EUROPROT+

Distributed busbar differential and breaker failure protection

PROTECTA HUNGARY

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User's manual version information

Version	Date	Modification	Compiled by
Preliminary	2011-10-11	Preliminary version	Petri
V1.0	2011-11-18	V1.0 with technical information	Petri
V1.1	2016-09-30	**Added**: • description of the Disable, Signal1, Signal2, TestMode, BFPTrip binary status inputs and/or binary output status signals • 4 Setting of the communication **Modified**: • Parameter ranges of k Zone, k checkzone, k CT failure, Max.I_load parameters • Minor corrections	Seida

CONTENTS

1 Distributed busbar differential protection function and breaker failure protection

Protecta provides two different types for busbar protection. Both of them perform basically the well-known principle: the sum of the currents flowing into and out of the busbar results zero, if there are no internal faults. If the sum is not zero then there is an internal fault, and a fast trip command is generated. The scheme in both versions is the low impedance, biased differential scheme, the application of Kirchhoff`s node law.

The difference between the two types is the structure of the differential protection system:

- Centralized version:
    - If the number of bays connected to the busbar is limited (there are not more bays than 6) the tasks related to the three-phase busbar differential protection function are performed within one device.
    - With increasing number of the bays the tasks are divided among three independent devices. Each of them is responsible for the differential protection of one phase (L1, L2 or L3) of the busbar. This version can be considered also as a centralized version.

- Distributed (Decentralized) version:
    - In this version other individual protective devices of the bays (e.g. distance protection, overcurrent protection, etc., but also dedicated bay units can perform the related tasks) are involved in the busbar protection scheme. They are located in the substation according to the bay structure of the primary system. These devices perform the sampling of the currents and have access to all information needed for the busbar protection system. This information is sent by fiber optic link to the central unit. The calculation and decision is performed by the central unit, and the dedicated trip commands are sent back to the devices also via fiber optic links.

This description contains the details of the distributed version; the centralized version is described in a separate document.

The numerical protection integrates two independent protection functions:
- numerical differential protection,
- breaker failure protection.

The joint discussion of these functions is based on the fact that the breaker failure protection utilizes the processed status information of the busbar protection to disconnect only the section of the busbar to which the faulty circuit breaker is connected. So the other zones can remain in continuous service.

2 Distributed numerical busbar differential protection

In this version other individual protective devices of the bays (e.g. distance protection, overcurrent protection, etc.) are involved in the busbar protection scheme. They are located in the substation according to the bay structure of the primary system. These devices perform the sampling of the currents and have access to all information needed for the busbar protection system. This information is sent by fiber optic link to the central unit. The calculation and decision is performed by the central unit, and the dedicated trip commands are sent back to the devices also via fiber optic links.

2.1 Main features of the distributed numerical busbar differential protection

The main features of the busbar differential protection function can be summarized as follows:

- The function is performed within one central device, but the analog currents and status signals from all bays of the busbar are accessed by protection devices dedicated to the bay;
- The bay units can perform any other protection functions, but they communicate binary information and sampled values with the device via fiber optic links;
- Dynamic busbar replica, based on disconnector status signals;
- High stability in case of external faults in spite of current transformer saturation;
- Short tripping time;
- Selectivity for internal fault, only the bays connected to the faulty busbar section are disconnected, all other bays remain in continuous operation;
- Easily to extend according to the busbar configuration;
- Easy adaptation of the function for different primary bus systems:
    - Single busbar,
    - Up to quadruple busbar,
    - Ring bus,
    - 1 ½ circuit breaker arrangement,
    - Bus couplers,
    - Bus sectionalizers with one or two current transformers,
    - Transfer bus;
- Individual numerical calculation and decision for all three phases;
- Stabilized differential current characteristics;
- The security and stability are increased with special software methods;
- Voltage breakdown condition,
- Check zone application (details see below),
- Saturated waveform compensation,
- Directionality check,
- Current transformer failure detection,
- Checking the disconnector status signals,
- Included breaker failure protection.

2.2 The configuration of the function

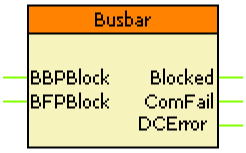
In the distributed version, the functionality of the busbar differential protection function is performed in co-operation of one central unit and of several bay units.

2.2.1 The applied function blocks in the central device

In the factory configuration process, the required software function blocks are configured. The applied functions blocks in the central device are as follows:

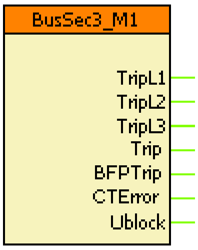
1. **"Busbar" function block**: this performs the organization of the busbar protection system, and also the numerical calculations and decisions are performed in this module. Based on the disconnector status information, received from the bus sections, "Measuring elements" are composed. A "Measuring element" processes all currents, which flow into or out of the interconnected bus sections. Accordingly, the number of the processed "Measuring elements" can be the number of the individual bus sections, as a maximum; or there can be less "Measuring elements", if some bus sections are interconnected with each other.

   The busbar protection function always contains one "Busbar" function block. Its task is also to process the parameters of the busbar protection function. The symbol of the "Busbar" function block, as it appears in the graphic logic editor, is as follows.

   Programming the inputs of the "Busbar" block, the busbar protection and/or the breaker failure protection functions can be enabled or disabled.

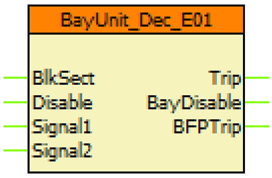
2. **"Bus section" function blocks**: the number of these blocks coincides with the maximum number of the bus sections. Up to 12 sections can be included. The task of this function block is to process the status signals, and to send them to the "Busbar" block to form the "Measuring elements". (The "Measuring element" performs the algorithm for the interconnected busbar sections, as it is described in Chapter 2.3.2.) The symbol of the "Bus section" function block, as it appears in the graphic logic editor, is as follows.

3. **"Bay unit" function blocks**: the number of these blocks coincides with the number of the bays in the substation. The task of this block is to receive all information from the distributed bay unit protection devices of the bay via fiber optic channels:
   - Sampled values of three currents,
   - Status signals of the disconnectors: these signals are received with dual signals (disconnector open and diconnector closed). Up to 4 disconnectors can be configured to a physical bay,
   - Status signal for the voltage break-down condition,
   - Breaker failure signal from the bay protection.

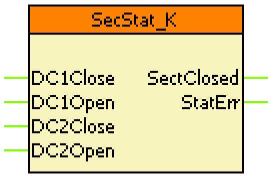
   This block passes the trip command to the circuit breaker via the protection device related to the bay. It can send also two user defined binary signals to the bay devices. „Signal1" and „Signal2" binary input signals of the function serve this purpose.

The symbol of the “Bay unit” function block, as it appears in the graphic logic editor, is as follows.



The “BlkSect” blocking input signal disables the operation of the “Measuring element”, to which this bay is dynamically assigned. The bay unit itself can be disabled with the “Disable” binary input signal (it has the same effect as the Bay disable Boolean parameter).

4. **“Sectionalizer unit” function blocks**: These blocks serve mapping the sectionalizer bays, the bays which interconnect bus sections with disconnectors. These blocks receive up to two disconnector status signals.



Appendix I describes the configuration process which can be performed by the user with “Master” access level. This appendix shows also application examples for some frequent practical cases.

For the configuration the central device parameter values are needed; these parameter values are to be set in the central device for the bays individually.

Enumerated parameters for the distributed busbar differential protection function, bay unit are listed in *Table 2-1*. They are to be set for the bays individually. In the parameter names “xxx” is different for each connected bays:

Parameter name	Title	Selection range	Default
Rated secondary current of the current transformer in the bay			
BayUnit_Nom_EPar_	Rated Secondary	1A,5A	1A
Parameter for positive direction of the current, indicated as the location of the grounded point of the three current transformers in the bay			
BayUnit_Dir_EPar_	Starpoint I1-3	Line,Bus	Line

Table 2-1 The enumerated parameter of the distributed busbar differential protection function, bay unit

Boolean parameter for the distributed busbar differential protection function, bay unit is shown in *Table 2-2*:

Parameter name	Title	Default	Explanation
Disabling the bay			
BayUnit_BayDisable_BPar_	Bay Disable	0	0 means enabling; 1 means that the current values and the status signals received from the bay are not considered (to be applied for maintenance purposes).

Table 2-2 The Boolean parameters of the distributed busbar differential protection function, bay unit

Integer parameter for the distributed busbar differential protection function, bay unit is shown in *Table 2-3*:

Parameter name	Title	Unit	Min	Max	Step	Default
Rated primary current of the current transformer in the bay						
BayUnit_CTNom_IPar_	CT nominal	A	100	10000	1	1000

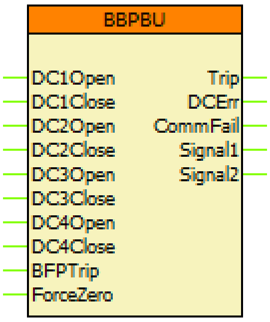
Table 2-3 The integer parameter for the "Max.I_load" calculation

2.2.2 The applied function blocks in the bay device

In the factory configuration process, the required software function blocks are configured. The applied functions blocks in the bay device are as follows:

"Busbar bay unit" function block: This block is the "interface" between the power technology (measuring transformers, disconnector status signals, circuit breaker trip commands) and the busbar protection function in the central device. In the bay device it receives the disconnector status information, the breaker failure signal from the protection function (according to the graphic assignment), and a special signal (ForceZero input) to exclude the measurements from the evaluation. This last input is used for buscoupler bays for correct handling of dead zone faults.

If the bay protection is to be involved in the busbar protection scheme, this function block is mandatory. The busbar protection function in the central device always contains one "Busbar" function block. Its task is also to process the parameters of the busbar protection configuration received from the "Busbar bay unit" function blocks. The symbol of the "Busbar bay unit" function block, as it appears in the graphic logic editor, is as follows.



In the "background" this block samples the assigned phase currents and voltages, and sends them, together with the status information to the central device via fiber optic network.

2.3 Method of operation for the busbar protection function

2.3.1 The busbar replica evaluation

The algorithm is processed in the central device.

The algorithm continuously evaluates the status signals of the disconnectors and if there are changes in the status signals then based on the received signals the algorithm performs "configuration", which means determination of the busbar replica of the substation and an assignment of "Measuring elements" to each interconnected bus sections.

NOTE: if bus sections are interconnected with each other then only one of the assigned measuring elements performs the calculation and the results are passed to all other inactive measuring elements of interconnected bus sections. It means that the on-line displayed values will be the same for these bus sections.

2.3.2 The protection algorithm

The bay units perform synchronous sampling of all analog signals and send them to the central device. These values are used by the assigned "Measuring elements" of the central unit. The "Measuring elements" perform the following tasks:

2.3.2.1 The differential current calculation

The method of the differential current calculation is as follows:

- Summation of the sampled I_p momentary current values for the bays connected to the "Measuring element". The result is the calculated momentary value of the differential current:

$$I_{d.p} = \sum I_p$$

- Filtering the current DC component by subtracting the value sampled 10 ms before from the actual value, and the difference is divided by two. The result is the calculated momentary value of the differential current without the DC component.

$$I_{d.p1} = \frac{I_{d.p} - I_{d.p-10ms}}{2}$$

- The magnitudes of the ten last calculated values are averaged, receiving the *Id* trip current. The result is the "rectified average" of the differential current. (The method is the numerical realization of the measuring principle of the Depres measuring instruments.)

$$Id = \frac{\sum_{n=1}^{10} \left| I_{d.pn} \right|}{10}$$

2.3.2.2 The biasing current calculation

The method of the biasing current calculation is as follows:

- From the absolute value of the sampled I_p momentary current values a predetermined "$Max.I\_load$" current peak value, determined with parameter setting is subtracted:

$$\left|I_p\right| - Max.I\_load$$

Here $Max.I\_load$ is a parameter setting, the proposed value of it is the expected maximum load current value of all bay currents. The result is that in normal operation, when all bay currents are below the maximum load current, the calculated values get negative.

- Out of these differences only the values above 0 (if $(\left|I_p\right| - Max.I\_load) > 0$) are summed

$$I_{s.p} = \sum(\left|I_p\right| - Max.I\_load)$$

The differences can be positive only if there are currents above the maximum load values, i.e. there is a fault (either external or internal of the busbar).

- Then the average of this value and that received 10 ms before is calculated:

$$I_{s.p1} = \frac{I_{s.p} + I_{s.p-10ms}}{2}$$

- The last ten calculated values stored in the memory are averaged, receiving the Is biasing current:

$$Is = \frac{\sum_{n=1}^{10} I_{s.pn}}{10}$$

2.3.2.3 The differential characteristics

The trip characteristic for a measuring element is shown in *Figure 2-1*.

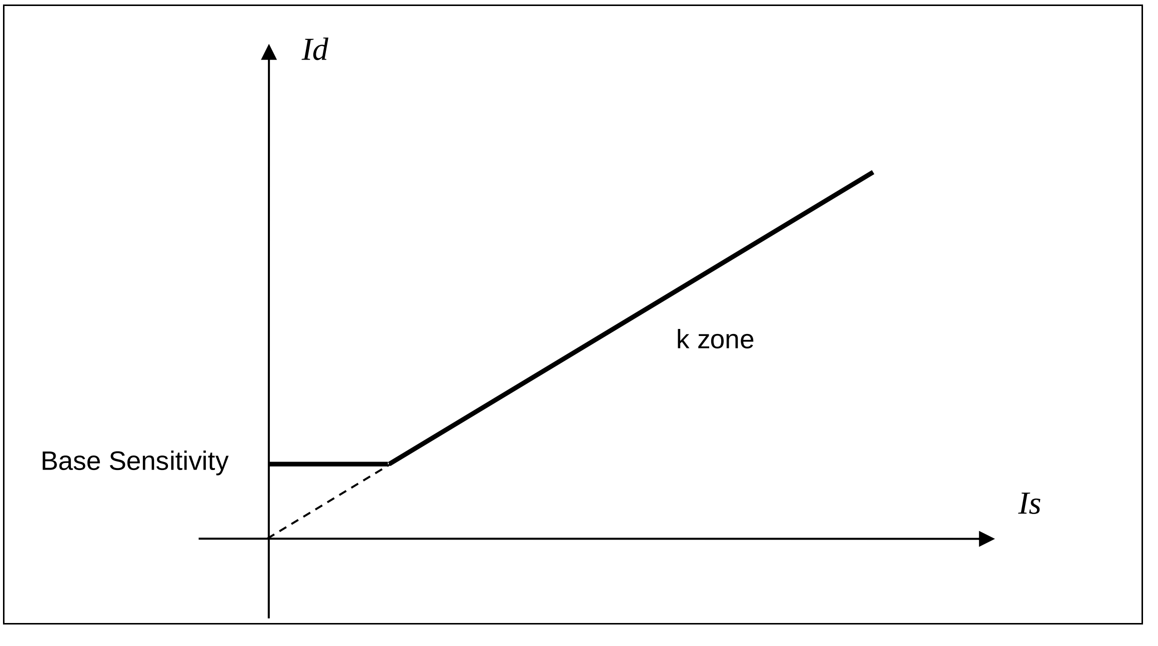


Figure 2-1The trip characteristic of the busbar differential protection

Integer parameters of the differential characteristics are listed in *Table 2-4*.

Parameter name	Title	Unit	Min	Max	Step	Default
Differential protection trip characteristic, base sensitivity						
Busbar_ZoneSens_IPar_	Base Sensitivity	(primary) A	100	10000	1	1000
Differential protection trip characteristic, slope*						
Busbar_ZoneK_IPar_	k zone*	%	40	90	1	60

** NOTE: In case of detected through fault, the slope of the characteristic is dynamically changed to 90%. This fact has to be considered when the characteristic is tested with through faults.*

Table 2-4 The integer parameters of the differential characteristics

Enumerated parameter to enable the differential protection is shown in *Table 2-5*.

Parameter name	Title	Selection range	Default
Parameter to enable the centralized busbar differential protection function:			
Busbar_BBPOper_EPar__	Operation	Off, On	Off

Table 2-5 Enabling the operation of the differential protection function

2.3.3 Role of the maximum current setting ("*Max.I_load*") for normal operation

There are two main requirements for the busbar differential protection:

- In case of busbar fault the operation shall be fast;
- In case of external faults the protection must be stable; no trip command may be generated.

Subtracting the "*Max.I_load*" value from all current samples serves both these aims. In normal operation all current samples are expected to be below this setting value, which is to be the maximum possible current peak value. Consequently in normal operation the bias current is zero.

If in this state an internal fault occurs then the current samples get very fast above "*Max.I_load*" value. Consequently the locus of the Id-Is points on the plane of the differential characteristics (*Figure 2-1*) is at once above the broken line described by the slope "k" (parameter setting "*k_zone*") and the base sensitivity (parameter setting "*Base Sensitivity*"). In this case the trip command needs a few checking points only, the trip command can be fast.

In case of external fault however, the locus of the Id-Is points on the plane of the differential characteristics (*Figure 2-1*) start moving in the direction of the Is axis. If the algorithm recognizes this movement, i.e. the locus is below the line described by the slope "k" then the number of the required check points gets a high value. This extended checking period does not permit trip command generation during the time period, when the iron core of the overloaded current transformer gets saturated, and it cannot deliver proportional secondary current for the measurement. (Additionally to this method, the "saturated waveform compensation" is another means to avoid unwanted trip generation; See Chapter 2.3.6.)

The required parameter setting is described in the table below:

Integer parameter for the offset setting is shown in Table 2-6.

Parameter name	Title	Unit	Min	Max	Step	Default
Maximum load current						
Busbar_Offset_IPar_	Max.I_load*	(primary) A	100	10000	1	1000

** NOTE: This parameter value should not be higher than the “Base sensitivity” of the differential characteristics. In case of wrong setting the top left LED on the front panel of the device gets yellow, indicating a warning.*

Table 2-6 The integer parameters of the “Max.I_load” calculation

2.3.4 Voltage breakdown condition

In case of current transformer circuit error, the missing current from any of the bays, the measuring element detects current difference. This could result a trip command to the bus section. To prevent this kind of operation error, the trip command is released only if in the affected bus section the voltage collapses.

To perform this supervision, the presence of the voltage is monitored with a quick voltage measuring function. The result of the supervision is considered in every millisecond. If before increasing the current, the voltage is in the range of the normal operating voltage (above approximately 0.6Un), and then during a fault any of the phase voltages is below 0.6Un, the function enables the operation of the differential protection function. If the currents fulfill the differential criteria, the algorithm generates a trip command.

If the differential protection function started and any of the bay units received trip command then this voltage condition does not play any role. The trip command resets only if the currents are outside the tripping zone of the characteristics.

A voltage monitoring function can allow trip command only for 0.5 s, then the function is disabled until the measured voltage returns to healthy state again, or a new initializing is performed (caused by disconnector status change, switching on or off, parameter changes).

If all voltage monitoring functions assigned to a measuring element detect low voltage then the bus-bar section is considered to be disconnected, and the operation of the bus-bar differential protection is enabled again (to cover the switch-on-to-fault condition).

If the trip command is disabled by the voltage condition then the “On-line” screen of the connected PC displays the status signal as “U>disable: +“. If one or more voltage supervisions detect low voltage then the display changes form “+“ to “-”. At that moment a 0.5s timer is started, and when it expires then the operated voltage supervision function is disabled. As a consequence the signal shows “+“ again.

The parameters for the voltage breakdown condition are fix values, the function does not need any parameter setting.

2.3.5 The check zone

If any of the status signals received from the bays is wrong then the false operation based on this wrong signal could disconnect the bus section. To avoid this kind of errors the “check zone” is applied. This additional “check zone measuring element” supposes the whole busbar system as a single node. It gets all current samples from the bays (except those sampled from the current transformers connecting bus sections; this is to be selected in the process of the topology configuration by the user with “Master” access rights) and adds them all to get the check zone differential current. The individual measuring elements can generate a trip command only if also the “check zone measuring element” detects an internal busbar fault. The check zone operation must be enabled by the binary parameter *“CheckZone”*.

The parameters of the “check zone measuring element” are similar to those of the individual measuring element, but the values can be set independently.

The parameters of the check zone differential characteristics are listed in the tables below.

Integer parameters of the check zone differential characteristics are listed in *Table 2-7*.

Parameter name	Title	Unit	Min	Max	Step	Default
Checkzone characteristic, base sensitivity						
Busbar_CheckSens_IPar_	CheckZone Sens.	(primary) A	100	10000	1	1000
Checkzone characteristic, slope						
Busbar_CheckK_IPar_	k checkzone	%	40	90	1	60

Table 2-7 The integer parameters of the check zone differential characteristics

Enumerated parameter to enable the check zone supervision is shown in *Table 2-8*.

Parameter name	Title	Selection range	Default
Parameter to enable the supervision by the “check zone”			
Busbar_CheckOper_EPar_	CheckZone Operation	Off, On	Off

Table 2-8 Parameter to enable the check zone supervision

2.3.6 Saturated waveform compensation

In case of external fault, with the exception of the faulty bay, all bays deliver currents towards the busbar. The sum of these currents flows through the current transformer of the faulty bay. Consequently this current can be extremely high, which can saturate the iron core of this current transformer. The shape of this secondary current gets distorted, and the “missing” section of the wave-shape is a differential current.

To prevent unwanted operation of the busbar differential protection function for these external faults, there are several remedies. One of them is the “saturated waveform compensation”. When saturation is detected, the algorithm “keeps” the detected current peak till the end of the half period, decreasing the chanche for the false trip decision.

This method does not need any special parameter setting.

2.3.7 Directionality check

In case of internal fault all bays deliver currents towards the busbar. In case of external fault however, with the exception of the faulty bay, all bays deliver currents towards the busbar, and the current of the faulty bay flows out of the busbar. When considering this basic difference, the stability of the busbar differential protection can be improved by “directionality check”.

The busbar differential protection algorithm compares the sign of all current samples in a “measuring element”. If during the majority of the samples one of the currents shows opposite sign, indicating opposite direction, then this fact prevents generation of the trip command.

2.3.8 Current transformer failure detection

If the current transformers do not deliver correct currents for the evaluation then the correct decision of the busbar differential protection is not possible.

The currents are continuously supervised also during normal operation of the system, when the currents are below the operation level of the differential protection. If in this state any of the currents is missing then a relatively high differential current is measured (which is still not sufficient to operate the differential protection). The algorithm performs the current supervision based on a similar characteristic as the trip characteristic, which has a sensitive base *(„CT failure Sens")* and a slope *(„k CT failure")* setting. (See also *Figure 2-1*) These have to be set below the trip characteristic, of course.

If the measured currents result an Id–Is point above this characteristic, then after a time delay set by the *„CT failure Delay"* paremeter, the "measuring element" gets blocked.

Integer parameters for current transformer failure detection are shown in *Table 2-9*.

Parameter name	Title	Unit	Min	Max	Step	Default
CT error detection, base sensitivity						
Busbar_CTErrSens_IPar_	CT failure Sens.	A	50	5000	1	500
CT error detection, slope						
Busbar_CTErrK_IPar_	k CT failure	%	40	90	1	60

Table 2-9 The integer parameters of the current transformer failure detection

Timer parameter for current transformer failure detection is shown in *Table 2-10*.

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for signaling CT error						
Busbar_CTErrDelay_TPar_	CT failure Delay	msec	100	60000	1	1000

Table 2-10 The timer parameters of the current transformer failure detection

2.3.9 Checking the disconnector status signals

The actual configuration of the busbar (interconnected or separated bus sections and the connection of the bays to the bus sections) is evaluated using status signals of the disconnectors. The status of each disconnectors is characterized by dual signals: "Disconnector open" and "Disconnector closed". Only one of them can be true and one of them can be false at the same time. This function checks these status signals, and performs the decision based on parameter setting.

In normal operation when receiving faulty status signals from the disconnectors the device keeps the previous state for a time period defined by parameter setting "BadState Delay". After this time delay the reaction of the algorithm depends on the setting of the dedicated enumerated parameter. If the setting of the "BadState Tolerate" is true, then the operation neglects the faulty status signal, and the last valid status is kept. In case of setting "BadState Tolerate" parameter to "false", the "measuring element" gets blocked.

If the status error is detected after energizing or following parameter changes, the protection remains disabled until the faulty status is corrected, and generates "Blocked" status signal and event.

Enumerated parameter for checking the disconnector status signals is shown in *Table 2-11*.

Parameter name	Title	Selection range	Default
Toleration of the disconnector status signal errors			
Busbar_BadTol_EPar_	BadState Tolerate	Off, On	Off

Table 2-11 The enumerated parameter for checking the disconnector status signals

Timer parameter for checking the disconnector status signals in the central device is shown in *Table 2-12*.

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for signaling bad state						
Busbar_BadDelay_TPar_	BadState Delay*	msec	100	60000	1	1000

** This parameter is applicable only if the central unit receives the status signals of the busbar sectionalizers. If the busbar configuration includes more than one sectionalizer then this parameter is common for all of them.*

Table 2-12 The timer parameters for checking the disconnector status signals in the central device

In each bay device there is also a timer parameter needed for checking the disconnectors, monitored by the bay device:
Timer parameter for checking the disconnector status signals in the bay device is shown in *Table 2-13*.

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for signaling bad state						
BBPBU_BadDelay_TPar_	BadState Delay	msec	100	60000	1	1000

Table 2-13 The timer parameters for checking the disconnector status signals in the bay device

2.4 Measured values

For each bays the device displays one phase current. * The reference vector selection depends on the factory configuration.
Table 2-14 shows as an example the current of a bay.

Measured value	Dim.	Explanation
Current Ch - I1	(secondary) A	Phase current L1, Fourier base component
Angle Ch - I1	deg*	Phase angle of the current in L1
		The measurement is repeated for each bay

** The reference vector selection depends on the factory configuration.*

Table 2-14 The measured analogue currents of the centralized busbar differential protection function (example)

For each bus sections the device measures and displays the differential currents and the bias currents per each phases. *Table 2-15* shows as an example the currents of a bus section. (If the bus sections are interconnected with each other then the displayed values are the same of the interconnected sections.)

Measured value	Dim.	Explanation
I Diff L1	(primary) A	Differential current L1, Fourier base component
I Diff L2	(primary) A	Differential current L2, Fourier base component
I Diff L3	(primary) A	Differential current L3, Fourier base component
I Bias L1	(primary) A	Bias current L1, Fourier base component
I Bias L2	(primary) A	Bias current L2, Fourier base component
I Bias L3	(primary) A	Bias current L3, Fourier base component
		The measurement is repeated for each bus section

Table 2-15 The measured analogue currents of the centralized busbar differential protection function (example)

Note: The evaluated basic harmonic values of the measured input phase currents help the commissioning of the distributed busbar differential protection function.

3 The breaker failure protection function

After a protection function generates a trip command, it is expected that the circuit breaker opens and the fault current drops below the pre-defined normal level.

If not, then an additional trip command must be generated for all backup circuit breakers to clear the fault. At the same time, if required, a repeated trip command can be generated to the circuit breaker(s) which are expected to open.

The breaker failure protection function can be applied to perform this task.

3.1 Breaker failure protection function in the central device

The breaker failure protection in the central device does not need any extra configuration.

In the central device there is only one parameter related to the breaker failure protection function:

Enumerated parameter for the breaker failure protection function for enabling or disabling the operation in the central device is shown in *Table 3-1*.

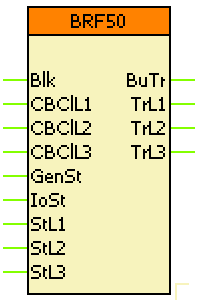
Parameter name	Title	Selection range	Default
Parameter to enable the trip command processing in the breaker failure protection function in the bay			
Busbar_BFPOper_EPar_	Intertrip Operation	Off, On	Off

Table 3-1 Enabling the operation of the breaker failure protection function in the central device

All other parameters are set in the bay devices.

3.2 Breaker failure protection function in the bay devices

"Breaker failure unit" function block: This block is identical to the BFP function block used in the EP+ protection devices. The backup trip output (BuTr) shall be connected to the BFPTrip input of the BBPBU function block of the bay unit, which sends this signal to the central unit. The breaker failure trip signal arriving from the central unit is factory connected to the TRIP module of the bay unit.



The breaker failure protection function needs parameters related to the bays individually.

These parameters are as follows:

Enumerated parameters for the breaker failure protection function, bay modules are listed in *Table 3-2*:

Parameter name	Title	Selection range	Default
Enabling the bay to participate in the breaker failure protection function			
BRF50_Oper_EPar__	Operation	Off,Current,Contact,Current/Contact	Off
Enabling the repeated trip command in the bay itself			
BRF50_ReTr_EPar__	Retrip	Off,On	Off

Table 3-2 The enumerated parameter of the breaker failure protection function, bay devices

Integer parameters for the breaker failure protection function, bay modules are listed in *Table 3-3.*

Parameter name	Title	Unit	Min	Max	Step	Default
Phase current condition for the breaker failure protection function						
BRF50_StCurrPh_IPar_	Start Ph Current	%	20	200	1	30
Residual current condition for the breaker failure protection function						
BRF50_StCurrN_IPar_	Start Res Current	%	10	200	1	20

Table 3-3 The integer parameters of the breaker failure protection function, bay devices

Timer parameters for the breaker failure protection function, bay modules are listed in *Table 3-4.*

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for the retrip command generation						
BRF50_TrDel_TPar__	Retrip Time Delay	msec	0	1000	1	100
Time delay for the backup trip command generation						
BRF50_BUDel_TPar__	Backup Time Delay	msec	60	1000	1	200
Trip impulse duration						
BRF50_Pulse_TPar__	Pulse Duration	msec	0	60000	1	100

Table 3-4 The timer parameters of the breaker failure protection function, bay devices

3.3 Method of operation for the breaker failure protection function

The starting signal of the breaker failure protection function is usually the trip command of any other protection functions. **The user has the task to define these starting signals using the graphic editor** as the "GenSt", or if the operation of the individual phases is needed, then the start signals for the phases individually. The phase start signals are: "StL1", "StL2" and "StL3".

For operation the phase current or the residual current of the bay must be above the level, as set by two integer parameter values (Start Ph Current, Start Res Current).

Dedicated timers start at the rising edge of the start signals, one for the backup trip command and one for the repeated trip command, separately for operation in the individual phases. During the running time of the timers the function optionally monitors the currents, the closed state of the circuit breakers or both, according to the user's choice. The selection is made using the enumerated parameter BRF50_Oper_EPar_ (Operation), where the choice is (Off, Current, Conract, Current/Contact):

- If this parameter setting is "Current", the current limit values BRF50_StCurrPh_IPar_ (Start Ph Current) and BRF50_StCurrN_IPar_ (Start Res Current) must be set correctly. The binary inputs indicating the status of the circuit breaker poles have no meaning.

- If this parameter setting is "Contact", the current limit values BRF50_StCurrPh_IPar_ (Start Ph Current) and BRF50_StCurrN_IPar_ (Start Res Current) have no meaning. The binary inputs indicating the status of the circuit breaker poles must be programmed correctly using the graphic logic editor. The input variables to be programmed are: BRF50_**CBClL1**_GrO_ (CB closed L1), BRF50_**CBClL2**_GrO_ (CB closed L2) and BRF50_**CBClL3**_GrO_ (CB closed L3).

- If this parameter setting is "Current/Contact", the current parameters and the status signals must be set correctly. The breaker failure protection function resets only if all conditions for faultless state are fulfilled.

- The breaker failure protection function can be disabled by setting this parameter to "Off".

If at the end of the running time of the backup timer the currents do not drop below the pre-defined level, and/or the monitored circuit breaker is still in closed position, then a backup trip command is generated. The time delay is defined using the parameter BRF50_BUDel_TPar_ (Backup Time Delay).

If repeated trip command is to be generated for the circuit breakers that are expected to open, then the enumerated parameter BRF50_ReTr_EPar_ (Retrip) must be set to "On". In this case, at the end of the retrip timer(s) the delay of which is set by the timer parameter BRF50_TrDel_TPar_ (Retrip Time Delay), a repeated trip command is also generated in the phase(s) where the backup timer(s) run off.

The pulse duration of the trip command is not shorter than the time defined by setting the parameter BRF50_Pulse_TPar_ (Pulse Duration).

The breaker failure protection function can be enabled or disabled by setting the parameter BRF50_Oper_EPar_ (Operation) to "Off".

Dynamic blocking is possible using the binary input BRF50_**Blk**_GrO_ (Block). **The conditions are to be programmed by the user, using the graphic logic editor**.

In the central device, based on the status signals of the disconnectors, received from the bay units via fiber optic communication network, the algorithm selects all bays, which are interconnected with the bay announcing breaker failure. Accordingly only the minimum number of the bays gets the trip command, the other bus-sections remain in continuous operation.

Each "Bay unit" function block in the central device has an BFPTrip binary status output. This output is activated if the breaker failure starting signal comes from the related bay.

4 Setting of the communication

The currents, status signals from the bay devices and the commands are sent via Ethernet network on proprietary protocol. The VLAN-addresses for this communication have to be set only in the bay devices, because the addresses in the central device are determined by the position of the communication port. The rx- and tx-addresses have to be identical for the same bay.

Every central device of the busbar protections has a service page among the LCD screens which provides information about the VLAN-addresses which have to be set in the bay-devices. These addresses and connection-positions are obligatory, do not mix the cables or the addresses! An example for such a service page for a central device with 6 bays can be seen on Figure 4-1.

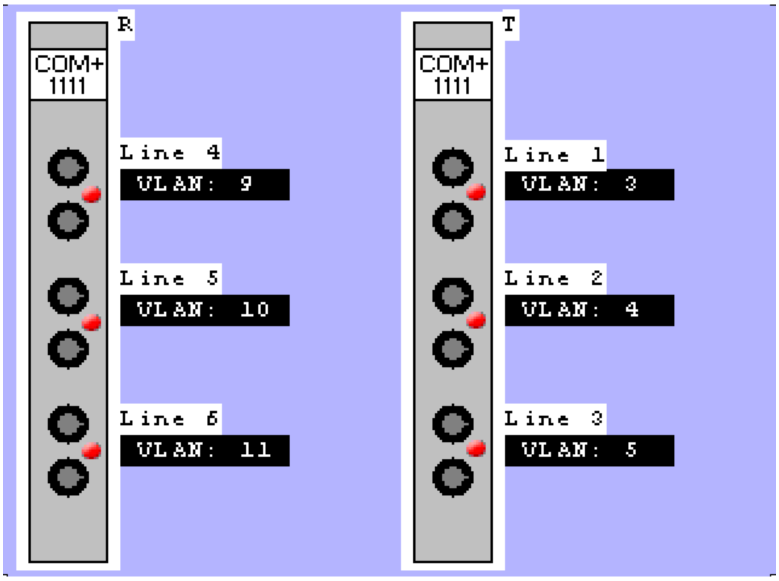


Figure 4-1 Service page on the LCD-screen of a central device with 6 bays

The VLAN-address can be calculated for each bay with the following formal:

$$VLAN = 3 \cdot P_m + P_p,$$

where:

- *VLAN* is the common VLAN address of the bay,
- P_m is identifier for the position of the module to which the bay device connects. It is a number between 0…21. The last position (pos. V) gets the number 0, and the other positions get a number according to the distance to the last position in ascending order.
- P_p is the identifier of the port to which the bay device connects on the module. It is number between 0…2. The upper position gets the number 0, the middle position 1, and the lower position 2.

These addresses are parameters of the "BB communication" function block in the bay devices. The values of the "Priority" and "MCast Addr" parameters are to be left on default. The value 4 for the Priority is the default value according to the standard, and the value 1 for MCast Addr is what the central device expects.

Parameters of the communication:

Integer parameters:

Parameter name	Title	Unit	Min	Max	Step	Default
VLAN addresses (these have to be set identical to each other for the same bay device)						
CPUBB_TxVLAN_IPar_	TxVLAN	-	1	4096	1	1
CPUBB_RxVLAN_IPar_	RxVLAN	-	1	4096	1	1
Priority, recommended to be left as default						
CPUBB_Priority_IPar_	Priority	-	0	7	1	2
MCast Addr, recommended to be left as default						
CPUBB_MCast_IPar_	MCast Addr	-	1	65535	1	1

Table 4-1 Parameters of the "BB communication" function block (bay devices)

5 Technical summary

5.1 Technical data

Function	Value	Accuracy
Current measurement		±2%
Current reset ratio	0.7*	
Operate time (Idiff>2 x In) (Idiff>5 x In)	 Typical 30 ms <20 ms	
Reset time	60 ms	

** The reset ratio is the result of the applied special algorithm*

Table 5-1 Technical data of the distributed busbar differential protection

5.2 The parameters of the distributed busbar differential protection function

The parameters of the distributed busbar differential protection function are explained in the following tables.

5.2.1 Parameters of the central device

5.2.1.1 Parameters for the “Busbar” function block in the central device

Enumerated parameters for the distributed busbar differential protection function, central device are summarized in *Table 5-2*:

Parameter name	Title	Selection range	Default
Parameter to enable the centralized busbar differential protection function:			
Busbar_BBPOper_EPar__	BBP Operation	Off, On	Off
Parameter to enable the supervision by the “check zone”			
Busbar_CheckOper_EPar_	CheckZone Operation	Off, On	Off
Toleration of the disconnector status signal errors			
Busbar_BadTol_EPar_	BadState Tolerate	Off, On	Off

Table 5-2 The enumerated parameter of the distributed busbar differential protection function, central device

Integer parameters for the distributed busbar differential protection function, central device are summarized in *Table 5-3*.

Parameter name	Title	Unit	Min	Max	Step	Default
Differential protection trip characteristic, base sensitivity						
Busbar_ZoneSens_IPar_	Base Sensitivity	(primary) A	100	10000	1	1000
Differential protection trip characteristic, slope						
Busbar_ZoneK_IPar_	k zone	%	40	90	1	60
Checkzone characteristic, base sensitivity						
Busbar_CheckSens_IPar_	CheckZone Sens.	(primary) A	100	10000	1	1000
Checkzone characteristic, slope						
Busbar_CheckK_IPar_	k checkzone	%	40	90	1	60
CT error detection, base sensitivity						
Busbar_CTErrSens_IPar_	CT failure Sens.	(primary) A	50	5000	1	500
CT error detection, slope						
Busbar_CTErrK_IPar_	k CT failure	%	40	90	1	60
Maximum load current						
Busbar_Offset_IPar_	Max.I_load	(primary) A	100	10000	1	1000

Table 5-3 The integer parameters of the distributed busbar differential protection function, central device

Timer parameters for the distributed busbar differential protection function, central device are summarized in *Table 5-4*.

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for signaling bad state						
Busbar_BadDelay_TPar_	BadState Delay	msec	100	60000	1	1000
Time delay for signaling CT error						
Busbar_CTErrDelay_TPar_	CT failure Delay	msec	100	60000	1	1000

Table 5-4 The timer parameters of the distributed busbar differential protection function, central device

5.2.1.2 Parameters for the "Bay unit" function block in the central device

Boolean parameter for the distributed busbar differential protection function, bay unit function blocks in the central device are summarized in *Table 5-5*.

Parameter name	Title	Default	Explanation
Disabling the bay			
BayUnit1f_BayDisable_BPar__T1	Bay Disable	0	0 means enabling; 1 means that the current values and the status signals received from the bay are not considered (to be applied for maintenance purposes).

Table 5-5 The Boolean parameters of the distributed busbar differential protection function, bay unit function blocks

Enumerated parameters for the distributed busbar differential protection function, bay unit function blocks in the central device are summarized in *Table 5-6*:

Parameter name	Title	Selection range	Default
CT secondary rated current			
BayUnit1f_Nom_EPar__T1	Rated Secondary	1A, 5A	1A
Location of the CT star point for the CT-s in three lines			
BayUnit1f_Dir_EPar__T1	Star point I1-3	Line, Bus	Line

Table 5-6 The enumerated parameter of the distributed busbar differential protection function, bay unit function block in the central device

NOTE: If the bay does not include a current transformer then these parameters are missing.

Integer parameter for the distributed busbar differential protection function, bay unit function blocks in the central device are summarized in *Table 5-7*:

Parameter name	Title	Unit	Min	Max	Step	Default
CT primary rated current						
BayUnit1f_CTNom_IPar__T1	CT nominal	A	100	10000	1	1000

Table 5-7 The integer parameter of the distributed busbar differential protection function, bay unit function block in the central device

NOTE: If the bay does not include a current transformer then this parameter is missing.

5.2.2 Parameters of the bay devices

There is only one parameter in the BBP Bay Unit function of the bay devices related to the busbar protection function. This parameter sets the time delay for the reaction of bad status signals received from the disconnectors of the bay:

Timer parameter for the distributed busbar differential protection function, bay device are summarized in *Table 5-8*:

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for signaling bad state						
BBPBU_BadDelay_TPar_	BadState Delay	msec	100	60000	1	1000

Table 5-8 The timer parameter of the distributed busbar differential protection function, bay device

With the parameters of the BB communication function block the communication between the central and the bay devices can be set, see chapter 4:

Integer parameters:

Parameter name	Title	Unit	Min	Max	Step	Default
VLAN addresses (these have to be set identical to each other for the same bay device)						
CPUBB_TxVLAN_IPar_	TxVLAN	-	1	4096	1	1
CPUBB_RxVLAN_IPar_	RxVLAN	-	1	4096	1	1
Priority, recommended to be left as default						
CPUBB_Priority_IPar_	Priority	-	0	7	1	2
Priority, recommended to be left as default						
CPUBB_MCast_IPar_	MCast	-	1	65535	1	1

Table 5-9 Parameters of the "BB communication" function block (bay devices)

5.2.3 Parameters of the breaker failure module

5.2.3.1 Parameter for the breaker failure module in the “Busbar” function block of central device

Enumerated parameter for the breaker failure protection function for enabling or disabling the trip command distribution in the central device are summarized in *Table 5-10*:

Parameter name	Title	Selection range	Default
Parameter to enable the trip command distribution of the breaker failure protection function (in Busbar function)			
Busbar_BFPOper_EPar_	Intertrip Operation	Off, On	Off

Table 5-10 The enumerated parameter of the breaker failure protection function in the central device

5.2.3.2 Parameter for the “Breaker failure” function block in the bay devices

The breaker failure protection function needs parameters related to the bays individually.

These parameters are as follows:

Enumerated parameters for the breaker failure protection function, bay devices are summarized in *Table 5-11*:

Parameter name	Title	Selection range	Default
Enabling the bay to participate in the breaker failure scheme			
BRF50_Oper_EPar_	Operation	Off,Current,Contact,Current/Contact	Off
Enabling the retrip command			
BRF50_ReTr_EPar_	Retrip	Off,On	Off

Table 5-11 The enumerated parameter of the breaker failure protection function, bay devices

Integer parameters for the breaker failure protection function, bay devices are summarized in *Table 5-12*:

Parameter name	Title	Unit	Min	Max	Step	Default
Phase current condition for the breaker failure protection function						
BRF50_StCurrPh_IPar_	Start Ph Current	%	20	200	1	30
Residual current condition for the breaker failure protection function						
BRF50_StCurrN_IPar_	Start Res Current	%	10	200	1	20

Table 5-12 The integer parameters of the breaker failure protection function, bay devices

Timer parameters for the breaker failure protection function, bay devices are summarized in *Table 5-13*:

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for the retrip command generation						
BRF50_TrDel_TPar__	Retrip Time Delay	msec	15	1000	1	100
Time delay for the backup trip command generation						
BRF50_BUDel_TPar__	Backup Time Delay	msec	60	1000	1	200
Trip impulse duration						
BRF50_Pulse_TPar__	Pulse Duration	msec	0	60000	1	100

Table 5-13 The timer parameters of the breaker failure protection function, bay devices

5.3 Binary output status signals

The binary output status signals of the function blocks for the distributed busbar differential protection function are summarized in the Tables below.

5.3.1 Binary output status signals of the central device

5.3.1.1 Binary output status signals of the “Busbar” function block in central device

Binary output signals	Signal title	Explanation
Busbar_Blocked_Grl_	Blocked	The busbar protection is in blocked state
Busbar_CommFail_Grl_	CommFail	Communication error
Busbar_DCError_Grl_	DCError	Disconnector status error
Busbar_TestMode_Grl_	TestMode	The central device is in “test/blocked” mode.

Table 5-14 The binary output status signals of the distributed busbar differential protection function, busbar function block

5.3.1.2 Binary output status signals of the “BusSec” (bus section) function block in the central device

Binary output signals	Signal title	Explanation
BusSec_TripL1_Grl_	TripL1	L1 trip signal for the bus section
BusSec_TripL2_Grl_	TripL2	L1 trip signal for the bus section
BusSec_TripL3_Grl_	TripL3	L1 trip signal for the bus section
BusSec_Trip_Grl_	Trip	General trip command for the bus section
BusSec_BFPTrip_Grl_	BFPTrip	Trip command generated by the breaker failure protection function
BusSec_CTError_Grl_	CTError	Error in current measurement
BusSec_Ublock_Grl_	Ublock	The differential protection is blocked by voltage condition

Table 5-15 The binary output status signals of the distributed busbar differential protection function, bus section function block

5.3.1.3 Binary output status signals of the “Bay unit” function block in the central device

Binary output signals	Signal title	Explanation
BayUnit_Trip_Grl_	Trip	Trip command to the circuit breaker of the bay
BayUnit_BayDisable_Grl_	BayDisable	Bay disabled
BayUnit_BFPTrip_Grl_	BFPTrip	The Breaker failure protection of the related bay has tripped.

Table 5-16 The binary output status signals of the distributed busbar differential protection function, bay unit function block

5.3.1.4 Binary output status signals of the “SecStat” (sectionalizer) function block in the central device

Binary output signals	Signal title	Explanation
SecStat_SectClosed_Grl_	SectClosed	Closed state of the sectionalizer
SecStat_StatErr_Grl_	StatErr	Status signal error

Table 5-17 The binary output status signals of the distributed busbar differential protection function, sectionalizer function block

5.3.2 Binary output status signals of the bay devices

5.3.2.1 Binary output status signals of the “BBP Bay unit” protection function block in the bay devices

Binary output signals	Signal title	Explanation
BBPBU_Trip_GrI_	Trip	Trip command to the circuit breaker of the bay
BBPBU_DCErr_GrI_	DCErr	Disconnector status error
BBPBU_CommFail_GrI_	CommFail	Communication failure
BBPBU_Signal1_GrI_	Signal1	Binary signal receiving from the central device
BBPBU_Signal2_GrI_	Signal2	Binary signal receiving from the central device

Table 5-18 The binary output status signals of the distributed busbar differential protection function, bay unit function block

5.3.2.2 Binary output status signals of the “Breaker failure” function block in the bay devices

Binary output signal	Signal title	Explanation
BRF50_BuTr_GrI_	BuTr	Trip command for the bay, generated by the breaker failure function
BRF50_BuTrL1_GrI_	BuTrL1	Trip command for the bay in phase L1, generated by the breaker failure function
BRF50_BuTrL2_GrI_	BuTrL2	Trip command for the bay in phase L2, generated by the breaker failure function
BRF50_BuTrL3_GrI_	BuTrL3	Trip command for the bay in phase L3, generated by the breaker failure function

Table 5-19 The binary output status signals of the distributed busbar differential protection function, bay devices

5.4 Binary input status signals

The conditions are defined by the user applying the graphic logic editor.

The binary input status signals of the function blocks for the distributed busbar differential protection function are summarized in the Tables below.

5.4.1 Binary input status signal of the central device

5.4.1.1 Binary input status signal of the “Busbar” function block in central device

Binary input signals	Signal title	Explanation
Busbar_BBPBlock_GrO_	BBPBlock	Blocking the busbar differential protection function
Busbar_BFPBlock_GrO_	BFPBlock	Blocking the breaker failure protection function

Table 5-20 The binary input status signal of the distributed busbar differential protection function, busbar function block central device

5.4.1.2 Binary input status signals of the “BusSec” (bus section) function block in the central device

The Bus section function block does not have binary input status signals.

5.4.1.3 Binary input status signals of the "Bay unit" function block in the central device

Binary input signals	Signal title	Explanation
BayUnit_BlkSect_GrO_	BlkSect	In TRUE state of this input signal the measuring element related to this bay gets in blocked state
BayUnit_Disable_GrO_	Disable	The bay can be disabled with this input
BayUnit_Signal1_GrO_	Signal1	Binary signal transmitting to the bay device device
BayUnit_Signal2_GrO_	Signal2	Binary signal transmitting to the bay device device

Table 5-21 The binary input status signals of the distributed busbar differential protection function, bay unit function block

5.4.1.4 Binary output status signals of the "SecStat" (sectionalizer) function block in the central device

Binary input signals	Signal title	Explanation
SecStat_DC1Close_GrO_	DC1Close	Disconnector 1 in closed state
SecStat_DC1Open_GrO_	DC1Open	Disconnector 1 in open state
SecStat_DC2Close_GrO_	DC2Close	Disconnector 2 in closed state
SecStat_DC2Open_GrO_	DC2Open	Disconnector 2 in open state

Table 5-22 The binary input status signals of the distributed busbar differential protection function, sectionalizer function block

5.4.2 Binary input status signals of the bay devices

5.4.2.1 Binary input status signals of the "BBP Bay unit" function block in the bay devices

Binary input signals	Signal title	Explanation
BBPBU_DC1Close_GrO_	DC1Close	Disconnector 1 in closed state
BBPBU_DC1Open_GrO_	DC1Open	Disconnector 1 in open state
BBPBU_DC2Close_GrO_	DC2Close	Disconnector 2 in closed state
BBPBU_DC2Open_GrO_	DC2Open	Disconnector 2 in open state
BBPBU_DC3Close_GrO_	DC3Close	Disconnector 3 in closed state
BBPBU_DC3Open_GrO_	DC3Open	Disconnector 3 in open state
BBPBU_DC4Close_GrO_	DC4Close	Disconnector 4 in closed state
BBPBU_DC4Open_GrO_	DC4Open	Disconnector 4 in open state
BBPBU_BFPTrip_GrO_	BFPTrip	Breaker failure signal from the protection of the bay. The breaker failure protection passes this signal to all bays of the interconnected bus sections, related to this particular bay
BBPBU_ForceZero_GrO_	ForceZero	In TRUE state of this input signal the bay unit sends zero value as the sampled current

Table 5-23 The binary input status signals of the breaker failure modules

5.4.2.2 Binary input status signals of the "Breaker failure" function block in the bay devices

Binary input signals	Signal title	Explanation
BRF50_Blk_GrO_	Blk	Blocking of the breaker failure protection function
BRF50_CBClL1_GrO_	CBClL1	Signal indicating the closed state of the circuit breaker in phase L1
BRF50_CBClL2_GrO_	CBClL2	Signal indicating the closed state of the circuit breaker in phase L2
BRF50_CBClL3_GrO_	CBClL3	Signal indicating the closed state of the circuit breaker in phase L3
BRF50_GenSt_GrO_	GenSt	General starting signal
BRF50_StL1_GrO_	StL1	Starting signal in phase L1
BRF50_StL2_GrO_	StL2	Starting signal in phase L2
BRF50_StL3_GrO_	StL3	Starting signal in phase L3
BRF50_IoSt_GrO_	IoSt	Starting signal for the residual current

Table 5-24 The binary input status signals of the breaker failure modules

5.5 The function blocks

The function blocks of the distributed busbar differential protection function, central device are shown in *Figure 5-1.* These blocks show all binary input and output status signals that are applicable in the graphic logic editor. The block of the distributed busbar differential protection function, bay devices is shown in *Figure 5-2.*

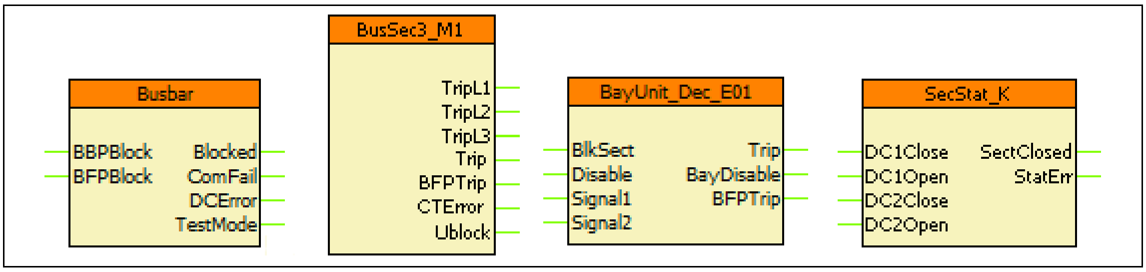


Figure 5-1 The function blocks of the distributed busbar differential protection function, central device

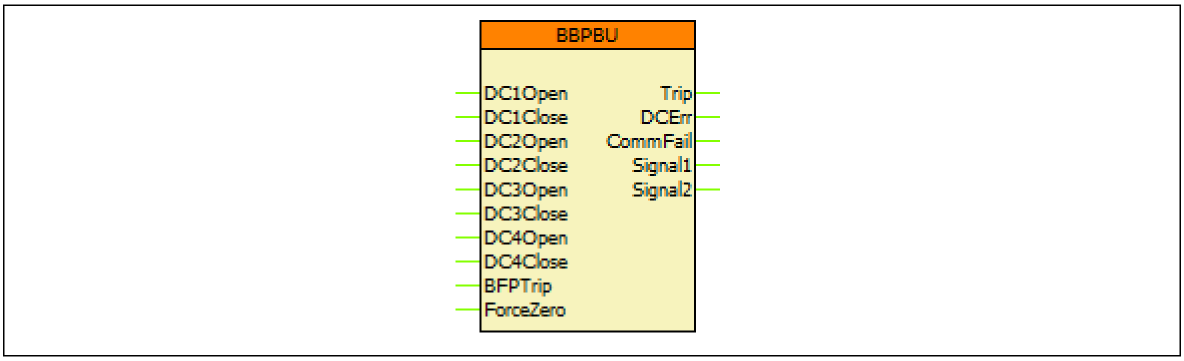


Figure 5-2 The function block of the distributed busbar differential protection function, bay device

The function block of a breaker failure protection scheme in the bay device is shown in *Figure 5-3.*

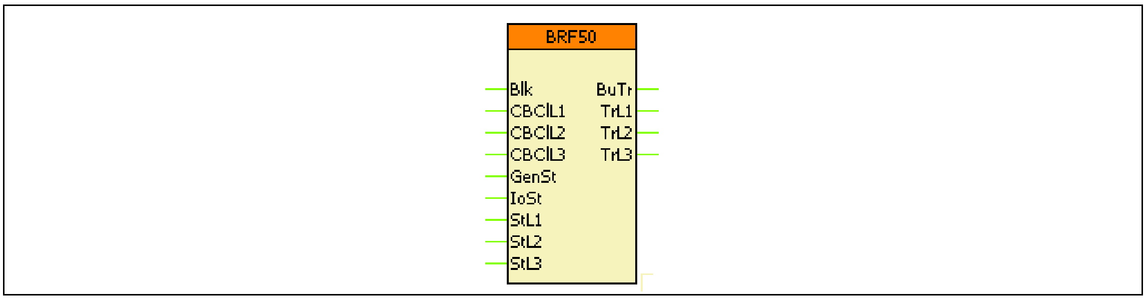


Figure 5-3 The function block of the breaker failure protection function, bay device

6 Appendix I

6.1 The procedure of the busbar protection configuration

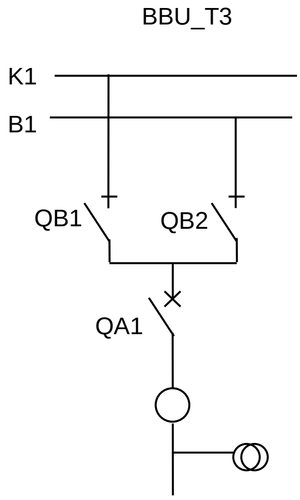
6.1.1 Configuration in the factory

The factory configuration assembles the needed number of hardware elements and the related software elements. If the description of the bay system is not specified at ordering, or if the substation is extended by new elements, then the user has the task to describe the busbar topology.

In the factory configuration each bay unit gets the assigned hardware elements, e.g. analog current inputs, analog voltage inputs if any, available disconnector status signal inputs, and the assigned trip contacts.

6.1.2 Defining the bay topology

The definition of a topology in the central device of the busbar protection system is illustrated with the example of a bay connected to a double busbar below:



The user describes the topology, stating to which busbar sections the given bay is connected. This is performed using the “EuroCap” configuration software with the application of dialog window in the menu “Software configuration / Functions / Busbar protection / Bay topology” as in the Figure below. In the topology element related to this window the bay “BBU-T3” is connected via “Disconnector 1” (QB1) to the busbar section “K1” and via “Disconnector 2” (QB2) to the busbar section “B1”

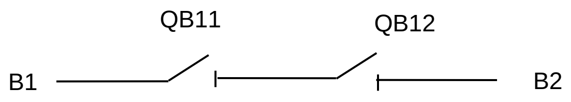
In this application disconnectors 3 and 4 are not applied. The information “Include to check zone” states that the information of this bay is applied also for check zone calculation. (As an example the current of a bus couple bay generally may not be involved in the check zone calculation.)

The subsequent parameter in the Figure below (CT dir inverted) states that the positive direction of the current is not inverted. (As an opposite example the current transformer direction in a bus coupler bay must be inverted for one of the bus sections.)

The “Connection ref. No.” setting is usually 0, indicating that the bay is not interconnected with any of other bays. The code number deviating from zero means that the may is interconnected with bays having the same value for this parameter.

Assigned bay [l]:	0198 Bay units
	BayUnit1f_BU_BBU__T3 (Bay Unit)
1. disconnector section [h]:	0197 Sections
	BusSection_K1 (BusSection)
2. disconnector section [h]:	0197 Sections
	BusSection_B1 (BusSection)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	0
CT Dir.Inverted [0,1]:	0
Connection ref.No. [0,255]:	101

6.1.3 Defining the sectionalizers



The user describes the topology, stating how the sectionalizers connect the busbar sections. This is performed using the "EuroCap" configuration software with the application of dialog window in the menu "Software configuration / Functions / Busbar protection / Sectionalizers" as in the Figure below.

1. disconnector on [u]:	0213 Graphed input Status
	SecStat_SectClosed_GrI__B ()
Sect.disconnector status error [u]:	0213 Graphed input Status
	SecStat_StatErr_GrI__B (Status Error)
1. disconnector section [h]:	0197 Sections
	BusSection_B1 (BusSection)
2. disconnector section [h]:	0197 Sections
	BusSection_B2 (BusSection)

In this example the sectionalizer interconnects the bus sections B1 and B2. The closed status is the result of closed states QB11 AND QB12. This is the task of the user to compose a graphic binary logic for the binary variable "SecStat_SectClosed_GrI_B()".

Similarly the disconnector status error is composed in a binary logic for the graphic binary variable "SecStat_StatErr_GrI_B(Status Error"").

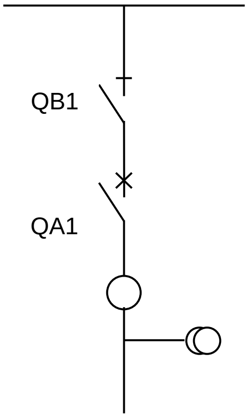
The chapter below shows further application examples for some frequent practical cases.

7 Appendix II

7.1 Application examples

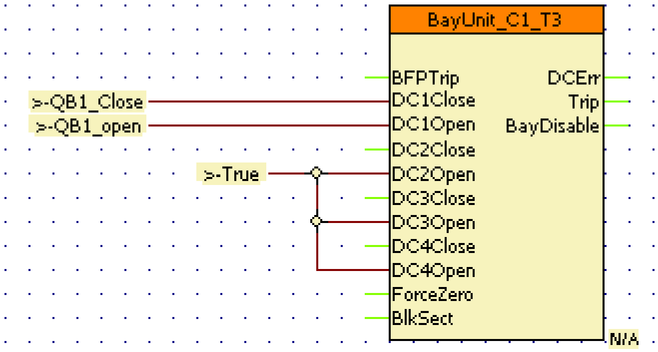
These application examples show typical solutions for defining the busbar topology. Based on these examples, also the details of here not discussed busbar configurations can be defined. The individual examples show the graphic connections of the bay units and the parameter setting of the topology objects.

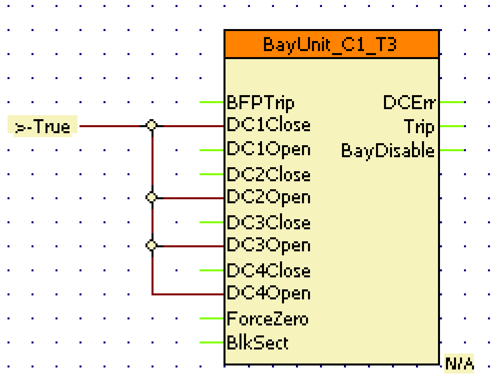
7.1.1 Example 1: Bay connected to a single busbar



In this simple bay configuration the status signals indicating the closed and open state of the disconnector are connected to “DC1Close” and “DC1Open inputs”. All other “DCOpen” inputs are connected to logic “True”.

In the second indicated solution the connection of the bay is fixed to “DC1Close” of the function block. All other “DCOpen” inputs are also connected to logic “True”.

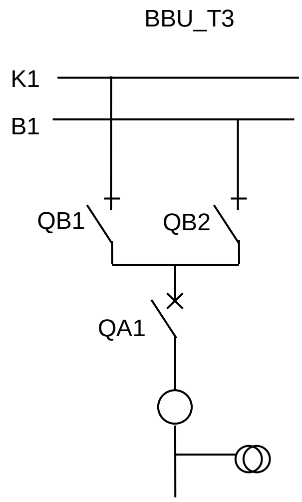




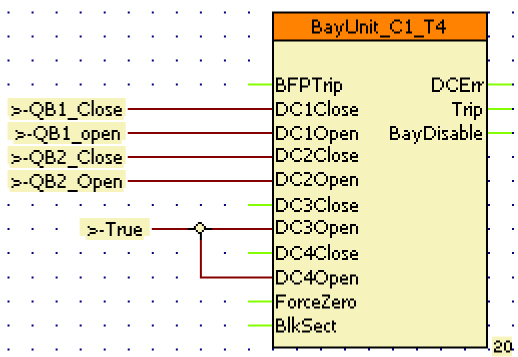
The parameters describing the topology are shown in Figure below:

Assigned bay [l]:	0198 Bay units
	BayUnit1f_BU_BBU__T3 (Bay Unit)
1. disconnector section [h]:	0197 Sections
	BusSection_K1 (BusSection)
2. disconnector section [h]:	
	(nothing)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	1
CT Dir.Inverted [0,1]:	0
Connection ref.No. [0,255]:	0

7.1.2 Example 2: Bay connected to a double busbar



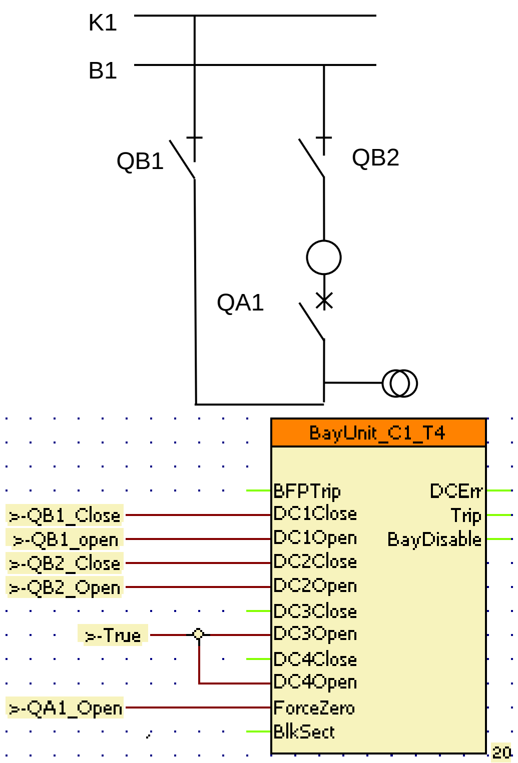
The function block:



The parameters describing the topology are shown in Figure below:

Assigned bay [l]:	0198 Bay units
	BayUnit1f_BU_BBU__T3 (Bay Unit)
1. disconnector section [h]:	0197 Sections
	BusSection_K1 (BusSection)
2. disconnector section [h]:	0197 Sections
	BusSection_B1 (BusSection)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	1
CT Dir.Inverted [0,1]:	0
Connection ref.No. [0,255]:	0

7.1.3 Example 3: Bus coupler bay with one current transformer



There are two topology elements assigned to this bus coupler bay: one for the side of QB1 and one for the side of QB2, the current positive direction for the second one must be inverted.

Both topology elements refer to the same bay unit.

In this application also the state of the circuit breaker is considered: in its open state the measured current must be disclosed to correctly clear the dead zone faults between the circuit breaker and the current transformer.

The algorithm automatically disclosed the current measured by this current transformer if the connected busbar sections are interconnected also by any other element of the busbar system. This bypass is identified if two topology elements refer to the same bay unit.

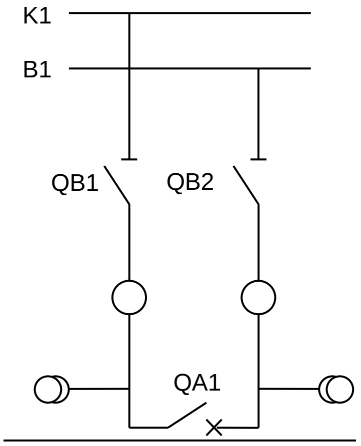
The topology element related to QB1 is as follows:

Assigned bay [I]:	0198 Bay units
	BayUnit1f_BU_BBU__T3 (Bay Unit)
1. disconnector section [h]:	0197 Sections
	BusSection_K1 (BusSection)
2. disconnector section [h]:	
	(nothing)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	0
CT Dir.Inverted [0,1]:	1
Connection ref.No. [0,255]:	0

The topology element related to QB2 is as follows:

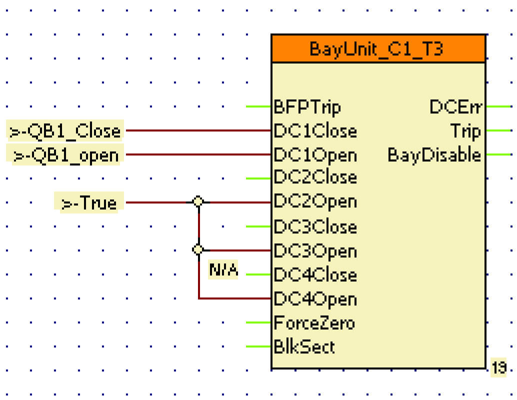
Assigned bay [I]:	0198 Bay units
	BayUnit1f_BU_BBU__T3 (Bay Unit)
1. disconnector section [h]:	
	(nothing)
2. disconnector section [h]:	0197 Sections
	BusSection_B1 (BusSection)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	0
CT Dir.Inverted [0,1]:	0
Connection ref.No. [0,255]:	0

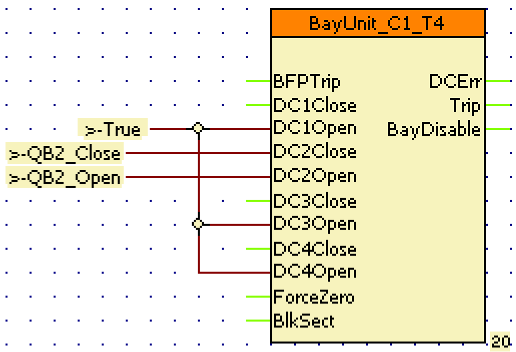
7.1.4 Example 4: Bus coupler bay with two current transformers



To describe this configuration two “Bay unit” function blocks are applied. The current transformers must be connected in overlapping arrangement. Because of overlapping, the “Open” state of the circuit breaker need not disclose the current.

When however the bus sections are interconnected also by any other element of the busbar system, then the automatic disclosing the current is also needed. For this purpose the algorithm must be informed about the bypass of the bus coupler bay. For this purpose the parameter “Connection ref.No” is applied. If the identifiers of these two bay units have identical (but not 0) identifier then these bays are considered to be interconnected.





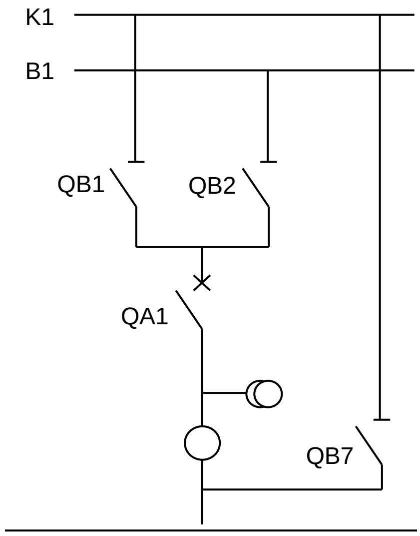
The topology element related to QB1 is as follows:

Assigned bay [l]:	0198 Bay units
	BayUnit1f_BU_BBU__T3 (Bay Unit)
1. disconnector section [h]:	0197 Sections
	BusSection_K1 (BusSection)
2. disconnector section [h]:	
	(nothing)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	0
CT Dir.Inverted [0,1]:	0
Connection ref.No. [0,255]:	100

The topology element related to QB2 is as follows:

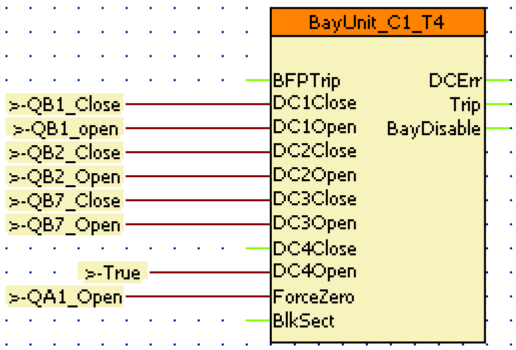
Assigned bay [l]:	0198 Bay units
	BayUnit1f_BU_BBU__T4 (Bay Unit)
1. disconnector section [h]:	
	(nothing)
2. disconnector section [h]:	0197 Sections
	BusSection_B1 (BusSection)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	0
CT Dir.Inverted [0,1]:	0
Connection ref.No. [0,255]:	100

7.1.5 Example 5: Double bus connection with bypass



This bay can serve as bus coupler or as a feeder bay.

The graphical connections of the applied bay unit are as follows:

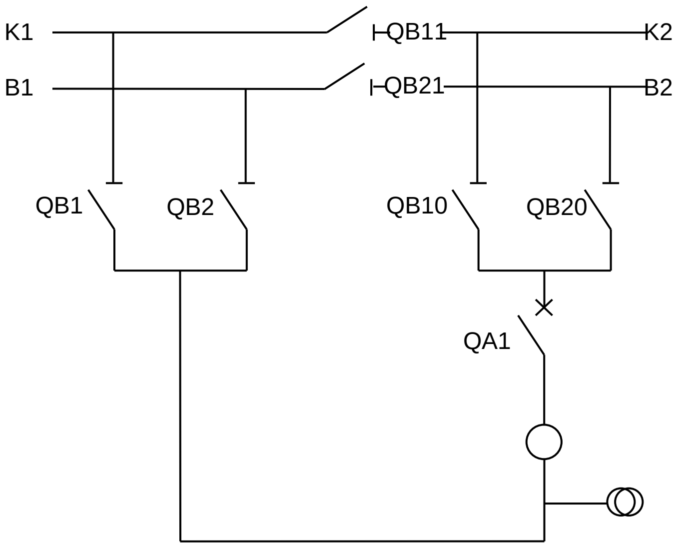


The related topology elements are as follows:

Assigned bay [I]:	0198 Bay units
	BayUnit1f_BU_BBU__T4 (Bay Unit)
1. disconnector section [h]:	0197 Sections
	BusSection_K1 (BusSection)
2. disconnector section [h]:	0197 Sections
	BusSection_B1 (BusSection)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	1
CT Dir.Inverted [0,1]:	0
Connection ref.No. [0,255]:	0

Assigned bay [l]:	0198 Bay units
	BayUnit1f_BU_BBU__T4 (Bay Unit)
1. disconnector section [h]:	
	(nothing)
2. disconnector section [h]:	
	(nothing)
3. disconnector section [h]:	0197 Sections
	BusSection_K1 (BusSection)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	1
CT Dir.Inverted [0,1]:	1
Connection ref.No. [0,255]:	0

7.1.6 Example 6: Bus coupler in a double busbar system

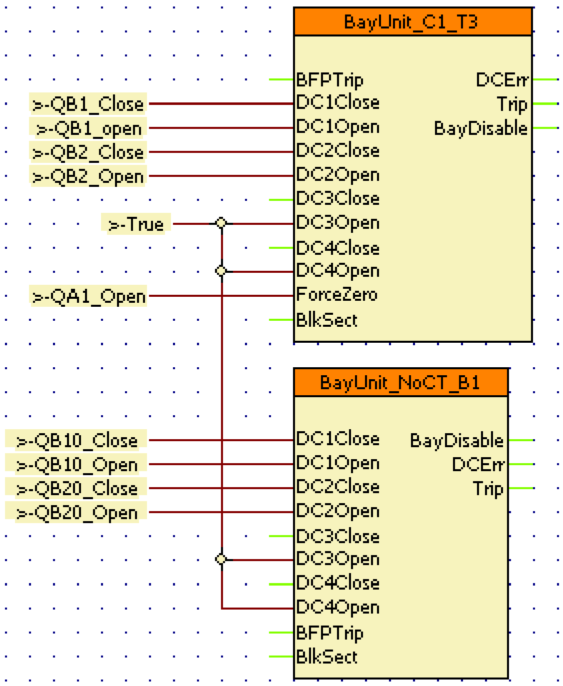


This configuration can be describes in two ways:

If the description is realized with a single bay unit, then the method is the same as a bay single bay coupler with a single current transformer. The only difference is that two disconnectors are applied in both sides. One of them is connected to the inputs DC1-DC2, the other side applies the inputs DC3-DC4.

If the description applies two bay units, or if the number of busbars is more than two (e.g. triple bay system) then the solution is as follows:

Here a function block is to be applied which operates without current transformer. With this solution a quadruple system (consisting of four busbars) can be described.



The setting of the topology elements is as follows:

Assigned bay [l]:	0198 Bay units
	BayUnit1f_BU_BBU__T3 (Bay Unit)
1. disconnector section [h]:	0197 Sections
	BusSection_K1 (BusSection)
2. disconnector section [h]:	0197 Sections
	BusSection_B1 (BusSection)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	0
CT Dir.Inverted [0,1]:	0
Connection ref.No. [0,255]:	101

Assigned bay [l]:	0198 Bay units
	BayUnitNoCT_BU_BBU__B1 (Bay Unit)
1. disconnector section [h]:	0197 Sections
	BusSection_K2 (BusSection)
2. disconnector section [h]:	0197 Sections
	BusSection_B2 (BusSection)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	0
CT Dir.Inverted [0,1]:	0
Connection ref.No. [0,255]:	101