EX: 15 HP 440V 3φ 60 Hz 8-pole wound-rotor induction motor. Stator & Rotor both in WYE.

$b = 2.4:1$

$P_{WF} = 220\ W$ $\quad P_{STRAY} = 120W$

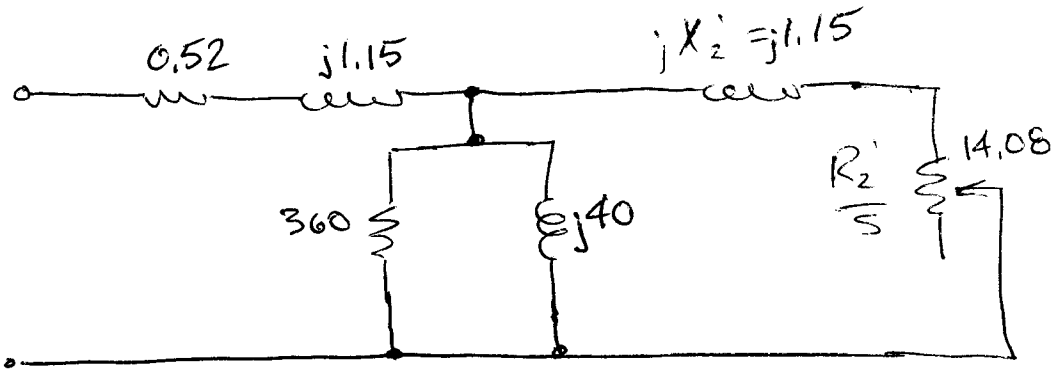
$R_1 = 0.52$ $\quad R_2' = 0.110$

$X_1 = 1.15$ $\quad X_2' = 0.20$

$X_M = 40$

$R_c = 360$

a) $s = 0.045$



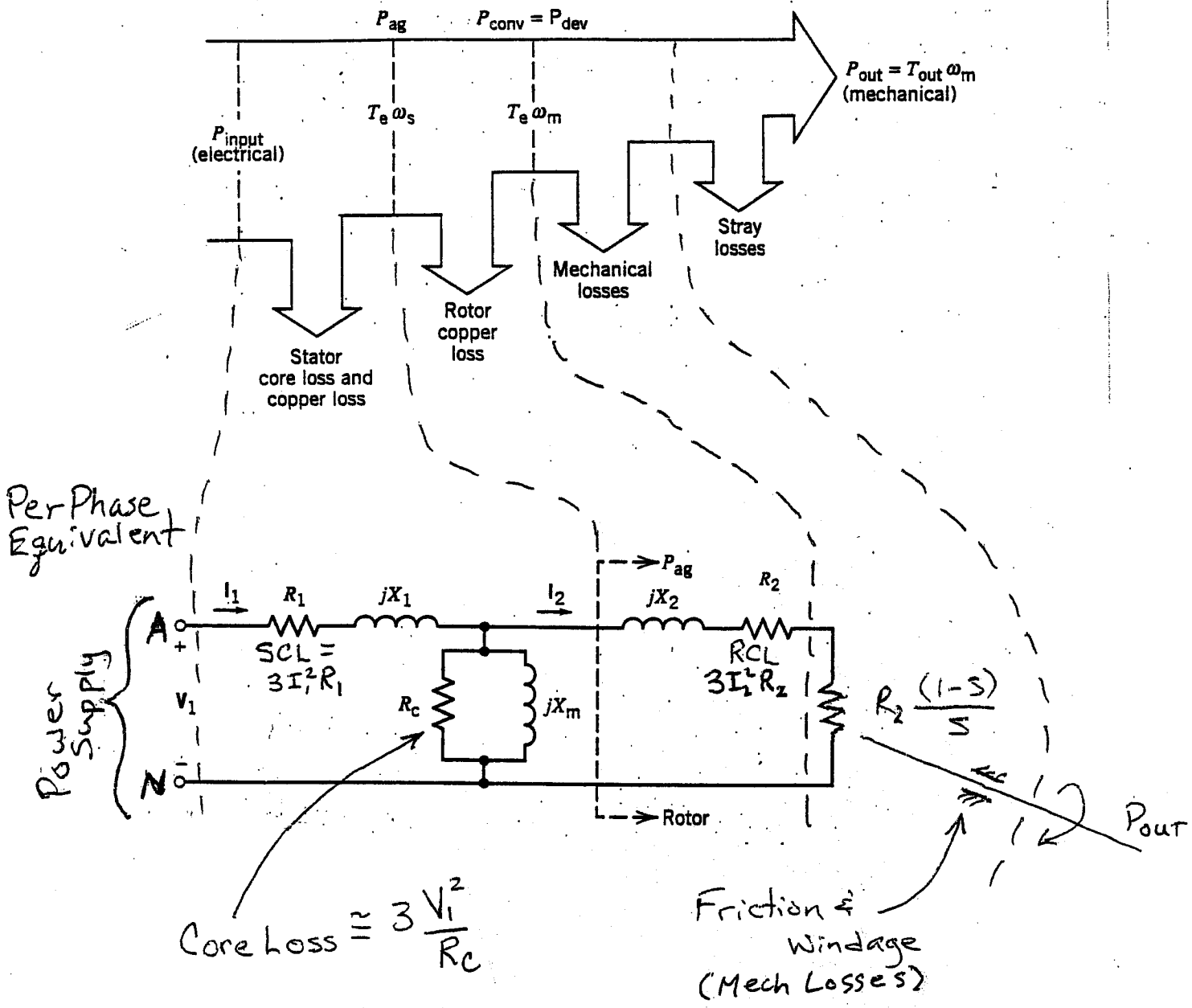
$X_2' = b^2 X_2 = (2.4)^2(.20) =$ 1.152

$R_2' = b^2 R_2 = (2.4)^2(.110) =$ 0.6336

$Z_{ROTOR} = 14.08 + j1.15\ \Omega/phase = 14.13 \angle 4.7°$

$Z_M = 360 // j40 = 4.40 + j39.5\ \Omega/ph = 39.8 \angle 83.65°$

$Z_1 = 0.52 + j1.15 = 1.26 \angle 65.6°$



$$RCL = 3I_2^2R_2$$

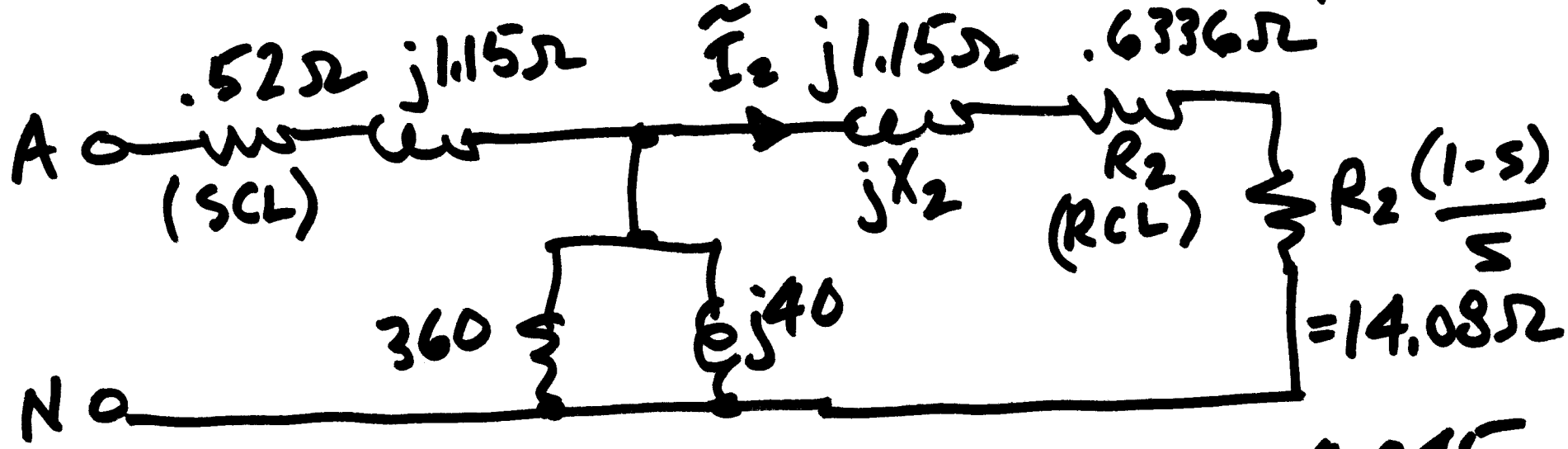
$$P_{DEV} = 3I_2^2R_2\frac{(1-s)}{s}$$

$$P_{AG} = RCL + P_{DEV}$$

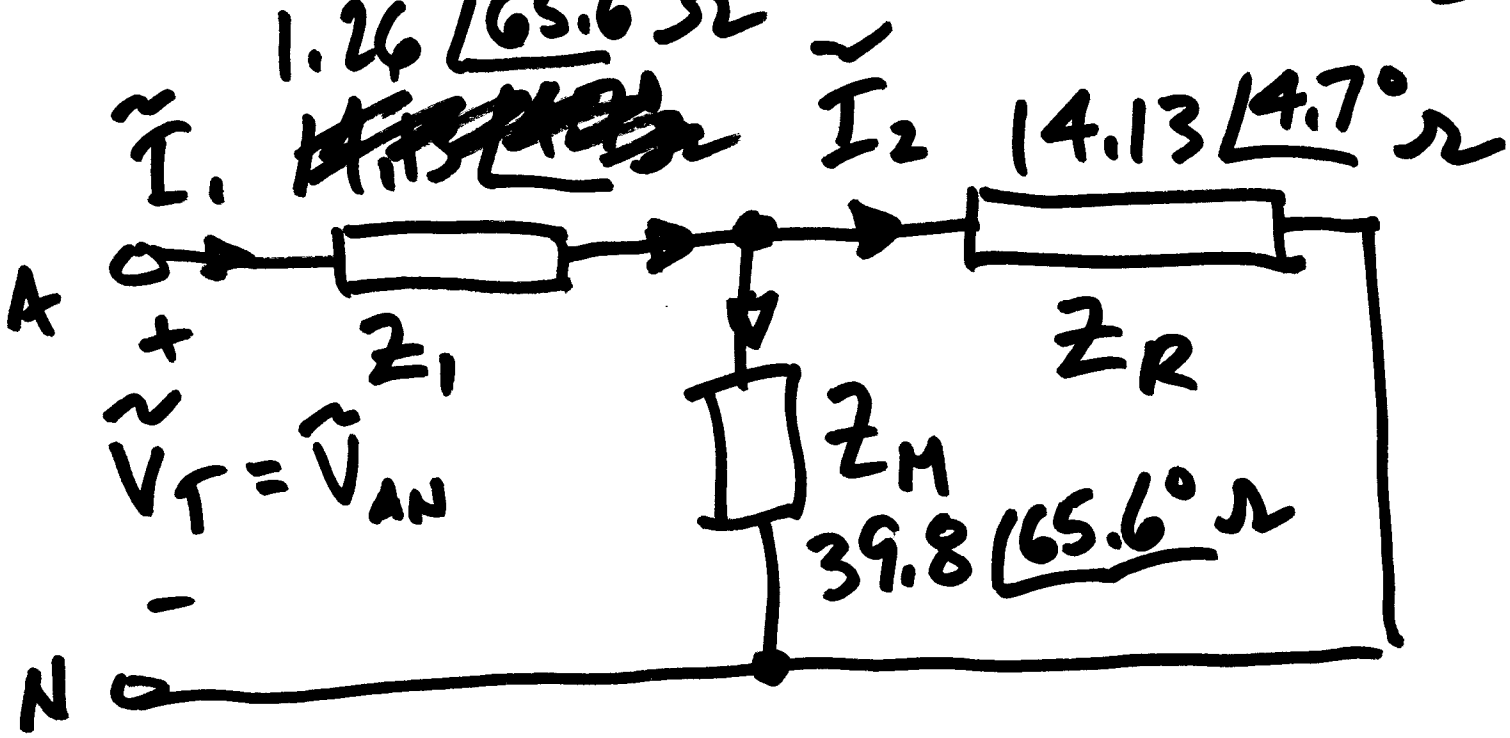
$$\frac{P_{DEV}}{RCL} = \frac{(1-s)}{s}$$

$$P_{AG} = RCL + P_{DEV}$$

15-HP 440V 3ϕ 60 Hz 8-pole



$s = \underline{0.045}$



$$\tilde{I}_1 = \frac{\tilde{V}_T \leftarrow \frac{440}{\sqrt{3}} \angle 0^\circ}{\bar{Z}_1 + \left(\frac{\bar{Z}_M \bar{Z}_R}{\bar{Z}_M + \bar{Z}_R}\right)} = \underline{\underline{18.85 \angle -26.4^\circ A}}$$

ϕ

$PF = \cos(+26.4^\circ)$

$= \underline{\underline{.895 \text{ Lag}}}$

Θ

$$\tilde{I}_2 = \tilde{I}_1 \left(\frac{\bar{Z}_M}{\bar{Z}_M + \bar{Z}_R}\right) = \underline{\underline{16.75 \angle -8.35^\circ A}}$$

$$P_{conv} = P_{dev} = P_{EM}$$

$$= 3\left[I_2^2 R_2 \left(\frac{1-s}{s}\right)\right]$$

$$= 3(16.75)^2(14.08) = \underline{11,300\,W}$$

Think: $(15\,HP \times 746\,W/HP) = 11,190\,W$

$$P_M = P_{conv} - P_{FW} - P_{stray}$$

$$= 11,300 - 220W - 120W = \underline{10,960W}$$

$$\eta = \frac{P_{OUT}}{P_{IN}} = \frac{10{,}960}{\sqrt{3}(440)(18.85)(.895)}$$

$$= 0.851 \Rightarrow \underline{85.1\%}$$

Torque: $T_M = \frac{P_M}{\omega}$

$P = T\omega$

$n_r = n_s(1-s)$

$= 859.5$

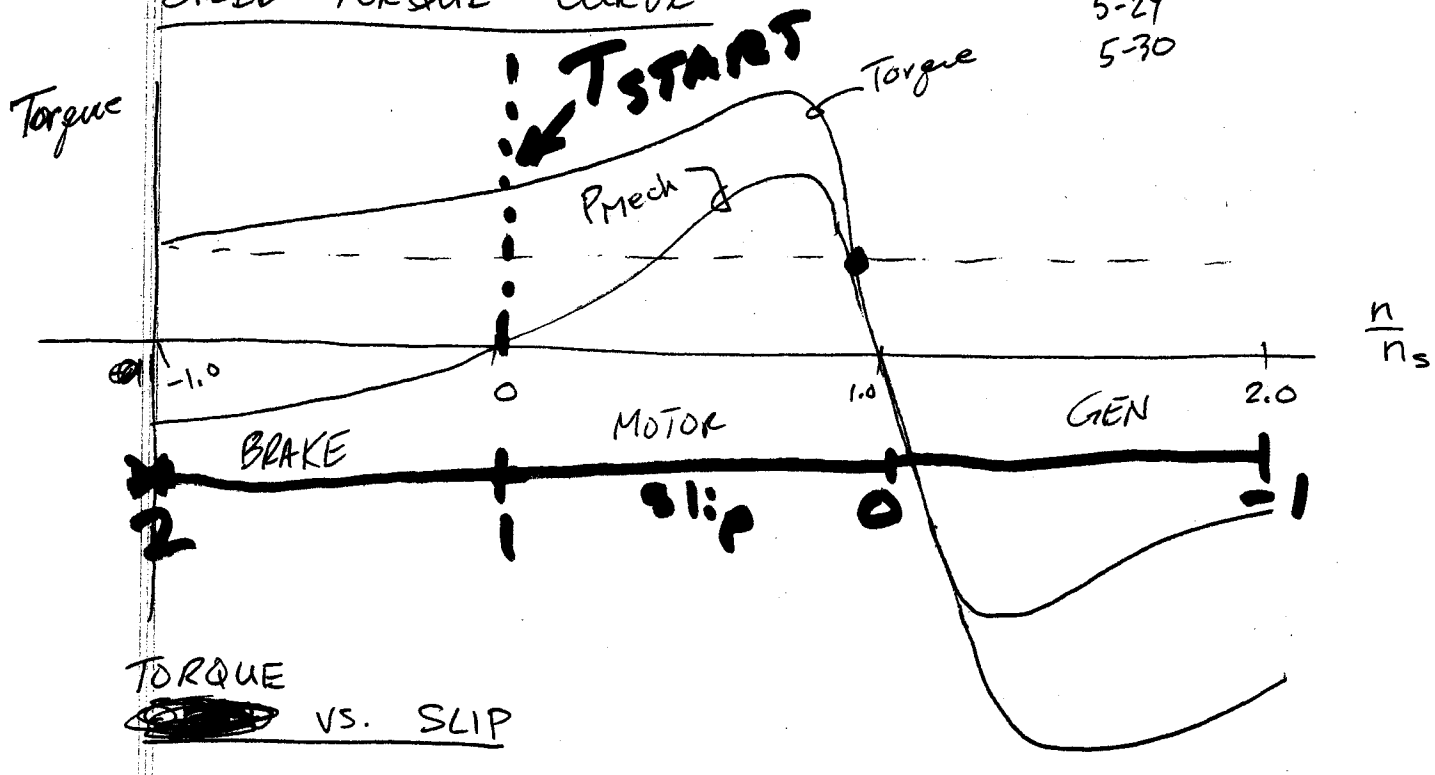
$$= \frac{10{,}960\,W}{859.5\left(\frac{2\pi}{60}\right)}$$

$= 121.8$ N-m

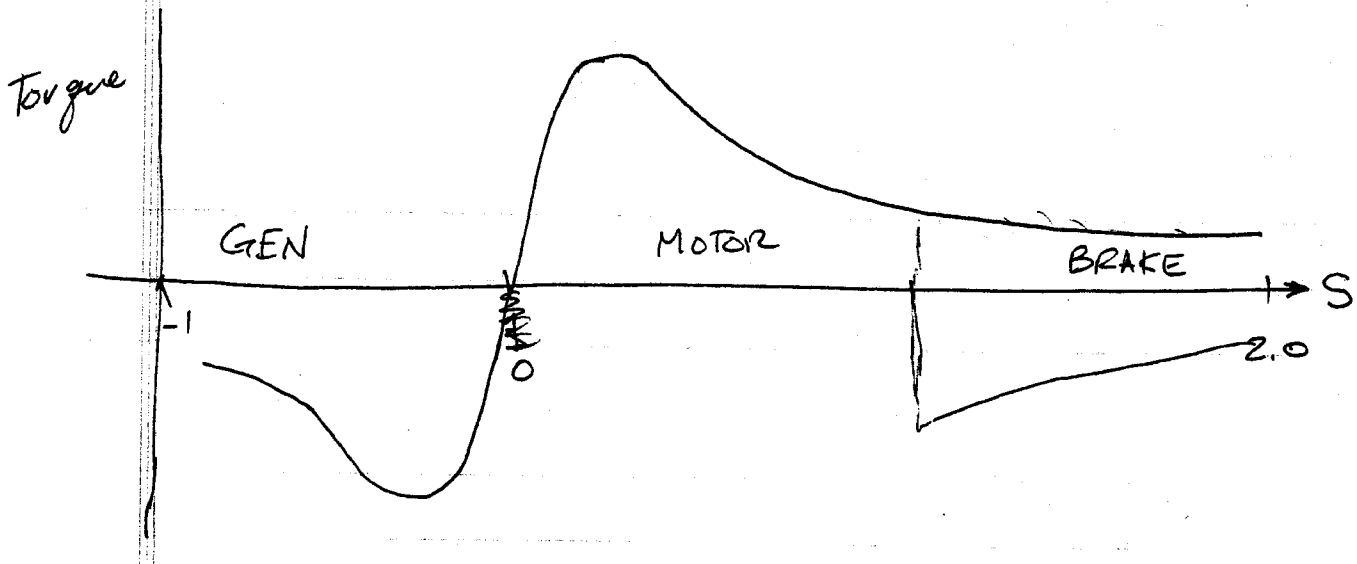
$\times (3.28\,ft/m)\left(\frac{2.2}{9.8}\right) = \underline{89.7\,ft\text{-}lb}$

Probs: 5-26 ~ 5-27
5-29
5-30

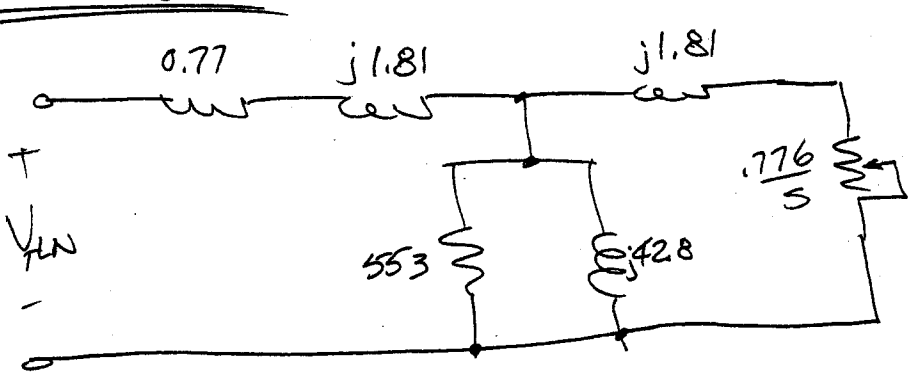
SPEED - TORQUE CURVE



TORQUE vs. SLIP



EQUIN CKT

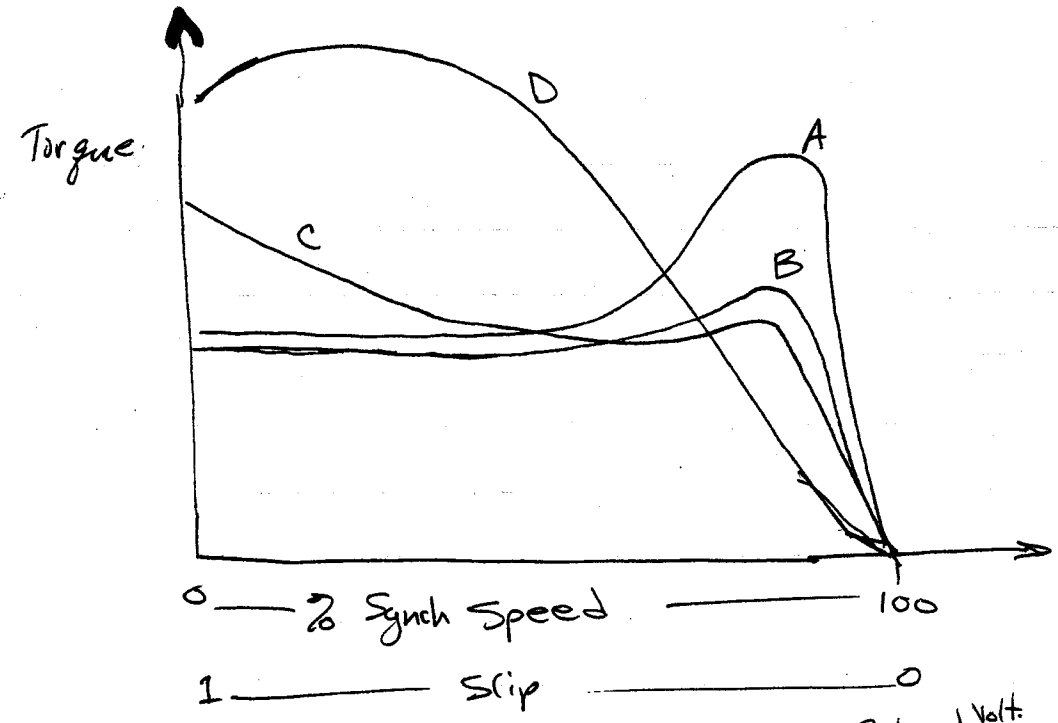


IEEE Test Code 112A
Read on Page 272

MOTOR CLASSES

increase in R_2 ↓ Same

Class A	$X_1 = X_2' = X_L/2$
B	$X_1 = 0.4\ X_L$; $X_2' = 0.6\ X_L$
C	$X_1 = 0.3\ X_L$; $X_2' = 0.7\ X_L$
D	$X_1 = 0.5\ X_L = X_2$



Reduced Volt. starting:

machine tools, fans, blowers, pumps — (A - Standard below 7.5 Hp and above 200 HP. (Low slip) Full voltage starting can draw alot of current. (7.5-200 Hp)

(B - Normal starting torque, Low I_{START}, Low slip

Compressors Conveyors — C - High Starting torque, low I_{START}. (Double Cage Rotor)

intermtt loads (Elevator) — D - High Starting torque, high slip. 7-11% @ full load.

INDUCTION MOTOR STARTING CURRENT

THREE METHODS:

1. EXACT MODEL – set $s = 1$ (locked rotor) and solve for I_{START} $(\tilde{I}_1)$

2. RULE OF THUMB –

$$I_{START} = I_{RATED} \times P.F. \times 6$$

3. NEC Section 430-7(b) MOTOR CODE LETTERS

Code Letter	Kilovolt-Amperes per Horsepower with Locked Rotor
A	0 — 3.14
B	3.15 — 3.54
C	3.55 — 3.99
D	4.0 — 4.49
E	4.5 — 4.99
F	5.0 — 5.59
G	5.6 — 6.29
H	6.3 — 7.09
J	7.1 — 7.99
K	8.0 — 8.99
L	9.0 — 9.99
M	10.0 — 11.19
N	11.2 — 12.49
P	12.5 — 13.99
R	14.0 — 15.99
S	16.0 — 17.99
T	18.0 — 19.99
U	20.0 — 22.39
V	22.4 — and up

EXAMPLE: 10 HP 240V, 3Ø IND MOTOR, CODE D

$$I_{START} = \frac{\left(4.49 \frac{KVA}{HP}\right) \times (10\ HP)}{\sqrt{3} \times .24\ KV}$$

$$= \boxed{108\ AMPS}$$