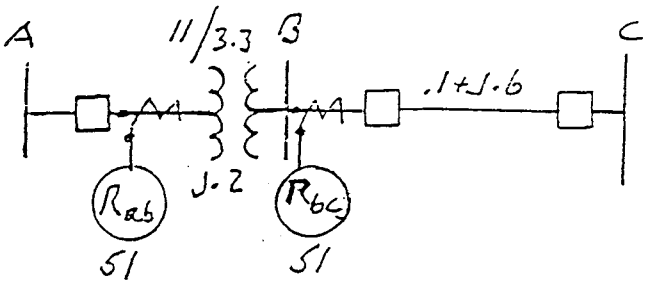
SOLUTIONS TO CHAPTER 8

8.1



$I_h = \frac{100 \times 10^3}{11kV} = 9.1$ Amperes

use CTR = 10:5 (2/1)

$I_l = \frac{100 \times 10^3}{3.3kV} = 30.3$ Amperes

use CTR = 40:5 (8/1)

Fault @ Bus C = $\frac{1.0}{.1 + j.8} = 1.2$ pu

Max load = 1.25 x I_{fl} = 37.88 A.

R_{bc} must be set above max.load but at this setting it cannot see faults at Bus C

Fault @ Bus B = $\frac{1.0}{0.2} = 5.0$ pu. R_{bc} can protect for close-in faults.

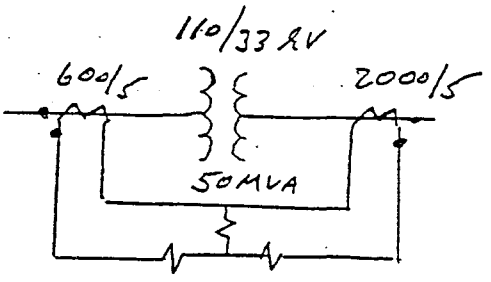
Set R_{bc} at $\frac{1.25 \times 30.3}{8} = 4.7$ Amperes---Set on 4.8 tap; T.D = #1/2

For fault at Bus B, R_{bc} has $\frac{5 \times 30.3}{8 \times 4.8} = 3.95 \times$ pu and operates in 0.50 seconds. Add 0.3 seconds coordinating time = 0.80 seconds.

Set R_{ab} at $\frac{1.2 \times 9.1}{2} = 5.7$ amperes--- Set on 6.0 tap.

For fault at Bus B, R_{ab} has $\frac{5 \times 9.1}{6 \times 2} = 3.8 \times$ pu. To operate in 0.87 seconds set on T.D. = #1

8.2



Max.load = 120% x 50 = 60 MV
LTC = ± 10% CT error = 5%

$I_h = \frac{60 \times 10^6}{110 \times 10^3} = 545.45$ Amperes

use CTR = 600:5 (120/1)

$I_{hsec} = 4.545$ Amperes Tap = 4.8

$I_l = \frac{60 \times 10^6}{33 \times 10^3} = 1818.18$ Amperes

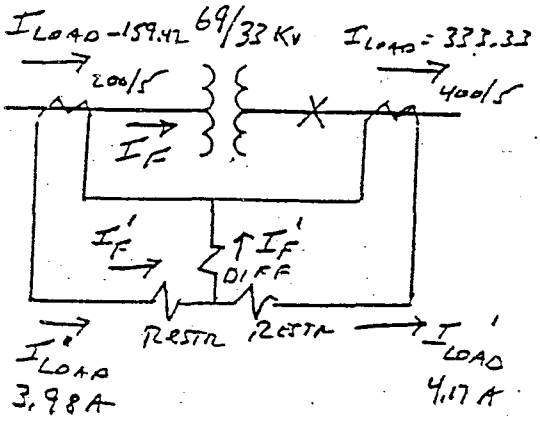
use CTR = 2000:5 (400/1)
I_{lsec} = 4.545 Amperes Tap = 4.3
CT mismatch = 0

Error due to LTC	= 10%
Error due to CT	= 5%
Safety margin	= 5%
slope	= 20% Use lowest pickup tap provided on specific relay.

8.3

Yes. With no tapchanger the slope could be 10%.

8.4



Single Phase Transformer Percentage Differential relay slope = 20% and minimum pickup = 0.25 Amperes

Max.overload = 110% x 10
= 11 MVA

$$I_h = \frac{11 \times 10^6}{69 \times 10^3} = 159.42 \text{ Amperes}$$

use CTR = 200:5 (40/1)

I_{hsec} = 3.98

$$I_l = \frac{11 \times 10^6}{33 \times 10^3} = 333.33 \text{ Amperes}$$

use CTR = 400:5 (80/1)
I_{lsec} = 4.17

At No-load- $I_{restr} = 0 - I_{diff} = \frac{I_f}{40} > 0.25$ - So $I_f > 10$ Amperes pri.

At Max overload- $I_{restr} = \frac{1}{2} \times \left(\frac{159.42}{40} + \frac{333.33}{80}\right) = 4.08$

$I_{diff} = 0.2 \times I_{restr} = 0.816$ Amperes to operate.

For Internal Fault, assuming no source on the 33 kV side,
$I_f = .816 \times 40 = 32.64$ Amperes primary.

At No-load the percentage winding protected is
$(1 - \frac{10}{159.4}) \times 100\ \% = 93.7\ \%$
At Max. overload the percentage winding protected
$(1 - \frac{32.64}{\quad}) \times 100\%$ = 79.5%