EECE 471 Final Exam Summer 2010

August 10, 2010.

1. As Problem 1 in FE of February 3, 2009.

2. As Problem 2 in FE of February 3, 2009.

3.

a) Base impedances at

* Node 1: $Z_{B1} = 20^2/100 = 4\,\Omega$
* Node 2 and 3: $Z_{B2} = \frac{220^2}{100} = 484\,\Omega$
* Node 4: $Z_{B4} = \frac{66^2}{100} = 43.56\,\Omega$

$$X'_{d1} = 0.32 \times \frac{100}{250} = 0.128 \text{ p.u.}$$

$$X_{line} = \frac{60}{484} = 0.124 \text{ p.u.}$$

$$X_{T1} = 0.12 \times \frac{100}{250} = 0.048 \; (= X_{T2})$$

$$X_{T3} = 0.12 \times \frac{100}{125} = 0.096$$

$$X'_{d2} = 0.2 \times \frac{100}{120} = 0.167$$

Total reactance of generator 2 connected to node 4:

$$X_{g2} = X_{T3} + X'_{d2} = 0.263$$

$$Z_{load} = \frac{66^2}{10(3+j1.2)} = 12.5 - j5 \Rightarrow Y = 0.069 + j0.0275$$

Admittance Matrix for fault Calculations:

	1	2	3	4
1	$-j28.65$	$j20.83$	0	0
2	$j20.83$	$-j36.96$	$j16.13$	0
3	0	$j16.13$	$-j36.96$	$j20.83$
4	0	0	$j20.83$	$-j24.64$

b)

Z_{kk} is the Thevenin impedance of the positive sequence circuit seen between node k and ground. If the prefault voltage is V_{Fk} then the fault current in per unit is given by:

$$I_{Fk} = \frac{V_{Fk}}{Z_{kk}}$$

Fault Currents in per unit and in kA assuming the prefault voltage is 1.0 per unit:

Node	Fault Current (mVA)	Fault Current (kA)
1	965	27.9
2	770	2.02
3	682	1.79
4	687	6.01

c)

$$V_{Fn} - Z_{nk} I_{Fk} = E_n$$

but $$I_{Fk} = \frac{V_{Fk}}{Z_{kk}}$$

Thus $$E_n = V_{Fn} - \frac{Z_{nk}}{Z_{kk}} V_{Fk}$$

With $V_{Fk} \sim V_{Fn} = 1.0$ p.u

$$E_n = \left(1 - \frac{Z_{nk}}{Z_{kk}}\right)$$

So for a fault at node 2:

$$E_1 = 1 - \frac{j0.0944}{j0.1298} = 0.273 \text{ p.u}$$

$$E_2 = 0$$

$$E_3 = 1 - \frac{j0.1105}{j0.1298} = 0.149 \text{ p.u}$$

Fault current from generators:

$$I_{G1} = \frac{E_1 - E_2}{jX_{T1}} = \frac{0.273}{j0.048} = -j5.68 \text{ p.u.}$$

$$I_{G2} = \frac{E_3 - E_2}{jX_{L/2}} = \frac{0.149}{j\left(\frac{0.124}{2}\right)} = -j2.40 \text{ p.u.}$$

$$I_{F2} = I_{G1} + I_{G2} = -j8.09$$

d)

The circuit breaker of generator 1 should be picked up from Table I as GB2 with the following minimum ratings:

Nominal kV: >20kV
Rated Current (A): > 7220 A
Breaking Current (kA): > 28kA

CB on generator 2 should also be a GB2 class with following minimum ratings:

Nominal (kV): > 15kV
Rated Current (A): > 4800 A
Breaking Current (kA): > 33 kA

CB at the 220k voltage, should be of type EHV2:

Nominal kV: 230 kV
Rated Current: 1600A (> 656 A)
Breaking Current: 31 kA (> 2.02 kA).

CB at the 66kV voltage (at load) should be UV4 for each feeder:

Rated Current A: 1200A (> 87A)
Breaking Current kA: 19 kA (> 6)