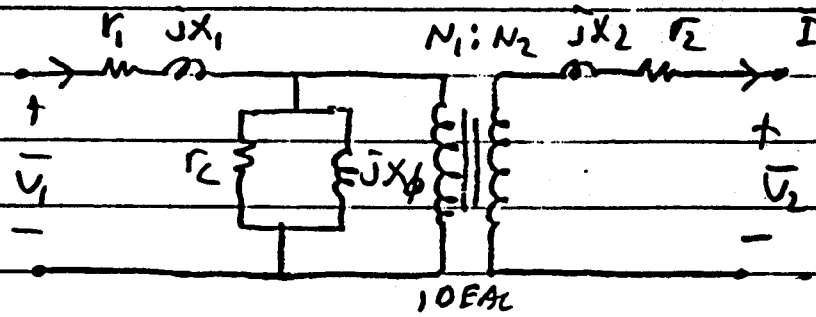
FINAL EXAM SPRING 1998

3 Hours, closed book, closed notes, open mind

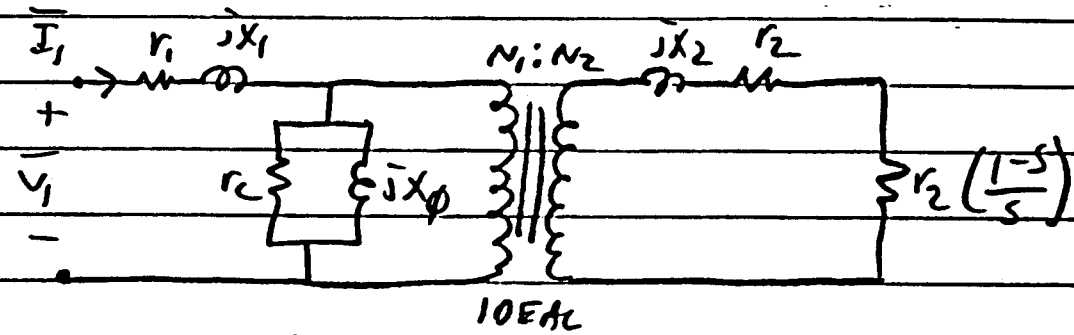
Given information:

$$P_{3\phi} = \sqrt{3}\, V_{LL} I_L \cos\phi$$

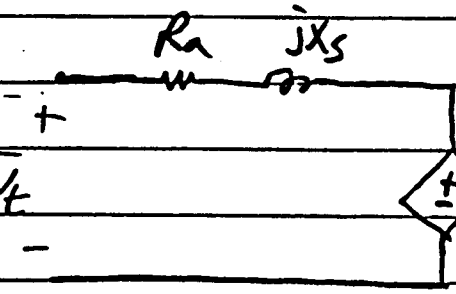
Transformer

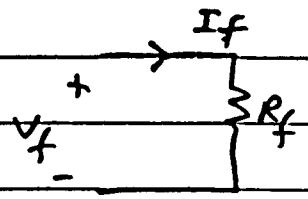



Induction




Synchronous

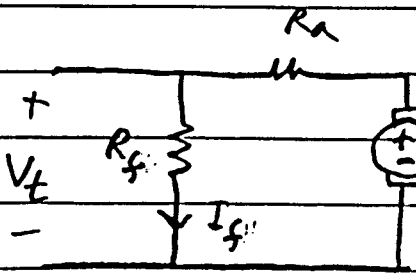



$$P_{IN,3\phi} = \frac{3|V_t||E_f|}{X_S}\sin(-\delta_t)$$

$$Q_{IN,3\phi} = \frac{3|V_t|^2}{X_S} - \frac{3|V_t||E_f|}{X_S}\cos(-\delta_t)$$

DC (shunt)




$$T = \frac{P}{\omega}$$

**Problem #1**
**30 points**

A balanced 3ϕ, 3 wire source is serving a balanced 3ϕ, 3 wire load. A wattmeter with its voltage coil measuring $\bar{V}_{AB}$ and its current coil measuring $\bar{I}_c$ (into the load) reads 1200 Watts. A voltmeter reads 208 V (l-l) and an ammeter reads 10 Amps. What is the power factor of the balanced load? Assume ABC seq.

**Problem #2**
**40 points**

3-50 KVA transformers are each rated at 12,470V/240V. They are connected in a ΔY, with the Δ primary connected to 12,470 V (l-l).

(a) What is the secondary line to line voltage?

(b) If the secondary is loaded with 4 Ω connected between each line (in Δ connection), what % loaded is each transformer?

(c) What is the primary line current in (b)?

(d) What is the voltage across each 4 Ω resistor if one transformer is removed?

**Problem #3**
**30 points**

A 3ϕ, 60Hz, 4pole, 480v (l-l) induction motor is loaded such that it draws 8 Amps line current and 4,000 watts (3ϕ).

(a) Assuming that the real-power load remains constant, compute the value of capacitance in μF needed to be connected between each line (Δ connection) to reduce the line current to a minimum.

(b) What is the line current minimum?

**Problem #4**
**30 points**

A 3ϕ, 2pole, 60Hz Synchronous motor is running with a load of 10,000 watts (3ϕ). When it is loaded to 15,000 watts (3ϕ), the torque angle changes by 20° mechanical.

(a) What is the initial torque angle?

(b) What is the maximum possible 3ϕ power that this machine can deliver?

**Problem #5**
**30 points**

A Shunt DC motor has the following parameters: $R_a = 5\,\Omega$, $K_f^{SH} = 1.2\ \Omega\ \text{sec/rev.}$, $R_f = 150\,\Omega$

(a) How much resistance should be added in series with a 230 V source to limit the terminal current to 8 Amps at startup?

(b) What is the starting torque with this R inserted?

**Problem #6**
**40 points**

A 3ϕ, 6 pole, 60 Hz, 120 V (l-n) induction motor is driving a Shunt DC generator. All you know is that a blocked-rotor test on the induction motor gives $R_2' = 2\,\Omega$.

NOTE: You may assume $r_1 = X_1 = X_2 = 0$, $r_c = \infty$ for the motor and $R_a = 0$ for the gen.

The DC generator $R_f$ is adjusted automatically to maintain 240 V terminal voltage at all loads and speeds. It is 200 Ω at no load with 1200 RPM.

The DC generator is loaded and the speed drops to 1100 RPM

(a) Estimate the real power into the induction motor.
(b) Estimate the real power out of the induction motor.
(c) Estimate the real power out of the DC generator.