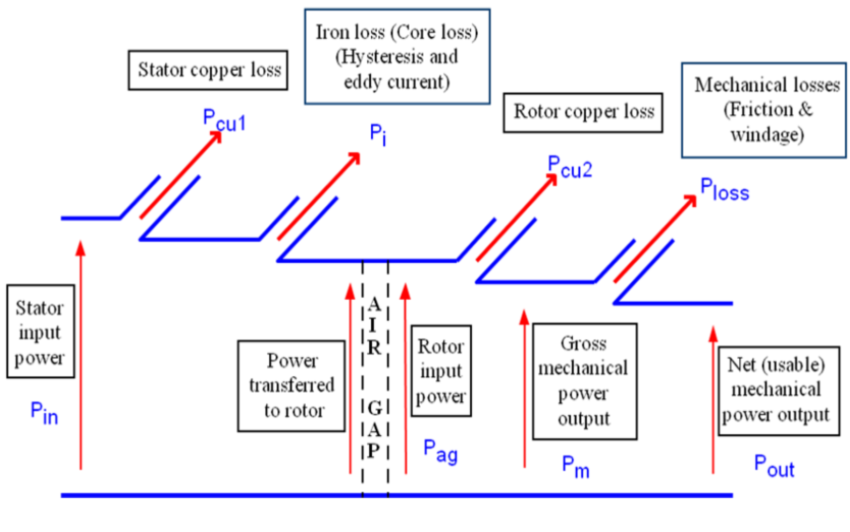
EXERCISE 1 2021

Question No.: A1 (related topic area: DC drives)

(ai) (aii)	For wave wound : $E=2ZN\Phi P/60C = (2 \times 30\times 8\times 1200 \times 0.0174\times 3)/(2\times 60) = 250.56V$ For Lap wound: $E=2ZN\Phi P/60C = (2 \times 30\times 8\times 1200 \times 0.0174\times 3)/(2\times 3 \times 60) = 83.52V$	
(b)	DC machine consist of: 1. Stator, field pole, this part of the machine does not move and normally is the outer frame of the machine. 2. Rotor, armature, this part of the machine is free to move and normally is the inner part of the machine.	

Question No.: A2 (related topic area: ind. motor)

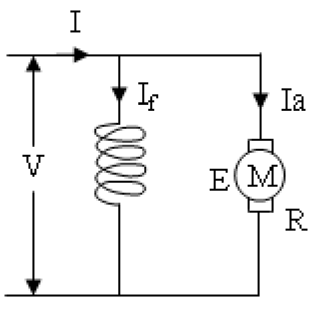
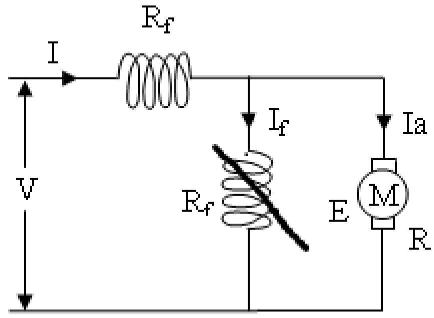
(a) (b) (c) (d)	Stator copper loss is current flows in the primary circuit, heat is produced in the stator conductor as copper loss. Iron loss is hysteresis and eddy current losses. Rotor copper loss is the current in the rotor winding cause copper loss. Mechanical losses is due to electrical energy is converted to mechanical energy, energy lost as friction and windage losses.	



Question No.: A3 **(related topic area: AC motor)**

(ai)	The synchronous speed is: $$N_s = \frac{60 \times 50}{2} = 1500 rpm$$	
(aii)	Speed of the rotor at full load condition is: $$N_r = (1-s)xN_s = (1-3\%)x1500 = 1455rpm$$	
(b)	**(any two of the following)** 1.Suppressing emissions - Proper layout with EM concept - Using component with low edge rate as possible 2. Reducing the efficient of the coupling path - Using shielded enclosure 3. Reducing the susceptibility of the receptor - Differential pairs - Error-correcting code	

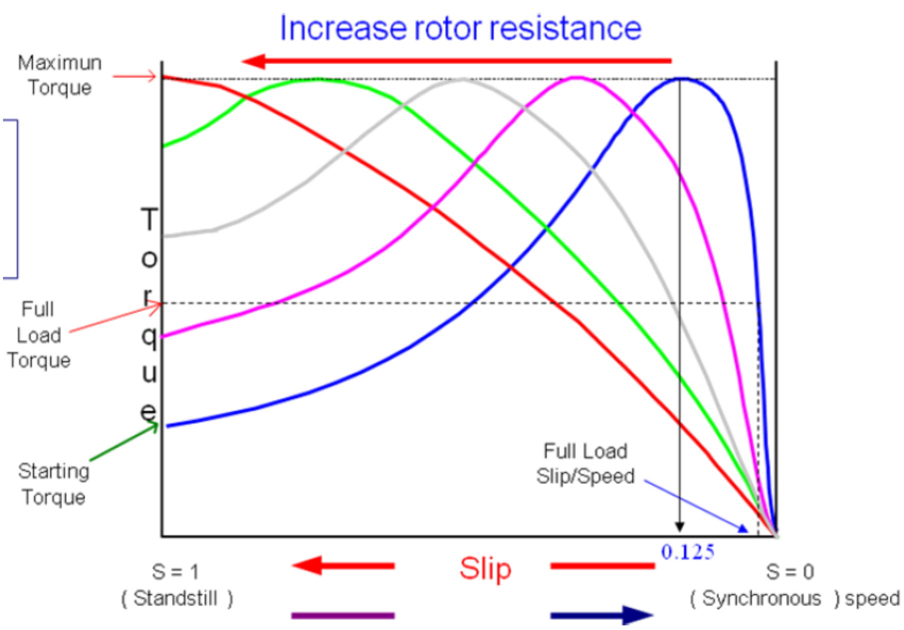
Question No.: A4 (related topic area: _DC motor___ ___)

(ai) (aii)	 Shunt Motor  Compound Motor	
(b)	(any two, 2% each) - Journal resistance is friction between journal and bearing - Rolling fraction is the friction between wheel and rail - Track resistance is the deform track structure creates resistance. - Flange resistance in the curve track. - Air resistance.	

Question No.:	A5	(related topic area: _Tractive__)	
	Given V = 400V, N=1500rpm, input power=1000W, I_{sh}=1A, Ra=0.2Ω		
(i)	Line current at no load = 1000 / 400 = 2.5A		
(ii)	Armature current at no load = 2.5 – 1 = 1.5A		
(iii)	Armature copper loss at no load (Ia^2Ra) = $1.5^2 \times 0.2$ = 0.45W		
(iv)	Constant loss = 1000 – 0.45 = 999.55W For maximum efficiency, constant loss = variable loss If Ia be the armature current at maximum efficiency condition then $Ia^2 \times 0.2 = 999.55$ where Ia = 70.69A Line current = 70.69 + 1 = 71.69A		
(v)	At maximum efficiency, total loss = 2 $\times$ 999.55 = 1999.1W Input power = 400 $\times$ 71.69 =28676W Maximum efficiency = (28676 – 1999.1)/ 28676 = 0.93 =93%		

EXERCISE 2 2021

Question No.: B1 (related topic area: tractive, torque)

(a)	Starting torque can be controlled to maximum value by varying the rotor resistance. 	
(b)	(i) - SB1 as start button and have been pressed - KM coil has magnetic action and control KM contactor to action. - KM parallel with SB1 keep 5 to 7 closed, and KM contactor connected with motor is closed, motor will be started. (ii) The function of the circuit including: - Thermal overload protection by FR, thermal sensor at 3 and 9. - Fuse protection of three phase power - SB1 control motor to start - SB2 control motor to stop - L1, L2, L3 as lamp indicator	
(c)	Compare to induction motor, there is no P_{CU2} power loss in permanent magnet synchronous motor, because there is not induction electrical current in the roto. Thus, there is no P_{CU2} power loss.	

Question No.: B2 **(related topic area: EMC, drives)**

(ai)	A diode is a two-layer semiconductor device. If a reverse voltage is applied across the diode, tt behaves essentially as an open circuit. If a forward voltage is applied, it starts conducting and behaves essentially as a close switch.	
(aii)	IGBT is a hybrid power semiconductor device which combines the attributes of the BJT and the MOSFET. It has a MOSFET type gate and therefore has a high input impedance. The gate is voltage driven. IGBT has low on-state voltage drop similar to BJT.	
(b)	EN50121-1-X series is subdivided into parts: 1. Part 1 provides a general introduction, describes the railway environment and defines the management of EMC between rolling stock and the infrastructure; it calls upon EN 50238. 2. Part 2 is concerned with the interface between the railway system and the outside world. It defines limits of emissions and appropriate measurement techniques. 3. Part 3 is sub-divided. - 3-1 covers the train and complete vehicle, emission limits and measurement techniques are defined. - 3-2 covers train-borne apparatus. Emission limits, immunity levels and measurement methods are specified. This standard also defines, immunity criteria, which in general are more stringent than the generic standards. 4. Part 4 covers signaling and telecommunication apparatus. Emission limits, immunity levels and measurement methods are specified. Part 4 is also the part that any other apparatus that does not fit into the other parts is tested to. 5. Part 5 covers fixed power supply apparatus and installations, for example traction sub stations.	

Question No.: B3 (related topic area: Drives, operating)

(a)	At starting, the back emf Ea is equal to zero. The starting current will be very large $\frac{(V_t - V_{Brush} - E_a)}{Ra}$ and damage the brush and the armature winding. Therefore, additional resistors need to be inserted in series with the armature windings for reducing the starting current.	
(bi)	The output current, It = $\frac{\text{Po}}{\text{V}} = \frac{120000}{375} = \underline{\underline{320A}}$	
(bii)	The field circuit current, $I_f = \frac{\text{Pf}}{\text{V}} = \frac{2000}{375} = \underline{\underline{5.33A}}$	
(biii)	The armature current, Ia = $I_t + I_f$ = 320 +5.33 = $\underline{\underline{325.33\text{A}}}$	
(biv)	The armature resistance, Ra = $\frac{\text{Pa}}{Ia^2} = \frac{8000}{325.33^2} = \underline{\underline{0.0756\Omega}}$	
(bv)	The field circuit resistance, Rf = $\frac{\text{V}_t}{I_f} = \frac{375}{5.33} = \underline{\underline{70.36\Omega}}$	
(bvi)	The driven electromagnetic torque, $T = \frac{EaIa}{2\pi Nr} = \frac{(V + IaRa) \times Ia}{2\pi \times 1210/60}$ $= \frac{(375 + 325.33 \times 0.0756) \times 325.33}{2\pi \times 1210/60} = \underline{\underline{1026Nm}}$	