TECHNICAL DOSSIER AND GUIDE

NOVA 440

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Contents

1 DESCRIPTION OF THE HEAT PUMP

- Cooling system: Air/water-heat pump for deployment in outdoor environments only.
- PED category II.
- Conformity assessment module A2.
- Factory made system of independent units/modules where all components containing refrigerant are located inside the heat pump itself.
- When leaving the factory each heat pump module is fully prepared, tested and ready for use, with no need for intervention with the cooling circuit.
- All parts containing refrigerant are assembled as a sealed system with permanent connections.
- No ignition sources or spark generating components exist inside the cabinet of the heat pump, which surrounds alle cooling/refrigerant components and pipes.
- The refrigerant is propane gas.
  The cooling circuit of the heat pump is equipped with a natural refrigerant, propane gas R290, in part due to the environmental impact of an unintended discharge (leakage). The environmental impact of a discharge/leakage is minimal.

WARNING
Upon discharge propane gas is flammable as well as explosive provided that the critical mixture between ambient air and gas is reached.
System components are physically split into ventilated zones with under- and over-pressurized compartments, respectively. Spark generating components (ignition sources) are isolated from areas with risk of unintended discharge of propane gas.

The heat pump is built up as a cascaded system consisting of independent heat pump units where each sub-heat pump is equipped with the following parts:

- 6-cylinder semi-hermetic compressor (speed regulated)
- Frequency converter
- Condenser
- Hotgas condenser (finned pack heat exchanger) (option)
- Subcooling condenser (finned pack heat exchanger) (option)
- Two evaporators (direct evaporation DX)
- Two ventilators (speed regulated)

The water hydraulics of the heat pump are on the warm side assembled as condensers in series connection, subcooling condensers in series connection and hotgas condensers in parallel connection.
The return water from the external heating system is thereby heated to the desired temperature in independent steps.
This method is unique and yields a higher COP value and allows for elevated forward water temperatures.

Step 1: The return water from the external heating system is preheated by the (series connected) subcoolers.
By subcooling of the refrigerant (R290) the thermodynamic properties are improved - larger heating effect and higher COP.

Step 2-5: The series connected condensers then heats the already preheated water into gradually higher and higher temperatures.

Step 6: Finally, the water is directed through the hotgas condensers (in parallel) where a final round of heating takes place.
The energy in the superheated refrigerant (80-100°C) residing within the high pressure line from the compressor is separated out via the hotgas condenser and thereby used for further elevation of the temperature in the external heating system.

The heat pump is equipped with:

- Circulation pump (speed regulated) which transports the water through all individual heat exchange units inside each heat pump module and further on to the buffer tanks of the external heating system.
- Dirt filter on the return side of the heating system.
- Pressure sensor before and after the dirt filter.
- Blocking valves at the forward and return side of the heating system.
- Safety valve (10 bar).
- Vent valves (forward and return).
- A heat meter measuring the overall production of energy (option).
- Power meter measuring the overall consumption of electricity (option).
- Gas detector (option).
- Common electrical cabinet/panel supplying and regulating the individual heat pump modules:
    - Automation and connection terminals for connectivity and regulation of external components such as supply heat from boilers, electrical heating elements, motorized control valves etc.
    - Possibility for external control and monitoring using wired signals or via Modbus RS485.
    - Gateway for remote control/monitoring using a wired internet connection or a 4G modem (option).

1.1 Capacity regulation

The instantaneous heating effect of the heat pump is adapted to the actual demand partly by speed regulation of the individual compressor units and partly by disconnection of one or several compressor units.
The control mechanism looks at the actual (measured) temperature and the desired (setpoint) temperature of the water in the buffer tank of the external heating system.
The setpoint temperature is chosen by the user, either as a fixed number or as auto-adjusted from a weather compensation option.
The heating effect of the heat pump is reduced once the actual/measured temperature exceeds the setpoint temperature and the opposite takes place when the actual temperature is smaller than the setpoint temperature.

Overall rules of thumb for yielding highest possible COP:

- Keep as many compressor units running as possible.
- Run all compressor units at identical speeds.
- When lowest possible RPM is reached then disconnect one or more compressor units (lower heat demand).
- If the heat effect demand drops below the level offered by one compressor unit at minimum RPM, then transition this module into start/stop (pause operation) with appropriately sized pause intervals.

1.2 Defrosting

When the outdoor temperature drops below 5-7 degrees the water contents in the air (humidity) start to freeze directly onto the ribbed fins of the evaporators. Frost gradually builds up and thereby hinders air to flow through the evaporators (aggravating trend). Defrosting the evaporators' ribbed fins is therefore needed at regular intervals.

Defrosting is achieved by temporary reversal of the directionality of the heat pump's cooling circuit. The ribbed fins of the evaporators get heated – frost melts away – and the resulting water gets directed to a drain.
The heat pump is now ready for a new period of normal operation.
The heat energy required for a defrosting operation is absorbed from the heating system. Obviously, this leads to a temporary decrease/dip in water temperature. This dip is usually of no real significance since it partly gets smeared away by the buffer tank of the heating system. The user will rarely take any notice of the defrosting operation. However, if the heating system is sensitive to sudden dips in temperature a separate buffer tank for defrosting can be installed as shown in section 5 *(flowchart for external installations)*. Such a separate buffer tank provides the necessary energy for defrosting and gets recharged from the return line of the external heating system.

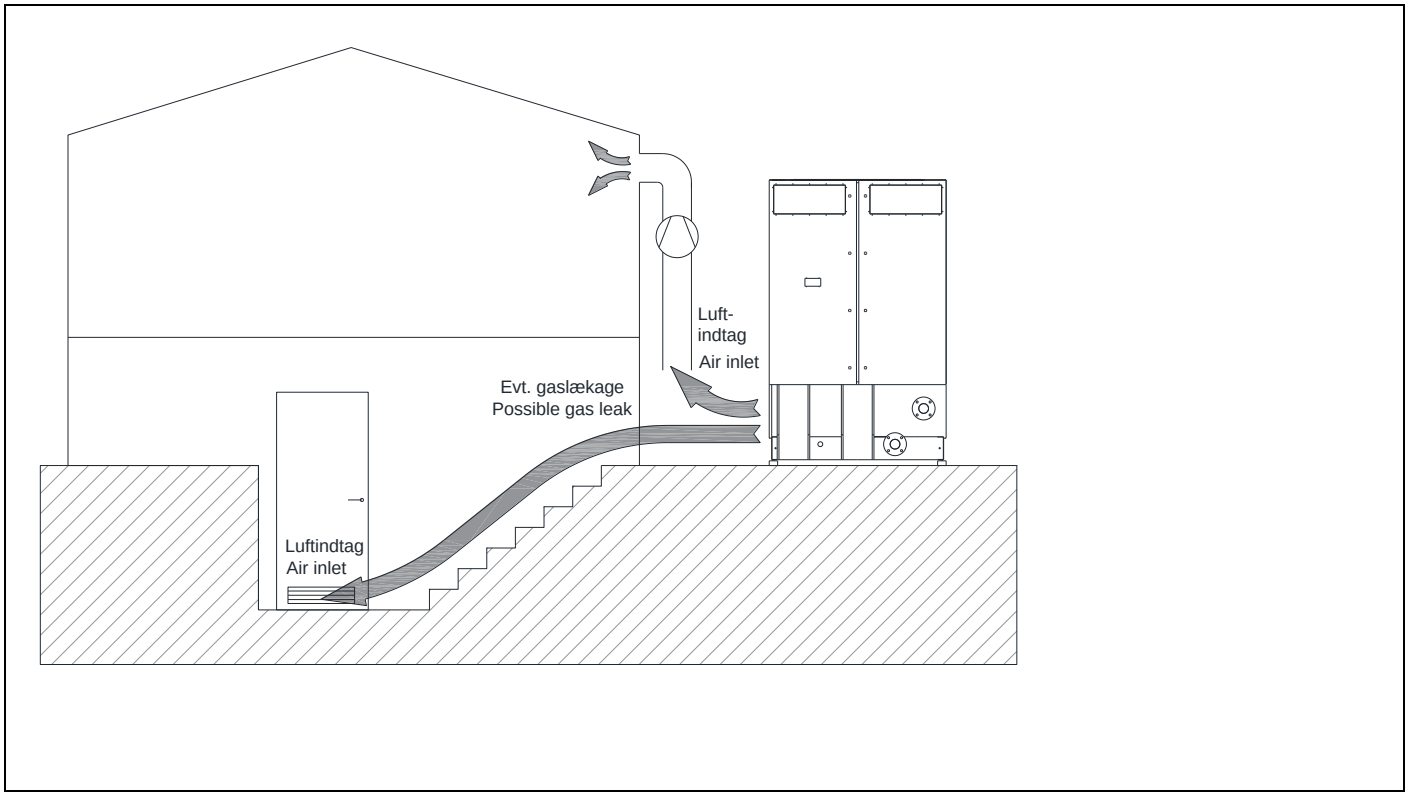
The defrost controller is designed with emphasis on the lowest possible energy consumption. This is achieved by lowering the number of defrost cycles as well as the defrost durations as much as possible. The actual control of defrost cycles is done by bookkeeping of various timers, ambient temperature and evaporation temperature.

- Defrost cycle time is 90-180 minutes (in between) depending on ambient temperature and humidity.
- Defrost duration is approx. 4-6 minutes.
- Need for defrosting kicks in at ambient temperatures below 5-7 degrees.

2 REQUIREMENTS FOR PLACE OF INSTALLATION

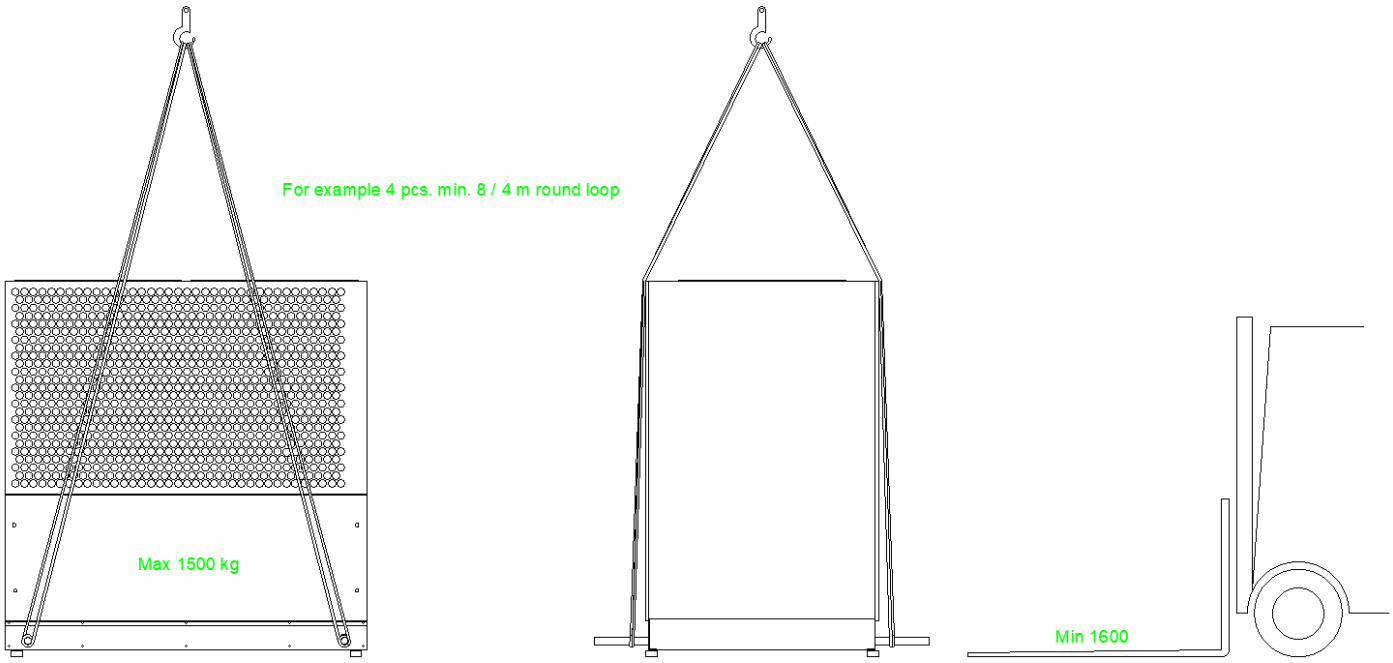
WARNING

Due to the flammable refrigerant the heat pump is only allowed to be installed outdoors and above terrain.
The place of installation must be chosen such that unintended discharge of refrigerant (heavier than atmospheric air) cannot accumulate in low valleys or enter buildings through e.g., stairwells, venting tunnels, or air inlets.

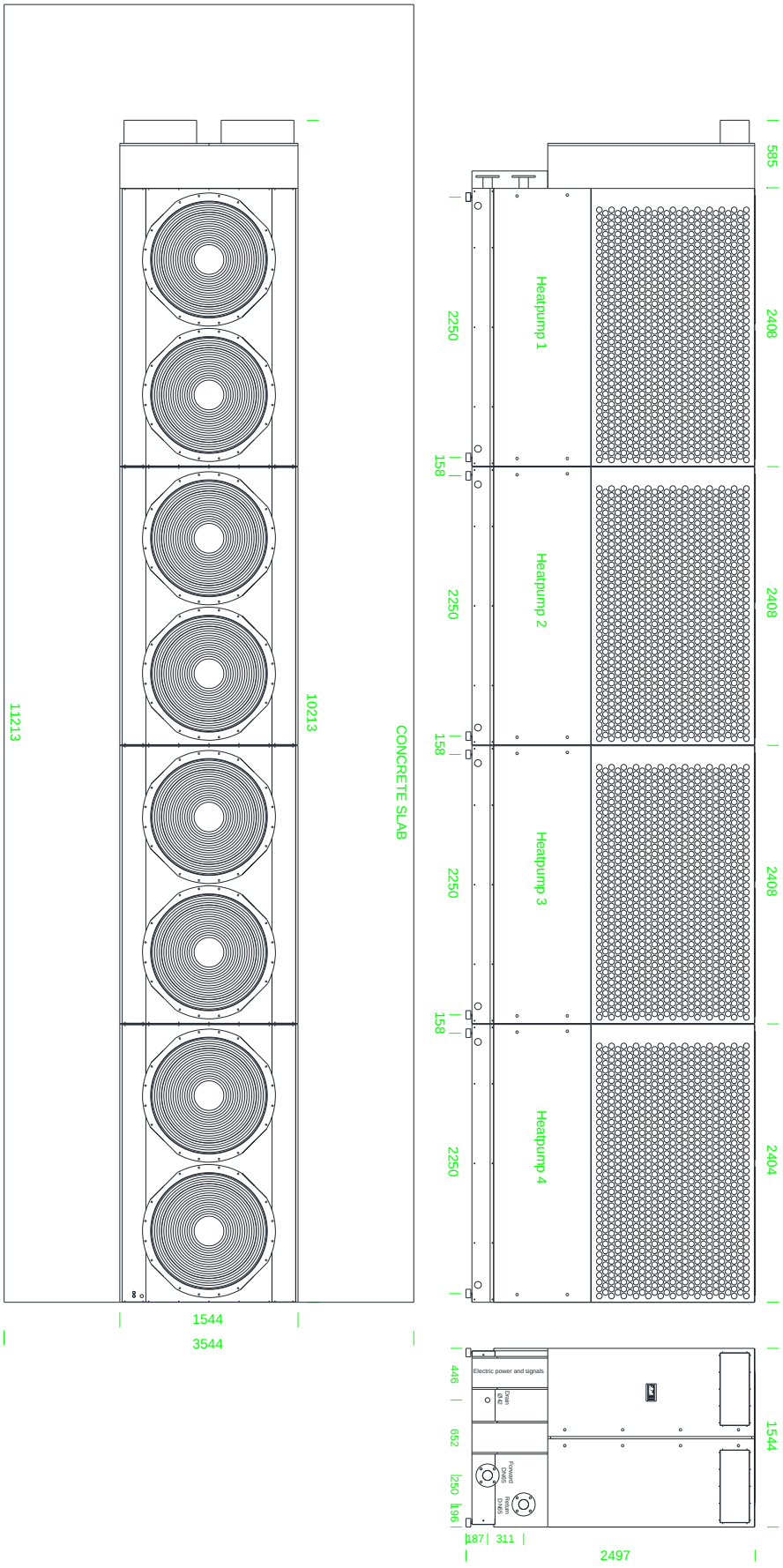


2.1 Placement

For reasons of transportation the overall heat pump is delivered as independent heat pump modules to be assembled and connected at the place of installation.
The heat pump is commonly placed on a horizontally levelled plate of concrete having the same physical extent as the heat pump plus one additional meter in both directions – for reasons of service access.
Minimum separation distance to walls is one meter and preferably more.
The heat pump modules are standing on adjustable machine type shoes.



3 SET UP


11213
10213
CONCRETE SLAB
1544
3544
585
Heatpump 1
2250
2408
158
Heatpump 2
2250
2408
158
Heatpump 3
2250
2408
158
Heatpump 4
2250
2404
446
652
250
196
Electric power and signals
Drain
Power/
DMS
Return
187
311
1544
2497

4 DESCRIPTION OF EXTERNAL INSTALLATIONS

Installation of the heat pump must be carried out by a qualified company/person in accordance with national- and local regulations as well as this document/guide.

4.1 Pressure loss (wrt. pipe- and valve dimensions)

- Overall loss of pressure throughout the hydraulic system must be kept at a minimum (reduces energy consumption of the circulation pump and ensures best possible operational conditions). A sufficiently large piping dimensionality is therefore required. Avoid by design all unnecessary use of piping angles and bends as well as other kinds of pressure reducing fittings.
- Dimensionality of valves etc. is to be chosen in accordance with the pipe dimensions.
- 3-way electric motor valves are to be oriented such that ”heat operation” (predominant wrt. hours) is flow-wise direct current through the valve.

4.2 Expansion and water pressure

The size of the external heating system’s expansion tank should be based on the total accumulated water volume in the system and in accordance with standard/normal rules.
To ensure optimal operational conditions and to safeguard the circulation pump against cavitation the system pressure at rest should be at least 1,5 bar.

4.3 Frost protection of water circuit

To safeguard the internal water circuit of the heat pump against frost blasting an automatic mechanism is put in place to ensure a minimum desired water temperature (approx. 10˚C) during freezing weather conditions. This minimum temperature is achieved by regular start/stop of the heat pump’s internal circulation pump.

4.4 Condensation drain

- The evaporators of the heat pump generates vast amounts of condensation water during ordinary operation and defrosting.
- The heat pump’s Ø40 condensation drain pipe must be connected to a rainwater drain or similar while ensuring frost-free conditions all along.
- Frost protection is usually achieved by el-tracing (heating cable running inside the drainpipe, approx. 10-15 W/m).
- Outside insulation of the drainpipe is usually not necessary.
- The heat pump controller is equipped with a relay outlet for connection of el-tracing.
- The relay automatically gets activated when the ambient temperature drops sufficiently low.
- 230V el-tracing is to be connected at terminals 0-15 and 1-N inside the heat pump’s electrical cabinet.

WARNING

If the heat pump is placed physically on a roof construction or similar, then a frozen/blocked drain can with time risk to cause vast amounts of (frozen) water to build up at the roof construction itself. In such cases the construction can become structurally overloaded with a risk of collapsing. Therefore, make sure to frequently inspect and check correct functionality of the condensation drain.

4.5 Buffer tank

- The buffer tank must be installed as shown in section 5 *(flowchart for external installations)*.
- The purpose of the buffer tank is to separate flows, building water and heat pump water, such that both parties experience an optimal and undisturbed flow. Additionally, the buffer tank helps ensure the bulk of energy required for defrost cycles without causing pronounced dips in forward temperature of the heating system.
- Potential differences between the two flows get equalized via the by-pass pipe (bi-flow) which must have the same dimensionality as all other surrounding pipes.
- The buffer tank can be equipped with one or several electrical heating elements for the purpose of yielding a supply heat functionality (option). Such electrical heating elements must have their own power supply, built-in temperature delimiters (safety thermostats) and ordinary control thermostats. In order to put priority at the heat pump and to use the electrical heating elements only when necessary, these are usually activated from the heat pump controller using a relay (option) connected to the power line of electrical flow heaters. A 230V control voltage of the relay is to be connected at terminals 0-14 and 1-N inside the heat pump’s electrical cabinet.

- The buffer tank must be equipped with temperature sensor TS12 (NTC 10kΩ) (delivered together with the heat pump). The sensor is to be mounted inside a stem tube in the upper half of the tank (above electrical flow heater). The stem tube must be of sufficient length for the sensor to yield correct temperature readings. The temperature sensor is to be connected at terminals 0-6 and COM inside the heat pump's electrical cabinet.

4.6 Domestic hot water tank (with priority)

- Buildings with a large consumption of domestic hot water and equipped with a centralized domestic hot water tank can be configured with priority for hot water. The advantage of this method is a higher COP for room heating since the heat pump can often be operated using a lower setpoint temperature (e.g. adjusted automatically based on ambient temperature).
- A requirement for the method to make sense is that the centralized domestic hot water tank is large enough to absorb the entire heat effect of the heat pump and must therefore always be a flow-through tank where the domestic water gets heated through a spiral (or similar exchange unit) of appropriate size.
- The centralized domestic hot water tank should be installed as shown in section 5 *(flowchart for external installations)* and must always be inserted before the buffer tank.
- A 230V control voltage for a 3-way motorized control valve is to be connected at terminal 0-22, 0-23 and 1-N inside the heat pump's electrical cabinet.
- The domestic hot water tank must be equipped with temperature sensor TS7 (NTC 10kΩ) (delivered together with the heat pump). The sensor is to be mounted inside a stem tube in the upper half of the tank. The stem tube must be of sufficient length for the sensor to yield correct temperature readings. The temperature sensor is to be connected at terminals 0-37 and COM inside the heat pump's electrical cabinet.

4.7 Buffer tank for defrosting

- Heating systems particularly sensitive to sudden dips in forward temperature caused by defrosting operations (lasting up to 10 minutes) can be equipped with a separate buffer tank for defrosting purposes.
- During defrosting the flow of water is redirected through this dedicated buffer tank using a 3-way motorized control value.
- The buffer tank must be installed as shown in section 5 *(flowchart for external installations)* and should always be inserted as the first unit in the flowchart.
- A 230V control voltage for the 3-way motorized control valve is to be connected at terminals 0-20, 0-21 and 1-N inside the heat pump's electrical cabinet.

4.8 Supply heat from boiler

- The heating system can be equipped with a boiler for providing a supply heat functionality (option). The boiler and its dedicated circulation pump must have its own power supply, built-in temperature delimiter (safety thermostat) and ordinary control thermostat. To put priority at the heat pump and to occupy the boiler in a minimalistic fashion only, a 3-way modulating shunt valve is usually operated by the heat pump controller. The shunt valve directs, depending on the need for supply heat, an appropriate amount of flow through the boiler. To ensure correct functioning of the shunt valve the boiler thermostat must be set at a higher value than the desired forward temperature (usually 10 degrees above).
- The boiler must be installed as shown in section 5 *(flowchart for external installations)* and should always be inserted as the last unit in the flowchart.
  If the boiler is suited for the purpose and features a remote start/stop mechanism (potential free), then this functionality can be interfaced to the heat pump controller using a 230V helper relay. The boiler will then automatically be switched off when supply heat is no longer needed.
  A 230V helper relay is to be connected at terminals 0-14 and 1-N inside the electrical cabinet (230V = boiler on).
- A 230V control voltage for the shunt valve is to be connected at terminals 0-12 (supply on), 0-13 (supply off) and 1-N inside the electrical cabinet of the heat pump.

4.9 Motorized control valve at forward line or return line

- In certain heating systems where zero water flow through the heat pump is desired when the heat pump is not running (natural circulation or circulation caused by other pumps or similar) there is a possibility to install a 2-way motorized control valve in either the forward line or the return line of the hydraulic system.
- It is usually not necessary to install such a valve since the (anyway) limited flow of water does not disturb the heat pump when it's at rest.

- For reasons of frost protection of the heat pump's hydraulic line when at rest it is essential that the 2-way valve (if installed) be connected to terminals 0-24, 0-25 and 1-N inside the electrical cabinet of the heat pump.

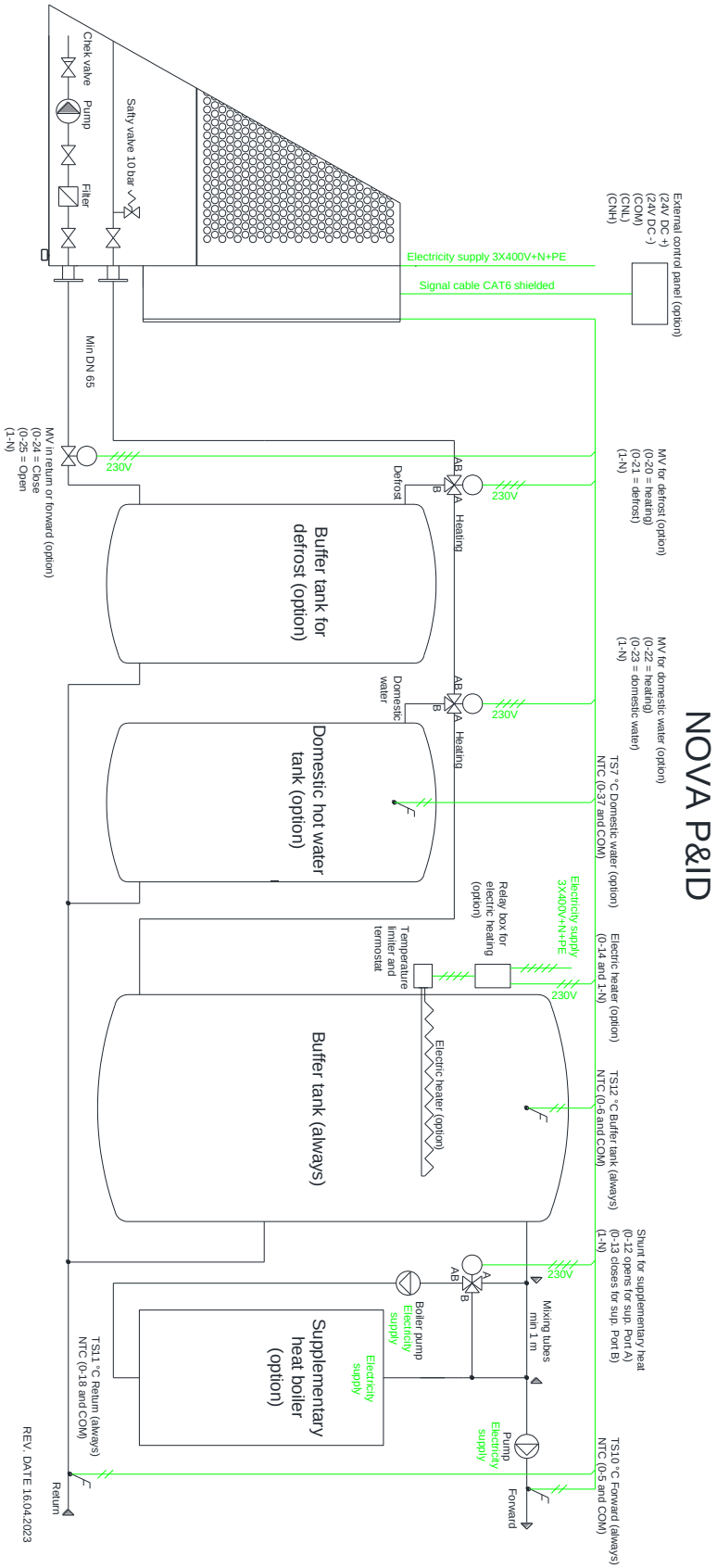
4.10 Temperature sensor at forward line

- The heating system's forward line (after supply heat, if any) must be equipped with temperature sensor TS10 (NTC 10kΩ) (delivered together with the heat pump).
- The sensor is to be mounted inside a stem tube or as an insulated surface sensor mounted on a steel pipe.
- TS10 is part of the heat pump controller mechanism for supply heat (when installed).
- Sensor TS10 is together with TS11 part of the heat pump controller mechanism for circulation pump speed regulation (if this functionality is enabled)
- Sensor TS10 is to be connected to terminals 0-5 and COM inside the heat pump's electrical cabinet.

4.11 Temperature sensor at return line

- The heating system's return line must be equipped with temperature sensor TS11 (NTC 10kΩ) (delivered together with the heat pump).
- The sensor is to be mounted inside a stem tube or as an insulated surface sensor mounted on a steel pipe.
- Sensor TS11 is together with TS10 part of the heat pump controller mechanism for circulation pump speed regulation (if this functionality is enabled)
- Sensor TS11 is to be connected to terminal 0-18 and COM inside the heat pump's electrical cabinet.

5 FLOWCHART FOR EXTERNAL INSTALLATIONS



6 ELECTRICAL CONNECTION

Installation and connection of power cables must be carried out by an authorized company adhering to national and local regulations as well as this document/guide.

6.1 Description of electrical cabinet

- The panel inside the electrical cabinet supplies and controls the individual heat pump modules.
- The panel/cabinet is built as a complete machinery, is fully assembled from the factory, and has undergone functional testing.
- Due to the panels short circuit value and absorption current the entire installation must be pre-fused at a level of 250A (usually a circuit breaker with a built-in residual-current device)
- The panel is not double insulated and hence must be equipped with a residual-current circuit breaker.
- The main supply cable should be inserted from the bottom of the cabinet and connected from below at the main circuit breaker (terminals for M8-bolt and nut)
- Ground wire should be connected to the dedicated ground clamp at the main circuit breaker (AL/CU 25-150 mm^2)

Subset of name plate

Supply voltage	3X400V+N+PE
Frequency	50 Hz
Maximum phase current	232 A
Maximum power draw	140 kW
Recommended pre-fusing	250 A

- The cabinet is equipped with a mechanically pressurized venting system to remove excess heat from the frequency converters as well as to safeguard the cabinet from potentially explosive conditions caused by unintended leakage of propane gas.
- The panel contains the following components in its main power circuitry, connected as shown in section 12:

  1 pcs. 4-pole 250A lockable main circuit breaker, able to completely interrupt/disconnect the supply of power

  4 pcs. 3X63A group fuses (1 pcs. per heat pump module)

  4 pcs. 63A AC/DC sensitive residual-current circuit breaker. Type B. 300 mA (1 pcs. per heat pump module)

  1 pcs. 3-phase power meter (option)

  4 pcs. 3-phase frequency converter for regulation of compressor speed (1 pcs. per heat pump module)

  4 pcs. 3X10A group fuses (1 pcs. per heat pump module)

6.2 Remarks

Frequency converters can cause radio frequency disturbances which may interfere with equipment in residential and densely populated areas. Additional damping/shielding measures may be needed is such cases.

WARNING
Frequency converters are subject to high voltages as soon as supply power is connected.

WARNING
Frequency converters contain DC-link-capacitors, which remain charged even after the supply power is disconnected.
Procedure for service- and maintenance work:
Disconnect the supply power and wait for at least 15 minutes until the internal capacitors are completely discharged.

WARNING
Leakage current of the frequency converter exceeds 3,5 mA, unless device is properly attached to ground potential. Accordingly, ensure that the electrical cabinet is correctly attached to ground potential before supply power is connected.

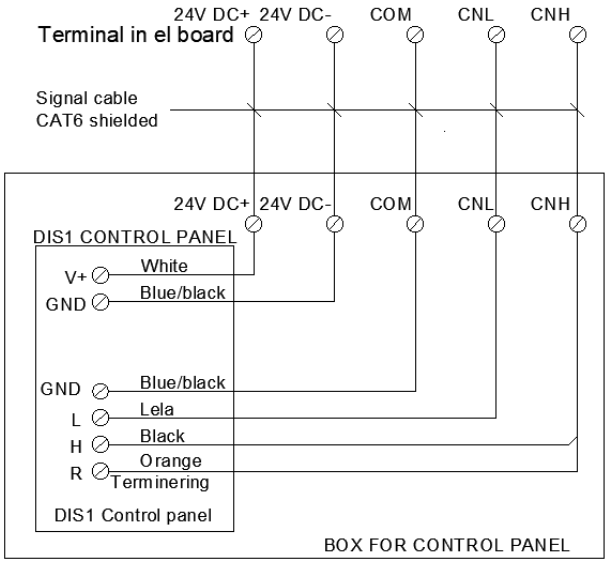
WARNING
Startup, repair and maintenance must be carried out by qualified personnel only.

7 EXTERNAL CONTROL AND MONITORING USING WIRED SIGNALS

External control panel (option)

The control panel is usually mounted in a centrally adequate spot somewhere in the building.

- Wiring between the control panel and the appropriate terminals in the heat pump's electrical cabinet (canbus) should be done using shielded signaling cable, e.g. CAT6 ethernet cable.



Operation on/off

- A switch can be attached to the heat pump controller such that on/off actions get remotely controlled.
- A potential-free switch is to be connected at terminals 0-1 and COM.
  Open switch = operation off. Closed switch = operation on.

Warning

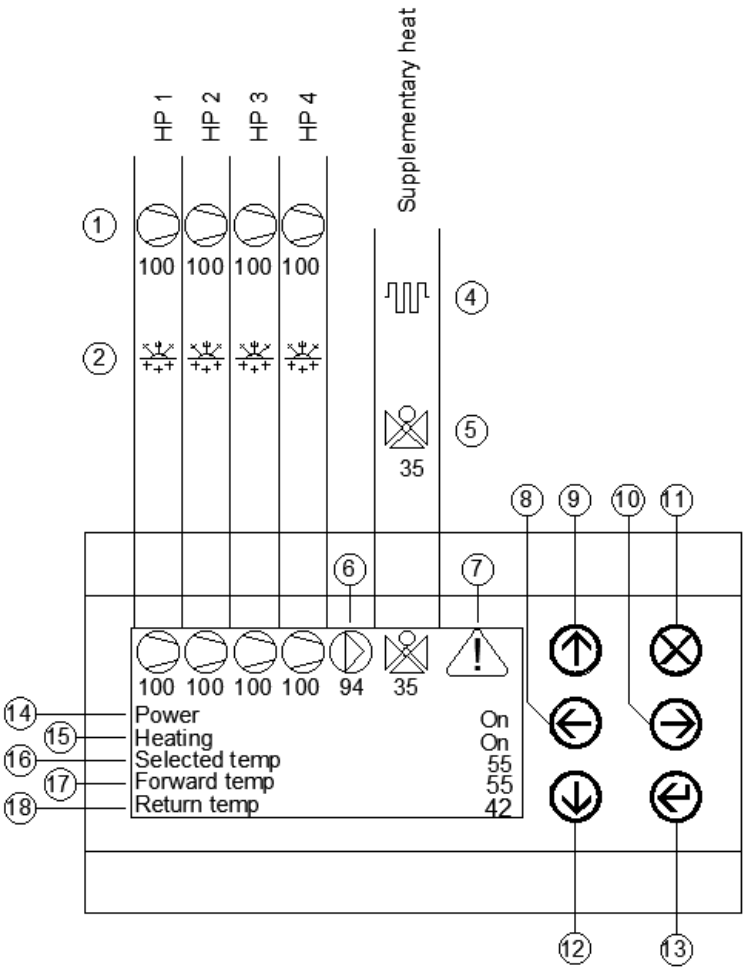
- A potential-free switch in the heat pump controllers gets activated if a warning occurs somewhere in the internal logic (this does not stop the heat pump).
- The type of warning can be read out using the control panel.
- This functionality can be used for remote monitoring of warnings.
- The functionality is to be connected at terminals 0-8 and 0-9.
  Closed switch = no warning
  Open switch = warning (time delay 10 minutes)

Alarm

- A potential-free switch in the heat pump controllers gets activated if an alarm occurs somewhere in the internal logic (heat pump stops running).
- The type of alarm can be read out using the control panel.
- This functionality can be used for remote monitoring of alarms.
- The functionality is to be connected at terminals 0-10 and 0-11.
  Closed switch = no alarm
  Open switch = alarm (time delay 10 minutes)

8 INSTRUCTIONS FOR CONTROL PANEL

OVERVIEW MENU



1: Symbol appears, when each individual heat pump module is on. The number below shows the compressor speed in percentage.

2: Symbol appears, when the individual heat pump module is defrosting.

4: Symbol appears, if supply heat is available from an electrical heating element and is switched on.

5: Symbol appears, if a modulating shunt valve is available for providing supply heat from a boiler.
The number shows the opening degree of the valve in percentage points.
0%: Supply heat off.
100%: Supply heat fully engaged.

6: Symbol appears, when the circulation pump is running.
The number shows its current speed in percentage points.

7: Symbol appears, if an alarm or a warning is currently active.
Press the cross X [11] to see what kind, or go to settings menu, and choose ALARM to see what kind and/or reset.

8: Arrow left: No intended use.

9: Arrow up: Move to entry above.

10: Arrow right: No intended use.

11: Cross X [esc]: Go back one level.

12: Arrow down: Move to entry below.

13: Enter: Enter this entry / confirm.

14: Off: Power is switched off.
On: Power is switched on.

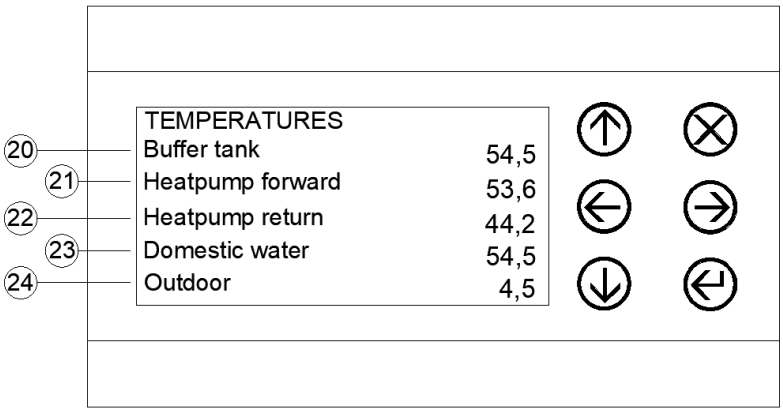
15: On: Heating is on.
Off: Heating is off.

16: Shows setpoint temperature.

17: Shows forward line temperature.

18: Shows return line temperature.

Press *Arrow down* to move to next screen of entries



20: Shows temperature in buffer tank.

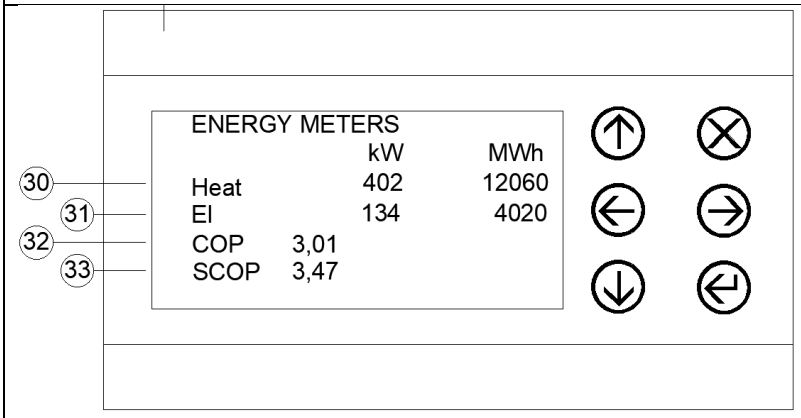
21: Shows the forward temperature at the heat pump itself.

22: Shows the return temperature at the heat pump itself.

23: Shows domestic hot water temperature, if mounted/installed.

24: Shows the ambient temperature, as witnessed by the heat pump itself.

Press *Arrow down* to move to next view



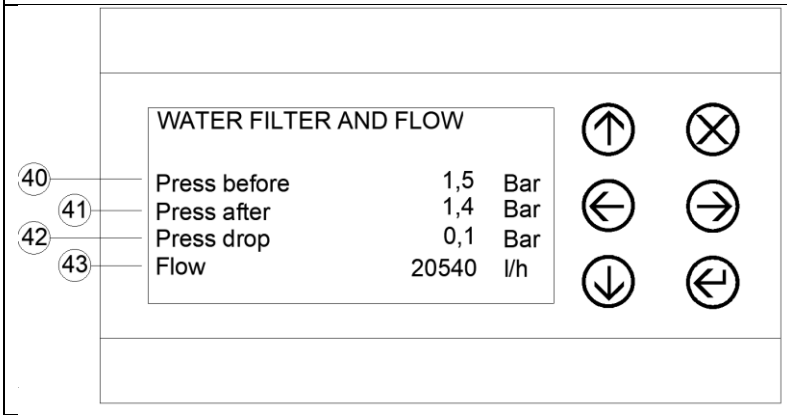
30: Shows the heat effect of the heat pump in kW and the total accumulated energy production in MWh (if energy meter is installed).

31: Shows the power drawn by the heat pump in kW and the overall summed power consumption in MWh.

32: Shows the heat pump's COP value [released kW / supplied kW] (only if energy meter is installed).

33: Shows the heat pump's SCOP value [released MWh / supplied MWh] (only if energy meter is installed).

Press *Arrow down* to move to next view

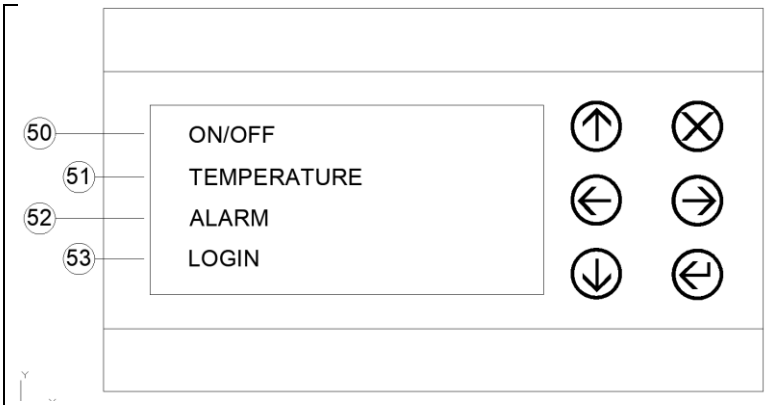


40: Water pressure before filter in bar.

41: Water pressure after filter in bar.

42: Pressure drop across filter in bar. *Filter needs cleaning if pressure drop is larger than 0,5 bar.*

43: Water flow through the heat pump in liters per hour. (only if energy meter is installed).



50: On/Off

- Power On/Off
- Heating On/Off
- Supply heat On/Off
  On: Supply heat automatically switched on if demand is greater than heat pump yield
  Off: Supply heat off
- Temperature Fixed/Weather compensation
  Fixed: System is controlled according to a fixed temp.
  Weather compensation: *System is controlled according to a*

	variable temperature depending on ambient temp. 51: Temperature (buffer tank) • Fixed temperature set *(Only active when weather compensation is off)* • Weather compensation at -12. Target temperature at an ambient temperature of -12 *(Only active when weather compensation is on)* • Weather compensation at +20. Target temperature at an ambient temperature of +20 *(Only active when weather compensation is on)* • Weather compensation min. temperature *(Only active when weather compensation is on)* • Weather compensation max temperature *(Only active when weather compensation is on)* • Hot water temperature 52: Alarm • Active alarm • Reset alarm • Log Shows which alarms have been active • Delete log • Reset module alarm • Reset gas alarm 53: Login

9 COMMISSIONING PROGRAMMING GUIDE

As part of the commissioning and before the heat pump is put to actual work, the following choices/settings must be applied by the technician or installation contractor who oversees the heat pump installation.
Use *login* menu and password 200 to enter the dedicated menu with adequate permissions.

Choose *Settings*
Choose *Supply heat*

Supply heat installed
- On: Supply heat is installed (electrical heating element or boiler) and is controlled by heat pump controller
- Off: Supply heat is not available, or not controlled by heat pump controller
- Factory setting: Off

Supply heat type
- Electrical heating element: Electrical heating element installed
- Boiler: Boiler is installed and is controlled using 3-way shunt valve
- Factory setting: Electrical heating element

Shunt turning time
- Turning time from closed to fully open in seconds (read value on motorized valve)

Shunt manual
Used for testing correct functionality of the shunt valve
- Automatic: Shunt valve is controlled by heat pump controller
- Close: Shunt valve closes the supply heat
- Open: Shunt valve opens the supply heat
- Set to *Automatic* after testing
- Factory setting: *Automatic*

Supply heat delay
- Time delay in minutes for kick-in of supply heat (from the demand appears)
- A higher value decreases the need for supply heat
- Factory setting: 20 minutes

Manual heating element step 1
Used for testing correct functionality of the electric heating element.
- Automatic: Heating element step 1 is controlled by heat pump controller
- Manual: Heating element step 1 switched on
- Set to *Automatic* after testing
- Factory setting: *Automatic*

Manual heating element step 2
Used for testing correct functionality of the electric heating element.
- Automatic: Heating element step 2 is controlled by heat pump controller
- Manual: Heating element step 2 switched on
- Set to *Automatic* after testing
- Factory setting: *Automatic*

Choose *Settings*
Choose *Domestic hot water*

Hot water priority installed
- On: The system is equipped with a 3-way motorized control valve, temperature sensor (TS7) and a centrally located tank for domestic hot water
- Off: The system is not equipped for priority on domestic hot water
- Factory setting: Off

Choose *Settings*
Choose *Pump*

Pump manual operation
- Man operation: The pump runs at constant speed (used at startup and for air venting of the pipes)
- Aut operation: The pump is running only when heat pump running

Pump manual speed
- Pump speed at manual operation 0-10 volts

Pump: Constant/variable speed
- Constant: The pump runs at constant speed whenever the heat pump is running
- Variable: The pump runs at variable speed/flow such that the flow through the heat pump is adjusted to match/fit the flow of the external heating system. Appropriate mixing takes place inside the buffer tank and the return temperature at the heat pump matches the return temperature of the external heating system.
  The method requires a temperature sensor in the return line of the external heating system (TS11).
  This method usually yields the highest COP.

Pump: Constant speed V
- The actual pump speed when constant speed is chosen 0-10V

Choose *Settings*
Choose *External control*

Ext wired signal active: Heating On/Off
- On: Heating On/Off is controlled from wired terminal (functionality in control panel deactivated)
- Off: Heating On/Off is controlled from the heat pump's control panel
- Factory setting: Off

The settings below are to be used for external control and monitoring via centrally located control rooms or similar. Comminucation protocol is Modbus RS485 RTU.
If one or several of the *"Ext modbus active: XXXXX"* settings are changed from Off to On, then the specific setting can only be changed using the Modbus interface. The corresponding setting in the control panel is deactivated.

Ext modbus active: Heating On/Off
- On: Operated via Modbus
- Off: Operated from the heat pump's control panel
- Factory setting: Off

Ext modbus active: Domestic hot water On/Off
- On: Operated via Modbus
- Off: Operated from the heat pump's control panel
- Factory setting: Off

Ext modbus active: Supply heat On/Off
- On: Operated via Modbus
- Off: Operated from the heat pump’s control panel
- Factory setting: Off

Ext modbus active: Fixed or weather compensation
- On: Operated via Modbus
- Off: Operated from the heat pump’s control panel
- Factory setting: Off

Ext modbus active: Fixed temperature set
- On: Operated via Modbus
- Off: Operated from the heat pump’s control panel
- Factory setting: Off

Ext modbus active: Weather comp. min temp set
- On: Operated via Modbus
- Off: Operated from the heat pump’s control panel
- Factory setting: Off

Ext modbus active: Weather comp. at -12 set
- On: Operated via Modbus
- Off: Operated from the heat pump’s control panel
- Factory setting: Off

Ext modbus active: Weather comp. at +20 set
- On: Operated via Modbus
- Off: Operated from the heat pump’s control panel
- Factory setting: Off

Ext modbus active: Weather comp. max temp 12 set
- On: Operated via Modbus
- Off: Operated from the heat pump’s control panel
- Factory setting: Off

Ext modbus active: Hot water temp set
- On: Operated via Modbus
- Off: Operated from the heat pump’s control panel
- Factory setting: Off

10 EXTERNAL CONTROL AND MONITORING VIA MODBUS RS-485 RTU

Apart from the wired signals, as described in section 7, there is also an option for external control and monitoring via the Modbus RS-485 RTU-protocol. Programmatic requests can be shipped to the heat pump which paves the way for integration of functionality and data in external systems, e.g. for use in control rooms. Thermonova provides a list of relevant Modbus addresses which facilitates correct interpretation of the exposed values.

Each control setting appearing in the Modbus list on the forthcoming page requires manual activation one after another using the heat pump's external control panel. Prior to this activation the heat pump controller will treat the Modbus interface as "read only". The column called "RW" indicates the set of Modbus addresses allowing for write operations after correct activation in the control panel. Activation of Modbus functionality is achieved as described in section 8 under the item called **Login** where after successful login (200 = Installationsmenu) one must navigate to **Settings** og thereafter to **External control** and this menu contains a handful of Modbus On/Off settings. When each of these are changed from **Off** to **On** then the heat pump controller will no longer treat the specific setting as "read only". The heat pump can now for instance be switched on and off via Modbus communication.

Notice that specific lines/items on the Modbus list may be irrelevant for certain heat pumps. If the heat pump does not come with an energy meter then those lines should simply be disregarded.

Most items on the Modbus list are represented in binary using a "signed 16 bit" register. However, a few items on the list associate a 32 bit binary representation in order to contain large numerical values, e.g. the total number of kilo Watt hours from the energy meter or the total number of running hours of a specific heat pump module. The software package used for integration of the Modbus RTU-protocol up against the heat pump controller is crucial for how a sequence of bits are being interpreted. Some software packages are able to read a 32 bit variable using a single function call (two consecutive 16 bit registers). Other software packages are only able to read one 16 bit register per function call. In that case the procedure is to manually perform two calls and then remember to apply "bit-shifting" on the smaller address before the two values are added together, se the illustration below.

<table>
<tr><td colspan="2">32 bit variable</td></tr>
<tr><td>16 bit</td><td>16 bit</td></tr>
<tr><td>ModbusIndex = 8888</td><td>ModbusIndex = 8889</td></tr>
<tr><td>Register address = 8888 - 1</td><td>Register address = 8889 - 1</td></tr>
<tr><td>"bit-shifting" (x << 16)</td><td></td></tr>
</table>

Pseudo-code validation example of correct interpretation of 32 bit variable:

read_32bit_register(address=8888-1, functioncode=3) # should return 136122

read_16bit_register(address=8888-1, functioncode=3) # should return 2

read_16bit_register(address=8888-1, functioncode=3) # should return 5050

Pseudo-code validation example of correct interpretation of signed 16 bit variable:

read_16bit_register(address=8900-1, functioncode=3) # should return -9125

Please pay careful attention to the column called "Decimals" stating the number of decimals needed to obtain correct interpretation of the numerical values at the Modbus addresses. A value of 2 means that division by 100 is required. Thus, the integer 1137 should be interpreted as the floating point number 11.37 if Decimals=2 and as the floating point number 113.7 if Decimals=1 and simply as the integer 1137 if Decimals=0.

Modbus list Nova 440

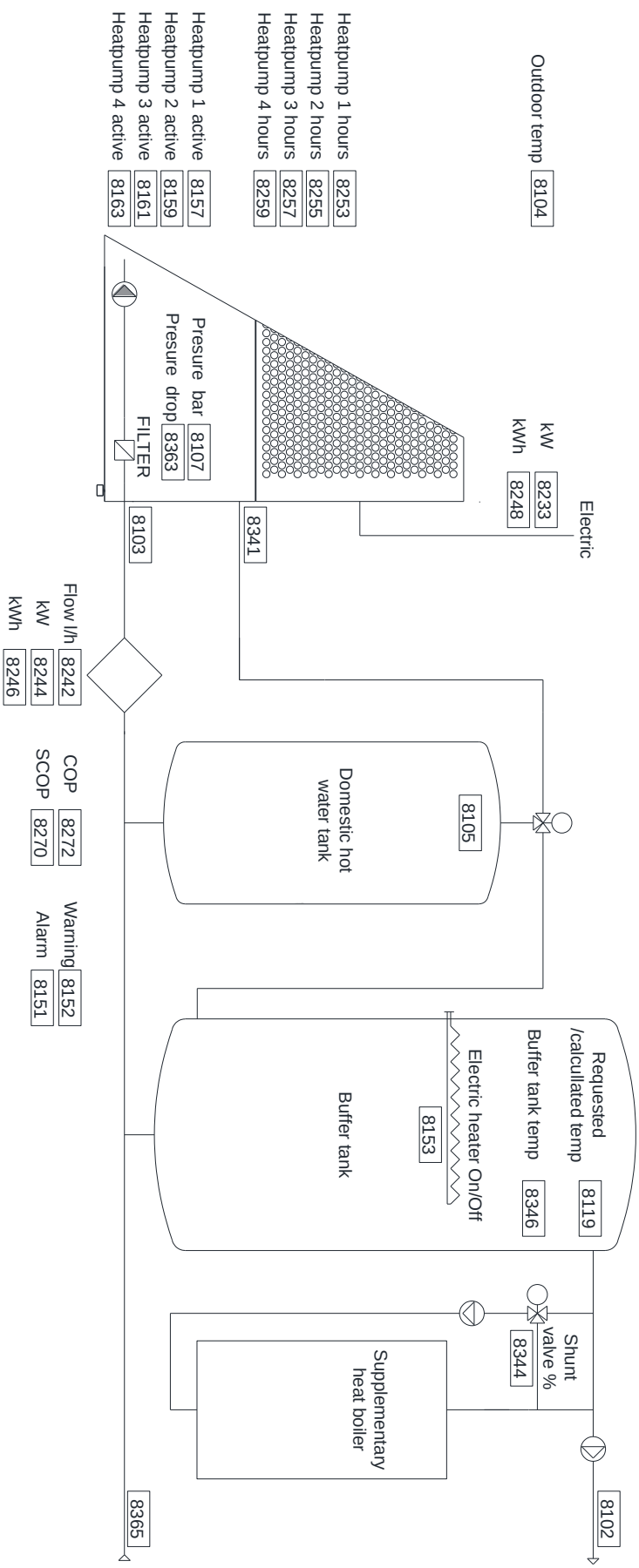
(created on 2023-06-21, SW version 1.12.0000)

Modbus serial ID/address: 100, Baudrate: 19200, Parity: Even, Bits: 8, Stopbit: 1

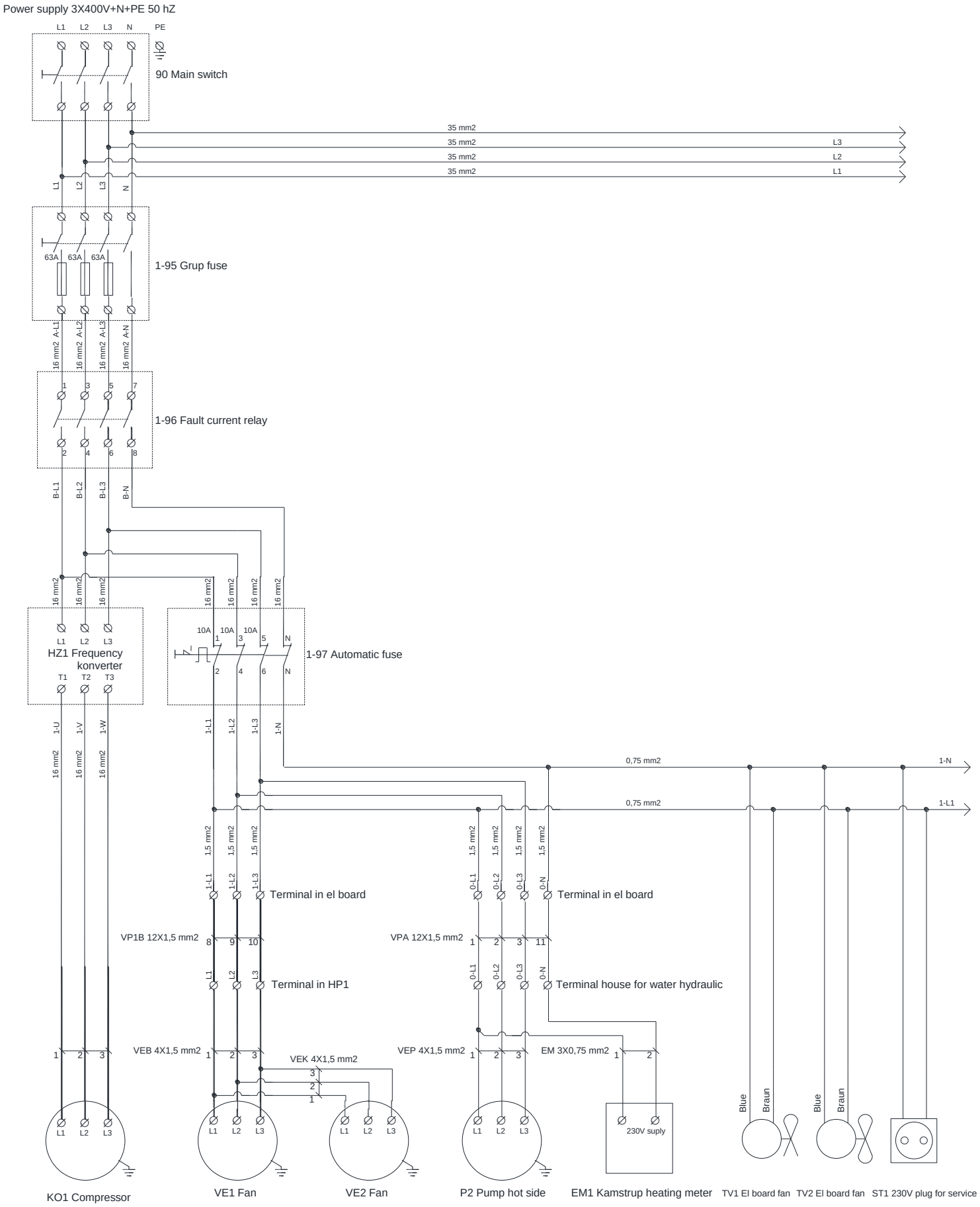
Functioncode 3 for reading and functioncode 6 for writing (use ModbusIndex-1 to get address)

Description	Min	Max	Unit	Decimals	RW	Bits	ModbusIndex
On/Off settings							
Heating On Off	0	1	On/Off	0	RW	16	8369
Domestic water On Off	0	1	On/Off	0	RW	16	8370
Supplementary heat On Off	0	1	On/Off	0	RW	16	8371
Temp fixed and weather comp	0	1		0	RW	16	8383
Temperature settings							
Fixed temperature set	0	65	°C	0	RW	16	8373
Weather comp at -12 set	0	65	°C	0	RW	16	8378
Weather comp at +20 set	0	65	°C	0	RW	16	8379
Weather comp min temp set	0	65	°C	0	RW	16	8377
Weather comp max temp set	0	65	°C	0	RW	16	8380
Domestic water temp set	0	60	°C	0	RW	16	8381
Status variables							
Outdoor temp	-30.0	50.0	°C	1	Read	16	8104
Return temp	-30.0	100.0	°C	1	Read	16	8365
Forward temp	-30.0	100.0	°C	1	Read	16	8102
Requested / calculated temp	0.0	100.0	°C	1	Read	32	8119
Buffer tank temp	-30.0	100.0	°C	1	Read	16	8346
Domestic water temp	-30.0	100.0	°C	1	Read	16	8105
Heat pump return temp	-30.0	100.0	°C	1	Read	16	8103
Heat pump forward temp	-30.0	100.0	°C	1	Read	16	8341
Pressure before water filter bar	0.0	10.0	Bar	1	Read	16	8107
Pressure drop water filter bar	0.0	10.0	Bar	1	Read	16	8363
Heat pump 1 active	0	1		0	Read	16	8157
Heat pump 2 active	0	1		0	Read	16	8159
Heat pump 3 active	0	1		0	Read	16	8161
Heat pump 4 active	0	1		0	Read	16	8163
Supplementation heate shunt %	0	100	%	0	Read	16	8344
Supplementation heate step 1	0	1		0	Read	16	8153
Kamstrup Flow l/h	0	50000	l/h	0	Read	32	8242
Kamstrup kW	0.0	1000.0	kW	1	Read	32	8244
Kamstrup kWh	0	100000000	kWh	0	Read	32	8246
EL meter kW	0.0	500.0	kW	1	Read	32	8233
El meter kWh	0	100000000	kWh	0	Read	32	8248
COP	0.00	10.00		2	Read	16	8272
SCOP	0.00	10.00		2	Read	16	8270
Heat pump 1 hours	0	200000	h	0	Read	32	8253
Heat pump 2 hours	0	200000	h	0	Read	32	8255
Heat pump 3 hours	0	200000	h	0	Read	32	8257
Heat pump 4 hours	0	200000	h	0	Read	32	8259
Warning	0	1		0	Read	16	8152
Alarm	0	1		0	Read	16	8151
Reset handles							
Reset modul alarm	0	1		0	RW	16	8165
Validation addresses							
Validation case 32bit	136122	136122		0	Read	32	8888
Validation case signed 16bit	-9125	-9125		0	Read	16	8900

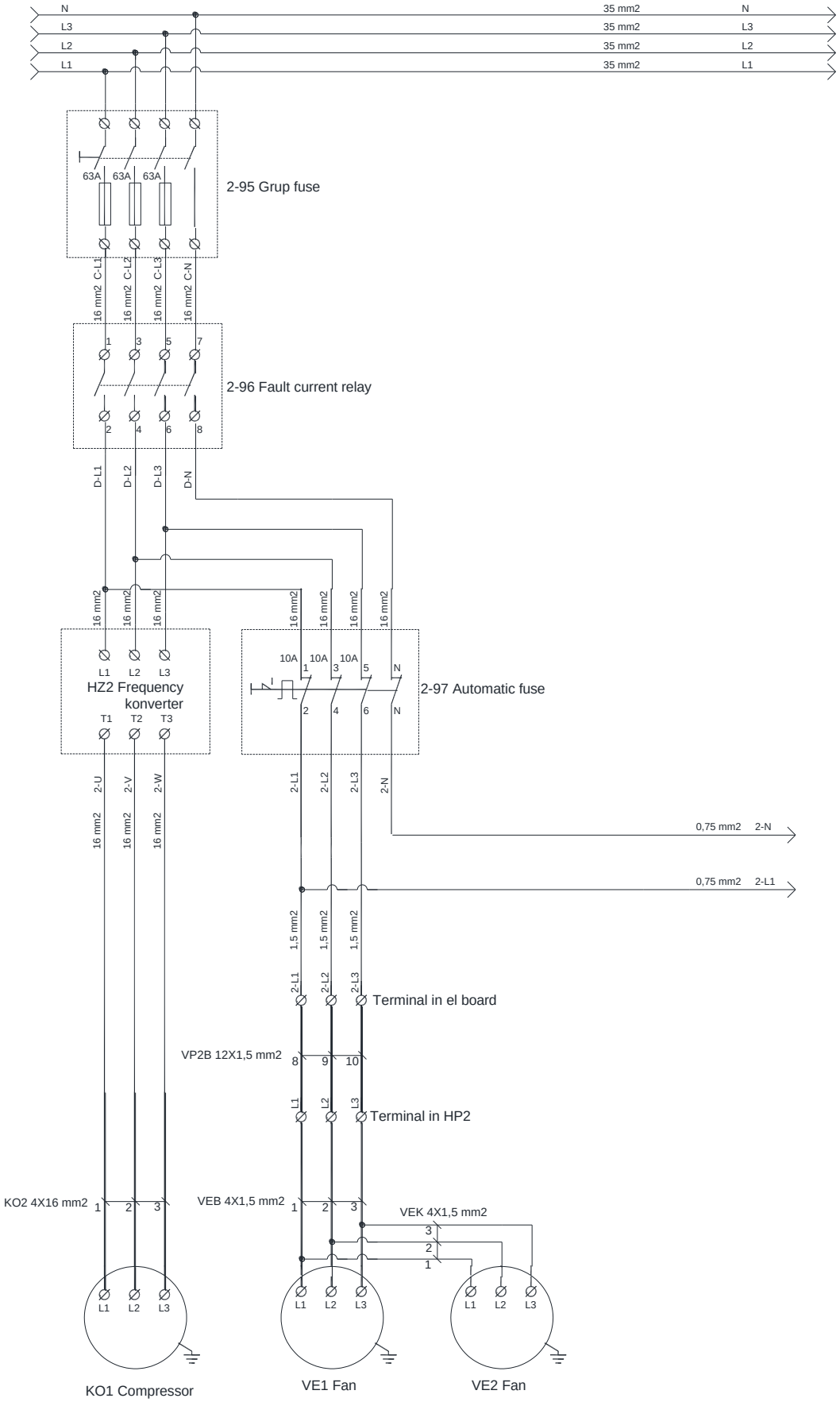
11 EXAMPLE SHOWCASE OF MODBUS DATA



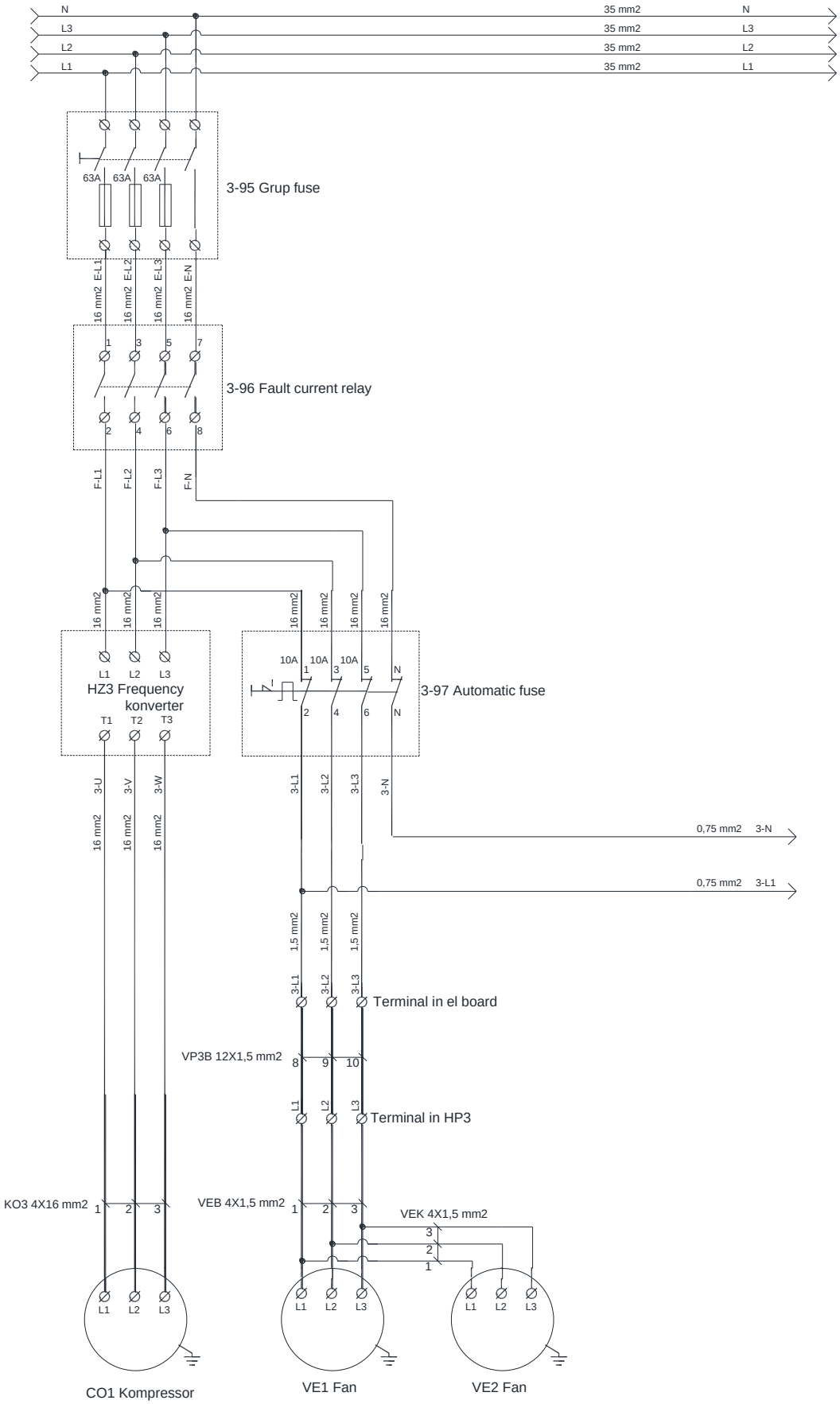
12 MAIN POWER CHART FOR HEAT PUMP MODULE 1



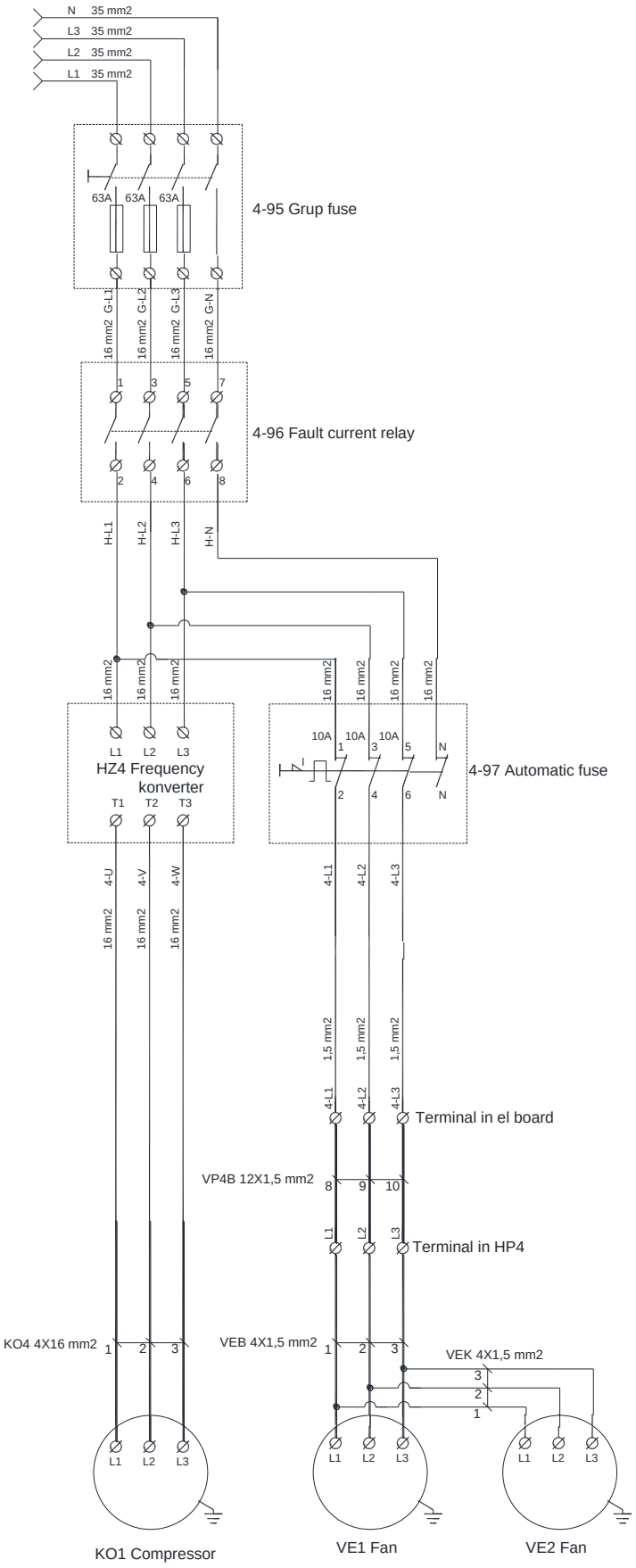
13 MAIN POWER CHART FOR HEAT PUMP MODULE 2



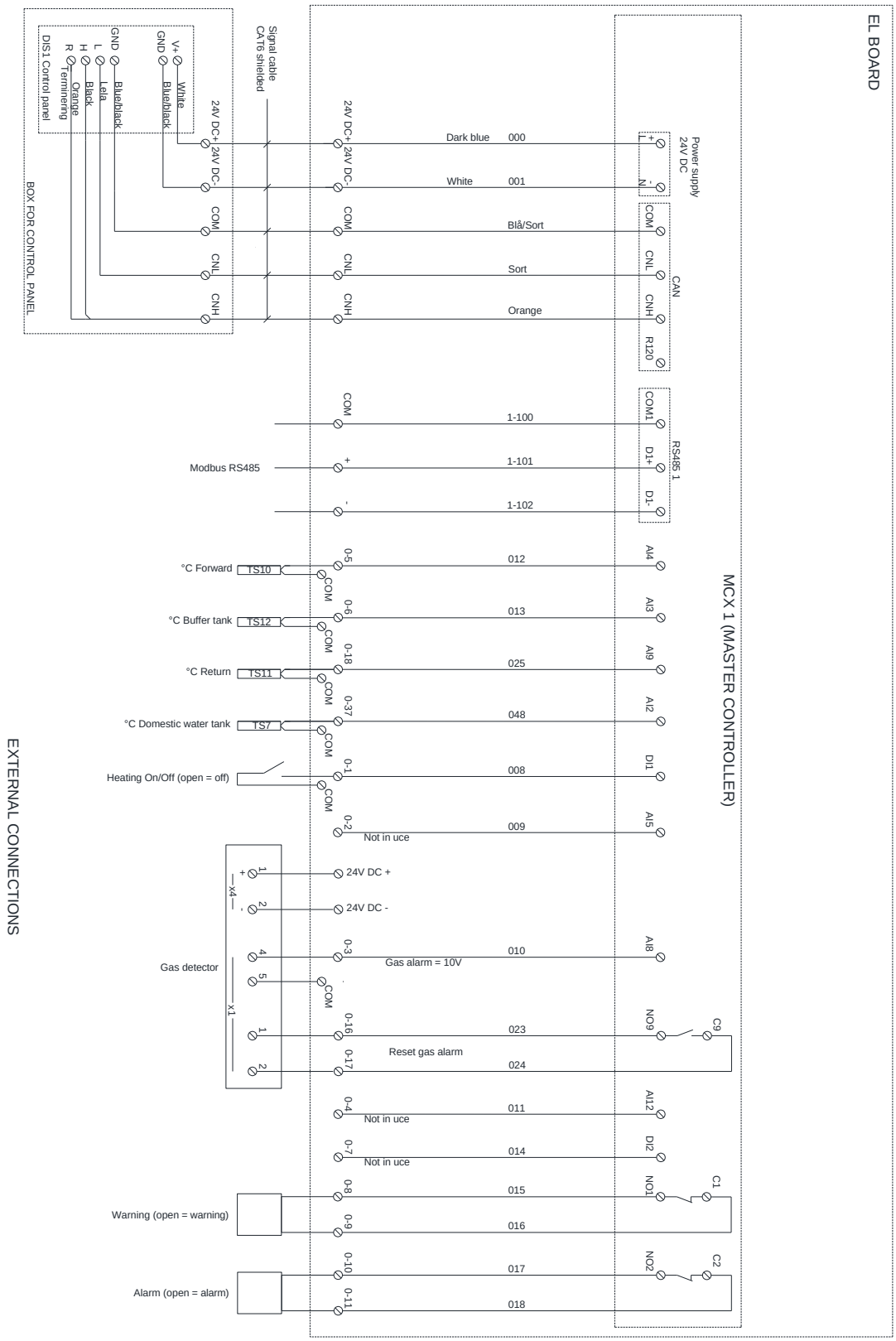
14 MAIN POWER CHART FOR HEAT PUMP MODULE 3



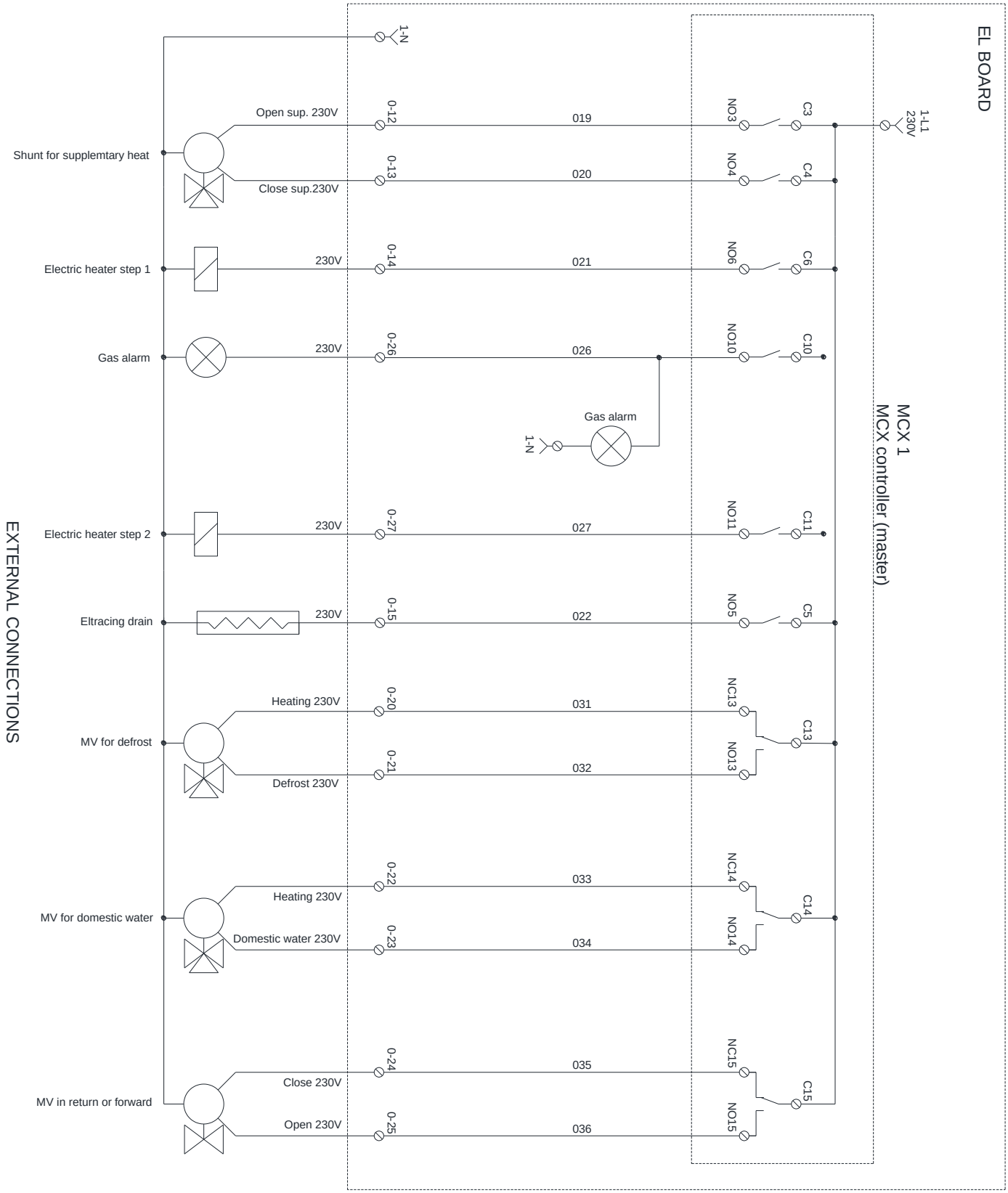
15 MAIN POWER CHART FOR HEAT PUMP MODULE 4



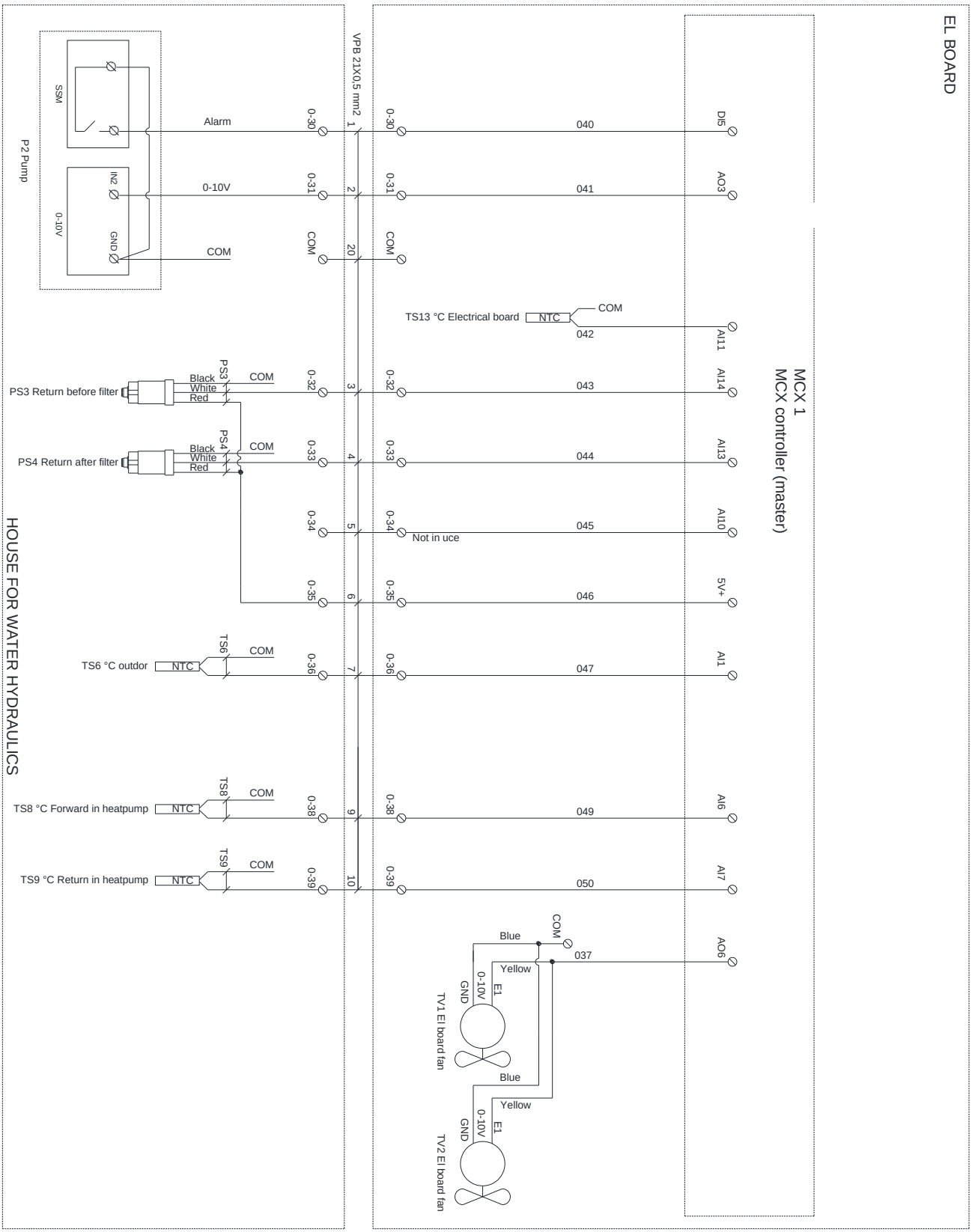
16 POWER CHART FOR EXTERNAL CONNECTIONS



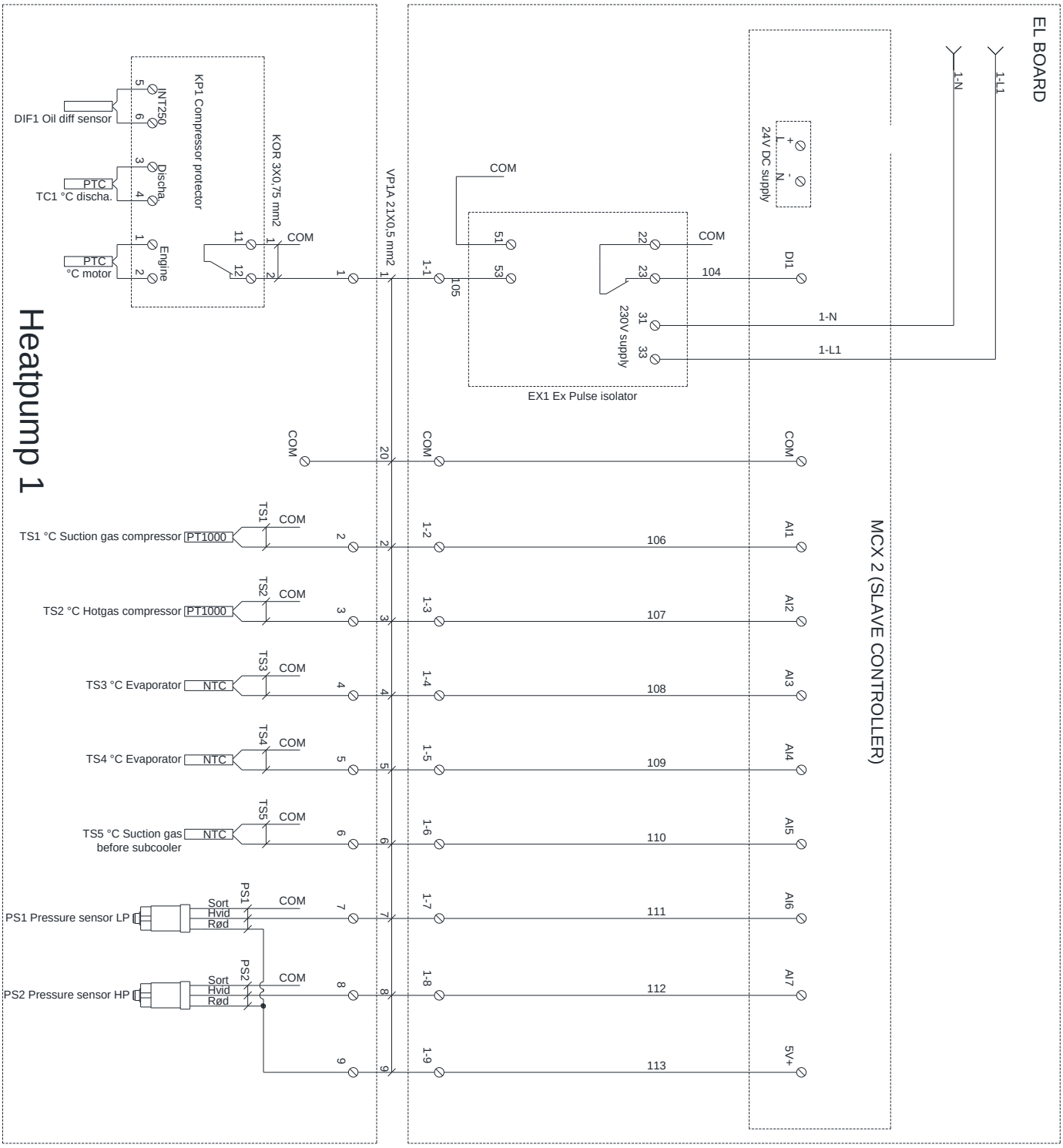
POWER CHART FOR EXTERNAL CONNECTIONS



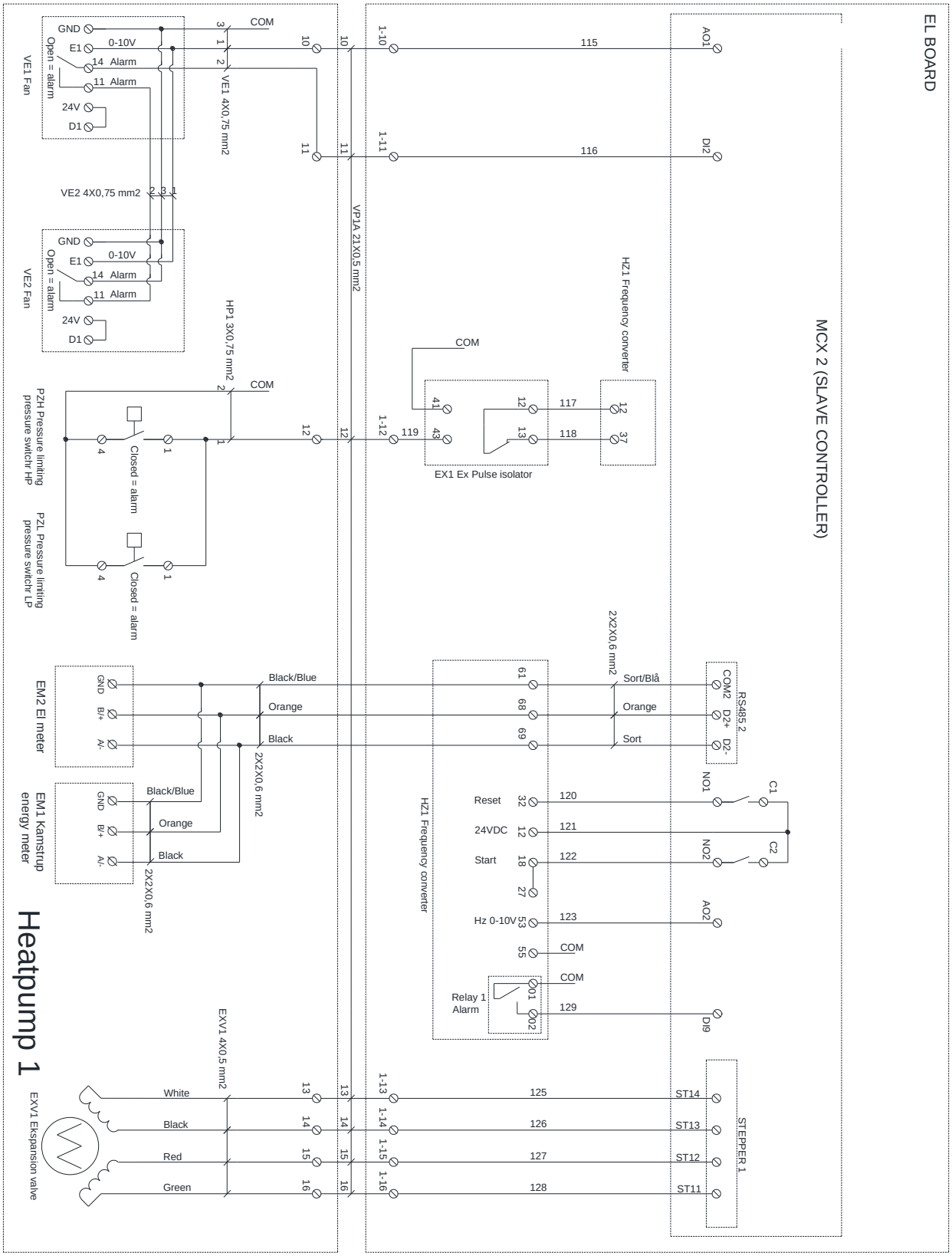
17 POWER CHART CONTROL



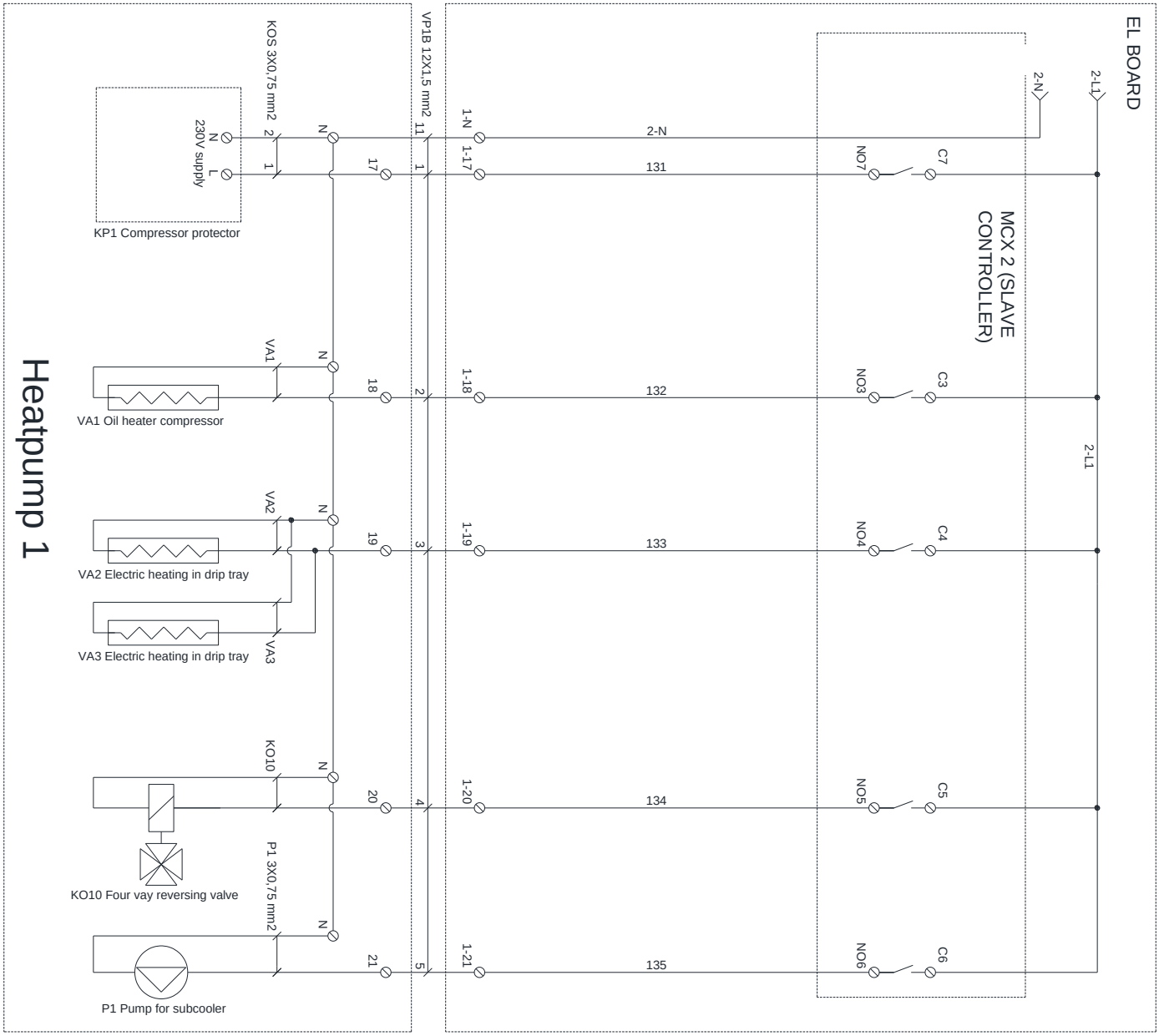
18 POWER CHART CONTROL FOR HEAT PUMP MODULE 1



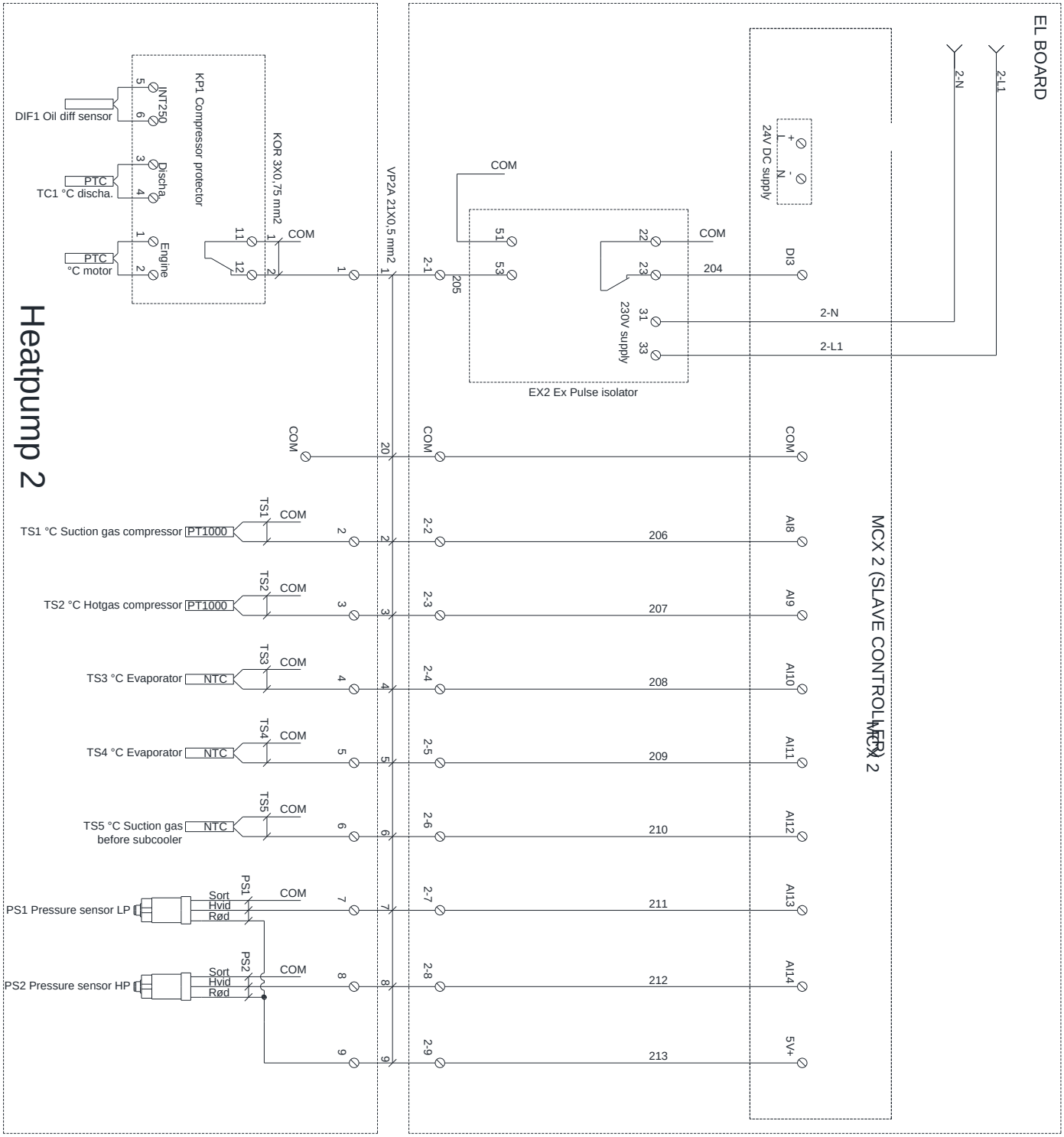
POWER CHART CONTROL FOR HEATMPUMP MODULE 1



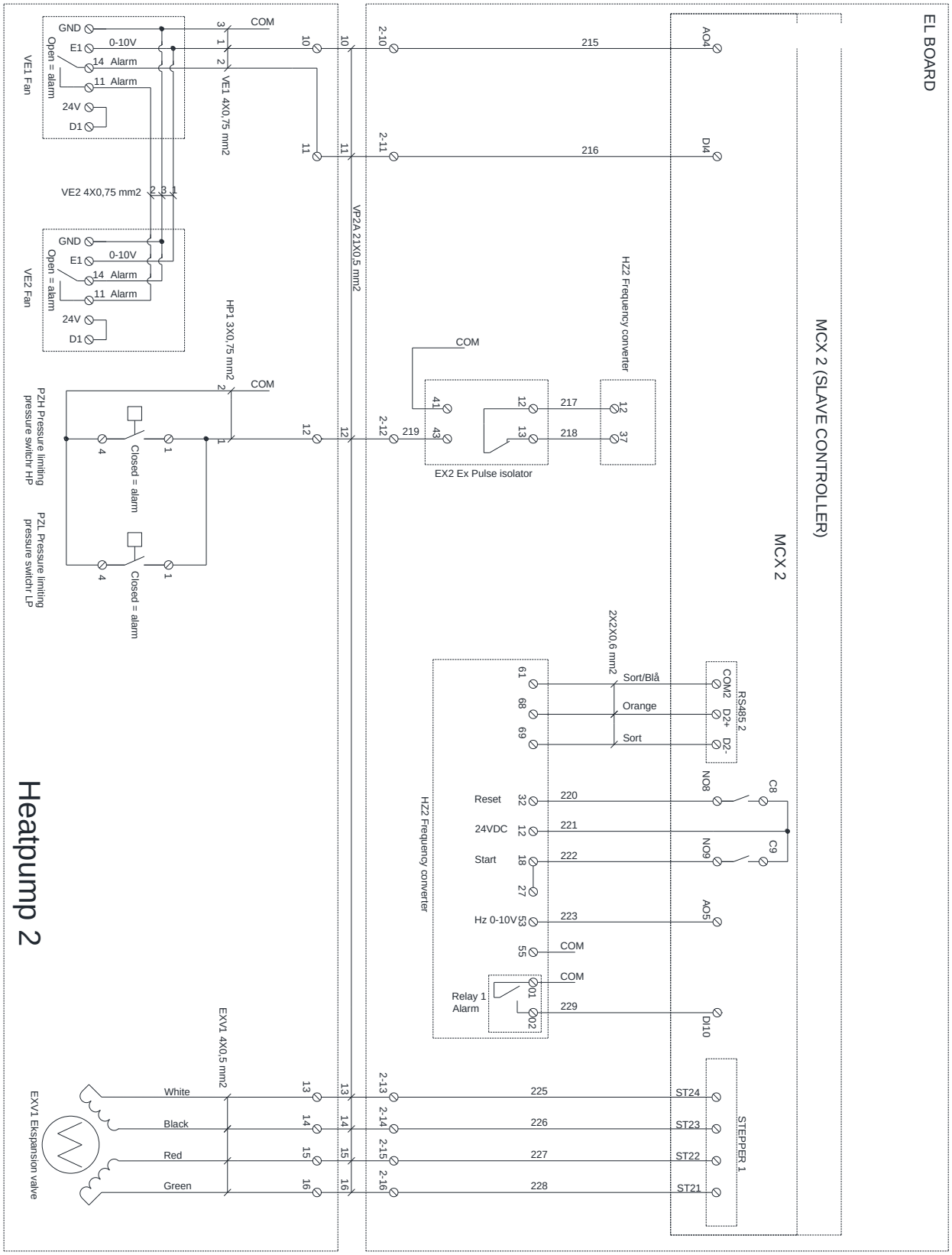
POWER CHART CONTROL FOR HEATMPUMP MODULE 1



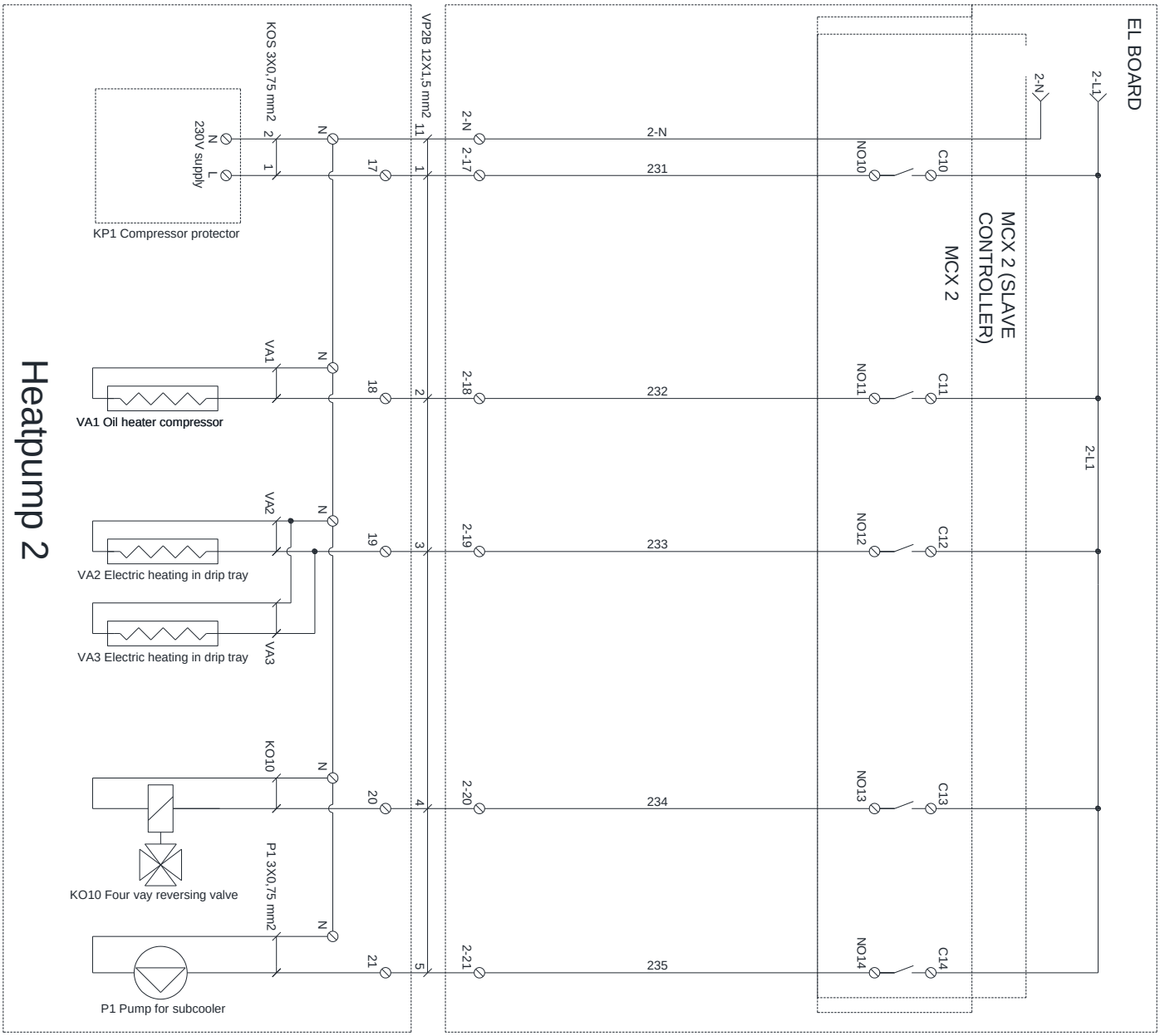
19 POWER CHART CONTROL FOR HEAT PUMP MODULE 2



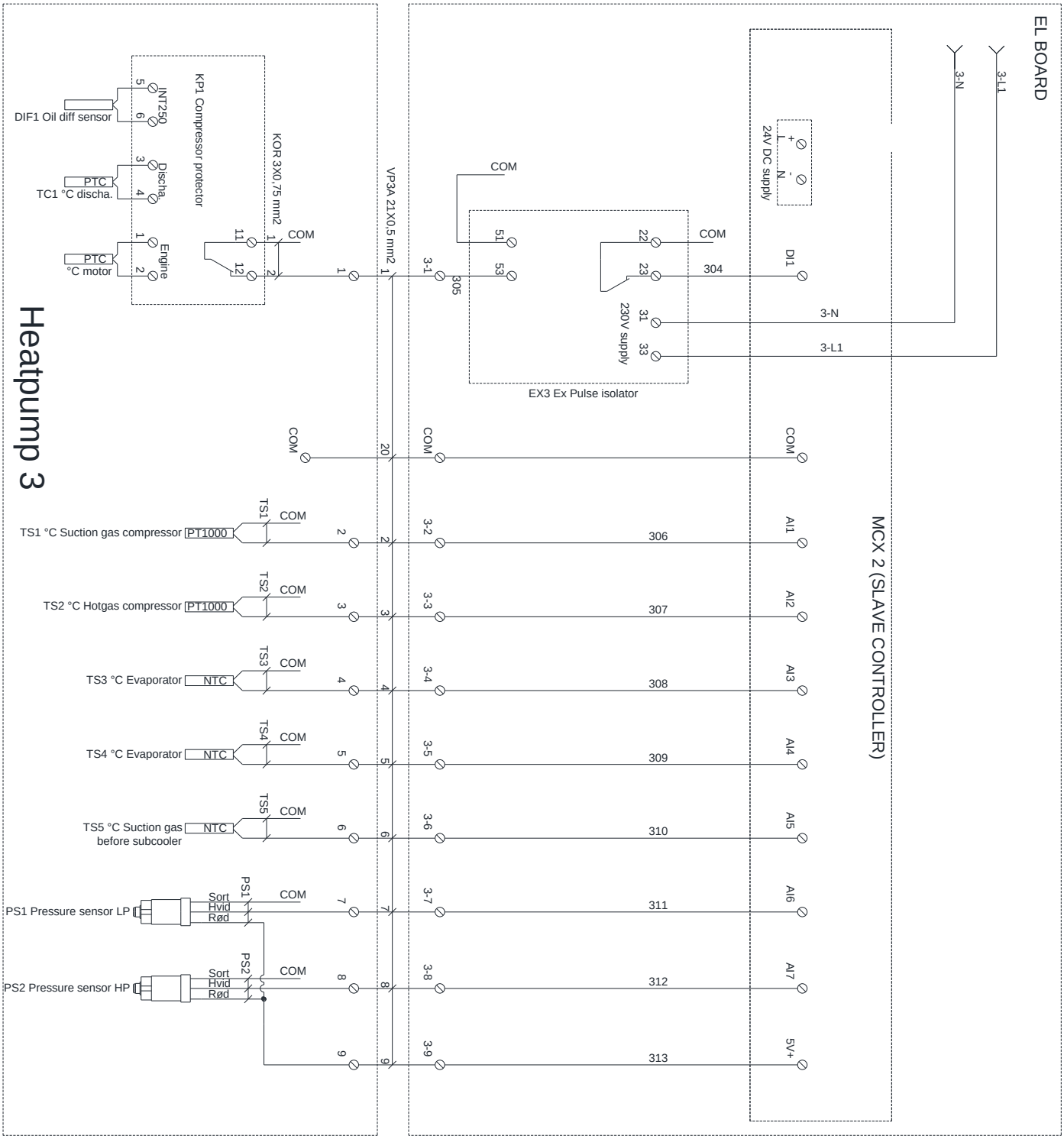
POWER CHART CONTROL FOR HEATMPUMP MODULE 2



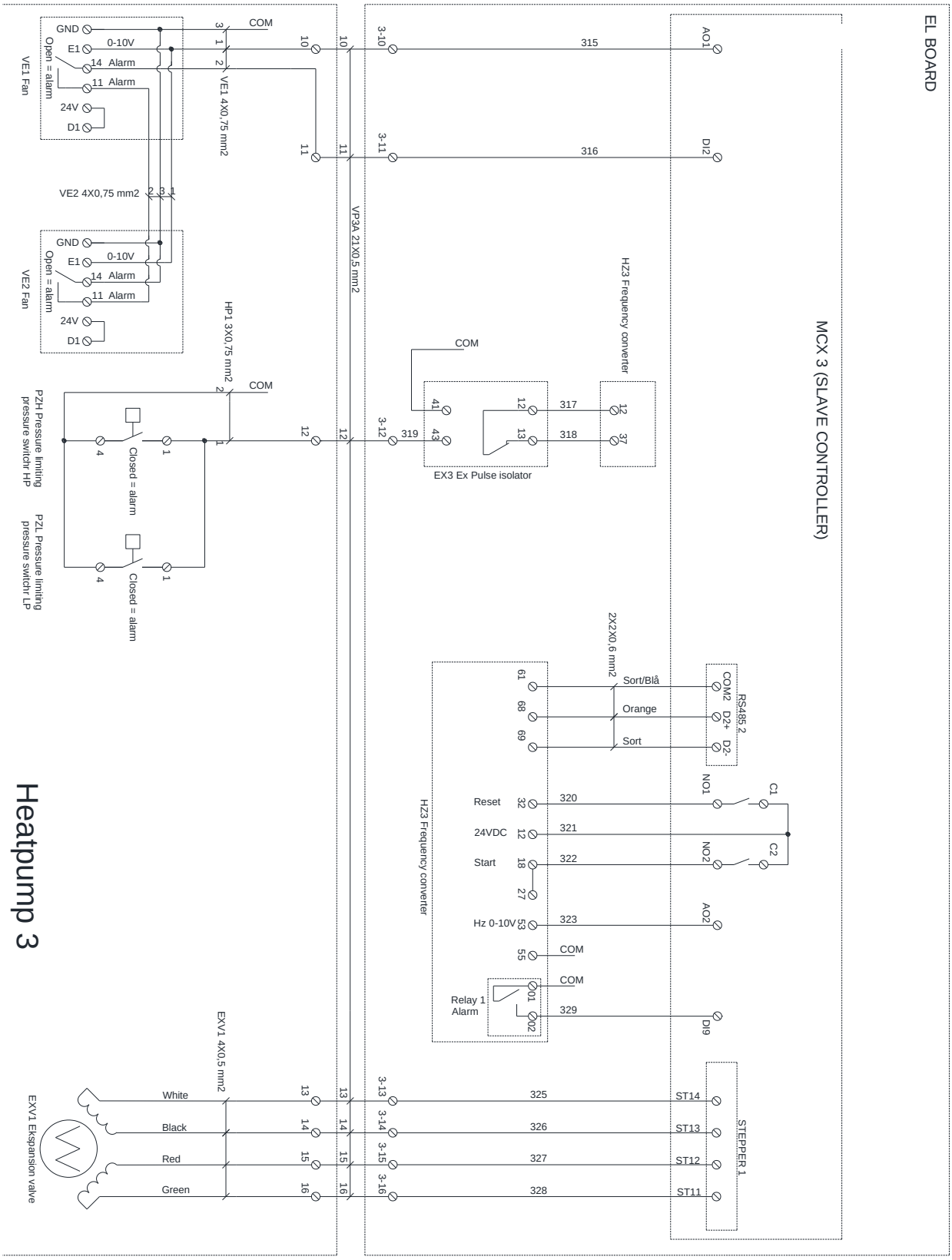
POWER CHART CONTROL FOR HEATMPUMP MODULE 2



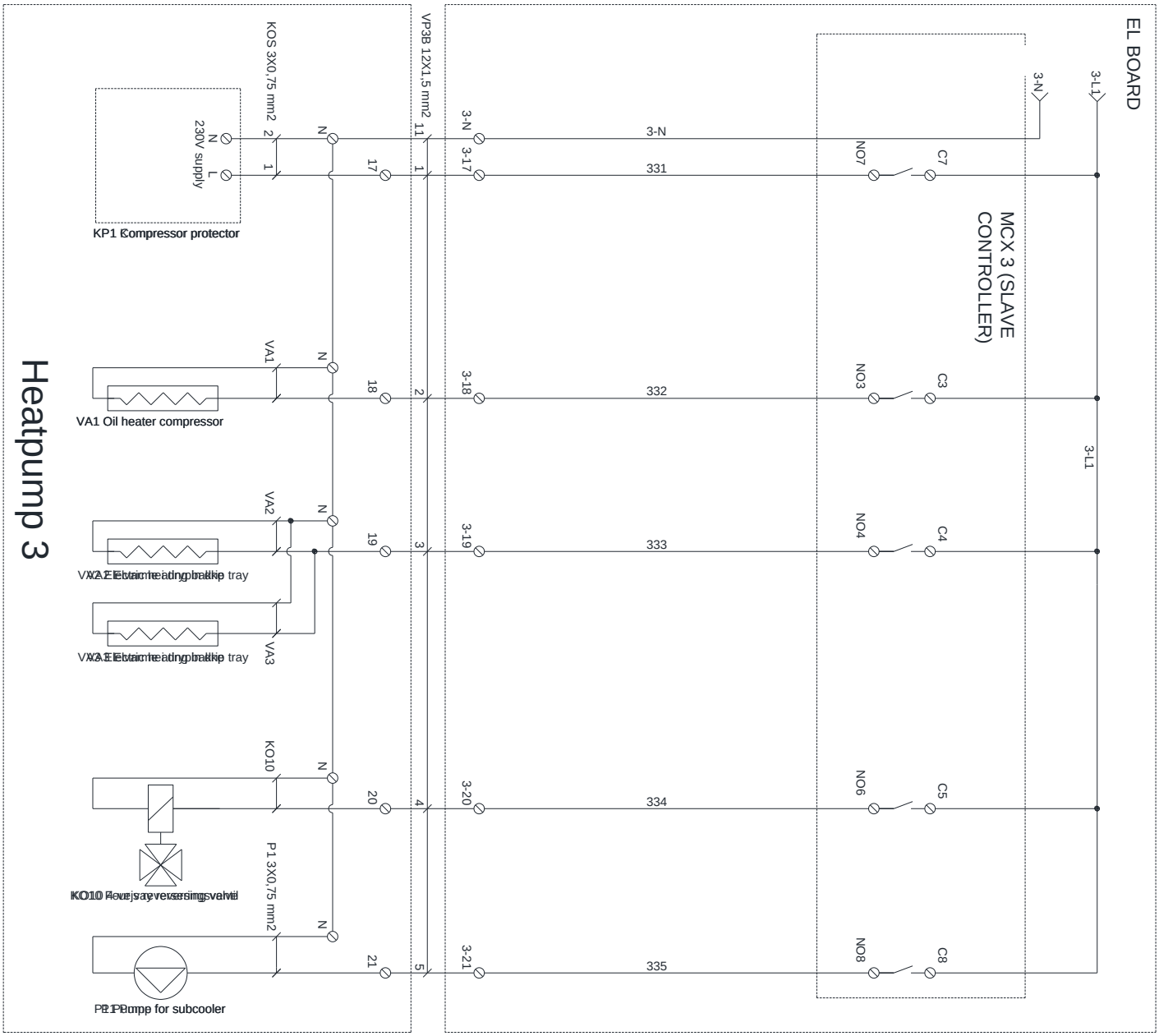
20 POWER CHART CONTROL FOR HEAT PUMP MODULE 3



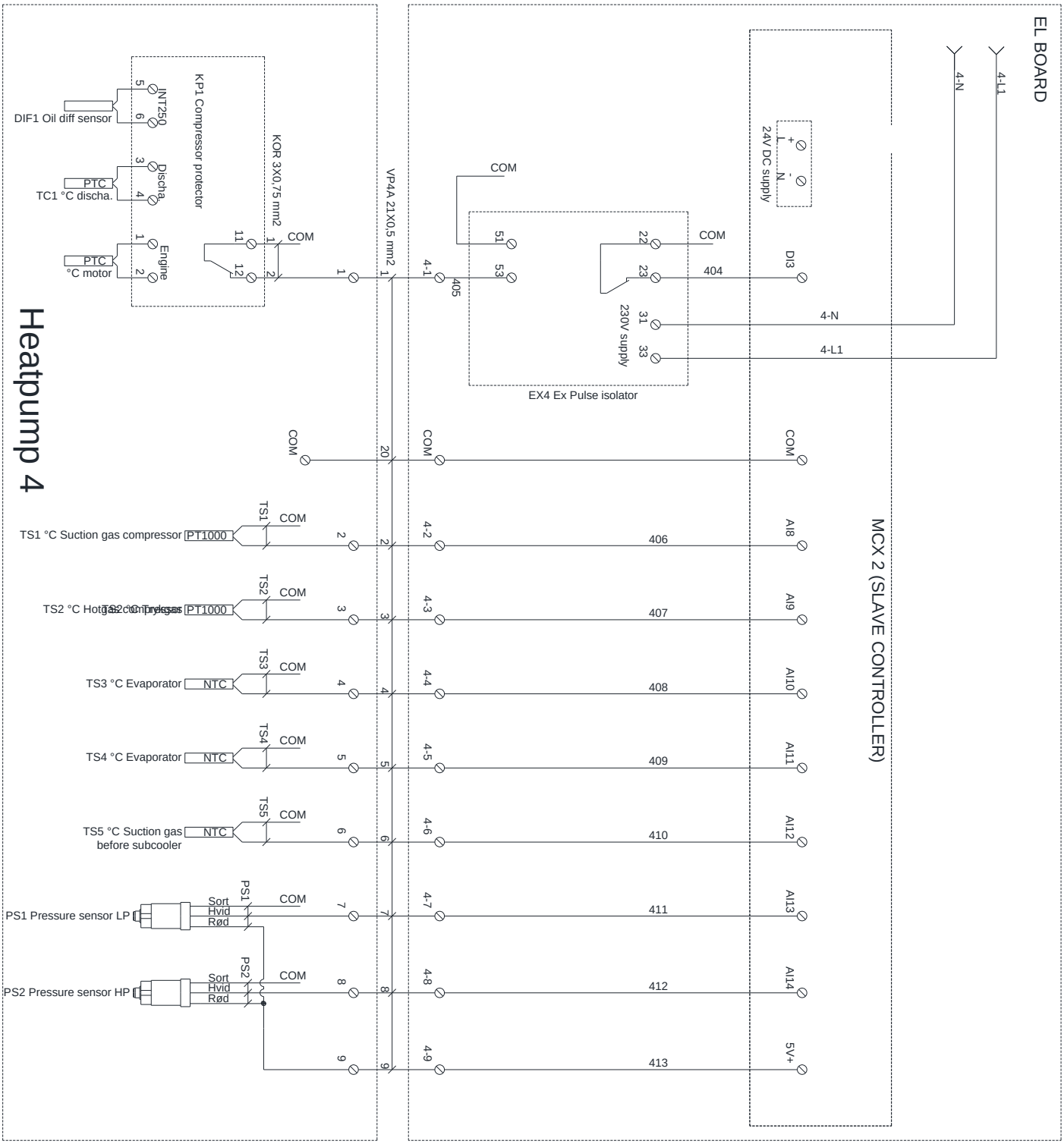
POWER CHART CONTROL FOR HEATMPUMP MODULE 3



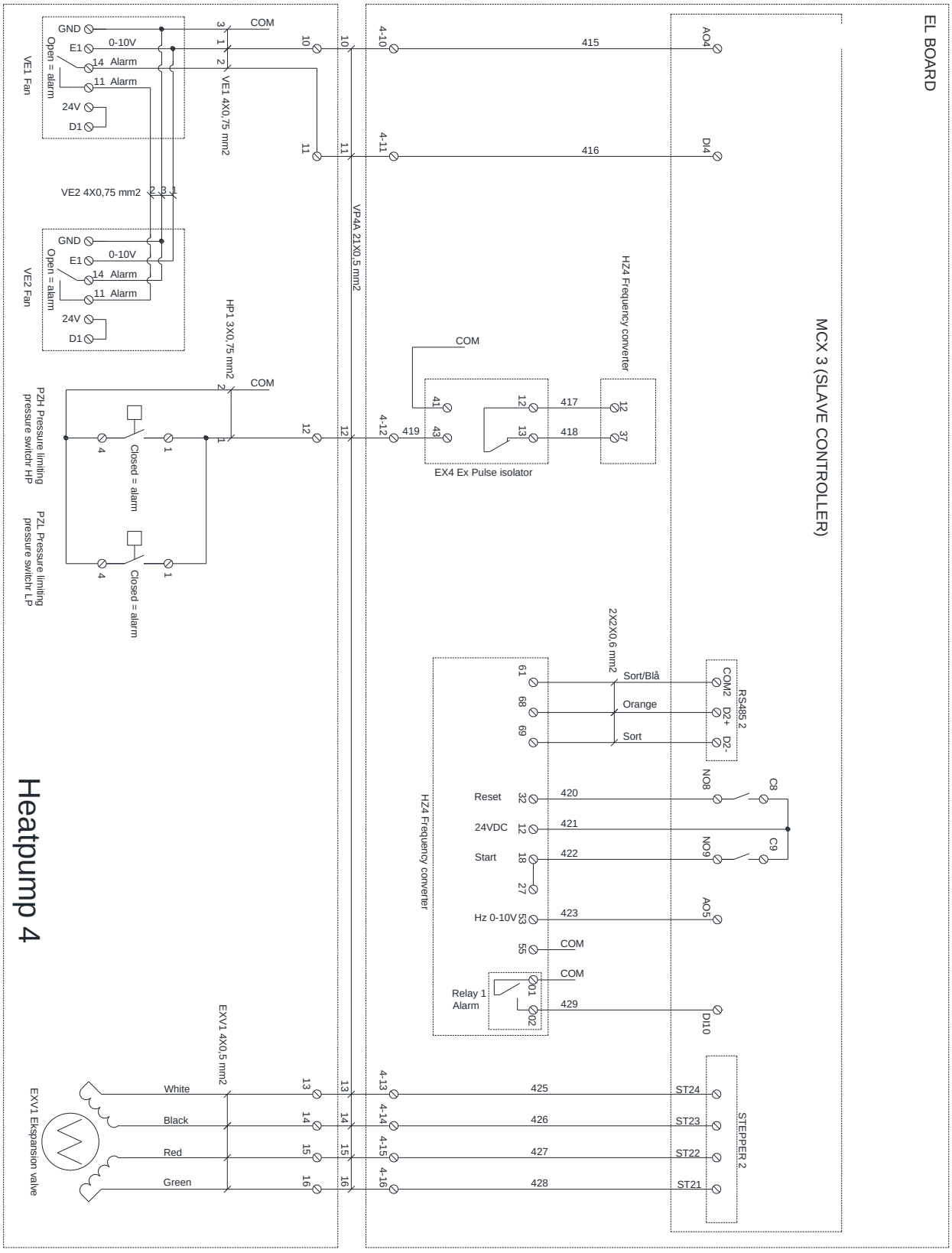
POWER CHART CONTROL FOR HEATMPUMP MODULE 3



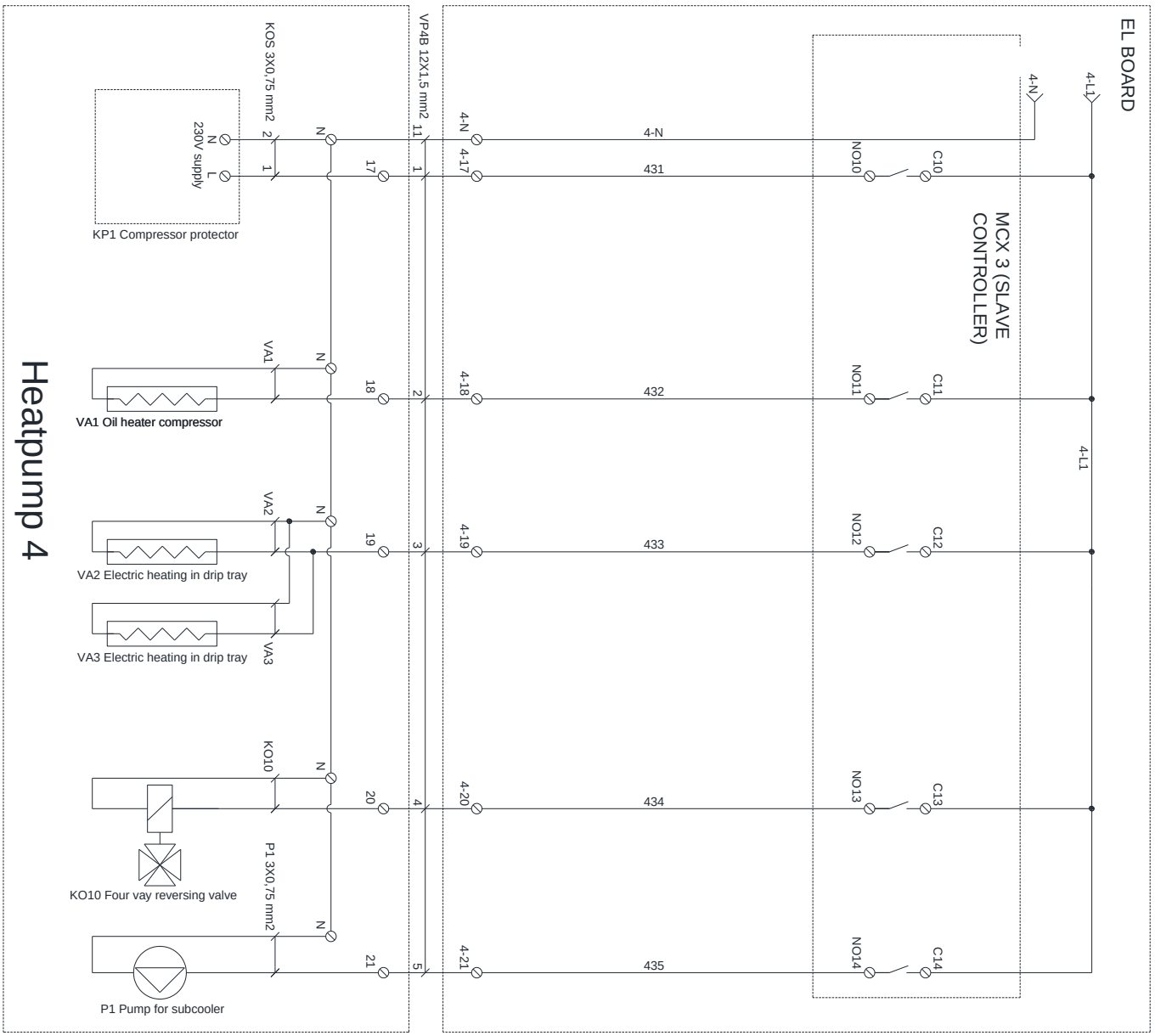
21 POWER CHART CONTROL FOR HEAT PUMP MODULE 4



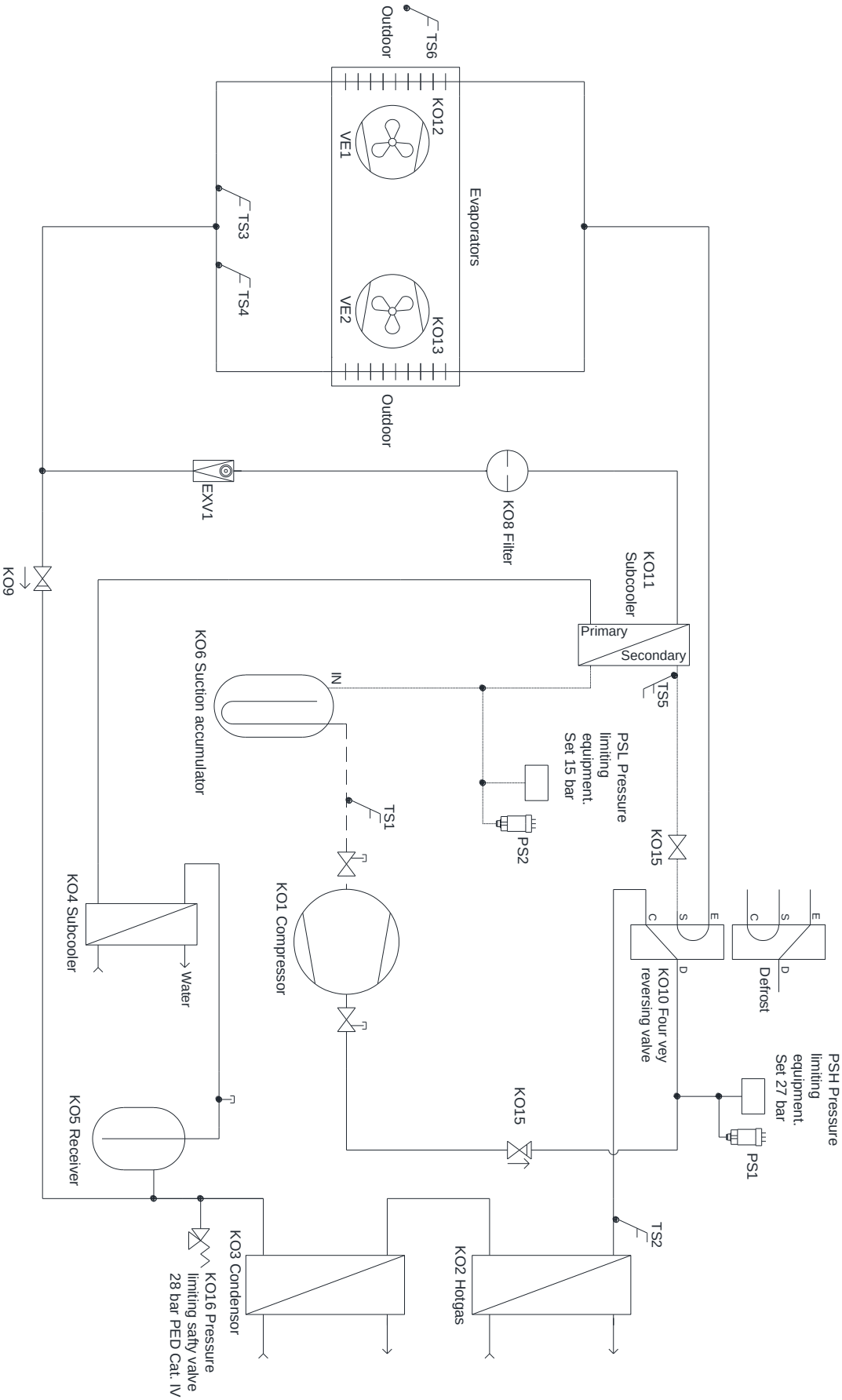
POWER CHART CONTROL FOR HEATMPUMP MODULE 4



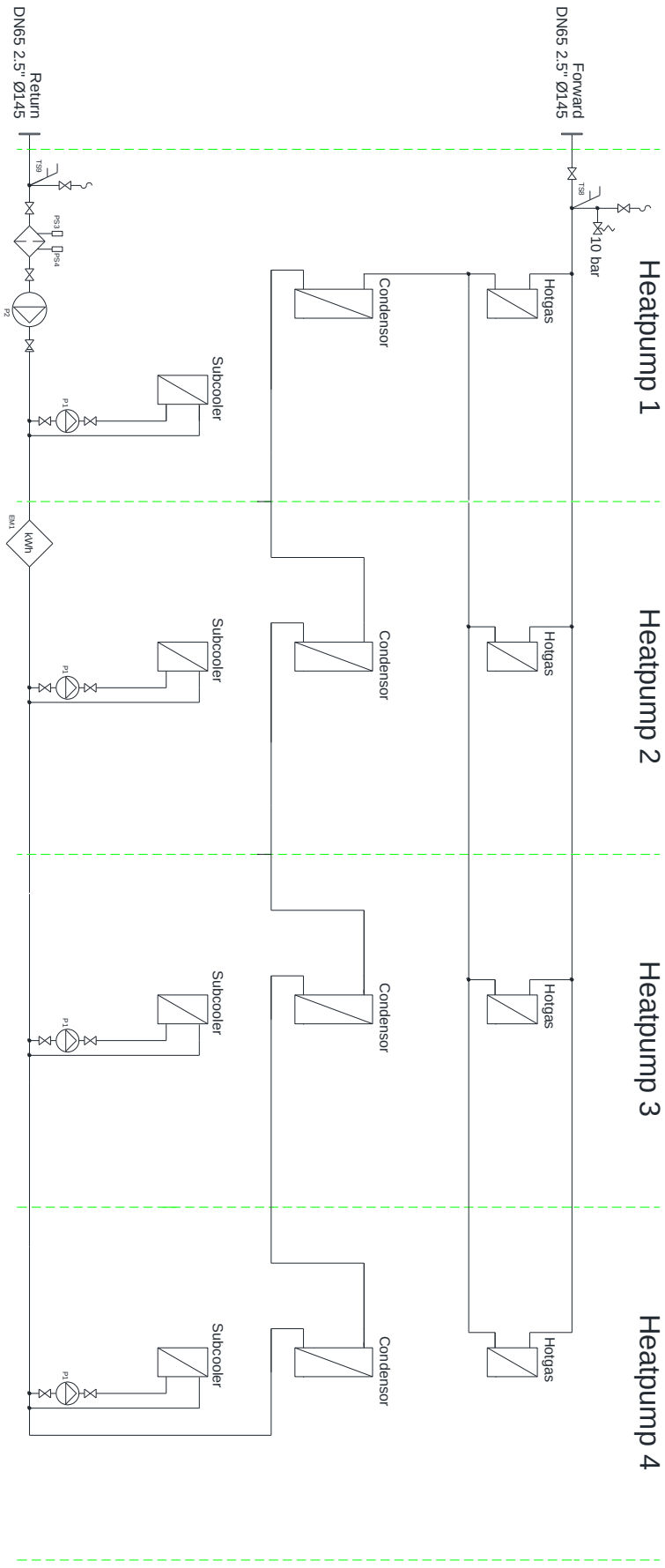
POWER CHART CONTROL FOR HEATMPUMP MODULE 4



22 FLOW CHART FOR COOLING CIRCUIT



23 FLOW CHART FOR WATER CIRCUIT



24 SERVICE INSTRUCTIONS

24.1 Control class

The control class states which investigations, service inspections or tests the system must be subjected to.
The heat pump is manufactured in PED-category II, implying that it belongs to control class C.

24.2 Control class C

- This control class does not require the heat pump to be monitored by some accredited inspection body prior to commissioning and operation.
- The control class demands the owner/user to let the heat pump undergo a legally required service inspection at least once every year.
- The service inspection must be carried out by a certified person/company.
- Since the refrigerant is flammable propane gas (Fluid group 1, safety class A3), the person/company must possess an extended certificate for working on this type of installation.
  Furthermore, the person/company should be qualified in terms of both education and experience.

24.3 Yearly service inspection

- Includes examination of the heat pump and its safety equipment/procedures.
- The inspection is performed among others to ensure that the installation is still in agreement with current legal regulations and that continued operation is still safe.

24.4 Scope of service inspection

Legally required part:

- Control of functionality of safety switches in pressure limiters (pressure switches)
- Control of potential leakage of refrigerant
- Control of correct/intended functionality of switches and buttons
- Control and potential cleaning of safety venting holes in the heat pump cabinet
- Control of ventilators for pressurized venting in electrical cabinet
- Cleaning of air filter for pressurized venting in electrical cabinet
- Control of mechanical safety enclosures around components (cabinet doors and covers)

Not legally required, but should still be carried out:

- Control of functionality and cleaning of ventilators/grids
- Control and cleaning of evaporators and drip trays
- Control for leakage and potential cleaning of condensation drains
- Control for potential leakages in the water hydraulic circuit
- Cleaning of filter in the water hydraulic circuit
- Control and potential tightening of pipe carriers in cooling and hydraulic circuits
- Control and potential repairs of pipe insulation in cooling and hydraulic circuits
- Control of functionality and settings of water pumps
- Control of functionality of electrical heating in drip trays
- Control of functionality of potential el-tracing in external condensation pipes
- Control of defrosting functionality
- Control of sufficient refrigerant filling
- Control of quality and sufficient oil filling in compressors
- Control of condensation temperature
- Control of evaporation temperature
- Control of superheating
- Control of functionality of compressor-protector
- Control of correct display of temperature sensor values in the heat pump controller
- Control of electrical cabinet/panel wrt. heat induced damages on wires and terminals
- Inner cleaning of electrical cabinet
- Control of error-log in controller and potentially fixing any root causes
- Optional update of controller software to newest available version
- Apply updates in agreement with potential service announcements from ThermoNova A/S

25 LIST OF COMPONENTS FOR POWER CABINET

No	Text	Manufacturer	Type
90	Main switch	KATKO	VKA4250-LS/VS 4P 250A
1-95	Group fuse	K Electric	TYTAN II 3P+N 63A
2-95	Group fuse	K Electric	TYTAN II 3P+N 63A
3-95	Group fuse	K Electric	TYTAN II 3P+N 63A
4-95	Group fuse	K Electric	TYTAN II 3P+N 63A
1-96	Residial-current relay	CHINT	NL210 Type B 4P 63A 300 mA
2-96	Residial-current relay	CHINT	NL210 Type B 4P 63A 300 mA
3-96	Residial-current relay	CHINT	NL210 Type B 4P 63A 300 mA
4-96	Residial-current relay	CHINT	NL210 Type B 4P 63A 300 mA
1-97	Automatic fuse	CHINT	3P+N 10A
2-97	Automatic fuse	CHINT	3P+N 10A
3-97	Automatic fuse	CHINT	3P+N 10A
4-97	Automatic fuse	CHINT	3P+N 10A
TR1	Power supply	RS	230/24V DC 120W
DIS1	Control panel	Danfoss	MMIGRS2
MCX1	MCX controller (master)	Danfoss	MCX152
MCX2	MCX controller (slave)(heatpump 1-2)	Danfoss	MCX152
MCX3	MCX controller (slave)(heatpump 3-4)	Danfoss	MCX152
EX1	Ex Pulse isolator (heat pump 1)	PR Electronic	5202B
EX2	Ex Pulse isolator (heat pump 2)	PR Electronic	5202B
EX3	Ex Pulse isolator (heat pump 3)	PR Electronic	5202B
EX4	Ex Pulse isolator (heat pump 4)	PR Electronic	5202B
TS6	°C Outdoor	Otom Group	NTC 10 kOhm
TS7	°C Domestic water tank	Otom Group	NTC 10 kOhm
TS13	°C El board	Otom Group	NTC 10 kOhm
TS10	°C Forward	Otom Group	NTC 10 kOhm
TS11	°C Return	Otom Group	NTC 10 kOhm
TS12	°C Buffer tank	Otom Group	NTC 10 kOhm
TV1	El board fan	Ziehl Abegg	GR 19V-4IP.Z8.AR
TV2	El board fan	Ziehl Abegg	GR 19V-4IP.Z8.AR
ST1	230V plug for service		
HZ1	Frequency converter (heat pump 1)	Danfoss	FC102, 37 kW 131H2987
HZ2	Frequency converter (heat pump 2)	Danfoss	FC102, 37 kW 131H2987
HZ3	Frequency converter (heat pump 3)	Danfoss	FC102, 37 kW 131H2987
HZ4	Frequency converter (heat pump 3)	Danfoss	FC102, 37 kW 131H2987

26 LIST OF COMPONENTS FOR HEAT PUMP MODULE 1-4

No	Text	Manufacturer	Heat pump 1 type	Heat pump 2 type	Heat pump 3 type	Heat pump 4 type
KO1	Compressor	Frascold	Z40-126AXH	Z40-126AXH	Z40-126AXH	Z40-126AXH
KO2	Hotgas heat exchanger	Alfa Laval	CB30-100M	CB30-100M	CB30-100M	CB30-100M
KO3	Condenser	Alfa Laval	CB112-90	CB112-90	CB112-90	CB112-90
KO4	Subcooler	Alfa Laval	CBH30-40	CBH30-40	CBH30-40	CBH30-40
KO5	Receiver	Frigo Mec	7,1 ltr.	7,1 ltr.	7,1 ltr.	7,1 ltr.
KO6	Suction accumulator	Frigo Mec	11 ltr.	11 ltr.	11 ltr.	11 ltr.
KO8	Filter	Danfoss	DCL 417s 7/8”	DCL 417s 7/8”	DCL 417s 7/8”	DCL 417s 7/8”
KO9	Check valve	Danfoss	NRV 19s 7/8”	NRV 19s 7/8”	NRV 19s 7/8”	NRV 19s 7/8”
KO10	Four way reversing valve	SANHUA	SHF-50025 230V	SHF-50025 230V	SHF-50025 230V	SHF-50025 230V
KO11	Subcooler	ThermoNova	1-5/8 X 7/8	1-5/8 X 7/8	1-5/8 X 7/8	1-5/8 X 7/8
PS1	Pressure sensor LP	Danfoss	DST P110 0-15 bar	DST P110 0-15 bar	DST P110 0-15 bar	DST P110 0-15 bar
PS2	Pressure sensor HP	Danfoss	DST P110 0-30 bar	DST P110 0-30 bar	DST P110 0-30 bar	DST P110 0-30 bar
PS3	Pressure sensor before filter	Danfoss	DST P110 0-15 bar			
PS4	Pressure sensor after filter	Danfoss	DST P110 0-15 bar			
PZL	Pressure switch LP side Set 18 bar	Danfoss	KP7EW	KP7EW	KP7EW	KP7EW
PZH	Pressure switch HP side Set 28 bar	Danfoss	KP7EW	KP7EW	KP7EW	KP7EW
EXV1	Expansion valve	Danfoss	ETS 25C Colibri	ETS 25C Colibri	ETS 25C Colibri	ETS 25C Colibri
TS1	°C Suction gas compressor	Otom Group	PT 1000	PT 1000	PT 1000	PT 1000
TS2	°C Pressure gas compressor	Otom Group	PT 1000	PT 1000	PT 1000	PT 1000
TS3	°C Evaporator	Otom Group	NTC 10kOhm	NTC 10kOhm	NTC 10kOhm	NTC 10kOhm
TS4	°C Evaporator	Otom Group	NTC 10kOhm	NTC 10kOhm	NTC 10kOhm	NTC 10kOhm
TS5	°C Suction gas before subcooler	Otom Group	NTC 10kOhm	NTC 10kOhm	NTC 10kOhm	NTC 10kOhm
TS8	°C Forward heatpump	Otom Group	NTC 10 kOhm			
TS9	°C Return heatpump	Otom Group	NTC 10 kOhm			
KP1	Comp. protector	KRIWAN	INT69 22A 495 S52	INT69 22A 495 S52	INT69 22A 495 S52	INT69 22A 495 S52
DIF1	Oil diff sensor	KRIWAN	INT 250	INT 250	INT 250	INT 250
TC1	°C discharge	KRIWAN	PTC 140 02D512S51	PTC 140 02D512S51	PTC 140 02D512S51	PTC 140 02D512S51
VA1	Oil heater compressor	Frascold	230V 50W	230V 50W	230V 50W	230V 50W
KO12	Evaporator	Deltacoils	ED 56T 4R 2200 3P	ED 56T 4R 2200 3P	ED 56T 4R 2200 3P	ED 56T 4R 2200 3P
KO13	Evaporator	Deltacoils	ED 56T 4R 2200 3P	ED 56T 4R 2200 3P	ED 56T 4R 2200 3P	ED 56T 4R 2200 3P
KO15	Check valve	Danfoss	NRV 28s	NRV 28s	NRV 28s	NRV 28s
P1	Pump for subcooler	Wilo	Para G 25/8-75/SC	Para G 25/8-75/SC	Para G 25/8-75/SC	Para G 25/8-75/SC
P2	Pump for hot side	Wilo	Stratos GIGA 50/1-44/3,2			
VE1	Fan	Ziehl Abegg	ZN100-ZIL.GG.V5P1	ZN100-ZIL.GG.V5P1	ZN100-ZIL.GG.V5P1	ZN100-ZIL.GG.V5P1
VE2	Fan	Ziehl Abegg	ZN100-ZIL.GG.V5P1	ZN100-ZIL.GG.V5P1	ZN100-ZIL.GG.V5P1	ZN100-ZIL.GG.V5P1
VA2	Electric heater in drip tray	HeatCom	230V 136W 10,5 m	230V 136W 10,5 m	230V 136W 10,5 m	230V 136W 10,5 m
VA3	Electric heater in drip tray	HeatCom	230V 136W 10,5 m	230V 136W 10,5 m	230V 136W 10,5 m	230V 136W 10,5 m
EM1	Energy meter (option)	Kamstrup	Multical 603 25 m^3/h. return			

27 NAME PLATE

Type		**HEAT PUMP NOVA 440**							
Manufacturing date		XX/XXXX							
Voltage		400V-3ph+N							
Frequency	Hz	50							
FLA	A	232							
FLI	kW	140							
Fuse protection	A	250							
Weight	kg	4000							
Serial number	no	HP1-XXXXXX		HP2-XXXXXX		HP3-XXXXXX		HP4-XXXXXX	
Refrigerant type		 R290 propane		 R290 propane		 R290 propane		 R290 propane	
Refrigerant charge	kg	8		8		8		8	
Fluid group		1		1		1		1	
GWP		3		3		3		3	
CO2 equivalent	ton	0,03		0,03		0,03		0,03	
PED CAT		II		II		II		II	
		LP side	HP side	LP side	HP side	LP side	HP side	LP side	HP side
TS min	°C	-20	-20	-20	-20	-20	-20	-20	-20
TS max	°C	50	80 liq 125 gas	50	80 liq 125 gas	50	80 liq 125 gas	50	80 liq 125 gas
PS	Bar	18	28	18	28	18	28	18	28
Producent	ThermoNova A/S Ejdrupvej 46 DK 9240 Nibe info@thermonova.dk					CE NoBo 1727			

28 DECLARATION OF CONFORMITY

Declaration of Conformity

Fabrikant/Manufacturer: Thermonova A/S
Ejdrupvej 46
DK-9240 Nibe
Denmark

Tel. +45 60 60 83 97
e-mail info@thermonova.dk
CVR 38132369
VAT DK38132369

Thermonova erklærer hermed at varmepumpe:
Thermonova hereby confirm that heat pump:

Model Model	**Bemærkning** Remark	NoBo
Nova 110	**Nova 110** Nova 110	**1727 Kiwa Inspecta A/S**
Nova 220	**2 stk. Nova 110 i kaskade** 2 pcs. Nova 110 in cascade	**1727 Kiwa Inspecta A/S**
Nova 330	**3 stk. Nova 110 i kaskade** 3 pcs. Nova 110 in cascade	**1727 Kiwa Inspecta A/S**
Nova 440	**4 stk. Nova 110 i kaskade** 4 pcs. Nova 110 in cascade	**1727 Kiwa Inspecta A/S**

er produceret i overensstemmelse med
is manufactured in accordance with

•:• Europa - Parlamentet og Rådets direktiv 2014/68/EU (Trykudstyrsdirektiv)
Directive 2014/68/EU (PED)
•:• Europa-Parlamentet og Rådets direktiv 2006/42/EF (Maskindirektivet)
Directive 2006/42/EC (Machinery Directive)
•:• Europa-Parlamentet og Rådets direktiv 2014/35/EU (Lavspændingsdirektivet)
Directive 2014/35/EU (Low voltage Directive)
•:• Europa-Parlamentet og Rådets direktiv 2014/30/EU (EMC-direktivet)
Directive 2014/30/EU (EMC Directive)
•:• Europa-Parlamentet og Rådets direktiv 2009/125/EF (ECO design-direktivet)
Directive 2009/125/EC (ECO Design directive)
DS/EN 14825-2013
DS/EN 14511-2013 part 1, 2 and 3
•:• Europa-Parlamentet og Rådets direktiv 2010/30/EU (Energimærkningsdirektivet)
Directive 2010/30/EU (Energy labeling directive)
•:• Europa-Kommisionens forordning EU nr. 813/2013
Regulation EU no . 813/2013
•:• DS/EN 378-2:2016 Køleanlæg og varmepumper sikkerheds- og miljøkrav
•:• DS/EN 60204-1 Maskinsikkerhed - Elektrisk udstyr på maskiner

18.11.2022

Navn, titel og underskrift af fabrikanten
Name, title and signature of manufacturer

_____
Mads Hougaard
Direktør
Manager

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