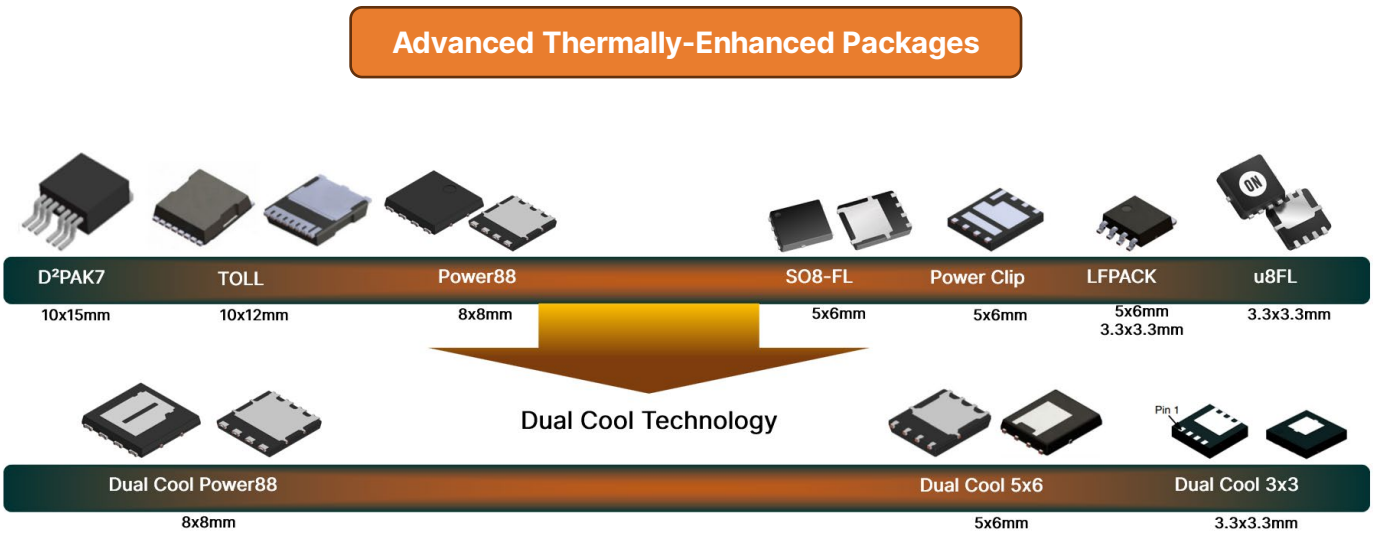
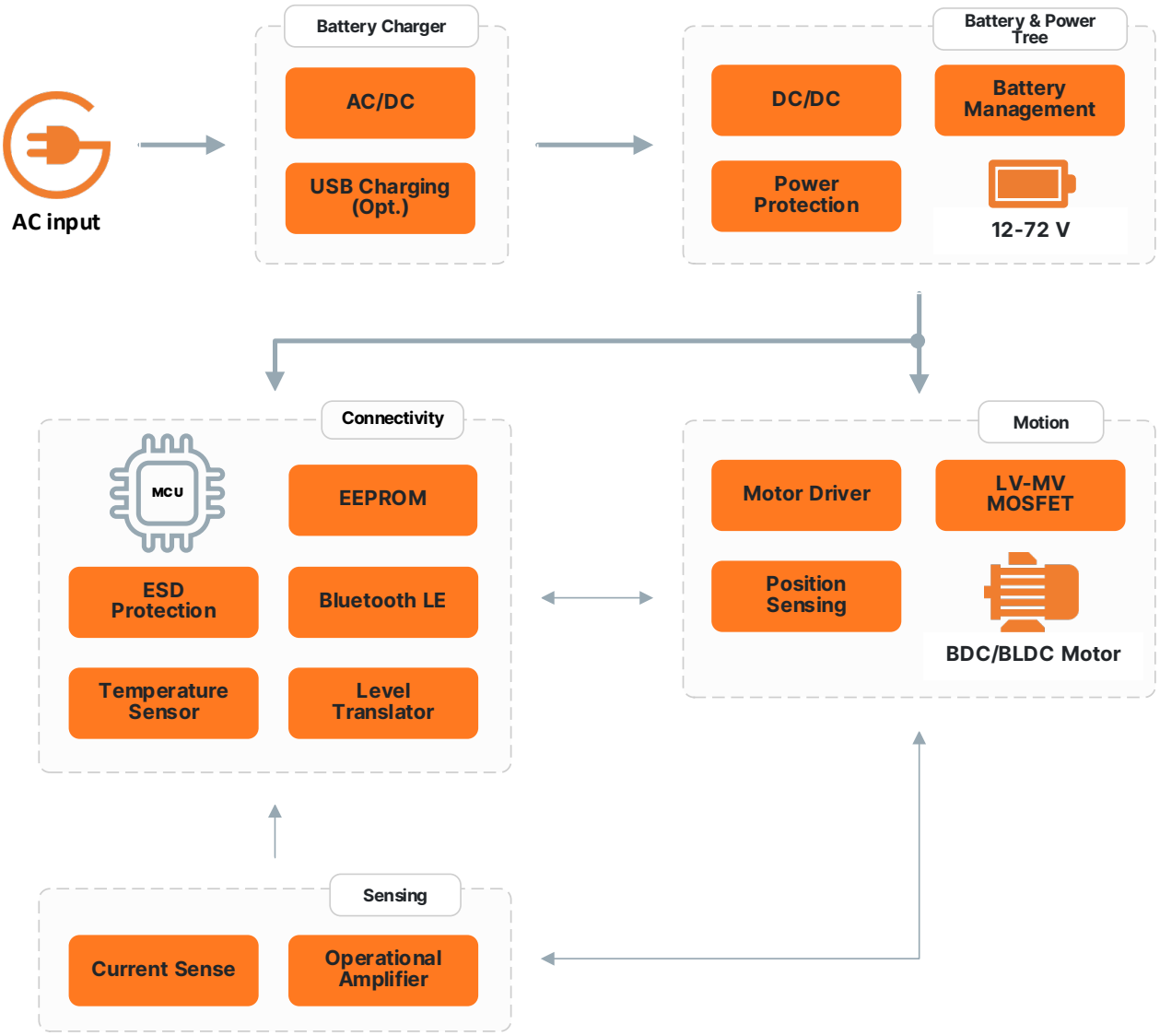



*Figure 5: **onsemi**'s LV-MV MOSFET Package for Battery-powered Tools*

## Solution Overview

### Top level topology

- Block diagram below represents Battery-powered Tools solution created by **onsemi**.
- Majority of the functional block devices can be sourced by the **onsemi** solutions as shown in the following device tables.




Find Interractive Block Diagram on the Web

## System Description

### Battery Charger

The battery charger is an essential component for battery-powered tools that efficiently recharges secondary (rechargeable) battery packs, typically including conversion from single phase 115/230 VAC to the specific battery pack voltage. The battery charger features a compact design for portability and storage and is compatible with standard electrical outlets for AC power input. The system consists of AC/DC conversion stage and safety protection subsystems against overcharging and overheating conditions.

The AC-DC charger requires PFC to improve efficiency, reduce harmonic distortion, comply with regulatory standards, and ensure stable power delivery. The topologies with more efficient performance and higher switching frequency are needed. Two stage SMPS are used for battery charger. Normally **CrM PFC + HF QR** or **ACF topologies** are used for low power applications, meanwhile **Totem Pole PFC + LLC** topologies are used for medium to high power applications.

*Table 2: Typical topologies for different power level*

| Power Level | AC-DC Topology | Switching Frequency | Efficiency |
|---|---|---|---|
| 50W – 150W | **CrM PFC + HF QR** | 100 – 200kHz | 90+% |
| 120W – 240W | **CrM PFC + ACF** | 200 – 400kHz | 91+% |
| 200W – >1kW | **Totem Pole PFC + LLC** | 500kHz | 93+% |

## Solution Overview

### AC-DC Stage (PFC Stage)

PFC is a crucial stage for AC/DC conversion. The key mission of PFC is to shape the input current to sine wave and increase overall efficiency. It could also reduce the high−frequency harmonic current to minimizes losses and costs associated not only with the distribution of the power, but also with the generation of the power and the capital equipment involved in the process.

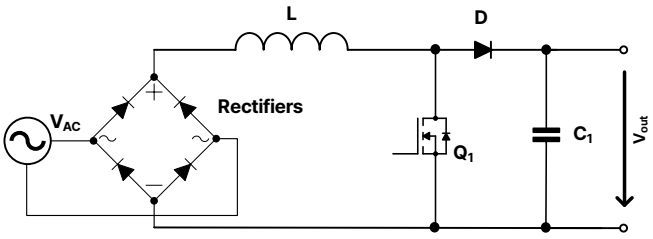



*Figure 6: Single Boost PFC*

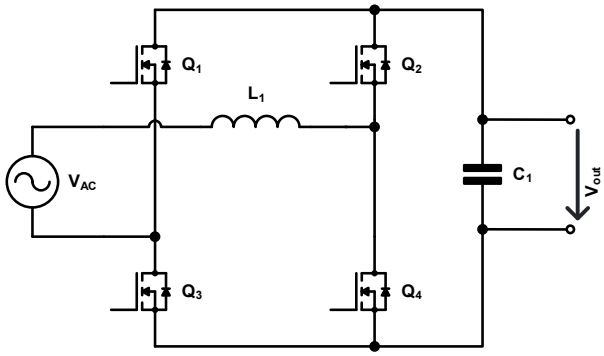



*Figure 7: Totem Pole PFC*

### DC-DC Stage (Step-down Converter/Flyback)

DC-DC stage is normally designed to incorporate a high frequency transformer between input and output for isolation to step down output voltage, and to enhance safety and signal immunity. By changing the turns ratios and duty cycle, output voltage can be easily adjusted for a large step-up or step-down. It can also realize multiple outputs by adding secondary windings and output circuits.

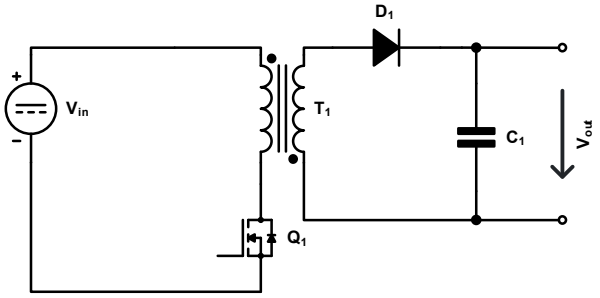



*Figure 8: Quasi-Resonant (QR) Flyback*

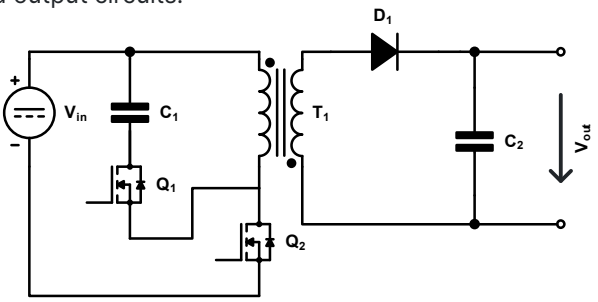



*Figure 9: Active Clamp Flyback (ACF)*

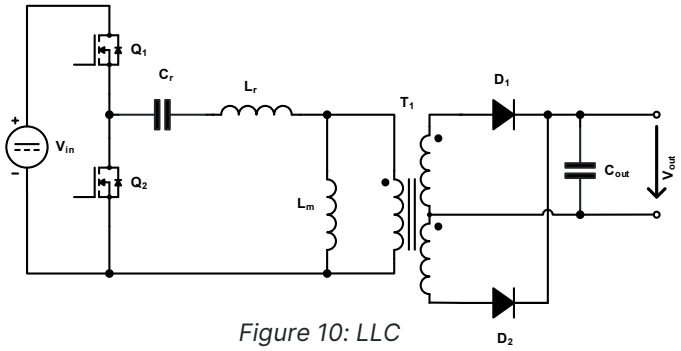



*Figure 10: LLC*

## Solution Overview

### SUPERFET, Super-junction (SJ) MOSFET Families, 600/650 V

**onsemi**'s SUPERFET® super−junction (SJ) MOSFETs families deliver best−in−class figure of merit to improve both heavy load but also light load efficiency. The 600V SUPERFET V and 650V SUPERFET III series provides design benefits through reduced conduction and switching losses, while providing superior switching performance and supporting extreme $dV_{DS}/dt$ ratings. The SUPERFET SJ MOSFETs with Fast, Easy Drive and FRFET versions offer board portfolios to meet various requirements by delivering the highest efficiency and best price/performance ratio.

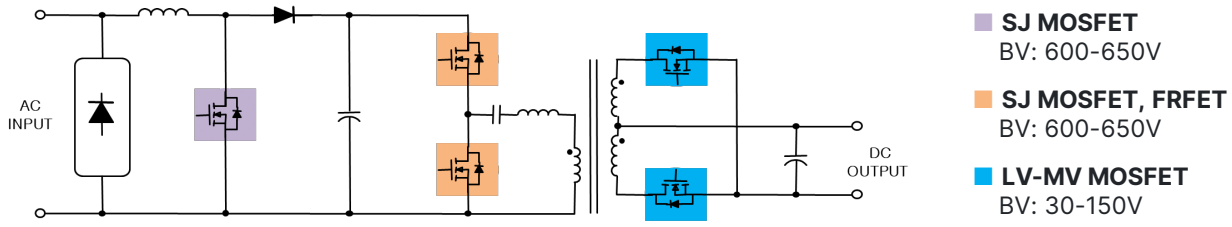



*Figure 11: Typical Battery Charging Schematic*

### SUPERFET V MOSFET NTMT080N60S5

- Ultra Low Gate Charge (Typ. Qg(tot)= 56.2 nC)
- Leadless Ultra-thin SMD package
- Kelvin Source Configuration
- 650 V @ $T_J$ = 150°C
- Typ. $R_{DS(on)}$ = 64 mΩ, $I_D$ Max = 40 A
- 100% Avalanche Tested
- RoHS Compliant
- Typical Internal Gate Resistance: 5.66 Ω

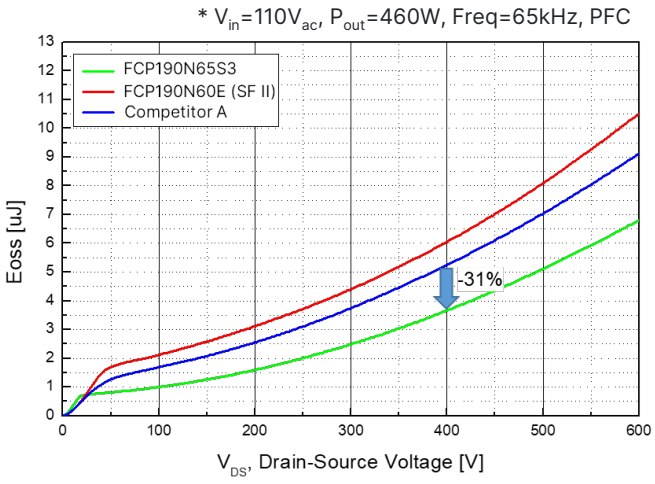
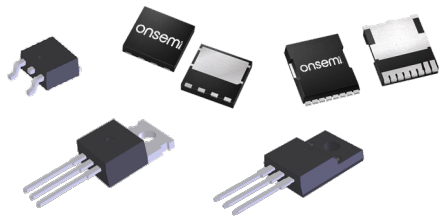



*Figure 12: Stored Energy in Output Capacitance*



*Package Variants of SUPERFET SJ MOSFET for Battery-powered Tools: D²PAK, Power88, TOLL, TO-220, TO-220F*

### SUPERFET III MOSFET FCP190N65S3

- Ultra Low Gate Charge (Typ. Qg(tot)= 33 nC)
- Low Effective Output Capacitance (Typ. Coss(eff.) = 300 pF)
- Optimized Capacitance
- 700 V @ $T_J$ = 150°C
- Typ. $R_{DS(on)}$ = 159 mΩ, $I_D$ Max = 17 A
- 100% Avalanche Tested
- RoHS Compliant
- Typical Internal Gate Resistance: 7.0 Ω

*Simulation models available on product page:*
*SIMetrix, PSpice, LTspice*

## System Description

### Battery Management and Power Tree

Battery, Battery Management and Power Tree systems are on-board parts of the power tools.

- Battery types differ case by case. Typically, cordless power tools adopt Li-ion from NiCd & NiMH batteries. Li-ion batteries have higher energy density and longer lifespan.
- Battery capacity and voltage depend on a required payload, a distance to be driven and by its charging type. Most used are battery pack systems in range of 12-72V which can be paralleled to boost the performance
- Power Tree supplies all logic levels and low voltage power rails in the system. Typically, it does not require isolation (with battery voltages below 50 V) and is implemented as multiple parallel buck converters, in combination with Linear regulators (LDOs).

The Battery Power Tree, utilizing both SMPS and LDOs, efficiently delivers necessary voltage levels to subsystems. **onsemi**'s LDOs present an optimal solution for providing precise, low-current multiple voltage levels required by various sub-components like Gate Drivers or Image Sensors.

### Linear Voltage Regulators (LDO)

**onsemi's** wide LDO families are based on a unique combination of features – ultra-low quiescent current, fast transient response and high input and output voltage ranges. Additional features, such as high PSRR & low noise, are being added as an option as well.

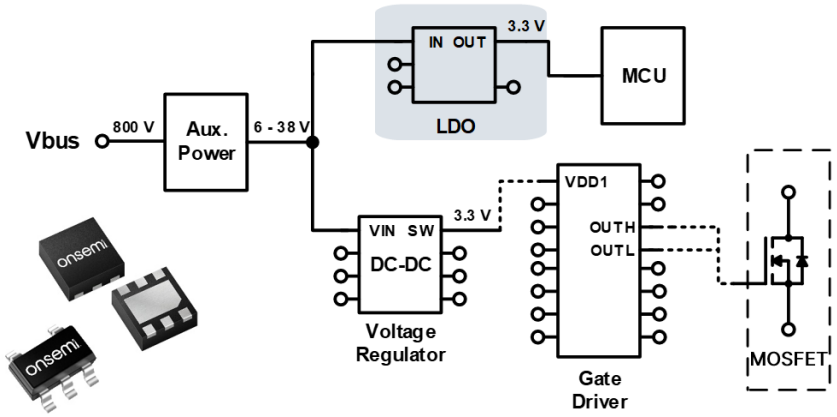
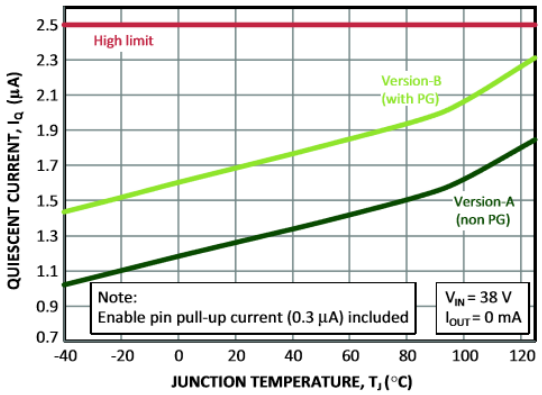



*Figure 13: LDO Application Block Diagram*

### LDO Benefits for Power Tools

- Robust operation @ extreme condition at highest temperature
- The lowest quiescent current consumption (Typ. $I_Q$ : 1.3uA @ 25°C) → Reduce charging time interval
- Safe Operating Area with Protection function (Thermal, Current)
- Diverse package availability, SOT-23, WDFN, DFN6
- Stable @ wide temp -40°C to 125°C
- Thermal Shutdown @ 165°C



## System Description

### NCP730 LDO Regulator

The NCP730 is a next generation CMOS LDO regulator designed for up to 38V input voltage and 150mA output current. Designed to meet the requirements for industrial wide-input voltage circuits. The NCP730 device provides ultra−low quiescent current of only 1uA, which makes this device ideal solution for battery powered application. Output voltage can be set from 1.2 to 24V, adjustable or fixed. The device also offer excellent load/line transient regulation and output Power Good function to reset MCU. The device is available in TSOP-5 and WDFN-6 packages.

**Key Features:**

- 2.7V to 38V input voltage
- Ultra-Low Iq : 1µA typ
- Built-in Soft Start Circuit
- Power Good function (Ver B)
- Short Circuit Protection, Thermal Shutdown Protection


TSOP-5


WDFN (2*2)

**Key Benefits:**

- Support multi-cell battery application
- Extend battery life / save power
- Suppress inrush current to protect IC
- Reset MCU to avoid malfunction

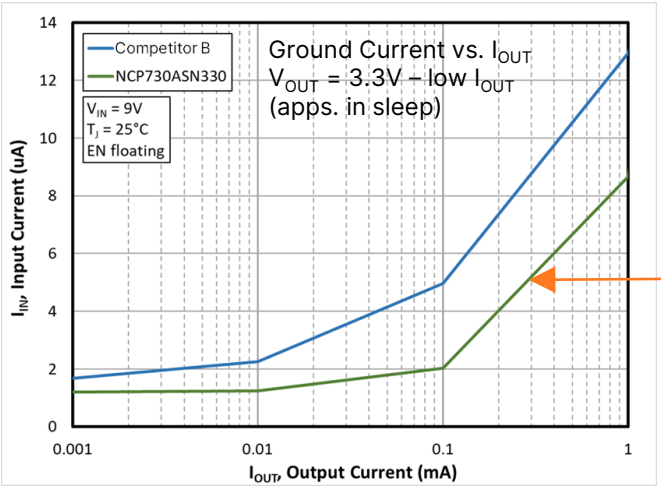



*Figure 14: NCP730 vs Competitor B Comparison*

**onsemi** provides cohesive tools which help our customers to choose the best LDO for their application.

### Web Designer+

Design your power supply with the online Web Designer+ Power Supply design tool. Select the best suitable **onsemi** products customized for your application requirements. Within seconds, we verify hundreds of possible solutions for you. Help you choose the best. This easy-to-use tool helps you save time and effort.

Create Design

## System Description

### Motion – Power Stage

Drills, garden tools & vacuum cleaners rely on Li-ion battery-powered motor drives with low-voltage setups ranging from two to tens of cells. These tools commonly feature either brushed DC (BDC) or 3-phase brushless DC (BLDC) motors. The power stage responsible for driving these motors must fulfill several crucial performance criteria to ensure optimal functionality. These criteria include a compact form factor to facilitate versatile mounting within the tool, improve board layout efficiency, and enable cost-effective designs. High efficiency is paramount for extending battery life and minimizing cooling demands. Furthermore, dependable operation and protective measures are essential for long-lasting performance and upholding product reputation.

To operate a BDC motor bi-directionally, a full bridge setup comprising two half bridges, each containing two MOSFETs, is necessary. Conversely, driving a 3-phase BLDC motor requires a 3-phase inverter consisting of three half bridges, totaling 6 MOSFETs. The topologies with proper control algorithms enable precise control over motor speed and direction, ensuring the efficient and reliable operation of battery-powered tools. The motor control uses a PWM signal to determine the commutation between the ON and OFF states. This is called the Variable Frequency Drive (VFD).

**Gate driver** serves a critical role in controlling **MOSFETs**. It essentially translates low-power control signals from the motor controller or microcontroller into high-power signals capable of driving the MOSFETs effectively, ensuring the MOSFETs switch on and off rapidly and efficiently, enabling precise control over the motor's speed and direction. They also provide protection features such as overcurrent and overvoltage protection to safeguard the motor and the drive circuitry.

**Position sensors** measure the rotation of wheels or other moving parts, to accurately track their position and orientation in their environment. They can be employed as part of the electronic commutation of the BLDC control. Inductive encoders offer many advantages over the traditional optical or magnetic sensing. They are robust, lightweight, require few components and are not sensitive to vibration or contamination.

**onsemi** offers a wide portfolio of discrete LV-MV MOSFETs, gate drivers, motor drivers and rotary position sensors for the motion block of battery-powered tools.

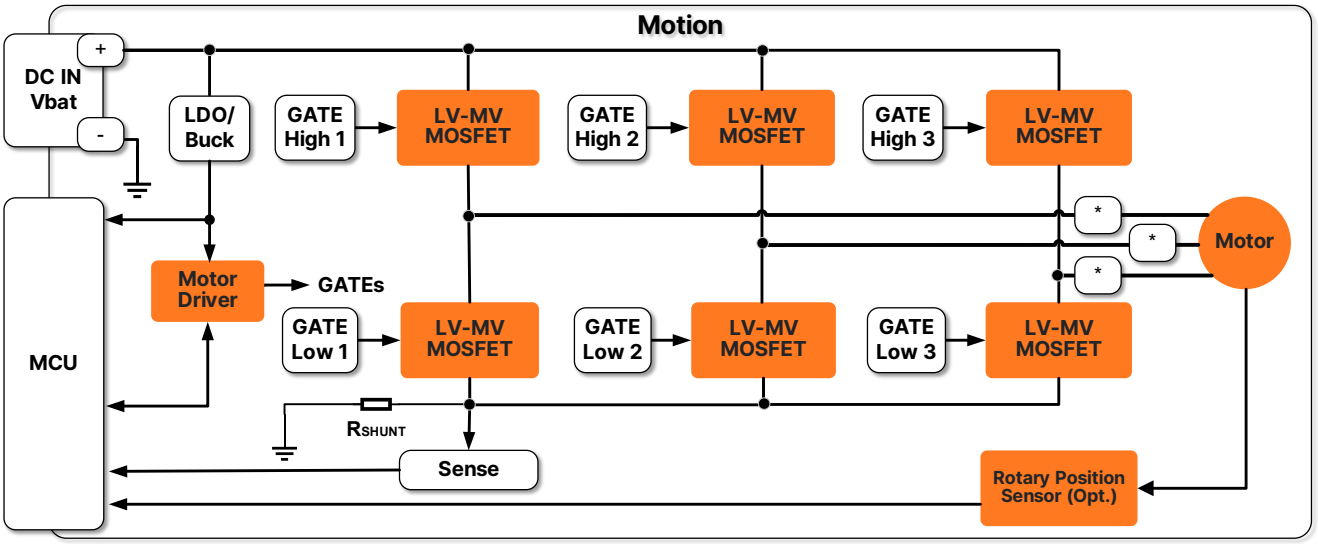



*Figure 15: Example of BLDC Motion Block Schematic*

## Solution Overview

### Gate Drivers

**onsemi**'s gate driver products offer enhanced performance, efficiency, and reliability for motor drive systems, providing precise control, minimize switching losses, and integrate robust protection features for longevity. These drivers are versatile, compatible with various motor types, and include advanced features for optimized performance and simplified troubleshooting.
The key advantages of **onsemi**'s gate drivers for high-power applications include efficiency enhancement when paired with MOSFETs, precise control over switching operations, high efficiency, and technical expertise. Leveraging **onsemi**'s solutions ensures reliable performance and reduced losses in power electronics systems. Figure 16 can be used to select the appropriate gate driver family depending on the operating voltage and drive current.

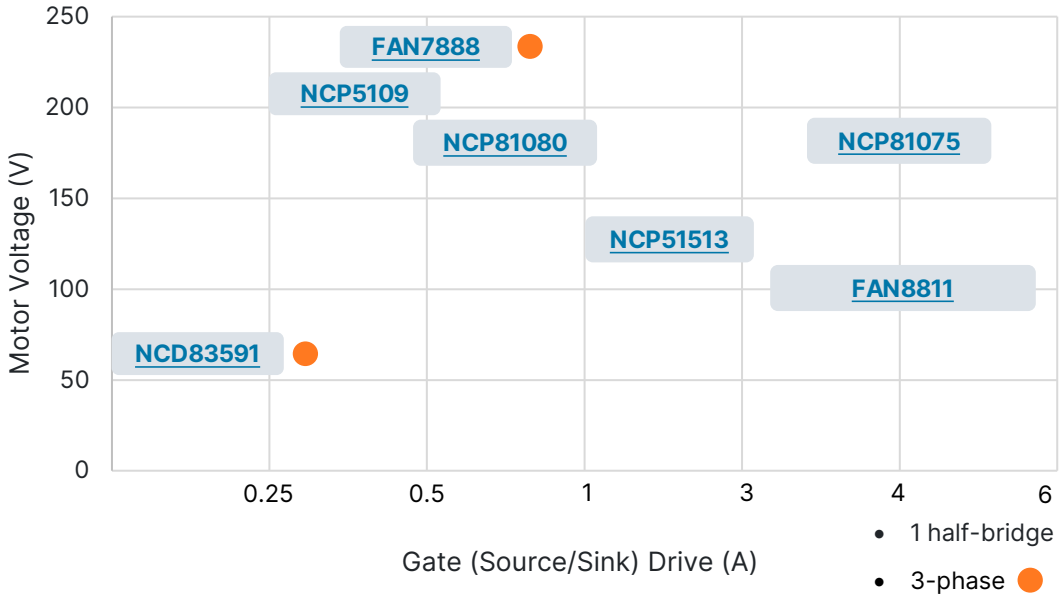
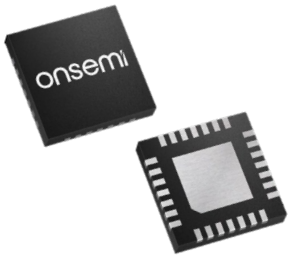



*Figure 16: **onsemi's** Gate Driver Portfolio Capabilities BLDC Motor Control*

### Gate Driver NCD83591




Three-Phase Gate Driver ideal for Industrial Applications
- **Optimized for low BOM cost**
- 5-60V operation supply range
- **Constant current drive** of FET with up to 250mA
- Embedded high GBW general purpose amplifier with external configurable gain
- Up to 30kHz motor PWM with individual six gate control mode
- Integrated Protection: UVLO, HBM and CDM ESD, internal gate pull-down during power loss
- 28-pin QFN

The constant current drive provides the same switching net transition time, but it saves the cost of a series gate resistor and requires a smaller driver circuit. Eliminating the series gate resistor also helps to prevent the self-turn on.

## Solution Overview

### LV-MV MOSFETs

**onsemi**'s LV-MV MOSFETs offer a comprehensive performance across various voltage ranges by minimizing power dissipation with low $R_{DS(on)}$ and providing efficient power subsystems. Leveraging **onsemi**'s MOSFETs enhances power factor, active-mode efficiency, and standby-mode power consumption.
The new **onsemi**'s T10 N-Channel MOSFET generation is gate shielded trench technology optimized for power applications. This devices technology presents superior figure of merits. The MOSFET includes an excellent body diode with a soft reverse recovery. Additionally, the technology works like having an integrated snubber enabling less ringing under switching applications.

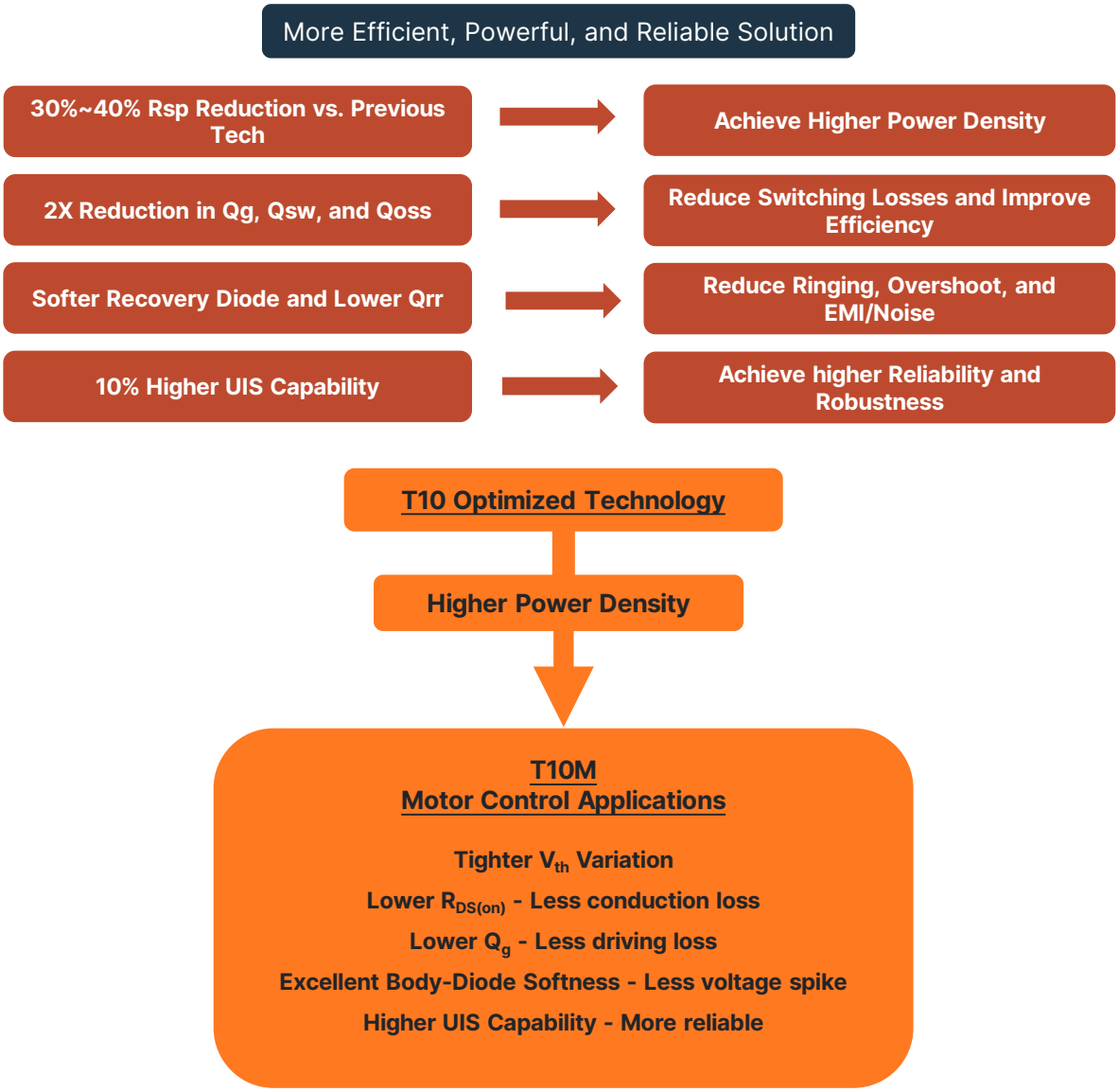



*Figure 17: T10 Technology Value Proposition*

## Solution Overview

The recommended LV-MV MOSFETs are listed on Figure 18 and could be selected according to the operating voltage and drive current.

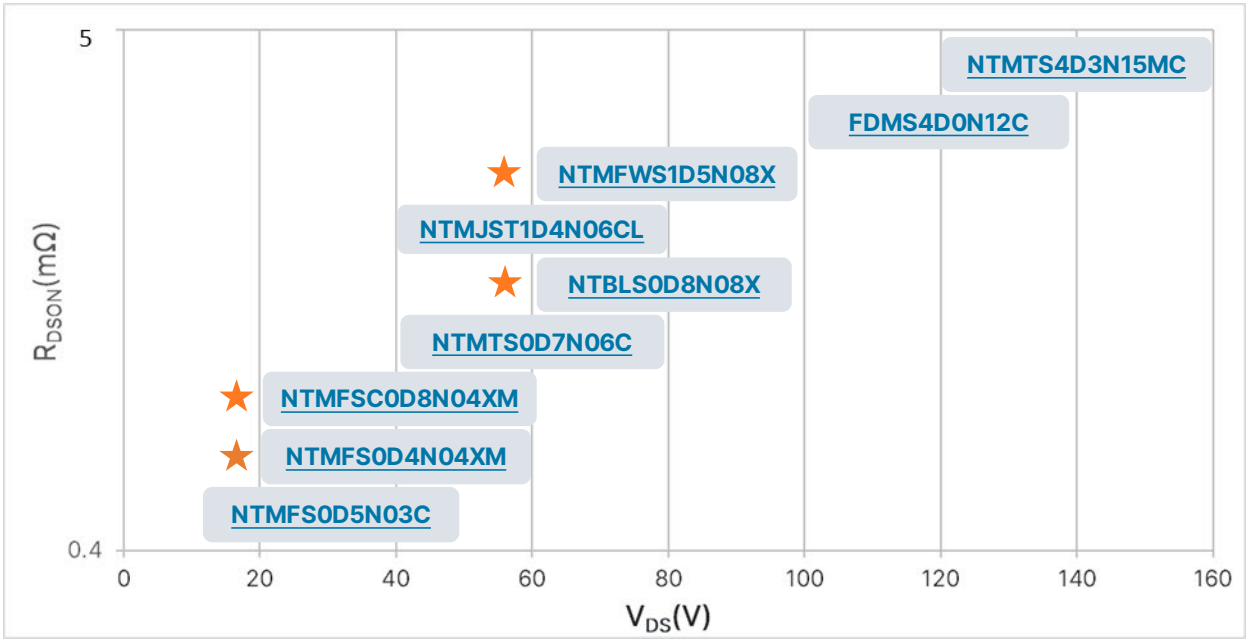
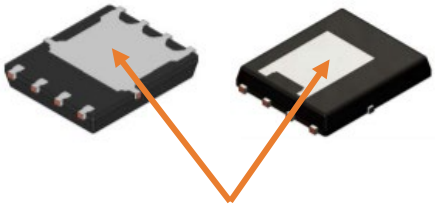



*Figure 18: **onsemi's** MOSFETs Used for BLDC Motor Control* ★ *New T10 Technology*

### MOSFET NTMFWS1D5N08X

Best-in-class 80V MOSFET from T10 family

- **Best-in-Class FOM**
  – At least 40% less than lead competitor
- **Best-in-Class On-Resistance**
  – Eliminate paralleling in the old board
- **Smaller 5 x 6mm Package**
  – Cost-effective advantage
- **Best-in-Class Soften Recovery**
  –18% less voltage spike than competitor



*Dual Cool 5 x 6mm Package*

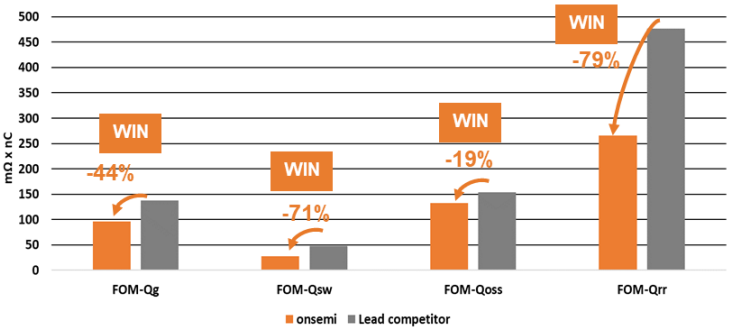



*Figure 19: T10 80V MOSFET FOM Comparison*

### MOSFET NTMFSC0D8N04XM

Latest 40 V Power MOSFET Technology from T10M

- Best-in-Class ultra low $R_{DS(on)}$
- **Dual Cool 5 x 6mm Package for higher thermal performance**
- Lower Gate Charge
- Superior Soften Recovery with low voltage spike reducing stress and EMI issues

## System Description

### Connectivity

Robotic lawn mowers are emerging as a popular tool for garden applications. In robotic lawn mowers, connectivity systems often utilize Bluetooth Low Energy to enhance functionality and user experience. Bluetooth LE provides wireless communication, enabling users to remotely control the mower, transfer data, receive notifications, and perform firmware updates via mobile devices. On the other hand, EEPROM is used for persistent data storage, holding critical configuration parameters, user settings, and operational logs that need to be retained even when the mower is powered off. Together, these technologies ensure reliable operation, convenient user interaction, and efficient maintenance of the robotic mowing system.

**onsemi** offers advanced Bluetooth LE and EEPROMs portfolios for intelligent communication management.

### Bluetooth(R) Low Energy RSL15

- Industry's lowest power flash-based secure Bluetooth Low Energy MCU
- Latest in embedded security with root of trust
- Latest in Bluetooth low energy with long range and localization

**Find more information in System Solution Guide:**

**Smart & Mobile Robotics**

Autonomous Mobile Robots (AMRs) and Automated Guided Vehicles (AGVs) are unmanned robots incorporating mobility, perception and connectivity capabilities used to transport and move around loads of various weights and size, as well as other functions.

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## Recommended Products

| Suggested Block | Part Number | Description |
|---|---|---|
| **Battery Charger – AC/DC** | | |
| **Power Management** | NCP1680 | Totem Pole CrM Power Factor Correction Controller |
| | NCP1681 | Totem Pole CCM/ Multi-mode (CrM-CCM) PFC Controller |
| | NCP1623 | CrM PFC Controller, Follower Boost |
| | Application Recommended PFC Controller | |
| | NCP1342 | Quasi-Resonant Flyback Controller with Valley Lock-out Switching |
| | NCP1343 | Quasi-Resonant Flyback Controller with Power Excursion Mode |
| | NCP1568 | AC-DC Active Clamp Flyback PWM Controller |
| | Application Recommended Flyback Controller | |
| | NCP13994 | Current Mode Resonant Controller with Integrated High Voltage Drivers, High Performance, Active X2 |
| | NCP13992 | Current Mode Resonant Controller with Integrated High Voltage Drivers, Enhanced Light Load |
| | Application Recommended LLC Controller | |
| | NCP4305 | Sync. Rectification Driver for QR, Forward & LLC |
| | NCP4318 | Dual Channel Sync. Rectification Driver for LLC |
| | Application Recommended SR Controller | |
| **HV SJ MOSFET** | NTBL070N65S3 | HV MOSFET, 650 V, 70 mΩ, 44 A, SUPERFET® III, Easy Drive, TOLL |
| | NTPF082N65S3F | HV MOSFET, 650 V, 82 mΩ, 40 A, SUPERFET® III, FRFET, TO-220F |
| | FCP190N65S3 | HV MOSFET, 650 V, 190 mΩ, 17 A, SUPERFET® III, Easy Drive, TO-220 |
| | NTMT061N60S5F | HV MOSFET, 600 V, 61 mΩ, 41 A, SUPERFET® V, FRFET, Power88 |
| | NTMT080N60S5 | HV MOSFET, 600 V, 80 mΩ, 40 A, SUPERFET® V, Easy Drive, Power88 |
| | NTP125N60S5FZ | HV MOSFET, 600 V, 125 mΩ, 22 A, SUPERFET® V, FRFET, TO-220 |
| | Application Recommended MOSFET | |
| **SiC Diode** | FFSP0665B | SiC Schottky Diode – EliteSiC, 6 A, 650 V, D2, TO-220-2 |
| | FFSM0865B | SiC Schottky Diode – EliteSiC, 8 A, 650 V, D2, Power88 |
| | FFSB1065B | SiC Schottky Diode – EliteSiC, 10 A, 650 V, D2, D2PAK-2 |
| | Application Recommended Diode | |
| **Gate Driver** | NCP51530 | High Performance, 700 V - 3.5/3.0 A High and Low Side MOSFET Driver |
| | NCP5183 | High Voltage 4.3/4.3 A High and Low Side Driver |
| | NCP51810 | High Performance, 150 V - 1/2 A Half Bridge Gate Driver for GaN Power Switches |
| | NCP51561 | 4.5/9 A Isolated Dual Channel Gate Driver with 8V UVLO and DISABLE |
| | Application Recommended Gate Driver | |

## Recommended Products

| Suggested Block | Part Number | Description |
|---|---|---|
| LV-MV MOSFET | NTMFS0D4N04XM | Power MOSFET, N-Channel, 40 V, 0.42 mΩ, 509 A, SO8-FL 5x6 |
| | NTMFSC0D8N04XM | Power MOSFET, 40 V, 0.78 mΩ, 310 A, N-Channel, DUAL COOL 5x6 |
| | NTMFWS1D5N08X | Power MOSFET, N-Channel, 80 V, 1.43 mΩ, 253 A, SO8-FL-HEFET |
| | NTBGS004N10G | Power MOSFET, N-Channel, 203 A, 100 V, D2PAK 7L |
| | NTMFS3D2N10MD | N-Channel Shielded Gate PowerTrench® MOSFET 100 V, 142 A, 3.2 mΩ |
| | NTMFS7D5N15MC | N-Channel Shielded Gate PowerTrench® MOSFET 150 V, 95.6 A, 7.9 mΩ |
| | Application Recommended MOSFET | |
| **Battery Charger – USB-C Charging Solution (Opt.)** | | |
| Power Management | NCP1680 | Totem Pole CrM Power Factor Correction Controller |
| | NCP1345 | Quasi-Resonant flyback controller for offline USB-PD and USB Type-C |
| | NCP4307 | Secondary Side Synchronous Rectification Driver with Dual Supply |
| Interfaces | FUSB15101 | Programmable USB Type-C and Power Delivery 3.1 Source Controller with PPS Support |
| HV SJ MOSFET | NTBL070N65S3 | HV MOSFET, 650 V, 70 mΩ, 44 A, SUPERFET® III, Easy Drive, TOLL |
| | NTPF082N65S3F | HV MOSFET, 650 V, 82 mΩ, 40 A, SUPERFET® III, FRFET, TO-220F |
| | FCP190N65S3 | HV MOSFET, 650 V, 190 mΩ, 17 A, SUPERFET® III, Easy Drive, TO-220 |
| | NTMT061N60S5F | HV MOSFET, 600 V, 61 mΩ, 41 A, SUPERFET® V, FRFET, Power88 |
| | NTMT080N60S5 | HV MOSFET, 600 V, 80 mΩ, 40 A, SUPERFET® V, Easy Drive, Power88 |
| | NTP125N60S5FZ | HV MOSFET, 600 V, 125 mΩ, 22 A, SUPERFET® V, FRFET, TO-220 |
| Gate Driver | NCP51530 | High Performance, 700 V - 3.5/3.0 A High and Low Side MOSFET Driver |
| | NCP51810 | High Performance, 150 V - 1/2 A Half Bridge Gate Driver for GaN Power Switches |
| LV-MV MOSFET | NTMFS0D4N04XM | Power MOSFET, N-Channel, 40 V, 0.42 mΩ, 509 A, SO8-FL 5x6 |
| | NTMFSC0D8N04XM | Power MOSFET, 40 V, 0.78 mΩ, 310 A, N-Channel, DUAL COOL 5x6 |
| | NTMFWS1D5N08X | Power MOSFET, N-Channel, 80 V, 1.43 mΩ, 253 A, SO8-FL-HEFET |
| | NTBGS004N10G | Power MOSFET, N-Channel, 203 A, 100 V, D2PAK 7L |
| | FDMS4D0N12C | N-Channel Shielded Gate PowerTrench® MOSFET 120 V, 118 A, 4.0 mΩ |
| | NTMFS3D2N10MD | N-Channel Shielded Gate PowerTrench® MOSFET 100 V, 142 A, 3.2 mΩ |
| | NTMFS7D5N15MC | N-Channel Shielded Gate PowerTrench® MOSFET 150 V, 95.6 A, 7.9 mΩ |

## Recommended Products

| Suggested Block | Part Number | Description |
|---|---|---|
| **Protection** | | |
| **eFuse** | NIS3071 | eFuse, 4 channel, 60 V, 10 A, 155 mΩ |
| | NIS6350 | eFuse, 5 V, 3 A, 85 mΩ |
| | NIS6452 | eFuse, 3.3/5 V, 5 A, 60 mΩ |
| | NIS5420 | eFuse, 12 V, 4 A, 50 mΩ |
| | Application Recommended eFuse | |
| **SmartFET** | NCV84045 | Self Protected High Side Driver with Analog Current Sense, 32 A |
| | NCV84090 | Self Protected High Side Driver with Analog Current Sense, 24 A |
| | NCV84120 | Self Protected High Side Driver with Analog Current Sense, 18 A |
| | Application Recommended SmartFET | |
| **Battery Protection** | NCID9 series | High Speed Dual/3ch/Quad Digital Isolator |
| | NRTS1560PFS | Schottky Diode, 60 V, 15 A |
| | NRTS30120MFS | Schottky Diode, 100 V, 30 A |
| | SZMMSZ52 | Zener Diode, 500 mW, SOD-123 |
| | FDMS86163P | P-channel MOSFET, 100 V, 50 A, 22 mΩ |
| | ATP304 | P-channel MOSFET, 60 V, 100 A, 6.5 mΩ |
| | NCS35011 | An ultra−low power protection integrated circuit managing Li−ion batteries from 3 to 5 cells in series |
| **Power Tree** | | |
| **DC/DC** | FAN65008B | Synchronous Buck Regulator, 65 V, 10 A |
| | FAN65004B | Synchronous Buck Regulator, 65 V, 6 A |
| | NCP5252 | Synchronous Buck Regulator, 13 V, 2 A |
| | NCP1589A | Synchronous Buck Regulator, 13 V, External MOSFET |
| | NCP6324 | Synchronous Buck Regulator, 5.5 V, 2 A |
| **LDO** | NCP781 | LDO, 100 mA, 150 V, High PSRR |
| | NCP730 | LDO, 150 mA, 38 V, 1 uA IQ, with Power good |
| | NCP164 | LDO, 300 mA, Ultra-low noise, Power good |
| | NCP189 | LDO, 500 mA, Low noise, Power good |
| | NCP59801 | LDO, 1 A, Low noise, High Accuracy with Power Good |
| | Application Recommended LDO | |

## Recommended Products

| Suggested Block | Part Number | Description |
|---|---|---|
| **Motion - Driving Stage** | | |
| Gate Driver | NCD83591 | Multi−purpose 3−phase gate driver, 60 V |
| | NCP5109 | Dual Input, High Voltage, High and Low Side, 200 V |
| | FAN7888 | Monolithic three-phase half-bridge gate-drive IC, 200 V |
| | NCP81080 | High and Low Side half bridge driver, 180 V |
| | NCP51513 | High and Low Side half bridge driver, 130 V |
| | NCP81075 | High Side and Low Side Gate Driver, High-Frequency, 180 V |
| | FAN8811T | High-Frequency, High Side and Low Side Gate Driver, 80 V |
| | Application Recommended Gate Driver | |
| LV-MV MOSFET | NTMFS0D5N03C | Power MOSFET, 30 V, 0.52 mΩ, 464 A, N-Channel, SO8-FL 5x6 |
| | NTMFS0D4N04XM | Power MOSFET, 40 V, 0.42 mΩ, 509 A, N−Channel, SO8-FL 5x6 |
| | NTMFSC0D8N04XM | Power MOSFET, 40 V, 0.78 mΩ, 310 A, N-Channel, DUAL COOL 5x6 |
| | NTMTS0D7N06C | Power MOSFET, 60 V, 0.72 mΩ, 464 A, N-Channel, PQFN 8x8 |
| | NTMJST1D4N06CL | Power MOSFET, 60 V, 1.49 mΩ, 198 A, N-Channel, TCPAK57 |
| | NTBLS0D8N08X | Power MOSFET, 80 V, 0.79 mΩ, 457 A, N-Channel, TOLL |
| | NTMFWS1D5N08X | Power MOSFET, 80 V, 1.43 mΩ, 253 A, N−Channel, SO8-FL 5x6 |
| | FDMS4D0N12C | Power MOSFET, 120 V, 4.4 mΩ, 114 A, N−Channel, PQFN 5x6 |
| | NTMTS4D3N15MC | Power MOSFET, 150 V, 4.45 mΩ, 174 A, N−Channel, PQFN 8x8 |
| | Application Recommended MOSFET | |
| **Motion – Control & Sensing** | | |
| Position Sensor | NCS32100 | Industrial Rotary Position Sensor - 6000 RPM full accuracy, 50 arcsec accuracy |
| | NCV77320 | Inductive Position Sensor Interface, linear or angular position, SPI |
| Motor Driver | LV8324C | 24V Single-phase BLDC Motor Driver, PWM control |
| | LV8961HUW | Sensorless three-phase BLDC motor controller and predriver |
| | LV8968BBUWR2G | Multipurpose three-Phase BLDC predriver, compliance with ISO 26262 |
| | LV8907UW | Sensorless three-Phase BLDC motor controller and predriver, Auto |
| | NCV70628 | LIN Micro-Stepping Motor Driver 800mA |

## Recommended Products

| Suggested Block | Part Number | Description |
|---|---|---|
| **Sensing** | | |
| **Current Sense** | NCS214R | Current Sense Amplifier, 26 V, Low-/High-Side Voltage Out, Bidirectional Current Shunt Monitor |
| | NCS21671 | Current-Shunt Monitors, Zero-Drift, 40 V Common Mode, Bidirectional, Shutdown |
| | NCS7030 | Current Sense Amplifier, 80 V Common Mode |
| **Operational Amplifier** | NCS21911 | Precision Operational Amplifier, 2 MHz Bandwidth, Low Noise, Zero-Drift, 25 µV Offset |
| | NCS333 | Low Power, Zero-Drift Operational Amplifier with 10 µV Offset |
| | NCS20166 | Precision Operational Amplifier, Low Offset, 10 MHz, Rail-to-Rail Input / Output |
| | NCS20034 | Quad Op-Amp, 7 MHz, High Slew Rate, Rail-to-Rail Output |
| | Application Recommended Operational Amplifier | |
| **Connectivity** | | |
| **Temperature Sensor** | N34TS108 | Low-Voltage Digital Temperature Sensor |
| **EEPROM** | CAT24C64 | EEPROM, 64Kb I2C |
| | CAT24C128 | EEPROM, 128Kb, I2C |
| | CAT24C256 | EEPROM, 256Kb, I2C |
| | CAT24M01 | EEPROM, 1Mb, I2C |
| **Level Translator** | NLA9306 | Level Translator for I2C |
| | FXMA2102 | Level Translator for I2C |
| | FXMA2104 | Level Translator for SPI |
| **ESD Protection** | ESD5101 | ESD, 3.3V, 5.5pF, DSN-2 |
| | ESD7504 | ESD, 3.3V, 0.55pF, UDFN-10 |
| | ESD7551 | ESD, 3.3V, 0.55pF, X2DFN-2 |
| **Bluetooth LE** | RSL15 | Bluetooth 5.2 Secure Wireless MCU |

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## Technical Documents

| Type | Description & Link |
|---|---|
| **General** | |
| Blog | The Cordless Power Tool Ecosystem |
| Webinar | Brushless DC(BLDC) Motor Design: A New Starting Point |
| Collateral | Power Supply Solutions |
| Tutorial | Next Generation Li Ion Battery Management Solutions |
| **PFC & LLC** | |
| Whitepaper | Popular Topologies in Offline Power Supplies |
| Webinar | Ultra-high density 300W Power Supplies with Totem Pole PFC and Integrated Driver GaN |
| Webinar | 1kW and 600W Power Supply Reference Designs |
| Application Note | NCP1680 – CrM Totem Pole PFC IC Tips and Tricks |
| **Super Junction MOSFET** | |
| Application Note | Driving and Layout Design for Fast Switching Super-Junction MOSFETs |
| Application Note | 650V SUPERFET III Easy Drive, the optimized high voltage Super Junction MOSFETs for hard and soft |
| **LV-MV MOSFET** | |
| Application Note | MOSFET Basics |
| Application Note | Top Cool Package for Power Discrete MOSFETs |
| Whitepaper | Physically Based, Scalable SPICE Modeling Methodologies for Modern Power Electronic Devices |
| Whitepapers | Advanced Industrial Motor Control for Increased Power Efficiency |
| **Gate Driver** | |
| Webinar | Ultra-high density 300W Power Supplies w/ Totem Pole PFC & Integrated Driver GaN |
| Application Note | Application Review and Comparative Evaluation of Low-Side Gate Driver |
| Application Note | Practical Design Guidelines on the Usage of an Isolated Gate Driver |
| Application Note | Design and Application Guide of Bootstrap Circuit for High-Voltage Gate-Drive IC |
| Application Note | Analysis of Power Dissipation and Thermal Considerations for High Voltage Gate Drivers |
| **LDO Regulator** | |
| Webinar | Understanding PSRR Performance with High Performance LDO Products |
| Application Note | Stability in High Speed Linear LDO Regulators |

## Technical Documents

| Type | Description & Link |
|---|---|
| **Connectivity** | |
| System Solution Guide | System Solution Guide - Smart & Mobile Robotics |
| Whitepaper | Designing Power-Efficient Wireless Location Finding Systems |
| Application Note | Developing a Location Finding System |
| **Inductive Sensor** | |
| Application Note | Inductive Sensor Design Principles |
| Webinar | Inductive Position Sensors for Industrial and Transportation Markets |
| **BLDC Motor** | |
| Whitepaper | DC Motor Driver Fundamentals |
| Whitepaper | Trapezoidal Control of BLDC Motors |
| Evaluation Kit | Evaluation board for LV8968B |
| Evaluation Kit | Evaluation Kit for LV8961H |

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