Types of motors

- DC
  - BL
    - outrunner
    - inrunner
  - B
    - Series wound
    - Shunt wound
    - compound wound
    - Permanent magnet
- AC
  - Synch
  - Asynch
    - 3 phase
    - 1 phase

BLDC → 1) rotor has 2 permanent magnets

Type 1

2) The stator has 3 pairs of coils for 3 phase
4 — 2 phase
2 — 1 phase

3) The closest anti parallel anti pole coil pair is energized rotation works on attractive magnetic force

4) The sequence for positive V pulses is
ABC A' B' C'

5) Only 1 coil energized, Power output is less.

Type 2

1) Rotor is spun by 2 coil pair front & behind, Torque is increased.

(AB) (BC) (CA') (A'B') (B'C') (C'A)

6) Hall sensor determines position, the motor controller switches the coils to be energized.

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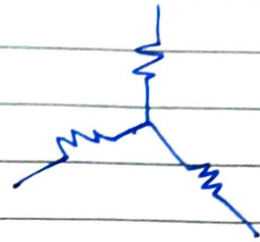
2 types of wiring

Delta

less torque
more speed

Lower efficiency due to 1/2 voltage applied on the 2 resistor for a node increasing resistive losses

Y



more torque
less speed
Higher efficiency

Controller uses either
1) Hall effect sensor
2) Rotary encoder
3) Back emf.

Performance parameters:

K_T & $K_e = \frac{1}{K_v}$

Torque constant

back-emf

velocity

+ good for long run

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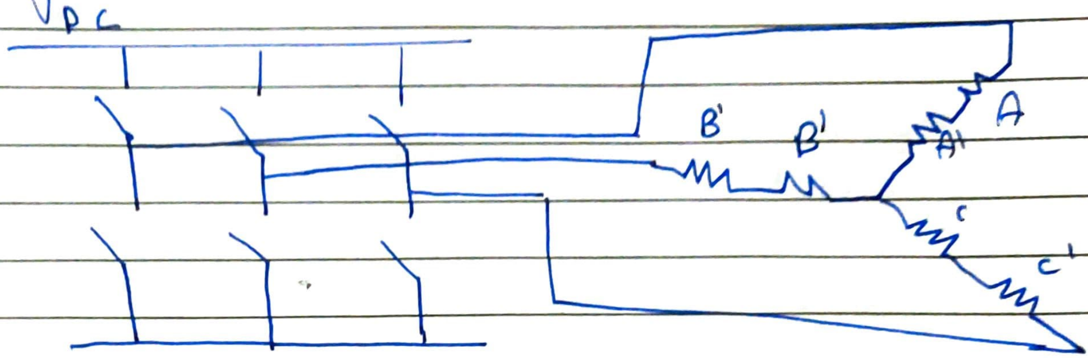

We need an ESC with several MOSFETS ~~to~~, they use PWM for the switching.

Outrunner — $T \uparrow$ efficient $\uparrow$
Inrunner — $\omega \uparrow$ need to use gearbox for high load.

	BLDC vs	BDC
Life/maintenance	longer	shorter
Speed / T	flat	moderately flat
Size	small	larger
Power output	high	moderate
Rotor inertia	low	high
Speed range	high	low due to friction
Cost	high	low
Control	ESC req	direct

Application: EV, cooling fans

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	BLDC vs	AC induction
Speed/Torque CRT	Flat	Non-Linear
Output power	High	Moderate
inertia	low	High
control	ECS	none req
Slip	no slip	slip increases as load increases

II ~~BDC Motor~~
Selecting a proper motor

- Peak τ required
- RMS τ required
- operating speed Range

$$\tau_p = \underset{\tau_L}{\tau_{Load}} + \underset{\tau_f}{\tau_{friction}} + \underset{\tau_j}{\tau_{inertia}} * (1 + \text{safety factor})$$

$$\tau_j = (J_L + M) * \alpha$$

~~Load~~ Load inertia — rotor inertia — req angular acceleration

$$\tau_{RMS} = \sqrt{\frac{\tau_p^2 \cdot T_A + (\tau_L + \tau_F)^2 \cdot T_R + (\tau_j - \tau_L - \tau_F)^2 \cdot T_D}{(T_A + T_R + T_D)}}$$

T_A = acceleration time
T_R = runtime
~~T~~ T_D = deceleration time

II Brush DC motor

Commutator rings ~~at~~ are segmented so as to always provide power to the coil which is currently opposing the magnetic field.

Between the coils there is highly permeable metal so as to improve flux.

The magnet of stator can either be an electric or permanent

electric ↓ large applications

permanent ↓ for small applications

Shunt

Rotor || Stator
~~good start τ~~
~~load ↑ speed ↓~~
linear moderate τ

Series

Rotor series to Stator
~~also~~ good start τ
load ↑ speed ↓

generally

$$I = \frac{\cancel{} V - E_b}{R}$$

$E_b \propto$ velocity

__/__/__

There is a compound DC motor
2 categories
1) Short shunt ~~(parallel across~~
2) Long shunt

1) cummulative (Preferred)
2) Differential (very low torque) (due to reduced flux)

Due to compounding we get best of both the worlds.

Methods to control speed

a) Rheostat near the stator

b) Rheostat near the rotor

Advantages
1) can be used without load, no problem

Disadvantages
1) sparking

Uses
elevator / mills.

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III Induction motors

Stator - Thin permeable stacked iron sheets, on which 3 sets of coil are present.

The field is the vector summation of fields across all the windings.

The field rotates and stays with the same magnitude

Rotor: squirrel cage, angled bars with thin stacked insulated iron cores

The rotor has induced current in it & it will make a field opposing to the rotating magnetic field.

$$N_R \propto f$$

$$@ \quad N_{rotor} < N_{stator}$$

slip is created

$$slip = \frac{N_S - N_R}{N_S}$$

+ve

No Brushes

No rings

No magnets

No ~~po~~ Hall sensors.

usage lifts, electric cars

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Single Phase motor

Not self starting.

2 sets of wires used

1 set (auxillary capacitor starter)

2 set (for continuing rotation)

when we start with ① & ②

$\downarrow$

is delayed by 90°

and hence starts the motor.

When the max speed is achieved
Torque becomes zero as the wire ②
has 2 opposite & equal magnetic fluxes.

-ve low start τ

Some nomenclature

Insulation Protection of windings

class	A	105
	B	130
	F	155
	H	180

Ingress Protection (from environment)

I P 5 5

solid $\nearrow$ $\uparrow$ liquid.

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IV Synch Motors

stator has 3 AC, hence RMF is developed.

Rotor has either electromagnet or permanent magnet

Opposite poles of R & S lock magnetically.

$$N_S = \frac{120f}{P}$$

- Requires starting force.

· Not self

↓

hence squirrel cage also used to self start.

↓

when it achieves required momentum

↓

coils are energized with RMF and lock with rotor.

↓

when rotating, no use of squirrel cage.

Out of synch Problems.

· Overload of motor
· Low supply V
· Low excitation V