EPLAN Electric P8- layout, single-line and multiline drawings and pilot project

Development of layout, single-line and multiline drawings for E-CAE tool and its implementation in project documentation

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Bachelor's thesis

Electrical Engineering

Vaasa 2014

BACHELOR’S THESIS

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Specialization:	Automation
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Title: *EPLAN Electric P8 – layout, single-line and multiline drawings and pilot project*

Date 10.4.2014 Number of pages 32 Appendices 6

Abstract

The work was commissioned by Vacon Plc and has been done in cooperation with the Process Industry Competence Center department. An older E-CAE design tool is currently being used for designing electrifications for cabinet drive systems. It was decided that the older design tool EPLAN 21 will be replaced by its sequel EPLAN Electric P8.

The goal of the project was to develop layout, single-line and multiline drawings for EPLAN Electric P8. After developing the layout and schematic pages and implementing the required standards, the circuits will be cut up into partial circuits, so called macros. The macros will be placed in a macro project, where they will later be utilized in the development of Vacon Documentation Wizard 2. A pilot project was created for an NXC cabinet drive system to test the functionalities of the macros.

This thesis work has resulted in developed electrical drawings that are based on the EPLAN Electric P8 platform, and symbol project page macros in both single-line and multiline representation types ready to be used in future project designing. The goal of the pilot project was to test the macros in real project conditions.

Language: English
Key words: EPLAN, layout, single-line, multiline, Vacon Plc

EXAMENSARBETE

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Titel: *EPLAN Electric P8-layout, enlinje- och flerlinjeritningar och pilotprojekt*

Datum 10.4.2014 Sidantal 32 Bilagor 6

Abstrakt

Arbetet är beställt av Vacon Abp och har gjorts i samarbete med Process Industry Competence Center avdelningen. Ett äldre E-CAE designverktyg används för tillfället för planering av elektrifiering för skåpkapslade frekvensomriktarsystem. Det bestämdes att det äldre designverktyget EPLAN 21 skall ersättas av dess uppföljare EPLAN Electric P8.

Målet med projektet var att utveckla layout, enlinje- och flerlinjeritningar för EPLAN Electric P8. Efter utvecklingen av layout och schematiska sidorna och implementeringen av erfordrade standarder, kommer kretsarna att styckas upp till partiella kretsar, så kallade makros. Makrona placeras i ett makroprojekt, där de senare kommer att utnyttjas i utvecklingen av Vacon Documentation Wizard 2. Ett pilotprojekt skapades för ett NXC-skåpkapslat frekvensomriktarsystem för att testa funktionaliteten hos makrona.

Resultatet blev utvecklade elektriska ritningar som är baserade på EPLAN Electric P8 plattformen, och symbol project page makron representerade i både enlinje- och flerlinjeformat, redo för användning i framtida projektplaneringar. Målet med pilotprojektet var att testa makrona på riktiga projektvillkor.

Språk: engelska
Nyckelord: EPLAN, layout, enlinje, flerlinje, Vacon Abp

Contents

Abbreviations

VDW – Vacon Documentation Wizard

E-CAE – Electrical Computer-Aided Engineering

CAD – Computer-Aided Design

API – Application Programming Interface

PPM – Project Page Macro

THDi – Total Harmonic current Distortion

GUI – Graphical User Interface

VST – Vacon Sales Tool

DT – Device Tag

Preface

I want to take the opportunity to thank my supervisors Mr. Kyösti Rajala at Vacon and Mr. Lars Enström at Novia University of Applied Sciences, Vaasa for the support and guidance they have offered me throughout this project. I also wish to thank the whole Process Industry Competence Center department at Vacon in Vaasa for all the help and Mr. Juha-Pekka Suomela for making the work possible.

1 Introduction

This Bachelor's thesis is made for Vacon Oyj and revolves around the softwares EPLAN 21, EPLAN Electric P8 and EPLAN Engineering Center One. The work and research done for this thesis will be used in future project designing and in the Vacon Documentation Wizard 2.

1.1 Background

The Process Industry Competence Center at Vacon Oyj is currently using a database-driven software EPLAN 21 for creating electrical documents for their cabinet drives. It was earlier decided that EPLAN 21 will be replaced with its sequel EPLAN Electric P8 in the future, since EPLAN 21 no longer releases updates or offers any support for the software. The engineering team had concluded in the early stage of the transition phase that the transition would not be easy. This is because the data importing from EPLAN 21 to EPLAN Electric P8 is not sufficient. Tests had been done where old projects were imported but the results were not satisfying. The main cause for this was that there was no complete database that was compatible with both EPLAN 21 and EPLAN Electric P8, which resulted in corrupt data and quality inconsistency.

In 2012 Christoffer Avela wrote a Bachelor's thesis named "*EPLAN Electric P8 – parts database and pilot project*", developing a component database in EPLAN Electric P8 that would be used in the transition. However, more work was needed before the transition could be carried out. During the summer 2013 I worked at Vacon as an electrical engineer with the task of updating the layout, single-line and multiline drawings from EPLAN 21 to EPLAN Electric P8.

1.2 Target

The main goal of my thesis work was to develop layout, single-line and multiline drawings for EPLAN Electric P8. The first phase was to generate project documentation about several NXC drive systems through Vacon Documentation Wizard, obtaining both data about the parts that can be found in the drives, and electrical drawings that can be used as models. The next task was to implement the IEC 81346-2 standard for all devices, which was done by creating a single document where all parts were compiled and then they were classified by following the standard and comparing them with the existing EPLAN Electric

P8 parts database and adding the parts that were missing. It was decided to do this at an early stage, since new parts had been added and the device identifiers had been changed during the last year.

The second phase was to import all layout pages into EPLAN Electric P8 and update the device identifiers on the layout pages. This was done using the layout pages from the project documentation gained in the earlier phase. No major modifications had to be done with the layout pages, since layout pages are not affected by single-line or multiline drawing structure changes.

The third phase was to draw and develop both single-line and multiline drawings of the NXC cabinet drives. Single-line drawings had been made using EPLAN Electric P8 at the Vacon Solar department for Solar cabinet drives, so it was possible to get support from them. The multiline drawings would be the most time consuming task as the whole structure of the drawings would be changed and the implementation of new symbols following the IEC 60617 standard was to be created. All new symbols were placed in a *project page macro*.

The multiline drawings will later be utilized in the creation of a *macro project*. The drawings will be cut up into partial circuits, so called macros. The macro project contains macros from the layout pages, single-line and multiline drawings. The idea is to later use this project when creating the pilot project and in the development of the Vacon Documentation Wizard 2.

The goal of the pilot project was to implement the macros created in a project and from them generate project documentation, in order to be able to review the macros in real project conditions. The pilot project would be created so that it resembles an updated version of the project documentation that can be obtained from the current Vacon Documentation Wizard. The idea is to use the drawings and macros in the future development of the Vacon Documentation Wizard 2.

2 Vacon Plc

In January 1993 ABB announced that its low-voltage AC drives operations would be transferred from Vaasa to Helsinki. Not all of the employees wanted to move to Helsinki. As a result, 13 employees decided to establish a new company in Vaasa under the name Vaasa Control Oy on 9 November 1993. Their goal was to focus on variable speed drives 100 % and the company is now the leading dedicated AC drive manufacturer in the world. Their first product range of Vacon CX was launched only two years after the company was established. In the year 2000 Vaasa Control Oy changed its name to Vacon and was listed on the Helsinki Stock Exchange. /31/

Vacon has now production and R&D facilities in Europe, Asia and North America, sales offices in 29 countries with sales representatives and service partners in nearly 90 countries. The headquarters is located in Vaasa, Finland. In 2012 their revenues amounted to 388,4 million EUR. The company employs globally 1513 people, where 64 % are white-collars and 36 % blue-collars. Vacon's business culture is based around a set of values: stronger together, trust and respect, taking ownership and passion for excellence. /30/ /31/

In March 2012 the Vacon Drives Finland Organization combined the Application Team, Sales & Solution Support, Service and Training functions to a new unit called Product Support, Solutions & Services for the purpose of creating a single point of contact for Product Support in the Vacon's sales and service network. The Process Industry Competence Center, formerly known as Sales & Solution Support, is located in the headquarters in Vaasa, Finland. The unit is responsible for Solution Engineering & Project Management, Electrical and Mechanical Engineering, Standard Cabinet Drives Development and Engineered Drives Development. /25/

The *standard drive* represents the Vacon NXC, which is an enclosed variable speed AC drive for harsh operating conditions. The drive is available with a wide range of additional options (see Appendix 1). They are categorized in frames, ranging from 9 to 14. A larger frame equals greater rated continuous current, ranging from 261 A (frame 9) up to 2250 A (frame 14). The Vacon NXC can be obtained with a 6- or 12-pulse supply or as a regenerative low-harmonic drive. The low-harmonic drive provides important benefits, such as regenerative braking and voltage boost for maximum output power, it is used in applications where low total harmonic current distortion (THDi) is required. The low-harmonic drive starts at the frame size 10, up to 14. The drives are typically put to work in segments, such as mining, oil & gas, water and wastewater. The *engineered drive* is customer specific and thoroughly planned and dimensioned. This ensures that the configuration of the drive is optimal for the customer’s process. /26/ /27/

Figure 1. Vacon NXC frame 12 cabinet drive.

3 E-CAE

Computer-Aided Design (CAD) is the use of computers to assist in the creation, modification, analysis and optimization of a design. The purpose of CAD is to increase the productivity of the designer and the quality of the design as well as to create a database for manufacturing.

Electrical Computer-Aided Engineering (E-CAE) software is an advanced form of the CAD tool, where a central database is being used that brings together a wide range of information in one accessible database. This database can hold a large archive of recurrent content, reducing time for error-checking. Engineers can convert project documentation into different languages or regional, national and international standards. During the design process, engineers can import component data directly from vendor catalogs. An example of this is EPLAN Electric P8’s Data Portal. E-CAE delivers a systematic reduction of errors, improvement in error-checking and near elimination of data redundancy. The data is updated simultaneously and can be seen by anyone working on the project. Traditionally engineering disciplines work on different platforms, passing the project back and forth as content is being added or changed. The database supports more than one discipline and the modifications are transparent, improving the workflow and enabling the designers to work simultaneously instead of sequentially on a project. Since the data is shared across all disciplines, the system updates it automatically, always making the documentation correct; from electrical, to fluid, to process, and to panel layouts.

It is possible to integrate the database into a company’s IT architecture, allowing other departments to monitor the progress for more accurate system modifications and project coordination. The benefits of this are closer collaboration between project partners, more accurate customer quotes and delivery scheduling and keeping the projects running smoothly. /1/

4 EPLAN

EPLAN Software & Service was founded 1984 in Germany and is part of Rittal Software systems, with 700 employees globally. EPLAN has more than 40,000 customers worldwide and over 100,000 EPLAN software solutions are being used globally. The headquarters are located in Monheim am Rhein, Germany. EPLAN Software & Service was the first company to create a PC-based electronic design automation software. /2/

EPLAN advises companies in the optimization of their engineering processes and is also a developer of CAE/CAD solutions that reduce the configuration time and the engineering costs. They offer tools for several engineering solutions, for example:

- Mechatronic
- Electrical engineering
- Fluid power engineering
- Mechanical engineering
- PCT engineering
- Integration

These EPLAN solutions can be connected to each other via the EPLAN Platform, since the applications use the same basic functions and data. It is possible to implement one’s own developments into EPLAN because the platform is based on Application Programming Interface (API). This allows the users of other programs to use EPLAN functions and data without having to leave their original work environment, which means that results are available faster and more economically. /2/ /11/ /13/

4.1 EPLAN 21

EPLAN 21 is an E-CAD software program developed in the 90´s. It is optimized to meet the needs of electrical controls’ design applications. Aside from normal CAD functions for schematics generation, EPLAN 21 eliminates routine error checking and provides a vast number of automatic functions for cross-referencing, numbering and interconnections and terminal diagrams as well as device lists. EPLAN 21 is a 32-bit application with a graphical user interface (GUI), object-oriented graphics and comes equipped with an application programming interface (API) based on any programming language that is able to create or use DLLs.

All symbol-specific and schematic relevant information is contained in a database that stores all logical design information. During the processing of a project, the editors access this information and display the data graphically. There is no data redundancy as each object exists only in the database as a line, symbol or letter.

A project is made up of a series of pages which are created either interactively or automatically, in addition to descriptive data about the project, the project header contains the details about the type of project, page numbering and ID formats of device tags, cables and terminals. The data contained within the data header file are completely user-definable with the documentation management. /12/

EPLAN 21 is no longer being developed and was replaced by EPLAN Electric P8. EPLAN 21 is still being used by Vacon's electrical engineers, but the idea is to move all of the electrical designing to EPLAN Electric P8.

4.2 EPLAN Electric P8

EPLAN Electric P8 is a graphical database-driven E-CAE software that is used for electrical planning and engineering. From now on EPLAN Electric P8 will be referred to as 'Eplan P8'. The software offers unlimited possibilities for project planning, documentation and management of automation projects. Data from other project areas can be exchanged via interfaces with the CAE software, guaranteeing consistency and integration throughout the entire project. Compared to EPLAN 21, Eplan P8 offers more possibilities for how to operate the tool, as the principle is to let the user decide how to operate the tool. The software is internationally standardized and supports global standards, such as IEC, NFPA, GOST and GB. Eplan P8 comes with a built-in web service called Data Portal (see chapter 9), which provides online access to device data from numerous component manufacturers. This chapter concentrates on the most vital Eplan P8 features that are related to this project. /6/

4.2.1 Project basics

The EPLAN term *project*, is the "place" where all the information about the project is managed. Projects are stored in a database called *Project Management*. The project can for example contain general information about the project, schematics, layouts, reports and attached documents such as lists and overviews which are created as pages within the project. The schematics and layouts are designed within the project, but it is possible to import schematics that have been designed using other software into the project. *Project structure* is based on the IEC 81346-1 standard, and the combination of all identifier structures used in the project for objects, pages devices and functions. The identifiers for project structure are called *structure identifiers*.The objects are placed in a hierarchical structure within the project so that the pages and devices can be found more easily. /7/ /8/

==	Functional assignment
=	Higher-level function
++	Installation site
+	Mounting location
&	Document type

4.2.2 Schematics

Schematics represent elements using graphical symbols. A component is a graphical element for the representation of a function. The component consists of the function and a symbol. The symbol itself does not contain any logical data, whereas the function does, meaning that the function contains the logical data and the symbol contains the graphical data. By using the *Parts Management* it is possible to assign the component a part, which represents the real component of the symbol. The “parts data” contains information about the component, such as size, price and technical information. Components are named with device tags (DT).

Using the graphical editor you create and modify the elements on schematics and mechanical drawings. The editor uses a coordinate system for positioning the cursor and symbols. /9/

4.2.3 Graphical reports

Reports are project pages that Eplan P8 can produce by using the data from the schematics. There are different kinds of reports, such as circuit diagrams, terminal diagrams, wiring lists, parts lists, cable lists and so on. These reports can then be selected and added automatically to the output project documentation. /10/

4.3 EPLAN Engineering Center One

EPLAN Engineering Center One allows you to automatically create schematics for Eplan P8 on the basis of partial circuits, schematic macros and table-based project information. The EPLAN Engineering Center One consists of three main elements:

- Typical file
- EPLAN Engineering Center One-Module
- EPLAN Engineering Center One-Excel-Editor

The module automatically allows the generation of schematics based on macros and a typical file. The typical file is where you enter information on the macros to be used for automatic schematic generation, for example: project data, macro names and control commands. Each project needs its own typical file. The Excel-Editor is used for controlling the EPLAN Engineering Center One-Module and for defining the basic folders and files that are needed for the schematic generation. /4/ /5/

From now on EPLAN Engineering Center One will be referred to as ‘EEC One’.

5 Vacon Documentation Wizard

Vacon Documentation Wizard (VDW) is a technical documentation tool that operates beside the EPLAN 21 system and is developed by Vacon themselves. The tool makes complete drawings and diagrams of various kinds of combinations of the standard NXC cabinets, with additional options. The output documents include the following pages:

- Title page
- Table of contents
- Layout
- Circuit diagram
- Terminal diagram
- Wiring list
- Parts list
- Cable diagram
- Interconnection diagram
- Plate list

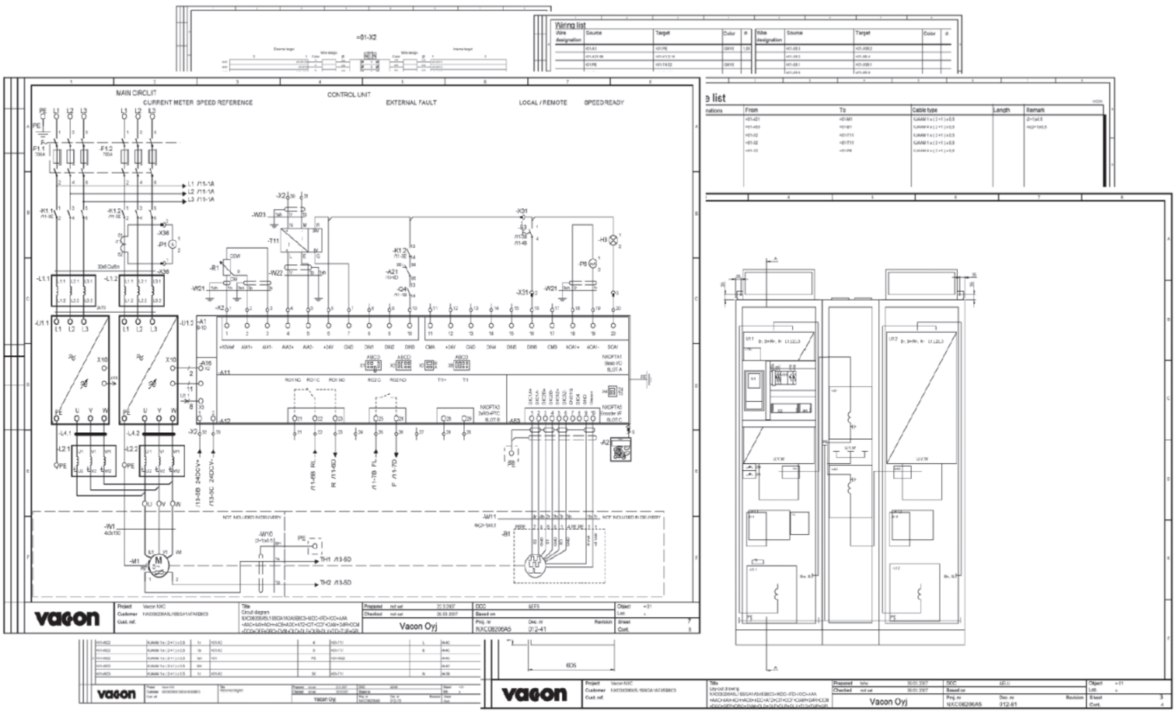


Figure 2. Example output documentation for the Vacon NXC cabinet drive.

The Vacon Documentation Tool has many useful configurations, such as exporting the documentation to a portable document format file, a DWG-, DXF- or a PRJ-file. The user may also choose whether to include or exclude layout drawings and schematics. /21/ /28/

The tool can be reached from the Internet, and is used on a daily basis by many customers and partners, since it is a quick way of generating documentation for NXC solutions without involving Vacon for planning. Electrical engineers and mechanical engineers can use it to get base drawings and then if needed, tailor it to the end user's needs. The sales team use it for quotation. Vacon Documentation Wizard also works together with the Vacon Sales Tool (VST), which the sales engineers use when they quote any NXC product. The VST requests corresponding drawings in PDF format from VDW and then attaches it to the quotation. The documentation can even be used in the manufacturing process as part of the assembly line instructions or be used as work guidance. Since it includes all electrical parts, the documentation can be used as production bill of materials. Several deals have been secured with the help of the Vacon Documentation Wizard. (Personal communication with project manager K. Rajala, 10.3.2014)

When entering the product and option codes of the drive wanted, VDW then utilizes EPLAN 21 macros to generate the schematics and reports. The code handling the ratings and configurations is defined in a series of files; Microsoft Excel spreadsheets, C++ program files and text print files. VDW can produce complete output documentation in just three to five minutes. In some cases the documentation provided by VDW needs additional designing, for example with customer-specific options. Then the output project from VDW is forwarded to an engineer and manually designed to the customer's needs using EPLAN 21. /22/

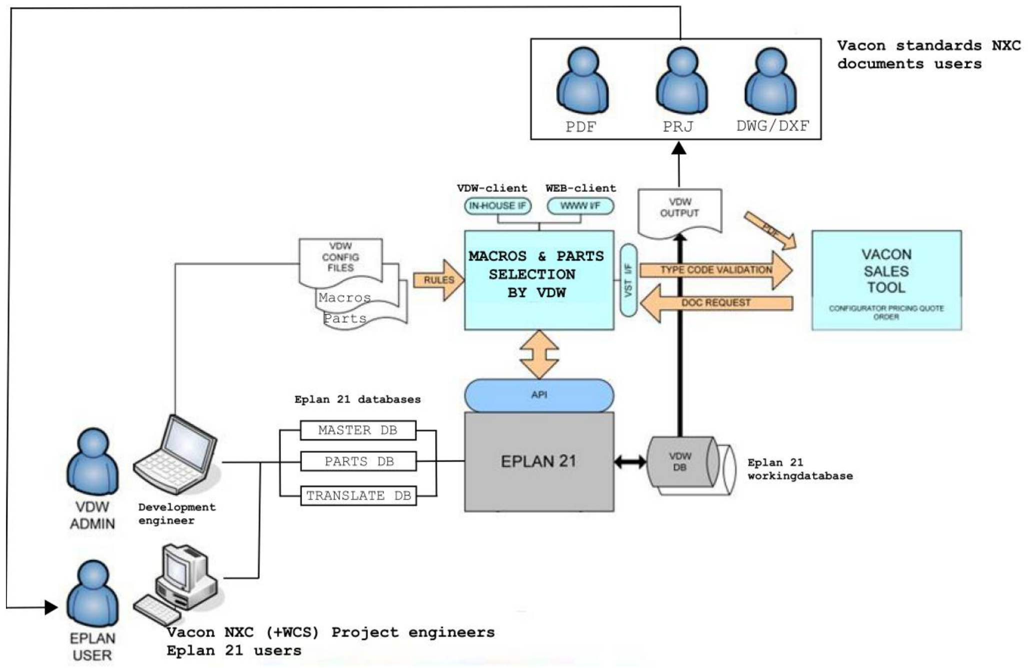


Figure 3. Vacon Documentation Wizard environment preview.

However, EPLAN 21 and Vacon Documentation Wizard databases have grown too large and complex to manage, which limits the possibility of updating the database. These problems have resulted in several errors and bugs on the output documentation. Taking these problems into consideration and with EPLAN 21 no longer being updated or supported, it was decided to develop a new Vacon Documentation Wizard, where the macros are based on the Eplan P8 platform.

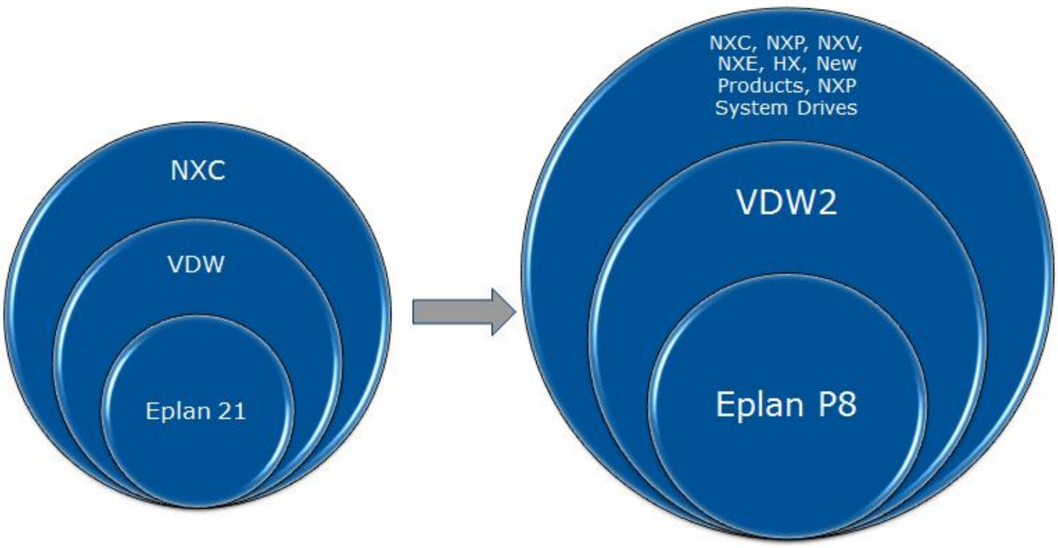


Figure 4. The old Vacon Documentation Wizard design to the left and the Vacon Documentation Wizard 2 project design platform to the right.

This offers the possibility of implementing new standards, updating products and parts, fixing bugs, and the possibility of changing the whole structure with newer and more intelligent software. /23/

6 Development of electrical drawings

Electrical drawings are technical drawings that consist of lines, symbols, dimensions and notations. When the development phase started, a research was conducted on what old material could be reused without quality loss. It was concluded that the layout pages could be imported into Eplan P8 without any major difficulties. The single-line and multiline drawings were decided to be drawn from scratch, implementing new standards and improving the quality of the drawings at the same time. In this chapter the development of the drawings and the reason behind the changes will be explained.

6.1 Standards

When developing and designing electrical drawings it is extremely important to consider what standards to specify. A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purposes. Standards are approved by standard settings organizations, whose primary activities are developing, coordinating and interpreting and producing standards. To overcome technical barriers in inter-local or inter-regional commerce caused by differences among technical regulations and standards developed separately by each local, the standards are established on three different geographical levels: /14/ /20/

- National standard
- Regional standard
- International standard

In Finland the Finnish Standards Association, SFS, is the central standardization organization that controls and co-ordinates national standardization work. In Europe some standards are controlled by the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC). International standards are developed by many organizations, such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

The existence of a published standard does not imply that it is always useful or correct. It is the people using the item or service, or the ones specifying it that have the responsibility to consider the available standards and specify the correct one and then use the item following the implied standard. Standards often get reviewed and updated.

When referencing standards it is crucial to always refer to the most current version of the published standard.

The standards that had to be taken into consideration in the development of the electrical drawings for symbols and designations are the two following:

- SFS-EN 81346-2 (2009) standard; *Classification of objects and codes for classes*
- IEC 60617 standard; *Graphical Symbols for Diagrams*

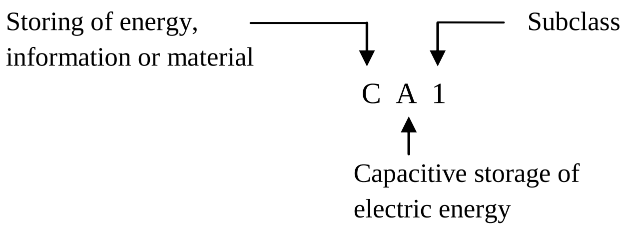
The aim of the classification standard is:

> "The aim of this part of IEC 81346 is to establish classification schemes for objects with associated letter codes which canbe applied throughout all technical areas, e.g. electrical, mechanical and civil engineering as well as all branches ofindustry, e.g. energy, chemical industry, building technology, shipbuilding and marine technology. The letter codes are intended for use with the rules for the construction of reference designations in accordance with IEC 81346-1." /15/

Part of the standard that has to be followed is chapter *5.1 Classes of objects according to intended purpose or task* and chapter *5.2 Subclasses of objects according to intended purpose or task*. The classification is based on a two-letter code, where the first letter (see Appendix 2) defines the main class and the second letter (see Appendix 3) the subclass. If additional subclasses are needed to provide a more detailed classification, one can define additional subclasses according to Rule 6*: Additional subclasses to those defined in Table 2, may be applied if:*

- *no subclass of Table 2 is applicable;*
- *the subclasses are defined in accordance with the basic grouping of subclasses in Table 2;*
- *the application of the subclasses is explained in the document where it is used or in supporting documentation*

An example of a capacitor is shown below.



The IEC 60617 standard is a database that contains international official standardized graphical symbols used in electrical drawings and diagrams. The database is the official source of IEC 60617. The database provides classified views (by shape, function and application) and a search function. The database contains over 1550 graphical symbols and 300 application guidelines. Each object in the database has an identifier (symbol identifier number), a name, a status level, a graphical representation and a set of optional attributes (e.g. remarks, replaces, replaced by, application class and so on). In 2004 the member countries of CENELEC decided that all member countries use IEC 60617 as the reference standard. This means that no national standardization organizations may create their own symbols into IEC 60617 without the permission of CENELEC. /19/ /24/

6.2 Updating parts database

In the first phase it was necessary to update the Eplan P8 parts database so that the database would be up to date and contain all the new parts. By using Eplan P8's export function it was possible to compile all parts that existed in the database to Excel. The Microsoft Excel software offers easy sorting and filtering possibilities that was needed. By then generating project reports through Vacon Documentation Wizard for NXC cabinet drives, from frames 9 to 14, including all the additional options, it was possible to obtain all parts that were used in the cabinets. The parts obtained from the Vacon Documentation Wizard were then added to the Excel sheet that was exported earlier from Eplan P8. However, the Eplan P8 parts database was created following the IEC 81346-2 standard for the electrical components, and Vacon Documentation Wizard output documentation was still using the former IEC 60417 standard, resulting in a significant amount of duplicate parts. In total the Excel sheet contained 11 417 parts, and after clearing duplicates 151 unique parts remained that had to be added to the Eplan P8 parts database. The parts were added to the Eplan P8 parts database following the IEC 81346-2 classification standard.

6.3 Layout

The layout pages show the cabinet from different views, cut-view from the side, front-view with door open and closed, and from the bottom and top. The layout pages include all the important dimensions and devices that are in the cabinet. Since the layout pages are not affected by schematic structure changes, it was possible to reuse them in this project. It was not possible to directly import the layout pages from EPLAN 21 format into Eplan P8. The reasons behind this were that the scaling and the layers would become incorrect.

Eplan P8 uses several different types of layers. Layers are an essential element originating from mechanical engineering (CAD). Information of the same type (e.g. dimensions) is placed on the same layer. For example, the form, font size or other formats of this layer can later be changed at a central place easily and without errors. The layer describes what kind of object it is. Texts should e.g. use the layer *EPLAN108, Graphic.Texts* and continuous lines should use the *EPLAN103, Graphic.Continuous lines* layer. When importing the layout pages directly from EPLAN 21 format into Eplan P8, the layers are not included and are assigned as *Free_graphics*. The layers had to be corrected into Eplan P8 standard. Instead of assigning each line and object into its correct layer, it was decided to assign all graphical objects to the *EPLAN100, Graphic.General* layer except the texts into the *EPLAN108, Graphic.Texts* layer. Assigning each object into the correct layer would have been a too much time-consuming task. The Vacon Documentation Wizard was re-programmed to change all layers from EPLAN 21 into our desired Eplan P8 layers. The re-programming was done in the first phase, before the generation of project documentation commenced, since the layer problem was a known issue. /18/

The Vacon Documentation Wizard uses two different scaling values depending on the cabinet frame size. This is because the cabinet has to fit the layout page and not go outside the plot frame. When importing the layout pages into Eplan P8 the scaling values that were used were 1:12 for frames 9 to 13 (low harmonic frames 10 to 12) and 1:17 for frame 14 (low harmonic frames 13 to 14).

After importing all layout pages into Eplan P8, the device designations had to be updated on the layout pages to meet the IEC 81346-2 standard.

6.4 Schematics

The next task was to develop the schematic pages. The schematics consist of single-line and multiline drawings. The schematics show what electrical components are inside the product and how they are wired. The task was to draw them from scratch in Eplan P8, and implement two new standards. The development began with the single-line drawings, since they will be used as models when drawing the multiline drawings.

6.4.1 Single-line

With single line drawings, electrical circuits are represented using one line, instead of drawing 3 separate lines for three phases. This is because the single-line drawings will mainly be used as an overview of the main circuit in the electrical design of the cabinet drawings, which is why some information can be left out. Some of the information that will not be shown in single-line drawings are e.g. cable type and size, cable cross-section and parts-data.

Eplan P8 has a symbol library with both single line and multiline IEC 60617 symbols. However, it lacks many important symbols that Vacon uses, therefore it was necessary to create some new symbols. The symbols that were created were saved in a single-line common project, so that other design engineers could use the symbols if needed (see Appendix 4).

The single-line schematics were designed so that each option would get its own page in the single-line project. For example, if we take the input contactor (+ICO) option, then the drawing only consists of input terminals, the contactor, the frequency converter and the motor. This was repeated for every option affecting the main circuit for the frames 9-14. The reason behind this decision was that every device has its specific position in the schematic, depending on the option chosen. There is no point in drawing two input devices that share the same positions on the same page, as only one input device is allowed at a time. Some circuits containing several symbols were simplified to only one, as it was not necessary to show the whole circuit in the single-line schematics. An example of this is the pre-charging circuit in low-harmonic drives. At first the whole pre-charging circuit was drawn but after discussions with the design team it was decided to change the circuit to only one symbol.

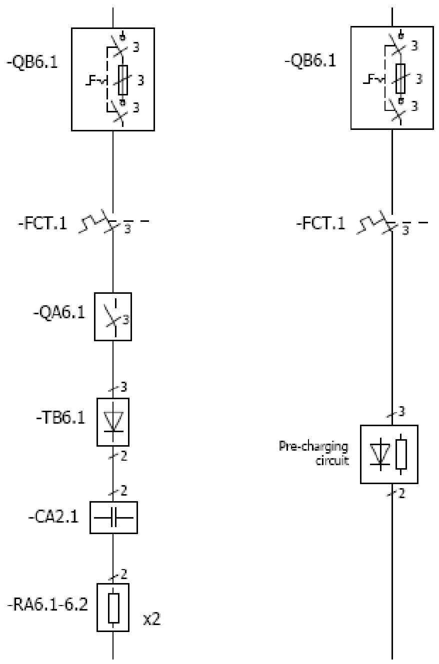


Figure 5. Low harmonic pre-charging circuit change represented in single-line format.

6.4.2 Multiline

Multiline schematics show all three phases, unlike single-line that shows all three phases as one line. When representing schematics in multiline, components are shown with all connections and the total number of connections of cable connections. It is crucial that the multiline schematics are correctly drawn and that they do not contain any major errors. The schematics can be used in the manufacturing process as part of the assembly line instructions or be used as work guidance.

The project reports that were generated in the first phase were used as models when the multiline development phase started. In the schematics that the Vacon Documentation Wizard generates, as much as possible is fit onto one page, depending on the frame size. It was decided that the schematic pages needed more space for the devices so that they would be easier to read. As a result of this decision the whole structure of the multiline drawings was changed. The task in the drawing phase was to develop the drawings and draw the main circuits.

The multiline schematic pages now consist of two to three pages, depending on the frame size. Frames 9-12 use two pages, the first for input devices and the second for the frequency converters and the output filter. Frames 13 and 14 use three pages, the first for input devices, the second for other optional devices and the rectifiers. The third page is for inverter units and the output filters. The main circuit was now organized; each device had its own place in the schematic. The old multiline schematics could sometimes be un-organized, meaning that the devices did not seem to have their own places, but put where there was free space.

The multiline schematic pages were drawn as *max projects*, where as many devices as possible were placed in the schematics. By doing this the structuring process became much easier since it was then possible to see how much space each symbol needed without the devices being too close to each other, as the aim was to make the drawings easier to read.

The majority of the symbols were taken from Eplan P8's symbol library. Some had to be created and placed in a multiline common project, so that other design engineers could use the symbols if needed (see Appendix 5). Throughout the development phase discussions were held with the other electrical engineers about the changes and about everybody's views, with the aim of getting the best possible result. The differences between single-line and multiline schematics are shown below in the figure of the pre-charging circuit in multiline representation.

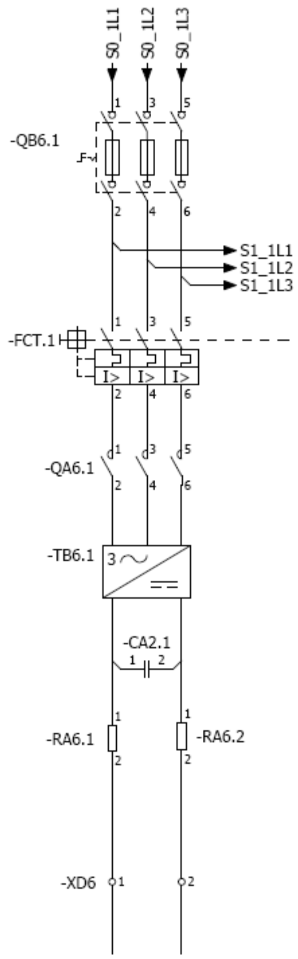


Figure 6. Pre-charging circuit in multiline representation.

6.4.3 Option boards

Vacon NX range embodies a wide selection of *expander* and *adapter boards* with which the available I/O of Vacon NX frequency converter can be increased and its versatility improved. The input and output configuration (I/O) of Vacon NX is designed with modularity in mind. The entire I/O comprises option boards, each having its own input and output configuration. The boards contain not only normal analogue and digital inputs and outputs, but also fieldbuses and additional application-specific hardware. The expander and adapter boards are placed in the *board slots* on the control board of the frequency converter. There are five board slots (labelled A to E) on the control board. The control board is located inside the control unit of the Vacon NX frequency converter. Usually when the frequency converter is delivered from the factory, the control unit includes at least the standard compilation of two basic boards, the OPT-A1 (I/O board) and OPT-A2 (relay board) which are installed in slots A and B. The three expander slots C, D and E are available for different option boards i.e. I/O expander boards, adapter boards and fieldbus boards. /29/

In the old schematics the option boards could be seen on the same page as the frequency converter, which sometimes resulted in the fact that the page was filled with devices on a very tight page. Therefore it was decided that each option board gets its own page in the schematics. The option boards will be located in the bottom of the schematic page, facing upwards so there is enough space where the wiring can be designed. This resulted in standardized option boards, as they are always located in the same position and are of the same size. The option boards are represented in multiline format. Some of the option boards had already been drawn, but they were incomplete as they did not have the correct identifiers, and they were outdated. The task was to draw the remaining option boards and go through each manual for every board to make sure that the information was correct and up to date, and also to implement the IEC 81346-2 classification standard. Below is a figure of the basic I/O, OPT-A1 option board.

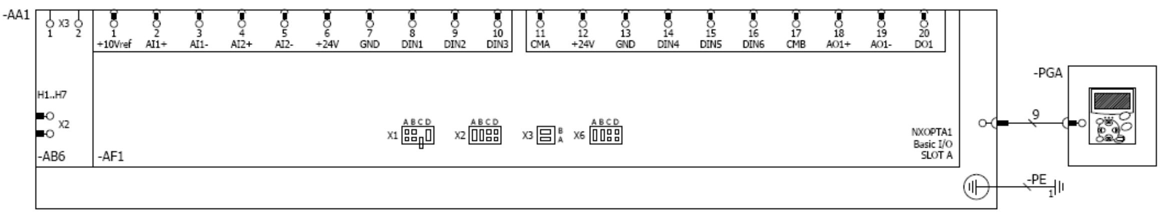


Figure 7. The basic I/O option board, OPT-A1 including the panel and the control unit.

7 Macro project

Eplan P8 has different types of macros. These can be window, page and symbol macros. When using or creating macros there is no difference whether this is a window macro on a multiline page or a symbol macro on a graphical page. Window macros are the smallest partial circuits in Eplan P8. Window macros can include single or multiple devices and objects within an area, or several items within a page. /16/

After the layout as well as the single-line and multiline drawings were created, the next step was to create a *macro project*. The circuit and devices were cut into pieces and made into macros. In this chapter the stages of making macros and the purpose behind them and the macro project will be described.

7.1 Window macro

In the macro project window macros will be used, since it is the smallest macro that can include several objects. The idea was to cut the whole cabinet and schematics into macros and then place them into a project, sorted by their purposes. Each device will get its own macro. When creating a macro of a device, the macro will include the layout, single-line and the multiline section cut into different variants, which is why the macro project could only be started after the drawings were done. Below is a figure that shows what the macro consists of for the +IFD option, which is a switch fuse and fuses.

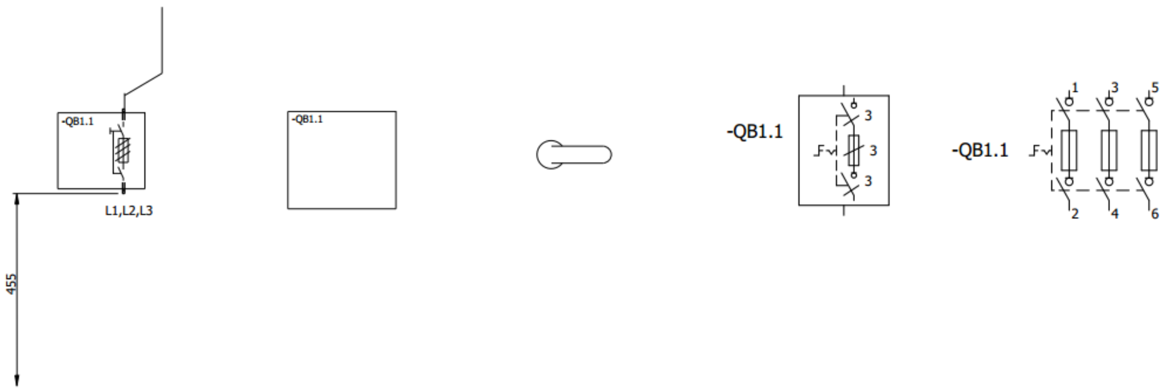


Figure 8. The switch fuse and fuses macro.

The three first parts to the left are part of the layout, the fourth is the switch fuse in single-line representation and the fifth in multiline.

Macros like this were done for every part of the cabinet layout and the schematic pages. This resulted in macros consisting of every device and layout that can be inserted, piece by piece, to form any kind of NXC cabinet drive system.

7.2 Placeholder objects

In addition to the basic macro and its properties, such as technical characteristics, part numbers, etc. of the various objects in the macro, it is possible to define the macro with additional functionalities, *value sets*. The value sets are activated via a particular symbol, the *placeholder object*. A value set is a collection of variables of selected objects stored in a macro. Value sets are managed in a type of table “behind the placeholder object” and, in addition to all the device properties, they contain additional information such as actual values or the variables for the values. Every property of a device can be provided with any desired variable name, as long as the names are surrounded by “less than” (<) and “greater than” (>) characters. /17/

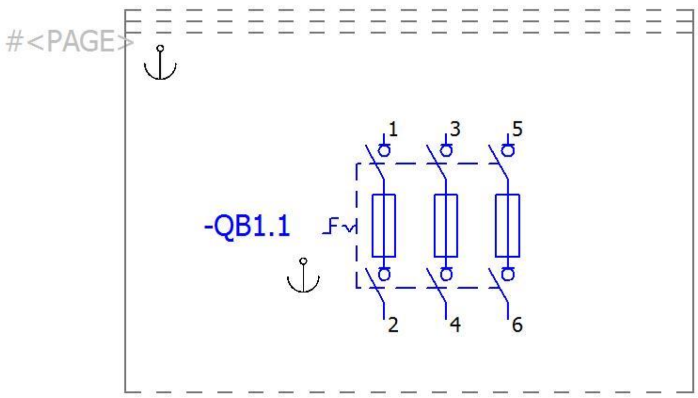


Figure 9. A window macro for the switch fuse and fuses with two placeholder objects.

In the figure above is a macro for the switch fuse and fuses in multiline representation. The dashed boxes are called *macro boxes*, where you assign the macro a name, assign the macro a variant (letters from A to P), macro representation type (e.g. single-line, multiline or panel layout), descriptions and so on. There are three macro boxes, since the macro was made for frames 9 and 10, where there are three different current ratings that affects the device size in the layout pages. All three representation types are linked together via the macro name, therefore three macro boxes are needed. The macro contains two placeholder objects, the anchors. As seen in the figure, the top anchor is shown with a “#<PAGE>”

name, where inside the table of the placeholder object the macro is assigned with a page number (the value set of the variable). The second anchor is used for defining which device part the symbol should contain, depending on the current rating.

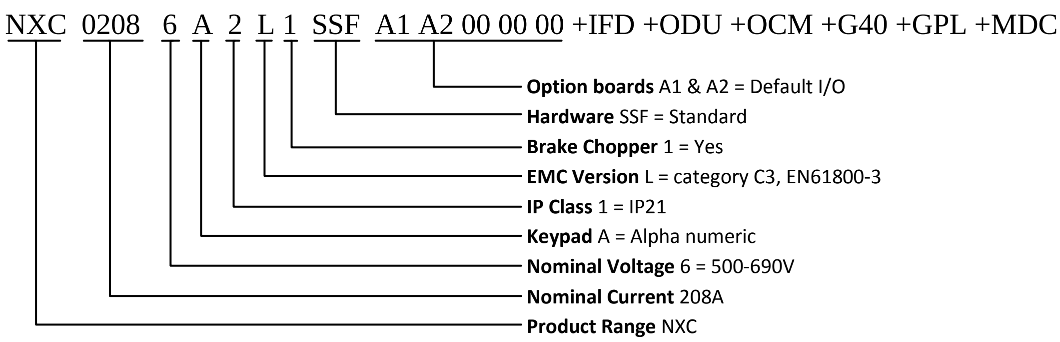
All macros and value sets can be handled and utilized efficiently using EEC One. The idea is to use EEC One as the main software that handles the macros in the Vacon Documentation Wizard 2.

8 Pilot project

A pilot project was created for testing the macros in a project environment. This was necessary to ensure that the macros worked in the project as they were intended to do. When creating the pilot project a new macro project was built, following the same idea that was behind the main macro project, but only including the macros that were needed. This was done to make it easier to follow up the macros and correct them if necessary.

8.1 Selecting project options

To cover macros of every category, it was decided to select one input device, one main circuit option, two output filters, one additional empty cabinet and 100 mm base for a basic NXC drive system. To be able to compare the pilot project with the old drawings, project documentation was generated through the Vacon Documentation Wizard with the same options. The decided product and options that cover all of our categories with type code and explanation can be seen below:



- +IFD, Switch fuse and fuses
- +ODU, du/dt filter
- +OCM, Common mode filters
- +G40, 400mm empty cabinet
- +GPL, 100mm base
- +MDC, Terminals in cabinet for DC / brake chopper

8.2 Implementation of macros

After having selected a suitable drive with options, a macro project was created specifically for the pilot project. The macros were transferred directly from the original macro project to ensure that the macros followed the same structure.

After the macros had been transferred to the macro project, they needed to be generated. This was done using Eplan P8’s built-in function, *Generate macros from macro project*.

The function generates window macros of all the macros inside the project and places them in a folder, which makes it possible to share them with others or move them to a different location. Now it was possible to insert the window macros, one by one into the pilot project, until the project was complete. When inserting a window macro into the project it is possible to choose which variant of the macro to insert, depending on the schematic type being designed.

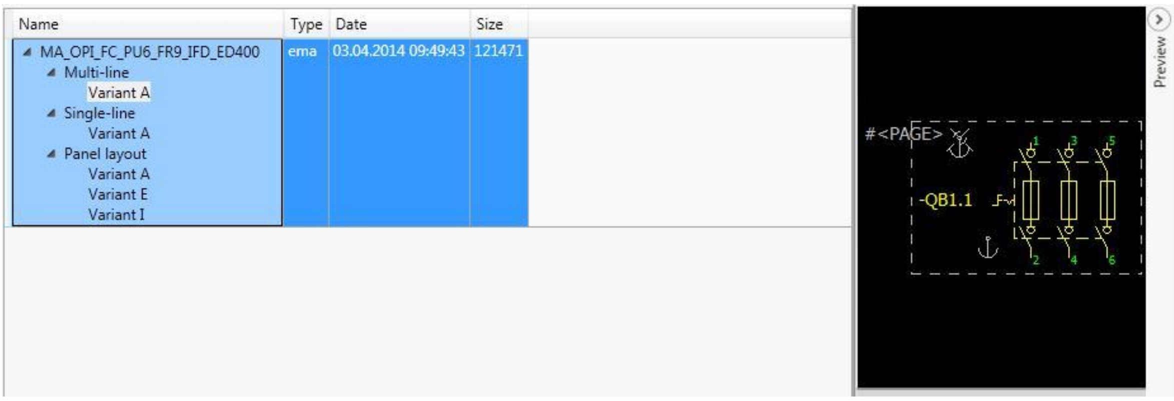


Figure 10. Screenshot of the variant selection window.

When inserting the wanted variant of the macro, the macro is placed automatically on the correct page since every macro contains a pre-defined *value set* for the #<PAGE> variable, which had been defined in the macro project. The macro is placed in the same position that it was in the macro project. This makes macro insertion simple, as all information is defined inside the macro.

8.3 Result

The pilot project proved to be useful, as several errors were detected and improvements were done to the macros and their structures, e.g. macro positioning, symbol and cable corrections etc. After the macros were fixed, project reports were generated of the pilot project (see Appendix 6). The idea is to use EEC One as the main software to handle the macros, instead of inserting them one by one manually. EEC One was decided not to be used in the pilot project, as the aim was only to test the macros’ functionalities in a pilot project and if needed make improvements.

9 Data Portal

EPLAN Data Portal is a web service that was launched in 2008 and is built into the EPLAN Platform. The service provides online access to device data from numerous component manufacturers. In November 2013 EPLAN Data Portal provided over 350,000 component data from 56 manufacturers. Every company can send data of their devices to EPLAN, which then reviews the data and transfers them into the online portal. By using the Data Portal component manufacturers get closer to their customers, since anyone who is registered in the Data Portal can view the data. The desired component can be inserted directly from the server into the project or the system environment. /3/

Examples of useful device data:

- General
  - Part number
  - ERP number
  - Designation
  - Manufacturer
  - Supplier
  - Order number
  - Description
- Macros
  - Electrical
  - Graphical
- Images
- Drawings
  - Mechanical, 2D/3D
  - Electrical, 2D/3D
- Price
  - Price unit
  - Quantity unit
  - Barcode number
  - Certifications
- Dimensions
  - Weight
  - Height, width, depth
  - Mounting surface
  - Mounting clearance

Since new parts and macros had been changed or added to the database, it was necessary to update the device information for the devices, so that the Data Portal would be up to date.

An Excel sheet had been made where the most important devices that had to be updated in the Data Portal were listed. The list contained 39 different option boards and 102 converters with the relevant product information. The first task was to gather the newest product information and compare this with the one in the list, to make sure that the information was still up to date. As most macros listed in the Excel sheet had already been made in the earlier stage of the project, the macros were saved in a specific folder and then imported to the new database. The ones that didn’t exist were then drawn using Eplan P8 in multiline format. There was no need to make the macros into single-line format, as the converters all use almost identical single-line symbols. Moreover, the option boards will not be shown in the single-line project documentation.

After the devices were updated, the next step was to send them to EPLAN for reviewing. However, since more parts will be added as the project progresses, it was decided to send them for review at a later date.

10 Results

The result of this work were fully developed electrical drawings that are in Eplan P8 format, and symbol PPMs in both single-line and multiline representation types ready to be used by any electrical design engineer at Vacon. The resulted drawings were updated so that they comply with the required standards. The parts database was updated with the latest parts and information. An Excel sheet was created that lists all the components in the NXC cabinet drives, with identifiers that are updated to the IEC 60617 classification standard. Both single-line and multiline drawings were developed and ready to be used in macro projects. The result was also a complete documentation of a project that was made using the updated parts database and the macro project from the new electrical drawings (see Appendix 6). The pilot project proved that the drawings were functional and ready to be used in future electrical designing and in the development of the Vacon Documentation Wizard 2.

The following phase in the evolution of the macro project would be to add the remaining macros from the frames 10-14. It was decided that another member of the team will develop the control circuit, as the time was limited and additional testing had to be done. The target was to start with frame 9 and test the macros’ functionalities and later implement the remaining macros. As the electrical drawings are now done and the new IEC standards are implemented, the remaining macros are ready to be implemented.

In the future all macros will be handled with EEC One and they will be automized, to increase the quality and to avoid common design errors through repeatability.

11 Discussion

The thesis work has been demanding to some degree, since the whole EPLAN platform was new to me. During the summer of 2013, EPLAN 21 and Eplan P8 training was given to help me get to know the softwares. To be able to develop electrical drawings for the cabinet drives it was necessary to understand how each of the components worked and what their purposes were. This resulted in a lot of research using manuals and discussing with engineers in the department. The structure of the electrical drawings were changed and improved multiple times, which was time demanding as the drawings then had to be re-drawn. I had the opportunity to attend an EPLAN EEC One training session, which helped me understand how the EPLAN macros could be utilized efficiently.

My thesis work has also contributed to giving me a better understanding of E-CAE tools and why automatization is so important. I am satisfied with the work and the results that I have achieved during this project. The results will be used in the Vacon Documentation Wizard 2, which will be used on a daily basis by a great number of people.

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Appendices

VACON NXC OPTIONS

Control terminal options (T group)	
+TIO*	Basic I/O wired to external single-tier terminals
+TID*	Basic I/O wired to external two-tier terminals + additional terminals
+TUP*	Terminals for 230 VAC control voltage
Input device options (I group)	
+ILS*	Load switch
+IFD	Switch fuse and fuses
+ICB*	Circuit breaker
+ICO	Input contactor
+IFU	Input fuses
Main circuit options (M group)	
+MDC	Terminals in cabinet for DC / brake chopper
Output filter options (O group)	
+OCM	Common mode filters
+OCH	Common mode filters with output terminals
+ODU	du/dt filter
+OSI	Sine wave filter
Protection devices (P group)	
+PTR	External thermistor relay
+PES	Emergency stop (cat 0)
+PED	Emergency stop (cat 1)
+PAP	Arc protection
+PIF	Insulation fault sensor
General options	
+G40	400 mm empty cabinet
+G60	600 mm empty cabinet
+G80	800 mm empty cabinet
+GPL	100 mm base
+GPH	200 mm base
+FAT	Factory acceptance tests
+MAR	Marine construction
+SWP	Seaworthy packing

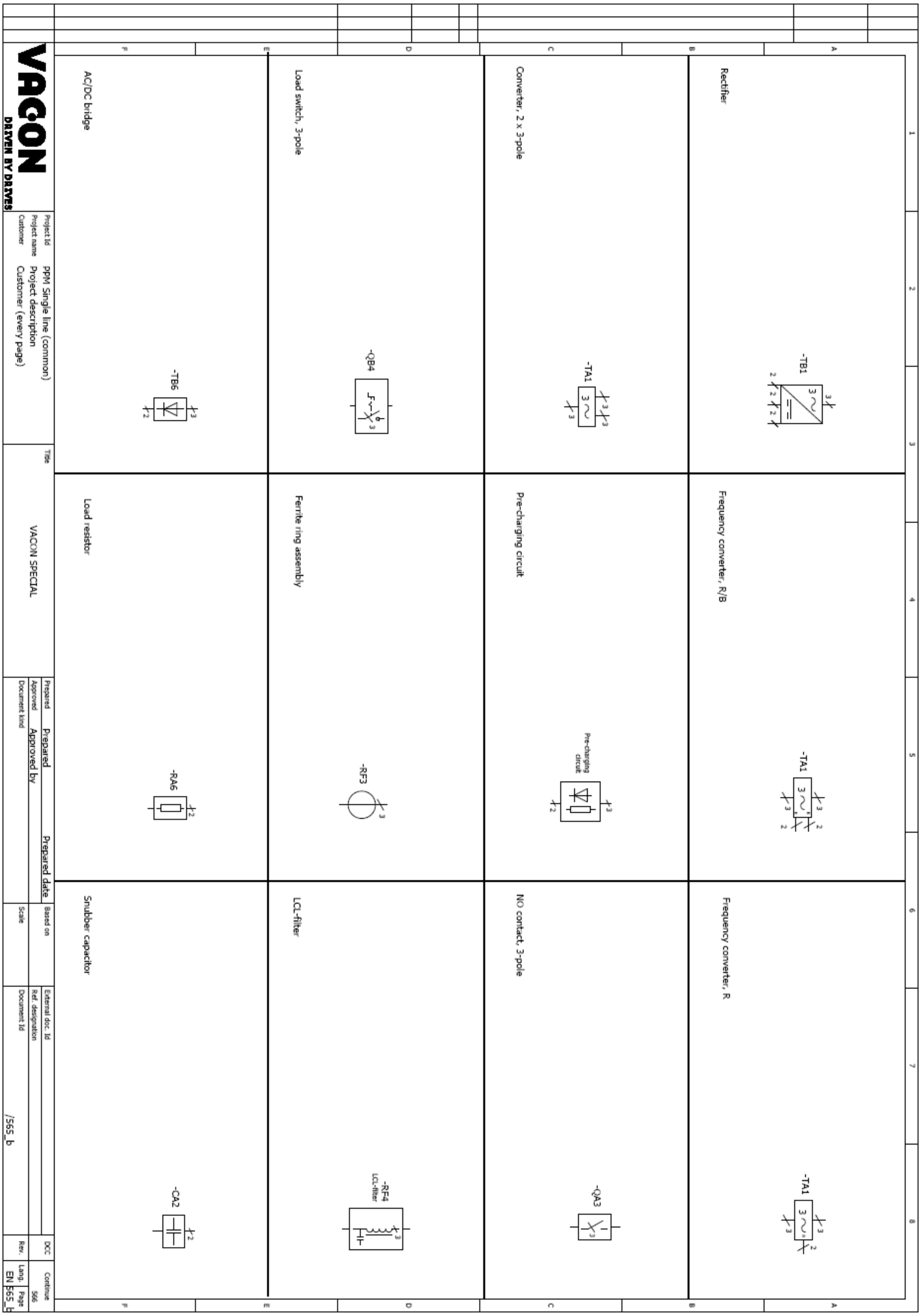
* Included as standard in low-harmonic drives

Cabling options (C group)	
+CIT	Input (mains) cabling from top
+COT	Output (motor) cabling from top
Auxiliary equipment (A group)	
+AMF	Motor fan control
+AMH	Motor heater feeder
+AMB	Mechanical brake control
+AMO*	Motor operator for +ICB
+ACH	Cabinet heater
+ACL	Cabinet light
+ACR	Control relay
+AAI	Analogue signal isolator
+AAA	Auxiliary contact (control voltage devices)
+AAC	Auxiliary contact (input device)
+AT1	Auxiliary voltage transformer 200 VA
+AT2*	Auxiliary voltage transformer 750 VA
+AT3	Auxiliary voltage transformer 2500 VA
+AT4	Auxiliary voltage transformer 4000 VA
+ADC*	Power supply 24 VDC 2.5 A
+ACS	230 VAC customer socket
Door-mounted options (D group)	
+DLV	Pilot light (Control voltage on)
+DLD	Pilot light (DO1)
+DLF	Pilot light (FLT)
+DLR	Pilot light (RUN)
+DCO*	Main contactor operation switch
+DRO*	Local / Remote operation switch
+DEP	Emergency stop push-button
+DRP	Reset push-button
+DAM	Analogue meter (AO1)
+DAR	Potentiometer for reference
+DCM	Analogue meter & current transformer
+DVM	Analogue voltage meter with selection switch

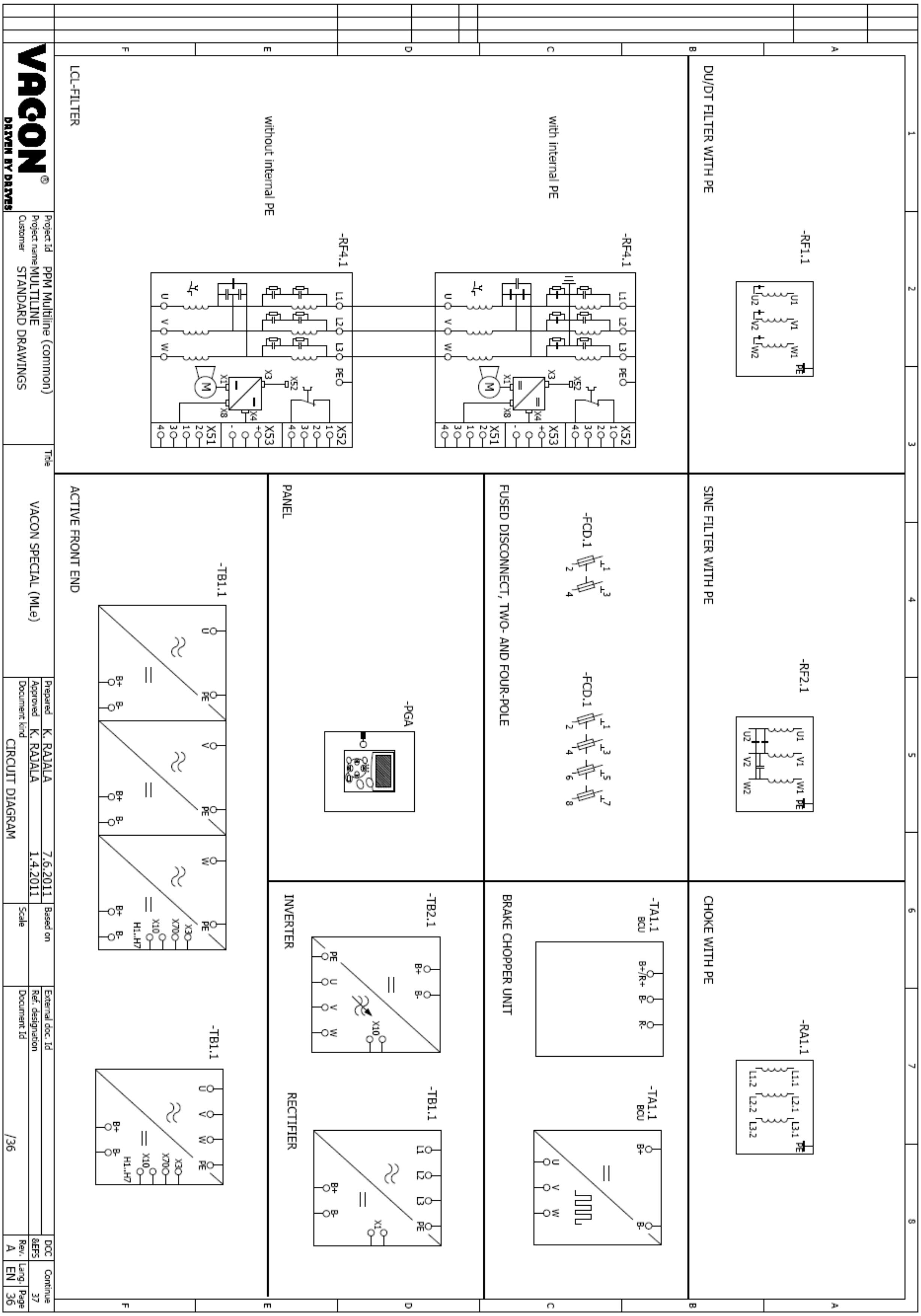
Code	Intended purpose or task of object
A	Two or more purposes or tasks NOTE This class is only for objects for which no main intended purpose or task can be identified.
B	Converting an input variable (physical property, condition or event) into a signal for further processing
C	Storing of energy, information or material
D	*Reserved for futurestandardization*
E	*Providing radiant or thermal energy*
F	Direct protection (selfacting) of a flow of energy, signals, personnel or equipment from dangerous or unwanted conditions.Including systems and equipment for protective purposes
G	Initiating a flow of energy or material. Generating signals used as information carriers or reference source
H	Producing a new kind of material or product
I	*Not to be applied*
J	*Reserved for futurestandardization*
K	Processing (receiving, treating and providing) signals or information (excluding objects for protective purposes, see Class F)
L	*Reserved for futurestandardization*
M	Providing mechanical energy (rotational or linear mechanical motion) for driving purposes
N	*Reserved for futurestandardization*
O	*Not to be applied*
P	Presenting information
Q	Controlled switching or varying a flow of energy, of signals (for signals in control circuits, see Classes K and S) or of material
R	Restricting or stabilizing motion or a flow of energy, information or material
S	Converting a manual operation into a signal for further processing
T	Conversion of energy maintaining the kind of energy Conversion of an established signal maintaining the content of information Conversion of the form or shape of a material
U	Keeping objects in a defined position
V	Processing (treating) of material or products (including preparatory and post-treatment)
W	Guiding or transporting energy, signals, material or products from one place to another
X	Connectingobjects
Y	Reserved for futurestandardization
Z	Reserved for futurestandardization

Main class C		
Storing of energy, information or material		
Code	Definition of subclass based on kind of storage	Examples of components
CA	Capacitive storage of electric energy	Capacitor
CB	Inductive storage of electric energy	Coil,superconductor
CC	Chemical storage of electric energy	Buffer battery. NOTE Batteries seen as energy sources are assigned to main Class G.
CD	*Not used*	
CE	*Not used*	
CF	Storage of information	CD-ROM, EPROM, event recorder, hard disk, magnetic tape recorder, memory, RAM, video recorder, voltage recorder
CG	*Not used*	
CH	*Not used*	
CJ	*Not used*	
CK	*Not used*	
CL	Open storage of material at fixed location (collection, housing)	Bunker, cistern, paper reel stand, pit, pool
CM	Closed storage of material at fixed location (collection, housing)	Accumulator, barrel, boiler, buffer, container, depository, flash tank, gas holder, safe, silo, tank
CN	Moveable storage of material (collection, housing)	Container, drum, gas cylinder, shipping container
CP	Storageofthermalenergy	Hot water accumulator, hybrid heat storage, ice tank, steam storage, thermal energy storage, underground thermal energy storage
CQ	Storageofmechanicalenergy	Flywheel, rubber band
CR	*Not used*	
CS	*Not used*	
CT	*Not used*	
CU	*Not used*	
CV	*Not used*	
CW	*Not used*	
CX	*Not used*	
CY	*Not used*	
CZ	Combined tasks	

Appendix 4


VACON
DRIVEN BY DRIVES
Project Id
PPM Single line (common)
Project name
Project description
Customer
Customer (every page)
Title
VACON SPECIAL
Prepared
Prepared
Approved
Approved by
Document kind
Prepared date
Based on
Scale
External doc. Id
Ref. designation
Document Id
/565_b
DCC
Rev.
Continue
566
Lang.
Page
EN
565_b
Rectifier
-TB1
Frequency converter, R/B
-TA1
Frequency converter, R
-TA1
Converter, 2 x 3-pole
-TA1
Pre-charging circuit
Pre-charging circuit
NO contact, 3-pole
-QA3
Load switch, 3-pole
-QB4
Ferrite ring assembly
-RF3
LCL-filter
-RF4
LCL-filter
AC/DC bridge
-TB6
Load resistor
-RA6
Snubber capacitor
-CA2

Appendix 5


DU/DT FILTER WITH PE
-RF1.1
SINE FILTER WITH PE
-RF2.1
CHOKE WITH PE
-RA1.1
with internal PE
-RF4.1
FUSED DISCONNECT, TWO- AND FOUR-POLE
-FCD.1
BRAKE CHOPPER UNIT
-TA1.1
BCU
LCL-FILTER
without internal PE
PANEL
-PGA
INVERTER
-TB2.1
RECTIFIER
ACTIVE FRONT END
-TB1.1
VACON
DRIVEN BY DRIVES
Project Id
PPM Multiline (common)
Project name
MULTILINE
Customer
STANDARD DRAWINGS
Title
VACON SPECIAL (MLe)
Prepared
K. RAJALA
7.6.2011
Approved
K. RAJALA
1.4.2011
Document kind
CIRCUIT DIAGRAM
Based on
Scale
External doc. Id
Ref. designation
Document Id
/36
DOC
&EFS
Rev.
A
Lang.
EN
Continue
37
Page
36

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Fax:

Project number:	Vacon_Pilot_Project
Description of Project:	Pilot Project

Customer:	Delivery address:
CUSTOMER NAME	STANDARD DRAWINGS
CUSTOMER STREET	DELIVERY STREET
CUSTOMER CITY CUSTOMER COUNTRY	DELIVERY CITY DELIVERY COUNTRY

Drive system:	NXC02086A2L1SSFA1A2+IFD+ODU+OCM+G40+GPL+MDC
Project manager:	Kyösti Rajala

Prepared:	Mattias Lebeitsuk	Total number of pages:	18
Modification date:	7.4.2014		

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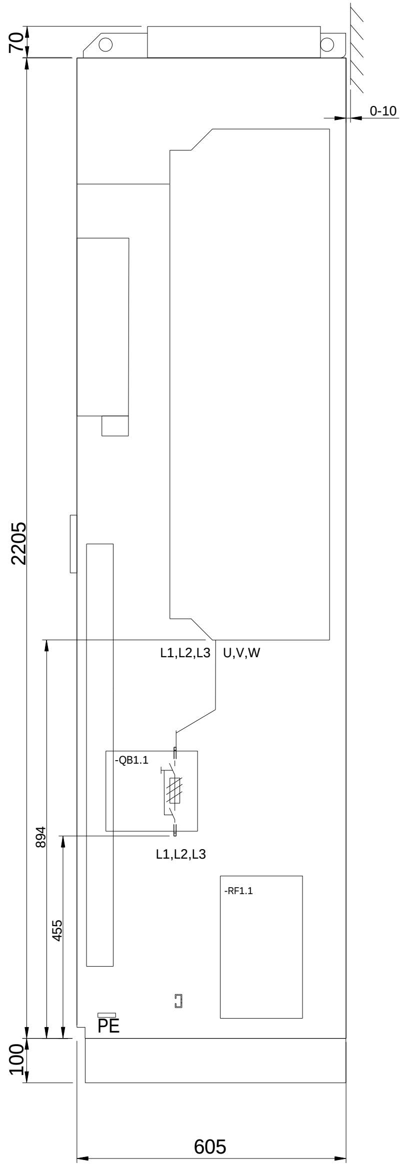
VACON_F06_002

View A-A



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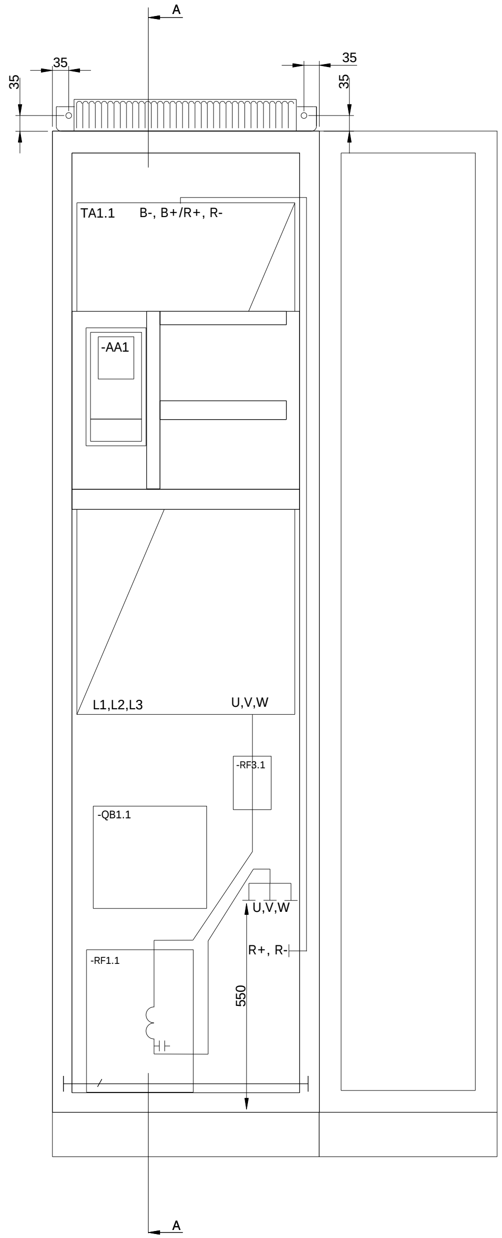

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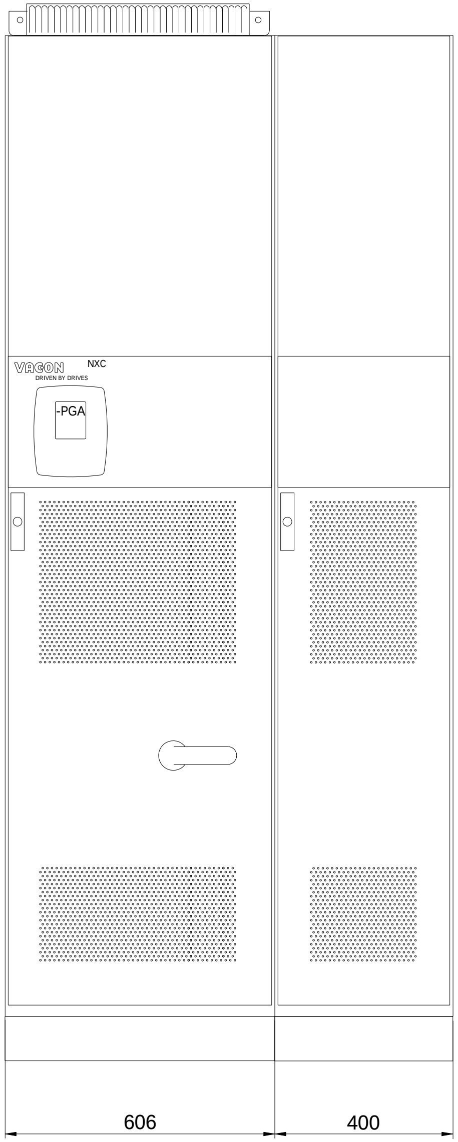
Rated conditional short-circuit current
Icc / Icf 40kA



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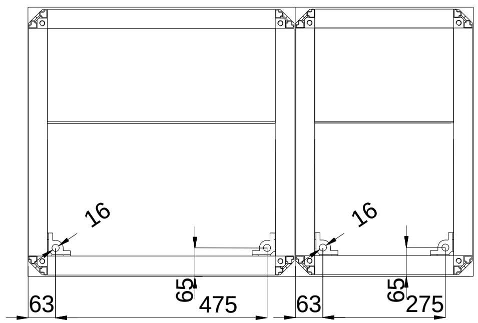
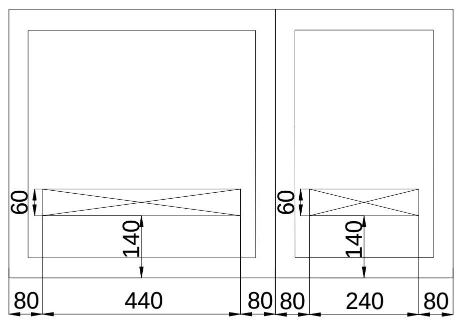
Floor fixing



Bottom cabling IP21 through hole



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Project name: Pilot Project		Approved: Kyösti Rajala 7.4.2014		Ref. designation: =VCA +PLO
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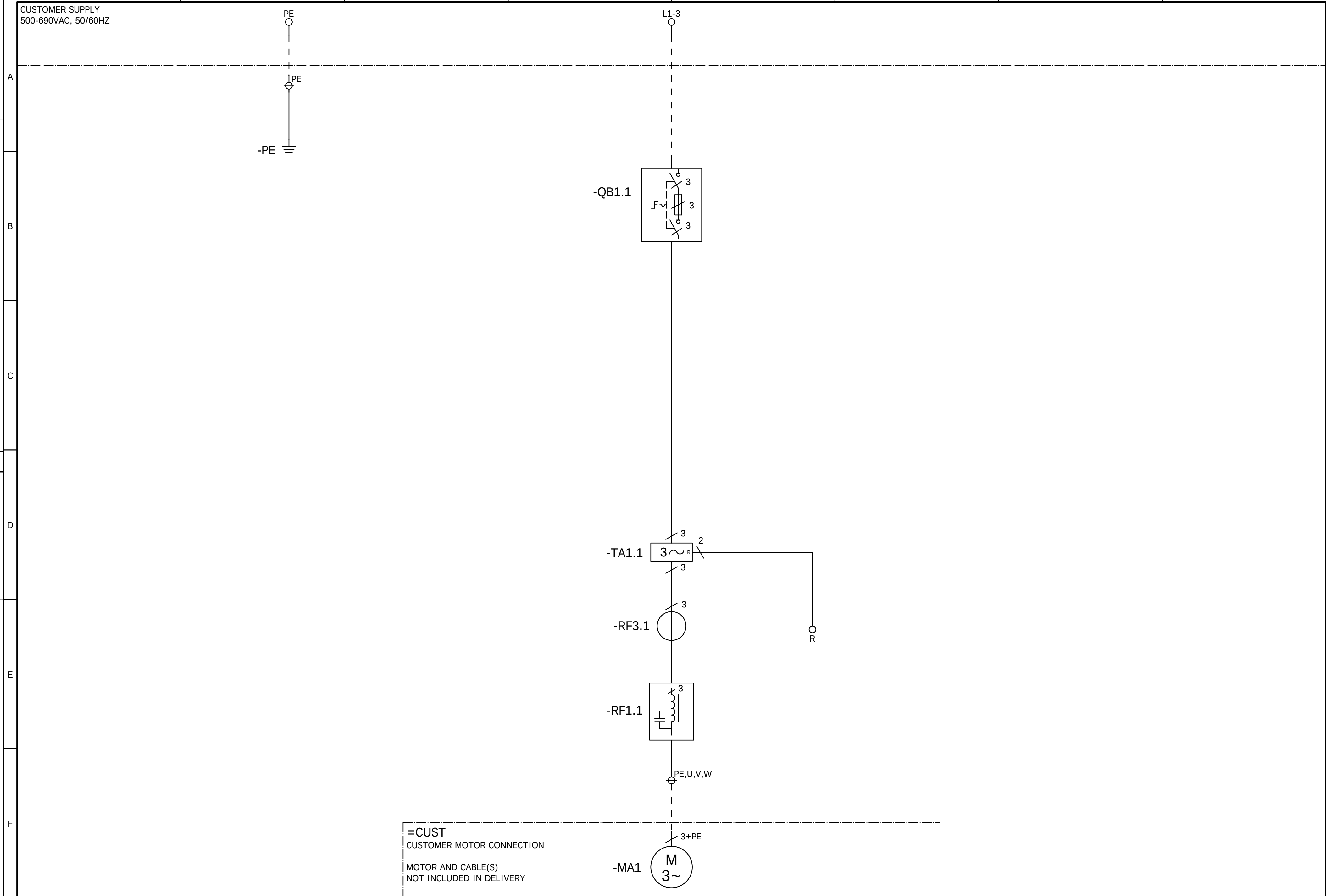

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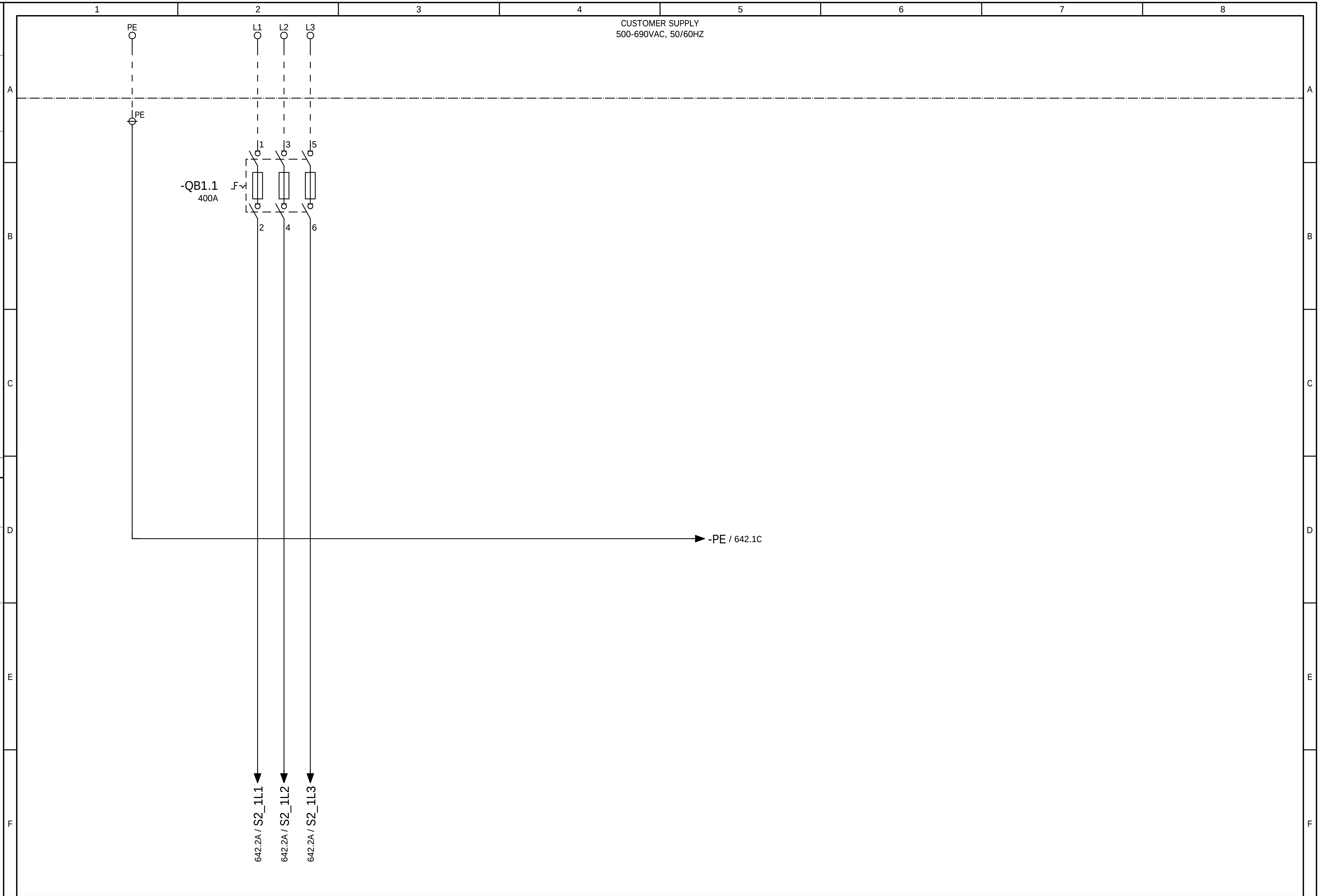

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	Project name	Pilot Project			Approved	Kyösti Rajala	7.4.2014	
	Customer	STANDARD DRAWINGS			Document kind			Scale

External doc. Id		DCC	Continue	
Ref. designation	=VCA +SML		642	
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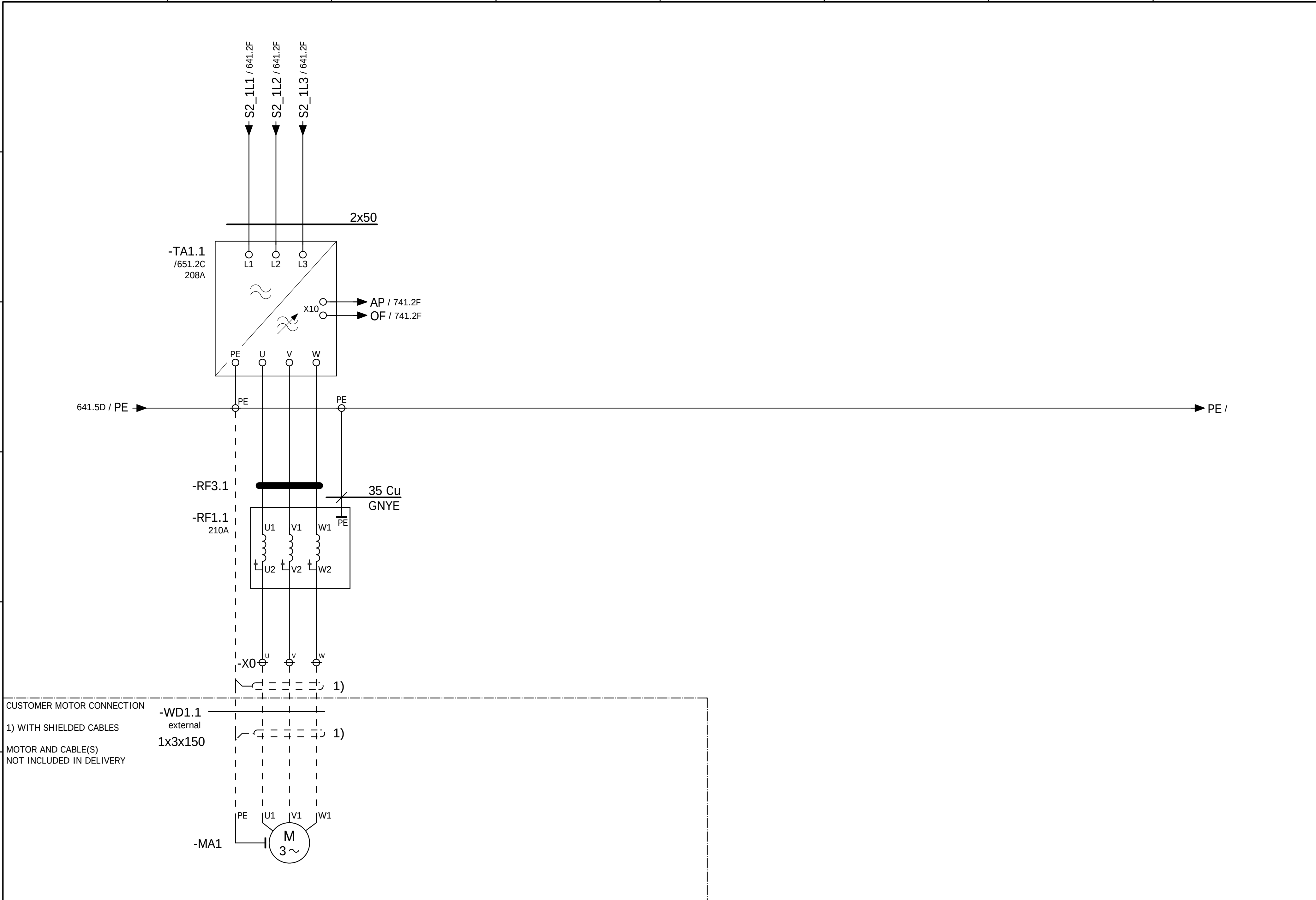

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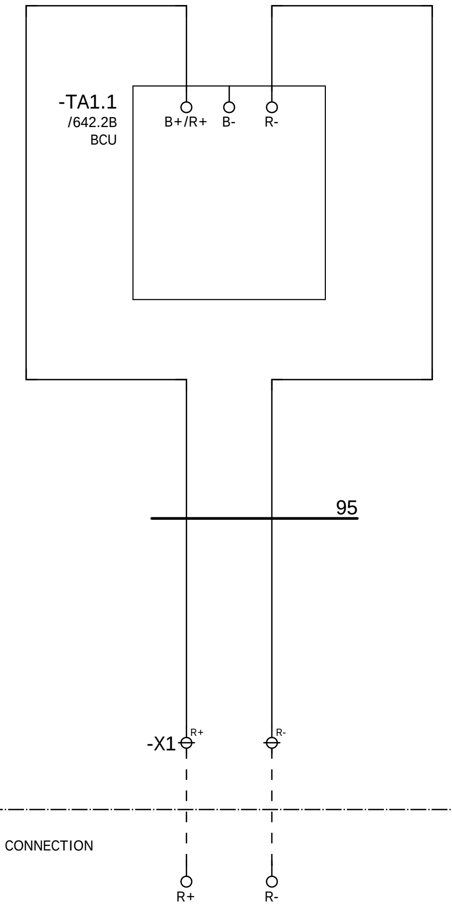
INTEGRATED BRAKE CHOPPER



CUST
CUSTOMER BRAKE RESISTORS CONNECTION

NOT INCLUDED IN DELIVERY

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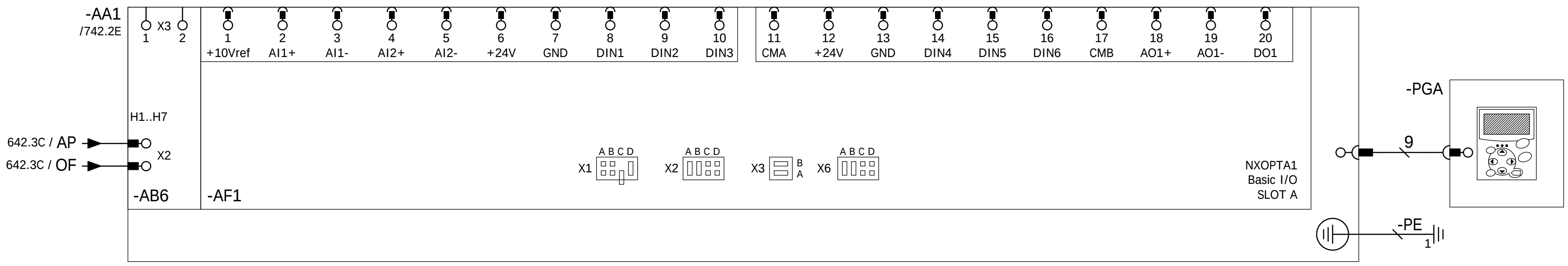
	Project name: Pilot Project	Approved: Kyösti Rajala 7.4.2014	Ref. designation: =VCA +SML
	Customer: STANDARD DRAWINGS	Document kind	Document Id: =VCA+SML/651
	Title: VACON CABINET Multiline	Based on / Scale	DCC; Continue: 741; Rev.; Lang.: EN; Page: 651



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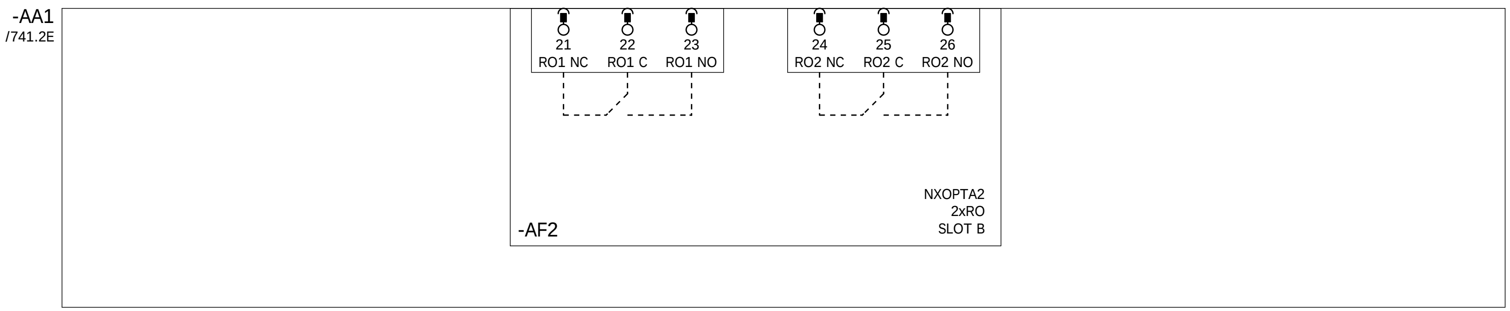

VACON
DRIVEN BY DRIVES

Project Id Vacon_Pilot_Project
Project name Pilot Project
Customer STANDARD DRAWINGS

Title VACON CABINET
Multiline

Prepared Mattias Lebeitsuk 7.4.2014
Approved Kyösti Rajala 7.4.2014
Document kind

Based on
Scale

External doc. Id
Ref. designation =VCA +SML
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Assembly wire connection list (Conductor / Wire)

Vacon_F27_003_Conductor_Wire

Connection	Target 1		Target 2		Color	Cross-section
	+SML-PE:1	+SML/741.8F	+SML-PE:PE	+SML/741.7F	GNYE	1,5 mm²

Internal power wire / busbar / Harness connection list (Internal)

Vacon_F27_003_Internal

Connection	Target 1		Target 2		Color	Cross-section
AP	+SML-AB6:3	+SML/741.2F	+SML-TA1.1	+SML/642.2C		mm
OF	+SML-AB6:4	+SML/741.2F	+SML-TA1.1	+SML/642.2C		mm
PE	+SML-PE	+SML/642.3C	+SML-RF1.1:PE	+SML/642.3D	GNYE	35 Cu mm²
PE	+SML-PE	+SML/642.2C	+SML-TA1.1:PE	+SML/642.2C	GNYE	35 Cu mm²
	+SML-QB1.1:2	+SML/641.2B	+SML-TA1.1:L1	+SML/642.2B	BK	2x50 mm²
	+SML-QB1.1:4	+SML/641.2B	+SML-TA1.1:L2	+SML/642.2B	BK	2x50 mm²
	+SML-QB1.1:6	+SML/641.2B	+SML-TA1.1:L3	+SML/642.2B	BK	2x50 mm²
	+SML-RF1.1:U1	+SML/642.2D	+SML-TA1.1:U	+SML/642.2C	BK	95 mm²
	+SML-RF1.1:U2	+SML/642.2D	+SML-X0:U	+SML/642.2E	BK	70 mm²
	+SML-RF1.1:V1	+SML/642.2D	+SML-TA1.1:V	+SML/642.2C	BK	95 mm²
	+SML-RF1.1:V2	+SML/642.2D	+SML-X0:V	+SML/642.2E	BK	70 mm²
	+SML-RF1.1:W1	+SML/642.2D	+SML-TA1.1:W	+SML/642.2C	BK	95 mm²
	+SML-RF1.1:W2	+SML/642.2D	+SML-X0:W	+SML/642.2E	BK	70 mm²
	+SML-TA1.1:B+/R+	+SML/651.2C	+SML-X1:R+	+SML/651.2F	BK	95 mm²
	+SML-TA1.1:R-	+SML/651.2C	+SML-X1:R-	+SML/651.2F	BK	95 mm²

External /undefined connection list (Connection, general)

Vacon_F27_003_Undefined

Connection	Target 1		Target 2		Color	Cross-section
L1	L1	+SML/641.2A	+SML-QB1.1:1	+SML/641.2B		mm²
R-	R-	+SML/651.2F	+SML-X1:R-	+SML/651.2F		mm²
L2	L2	+SML/641.2A	+SML-QB1.1:3	+SML/641.2B		mm²
L3	L3	+SML/641.2A	+SML-QB1.1:5	+SML/641.2B		mm²
R+	R+	+SML/651.2F	+SML-X1:R+	+SML/651.2F		mm²
PE	PE	+SML/641.1A	+SML-PE	+SML/641.1A		mm²

Parts list

Vacon_F01_003_ID_b

Device tag	Type designation	Quantity	Designation	Order number	Technical characteristics	Manufacturer	Part ID	Location	Page
-AA1	NXP	1	CONTROL UNIT			VACON		=VCA+SML	+SML/741.2E
-AB6	PC228 D	1	OPTICAL INTERFACE CARD			VACON		=VCA+SML	+SML/741.2E
-AF1	NX OPT A1	1	NX, I/O BOARD, SLOT A			VACON		=VCA+SML	+SML/741.2E
-AF2	NX OPT A2	1	NX, I/O BOARD, SLOT B			VACON		=VCA+SML	+SML/742.4E
-PGA	254A	1	CONTROL PANEL	LCD DISPLAY		VACON		=VCA+SML	+SML/741.8E
-QB1.1	OS400D03P	1	SWITCH FUSE	1SCA022719R0250	400A	ABB		=VCA+SML	+SML/641.2B
-QB1.1	6,9 URD 1 PV 0400	3	FUSE 400 A	6,9 URD 1 PV 0400	400A	FERRAZ-SHAWMUT		=VCA+SML	+SML/641.2B
-RF1.1	DUT-0210-6-0-P	1	DU/DT FILTER		210A	PLATTHAUS		=VCA+SML	+SML/642.2D
-RF3.1	6x3F85-62-20	1	FERRITE RING ASSEMBLY	FER_FGT		VACON		=VCA+SML	+SML/642.2D
-TA1.1	NXP 0208 6	1	NXP, standard drive, 200kW / 275HP, IP21/IP54		208A	VACON		=VCA+SML	+SML/642.2B
-X0	EN 70-185	2	POWER TERMINAL	EN 70-185		OUNEVA		=VCA+SML	+SML/642.2E
-X1	EN 70-185	3	POWER TERMINAL	EN 70-185		OUNEVA		=VCA+SML	+SML/651.2F

Cable overview

Vacon_F10_003

Cable designation	from	to	cable type	Condctrs	ø	Length	function text
+SML-WD1.1	+SML-MA1	+SML-PE		5			external
		+SML-X0					

Cable diagram

Cable name =VCA+SML-WD1.1			Cable type					
Remark			No. of conductors 5			Cross-section		Cable length
	Page / column	Target designation from	Connection point	Conductor	Target designation to	Connection point	Page / column	Function text
	/642.2F	-MA1	PE	BK	-PE		/642.2C	
	/642.2F	-MA1	U1	BK	-X0	U	/642.2E	
	/642.2F	-MA1	V1	BK	-X0	V	/642.2E	
	/642.2F	-MA1	W1	BK	-X0	W	/642.2E	