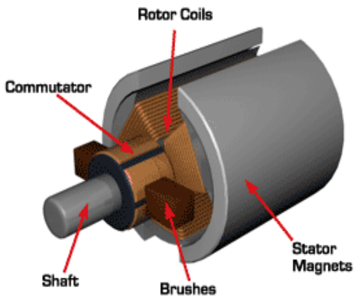


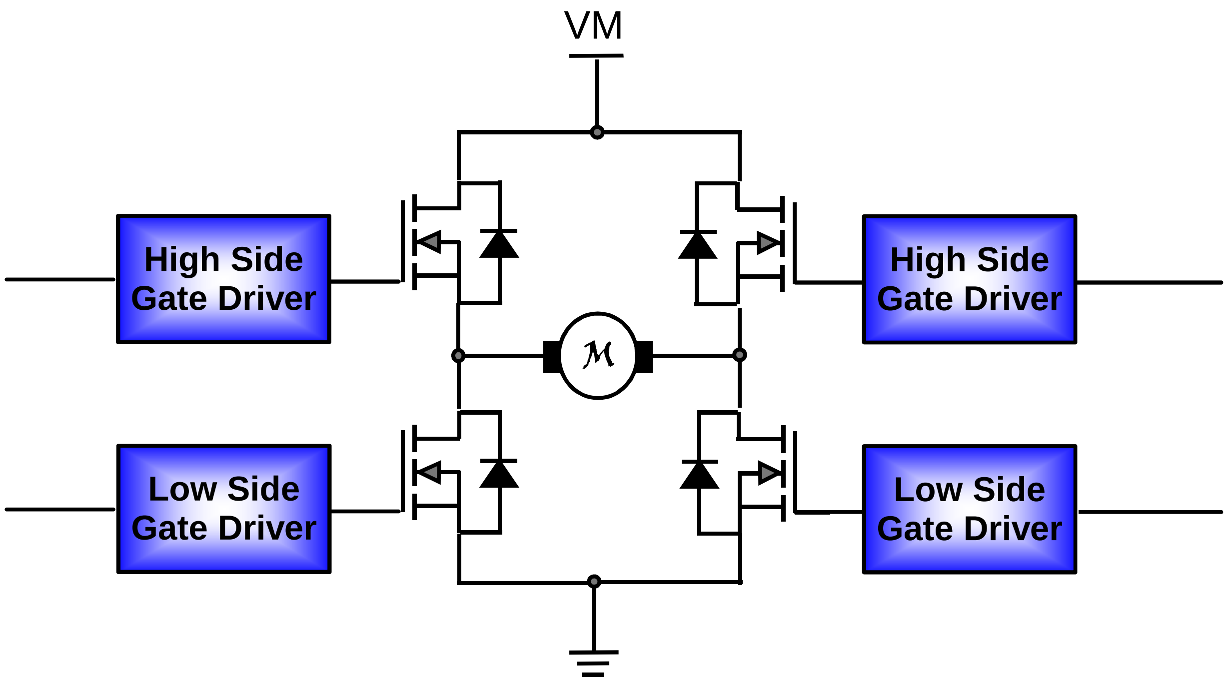
TI Spins Motors.

Texas Instruments

Smarter. Safer. Greener.

Motor Drive Business Unit
Gem Li
Marketing Manager

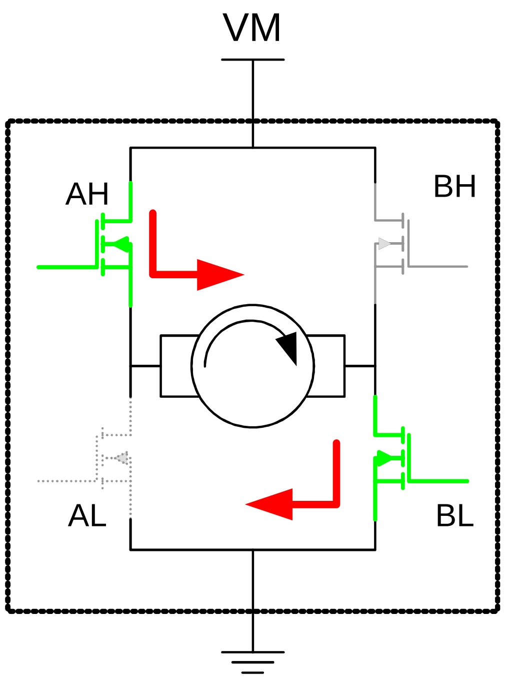
H-Bridge: The Heart of the Driver

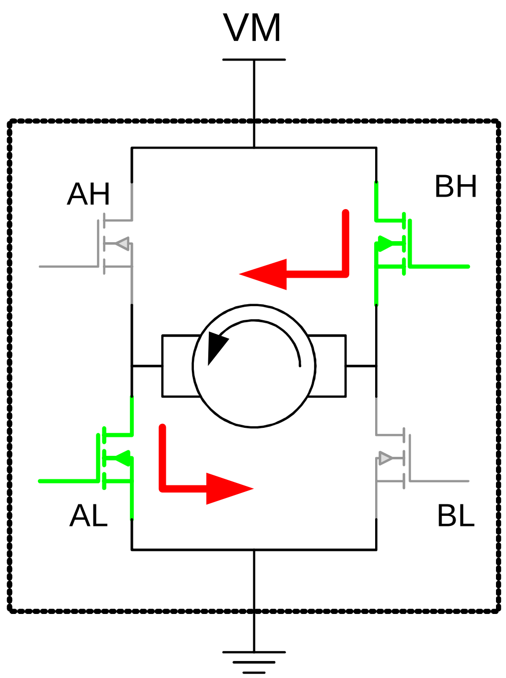


Critical Specs / Care abouts:

RDSON	Shoot-through protection	Short Circuit protection
100% Duty Cycle	Switching Frequency	Over temp & UVLO protection
Body Diodes	Dead Time / Linearity	Voltage & Current Range

H-Bridge: Spinning a Brushed DC Motor





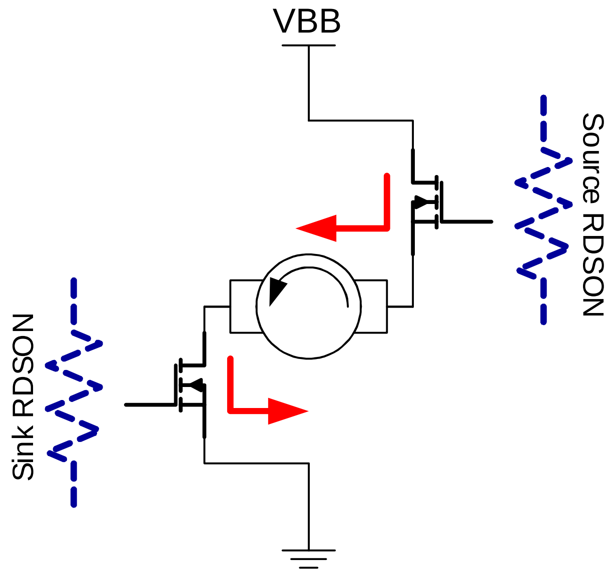
Critical Points:

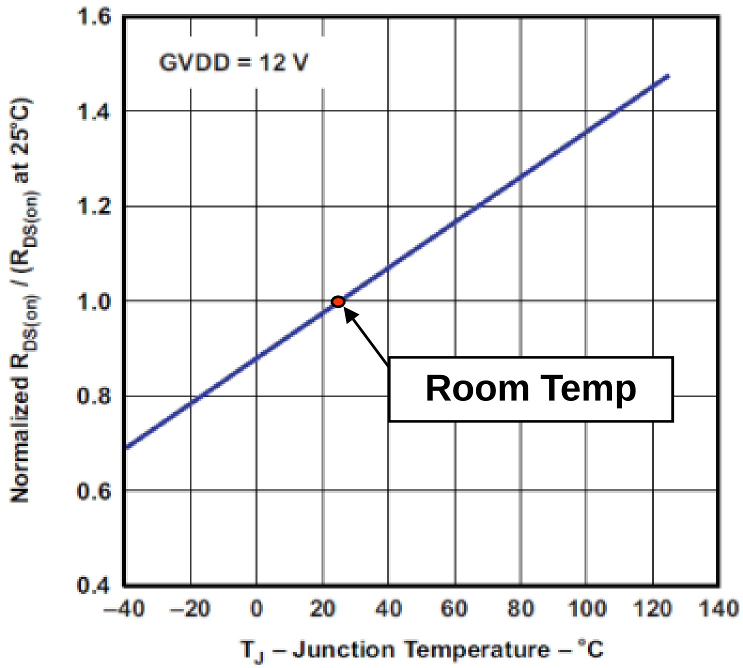
The H-Bridge / motor driver amplifies the control signals to the proper voltage and current level required to drive the motor.

Applied motor voltage may be PWMed (chopped) or continuous.

PWMing is a very efficient way to apply a voltage

RDSON: FET "On" Resistance





Critical Points:

RDSON is the dominant factor in a Driver's efficiency

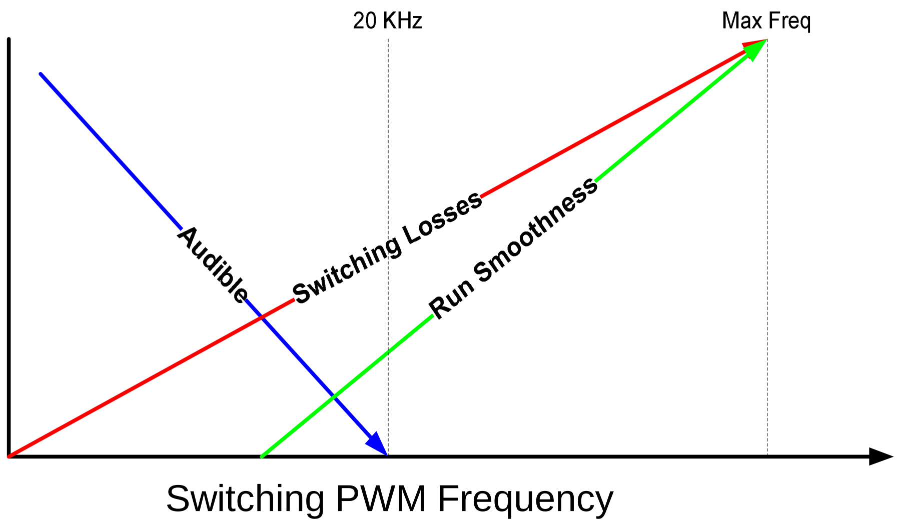
- – Switching losses are the other major factor

RDSON is a major factor in a Driver's thermal performance

- – Package and board layout are the others

RDSON increases over temperature

PWM Switching Frequency



Critical Points:

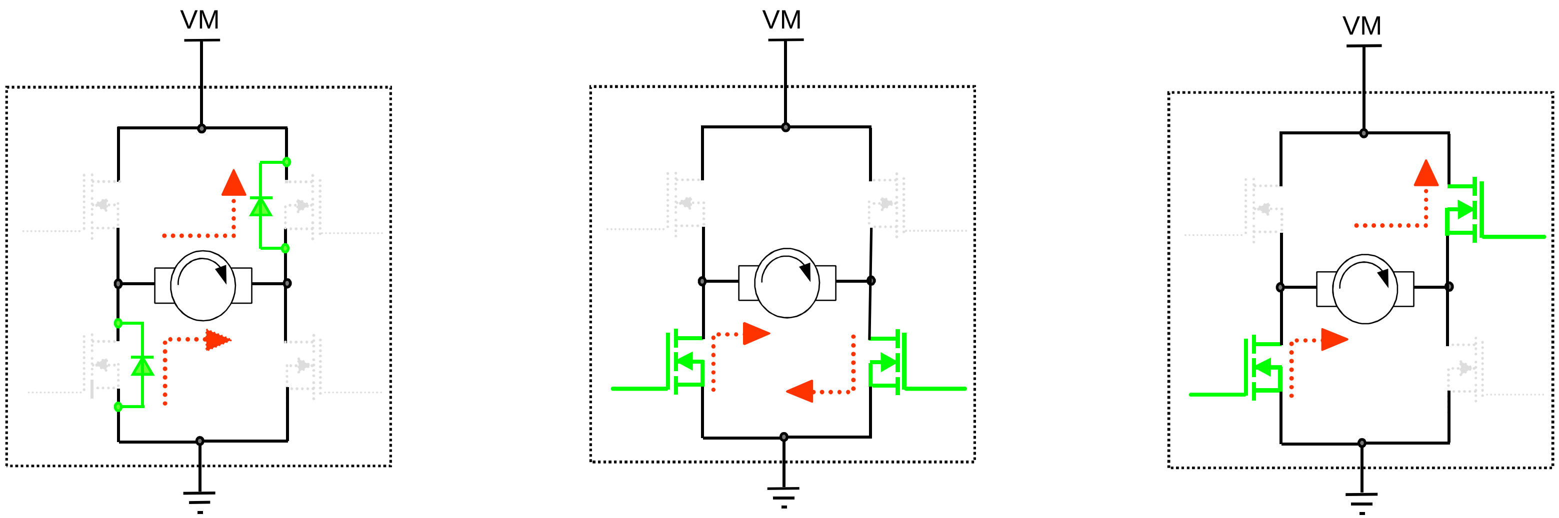
The higher the PWM frequency, the less torque ripple and smoother the motion profile

Ideally, PWM frequency should be above 20 KHz to avoid audible noise.

But…

The higher the frequency, the higher the switching losses at the H-Bridge.

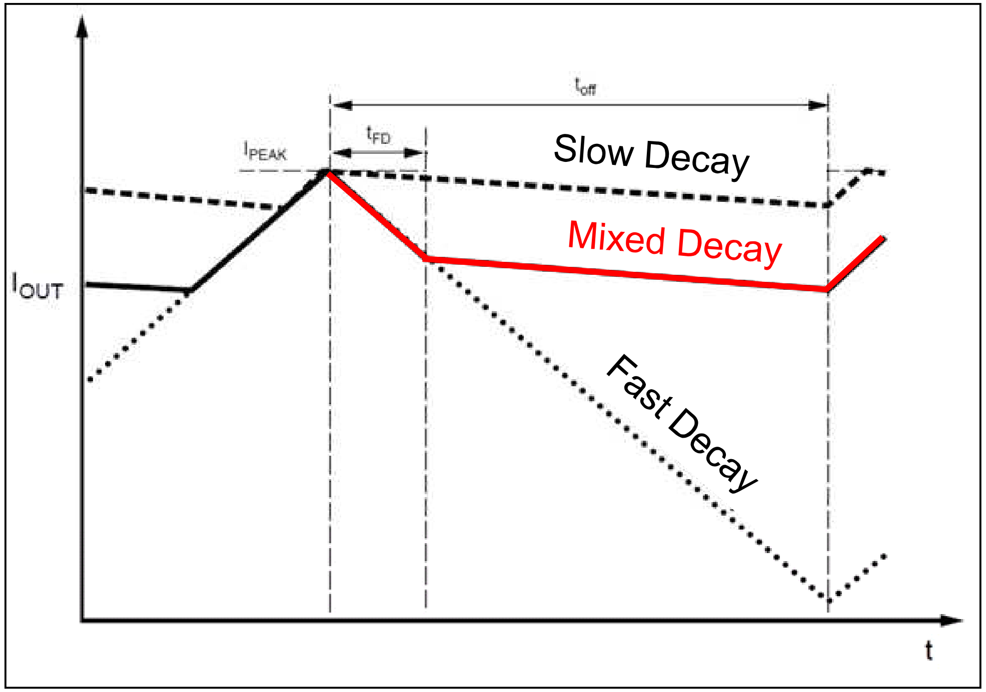
Decay Mode Performance Tradeoffs

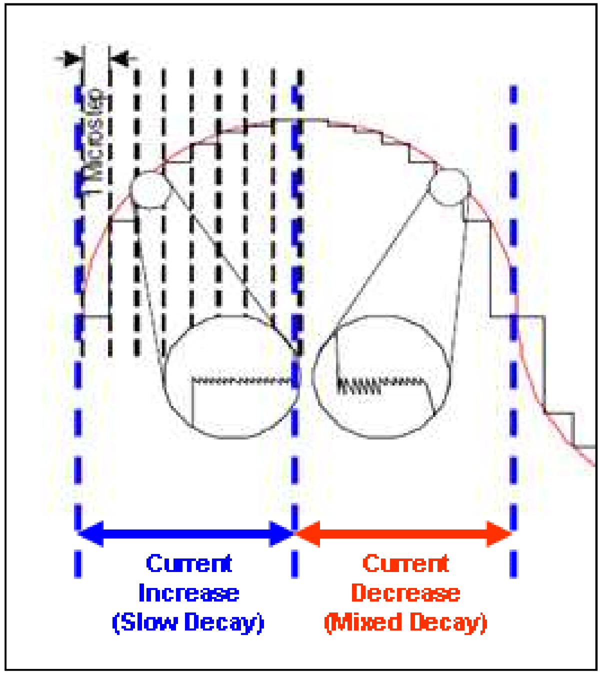


Asynchronous Decay **Slow Decay** **Fast Decay**

Mode	Current Decay	Torque Ripple/ Audible Noise	Voltage to the load	Efficiency	Control when winding current is decreasing
ASync Decay	Fast	Poor	Lower	Poor	Better
Slow Decay	Slow	Good	Higher	Good	OK
Fast Decay	Fast	Poor	Lower	Good	**Better**

Mixed Decay Mode: The best of Both?





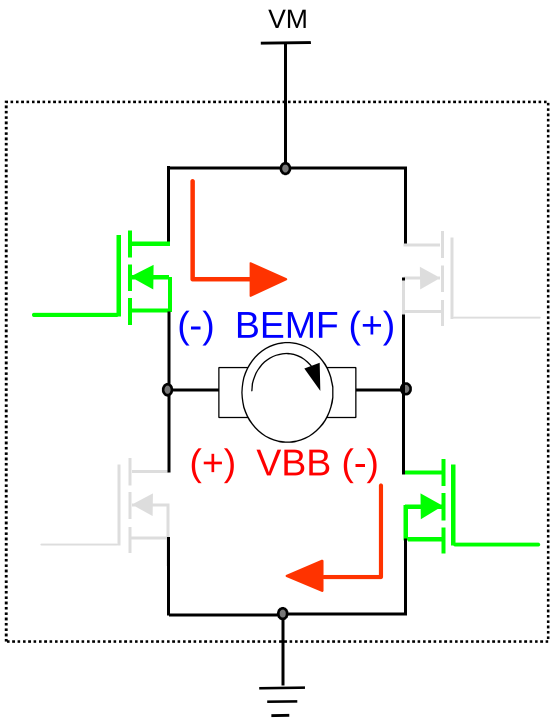
Critical Points:

Mixed decay: % of the decay cycle is fast decay followed by slow decay

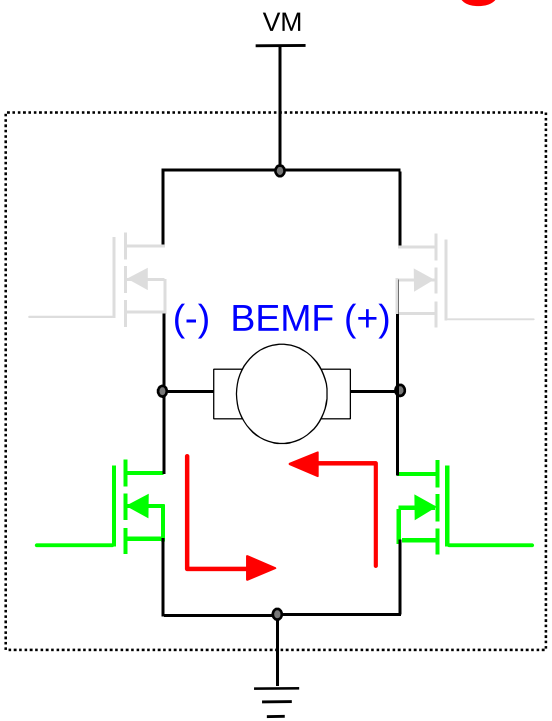
Fast and slow decay ratio may be programmable depending on the driver

Mixed decay is ideally suited for micro-stepping

Brushed DC Motors: Dynamic Braking



Normal Operation
VM > BEMF



Braking
BEMF Stops Motor

Critical Points:

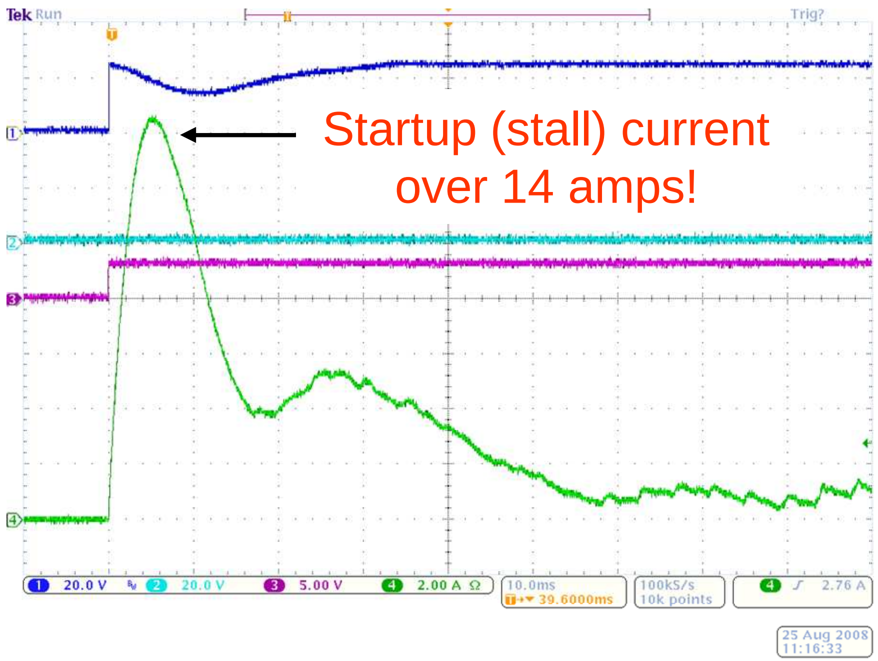
By shorting the motor leads, you allow the Back EMF voltage to drive current in the opposite direction of the supply current, quickly bringing the motor to a stop.

The energy of the motor is dissipated by the "resistive load"

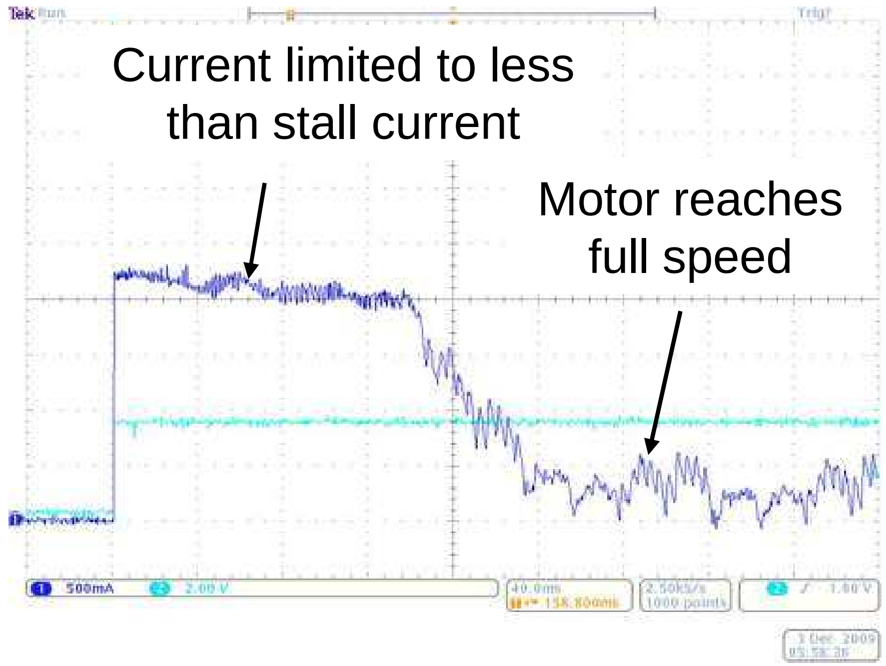
Current Regulation Example

Using current control with a DC brushed motor can allow you to limit the high starting current, and use a motor driver IC that is rated for less current than the stall current of the motor

Motor startup without current control



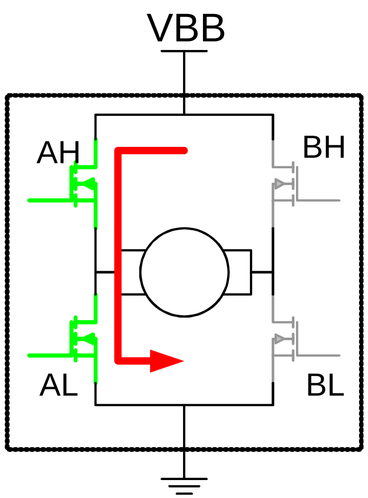
Motor startup with current control



Undervoltage/Cross Conduction Protection

- **Undervoltage protection**
  - Supply voltage level is constantly monitored and the device is tri-stated when the voltage level is too low to ensure proper control over the H-Bridge

- **Shoot-through Protection**
  - High side and low side are never allowed to turn on at the same time. A small amount of delay (dead time) is inserted after turning off the high side and turning on the low side. The longer the dead-time, the safer the operation but the worse the linearity and efficiency.



Shoot–through!!

Motor driver control interfaces

Motor drivers are typically controlled by a processor or microcontroller. A number of different types of interfaces have evolved, including:

- **Parallel (PHASE/ENABLE)**
  - Bridge is controlled with an enable and direction signal. You can PWM the Phase or Enable pin to control the motor speed.
- **Indexer (Stepper Motors)**
  - Motor is controlled with a STEP and DIRECTION signal
    - Each PWM pulse on the STEP pin advances / retracts the stepper one step
  - The on-chip indexer supports full step / micro-stepping. Step size (I.E. 1/2 vs. 1/8 vs. 1/32) is set by the mode pins.
- **PWM**
  - Bridge output states follow PWM inputs signal
  - May provide separate control for each FET, ½ bridge, or full bridge.
- **Serial**
  - SPI, I^2C, or other serial I/F; Supports multiple motors on a single low pin count bus

DRV8x Motor Drivers

Supports Up to 60V/60A

Brushed & Stepper Drivers

- Voltage Range: < 50V
- Majority of parts: 2.5A peak and below
- Max Current: 12A Peak / 24A (Brushed)
- Up to 256 and greater microstepping



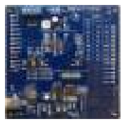
Three-Phase Drivers

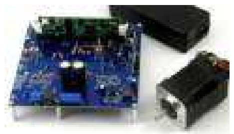
- Voltage Range: < 60V
- Pre-drivers support > 60A
- Integrated drives support up 13A peak



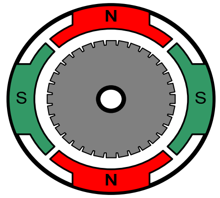
MCU + DRV Kits

- DRV8312-C2-Kit
- DRV8412-C2-Kit
- DRV8x EVMs w/ MSP430





Stepper Motor Drivers



Indexer Ctrl I/F

DRV8821
- 1.5A (8 to 32V)
- 1/8 uStep
- **2x Stepper**

DRV8824 ← P2P → **DRV8825**

DRV8824
- 1.6A (8 to 45V)
- 1/32 uStep

DRV8825
- 2.5A (8 to 45V)
- 1/32 uStep

DRV8811
- 1.9A (8 to 38V)
- 1/8 uStep

Phase Enable Ctrl I/F

DRV8812 ← P2P → **DRV8813**

DRV8812
- 1.6A (8 to 45V)
- 4x Current levels

DRV8813
- 2.5A (8 to 45V)
- 4x Current Levels

DRV8828 ← P2P → **DRV8829**

DRV8828
- 3A (8 to 45V)
- 32x Current levels
- **½ Stepper**

DRV8829
- 5.0A (8 to 45V)
- 32x Current Levels
- **½ Stepper**

Serial Ctrl I/F

DRV8823
- 1.5A (8 to 32V)
- 8x Current Levels
- **2x Stepper**

PWM Ctrl I/F

4Q11

DRV8833
- 1A **(2.7 to 10.8V)**

DRV8841/43
- 2.5A (8 to 45)
- 4x Current Levels

DRV8842
- 5A (8 to 45)
- 32x Current Levels
- **½ Stepper**

DRV8412
- 6A (0 to 52V)
- Up to 97% Efficient
- 500kHz / 5ns Dead-time

DRV8432
- 12A (0 to 52V)
- Up to 97% Efficient
- 500kHz / 5ns Dead-time

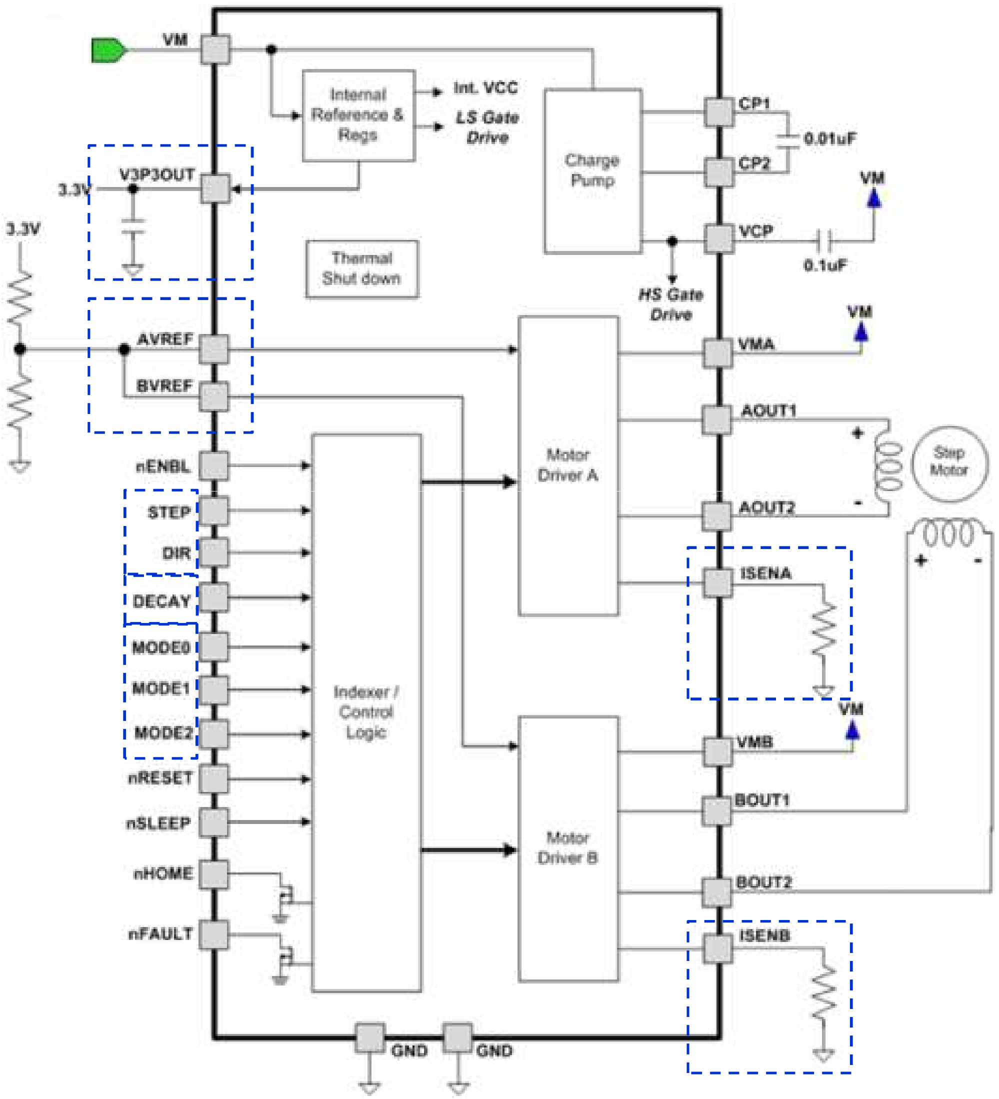
Production | Sampling | In Design

DRV8825

2.5A Bipolar Stepper Motor Driver with On-Chip 1/32 Microstepping Indexer

Features

- Dual H-Bridge motor driver
  - Supply Voltage: 8.2 to 45V
  - Current per bridge: 1.75A RMS / 2.5A peak
  - Low RDSON: 200mΩ per FET
- Step / Direction control interface with on-chip indexer supporting up to 1/32 micro-stepping.
- Slow, fast and mixed decay modes
- P2P with the DRV8824 (1.6A peak)
- Integrated protection features including over-current, thermal, shoot-through and UVLO protection.

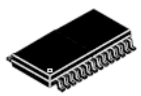


Applications

- Bipolar Stepper Motor

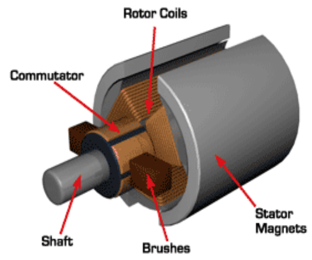
In Production

1K Pricing: $2.40



9.7 x 6.4mm, 28-pin HTSSOP package

Brushed DC Motor Drivers



Phase Enable Ctrl I/F

DRV8802 (June — P2P with DRV8814)
- 1.6A (8 to 45V)
- Inrush Protection
- **2x Brushed**

DRV8814
- 2.5A (8 to 45V)
- Inrush Protection
- **2x Brushed**

DRV8800/1
- 2.2 (8 to 36V)

DRV8840
- 5.0A (8 to 45V)
- Inrush Protection

PWM Ctrl I/F

DRV8832
- 1A **(2.7 to 6V)**
- **Voltage Regulation**
- Inrush Protection

DRV8841/43
- 2.5A (8 to 45V)
- Inrush Protection
- **2x Brushed**

DRV8842
- 5A (8 to 45V)
- Inrush Protection

DRV8833 (4Q11)
- 1A **(2.7 to 10.8V)**
- Inrush Protection
- **2x Brushed**

DRV8412
- 6A Dual (0 to 52V)
- 12A Single
- Inrush Protection
- **2x Brushed**

DRV8432
- 12A Dual (0 to 52V)
- 24A Single
- Inrush Protection
- **2x Brushed**

Serial Ctrl I/F

DRV8823
- 1.5A (8 to 32V)
- Inrush Protection
- **4x Brushed**

DRV8830
- 1A **(2.7 to 6V)**
- **Voltage Regulation**
- I2C I/F (up to 9x)
- Inrush Protection

Production | Sampling | In Design

Latest DRV8x Drivers

Stepper Drivers

PH/EN

DRV8813
- 2.5A
- 4x current levels

DRV8829
- 5.0A, ½ stepper
- 32x current levels

Indexer

DRV8825
- 2.5A
- 1/32 micro-stepping

Stepper or Brushed

PWM

DRV8841
- 2.5A, 2x brushed
- 4x current levels

DRV8842
- 5A, ½ stepper
- 32x current levels

DRV8843
- 2.5A, 2x brushed
- 4x current levels

Brushed-DC Drivers

PH/EN

DRV8814
- 2.5A, 2x brushed
- Inrush protection

DRV8840
- 5.0A
- Inrush protection

Fully Protected

Simple control I/F Options

> 60% lower RDSON

1/32 and greater u-steps