STUDY OF OVERCURRENT AND EARTH FAULT PROTECTION SYSTEM BY USING PSS-ADEPT

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Abstract -**This paper studies the protective relay setting and coordination using PSS-Adept. Faults and failures normally occur in power system. Power system needs an auxiliary system that must take corrective action on the occurrence of a fault. This auxiliary system is knows as protection system. Protection systems are sets of equipments to detect faults in the protected elements of the power systems, to disconnect the faulted element and to re-establish the service. This paper approach for over current and earth fault as protection system. Protective device coordination is the process of determining the best timing of current interruption when abnormal electrical conditions occur. This paper also using Bus power system distribution network and implement using protection equipment application in power system simulation programmed for planning, design and analysis of distributed system (PSS/Adept).This paper conclude by the result of study carried out on analysis protective relays configuration.**

Keywords –Overcurrent relay,Earth fault relay,Fault, PSS-Adept.

1. INTRODUCTION

The main purpose of power systems is to generate, transmit, and distribute electric energy to customers without interruptions and in the most economical and safe manner. To achieve the objective of power systems are divided in generation, transformation, transmission and distribution subsystems [2].Faults and failures normally occur in power system at transformer feeder, transformer, bus section and transmission. Due to the great amounts of energy involved, faults represent a threat to the operation and security of power systems if the faults are not promptly corrected [1].Power systems need a protective relay as protective system that must take corrective actions on the occurrence of a fault. IEEE defines a protective relay as "a relay whose function is to detect defective lines or apparatus or other nature and to initiate appropriate control circuit action [7].

This paper approach for overcurrent and earth fault relay as protection system. The protective relaying which responds to a rise in current flowing through the protected element over a pre-determined value is called overcurrent protection and the relays used for this purpose are known as overcurrent relays [3]. Earth fault protection again requires current transformers and senses an imbalance in a three-phase circuit. Normally a three-phase circuit is in balance, so if a single or multiple phases are connected to earth an imbalance in current is detected [1]. If this imbalance exceeds a pre-determined value a circuit breaker should operate. The design of a comprehensive protection scheme in a power system requires the detailed study of time-current characteristics of the various relays used in the scheme [1].

Thus it is necessary to obtain the time- current characteristics of these relays. The pick-up current setting can thus be varied by the use of such plug multiplier setting. The pick-up current values of earth fault relays are normally quite low [5]. The operating time of all overcurrent relays tends to become asymptotic to a definite minimum value with increase in the value of current [9]. The time-current tripping characteristic of IDMT relays may need to the tripping time required and the characteristics of other protection devices used in the network. The simulation model of power bus system network develops by using PSS/Adept software to study the behaviour of the proposed technique.

A. Objectives

The objectives of this project as follows:

- To analyze overcurrent and earth fault system protection and prediction by using PSS/Adept for 33/11KV schematic diagram of Mara University of Technology (Uitm) Shah Alam Selangor Malaysia bus system network.
- To compare performance trip current time with some other bus network in same system.
- To study how to setup CT ratio same as TNB rate by using PSS/Adept.

B. Scope of Studies

- To identify the occurrence of faults in the bus system and know the maximum fault currents or short circuit current occur in this location of bus system.
- To setting and coordinating protective relay according to Tenaga National Berhad (TNB) standard.
- To find suitable CT ratio, time dial setting and pick up (tap) for coordinating and setting protective relay.

II. METHODOLOGY

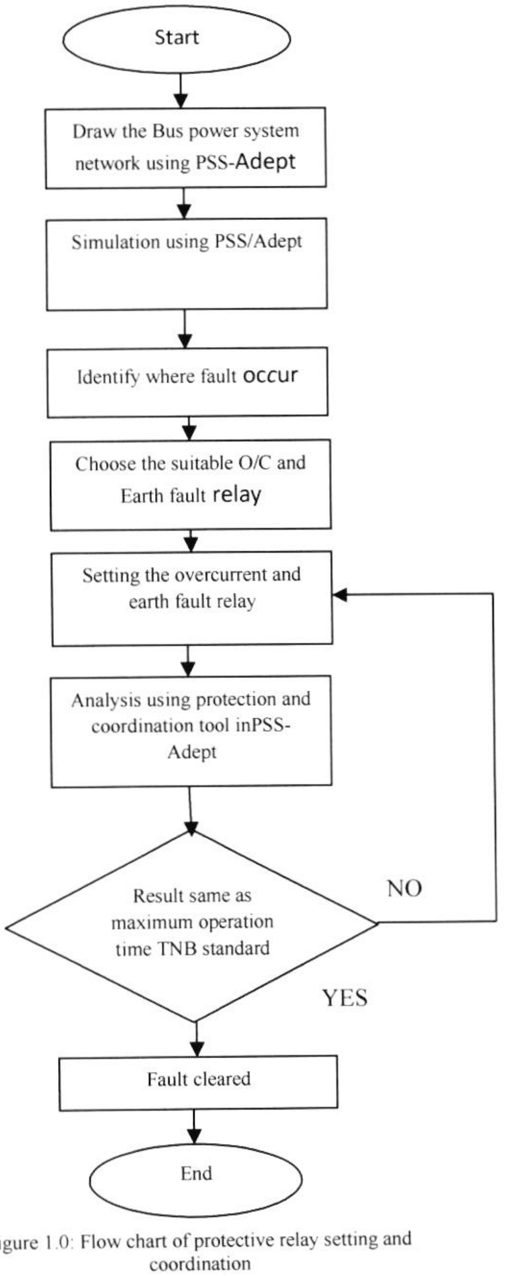

Figure 1.0: Flow chart of protective relay setting and coordination

A. PSS-Adept simulation software

The simulation was executed using commercial load flow software called Power System Simulator and Advance Distribution Engineering Productivity Tool (PSS/Adept). The function of this simulation is a network simulation program for planning, designing and analyzing distribution system. PSS/Adept utilities the Gauss-Seidel method for the solving load flow equation. The protection and coordination module is an option in PSS/ADEPT. The protection and coordination module displays the characteristic curves of selected overcurrent relays and fuses along with operating times of these protective devices for use in a coordination study [5].

B . Network Design

Figure 2.0 shows the 33/11KV schematic diagram of Mara University of Technology (Uitm) Shah Alam Selangor Malaysia bus system network. The network model has been design by PSS/Adept software. The main step down substation (in Malaysia normally called main intake substation) is connected to the grid at nominal voltage of 33kV, i.e., the source [6]. The maximum 3-phase currents at the source are indicated in Figure 2.0 which means that on a 3-phase solid fault on the 33kV bus, the fault current that is contributed by the source is 20kA and 15kA on a single-phase to ground fault. The 33kV is stepped down to 11kV using three 10/12.5MVA transformers and one 350KVA transformer whose parameters are also indicated in Figure 2. It is important that the transformer parameters such as resistance, tap settings and controls are properly modelled. The location that the highest frequent trip is location Akademik compare others location. The analysis focus on Akademik location with 4 different types of fault current.

C. Setting of protective relay

Relay operating characteristics and their setting must be carefully coordinated in order to achieve selectivity [9]. The aim is basically to switch off only the faulted component and to leave the rest of the power system in service in order to minimize supply interruptions and to assure stability. The type of relay, CT setting, time dial setting and pick Up (Tap) need to be setting before analysis this network [9].

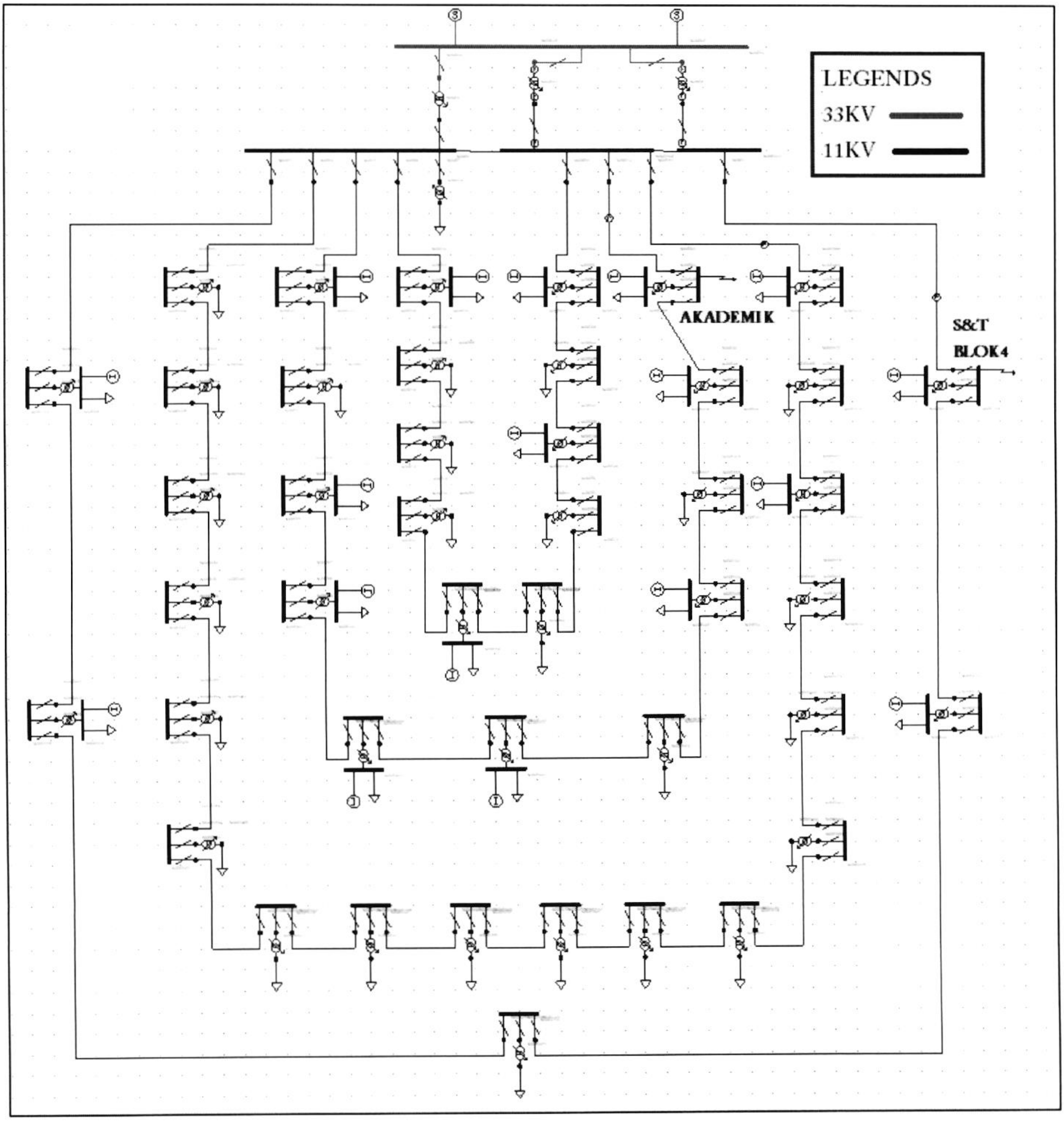

Figure 2.0: 33/11KV Schematic Diagram.

III. RESULTS AND DISCUSSION

A. Overcurrent Relay Coordination

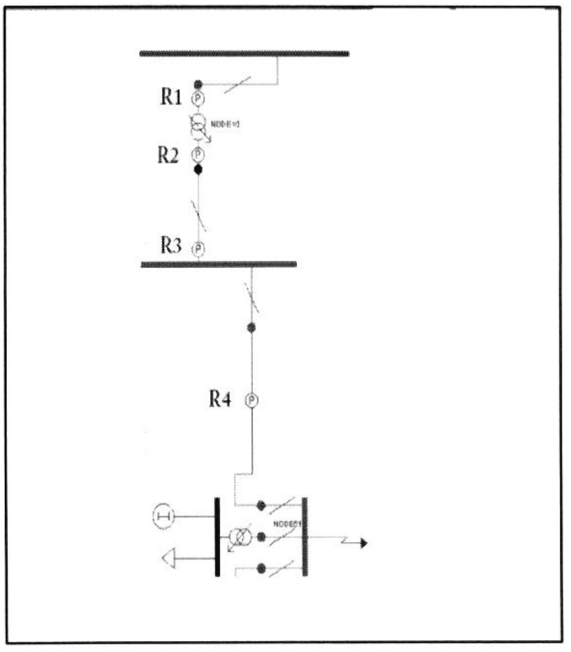

Figure 1: Protective Relays: R1, R2, R3, R4

This project uses four protective relay of Normal Inverse characteristics. Protective relay installed in the transformer feeder, transformer, transmission feeder and bus section.

- R1 install at transformer feeder.
- R2 install at transformer.
- R3 install at bus section
- R4 install at transmission feeder.

When coordinating overcurrent relays, fault is set with 4 different types to 3-Phase-To-Ground, Phase-to-phase, Phase-to-phase-to-ground, Phase–to-ground and all protective relays use the same device in Tenaga National Berhad (TNB) standards, the protective relay at the main intake R1 is set to operate ideally at 2.0 seconds for the protective relay at transformer feeder. R2, is set to operate ideally at 1.6 seconds whereas for the protective relays that resides at the bus section, is set to be initialized at 1.4 seconds which is slightly faster than transformer feeder's relay and slightly slower when compared to outgoing feeder's relay [10]. The outgoing feeder's relay must be initialized ideally at 1.2 seconds. TNB also using Normal Inverse for type of relay characteristics [10].

TABLE 1: Overcurrent Protective Relays Configurations 3-Phase-To-Ground.

Relay	CT Settings	Time Dial (s)	Pick Up (Tap)	Relay Characteristics	Max Operation Time (s)
R1	1600/5	0.18	5	NORMAL INVERSE	2.030
R2	1600/5	0.39	5	NORMAL INVERSE	1.614
R3	1600/5	0.34	5	NORMAL INVERSE	1.386
R4	600/5	0.10	5	NORMAL INVERSE	<=0.01

TABLE 2: Overcurrent Protective Relays Configurations Phase-To-Phase.

Relay	CT Settings	Time Dial (s)	Pick Up (Tap)	Relay Characteristics	Max Operation Time (s)
R1	1600/5	0.18	5	NORMAL INVERSE	2.030
R2	1600/5	0.36	5	NORMAL INVERSE	1.586
R3	1600/5	0.32	5	NORMAL INVERSE	1.405
R4	600/5	0.10	5	NORMAL INVERSE	<=0.01

TABLE 3: Overcurrent Protective Relays Configurations Phase-To-Phase-To-Ground.

Relay	CT Settings	Time Dial (s)	Pick Up (Tap)	Relay Characteristics	Max Operation Time (s)
R1	1600/5	0.18	5	NORMAL INVERSE	2.030
R2	1600/5	0.37	5	NORMAL INVERSE	1.595
R3	1600/5	0.33	5	NORMAL INVERSE	1.412
R4	600/5	0.10	5	NORMAL INVERSE	<=0.01

TABLE 4: Overcurrent Protective Relays Configurations Single-Phase-To-Ground.

Relay	CT Settings	Time Dial (s)	Pick Up (Tap)	Relay Characteristics	Max Operation Time (s)
R1	1600/5	0.18	5	NORMAL INVERSE	No-op
R2	1600/5	0.32	5	NORMAL INVERSE	1.589
R3	1600/5	0.28	5	NORMAL INVERSE	1.378
R4	600/5	0.10	5	NORMAL INVERSE	<=0.01

Table 1 show the overcurrent protective relay configuration for 3-Phase-To-Graound. The over current unit has three values to be set, the CT ratio setting the pickup current value (Ip), and the time dial setting and pick up tap. The maximum operation time of R1 is 2.030second, R2 is 1.614second, R3 is 1.386second and R4 is 0.01second and fault current at 13.857kA. Same as three others configuration fault setting, result obtained from analysis using PSS-Adept same as operation time(s) TNB standard at location Akademik 3 cause this location bus system higest frequent trip. CT ratios are expressed as a ratio of the rated primary current to the rated secondary current. Current transformers are instrument transformers that are used to supply a reduced value of current to protective relay [4]. The most common CT secondary full-load current is 5 amps which matches the standard 5 amp full -scale current rating of protective relay. Current of 10 to 20 times (or grater) normal rating often occur in CT winding for few cycles during short circuits [7].Ideally, CT ratio setting depend on short circuit current or fault current and follow by CT ratio standard. The maximum secondary current is taken from maximum fault current occur at location of fault using by PSS-Adept simulation. The Equation(1) as Normal Inverse protective relay. This equation is related the analysis using PSS-Adept simulation.

$$t = \frac{0.14}{(\frac{I}{Ip})^{0.02} - 1} \times Tp(s) \text{......(Equation 1)}$$

t = Tripping time
Tp = Setting value of the time multiplier
I = Fault current
Ip = Setting value of the current

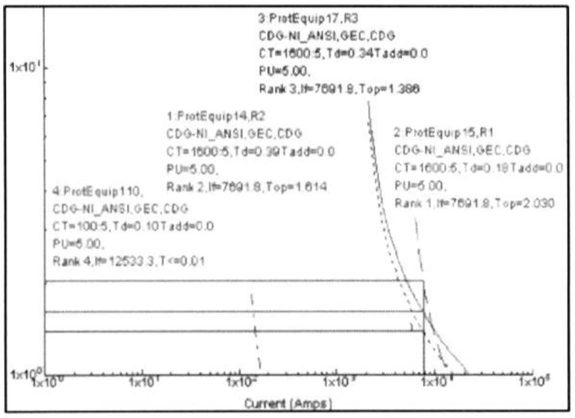

Figure 2: Time verse current curve for overcurrent protective relay 3-Phase-To-Ground.

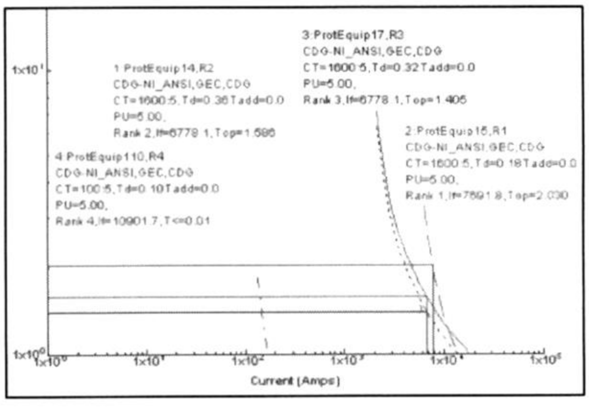

Figure 3: Time verse current curve for overcurrent protective relay Phase-To-Phase.

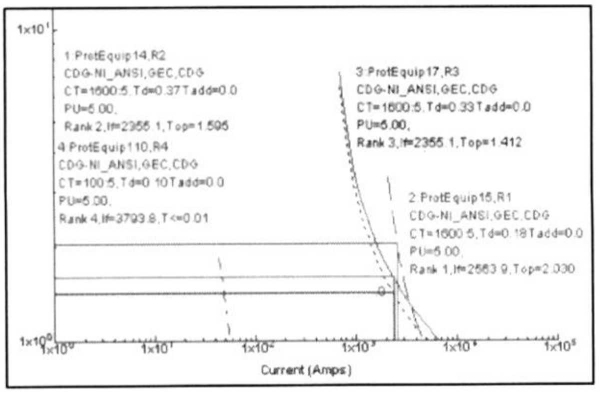

Figure 4: Time verse current curve for overcurrent protective relay Phase-To-Phase-To-Ground.

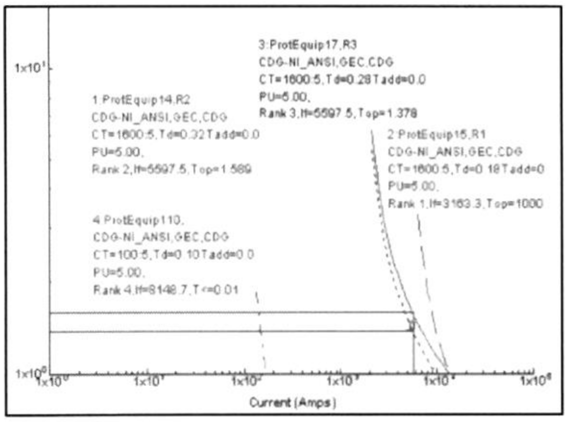

Figure 5: Time verse current curve for overcurrent protective relay Single-Phase-To-Ground

Figure 2, 3, 4, 5 shows the time verse current for overcurrent protective relay. The overcurrent relay 4(R4) is set at shortest time delay when fault occur in bus power system and clear the fault before the relay R3,R2 and R1 have time to operate. For all the test of fault current, the highest fault current is when 3-Phase-To-Ground with others situation.

B. Earth Fault Relay

The coordinating earth fault relays, fault is set to 3-phase-to-ground and all protective relays use the earth fault relay device ID. In TNB standards, the protective relay at transformer feeder R2 is set to operate ideally at 1.6 seconds. Beside that outgoing feeder's relay must be initialized ideally at 1.2 seconds. Firstly, only R2 and R4 have to be replaced with earth fault device. Table 2 show the maximum time from four protective earth fault relay .The result obtained from setting CT ratio, time dial setting and pick up (Tap) before analysis by using PSS-Adept. The maximum operation time of R1 is 1.614 second and R2 is 0.01second. This result obtained from analysis using PSS-Adept same as operation (s) as TNB standard. Figure 6 show the time verse current curve for overcurrent protective relay. The earth fault relay 4(R4) is set at shortest time delay when fault occur in bus power system and clear the fault before the relay R2 have time to operate. Figure 7 show different result time delay when fault occur in bus system compare with figure 6, time dial for S&T Blok4 are more highest then Akademik location. This happen because the then faults current at S&T Blok4 is 15.190kA high then Akademik location is only 13.857kA.

TABLE 5: Earth Fault Protective Relays Configurations for Akademik 3-Phase-To-Ground.

Relay	CT Setting	Time Dial (s)	Pick Up (Tap)	Relay Characteristics	Max Operation Time (s)
R2	1600/5	0.39	5	NI	1.614
R4	600/5	0.10	5	NI	<=0.01

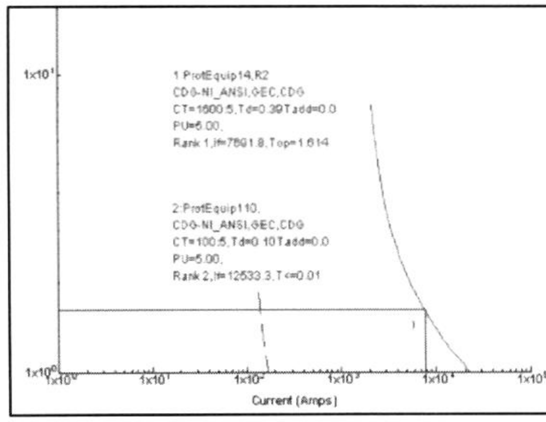

Figure 6: Time verse current curve for earth fault protective relay.

TABLE 6: Earth Fault Protective Relays Configurations for S&T Blok 4 3-Phase-To-Ground.

Relay	CT Setting	Time Dial (s)	Pick Up (Tap)	Relay Characteristics	Max Operation Time (s)
R2	1600/5	0.53	5	NI	1.605
R4	600/5	0.42	5	NI	1.190

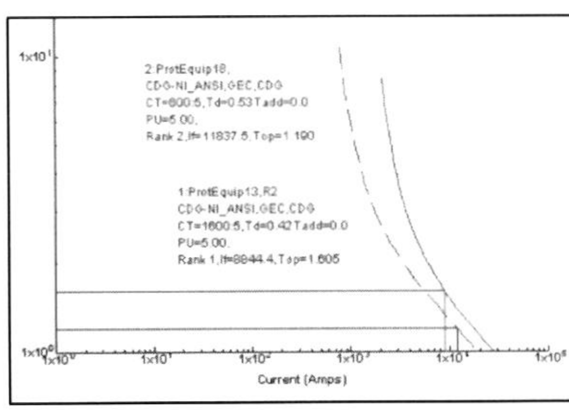

Figure 7: Time verse current curve for earth fault protective relay.

IV. CONCLUSION

This project is expected to analyze and predict the protective relay system setting by using PSS/Adept. The performance of relay will be known and compare with trip current at other bus network in same system. At the same time to study about to setting CT setting, time dial, pick up (tap) and characteristic of protective relay. In real life, the maximum operations time cannot get setting exactly as TNB define but only can settings almost dual to TNB demand. As a result shows the setting protective relay same as TNB standard. Simulated and analysis examples help students increase their understanding of over current and earth fault system protection operation, fundamentals of relay system and its application into bus network system, providing them a complete view of relay system protection in power system.

V. RECOMMENDATIONS

The basic rules for correct relay co-ordination can generally be stated use the relay with the same operating characteristic in series in each other. Besides that, make sure that the relay farthest from the source has current setting equal or less than the relay behind it, that is, relay in front is always equal to or less than primary current required operating the relay behind it.

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