Assignment - 02 (HEV)

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Assignment - 2 ; EE 6620E - Hybrid Electric Vehicles

Que 01 A battery has 96 cells in series with two parallel strings. Each cell has a no-load voltage of 4.18 V and an internal resistance of 2.8 mΩ.

i) Determine the pack current and voltage under a 80 kW discharge if the battery is fully charged.

ii) Determine the discharge efficiency of the battery.

Solution :-

Concept : Current: +ve → discharging, -ve → charging

Power: +ve → discharging, -ve → charging

formula :

Current $$I_b = \frac{V_{b(nl)} - \sqrt{V_{b(nl)}^2 - 4R_b(+P_b)}}{2R_b}$$ {discharging → +ve}

$$I_b = \frac{V_{b(nl)} - \sqrt{V_{b(nl)}^2 - 4R_b(-P_b)}}{2R_b}$$ {charging → -ve}

Voltage $V_b = V_{b(nl)} - R_b I_b$

Given values :- $N_{series} = 96$ $\quad R_b = 2.8\,m\Omega = 0.0028\,\Omega$

$N_{parallel} = 2$ $\quad P_b = +80\,kW$

$V_{b(nl)} = 4.18V$

for 96 cells in series → $V_b(nl) = 96 \times 4.18 = 401.28V$

IIly $R_b' = 96 \times 2.8\,m\Omega = 268.8\,m\Omega$

for 2-II^el strings - $R_b = \frac{268.8 \times 268.8}{2 \times 268.8} = 134.4$

(or)

Calculating R_b by using formula: $\frac{N_{series}}{N_{\parallel}} \times R_b$

$R_b = \frac{96}{2} \times 2.8 = 134.4\,m\Omega$

i) Pack current
$$I_b = \frac{401.28 - \sqrt{401.28^2 - 4 \times 134.4 \times 10^{-3}(80 \times 10^3)}}{2 \times 134.4 \times 10^{-3}}$$

$$I_b = 214.81\ A$$

Voltage $V_b = V_{b(nl)} - R_b I_b$

$= 401.28 - 134.4 \times 10^{-3} \times 214.81$

$= 372.4\ V$

ii) Discharge efficiency :-

$$\eta_{dis} = \frac{V_b}{V_{b(nl)}} \times 100 = \frac{372.4}{401.28} \times 100 = 92.8\%$$

Qn (02) Determine the pack current and voltage under a 50KW charge if the battery is fully discharge. The cell voltage drop of 2.5V when fully discharged. How efficient is the charging of the battery at this power level?

Solution :-

Given : $N_{series} = 96$ $V_{b(nl)} = 2.5V$

$N_{||el} = 2$ $P_b = -50\ KW$ (charge)

$R_b = 2.8 m\Omega$

For 96 cells in series and two cells in ||el

$V_{b(nl)} = 96 \times 2.5 = 240V$

$R_b = 134.4\ m\Omega$

$\therefore$ Pack current
$$I_b = \frac{V_{b(nl)} - \sqrt{V_{b(nl)}^2 - 4 \times R_b \times (-P_b)}}{2R_b}$$

$$= \frac{240 - \sqrt{240^2 - 4 \times 134.4\ m\Omega \times (-50\ kW)}}{2 \times 134.4 \times 10^{-3}}$$

$= -188.44\ A$

Voltage $V_b = V_{b(nl)} - I_b R_b$

$V_b = 240 - (134.4 \times 10^{-3})(-188.44)$

$V_b = 265.32\ V$

changing efficiency $\eta_{charging} = \frac{V_{b(ind)}}{V_b} \times 100$

$$\eta_{charging} = \frac{240}{265.32} \times 100$$

$$\eta_{charging} = 90.5\,\%$$

Ans (03) The capacity of the cell is approximately 33.3 Ahr at C/3 with a rated voltage of 3.75V Assume $R = 2.8\,m\Omega$. Summarize the following parameters for C/3, 1C and 3C.

Parameters	C/3	1C	3C
x	1/3	1	3
V	3.75	3.69	3.5
Ah	33.3	33.3	33.3
Wh	124.88	122.8	116.6
Efficiency	99.2	97.5	92.6

Solution:

Given:

$Ah_{rated} = 33.3\ Ah$

$C_{rated} = C/3$

$I_{rated} = \frac{33.3}{3} = 11.1\ A$

$V_{rated} = 3.75V$

$R = 2.8\ m\Omega = 0.0028\ \Omega$

(i) for C/3

$$E_{cell} = Ah_{rated} \cdot V_{rated} + R_b \cdot I_{rated}^2 \cdot \frac{h}{C_{rated}}$$

$$= \left(33.3 \times 3.75 + 0.0028 \times 11.1^2 \times \frac{1}{1/3}\right) Wh$$

$$= 33.3 \times 3.75 + 0.0028 \times 11.1^2 \times 3\ Wh$$

$$= 125.91\ Wh$$

$$E_{xc} = E_{cell} - R_b \cdot I_{x}^2 \cdot \frac{h}{x}$$

$$= 125.91 - 0.0028 \times 11.1^2 \times 3\ Wh$$

$$= 124.88\ Wh$$

$$\eta_{dis} = \frac{E_{nc}}{E_{cell}} \times 100 = \frac{124.88}{125.91} \times 100$$

$$\eta_{dis} = 99.18\% = 99.2\%$$

now we have: $x = 1/3$, $V = 3.75V$, $Ah = 33.3$, $Wh = 124.88$, $\eta = 99.2\%$.

(ii) for 1C :- $x = 1$, $Ah = 33.3$

$I_{nc} = 33.3A$, (33.3×1)

$$V_{nc} = V_{rated} - R_b(I_{nc} - I_{rated})$$
$$= 3.75 - 0.0028(33.3 - 11.1)$$
$$= 3.687\ V$$

$V_{nc} = 3.69V$

$E_{cell} = 125.91\ Wh$ (same as C/3)

$$\therefore E_{nc} = E_{cell} - R_b \cdot I_{nc}^2 \cdot \frac{h}{x}$$
$$= (125.91 - 0.0028 \times 33.3^2 \times \frac{1}{1})\ Wh$$
$$= 122.8\ Wh$$

$E_{nc} = 122.8Wh$

$$\eta_{dis} = \frac{E_{nc}}{E_{cell}} \times 100 = \frac{122.8}{125.91} \times 100 = 97.5\%.$$

now we have: $x = 1$, $V = 3.69V$, $Ah = 33.3$, $Wh = 122.8$, $\eta = 97.5\%$.

(iii) ~~4~~ 3C : $x = 3$, $Ah = 33.3$

$I_{nc} = 33.3 \times 3 = 99.9A$

$$V_{nc} = V_{rated} - R_b(I_{nc} - I_{rated})$$
$$= 3.75 - 0.0028(99.9 - 33.3)$$
$$= 3.50\ V$$

$E_{cell} = 125.91\ Wh$ (same as C/3)

$$E_{nc} = E_{cell} - R_b \cdot I_{nc}^2 \cdot \frac{h}{x}$$
$$= (125.91 - 0.0028 \times 99.9^2 \times \frac{1}{3})\ Wh$$
$$= 116.59\ Wh$$

$$\eta_{discharging} = \frac{E_{out}}{E_{in}} \times 100$$

$$= \frac{116.6}{125.91} \times 100 = 92.6\,\%$$

Now, we have:

$x = 3$, $V = 3.5V$, $Ah = 33.3$, $Wh = 116.6$, $\eta = 92.6\%$

Qu-04 :- An EV battery has a 100% SOC of 85 KWh. The battery can be charged at high power when the battery DOD is maintained within a range of 20% to 100%. The pack has 96 cells in series per string with 74 parallel strings. Each cell has an average no-load cell voltage during charge of 3.64 V and an internal resistance of 65 mΩ.

i) Determine the battery terminal voltage, current and efficiency for a 120 KW charge.

ii) What approximate time is required to charge the battery from a DOD of 100% to 20% ?

Solution: Given: $N_{series} = 96$, $N_{||el} = 74$, $V_{b(nl)} = 3.64V$

$R_b = 65\,m\Omega = 0.065\,\Omega$, $P_b = -120\,KW$ (charging)

for 96 cells in series & 74 cells in parallel

$$V_{b(nl)} = 96 \times 3.64 = 349.5\,V$$

$$V_{b(nl)} = 349.5\,V$$

$$R_b = \frac{N_{series}}{N_{||el}} \times R = \frac{96}{74} \times 65$$

$$= 84.32\,m\Omega$$

(i) ∵ We know for charging $I_b = \dfrac{V_{b(nl)} - \sqrt{V_{b(nl)}^2 - 4R_b(-P_b)}}{2R_b}$

$$I_b = \frac{349.5 - \sqrt{349.5^2 - 4 \times 84.32 \times 10^{-3} \times (-120 \times 10^3)}}{2 \times (0.08432)}$$

$$= -318.9\,A$$

$$V_b = V_{b(nl)} - R_b I_b$$

$$= 349.5 - (0.08432) \times (-318.9)$$

$$= 376.38\,V$$

$$\eta_{charging} = \frac{V_{b(nl)}}{V_b} \times 100 = \frac{349.5}{376.38} \times 100\%$$

$$= 92.85\%$$

(ii) DOD : 100% to 20%.

$\because$ 100% $\rightarrow$ 85 KWh till 20% :- $85\,KWh \times \frac{20}{100}$

tapping the energy from the battery = 17 KWh

$\therefore$ Remaining $\rightarrow$ (85 − 17) KWh = 68 KWh $\rightarrow$ We are consuming

$$= \frac{68\,KWh}{120\,KW} = \frac{68}{120}\,h = 34\,min$$

$\therefore$ Approximate time is required to charge the battery $\underline{T = 34\ mins}$ Ans

Ques 05: A Li-ion cell is rated at 3.6V, 3.4Ah at 0.2C and has an internal resistance of 65 mΩ. Determine the cell Wh, Ah, and efficiency for the 4C rate.

Solution; Given: $V_{rated} = 3.6V$,

$Ah_{rated} = 3.4$

$R_b = 65\,m\Omega = 0.065\,\Omega$

$I_{rated} = 34 \times 0.2 = 0.68\ A$

$C_{rated} = 0.2C$

Calculation for finding cell Wh, Ah & η:

$\forall$ 4C rate: $x = 4$

$Ah = 3.4$

$I_{xc} = 3.4 \times 4 = 13.6\ A$

$$E_{cell} = Ah_{rated} \cdot V_{rated} + R_b \cdot I_{rated}^2 \cdot \frac{h}{C_{rated}}$$

$$= \left(3.4 \times 3.6 + 0.065 \times 0.68^2 \times \frac{1}{0.2}\right) Wh$$

$$= 12.4\ Wh$$

$$E_{xc} = E_{cell} - R_b - I_{xc}^2 \cdot \frac{h}{x}$$

$$= \left(12.4 - 0.065 \times 13.6^2 \times \frac{1}{4}\right) Wh = 9.39\ Wh$$

$$E_{xc} = 9.39\ Wh$$

$$\eta = \frac{9.39}{12.4} \times 100 = 75.7\% \quad \text{Ans}$$

Qn 06: A BEV has the following requirements: eight years of operation at an average of 24,000 km per year, averaged out over 365 days per year. Assume an average battery output of 204 Wh/km and a rated cell voltage of 3.6V, a capacity of 3.4 Ah, and a lifetime index of L = 1.

i) Determine the BOL kWh storage.

ii) How many cells do you need and what is the BOL range?

iii) What is the BOL storage and how many cells are required for a larger pack in order to increase the BOL range to 425 km?

iv) How many parallel strings are required if the pack has 96 cells in series?.

v) What is the battery pack mass, assuming a battery with a pack density of 150 Wh/kg?

vi) If the peak power is 325 kW, what is the P/E ratio of the battery for the larger pack?

Solution: Given: $V_{rated} = 3.6V$, $E_{km} = 204$ Wh/km

$Ah_{cell} = 3.4$ Ah, $L = 1$, Time = 8 years

(i) The average daily battery output energy,

$$E_{daily} = S_{daily} \times E_{km}$$

$$\because S_{daily} = \frac{24000}{365}$$

$$E_{daily} = \frac{24000}{365} \times 204 \text{ Wh}$$

$$= 13413.7 \text{ Wh} \simeq 13.4 \text{ kWh}$$

$$\because E_{BOL} = \frac{E_{daily}}{DOD}$$

$$DOD = \left(\frac{N_{100\%}}{N}\right)^{1/L} \times 100\%$$

let $N_{100\%} = 1000$, $N = 365 \times 8 = 2920$

$$DOD = \left(\frac{1000}{2920}\right)^{1/1} * 100\% = 34.2\%.$$

$$DOD = 0.342465$$

$$\therefore E_{BOL} = \frac{13.4137}{0.342465} = 39.16 \text{ KWh}$$

$$E_{BOL} = 39.16 \text{ KWh} \quad \text{Ans}$$

ii) The cell Ah $= \frac{E_{BOL}}{V_{bp}} = 3.4$

Assume that the no. of string = 1

V_{bp} = battery pack voltage

$$V_{bp} = \frac{E_{BOL}}{3.4} = \frac{39.16 * 10^3}{3.4}$$

$$V_{bp} = 11517.647 \text{ V}$$

Also $V_{bp} = N_{cell} * 3.6$

$$\Rightarrow N_{cell} = \frac{V_{bp}}{3.6} = \frac{11517.647 \text{ V}}{3.6} = 3199.346$$

$$N_{cell} = 3199.346 \simeq 3200$$

$$\text{BOL range} = \frac{E_{BOL}}{E_{km}} = \frac{39.16 * 10^3}{204} = 191.96 \text{ Km} \simeq 192 \text{ Km} \quad \text{Ans}$$

iii) If BOL range increased to 425 Km: then:

$$\frac{E_{BOL}}{E_{km}} = 425 \text{ Km}$$

$$\Rightarrow E_{BOL} = 425 * E_{km} = 425 * 204 \text{ Wh/Km}$$

$$= 86.7 \text{ kWh}$$

$$\text{No. of cells required} = \frac{E_{BOL}}{Ah_{cell} * V_{cell}} = \frac{86.7 * 10^3}{3.4 * 3.6} = 7083.33$$

$$N_{cells} = 7083.$$

iv) Let the no. of ∥el string be N :

the battery pack voltage (V_{bp}) = $N_{series} \times V_{rated}$

$V_{bp} = 96 \times 3.6$ $\{\because N_{series} = 96\}$

$= 345.6V$

$V_{bp} = 345.6V$

The battery pack Ah $= \dfrac{E_{BOL}}{V_{bp}} = Ah_{bp}$

$Ah_{bp} = \dfrac{86.7 \times 10^3}{345.6} = 250.86\ Ah$

$Ah_{bp} = 250.86\ Ah$

$\because Ah_{cell} = \dfrac{Ah_{bp}}{N} = 3.4\ Ah$

$\Rightarrow N = \dfrac{Ah_{bp}}{3.4} = \dfrac{250.86}{3.4} = 73.78$

$\Rightarrow N = 74$ Ans

v) Battery pack mass (M_{bp}) $= \dfrac{E_{BOL}}{\text{Pack density}}$

$m_{bp} = \dfrac{86.7 \times 10^3}{150} = 578\ kg$

$m_{bp} = \underline{578\ kg}$ Ans

vi) $\because$ Given $P = 325\ kW$
$E = 86.7\ kWh$ {above calculated}

$\therefore \dfrac{P}{E} = \dfrac{325}{86.7} = \underline{3.7}$

Que (07) A NiMH HEV battery pack is sized based on the following requirements: 1000 cycles of 60 Wh per year for ten years, a 6.5 Ah cell with a rated voltage of 1.2V and an index of L = 1.5

(i) What is the BOL battery pack energy storage ?

(ii) What is the total no. of cells required ?.

iii) What is the peak voltage if the cells are all in series?

iv) If the peak power is 30 kW, What is the P/E ratio of the battery?

Solution: Given: $N = 10,000$

$E_{cycle} = 100 \text{ Wh / cycles}$

$V_{cell} = V_{rated} = 1.2V$

$Ah_{cell} = 6.5 \text{ Ah}$, $L = 1.5$

i) No. of cycles per day $= \dfrac{10,000}{365 \times 10} = 2.739$

$E_{day} = S_{cycle} \times E_{cycle}$ $\{ S_{cycle} = 2.739$

$E_{day} = 2.739 \times 100 = 273.9 \text{ Wh}$

Assume $N_{100\%} = 10000$

$$DOD = \left(\frac{N_{100\%}}{N}\right)^{1/2} \times 100\%$$

$$= \left(\frac{1000}{10,000}\right)^{1/1.5} \times 100\%$$

$DOD = 21.54\%$

$$E_{BOL} = \frac{E_{day}}{DOD} = \frac{273.9 \text{ Wh}}{0.21} = \underline{1304.2 \text{ Wh}}$$ Ans

ii) No. of cell required $= \dfrac{E_{BOL}}{Ah_{cell} \times V_{cell}}$ $\{$ Assume no. of strings $= 1 \}$

$$= \frac{1.3 \times 10^3}{6.5 \times 1.2}$$

$$= 166.67$$

No. of cells $\simeq 166$

iii) Pack voltage (V_{pack}) $= 166 \times 1.2 = 199.2 \text{ V}$

iv) $\because P = 30 \text{ kW}$, $E = 1.3 \text{ kWh}$ (cal^{cd})

$$\frac{P}{E} = \frac{30}{1.3} = 23.07$$

Qn 08 1250 CC capacity of IC engine car is having 14 inches of wheel diameter. It can run the maximum speed of 240 kmph with 190 Nm. If it is modified as battery operated vehicle, what is the required motor sizing (BHP) and also estimate the number of batteries to run 8 hrs continously while driving consistently 60 ~~kph~~ Kmph. Each battery has the rating of 100 Ah for 240 V DC.

Solution: Given: $v = 240$ km/h, diameter = 14 inches

$\tau = 190$ Nm, Time = 8 hrs, Ah rating = 100 for 240 V DC

To calculate : No. of batteries

km/h $\longrightarrow$ rpm

$$\text{Km/h} = \text{Diameter} \times \text{rpm} \times 1.885 \times 10^{-3}$$

$$1 \text{ inch} = 2.54 \text{ cm}$$

$$\text{rpm} = \frac{\text{Km/h}}{\text{Diameter} \times 1.885 \times 10^{-3}}$$

$$\Rightarrow \text{Diameter} = 14 \times 2.54 \text{ cm} = 35.56 \text{ cm}$$

$$\therefore \text{rpm} = \frac{240 \text{ Km/h}}{35.56 \text{ cm} \times 1.885 \times 10^{-3}} = 3580.45$$

$$N = 3580.45 \text{ rpm}$$

Power $$P = \frac{2\pi NT}{60} \quad (\text{kW})$$

$$P = \frac{2\pi \times 3580.45 \times 190}{60} = 95.49$$

$$P(\text{HP}) = \frac{71.24 \text{ kW} \times 10^3}{746} = 95.49$$

$$\boxed{P(\text{HP}) = 95.5 \text{ Hp}}$$

Ah rating : kWh $\longrightarrow$ $71.24 \times 8 = 569.92$ kWh

$= 570$ units

$$\frac{570 \times 10^3 \text{ Wh}}{240 \text{ V}} = 2375 \text{ Ah} \quad \text{Ans}$$

Numbers of batteries required to run 8h:

$$= \frac{2375 \text{ Ah}}{100 \text{ Ah}} = 23.75 = 24 \text{ batteries}$$

Qn (05): Design a medium duty electric vehicle to run 60 kmph with 50 Nm. It should run atleast 5 hrs continuously while the wheel diameter of 10 inches. (Ah rating, motor ~~rating~~ sizing, suitable motor, power converter circuit for regeneration and power devices rating).

Solution: Given: $V = 60$ Km/h, $T = 50$ Nm, Time $= 5$ hrs

Diameter $= 10$ inches, Assume $V = 240$ V

$$\text{Diameter} = 10 \times 2.54 \text{ cm}$$

$$= 25.4 \text{ cm}$$

$$\text{rpm} = \frac{60 \text{ Km/h}}{10 \times 2.54 \times 1.885 \times 10^{-3}}$$

$$= 1253.16 \text{ rpm}$$

$$P = \frac{2\pi NT}{60}$$

$$= \frac{2\pi \times 1253.16 \times 50}{60} \text{ kW}$$

$$= 6.56 \text{ KW}$$

$$P(\text{HP}) = \frac{6.56 \times 10^3}{746} = 8.79 \text{ HP}$$

$$P = 8.8 \text{ HP}$$

$$\text{KWh} \longrightarrow 6.56 \times 5 = 32.8 \text{ KWh}$$

$$\text{Ah} \longrightarrow \frac{32.8 \times 10^3}{240} = 136.67 \text{ Ah}$$

$$\text{Ah}_{\text{rating}} = 136.67 \text{ Ah}$$

Motor sizing: In this case 6.56 kW is the requirement of the mechanical power equivalent to electric power so, motor rating has to ~~accept~~ accept this much minimum power so that our design should be 1.25 to 1.5 time of higher than this one:

$$6.56 \times 1.25 = 8.2 \text{ KW}$$

(or)

$$6.56 \times 1.5 = 9.84 \text{ KW}$$

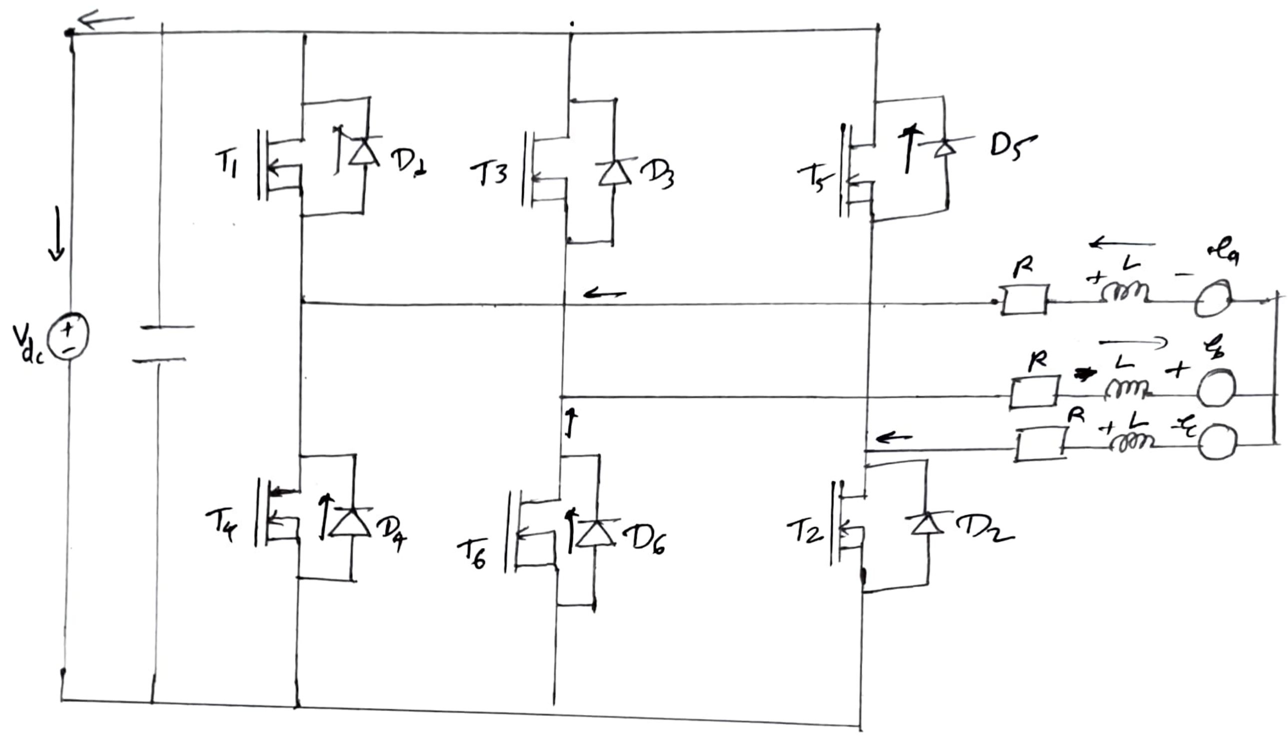
Range of motor sizing = 0.2 to 9.64 kW

Suitable motor: For medium duty electric vehicle: BLDC is the best suitable motor.

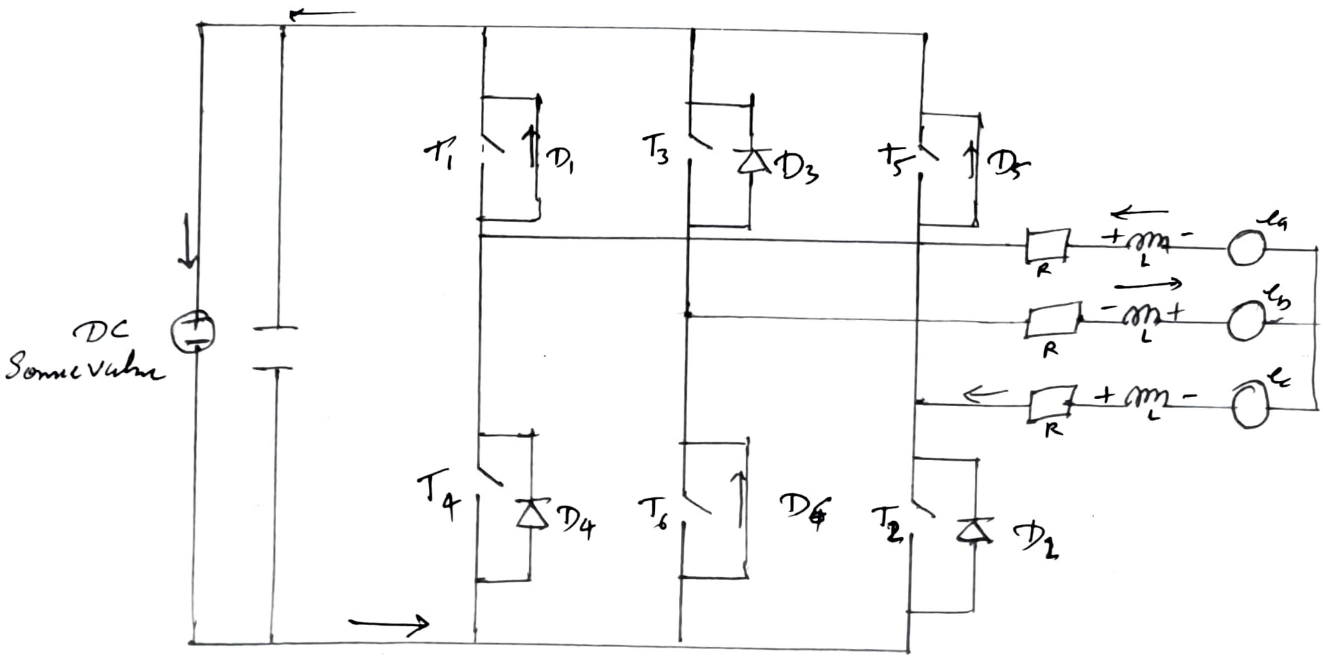
Circuit for regeneration of BLDC:

Regenerative braking:-

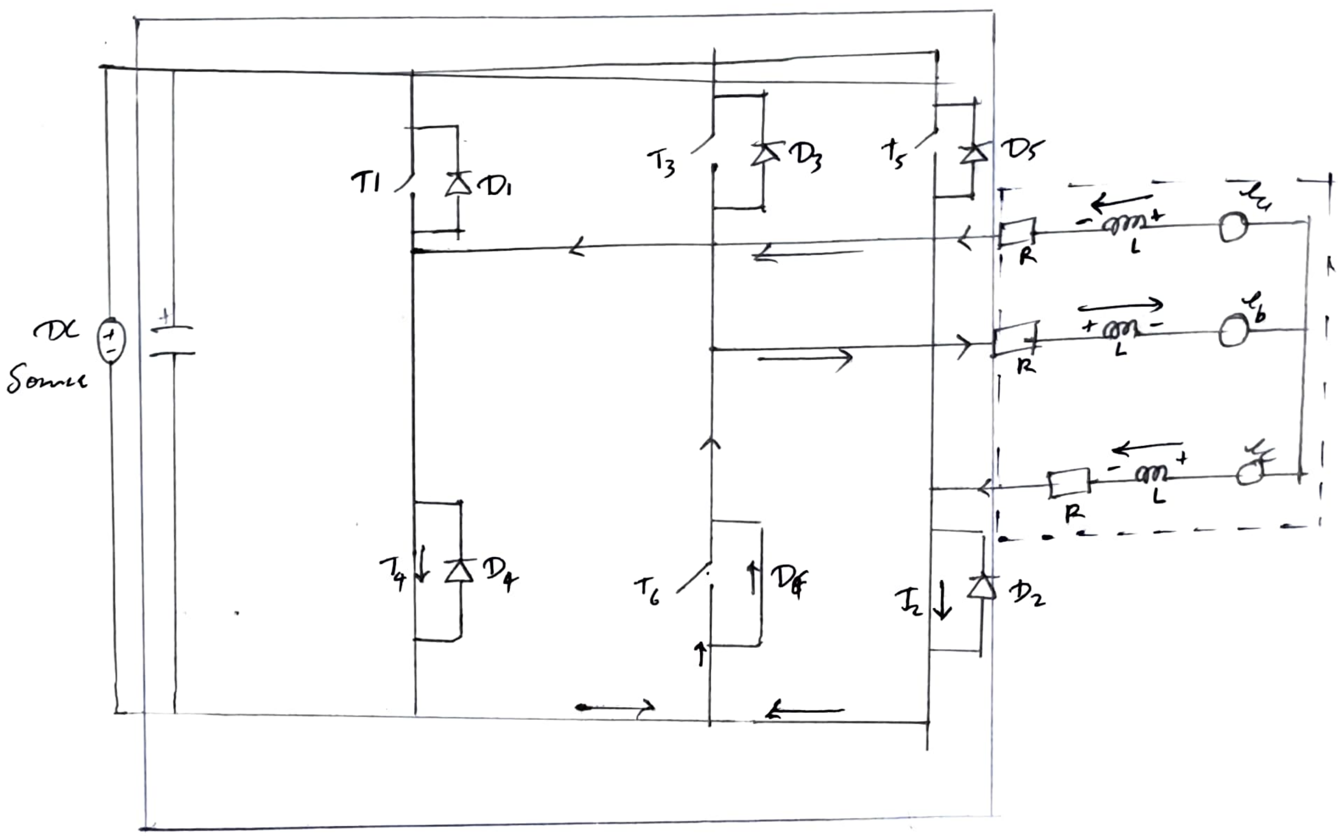
Power Converter circuit for regeneration:-

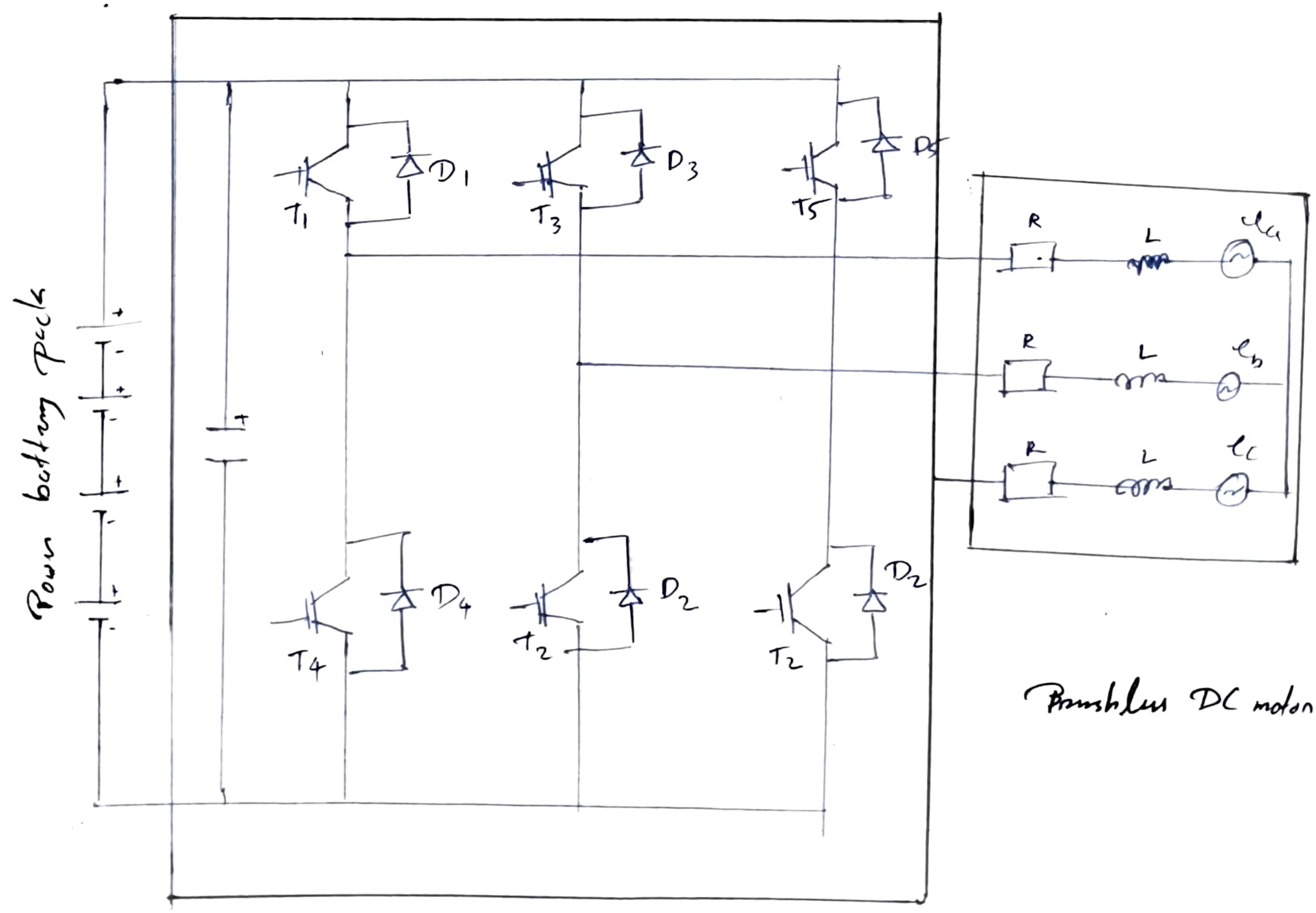


L - Discharging:- a+c = b D_1, D_5 & D_6 — active

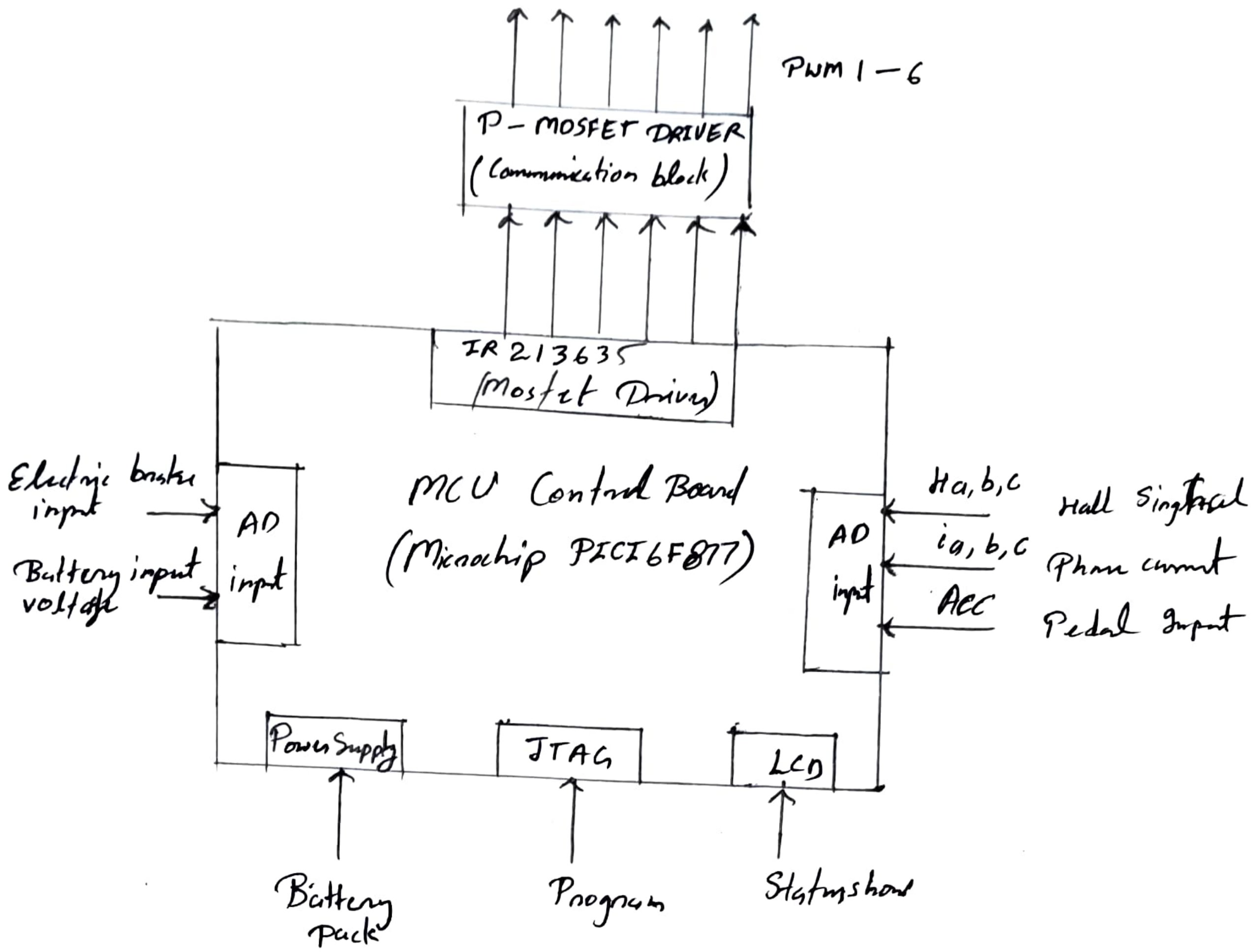


L - Charging T_4, D_6 & T_2 — Active





Brushless DC motor



Power device rating:

→ Voltage rating = 240V

It is 3-ϕ (there are two switches)

240V → Connected with upper switch & lower switch.

$\frac{240}{2} = 120V$ → each switch.

∴ Voltage rating for each switch is ≥120V

Current:

→ Let us take 1.25 times of power rating: 6.56×1.25
$= 8.2\ kW$

DC

- Normal current is taken whatever we have calculated

AC

- Rms current is taken
- We have calculated peak current so $\sqrt{2}$ times of peak current should be taken

$I_{rms} = \sqrt{2} \cdot I_{peak}$

In this case, we can take directly because it is DC

$$I = \frac{6.56 \times 1.25 \times 10^3}{240} A = 34.167 A$$

Current rating : 35 to 40 A

$I_{rating} \geq 34.167 A$

Que (10) Design a light duty e-scooter to run 30 Kmph to lift 100kg of weight (plus 75 Kg of body weight) with diameter of 8 inches. It should run at least 100 km for one shot charge when the friction coefficient factor is 0.9.

Solution: Given: $Mass = (100 + 75) Kg = 175 Kg$

$V = 30 Km/h$, $T = 25 Nm$, $D = 8$ inches, $\mu = 0.9$, $S = 100km$

$\therefore D = 8 \text{ inches} = 8 \times 2.54 cm = 20.32 cm$

As we know

$$Km/h = Diameter \times rpm \times 1.885 \times 10^{-3}$$

$$N\ rpm = \frac{Km/h}{Diameter \times 1.885 \times 10^{-3}}$$

$$= \frac{30 \times 1000}{20.32 \times 1.885}$$

$$N = 783.2\ rpm$$

$$P = \frac{2\pi NT}{60} = \frac{2\pi \times 783.2 \times 25}{60} = 2050 W$$

$$P = 2.05 KW$$

$$P(Hp) = \frac{2050}{746} = 2.74 Hp$$

$$Time = \frac{Distance}{speed} = \frac{100km}{30 Km/h} = 3.33 h$$

$$KWh \rightarrow (2.05 \times 3.33) KWh = 6.82 KWh$$

Assume $V = 24V$ → for light duty vehicle

$$Ah \rightarrow \frac{6.82 \times 10^3}{28V} = 243.57\ Ah.$$

Standard value of Ah for light duty vehicle is assumed - 45 Ah

No. of batteries to run 3.33h $= \dfrac{243.57\ Ah}{45\ Ah}$

$$= 5.41 \simeq 6$$

Ans: 6 batteries

Motor Sizing: In this case 2.05 KW is the requirement of the mechanical power. So motor rating has to accept this much max^m power, so that our design should be 1.25 to 1.5 time of higher than this one:

$$2.05 \times 1.25 = 2.56\ KW$$

(or)

$$2.05 \times 1.5 = 3.075\ KW$$

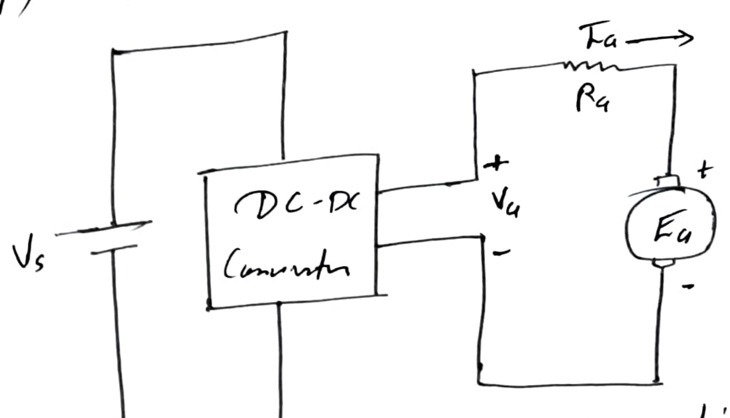
Take 1.25; Motor sizing = 2.56 KW

Suitable Motor:

for light duty electric vehicle, PMDC is the best suitable motor.

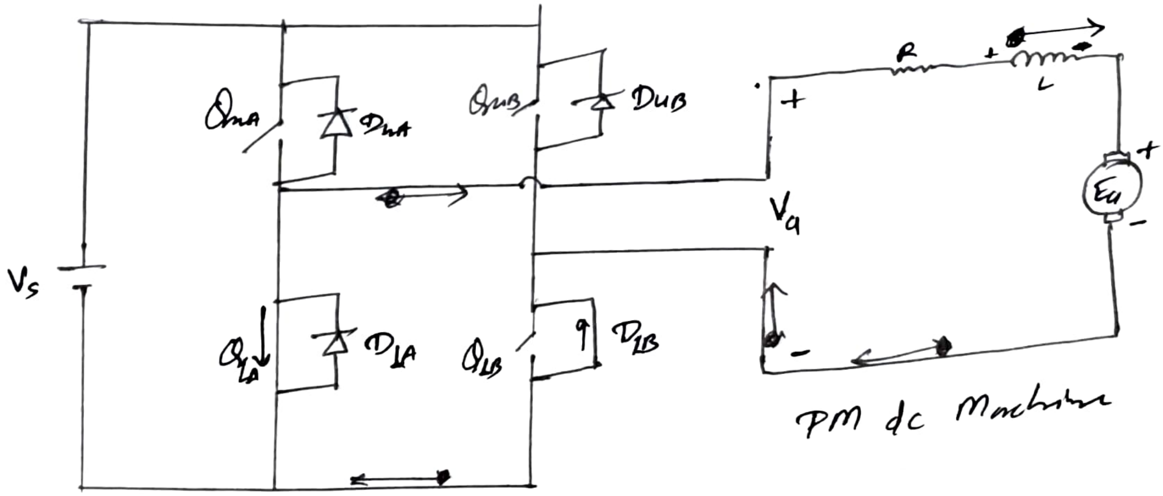
Circuit for regeneration of PMDC :-

(a)

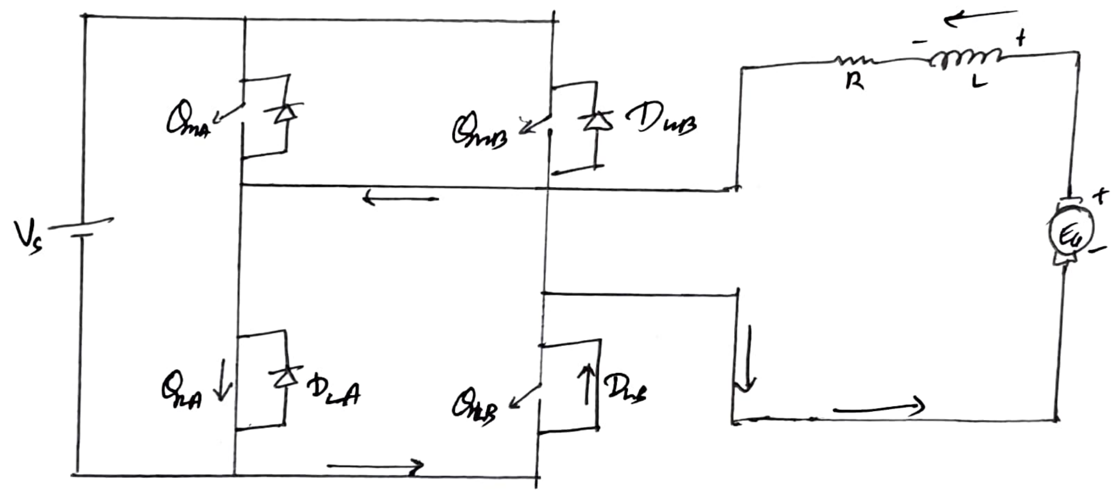


forward motoring

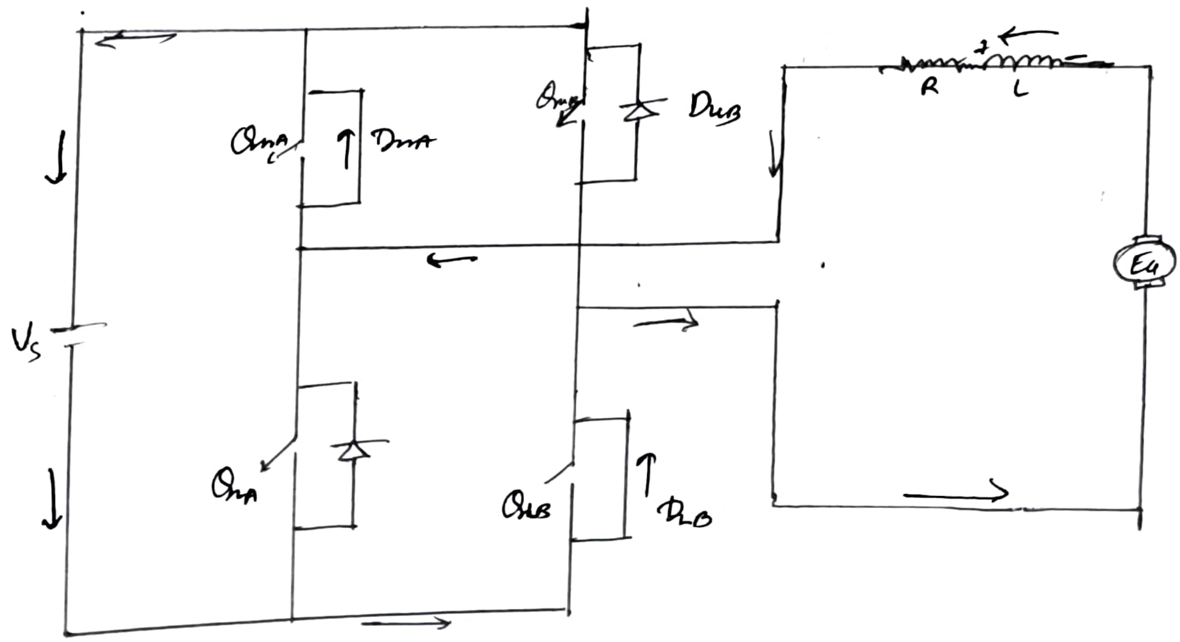
PMDC machine



→ L - charging Q_{uA} , D_{LB} → Active



D_{uA} , D_{LB} → Active ⟹ L Discharging !.



Power device rating;

- Voltage rating $\geq 24\,V$ or $24\,V$ to $30\,V$

DC current: Normal current is taken no need to take Rms.

Current Rating: $P = (2.05 \times 1.25)\,kW = 2.56\,kW$

$$I = \frac{2.56 \times 10^3}{24}\,A = 106.67\,A$$

$I_{rating} \geq 107\,A$ or $107\,A$ to $110\,A$

We have

$V_{rating} \geq 24V$, $I_{rating} \geq 107\,A$