H-Bridge Demystified

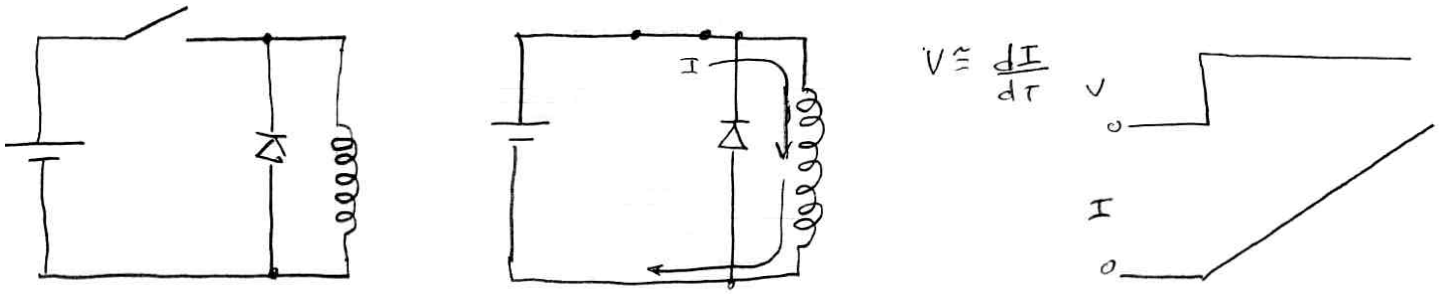
- Basic electronic theory
- How H-Bridges work
- Explain terminology
- Explain where the power goes

Basic Theory: Ohms law

- Power = Voltage * Current
- Voltage = Current * Resistance
  Examples:
  - .5A * 10 ohms = 5v
  - 5v * .5A = 2.5 watts
  - .5v / .05 ohms = 10a
  - 10a * .5v = 5 watts
- Power = Current^2 * resistance

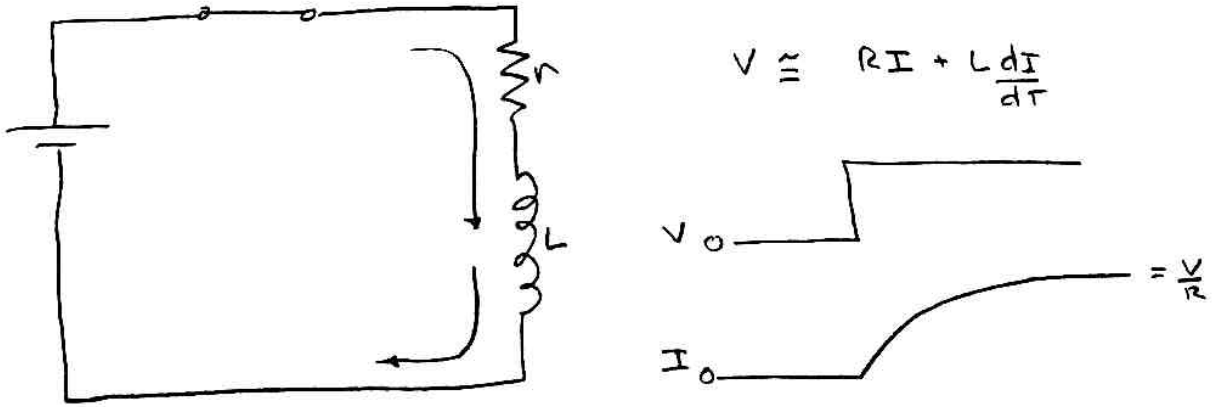
Basic Theory: Inductors

- V = L * dI/dT - What does that mean???



- Current rises indefinitely based upon inductance and voltage.

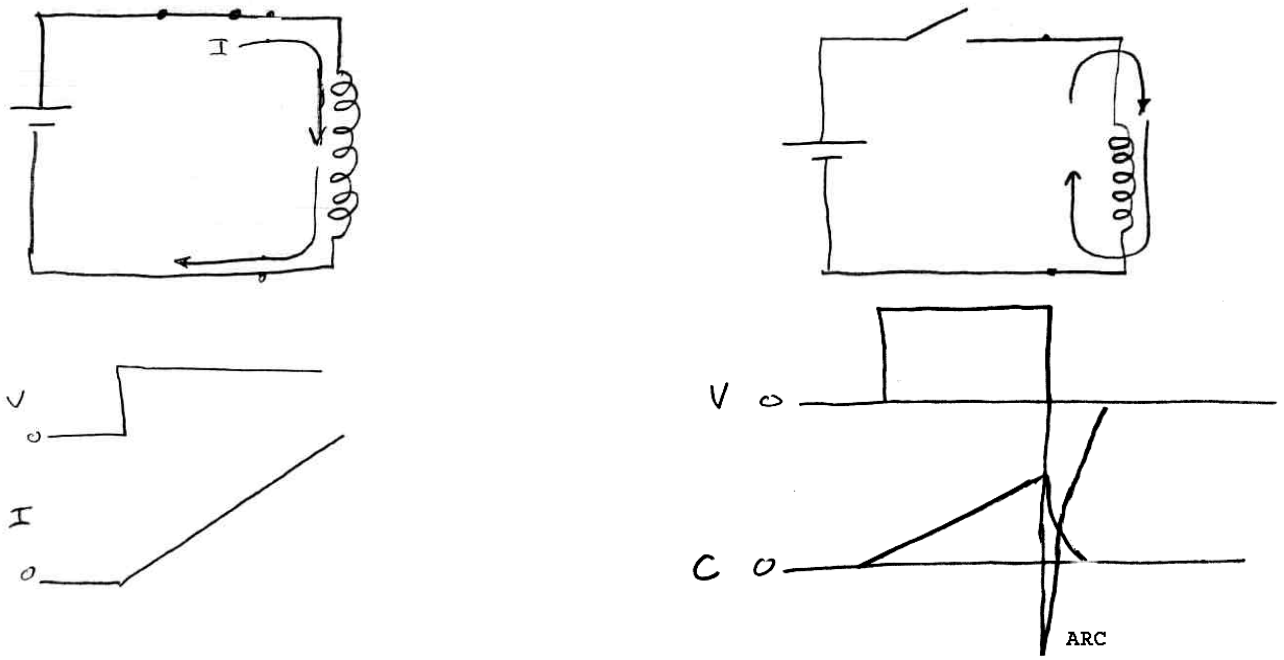
Basic Theory: Real Inductors



- Real inductors have resistance
- Current * resistance = voltage
- Eventually current levels out
- Strength of magnetic field + level of stored energy are proportional to the current.

Basic Theory: Inductors

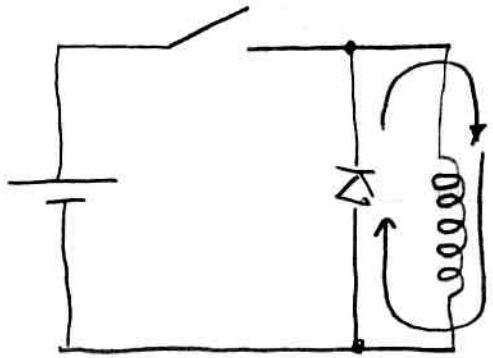
- What happens when switch is opened?



- Current dissipates quickly in the ARC

Basic Theory: Inductors

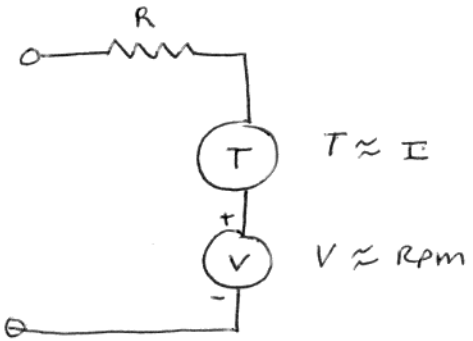
- Diodes used to suppress arcing
- Recirculating currents dissipate slower



- Note: current continues to flow in inductor
- Power is dissipated across diode & inductor internal resistance.

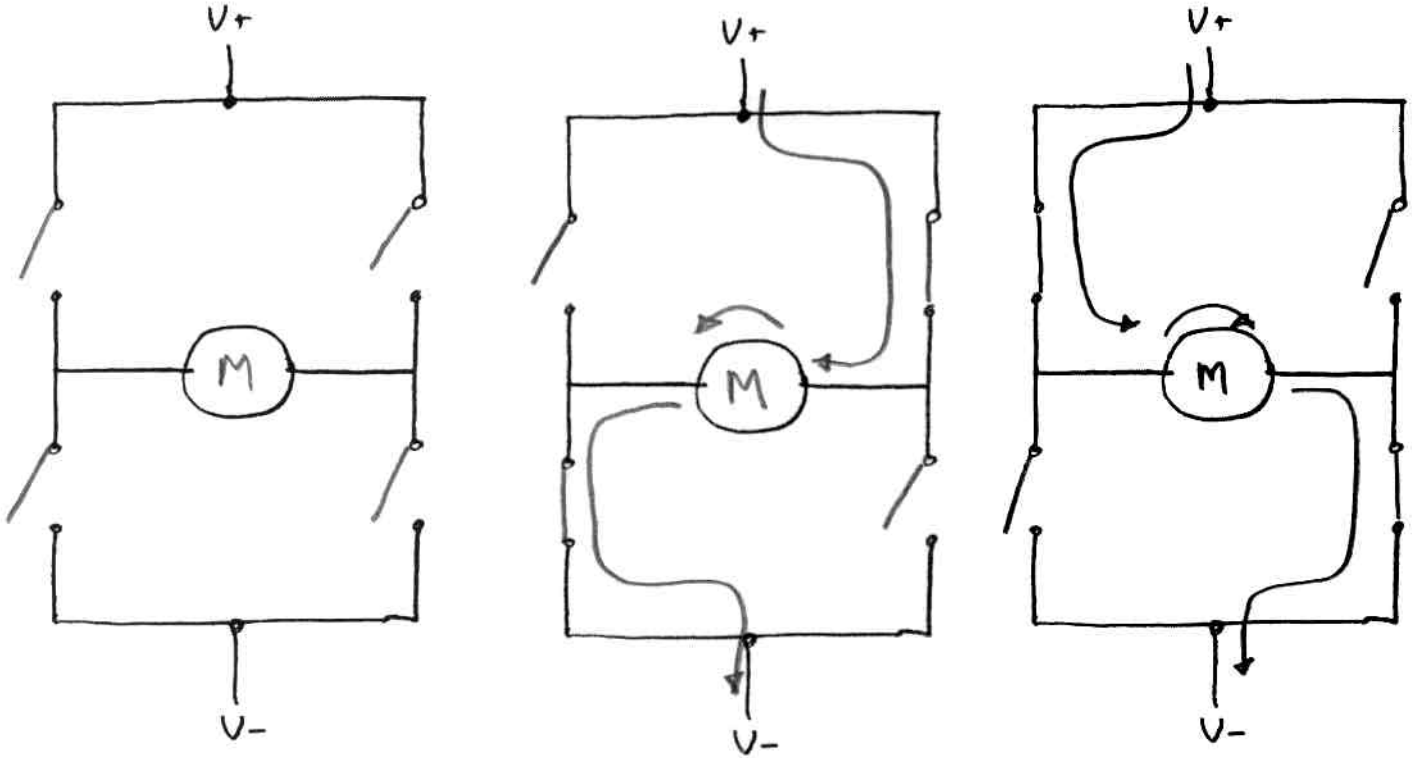
Basic Theory: PMDC motor

- PMDC motors can be modeled as an inductor, a voltage source and a resistance.
- Torque is proportional to the current



- The internal voltage source is proportional to the RPM (Back-EMF)
- Stall current/max torque is proportional to the internal resistance.

How H-Bridge works

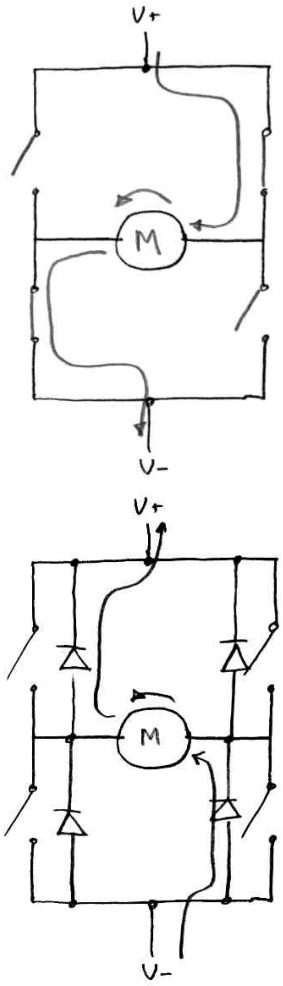


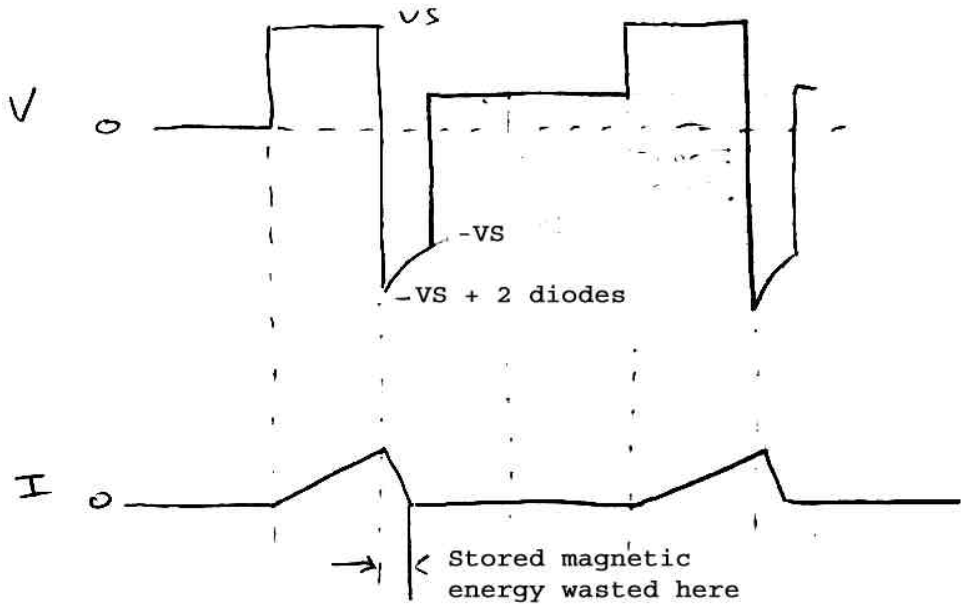
Off

Forward

Reverse

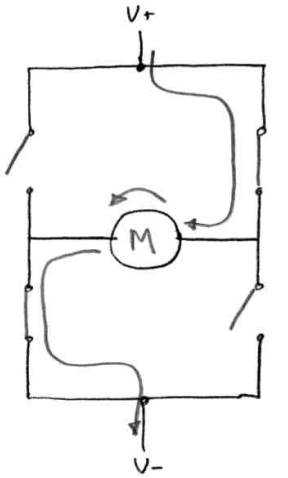
How H-Bridge Works

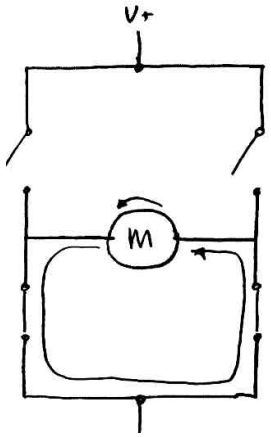


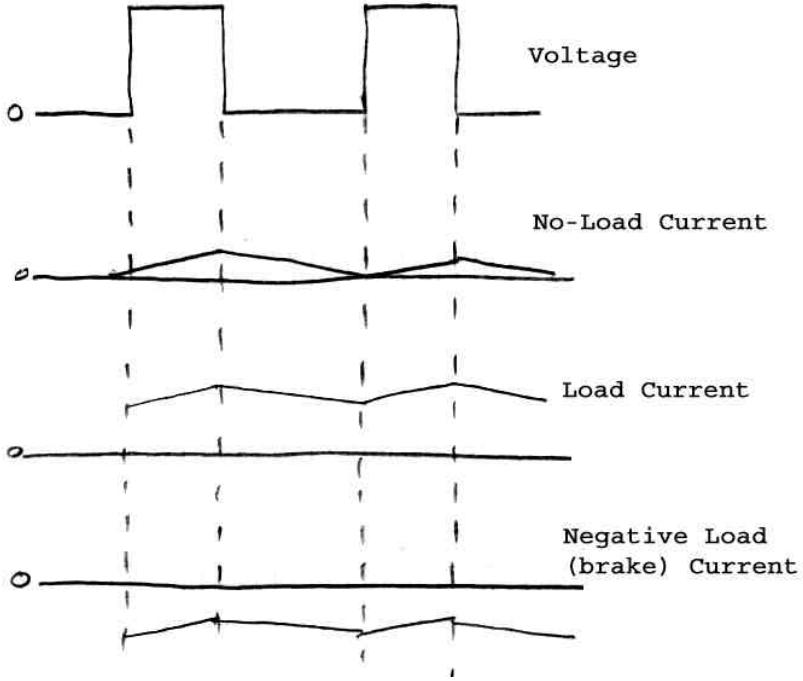


- This represents traditional PWM motor control
- Note low average current flow

H-Bridge: Synchronous Rectification



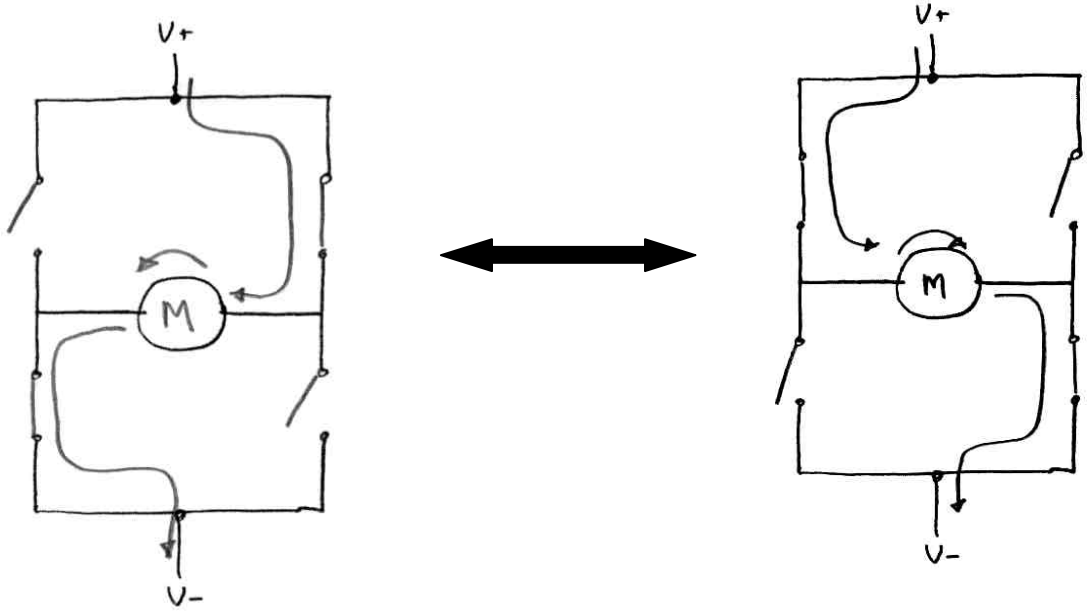




- Use switches instead of diodes
- Much more efficient, regenerative braking

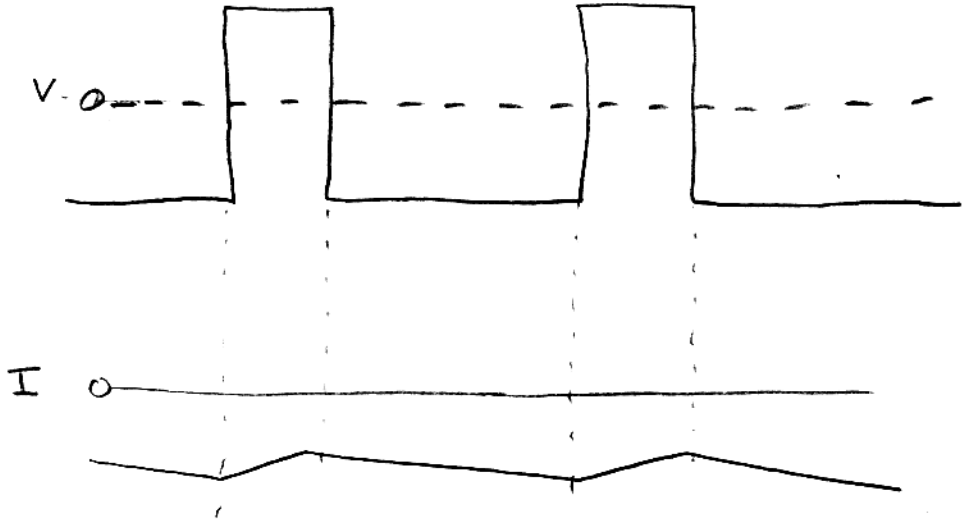
H-Bridge Locked-Antiphase

- Pro: one line needed for forward/reverse
- Con: higher frequencies needed



Locked Antiphase

- Voltage swings from +V to –V
- No rectification needed
- Current ripple twice as large



H-Bridge Examples

L293, L298, MC33886, TLE5206, TPIC0108b, etc

Simple logic: output = input. Some chips have disables to disconnect all outputs. Advance chips output protection.

Functional Truth Table				
IN1	**IN2**	**OUT1**	**OUT2**	**Comments**
L	L	L	L	Brake; both low transistors on
L	H	L	H	Forward
H	L	H	L	Reverse
H	H	H	H	Brake; both high transistors on.

H-Bridge Examples

LM18200, TLE5205, TPIC0107b, etc.

Functional Truth Table (LM18200)					
PWM	**DIR**	**Brake**	**OUT1**	**OUT2**	**Comments**
H	H	L	H	L	Forward
H	L	L	L	H	Reverse
L	X	L	H	H	High Side BRAKE
H	H	H	L	L	Low Side Brake
H	L	H	L	L	Low Side BRAKE
L	X	H	Z	Z	None

Demonstration

- Actual current flow & voltage charts
- Resistor
- Inductor (motor)
  - No load
  - Load (power delivered)
  - Negative Load (Regenerative braking)

H-Bridge/Inductor Demonstration