Electronics for IoT

H-Bridge

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DC Motor Control

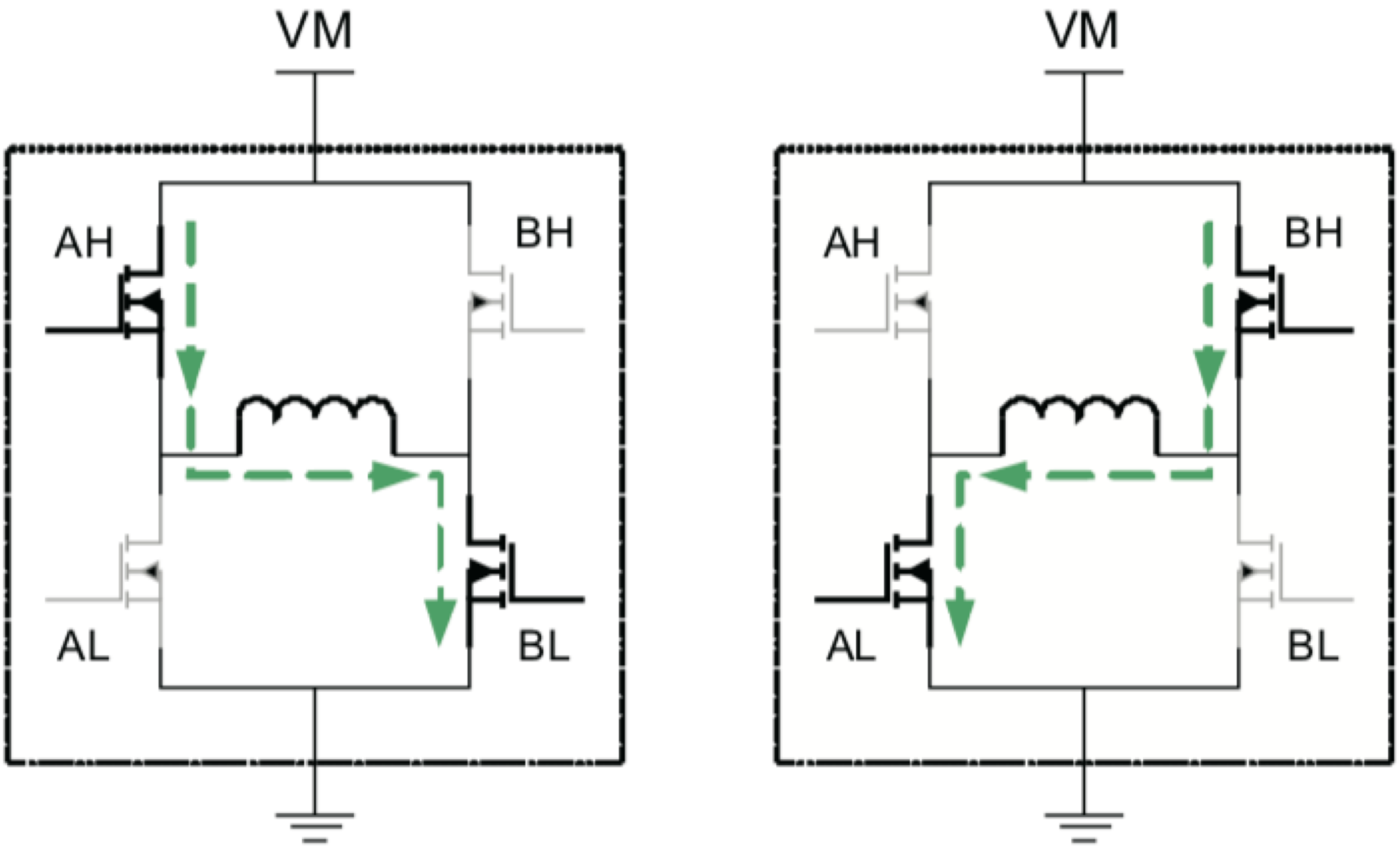
- Direction of Rotation
- Speed / Torque

On-Off Control

Direction of Rotation

http://www.ti.com/lit/an/slva321/slva321.pdf

H-Bridge

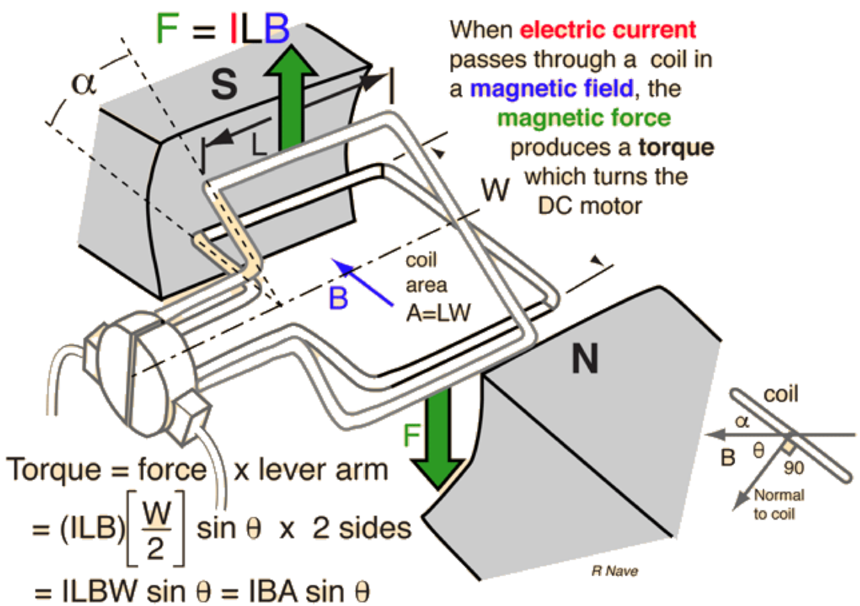


Turning Off …

Attempt to “destroy” Energy

Motor: Energy

Magnetic Energy



Water / Current Analogy

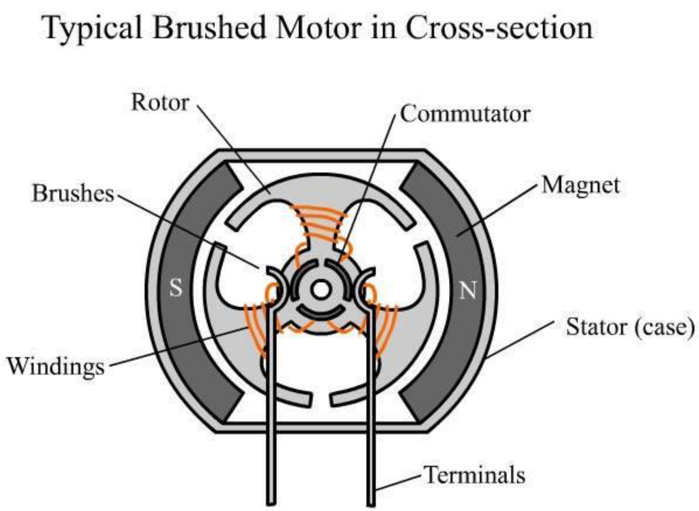
Water: kinetic energy

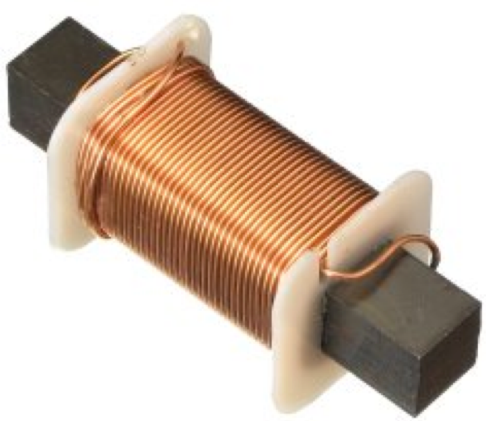
$$E_k = \frac{1}{2}mv^2$$

Current: magnetic energy

$$E_m = \frac{1}{2}Li^2$$

Inductance

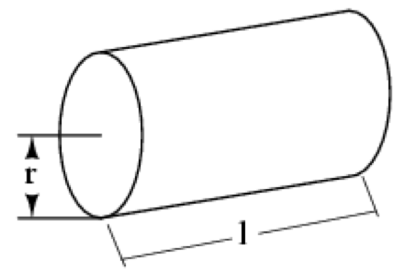




Calculate (just like inertia). E.g.

$$L = \frac{N^2 \mu A}{l}$$

$$\mu = \mu_r \mu_0$$



Where,

L = Inductance of coil in Henrys

N = Number of turns in wire coil (straight wire = 1)

μ = Permeability of core material (absolute, not relative)

μ_r = Relative permeability, dimensionless (μ_0=1 for air)

μ_0 = 1.26 x 10^{-6} T-m/At permeability of free space

A = Area of coil in square meters = πr^2

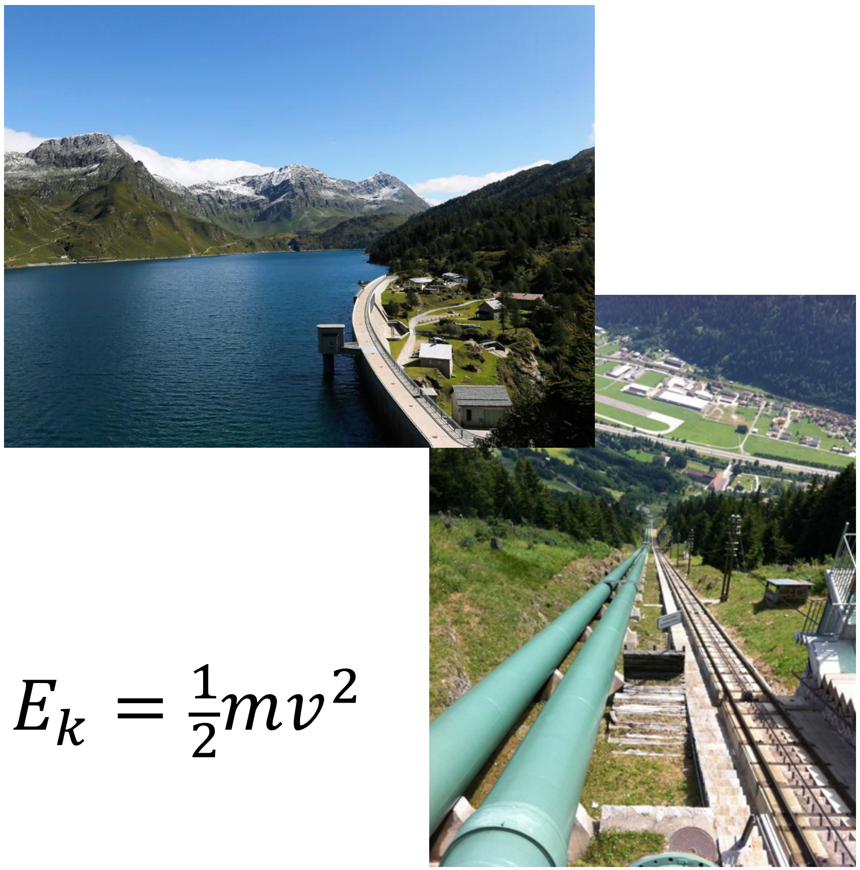
l = Average length of coil in meters

Finite element simulation for more complicated geometries

Inductor Symbol

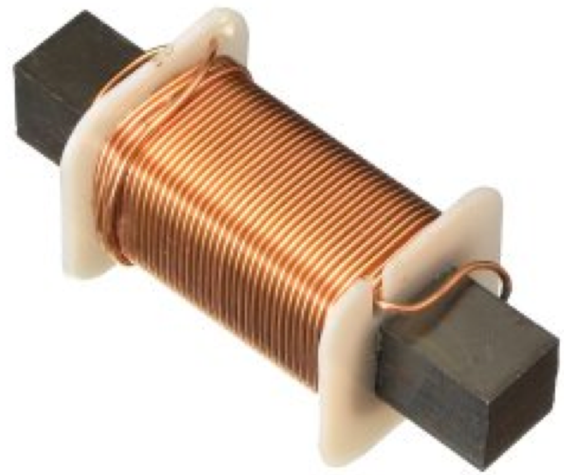
“Destroying” Magnetic Energy

Kinetic energy



$$E_k = \frac{1}{2}mv^2$$

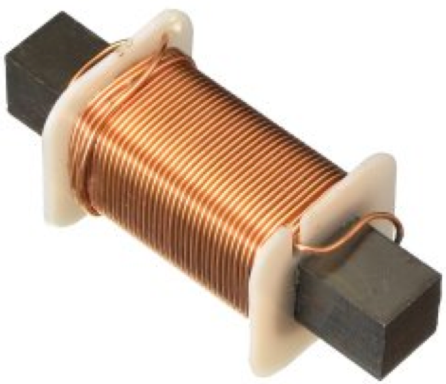
Magnetic energy



Inductor I/V Relationship

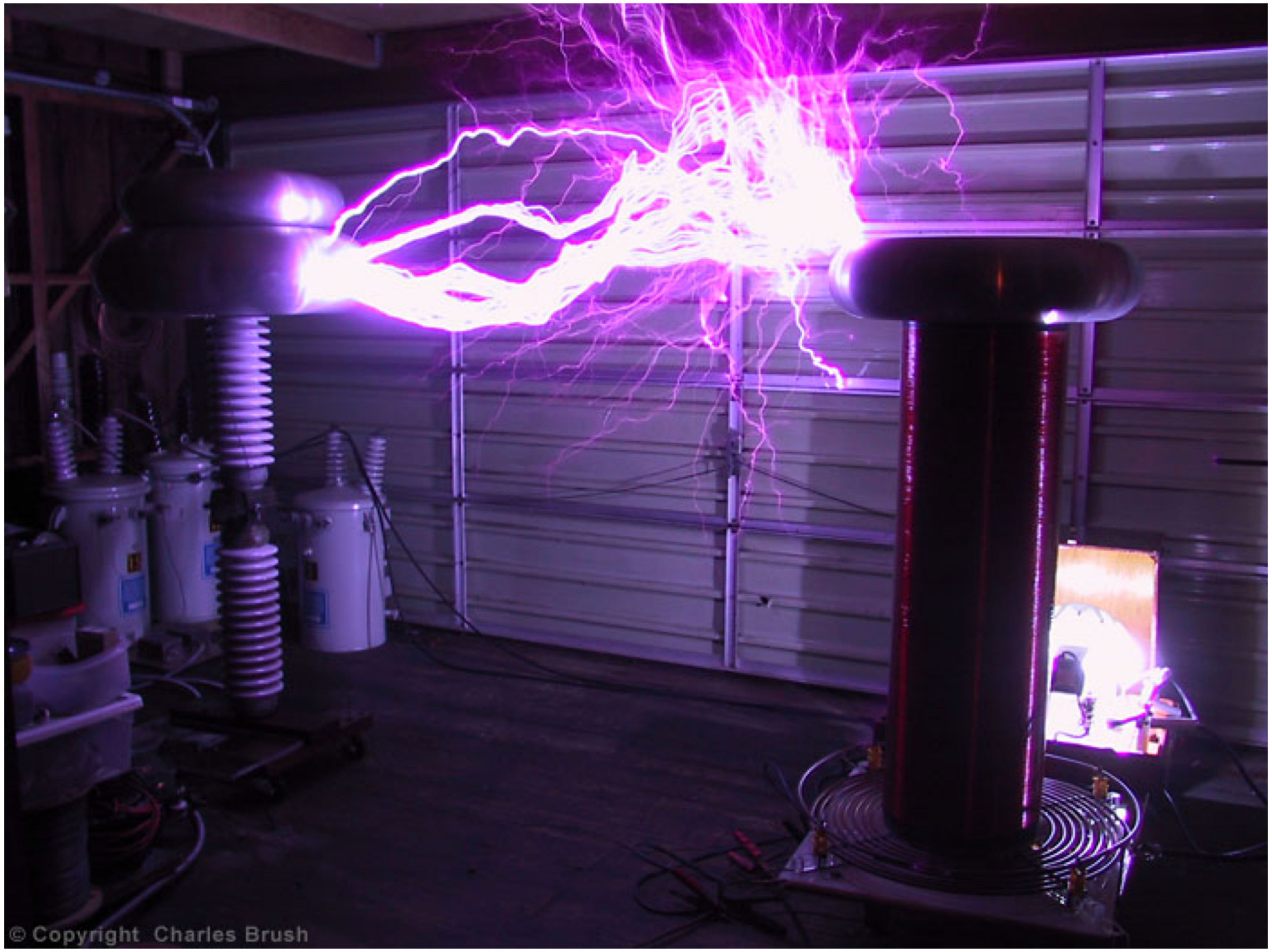
- Analogous to "Ohm's Law"
  - But for inductors

Shutting off Inductor Current

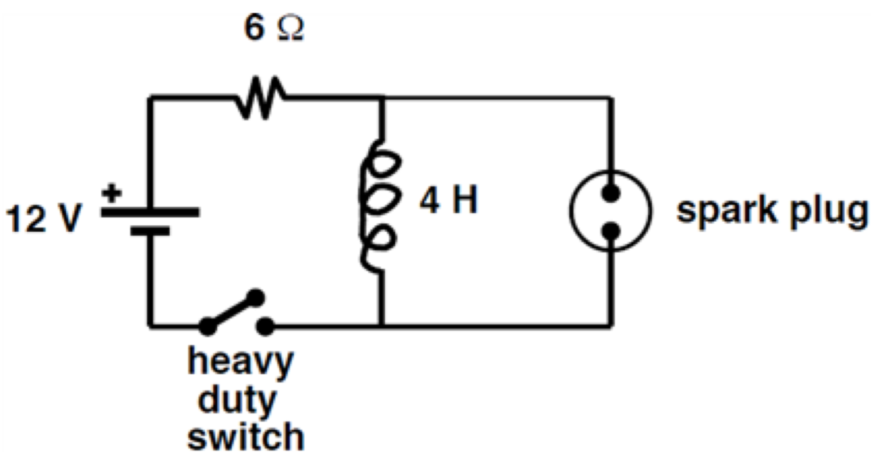


$$v = L\frac{di}{dt}$$

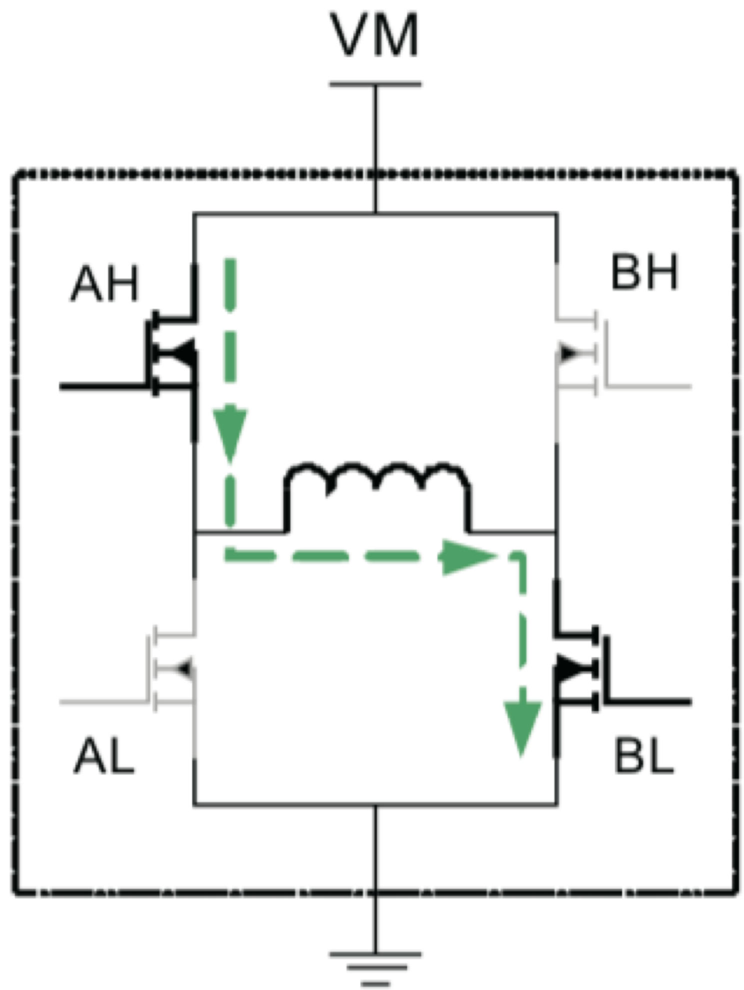
Tesla Coil



Spark Plug

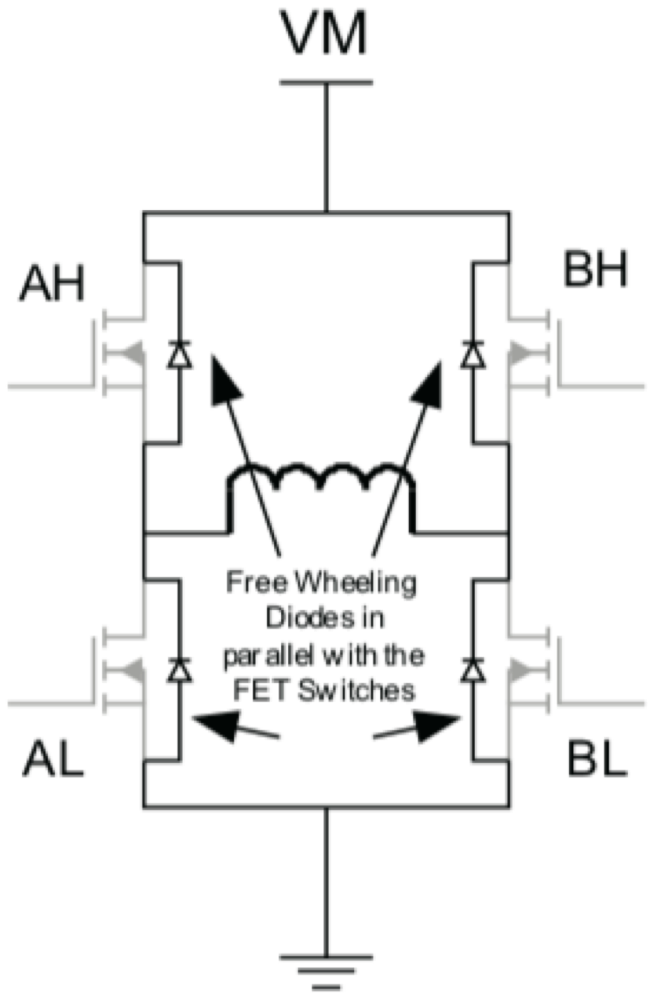


Water versus Current

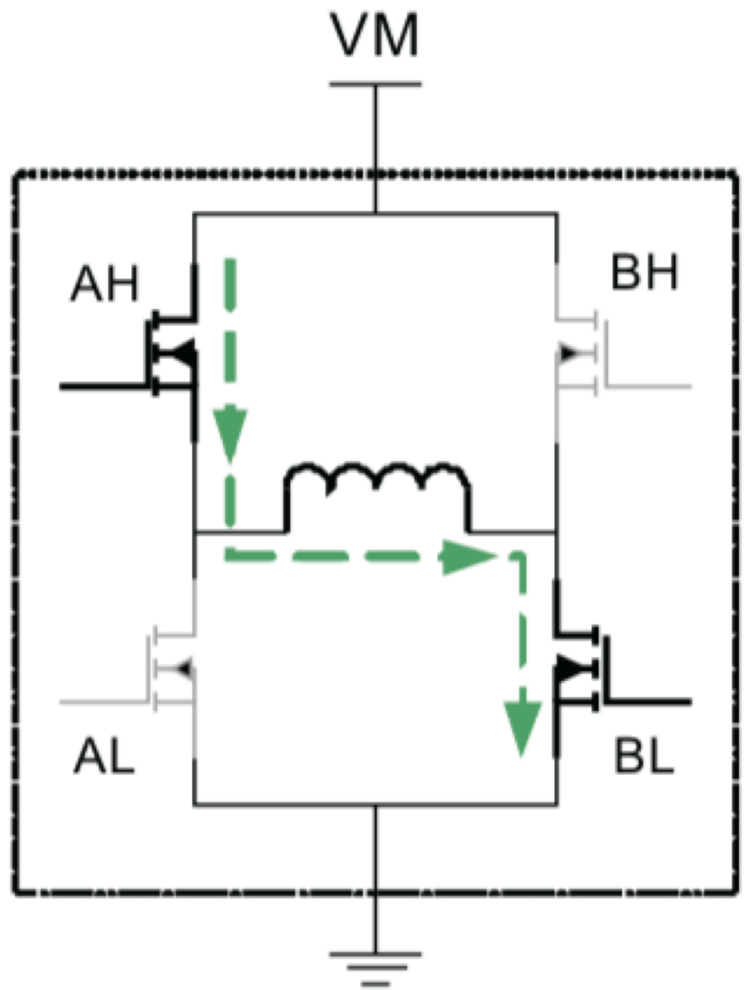


Diode

Free-Wheeling Protection Diodes

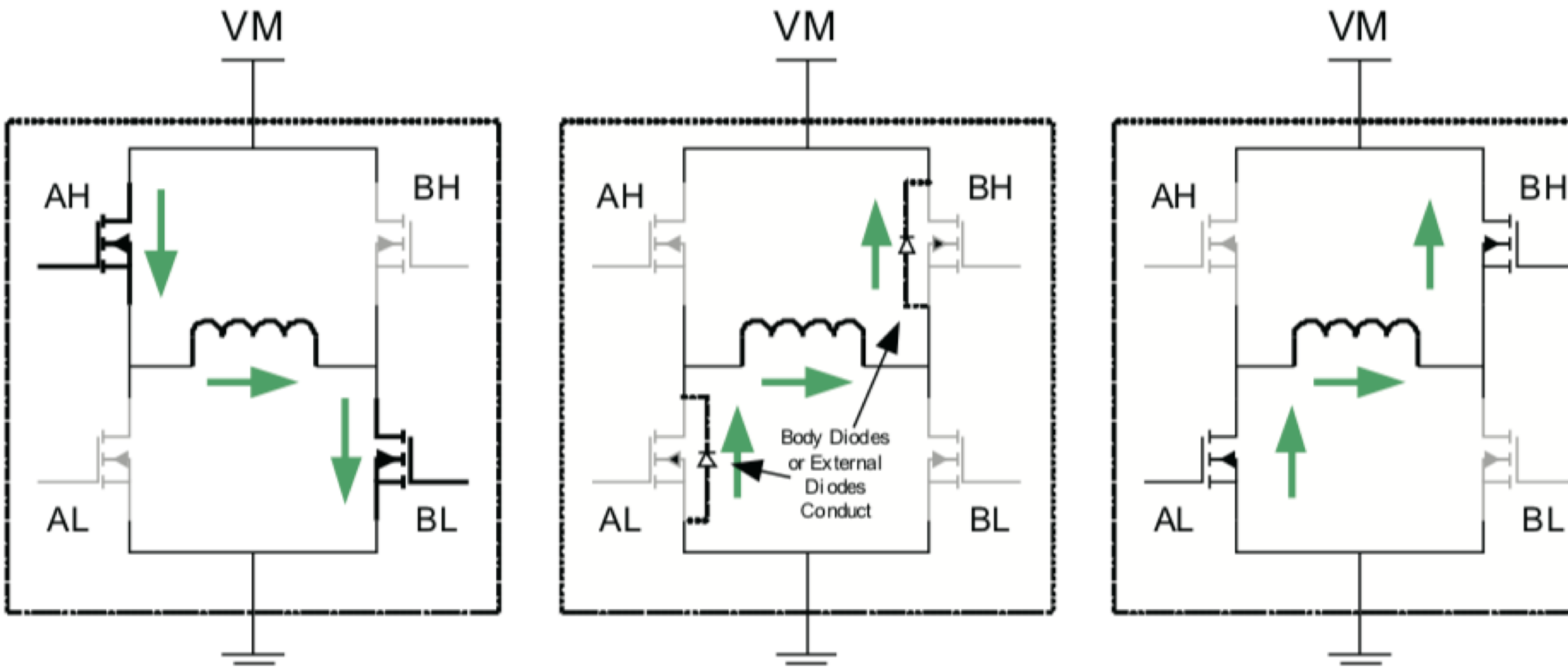


Speed / Torque Control



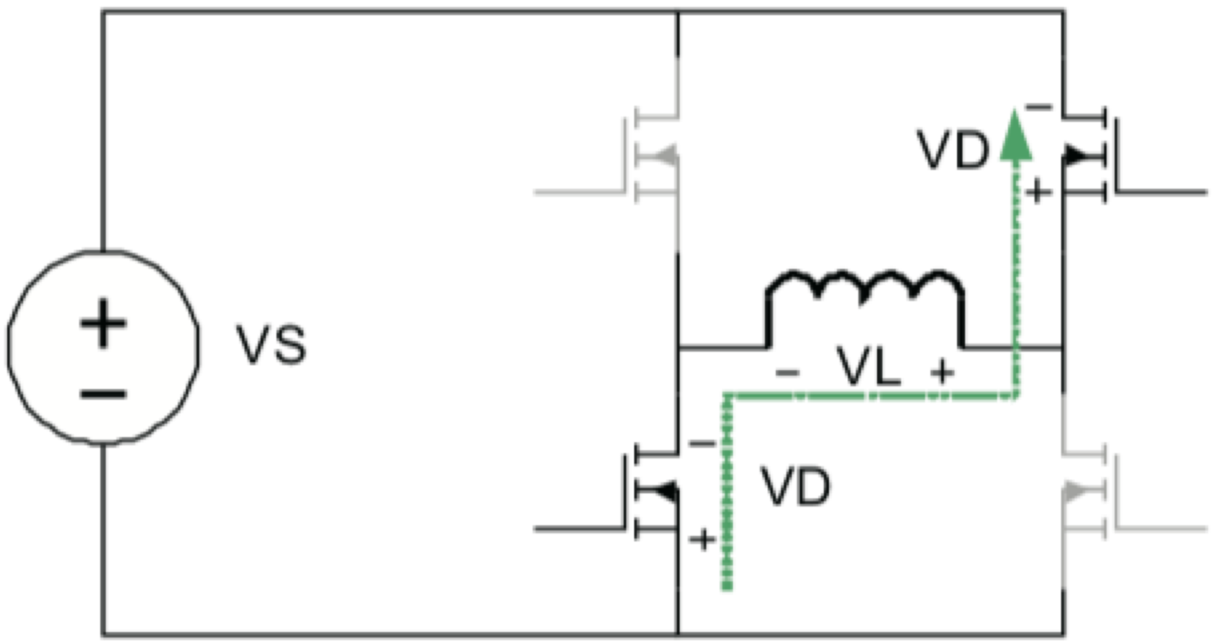
Switching “Off”

Fast Decay



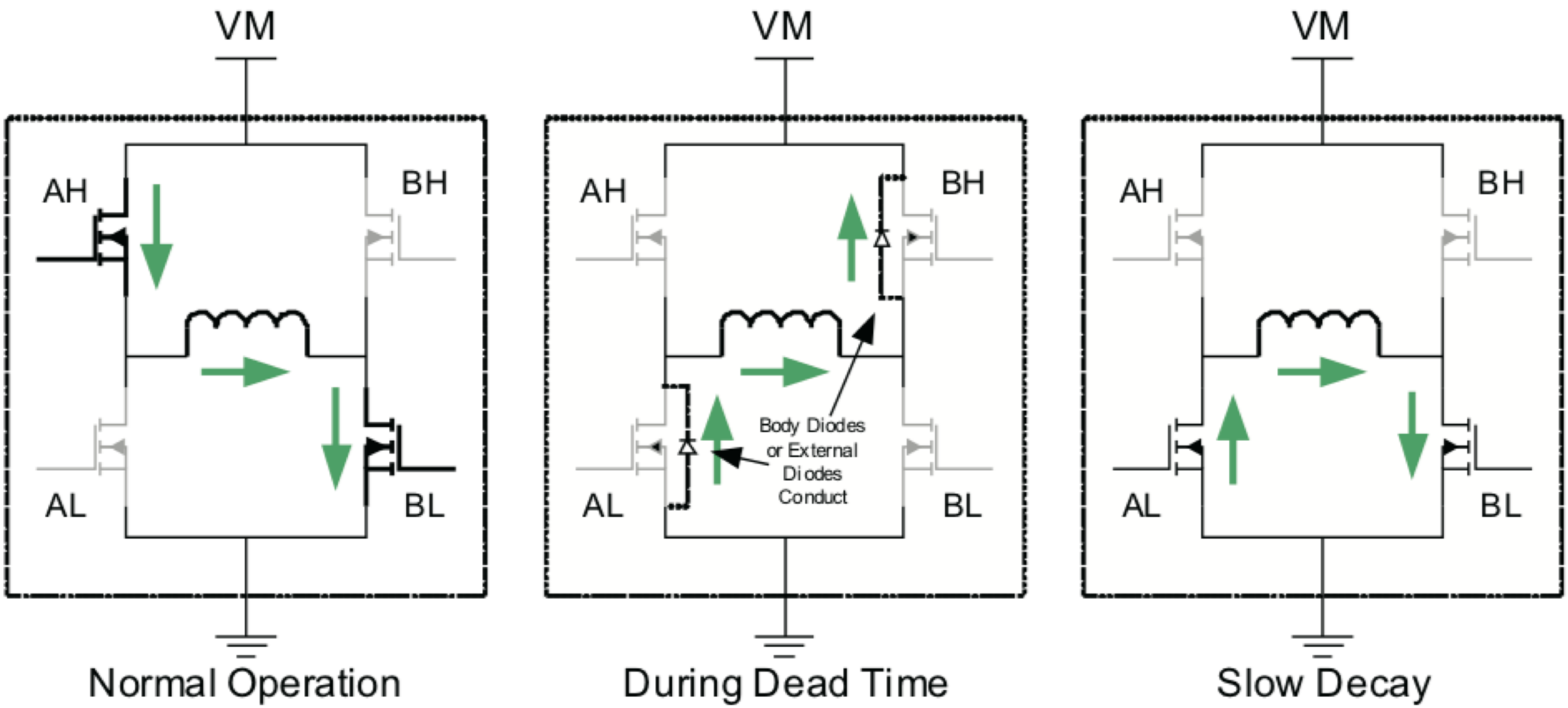
Normal Operation | During Dead Time | Fast Decay

Fast Decay: Voltage across Motor

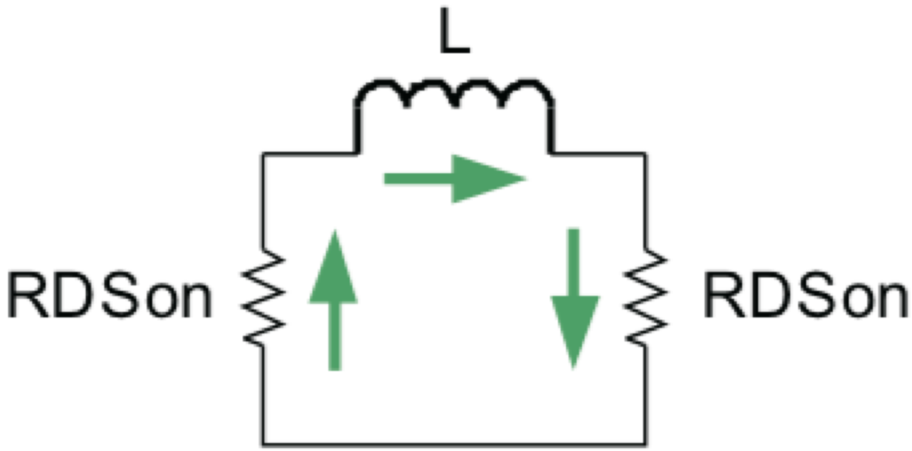


VL = VS + 2VD

Slow Decay


VM
AH
BH
AL
BL
Normal Operation
VM
AH
BH
Body Diodes or External Diodes Conduct
AL
BL
During Dead Time
VM
AH
BH
AL
BL
Slow Decay

Current Decay



Motor PWM Control

- Analogous to LED dimming

$$v = L\frac{di}{dt}$$

PWM Frequency

DRV8833

TEXAS INSTRUMENTS

DRV8833 Dual H-Bridge Motor Driver

1 Features

- Dual-H-Bridge Current-Control Motor Driver
  - Can Drive Two DC Motors or One Stepper Motor
  - Low MOSFET ON-Resistance: HS + LS 360 mΩ
- Output Current (at V_M = 5 V, 25°C)
  - 1.5-A RMS, 2-A Peak per H-Bridge in PWP and RTY Package Options
  - 500-mA RMS, 2-A Peak per H-Bridge in PW Package Option
- Outputs can be in Parallel for
  - 3-A RMS, 4-A Peak (PWP and RTY)
  - 1-A RMS, 4-A Peak (PW)
- Wide Power Supply Voltage Range: 2.7 to 10.8 V
- PWM Winding Current Regulation and Current Limiting
- Thermally Enhanced Surface-Mount Packages

3 Description

The DRV8833 device provides a dual bridge motor driver solution for toys, printers, and other mechatronic applications.

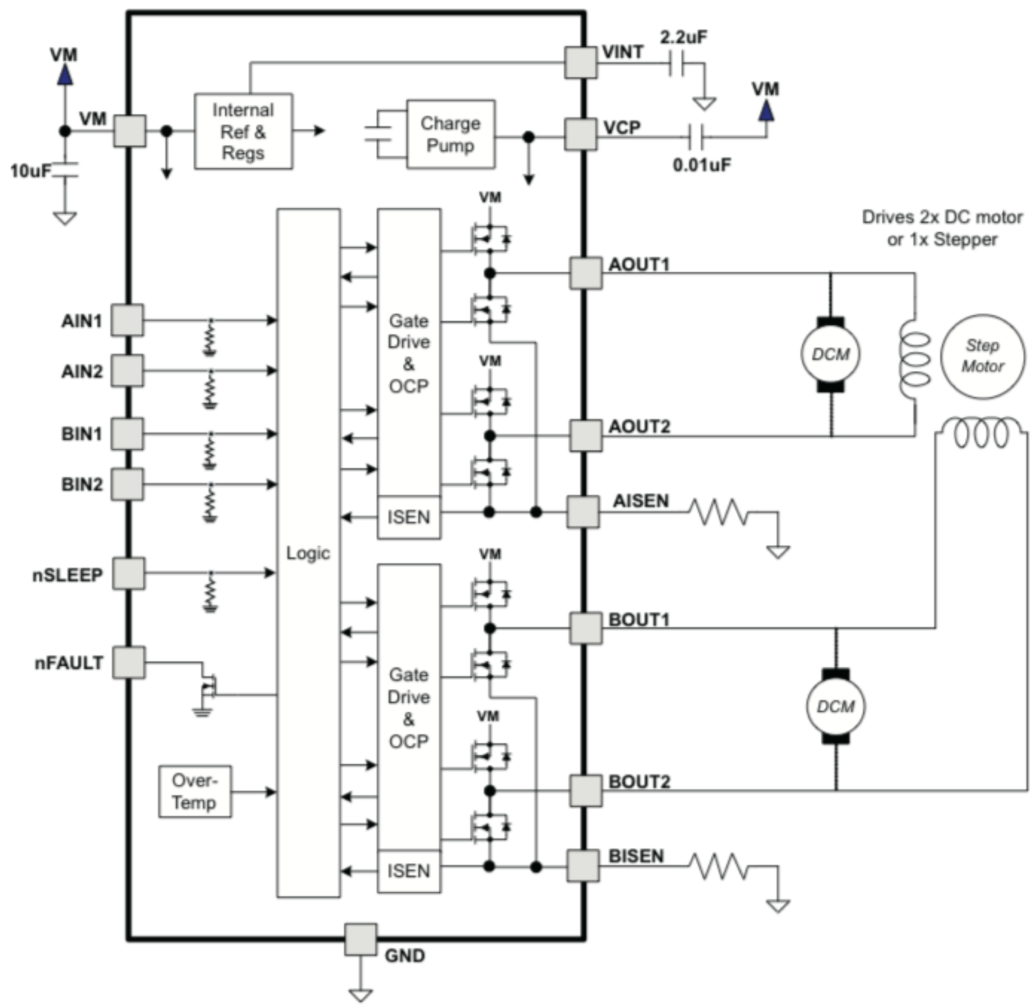
The device has two H-bridge drivers, and can drive two DC brush motors, a bipolar stepper motor, solenoids, or other inductive loads.

The output driver block of each H-bridge consists of N-channel power MOSFETs configured as an H-bridge to drive the motor windings. Each H-bridge includes circuitry to regulate or limit the winding current.

Internal shutdown functions with a fault output pin are provided for overcurrent protection, short-circuit protection, undervoltage lockout, and overtemperature. A low-power sleep mode is also provided.

The DRV8833 is packaged in a 16-pin WQFN package with PowerPAD™ (Eco-friendly: RoHS & no Sb/Br).

Block Diagram



Direction Control

Table 1. H-Bridge Logic

xIN1	xIN2	xOUT1	xOUT2	FUNCTION
0	0	Z	Z	Coast/fast decay
0	1	L	H	Reverse
1	0	H	L	Forward
1	1	L	L	Brake/slow decay

PWM Control

Table 2. PWM Control of Motor Speed

xIN1	xIN2	FUNCTION
PWM	0	Forward PWM, fast decay
1	PWM	Forward PWM, slow decay
0	PWM	Reverse PWM, fast decay
PWM	1	Reverse PWM, slow decay

PWM Signals

Table 2. PWM Control of Motor Speed

xIN1	xIN2	FUNCTION
PWM	0	Forward PWM, fast decay
1	PWM	Forward PWM, slow decay
0	PWM	Reverse PWM, fast decay
PWM	1	Reverse PWM, slow decay

Summary

- H-bridge
  - Motor speed
  - Direction
- Magnetic energy, inductance
- PWM
  - Torque / speed control
  - PWM Frequency
- Magnetic energy management
  - Freewheeling diodes
  - Fast decay
  - Slow decay