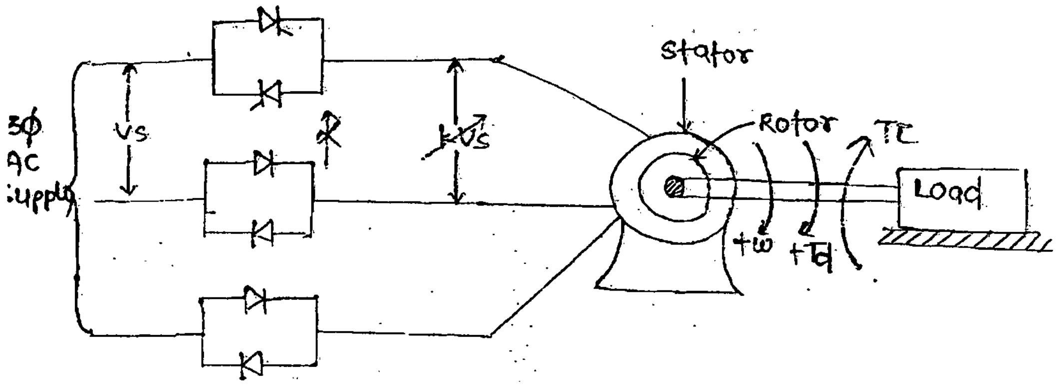
Applications of Power electronics

Ac drives →

(1) Stator voltage control of IM, using AC voltage controllers:-



* At starting, $T_d > T_L \therefore \omega\uparrow$
* After reaching steady state speed, $T_d = T_L$
* If developed torque $(T_d) < T_L$, $\omega\downarrow$ (m/c retard)

mech loads:-

(i) $T_L = const$. (Load torque is independant of speed)

(ii) $T_L \propto \frac{1}{\omega}$ [$(T_L \cdot \omega = 1)$ Constant power load].

(iii) $T_L \propto \omega^2$

(iv) $T_L \propto \omega$

2) Check weather the constant torque loads are suitable (or) not for the given ele. drive? case (I) $T_L = const$.

Ans:- * Let us consider that the m/c is running at rated load & rated speed.

If $(KV_s)\downarrow$, $T_d\downarrow$, $(T_d < T_L)$ $\therefore \omega\downarrow, s\downarrow, I\uparrow$.

* Here the m/c will slow down & draws more current from supply to build up the torque until $T_d = T_L$
* Here the m/c draws more current from the supply to build up the torque this overheats the m/c wdgs & much dearating is required for const. torque loads

Therefore this type of mech. loads are not prefered for a given ele. drive.

Case(2) $T_L \propto \omega^2 \rightarrow$

$$(Vs)\downarrow, T_d\downarrow, (T_d < T_L) \therefore \omega\downarrow, T_L\downarrow$$

* Here the m/c will slowdown untill $T_L = T_d$
* Here T_L reduces along with the speed & developed torque.

Therefore there is no necessity to build up the torque

* Hence the m/c will not draw more current from supply.

Therefore much derating is not required & hence this type of mech. loads can be used for given ele. drives. Eg:- Fan loads, compressers, reciproceting pmp

Case(3) $T_L \propto \omega \rightarrow$

Case (2) & case (3) are same; but in case (3) speed is less as compare to above.

Case (4) $T_L \propto \frac{1}{\omega} \rightarrow$

$$\uparrow T_L \propto \frac{1}{\omega\downarrow}$$

(2) Stator Frequency Control →

$\omega < \omega_r$:- $\frac{V}{F}$ control

$$\downarrow N_s = \frac{120F}{P}\downarrow \quad \downarrow N = (1-S)N_s\downarrow \quad \downarrow V_s \propto \phi F\downarrow \quad \frac{V\downarrow}{\downarrow F} \rightarrow \text{constant} \quad \therefore \phi \rightarrow \text{const}$$

* In this case V/F ratio should be kept constant in the entire range of speed control in order to maintain constant flux.
* We can realise the V/F control by using cycloconverter.
* With cyclo. the max^m speed is limited to 40% of its rated value.
* We can also use pwm inverter for V/F control of IM.

$$\downarrow P_d = T_d \cdot \omega\downarrow$$

$\omega > \omega_r \rightarrow$

$$\uparrow V_s \propto \phi\downarrow F\uparrow \qquad \underset{(const)}{P_d} = \downarrow T_d \cdot \omega\uparrow$$

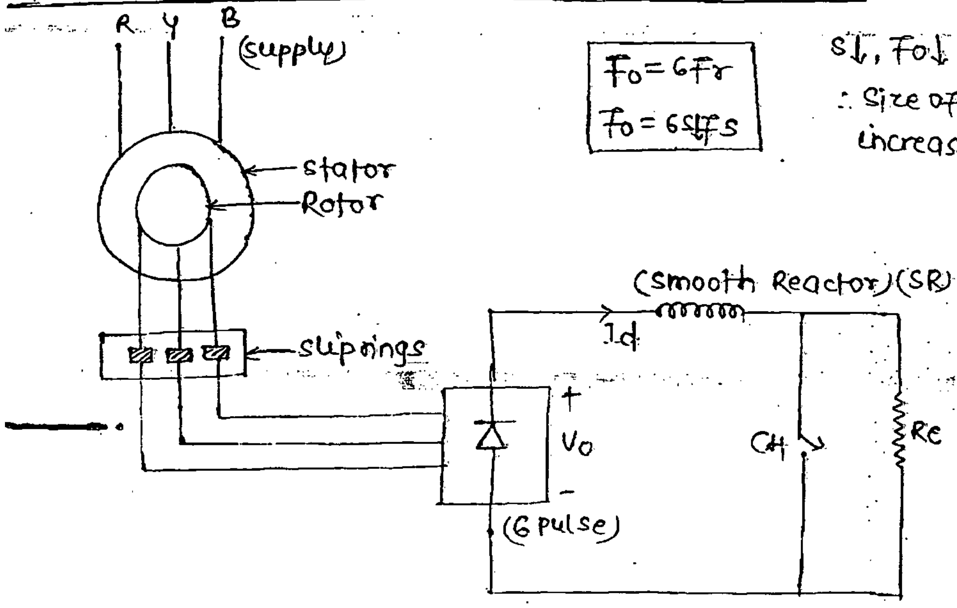
* In this case V/F ratio can't be kept constant because we can't increase the stator vol. more then its rated value.

Therefore the stator vol. is fixed that its rated value.

* To increase the speed ($\omega\uparrow$), $F\uparrow$ $\therefore \phi\downarrow$ ($\because V_s \rightarrow$ Rated value) $\therefore T_d\downarrow$

* In this case we can use sq. wave inverter or PWM inverter.

(3.) Static resistance control (using chopper control) →



$F_0 = 6F_r$

$F_0 = 6sf_s$

$s\downarrow$, $F_0\downarrow$ $\therefore$ Ripple in $I_d\uparrow$

$\therefore$ Size of the SR should be increased.

$(1-\alpha)R_e = R_{eff}$

$$\text{Total cu loss} = 3I_r^2R_r + I_d^2(1-\alpha)R_e$$

$$I_{sr} = \sqrt{\frac{2}{3}}I_0$$

$$I_r = \sqrt{\frac{2}{3}}I_d$$

$$I_d = \sqrt{\frac{3}{2}}I_r$$

$$\text{Total cu loss} = 3I_r^2R_r + \left(\frac{3}{2}\right)I_r^2(1-\alpha)R_e$$

$$SPg. = 3I_r^2\left[R_r + 0.5(1-\alpha)R_e\right]$$

$\therefore$ Effective resistance connected in series with rotor ckt $= 0.5(1-\alpha)R_e$

$\frac{12}{57}$

$$\text{Avg. Resistance} = \text{Series } R + \left[0.5(1-\alpha)R_e\right]$$

$$= 2 + \left[0.5(1-\alpha)4\right]$$

$$(1-\alpha) = \frac{T_{OFF}}{T} = T_{OFF}\cdot F = 4\times10^{-3}\times 200 = 0.8$$

$$\text{Avg. resistance} = 2 + \left[0.5\times0.8\times4\right] = 18/5$$

This is not an efficient method because the slip power is dessipated in the external resistance in order to slow down the speed.

(4.) slip power recovery method → * This is an efficient method ~~& the~~ because the slip power is recovered & it can be utilised to the load itself (or) given back to the supply line.