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Design Schematic Diagram of Endwall Control Panel to Electric Rail Train T3 Commuter Line

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ABSTRAK

The number of Electric Rail Train (KRL) passengers in Indonesia increased by 20.62 million in February 2023, with an average of 736.5 thousand passengers per day, after the subsiding of Covid-19. In response to this increase and the push for more modern technology, PT KAI Commuter and PT INKA have collaborated to implement upgrades aimed at improving service quality and enhancing the efficiency of the train operation system. One of these upgrades was applied to the Commuter Line Electric Trains (KRL KCI) series 05 and 6000. The updates include the propulsion system, additional trainsets, and changes to the electrical panel layout. The reconfiguration of the electrical panel involved relocating the control system, previously located mainly under the train (underframe), now to both the underframe and the endwall. The endwall control panels are divided into two types: Endwall Control Panel A and Endwall Control Panel B.

1. Introduction

The use of rail transportation is slowly becoming popular with Indonesian citizens again after the Covid-19 pandemic subsided. Based on a report from the Central Statistics Agency (BPS), the number of train passengers in Indonesia reached 30.53 million people in May 2023. The number of passengers increased by 29.41% compared to the previous year [1]. Meanwhile, the number of passengers for Electric Rail Trains (KRL) reached 20.62 million people in February 2023, with an average daily passenger of 736.5 thousand people [2]. This is the highest record since the Covid-19 pandemic subsided.

As a result of the increase in passengers and the demand for an increasingly modern technological era, PT. The Railway Industry (INKA) strives to continue to carry out various innovations and updates to improve the quality and quality of service. Not only that, increasing the efficiency of the train working system must also be considered to reduce costs. One of the updates to the train work system occurred in the Commuter Line Electric Rail Train (KRL) or what could be called KRL KCI with series 05 and 6000 [3].

The KRL KCI is a fast transportation that connects urban center businesses with the outskirts of the city with a propulsion supply using electrical energy [4]. The propulsion technology used on the KRL KCI initially used a DC Chopper propulsion control system to supply DC electricity to the DC traction motor. However, the use of this propulsion requires extra maintenance, resulting in an update to the KCI KRL propulsion control system, namely using a VVVF (Variable Voltage Variable Frequency) inverter with a 3phase induction traction motor [5]. The updates were not only made to the propulsion control system, but there were also changes to the train formation, namely the addition of T2 and T3 carriages and changes to the layout and arrangement of the electrical panels [6]. These technological updates allow trains to have higher efficiency.

2. Research Methods

The method used in making the "Design Schematic Diagram of Endwall Control Panel to Electric Rail Train T3 Commuter Line" is qualitative descriptive analysis. This qualitative descriptive analysis places more emphasis on analysis of panel layout requests and analysis of various schematic data of existing control systems to create control panel designs that suit requests and needs [7].

2.1. Time and Location

The design of the Endwall Control Panel was carried out during industrial practice activities from 30 October to 22 December 2023 in the Electrical Design workroom of the Technology Division of Indonesian Railways Industry (PT. INKA) which is located on Yos Sudarso Street, Manguharjo District, Madiun City, East Java.

2.2. Panel Design Components

The Endwall Control Panel is formed from an arrangement of several types of protection and control components from various types of train electrical systems, both from driving force and electrical loads. The following are the components that are arranged in the Endwall Control Panel, namely:

- No Fuse Breaker (NFB)
- Relay
- Contactor
- Selector Switches
- Pressure switches
- Reed Switches
- Indicator Light

2.3. Research Flowchart

The Endwall Control Panel design has gone through various stages in its creation. The following steps are carried out according to the flow described in Figure 1 below:

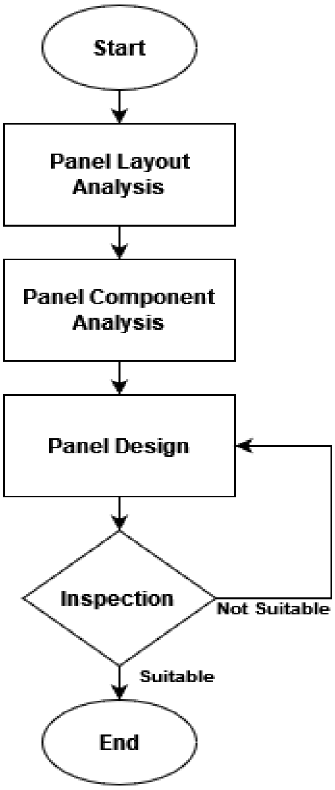


Figure 1. Research Flowchart

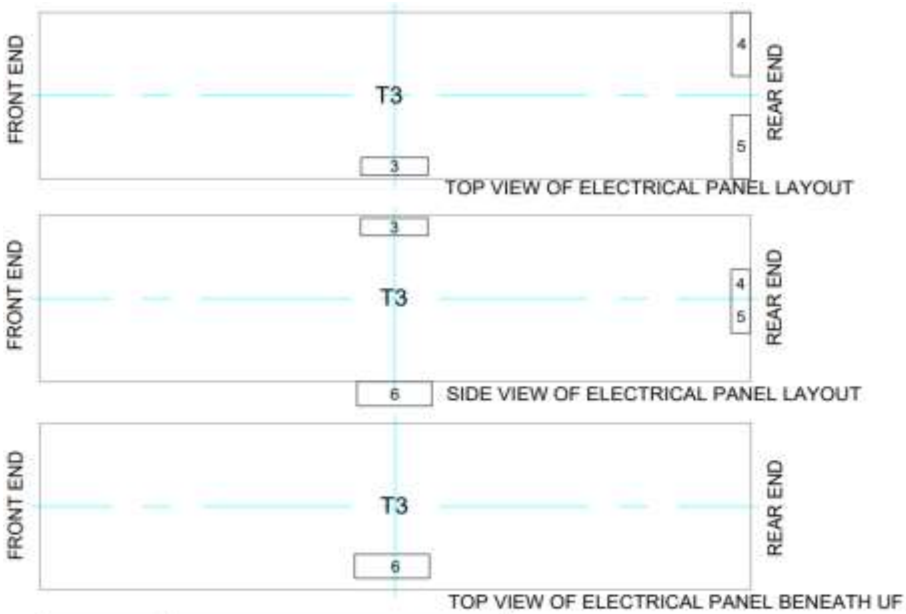
In the KCI KRL retrofit, there was a request to change the layout of the control system, which was previously dominant under the train (underframe), now the control system is divided into the underframe and endwall. The request for Endwall Control Panels is also divided into two types, namely Endwall Control Panel A and Endwall Control Panel B. Endwall Control Panel A will contain a control system in the form of relays, contactors, switches and indicator lights. Meanwhile, the Endwall Control Panel B contains an electrical protection system, such as CB (Circuit Breaker) and NFB (No Fuse Breaker).

After the panel components have been determined, the design is made by sorting and selecting components and connections from various control system schematics that will be inserted into the Endwall Control Panel A and B. Then, the panel designs that have been made will be checked first before being released to the vault storage system. If the design still contains errors and deficiencies, revisions will be made until the control panel design meets requirements.

3. Results and Analysis

3.1. Panel Layout Analysis

Before the retrofit, the KCI KRL control system was located at the underframe of the train. However, after the retrofit, the control system placement is divided into underframe panels and endwall panels. The underframe panel contains phase and neutral electrical power distribution which will be used to supply electrical energy to the endwall panels. Meanwhile, the endwall panel will contain an electrical load control system and its protection. The following is an overview of the layout of the electrical panels on the electric train commuter line retrofit, especially on the T3 carriage.



NOMOR	DESCRIPTION
3	AIR CONDITIONER PANEL
4	ENDWALL CONTROL PANEL A
5	ENDWALL CONTROL PANEL B
6	UNDERFRAME PANEL

Figure 2. Arrangement Layout of T3 Carriage Electrical Panel

Based on Figure 2, you can see boxes number 4 and 5 which show Endwall Control Panels A and B which are located at the end of the rear wall of the train, precisely close to the train aisle. This placement aims to facilitate testing, inspection, monitoring and control carried out by workers on the train electrical system.

3.2. Design Schematic Diagram of Endwall Control Panel A (T3)

Endwall Control Panel A is a series of several control components in the form of relays, contactors, switches, and indicator lights from several train electrical control system schematics combined in one panel, both from the driving force and the electrical load. The control system included in the Endwall Control Panel for each carriage is also different, depending on the functions and systems in the carriage. Especially for the T3 carriage, which is a type of trailer train whose function is to transport passengers or loads that will be moved or pulled by the M (motor) train.

The control system of the T3 carriage is quite simple and not as complex as other carriages. The control system on the T3 carriage includes: air conditioner control, brake & traction safe control, lighting control, tangential fan control, and door control. The following is a schematic diagram of Endwall Control Panel A which will be explained through a block diagram of each system incorporated in Endwall Control Panel A of carriage T3.

3.2.1 Air Conditioner (AC) Control System

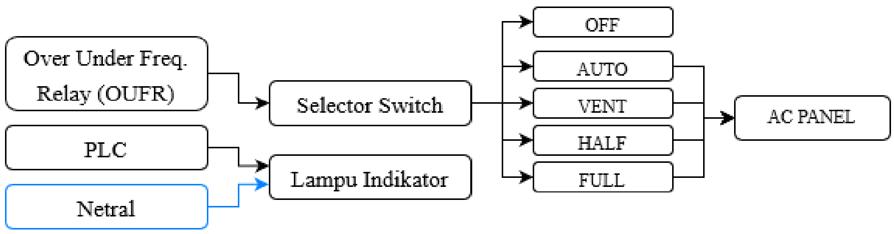


Figure 3. Air Conditioner (AC) Control System

Design schematic diagram of Endwall Control Panel A for carriage T3, starting from the AC load control system, which is explained in Figure 3, starting from the OUFR contact on the AC panel connected to the selector switch on the Endwall Control Panel A. This selector switch is used to set the AC mode, including off, automation, vent, half, and full. Next, the AC mode settings will be forwarded to the AC Panel. Then, in this AC control system there is also an indicator light which is used to indicate the condition of the AC. This indicator light gets input from the PLC (Programmable Logic Controller) output value located on the AC panel. This PLC contains instructions and various AC control functions which are used for monitoring and controlling the AC in real time.

3.2.2 Brake and Traction Safe Control System

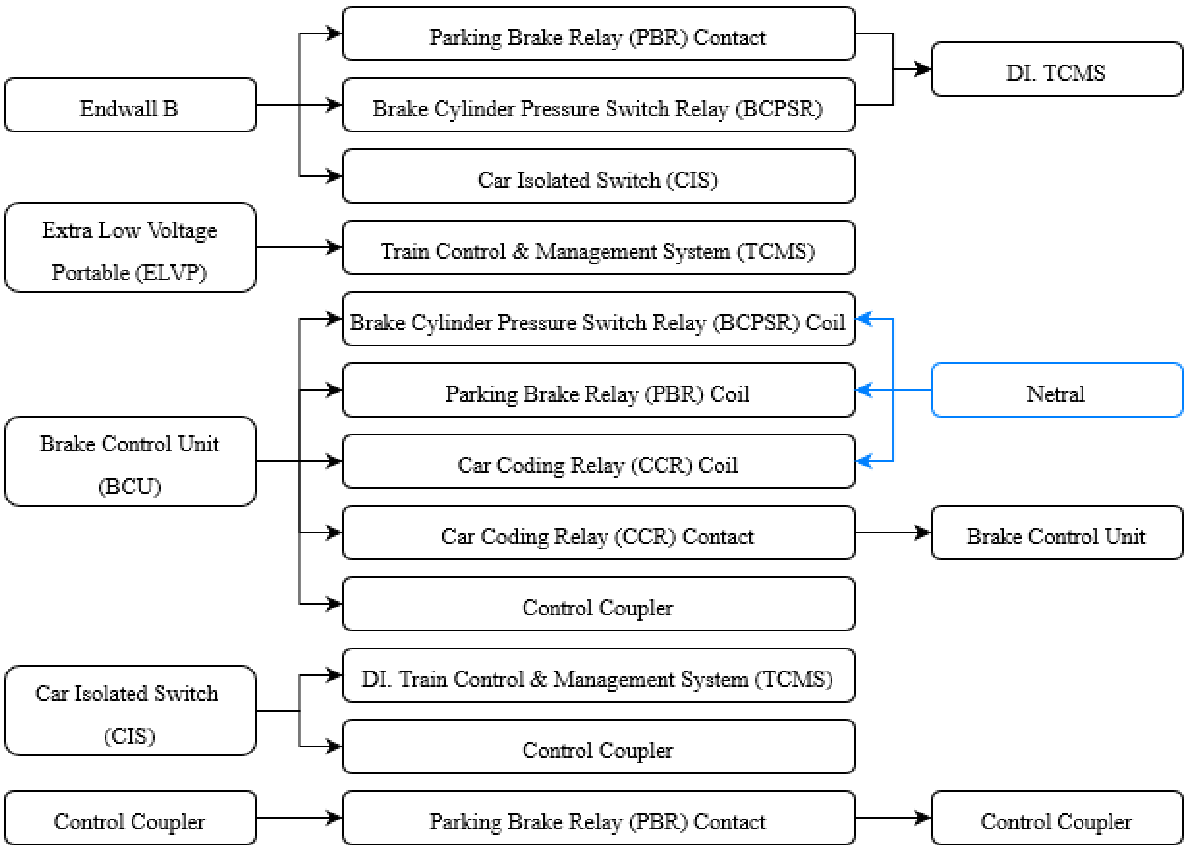


Figure 4. Brake and Traction Safe Control System

The second control system incorporated in Endwall Control Panel A is the braking and traction control system. This connection starts from the protection system located on endwall B to the PBR, BCPSR, and CIS contacts. Then the PBR and BCPSR contact lines are connected to the TCMS as a digital braking control input in the TCMS. Next there is ELVP which is the 110VDC electricity supplier for TCMS in the braking control section. Then there is the BCU which is a special module for braking control, this module is connected to the CCR contactor, PBR coil, and control coupler, which functions to control braking on the T3 carriage where the braking is connected to the braking settings of other carriages.

3.2.3 Lighting Control System

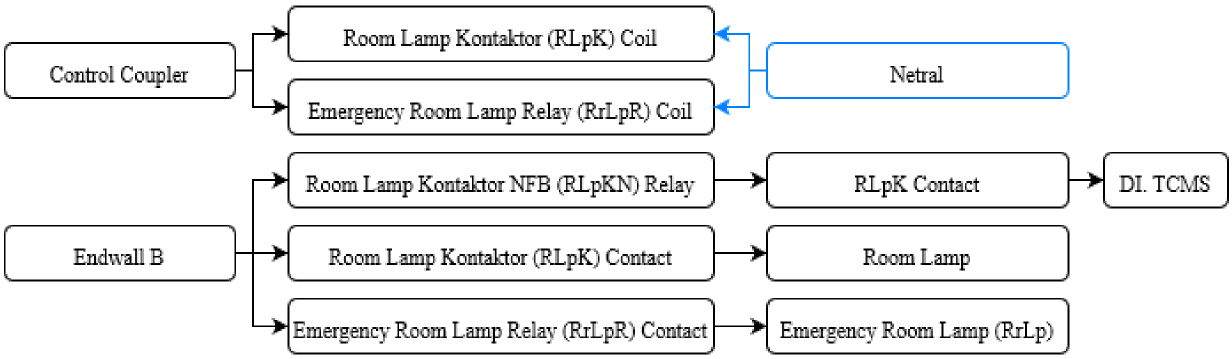


Figure 5. Lighting Control System

The next control system is the lighting control system, from the control coupler to the RLpK and RrLpR coils as closed supplies and the opening of the RLpK and RrLpR relay contacts to turn off and on the train room lights and emergency lights. Next, there is a connection from endwall B in the form of a light control protection system to the relay RLpKN, RLpK, and RrLpR. RLpKN is then connected to RLpK and then goes to the TCMS digital input as a light intensity regulator. There is also an RLpK contact which is connected to the train room lighting and also an RrLpR contact which is connected to the emergency lights.

3.2.4 Tangential Fan Control System

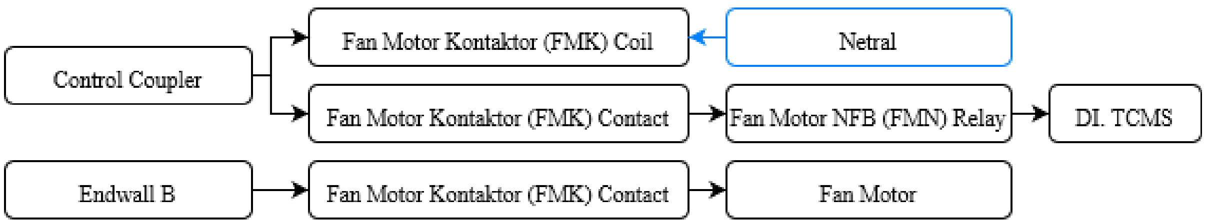


Figure 6. Tangential Fan Control System

The fourth control system is the tangential fan control system which functions as a panel cooler by circulating the air inside the panel evenly. The tangential fan control system, which is located in the Endwall Control Panel A, includes the FMK coil and contacts which are connected to the control coupler and the protection system of the tangential fan. The FMK contact line connected to the control coupler and FMN relay is the input value line for the TCMS. Meanwhile, the FMK contact from endwall B is used to start the motor or tangential fan drive.

3.2.5 Door Control System

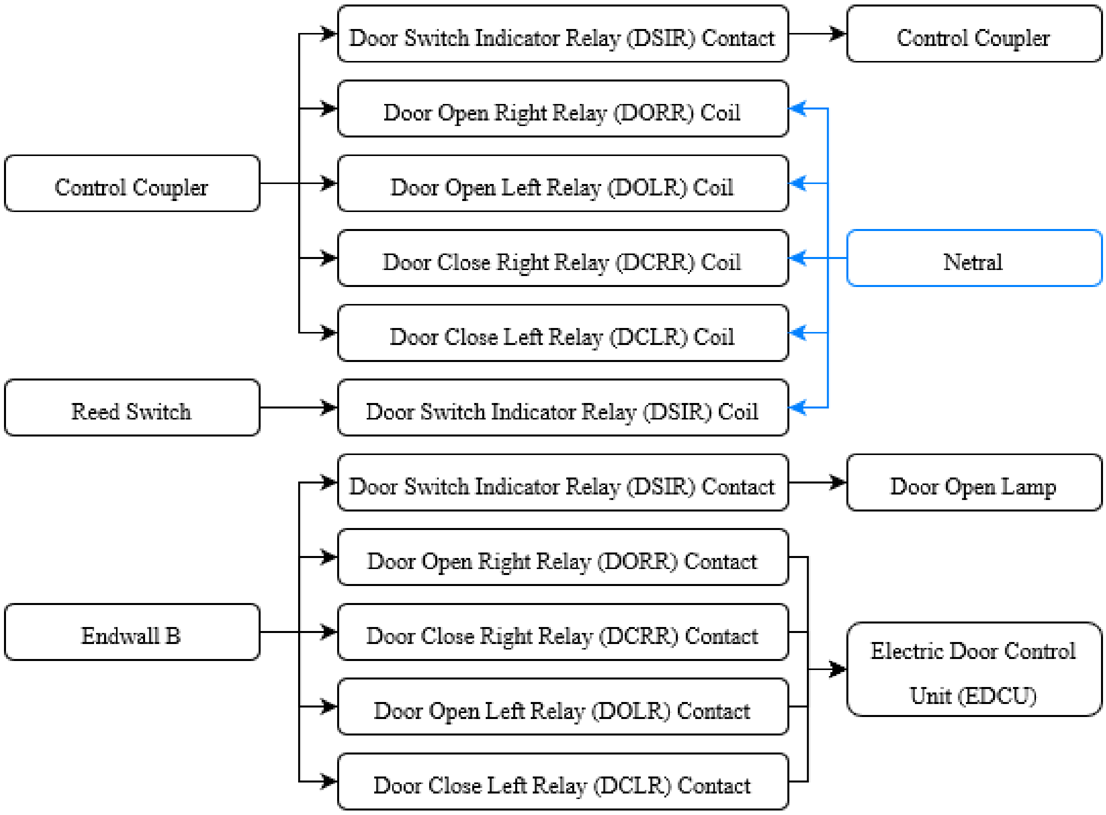


Figure 7. Door Control System

The last control system incorporated in the Endwall Control Panel A of carriage T3 is the train door control system, which is divided into right doors (open/closed) and left doors (open/closed). Starting from the control coupler output connection which is connected to the DSIR contact as a switch contact whose coil is connected to the reed switch. This reed switch functions as a sensor to detect door movement when it opens and closes, which will affect the DSIR contact which will then light up an indicator or notification in the form of a Door Open Lamp. The control coupler is also connected to the DORR, DOLR, DCRR and DCLR coils, each of these coils requires neutral electricity. Then the DORR, DOLR, DCRR and DCLR contacts from the NFB protection system go to the EDCU which is a control module that contains a train door control program with an electric motor.

3.3. Design Schematic Diagram of Endwall Control Panel B (T3)

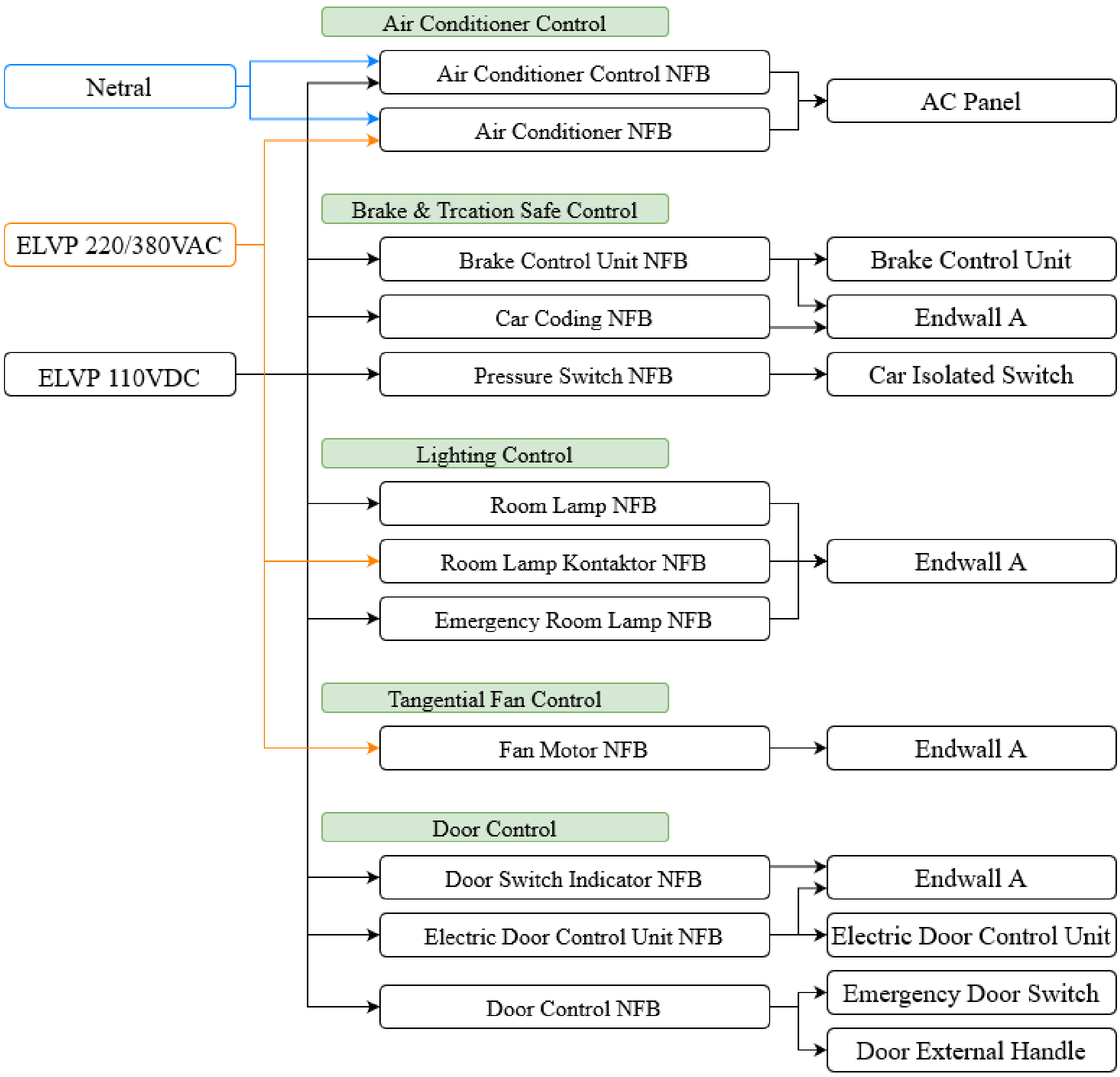


Figure 8. Design Schematic Diagram of Endwall Control Panel B for T3 Carriage

Endwall Control Panel B is a series of protection systems, in the form of CB (Circuit Breaker) and NFB (No Fuse Breaker) from several electrical control systems for electric rail trains. The function of this protection system is to prevent damage to components in the event of overcurrent and errors in system operation, by cutting off the flow of electricity from the power supply to the load. The protection control system incorporated in the Endwall Control Panel B of the T3 carriage also includes: air conditioner control, brake & traction safe control, lighting control, tangential fan control, and door control.

The schematic diagram of the Endwall Control Panel B (T3) starts from the ELVP (Extra Low Voltage Portable) which is used as a power supplier to the train's electrical system. There are 2 types of electricity sources from ELVP, namely ELVP with 220/380VAC power and ELVP with 110VDC power. ELVP with AC voltage is used to supply 1 phase and 3 phase AC motor loads. This 1 phase AC motor load is in the form of an NFB Fan Motor in the tangential fan control system. Meanwhile, the 3-phase AC motor load is in the form of a compressor, condenser and evaporator motor in the AC (Air Conditioner) control system [8].

Then, ELVP with 110VDC power is used to supply control loads, such as sensors, switches and relays. Therefore, the entire control system in the endwall panel requires VDC electricity which must be equipped with a protection system first. However, with the exception of the tangential fan control system, the control is centered on the TC (Trailer Car), so that the T3 carriage for the tangential fan system does not require DC voltage protection.

4. Conclusion

The KCI KRL retrofit request has begin to be designed and implemented, one of which is by designing the Endwall Control Panel on the newest formation, namely the T3 carriage. The control systems incorporated in the T3 car end wall control panel include: air conditioning control, brake & traction safety control, lighting control, tangential fan control and door control. Endwall Control Panels are divided into 2 types, namely Endwall Control Panel A and Endwall Control Panel B. Endwall Control Panel A contain control components in the form of relays, contactors, switches and indicators. Meanwhile, the Endwall Control Panel B contains a protection system in the form of NFB. The power supply used to supply the electrical load on the Endwall Control Panel uses ELVP with a voltage of 220/380VAC and also ELVP with a voltage of 110VDC. The Endwall Control Panel is expected to make it easier for workers to test, check, monitor, and control the train electrical system.

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