

Homework 8 Solutions

- 7.6 (a) Neglecting the transformer winding resistance,

$$I'' = \frac{Eq}{X_d'' + X_{TR}} = \frac{1.0}{0.17 + 0.1} = \frac{1}{0.27} = 3.704 \text{ pu}$$

The base current on the HV side of the transformer is:

$$I_{base H} = \frac{S_{rated}}{\sqrt{3} V_{rated H}} = \frac{1000}{\sqrt{3} (345)} = 1.673 \text{ kA}$$

$$I'' = 3.704 \times 1.673 = 6.198 \text{ kA}$$

- (b) Using Eq (7.2.1) at $t = 3$ cycles = 0.05 S with the transformer reactance included,

$$\begin{aligned} I_{ac}(0.05) &= 1.0 \left[\left(\frac{1}{0.27} - \frac{1}{0.4} \right) e^{-0.05/0.05} + \left(\frac{1}{0.4} - \frac{1}{1.6} \right) e^{-0.05/1.0} + \frac{1}{1.6} \right] \\ &= 2.851 \text{ Pu} \end{aligned}$$

From Eq (7.2.5)

$$i_{dc}(t) = \sqrt{2} (3.704) e^{-t/0.1} = 5.238 e^{-t/0.1} \text{ pu}$$

The rms asymmetrical current that the breaker interrupts is

$$\begin{aligned} I_{rms}(0.05S) &= \sqrt{I_{ac}^2(0.05) + i_{dc}^2(0.05)} \\ &= \sqrt{(2.851)^2 + (5.238)^2 e^{-2(0.05)/0.1}} \\ &= 4.269 \text{ pu} = 4.269(1.673) = 7.144 \text{ kA} \end{aligned}$$

$$7.13 \quad (a) \quad X_{Th} = (0.20 + 0.24 + 0.40) // (0.20 + 0.10 + 0.17) // (0.20 + 0.1333 + 0.24)$$

$$X_{Th} = 0.84 // 0.47 // 0.5733 = \frac{1}{\frac{1}{0.84} + \frac{1}{0.47} + \frac{1}{0.5733}} = 0.1975 \text{ per unit}$$

$$(b) \quad \vec{I}_F = \frac{\vec{V}_F}{\vec{Z}_{Th}} = \frac{1.05 \angle 0^\circ}{j0.1975} = -j5.3155 \text{ per unit}$$

$$\vec{I}_F = (-j5.3155)(1.155) = -j6.1379 \text{ kA}$$

$$(c) \quad \vec{I}_{12} = \frac{1.05 \angle 0^\circ}{j0.84} = -j1.25 \text{ per unit} = (-j1.25)(1.155) = -j1.443 \text{ kA}$$

$$\vec{I}_{32} = \frac{1.05 \angle 0^\circ}{j0.47} = -j2.234 \text{ per unit} = (-j2.234)(1.155) = -j2.580 \text{ kA}$$

$$\vec{I}_{42} = \frac{1.05 \angle 0^\circ}{j0.5733} = -j1.8315 \text{ per unit} = (-j1.8315)(1.155) = -j2.115 \text{ kA}$$

$$7.19 \quad \vec{Y}_{BUS} = -j \begin{bmatrix} 6.5625 & -5 & 0 & 0 \\ -5 & 15 & -5 & -5 \\ 0 & -5 & 8.7037 & 0 \\ 0 & -5 & 0 & 7.6786 \end{bmatrix} \text{ per unit}$$

Using the personal computer subroutine

$$\vec{Z}_{bus} = j \begin{bmatrix} 0.2671 & 0.1505 & 0.0865 & 0.098 \\ 0.1505 & 0.1975 & 0.1135 & 0.1286 \\ 0.0865 & 0.1135 & 0.1801 & 0.0739 \\ 0.098 & 0.1286 & 0.0739 & 0.214 \end{bmatrix} \text{ per unit}$$

7.28 For a three phase fault at bus 16 (PETE69), the generators supply the following per unit fault currents: 14 (WEBER69) = 0.000 (off-line), 28 (JO345) G1 = 2.934, 28 (JO345), G2=2.934, 31 (SLACK345) = 5.127, 44 (LAUF69) = 3.123, 48 (BOB69) = 0.000 (off-line), 50 (ROGER69) = 1.987, 53 (BLT138) = 8.918, 54 (BLT69) = 8.958. During the fault a total of 27 of the 37 buses have voltages at or below 0.75 per unit (one bus has a voltage of 0.74994 so some students may round this to 0.75 and say 26 buses are BELOW 0.75).