ECE 370 POWER & ENERGY SYSTEMS
Induction motor equivalent circuit model

The objective of the pre-lab for Lab # 7 is to develop a computer program that will calculate the **"exact"** equivalent circuit for a 3ϕ induction motor. The input data consists of the following:

- The horsepower rating.
- The rated speed and number of poles.
- The voltage rating.
- The results of the no-load and locked-rotor tests.
- The dc resistance of the stator winding.
- The rotational losses and the speed at which they were measured.

The program must output the following information:

- The ***exact equivalent circuit parameters*** and the following graphs as speed goes from zero to 120% of n_s.
- Output torque vs. speed.
- Efficiency vs. speed.
- Input current magnitude vs. speed.
- Input power factor vs. speed.
- Input real power (W or kW) vs. speed.
- Input reactive power (VAR or kVAR) vs. speed.
- Output power (hp) vs. speed.

Use the foregoing to determine the rated values of the graphed quantities.

The programming language is your choice. The following is a sample case that can be used to test your program (it produces the same equivalent circuit as Examples 7.5 & 7.6, so you can check one data point on each graph).

Nameplate data: 550 V, 15 hp, 4 pole, 1746 rpm, 60 Hz.
No-load test: 550 V, 5.8 A, 754 W.
Locked-rotor test: 123 V, 25.0 A, 2419 W. (Performed @ 60 Hz, not 15 Hz)
dc resistance: 30 V, 25.0 A.
Rotational losses: 1.794 Nm @ 1746 rpm (assume these are proportional to speed^2)

The program should be an extension of the one written for lab # 4, the input has to be modified to take the extra data and care must be taken to allow for the 3ϕ nature of the motor, but the equivalent circuit parameters will be similar to those of the transformer.

Note that the Yokagawa meter will give you 1ϕ voltage (no need to divide by $\sqrt{3}$) but total 3ϕ power (need to divide by 3). Take care how you enter this into your program.

Once these parameters have been determined, increment speed from zero to 120% of n_s (you may want to subtract a tiny value from n_s to avoid divide by zero).

Then calculate the corresponding slip for each speed and the rotational losses. Determine the load resistance, input impedance, input current, rotor current, and hence developed power. The other required quantities can be derived from these using the following expressions.

$s = \frac{n_s - n_m}{n_s}$ $R_L^{'} = \frac{R_2^{'}}{s}(1 - s)$ $Z_{in} = (R_1 + jX_1) + R_c // jX_m // (R_2 + R'_L + jX_2)$

$I_1 = \frac{V_1 \angle 0}{Z_{in}}$ Use this to produce the $|I_1|$ and pf vectors

$P_{in} = \sqrt{3} \times V_L \times |I_1| \times pf$ or $P_{in} = \mathrm{Re}\{3 \times \boldsymbol{V_1} \times \boldsymbol{I^*_1}\}$

$E_1 = V_1\underline{/0} - (R_1 + jX_1) \times \boldsymbol{I_1}$

$$I_2^{'} = \frac{E_1}{R_2 + R_L + jX_2}$$

$P_D = 3 \times |I_2|^2 \times R'_L$

$$P_{rot} = P_{rot\text{-}test}\left(\frac{n_m}{n_{rot-test}}\right)^2$$

$P_{out} = P_D - P_{rot}$

$\eta = \frac{P_{out}}{P_{in}}$ when $n_m < n_s$, but $\eta = \frac{P_{in}}{P_{out}}$ when $n_m > n_s$

$T_D = \frac{P_{out}}{\omega_m}$ (Get ω_m from n_m)

Plot the 7 required graphs. Make each one at least half a page (a full page is even better.)

Remember to output the equivalent circuit parameters.