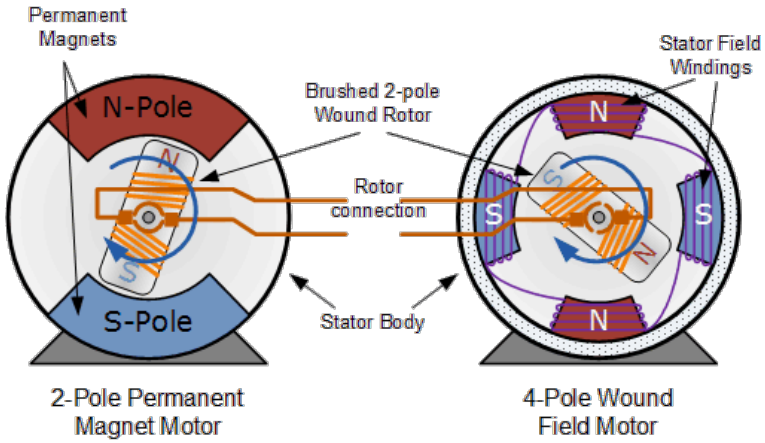
UAV Workshop

Quadrotor Motors

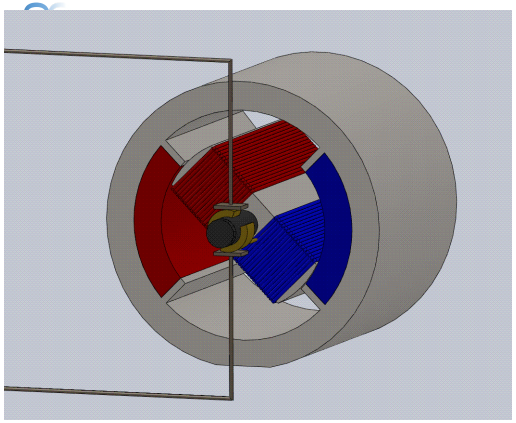
Prof. Venki Muthukumar, Ph.D.

Types of Motors

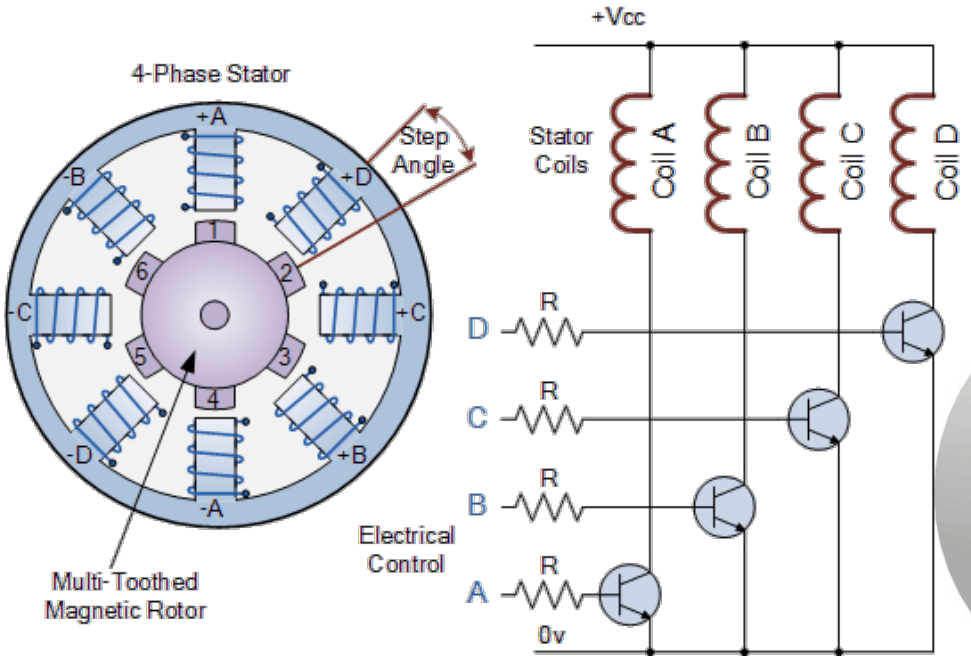
- DC Motors
- Stepper Motors
- Servo Motors

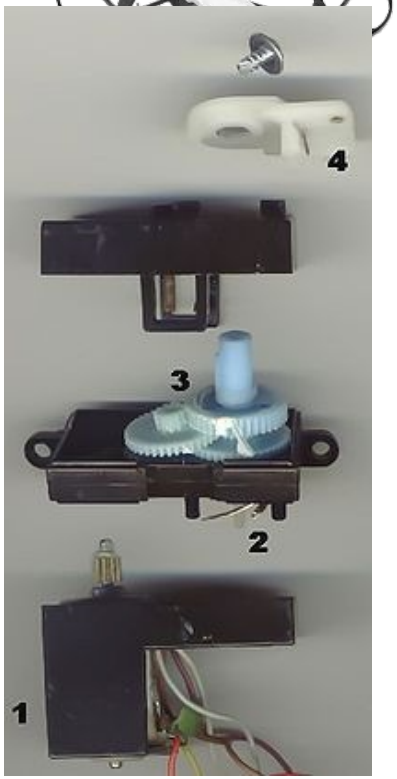


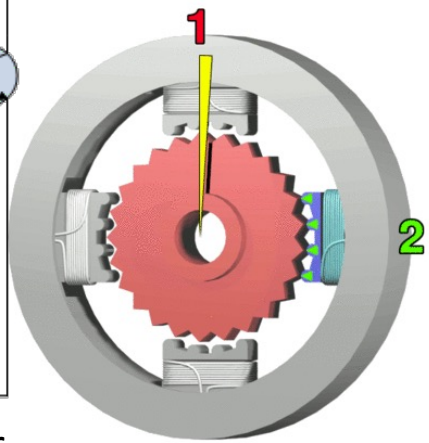
DC motor



DC motor







Stepper motor

DC motors (brushed and brushless)

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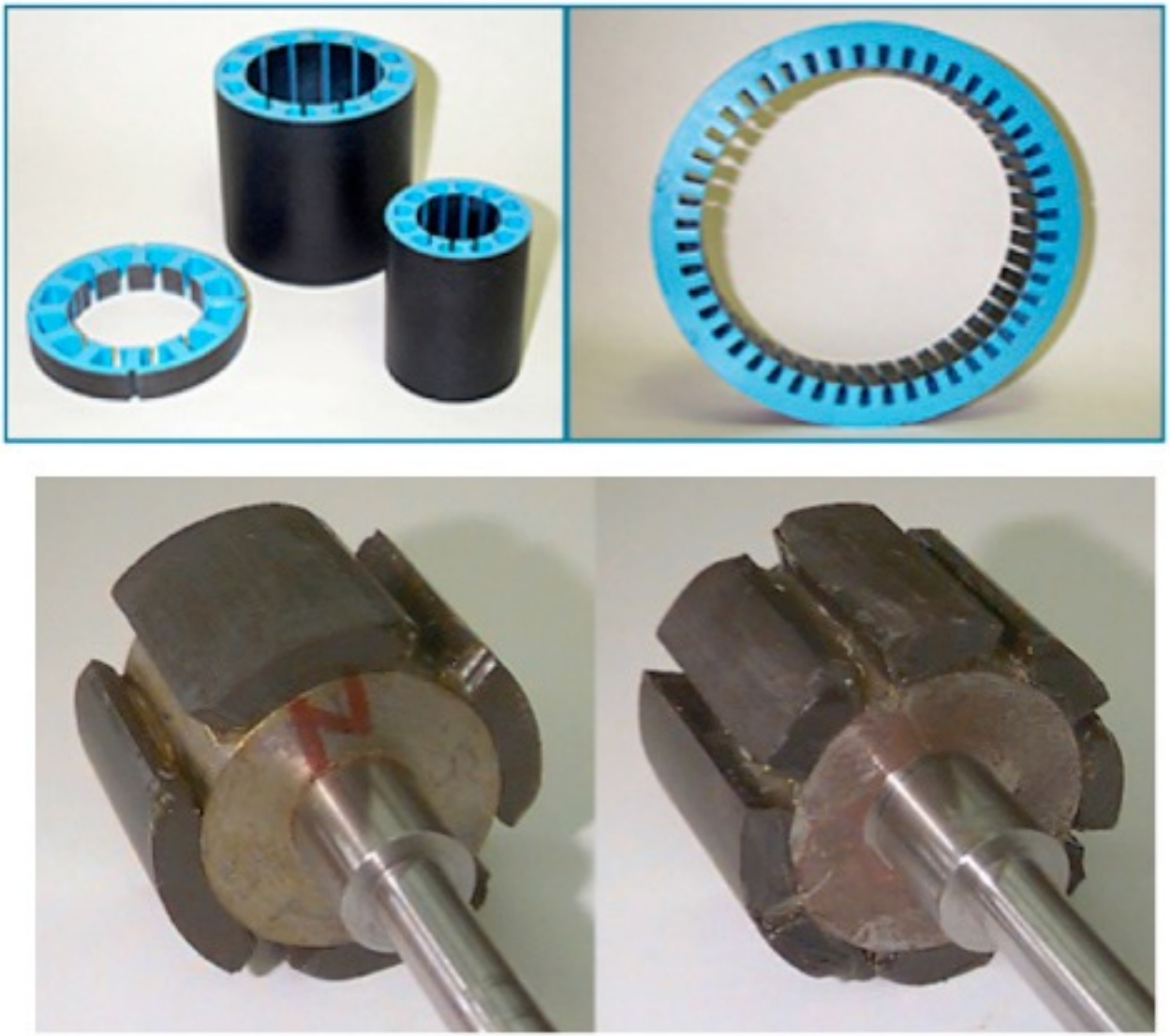

Figure 3: 4 pole and 8 pole – Permanent magnet rotor

BDC & BLDC motors

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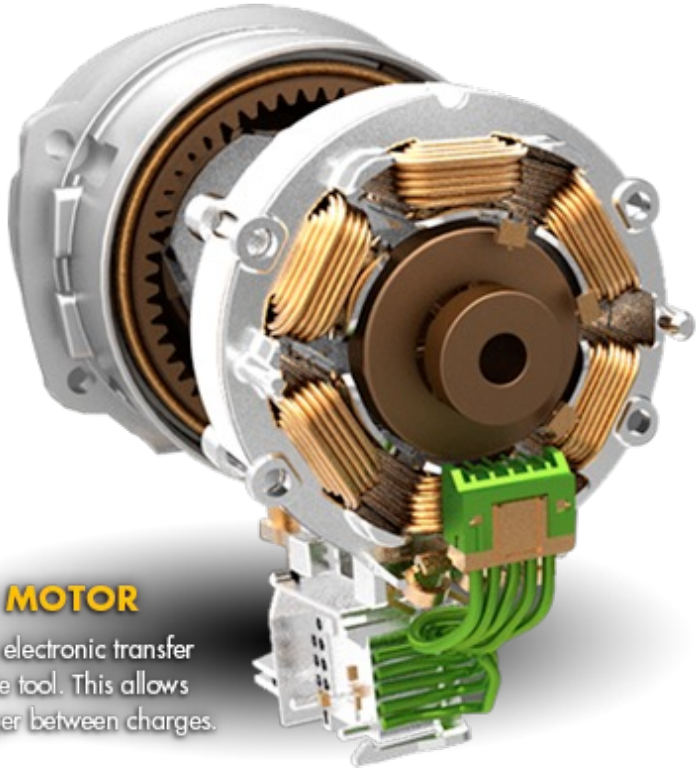
SIDE BY SIDE COMPARISON

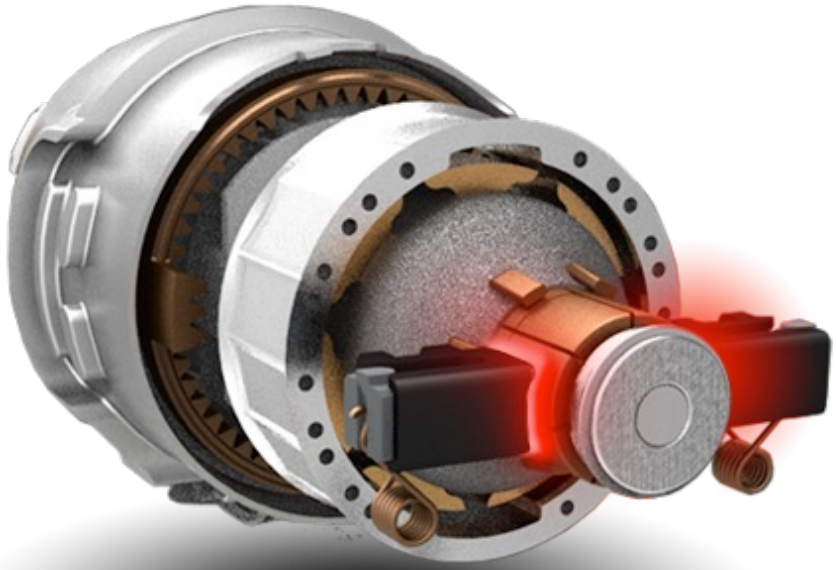
Comparing the DEWALT Brushless motor to a standard motor.



BL MOTOR

BRUSHLESS MOTOR

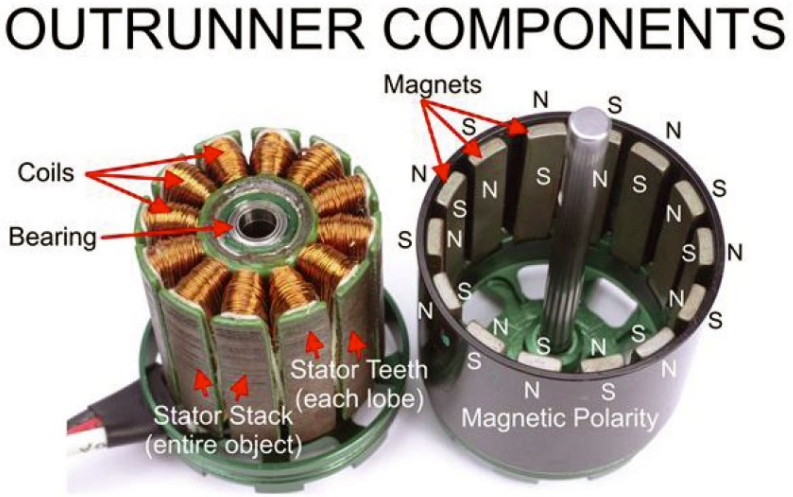
"Green" indicates electronic transfer of energy within the tool. This allows the tool to run longer between charges.

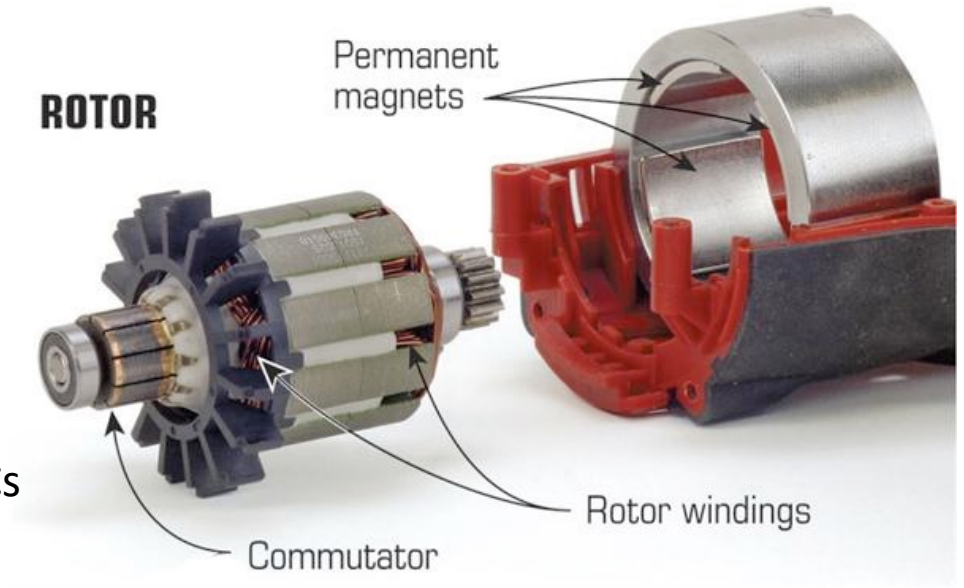


BRUSHED MOTOR

"Red" Indicates friction caused by brushes on conventional motors. This slows the motor down and generates heat.

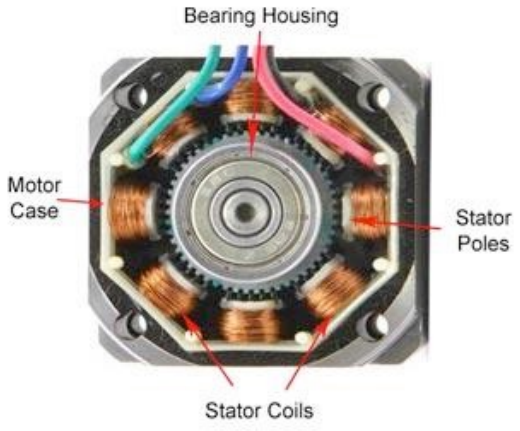
More motors

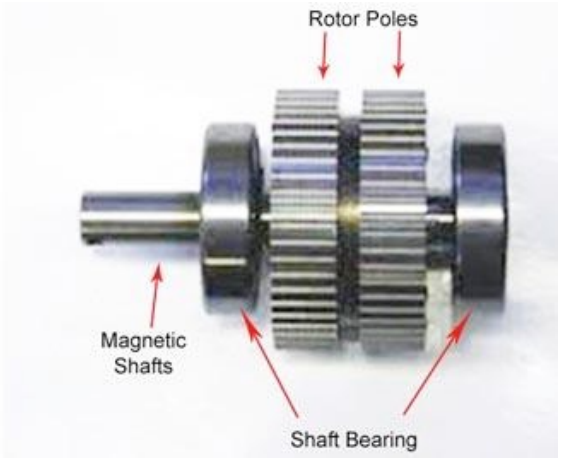




BLDCs

Servo





Stepper

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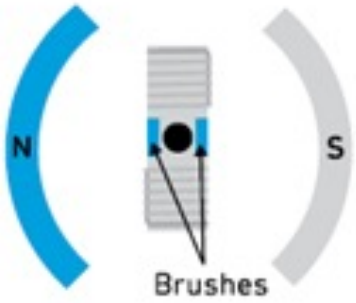
Brushed DC



Advantages:
- Easy to drive
- Low cost

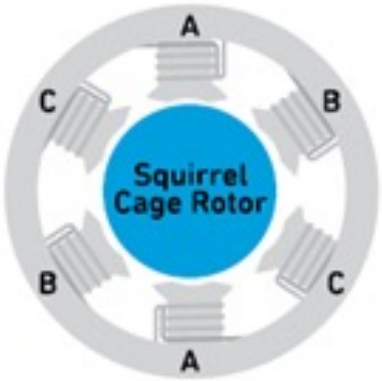
Disadvantages:
- High construction complexity
- High maintenance (brushes)
- Terrible EMI (brushes)

Stepper

Advantages:
- Precise positioning
- Low cost
- Simple control I/F

Disadvantages:
- Noise/resonance
- Heat/inefficient

Induction



Advantages:
- Low cost
- Easy to spin

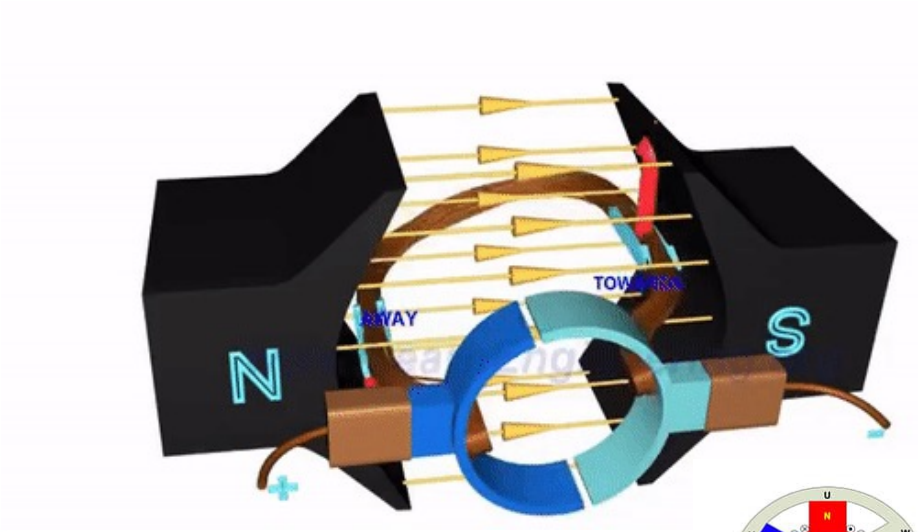
Disadvantages:
- Heat/inefficient
- High voltage solution
- Large physical construction

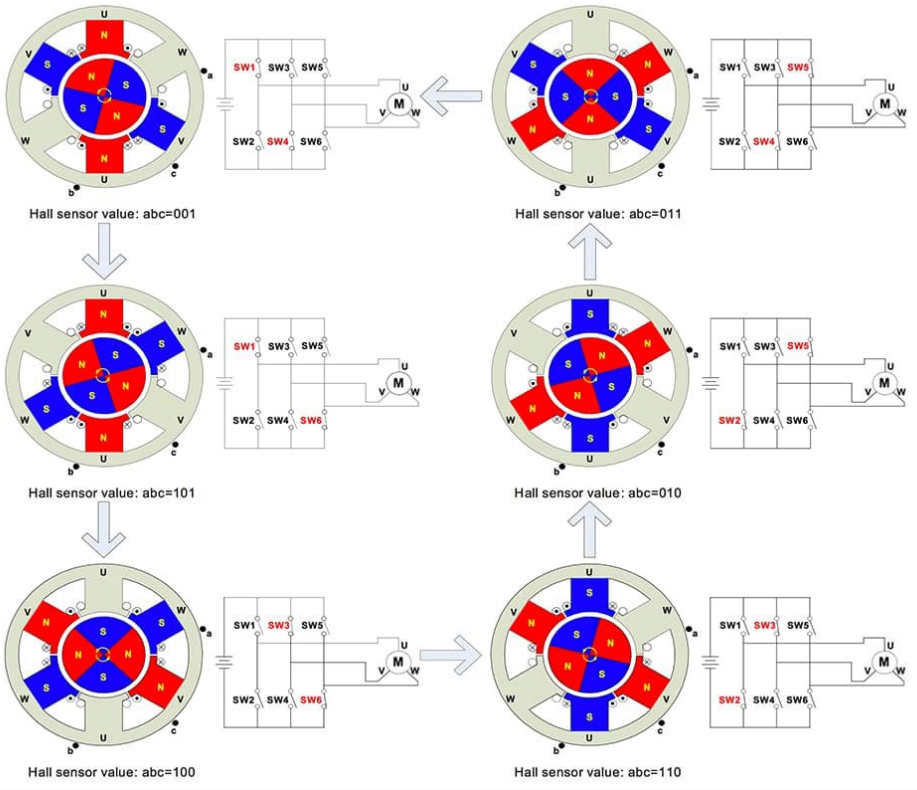
BLDC/PMSM

Advantages:
- No brushes, low EMI
- High efficiency
- Medium construction complexity

Disadvantages:
- Requires electronic control
- Complex drive design

Working of DC & BLDC Motors





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Unidirectional DC Motor Control

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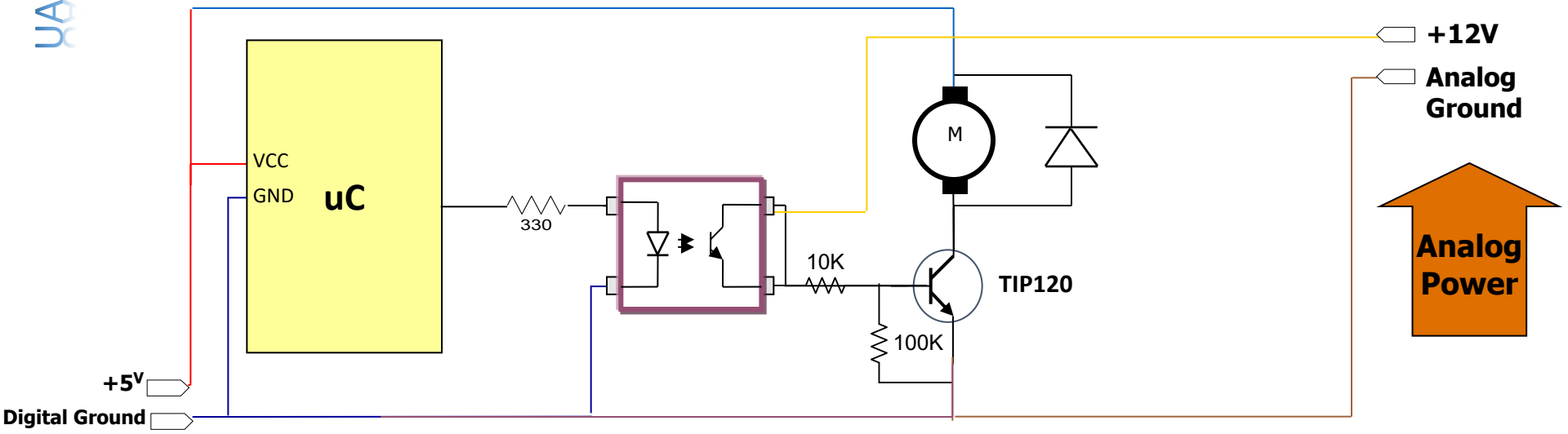

DC Motor Control

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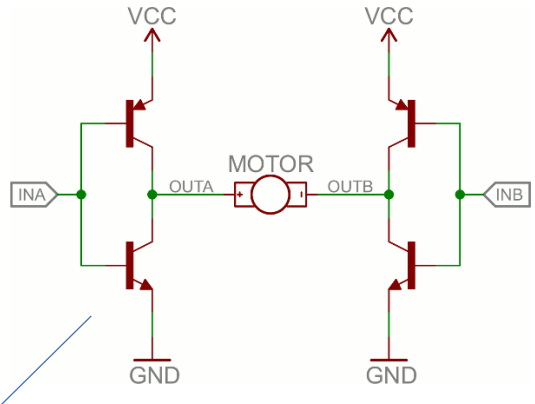
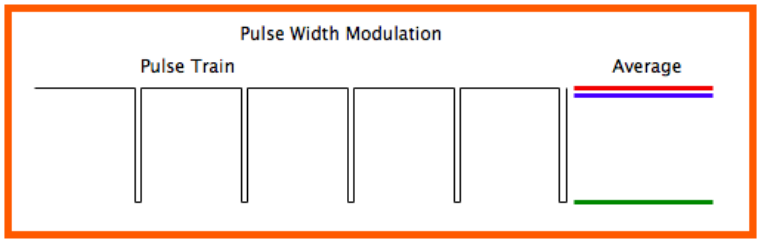




Larger Pulse

Motor Voltage

0~12V

VCC
GND
uC

0~5V

Smaller Pulse

Motor Driver/ ESC
(boost current & switch direction)

M

Switch direction

+5V

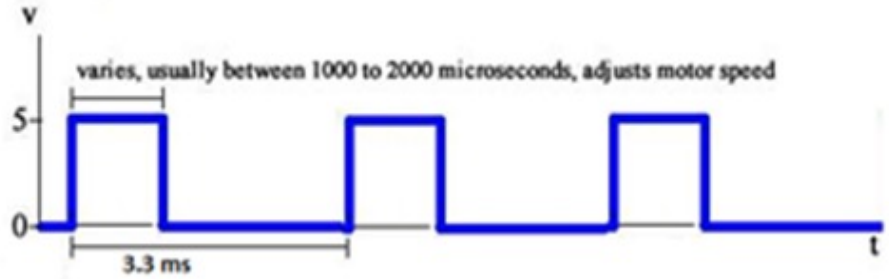
Digital Ground

Quad-copter components

Electronic Speed Controller (ESC)

Signal output from MCU to ESC

ESC handle (1-2 ms) pulse width but we use output signal frequency 300Hz not 500Hz .



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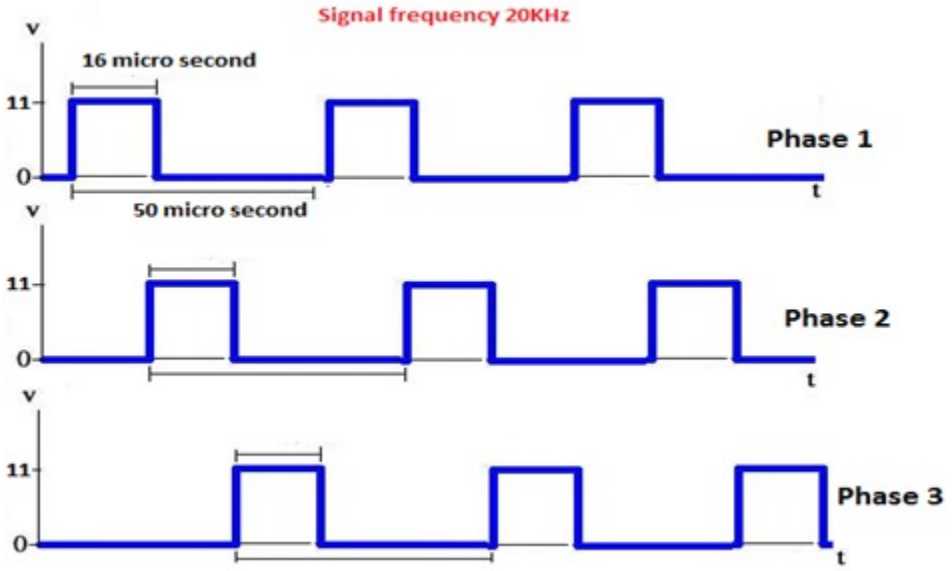
Signal output from ESC to motor

The frequency of output signal from ESC to motors 10-30KHz.



Brushless Motors

- Electromagnets are stationary
- Permanent magnets on the axis (either inside or outside)
- Three coils (or more)
- No brushes (less maintenance, higher efficiency)

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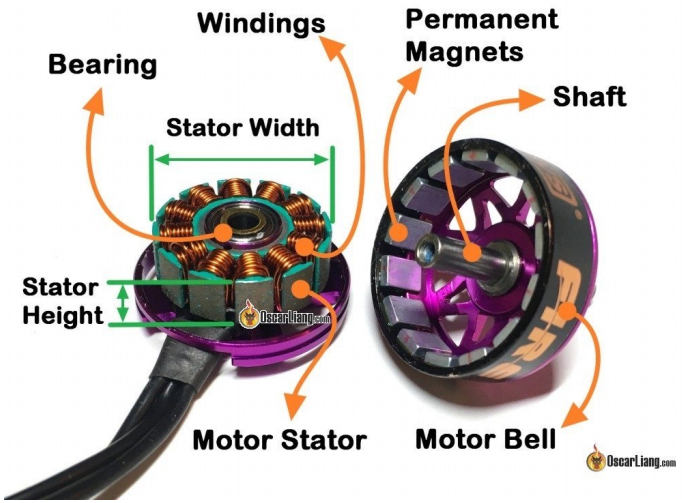

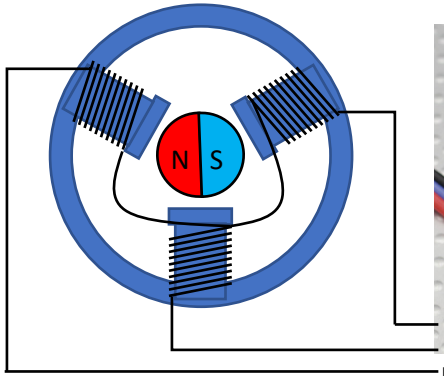

https://www.hobbyking.com/hobbyking/store/__25556__AX_2810Q_750KV_Brushless_Quadcopter_Motor.html

Brushless Controllers

- Typically one microcontroller per motor
- Generates PWM signal for the three motor phases
- AC signal converter (MOSFET) to convert PWM to analogue output
- Measure motor position/speed using back-EMF

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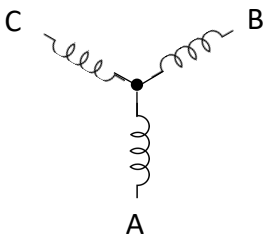

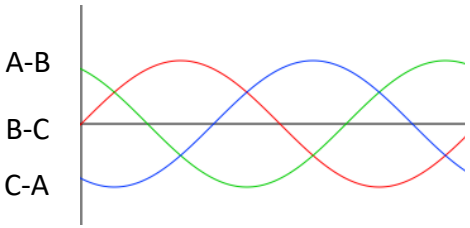

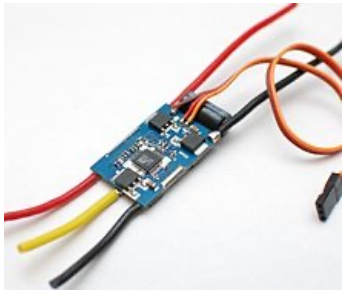

http://en.wikipedia.org/wiki/File:ESC_35A.jpg

Inside look of ESC

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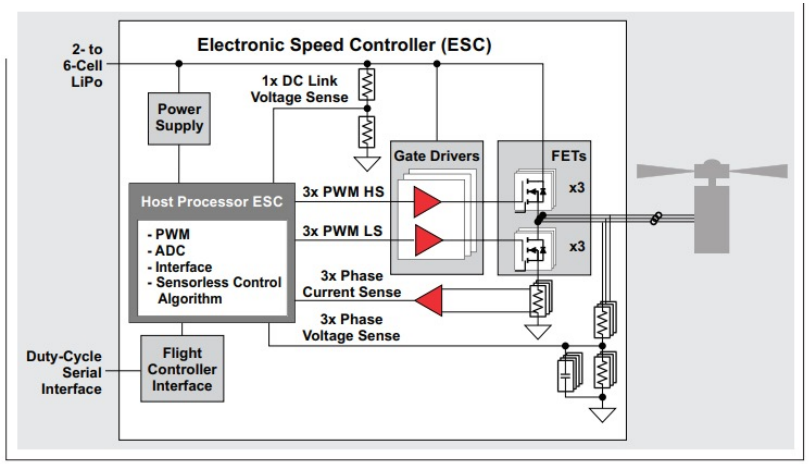

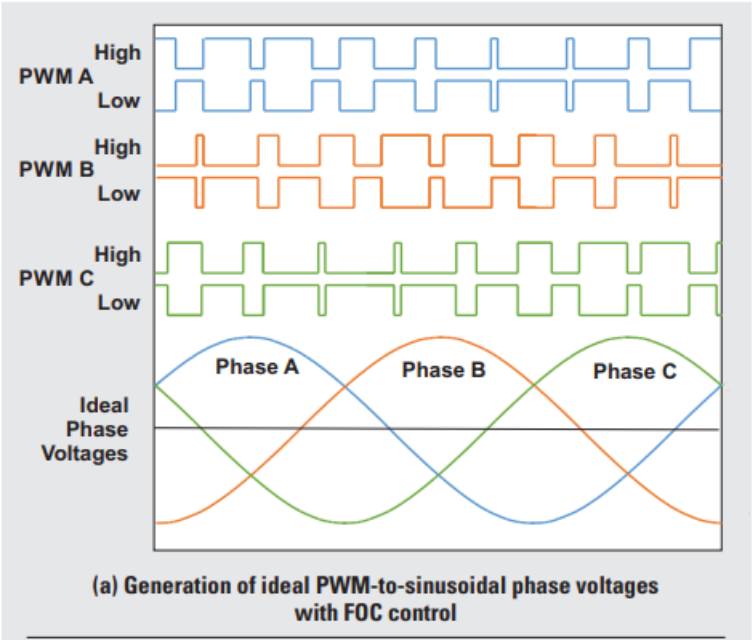

(a) Generation of ideal PWM-to-sinusoidal phase voltages with FOC control

Example: Parrot Ardrone

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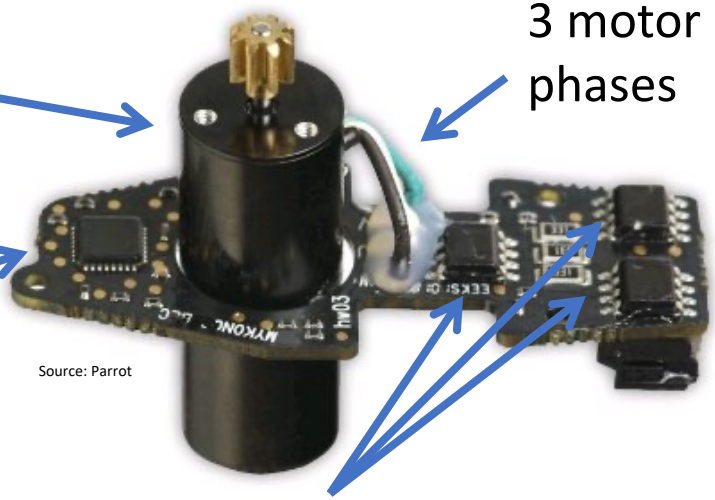
Brushless motor

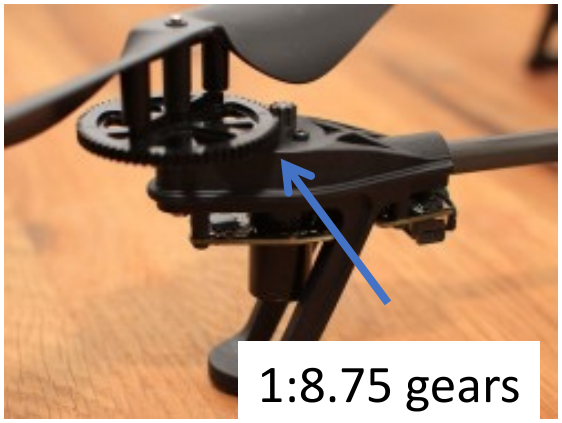
3 motor phases

AVR CPU (8 MIPS)



Source: Parrot

3x AC converters (MOSFET)



http://droneflyers.com/category/ar_drone/

How to select the motor?

- https://www.omnicalculator.com/other/drone-motor
- https://oscarliang.com/quadcopter-motor-propeller/

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