Substation Automation Products

Distributed busbar protection REB500 Technical Manual

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standards EN 50263 and EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The product is designed in accordance with the international standards of the IEC 60255 series.

Safety information

Dangerous voltages can occur on the connectors, even though the auxiliary voltage has been disconnected.

Non-observance can result in death, personal injury or substantial property damage.

Only a competent electrician is allowed to carry out the electrical installation.

National and local electrical safety regulations must always be followed.

The frame of the IED has to be carefully earthed.

Whenever changes are made in the IED, measures should be taken to avoid inadvertent tripping.

The IED contains components which are sensitive to electrostatic discharge. Unnecessary touching of electronic components must therefore be avoided.

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Section 1 Introduction

1.1 This manual

The technical manual contains application and functionality descriptions and lists function blocks, logic diagrams, input and output signals, setting parameters and technical data sorted per function. The manual can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

1.2 Intended audience

This manual addresses system engineers and installation and commissioning personnel, who use technical data during engineering, installation and commissioning, and in normal service.

The system engineer must have a thorough knowledge of protection systems, protection equipment, protection functions and the configured functional logic in the IEDs. The installation and commissioning personnel must have a basic knowledge in handling electronic equipment.

1.3 Product documentation

Manual	Document number
Product Guide	1MRK 505 319-BEN
Application Manual	1MRK 505 333-UEN
Technical Manual	1MRK 505 335-UEN
Operation Manual	1MRK 500 121-UEN
Commissioning Manual	1MRK 505 336-UEN
Cyber Security Guideline	1MRK 511 345-UEN
Communication Protocol Manual, IEC 61850	1MRK 511 342-UEN
Communication Protocol Manual, IEC 60870-5-103	1MRK 511 343-UEN

1.4 Symbols and conventions

1.4.1 Symbols

The electrical warning icon indicates the presence of a hazard which could result in electrical shock.

The warning icon indicates the presence of a hazard which could result in personal injury.

The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

The information icon alerts the reader of important facts and conditions.

The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms in this manual are spelled out in the glossary. The glossary also contains definitions of important terms.
- Push button navigation in the LHMI menu structure is presented by using the push button icons, e.g.:

  To navigate the options, use  and  .

- HMI menu paths are presented in **bold**, e.g.:

  Select **Main menu/Settings**.

- LHMI messages are shown in `Courier` font, e.g.:

  To save the changes in non-volatile memory, select `Yes` and press .

- Parameter names are shown in *italics*, e.g.:

  The function can be enabled and disabled with the *Operation* setting.

- The * character after an input or output signal name in the function block symbol given for a function indicates that the signal must be connected to another function block in the application configuration to achieve a valid application configuration.

Section 2 Signals

Section 2.1 gives an overview on the numbering and naming conventions for signals.

In the following sections list binary input and output signals on bay units and central units. All signals are listed in ascending order of their numbers in their respective filter groups.

2.1 Signal designations

The REB500 configuration assigns the signals to predefined inputs and outputs. Signals are designated according to the following convention:

Table 1 Abbreviations used for the different signal texts

Category	Abbreviation
Bay unit	BU_
Central unit	CU_
General signals	SYS_
Busbar protection signals	BBP_
Breaker failure signal	BFP_
End fault protection signal	EFP_
Time-overcurrent protection signal	OCDT_
Disturbance recorder signal	DR_
Circuit-breaker pole discrepancy protection signal	PDF_
Low-voltage check feature	UV_
Input	I
Output	O
Internal system signal	SYS_INT

Table 2 Abbreviations used for the various functions

Function	Abbreviation
Busbar protection	BBP
Breaker failure protection	BFP
End fault protection	EFP
Time-overcurrent protection	OCDT
Disturbance recorder	DR
Circuit-breaker pole discrepancy protection	PDF
Low-voltage check feature	UV

A signal designation consists of a 5 digit signal number and a signal label, e.g. 37205 Block PDF.

Table 3 Signal Numbers Nomenclature

Digit 1 Category		Digit 2 Protection function		Digit3 Signal function		Digit 4, 5 Sequence number
1	Input on Bay unit	0	INT	1	TRIP	05
2	Output on Bay unit	1	SYS	2	Block command	10
3	Input on Central unit	2	BBP	3	Tripping Signal	15
4	Output on Central unit	3	BFP	4	Blocking Signal	20
5	System Signal	4	EFP	5	Bus image	etc.
		5	OCDT	6	Control	
		6	DR	7	Start	
		7	PDF	8	General Alarm	
		8	UV			

Table 4 Signal text nomenclature

Signal kind	Nomenclature	Upper and lower case rules
Signal Input	[Effect] [Function] [Phase] [Order] e.g. Start BFP L1 1 Block BFP	[Effect] First letter upper case, other letters lower case. [Function] All letter upper case. [Phase] [Order] Conform to national upper and lower case conventions.
Signal Output	[Function] [Effect] [Phase] [Order] e.g. BFP Trip L1	[Effect] First letter upper case, other letters lower case. [Function] All letter upper case. [Phase] [Order] Conform to national upper and lower case conventions.
Direct tripping signals	[Function] [TRIP] [Phase] [Order] e.g. BFP TRIP SSS TRIP L1	[Function] All letter upper case. [Phase] [Order] Conform to national upper and lower case conventions.
Input signals that can initiate tripping	[Origin] [Location] e.g. Ext TRIP BB-Zone	no explicit rule
Output signals used for transfer tripping	[Function] [Target] [TRIP] e.g. BBP Remote TRIP	[Function] All letter upper case. [Target] First letter upper case, other letters lower case.

2.2 Binary inputs on bay units

Table 5 BU general input signals

Signal	Description
11105_External TRIP	Tripping command received from another protection device (including one in the remote station) and used for the REB500 tripping contact to trip faults on a line or a power transformer.
11110_External TRIP BB zone	Used when an external signal has to trip the entire bus zone to which the feeder is connected (e.g. for an external BFP signal). Applied to all the bay units of the bus zone and sections of busbars interconnected by an isolator (intertripping).
11115_Ext_Test_TRIP	Activates the signal 21120_EXT_TEST_TRIP to operate several tripping relays simultaneously.
11120_BP External TRIP	Tripping signal generated by the feeder protection part. Trips faults on a line or power transformer with the aid of the REB500 tripping contact. Tripping thus takes account of the busbar configuration at the time. To function correctly, the signal has to be assigned to a feeder. The simplest arrangement corresponds to the assignment of the signal 11105_Ext. TRIP to feeders. If signal 11105_Ext. TRIP is not available, a binary output has to be configured for 11120_BP External TRIP which is then assigned to a feeder. The signal is activated by the feeder protection directly and does not therefore appear as binary input signal.
11125_BP External TRIP BB	This is a tripping signal generated by the feeder protection part which

Signal	Description
zone	is used to trip the entire bus zone to which the feeder is connected. The tripping command is applied to all the bay units of the bus zone and sections of busbars interconnected by an isolator (intertripping).
11205_Block SP	A signal applied to this input blocks the local station protection functions (BFP, EFP, OCDT and PDF), “External Trip”, tripping by the busbar protection and intertripping of the respective bay unit. The Bus Bar Protection continues to be active as a system function. The primary injection of the concerned bay unit can lead to a trip of the respective zone.
11210_Block output relays	All the output contacts configured for a bay unit are blocked.
11215_Ext. measuring disturbed	This signal is active when invalid analog values are received from an external device. The busbar protection (i.e. the specific protection zone of the busbar) and all the local protection functions are blocked. If the disturbance lasts longer than 400 ms, diagnostic events are generated (BBP Minor Error 7 and BBP Minor Error 29). This input should only be used in special cases and only when engineering a REB500 system.
11505_Close command CB	The circuit-breaker close command is needed by the busbar and end fault protection in bus-tie breaker and configured feeder bay units to control the REB500 measuring system.
11510...11525_Supervision aux. voltage_x	The supervision of the auxiliary supply is configured when the compliance of the auxiliary contacts on the isolators with the required switching sequence cannot be guaranteed and for this reason the “Not OPEN = CLOSED” logic has to be used. These signals ensure that the protection responds correctly should the auxiliary supply to the isolators fail. This signal is only applicable in the case of “Not OPEN = CLOSED”!
11530_Isolator/Breaker Position	The position of a circuit-breaker or an isolator is signaled by one or two auxiliary contacts.
11605_External release Trip	Providing they have been configured, a signal applied to this input enables tripping by the busbar protection and the intertripping function in the bay unit (AND logic of tripping and enabling signals). The input has no influence on other protection functions. This input can be used in special cases to interlock tripping by the protection by, for example, an external undervoltage relay.
11610_External reset	Tripping commands and signals can be configured to latch after picking up, in which case they must be reset by applying a signal to this input. It also resets the text display and LED’s on the local control unit. A reset signal resets the entire system.
11615, 11625, 11635, 11645_Inspection_x-Off	These inspection inputs (x = 1 to 4) activate the isolator or circuit-breaker inspection mode for the cases 1 to 4. As with the isolator inputs for the busbar image, two anti-coincident signals can be connected to these inputs. If the status of both inputs is identical, this is interpreted as an error. The last valid position is maintained and the LHMI on the bay unit indicates the error message ‘Insp. Alarm x’ (x= 1..4 corresponding to the number of the inspection input). These signals are only used when anticoincidence supervision of the inspection inputs is specified. The signal pairs in Table 6 result in relation to the inspection cases. Also refer to Section 11.12. xxxx “Inspection and maintenance”.
11620, 11630, 11640, 11650_Inspection_x-On	These inspection inputs (x = 1 to 4) activate the isolator or circuit-breaker inspection mode. They are only used both in cases where there is only one inspection signal (without anticoincidence supervision) and where there are anticoincidence signals (with

Signal	Description
	anticoincidence supervision) (see Table 6).
11655_Maintenance-Off	Anti-coincident maintenance input. Refer to the description for the “Inspection_x-Off” signals. If the status of both inputs is identical, the LHMI on the bay unit indicates ‘MaintenanceAlarm’.
11660_Maintenance-On	This input is excited by the maintenance function. It is used should only one maintenance signal be available.
11765_General Start DR	This signal is configured in the bay unit and together with the input signal “36705_General Start DR” from the central unit triggers the disturbance recorder in the bay unit. Without this signal, the bay unit does not respond to a general start of the disturbance recorder. It is only used for interlocking the general start signal for the disturbance recorder and may not be configured onto an optocoupler input. This is achieved by setting the mode to “No auxiliary contact” after opening the dialog “Binary module” and clicking on the tabs “Inputs” and “Details”
11840…11885_GP_In_x	With a properly configured event configuration, the input signal can be transmitted via LON or IEC103 and displayed on the control system. It is also possible to display the state of the signal on the local HMI LED’s of the bay unit.

Table 6 Signal pairs supervised for anticoincidence

Status	Inspection 1	Inspection 2	Inspection 3	Inspection 4
OPEN	11615	11625	11635	11645
CLOSED	11620	11630	11640	11650

In Table 7, some signals cannot be used to trigger a disturbance record:

- 13210_BP Block BFP
- 13610_BP Trip transferred
- 13761_BP Start BFP L1L2L3_5
- 13770...13780_BP Start BFP Lp
- 13785_BP Start BFP L1L2L3
- 13790_BP External start BFP

Table 7 BU input signals for BFP, EFP, OCDT, and PDF

Signal	Description
12605_Bypass Check Zone	The check zone criterion for the release of the bus bar protection is bypassed.
13205_Block BFP	Blocks operation of BFP for the corresponding bay unit. When the blocking signal is cancelled, the timers start again at t = 0.
13210_BP Block BFP	Blocks operation of BFP of the corresponding feeder. When the blocking signal is cancelled and providing a starting signal is present and current is flowing, the timers start again at t = 0.
13605_Trip transferred	The circuit-breaker sets this input when it cannot open, e.g. because the air pressure is too low or there is a leak in the case of GIS (Alarm Stage 3 - Circuit-breaker blocked). A tripping signal is then transferred to the adjacent breakers (busbar trip) and possibly the remote station.
13610_BP Trip transferred	Reserved for special applications. This Bay Protection (BP) signal allows triggering the trip redirection functionality if the signal 13605_Trip transferred is active. This signal is directly activated by BP and does not therefore appear as a binary input signal.
13705_External Start BFP	A signal applied to this input starts the breaker failure protection timer (independently of the overcurrent measurement).
13710...13735_Start BFP Lp_x	Phase-selective (p = 1 to 3) starting of the breaker failure protection with two inputs per phase (x = 1 to 2). The breaker failure timer is started by this input signal providing the current in the respective phase is above pick-up.
13740...13765_Start BFP L1L2L3_x	Three-phase starting of BFP by six inputs (x = 1 to 6). The BFP timer is started by a signal at one of these inputs providing the current in at least one phase is high enough.
13761_BP Start BFP L1L2L3_5	Functionally identical to signal "13760_Start BFP L1L2L3_5" but directly activated by the bay protection unit and not appearing as binary input signal.
13770...13780_BP Start BFP Lp	BFP with phase-selective starting (p = 1, 2 or 3). The BFP timer starts when this signal is activated by the bay protection function and the BFP measures a current in the corresponding phase.
13785_BP Start BFP L1L2L3	BFP with three-phase starting. The BFP timer starts when this signal is activated and the BFP measures a current in any phase.
13790_BP External start BFP	BFP with three-phase starting. The BFP timer starts when this signal is activated regardless of the current measurement.
13795...13796_Start BFP L0_x	L0-starting of BFP with two inputs (x = 1 or 2). The BFP timer is started by this input signal providing the current in the neutral system is above pick-up.
13797_BP Start BFP L0	Breaker failure protection with L0 - starting. The breaker failure protection timer starts when this signal is activated by the bay protection function and the BFP measures a current in the neutral system.
14205_Block EFP	Blocks operation of EFP for corresponding bay unit. When the blocking signal is cancelled, the timers start again at t = 0.
14405_BP EFP Manual Close	This signal is set by the bay protection when the circuit-breaker receives a close command to prevent EFP from tripping.
15210_Block OCDT	Blocks operation of OCDT. When the blocking signal is cancelled, the timer starts again at t = 0.
17205_Block PDF	Blocks operation of PDF. The timers start at t = 0 when the input resets.
17710_PDF ext release	Providing this input is configured, PDF is enabled by an external signal.

Table 8 BU input signals for disturbance recorder (DR)

Signal	Description
16705...16750_Start DR_x	The disturbance recorder function is started by an external signal applied to one of these 10 inputs (x = 1 to 10), or they can be simply used for recording purposes. The external signal may come, for example, from the tripping contact of a bay protection relay or the starting contact of a time-overcurrent relay. Optocouplers are configured for these inputs. The signal “16750_Start DR_10” is also transferred to the central unit where it initiates the general start of all disturbance recorders.
16760_BP Global Start DR	Those disturbance recorders in the bay units that are configured start. The signal ‘Central start DR’ in the bay units must be configured. This signal is directly activated by the bay protection unit and does not therefore appear as a binary input signal.

Table 9 BU input signals for voltage release (UV)

Signal	Description
18205_Fuse failure superv. UV	Provision is made for a tripped MCB to apply a signal to the input “18205_Fuse failure superv. UV” and enable tripping of the protection zone concerned.

Table 10 BU input signals for bay protection

Signal	Description
19205_Block BP	Blocks the protection output signals of the respective bay unit. Internal processing of the functions continues and therefore measurements and signals continue to be displayed on the local HMI.
19600_Activation BP ParSet_1	The protection functions and settings assigned to parameter set 1, 2, 3, or 4, respectively, are active. They remain active after the signal has been reset.
19605_Activation BP ParSet_2	
19610_Activation BP ParSet_3	
19615_Activation BP ParSet_4	
BP input signals available for configuration	In addition to the bay protection input signals in this table, which are always available, use can also be made of the signals configured for the binary signal input block of the bay protection. The number of these signals depends on the protection functions and signals included in the bay protection.

2.3 Binary outputs on bay units

Table 11 BU general output signals

Signal	Description
21105_EXTERNAL TRIP	Tripping command generated by the external input 11105_EXTERNAL TRIP.
21110_TRIP	Tripping command generated by the station protection intertripping function (BBP, BFP t2 etc.).
21115_REMOTE TRIP	Any of the protection functions that are capable of tripping an entire section of busbar (intertripping) can initiate a remote trip signal. Protection functions of this kind are: BBP, BFP, EFP, or the command “EXTERNAL TRIP”. Remote tripping can only take place if a fault cannot be cleared by the circuit-breaker in the bay concerned. This applies in the following cases: • 1½ breaker schemes • Bypass operation with the bus tie breaker being used for a feeder • Circuit-breaker bypassed by an isolator • Feeder not equipped with an own circuit-breaker. More details on special application cases are given in the Application Manual.
21120_EXT_TEST_TRIP	Generates a multi-pole trip for test purposes. Controlled by the binary input signal **11115_Ext_Test_TRIP**.
21305_Trip	Signals tripping by the bay unit and can be set by any of the station protection functions.
21405_SP blocked	Signals that the station protection functions including “EXTERNAL TRIP” and intertripping are blocked (either the bay concerned or throughout the station).
21410_Output relays blocked	All the output contacts configured in the bay unit concerned are blocked.
21805_In service	Signal set by the diagnostic function that shows whether or not a bay unit is operational and standing by.
21810_Loss of supply voltage	This signals a failure of the isolator auxiliary supply (“Supervision aux. voltage_x”) in the bay unit.
21815_Inspection/maintenance	This signal appears when an inspection or maintenance input is set in the bay unit and a position indicator on an isolator or circuit-breaker connected to the bay unit is forced into a particular status. Forcing of an isolator or circuit-breaker in this context means: The item of switchgear changes either from CLOSED to OPEN or from OPEN to CLOSED.
21820_Alarm	Signals an alarm situation in a bay unit: if an auxiliary supply fault is being signaled or if a bay unit diagnostic system has detected an analog signal processing error.

In Table 12, the column “T” signifies the type of the signal: ● are considered for trip output while ○ are considered for signalization purpose. Column “L” shows whether the signal additionally appears in the trip list (●), in the alarm list (○), or in no list (-).

Table 12 BU output signals for BBP , BFP, EFP, OCDT, PDF

Signal	T	L	#	Description
22405_BBP blocked	○	-	1	Signals that BBP is blocked (either individual protection zones or the entire system).
23105_BFP TRIP	●	●	2	Trip generated by BFP (after t1).
23110_BFP REMOTE TRIP	○	-	2	Tripping command issued to the remote station by BFP. This signal can be assigned to an output contact by the signal “REMOTE TRIP”.
23305_BFP trip t1	○	●	1	Signals tripping by BFP after time step 1.
23310_BFP trip t2	○	●	1	Signals tripping by BFP after time step 2.
23315_BFP TRIP L1	○	●	2	BFP detected a fault on phase L1 and has tripped.
23320_BFP TRIP L2	○	●	2	BFP detected a fault on phase L2 and has tripped.
23325_BFP TRIP L3	○	●	2	BFP detected a fault on phase L3 and has tripped.
23330_Trip transferred	○	-	1	Tripping has been redirected, providing a signal is being applied to the input “13605_Trip transferred”.
23335_Trip by BFP	●	-	1	BFP has issued an intertripping command.
23340_BFP TRIP L0	●	●	2	BFP detected a fault on neutral system (L0) and has tripped.
23405_BFP blocked	○	○	1	BFP is blocked (either the bay or the whole system).
24105_EFP REMOTE TRIP	●	●	2	Tripping command issued by EFP.
24305_EFP trip	○	●	1	EFP has tripped.
24405_EFP blocked	○	○	1	EFP is blocked (either the bay or the whole system).
24805_EFP start	○	○	1	EFP has started
25105_OCDT TRIP	●	●	2	Tripping command issued by OCDT.
25305_OCDT trip	○	●	1	Signals tripping by OCDT.
25405_OCDT blocked	○	○	1	OCDT is blocked (either the bay or the whole system).
25805_OCDT start	○	○	1	OCDT has started
27105_PDF TRIP	●	●	2	Tripping command by PDF.
27305_PDF trip	○	●	1	Signals tripping by PDF.
27405_PDF blocked	○	○	1	PDF is blocked (either the bay concerned or the entire system).
27805_PDF start	○	○	1	PDF has started

Table 13 BU output signals for disturbance recorder (DR)

Signal	Description
26805_DR ready	DR is standing by.
26810_DR memory full	DR memory is full.
26815_DR recording	DR is in the process of recording.
26820_DR record available	Disturbance records are available.

Table 14 BU output signals for voltage release (UV)

Signal	Description
28805_Voltage criterion	The voltage release criterion of this bay unit is fulfilled (measuring voltage is below the setting of the voltage criterion).

Table 15 BU output signals for bay protection (BP) (REB500sys only)

Signal	Description
29405_BP blocked	The outputs of the bay protection functions are blocked (either the bay concerned or throughout the system).
29410_BP partial blocked	Certain bay protection functions are blocked (see 49405_BP blocked).
29600 ParaSet_1 active	Parameter set 1, 2, 3, or 4, respectively, is active. This can take place via the station bus or an input signal.
29605 ParaSet_2 active	
29610 ParaSet_3 active	
29615 ParaSet_4 active	
29805_BP Test Sequence active	The test sequencer is active.
BP output signals available for configuration	In addition to the bay protection output signals listed above which are always available, use can also be made of the signals configured for the binary signal output block of the bay protection. The number of these signals depends on the protection functions and signals included in the bay protection.

2.4 Binary inputs on central unit

Most central unit signals can only be assigned once. However, two input signals (31105_External TRIP BB zone and 31805_External release BB zone) occur for each busbar zone. Thus the busbar section must be given when selecting one of these signals.

Table 16 CU general input signals

Signal	Description
31105_External TRIP BB zone (BB zone tripped by external signal)	A busbar section can be tripped by a signal applied to this input. A maximum of 12 bus zones resp. external tripping signals can be configured in one BIO unit. One input can be configured for each section. Sections connected by isolators are tripped together (intertripping).
31205_Block SP	Blocks the station protection (SP) functions (BBP, BFP, EFP, OCDT and PDF) including “External Trip”, “External TRIP BB zone” and intertripping throughout the system.
31210_Block output relays	All the output contacts configured for the central unit and all the bay units are blocked, i.e. the current status of the relays is maintained.
31215_Block IEC master direction	The system does not transfer any events, error messages, measurements etc., to the master station via the station bus IEC 60870-5-103 when this input is active.
31505_Accept bus image alarm	Acknowledges (resets) an isolator alarm. If it is continuously active, a new isolator alarm is immediately reset.
31805_External release BB zone	Enables the tripping signal for a section of busbar (AND gate with tripping and enabling inputs). A maximum of 12 bus zones resp. external release signals can be configured in one BIO unit. The entire protection zone surrounding the busbar section is enabled

Signal	Description
	(transfer tripping). Sections connected by isolators are also enabled (transfer tripping). The input can be used in **special cases**, for example, to interlock the tripping signal by an undervoltage relay. This will generally delay tripping.
31230_Block BB zone	With this signal of the bus bar protection the inter-tripping and the external trip of the BB block is blocked. A maximum of 12 bus zones resp. blocking signals can be configured in one BIO unit. A complete bus zone in which the BB block is located would be blocked (inter-tripping). If the bus block is associated with an isolator then it is also blocked (inter-tripping). The input operates with a time delay of up to 300 ms.
31810_External reset	Tripping commands and signals can be configured to latch and when they are, they are reset by a signal applied to this input. The same signal also resets the LED's (alarm and tripping). The reset signal applies to the entire system.
31815_Ext. superv. in service_1	Inputs for monitoring any fans, external supplies etc. Signal 41805_Alarm is set in the central unit when any of these signals changes from logical 1 to 0.
31820_Ext. superv. in service_2	
31840…31885_GP_In_x	With a properly configured event configuration, the input signal can be transmitted IEC103 and displayed on the control system.

Table 17 CU input signals for protection functionality

Signal	Description
32205_Block BBP	Blocks BBP throughout the system.
32605_Bypass Check Zone	Bypasses the check zone criterion for the release of BBP
33210_Block BFP	Blocks BFP throughout the system. When cancelled, the timers start again at t = 0 if the current is higher than setting.
34215_Block EFP	Blocks EFP throughout the system. When cancelled, the timers start again at t = 0 if the circuit-breaker is open and the current higher than setting.
35220_Block OCDT	Blocks OCDT throughout the system. When cancelled, the timers start again at t = 0.
36705_General Start DR	The disturbance recorders in all the bay units are started by this input if configured. The signal "General start disturbance recorder" must also be configured in the bay units.
37205_Block PDF	Blocks PDF throughout the system. The timers restart at t = 0 when the signal is reset.
39205_Block BP	Blocks bay protection output signals throughout the system. Internal processing of the functions continues and therefore measurements and signals continue to be displayed on the local HMI.

2.5 Binary outputs on central unit

Table 18 CU general output signals

Signal	Description
41305_Trip BB zone (busbar designation)	Signals which busbar sections have been tripped. An output can be configured for each busbar section, which is then correspondingly designated. There are as many output relays as there are busbar zones and where the number of busbar zones is high, a second BIO module is needed.
41310_Trip transferred	Tripping has been redirected by the input “13605_Trip transferred” on a bay unit.
41405_SP blocked	All the station protection functions including “External TRIP”, “External TRIP BB zone” and inter-tripping are blocked throughout the system.
41410_Output relays blocked	All the output contacts that are configured are blocked.
41505_Isolator alarm	At least one isolator or circuit-breaker is not reporting a defined position (neither CLOSED nor OPEN). It is issued at the end of the set time delay and is reset by the input “Acknowledge isolator alarm”, respectively set again by the next isolator alarm.
41805_Alarm	Set in the following cases: • Supply failure • Failure or disturbance of a central unit module • Failure of the communication with a bay unit • Failure of a bay unit • Failure of a bay unit function • Error when refreshing the data in the protection system • Communication error in the central unit • “Ext. supervision in service_1/2” inputs not set • An ABB reference (bay) was deactivated under the HMI500 menu “Settings Activate/ deactivate device” first and activated with the limitation “no objects” afterwards. Due to this setting the single line diagram shows an active bay node (bay name), but a deactivated bay figure. If no bay unit is connected for this bay, the alarm signal is set.
41810_In service	Signal set by the diagnostic function that shows that the central unit is operational or stand-by.
41815_Diff. current alarm	The differential current of a protection zone exceeded the set alarm level during the preset interval.
41820_Loss of supply voltage	Signals the failure of the isolator auxiliary supply on a bay unit (“Supervision aux. voltage_x”). It is used in conjunction with “Not OPEN = CLOSED”.
41825_Inspection/maintenance	Signals that an inspection or maintenance input is set on one of the protection units.
41830_Switch inhibit	This signal appears together with “Isolator alarm”. No switching of the primary system may take place as long as this signal is active, because the image of the primary system in the protection would not then correspond to the actual situation.
41835_Test generator active	The test generator is in active within the busbar protection system.
41840_PRP LineA ready	Signal the status of the IEC 61850 redundant lines A and B, respectively (CIM module Ethernet ports LAN1 and LAN2). The signal is active if a link has been established.
41845_PRP LineB ready	
41415 BB zone blocked	Signals the blocking of BBP or the inter-tripping system of a bus zone. This signal is a combined signal i.e. both the blocking of BBP and also blocking of the inter-tripping system are signaled.

Table 19 CU output signals for protection functionality

Signal	Description
42305_BBP trip	BBP has tripped.
42310_BBP trip L0	A fault was detected on phase L0, L1, L2, or L3, respectively, and BBP has tripped.
42315_BBP trip L1	
42320_BBP trip L2	
42325_BBP trip L3	
42330_Check_Zone_Operated	The check zone has operated.
42405_BBP blocked	BBP is blocked (either individual protection zones or the entire system).
42805_ Check Zone Bypassed	The check zone release function for BBP is bypassed.
42810_Check_Zone_Diff_Alarm	The differential currents of the check zone exceed the set alarm level.
43305_BFP trip t1	BFP tripped in time step 1.
43310_BFP trip t2	BFP tripped in time step 2.
43405_BFP blocked	BFP is blocked (either a bay unit or the entire system).
44305_EFP trip	EFP has tripped.
44405_EFP blocked	EFP is blocked (either a bay unit or the entire system).
45305_OCDT trip	OCDT has tripped.
45405_OCDT blocked	OCDT is blocked (either a bay unit or the entire system).
45805_OCDT start	One of the feeder time-overcurrent functions has picked up.
47305_PDF Trip	Signals tripping by PDF.
47405_PDF blocked	PDF is blocked (either individual bays or the entire system).
48805_Voltage criterion	UV has been activated (either individual bays or throughout the system).
49405_BP blocked	The outputs of the bay protection functions are blocked (either individual bays or throughout the system).
49410_BP partial blocked	Certain bay protection output signals in specific bays or throughout the entire system are blocked.

2.6 System blocking design

Certain central and bay unit input signals can directly influence output signals. Figure 1 shows the blocking system. The numbered items in that figure mean:

1. Default value “1” if the input or function is not configured.
2. The output is blocked when “Block output relays” is active and signal 2) on HMI500 is configured for blocking.
3. Blocked by isolator or differential current alarm (providing correspondingly configured via HMI500).
4. Protection function disabled.
5. CTs line side: transfer tripping
   CTs busbar side: busbar intertripping
6. Detected automatically by the software when, for example, the CB is bridged.
7. Blocking the bay protection does not block the protection function itself, but only the logical outputs of the bay protection functions, i.e. although blocked measurements are still displayed and trips signaled.
8. A BP output signal can be assigned for blocking the BFP function via the default blocking signal “13210_BP Block BFP”

When signal “31210_Block output relays” is activated, the last status of all the protection function outputs is retained.

Table 21 and Table 22 list how an input can affect the output signal as explained in Table 20:

Table 20 Effects of input signals to output signals

Effect	Description
B	The signal is not changed (retained) providing it was configured for blocking.
E	The signal is not changed (retained).
F	Signal enabled (trip interlocked by enabling signal).
K	Blocks providing this blocking function were configured using HMI500.
M	Logic signal
P	Partially blocked, i.e. the busbar protection does not issue any tripping commands or signals. Other functions (BFP, EFP), which can also set this output, are not affected by the blocking signal.
S	The signal is set.
Z	The signal is either reset and blocked or simply blocked if it was not already blocked when the blocking signal was generated.

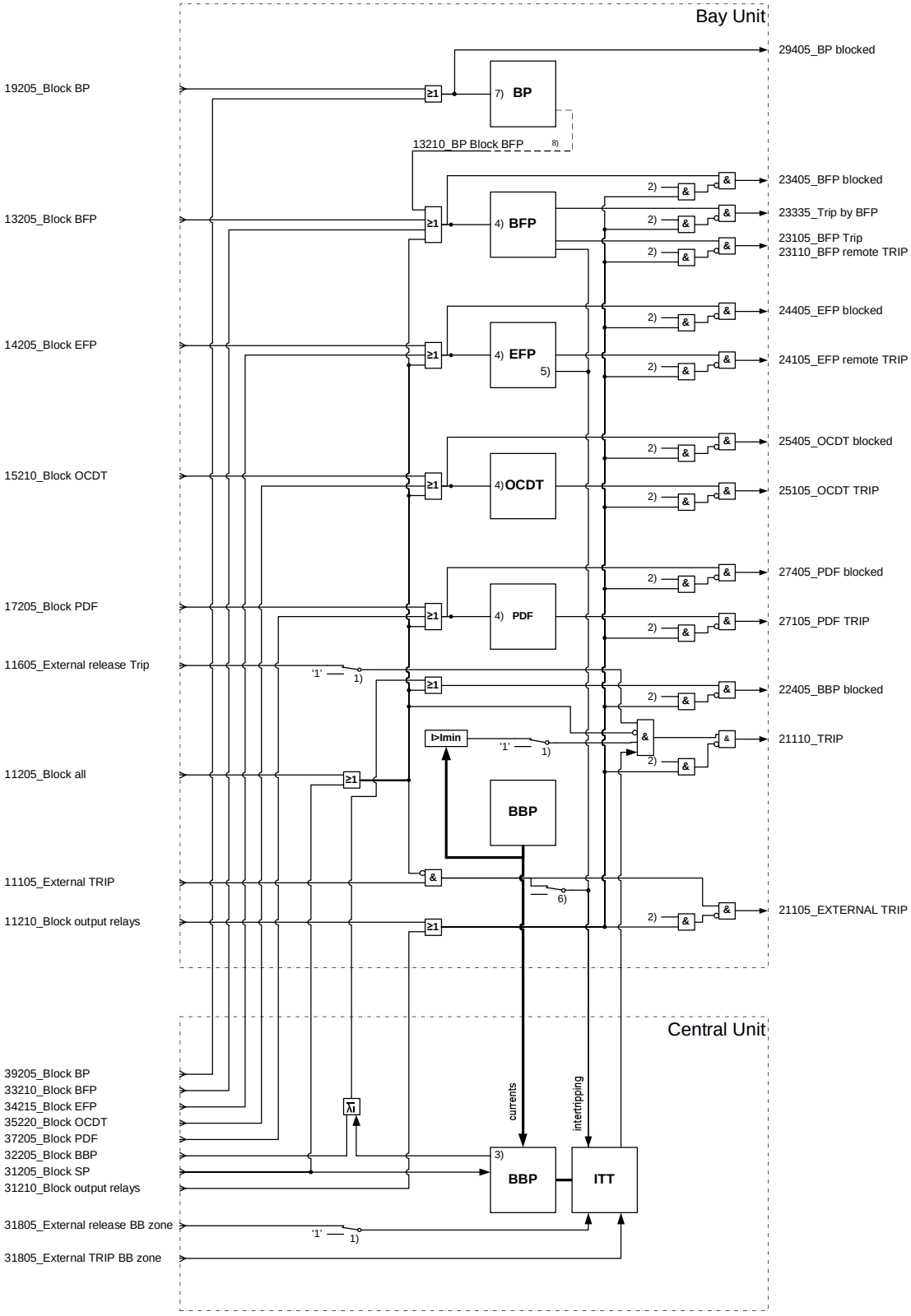

Figure 1 REB500 blocking system

Table 21 Central Unit blocking system

Input																				Output
Blocking Inputs																Alarms		Enable		
BU							CU									CU		BU	CU	CU
11205_Block SP	11210_Block output relays	13205_Block BFP	14205_Block EFP	15210_Block OCDT	17205_Block PDF	19205_Block BP	31205_Block SP	31230_Block BB zone	31210_Block output relays	32205_Block BBP	33210_Block BFP	34215_Block EFP	35220_Block OCDT	37205_Block PDF	39205_Block BP	Isolator alarm	Differential current alarm	11605_External release trip	31805_Ext. release BP zone	
							E		B	P						Z			F	41305_Trip BP zone
									B											41310_Trip transferred
							S		B	S										41405_SP blocked
							S	S	B	S						K	K			41415_BB zone blocked
									B											41410_Output relay blocked
									B							S				41505_Isolator alarm
									B											41805_Alarm
									B											41810_In service
							E		B	E							S			41815_Differential current alarm
									B											41825_Inspection/maintenance
									B							S				41830_Switch inhibit
									B											41835_Test generator active
							E		B	E									F	42305_BBP trip
							E		B	E									F	42310_BBP trip L0
							E		B	E									F	42315_BBP trip L1
							E		B	E									F	42320_BBP trip L2
							E		B	E									F	42325_BBP trip L3
							S		B	S						K	K			42405_BBP blocked
							Z		B		Z								F	43305_BFP trip t1
							Z		B		Z								F	43310_BFP trip t2
		S					S		B		S								F	43405_BFP blocked
							Z		B			Z							F	44305_EFP trip
			S				S		B			S							F	44405_EFP blocked
							Z		B				Z						F	45305_OCDT trip
				S			S		B				S						F	45405_OCDT blocked
							Z		B				Z						F	45805_OCDT start
							Z		B					Z					F	47305_PDF trip
					S		S		B					S					F	47405_PDF blocked
									B											48805_Voltage criterion
						S			B						S					49405_BP blocked

Table 22 Bay Unit blocking system

Input																				Output
Blocking Inputs																Alarms		Enable		
BU							CU									CU		BU	CU	CU
11205_Block SP	11210_Block output relays	13205_Block BFP	14205_Block EFP	15210_Block OCDT	17205_Block PDF	19205_Block BP	31205_Block SP	312230_Block BB zone	31210_Block output relays	32205_Block BBP	33210_Block BFP	34215_Block EFP	35220_Block OCDT	37205_Block PDF	39205_Block BP	Isolator alarm	Differential current alarm	11605_Ext. release trip	31805_Ext. release BP z.	
Z	B						Z		B											21105_EXTERNAL TRIP
Z	B						Z	Z	B	P							P	F	Z	21110_TRIP
Z	B						Z	Z	B	P						Z	P	F	Z	21115_REMOTE TRIP
Z	B						Z	Z	B	P							P	F	Z	21305_Trip
S	B						S	S	B											21405_SP blocked
	S								S											21410_Output relays blocked
	B								B											21805_In service
	B								B											21815_Inspection/maintenance
	B						S	S	B	S						Z				22405_BBP blocked
Z	B	Z					Z		B		Z									23105_BFP TRIP
Z	B	Z					Z		B		Z									23110_BFP REMOTE TRIP
Z	B	Z					Z		B		Z									23305_BFP trip t1
Z	B	Z					Z		B		Z									23310_BFP trip t2
Z	B	Z					Z		B		Z									23315_BFP TRIP L1
Z	B	Z					Z		B		Z									23320_BFP TRIP L2
Z	B	Z					Z		B		Z									23325_BFP TRIP L3
	B								B											23330_Trip transferred
Z	B	Z					Z		B		Z									23335_Trip by BFP
S	B	S					S		B		S									23405_BFP blocked
Z	B		Z				Z		B			Z								24105_EFP REMOTE TRIP
Z	B		Z				Z		B			Z								24305_EFP trip
S	B		S				S		B			S								24405_EFP blocked
Z	B			Z			Z		B				Z							25105_OCDT TRIP
Z	B			Z			Z		B				Z							25305_OCDT trip
S	B			S			S		B				S							25405_OCDT blocked
	B								B											26805_DR ready
	B								B											26810_DR memory full
	B								B											26815_DR recording
	B								B											26820_DR record available
Z	B				Z		Z		B					Z						27105_PDF TRIP
Z	B				Z		Z		B					Z						27305_PDF trip
S	B				S		S		B					Z						27405_PDF blocked
	B								B											28805_Voltage criterion
	B					S			B						S					29405_BP blocked

Section 3 System Settings

3.1 Circuit breakers

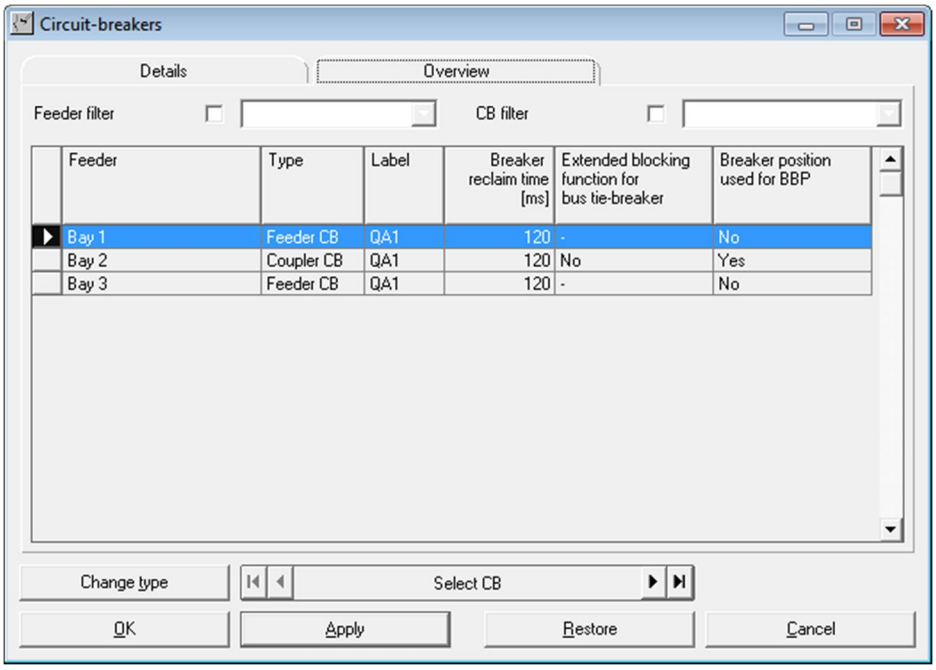

Figure 2 Settings / Circuit-breakers - Overview

The “Overview” tab opens a dialog with a list of all the feeder breakers and bus-tie breakers shown in the single-line diagram are together with their labels, bay labels, type of circuit-breaker (feeder or bus-tie) and the circuit-breaker reclaim time.

When “Extended blocking function for bus tie-breaker” is set to “No”, the standard blocking function for bus tie-breakers is activated. If this setting is “Yes”, the extended blocking function for “bus-ties in series” is activated. This setting is relevant only for coupler breakers.

When “Breaker position used for BBP” is set to “No”, the current measurement of busbar protection is enabled regardless of the feeder circuit-breaker. When set to “Yes”, the current measurement of busbar protection is enabled or disabled depending on the position of the circuit-breaker. In this case, configuring the signal “11505_Close command CB” is imperative.

Details

In the “Details” view the “Label” field can be edited and the reclaim time for each circuit-breaker is entered in the corresponding field.

The setting of the reclaim time t_{rec} is the sum of three values rounded to 20 ms steps ($t_{rec} = t_{CB} + t_{reset} + t_s$, see Table 23 for possible values):

- t_{CB}: Maximal opening time of the CB including the arc extinction time
- t_{reset}: Reset time of the breaker reclaim function depending on two factors:
  - the adjusted pick up value of the busbar protection differential current measurement $I_{kmin-set}$
  - the maximal primary busbar fault current I_{kmax}
  - This value can be looked up in Table 24 for 50 and 60 Hz.
- t_s: Additional safety time (10 ms)

Table 23 Range of the reclaim time setting for circuit-breakers

Parameter	Min.	Max.	Default	Step	Unit
Reclaim time	20	500	160	20	ms

Table 24 Reset time t_{reset} of the breaker reclaim function (50/60Hz)

	Maximal busbar fault current I_{kmax}		
$I_{kmin-set}$	≤ 10kA	>10kA to ≤ 20kA	>20kA to ≤ 50kA
= 500A	77ms	87ms	100ms
> 500A	63ms	73ms	88ms

Setting example for the reclaim time:

$$\left.\begin{array}{l} I_{kmin-set} = 2500\text{A} \\ I_{kmax} = 30\text{kA} \end{array}\right\} \begin{array}{rl} t_{CB} &= 40\text{ms} \\ t_{reset} &= 88\text{ms} \\ t_s &= 10\text{ms} \\ \hline t_{rec} &= 138\text{ms} \rightarrow \mathbf{140ms} \end{array}$$

The operation of feeder and bus-tie breakers and the reclaim time are described in detail in the Application Manual.

3.2 Isolators

The “Overview” tab opens a dialog with a list of all the isolators in the single-line diagram with their labels and bay labels. The isolators of a particular bay can be viewed by activating the check box “Feeder filter” and selecting a bay from the list.

The label in the “Markings” field of the “Details” dialog can be edited.

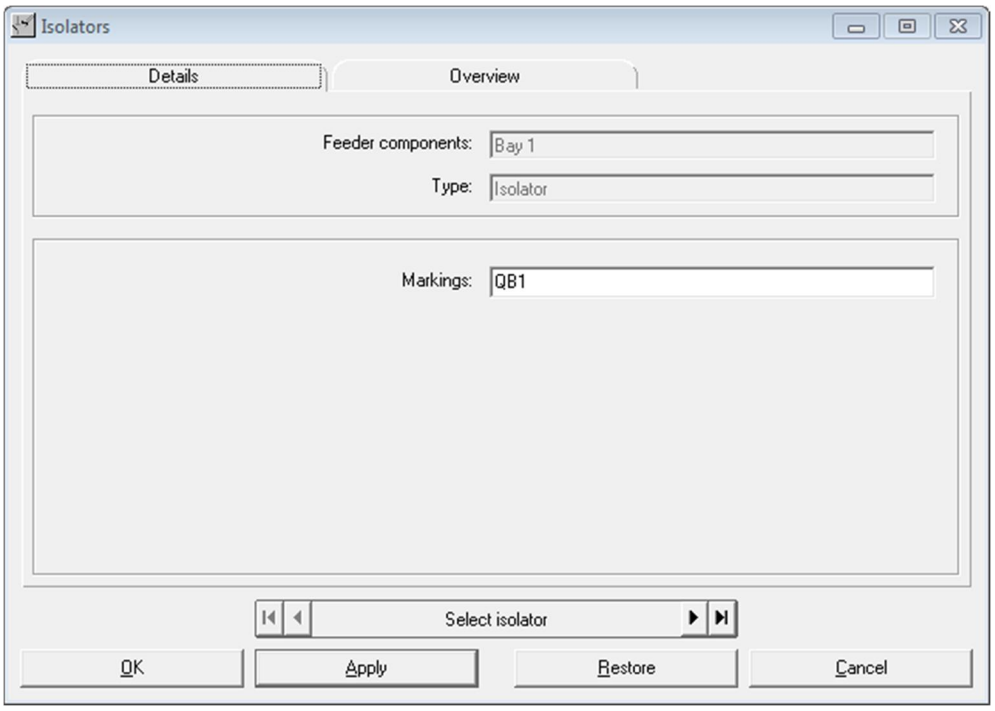

Figure 3 Settings / Isolators - Details

3.3 Current transformers

The “Overview” tab opens a dialog with a list of all the current transformers in the single-line diagram with their labels, bay labels, primary and secondary rated currents.

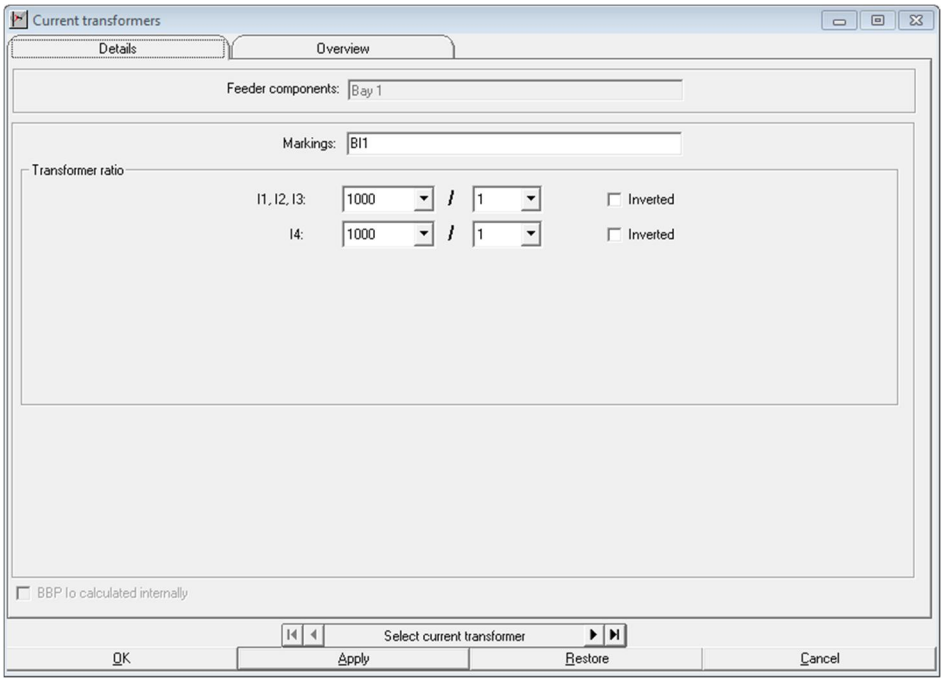

Figure 4 Settings / Current transformer - Details

In the “Details” view the label in the “Markings” field can be edited. The ratios in the “Transformer ratio” fields are entered in terms of the primary and secondary rated currents. The secondary setting is only for information. The selection of 1 A or 5 A as the secondary rating is achieved by appropriately connecting the CT inputs on the REB500 bay unit.

Table 25 Parameter ranges of current transformers

		Min.	Max.	Step
Primary [A]	I1, I2, I3, I4	50	10000	1
Secondary [A]	I1, I2, I3, I4	1	5	N/A

The direction of the bay unit currents can be reversed by enabling the checkbox “Inverted”. REB500 internally the “Inverted” setting has the effect of a scaling factor of -1. Normally, the setting of the “Inverted” checkbox remains unchanged (default setting = “not inverted”).

Should it be necessary to reverse the current direction permanently, it is recommended to achieve this via the current input wiring of the bay unit and not by the “Inverted”-setting.

3.4 Voltage transformers

The “Overview” tab opens a dialog with a list of all the voltage transformers in the single-line diagram with their labels, bay labels primary and secondary rated voltages.

In the “Details” view the description can be edited in the input field “Markings”. The ratio is determined by the primary and secondary ratings entered in the “Transformer ratio” input field. The VT input is a single winding, which is suitable for all the main VT secondary ratings, the effective voltage being set via HMI500 to either 100 V or 200 V. Other voltages are accommodated by appropriately setting the scaling factor. The mode of VT connection (star or delta) and the scaling factor are entered in addition to the primary/ secondary rating. The scaling factor adjusts the setting for the rated secondary voltage to equal the effective rated secondary voltage.

This menu item appears only if voltage transformers have been fitted.

Setting example

- VT data:

  UN primary = 220 kV / $\sqrt{3}$

  UN secondary = 110 V / $\sqrt{3}$

  Connection to REB500: 3 phases_star

- Settings made in HMI500

VT connection:	3 phases_star
Primary voltage:	220,000 V
Secondary voltage:	100 V
Scaling factor:	1.1

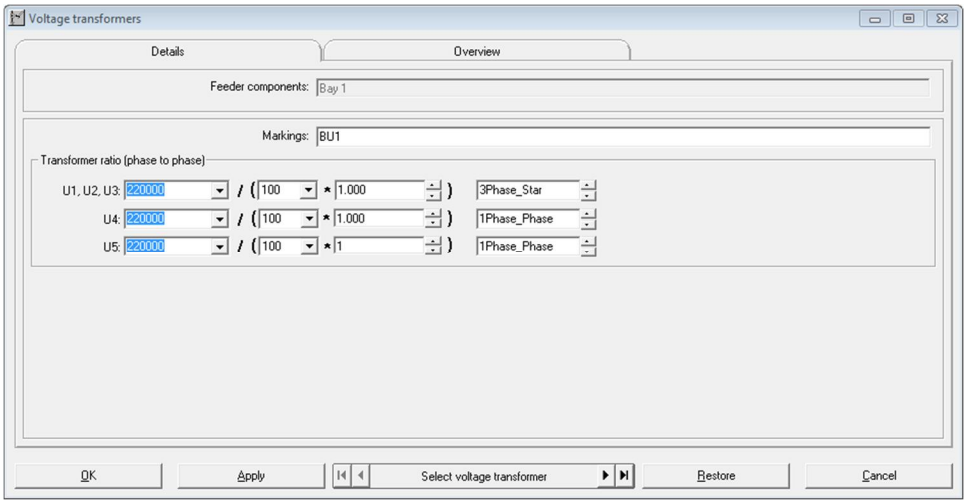

Figure 5 Settings / Voltage transformers - Details

3.5 System response

"System response" in the "Settings" menu opens a dialog that provides a choice of how the system should react to differential current alarms and to isolator alarms.

Details of the differential current supervision and isolator status supervision systems are given in the Application Manual.

3.5.1 System response to a differential current alarm

- Continue in operation: The busbar protection continues to function.
- Block busbar protection: Operation of the entire busbar protection is blocked.
- Selective block busbar protection (preferred): Operation of the busbar protection is only blocked for the section of busbar (protection zone) concerned.

Setting the response to "Block" is more likely to cause a failure to trip and to "Continue in operation" a mal-operation.

3.5.2 System response to an isolator alarm

- Continue in operation: The busbar protection continues to function.
- Block busbar protection and Intertripping: Operation of the busbar protection and intertripping scheme is blocked throughout the system.
- Selective block busbar protection and Intertripping (preferred)
  The busbar protection and intertripping are only blocked for the section of busbar (protection zone) concerned.

Setting the response to “Block” is more likely to cause a failure to trip and to “Continue in operation” a mal-operation.

3.5.3 Isolator alarm delay

The busbar protection has a common alarm circuit and timer for monitoring the operation of all the isolators and bus-tie breakers. The setting of the isolator operating time thus applies for all the isolators and circuit-breakers in the system.

The time delay must be set longer than the slowest isolator operating time.

3.5.4 Remote trip impulse width

BBP and, where configured, BFP and EFP can send an intertripping signal to a remote station via PLC or optical fiber communication channel:

- 21115_REMOTE TRIP
- 23110_BFP REMOTE TRIP
- 24105_EFP REMOTE TRIP

The impulse width generally has to be limited, typically to 200 ms.

Table 26 Setting range of the remote trip impulse width

Parameter	Min.	Max.	Default	Step	Unit
Remote trip impulse width	100	2000	200	10	ms

3.6 Event memory

The busbar protection includes an event memory for each individual unit (central unit and bay units) in which changes in the statuses of binary signal are recorded. The event memories have a capacity for 100 events in bay units and 1000 events in the central unit. The user can select one of the storage strategies in Table 27.

A time stamp (date and time with an accuracy of 1 ms), a text defined using the operator program and a status (set or reset) are attached to every event. Individual texts can be entered for each status.

Generally, one event is configured for every input and output, but events can also be assigned to optocoupler inputs or relay outputs.

A central unit signal can only be stored in the event memory in the central unit, while a bay unit signal can be stored in either the event memory in the central unit or in the bay unit or in both.

Table 27 Event memory storage strategy

Strategy	Explanation
Keep the oldest (FIX)	No further events recorded when the memory is full
Keep the latest (FIFO)	The oldest event should be overwritten (ring buffer)
Keep <n> old and latest	Keeps the given number of old events, then overwrite

3.7 Time synchronization

The following section lists the options for time-synchronizing the REB500 to an external source.

These options can be selected using the HMI500 menu item “Settings – Time – Time Synchronization”.

3.7.1 Synchronizing using IRIG-B

Electrical IRIG-B synchronization is supported using the X1008 connector on the central unit.

Table 28 Connections for synchronizing with electrical IRIG-B

Connector	Explanation
X1008.06	IRIG-B -
X1008.07	IRIG-B_GNDC
X1008.13	IRIG-B +
X1008.14	IRIG-B_GND

Optical IRIG-B synchronization is supported using the Rx-interface X1010 on the central unit.

3.7.2 Synchronizing using PPS

Synchronization via PPS is supported both via an electrical or an optical pulse.

Electrical synchronizing impulses use the interface X1008 on the central unit.

Table 29 Connections for synchronization using electrical PPS

Connector	Explanation
X1008.06	electrical PPS -
X1008.13	electrical PPS +

Optical synchronizing impulses use the Rx-interface X1010 on the central unit.

PPS impulses are only processed when they are received at a rate of 1 s ±50 ms. An error message is generated should this not be the case and the system switches over to the internal REB500 clock. Valid second impulses correct the internal clock by a maximum of ±0.5 seconds.

3.7.3 Synchronization by SNTP

Using 61850 station bus communication requires the use of SNTP as an overall synchronization method for valid timestamps and qualities.

To synchronize the REB500 via SNTP, at least one SNTP-server is necessary. Redundant SNTP in case of device failure is optionally supported by specifying a second server.

Table 30 Configuration parameters for synchronizing via SNTP

Setting	Description	Default setting
SNTP1	TCP/IP Address of the SNTP time master	127.0.0.1
SNTP2	TCP/IP Address of the SNTP standby time master	127.0.0.1

3.7.4 Additional settings

This section provides additional options for system-time parameters.

3.7.4.1 Time zone correction

This menu permits the adjustment of the deviation between local time (of installed REB500 system) and UTC (Universal Time coordinated).

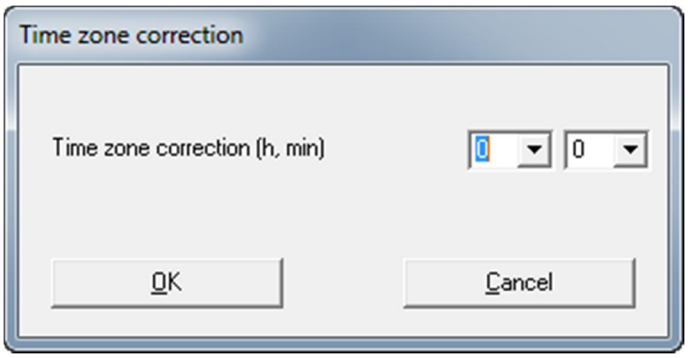

Fig. 3.1 Settings / Time -Time zone correction

3.7.4.2 Daylight saving time

This menu permits the configuration of an automatic switching between standard and summer time.

If the “Daylight saving time” (DST) mode is enabled the user can define the moment of “Start” and “End” of the DST period. The DST settings are saved by pressing the “OK” or “Apply” button.

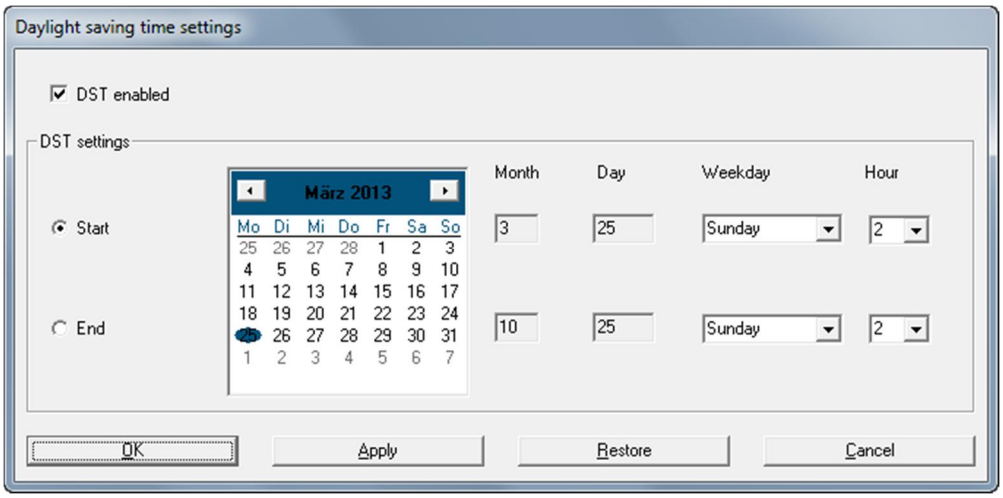

Fig. 3.2 Daylight saving time settings

Section 4 Busbar protection

4.1 Configuration

In the busbar protection settings dialog, there are three tabs for setting parameters for the different operating characteristics. Table 31 lists the allowed ranges for these parameters.

Table 31 Busbar protection settings

Operating characteristic	Parameter	Min.	Max.	Default	Step	Unit
L1, L2, L3	I_{Kmin}	200	6000	1000	100	A
	k'	0.7	0.9	0.80	0.05	
	Differential current alarm	5	50	10	5	% I_{Kmin}
	Delay (Differential current alarm)	1	50	5	1	s
L0	I_{Kmin}	100	6000	300	100	A
	k	0.7	0.9	0.80	0.05	
	Differential current alarm	5	50	10	5	% I_{Kmin}
	Delay (Differential current alarm)	1	50	10	1	s
Check-Zone	I_{Kmin}	200	6000	1000	100	A
	k	0	0.9	0.25	0.05	
	Differential current alarm	5	50	10	5	% I_{Kmin}
	Delay (Differential current alarm)	2	50	5	1	s

The operating characteristic shown in Figure 6 only applies for the restrained current amplitude comparison algorithm. There are no settings for the phase comparison algorithm.

The tab “L1, L2, L3 operating characteristic” is for entering the parameters applicable to the phase fault operating characteristic; “L0 operating characteristic” for setting the ground fault characteristic. This tab is only available if a neutral current measurement has been configured.

The third tab “Check Zone operating characteristic” is only available if a check zone protection has been configured.

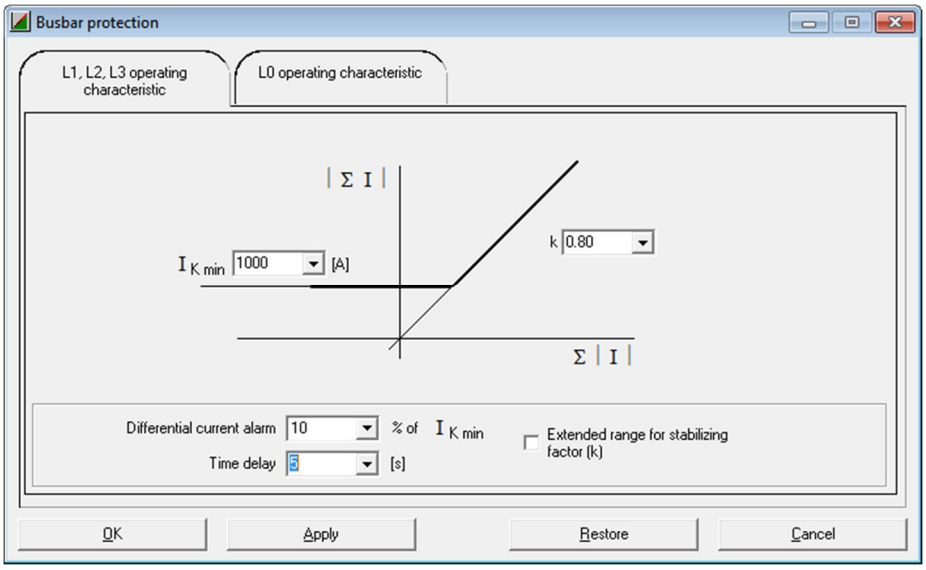

Figure 6 Busbar protection - Operating characteristics

The setting for the differential current alarm is entered as a percentage of the minimum fault current setting I_{Kmin}. The alarm should be set **lower than the lowest load current**. A typical setting is 5%.

Should the differential current alarm pick up, alarm is not actually given until the set time delay has expired. A typical setting is 5s.

Nothing has to be configured in HMI500 for the phase comparison algorithm. The settings for this function are determined when engineering the scheme for a particular application. The parameters involved are the operating angle φ_{max} and the two minimum current settings (L1, L2, L3 and L0) for the inclusion of a feeder in the evaluation.

4.2 Tripping logic

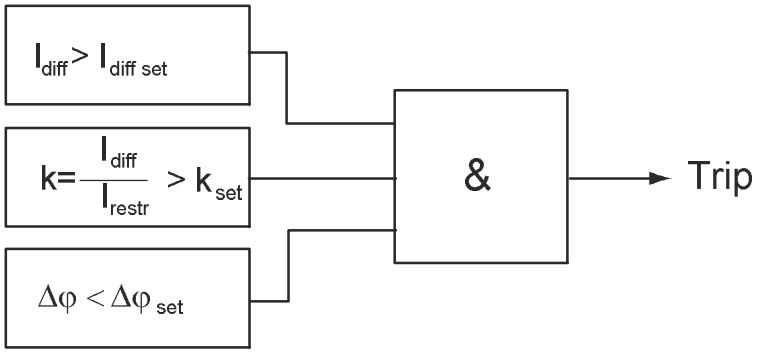

Figure 7 Busbar protection tripping logic

Section 5 Additional protection options

5.1 Breaker failure protection

5.1.1 Mode of operation

The circuit-breaker is the last and most important link in the protection chain. The purpose of BFP is to take the right action should the circuit-breaker fail to execute a trip command. This involves tripping the circuit-breakers surrounding the fault, which are mainly in the same station, but may also include circuit-breakers at the remote ends of lines (intertripping).

The principle of BFP is based on monitoring the time the fault persists after a trip command has been issued to the circuit-breaker (starting of BFP has been enabled by the main protection, e.g. feeder protection).

A complete block diagram of BFP, including additional functions such as initiation logics and I0-measurement, can be seen in Figure 8.

The following internal REB500 functions can start the breaker failure function in all three phases:

- REB500 intertripping system (BBP, BFP, etc.)
- An external trip command
- Time-overcurrent if logic 3 is configured
- Breaker pole discrepancy protection if logic 3 is configured

BFP can be started phase-selectively via two separate inputs. All three phases can be started via up to 6 different inputs and the currents of all three phases monitored.

It is recommended to adjust the pick-up current of the phase measurement such that $I_E = 0.8 \cdot I_{Kmin}$.

This setting applies to phase faults und ground faults as well under the condition that I_{Kmin} reflects the minimal short circuit current out of these fault types. In certain cases, the ground fault current may be much lower than the phase fault value (e.g. low resistive grounded networks). Under such exceptional cases, the BFP Io (adjusted with a lower pickup value) can be used in addition to the breaker failure phase system (see Section 5.2)

Operation of BFP can also be started by the internal signals. These internal signals are shown with the following symbol ▶ Name in the block diagram of BFP. The inputs are on the left and the outputs on the right.

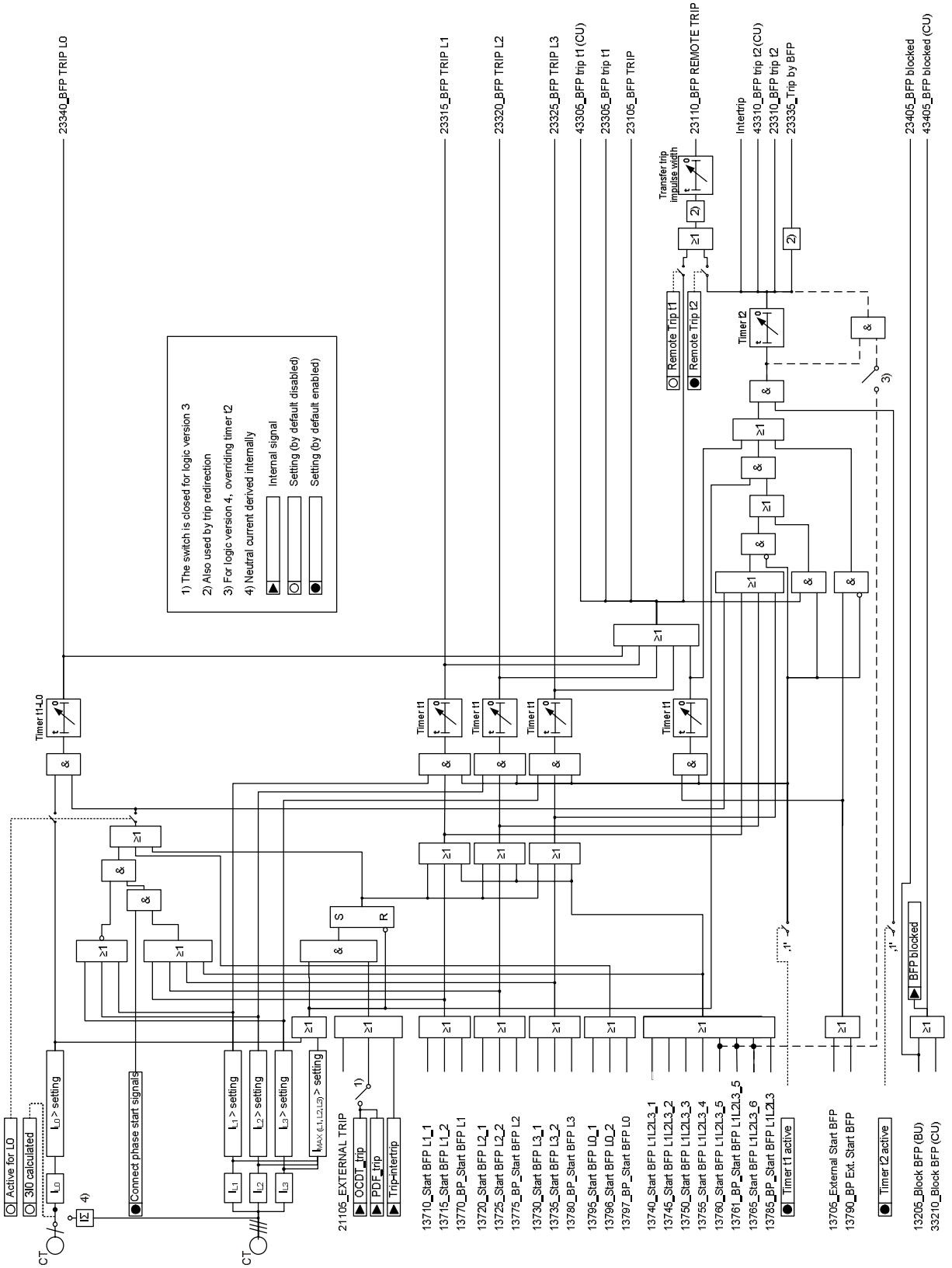

Figure 8 Block diagram of BFP (logic type 1)

5.1.2 Configuration

BFP has two adjustable timers. At the end of time t_1, a second attempt is made to trip the breaker that has failed to trip; at the end of time t_2 the surrounding breakers are tripped. A transfer-tripping signal to the remote station generated either at the end of time t_1 or t_2 can also be enabled using HMI500.

The currents of the three phases are measured individually and compared with the pick-up setting, which is identical for the three phases.

Since there are three separate t_1 timers for the individual phases, the REB500 BFP responds correctly to an evolving fault.

Logic 4 can be used in stations with 2 redundant REB500 units, one for busbar and the other for breaker failure protection. In this case, the special inputs “13760_Start BFP L1L2L3_5” and “13765_Start BFP L1L2L3_6” on the REB500 for BFP are used to instantly initiate intertripping after t_1 independently of the time setting of t_2.

The following breaker failure parameters can be set using HMI500:

Table 32 Parameters for setting BFP

Parameter	Min.	Max.	Default	Step	Unit
BFP active			inactive		
Setting (per current transformer)	0.1	2.0	1.2	0.1	I_N
Timer 1 active			active		
Timer 2 active			active		
Timer t_1	10	5000	100	10	ms
Timer t_2	0	5000	120	10	ms
Intertripping pulse duration	10	5000	100	10	ms
Logic type	1	4	1	1	

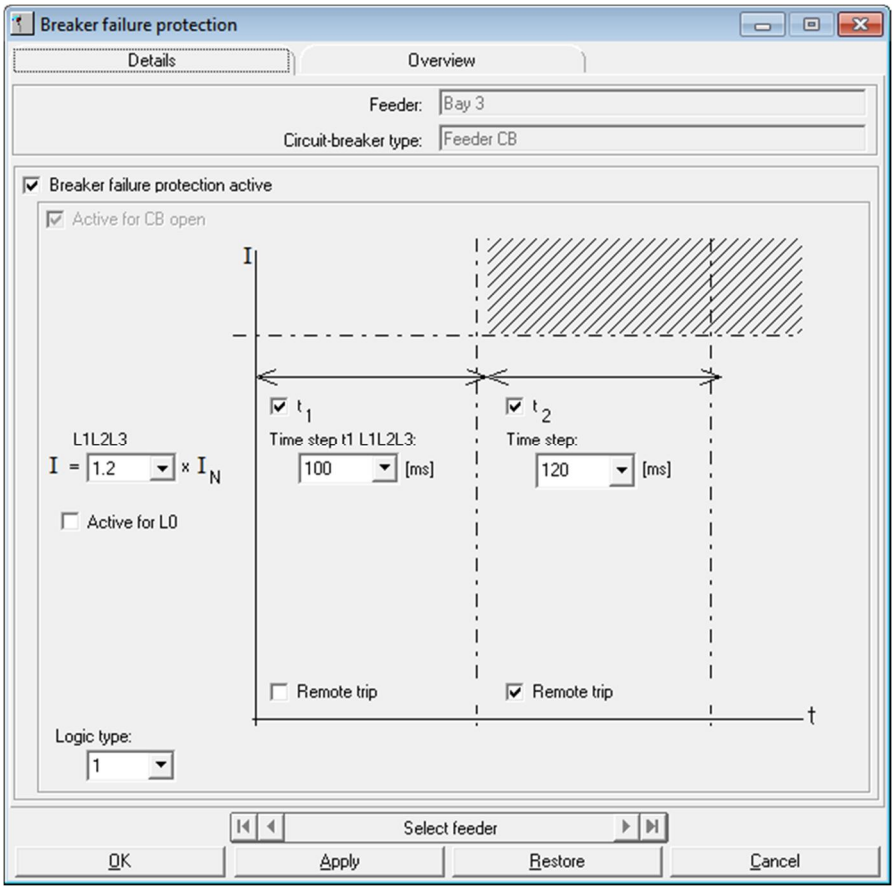

Figure 9 Settings of BFP

In the “Details” view, BFP can be activated per bay: Intertripping (remote trip) can be applied after completion of either timer t_1 or t_2. For a description of the different logic types, please refer to the Application Manual.

5.2 BFP neutral measurement system (BFP L0)

5.2.1 Mode of operation

Certain network configurations (e.g. impedance grounded networks) might cause fault currents which are below the normal load current. While protection devices such as sensitive earth fault protections or similar are still starting and tripping the breaker, the conventional BFP is usually set at levels above normal load currents for the phase systems. In such situations a separate setting for the neutral current I_0 might be helpful.

Detailed knowledge of the network, the protection systems and possible fault scenarios is necessary to configure this function

correctly. Misconfiguration might lead to unselective tripping and loss of supply.

The BFP L0 system is an integrated part in the conventional BFP function that can be activated and configured separately.

The neutral measuring system of BFP for I_0 covers the ground potential as a fourth phase and evaluates breaker failure conditions accordingly. To allow for individual fault handling, separate configuration for the I_0 threshold and timer stage t_1 is possible.

When activated, the function is completely integrated into the existing BFP function. With the exceptions mentioned above, both timer t_2 and the intertripping system are used by the BFP phase and L0 system.

The following diagram shows a simplified representation of the extension of the conventional BFP system with the L0 system.

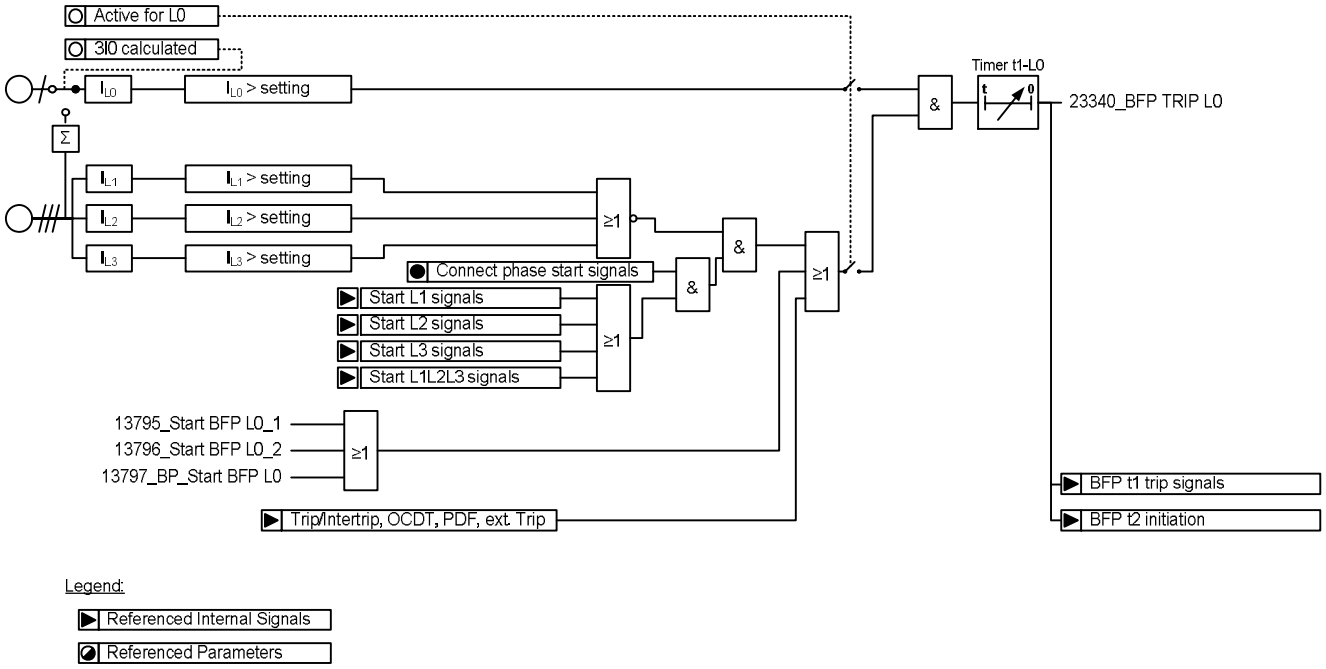

Figure 10 Simplified block diagram of the BFP L0 system

When enabled, the L0 system of BFP can be started by dedicated logical starting signals.

Logical starting signals of the BFP phase system can be connected to the BFP L0 system by enabling the parameter “Connect phase start signals” (see Section 5.2.2).

To avoid bypassing of the conventional BFP, timer t_1 of the BFP L0 system will only be initiated by start signals for the phase system if each of the independent phase currents is below the setting for the phase system.

The signal 23340_BFP TRIP L0 by itself does not allow for phase segregated tripping and will therefore normally be used for three-phase-tripping of the circuit breaker.

When connecting phase start signals to the BFP L0 system, functions depending on single phase tripping signals such as autoreclosure might be bypassed by a three phase trip after BFP L0-t_1.

5.2.2 Configuration/ Current setting of BFP L0 system

Similar to the conventional BFP for the phase system, the BFP L0 system works with two timer stages. To allow for independent fault clearance behavior, timer stage t_1-L0 is implemented as a completely separate timer, independent from the timer stages t_1 of the BFP phase system. Timer stage t_2 is implemented as a single timer and can be initiated after t_1 by both phase and neutral system. The simplified block diagram can be seen in Figure 10.

The behavior of timer stage t2 is the same as for the phase-system. Remote tripping signals can be set after the end of timers for stage t_1 or at the end of t_2.

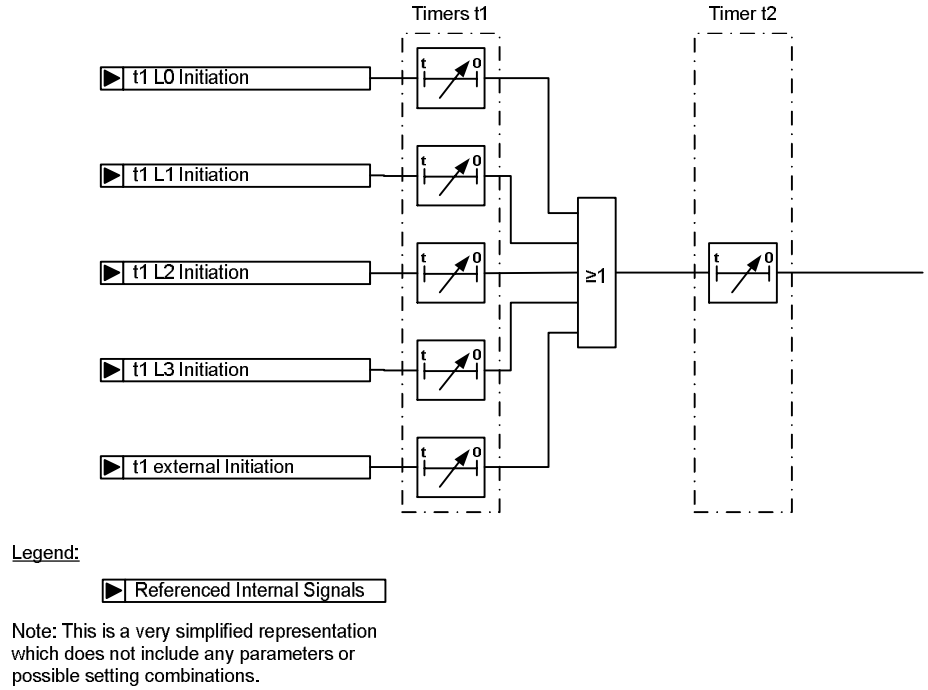

Figure 11 Simplified block diagram of the BFP Initiation logic

Table 33 Parameters for the BFP L0 system

Parameter	Min.	Max.	Default	Step	Unit
Active for L0			inactive		
Pick-up setting	0.05	2.00	1.2	0.05	I_N
I0 calculated			inactive		
Connect phase start signals			active		
Timer t_1-L0	10	5000	100	10	ms

5.2.2.1 Details

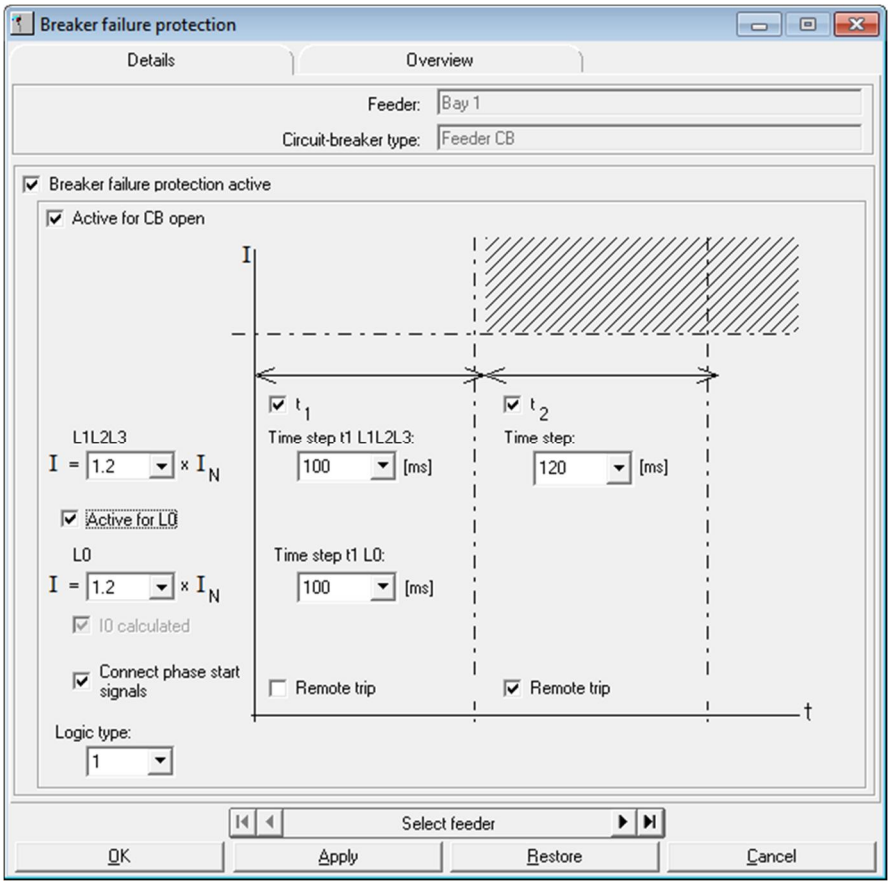

Figure 12 BFP (L0 system activated)

In the “Details” view, the neutral system L0 of BFP can be activated and configured per bay by enabling the checkbox “Active for L0”:

- The current level for the BFP L0 is set independently from the phase setting
- Instead of external wiring of a fourth current input (L0), I0 can be calculated internally by setting “I0 calculated”. This setting is mandatory for bay units that do not have a separate L0 current input for neutral current measurement or use a metering transformer.
- By enabling “Connect phase start signals” all logical start signals for the BFP phase system will be used to initiate the timer of the BFP L0 function.
- With “Time step t1 L0” the setting for timer t_1-L0 is made.

For considerations on the different possibilities to connect the BFP L0 system refer to the Application Manual.

5.3 Overcurrent definite time protection

5.3.1 Mode of operation

The overcurrent protection (def. time) function operates entirely independently of the other protection functions in each of the bay units and does not intertrip the respective busbar protection zone.

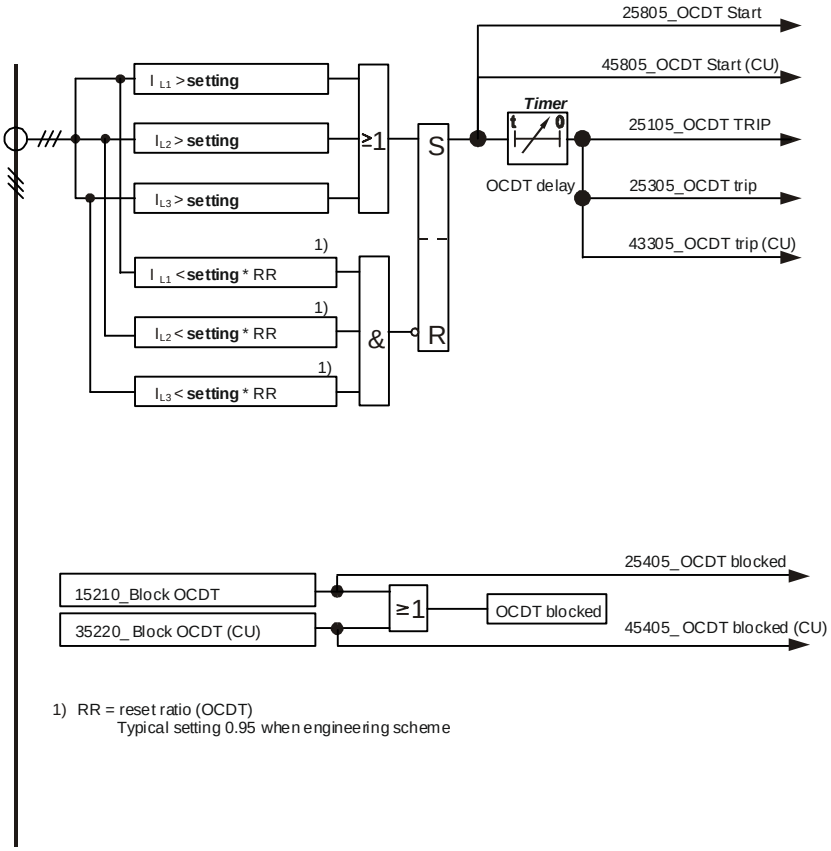

Figure 13 Block diagram of the overcurrent protection

5.3.2 Configuration of overcurrent protection

HMI500 provides the following parameters for setting overcurrent protection.

Table 34 Parameters for setting overcurrent definite time protection

Parameter	Min.	Max.	Default	Step	Unit
OCDT active			inactive		
Pick-up value	0.1	20.0	2.0	0.1	I_N
Delay	0	20000	2000	10	ms

All bay and current transformer details are shown in the overview. In the Details view, the overcurrent protection can be activated per bay and the pick-up setting can be set.

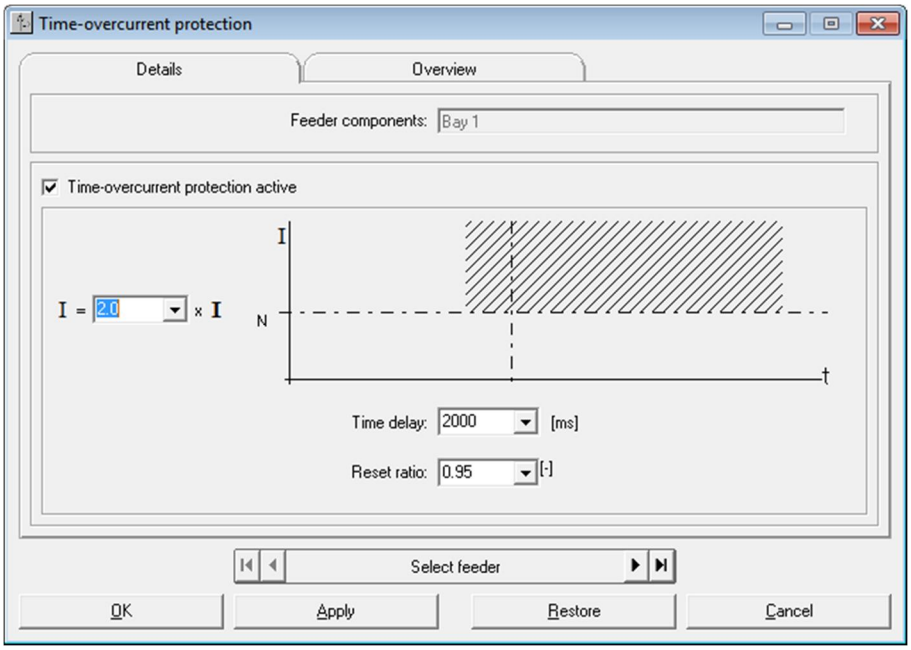

Figure 14 Settings of overcurrent protection

5.4 End fault protection

5.4.1 Mode of operation

The end fault protection detects faults between an open circuit-breaker and the CT, which cannot be cleared by the busbar protection on its own.

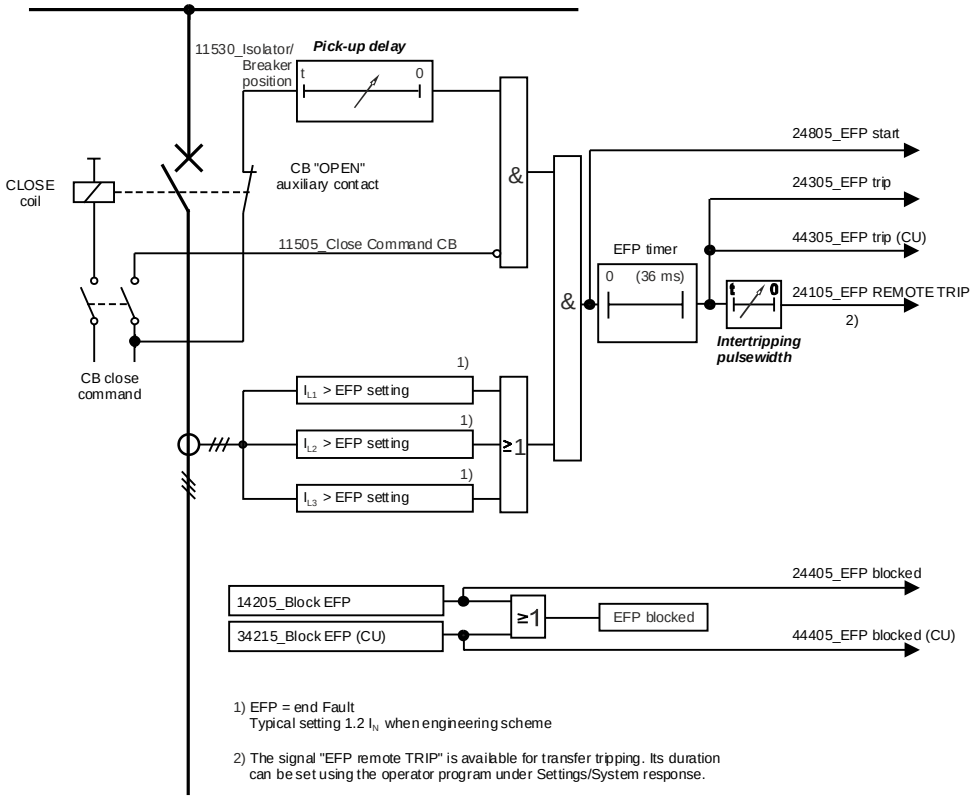

Figure 15 Block diagram of EFP with CTs on the line side

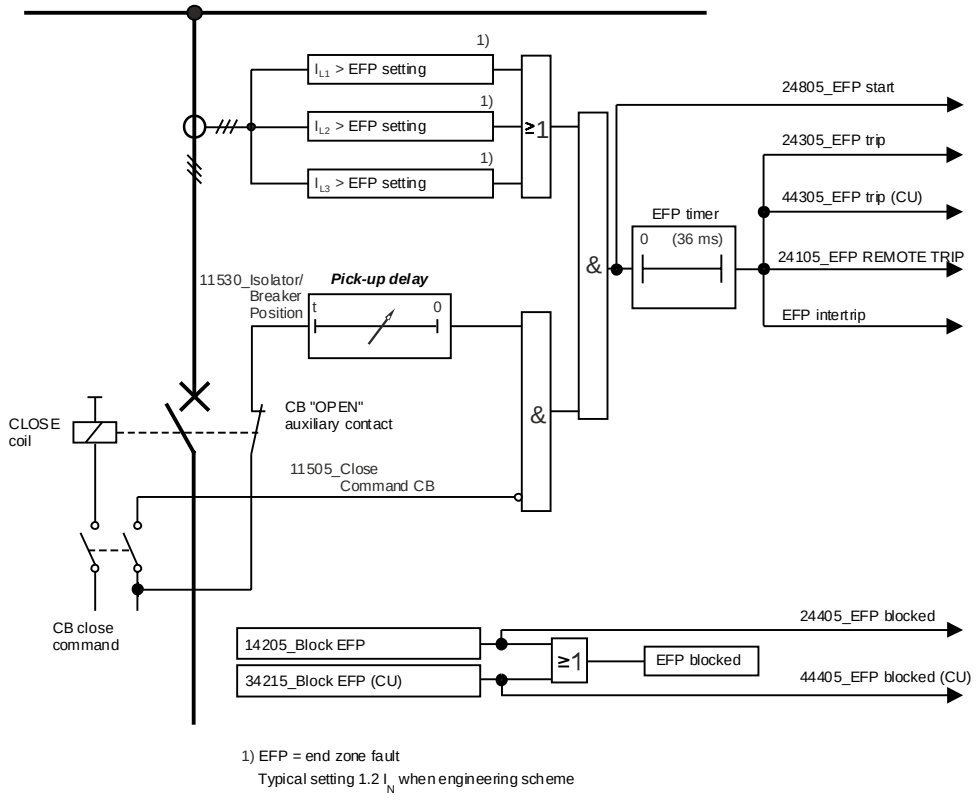

Figure 16 Block diagram of EFP with CTs on the busbar side

To ensure that the end fault protection bases its decision on an effective image of the circuit-breaker status, the signal “circuit-breaker open” is delayed while the circuit-breaker is actually opening. If a current is measured when the circuit-breaker is open, a tripping command is issued after a further delay (set to 36 ms). The purpose of this timer is to enable a circuit-breaker close command to be detected that is subject to internal signal transit times and breaker contact bounce times.

5.4.2 Configuration

The following parameters can be set for the end fault protection using the HMI500:

Table 35 Parameters for EFP

Parameter	Min.	Max.	Default	Step	Unit
EFP active			inactive		
Pick-up delay	0.1	10.0	0.4	0.1	s
Pick-up setting	0.1	2.0	1.2	0.1	I_N

To avoid false tripping after the circuit-breaker has opened, the delay for the end fault protection must be set longer than the time t1 of BFP.

The current pick-up setting can be set the same as for BFP.

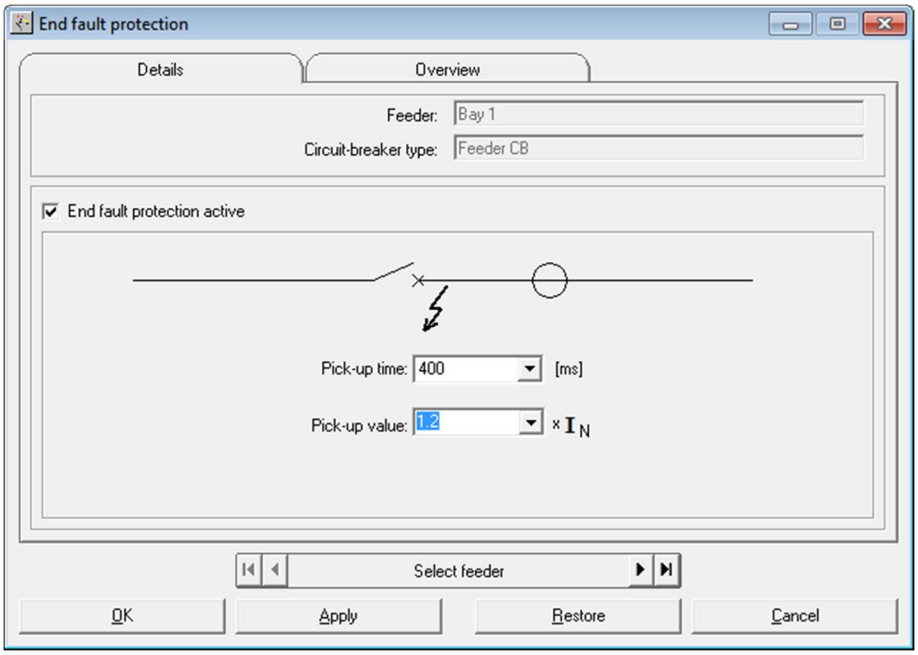

Figure 17 Settings of EFP

The details view makes provision for activating and setting the pick-up value and delay of the end fault protection for each bay. (The pick-up delay is only of consequence when opening the circuit-breaker.)

5.5 Breaker pole discrepancy protection

5.5.1 Mode of operation

The breaker pole discrepancy protection is a local protection function in the bay unit which supervises the three phase currents to ensure that the three circuit-breaker poles open and close simultaneously. The tripping condition is fulfilled when at least one of the phase currents is higher than setting (I_{mset}) and the difference between the phase currents (discrepancy factor Δpd_{set}) exceeds a given minimum for the set time.

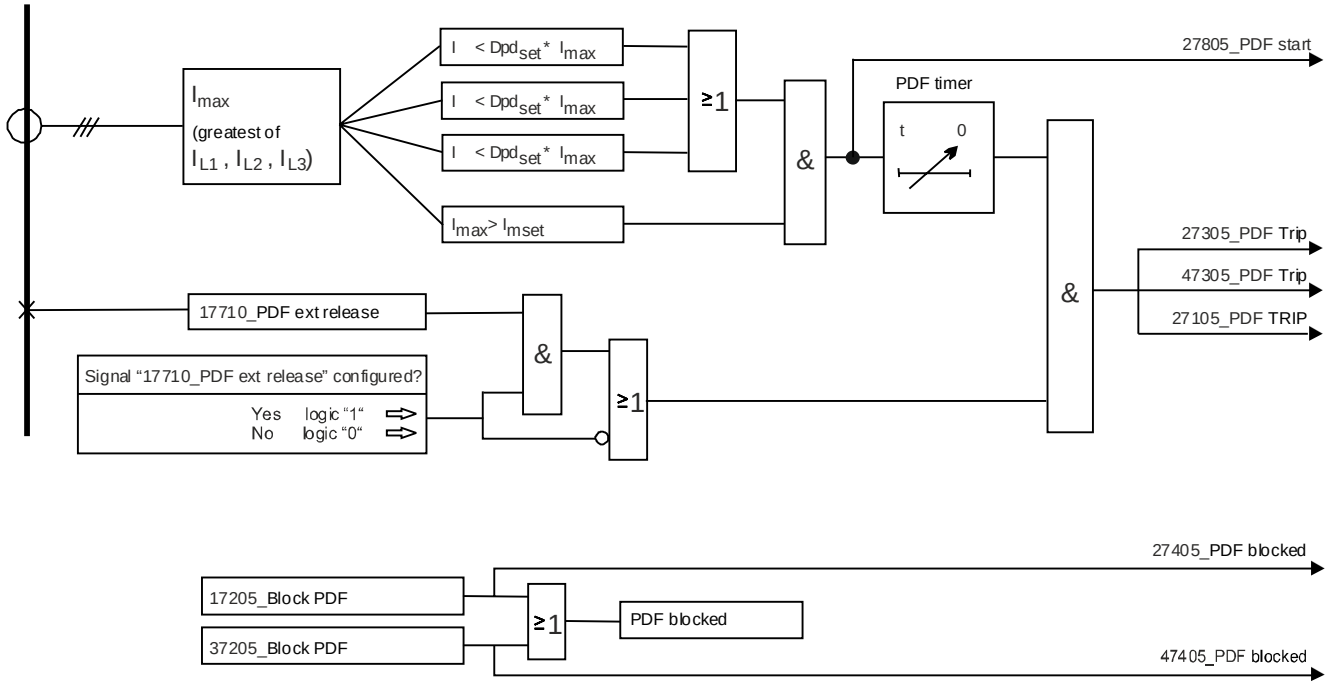

Figure 18 Block diagram of breaker pole discrepancy protection

Δpdset: Pole discrepancy factor e.g. 0.6 × Imax

Imset: Pole discrepancy setting e.g. 0.2 × IN

To verify a pole discrepancy, the current criteria and the condition of the circuit-breaker auxiliary contacts must be taken into account (external plausibility check). As can be seen from the Figure 18, the output signal of the function is enabled by the binary input "17710_PDF ext release".

If the input “17710_PDF ext release” is not configured, the function is enabled by default.

The breaker pole discrepancy protection does not intertrip the respective busbar zone.

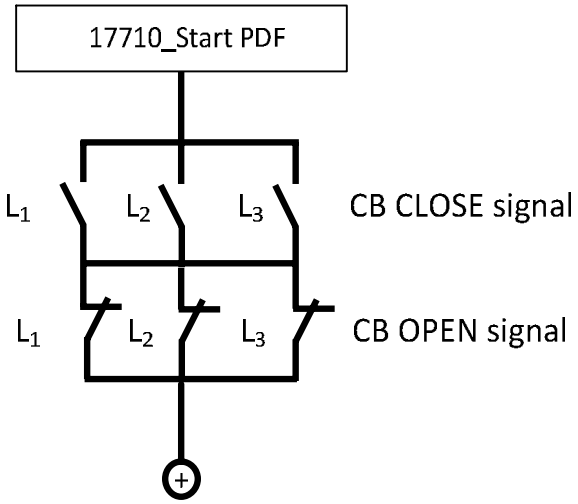

Figure 19 External plausibility check

Under certain conditions, the breaker at the remote end or possibly some other breaker may be involved **without a plausibility check**.

5.5.2 Configuration

Breaker pole discrepancy protection settings:

Table 36 Setting parameters of the breaker pole discrepancy protection

Parameters	Min.	Max.	Default	Step	Unit
PDF enabled			Disabled		
Setting I_{mset}	0.1	2.0	0.2	0.1	I_N
Delay	100	10000	1500	100	ms
Discrepancy factor Δpd_{set}	0.01	0.99	0.6	0.01	I_{max}

Where single-phase auto-reclosure is being applied on a line, the time delay of the breaker pole discrepancy protection must be set longer than the total auto-reclosure cycle time. The pick-up value is given by the maximum current multiplied by the discrepancy factor.

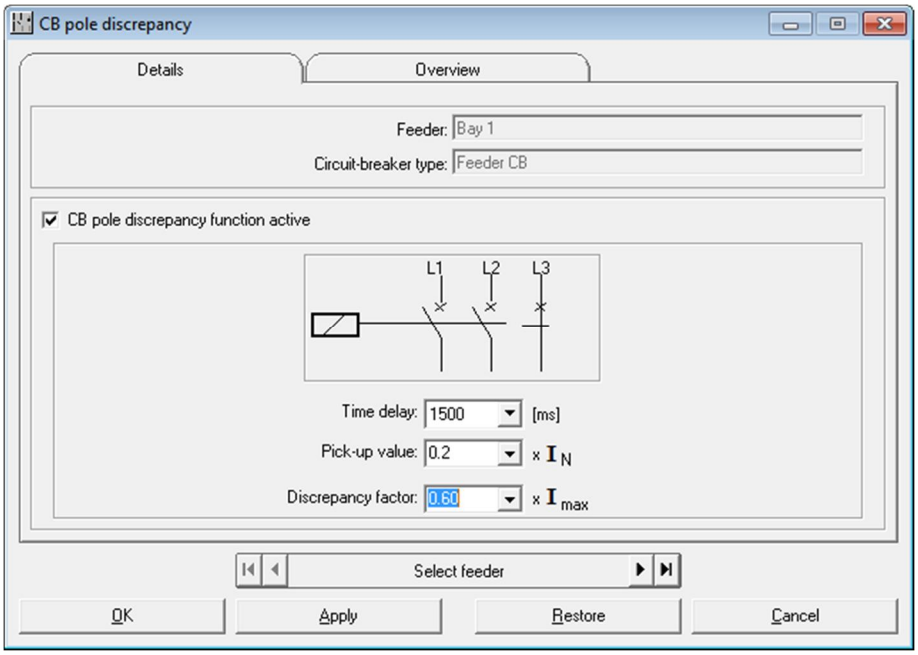

Figure 20 Breaker pole discrepancy protection

Section 6 Additional functions

6.1 Voltage release

The voltage function is used to enable tripping or other functions as described below. It forms part of a bay unit equipped with the corresponding VTs. The internal output signal of the voltage function is an enabling signal.

An enabling logic (matrix) provides facility for assigning the enabling (release) signal to the respective functions.

The enabling signal can be assigned to a feeder, a bus-tie breaker or a protection zone. The assignment is performed by the ABB engineering department and cannot be changed subsequently by customers.

The dialog “Voltage release” enables the voltage function to be configured and set.

“Overview” lists the VTs, their assignment to bay units, any direct assignments to protection zones and also whether they are active or inactive.

In the “Detailed view”, the voltage function can be activated and configured to detect under- or overvoltage, and the operating voltage can be set.

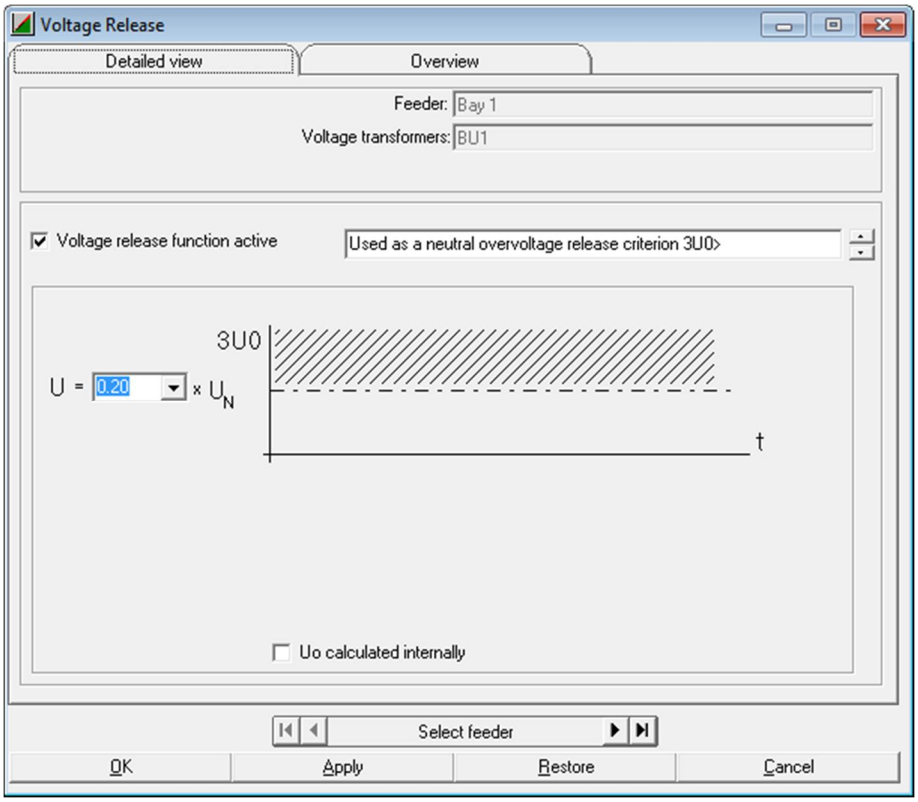

Figure 21 Voltage Release

Used as an undervoltage release criterion U< : The phase-to-neutral voltages (U_{L1}, U_{L2}, U_{L3}) are measured.

Used as a neutral overvoltage release criterion 3U0>: The neutral voltage is either evaluated and is derived from the three phase voltages ($3U_0 = U_{L1} + U_{L2} + U_{L3}$) or is fed externally ($3U_0$).

Should a voltage be interrupted either due to a tripped MCB or an open-circuit, a voltage function configured for overvoltage will disable, while one configured for undervoltage will enable.

An open VT circuit connected to an undervoltage function can be detected by monitoring the signal “28805_Voltage criterion”.

6.1.1 Combined over- and undervoltage release

The measurement of the undervoltage function is derived from the phase voltages (U_{L1}, U_{L2}, U_{L3}).

The measurement of the overvoltage function is derived from the neutral voltage or is calculated from the phase voltages ($3U_0 = U_{L1} + U_{L2} + U_{L3}$) or is fed externally ($3U_0$).

In the detailed view the voltage level can be set and the function can be activated.

In a combination of over- and undervoltage function (within a bay unit or in the complete system) the overvoltage function has an effect on the neutral system of the busbar protection (SSS_I0), and the undervoltage function of the remaining functions (see also release matrix in Section 6.2.2)

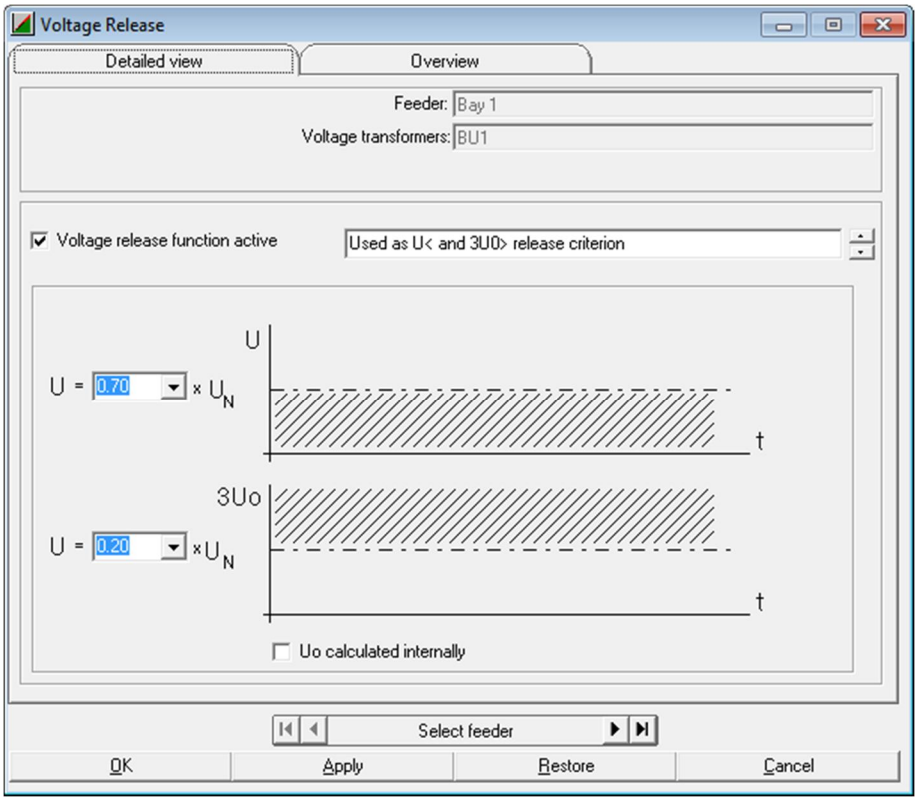

Figure 22 Voltage Release – Combined voltage release

6.1.2 VT assignment

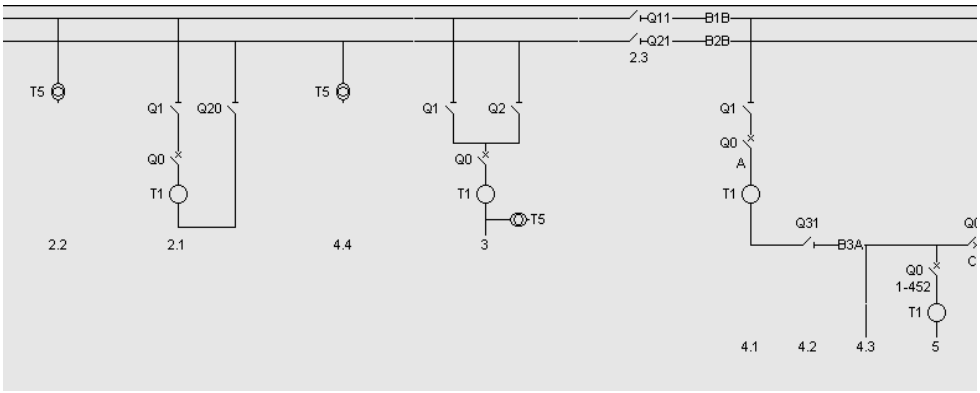

Figure 23 VT assignment

6.1.2.1 Assignment to a feeder or a bus-tie breaker

Figure 23 shows that VT T5 is assigned to feeder 3 and therefore measures the feeder voltage.

6.1.2.2 Assignment to a protection zone

Figure 23 shows that VT T5 (2.2) measures the voltage at bus-tie breaker 2.1. Both are integrated in the hardware of bay unit 2, but VT T5 (2.2) measures the voltage on the busbars in protection zone I.

The same applies to protection zone II, i.e. VT T5 (4.4) is connected at bus-tie breaker 4.1. It is integrated in the hardware of bay unit 4 but measures the voltage on the busbars in protection zone II.

6.2 Enabling tripping commands

6.2.1 Overcurrent release of the trip command

It is occasionally specified that when tripping a busbar zone only those feeders are tripped which are actually conducting fault current (active feeders), while those which are not (passive feeders) are left connected. This logic can be achieved by configuring an additional low current check feature per bay unit, which only enables tripping of feeders that are actually conducting current.

The overcurrent release (low current check feature) is used to enable tripping and intertripping commands generated by the BBP, BFP and EFP and/or trip redirection (configurable). If the measured feeder current lies below the pick-up setting of the overcurrent release, tripping of the particular feeder is prevented.

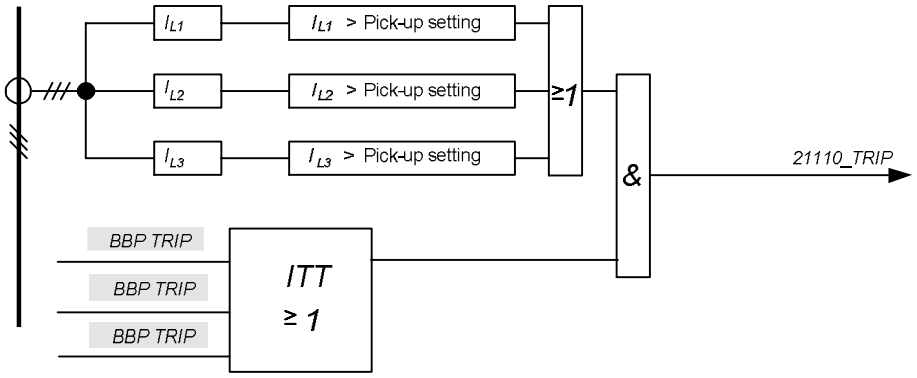

Figure 24 Principle of the overcurrent release function

Although in the event of a busbar trip and feeder current not exceeding the pick-up of the low current check feature the feeder concerned is not tripped, a trip event is generated by the central unit and displayed on its (see Section 3.7.3. “Intertripping/ transfer tripping”).

The current pick-up setting can also be used for trip redirection regardless of whether the low current check feature is configured or not.

Parameter	Min.	Max.	Default	Step	Unit
Overcurrent release active			inactive		
Pick-up setting when active	0.1	4.0	0.7	0.1	IN

The overcurrent release function is processed independently of the release logic.

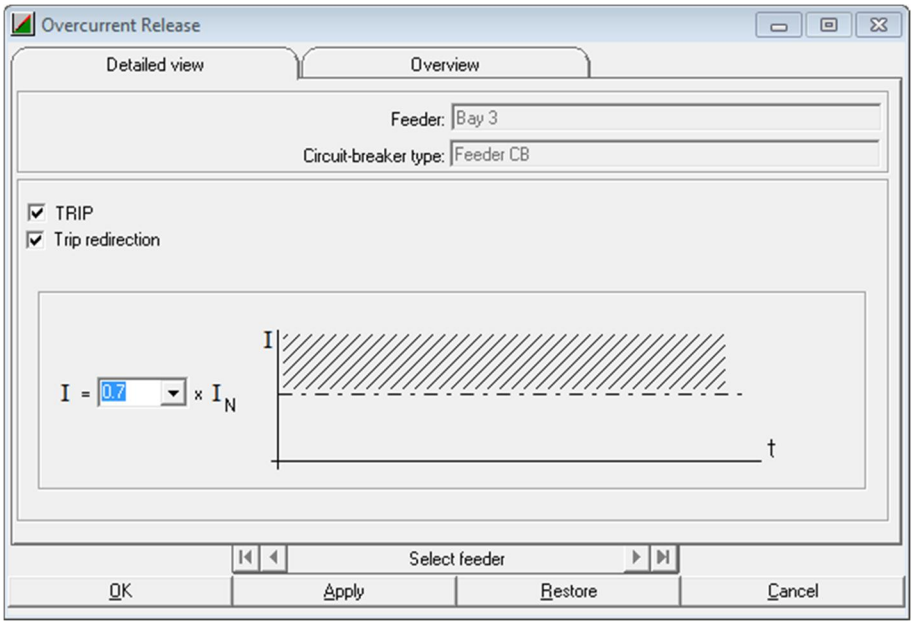

Figure 25 Settings / Overcurrent Release

6.2.2 Release logic / matrix

The overcurrent release described in Section 6.2.1 is completely independent of the functions described in this section.

The operation of the internal voltage release (option) and the general enabling inputs for each protection zone is determined by the configuration of the release logic (matrix). This involves entering the release criteria in the columns and the protection functions they affect the rows.

The release criteria can refer to bay unit functions or a protection zone.

6.2.2.1 Enabling bay unit functions (column 5)

Checking the boxes in column 5 of Figure 26 subjects tripping of the functions in the bay concerned to being enabled by the voltage release. These include breaker failure protection, end fault protection and bay unit “External TRIP” signal. The release condition still applies when the feeder is not assigned to a protection zone.

6.2.2.2 Enabling protection zone functions (columns 1 to 4)

Checking the boxes in column 1 to 4 of Fig. Figure 26 subjects inter-tripping of protection zones or the functions of bay units switched onto the respective protection zone to being enabled by the voltage release.

- Releasing “BBP_L1L2L3”, “BBP_L0”, “External TRIP BB Zone (CU)” and “External TRIP BB Zone (BU)” always involves enabling intertripping of the respective protection zone.
- Releasing “OCDT” and “PDF” always involves enabling the respective function and only applies if the feeder is connected to the respective protection zone. This is determined by the intertripping logic.
- Releasing “BFP” and “EFP” in columns 1 to 4 involves enabling intertripping of these functions (e.g. BFP trip after t2).

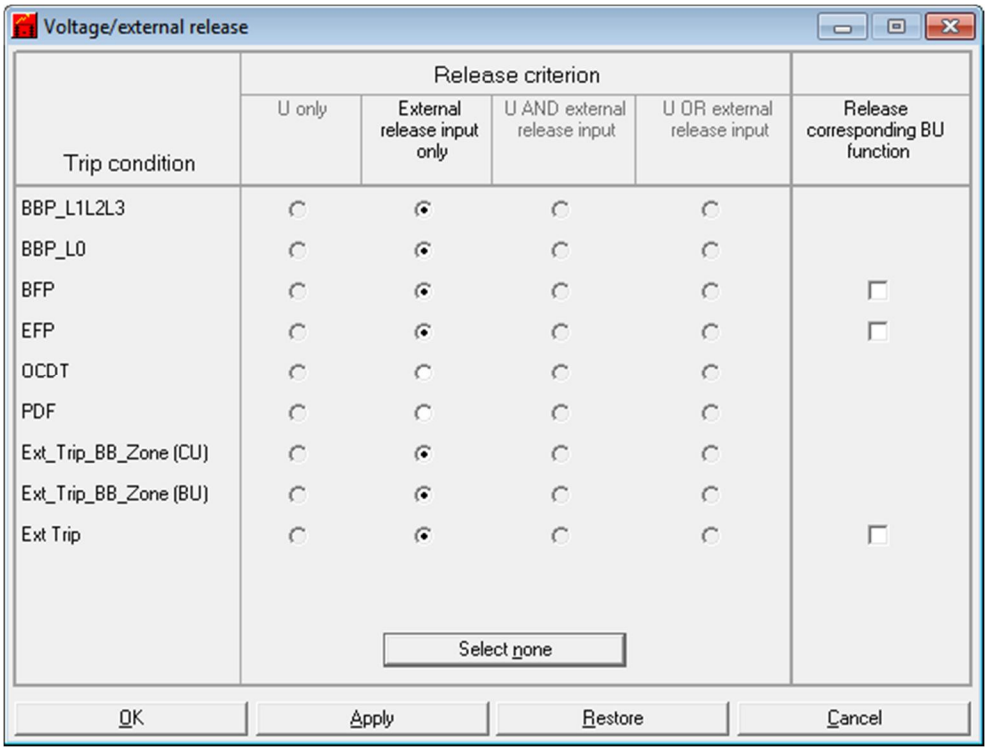

Figure 26 Release criteria

Table 37 Release criteria

Release criterion	Description
U only	Can only be selected if the voltage release function has been configured.
External release input only	Can only be selected if input “31805_External release BB-zone” has been configured.
U AND external release input	“AND” logic of the voltage release criterion and the input “31805_External release BB-zone”. This can only be selected if the voltage release criterion and the input “31805_External release BB-zone” have been configured.
U OR external release input	“OR” logic of the voltage release criterion and the input “31805_External release BB-zone”. This can only be selected if the voltage release criterion and the input “31805_External release BB-zone” have been configured.
Release corresponding BU function	Can only be selected if a corresponding criterion in the other 4 columns has been configured.

6.2.3 Release by “31805_External release BB zone”

There is a “31805_External release BB zone” signal for every protection zone configured on the central unit (e.g. enable trip-ping of BB zone 1, enable tripping BB zone 2 etc.).

They are binary inputs and enable intertripping of the busbar zones by the respective functions (see Fig. Figure 26).

If busbar sections are connected (e.g. by a longitudinal isolator), tripping is only enabled when all the relevant “31805_External release BB zone (n)” are active (AND logic).

6.2.4 Release by the internal voltage function

When the breaker failure protection is started by a trip from an external distance protection measuring a remote fault, it is possible that the voltage collapse at the REB500 location is too little for the undervoltage criterion to respond. In such cases we do not normally recommend that the undervoltage function interlocks a breaker failure trip. If this is done anyway, the undervoltage release setting must be verified by calculating the power system conditions.

Should the voltage measurement be invalid (i.e. the bay unit is switched off or there is a power supply failure), tripping by the respective bay is enabled since the protection must not be blocked.

The release by the internal undervoltage criterion can refer to bay unit functions or to a protection zone.

All VTs assigned to a protection zone are evaluated when enabling tripping of a complete protection zone. Assignment is done by the intertripping logic, i.e. it depends on the status of the isolators. Tripping is only enabled when all voltage functions assigned to the protection zone in question generate an enabling signal (AND logic).

6.3 Trip redirection

If a circuit breaker is unable to trip (e.g. air pressure too low), REB500 receives the signal “Trip redirection” from it.

When this signal is active and a trip signal being applied to the circuit-breaker (e.g. “External TRIP” or “BBP TRIP”, see Figure 27) REB500 automatically trips all circuit-breakers surrounding the fault.

For this to take place in the event of a trip generated by a device other than REB500 (e.g. transformer differential protection), the trip signal generated by the transformer differential protection must also go to the input “External TRIP”.

The trip redirection function is basically independent of the breaker failure protection, but uses the intertripping output signals “23110_BFP REMOTE TRIP” and “23335_Trip by BFP”.

A low-current check feature can be configured for the trip redirection function so that redirection only takes place when the respective feeder is conducting a given current. The overcurrent check feature is used for this purpose (regardless of whether it is otherwise configured or not). This option has to be also configured there.

Providing the trip redirection function is active, a tripping command is not issued locally to the circuit breaker in question.

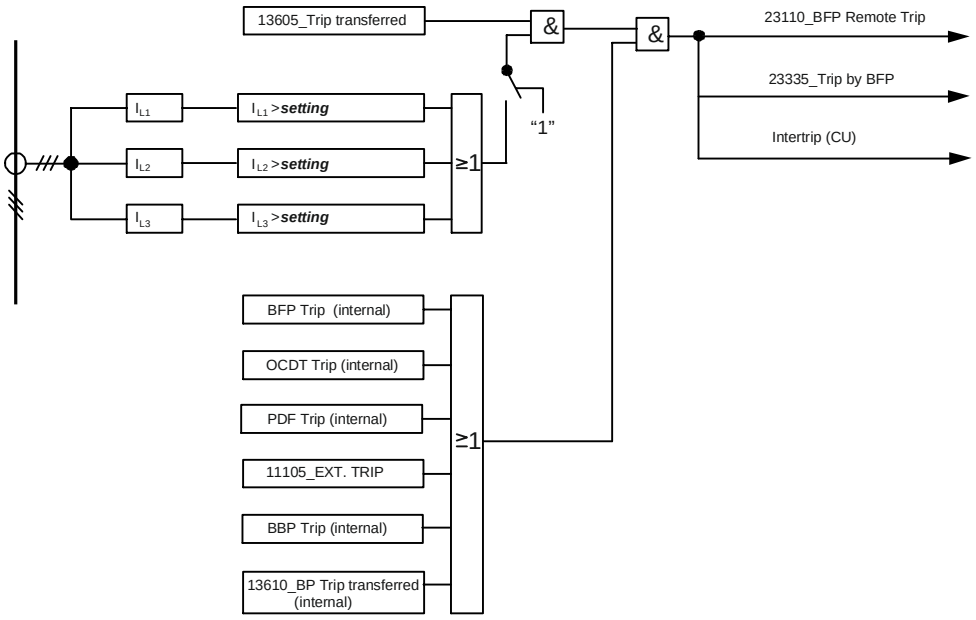

Figure 27 Trip redirection

If the BFP function is not available (not released during the engineering phase) the trip redirection function is also not available. As a result the signal 13605_Trip transferred cannot be selected in the list of binary input signals.

The trip redirection function is connected with the timing of the BFP function. Since the external tripping commands are connected to BFP starting inputs, the input signal 11105_EXT.TRIP is then not needed, because the BFP starting signals perform this function.

For BFP, an additional function has been included: When the input “Trip transferred” is active, the breaker failure delays (t_1 and t_2) are reduced to their minimum (10 ms).

The operating sequence for the example of a line fault is:

1. The gas pressure is too low and the circuit-breaker operation is blocked and the signal “Trip transferred” is sent to REB500.
2. A fault occurs on the line.
3. The line protection detects the fault and sends simultaneous signals to trip the circuit-breaker and start BFP.
4. Since the circuit-breaker is blocked, it cannot respond.
5. The overcurrent criterion and therefore the starting conditions for BFP are fulfilled.
6. As the input “Trip transferred” has set the delays t1 and t2 to 10 ms, BFP intertripping of the local circuit-breakers and transfer tripping of remote circuit-breakers.
7. REB500 thus issues a tripping command to the surrounding circuit-breakers after about 20 ms to isolate the fault.

The input signal “11105_External TRIP” is not needed in this example.

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