

Small Motors in Large Appliances

Vashist Bist, Analog Motor Drives



Introduction

A recent trend has been seen in appliances (both large-home and small-home appliances) for moving from high-voltage (HV) motors to low-voltage (LV) motors for low power application (<100-W). This transition is due to availability of low power drivers which have the following advantages over high voltage systems.

- **High Integration:** Highly integrated motor drivers with driver which include the power-stage, regulators and controllers in a single package
- **High Protection and Diagnostics:** Integrated protection features with detailed diagnostics
- **Better Control:** With low voltage application, the current requirement increases which allows an accurate sensing and control of motor currents
- **Reduced Size / Low Form-Factor:** LV drivers have low creepage and clearance needs
- **Reduced Design Time:** Integration helps in plug and play designs
- **Low Cost:** Reduced size saves on PCB, and no high-voltage components are required which are costlier than low voltage components
- **Safety:** Low voltage is safe for humans

Low voltage brushed DC and stepper motors are increasingly being used in large-home appliances. There are numerous applications requiring brushed DC motors such as ice-makers and ice-crushers in refrigerators, cleaning motors in air-conditioners, dryer-fan motors, detergent dispensers and door-lock motors in dish-washers / washers and dryers. The brushed DC motors also finds applicability in self-cleaning applications in cooking ranges and water valves in residential water heaters. Moreover, the applications which requires a precise control of position such as the damper motor for refrigerant flow-control in refrigerators or the louver motors in air-conditioners for air-flow control uses stepper motors. A lot of low-voltage brushed and stepper motor are also finding applicability in small-home appliances such as the coffee-machines, vacuum cleaners, fans, air-purifiers, mixers, blenders and food processors. This Tech-Note targets motor driver for these applications which requires a low voltage (<20-V) and a low power motor (<12-W).

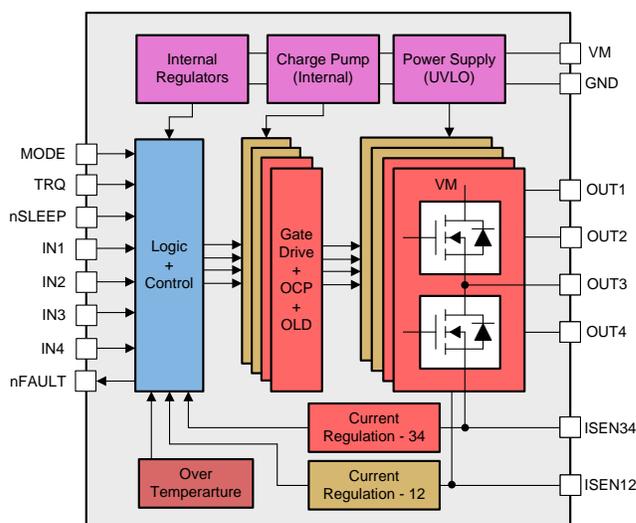


Figure 1. High Integration in Motor Drivers

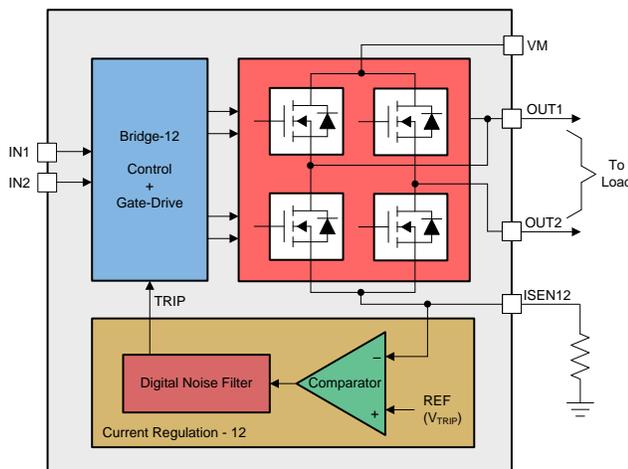
A full bridge is required for bi-directional control of brushed DC motor; whereas, two full bridges are required to control of a bipolar stepper motor. The full-bridge enables the operation of brushed-DC motor in either of four different modes such as the forward-direction mode, reverse-direction mode, coasting-mode (fast-decay) and brake-mode (slow-decay). The motor (BDC or stepper) is expected to work in any of these modes or the combination of these modes to achieve current regulation.

The [DRV8847](#) device is a highly-integrated dual full-bridge (H-bridge) motor driver with integrated FETs as shown in [Figure 1](#). This device supports a minimum voltage of 2.7-V and maximum voltage of 18-V and fully-optimized for the 12-V DC input voltage applications. It consists of a fully-integrated charge-pump to drive 8-NMOS FETs in two full bridges. The charge-pump in DRV8847 doesn't require any external capacitors, thus saving the BOM cost and design complexity. This device consists of internal low on-state resistance ($R_{DS(ON)}$) FETs which allows to drive 1-A current per full-bridge.

The DRV8847 device has four interface options which provides a flexibility to connect different type of loads. Each of the four modes is optimized for the type of load, performance requirements and the number of controller GPIO resources. The interfaces are classified based on the type of load as shown in [Table 1](#).

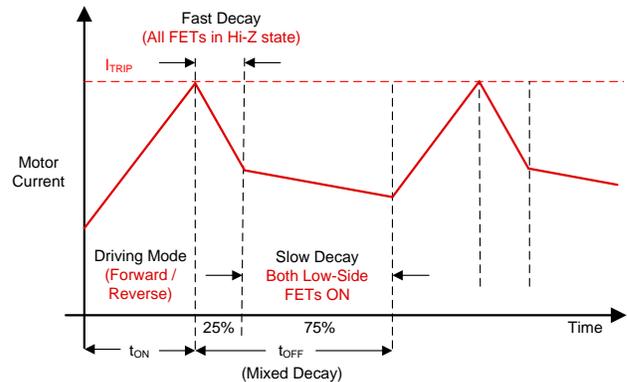
Table 1. Type of Loads and Interface Options

Motor Type	Operation	Interface	GPIO Requirements
Stepper Motor	Full-Step	2-Pin	2-Pins
	Half-Step	4-Pin	4-Pins
Brushed DC Motor	2 Motors Independent	4-Pin	4-Pins
	1 Motor (High Current)	Parallel	2-Pins
Solenoids Loads	Independent Half Bridges	Independent	1-Pin / Solenoid


Figure 2. Current Regulation in Full Bridge of DRV8847

The device contains integrated protection features to alert the system of any abnormal condition. These protection features include power-supply undervoltage lockout (UVLO), overcurrent protection (OCP) on each FETs, open load detection (OLD) for detection of any OUTx pin dis-continuity, and over-temperature shutdown (OTSD) for protecting against high temperatures. All the fault events are reported on the nFAULT pin which can be monitored by external controller.

The device also integrates the current regulation feature for limiting the motor current. Figure 2 shows the block diagram of the current regulator circuit (single full-bridge) in DRV8847. As shown in this figure, a sense-resistor connected on the source of the low-side FETs is used to sense the bridge current. This sense voltage is compared to an internal reference trip-voltage (V_{TRIP}) to control the bridge state. Once, the current limit is hit, the bridge operates in fast-decay (coast-mode), followed by a slow-decay (brake-mode) to achieve current regulation as shown in Figure 3. This current regulation features enables the motor driver to limit the starting inrush current of brushed DC motor and for achieving current limit for stepper motor.


Figure 3. Current Limit Operation in DRV8847

DRV8847 device also comes with a I²C interface-variant (DRV8847S) which provides a detailed diagnostics, high configurability and control of the driver. In DRV8847S, many extra features are enabled over I²C bus such as bridge control, bridge operation selection in open-load / over current scenarios, current decay settings, slew-rate configurability and detailed diagnostics of the faults on registers. The DRV8847S device also allows a multi-slave operation, by which multiple devices can be controlled via a single I²C bus. Such feature reduces the peripheral (GPIO) requirements from the controller, reduces controller cost and simplifies the driver boards design. With such high level of integration, protection and configurability, this device becomes a easy plug and play option for the user driving variety of loads.

Alternate Device Recommendation

Depending on the necessary system requirement, there are additional devices available that may provide the required performance and functionality. For applications requiring micro-stepping control of stepper motor and adaptive current decay (AutoTune), [DRV8846](#) is recommended.

Table 2. Alternative Device Recommendations

Device	Optimized Parameters	Performance Trade-Off
DRV8846	Supports 1/32 Micro-stepping for Stepper Motor Supports Adaptive Current Decay (AutoTune) for Lower Current Ripple	Brushed-DC motors and Solenoid Loads are Not Supported

Table 3. Related Documentation

SLVA504	Calculating Motor Driver Power Dissipation
TIDA-00297	Refrigerator Damper and Fan Motor Control Solutions

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