DC Motor Basics

Last updated 12/2/19

DC Motors

• Basic construction
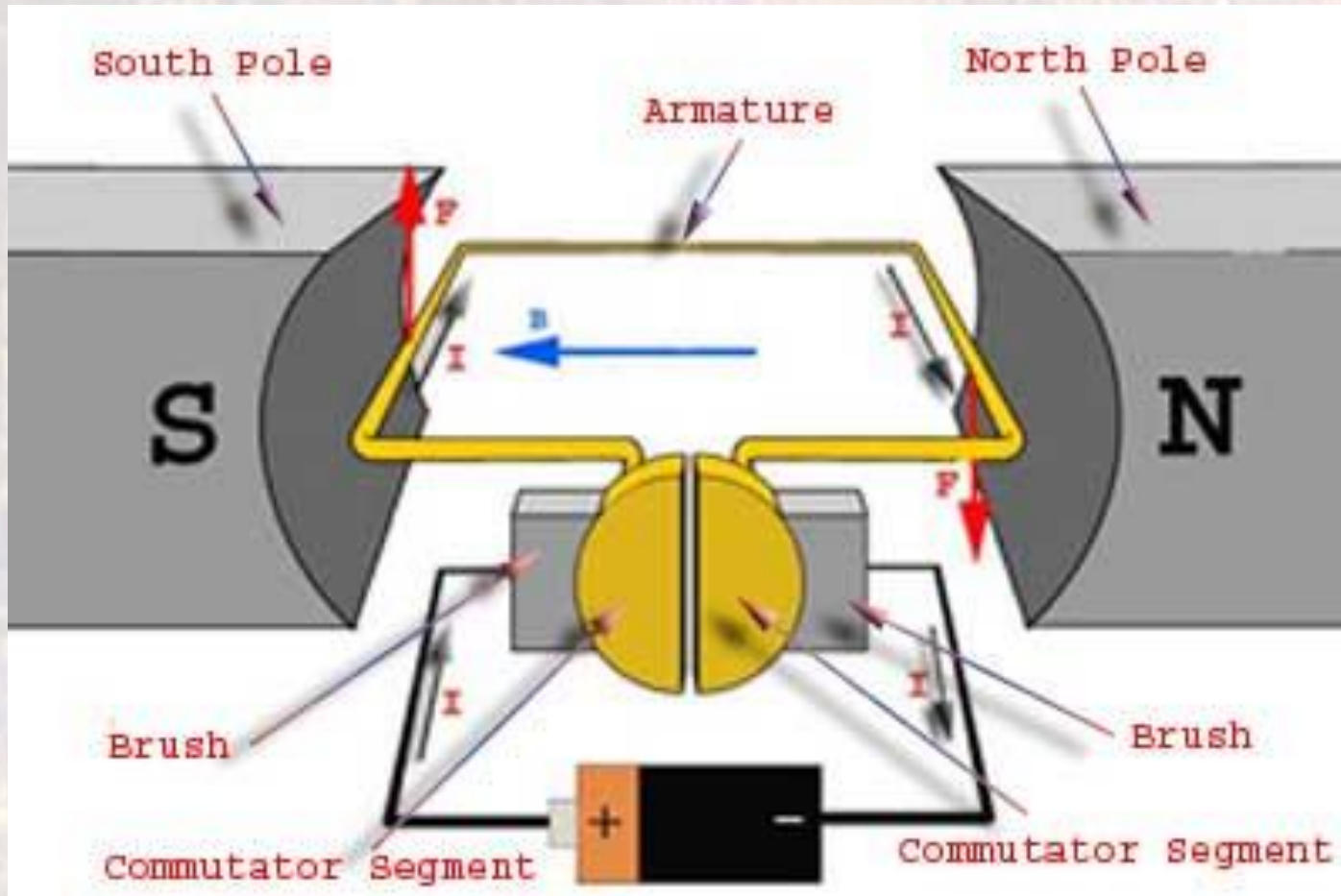

image src: http://www.electrical4u.com/

DC Motors

• Basic operation

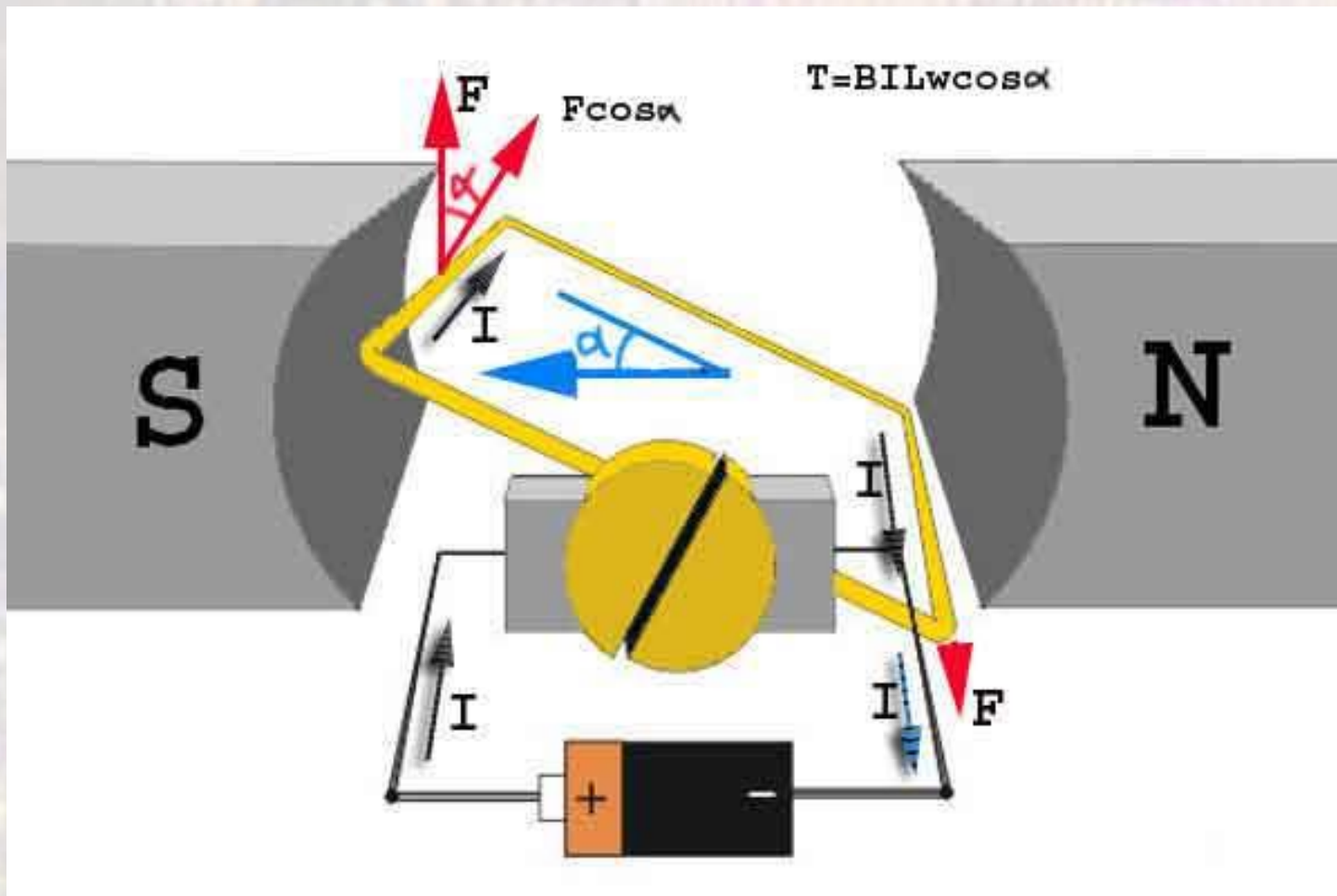

image src: http://www.electrical4u.com/

DC Motors

- Rotational speed

$s = k_2 \, (V - RI) \, / \, \Phi$

= constant of proportionality * effective voltage / flux

k_2 – fixed

R – fixed

Φ - fixed

We can change the speed by changing V

DC Motors

- Torque

$$\tau = k_1 \, I \, \Phi$$

= constant of proportionality * I * Flux

k_1 – fixed

Φ - fixed

We can change the torque by changing I
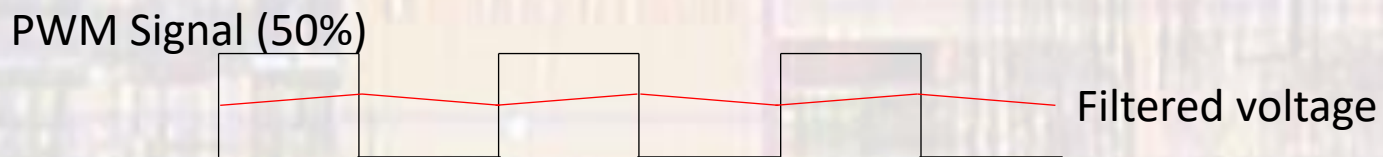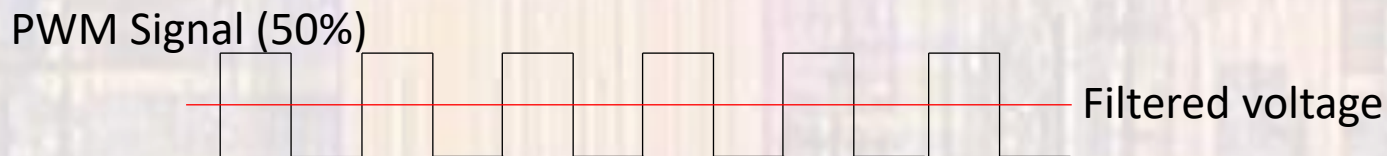
DC Motors

- Motor control

  - We want to vary speed of the motor (V)
    - allows for variation is speed
    - allows for change in direction with independent motors

  - Want to maximize the torque (I)
    - Need to push another bot out of the ring

DC Motors

- Motor control

  - With our microcontroller we have no true analog output capability
    - Must use PWM

  - Fortunately, the motor looks like a low pass filter
    - PWM signal will look like a DC signal for well chosen frequencies

  - Vary pulse width to modulate speed

  - BUT – what pulse widths, what frequency

DC Motors

- Motor control
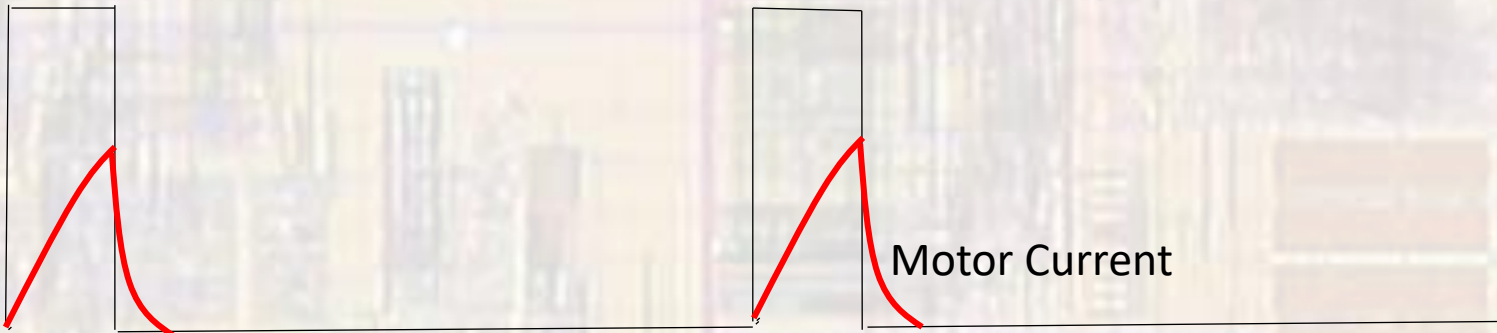
  - PWM Low Frequency Considerations

PWM Signal (50%)

Filtered voltage

PWM Signal (50%)

Filtered voltage

DC Motors

- Motor control

  - PWM Pulse Width and High Frequency Concerns

PWM Signal

Motor Current

PWM Signal

Motor Current

DC Motors

- Motor control

  - For our motors and using the motor driver the "best" PWM frequency is ???

  - You should experiment a little and determine this yourself

DC Motors

- Motor control

  - Still want to maximize voltage and current

  - MSP432 is limited to 3.3V and 6mA (20mA) for a digital output

but

  - We have five 1.5V batteries → 7.5V available
    - need to control the 7.5V with a 3.3V digital signal
   - would like to get more than 6mA (20mA) for the motor

DC Motors

- Motor control

  - Driver chip – TB6612FNG
    - 1.2A ave output current per channel
    - 3.2A peak output current(non repetitive) per channel
    - Enable/Standby
    - Thermal shutdown
    - Up to 13.5V motor supply voltage
    - 2.7 – 5.5V logic/control supply voltage
    - PWM frequency up to 100KHz

DC Motors

- Motor control

  - Driver chip - TB6612FNG

Output pin; 01, 02

VM

01 02

PGND
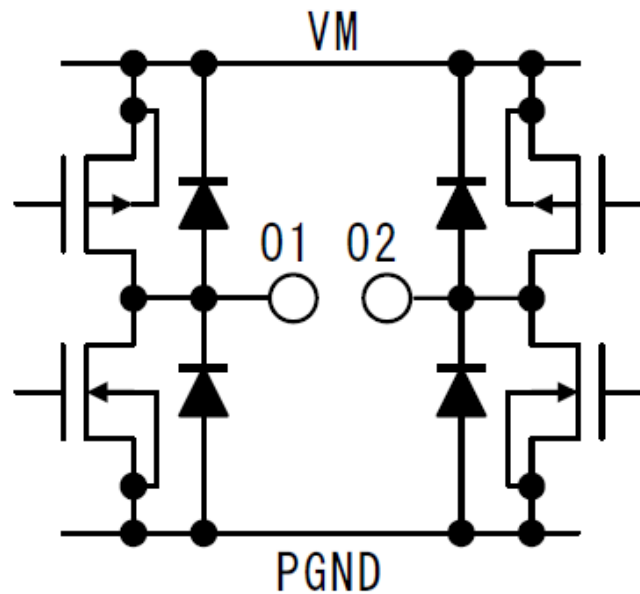
DC Motors

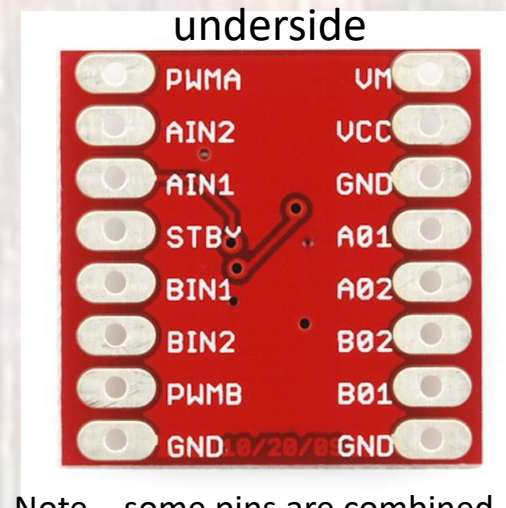- ## Motor control

  - ### Driver chip - TB6612FNG
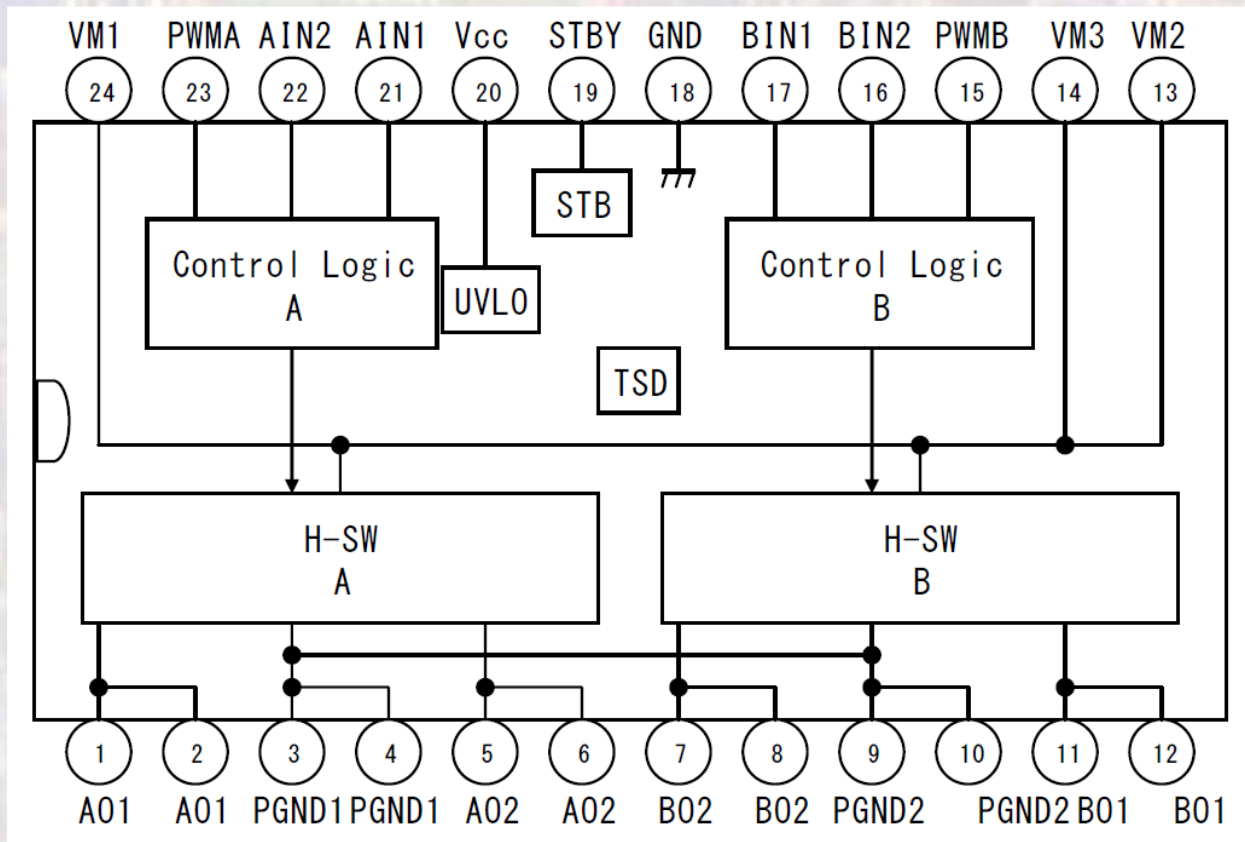
DC Motors

- ## Motor control

  - ### Driver chip - TB6612FNG-breakout board

underside
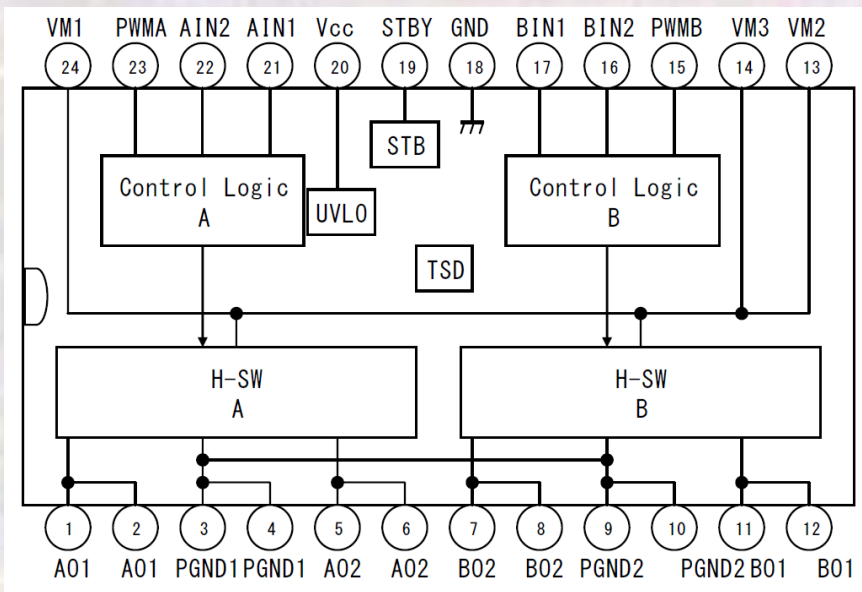
Note – some pins are combined
on the board

DC Motors

- ## Motor control
  - ### Nominal Setup

underside

50% duty cycle → PWMA ... VM → **7.5V**

AIN2 ... VCC → **3.3V**

AIN1 ... GND

"1" stby_bar → STBY ... A01

BIN1 ... A02 → M **R**

BIN2 ... B02

50% duty cycle → PWMB ... B01

GND ... GND → **L** M

Assumes motors are mounted in mirror configuration
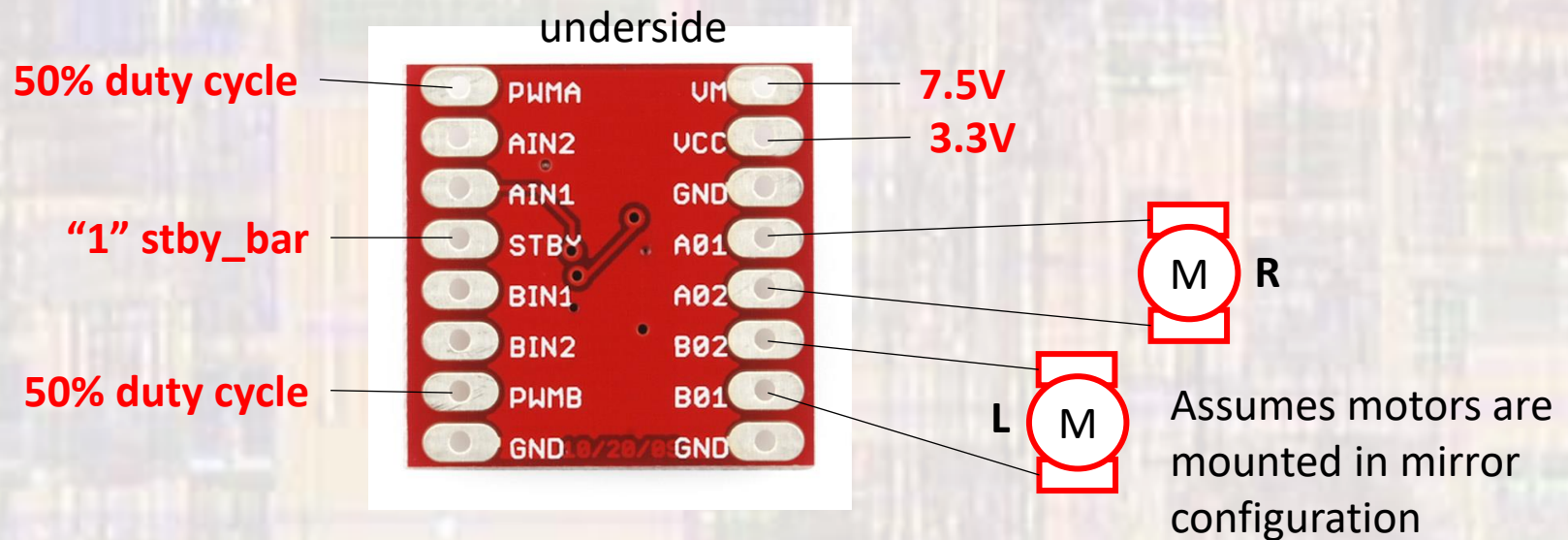
Note: Supply Decoupling and GND connection not shown

DC Motors

- ## Motor control
  - ## Example 1 forward together (lt and rt wheel fwd)

underside

50% duty cycle — PWMA   VM — **7.5V**

0 — AIN2   VCC — **3.3V**

1 — AIN1   GND

"1" stby_bar — STBY   A01

1 — BIN1   A02 — M **R**

0 — BIN2   B02

50% duty cycle — PWMB   B01 — **L** M

GND   GND

Assumes motors are mounted in mirror configuration
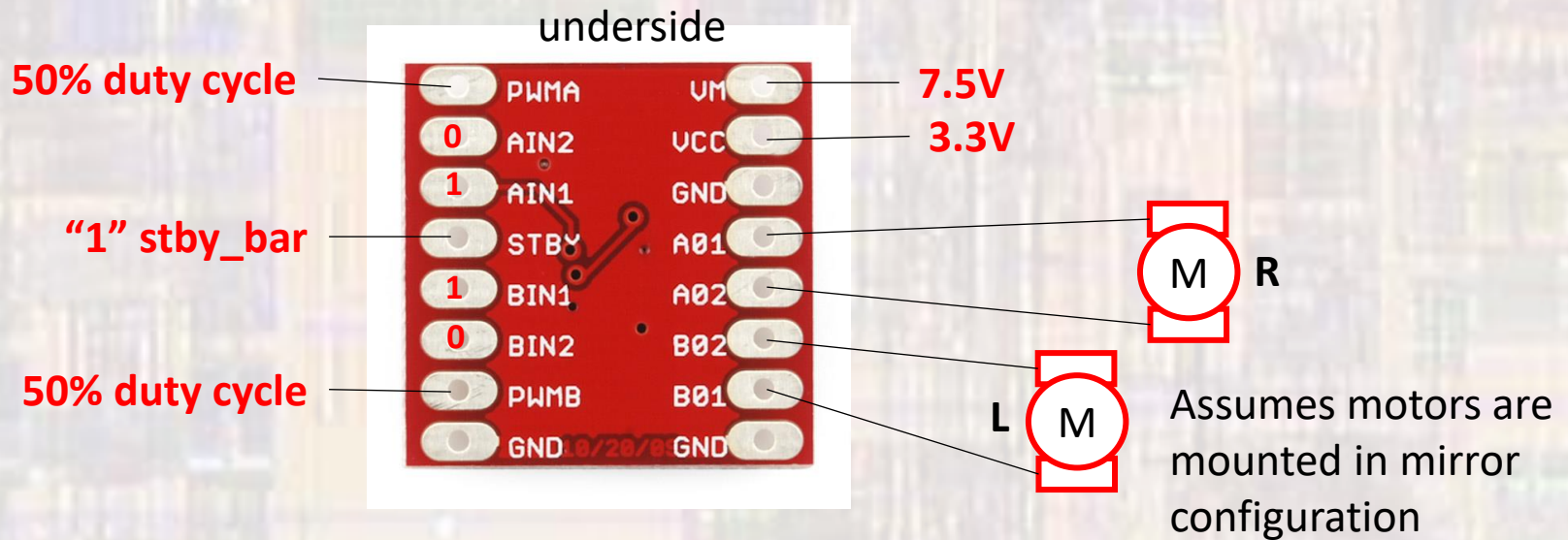
Note: Supply Decoupling and GND connection not shown

DC Motors

- Motor control
  - Example 2 backwards together (lt and rt wheel bwd)

underside

50% duty cycle — PWMA   VM — 7.5V

1 — AIN2   VCC — 3.3V

0 — AIN1   GND

"1" stby_bar — STBY   A01 — M   R

0 — BIN1   A02

1 — BIN2   B02

50% duty cycle — PWMB   B01 — L   M

GND   GND

Assumes motors are mounted in mirror configuration
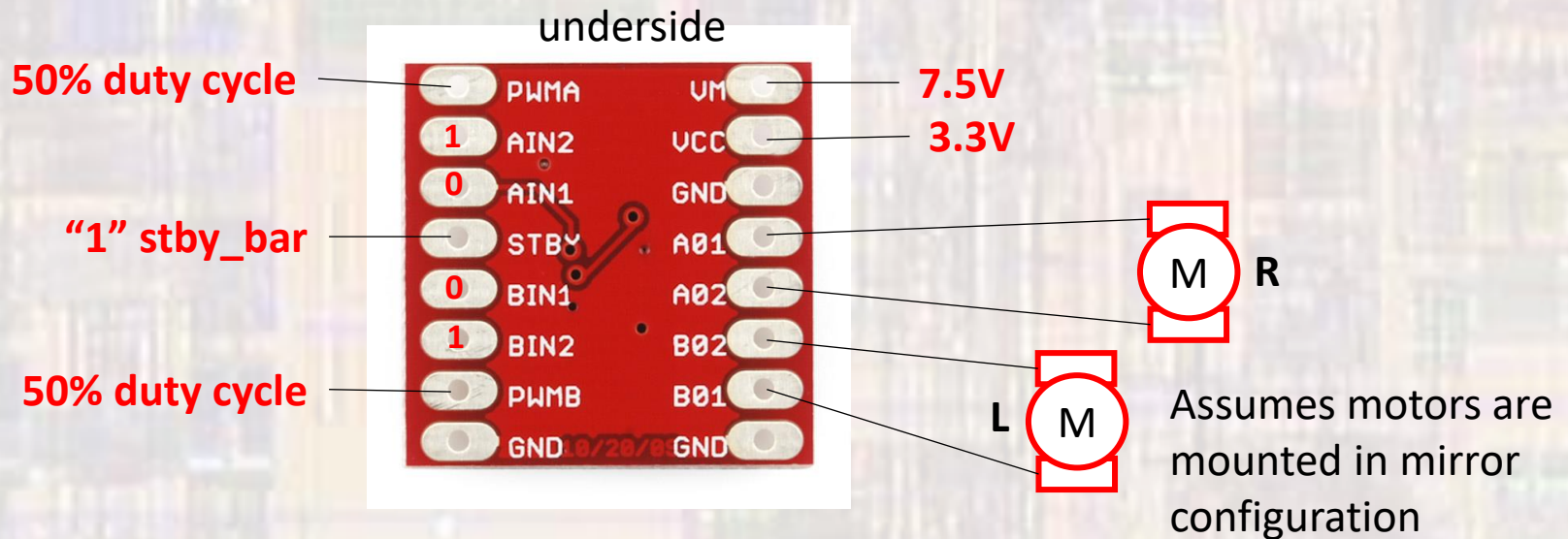
Note: Supply Decoupling and GND connection not shown

DC Motors

- Motor control
  - Example 3 wide right turn (lt wheel fwd fast, rt wheel fwd slow)

underside

40% duty cycle — PWMA   VM — **7.5V**

0 AIN2   VCC — **3.3V**

1 AIN1   GND

"1" stby_bar — STBY   A01 —— M R

1 BIN1   A02

0 BIN2   B02

60% duty cycle — PWMB   B01 —— L M

GND   GND

Assumes motors are mounted in mirror configuration
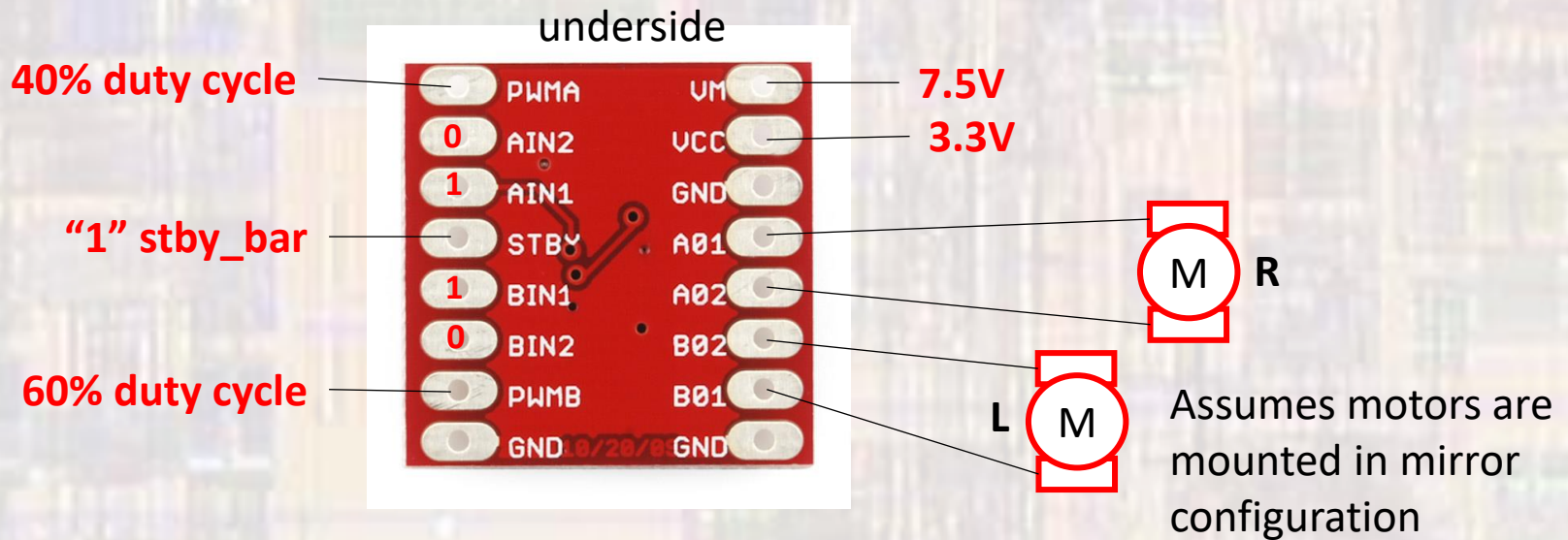
Note: Supply Decoupling and GND connection not shown

DC Motors

- Motor control
  - Example 4 slow tight left turn (lt wheel bwd, rt wheel fwd)

underside

20% duty cycle — PWMA   VM — **7.5V**

0 AIN2   VCC — **3.3V**

1 AIN1   GND

"1" stby_bar — STBY   A01 — M **R**

0 BIN1   A02

1 BIN2   B02

20% duty cycle — PWMB   B01 — **L** M

GND   GND

Assumes motors are mounted in mirror configuration
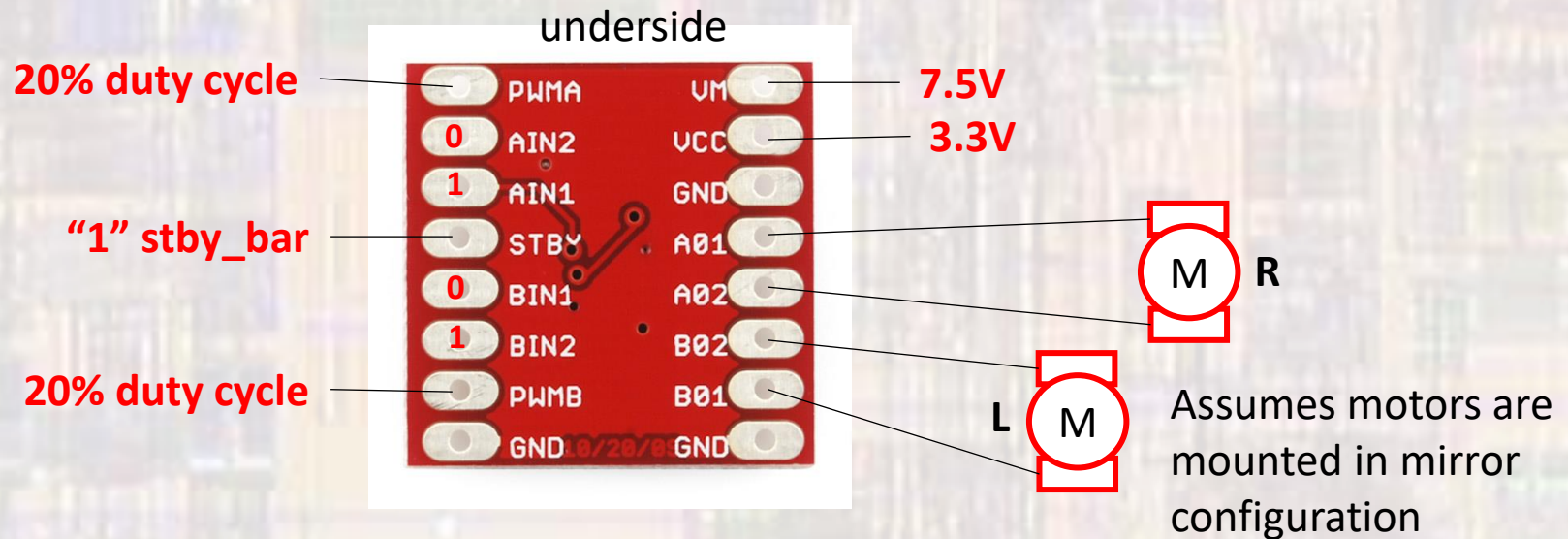
Note: Supply Decoupling and GND connection not shown

DC Motors

- Motor control
  - Supply decoupling already on the breakout board
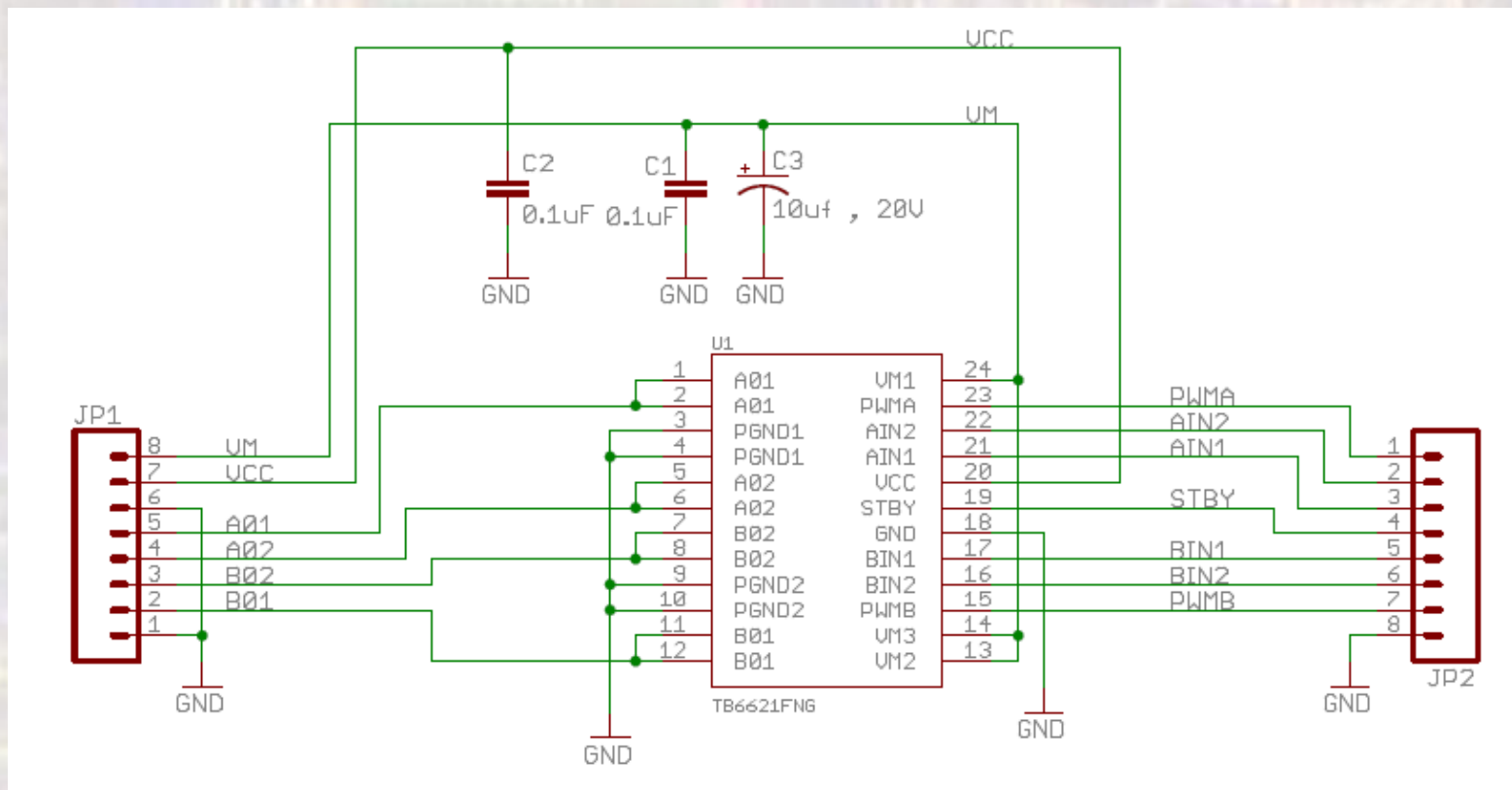
DC Motors

- Motor control
  - Noise Suppression

  - 0.1uF ceramic capacitors

  - 0.1uf = 100,000pf → 10 + 4 zeros
    → 104 marked on the capacitor