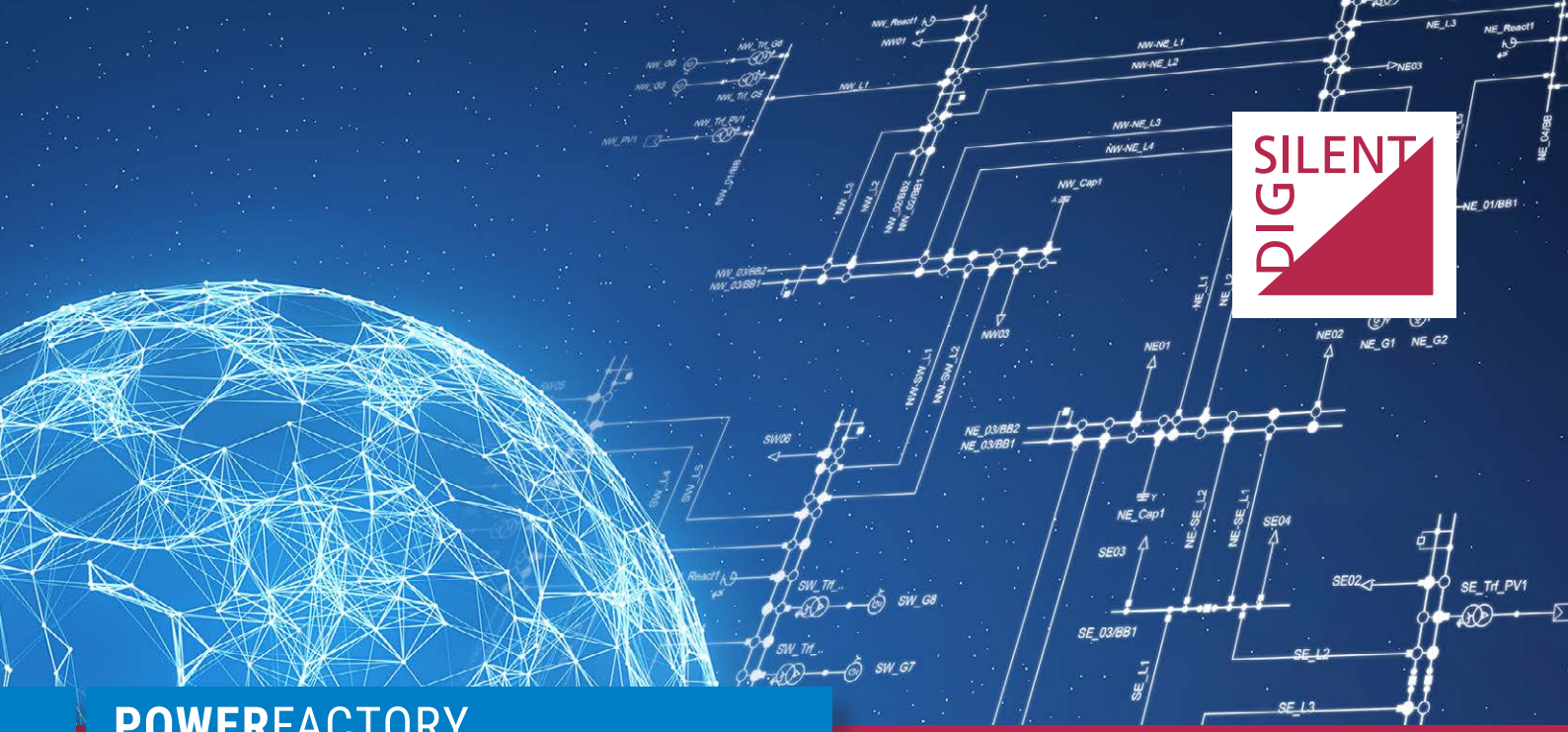

POWERFACTORY

PowerFactory 2021

Technical Reference

Common Time Characteristic

RelChar, TypChar

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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1 General Description

The *Common Time Characteristic*"RelChar" block implements a directional or non directional time dependent element. The block can be configured to use as input quantities one of the following

- Active Power (P)
- Reactive Power (Q)
- Apparent Power (S)
- Voltage
- Frequency
- df/dt
- V/Hz
- Three generic input quantity
- A single input quantity

The block defines a trip curve shape with associated reset characteristic, a threshold, a time delay, a maximum and a minimum trip time, and a reset time.
Moreover the user can define a "Total Clear Curve" characteristic to represent the overall time spent to remove the fault or the maximum time spent by the device to detect the fault. The block can be set to calculate the trip time using the "Minimum Trip Curve" or the "Total Clear Curve" characteristic. The *Common Time Characteristic*"RelChar" block is operational during short circuit, load flow and RMS/EMT simulations. No graphical representation of the trip characteristic is provided in the PowerFactory user interface but each characteristic can be displayed in its own dialogue ("TypChatoc" class).

2 Features & User interface

2.1 Common Time Characteristic(RelChar)

The user can change the block settings using the "Common Time Characteristic" dialogue ("RelChar" class). The dialogue consists of three tab pages: *Basic data*, *Tripping times*, and *Description*. The main settings are located in the *Basic data* tab page.

2.1.1 Basic data

The "Common Time Characteristic" dialogue provides a *presentation* area where the red text shows some info regarding:

- The international symbols used to represent the block protective function.
- Which quantities are measured by the block.

The block can be disabled using the “Out of service” check box. A directional feature can be set using the “Tripping direction” combo box. Please notice that the directional logic relies on a separate block (i.e. the “Directional Overcurrent” ,“RelDir” class). The trip curve shape is set using the “Characteristic” combo box. The threshold, time delay, reset delay, and minimum and maximum trip time can be set using the “Input Setting”, the “Time dial”, the “Reset delay”, the “Min. Time”, and the “Max. Time” control. They are showed as a combo box for ranges of discrete values or otherwise as an edit box. The ranges are defined inside the trip characteristic dialogue (“TypChatoc” class). In this way it is possible to define different ranges for each trip characteristic.
The blue text provides additional info regarding the input threshold in terms of primary values.

2.1.2 Tripping times

The *Tripping times* tab page allows the user to select whether the *Minimum Trip Curve* or the *Total Clear Curve* is used to calculate the element tripping time. The radio buttons are only displayed if the *Total Clear Curve* has been defined and is associated with the *Minimum Trip Curve* which has been selected.

2.1.3 Description

The *Description* tab page can be used to insert some information to identify the Common Time Characteristic 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 Common Time Characteristic Type(TypChar)

The *Common Time Characteristic* block main characteristics must be configured in the “Common Time Characteristic Type” dialogue (*TypChar* class). The dialogue contains two tab pages: *Basic data*, and *Total Clear curve*.

2.2.1 Basic data

The *Basic data* tab page contains most of the controls used to configure the *Common Time Characteristic* block.

The block can be configured using the “Type” combo box variable as:

- 3ph(other)
- 1ph(other)
- Active Power (P)
- Reactive Power (Q)
- Apparent Power (S)
- Voltage (V)
- Frequency (f)

- df/dt
- V/Hz

The block can be controlled by a recloser block (“RelRecl” object). The “Normal” item (to perform a multi-shot reclosing)or the “Lockout” item (to block the recloser after the first trip) must be set in the “Recl.Feature” combo box for this purpose.

The purpose of the types detailed above is to provide the right measurement unit label in the dialogue. The underlying types are:

- a 3 phase block (*3ph(other)*, *Active Power (P)*, *Reactive Power (Q)*, *Apparent Power (S)*, *Voltage (V)*, *Frequency (f)*, *df/dt*, *V/Hz* type)
- a single phase block (only for the *1ph(other)* type).

The *Common Time Characteristic* (“RelChar”)element has been conceived to work together with the other relay elements: some settings can be set to depend upon the settings of other *Common Time Characteristic* blocks:

- The element can be set to get a threshold value reference from another block: the “Input Setting” value becomes a multiplier of the current threshold set in the other block.
- The directional characteristic can be set using the *Common Time Characteristic*“RelChar” block dialogue or can be set depending on the setting of an external “Directional” block.

Additional fields To support certain models of US reclosers the “Additional fields” frame has been added inside the “TypChar” dialogue. When the frame is enabled the “Time adder” and the “Min resp.Time” controls are enabled and the relevant controls are shown inside the *Common Time Characteristic*“RelChar” dialogue. The trip time is calculated using the “Time dial” value, the “Time Adder” value and the “Min.Response Time” value. If the “Min.Response Time” value multiplied by the “Time Dial” value is greater than the trip value calculated using the “Time dial” value, the “Min.Response Time” value multiplied by the “Time Dial” value is used as the trip value. The “Time Adder” value is added then to the trip time calculated in the previous step. Please refer to the US recloser manuals (i.e. Cooper Power Systems Form4C) for more details about such settings.

Trip characteristic The list of the available trip curves is shown in lower part of the “Common Time Characteristic Type” dialogue (“TypChar” class). The trip characteristics are on the left in the “Characteristic” column, the reset characteristics are on the right in the “Reset Characteristic” column. Clicking the right mouse button on one of the columns a pop up menu is displayed; through this menu it is possible to create new characteristics, to delete or to edit an existing characteristic.

Selecting the “Edit Element/Type” item the “Characteristic” dialogue is opened(“TypChatoc” class).

The *Characteristic* dialogue allows the definition of the Common Time Characteristic (“TypChatoc” class), both an equation or a set of points can be used for this purpose. Please note that the range of the time dial is defined independently for each characteristic. In the “Time dial” frame the “Range” control defines the allowed range for the characteristic’s “time dial” variable.

Reset characteristic Just above the list of the available characteristics, the “Reset characteristic configuration” combobox allows enabling/disabling the reset characteristics; 3 options are available:

- Enabled
- Disabled
- User Configurable

Please note that the the “Reset Characteristic” column can be modified only when the “Enabled” or the “User Configurable” option is selected. When the “User Configurable” option is selected an additional combo box is displayed in the Common Time Characteristic dialogue (“RelChar” class) which allows the user to enable or disable the reset characteristic. When the reset characteristic is disabled and the current goes below the trip threshold multiplied by the reset factor (kr variable available in the TypChar dialogue) the Common Time Characteristic elements reset after the reset time delay has expired (Tr variable available in the TypChar dialogue).

The reset characteristics are managed exactly as the trip characteristics. It is important to understand that the reset characteristic must be defined for I/Ip $>=$ 0 and I/Ip $<$ 1. For instance the “Min Current” (imin variable) value can be 0 I/Ip and the “Max current” (imax variable) value can be 0.999 I/Ip. Please notice that in the range where the reset characteristic is not defined the reset is not performed.

If the “User Configurable” option is selected in the “Reset characteristic configuration” combo box of the“Common Time Characteristic Type” dialogue (“TypChar” class), then the “Reset characteristic” check box is displayed in the “RelChar” dialogue.

2.2.2 Total Clear Curve

The “Total clear curve” tab page contains settings which allow definition of the curve representing the overall time spent clearing the fault or the maximum time spent by the device in order to detect the fault.

The following features are available:

- Ability to automatically add the *Breaker Opening Time* to the *Total Clear Curve* characteristic.
- Definition of the input quantity threshold and time multipliers and shift factors applied to the *Minimum Trip Curve* in order to generate the *Total Clear Curve* characteristic.

Breaker operating time The “Total Clear Curve” can include the “Breaker operating time” if required.
The user can configure the behaviour by adapting the “Include Breaker Operating Time” check box.
The *Breaker operating time* value can be inserted inside the “Breaker time” control located in the *Basic Data* tab page (“t_open” variable)inside the “Switch Type” dialogue of the switch gear associated with the relay.

If in the Common Time Characteristic element dialogue (RelChar class) the “Compute Time Using” is set to “Total Clear Curve” and in the *Common Time Characteristic Type*(“TypChar”) dialogue the “Include Breaker Operating Time” check box is not checked, the tripping time is

equal to the breaker operating time plus the tripping time calculated using the “Total Clear” curve characteristic.
No value is added to the tripping time calculation if no switch type is available or if the “Breaker time” is zero.

“Total Clear Curve” definition The “Enable” check box can be used to enable or disable the “Total Clear” curve definition and the relevant controls in the dialogue.

The “Total Clear” curve can be defined with the application of a “shifter” and “multiplier” both to the current values and to the time values which define the “Min trip” curve. The “shifter” is simply an additive factor, the “multiplier” is a multiplicative factor.

The “Total Clear” curve input quantity values are calculated using the following formula:

$$I_{TotalClear} = (Input_{MinTrip} * \text{“}inputquantityMultiplier'') + \text{“}inputquantityShifter'' \quad (1)$$

The “Total Clear” curve time values are calculated using the following formula:

$$t_{TotalClear} = (t_{MinTrip} * \text{“}TimeMultiplier'') + \text{“}TimeShifter'' \quad (2)$$

3 Integration in the relay scheme

The *Common Time Characteristic*“RelChar” type class name is *TypChar*. The *Common Time Characteristic* dialogue class name is *RelChar*.
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.
If inside the “TypChar” dialogue if the “Type” is set as “3ph (other)” (or “1ph (other)”) a generic 3 phase Common Time Characteristic element (or a single phase “RelChar”)with *pu* as unit string in the dialogue is used. It can be useful if the *Common Time Characteristic*“RelChar” element is for instance used for control purposes processing some sort of calculated quantity.

The typical connection of a single phase *Common Time Characteristic*“RelChar” block is showed in Figure 3.1.

Figure 3.1: *DIgSILENT* The typical connection scheme of a single phase *Common Time Characteristic*“RelChar” block.

The connections associated with a three phase *Common Time Characteristic*“RelChar” block are quite similar. The main difference is that a input quantity signal for each phase is present. The connections associated with a three phase *Common Time Characteristic*“RelChar” are shown in Figure 3.2.

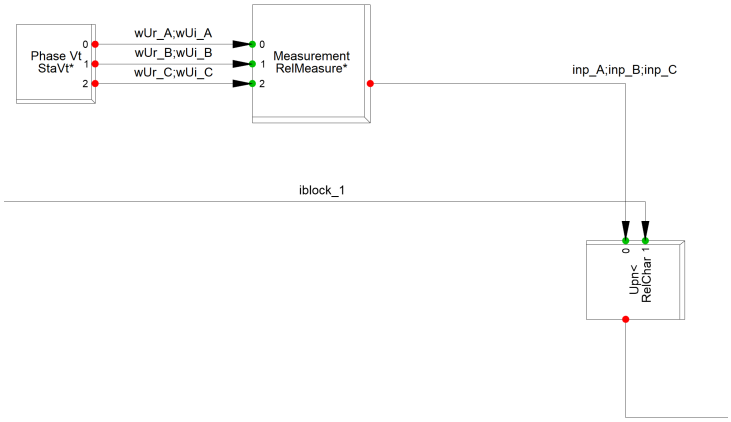


Figure 3.2: *DIgSILENT* Typical connection scheme of a three phase non directional *Common Time Characteristic*“RelChar” block.

If the *Common Time Characteristic*“RelChar” block is directional the “wfwd” and the “wrev” signals must be connected to a block containing the directional discrimination logic.
If the block is three phase a forward/reverse directional signal for each phase must be provided.
The *Common Time Characteristic*“RelChar” block can be made sensitive to the input quantity

flow direction by using the “Tripping direction” combobox in the “RelChar” dialogue.

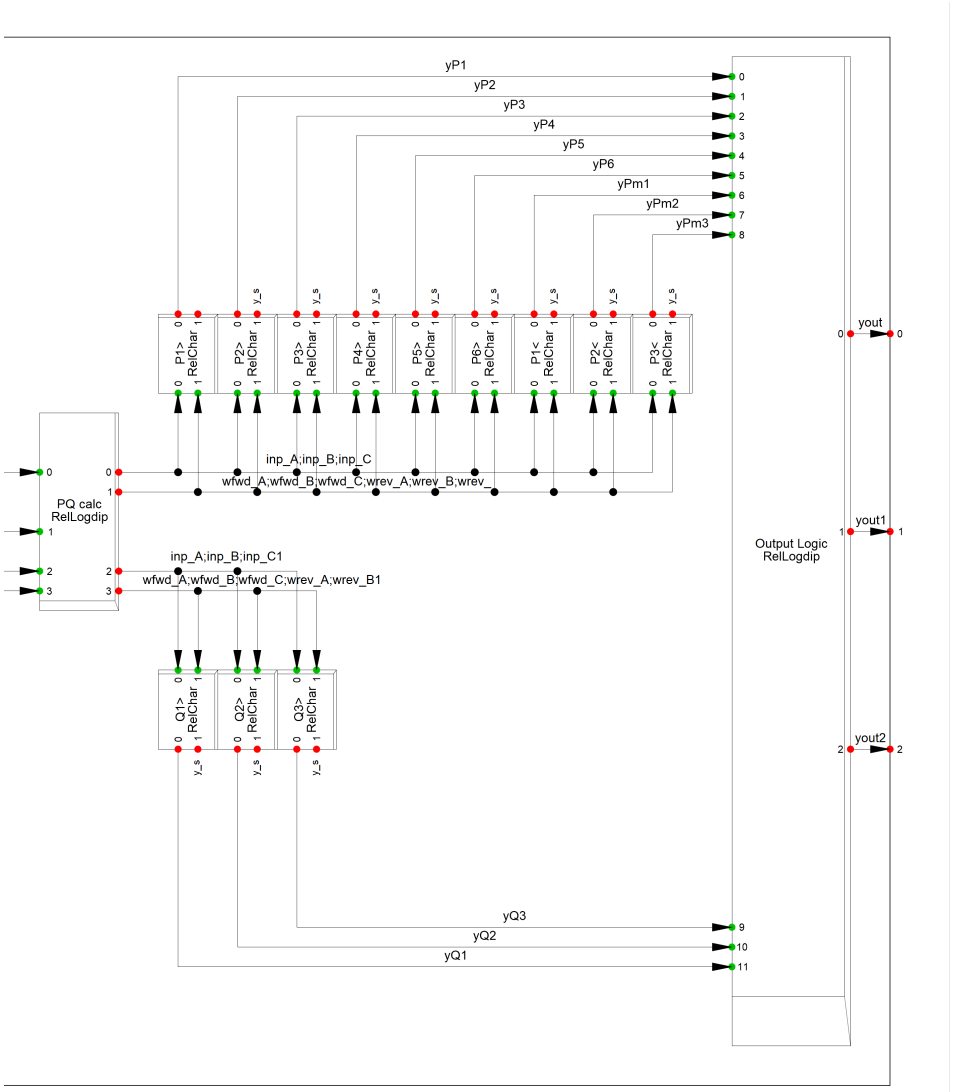


Figure 3.3: *DIgSILENT* Typical connection scheme of a three phase directional *Common Time Characteristic*“RelChar” block.

The available options present in the combobox must be set using the “Directional” combobox in the “TypChar” dialogue. Please keep in mind the follow rules:

- If the “Forward” direction is set the “fwd” signal (“fwd_A” or “fwd_B” or “fwd_C” for the 3phase version)must be activated to allow starting of the element.
- If the “Reverse” direction is set the “rev” signal (“rev_A” or “rev_B” or “rev_C” for the 3phase version)must be activated to allow starting of the element.
- If the “External” direction is set the “fwd” signal (“fwd_A” or “fwd_B” or “fwd_C” for the 3phase version)must be activated to allow starting of the element. The “rev” signal status is ignored (it can be disconnected). “External” makes the block direction dependent on an external “directional” block setting.

If the “External Starting” check box is set the block starting depends upon the status of the wstart

input signal: in the 3 phase version each phase works independently so the starting depends upon the status of the wstart_A, wstart_B, wstart_C input signals.

To control a *Common Time Characteristic*"RelChar" block with a reclosing element ("RelRecl" object) the following configuration must be used:

- the "iblock" input signal must be connected with the output signal of the reclosing element, where the reclosing element has been programmed to block (yblock_TOCx with $1 <= x <= 5$ or yblock_Logick with $1 <= k <= 16$) . Please read the"RelRecl" documentation for more details about the way to program a reclosing sequence.
- in the "TypChar" dialogue the "Recl. Feature" combobox must be selected to "Normal" or "Lockout". If "Normal" is selected a standard reclosing sequence is triggered, if "Lockout" is selected a trip of the *Common Time Characteristic*"RelChar" element puts the reclosing element in lockout status and no other reclosing is attempted. Please note that if "None" is the selected option in the "Recl. Feature" combobox no reclosing operation is attempted. This is also true if the *Common Time Characteristic*"RelChar" element "iblock" input is connected to a reclosing element. If a reclosing element is not present the iblock signal (in the 3 phase version also iblock_A, iblock_B and iblock_C to act on each phase) can be used by any other element to block the starting of the *Common Time Characteristic*"RelChar" element.

To get a input quantity threshold value reference from another block the following operation must be performed :

- Inside the "TypChar" dialogue set the "Ref. from" item with the link to the element from which the *Common Time Characteristic*"RelChar" element gets the reference value.
- Inside the "TypChar" dialogue set the "Range" unit equal to "p.u.". Please note that if one of the following units has been selected
  - "Sec.W" (for the *Active Power(P)*)
  - "Sec.Var" (for the *Reactive Power(Q)*)
  - "Sec.VA" (for the *Apparent Power(S)*
  - "Sec.V" (for the *Voltage*
  - "Hz" (for the *Frequency*)
  - "Hz/s" (for the *df/dt*)
  - "sec.V/Hz" (for the *V/Hz*)

  then the whole feature does not work and the *Common Time Characteristic*"RelChar" secondary threshold is used.

4 Logic

4.1 Single phase

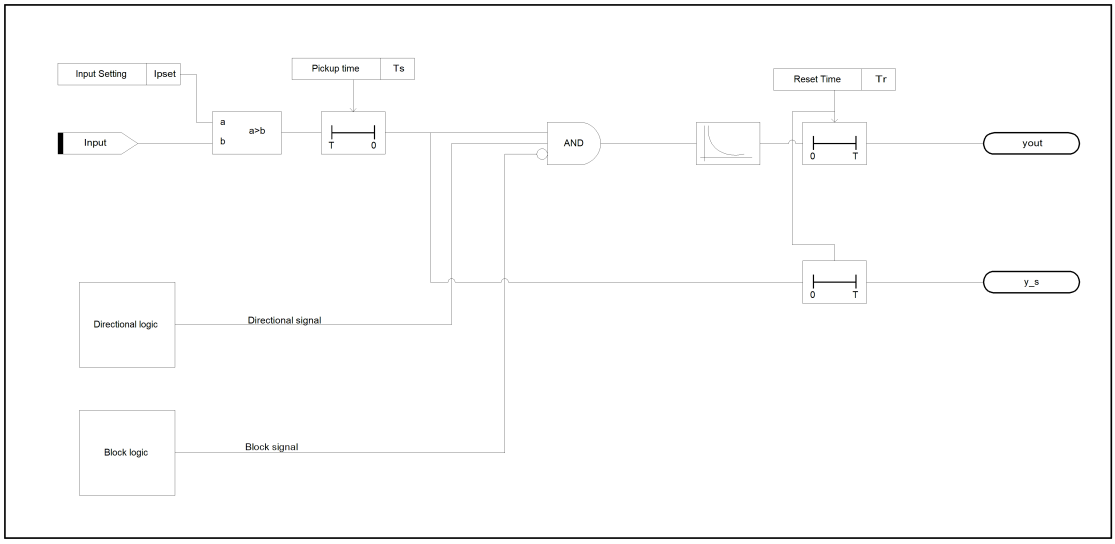


Figure 4.1: The *DIgSILENT Common Time Characteristic (RelChar) logic*

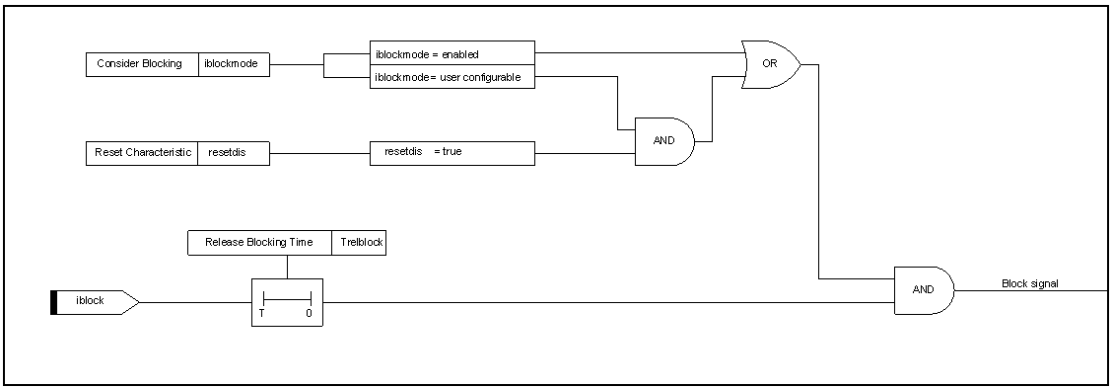
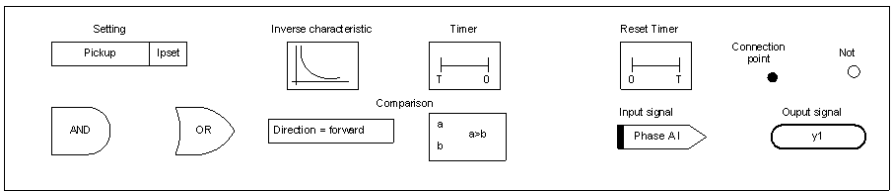


Figure 4.2: The *DIgSILENT Common Time Characteristic (RelChar) Block logic*



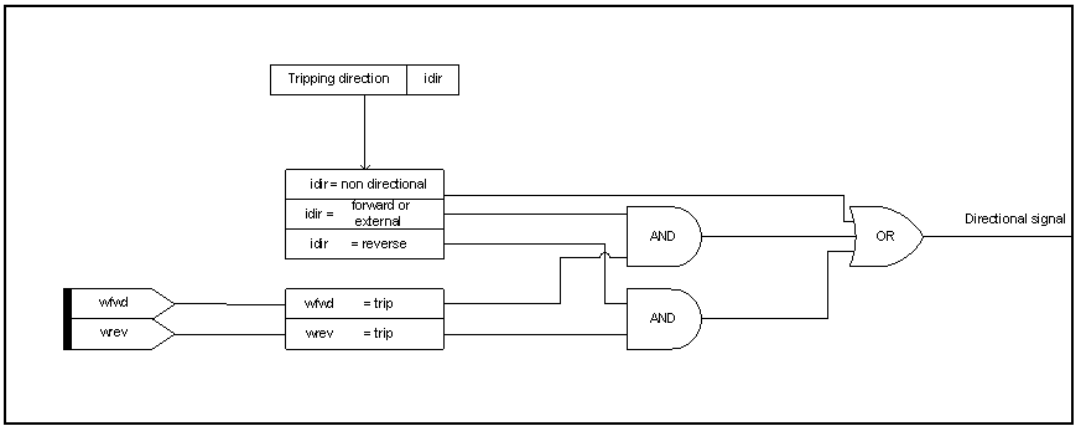
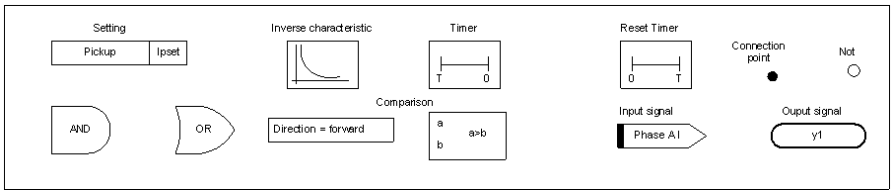


Figure 4.3: The *DIgSILENT Common Time Characteristic (RelChar) Directional logic*



4.2 3 phase

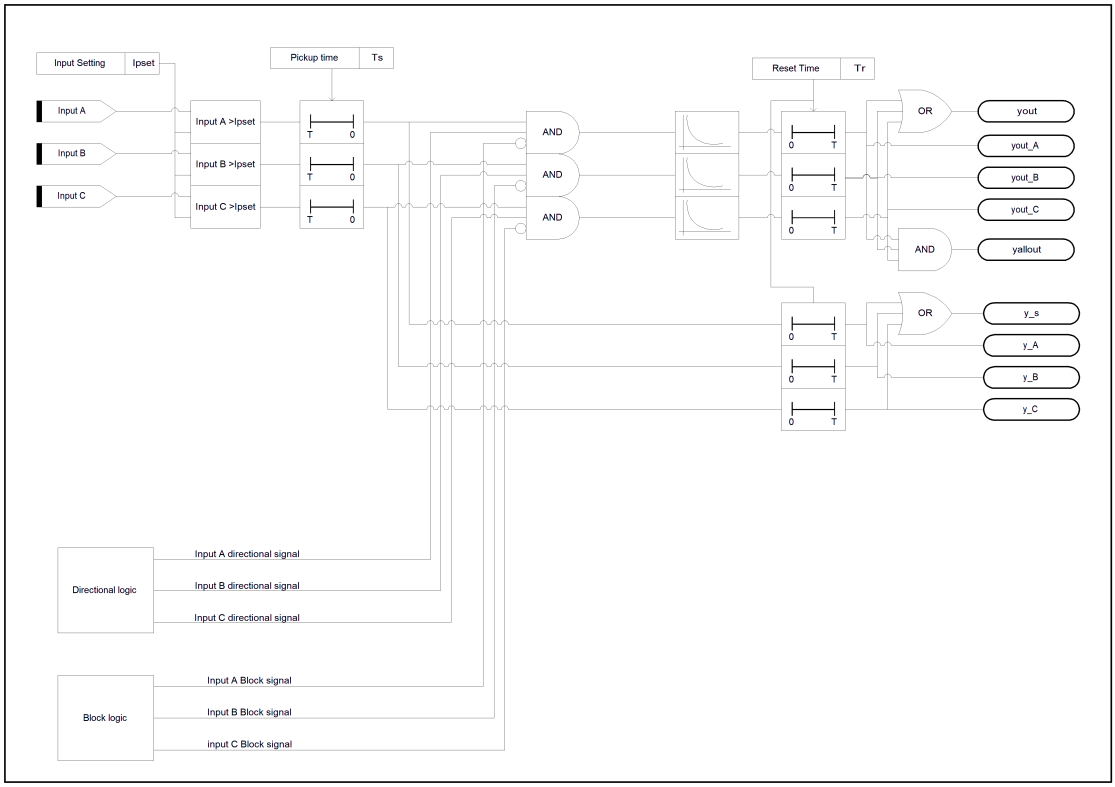
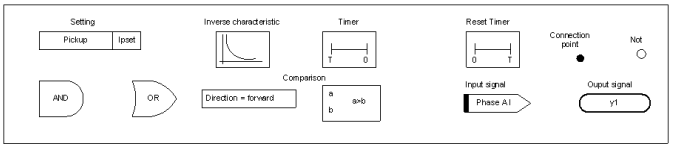


Figure 4.4: The *DIgSILENT Common Time Characteristic (RelChar) logic*



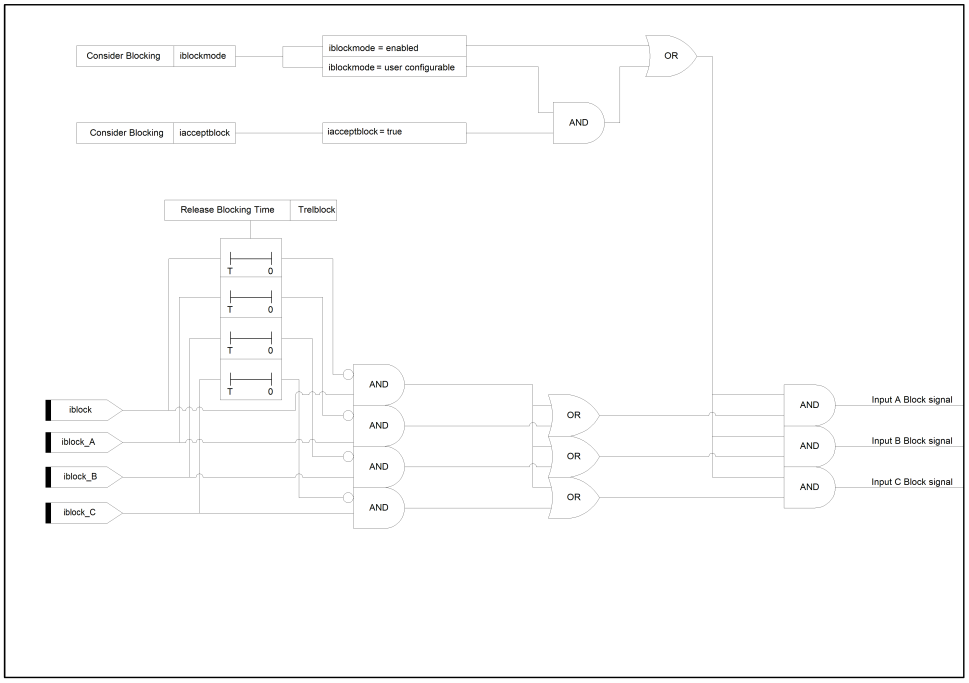


Figure 4.5: The *DIgSILENT Common Time Characteristic (RelChar) Block logic*

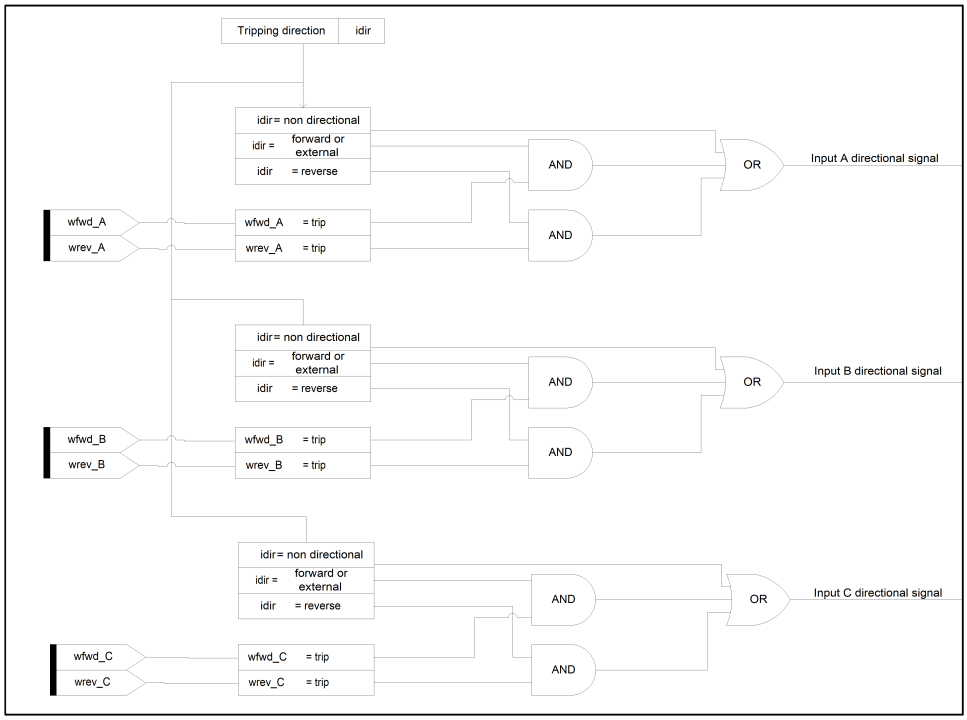
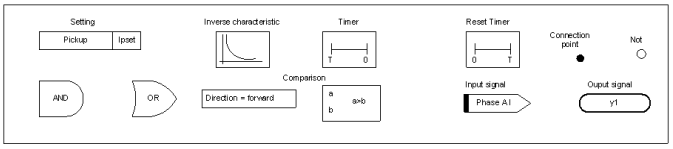


Figure 4.6: The *DIgSILENT Common Time Characteristic (RelChar) Directional logic*



4.3 Inverse characteristic trip time calculation

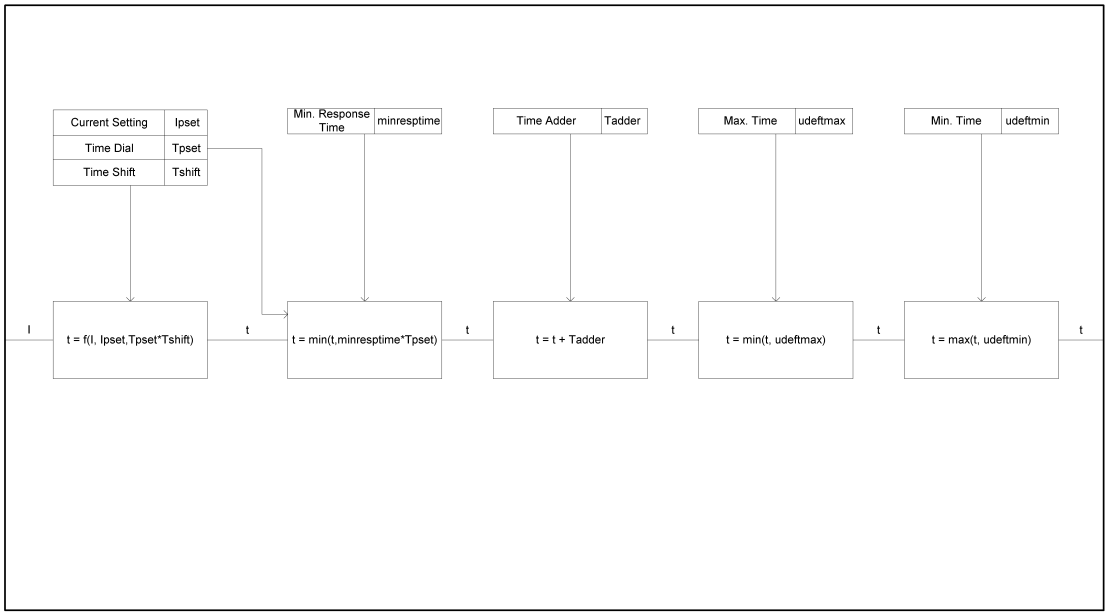


Figure 4.7: The *DIgSILENT Inverse characteristic trip time calculation logic*

A Parameter Definitions

A.1 Common Time Characteristic Type (TypChar)

Table A.1: Input parameters of Common Time Characteristic type (*TypChar*)

Parameter	Description	Unit
loc_name	Name assigned by the user to the block type	Text
sfiec	IEC symbol (I>>,IE>>,I2>>)	Text
sfansi	ANSI symbol (50,50N,46)	Text
itype	Block Type (*Active Power (P)*, *Reactive Power (Q)*, *Apparent Power (S)*, *Voltage*, *Frequency*, *df/dt*, *V/Hz*, *Three generic input quantity*, *A single input quantity*)	Integer
Irecltarget	Reclosing feature (None, Normal, Lockout)	Integer
inegout	Flag to set the element to act as an undercurrent element	Integer
idirpos	Directional available options (None, None/Forward, None/Forward/Reverse, Forward/Reverse,None/External,External)	Integer
iincTs	Are the timers including the pick up time?	Y/N
Iextstart	Is the block starting depending upon an external signal?	Y/N
pIref	Pointer to the block providing the input quantity reference(optional)	Pointer
rIpset	Range of the input quantity threshold	Text
iunit	Input quantity threshold unit (Sec. Amps, pu)	Integer
rTshift	Range of the Time Shift	Seconds
cpslayout	Flag to enable/disable the new controls added to support the US reclosers	Y/N
rTadder	Range of the time adder variable	Text
itaddunit	Time adder unit (Seconds, cycles)	Integer
rminresptime	Range of the minimum response time variable	Text
imrtunit	Minimum response time unit(Seconds, cycles)	Integer
pcharac	Vector of the available trip characteristic shapes	Vector
iresetconf	Reset configuration (available options “Enabled”, “Disabled”, “User configurable”)	Integer
Ts	Pick up time, i.e. the time spent measuring the input quantity in the load flow and short circuit calculation and in the RMS simulation	Seconds
Tr	Reset time, i.e. the delay with which the block reset the trip outputs after that the input quantity went below the trip threshold * Kr	Seconds
Kr	Reset ratio	Real
iinckbreakt	Flag: if it is “true” the clear curve definition already includes the breaker time operating time, so the breaker operating time is not added to the curve itself	Y/N
ienable	Flag to enable/disable the curve definition	Y/N
ishifter	Additive factor added to each input quantity value of the points belonging to the “Min trip” curve to generate the “Total clear” curve	pu or Sec.Amps
imultiplier	Multiplicative factor applied to each input quantity value of the points belonging to the “Min trip” curve to generate the “Total clear” curve	Real
imcunit	ishifter unit (pu or Sec.Amps)	Integer
tshifter	Additive factor added to each time value of the points belonging to the “Min trip” curve to generate the “Total clear” curve	Seconds or cycles
tmultiplier	Multiplicative factor applied to each time value of the points belonging to the “Min trip” curve to generate the “Total clear” curve	Real
tmcunit	tshifter unit (seconds or cycles)	Integer
iblockmode	How the input block signals is considered (*Ignored*, *Always considered*, *User configurable*)	Integer
rTrelblock	Range of the *Release Blocking Time* variable	Text

A.2 Common Time Characteristic Element (RelChar)

Table A.2: Input parameters of the Common Time Characteristic element (*RelChar*))

Parameter	Description	Unit
loc_name	Name assigned to the user to the block element	Text
Typ_id	Pointer to the relevant TypChar object	Pointer
outserv	Flag to put out of service the block	Y/N
idir	Tripping direction (None, external, forward, reverse the available options depend upon the idirpos value in the relevant TypChar object)	Integer
Ipset	Input quantity threshold in Amps	Sec Amps
Ipsetr	Input quantity threshold in pu	pu
Tpset	Time dial	Real
ResetT	Reset Delay	Seconds
udeftmin	Minimum Time	Seconds
udeftmax	Maximum Time	Seconds
Tshift	Time shifter	Seconds
pcharac	Trip characteristic shape	Vector
Modframe	Flag to enable the additional modifiers added to support the US reclosers	Y/N
Tadder	Time adder variable in seconds	Seconds
cTadder	Time adder variable in cycles	Cycles
minresptime	Minimum response time in seconds	Seconds
cminresptime	Minimum response time in cycles	Cycles
resetdis	Flag to enable/disable the reset characteristic (available only if the reset is “User configurable”, iresetconf variable in the TypChar class)	Y/N
calcuse	Flag to select which curve should be used to calculate the element tripping time. 0 = “Minimum trip curve”, 1= “Total time curve”	Integer
iacceptblock	Flag to enable/disable the ability to consider input block signal (available only if “Consider blocking”(“iblockmode” variable in the TypChar class) is “User configurable”)	Integer
Trelblock	Maximum time that the input block signals are considered	Seconds

B Signal Definitions

B.1 Single phase

Table B.1: Input/output signals of the single phase Common Time Characteristic element (*CalChar1p*)

Name	Description	Unit	Type	Model
inp	Input quantity		IN	Any
iblock	Blocking signal	Seconds(or 1/0 RMS/EMT simulation)	IN	Any
wfwd	Forward signal	Seconds(or 1/0 RMS/EMT simulation)	IN	Any
wrev	Reverse signal	Seconds(or 1/0 RMS/EMT simulation)	IN	Any
wstart	External starting signal (available only if iextstart = 1 in TypChar)	Seconds (or 1/0 RMS/EMT simulation)	IN	Any
yout	Trip signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
y_s	Start signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any

Table B.2: Single phase Common Time Characteristic element state variables

Name	Description	Unit
xl	Integrated input quantity (1 = trip)	Real

B.2 3 phase

Table B.3: Input/output signals of 3 phase Common Time Characteristic element (*CalChar*)

Name	Description	Unit	Type	Model
Inp_A	Phase A input quantity		IN	Any
Inp_B	Phase B input quantity		IN	Any
Inp_C	Phase C input quantity		IN	Any
iblock	Blocking signal	Seconds (or 1/0 RMS/EMT simulation)	IN	Any
iblock_A	Phase A Blocking signal	Seconds (or 1/0 RMS/EMT simulation)	IN	Any
iblock_B	Phase B Blocking signal	Seconds (or 1/0 RMS/EMT simulation)	IN	Any
iblock_C	Phase C Blocking signal	Seconds (or 1/0 RMS/EMT simulation)	IN	Any
wfwd_A	Phase A forward signal	Seconds (or 1/0 RMS/EMT simulation)	IN	Any
wfwd_B	Phase B forward signal	Seconds (or 1/0 RMS/EMT simulation)	IN	Any
wfwd_C	Phase C forward signal	Seconds (or 1/0 RMS/EMT simulation)	IN	Any
wrev_A	Phase A reverse signal	Seconds (or 1/0 RMS/EMT simulation)	IN	Any
wrev_B	Phase B reverse signal	Seconds (or 1/0 RMS/EMT simulation)	IN	Any
wrev_C	Phase C reverse signal	Seconds (or 1/0 RMS/EMT simulation)	IN	Any
wstart_A	Phase A external starting signal (available only if iextstart = 1 in TypChar)	Seconds(or 1/0 RMS/EMT simulation)	IN	Any
wstart_B	Phase B external starting signal (available only if iextstart = 1 in TypChar)	Seconds(or 1/0 RMS/EMT simulation)	IN	Any
wstart_C	Phase C external starting signal (available only if iextstart = 1 in TypChar)	Seconds(or 1/0 RMS/EMT simulation)	IN	Any
yout	Trip signal (any phase)	Seconds (or 1/0 RMS/EMT simulation)	OUT	Any
yout_A	Phase A trip signal	Seconds (or 1/0 RMS/EMT simulation)	OUT	Any
yout_B	Phase B trip signal	Seconds (or 1/0 RMS/EMT simulation)	OUT	Any
yout_C	Phase C trip signal	Seconds (or 1/0 RMS/EMT simulation)	OUT	Any
yallout	All phases trip signal	Seconds (or 1/0 RMS/EMT simulation)	OUT	Any
y_s	Start signal (any phase)	Seconds (or 1/0 RMS/EMT simulation)	OUT	Any
y_A	Phase A start signal	Seconds (or 1/0 RMS/EMT simulation)	OUT	Any
y_B	Phase B start signal	Seconds (or 1/0 RMS/EMT simulation)	OUT	Any
y_C	Phase C start signal	Seconds (or 1/0 RMS/EMT simulation)	OUT	Any

Table B.4: 3 phase Common Time Characteristic element state variables

Name	Description	Unit
xl_A	Phase A integrated quantity (1 = trip)	Real

Table B.4: 3 phase Common Time Characteristic element state variables

Name	Description	Unit
xI_B	Phase B integrated quantity (1 = trip)	Real
xI_C	Phase C integrated quantity (1 = trip)	Real

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