Emergency Power Supply of Control Rod for RDE

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Abstract. The electrical system design of RDE control rod has been conducted. The requirement system designed must be reliable operated, safety to personnel and equipment, ease of maintenance and operation, protection of equipment electrically, interchangeability of equipment and addition of the several model of transducer. In order to achieve the above goals and obtain the desired results, the system based on electrical and instrumentation practical experiences will be needed. This paper consists of the design and the analysis of control rod electrical design and the instrumentation as well as control system. The criteria and the methods of designs of electrical and instrument equipment of the system have been discussed and investigated. The electrical and instrumentation control system drawing and requirement of design will be presented as the outcome of the design. The design of power system analysis and also to overcome the problem of under voltage is consequently simulated by ETAP 12.6.

Keywords: load flow analysis, control rod, RDE, and ETAP.

1. Introduction
Power supply Reactor Protection System (RPS) and test facilities of the Reaktor Daya Eksperimental (RDE) control road is designed from 3 sources, PLN, two diesel generators each 150 kVA and batteries. The power supply coming from the generator and battery is included in the emergency power supply system. Battery power supplies are grouped into Uninterruptible Power Supply (UPS) systems.

Batteries to be at the test facility consist of 3 (three) batteries with output voltage each (220 V-DC), and 6 (six) batteries, 3 units for +24 V and 3 other units respectively to -24 V as type with RSG GAS.

This UPS will be designed to consist of rectifiers and inverters having a capacity of 20 kVA, 3 phases that can be powered from PLN or Diesel Generator of 150 kVA each. Under normal conditions the rectifier output voltage and current will be charging the batteries, when the power supply loses from the PLN, the batteries will supply the current to the load (discharge) through the inverter.

The design a power supply of 10 control rods system, each driven by a stepper motor of 1 kVA, the total load is 10 kVA and the power supply 2 kVA for the control system. All power requirements are supplied through the main transformer PTKRN TR-1 and QMF-9. The power flow analysis is performed for each component's required rating and for future expansion of load requirements. Analysis of power flow using ETAP software becomes very important to know the current load requirement and future load requirement if needed addition of load requirement.
2. System Description of UPS

Uninterruptible power supply providers, also called AC-powered uninterruptible power supply (UPS-AC) are power suppliers that can serve customers continuously, and are a combination of the main PLN power providers, battery providers, rectifiers, inverters.

In general, the working principle of UPS under normal conditions is, the load is supplied through rectifier and reversing direction. Through the rectifier also the battery is loaded, thus if the main power supply fails or the rectifier is interrupted, the load remains united by the battery. The UPS at RSG-GAS is supplied by input voltage of 380 volts, 3 phases, 50 Hz, by the AC voltage rectifier converted to DC voltage of 240 volts. In normal operation, the rectifier will directly supply consumer dc (batteries) through L-C filters continuously with floating charging. Thus, the load remains united by the battery through the inverters when the main power supply (PLN) fails or the rectifier is interrupted. UPS-ac block diagram can be seen in Figure 1.

![Block diagram of RDE UPS system](image)

**Figure 1.** Block diagram of RDE UPS system

UPS-AC is arranged in one module with the main components are: 1. Rectifier (rectifier), 2. Inverter (reversing direction), 3. Battery and 4. System of protection and control.

The Data Specification uninterruptible power supply (UPS) used is Power-plus, PCW-20T 20 kVA type with input voltage 380 Volt, 3 phase and 380 Volt, 3 phase output voltage. The specification data as follow:

**Rectifier input**

| Model | : PCW-20T 20Kva |
|-------|-----------------|
| Rated of power | : 20 kVA |
| Input 1 phase maximum current | : 50 A |
| Phase | : 3 Phase + N + G |
| Voltage | : 380 Vac ± 20% |
| Frequency | : 50 Hz ± 10% |

**The data of Rectifier output**

| Model | : 20 Kva |
|-------|----------|
| Rated capacity (kVA) | : 20 kVA |
| Maximum Voltage | : 275 VDC |
| Regulator Charge | : 10A ~ 20A |
The data of Inverter

Model: 20Kva
Rated of power at cos φ = 0.8: 16 kW
Rated of Voltage: 380 Vac ± 1%
Frequency: 50 Hz ± 0.05%
Output Wave: Sinus
Overload: 125% full load for 10 minutes

The data of DC Battery

Rated capacity: 20 kVA
Maximum Discharge Current: 56A
Batteries unit: 111 units 2 volts vented lead acid battery
Rated battery voltage: 220 volts dc
Floating voltage: 275 volts dc
Charging battery: 10A~20A adjustable

The specification of rectifier is an ac voltage converter circuit (alternating) into a dc voltage (direct) through a diode. In Fig. 2 which is a rectifier circuit, it can be seen that the incoming voltage at the primary winding is 380 volts ac and the output voltage on the twist winding is 241 volts. Before the voltage goes into the transformer, skip past Q3. Where the fuses serve as a safety system when there is more current caused by both the mesh and load tension, so equipment will be passed safely.

$$V_{dc} = \frac{1}{T} \int V_0(t) \, dt$$  (1)

$$V_{rms} = \sqrt{\frac{1}{T} \int V_0^2(t) \, dt}$$  (2)

![Figure 2. Rectifier of RDE]
The battery is a standby power source in the UPS system, and as an important provider of energy supply guarantees in the event of a power supply failure in the main power supply.

The battery used in this UPS system is a block type, leaded with sulfuric acid solution. The initial voltage of the battery under normal conditions is 2 volts/cell. Each battery is equipped with AquaGen which serves to restore water vapor (hydrogen and oxygen) from evaporation back to the battery, so water does not decrease as long as no leakage occurs in the battery. The battery is capable of working for 45 minutes with full load (20 kVA) with a final voltage of 1.87 volts/cell. Float Operation is a battery loading operation mode with floating charging under normal circumstances, the battery will be loaded continuously at 2.25 Volt / cell ± 1% to keep the battery at full capacity. This loading is also called drop loading (trickle charging). The total voltage on the loading of the drip (trickle charging) of 270 volts dc. To shorten the charging time, the loading voltage is increased to 2.33 - 2.40 Volts/cell. This mode of operation is performed to produce a faster loading compared to threshold loading. The loading process does not require constant monitoring and can be done continuously for 48 hours.

3. Methodology
The step of load flow analysis electrical power supply of control rod shown Figure 3.

4. Result and Discussion
4.1. UPS characteristic
Characterization of UPS used for emergency power supply system and RPS power supply system by utilizing UPS and Battery in RSG - GA Siwabessy. Battery capacity is 176 AH, and from current measurement, the total current is obtained after 7 hours of discharge is 23.4 A. The measurement is stopped after 7 hours discharge so that when the load current calculation is 176 Ah/7 h = 25,14 A. Battery voltage drop characteristics in UPS are shown in Figure 4 shows the voltage drop during discharge on the battery.
While the characteristics of decreasing battery current on the UPS are shown in Figure 5.

The measurement of the total battery voltage and current during discharge, with the hourly measurement period, shows a decrease in voltage from 245 V to 213 V (13.06%) during 7 hours, so that the voltage per cell becomes 1.775 Volt and the system gives the alarm under voltage. Similarly, the battery current, as shown in Figure 5, had increased the current at 14.00 hours due to an increase in load, then dropped to 17.3 A.

4.2. Load flow characteristics

Single line diagram in the control rod power system and RPS system using ETAP is shown in Figure 6. From Figure 6 shows a single line diagram with field data input on PC1 panel and PLN transformer, also data obtained from the load design for load requirements of the HPS test facilities to be installed. After the load flows on all buses are no problem, then the simulation of the short circuit analysis is run. If there is a problem in one of its buses, i.e.: there is a red bus indicated at panel bus, check the error of parameter data input.
Figure 6. Single Line Diagram Power Supply of Control Rod RDE

The result of Load Flow analysis using ETAP is shown in Figure 7.

Figure 7. Load Flow Analysis of Control Rod RDE
From Figure 7 shows that the voltage drops at Control Rom Panel to supply of control Rod only 1 Volt. From RPS panel the voltage is 380 Volts, and there is no voltage drop for the panel. The Load Flow report from ETAP as shown at Table 1.

Table 1. Load Flow Analysis using ETAP

| Bus                  | Voltage | Generation | Load         | Bus                  | Voltage | Generation | Load         |
|----------------------|---------|------------|--------------|----------------------|---------|------------|--------------|
| CONTROL ROOM PANEL   | 0.380   | 99.823     | 0.080        | RPS-PANEL            | 0.380   | 100.00     | 0.080        |
| PANEL_PC-1           | 0.380   | 100.00     | 0.080        | QFM-82               | 0.380   | 100.00     | 0.080        |
| * Bus1               | 20.800  | 100.00     | 0.080        | * Bus11              | 0.380   | 100.00     | 0.080        |
| * Bus17              | 0.380   | 100.00     | 0.080        | * Bus11              | 0.380   | 100.00     | 0.080        |

The Table 1 shows the load analysis of the control rod power supply. It shows both the current flows and the voltage drop on the load component.

5. Conclusion
The voltage and current of the battery (DC) for 7 hours discharge decreased, i.e. V = 213 Volts and current I = 17.3 A, where the below voltage alarm works because the battery voltage has reached 1.78 Volt per battery or per cell. This value is very reliable to use for power supply control rod and RPS RDE. Electrical load flow analysis on control rod RDE electrical system has been conducted using ETAP software. The design of load flow analysis and also to overcome the problem of under voltage the maximum of load is simulated by ETAP.

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