MASTER DEGREE IN INDUSTRIAL ENGINEERING

MASTER'S FINAL THESIS

ELECTRICAL PROJECT DESIGN FOR A CABINET IN AN ENGINE ROOM OF A COOLING PLANT

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- TITLE: Electrical project design for a cabinet in an engine room of a cooling plant.
- ABSTRACT: In the master's thesis presented below, the reconstruction design of an electrical cabinet is carried out to suit the new needs of the consumers in the engine room of a cooling plant in the meat sector. The aim is to present the control and protection of this engine room by means of a unifilar scheme, which includes identification of consumers, valves, cable selection, correct wiring connection for the proper functioning of the PLC, selection of protection elements, and so on. To carry out the development of this design, the EPLAN software will be used.
- KEY WORDS: Project design, cabinet, protection, control, engine room, EPLAN.

- TÍTULO: Diseño del proyecto eléctrico de un armario en la sala de máquinas de una planta de refrigeración.
- RESUMEN: En el trabajo de fin de máster que se presenta a continuación, se lleva a cabo el diseño de reconstrucción de un armario eléctrico que se adecúe con las nuevas necesidades de los consumidores de la sala de máquinas de una planta de refrigeración del sector cárnico. Se pretende presentar mediante un esquema unifilar el control y la protección de la mencionada sala de máquinas, lo que incluye identificación de consumidores, válvulas, selección de cables, correcta conexión del cableado para el buen funcionamiento del PLC, selección de elementos de protección, etc. Para llevar a cabo el desarrollo de dicho diseño, se hará uso del software EPLAN.
- PALABRAS CLAVE: Diseño del proyecto, armario, protección, control, sala de máquinas, EPLAN.

- NASLOV: Projekt elektroinstalacija razdjelnika u strojarnici rashladnog postrojenja.
- SAŽETAK: U diplomskom radu je prikazan tijek izrade projekta rekonstrukcije električnog ormara koji se prilagođava novim zahtjevima nvestitora. Ormar se nalazi u strojarnici rashladnog postrojenja u prehrambenoj industriji. U projektnoj dokumentaciji se nalazi crtani dio, lista potrošača i kabela, projektni proračuni i tehnički opis. Za razvoj ovog dizajna koristit će se softver EPLAN.
- KLJUČNE RIJEČI: Projektiranje projekta, kabinet, zaštita, kontrola, strojarnica, EPLAN.

- IZENBURUA: Hozte-instalazio bateko makina-gelaren armairu elektriko baten proiektu elektrikoa diseinua.
- LABURPENA: Jarraian aurkezten den master amaierako lanean, armairu elektriko bat berreraikitzeko diseinua egiten da, haragi-sektoreko hozte-instalazio bateko makina-gelako kontsumitzaileen behar berrietara egokitzeko. Eskema unifilar baten bidez aurkeztu nahi da aipatutako makina-gelaren kontrola eta babesa, eta horrek barne hartzen du kontsumitzaileen identifikazioa, balbulak, kableen hautaketa, PLCren funtzionamendu egokirako kableen konexio egokia, babes-elementuen hautaketa, etab. Diseinu hori garatzeko, EPLAN softwarea erabiliko da.
- GAKO-HITZAK: Proiektuaren diseinua, armairua, babesa, kontrola, makina-gela, EPLAN.

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I. MEMORY

1. INTRODUCTION

Due to the good work of a Croatian meat company, it has seen in its annual numbers a profit, that in order to increase it, they need their meat production to increase as well. The Croatian company has its own facilities, which contain the necessary machinery to process the amount of meat they produce now a days. However, they have enough space to carry out a possible improvement and expansion of the machinery that would mean an increase in the production of their goods.

The company, with the resources currently available in its production plant, has reached its profit ceiling and since there is still room for improvement and greater profits, the company is preparing to acquire new machinery and redesign the current plant so that it can continue to increase its production.

Improving the facilities will allow them to find out how far they can increase their production, so that the offer and demand of their goods will reach the optimal point and not be limited by their own facilities.

It is for all these reasons, that in the following document it is defined the reconstruction and remodeling to be carried out in the industrial plant. Being more precise, of what the entire project would cover, in this thesis it will only be taken place the remodeling and design of a new electric cabinet for the engine room of the whole cooling plant.

The development of the project has to be carried out with the participation of diverse engineering fields. The coordination and communication between the different departments is crucial to speed up and facilitate the labor. In the present project, as it is worked by the point of view of the electrical engineering department, it is needed to know the requirements, in terms of new consumers and their dispositions, that the energy engineering department establish for the remodeling and expansion of the resources in the facilities. It is also recommendable to know the preferences of the automatic engineering department to elaborate the design which best fits with their programming technique.

This project involves the elaboration of an electrical cabinet that fulfills the functions of protection and control of the electrical installation of the engine room of the meat industry referred to at the beginning of the introduction, in accordance with the needs and preferences established as explained in the previous section, by the other sets of engineering. For this purpose, it will be carried out the selection of protection elements according to the currents demanded by the consumers, correct selection of the contactors, selection of the appropriate wiring to suit the necessary technical requirements, the correct connection of the wiring of the consumers with the controller, etc.

2. PROJECT ASSIGNMENT

As can be read in the introductory part of the project, in this project the current engine room of the refrigeration plant of a meat company will have to be remodeled practically in its entirety. There are several objectives to be met by the project to successfully achieve the reform for which the reform is carried out.

First, new motors and pumps will have to be added in order to expand the system to accommodate the increased production of goods. Without this extra equipment, it would not be possible to increase the number of goods produced, as the facilities prior to this project were already working at maximum capacity.

As expected, the acquisition of new and more powerful machinery means that for regulatory reasons, new motor and pump start-up equipment will have to be added, i.e., new Soft Starters and more AC-Drives will have to be implemented.

To be able to handle all this new machinery and new control equipment, the controller that the plant has before this project is obsolete to be able to manage the control tasks, so it will be necessary to incorporate a new PLC to replace the existing control system.

The wiring of the system is also inadequate for the new elements to be added and what they cause. New calculations will have to be carried out in terms of load, voltage drop, impedance calculation, cable and protection conditions, and short circuits. Thanks to the parameterization that will be obtained from these calculations, it will be possible to choose the cabling that will replace the current one, and that will better adapt to the new needs of the system.

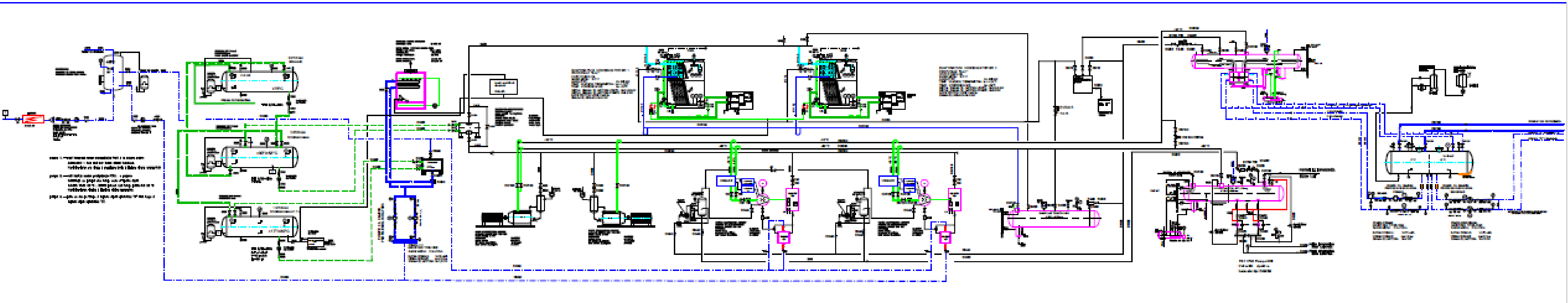

Figure 1. Engine Room Layout

3. TECHNICAL DESCRIPTIONS

3.1. MAIN DIVIDER ON/OFF IN EMERGENCY

Switching on the distributor is done by switching on the main power switch -Q0. Shutdown (emergency) is performed by pressing the emergency button -S0, while reconnection after emergency switch-off is done by pulling out the emergency button -S0, lowering the main switch lever -Q0 to position 0, then raising / switching on again switch to position 1.
The 230VAC control circuit is switched on / off via the -Q01 circuit breaker. Managing 230VAC circuit is intended for individual light signaling elements and control circuits of individual plug-in relays, thermal relays and contactors. The 24VDC control circuit is switched on / off via circuit breaker -Q00. The control circuit driven by the rectifier -V0 is intended for power supply regulators, individual light signaling elements, control circuits of individual plug-ins relays and power supply to the frequency and voltage converter control segments. Steering on / off the circuit of the 24VDC control system of the electric motor actuators of the valve is performed via circuit breaker.

3.2. CONDENSING TOWER OPERATION CONTROL

Switching on the condensing towers' consumers is done by setting the switches in the ON state, provided that the protective elements of the fan inverter pumps are switched ON. The switches are located on the closet door. The main control element of capacitor towers is the -A1 controller (PLC) which, guided by a signal from the pressure and outside temperature sensors, controls the switching of the fans and pumps of the associated capacitors, as well as the operation of the frequency converters of the fan capacitors. Converters of frequencies -U112 and -U113 according to the signal from the main controller -A1 control the fan speed condenser (PID speed control according to the difference between the desired reference and the actual amount of pressure).
The pressure reference is taken with respect to the outside temperature above the set temperature, outside air (floating reference) or as a constant reference if the actual outdoor temperature is below the set outdoor temperature limit. The pumps are switched on according to the three-position system regulation with hysteresis, ie according to the difference of temperature / pressure of ammonia in the condenser line ammonia.

If the condenser water temperature falls below the set value, condenser water heaters are switching ON. Additional condition for operation of the heater (with low water temperature) is also the activation of the level switch which is placed on the capacitor tower in the designated place and serves as a securing element off if the water in the condenser tower is at a critically low level (below the heaters themselves). By that, heaters are protected from possible overheating, ie power failure.

The operation signal is located on the cabinet door: operation signals / fan blockage and signals operation / blockage of pumps of associated condensers.

3.3. COOLING TOWER OPERATION CONTROL

Switching on the cooling tower elements is done by a switch. The switch is located on the door closet.
The main control element for controlling the operation of the cooling tower is the -A1 controller (PLC) which, guided by the temperature sensor signal at the inlet of the three-way valve, controls the switching and cooling tower pumps, and placing the three-way valve in the appropriate position (position A: heat dissipation from screw compressor oil to hot glycol tank – reheating TG tank; position B: heat dissipation from the oil of the screw compressors to the refrigeration tower – refrigeration oil cooler medium). The pump and fan are switched on according to the three-position control temperature hysteresis.

If the water temperature in the cooling tower falls below the set value, the cooling tower water heaters switch ON. Additional heater operating condition (with low water temperature) is also the switching of the level switch which is mounted on the cooling tower in the designated place and serves as an element of securing the shutdown if there is water in the cooling tower at a critically low level (below the heaters themselves). This protects the heaters from possible overheating, ie power failure. By turning on the water heater of the cooling tower can be connected additional heater pumps provide reheating of the pump in critical situations, for which there is a defined electrical a circle located in the divider. Reheating circuit in critical low temperature situations also it also includes reheating via a water pipe heater located in the open space. Heaters for water supply pipes on the cooling tower and both condenser towers are regulated by a common thermostat placed in an open space under the cable ducts near the cooling tower.
The operation signal is located in the cabinet door: the operation signals of the fan and the cooling pump tower.

3.4. AMMONIA CONTROL SYSTEM FOR PUMPS, SEPARATORS AND COLLECTORS

Switching on the -30 ° C separator is done with a PLC, which makes it possible to operate the pumps in 4 modes:

0 – Turned OFF
1 – Pump 1 ON
2 – Pump 2 ON
3 – Both pumps ON

The operating conditions of each separator pump are:

a) Motor protection switch switched on (-Q41 / -Q42).
b) Thermal protection of the pump switched on (-K411 / -K421).
c) Lower level switch turned on (ammonia level in the separator above allowed lower levels).
d) Differential pump pressure switched on.
e) Activated operation order by at least one tunnel evaporator controller via relay.

If one pump is blocked, the operation is automatically switched to another (and vice versa), if the other pump is not blocked.
Upper level switch -SNH30.0 on the -30 ° C separator acts as a lock signal of screw compressor and serves to ensure that screw compressors do not operate if a critically high level of ammonia occurs in a separator -30 ° C. The upper level switch -SNH10.0 on the -10 ° C separator acts as

blocking for piston compressor and serves to ensure that piston compressors do not operate if critically high levels of ammonia in the separator -10 ° C.

Automatic regulation of the operation of the elements on the separator includes the following elements and theirs tasks:

a) regulator -A1 (PLC) - controls the operation of the valve with electric motor drive + NH3SEP30-Y1 for ammonia inflow to separator -30 ° C, by monitoring ammonia level in a separator -30 ° C via a level probe + NH3SEP30-B1. Valve position control mode is continuous PI regulation. The device also monitors the condition of the upper level in the separator -30 ° C (blocks flow, if switch turns off) and valve open condition. Top level switch when the permissible value of the ammonia level is exceeded, the solenoid valve switches off (closes the valve), thus ensuring the stoppage of the flow of ammonia into the separator -30 ° C.

b) regulator -A1 (PLC) - controls the operation of the valve with electric motor drive + NH3SEP10-Y2 for ammonia inflow to -10 ° C separator, by monitoring ammonia level in a separator -10 ° C via a level probe + NH3SEP10-B2. Valve position control mode is continuous PI regulation. The device also monitors the condition of the upper level in the separator -10 ° C (blocks flow, if switch turns off) and valve open condition. Top level switch when the permissible value of the ammonia level is exceeded, electromagnetic valve switches off (closes the valve), which ensures that the flow of ammonia to the separator -10 ° C is stopped.

c) regulator -A1 (PLC) - controls the operation of the valve with electric motor drive for ammonia inflow to the collector, by monitoring the ammonia pressure in tunnel pipeline via pressure probe. The valve position control mode is continuous PI regulation. The device also monitors the level of the level in the collector via a level probe + NH3SEPTUN-B3.

d) The electric motor drive of the valve is controlled manually, by switching switch, where state 1 of the switch corresponds to switching the valve to medium mode -10 ° C, while state 0 corresponds to the valve setting to -30 ° C mode.

3.5. REGULATION OF THE OPERATION OF THE PRIMARY AND SECONDARY COOLING CIRCUIT WITH GLYCOL

Switching on the primary glycol pumps is done with switches, where each switch positions represent the following:

- 0 – Off
- 1 – Manual operation of the pump (open regulation)
- 2 - automatic pump operation (closed pump control is controlled by controller -A1);

The protection conditions for the operation of the primary glycol circuit pumps are: pump motor protection switch switched ON and integrated pump thermal relay. In manual operation the pumps work by directly switching the switch to position 2. In automatic pump mode (subject to conditions

protection) is controlled by the PLC. The measuring signal of the regulation is the temperature probe placed in the left side of the glycol tank, while the temperature probe on the right side of the tank is used for monitoring. Type regulation is three-position, with temperature hysteresis.
The operation signal is located on the cabinet door: operation signals / blockage of the primary glycol pumps.

Glycol secondary pumps are switched on by switching on -SM312 / -SM322 power supply of frequency and voltage converter control circuits -U312 / -U322 that control the pump speed secondary. Inverters function as regulatory protection elements and signal both operation and interlock individual pumps. The inverters also control the rotation speed via a pressure signal on two pipelines (consumers of expeditors / consumers of the technological part) through continuous PID regulation (references and actual pressure values in the system). Via analog signals that the converters send to the inputs of the PLC, the monitoring of operation of the pumps secondary is enabled on central – monitoring system.

The pump operation signal is located on the cabinet door: operation signals / blocking of pumps primary glycol.

3.6. SCREW COMPRESSOR OIL COOLER PUMP CONTROL

Switching on the working pump of the oil cooler of the screw compressors is done with a switch, where switch positions correspond to the following states:

- 0 – Off
- 1 – Pump 1 On
- 2 – Pump 2 On

A pump in operation runs at the same time as at least one of the two screw compressors.
The protection conditions for the operation of the oil cooler pumps are: the motor protection switch of the pump switched on (-Q61 / -Q62) and switched on pump thermal relay (-K611 / -K621).
If one pump is blocked, the operation is automatically switched to the other (and vice versa), if the other pump is not blocked.
The pump operation signal is located on the cabinet door: operation signals / blocking of oil cooling pumps.

3.7. CONTROL OF SYSTEM OF PUMP OPERATION FOR CONSUMABLE HOT WATER

The three-stage switching PTV pumps is done by switches.
The operating condition of the 1st stage pump is, in addition to the, the motor protection switched on and the signal relay of the drive of one of the screw compressors is switched on. The 1st stage pump is running when at least one of the screw compressors is in operation. The speed control of the pump is controlled by a frequency converter which located at the pump itself. Regulation is performed via a digital pressure and heat sensor, while on the inverter it can also monitor the temperature in the PTV stage 1.

The operating condition of the 2nd stage pump is, with a switch and the motor protection switched on and the signal relay of the drive of one of the compressors is switched on. The 2nd stage pump works when at least one of the compressors is in operation. The pump speed control is controlled by a frequency converter located on the pump itself. The control is performed via a digital pressure and heat sensor.

The operating condition of the 3rd stage pump is, in addition to a switch, the motor protection switched on and the signal relay of the drive of one of the screw compressors is switched on. Pump speed is controled by frequency converter located on the pump itself. Regulation is performed via two Pt1000 probes placed in 2nd and 3rd stage tanks and guided by the temperature difference. If the temperature of water in the 2nd stage tank is higher than that in the 3rd stage tank the pump is running. It's also possible to monitor pressure and temperature on converter via digital sensor.
The pump operation signal is located on the cabinet door: operation signal / blocking of pumps three-stage PTV.

3.8. CONTROL OF PUMPS AND REHEATING HEATERS ON THE HOT GLYCOL SYSTEM

Switching on the melting pump is done with 2 switches (hot glycol pipeline pump according to consumers of the forwarder / technological part).
The operating condition of the tank reheat pump is the motor protection switched on and switched-on signal relay request by at least one regulator on expedition / technological part that works with dissolving hot glycol. Automatic pump operation controlled by the PLC, via the signal of temperature probe located on the suction side pumps. The type of regulation is three-position, with temperature hysteresis. In manual operation, the pump works by fitting a separate terminal located in the terminal box -X24VDC.

The operating condition of the hot glycol piping pump to evaporators is switched on motor protection switch and switched-on relay signal request by at least one regulator on the expedition / technological part that works with dissolving hot glycol. The signal relay for dissolving can be bypassed as a condition of operation by switching on the isolating terminal located next to the relay dissolution signal. In this case, the pump only operates with basic switching conditions (motor safety switch and control switch). The regulation of speed of the pump is done by a frequency converter which controls the pump speed via a digital temperature and pressure sensor.

Switching on the reheating heater is done by switching on the switch located inside divider. The operation of the heaters is fully automatic, and they are controlled by the PLC via temperature probe located in the hot glycol tank. If the temperature drops below the set levels of the controller starts a certain degree of reheating (one, two or all three heaters).
The regulation is cascading with three temperature hysteresis.
In addition to monitoring the operation of the elements in the hot glycol system, the PLC also enables monitoring of analog (speed) and digital (operation signals/ blocking) pump operation signals on the secondary glycol circle.
Pump and heater operation signaling is located on the cabinet door: operation signals / blockage of pumps and switching on signal of heater for reheating.

3.9. OPERATION AND PURPOSE OF OTHER ENGINE ROOM AND CONTROL ROOM CONSUMERS

The divider also contains protective and switching elements for the booster pump station pressure, optional protection, start / stop, and associated operation signaling and blockage fan for air extraction in the control room (if installed), protection of non-condensing gas separator, electrical reserve, and power switch tunnel dryer distributor.

4. ELECTRICAL CONSUMER DESCRIPTION

4.1. CONDENSER SYSTEM (X2)

These condenser towers are used to condense the vapor that circulates through the condensing coil. To carry out this commitment, the condenser tower is provided with 1 pump, 2 fans, and 1 water heater to avoid the possibility of water freezing in the water basin in cold seasons.

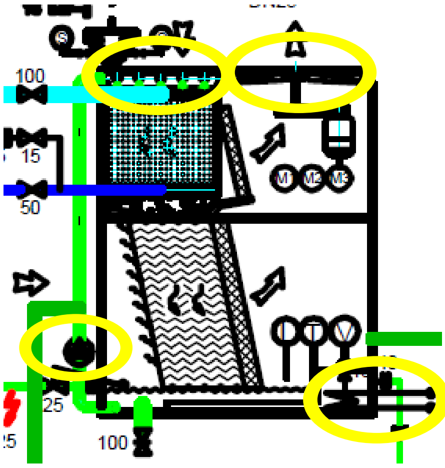

Figure 2. Condenser Tower

4.1.1. SPRAY PUMP

Figure 3. Condenser Spray Pump

P	5,5 KW
V	3x400 V
I	11,3 A

Table 1. Spray Pump's T.C.

4.1.2. FAN (X2)

The purpose of the first axial fan is to draw outside cold air to the condensing coil to help the spray system to cool the vapor going into the coil. The second of the fans is an axial fan which extracts to the outside the warm saturated air which comes from the drift eliminator. The 2 fans are identical, so we are just going to show the picture of one of them and its technical characteristics.

Figure 4. Condensers' fans

P	5'5 KW
V	3x400 V
I	11,3 A

Table 2. Condensers' fan T.C.

4.1.3. WATER HEATER

The main task of this heater is to prevent the water that is cooled in the water basin from freezing, what could damage the pump in case of recirculate ice fragments.

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P	8 KW
V	230 V
I	34.8 A

Table 3. Condenser Water Heater's T.C.

4.2. CONDENSER CIRCUIT PUMPS

These 2 pumps, that they are identical, they are situated under the NH3 -30°C tank. The pumps have the characteristic that they are strew pumps, so they can compress the liquid inside them and pump it easier when it is too dense.

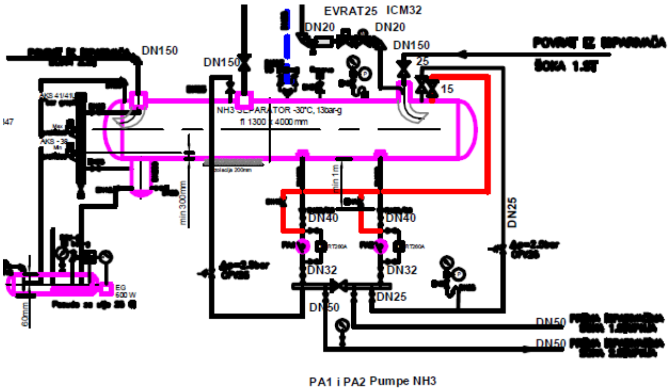

Figure 5. Condenser Circuit's Pumps

Figure 6. Pump Hermetic Cam (r) 2/4

Motor	AGX 4.5
P	4.5 KW
V	3 x 400 V
I	10.4 A

Table 4. Condenser Circuit Pumps' T.C.

4.3. PGW COOLING SYSTEM

The PGW cooling system has 2 commitments. The first one is to pump this coolant to the room where the goods are manipulated. For that task we have 2 electric motors/pumps (P1, P2). The second task of the system is to send refrigerant to the room where the goods are stored. In this case the electric motors/tasks needed are larger (P3, P4) than the used for the first task.

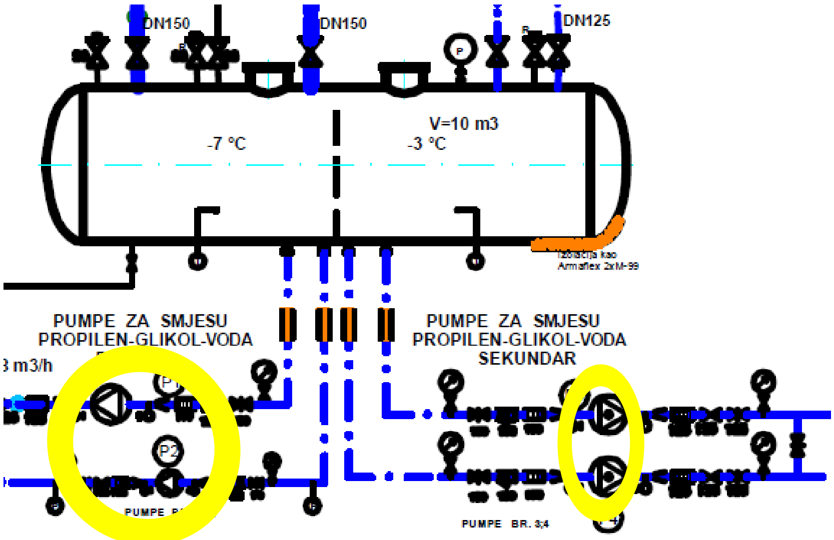

Figure 7. PGW Cooling System

4.3.1. PUMPS 1-2

They use soft starters for the motor starting. Soft Starter is used when the load is very big since the beginning, and it will ask for high current. That is why it is used a soft starter, to control those current peaks, starting slower (littler by little) the motor until it reaches its nominal speed.

Figure 8. Grundfos TP100-130/4

P	4 KW
V	3 x 380-420D
I	7,9-8,15 A
f.d.p.	0,8

Table 5. Pumps' 1-2 T.C.

4.3.2. PUMPS 3-4

They use AC drives for the motor starting and regulation. AC drive is used in a similiar way as the soft starter. We can control the speed of the motor varying the output frecuency we send to the motor. Because the voltage is varied in the process of changing the speed/frecuency, the startup current is also controled.

Figure 9.Grundfos TPE 100-310/2 A-F-A-BQQE-OX1

P	15 KW
V	3 x 380-480 V
I	30.0-26.0 A
f.d.p.	0.91-0.86

Table 6. Pumps' 3-4 T.C.

4.4. WARM PGW TANK

The Warm PGW Tank is formed by 2 motors which have installed an AC-Drive on them. It is also formed by 6 heaters as it is shown in the following picture.

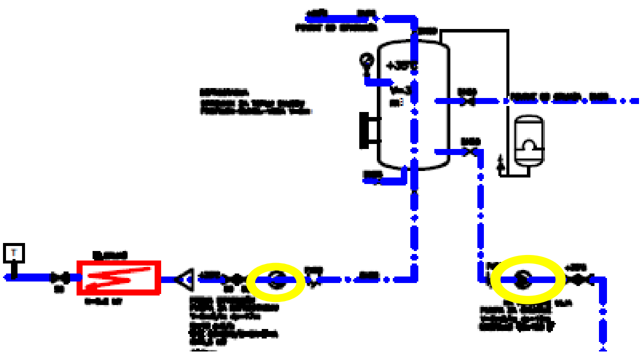

Figure 10. Warm PGW Tank

4.4.1. PUMP (X2)

Figure 11. Grundfos TPE3 50-240-S A-F-A-BQQE

P	2.2 KW
V	3 x 380-500 V
I	4.35-3.55 A
f.d.p.	0.91-0.85

Table 7. Pump's T.C.

4.4.2. HEATER (X6)

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P	2 KW
V	230 V
I	9,0 A

Table 8. Heater's T.C.

4.5. WARM WATER TANKS

The Warm Water Tank circuit is composed by 3 identical pumps that are located under of each tank. Each pump serves for each stage of the warm water.

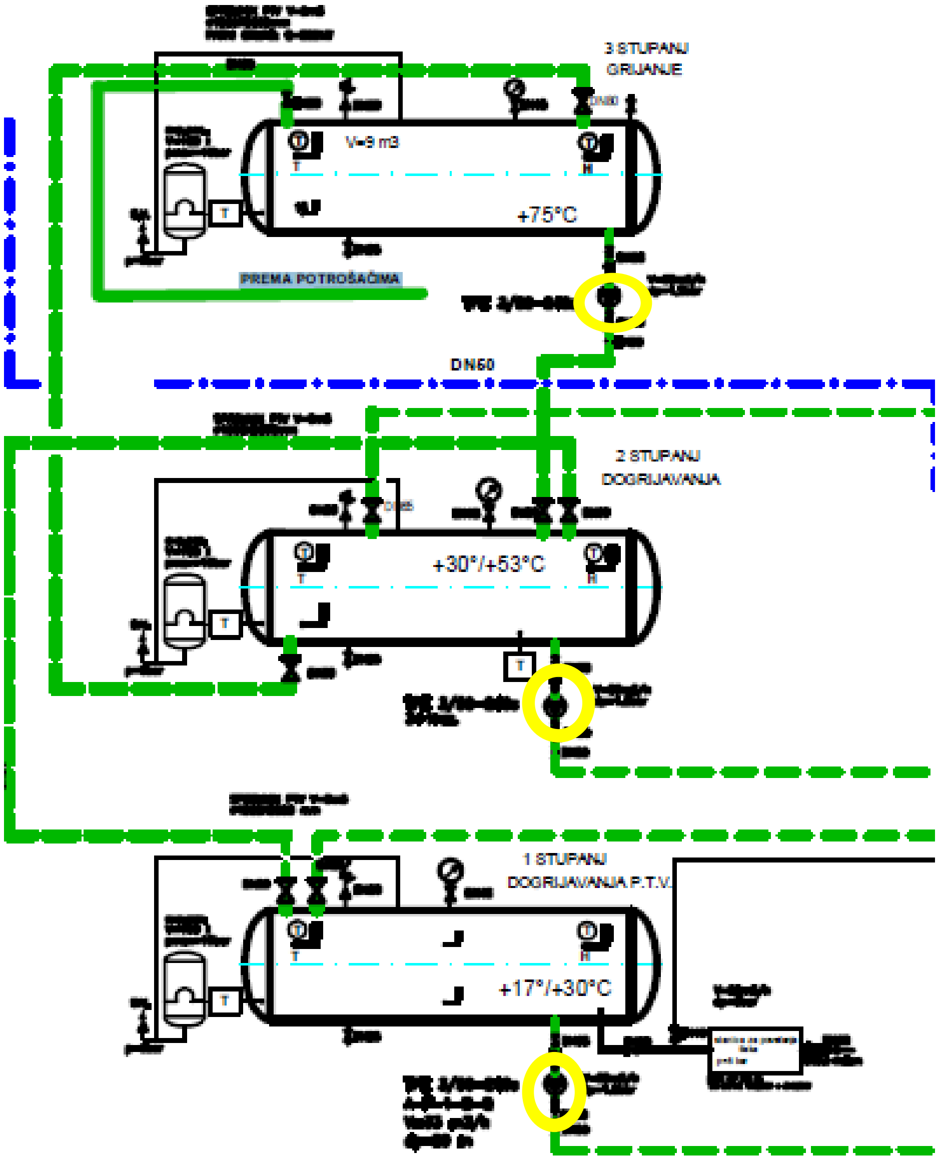

Figure 12. Warm Water Tanks

4.5.1. PUMP (X3)

This are 3 identical pumps which have an AC Drive installed in themselves soy they can regulate the speed of their rotational movement.

Figure 13. PUMP Grundfos TPE 40-270/2 S-A-F-A-BQQE-HDB

P	1.5 KW
V	3 x 380-500 V
I	2.9-2.4 A
f.d.p.	0.92-0.85

Table 9. Pump's T.C.

4.6. OIL COOLING CIRCUIT

This Circuit is formed by 2 pumps that are in charge of move the oil, and it is also formed by a little cooling tower which includes a pump and a fan.

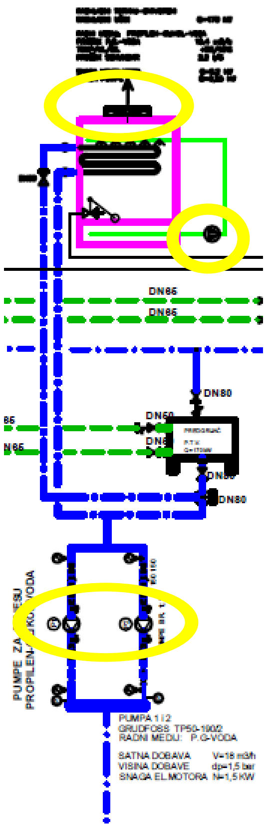

Figure 14. Oil Cooling Circuit

4.6.1. MAIN PUMP (X2)

This pump works directly connected on line. Its power demand is so low that it allows us to connect t directly on line independently of the current peaks that may appear.

Figure 15. Grundfos TP 50-190/2 A-F-A-BQQE-HX1

P	1.5 KW
V	1 x 220-230/240 V
I	8,9-9,9 A
f.d.p.	0.98/0.99

Table 10. Main Pump's T.C.

4.6.2. COOLING TOWER'S PUMP

This is a direct on line pump due to his low current demand, in deed is the consumer with the lowest current demand.

Photography not found

P	0.25 KW
V	3 x 400 V
I	0.80 A
f.d.p.	0.7

Table 11. Cooling Tower's Pump's T.C.

4.6.3. COOLING TOWER'S FAN

This motor, as the same as the cooling tower's pump, it is a direct on line motor. Although it has higher current and power demand than the pump before, it is low enough to endure the current peaks when starting directly on line the motor.

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P	2.2 KW
V	3 x 400 V
I	5.0 A
f.d.p.	0.81

Table 12. Cooling Tower's Fan's T.C.

II. METHODOLOGY FOLLOWED IN THE DEVELOPMENT OF THE PROJECT

This section will describe the tasks and steps that have been followed to carry out this project. The necessary calculations will be clearly explained and developed in the corresponding section.

The first part of this section will focus on the explanation of each step that has been followed to carry out the development of the project.

In the second part, the time required to carry out each of the tasks related to the project will be graphically visualized by means of the Gantt diagram.

1. DESCRIPTION OF PROJECT PHASES

1.1. STAGE 1: IDENTIFYING CONSUMERS

In the first stage of the development of the project, the purpose was to identify the consumers that make up the machine room of the meat company's refrigeration plant. To this end, the plans of the machine room were carefully and closely studied, highlighting those energy-consuming elements to be considered in the design of the electrical protection and control cabinet. Once the consumers of the system have been located, they are grouped in groups, in such a way that we can work in blocks. These groups are the following: Condenser system (x2), Condenser circuit pumps, PGW cooling system, Warm PGW tank, Warm water tanks and Oil cooling circuit.

After grouping and locating the consumers, we will identify the manufacturer and model of the consumers used in the machine room. In case the department in charge of selecting the devices and constituent elements of the machine room does not know the technical characteristics of the consumers, it will be necessary to go to the manufacturer's website to obtain the data sheet of the consumers and thus be able to tabulate the technical characteristics of each one of them.
The result of this section is what can be found in section 4 of chapter I Memory.

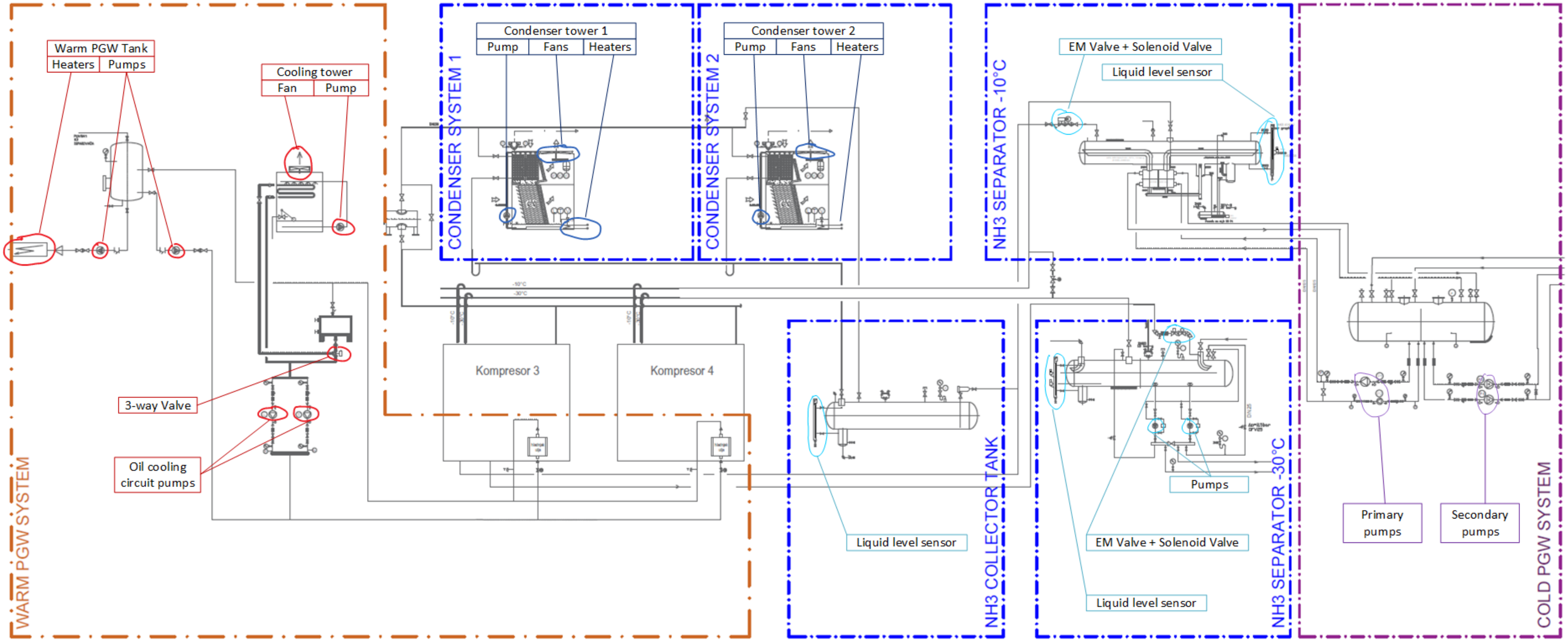

Figure 16. Localization of the consumers (w/o WWT)

1.2. STAGE 2: SELECTION OF CONSUMER´S CIRCUIT BREAKERS

Once the technical characteristics of the consumers are known, we move on to the second stage of the project, which is none other than the selection of the circuit breakers for the consumers. To carry out this selection we must take into account specifically the current demand of the consumers. The objective is to find a circuit breaker that, in addition to being suitable for the number of phases of the consumer, the rated current that it allows to circulate is just above the current demanded by the consumer.
To carry out this selection of protection elements we have used the catalog of the manufacturer EATON, that is why and for a greater homogenization of the electrical cabinet we have tried to respect and take the circuit breakers of the same family, the PKZM0. This last one is something totally optional, but it makes that the cabinet looks better in its interior. At the same time, it is also optional that these circuit breakers have, in case of single phase, 2 NO, and in case of three phase, 4 NO, so that the remaining one after having connected the phases can be connected to a possible monitoring of the protection system.
For this particular project, the only models that are not of the PKZM0 family are those that protect the consumers that are connected directly on line, for these cases the FAZs have been chosen.
When choosing these circuit breakers, it is important to know how to choose the maximum time that can let an overcurrent flow, since the moment of connecting the consumers an over current demand will be registered, so without being a fault, the circuit breaker has to be cautious to let this current flow for a maximum period of time. If this time is exceeded, the circuit breaker will disconnect the consumer from the grid thinking that a fault has occurred. This maximum period of time of current flow is represented by the first letters of the alphabet, A, B, C, D, and the most used ones as it has been in this project, are the circuit breakers of type B and C.

1.3. STAGE 3: SELECTION OF CONSUMER'S CONTACTORS

For this third stage, similar to what happened in the previous section, we will have to look at the technical characteristics of the consumers, but instead of looking at the current demanded by the consumers, this time we will take into account the power demanded by the consumers. From a certain quantity of power already established by norm, the direct connection to the grid of the consumers who demand a higher power than the mentioned one is not allowed. This is because in case of a direct connection to the grid there will be an over current demand that could unbalance the power supply system and in turn, due to its high amperage, it could also damage the elements connected to that consumer including itself.
For motors that do not allow a direct connection to the power buses, because otherwise it would be quickly solved with the use of NO simple contactors connected to a coil that would give them the order to open and close the circuit, we have used 2 different variants in the project. The first alternative that has been used in the project is the addition of AC-Drives to those motors or pumps that are interesting to regulate their speed in the case they already do not come with AC-Drives connected to themselves.
The second solution is the use of a Soft Starter. This is helpful to avoid the mentioned overcurrent when a consumer is started and there is no interest in regulating the speed of the consumer.

1.4. STAGE 4: SHORT CIRCUITS AND CABLES CONDITIONS' CALCULATIONS

After selecting the consumer, the circuit breaker, and the contactor, what will be needed is the cable that connects these elements together and connects them also to the mains. For this, in this stage, by means of some formulas we are going to study the load, the voltage drop that occurs in the cable, the impedance of the cable, cable and protection, and short circuit.

1.4.1. THE LOAD

What is studied in this section is the total current that will flow through the power buses, in order words, it will be calculated the current that the consumers demand to each power buses. This way it can be determined the main power circuit breaker's dimension and it will be also helpful to determine the cross-section of the main buses. What it has to be considered in order to obtain a real value is that all the consumers may not work at the same time, because while some of them may be working, there can be other consumers' effects are the opposite, so that is why the maybe not work at the same time. So, calculating the main load it is not only a question of summing up all the currents of the consumers, it also has a logistical part which make you consider the worst situation possible. Let see this with our project's calculation.

DT adress	Active power [W]			Current [A]		
	L1	L2	L3	L1	L2	L3
-M111	2218,2	2218,2	2218,2	11,3	11,3	11,3
-M112	2557,4	2557,4	2557,4	11,3	11,3	11,3
-M113	2557,4	2557,4	2557,4	11,3	11,3	11,3
-WH111	8000,0	0,0	0,0	34,8	0,0	0,0
-M121	2218,2	2218,2	2218,2	11,3	11,3	11,3
-M122	2557,4	2557,4	2557,4	11,3	11,3	11,3
-M123	2557,4	2557,4	2557,4	11,3	11,3	11,3
-WH121	0,0	8000,0	0,0	0,0	34,8	0,0
-M21	2041,5	2041,5	2041,5	10,4	10,4	10,4
-M22	2041,5	2041,5	2041,5	10,4	10,4	10,4
-M311	1570,4	1570,4	1570,4	8	8	8
-M312	5889,0	5889,0	5889,0	30	30	30
-M321	1570,4	1570,4	1570,4	8	8	8
-M322	5889,0	5889,0	5889,0	30	30	30
-M41	853,9	853,9	853,9	4,4	4,4	4,4
-M42	853,9	853,9	853,9	4,4	4,4	4,4
	4000	0	0	17,4	0	0
-WH41	0	4000	0	0	17,4	0
	0	0	4000	0	0	17,4
-M51	569,3	569,3	569,3	2,9	2,9	2,9
-M52	569,3	569,3	569,3	2,9	2,9	2,9
-M53	569,3	569,3	569,3	2,9	2,9	2,9
-M61	0	0	2231,5	0	0	9,9
-M62	0	0	2231,5	0	0	9,9
-M63	196,3	196,3	196,3	0,8	0,8	0,8
-M64	981,5	981,5	981,5	5	5	5
	26871,4	26871,4	31334,3	126,8	126,8	146,6

Table 13. Load Calculations

As it can be seen in the "Load Calculations" table, the maximum amount of current will be carried by the L3. It can also be pointed out that the load is not perfectly symmetrical, but it depends on what consumers are running. For example, the yellow squares are not considered to calculate the main load for each power line, because having those heaters working would mean there would be some other consumers that would not be working. Anyways, when it comes to select the main circuit breaker, the quantity calculated is only the 70-80% of the endurance of the main circuit breaker, just to consider new possible consumers, or that it has been connected some consumers while they would not be working simultaneously.

1.4.2. VOLTAGE DROP

The conductors that make up the system have impedances that may affect to the voltage that reaches the consumers. The impedance of the cables is low, but it has always to be considered. When the current flows through the cable it appears a voltage drop from the beginning of the cable to the circuit consumer, so it has to try to maintain the same rated voltage in the beginning of the cable until the consumer.
As it may seem logical, there are some rules which determine the maximum voltage drop permitted in the path of each cable throughout the circuit. The value that it has to be considered in this project it is a maximum voltage-drop of the 5%. This voltage drop is calculated considering steady-state conditions. In the table below are shown the voltage drop calculations regarding this project.

DT adress	Voltage [V]	Active power[kW]	Current [A]	Length [m]	Total cross section [mm^2]	Voltage drop on cable [%]	Total voltage drop [%]
	400	85,1	146,6	**120**	**120**	0,933	0,933
-M111	400	6,7	11,3	80	4,0	1,459	2,392
-M112	400	7,7	11,3	80	4,0	1,683	2,616
-M113	400	7,7	11,3	80	4,0	1,683	2,616
-WH111	230	8,0	34,8	80	16	2,653	3,586
-M121	400	6,7	11,3	80	4	1,459	2,392
-M122	400	7,7	11,3	80	4	1,683	2,616
-M123	400	7,7	11,3	80	4	1,683	2,616
-WH121	230	8,0	34,8	80	16	2,653	3,586
-M21	400	6,1	10,4	15	1,5	0,672	1,605
-M22	400	6,1	10,4	15	1,5	0,672	1,605
-M312	400	17,7	30,0	45	6	1,453	2,386
-M322	400	17,7	30,0	45	6	1,453	2,386
-M311	400	4,7	8,0	40	1,5	1,378	2,311
-M321	400	4,7	8,0	40	1,5	1,378	2,311
-M41	400	2,6	4,4	40	1,5	0,749	1,682
-M42	400	2,6	4,4	40	1,5	0,749	1,682
-WH41	230	4,0	17,4	40	4	2,653	3,586
	230	4,0	17,4	40	4	2,653	3,586
	230	4,0	17,4	40	4	2,653	3,586
-M51	400	1,7	2,9	65	1,5	0,811	1,744
-M52	400	1,7	2,9	55	1,5	0,687	1,62

-M53	400	1,7	2,9	50	1,5	0,624	1,557
-M61	230	2,2	9,9	60	4	2,22	3,153
-M62	230	2,2	9,9	60	4	2,22	3,153
-M63	400	0,6	0,8	80	1,5	0,344	1,277
-M64	400	2,9	5,0	80	2,5	1,033	1,966

Table 14. Voltage Drops Calculations

To obtain the voltage drop % of each cable it has applied a formula that can be seen in any manufacture manual, but what it is important to consider is that the total voltage drop % is the one that starts in the LV part of the transformer until it reaches the consumer. So, the total voltage drop has to be the addition of the main cable's voltage drop and each consumer's cable voltage drop.

To minimize the voltage drop there are several parameters that can be changed. The current and the length are two parameters that they can be changed to minimize the voltage drop, but at the same time it has not much change, because the current is what the consumer needs, and the length of the cable is supposed to be as short as possible to be a cheaper installation and have less voltage drop. After discarding those parameters, the characteristic that it will be changed is the cross-section of the cable. The larger the section, the smaller it will be the voltage drop. Theoretically, it shouldn't be a cable with a section largen than 6 mm^2, that is the maximum the terminals in the cabinet allow, but even though, the heaters' cables need bigger cables, so to maintain a voltage drop below the danger zone (4%-5%) not only it was necessary to increase the cross-section of the cables, but it was also necessary to increase the cross-section of the main cables from 75 mm^2 to 120 mm$^{2.}$

1.4.3. IMPEDANCE CALCULATION

In this part of the calculations, it is calculated the impedance of the cable circuit from the LV part of the transformer to the consumer. These calculations are required to obtain the calculations of the maximum and minimum short circuit currents that it may appear. To fulfill the following table it has to consult the data sheet of the cable manufacture in order to obtain *rcable* and l_{cable}

DT adress	Length [m]	rcable [mΩ/m]	l_{cable} [mH/km]	Rk [mΩ/phase]	Xk [mΩ/phase]	R [mΩ/phase]	X [mΩ/phase]	Z [mΩ/phase]
	120	0,15	0,256	18,36	9,65	18,36	9,65	20,74
-M111	80	4,61	0,34	368,8	8,54	387,16	18,19	387,59
-M112	80	4,61	0	368,8	0,00	387,16	9,65	387,28
-M113	80	4,61	0	368,8	0,00	387,16	9,65	387,28
-WH111	80	1,15	0,262	92	6,58	110,36	16,23	111,55
-M121	80	4,61	0,34	368,8	8,54	387,16	18,19	387,59
-M122	80	4,61	0	368,8	0,00	387,16	9,65	387,28
-M123	80	4,61	0	368,8	0,00	387,16	9,65	387,28
-WH121	80	1,15	0,262	92	6,58	110,36	16,23	111,55
-M21	15	12,1	0,366	181,5	1,72	199,86	11,37	200,18
-M22	15	12,1	0,366	181,5	1,72	199,86	11,37	200,18
-M312	45	3,08	0	138,6	0,00	156,96	9,65	157,26
-M322	45	3,08	0	138,6	0,00	156,96	9,65	157,26

-M311	40	12,1	0,366	484	4,60	502,36	14,24	502,56
-M321	40	12,1	0,366	484	4,60	502,36	14,24	502,56
-M41	40	12,1	0,366	484	4,60	502,36	14,24	502,56
-M42	40	12,1	0,366	484	4,60	502,36	14,24	502,56
-WH41	40	4,61	0,348	184,4	4,37	202,76	14,02	203,24
	40	4,61	0,348	184,4	4,37	202,76	14,02	203,24
	40	4,61	0,348	184,4	4,37	202,76	14,02	203,24
-M51	65	12,1	0,366	786,5	7,47	804,86	17,12	805,04
-M52	55	12,1	0,366	665,5	6,32	683,86	15,97	684,05
-M53	50	12,1	0,366	605	5,75	623,36	15,39	623,55
-M61	60	4,61	0,316	276,6	5,95	294,96	15,60	295,37
-M62	60	4,61	0,316	276,6	5,95	294,96	15,60	295,37
-M63	80	12,1	0,366	968	9,19	986,36	18,84	986,54
-M64	80	7,41	0,366	592,8	9,19	611,16	18,84	611,45

Table 15. Cable Impedance Calculations.

What it has a lot of influence in these cable impedance calculations is the length of each cable.

1.4.4. CABLE AND PROTECTION CONDITIONS' CALCULATIONS

The following calculations are necessary to fulfill some of the norms that all electrical project design has to suit regarding the consumer's nominal current, the circuit breaker that has been selected, and the endurance of the selected cable. Once the previously devices are selected, it is needed to check out their data sheets to fill the following table, because after some easy multiplications there are 2 conditions that must be fulfill.

The first condition that must be respected it that the nominal current of the consumer has to be lower than the protective element's nominal current and lower than the cable´s nominal current endurance.

The second norm says that the protective element's breaking current must be lower than the cable's nominal current endurance times 1.45.

The calculations regarding this section of the actual project are the next ones:

DT adress	Current Ip [A]	Protective element nom. current In [A]	Protective element breaking current I2 [A]	Length [m]	Total cross section [mm²]	Cable current		Condition 1 Ip ≤ In ≤ Iz	Condition 2 I2 ≤ 1.45*Iz
						Nominal Iz [A]	30min max 1.45*Iz [A]		
	146,6	200	250,0	120	120	318	461,1	YES	YES
-M111	11,3	12	15	80	4	25	36,3	YES	YES
-M112	11,3	12	15	80	4	26	37,7	YES	YES
-M113	11,3	12	15	80	4	26	37,7	YES	YES
-WH111	34,8	40	50	80	16	79	114,6	YES	YES
-M121	11,3	12	15	80	4	25	36,3	YES	YES
-M122	11,3	12	15	80	4	26	37,7	YES	YES
-M123	11,3	12	15	80	4	26	37,7	YES	YES

-WH121	34,8	40	50	80	16	79	114,6	YES	YES
-M21	10,4	12	15	15	1,5	19,5	28,3	YES	YES
-M22	10,4	12	15	15	1,5	19,5	28,3	YES	YES
-M312	30,0	32	40	45	6	34	49,3	YES	YES
-M322	30,0	32	40	45	6	34	49,3	YES	YES
-M311	8,0	10	12,5	40	1,5	19,5	28,3	YES	YES
-M321	8,0	10	12,5	40	1,5	19,5	28,3	YES	YES
-M41	4,4	6,3	7,9	40	1,5	19,5	28,3	YES	YES
-M42	4,4	6,3	7,9	40	1,5	19,5	28,3	YES	YES
	17,4	20	25	40	4	34	49,3	YES	YES
-WH41	17,4	20	25	40	4	34	49,3	YES	YES
	17,4	20	25	40	4	34	49,3	YES	YES
-M51	2,9	4	5	65	1,5	19,5	28,3	YES	YES
-M52	2,9	4	5	55	1,5	19,5	28,3	YES	YES
-M53	2,9	4	5	50	1,5	19,5	28,3	YES	YES
-M61	9,9	10	12,5	60	4	34	49,3	YES	YES
-M62	9,9	10	12,5	60	4	34	49,3	YES	YES
-M63	0,8	1	1,3	80	1,5	19,5	28,3	YES	YES
-M64	5,0	6,3	7,9	80	2,5	19,5	28,3	YES	YES

Table 16. Cable and Protection Conditions' Calculations

1.4.5. MAXIMUM AND MINIMUM SHORT CIRCUIT CONDITIONS' CALCULATIONS

In this section it has to be calculated the maximum short circuit that it can happen in our project's circuit, and also the minimum short circuit current that it can occur.
The circuit that composes the project it is formed by 3 phases. What it has to be found is what would be the worst scenario the circuit breaker may have to face. The condition related to these calculations mentioned previously is that the maximum short circuit current must be lower than the protective element's short circuit breaking current (Icu).
As the project is a 3-phase circuit, the maximum short circuit current than can appear is the one caused by a 3-phase short circuit fault. To calculate the value of this current it has to be previously calculated (1.4.3. IMPEDANCE CALCULATION**)** the impedance of the cables, because it is where the fault is going to circulate to close the circuit caused by the fault.
The second condition that has to be fulfilled is that the protective element's max breaking current (Irm) must be lower than the minimum short circuit current. The protection device should be able to operate in a maximum time to ensure people and circuit safety, for all short circuit current or fault current that may occur. To check that behavior, calculation of minimal short-circuit current or fault current is mandatory. Also, the elimination of the minimum short circuit current has to be done in less than 5 seconds to be compatible with the thermal constraints of the circuit conductors,
The minimum short circuit current that may appear on this project is the one caused by a single-phase fault with the earth. Applying their corresponding formulas, both norms must be fulfilled.

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Universidad del País Vasco Euskal Herriko Unibertsitatea

BILBOKO INGENIARITZA ESKOLA ESCUELA DE INGENIERÍA DE BILBAO

DT adress	Voltage [V]	Protective element max breaking current (Short-Circuit Realease) *Irm* *[A]*	Protective element short circuit breaking current (Rated short-circuit breaking capacity) *Icu* *[A]*	Total cross section [mm^2]	3p s.c. current *ISCmax* *[A]*	Min. 1p s.c. current *Ik1min* *[A]*	Max allowable duration of s.c. *T (s)*	Condition 1: ISCmax < Icu	Condition 2: Irm < min(Ik1, Ik2)
	400	2000	50000	120	7042,99	4435,93	3,84	YES	YES
-M111	400	186	50000	4	655,42	237,37	0,49	YES	YES
-M112	400	186	50000	4	655,94	237,55	0,49	YES	YES
-M113	400	186	50000	4	655,94	237,55	0,49	YES	YES
-WH111	230	400	15000	16	1309,49	824,77	1,97	YES	YES
-M121	400	186	50000	4	655,42	237,37	0,49	YES	YES
-M122	400	186	50000	4	655,94	237,55	0,49	YES	YES
-M123	400	186	50000	4	655,94	237,55	0,49	YES	YES
-WH121	230	400	15000	16	1309,49	824,77	1,97	YES	YES
-M21	400	186	50000	1,5	1269,01	459,58	0,02	YES	YES
-M22	400	186	50000	1,5	1269,01	459,58	0,02	YES	YES
-M312	400	496	50000	6	1615,42	585,03	0,18	YES	YES
-M322	400	496	50000	6	1615,42	585,03	0,18	YES	YES
-M311	400	155	150000	1,5	505,48	183,06	0,12	YES	YES
-M321	400	155	150000	1,5	505,48	183,06	0,12	YES	YES
-M41	400	97,7	150000	1,5	505,48	183,06	0,12	YES	YES
-M42	400	97,7	150000	1,5	505,48	183,06	0,12	YES	YES
-WH41	230	200	15000	4	718,69	452,66	0,41	YES	YES
	230	200	15000	4	718,69	452,66	0,41	YES	YES
	230	200	15000	4	718,69	452,66	0,41	YES	YES
-M51	400	62	150000	1,5	315,55	114,28	0,30	YES	YES
-M52	400	62	150000	1,5	371,37	134,49	0,22	YES	YES
-M53	400	62	150000	1,5	407,40	147,54	0,18	YES	YES
-M61	230	100	15000	4	494,53	311,47	0,87	YES	YES
-M62	230	100	15000	4	494,53	311,47	0,87	YES	YES
-M63	400	15,5	150000	1,5	257,50	93,26	0,45	YES	YES
-M64	400	97,7	150000	2,5	415,46	150,46	0,48	YES	YES

Table 17. Short Circuit condition's Calculations

What these last calculations also says is that the cross-sections of the cables are relevant in term of short circuit currents' permissibility, because in contrast to the case of the voltage drop, the bigger the cross-section is, the larger the short circuit current will be, it has less impedance. So, it is logical to think that a bigger cross section may benefit the project because the voltage drop will always be lower while the consumers are working, but in the other side, if a short circuit occurs it would have worse consequences.

1.5. STAGE 5: SELECTION OF THE CABLES

Once the calculations explained in the previous stage have been made and the conditions required by the cables to fulfill the regulations in the Voltage Drop, Cable and Protection, and Short Circuit sections have been successfully satisfied, the only difficulty that the choice of cables will present from this moment on is mainly to know if the cable needs to have a screen or not.

The wiring system will be divided into 3 main groups. The first one will deal with the Main Supply wiring, the second one will deal with the wiring corresponding to the consumers, and the third group will be the one corresponding to the control system and valves.

The Main Supply wiring is the simplest since it only covers the power input from the transformer to our cabinet. This wiring is made up of 4 cables, the 3 power buses and PEN, which will later be separated into PE and N. This wiring will be without screen and will have the measures established in the calculations of the previous section.

In the second group, the wiring that goes from the cabinet to the consumers, will have the measures established in the previous stage and will be of the NYY or NYCY type. The difference when choosing between one or the other is based on the need for shielding in the wiring. In the case where a shield is needed, it will be because the consumer is connected to an AC-Drive outside the motor itself (the AC-Drive is not incorporated). NYCY type wiring will be used for these cables. If no shielding is required, NYY type wiring will be used.

And finally, for the group of cables referring to the control system and valves, it is necessary to be very meticulous with the characteristics of the current that they transport, to know if it is transcendental or not that the information that they transport is sensitive and important that not even the smallest variations in the transported current are produced. In case you want to protect these cables with a shield, you will use LiYCY type cables, and for cables that do not need this additional protection for the transport of current, you will use OB-500 type cables.

To sum up this stage, it is key to know the purpose and destination of the cable to finally choose it correctly.

PROPYLEN-GLYCOL-WATER COOLING SYSTEM

PUMPS 1-2. GRUNDFOS TP100-130/4 (x2)		CIRCUIT BREAKER		CONTACTOR		Cable	
		PKZM0-10/AK		(Soft Starter) DS7-340SX009N0-N		Power NYY 4x1,5	
P	4 KW	P (kW)	4	P (Kw)	4	Construction	Re
V	3 x 380-420D	Iu=Ie (A)	10	Ie (A)	9	Ext. Diameter (mm)	12,0-16,0
I	7,9-8,15 A	Ir (A)	6,3-10	Uc (V)	24	Insulation Thickness (mm)	0,8
f.d.p.	0,8	Irm (A)	155	Us (V)	24	Short Circuit Current 1s (A)	170
		Ue (V AC)	690	Uln (V)	200-480	Cu Weight (kg/km)	57,6
		Uimp (V)	6000	Ue (V)	400	Cable Weight (kg/km)	220
		Heat Loss (W)	6,48				

PUMPS 3-4. GRUNDFOS TPE 100-310/2 A-F-A-BQQE-OX1 (x2)		CIRCUIT BREAKER		CONTACTOR		CONTACTOR (OPTIONAL)		CABLE	
		PKZM0-32/AK		(AC Drive) ACS880-01-032A-3		(Direct On Line) DILM32-10 (24V 50Hz)		Power NYCY 4x6/6	
P	15 KW	P (kW)	15	Frame Size	R3	P (kW)	15	Construction	Re
V	3 x 380-480 V	Iu=Ie (A)	32	I_n (A)	32	Ie (A)	32	Diameter (mm)	2,9
I	30.0-26.0 A	Ir (A)	25-32	$Imax(A)$	42	Heat Loss (W)	6,6	Ext. Diameter (mm)	17-21
f.d.p.	0.91-0.86	Irm (A)	496	P_n (KW)	15			Insulation Thickness (mm)	1
		Ue (V AC)	690	$I_{Ld}(A)$	30			Seath Thickness (mm)	1,8
		Uimp (V)	6000	P_{Ld} (KW)	15			Short Circuit Current 1s (A)	690
		Heat Loss (W)	9,56	I_{Hd} (A)	25			Cu Weight (kg/km)	297
				P_{Hd} (KW)	11			Cable Weight (kg/km)	580
				Noise level (dB(A))	60				
				Heat dissipation (W)	457				
				Air flow (m3/h)	134				

Table 18. Example of PGW Cooling System with the data we have been able to obtain until this moment

1.6. STAGE 6: SELECTION OF THE TERMINALS

In this stage, which is arguably the shortest of all the stages, the task that has to be done is the selection of the terminals that are set on the cabinet which are used as the annex between the end of the cable inside the cabinet, and the start of the cable that goes to the consumer. The selection of this terminals is based on the cross-section area of the cables that reach the consumers. The placement of the terminals is intended to be done by consumer groups, and they are place together inside the cabinet. These terminals will be also located on the cables regarding the connection to the PLC, and as it has been told before, the selection of these terminals will depend directly of the cross-section of the control cables.

1.7. STAGE 7: SUPPLY FOR THE VALVES AND CONTROL DEVICES

In order to use the control elements, which in the case of this project will be a PLC, and for the correct operation of the valves, it will be necessary to connect a power converter with 24VDC output. The power system of the grid is 400VAC (230VAC phase-neutral) and the control equipment and valves cannot be connected directly to the power buses. In the case of this particular project, it has been decided to make use of 2 converters that have been connected to bus 3 (L3) to obtain as output of each one of them 2 additional 24VDC lines that will serve as supply for the protection equipment and valves independently.

1.8. STAGE 8: IDENTIFICATION OF VALVES, SENSORS, AND PROBES

As in a similar way to the stage 1, the purpose of this stage is to identify in the schematics the placement of the valves, probes, and sensors that have to be powered and controlled by the system. Since this assignment comes after having identify the consumers, it easier to find and place these devices in the schematics because it is more intuitive which consumer may need a sensor or a probe, or which system may need a regulation via a valve. Once we have identified the valves, sensors, and probes it will be useful to obtain their data sheets to acquire the knowledge needed regarding their supply needs and control connections terminals.

1.9. STAGE 9: SELECTION OF THE CONTROLLER AND ITS MODULES

The next stage, which begins the control section, has been the most complex of this project. When it came to the control of the engine room, the element chosen as controller was a Siemens S7-1500 PLC. This device is going to be the brain that monitors the states and controls, at the same time, the different consumers of the system taking into account the information that arrives to its inputs.

As for the modules that will accompany the CPU will depend on the number of consumers, valves, sensors and probes to be controlled.

To start with, a single DI module will be needed. The module in question will have 32 inputs which will be used to accomplish different tasks. On the one hand, it will be used for monitoring the states of the circuit breakers of the consumers that are connected directly on line or are connected to soft starters. Those connected to an AC-Drive will not be necessary as the data transfer of these will be done by means of an etherline cable. The DI module also monitors the status of the valves in the -30 degree and -10 degree ammonia separators, one valve for each system. Finally, the DI module is in charge of receiving the ammonia level status in the separator tanks, monitoring the maximum and minimum ammonia level status in each of them.

As far as the DQ modules are concerned, only one module with 8 outputs will be required. These outputs will be used to make the connection to the grid of the consumers that are connected directly on line or by means of a soft starter as a start-up procedure.

For the control system we will also need an analog input module that will allow us to monitor and acquire the status of different probes located in different systems that make up the engine room. These probes are temperature sensors and level sensors that deliver an analog response with values between 4mA and 20mA.

As an additional analog control element, an AI/AQ module will be used in which 4 of its pins will be connected to 2 valves, 2 pins for each valve, which have the function of opening/closing the valves in the -30 degrees and -10 degrees ammonia separators to a greater or lesser extent in a progressive and desired manner.

The last module that will be necessary to add to the control system is the scalance module, by means of which it is possible to monitor, receive and act on the consumers that have an AC-Drive incorporated in themselves or that one is used for their control. This is possible because, as mentioned earlier in the paper, the AC-Drives are connected to the PLC via etherline cables.

1.10. STAGE 10: WIRING OF THE AC DRIVES OF THE MOTORS

When approaching this stage, it is important to differentiate between 2 groups.

The first one deals with stand-alone AC-Drives, these are those that are part of the control system of some of the consumers that do not have AC-Drives included in themselves. For this, what is done is a first selection of the model, of the company from which you want to acquire the AC-Drive, which in this case has opted for the AC-Drive of ABB. Once the AC-Drive has been selected, the user's manual is obtained, and then we go more specifically to the wiring section. Next, go the analogical inputs and relays output to know which pins of the AC-Drive are going to be needed and used. Analogical input will be needed to receive the information from the pressure sensors spread through the system, and the relays outputs will be used to monitor via a green and red light if the consumer connected to them is running or not. The rest of the monitoring and control of the AC-Drive is done by the PLC, as it has been described in previous stages, with the connection of an etherline cable.

The second group of AC-Drives concerns the AC-Drives that are installed itself to the actual consumer. To carry out the wiring of these AC-Drives, as it has been done with the previous group, there are needed the manuals of the consumers so it can be analyzed the pins that are going to be needed. In these AC-Drives there will also be added some lamps to monitor the actual situation of the consumer, a switch, and again, the etherline cable that will be connected to the PLC.

1.11. STAGE 11: WIRING OF THE CONTROL SYSTEM TO THE PLC

In the following stage there will be also a differentiation between 2 groups because of the disposition in the way they are set to make the consumers run, because the wiring itself is almost identical.

The first of the groups involves the consumers which are directly connected on line. The connection that allows the PLC to make the consumer run it is made by a coil and contactor. A coil is connected after the DQ module. When this coil receives the signal, it closes a NO contactor (24VDC), which at the same time it closes the control circuit, allowing the feeding of another coil which closes the main contactor (NO 230VAC) of the consumer making the direct online possible.

The second group corresponds to the consumers which are started with a soft starter. It is a similar case to the other group, but in this case, when the NO contactor (24VDC) closes, the contactor is feeding the soft starter making it work and starting the consumer if the protection of the control wiring allows it. It is explained in the next stage.

1.12. STAGE 12: SELECTION OF PROTECTION FOR CONTROL WIRING

The wiring control system that has been explained in the previous 2 stages has its own protection system to guarantee and ensure with more than one requirement the safety of the devices and the staff who may work in the maintenance of the devices.

The purpose of this stage is to add a second protection requirement to the consumer activation system so it cannot be started by a mistake.

To raise the security level, what it has been done independently the consumer is started by an AC-Drive, by a soft starter or by a direct on line connection, in all 3 cases, it also has to be turned on a switch which activates an auxiliary contactor (in the case of direct on line it would be the main contactor) that works with 230VAC. And finally, to protect this switch, coil, and contactor, it is also added a fuse which is cheap, not expected to melt, and protect the mentioned devices against possible short circuits.

1.13. STAGE 13: SELECTION OF COILS AND CONTACTORS FOR THE CONTROL SYSTEM

Finally, there have to be selected the coils that work with PLC, and there are also having to be selected the auxiliary contactors that give that extra protection level in the control system of the consumers.

The coils that work with the PLC may be found in the manual of the modules of the PLC. Otherwise, knowing that the PLC works with a 24VDC and that these coils are intended to be connected to same supply, the coils that are supposed to be chosen to have to work with 24VDC. Once the coils have been chosen, is typical for this kind of coils to have to also select a housing for them.

To choose the auxiliary contactor what it has to be done is first choose a 230VAC contactor, because that is the voltage that is used for the control system in the consumers. After that, we have to choose a contactor with a power level just above of the power that demands the consumer. In the case that a consumer is a heater or a resistive consumer, it can be chosen a contactor for motors (AC-3) but in this case a contactor which power capability is below the resistive consumer's power demand (and continue going down if there is a better fit), because maybe its AC-3 current may not fit, but these devices have Ith thermal current, which indicates the current they endure in case of the consumer is a AC-1 consumer and it is higher than the AC-3 current. That is why at first look having lower power capability and a lower current endurance may seems it does not fit the resistive consumer, but it does. The only exception in this project has been the selection of the contactors for the heaters of the condenser systems. They are so big, that the contactor needed to fit the needs of these heaters are 4 NO contactors when only 1 phase is needed per heater.

1.14. STAGE 14: CHECK OUT PART LISTS AND CABLE OVERVIEW

This stage is only proposed once the drawing of the schematics is done, to make sure all the elements drawn in the schematics have their element selected in the part tab. And same with the cable selection, after the drawing is done it is good the make sure in the cable overview list that every cable drawn has assigned a cable type.

1.15. STAGE 15: DISPOSITION OF THE CABINET

In this last stage, the main purpose of it is to draw a 2D or 3D layout of the cabinet with all the elements that go inside it or them (depending on the amount on the elements that are needed to place inside. This stage is not compulsory to fulfill the aim of the project, but it is always a great sketch to have to check out how it would like the final disposition of the elements.

III. CONCLUSIONS

When carrying out cabinets project designs it is essential to have a good organization and to have clear what is needed to carry out the stages that have been followed as a roadmap to carry out the project.
It could be said that there are two parts that are differentiated at the time of carrying out the project.
The first one is related to the consumer side. For this phase it is not necessary to have a great understanding of the overall project, and how or why the engines do the work. In this first part of the project, it is essential to have the data sheet of the motors, since we mainly need the data of the current, the power and its location or distance to the cabinet. Knowing these three data we can carry out the first 8 stages, or what is the same, we can make the selection of the protection elements, contactors, and cables that each consumer will need.
The second part of the project involves the selection and connection of the control elements. This part can be considered more complex because this time you will need a general knowledge of the project and the new system you are trying to create, as well as when and how the consumers are activated. In addition to this it is needed ingenuity and imagination to carry out the design of the control wiring in a clear and concise manner, making the schematics easy to read and easily understandable. To carry out this task in addition to the above, it will also be necessary to read the manual of the control elements and the elements that they will control (such as AC-Drives), to understand which pins will have to be used in each case to ensure proper operation of the system.
It is important to keep in mind that at any time a decision can be taken from other engineering departments, and it is necessary to improvise a new solution to what has already been proposed or incorporate a new element or machine to the project and be agile to incorporate it into the schematics.

In summary, it could be said that there is a part of the project that can be done automatically, since it involves little more than the use of a few formulas and a few data sheet data. However, for the second part where a greater understanding of the project and its component elements is required (wiring and operation manuals are needed), the experience of the project designer is a key factor in designing the wiring and operation of the control system. The more experience you have, the more resources you have internalized to carry out the design of the cabinet more quickly and efficiently, and the easier it is to overcome possible unforeseen events.

IV. BIBLIOGRAPHY

ABB Group. Leading digital technologies for industry — ABB Group. (s/f). Recuperado el 15 de julio de 2021, de Global.abb website: https://global.abb/group/en

Electrical and Industrial. (s/f). Recuperado el 15 de julio de 2021, de Eaton.com website: https://www.eaton.com/us/en-us.html

Lapp Kabel. (s/f). Recuperado el 15 de julio de 2021, de Lappkabel.com website: https://www.lappkabel.com/

S7-1500. (2021). Recuperado de https://mall.industry.siemens.com/mall/en/hr/Catalog/Products/10204162?tree=CatalogTree

Schneider Electric Global. (s/f). Recuperado el 15 de julio de 2021, de Www.se.com website: https://www.se.com/ww/en/

Schrack Technik International: International. (2021, marzo 19). Recuperado el 15 de julio de 2021, de Schrack.com website: https://www.schrack.com/

Tim Kabel - Početna. (s/f). Recuperado el 15 de julio de 2021, de Tim-kabel.hr website: http://www.tim-kabel.hr/index.php?lang=hrvatski

Danfoss – Engineering Tomorrow. (s/f). Recuperado el 15 de julio de 2021, de Danfoss.com website: https://www.danfoss.com/en/

(S/f). Recuperado el 15 de julio de 2021, de Grundfos.com website:

https://www.grundfos.com/

V. ANNEXES

TVŽ TEHNIČKO VELEUČILIŠTE U ZAGREBU
POLYTECHNICUM ZAGRABIENSE
www.tvz.hr
Vrbik 8a, 10000 Zagreb

Customer:	Tehničko veleučilište u Zagrebu Vrbij 8a, 10000 Zagreb Hrvatska	End customer:	Tehničko veleučilište u Zagrebu Konavoska 2, 10000 Zagreb Hrvatska	Object:	Elektrotehnički odelj TVZ-a Konavoska 2, 10000 Zagreb Hrvatska

Project name: Electrical project design for a cabinet in an engine room of a cooling plant

Cabinet name: **H1**
Cabinet description: **Cabinet Engine Room**

Drawn:	Xabier Gregorio, bach. eng. el.	Project number:	MFT-20/21	Supply voltage:	400VAC, 50Hz
Checked:	Tomislav Špoljarić, dipl.eng. el.	Project date:	07.2021	Control voltage:	230VAC, 50Hz; 24VDC
Approved:	Tomislav Špoljarić, dipl.eng. el.	Revision:	R0	Rated current:	146.6A
Number of page:	61	Revision date:	16.07.2021	Rated short circuit current:	200A

Company name

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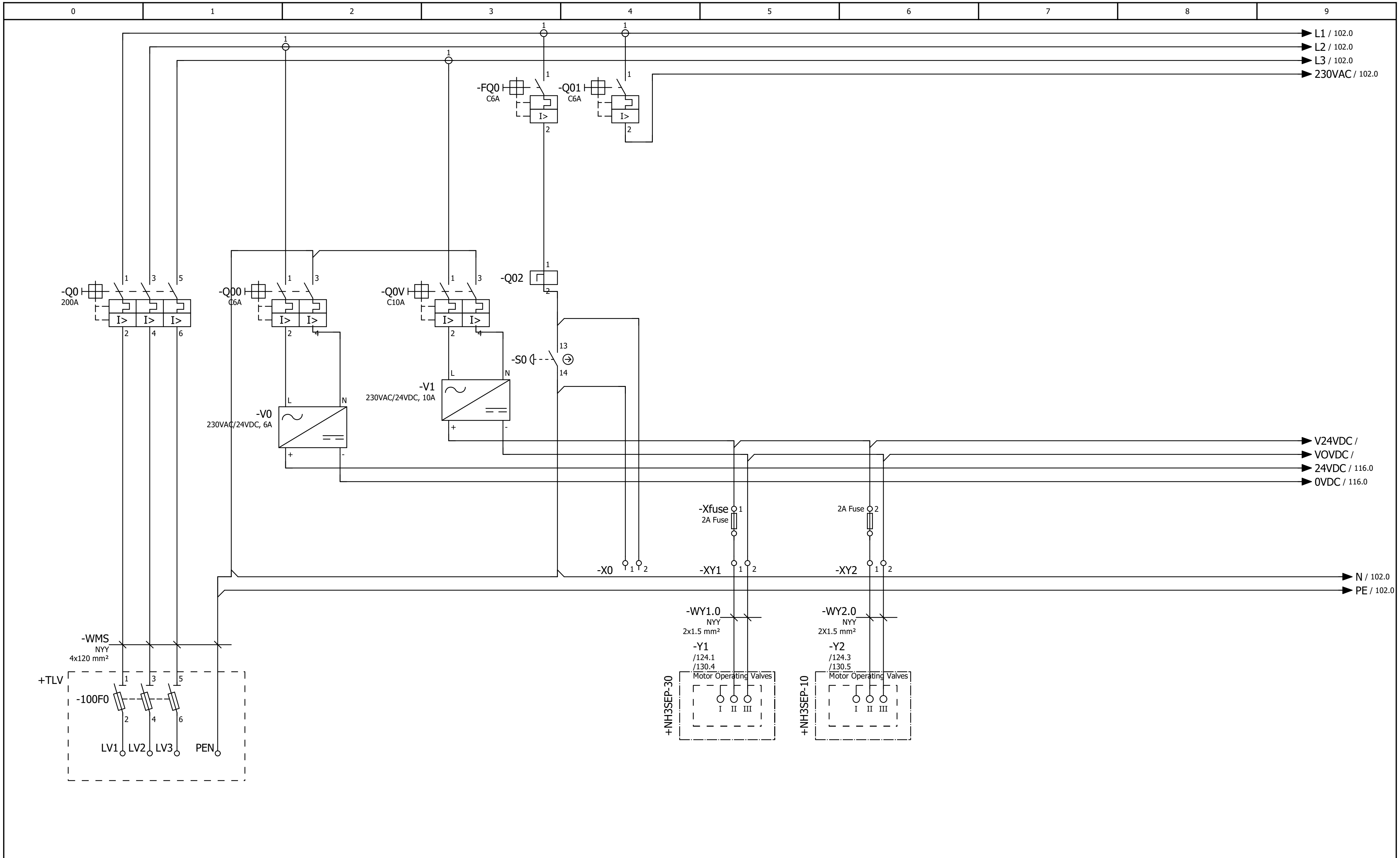

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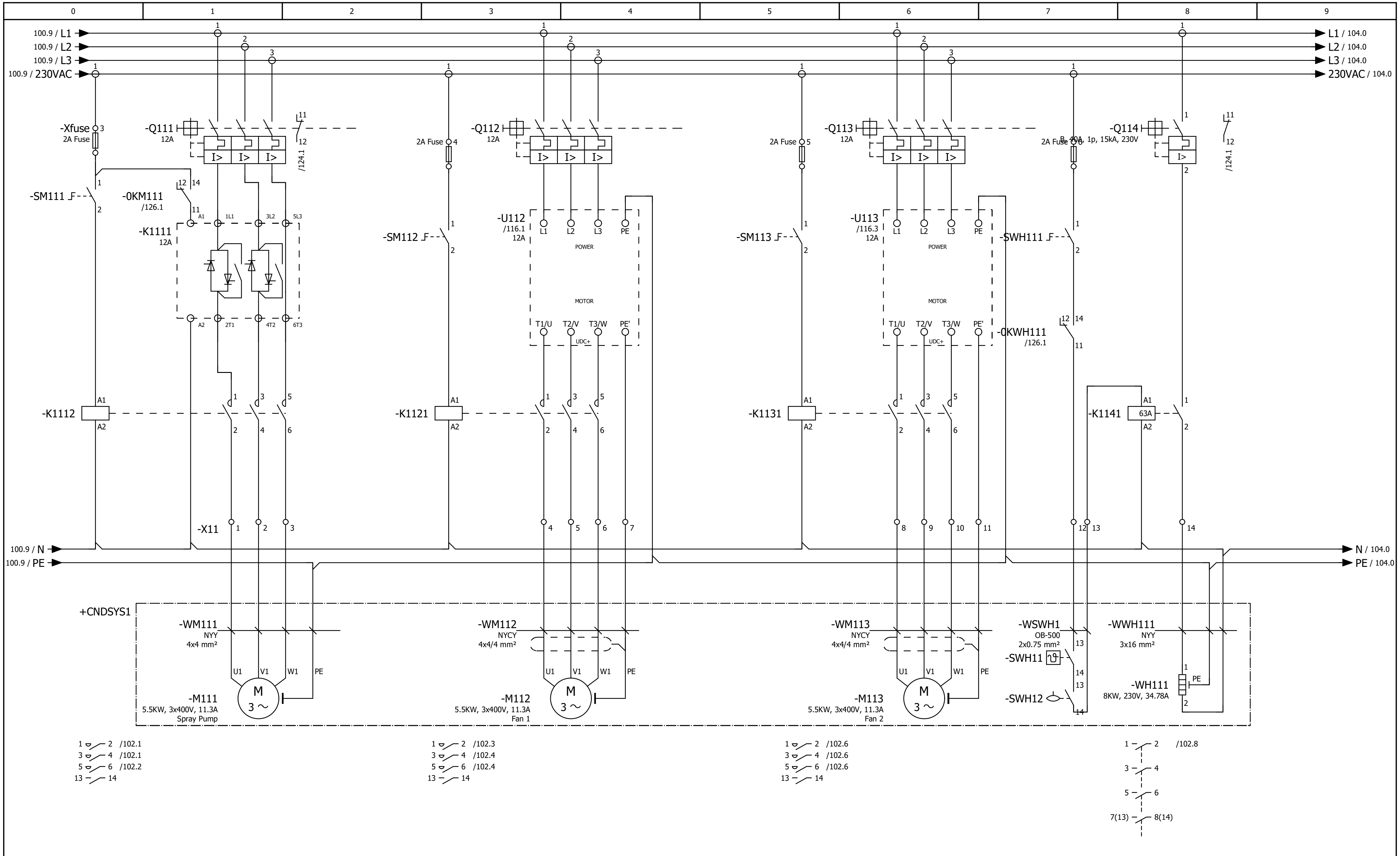
Approved: Tomislav Špoljarić, dipl.eng. el.						Follow: 102



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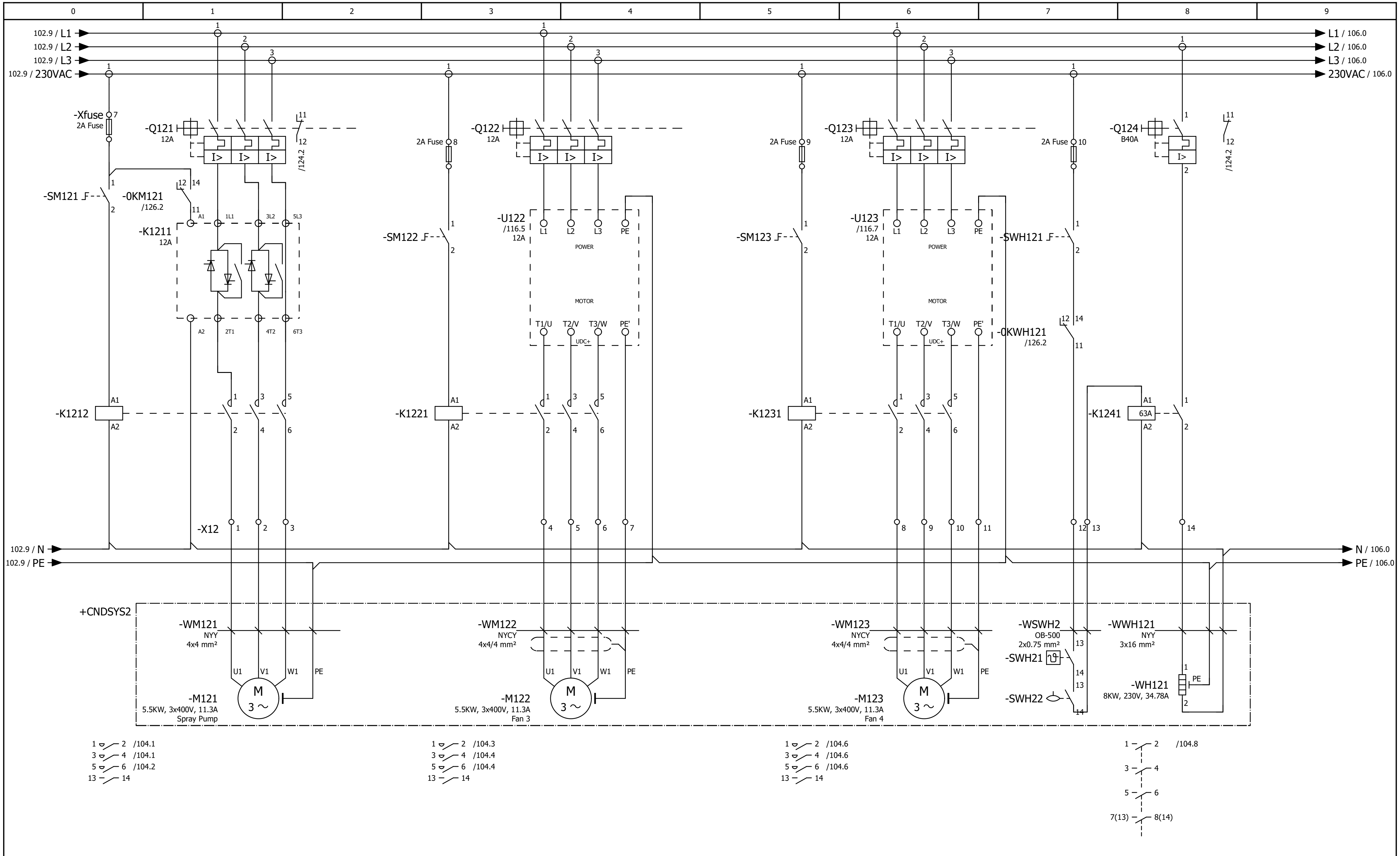

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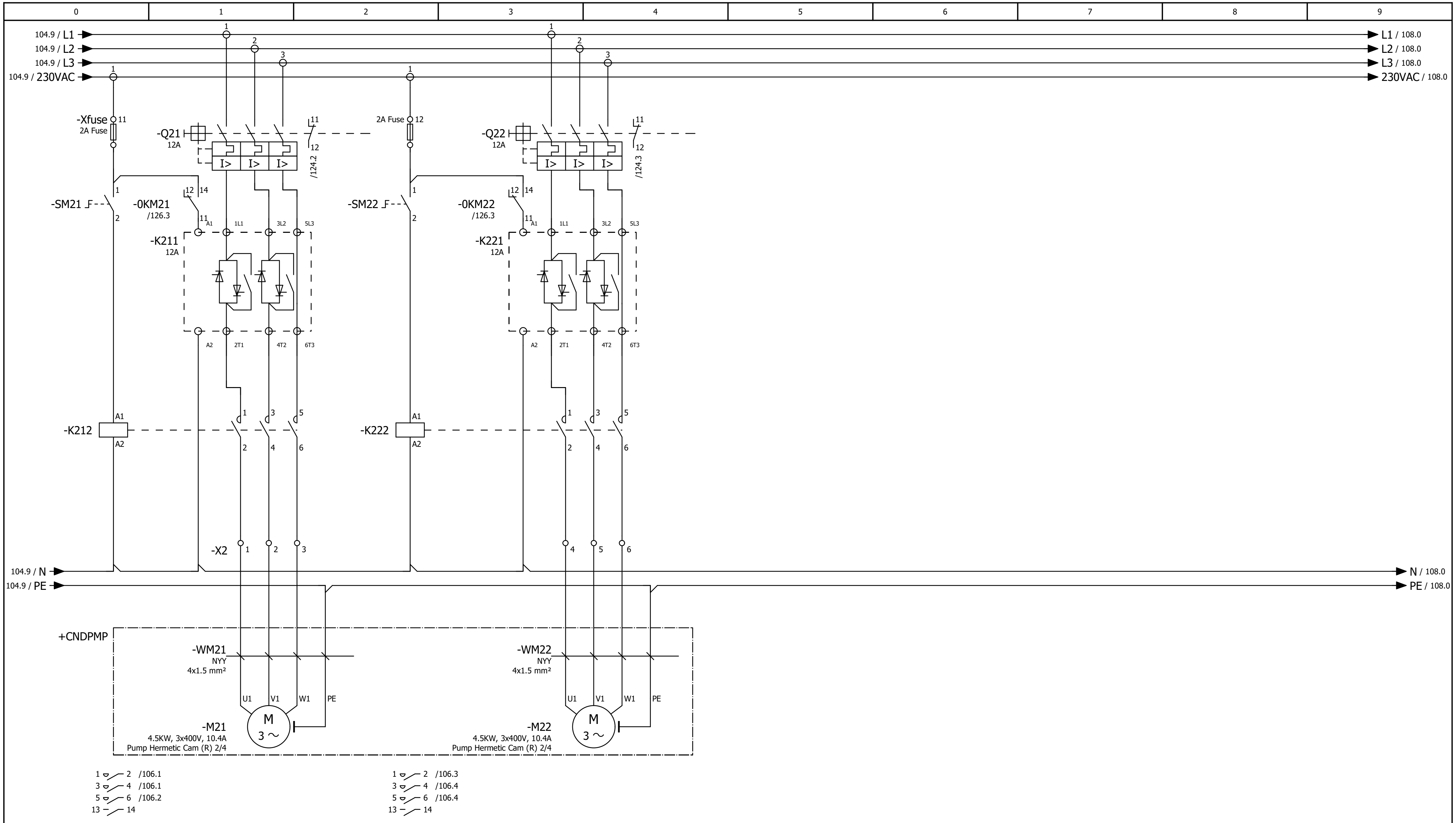

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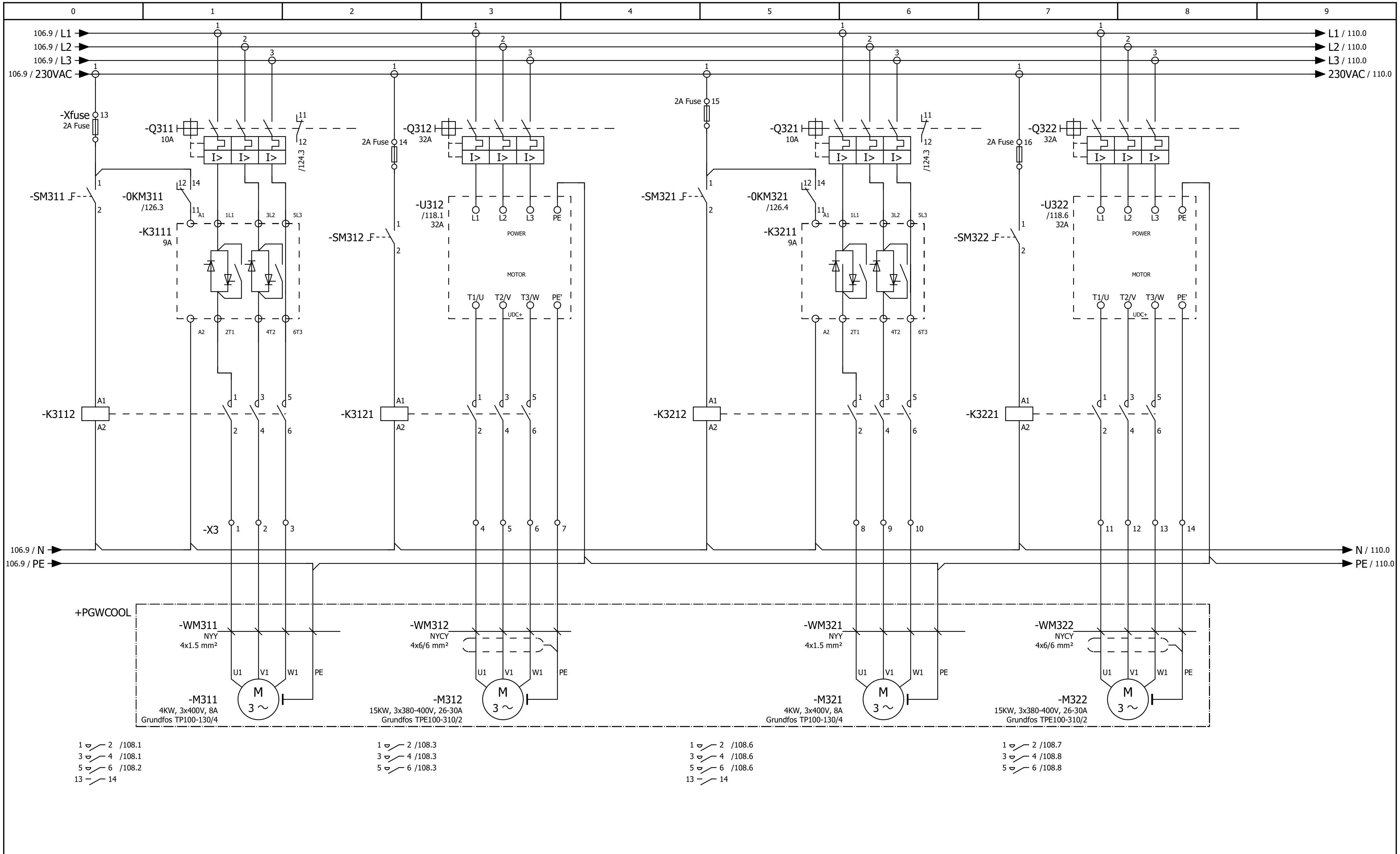

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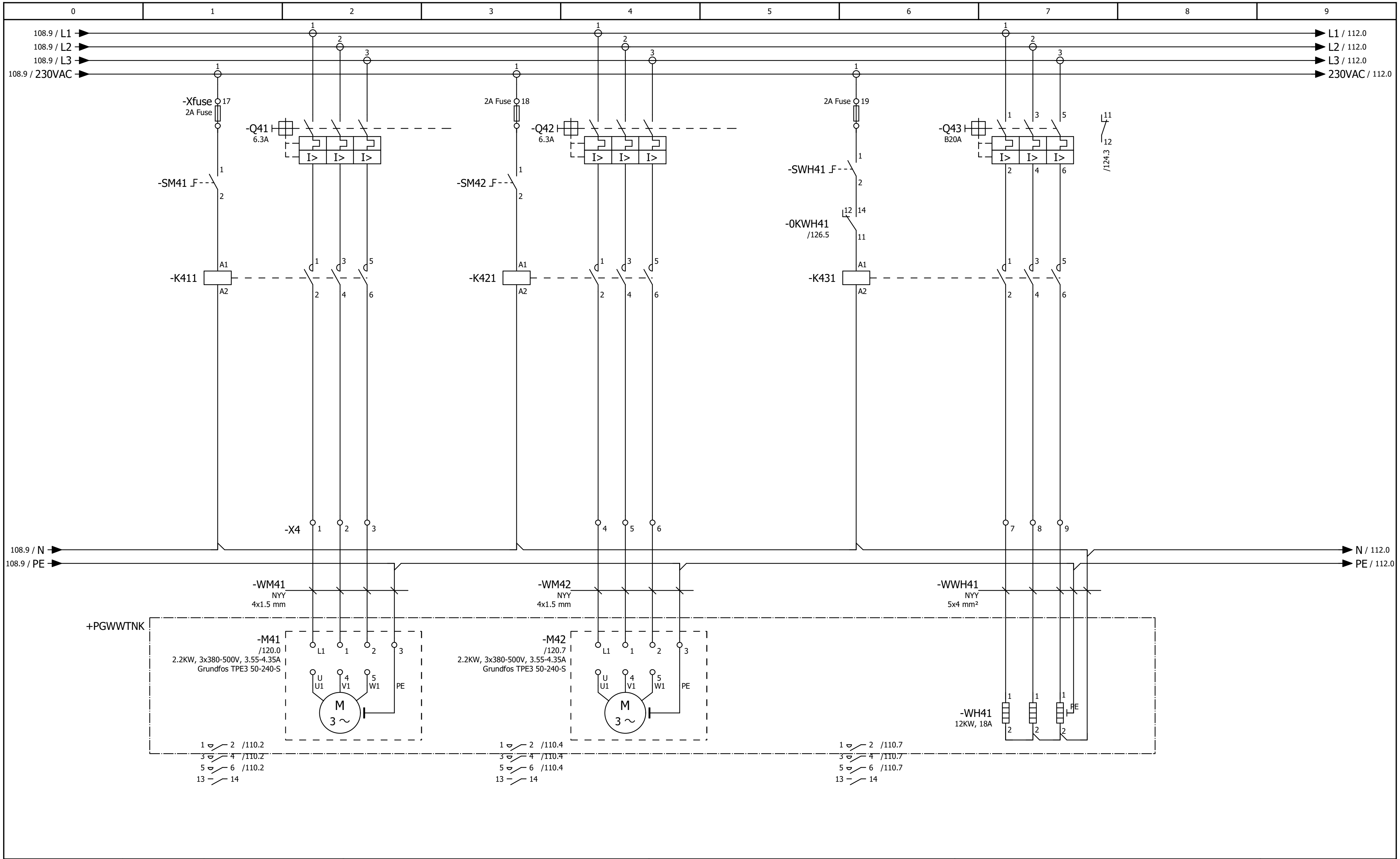

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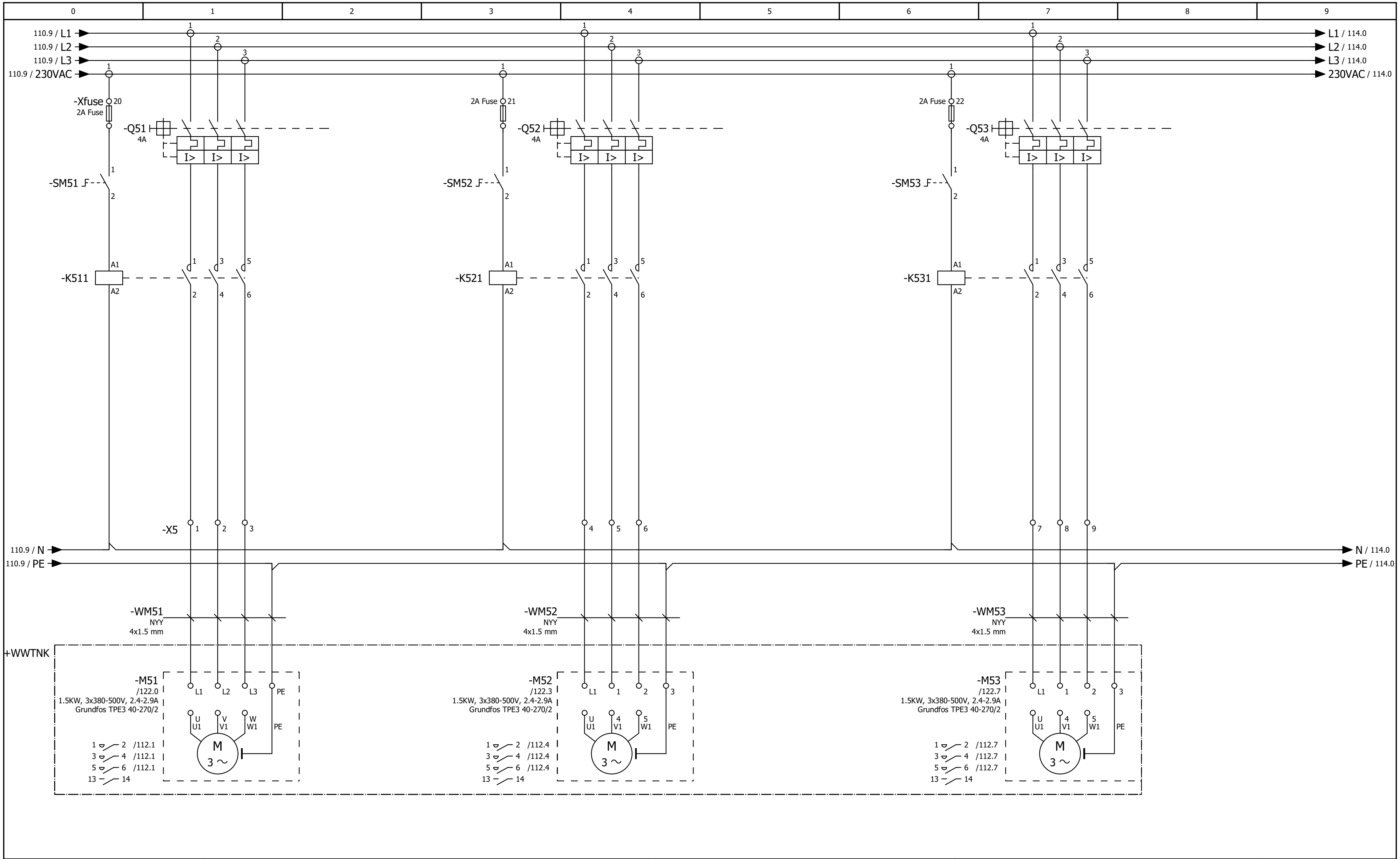

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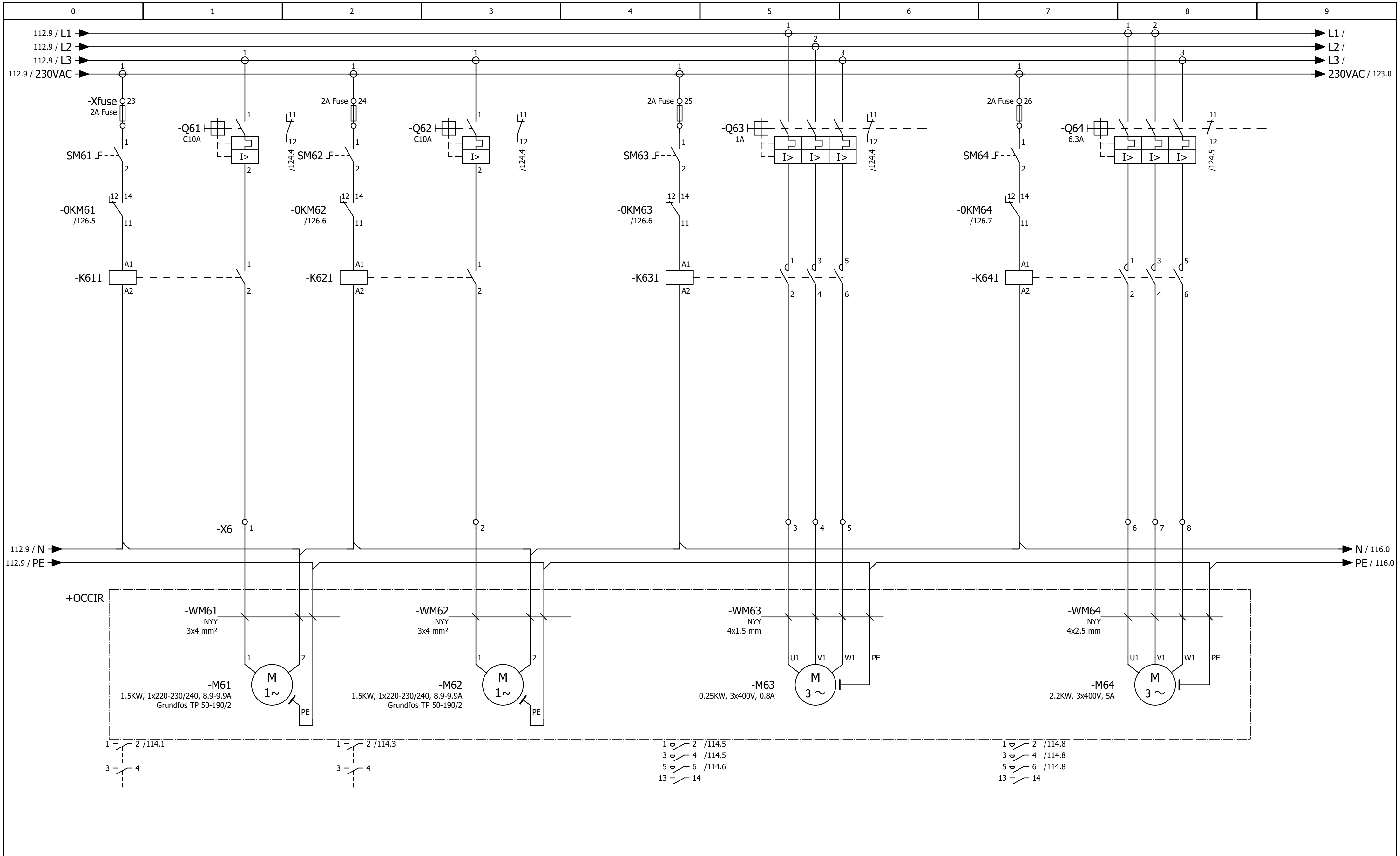

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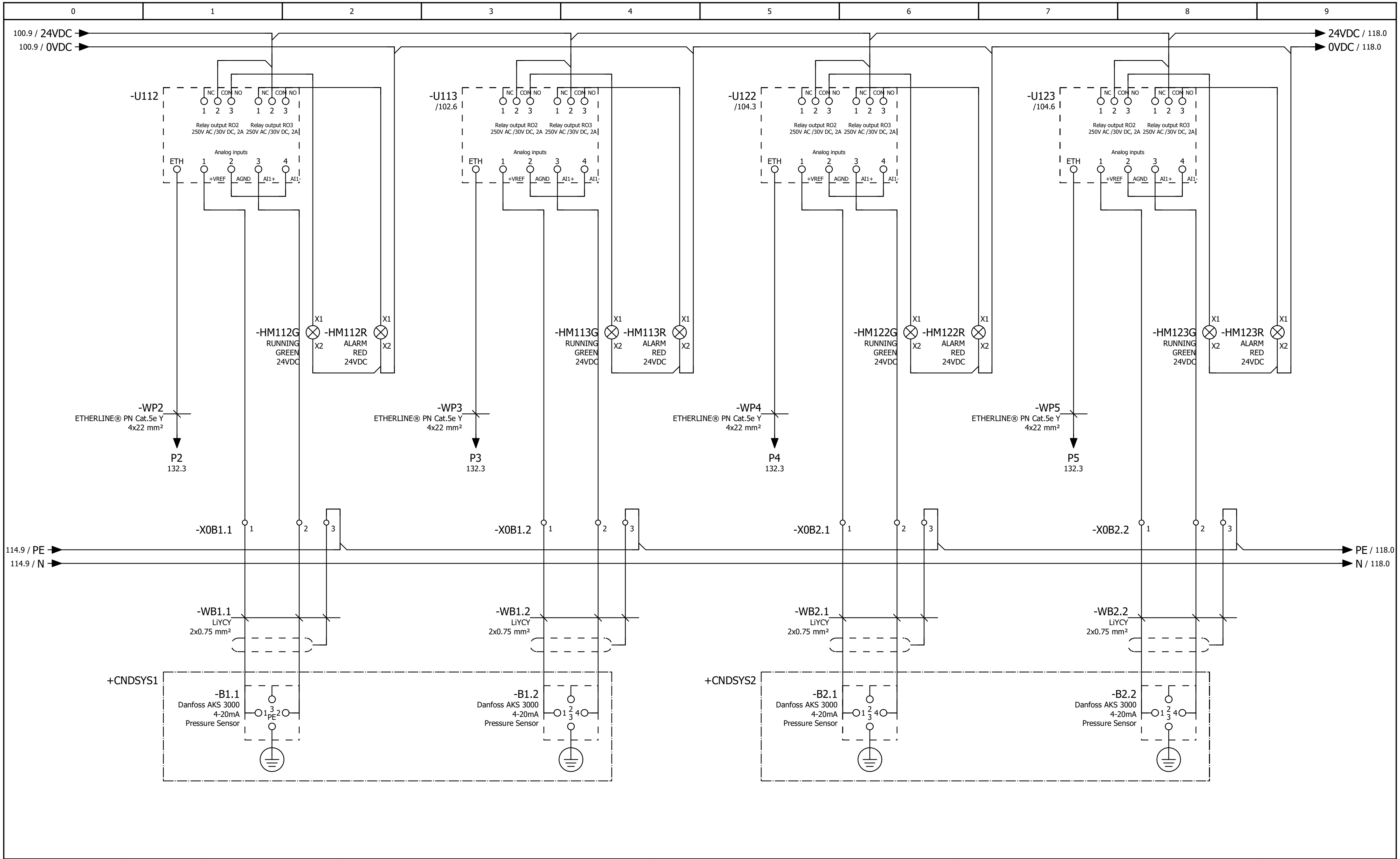

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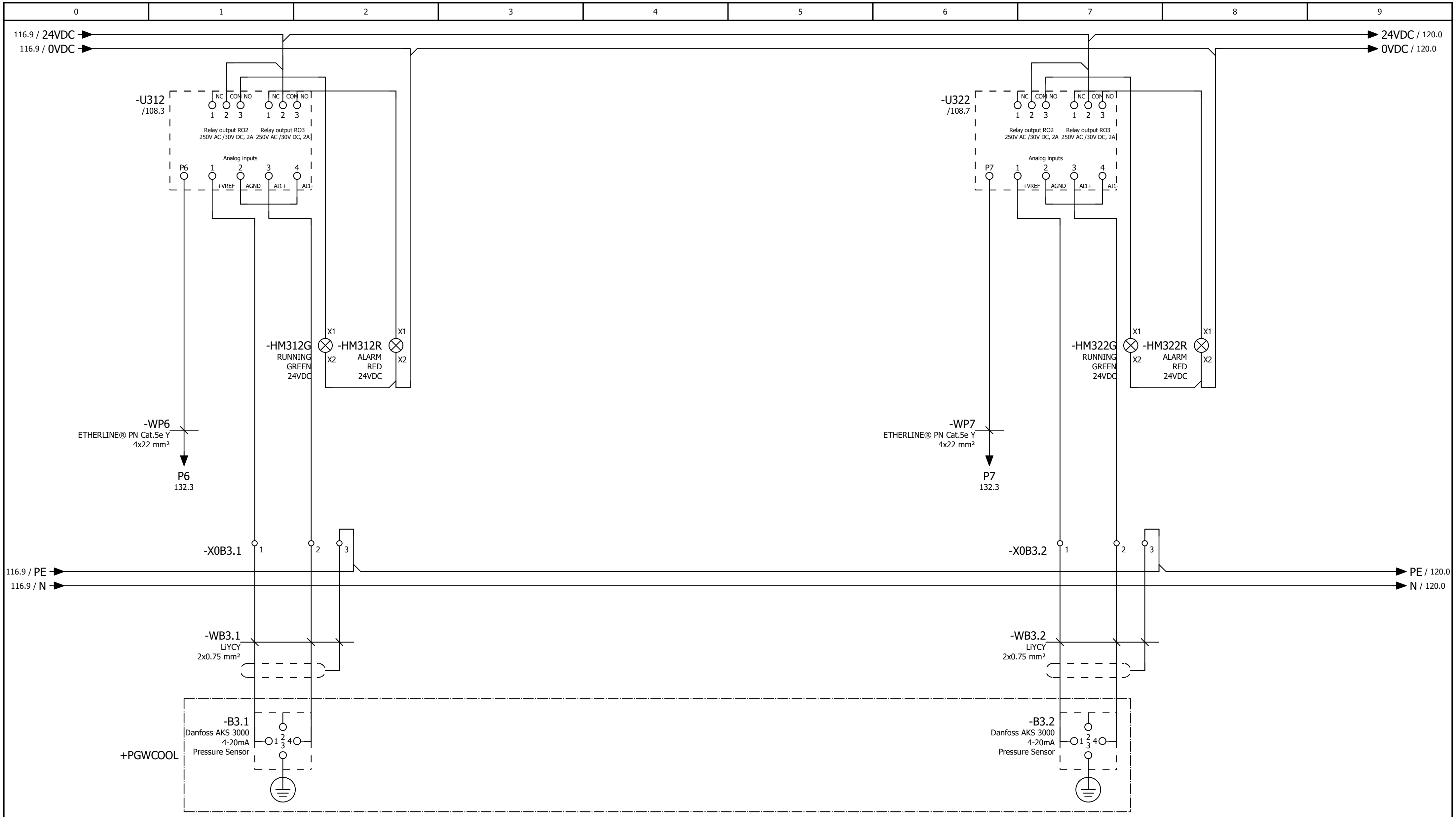

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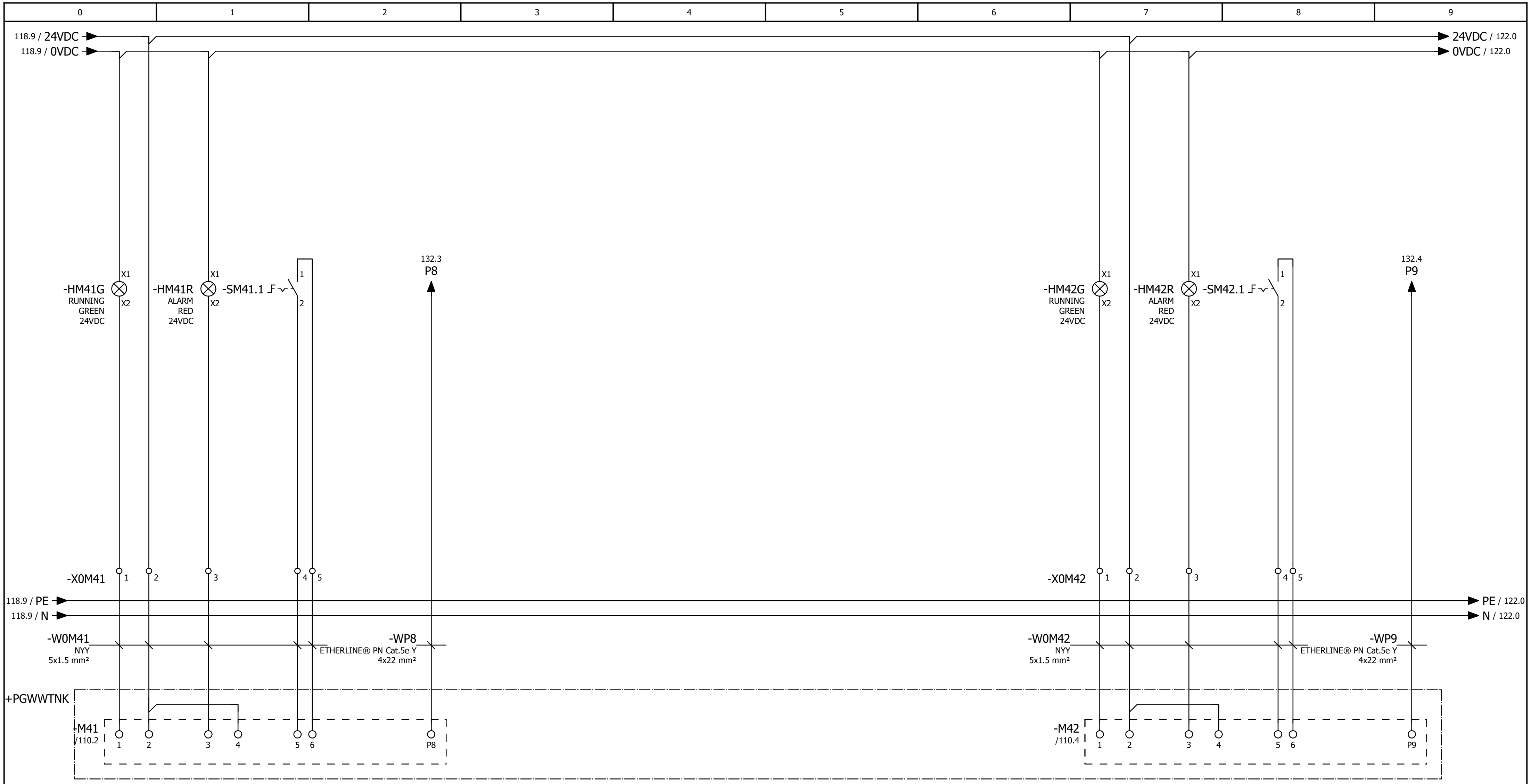
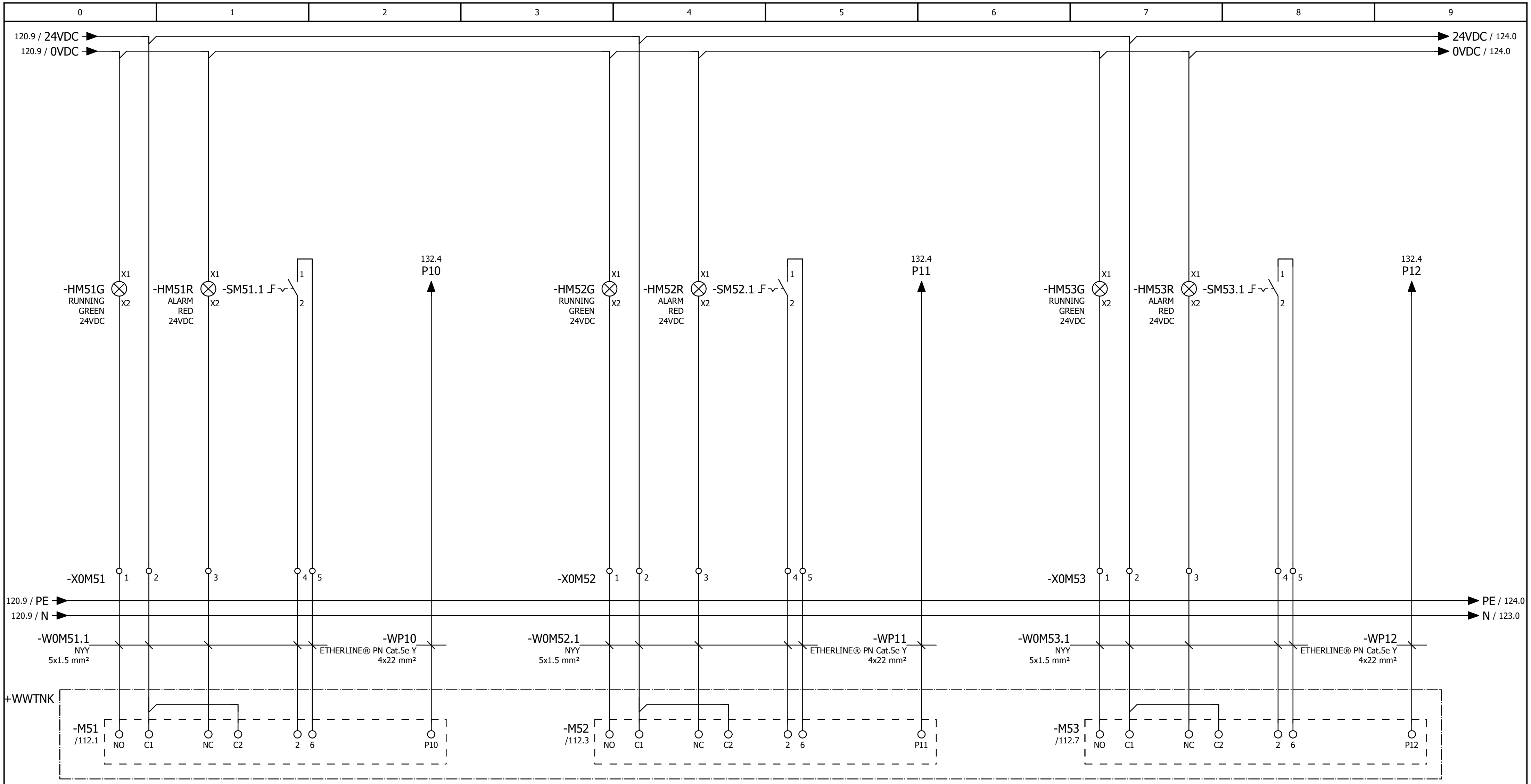
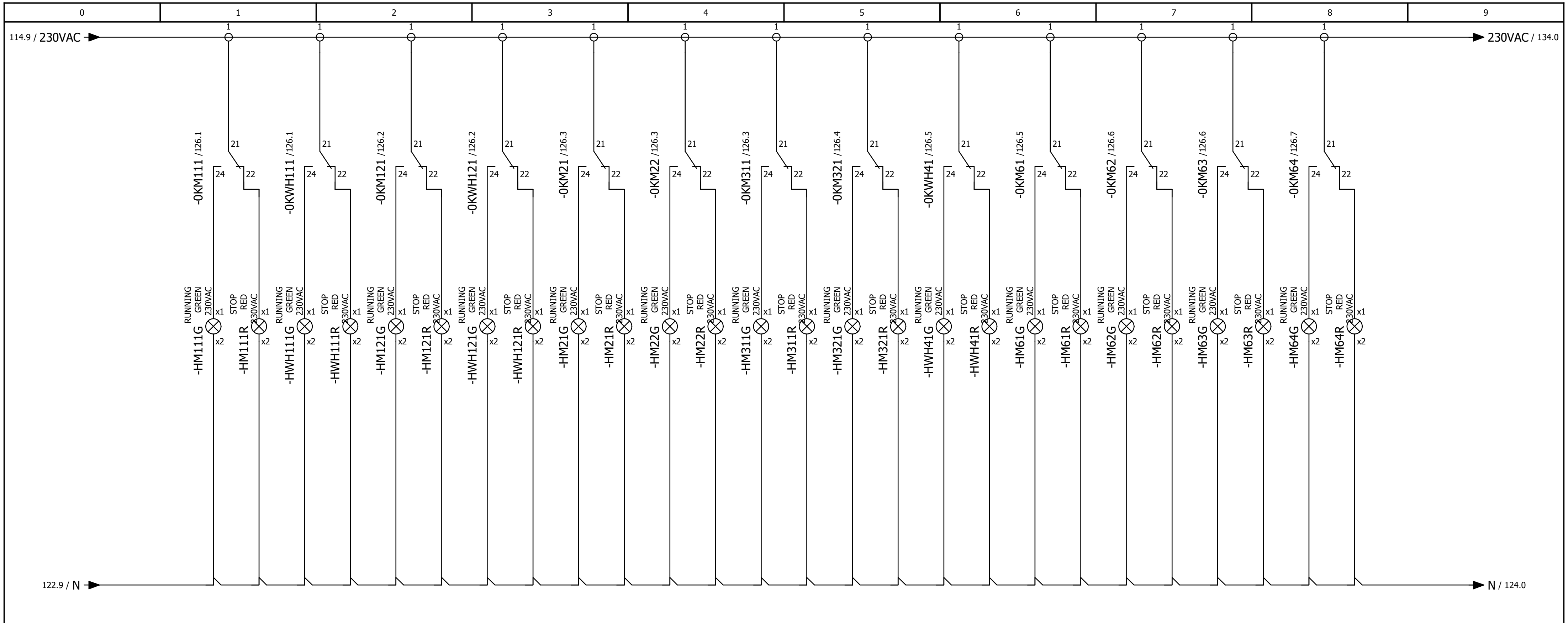
Approved: Tomislav Špoljarić, dipl.eng. el.						Follow: 120



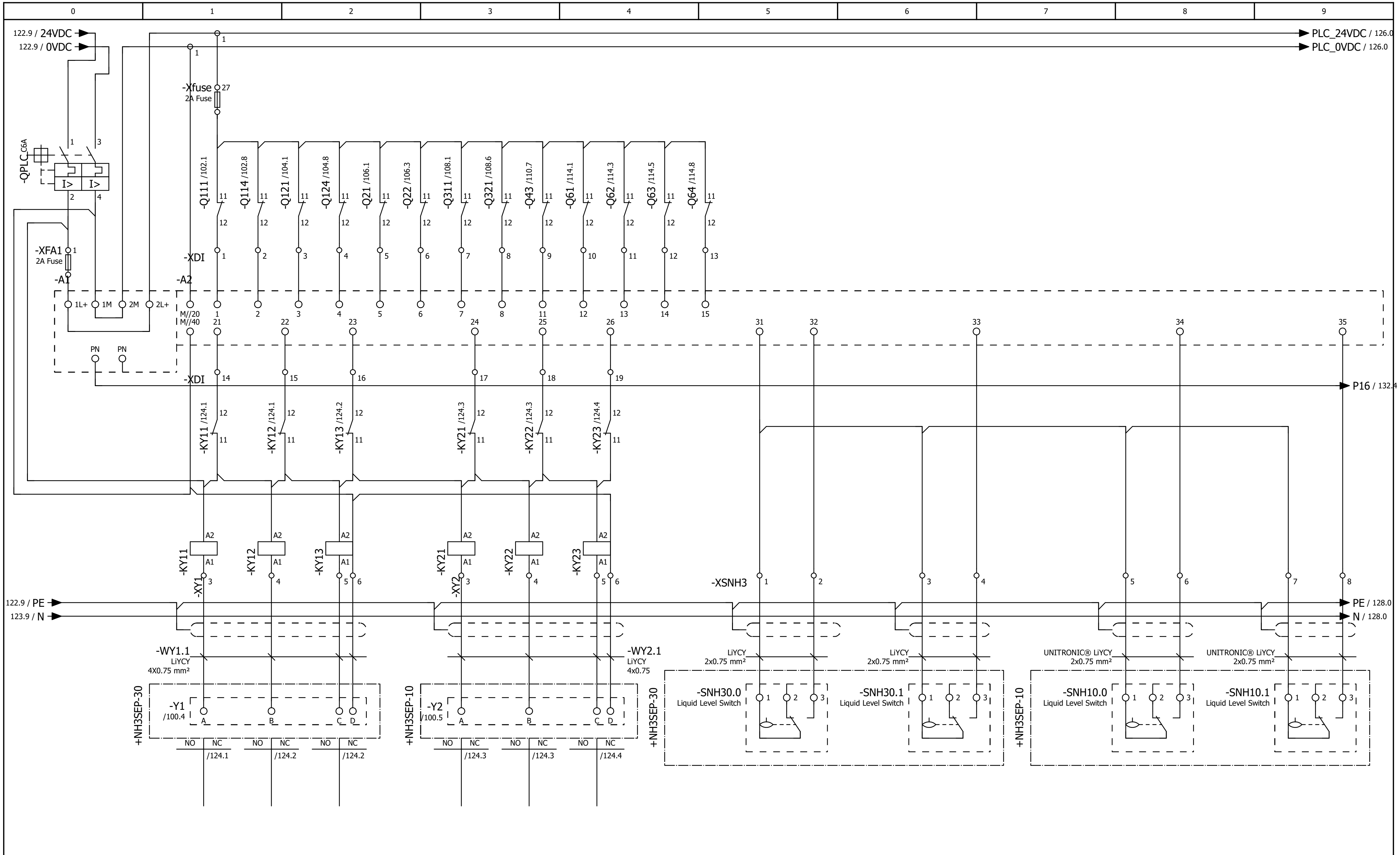
Project no.: MFT-20/21 Revision: R0 Revision date: 16.07.2021	TVZ TEHNIČKO VELEUČILIŠTE U ZAGREBU POLYTECHNICUM ZAGRABIENSE	Customer: Tehničko veleučilište u Zagrebu	Object: Elektrotehnički odelj TVZ-a	Cabinet: +Y1
Drawn: Xabier Gregorio, bach. eng. el.		Vrbij 8a, 10000 Zagreb	Konavoska 2, 10000 Zagreb	Plant: =H1
Checked: Tomislav Špoljarić, dipl.eng. el.	Page description: **WARM PGW TANKS' PUMPS CONTROL SYSTEM**	End customer: Tehničko veleučilište u Zagrebu	Project name: Electrical project design for a cabinet in an engine room of a cooling plant	Page: 120
Approved: Tomislav Špoljarić, dipl.eng. el.		Konavoska 2, 10000 Zagreb		Follow: 122



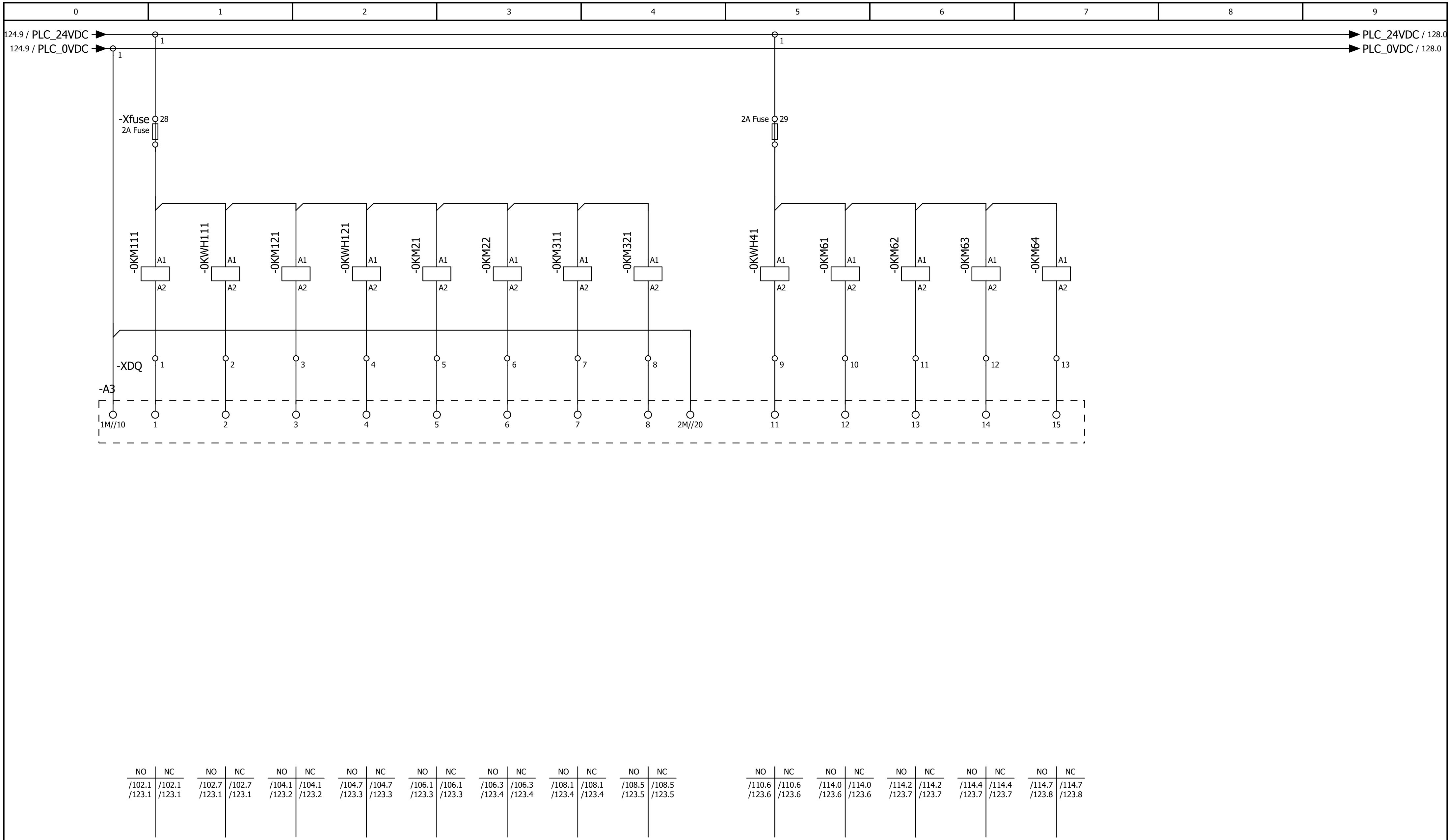
Project no.: MFT-20/21	Revision: R0	Revision date: 16.07.2021	TEHNIČKO VELEUČILIŠTE U ZAGREBU POLYTECHNICUM ZAGRABIENSE	Customer: Tehničko veleučilište u Zagrebu Vrbij 8a, 10000 Zagreb	Object: Elektrotehnički odelj TVZ-a Konavoska 2, 10000 Zagreb	Cabinet: +Y1
Drawn: Xabier Gregorio, bach. eng. el.						Plant: =H1
Checked: Tomislav Špoljarić, dipl.eng. el.			Page description: **WARM WATER TANKS CONTROL SYSTEM**	End customer: Tehničko veleučilište u Zagrebu Konavoska 2, 10000 Zagreb	Project name: Electrical project design for a cabinet in an engine room of a cooling plant	Page: 122
Approved: Tomislav Špoljarić, dipl.eng. el.						Follow: 123



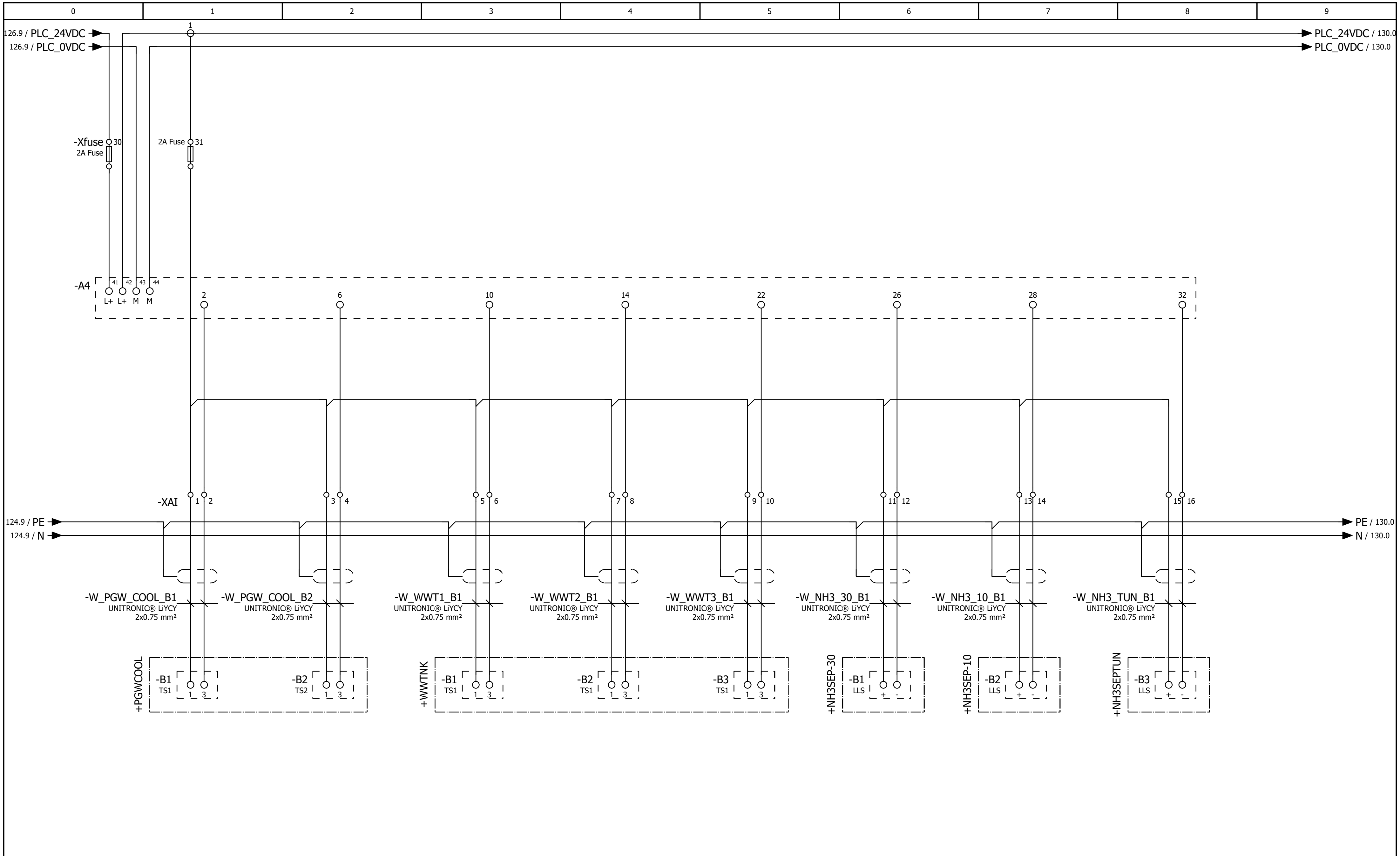
Project no.: MFT-20/21 Revision: R0 Revision date: 16.07.2021	TVZ TEHNIČKO VELEUČILIŠTE U ZAGREBU POLYTECHNICUM ZAGRABIENSE	Customer: Tehničko veleučilište u Zagrebu	Object: Elektrotehnički odelj TVZ-a	Cabinet: +Y1
Drawn: Xabier Gregorio, bach. eng. el.		Vrbij 8a, 10000 Zagreb	Konavoska 2, 10000 Zagreb	Plant: =H1
Checked: Tomislav Špoljarić, dipl.eng. el.	Page description: **MONITORING SOFT STARTERS AND DOL CONSUMERS**	End customer: Tehničko veleučilište u Zagrebu	Project name: Electrical project design for a cabinet in an engine room of a cooling plant	Page: 123
Approved: Tomislav Špoljarić, dipl.eng. el.		Konavoska 2, 10000 Zagreb		Follow: 124



Project no.: MFT-20/21	Revision: R0	Revision date: 16.07.2021	TVZ TEHNIČKO VELEUČILIŠTE U ZAGREBU POLYTECHNICUM ZAGRABIENSE	Customer: Tehničko veleučilište u Zagrebu	Object: Elektrotehnički odelj TVZ-a	Cabinet: +Y1
Drawn: Xabier Gregorio, bach. eng. el.				Vrbij 8a, 10000 Zagreb	Konavoska 2, 10000 Zagreb	Plant: =H1
Checked: Tomislav Špoljarić, dipl.eng. el.			Page description: **PLC CPU+DIGITAL INPUT MODULE**	End customer: Tehničko veleučilište u Zagrebu	Project name: Electrical project design for a cabinet in an engine room of a cooling plant	Page: 124
Approved: Tomislav Špoljarić, dipl.eng. el.				Konavoska 2, 10000 Zagreb		Follow: 126

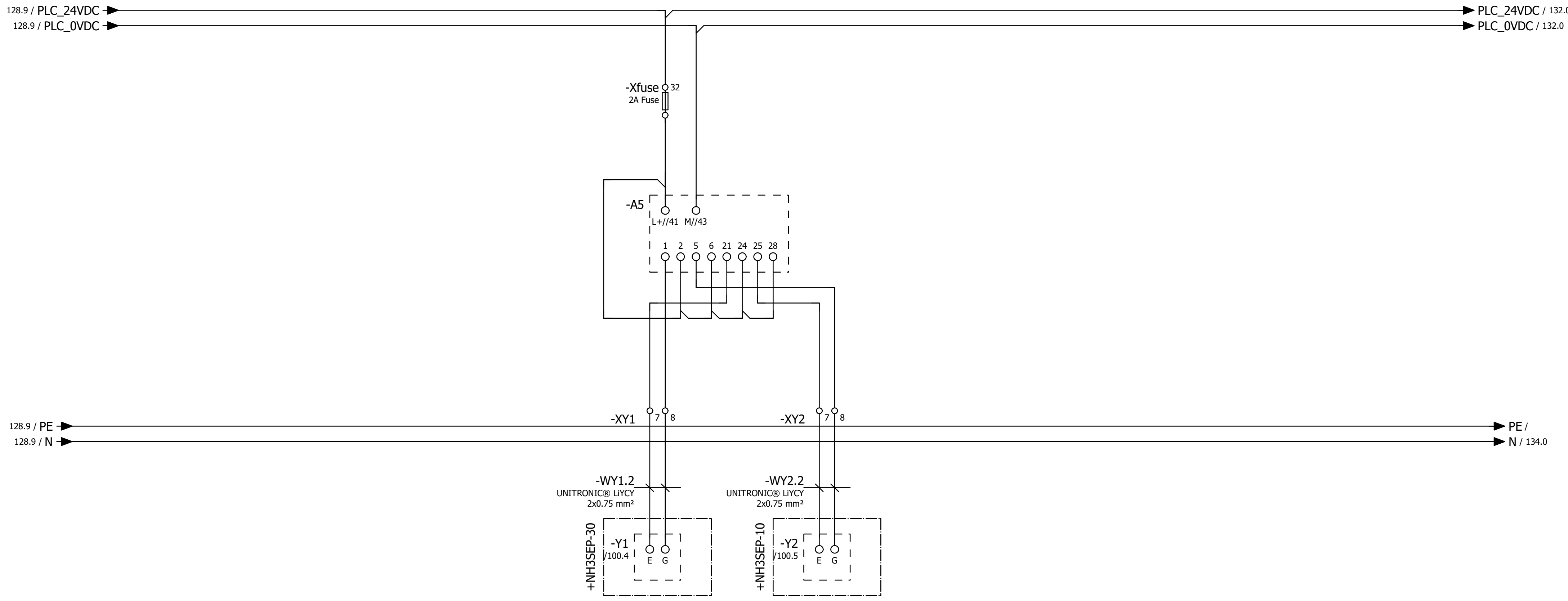


Project no.: MET-20/21	Revision: R0	Revision date: 16.07.2021	TEHNIČKO VELEUČILIŠTE U ZAGREBU POLYTECHNICUM ZAGRABIENSE	Customer: Tehničko veleučilište u Zagrebu	Object: Elektrotehnički odelj TVZ-a	Cabinet: +Y1
Drawn: Xabier Gregorio, bach. eng. el.				Vrbij 8a, 10000 Zagreb	Konavoska 2, 10000 Zagreb	Plant: =H1
Checked: Tomislav Špoljarić, dipl.eng. el.			Page description: **PLC DIGITAL OUTPUT MODULE**	End customer: Tehničko veleučilište u Zagrebu	Project name: Electrical project design for a cabinet in an engine room of a cooling plant	Page: 126
Approved: Tomislav Špoljarić, dipl.eng. el.				Konavoska 2, 10000 Zagreb		Follow: 128



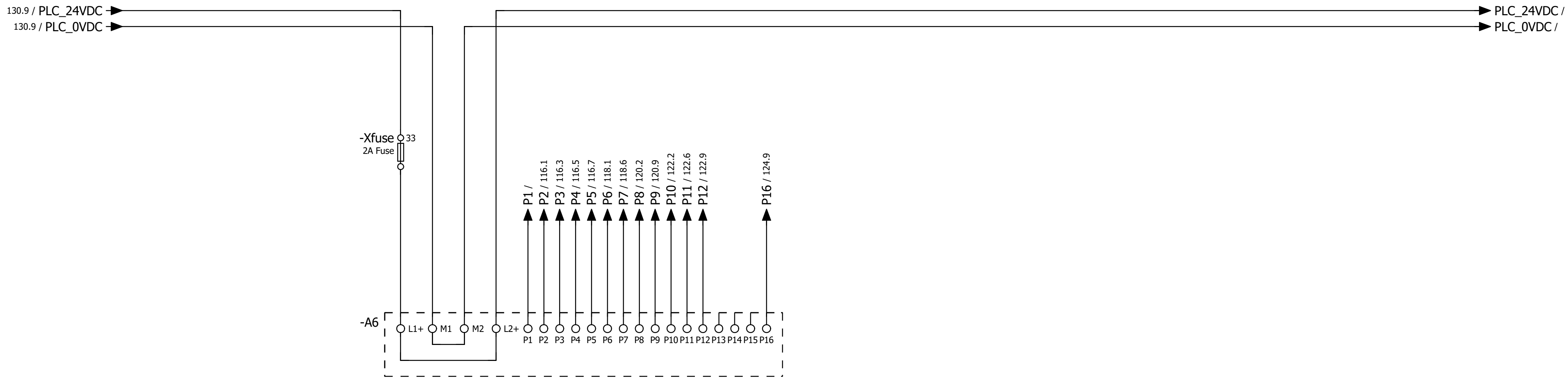
Project no.: MFT-20/21	Revision: R0	Revision date: 16.07.2021	TVZ TEHNIČKO VELEUČILIŠTE U ZAGREBU POLYTECHNICUM ZAGRABIENSE	Customer: Tehničko veleučilište u Zagrebu	Object: Elektrotehnički odelj TVZ-a	Cabinet: +Y1
Drawn: Xabier Gregorio, bach. eng. el.				Vrbij 8a, 10000 Zagreb	Konavoska 2, 10000 Zagreb	Plant: =H1
Checked: Tomislav Špoljarić, dipl.eng. el.			Page description: **PLC ANALOGICAL MODULE**	End customer: Tehničko veleučilište u Zagrebu	Project name: Electrical project design for a cabinet in an	Page: 128
Approved: Tomislav Špoljarić, dipl.eng. el.				Konavoska 2, 10000 Zagreb	engine room of a cooling plant	Follow: 130

0	1	2	3	4	5	6	7	8	9

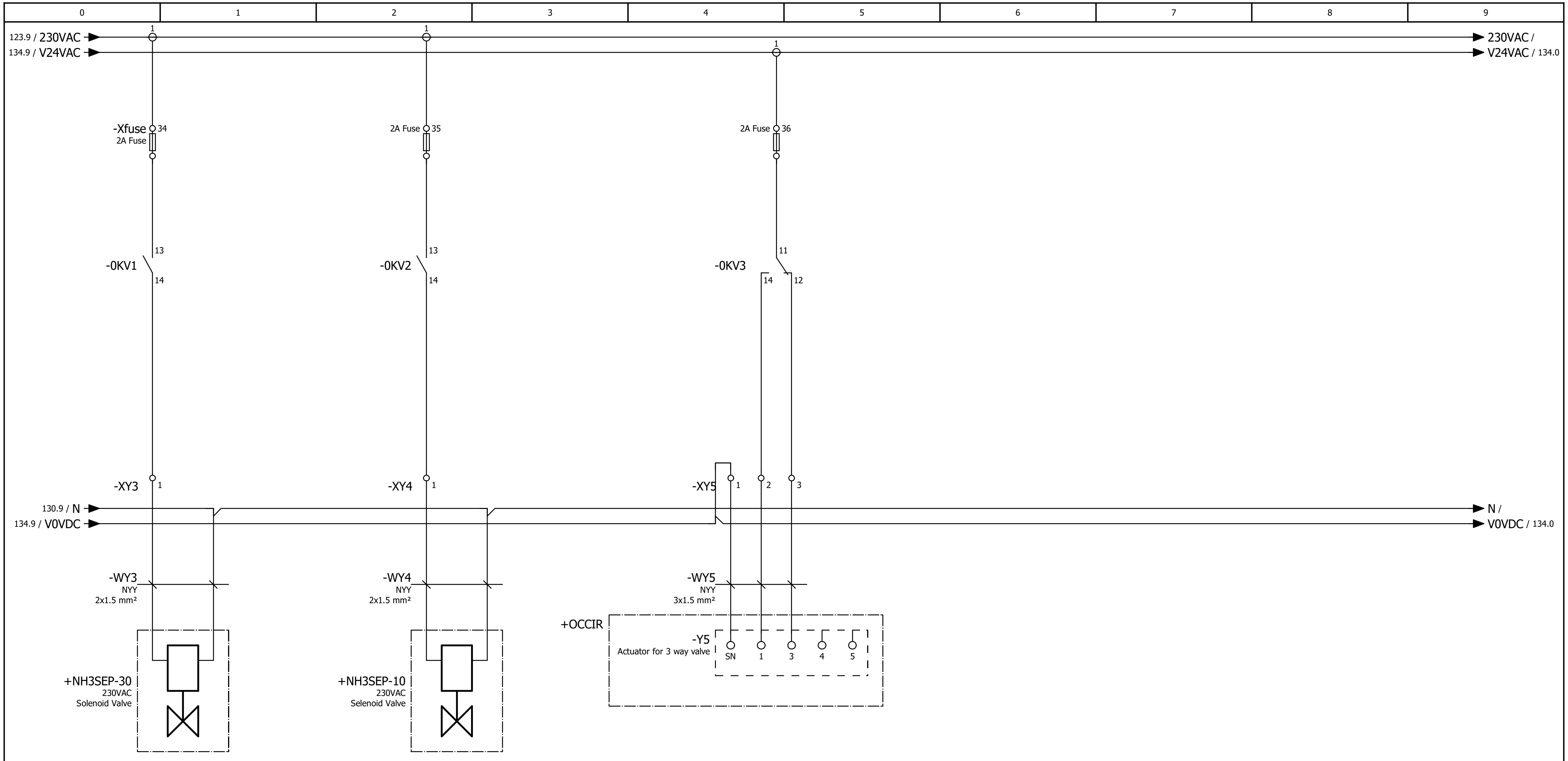


Project no.: MFT-20/21	Revision: R0	Revision date: 16.07.2021	TVZ TEHNIČKO VELEUČILIŠTE U ZAGREBU POLYTECHNICUM ZAGRABIENSE	Customer: Tehničko veleučilište u Zagrebu	Object: Elektrotehnički odelj TVZ-a	Cabinet: +Y1
Drawn: Xabier Gregorio, bach. eng. el.				Vrbij 8a, 10000 Zagreb	Konavoska 2, 10000 Zagreb	Plant: =H1
Checked: Tomislav Špoljarić, dipl.eng. el.			Page description: **PLC AI/AO MODULE**	End customer: Tehničko veleučilište u Zagrebu	Project name: Electrical project design for a cabinet in an engine room of a cooling plant	Page: 130
Approved: Tomislav Špoljarić, dipl.eng. el.				Konavoska 2, 10000 Zagreb		Follow: 132

0	1	2	3	4	5	6	7	8	9



Project no.: MFT-20/21	Revision: R0	Revision date: 16.07.2021	TVZ TEHNIČKO VELEUČILIŠTE U ZAGREBU POLYTECHNICUM ZAGRABIENSE	Customer: Tehničko veleučilište u Zagrebu Vrbij 8a, 10000 Zagreb	Object: Elektrotehnički odelj TVZ-a Konavoska 2, 10000 Zagreb	Cabinet: +Y1
Drawn: Xabier Gregorio, bach. eng. el.						Plant: =H1
Checked: Tomislav Špoljarić, dipl.eng. el.			Page description: **PLC SCALANCE SWITCH**	End customer: Tehničko veleučilište u Zagrebu Konavoska 2, 10000 Zagreb	Project name: Electrical project design for a cabinet in an engine room of a cooling plant	Page: 132
Approved: Tomislav Špoljarić, dipl.eng. el.						Follow: 134



Project no.: MFT-20/21	Revision: R0	Revision date: 16.07.2021	TVZ TEHNIČKO VELEUČILIŠTE U ZAGREBU POLYTECHNICUM ZAGRABIENSE	Customer: Tehničko veleučilište u Zagrebu	Object: Elektrotehnički odelj TVZ-a	Cabinet: +Y1
Drawn: Xabier Gregorio, bach. eng. el.				Vrbij 8a, 10000 Zagreb	Konavoska 2, 10000 Zagreb	Plant: =H1
Checked: Tomislav Špoljarić, dipl.eng. el.			Page description: **SELENOID & 3WAY VALVES**	End customer: Tehničko veleučilište u Zagrebu	Project name: Electrical project design for a cabinet in an engine room of a cooling plant	Page: 134
Approved: Tomislav Špoljarić, dipl.eng. el.				Konavoska 2, 10000 Zagreb		Follow: 135

Terminal diagram

Terminal strip

=H1+Y1-X0

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1		-Q00	3		/100.4
					-K1112			
			2		-S0	13		/100.4

Terminal diagram

Terminal strip

=H1+Y1-X0B1.1

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1	'				/116.1
			2	'				/116.2
			3	'	-X0B1.2	3:1		/116.2

Terminal diagram

Terminal strip

=H1+Y1-X0B1.2

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1	'				/116.3
			2	'				/116.4
			3	'	-X0B1.1	3:1		/116.4
					-X0B2.1			

Terminal diagram

Terminal strip

=H1+Y1-X0B2.1

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1	'				/116.6
			2	'				/116.6
			3	'	-X0B1.2	3:1		/116.6
					-X0B2.2			

Terminal diagram

Terminal strip

=H1+Y1-X0B2.2

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1	'				/116.8
			2	'				/116.8
			3	'	-X0B2.1	3:1		/116.8
					-X0B3.1			

Terminal diagram

Terminal strip

=H1+Y1-X0B3.1

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1	'				/118.1
			2	'				/118.2
			3	'	-X0B2.2	3:1		/118.2
					-X0B3.2			

Terminal diagram

Cable name / Cable type	Connection point	External target	Terminal strip =H1+Y1-X0B3.2: Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1	'				/118.7
			2	'				/118.7
			3	'	-X0B3.1	3:1		/118.7

Terminal diagram

Terminal strip

=H1+Y1-X0M41

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1					/120.0
			2		-X0M42	2:1		/120.0
			3					/120.1
			4					/120.1
			5					/120.2

0 1 2 3 4 5 6 7 8 9

Terminal diagram

Terminal strip

=H1+Y1-X0M42

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1	'				/120.7
			2	'	-X0M41	2:1		/120.7
					-X0M51			
			3	'				/120.7
			4	'				/120.8
			5	'				/120.8

Terminal diagram

Terminal strip

=H1+Y1-X0M51

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1					/122.0
			2		-X0M42	2:1		/122.0
					-X0M52			
			3					/122.1
			4					/122.1
			5					/122.2

Terminal diagram

Terminal strip

=H1+Y1-X0M52

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1					/122.3
			2		-X0M51	2		/122.4
					-X0M53			
			3					/122.4
			4					/122.5
			5					/122.5

Terminal diagram

Terminal strip

=H1+Y1-X0M53

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1					/122.7
			2		-X0M52	2		/122.7
			3					/122.7
			4					/122.8
			5					/122.8

Terminal diagram

Terminal strip

=H1+Y1-X2

Cable name	Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
+CNDPMP-WM21	NYY								
+CNDPMP-WM22	NYY								
		U1	+CNDPMP-M21	1	'	-K212	2		/106.1
		V1	+CNDPMP-M21	2	'	-K212	4		/106.1
		W1	+CNDPMP-M21	3	'	-K212	6		/106.2
		U1	+CNDPMP-M22	4	'	-K222	2		/106.3
		V1	+CNDPMP-M22	5	'	-K222	4		/106.4
		W1	+CNDPMP-M22	6	'	-K222	6		/106.4

Terminal diagram

Cable name	Cable type
+PGWCOOL-WM322	NYCY
+PGWCOOL-WM321	NYY
+PGWCOOL-WM312	NYCY
+PGWCOOL-WM311	NYY

Terminal strip

=H1+Y1-X3

Connection point	External target	Terminal	Jumper	Internal target	Connection point	Page
U1	+PGWCOOL-M311	1	'	-K3112	2	/108.1
V1	+PGWCOOL-M311	2	'	-K3112	4	/108.1
W1	+PGWCOOL-M311	3	'	-K3112	6	/108.2
U1	+PGWCOOL-M312	4	'	-K3121	2	/108.3
V1	+PGWCOOL-M312	5	'	-K3121	4	/108.3
W1	+PGWCOOL-M312	6	'	-K3121	6	/108.3
PE	+PGWCOOL-M312	7	'	-U312	PE'	/108.3
U1	+PGWCOOL-M321	8	'	-K3212	2	/108.6
V1	+PGWCOOL-M321	9	'	-K3212	4	/108.6
W1	+PGWCOOL-M321	10	'	-K3212	6	/108.6
U1	+PGWCOOL-M322	11	'	-K3221	2	/108.7
V1	+PGWCOOL-M322	12	'	-K3221	4	/108.8
W1	+PGWCOOL-M322	13	'	-K3221	6	/108.8
PE	+PGWCOOL-M322	14	'	-U322	PE'	/108.8

Terminal diagram

Terminal strip

=H1+Y1-X4

Cable name	-WWH41	-WM42	-WM41
Cable type	NYY	NYY	NYY

Connection point	External target	Terminal	Jumper	Internal target	Connection point	Page
L1	+PGWWTNK-M41	1	'	-K411	2	/110.2
1	+PGWWTNK-M41	2	'	-K411	4	/110.2
2	+PGWWTNK-M41	3	'	-K411	6	/110.2
L1	+PGWWTNK-M42	4	'	-K421	2	/110.4
1	+PGWWTNK-M42	5	'	-K421	4	/110.4
2	+PGWWTNK-M42	6	'	-K421	6	/110.4
1	+PGWWTNK-WH41	7	'	-K431	2	/110.7
1	+PGWWTNK-WH41	8	'	-K431	4	/110.7
1	+PGWWTNK-WH41	9	'	-K431	6	/110.7

0	1	2	3	4	5	6	7	8	9

Terminal diagram

Cable name: -WM53, -WM52, -WM51

Cable type: NYY, NYY, NYY

Terminal strip

=H1+Y1-X5

Connection point	External target	Terminal	Jumper	Internal target	Connection point	Page
L1	+WWTNK-M51	1	'	-K511	2	/112.1
L2	+WWTNK-M51	2	'	-K511	4	/112.1
L3	+WWTNK-M51	3	'	-K511	6	/112.1
L1	+WWTNK-M52	4	'	-K521	2	/112.4
1	+WWTNK-M52	5	'	-K521	4	/112.4
2	+WWTNK-M52	6	'	-K521	6	/112.4
L1	+WWTNK-M53	7	'	-K531	2	/112.7
1	+WWTNK-M53	8	'	-K531	4	/112.7
2	+WWTNK-M53	9	'	-K531	6	/112.7

Terminal diagram

Terminal strip

=H1+Y1-X6

+OCCIR-WM64	+OCCIR-WM63	+OCCIR-WM62	+OCCIR-WM61	Cable name							Cable name	
NYY	NYY	NYY	NYY	Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable type	Page
					1	+OCCIR-M61	1	·	-K611	2		/114.1
					1	+OCCIR-M62	2	·	-K621	2		/114.3
					U1	+OCCIR-M63	3	·	-K631	2		/114.5
					V1	+OCCIR-M63	4	·	-K631	4		/114.5
					W1	+OCCIR-M63	5	·	-K631	6		/114.6
					U1	+OCCIR-M64	6	·	-K641	2		/114.8
					V1	+OCCIR-M64	7	·	-K641	4		/114.8
					W1	+OCCIR-M64	8	·	-K641	6		/114.8

0	1	2	3	4	5	6	7	8	9

Terminal diagram

Terminal strip

=H1+Y1-X11

Cable name	+CNDSYS1-WWH111	+CNDSYS1-WSWH1	+CNDSYS1-WM113	+CNDSYS1-WM112	+CNDSYS1-WM111
Cable type	NYY	OB-500	NYCY	NYCY	NYY

Connection point	External target	Terminal	Jumper	Internal target	Connection point	Page
U1	+CNDSYS1-M111	1	•	-K1112	2	/102.1
V1	+CNDSYS1-M111	2	•	-K1112	4	/102.1
W1	+CNDSYS1-M111	3	•	-K1112	6	/102.2
U1	+CNDSYS1-M112	4	•	-K1121	2	/102.3
V1	+CNDSYS1-M112	5	•	-K1121	4	/102.4
W1	+CNDSYS1-M112	6	•	-K1121	6	/102.4
PE	+CNDSYS1-M112	7	•	-U112	PE'	/102.4
U1	+CNDSYS1-M113	8	•	-K1131	2	/102.6
V1	+CNDSYS1-M113	9	•	-K1131	4	/102.6
W1	+CNDSYS1-M113	10	•	-K1131	6	/102.6
PE	+CNDSYS1-M113	11	•	-U113	PE'	/102.7
13	+CNDSYS1-SWH11	12	•	-0KWH111	11	/102.7
14	+CNDSYS1-SWH12	13	•	-K1141	A1	/102.7
1	+CNDSYS1-WH111	14	•	-K1141	2	/102.8

Terminal diagram

Cable name	+CNDSYS2-WWH121	+CNDSYS2-WSWH2	+CNDSYS2-WM123	+CNDSYS2-WM122	+CNDSYS2-WM121
Cable type	NYY	OB-500	NYCY	NYCY	NYY

Terminal strip

=H1+Y1-X12

Connection point	External target	Terminal	Jumper	Internal target	Connection point	Page
U1	+CNDSYS2-M121	1	'	-K1212	2	/104.1
V1	+CNDSYS2-M121	2	'	-K1212	4	/104.1
W1	+CNDSYS2-M121	3	'	-K1212	6	/104.2
U1	+CNDSYS2-M122	4	'	-K1221	2	/104.3
V1	+CNDSYS2-M122	5	'	-K1221	4	/104.4
W1	+CNDSYS2-M122	6	'	-K1221	6	/104.4
PE	+CNDSYS2-M122	7	'	-U122	PE'	/104.4
U1	+CNDSYS2-M123	8	'	-K1231	2	/104.6
V1	+CNDSYS2-M123	9	'	-K1231	4	/104.6
W1	+CNDSYS2-M123	10	'	-K1231	6	/104.6
PE	+CNDSYS2-M123	11	'	-U123	PE'	/104.7
13	+CNDSYS2-SWH21	12	'	-0KWH121	11	/104.7
14	+CNDSYS2-SWH22	13	'	-K1241	A1	/104.7
1	+CNDSYS2-WH121	14	'	-K1241	2	/104.8

Terminal diagram

Cable name	-W_NH3_TUN_B1	-W_NH3_10_B1	-W_NH3_30_B1	-W_WWT3_B1	-W_WWT2_B1	-W_WWT1_B1	-W_PGW_COOL_B2	-W_PGW_COOL_B1
Cable type	UNITRONIC® LiYCY	UNITRONIC® LiYCY	UNITRONIC® LiYCY	UNITRONIC® LiYCY	UNITRONIC® LiYCY	UNITRONIC® LiYCY	UNITRONIC® LiYCY	UNITRONIC® LiYCY

Terminal strip

=H1+Y1-XAI

Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
1	+PGWCOOL-B1	1		-Xfuse	31:B		/128.1
3	+PGWCOOL-B1	2		-A4	2		/128.1
1	+PGWCOOL-B2	3					/128.2
3	+PGWCOOL-B2	4		-A4	6		/128.2
1	+WWTNK-B1	5					/128.3
3	+WWTNK-B1	6		-A4	10		/128.3
1	+WWTNK-B2	7					/128.4
3	+WWTNK-B2	8		-A4	14		/128.4
1	+WWTNK-B3	9					/128.5
3	+WWTNK-B3	10		-A4	22		/128.5
+	+NH3SEP-B1	11					/128.6
-	+NH3SEP-B1	12		-A4	26		/128.6
+	+NH3SEP-B2	13					/128.7
-	+NH3SEP-B2	14		-A4	28		/128.7
+	+NH3SEPTUN-B3	15					/128.8
-	+NH3SEPTUN-B3	16		-A4	32		/128.8

Terminal diagram

Terminal strip

=H1+Y1-XDI

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
	1	-A2	1	·	-Q111	12		/124.1
	2	-A2	2	·	-Q114	12		/124.1
	3	-A2	3	·	-Q121	12		/124.2
	4	-A2	4	·	-Q124	12		/124.2
	5	-A2	5	·	-Q21	12		/124.2
	6	-A2	6	·	-Q22	12		/124.3
	7	-A2	7	·	-Q311	12		/124.3
	8	-A2	8	·	-Q321	12		/124.3
	11	-A2	9	·	-Q43	12		/124.3
	12	-A2	10	·	-Q61	12		/124.4
	13	-A2	11	·	-Q62	12		/124.4
	14	-A2	12	·	-Q63	12		/124.4
	15	-A2	13	·	-Q64	12		/124.5
	12	-KY11	14	·	-A2	21		/124.1
	12	-KY12	15	·	-A2	22		/124.2
	12	-KY13	16	·	-A2	23		/124.2
	12	-KY21	17	·	-A2	24		/124.3
	12	-KY22	18	·	-A2	25		/124.3
	12	-KY23	19	·	-A2	26		/124.4

Terminal diagram

Terminal strip

=H1+Y1-XDQ

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
	1	-A3	1	'	-0KM111	A2		/126.1
	2	-A3	2	'	-0KWH111	A2		/126.1
	3	-A3	3	'	-0KM121	A2		/126.2
	4	-A3	4	'	-0KWH121	A2		/126.2
	5	-A3	5	'	-0KM21	A2		/126.3
	6	-A3	6	'	-0KM22	A2		/126.3
	7	-A3	7	'	-0KM311	A2		/126.3
	8	-A3	8	'	-0KM321	A2		/126.4
	11	-A3	9	'	-0KWH41	A2		/126.5
	12	-A3	10	'	-0KM61	A2		/126.5
	13	-A3	11	'	-0KM62	A2		/126.6
	14	-A3	12	'	-0KM63	A2		/126.6
	15	-A3	13	'	-0KM64	A2		/126.7

0	1	2	3	4	5	6	7	8	9

Terminal diagram

Terminal strip

=H1+Y1-XFA1

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
	1L+	-A1	1	'	-QPLC	2		/124.0
					-KY11			

Terminal diagram

Terminal strip

=H1+Y1-XSNH3

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
	1	+NH3SEP-SNH30.0	1		-A2	31		/124.5
	3	+NH3SEP-SNH30.0	2		-A2	32		/124.5
	1	+NH3SEP-SNH30.1	3					/124.6
	3	+NH3SEP-SNH30.1	4		-A2	33		/124.7
	1	+NH3SEP-SNH10.0	5					/124.8
	3	+NH3SEP-SNH10.0	6		-A2	34		/124.8
	1	+NH3SEP-SNH10.1	7					/124.9
	3	+NH3SEP-SNH10.1	8		-A2	35		/124.9

0	1	2	3	4	5	6	7	8	9

Terminal diagram

Terminal strip

=H1+Y1-XY1

-WY1.2	-WY1.1	-WY1.0	Cable name							Cable name	
UNITRONIC® LIYCY	LIYCY	NYY	**Cable type**	**Connection point**	**External target**	**Terminal**	**Jumper**	**Internal target**	**Connection point**	**Cable type**	**Page**
				II	+NH3SEP-Y1	1	'	-Xfuse	1:B		/100.5
				III	+NH3SEP-Y1	2	'	-V1	-		/100.5
								-XY2			
				A	+NH3SEP-Y1	3	'	-KY11	A1		/124.1
				B	+NH3SEP-Y1	4	'	-KY12	A1		/124.1
				C	+NH3SEP-Y1	5	'	-KY13	A1		/124.2
				D	+NH3SEP-Y1	6	'	-A2	M//40		/124.2
								-XY2			
				E	+NH3SEP-Y1	7	'	-A5	21		/130.4
				G	+NH3SEP-Y1	8	'	-A5	1		/130.4

Terminal diagram

-WY2.2	-WY2.1	-WY2.0	Cable name	Terminal strip =H1+Y1-XY2						Cable name	
UNITRONIC® LIYCY	LIYCY	NYY	Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable type	Page
				II	+NH3SEP-Y2	1	'	-Xfuse	2:B		/100.6
				III	+NH3SEP-Y2	2	'	-XY1	2:1		/100.6
				A	+NH3SEP-Y2	3	'	-KY21	A1		/124.3
				B	+NH3SEP-Y2	4	'	-KY22	A1		/124.3
				C	+NH3SEP-Y2	5	'	-KY23	A1		/124.4
				D	+NH3SEP-Y2	6	'	-XY1	6:1		/124.4
				E	+NH3SEP-Y2	7	'	-A5	25		/130.5
				G	+NH3SEP-Y2	8	'	-A5	5		/130.5

Terminal diagram

Terminal strip

=H1+Y1-XY3

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1	'	-0KV1	14		/134.0

Terminal diagram

Terminal strip

=H1+Y1-XY4

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
			1	•	-0KV2	14		/134.2

Terminal diagram

Terminal strip

=H1+Y1-XY5

Cable name: -WY5

Cable type: NYY

Connection point	External target	Terminal	Jumper	Internal target	Connection point	Page
SN	+OCCIR-Y5	1				/134.4
1	+OCCIR-Y5	2		-0KV3	14	/134.4
3	+OCCIR-Y5	3		-0KV3	12	/134.5

Terminal diagram

Terminal strip

=H1+Y1-Xfuse

Cable name / Cable type	Connection point	External target	Terminal	Jumper	Internal target	Connection point	Cable name / Cable type	Page
	[illegible]	[illegible]	[illegible]		-V1	[illegible]		[illegible]
	[illegible]	[illegible]	[illegible]			1		[illegible]
	[illegible]	[illegible]	[illegible]			1		[illegible]
	1	-SM121	7			1		/104.0
	1	-SM21	11			1		/106.0
	1	-SM22	12			1		/106.2
	1	-SM311	13			1		/108.0
	1	-SM41	17			1		/110.1
	1	-SM42	18			1		/110.3
	1	-SWH41	19			1		/110.6
	1	-SM51	20			1		/112.0
	1	-SM52	21			1		/112.3
	1	-SM53	22			1		/112.6
	1	-SM61	23			1		/114.0
	1	-SM62	24			1		/114.2
	1	-SM63	25			1		/114.4
	1	-SM64	26			1		/114.7
	11	-Q111	27					/124.1
	A1	-0KM111	28					/126.1
	A1	-0KWH41	29					/126.5
	L+	-A4	30		-A1	2L+		/128.0
	1:1	-XAI	31			1		/128.1
	L+//41	-A5	32		-A4	L+		/130.4
		-A6-L1+	33					/132.2

Part list

Device tag	Part description	Part number	Manufacturer	Quantity	Page
-A1	SIMATIC S7-1500, CPU 1511-1 PN, CENTRAL PROCESSING UNIT WITH WORKING MEMORY 150 KB FOR PROGRAM AND 1 MB FOR DATA, 1. INTERFACE:	6ES7511-1AK02-0AB0	SIE	1	/124.0
-A2	SIMATIC S7-1500, DIGITAL INPUT MODULE DI 32xDC 24V HF, 32 CHANNELS IN GROUPS OF 16/ INPUT DELAY 0.05... 20MS/ INPUT TYPE 3 (IEC 61131)/	6ES7521-1BL00-0AB0	SIE	1	/124.1
-A3	SIMATIC S7-1500, DIGITAL OUTPUT MODULE DQ 32 X 24V DC/0.5A HF/ 32 CHANNELS IN GROUPS OF 8, 4 A PER GROUP/ SINGLE-CHANNEL DIAGNOSIS/	6ES7522-1BL01-0AB0	SIE	1	/126.0
-A4	SIMATIC S7-1500, ANALOG INPUT MODULE AI 8 X U/I HF, 16 BITS OF RESOLUTION, ACCURACY 0.1%, 8 CHANNELS IN GROUPS OF 1/ COMMON MODE	6ES7531-7NF00-0AB0	SIE	1	/128.0
-A5	SIMATIC S7-1500, ANALOG IN-/OUTPUT MODULE AI 4X U/I/R/RTD/TC ST/ 4 CHANNELS IN GROUPS OF 4 PROCESSALARMS/ DIAGNOSTICS AQ 2X U/I ST/ 2	6ES7534-7QE00-0AB0	SIE	1	/130.4
-A6	SCALANCE XC216 MANAGEABLE LAYER 2 IE-SWITCH; 16X 10/100 MBIT/S RJ45 PORTS; 1X CONSOLE PORT; DIAGNOSITICS-LED; REDUNDANT POWER SUPPLY;	6GK5216-0BA00-2AC2	SIE	1	/132.2
-FQ0	High quality miniature circuit-breaker, rated operating voltage 230/400V, rated switching capacity 10 kA according to UL 1077, CSA C22.2 No 235 and IEC/EN	FAZ-C6/1	ETN	1	/100.3
-HM21G		XB4BV43	SE	1	/123.3
-HM21R		XB4BV44	SE	1	/123.3
-HM22G		XB4BV43	SE	1	/123.4
-HM22R		XB4BV44	SE	1	/123.4
-HM41G		XB4BVB3	SE	1	/120.0
-HM41R		XB4BVB4	SE	1	/120.1
-HM42G		XB4BVB3	SE	1	/120.7
-HM42R		XB4BVB4	SE	1	/120.7
-HM51G		XB4BVB3	SE	1	/122.0
-HM51R		XB4BVB4	SE	1	/122.1
-HM52G		XB4BVB3	SE	1	/122.3
-HM52R		XB4BVB4	SE	1	/122.4
-HM53G		XB4BVB3	SE	1	/122.7
-HM53R		XB4BVB4	SE	1	/122.7
-HM61G		XB4BV43	SE	1	/123.6
-HM61R		XB4BV44	SE	1	/123.6
-HM62G		XB4BV43	SE	1	/123.7
-HM62R		XB4BV44	SE	1	/123.7
-HM63G		XB4BV43	SE	1	/123.7
-HM63R		XB4BV44	SE	1	/123.8
-HM64G		XB4BV43	SE	1	/123.8
-HM64R		XB4BV44	SE	1	/123.8
-HM111G		XB4BV43	SE	1	/123.1
-HM111R		XB4BV44	SE	1	/123.1
-HM112G		XB4BVB3	SE	1	/116.2
-HM112R		XB4BVB4	SE	1	/116.2
-HM113G		XB4BVB3	SE	1	/116.4
-HM113R		XB4BVB4	SE	1	/116.4
-HM121G		XB4BV43	SE	1	/123.2

0	1	2	3	4	5	6	7	8	9

Part list

Device tag	Part description	Part number	Manufacturer	Quantity	Page
-HM121R		XB4BV44	SE	1	/123.2
-HM122G		XB4BVB3	SE	1	/116.6
-HM122R		XB4BVB4	SE	1	/116.7
-HM123G		XB4BVB3	SE	1	/116.8
-HM123R		XB4BVB4	SE	1	/116.9
-HM311G		XB4BV43	SE	1	/123.4
-HM311R		XB4BV44	SE	1	/123.5
-HM312G		XB4BVB3	SE	1	/118.2
-HM312R		XB4BVB4	SE	1	/118.2
-HM321G		XB4BV43	SE	1	/123.5
-HM321R		XB4BV44	SE	1	/123.5
-HM322G		XB4BVB3	SE	1	/118.7
-HM322R		XB4BVB4	SE	1	/118.8
-HWH41G		XB4BV43	SE	1	/123.6
-HWH41R		XB4BV44	SE	1	/123.6
-HWH111G		XB4BV43	SE	1	/123.1
-HWH111R		XB4BV44	SE	1	/123.2
-HWH121G		XB4BV43	SE	1	/123.3
-HWH121R		XB4BV44	SE	1	/123.3
-K211	The types of the DS7 series are soft starters for gently starting three-phase current motors for applications with normal operating frequency and a performance	DS7-340SX012N0-N	ETN	1	/106.1
-K212	Contactor 3pole, 5,5kW, AC3, 14A, 230VAC + 1NO built in	LA301413N-	SCHR	1	/106.0
-K221	The types of the DS7 series are soft starters for gently starting three-phase current motors for applications with normal operating frequency and a performance	DS7-340SX012N0-N	ETN	1	/106.3
-K222	Contactor 3pole, 5,5kW, AC3, 14A, 230VAC + 1NO built in	LA301413N-	SCHR	1	/106.2
-K411	Contactor 3pole, 4kW, AC3, 10A, 230VAC + 1NO built in	LA301013N-	SCHR	1	/110.1
-K421	Contactor 3pole, 4kW, AC3, 10A, 230VAC + 1NO built in	LA301013N-	SCHR	1	/110.3
-K431	Contactor 3pole, 5,5kW, AC3, 14A, 230VAC + 1NO built in	LA301413N-	SCHR	1	/110.6
-K511	Contactor 3pole, 4kW, AC3, 10A, 230VAC + 1NO built in	LA301013N-	SCHR	1	/112.0
-K521	Contactor 3pole, 4kW, AC3, 10A, 230VAC + 1NO built in	LA301013N-	SCHR	1	/112.3
-K531	Contactor 3pole, 4kW, AC3, 10A, 230VAC + 1NO built in	LA301013N-	SCHR	1	/112.6
-K611	Modular contactor 25A, 2NO, 24VAC 1MW Rated output AC-3/230V 1,30kW	BZ326474--	SCHR	1	/114.0
-K621	Modular contactor 25A, 2NO, 24VAC 1MW Rated output AC-3/230V 1,30kW	BZ326474--	SCHR	1	/114.2
-K631	Contactor 3pole, 4kW, AC3, 10A, 230VAC + 1NO built in	LA301013N-	SCHR	1	/114.4
-K641	Contactor 3pole, 4kW, AC3, 10A, 230VAC + 1NO built in	LA301013N-	SCHR	1	/114.7
-K1111	The types of the DS7 series are soft starters for gently starting three-phase current motors for applications with normal operating frequency and a performance	DS7-340SX012N0-N	ETN	1	/102.1
-K1112	Contactor 3pole, 5,5kW, AC3, 14A, 230VAC + 1NO built in	LA301413N-	SCHR	1	/102.0
-K1121	Contactor 3pole, 5,5kW, AC3, 14A, 230VAC + 1NO built in	LA301413N-	SCHR	1	/102.3

Part list

Device tag	Part description	Part number	Manufacturer	Quantity	Page
-K1131	Contactor 3pole, 5,5kW, AC3, 14A, 230VAC + 1NO built in	LA301413N-	SCHR	1	/102.5
-K1141	Modular contactor 40A, 4NO, 230VAC 3MW Rated output AC-3/230V 2,60kW, Rated output AC-3/400V 12,50kW	BZ326442--	SCHR	1	/102.8
-K1211	The types of the DS7 series are soft starters for gently starting three-phase current motors for applications with normal operating frequency and a performance	DS7-340SX012N0-N	ETN	1	/104.1
-K1212	Contactor 3pole, 5,5kW, AC3, 14A, 230VAC + 1NO built in	LA301413N-	SCHR	1	/104.0
-K1221	Contactor 3pole, 5,5kW, AC3, 14A, 230VAC + 1NO built in	LA301413N-	SCHR	1	/104.3
-K1231	Contactor 3pole, 5,5kW, AC3, 14A, 230VAC + 1NO built in	LA301413N-	SCHR	1	/104.5
-K1241	Modular contactor 40A, 4NO, 230VAC 3MW Rated output AC-3/230V 2,60kW, Rated output AC-3/400V 12,50kW	BZ326442--	SCHR	1	/104.8
-K3111	The types of the DS7 series are soft starters for gently starting three-phase current motors for applications with normal operating frequency and a performance	DS7-340SX009N0-N	ETN	1	/108.1
-K3112	Contactor 3pole, 4kW, AC3, 10A, 230VAC + 1NO built in	LA301013N-	SCHR	1	/108.0
-K3121	Contactor, 3pole,15kW/32A AC3, 65A AC1, 230VAC	LA303233--	SCHR	1	/108.2
-K3211	The types of the DS7 series are soft starters for gently starting three-phase current motors for applications with normal operating frequency and a performance	DS7-340SX009N0-N	ETN	1	/108.5
-K3212	Contactor 3pole, 4kW, AC3, 10A, 230VAC + 1NO built in	LA301013N-	SCHR	1	/108.5
-K3221	Contactor, 3pole,15kW/32A AC3, 65A AC1, 230VAC	LA303233--	SCHR	1	/108.7
-0KM21	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.3
-0KM21	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.3
-0KM22	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.3
-0KM22	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.3
-0KM61	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.5
-0KM61	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.5
-0KM62	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.6
-0KM62	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.6
-0KM63	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.6
-0KM63	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.6
-0KM64	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.7
-0KM64	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.7
-0KM111	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.1
-0KM111	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.1
-0KM121	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.2
-0KM121	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.2
-0KM311	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.3
-0KM311	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.3
-0KM321	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.4
-0KM321	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.4
-0KWH41	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.5
-0KWH41	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.5
-0KWH111	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.1

0	1	2	3	4	5	6	7	8	9

Part list

Device tag	Part description	Part number	Manufacturer	Quantity	Page
-0KWH111	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.1
-0KWH121	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/126.2
-0KWH121	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/126.2
-KY11	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/124.1
-KY11	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/124.1
-KY12	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/124.1
-KY12	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/124.1
-KY13	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/124.2
-KY13	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/124.2
-KY21	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/124.3
-KY21	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/124.3
-KY22	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/124.3
-KY22	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/124.3
-KY23	The CR-M024DC4 pluggable interface relay is from the CR-M (miniature) relay range. This relay operates with a 24 V DC rated control supply voltage and has a 4	CR-M024DC4	ABB	1	/124.4
-KY23	The CR-M4SS socket is from the CR-M (miniature) relay range. The standard socket is suitable for CR-M relays with 2 and 4 c/o (SPDT) output contacts. The socket	CR-M4SS	ABB	1	/124.4
-200M0				0	/200.0
-200M1				0	/200.1
-200M3				0	/200.3
-200M5				0	/200.5
-200M6				0	/200.6
-200M8				0	/200.8
-Q0	Moulded Case Circuit Breaker Type A, 3-pole, 50kA, 200A Anlagen- und Kabelschutz	MC220231--	SCHR	1	/100.0
-Q0	Shunt trip 208-250VAC/DC for MC2/3	MC299763--	SCHR	1	/100.0
-Q0V	High quality miniature circuit-breaker, rated operating voltage 230/400V, rated switching capacity 10 kA according to UL 1077, CSA C22.2 No 235 and IEC/EN	FAZ-C10/1	ETN	1	/100.3
-Q00	High quality miniature circuit-breaker, rated operating voltage 230/400V, rated switching capacity 10 kA according to UL 1077, CSA C22.2 No 235 and IEC/EN	FAZ-C6/2	ETN	1	/100.2
-Q01	High quality miniature circuit-breaker, rated operating voltage 230/400V, rated switching capacity 10 kA according to UL 1077, CSA C22.2 No 235 and IEC/EN	FAZ-C6/1	ETN	1	/100.4
-Q21	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-12/AK	ETN	1	/106.1
-Q22	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-12/AK	ETN	1	/106.3
-Q41	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-6,3/AK	ETN	1	/110.2
-Q42	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-6,3/AK	ETN	1	/110.4
-Q43	High quality miniature circuit-breaker, rated operating voltage 230/400V, rated switching capacity 10 kA according to UL 1077, CSA C22.2 No 235 and IEC/EN	FAZ-B20/3	ETN	1	/110.7
-Q51	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-4/AK	ETN	1	/112.1
-Q52	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-4/AK	ETN	1	/112.4
-Q53	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-4/AK	ETN	1	/112.7
-Q61	High quality miniature circuit-breaker, rated operating voltage 230/400V, rated switching capacity 10 kA according to UL 1077, CSA C22.2 No 235 and IEC/EN	FAZ-C10/1	ETN	1	/114.1
-Q62	High quality miniature circuit-breaker, rated operating voltage 230/400V, rated switching capacity 10 kA according to UL 1077, CSA C22.2 No 235 and IEC/EN	FAZ-C10/1	ETN	1	/114.3

Part list

Device tag	Part description	Part number	Manufacturer	Quantity	Page
-Q63	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-1/AK	ETN	1	/114.5
-Q64	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-6,3/AK	ETN	1	/114.8
-Q111	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-12/AK	ETN	1	/102.1
-Q112	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-12/AK	ETN	1	/102.3
-Q113	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-12/AK	ETN	1	/102.6
-Q114	High quality miniature circuit-breaker, rated operating voltage 230/400V, rated switching capacity 10 kA according to UL 1077, CSA C22.2 No 235 and IEC/EN	FAZ-B40/1	ETN	1	/102.8
-Q121	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-12/AK	ETN	1	/104.1
-Q122	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-12/AK	ETN	1	/104.3
-Q123	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-12/AK	ETN	1	/104.6
-Q124	High quality miniature circuit-breaker, rated operating voltage 230/400V, rated switching capacity 10 kA according to UL 1077, CSA C22.2 No 235 and IEC/EN	FAZ-B40/1	ETN	1	/104.8
-Q311	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-10/AK	ETN	1	/108.1
-Q312	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-32/AK	ETN	1	/108.3
-Q321	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-10/AK	ETN	1	/108.6
-Q322	Motor-protective circuit-breaker with lockable rotary handle to IEC/EN60947, 3 pole size PKZM0, with adjustable overload and non-delayed short-circuit release,	PKZM0-32/AK	ETN	1	/108.7
-QPLC	High quality miniature circuit-breaker, rated operating voltage 230/400V, rated switching capacity 10 kA according to UL 1077, CSA C22.2 No 235 and IEC/EN	FAZ-C6/2	ETN	1	/124.0
-S0		XB4BS8445	SE	1	/100.3
-SM21	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/106.0
-SM22	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/106.2
-SM41	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/110.1
-SM41.1	Cam switch according to IEC/EN60947, size T0, installation form, front plate 48x48, degree of protection Front IP65 with black thumb grip, rated uninterrupted	T0-1-8200/E	ETN	1	/120.1
-SM42	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/110.3
-SM42.1	Cam switch according to IEC/EN60947, size T0, installation form, front plate 48x48, degree of protection Front IP65 with black thumb grip, rated uninterrupted	T0-1-8200/E	ETN	1	/120.8
-SM51	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/112.0
-SM51.1	Cam switch according to IEC/EN60947, size T0, installation form, front plate 48x48, degree of protection Front IP65 with black thumb grip, rated uninterrupted	T0-1-8200/E	ETN	1	/122.1
-SM52	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/112.3
-SM52.1	Cam switch according to IEC/EN60947, size T0, installation form, front plate 48x48, degree of protection Front IP65 with black thumb grip, rated uninterrupted	T0-1-8200/E	ETN	1	/122.5
-SM53	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/112.6
-SM53.1	Cam switch according to IEC/EN60947, size T0, installation form, front plate 48x48, degree of protection Front IP65 with black thumb grip, rated uninterrupted	T0-1-8200/E	ETN	1	/122.8
-SM61	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/114.0
-SM62	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/114.2
-SM63	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/114.4
-SM64	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/114.7
-SM111	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/102.0
-SM112	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/102.3
-SM113	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/102.5
-SM121	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/104.0

Part list

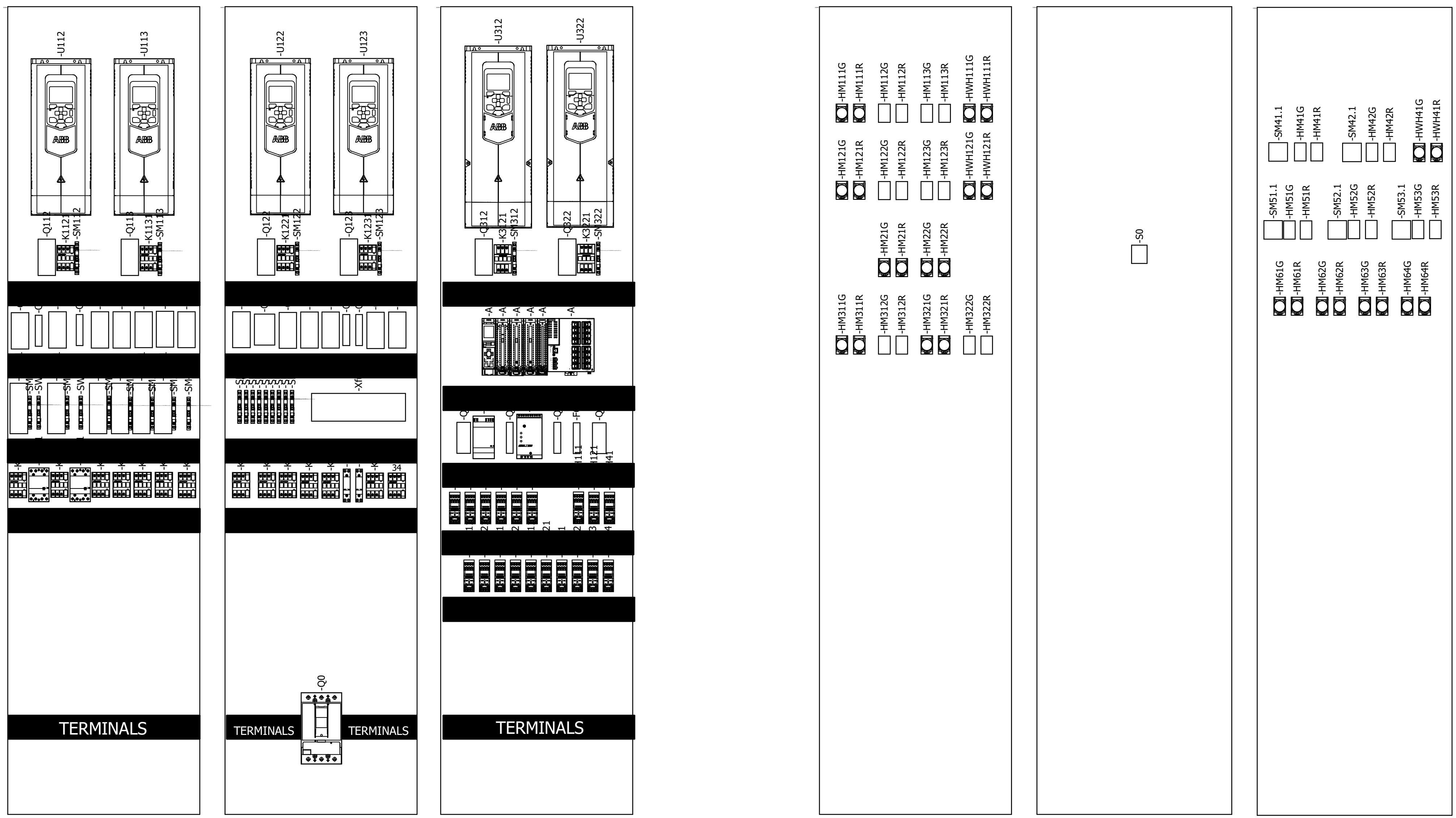
Device tag	Part description	Part number	Manufacturer	Quantity	Page
-SM122	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/104.3
-SM123	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/104.5
-SM311	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/108.0
-SM312	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/108.2
-SM321	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/108.5
-SM322	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/108.7
-SWH41	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/110.6
-SWH111	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/102.7
-SWH121	On-Off switches according DIN EN 60669-1, VDE 0632 Part 1, Rated currents: 16/25/32 A, 250/400 VACPDC, Contacts: 1 NO/2 NO/3 NO/4 NO, Module width: 0,5/1	E211-16-10	ABB	1	/104.7
-U112		ACS880-01-12A6-3	ABB	1	/102.3
-U112	Fieldbus: Ethernet	FENA-01	ABB	1	/102.3
-U113		ACS880-01-12A6-3	ABB	1	/102.6
-U113	Fieldbus: Ethernet	FENA-01	ABB	1	/102.6
-U122		ACS880-01-12A6-3	ABB	1	/104.3
-U122	Fieldbus: Ethernet	FENA-01	ABB	1	/104.3
-U123		ACS880-01-12A6-3	ABB	1	/104.6
-U123	Fieldbus: Ethernet	FENA-01	ABB	1	/104.6
-U312		ACS880-01-032A-3	ABB	1	/108.3
-U312	Fieldbus: Ethernet	FENA-01	ABB	1	/108.3
-U322		ACS880-01-032A-3	ABB	1	/108.7
-U322	Fieldbus: Ethernet	FENA-01	ABB	1	/108.7
-V0	Single-phase Power Supply, pulsing, 230VAC/24VDC, 6A at 50°C electronic power supply, housing for DIN rail mounting	LP412406--	SCHR	1	/100.2
-V1	Single-phase Power Supply, pulsing, w.UPS, 230VAC/24VDC, 10A electronic power supply with UPS function, housing for DIN rail mounting	LP442410--	SCHR	1	/100.3
-Xfuse				0	/200.2

Cable overview

Cable name	Source	Target	Cable type	Wires	Cross-section [mm²]	Length [m]	Page
-W0M41	-X0M41	+PGWWTNK-M41	NYY	5	1.5		/120.0
-W0M42	-X0M42	+PGWWTNK-M42	NYY	5	1.5		/120.7
-W0M51.1	-X0M51	+WWTNK-M51	NYY	5	1.5		/122.0
-W0M52.1	-X0M52	+WWTNK-M52	NYY	5	1.5		/122.3
-W0M53.1	-X0M53	+WWTNK-M53	NYY	5	1.5		/122.7
-WB1.1	-X0B1.1	+CNDSYS1-B1.1	LiYCY	2	0.75		/116.1
-WB1.2	-X0B1.2	+CNDSYS1-B1.2	LiYCY	2	0.75		/116.3
-WB2.1	-X0B2.1	+CNDSYS2-B2.1	LiYCY	2	0.75		/116.5
-WB2.2	-X0B2.2	+CNDSYS2-B2.2	LiYCY	2	0.75		/116.8
-WB3.1	-X0B3.1	+PGWCOOL-B3.1	LiYCY	2	0.75		/118.1
-WB3.2	-X0B3.2	+PGWCOOL-B3.2	LiYCY	2	0.75		/118.7
-WM41	+PGWWTNK-M41	-X4	NYY	4	1.5		/110.2
-WM42	-X4	+PGWWTNK-M42	NYY	4	1.5		/110.4
-WM51	-X5	+WWTNK-M51	NYY	4	1.5		/112.1
-WM52	-X5	+WWTNK-M52	NYY	4	1.5		/112.3
-WM53	-X5	+WWTNK-M53	NYY	4	1.5		/112.7
-WMS	+TLV-PEN	-Q00	NYY	4x	120		/100.0
-WP2	-A6-P2	-U112	ETHERLINE® PN Cat.5e Y	4	22		/116.1
-WP3	-A6-P3	-U113	ETHERLINE® PN Cat.5e Y	4	22		/116.3
-WP4	-A6-P4	-U122	ETHERLINE® PN Cat.5e Y	4	22		/116.5
-WP5	-A6-P5	-U123	ETHERLINE® PN Cat.5e Y	4	22		/116.7
-WP6	-A6-P6	-U312	ETHERLINE® PN Cat.5e Y	4	22		/118.1
-WP7	-A6-P7	-U322	ETHERLINE® PN Cat.5e Y	4	22		/118.6
-WP8	-A6-P8	+PGWWTNK-M41	ETHERLINE® PN Cat.5e Y	4	22		/120.2
-WP9	-A6-P9	+PGWWTNK-M42	ETHERLINE® PN Cat.5e Y	4	22		/120.9
-WP10	-A6-P10	+WWTNK-M51	ETHERLINE® PN Cat.5e Y	4	22		/122.2
-WP11	-A6-P11	+WWTNK-M52	ETHERLINE® PN Cat.5e Y	4	22		/122.5
-WP12	-A6-P12	+WWTNK-M53	ETHERLINE® PN Cat.5e Y	4	22		/122.9
-WWH41	-X4	+PGWWTNK-WH41	NYY	5	4		/110.7
-WY1.0	-XY1	+NH3SEP-Y1	NYY	2x	1.5		/100.5
-WY1.1	-XY1	+NH3SEP-Y1	LiYCY	4X	0.75		/124.1
-WY1.2	-XY1	+NH3SEP-Y1	UNITRONIC® LiYCY	2	0.75		/130.4
-WY2.0	-XY2	+NH3SEP-Y2	NYY	2X	1.5		/100.6
-WY2.1	-XY2	+NH3SEP-Y2	LiYCY	4x	0.75		/124.3
-WY2.2	-XY2	+NH3SEP-Y2	UNITRONIC® LiYCY	2	0.75		/130.5
-WY3			NYY	2x	1.5		/134.0

Cable overview

Cable name	Source	Target	Cable type	Wires	Cross-section [mm²]	Length [m]	Page
-WY4			NYY	2x	1.5		/134.2
-WY5	-XY5	+OCCIR-Y5	NYY	3x	1.5		/134.4
-W_NH3_10_B1	-XAI	+NH3SEP-B2	UNITRONIC® LiYCY	2	0.75		/128.7
-W_NH3_30_B1	-XAI	+NH3SEP-B1	UNITRONIC® LiYCY	2	0.75		/128.6
-W_NH3_TUN_B1	-XAI	+NH3SEPTUN-B3	UNITRONIC® LiYCY	2	0.75		/128.8
-W_PGW_COOL_B1	-XAI	+PGWCOOL-B1	UNITRONIC® LiYCY	2	0.75		/128.1
-W_PGW_COOL_B2	-XAI	+PGWCOOL-B2	UNITRONIC® LiYCY	2	0.75		/128.2
-W_WWT1_B1	-XAI	+WWTNK-B1	UNITRONIC® LiYCY	2	0.75		/128.3
-W_WWT2_B1	-XAI	+WWTNK-B2	UNITRONIC® LiYCY	2	0.75		/128.4
-W_WWT3_B1	-XAI	+WWTNK-B3	UNITRONIC® LiYCY	2	0.75		/128.5



Project no.: MFT-20/21	Revision: R0	Revision date: 16.07.2021	TVZ TEHNIČKO VELEUČILIŠTE U ZAGREBU POLYTECHNICUM ZAGRABIENSE Vrbik 8a, 10000 Zagreb	Customer: Tehničko veleučilište u Zagrebu Vrbij 8a, 10000 Zagreb	Object: Elektrotehnički odelj TVZ-a Konavoska 2, 10000 Zagreb	Cabinet: +Y1
Drawn: Xabier Gregorio, bach. eng. el.						Plant: =H1
Checked: Tomislav Špoljarić, dipl.eng. el.			Page description: **Disposition of Cabinet**	End customer: Tehničko veleučilište u Zagrebu Konavoska 2, 10000 Zagreb	Project name: Electrical project design for a cabinet in an engine room of a cooling plant	Page: 200
Approved: Tomislav Špoljarić, dipl.eng. el.						Follow: