Independent Half-Bridge Drive with DRV8837

Zhao Tang, Wilson Zuo, and Alvin Zheng

ABSTRACT

This document is provided as a supplement to the DRV8837 datasheet (SLVSBA4). It details the method of separating an H-bridge with built-in IN/IN interface into two independent half-bridges, and subsequently driving two independent inductive loads such as DC motors and solenoids simultaneously.

Contents

List of Figures

List of Tables

1 Introduction

The DRV8837 provides an integrated H-bridge for single inductive load drive, for example, DC motor, solenoid, or one winding of a bipolar stepper motor, with optimized built-in control logic driven by an *IN/IN* interface. Its truth table offers two ways of stopping a spinning DC motor: IN1 and IN2 both low tri-states the output stage leading to ***motor coasting***, while IN1 and IN2 both high shorts the two terminals of the winding together through both low-side FETs and thus ***dynamic braking*** is achieved, as shown in Figure 1.

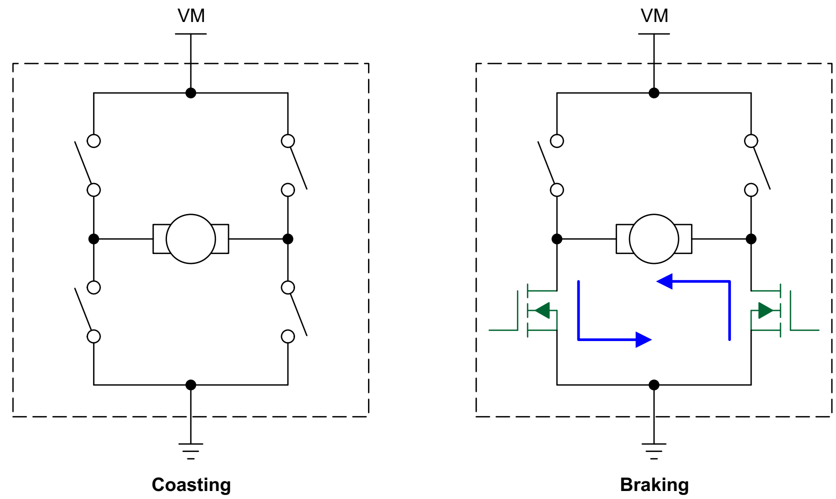

Figure 1. Coasting and Dynamic Braking

If the application employs two independent inductive loads which only require unidirectional current flow throughout their respective windings, it is more convenient and cost-competitive to separate the H-bridge into two half-bridges to drive the two loads simultaneously with a single device. However, under such application, the logic described above is ambiguous when IN1 and IN2 both high (brake) or both low (coast) presents at logic inputs, as highlighted in the original truth table shown in Table 1. This application note serves to introduce a simple solution to the logic ambiguity and make DRV8837 suitable for independent half-bridge control.

Table 1. DRV8837 Original Truth Table

IN1	IN2	OUT1	OUT2	DC Motor Function
0	0	Z	Z	Coast
0	1	L	H	Reverse
1	0	H	L	Forward
1	1	L	L	Brake

2 Independent Half Bridge Drive

2.1 Application Circuit

Independent drive can be easily implemented without adopting more discrete components, as shown in Figure 2. Two inductive loads (M1 and M2), which could be motors or solenoids, are tied between VM and OUTx, while the corresponding inputs (C1 and C2) are swapped before being fed to INx. Although the swap can be achieved via hardware connection, it is still recommended to swap the generation of C1 and C2 within software coding to avoid confusion on hardware labels.

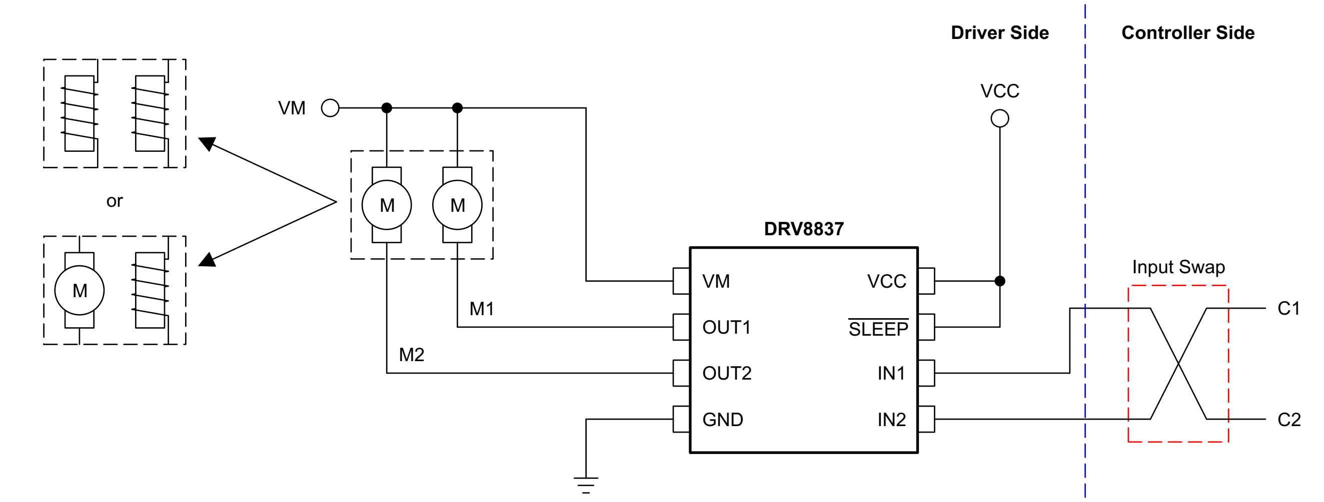

Figure 2. Simplified Independent Half Bridge Drive Application Circuit

2.2 Control Logic Truth Table

Combining the truth table from the DRV8837 datasheet, the control logic for independent half-bridge drive is updated as shown in Table 2.

Table 2. Combined Truth Table

C1	C2	IN1	IN2	OUT1	OUT2	M1	M2
0	0	0	0	Z	Z	Off: Braking mode 1 (1)	Off : Braking mode 1
1	0	0	1	L	H	On: Driving mode (1)	Off: Braking mode 2 (1)
0	1	1	0	H	L	Off: Braking mode 2	On: Driving mode
1	1	1	1	L	L	On: Driving mode	On: Driving mode

(1) Braking mode 1, braking mode 2 and driving mode are described in Section 2.4.

Columns INx and OUTx show the original logic of the DRV8837. Note that although a swap is included in this implementation, it is still valid that Cx = 1 spins a motor or energizes a solenoid connected at corresponding Mx, while Cx = 0, stops the motor or discharges the solenoid.

2.3 On/Off Control and PWM Control

The new logic can be applied to both On/Off control (100% or 0% drive) and PWM control. When PWM control mode is selected, independent PWM signals with different frequency and/or duty cycle can be applied to C1 and C2 (and thus IN1 and IN2). Within a PWM cycle, the ***HIGH*** period energizes the winding while the ***LOW*** period recirculates winding current through either a high-side MOSFET (braking mode 2) or its integrated body diode (braking mode 1).

2.4 Current Decay Paths under PWM Control

Figure 3 shows driving mode and two current decay paths during current recirculation when PWM control is used. When the half-bridge is operated in driving mode, winding current flows from VM to ground via the inductive load and the low-side MOSFET, while the high-side MOSFET stays ***OFF*** all the time.

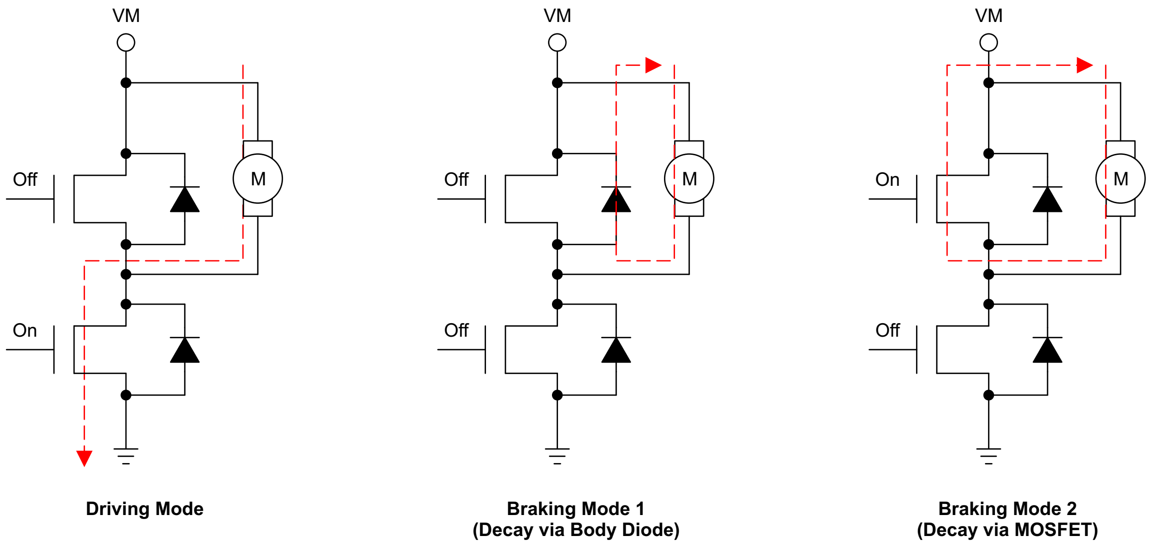

Figure 3. Normal Driving and Current Decay Modes

In braking mode1, both the high- and low-side MOSFETs of the half-bridge are tri-stated, and the recirculation current flows through the body diode of the high-side MOSFET as well as the motor itself, as shown by the red dashed line in Figure 3. This mode happens when both C1 and C2 are ***LOW*** with the two independent PWM inputs.

In braking mode 2, the low-side FET is ***OFF*** while its high-side counterpart is ***ON***. The recirculation current flows through the high-side MOSFET and the motor, as shown in Figure 3. This mode happens when one half-bridge is recirculating while the other is in driving mode.

Figure 4 gives an example on motor states when driven by two independent PWM signals with completely different frequencies and duty cycles, in which case, a mixture of braking mode 1 and braking mode 2 presents when motor currents recirculate. This mixture, or interaction between different braking modes, can impact the average motor speed. To be specific, when the two PWM signals happen to be low simultaneously, braking mode 1 is automatically selected and recirculation current in both motors flow through body diodes, as marked red in Figure 4. This dissipates more power than braking mode 2 does and thus contributes to a lower-than-expected average speed on both motors. The more often braking mode 1 happens, the lower the average speed is. Moreover, if braking mode 1 happens too often, the device heats up which could result in temperature trips due to recirculation currents flowing through body diodes.

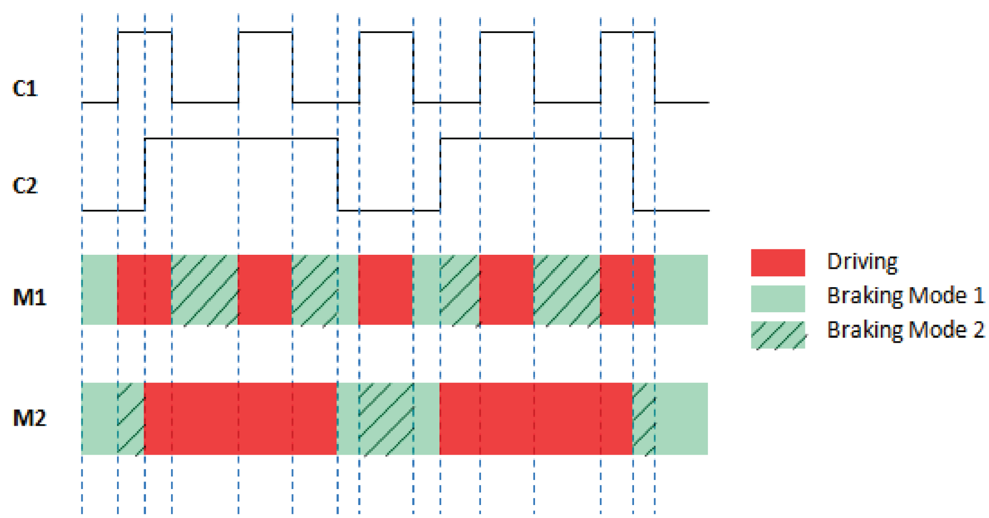

Figure 4. Driving and Decay Examples with Independent PWM Inputs

To reduce the effect on motor speed when mixed braking mode happens, external Schottky diodes are recommended to be connected in parallel with high-side MOSFETs, as shown in Figure 5. The lower the forward voltage of the Schottky diode is, the less power is wasted and the closer the motors spin to the expected speed. A Schottky diode with a VF less than 0.6 V is preferred in real applications, an example for which could be CDBA140.

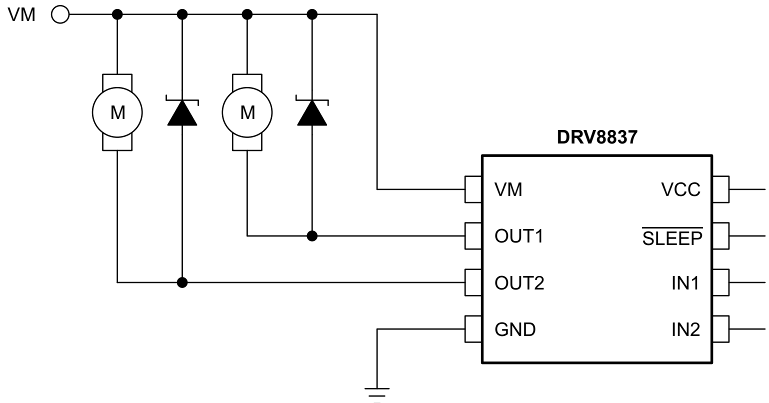

Figure 5. Improved Application Circuit for Better Motor Performance

Note that if On/Off control mode (constant HIGH or LOW at inputs) is used, the two braking modes do not interact with each other and hence have no effect on the average speed of the two motors.