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University of Jordan Faculty of Engineering & Technology Electrical Engineering Department
EE482: Power System Analysis (2) First Exam Second Semester 2015-2016 13/03/2016 Time: 1200:13:00

Student Name: [redacted] **Student ID #:** [redacted] **Serial #:** [redacted]

Question # 1 (8 points)

Question No.	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
Answer	C	C	d D	a	b	c	D	c
Question No.	1.9	1.10	1.11	1.12	1.13	1.14	1.15	1.16
Answer	b	c	d D	b	D	C	b	D

Circle the correct answer of Question #1 and fill in the provided Table.

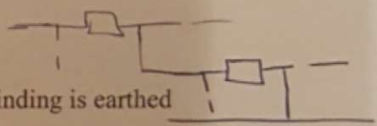
1.1 In case of L-G fault, the fault current is equal to

a. $\frac{E_a}{3(Z_1+Z_2+Z_0)}$ b. $\frac{3E_a}{Z_0}$ (c.) $\frac{3E_a}{Z_1+Z_2+Z_0}$ d. $\frac{3E_a}{(Z_1+Z_2)}$

1.2 The various power system faults can be arranged in the order of increasing severity is

a. L-G, L-L, L-L-G, L-L-L-G
b. L-L-G, L-L-L-G, L-G, L-L
(c.) L-L-L-G, L-L-G, L-L, L -G
d. L-L-L-G, L-L-G, L-G, L-L

1.3 The zero sequence current in Δ winding of a Y/Δ transformer is found



a. if neutral point of Y winding is not earthed
b. if neutral point of Y winding is earthed
c. whether the neutral point of the star winding is earthed or not earthed
(d.) none of these.

1.4 For a Y-Δ transformer Y-side grounded, the zero sequence current

(a.) exists in the lines on the Y-side
b. exists in the lines on both Y and Δ sides.
c. exists in the lines on the Δ-side
d. has no path to ground

1.5 A CT is connected in __________________ with the line .

a. across (b.) series c. not connected d. both A and B

1.6 ……. is one of the attributes of power system protection philosophy. It is defined as the ability to detect and isolate the faulty item only.

a. *Sensitivity* b. *Speed* (c.) *Selectivity* d. *Security*

1.7 An efficient and a well designed protective relaying should have

a. high speed and selectivity b. economy and simplicity c. good reliability (d.) All of the above

1.8 Burden of a protective relay is the power

a. required to operate the circuit breaker
b. developed by the relay circuit
(c.) absorbed by the circuit of relay
d. none of the above

Power Unit

1.9 The standard current ratings of the electromagnetic relay are

a. 5 A and 15 A b. 1 A and 5 A c. 15 A and 20 A d. Any one of the above

1.10 The standard voltage ratings of the electromagnetic relay are

a. 110V/63.5 V b. 230V/154V c. 220V/110V d. 400V/231V

1.11 If the fault current is 2000 A for a relay with a plug setting of 50% and the CTR is 400/5, the plug setting multiplier (PSM) would be approximately

a. 5 b. 7 c. 8 d. 10

1.12 A 50-Hz single-phase CVT has $C_1 = 0.5$ mF and $C_2 = 4.5$ mF. The leakage inductance (L) of the transformer should be equal to…., such that there is no phase displacement between the line voltage and the output of the CVT.

a. $L = 1$ mH b. $L = 2$ mH c. $L = 0.5$ mH d. $L = 5$ mH

1.13 A 500:5 CT with class C250 has a rated burden impedance Z_{burden} of

a. 2.0 Ω b. 5.0 Ω c. 0.5 Ω d. 2.5 Ω

1.14 A 1200/5 CT has a burden resistance of 1 Ω, C.T. secondary resistance of 2 Ω, and total lead resistance of 2 Ω. If the fault current seen by the CT primary is 9.6 kA, then the terminal voltage that develops across the terminals of the CT secondary will be

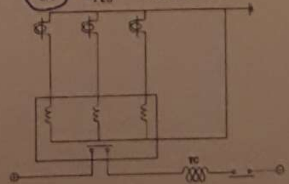
a. 40 V b. 100 V c. 200 V d. 280 V

1.15 A 5A-IDMT OC relay with normal inverse characteristic $t = \dfrac{3.0}{\log(M)} \times TMS$ is supplied via a 100/5 current transformer with a plug setting of PS=175%. If the relay should operate after 1.2 sec for a fault current $I_f = 1.5$ kA, the time multiplier setting (TMS) will be

a. 0.5 b. 0.4 c. 0.7 d. 1.1

1.16 The circuit shown below has 400:5 class C100 CTs. For a SLG fault of phase A to ground on the line, with fault current magnitude of 8000 A. The phase and residual lead currents are equal to ….. .

a. $I_{res} = 2.0$ A b. $I_{res} = 20$ A c. $I_{res} = 8.0$ A d. $I_{res} = 100.0$ A



Question # 2 (2.5 points)

A portion of an 11 kV radial system is shown in Fig.Q2. The system may be operated with one rather than two source transformers under certain operating conditions. Assume high voltage bus of transformer is an infinite bus. Protection system for three-phase and line-to-line faults has to be designed. Transformer and Transmission line reactances in ohms are referred to the 11 kV side as shown in the Fig. Q2. Calculate the maximum fault currents (I_{fmax}) at buses 1-5.

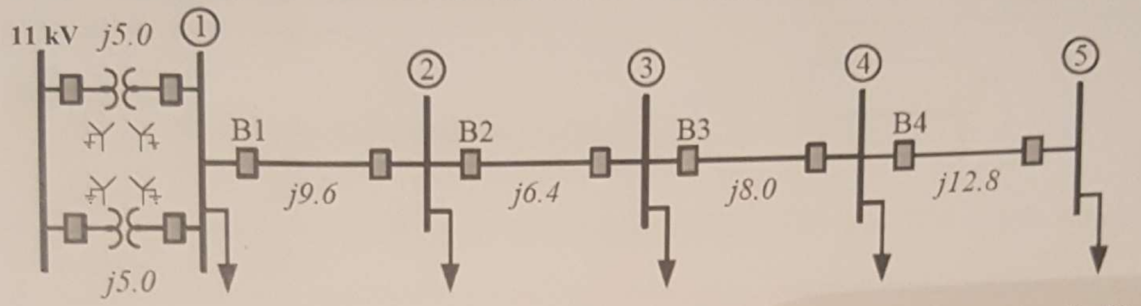


Fig. Q2

Fault Level	Fault at Bus				
	1	2	3	4	5
Max Fault Current (A)					

$I_{L-L} = \frac{\sqrt{3}}{2} I_{3-\phi}$

2.5

Question # 3 (2.5 points)

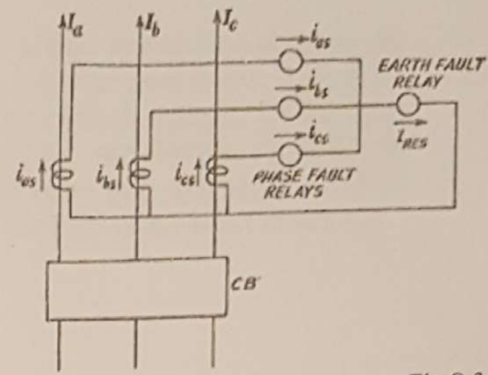


Fig.Q 3

The circuit of Fig.Q3 has 1000:5 class C100 CTs. Given the following:

CT Winding Resistance $R_C = 0.342\ \Omega$

Burden resistance for phase relay $R_{ph} = 0.50\ \Omega$

Burden resistance for E/F relay $R_E = 0.59\ \Omega$

Lead Resistance $R_L = 0.224\ \Omega$

Determine,

a. the LG fault current seen by the secondary of the CT, I_{fLGS}.
b. the LLL fault current seen by the secondary of the CT, I_{fLLLS}.
c. the CT secondary voltage (V_{sLG}) for line to ground fault on the line, with a fault current magnitude I_{fLG} of 12 kA.
d. the CT secondary voltage (V_{sLLL}) for a three fault on the lines, with fault current magnitude I_{fLLL} of 18 kA.
e. In which case the CT does saturate? L-G fault Since V_{FLG} > V kneepoint

I_{fLG}	I_{fLGs}	V_{sLG}	I_{fLLL}	I_{fLLLs}	V_{sLLL}
12000 A	60	112.8	18000 A	90	95.94

$I_{FLG} = 12\ k\ Amp$

$I_{FLGs} = 12k \times \frac{5}{1000} = 60$

$V_{sLG} = I_{FLGs} \times Z_{tot}$

$Z_{tot} = R_C + R_{ph} + R_L \times 2 + R_E$

$= 1.88$

$V = 112.8$

$I_{FLLL} = 18\ k$

$I_{FLGs} = 18k \times \frac{5}{1000} = 90$

$V_{FLG} = I \times Z_{tot}$

$Z_{tot} = R_C + R_{ph} + R_L$

$= 1.066$

$V = 95.94$

Power Unit

Question # 4 (7 points) ABET outcome 'C' Assessment

Consider the 13.8 kV radial system shown in FigQ4. For the above system, an **overcurrent protection system** has to be designed for three-phase faults. The relays at each bus 1, 2, 3, and 4 are designated by R1, R2, R3, and R4, respectively. The maximum fault current, CTRs, relay current tap settings (CTS) are given in the Table below. The IFC-53 is a **very inverse overcurrent relay** whose characteristic equation is given below. **Determine the relay time dial settings (TDS) for relays R3-R1, assuming a grading step time Δt of 0.3 s and the TDS of R4 is set at 0.5.**

$$t_p = \left(\frac{3.88}{I_r^2 - 1} + 0.0963 \right) \times TDS$$

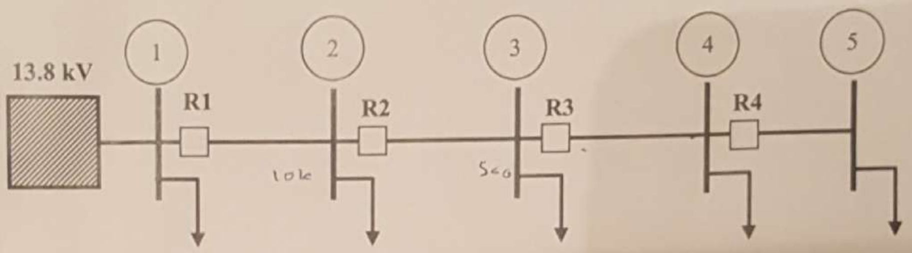


Fig. 4

Bus	1	2	3	4
I_{fmax} (A)	3187	659	431	301
CTR	100/5	100/5	50/5	50/5
CTS (A)	5	4	5	5
TDS			~~8~~ 5	0.5

$I_r = \frac{I_F}{I_{pickup}}$

$= \frac{301}{25} = 12.04$

CTS = I rated

$CTS = \frac{I_{pickup}}{I_{rated}}$

$I_{pickup} = 5 \times 5 = 25$

$T_{P_4} = .06162$ (.56162)

$T_{P_3} = \left(\frac{3.88}{\left(\frac{301}{25 \cdot 5}\right)^2 - 1} + .0963 \right) TDS$

~~.10166~~ .123

.06162 → 1

.56162 → x

TDS = 9.11 → 5

T_{P_3} = ~~10166~~ → .50166

$T_{P_2} = \frac{3.88}{431}$

$T_{P_3} = \left(\frac{3.88}{\left(\frac{431}{25}\right)^2 - 1} + .0963 \right) \times 5$

$= .547$

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