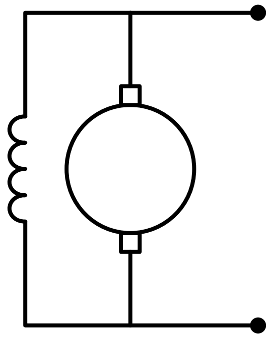
1. A 300V, 15A, 1000rpm DC shunt motor is having an armature resistance of 0.1 Ω and field winding resistance of 200 Ω (Applied voltage to the motor is 300V and it draws 15A from the source and runs at 1000rpm while driving the full load). Determine:
   a. Armature current on full load. **(0.5)**
   b. Armature current at 50% of full load. **(0.5)**
   c. Current drawn from the source while driving 50% of full load. **(0.5)**
   d. Back EMF on full load. **(0.5)**
   e. Back EMF and speed while driving 50% of full load. **(1)**



Sol ⇒ $I_F = \frac{300}{R_F} = \frac{300}{200} = \underline{1.5A}$

a) $I_a = I_L - I_F = 15 - 1.5A = \underline{13.5A}$

b) at 50% load $I_a' = \frac{I_{a\,\text{full load}}}{2} = \frac{13.5A}{2} = \underline{6.75A}$

c) current drawn from source $= I_a' + I_F$

$= 6.75 + 1.5 = \underline{8.25A}$

d) $V_{in} = E_b + I_a R_a = E_b + 13.5 \times 0.1$

$\Rightarrow E_b = 300 - 13.5 \times 0.1 = \underline{298.65V}$

$E_b' = 300 - I_a' R_a$
$= \underline{299.325}$

e) $E_b = K\phi\omega$ here K & ϕ are constant

$\therefore \frac{E_b}{E_b'} = \frac{\omega}{\omega'} \Rightarrow \frac{298.65}{299.325} = \frac{1000}{\omega'} \therefore \underline{\omega' = 1002.26}$

2. The rotor speed of 3-phase, 50 Hz induction motor while driving a full load is 291 rpm. Determine:
   a. Number of poles and synchronous speed. **(0.5+0.5)**
   b. Speed of the rotor field with respect to rotor. **(0.5)**
   c. Speed of the rotor field with respect to stator. **(0.5)**
   d. Frequency of rotor current at starting (speed of rotor=0) **(0.5)**
   e. Frequency of rotor current when $N_r = 291$ rpm. **(0.5)**

$S \leq 4\%$

Sol ⇒ a) as motor is operating at 50 Hz $f = 50$

$N_s = 300$ rpm as $N_r = 291$ and $s \leq 4\%$

$\therefore\ 300 = \frac{120 f}{p} \Rightarrow p = \frac{120 \times 50}{300} = 20$

b) speed of rotor field $= N_s = 300$ rpm

$\therefore$ speed of rotor field w.r.t. rotor $= N_s - N_r = 300 - 291 = 9$ rpm

c) speed of rotor field w.r.t to stator will be N_s as stator is stationary $= 300$ rpm

d) When speed of rotor $= 0$, the rotor will have a current of frequency which is equal to stator current.

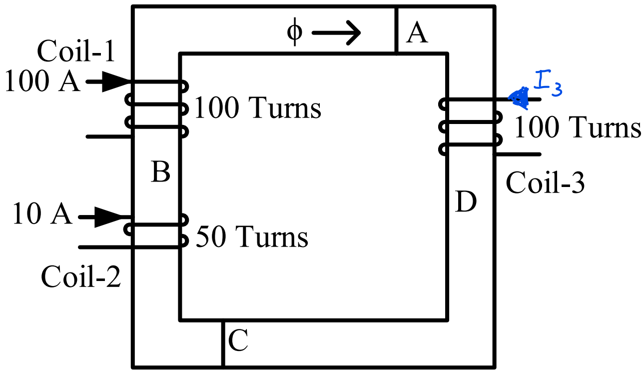
$\therefore$ 50 Hz

e) When $N_r = 291$, the rotor will have a current corresponding to slip frequency

$\therefore\ N_{slip} = N_s - N_r = 9$ rpm

$9 = \frac{120 f}{p} \Rightarrow f = 1.5$ Hz

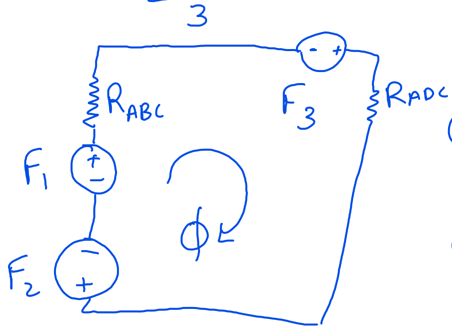
3. Magnetic Circuit has 2 portions ABC and ADC of identical dimensions (no air gap). μ_r of portion ABC is 3 times that of the portion ADC. The reluctance of ADC is 750. Coil-1 and coil-2 are carrying a current of 100 A and 10 A respectively in the direction shown. If the flux $\phi=1\ wb$ is to be produced in the direction shown. Determine:



a. The magnitude and direction of the current in coil-3. **(2)**
b. What should be the magnitude and direction of current in coil-3 for producing the same flux in the opposite direction to that shown in figure. **(1)**

$R_{ADC} = 750$, $\mu_{rABC} = 3 \times \mu_{rADC}$, $\phi = 1wb$

$$R_{ABC} = \frac{R_{ADC}}{3} = 250$$



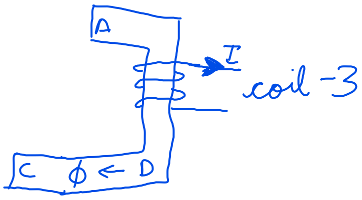
$$0 = F_1 + F_3 - F_2 - \phi(R_{ABC} + R_{ADC})$$

$$0 = 10000 + F_3 - 500 - 1[750 + 250]$$

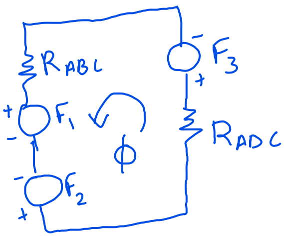
$$F_3 = -8500AT$$

$F_3 = I_3 \times N = -8500$

$\underline{I_3 = -85\ A}$



b)

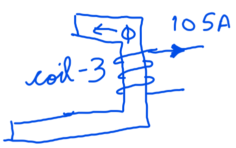


$\phi = 1wb$

$$0 = F_2 - F_1 - F_3 - \phi(R_{ABC} + R_{ADC})$$

$$= 500 - 10000 - F_3 - 1000$$

$$F_3 = -10500 = NI_3 \Rightarrow I_3 = -105A$$



4. Assume that the following passive components and power supplies are available to you.

   i. ~~3 Phase variable voltage variable frequency supply.~~
   ii. 3 Phase R-L bank. (R- Resistor; L-Inductor)
   iii. Variable voltage DC source.
   iv. Variable resistor.

   You have been told that 3 phase induction motor draws 6-7 times the rated current during starting if rated voltage at rated frequency is applied.

   a. Suggest an elegant method to reduce this current using one of the above mentioned component/supply. **(0.5)**
   b. Justify your answer. (Be Precise.) **(0.5)**

   (**Note:** Credit for part (a) will be given only if the answer to part (b) is correct)

Sol $\Rightarrow$

a) Using a variable voltage variable frequency 3 ϕ supply.

b) When using a variable frequency drive the we can reduce the relative speed between N_s and N_r. hence the current requirement will be low.