

A89212 Motor Control System on Chip

# Unleashing the Potential of Battery-Operated Power Tools



SENSING AND POWER REIMAGINED

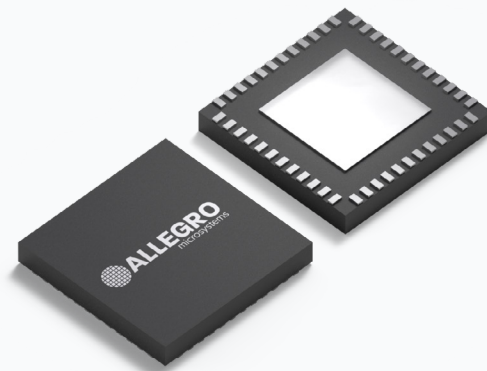


## The Power Tool Revolution: A Need for Innovation

The professional power tool industry is undergoing a significant transformation, driven by the increasing demand for high-performance, cordless, battery-operated solutions. Professionals are embracing these tools for their unparalleled convenience, portability, and performance. This shift necessitates innovative motor control solutions that can deliver maximum power and efficiency within increasingly compact and robust designs, creating unique and complex challenges for design engineers.

### The A89212: A Cutting-Edge Solution for Professional-Grade Tools

The A89212 emerges as a cutting-edge System-on-Chip (SoC) solution, purpose-built to address the unique challenges of battery-operated power tool design for professional applications. By integrating a wide operating voltage range, high-performance motor control capabilities, and robust protection features, the A89212 empowers designers to create a new generation of power tools that are more powerful, efficient, and reliable than ever before. This white paper explores the key benefits of the A89212, demonstrating how its innovative design addresses key design bottlenecks and enhances overall system performance while reducing development costs and accelerating time to market.



### The Challenge: Designing for Diverse Professional Power Tool Needs

The professional power tool market is characterized by a wide array of applications, each demanding specific performance characteristics. From lightweight hand-held drills to heavy-duty chain saws and concrete breakers, manufacturers face the challenge of creating tools that meet diverse voltage, current, and torque requirements for demanding professional use. This has traditionally required multiple tool platform designs to meet all the diverse performance requirements.

Traditionally, this diversity has led to fragmented designs, with manufacturers developing separate platforms for different product ranges. Each platform requires its own set of components, software, and validation processes. This approach results in:

- ▶ **Increased Development Costs:** Multiple platforms mean duplicated engineering efforts, higher component inventories, and increased testing expenses.
- ▶ **Extended Time-to-Market:** Developing and maintaining multiple platforms slows down the introduction of new products.
- ▶ **Limited Scalability:** Adapting existing designs to new power levels or feature sets can be difficult and time-consuming.

## The A89212: The Single-Platform Solution for Professional Power Tools

The A89212 is a high-performance system-on-chip (SoC) motor controller designed to meet the evolving needs of battery-operated power tools. By integrating key functionalities into a single chip, the A89212 enables designers to create flexible, scalable, and cost-effective power tool platforms, reducing development cycle times and costs, and enabling rapid adaptation to new market demands and technology advancements.

## Key Benefits of A89212 in Professional Power Tool Applications:

- **Scalability:** The large operating voltage range (5.5V to 90V) enables the support of various battery types and power ratings. This may range from small 12V handheld drills to a large 56V lawnmower, eliminating the need for separate designs for different power levels. The A89212 allows system designers to use the same PCB, saving test time, offloading software resources, and faster development and enabling scalability. Compared to a typical conventional approach, based on fragmented individual designs per application, the development cost and time can be reduced by up to 50%.

- **High Integration:** The A89212 incorporates essential motor control functions, including:

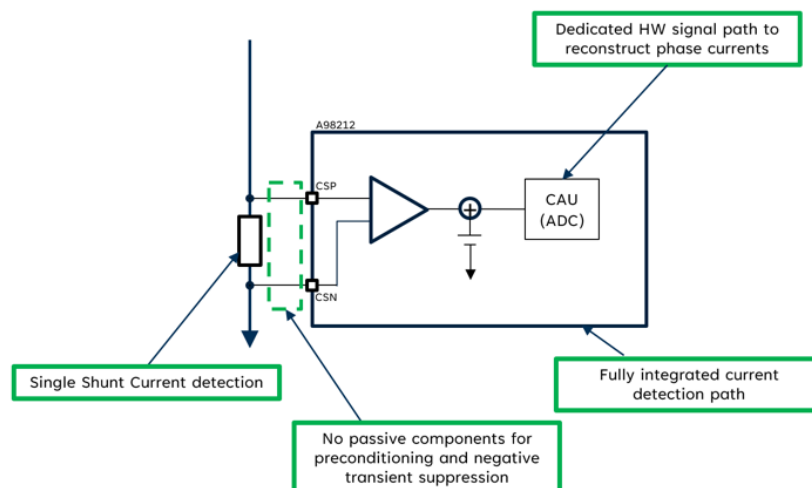
**40 MHz ARM Cortex-M4 CPU Core with FPU:** Provides ample processing power and memory for advanced motor control algorithms. The Cortex-M4 processor core also offers a Single-precision Floating Point Unit (FPU) and DSP instruction set which accelerates math calculations, further enhancing motor control algorithm processing with minimal overhead.

**Single solution of microcontroller and integrated 3-phase GDU (Gate Driver unit)** enabling area savings on PCB and more compact overall Hardware design. Leveraging from the expertise of Allegro in Power solutions, the GDU is designed as an N-channel power MOSFET driver capable of controlling MOSFETs connected on a three-phase bridge arrangement. It is specifically designed for power applications with high-power inductive loads, such as BLDC motors, which are becoming increasingly common across all industrial applications.

**PWM Generator:** Enables precise control of motor speed and torque via dead time and two different options for inverter switches duty cycles updates, to maximize efficiency and smoothness of operation.

By employing a **single shunt resistor for current sensing**, the A89212 minimizes the external component count, reducing both BOM costs and PCB area requirements. This streamlined approach simplifies design and enhances system reliability.

**Programmable high performance sensing amplifier**, located in the GDU, unlocks flexibility for difference current sensing range. The A89212's high-speed current acquisition, achieved in less than 1 $\mu$ s, enables precise, real-time motor control and minimizes the impact of PWM switching noise, resulting in smoother operation and improved performance.



The Current Acquisition Unit block, coupled with the current sensing amplifier delivers accurate current measurements for efficient motor control and protection with up to 12 bits resolution, employing up to 3 ADCs blocks.

Dual Serial Communication interfaces (SCI) via both UART and SAP facilitate seamless communication with other system components. This high level of integration reduces the bill of materials (BOM) cost, simplifies PCB layout, and enables compact designs.

Versatility in functionality due to up to 8 General Purpose Input/Output Terminals

Advanced Motor Control support via the AMCT block which offers specific HW features which enable the development of both sensed (Hall sensors reading) and sensorless solutions

Ample memory storage for SW deployment:

- Up to 256kB Flash
- 32kB DRAM
- 8kB IRAM
- 32kB Boot ROM

► **Robustness:** The A89212 is designed to withstand the harsh electrical environments common in power tool applications. Amongst others it boasts best-in-class negative transient protection down to -18V, built directly into the circuitry. This is crucial for power tools, where large transient pulses are common when switching MOSFETs controlling high-power motors. This built-in protection minimizes the need for external components, saving board space and BOM costs. Furthermore, the A89212 incorporates a comprehensive suite of protection features, safeguarding the system against potential faults and ensuring reliable operation even in harsh power tool environments. These protection features include:

**Overtemperature Protection (OTP):** The OTP circuit monitors the junction temperature of the A89212. If the temperature exceeds a predefined threshold, the OTP is triggered to prevent a thermal runaway and potential damage to the part and its surrounding components.

**Overcurrent Protection (OCP):** OCP safeguards the A89212 and protects the system from damage due to excessive current, preventing component failures and ensuring safe operation.

**Overvoltage Protection (OVP):** OVP protects the A89212 and the external MOSFETs from excessive voltage levels, which can occur due to voltage spikes, load dumps, or other transient events.

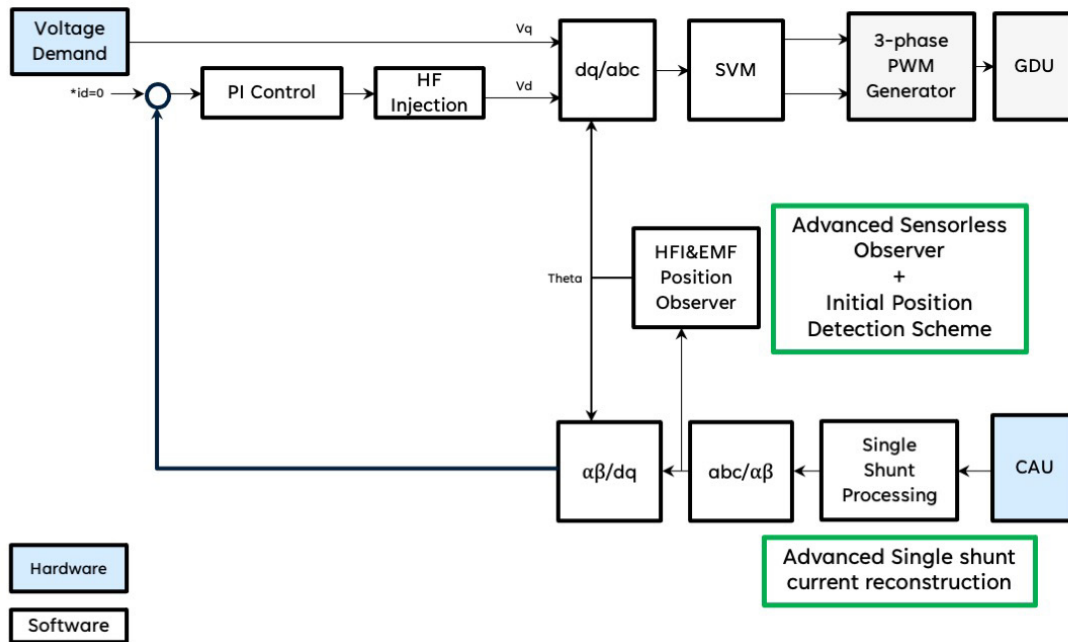
**VDS Monitoring:** VDS monitoring detects faults on the external MOSFETs by monitoring their drain-source voltage (VDS). This allows for the detection of short circuits, open circuits, and other MOSFET failures.

## Flexibility and Performance

The programmability of its ARM Cortex-M4 core further enhances its flexibility. Designers can configure various parameters, such as PWM frequency, dead time, and current limits, to optimize performance for specific motor and load conditions. This programmability enables designers to fine-tune the A89212 for a wide range of power tools, from high-speed cutting tools to high-torque fastening tools.

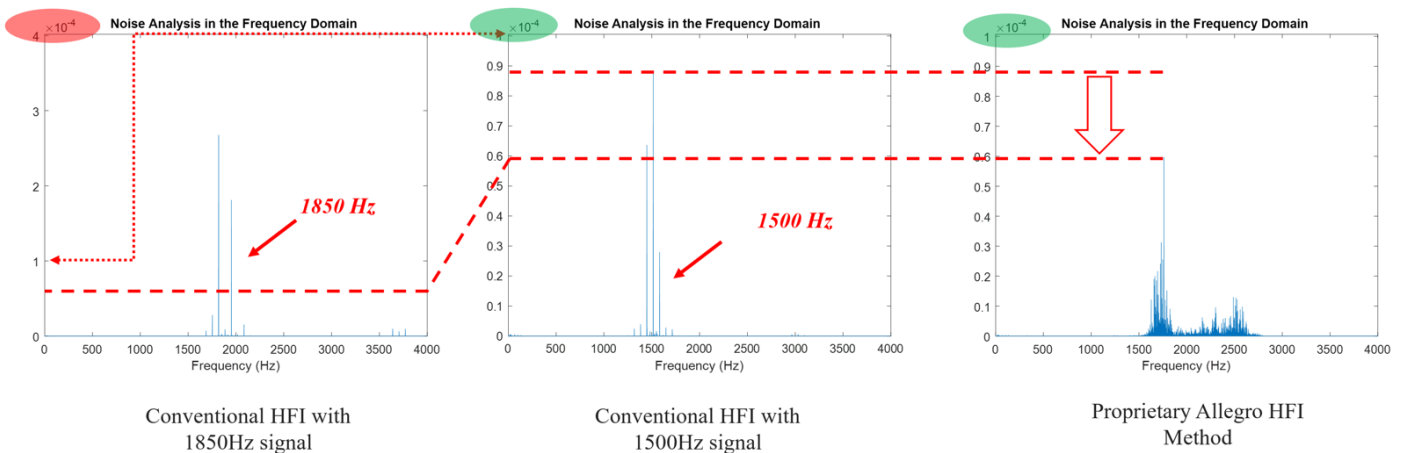
The A89212's core enables the implementation of sophisticated motor control algorithms, such as Field-Oriented Control (FOC), which optimize motor efficiency and performance. This allows power tools to deliver more power with less energy consumption. The fast capture and conversion time allow maximum time for a motor control algorithm to calculate the FOC algorithm before the next PWM duty cycle.

The A89212 via the AMCT retains the capability of sensor-ed motor control, as well as it unlocks the ability for sensors free solutions for speed and rotor position estimation, enabling advanced sensorless Field-Oriented Control (FOC) and High Frequency Injection (HFI).



HFI for sensorless operation removes external sensors, reducing system complexity and BOM cost, and provides reliable torque at zero speed. This allows for more precise control and improved starting torque, crucial for demanding applications. Additionally, it is possible to reach noise reduction related to system operation with spectral signals related to the intrinsic motor functionality in high-frequency-injection. The proprietary Allegro Microsystems Motor Control

Library is an example of this, being able, with a single shunt current sensor, to employ a high-frequency-injection based control method for low-speeds and high torques demands. This provides a significant noise reduction, due to multi-tone injection against a common industrial standard of mono-tone injection (up to 25% noise reduction).



## Example Applications for the Professional Market

The A89212 is ideally suited for a wide range of battery-operated power tools, including:



**Drills and Drivers:** The A89212 can provide precise speed and torque control for drills and screw-drivers, maximizing battery life and ensuring consistent performance for demanding professional tasks.



**Saws:** The A89212's overcurrent protection and VDS monitoring features safeguard against blade jams and motor failures in saws, improving safety and reliability for professional users.



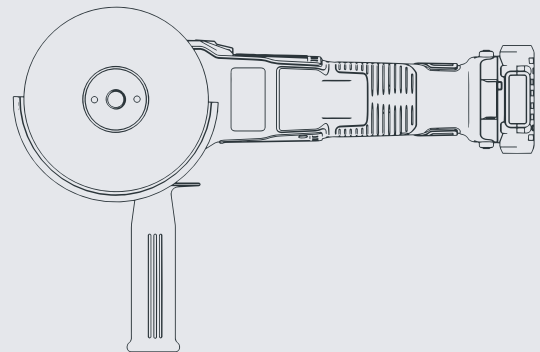
**Angle grinders:** the A89212 is able to deal with significantly high-power/high-speed tools requiring high frequency electric motor current control, with demanding accelerations start-up zero to full speed, and with sudden stop for safety



**Lawn Mowers and Garden Tools:** The A89212 can enable efficient and reliable operation of lawn mowers, string trimmers, and other garden tools, extending runtime and reducing maintenance requirements for commercial landscaping applications.

## Conclusion: A89212 – Powering the Future of Battery-Operated Tools for Professionals

The A89212 stands as the ideal system-on-chip solution for battery-operated power tools, empowering designers to create a new generation of high-performance, efficient, and robust products. Its wide operating voltage range, high integration, and comprehensive protection features address the key challenges of power tool design, enabling a single-platform approach that reduces development costs and time-to-market. With the A89212, Allegro continues to drive innovation in motor control solutions, paving the way for a future where power tools are more powerful, reliable, and user-friendly than ever.



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