#1. a) $S_{Base} = 500\ MVA = P_{BASE} = 500\ MW = Q_{BASE} = 500\ MVAR$

$V_{LN,BASE} = 20\ kV$

$$I_{BASE} = \frac{S_{BASE}}{V_{LN,BASE}} = \frac{500\ MVA}{20\ kV} = 25\ kA$$

$$Z_{BASE} = \frac{V_{BASE}^2}{S_{BASE}} = \frac{(20\ kV)^2}{500\ MVA} = .8\ \Omega$$

$R_{BASE} = X_{BASE} = Z_{BASE} = .8\ \Omega$

b) $Z = (1.1\ pu)(.8\ \Omega) = .88\ \Omega$

c) $$Z_{pu\,(New)} = Z_{pu\,(old)} \frac{[V_{BASE\,(old)}]^2\ S_{BASE\,(new)}}{[V_{BASE\,(new)}]^2\ S_{BASE\,(old)}}$$

$$Z_{pu\,(New)} = (1.1\ pu)\frac{(20\ kV)^2(200\ MVA)}{(22\ kV)^2\ (500\ MVA)} = .364\ p.u.$$

#2 $S_{BASE} = 7.4\ KVA$ $V_{BASE_1} = 1.2\ KV$ $V_{BASE,2} = 120\ V$

$N_1 = 800$ turns

a) $$\frac{N_1}{N_2} = \frac{V_{BASE1}}{V_{BASE2}}$$

$$N_2 = N_1\left(\frac{V_{BASE,2}}{V_{BASE,1}}\right) = (800)\left(\frac{120\ V}{1.2\ KV}\right) = 80 \text{ turns}$$

b) $$I_{BASE,1} = \frac{S_{BASE}}{V_{BASE,1}} = \frac{(7.4\ KVA)}{(1.2\ KV)} = 6.17\ A$$

$$I_{BASE,2} = \frac{S_{BASE}}{V_{BASE,2}} = \frac{(7.4\ KVA)}{(120\ V)} = 61.7\ A$$

c) $S_{BASE} = 6\ KVA = P_{BASE}$

p.f. = .8 lagging

$\theta = \cos^{-1}(.8) = 36.87°$

$$Z_2 = \frac{(120\ V)^2}{6 \times 10^{+3} VA}\angle 36.87 = 2.4\angle 36.87°\ \Omega$$

d) $Z_2' = \left(\frac{N_1}{N_2}\right)^2 Z_2 = (10)^2(2.4\angle 36.87°\ \Omega)$

$Z_2' = (100)(2.4\ \angle 36.87°\ \Omega) = 240\angle 36.87°\ \Omega$

I Expected Z_2' to be larger since $P_{BASE,1} = P_{BASE,2}$ & $V_{BASE,1}$ is larger than $V_{BASE,2}$. This is also a step down transformer which means that $Z_2 < Z_2'$.

e) $I_1 = \frac{V_{BASE,1}}{Z_2'} = \frac{1.20\ KV}{240\ \angle 36.87°} = 5.0\ \angle -36.87°\ A$

$P_{supplied} = V_{BASE,1} \cdot I_1 = (1.20\ KV)(5.0\ A) = 6\ KW$, .8 leading

Yes, the answer match my expectations.

#3 $V_{BASE,1} = 1.2\ KV$ $V_{BASE,2} = 120V$ $S_{BASE} = 7.4\ KVA$

$r_1 = .8\Omega$ & $r_2 = .01\Omega$ $X_1 = 1.2\Omega$ $X_2 = .01\Omega$

a) There is a larger voltage on the primary side which is why the other quantities are also larger.

b) $a = \frac{N_1}{N_2} = \frac{V_{BASE,1}}{V_{BASE,2}} = \frac{1.2\times10^3\ V}{120\ V} = 10$

$R_1 = r_1 + a^2 r_2 = .8\ \Omega + (100)(.01\Omega) = 1.8\ \Omega$

$X_1 = X_1 + a^2 x_2 = 1.2\Omega + (100)(.01\Omega) = 2.2\ \Omega$

$Z = 1.8\Omega + j2.2\ \Omega$

c) $Z' = .018 + j.022\ \Omega \doteq \frac{Z}{a^2}$

d) $Z_{BASE,1} = \frac{(V_{B,1})^2}{S_B} = \frac{1.44\times10^6}{7.4\times10^3} = 1.95\ K\Omega$ $\quad Z_{1pu} = \frac{1.8 + j2.2\ \Omega}{1.95K\Omega} = .015\ p.u.$

$Z_{BASE,2} = \frac{(V_{B2})^2}{S_B} = \frac{(120)^2}{7.4\ KVA} = 1.95\ \Omega$ $\quad Z_{2pu} = \frac{.018 + j.022\ \Omega}{1.95\ \Omega} = .015\ pu$

c) $a = 10$ $S_{BASE,2} = 7.4 \text{ KVA}$ $V_{BACE,2} = 120 \text{ V}$

$$I_2 = \frac{S_{BASE,2}}{\sqrt{3} \cdot V_{BASE,2}} = \frac{7.4 \text{ KVA}}{\sqrt{3} \cdot 120 \text{ V}} = 35.6 \angle 0^\circ \text{ A}$$

$$I_2' = \frac{I_2}{a} = \frac{35.6 \angle 0^\circ \text{ A}}{10} = 3.56 \angle 0^\circ \text{ A}$$

$$V_1 = 1200 + I_2' Z_{TOT,2}$$
$$V_1 = 1200 + (3.56 \angle 0^\circ \text{ A})(1.8 + j2.2\ \Omega)$$
$$V_1 = 1200 + 6.408 + j7.832$$
$$\boxed{V_1 = 1206.408 + j7.832 = 1206.43 \angle .372^\circ \text{ V}}$$

f) $V_2 = V_1 / a$

$$V_2 = \frac{1206.43 \text{ V}}{10} = 120.64 \text{ V}$$

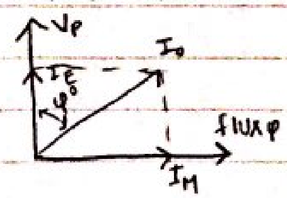
g) $$VR = \frac{V_{RNL} - V_{RFL}}{V_{RFL}} \times 100 = \frac{120.64\text{ V} - 120}{120} = .533\bar{3}\ \%$$

h) 0 since the voltage is 0.

#4. a) In an ideal transformer, there is no impedance, so the current would be infinite.

$$I = \frac{V}{0} \rightarrow I \rightarrow \infty$$

b) The impedance will determine the current in the primary winding. There will be an in-phase current, I_E which supplies the core losses (eddy current & hysteresis) & I_m @ 90° to the voltage which sets up the magnetic flux.



c) There won't be varying magnetic flux, since there is no change in magnetic flux linking to the coil when DC voltage is applied. The secondary coil will not have an emf so no output.

The transformer will draw excessive current from the source. The winding will heat up which may cause damage to the insulation, burn the winding & blow the incoming fuse.

d) If DC is applied to an ideal transformer, it is applied across the magnetizing inductance, so $V_L = L\, di/dt$ which is linearly rising magnetizing current through magnetizing Inductance, which means there is a constant flux rate. φ will increase till the excitation point of the B-H curve & then decrease, in turn current becomes large & can damage windings.

Homework 6

#5 a) Changed the label

b) line: which buses connect to each other. There is also information about impedance & nominal voltage. The transformer tab has info about the turns ratio

c) Range: 306.96 KV - 375.18 KV

Tap Changes: 33

1.1000 Tap: 375.18 KV $\rightarrow \frac{375.18\text{KV}}{345.00\text{KV}} = 1.087$ p.u.

.9000 Tap: $\frac{306.96\text{KV}}{345.00\text{KV}} \rightarrow .9000$ p.u.

1.0000 Tap: $\frac{341.07\text{KV}}{345.00\text{KV}} \rightarrow .989$ p.u.

d) When reactive power is 0 MVAR & Real power is 100 MW, the p.u. value is closest to 1.0. As Q↓, the bus voltage increases, & as P↑ & Q↑, bus voltage decreases.

e) The tap changed once from 1.012 to 1.01875 @ 1200 MW
The LTC changes to 1.01250 when we reach 800 MW from 1200 MW & it does not change again no matter how much we decrease real power load.

f) The LTC operation increases as we increase the MVARs. At 200 MVARs it changes to 1.01875 & it increases at every step we increase the MVARs. At 1100 MVARs, we reach the thermal threshold. The voltage at the thermal limit is 331.72 KV.

g) The tap decreases as we decrease the load MVARs. We reach the thermal limit at -1250 MVAR, the tap value is .90000 & the voltage is 345.38 KV.

h) It operates between .90000 & 1.1000