MicroSCADA Pro
DMS 600 4.2

System Overview
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1. About this manual

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Document number: 1MRS755272

Release: E/2008

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1.3.  General

This manual describes MicroSCADA Pro Distribution Management System DMS 600 (later in this manual DMS 600) software. DMS 600 4.2 is direct successor to DMS 600 4.0/4.1 and Open++ Opera 3.3.

This document complies with the DMS 600 program version 4.2 SP1.

Additional information such as Release Notes can be found on the program distribution media.

1.4.  Use of symbols

This publication includes warning, caution and information symbols where appropriate to point out safety-related or other important information. It also includes tips to point out useful hints to the reader. The corresponding symbols should be interpreted as follows:

⚠️  Warning icon indicates the presence of a hazard which could result in personal injury.

⚠️  Caution icon indicates important information or a warning related to the concept discussed in the text. It might indicate the presence of a hazard, which could result in corruption of software or damage to equipment/property.

ℹ️  Information icon alerts the reader to relevant factors and conditions.

💡  Tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, and caution hazards are associated with equipment or property damage, it should be understood that operation of damaged equipment could, under certain operational conditions, result in degraded process
performance leading to personal injury or death. Therefore, comply fully with all warnings and caution notices.

1.5. Document conventions

The following conventions are used for the presentation of material:

- The words in names of screen elements (for example, the title in the title bar of a window, the label for a field of a dialog box) are initially capitalized.
- Lowercase letters are used for the name of a keyboard key that is not labeled on the keyboard. For example, the space bar, comma key, and so on.

1.6. Terminology

The following is a list of terms associated with DMS 600 that you should be familiar with.

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Program Interface; API</td>
<td>A set of routines that an applications program uses to request and carry out lower-level services performed by a computer operating system.</td>
</tr>
<tr>
<td>Certainty factor</td>
<td>Certainty factors are used during inferencing to define the stress on individual inference rules.</td>
</tr>
<tr>
<td>DMS 600 database</td>
<td>Database for dynamic data in DMS 600.</td>
</tr>
<tr>
<td>DMS Interface Package</td>
<td>A tool used to cross-connect MicroSCADA and DMS 600.</td>
</tr>
<tr>
<td>DMS 600 Network Editor; DMS 600 NE</td>
<td>A program primarily used to model the distribution network onto the network database.</td>
</tr>
<tr>
<td>DMS 600 Server Application; DMS 600 SA</td>
<td>An application used for data exchange between MicroSCADA and instances of DMS 600.</td>
</tr>
<tr>
<td>DMS 600 Workstation; DMS 600 WS</td>
<td>DMS 600 Workstation (DMS 600 WS) is a program for the operative personnel of electric companies to monitor and operate their medium and low voltage distribution networks.</td>
</tr>
<tr>
<td>Fault distance</td>
<td>The fault distance is determined by comparing the measured short-circuit current and the type of fault with the calculated short-circuit currents along the feeder in which a fault has been occurred. The fault location of DMS 600 WS is based on fault distance calculation and fault detector data.</td>
</tr>
<tr>
<td>Fault file</td>
<td>Fault snapshot file created by DMS 600 SA. File names of fault snapshot files are Fau&lt;xxx&gt;.txt, where &lt;xxx&gt; is a running number.</td>
</tr>
<tr>
<td>Free data form</td>
<td>Free data forms are the general way to present DMS 600 database content.</td>
</tr>
<tr>
<td>Free database object</td>
<td>Free database objects are user-defined object types which can be added to the network database.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Hot Stand By; HSB</td>
<td>A system to secure database connection with two servers. Each server is capable of continuing the service by itself, if the connection to the other server is lost.</td>
</tr>
<tr>
<td>Internet Protocol; IP</td>
<td>The messenger protocol of TCP/IP, is responsible for addressing and sending TCP packets over the network. IP provides a best-effort, connectionless delivery system that does not guarantee that packets arrive at their destination or that they are received in the sequence in which they were sent. See also Transmission Control Protocol.</td>
</tr>
<tr>
<td>IP address</td>
<td>Internet address (for example, 127.0.0.1)</td>
</tr>
<tr>
<td>Local Area Network; LAN</td>
<td>A group of computers and other devices dispersed over a relatively limited area and connected by a communications link that enables any device to interact with any other device on the network. See also Wide Area Network.</td>
</tr>
<tr>
<td>MicroSCADA OPC Server</td>
<td>An implementation of the interface specification OPC Data Access Custom Interface Standard, Version 2.05A, on the MicroSCADA system.</td>
</tr>
<tr>
<td>MicroSCADA station picture</td>
<td>A type of MicroSCADA application picture, which gives an overview of the processes in a station. The station picture is often designed according to a single line diagram.</td>
</tr>
<tr>
<td>Network database</td>
<td>Database for network data.</td>
</tr>
<tr>
<td>OPC item</td>
<td>OPC item is an index for MicroSCADA process object containing the whole path with an application number. OPC item has properties (process object attributes) such as alarms and time stamps.</td>
</tr>
<tr>
<td>Process object</td>
<td>A MicroSCADA process object, which has a connection to a real process.</td>
</tr>
<tr>
<td>Protocol</td>
<td>A set of semantic and syntactic rules that determine the behavior of functional units in archiving communication.</td>
</tr>
<tr>
<td>Raster map</td>
<td>Map information consisting of dots. The number of dots depends on the resolution of the map. Each dot has some color information according to the number of colors used. See also Vector map.</td>
</tr>
<tr>
<td>SCIL API</td>
<td>MicroSCADA API for C programmers that is used to connect DMS 600 to MicroSCADA.</td>
</tr>
<tr>
<td>Support System Interface; SSI</td>
<td>A standardized method of transferring data between the applications.</td>
</tr>
<tr>
<td>System specific settings</td>
<td>The settings which define the functions of all instances of DMS 600 NE and DMS 600 WS.</td>
</tr>
<tr>
<td>Temporary network file</td>
<td>The file containing temporary network data (Tempnet.dat).</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission Control Protocol; TCP</td>
<td>A software protocol developed by the Department of Defense for communications between computers. It is a connection-based Internet protocol responsible for breaking data into packets, which the IP protocol sends over the network. This protocol provides a reliable, sequenced communication stream for network communication. See also Internet Protocol.</td>
</tr>
<tr>
<td>Transmission Control Protocol/Internet Protocol; TCP/IP</td>
<td>A set of networking protocols that provides communications across interconnected networks made up of computers with diverse hardware architectures and various operating systems. TCP/IP includes standards for computer communication and conventions for network connections and traffic routing. See also Transmission Control Protocol and Internet Protocol.</td>
</tr>
<tr>
<td>Vector map</td>
<td>Map information that consists of lines and curves. See also Raster map.</td>
</tr>
<tr>
<td>Virtual process point</td>
<td>A MicroSCADA process point which does not have a connection to a real process.</td>
</tr>
<tr>
<td>Wide Area Network; WAN</td>
<td>A communications network that connects geographically separated areas. See also Local Area Network.</td>
</tr>
<tr>
<td>Workstation specific settings</td>
<td>The settings which define the functions of a local workstation (DMS 600 NE or DMS 600 WS).</td>
</tr>
</tbody>
</table>

### 1.7. Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>API</td>
<td>Application Program Interface</td>
</tr>
<tr>
<td>bmp</td>
<td>Windows bitmap format</td>
</tr>
<tr>
<td>DMS</td>
<td>Distribution Management System</td>
</tr>
<tr>
<td>DMS 600</td>
<td>MicroSCADA Pro Distribution Management System DMS 600</td>
</tr>
<tr>
<td>dxf</td>
<td>Vector file format</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>GSM</td>
<td>Global System for Mobile Communications</td>
</tr>
<tr>
<td>HV</td>
<td>High voltage</td>
</tr>
<tr>
<td>HSB</td>
<td>Hot Stand By</td>
</tr>
<tr>
<td>IEC 61850</td>
<td>Standard defined by IEC: Communication networks and systems in substations</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network.</td>
</tr>
<tr>
<td>LIB 500</td>
<td>MicroSCADA Application Library</td>
</tr>
</tbody>
</table>
### Abbreviation

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIB 510</td>
<td>MicroSCADA MV Application Library</td>
</tr>
<tr>
<td>LV</td>
<td>Low voltage</td>
</tr>
<tr>
<td>MicroSCADA</td>
<td>MicroSCADA SYS 500 version 8.4.2, 8.4.3, 8.4.4 or 8.4.5 or MicroSCADA Pro Control System SYS 600 version 9.x</td>
</tr>
<tr>
<td>MV</td>
<td>Medium voltage</td>
</tr>
<tr>
<td>NMEA-0183</td>
<td>NMEA-0183 is a serial communications standard for the encoding and sending of GPS and other navigation information between devices.</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control And Data Acquisition</td>
</tr>
<tr>
<td>SCIL</td>
<td>Supervisory Control Implementation Language. SCIL is a picture and object oriented, high-level language for application programming in MicroSCADA.</td>
</tr>
<tr>
<td>SMS</td>
<td>Short Message Service. Service for sending messages to mobile phones that use Global System for Mobile (GSM) communication.</td>
</tr>
<tr>
<td>SSI</td>
<td>Support System Interface</td>
</tr>
<tr>
<td>SYS 600</td>
<td>MicroSCADA Pro Control System SYS 600 version 9.x</td>
</tr>
<tr>
<td>TCP</td>
<td>Transmission Control Protocol</td>
</tr>
<tr>
<td>TCP/IP</td>
<td>Transmission Control Protocol/Internet Protocol</td>
</tr>
<tr>
<td>WAN</td>
<td>Wide Area Network</td>
</tr>
<tr>
<td>vg2</td>
<td>DMS 600 internal vector file format</td>
</tr>
</tbody>
</table>

## 1.8. Related documents

**Table 1.8-1 MicroSCADA Pro DMS 600 related documents**

<table>
<thead>
<tr>
<th>Name of the manual</th>
<th>MRS number</th>
</tr>
</thead>
<tbody>
<tr>
<td>MicroSCADA Pro DMS 600 4.2</td>
<td>1MRS755273</td>
</tr>
<tr>
<td>Integration with SYS 600</td>
<td>1MRS755273</td>
</tr>
<tr>
<td>MicroSCADA Pro DMS 600 4.2</td>
<td>1MRS755274</td>
</tr>
<tr>
<td>Operation Manual</td>
<td>1MRS755274</td>
</tr>
<tr>
<td>MicroSCADA Pro DMS 600 4.2</td>
<td>1MRS755275</td>
</tr>
<tr>
<td>Installation Manual</td>
<td>1MRS755275</td>
</tr>
<tr>
<td>MicroSCADA Pro DMS 600 4.2</td>
<td>1MRS755276</td>
</tr>
<tr>
<td>System Administration</td>
<td>1MRS755276</td>
</tr>
</tbody>
</table>
### Document revisions

<table>
<thead>
<tr>
<th>Version</th>
<th>Revision number</th>
<th>Date</th>
<th>History</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.0</td>
<td>30.6.2004</td>
<td>Document created. This document replaces all versions of document 1MRS 751467-MUM.</td>
</tr>
<tr>
<td>C</td>
<td>4.1</td>
<td>28.2.2005</td>
<td>Changes for software revision 4.1.</td>
</tr>
<tr>
<td>D</td>
<td>4.2</td>
<td>30.6.2006</td>
<td>Changes for software revision 4.2</td>
</tr>
<tr>
<td>E</td>
<td>4.2</td>
<td>28.3.2008</td>
<td>Changes for software revision 4.2 SP1</td>
</tr>
</tbody>
</table>
2. Introduction

2.1. General about DMS 600 software

MicroSCADA Pro Distribution Management System DMS 600 4.2 (DMS 600) is a direct successor to DMS 600 4.0/4.1 and Open++ Opera software version 3.3 with extended functionality. DMS 600 functionality is very deeply integrated to MicroSCADA Pro Control System SYS 600 version 9.x (SYS 600). Most of the functionality can be used also with MicroSCADA SYS 500 version 8.4.2, 8.4.3, 8.4.4 or 8.4.5.

The abbreviation SYS 600 is used only when the topic is valid only for SYS 600. Abbreviation MicroSCADA is used when the topic is valid for both SYS 500 and SYS 600.

DMS 600 is a geographical distribution network management system (DMS). The software extends traditional SCADA capabilities by providing geographically based network views. DMS 600 (Base) package provides network component data management and network modeling to provide network overview and topological coloring to see the network's state. In addition, DMS 600 has many optional modules with advanced functions. DMS 600 can be used with MicroSCADA, without SCADA or with other SCADA systems using OPC Data Access interface. The software has been designed to assist the operation’s personnel of electric companies in monitoring and operating their networks.

Both raster and vector based maps can be used as backgrounds for the network window. It is also possible to create and use schematic network views, instead of geographically based network presentations and maps.

The software runs on PCs using MS Windows 2000, MS Windows XP or MS Windows Server 2003™ operating systems both in separate workstations or workstations connected to fileserver. Additional (regional) servers can be used to store network data to keep the start up time reasonable in low speed LAN/WAN networks. The saving of network and process data is made with MS Access 2000 or MS Access 2002 database management software. The graphics-based user interface of DMS 600 is unambiguous and the standard Windows ‘look and feel’, together with the online help, makes it easy to learn.

2.2. New features and functions in DMS 600 4.2

Extended automatic fault isolation and restoration

In addition to control actions, the generated sequence file includes the circuit breakers to be checked. The information can be used to check that the circuit breaker feeding the back-up connection remains closed. If that circuit breaker is opened due to relay trip, the restoration will be cancelled.
Switch state updates with modified time and possibility to correct times in event list

The switch control dialog for manual devices includes a control that gives the real time when the switch was operated. In addition, the event time can be changed in the DMS 600 event list afterwards. This enables, for example, the creation of outage reports with corrected event times.

Relational database servers

DMS 600 can use relational database servers (such as MS SQL Server and Oracle) instead of MS Access database to store data. The connection to a database is made using ODBC data source name (DSN) definitions. MS Access databases without DSN definitions are still supported. For Hot Stand By systems, two relational database servers with a replication feature are recommended instead of Access databases.

Parallel network views

It is possible to select the used network view independently in each program instance (workstation). The user has the possibility to create a new view by moving and hiding nodes and lines in the main view without overwriting already existing data. For example, a parallel schematic diagram can be created (orthogonal schema) to make network operation clear and effective but exact locations of objects can be viewed on a map using a geographic view. All views can use the real time network coloring to show the state of the network as before.

Switch state quality (status) separated from switch state

Separate symbols can be defined for uncertain switch states (open, uncertain or closed, uncertain). These symbols are used when the switch state is known in the SCADA database but quality is uncertain. In the OPC interface this means that OPC quality QUALITY_UNCERTAIN used, and in the SCIL API interface the status values 1, 2 or 3 are used. The OPC quality QUALITY_BAD or status 10 (not sampled) cause the state of the switch to be shown as error, as before. The user can define if uncertain state will cause network coloring to use unknown color. Error state will always cause unknown coloring.

Manual state update for switches connected to SCADA

Disconnectors and circuit breakers that normally reserve the state from SCADA can be moved to manual state update in DMS 600. This can be used as a temporary solution, for example, to see known state in DMS 600 if communication to station is broken and SCADA is not showing the known state. There are separate symbol definitions for closed and open, manually updatable switches.
Distribution Contingency analysis

The user can define sequences that can be used to check if the system is capable of handling known fault situations with present loads. For example, the sequence can check whether there are acceptable back-up feeds when some main transformers have to be switched off. The power of generators and motors can be changed in the study, too.

Power values for motors and generators

Real time measurement values from SCADA can be linked to motors and generators so that the load flow calculation in state monitoring mode can use measured values. In the simulations the user of WS can change the values with simulation dialogs.

IED (relay) modeling

For documentation purposes the network database can include data for any kinds of protection and control devices. For example, distance and differential protection devices with their properties and setting values data can be added. The user can define additional data fields for any protection devices.

LIB 500 not required anymore

DMS 600 can be used with SYS 600 without installing LIB 500. The tools that were earlier available only when also LIB 500 was installed are now available without a LIB 500 installation.

Improved fault management

• Switching to another fault instance is faster than before since all existing faults are in main memory.
• Operation is faster when there are several unrepaired faults since switch state changes are not anymore stored to each fault file. For reporting the switch state changes are read from the event log instead of the fault files.
• The fault management dialog is resizable. For example, the list presentation of present faults can be increased so that more information can be seen at the same time.
• Extreme conditions switch is added. When there are a lot of simultaneous faults and lots of switch state changes, the operation of the system can be changed by pressing one button so that the screen update interval is increased and automatic load flow after changes is switched off.
Customer service points in MV network

A customer service point can be added to the MV network to represent a so called MV customer that has their own transformers. The load or energy data can be given for a service point so that the service point will be included in the load flow calculation without modeling MV/LV transformers owned by the customer.

Generic OPC DA client

The DMS 600 OPC DA client can be used with any compatible OPC DA server to get real time switch states and measurements to DMS. However, alarm indications can be obtained with OPC DA only from MicroSCADA Pro SYS 600 by using SYS 600 specific alarm attributes.

Extended tracing functionality

The user has a possibility to view all switching devices along the selected trace in the tracing order. The list shows the type and the existing state of each switch. Through this dialog a selected switch can be located and it’s switching state can be changed. If the state of any of the switches in the list is changed, the dialog becomes outdated and the trace coloring will be cancelled and the dialog closed. The network window can be zoomed to show all line sections included in the trace to easily see how far the trace continues in the network. This zoom function is available in same shortcut menu where trace functions are located.

Network presentation enhancements

A radial network fed by a circuit breaker but not having any loads connected can be presented with a special no-load color. This helps the user to see which circuit breakers can be opened without harm. There is a different symbol for unsupplied primary transformers. This clarifies the network view and switching operations on substations. A dashed line can be used for coloring an unsupplied (no voltage) network.

2.3. New features and functions in DMS 600 4.1

Advanced switch order management

The data content in Switch Order Management (Switching planning) can be freely defined. This can include freely defined actions like checking and approving the switch order. The power company’s own templates in MS Word can be used to create and print switch order documents.
Network coloring

The user is able to choose nominal voltage levels as the selected network coloring mode. This means that every medium voltage line visible in the network window is colored after its nominal voltage level. Chosen voltage levels can be defined hidden so that line sections and nodes of those voltage levels are not drawn and only the selected voltage levels are included in network presentation.

Fixed colors

The user can choose to use fixed colors for main transformers when coloring the network by primary transformers and for MV-feeders when coloring the network by feeders. The predefined colors and pen widths can be used in parallel with the existing dynamic network coloring where colors are changing depending on network topology.

Faults without opened circuit-breaker to outage reporting

Outage reports classified as faults can be created also when there is no opened feeding circuit-breaker. The user can show the area under fault outage by selecting the bordering switches. For example a fault outage report can be made for a line branch isolated directly by a disconnector.

Changing feeding voltage in simulation

The voltage level in feeding primary substation bus can be changed in simulation mode for example when checking back-up connections in switching planning.

Checking voltage levels and transformer phasor groups

When closing an open switch the system checks that the connected lines have the same nominal voltage level and the feeding primary transformers have the same phasor group angle.

Load-protection coordination

The system checks if the calculated load current can cause a relay or fuse operation. The alarm is listed in notification list and the problematic protection device can be located on screen.
Changed license structure

The module "Outage Reporting and Statistics" can be added without the module "Fault Location". For more information, see 4.1, General about licenses.

2.4. New features and functions in DMS 600 4.0

All functions and features of earlier Open++ Opera versions have been included into DMS 600 software.

Major new features and improvements are listed in the following:
• Improved network editing
• Outage information using GSM messages
• Outage information using telephone answering machine
• GPS coordinates for field crew location
• Using of GPS data in network editing (includes WGS84 coordinate system; spherical coordinates)
• Switching state document (outage data in intranet/internet)
• Outage data export
• Printing of various lists
• Findings to show added information on network windows
• Setting of date and time for network analysis
• Management of LV outage
• Impedance-based fault distance calculation
• Simulation of historical events
• Common login from SYS 600
• Importing station pictures (single line diagrams) from SYS 600 to network database using OPC Data Access
• Opening SYS 600 station pictures and control dialogs directly from DMS 600 WS network window
• Switch states and measurement values using OPC Data Access
• Alarms and warnings (also classification) using OPC Data Access
• Common style of graphic symbols with SYS 600
• Showing the selected symbol as blinking for objects having an unacknowledged alarm
• Locating of network components in DMS 600 network window from the Monitor Pro graphics and the alarm and events lists
• Tracing feeder (downstream) in DMS 600 network window from the Monitor Pro graphics (line indicator and circuit breaker)
• Feeder data from DMS 600 is available to SYS 600 single line diagrams
• No need for MS Access license in basic project without extended data management and regions

System Overview
3. Operational environment

3.1. System requirements

The following table shows the minimum software and hardware requirements for DMS 600 distribution management system. The proposed system configuration contains 1-3 PCs with possible Hot Stand By support.

All network adapter cards supported by the MS Windows 2000, MS Windows XP and MS Windows Server 2003 operating system are supported by DMS 600 software. The device drivers are included in the MS Windows operating system package.

DMS 600 can also be used without MicroSCADA or other SCADA systems.

Table 3.1-1 System requirements for DMS 600

<table>
<thead>
<tr>
<th>Component</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer</td>
<td>Intel® Pentium® processor</td>
</tr>
<tr>
<td>Memory</td>
<td>512 MB</td>
</tr>
<tr>
<td></td>
<td>Recommended amount of RAM is 500 Mb at minimum.</td>
</tr>
<tr>
<td>Disk space</td>
<td>For basic installation 100 Mb free disk space is enough but the real need depends on the amount of background maps which can use even a few gigabytes of server disk space.</td>
</tr>
<tr>
<td>Monitor</td>
<td>VGA, 1024x768 resolution, 65536 colors (16-bit), 70 Hz refresh frequency</td>
</tr>
<tr>
<td>Mouse</td>
<td>Any Windows compatible mouse</td>
</tr>
<tr>
<td>Optional components</td>
<td>One or more network adapter cards, when using DMS 600 software on a LAN with a TCP/IP protocol</td>
</tr>
<tr>
<td></td>
<td>CD-ROM drive</td>
</tr>
<tr>
<td>Software</td>
<td>MS Windows 2000 with Service pack 3 or later or MS Windows XP with Service pack 1 or later or MS Windows Server 2003 recommended.</td>
</tr>
<tr>
<td>Component</td>
<td>Requirement</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Optional software</td>
<td>MicroSCADA SYS 500 version 8.4.2, 8.4.3, 8.4.4, 8.4.5 with LIB 500 Application Library and LIB 510 MV Application Library version 4.0.2, 4.0.3, 4.0.4 or 4.0.5 or MicroSCADA Pro Control System SYS 600 version 9.x.</td>
</tr>
<tr>
<td></td>
<td>MS Access 2000 or MS Access 2002 relational database software (MS Access 95 or 97 during upgrading)</td>
</tr>
<tr>
<td></td>
<td>The Hummingbird™ Exceed version 5.1.3 or later.</td>
</tr>
<tr>
<td></td>
<td>PaintShopPro™ is needed when converting other raster formats to BMP format, editing the color palette of the BMP formatted map material, cutting the BMP formatted map material into smaller pieces or changing them into different accuracy levels.</td>
</tr>
<tr>
<td></td>
<td>CorelDraw® or FontLab® is needed, if new True Type symbol fonts need to be created.</td>
</tr>
</tbody>
</table>

### 3.2. Relational database

DMS 600 can use relational database servers (such as MS SQL Server and Oracle) or MS Access database to store data. The connection to database uses ODBC and data source name (DSN) definitions. MS Access databases are also supported. In this case ODBC and DSN definitions are not needed. Instead of Access databases, two relational database servers with replication feature are recommended for Hot Stand By systems. This way all network changes (even those regarding static network data) can be replicated to two servers. Relational database servers provide a fast and a reliable database access but MS Access provides an environment that is easy to install and to maintain.

### 3.3. Generic OPC DA client

DMS 600 OPC DA client can be used instead of MicroSCADA Pro SYS 600 with any compatible OPC DA server to get real time switch states and measurements to DMS. However, alarm indications can be obtained with OPC DA only from SYS 600. The third party OPC DA server replaces MicroSCADA and acts as a generic SCADA system. Most functionalities in DMS 600 are available as described in the manuals and the term SYS 600 and SCADA can mean also other real time data sources using OPC DA. However, user interface integration, for example opening remote control dialogs and graphic displays, is developed especially for SYS 600 and is not available with other OPC DA servers.
3.4. **Requirements for fault location**

The following is a list of the protection units that can be used with fault location of DMS 600 WS. Other equipment capable of providing at least the minimum data required can be used as well.

**Table 3.4-1 ABB protection units for fault location of DMS 600**

<table>
<thead>
<tr>
<th>SPACOM modules</th>
<th>SPACOM modules</th>
<th>REF units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPCJ 1C7</td>
<td>SPCJ 4D40</td>
<td>REF 541</td>
</tr>
<tr>
<td>SPCJ 1C8</td>
<td>SPCJ 4D44</td>
<td>REF 542</td>
</tr>
<tr>
<td>SPCJ 1C20</td>
<td>SPCJ 4D61</td>
<td>REF 542plus</td>
</tr>
<tr>
<td>SPCJ 2C30</td>
<td>SPCS 2D26</td>
<td>REF 543</td>
</tr>
<tr>
<td>SPCJ 3C3</td>
<td>SPCS 2D32</td>
<td>REF 545</td>
</tr>
<tr>
<td>SPCJ 3C48</td>
<td>SPCS 2D37</td>
<td>REF 610</td>
</tr>
<tr>
<td>SPCJ 3C35</td>
<td>SPCS 3C4</td>
<td>REF 615</td>
</tr>
<tr>
<td>SPCJ 4D24</td>
<td>SPCS 4D11</td>
<td></td>
</tr>
<tr>
<td>SPCJ 4D28</td>
<td>SPCS 4D12</td>
<td>REX units</td>
</tr>
<tr>
<td>SPCJ 4D29</td>
<td>SPCS 4D13</td>
<td>REX 521</td>
</tr>
<tr>
<td>SPCJ 4D34</td>
<td>SPCS 3C2</td>
<td></td>
</tr>
<tr>
<td>SPCJ 4D36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.5. **Architecture of DMS 600**

3.5.1. **General about DMS 600 architecture**

The DMS 600 system consists of three programs from the user’s point of view: DMS 600 Network Editor (DMS 600 NE), DMS 600 Server Application (DMS 600 SA), and DMS 600 Workstation (DMS 600 WS).

All programs (DMS 600 NE, DMS 600 SA, and DMS 600 WS) can run on the same or different computers. Additionally, programs can run on the MicroSCADA system computer. DMS 600 WS and DMS 600 NE can be used in a multiscreen environment without 'dialog box-centering' or similar features in a multiscreen graphics adapter. DMS 600 supports running several instances of DMS 600 WS in the same workstation computer. In a standard workstation, only one DMS 600 NE is allowed.
3.5.2. DMS 600 Network Editor

DMS 600 Network Editor (DMS 600 NE) is primarily used to model the distribution network onto the network database located in the primary fileserver of the fileserver system.

It is also the administrator's tool for managing the whole DMS. The system can be used to manage both medium and low voltage distribution networks. The initialization of the background maps, defining of symbols and the management of the integration between MicroSCADA and DMS 600 are the important tasks of this program. Many other descriptions and definitions are made by DMS 600 NE.

DMS 600 NE can be used while DMS 600 SA and instances of DMS 600 WS are running. DMS 600 NE can be started only if the primary fileserver is connected. Several DMS 600 NE sessions can be run at the same time. The number of simultaneously allowed DMS 600 workstations is defined by the license. The users have a responsibility, however, to check that they are not editing the same network components (same area) of the medium voltage network at the same time.

DMS 600 NE updates the binary network file (*Network.dat*) of the network database and the temporary network file (*Tempnet.dat*) from the user input. Binary network modeling is used to speed up the operations of DMS 600 software. A mechanism for informing DMS 600 NE and instances of DMS 600 WS from the new binary network and temporary network files is included. The users receive information about new network data and can choose, by the user input, to load the new models at once or later. In the fileserver system, network database is not replicated to secondary fileserver. For more information about licenses, see 4.1, General about licenses.

Open++ Integra is a geographical distribution network information management system, which can be used to replace DMS 600 NE in DMS 600 -distribution management system.

3.5.3. DMS 600 Workstation

DMS 600 Workstation (DMS 600 WS) is a program for the operative personnel of electric companies to monitor and operate their medium and low voltage distribution networks.

The program contains the following functions:

- Alarming,
- Network topology management,
- Network analysis including power flow and fault current calculations together with protection analysis,
- Operational simulations,
- Fault location based on fault distance calculation and fault detector data,
- Restoration,
• Switching planning,
• Contingency analysis,
• Outage data management,
• Field crew management,
• Load estimation,
• Customer service,
• Database analysis,
• Document archive and
• Map printing.

The functional content of the system depends on the licenses, sublicenses and definition of optional functions.

The basis of DMS 600 WS is a distribution network database managed by DMS 600 NE and real time process data from MicroSCADA. Control actions can be done using MicroSCADA station pictures and control dialogs can be opened directly from DMS 600 WS. In the opened control dialog the user has control rights only if the username and password in the DMS 600 match with the user information in SYS 600 and if the user is authorized to control the selected switch.

3.5.4. DMS 600 Server Application

The main function of DMS 600 Server Application (DMS 600 SA) is to serve communication routines for DMS 600 software. The communication routines of DMS 600 SA consist of two parts: communication between DMS 600 SA and MicroSCADA, and communication between DMS 600 software. The connection between DMS 600 SA and MicroSCADA is defined by the sublicense.

Earlier Open++ Opera versions' communication has been based on DMS 600 SA communication (SCIL API interface), and it is possible to use it also in DMS 600. OPC Data Access interface of DMS 600 can be used parallel with SCIL API in some communication tasks.

The user interface of DMS 600 SA is very simple and without network presentation. In SCIL API interface, DMS 600 SA provides real time information as well as station and control pictures from MicroSCADA for instances of DMS 600 WS. Information is transferred via the DMS 600 database and fault files (Fau<xxx>.txt).

DMS 600 SA functions for MicroSCADA integration are:
• Establishing and breaking a connection to MicroSCADA using SCIL API.
• Managing switching state, measurement, alarm and warning data from MicroSCADA to DMS 600 WS (alternatively can be managed with OPC Data Access interface).
• Sending a picture open request of the picture from DMS 600 WS to MicroSCADA (alternatively can be managed with OPC Data Access interface).
• Sending information about a new fault and managing fault location information from MicroSCADA to DMS 600 WS.
• Management of automatic fault isolation and restoration.
• Changing the position data of fault detectors in MicroSCADA.
• Controlling feeder's root point coloring to MicroSCADA (alternatively can be managed with OPC Data Access interface).

DMS 600 SA functions for DMS 600 WS and DMS 600 NE are:
• Managing the login information.
• Changing system specific settings.
• Changing data in the DMS 600 network data.
• Informing about database updates.

3.6. **Hot Stand By**

Hot Stand By (HSB) is a system used to secure database connections with two servers, which are capable of continuing service alone if the connection to the other is lost.

HSB support is included in the Support System Interface (SSI), the dynamic DMS 600 database, binary network file and the fault files, if so defined in the sublicense. In the SSI, DMS 600 SA must be ready to reconnect to HSB SYS of MicroSCADA.

DMS 600 databases and fault files are redundant, so the malfunction of a DMS 600 SA computer does not stop operation of the system. DMS 600 WS can be started using the redundant fileserver and DMS 600 SA. When using MS Access databases, DMS 600 NE can be started only if the primary fileserver is connected.

If there are two SA instances running simultaneously, the DMS will handle this itself internally. Though this is an error, it will not prevent the usage of the system. The last SA instance that was started takes over and continues normally.

Two relational databases with a replication feature are recommended for HSB systems.

3.7. **Slow network connections**

DMS 600 can be optimized for slow network connections. This feature is useful if there is a slow Wide Area Network (WAN) connection instead of a LAN between central and district offices and terminal services are not used. Additional regional servers can be used to store network data to keep the start-up time of the programs reasonable.

3.8. **Terminal services**

Normally DMS 600 uses client-server architecture, which means that for example DMS 600 WS applications are run using the client computer processor and memory. The network model is loaded to the main memory of the client workstation.

However, DMS 600 programs can be run in a terminal session using Windows 2000 Server or Windows Server 2003 (these include Terminal Services). This is advantageous
for example in case of slow network connections or when using dial-up networking with modems. This is often needed in order to use DMS 600 in a home workstation. Additionally, it can be advantageous that occasional users from office workstations use terminal services since upgrading and maintenance of the software need to be done only on the server. Simultaneously in the same system the power users for example in the control center can use standard workstations.

With MicroSCADA Pro SYS 600 new monitor type (MicroSCADA Monitor Pro) terminal services are used instead of Exceed to spread applications to workstations at least when Monitor Pro graphics and tools are used. In this case also DMS 600 shall be run under terminal services so that the integration of user interfaces can work.

3.9. Communication in DMS 600 environment

3.9.1. General about communication

DMS 600 has three communication interfaces (numbers referred in image below):

1. SCIL-API interface
2. OPC interface
3. DMS600 internal communication interface

![DMS Communication Interfaces](image-url)

*Figure 3.9.1-1 DMS 600 communication interfaces*
• Double-arrow lines: read and write actions
• Single-arrow lines: read only actions
• Double-arrow dashed lines: create/modify

DMS 600 software applications use a dedicated Windows service as a message routing component. This service has a crucial part in DMS 600 messaging as all messages are routed through it. In an HSB environment, the service is redundant. DMS 600 messaging uses TCP protocols directly through the Windows Sockets API.

DMS 600 NE updates network data changes directly to the relational network database of the local workstation or of the primary fileserver in the fileserver system. Ready changes are then saved into the binary network file to achieve fast upload to workstation memory. Information about the new binary network file is sent to DMS 600 SA, as well as DMS 600 WS and DMS 600 NE. These read the new network data from the binary network file. DMS 600 WS uses the source network database only when opening a network component or free form object data.

DMS 600 NE uses a temporary network file for temporary network data that is read together with real network data into the memory of DMS 600 WS workstations.

3.9.2. Communication between DMS 600 and MicroSCADA

3.9.2.1. General about communication between DMS 600 and MicroSCADA

DMS 600 SA is used for data exchange between MicroSCADA and instances of DMS 600 software by using SCIL API and Support System Interface (SSI). Earlier Open++ Opera version’s communication was totally based on SCIL API interface, which can be used also in DMS 600.
MicroSCADA Pro Control System SYS 600 version 9.x and MicroSCADA SYS 500 version 8.4.5 have a new communication feature based on OPC Data Access. All the process objects of SCADA are exposed by the server as OPC items and all the attributes of process objects as OPC item properties. The OPC Data Access interface of DMS 600 can be used in parallel with SCIL API in some communication tasks. DMS 600 can also communicate with other SCADA systems using the OPC Data Access interface.

If defined, the OPC interface is primarily used for communication. Only if the OPC interface is closed, the SCIL API interface is open and also scada code for the component is defined, the SCIL API interface is used for communication.

3.9.2.2. Communication with SCIL API interface

Real-time switch state change causes sending of an event-based data message from MicroSCADA to DMS 600 SA. DMS 600 SA then sends this data message to all DMS 600 Workstations. DMS 600 WS does not read a server disk or database in this case. Switch state changes are also updated to DMS 600 database.

Measurement values are obtained to DMS 600 SA like switching states. New measurement values are updated to DMS 600 database and sent to all DMS 600 Workstations. Measurement data is transferred cyclically and in an event-based manner from MicroSCADA to DMS 600 software.

Alarm and warning attributes are handled together with switching states and measurement values through the SCIL API interface.

When a new fault occurs, an event-based data message is sent to DMS 600 SA from MicroSCADA. DMS 600 SA saves fault data into a fault file, part of the fault data (the running number of the fault, the state of the fault, and the title of the fault) into the DMS 600 database, and sends a message to all DMS 600 Workstations. DMS 600 Workstations then read additional data from fault files and DMS 600 database.

Automatic fault isolation and restoration is managed from only one DMS 600 Workstation. The generated switching sequence in DMS 600 WS is automatically transferred from DMS 600 WS to MicroSCADA and execution is started. A special process object is used to indicate the automatic fault isolation and restoration sequence status.

3.9.2.3. Communication with OPC Data Access interface

This chapter is valid only for MicroSCADA Pro Control System SYS 600 version 9.x (SYS 600) and for MicroSCADA SYS 500 version 8.4.5.
OPC Server and OPC Clients are used for data exchange between SCADA and instances of DMS 600 software by using OPC Data Access. Communication between DMS 600 and SCADA requires a connection between OPC items and DMS network components and free form objects. The connection is made with the configuration tool in DMS 600 NE.

Real-time switch state change and measurement value change cause sending of an event from MicroSCADA SYS 600 OPC Server to all instances of DMS 600 WS and also DMS 600 SA. DMS 600 sends a feedback of an event data if defined so in the settings. Alarm and warning properties are handled together with switching states and measurement values.
4. Licenses

4.1. General about licenses

The functioning of DMS 600 software depends on the licenses and sublicenses containing information about the main and optional functions together with information about the connection between DMS 600 SA and SCADA.

The available commands in the user interface reflect the capabilities of the program in accordance with the installed licenses, sublicenses and selectable functions.

DMS 600 software 4.2 requires licenses for the version 4.2 to function correctly. Additionally, version 4.0/4.1 licenses are compatible and accepted for 4.2. If previous license (Open++ Opera version 3.2 or 3.3 license) is used with DMS 600 software version 4.2, warnings message "License version number is incorrect! ABB assumes no responsibility for any error that may occur while using this program!" is displayed. DMS 600 software version 4.2 licenses are delivered with DMS 600 software version 4.2 program update.

4.2. Functionality of DMS 600

Table 4.2-1 Functionality of DMS 600 licenses

<table>
<thead>
<tr>
<th>License</th>
<th>Sublicense</th>
<th>Selectable Functions</th>
<th>Operational Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMS 600 (Base)</td>
<td></td>
<td>• Temporary network data</td>
<td>• Distribution network topology management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Events</td>
<td>• Temporary network data</td>
</tr>
<tr>
<td>SCADA connection</td>
<td></td>
<td></td>
<td>• Connection between DMS 600 SA and SCADA</td>
</tr>
<tr>
<td>Hot Stand By</td>
<td></td>
<td></td>
<td>• Two server systems to secure database connection</td>
</tr>
<tr>
<td>Demo</td>
<td></td>
<td></td>
<td>• Demo to allow introducing of DMS 600 software with limited MicroSCADA connection (6 hours without reopening) and network editing only to temporary networks</td>
</tr>
<tr>
<td>Low voltage networks</td>
<td></td>
<td></td>
<td>• Management of low voltage network</td>
</tr>
<tr>
<td>GPS Support</td>
<td></td>
<td></td>
<td>• GPS data in network editing and field crew management</td>
</tr>
<tr>
<td>License</td>
<td>Sublicense</td>
<td>Selectable Functions</td>
<td>Operational Functions</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>----------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>GSM messages</td>
<td></td>
<td></td>
<td>• GSM messages used for sending outage information or other messages.</td>
</tr>
<tr>
<td>Switching State Document</td>
<td></td>
<td></td>
<td>• Switching state document</td>
</tr>
<tr>
<td>General extensions</td>
<td>• Field crew management</td>
<td>• Field crew management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Customer information</td>
<td>• Map printing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Alarms</td>
<td>• Customer information</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Alarm and warning presentation</td>
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<tr>
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<td>• Measurements presentation</td>
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<td>• Document archive</td>
<td>• Document archive</td>
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</tr>
<tr>
<td></td>
<td>• Free database objects</td>
<td>• Free database objects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Free data form</td>
<td>• Free data forms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Free data form for DMS 600 WS</td>
<td>• Queries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Queries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network Analysis</td>
<td></td>
<td></td>
<td>• Network and protection analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Operational simulations</td>
</tr>
<tr>
<td>Extended Load Modeling</td>
<td>• Load estimation</td>
<td>• Load estimation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Use of Velanders factors or load curves</td>
<td>• Load curves</td>
<td></td>
</tr>
<tr>
<td>Operations Planning</td>
<td></td>
<td></td>
<td>• Switching planning</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Contingency analysis</td>
</tr>
<tr>
<td>Reconfiguration</td>
<td></td>
<td></td>
<td>• Reconfiguration</td>
</tr>
<tr>
<td>Fault Location</td>
<td></td>
<td></td>
<td>• Fault management</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Fault simulation</td>
</tr>
<tr>
<td>Restoration Support</td>
<td></td>
<td></td>
<td>• Fault restoration</td>
</tr>
<tr>
<td>Automatic Fault Isolation and Restoration</td>
<td></td>
<td></td>
<td>• Automatic fault isolation and restoration</td>
</tr>
<tr>
<td>Telephone answering machine</td>
<td></td>
<td></td>
<td>• Outage information using telephone answering machine</td>
</tr>
<tr>
<td>Outage Reporting and Statistics</td>
<td></td>
<td></td>
<td>• Outage report</td>
</tr>
<tr>
<td>Advanced Report Management</td>
<td></td>
<td></td>
<td>• Outage data export</td>
</tr>
</tbody>
</table>
DMS 600 (Base) license authorizes the most limited functionality of the program and is always required for additional functionality licenses. The following list contains some recommendations for licenses:

The following list contains some recommendations for licenses:
- Network Analysis license is strongly recommended for optimal performance of restoration support functionality.
- Low voltage networks and operations planning are strongly recommended for optimal performance of outage reporting and statistics.

The following picture shows license modules and their dependencies in DMS 600 4.0. In version 4.2 license "Outage Reporting and Statistics" can be added without the module "Fault Location".

![DMS_licenses_a.jpg](DMS_licenses_a.jpg)

*Figure 4.2-1 DMS 600 software licenses*
4.3. Dimensions of the network

License files define not only the functionality of DMS 600 software but also the dimensions of the network database (number of primary substations having a feeding primary transformer, transformers and disconnectors). Network size can be Small, Medium, Large or No Limit.

Table 4.3-1 Maximum numbers of network components for different licenses

<table>
<thead>
<tr>
<th>Network size</th>
<th>Number of network components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>• 5 feeding HV/MV primary substations,</td>
</tr>
<tr>
<td></td>
<td>• 400 transformers and</td>
</tr>
<tr>
<td></td>
<td>• 800 disconnectors</td>
</tr>
<tr>
<td>Medium</td>
<td>• 15 feeding HV/MV primary substations,</td>
</tr>
<tr>
<td></td>
<td>• 1000 transformers and</td>
</tr>
<tr>
<td></td>
<td>• 3000 disconnectors</td>
</tr>
<tr>
<td>Large</td>
<td>• 30 feeding HV/MV primary substations,</td>
</tr>
<tr>
<td></td>
<td>• 4000 transformers and</td>
</tr>
<tr>
<td></td>
<td>• 8000 disconnectors</td>
</tr>
<tr>
<td>Extra Large- No Limit</td>
<td>• Unlimited number of feeding HV/MV primary</td>
</tr>
<tr>
<td></td>
<td>substations, transformers and disconnectors</td>
</tr>
</tbody>
</table>

4.4. Number of workstations

License files define also the number of DMS 600 software workstations (DMS 600 NE and DMS 600 WS workstations used simultaneously). The number of workstations can be between 1...999.
5. User interface

5.1. General about user interface

The user interface of DMS 600 NE and DMS 600 WS consists of a title bar, menu, toolbar/toolbox, shortcut menus, status bar, together with main and auxiliary network windows showing the distribution network. The user interface of DMS 600 SA is very simple and without a network presentation.

The main network window of DMS 600 NE and DMS 600 WS uses raster and vector based geographic maps as a background for the network presentation. The outlook of map material can be set workstation specific. It is also possible to create and use schematic network views, instead of geographically based network presentations and maps.

5.2. Network windows

DMS 600 NE and DMS 600 WS represent the distribution network in two network windows. The auxiliary network window always shows the whole network. The main network window shows the area of the network in more detail. The area covered by the main network window is shown as a rectangle in the auxiliary network window. Normally the medium voltage network is visible in network windows. Low voltage networks are always separately read to the memory. After a change to the low voltage network, the medium voltage network is presented dimmed in network windows.

If you hold the mouse cursor for a moment over a network node or a line section in the main window, a tool tip is opened presenting information about the node or line section, and real and reactive powers defined by the network analysis.

Network data is presented using data forms and dialog boxes, together with colors in graphics-based network windows and diagrams.

Network windows can be zoomed and panned. Zoom view can be saved and restored into the main network window. The size and location of network windows can be changed and the data is saved during the shutdown of the program.

DMS 600 has many commands to show and handle network data using the network window, for example node and line section data, feeder data, downstream and upstream traces and important transformers.

5.3. Network diagrams

DMS 600 NE and DMS 600 WS can also present selected parts of the network as diagrams. The network diagram is generated automatically using the existing network data
so that no special tasks are needed during network data entry. The network diagram window can be opened by right-clicking the network in the main network window and selecting it from the opened menu.

5.4. Parallel network views

It is possible to select the used network view independently in each program instance (workstation). The user has the possibility to create a new view by moving and hiding nodes and lines in the main view without overwriting already existing data. For example, a parallel schematic diagram can be created (orthogonal schema) to make network operation clear and effective but exact locations of objects can be viewed on a map using a geographic view. All views can use the real time network coloring to show the state of the network as before.

5.5. Station diagrams and other diagrams

Station diagrams are used to handle station components in greater detail and to show the switching states of station components. In DMS 600 WS station and control pictures are used to control the states of switches. The administrator defines the cross-connections between MicroSCADA station and control pictures and DMS 600 stations by using DMS 600 NE. The data is saved into the network database.
DMS 600 NE uses only internal station diagrams. DMS 600 WS uses two kinds of station diagram presentations:

- Station and control pictures from MicroSCADA and
- Internal station diagrams.

Normally internal station diagrams are converted from MicroSCADA. Station diagrams can also be created in DMS 600 NE.

MicroSCADA old and new style (SYS 600) station pictures and control dialogs can be used.

A particular symbol in the network window means that the object has a station diagram presentation. The internal station diagram becomes visible after zooming in close enough. In DMS 600 WS the MicroSCADA station or control picture and in DMS 600 NE the internal station diagram is opened to a separate window when the symbol or station diagram in the network window is right-clicked. The separate station window can also be opened with a menu command. It is possible to have multiple station diagram windows open at the same time.

Other medium and low voltage network diagrams can also be created in DMS 600 NE. These diagrams contain network objects, which can be shown in more detail in diagram mode (for example MV/LV stations and disconnector stations). This type of connection between network objects is called a site node.

![Substation Diagram Dialog](image.png)

Figure 5.5-1 An example of an internal station diagram in DMS 600 NE
Network symbols, codes and coloring

DMS 600 NE and DMS 600 WS have default values for network symbols and coloring as well as for other network view settings, but the user can easily change them. Some object types can also be defined to show only in low voltage network view.

Network lines can be colored in main or auxiliary network window according to the topology, line types or results of the network and protection analysis. The colors and symbols used in the network diagram and the internal station diagram windows are the same in the feeder topology presentation mode of the network window. The colors of the root points of the feeders in the MicroSCADA station and control pictures opened in DMS 600 WS are also always the same as in the feeder topology presentation mode.

The state of the switches defines the topology of the network. DMS 600 NE creates the topology according to the states of the switches in the network database. Real time topology coloring in DMS 600 WS is based on the integration of DMS 600 and MicroSCADA. The change in switching state updates automatically the network topology on the screen. The appropriate low voltage networks must be loaded into the memory to see the switching state of the low voltage network.

After definition of the connection, the process, measurement values and alarms can be seen in the network window. Measurements and alarms from MicroSCADA are automatically updated to the use of DMS 600 software.

Warning level and alarm level colors are used to present network and protection analysis results when the calculated values exceed the corresponding settings for the limits. Alarms and warnings are also generated in DMS 600 WS based on network topology and fault location.

The presentation of network component codes and labels assists in finding the network component in the network. Codes and labels can be shown for substation, MV/LV station, switches, motors, generators, circuit breakers, primary transformers and feeders. Also symbols and/or labels of free database object types, text object types and measurements can be shown in the network window. MV/LV station and switch codes are always shown in the diagram.

DMS 600 WS shows also the data of temporary networks with the colors in the network window.

User interface controls

Network data and other data are presented using data forms and dialog boxes, lists, together with colors in graphics-based network windows and diagrams. Functions are selected from mouse and keyboard-controlled menus and submenus or from toolbar/toolbox buttons. The main way to find the network component or free form object data is by selecting from the basic user interface network window. The dialog boxes contain
scrolling bars, list boxes, check boxes, option buttons, command buttons, and other elements from the MS Windows user interface.

5.8. **Data forms**

Network data is managed by the graphics-based user interface of DMS 600 NE with network windows and geographic background maps. The graphics-based data is inserted and edited using the mouse in the network windows and the non-graphics-based data via data forms. Data forms are also used for the browsing of network component and free database object data. Data forms are views into the DMS 600 network database.

DMS 600 uses two kinds of data forms:
- Fixed data forms
- Free data forms

**Figure 5.8-1 An example of fixed data form in DMS 600 NE**

Fixed data forms are used in DMS 600 NE. DMS 600 WS uses only free data forms. Data forms consist of boxes and buttons, which are used to insert and update network component and free form object data. Several data forms can be opened simultaneously. Free data forms can be used to define the layout of data forms. The administrator of the system can define the contents of the free data forms (boxes, labels, language, drop-down lists). Data forms also contain buttons with different kinds of functions (for example calculation of line section length and maintaining the history of transformers).
5.9. **Online help**

DMS 600 NE and DMS 600 WS have an online help containing online manuals with contents, index and free text search features, together with context-sensitive resources.
6. Configuration of DMS 600 distribution management system

6.1. General about DMS 600 configuration

The foundation of DMS 600 is an existing SCADA application, network data and background map material. DMS 600 can also be used without MicroSCADA or other SCADA systems. The network database can be created using DMS 600 NE or it can be imported from another system (needs specific engineering).

The DMS 600 distribution management system is created by the Setup Program of DMS 600 software, MicroSCADA tools and DMS 600 NE.

Configuration of the DMS 600 distribution management system contains the following main steps:
• Initialization of the background maps
• Setting up the DMS 600 SA specific settings and opening a connection to MicroSCADA
• Creation of the distribution network database
• Importation of the MicroSCADA station diagrams
• Definition of the process objects (for SCIL API interface) or definition of the OPC item connection (for OPC interface), definition of virtual process points and picture names
• Configuration of the data transfer groups
• Definition of the measurements
• Definition of the regions and the users levels
• Definition of the symbols
• Setting up the system specific settings.

6.2. Background maps

The user interface of DMS 600 NE and DMS 600 WS uses raster and vector based geographic maps in the network window. Therefore, geographic map material has to be imported to the system.

The system supports the following map formats:
• Raster maps in bmp (Windows bitmap format).
• Vector maps in AutoCAD® dxf format.

All background maps used in DMS 600 should be converted to these map formats and adjusted to a single orthogonal orientation, where the x-axis is horizontal (left to right) and the y-axis is vertical (down to up).

Raster material can be either obtained as computer data or scanned from paper maps. The conversion of raster formatted map materials to bmp is made by using an external
tool, for example PaintShopPro. Raster formatted map material can also be modified by changing the color palette, cutting large bmp raster maps into smaller pieces and by changing them into different accuracy levels using, for example, PaintShopPro. This kind of modification can be used to view the background maps more quickly on the screen. The conversion of the supported vector formatted dxf map material to DMS 600 internal vg2 format is done by DMS 600 NE.

DMS 600 NE can also be used to adjust the supported map materials. Dxf conversion function adjusts the vector maps automatically during the conversion. Vector maps in vg2 format can also be adjusted without conversion. The adjustment of raster maps can be done in two different ways: based on the coordinates of the map corners or on the coordinates of a free selection.

Map management by DMS 600 WS makes the changing of the outlook and storing location of background maps possible.

6.3. Databases

6.3.1. Network database

6.3.1.1. General about network database

The network database is the basis of the DMS 600 system. The dimensions of the network database are not technically limited but maximum network size may be limited by the license. Depending on the existence of the appropriate sublicense, the network database includes only medium voltage or both medium and low voltage networks. Network data entry is made in DMS 600 Network Editor (DMS 600 NE). Network data is stored by MS Access 2000 or MS Access 2002 relational database software.

Network data can also be imported from another system. This alternative will need specific engineering.

6.3.1.2. Network database and binary network file

DMS 600 uses two kinds of network databases: the network database and the binary network file (Network.dat). Updates of the network data in DMS 600 NE go directly to the network database of a local workstation or of the primary fileserver in the fileserver system. DMS 600 NE updates the binary network file from the database from user input. After this command is given, a message is sent to all workstations (all instances of DMS 600 WS and DMS 600 NE) to inform them about the new network data. This data can be updated immediately by accepting the suggestion in the message window or later by using the command in instances of DMS 600 WS. Because of this, the medium voltage network data of the same area cannot be updated simultaneously in different workstations. The binary network file is saved only to the local workstation, if the updating for all is
prohibited. The scheduled update of the binary network file can be defined to ensure that the last network changes are available to all workstations.

6.3.1.3. **Content of network data**

The database contains data on the lines, components and free form objects of the distribution network. Load data and protection relay data for each protection unit - overcurrent, earth-fault, and reclose - also has to be imported into the network database if the network analysis is included in DMS 600 WS. Relay setting data can also be obtained from the relays via MicroSCADA.

Network analysis uses load data to calculate the load flow of the electrical network. Protection relay data is used to check the acceptance of protection during network analysis. Additionally, the database can contain free database objects (for example data of tenancies and measurements), documents attached to the components or free form objects, temporary network data and customer data. The type data of disconnectors, MV fuses, MV and LV conductors of a network are used in analysis of DMS 600 WS. Equivalent temperature for MV and LV conductor types are used for calculation of the conductor resistance.

The basic data items are nodes and the line sections connecting them. DMS 600 software also uses the concept "site node". Site node contains network objects located near each other. For example, a disconnector station can be depicted with a site node. Tables representing data from different network components or free form objects are linked to the nodes. A data model of the network is presented in the following figure.
The primary substations, in which one nominal voltage is above transmission voltage level, are functioning as feeding points. Technical data (e.g. short-circuit impedance) of the feeding primary stations is needed for the network and protection analysis of DMS 600 WS. Technical data of the primary transformers (e.g. negative sequence and zero sequence resistance and reactance values) are needed for the unbalanced fault analysis of DMS 600 WS.

The off load tap changer step in MV/LV station data form affects the network analysis by increasing the reduction factor of the transformer. Negative values can also be used.

The switching state data of circuit breakers, disconnectors, MV fuses and LV switches is used in topology creation in DMS 600 NE.

Two types of generators can be added to the MV network. These generators are taken into account in the load flow calculations of DMS 600 WS:

- Large regulating generators in power plants, which are used to regulate the voltage.
- Smaller distributed controlling generators produce active power and reactive power by regulating the reactive power produced.
Two types of arc suppression coils can be added to the MV network:

- Automatically controlled arc suppression coil
- Distributed stationary arc suppression coil.

Only the automatically controlled arc suppression coils are taken into account in the load flow calculations of DMS 600 WS.

MV fuses and LV switches are taken into account in the protection analysis of DMS 600 WS.

Summation current transformer, neutral current transformer and voltage transformer data can be inserted into the database. Measurement transformer data is used to define the relay values for the protection analysis of DMS 600 WS.

Grounding data of medium and low voltage networks can be added into the network database. The groundings can be viewed on the network window, but the data is not used in the network analysis of DMS 600 WS.

6.3.1.4. Editing network data

Network data is managed by the graphics-based user interface of DMS 600 NE with network windows and geographic background maps. Graphics-based data is inserted and edited using the mouse in the network windows, and network component or free form object data using data forms or optional free data forms. Internal station diagrams can be converted from MicroSCADA or created with DMS 600 NE.

Inserting and updating of network data is allowed in the Data Edit Mode of the system. The Data View Mode only allows the browsing of the existing network data. Browsing, updating and inserting temporary network data is made in the separate Temporary Network Mode.

In DMS 600 NE data for distribution network components can be entered and updated using ready-made data forms. During the addition of new lines to the network, empty data forms are automatically opened when new network component data is required. These data forms can be completely filled in immediately or just given some primary data (generally code and voltage level) and filled in with extra data later.

Mass update enables the data to be inserted and updated for all object type records or for graphically selected targets of the same object type. Mass update can also be used to update graphically selected line section data (for example conductor data).

6.3.1.5. MicroSCADA integration data

The optional integration of DMS 600 and MicroSCADA requires that links between network components in different software are included in the database. The links between process objects, the virtual points and MicroSCADA measurements to the network
objects are updated in DMS 600 NE and saved in the database. Cross-connections between MicroSCADA pictures and DMS 600 stations are also saved in the database.

6.3.1.6. Customer information

DMS 600 contains a customer service function. DMS 600 software does not include customer data management. Customer data can be imported to network database using the MS Access import function (e.g. via ASCII text file). It is also possible to create a linked table to use an external customer database via ODBC.

In DMS 600, a customer service point can be added both to an MV network (MV customer) and to an LV network (LV customer).

6.3.1.7. Load data

DMS 600 uses Velanders factors or defined load models (load curves) to change the annual energy of a customer to active and reactive power. The load model is selected during installation.

The customer loads can be imported to the network database using the MS Access import function. If DMS 600 uses defined load models (load curves), and the real customer energy data cannot be imported from an external customer database, insert load data directly to a database table. Otherwise, load data can be inserted to MV/LV stations or MV customers if only a medium voltage network is used in DMS 600 software. If a low voltage network is used, the load data is entered to a low voltage (or medium voltage) consumer. The loads inside the primary substations are not modeled.

6.3.1.8. Free database

Free database enables customized object types and free fields to primary network objects. The administrator of DMS 600 software defines free database object types into network database using MS Access. Free database enables the adding of extra fields to the tables of existing node and line section types containing initial fixed data content. Also text data is managed with free database objects.

The data of a free databases is presented in free data forms.

6.3.1.9. Document archive

Documents are data files (for example pictures, text documents or video clips) attached to the nodes of the network (network objects or free form objects). Documents can be any files, which can be run with a program in the workstation. Documents are attached to nodes in DMS 600 NE. The attached documents can be browsed in DMS 600 NE and DMS 600 WS.
GPS data

A GPS device can be used to collect coordinate data (waypoints) from the terrain. GPS waypoints are inserted batched or continuous to the network database and these points can then be used during network editing. GPS waypoints are stored using WGS84 datum, in latitude/longitude format.

The continuous locating function shows the real time location of the GPS device connected to for example a laptop computer, carried by a field crew. The continuous locating function supports both WGS84 and national map datums.

Temporary network data

The management of temporary networks enables the maintenance of medium and low voltage temporary network data. The data is saved in a separate file from the network database (Tempnet.dat).

Temporary network components cannot be integrated in process points of MicroSCADA. The network component needs to be inserted in the network database in order to be integrated. Network coloring can be used to distinguish objects in a temporary network.

During start up of DMS 600 NE, only the real network data from the binary network file is loaded. The handling of temporary network data always occurs in a separate Temporary Network Mode.

DMS 600 WS loads the temporary network data during start-up and shows the data together with other network data in the network windows.

DMS 600 database

The DMS 600 database is another central part of the DMS 600 software. It is stored by MS Access 2000 or MS Access 2002 relational database software. The database contains for example data about user and region management, DMS 600/MicroSCADA integration and process.

Integration of DMS 600 and MicroSCADA

Functionalities of the integration

The connection between MicroSCADA and DMS 600 functions requires the appropriate sublicense. DMS 600 can also be used without MicroSCADA or other SCADA systems. The offline functionality can be used also for example in the beginning of MicroSCADA or DMS 600 projects.
Integration of DMS 600 and MicroSCADA enables:

- Importing of station pictures from MicroSCADA to the network database in DMS 600 NE.
- Starting the DMS 600 session via MicroSCADA.
- Control actions by opening MicroSCADA classic or Monitor Pro graphics or SYS 600 control dialogs directly from DMS 600 WS.
- Getting all the position indication data from SCADA to the topology management of DMS 600 WS.
- Getting measurement, alarm and warning data from SCADA to the load estimation, alarming and displaying of DMS 600 WS.
- Getting required process data for DMS 600 WS fault location functions.
- Automatic fault isolation and restoration using the switching plan produced by DMS 600 WS to control MicroSCADA.
- Getting real relay settings for DMS 600 WS protection analysis.
- The transfer of root point coloring and power flow direction from DMS 600 WS to MicroSCADA station pictures.
- Locating of network components in DMS 600 WS network window from the Monitor Pro graphics and alarm and events lists.
- Downstream tracing feeder in DMS 600 WS network window from the Monitor Pro graphics (line indicator and circuit breaker)
- Showing feeder data from DMS 600 WS in SYS 600 single line diagrams

6.4.2 Data transfer and databases

DMS 600 contains an optional high-level interface to MicroSCADA, which provides real time and static data transfer to and from DMS 600.

The data transfer from the MicroSCADA system is both static and dynamic:

- MicroSCADA old and new style station pictures are imported only occasionally using the importing function supported by DMS 600 NE and the data is static in the network database. Other pictures from MicroSCADA can also be defined to be displayed in DMS 600 WS.
- Relay settings data is transferred for the use of protection analysis using MicroSCADA.
- The transfer of the states of the switches, alarms and warnings is based on events in the MicroSCADA system and performed by DMS 600 SA or OPC Data Access. This data is saved in the dynamic DMS 600 database used by DMS 600 WS.
- The measurement data of MicroSCADA is transferred at regular intervals or event-based for network monitoring and analysis by DMS 600 SA or OPC Data Access.
- The transfer of the fault data is based on events in the MicroSCADA system and performed by DMS 600 SA. This data is saved in the dynamic DMS 600 database used by DMS 600 WS.
- Automatic fault isolation and restoration is managed from only one DMS 600 WS workstation. The generated switching sequence in DMS 600 WS is automatically transferred from DMS 600 WS to MicroSCADA and executed.
DMS 600 has a command to show the events generated by DMS 600 and the events transferred from MicroSCADA.

The full integration of MicroSCADA and DMS 600 is supported in MicroSCADA SYS 500 version 8.4.2, 8.4.3, 8.4.4, 8.4.5 with LIB 500 Application Library and LIB 510 MV Application Library version 4.0.2, 4.0.3 or 4.0.4 or MicroSCADA Pro Control System SYS 600 version 9.x. With the older version of MicroSCADA, the interface is limited and requires special engineering.

6.4.3. Cross connections between DMS 600 and MicroSCADA when using SCIL API

All network components, which relate to data transfer between MicroSCADA and DMS 600, should be cross connected by the process objects or virtual process points of MicroSCADA using the LIB 500 Application Library DMS Interface Package and DMS 600 NE.

- The process object codes (scadacodes) for primary stations, primary transformers, circuit breakers, disconnectors, feeders and fault detectors.
- The process object codes (scadacodes) for the measurements of MicroSCADA to be used in DMS 600.
- Virtual process points of MicroSCADA for manually operated switches in DMS 600 NE. These virtual process points are defined as objects and used for storing the states of the switches and for getting the operation events in MicroSCADA.
- Virtual process points of MicroSCADA for primary substations and the MicroSCADA station and control pictures. The geographic selection of the MicroSCADA station and control pictures in DMS 600 WS makes it possible to implement control actions on the same monitor screen as DMS 600 WS.

To be included in MicroSCADA alarm and events lists, it is recommended that all switches of the network, also manually operated ones, are connected to the MicroSCADA database and data transfer groups.

6.4.4. Cross connections between DMS 600 and SCADA when using OPC Data Access

This chapter is valid only for MicroSCADA Pro Control System SYS 600 version 9.x (SYS 600) and for MicroSCADA SYS 500 version 8.4.5.

All the process objects of SCADA are exposed by the server as OPC items and all the attributes of process objects as OPC item properties. Communication between DMS 600 and SCADA requires a connection between OPC items and DMS network components. The connection is made with the configuration tool in DMS 600 NE.
The following network components are part of the data transfer between MicroSCADA and DMS 600: primary stations, primary transformers, circuit breakers, disconnectors, feeders, line indicators, fault detectors, generators and measurements.

OPC connection contains OPC item as key values, object type and DMS network component codes as data values.

### 6.4.5. Interfaces and protocols

DMS 600 and MicroSCADA can be integrated by using:
- An application program interface (API) based on socket and TCP/IP data transmission protocols (SCIL API interface) and
- OPC Data Access (OPC Data Access interface) with MicroSCADA Pro Control System SYS 600 version 9.x and MicroSCADA SYS 500 version 8.4.5

In the SCIL API interface, DMS 600 SA performs the data exchange with MicroSCADA and instances of DMS 600 WS by using SSI to MicroSCADA. DMS 600 SA asks periodically for data of all data transfer groups. DMS 600 SA sends a data request to MicroSCADA (for example at 20-minute intervals) for every data group. The interval between data requests depends on the data transfer intensity level of DMS 600 SA. Data transfer can also be defined to be spontaneous by using events of MicroSCADA.

In OPC Data Access interface (SYS 600), OPC Server and OPC Clients are used for data exchange between SCADA and instances of DMS 600 software. OPC connection with OPC item as a key value, object type and DMS network component code as data values are used. In communication with DMS 600 and SCADA, OPC items will be handled as groups. The group level properties are update interval and type of the group. For position indication types of groups the default value of the update interval is zero and for other types 1000 ms.

### 6.5. User and region management

#### 6.5.1. General about user and region management

User management enables login and logout functions with user identifiers (username and password) without restarting the software. Region management enables dividing the network data into several regions according to feeding primary transformers and generators. The total amount of feeding primary transformers and generators defines the maximum number of regions. The user right level can be defined for each region separately. This offers for example a possibility to divide the fault restoration responsibility to local control centers. The administrator defines user identifiers, regions and user levels for regions.

User management of DMS 600 software supports Hot Stand By (HSB). Login will succeed in HSB, if one fileserver is connected. However, the user manager can be used only if
the primary fileserver is connected. User management data is saved into the DMS 600 database.

6.5.2. **User levels**

If the login is quitted or failed during start up, DMS 600 software will switch to the logoff state. DMS 600 software has very strictly restricted functions during the logoff state. After successful login, network windows show all parts of the medium voltage network that associates with regions that the user has rights to view. The program operates according to the rights given to the logged in user.

DMS 600 software contains four user levels with different rights:

*Table 6.5.2-1 DMS 600 user levels with different user rights*

<table>
<thead>
<tr>
<th>Number</th>
<th>User Level</th>
<th>User Rights</th>
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<tbody>
<tr>
<td>1</td>
<td>Admin</td>
<td>Administrator, all rights</td>
</tr>
<tr>
<td>2</td>
<td>Common User</td>
<td>Control rights</td>
</tr>
<tr>
<td>3</td>
<td>Guest</td>
<td>View rights</td>
</tr>
<tr>
<td>4</td>
<td>No view rights</td>
<td>No view rights</td>
</tr>
</tbody>
</table>

The user needs control rights for example to carry out the switching operation. The user level 4 can be used to prevent viewing network of some special region.

6.5.3. **Region types**

DMS 600 software uses three different types of regions:

- **Dynamic region** contains all supplied network components of the feeding primary transformer or generator in the current switching state. The region content changes dynamically according to the switching state. Unsupplied section of the network is not included in the region.
- **Normal region** contains all network components during normal switching state (also an unsupplied network component). The user rights of an unsupplied network component are defined by normal region.
- **Extra regions** can be defined to contain freely chosen network components and nodes. This makes it possible for example to control the same switching device from control rooms of several regions. Extra regions can be defined to only for example disconnectors and switching devices, or to all nodes in a selected area.

To carry out a switching operation, the user needs the control rights to only one region type (dynamic, normal or extra region).
6.6. Network symbols

Symbols represent network objects and objects of the free database in the network windows. Symbols also show for example locations of selected objects, alarms and warnings, field crews and query results in network windows.

You can define an object or an object type specific symbol for three different zoom ranges. In the case of the free database object types and some special symbols there is a fourth zoom range (overview window) for representation of the object in an auxiliary network window.

There are two types of symbols that can be used in DMS 600 software:
1. Default symbols are in use if nothing else has been defined.
2. TrueType symbols, which override default symbol types. DMS 600 software contains the standard TrueType symbol library (Opera.ttf), which contains common style of graphic symbols with SYS 600.

TrueType symbols are in fact TrueType fonts. Any existing TrueType symbol font can be used if it contains a suitable symbol. Fonts can also be created with any font editor or drawing program that supports saving as a TrueType file (ttf). The FontLab font editor program and CorelDraw drawing program are examples of such programs.

DMS 600 contains default symbols for all primary network components and all location symbols for all zoom ranges. The TrueType symbols can be defined for primary network components and various location symbols. DMS 600 contains the standard True Type symbol library (Opera.ttf).

Free database objects have no default symbols. The representation of free database object using symbols requires a definition of the symbols. Free database object types can also be represented with symbols in the auxiliary network window. The size and color of the symbols and the line width and color of the reference line are defined during symbol definition.

If the symbol is not defined and label properties are defined, only the label is seen in the network window. This is used to represent text object types.

Blinking symbols can be used for unacknowledged alarming network components: primary substations, circuit breakers, disconnectors, fault detectors and measurements. The symbol is the same that is used for unalarming object, but the color is changed to defined a blinking alarm color and back to normal symbol color.

6.7. DMS 600 settings

Settings are used to define, for example, the outlook of the network view and background maps. In addition, the functions of the systems can be customized using, for example, the fault location and network analysis settings.
The system settings are categorized in three groups:
• System specific.
• Workstation specific.
• DMS 600 SA specific.

The system specific settings that affect all instances of the system are saved to the working directory of the fileserver. They are mainly set in DMS 600 NE. The system specific settings have to be confirmed before the changes. Examples of these settings are line color definitions and the zoom ranges of symbols.

Workstation specific settings are used to modify separate workstations and they are saved to the working directory of the workstation. The outlook of background maps is an example of these settings.

If the settings of DMS 600 WS are changed in Simulation Mode, they are only temporarily updated on that workstation. The definition and saved settings are restored when returned to the normal mode.

DMS 600 SA specific settings are defined by DMS 600 SA. Examples of these settings include TCP/IP addresses.

DMS 600 contains default values for all operational settings. However, the administrator can easily update the system and DMS 600 SA specific settings and the users workstation specific settings. The language of the user interface and online help used in each workstation (DMS 600 NE and DMS 600 WS) is runtime changeable.

Settings for automatic fault isolation and restoration and automatic GSM message sending in fault cases can be defined for only one DMS 600 WS workstation.
7. **Operational functions**

7.1. **General about operational functions**

DMS 600 has been designed to assist the operation personnel of electric companies in monitoring and operating their networks. It extends the traditional SCADA capabilities by providing geographic network views and advanced functions.

DMS 600 NE provides network component data management and network modeling to provide network overview for DMS 600 WS. DMS 600 NE is also the administrator's tool for managing the whole DMS 600.

The main operational functions provided by DMS 600 WS are:

- Network topology management
- Network and protection analysis
- Meshed network analysis
- Fault management
- Operational planning
- Field crew management
- Customer service
- Outage management
- Data analysis

The functional content of the system depends on the licenses and sublicenses containing information about main and optional functions together with information about connection between DMS 600 SA and MicroSCADA. The user right level of DMS 600 software can be defined for each region separately. The user can even add own features to the software by adding a maximum of ten feature commands at a time (for example starting external programs, for example MS Excel).

DMS 600 WS and DMS 600 NE contain versatile graphical printing properties. Database data, together with geographical background maps, gives plenty of alternatives to print out lists, network diagrams, site maps, station diagrams and so on. All list windows contain shortcut menus for saving or printing the list data.

7.2. **Operational modes**

Different operational modes are used during the use of DMS 600 NE and DMS 600 WS.

DMS 600 NE also operates in three modes:

- *Data View Mode*,
- *Data Edit Mode* and
- *Temporary Network Mode*.
In the *Data View Mode* of DMS 600 NE, you can only browse the existing network data. Modifications to network data are made in the *Data Edit Mode* of DMS 600 NE. Browsing, updating and inserting temporary network data is made in the separate *Temporary Network Mode*. In *Temporary Network Mode* the updating and inserting of temporary network data requires also *Data Edit Mode*.

DMS 600 WS operates in five modes:

- *State Monitoring Mode*
- *Simulation Mode*
- *Switching Planning Mode*
- *Automatic Fault Isolation and Restoration Mode* and
- *Optimization Mode*.

Any modification made in *Simulation Mode* is not saved to the database; it is saved only temporarily for the use of the workstation.

If the connection to MicroSCADA is lost, a message is displayed and DMS 600 WS switches automatically to *Simulation Mode*. The last states of the switches are read from the DMS 600 database. After reconnection to MicroSCADA, DMS 600 WS switches to *State Monitoring mode* and the real switching state data is read from MicroSCADA.

*Automatic Fault Isolation and Restoration Mode* can be defined for only one DMS 600 WS workstation.

### 7.3. General about notes and findings

Notes and findings are labels containing short texts. They can be attached somewhere in the network window. They can be used to maintain any kind of important information for operational personnel, for example, detailed information about a fault.

### 7.4. Alarming

#### 7.4.1. Notices and events

DMS 600 WS generates notices based on network topology, network and protection analysis and fault management. These notices are presented using the notice list. Each notice can be located in a network window.

Events are generated for example based on switching state changes, login and logout, faults, alarms and so on. MicroSCADA and DMS 600 alarms and warnings are visible in DMS 600 events list. Events are presented using the events list. The data of the events list is saved into the permanent event log file. Events of previous weeks can be reloaded in DMS 600 WS.
### 7.4.2. MicroSCADA alarms

The presentation of MicroSCADA alarms and warnings is in use if there is an appropriate sublicense and the functionality has been selected.

The alarming of the following object types with criticality order are transferred from MicroSCADA to DMS 600 WS:

- Disconnector
- Primary substation
- Circuit breaker
- Measurement
- Fault detector.

MicroSCADA alarms and warnings are presented with user-defined symbols (blinking can also be used) on network windows and changes in object alarm states presented by inserting text to events list. DMS 600 contains common style symbols with SYS 600 also for alarming and warning symbols. Unacknowledged alarming primary substations, circuit breakers, disconnectors, fault detectors and measurements can be blinking using defined colors.

If the primary substation is drawn using a substation symbol, the alarm symbol common for all substation components is used. If the substation has several objects having alarm or warning, the alarm symbol for the whole substation is the most critical using the criticality order.

MicroSCADA alarms are also visible in DMS 600's events list. By double-clicking the alarm or warning on the events list, the alarmed network area is shown with the warning color, or alarmed node with the location mark, in the main network window.

### 7.4.3. DMS 600 alarms and warnings

Alarms and warnings of DMS 600 WS are generated based on network topology, network and protection analysis and fault location. These alarms and warnings are presented using the notices list.

The following internal alarms can be shown in DMS 600:

- Planned switching action to looped connections or connections to earthed network (given only when the switch is selected from the user interface of DMS 600 WS, not from the MicroSCADA station or control picture)
- Looped connections (definition of feeders or feeder pairs not to alarm)
- Cold lines
- Uncertain lines (parts of the network, which are not energized)
- Uncertain state (state of a switch is uncertain and it is not known if the network is energized)
- Earthed lines (network connected to the earth, for example by temporary grounding or an grounding switch)
- Unsupplied MV/LV transformers
Warning and alarm colors are used to present network and protection analysis results of DMS 600 WS when the calculated values exceed the corresponding settings for the limits.

The following alarms are based on analysis:
- Voltage drops (MV and LV)
- Detection ability of short-circuit protection (MV)
- Detection ability of fault current/fuse value (LV)
- 3-phase short-circuit capacity (MV)
- Detection of short-circuit protection (LV)
- Detection ability of earth-fault protection (MV)
- Load levels (MV)
- Detection of overload protection (LV)
- Protection coordination

Alarms and warnings are presented using colors in the network windows and inserting text to notices and events list. By double clicking the alarm or warning on the notices list, the alarmed network area is shown with the warning color, or alarmed node with the location mark, in the main network window.

7.5. Simulation of historical events

Any switch state change event can be found from saved event history log files. Step by step proceeding of the state change event can be used to analyze the situation before and after the historical event. Topology analysis, load flow and fault current calculation are performed and results shown on screen after each step. Load models for the selected time are used in network analysis if the load curves are in use. The simulation can be used for training purposes with real situations.

7.6. Network topology management

7.6.1. General about network topology management

DMS 600 WS network topology management is an advanced and computerized method, which replaces the pins on the wall and/or mimics.

The topology of the distribution network is defined by the state of the switches. DMS 600 WS contains information on the state of all remote and manually operated switches and line sections. In addition, the manually updateable measurement data of the border switches can be used in topology management.

Network topology management is based on the integration of DMS 600 and MicroSCADA. Every change in the state of the switches (both in MicroSCADA and in DMS 600 WS) causes an update of the network topology on the screen. DMS 600 receives also the quality (status) of switches from SYS 600 and there are own symbols for
uncertain switch states. Also unsupplied MV/LV stations can be defined to be updated automatically. The new network topology is immediately displayed in the user interface. The appropriate low voltage networks must be loaded into the memory to see the switching state of the low voltage network.

7.6.2. Network topology coloring

The topology of the network is displayed as feeders or as primary feeding stations using network coloring in the network window. The feeder topology color settings are used in the network diagrams, station diagrams, and in the root points of the MicroSCADA station and control pictures. In topological coloring the colors for feeders and primary transformers can be selected automatically using a defined color series, or a fixed freely selected color can be defined for each feeder and primary transformer. Additionally, topological coloring can use the nominal voltages of line sections with the colors defined for each voltage level used in the installation.

Network topology coloring has special colors for:
- Looped connections (also alarm)
- Unsupplied lines (also alarm)
- Unsupplied MV/LV stations (also alarm)
- Uncertain state
- Earthed lines (temporary grounding or grounding switch)

Network topology uses defined symbols for:
- The state of a switch
- Medium voltage switches, the state of which differs from the defined normal switching state
- Low voltage switch changes

7.6.3. Downstream and upstream traces

Monitoring and topology management are made easier by using a function called downstream and upstream traces. A downstream trace means the line sections fed via the selected line section. An upstream trace means the line sections feeding the selected line section. The trace is then colored with a warning color in the network and diagram windows. The trace functions can be used, for example, to check the influence of opening a switch or to check the connectivity of the network components.

7.6.4. State of the switches and line sections

The switching state of all switches connected to MicroSCADA is updated using MicroSCADA station and control pictures. Updating can be done in MicroSCADA or by opening MicroSCADA station and control pictures in DMS 600 WS by selecting the switch with the mouse. Switches can be remote operated real process objects or manually
operated virtual process points. In addition, the state of an MV fuse can be changed in DMS 600 WS, if defined so in DMS 600 NE.

The user has to update the state of the switches, which are not connected to MicroSCADA (i.e. not defined as MicroSCADA real process objects or virtual process points), using the dialog box of DMS 600 WS. In the dialog box the real time when the operation was performed can be given if operations are updated to the system after some delay.

In case of a failure in the MicroSCADA system or in data transfer between DMS 600 WS and MicroSCADA the switching state of switches is updated using dialog boxes of DMS 600 WS. In that case, DMS 600 WS proposes a switch to Simulation Mode and MicroSCADA station and control pictures are not useable. When data transfer capabilities return, the real time switch status is automatically read from MicroSCADA and the network topology is updated accordingly.

Disconnectors and circuit breakers that normally receive the state from SCADA can be moved to manual state update in DMS 600. In manual mode the state can be updated the same way as the switches that are not connected to SCADA. This can be used as a temporary solution to update and see the known state if, for example, communication to station is broken.

The status of line sections is always updated in DMS 600 WS. Close, open, and earthed are the possible line section states.

To change the switching state of the low voltage network, the LV network is loaded and the switch state changed.

### 7.6.5. Checking of switching actions

The system provides checking of switching actions, which means that the checking of the connection to a loop or to an earthed network is made after selecting the switch in DMS 600 WS. If the closing of the selected switch causes a loop connection or engaging to the earthed network, an alarm is given before opening the MicroSCADA station or control picture or the internal dialog box. Checking of switching actions can also be removed by settings. The system also checks that networks with different nominal voltages or with feeding primary transformers with different phasor groups cannot be connected to a loop.

An alarm is given only when the switch is selected from the user interface of DMS 600 WS. When the switch is selected from the MicroSCADA station or control picture, the checking is not performed before the switching action. In this case, the alarm is given just after topology monitoring.
7.6.6. **Border switch**

The border switch can be modeled using a manually updateable measurement point. The border switch is handled in topology management as a normal switch if the state of the switch is open. The closed border switch supplies energy to or from the other network depending on the sign of the measurement value. The branch becomes energized or a loop connection is formed, if the electricity supply to the switch is also coming from another direction.

7.7. **Network and protection analysis**

7.7.1. **General about network and protection analysis**

Network and protection analysis functions require the appropriate license.

DMS 600 WS network analysis replaces traditional off-line calculations with on-line calculations using real-time state of the network.

Network and protection analysis are used to define the electrical state and the protection functionality of the distribution network in a real time or simulated network topology using network calculations, load flow and fault current calculations (2- and 3-phase short-circuits and earth-faults) together with the protection analysis of radially operated and meshed networks. Features of the calculations depend on the user-defined settings. The change in network and/or switching state data automatically executes the analysis for radial feeders and updates network coloring on the screen.

Network analysis has different kinds of aims in network information system and distribution management system. Network analysis of the network information system is made in peak load condition to enable the focusing of the improvements and additions to the network. Network analysis in DMS 600 WS is used to analyze the real time network state for the most effective and safe use of the network. The load flow in DMS 600 WS is calculated using the given or estimated load information.

Generators and synchronous motors are taken into account as a short-circuit current source. The big starting currents of asynchronous induction motors can be studied in load flow calculation. Using of starting motor data means that the real and reactive powers of induction motors are replaced with the starting current and power factor during network analysis. Additionally, the distributed generators and capacitors are taken into account in the load flow calculations. Calculations of DMS 600 WS can also use real time measurement data for motor and generator nodes, provided by MicroSCADA to make the network calculations more accurate.

The protection analysis function can analyze definite time-delay and inverse time type overcurrent relays. Data source for all relay settings can be changed between network model and active relay settings via MicroSCADA. Also the medium voltage fuses are
taken into account during protection analysis. The solid earthed networks and networks earthed via resistor are supported in the protection analysis.

7.7.2. Load modeling

Load modeling uses Velanders factors or defined load models (load curves) to change annual energy information to active and reactive power. The load model is selected normally during the installation. The load model selection can be changed later on.

The MV/LV station and low/medium voltage customer loads and the effect of the capacitors are taken into account in load modeling during network analysis. Load modeling uses single-line modeling capable to analyze balanced medium voltage networks (all medium voltage lines are 3-phased and the load in medium voltage side is nearly equally distributed to all three phases). The loads inside primary substations are not modeled.

Load data is inserted to MV/LV stations or MV customers if only a medium voltage network is used in DMS 600 software. If a low voltage network is used, the load data is entered to the low voltage consumer. The load data of the MV/LV stations is entered into the network database in DMS 600 NE. One or several load measurements or estimates can be given for each load point. If many transformers are located in the same MV/LV substation, the load is allocated to the first transformer. The measurements/estimates can be given as real power or annual energy. Additionally, the load factor (cosφ) can be given for each load measurement. If the load is given as annual energy, empirical factors (Veland's factors) are used to convert the annual energy to peak power. Veland's factors can be adjusted in DMS 600 WS.

It is possible to link a measurement from SYS 500/600 database to automatically update the real time values for active (P) and reactive (Q) power of motors and generators. Used measurement types are Active power, Reactive power and Current measurement. If only current measurement is available it is used so that the voltage in the measurement point is used to estimate the total power (S). This power is devided to active and reactive parts using the proportions of statically given P and Q. The change in motor measurement data affects the load flow calculation results in radial calculation of WS and the change in generator measurement data affects the meshed network load flow calculation results in loop calculation of WS. In Simulation Mode a separate dialog appears to let the user change the P and Q values of motor and generator measurement points. When returning to State Monitoring the real time measurement values are restored.

The settings of DMS 600 WS determine if the power is to be analyzed as constant real power or if Veland's factors, together with annual energy, are used. Veland's factors take into account that the given real powers of load points are not likely to occur at the same time. This way the sum load (for example of a feeder) cannot be as great as the direct sum of the load point real powers.

It is also possible to use a constant factor setting, with which all loads in a network database are multiplied in network calculations. This is given as a system specific setting, but can be changed temporarily for each workstation during simulation. This can be
used, for example, to make a worst-case analysis with larger loads. In addition, effects on boosting voltage in busbars of feeding substations can be studied in simulation.

Manually updateable, separate load points connected to any node of the distribution network can be used to model the separate load point, load of the border switch or backup feeder. The separate load points are taken into account during network calculation by adding the active power of the load point to the active power of the node. Manually updateable, separate load points connected to a disconnector, which is the ending point of a branch, can be used to model an additional load or supply from a neighboring network that is not included in the network database. If the state of this switch is ‘open’, the switch is handled normally in calculations. If the state is ‘closed’ and the value of the measurement is negative (<0), the switch node supplies the electricity to the network. This network is not calculated during the load flow calculation. If the positive active power measurement is inserted into the switch, the amount of the active power is added to the power of the node as in the case of separate load points.

DMS 600 can also use load models (load curves), when the real customer energy data can be imported from an external customer database or inserted directly to the network database table.

### 7.7.3. Load forecasting and load estimation

Load forecasting means the calculation of load forecast for MV/LV stations and line sections for the next 0...168 hours. The forecast is based on the load data of MV/LV stations or LV/MV network customers depending on the selected load modeling method.

Load estimation means the correction of loads given to MV/LV stations so that the total calculated loads of the feeders approximate to the current measurement of the feeder. The electrical state of the network can then be calculated as accurately as possible. The absence of load estimation means that the forecasted loads are created directly from the given MV/LV station load data.

DMS 600 SA automatically calculates a load estimation and a load forecast for the MV/LV stations once an hour. The calculations use the latest MicroSCADA measurement data (busbar voltage, feeder current and other 1-phase current measurements). After the load forecast database is updated, it is loaded to be used in DMS 600 WS workstations.

DMS 600 WS contains commands for showing the forecasted and estimated loads for line sections, MV/LV stations and end nodes for the next week with the help of load curves. The window also contains the forecasted maximum and minimum powers and their interval from the present time. The load curve information for a selected line section can be used to find a convenient time period, for example, for a maintenance outage.
7.7.4. Using of MicroSCADA measurement data in network analysis

The definition of the connection between MicroSCADA measurements and the DMS 600 network database is made in DMS 600 NE/Integra.

If the measurement data is connected to the nodes of the network, the measurement data serves as input data for the network analysis of DMS 600 WS in the following way:

- The current measurement connected to a node of the feeder or to the node limiting the MV/LV station and the feeder (node type feeder) is used during load estimation to make the load data of the feeder and MV/LV stations more accurate using load estimation. The current measurements connected to a node belonging to a feeding HV/MV substation cannot be used in load estimation.
- The primary substation voltage measurement is used as a supplying voltage for feeders in load flow calculations. The voltage measurement is always used instead of a primary transformer nominal voltage of setting the default busbar voltage when it is available. The voltage measurement must be connected to a node belonging to a HV/MV substation to be used in calculation. A voltage measurement connected to a feeder node cannot be used in the calculation.
- Separate load points connected to any node of the medium voltage network can be used in network calculations. The separate load points are taken into account during network calculation by adding the active power of the measurement to the active power of the node.
- Separate load points connected to a disconnector, which is the ending point of a branch can be used to model additional loads or a supply from a neighboring network that is not included in the network database.
- A current measurement, an active power (P) measurement, or a reactive power (Q) measurement connected to a motor node affects the load flow calculation results in radial calculation of WS.
- A current measurement, an active power (P) measurement, or a reactive power (Q) measurement connected to a generator node that is connected to a Generator Block Transformer affects the meshed network load flow calculation results in loop calculation of WS.

7.7.5. Load flow calculation

The load flow for the whole MV network is calculated using modified Newton-Raphson algorithm.

The load data is applied to the network starting from the last node of the feeder. The calculation proceeds from the last node towards the supply point, calculating at the same time the maximum power, maximum load current, and power loss of each line section as well as the capacitive reactive power and the voltage drop.

Load flow calculations are the base for the presentation of the voltage drops and load levels.
If the cursor is held for a moment over a network node or line section in the main network window, a tooltip is opened presenting information about nodes and real and reactive powers defined by the network analysis.

7.7.6. Fault current calculation

The calculation of short-circuit currents needs a description of the distribution network and the relay settings used in overcurrent protection as well as the impedance of the primary transformer and the short-circuit impedance of the supplying network.

The short-circuit currents of symmetrical 3-phase short-circuits are calculated using Thevenin's theorem by assuming the voltage of the fault point is the same as the voltage which has been given as a calculation setting.

The highest permitted 3-phase short-circuit current of each conductor of a line section is calculated from the conductor's highest permissible short-circuit current (1 s) and by the duration of the short-circuit. The duration of the short-circuit is determined by the starting and operating time of the (constant time) relay and by the breaker operating time. Due to autoreclosure, attention should also be paid to the prolonged duration of the fault current. In the period of non-voltage between rapid and delayed autoreclosure, the cooling of the conductor is taken into account by calculating the so-called equivalent duration of the short-circuit.

Unsymmetrical fault like 2-phase short-circuit current is calculated using so called sequence networks. For this reason the negative sequence impedance is needed for feeding substations and generators.

In earth-fault calculation the earth isolated, neutral earthed and resonant-earthed networks can be analyzed. For the calculation of earth-fault currents, the program calculates the total earth capacitance of all feeders by using the earth capacitance of the conductors and the conductor lengths of feeder sections. On the basis of the total earth capacitance of the network and by Thevenin's theorem, the program calculates the earth-fault currents corresponding to the fault resistance defined, so that the internal impedance of Thevenin's source is assumed to be formed merely by the network's earth capacitance.

7.7.7. Protection analysis

Protection coordination is analyzed based on fault current calculations.

During protection analysis the supported characteristic curves (based on standard IEC 60255-4) for the relays are:

- Constant time
- Normal inverse
- Very inverse
- Extremely inverse
- Long-time inverse
• User defined inverse
• RI-type for obtaining time grading with mechanical relays
• RD-type for earth-fault protection.

The detection ability of the short-circuit protection means that the operation of relays in 2-phase short-circuits is checked in every end node of a section by comparing the 2-phase short-circuit current and the operating value of the relay. Also line sections protected by medium voltage fuses are analyzed.

Short-circuit capacity means the percentage ratio of 3-phase short-circuit current over the calculated maximum permissible short-circuit current for the conductor calculated using the equivalent duration of short-circuit and the short-circuit capacity (1 s) of the conductor. If the relative value is less than 100 %, the conductor can stand the short-circuit.

Relay settings are inserted into the network database. The administrator can change the relay settings in the network database in DMS 600 NE. For SPACOM and RED 500 typed relays protection analysis can also be performed using relay settings obtained via MicroSCADA. The data source for all relays can be changed workstation specifically between network model and active relay settings via MicroSCADA.

### 7.7.8. Results of the network and protection analysis

The network topology is automatically updated and network analysis executed after every switching state change for radial feeders, if the feature is not disabled by settings.

According to the results of the network and protection analysis the network lines can be colored to show:

• Voltage drops in medium and low voltage networks
• Load levels in medium voltage networks
• Detection ability of short-circuit protection in medium and low voltage networks
• 3-phase short-circuit capacity in medium voltage networks
• Detection ability of earth-fault protection in medium voltage networks
• Detection ability of the overcurrent protection in low voltage networks.

The representation of the calculation results depends on the user-defined settings. Warning level and alarm level colors are used in presenting network analysis results when the calculated values exceed the corresponding settings for the limits.

Numerical presentation of the network analysis of the node/line section can be viewed in a separate dialog (the data of the dialog can be defined during projecting). The protection analysis dialog contains the operation data for all relays detecting the fault current in the given fault location. In radial operated network all relays and fuses toward the substation are analyzed. The earth-fault protection analysis dialog contains the operation data for all feeders.
Power flow direction of network analysis is transferred from DMS 600 WS to MicroSCADA.

**7.7.9. Network analysis used for simulation**

Network analysis in DMS 600 WS is normally used to analyze the real time network state for the most effective and safe use of the network.

The switching state of a distribution network is changed periodically to keep the network near the optimal state. Load changes, maintenance and service tasks together with fault situations cause a need for changes in the switching state.

All switching actions can be checked beforehand by using the simulation of DMS 600 WS. After changing the switching state, network analysis can be used to determine the electrical state of the distribution network with the changed network topology.

In order to analyze the settings of protection relays or the influence of the network analysis settings (for example by making the worst case analysis with larger loads), changes to this data are made and the analysis executed again. The load forecasts can be used during simulation of the network state.

It is possible to simulate the network analysis with DMS 600 WS using the defined date and time. The load flow in DMS 600 WS is calculated using the given or estimated load information of the defined date and time.

During simulations in DMS 600 WS, the relay settings, load calculation methods, and network topology can be changed. This data is saved temporarily in the working directory of the workstation. No changes to the real network database or DMS 600 database are made.

**7.8. Meshed network analysis**

**7.8.1. General about meshed network analysis**

In meshed network analysis all the networks having a voltage level under the defined transmission voltage level are included in the MV network and analyzed.

The primary transformers that have one nominal voltage above the transmission voltage level are used as feeding points having the defined busbar voltage as nominal voltage. The nodes of node type 'Feeding point' can be used in the transmission network for topology analysis but the transmission network is not analyzed for load flow or fault currents. However, radial or meshed sub-transmission network can be included in network analysis. For example, one or several 400/220 kV primary transformers can be used as feeding points for 220 kV network when transmission voltage level is set to over 220
kV but less then 400 kV. Naturally, other primary transformers are used to transform the voltage to medium voltage levels.

After a change in network and/or switching state data, the meshed network load flow and maximum short-circuit current calculation for the whole medium voltage network is automatically performed, if this is defined by the settings and the time interval from the last calculation has elapsed.

### 7.8.2. Meshed network load flow

The meshed network load flow for the whole MV network is calculated using a modified Newton-Raphson algorithm. The meshed network load flow cannot use voltage measurements at primary substations to set busbar voltages. The nominal voltages of the network are directly used to transform the feeding busbar voltage to lower voltage levels.

The load flow is calculated for the total network even if it consists of several isolated islands. An isolated island is a part of the network fed by one or several feeding primary transformers but isolated from the rest of the network. The islands can be connected to each other but isolated by an open switch.

Big power plants have voltage-regulating generators, where active power and voltage are known. In addition the load flow supports also smaller distributed generators where generators are producing active power and reactive power by regulating the reactive power produced. These generators can be connected to the network model using a 'block transformer', which is modeled in the network model as a transformer, but getting the power from the generator. A current measurement, an active power (P) measurement, or a reactive power (Q) measurement connected to a generator node that is connected to Generator Block Transformer affects the meshed network load flow calculation results in loop calculation of WS.

As a result of the meshed network load flow analysis the node voltages and power flows of line sections are calculated and used in network voltage drops and load levels coloring.

### 7.8.3. Meshed network short-circuit analysis

For meshed network short-circuit calculation, the feeding network short-circuit impedance is given for the primary substations where these feeding primary transformers are located. During the analysis of the feeding network, synchronous motors and generators are used as current sources.

In case of an automatic meshed network analysis after switch status change the maximum short-circuit currents are calculated for all the isolated islands. In other islands, the short-circuit currents are zero. This gives the opportunity to check the fault currents flowing through for example the relayed feeding the loop where the fault is.
2- and 3-phase short-circuit currents are calculated for each line section with a given fault location. These values can be used to study the relay operations in specific fault situations.

### 7.8.4. Meshed network protection analysis

During protection analysis of meshed network the location (node) of the short-circuit is pointed by a mouse. The maximum short-circuit currents of meshed network calculation are calculated for all line sections in the MV network. However, protection analysis is performed only for parts of the network where the relay is feeding a radial branch.

### 7.9. Fault management

#### 7.9.1. Progression of MV fault management

Fault management functions require the appropriate license with sublicenses.

The main functions in MV fault management are:
1. Fault location
2. Sending of GSM messages to important customers
3. Fault isolation and restoration planning
4. Execution of the planned switching sequences
5. Fault reporting
6. Fault archiving

Several medium voltage faults can be managed at the same time with fault management. The number of simultaneous faults in the memory of DMS 600 WS is limited to 50 faults. Automatic fault isolation and restoration operates only with one fault at a time.

The customer normally notifies of a low voltage network fault. Maintenance outage data is acquired from operation planning. DMS 600 WS contains manual management of low voltage network faults (fault reporting and archiving).

General MV fault clearance of DMS 600 WS is described in the following.
Figure 7.9.1-1 Fault clearance of DMS 600

The progression of the fault management depends on the use of the automatic fault isolation and restoration function and the type of the fault. A new fault causes automatic zooming into the area of the faulted feeder. Other simultaneous faults are not zoomed, but the faults are processed in the background.

Fault management starts with fault location. After fault location, a GSM message about the outage can be sent to important customers automatically or manually. The default values used in the message are based on the active fault and possible reconfiguration. The default GSM message is focused on customers without supply.

If DMS 600 WS is in Automatic Fault Isolation and Restoration Mode and the fault is definitely located during the fault location function, the isolation and restoration planning is automatically started. If the automatic function is not in use or the fault cannot be located definitely, the isolation and restoration planning can be manually started after location of the fault.

After fault isolation and restoration planning DMS 600 WS can execute the planned switching sequence. The execution is automatic or manual depending on the function settings. After the fault is repaired the fault data is saved to the fault archive.
7.9.2. Fault location

7.9.2.1. General about fault location

The fault location function of DMS 600 WS deals with permanent feeder faults in radial operated neutral isolated, compensated or neutral earthed medium voltage networks. In meshed networks, the fault location works only if the faulted feeder or an opened circuit breaker is in a radial branch. Busbar faults (there is no feeder for an opened circuit breaker) are located the same way as radial feeder faults. If there is a problem with the MicroSCADA connection, the fault location simulation can also be used for real faults.

Permanent faults in a distribution network are detected by relays connected to MicroSCADA. After a permanent fault has occurred, the required fault data collected by MicroSCADA is automatically sent to DMS 600 WS. The states of the remotely readable fault detectors are obtained from MicroSCADA.

After that, DMS 600 WS automatically starts the fault location function and shows the present topology of the network. DMS 600 WS analyses the fault data and infers the most likely fault locations. All line sections that are possible fault locations based on the fault distance calculation, are shown on the screen using the alarm color.

The possible fault locations along a feeder in which a fault has been happened are determined based on:
- Fault distance calculation (based on sequence representation if necessary).
- Fault detector data.
- Type of line sections (underground cable/overhead line).
- Overload conditions for distribution transformer and cables.

The user of DMS 600 WS can set the importance for the fault location base data using factors. The values for the factors are in the range 0-1. A high value stresses the information and increases its importance in the inferencing. A value of 0 means that the information is not used in the inferencing. DMS 600 WS contains recommended default values for factors.

Fault location of short-circuits and earth-faults based on the transferred fault detector data can be used in any kinds of networks. However, fault location based only on fault detectors can locate a fault to a feeder zone determined by fault detectors not accurately to a point along a feeder.

Fault distance calculation requires fault current or impedance registration, for example at relays and data transfer from process via MicroSCADA. The fault data needed for the fault location function of DMS 600 WS can be automatically transferred from MicroSCADA. Only on-site readable fault detector data has to be updated manually in DMS 600 WS.

Fault location in radial feeders fed by a meshed network works in the following way:
- 3-phase short-circuit fault in radial feeder uses fault current based location.
• 2-phase short-circuit fault in radial feeder uses fault current based location.
• 1-phase earth-fault in radial feeder uses earth-fault location (no fault current based location)
• 2-phase earth-fault in radial feeder uses earth-fault location (no fault current based location)

7.9.2.2. Fault distance calculation

Fault distance calculations can use the following methods:
1. Magnitude of short circuit current (A)
2. Impedance (reactance) from the relay to the fault location

The method using current magnitude can calculate the fault distance in case of 2- or 3-phase short-circuits and 1-phase or 2-phase to earth short-circuits in earthed networks. However, earth short circuits cannot be located if the substation is fed from a loop because the feeding impedance components cannot be determined. In neutral isolated or compensated networks, 1-phase or 2-phase to earth short-circuits cannot be located using the current magnitude method.

The method using reactance from the relay to the fault location can be used in any kinds of networks. The distance to fault can also be calculated in case of 1-phase to earth faults in neutral isolated networks. In these cases the given reactance is the sum of positive and zero sequence reactances. Normally the accuracy of available reactance measurement is lower, especially in compensated networks.

7.9.2.3. Fault detector data

The states of the remotely readable fault detectors are obtained from MicroSCADA or updated by the operator and on-site readable detectors are managed by the user interface of DMS 600 WS.

The fault location function inferences the fault detector zones, which the fault is in (exact regions of the network bordered by fault detectors). The line sections of the detector zone, in which a fault has occurred, are the possible fault locations in the fault location inferencing.

The function analyses the consistency of the operation of several fault detectors by using the network topology (for example checking if some detector has not operated in series and if there are operations in two different branches). The function also analyses the direction of the earth-fault current in case of a non-directional earth-fault indication.

If there is some inconsistency or there are two simultaneous faults along the feeder in which a fault has occurred, the factor of the fault detector data used for inferencing is set very low. The user can update with the correct detector data and run the fault situation again.
7.9.2.4. **Line section type**

The type of line section has an effect on the possibility of fault location.

The types are divided into three groups:
- Bare overhead lines
- Covered overhead lines
- Underground cables.

All the line sections of the feeder in which a fault has occurred are processed. Based on the line type, the possibility of a fault being found in a line section is increased based on the maximum value of the factor and the length of the line section.

7.9.2.5. **Overloading of cables and transformers**

If DMS 600 WS includes the load flow calculation of the network analysis, the overload conditions for cables and transformers before the fault can be checked. The calculated values of the loading conditions are compared to the technical limits of the conductors and transformers obtained from the network database.

If the overload exceeds the overload limit defined in the fault location parameters, the possibility of a fault being found in a line section object is increased based on user defined factors.

7.9.3. **Fault isolation and restoration planning**

Operational planning functions require the appropriate license with optional sublicense. Fault isolation and restoration planning made during fault management also requires the appropriate license and sublicenses.

Isolation and restoration planning function offers support for planning of operations needed after feeder faults. The function handles only operations, which can be carried out by remote control. The initial state of the function is the result of the fault location. The fault location can be based on the automatic fault location function or the faulted zone can be defined manually.

Isolation planning isolates the located fault as soon as possible and at the same time causes as few disadvantages to the customers as possible. Restoration planning tries to restore the supply as soon as possible to as many customers as possible while repairing the isolated fault. The fault isolation and restoration planning function generates a switching sequence, which notices the technical constraints of the network and the protection demands. Voltage drop, short-circuit detection, earth-fault detection, short-circuit capacity and load level for each line section included in the planning are checked.

The switching sequence can then be executed manually or automatically using Micro-SCADA.
The manual isolation and restoration planning can also be used as a tool for experimental switching planning.

7.9.4. **Automatic fault isolation and restoration**

Isolation and restoration planning can be used to produce the switching sequence for automatic fault isolation and restoration. The function speeds up the service restoration especially for unmanned control centers.

The administrator of the system has a possibility to set automatic fault isolation and restoration functionality on one workstation. If the functionality is not switched on, the operator does the fault isolation and restoration switching actions.

If the automatic functionality is turned on and the fault can be definitely located, DMS 600 WS generates the switching sequence and runs the automatic execution by MicroSCADA.

Only if the whole switching sequence is run successfully DMS 600 WS can continue normally and start another restoration sequence if a new fault appears. In case of an error or stopped sequence, DMS 600 WS is blocked so that it cannot start another sequence before manual resetting.

7.9.5. **Fault location simulation**

The fault location simulation of DMS 600 WS can be used to:

- Locate the real fault with the changed SCADA information (for example the first fault current before autoreclosing operations or alternative feeding network impedance values) or fault location parameters (for example certainty factors).
- Insert a new real fault data and locate the fault (especially if there is some problem with the MicroSCADA connection).
- Demonstrate a fault for purely simulation purposes (for example a fault cleared by the autoreclosing function of the protection relay can be studied afterward using the manually read measured values of the relay).

During simulation, DMS 600 WS is not connected to process through MicroSCADA and the changes are saved temporarily for use at the workstation.

7.10. **Operational planning**

7.10.1. **General about operational planning**

Operational planning functions require the appropriate license with optional sublicense.
The main functions of operational planning are:

• Isolation and restoration planning, which can be used in experimental switching planning.
• Maintenance outage planning, which is used to plan switching actions needed to disconnect the line sections for outages and restore the supply after outages by causing as little disturbance to the customers as possible.
• Contingency analysis, where some predefined fault and outage situations can be studied.
• Reconfiguration planning is used to help in finding an optimal switching state with minimal losses in an existing load situation.

The switching planning functions are based on the network data and the switching planning models. Automatic planning functions generate the switching sequence, which notices the technical constraints of the network and the protection demands. Voltage drop, short-circuit detection, earth-fault detection, short-circuit capacity and load level for each line section included in the planning are checked. In addition to the automatic switching planning, DMS 600 WS can be used to manually create a switching sequence.

A switching sequence contains openings and closings of the switch devices and other actions needed during the outage. A switching sequence created manually or by the maintenance outage-planning function, can be modified, simulated and executed. Performed maintenance outage data can be reported and archived.

In addition to the switching planning functions, simulation of DMS 600 WS can be used to examine the electrical state of the network and the functioning of the protection in any switching state. Simulation can be utilized in any switching planning situation. Also, the use of load estimation during network analysis to the existing network or to the simulated switching state supports the switching planning.

### 7.10.2. Outage planning

In a normal switching state switching planning is needed to plan switching actions to disconnect the line sections for outages and restore the supply after outages. The maintenance outages can be planned in advance and there is no hurry during switching actions.

DMS 600 WS contains the functions for planning the maintenance outages. The function starts by defining the point and location of the maintenance outage. Also, the required breaking capacity of the switches is defined. Then, the switching sequence containing both remote and manually controlled switches is generated using the switching planning models.

In addition to the automatic switching planning functions DMS 600 WS can be used to manually create a switching sequence. A switching sequence created manually or by the maintenance outage planning function can be edited, simulated and executed supported.
7.10.3. **Reconfiguration**

The reconfiguration function helps to find an optimal switching state with minimal losses in an existing load situation. The function is applicable for radial operated networks.

The reconfiguration function searches for pairs of an open switch to close and a closed switch to open in order to achieve maximum reduction of losses. The function offers two modes; optimization with all switches and optimization with only remote controlled switches. There is also a possibility to freeze open points to be included in the optimization. The results can easily be studied with an interactive tool provided by the system. The operator makes the real switching actions.

From a practical point of view several different cases for applying the reconfiguration methods can be distinguished. Reconfiguration using all switches corrects any errors in the original selection of the open points. The procedure is repeated occasionally and especially using the maximum load situation of the network. It is also appropriate to implement the manual changes in conjunction with returning to normal state after restoration or scheduled outage. During the peak power even manual switching for loss reduction could be beneficial, because the marginal cost of energy is very high. In normal operation it is reasonable to make only remote-controlled switching changes.

7.10.4. **Contingency analysis**

Contingency analysis can be performed by stepping through predefined sequences. The sequences present major outage situations in the network. The measurement value adjustment of load and generation points (motor and generator power changes) can be included into the sequences. It is also possible for the user to insert 'Analyze Contingency' commands into the sequences, and if in any step constraint violations are found during those network analyses, a report will be generated (a user definable setting is available to decide if the report contains both topology and calculation violations, or only violations during the network calculation).

7.11. **Outage data management**

7.11.1. **General about outage data management**

Outage data management requires the appropriate sublicenses.

The control center operators are required to complete an outage report form after each fault or maintenance outage. DMS 600 WS contains computer-aided generation of fault and maintenance outage report. In addition, an input data for general and customer (or MV/LV substation) based statistics is generated. Most of the input data comes from the normal use of DMS 600 WS during fault management. There is also a possibility to indicate the outage area with the mouse.
The main functions in outage data management are:
• LV network outage reporting
• MV fault reporting
• MV maintenance outage reporting
• Reclosing reporting
• Retrieval of customer and MV/LV station specific outage data
• Archiving of outage reports.

7.11.2. Management of LV network outage

The customer normally notifies of a low voltage network fault. The information about the fault can be saved to DMS 600 WS. LV outage maintenance data can also be saved using LV network outage management in the same way as in fault cases.

The data about saved LV outages can be used to create an LV network outage report, which can be archived to a separate archive.

7.11.3. Reporting MV fault, maintenance and reclosing outages

Outage reporting is used to report basic data of the outage and actions during fault clearance, maintenance outage and reclosings. DMS 600 SA saves the reclosing data automatically.

DMS 600 WS generates an outage report template, where most of the fields are filled in beforehand based on executed sequence.

The automatically generated data is listed in the following:
• Times of the actions.
• Basic data of the fault (district office, substation, feeder, fault type, fault current).
• Switching actions (transferred from the performed switching sequence).
• The key figures of the outage (amount of the substations, total outage times of the substations, amount of the affected customers, total outage times of the affected customers, amount of non-delivered energy).

The operator can define the exact fault location by pointing the location in the network window before reporting. The operator can also edit the automatically stored switching data of the fault clearance and maintenance outage. The operator completes the report and saves the data into the archives for later use.

The fault reporting function is used after the fault has been repaired, the supply is restored and the fault is set to repair. The maintenance outage reporting function is used after the outage has been arranged and the supply is restored.

Outage reporting is performed in the control center. Other workstations can only scan the outage report data. Only the user, who has rights to fault management and is
responsible for the appropriate fault or maintenance outage can update the fault report data or report the appropriate outage.

7.11.4. Archiving outage data

The outage data of repaired faults, performed maintenance outage and reclosings can be archived for later consideration, for example for reporting and collecting the customer and MV/LV substation outage data.

7.11.5. Customer and MV/LV substation outage data

Outage queries are used to study outage data in a scope (report type, starting and ending time, duration of outage) of a single customer or MV/LV substation.

7.11.6. Exporting outage data

DMS 600 WS enables the exporting of defined outage data. This outage data file can then be imported for example to the customer information system, where the outage data can be browsed for example customer based.

Exported outage data is collected from reported outages in DMS 600 database using the query. The query is formed using the outage types, starting and ending dates and outage duration. The export file contains outage areas and data about them.

7.12. Field crew management

During fault clearing not only the remote controlled switches but also the manually operated switches need to be used. The control of manually operated switches needs the attendance of the field crew. The repairing of the fault requires the field crew to be able to move in the terrain.

The efficient organization of the field crew movements speeds up the fault clearance by reducing the time needed to disconnect and repair the fault.

DMS 600 WS supports creating a general view with the locations of field crews and possible faults.

The locations of field crews are maintained:

- Manually using the mouse to locate the crew or
- Using GPS data.

The data content of the field crews in the database can be freely expanded. Additionally, a common document is available for field crews and can be used, for example, to manage working shifts and holidays of personnel.
7.13. **Customer service**

The customer service function is based on customer data. The customer data with customer loads can be imported to the network database using the MS Access import function (e.g. via ASCII text file). It is also possible to create a linked table to use an external customer database via ODBC.

In a fault situation customers call the control center to report that they have no supply. The customer service function provides fast search for the feeding transformer of the customer based on name, code or other information available. The result of the search is the secondary substation to which the customer is connected. The found substation is shown in the network.

7.14. **Outage information using GSM messages**

DMS 600 WS has a function to send GSM messages about outages to important customers automatically after the fault or manually in any outages.

The default values used in a message are based on the active fault and possible reconfiguration. The default GSM message is focused on customers without supply.

GSM messages are used to inform the chosen important customers about the maintenance and fault outages. The GSM messages can be sent manually or automatically depending on the settings.

The basic outage information data and data about sent GSM messages are saved into the DMS 600 database.

GSM messages are based on SMSServ 2.1 software (Apex Automation Oy) and MicroSCADA.

7.15. **Outage information using telephone answering machine**

Many customer calls during a fault are time consuming for the control center personnel. DMS 600 WS has a function to control an automatic telephone answering machine for informing the calling customer about the maintenance and fault outages. This function gives more fault clearance time for operational personnel.

The message of the answering machine is created partly automatically using fault or maintenance outage data and a separate database (Tam.mdb). The message contains the situation of the fault clearance and an estimate about the repairing time or data about the maintenance outage.

Automatically created telephone answering messages can be used to alarm internally or defined customers.
The telephone answering machine and alarms are based on NextInfo and NextAlarm (Voicebit Oy).

7.16. **Switching state document**

The switching state document is a colored graphical representation of the whole distribution network above the geographical background map. The document contains information about unsupplied MV/LV stations. The switching state document can be created manually or automatically. The file formats are doc and htm.

The document can be used for example in an intranet or the Internet to inform about the real time switching state of the distribution network.

7.17. **Database analysis**

The results of a database analysis are summaries and the collection of data from the network database. The database analysis is based on queries. A query can be focused on the entire network data or to the object group selected beforehand. The rules of a query can contain one or more constraints (for example manufactured before year 70 and last maintenance done before year 95), which are used to pick up data needed from the database.

The administrator can create queries using MS Access capabilities or the DMS 600 tool for geographical database queries. The results can be seen in table format in MS Access or graphically on a network presentation. The queries containing coordinate or node code data can be viewed in graphical form.

Definitions of reports and forms enable the reporting of the network database content using a DMS 600 software menu command. The administrator of DMS 600 software defines the reports and forms into the network database using MS Access.
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