HEV - Test - 2

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Q② : BLDC operation in Electric Vehicles

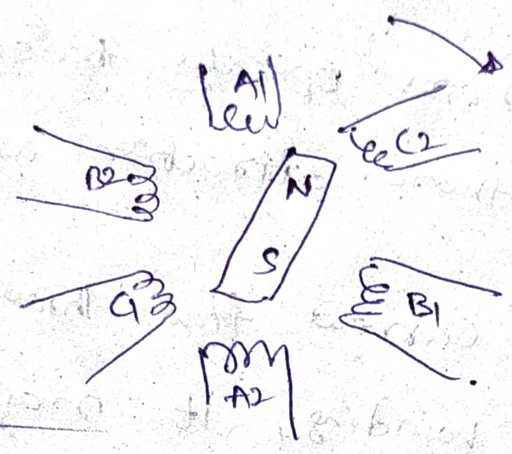
* BLDC motors operates based on the principle of magnetic attraction and repulsion.

* When current flow through one of three stator winding, it magnetises that particular winding creating a electromagnet. when Therefore, it attracts permanent magnet which is rotor itself.

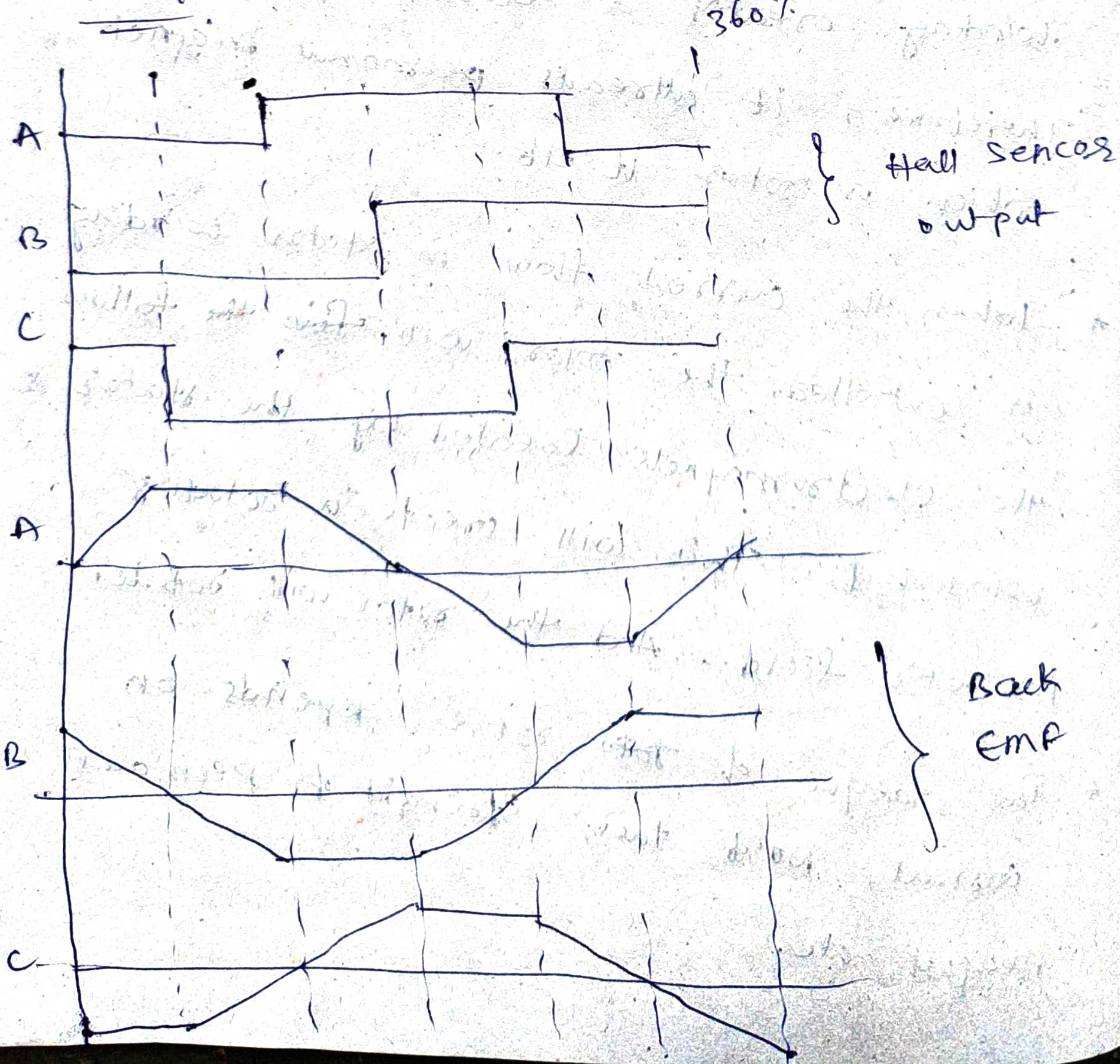
* When the current flow in stator winding is controlled, the rotor will ~~foio~~ ~~the~~ follow the electromagnets created by the stator windings. This will create a rotating magnetic field. And the rotor will rotate.

* The torque of ~~roto~~ rotor depends on current, No. of turns, strenght of permanent magnet etc.

* Hall sensors are very important for BLDC motor as it detects the location or allignment of rotor with stator wdg. So that the nearest wdg is supplied current which inturn rotates the rotor.



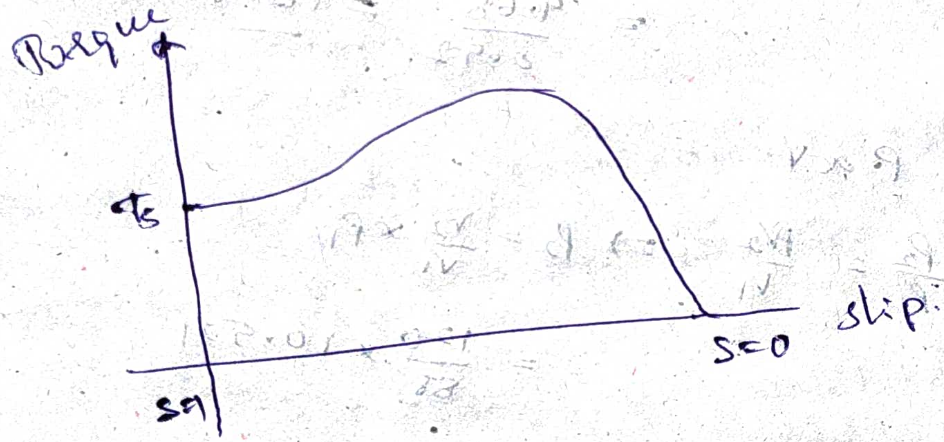
wave forms



Q(1). Induction motors has following benefits,

* Simple installation & maintanence,
* Low motor starting current
* Energy saving by VVF
* High power factor

Torque-slip characterist of Induction motor,



* It can be seen from Torque-slip characteristics, the starting torque of IM is high even at zero speed. This helps the moving of vehicle. Initiall.

Q(3) Given, 55 kwh - batter pack.

range = 500 km at 88 kmph.

with 92% power train efficie.

$$\text{Time} = T = \frac{500 \text{ km}}{88} = 5.68 \text{ hrs.}$$

$$\text{Power } P = \frac{E}{\text{Time}} = \frac{55}{5.68} = 9.68 \text{ kw.}$$

Given 92% efficient ⇒ Power Required

$$= \frac{9.68}{0.92} = 10.521 \text{ kw.}$$

We know $P \propto V$.

$$\Rightarrow \frac{P_2}{P_1} = \frac{V_2}{V_1} \Rightarrow P_2 = \frac{V_2}{V_1} \times P_1$$

$$= \frac{120}{88} \times 10.521$$

$$= 14.34 \text{ kw.}$$

Given ~~Total~~ 85% efficient

$$\Rightarrow P_2 = \frac{14.34}{0.85} = 16.878 \text{ kw.}$$

$$\text{Total Power} = 16.878 + 3 = 19.878 \text{ kw.}$$

$$\text{Time} = T = \frac{E}{P} = \frac{55}{19.87} = 2.76 \text{ hr.}$$

$$\therefore \text{New Range} = 120 \times 2.76 \text{ h}$$

$$= 332.01 \text{ km}$$

Q4: C-Rating of Battery :

In describing the batteries, Discharge current is often expressed as a C-rate, in order to normalize against battery capacity, which is often very different b/w batteries.

C-Rate is a measure of the rate at which a battery is discharged relative to it's maximum capacity.

For eg: a battery with capacity 100 Ah, this implies discharge current of 100 A for 1 hour.

For 5C rated battery this would be 500 Amp for 1/5 hours.

For 1/2 rate, battery this would be 50 A for 2 hours.

BOL [Beginning of Life] :

The BOL is the values for capacity and internal Resistance, of a battery when it is manufactured initially.

EOL [End of Life] :

This is value of capacity and internal resistance of battery once they degrade with time.

* ~~Cap~~ After certain time capacity of the battery drops to 80% of BOL and internal resistance increases by 50%

Q(5): 8 years of operation, 24000 km/year averages over 365 days/year.

Battery output = 150 Wh/km

$V_{cell} = 3.16V$, Capacity = 4.5 Ah , L=1

N = No. of cycles = 8 years × 365 days

= 2920 cycles.

Let $N_{100\%} = 1000$.

$$\therefore DOD = \frac{N_{100\%}}{N} \times 100\%$$

$$= \frac{1000}{2920} \times 100$$

$$= 34.24\%$$

~~BOL~~ = Given 24000 km / year

$\Rightarrow \frac{24000 \text{ km}}{365}$ ~~day~~ /day

= 65.75 km / day.

Energy required per day = .150 ~~wh~~ × 65.75 wh

= 9862.5 wh

= 9.862 kwh.

This energy is only for DOD = 34.24 %.

$\Rightarrow$ Total Energy = $\frac{9.862}{0.3424}$ = 28.804 Kwh.

(i)

$\Rightarrow$ $\boxed{BOL = 28.804 \text{ Kwh}}$

$\Rightarrow$ BOL range = $\frac{28.804 \times 10^3}{150}$ km

= 192.0267 km.

$\Rightarrow$ To increase BOL range to 400 km,

$\Rightarrow$ 400 km = $\frac{BOL}{150}$

$\Rightarrow$ BOL = 60000 wh $\Rightarrow$ 60 kwh for each cell, wh = 3.16×4.5

$= 14.22$ wh

$\therefore$ Total No. of Cellss required for

60000wh is $\frac{60000}{14.22} = 4219.409$

(ii)
$\Rightarrow$ Total No. of Cells required to increase the BOL range to 400 km is $\simeq \underline{\underline{4220}}$

(iii) Given Pack Density = 150 wh/kg.

$\rightarrow$ for 60000wh, $(\text{Mass})_{\text{battery}} = \frac{60000}{150}$

$\Rightarrow$ Battery Mass = 400 kg.

$\underline{\text{iv}}$) Peak Power = 300kW.

Q⑥ : $m = 1200 kg,$

$C_d = 0.44,$ $\mu = 0.013$

$A = 2 m^2,$ Battery = 50 units of energy

$\rho = 1.2 kg/m^3$

Vehicle reached 0.2 km within $\boxed{10 sec}$

$V = 50 kmph = 13.889 m/s$

① Aerodynamic Drag force

$$f_D = \frac{1}{2} \times \rho \times C_d \times A \times (V + V_{air})^2$$

$\boxed{V_{air} = 0}$

$$= \frac{1}{2} \rho C_d A V^2$$

$$= \frac{1}{2} \times 1.2 \times 0.44 \times 2 \times (13.889)^2$$

$$f_D = 101.85 N$$

② Rolling Resistance force. (F_R)

$$F_R = mg\mu$$

$$= 1200 \times 9.81 \times 0.013$$

$$= 153.036 N.$$

* Gradient force (F_g)

$F_g = mg \sin\theta$

Here $\theta = 0$

$\Rightarrow \boxed{F_g = 0}$

* Accelaration force (F_a)

$F_a = ma$

$F_a = m \times \frac{\text{distance}}{\text{time}^2}$

$= 1200 \times \frac{0.2 \times 10^3}{(10)^2}$

$\boxed{F_a = 2400 \text{ N.}}$

(2) For head wind velocity, of 15 km/h

$\Rightarrow 4.1667$ m/s

~~V~~ = 1

$V_{effective} = 13.889 + 4.1667 = 18.0557$ m/s

$\Rightarrow F_D = \frac{1}{2} \times 1.2 \times 0.44 \times 2 \times (18.0557)^2$

$= 172.13\ N.$

$\therefore$ Total Force $(F) = F_D + F_R + F_4 + F_a$

$\Rightarrow F = 172.13 + 153.036 + 0 + 2400$

$= 2725.166\ N.$

$\Rightarrow$ Power $= Fv.$

$= 2725.166 \times 13.889$

$= 37849.33\ W \Rightarrow 37.849\ kW.$

$\Rightarrow$ Given Battery capacity $= 50$ units

$= 50\ kWh.$

$\Rightarrow$ Total Time Vechicle can be running

$= \frac{50}{37.849} = 1.3210\ hr$

$\Rightarrow$ At $50\ km/hr$, Vehicle can go upto,

$50 \times 1.3210 \Rightarrow 66.050\ km$ //

(iii) Power required for the motor,

from (ii) is $P = 37.849\, kW$. [mechanical]

Assuming 14% loss in motor,

Power Input to motor $= 1.14 \times 37.849\, kW$

$= 43.1478\, kW$.

$\therefore$ BHP rating of motor $= \dfrac{43.1478}{0.746}\, hp$

$= 57.8339\, HP$

iv) For 10° slope,

Gradient force $= (f_g) \Rightarrow mg \sin\theta$.

$\Rightarrow f_g = 1200 \times 9.81 \times \sin 10^\circ$

$= 2044.1863$.

Extra Power Require $\Delta P = \Delta F\, v$.

$\Rightarrow \Delta P = 2044.1863 \times 13.889$

$= 28391.70\, W$

$= 28.391\, kW$ Power is require extra.

Q(f): maximum speed = 80 kmph

$= 22.22 \ m/s.$

Torque = 50 Nm.

We know, To convert kmph to RPM,

formula = $(RPM) = \dfrac{kmph}{0.1885 \times D}$.

$D \rightarrow$ Diameter in m.

D = 10 inches = 0.254 m.

$\Rightarrow RPM = \dfrac{80}{0.1885 \times 0.254} = 1670.87 \ rpm.$

$\Rightarrow \omega = \dfrac{2\pi}{60} \times RPM = \dfrac{2\pi}{60} \times 1670.87$

$= 174.97 \ s^{-1}$

$\Rightarrow$ Power $P = T\omega \Rightarrow 50 \times 174.97$

$\Rightarrow P = 8748.70 \ W.$

$\Rightarrow$ motor capacity = 8748.70 W

$= \dfrac{8748.70}{746}$

$= 11.72 \ HP.$

At 40kmph,

$$RPM = \frac{40}{0.1885 \times 0.254} = 835.43$$

$$w = \frac{2\pi}{60} \times 835.439 = 87.48751$$

⇒ Power $P = T\omega = 50 \times 87.487$

$= 4374.35\ W.$

⇒ Energy Required for 2hrs

$E = 4374.35 \times 2$

$= 87480700\ Wh.$

⇒ Given Battery pack voltage = 240

⇒ Ah rating $= \frac{E}{V} = \frac{8748.700}{240}$

⇒ Ah rating of Battery = ~~36.4529~~ Ah. 36.4529 Ah