STARTING OF INDUCTION MOTOR

SQUIRREL ROTOR MOTOR

STATOR STARTING MUST BE USED FOR CAGE ROTOR MACHINE

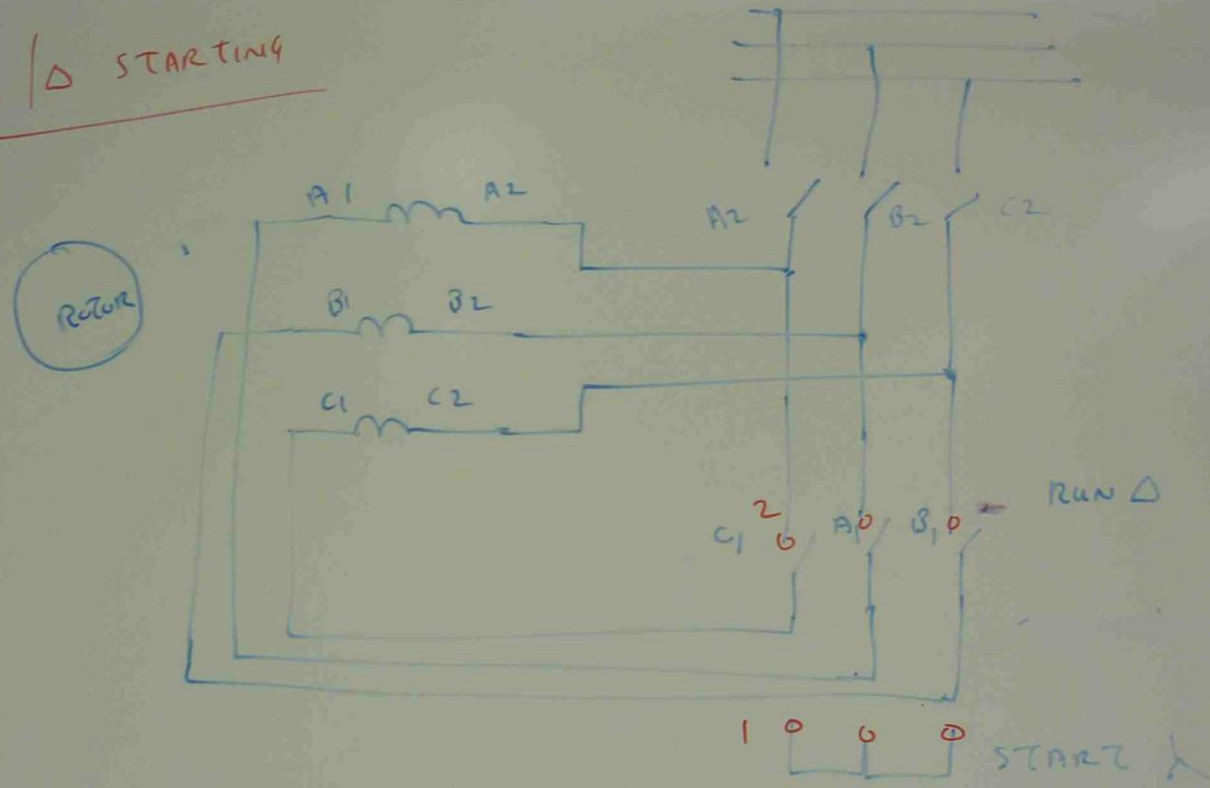
DIRECT ONLINE STARTER (DOL)

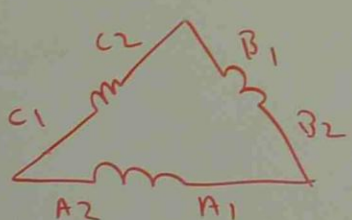
DOL STARTER CAN BE RESTRICTED TO 2KW (OR) LESS

REDUCED VOLTAGE STARTER

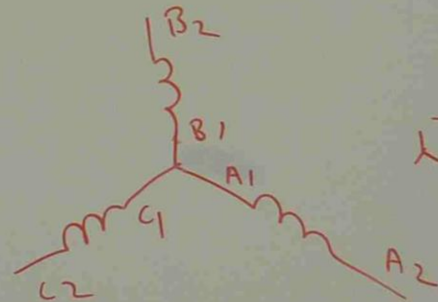
- STATOR IS STAR CONNECTED IN STARTING.
- APPLIED VOLTAGE IS REDUCED TO $\frac{1}{\sqrt{3}}$ TIME.
- LINE CURRENT IS REDUCED TO $1/3$
- STARTING TORQUE IS REDUCED TO $1/3$
- AT RUNNING TIME, MOTOR WINDING IS CONNECTED TO DELTA.

λ / Δ STARTING





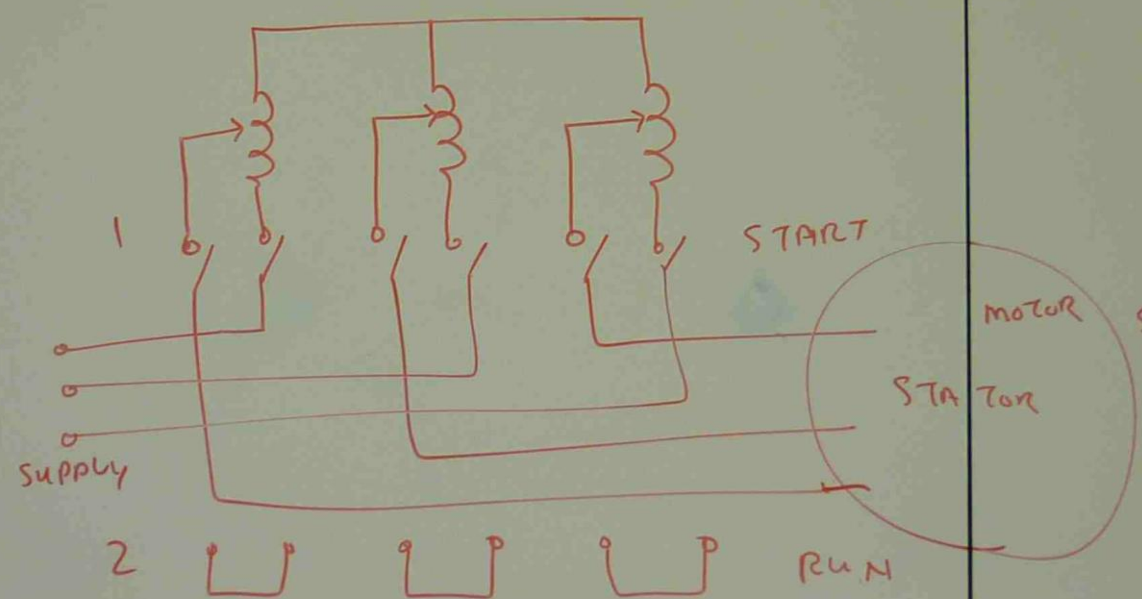
RUN



START

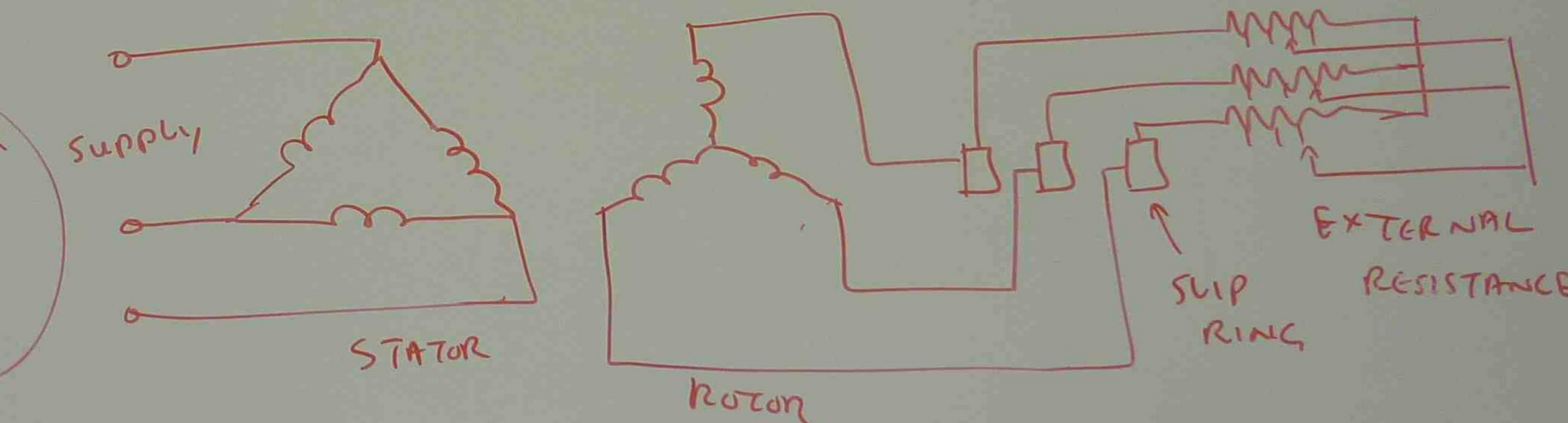
AUTO TRANSFORMER STARTING

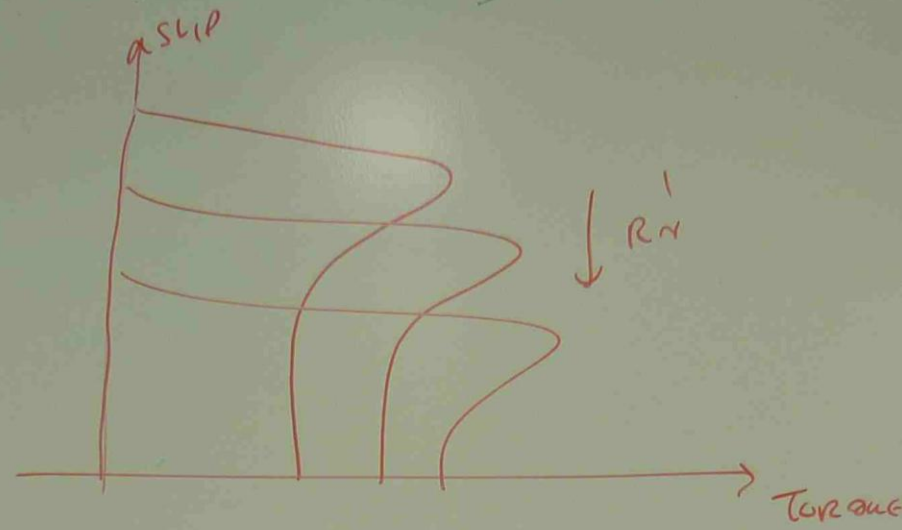
- AT LEAST THREE TAPPINGS
- 40, 60, 75 % OF LINE VOLTAGE FOR STARTING
- WHEN THE MOTOR HAS RUN TO SPEED, IT IS SWITCHED DIRECTLY TO MAIN.



SLIP RING MOTOR

SLIP RING MACHINES ARE STARTED BY MEANS OF EXTERNAL RESISTANCES CONNECTED THROUGH THE SLIP RINGS TO THE ROTOR CIRCUIT. THE MACHINE IS STARTED WITH ALL THE RESISTANCES IN, GIVING THE HIGH STARTING TORQUE. AS THE MACHINE RUNS UP TO SPEED, THE EXTERNAL RESISTANCE IS REDUCED UNTIL THE MACHINE ATTAINS FULL SPEED WITH NO EXTERNAL RESISTANCES.





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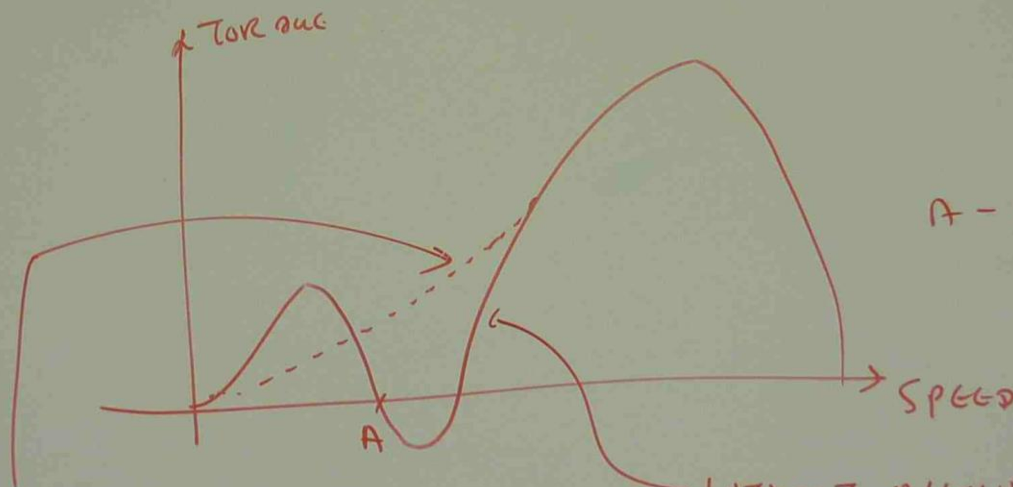

IF THE LOAD IS PUT AFTER THE MACHINE ATTAINS THE FULL SPEED, THE CHARACTERISTICS WILL FOLLOW THE DOTTED LINE

WITHOUT ALLOWING THE MACHINE TO ATTAIN THE FULL SPEED, IF THE LOAD IS PUT ON, THE MACHINE WILL SUFFER CRAWLING

EX (40)

A 3 PHASE SQUIRREL CAGE INDUCTION MOTOR HAS A STATOR RESISTANCE PER PHASE OF 0.5Ω AND A ROTOR RESISTANCE PER PHASE REFERRED TO THE STATOR OF 0.5 Ω. THE TOTAL STANDSTILL REACTANCE PER PHASE REFERRED TO THE STATOR IS 4.92Ω. IF THE RATIO OF MAXIMUM TORQUE TO FULL LOAD TORQUE IS 2 : 1, FIND THE RATIO OF ACTUAL STARTING TO FULL LOAD TORQUE FOR (a) DIRECT STARTING (b) STAR / DELTA STARTING AND (c) AUTO TRANSFORMER STARTING WITH A TAPPING OF 75 %..

$R_s = 0.5\Omega$ $\quad (X_s + X_r) = 4.92\Omega$

$R_1 = 0.5\Omega$

FULL LOAD TORQUE $= \frac{1}{2}$ MAXIMUM TORQUE

$$\text{MAXIMUM TORQUE} = \frac{3V_s^2}{4\pi m_0}\left[\frac{1}{\sqrt{R_s^2 + (X_s+X_r)^2} \pm R_1}\right]$$

(+) → MOTOR ACTION

(−) → GENERATOR ACTION

$$T_{max} = \frac{3V_s^2}{4\pi m_0}\left[\frac{1}{\sqrt{R_s^2+(X_s+X_r)^2}+R_1}\right]$$

$$\frac{3}{4\pi m_0} = \text{CONSTANT} = K$$

$$T_{max} = k v_s^2 \left[\frac{1}{\sqrt{R_s^2 + (X_r + X_s)^2} + R_r} \right]$$

$$= k v_s^2 \left[\frac{1}{\sqrt{0.5^2 + 4.92^2} + 0.5} \right]$$

$$T_{max} = \frac{k v_s^2}{4.44}$$

FULL LOAD TORQUE $= \frac{1}{2} T_{max} = \frac{1}{2} \times \frac{k v_s^2}{4.44} = \frac{k v_s^2}{4.89}$

(a) STARTING TORQUE

$$T_{st} = \frac{3 v_s^2}{2\pi n_0} \times \frac{S R_r^1}{(S R_s + R_r^1)^2 + S^2 (X_s + X_r^1)^2}$$

[DIRECT STARTING
S = 1]

$$= \frac{3 v_s^2}{2\pi n_0} \quad \frac{1 \times 0.5}{(1 \times 0.5 + 0.5)^2 + 1^2 (4.92)^2}$$

$$T_{st} = \frac{3 v_s^2}{2\pi n_0} \times \frac{0.5}{25.2} = 2k \times v_s^2 \times \frac{0.5}{25.2}$$

$$T_{st} = \frac{k v_s^2}{25.2}$$

$$\frac{\text{DOL STARTING TORQUE}}{\text{FULL LOAD TORQUE}} = \frac{\frac{K\,Vs^2}{25.2}}{\frac{K\,Vs^2}{9.89}} = \frac{K\,Vs^2}{25.2} \times \frac{9.89}{K\,Vs^2} = 0.4 \rightarrow T_{st_{DOL}} = 0.4\,T_{FL}$$

(b) $$T_{\lambda\Delta} = \left(\frac{1}{\sqrt{3}}\right)^2 T_{DOL\ STARTING}$$

$$= \frac{1}{3} \times 0.4\,T_{FL} = 0.133\ T_{FL}$$

(c) AUTO TRANSFORMER STARTING

$$T_{AUTO} = \left(\%\ \text{TAPPING}\right)^2 \times T_{DOL\ STARTING}$$

$$= (0.75)^2 \times 0.4\,T_{FL}$$

$$= 0.231\,T_{FL}$$