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MICROSCADA PRO HISTORIAN – REDUNDANCY FEATURES AND PERFORMANCE, IMPLEMENTATION IN MICROSCADA SYSTEM

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Opinnäytetyö suoritettiin ABB Power Grids Finland Oy:n Vaasan yksikköön.

Opinnäytetyön tavoitteena oli kehittää redundanttisen MicroSCADA PRO Historian järjestelmän asennusta ja implementointia. Redundanttisen Historian järjestelmän asennusohjeita ei löydy entuudestaan ohjekirjoista, eikä asennusta ole aiemmin dokumentoitu riittävällä tasolla. Opinnäytetyön aikana suoritettiin simuloitu Historian asennus ja sen toiminta varmistettiin.

Opinnäytetyössä MicroSCADA PRO järjestelmää simuloitiin virtuaalikoneiden avulla. Tutkimuksen lopputuote on yksityiskohtainen asennusohje redundanttisen Historian järjestelmän asennusta varten.

Avainsanat MicroSCADA PRO, SYS600, SYS600 Historian

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ABSTRACT

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This thesis has been written for the ABB Power Grids Finland Oy in Vaasa.

The purpose with this thesis was to develop the installation and implementation of redundant MicroSCADA PRO Historian. No Redundant Historian installation instructions can be found in the software manuals and it has not been documented at a sufficient level before. During the thesis, a simulated Historian installation was performed, and its operation was verified.

The MicroSCADA PRO system was simulated using virtual machines in the thesis. The final product of the research is a detailed installation introduction for the installation of the Redundant Historian application.

Keywords MicroSCADA PRO, SYS600, SYS600 Historian

LIST OF TERMS AND ABBREVIATIONS

CMD	Command Prompt
CPU	Central Processing Unit
DA	Database Address
GUI	Graphical User Interface
HSB	Hot Stand-By
IED	Intelligent Electronic Device
IP	Internet Protocol
LAN	Local Area Network
MicroSCADA	ABB product family
NCC	Network Control Center
PLC	Programmable Logic Controller
RAID	Redundant Array of Independent Disks
RTDB	Real-time database
RTU	Remote Terminal Unit
SA	Substation Automation
SAS	Serial Attached SCSI
SCADA	Supervisory Control And Data Acquisition
SCS	Substation Control System

SCSI	Small Computer System Interface
SYS600	ABB SCADA software
SYS600 Historian	ABB database software
TCP	Transmission Control Protocol
WD	Watchdog
Vtrin	SYS600 Historian GUI

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1 INTRODUCTION

Modern processes involve a large number of measurements. Measurements provide a huge amount of accurate data on process status and events. Properly managed, the information obtained from the process will enable fact-based solutions to be made for both preventive maintenance and future system expansion. It is important to know history in order to be able to predict the future. When data can be stored in the long run, trends and potential problem situations can be found from it, the information obtained from which can be applied in predicting and solving future needs and problem situations. Thus, properly managed, the knowledge gained from the past is very valuable in the development of the company's operations.

The modern SCADA system has a limited ability to store the data obtained from the process and present graphs and tables based on it. When the benefit of the process data needs to be maximized, a separate database system enters the picture. The database system provided by ABB is called SYS600 Historian. SYS600 Historian can record and present process data for up to decades, depending on the project-specific system configuration.

Due to the long service life of the equipment and the large number of operating hours, the possibility of equipment failures and the need for maintenance measures increases. System maintenance usually means a break in the tasks performed by the device. For example, there will be a gap in the process data collected during a database system outage or failure. This problem can be avoided with a redundant system.

In addition to the machine controlling / monitoring the process, there is another identical machine in reserve in the redundant system, which is able to perform the tasks controlled by the machine during a possible fault or maintenance outage. The redundant system significantly reduces damage caused by system failures and increases reliability. Redundant solutions can prevent financial losses to the company's operations and increase security.

The main goal of this thesis is to get acquainted with and develop the installation and implementation of redundant Historian. No Redundant Historian installation instructions can be found in the software manuals and it has not been documented at a sufficient level before. During the thesis, a simulated Historian installation is performed, and its operation is verified. The final product of the research is a detailed installation introduction for the installation of the Redundant Historian application.

In the background of the work, information has been gathered about the structure of ABB's SCADA system, based on which the reader is able to understand the most important components of the MicroSCADA system and their tasks. Based on this information, it is possible to understand the significance and location of the Historian database in the MicroSCADA PRO system.

2 MICROSCADA PRO SYS600

SYS600 is a modular and scalable control system for substation automation and network control. SYS600 is designed mainly for the electric power process but can also be used for industrial processes. The system is scalable regarding capacity, performance and functionality. This chapter introduces the basic components of the SYS600 system and their functions, redundant capabilities and reporting capabilities. The same issues are discussed in chapter 3 of the SYS600 Historian, on the basis of which it is possible for the reader to understand the location of the Historian server in the SYS600 system and to compare redundant capabilities and reporting capabilities.

2.1 SYS600 Architecture

SYS600 systems can provide suitable solutions from small computer monitoring systems to large hierarchical systems with multiple redundant servers.

The main components of a SYS600 system are /1/:

- System servers (2.1.1)
- Communication servers (2.1.2)
- Workstations (2.1.5)
- Printers, GPS clocks, alarm devices
- Communication equipment including switches, routers, modems
  IEDs, process devices, data acquisition units, RTU’s and PLC’s

2.1.1 System Servers

System server handles most of the functions in SYS600. Each system server has one base system that is responsible for the central data processing services. One or several applications can be included in one base system. Different applications can interact with each other, but they are still independent. Number of system servers and applications can vary depending on the size of the SA system. The applications can be divided according to the application area or task. Figure 1 is example of task divided system. System in picture has main system server, system server for reporting, system server for other CPU application for example process display handling and separate communication server. Communication services needed for remote communication and process communication can also be included in the system server.

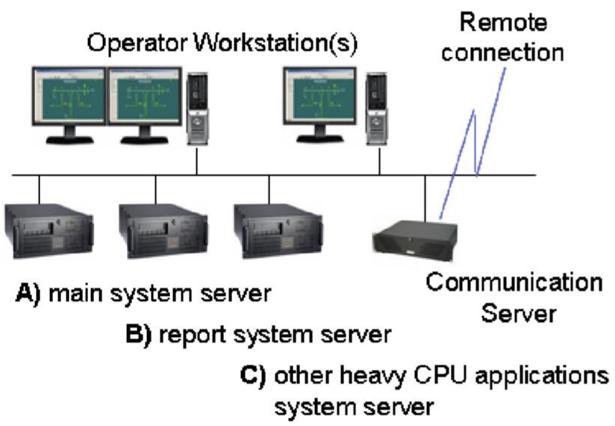


Figure 1. Task divided SYS600 system /1/.

A typical single computer system has one system server with one base system and one application. Large distributed control system can have several servers with several application each. System can also include hot stand-by servers. In HSB configuration all process data, configuration data and so on, are shadowed from hot application over to the stand-by application. Separate system servers decrease impact of hardware failure. HSB configuration is introduced more in chapter 2.2 /1-2/.

2.1.2 Communication Servers

Separate communication server is needed when system demands higher performance and capacity than what one server with everything integrated can handle. Separate communication servers are needed also when system requires redundant communication servers.

Communication between communication server and system server is typically build with LAN connection. If the communication server provides data to several system servers communication server can be configured to have its own process database. Included process database provides higher buffering capacity of the data between the communication server and the system server. Local data processing in the communication server can be also the reason for including the process database. When communication server includes its own process database, it communicates with the system server by means of the process data mirroring function. It provides a powerful means for sharing process data in a SYS600 network with minimal engineering effort. Main components of typical communication server are:

- SYS600 base system
- PC-NET
- IEC61850 OPC Server
- External OPC DA Client

PC-NET includes protocol drivers for all supported protocols, except IEC61850. IEC61850 OPC Server is an IEC61850 client that is connected to SYS600 base system over OPC. External OPC DA Client is used to connect IEC61850 OPC Server to the SYS600 base system /1-2/.

2.1.3 Process Communication

The process communication links process devices like IEDs, RTUs and PLCs to SYS600 system server or communication server. The process communication uses various types of communication protocols depending on the process device. Supported communication protocols are listed later in this chapter. Each protocol has its own characteristics and the physical media and software interfaces. The communication unit (NET) handles the software interface in SYS600. The communication protocol that is used defines the communication unit. Two most common communication units are PC-NET and NET for IEC 61850 protocol. As previously mentioned, PC-NET can handle almost all supported protocols in SYS600 except IEC

61850. IEC61850 is handled by the IEC61850 OPC Server and the External OPC DA Client /1-2/.

To achieve data flow between the process devices and the SYS600 application database installation of the standard functions are needed. Standard functions are predefined and configurable units representing the process devices. For example, a switching device, bay local remote switch or measurement. A standard function contains a set of configurable attributes, which specify how the signal flow is passed between the process devices and the application database. A standard function can be created in the SYS600 Object navigator. There are two standard function libraries available in SYS600, Power process library for electrical applications and Pipeline library for water applications and heat distribution applications. Supported communication protocols in MicroSCADA are the following /3-4/:

- -SPA
- -ANSI
- -LON
- -RP-570
- -RP-570 with FTABs
- -IEC 60870-5-101/104
- -IEC 60870-5-103
- -IEC 61850-8
- -DNP 3.0
- -MODBUS RTU/ASCII/TCP
- -PROCOL

2.1.4 Upper Level Communication

To communicate between process communication and remote communication, gateway is needed. The communication gateway is a system server with a gateway application. The SYS600 gateway application is called COM500i. It can provide a gateway between process devices and up to eight network control centers. The main tasks of COM500i are signal re-routing and protocol conversions from the SCS to the NCC. It can also provide communication supervision and command authority checking. COM500i can be combined with any other SYS600 product option.

COM500i combined with SYS600 can act both as a communication gateway and SCS /1-2/.

2.1.5 Workstations

Workstations are the computers, in which the SYS600 workplace is used. There are two different workplaces in SYS600 systems, Operator and Engineering Workplaces.

The operator workplace is used to supervise and interact with the process with the help of the graphical user interface (GUI). With the operator workplace, it is possible to monitor and control the state of process devices like circuit breakers, earth switches and disconnectors. Real-time measurement data, such as currents, voltages, active powers etc. can be monitored from operator workplace. There are three different supported generations of workplace: Classic, Pro and Workplace X.

The engineering workplace is used for engineering and configuring the system. Two supported engineering workplaces are Classic workplace and Pro workplace. Classic and Pro workplaces can be used for both operation and engineering. User specific access rights can be defined.

Workplaces are in all cases connected to a system server. Each system server can have its local workplace. It is also possible to distribute workplace to other computers and locations. Each system server can have 50 pro workplaces and/or 100 classic workplaces simultaneously in use.

The latest version MicroSCADA X SYS600 10 includes a new workplace so called Workplace X. Workplace X operator workplace allows both local and remote access over the network with Windows application or regular web browser. One of new features that comes with Workplace X is possibility to monitor process with a mobile device.

Pro and classic workplaces remote workplace concept is based on Microsoft's Remote Desktop Services /1-2/.

2.2 SYS600 Redundancy

MicroSCADA Pro supports a redundant architecture to improve availability and to increase the reliability of the system.

In hot stand-by configuration there are two separate base systems, one hosting main application and the other one hosting the back-up application. Base systems are connected through LAN.

During normal operation the main application is active, and it receives the process data. The main application is also managing displays and providing data for the displays. At the same time, the application data of the main application is continuously copied to the back-up application. Both applications are all times exactly the same. Figure 2 presents the state of the system during normal operation.

In case of fault in the main application, the back-up application is started and takes over all operational functions. After the recovery and restart of the former main application, it can be used as a new back-up application or applications can be returned to their original tasks.

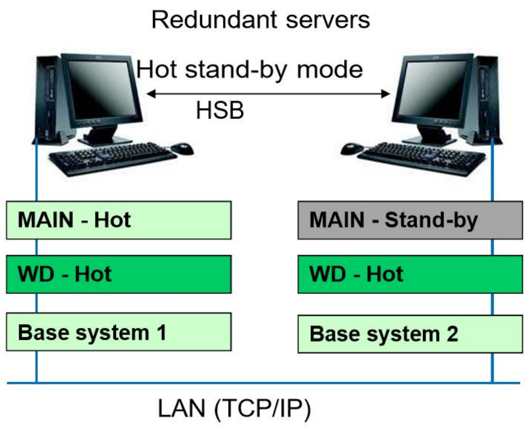


Figure 2. HSB configuration during normal operation /2/.

Only changes of process and report data stored in the RAM and all changes of files under the application subdirectories are shadowed from the main application to stand-by application.

During normal operation, the main application cyclically sends diagnostic messages to the stand-by application. If the main application does not receive acknowledgments from the stand-by system, shadowing stops. During connection failure, the Watchdog (WD) application sends commands cyclically to the stand-by system. This way the watchdog application can check the connection. Shadowing starts when the connection is re-established and file and RAM dump is completed.

During normal operation, the WD application of stand-by system monitors the messages sent from the main application. Takeover is started if the WD application does not receive messages from the main application during specified time. The stand-by application is set to HOT. Figure 3 presents the state of the system during takeover. As mentioned earlier, during failure the WD application checks the connection. When the connection to the former main application is re-established, the former stand-by application can continue as a main application or the system can be returned to the original state.

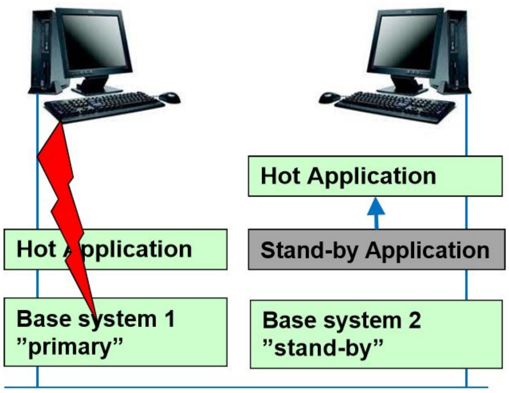


Figure 3. HSB configuration during takeover /2/.

When communication is established after the HSB system start-up or takeover, the stand-by application sends a list of all files under the application subdirectories to the main application. The main application compares its own similar list to the list from the stand-by application. The list of actions to be taken in order to get the files identical is created based on the comparison of two lists. Two files are considered identical if their name, creation time, modified time and size are identical. Executing the action list is called 'file dump'. All application data of the main application stored in the RAM is copied to the stand-by system. The copying of RAM data is called 'RAM dump'. The shadowing starts after the file and RAM dump is completed /1-2/.

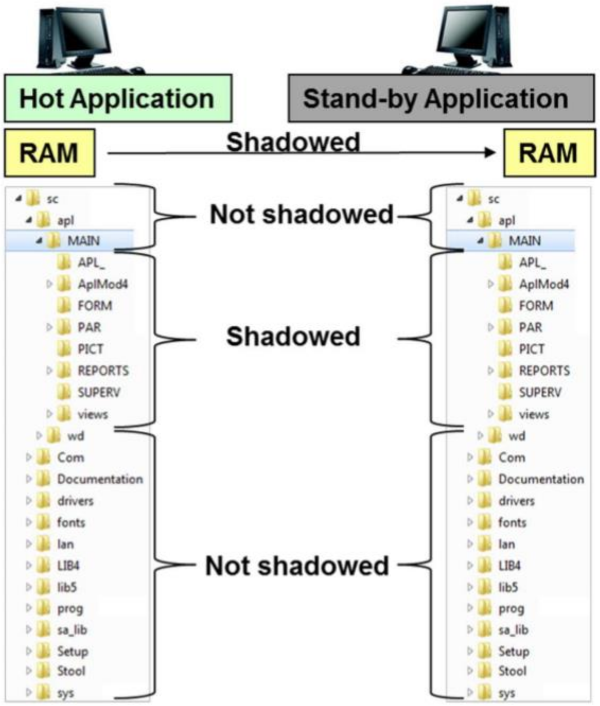


Figure 4. Files that are shadowed during file dump /2/.

2.3 SYS600 Reporting

SYS600 has built in flexible data logging mechanism that is capable of cyclic and event-based logging of data of various data types. The data of the system is stored in data objects. One data object can hold between 1-2 000 000 data entries of one data type only. The maximum number of data objects and command procedures is 2 000 000, so the total number of data entries is 4*10^12. If the system requires more storage for data, the SYS600 Historian database has to be used.

Collected process data can be visualized with graphs and reports. SYS600 has Trends and Measurement Reports packages that are easy to configure and use. Packages include predefined application objects.

The trends display can be used for visualizing measured values in the graphical view mode or the tabular view mode. All kind of process objects can be shown as trends. The update interval of the trend display can be configured from 10 seconds to 10 minutes. It is possible to edit and clear trend data by the user. Data can be also exported to .CSV file or copied to clipboard /1, 5/.

Measurement reports are used when log and report data is needed from a longer period. The measurement reports display is dedicated for current, voltage, energy and frequency reports. Available report types are hourly, daily, weekly, monthly and yearly report. The time resolution of hourly report can be configured to 1, 2, 3, 5, 6, 10, 15, 20 or 30 minutes. Raw data can be stored for 100 days. The time resolution of daily report can be configured to 10, 15, 30 or 60 minutes. Base period values are calculated from raw data and can be stored for five years. Weekly and monthly reports have time resolution of one day. The yearly report has time resolution of one month. Weekly, monthly and yearly report values are calculated from period values and data is not stored. Longer storage periods can be achieved with external reporting database /1, 4/.

3 MICROSCADA PRO SYS600 HISTORIAN

Modern day intelligent network solutions provides a large amount of important information of the primary process. To get all the advantage of the available data, more efficient reporting capabilities are needed. SYS600 historian provides long time storage for all process data and further improved visualization and reporting features. Information from SYS600 historian can be used for system maintenance & planning, troubleshooting & diagnosis, business planning and customer service.

3.1 Historian Server

Historian is mainly used from a dedicated server but integration with the system server is possible for light usage. The Historian server communicates with the system server over a TCP/IP LAN. As presented in Figure 5 one system server can provide data for multiple Historian servers and each Historian server can collect data from multiple system servers. With a traditional license, the system server can connect to 10 Historian databases and write to 200,000 tags in all databases together. The license limits the number of workplaces in the Historian system to 20. The Historian can be connected to a running MicroSCADA system without interruption to the operation /6/.

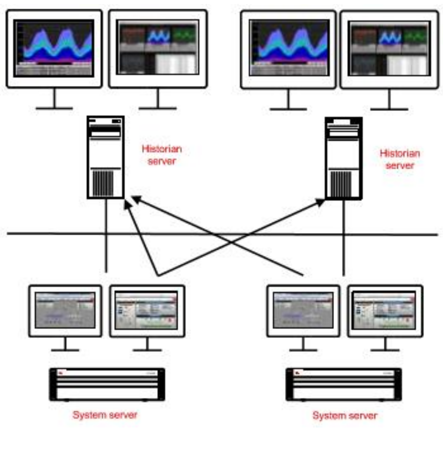


Figure 5. Example of Historian system architecture /6/.

Historian is not CPU intensive, so all modern server CPUs can perform at the required level. SYS600 Historian is highly IO intensive. The disk containing RTDB must have a high rotational speed, so SAS disks are usually used for this purpose. RAID configuration can be used to gain performance and redundancy. RAID 1+0 is the preferable RAID level for I/O-intensive applications. Figure 6 shows example of possible Disk Configuration.

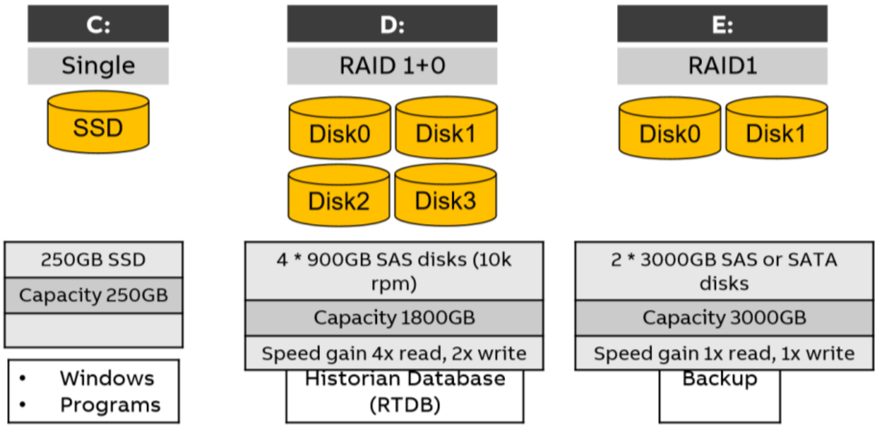


Figure 6. Example of Historian Disk Configuration /6/.

SYS600 Historian database can be located in any Windows folder but, in typical installation the database is located in a separate hard disk drive. The SYS600 Historian database must located in a single Windows folder. The RTDB database cannot be partially divided in to two different storage places at the same time. Queries and data storage shall be always done into one place. For performance reasons, it is recommended, whenever possible, to have the disk containing SYS600 Historian database to be formatted using 64kB block size. The SYS600 Historian software is typically located on the system disk C. Online, essential and application backups of SYS600 Historian are also located in separated data disk. Network drivers can also be used for backup. The size of the database online backup must be at least the same as of the actual database. Figure 7 visualizes a basic Historian setup /6/.

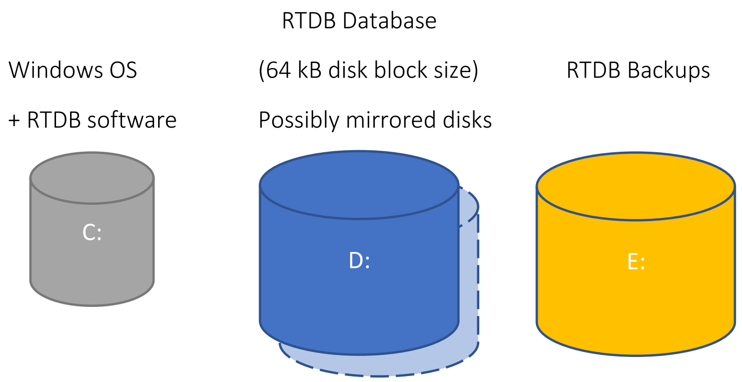


Figure 7. Basic Historian disk configuration.

3.2 History Tables

Historian data logging is based on the History tables. A CurrentHistory table contains all updates reported from MicroSCADA system. As shown in Figure 8, all other history tables contains transformed data from CurrentHistory. With Vtrin user can modify or create new History tables.

Figure 8. Historian History Tables.

Each History tables has its own settings. The settings specify the source, cycles and interval, length and edit permissions for the History table. The length of the History table can be determined by time or size.

Historian uses file splitting in order to increase the performance. File splitting splits one History table into several files on the disk. The split length is determined by a time parameter. The recommended number of splits is less than 50, but the absolute maximum number allowed is 400. Exceeding the maximum number of splits limit will stop collecting data to the table in question, so it is very important to calculate the number of splits when configuring History table 6-7/. For example:

-Needed History duration is 10 years = 3650 days

-Split length is determined 14 days

-3650/14= 260 < 400

3.3 Vtrin

The SYS600 Historian database is accessed using a separate user interface, called Vtrin. It allows the user to visualize data in form of trends and reports. With Vtrin the user can also modify database values /7/.

This chapter introduces basic features, functions and capabilities of Vtrin briefly.

3.3.1 Vtrin User Interface

Four local user groups are created in Windows by SYS600 Historian installation. All groups have different user interface views and access rights.

-RTDB-admin: All rights to the RTDB-system and full access within Vtrin user interface (Administrator and MicroSCADA roles)

-RTDB-operator: Operator rights to the RTDB-system and has limited access control to the tree view nodes/leafs and some of the functions are hidden (Engineer role)

-RTDB-readonly: Read-only rights to the RTDB-system (User role)

-RTDB-robots: RTDB-robots is meant to be used by non-interactive software. Interactive users should not be included into RTDB-robots group.

When logged in as an Administrator, each role can be accessed from left down corner in user interface (Figure 9, 1). The Vtrin user interface consist of three basic user interface components, Tree view (Figure 9, 2), generic properties window (Figure 9, 3) and Window area (Figure 9, 4). Tree and Window area are visible for all roles. The generic properties window is visible for the admin role only. This chapter introduces these three basic components.

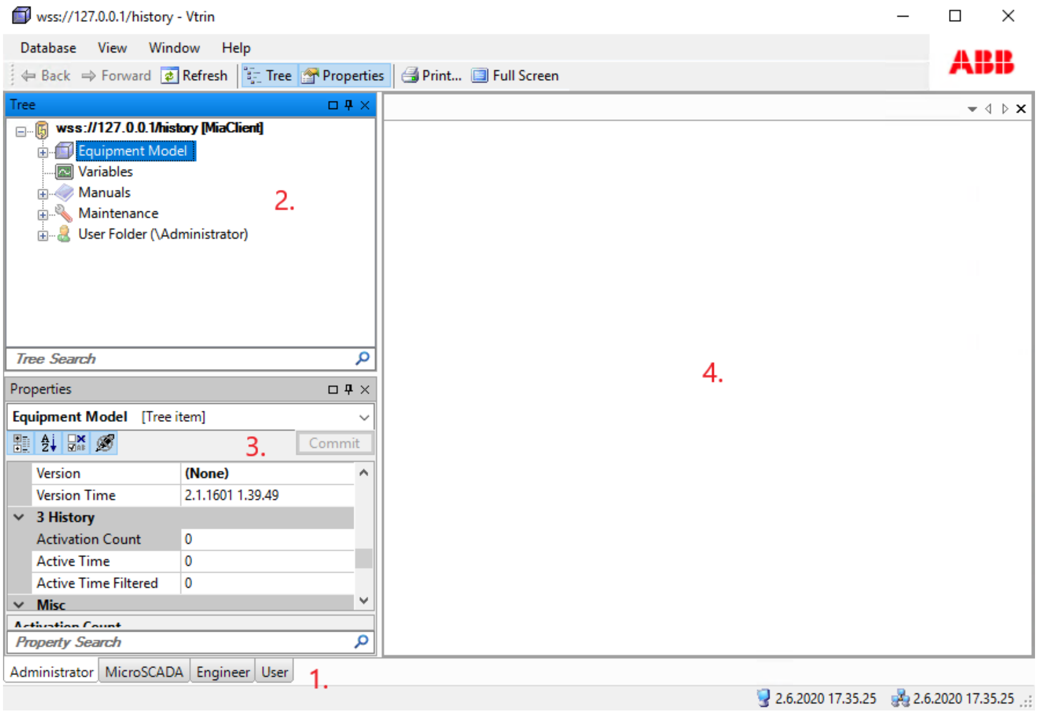


Figure 9. Vtrin administrator User Interface.

The tree view provides access to all displays. It can be hidden or shown with the Tree button on toolbar. The text colour of the Tree indicates the access rights of the user. The black text indicates write access and the blue text read-only access. The content that is shown in the tree view depending on role of the user. The content available for the admin user is described in this chapter. The Tree view is presented in Figure 10.

In the tree view the root of tree shows the name of the data source connected. Under the root is Equipment Model that is empty by default. Under Equipment Model is the hierarchic structure of variables and tags represent after configuration in SYS600.

All available variables of the system are shown on Variables list.

Links to SYS600 Historian manuals can be found under Manuals.

The maintenance folder contains many useful lists and tools for administration. From the Maintenance, the user can, for example create tags, add new history transformations, monitor component status and configure service parameters. Redundancy monitoring can be also added under maintenance.

In the User Folder, elements that should only be visible for a particular user can be created. Only the admin can access all users' folders. The user always has write access to their own User Folder.

At the bottom of the Tree window there is a Tree search. The tree search is a very valuable tool for filtering and finding components fast. It is used simply by starting to write a component name in the search field /6-7/.

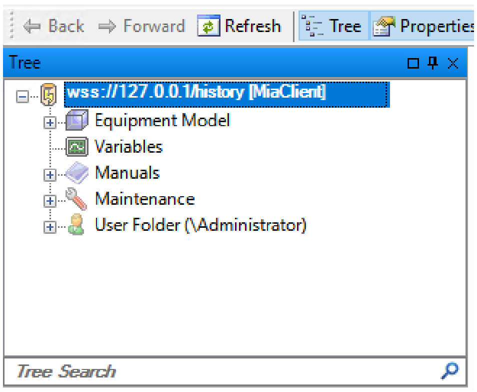


Figure 10. Vtrin Tree View.

The Generic properties window displays the information of the currently selected object. The selected object can be either a graphical user interface element or actual process data from database. The Generic properties window is presented in Figure 11. The buttons in the toolbar can be used to sort and filter properties. The first button from left organizes properties by category. The second button from left sorts properties alphabetically. The third button from left shows selected properties only. The fourth button from left includes read-only properties.

At the bottom of the generic properties window there is property search. The property search works in the same way as Tree search /6-7/.

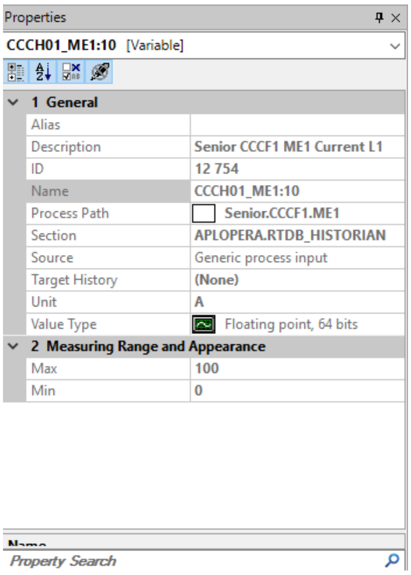


Figure 11. Generic properties window.

The Window area is used to view list windows and chart windows. Windows can be opened to a full screen size, in which case the windows will appear as tabs in the top bar. As shown in Figure 12, from the window area it is also possible to observe several pages at the same time. The configured window area view can be saved so that the next time the Vtrin is started, the window area will open with the same workspace layout. Workspace layouts are user specific.

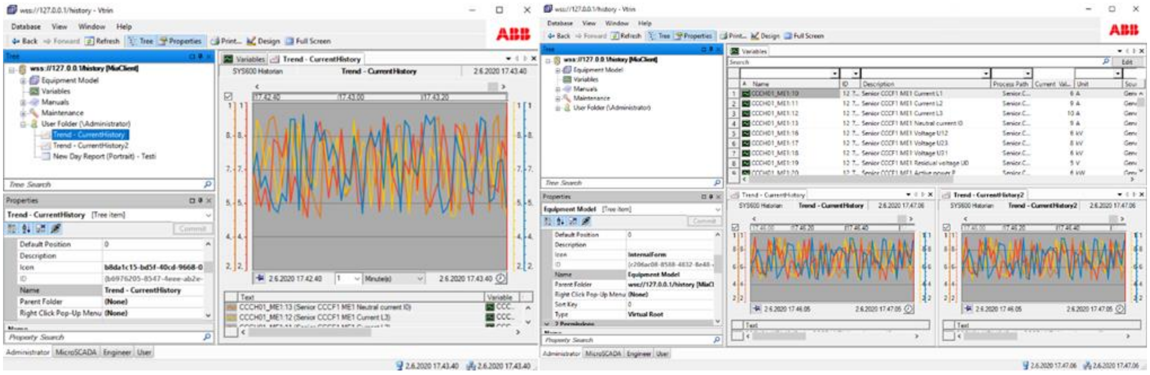


Figure 12. Windows can be opened to full screen size or several pages at the same time

The Vtrin List windows are used for presenting signal and log lists. The List window shows the selected properties of selected class. With the List window, it is possible to sort and filter data based on any selected property. It is also possible for the user to specify the content the list is showing. This way user can pre-configure different kinds of lists for various use-cases. The variables window is a good example of signal lists.

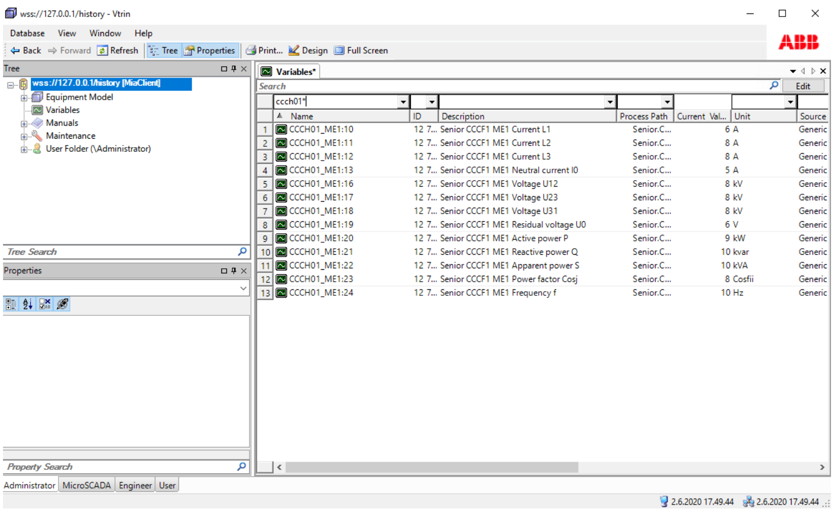


Figure 13. Variables list.

Log lists are used for presenting logs. The log list has a time scale in the same way as trends. The timeline can be seen at the bottom of Figure 14. The time scale is a useful tool for fast searching for events in a specific interval. More detailed information about the possibilities of time scale configuration can be found later in this chapter. The CVMC message Log that gathers diagnostic messages from Historian system is a good example of Log lists.

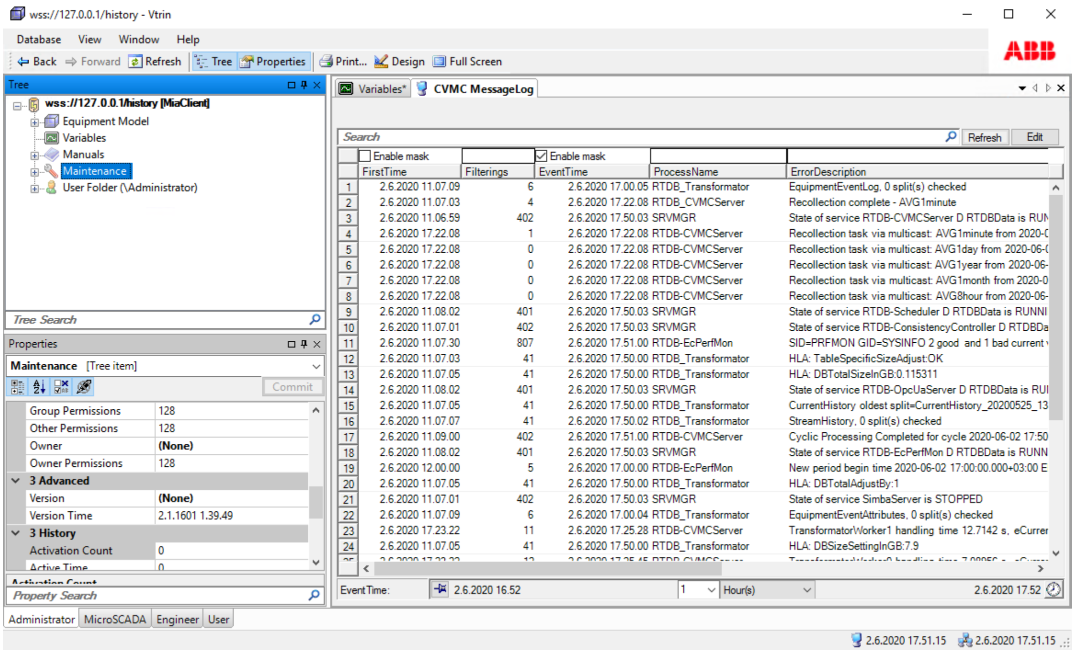


Figure 14. CVMC MessageLog.

The Vtrin chart window is used to present charts. The chart is named automatically based on the name that it has in the tree (Figure 16, 1). The name can be edited in the title area.

The scaling limits (Figure 16, 2) are displayed on left side or both sides of the plot area depending on number of charts. Each chart has its own area for limits. Scaling limits can be displayed with the upper and lower limits of scaling displayed in the boxes, or by using scales whose end points correspond to the upper and lower limits /8/.

The time bar (Figure 16, 3) allows the user to select the time range for displaying the plots of the variables. The time bar displays the start time of the time span in the left end of the row and the end time of the time span on the right end. The time span that is the difference between the start time and the end time is located in the middle of the time bar. The user can change the interval of the time span by changing either the value and/or unit. Both ends of the time bar has pin icons that indicates the state of the updating /8/.

	The time next to the pin is updated (only used at the right end)
	The time next to the pin is unlocked
	The time next to the pin is locked

Figure 15. Definitions of pin icons /8/.

Legend (Figure 16, 4) displays data related to variables of the chart area. The legends of the trend charts are usually located below the chart area. Each chart has its own legend. The legend can be configured to display for example variable names, aliases, IDs, descriptions, current values and units of current value. The legend can also show data for items which there is no chart visualization /8/.

The pointer value column (Figure 16, 5) shows the time related value assigned from the graph. The desired time related value can be pointed from the chart by clicking on the desired point on the chart. By clicking on the plot area, the turquoise vertical trend value line will appear at the cursor position. Clicking anywhere in the plot area will make the trend value line disappear. Clicking the plot area again will display a new trend value line with time and variable values /8/.

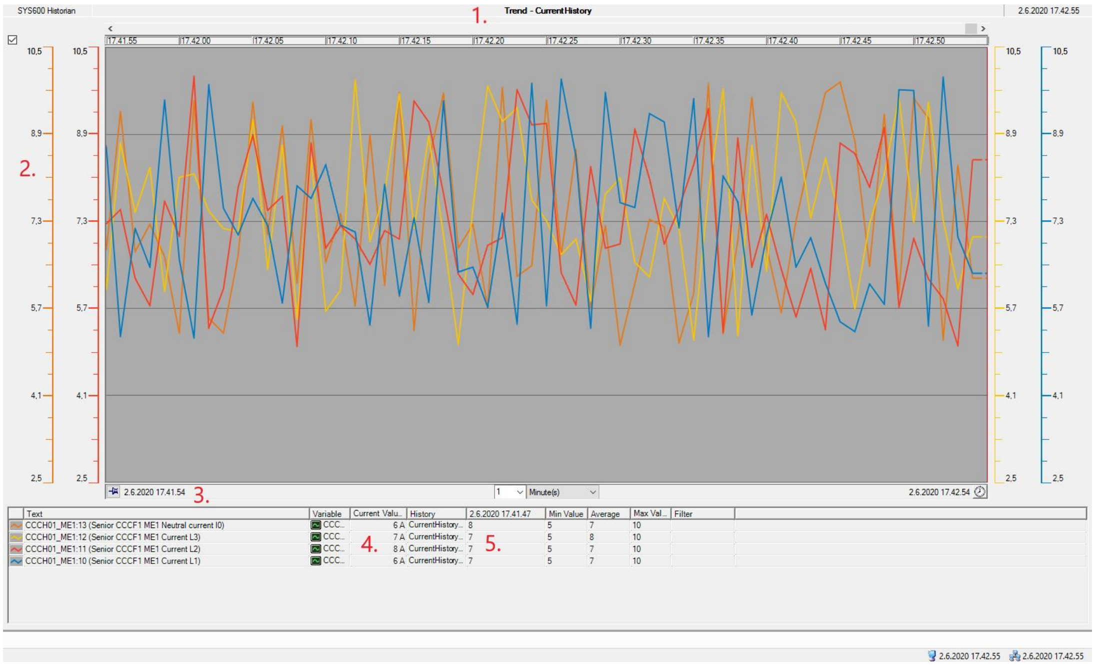


Figure 16. Vtrin Chart Window.

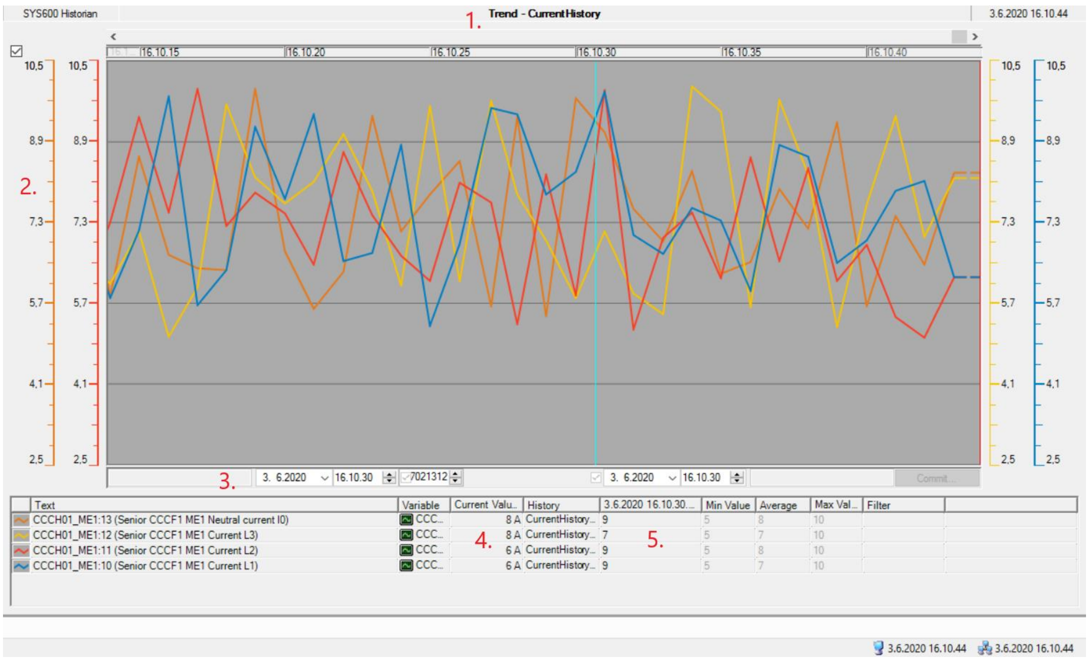


Figure 17. Vtrin Chart Window when pointer value is selected.

3.3.2 Vtrin Charts

Vtrin displays graphical information is shown in charts. Charts can contain for example pictures, graphs, plots, value controls and text blocks. One chart can display multiple graphical elements. This chapter introduces basic features and possibilities of Vtrin charts.

The fastest way to view database variables as graphs is to select the desired variable from the variables list and click send to trend. More variables can be added to the same graph by dragging them from variable list or from graph properties dialog. This is a temporary way to create charts, so the trend is not saved for later use.

If the chart needs to be viewed more than once, the tree item should be created for the chart. A new tree item can be created by right clicking the icon or the folder where the new folder should be created > New Tree Item > type of wanted trend. The trend is named after creation. More variables can be added into the graph by dragging them from variable list or from graph properties dialog

Calculated trend items can be created based on existing trend items from properties dialog.

Each item in trend can take data from different history tables. The same variable can be added as several items into the trend. This way it is possible to view for example MIN, MAX and AVG values of the same variable in the same trend (Figure 18, 1).

With Filter column (Figure 18, 2) any user can add calculations to a trend graph. A filter can be entered directly in the legend or in the properties dialog.

From the properties dialog is also possible to edit background pictures and colours, pointing options and default line colours etc /6, 8/.

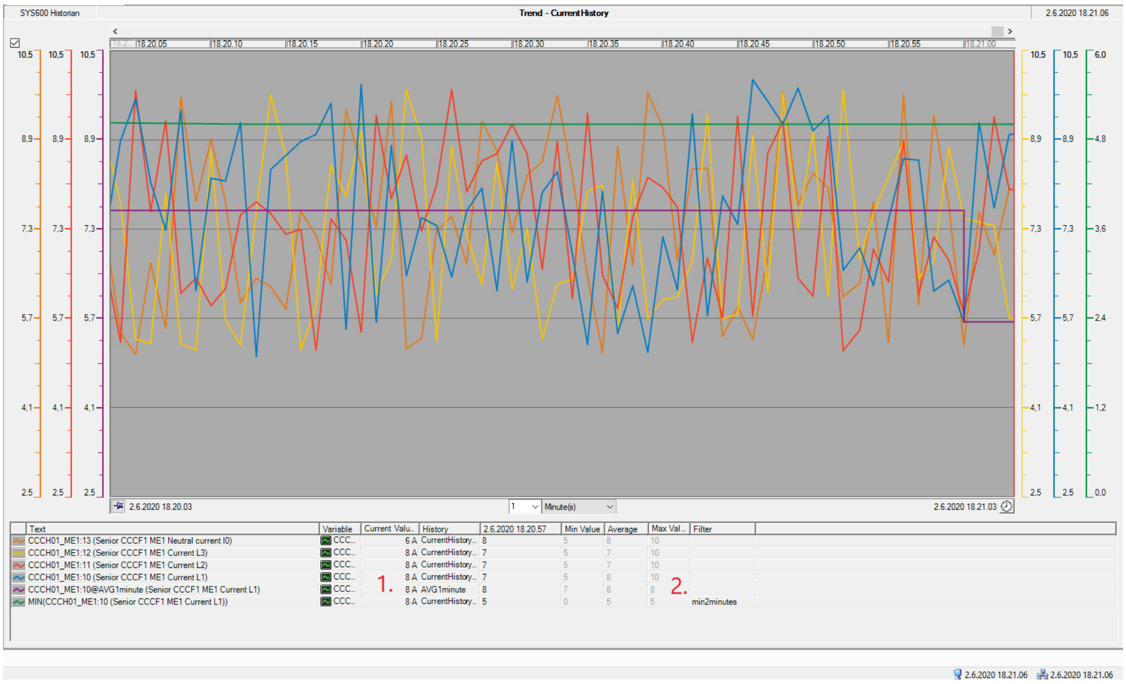


Figure 18. Vtrin Chart.

3.3.3 Vtrin Reports

Available report types in Vtrin are day, week, month and year report.

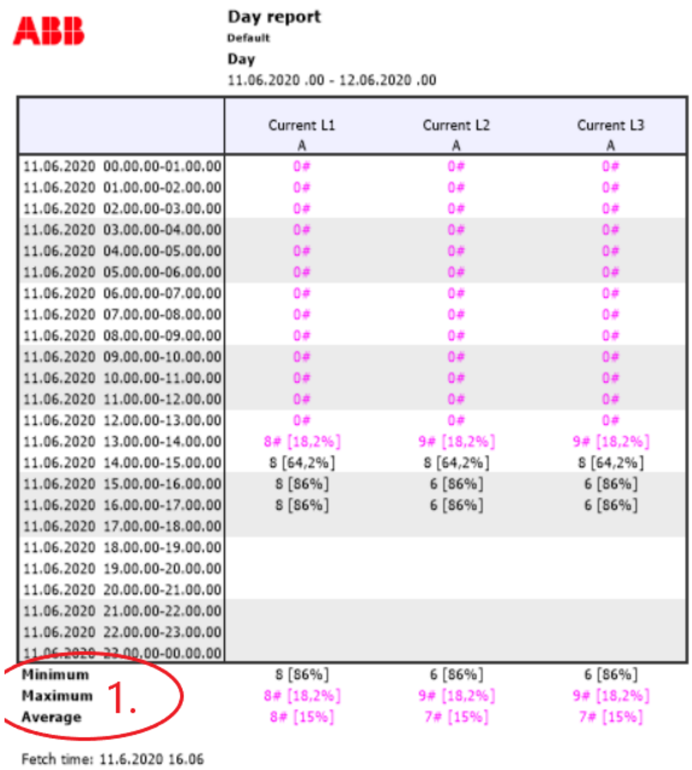
A Vtrin report is created by selecting the folder where the new report should be created > New Tree Item > Trend type. Variables can be added to report with dragging them from variables list.

From the report configuration the user can define the orientation of report. The orientation defines in this context how values are listed. Portrait means the values are listed from top to bottom while landscape means the values are listed from left to right.

From report configuration > Levels > Variables the user can define reports variable names, units, number of decimals and allow editing of values. The parameters are defined for each variable separately.

Column width can be changed from Levels > General > Layout.

Additional values (Figure 19, 1.) can be added from report configuration > Advanced > Additional values. A report has minimum and maximum values by default.



	Current L1 A	Current L2 A	Current L3 A
11.06.2020 00.00.00-01.00.00	0#	0#	0#
11.06.2020 01.00.00-02.00.00	0#	0#	0#
11.06.2020 02.00.00-03.00.00	0#	0#	0#
11.06.2020 03.00.00-04.00.00	0#	0#	0#
11.06.2020 04.00.00-05.00.00	0#	0#	0#
11.06.2020 05.00.00-06.00.00	0#	0#	0#
11.06.2020 06.00.00-07.00.00	0#	0#	0#
11.06.2020 07.00.00-08.00.00	0#	0#	0#
11.06.2020 08.00.00-09.00.00	0#	0#	0#
11.06.2020 09.00.00-10.00.00	0#	0#	0#
11.06.2020 10.00.00-11.00.00	0#	0#	0#
11.06.2020 11.00.00-12.00.00	0#	0#	0#
11.06.2020 12.00.00-13.00.00	0#	0#	0#
11.06.2020 13.00.00-14.00.00	8# [18,2%]	9# [18,2%]	9# [18,2%]
11.06.2020 14.00.00-15.00.00	8 [64,2%]	8 [64,2%]	8 [64,2%]
11.06.2020 15.00.00-16.00.00	8 [86%]	6 [86%]	6 [86%]
11.06.2020 16.00.00-17.00.00	8 [86%]	6 [86%]	6 [86%]
11.06.2020 17.00.00-18.00.00			
11.06.2020 18.00.00-19.00.00			
11.06.2020 19.00.00-20.00.00			
11.06.2020 20.00.00-21.00.00			
11.06.2020 21.00.00-22.00.00			
11.06.2020 22.00.00-23.00.00			
11.06.2020 23.00.00-00.00.00			
Minimum	8 [86%]	6 [86%]	6 [86%]
Maximum	8# [18,2%]	9# [18,2%]	9# [18,2%]
Average	8# [15%]	7# [15%]	7# [15%]

Figure 19. Example of day report.

It is possible to add calculations and graphs to the reports. Charts can be added from report configuration > Charts. Variables are added to chart from Levels > Variables > Charts. Each variable is added separately.

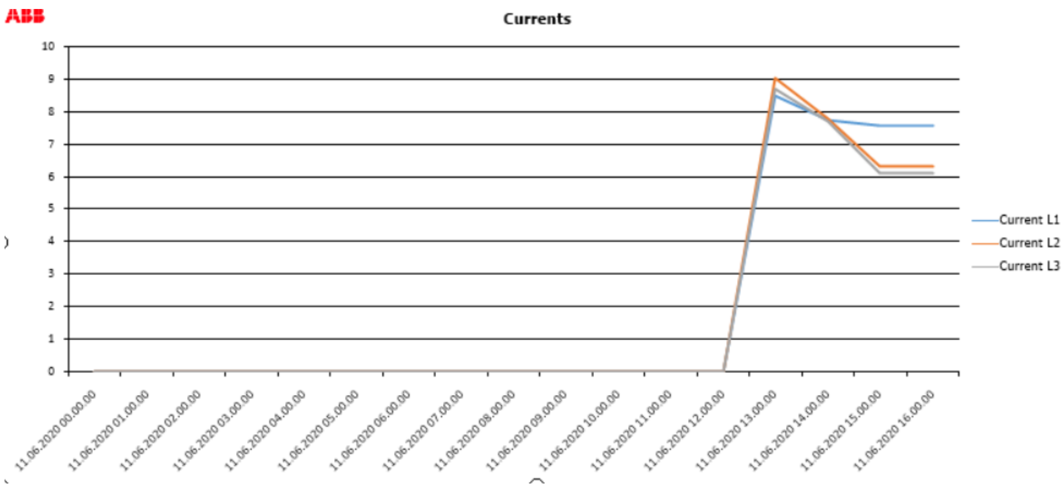


Figure 20. Day report chart.

Calculations can be added from Levels > Variables > add new. Formulas can be easily entered by clicking the formula helper button.

Vtrin reports can be saved as Excel workbooks. Excel workbooks can be saved by right-clicking on the toolbar > To attachment /6/.

3.4 SYS600 Historian Redundancy

SYS600 Historian supports redundant architecture like all the other products in MicroSCADA Pro product family.

The redundant Historian system is very similar in features and operation to the SYS600 redundant system except few differences. The redundant Historian system consists of two separate Historian servers. Servers are usually connected to each other over TCP / LAN communication.

When the system is operating normally, one server collects information from the SYS600 system, and the other server synchronizes the History tables from the server connected to the SYS600 system. The Vtrin interfaces of the Historian servers are completely similar.

Monitoring the connection between the SYS600 and the Historian server and controlling the change between databases in the event of a fault is performed in the SYS600 program. The communication status of the SYS600 and the history servers can be monitored in the SYS600 program from the path: Tool manager > Object manager > Logging Profiles > Database. Database Address (DA) displays database connected. The Object Status (OS) displays the state of the connection between SYS600 and Historian database. Figure 21 shows the Database view on the left when the connection is lost and on the right when the connection is active.

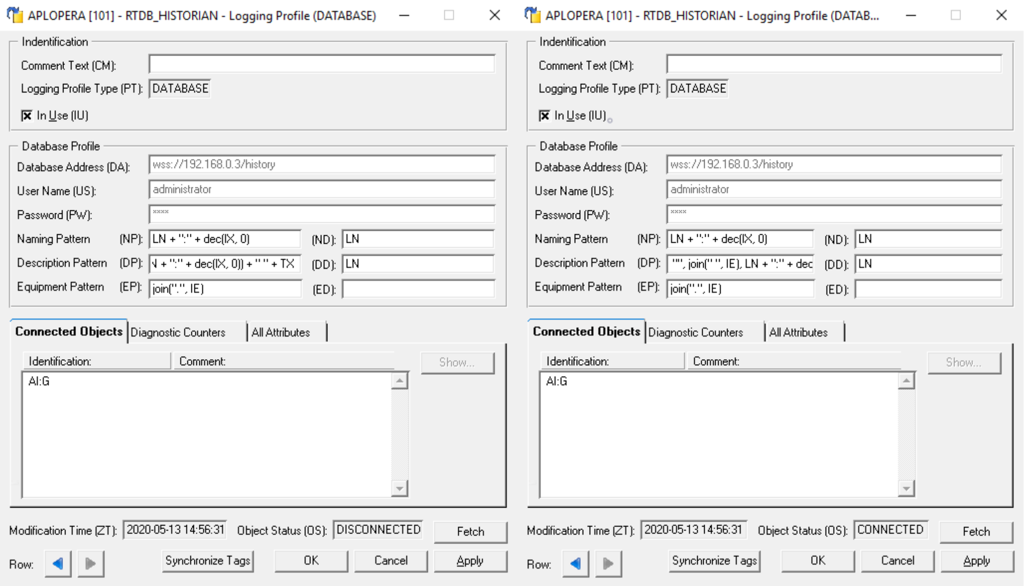


Figure 21. Database status on the left when the connection is down and, on the right, when the connection is active.

The database exchange control in the case of a system failure is implemented in a redundant Historian system with a separate command procedure added to the SYS600 program. When the connection is lost, the SYS600 creates an event based on a change in the system. HISTORIAN_EVENT command procedure monitors events created in SYS600 system and based on them make changes to the Database Address (DA). If the connection does not start working despite the change of address, there is a separate HISTORIAN_CYCLICAL procedure for cyclic handover in the added command procedure for such situations. Cyclic switching attempts to connect to both History servers alternately at certain intervals until a connection is reached.

Unlike the SYS600 HSB configuration, in the History system, when the connection returns after a failure, the machine that was hot during the failure remains always hot and the machine that was hot before the failure takes the standby role. The system is satisfied with the state in which the SYS600 is connected to either database and does not proceed to restore the situation prior to the failure. When the system connection is restored, the History servers automatically synchronize the server database that was down during the failure. This may take some time depending on the amount of data. In addition to the database data, the system also synchronizes for example changes to graphs and reports during the fault.

The redundancy status of the Historian system can be monitored using the Redundancy folder added to the Vtrin program. The Redundancy Control page in the Redundancy folder allows the user to monitor the overall status of the system and view the time of the last synchronization.

In the situation in Figure 22, the connection to the Historian server HIS1 is active and the other Historian server HIS2 is down. From the Redundancy Control page status column, it can be stated that the status of the HIS2 server is inactive. From the Redundancy Control page tables column, it can be stated that no table is synchronizing.

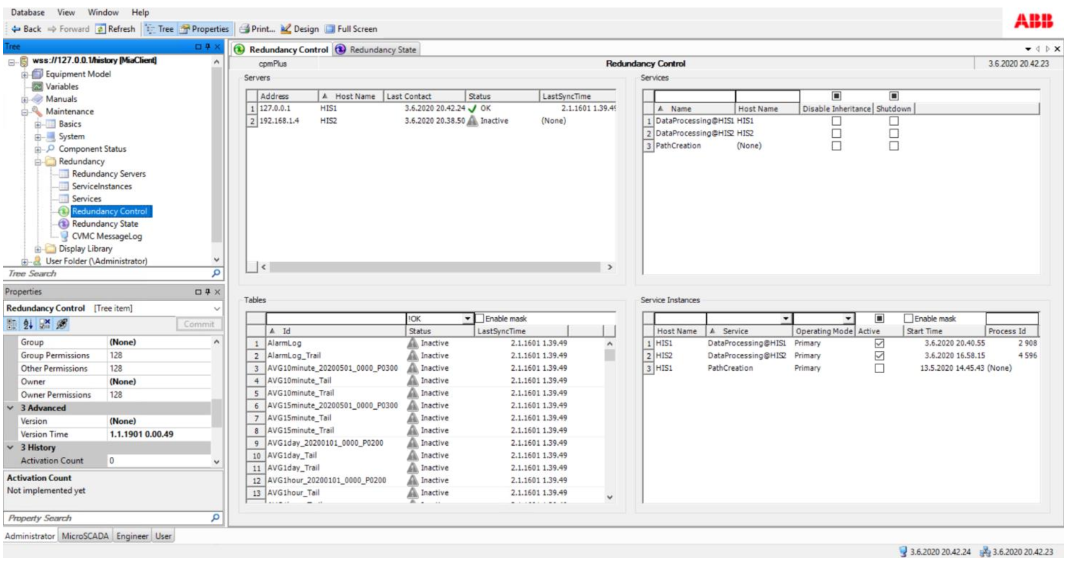


Figure 22. Redundancy Control page when the connection between the Historian servers is down.

In the situation in Figure 23, the connection between Historian servers is active. In the Redundancy Control page status column, it can be stated that servers are synchronizing. The Historian server receives new data from the SYS600 all the time, so the servers are practically never fully synchronized. The LastSyncTime column of the Redundancy Control page shows the last synchronization time of the system. The status of the tables on the Redundancy Control page indicates that the system is synchronizing the CurrentHistory table.

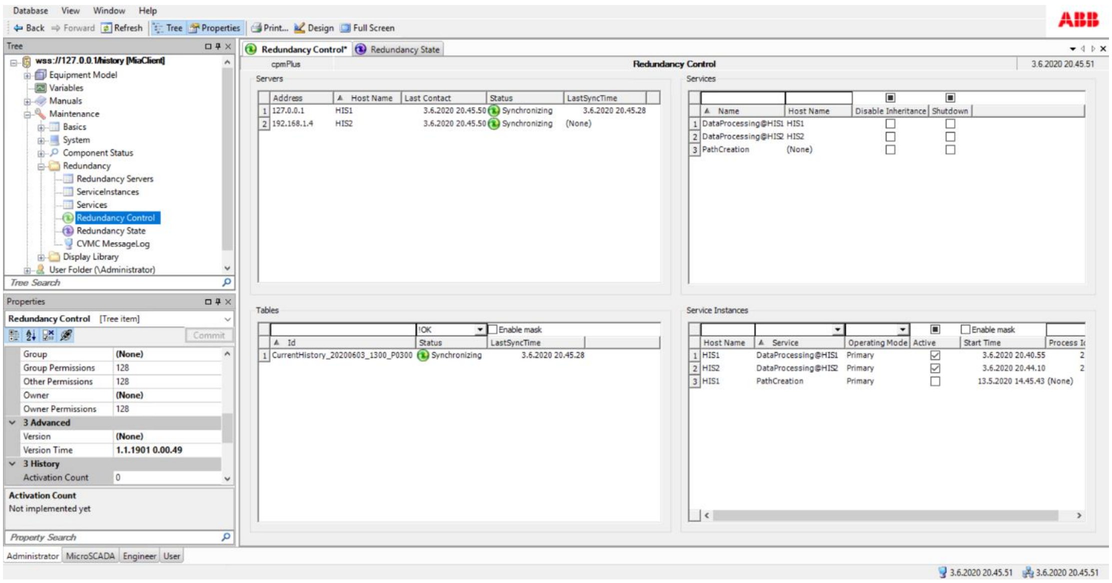


Figure 23. Redundancy Control page when the connection between the Historian servers is active.

From the Redundancy state page of the Redundancy folder, the user can monitor the synchronization status of the History tables on a table-by-table basis.

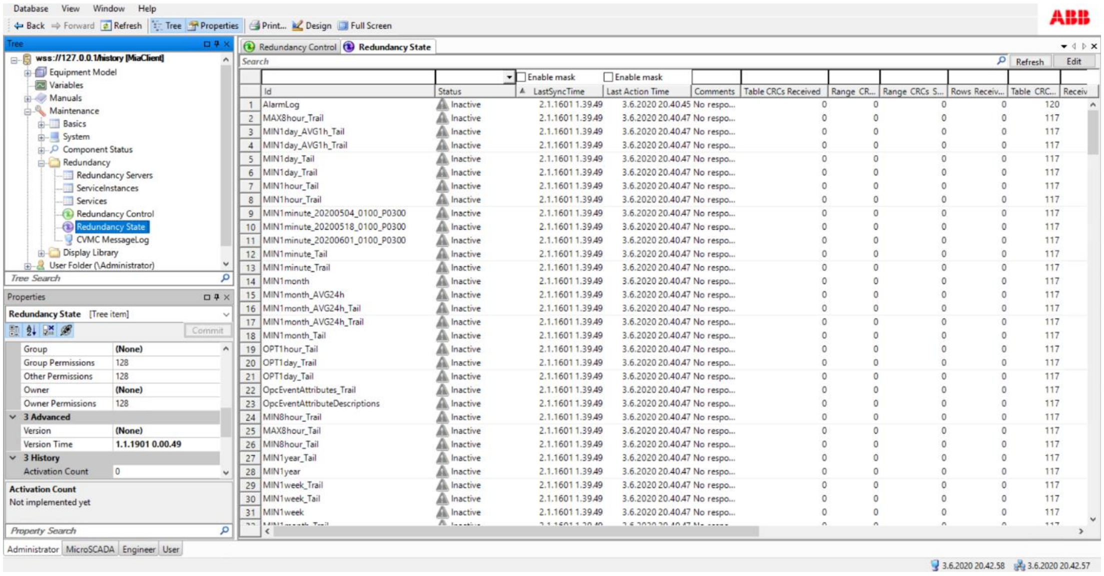


Figure 24. Redundancy State page when the connection between the Historian servers is down.

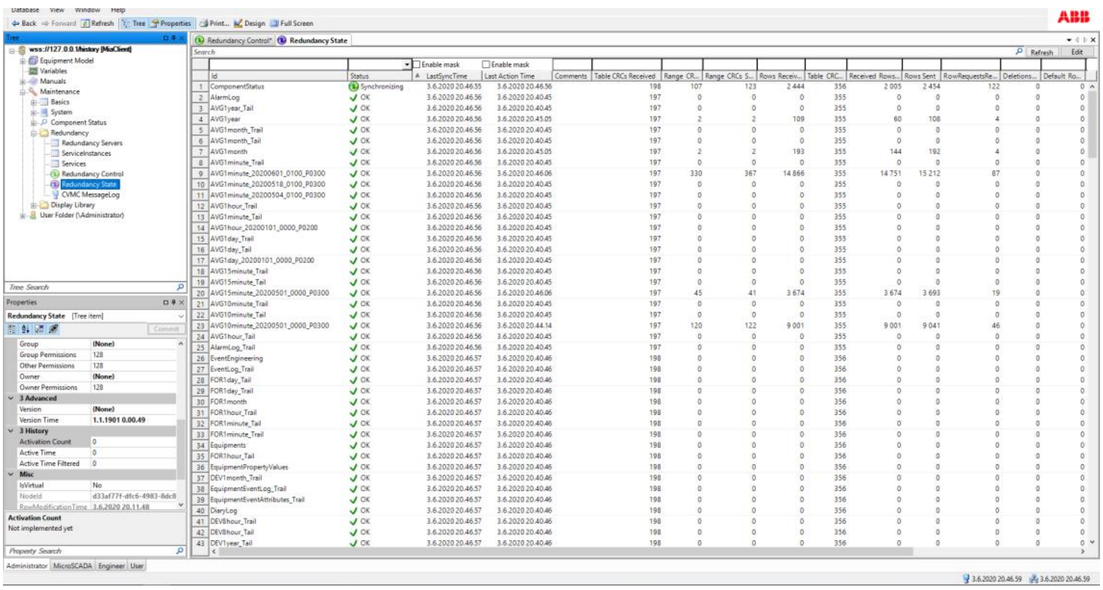


Figure 25. Redundancy State page when the connection between the Historian servers is active and tables are synchronized.

4 REDUNDANT SYS600 HISTORIAN INSTALLATION

Based on the understanding of the basic features and operation of the SYS600 and SYS600 historian system, it was possible to move on to the development phase of the work. The main goal of the thesis was to develop a redundant installation and implementation of SYS600 Historian in the SYS600 system.

In the development phase of the work, a virtual environment was created to simulate the redundant SYS600 Historian installation and commissioning. The end product of the work was a step-by-step installation and commissioning guide.

This chapter introduces the installation preparation, the redundant SYS600 History installation, and the implementation of the connection between SYS600 and SYS600 Historian.

4.1 Preparing Installation

The best way available for simulating a real life SYS600 and SYS600 historian redundant system configuration is to build a virtual computer system with three virtual computers, one pc with SYS600 installation and two pc’s with Historian installations. One of Historian computers will act as a main application and another one will act as stand by application. A virtual pc configuration was done in this case with Windows Hyper-V.

Installation preparing started with the configuration of three identical virtual machines. All machines were configured to have 1024MB of RAM, two virtual processors, one virtual hard drive and one network adapter. To achieve communication between historian computers, one network adapter was added for each Historian computer after Windows installation. In Windows installation a virtual hard disk was separated in to two partitions. This way each computer has two separate hard drives C and D. As mentioned earlier, in typical real-life Historian configuration, there are three different disks. C: for Windows operating system and product software, D: for RTDB database and E: for RTDB backups. In this simulation RTDB backups are included in the D: disk. The RTDB database disk was formatted using 64kB block size.

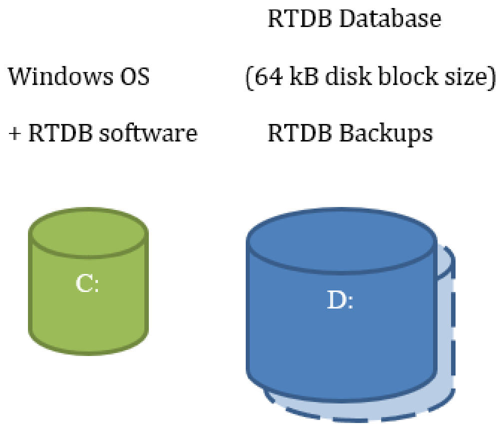


Figure 26. Simulations disk configuration.

The virtual machine names were changed after Windows installation and virtual hard disk formatting. The virtual machine that runs SYS600 was named as MicroSCADA. The SYS600 Historian virtual machines were named as HIS1 and HIS2. Windows requires a restart to apply changes of the device names. Network adapters were configured after restarting virtual machines. Configured IP addresses are listed in Table 1.

Table 1. Virtual machine names and IP addresses.

Virtual Machine Name	Network adapter P1 IP Address	Network Adapter P2 IP Address
MicroSCADA	192.168.0.1	
HIS1	192.168.0.3	192.168.1.3
HIS2	192.168.0.4	192.168.1.4

The IP addresses of the virtual machine can be verified with CMD command “ip-config”. Communication between virtual machines can be tested with CMD by entering command “ping” and IP address to be tested. Both commands are presented in Figure 27.

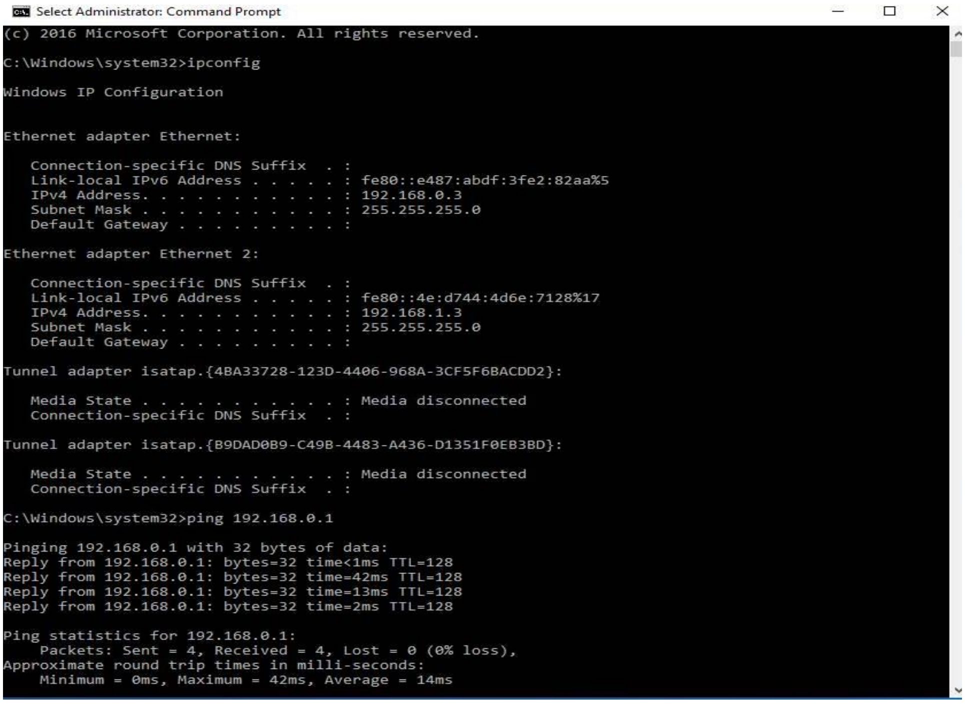


Figure 27. Verifying IP addresses and testing connection with CMD

Files required for installation were copied to the virtual machines after the communication between the virtual machines was established. The required files for redundant Historian installation are listed below:

-SYS600_10_0 Historian 13.exe (HIS1 & HIS2)

-VtrinRedundancyEng.txt (HIS1 & HIS2)

-HISTORIAN.SDB (MicroSCADA)

Basic Historian installation does not include a redundancy library where redundancy state can be monitored. Redundancy monitoring can be added on Vtrin with external file VtrinRedundancyEng.txt.

Controlling connection switching between SYS600 and Historian machines can be done with HISTORIAN.SDB file. HISTORIAN.SDB file consist needed command procedures that can be imported into SYS600. HISTORIAN_EVENT command procedure controls connection based on events. If the connection is lost, HISTORIAN_EVENT changes existing Database Address to the stand-by database address. In case of a longer connection failure, HISTORIAN_CYCLICAL command procedure cyclically switches between two historian database addresses until a connection is established. VtrinRedundancyEng.txt and HISTORIAN.SDB files are only available for ABB employees.

The MicroSCADA machine basic SYS600 installation was done before Historian installation. The Basic SYS600 installation is not covered in detail in this thesis.

4.2 SYS600 Historian Installation

When the way in which a functional redundant Historian installation can be implemented was found, an exact installation guide was created based on it. The aim of the guide was to include in detail each step necessary for the installation of the SYS600 Historian. The functionality of the guide was tested several times and by several people.

No instructions for redundant History installation can be found in the manuals so for the future it is important to have documented work instructions for installation.

4.3 Connecting SYS600

After a successful redundant Historian installation, the connection of the SYS600 and the Historian database could be accomplished using the SYS600 program. The connection can be implemented in SYS600 Monitor Pro software from path Tools > Engineering Tools > Tool manager > Application Objects > Obj Navigator.

The first step in order to connect SYS600 and Historian database is to determine where the data will be written. This can be configured in Object Navigator by creating a new database logging profile. Only one object is created for each Historian database. Database object creates Data Acquisition between SYS600 and Historian Database. It also handles starting and stopping communication between MicroSCADA and Historian database. Creating a Database logging profile is also included in the Historian installation guide.

A new Database logging profile was created and named as RTDB_HISTORIAN.

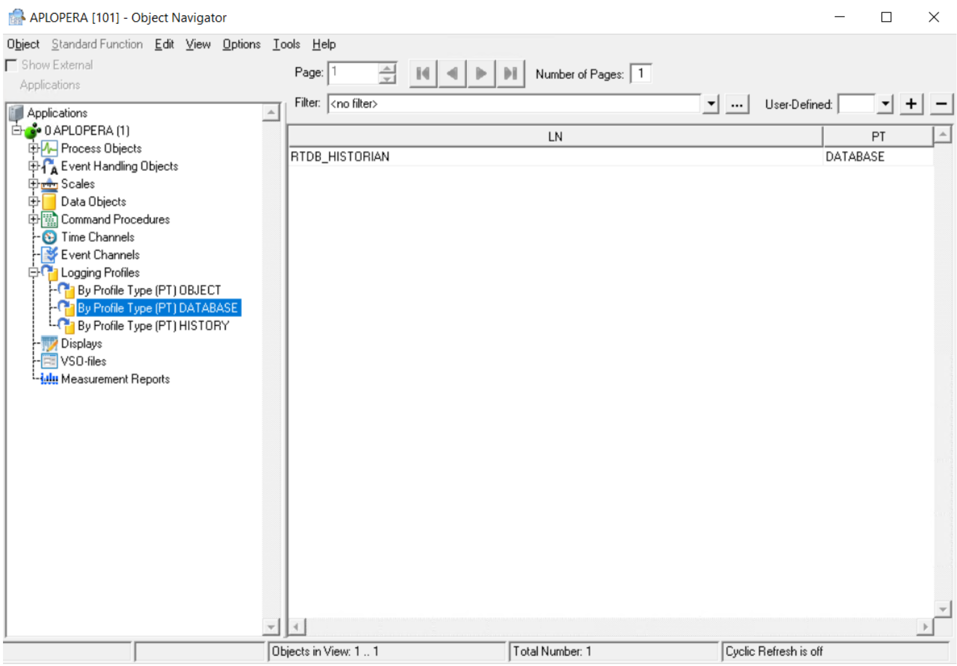


Figure 28. Created Database logging profile.

Database Adress (DA) was changed to match the IP address of the Historian machine: wss://192.168.0.3/history.

User Name (US) was specified as the Historian machine's windows administrator username and password. Settings were taken in use by selecting In Use and clicking Apply.

Object status (OS) indicates the status of the connection.

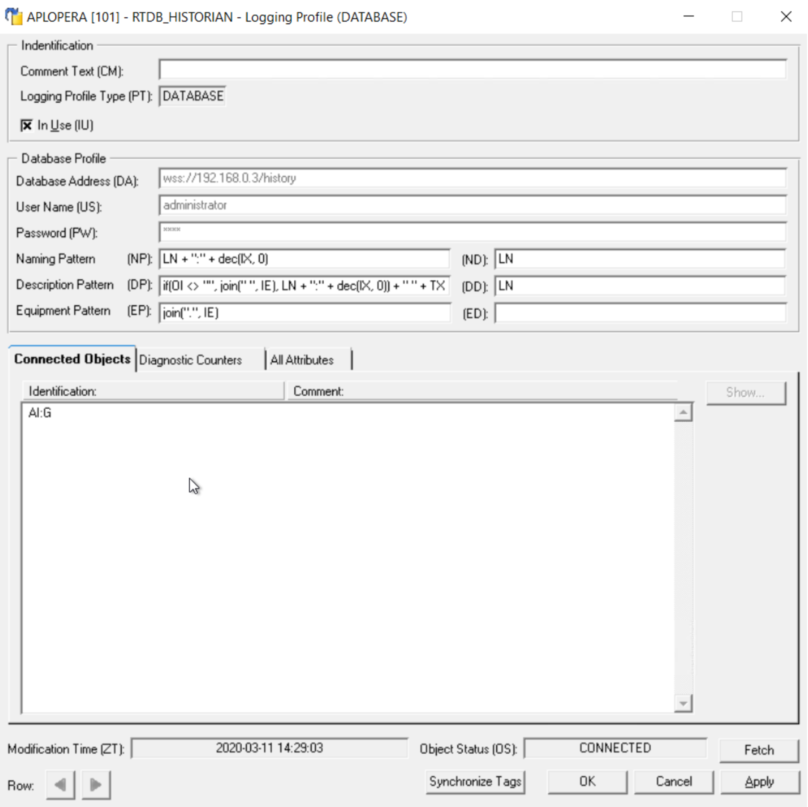


Figure 29. Database logging profile configuration.

Once the system knows where the data is going to be written, the user needs to specify how the data will be written. This can be configured in Object Navigator by creating a new history logging profile. It defines to what history table historian variables are collected into. One or many groups of signals can be selected.

A new History logging profile was created and named as AVG.

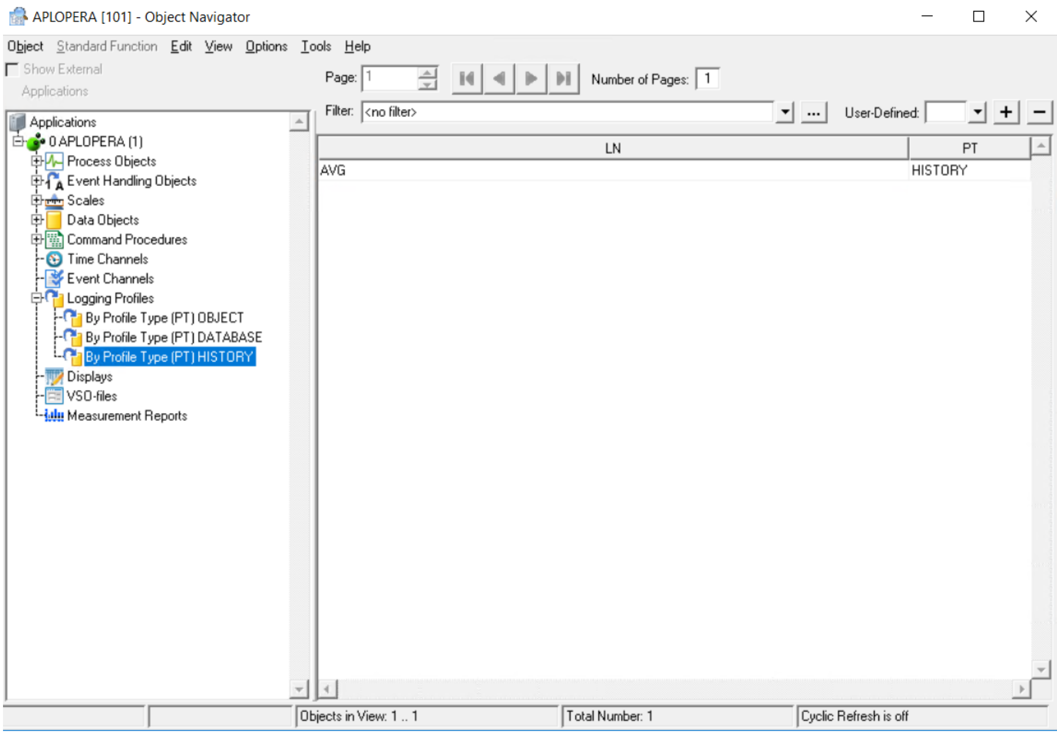


Figure 30. Creating History logging profile.

Only the AVG history collection template was selected for the simulation. Settings were taken in use by selecting In Use and clicking Apply.

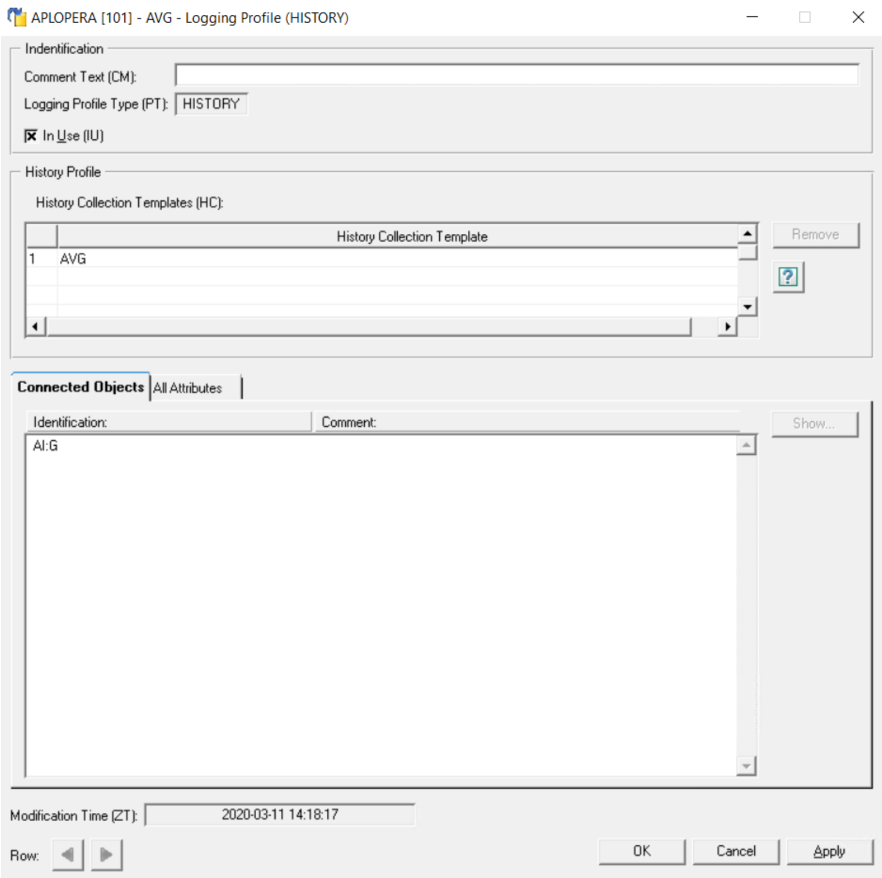


Figure 31. Selecting History collection template.

After creating the database and history objects the user needs to determine what to log with reference to where and how.

A new Object logging profile group was created and named as AI. The user can create multiple groups of signals but in this simulation only one was needed.

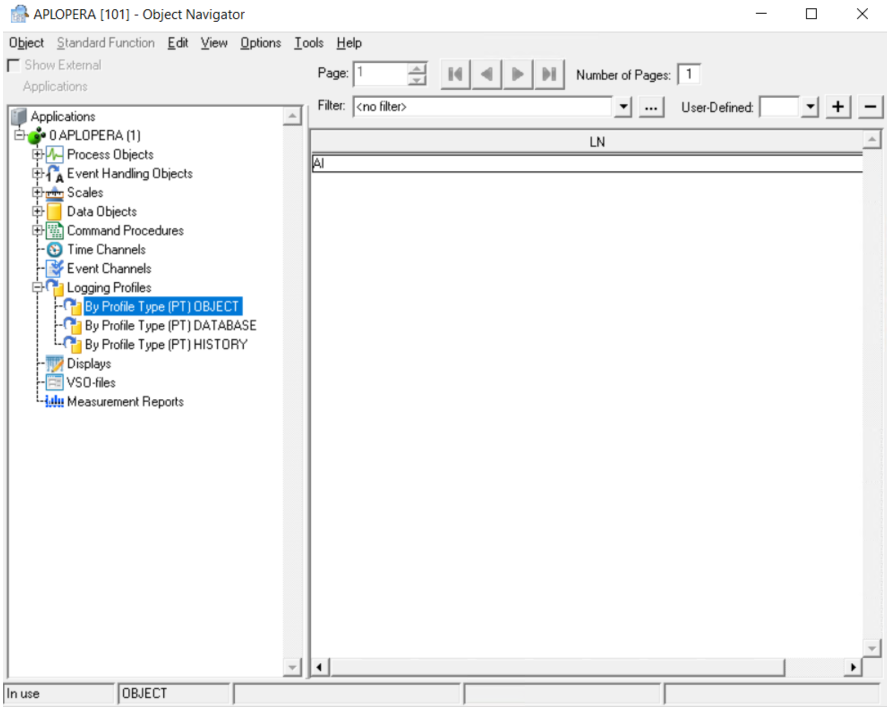


Figure 32. Creating Object logging profile.

In order to create a reference to the database, the name of the previously created database was specified into the Database Profile column. A reference to the history object was also created by entering the previously created history object name into the History Profile column.

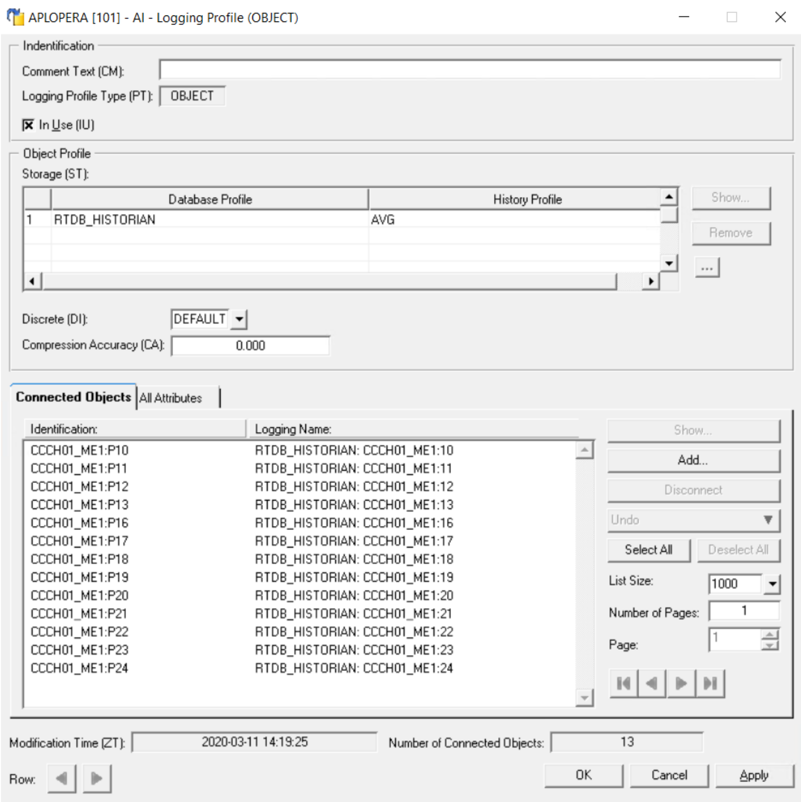


Figure 33. Specifying Database and History objects.

Signals were added by selecting Add > Select. The Object manager opens the Object selector window. Desired signals can be selected from the Object selector window and after that imported to the connected objects leaf by clicking Ok. Setting can be taken in use in the same way as in database configuration.

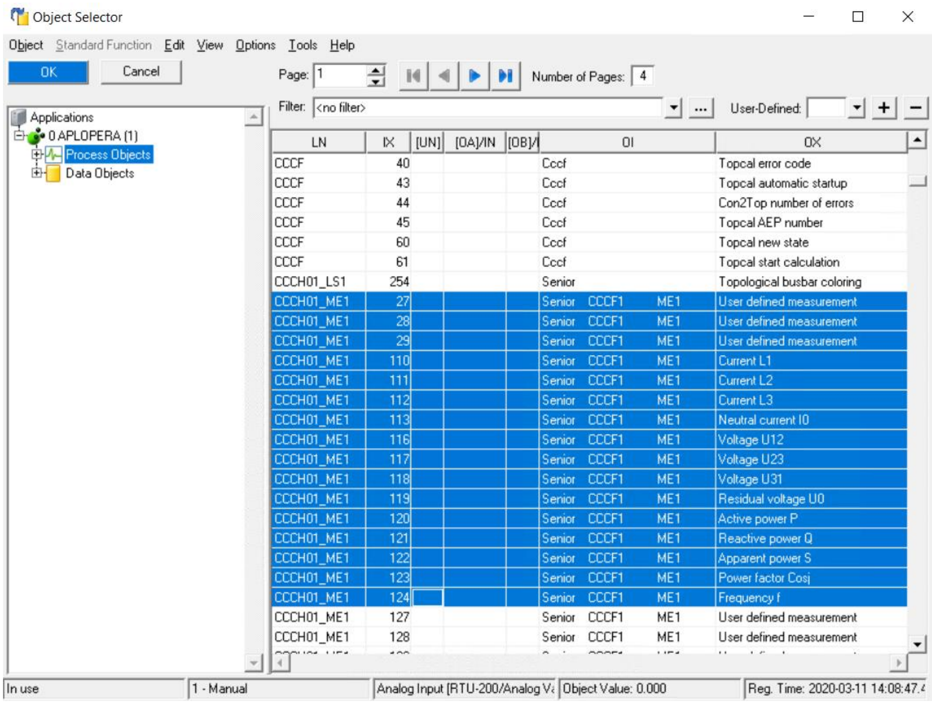


Figure 34. Selecting signal from Object selector window.

After adding the signals and applying the settings, it was possible to check from the Historian machine's Vtrin user interface whether the signals were successfully transferred. Signals can be checked from the Variables list page of the Vtrin user interface.

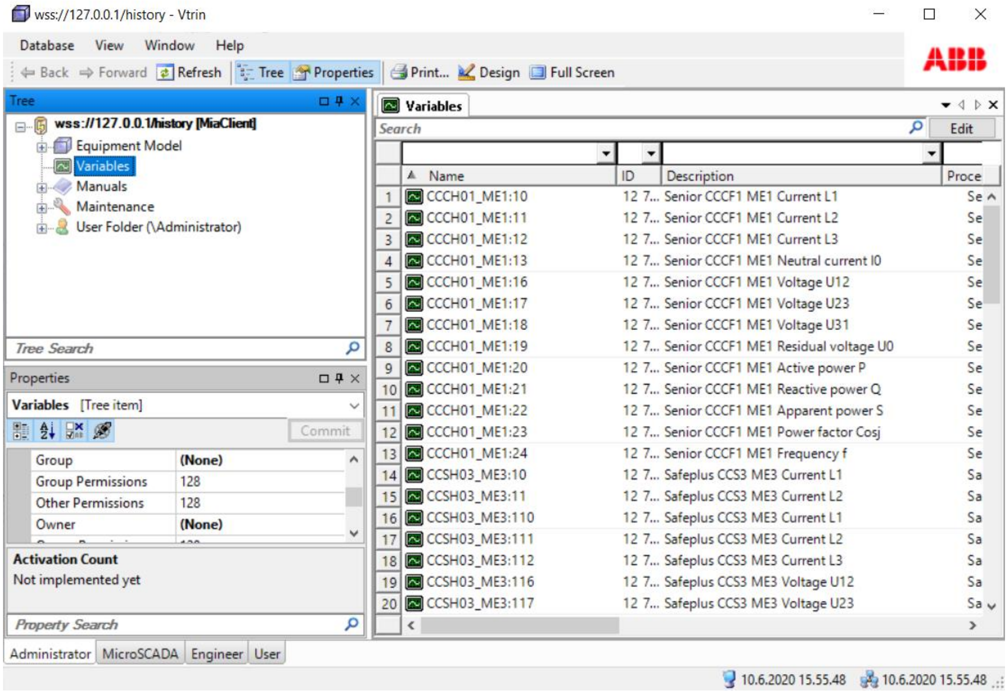


Figure 35. Vtrin Variables list.

5 SYSTEM TESTING

This chapter describes the tests that were performed to verify the operation of the simulation installation based on the installation guide.

The objectives of the testing were to state:

- The Operation of SYS600 and SYS600 Historian communication

- The operation of the connection between the history servers and the operation of the database synchronization

- The Operation of Event-based database address change and, in this situation, operation of database synchronization

- The operation of cyclic database address change and, in this situation, operation of database synchronization

The built-in APLOPERA demo application was used as the SYS600 application for testing. To simulate the values of the signals, it was possible to create a test dialog that draws values between 5 and 10 for the signals selected in one-second cycles. Test dialogs can be created using the SYS600 Monitor Pro in the path Tools > Engineering Tools > Tool manager > Miscellaneous > Test Dialog > Programs.

At the start of testing, the SYS600 database as well as both SYS600 Historian databases were started. The start-up of the SYS600 database can be monitored using SYS600 Notify. The start-up of the SYS600 History database can be monitored using the Windows Service desktop app and Task Manager.

5.1 Testing Operation of SYS600 and SYS600 Historian Communication

The operation of the communication between SYS600 and SYS600 History was first verified. The operation of the communication was detected by manually changing the Database Address (DA) in the SYS600 object navigator. The testing was performed for both History Database addresses. At the same time, it was checked that the simulated variables change on the Vtrin variable list page on both machines.

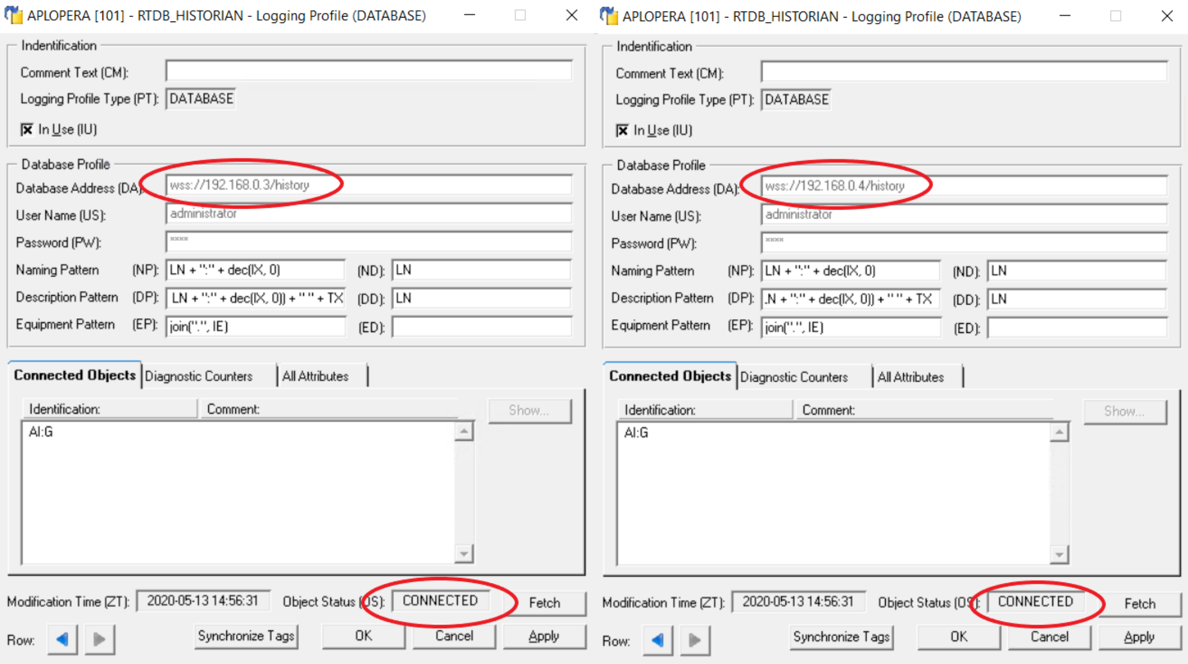


Figure 36. Connecting both databases.

It was then tested that the MicroSCADA machine could be connected to both Historian database user interfaces using Vtrin.

5.2 Testing the Redundancy of Historian Servers

After testing the communication between the SYS600 and SYS600 Historian, the state of the database synchronization and the time of last synchronization were verified. These can be verified from the Redundancy Control page of the Redundancy folder. Figure 37 demonstrates the operation of redundancy and that synchronization has been completed successfully after the databases were started. The Status column shows the status of the synchronization and the LastSyncTime column shows the last time the synchronization was performed.

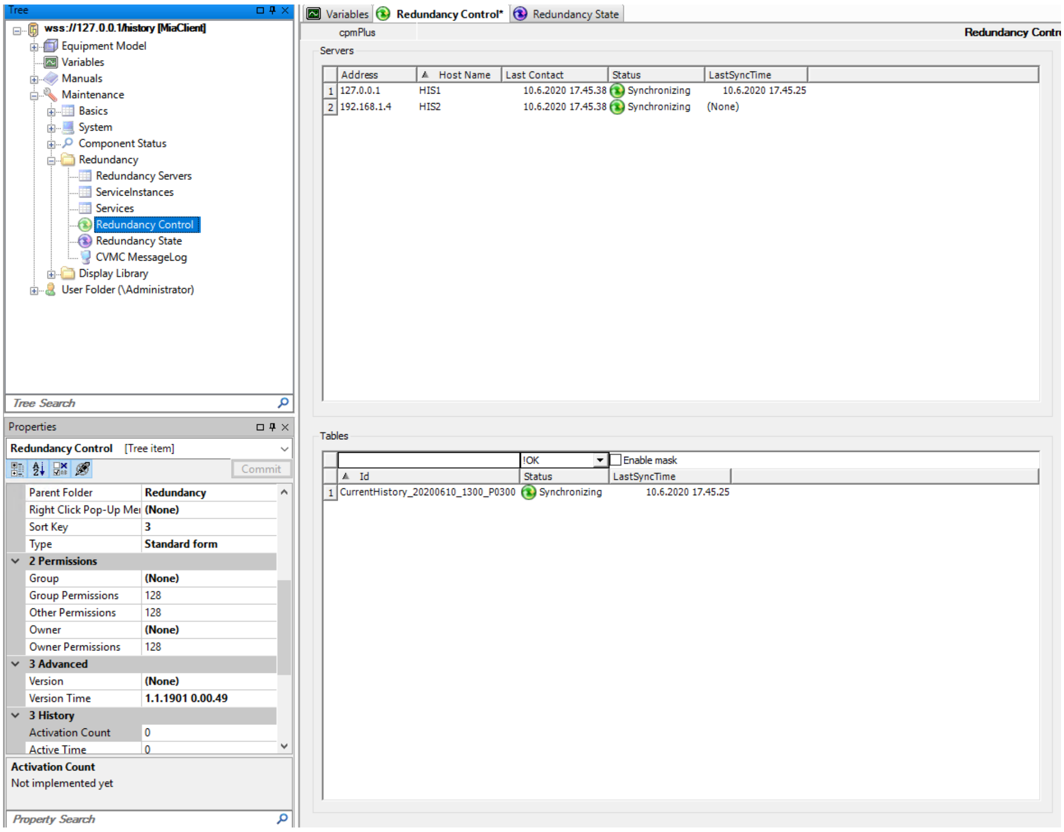


Figure 37. Redundancy Control page during normal operation.

5.3 Testing the Event-based Database Address Change

After the state of the database synchronization and the time of last synchronization were verified, Event-based database address change operation was tested.

The operation can be tested by shutting down the database of one of the History machines and at the same time monitoring the Object Status (OS) and Database Address (DA) from the SYS600 object Manager. The status of the SYS600 object Manager can be updated by pressing the Fetch button.

At the start of testing, the SYS600 system was connected to the HIS2 machine address. Thus, the HIS2 database was shut down from the SYS600 Historian Control Panel using Stop RTDB. The state of connection after HIS2 shut down can be seen in Figure 38.

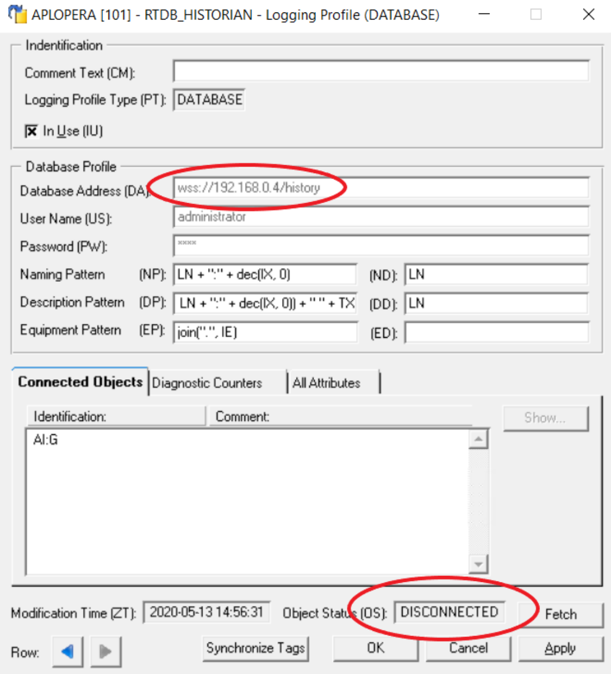


Figure 38. Object manager after HIS2 shut down

As can be seen in Figure 39, after shutting down the HIS2 database, the SYS600 automatically connected to the HIS1 database address, so it can be stated that the switch works.

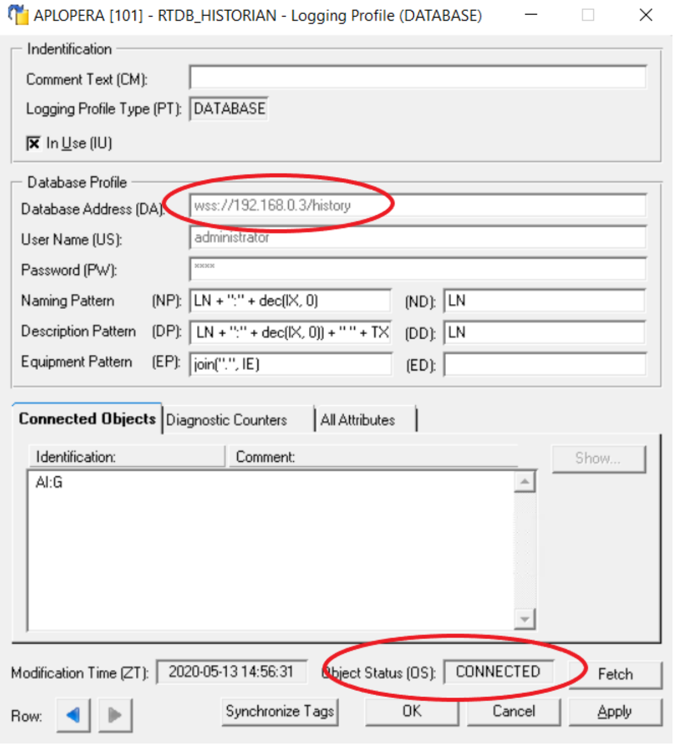


Figure 39. State of connection after event-based database address change.

From the Redundancy Control page of the HIS1 Vtrin user interface, it was able to state that the HIS2 database is in the Inactive mode and the synchronization does not work. The view of the Vtrin user interface is presented in Figure 40.

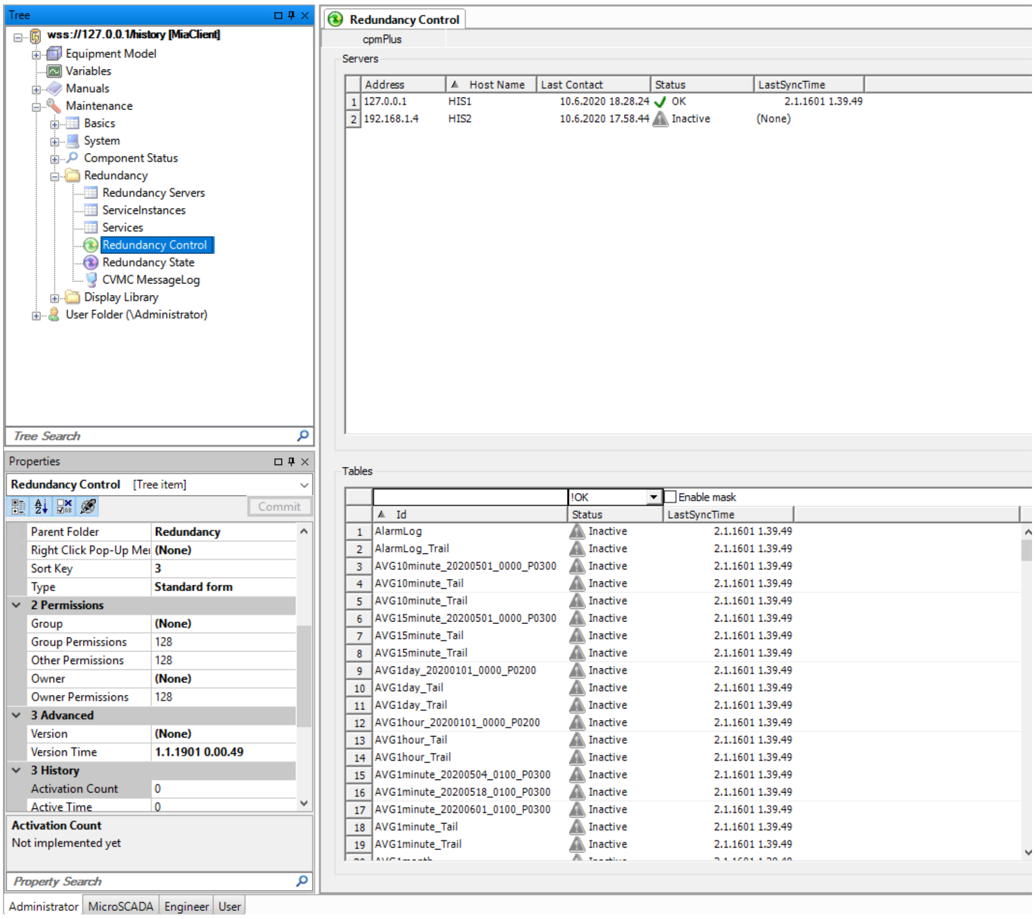


Figure 40. Redundancy Control page after event-based database address change.

In the next phase of testing, the HIS2 database was started and at the same time the Redundancy Control status of the HIS1 Vtrin user interface was monitored. The HIS2 database was started from the SYS600 Historian Control Panel using Start RTDB.

After starting the HIS2 database, the system returned to normal operation and synchronized the databases.

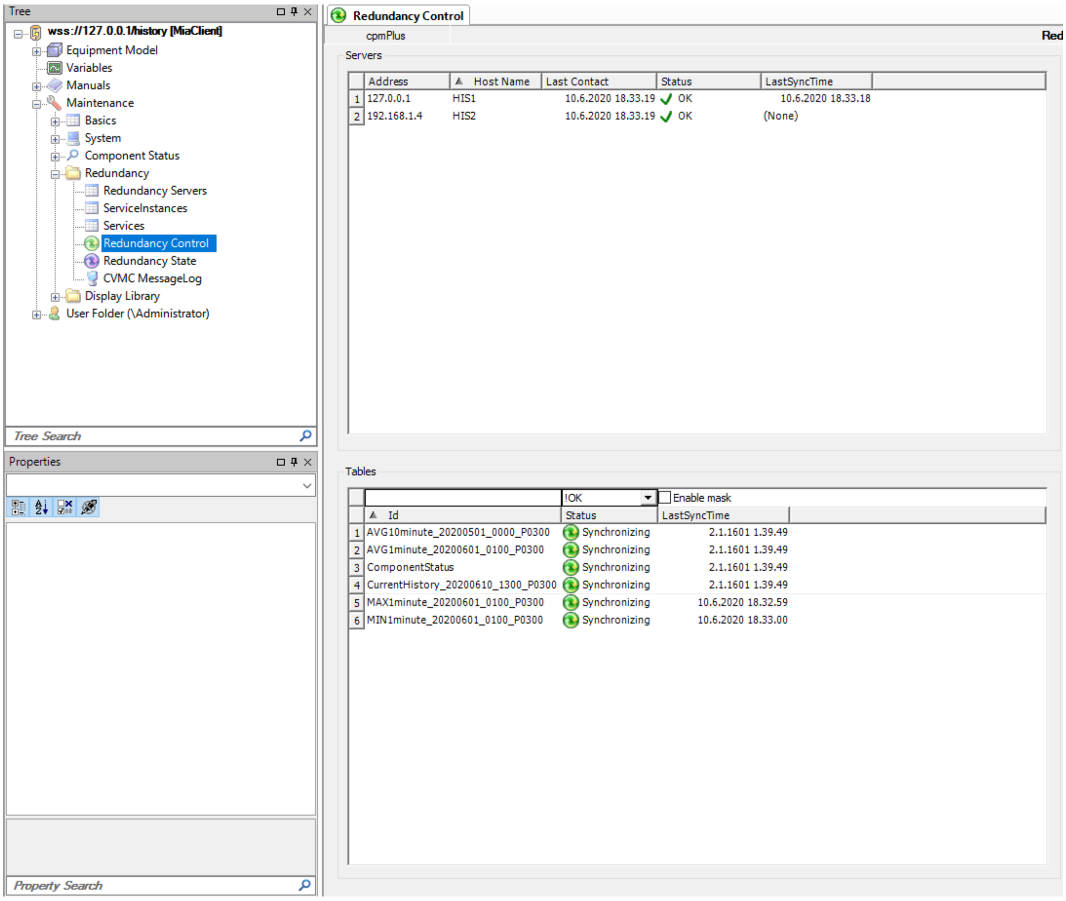


Figure 41. Redundancy Control page after starting the HIS2 database.

From the Vtrin Redundancy State page, the status and operation of the synchronization for each history table can be found. The Redundancy State page is presented in Figure 42.

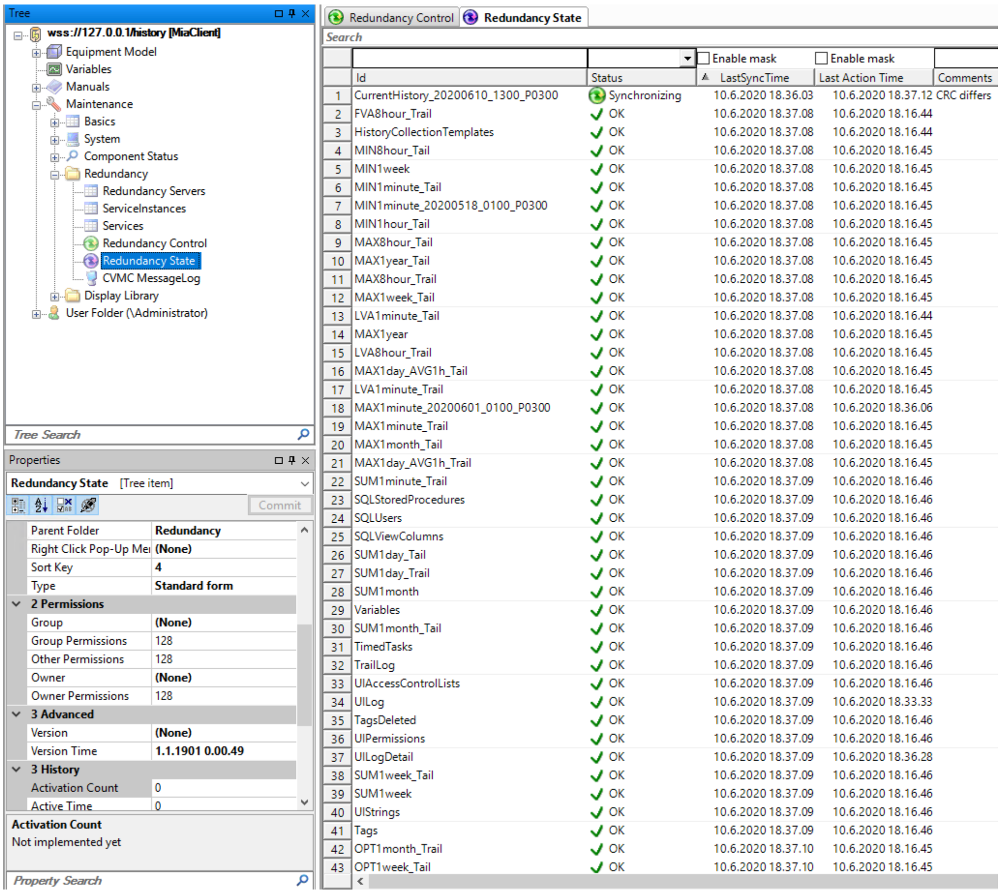


Figure 42. Redundancy State page after synchronization.

The same steps were repeated by shutting down the HIS1 database.

5.4 Testing the Cyclic Database Address Change

In the next phase of the testing, the operation of cyclic database address change was tested. The operation can be verified by shutting down both databases at the same time and monitoring the SYS600 Object Manager database address.

When a connection to the backup database cannot be established, the Object Manager Database Address should begin to switch cyclically between Historian database addresses.

After shutting down the databases, the object manager's database address began to change cyclically. The database address changes as long as the connection to either Historian database address can be established.

The HIS1 database was a connected database at the beginning of the testing so the HIS1 database was started. The object manager automatically connected to the HIS1 database address, so it can be stated that the cyclic database address change works.

From the Redundancy Control page of the Vtrin user interface of the HIS1 machine, it was able to state that the HIS2 database is in the Inactive mode and the synchronization does not work. The view of the Redundancy Control page is presented in Figure 43.

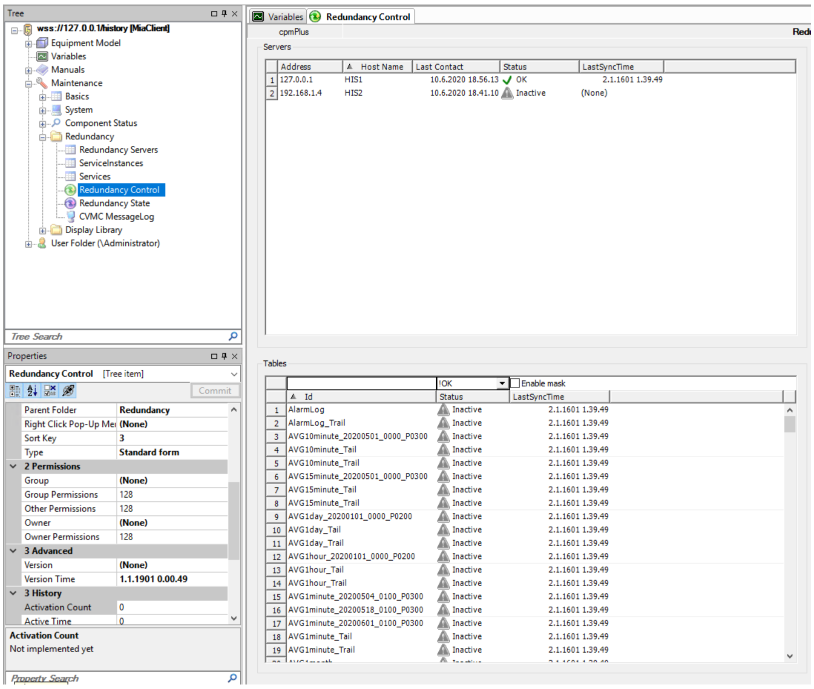


Figure 43. Redundancy Control page after cyclic database address change

After connecting HIS1 Database, HIS2 database was started in order to verify the operation of synchronization.

As can be seen in the Figure 44, the synchronization started working immediately after starting the HIS2 database, so it can be stated that the cyclic database change and the synchronization of the databases after failure works.

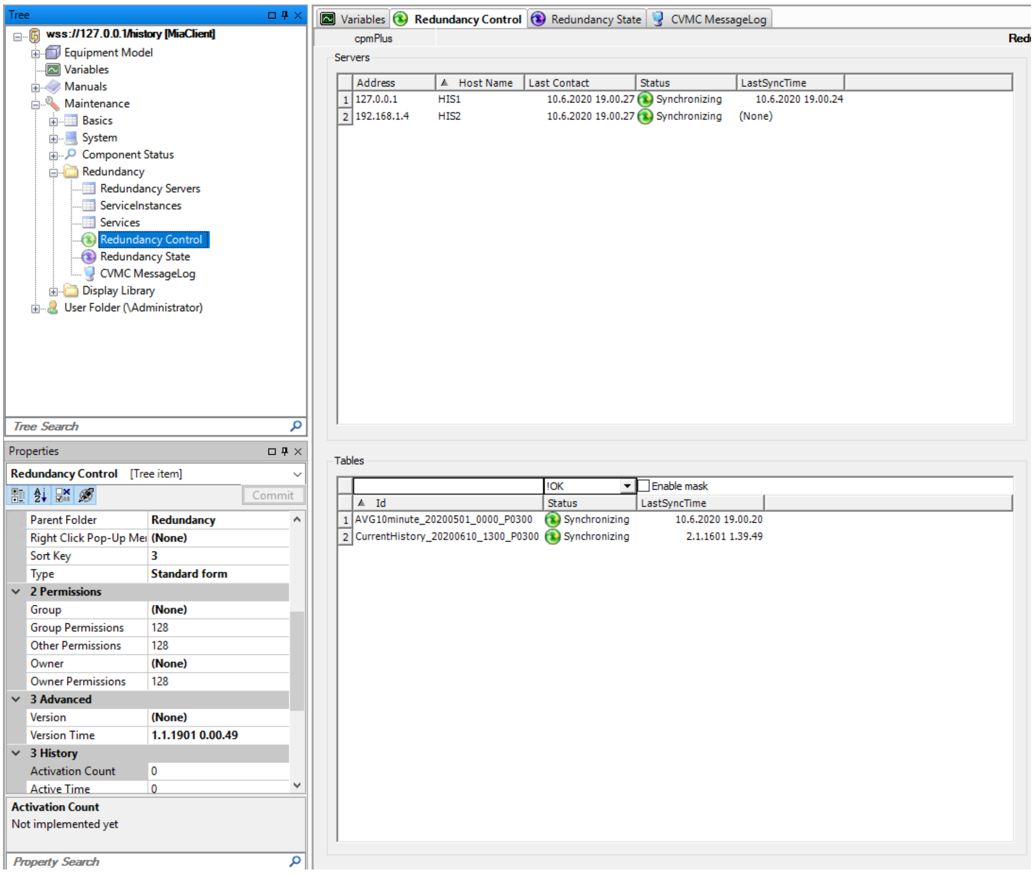


Figure 44. Redundancy Control page after HIS2 database start up.

6 CONCLUSIONS

The aim of the work was to study and develop the installation of redundant Historian software and to create installation instructions based on this. The final product of the work was a detailed installation guide, which can be used to perform the installation of a redundant Historian system. Based on this, it can be stated that the objectives of the work were achieved.

As mentioned earlier in the thesis, no previously made documentation of redundant Historian installation can be found. Redundant Historian installations of future projects can be made based on the installation instructions. I believe this will make software installations easier and faster.

I would have found it interesting to get a deeper insight into the operation of the Historian software and, above all, the performance of redundancy. However, this was not possible given the scope of the thesis and its schedule. Furthermore, the performance of redundancy could not be tested at the required level using the virtual environment used in the thesis. This could be the topic of the thesis for the future.

The thesis was successful in the best possible way, taking into account the significant effects of the COVID-19 pandemic that overshadowed the making of the thesis. Due to the coronavirus, the effects of limited orientation and work done remotely from home cannot be underestimated.

REFERENCES

/1/ MicroSCADA X SYS60010.0 System Configuration

/2/ P301 MicroSCADA X SYS600 10 SA Engineering

/3/ Micro SCADA X SYS600 10.0 Application Design

/4/ P302 MicroSCADA X SYS600 10 SCADA Engineering

/5/ P281 MicroSCADA Pro SYS600 9.4 FP2 Operation

/6/ P289 MicroSCADA PRO SYS600 Historian 1.2

/7/ MicroSCADA X SYS600 10.0 Historian Configuration and Administration

/8/ MicroSCADA X SYS600 10.0 Historian Operation