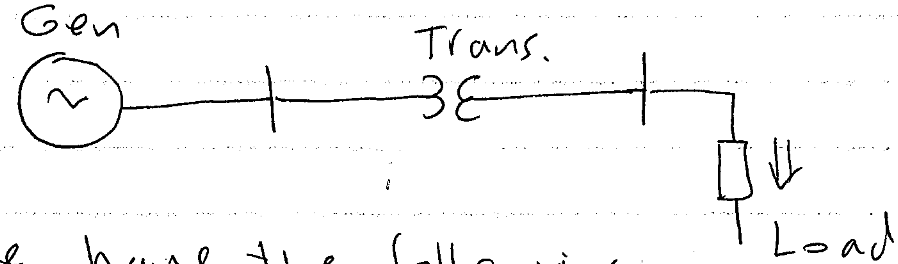
ECE 4620/5620 [$\bar{Q}_2$; SP 2013]; NO: Name:

Prob 1: Consider the power system shown below:



We have the following parameters and ratings:

Gen: $X_d = 1.0^{p.u.}$, $X'_d = 0.25^{p.u.}$, $X''_d = 0.12^{p.u.}$

100-MVA, 13.8 KV, 60 HZ

Transformer: $13.8^{KV}/220^{KV}$, 100 MVA; $X_T = 0.2^{p.u.}$

Load: 220^{KV}, 100^{MVA}, pf = 0.8 (lag)

The generator delivers 90^{MVA} at 220^{KV} to the load.

Suddenly a 3-phase short circuit fault occurs at the generator terminal.

Find the generator current during:

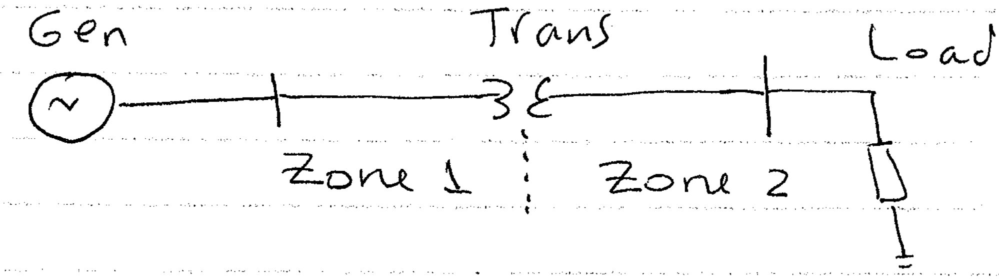
a) subtransient (I''_d)

b) transient (I'_d)

c) long after transient period (I_d)

ECE 4620/5620 [$\bar{Q}_2$; SP 2013] Key

Prob 1



- Let's choose the system-wide base values as:

$$S_B = 100^{MVA}, \quad V_{B_1} = 13.8^{kV}; \text{ for Zone 1}$$

With these base values the p.u. values of the reactances will not change.

Now, the base value in zone 2 is found as:

$$V_{B2} = \frac{220}{13.8} V_{B_1} = \frac{220}{13.8} \times 13.8 = 220^{kV}$$

- Now, the load is located in Zone 2, Then:

$V_L \triangleq$ the load voltage

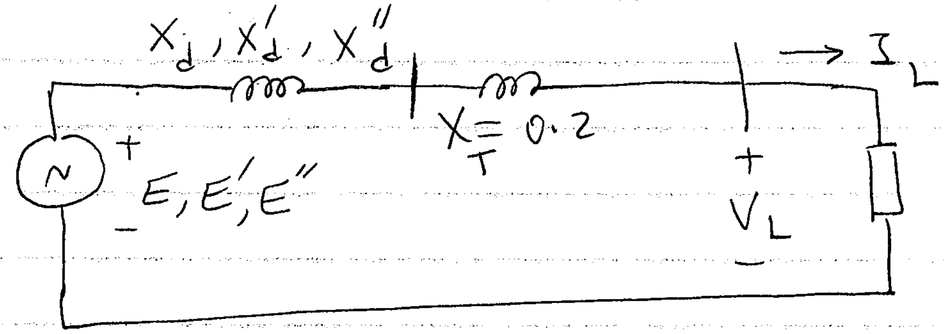
$$= 220^{kV} = \frac{220^{kV}}{V_{B2}} = \frac{220^{kV}}{220} = 1^{p.u.}$$

- Choosing V_L as the reference voltage:

$$V_L = 1 \angle 0$$

$$S_L = 90^{MVA} \angle \cos^{-1}(pf) = \frac{90}{100} \angle \cos^{-1}(0.8)$$
$$= 0.9 \angle 36.87^\circ; \text{ in p.u.}$$

Prior to the fault we have:



$$S_L = V_L I_L^* \Rightarrow I_L^* = \frac{S_L}{V_L}$$

$$\Rightarrow I_L = \frac{S_L^*}{V_L^*} = \frac{0.9 \angle -36.87}{1 \angle 0} = 0.9 \angle -36.87^\circ$$

Now,

$$\gg E = (jX_d + jX_T) I_L + V_L$$

$$= (j1 + j0.2)(0.9 \angle -36.87^\circ) + 1$$

$$= 1.08 \angle 53.13 + 1 = 0.65 + j0.86 + 1$$

$$= 1.65 + j0.86 = 1.86 \angle 27.53^\circ$$

$$\gg E' = (jX_d' + jX_T) I_L + V_L$$

$$= (j0.25 + j0.2)(0.9 \angle -36.87^\circ) + 1$$

$$= 0.41 \angle 53.13 + 1 = 0.25 + j0.33 + 1$$

$$= 1.25 + j0.33 = 1.29 \angle 14.79^\circ$$

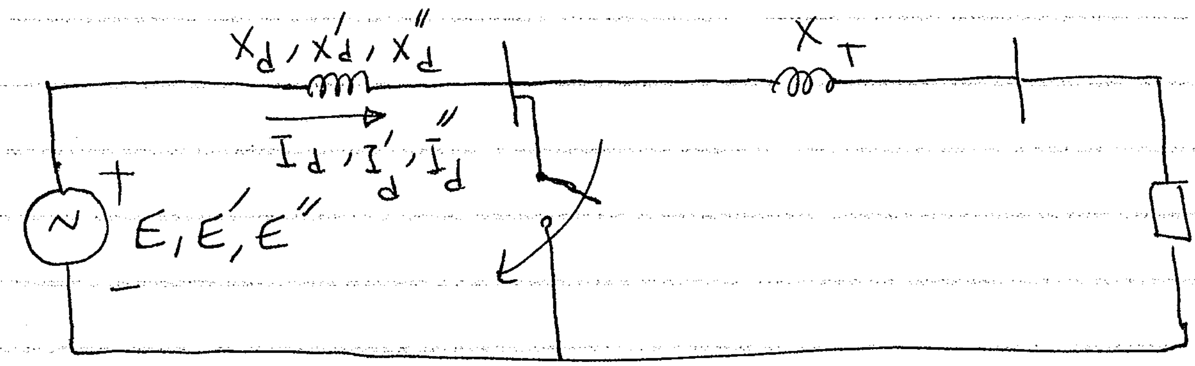
$$\Rightarrow E'' = (jX''_d + jX_T)\, I_L + V_L$$

$$= (j\,0.12 + j\,0.2)(0.9\angle -36.87^\circ) + 1$$

$$= 0.29\angle 53.13 + 1 = 0.17 + j\,0.23 + 1$$

$$= 1.17 + j\,0.23 = 1.19\angle 11.12^\circ$$

- During fault the circuit becomes:



a) $$I''_d = \frac{E''}{jX''_d} = \frac{1.19\angle 11.12^\circ}{j\,0.12} = 9.92\angle -78.88^\circ$$

b) $$I'_d = \frac{E'}{jX'_d} = \frac{1.29\angle 14.79^\circ}{j\,0.25} = 5.16\angle -75.21^\circ$$

c) $$I_d = \frac{E}{jX_d} = \frac{1.86\angle 27.53^\circ}{j\,1} = 1.86\angle -62.47^\circ$$