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LOAD FLOW ANALYSIS FOR NON COMMERCIAL POWER REACTOR 10 MW ELECTRICAL EMERGENCY POWER SUPPLY

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ABSTRACT

Load flow analysis has been carried out for the emergency power supply system on Non-Commercial Power Reactors. The function of the electric power supply is very important so if there is a failure of the electric power supply it can have an impact on the continuity of the reactor operation. The only emergency diesel generators available are enough to supply the power supply for equipment needs related to the reactor safety system. The RDNK electrical system is designed in such a way that it is able to supply reliable electrical energy to loads consisting of various safety classifications. From the results of the analysis of power flow using ETAP simulation shows that all electrical power requirements related to the reactor safety system can be done properly and safely.

Keywords: load flow, emergency power supply, RDNK

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1. INTRODUCTION

The main electrical distribution supplied by the *PLN* grid is a very important factor in the operation of electrical equipment in the Non Comercial Nuclear Power Reactor. The role of the electrical power supply is very important so that if there is a failure of the electrical power supply it can have an impact on the continuity of reactor operation. The only emergency diesel generators available are enough to supply power supplies for equipment related to the reactor safety system. The success of reactor operations is largely influenced by the availability and reliability of the electrical system. The Non-Commercial Power Reactor (*Reaktor Daya Non Komersial, RDNK*) electrical system is designed in such a way that it is able to supply reliable electrical energy against loads consisting of various safety classifications [1,2,3]. For the safety of electric motors and other electrical equipment in the event of a disruption in the main power supply, the protection system will work, namely a power breaker in the form of a Circuit Breaker to open (OFF) to secure the electrical equipment it supplies, as well as vice versa when the power supply returns to normal then the power breaker (CB / Breaker) will close (ON) to serve the load. The reactor scram is not necessarily caused by a main power supply breakdown, but by a cooling system variable such as the flow rate of the primary cooling system pump. To ensure the safe operation of the reactor for humans, installations and the environment, the electrical system in the power reactor has been designed for two modes of operation namely normal operation and operation in emergency / abnormal conditions.

2. SYSTEM DESCRIPTION

The main electrical power supply supplying the electricity needs of the reactor installation is the electric power supply from the *PLN* distribution network with a capacity of 20 kV. Through two 20 kV / 400 V step down transformers namely the TR 01 power transformer and TR 02, the 20 kV threshold is reduced to a 400 V threshold on the secondary side. The capacity of the power transformer is 3000 kVA. Thus the total installed power for the reactor's need is 2506 kVA. The single line diagram of emergency power supply system is shown in figure 1.

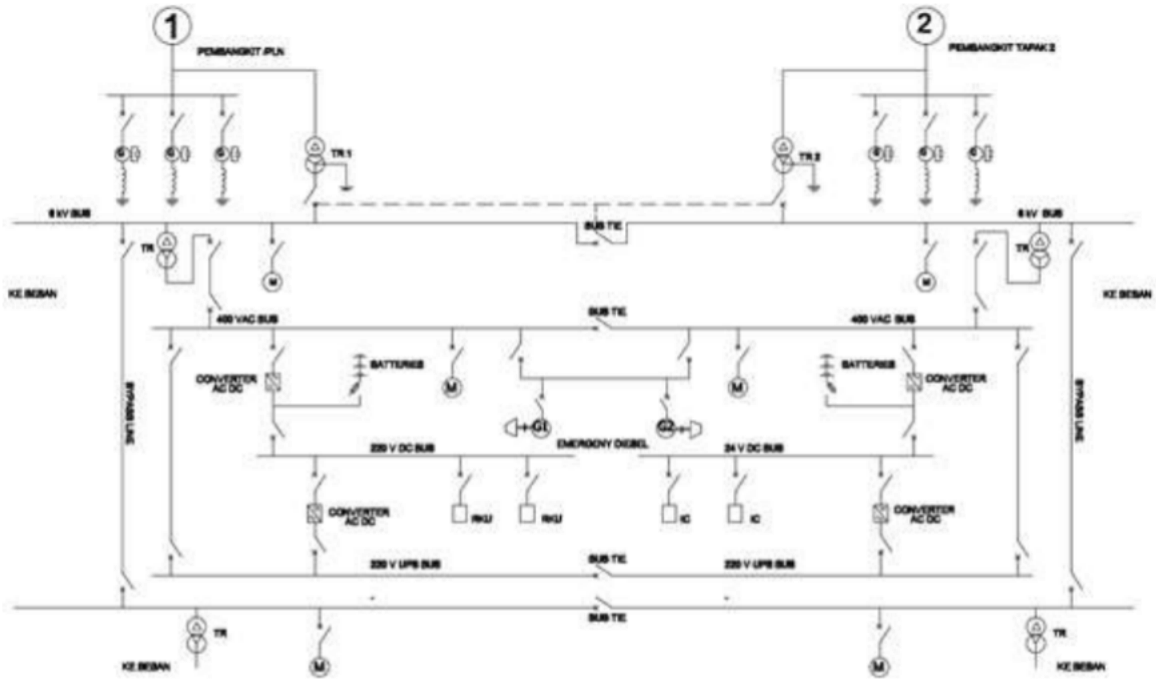

Figure 1 The RDNK 10 MW Emergency Power Supply System

The main electrical power supply supplying the electricity needs of the reactor installation is the electric power supply from the PLN distribution network with a threshold of 20 kV. Through two 20 kV / 400 V step down transformers, namely the power transformer TR_{01} and TR_{02}, the 20 kV threshold is reduced to a 400 V threshold on the secondary side. The capacity of the power transformer is kVA. The total installed power for the reactor's need is 2130 kWatt or 2506 kVA.

The gap between the phases and the phase on the receiver side of the power panels at 380 volt ac is adjusted to the rating of the electrical equipment connected to it. In the RDNK electricity planning it has been calculated that in the distribution cable network a drop of threshold of 20 volts occurs so that the threshold that can be reached is 380 volts on the receiver side.

The load distribution in the RDNK reactor electrical system is divided into two load groups namely the load group connected to bus A, and the load group B on Train A bus is supplied by a TR_{01} power transformer of 3000 kVA train B by a TR_{02} power transformer of 3000 kVA. Failures that occur on one bus will not affect the operation of other buses. Main bus bar II supplies emergency bus bars on the same train. Especially for emergency bus bars supplied interlocked by the generator diesel generator.

2.1. Emergency Power Supply

An emergency power supply system is a power supply system that works only if the main PLN power supply system is interrupted. As a source of emergency power supply is taken from two G1 diesel generator units and 550 KVA generator diesel generators that work independently. What is meant by a diesel generator is a power generating system that uses a diesel engine as a prime mover that works to turn the shaft of an electric generator as a source of electric power, along with its assistance system. The capacity of each diesel generator is 550 kVA with a capacity of 400/230 Volts. In normal operation, the gap on the emergency bus bar bus 1, and bus 2, supplied from PLN electricity in the form of a low voltage is 380 volts (phases). This threshold is monitored continuously by the reactor safety system (RPS). If at this time the threshold is less than 10% by the nominate, the RPS system provides a start-up signal to the generating diesel generator after an interval of 1 or 2 seconds since the event the signal is automatically inputted by the PPS.[4,5]. At the same time the emergency bus bar connection with the main bus bar II on ON (this system is working). For a while the load will lose power. In this condition the load will be served again by the generator diesel generator after an interval of (t) 120 seconds since the diesel generator start-up. Load services carried out by diesel generators are referred to as emergency operations as emergency power supplies. If the PLN power supply returns to normal, then the CB from the diesel generator generator will open (OFF) and the CB contained in the control panel that connects the main bus bar II with the emergency bus bar will close (ON), the interlock system returns to work. This way of working is implemented to prevent the closure of the two CBs simultaneously, because the parallel work of a diesel generator with a PLN grid is undesirable. During the CB interlocking transition, a short cut occurs again the electrical power supply to the load. If during the switch back to normal operation the PLN power supply fails again, the system will automatically return to emergency operation, and so on.[6,7,8].

2.2. Uninterruptible Power Supply

Make a design of uninterruptible power supplies, namely power supply systems that are the result of a combination of the main PLN power supply, battery power supply, conventer and inventer / UPS. From the viewpoint side, the electrical system in the Non-Commercial Power Reactor, consists of three uninterruptible power supply systems, namely:

1. Uninterruptible power supply 220 Vott ac, called UPS-ac.
2. Uninterruptible power supply 220 Volt dc, called UPS-dc.
3. Uninterrupted day supply + 24 Volt dc, called NBS or dc system.

The working principle of the uninterruptible power supply system is that when in normal circumstances it supplies the load while simultaneously charging (charging) the battery, and if the PLN power supply fails then the battery will release its load (discharging) supplying the load. Two Unintrrupıible Power Supply 1 UPS-ac units with 220 Volt, 50 Hz are provided to supply process computers and control equipment via a redundant bus.

3. METHODOLOGY

The calculation steps are carried out in the following stages:

a. Modeling the System using ETAP 12.6.0 Software

b. Input data, namely: PLN Source data, Transformers, Channels, and loads obtained from the system related to the RDNK power supply in this case using the diesel generator emergency power supply on the 10 MW RDNK and in the further development planning and data can be updated for the needs of the nuclear power supply emergency system.

c. Calculate the power flow using Newton-Raphson method

d. Evaluate the power flow and bus voltage on each bus in the system.

4. RESULTS AND DISCUSSION

4.1. Design of UPS

The results of the design of the UPS-dc (uninterruptible Power Supply-dc) system are provided to supply emergency lights and emergency signs via DC buses. As shown in Figure 2

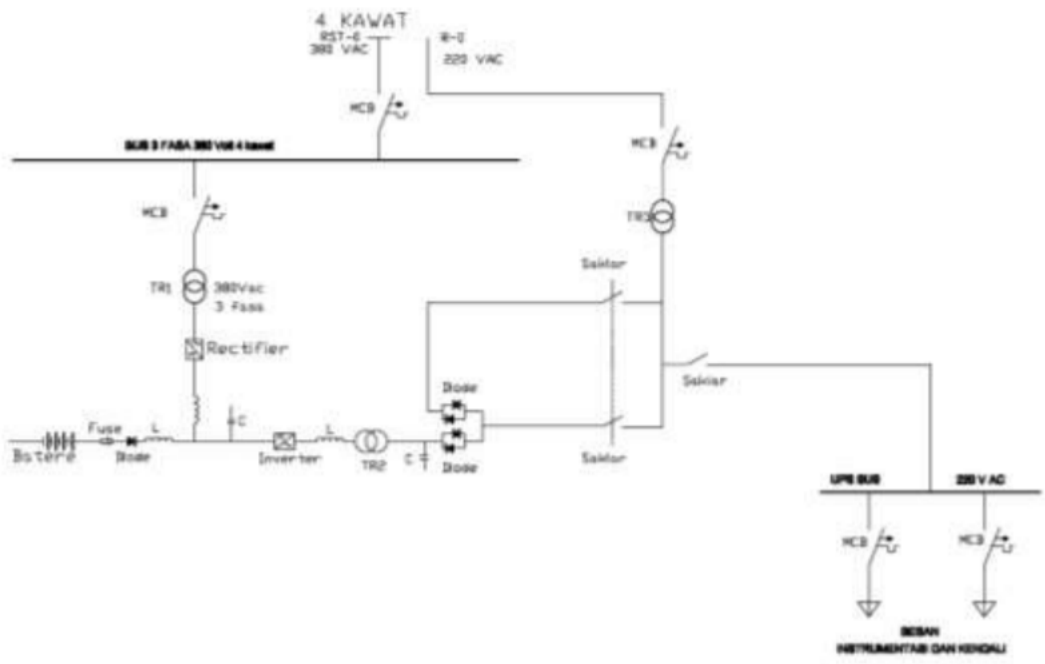

Figure 2 Emergency 3-phase Power Supply and 1-phase UPS

4.2. Emergency Power Supply Modeling

Emergency power supply system is a power supply system that works only if the main power supply from the PLN supply through the distribution transformer TR1 and TR2 is interrupted. As a power source, 2 (two) units of diesel power plants are used, or referred to as diesel generators, respectively G1 and G2. The G1 and G2 Diesel generators, which are used as backup power supplies for the RDNK Power Reactor, are a source of electricity that is generated by generators using diesel engines as initial motors. All types of safety system loads in the RDNK Estimate Power Consumption plant need electricity for all equipment in the Nuclear Area that is backed up from the UPS / battery system and diesel generators as shown in the following Figure 3 and Figure 4.

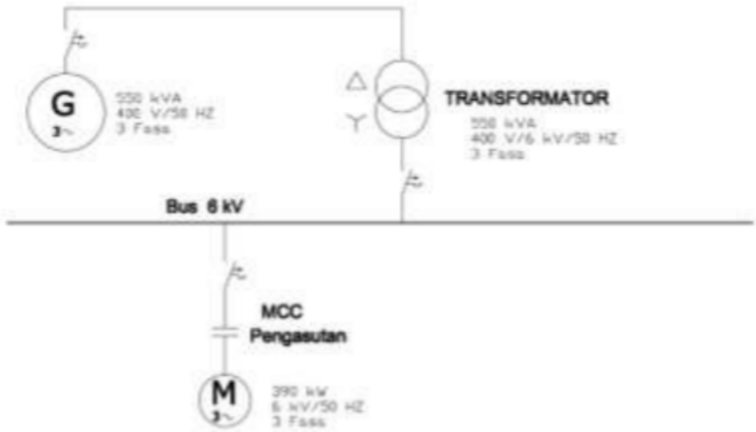

Figure 3 Emergency power supply of 390 kW RDNK blower motor

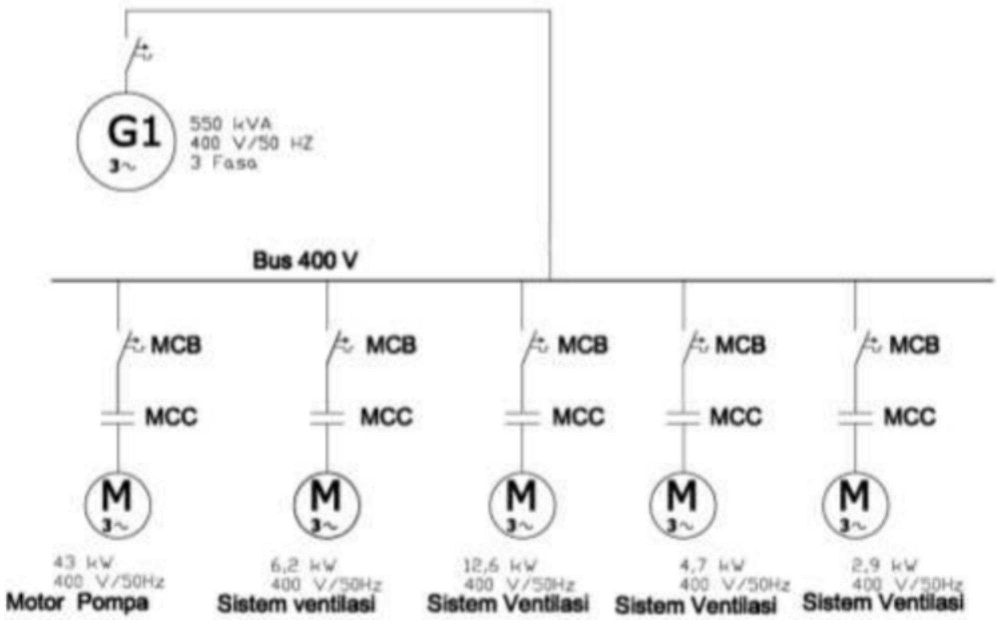

Figure 4 Emergency Power Supply for 10 MW RDE-RDNK Ventilation and Pump systems

The system modelling single line diagram of RDNK Emergency Power Supply Figure 5

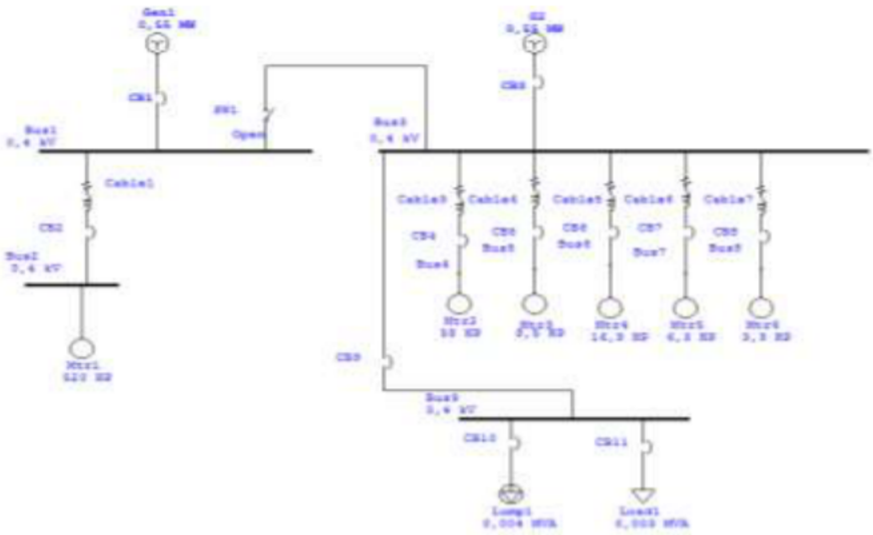

Figure 5 Modeling Single line diagram of RDNK Emergency Power Supply

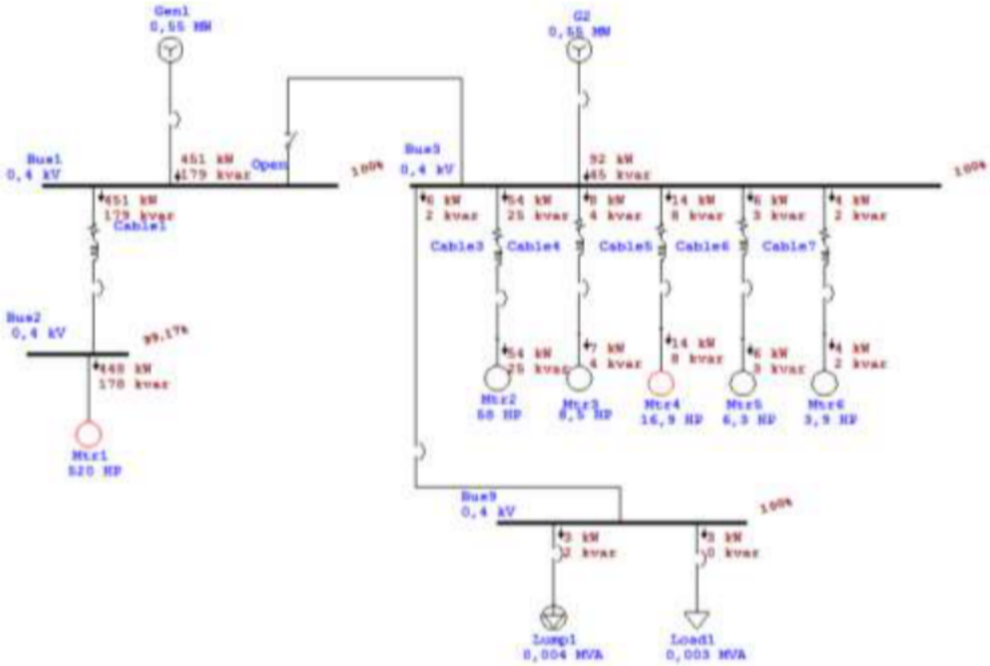

Figure 6 Results of load flow analysis of emergency power supply loads

It can be seen that generator 1 with 550 kW power supplies primary pump of 448 kW with PF of 92.83%. By design safe. for Generator 2 the load power is 91,623 kW with PF 89,72.

Table 1 Load flow on buses and connecting panels for RDNK emergency power supplies

ID	Type	kWc Flow	kvar Flow	Amp Flow	% Loading
Cable1	Cable	448	180	697,3	-
Cable2	Eq. Cable	416	176	697,6	270,3
Cable3	Cable	54,031	25,005	85,93	93,8
Cable4	Cable	7,508	4,414	12,57	71,3
Cable5	Cable	14,494	7,889	23,82	68,8
Cable6	Cable	5,636	3,419	9,514	54
Cable7	Cable	3,559	2,268	6,092	34,6

5. CONCLUSION

Load flow analysis has been carried out on the 10 MW RDNK emergency power supply system. the results of the analysis using ETAP software showed that generator 1 with 550 kW power supplied the primary pump by 448 kW with a PF of 92.83%. for Generator 2, the load power is 91,623 kW with PF 89,72. So that the design of the emergency power supply system can be used properly and safely.

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