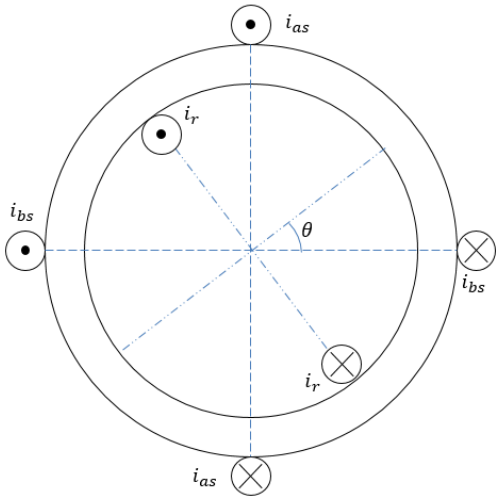
ECE 330 HW #11

In class quiz – Thursday Apr 12.
Copies of the textbook are kept at the Grainger Engineering Library Reserve

Problem 1:
The rotational electromechanical system shown below has two sets of stator windings (as, bs) and one set of rotor windings (r).



When the rotor's angular position is given by θ as indicated, the flux linkages of the windings are given by:

$$\lambda_{as} = L_s i_{as} + M\cos(\theta)\, i_r,$$
$$\lambda_{bs} = L_s i_{bs} + M\sin(\theta)\, i_r,$$
$$\lambda_r = M\cos(\theta)\, i_{as} + M\sin(\theta)\, i_{bs} + L_r i_r,$$

where i denotes the current into the respective windings, and L_{as}, L_{bs}, L_r, M are positive constants.

a) Compute $W'_m(i_{as}, i_{bs}, i_r, \theta)$ and $T^e(i_{as}, i_{bs}, i_r, \theta)$.
(**Partial Answer**: $T^e(i_{as}, i_{bs}, i_r, \theta) = -M\sin(\theta)\, i_{as} i_r + M\cos(\theta)\, i_{bs} i_r$.)

b) Suppose the stator currents are sinusoidal functions of time, given by $i_{as} = I_s\cos(\omega_s t)$ and $i_{bs} = I_s \sin(\omega_s t)$. The rotor current is given by $i_r = I_r$, and the angular position varies as $\theta = \omega_m t + \gamma$. In these relations, I_s, I_r, γ are constants. Find the so-called *frequency condition* on ω_s and ω_m so that the average value of $T^e(i_{as}, i_{bs}, i_r, \theta)$ is non-zero. (**Answer**: $\omega_s = \omega_m$)

c) Assume that the rotor experiences two different torques - one from a mechanical governor and another of electrical origin (T^e). What is the average mechanical power input from this governor, if the machine is operated in steady-state and it satisfies the frequency condition you derived in part (b)?
(**Answer**: $MI_sI_r\,\omega_m\sin(\gamma)$)