ABET Outcomes Assessment: c and f

GRADE = 20 /20

University of Jordan | School of Engineering | Electrical Engineering Department

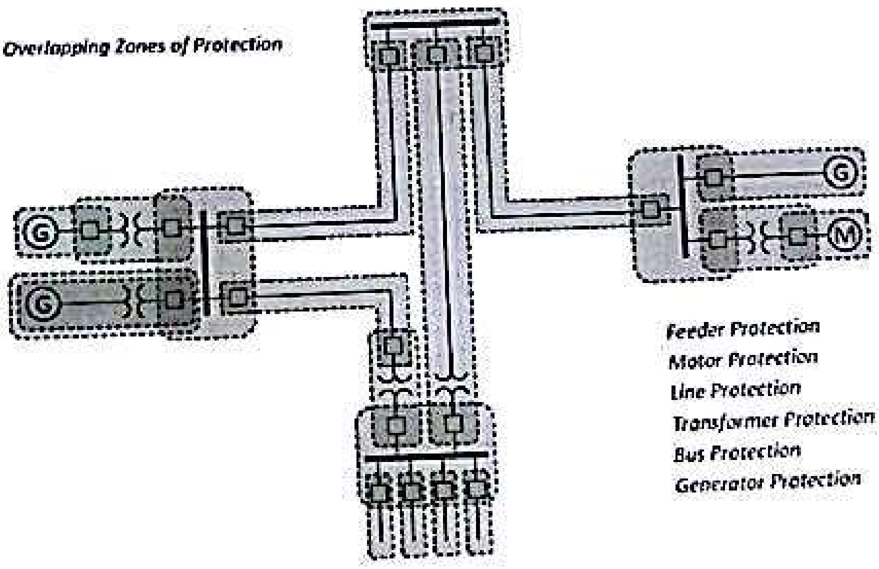
EE482: Power System Analysis (2) First Exam 2nd Semester 2016-2017 12/03/2017 Time: 10:00-11:00 am

Q # 1 (22)	*Q # 2 (15)	Q # 3 (20)	Q # 4 (28)	Q # 5 (28)	GRADE
22	15	15	20	28	100/100

Student Name: **Student ID #:** **Serial #:**

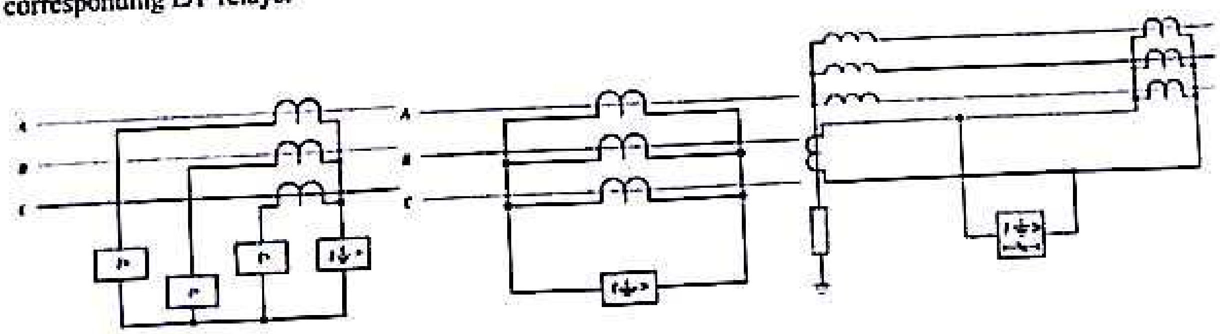
Question # 1 (22 points)

Draw the protection zones for the following power system shown below taking into consideration zones overlaps.



Question # 2 (15 points)

Draw three protections schemes for detecting earth faults showing the connections of CTs and the corresponding E/F relays.



Question # 3 (15 points)

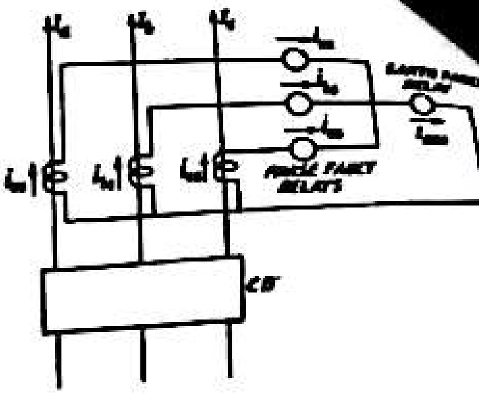
The circuit shown below has 500:5 class C100 CTs. Given the following:

CT Winding Resistance $R_C = 0.342\ \Omega$

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

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

Leed Resistance $R_L = 0.224\ \Omega$



For a line to ground fault on the line, with a fault current magnitude I_{fLG} of 6000 A and a three fault on the lines, with fault current magnitude I_{fLLL} of 9000 A, determine:

a.	the LG fault current seen by the secondary of the CT, I_{fLGS}	$I_{fLGs} = 60$	A
b.	the LLL fault current seen by the secondary of the CT, I_{fLLS}	$I_{fLLLs} = 90$	A
c.	the CT secondary voltage for line to ground fault on the line, V_{sLG}	$V_{sLG} = 112.8$	V
d.	the CT secondary voltage for three fault on the lines, V_{sLLL}	$V_{sLLL} = 95.9$	V
e.	Which fault causes CT saturation?	*LG*	*LLLL*

Solution

a. Secondary LG Fault Current I_{fLGs}

$I_{fLGs} = I_{fLG}/CTR$ =12000/(500/5) =6000/100 = 60 A

b. Secondary LLL Fault Current I_{fLLLs}

$I_{fLLLs} = I_{fLLL}/CTR$ =18000/(100/5) =9000/100 = 90 A

c. $V_{sLG} = I_{fLGS} \times (R_c + R_{ph} + R_E + 2 \times R_L) = 60 \times (0.342 + 0.5 + 0.59 + 2 \times 0.224) = 112.8\ V$

d. $V_{sLLL} = I_{fLLL} \times (R_c + R_{ph} + R_L) = 90 \times (0.342 + 0.50 + 0.224) = 95.9\ V$

e. The CT saturates in the case of LG fault.

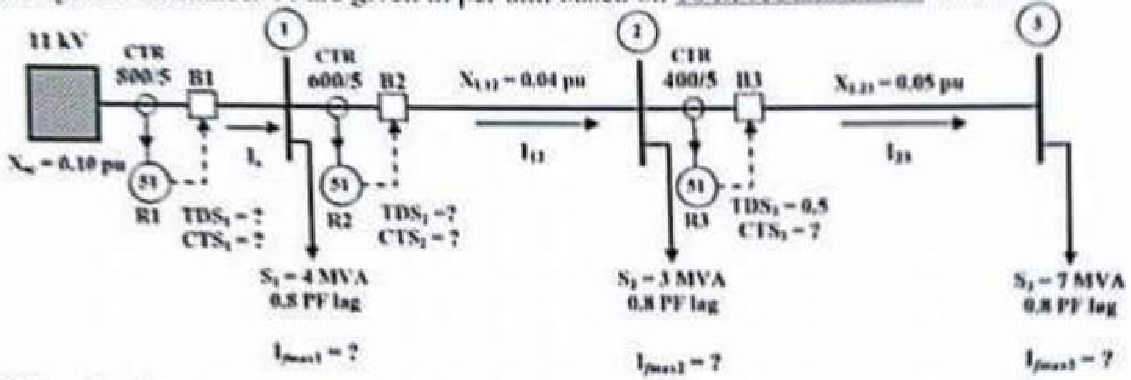
Question # 5 (28 points) ABET outcome "e" Assessment **SHOW YOUR CALCULATIONS**

Consider the 11 kV radial system shown below. The system is supplying its peak load as indicated below. For the above system, an **overcurrent protection system** has to be designed for three-phase and line-to-line faults. The relays at buses 1, 2, and 3, designated by R_1, R_2 and R_3 are all CO-7 **moderate inverse overcurrent relay** (OCR) whose characteristic equation, current tap settings and time-dial settings are given below:

Current Tap Setting (A)	4	5	6	7	8	10	12
Time Dial Setting	0.5	1	2	3	4	5	6

$$t_p = \left(\frac{0.0515}{\left(\frac{I_f}{I_p}\right)^{0.02} - 1} + 0.114 \right) \times \frac{TDS}{7}$$

The system reactances of are given in per unit based on 10 MVA and 11 kV bases.



Using the following design principles for calculations

1. Start you solution first with the calculations for R_3 with time dial setting $TDS_3 = 0.5$.
2. For relay X, backing up the next downstream relay Y, relay X must pick up
   a. For $2I_{fli} \le I_{pi} \le 1/3 I_{fmini}$ 1/3 of the current seen by Y
   b. For the maximum current seen by Y but no sooner than 0.4 s after Y should have picked up for that current.

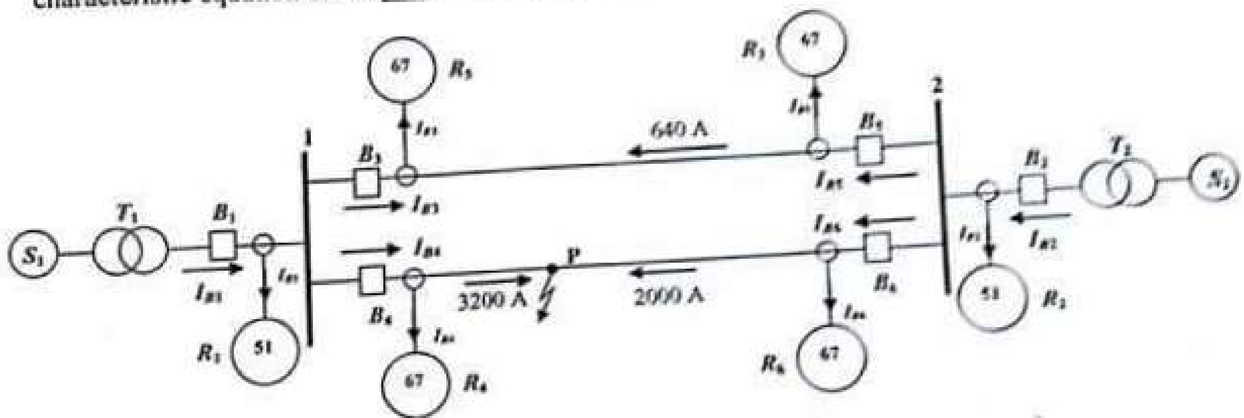
Calculate:

a.	the peak load currents I_{L3}, I_{L2} and I_{L1} in Ampere.	I_{L3} = 367 I_{L2} = 158 I_{L1} = 210	A A A
b.	the line currents I_{23}, I_{12} and I_s in Ampere.	I_{23} = 367 I_{12} = 524 I_s = 735	A A A
c.	the maximum fault current at buses 3, 2 and 1 I_{fmax3}, I_{fmax2} and I_{fmax1} in Amperes.	I_{fmax3} = 2762 I_{fmax2} = 3749 I_{fmax1} = 5249	A A A
d.	the actual current tap setting CTS_3, CTS_1 and CTS_1 of the relay according to the standard current settings of the relay given in the Table above. The relay must pickup and operate for all currents that are $2I_{FLi} \le I_{pi} \le 1/3 I_{fmini}$.	CTS_3 = 8 CTS_3 = 8 CTS_3 = 10	A A A
e.	The actual time dial settings TDS_2 and TDS_1 according to standard time dial settings of the relay given in the Table above.	TDS_3 = 0.5 TDS_2 = 2 TDS_1 = 3	

Question # 4 (20 points) ABET outcome "f" Assessment **SHOW YOUR CALCULATIONS**

The power network shown below is protected using 6 non-directional and directional over current relays (OCR). The system is subjected to a 3-phase fault at phase *A* of one of its lines. The phase-*A* currents flowing during the fault are illustrated in the figure. Study the response of all phase relays for all units, then

a. specify the ANSI relay code of the relays R_1, R_2, R_3, R_4, R_5 and R_6.
b. determine the primary fault current I_{B1}, I_{B2}, I_{B3}, I_{B4}, I_{B5} and I_{B6} flowing through each breaker
c. calculate the secondary fault current seen by each relay I_{R1}, I_{R2}, I_{R3}, I_{R4}, I_{R5} and I_{R6}).
d. specify the relays that will trip (*T*) and that will block (*B*) its operation (Use a tick mark ✓ for either tripping or blocking operation.).
e. For the relays that will issue a **TRIP signal**, determine its operating time t_i. The inverse time characteristic equation of the CO-8 relay is given by:



$$t_i = \left(\frac{5.95}{\left(\frac{I_{Ri}}{I_{pi}}\right)^2 - 1} + 0.18 \right) \times TDS_i$$

Relay	I_{Bi} (A)	CTR	I_{Ri} (A)	OCR$_i$ Code	Signal T	Signal B	Phase Relays CTS$_i$ (A)	TDS$_i$	t_i (s)
B1	2560	800:5	16	51	✓		6	4	4.61
B2	2640	800:5	16.5	51	✓		6	4	4.35
B3	-640	400:5	-8	67		✓	5	3	-
B4	3200	400:5	40	67	✓		5	3	0.82
B5	640	400:5	8	67	✓		5	3	11.98
B6	2000	400:5	25	67	✓		5	3	1.28