<u>**ESO203 Tutorial 7**</u>

<u>**Question 1:-**</u> A 5kVA, 50V/100V, single-phase transformer has a secondary terminal voltage of 95V when loaded. The regulation of transformer is-

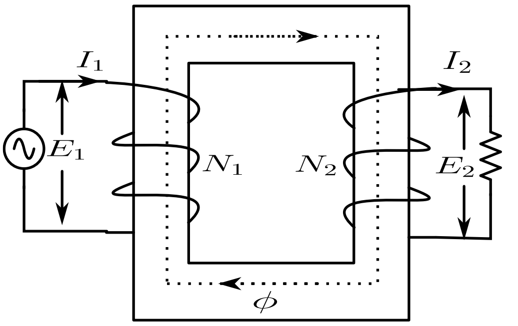
**Solution:-**

Given data

5kVA, 50V/100V, single phase transformer secondary terminal voltage when loaded =95V.

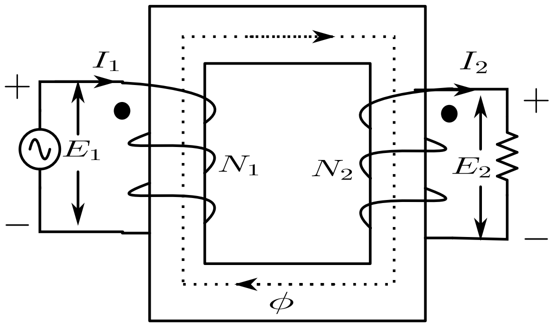
$$Voltage\ regulation = \frac{V_1' - V_2}{V_1'} \times 100 = \frac{100 - 95}{100} \times 100 = 5\%$$

<u>**Question 2:-**</u>Figure shows ideal single-phase transformer, the primary and secondary coil wound on same core as shown. Turns ratio (N1/N2) = 2. Draw the correct phasor of voltage $E_1$, $E_2$, current $I_1$, $I_2$ and core flux $\emptyset$.




<u>**Solution:-**</u>

The transformer of problem shown in fig.




I. Since the direction of windings are given, we can obtain location of dots using basic laws. These are shown in fig.

II. The polarity marking and direction markings are entirely arbitrary, and we can select them any way we like. Their values then are not arbitrary. They depend on what we selected.

III. Please see the dot convention. Using it, we can conclude that-

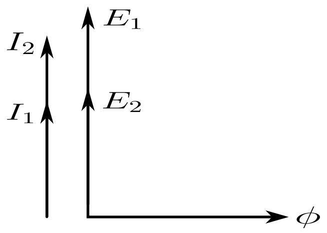
a) $\overline{E_1}$ and $\overline{E_2}$ are in phase.

b) $\overline{I_2}$ is in phase with $\overline{E_2}$ .

c) $\overline{I_1}$ and $\overline{I_2}$ are in phase (for amp-turn balance).

d) With the reference direction chosen for $\emptyset$, and refence polarity chosen for $\overline{E_1}$ and $\overline{E_2}$, $\overline{E_1}$ and $\overline{E_2}$ lead $\emptyset$ by $90^0$

e) Turns ration is to be used to determined the relative magnitude of the different phasors.




**<u>Question 3</u>:-**A separately excited dc motor has an armature resistance $R_a$ = 0.05Ω. The field excitation is kept constant. At an armature voltage of 100V, the motor produces a torque of 500Nm at zero speed. Neglecting all mechanical losses, the no load speed of motor (in radian/s) for armature voltage of 150 is –

**Solution:-**

Circuit for separately excited DC motor: (At starting)

At zero speed, ω = 0

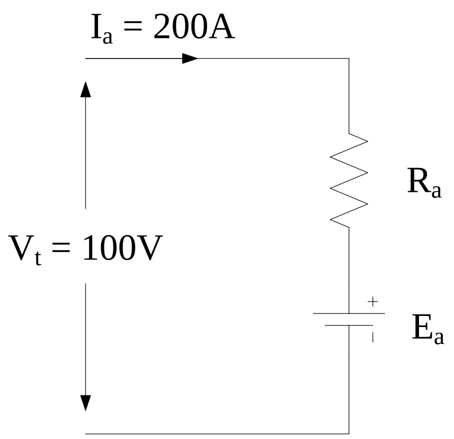
In a DC machines,

$$E_a = k_a \emptyset\ \omega$$

$$E_{a0} = 0 \quad (\text{Because, } \omega = 0)$$

So,

$$I_{a0} = \frac{V_t - E_{a0}}{R_a} = \frac{100 - 0}{0.05} = 200A$$



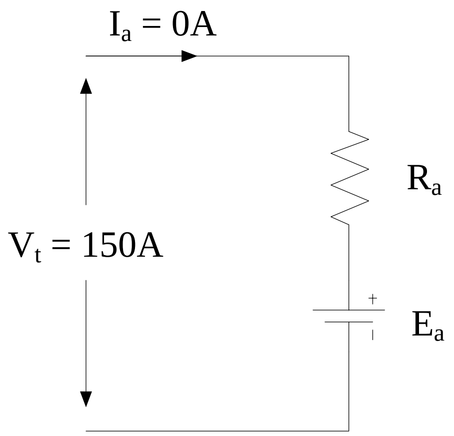

Given that at zero speed, torque = 500Nm

$$T = k_a \emptyset I_a$$

$$500 = (k_a \emptyset)(200)$$

$$k_a \emptyset = 1/4$$

Flux maintained constant and terminal voltage is changed to 150V, the new equivalent circuit is: (at no load)




$$\text{Load} = 0 \Longrightarrow \text{Torque} = 0 \Longrightarrow I_a = 0$$

$$E_a = V_t = 150V$$

We know, $E_a = k_a \emptyset\, \omega$

$$150 = (1/4)\,\omega$$

$$\omega = 600 \text{ rad/sec}$$

No load speed ($\omega$) = 600 rad/sec

**Question 4:-** A 240V dc series motor take 40A when giving its rate output at 1500 rpm. Its resistance is 0.3 ohms. The value of resistance which must be added to obtain rated torque at 1000 rpm is.

**Solution:-**

Given $V = 240V,\ I_a = 40A$

$$R_a + R_{sc} = 0.3\Omega$$

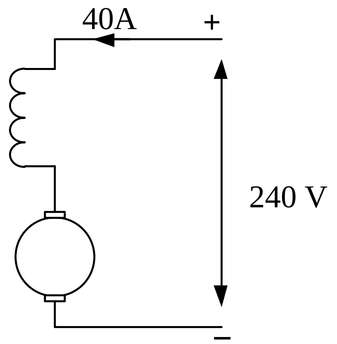
$$N = 1500\ rpm$$

$$E_{b1} = V - I_a(R_a + R_{sc})$$

$$E_{b1} = 240 - 40(0.3)$$

$$E_{b1} = 228\ V$$

$$T \propto \phi I_a = T \propto I_a^2 \qquad (\phi \propto I_a)$$




To have same torque even at 1000 rpm armature current must be same in both cases.

$$N \propto \frac{E_b}{\phi} = N \propto \frac{E_b}{I_a} = N \propto E_b$$

Where $I_a$ is constant

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}}$$

$$\frac{1000}{1500} = \frac{240 - 40(0.3 + r)}{228}$$

By solving

$$r = 1.9\ \Omega$$

The resistance to be inserted $(r) = 1.9\ \Omega$.

**<u>Question 5:-</u>** A 8 pole dc generator has a wave wound armature containing 32 coils of 6 turn each. Its flux per pole is 0.06 Wb. The machine is running at 250 rpm. Calculate The induced armature voltage value.

**<u>Solution:</u>**

Induced emf in a DC generator

$$E = \frac{\phi ZN}{60} \times \frac{P}{A}$$

$$E = \frac{0.06 \times (32 \times 6 \times 2) \times 250}{60} \times \frac{8}{2}$$

$$E = 384\ V$$

**<u>Question 6:-</u>** A 50kW DC shunt motor is loaded to draw rated armature current at any given speed. When driven

(i) At half the rated peed by armature voltage control and
(ii) At 1.5 times the rated speed by field control, the respective output power delivered by the motor are approximately.

**<u>Solution:</u>**

Since data is not given, for simplicity neglect all losses including armature losses. This means we assume $R_a = 0$

Problem specifies that at any speed, armature current has the same value which is equal to the rated value.

Let $V_{rated}$ and $I_{rated}$ be the rated values. Then rated input power = rated output power $= V_{rated} I_{rated} = 50kW$.

**(i)** To obtain half the speed by armature voltage control (field current is assumed to remain unchanged), armature voltage must be made $\frac{V_{rated}}{2}$. This result is proved as follow. For the shunt motor $E = K\phi\omega_r = V - I_a R_a = V$ Since $R_a$ is neglected.

Let field excitation be kept constant. Then neglecting armature reaction, $K\phi$ is constant, say $K_1$ and $V = K_1\omega_r$. At rated operation $V_{rated} = K_1\omega_{r_{rated}}$.

To get $\omega_r = \frac{1}{2}\omega_{r_{rated}}$; $V$ must be $\frac{V_{rated}}{2}$

Power=$\frac{V_{rated}}{2} \times I_{rated}$

Power = 25 kW

**(ii)** With V kept at $V_{rated}$ ; $\omega_r$ is to be changed to $\frac{3}{2}\omega_{r_{rated}}$ by field control but the current is still $I_{rated}$ for the given data.

Hence power=$V_{rated}I_{rated} = 50\ kW$

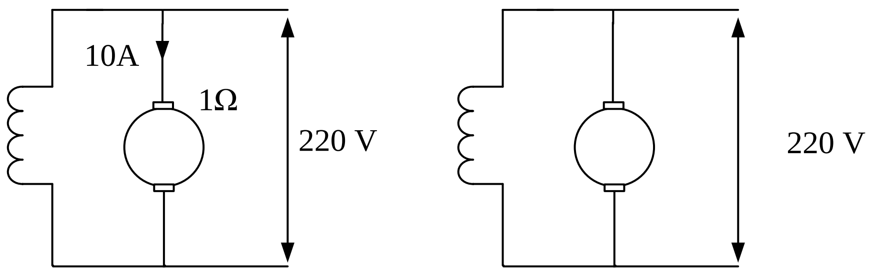
**<u>Question 7:-</u>** A 220 V DC shunt motor is operating at a speed of 1400 rpm. The armature resistance is 1Ω and armature current is 10 A. If excitation of the machine is reduced by 10%, the extra resistance to be put in the armature circuit to maintain the same speed and torque will be.

**<u>Solution:-</u>**

Given data:

$$N_1 = 1440\ rpm$$

$$I_{a1} = 10\ A, \quad \phi_2 = 0.9\phi_1, \quad N_2 = 1440\ rpm$$




Given, $T_2 = T_1$

$$T_2 = T_1$$

$$\phi_1 I_{a1} = \phi_2 I_{a2}$$

$$\phi_1 \times 10 = 0.9 \times \phi_1 \times I_{a2}$$

$$I_{a2} = 11.11\ A$$

$$E_{b1} = V - I_a R_a$$

$$E_{b1} = 220 - 10 \times 1$$

$$= 210\,V$$

$$E_{b2} = 220 - 11.11 \times (1 + R)$$

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b^1}} \times \frac{\phi_1}{\phi_2}$$

$$1 = \frac{220 - 11.11(1 + R)}{210} = \frac{\phi_1}{0.9\phi_1}$$

$$R = 1.79\,\Omega$$