Software Development and Engineering the Future

Substation Automation System

V 1.0

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Kajganic Energy Systems GmbH
Graudenzer Linie 43
68307 Mannheim, Germany
Tel.:   +49 621 4309631
Fax: +49 621 30787808
Web: www.kajganic.com
E-mail:info@kajganic.com

Please contact

Dr. Boris Kajganic
Tel.:   +49 621 4309631
Email: boris.kajganic@kajganic.com

Table of Contents

1 SAS Overview

This document consists the technical specification and short manual of KES NetzAgent Substation Automation System.

As default, SAS uses IEC 61850 SCL configuration files (Substation Configuration *.scd) or IED configuration file *.icd). For basic case, receiving analogs and signalization, charts, storing into database, no additional engineering is required. This dramatically reduce the amount of work to prove the communication and data. The setup file is the same as is used for protection itself.

Start of the system is just open file operation and start the communication. The system is up and running in few minutes.

HMI interface for single line diagram is based on Scalable Vector Graphics (SVG). This allows easy scaling of the pictures and all used symbols in the project are user defined. High flexibility and no proprietary format.

All data are stored inside SQLite3 database (up to 140TB). The database is not encrypted, it could be open with any other tools or simple moved between different operation systems or computers.

1.1 SAS features

NetzAgent SAS has the following features:

- Single user Master SCADA/SAS with integrated HMI interface
- Single line diagram (SLD) with Scalable Vector Graphics (SVG)
- SVG Editor Inkscape is used for SLD
- Logging
    - Alarms
    - Events
- Hierarchically relation of objects in database and presentation
- Relation database SQLite3
- Possibility to interchange database between Windows and Linux systems. File copy operation.
- Database is NOT encrypted. User with appropriate right can use simple SQL command to browse DB.
- No addition cost of third party software
- User defined number of Masters
- Supported protocols
    - IEC 61850
    - IEC 60870-5-104 (optional)
    - MODBUS (optional)
- Number of I/O Point is limited with license contract
- Plotting
    - Real-time plots of current values
    - Charts from historical database
- Storing of data for analysis and export. Received measurements and signalization are stored into database with timestamps.
- DB Export
    - Export into CSV file
    - DB can by simply copied and used
- DB Backup
- In house developing and testing
- Platform independent and portable code, directly support
    - Linux 64 bits (Centos 7)
    - Microsoft Window 64 bits
- Object oriented development based on C++11
- 1 year warranty period included
- upgrade and maintenance for user defined period (optional)

2   NetzAgent Short Manual

This is the short manual related to Windows and Linux version of the SAS NetzAgent.

The NetzAgent™ is single user SCADA / Substation Automation System (SAS), uses the latest technology, supports main communication protocols (including the new standard protocol IEC 61850) and is independent from the operating system. It can work under Windows, Linux as well as other devices such as raspberry PI. This feature is of major importance for incorporating low cost solutions that are also compatible with the existing data. Another important feature is that the SCADA-System includes an interface to the real-time database, which enables the incorporation of further applications independent from the ones we offer. These features enable to reduce significantly the installation costs, especially when targeting a distributed model in the distribution network, for example by using Raspberry PI devices.

Build-in Single line diagram (SLD) is the representation of a power system using the simple symbol for each component. The SLD of a power system is the network which shows the main connections and arrangement of the system components along with their data. SLD takes the current status of the topology elements and shows different symbols according the topology status.

3   Installation

The software installation comes as the archive in two types:

NetzAgent_ZZZXXYY.tar.gz   Linux Centos 7 64 bits

NetzAgent_ZZZXXYY.7z   Windows 64 bits

3.1 Windows Installation

3.1.1   Preinstallation Requirements

The NetzAgent, requires installation of WinPcap driver. WinPcap is the industry-standard tool for link-layer network access in Windows environments: it allows applications to capture and transmit network packets bypassing the protocol stack, and has additional useful features, including kernel-level packet filtering, a network statistics engine and support for remote packet capture.

Download WinPcap_4_1_3.zip from FTP site (ftp.kajganic.com). Unpack the archive to one destination folder. Start installation program WinPcap_4_1_3.exe and install Winpcap driver on your system.

3.1.2   Installation

Download NetzAgent from FTP site (ftp.kajganic.com). Unpack the archive to one destination folder. The archive is not password protected.

3.2 Linux Installation

Linux version of NetzAgent is tested on:

```
[kes@KES]$ cat /etc/redhat-release
CentOS Linux release 7.3.1611 (Core)
```
And

```
[kes@KES]$ cat /etc/redhat-release
CentOS Linux release 7.2.1511 (Core)
```

3.2.1   Preinstallation Requirements

Usage of NetzAgent required one computer with Centos 7 64 bits operation system. Download the ISO disk (CentOS-7-x86_64-Everything-1611.iso) from Centos web site (https://www.centos.org/download/)

a)   Install Centos 7 64 bits version with default settings.

Write down root password and create user for the usage of NetzAgent. Let's call user *kes* in the rest of the documentation.

b)   Login in the system as root

Open terminal and install the missing software.

```
[root@KES]$ yum install gnome-packagekit-updater
[root@KES]$ yum install gnome-packagekit-installer
[root@KES]$ yum install dconf-editor
[root@KES]$ yum install SDL
[root@KES]$ yum install xerces-c
```

c)   VNC Server

Strictly speaking VNC server is not require for proper work of NetzAgent, but it is used for remote access in the case of software update or maintenance. Install as root:

```
[root@KES]$ yum groupinstall "GNOME Desktop"
[root@KES]$ yum install tigervnc-server
[root@KES]$ firewall-cmd --permanent --zone=public --add-service
vnc-server
[root@KES]$ firewall-cmd --permanent --add-port=5900-5999/tcp
[root@KES]$ firewall-cmd --permanent --add-port=5800-5899/tcp
[root@KES]$ firewall-cmd --reload
```

d)   Add **sas** folder

```
[root@KES]$ cd /
[root@KES$ mkdir sas
[root@KES]$ chmod 777 sas
```

e)   Reboot the computer

f)   Login as user *kes*. This could be any user chosen during the installation process.

g)   Start VNC Server

Open terminal.

```
[kes@KES]$ vncserver -geometry 1280x960 :33
```

First time, the program will ask for the password of the remote session.
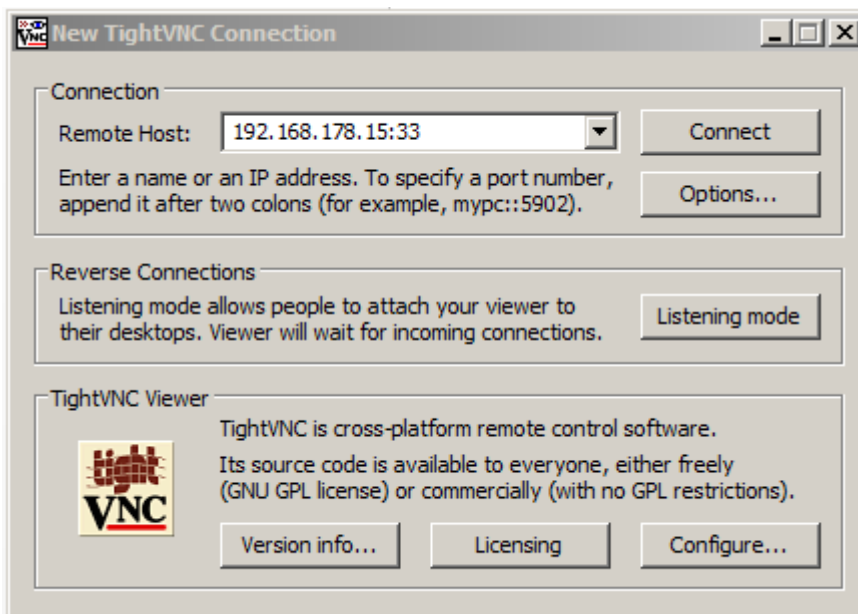
To stop `vncserver` use kill command.

```
[kes@KES]$ vncserver -kill :33
```

h) Test VNC connection from Windows to Linux computer

Download on Windows computer TightVNC software from http://www.tightvnc.com/download.php. and start the installation. Use custom installation and install only VNC Viewer, Server side is not required.
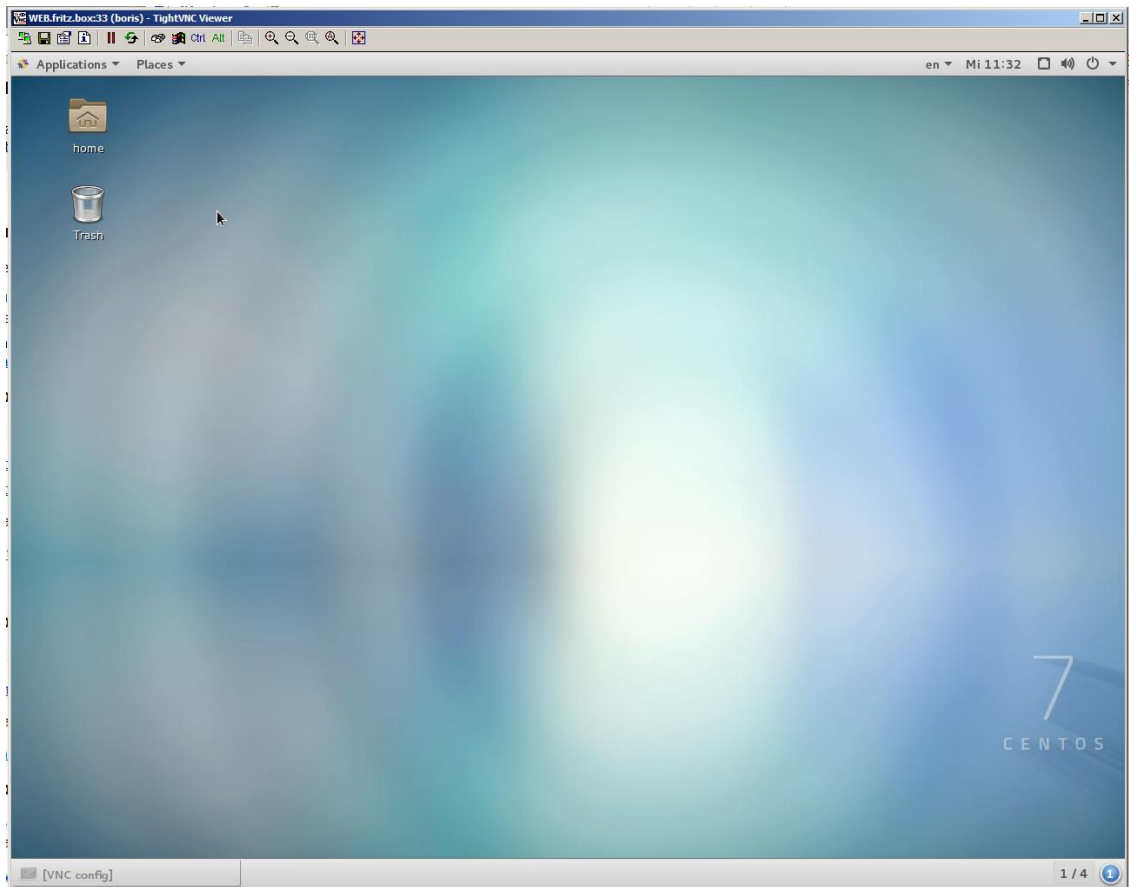
Start TightVNC Viewer

Use IP address of the Centos computer with the same number used to start `vncserver`.
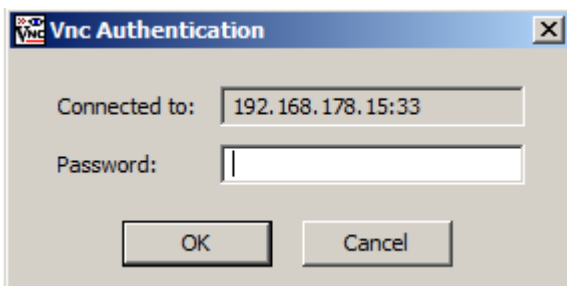
For the password use the same password used to start vncserver first time.

i) How to execute a script just by double clicking like .EXE files in Windows?

Follow these steps:

Hit `Alt+F2`, type `dconf-editor` and hit `Enter`.

In dconfg-editor goto: `org` ➤ `gnome` ➤ `nautilus` ➤ `preferences`

Click on `executable-text-activation` and from drop down menu select:

launch: to launch scripts as programs.

OR

ask: to ask what to do via a dialog. This is preferable option in the test phase.

Close dconf-editor. That's it!

3.2.2 Installation

The installation of the software is under normal user (not root).

Download Linux version (extension tar.gz) of NetzAgent from FTP site (ftp.kajganic.com). Unpack the archive to *sas* folder, created as root in previous step. The archive is not password protected.

```
[kes@KES]$ tar -xzvf NetzAgent_ZZZXXYY.tar.gz
```

New folder NetzAgent with appropriate structures and the programs is created.

Copy as root user, the file 99-matrix.rules into /etc/udev/rules.d and test if the dongle is founded.

```
[kes@KES]$ ./dongletest
There is a MXSPS dongle connected to USB.
Model:   651
Version: 6.0
Memory:  60
```

4 Start of NetzAgent

4.1 Windows version of NetzAgent

The program could be started with double click on the NetzAgent.exe from Windows Explorer.
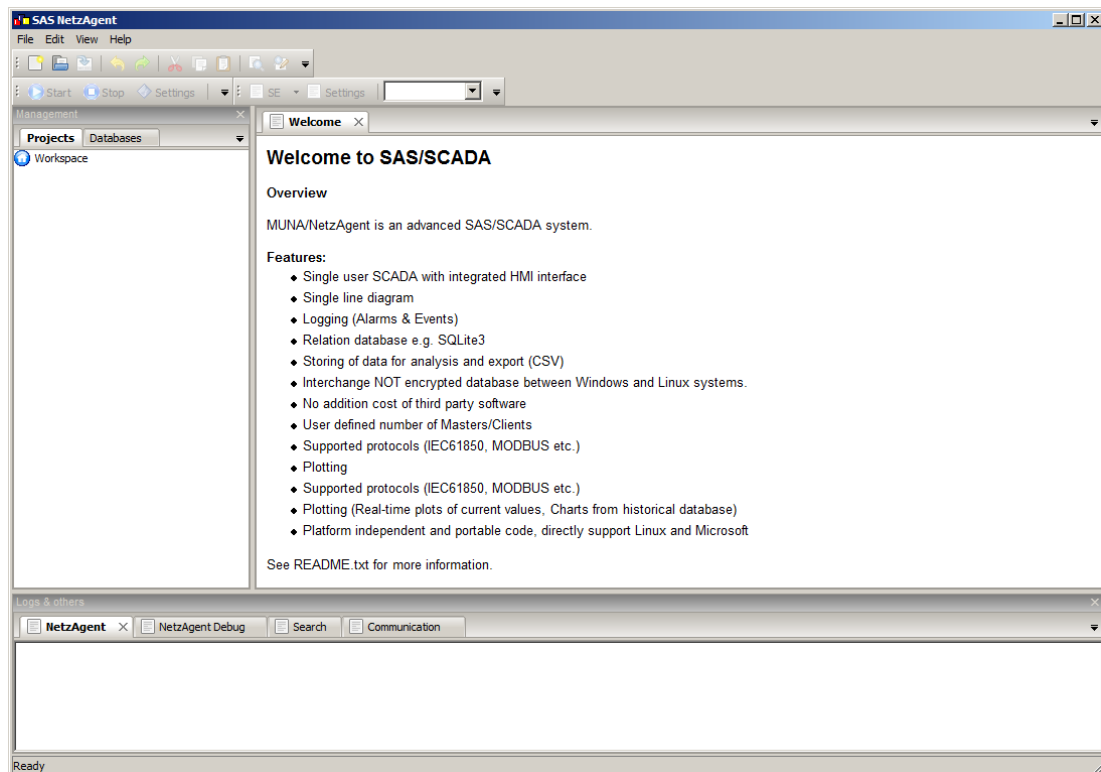

4.1.1 Debug Output

NetzAgent has integrated debug output window. To achieve debug output, the application must be started with /D as command parameter or simple execute debug.bat.

In the debug output user can see internal states of the program as the complete communication between NetzAgent and IEDs.
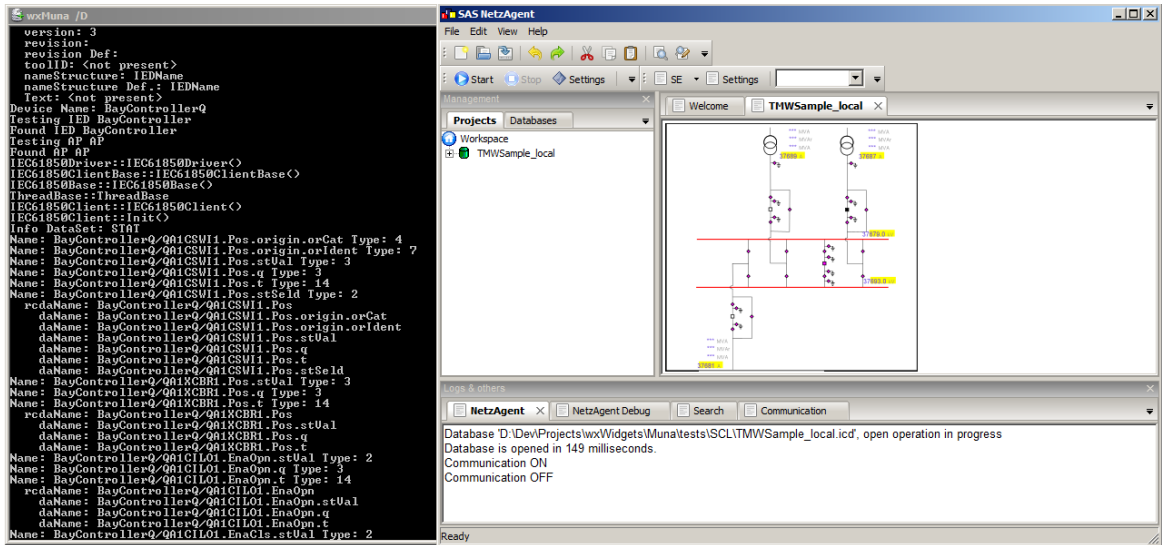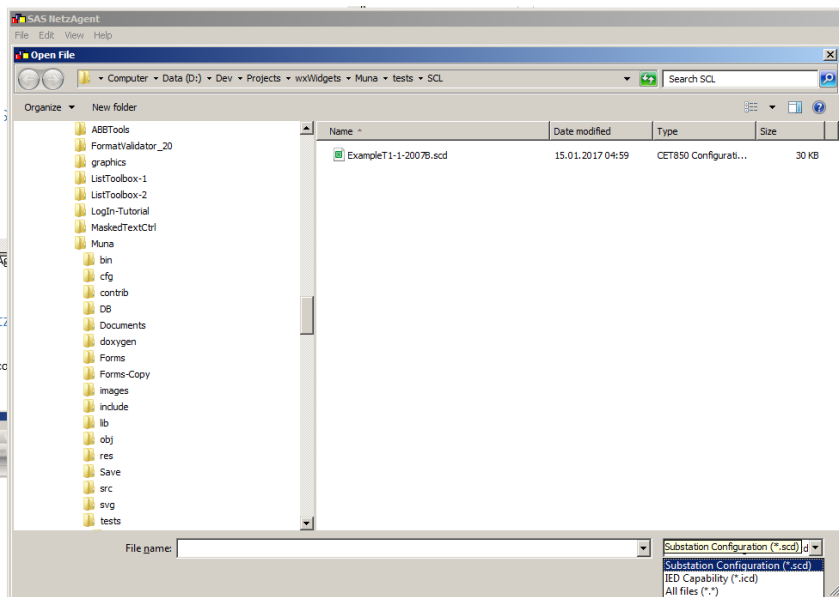
4.1.2 Open SCL configuration file

User could use `File ➤ Open` or press Open icon.
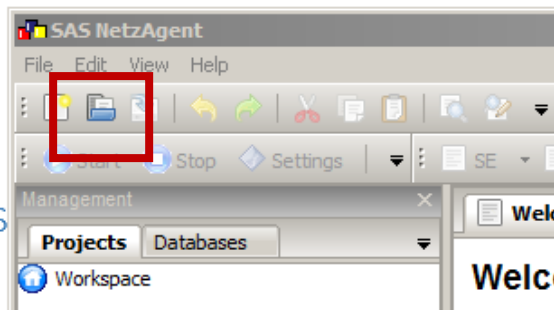
In Open dialog chose Substation Configuration (*.scd) or IED configuration file (*.icd)

The Imported configuration file create workspace and the project inside the program as is showed in the next picture.


4.1.3 Single Line Diagram

If exists a single line diagram file (*.svg) with the same name as the IED configuration, the file will be opened automatically when user opens the IED configuration file. Otherwise open the file with selecting open operation (File ➤ Open). Demo predefined SLD (Demo.svg) are located inside Demo folder.

Remarks: The measurements and the signalizations are connected inside Demo.svg.
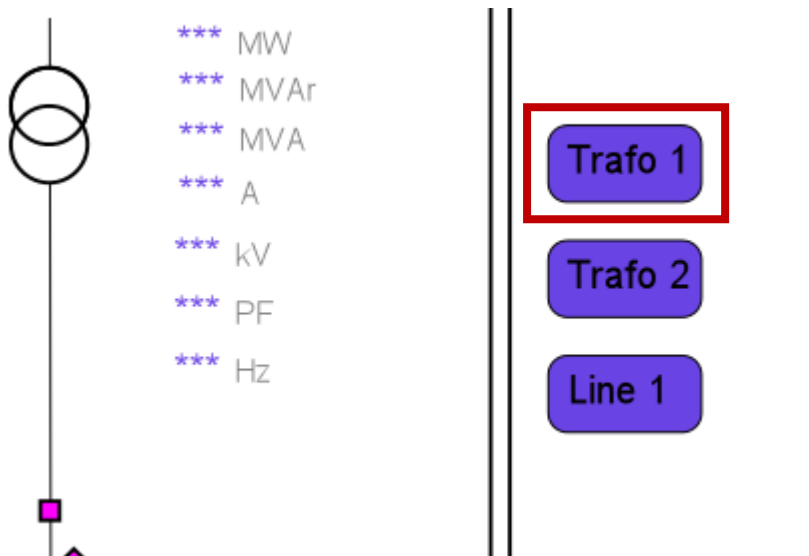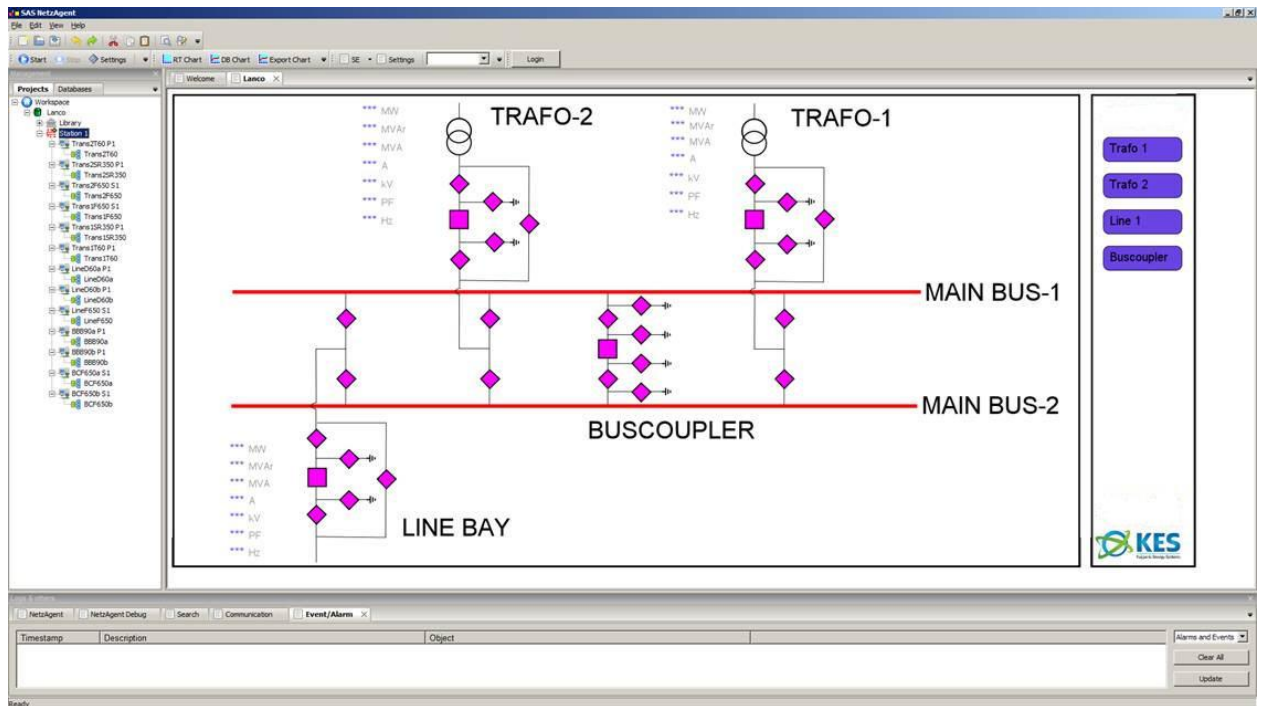
Click on the "Button" opens the new SLD picture. Click on the measurement opens real time plots and the click on the breaker or disconnector change the topology.
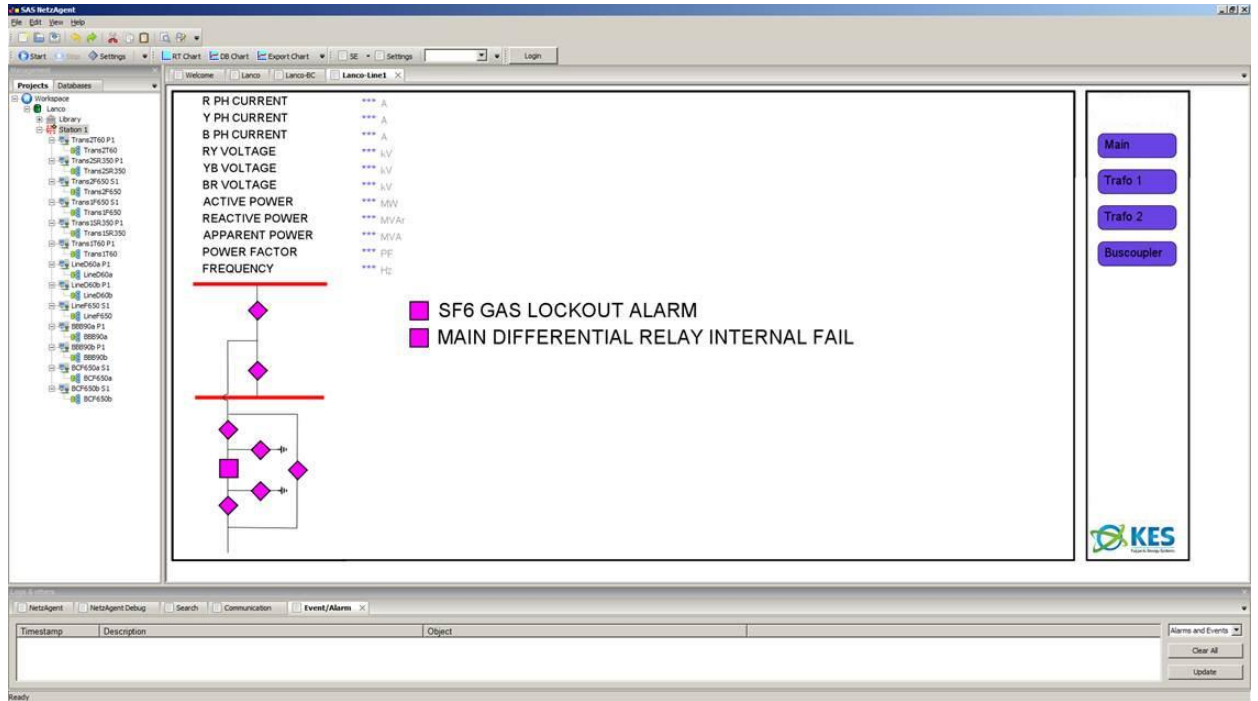
4.1.4 Communication

`Start` and `Stop` of the communication is toggle operation.

Configuration data from SCL file is sent to IEC61850 Driver. The driver sent the received data back to the application. Some IEDs as GE F650 has only rudimentary support of IEC61850. The report are not working properly. If the driver detect error in the subscription of the report, the driver will emulate report with cyclic pooling of the data set.
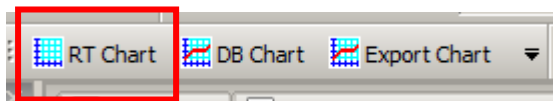
4.1.5 RT Chart

Click on analog measurement will open real time chart for the current selected measurement. The chart is updated as the new data are received.
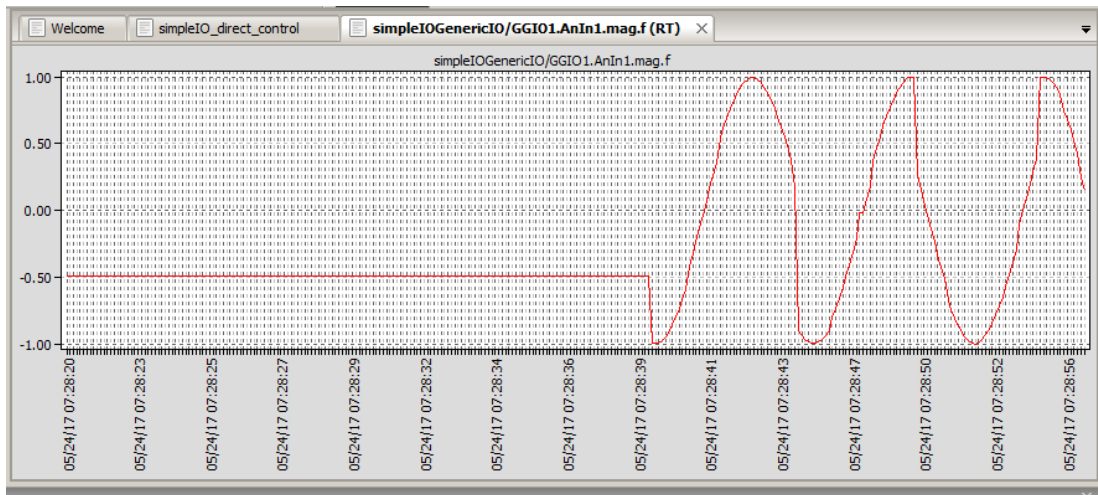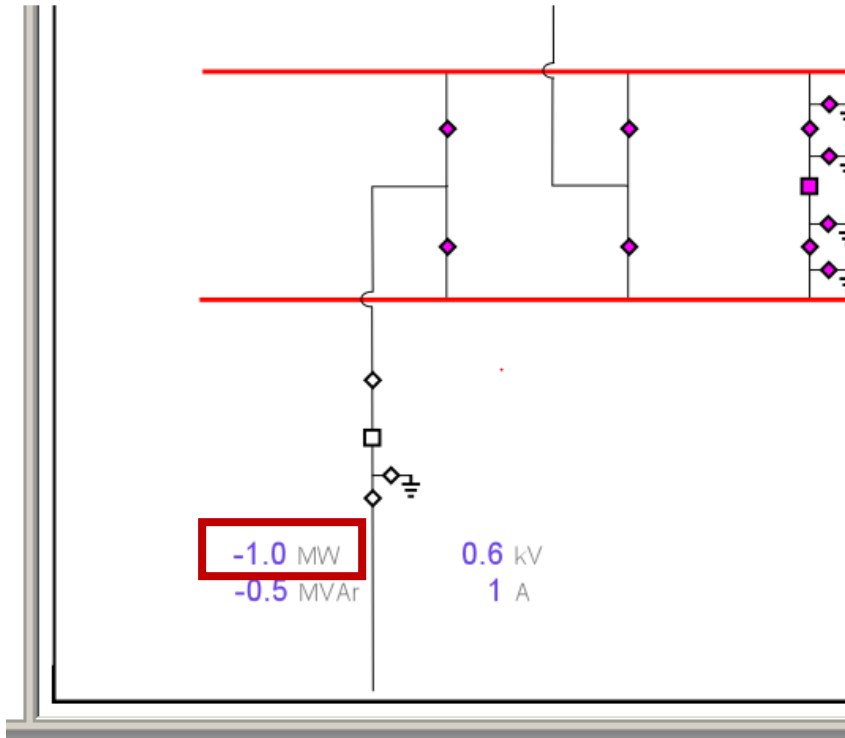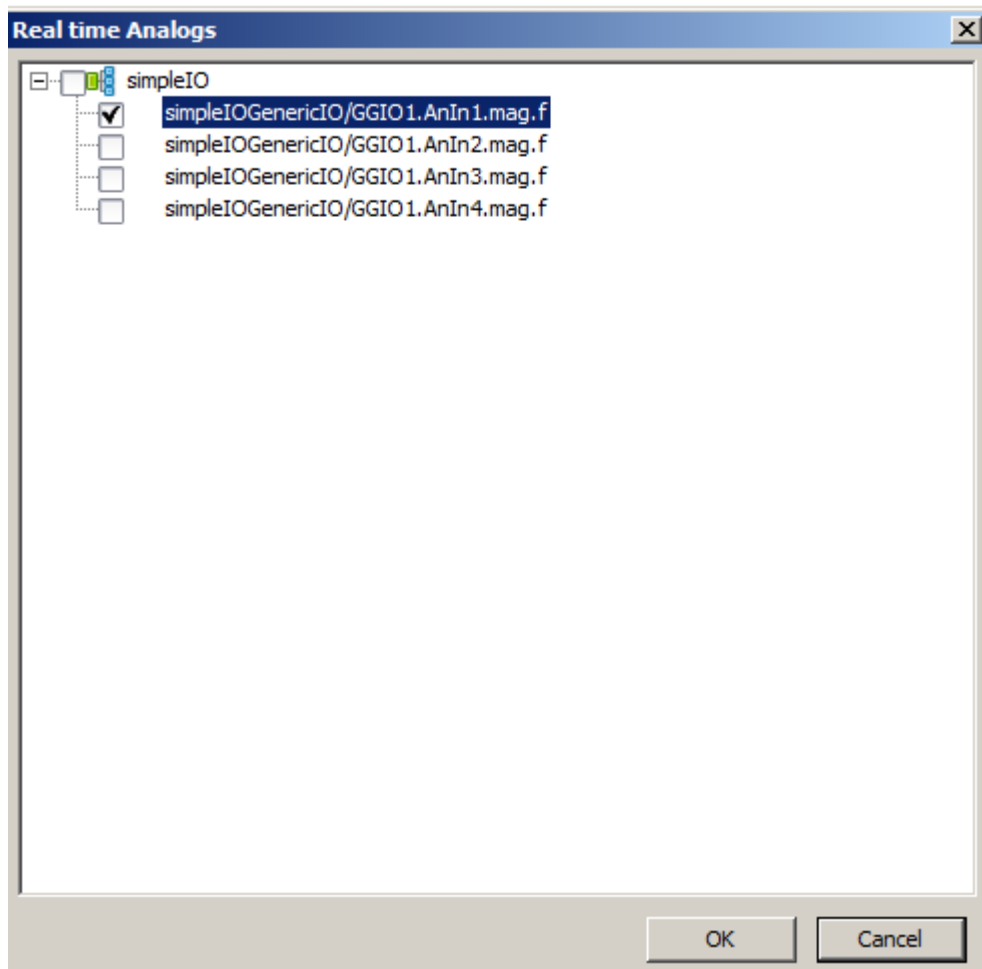
Second option to open real time chart is from toolbar. Select the first IED in the tree control.
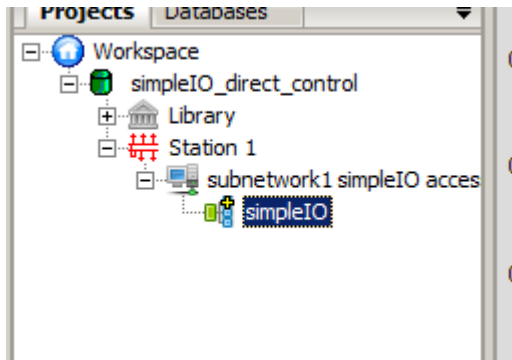
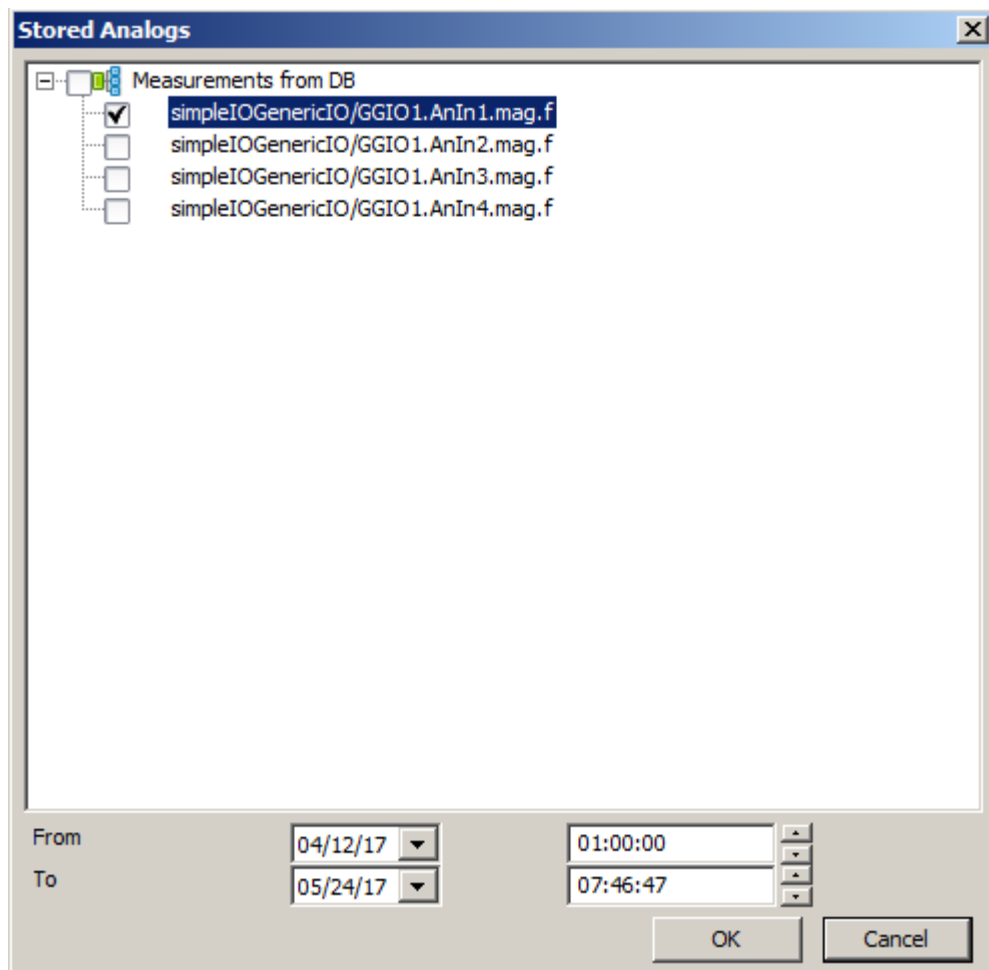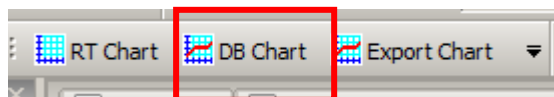Click on RT Chart in the toolbar.

Chose one or more (all) analog measurements assigned to the IED.

The same chart will be opened as is chosen from single line diagram. The dialog is receiving the data from connected IED. The communication must work otherwise the dialog is empty.
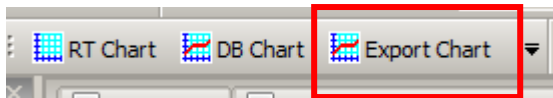
4.1.6   DB Chart

Every received measurement are stored in the relation database with appropriate timestamp. Click on DB Chart in the toolbar.
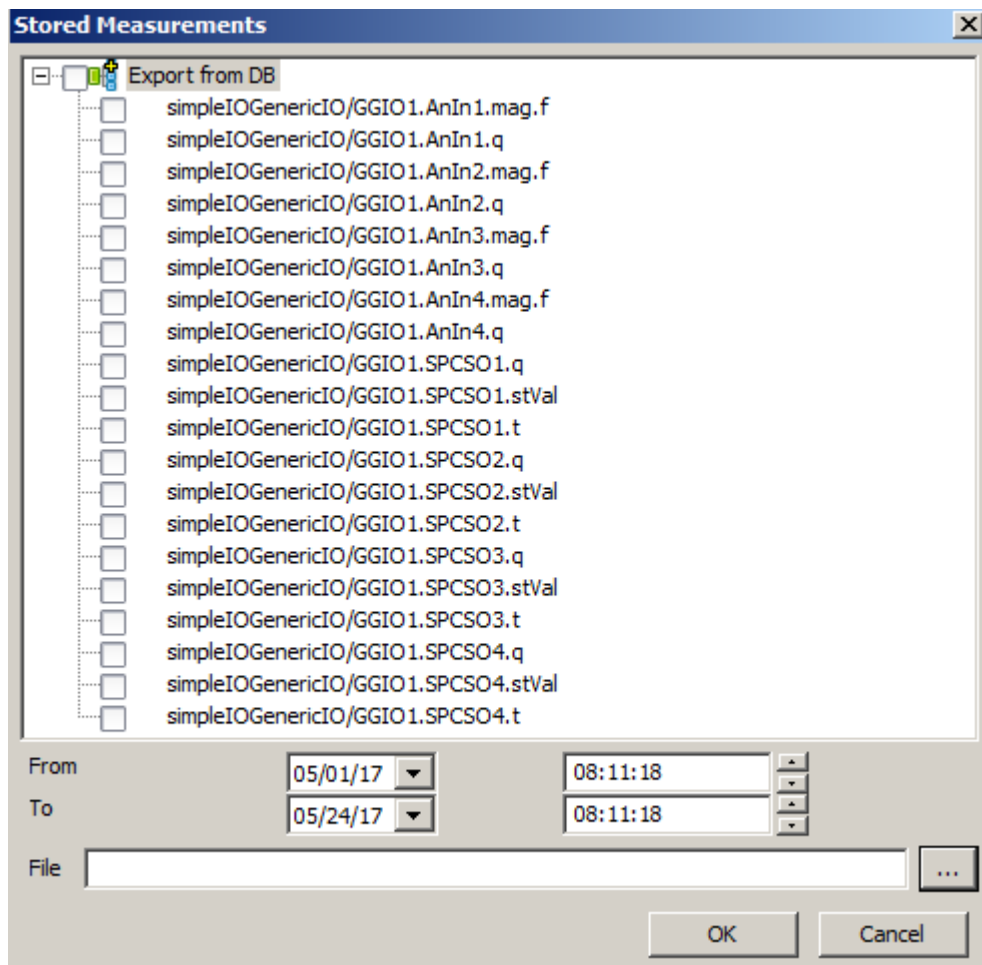

Chose the analog measurement(s) and the interval.

4.1.7   Export Chart

All received data are stored in the relation database with appropriate timestamp. Click on Export Chart in the toolbar.

Select time range, exported values and the name of the CSV file where the data will be stored.


Example: Part of the exported data:

```
entryID;timeOfEntry;reasonCode;dataRef;value
1;2017-05-06 09:04:19;4;simpleIOGenericIO/GGIO1.SPCSO1.stVal;true
2;2017-05-06 09:04:19;4;simpleIOGenericIO/GGIO1.SPCSO2.stVal;false
3;2017-05-06 09:04:19;4;simpleIOGenericIO/GGIO1.SPCSO3.stVal;true
4;2017-05-06 09:04:19;4;simpleIOGenericIO/GGIO1.SPCSO4.stVal;false
5;2017-05-06 09:04:19;4;simpleIOGenericIO/GGIO1.SPCSO1.stVal;true
6;2017-05-06 09:04:19;4;simpleIOGenericIO/GGIO1.SPCSO2.stVal;false
7;2017-05-06 09:04:19;4;simpleIOGenericIO/GGIO1.SPCSO3.stVal;true
8;2017-05-06 09:04:19;4;simpleIOGenericIO/GGIO1.SPCSO4.stVal;false
9;2017-05-06 09:04:19;0;simpleIOGenericIO/GGIO1.SPCSO1.q;0000000000000
9;2017-05-06 09:04:19;0;simpleIOGenericIO/GGIO1.SPCSO1.stVal;true
9;2017-05-06 09:04:19;0;simpleIOGenericIO/GGIO1.SPCSO1.t;20170506055426.626Z
10;2017-05-06 09:04:19;0;simpleIOGenericIO/GGIO1.SPCSO2.q;0000000000000
10;2017-05-06 09:04:19;0;simpleIOGenericIO/GGIO1.SPCSO2.stVal;false
10;2017-05-06 09:04:19;0;simpleIOGenericIO/GGIO1.SPCSO2.t;19700101000000.000Z
11;2017-05-06 09:04:19;0;simpleIOGenericIO/GGIO1.SPCSO3.q;0000000000000
11;2017-05-06 09:04:19;0;simpleIOGenericIO/GGIO1.SPCSO3.stVal;true
11;2017-05-06 09:04:19;0;simpleIOGenericIO/GGIO1.SPCSO3.t;20170506055426.696Z
```

CSV file could be open directly with Microsoft Excel for the additional analysis.

4.1.8   Topology Change Commands

If the communication is established, click on the breaker or disconnector will open the dialog to change the topology status of the selected element.
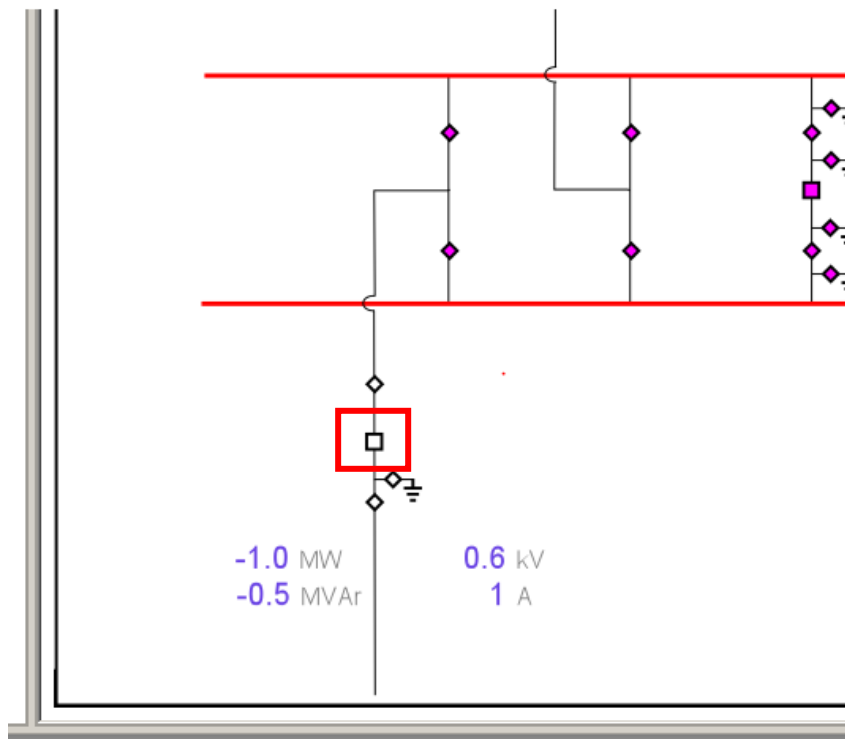
Changed status:
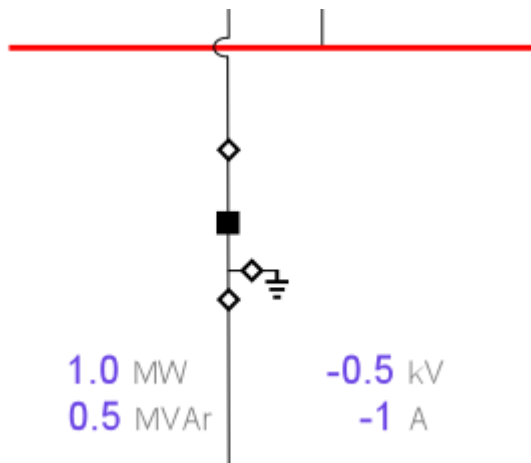
Remarks: This could work only if the SCL configuration file for the IED has commands and it is appropriate configured.

4.1.9 Login

Depends on the project configuration it is possible to set up the commands to be active only in the case if the user is login in the system.
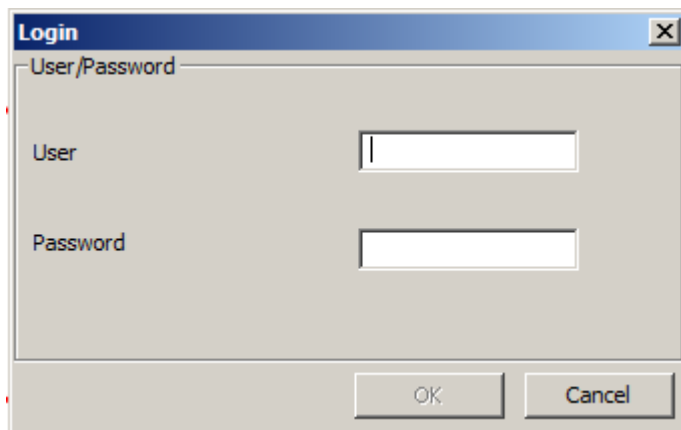
Default user and password are: sadmin/sadmin.

4.1.10 Users administration

By clikcking on the "Users" and "User List" menu shown on main screen, the dialog with user administration pops up.
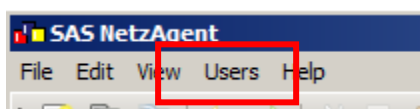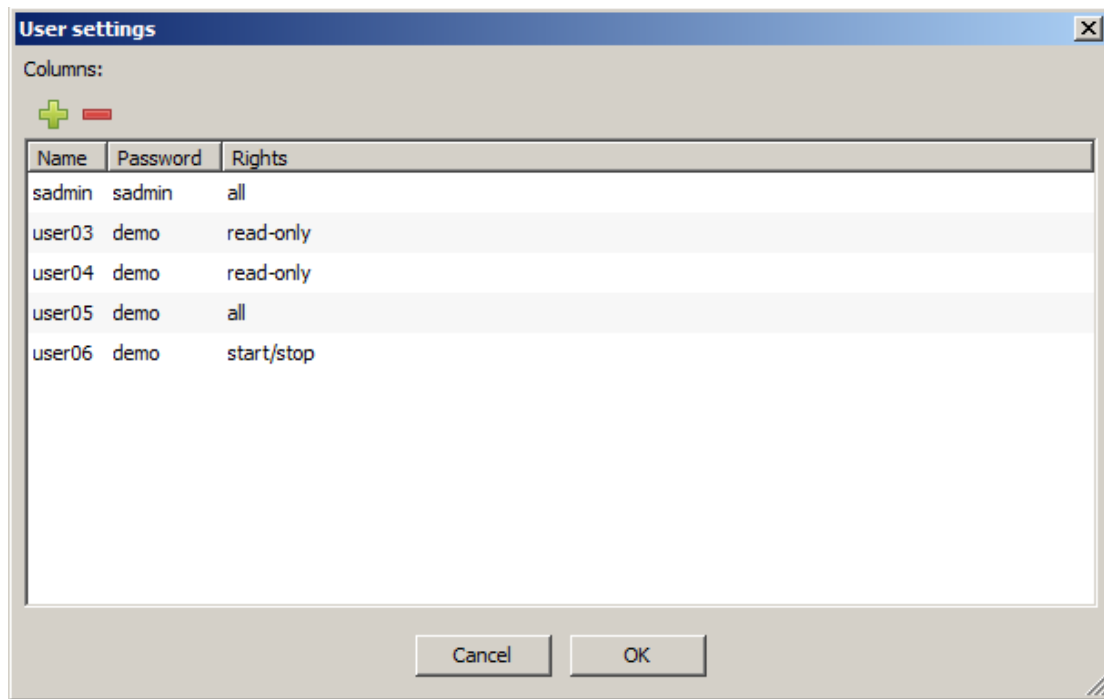
4.1.11 Alarm and Event List

Alarms and Events are logged. The screen shows all alarms and events related to switchgear or protective relays that are important for substation operation. Alarms and Events appearing in the list ion strict chronological order.

Filter operation allows:

- Alarm and Events
- Alarm Only
- Event Only
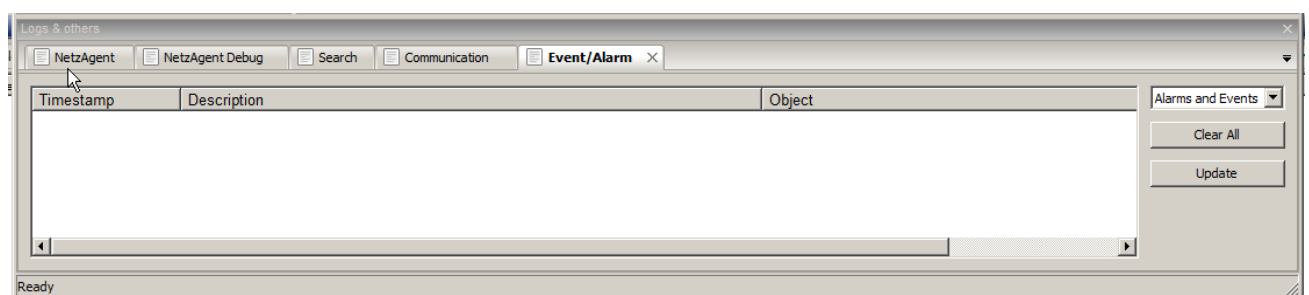
4.2 Linux version of NetzAgent

The program could be started with double click on the **NetzAgent.sh** from File Explorer.
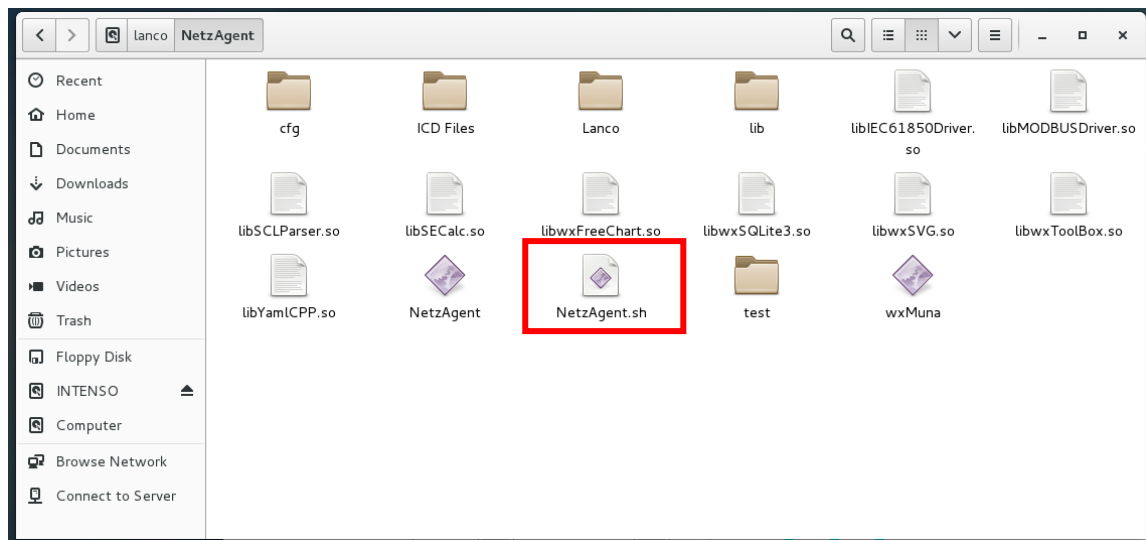
Depend on chosen option in `dconf-editor` program will start or one addition dialog will popup.
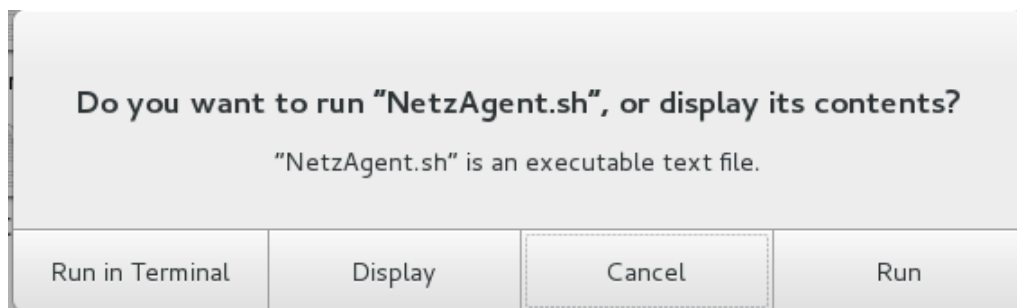
`Run` starts the program NetzAgent.

`Run in Terminal` opens additional terminal and then start NetzAgent. This additional terminal shows the same debug output as is NetzAgent started with option /D in Windows version. This is useful for tracking the communication messages.
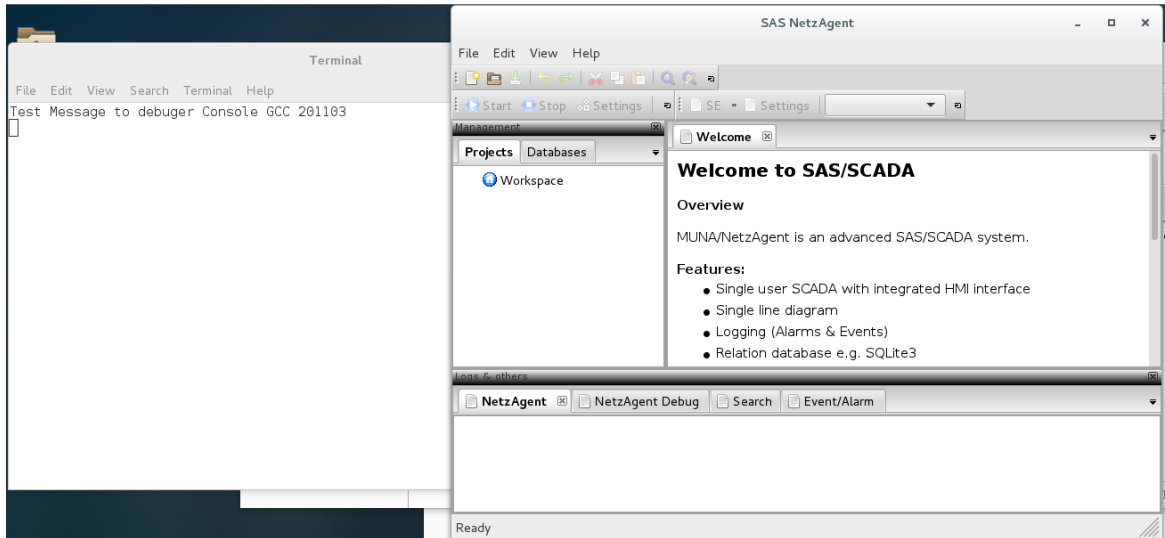
The rest of the program usage is the same as for the Windows version.

5 Editing Single Line Diagram

The single line diagram is SVG file. Scalable Vector Graphics (SVG) is an XML-based vector image format for two-dimensional graphics with support for interactivity and animation. The SVG specification is an open standard developed by the World Wide Web Consortium (W3C) since 1999.

Inkscape Editor (v 0.92) is used for the demo project. Download the last version from https://inkscape.org
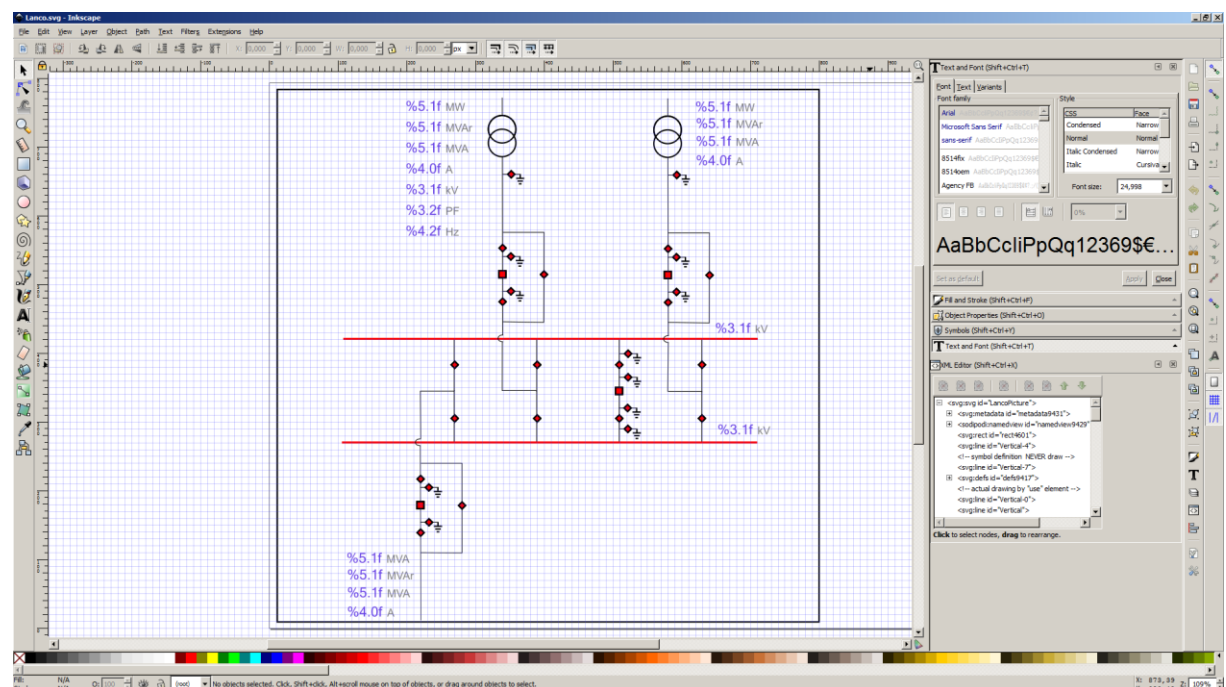
The SLD owns some symbols which could be reused. You can open the symbols pressing `Shift+Ctrl+Y` or from Menu `Object` ➤ `Symbols`
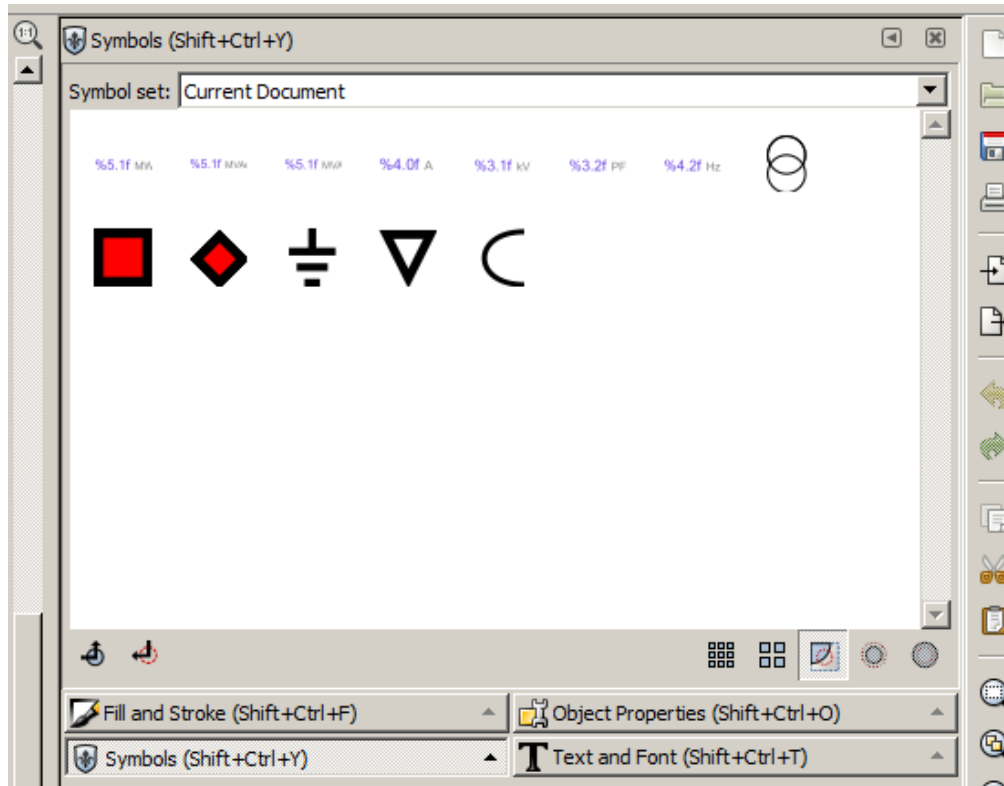
Assign of the new values to the measurement is quite simple. Open XML Editor (`Shift+Ctrl+X` or from Menu `Edit` ➤ `XML Editor`)
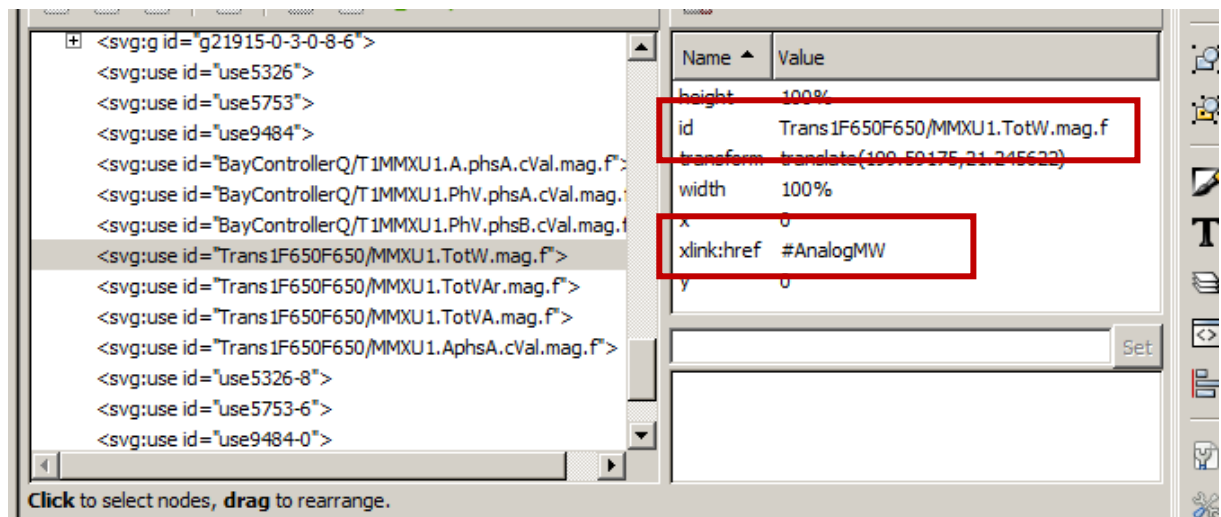
For Object id use the 61850 address and the link is reference to the symbol. In the example, the analog measurement from Transformer Bay 1 will be present as symbol AnalogMW. The symbol is predefined and all objects with the reference to the symbol, will look the same on the screen. In the symbol Analog MW %5.1 is use as output format of the value. If you are changing the id or symbol reference don't forget to press **Set** otherwise the changes are ignored.

The same logic is used for the circuit breaker.
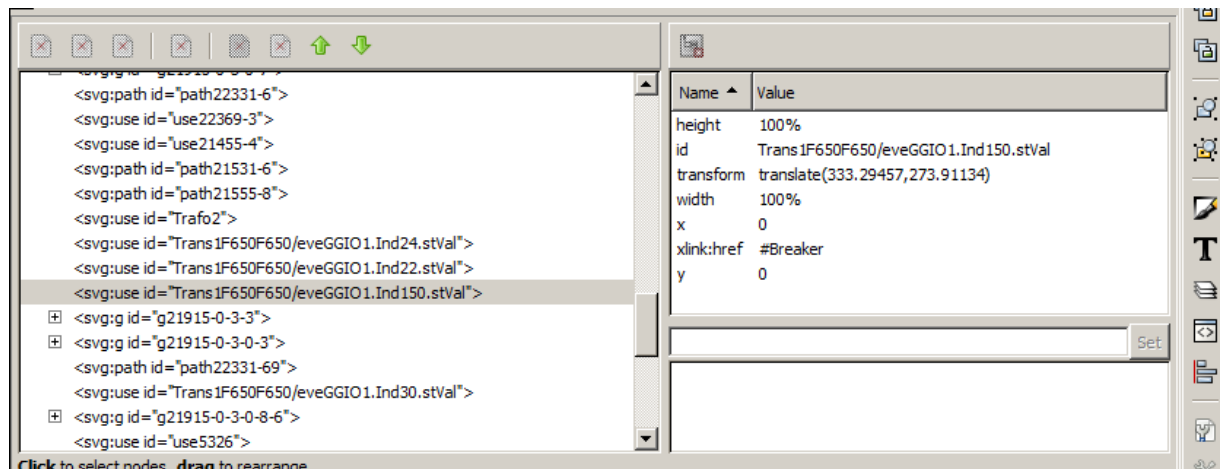
Example of the disconnector.
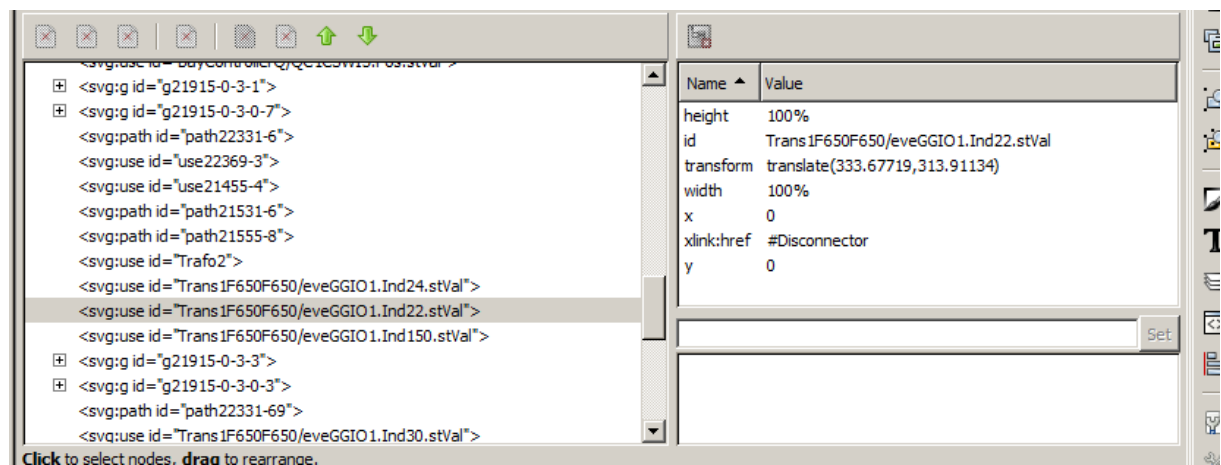
The second way to assign IEC61850 address to the ID is with the help of Object properties (`Shift+Ctrl+X` or from Menu `Object ➤ Object Properties`)

If you have changed the id, don't forget to press **Set** otherwise the changes are ignored. One additional remark for Object properties. Inkscape do not like "/" as part of the ID.

The IEC61850 address "Trans1F650F650/eveGGIO1.Ind20.stVal" will be stored as "Trans1F650F650_eveGGIO1.Ind20.stVal". This is internally handled by NetzAgent and converted back to "Trans1F650F650/eveGGIO1.Ind20.stVal". In any case you can use XML Editor to set id and avoid this difference between IEC61850 addresses and IDs.

ID: Trans1F650F650/eveGGIO1.Ind20.stVal

Label: #Trans1F650F650/eveGGIO1.Ind20.stVal

Title:

Description:

☐ Hide   ☐ Lock   Set

⊞ Interactivity

Fill and Stroke (Shift+Ctrl+F) ▲ | Symbols (Shift+Ctrl+Y) ▲ | Object Properties (Shift+Ctrl+O) ▲
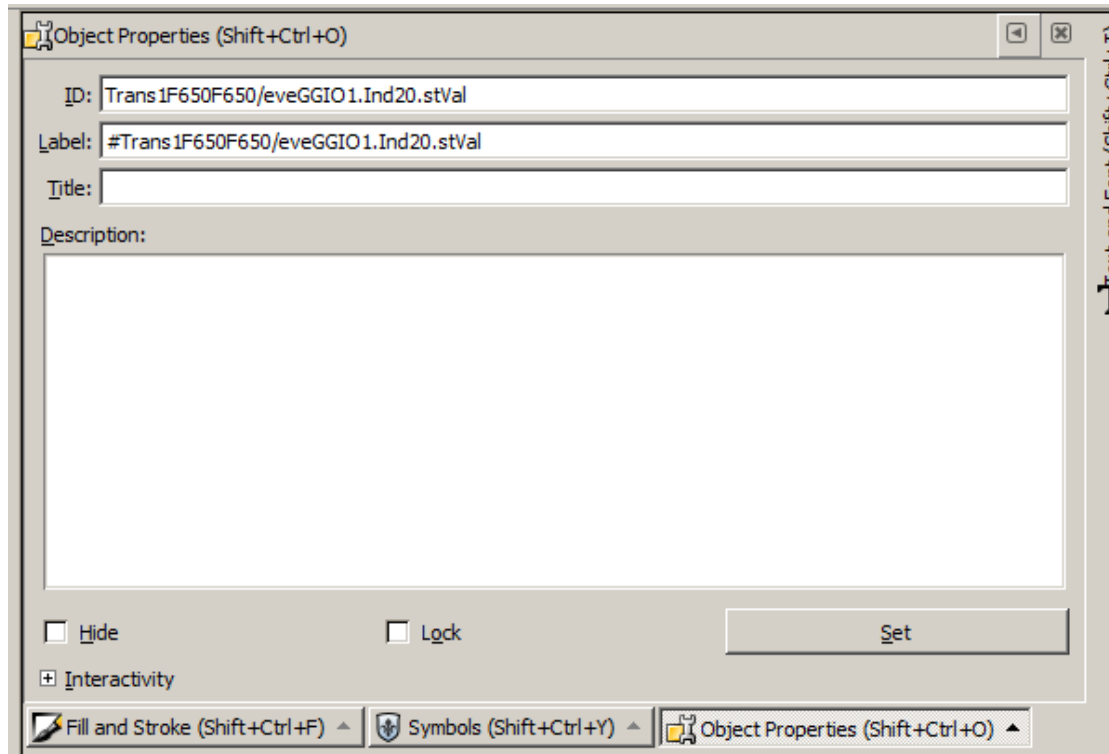
5.1 Symbols

Using the references to the symbols open the possibility of unlimited use of different symbols. The symbols are not hard coded in the application, the symbols are completely in the user domain, and the user can change any symbols. Only required is to define class for the symbol

Example: Class="Analog".

This defines an analog measurement. The type of the analog measurement is defined with symbol id and it is used as reference from the object to the symbol.

Example:

```
<symbol
      id="AnalogMVA"
      class="Analog">
    <rect
        id="AnalogMVA_background"
        x="0"
        y="0"
        width="55"
        height="21"
        style="fill:#ffffff;stroke:#000000;stroke-width:0" />
    <text
        style="font-style:normal;font-variant:normal;font-weight:normal;font-
stretch:normal;font-size:20px;line-height:125%;font-family:'Microsoft  Sans  Serif';-
```

```
inkscape-font-specification:'Microsoft        Sans        Serif';text-align:end;letter-
spacing:0px;word-spacing:0px;writing-mode:lr-tb;text-anchor:end;fill:#6a43e5;fill-
opacity:1;stroke:none"
       x="50"
       y="21"
       id="AnalogMVA_value">%5.1f</text>
    <text
       style="font-style:normal;font-variant:normal;font-weight:normal;font-
stretch:normal;font-size:16px;line-height:125%;font-family:Arial;-inkscape-font-
specification:Arial;text-align:start;letter-spacing:0px;word-spacing:0px;writing-
mode:lr-tb;text-anchor:start;fill:#808080;fill-opacity:1;stroke:none"
       x="57"
       y="21"
       id="AnalogMVA_unit">MVA</text>
  </symbol>
```

All symbols with the same class have "value" and "unit". Value is format how will be number present to the user. In this case the format is %5.1f. The syntax is the same as printf in C or C++ language. Unit is just a text.

Changing data associated with the symbol will affect all elements referencing to changed symbol in the svg file. The symbols are stored together with the file, there are no global symbols.

5.2 Breaker and Disconnector

Digital Measurements (single and double bits) are defined as N objects, with the same position (coordinates). Depend on a signalization only one of the status will be present to the user.

Example:

```
<symbol
id="Breaker"
    class="Switch">
    <rect
       id="B_NU"
       x="1"
       y="1"
       width="10"
       height="10"
       style="visibility:visible;fill:#ff00ff;stroke:#000000;stroke-width:2" />
    <rect
       id="B_00"
       x="1"
       y="1"
       width="10"
       height="10"
       style="visibility:hidden;fill:#ffff00;stroke:#000000;stroke-width:2" />
    <rect
```

```
        id="B_on"
        x="1"
        y="1"
        width="10"
        height="10"
        style="visibility:hidden;fill:#000000;stroke:#000000;stroke-width:2" />
    <rect
        id="B_off"
        x="1"
        y="1"
        width="10"
        height="10"
        style="visibility:hidden;fill:#ffffff;stroke:#000000;stroke-width:2" />
    <rect
        id="11"
        x="1"
        y="1"
        width="10"
        height="10"
        style="visibility:hidden;fill:#ff0000;stroke:#000000;stroke-width:2" />
</symbol>
```

For double bits status it is predefined:

NU	Status is not updated, initial state of the switch
00	intermediate status
off (01)	Switch is open
on (10)	Switch is closed
11	bad status

For single bit status it is predefined:

NU	Status is not updated, initial state of the switch
off	Switch is open
on	Switch is closed

5.3 Alarms

Alarms are defined as N objects, with the same position (coordinates). Depend on a received signalization only one of the status will be present to the user.

Example:

```
<symbol
    class="Alarm"
    id="Alarm">
  <rect
      style="visibility:visible;fill:#ff00ff;stroke:#000000;stroke-width:2"
```

```
            height="30"
            width="30"
            y="1"
            x="1"
            id="A_NU" />
        <rect
            style="visibility:hidden;fill:#000000;stroke:#000000;stroke-width:2"
            height="30"
            width="30"
            y="1"
            x="1"
            id="A_on">
          <animate
              attributeType="XML"
              attributeName="fill"
              values="#800;#f00;#800;#800"
              dur="1"
              repeatCount="indefinite" />
        </rect>
        <rect
            style="visibility:hidden;fill:#ffffff;stroke:#000000;stroke-width:2"
            height="30"
            width="30"
            y="1"
            x="1"
            id="A_off" />
    </symbol>
```

Alarms has predefined statuses:

NU	Alarm status is not updated, initial state of the alarm
off	Alarm gone
on	Object in alarm state (red blinking state)

Kajganic Energy Systems GmbH
Graudenzer Linie 43
68307 Mannheim, Germany
Tel.:   +49 621 4309631
Fax: +49 621 30787808
Web: www.kajganic.com
Email: info@kajganic.com