

# What Happens When Low-voltage BLDC Motors Drive Appliance Subsystems

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Given their high efficiency, lower audible noise and long life cycles, brushless DC (BLDC) motors are widely used in household appliance subsystems such as refrigerator, dishwasher and washing machine fans and pumps. These subsystems usually require less than 100W of output power for the motor and are typically driven by high DC voltages (over 150/300V) derived from the 110/230V<sub>AC</sub> mains. In this blog post, I'll discuss an alternative solution for driving appliance subsystems using a low-voltage (typically 24V) motor drive.

For high-voltage motors, the AC mains supply is rectified to get the high-voltage DC bus, which drives the inverter stage consisting of discrete insulated-gate bipolar transistors (IGBTs), MOSFETs or integrated power modules (IPMs). The system usually requires a bias power supply to provide 5V<sub>DC</sub> or 3.3V<sub>DC</sub> supplies to the controller units and 12V or 15V for the gate driver. [Figure 1](#) shows the typical block diagram of a high-voltage motor-control system.

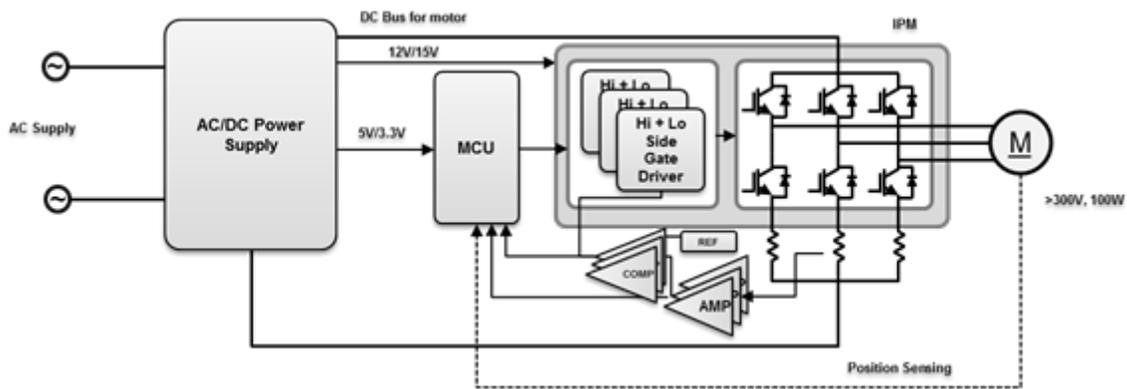


Figure 1. System Block Diagram for a High-voltage Motor Control System

In low-voltage DC motor-drive systems, the AC/DC power-supply unit generates a lower DC bus voltage (such as 24V) with the required output-power capability. The power stage uses this low DC bus voltage to drive the motor. Using voltage regulators enables the AC/DC power-supply unit to derive the required bias power supplies.

Figure 2 shows the typical block diagram of a low-voltage motor-control system.

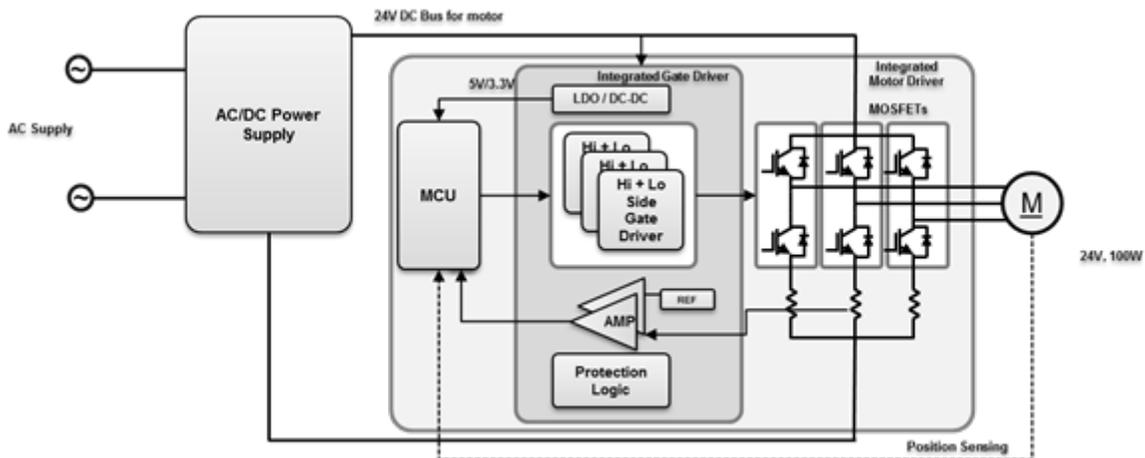


Figure 2. System Block Diagram for a Low-voltage Motor-control System

Here are some benefits of low-voltage motor-control systems:

- **Safety.** The most obvious benefit of low-voltage motors is that they make systems safer for maintenance service personnel and designers. Moving pumps and fans to a low voltage keeps the major part of the system isolated from the high-voltage input.
- **Integration level.** The latest low-voltage motor controller integrated circuits (ICs) are highly integrated, with features like cycle-by-cycle overcurrent protection, overtemperature protection, stall detection, auto dead-time insertion, and slew-rate control. Some driver ICs are equipped with linear or switching voltage regulators, operation amplifiers for shunt current sensing, power stages and embedded control algorithms. Highly integrated drivers like the TI DRV10983 three-phase sensorless BLDC motor controller integrate the MOSFET's gate driver and control algorithm into a single IC, and implement sinusoidal current control without any current-shunt resistors.
- **Shorter design cycle.** With such a high integration level, using an advanced low-voltage BLDC motor-driver IC may significantly reduce the subsystem's design cycle. For example, using the DRV10983 for a fan control subsystem design does not require any software effort on the motor-control algorithm. You would only need to tune the motor parameters via the I<sup>2</sup>C communication interface to the controller IC and start evaluating.
- **Flexibility.** You can use low-voltage motors and drives for either 110V or 220V line-input operation using a universal input AC/DC converter. The low-voltage motor drive sub-system is easily adaptable into battery

and/or solar-powered systems. This gives the benefit of using a single motor and controller platform for a wide number of systems.

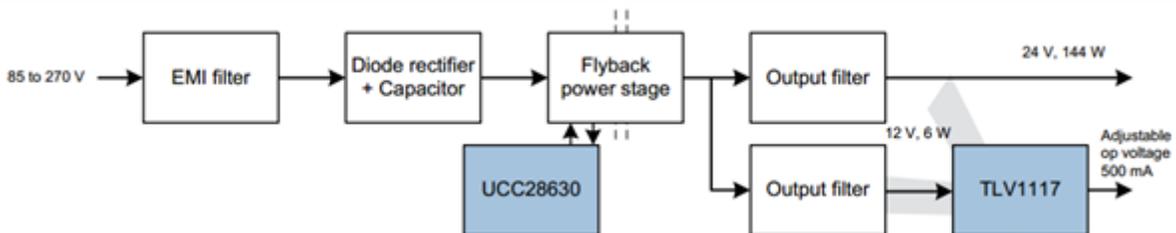
- **Size and cost.** Low-voltage motor-control ICs are usually with much smaller packages compared to high-voltage IPMs, given the different technologies used and the low clearance and creepage distance requirements. While designing the printed circuit board (PCB), the high-voltage area on the board usually requires more clearance, creepage distance and care for isolation than the low-voltage area, which could result in a larger board size. In low-voltage low-power applications, even with higher current, the optimized  $R_{DS(on)}$  and the gate charge of the MOSFET help achieve very low FET losses. With optimized thermal management, the power stage may not require extra heat-dissipation components, thus saving on overall system cost.
- **Audible noise.** Audible noise generated by electric motors is a result of the motor-output torque ripple. The six-step commutation-based trapezoidal control in BLDC motors can create commutation torque ripple and hence audible noise. The sinusoidal current in motor winding, along with sinusoidal back electromotive force (EMF), will ideally give zero torque ripple. The DRV10983 with sinusoidal current output helps achieve very low audible noise.

However, using low-voltage BLDC motors in the system requires a power supply capable of providing a low-voltage DC output to power the motor drive.

### AC/DC Converter

To address the challenge of using low-voltage motors, the [TI Designs 150W High Efficiency Primary Side Regulated DCM/CCM Flyback Supply Reference Design](#) features a 24V, 12V output, 150W isolated primary-side regulation (PSR) flyback controller-based power supply, with built-in protections for overcurrent, overvoltage, feedback-loop open/short detection, overtemperature, overload timer, AC line undervoltage and brownout. PSR helps eliminate the need for secondary-side feedback and regulation components and an optocoupler, enabling cost optimization and increasing reliability. The additional 12V can power up the gate drivers and generate the bias power supplies.

[Figure 3](#) shows the block diagram of the 150W PSR flyback power supply. The power supply is designed and tested for a universal input AC range from 85-270V<sub>AC</sub>. The electromagnetic interference (EMI) filter at the front end of the circuit is designed to meet EN55011 Class A conducted emission levels. The design achieves low standby power of 200mW at 230V<sub>AC</sub>.



**Figure 3. 150W PSR Flyback Power Supply Block Diagram**

I hope you now understand the benefits of a low-voltage BLDC drive for low-power applications in terms of safety, integration, size, cost and design-cycle reduction, especially compared to a high-voltage system.

### Additional Resources

- See the [Appliances applications page](#) for more design information.
- Check out these TI Designs reference designs:
  - The [24V Dual Brushless DC Motor Drive Reference Design for Major Home Appliances](#) uses the DRV8303 and DRV10983 on the same board.
  - [Mains Operated, 24V, 30W BLDC Motor Drive with Highly Efficient, High Power Factor Power Supply](#).
  - [Current Controlled Driver for 230V AC Solenoids Reference Design](#).
  - [Offline AC/DC 120W Multioutput Flyback Power Supply Reference Design](#).
- Learn more about an even [lower-power-level design reference](#).

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