VAASAN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES

Roni Hyvärinen

STANDARDIZATION AND OPTIMIZATION OF THE SCADA SYSTEM ENGINEERING FOR SUBSTATION

Tekniikka
2022

VAASAN AMMATTIKORKEAKOULU
Sähkötekniikka

TIIVISTELMÄ

Tekijä	Roni Hyvärinen
Opinnäytetyön nimi	Sähköasemien SCADA järjestelmien suunnittelun standardisointi ja optimointi
Vuosi	2022
Kieli	englanti
Sivumäärä	35+1
Ohjaajat	Jari Koski, Arunothai Channgam, Tobias Selin

Tämän opinnäytetyön tavoitteena oli optimoida ZEE600 -järjestelmällä toteutettavaa sähköasemien SCADA -järjestelmien suunnittelutyötä. Työhön sisältyi eri osa-alueiden standardisointia uuteen ZEE600 2.0 -versioon. Opinnäytetyön toimeksiantajana toimi ABB Oy Distribution Solutions -yksikkö.

Opinnäytetyön teoriaosuudessa käsitellään yleisesti SCADA -järjestelmiä, mitä ne ovat ja miksi niitä käytetään. Myös ZEE600 -järjestelmää tarkastellaan alustavasti teoriaosuudessa. Käytännön osuudessa kerrotaan järjestelmän ominaisuuksista, joiden avulla työ toteutettiin ja esitellään valmiit standardisoidut mallit. Opinnäytetyön aikana vanhojen mallien puutteita korjattiin ja tämän jälkeen nämä tallennettiin kirjastoihin, joissa ne ovat helposti saatavilla.

Työn tavoitteet onnistuttiin saavuttamaan hyvin. Opinnäytetyön tuloksista ja siitä saadusta kokemuksesta on hyötyä tulevissa projekteissa.

Avainsanat SCADA , ZEE600, sähköasema, ohjelma

VAASAN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES
Electrical engineering

ABSTRACT

Author	Roni Hyvärinen
Title	Standardization and optimization of the SCADA system engineering
Year	2022
Language	English
Pages	35+1
Supervisors	Jari Koski, Arunothai Channgam, Tobias Selin

The aim of this thesis was to optimize the design work of the SCADA system for substations, which has been implemented by using the ZEE600 system. The thesis included the standardization of different subareas for the new ZEE600 2.0 version. The thesis was commissioned by ABB Oy Distribution Solutions unit.

Theory part of the thesis generally deals with SCADA systems, what they are and why they are in use. Theory part also examines preliminary ZEE600 system. Practical part describes about features of system, which were used during implementation of work and introduces standardized templates. During this thesis, deficiencies of original templates were improved and after these new templates were saved to the libraries where they are easily available.

Aim of thesis was successfully reached. The results of the thesis and the received experience are useful in future projects.

Keywords SCADA, ZEE600, substation, software

CONTENTS

LIST OF FIGURES

ABBREVIATIONS

ALC	Automatic Line Coloring
CMS	Central Monitoring System
COM600	Substation management unit
FC	Functional Constraint
IED	Intelligent Electronic Device
PLC	Programmable Logic Controller
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition
SLD	Single Line Diagram
SSC600	Substation control and protection device

1 INTRODUCTION

1.1 Aims of the Thesis

ABB has used ZEE600 system for a couple of years in SCADA system design and they already have templates for its general features. The problem was that templates of new 2.0 version were not sufficient and because of this, the same changes had to be done again in every project. This manual work slowed down the engineering work and increased the risk for the delays in the project schedule. During this thesis, deficiencies of these templates were improved and after these new templates were saved to the libraries where they are easily available.

The aim of this thesis was to study ABB's ZEE600 system and standardize the subareas which have been used in the design of control and monitoring systems for substations. The subareas were selected according to the needs of company. The purpose was to create an example project the features of which can be used in future and this way expedite engineering work.

The theory part of the thesis explains generally what SCADA systems are and describes about the ZEE600 system in more detail. Chapter 2 discusses the applications of the SCADA system and what benefits are achieved by using them, this chapter also addresses ZEE600 solutions at the station level in detail and SCADA systems.

The implementation part examines each standardized subarea of the ZEE600 system, how they have been implemented and what features of system have been used. The implementation part is divided into six chapters, which are general templates, SLD, variables terminology, bay popup controllers, system diagnostic and reaction matrix. The last part of thesis deals with the problems occurring during the thesis and discusses if the end result was as good as possible.

1.2 ABB OY

ABB is the world's leading technology company whose business activities are divided in four areas that are Electrification, Robotics and Discrete Automation, Motion and Process Automation. The company employs 105 000 people in over 100 different countries.

In Finland ABB is one of the largest industrial employers and it employs 5 000 peoples. ABB has business activities in 20 cities and factories are located in Vaasa, Helsinki, Porvoo and Hamina.

1.2.1 ABB Distribution Solutions

ABB Distribution Solutions unit operates worldwide from Finland and develops, manufactures, sells and markets protection relays and automation, control and monitoring equipment for the electricity distribution. Currently the unit has sales to more than 90 countries and it employs about 350 people. The factory is located in Vaasa, but unit has an office also in Tampere and service facilities in six different locations. [1]

[1] ABB. Accessed 6.5.2022. https://new.abb.com/fi

2 PRESENTATION OF TECHNOLOGIES

2.1 SCADA

SCADA is a control room system that enables displaying of data in an easy to understand visual format, for example from PLC logics or production and measurement instruments. It is possible to apply the control room system to the use of any industrial system and data can be defined very accurately. The SCADA system usually consist of CMS and one or more RTU or PLC remote stations. An example of a SCADA system is shown in Figure 1.

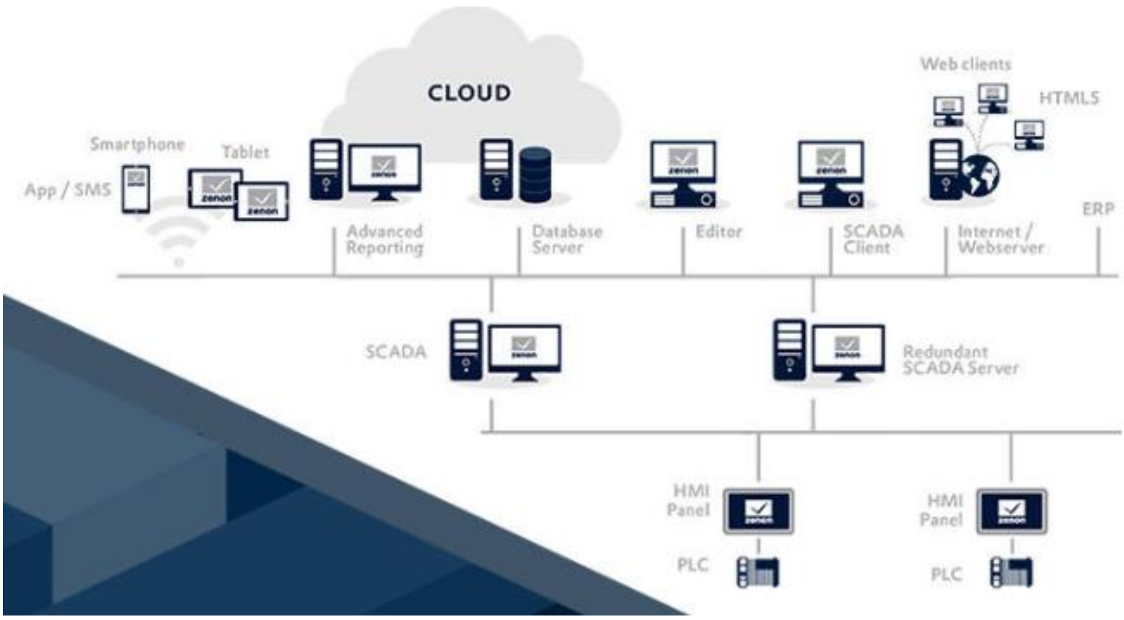


Figure 1. Example of the SCADA system structure

The system allows controlling of multiple items from the same location and the operation of the system can be viewed in real time as well as the event history. The software works on the network and because of this, it is possible to monitor and control the operation of the systems remotely, which speeds up the localization of the fault and the necessary actions can be started immediately in case of failure. Usually SCADA systems are isolated to their own subnets and they do not have direct connection to the normal internet. Remote access can be used via a PC interface, web browser or mobile device. [2][3]

2.2 ZEE600

ZEE600 is a control and monitoring system developed by ABB, which can include multiple servers and user interfaces. ZEE600 library functions are built on Zenon's basic SCADA license to optimize and standardize engineering and commissioning work. Zenon includes two main components, runtime and editor software. The runtime supports graphic display possibilities for HMI or SCADA projects. The software makes possible to control and monitor the operation of the system in real time. The runtime is visually and functionally specified in the editor software. [4][5]

ZEE600 includes drivers for more than 300 drivers for products from different manufacturers, which allows connection of devices to the system. Due to drivers,

---

[2] Sermatech. Sermatech website. Accessed 6.5.2022. https://www.sermatech.fi/valvomot-osana-automaatiojarjestelmaa/

[3] Ahoniemi, T. 2017. Energiayhtiön SCADA verkon kehittäminen. Opinnäytetyö. Kaakkois-Suomen Ammattikorkeakoulu, Tietotekniikka. Accessed 23.5.2022. https://www.theseus.fi/bitstream/handle/10024/127565/ahoniemi_teemu.pdf?sequence=1&isAllowed=y

[4] Copadata. Zenon editor user manual. Accessed 8.5.2022. https://download.copadata.com/fileadmin/user_upload/Downloads/Dokumentation/810SP0/ENGLISH/Manual/Editor.pdf

[5] Copadata. Zenon runtime user manual. Accessed 8.5.2022. https://download.copadata.com/fileadmin/user_upload/Downloads/Dokumentation/760SP0/ENGLISH/Manual/Runtime.pdf

need for various converters and auxiliary devices is minimal. Because of aforementioned features, the system is also cost-effective.

2.2.1 Structure of ZEE600 system for Substations

In the substation solution, switchgears and logic devices are connected to the switch. Communication protocols can be used here, for example IEC61850 or Modbus. The switch is connected to a server that is connected to an existing SCADA system, as seen in Figure 2. The ZEE600 also includes logic features such as default, this feature allows the building of different types of interlocking systems at the station level.

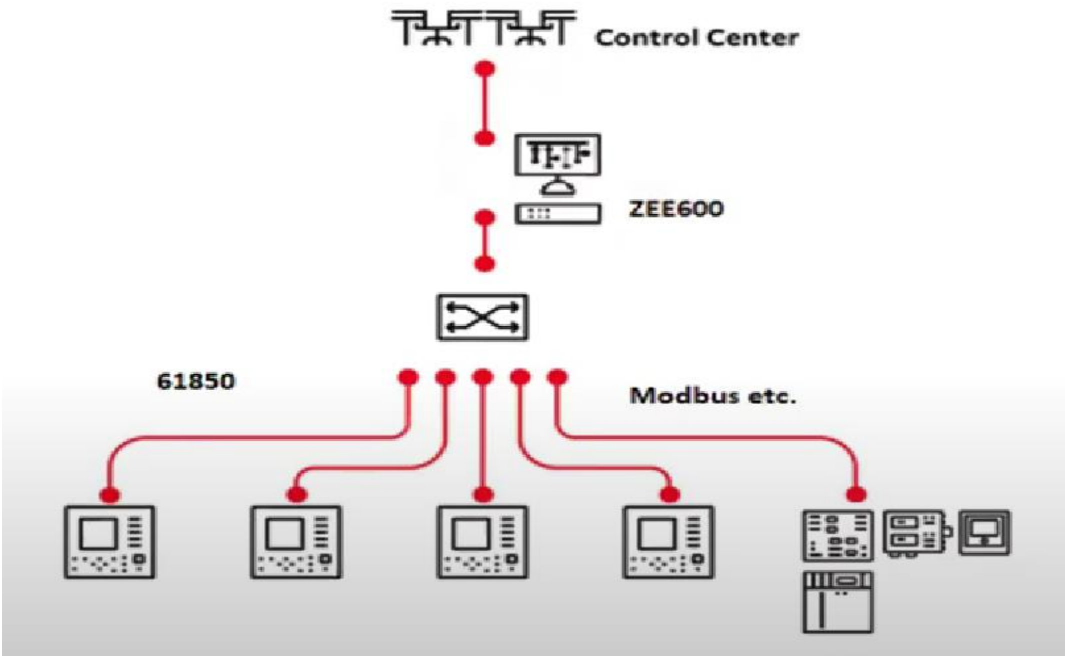


Figure 2. Example of ZEE600 systems structure at substation

2.2.2 Structure of ZEE600 SCADA System

The ZEE600 SCADA control room solution includes several substations which use the ZEE600 system and all of them are connected to the SCADA system. Other substation management solutions as COM600 or SSC600 can also be connected to the system. In this case, a single control room or a distributed control room system can manage all the station entities and consequently the entire grid.

It is possible to perform mirroring for the system, as shown in Figure 3, that makes it redundant. Redundancy means that one of servers can be shut down, for example, due to a fault and the other server automatically keeps the system running. In addition, user interfaces can always be built entirely according to the user`s needs.[6]

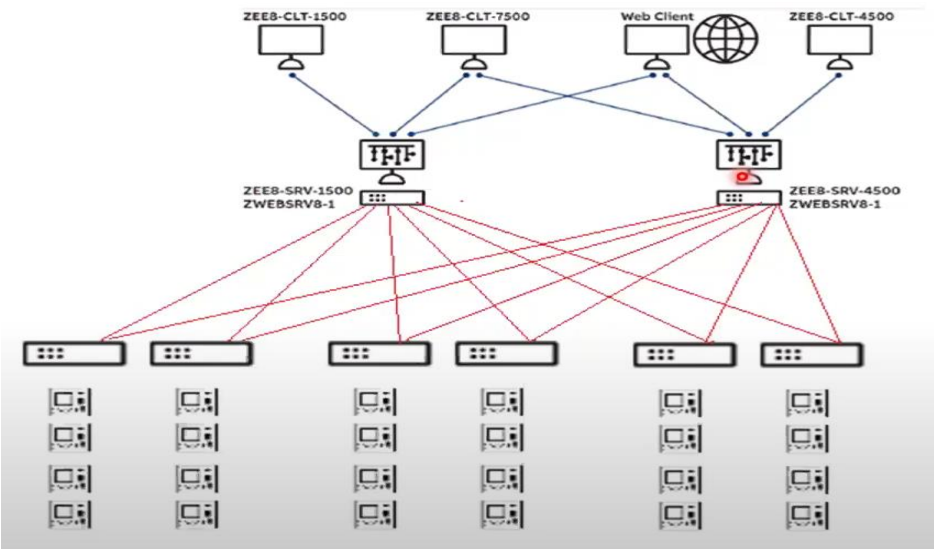


Figure 3. ZEE600 SCADA system with mirroring of servers and user interfaces

[6] ABB. ABB Suomi webinaari: Moderni SCADA -järjestelmä sähkönjakelun valvontaan ja hallintaan. Accessed 8.5.2022 https://www.youtube.com/watch?v=fDnkEzq7AZY

3 GENERAL TEMPLATES

This chapter deals with creating a new project, general views of standardized lists and trend view, as well as the features of the ZEE600 system which have been used in creating these. ZEE600 includes default templates, which were modified in such a way that they suit for substation control and monitoring systems. The last part of this chapter examines the language switch function.

3.1 Creating of a New Project

The first step was to create a new project via ABB ZEE600 – Template Wizard, the work was named as Standardization and English was selected as a language of runtime. Then the page numbers of subnavigations were defined for navigation windows, as seen in Figure 4 and after this the project was built.

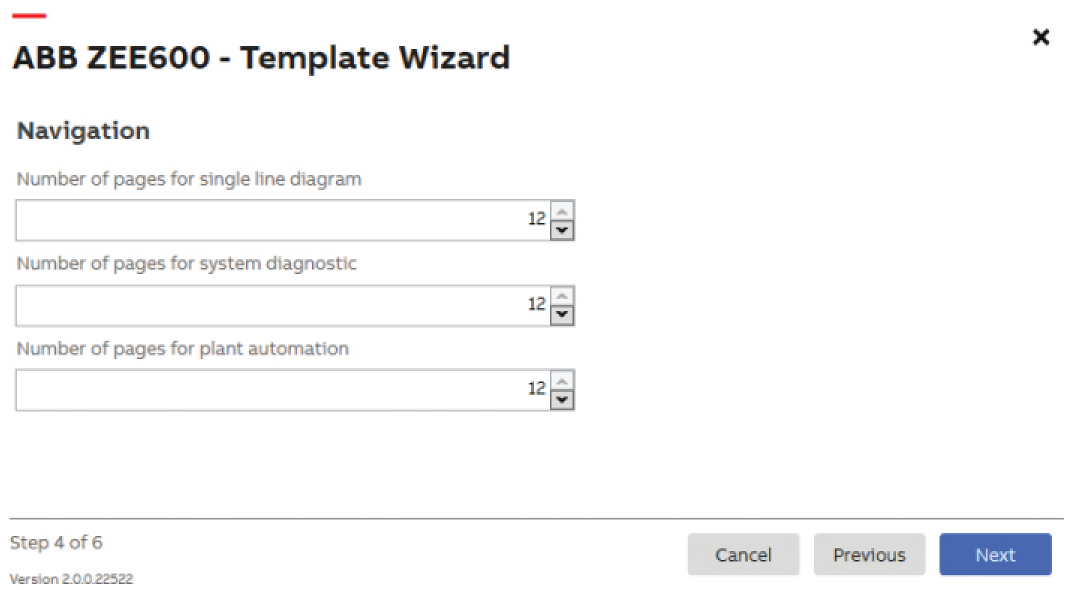


Figure 4. Default navigations and number of subnavigations

3.2 Event List

The first step in creating of event list was to create an event list button to the top bar. The button was named an event list and the icon was selected for it from the ZEE600 symbol library. Figure 5 shows the menu for button settings. In the end, the function assigned a button, which in this case was the opening of page navigation 3.

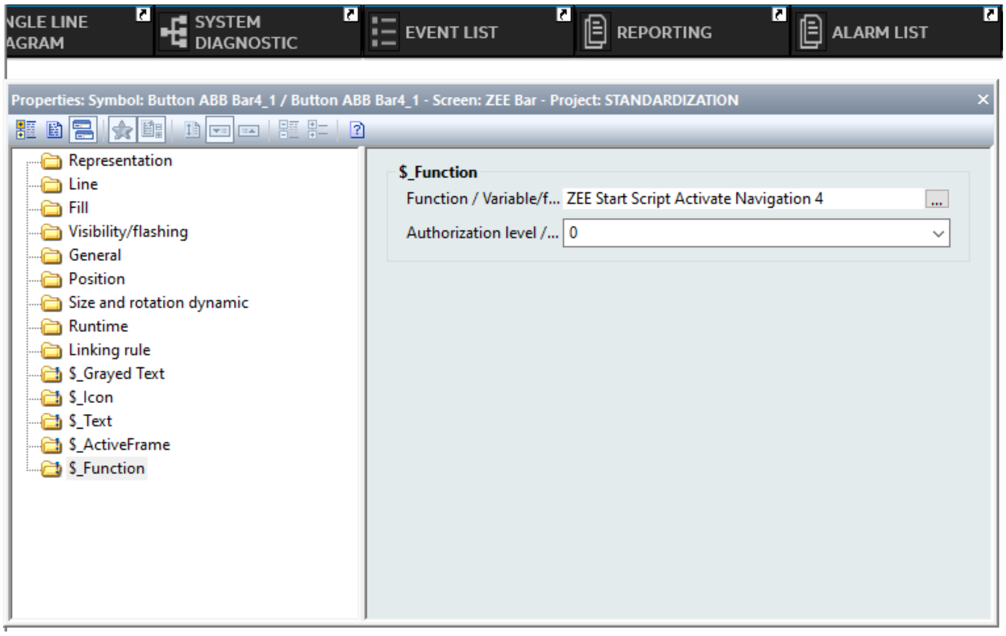


Figure 5. Specification of event list button

When the button was defined, the ZEE600 default event list was brought to the navigation 3 window. The default template was modified to correspond the applications. The columns of the event list were defined again and the buttons were clearly named, as seen in Figure 6.

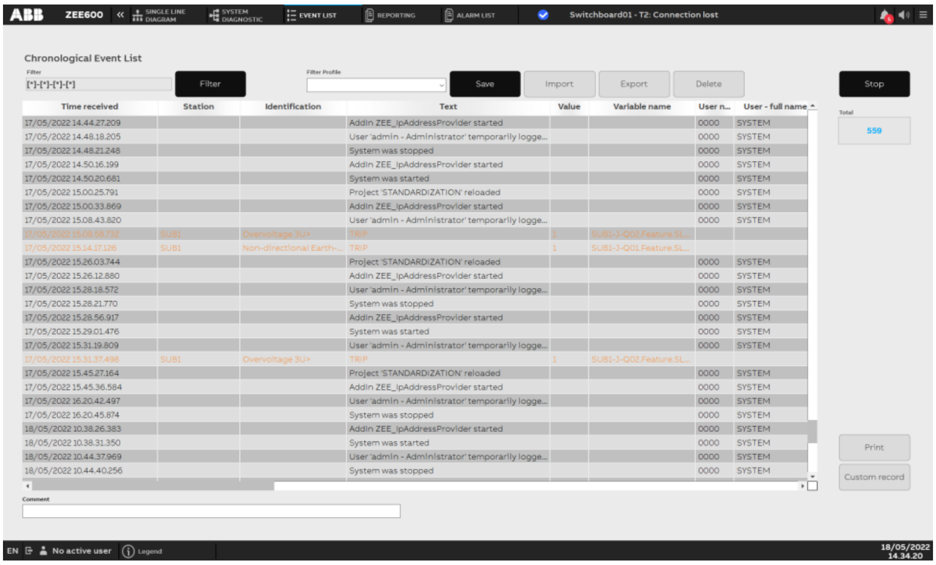


Figure 6. Event list

The event list automatically keeps track of all systems actions. It is also possible to filter the data and change the number of events to be saved from the filter menu, which is a default feature of the ZEE600 system. The event list also includes buttons for stopping the updating and printing of events, by using the custom record button it is possible to add own comments to the event list.

3.3 Alarm List

The creation of alarm list button was began in the same way as the creation of the event list button. The button was named an alarm list and the icon was selected from the ZEE600 symbol library. In the end function was defined a button, which in this case was opening of page navigation 4. After this the ZEE600 default alarm list was brought to the navigation 4 window. After this the default template of the alarm list was modified to correspond the applications, the columns of alarm list were defined again and the buttons were clearly named. The alarm list is shown in the figure 7. Alarm list uses the same filtering system as the event list and the buttons have the same features as the event list buttons. The alarm list contains detailed information of all pending errors and historical errors. The alarm states are symbolized by icons which has different coloring, as seen in Figure 8.

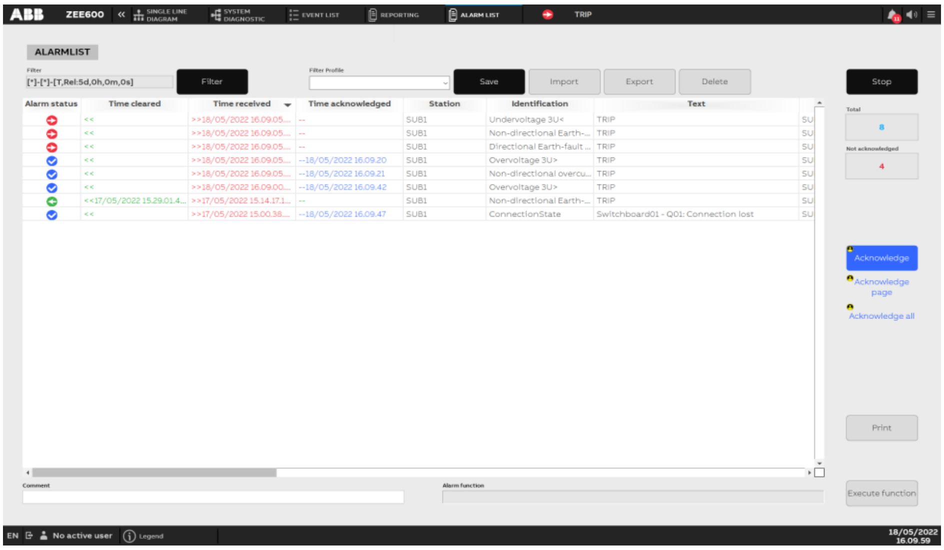


Figure 7. Main alarm list

Icon	Description
	Alarm received
	Alarm cleared
	Alarm reactivated
	Alarm acknowledged

Figure 8. Alarm status icons

The top bar also includes a smaller alarm list where the same alarms are visible regardless, which window is open at the moment. It is also possible to acknowledge alarms in this list as well as in the main list. The acknowledgement of alarms requires a system username and password. This list is ZEE Bar Alarm list, shown in Figure 9 and it is a default feature of ZEE600, this list opens by clicking the bell symbol which is located on the right side of top bar.

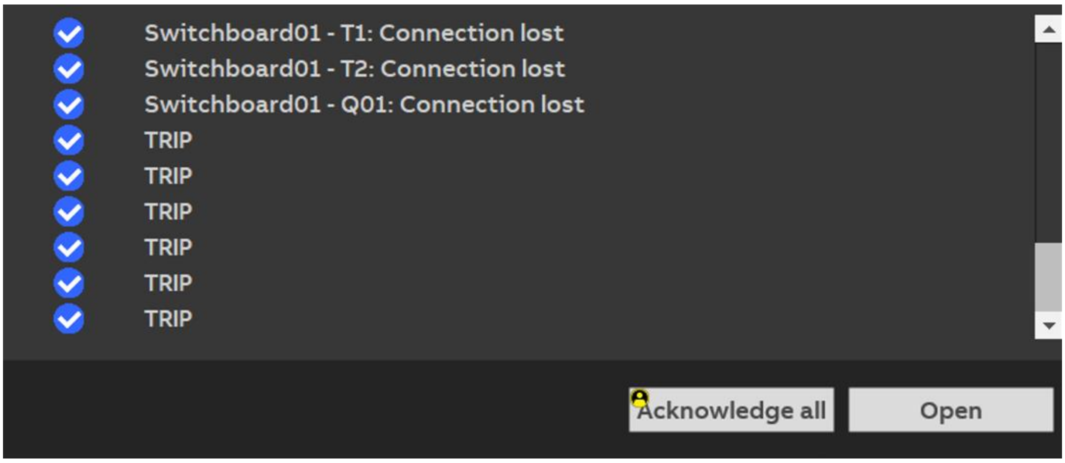


Figure 9. ZEE Bar Alarm List

3.4 Trend View

In this thesis was no need for plant automation navigation, shown in Figure 4. Because of this, the name of this button was changed to reporting and its function is to open navigation 4. Then a default trend view was added to this navigation and it includes window for the trend curves of measurements. This main view contains all desired measurements from substation and variables can be added or deleted via the diagram button. The main trend window is introduced in figure 10. It is also possible to define which trend curves and axes are active in the menu that is located in the lower right corner of trend window, as seen in Figure 11. This window also contains buttons with different default features, as adding of cursors, zooming and changing curve settings.

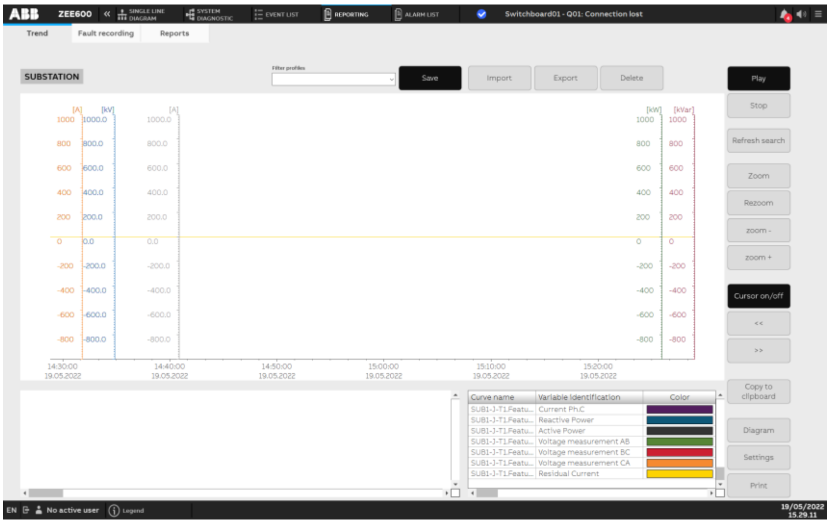


Figure 10. Trend main window

Area dis...	Y axis	Active	Variable identification
☐	☐	☑	Current Ph.B
☐	☐	☑	Current Ph.C
☐	☐	☑	Reactive Power
☐	☐	☑	Active Power
☐	☐	☑	Voltage measurement AB
☐	☐	☑	Voltage measurement BC
☐	☐	☑	Voltage measurement CA

Figure 11. Selection of active trend curves

The next part was to create a trend view for every device of the bay. The first step was to create functions for measurements, via the zenon project manager shown in Figure 12. The functions were named according to the location of measurements. Variables were created for primary and secondary phase currents, primary and secondary voltages, apparent power, active power and reactive power. In the end the variables were added to the trend functions. These same variables can also be added to the main trend window. The button which opens this trend view is located in the default popup window of device, which is shown in picture 13. The popup window opens by clicking the device symbol of the bay in single line diagram.

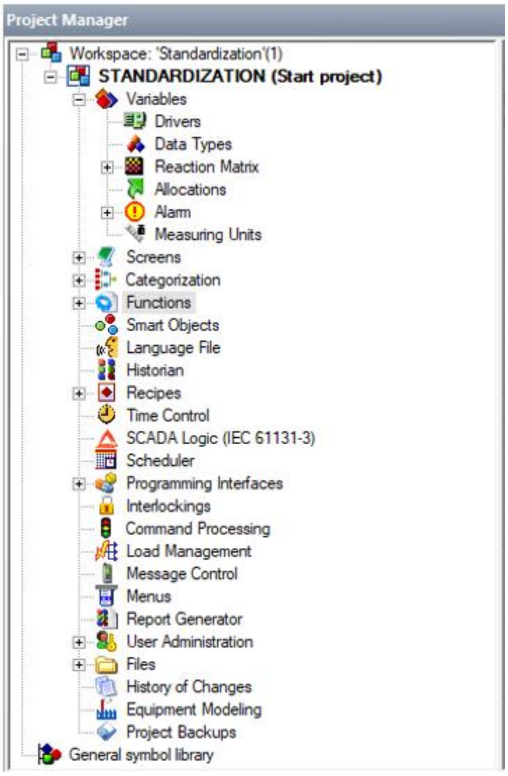


Figure 12. Zenon project manager

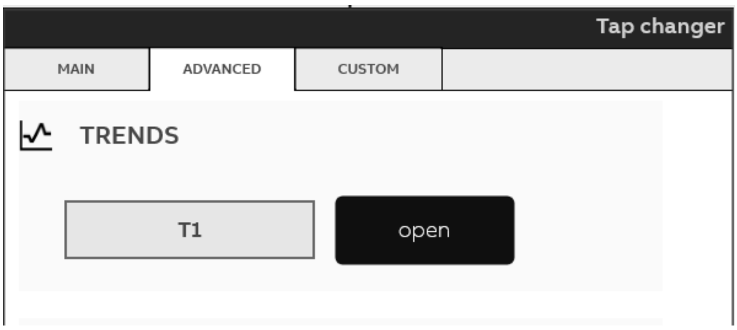


Figure 13. Opening trend view from device popup window

3.5 Language Switch Function

Next, the language switch function was added to the work, which makes it possible to select either English of Finnish language. The English function was the default option in the software, but the function for Finnish language had to be created separately. First, the Finnish language switch button was added to the language menu of the runtime. The task bar already included a default button, the function of which was to open the language menu with buttons for language options. The next step was to create a language switch function for Finnish. After this function was added for button, as shown in Figure 14.

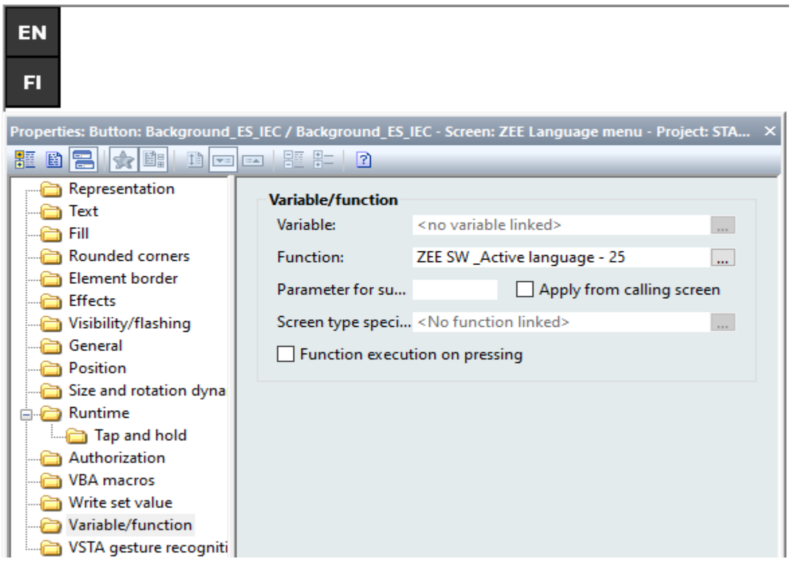


Figure 14. Adding of function for Finnish language button

Then, a Finnish text file was attached as a parameter of the function, as seen in Figure 15. The text file was already created before, but it did not include all necessary words. During the project, these missing words were added to the language file. Figure 16 shows the Finnish language in use.

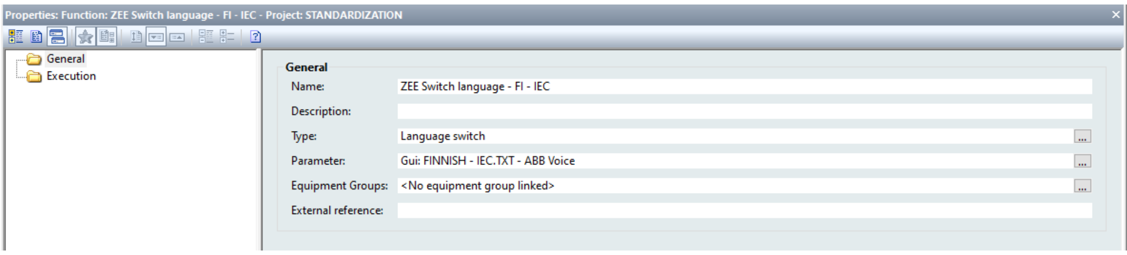


Figure 15. Finnish text file attached as a parameter

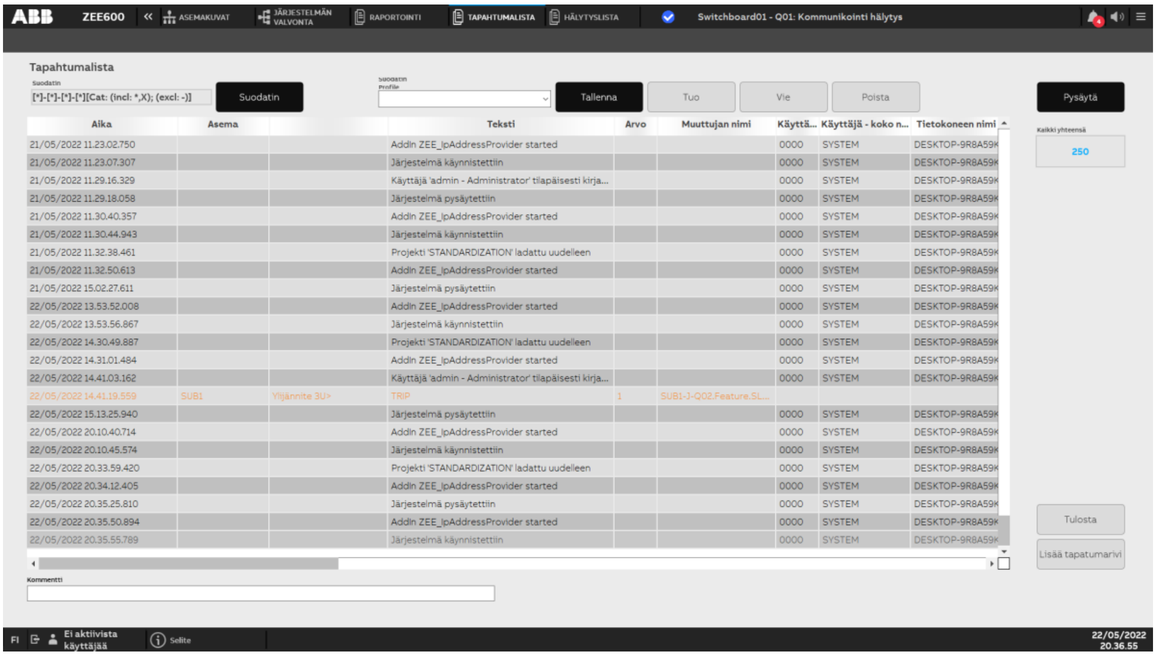


Figure 16. Language changed to Finnish

4 VARIABLE TERMINOLOGY

Variables are interface between data source and ZEE600. The task of variables is to represent measured values or states of the hardware. The variables are defined in the central variable list, but they are also available from functions. All functions used in a project are based on existing system functions and they are easy to parameterize and use.

The structure of variable name follows the following example, Bayname/Feature/Target/Device/Status. The name of bay is formed from the substation name, voltage level and Device name. A symbolic address is the part what makes data transfer possible, it can be used for addressing as an alternative to the name or identification. This property is entered automatically when variables are imported from supported drivers. Its structure is Server/Technicalkey/IECName/FC. The technicalkey part contains the name of specific IED device, which transfers information to the system. The correct datatypes were defined for all variables. All information to the creation of these variables was found from the REX640 relay parameter list. It is also possible to import scd files from IED and required parameters can be selected from files. The scd file which was used in this project did not include all necessary variables so some of them were created manually.[7]

4.1 IEC61850

IEC61850 is a communication protocol what is published in 2004. Before this, equipment manufacturers had their own communication protocols for their

[7] Copadata. Zenon functions user manual pdf. Accessed 23.5.2022. https://download.copadata.com/fileadmin/user_upload/Downloads/Dokumentation/700SP0/ENGLISH/Manual/Functions.pdf

devices. IEC61850 is a solid international solution to the substation automation and its purpose, is to standardize communication of substations. This means that because of this standard it is possible to implement communication between devices of different manufacturers.[8] All created variables of this project are connected to the IEC61850 driver, which was selected from available drivers menu.

4.2 Circuit Breaker, Earth Switch and Disconnector Variables

Variables which added for circuit breaker were position indications, control and control enabled. Variables were created as shown in Figure 17.

Resources label	Name	Identification
Filter text	*Q01.Feature.SLD.CB*	Filter text
Drivers : IEC850 - IEC1 (11 Elements)		
SUB1	SUB1-J-Q01.Feature.SLD.CB[1].CloseEnable	Close enable consent
SUB1	SUB1-J-Q01.Feature.SLD.CB[1].Control	Object control
SUB1	SUB1-J-Q01.Feature.SLD.CB[1].OpenEnable	Open enable consent
SUB1	SUB1-J-Q01.Feature.SLD.CB[1].Pos	Object position

Figure 17. Circuit breaker variables

For earth switches and disconnectors, only position indications were added. The variables for position indications are shown in Figure 18.

SUB1	SUB1-J-Q01.Feature.SLD.DC[1].Pos	Object position
SUB1	SUB1-J-Q01.Feature.SLD.ES[1].Pos	Object Position
SUB1	SUB1-J-Q01.Feature.SLD.ES[2].Pos	Object Position

Figure 18. Variables for earth switches and disconnector

[8] Länsman, H. 2019. 110 kV digitaalisen sähköaseman toteutusvaihtoehdot. Diplomityö. Vaasan yliopisto, Tekniikan ja innovaatiojohtamisen yksikkö, sähkötekniikka. Accessed 21.5.2022. https://osuva.uwasa.fi/bitstream/handle/10024/10276/UniVaasa_2019_Heija_Lansman.pdf?sequence=2&isAllowed=y

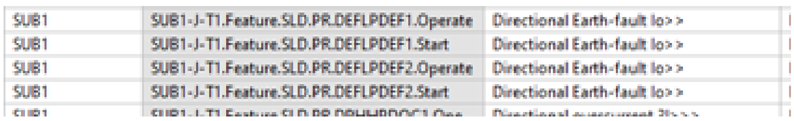
4.3 Transformer with Tap Changer Variables

The tap changer is a device which makes possible to change voltage ratio of transformer. Changing the position of the switch converts the number of revolutions of the transformers winding and that way affects the voltage. The position, control, connection and condition monitoring variables of the tap changer were added to the variable list. These variables are shown in figure 19. Some of the most used protection signals were also added to the variable list and it includes the trip and start signal for every protection function, as seen in Figure 20.


Drivers : IEC850 - IEC1 (10 Elements)

SUB1	SUB1-J-T1.Feature.TapChanger.Auto.stVal	TapChanger auto/manual indication
SUB1	SUB1-J-T1.Feature.TapChanger.AlmReas	Status and reason for alarm
SUB1	SUB1-J-T1.Feature.TapChanger.AutoOper	TapChanger auto/manual operation
SUB1	SUB1-J-T1.Feature.TapChanger.Control	Object control
SUB1	SUB1-J-T1.Feature.TapChanger.Error	Alarm status

Figure 19. Tap changer's variables



SUB1	SUB1-J-T1.Feature.SLD.PR.DEFLPDEF1.Operate	Directional Earth-fault Io>>
SUB1	SUB1-J-T1.Feature.SLD.PR.DEFLPDEF1.Start	Directional Earth-fault Io>>
SUB1	SUB1-J-T1.Feature.SLD.PR.DEFLPDEF2.Operate	Directional Earth-fault Io>>
SUB1	SUB1-J-T1.Feature.SLD.PR.DEFLPDEF2.Start	Directional Earth-fault Io>>

Figure 20. Protection signals

4.4 Reaction Matrix

By using a reaction matrix, the limit value information can be defined from a central point. In the configuration dialog it is possible to define the limit values for the reaction matrix. The different types of reaction matrices are binary, multi binary, numeric, multi numeric and string, as described in Figure 21. In this project, a reaction matrix was created for circuit breaker positions, (Figure 22) and its type is multi numeric. The value specifications of the circuit breaker were 0 =

Intermediate, 1 = Open, 2 = Closed and 3 = Faulty and the event list was defined as a list where this data is visible. [9]

Parameter	Description
Binary	Simplified evaluation of discrete states (bit-orientated) for the compatibility to older zenon versions.
Numeric	Simplified evaluation of analog states (value-orientated) for the compatibility to older zenon versions.
Multi binary	Extended evaluation of 32 bit variables; the first 16 bits determine the value of the variable and are passed on as numeric value; evaluation of the status bits of the variable; special function (switch-off of variables when status bit is set)
Multi numeric	Extended evaluation of the value and the status bits of the variable; special function (switch-off of variables when status bit is set)
String	collation

Figure 21. Reaction matrix types

[9] Copadata. Zenon variables user manual pdf. Accessed 23.5.2022. https://download.copadata.com/fileadmin/user_upload/Downloads/Dokumentation/800SP0/ENGLISH/Manual/Variables.pdf

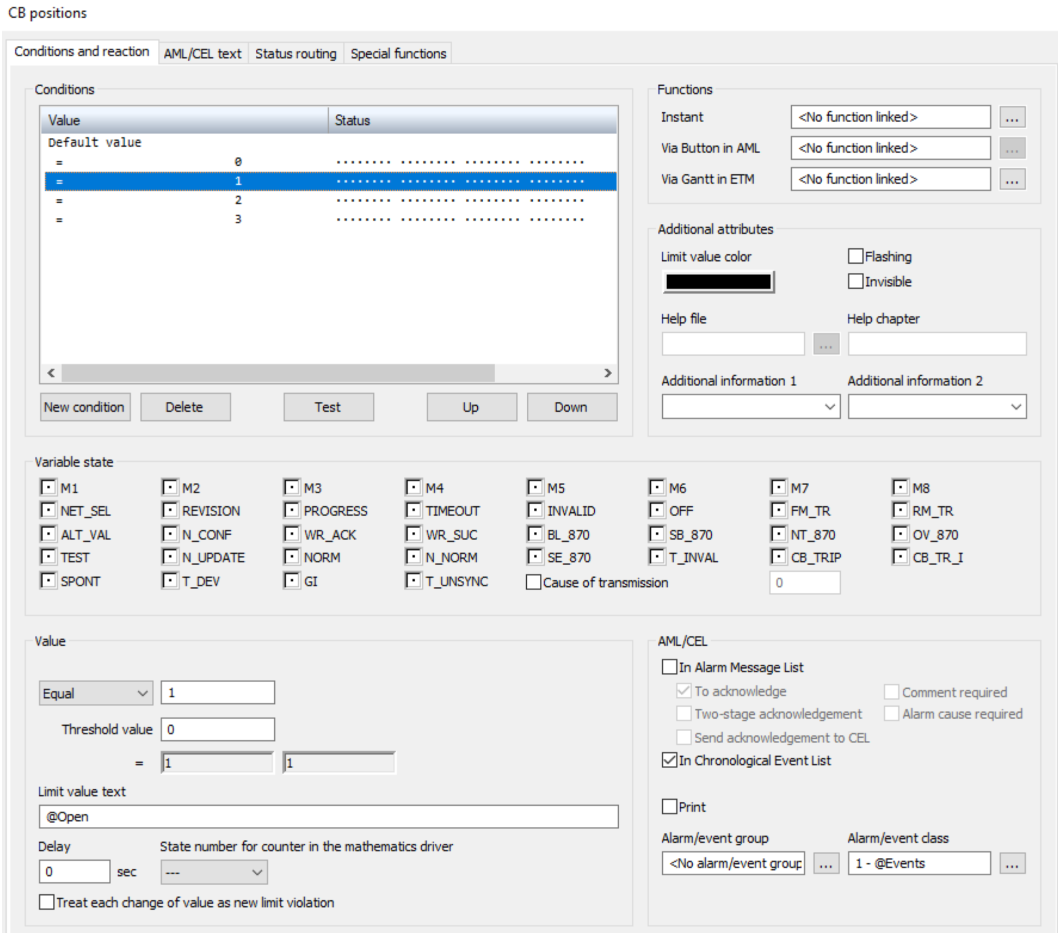


Figure 22. Reaction matrix specifications

5 SINGLE LINE DIAGRAM (SLD)

The project already included a button for single line diagram, as seen in Figure 4. Its function was to open navigation 1. The single line diagram includes busbar, circuit breakers, earth switches, disconnectors and transformers. The example single line diagram uses a single busbar system and this includes two bays, as shown in Figure 23.

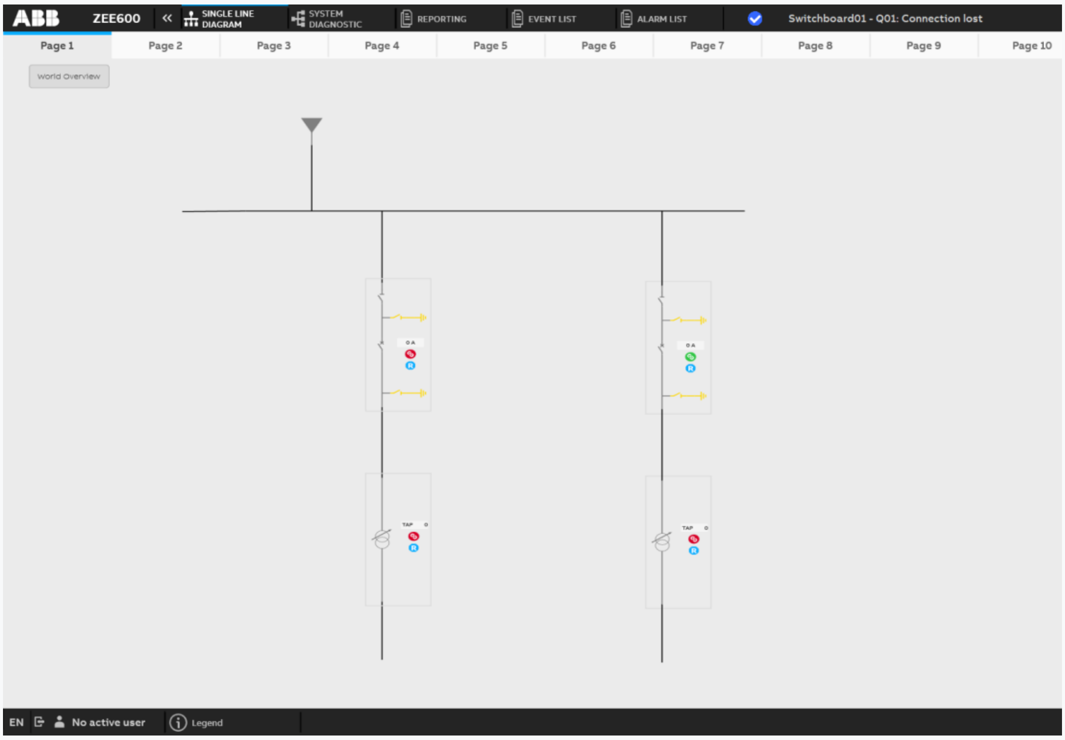


Figure 23. Single line diagram in runtime

Every line and device contain an ALC setting, this means that the color of line is defined automatically with the voltage level. The voltage level was defined during the project in ABB ZEE600 object import wizard.

5.1 Creation of Bays and Devices

The first part in the bay creation was to open the ABB ZEE600 - object import wizard and to add name, voltage level and ID for new bay, (Figure 24). After this, the equipment model and navigation window for the bay were selected. Navigation 1 and subnavigation 1 was defined for location of the bay. The next step was the determination of devices that should have remote control, in this case remote control was in use just for the circuit breaker. The last part was the configuration of the driver, as shown in Figure 25.

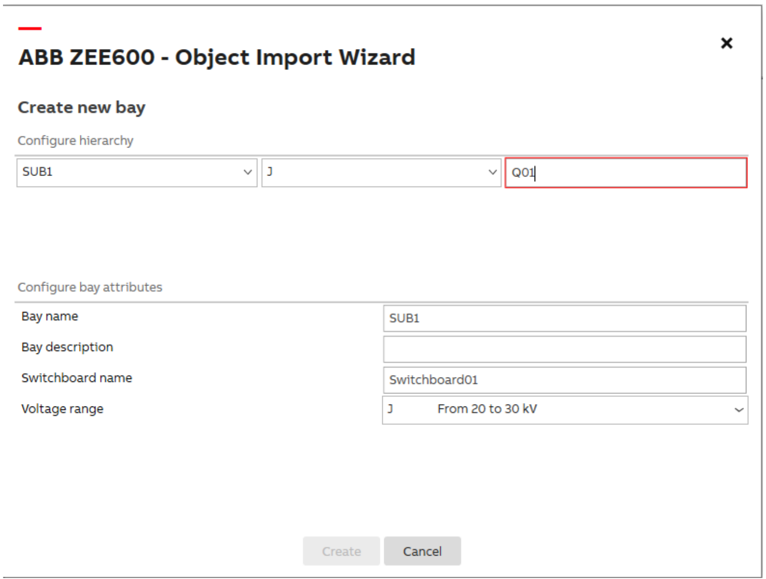
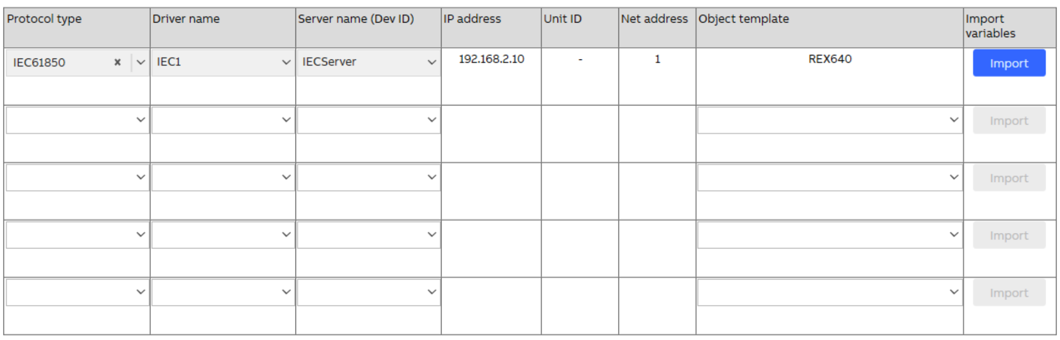


Figure 24. Adding of name, voltage level and ID for bay



Protocol type	Driver name	Server name (Dev ID)	IP address	Unit ID	Net address	Object template	Import variables
IEC61850	IEC1	IECServer	192.168.2.10	-	1	REX640	Import
							Import
							Import
							Import
							Import

Figure 25. Configuration of driver

5.2 Alarm Signals

After the circuit breaker was created for the bay, alarm boxes were defined to the status pop-up window of the bay. This pop-up window opens by clicking the symbol in the single line diagram. The alarm boxes were named in the default variables of pop-up window. After this, functions were created for the alarm boxes and an alarm status was set as its parameter. The next step was to select a protection signal which activates alarm box, different signal was added for every box.

The last step was to link the created function to the variable, to define lists where the alarm is visible and acknowledgement settings. The settings are shown in Figure 26. Acknowledgement was activated by adding an alarm status to the alarm handling. It was possible to test the functioning of the alarm boxes by using the runtime variable diagnosis feature, where changing of limit value was possible. The bay status details window during the test is shown in Figure 27.

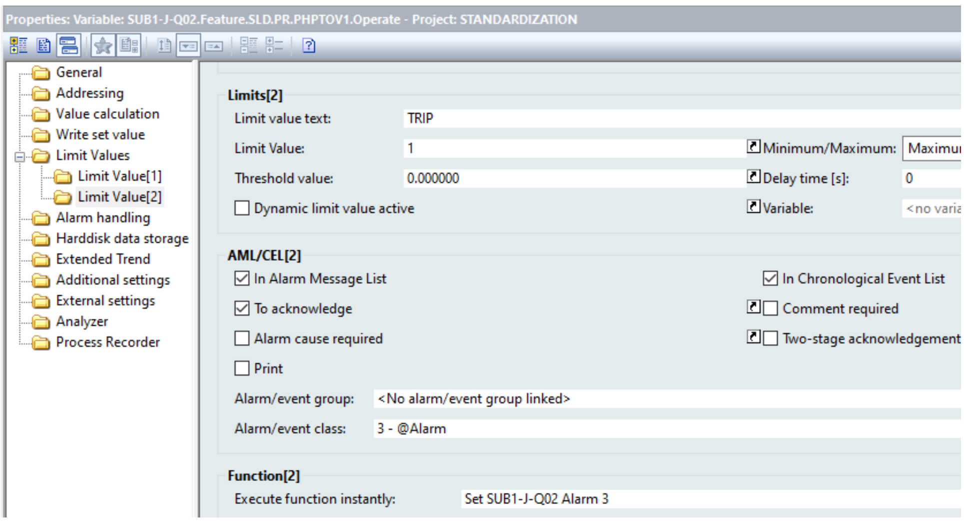


Figure 26. Protection signal variable's settings

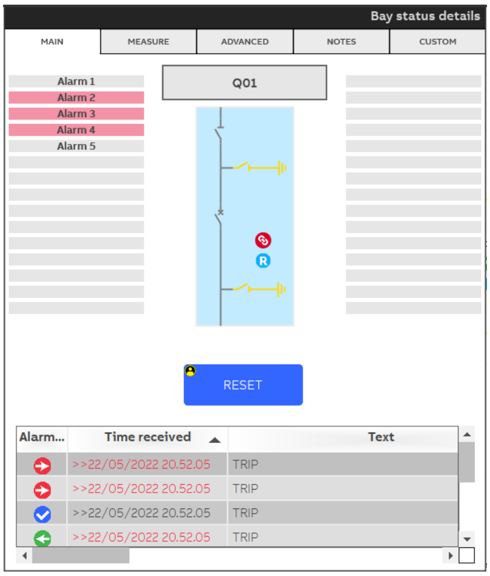


Figure 27. Bay status details and alarms

5.3 Circuit Breaker Control

During the creation of the bay, a circuit breaker was selected for the equipment model of the bay and after this, the type of measurement pop-up was defined in the ABB ZEE600 - object import wizard. The circuit breaker can be controlled via the popup window, as shown in Figure 28. This pop-up window opens by clicking the device symbol of the status pop-up and it is default pop-up of ZEE600. The control feature requires a login to the system every time. Earth switches and disconnector do not have remote control possibility in this case. [10]

[10] ABB. ABB ZEE600 v.2.0 Configuration Manual. Accessed 25.5.2022. https://library.e.abb.com/public/97deff6da70a40b7b1f778c1d0af0fd1/ABBZEE600_v2.0_conf_2NGA000150_ENb.pdf

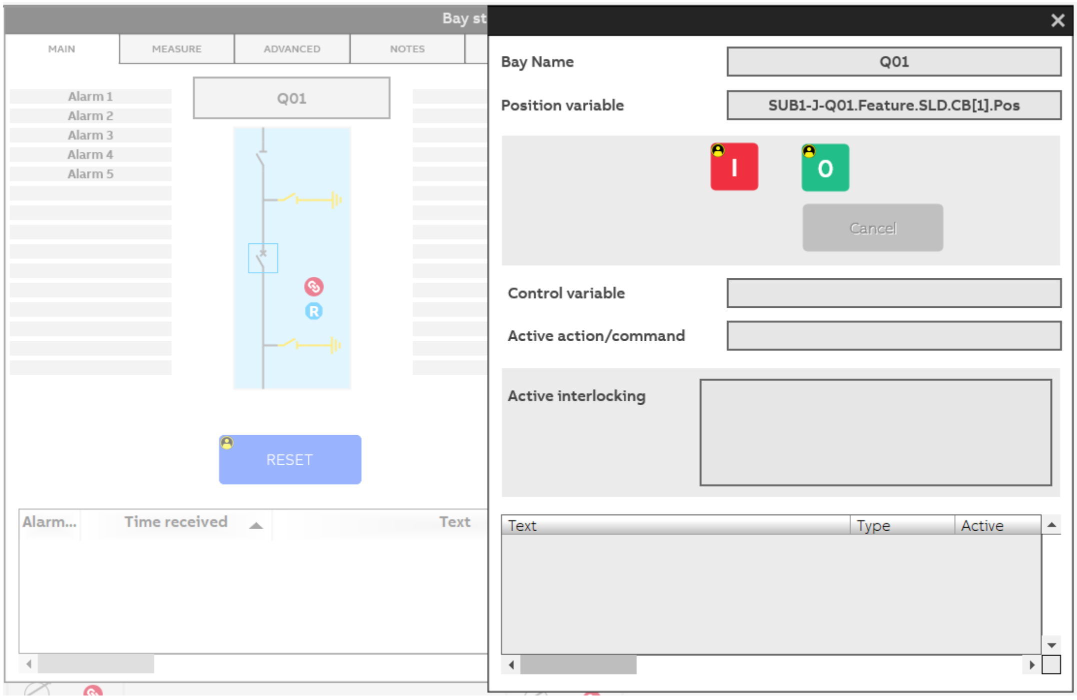


Figure 28. Circuit breaker control window

6 SYSTEM DIAGNOSTICS

The tasks of the system diagnostics page is to show device-specific network representations. Symbols have an icon that symbolizes the connection status and these icons can be colored in different ways, depending on the status. The symbols also have pop-up windows which opens by clicking symbol, as seen in Figure 29. The task of these windows is to show more information about devices.

During this project, symbols were created for the ZEE600 server as well as for the switches. The information fields and info panels of the symbols were defined in the default variables. All these symbols are also buttons and info panel pop-up functions were added for all of these. [11]

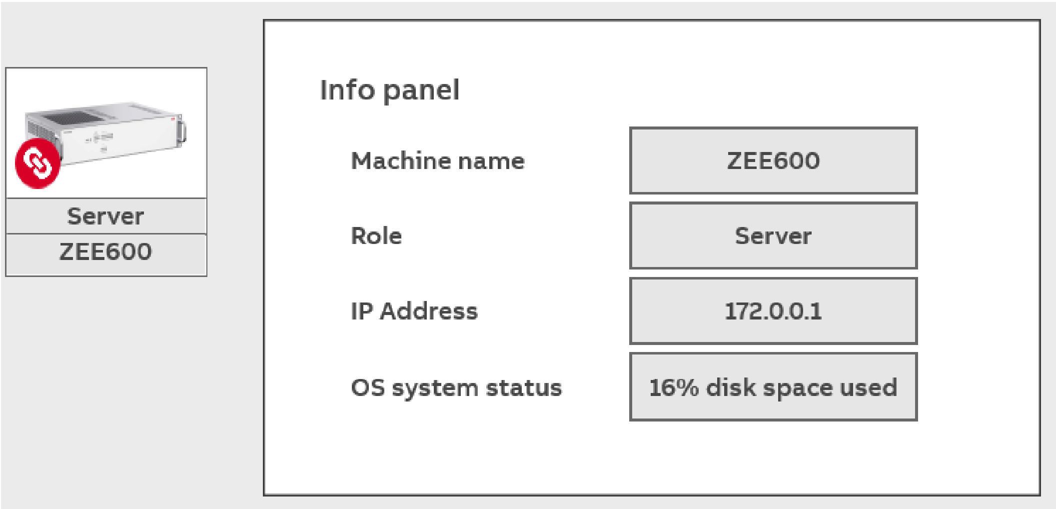


Figure 29. Created system diagnostic symbol and information window

[11] ABB. ABB ZEE600 Operation Manual. Accessed 25.5.2022. https://library.e.abb.com/public/5c991f2dbfe847058cd216e35b652868/ABBZEE600_v2.0_oper_2NGA000149_ENb.pdf

7 CONCLUSIONS

The aim of thesis was to standardize the most used subareas of the ZEE600 2.0 version and this way enhance engineering work. In the end created templates were stored to the libraries where they are easily available. General templates were modified to a clear and easy to use form. The features of single line diagram and devices were implemented successfully, also the adding of desired variables, functions and symbols to the project succeeded well.

The topic of thesis was very interesting and challenging enough. The SCADA systems were a new field for me, but during the work my interest grew continuously and working with the topic was nice and instructive. Software which was in use during this thesis was new for me and it took some time to learn to use them. The different sectors of thesis included many steps and remembering as well as solving of these was sometimes difficult, but at the same time it was also interesting. The schedule of thesis was also a somewhat challenging.

Work succeeded as a whole well and aim was successfully achieved. During this thesis, the deficiencies of these templates were improved and after these new templates were saved to the libraries where they are easily available. This speeds up the engineering work of ZEE600 projects and makes the work more efficient. The scope of this work was to standardize templates for substations but it is possible that the standardization work of 2.0 version is extended till the future, for example to the templates of industry. I also believe that the skills which I have learned during the work are useful in future projects.

SOURCES

ABB. Accessed 6.5.2022. https://new.abb.com/fi

ABB. ABB Suomi webinaari: Moderni SCADA -järjestelmä sähkönjakelun valvontaan ja hallintaan. Accessed 8.5.2022 https://www.youtube.com/watch?v=fDnkEzq7AZY

ABB. ABB ZEE600 Operation Manual. Accessed 25.5.2022. https://library.e.abb.com/public/5c991f2dbfe847058cd216e35b652868/ABBZEE600_v2.0_oper_2NGA000149_ENb.pdf

ABB. ABB ZEE600 v.2.0 Configuration Manual. Accessed 25.5.2022. https://library.e.abb.com/public/97deff6da70a40b7b1f778c1d0af0fd1/ABBZEE600_v2.0_conf_2NGA000150_ENb.pdf

Ahoniemi, T. 2017. Energiayhtiön SCADA verkon kehittäminen. Opinnäytetyö. Kaakkois-Suomen Ammattikorkeakoulu, Tietotekniikka. Accessed 23.5.2022. https://www.theseus.fi/bitstream/handle/10024/127565/ahoniemi_teemu.pdf?sequence=1&isAllowed=y

Copadata. Zenon editor user manual. Accessed 8.5.2022. https://download.copadata.com/fileadmin/user_upload/Downloads/Dokumentation/810SP0/ENGLISH/Manual/Editor.pdf

Copadata. Zenon functions user manual. Accessed 23.5.2022. https://download.copadata.com/fileadmin/user_upload/Downloads/Dokumentation/700SP0/ENGLISH/Manual/Functions.pdf

Copadata. Zenon runtime user manual. Accessed 8.5.2022. https://download.copadata.com/fileadmin/user_upload/Downloads/Dokumentation/760SP0/ENGLISH/Manual/Runtime.pdf

Copadata. Zenon variables user manual. Accessed 23.5.2022. https://download.copadata.com/fileadmin/user_upload/Downloads/Dokumentation/800SP0/ENGLISH/Manual/Variables.pdf

Länsman, H. 2019. 110 kV digitaalisen sähköaseman toteutusvaihtoehdot. Diplomityö. Vaasan yliopisto, Tekniikan ja innovaatiojohtamisen yksikkö, sähkötekniikka. Accessed 21.5.2022. https://osuva.uwasa.fi/bitstream/handle/10024/10276/UniVaasa_2019_Heija_Lansman.pdf?sequence=2&isAllowed=y

Sermatech. Sermatech website. Accessed 6.5.2022. https://www.sermatech.fi/valvomot-osana-automaatiojarjestelmaa/