UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: October 2019

Module Number: EE7213 **Module Name: Power System Protection**

[Three Hours]

[Answer **all questions**, each question carries **10 marks**]

Q1. a) i) Clearly mention the difference between TT, TN-C-S and IT earthing systems with aid of sketches.

ii) Discuss the possibility of using an Earth Fault Relay (EFR) with Current Transformers (CTs) for earth fault protection in a TT system having earth loop impedance of 55 Ω. Take the demand of the system as 120 A.

[4.0 Marks]

b) Havelock City is a 24-story luxury apartment complex project. The calculated demand of the building is 3580 A.

i) Determine the size of the protective conductor (earth cable), if the fault loop impedance of TN-C-S system at Havelock City is 0.1 Ω. Take the fault clearing time as 1 s. Required conductor cross sectional area (s) of the earth cable can be expressed using following equation where notations have their usual meanings. Values of k for common conductor materials are given in Table Q1.

$$s = \frac{\sqrt{I^2 t}}{k}$$

ii) Calculate the fault level of the low voltage bus bar if the percentage impedance of the transformer is 6%. Clearly state any assumptions you make.

[6.0 Marks]

Q2. a) Feeder 08 (F8) of Ratnapura Grid Substation (GSS) has a 25 MW installed capacity of Mini Hydro Power (MHP) generation. The maximum feeder demand in the dry season is 20 MW. F8 and three other feeders (F2, F4 and F6) are fed by a single transformer at the GSS. In the wet season, when MHP generation is at its maximum, F2 trips due to an earth fault and F8 also trips simultaneously for the same fault. Trip settings of the relay for earth fault protection of both feeders at the GSS are shown in Table Q2. Explain the possible reason for the above incident and suggest a solution to overcome this problem.

[5.0 Marks]

b) In wet season, the Auto Recloser (AR) installed at feeder 08 (F8) of Ratnapura GSS observes a delayed tripping for a fault occurred in the feeder section shown in Figure Q2. Critically analyze the above incident.

[5.0 Marks]

Q3 a) Define a 'Fault' in a power system.

[1.0 Mark]

b) State six breaker types and explain their differences.

[3.0 Marks]

c) State five important parameters in a name plate of a breaker.

[3.0 Marks]

d) Compare numerical and electromagnetic relays.

[2.0 Marks]

e) What is 'Accuracy Class' of a current transformer?

[1.0 Mark]

Q4 Two Auto Reclosers (ARs) are installed in a feeder and system parameters of those points are shown in Table Q4.

a) Maintaining protection coordination, set all relays including GSS against earth fault and over current using IEC-SI curve expressed by following equation where notations have their usual meanings.

$$t_d = \frac{0.14}{\left(\frac{I_f}{I_{Pickup}}\right)^{0.02} - 1} \times TMS$$

[6.0 Marks]

b) Repeat part a) using IEC-EI curve expressed by following equation where notations have their usual meanings.

$$t_d = \frac{80}{\left(\frac{I_f}{I_{Pickup}}\right)^{2} - 1} \times TMS$$

[2.0 Marks]

c) Compare the results in part a) and part b).

[2.0 Marks]

Q5 Propose a protection setting against over current and earth fault using IEC-SI curve for a downstream protection device installed 40 km from the GSS breaker in a 33 kV Lynx circuit. The GSS breaker settings are given in Table Q5. The feeder load is 280 A and Lynx conductor has a current carrying capacity (CCC) of 400 A, a positive sequence impedance (Z_1) of 0.178+0.321i Ω/km and a zero sequence impedance (Z_0) of 0.327+1.453i Ω/km. Fault currents can be expressed using following equations where Z_2 is the negative sequence impedance. Clearly state any assumptions you make.

$$\text{Single Line to Ground Fault} = \frac{\text{System Voltage}}{Z_1 + Z_2 + Z_0}$$

$$\text{Line to Line Fault} = \frac{\text{System Voltage}}{Z_1 + Z_2}$$

$$\text{Double Line to Ground Fault} = \frac{\text{System Voltage}}{Z_1 + \frac{Z_0 Z_2}{Z_0 + Z_2}}$$

[10.0 Marks]

Table Q1: Values of k of common conductor materials, for calculation of the effects of fault current for disconnection times up to 5 s

Conductor Insulation	**Thermoplastic**				**Thermosetting**		**Mineral insulated**	
	90 ⁰C		70 ⁰C		90 ⁰C	60 ⁰C	Thermoplastic sheath	Bare (unsheathed)
Conductor cross-sectional area [mm²]	≤ 300	> 300	≤ 300	> 300				
Initial temperature [⁰C]	90		70		90	60	70	105
Final temperature [⁰C]	160	140	160	140	250	200	160	250
Copper conductor	k=100	k=86	k=115	k=103	k=143	k=141	k=115	k=135/115[a]
Aluminum conductor	k=66	k=57	k=76	k=68	k=94	k=93		
Tin soldered joints in copper conductors	k=115	k=115	k=115	k=115	k=115	k=115		

Table Q2: Trip settings for earth fault protection

Setting	F2	F8
Pickup current [A]	40	40
TMS	0.1	0.1
Curve	IEC-SI	IEC-SI
Instantaneous Trip Current [A]	320	320
Instantaneous Trip Delay [s]	0.1	0.1

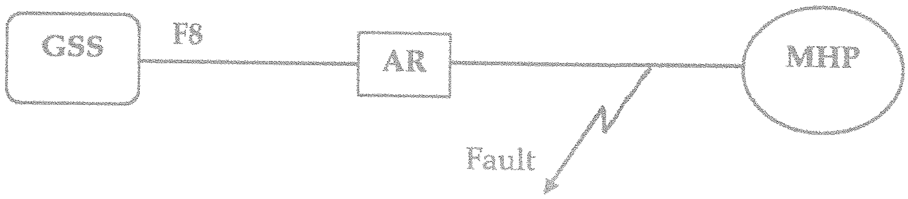

Figure Q2: Fault location in Feeder 08

Table Q4: System parameters of the feeder at different points

System Parameter	At GSS	At First AR Location	At Second AR Location
Load [A]	400	300	150
LG Fault [A]	350	320	280
LL Fault [A]	7200	6000	5500

Table Q5: Breaker settings at GSS

	Overcurrent setting	Earth fault setting
Pickup [A]	400	40
TMS	0.1	0.1
Curve	IEC-SI	IEC-SI
Instantaneous Trip Current [A]	1600	320
Instantaneous Trip Delay [ms]	100	100