ECE 4620/5620 [Q_2; SP 2013]; NO:

Name:

Prob 1: Consider the power system shown below.

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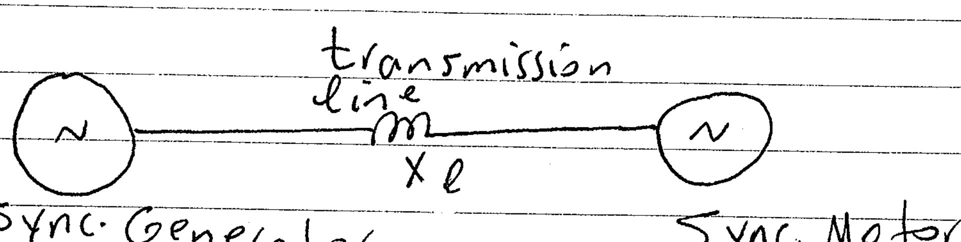

The ratings of the components are:

Generator	Motor	line
100 MVA,	100 MVA	20 kV
20 kV	20 kV	$X_\ell = 0.2^{\text{p.u.}}$
$X'_d = 0.25^{\text{p.u.}}$	$X'_d = 0.25$	

Where the line impedance in p.u. is given assuming $S_B = 100$ MVA, $V_B = 20$ kV.
The motor is taking 100 MVA at 20^{kV} with power factor 1.
Assume a 3-phase short circuit fault at the motor terminal.
Find the transient currents for both the generator and the motor.

Prob 2: In prob 1, assume the motor is not receiving any power. For the same fault find both subtransient and transient currents of the motor and the generator assuming $X''_d = 0.1^{\text{p.u.}}$ for both machines.

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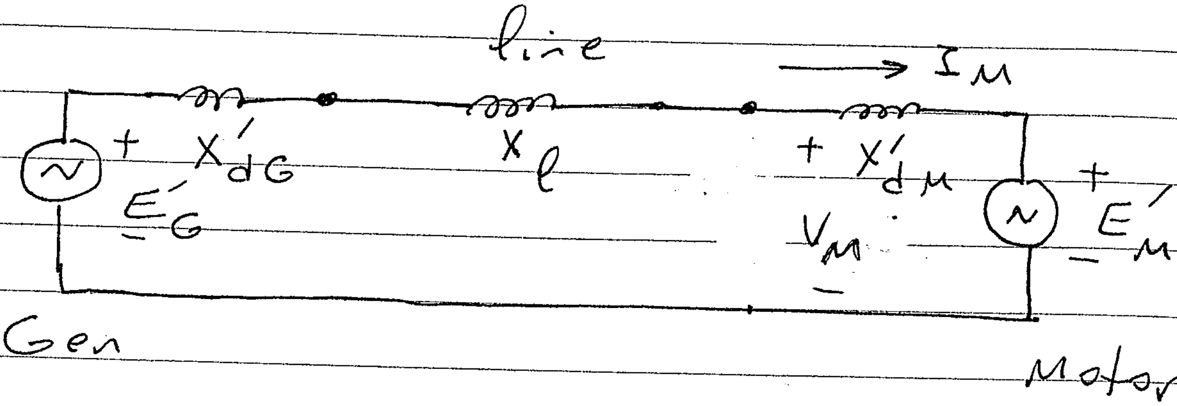
Prob 1.



Given the base power and base voltage for all equipments are the same as their ratings and are equal, the p.u.-values for the reactances need not be recalculated.

Before Fault:

$$\begin{cases} S_M = 100\,MVA\ ;\ pf = 1 \\ V_M = 20^{kV} \end{cases}$$

Or,

$$\begin{cases} S_M = \dfrac{100^{MVA}}{S_B} = \dfrac{100}{100} = 1^{p.u.} \\ V_M = \dfrac{20^{kV}}{V_B} = \dfrac{20^{kV}}{20\,kV} = 1\ p.u. \end{cases}$$

$$\Longrightarrow$$

$$I_M = \left(\frac{S_M}{V_M}\right) \angle -\cos^{-1}(pf)$$

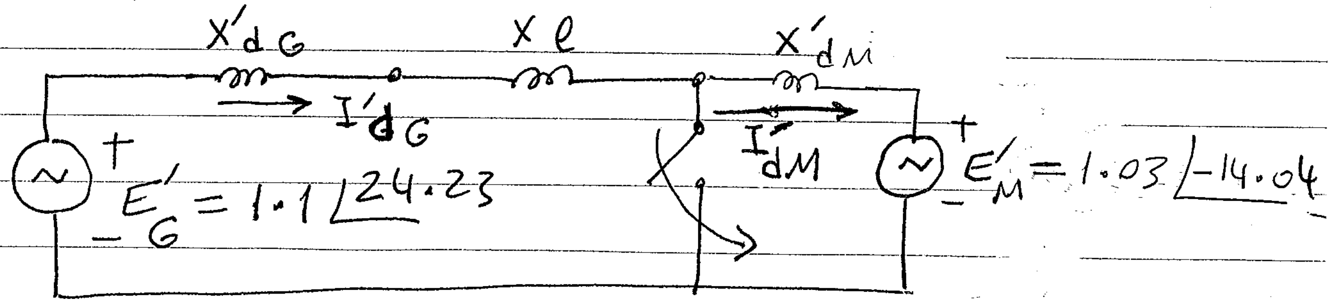
$$= \frac{1}{1} \angle -\cos^{-1}(1) = 1 \angle 0\ p.u.$$

Now, using this prefault current we find E'_M and E'_G as follows:

$$E'_M = V_M - jX'_{dM} \cdot I_M$$
$$= 1 - j(0.25)(1) = 1 - j0.25$$
$$= 1.03 \angle -14.04$$

$$E'_G = j(X'_{dG} + X_\ell) I_M + V_M$$
$$= j(0.25 + 0.2)(1) + 1$$
$$= 1 + j0.45 = 1.1 \angle 24.23$$

During transient period of the fault:



$$I'_{dG} = \frac{+E'_G}{j(X'_{dG} + X_\ell)}$$; from the left loop

$$= \frac{+1.1 \angle 24.23}{j(0.25 + 0.2)} = \frac{1.1 \angle 24.23}{0.45 \angle 90} = 2.44 \angle -65.77^\circ$$

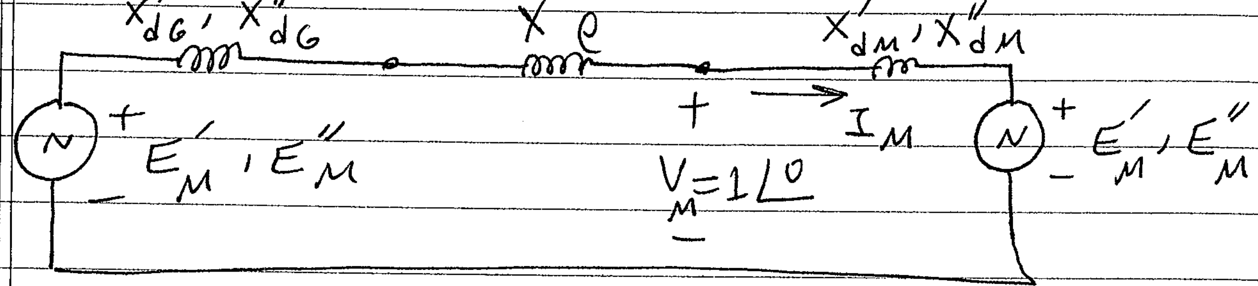
$$I'_{dM} = \frac{-E'_M}{jX'_{dM}}$$; from the right loop. Note the direction of the motor current has changed.

$$= \frac{-1.03 \angle -14.04}{j0.25} = -4.12 \angle -114.04$$

note motor current during the fault is a lot larger than the generator current since it is closer to fault

Prob 2

Before fault: we have $I_M = 0$ since the motor is not receiving any power:



Given $V_M = 1\angle 0$ and $I_M = 0$, the voltage at all points must be the same as V_M; or,

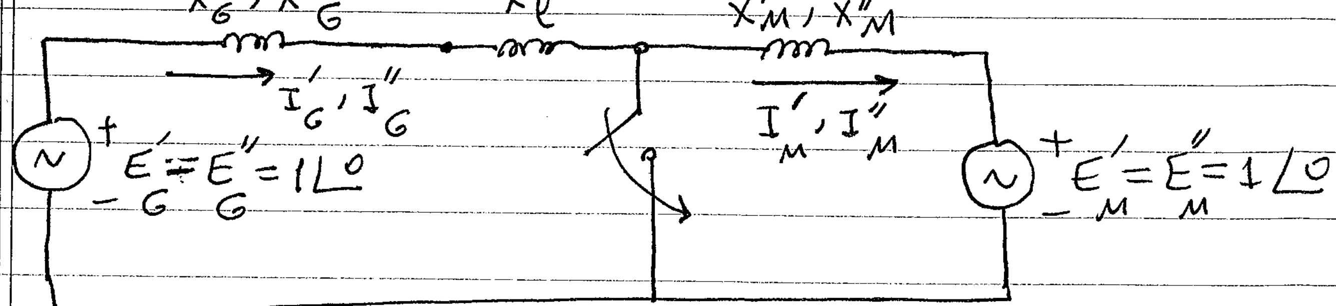
$$\rightarrow E'_M = V_M - j(X'_{dM})\underbrace{I_M}_{=0} = V_M = 1\angle 0$$

$$\rightarrow E''_M = V_M - j(X''_{dM})I_M = \cdots = 1\angle 0$$

$$\rightarrow E'_G = V_M + j(X_\ell + X'_{dG})I_M = \cdots = 1\angle 0$$

$$\rightarrow E'_G = V_M + j(X_\ell + X''_{dG})I_M = \cdots = 1\angle 0$$

During the transient and subtransient periods of the fault we have:



$$I'_G = \frac{E'_G}{j(X'_G + X_\ell)} = \frac{1\angle 0}{j(0.25+0.2)}$$

$$= \frac{1\angle 0}{j\,0.45} = -j\,2.22 \text{ p.u.}$$

$$I''_G = \frac{E''_G}{j(X''_G + X_\ell)} \;; \quad X''_G = X''_d = 0.1 \text{ was given}$$

$$= \frac{1\angle 0}{j(0.1+0.2)}$$

$$= \frac{1\angle 0}{j\,0.3} = -j\,3.33 \text{ p.u.}$$

$$I'_M = \frac{-E'_M}{j\,X'_M} = \frac{-1\angle 0}{j\,0.25} = j\,4 \text{ p.u.}$$

$$I''_M = \frac{-E''_M}{j\,X''_M} \;; \quad X''_M = X''_d = 0.1 \text{ ; was given}$$

$$= \frac{-1\angle 0}{j(0.1)}$$

$$= j10 \text{ ; p.u.}$$