KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS
Electrical Engineering Department

EE 466 Major Examinations **II** **Term 062**

Course	**EE 466**
Date	**May 15, 2007**
Time	**17:00-18:15**
Place	**59-2107**

Student Name:_____

Student Id # _____

Section #:_____

Student Sequence #----------

Question #	Score
Q 1(20)	
Q 2(40)	
Q 3(40)	
Total	

Q1(20) points)

(a) The output of three CTs with designations of 06C600, 06C300, and 06C150 are connected in parallel. What is the class designation of this combination considered to be a single CT?

(b) A 1000:5 CT has the following data:

Primary fault current	=	20000 Ampere
Leakage impedance	=	j0.2 Ohms
Burden impedance	=	j2.0 Ohms
Magnetizing impedance	=	j20.0 Ohms

Find :

(i) The secondary current.
(ii) The magnetizing current
(iii) The CT error (ε)
(iv) The CT Ratio Correction Factor (R).

(c) Describe with the aid of diagram the following protection concepts:

1. Directional Relay
2. Impedance Relay

a) $I_{m_1} = 6A$; $Z_{m_1} = \frac{600}{6} = 100\,\Omega$

$I_{m_2} = 6A$; $Z_{m_2} = \frac{300}{6} = 150\,\Omega$

$I_{m_3} = 6A$, $Z_{m_3} = \frac{150}{6} = 25\,\Omega$

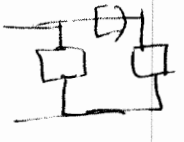
$Z_m = Z_{m_1} // Z_{m_2} // Z_{m_3} = 14285$

; $E_2 = 6(14285) = 85.7$

CT : 06C85.7

b) (i) $I_1 = \frac{20000}{1000}(5) = 100\,A$; $I_1 = I_2 + I_m$

(ii) $I_m = \frac{j I_1 (2.2)}{22.2} = 9.9A$



(iii) $\epsilon = \frac{I_m}{I_1} = 0.099$

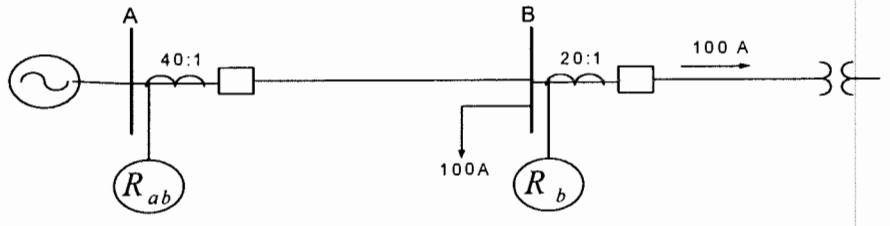
(iv) $R = \frac{1}{1-\epsilon} = 1.11$

Q2 (40 points)

(a) The input to the relay whose characteristics are attached is 60A Determine the operating time of the relay for the following conditions:

(i) Pickup current 6.0A and Time Dial Setting ½.
(ii) Pickup current 12.0 A and Time Dial Setting 7.
(iii) Pickup current 20.0 A and Time Dial Setting 7.
(iv) Pickup current 75 A and Time Dial Setting 1.

(b) For the radial system shown in the figure, calculate the TDOC relay settings at each bus. Assume the transformer must not be deenergized and that the relays at bus B are "looking into" a transformer differential and don't need to coordinate with it. Assume that any pickup tap is available and use the relay characteristics shown.



a (i) : ① $\frac{60}{60}$ = 1pu TD# $\frac{1}{2}$ top = 0.175 sec

② $\frac{60}{12}$ = 5pu , TD# 7 , top = 2.5sec

$\frac{60}{20}$ = 3pu ; TD# 7 ; top = 7sec.

$\frac{60}{75} < 1$ No operation

(ii) R_b 2 * 100 — $\frac{800}{3}$; $\frac{2*100(5)}{100}$ ⟷ $\frac{800*5}{100(3)}$; 10 — $\frac{40}{3}$

12A TD# $\frac{1}{2}$

[12 TD# $\frac{1}{2}$];

R_{ab} backup with R_b — If = 2400A

Cpickup = $\left(\frac{800*5}{200*3}\right) \simeq 6.67 = 8A$;

operating of R_b for 2400 A | multiples $\frac{2400*5}{100*12} = 10pu$; at TD# $\frac{1}{2}$

∴ top = 0.175 ∴ top Rab = 0.475

$R_{ab} = \frac{2400*5}{200(8)} = 7.5pu$; TD# 1.5

$R_b(50) = \frac{1.35(2400)*5}{100} = 162A$; check for min no operation

$R_b(52) = \frac{1.3*4800*5}{200} = 162A$. 2400/162 ≃ twice

Q3 (40 points)

(a) Discuss the factors to be considered before a percentage a differential is used for the protection of a generator. Sketch the characteristics of such relay showing clearly the trip and non-trip regions

(b) A 300 HP heavy duty motor connected to 4 KV-bus. The bus and motor parameters are shown below. Assume that the motor has a ground resistance to limit the ground fault to 1200A.

1. Determine the C.T ratio
2. Determine settings for phase and ground relays

Assume the following bus and motor parameters.

- Phase-to-phase bus fault=15000A
- Three-phase bus fault =25000A
- Maximum ground fault=1200A
- Motor efficiency = 90%
- Motor power factor=80%
- Motor locked rotor current=250A
- Motor starting time =1.5 seconds

Input power $= \frac{300(0.746)}{\eta * pf} = \frac{300(.746)}{0.9 \times 0.8} =$

Input current $= \frac{300(.746)}{0.9 \times 0.8(\sqrt{3})4} = 44.56A$

① pickup $= 1.25 \times 1.15(44.56) = 64.5A.$

① CT 100/5 pickup $\approx 3.2A$ Tap 4.0

Locked as multiples of pickup $= \frac{250 \times 5}{100(4)} = 3.125A$

TD to provide 1.5 sec; TD # 2

50R : Setup: $\frac{1.7(250) \times 5}{100} = 21.25 \approx 25A$

Check $= \frac{15000 \times 5}{100(25)} \geq 30$ Excellent

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$\frac{1200 \times 5}{100(3)} \approx 20A$ TD # $\frac{1}{2}$ – 1

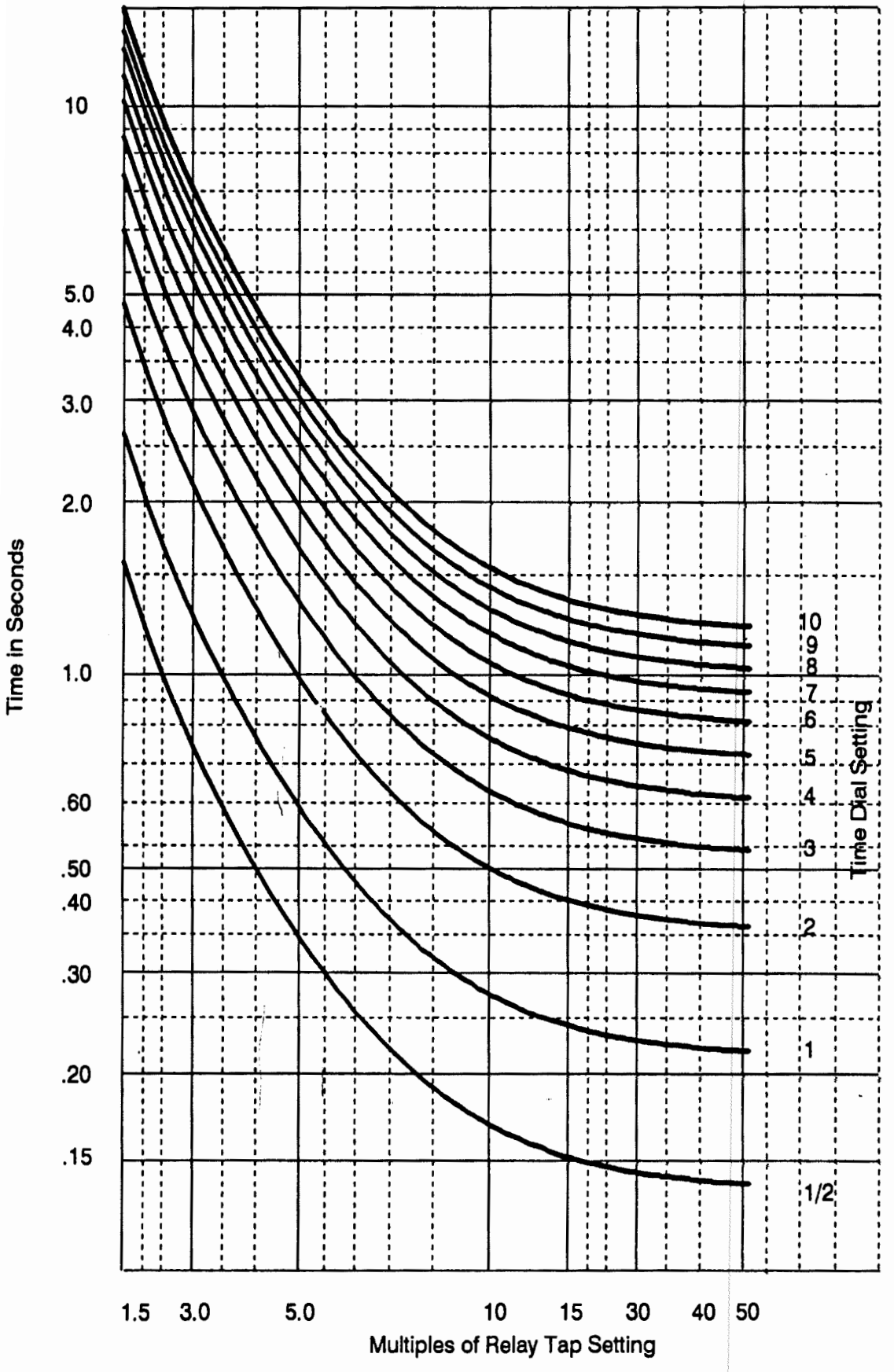

Figure 4.5 Time-delay overcurrent relay operating characteristics.