EUROPROT +

DGYD
configuration description

PROTECTA HUNGARY

Budapest, May 2016

User’s manual version information

Version	Date	Modification	Compiled by
V1.0	20.01.2015	First Edition	Tóth
V1.1	09.05.2016	Modified: Redefined the available DGYD configurations *Figure 1* Implemented protection diagram *Figure 2* The 84 inch rack of EuroProt+ family with 5,7” TFT display and RJ-45 service port Added: Connection diagrams for single-phase and three-phase versions	Tóth

CONTENTS

1 Configuration description

The DGYD protection device is a member of the ***EuroProt+*** product line, made by Protecta Co. Ltd. The ***EuroProt+*** type complex protection in respect of hardware and software is a modular device. The modules are assembled and configured according to the requirements, and then the software determines the functions. This manual describes the specific application of the DGYD type of the general factory configuration.
NOTE: The document does not separate the different CBBP configuration, which can be handle the several number of bays.

1.1 Application

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 *centralized* version; the decentralized version is described in a separate document:
http://www.protecta.hu/protecta_open/fileOpen.php?documentation=438

This description focuses on the three-phase version, but if needed, the difference as compared to the single phase version is also indicated.

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

- The relay collects currents and status signals from all protected bays of the busbar;
- 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.

The **DGYD type** has collection of the following configurations:

E11-CBBP: Centralized single-phase busbar protection for 12 bays

E33-CBBP: Centralized three-phase busbar protection for 3 bays*
E34-CBBP: Centralized three-phase busbar protection for 4 bays*
E35-CBBP: Centralized three-phase busbar protection for 5 bays*
E36-CBBP: Centralized three-phase busbar protection for 5 bays*

* The implemented number of bus sections is ordering option.

1.1.1 Protection functions

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.

Protection functions	**IEC**	**ANSI**	**DGYD**
Busbar differential	$3I_dT>$	87B	X
Breaker failure protection	CBFP	50BF	X

Table 1 The protection functions of the DGYD configurations

The configured functions are drawn symbolically in the Figure below.
NOTE: The voltage measuring is optional for the higher stability (voltage breakdown condition).

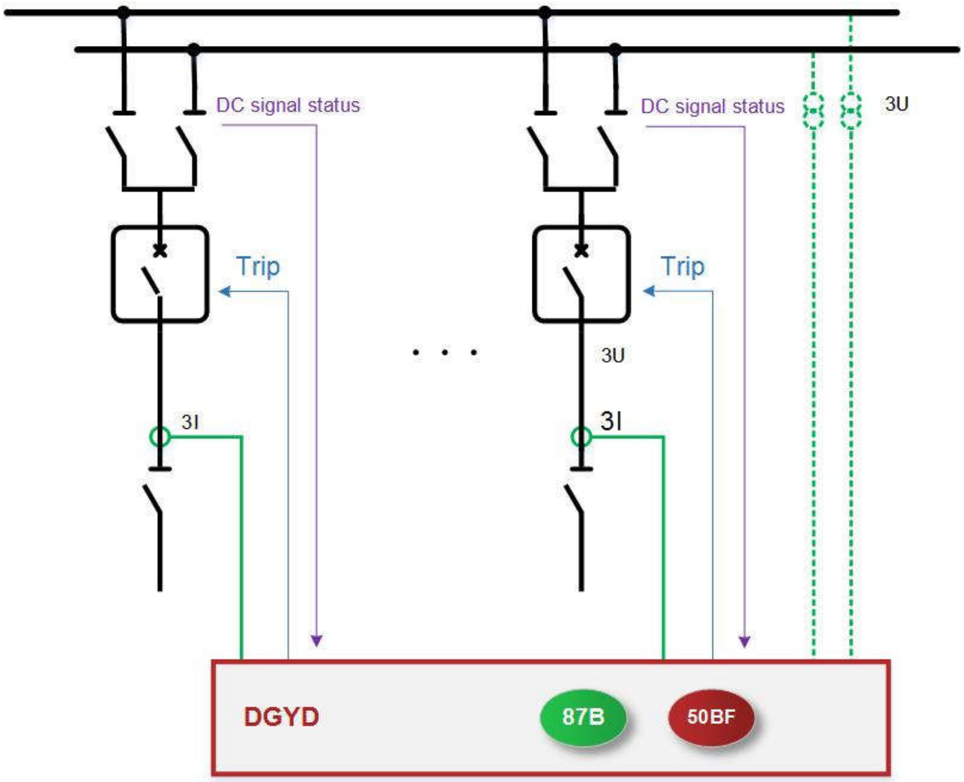


Figure 1 Implemented protection functions

1.1.2 Hardware configuration

The number of inputs and outputs of the DGYD configurations are listed in the Table below.

Hardware configuration	ANSI	E11-CBBP	E33-CBBP	E34-CBBP	E35-CBBP	E36-CBBP
Mounting		op.	op.	op.	op.	op.
Current inputs		12	12	16	20	24
Voltage inputs		op.*	op.*	op.*	op.*	op.*
Digital inputs		12	12	12	12	12
Digital outputs		8	8	8	12	12
Fast trip outputs		12	8	8	12	12
Temperature monitoring (RTDs) *	38 / 49T	op.	op.	op.	op.	op.

Table 2 The basic hardware configuration of the available DGYD configurations

*The voltage inputs are involved with the voltage breakdown condition ordering option .

The basic module arrangement of the available DGYD configurations are shown below.

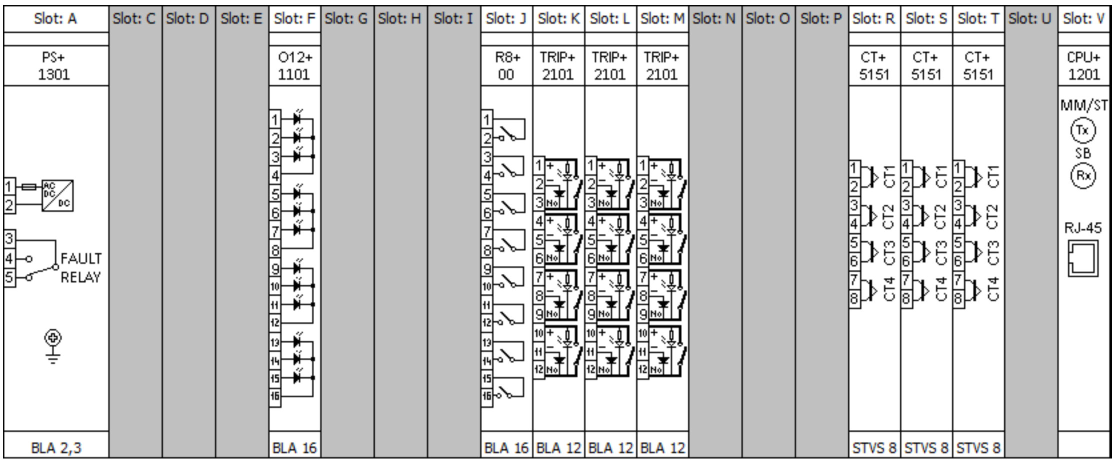


Figure 2 The module arrangement of the E11-CBBP configuration (rear view)

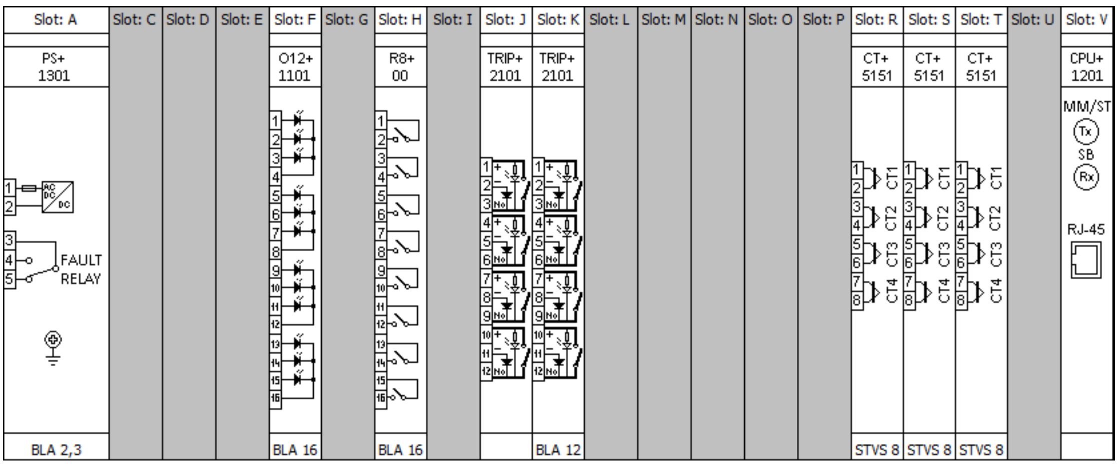


Figure 3 The module arrangement of the E33-CBBP configuration (rear view)

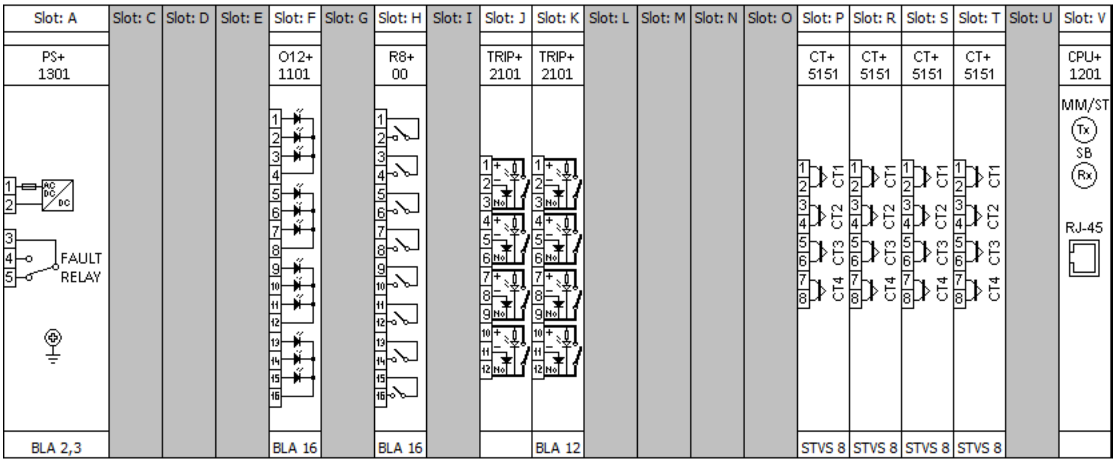


Figure 4 The module arrangement of the E34-CBBP configuration (rear view)

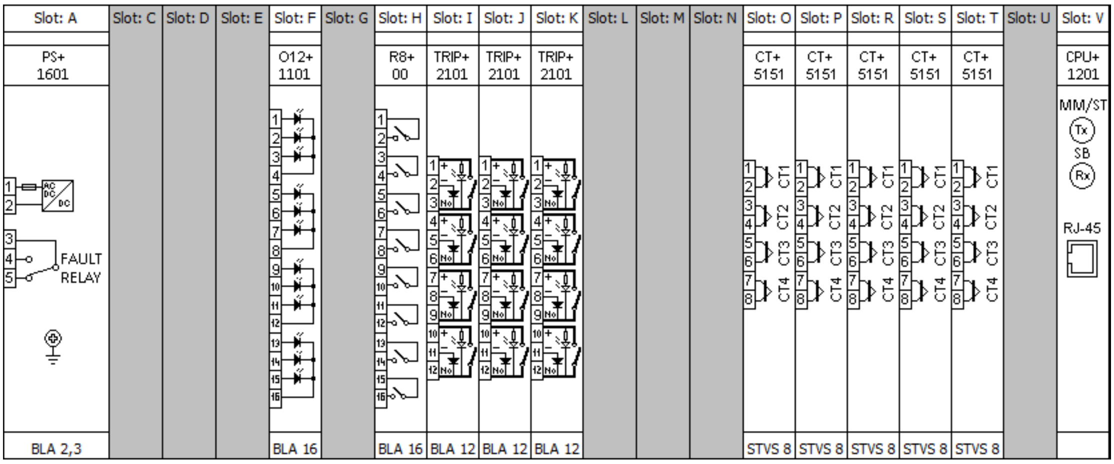


Figure 5 The module arrangement of the E35-CBBP configuration (rear view)

1.1.3 The applied hardware modules

The applied modules are listed in Table 3.

The technical specification of the device and that of the modules are described in the document "***Hardware description***".
http://www.protecta.hu/protecta_open/fileOpen.php?documentation=10

Module identifier	Explanation
PS+ 2601	Power supply unit
O12+ 2201	Binary input module
R8+ 00	Signal relay output module
TRIP+ 2101	Trip relay output module
CT + 5151	Analog current input module
CPU+ 1201	Processing and communication module

Table 3 The applied modules of the DGYD configurations

1.2 Meeting the device

The basic information for working with the ***EuroProt+*** devices are described in the document "***Quick start guide to the devices of the EuroProt+ product line***".

Figure 6 The 84 inch rack of ***EuroProt+*** *family with 5,7" TFT display and RJ-45 service port (recommended for busbar protection application)*

1.3 Software configuration

1.3.1 Protection functions

The implemented protection functions are listed in Table 4. The function blocks are described in details in separate documents which you can find under the “Downloads :: EuroProt+ :: Function blocks detailed” menu on Protecta website (http://www.protecta.hu/downloads/europrot?t=1#dt18)
.

Name	Title	Document name of function block detailed descriptions
BusDistr	Busbar and Breaker Failure	***Centralized busbar differential and breaker failure protection function***

Table 4 Implemented protection functions

1.3.1.1 Centralized busbar differential protection function and breaker failure protection

The algorithm in the busbar protection function 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.

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:

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.)

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

The biasing current calculation **is as follows:**

- From the absolute value of the sampled I_p momentary current values a predetermined "$Max.I\_load$" 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 sum of these values 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).

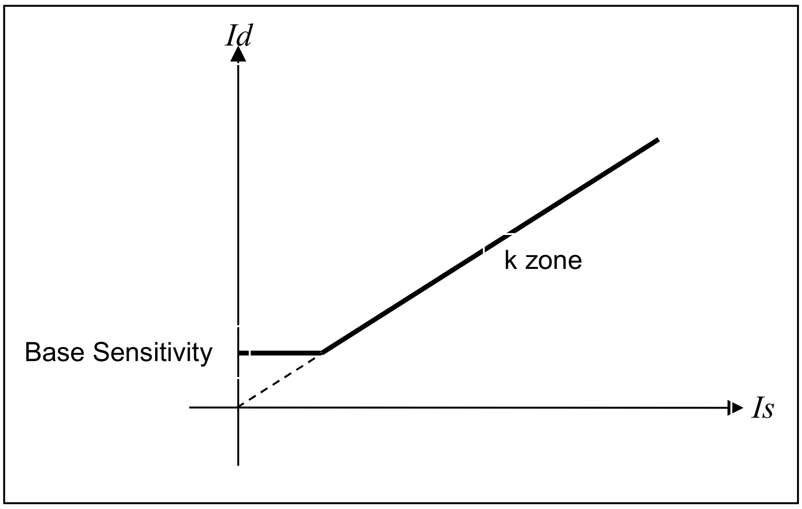
- Then the average of this value and that received 10 ms before is calculated:

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

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

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

The differential characteristics*:* the trip characteristic for a measuring element is shown in the Figure below.



In case of detected through fault, the slope of the characteristic is dynamically changed to 90%. When tested, the applied method results a constant 90% measured value for the slope.

Role of the subtracting the "$Max.I\_load$" value from all current samples: 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 above) is at once above the line described by the slope "k" (parameter setting "k zone"). 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 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.

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).

The parameters for the voltage breakdown condition are fix values (0.6Un), the function does not need any parameter setting.

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 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 parameter setting.

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". The algorithm "keeps" the detected current peak till the end of the half period, decreasing the chanche for the false trip decision.

***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.

***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 setting and a given slope.

If the measured currents result an Id–Is point above this characteristic, then after a time delay the “measuring element” gets blocked.

***Checking the disconnector status signals**:* the actual configuration of the busbar 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. 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. 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 (On), then the operation neglects the faulty status signal, and the last valid status is kept. In case of setting “false” (Off), 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 “Differential protection disabled” and “Breaker failure disabled” status signals as well.

The breaker failure protection function: The starting of the breaker failure protection is received on dedicated binary input channels. For operation, at least one of the phase currents of the bay must be above the level, as set an integer parameter value for each bay. Also the time delay of the function and the duration of the pulse are parameter values.

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.

Technical data

Function	Value	Accuracy
Current measurement		±2%
Current reset ratio	0.7*	
Operate time (Idiff>2 x In) (Idiff>5 x In)	 Typical 20 ms <15 ms	
Reset time	60 ms	

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

The parameters of the centralized busbar differential protection function

Parameters of the “Busbar general” function block

Enumerated parameters

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

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Percentage characteristic, base sensitivity						
Busbar_ZoneSens_IPar_	Base Sensitivity	A	100	10000	1	1000
Percentage characteristic, slope						
Busbar_ZoneK_IPar_	k zone	%	40	90	1	80
Checkzone percentage characteristic, base sensitivity						
Busbar_CheckSens_IPar_	CheckZone Sens.	A	100	10000	1	1000
Checkzone percentage characteristic, slope						
Busbar_CheckK_IPar_	k checkzone	%	40	80	1	50
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	80	1	40
Maximum load current						
Busbar_Offset_IPar_	Max.I_load	A	0	10000	1	1000

Timer parameters

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

Parameters of the “Bus section” function block

The bus section units do not need parameter setting.

Parameters of the “Bay unit” function block

The different type of parameters for the centralized busbar differential protection function, bay unit are listed in the tables below. They are to be set for the bays individually. In the parameter names “xxx” is different for each connected bays:

Boolean parameters

Parameter name	Title	Default	Explanation
Disabling the bay			
BayUnit1f_BayDisable_BPar_xxx	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).

Enumerated parameters

Parameter name	Title	Selection range	Default
CT secondary rated current			
BayUnit1f_Nom_EPar__xxx	Rated Secondary	1A, 5A	1A
Location of the CT star point for the CT-s in three lines			
BayUnit1f_Dir_EPar__xxx	Star point I1-3	Line, Bus	Line

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

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
CT primary rated current						
BayUnit1f_CTNom_IPar_xxx	CT nominal	A	100	10000	1	1000

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

Parameters of the breaker failure bay modules

Enumerated parameter for the breaker failure protection function for enabling or disabling the operation:

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

The breaker failure protection function needs parameters related to the bays individually.
In the parameter names “xxx” is different for each connected bays.

These parameters are as follows:

Enumerated parameters for the breaker failure protection function, bay modules:

Parameter name	Title	Selection range	Default
Enabling the bay to participate in the breaker failure protection function			
BRF50BB_Oper_EPar__xxx	Operation	Off,On	Off

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Current condition for the breaker failure protection function						
BRF50BB_StCurrPh_IPar__xxx	Start Ph Current	%	20	200	1	30

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for the breaker failure protection function						
BRF50BB_BUDel_TPar__xxx	Backup Time Delay	msec	60	1000	1	200
Pulse duration						
BRF50BB_Pulse_TPar__xxx	Pulse Duration	msec	0	60000	1	100

1.3.2 Monitoring functions

1.3.2.1 Disturbance recorder function

The DGYD configuration contains a disturbance recorder function. The details are described in the document shown in Table 5. The function blocks are described in details in separate documents which you can find under the “Downloads :: EuroProt+ :: Function blocks detailed” menu on Protecta website (http://www.protecta.hu/downloads/europrot?t=1#dt18)

Name	Title	Document
DRE	Disturbance Rec	**Document name of function block detailed descriptions**

Table 5 Implemented disturbance recorder function

The recorded analog channels:

Recorded analog signal	Explanation
IL1 1	Measured current in phase L1 of bay unit 1
IL2 1	Measured current in phase L2 of bay unit 1
IL3 1	Measured current in phase L3 of bay unit 1
IL1 2	Measured current in phase L1 of bay unit 2
IL2 2	Measured current in phase L2 of bay unit 2
IL3 2	Measured current in phase L3 of bay unit 2
⋮	⋮

The recorded analog channels are repeated for the each additional bay.

Table 6 Disturbance recorder, recorded analog channels

The recorded binary channels:

Recorded binary signal	Explanation
Bay01 disabled	Bay01 disabled by user
Bay02 disabled	Bay02 disabled by user
⋮	⋮
Bay01 trip	Trip command of Bay01
Bay02 trip	Trip command of Bay02
⋮	⋮
Blocked	Busbar prot. blocked
DC Error	Disconnector error state of one of the bays
BFP trip 1	Breaker failure prot. trip command in bus section 1
⋮	⋮
BusSec1 trip	Trip command in bus section 1
⋮	⋮
CT Error 1	Current unbalance error signal in bus section 1

:	:
:	:
Trip L1 1	Trip command in phase L1 of bus section 1
Trip L2 1	Trip command in phase L2 of bus section 1
Trip L3 1	Trip command in phase L3 of bus section 1
:	:

The recorded binary channels are repeated for the each additional bay and bus section.

Table 7 Disturbance recorder, recorded binary channels

Enumerated parameter:

Parameter name	Title	Selection range	Default
Parameter for activation			
DRE_Oper_EPar_	Operation	Off, On	Off

Table 8 The enumerated parameter of the disturbance recorder function

Timer parameters:

Parameter name	Title	Unit	Min	Max	Step	Default
Pre-fault time:						
DRE_PreFault_TPar_	PreFault	msec	50	500	1	200
Post-fault time:						
DRE_PostFault_TPar_	PostFault	msec	50	1000	1	200
Overall-fault time limit:						
DRE_MaxFault_TPar_	MaxFault	msec	200	5000	1	1000

Table 9 The timer parameters of the disturbance recorder function

1.3.2.2 Event recorder

The events of the device and those of the protection functions are recorded with a time stamp of 1 ms time resolution. This information with indication of the generating function can be checked on the touch-screen of the device in the “Events” page, or using an Internet browser of a connected computer.

The following table collected the recorded event of the applied function blocks of the DGYD type. The number of the several function blocks depends on the topology (the number of the bays, bus sections etc.)

Event	Explanation
Busbar protection function (Busbar)	
Blocked	
Status error	
Comm. error	
Bus Section (BusSec3_) same for the all bus section	
Trip L1	Trip command in phase L1
Trip L2	Trip command in phase L2
Trip L3	Trip command in phase L3
Trip	General trip command
BFP Trip	Breaker failure protection trip command
CT Failure	Current unbalance error
U block	Trip command blocking by healthy voltage
⋮	
User defined four channel control block (Con4Ch)	
Status Ch1	Status of channel 1
Status Ch2	Status of channel 2
Status Ch3	Status of channel 3
Status Ch4	Status of channel 4
User defined event channels (GGIO16_1)	
Input01	Event channel, free programmable by the user
Input02	Event channel, free programmable by the user
Input03	Event channel, free programmable by the user
Input04	Event channel, free programmable by the user
Input05	Event channel, free programmable by the user
Input06	Event channel, free programmable by the user
Input07	Event channel, free programmable by the user
Input08	Event channel, free programmable by the user
Input09	Event channel, free programmable by the user
Input10	Event channel, free programmable by the user
Input11	Event channel, free programmable by the user
Input12	Event channel, free programmable by the user
Input13	Event channel, free programmable by the user
Input14	Event channel, free programmable by the user
Input15	Event channel, free programmable by the user
Input16	Event channel, free programmable by the user

Table 10 List of the possible events

1.3.3 Measured values

The measured values can be checked on the touch-screen of the device in the "On-line functions" page, or using an Internet browser of a connected computer. This specific block displays the measured values in primary units, using the CT primary value settings in busbar bay unit.

The measured and displayed values of the centralized busbar differential protection function are listed below.

For each voltage inputs the device measures and displays the phase voltages. The following table shows as an example the voltages of a bus section.

Measured value	Dimension	Explanation
Voltage Ch - U1	(secondary) V	Phase voltage L1, Fourier base component
Voltage Ch – U2	(secondary) V	Phase voltage L2, Fourier base component
Voltage Ch – U3	(secondary) V	Phase voltage L3, Fourier base component

Table 11 The measured analogue voltages of the centralized busbar differential protection function (example)

For each bays the device measures and displays the phase currents.

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

Table 12It can be seen as an example the currents of a bay in the table below.

Measured value	Dimension	Explanation
Current Ch - I1	(secondary) A	Phase current L1, Fourier base component
Angle Ch - I1	deg*	Phase angle of the current in L1
Current Ch – I2	(secondary) A	Phase current L2, Fourier base component
Angle Ch – I2	deg*	Phase angle of the current in L2
Current Ch – I3	(secondary) A	Phase current L3, Fourier base component
Angle Ch – I3	deg*	Phase angle of the current in L3

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

Table 12 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. The following table 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

Table 13 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 Centralized busbar differential protection function.

2 Appendix I

2.1 The applied function blocks of the centralized busbar protection function

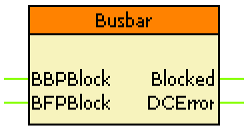
The capabilities of the busbar differential protection function depend on the hardware configuration. This is a task of the factory process: Based on the ordering, the required number of current inputs, binary inputs for disconnector status signals and the required number of trip outputs are assembled into the device. The number and type of the hardware modules depend on:

- The size, complexity and functionality of the busbar;
- Whether the protection is
    - A three-phase version or
    - The system consists of three single-phase units.

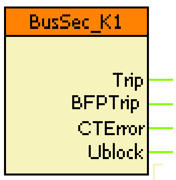
At the same time, in the factory configuration process, the required software function blocks are configured. The applied functions blocks are as follows:

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 are flowing 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.

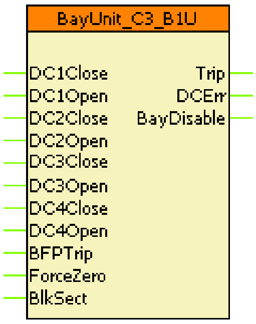
2. **“Bus section” function blocks**: the number of these blocks coincides with the number of the bus sections. Up to 12 sections can be included. The task of this function block is to process the status signals, and to send them to the “Busbar” block to form the “Measuring elements”. The symbol of the “Bus section” function block, as it appears in the graphic logic editor, is as follows.

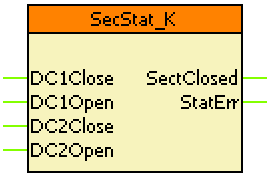
3. **“Bay unit” function blocks**: the number of these blocks coincides with the number of the bays in the substation. The task of this block is to receive and process all information from the primary devices of the bay”:
    - Currents (Three phase currents or one phase current, depending of the selected option)
    - Voltages (Three phase voltages or one phase voltage, depending of the selected option)
    - 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.

This block passes the trip command to the circuit breaker of the bay.

This block also inputs the breaker failure signal from the bay protection units, and information related to the “stub” protection. The blocking input signal received by this bay unit disables the operation of the “Measuring element”, to which this bay is dynamically assigned.



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.

3 Appendix II

3.1 The procedure of the busbar protection configuration

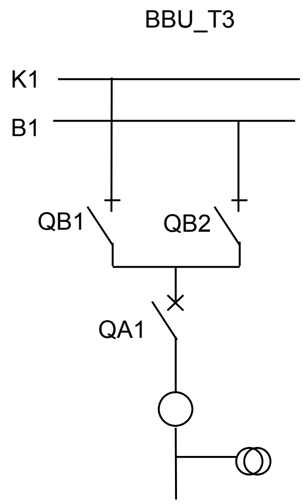
3.1.1 Configuration in the factory

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.

3.1.2 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:

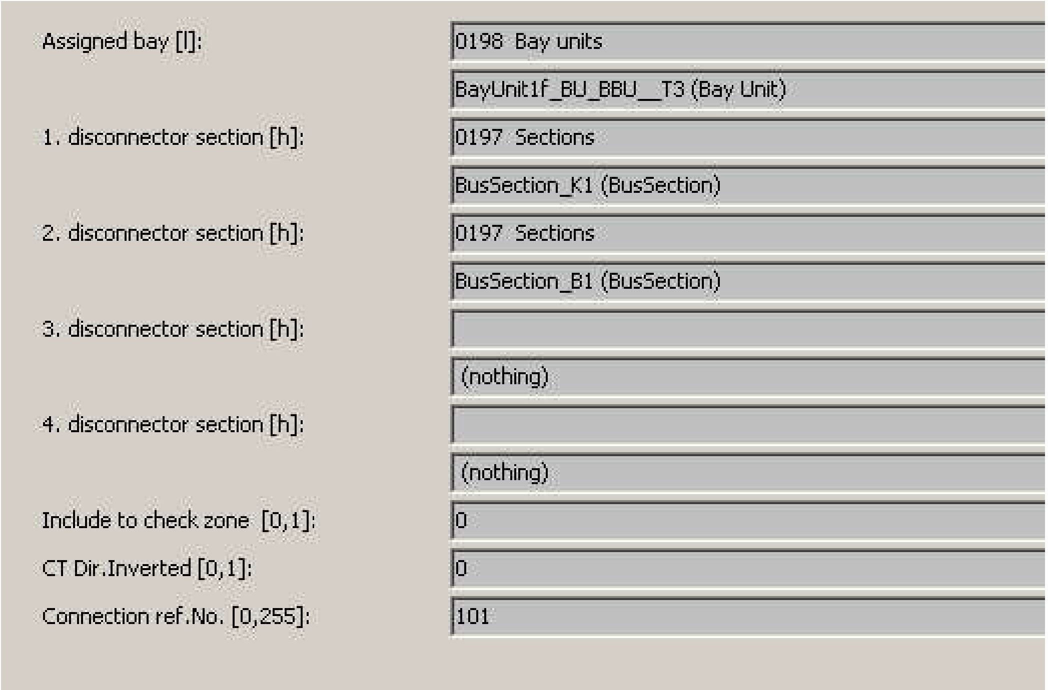


The user describes the topology, stating to which busbar sections the given bay is connected. This is performed using the “EuroCap” configuration software with the application of dialog window in the menu “Software configuration / Functions / Busbar protection / Bay topology” as in the Figure below. 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”

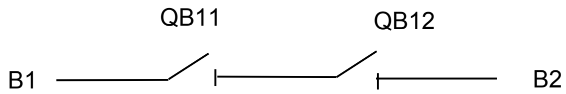
In this application disconnectors 3 and 4 are not applied. The information “Include to check zone” states that the information of this bay is applied also for check zone calculation. (As an example the current of a bus couple bay generally may not be involved in the check zone calculation.)

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.)

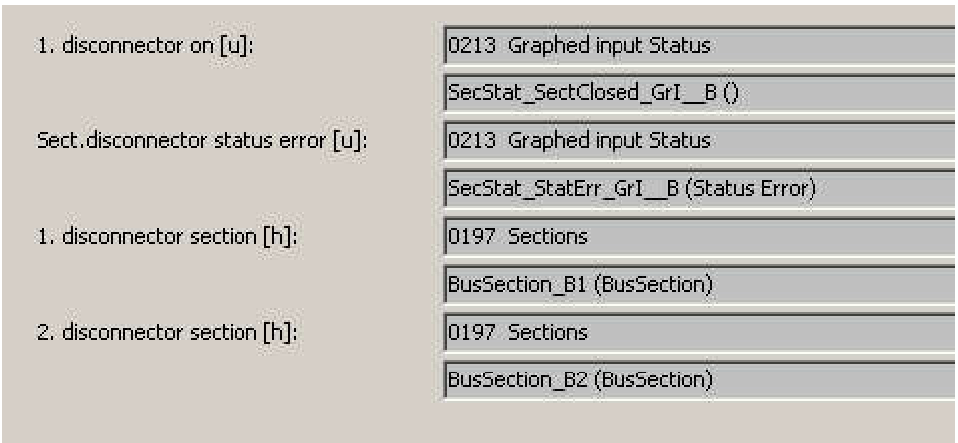
The “Connection ref. No.” setting is usually 0, indicating that the bay is not interconnected with any of other bays. The code number deviating from zero means that the may is interconnected with bays having the same value for this parameter.



3.1.3 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.



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””).

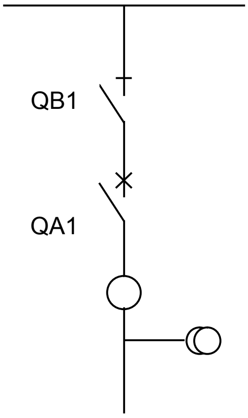
The chapter below shows further application examples for some frequent practical cases.

4 Appendix III

4.1 Application examples

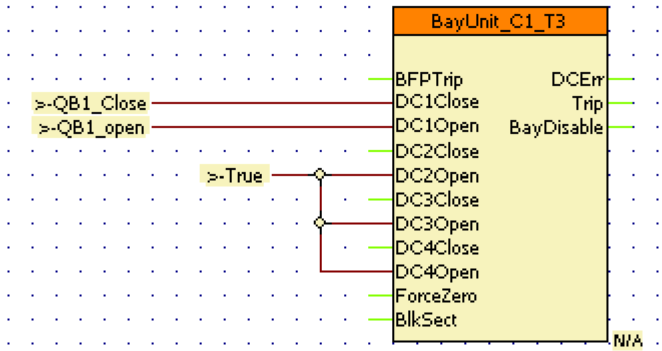
These application examples show typical solutions for defining the busbar topology. Based on these examples, also the details of here not discussed busbar configurations can be defined. The individual examples show the graphic connections of the bay units and the parameter setting of the topology objects.

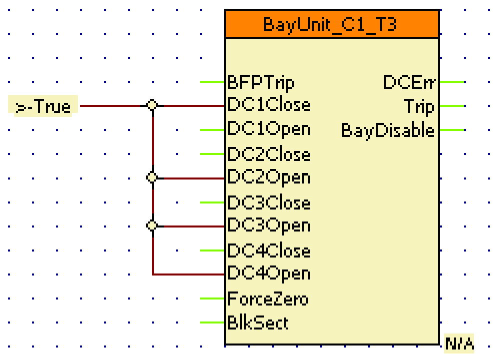
4.1.1 Example 1: Bay connected to a single busbar



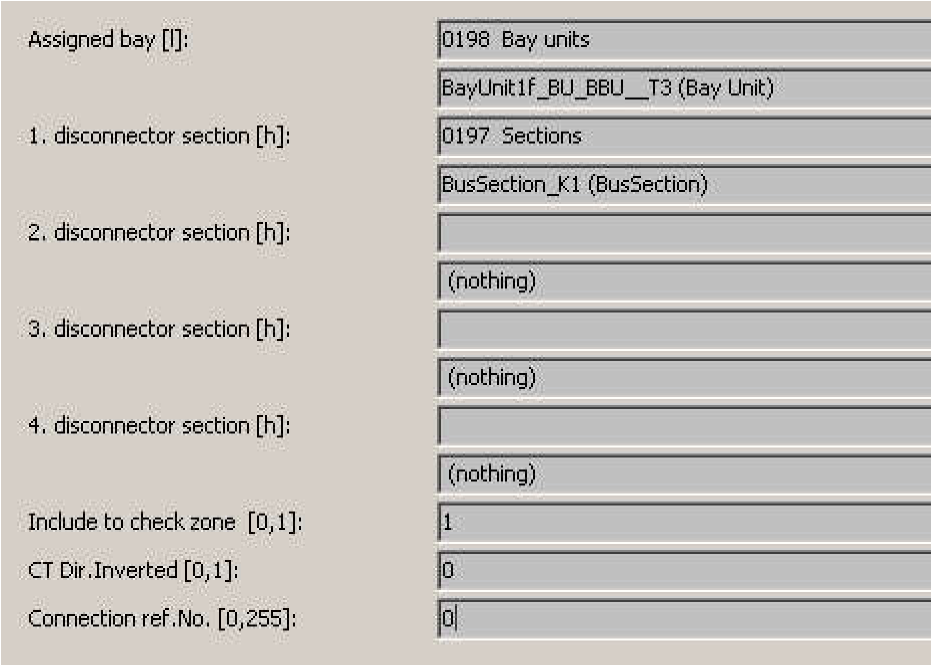
In this simple bay configuration the status signals indicating the closed and open state of the disconnector are connected to “DC1Close” and “DC1Open inputs”. All other “DCOpen” inputs are connected to logic “True”.

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”.



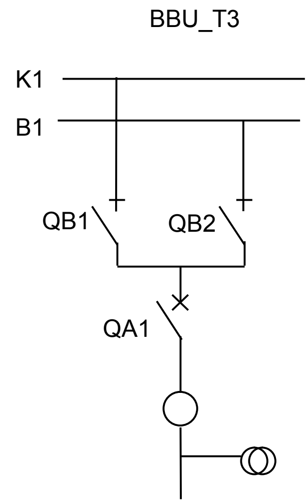


The parameters describing the topology are shown in Figure below:

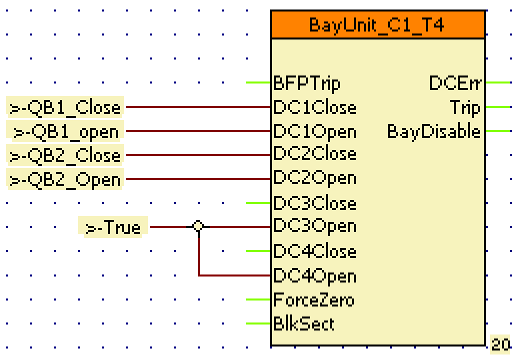


Assigned bay [l]:	0198 Bay units
	BayUnit1f_BU_BBU__T3 (Bay Unit)
1. disconnector section [h]:	0197 Sections
	BusSection_K1 (BusSection)
2. disconnector section [h]:	
	(nothing)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	1
CT Dir.Inverted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

4.1.2 Example 2: Bay connected to a double busbar



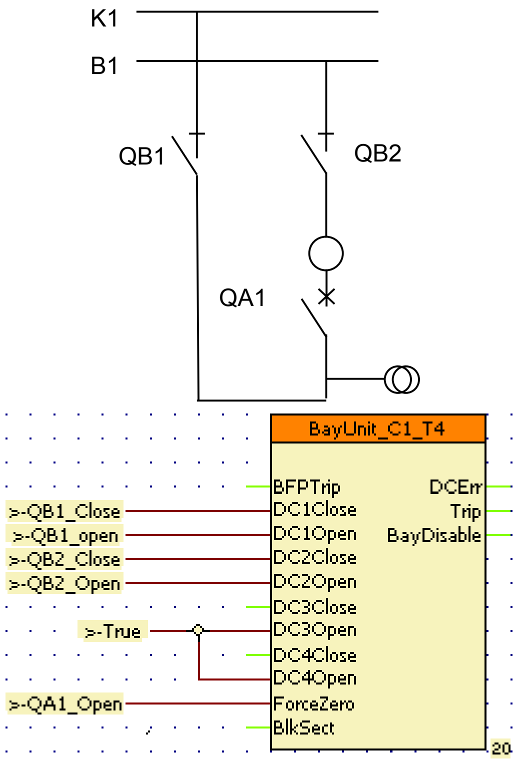
The function block:



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

4.1.3 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.

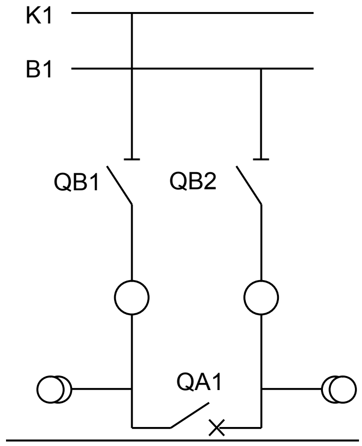
The topology element related to QB1 is as follows:

Assigned bay [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]:	1
Connection ref.No. [0,255]:	0

The topology element related to QB2 is as follows:

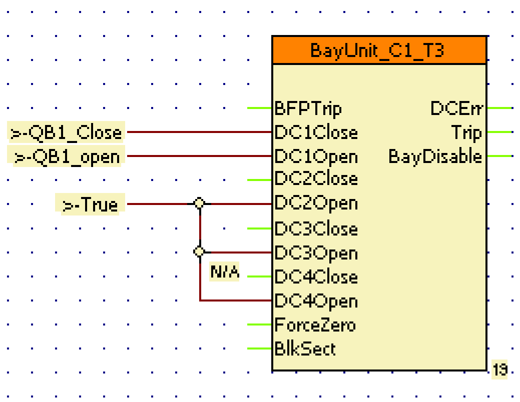
Assigned bay [l]:	0198 Bay units
	BayUnit1f_BU_BBU__T3 (Bay Unit)
1. disconnector section [h]:	
	(nothing)
2. disconnector section [h]:	0197 Sections
	BusSection_B1 (BusSection)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	0
CT Dir.Inverted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

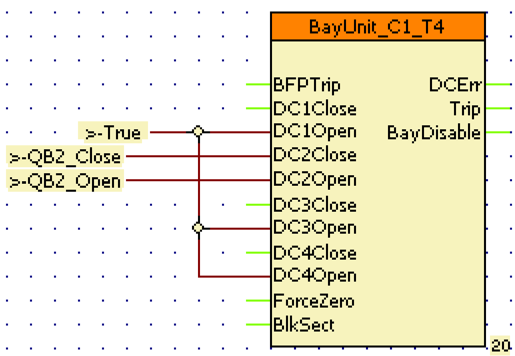
4.1.4 Example 4: Bus coupler bay with two current transformers



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.





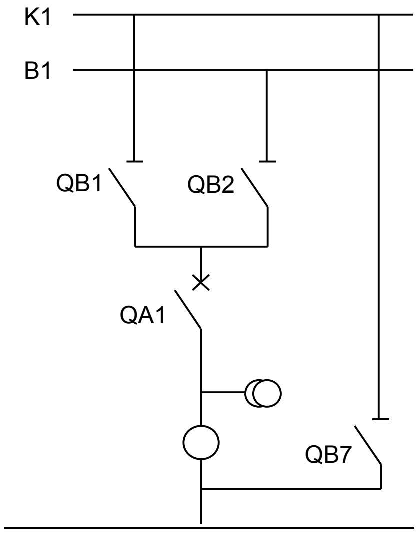
The topology element related to QB1 is as follows:

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:

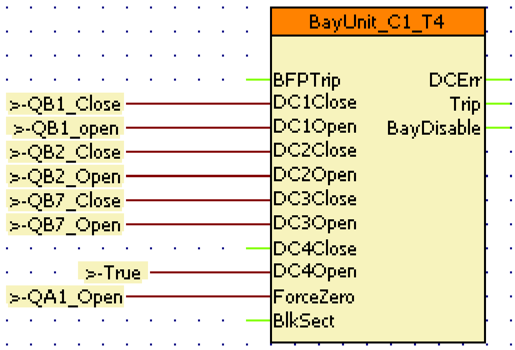
Assigned bay [l]:	0198 Bay units
	BayUnit1f_BU_BBU__T4 (Bay Unit)
1. disconnector section [h]:	
	(nothing)
2. disconnector section [h]:	0197 Sections
	BusSection_B1 (BusSection)
3. disconnector section [h]:	
	(nothing)
4. disconnector section [h]:	
	(nothing)
Include to check zone [0,1]:	0
CT Dir.Inverted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

4.1.5 Example 5: Double bus connection with bypass



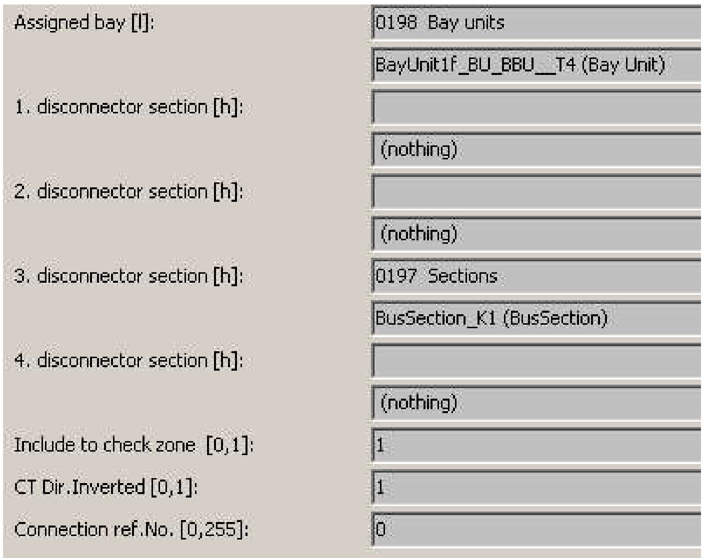
This bay can serve as bus coupler or as a feeder bay.

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



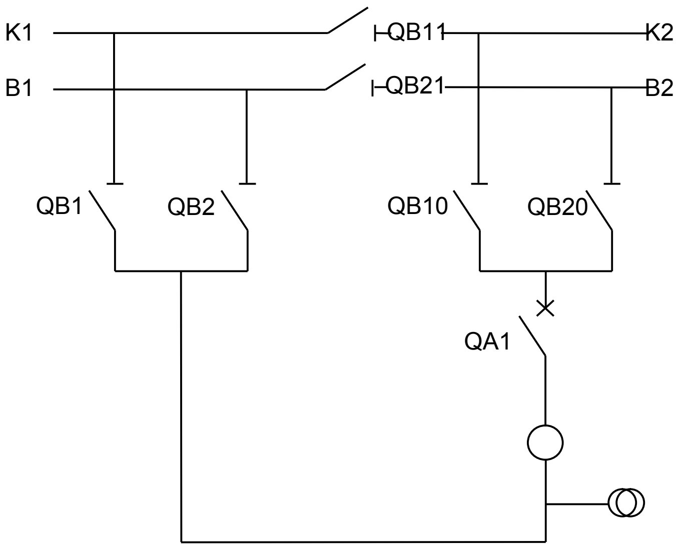
The related topology elements are as follows:

Assigned bay [l]:	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

4.1.6 Example 6: Bus coupler in a double busbar system

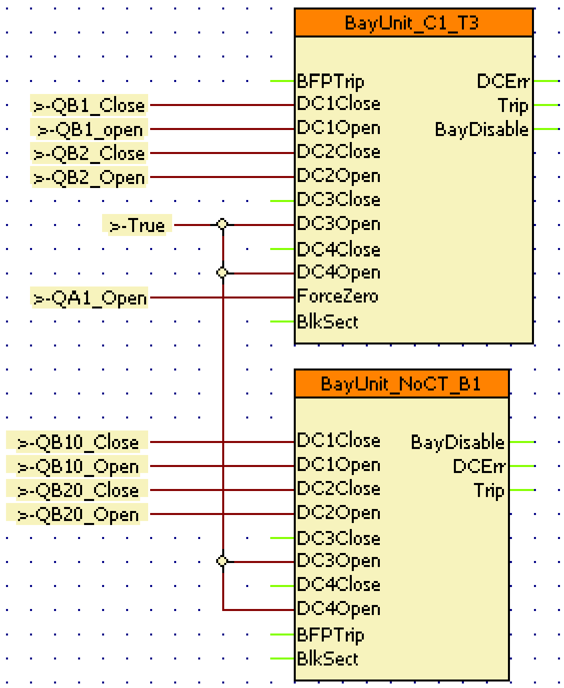


This configuration can be describes in two ways:

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:

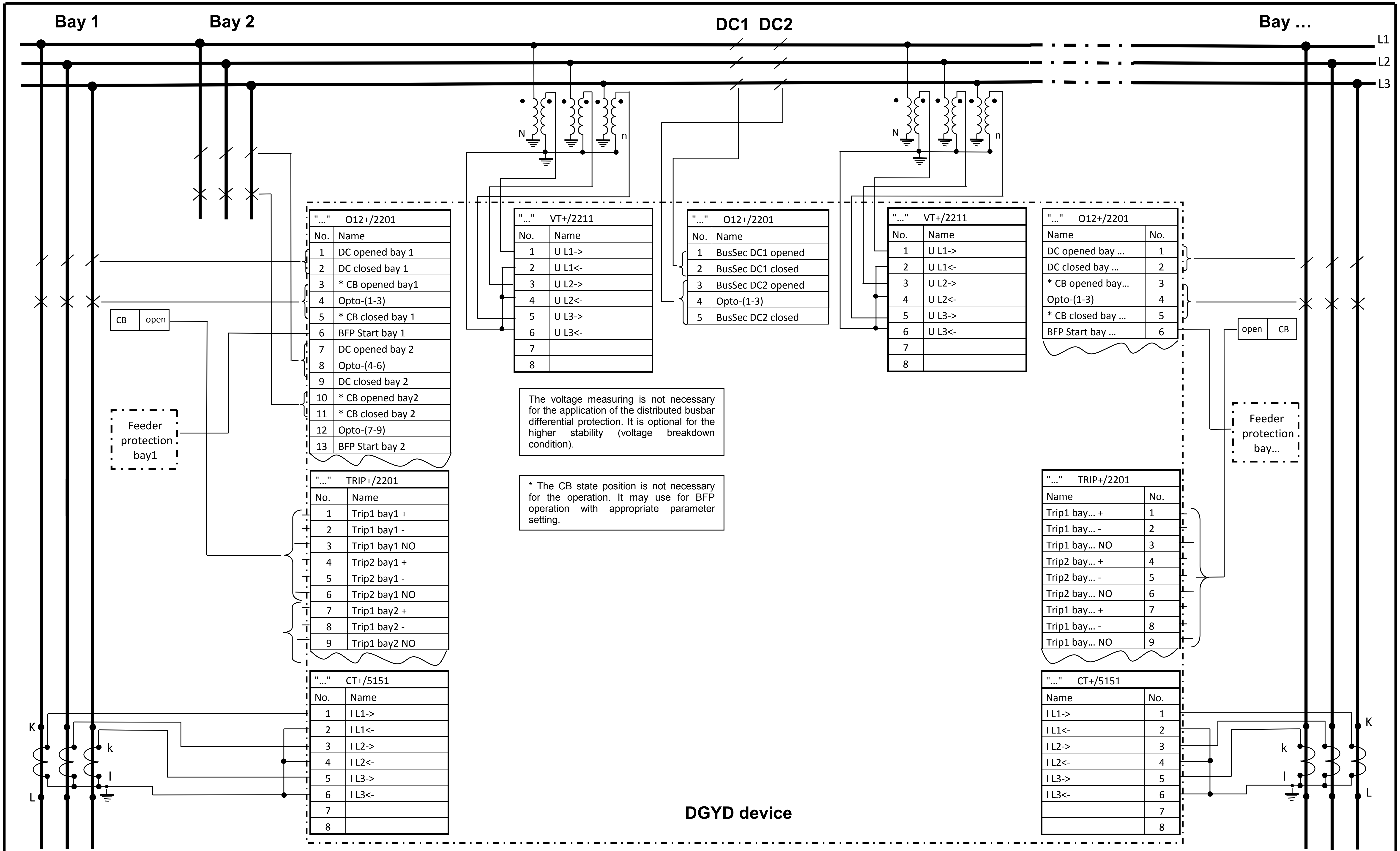
Here a function block is to be applied which operates without current transformer. With this solution a quadruple system (consisting of four busbars) can be described.



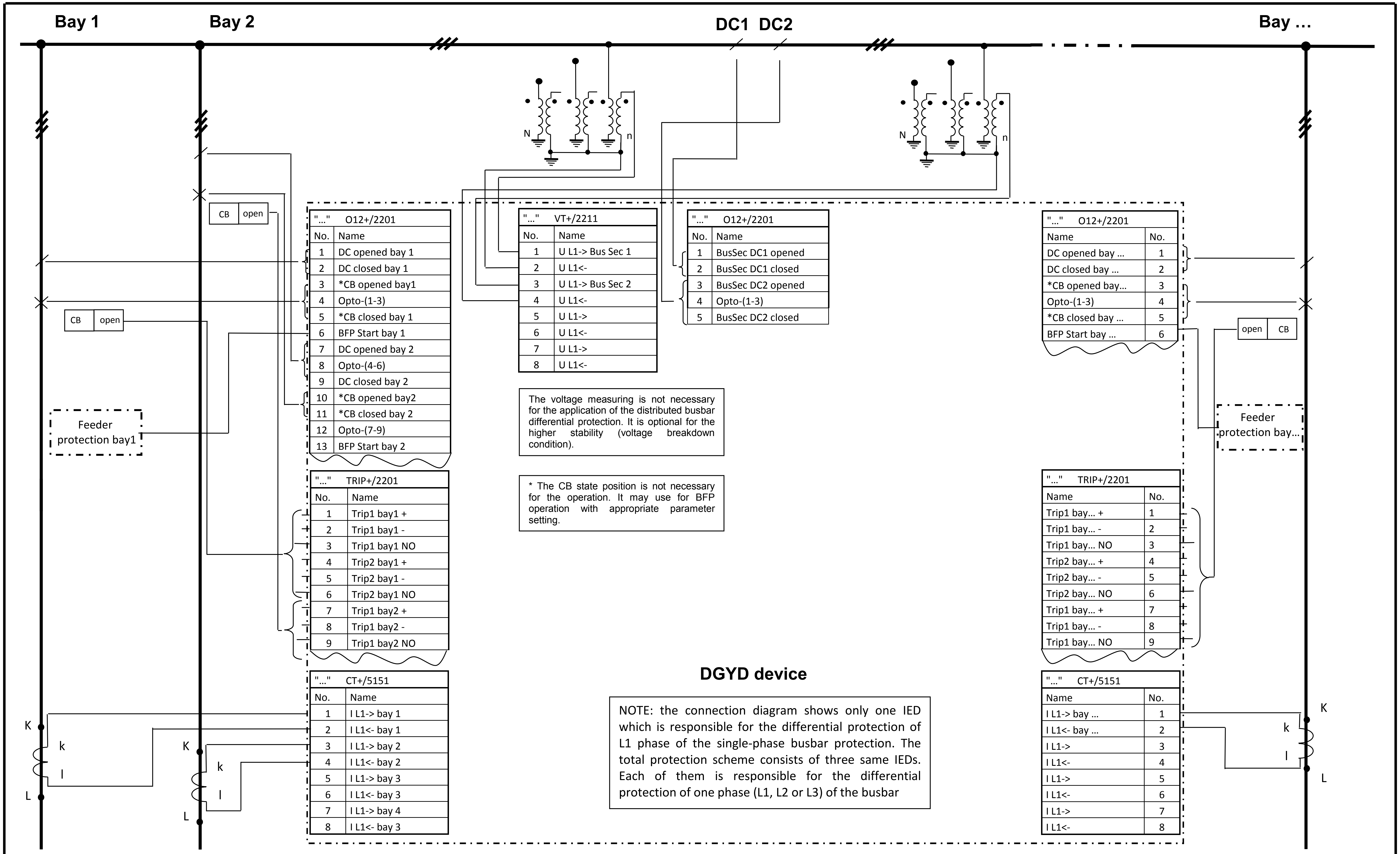
The setting of the topology elements is as follows:

Assigned bay [I]:	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 [I]:	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



Edit by	Tóth J.	Platform	IED-EP+	PROTECTA HUNGARY
Checked	Kazai N.	Type	DGYD	
Approved		Config		
Prod.manager				
Data	2015.01.22.	Subject	Connection diagram for the centralized three-phase busbar differential protection	ID PP-14-20936-00
				Pages:1



Edit by	Tóth J.	Platform	IED-EP+	PROTECTA HUNGARY
Checked	Kazai N.	Type	DGYD	
Approved		Config		
Prod.manager				
Data	2015.01.22.	Subject	Connection diagram for the centralized single-phase busbar differential protection	ID PP-14-20942-00
				Pages:1