SIEMENS

SIPROTEC
Fault Record Analysis
SIGRA 4

V4.50

Manual

E50417-H1176-C070-A6

NOTE

For your own safety, please observe the warnings and safety instructions contained in this document.

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Preface

Purpose of this manual

This manual describes the function and operational principles of the SIGRA 4 program for the analysis of fault records.

Target group

This manual is primarily aimed at those customers and their staff responsible for the analysis of fault events in the supply network in the context of power system management.

Validity of this manual

This manual is valid for SIGRA 4, V4.50V.

Standards

SIGRA 4 has been designed in compliance with the ISO 9001:2008 quality guidelines.

Further assistance

If you have any questions regarding **SIGRA 4**, please contact your regional Siemens Office.

Hotline

Our Customer Support Center provides around-the-clock support.

Phone: +49 (180) 524-7000
Fax: +49 (180) 524-2471
e-mail: support.energy@siemens.com

Training courses

If you are interested in our current training program, please contact our training center:

Siemens AG
Siemens Power Academy

Humboldtstr. 59
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Tel.: +49 (911) 433-7005
Fax: +49 (911) 433-7929
Internet: www.siemens.com/energy/power-academy-td

Notes On Safety

This manual does not constitute a complete catalog of all safety measures required for operating the equipment (module, device) in question, because special operating conditions may require additional measures. However, it does contain notes that must be adhered to for your own personal safety and to avoid damage to property. These notes are highlighted with a warning triangle and different keywords indicating different degrees of danger.

DANGER

Danger means that death or severe injury **will** occur if the appropriate safety measures are not taken.

✧ Follow all advice instructions to prevent death or severe injury.

WARNING

Warning means that death or severe injury **can** occur if the appropriate safety measures are not taken.

✧ Follow all advice instructions to prevent death or severe injury.

CAUTION

Caution means that minor or moderate injury can occur if the appropriate safety measures are not taken.

✧ Follow all advice instructions to prevent minor injury.

NOTICE

Notice means that damage to property can occur if the appropriate safety measures are not taken.

✧ Follow all advice instructions to prevent damage to property.

NOTE

is important information about the product, the handling of the product, or the part of the documentation in question to which special attention must be paid.

Qualified Personnel

Commissioning and operation of the equipment (module, device) described in this manual must be performed by qualified personnel only. As used in the safety notes contained in this manual, qualified personnel are those persons who are authorized to commission, release, ground and tag devices, systems, and electrical circuits in accordance with safety standards.

Use as Prescribed

The equipment (device, module) must not be used for any other purposes than those described in the Catalog and the Technical Description. If it is used together with third-party devices and components, these must be recommended or approved by Siemens.

Correct and safe operation of the product requires adequate transportation, storage, installation, and mounting as well as appropriate use and maintenance.

During the operation of electrical equipment, it is unavoidable that certain parts of this equipment will carry dangerous voltages. Severe injury or damage to property can occur if the appropriate measures are not taken:

- Before making any connections at all, ground the equipment at the PE terminal.
- Hazardous voltages can be present on all switching components connected to the power supply.
- Even after the supply voltage has been disconnected, hazardous voltages can still be present in the equipment (capacitor storage).
- Equipment with current transformer circuits must not be operated while open.
- The limit values indicated in the manual or the operating instructions must not be exceeded; this also refers to testing and commissioning

Contents

1 System Overview

Contents

1.1 General

The **SIGRA 4** application program supports the analysis of fault events in your network. It offers a graphic display of the data recorded during the fault event and uses the values measured to calculate further variables, such as impedances, outputs or r.m.s. values, which make it easier for you to analyze the fault record.

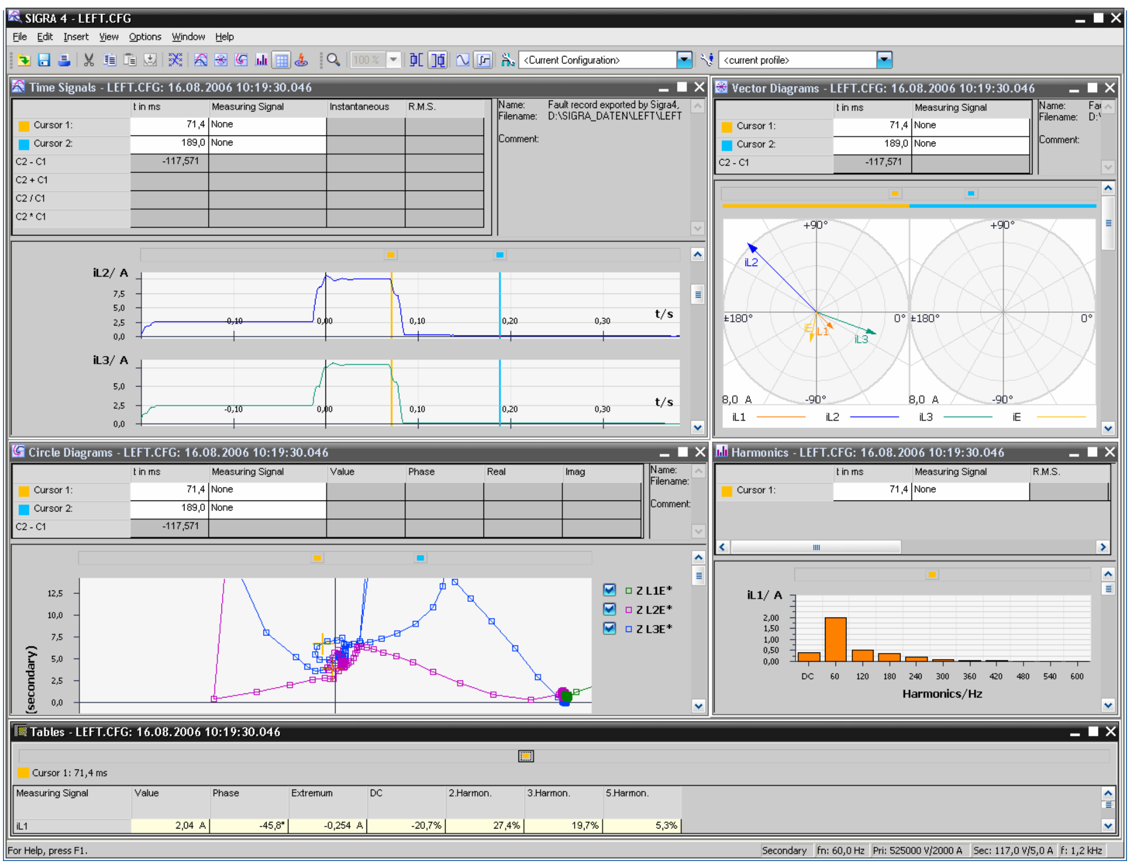
You can then represent these variables in any of the following diagrams of the views

- **Time Signal diagrams**
- **Vector diagrams**
- **Circle diagrams**
- **Harmonics**
- **Fault locators**

or in the

- **Table**

view.



DIGRA009.tif

Fig. 1-1 SIGRA 4, there are various diagram and table views available to display fault record data.

You can choose to display the signals of a fault record in the various views as either

- **primary values** or
- **secondary values**,

irrespective of the method of recording the measured values in the fault recorder.

Apart from the actual signals it is also possible to display the fundamental component as well as the harmonics of each signal and thus even better recognize special features of the signal curves.

In addition to its graphical display options, SIGRA 4 offers the following tools to support fault record analysis:

Cursor 1 / Cursor 2

Cursor 1 and cursor 2 are assigned to the **time axis**.

If you move a cursor along the time axis you can read the related instants in the corresponding tables in all views.

In the Time Signal view, cursor 1 and cursor 2 are shown as vertical lines across all diagrams of the view. In the Circle Diagram view they are displayed as crosshairs.

The transparency of the fault record analysis is increased by the color coding of the cursor. The color assignment can be found in tables, cursor symbols, lines or crosshairs and in dialog boxes which refer to the cursor position (such as Synchronize Fault Records).

Table

If you want to know the exact value of a particular signal at a defined instant, assign a cursor to this signal. The table of the selected view then displays the **signal name**, the **values** and the **instant** specified by the cursor position.
The structure of the table can be freely configured in the **View Properties** dialog. The type of displayed values, such as r.m.s. value, extreme value, phase, etc., can be changed at any time.

You can temporarily hide part or all of the on-screen display of the table. To do this, simply drag the lower border of the table towards the top of the screen.

Tooltip

If you move the mouse pointer onto a signal of a diagram, a tooltip pops up which displays the signal name and value(s) of the respective sampling instant.

Zoom

Use the convenient zoom functions to define the ideal display size for the value profile in each view. You can either **maximize** or **minimize** the whole diagram or selected sections, or **optimize** the **display scale**. The Zoom - Optimize function can be used separately for the X-axis and the Y-axis. Furthermore, if you want the display scales of various diagrams of a view to be uniform, you can select the **Match** function.

Status bar

The status bar shows the function of the currently selected toolbar button, the frequency, the primary and secondary data of primary current and voltage transformers and the sampling rate.

Parameter settings of the analysis

You can assign measured or calculated values to the individual diagrams of the graphical views or tables using the **Assign Signals** matrix or by simply using the drag-and-drop function.

Parameters defining the fault record display, such as the distribution of signals to specific diagram views and tables, color, line and font styles, etc. can be saved permanently in the form of **User Profiles**. These can then be assigned to other fault records by simply clicking the toolbar.

SIGRA 4 is equipped with a **session memory** which retains all settings and view arrangements of a session. This means that you can break off an analysis and, at a later point, simply resume where you left off.

Importing fault records

If you require a second fault record in order to analyze the data of a fault record, i.e. from the other end of the line, you can insert this in the current fault record analysis and evaluate the signal paths together.

Comment

The **Comment** dialog lets you file notes relevant to the fault record, such as the analysis results or notes for the planning dept., etc.
Furthermore, you can add comments at any position of the curve representation of the fault record. These comments can be stored with the fault record. You can thus assign your comments to important positions during evaluation.

Data Export

The **COMTRADE Export** function lets you export data of a fault record, complete with calculated values, in COMTRADE format.

To export diagrams or tables to other applications, such as Word, Excel, Powerpoint, simply **drag and drop** them or use the Windows Clipboard (Copy/Paste).

NOTE

The conventions used for the calculation and evaluation of variables under SIGRA 4 are explained in detail in chapter 5.

The properties dialog boxes let you define the appearance of the signals in the diagrams of the views.

View properties

The View Properties dialog lets you define settings which are applied to all diagrams of a single view, such as the display of gridlines or the font. It also lets you configure the table columns of the tables of the various views.

Diagram properties

This dialog box lets specify the properties of a diagram.
You can define properties, such as background color, axis name, gridlines or axis scale.

Signal properties

You can also specify the display of individual signals.
The dialog lets you define the color, weight and style of a line or graphical markings.
For the display of status signals (time marking of significant events), you can choose between various symbols, such as a triangle, circle, square or cross.

Filling gaps in signals

Missing measured values lead to gaps in the representation of time signals. You can decide whether the gaps shall remain or be filled with a line.
You can fill the gaps in the time signals of instantaneous and r.m.s. values.

Calculating signals

With SIGRA 4, you can define mathematical functions. These functions are used to generate calculated signals. The mathematical operators +, -, *, / and parentheses are available.
As output signals for the calculation you can use the measuring signals as well as the signals calculated by SIGRA 4.

NOTE

The following chapters provide a more detailed description of the functions described here in brief.

1.2 Cursors

SIGRA 4 features 2 cursors, **cursor 1** and **cursor 2**. In the **Time Signals** view they are shown as vertical lines across all diagrams of the view. In the **Circle Diagrams** view they are displayed as crosshairs.

The cursors are assigned to the **time axis**. If a cursor is moved in a view, its position in all other views is moved, too.

Cursor color

The transparency of the fault record analysis is increased by the **color coding of the cursor**. The color assignment can be found in the:

- tables
- cursor symbol
- line or crosshair
- dialog boxes which refer to the cursor position.

Cursor position and table

When you move the cursors along the time axis, you can read the associated **points in time** and **values** of the assigned measuring signals from the table.

Additionally, the following values are derived from the positions of the two cursors and displayed:

- sum and difference (using the same units)
- product and quotient (not for angles)

For further information, please refer to paragraph 3.2.2.

Behavior of the cursor lines

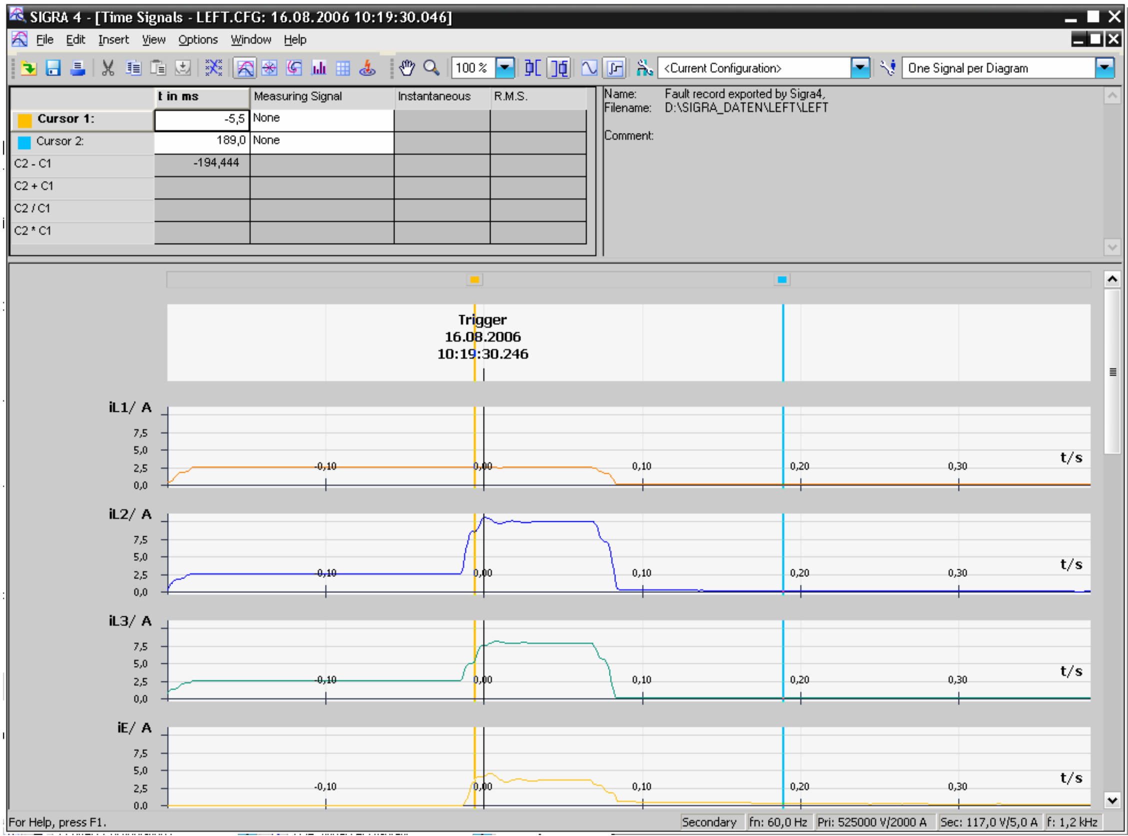
The behavior of the **cursor lines** can be determined via the menu item **Options**. Possible settings are:

- Magnetic cursor lines
- Snap-in cursor lines

For further information, please refer to paragraph 3.2.3.

1.3 Time signals

The Time Signal view is used to display **signals** as a **function of time**.



DIGRA002.tif

Fig. 1-2 SIGRA 4, an example of the representation of time signals.

In this view, you can define any number of diagrams of the following types:

- status diagrams
- analog curve diagrams
- binary tracking diagrams

Each diagram can be assigned any number of measured and calculated variables, binary or status signals (time markings) and subsequently be dragged and dropped between the various diagrams.

NOTE

In the default setting, SIGRA 4 assigns a separate diagram to each signal.

Instantaneous values / r.m.s. values

In the Time Signals view, you can choose to display the values as either **instantaneous** or **r.m.s. values**.

Status signals

In the **status diagram**, the trigger point for fault recording is displayed as a pre-defined status.
If you have selected **User-defined status signals** to mark the individual instants, they are displayed in the status diagram with the selected symbol (see chapter 3.2.4).

Table

In addition to the graphical representation, you can read the values of individual signals at a defined instant in a **table** as well as the current positions of cursor 1 and cursor 2 on the time axis (see chapter 3.2.1 and chapter 3.2.2). Additionally, the following values are also derived from the cursors:

- Sum and difference (using the same units)
- product and ratio (not for angles)

The structure of the table can be freely configured in the **View Properties** dialog. The type of displayed values, such as r.m.s. values, instantaneous values, d.c. component or extreme value, etc., can be changed at any time (see chapter 4.2).

You can temporarily hide part or the whole of the on-screen display of the table (see chapter 3.2.7).

Tooltip

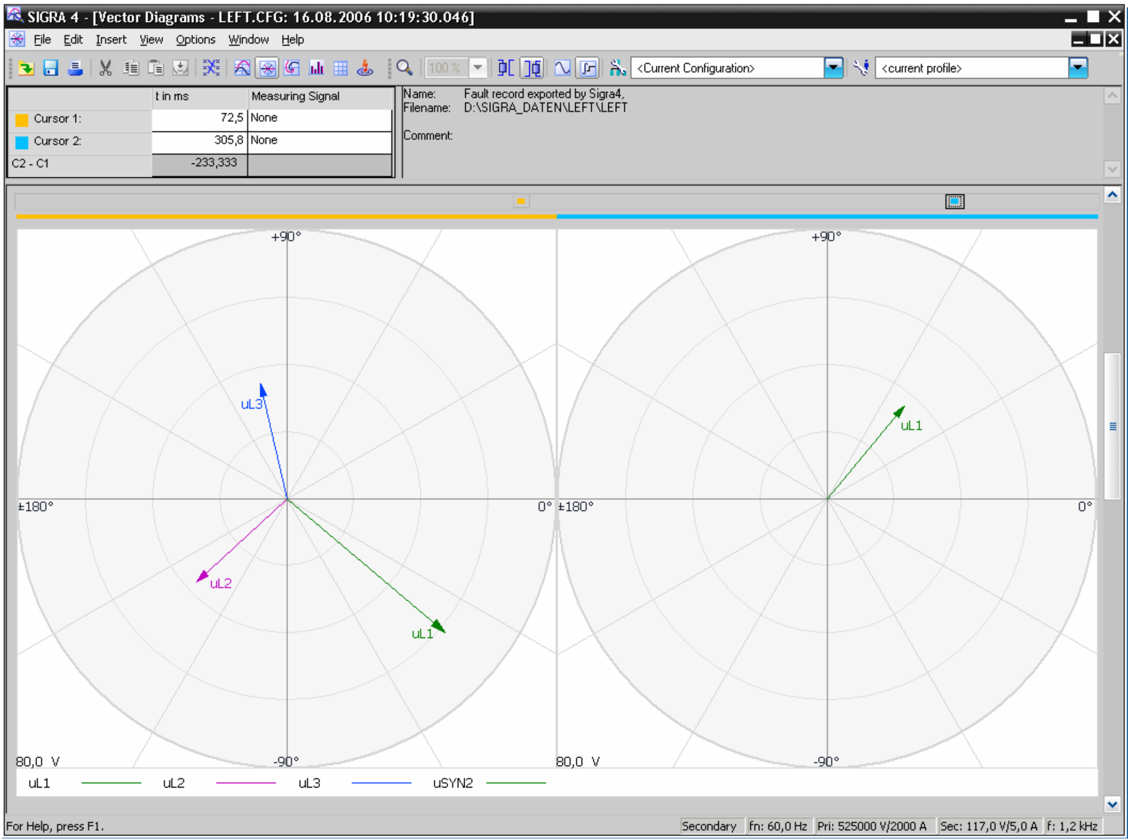
If you move the mouse pointer onto a signal of a diagram, a tooltip pops up which displays the signal name and value of the respective sampling instant.

NOTE

If a cursor is shifted in another view, its position in the Time Signal view changes to correspond to that new position.

1.4 Vector diagrams

The vector diagram view is used to display **measured and calculated variables** at a defined instant in the form of **complex vectors**.



DIGRA003.tif

Fig. 1-3 SIGRA 4, an example of the representation of phasors in vector diagrams.

Here, the instantaneous values of the point in time at which the two cursors are currently located are displayed in 2 diagrams each.

The **left-hand diagrams** are permanently assigned to **cursor**, the right-hand diagrams to **cursor 2**. The bars in the cursor color above the diagram clearly show this assignment.

The vectors of the measured variables are **r.m.s. values** of the fundamental component (nominal frequency T_N).
The absolute value and the angle of the vectors are determined by means of a **full-cycle DFT** (Discrete Fourier Transformation).
The **DFT measuring window** is always placed **to the left of the reference point** (cursor position) and its **length** corresponds to **one period of the nominal frequency T_N** (e.g. at 50 Hz this is 20 ms).

NOTE

The calculated **variables** are **valid** only if there is **no status change** (fault inception, tripping, gap in the measured value acquisition, etc.) within the **measuring window**!

With currents and voltages, the **vector angle** always **refers** to a **standard vector** $e^{j2\pi fN}$ (fN=nominal frequency) rotating at nominal frequency.

Phase position

Clicking the signal name zeros the phase position of this signal for the instant set by cursor 1. The values of all other signals are then aligned with this reference phase.

The changes also affect the representation of the signals in the **Circle Diagram** and **Table** views.

Table

In addition to the graphical representation, you can read the values of individual signals at defined instants in a **Table** and the current positions of cursor 1 and cursor 2 on the time axis (see chapter 3.2.1 and chapter 3.2.3).

The structure of the table can be freely configured in the **View Properties** dialog. The type of displayed values, such as absolute value, imaginary part or phase, etc., can be changed at any time (see chapter 4.2).

You can temporarily hide part or the whole of the on-screen display of the table (see chapter 3.2.3).

Tooltip

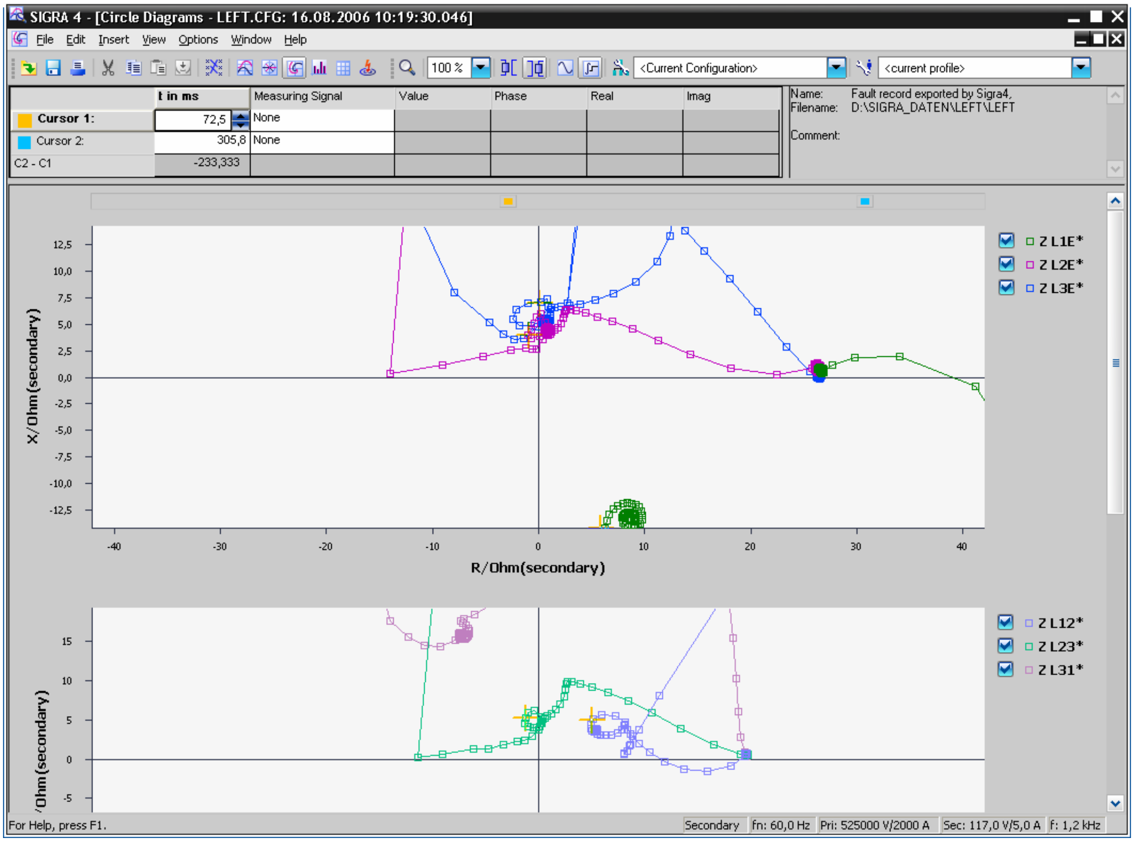
If you move the mouse pointer onto the arrow point of a diagram signal, a tooltip pops up which displays the signal name, value and phase position of the respective sampling instant.

NOTE

If a cursor is shifted in another view, the vector diagram changes to reflect this shift.

1.5 Circle diagrams

The **Circle Diagrams** view visualises the change of complex **variables** as a **circle diagram** over time.



DIGRA007.tif

Fig. 1-4 SIGRA 4, an example of the representation of complex variables in circle diagrams.

Trip zones Distance protection

In addition to the positive-sequence impedances, circle diagrams can also display the trip zones of distance protection devices.

The characteristics are stored in the *.RIO/*.XRIO file.

Each trip zone is processed by SIGRA 4 as an impedance signal and can be assigned to any number of diagrams.

Table

In addition to the graphical representation, you can read the values of individual signals at defined instants in a **Table** and the current positions of cursor 1 and cursor 2 on the time axis (see chapter 3.2.1 and chapter 3.2.3).

The structure of the table can be freely configured freely in the **View Properties** dialog. The type of displayed values, such as absolute value, imaginary part or phase, etc., can be changed at any time (see chapter 4.2).

You can temporarily hide part or all ofthe on-screen display of the table (see chapter 3.2.3).

Tooltip

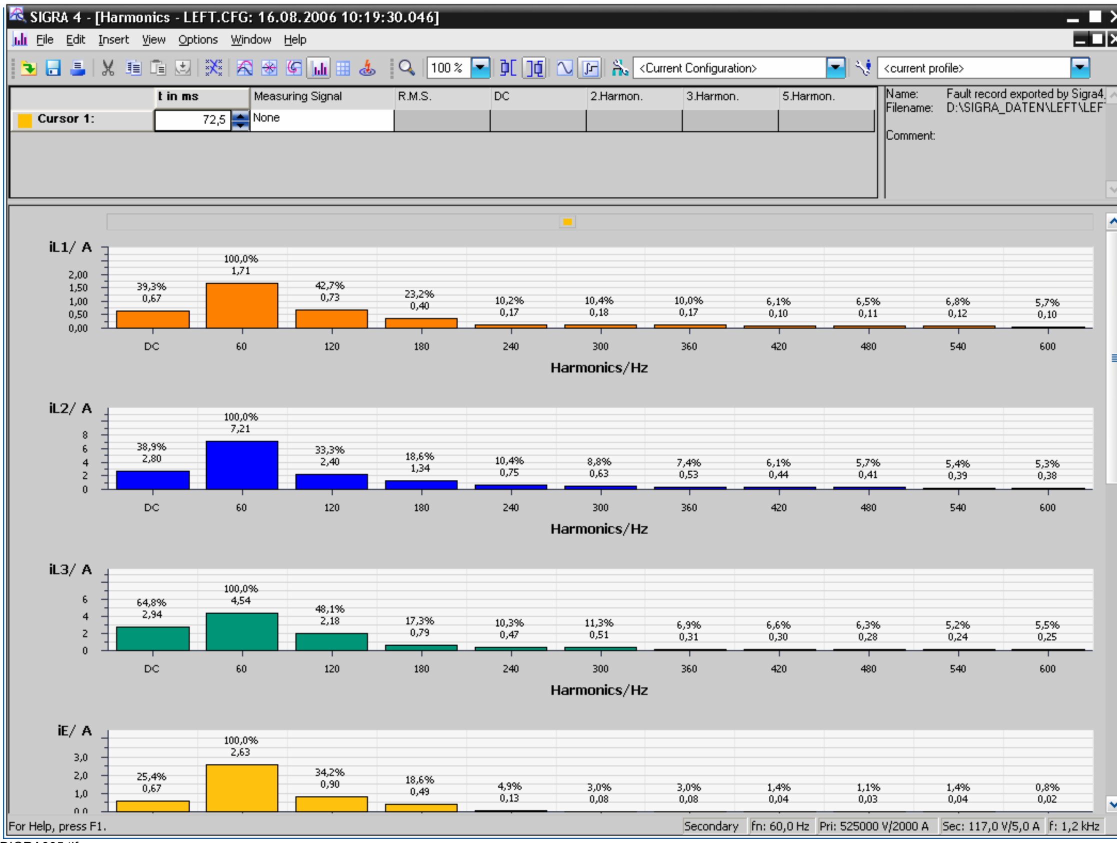
If you move the mouse pointer onto a signal of the diagram, a tooltip pops up which displays the signal name and instant of the respective sampling instant. If you move the mouse pointer onto the trip characteristics of the distance protection (zone), a tooltip appears which displays the zone name and zone time of the protection device.

NOTE

Cursor 1 and cursor 2 are displayed in this view as a small cross. If a signal is assigned to a cursor, the cursor changes to a crosshair of the same color as the cursor.
The instant shown in the table corresponds to the respective intersection point.

1.6 Harmonics

The Harmonics view displays the **r.m.s. values of the harmonics** of selected measured variables in the form of **bar charts**.



DIGRA005.tif

Fig. 1-5 SIGRA 4, an example of the representation of harmonics as r.m.s. values.

The harmonics are determined by a **full-cycle DFT** (Discrete Fourier Transformation) depending on the instantaneous value at the position of cursor 1. The **DFT measuring window** is always situated **on the left of the reference point** (position of cursor 1) and its **length corresponds to one period of the nominal frequency** $\mathbf{T_N}$ (e.g. at 50 Hz this is 20 ms).

NOTE

The calculated **variables** are valid only if there is **no status change** (fault inception, tripping, gap in the measured value acquisition, etc.) within the **measuring window.**

If there is enough space, i.e. only one signal per diagram is defined, the **r.m.s. value** and the **percentage value of the fundamental** are displayed as bars If more than one signal is assigned, these values are displayed in the tooltip.

Table

In addition to the graphical representation, you can read the values of individual signals at defined instants in a **table** and the corresponding position of cursor 1 on the time axis (see chapter 3.2.1 and chapter 3.2.3).

The structure of the table can be freely configured in the **View Properties** dialog. The type of displayed values, such as r.m.s. value, d.c. component or harmonic can be changed at any time (see chapter 4.2).

You can temporarily hide part or all ofthe on-screen display of the table (see chapter 3.2.3).

Tooltip

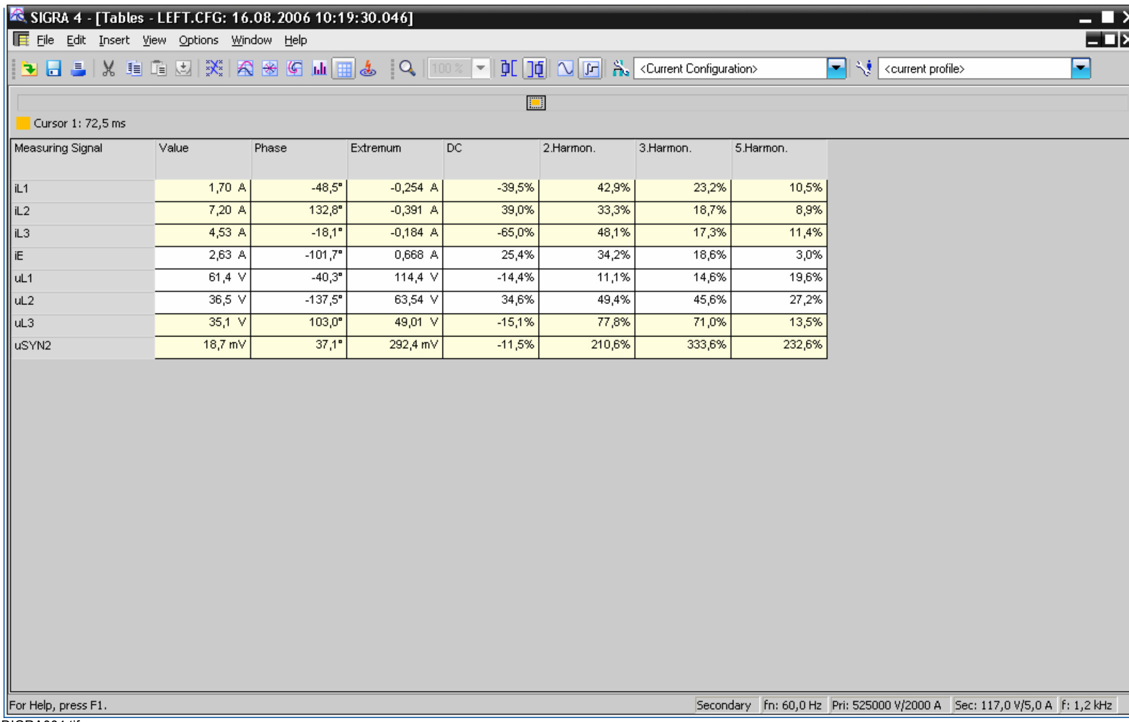
If you move the mouse pointer onto a signal of a diagram, a tooltip pops up which displays the signal name, value and frequency of the respective sampling instant.

NOTE

High-frequency oscillating components and balanced components are usually damped by filters integrated in the protection devices. However, SIGRA 4 does not take these device-specific factors into acount.

1.7 Table

The **table** view displays the behavior of several signals at the same instant. The displayed values are the instantaneous values at the position of **cursors 1**. To have the instantaneous values at other positions displayed, move cursor 1.



Measuring Signal	Value	Phase	Extremum	DC	2.Harmon.	3.Harmon.	5.Harmon.
iL1	1,70 A	-48,5°	-0,254 A	-39,5%	42,9%	23,2%	10,5%
iL2	7,20 A	132,8°	-0,391 A	39,0%	33,3%	18,7%	8,9%
iL3	4,53 A	-18,1°	-0,184 A	-65,0%	48,1%	17,3%	11,4%
iE	2,63 A	-101,7°	0,668 A	25,4%	34,2%	18,6%	3,0%
uL1	61,4 V	-40,3°	114,4 V	-14,4%	11,1%	14,6%	19,6%
uL2	36,5 V	-137,5°	63,54 V	34,6%	49,4%	45,6%	27,2%
uL3	35,1 V	103,0°	49,01 V	-15,1%	77,8%	71,0%	13,5%
uSYN2	18,7 mV	37,1°	292,4 mV	-11,5%	210,6%	333,6%	232,6%

DIGRA004.tif

Fig. 1-6 SIGRA 4, an example of the representation of values in table form.

The signals are arranged in rows, the individual columns contain the corresponding values, such as instantaneous value, r.m.s. value, phase, extreme value, etc. The column headings contain a short text. If you place the pointer over that text, a tooltip displays a more detailed text.

Phase position

Clicking the signal name zeros the phase position of this signal for the instant set by cursor 1. The values of all other signals are then aligned with this reference phase.

The changes also affect the representation of the signals in the **Vector Diagram** and **Dircle Diagram** views.

Sorting

If you want to **sort** the signals according to specific criteria (such as phase, absolute value, balanced component), click on the column heading.
The order of the signals (rows) changes according to the values in the selected column (values within a signal group in ascending order).

Configuration

You can configure the table rows in the **Assign Signals** view (see chapter 4.7).

Define the columns in the **View Properties** dialog (see chapter 4.2).

The configuration can be saved in the current **user profile** (see chapter 4.13). If the standard user profile is applied, the table configuration of the last evaluation session is used.

NOTE

If there are no values in the table cells, the specifications are not physically defined.

2 Operating Functions

Contents

2.1 General

SIGRA 4 is an application software which runs under Microsoft Windows and uses the windowing technique of these operating systems. To work with **SIGRA 4**, you need to have basic experience with these operating systems.

For information on how to **install/uninstall** SIGRA 4 , please refer to the product information and Readme.

Help system

SIGRA 4 provides a comprehensive help system:

- The general **Help** function can be called in any program level via the menu bar by clicking the **Help Topics** menu command. You can then look up information on individual topics. The chapters **How to...** offer standard methods of procedure for solving common tasks, such as "How to Define Your Fault Record Settings".
- Press **F1** for Help information on the menu commands.
- Click the **Help button** in the dialog boxes to obtain further information on the parameters of the selected dialog box.

2.2 Starting SIGRA 4

To start SIGRA 4 from the Windows desktop, proceed as follows:

✧ Click the **Start** button in the Windows taskbar and select **Siemens Energy > SIGRA 4 > SIGRA 4** from the start menu.

SIGRA 4 is started in the installation language.

✧ Now, load your fault record by selecting the **File > Open** menu command and start your analysis.

Alternatively, SIGRA 4 can be opened by double-clicking the .CFG file of a fault record.

Please refer to chapter 3.2 for further information on fault records settings.

2.3 Operation

2.3.1 Controls

You can operate SIGRA 4 by:

- selecting a menu command from the menu bar
- selecting a button from the toolbar
- selecting a context-sensitive function from the context menu

Menu bar

All the SIGRA 4 functions can be accessed via the menu bar.

✧ Click a menu command, such as **View**. From the drop-down menu, select the required function, such as **Primary Values**.

NOTE

If you press the **F1 key** while your mouse is positioned on a function of the pull-down list, a **Help page** with a brief explanation of this function appears.

Toolbars

Certain selection functions and the edit functions common to all Windows programs, such as Save, Copy, etc. can be found under the **Standard** and **View** toolbars.

SIGRA103.tif

Fig. 2-1 SIGRA 4, Standard toolbar

SIGRA102.tif

Fig. 2-2 SIGRA 4, View toolbar

The meanings of the individual buttons are explained in Table 2-1 in chapter 2.7.

Context menus

In SIGRA 4 the user is guided mainly by context-sensitive menus. You can use these menus, for example, to switch to the next dialog box, to activate copy functions, to insert diagrams or to maximize the screen display. SIGRA 4 always offers only the functions currently admissible in this context for selection.

To do this, proceed as follows:

- ✧ Move your mouse pointer to the object to be edited (multiple selection is possible);
- ✧ press your right mouse button. The relevant context menu appears;
- ✧ click the function you wish to be executed.

DIGRA031.tif

Fig. 2-3 SIGRA 4, an example of a context menu.

NOTE

We recommend the use of context menus for the selection of operator functions.

2.3.2 Copy / Paste / Cut

SIGRA 4 offers a range of convenient editing functions which help you to structure your fault record clearly and quickly. You can also use these functions to export data, such as diagrams or tables, to other applications such as Word, Excel or PowerPoint. When working in SIGRA 4, you can also use the drag-and-drop function and the Clipboard for fast assignment of signals to diagrams and tables, or of diagrams to the views.

The functions

- Copy
- Paste
- Cut

can be performed using the drag-and-drop technique, the context menu, the toolbar or the menu bar.

Duplicate objects, such as diagrams or signals, using the convenient drag-and-drop technique or the Copy and Paste commands. The object, including all parameters, is then duplicated.

For further information on these procedures, please refer to chapter 4.3 *Inserting diagrams* to chapter 4.8. *Copying signals*.

2.4 Displaying different views

You can display the SIGRA 4 views on the screen next to one another or in windows which overlap .

Switching views

If the selected view covers the whole screen, you can switch to another view, such as the Vector Diagrams view, as follows:

✧ Select **View > Vector Diagrams** from the menu bar;

or

✧ click the **Vector Diagrams button**in the Toolbar (see chapter 2.7).

The selected view type appears.

Displaying multiple views

If you would like to display more than one view on the screen at the same time, proceed as follows:

✧ First select all the views you want displayed;

✧ select a menu item from the **Window >** e.g. **Tile Horizontally from the menu bar**.

In this case, the views are arranged in separate windows on the screen so that they fit next to one another.

✧ You can now change the size of the individual windows.

Optimizing the window arrangement

To make optimum use of free spaces between the individual windows:

✧ In the upper right-hand window, click on the Cascade button.

SIGRA 4 increases the size of the window so that the available space is optimally used in all directions.

If you select a further view, SIGRA 4 places it in the available gap and makes it the maximum size possible.

If the window cannot be optimized, the button in the window is grayed.

Changing the size of a table

In the **Time Signals**, **Vector Diagrams**, **Circle Diagrams** and **Harmonics** views, a **table** appears for the display of selected measured or calculated variables.
If you want to temporarily hide or reduce the on-screen display of the table, proceed as follows:

✧ Move the mouse pointer to the lower border of the table.

The mouse pointer changes.

✧ Keep the left mouse button pressed and drag the border towards the top of the screen;

✧ drag the border back down to make part or the whole of the table visible again.

2.5 Changing the value display

In **SIGRA 4** you can choose different values for the display of measured and calculated variables of your fault record.

2.5.1 Primary values / secondary values

SIGRA 4 lets you represent the values of a fault record in the views as primary or secondary values.

Primary values

✧ Select **View > Primary Values** to display the primary values with reference to the nominal transformer values of the signals.

Secondary values

✧ Select **View > Secondary Values** to display the secondary values with reference to the nominal transformer values of the signals.

2.5.2 R.M.S. values / instantaneous values

The **Vector Diagrams**, **Circle Diagrams** and **Harmonics** views **always** display **r.m.s. values**. In the **Time Signals** view, you can also display diagrams with the **instantaneous values**.

R.M.S. values

✧ Select **View > R.M.S. Values** from the menu bar to display the signals as **R.M.S. values**.

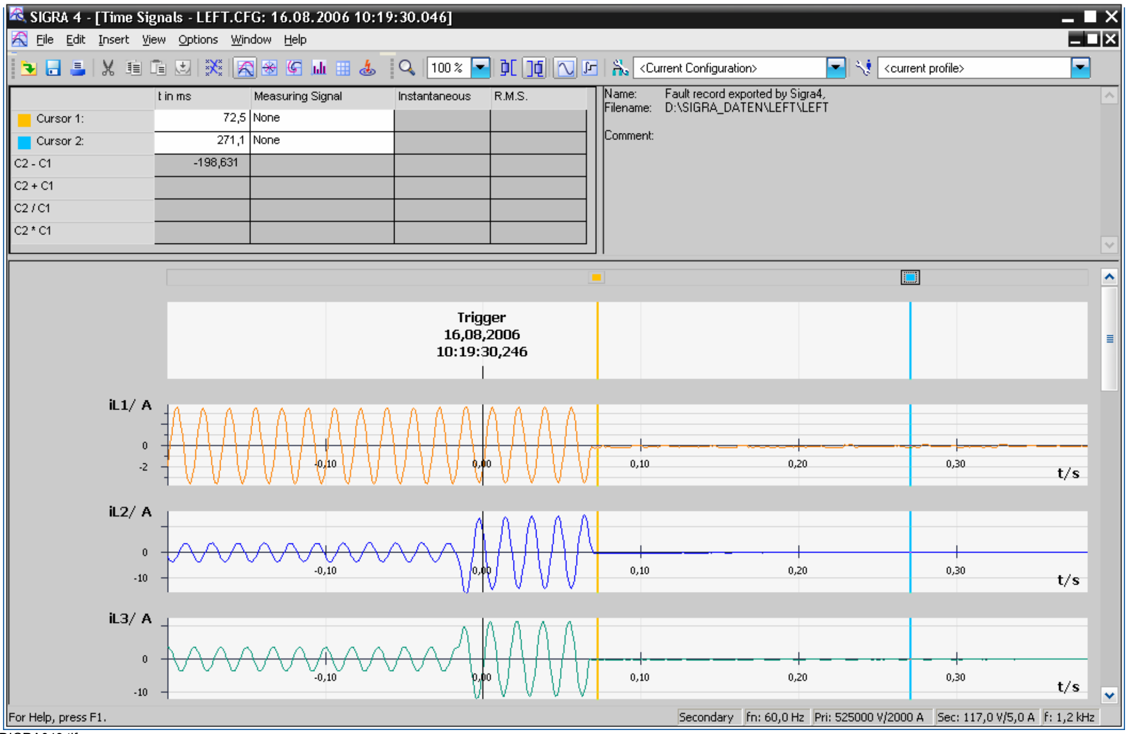
Instantaneous values

✧ Select **View > Instantaneous Values** from the menu bar to display the signals as **instantaneous values**.

The other views are not affected by this selection.

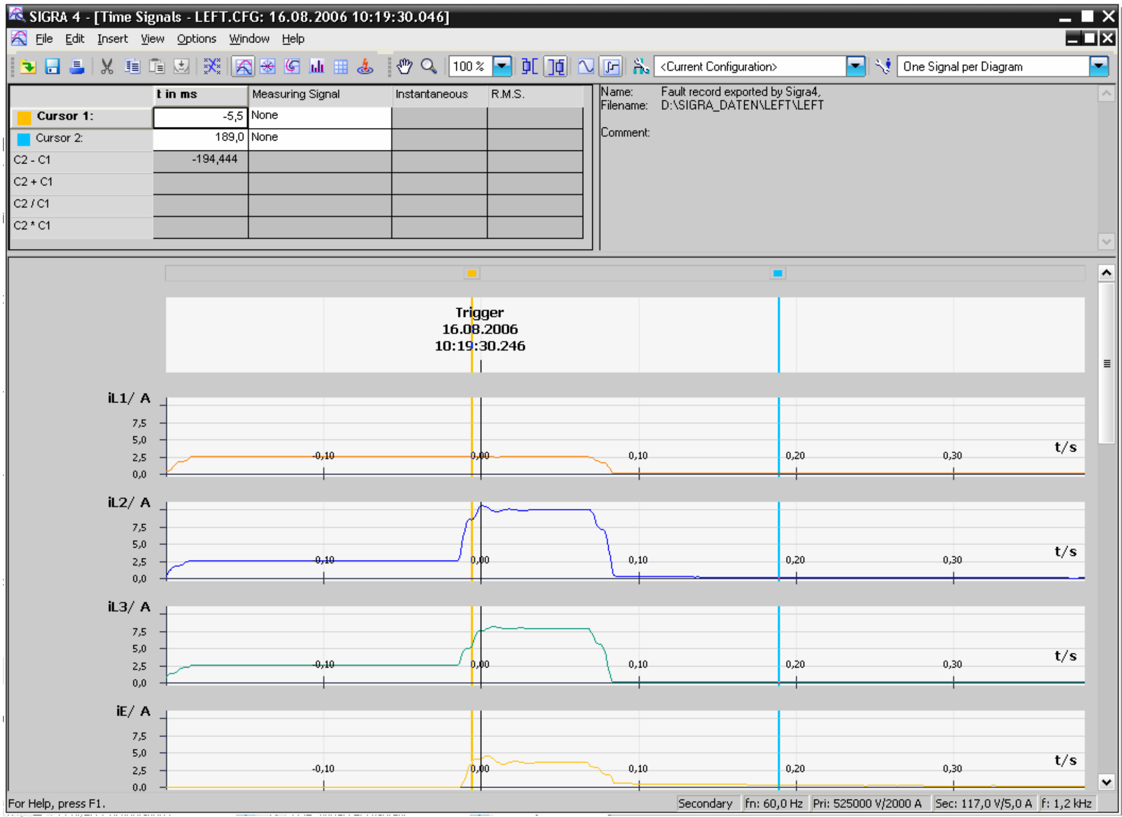
NOTE

You can specify which variables of the signals you want displayed in the **Table view** in the **View Properties** dialog.



DIGRA049.tif

Fig. 2-4 SIGRA 4, representation of time signals via instantaneous values.



DIGRA002.tif

Fig. 2-5 SIGRA 4, representation of time signals via r.m.s. values.

2.6 Zooming

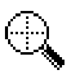
If you wish to change the **diagram scale** interactively, SIGRA 4 offers some convenient **zoom functions**.

When the zoom mode is activated, the mouse pointer changes, depending on its position in the views.
The symbols represent the various functions.

2.6.1 Activating the Zoom Mode

You can activate the **Zoom mode** either:

- by selecting **View > Zoom > Zoom** from the menu bar, or
- by clicking the **Zoom In/Out button** in the toolbar (see chapter 2.7)
- by choosing **Zoom** from the context menu.



When activating the zoom function, the mouse pointer symbol changes its shape to a magnifying glass.
With this function, you can maximize any section of a diagram.

2.6.2 Maximize / Minimize

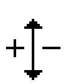
Maximizing a section

✧ Position the magnifying glass on the upper left-hand corner of the section to be enlarged while keeping the left mouse button depressed. Draw a frame over the whole area you wish to maximize and release the mouse button.
The section marked is enlarged.

✧ Repeat this procedure until the display has reached the size you want.

Changing the axis scale

If you approach one of the axes with the magnifying glass, you can change the axis scale as follows:

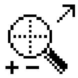


Use the left mouse button (+) to increase, or the right mouse button (–) to decrease the axis scale along the X- or Y-axis.

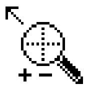
In the **Vector Diagrams** view, you can enlarge or reduce the display size of the individual vectors (voltages or currents) separately.

✧ Click one of the scales in the corners of the diagram with the magnifying glass.

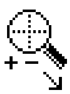
Depending on its position, the magnifying glass changes as follows:



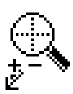
Upper right-hand corner of the vector diagram
Use the left mouse button (+) to increase, or the right mouse button (–) to decrease the scale



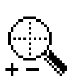
Upper left-hand corner of the vector diagram
Use the left mouse button (+) to increase, or the right mouse button (–) to decrease the scale



Lower right-hand corner of the vector diagram
Use the left mouse button (+) to increase, or the right mouse button (–) to decrease the scale



Lower left-hand corner of the vector diagram
Use the left mouse button (+) to increase, or the right mouse button (–) to decrease the scale



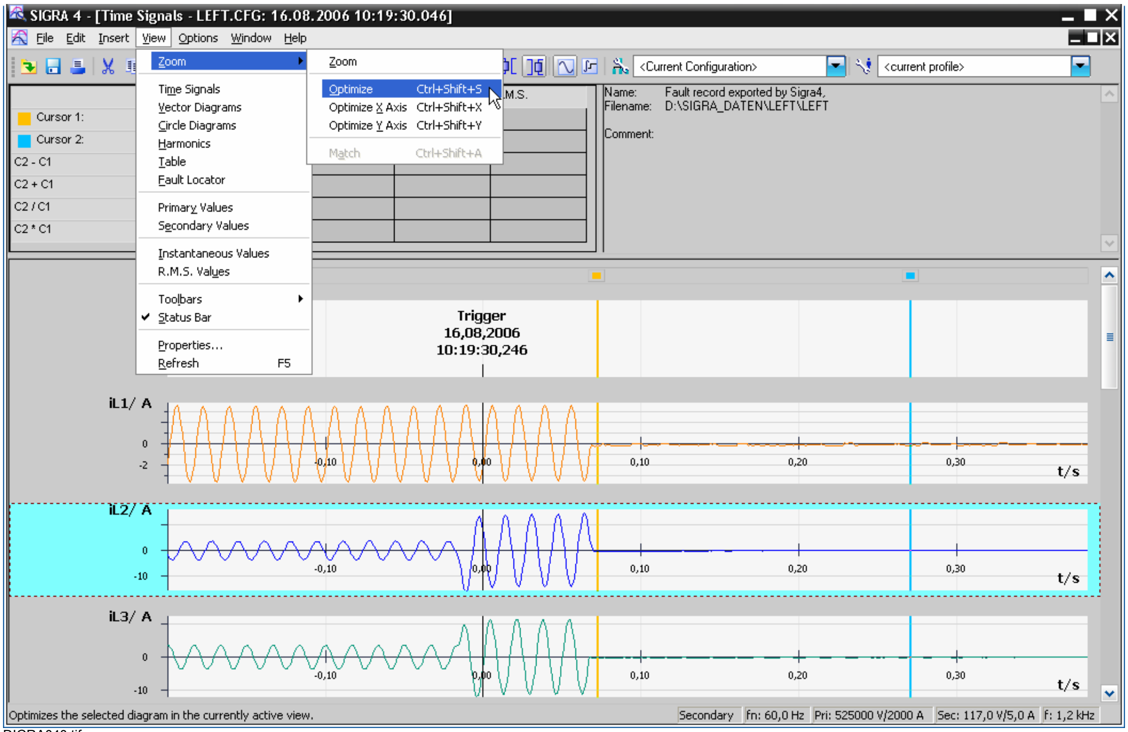
If you position the magnifying glass within the circle, you can change the display size of all vectors.
Use the left mouse button (+) to increase, or the right mouse button (–) to decrease the scale.

NOTE

In the Circle Diagrams view, the representation is conformal. This may mean that the displayed area is larger than the value specified.

2.6.3 Optimizing

In addition to the zoom functions described above, you can also optimize the diagram scale with SIGRA 4.



DIGRA040.tif

Fig. 2-6 SIGRA 4, optimizing the representation of the diagrams.

Proceed as follows:

- Select all diagrams to be displayed at maximum size in the selected view;
- select **Zoom > Optimize** from the context menu or
  View > Zoom > Optimize from the menu bar.

The X-axis and the Y-axis scales are optimized.

NOTE

SIGRA 4 chooses the maximum scale actually possible for the display of currents and voltages; in the case of impedances it chooses the “ideal” display, since the maximum of these variables is infinite.

Optimize X-Axis

- Select **Zoom > Optimize X-Axis** from the context menu or
  View > Zoom > Optimize X-Axis from the menu bar.

The scale of the time axis of all diagrams in a view is optimized, the Y-axis scale remains unchanged.

Optimize Y-Axis

- ✧ Select all diagrams to be displayed at maximum size along the Y-axis in the selected view;
- ✧ select **Zoom > Optimize Y-Axis** from the context menu or
  View > Zoom > Optimize Y-Axis from the menu bar.

The Y-axis scale is optimized, the X-axis scale remains unchanged.

NOTE

Due to the circular arrangement, X-axis and Y-axis optimization does not affect the vector diagrams.

2.6.4 Matching

You can use the Match zoom function to achieve a uniform scale of several diagrams displayed in one view.

- ✧ Select all the diagrams whose scale is to be matched.
- ✧ Set the focus on the master diagram (broken line around the diagram last marked).
- ✧ Select **Zoom > Match** from the context menu or
  View > Zoom > Match from the menu bar.

The scale of the selected diagrams (along the Y-axis) is matched to the scale of the diagram you have defined as the “master diagram”.

2.7 Toolbar buttons

The following table lists all the buttons and their respective functions of the SIGRA 4 **Standard** and **View** toolbars.

Table 2-1 SIGRA 4 toolbar buttons

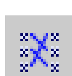
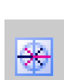
Button	Function/Meaning
	Opens a file
	Saves a file
	Prints the current selection
	Deletes the selected objects and places them on the Clipboard
	Copies the selected objects onto the Clipboard
	Pastes objects from the Clipboard
	Fills gaps in the signals
	Displays the Assign Signals matrix
	Displays the Time Signals view
	Displays the Vector Diagrams view
	Displays the Circle Diagrams view

Table 2-1 SIGRA 4 toolbar buttons

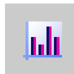
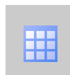
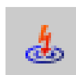
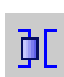
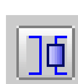
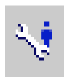
Button	Function/Meaning
	Displays the Harmonics view
	Displays the Table view
	Displays the Fault Locator view
	Shifting the display area, activate/deactivate
	Activates/deactivates zoom mode
	Changes the diagram height
	Displays primary values
	Displays secondary values
	Displays instantaneous values
	Displays r.m.s. values
	Selects the Network Configuration dialog

Table 2-1 SIGRA 4 toolbar buttons

Button	Function/Meaning
	Assigns the network configuration
	Selects the User Profile dialog
	Assigns the user profile

2.8 Changing the language

The language can be changed via the SIGRA 4 menu, for example during commissioning to the mother tongue of the service staff.

When the language is changed, opened fault records are closed and any changes made get lost. A corresponding warning is displayed. Therefore, save all fault records before changing the language.

How to change the language:

- ✧ Save opened fault records if you have made any changes and these are not to get lost.
- ✧ Select the desired language in the menu via **Tools > Language**.
  The **Change Language** dialog is opened.
- ✧ Close the dialog by clicking **Yes**.
  All opened fault records are closed. The language is changed.

NOTE

The language for SIGRA 4 can be set upon startup with a command line via a parameter. The available languages and associated parameters are the following:

- German = /a
- English = /b
- French = /c
- Spanish = /d
- Italian = /e
- Russian = /f
- Chinese = /k
- Turkish = /l

3 Fault records

Contents

3.1 General

Fault records to be analyzed by SIGRA 4 must be available in **COMTRADE format**. To this end, the fault records of the **SIPROTEC 4** device series can be retrieved from the devices using the **DIGSI 4** parameterization software and stored in COMTRADE format. These can then be processed directly by SIGRA 4 without any further modification.

For the analysis of these fault records, **SIGRA 4** uses the values measured to calculate further variables, such as impedances and outputs, and processes all measured and calculated variables and the associated binary signals for graphical display. The signals are displayed in the Time Signals, Vector Diagrams, Circle Diagrams, Harmonics and Table views (see chapter 1.3 to chapter 1.7).

You can **freely adapt** the **representation** of a fault record to suit your operating requirements and define your own settings with regard to the distribution of signals in the Table view and the individual diagrams. Dialogs are also available for specifying colors, labeling, diagram size, etc. You can save these individual parameter settings in the **user profiles** for analysis of further fault records. Each fault record can be permanently or temporarily assigned one of these individually defined user profiles via the toolbar (see chapter 4.13).

In the case of fault records of devices which do not belong to the SIPROTEC system range, the recorded measured variables must be adapted to suit SIGRA 4 conventions (see chapter 5 **Reference arrow definition**, **Calculations**).

You can establish compatibility of the data of these devices recorded in the fault record to SIGRA 4 via the **Network Configuration** and **Signal Properties - Analog Signals** dialogs (see chapter 3.10 and chapter 4.10).

Fault record files

A fault record is made up of several files which are stored under one name but with the following extensions:

*.CFG	COMTRADE configuration file Description of the fault record channels (signal name, sampling rate, etc.). Generated (for example) by DIGSI 4.
*.DAT	COMTRADE file Sampling values of the fault record channels (measured variables). Generated (for example) by DIGSI 4.
*.RIO	Available as an option protection settings (such as earth impedance factors). Generated (for example) by DIGSI 4.
*.DG4	Available as an option Contains SIGRA 4-specific settings related to a fault, such as cursor positions, color settings, etc., of the last evaluation session (session memory). Generated by SIGRA 4 when a file is saved.
*.HDR	Available as an option Comment on the fault record
*.INF	Available as an option Any comment on an individual signal.

NOTE

These files must be saved or moved together.

3.2 Fault record settings

Table

In addition to the graphical representation of the signals in the diagrams, the **Time Signals**, **Vector Diagrams**, **Circle Diagrams** and **Harmonics** views contain a **table** where you can directly read the absolute value of individual signals at different instants. You can freely configure which measured or calculated variables of the signals are to be displayed
(see chapter 4.2).

	t in ms	Measuring Signal	Instantaneous	R.M.S.	Extremum	DC
Cursor 1:	-5,5	uL1	-45,49 V	66,5 V	93,11 V	-0,002 V
Cursor 2:	189,0	uL2	0,861 V	1,71 V	-1,425 V	0,08 V
C2 - C1	-194,444	uL2 - uL1	46,347 V	-64,753 V	-94,537 V	84,611 mV
C2 + C1		uL2 + uL1	-44,624 V	68,171 V	91,687 V	80,182 mV
C2 / C1		uL2 / uL1	-18,94 m	25,71 m	-15,31 m	-37,20
C2 * C1		uL2 * uL1	-39,179 V²	113,582 V²	-132,712 V²	-182,483 uV²

DIGRA134.tif

Fig. 3-1 SIGRA 4, an example of the representation of time signals in table form.

If you want to know the exact value of a particular measured or calculated variable at a defined instant, you can

- assign this signal to a cursor (see chapter 3.2.1) and
- set the cursor to this instant (see chapter 3.2.2).

Signal names, **values** and the **instant** are shown in the table.

NOTE

Only cursor 1 is used in the **Harmonics** view.

The **Table** view does not contain any diagrams. The signals configured for the table (see chapter 4.7) are permanently assigned to cursor 1.

Tooltip

If you move the mouse pointer onto a signal of a diagram, a tooltip pops up which displays the sampling instant **signal name**, **value(s)** and **instant**.

Zoom

To improve analysis accuracy, change the **resolution** of the signal display in the diagrams quickly and conveniently using the **Zoom functions** (see chapter 2.6).

Markers / status signals

Marking the signals' sampling instants (see chapter 3.2.4) and the time marking of events by means of **status signals** (see chapter 3.2.5) also helps you to effectively analyze the fault record.

3.2.1 Assigning measured signals

This table lets you assign the significant signals required for fault record analysis.

	t in ms	Measuring Signal	Instantaneous	R.M.S.	Extremum	DC
Cursor 1:	38,3	uL1	89,75 V	66,3 V	-93,25 V	-0,002 V
Cursor 2:	189,0	uL2	0,861 V	1,71 V	-1,425 V	0,08 V
C2 - C1	-150,683	uL2 - uL1	-88,889 V	-64,578 V	91,828 V	84,478 mV
C2 + C1		uL2 + uL1	90,612 V	67,996 V	-94,679 V	80,315 mV
C2 / C1		uL2 / uL1	9,60 m	25,78 m	15,28 m	-39,58
C2 * C1		uL2 * uL1	77,306 V²	113,281 V²	132,914 V²	-171,514 uV²

SIGRA135.tif

Fig. 3-2 SIGRA 4, an example of the representation of vector diagrams in table form.

✧ Click the **Measuring Signal** box of **Cursor 1** and select a signal from the drop-down list, e.g. VL1;

✧ click the **Measuring Signal** box of **Cursor 2** and select a signal from the drop-down list, e.g. VL2.

The cursor position on the time axis is displayed in the t in ms box.
The other boxes display the respective values of the signal at this instant.

Meaning of the lines:

- **C2 - C1**
  This line shows the difference (time and values) calculated by SIGRA 4.
- **C2 + C1**
  This line shows the sum (values) calculated by SIGRA 4.
- **C2 / C1**
  This line shows the quotient (values) calculated by SIGRA 4.
- **C2 * C1**
  This line shows the product (values) calculated by SIGRA 4.

3.2.2 Assigning instants

Cursor 1 / Cursor 2

The current cursor position on the time axis is shown in the tables of all views.

In the Time Signals view, the cursors are also displayed by a vertical line across all diagrams, in the Circle Diagrams view they are represented as a small crosshair or, if a measured signal has been assigned, as a large crosshair.
The cursors are color-coded. The color assignment can be found in the cursor symbol, line or crosshair, the tables and in the dialog boxes.

Only cursor 1 is used for measuring in the Harmonics view.

Positioning the cursor

To position a cursor at a defined instant, proceed as follows:

- Click the cursor symbol and keep the left mouse button pressed. Move the cursor along the time axis to the left or the right. You can follow the positioning along the time axis in the **t in ms** box of the table. Release the mouse button when you have reached the desired point;

or

- enter the instant in the **t in ms** box of the table.
  SIGRA 4 then sets the cursor automatically to this instant;

or

- click the **t in ms** box and increase / decrease the value using the up / down arrows.
  SIGRA 4 then shifts the cursor automatically to this point.

NOTE

The **measuring window** for **calculation** is always situated **on the left** of the **reference point** (cursor position). The length of the measuring window corresponds to one period of the nominal frequency T_N which is, for example, 20 ms at 50 Hz.

The **calculated variables** are **valid only** if there is **no status change** (such as fault occurrence or disconnection) within the **measuring window**.

In the **Circle Diagrams** view, you can also position the cursor at a defined sampling instant as follows:

✧ Assign a signal to the cursor.
The cursor is displayed as a large crosshair;

✧ spproach the intersection of the cursor lines with your mouse pointer. The mouse pointer changes to a hand symbol. Keep the left mouse button pressed and move the hand to the required sampling instant.

NOTE

For easier identification of the individual sampling instants, we recommend **marking** the **signal** you want to measure via the **Object Properties** dialog. Each sampling instant is then marked by a symbol (triangle, circle, etc.) (see chapter 3.2.4).

3.2.3 Determining cursor behavior

Magnetic cursor lines

With the **Options > Magnetic Cursor Lines** menu command you can synchronize the movement of a cursor along the time axis quickly and exactly with:

- status changes of binary signals and
- status signals (marking of significant instants)

When a cursor approaches such an event, it is attracted “magnetically” and "snaps" to that point.

If you have also activated the **Snapping Cursor Lines** function, you can move the cursor to this event by jumping from one sampling instant to the next.

Snap-in cursor lines

With the menu command **Options > Snapping Cursor Lines** you can synchronize the movement of a cursor along the time axis with the sampling instants of the signals.

If you have also activated the **Magnetic Cursor Lines** function, when the cursor approaches a status change or a status signal, it is attracted “magnetically” to this event and "snaps" to that point.

NOTE

If **both functions are deactivated**, you can move the **cursor continuously** along the time axis.

3.2.4 Placing markers

When analyzing a fault record, it is often useful to highlight signals by means of graphical symbols. These **markers** are placed at the **signal sampling instants**. This function makes it considerably easier to position the cursor at defined instants, particularly when evaluating circle diagrams (see chapter 3.2.2).

To place the markers for analog signals in the **Signal Properties** dialog box, proceed as follows:

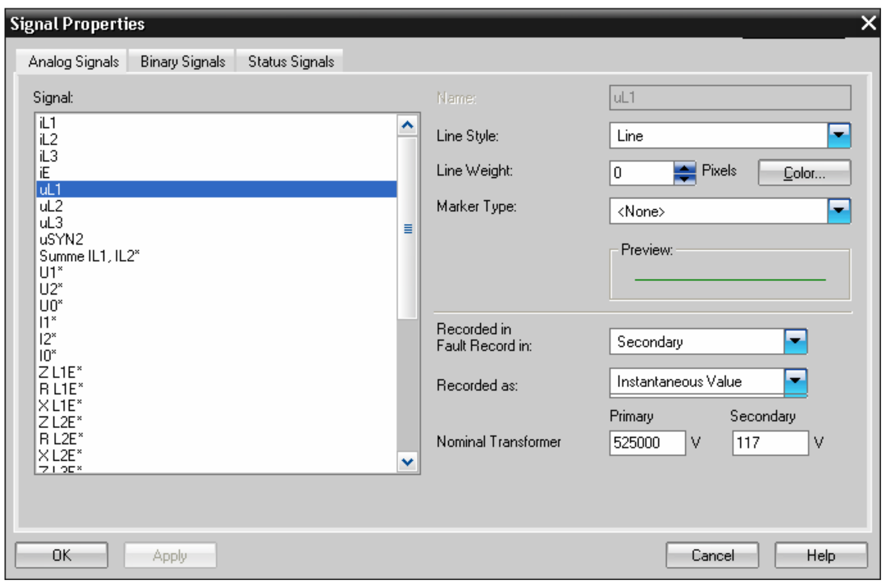
- ✧ Double-click the signal in the diagram legend,

or

- ✧ select the signal you want to mark in the diagram legend and open the corresponding dialog box by choosing **Object Properties** from the context menu or selecting **Edit > Object Properties** from the menu bar;

or

- ✧ select the **Signal Properties** dialog from the **Assign Signals** dialog box. To do this, right-click the **Signal name** or **Signal line** column and select **Properties** from the context menu;



dirgra048.tif

Fig. 3-3 SIGRA 4, editing the signal properties of analog signals.

NOTE

If you are only displaying a single signal in a diagram, select the **Signal Properties** dialog by double-clicking the signal name on the axis labeling.

- select the symbols you want to mark from the **Marker type** drop-down list.
  You can see the parameterized signal display in the preview section;
- confirm with **Apply** if you want to mark further signals. Select the next signal from the signal list and repeat the marking procedure;
- confirm your input with **OK**.

NOTE

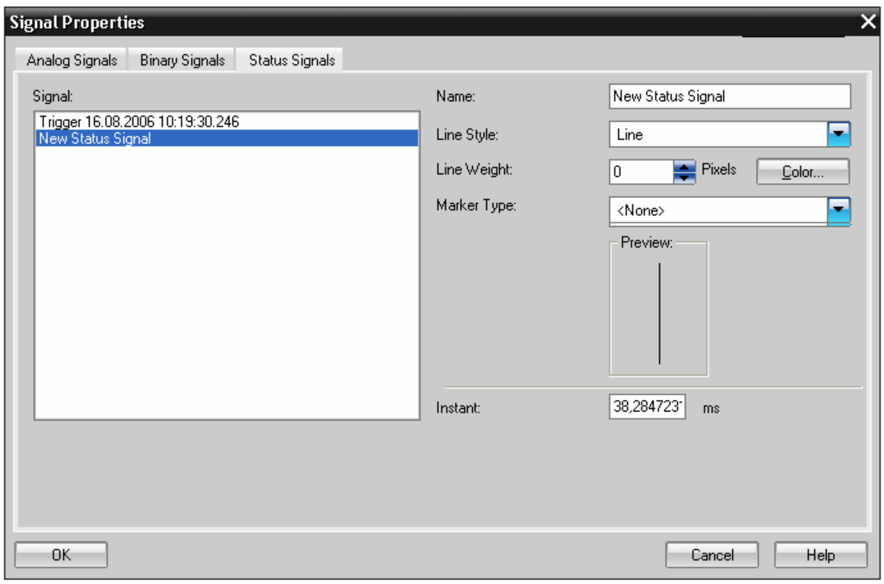
The selected marking is applied to the signal in **all diagrams** in which it is displayed, as well as the legends (not in the axis labeling).
Markers do not apply to vector diagrams.

3.2.5 Inserting status signals

In order to **time mark** significant events, you can define your individual **Status signals** in the **Time Signal** view.

The trigger point for fault recording is marked automatically by SIGRA 4 with a status signal (trigger).

- Select the status diagram in which you want to insert the status signal (multiple selection is possible);
- position cursor 1 on the instant you want to select;
- insert a new status signal by selecting **Insert > Status Signal** from the menu bar and define the **Signal Properties** in the corresponding dialog box.



DIGRA041.tif

Fig. 3-4 SIGRA 4, inserting a status signal into a diagram.

In the **Signal** list box you can see the names of all signals available.

The status signal inserted appears as **New Status Signal** and is highlighted.

- Rename the status signal identified as **New Status Signal** in the **Name** text box;
- select the desired **Line style** from the drop-down list where the different types of line display are provided, e.g. line, dots, dot-and-dash, etc.;
- use this box to enter the **Line weight** of a signal as an absolute number of pixels or by increasing/decreasing the value using the up/down arrows;
- select the symbol to be used for the status signal in the status diagram of the Time Signal view from the **Marker type** drop-down list;
- click the **Color** button and switch to the next dialog box where you can select a color or define a new shade.

The **Instant** text box shows the position of cursor 1.

- If necessary, you can correct the value in the **Instant** text box.

In the **Preview** section, you can see how the current settings affect the signal display in the status diagram.

✧ Confirm your input with **OK**.

The status signal is displayed in the status diagrams selected.

If no status diagram has been selected, SIGRA 4 opens the **Assign Signals** dialog box automatically.

✧ Assign the signal to all diagrams where you want it to be displayed (see chapter 4.7).

3.2.6 Deleting Status Signals

To delete a status signal, proceed as follows:

✧ Select the status signal in the status diagram or in the **Assign Signals** matrix. Delete the signal by selecting **Delete** from the context menu, by selecting **Edit > Delete** from the menu bar or by clicking the **button** in the toolbar.

The status signal is deleted from the display.

NOTE

If you delete a user-defined status signal from the last display used, it is also removed in the SIGRA 4 management.
The status signal, which marks the trigger point for fault record recording, can only be deleted from the display. However, it is still in the Assign Signals matrix.

3.2.7 Hide/Show table

If you do not need to display the values of individual signals in a view in table form, you can **reduce or hide the table**.

To do this, proceed as follows:

✧ Move the mouse pointer to the lower border of the table.

The mouse pointer changes.

Hide

✧ Keep the left mouse button pressed and drag the border towards the top of the screen.

Show

✧ Drag the border back down to make part or the whole of the table visible again.

3.3 Inserting a fault record

If you need an additional fault record for the analysis of a fault event, such as that from the remote side of a line, you can insert the diagrams of this fault record at the end of the selected view.
The **selected signals** of the fault record are displayed in these diagrams.

Proceed as follows:

- ✧ Select **Insert > Fault Record** from the menu bar;
- ✧ specify the name and storage location (path) of the fault record you want to insert.

The **signal names** of the fault record inserted are extended by an **index**, e.g. IL1_1.

NOTE

The fault record must be available in COMTRADE format!

Since recording devices at different installation locations are not usually synchronized, the signals of the two fault records must be synchronized to ensure correct evaluation.

3.4 Synchronizing fault records

When synchronizing the signals of the inserted fault record (B) with the fault record to be analyzed (A), SIGRA 4 shifts the signals of the inserted fault record along the time axis by a defined interval.

To do this, proceed as follows:

- ✧ Insert a new diagram in the time signal view (see chapter 4.3);
- ✧ copy a corresponding signal from fault record A, such as the conductor current affected by a short-circuit, and insert it in the new diagram (see chapter 4.8);
- ✧ copy a corresponding signal from fault record B and insert it in the diagram as well;
- ✧ if necessary, enlarge the display using the zoom functions (see chapter 2.6);
- ✧ position **cursor 1** on the **synchronization point** of the signal of **fault record A** (e.g. point of fault occurrence) and **cursor 2** on the **synchronization point** of the signal of **fault record B**;
- ✧ open the corresponding dialog box by selecting **Edit > Synchronize Fault Records** from the menu bar;
- ✧ check the synchronization points and shift interval in the text box **Shift fault record B by**;
- ✧ check the settings using the **Preview** function;
- ✧ adjust the synchronization points if necessary;
- ✧ confirm your settings with **OK**.

The signals of fault record B are shifted by the calculated interval.
The two fault records can now be evaluated together.

- ✧ If necessary, repeat the described steps to fine-tune the synchronization.

NOTE

The color-coding of the cursor is useful when setting the synchronization points. The synchronization points in the dialog box are identified by the corresponding cursor color.

NOTE

If a bidirectional fault location was carried out, the dialog **Synchronize Fault Records** cannot be selected because in this case the fault records were synchronized automatically.

DIGRA042.tif

Fig. 3-5 SIGRA 4, synchronizing the signals of two fault records.

In addition to the procedures described above, you may also synchronize the shift interval directly or perform fine tuning using the **Synchronize Fault Records** dialog box.

To do this, proceed as follows:

The **Fault record A** box shows the name of the fault record to be used as the master for synchronization. The name in this text box cannot be changed.

✧ Select the name of the inserted fault record to be synchronized from the drop-down list in the **Fault record B** box.

In this section, you initially see the values of the current position of cursor 1 and cursor 2 which have been set to their synchronization points in the diagram.

✧ Enter the significant instant in the **Synchronization point fault record B (cursor 2)** box;

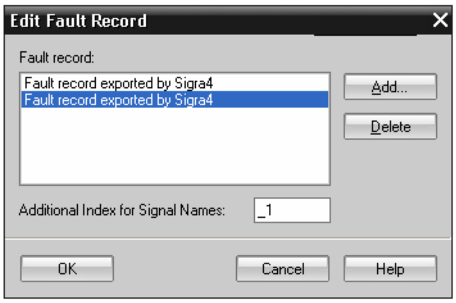
✧ enter the shift interval for fault record B in the **Shift fault record B by** box using the spinbuttons. A preview of the synchronization is generated automatically;

✧ confirm your settings with **OK**.

3.5 Editing fault records

If you want to add or delete a fault record previously inserted during fault record analysis, proceed as follows:

✧ Open the corresponding dialog box using the **Edit > Fault Record...** menu commands;



DIGRA043.tif

Fig. 3-6 SIGRA, adding or deleting a fault record.

✧ select the fault record you want to edit;

✧ select the **Add** button if you require the data of a further fault record;

✧ in the next dialog box **Open**, select the fault record (directory path);

✧ in the **Edit Fault Record** dialog box, enter the **additional index** for the signal name of the inserted fault record;

✧ confirm your settings with **OK**;

or

✧ if you no longer need the data of an inserted fault record, select the **Delete** button;

✧ confirm with **OK**.

NOTE

When using this dialog box, the fault record is deleted only in the SIGRA 4 data management.

3.6 Adding comments to a fault record

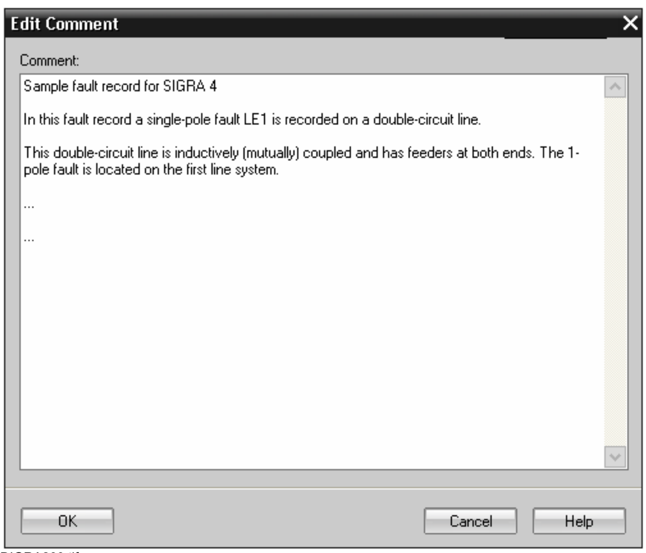
SIGRA 4 allows you to add own comments, e.g. evaluation results. You may add comments to:

- the **fault record**
  This comment is displayed in an own text field under **Comment** and stored in the fault record file ***.HDR**.
- an **individual signal**
  This comment is displayed in the diagram and stored in the ***.INF** file.

Commenting a fault record

To do this, proceed as follows:

✧ Select **Edit > Comment...** from the menu bar;



DIGRA200.tif

Fig. 3-7 SIGRA 4, an example of a fault record comment.

✧ type your comment in the **Edit Comment** dialog box;

✧ confirm your settings with **OK**.

Commenting a signal

Comments assigned to a signal can be added in the views **Time Signals** and **Circle Diagrams**. It is not possible to assign a comment to the signal of an r.m.s. value.

The following can be done with a comment:

- Add
- Edit
- Hide
- Delete

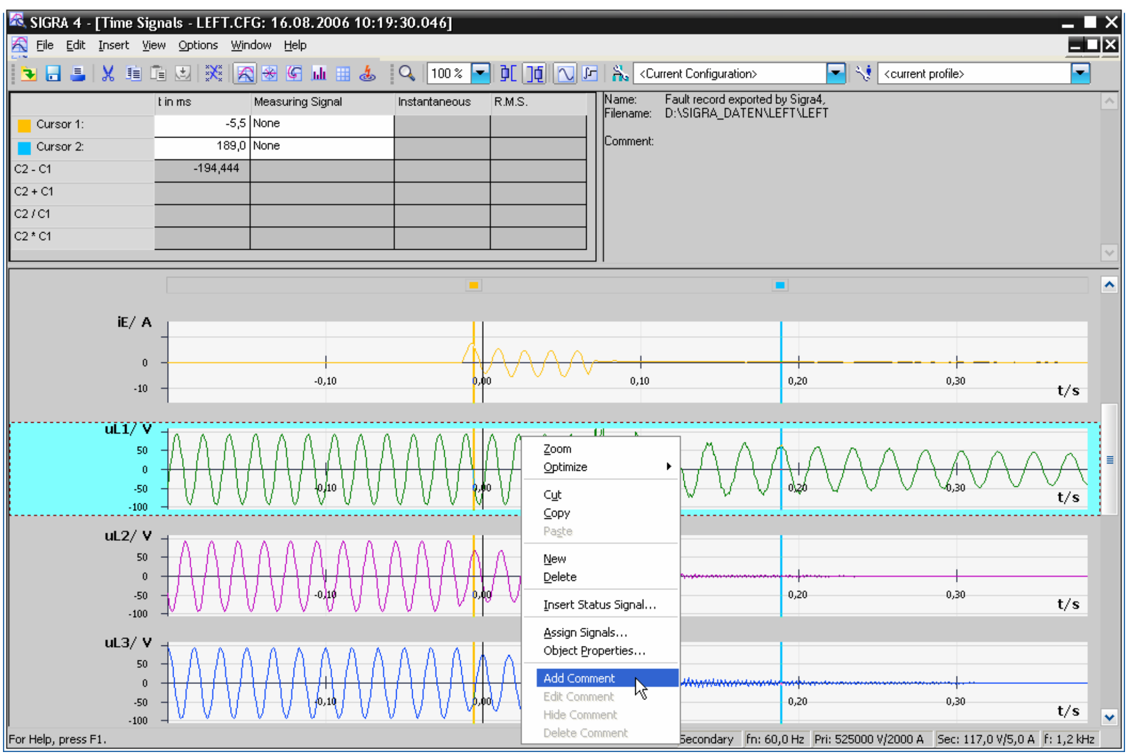
The functions are called via a context menu.

It is possible to add several comments to each signal. If you add the commented signal to another diagram, the comments are shown there, too.

The zoom function has no effect on the comment.

To add a comment to a signal, proceed as follows:

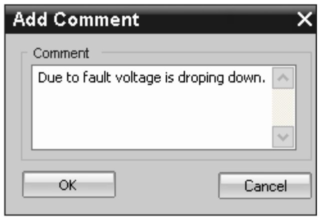
✧ Right-click the signal you want to comment.
The comment will later be added at the position on which you click.



SIGRA046.tif

Fig. 3-8 SIGRA 4, adding a comment to a signal.

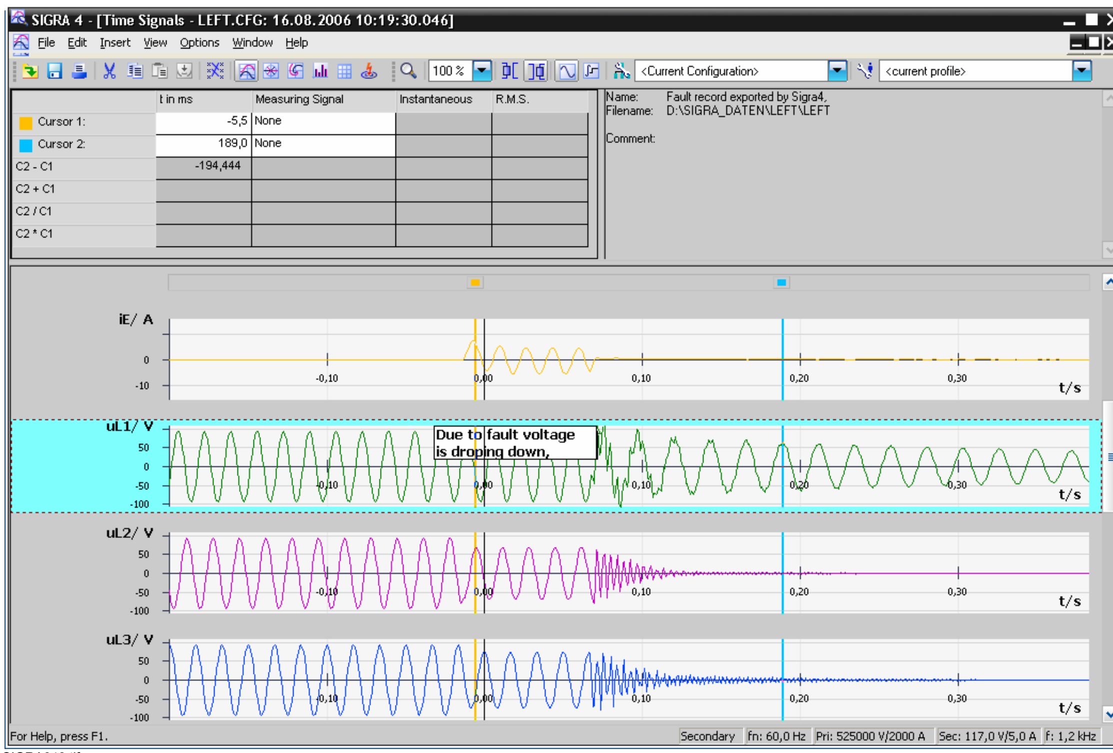
✧ From the context menu, select **Add Comment**.
The **Add Comment** dialog is opened.



SIGRA047.tif

Fig. 3-9 SIGRA 4, editing the comment.

✧ Enter the comment in the text input field and close the dialog with **OK**.
The comment is added to the diagram at the desired position.



SIGRA048.tif

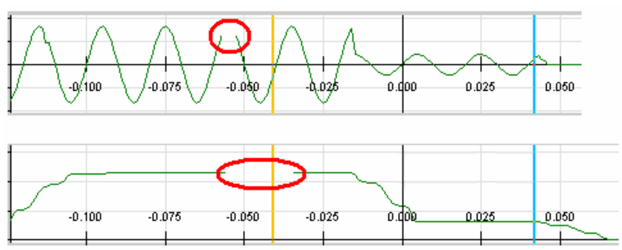
Fig. 3-10 SIGRA 4, the diagram with the added comment.

3.7 Filling gaps in signals

Missing measured values, i.e. information gaps in the fault record data, are shown as gaps in the signal representations. Nevertheless, it is possible to **fill these gaps with values** in order to achieve a continuous curve progression.

You can fill the gaps in the time signals of **instantaneous** and **r.m.s. values**.

You can decide whether the gaps are to be shown or filled with values. A fault record in which signal information is missing is shown with gaps after opening.
In the representation of r.m.s. values the gaps are larger than in the representation of instantaneous values because an r.m.s. value is calculated from the entire preceding period. Therefore, in the case of r.m.s. values the entire period is shown as a gap to prevent any misinterpretation due to the missing data.



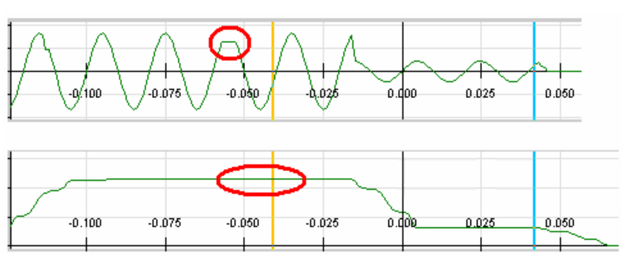
SIGRA065.tif

Fig. 3-11 SIGRA 4, the time signals contain gaps.

To toggle between the representations with and without gaps, proceed as follows:

✧ Go to the **Time Signals** view.

✧ From the menu, select **Edit > Fill Signal Gaps**.
The gaps in the signals are filled with values.



SIGRA066.tif

Fig. 3-12 SIGRA 4, the missing signal information is filled with values.

A checkmark is displayed before the menu item **Fill Signal Gaps**.

✧ To have the signal shown with gaps again, select **Edit > Fill Signal Gaps** from the menu again.

The option **Fill Signal Gaps** has effects on the following functions:

- Save
- Save as
- COMTRADE Export

These functions save/export the signals the way they are currently shown. If the option **Fill Signal Gaps** is activated, the signals are saved/exported with the fillers.

3.8 Printing fault records

You can print either the complete fault record or selected diagrams of a view.

Proceed as follows:

- ✧ Open the **Print** dialog box by selecting **File > Print** from the menu bar;
- ✧ specify the printer settings, such as type of printer, printer options (paper size, etc.), print area (complete fault record or selected areas) and the number of copies to be printed;
- ✧ confirm your settings with **OK**.

If you choose to print to a file, you are prompted for the name and storage location (path) of the target file.

NOTE

If using a monochrome printer, it may be useful to change the fault record layout for printing in order to be able to identify the different signals, e.g. by using different line styles (broken line, dotted line, etc.).

Define a specific layout for the printer and save this as a **user profile**. Assign this user profile before printing. For further details refer to chapter 4.13.

3.9 Exporting fault records

In the course of evaluating a fault, it may be necessary to further process the data of a fault record. All data of a fault record processed by SIGRA 4 can be exported. This means that, in addition to the variables recorded in the fault record, all calculated variables, such as impedances or outputs, are also available.

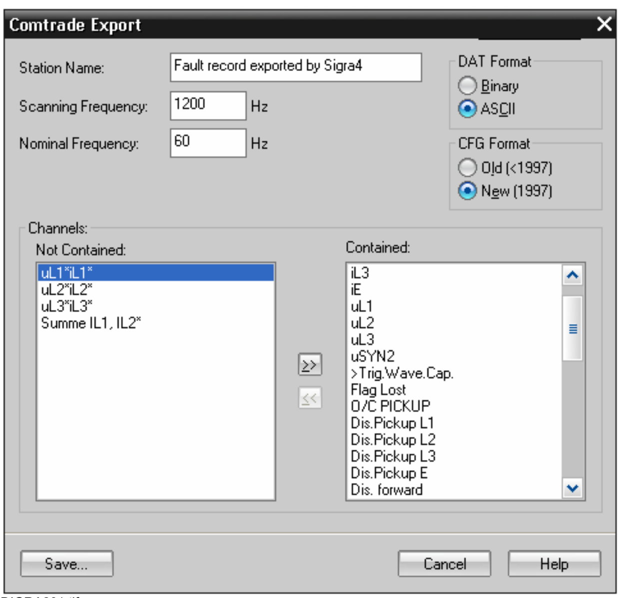
The following options are available for exporting data:

- Export to a file in COMTRADE format
- Export to other applications, such as Excel, Word, PowerPoint, etc.

3.9.1 COMTRADE Export

To export in COMTRADE format, proceed as follows:

✧ Open the **COMTRADE-Export** dialog box by selecting **File > COMTRADE Export** from the menu bar;



DIGRA201.tif

Fig. 3-13 SIGRA 4, an example of the COMTRADE export of a fault record.

- enter the relevant data of the fault record in the **Station name**, **Sampling rate** and **Nominal frequency** fields;
- select the data format in the **DAT Format** section and the standard according to which you want to store the data in the **CFG Format** section.

If you select the option **Old** under **CFG Format**, the fault record is stored in the **COMTRADE 91** format. If you select the option **New**, the fault record is stored in the **COMTRADE 99** format.

Specify the signals you want to export in the **Channels** section.

- To do this select all the relevant channels in the **Not Contained** box (multiple-selection possible) and click the double arrow pointing to the right.

The signals are placed in the **Contained** box.

- Check your selection and return any signals not required to the **Not Contained** box by clicking the double arrow pointing to the left;
- click the **Save** button and enter the file name and storage location (path) of the fault record in the subsequent **Save As** dialog.

NOTE

In the COMTRADE export the signals are resampled at the selected sampling rate.

3.9.2 Documentation of results

Analysis results can be documented very simply with other programs. The transfer of data to other programs is done in a very simple way:

- using the drag-and-drop function or
- transferring to and from the Clipboard using the Copy and Paste commands

These operations allow you to transfer tables or diagrams to office applications, such as Word or Excel.

Proceed as follows:

✧ Open the application.

✧ In SIGRA 4, select the data you want to export (multiple-selection possible).

✧ Hold the left mouse button and drag the selected area to your target position in the application (**drag-and-drop**).

or

✧ Select the **Copy** command via the context menu, the toolbar button or the Edit menu and then select the **Paste** command in the target application.

NOTE

By dragging and dropping the diagrams, you can adjust the diagram size in SIGRA 4 to the size you require in the target application. This improves the image quality as there is no need for further processing.

NOTE

If, for example, you copy a SIGRA 4 table to a Word document, the **Convert Text to Table** menu command in Word quickly and conveniently converts the inserted data to a Word table.

3.10 Parameterizing fault records

SIGRA 4 can process **all fault records** that are available in the **COMTRADE format**.
The conventions used under SIGRA 4 for the evaluation of fault records and calculation of further variables are designed for fault records generated by **DIGSI 4** (see chapter 5 *Calculations / Definitions*).

If you wish to evaluate fault records from other programs, the parameter settings of these records may need to be adapted.

Use the **Network Configuration** dialog to assign the physical meaning of the measured variables and specify the factors for the calculation of the positive-sequence impedances.
By saving a **network configuration** you can save assignments that you have made and open them again subsequently.

Via the **Settings** dialog you define the source of the network frequency and the settings for the impedance calculation.
Via the **Signal Properties** dialog, **Analog Signals** tab, you define the transformer data and type of values recorded in the fault record (primary or secondary values).

NOTE

This procedure is not required for fault records from SIPROTEC 4 devices!
However, you can also use the **Network Configuration** dialog to specify the impedance calculation for these devices by modifying the protection settings written to the fault record file by DIGSI 4 or higher.

3.10.1 Parameterizing network configuration

You can assign the physical meaning of the signals collected in a fault record under the **Signal Assignment** tab. This assigns the SIGRA 4 reference arrow definition to the currents and voltages of the SIGRA 4 network node (see chapter 5.3).

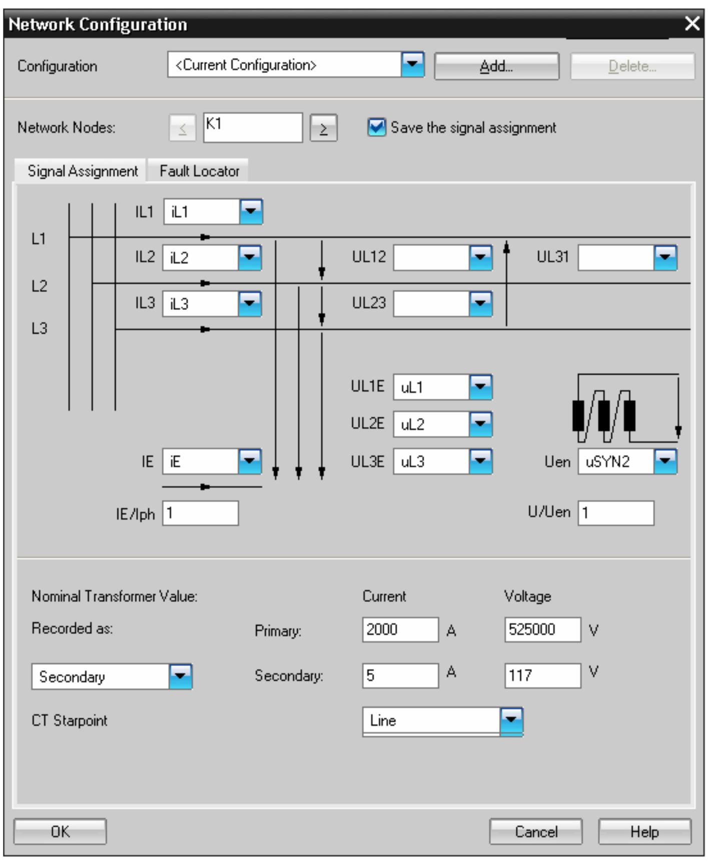
Fault records of SIPROTEC 4 devices only require the parameterization of the fault locator in the **Fault Locator** tab.

Using the **Configuration** function you can save a new network configuration and open it again subsequently. To save a configuration, click on the **A**dd button after having entered the network configuration details, give the configuration a name and then save the data. It can be opened again later via the toolbar. The network configuration includes the channel assignment as well as the line data used for locating a fault.

SIGRA 4 manages up to twelve different network nodes. You can assign these network nodes any name. The default settings for the node names are K1 to K12. If signals are assigned to more than one network node, SIGRA 4 prefixes these signal names with the network node names followed by a colon, e.g. K1:VL1E.

It is possible to assign the same signal to several network nodes.

✧ Open the dialog box by selecting the **Options > Network configuration...** from the menu bar.



SIGRA203.tif

Fig. 3-14 SIGRA 4, configuring the assignment of the recorded signals.

✧ Select the current network configuration from the **Configuration** drop-down list. Using this parameter you can save settings for various configurations and use them again subsequently.
  – Klick on **Add** to assign a name to a new configuration.
  – Select a configuration and click on **Delete** to delete the configuration.

✧ Type a name in the **Network Nodes** box (either directly or using the arrow keys).

✧ Activate **Save Signal Assignment** to save the set signal assignment.
The signal assignment is saved for all nodes in the network configuration file.

NOTE

Do not activate the **Save Signal Assignment** option if several devices are located at the nodes of this configuration. In this case it is much more simple to apply this network configuration to the fault records of the various devices.

✧ Use the **Signal Assignment** tab to assign the signals of your fault record to the network node according to their physical meaning.

✧ Select the earth current of the node at **IE**, if available.
If **None** is selected, the earth current is calculated from the 3 phase currents.

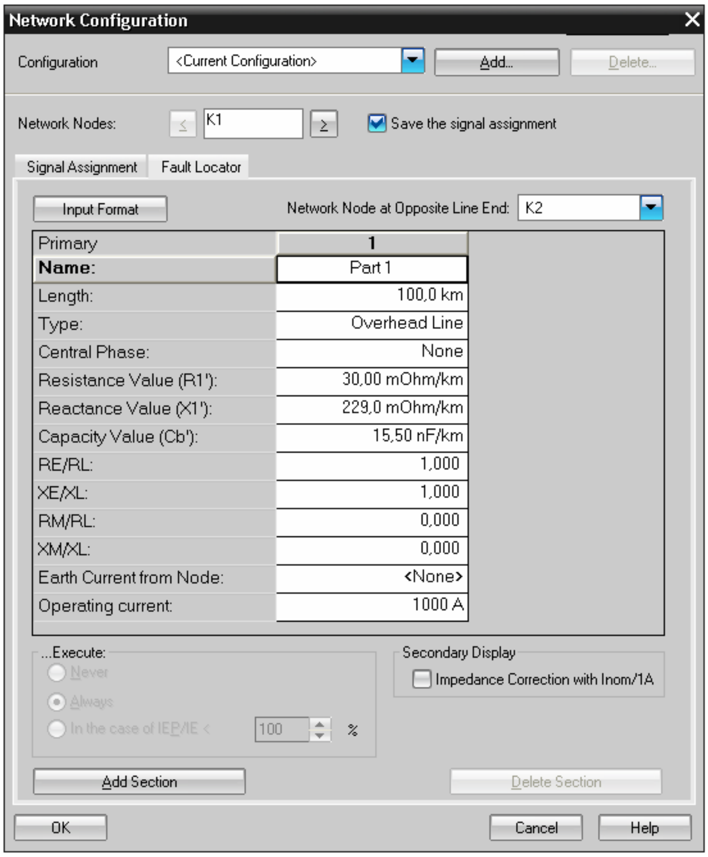
✧ If the earth current is selected at **IE**, the transformation ratio of IE has to be adjusted to that of the phase current transformers at **IE/Iph**.
IE/Iph = transformation ratio earth current transformer/transformation ratio phase current transformer

For the conversion between primary and secondary values, the transformer data are required. If the fault record does not contain any transformer data, as is the case with, for example, fault records in COMTRADE91 format, the correct nominal transformer data can be entered in the **Nominal** field.

✧ Enter the transformation ratios of the current and voltage transformers in the **Nominal** field.

Parameterizing the fault locator

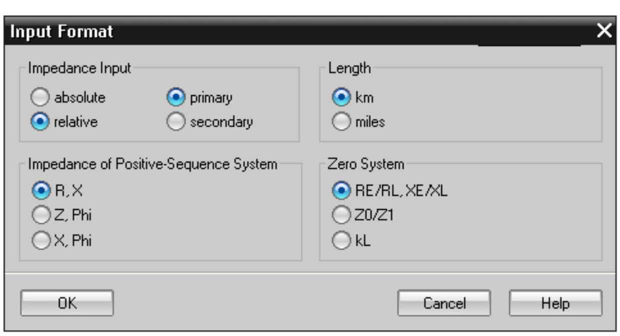
✧ Change to the **Fault Locator** tab.



SIGRA204.tif

Fig. 3-15 SIGRA 4, making the fault locator settings.

✧ To specify the format for the operating data of the transmission line in the **Input Format** dialog, click on **Input format...**.



SIGRA204b.tif

Fig. 3-16 SIGRA 4, defining the input format for the fault locator.

✧ Confirm your settings with **OK**.

✧ If you want to carry out bidirectional fault location then specify the **Network node at the opposite line end**.

✧ Define the line section properties in the table:

Field	Meaning
Name	Name of the line section
Length	Length of the line section in km/miles*
Type	Type of the line section. Available options are “Overhead Line“, “Three-core cable“ and “Single-core cable”. This information is used to determine appropriate values for the zero capacity.
Central Phase	The phase in the middle of the phase arrangement
Resistance (R1)/resistance per unit length (R1')*	Ohmic equivalent resistance (absolute in Ω or relative in Ω/km)
Reactance (X1)/reactance per unit length (X1')*	Inductive resistance (absolute in Ω or relative in Ω/km)
Impedance (Z1)/impedance per unit length (Z1')*	Impedance (absolute in Ω or relative in Ω/km)
Line impedance angle	The displacement of the line to the impedance phase.
Capacity (Cb)/capacity per unit length (Cb')*	Effective capacity If this is not known then you can also enter **unknown**. An appropriate value will then be calculated automatically depending on the type of line.
RE/RL, XE/XL	Earth impedance matching over the conditioning: RE=R1*(RE/RL)
kL Magnitude, kL Angle	Earth impedance matching over: kL = ZE/Z1
Z0/Z1 Magnitude, Z0/Z1 Angle	Earth impedance matching over: Z0/Z1
RM/RL, XM/XL	Coupling factors for parallel line compensation
Earth Current from Network Node	From the drop-down list, select the network node with the earth current of which the parallel line compensation is to be carried out.
Nominal Operating Current	Enter the nominal operating current in this field.

* Depends on the input format, the remaining variables are calculated.

For details on the earth impedances and coupling factors, please refer to paragraph 5.9.

A maximum of 10 line sections can be parameterized:

✧ Click on **Add section** to insert the parameter table for another section.

✧ Select a section and click on **Remove section** to delete a section.

✧ Under **Execute**, specify when the parallel line compensation is to be carried out and, if necessary, the **IEP/IE** ratio in %.

✧ Confirm your settings with **OK**.

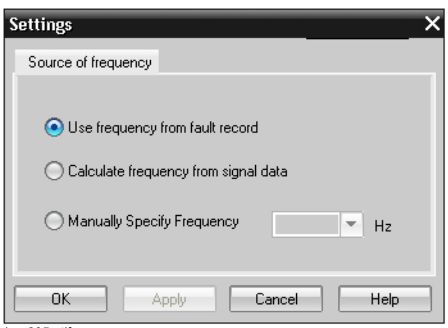
3.10.2 Selecting the frequency source

From the fault record data, SIGRA 4 calculates further values such as harmonics or vector values. The network frequency is included as parameter in these calculations.
The source of the network frequency is selected via the **Settings** dialog. The settings made in this dialog apply to all fault records.

The following can be selected as Source Of Frequency:

- the fault record with the frequency specification in the *.CFG file
- the frequency calculated from the signal data by SIGRA 4
- the frequency defined by the user
  If the automatic detection methods calculate the wrong frequency, it is possible to define this frequency.

✧ Select the menu item **Options > Settings**.
The **Settings** dialog is opened.



sigra205a.tif

Fig. 3-17 SIGRA 4, defining the frequency source of the fault record.

✧ Select the **Source** of the frequency. If selecting the option **Manually Specify Frequency**, additionally enter the power frequency in Hz. You can choose between 50 Hz and 60 Hz or enter any system frequency (e.g. 49.95 Hz).

After having closed the dialog with **OK**, all views are refreshed taking into account the selected frequency value.

3.10.3 Selecting harmonics

In the **Add harmonics** dialog it is determined which harmonics are to be available in the assignment matrix for adding and for displaying in the **Time signals** view.

Proceed as follows to select the harmonics:

✧ Select the menu item **Insert > Harmonics**.
The **Add harmonics** dialog is opened.

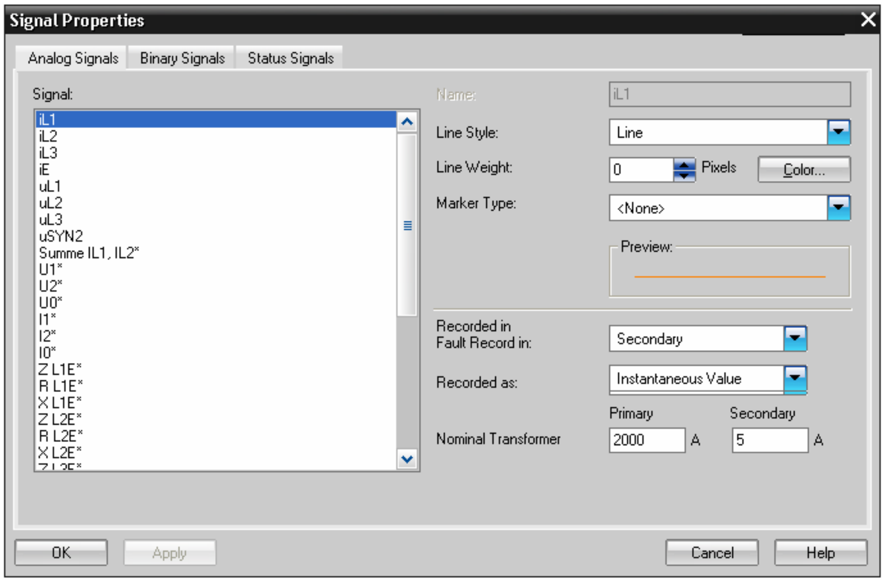
✧ Select one or several signal(s).

✧ Select the desired harmonics.

✧ Close the dialog with **OK**.

3.10.4 Parameterizing transformer data

- Select the **signal properties** of the individual signals of the fault record using the **Assign Signals** dialog or by clicking the signal names in the **legend** or **axis labeling** of the diagram (see chapter 4.10).



DIGRA205.tif

Fig. 3-18 SIGRA 4, parameterizing the signal properties of the analog signals.

- Specify whether the measured values of the fault record are available as primary or secondary values in the **Recorded in fault record as** drop-down list.
- In the **Recorded in Fault Record in** field, specify whether the recorded measured values are available as instantaneous or r.m.s. values.
- Enter the **nominal transformer values** in the **Primary** and **Secondary** boxes.
- Confirm your settings with **OK**.

NOTE

Negative nominal transformer values cause an inversion of the signal!

4 Views / Diagrams / Signals / Tables

Contents

4.1 Overview

SIGRA 4 offers a variety of convenient functions for the analysis of faults in your network by enabling the individual configuration of signals in graphical displays or tables.
As well as calculating measured values, SIGRA 4 can also be used for calculating further values, such as impedances or outputs.

For their graphical representation, the fault record data are organized as follows:

- signals are assigned to diagrams
- diagrams are combined in views.

The assignment options depend on the type of variables represented (currents, voltages, impedances, etc.). Context-sensitive plausibility checks are run on parameter assignments.

4.1.1 Views

SIGRA 4 displays the signals of a fault record in the diagrams or tables of the following views:

- Time signals
- Vector diagrams
- Circle diagrams
- Harmonics
- Table
- Fault locator

You can define the main parameters of a view, such as labeling, colors or diagram heights, in the **View Properties** dialog box.

For further details on the structure and contents of these views, please refer to chapter 1.3 to chapter 1.7.

When you open a fault record under SIGRA 4 for the first time, the measured signals are shown as r.m.s. values in the Time Signals view.
Each signal is assigned to a diagram.

NOTE

You can display any number of diagrams in the different views.
The Table view does not contain any diagrams.

4.1.2 Diagrams

The layout of a graphical view is basically defined by the arrangement of the diagrams and the signal assignment to the diagrams.

The following SIGRA 4 functions support the display of diagrams:

- Inserting diagrams
- Copying diagrams (using drag-and-drop or the clipboard)
- Deleting diagrams
- Defining the diagram properties
- Changing the order of the diagrams (via drag-and-drop)

NOTE

Each diagram can be assigned any number of signals.

4.1.3 Signals

The term signals applies to all variables included in the fault record and calculated by SIGRA 4.
Moreover, you can define mathematical functions for calculated signals.
These are divided into the following groups:

- Analog signals
- Binary signals
- Status signals (time markers of significant events)
- Components of analog signals (fundamental component, harmonics)

The signals of a fault record can be displayed in any number of diagrams of the graphical views and in the table view.

You can use the following SIGRA 4 functions to display these records according to your individual requirements:

- Assigning signals
- Copying signals (using drag-and-drop or the clipboard)
- Deleting signals
- Defining the signal properties

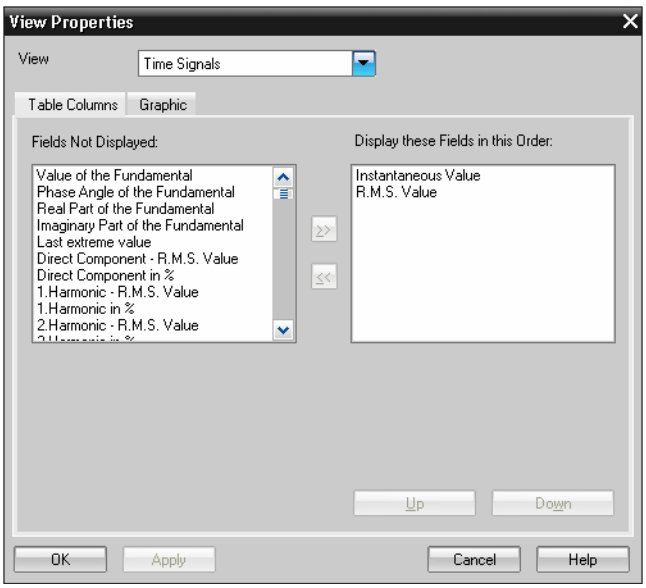
4.2 View properties

The **View Properties** dialog box contains the following tabs:

- Table Columns and
- Graphics.

Table columns tab

You can configure the **table of a view** in the **Table Columns** tab. In this table, you can read the values of assigned signals at the instants set by the cursors.



DIGRA206.tif

Fig. 4-1 SIGRA 4, defining the number and contents of the table columns of a view.

✧ Select the view whose table columns you want to configure from the **View** drop-down list;

✧ in the **Fields not Displayed** box, select all values you want to display (multiple-selection possible) and click the double arrow pointing to the right.

The values are entered in the **Display these Fields in this Order** box.

✧ If you want to change the order of the table columns, select a value in this box and click the **Up** or **Down** button;

✧ confirm your settings with **OK**;

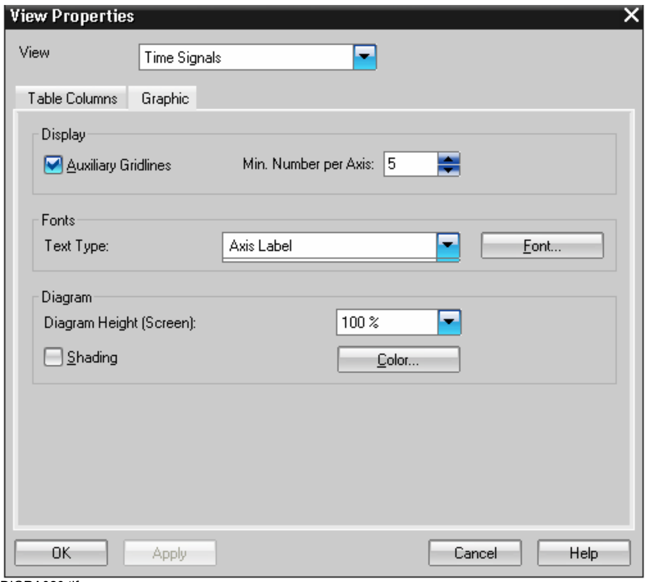
✧ if you no longer want to show a value in the table, select this value in the **Display these Fields in this Order** box and click the double arrow pointing to the left.

Graphics tab

The Graphics tab lets you specify the design of the different views by defining the settings such as color, font, axis labeling, gridlines, etc. according to your individual requirements.

The setting of these parameters applies to all diagrams of a view.

- Open the **View Properties** dialog box by choosing **Properties** from the context menu or by selecting **View > Properties** from the menu bar.



DIGRA020.tif

Fig. 4-2 SIGRA 4, defining the diagram display of a view.

- Choose the view of the parameters to be shown or edited from the drop-down list in the **View** box.
- In the **Display** section, activate the **Auxiliary Gridlines** function by clicking the corresponding check box.
- In the **Min. Number per Axis** box, enter an absolute value directly or increase/decrease the displayed value by clicking the up/down arrows. This defines the minimum number of gridlines required. The number currently displayed depends on the section of view being displayed.
- From the **Text type** drop-down list in the **Fonts** section, select the text element (e.g. axis labeling) for which you want to specify the font.
- Click the **Font** button to a secondary dialog box where you can define the font, size and color.
- Click the **Color** button in the **Diagram** section to switch to the next dialog box, where you can select a color or define a new shade.
- Change the **Diagram height (screen)** of the diagram view using the drop-down list. The diagram height is resized by the selected percentage.

NOTE

You can also set the resize factor for screen display using the toolbar (100%).

4.3 Inserting diagrams

To insert a diagram in a graphical view, choose one of the following options:

- Select **Insert > Diagram** from the menu bar.
  The empty diagram is inserted at the end of the view;

or

- select a diagram and insert a new diagram by selecting **Insert > Diagram** from the menu bar or **New** from the context menu. The empty diagram is inserted above the selected diagram;

or

- paste a copied diagram from the clipboard by choosing **Paste** from the context menu or by selecting **Edit > Paste** from the menu bar (see chapter 4.4).
  If a diagram is currently selected, the new diagram is placed above the selected one. If no diagram is selected, the new diagram is inserted at the end of the view;

or

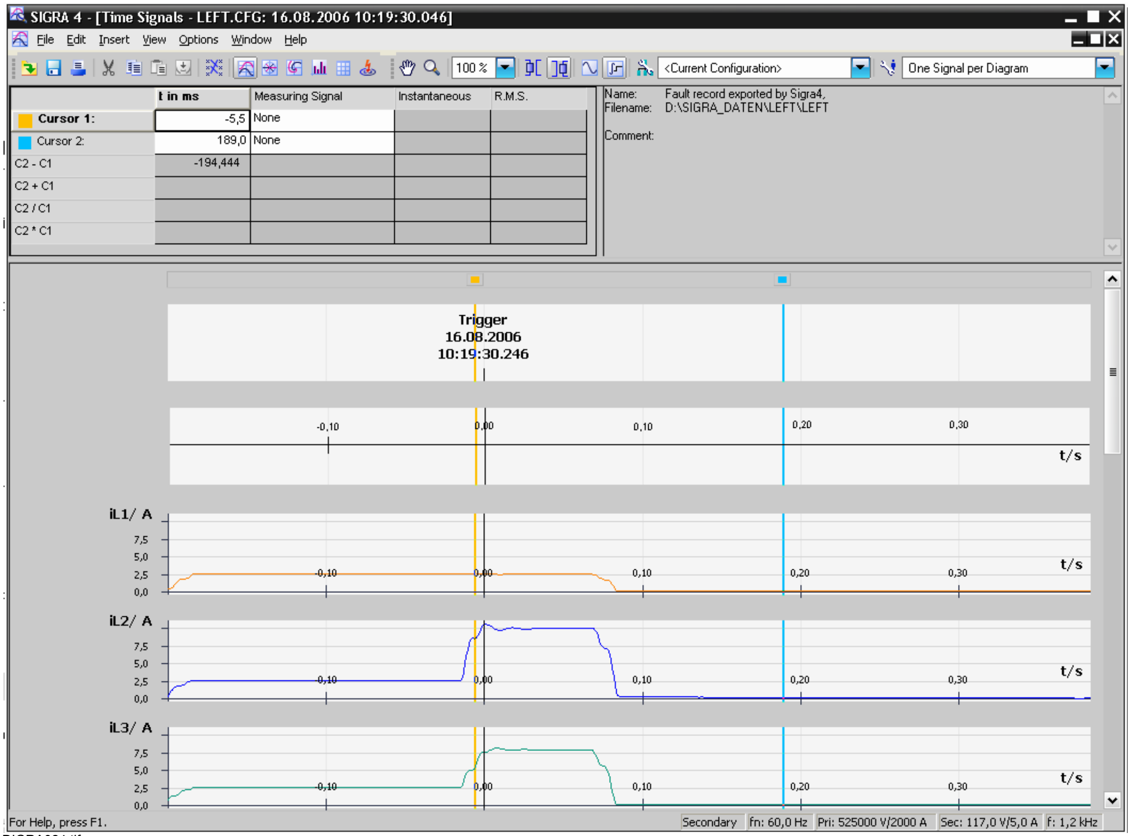
- select a diagram in a **view**, keep the left mouse button pressed and **drag and drop** it to the target position in the same or another view;

or

- select **Edit > Assign Signals** from the menu bar to open the **Assign Signals** matrix;
- click the header of a saved diagram or click a separating column and insert a new diagram by selecting **New** from the context menu.
  The new diagram is inserted above the selected one and automatically assigned a default name.

NOTE

A newly inserted diagram (without signal assignment) is initially "neutral". The diagram type (analog, binary, etc.) is defined only after the first signal has been assigned. If you insert a binary signal, a binary signal diagram is created, if the first signal is an analog signal, an analog signal diagram is created.



DIGRA024.tif

Fig. 4-3 SIGRA 4, inserting a diagram in the Time Signals view.

4.4 Dragging and dropping / copying diagrams

Dragging and dropping a diagram

Diagrams can be dragged and dropped within a view.

Proceed as follows:

- ✧ Select the **diagram** you want to drag and drop.
- ✧ Keeping the right mouse button pressed, drag and drop the selected diagram via the **drag-and-drop** function to the target position.

Copying diagrams

You can reproduce diagrams using the Copy function. When copying, all parameters such as graphical layout and signal assignment are also copied.

Proceed as follows:

- ✧ Select the **diagrams** you want to copy in the corresponding **view** or in the **Assign Signals** dialog box.
- ✧ Select **Copy** from the context menu.

or

- ✧ Select **Edit > Copy** from the menu bar.

or

- ✧ Click the **button** on the toolbar.

or

- ✧ Select the **diagrams** in the **view** that you want to copy.
- ✧ Keeping the left mouse button pressed, **drag** the selected diagram **and drop** it onto the target position (view, other application).

In Copy mode, the selected diagrams are placed on the clipboard and can then be pasted into a view at the selected point (see chapter 4.3).

Copy functions are basically possible between all views. For example, if you copy an analog signal diagram from the Time Signals view, you can paste it into a Vector Diagrams view or vice versa.

NOTE

Diagrams copied to the clipboard can also be pasted into other applications, such as Word files. The copied diagrams is saved as a Windows metafile (*.wmf).

4.5 Deleting diagrams

If you want to delete diagrams from graphical views, proceed as follows:

- ✧ Select the **diagrams** you want to delete directly in the **view** or in the **Assign Signals** dialog box.
- ✧ Select **Delete** from the context menu.

or

- ✧ Select **Edit > Delete** from the menu bar.

or

- ✧ Click the **button** on the toolbar.

The selected diagrams are deleted from the **view** and from the **Assign Signals** matrix.

4.6 Diagram properties

The Diagram Properties dialog box lets you define the diagram layout with regard to name, labeling and scaling.

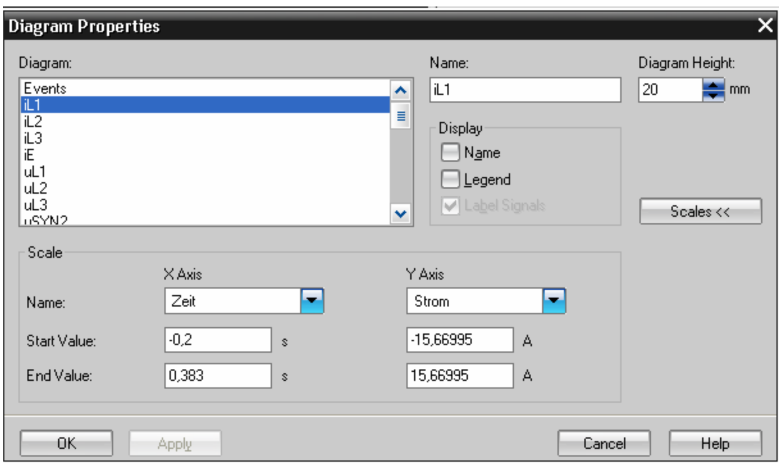
To open the **Diagram Properties** dialog box, proceed as follows:

✧ Select a diagram.

✧ Select **Object Properties** from the context menu.

or

✧ Select **Edit > Object Properties** from the menu bar.



DIGRA028.tif

Fig. 4-4 SIGRA 4, an example of editing the diagram properties.

The **Diagram** list box shows the names of all diagrams of the fault record. The name of the selected diagram is highlighted.

✧ You can change the diagram name in the **Name** box.

✧ Specify the height of the diagram in the **Diagram height** section by entering an absolute value in mm or increasing/decreasing the value by clicking the up/down arrows. The diagram height is only relevant when printing out the fault record. You can resize the diagram height of the on-screen display using the toolbar (100%).

✧ In the **Display** section, activate the various **labeling** options of the diagram by clicking the corresponding check box.
The functions that can be activated depend on the type of diagram selected.

Under **Display**, the following options can be activated:

- **Name**
  The text entered in the **Name** field is displayed.
- **Legend**
  The legend of the diagram is displayed. The legend is required to drag and drop signals between the diagrams via the drag-and-drop function.
- **Label Signals**
  The signal labels are displayed.

✧ Click the **Scale** button.

✧ Enter the **start value** and the **end value** for the X and Y-axes separately in the **scale** section.
The boxes available for the parameter settings depend on the type of diagram selected.
In the case of vector diagrams, enter the values for the left and right-hand diagrams of the view.
In the **Circle Diagrams** view, the representation is conformal. This may mean that the displayed area is larger than the value specified.

In the case of **diagrams** which display **different signals**, e.g. currents and voltages, **all** the corresponding **scales** are shown.

✧ To set the individual scales, select the corresponding value from the axis drop-down lists and parameterize the **start** and **end values**.

✧ You can switch to the parameter settings of another diagram by clicking another diagram name in the Diagram list box.

NOTE

If you want to change the properties of several diagrams simultaneously, you can select all these diagrams in the **Diagram** list box.
When using the **multiple selection** function, any properties which can be changed only in specific diagram types are grayed by SIGRA 4.

4.7 Assigning signals

To assign signals to the diagrams of the views, and the Table view, use the

- **drag-and-drop** function or the
- **Assign Signals** dialog box

Drag-and-drop

Proceed as follows:

✧ Select the signals in the legends or the axis labeling of a diagram (multiple-selection possible) and, keeping the left mouse button pressed, drag the signals to the target diagram of the same or another view, or to the Table view.

Assign Signals dialog box

The **Assign Signals** dialog box lets you individually assign the signals of a fault record to the diagrams of graphical views and the Table view.

This assignment is carried out in a **table** where

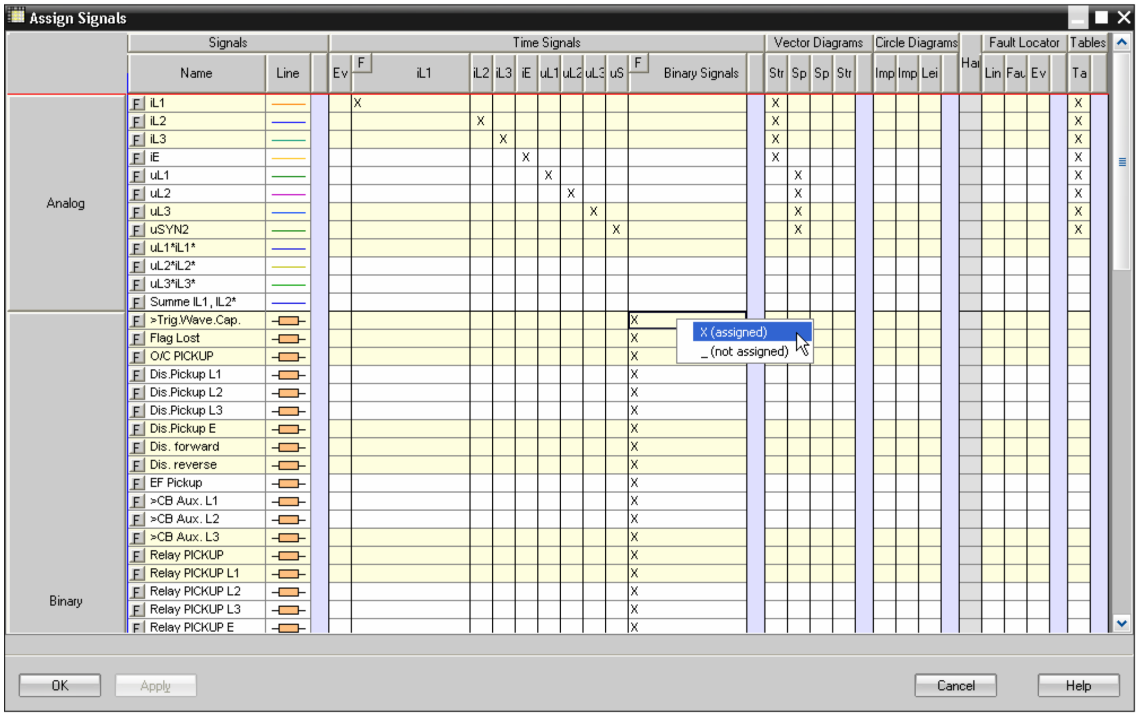
- each **column** corresponds to a **diagram** and
- each **row** corresponds to a **signal**.

The signals are grouped by

- analog signals
- binary signals
- status signals
- symmetrical components
- impedances
- powers
- fault locator

NOTE

The **signal names** of the variables calculated by SIGRA 4 are marked by an asterisk *.
Signal names of supplementary fault records are extended by an **index** (see chapter 3.3).
If signals have been assigned to more than one network node, the signal names are given the **network node name** as an extension (see chapter 3.10).



DIGRA025.tif

Fig. 4-5 SIGRA 4, assigning signals to the diagrams.

✧ Assign the signals to the diagrams by clicking the corresponding cell:
- empty cells are assigned,
- previous assignments are canceled;

or

✧ change the assignment via the context menu by choosing **X (assigned)** or _ **(unassigned)**

or

✧ type an **X** for assignment or delete the assignment by pressing the **spacebar**.

NOTE

If assignment is not possible, such as binary signal representation in a vector diagram, the mouse pointer changes and the corresponding box is grayed.

4.7.1 Opening the Object Properties dialog boxes

In the **Assign Signals** dialog box, you can open further dialog boxes to parameterize the following object properties:

- View properties
- Diagram properties
- Signal properties

Proceed as follows:

View properties

✧ Click the **column header** displaying the name of the **view** and open the **View Properties** dialog box by selecting **Properties** from the context menu.

Diagram properties

✧ Click the **F** button of a **column** (diagram) to open the **Diagram Properties** dialog box;

or

✧ click the **column header** (diagram) and open the **Diagram Properties** dialog box by selecting **Properties** from the context menu.

Signal properties

✧ Click the **F** button of a **row** (signal) to open the corresponding **Signal Properties** dialog box for:

- Analog signals or
- Binary signals or
- Status signals

or

✧ Click the **name** of a **signal** and open the **Signal Properties** dialog box by selecting **Properties** from the context menu.

or

✧ Click the **symbol** of a **signal**, e.g. the line symbol and open the **Signal Properties** dialog box by selecting **Properties** from the context menu.

4.7.2 Hide / Show areas

For a better overview, it may be necessary to temporarily hide or show some parts of the assignment matrix (columns / rows) in the display.

The following areas can be minimized /maximized:

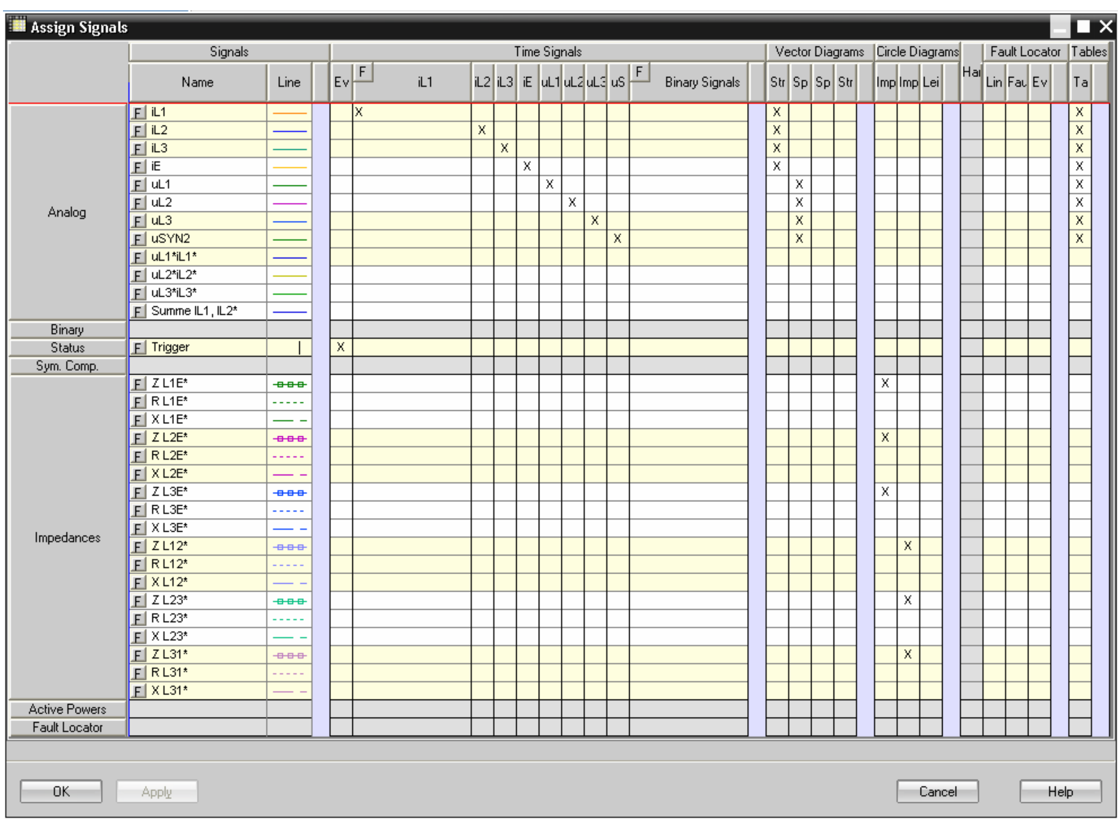
- Views
- Diagrams
- Signal groups (analog, binary, impedances, etc.)
- Signals column
- Name column (signal)
- Line column (signal)

To find out if an area of the table can be hidden/shown, place the mouse pointer above the relevant area (column/row header) and a tooltip appears with the required information.

✧ Double-click the header of a column (e.g. diagram).
The column is minimized/maximized.

✧ Double-click a signal group (e.g. analog).
The group is minimized/maximized.

✧ Double-click the Line column (signals).
The graphical display of the signals is minimized / maximized.



DIGRA023.tif

Fig. 4-6 SIGRA 4, changing the display of the **Assign Signals** dialog box.

4.8 Copying signals

You can use the Copy function to reproduce signals. When copying, all parameters, such as colors and line styles, are also copied.

Analog signals

Proceed as follows:

- ✧ Select the signals you want to copy in the **legend** or **axis labeling** of a **diagram** or in the **table row** of the Table view.

To display the legend, activate the **Legend** option in the **Diagram Properties** dialog, see paragraph 4.6.

- ✧ Keeping the left mouse button pressed, **drag** the signal **and drop** it onto the target position (diagram, view).

or

- ✧ Select **Copy** from the context menu.

or

- ✧ Select **Edit > Copy** from the menu bar.

or

- ✧ Click the **button** on the toolbar.

All selected signals are saved to the clipboard from where they can be pasted into the diagrams of individual views.

- ✧ Select the diagrams in which you want to insert the signals;
- ✧ paste the copied signals from the clipboard by selecting **Paste** from the context menu, selecting **Edit > Paste** from the menu bar or by clicking the **button** on the toolbar.

NOTE

During the Paste operation, SIGRA 4 checks the plausibility of the selection.
For example, if you choose a status diagram as the target for a binary signal, the Paste function is disabled.

Binary signals

To copy binary signals, proceed as follows:

- ✧ Select the labeling of the **binary signals** in the **diagram** and copy it using the **drag-and-drop** function, by selecting **Copy** from the context menu, via the menu commands **Edit > Copy** or by clicking the **Copy** button on the toolbar.

In Copy mode, the binary signals are placed on the clipboard from where they can be pasted into other binary signal diagrams.

Status signals

To copy status signals, proceed as follows:

- Select the **status signals** in the **status diagram** and copy it using the **drag-and-drop** function, **by selecting Copy** from the context menu, via the menu commands **Edit > Copy** in the menu bar or by clicking the **Copy** button on the toolbar.

In Copy mode, the status signals are placed on the clipboard from where they can be pasted into other status signal diagrams.

4.9 Deleting signals

Analog signals

If you want to delete analog signals from the views, proceed as follows:

- Select the **signals** you want to delete in the **legend** or **axis labeling** of a **diagram** or in the **table row** of the **Table** view.
- Select **Delete** from the context menu.

or

- Select **Edit > Delete** from the menu bar.

or

- Click the **button** on the toolbar.

The selected signals are deleted from the **diagram**.

Binary signals

To delete binary signals, proceed as follows:

- Select the labeling of the **binary signals** in the **diagram** and choose **Delete** from the context menu or select **Edit > Delete** from the menu bar or click the **button** on the toolbar.

NOTE

These signals remain in the SIGRA 4 data management, so that they can be reinserted in the diagrams of the graphical displays or the Table view at any time via the **Assign Signals** dialog.

Status signals

To delete status signals, proceed as follows:

- Select the **status signals** in the **status diagram** and delete them by choosing **Delete** from the context menu or by selecting **Edit > Delete** from the menu bar or by clicking the **button** on the toolbar.

The status signal is deleted from the display.

NOTE

If you delete a user-defined status signal from its last display, it is also deleted from the SIGRA 4 data management.
The status signal which marks the trigger instant for fault record recording can only be deleted from the display. However, it is still in the Assign Signals matrix.

4.10 Signal properties

In the Signal Properties dialog box; you can define the layout properties of a signal; such as color, line style or marker.

The signal properties are defined separately for:

- Analog signals
- Binary signals
- Status signals

4.10.1 Analog signals

To open the **Signal Properties** dialog box for analog signals, proceed as follows:

✧ Select a **signal** in the **legend** or the **axis labeling** of the **diagram** and select the signal properties via **Object Properties** in the context menu or via **Edit > Object Properties** in the menu bar.

or

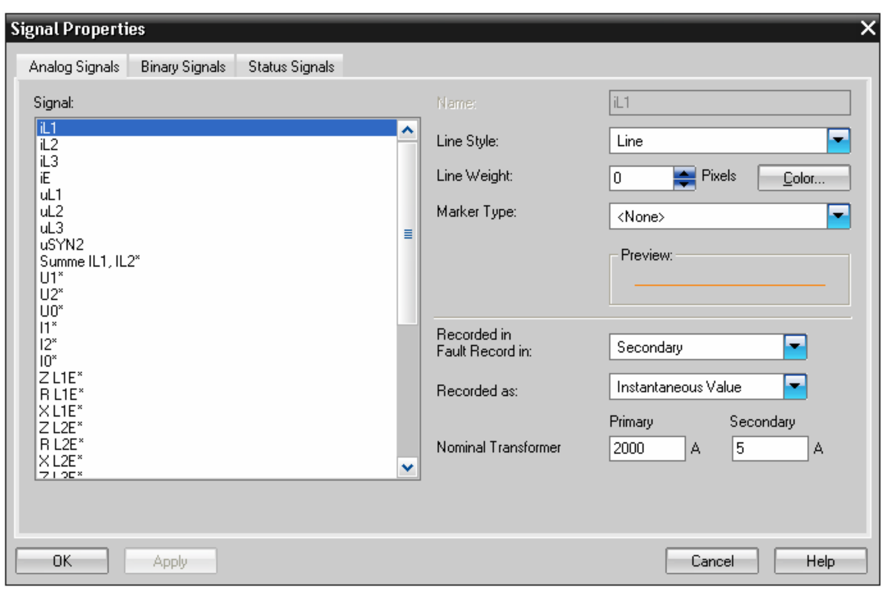
✧ Click the **F** box in front of the signal names in the **Assign Signals** matrix.

or

✧ Mark the **Signal name** or **Signal Line** column in the **Assign Signals** matrix and open the signal properties by selecting **Properties** from the context menu.

or

✧ Select the signal names in the **Table** view.



DIGRA041a.tif

Fig. 4-7 SIGRA 4, defining the display format of an analog signal.

The **Signal** list box shows the names of all signals available. The name of the selected signal is highlighted.

The **Name** text box shows the name of the signal selected. This name cannot be changed.

- Select the **Line style** from the drop-down list where the different types of line display such as line, dots or dot-and-dash are listed;
- use the **Line weight** box to enter the line weight of the signal directly as an absolute number of pixels or by increasing/decreasing the value by clicking the up/down arrows;
- use the **Marker type** box to specify if you want the sampling instant of a signal to be marked by graphical symbols;
- click the **Color** button to switch to a secondary dialog box, where you can select a color or define a new shade;
- check your settings in the Preview section;
- confirm with **OK**.

By clicking another signal name in the **Signal** list box can switch to the parameterization for this signal.

NOTE

If you want to change the properties of several signals simultaneously, you can select all these signals in the **Signal** box.
When using the **multiple selection** function, any properties which can be changed only for specific signals are grayed by SIGRA 4.

Transformer data

As well as defining the parameter settings of the graphical representation, this dialog also lets you define the transformer data of the signal. You need this information for the analysis of fault records which do not contain this information, such as fault records which were not recorded by DIGSI 4 (see chapter 3.10).

- Specify whether the measured values of the fault record are available as primary or secondary values in the **Recorded in Fault Record in** drop-down list.
- In the **Recorded as** field, specify whether the recorded measured values are available as instantaneous or r.m.s. values.
- Enter the **Nominal Transformer** values in the **Primary** and **Secondary** boxes.
- Confirm with **OK**.

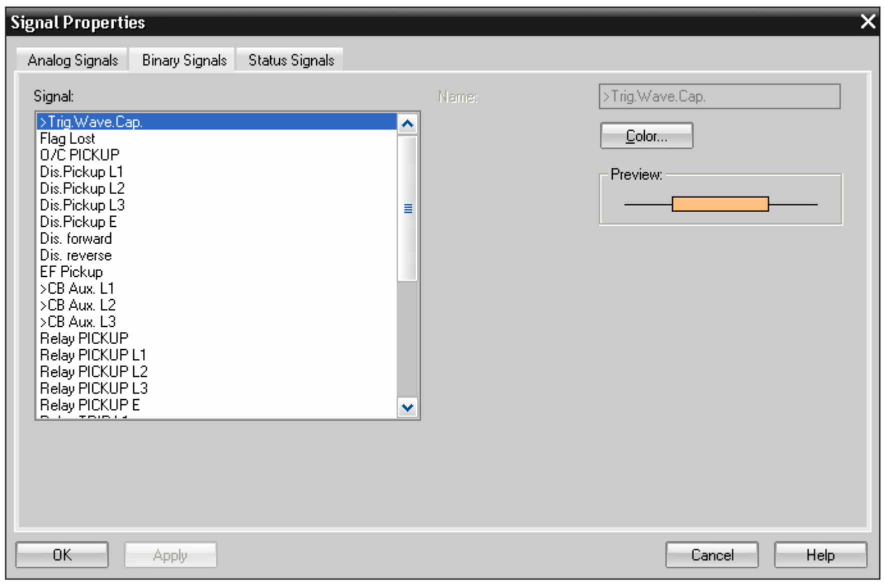
4.10.2 Binary signals

To open the **Signal Properties** dialog box for binary signals, proceed as follows:

- ✧ Select a **signal** in the **diagram labeling** and open the **Signal Properties** dialog box by choosing **Object Properties** in the context menu or by selecting **Edit > Object Properties** from the menu bar.

or

- ✧ Select the **Signal name** or **Signal Line** column in the **Assign Signals** matrix and open the signal properties by selecting **Properties** from the context menu.



DIGRA041b.tif

Fig. 4-8 SIGRA, defining the display format of an binary signal.

The **Signal** list box shows the names of all signals available. The name of the selected signal is highlighted.

The **Name** text box shows the name of the signal selected. This name cannot be changed.

- ✧ Click the **Color** button to switch to a secondary dialog box, where you can select a color or define a new shade.
- ✧ Check your settings in the Preview section.
- ✧ Confirm with **OK**.

By clicking another signal name in the **Signal** list box can switch to the parameterization for this signal.

NOTE

If you want to change the properties of several signals simultaneously, you can select all these signals in the **Signal** box.
When using the **multiple selection** function, any properties which can be changed only for specific signals are grayed by SIGRA 4.

4.10.3 Status signals

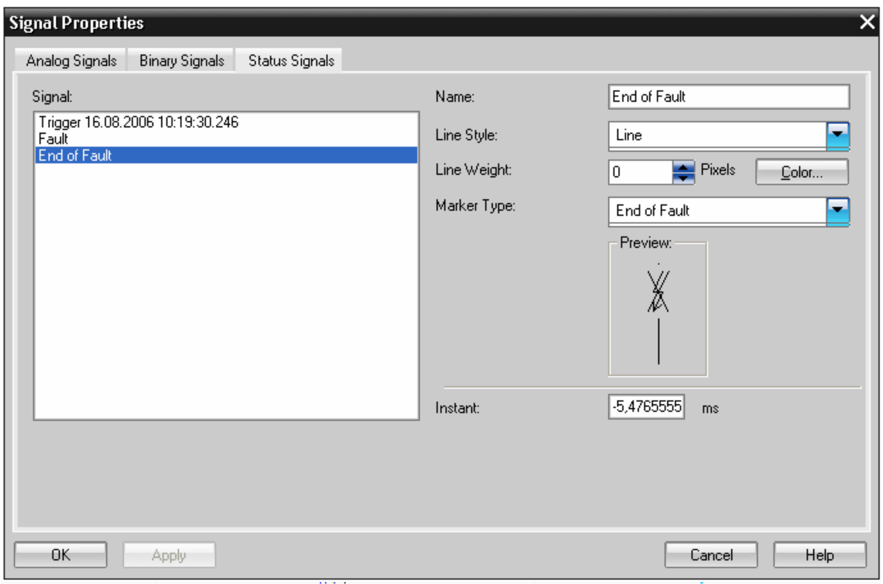
Status signals are used for the time marking of events.

To open the **Signal Properties** dialog box for status signals, proceed as follows:

- ✧ Select a **signal** in the status diagram and open the Signal Properties dialog box by choosing **Object Properties** from the context menu or by selecting **Edit > Object Properties** from the menu bar,

or

- ✧ select the **Signal name** or **Signal Line** column in the **Assign Signals** matrix and open the signal properties by selecting **Properties** from the context menu.



DIGRA041c.tif

Fig. 4-9 SIGRA, defining the display format of a status signal.

The **Signal** list box shows the names of all signals available. The name of the selected signal is highlighted.

The **Name** text box shows the name of the signal selected. The names of user-defined status signals can be changed.

- ✧ Select the **Line style** from the drop-down list where the different types of line display such as line, dots or dot-and-dash are listed.
- ✧ Use the **Line weight** box to enter the line weight of the signal directly as an absolute number of pixels or by increasing/decreasing the value by clicking the up/down arrows.
- ✧ Use the **Marker type** drop-down list to specify the marker symbol to be used for displaying the status signal in the status diagram.
- ✧ Click the **Color** button to switch to a secondary dialog box, where you can select a color or define a new shade.
- ✧ Check your settings in the Preview section.
- ✧ Confirm with **OK**.

NOTE

If you want to change the properties of several signals simultaneously, you can select all these signals in the **Signal** box.
When using the **multiple selection** function, any properties which can be changed only for specific signals are grayed by SIGRA 4.

4.11 Generating calculated signals

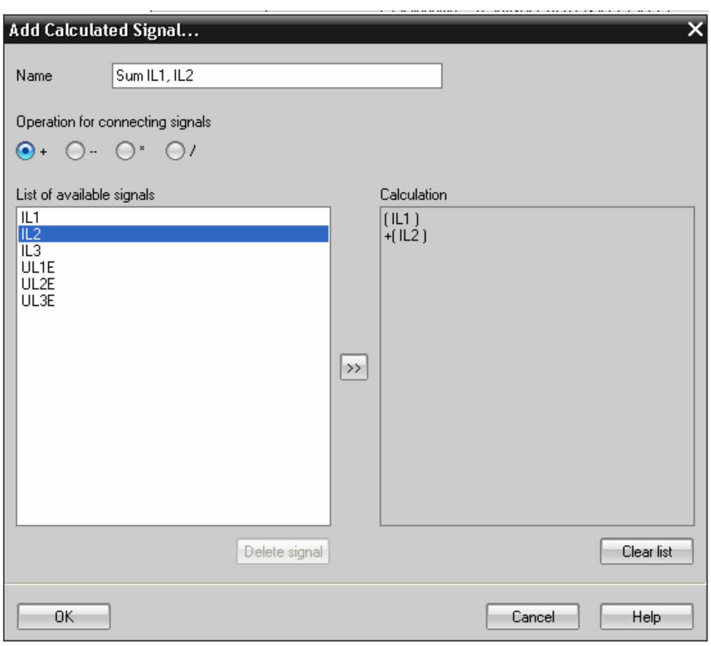
With SIGRA 4, you can define mathematical functions. These functions are used to generate calculated signals. The basic arithmetic operations +, -, *, and / are available as mathematical operators.
As output signals for the calculation you can use the measuring signals as well as the signals calculated by SIGRA 4.

The calculated signals are identified with ***** in the signal matrix. There, the signals can be assigned to the diagrams.

Generating a calculated signal

How to generate a calculated signal:

- Open a fault record.
- Select the menu item **Add > Calculated signal**.
  The **Add calculated signal** window opens.

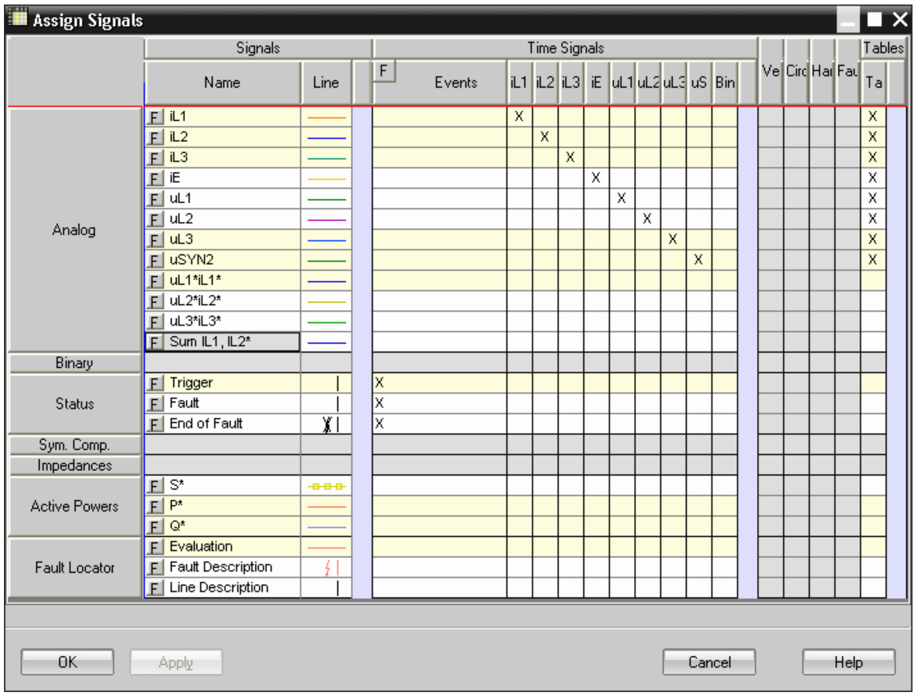


SIGRA220.tif

Fig. 4-10 SIGRA, defining the mathematical function and name of a calculated signal.

The following is a description of how to generate a sum signal from 2 currents. Other signals can be generated analogously with the help of mathematical functions.

- Enter the designation **Sum IL1, IL2** for the calculated signal in the **Name** field.
- In the **Select signals** field, double-click the signal **IL1**.
- Click on the operation **+**.
- In the **Select signals** field, double-click the signal **IL2**.
  The mathematical function **IL1+IL2** is displayed in the **Calculation** field.
- Close the dialog **Add calculated signal** with **OK**.
  The calculated signal is saved.
- Select **Edit > Assign Signals**.
  The **Assign Signals** window is opened.



SIGRA221.tif

Fig. 4-11 SIGRA, assigning the calculated signal to a diagram.

The new signal is listed and identified with its name and an *****. It can now also be assigned.

NOTE

The mathematical functions for the calculated signals are saved in the *.DG4 file of the respective fault record and are therefore only available for this fault record.

4.12 Configuring tables

You can set up the layout of the tables displayed in the views of the fault record in a dialog. The settings can be changed again at any time.

Table view

To configure the Table view, proceed as follows:

- ✧ Open the **Assign Signals** dialog box (see chapter 4.7).
- ✧ Select all the **Signals** whose values you want to display (**table rows**).
- ✧ Confirm with **OK**.
- ✧ Open the **View Properties** dialog box (see chapter 4.2).
- ✧ Select all the **values** you want to display, such as real part, imaginary part and phase position of the fundamental. This selection produces the **table columns**.
- ✧ Confirm with **OK**.

Table of the graphical views

The **table rows** of the table in the graphical views are assigned to cursors. To measure a fault record in the Time Signals, Vector Diagrams or Circle Diagrams views, you work with both cursor 1 and cursor 2, while in the Harmonics view you only work with cursor 1.

To configure the **table columns**, proceed as follows:

- ✧ Open the **View Properties** dialog box (see chapter 4.2).
- ✧ Select all the **values** you want to display, such as r.m.s. value, instantaneous value, balanced component, extreme value.
- ✧ Confirm with **OK**.

4.13 User profiles

In SIGRA 4, you can define user profiles to simplify the analysis of fault records.

Design the layout of a fault record in the various diagram views according to your requirements and save your settings in the **User Profile** dialog under a name of your choice.

All specified **parameters**, such as signal assignment to the individual diagrams, types of color, labeling, line styles, etc. are then **permanently available** under this name and can be assigned to the individual fault records.

You can use this method to temporarily assign a special layout to a fault record for printing on a monochrome printer which differs from the one used for the fault record analysis on the screen.

Depending on the devices used, the types and volume of the measured values and binary signals shown in the fault record may differ.
The signal display in the fault record can be matched accordingly.

For this reason it is advisable to define a suitable user profile for each device type and allocate it to the fault record of this device. When loading a fault record from the corresponding device, the parameter settings of this user profile are used automatically for display.

Scaling in groups

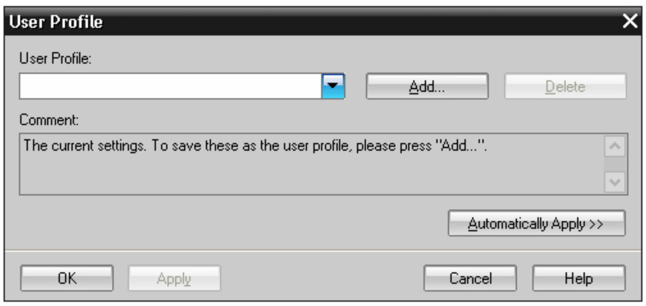
When you open a fault log or activate either a predefined user profile or a user profile you have configured yourself, all of the signals that belong to a scaling group are displayed using the same scale on the Y axis.

The minimum range for the display is calculated in such a way that it is not purely dependent on the maximum values of the signals contained. The minimum range is set to min. 5% of the nominal value of the signals.

4.13.1 Defining and saving a user profile

To define a user profile, proceed as follows:

- Design the layout your fault record (views, diagrams) with regard to signal assignment, color, lines and text fonts, table configuration, etc. according to your requirements.
- Select the **User Profile** dialog box via the **Options > User Profile** menu command or the **button** on the toolbar.



DIGRA050.tif

Fig. 4-12 SIGRA, defining a user profile.

- Click the **Add** button, enter the name of the new user profile in the secondary dialog box and confirm with **OK**.
- Enter a short description of the fault record layout in the **Comment** text box of the **User Profile** dialog box.
- Confirm with **OK**.

NOTE

User profiles are saved in the **SIGRA4.upf** file.

4.13.2 Allocating a user profile

If you wish to use a previously defined user profile for the analysis of a fault record, proceed as follows:

- Select a user profile, such as **One Signal per Diagram**, from the **drop-down list** on the **View toolbar**.

The variables of your fault record are calculated according to the user profile definition and displayed in the various views.

4.13.3 Deleting a user profile

To delete a SIGRA 4 user profile, proceed as follows:

- Select the **User Profile** dialog box via the **Options > User Profile** menu command or the **button** on the View toolbar.
- Select the user profile you want from the drop-down list in the **User Profile** box.
- Click the **Delete** button.
- Confirm with **OK**.

4.13.4 Automatically apply user profile

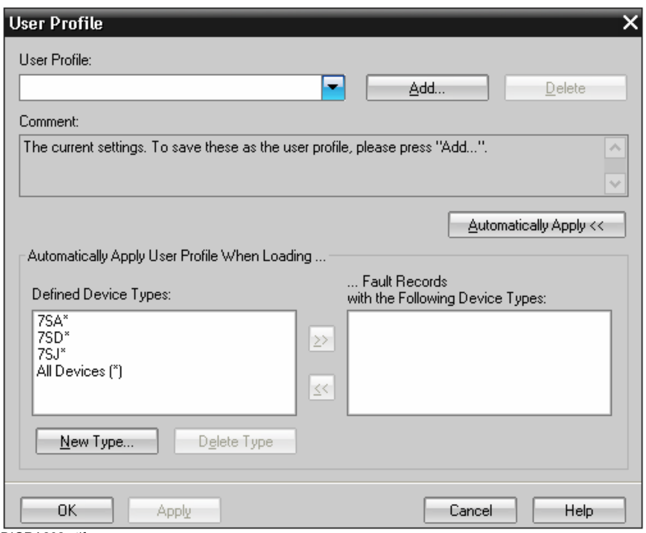
If you want to apply the same user profile to fault records of one device type, assign this profile to the respective device type. When loading one of these fault records, SIGRA 4 then automatically applies the corresponding definition.

Proceed as follows:

✧ Select the **User Profile** dialog box via the **Options > User Profile** menu command or the **button** on the toolbar;

✧ select a user profile from the drop-down list in the **User Profile** box;

✧ click the **Automatically Apply** button;



DIGRA202c.tif

Fig. 4-13 SIGRA 4, an example of defining the application of a user profile.

✧ in the **Automatically Apply User Profile When Loading...** section, select a device type from the **Defined Device Types** box and click the **double arrow pointing to the right**.

The device type is now moved to the right box **...Fault records with the Following Device Types** thus assigning it to the selected user profile.

This list shows all the device types assigned to the selected user profile.

You can undo your selection by clicking double arrow pointing to the left (<<).

✧ Confirm with **OK**;

or

✧ click the **Apply** button, if you want to assign further user profiles and devices.

Inserting a device type

If you are analyzing the fault record of a device type which is not contained in the **Defined Device Types** list, supplement the list as follows:

- Select the **User Profile** dialog box via the **Options > User Profile** menu command or the **button** on the toolbar;
- click the **Automatically Apply** button;
- click the **New Type** and open a secondary dialog box;
- in this dialog box, you can type the name under which you want to save the device type in the user profile management.

You can also combine several device types to groups and save their names by adding an asterisk), e.g. 7SA*. The assigned user profile is then applied to all devices whose names start with 7SA.

NOTE

The device name is part of a fault record in COMTRADE format.

To delete device types, proceed as follows:

- Select the **User Profile** dialog box via the **Options > User Profile** menu command or the **button** on the toolbar;
- click the **Automatically Apply** button;
- select the types you want to delete in the **Defined Device Types** box (multiple-selection possible);
- click the **Delete** button;
- confirm with **OK**.

4.14 The fault locator

Measurement of the distance to a fault in the event of a short circuit is a valuable addition to the functionality of the protection device. The line availability for network power transmission can be increased by faster location of the fault location and thus more rapid fault clearing.

4.14.1 Functional description

General

The fault locator is an independent and autonomous function, which allows the precise location of faults even on mixed line sections by using the line data entered. For double ended lines SIGRA also allows bidirectional fault location (optional), which enables significantly improved fault location, especially for lines with feed from both ends, faults involving earth, or faults with high resistance.

Unidirectional fault location takes place in any case. If data for the remote end of the line are also available then three fault locations are located in total:

- One calculated by means of bidirectional fault location
- Two calculated by means of unidirectional fault location (one from each end)

Using the accuracies determined it is easy to determine the most probable location of the fault. Usually the fault location calculated by bidirectional fault location is the most accurate, although for high current faults in the close vicinity of one end of the line the unidirectional fault location may be more reliable.

The object being protected may be an inhomogeneous line. The line may also be split into several sections for the calculation, for example, a short cable followed by an overhead line. For such configurations the line sections can be parameterized individually.

The system converts measurement errors, line symmetry and geometry based on the known voltage profile on the line into a difference in distance to decide whether to carry our bidirectional fault location. If this difference in distance is too great, in relation to the line section in question, then the result of the bidirectional fault location is rejected and the distance is only displayed as that calculated using unidirectional fault location. The calculated accuracy is reported on a scale from 0 to 10 with increasing accuracy.

Double faults with different base points, source-side faults and faults which are not on the line between the two measuring points are only calculated and displayed using unidirectional fault location.

Fault location using the unidirectional fault locator

The principle behind the method used for locating the fault is very much based on the method used by distance protection. The impedance is also used here.

First of all the fault record is broken down into its various parts by step analysis (for example, pre-fault, fault, disconnection).

The impedance is then calculated for the various states. This also takes the various line sections into account.

Bidirectional fault location

Bidirectional fault location also takes the line capacity and resistance into account. A great advantage of bidirectional fault location is that the claculation does not need earth impedance, which is often not known in adequate detail.

The bidirectional method of fault location assumes that, for an unbranched line with known current and known voltage and the feeders, the voltage at each point, x, can be calculated. This applies to both ends of the line. Since the voltage must be equal whichever end of the line it is calculated from, the error has to be at the point where the voltage curves cross. The voltage curves are calculated according to the telegraph equation using currents and voltages measured locally, and the impedance per unit length of the line. Figure 5-12 shows a simplified representation of this, assuming linear voltage characteristics.

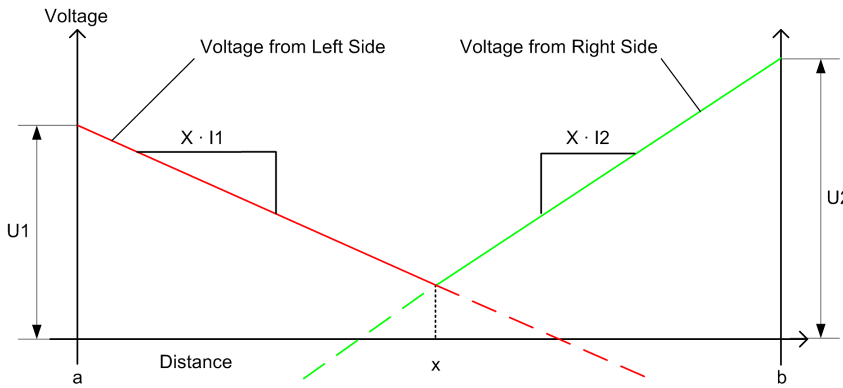


Fig. 4-14 The voltage characteristics on a faulty line (simplified).

The bidirectional method of fault location used here has the following advantages in comparison to unidirectional fault location:

- Accurate fault location is also possible when there is power flow, on doubly fed lines and if there is a high fault resistance;
- inaccurate setting of the earth impedance does not affect the accuracy of the fault location;
- the accuracy can be improved by taking the line asymmetry into account (by selection of the central phase);
- it is not necessary to locate the fault loop, which is often difficult.

Fault location results

The results of the fault location display the:

- Short-circuit loop, from which the fault reactance is measured
- The fault location in miles
- The resistance R of the fault loop in Ω primary
- The distance d of the fault proportional to the reactance in kilometers or miles of line, converted on the basis of the parameterized reactance per unit length of the line
- The distance d of the fault in % of line length, calculated on the basis of the parameterized reactance per unit length of the line and the parameterized line length

All of the results obtained are displayed: if only one fault record is available only the data for a unidirectional fault location, if two fault records are available bidirectional fault location is displayed.

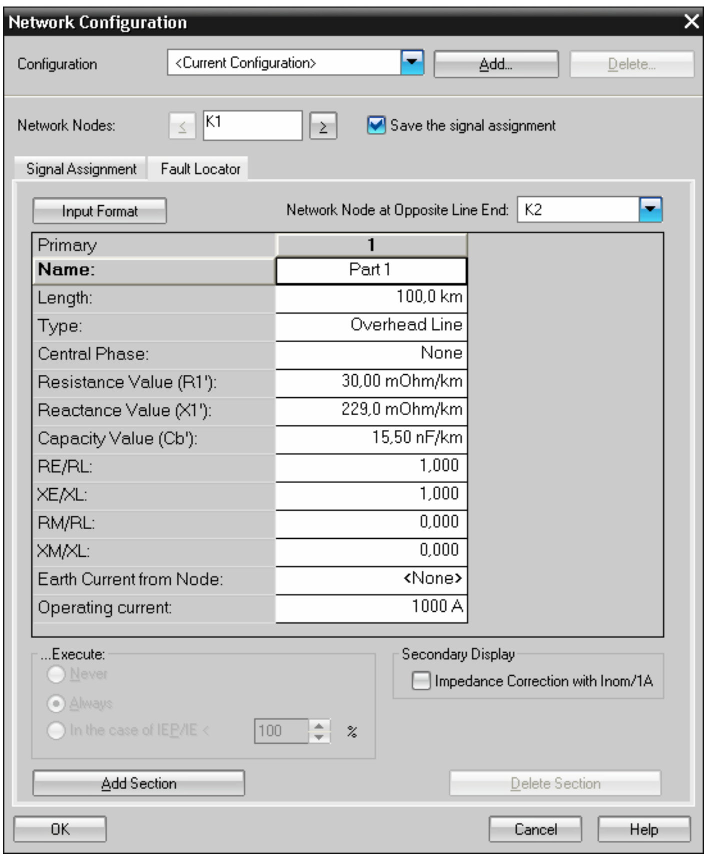
Line sections

The line data can be entered in the network configuration. A line may consist of several line sections, for example an overhead line that leads on to a cable.

For each line section you can enter the type. This setting affects the measurement process, since a cable has other physical characteristics than an overhead line.

To simplify data entry, it is possible to enter the line data in a variety of formats. For instance, the line impedance can be entered as the total impedance or as the relative impedance (Ω per km or mile).

There are also other tools to assist with data entry. For example, if the line capacity is not known, then a default value determined using a physical model can be used.



DSGRA207.tif

Fig. 4-15 SIGRA 4, making the fault locator settings.

For information on the parameterization of a line, please refer to paragraph 3.10.1.

You can select when the parallel line compensation is to be carried out and the **IEP/IE** ratio in %, if necessary.

Line symmetry (only for bidirectional fault location)

To achieve greater accuracy for bidirectional fault location, the line asymmetry can be taken into account. The line asymmetry is estimated on the basis of the layout of the conductors.
The central phase needs to be configured. If you do not want an estimation of the line asymmetry to be carried out then it can be deactivated. Lines are assumed to have a high degree of symmetry around the central phase, in particular the single-plane layout.

Figure 4-16 shows 2 mast systems with different phase arrangements. The phases are indicated by the **+** signs. In both arrangements, **L2** is the central phase.

The **central phase** is parameterized in the **Network Configuration** dialog, **Fault Locator** tab.

Twisted lines can be simulated by entering several line sections with different central phases.

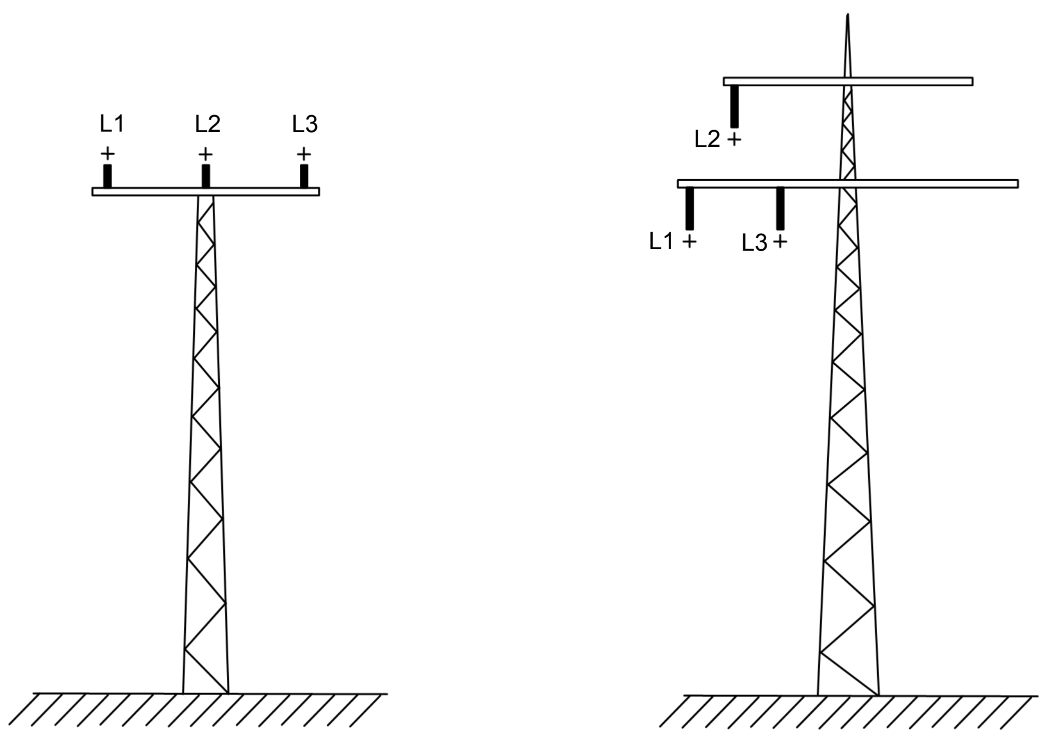


Fig. 4-16 Different options for a single-plane arrangement with a central phase.

4.14.2 Using the fault locator

In order to carry out a fault location, proceed as follows:

- Load a fault record;
- import a second fault record (for example by drag-and-drop);
- select the Fault Locator tab via the **Options > Network Configuration** menu command (see Figure 5-13);
- enter the parameters for the line sections;
- now select the menu item **View > Fault Locator** to start calculation of the fault location.

NOTE

The fault records are synchronized automatically.

- If the calculation is carried out correctly save the network configuration for future use. The next time a fault record is received from the same devices the right configuration can then be selected automatically.

NOTE

If the earth current of the parallel line is available, this can be taken into account for the unidirectional fault locator, see paragraph 3.10.1. The bidirectional fault locator is not affected by that.

5 Calculations / Definitions

Contents

5.1 Device fault records

The devices of the **SIPROTEC** series continuously record measured values and binary signals. These are saved in case of events, such as when a fault occurs or after an operator action, which can be parameterized for specific devices.

These data are read out via the parameterization software DIGSI 4 or a higher DIGSI version and saved as fault record in COMTRADE format.

On the basis of these data, SIGRA 4 calculates additional variables, such as impedances, and makes these variables and the measured values available for the graphical fault record analysis.

These procedures are based on conventions observed with all devices of the SIPROTEC product family.

SIGRA 4 has been designed as a device-independent analysis program, which can interpret any fault records available in a COMTRADE format. For this reason, it may become necessary to adapt the sequence of the values supplied, their physical meanings or the calculation parameters to the SIGRA 4 **reference arrow system** (see chapter 5.3).
These adjustments can be made in the **Network Configuration** and **Signal Properties - Analog Signals** dialogs.
For further details, please refer to chapter 3.10 and chapter 4.10.

The following chapters describe the handling of the measured variables and the **reference arrow definition** in three-phase systems.

5.2 Principles for the calculation of process variables

Calculations performed by **SIGRA 4** always refer to **primary values**.

SIPROTEC devices

The transformation of the measured variables to the primary system is based on the following relations:

$V_p = V_s \times V_{Np} / V_{Ns}$

$I_p = I_s \times I_{Np} / I_{Ns}$

V_{Np}: primary nominal transformer voltage

V_{Ns}: secondary nominal transformer voltage

I_{Np}: primary nominal transformer current

I_{Ns}: secondary nominal transformer current

The nominal values of the transformers are entered in the COMTRADE file of the fault record by DIGSI 4 or a higher DIGSI version and can thus be evaluated by SIGRA 4.

These settings can be checked and changed, if necessary, in the **Signal Properties** dialog, **Analog Signals** tab (see chapter 4.10).

Non-company devices

If you wish to analyze fault records from non-company devices which record the secondary values of the measured variables, you need to use the nominal transformer variables to ensure correct transformation of these values to the primary system. These parameter settings are specified in the **Signal Properties - Analog Signals** dialog (see chapter 4.10).

NOTE

Negative nominal values result in a 180^{o} **rotation** of the **measured signal**. You can use these values to establish compatibility when defining the SIGRA 4 reference arrow system.

The display of the calculated values in the secondary system is always based on the **ratio** of the **main current** or **main voltage transformers**.

Measuring window

If calculated variables are created via a measuring window, the window is always located to the **left** of the **reference instant**, e.g. the cursor position. The **length** of the measuring window corresponds to **one period** of the nominal frequency $\mathbf{T_N}$, e.g. 20 ms at 50 Hz. SIGRA 4.3 includes an algorithm that determines the actual network frequency on the basis of the pre-fault condition. This frequency is shown in the status bar and is used as the basis for the calculations.

NOTE

The **calculated values** are **valid only** if there is **no status change**, (such as fault occurrence or disconnection), within the measuring window.

NOTE

All variables calculated by SIGRA 4 are identified by an asterisk.

NOTE

The variables calculated by SIGRA 4 cannot always be used to draw conclusions on the reaction of the protection device used to acquire the fault record data.
The algorithms on which the protection devices base their internal calculations may deviate from standard SIGRA 4 conventions. Deviations may occur, particularly in the case of variables which are not perfectly sinusoidal.

Frequency measurement

Frequency measurement determines the network frequency on the basis of the pre-fault state:

- determination using IL1, IL2 and IL3 or VL1E, VL2E and VL3E by forming the positive sequence space vector,
- assessment of the pre-fault state,
- the frequency is determined using the length of the pre-fault state and the angle of the positive sequence space vector during this period,
- the criteria for a valid value are: I1 > 5% Inom, f > 5% fnom,
  Tpre > 1/fnom or at least 20 sampling points, or V1 > 5% Vnom, f > 5% fnom, Tpre > 1/fnom or at least 20 sampling points.

If a frequency can be determined then it is taken as the nominal frequency for the fault record and is displayed in the status bar, and is also taken as the default value for all subsequent calculations.

If no valid frequency can be determined then frequency analysis is not carried out and the value given in the COMTRADE file is used instead.

Additionally, frequency analysis is carried out for each network node in order to reveal the frequency curve of the signals and to provide this as a signal which can optionally be inserted into a diagram.

The analysis is also done using the space vector analysis, preferably with the voltages, but if these are not available then with the currents. As the measuring window for the frequency analysis the usual backward looking window with a length of 1/Fnom is chosen.

The **calculated values** are **valid only** if there is **no status change**, (such as fault occurrence or disconnection), within the measuring window.

5.3 Reference arrow definition

The calculations performed by SIGRA 4 are based on the following reference arrow definition:

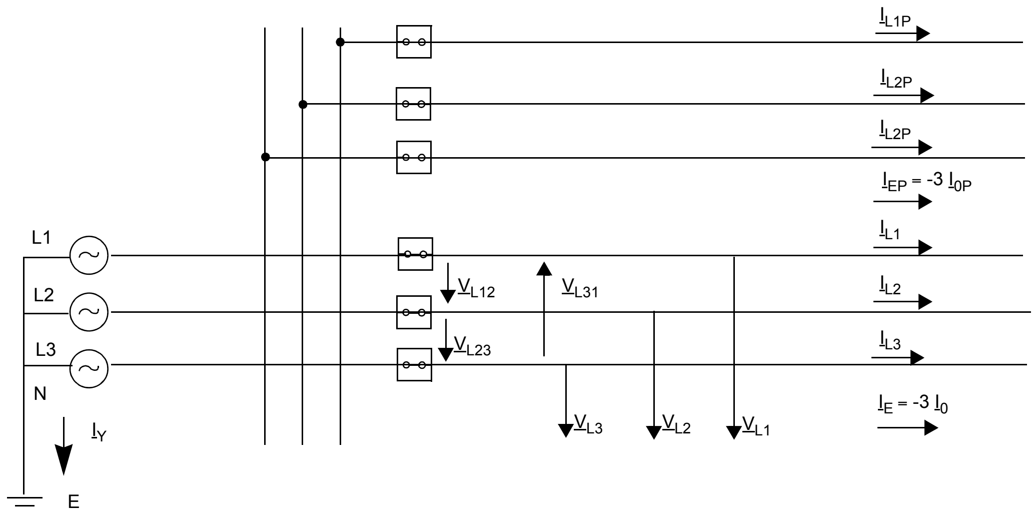


Fig. 5-1 The reference arrow definition used by SIGRA 4 for calculations.

5.4 Variables in the three-phase system

SIGRA 4 supplements the measured variables of the fault record by calculated variables, using the **nodal** or **Kirchhoff equations** in the three-phase system.

Calculation is based on the following relations and their conversion (for further details, see chapter 5.3 *Reference arrow definition*):

$$V_{L12} = V_{L1} - V_{L2}$$

$$V_{L23} = V_{L2} - V_{L3}$$

$$V_{L31} = V_{L3} - V_{L1}$$

$$V_{L12} + V_{L23} + V_{L31} = 0$$

$$V_{en} = 3V_0 = V_{L1} + V_{L2} + V_{L3}$$

$$I_E = -(I_{L1} + I_{L2} + I_{L3})$$

5.5 Symmetrical components

SIGRA 4 calculates the symmetrical components of the voltage and current system using the three-phase operator $\underline{a} = e^{j2/3\pi}$ according to the following equations:

$$\underline{V}_1 = 1/3\ (\underline{V}_{L1} + \underline{a}\ \underline{V}_{L2} + \underline{a}^2\ \underline{V}_{L3})$$

$$\underline{V}_2 = 1/3\ (\underline{V}_{L1} + \underline{a}^2\ \underline{V}_{L2} + \underline{a}\ \underline{V}_{L3})$$

$$\underline{V}_0 = 1/3\ (\underline{V}_{L1} + \underline{V}_{L2} + \underline{V}_{L3})$$

$$\underline{I}_1 = 1/3\ (\underline{I}_{L1} + \underline{a}\ \underline{I}_{L2} + \underline{a}^2\ \underline{I}_{L3})$$

$$\underline{I}_2 = 1/3\ (\underline{I}_{L1} + \underline{a}^2\ \underline{I}_{L2} + \underline{a}\ \underline{I}_{L3})$$

$$\underline{I}_0 = 1/3\ (\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3})$$

The **complex conductor variables** are **r.m.s. values** of the fundamental component (nominal frequency T_N).

The measuring window is situated **on the left** of the **reference point**, e.g. the cursor position, and its **length** corresponds to **one period** of the nominal frequency $\mathbf{T_N}$.

5.6 R.M.S. values

The calculation of r.m.s. values is based on the following definition of r.m.s. values:

$$X(t_c) = \frac{1}{T_N}\sqrt{\int_{t_c - T_N}^{t_c} x(t)^2\, dt}$$

The measuring window is situated **on the left** of the **reference point $\mathbf{t_c}$,** e.g. the cursor position, and its **length** corresponds to **one period** of the nominal frequency $\mathbf{T_N}$.

5.7 Harmonics

Harmonics are calculated by means of a **full-cycle DFT** (Discrete Fourier Transformation) and are **always r.m.s. values**.

The measuring window is situated **on the left** of the **reference point**, e.g. the cursor position, and its **length** corresponds to **one period** of the nominal frequency $\mathbf{T_N}$.

5.8 Vectors

The absolute value of complex vectors are **r.m.s. values of the fundamental component** (nominal frequency T_N), i.e. harmonics are filtered out.

The measuring window is situated **on the left** of the **reference point**, e.g. the cursor position, and its **length** corresponds to **one period** of the nominal frequency $\mathbf{T_N}$.

With currents and voltages, the vector angle always refers to a **standard vector $\mathbf{e^{j2\pi f N t}}$** rotating at nominal frequency.

5.9 Positive-sequence impedances

The positive-sequence impedances are calculated using the complex vectors of the voltages and currents of the three-phase system.
This is effected by considering the zero-sequence coupling and, if necessary, the inductive coupling to a parallel line.

SIGRA 4 calculates the **positive-sequence impedances** for all of the three

- Conductor-to-earth loops (L1E, L2E, L3E) and
- conductor-to-conductor loops (L12, L23, L31).

For example, SIGRA 4 calculates the positive-sequence impedances using the results of the following equations:

Conductor-to-conductor loop L12:

$$\underline{V}_{L12} = \underline{I}_{L1} R_1(L12) + j\underline{I}_{L1} X_1(L12) - \underline{I}_{L2} R_1(L12) - j\underline{I}_{L2} X_1(L12)$$

Conductor-to-earth loop L1E without parallel line compensation:

$$\underline{V}_{L1E} = \underline{I}_{L1} R_1(L12) + j\underline{I}_{L1} X_1(L12) - \underline{I}_E k_r R_1(L12) - j\underline{I}_E k_x X_1(L12)$$

Conductor-to-earth loop L1E with parallel line compensation:

$$\underline{V}_{L1E} = \underline{I}_{L1} R_1(L12) + j\underline{I}_{L1} X_1(L12) - \underline{I}_E k_r R_1(L12) - j\underline{I}_E k_x X_1(L12) - \underline{I}_{EP} k_{Mr} R_1(L12) - j\underline{I}_{EP} k_{Mx} X_1(L12)$$

The following equation applies:

$Z_1 = R_1 + jX_1 \quad = \quad Z_L = R_L + jX_L$

$k_r \quad = \quad R_E / R_L \quad = \quad (R_0 / R_1 - 1) \quad / 3$

$k_x \quad = \quad X_E / X_L \quad = \quad (X_0 / X_1 - 1) \quad / 3$

$k_{Mr} \quad = \quad R_M / R_L \quad = \quad R_{0M} / R_1 \quad / 3$

$k_{Mx} \quad = \quad X_M / X_L \quad = \quad X_{0M} / X_1 \quad / 3$

NOTE

With fault records of the **SIPROTEC devices**, the factors for **earth impedance matching** R_E / R_L und X_E / X_L as well as the factors for **parallel line compensation** are transferred by **DIGSI 4** or a higher DIGSI version to **SIGRA 4** together with the measured values.

For fault records from **other devices**, you can parameterize these factors in the **Network Configuration** dialog (see chapter 3.10.1). It also lets you define if and under what conditions parallel line compensation is carried out.

5.10 Three-phase outputs

SIGRA 4 calculates the following Three-phase outputs:

$\underline{S} = \quad VL1 \times IL1^* + VL2 \times IL2^* + VL3 \times IL3^*$

$P = \quad Re(\underline{S})$

$Q = \quad Im(\underline{S})$

5.11 Formulas

The following list shows the **meanings** and a brief description of the **formula symbols** used.

$\mathbf{R_{0M}}$		Mutual zero-sequence resistance (coupling resistance)
$\mathbf{X_{0M}}$		Mutual zero-sequence reactance (coupling reactance)
$\mathbf{R_0}$		Zero-sequence resistance of the protected object (e.g. a line)
$\mathbf{X_0}$		Zero-sequence reactance of the protected object (e.g. a line)
$\mathbf{k_r}$	$= R_E / R_L = (R_0 / R_1 - 1) / 3$	Earth impedance matching, resistance ratio
$\mathbf{k_x}$	$= X_E / X_L = (X_0 / X_1 - 1) / 3$	Earth impedance matching, reactance ratio
$\mathbf{k_{Mr}}$	$= R_M / R_L = R_{0M} / R_1 / 3$	Coupling impedance matching, resistance ratio
$\mathbf{k_{Mx}}$	$= X_M / X_L = X_{0M} / X_1 / 3$	Coupling impedance matching, reactance ratio
$\mathbf{R_1}$		Positive-sequence resistance of the protected object (e.g. a line)
$\mathbf{X_1}$		Positive-sequence reactance of the protected object (e.g. a line)
$\underline{\mathbf{Z}}_1$		Positive-sequence impedance of the protected object (e.g. a line)
$\underline{\mathbf{V}}_1$		Positive-sequence voltage
$\underline{\mathbf{V}}_2$		Negative-sequence voltage
$\underline{\mathbf{V}}_0$		Zero-sequence voltage
$\underline{\mathbf{I}}_1$		Positive-sequence current
$\underline{\mathbf{I}}_2$		Negative-sequence current
$\underline{\mathbf{I}}_0$		Zero-sequence current
$\mathbf{I_{L1}}$		Conductor current, phase L1
$\mathbf{I_{L2}}$		Conductor current, phase L2
$\mathbf{I_{L3}}$		Conductor current, phase L3
$\mathbf{I_E}$		Earth current
$\mathbf{V_{L1}}$		Voltage conductor L1 - earth
$\mathbf{V_{L2}}$		Voltage conductor L2 - earth
$\mathbf{V_{L3}}$		Voltage conductor L3 - earth
$\mathbf{V_{en}}$		Displacement voltage
$\mathbf{V_{L12}}$		Voltage conductor L1 - conductor L2

V_{L23}	Voltage conductor L2 - conductor L3
V_{L31}	Voltage conductor L3 - conductor L1
S	Apparent power
P	Active power
Q	Reactive power

Literature

/1/ SICAM PAS, Overview
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/2/ SICAM PQS, Overview
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/6/ SICAM PQ Analyzer
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/7/ SICAM PQ Analyzer, Incident Explorer
E50417-H8976-C465

/8/ SIPROTEC DIGSI 4, Start UP
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/10/ Ethernet & IEC 61850, Start UP
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/11/ Ethernet & IEC 61850, Conzepts, Implementation, Commissioning
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Index

S

T

U

V

W

Z