ECE471 INDUSTRIAL POWER SYSTEMS
Homework Set 3

From chapter 6 of the course text, turn in problems 4 and 5.

6.4. Refer to Figure 6.2(a). The transformer is 1000 kVA, its impedance is 5.75%, the primary feeder impedance is 0.75%, and the secondary voltage is 480Y/277 V. Calculate the short-circuit current on the secondary of the transformer under three-phase bolted fault conditions.

$$Z_S = 0.0075 + 0.0575 = 0.0650 \text{ p.u.}$$

$$I_{SC} = \frac{1.0}{0.0650} = 15.38 \text{ p.u.}$$

$$I_S \text{ (of transformer)} = \frac{1000 \times 1000}{1.732 \times 480} = 1203 \text{ A}$$

$$I_{SC} = 1203 \times 15.38 = 18{,}500 \text{ A symm.}$$

6.5. Repeat Problem 4, except the transformer is 1500 kVA, its impedance is 5.0%, and the primary feeder impedance is 0.5%.

$$Z_S = 0.005 + 0.050 = 0.055 \text{ p.u.}$$

$$I_{SC} = \frac{1.0}{0.055} = 18.18 \text{ p.u.}$$

$$I_S \text{ (of transformer)} = \frac{1500 \times 1000}{1.732 \times 480} = 1804 \text{ A}$$

$$I_{SC} = 1804 \times 18.18 = 32{,}800 \text{ A symm.}$$

From chapter 16 of the course text, turn in problems 2 and 3.

16.2. Power is supplied over a primary feeder to a 13,800-208Y/120 V, 500 kVA unit substation. The impedance of the transformer is 5.0%. The utility system short-circuit capability is 150,000 kVA. Assume 50% of the load is motors. Calculate the available short-circuit current at the main secondary bus of the substation.

I_S (of transformer) $= \dfrac{500 \text{ X } 1000}{1.732 \text{ X } 208} = 1388$ A

$Z_U = \dfrac{500}{150{,}000} = 0.0033$ p.u.

$Z_{UT} = 0.050 + 0.0033 = 0.0533$ p.u.

$I_T = \dfrac{1.0}{0.0533} = 18.76$ p.u. $= 18.76 \text{ X } 1388 = 26{,}038$ A

Motor load is 50%; $\Sigma I_M = 4 \text{ X } (0.5 \text{ X } 1388) = 2776$ A

$I_{SC} = 26{,}038 + 2776 \approx 28{,}800$ A sym.

16.3. Repeat Problem 2, except the secondary voltage is 480Y/277 V and motor load is 100%.

I_S (of transformer) $= \dfrac{500 \text{ X } 1000}{1.732 \text{ X } 480} = 601$ A

From problem 2; Z_{UT} is 0.0533 p.u. and $I_T = 18.76$ p.u.

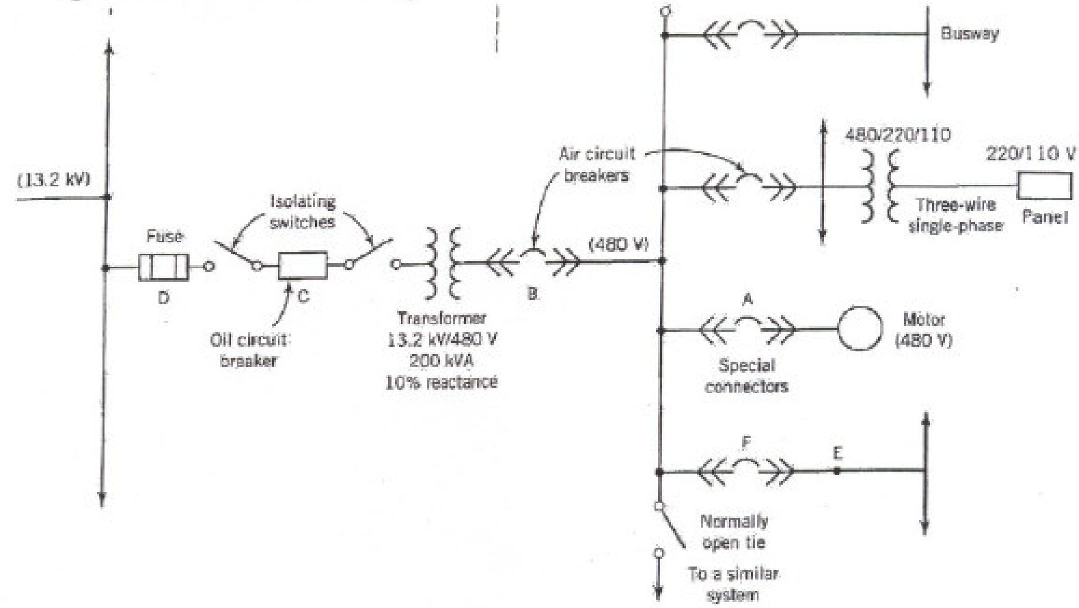
$I_T = 18.76 \text{ X } 601 = 11{,}275$ A

Motor load is 100%; $\Sigma I_M = 4 \text{ X } 601 = 2404$ A

$I_{SC} = 11{,}275 + 2404 \approx 13{,}700$ A sym.

Point out the much lower level of available fault current for the 480 volt system as compared to that in Problem 2 for the 208 volt system. This is another very important consideration in selecting the highest possible secondary voltage for distributing the power within a building.

The next problems refer to the following diagram, in which the four load groups on the right-hand side take respectively: 34 kVA @ 0.84 lag, 20 kVA @ 0.97 lag, 60 kVA (motor) @ 0.78 lag, and 38 kVA @ 0.89 lag.



1.
What is the current and power factor at the 13.2 kV supply?

Collect the loads together:

L1: $34\angle 32.9^\circ = 28.56 + j18.45$ kVA

L2: $20\angle 14^\circ = 19.40 + j4.86$ kVA

L3: $60\angle 38.7^\circ = 46.80 + j37.55$ kVA

L4: $38\angle 27.1^\circ = 33.82 + j17.33$ kVA

$128.58 + j78.18$ kVA $= 150.5\angle 31.3$

At the supply: $\tilde{I} = \left(\frac{S_\phi}{V_\phi}\right)^* = \dfrac{\frac{150.5\times10^3\angle -31.3}{3}}{\frac{13.2\times10^3\angle 0}{\sqrt{3}}}$

$\tilde{I} = 6.58\angle -31.3$ A

$pf = \cos(31.3) = 0.854$ lag

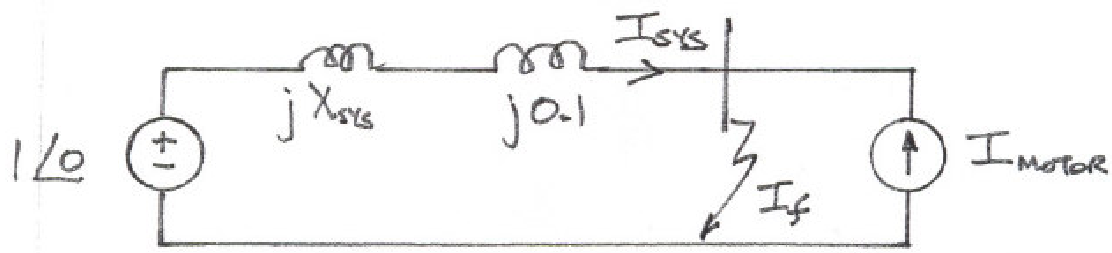
2.
What is the pu loading on the main 200 kVA transformer?

The base rating is 200 kVA and the load is 150.5 kVA

$$\therefore S_{pu} = \frac{150.5}{200} = \boxed{0.752 \text{ pu}}$$

3.
If the three-phase fault level at the 13.2 kV bus is 26.4 kA, what will be the fault level at the 480 V bus?

Only the motor and utility contribute to the fault, so the 1φ equivalent is:



On 13.2 kV side $I_{BP} = \frac{200\times10^3}{\sqrt{3}\times 13.2\times10^3} = 8.75\text{ A}$

$\therefore$ Fault level @ utility $= \frac{26.4\times10^3}{8.75} = 3018\text{ pu}$

$\therefore X_{SYS} = \frac{1}{3018} = 0.0003\text{ pu}$

$I_{SYS} = \frac{1}{0.1003} = 9.967\text{ pu}$ on 480 V side

$I_{BS} = \frac{200\times10^3}{\sqrt{3}\times 480} = 240.6\text{ A}$ $\therefore I_{SYS} = 2398\text{ A}$

Motor FLA $= \frac{60\times10^3}{\sqrt{3}\times480} = 72.2$ $\therefore I_{MOTOR} = 288.7\text{ A}$

$$\boxed{I_f = 2686\text{ A}}$$