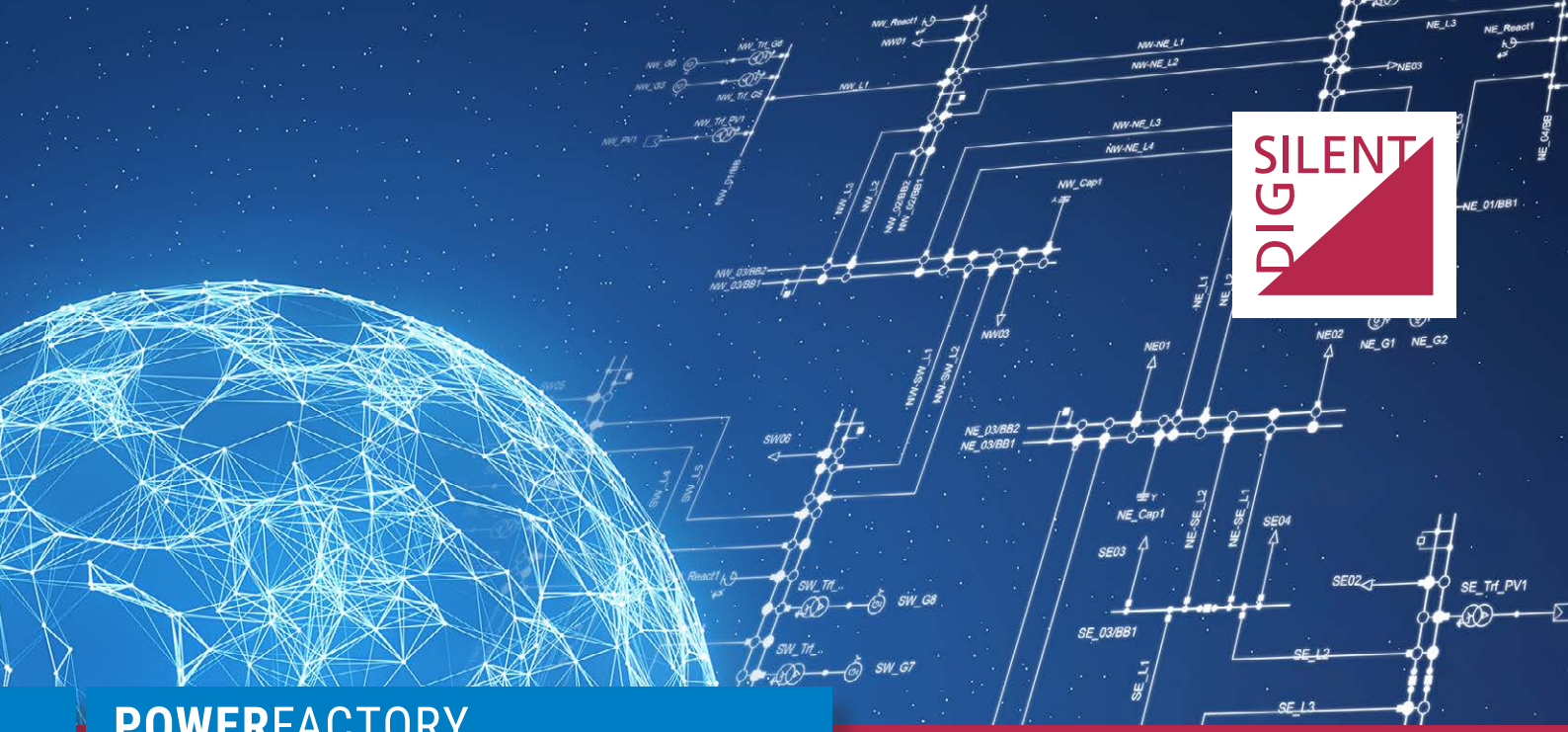

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PowerFactory 2021

Technical Reference

CT Adapter

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1 General Description

The *CT Adapter* “RelCtadapt” block can be used to simulate one of the following:

- An *Auxiliary Current Transformer* used by the electromechanical or static differential relays to adapt the primary and the secondary side currents taking care of the different CT ratios and of the transformer group and winding connections.
- The numerical compensation logic applied to the current phasor and used by the microprocessor differential relay to reproduce the behaviour of the *Auxiliary Current Transformer*.

Two different types of CT adapter block are available: the 3 phase CT adapter and the single phase CT adapter. The single phase CT adapter doesn't support the ability to compensate the transformer group and winding type.

The *CT Adapter* “RelCtadapt” block is operational during short circuit, load flow and RMS/EMT simulations.

2 Features & User interface

2.1 CT Adapter (RelCtadapt)

The user can change the block settings using the “CT Adapter” dialogue (“RelCtadapt” class). The dialogue consists of two tab pages: *Basic Data*, and *Description*. The main settings are located in the *Basic Data* tab page.

2.1.1 Basic Data

The “Basic Data” dialogue contains the following controls:

- An editbox which allows to insert a name to identify the *CT Adapter* (“loc_name” parameter).
- A pointer to a “CT Adapter type” object which defines the Ct adapter type and the configuration parameters ranges (“typ_id”).
- A check box to disable the element (“outserv” parameter).
- A graphical control which defines the “Current Transformer Ratio” (“CTratio” parameter).
- A graphical control which defines the “Terminal Line to Line Voltage” (“LLVolt” parameter).
- A combo box which defines the “Current Transformer connection” (“icontype” parameter).
- A combo box which defines the “Transformer Group” (“trasfgroup” parameter).
- A check box which allows to remove the zero sequence component from the phase currents (“iremoveI0” parameter).

The block can be disabled using the “Out of service” check box.
The current adaptation ratio can be set using the *Current Transformer Ratio*, the *Terminal Line to Line Voltage* and the *Current Transformer connection* controls. The adaptation formula can be found at 2.3. The “Current Transformer Ratio” and the “Terminal Line to Line Voltage” control are combo boxes if ranges of discrete values have been defined in the “CT Adapter Type” dialogue or otherwise edit boxes.

The “Transformer Group” combo box is visible only if if the block isn’t used as reference adapter. If no transformer is present the *0* item must be selected in the combo box. The transformations calculated to compensate the phase rotations due to the power transformer group are listed at 2.4.

The “Remove Earth Current” check box is visible only if in the CT Adapter Type dialogue (“TypCtadapt”) the selected item in the “Remove Earth Current” (“iremoveI0conf” parameter) combo box is *User Configurable*.

2.1.2 Description

The *Description* tab page can be used to insert some information to identify the CT Adapter protective element (both with a generic string and with an unique textual string similar to the *Foreign Key* approach used in the relational databases) and to identify the source of the data used to create it.

2.2 CT Adapter Type(TypCtadapt)

The *CT Adapter* block main characteristics must be configured in the “CT Adapter Type” dialogue (*TypCtadapt* class). The dialogue consists of two tab pages: *Basic Data*, and *Description*. The main settings are located in the *Basic Data* tab page.

2.2.1 Basic Data

A name for the CT Adapter Type can be inserted in the “Name” (“loc_name” parameter) edit box.

It’s possible to define a reference adapter: all currents entering the other adapters will be referred to this adapter currents.

The block can be configured as a 3phase or a single phase CT adapter using the “Phases” combo box (“nphase” parameter). The underlying types are:

- CalCtadapt (3 phase Ct adapter)
- CalCtadapt1p (a single phase Ct adapter)

The *Current Transformer Ratio*, and the *Terminal Line to Line Voltage* ranges can be defined in the two edit boxes contained inside the *Range Definitions* frame.

The ability to remove the zero sequence current component from the phase current is configured by the “Remove Earth Current” (“iremoveI0conf” parameter) combo box. One of the following three items can be selected:

- Disabled

- Enabled
- User Configurable

When the *User Configurable* item has been selected the ability to remove the zero sequence current can be activated selecting the “Remove Earth Current” check box in the “CT Adapter” dialogue (“RelCtadapt” class).

2.2.2 Description

The *Description* tab page can be used to insert some information to identify the CT Adapter protective element (both with a generic string and with an unique textual string similar to the *Foreign Key* approach used in the relational databases) and to identify the source of the data used to create it.

2.3 Ct Ratio and Voltage level compensation formula

The formula to compensate the different CT ratio and voltage levels is

$$\begin{bmatrix} I\_A_c \\ I\_B_c \\ I\_C_c \end{bmatrix} = \begin{bmatrix} \frac{Ratio_{CT}}{Ratio_{ReferenceCT}} & \frac{V_{CT}}{V_{ReferenceCT}} & \frac{WindingFactor_{CT}}{WindingFactor_{ReferenceCT}} \end{bmatrix} \begin{bmatrix} wI\_A \\ wI\_B \\ wI\_C \end{bmatrix} \quad (1)$$

where

wI_A, *wI_B* and *wI_C* are the three phase currents entering the block.

I_A_c, I_B_c and I_C_c are the compensated currents.

$Ratio_{CT}$ is the *Current Transformer Ratio* (“CTratio” parameter).

$Ratio_{ReferenceCT}$ is the *Current Transformer Ratio* (“CTratio” parameter) of the reference Adapter (“prefblock” parameter of the CT Adapter Type(“TypCtadapt” class)).

V_{CT} is the *Terminal Line to Line Voltage* (“LLVolt” parameter).

$V_{ReferenceCT}$ is the *Terminal Line to Line Voltage* (“LLVolt” parameter) of the reference Adapter (“prefblock” parameter of the CT Adapter Type(“TypCtadapt” class)).

$WindingFactor_{CT}/WindingFactor_{ReferenceCT}$ is $\sqrt{3}$ if the reference Adapter“Current Transformer connection” (“icontype” parameter) is *D* and the “Current Transformer connection” (“icontype”parameter) is *Y*.

It is $1/\sqrt{3}$ if the reference Adapter“Current Transformer connection” (“icontype” parameter) is *Y* and the “Current Transformer connection” (“icontype”parameter) is *D*.

2.4 Matrices used in transformer group compensation

The general expression for the transformer group compensation is:

$$\begin{bmatrix} I\_A_c \\ I\_B_c \\ I\_C_c \end{bmatrix} = \begin{bmatrix} C_m \end{bmatrix} \begin{bmatrix} wI\_A \\ wI\_B \\ wI\_C \end{bmatrix} \tag{2}$$

where
wI_A, *wI_B* and *wI_C* are the three phase current entering the block
[Cm] is the compensation matrix for the group *m* with *m* from 0 to 11
and
I_A_c, I_B_c and I_C_c are the compensated currents.

To compensate the transformer group the following matrices are used

$$C_0 = \frac{1}{\sqrt{3}} \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix} \tag{3}$$

$$C_1 = \frac{1}{\sqrt{3}} \begin{bmatrix} 1 & -2 & 1 \\ 1 & 1 & -2 \\ -2 & 1 & 1 \end{bmatrix} \tag{4}$$

$$C_2 = \frac{1}{\sqrt{3}} \begin{bmatrix} 0 & -1 & 1 \\ 1 & 0 & -1 \\ -1 & 1 & 0 \end{bmatrix} \tag{5}$$

$$C_3 = \frac{1}{\sqrt{3}} \begin{bmatrix} -1 & -1 & 2 \\ 2 & -1 & -1 \\ -1 & 2 & -1 \end{bmatrix} \tag{6}$$

$$C_4 = \frac{1}{\sqrt{3}} \begin{bmatrix} -1 & 0 & 1 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \end{bmatrix} \tag{7}$$

$$C_5 = \frac{1}{\sqrt{3}} \begin{bmatrix} -2 & 1 & 1 \\ 1 & -2 & 1 \\ 1 & 1 & -2 \end{bmatrix} \tag{8}$$

$$C_6 = \frac{1}{\sqrt{3}} \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \end{bmatrix} \tag{9}$$

$$C_7 = \frac{1}{\sqrt{3}} \begin{bmatrix} -1 & 2 & -1 \\ -1 & -1 & 2 \\ 2 & -1 & -1 \end{bmatrix} \tag{10}$$

$$C_8 = \frac{1}{\sqrt{3}} \begin{bmatrix} 0 & 1 & -1 \\ -1 & 0 & 1 \\ 1 & -1 & 0 \end{bmatrix} \tag{11}$$

$$C_9 = \frac{1}{\sqrt{3}} \begin{bmatrix} 1 & 1 & -2 \\ -2 & 1 & 1 \\ 1 & -2 & 1 \end{bmatrix} \tag{12}$$

$$C_{10} = \frac{1}{\sqrt{3}} \begin{bmatrix} 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix} \tag{13}$$

$$C_{11} = \frac{1}{\sqrt{3}} \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix} \tag{14}$$

3 Integration in the relay scheme

The *CT Adapter*"RelCtadapt" type class name is *TypCtadapt*. The *CT Adapter* dialogue class name is *RelCtadapt* . As already shown, there are two main versions of the block: a single phase and a three phase version. The number and the name of the input signals depends only upon which of these versions is used.

The CT Adapter block can be connected to one of the following blocks:

- to the Measurement outputs to simulate the behaviour of a microprocessor differential device which is compensating internally the currents coming from the CTs.
- To the CT outputs to simulate the CT adapter in the no-microprocessor differential devices

The typical connection of a single phase *CT Adapter*"RelCtadapt " block is showed in Figure 3.1.

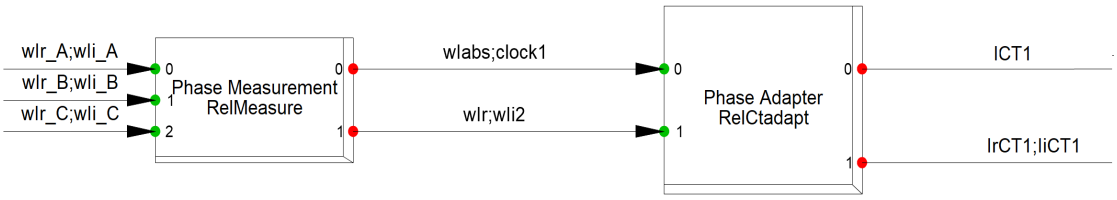

Figure 3.1: *DIgSILENT* Typical connection scheme of a single phase *CT Adapter*"RelCtadapt" block.

The connections associated with a three phase *CT Adapter*"RelCtadapt" block are quite similar. The main difference is that an input signal for each phase is included.

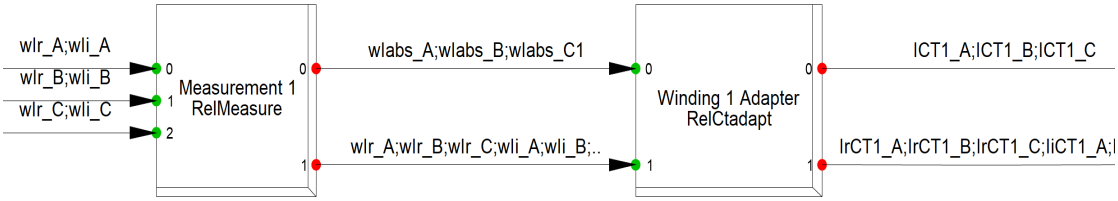

Figure 3.2: *DIgSILENT* Typical connection scheme of a three phase *CT Adapter*"RelCtadapt" block

A Parameter Definitions

A.1 CT Adapter Type (TypCTadapt)

Table A.1: Input parameters of the CT Adapter type (*TypCtadapt*)

Parameter	Description	Unit
loc_name	Name assigned by the user to the block type	Text
prefblock	A pointer to the Reference Adapter	Text
atype	The adapter type. It can be *single phase* or *3 phase*	
rCTratio	CT ratio compensation factor range	Text
rLLVolt	CT Line-Line Voltage compensation factor Range	Text
iremoveI0conf	Configuration of the logic removing the Earth Current	Integer

A.2 CT Adapter Element (RelCtadapt)

Table A.2: Input parameters of the CT Adapter element (*RelCtadapt*))

Parameter	Description	Unit
loc_name	Name assigned by the user to the block element	Text
CTratio	CT ratio compensation factor	Real number
LLVolt	CT Line-Line Voltage compensation factor	Real number
icontype	CT connection type. It can be *None* (the info is not important, all CTs have the same connection type) or *Delta* or *Wye*	Integer
trasfgroup	The group of the power transformer. It can be an integer value between *0* and *11* or *None*	Integer

B Signal Definitions

B.1 Single phase

Table B.1: Input/output signals of the single phase CT Adapter element (*CalCtadapt1p*)

Name	Description	Unit	Type	Model
wIabs	Ct adapter block input current (RMS value)	Sec Amperes	IN	Any
wIr	Ct adapter block input current real part	Sec Amperes	IN	Any
wIi	Ct adapter block input current imaginary part	Sec Amperes	IN	Any
clock	Synchronisation signal with the associated measurement block	1/0	IN	EMT only
Iabs	Output current (*adapted current*)(RMS value)	Sec Amperes	OUT	Any
Ir	Output current (*adapted current*) real part Sec Amps	Sec Amperes	OUT	Any
Ii	Output current (*adapted current*) imaginary part Sec Amps	Sec Amperes	OUT	Any

B.2 Three phase

Table B.2: Input/output signals of 3 phase CT Adapter element (*CalCtadapt*)

Name	Description	Unit	Type	Model
wIabs_A	Ct adapter block Phase A input current (RMS value)	Sec Amperes	IN	Any
wIabs_B	Ct adapter block Phase B input current (RMS value)	Sec Amperes	IN	Any
wIabs_C	Ct adapter block Phase C input current (RMS value)	Sec Amperes	IN	Any
wIr	Ct adapter block Phase A input current real part	Sec Amperes	IN	Any
wIi	Ct adapter block Phase A input current imaginary part	Sec Amperes	IN	Any
clock	Synchronisation signal with the associated measurement block	1/0	IN	EMT only

Table B.2: Input/output signals of 3 phase CT Adapter element (*CalCtadapt*)

Name	Description	Unit	Type	Model
Iabs_A	Phase A Output current (*adapted current*)(RMS value)	Sec Amperes	OUT	Any
Iabs_A	Phase B Output current (*adapted current*)(RMS value)	Sec Amperes	OUT	Any
Iabs_A	Phase C Output current (*adapted current*)(RMS value)	Sec Amperes	OUT	Any
Ir_A	Phase A Output current (*adapted current*) real part Sec Amps	Sec Amperes	OUT	Any
Ii_A	Phase A Output current (*adapted current*) imaginary part Sec Amps	Sec Amperes	OUT	Any
Ir_B	Phase B Output current (*adapted current*) real part Sec Amps	Sec Amperes	OUT	Any
Ii_B	Phase B Output current (*adapted current*) imaginary part Sec Amps	Sec Amperes	OUT	Any
Ir_C	Phase C Output current (*adapted current*) real part Sec Amps	Sec Amperes	OUT	Any
Ii_C	Phase C Output current (*adapted current*) imaginary part Sec Amps	Sec Amperes	OUT	Any

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