Protection Relay
REX 521

Technical Reference Manual, Standard Configurations

Contents

Copyrights

Trademarks

Guarantee

Please inquire about the terms of guarantee from your nearest ABB representative.

1. About this manual

1.1. General

This document provides detailed information about the separate functions of the protection relay REX 521 Revision G.

1.2. Use of symbols

This publication includes the following icons that point out safety-related conditions or other important information:

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 to relevant facts and conditions.

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

1.3. Related documents

Manuals for REX 521

- Technical Reference Manual, General 1MRS751108-MUM
- Operator's Manual 1MRS751107-MUM
- Installation Manual 1MRS750526-MUM
- Technical Descriptions of Functions (CD-ROM) 1MRS750889-MCD
- Modbus Remote Communication Protocol for REX 521, Technical Description 1MRS755017
- DNP 3.0 Remote Communication Protocol for RE_ 54_ and REX 521, Technical Description 1MRS755260

Parameter and event lists for REX 521

- Parameter List for REX 521 1MRS751999-RTI
- Event List for REX 521 1MRS752000-RTI
- General Parameters for REX 521 1MRS752156-RTI
- Interoperability List for REX 521 1MRS752157-RTI

Tool-specific manuals

- CAP505 Installation and Commissioning Manual 1MRS751901-MEN
- CAP505 User's Guide 1MRS752292-MEN
- CAP505 Protocol Mapping Tool Operator's Manual 1MRS755277
- Tools for Relays and Terminals, User's Guide 1MRS752008-MUM
- CAP 501 Installation and Commissioning Manual 1MRS751899-MEN
- CAP 501 User's Guide 1MRS751900-MUM

1.4. Document revisions

Version	Date	History
F	22.6.2004	New configuration, H08 New function block, 3U_B.
H	23.02.2006	Layout updated FB updates Standard configurations H09, H50, H51 added
K	29.09.2006	Small corrections to the standard configuration table

2. 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 device has to be carefully earthed.

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

Breaking the sealing tape on the rear panel of the device will result in loss of warranty and proper operation will no longer be guaranteed.

3. Introduction

This document provides descriptions of the standard configurations for REX 521. Chapter 4. Standard configurations describes the features of the different standard configurations one by one while Chapters 5 to 7 describe the signal routings and functionality. A short introduction of the function blocks available in different standard configurations of REX 521 is given in Chapter 8. Function block descriptions. Chapter 9. Example substations, Chapter 10. Application examples, Basic, Chapter 11. Application examples, Medium, and Chapter 12. Application examples, High present different application examples.

The standard configurations available are presented in Table 3.-1. Note that in the function block descriptions in the CD-ROM Technical Descriptions of Functions (see Related documents), the ABB standard FB names are used instead of the IEC or ANSI names.

Hardware (HW) versions for REX 521 are basic, medium, high and sensor. The sensor variant of the standard configuration is indicated with the letter ‘S’ in the `Config. name` parameter, for example H02S.

Differences between REX 521 and RED 500 platform in the function block descriptions

The REX 521 and the RED 500 platform differ in some respects concerning the function block descriptions in the CD-ROM Technical Descriptions of Functions (see Section 1.3. Related documents). Firstly, there are some terms that refer to other products than REX 521. Secondly, there are a few characteristics that appear only in REX 521:

- Event mask 1 is only for SPA communication.
- The direct control of the autoreclose function has been disabled.
- A limited number of inputs and outputs are used in standard configurations of REX 521.

Table 3.-1 Standard configurations for REX 521

HW versions			**Basic**		**Medium**		**High/Sensor**										
Standard configurations			**B01**	**B02**	**M01**	**M02**	**H01[a]**	**H02**	**H03**	**H04**	**H05**	**H06**	**H07**	**H08[bc]**	**H09[bc]**	**H50[b]**	**H51[b]**
IEC symbol	**ANSI device number**	**FB name (CD-ROM)**															
Protection																	
3I>	51-1	NOC3Low	x	x	x	x		x	x	x	x	x	x	x	x	x	x
3I>>	51-2	NOC3High	x	x	x	x		x	x	x	x	x	x	x	x	x	x
3I>>>	51-3	NOC3Inst	x	x	x	x	x		x	x	x		x	x	x	x	x
Io>	51N-1	NEF1Low	x	x						x[d]	x		x	x	x	x	x
Io>>	51N-2	NEF1High	x	x						x[d]	x		x	x	x	x	x
Io>>>	51N-3	NEF1Inst	x	x						x[d]	x			x	x		
Io-->[e]	67N-1	DEF2Low			x	x	x	x	x	x			x			x	x
Io>>-->[e]	67N-2	DEF2High			x	x	x	x	x	x			x			x	x
Io>>>-->[e]	67N-3	DEF2Inst			x	x	x	x	x	x							
3I>-->	67-1	DOC6Low					x[f]	x[f]		x[f]						x[f]	
3I>>-->	67-2	DOC6High					x[f]	x[f]								x[f]	x[f]
3U>	59-1	OV3Low									x	x	x	x	x	x	x
3U>>	59-2	OV3High									x	x	x	x	x	x	
3U<	27-1	UV3Low									x	x	x	x	x	x	x
3U<<	27-2	UV3High									x	x	x	x	x	x	
3I2f>	68	Inrush3	x	x	x	x	x	x	x	x	x			x	x	x	
Iub>	46	CUB3Low	x	x	x	x	x	x	x	x							
3Ith>	49F	TOL3Cab	x	x	x	x	x	x	x	x							
O-->I	79	AR5Func		x		x	x	x	x	x					x	x	
Uo>	59N-1	ROV1Low									x	x		x	x	x	x
Uo>>	59N-2	ROV1High									x	x		x	x	x	
Uo>>>	59N-3	ROV1Inst									x	x		x	x		
f1	81-1	Freq1St1						x		x		x	x		x	x	x
f2	81-2	Freq1St2										x			x	x	x
SYNC1	25-1	SCVCSt1					x		x								
Is2t n<	48	MotStart											x				x
3I()	46R	PREV3											x				x
I2>	46-1	NPS3Low											x				x
I2>>	46-2	NPS3High											x				
3I<	37-1	NUC3St1											x				
FUSEF	60	FuseFail											x				x
3Ithdev>	49M/G/T	Tol3Dev									x		x	x			x
U1U2<>_1	47-1	PSV3St1											x			x	x
Control functions																	
I<->O CB1	COCB1	COCB1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
I<->O IND1	COIND1	COIND1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
I<->O IND2	COIND2	COIND2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
I<->O IND3	COIND3	COIND3											x[g]				x[g]

Table 3.-1 Standard configurations for REX 521 (Continued)

HW versions			**Basic**		**Medium**		**High/Sensor**										
Standard configurations			**B01**	**B02**	**M01**	**M02**	**H01**[a]	**H02**	**H03**	**H04**	**H05**	**H06**	**H07**	**H08**[bc]	**H09**[bc]	**H50**[b]	**H51**[b]
IEC symbol	**ANSI device number**	**FB name (CD-ROM)**															
I<->O POS	COLOCAT	COLOCAT	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
ALARM1-8	ALARM1-8	MMIALAR1-8	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Measurement																	
3I	3I	MECU3A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Io	Io	MECU1A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Uo	Uo	MEVO1A			x	x	x	x	x	x	x	x	x	x	x	x	x
DREC	DREC	MEDREC	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
3U	3U	MEVO3A					x	x	x	x	x	x	x	x	x	x	x
3U_B	3U_B	MEVO3B												x	x		
f	f	MEFR1					x	x	x	x	x	x	x	x	x	x	x
PQE	PQE	MEPE7					x	x	x	x	x	x	x	x	x	x	x
AI1	AI1	MEAI1											x				x
Condition monitoring																	
CB wear1	CB wear1	CMBWEAR1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
TCS1	TCS1	CMTCS1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MCS 3I	MCS 3I	CMCU3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MCS 3U	MCS 3U	CMVO3					x	x	x	x	x	x	x	x	x	x	x
TIME1	TIME1	CMTIME1											x				x
Power quality monitoring																	
PQ 3Inf	PQ 3Inf	PQCU3H	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
PQ 3Unf	PQ 3Unf	PQVO3H					x	x	x	x	x	x	x	x	x	x	x
Standard																	
SWGRP	SWGRP	SWGRP	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

a. H01 available only as sensor version
b. Not available as sensor version
c. VTs are used to measure phase-to-earth voltages, calculated phase-to-phase voltages are shown by 3U_B
d. Configured fixedly to the Io (1/5 A) channel or Ios if selected
e. Can be used as Io>, Io>> and Io>>> or Uo>, Uo>> and Uo>>> function block with some limitations
f. 3I>--> and 3I>>--> cannot be set to operate as 3I>, 3I>> or 3I>>>
g. Motor status indication

Calculated Uo (Uos) is used in the Sensor versions of H01 and H03 configurations. Calculated Io (Ios) is available in H01-H05, H08, H09 and H50 configurations.

Table 3.-2 Protection functions available in the different standard configurations of REX 521

Function	Description
Is2t n<	Three-phase motor start-up supervision
3I>	Three-phase non-directional overcurrent protection, low-set stage
3I>>	Three-phase non-directional overcurrent protection, high-set stage
3I>>>	Three-phase non-directional overcurrent protection, instantaneous stage
3I()	Phase reversal protection
Io>	Non-directional earth-fault protection, low-set stage
Io>>	Non-directional earth-fault protection, high-set stage
Io>>>	Non-directional earth-fault protection, instantaneous stage
Io>-->	Directional earth-fault protection, low-set stage
Io>>-->	Directional earth-fault protection, high-set stage
Io>>>-->	Directional earth-fault protection, instantaneous stage
I2>	Negative phase sequence protection, low-set stage
I2>>	Negative phase sequence protection, high-set stage
3I>-->	Three-phase directional overcurrent protection, low-set stage
3I>>-->	Three-phase directional overcurrent protection, high-set stage
3I<	Three-phase undercurrent protection
3U>	Three-phase overvoltage protection, low-set stage
3U>>	Three-phase overvoltage protection, high-set stage
3U<	Three-phase undervoltage protection, low-set stage
3U<<	Three-phase undervoltage protection, high-set stage
3I2f>	Three-phase transformer inrush and motor start-up current detector
Iub>	Phase discontinuity protection
3Ith>	Three-phase thermal protection for cables
3Ithdev>	Three-phase thermal overload protection for devices
O-->I	Autoreclose function (5 shots)
Uo>	Residual overvoltage protection, low-set stage
Uo>>	Residual overvoltage protection, high-set stage
Uo>>>	Residual overvoltage protection, instantaneous stage
U1U2<>_1	Phase sequence voltage protection
f1	Underfrequency or overfrequency protection, stage 1
f2	Underfrequency or overfrequency protection, stage 2
FUSEF	Fuse failure protection
SYNC1	Synchro-check / voltage-check function

Table 3.-3 Control functions available in the different standard configurations of REX 521

Function	Description
I<->O CB1	Circuit breaker control with indication
I<->O IND1	Object indication
I<->O IND2	Object indication
I<->O IND3	Object indication
I<->O POS	Logic control position selector
ALARM1-8	Alarm LED 1-8

Table 3.-4 Measurement functions available in the different standard configurations of REX 521

Function	Description
3I	Three-phase current measurement
Io	Neutral current measurement
Uo	Residual voltage measurement
DREC	Transient disturbance recorder
3U	Three-phase voltage measurement
3U_B	Three-phase voltage measurement
f	System frequency measurement
PQE	Three-phase power and energy measurement
MEAI1	Analog measuring function

Table 3.-5 Condition monitoring functions available in the different standard configurations of REX 521

Function	Description
CB wear1	Circuit breaker electric wear 1
TCS1	Trip-circuit supervision 1
MCS 3I	Supervision function of the energizing current input circuit
MCS 3U	Supervision function of the energizing voltage input circuit
TIME1	Operation time counter

Table 3.-6 Power quality monitoring function available in the different standard configurations of REX 521

Function	Description
PQ 3Inf	Current waveform distortion measurement
PQ 3Unf	Voltage waveform distortion measurement

4. Standard configurations

4.1. HW version: Basic

4.1.1. Standard configuration B01

4.1.1.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Non-directional earth-fault protection with three stages
- Phase discontinuity protection for three phases
- Three-phase thermal protection for cables
- Three-phase transformer inrush and motor start-up current detector
- Supervision function for the energizing current input circuit
- Current waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

For more information about the features, refer to Chapter 8. Function block descriptions.

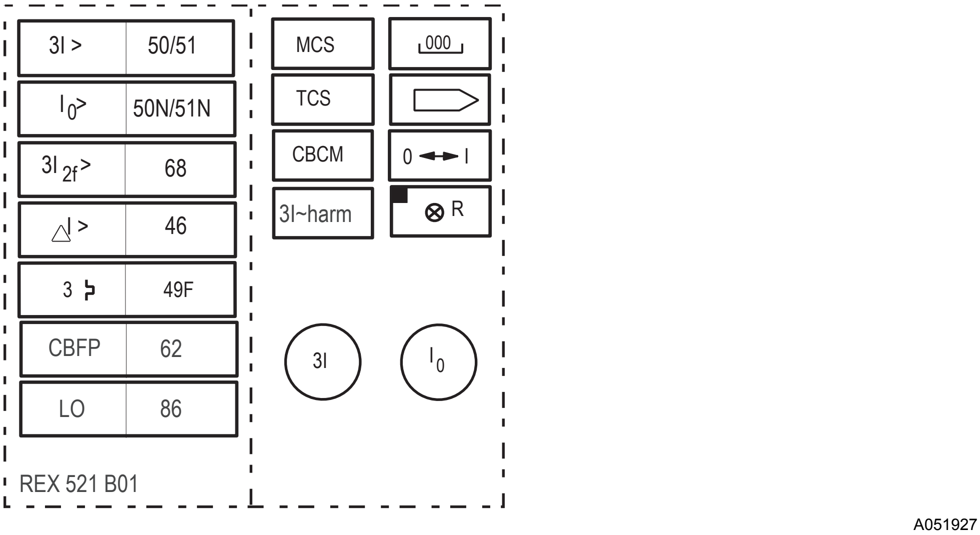


Fig. 4.1.1.1.-1 Block diagram of B01

4.1.1.2. Application

The B01 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective short-circuit, time overcurrent and earth-fault protection of radial isolated neutral networks, solidly earthed networks, resistant earthed networks and resonant earthed networks.

For more detailed information, refer to the application examples of B01 in Section 10.1. Outgoing feeder, Basic B01, Section 10.2. Incoming feeder, Basic B01 and Section 10.3. Transformer feeder, Basic B01.

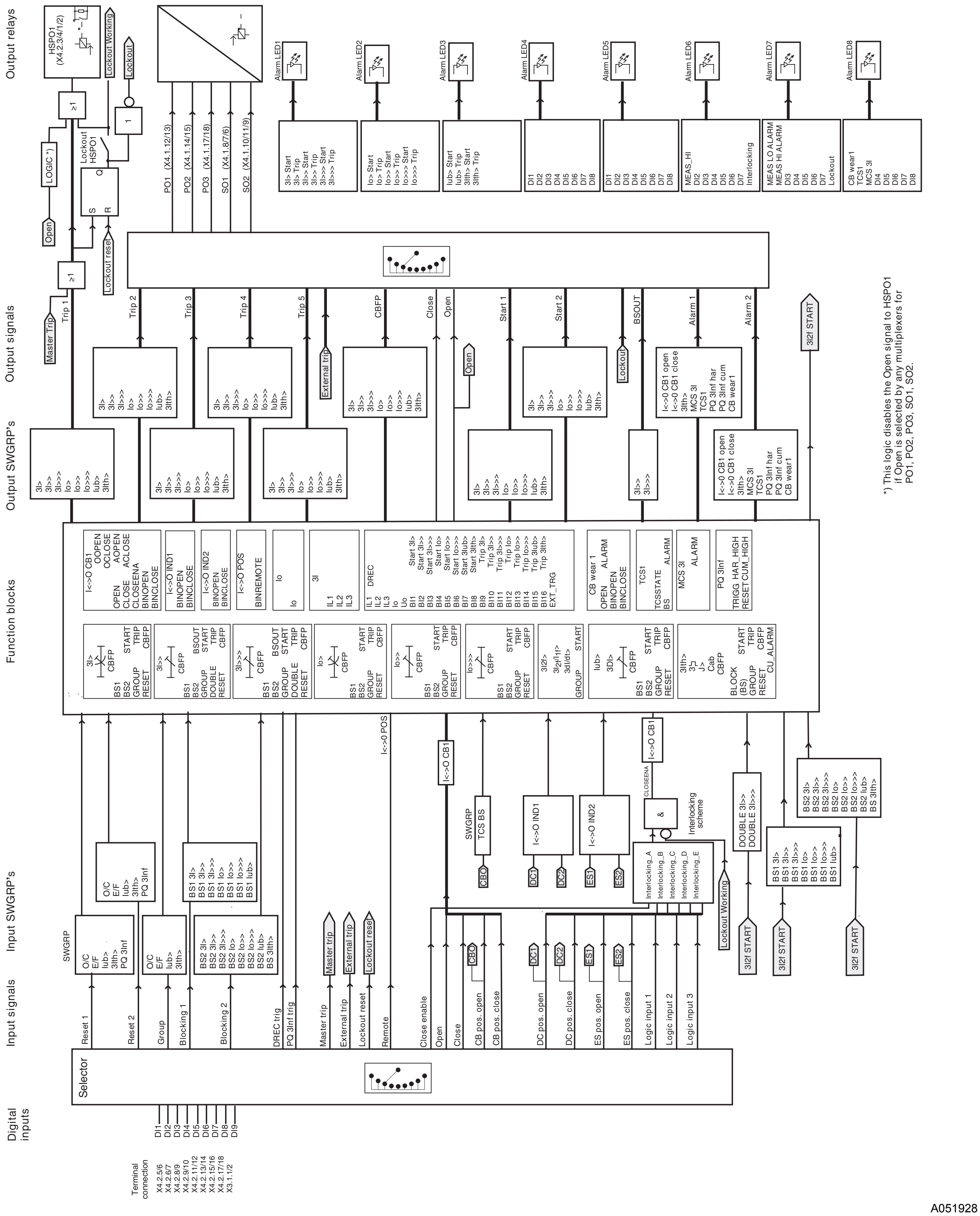


Fig. 4.1.1.2.-1 Block diagram of the standard configuration B01 for REX 521

4.1.2. Standard configuration B02

4.1.2.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Three-phase transformer inrush and motor start-up current detector
- Non-directional earth-fault protection with three stages
- Phase discontinuity protection for three phases
- Three-phase thermal protection for cables
- Supervision function for the energizing current input circuit
- Current waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Automatic reclosing 1...5 shots
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

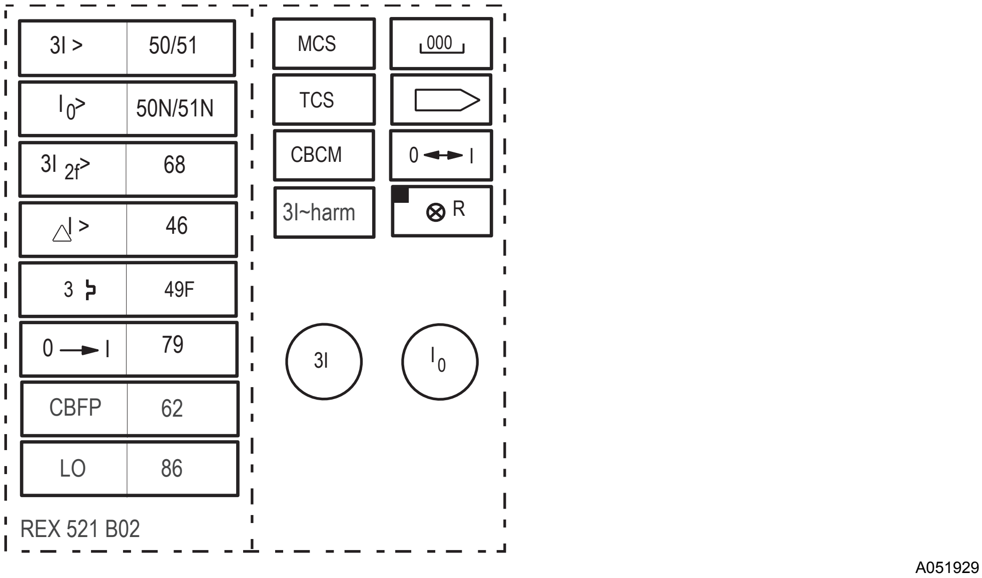
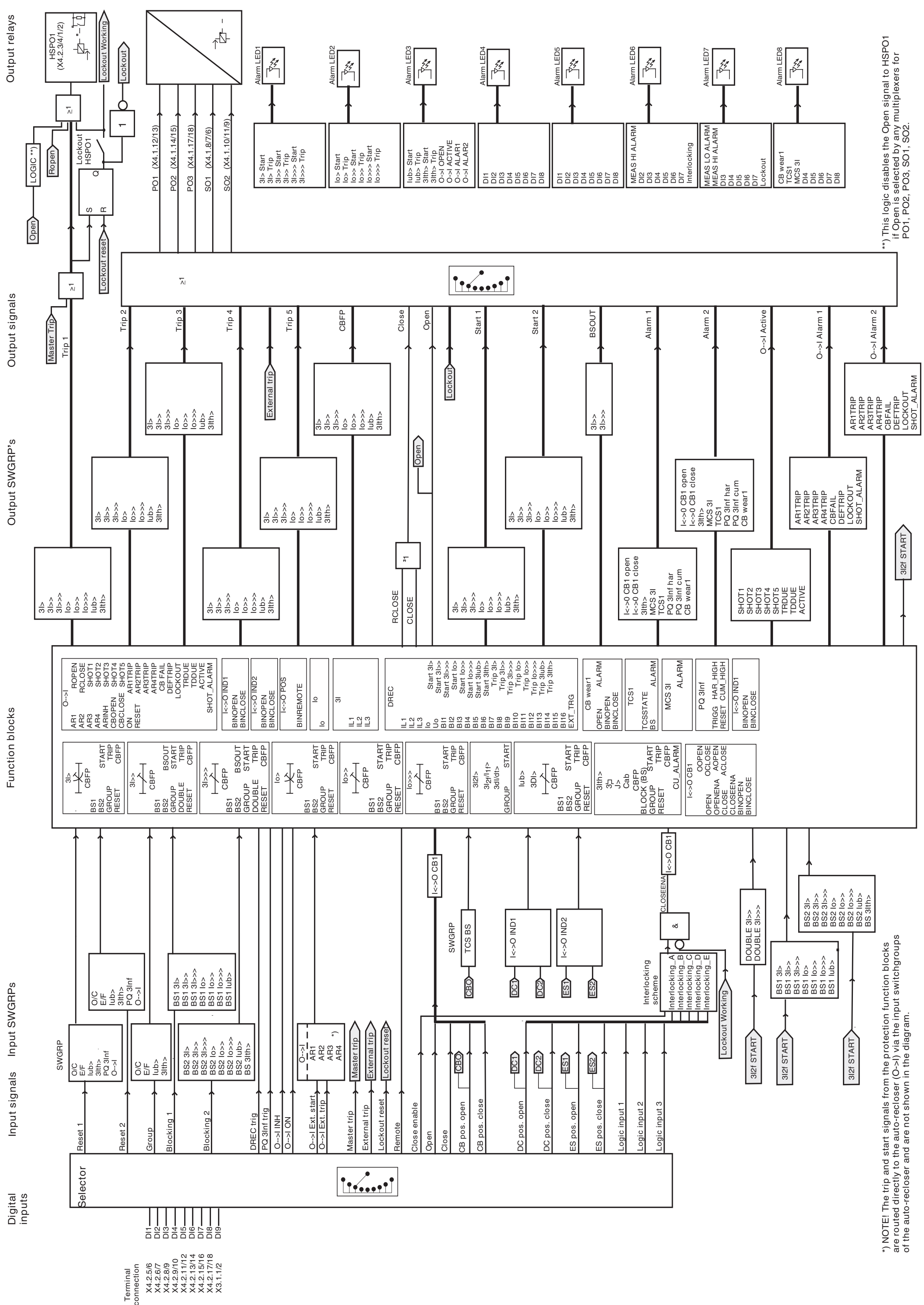


Fig. 4.1.2.1.-1 Block diagram of the standard configuration B02

4.1.2.2. Application

The B02 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective short-circuit protection, time-overcurrent protection, earth-fault protection and automatic reclosing. The configuration can be used in different types of networks such as radial isolated neutral networks, solidly earthed networks, resistant earthed networks and resonant earthed networks.

For more detailed information about the configuration, refer to the application examples of the standard configuration B02 in Section 10.4. Outgoing feeder, Basic B02.



A051930

Fig. 4.1.2.2.-1 Block diagram of the standard configuration B02 for REX 521

4.2. HW version: Medium

4.2.1. Standard configuration M01

4.2.1.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Three-phase transformer inrush and motor start-up current detector
- Directional earth-fault protection with three stages
- Phase discontinuity protection for three phases
- Three-phase thermal protection for cables
- Supervision function for the energizing current input circuit
- Current waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Residual voltage measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

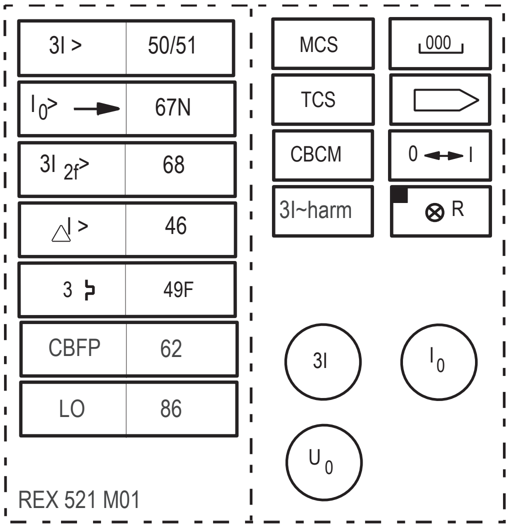


Fig. 4.2.1.1.-1 Block diagram of the standard configuration M01

4.2.1.2. Application

The M01 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective short-circuit, time overcurrent and directional earth-fault protection of radial isolated neutral networks, solidly earthed networks, resistant earthed networks and resonant earthed networks.

For more detailed information about the configuration, refer to the application examples of the standard configuration M01 in Chapter 11. Application examples, Medium and Section 11.2. Incoming feeder, Medium M01.

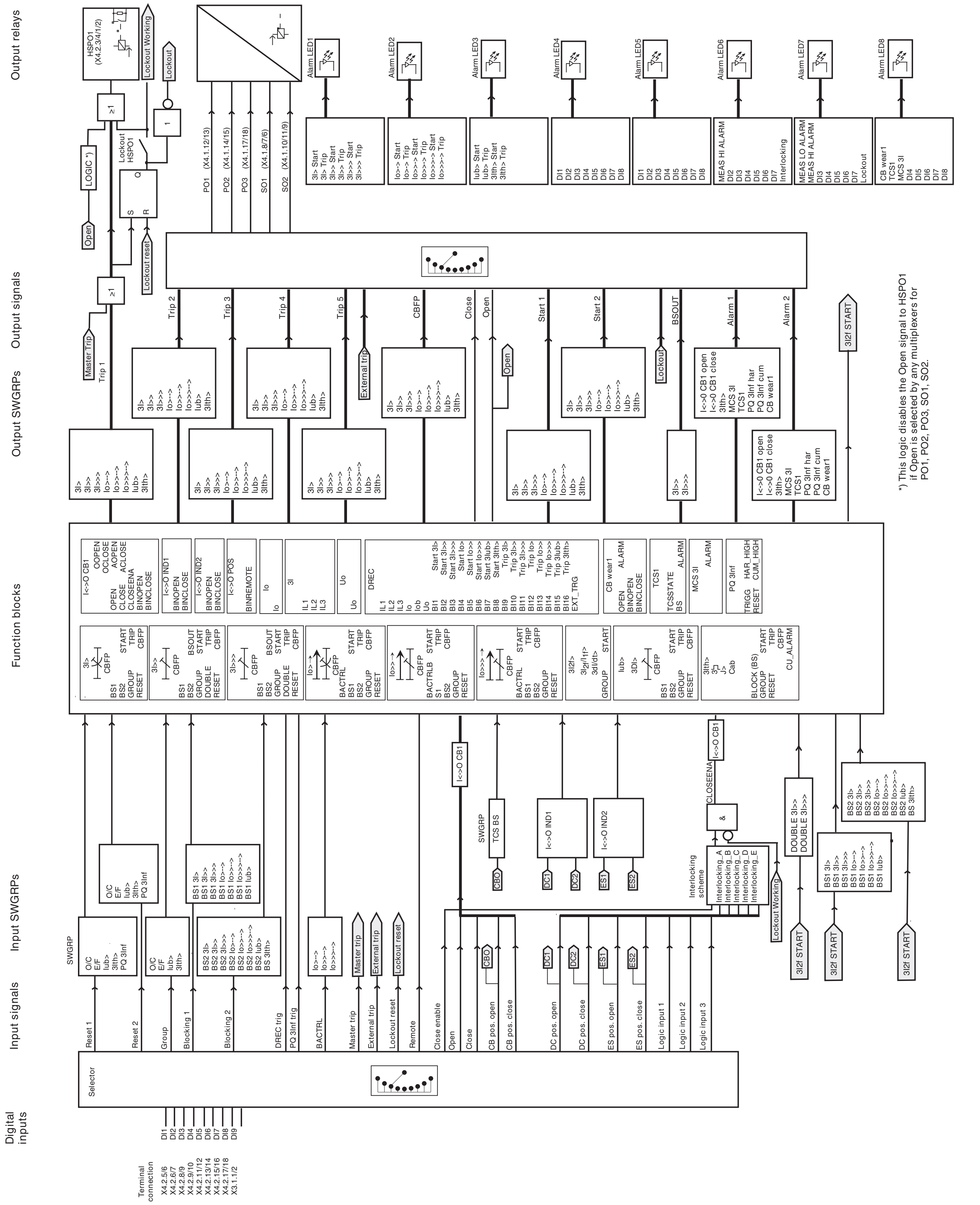


Fig. 4.2.1.2.-1 Block diagram of the standard configuration M01 for REX 521

4.2.2. Standard configuration M02

4.2.2.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Three-phase transformer inrush and motor start-up current detector
- Directional earth-fault protection with three stages
- Phase discontinuity protection for three phases
- Three-phase thermal protection for cables
- Supervision function for the energizing current input circuit
- Current waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Residual voltage measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Automatic reclosing 1...5 shots
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

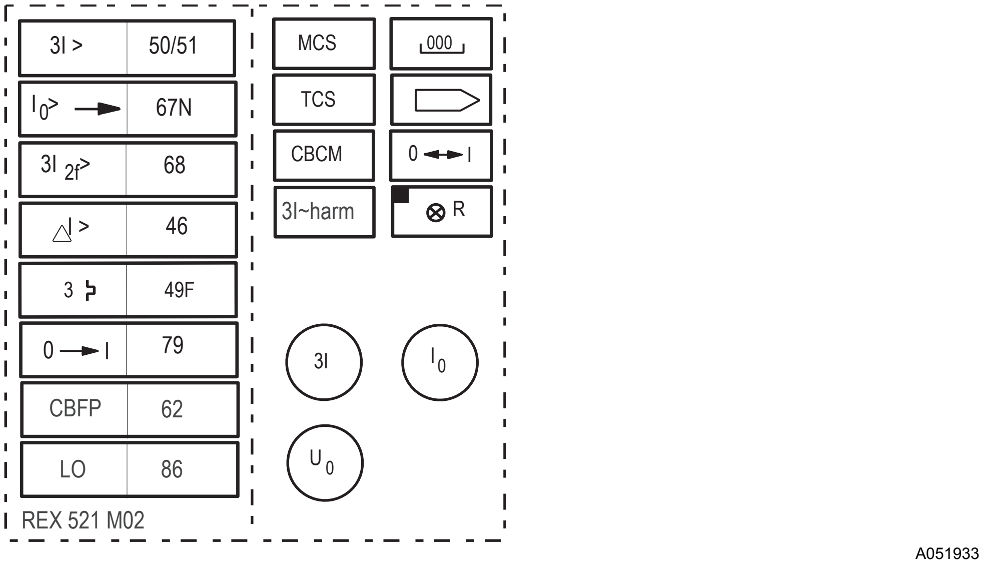


Fig. 4.2.2.1.-1 Block diagram of the standard configuration M02

4.2.2.2. Application

The M02 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective short-circuit protection, time-overcurrent protection, directional earth-fault protection and automatic reclosing. The configuration can be used in different types of networks such as of radial isolated neutral networks, solidly earthed networks, resistant earthed networks and resonant earthed networks.

For more detailed information about the configuration, refer to the application examples of the standard configuration M02 in Section 11.3. Outgoing feeder, Medium M02.

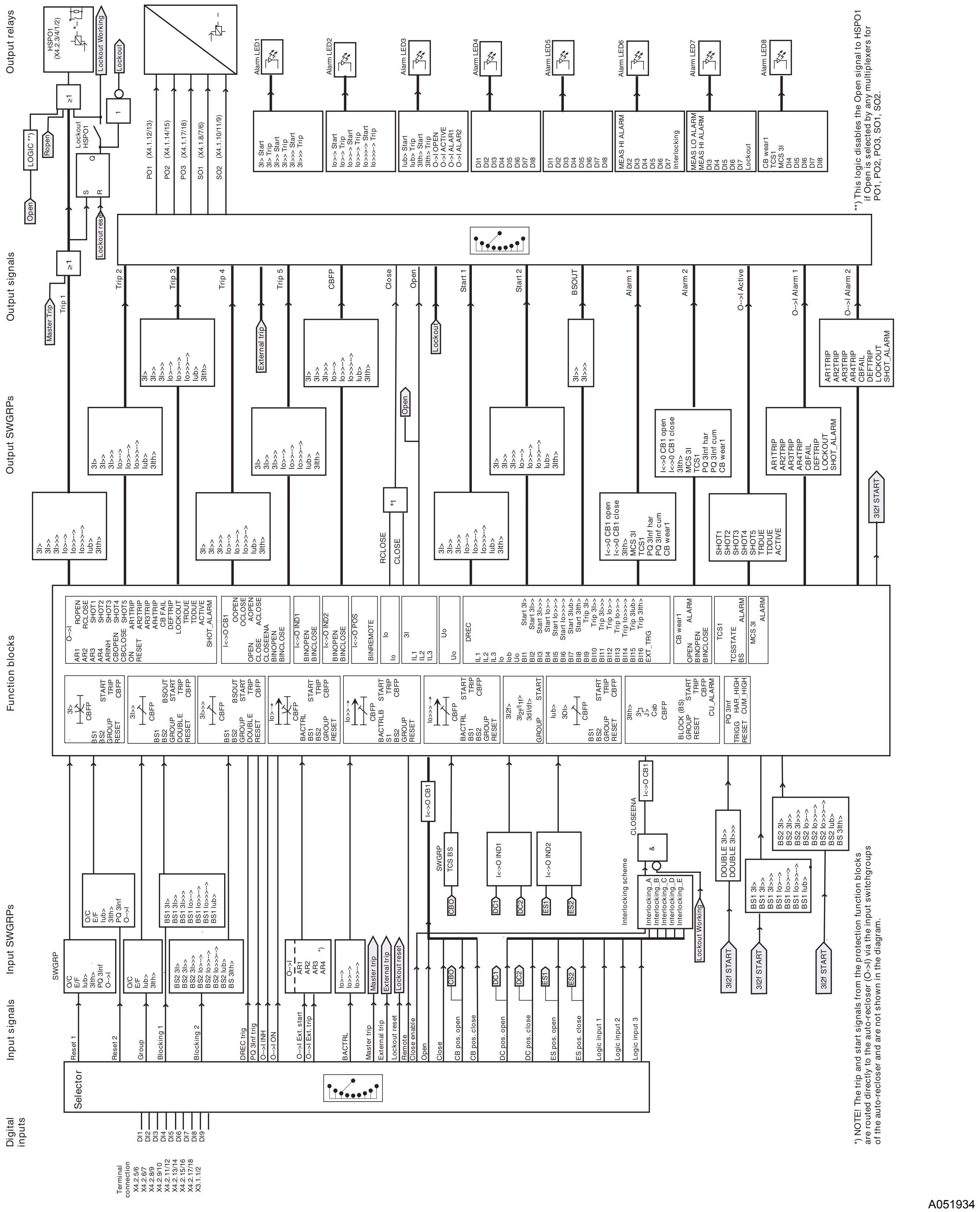


Fig. 4.2.2.2.-1 Block diagram of the standard configuration M02 for REX 521

4.3. HW version: High/Sensor

4.3.1. Standard configuration H01 (Sensor)

4.3.1.1. Features

- Three-phase directional overcurrent protection with two stages
- Three-phase non-directional overcurrent protection with one stage
- Three-phase transformer inrush and motor start-up current detector
- Directional earth-fault protection with three stages
- Phase discontinuity protection for three phases
- Three-phase thermal protection for cable
- Synchro-check/voltage-check function with one stage
- Supervision function for energizing current input circuit
- Supervision function for energizing voltage input circuit
- Current waveform distortion measurement
- Voltage waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Three phase-to-earth voltage measurements
- Residual voltage measurement
- System frequency measurement
- Three-phase power and energy measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Automatic reclosing 1…5 shots
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

The standard configuration H01 is available only with the sensor HW version.

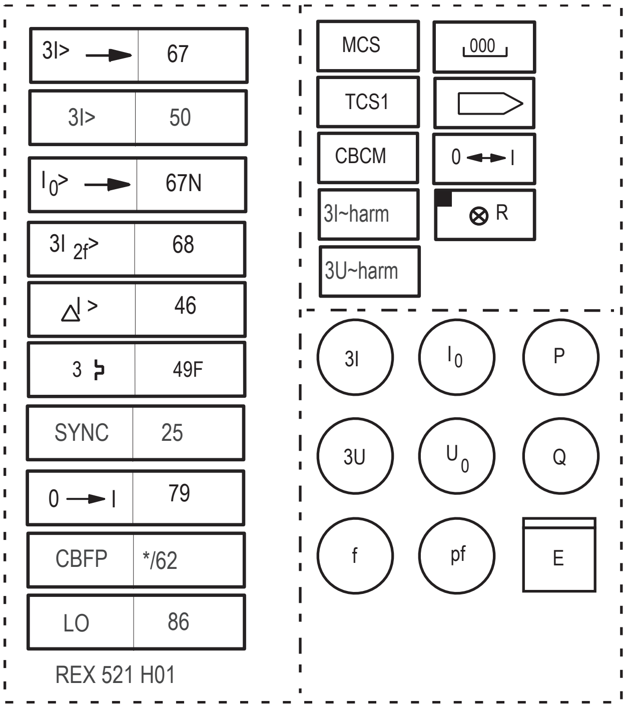


Fig. 4.3.1.1.-1 Block diagram of standard configuration H01

4.3.1.2. Application

The H01 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective directional and non-directional short-circuit protection, directional time-overcurrent protection, directional earth-fault protection and automatic reclosing with synchro- and voltage-check functionality.

For more detailed information about the standard configuration, refer to the application example of the standard configuration H01 in Section 12.1. Incoming feeder, High H01.

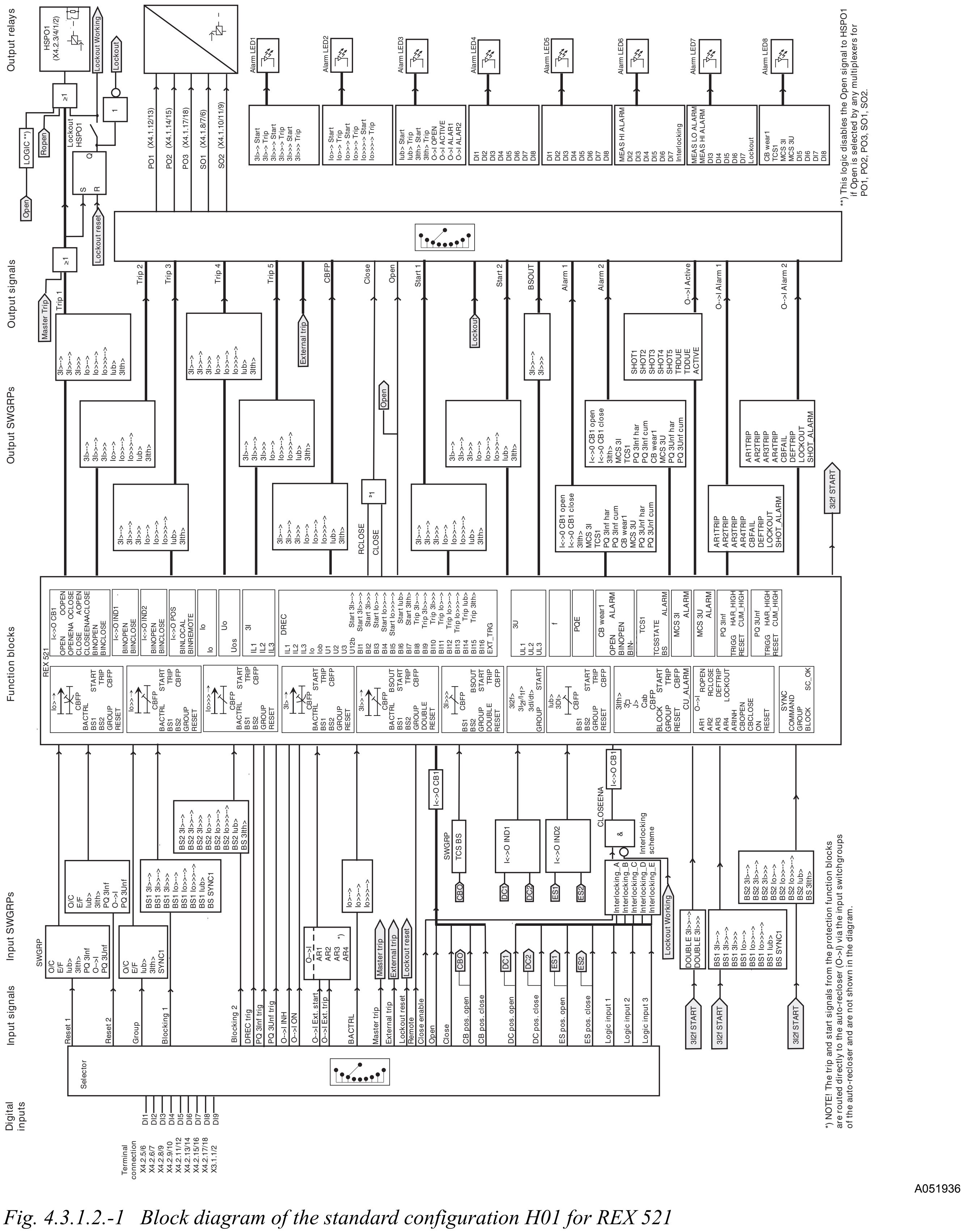


Fig. 4.3.1.2.-1 Block diagram of the standard configuration H01 for REX 521

4.3.2. Standard configuration H02

4.3.2.1. Features

- Three-phase directional overcurrent protection with two stages
- Three-phase non-directional overcurrent protection with two stages
- Three-phase transformer inrush and motor start-up current detector
- Directional earth-fault protection with three stages
- Underfrequency or overfrequency protection with one stage
- Phase discontinuity protection for three phases
- Three-phase thermal protection for cables
- Supervision function for energizing current input circuit
- Supervision function for energizing voltage input circuit
- Current waveform distortion measurement
- Voltage waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Three phase voltage measurements
- Residual voltage measurement
- System frequency measurement
- Three-phase power and energy measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Automatic reclosing 1…5 shots
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

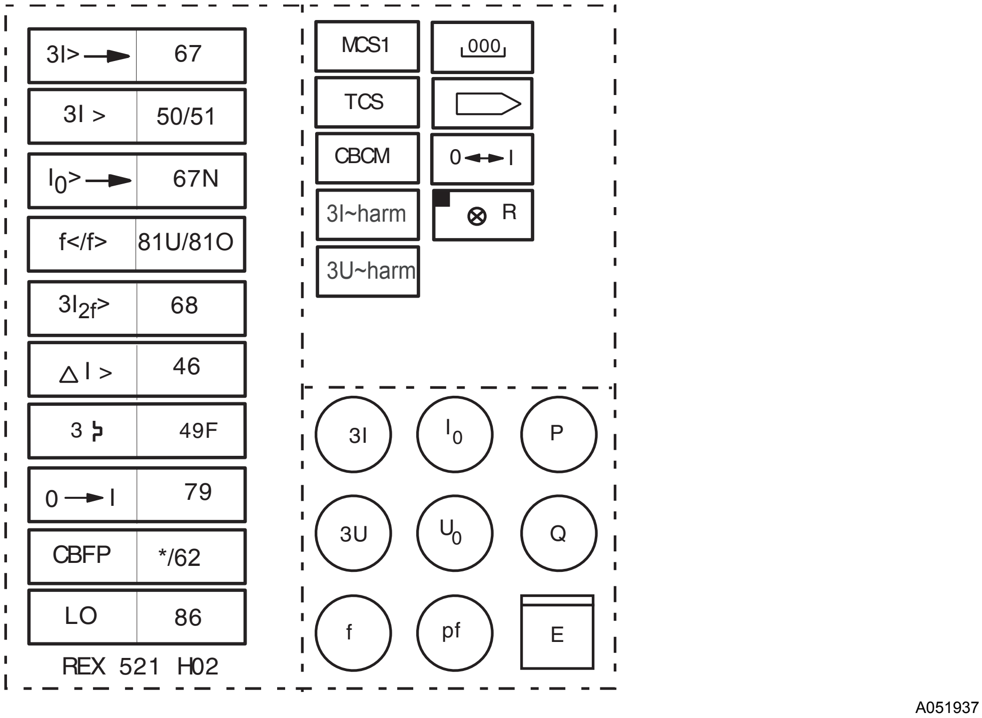


Fig. 4.3.2.1.-1 Block diagram of the standard configuration H02

4.3.2.2. Application

The H02 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective directional and non-directional short-circuit protection, directional and non-directional time-overcurrent protection, directional earth-fault protection and automatic reclosing.

For more detailed information about the standard configuration, refer to the application example of the standard configuration H02 in Section 12.2. Incoming feeder, High H02.

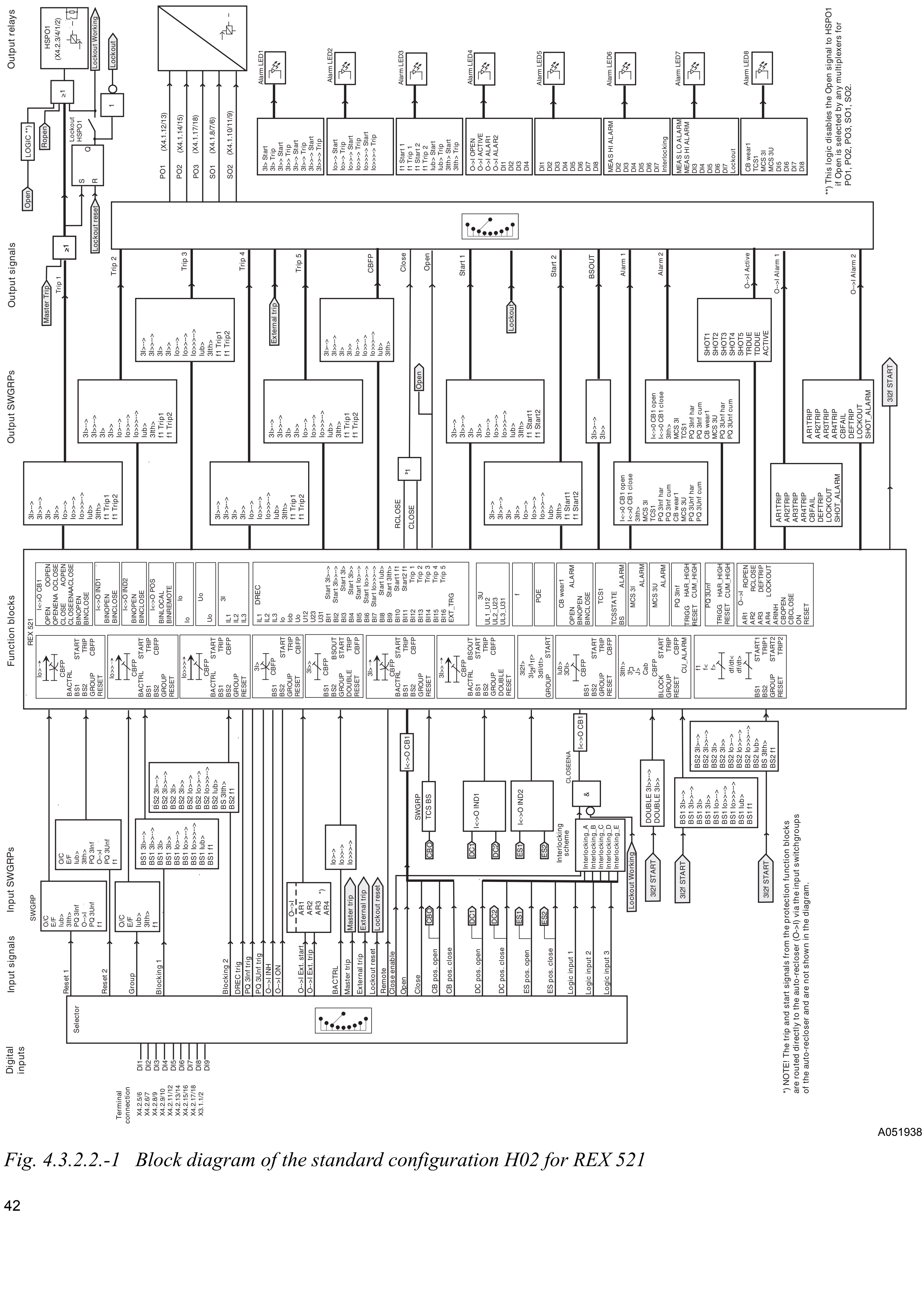


Fig. 4.3.2.2.-1 Block diagram of the standard configuration H02 for REX 521

4.3.3. Standard configuration H03

4.3.3.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Three-phase transformer inrush and motor start-up current detector
- Directional earth-fault protection with three stages
- Phase discontinuity protection for three phases
- Three-phase thermal protection for cable
- Synchro-check/voltage-check function with one stage
- Supervision function for energizing current input circuit
- Supervision function for energizing voltage input circuit
- Current waveform distortion measurement
- Voltage waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Three phase voltage measurements [1]
- Residual voltage measurement
- System frequency measurement
- Three-phase power and energy measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Automatic reclosing 1…5 shots
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

1. Only in Sensor version.

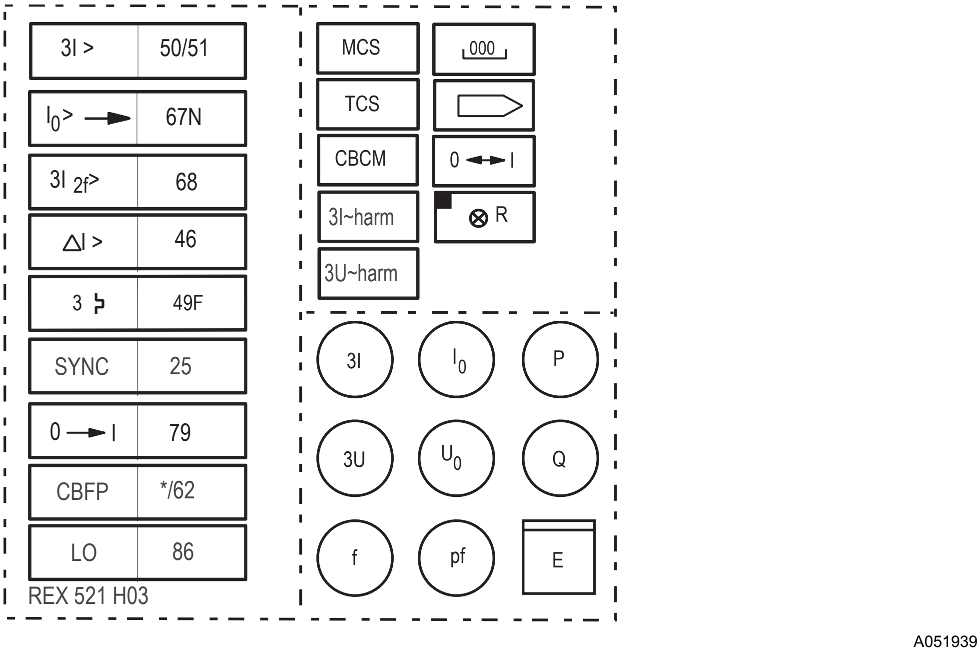


Fig. 4.3.3.1.-1 Block diagram of the standard configuration H03

4.3.3.2. Application

The H03 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective non-directional short-circuit protection, non-directional time-overcurrent protection, directional earth-fault protection and automatic reclosing with synchro- and voltage-check functionality.

For more detailed information about the standard configuration, refer to the application example of the standard configuration H03 in Section 12.3. Bus sectionalizer, High H03.

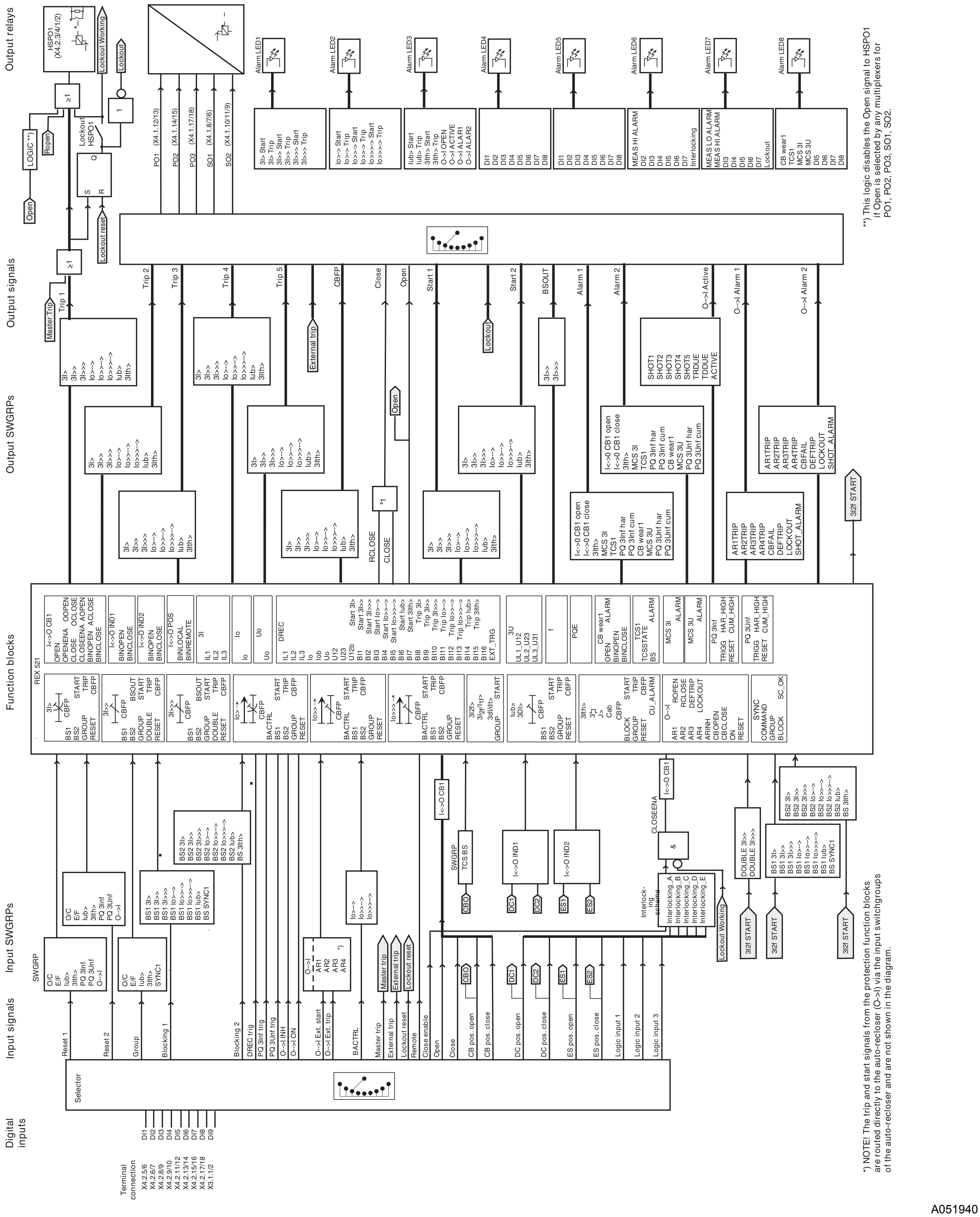


Fig. 4.3.3.2.-1 Block diagram of the standard configuration H03 for REX 521

4.3.4. Standard configuration H04

4.3.4.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Three-phase directional overcurrent protection with one stage
- Underfrequency or overfrequency protection with one stage
- Three-phase transformer inrush and motor start-up current detector
- Directional earth-fault protection with three stages
- Non-directional earth-fault protection with three stages[1]
- Phase discontinuity protection for three phases
- Three-phase thermal protection for cable
- Supervision function for energizing current input circuit
- Supervision function for energizing voltage input circuit
- Current waveform distortion measurement
- Voltage waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Three phase voltage measurements
- Residual voltage measurement
- System frequency measurement
- Three-phase power and energy measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Automatic reclosing 1…5 shots
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

1. The function blocks I_0>, I_0>>, I_0>>> are fixedly configured to the I_0 (1/5A) channel.

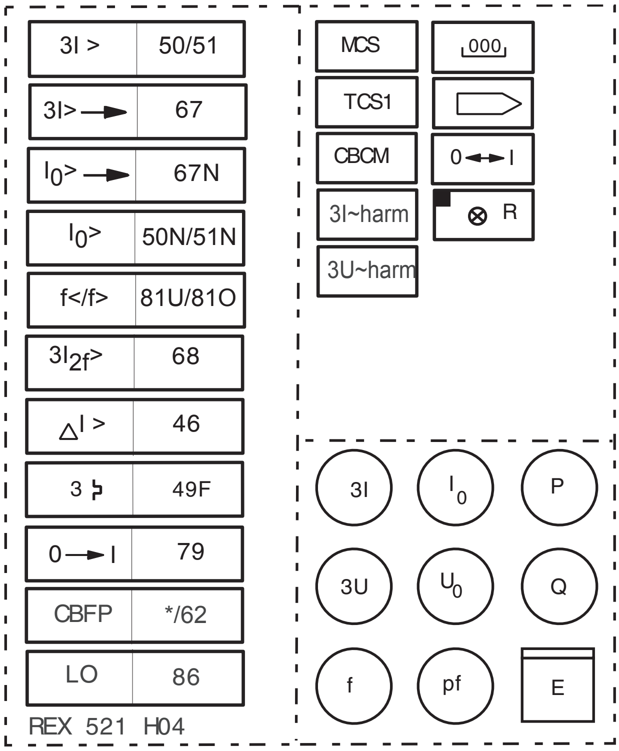
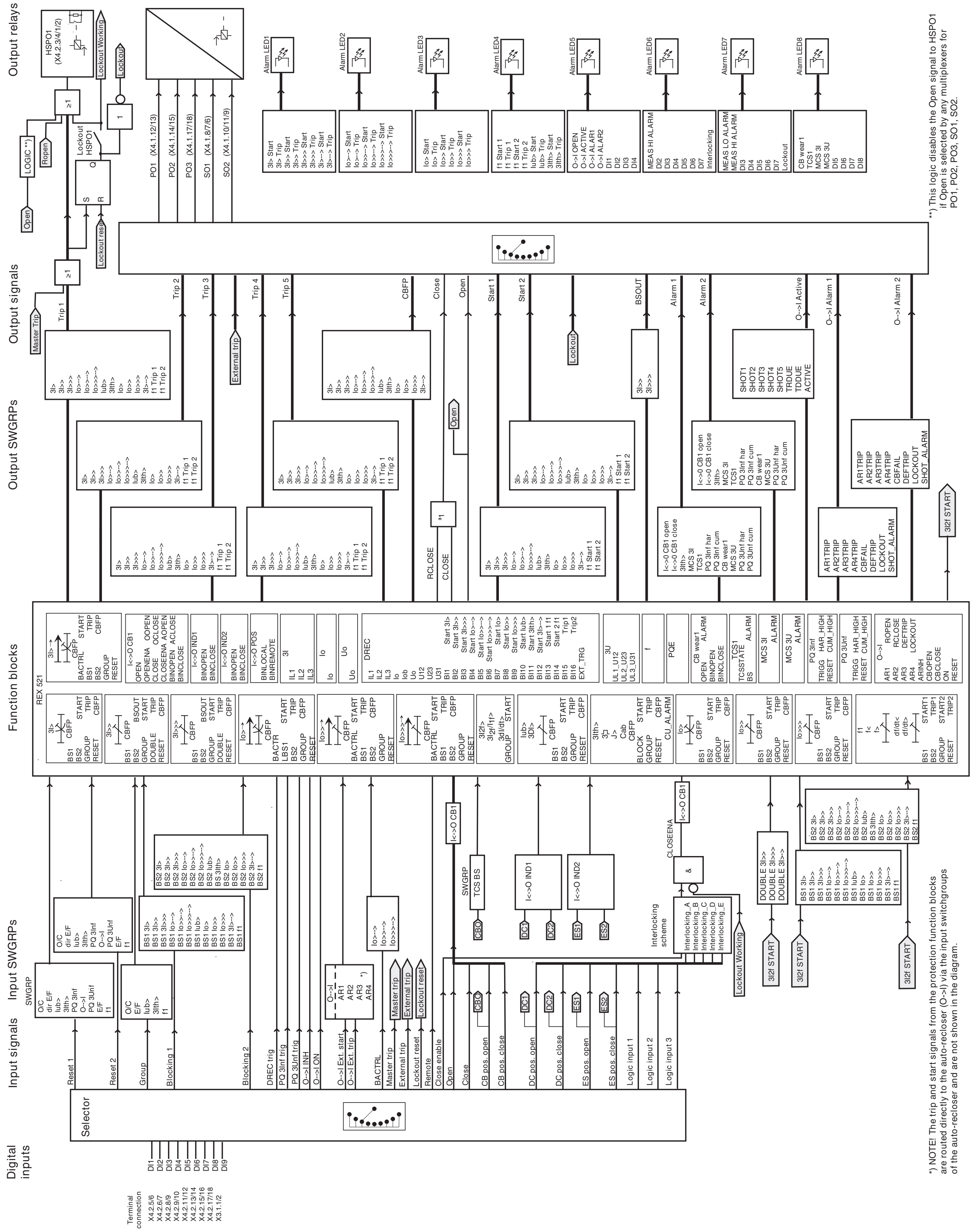


Fig. 4.3.4.1.-1 Block diagram of the standard configuration H04

4.3.4.2. Application

The H04 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective non-directional short-circuit protection, non-directional time-overcurrent protection, directional and non-directional earth-fault protection and automatic reclosing.

For more detailed information about the standard configuration, refer to the application example of the standard configuration H04 in Section 12.4. Outgoing feeder, High H04.



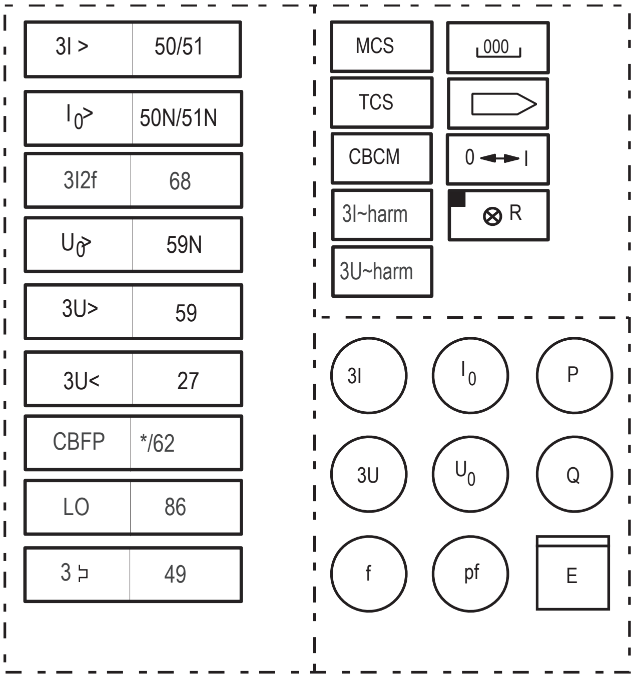
A051942

Fig. 4.3.4.2.-1 Block diagram of the standard configuration H04 for REX 521

4.3.5. Standard configuration H05

4.3.5.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Non-directional earth-fault protection with three stages
- Three-phase overvoltage protection with two stages
- Three-phase undervoltage protection with two stages
- Residual overvoltage protection with three stages
- Three-phase transformer inrush and motor start-up current detector
- Three-phase thermal overload protection for devices
- Supervision function for energizing current input circuit
- Supervision function for energizing voltage input circuit
- Current waveform distortion measurement
- Voltage waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Three phase voltage measurements
- Residual voltage measurement
- System frequency measurement
- Three-phase power and energy measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs



A051943

Fig. 4.3.5.1.-1 Block diagram of the standard configuration H05

4.3.5.2. Application

The H05 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective non-directional short-circuit protection, non-directional time-overcurrent protection, non-directional earth-fault protection, overvoltage protection, undervoltage protection and residual overvoltage protection.

For more detailed information about the configuration, refer to the application example of the standard configuration H05 in Section 12.5. Incoming feeder, High H05/H50.

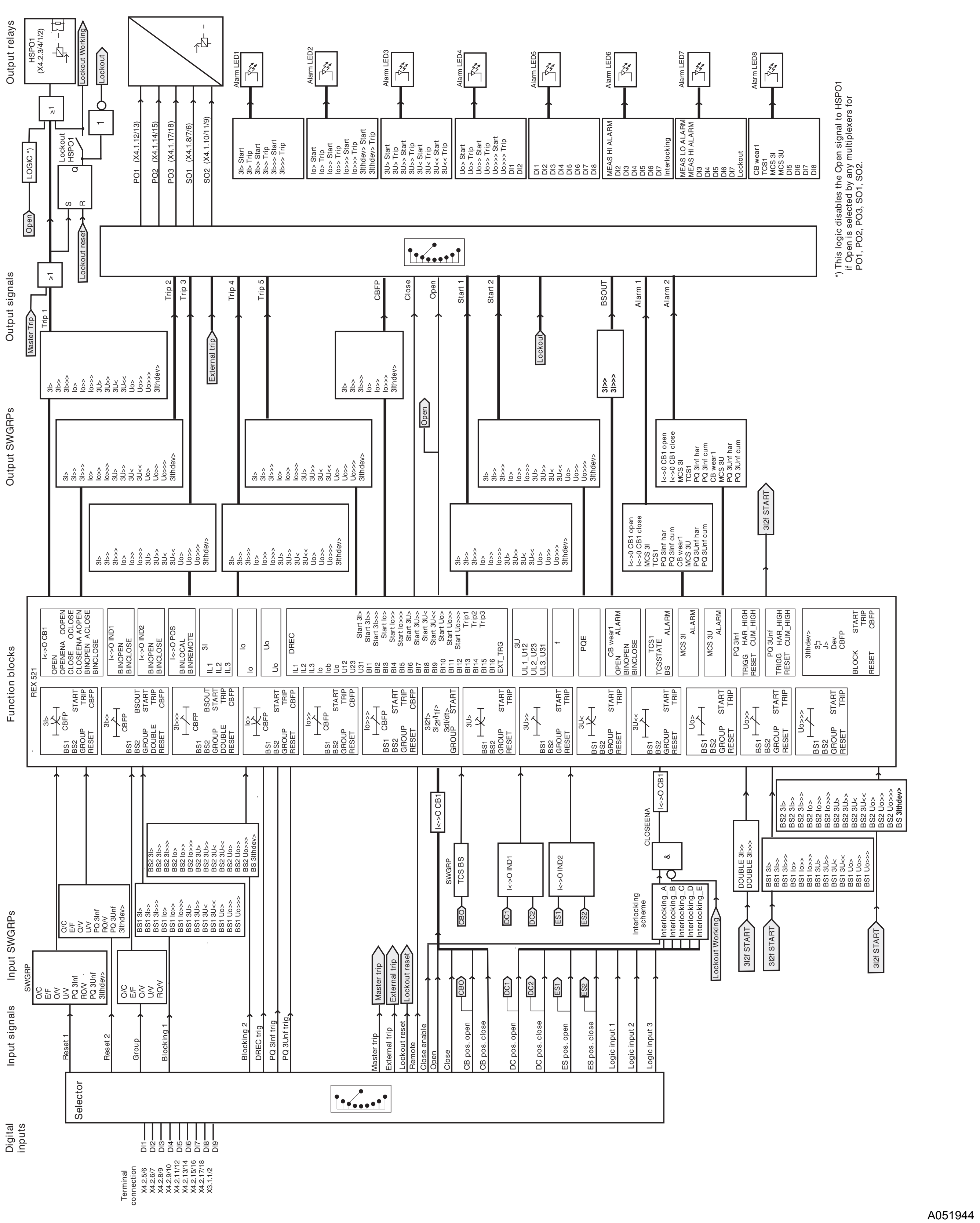


Fig. 4.3.5.2.-1 Block diagram of the standard configuration H05 for REX 521

4.3.6. Standard configuration H06

4.3.6.1. Features

- Three-phase non-directional overcurrent protection with two stages
- Three-phase overvoltage protection with two stages
- Three-phase undervoltage protection with two stages
- Residual overvoltage protection with three stages
- Underfrequency or overfrequency protection with two stages
- Supervision function for energizing current input circuit
- Supervision function for energizing voltage input circuit
- Current waveform distortion measurement
- Voltage waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Three phase voltage measurements
- Residual voltage measurement
- System frequency measurement
- Three-phase power and energy measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

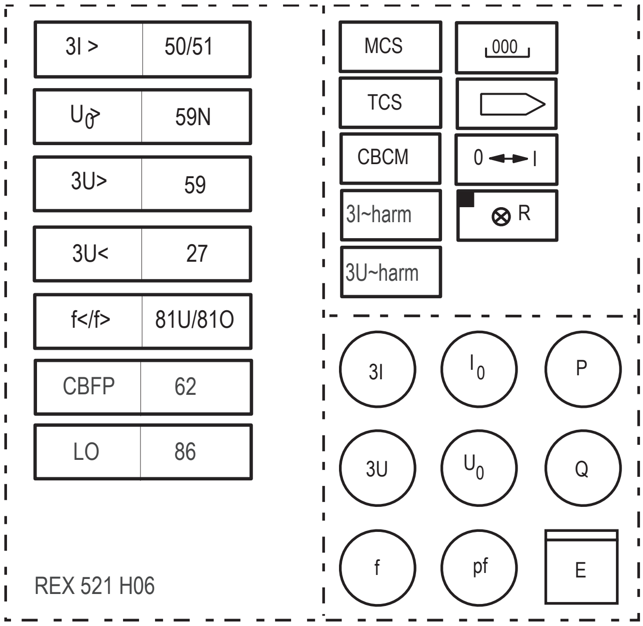


Fig. 4.3.6.1.-1 Block diagram of the standard configuration H06

4.3.6.2. Application

The H06 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective non-directional short-circuit protection, non-directional time-overcurrent protection, overvoltage protection, undervoltage protection, residual overvoltage protection, underfrequency protection and overfrequency protection.

For more detailed information about the standard configuration, refer to the application example of the standard configuration H06 in Section 12.6. Measurement cubicle, High H06.

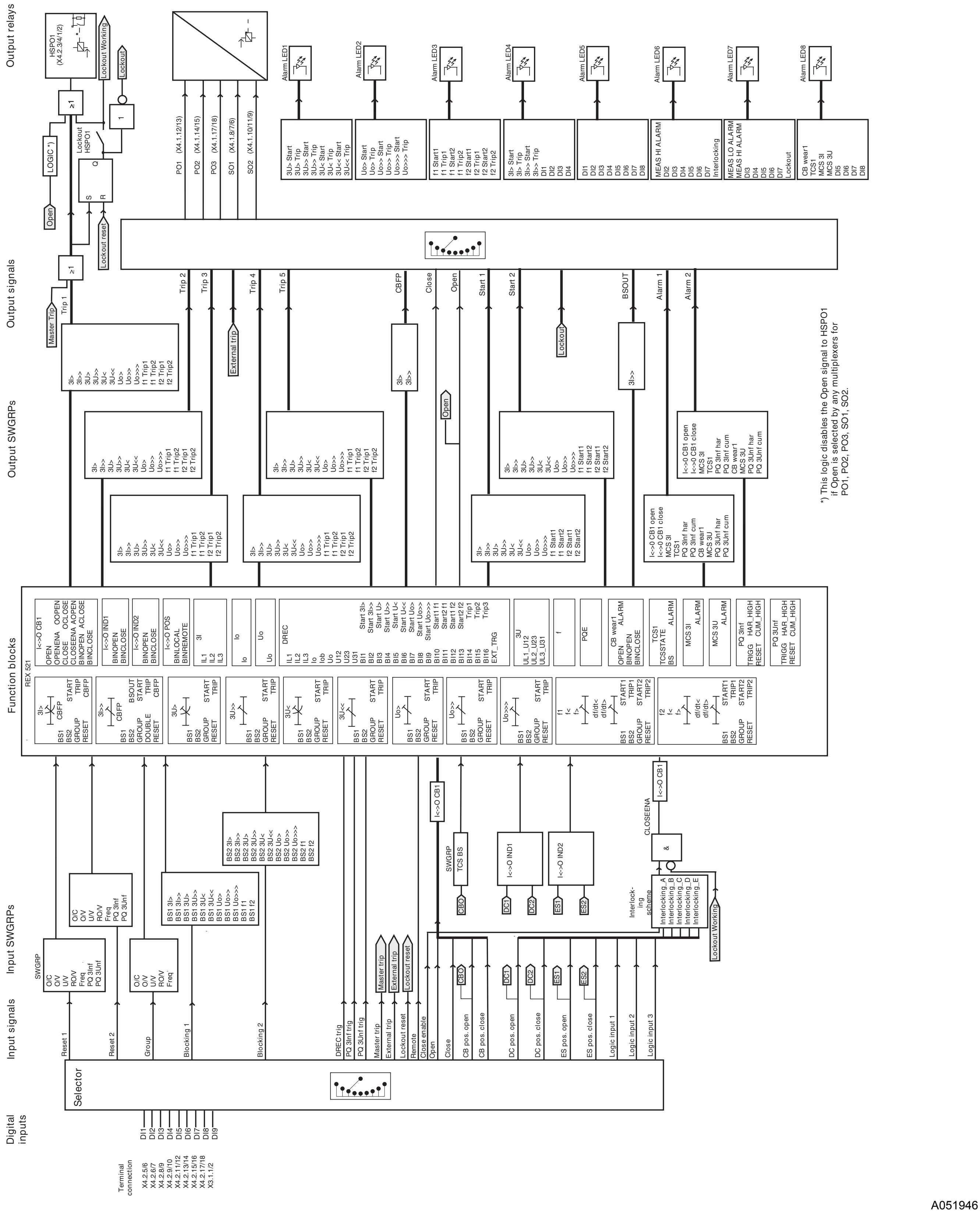


Fig. 4.3.6.2.-1 Block diagram of the standard configuration H06 for REX 521

4.3.7. Standard configuration H07

4.3.7.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Non-directional earth-fault protection with two stages
- Directional earth-fault protection with two stages
- Three-phase overvoltage protection with two stages
- Three-phase undervoltage protection with two stages
- Underfrequency or overfrequency protection with one stage
- Negative phase sequence (NPS) protection with two stages
- Three-phase motor start-up supervision
- Three-phase thermal overload protection for devices
- Phase reversal protection
- Phase sequence voltage protection
- Fuse failure protection
- Three-phase non-directional undercurrent protection with one stage
- Supervision function for energizing current input circuit
- Supervision function for energizing voltage input circuit
- Current waveform distortion measurement
- Voltage waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Three-phase voltage measurements
- Residual voltage measurement
- System frequency measurement
- Three-phase power and energy measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit breaker failure protection (CBFP) function
- Circuit breaker control with indication
- Operation time counter
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

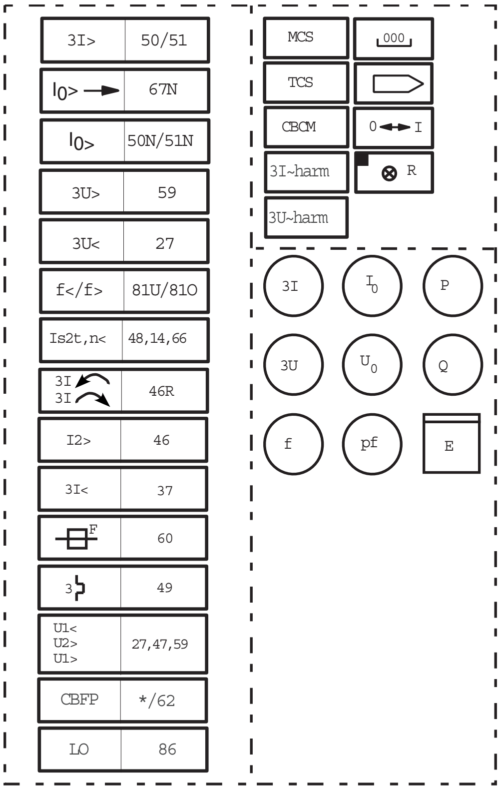


Fig. 4.3.7.1.-1 Block diagram of the standard configuration H07

4.3.7.2. Application

The H07 standard configuration for REX 521 is designed for protection of large or medium-size three-phase AC motors in circuit breaker controlled motor drives. Due to large number of protective functions integrated, the relay provides a complete protection against motor damage caused by electrical faults.

The H07 configuration can also be applied to other objects needing thermal overload protection (such as power transformers) and it can also be used in applications requiring overcurrent protection, under/overvoltage protection and/or directional or non-directional earth-fault protection.

For more information about the H07 standard configuration, refer to application example in Section 12.7. Motor protection, High H07/H51.

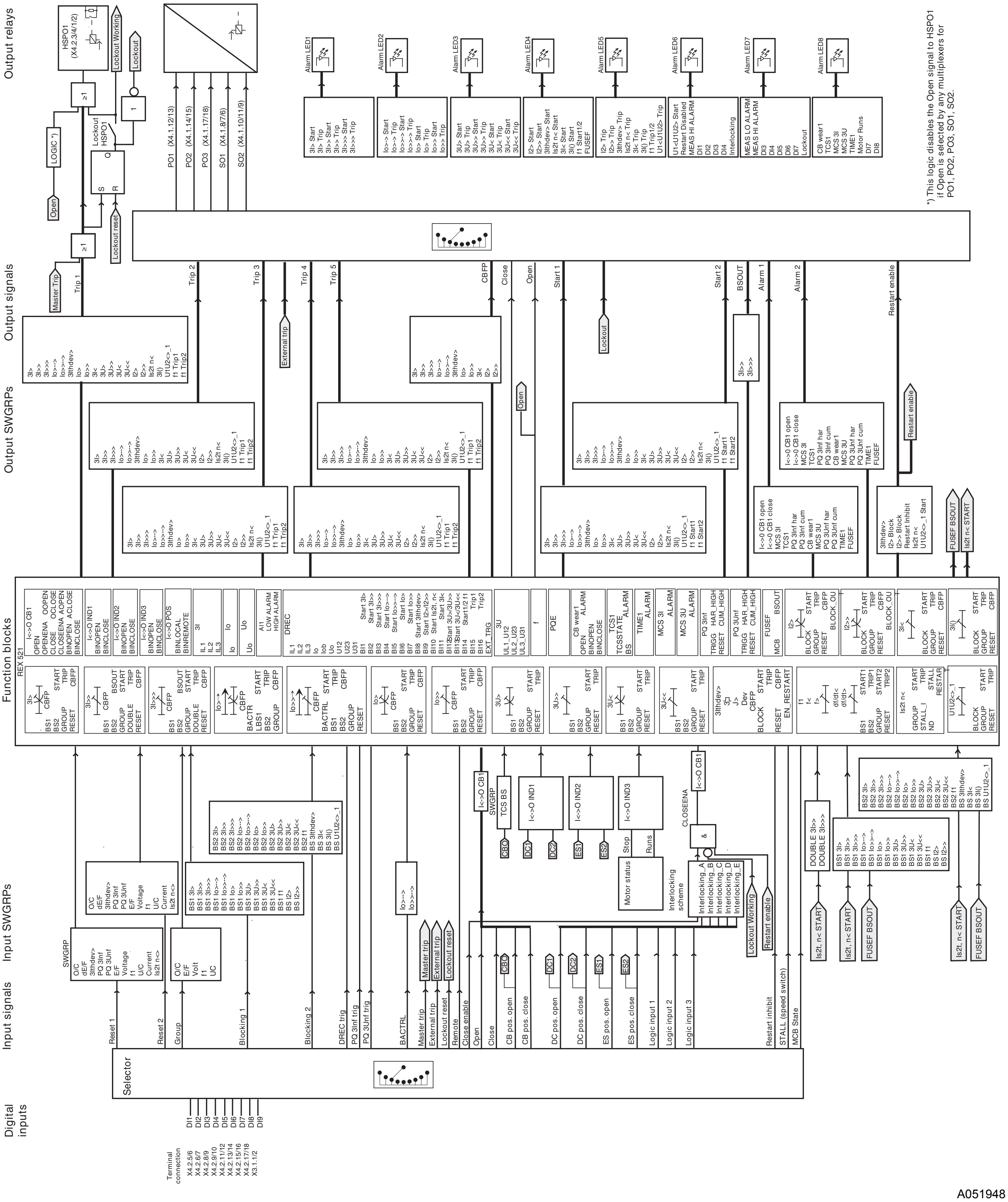


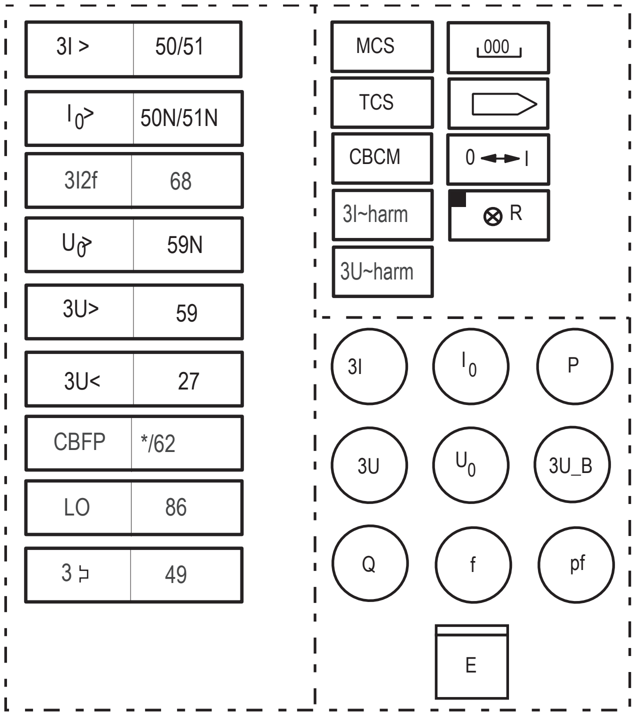
Fig. 4.3.7.2.-1 Block diagram of the standard configuration H07 for REX 521

4.3.8. Standard configuration H08 (No sensors)

4.3.8.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Non-directional earth-fault protection with three stages
- Three-phase overvoltage protection with two stages
- Three-phase undervoltage protection with two stages
- Residual overvoltage protection with three stages
- Three-phase transformer inrush and motor start-up current detector
- Three-phase thermal overload protection for devices
- Supervision function for energizing current input circuit
- Supervision function for energizing voltage input circuit
- Current waveform distortion measurement
- Voltage waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Three phase voltage measurements
- Residual voltage measurement
- System frequency measurement
- Three-phase power and energy measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

VTs are used to measure phase-to-earth voltages.



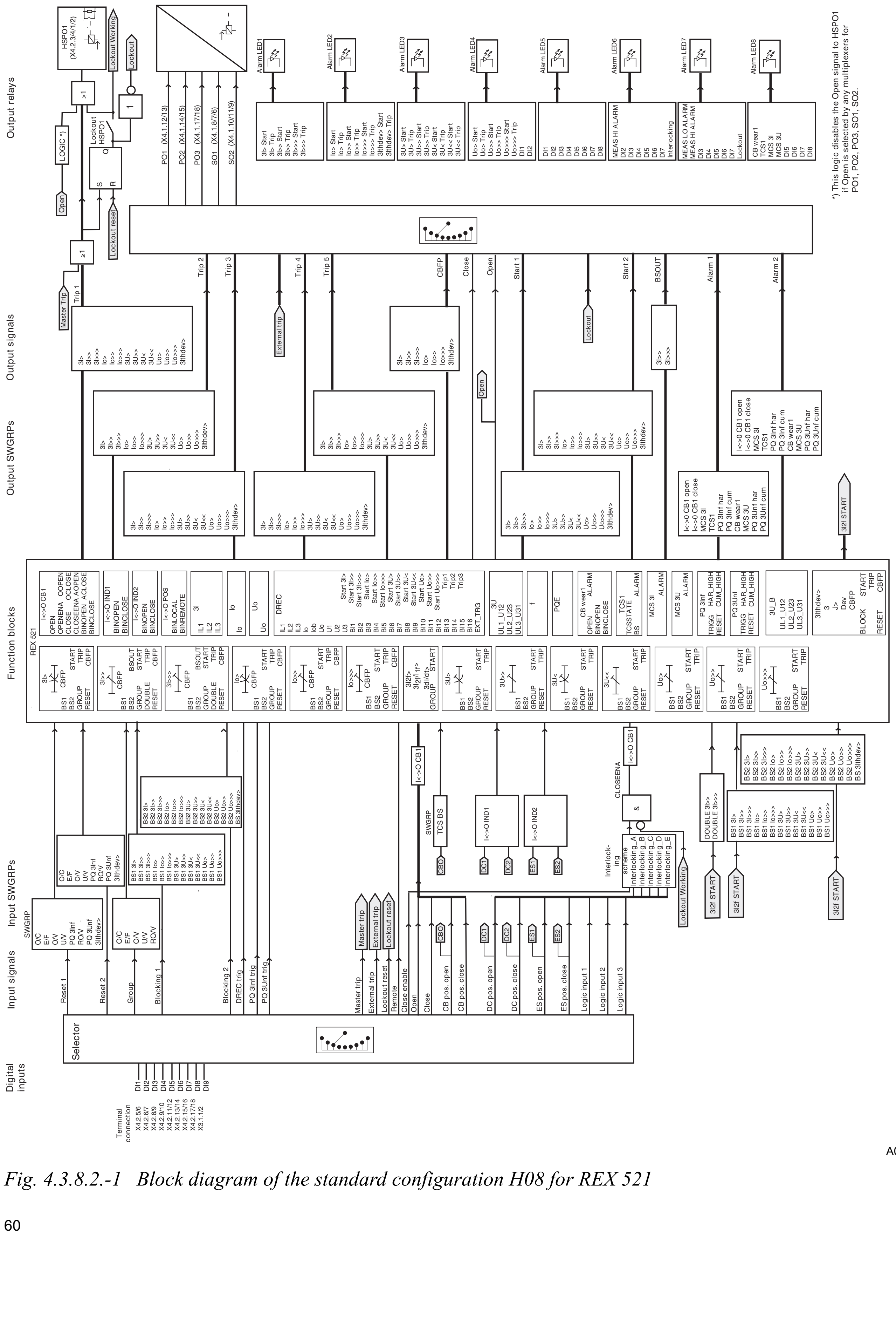
A051949

Fig. 4.3.8.1.-1 Block diagram of the standard configuration H08

4.3.8.2. Application

The H08 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective non-directional short-circuit protection, non-directional time-overcurrent protection, non-directional earth-fault protection, overvoltage protection, undervoltage protection and residual overvoltage protection.

For more detailed information about the configuration, refer to the application example of the standard configuration H08 in Section 12.8. Incoming feeder, High H08/H09.



A051950

Fig. 4.3.8.2.-1 Block diagram of the standard configuration H08 for REX 521

4.3.9. Standard configuration H09 (No sensors)

4.3.9.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Non-directional earth-fault protection with three stages
- Three-phase overvoltage protection with two stages
- Three-phase undervoltage protection with two stages
- Residual overvoltage protection with three stages
- Three-phase transformer inrush and motor start-up current detector
- Underfrequency or overfrequency protection with two stages
- Supervision function for energizing current input circuit
- Supervision function for energizing voltage input circuit
- Current waveform distortion measurement
- Voltage waveform distortion measurement
- Three-phase current measurement
- Automatic reclosing 1...5 shots
- Neutral current measurement
- Three phase voltage measurements
- Residual voltage measurement
- System frequency measurement
- Three-phase power and energy measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

VTs are used to measure phase-to-earth voltages.

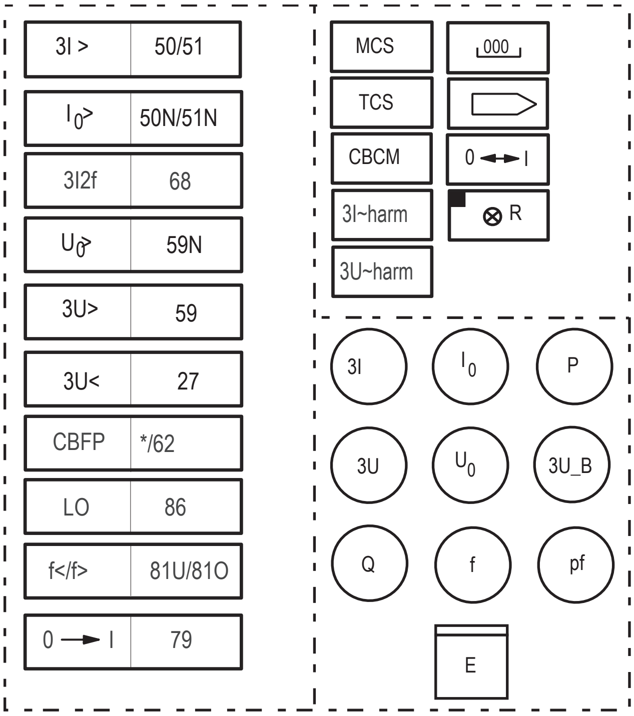


Fig. 4.3.9.1.-1 Block diagram of the standard configuration H09

4.3.9.2. Application

The H09 standard configuration for REX 521 is designed to be used in single busbar systems using one circuit breaker for selective non-directional short-circuit protection, non-directional time-overcurrent protection, non-directional earth-fault protection, overvoltage protection, undervoltage protection, residual overvoltage protection, underfrequency protection, overfrequency protection and automatic reclosing.

For more detailed information about the configuration, refer to the application example of the standard configuration H09 in Section 12.8. Incoming feeder, High H08/H09.

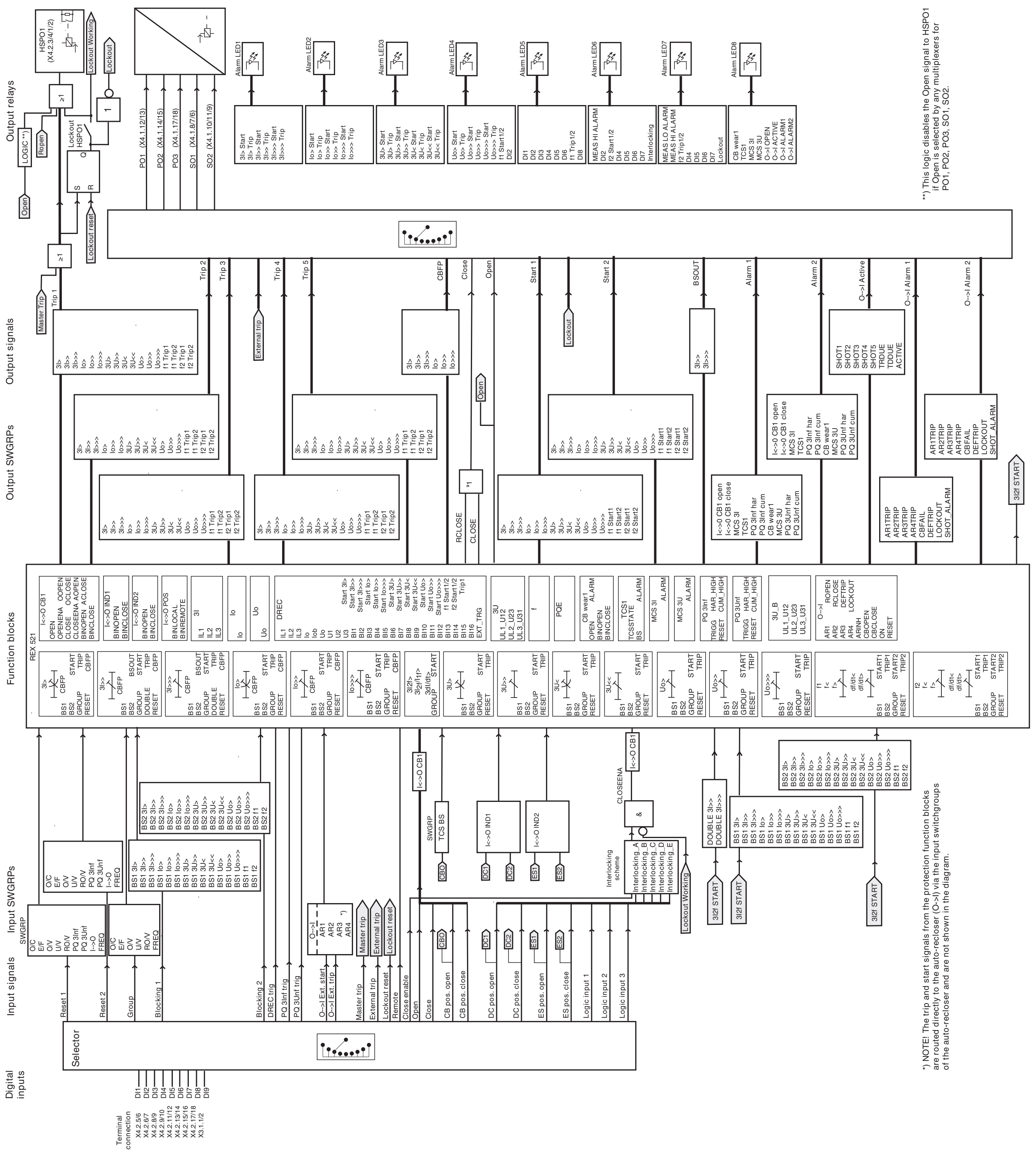


Fig. 4.3.9.2.-1 Block diagram of the standard configuration H09 for REX 521

4.3.10. Standard configuration H50 (No sensors)

4.3.10.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Three-phase directional overcurrent protection with two stages
- Directional earth-fault protection with two stages
- Non-directional earth-fault protection with two stages
- Three-phase overvoltage protection with two stages
- Three-phase undervoltage protection with two stages
- Residual overvoltage protection with two stages
- Three-phase transformer inrush and motor start-up current detector
- Underfrequency or overfrequency protection with two stages
- Phase-sequence voltage protection
- Supervision function for energizing current input circuit
- Supervision function for energizing voltage input circuit
- Current waveform distortion measurement
- Voltage waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Three phase voltage measurements
- Residual voltage measurement
- System frequency measurement
- Three-phase power and energy measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- Automatic reclosing 1...5 shots
- Circuit breaker control with indication
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs

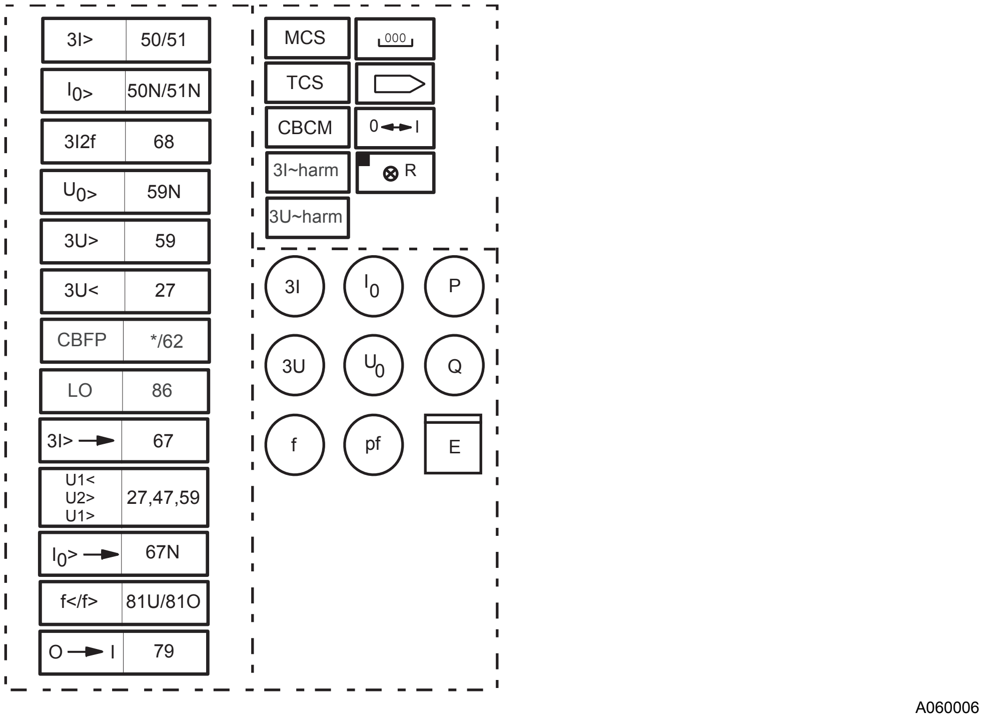
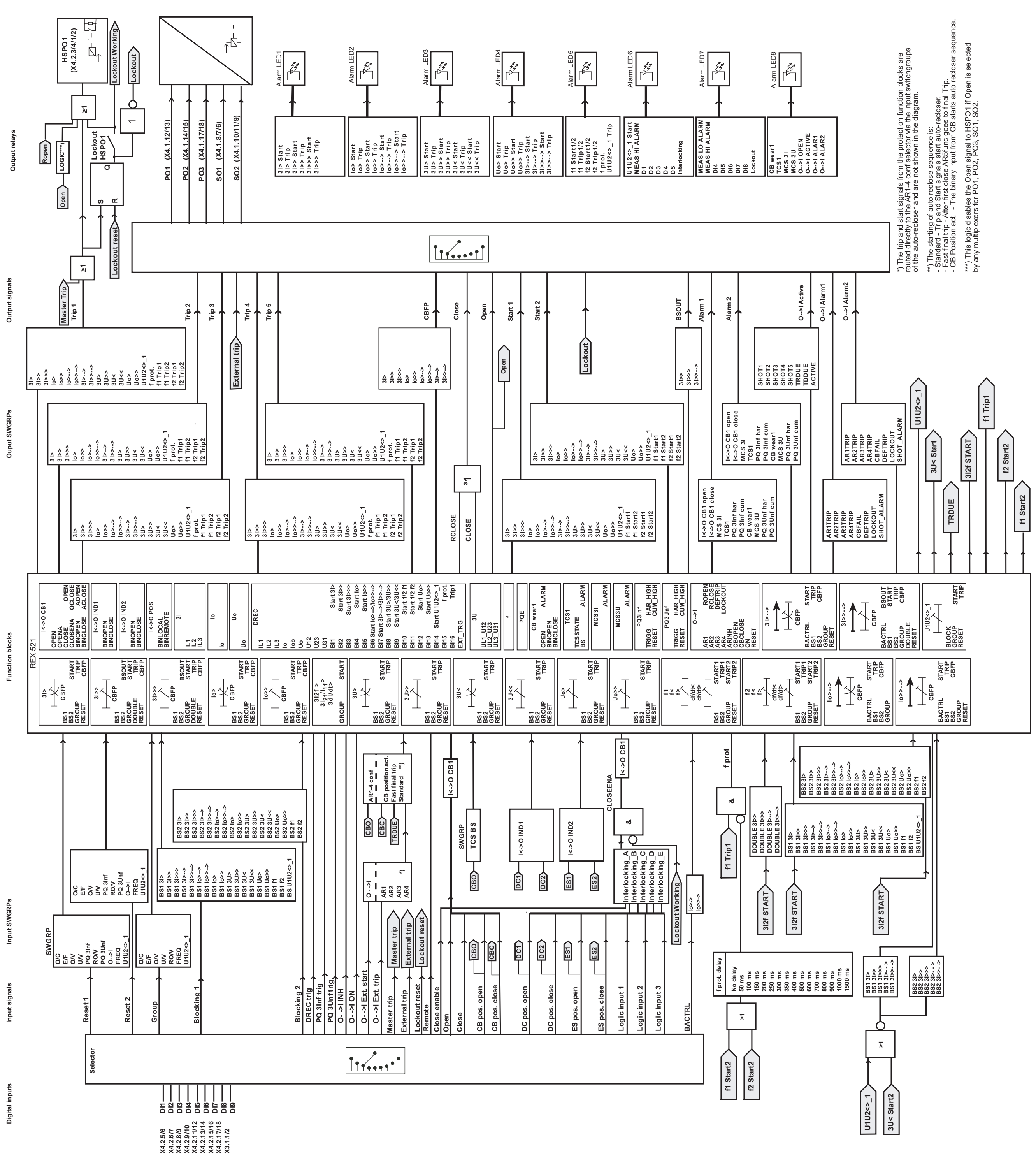


Fig. 4.3.10.1.-1 Block diagram of the standard configuration H50

4.3.10.2. Application

The H50 standard configuration for REX 521 is designed to be used in single busbar systems by using one circuit breaker for selective non-directional short-circuit protection, directional and non-directional time-overcurrent protection, directional and/or non-directional earth-fault protection, overvoltage protection, undervoltage protection, residual overvoltage protection, underfrequency protection, overfrequency protection and automatic reclosing.

For more detailed information about the configuration, refer to the application example of the standard configuration H50 in Section 12.5. Incoming feeder, High H05/H50.



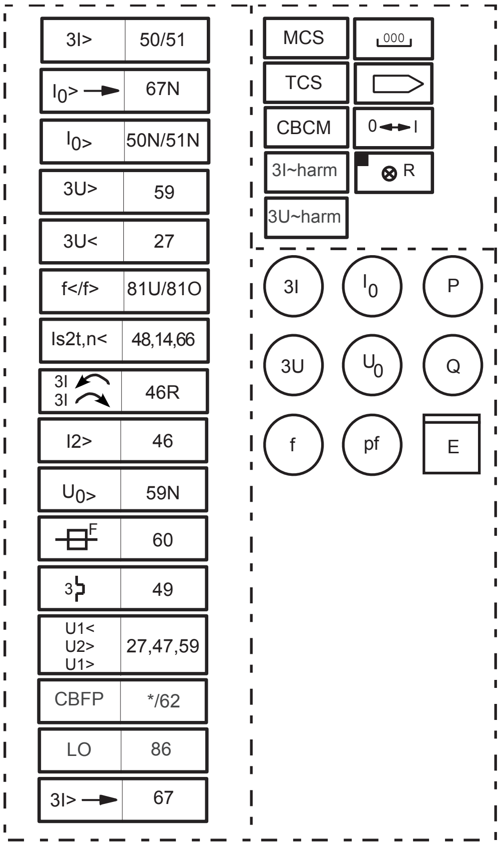
A060007

Fig. 4.3.10.2.-1 Block diagram of the standard configuration H50 for REX 521

4.3.11. Standard configuration H51 (No sensors)

4.3.11.1. Features

- Three-phase non-directional overcurrent protection with three stages
- Three-phase directional overcurrent protection with one stage
- Non-directional earth-fault protection with two stages
- Directional earth-fault protection with two stages
- Three-phase overvoltage protection with one stage
- Three-phase undervoltage protection with one stage
- Underfrequency or overfrequency protection with two stages
- Negative phase-sequence (NPS) protection with one stage
- Three-phase motor start-up supervision
- Three-phase thermal overload protection for devices
- Residual overvoltage protection with one stage
- Phase-sequence voltage protection
- Fuse-failure protection
- Three-phase non-directional undercurrent protection with one stage
- Supervision function for energizing current input circuit
- Supervision function for energizing voltage input circuit
- Current waveform distortion measurement
- Voltage waveform distortion measurement
- Three-phase current measurement
- Neutral current measurement
- Three-phase voltage measurements
- Residual voltage measurement
- System frequency measurement
- Three-phase power and energy measurement
- Calculation of the accumulated electric breaker wear of the circuit breaker (CB)
- Transient disturbance recorder
- Trip-circuit supervision
- Delayed trip output for the circuit breaker failure protection (CBFP) function
- Circuit breaker control with indication
- Operation time counter
- Lockout function
- Object indication
- Logic control position selector
- User-configurable I/Os
- Interlocking
- User-configurable alarm LEDs



A060005

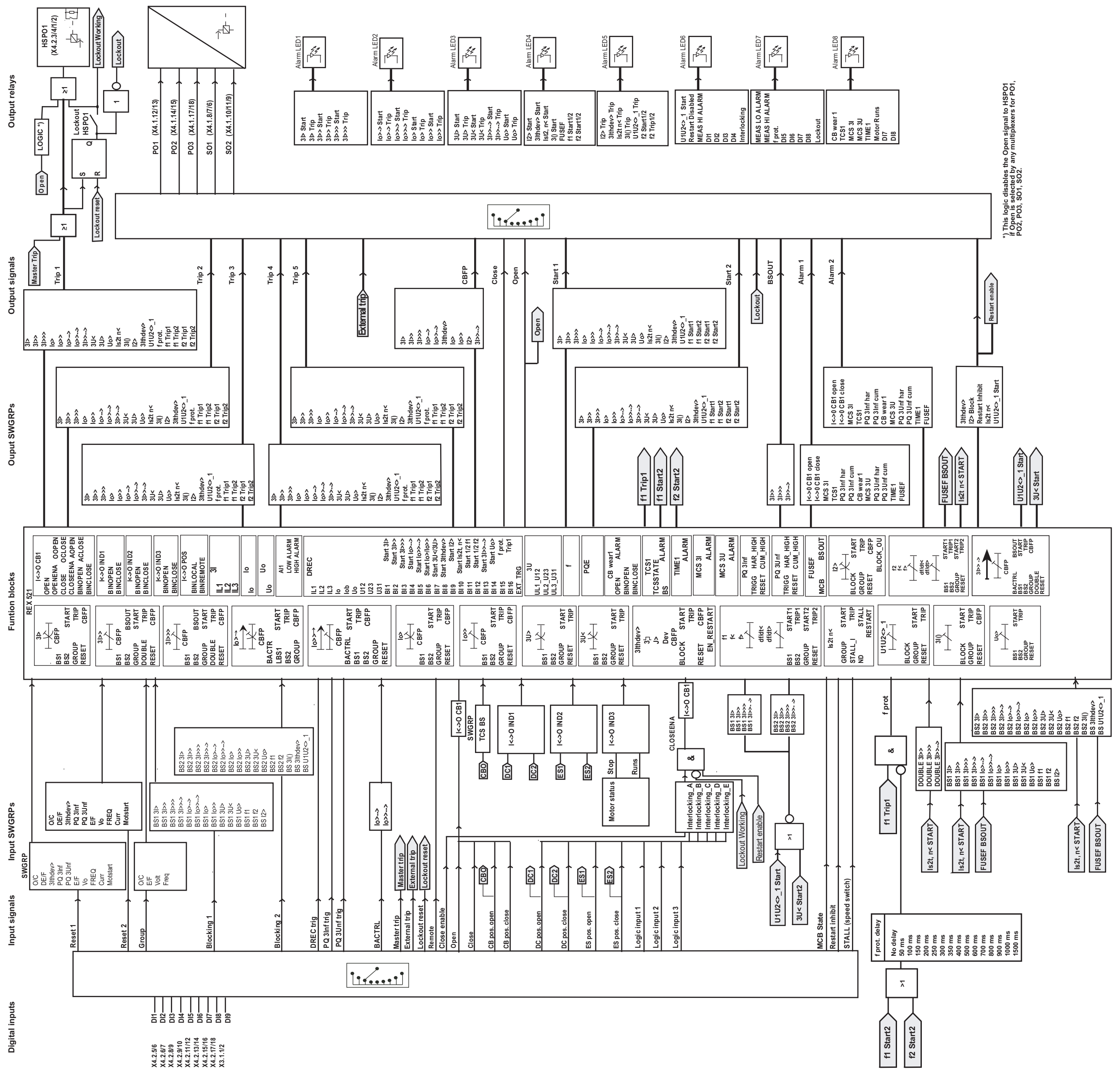
Fig. 4.3.11.1.-1 Block diagram of the standard configuration H51

4.3.11.2. Application

The H51 standard configuration for REX 521 is designed for protection of large or medium-size three-phase AC motors in circuit breaker controlled motor drives. Due to the large number of protective functions integrated, the relay provides a complete protection against motor damage caused by electrical faults.

The H51 configuration can be applied to other objects that need thermal overload protection (such as power transformers). It can also be used in applications requiring overcurrent protection, directional overcurrent protection, under/overvoltage protection, directional or non-directional earth-fault protection, underfrequency protection and/or overfrequency protection.

For more information about the H51 standard configuration, refer to the application example in Section 12.7. Motor protection, High H07/H51.



A060008

Fig. 4.3.11.2.-1 Block diagram of the standard configuration H51 for REX 521

5. Reading of the overview diagrams of the signal routings

The signals in a standard configuration can be programmed to perform various functions. Digital inputs can be connected to the different input signals (for example Blocking 1) by using selectors. Input signals can be routed to output relays (for example HSPO1) directly or they can be connected via the input switchgroups to inputs of the function block in order to perform different kinds of functions. This is done by setting the value of the input switchgroups.

Output signals of the function blocks can be connected to the output relays by first selecting the needed output signals from the function blocks, for example, Trip 1 (3I>, 3I>> and so on) by the output switchgroups and then connecting the selected group of signals to the dedicated output relays by setting the `Output signal` selector.

Analogue signals are connected to the corresponding protection and measurement function blocks. Analogue signals are not presented in the overview diagrams of the signal routings.

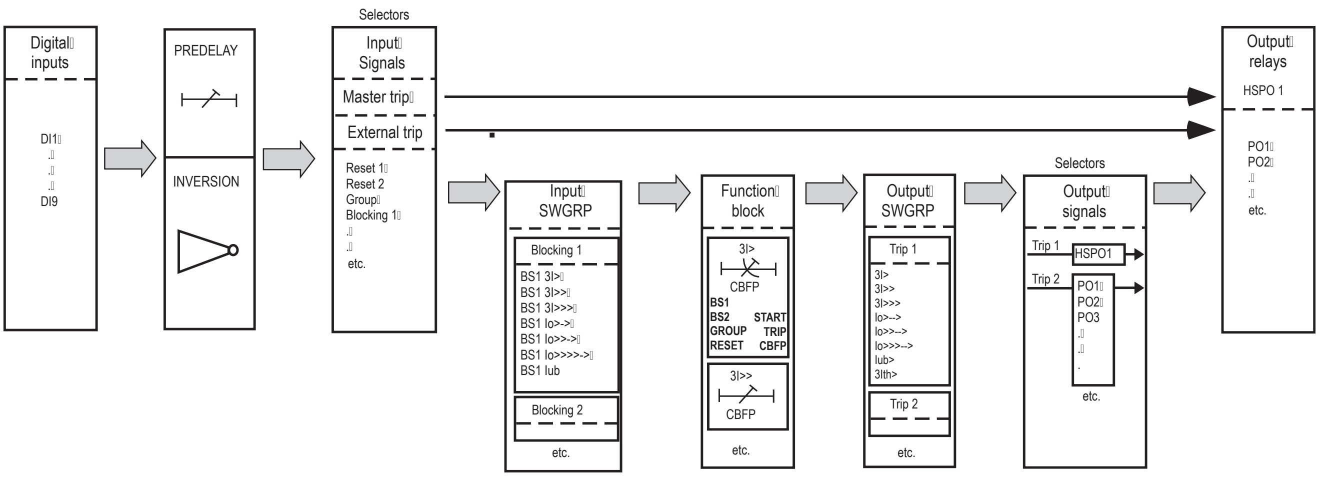


Fig. 5.-1 Main principle of the overview diagrams of the signal routings

5.1. Digital inputs

Digital inputs (DI1...DI9) can be connected to the inputs of the function block in order to obtain different functionalities. For example, digital inputs are used for performing blocking of protection, external triggering of disturbance recorder and local control.

Any of the digital inputs (DI1...DI9) can be programmed from menu selection to invert the signal and to set the predelay (filtering). For more information, refer to section “Digital inputs” in Technical Reference Manual, General (see Section 1.3. Related documents).

The routings between the digital inputs and different functionalities are set with selectors and switchgroups (SWGRP) for each functionality respectively. Settings are done with the Human-Machine Interface (HMI) or with the Relay Setting Tool.

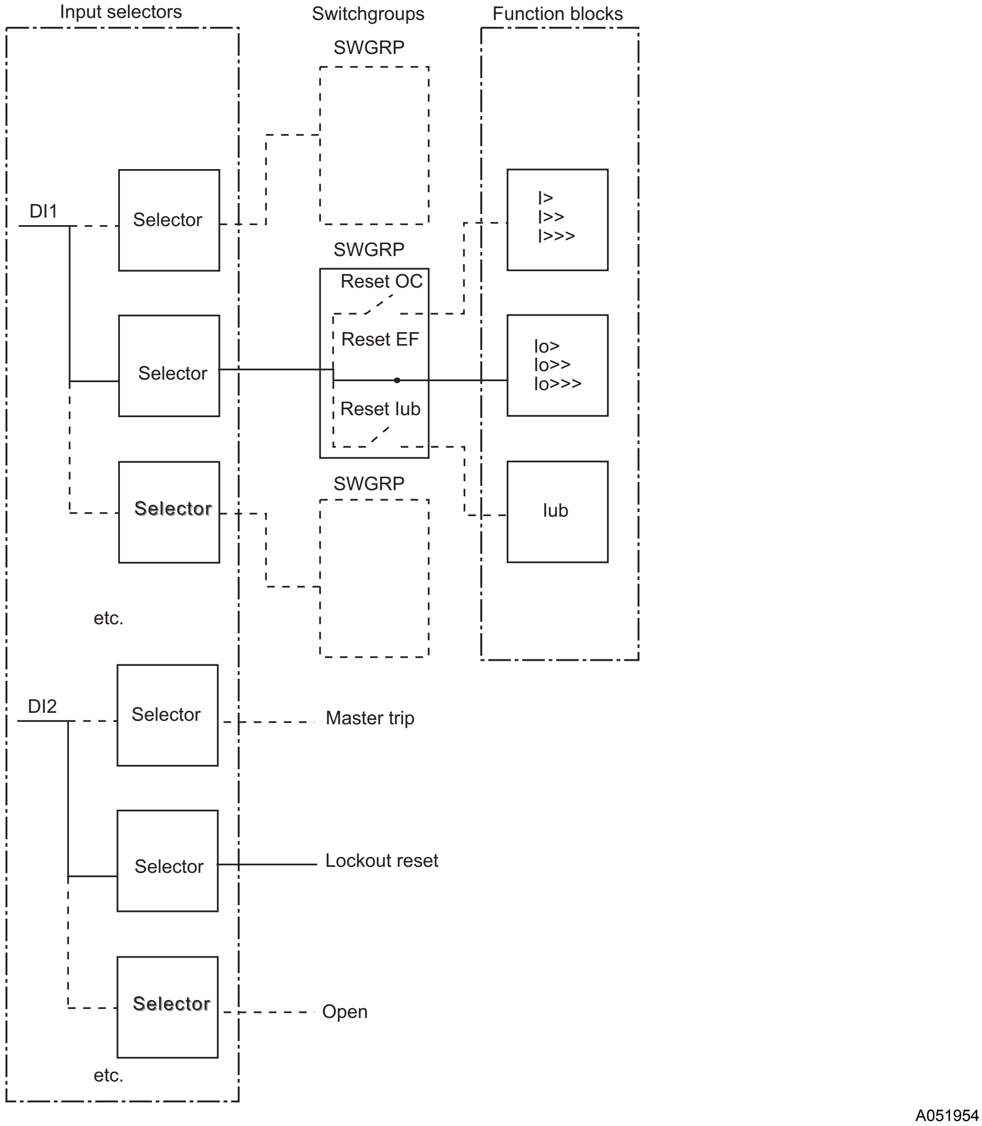


Fig. 5.1.-1 Digital input signals are routed via selectors and switchgroups to the function blocks (DI1 in the figure) or to the different functions (DI2 in the figure)

5.1.1. Input selectors

Each digital input (DI1...DI9) can be routed to a specified input signal by the settings in the input signal menu (`Main menu\Configuration\Input Signals`). Only one digital input per input signal can be selected. Refer to Chapter 6. Parametrization of the digital inputs.

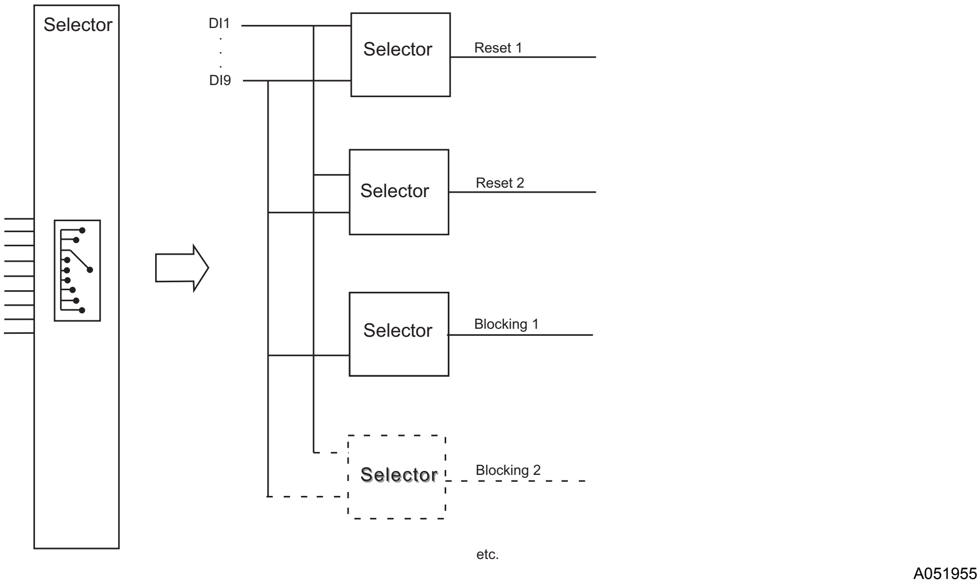


Fig. 5.1.1.-1 Use of input selectors

5.1.2. Input switchgroups (SWGRP)

Switchgroups are used for connecting input signals to the inputs of the function blocks. Switchgroups allow the connection of one input signal to several function block inputs. Refer to Fig. 5.1.3.-1 for all the signals available for each input switchgroup. The settings can be found in `Main menu\Configuration\Input SWGRP`.

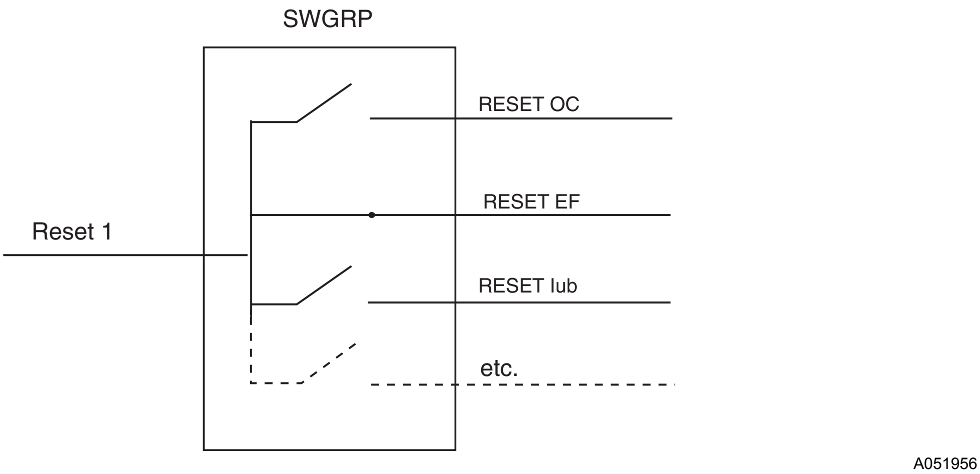


Fig. 5.1.2.-1 The input signal is routed with the switchgroup to one or several function block input(s)

Note that the symbol O/C (overcurrent) includes overcurrent function blocks I>, I>> and I>>>. The E/F (earth fault) symbol includes all three earth-fault function blocks Io>, Io>> and Io>>>, for example the Reset 1 signal resets all the three stages.

The symbols O/C and E/F are used in the overview diagrams of the signal routings and in the HMI menus.

5.1.3. Input signals

The figure below shows a part of the overview diagram focusing on input signals.

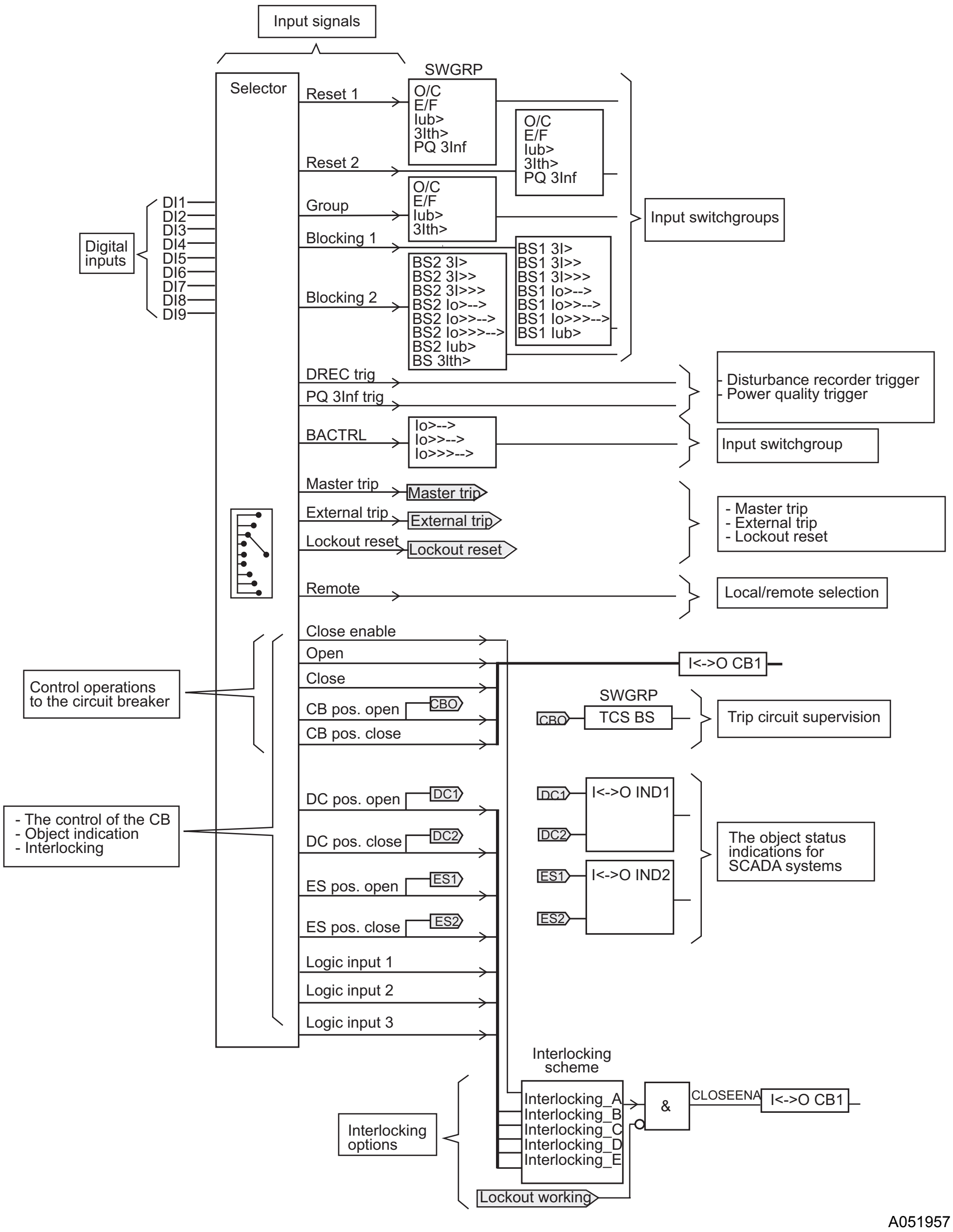


Fig. 5.1.3.-1 Description of the input signal routing diagram

Object status indications to SCADA systems

Function blocks 1<->0 IND1 and 1<->0 IND2 are used for generating events from the disconnector DC pos. open/close and earthswitch ES pos. open/close to the substation control system via the communication port.

5.2. Function blocks in the overview diagrams of the signal routings

All the function blocks used in each standard configuration are presented in the overview diagrams of the signal routings as follows (see Fig. 5.2.-1).

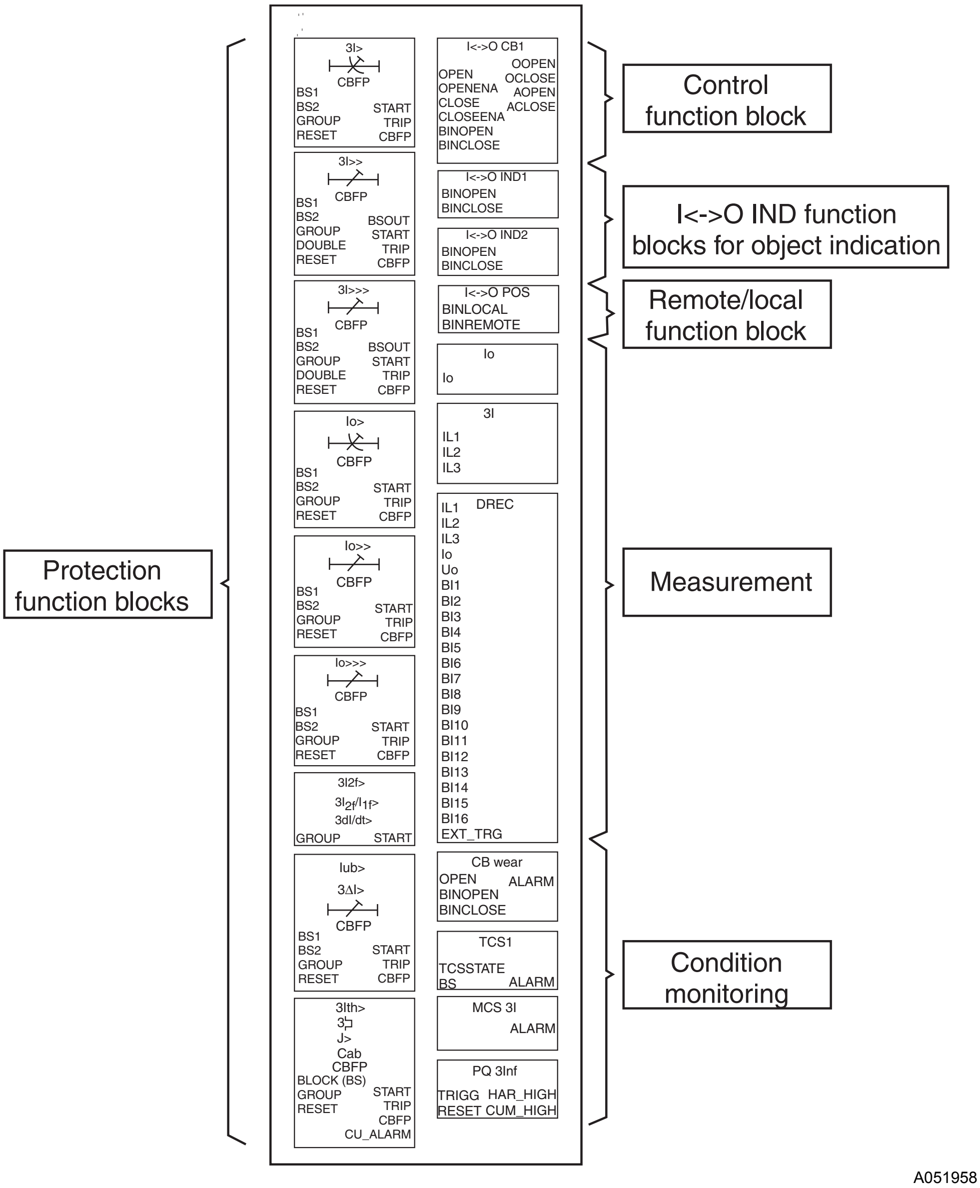


Fig. 5.2.-1 Function blocks in the overview diagrams of the signal routings

5.2.1. Function blocks

Each function block in the overview diagram represents the input and outputs used in a particular standard configuration. It also includes the type of protection function and the basic information of the time characteristics and other characteristics, for example CBFP, available in the function. For further information, refer to the CD-ROM Technical Descriptions of Functions (see Section 1.3. Related documents). See also Chapter 3. Introduction for differences between the REX 521 and the RED 500 platform in the function block descriptions of the CD-ROM.

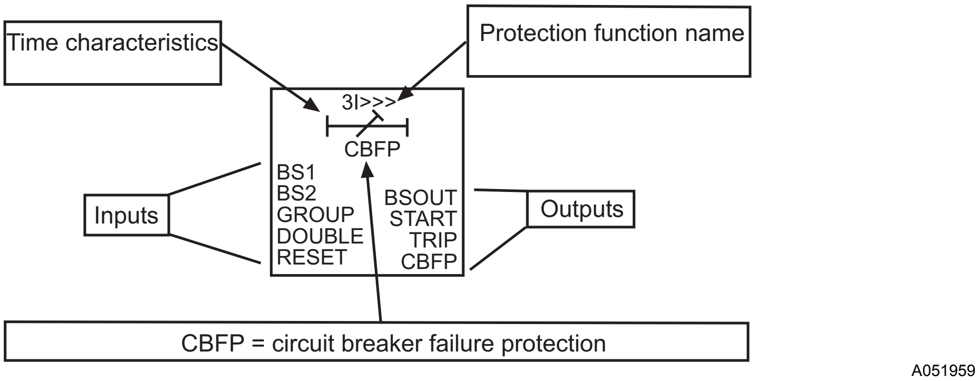


Fig. 5.2.1.-1 Description of function block symbols

More information concerning function blocks in this manual, refer to Chapter 8. Function block descriptions.

5.3. Output switchgroups (SWGRP)

The outputs from the function blocks (for example start, trip and alarm signals) are routed to the output signals by using the output switchgroups, for example Trip 2, see Fig. 5.3.-1 below.

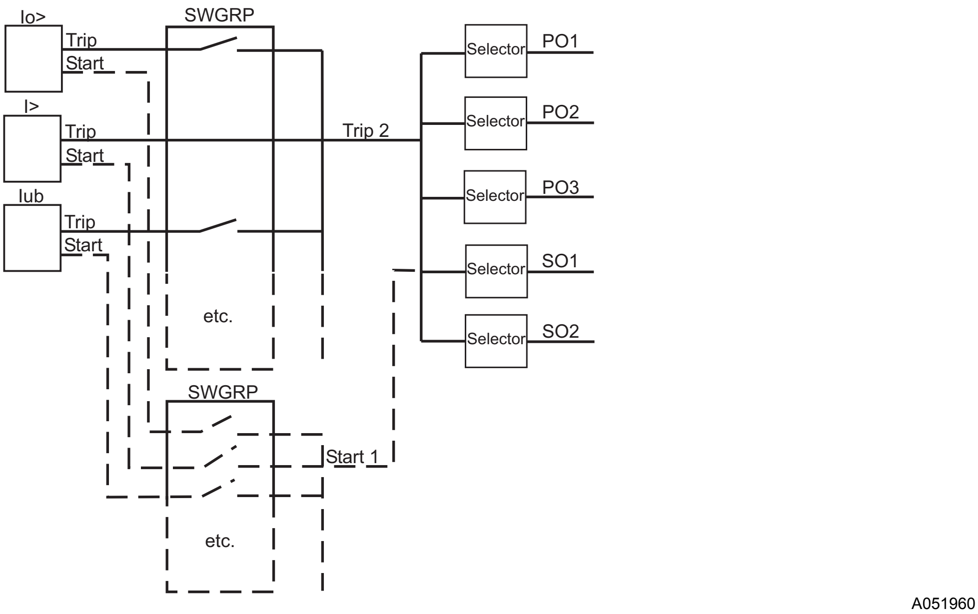


Fig. 5.3.-1 Output switchgroups

5.3.1. Output selectors

Output signals (for example Start 1, Trip 1) are routed to the output relays (for example PO1, HSPO1, SO1) by using output selectors.

5.4. Other functions described in signal overview diagrams

5.4.1. Lockout function

The lockout function is used for increasing the safety when performing control operations. The lockout function can be reset by using the input selector to connect one of the digital inputs (DI1...DI9) to the Lockout reset signal.

Note that the trip indication LED cannot be cleared with push buttons [C] or [C] + [E] until lockout reset occurs.

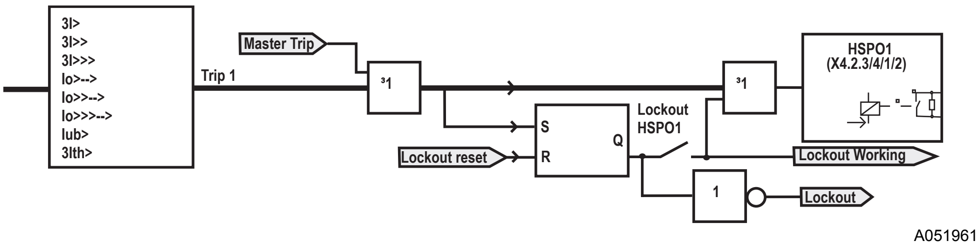


Fig. 5.4.1.-1 Lockout function in the block diagrams of the standard configurations

In the figure above (Fig. 5.4.1.-1) the Lockout working signal is connected internally to the CLOSEENA input of the COCB function block in order to activate the interlocking. This means that it is not allowed to perform control operations in case the lockout function is active.

The lockout function can be used in two different ways:

The first option is to use the HSPO1 output to perform the lockout function. The `Lockout HSPO1` selector is used for activating the forced latching. The latched output relay can only be reset via a digital input. The idea is to have an external switch which needs to be reset before the CB close operation is allowed. For example, a motor feeder has tripped and it is necessary to avoid the re-energizing of the motor before its temperature has cooled down to an acceptable level.

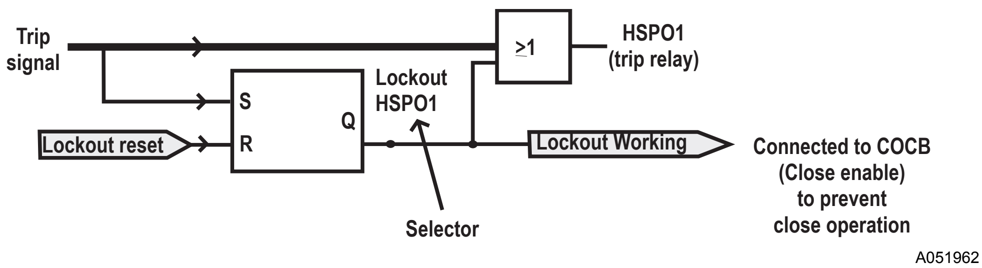


Fig. 5.4.1.-2 HSPO1 output performing the lockout function

Another option (see Fig. 5.4.1.-3) is to use the lockout function to connect the CB close control wiring in series with one of the power output relays by selecting lockout signal as an option for the desired output relay, for example PO1. This is done by selecting lockout for the corresponding output signal selector.

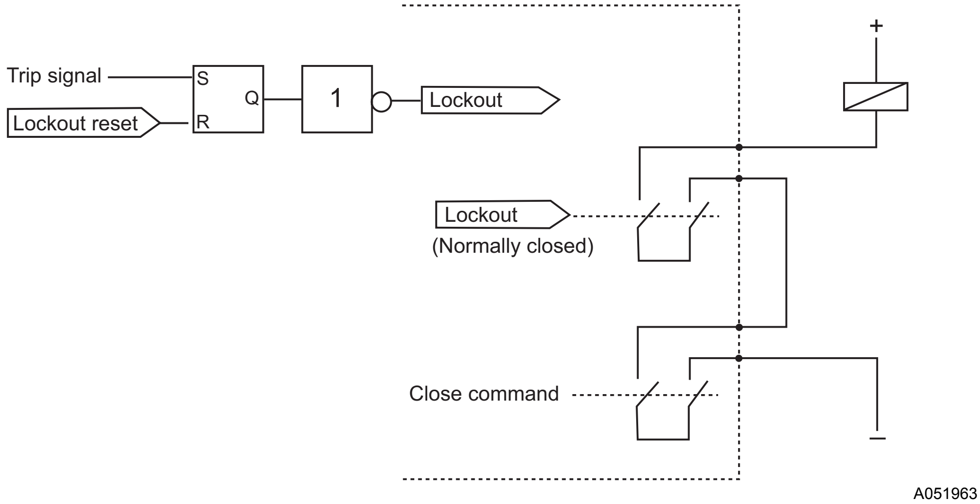


Fig. 5.4.1.-3 Lockout function via power output relay

Note that when the lockout function is in use and an auxiliary power failure occurs, the output relays return to off-state. The same happens in a situation where external lockout is used with the output relays PO1, PO2, PO3, SO1[1] and SO2[1] and the auxiliary power failure occurs. When the protection relay has been powered up again, the output relay states are restored to the state before the power failure and the output relay used for the lockout function is energized. If the lockout function is used with the HSPO1 relay, the control of the breaker could be possible when the auxiliary power of the protection relay is not connected.

To ensure maximum safety when using the lockout function, it is recommended to use a battery unit as an auxiliary power. Then the fault in the protected object does not effect the auxiliary supply of the protection relay and the state of the lockout function is safely stored in the protection relay's memory.

1. Change-over contact

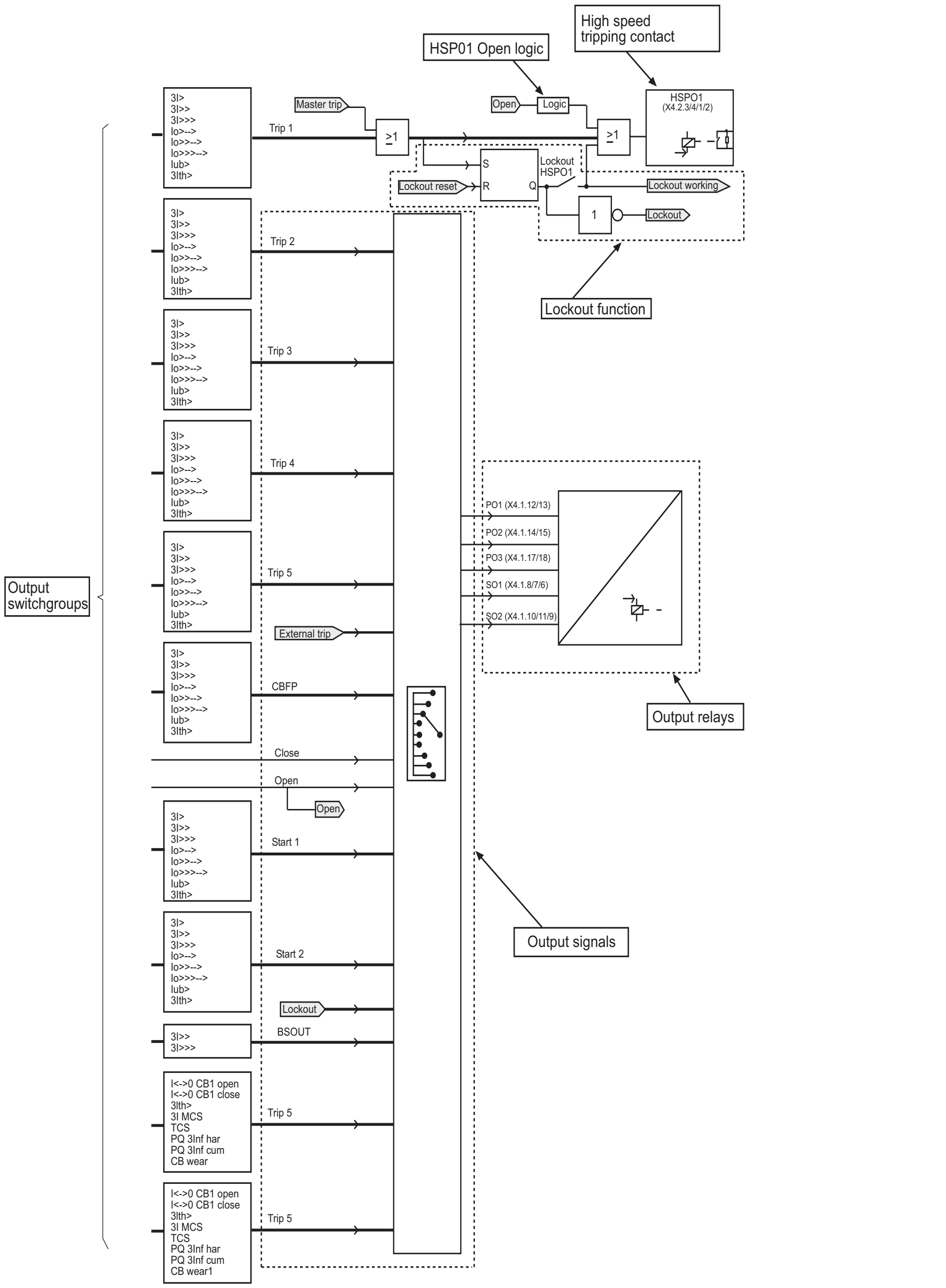


Fig. 5.4.1.-4 Description of the output signal routing diagram

5.4.2. HSPO1 Open logic

The Open signal can be configured to any output relay, as in Fig. 5.4.2.-1. When this is done, the logic automatically prevents the Open signal from passing through to HSPO1, as in Fig. 5.4.2.-2. If the Open signal is not connected to an output relay, it passes through the logic to HSPO1. This is the case by default.

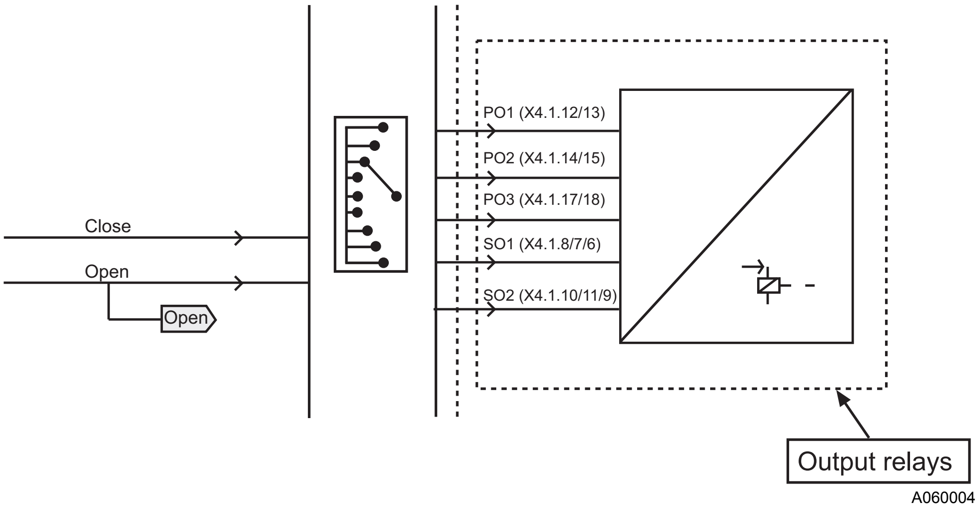


Fig. 5.4.2.-1 Open signal connected to output relays in the block diagrams of the standard configurations

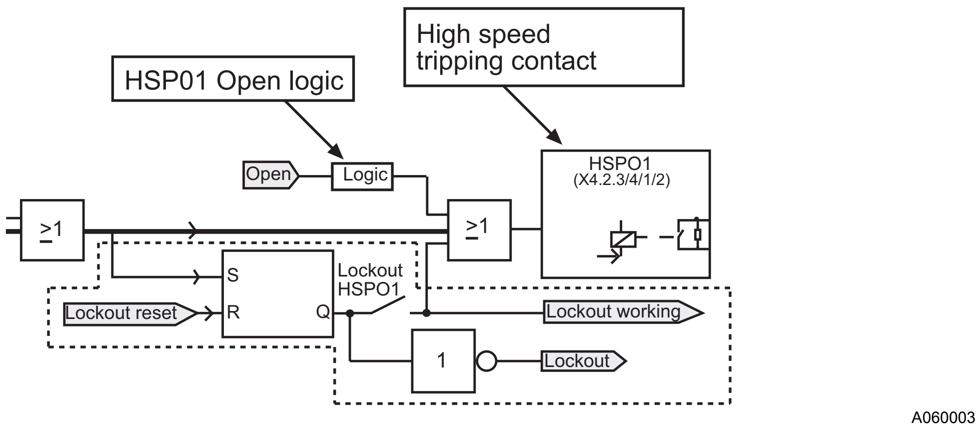


Fig. 5.4.2.-2 HSPO1 Open logic in the block diagrams of the standard configurations

5.4.3. Frequency protection logic, H50 and H51

The frequency protection logic is used to avoid unnecessary trips when the system transitory oscillates. Oscillation appears when a heavy load is connected to a system. The oscillation depends on the quality of the power transmission and the type of system load.

The df/dt function detects the oscillation. Basically, the frequency protection signal is activated when the frequency is stable and the set frequency limit has been exceeded. Here stable means that df/dt has not detected any oscillation during a certain period of time. The period of time is set in `Configuration/Special settings/f prot. delay`.

5.4.3.1. Functional description

If either of the two Start2 signals is high, the frequency protection signal is low regardless of the f1 Trip1 signal status. The delay time starts when both the f1 Start2 and f2 Start2 signals are low. The f prot. signal is activated when the delay time has elapsed, assuming that the f1 Trip1 is high. If either of the f1 Start2 or f2 Start2 signals are activated during the delay time, the delay time is reset, see Fig. 5.4.3.1.-1.

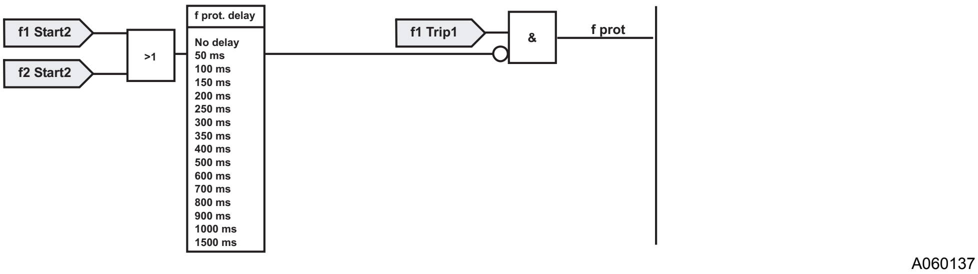


Fig. 5.4.3.1.-1 Frequency protection signal generation

Both Start2 signals have to be low for a longer time than the defined frequency protection delay time in order to activate the f prot. signal. Furthermore, the f1Trip signal also has to be high.

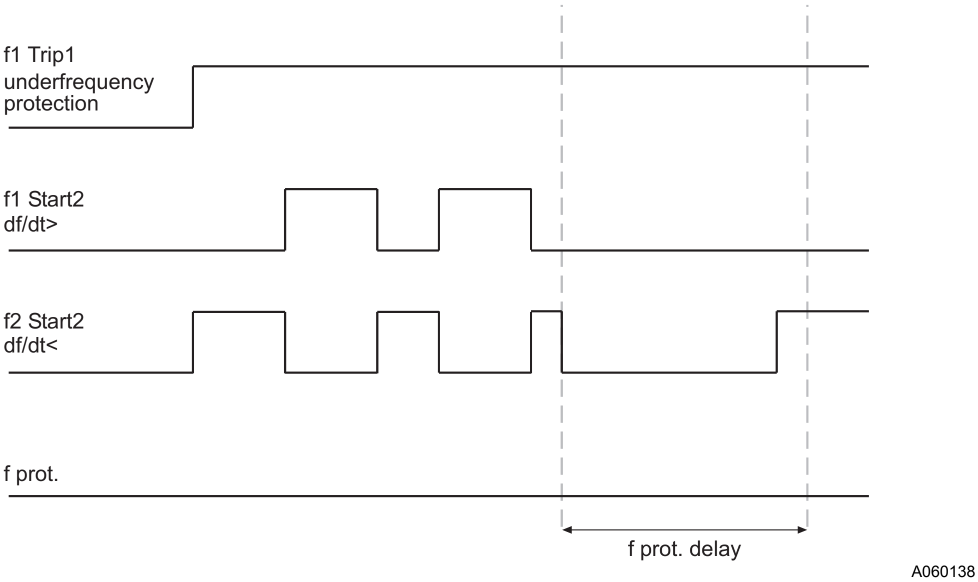


Fig. 5.4.3.1.-2 Example signal diagram for frequency protection signal explaining the df/dt blocking function

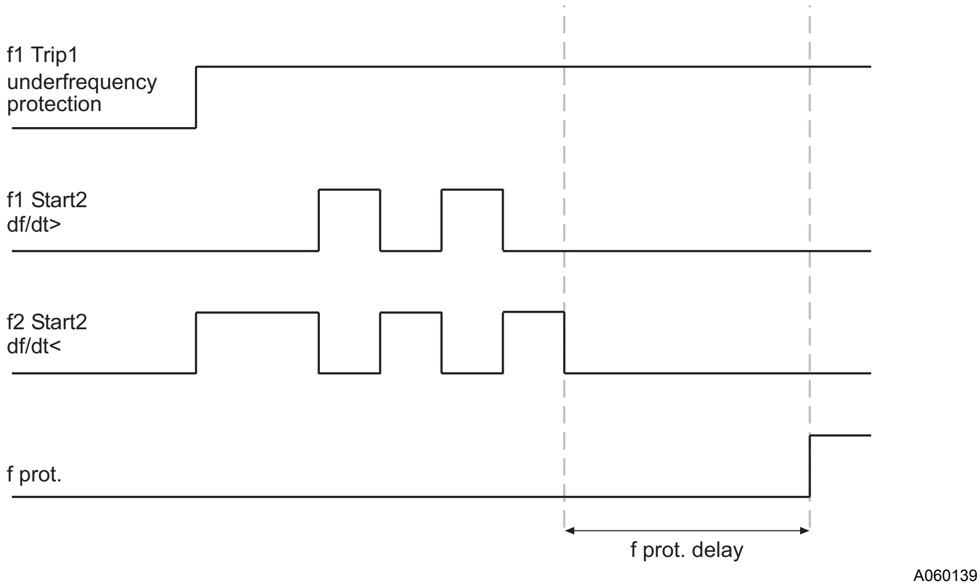


Fig. 5.4.3.1.-3 Example signal diagram for frequency protection signal explaining the activated frequency protection function

5.4.3.2. Example of usage

The following example describes how to configure the frequency protection blocks f1 and f2 to activate the f prot. signal.

The frequency protection signal is activated if df/dt has not detected any oscillation for a certain time and the operate time1 for f1 Trip1 has elapsed.

The signals f1 Trip2 and f2 Trip2 should be routed to the trip relay (as they are by default). This means that the relay will trip if a fast continuous rise or fall of the frequency occurs. The desired operating time can be set by the parameter `Operate time2` in f1 and f2.

Table 5.4.3.2-1 Example setting of the frequency protection signal usage

Settings		
	f1 Operating mode = f1</f> and df/dt> f2 Operating mode = f1</f> and df/dt< f1 Operate time 1 = 0.2 s f1 and f2 Set start frequency = 48.5 Hz f1 and f2 df/dt =10 Hz/s `Configuration/special settings/f prot.delay` = 100 ms Rated frequency = 50 Hz	
Signal status		
Frequency	**df/dt**	**f. prot**
> 48.5Hz	No influence	Low
< 48.5Hz	< 10 Hz/s for < 100 ms	Low
< 48.5Hz	> 10 Hz/s	Low
< 48.5Hz	< 10 Hz/s for > 100 ms	High

The f. prot signal is not routed to any output relay by default. To enable this signal it must be routed to any of the outputs.

5.4.4. Voltage-dependent overcurrent protection, H50 and H51

The voltage-dependent overcurrent protection logic can be taken into use when the actual fault current is smaller than the normal load current. It is possible to use the normal voltage level to block the overcurrent protection, abnormal voltage level unblocks overcurrent protection.

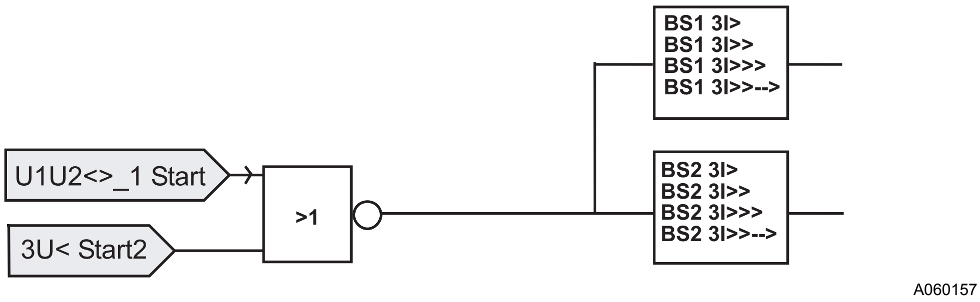


Fig. 5.4.4.-1 Example of voltage-dependent overcurrent protection logic in the standard blocking diagrams

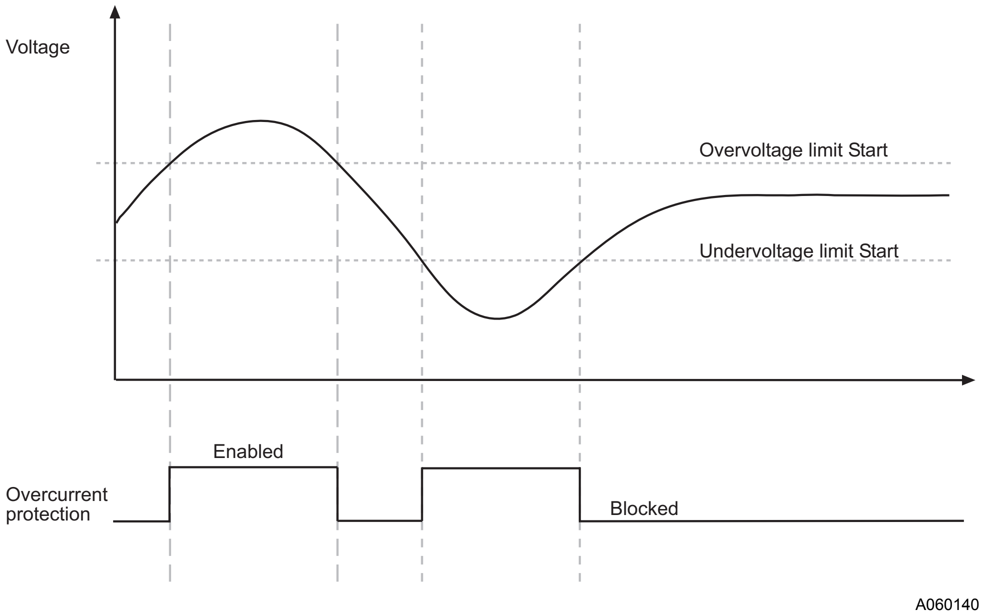


Fig. 5.4.4.-2 Voltage-dependent overcurrent protection

The voltage-dependent overcurrent protection logic is activated in `Configuration/Input SWGRP/U1<U1...3U< ->BS1` and `Configuration/Input SWGRP/U1<U1...3U< ->BS2`. The selected overcurrent protection blocks are unblocked when the start signal of either U1U2<>_1 or 3U< is active.

6. Parametrization of the digital inputs

Digital inputs can be used for performing different functions like resetting the desired function block by programming the selectors and switchgroups accordingly.

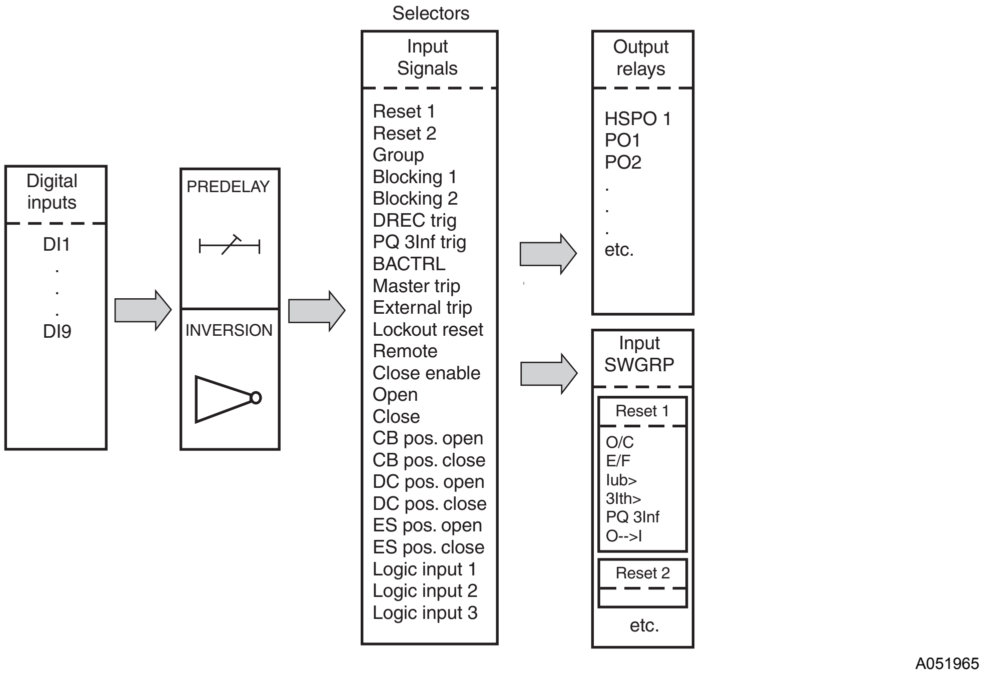


Fig. 6.-1 Overview of the selector options

6.1. Selectors

6.1.1. Reset

Selectors Reset 1 and Reset 2 can be programmed to connect any of the inputs DI1...DI9 to reset the latched trip signal and the recorded data of the functions (for example O/C, E/F, Iub>, 3Ith>, PQ 3Inf [1]).

6.1.2. Group

Group is used for switching between the setting groups 1 and 2 of the protection functions.

6.1.3. Blocking

Selectors BS1 and BS2 can be programmed to block the operation of the functions (for example 3I>, 3I>>, 3I>>> etc.[1]).

6.1.4. Disturbance recorder trigger

Any of the inputs DI1...DI9 can be used to start the disturbance recorder to record measurements.

1. Standard configuration specific.

6.1.5. Power quality trigger

Any of the inputs DI1...DI9 can be used to start the power quality recording measurements.

6.1.6. Master trip

An external trip signal can be routed to the heavy duty tripping contact via DI1...DI9. (The Master trip function bypasses the interlocking sequence.)

Master trip can be utilized by using the input selector Master trip to connect one of the digital inputs (DI1...DI9) to the high speed tripping relay (HSPO1).

6.1.7. External trip

An additional external trip signal can be routed to the output relays PO1...PO3 and SO1...SO2 (The external trip function bypasses the blocking sequence).

6.1.8. Lockout reset

Any DI1...DI9 can be programmed to reset the Lockout function.

6.1.9. Local/Remote

Any of the digital inputs can be used for activating the local mode of the relay if the Local/Remote selection is set to “external input”. In local position, the circuit breaker can be controlled via the binary inputs and the HMI but not through a communication port. In remote position, the circuit breaker can be controlled only through a communication port.

6.1.10. Close enable

DI1...DI9 can be used for giving the permission to close the circuit breaker. For example, SF6 gas low indication signal can be used to block the close operation of the CB (The Close command can be activated either via the digital inputs, the HMI or through the communication port).

6.1.11. Direct control (Open/Close)

DI...DI9 can be used for controlling the circuit breaker.

When using digital inputs to control the circuit breaker, the inputs must be activated with a pulse. Otherwise, if the input remains activated, a position change from remote to local can cause an immediate opening or closing of the circuit breaker

6.1.12. Object indication

Object indication is used to collect object status indications to MicroSCADA. The interlocking logic also uses the logical states of the digital inputs (according to the selected interlocking option).

The transferring of object status indication data to MicroSCADA is achieved by using the I<->O IND1 and I<->O IND2 function blocks.

6.1.13. Time synchronization

Digital input 9 can be used as a GPS time synchronization input.

6.1.14. AR inhibit, AR on input, start AR

The autoreclose function O-->I can be started, inhibited or turned on via DI1...DI9.[1]

6.1.15. BACTRL (Basic angle control)

The basic angle of the directional earth-fault protection depends on the earthing principle of the network. Basic angle can be changed via control signal BACTRL. [1]

6.1.16. Logic input 1...3

The logical inputs 1...3 are part of the interlocking options for close enabling of the breaker. These signals can be connected to any of the digital inputs DI1...DI9 and they can get indication from such signals as SF6 gas alarm, spring charge etc. (see Fig. 6.2.1.-5).

6.2. Interlocking

Closing the circuit breaker (CB) is permitted by the CLOSEENA input of the I<->O CB1 function block. Different kinds of logics for permitting close operations can be built by using the interlocking logic described in Fig. 6.2.-1 and Fig. 6.2.1.-4.

The logic states of an earth switch (ES), a disconnector (DC), and general digital inputs (DI1...DI9) can be used together with the interlocking logic in Fig. 6.2.-1.

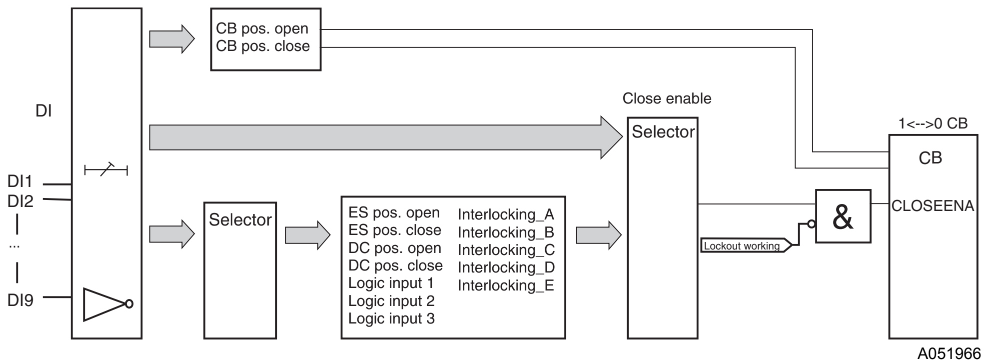


Fig. 6.2.-1 Interlocking

6.2.1. Interlocking options

The interlocking options include only the closing of the circuit breaker. The opening of the circuit breaker is always allowed. The settings are made via the HMI or the Relay Setting Tool in a menu (`Main menu\Configuration\Input Signals\Close enable`) where it is possible to manually set the interlocking to TRUE or to Not connected (FALSE).

1. Standard configuration specific.

Using a digital input directly

One of the digital inputs (DI1...DI9) can be selected directly to permit close operations. Use the selector named `Close enable` in the relay menu or the Relay Setting Tool to select the input. Furthermore, an input activation delay and inversion can be selected from the general digital input settings menu. Observe that the logical state 1 enables and the logical state 0 disables closing of the circuit breaker.

Using earth-switch state (disconnector state not available)

If the status indication signals of the earth switch are connected to the digital inputs and routed to ES pos. open and ES pos. close, these indications can be included in the interlocking scheme. The signal marked “Interlocking_A” will be logical 0 when the earth switch is closed and logical 1 when the earth switch is open. Use this signal to enable close operations by selecting “Interlocking_A” in the `Close enable` selector.

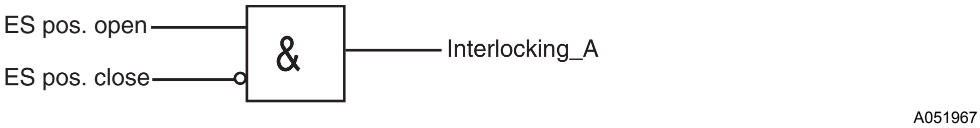


Fig. 6.2.1.-1 Interlocking using earth-switch state

Using disconnector state (earth-switch state not available)

If the status indication signals of the disconnector are connected to the digital inputs and routed to DC pos. open and DC pos. close, these indications can be included in the interlocking scheme. The signal marked “Interlocking_A” will be logical 1 when the disconnector is closed and logical 0 when the disconnector is open. Use this signal to enable close operations by selecting “Interlocking_A” in the `Close enable` selector.

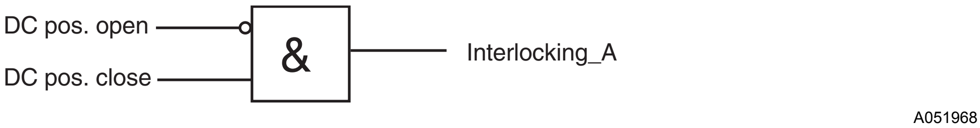


Fig. 6.2.1.-2 Interlocking using disconnector state

Using disconnector and/or earth-switch state

If both the disconnector and the earth-switch indications are available and routed to DC pos. open, DC pos. close, ES pos. open and ES pos. close, these indications can be included in the interlocking scheme. The signal marked “Interlocking_A” will be logical 1 when the disconnector is closed **or** the earth switch is open. The signal marked “Interlocking_B” will be logical 1 when the disconnector is closed **and** the earth switch is open. Use any of these two signals to enable close operations by selecting either “Interlocking_A” or “Interlocking_B” in the `Close enable` selector.

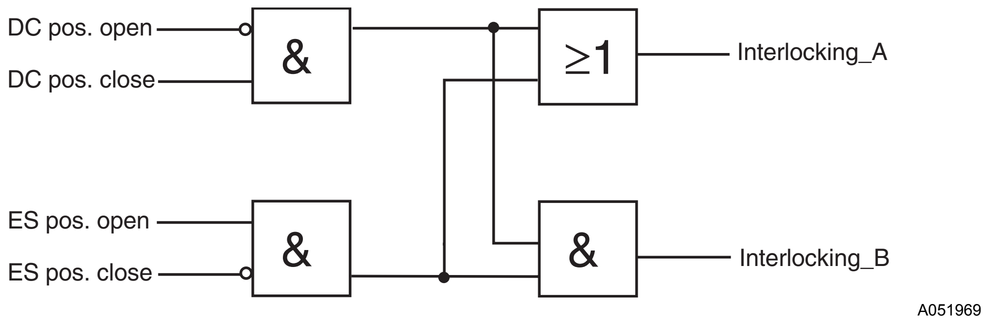


Fig. 6.2.1.-3 Interlocking using disconnector and/or earth-switch state

Using disconnector, earth-switch and logical inputs

In the cases mentioned above, additional signals, such as SF6 gas low, may be used to block close operations. Then, these signals should be connected to the interlocking template using the logic inputs 1...3 (Logic_inpX) selectors. By selecting “Interlocking_C”, “Interlocking_D” or “Interlocking_E” in the `Close enable` selector, different AND/ OR conditions can be created.

Examples:

- DC or ES **and** “Logic_inpX” = “Interlocking_C”
- DC and ES **and** “Logic_inpX” = “Interlocking_D”
- “Logic_inp1” **and** “Logic_inp2” **and** “Logic_inp3” = “Interlocking_E”

In addition to the ones mentioned here, many different kinds of interlocking schemes can be built by using the selectors to connect digital inputs, inversion to create AND/ OR logic and selecting different interlocking outputs (A...E). See Fig. 6.2.1.-4 for a complete block diagram.

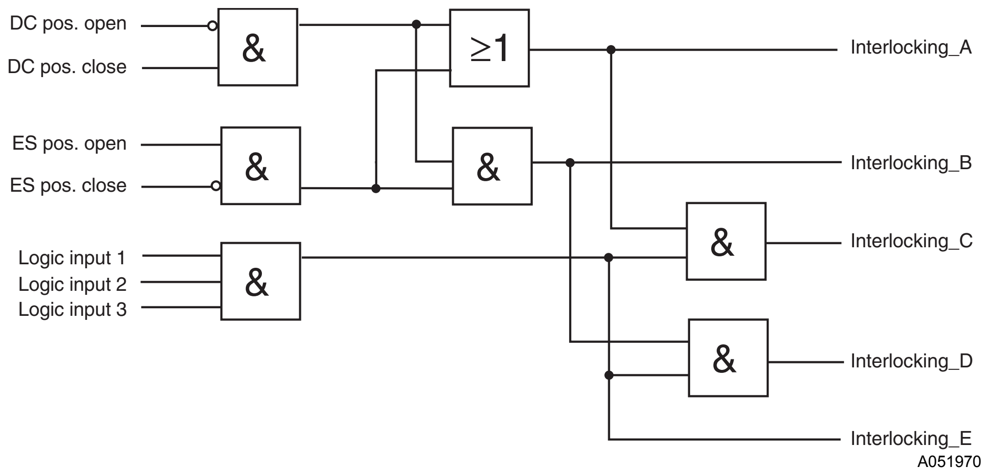


Fig. 6.2.1.-4 Interlocking using disconnector, earth-switch and logical inputs

Example of customized interlocking

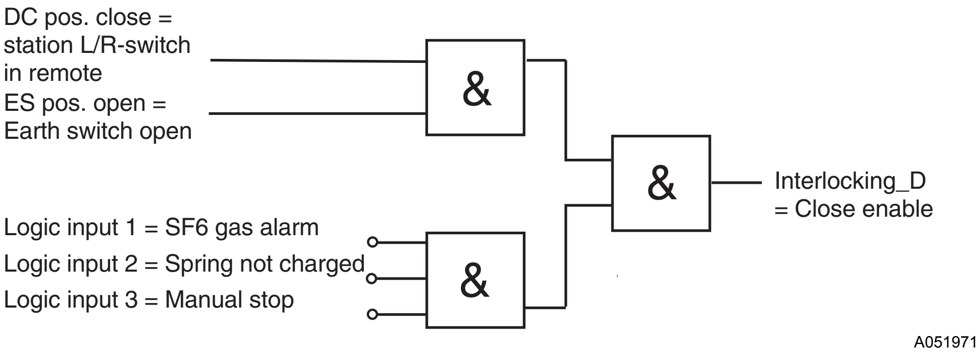


Fig. 6.2.1.-5 Example of interlocking

The AND gate becomes an OR function by inverting the digital inputs in the general digital input settings menu. Thus any of the connected fault signals can disable closing of the circuit breaker.

7. Default settings

These settings can be found in `Main menu\Configuration\`.

Table 7.-1 Input signals

HW versions	**Basic**		**Medium**		**High/Sensor**										
Standard configuration	**B01**	**B02**	**M01**	**M02**	**H01**	**H02**	**H03**	**H04**	**H05**	**H06**	**H07**	**H08**	**H09**	**H50**	**H51**
Input Signals	**Digital inputs connected**														
Reset 1	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Reset 2	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Group	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Blocking 1	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Blocking 2	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
DREC trig	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
PQ 3Inf trig	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
PQ 3Unf trig	-	-	-	-	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
O-->I INH	-	DI8	-	DI8	DI8	DI8	DI8	DI8	-	-	-	-	DI8	DI8	-
O-->I ON	-	NC	-	NC	NC	NC	NC	NC	-	-	-	-	NC	NC	-
O-->I Ext. start	-	NC	-	NC	NC	NC	NC	NC	-	-	-	-	NC	NC	-
O-->I Ext. trip	-	NC	-	NC	NC	NC	NC	NC	-	-	-	-	NC	NC	-
BACTRL	-	-	NC	NC	NC	NC	NC	NC	-	-	NC	-	NC	NC	-
Master trip	DI8	DI8	DI8	DI8	DI8	DI8	DI8	DI8	DI8	DI8	DI8	DI8	DI8	DI8	DI8
External trip	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Lockout reset	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Remote	DI9	DI9	DI9	DI9	DI9	DI9	DI9	DI9	DI9	DI9	DI9	DI9	DI9	DI9	DI9
Close enable	DI5	DI5	DI5	DI5	DI5	DI5	DI5	DI5	DI5	DI5	DI5	DI5	DI5	DI5	DI5
Open	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Close	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
CB pos. open	DI1	DI1	DI1	DI1	DI1	DI1	DI1	DI1	DI1	DI1	DI1	DI1	DI1	DI1	DI1
CB pos. close	DI2	DI2	DI2	DI2	DI2	DI2	DI2	DI2	DI2	DI2	DI2	DI2	DI2	DI2	DI2
DC pos. open	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
DC pos. close	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
ES pos. open	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
ES pos. close	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Logic input 1	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Logic input 2	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Logic input 3	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Stall	-	-	-	-	-	-	-	-	-	-	NC	-	-	-	NC
Restart inhibit	-	-	-	-	-	-	-	-	-	-	NC	-	-	-	NC
MCB state	-	-	-	-	-	-	-	-	-	-	NC	-	-	-	NC

Table 7.-2 Input SWGRP (Basic and Medium)

HW versions	Basic		Medium	
Standard configuration	**B01**	**B02**	**M01**	**M02**
Input Signals	**Input SWGRP**			
3I2f>-->Double	NC	NC	NC	NC
Reset 1	OC	OC	OC	OC
Reset 2	EF	EF	EF	EF
Group	OC EF Iub> 3Ith>	OC EF Iub> 3Ith>	OC EF Iub> 3Ith>	OC EF Iub> 3Ith>
Blocking 1	BS1 3I> BS1 3I>> BS1 3I>>>	BS1 3I> BS1 3I>> BS1 3I>>>	BS1 3I> BS1 3I>> BS1 3I>>>	BS1 3I> BS1 3I>> BS1 3I>>>
3I2f>-->BS1	NC	NC	NC	NC
Blocking 2	BS2 Io> BS2 Io>> BS2 Io>>>	BS2 Io> BS2 Io>> BS2 Io>>>	BS2 Io>--> BS2 Io>>--> BS2 Io>>>-->	BS2 Io>--> BS2 Io>>--> BS2 Io>>>-->
3I2f>-->BS2	NC	NC	NC	NC
O-->I/3I>	-	NC	-	NC
O-->I/3I>>	-	NC	-	NC
O-->I/3I>>>	-	NC	-	NC
O-->I/Io>	-	NC	-	-
O-->I/Io>>	-	NC	-	-
O-->I/Io>>>	-	NC	-	-
O-->I/Io>-->	-	-	-	NC
O-->I/Io>>-->	-	-	-	NC
O-->I/Io>>>-->	-	-	-	NC
O-->I/External	-	NC	-	NC
TCS1 Blocking	NC	NC	NC	NC
Reset indication	-	NC	-	NC
BACTRL	-	-	NC	NC

Table 7.-3 Input SWGRP (High/Sensor)

HW versions	**High/Sensor**						
Standard configuration	**H01**	**H02**	**H03**	**H04**	**H05**	**H06**	**H07**
Input Signals	**Input SWGRP**						
3I2f>-->Double	NC	NC	NC	NC	NC	-	-
Reset 1	OC	OC	OC	OC	OC	OC	OC
Reset 2	EF	EF	EF	DEF	EF	OV	DEF
Group	OC EF Iub> 3Ith>	OC EF Iub> 3Ith>	OC EF Iub> 3Ith>	OC EF Iub> 3Ith>	OC EF OV UV	OC OV UV ROV Freq	OC EF Voltage f1
Blocking 1	BS1 3I>--> BS1 3I>>--> BS1 3I>>>	BS1 3I>--> BS1 3I>>--> BS1 3I> BS1 3I>>	BS1 3I> BS1 3I>> BS1 3I>>>	BS1 3I> BS1 3I>> BS1 3I>>>	BS1 3I> BS1 3I>> BS1 3I>>>	BS1 3I> BS1 3I>>	BS1 3I> BS1 3I>> BS1 3I>>>
3I2f>--> BS1	NC	NC	NC	NC	NC	-	-
Is2t n<->BS1	-	-	-	-	-	-	NC
FUSEF -> BS1	-	-	-	-	-	-	NC
Is2t n< --> Double	-	-	-	-	-	-	NC
Blocking 2	BS2 Io>--> BS2 Io>>--> BS2 Io>>>-->	BS2 Io>--> BS2 Io>>--> BS2 Io>>>-->	BS2 Io>--> BS2 Io>>--> BS2 Io>>>-->	BS2 Io>--> BS2 Io>>--> BS2 Io>>>-->	BS2 Io> BS2 Io>> BS2 Io>>>	BS2 3U>> BS2 3U< BS2 3U<<	BS2 Io>--> BS2 Io>>--> BS2 Io> BS2 Io>>
3I2f>--> BS2	NC	NC	NC	NC	NC	-	-
Is2t n<->BS2	-	-	-	-	-	-	NC
FUSEF -> BS2	-	-	-	-	-	-	NC
O-->I/3I>	-	NC	NC	NC	-	-	-
O-->I/3I>>	-	NC	NC	NC	-	-	-
O-->I/3I>>>	NC	-	NC	NC	-	-	-
O-->I/3I>-->	NC	NC	-	NC	-	-	-
O-->I/3I>>-->	NC	NC	-	-	-	-	-
O-->I/Io>	-	-	-	NC	-	-	-
O-->I/Io>>	-	-	-	NC	-	-	-
O-->I/Io>>>	-	-	-	NC	-	-	-
O-->I/Io>-->	NC	NC	NC	NC	-	-	-
O-->I/Io>>-->	NC	NC	NC	NC	-	-	-
O-->I/Io>>>-->	NC	NC	NC	NC	-	-	-
O-->I/f1-1	-	NC	-	NC	-	-	-
O-->I/f1-2	-	NC	-	NC	-	-	-
O-->I/External	NC	NC	NC	NC	-	-	-
TCS1 Blocking	NC	NC	NC	NC	NC	NC	NC
Reset indication	NC	NC	NC	NC	-	-	-
BACTRL	NC	NC	NC	NC	-	-	NC
Motor Status	-	-	-	-	-	-	NC
Restart Enable	-	-	-	-	-	-	NC

Table 7.-4 Input SWGRP (High)

HW versions	**High**			
Standard configuration	**H08**	**H09**	**H50**	**H51**
Input Signals	**Input SWGRP**			
3I2f>-->Double	NC	NC	NC	-
Reset 1	OC	OC	OC	OC
Reset 2	EF	EF	EF	DEF
Group	OC OV EF UV	OC OV EF UV	OC OV EF UV	OC Voltage EF FREQ
Blocking 1	BS1 3I> BS1 3I>>> BS1 3I>>	BS1 3I> BS1 3I>>> BS1 3I>>	BS1 3I> BS1 3I>>> BS1 3I>>	BS1 3I> BS1 3I>>> BS1 3I>>
3I2f>--> BS1	NC	NC	NC	-
Is2t n<->BS1	-	-	-	NC
FUSEF -> BS1	-	-	-	NC
U1<U1...U3<->BS1	-	-	NC	NC
Is2t n< --> Double	-	-	-	NC
Blocking 2	BS2 Io> BS2 Io>>> BS2 Io>>	BS2 Io> BS2 Io>>> BS2 Io>>	BS2 Io> BS2 Io>>	BS2 Io> BS2 Io>--> BS2 Io>> BS2 Io>>-->
3I2f>--> BS2	NC	NC	NC	-
Is2t n<->BS2	-	-	-	NC
FUSEF -> BS2	-	-	-	NC
U1<U1...U3<->BS2	-	-	NC	NC
O-->I/3I>	-	NC	NC	-
O-->I/3I>>	-	NC	NC	-
O-->I/3I>>>	-	NC	NC	-
O-->I/3I>-->	-	-	NC	-
O-->I/3I>>-->	-	-	NC	-
O-->I/Io>	-	NC	NC	-
O-->I/Io>>	-	NC	NC	-
O-->I/Io>>>	-	NC	-	-
O-->I/Io>-->	-	-	NC	-
O-->I/Io>>-->	-	-	NC	-
O-->I/3U>	-	NC	NC	-
O-->I/3U>>	-	NC	NC	-
O-->I/3U<	-	NC	NC	-
O-->I/3U<<	-	NC	NC	-
O-->I/Uo>	-	NC	NC	-
O-->I/Uo>>	-	NC	NC	-
O-->I/Uo>>>	-	NC	-	-
O-->I/U1U2<>_1	-	-	NC	-
O-->I/f prot.	-	-	NC	-
O-->I/f1-1	-	NC	NC	-
O-->I/f1-2	-	NC	NC	-
O-->I/f2-1	-	NC	NC	-
O-->I/f2-2	-	NC	NC	-
O-->I/External	-	NC	NC	-
TCS1 Blocking	NC	NC	NC	-
Reset indication	-	-	NC	-
BACTRL	-	-	NC	NC
Motor Status	-	-	-	NC
Restart Enable	-	-	-	NC

Table 7.-5 Output SWGRP (Basic and Medium)

HW versions	**Basic**		**Medium**	
Standard configuration	**B01**	**B02**	**M01**	**M02**
Output SWGRP	**Output Signals**			
Trip 1	3I> 3I>> 3I>>> Io> Io>> Io>>> Iub> 3Ith>	3I> 3I>> 3I>>> Io> Io>> Io>>> Iub> 3Ith>	3I> 3I>> 3I>>> Io>--> Io>>--> Io>>>--> Iub> 3Ith>	3I> 3I>> 3I>>> Io>--> Io>>--> Io>>>--> Iub> 3Ith>
Trip 2	See Trip 1	See Trip 1	See Trip 1	See Trip 1
Trip 3	See Trip 1	See Trip 1	See Trip 1	See Trip 1
Trip 4	NC	NC	NC	NC
Trip 5	NC	NC	NC	NC
CBFP	See Trip 1	See Trip 1	See Trip 1	See Trip 1
Start 1	See Trip 1	See Trip 1	See Trip 1	See Trip 1
Start 2	NC	NC	NC	NC
BSOUT	3I>> 3I>>>	3I>> 3I>>>	3I>> 3I>>>	3I>> 3I>>>
Alarm 1	O<->I CB1 open O<->I CB1 close 3Ith> MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1	O<->I CB1 open O<->I CB1 close 3Ith> MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1	O<->I CB1 open O<->I CB1 close 3Ith> MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1	O<->I CB1 open O<->I CB1 close 3Ith> MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1
Alarm 2	NC	NC	NC	NC
O-->I Active	-	NC	-	NC
O-->I Alarm 1	-	NC	-	NC
O-->I Alarm 2	-	NC	-	NC
HSPO1 Lockout	NC	NC	NC	NC

Table 7.-6 Output SWGRP (High/Sensor)

HW versions	**High/Sensor**						
SC	**H01**	**H02**	**H03**	**H04**	**H05**	**H06**	**H07**
Output SWGRP	**Output Signals**						
Trip 1	3I>--> Iub> 3I>>--> 3Ith> 3I>>> Io>--> Io>>--> Io>>>-->	3I>--> Iub> 3I>>--> 3Ith> 3I> f1 Trip1 3I>> f1 Trip2 Io>--> Io>>--> Io>>>-->	3I> Iub> 3I>> 3Ith> 3I>>> Io>--> Io>>--> Io>>>-->	3I> Iub> 3I>> 3Ith> 3I>>> 3I>--> Io>--> f1 Trip1 Io>>--> f1 Trip2 Io>>>-->	3I> 3U> 3I>> 3U>> 3I>>> 3U< Io> 3U<< Io>> Uo> Io>>> Uo>> 3Ihtdev> Uo>>>	3I> Uo> 3I>> Uo>> 3U> Uo>>> 3U>> f1 Trip1 3U< f2 Trip1 3U<< f1 Trip2 f2 Trip2	-
Trip 1a	-	-	-	-	-	-	3I> 3I< 3I>> 3U> 3I>>> 3U>> Io>--> 3U< Io>>--> 3U<< 3Ithdev> I2> Io> I2>> Io>> Is2t n<
Trip 1b	-	-	-	-	-	-	3I() U1U2<>_1 f1 Trip1 f1 Trip2
Trip 2	See Trip 1	See Trip 1	See Trip 1	See Trip 1	See Trip 1	See Trip 1	-
Trip 2a	-	-	-	-	-	-	See Trip 1a
Trip 2b	-	-	-	-	-	-	See Trip 1b
Trip 3	See Trip 1	See Trip 1	See Trip 1	See Trip 1	See Trip 1	See Trip 1	-
Trip 3a	-	-	-	-	-	-	See Trip 1a
Trip 3b	-	-	-	-	-	-	See Trip 1b
Trip 4	NC	NC	NC	NC	NC	NC	-
Trip 4a	-	-	-	-	-	-	NC
Trip 4b	-	-	-	-	-	-	NC
Trip 5	NC	NC	NC	NC	NC	NC	-
Trip 5a	-	-	-	-	-	-	NC
Trip 5b	-	-	-	-	-	-	NC
CBFP	3I>--> Iub> 3I>>--> 3Ith> 3I>>> Io>--> Io>>--> Io>>>-->	3I>--> Iub> 3I>>--> 3Ith> 3I> 3I>> Io>--> Io>>--> Io>>>-->	3I> Iub> 3I>> 3Ith> 3I>>> Io>--> Io>>--> Io>>>-->	3I> Iub> 3I>> 3Ith> 3I>>> 3I>--> Io>--> Io>>--> Io>>>-->	3I> 3I>> 3I>>> Io> Io>> Io>>> 3Ihtdev>	3I> 3I>>	3I> Io> 3I>> Io>> 3I>>> 3I< Io>--> I2> Io>>--> I2>> 3Ithdev>
Start 1	3I>--> Iub> 3I>>--> 3Ith> 3I>>> Io>--> Io>>--> Io>>>-->	3I>--> 3I> 3I>>--> 3I>> Io>--> Iub> Io>>--> 3Ith> Io>>>--> f1 Start1 f1 Start2	3I> Iub> 3I>> 3Ith> 3I>>> Io>--> Io>>--> Io>>>-->	Io>--> 3I> Io>>--> 3I>> Io>>>--> 3I>>> f1 Start1 Iub> f1 Start2 3Ith> 3I>-->	3I> 3U> 3I>> 3U>> 3I>>> 3U< Io> 3U<< Io>> Uo> Io>>> Uo>> 3Ihtdev> Uo>>>	3I> 3U> 3I>> 3U>> f1 Start1 3U< f2 Start1 3U<< f1 Start2 Uo> f2 Start2 Uo>> Uo>>>	-

Table 7.-6 Output SWGRP (High/Sensor) (Continued)

HW versions	**High/Sensor**						
SC	**H01**	**H02**	**H03**	**H04**	**H05**	**H06**	**H07**
Output SWGRP	**Output Signals**						
Start 1a	-	-	-	-	-	-	3I> 3I< 3I>> 3U> 3I>>> 3U>> Io>--> 3U< Io>>--> 3U<< 3Ithdev> I2> Io> I2>> Io>> Is2t n<
Start 1b	-	-	-	-	-	-	3I() U1U2<>_1 f1 Start1 f1 Start2
Start 2	NC	NC	NC	NC	NC	NC	-
Start 2a	-	-	-	-	-	-	NC
Start 2b	-	-	-	-	-	-	NC
BSOUT	3I>>--> 3I>>	3I>>--> 3I>>>	3I>> 3I>>>	3I>> 3I>>>	3I>> 3I>>>	3I>>	3I>> 3I>>>
Alarm 1	I<->O CB1 open I<->O CB1 close 3Ith> MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1 MCS 3U PQ 3Unf har PQ 3Unf cum	I<->O CB1 open I<->O CB1 close 3Ith> MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1 MCS 3U PQ 3Unf har PQ 3Unf cum	I<->O CB1 open I<->O CB1 close 3Ith> MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1 MCS 3U PQ 3Unf har PQ 3Unf cum	I<->O CB1 open I<->O CB1 close 3Ith> MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1 MCS 3U PQ 3Unf har PQ 3Unf cum	I<->O CB1 open I<->O CB1 close MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1 MCS 3U PQ 3Unf har PQ 3Unf cum	I<->O CB1 open I<->O CB1 close MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1 MCS 3U PQ 3Unf har PQ 3Unf cum	I<->O CB1 open I<->O CB1 close MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1 MCS 3U PQ 3Unf har PQ3Unf cum TIME1 FUSEF
Alarm 2	NC	See Alarm 1	See Alarm 1	See Alarm 1	NC	NC	See Alarm 1
O-->I Active	NC	NC	NC	NC	-	-	-
O-->I Alarm1	NC	NC	NC	NC	-	-	-
O-->I Alarm2	NC	NC	NC	NC	-	-	-
HSPO1 Lockout	NC	NC	NC	NC	NC	NC	NC
Restart Enable	-	-	-	-	-	-	NC

Table 7.-7 Output SWGRP (High)

HW versions	High			
Standard conf.	**H08**	**H09**	**H50**	**H51**
Output SWGRP	**Output Signals**			
Trip 1	3I>, 3I>>, 3I>>>, Io>, Io>>, Io>>>, 3U>, 3U>>, 3U<, 3U<<, Uo>, Uo>>, Uo>>>, 3Ihtdev>	-	-	-
Trip 1a	-	3I>, 3I>>, 3I>>>, Io>, Io>>, Io>>>, 3U>, 3U>>, 3U<, 3U<<, Uo>, Uo>>, Uo>>>, f1 Trip1, f1 Trip2, f2 Trip1	3I>, 3I>>, 3I>>>, 3I>-->, 3I>>-->, Io>, Io>>, Io>-->, Io>>-->, 3U>, 3U>>, 3U<, 3U<<, Uo>, Uo>>, U1U2<>_1	3I>, 3I>>, 3I>>>, 3I>>-->, Io>, Io>>, Io>-->, Io>>-->, 3U>, 3U>>, Uo>, Is2t n<, 3I(), I2>, 3Ihtdev>, U1U2<>_1
Trip 1b	-	f2 Trip2	f1 Trip1, f1 Trip2, f2 Trip1, f2 Trip2	f1 Trip1, f1 Trip2, f2 Trip1, f2 Trip2
Trip 2	See Trip 1	-	-	-
Trip 2a	-	See Trip 1a	See Trip 1a	See Trip 1a
Trip 2b	-	f2 Trip2	f1 Trip1, f1 Trip2, f2 Trip1, f2 Trip2	f1 Trip1, f1 Trip2, f2 Trip1, f2 Trip2
Trip 3	See Trip 1	-	-	-
Trip 3a	-	See Trip 1a	See Trip 1a	See Trip 1a
Trip 3b	-	f2 Trip2	f1 Trip1, f1 Trip2, f2 Trip1, f2 Trip2	f1 Trip1, f1 Trip2, f2 Trip1, f2 Trip2
Trip 4	NC	-	-	-
Trip 4a	-	NC	NC	NC
Trip 4b	-	NC	NC	NC
Trip 5	NC	-	-	-
Trip 5a	-	NC	NC	NC
Trip 5b	-	NC	NC	NC
CBFP	3I>, 3I>>, 3I>>>, Io>, Io>>, Io>>>, 3Ihtdev>	3I>, 3I>>, 3I>>>, Io>, Io>>, Io>>>	3I>, 3I>>, 3I>>>, 3I>-->, 3I>>-->, Io>, Io>>, Io>-->, Io>>-->	3I>, 3I>>, 3I>>>, 3I>>-->, Io>, Io>>, Io>-->, Io>>-->, 3Ihtdev>
Start 1	3I>, 3I>>, 3I>>>, Io>, Io>>, Io>>>, 3U>, 3U>>, 3U<, 3U<<, Uo>, Uo>>, Uo>>>, 3Ihtdev>	-	-	-
Start 1a	-	3I>, 3I>>, 3I>>>, Io>, Io>>, Io>>>, 3U>, 3U>>, 3U<, 3U<<, Uo>, Uo>>, Uo>>>, f1 Start1, f1 Start2, f2 Start1	3I>, 3I>>, 3I>>>, 3I>-->, 3I>>-->, Io>, Io>>, Io>-->, Io>>-->, 3U>, 3U>>, 3U<, 3U<<, Uo>, Uo>>, U1U2<>_1	3I>, 3I>>, 3I>>>, 3I>>-->, Io>, Io>>, Io>-->, Io>>-->, 3U>, 3U>>, Uo>, Is2t n<, 3I(), I2>, 3Ihtdev>, U1U2<>_1
Start 1b	-	f2 Start2	NC	f1 Start1, f1 Start2, f2 Start1, f2 Start2

Table 7.-7 Output SWGRP (High) (Continued)

HW versions	**High**			
Standard conf.	**H08**	**H09**	**H50**	**H51**
Output SWGRP	**Output Signals**			
Start 2	NC	-	-	-
Start 2a	-	NC	NC	NC
Start 2b	-	NC	NC	NC
BSOUT	3I>> 3I>>>	3I>> 3I>>>	3I>> 3I>>--> 3I>>>	3I>> 3I>>--> 3I>>>
Alarm 1	I<->O CB1 open I<->O CB1 close MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1 MCS 3U PQ 3Unf har PQ 3Unf cum	I<->O CB1 open I<->O CB1 close MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1 MCS 3U PQ 3Unf har PQ 3Unf cum	I<->O CB1 open I<->O CB1 close MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1 MCS 3U PQ 3Unf har PQ 3Unf cum	I<->O CB1 open I<->O CB1 close MCS 3I TCS1 PQ 3Inf har PQ 3Inf cum CB wear1 MCS 3U PQ 3Unf har PQ 3Unf cum TIME1 FUSEF
Alarm 2	NC	NC	NC	See Alarm 1
O-->I Active	-	NC	NC	-
O-->I Alarm 1	-	NC	NC	-
O-->I Alarm 2	-	NC	NC	-
HSPO1 Lockout	NC	NC	NC	NC
Restart Enable	-	- -	-	NC

Table 7.-8 Output signals

HW versions	**Basic, Medium, High and Sensor**
Standard configuration	**B01, B02, M01, M02, H01, H02, H03, H04, H05, H06, H07, H08, H09, H50, H51**
Output relays	**Output signals**
PO1	Trip 2
PO2	CBFP
PO3	Close
SO1	Start 1
SO2	Alarm 1

Table 7.-9 Special settings

HW versions	**High**	
Standard configuration	**H50**	**H51**
f. prot delay	No delay	No delay
AR1 conf	Standard	-
AR2 conf	Standard	-
AR3 conf	Standard	-
AR4 conf	Standard	-

8. Function block descriptions

The information in this chapter is adapted from the function block descriptions in the CD-ROM Technical Descriptions of Functions (Section 1.3. Related documents). See also Chapter 3. Introduction for differences between the REX 521 and the RED 500 platform in the function block descriptions of the CD-ROM.

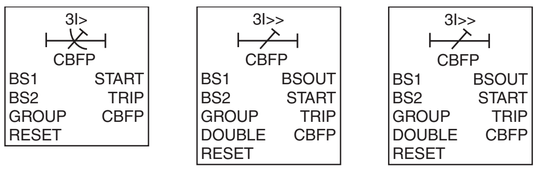
In this chapter, the function blocks are called by their IEC names. The corresponding ABB names for the function blocks can be found in Table 3.-1.

Note that in the CD-ROM Technical Descriptions of Functions there are more signals presented than in this manual.

8.1. Protection

8.1.1. 3I>, 3I>> and 3I>>>

The three-phase non-directional overcurrent function blocks are designed for non-directional two-phase and three-phase overcurrent and short-circuit protection whenever the DT characteristic or, as concerns 3I>, the IDMT (Inverse Definite Minimum Time) characteristic is appropriate. Suppression of harmonics is possible.



A051972

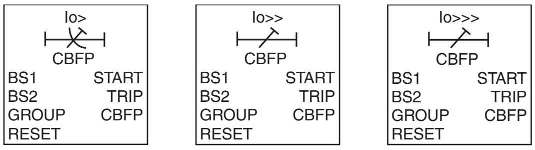
Fig. 8.1.1.-1 Function block symbols of 3I>, 3I>> and 3I>>

Three-phase non-directional overcurrent protection, low-set stage, 3I> (51-1)		
Start current	0.10…5.00 x In	
Operate time in DT mode	0.05…300.00 s	
Time multiplier in IDMT mode	0.05…1.00	
IEEE time dial in IDMT mode	0.5...15.0	
Operation mode	Not in use	IEEE Extremely inverse
	Definite time	IEEE Very inverse
	Extremely inverse	IEEE Inverse
	Very inverse	IEEE Short time inverse
	Normal inverse	IEEE Short time extr. inv.
	Long time inverse	IEEE Long time extr. inv.
	RI-type inverse	IEEE Long time very inv.
	RD-type inverse	IEEE Long time inverse
Measuring mode	Peak-to-peak	
	Fundamental frequency	
Drop-off time of the operate time counter	0...1000 ms	
	Note! The values below apply when f/fn = 0.95...1.05	
Operation accuracy	±2.5% of set value or ±0.01 x In	
Operate time	Injected currents > 2.0 x start current: internal time < 32 ms total time < 40 ms	
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)	
Reset ratio, typically	0.95	
Retardation time	< 45 ms	
Operate time accuracy in DT mode	±2% of set value or ±20 ms	
Accuracy class index E in IDMT mode	Class index E = 5.0 or ±20 ms	

Three-phase non-directional overcurrent protection, 3I>> (51-2) and instantaneous stage, 3I>>> (51-3)	
Start current	0.10…40.00 x In
Operate time	0.05…300.00 s
Operation mode	Not in use Definite time Instantaneous
Measuring mode	Peak-to-peak Fundamental frequency
Drop-off time of the operate time counter	0...1000 ms
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	0.1...10 x In: ±2.5% of set value or ±0.01 x In 10...40 x In: ±5.0% of set value
Start time	Injected currents > 2.0 x start current: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	< 45 ms
Operate time accuracy in DT mode	±2% of set value or ±20 ms

8.1.2. Io>, Io>> and Io>>>

The non-directional earth-fault protection function blocks are designed for non-directional earth-fault protection whenever the DT characteristic or, as concerns I_0>, the IDMT (Inverse Definite Minimum Time) characteristic is appropriate. Suppression of harmonics is possible.



A051973

Fig. 8.1.2.-1 Function block symbols of Io>, Io>> and Io>>>

Non-directional earth-fault protection, low-set stage, Io> (51N-1)		
Start current	1.0…500.0% of In	
Operate time in DT mode	0.05…300.00 s	
Time multiplier in IDMT mode	0.05…1.00	
IEEE time dial in IDMT mode	0.5...15.0	
Operation mode	Not in use	IEEE Extremely inverse
	Definite time	IEEE Very inverse
	Extremely inverse	IEEE Short time inverse
	Very inverse	IEEE Short time extr. inv.
	Normal inverse	IEEE Long time extr. inv.
	Long time inverse	IEEE Long time very inv.
	RI-type inverse	IEEE Long time inverse
	RD-type inverse	
Measuring mode	Peak-to-peak	
	Fundamental frequency	
Drop-off time of the operate time counter	0...1000 ms	
	Note! The values below apply when f/fn = 0.95...1.05	
Operation accuracy	±2.5% of set value + 0.0005 x In	
Start time	Injected currents > 2.0 x start current:	
	internal time < 32 ms	
	total time < 40 ms	
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)	
Reset ratio, typically	0.95	
Retardation time	< 45 ms	
Operate time accuracy in DT mode	±2% of set value or ±20 ms	
Accuracy class index E in IDMT mode	Class index E = 5.0 or ±20 ms	

Non-directional earth-fault protection, high-set stage, Io>> (51N-2), and instantaneous stage, Io>>> (51N-3)		
Start current	0.10…12.00 x In	
Operate time	0.05…300.00 s	
Operation mode	Not in use	Instantaneous
	Definite time	
Measuring mode	Peak-to-peak	
	Fundamental frequency	
Drop-off time of the operate time counter	0...1000 ms	
	Note! The values below apply when f/fn = 0.95...1.05	
Operation accuracy	±2.5% of set value or + 0.01 x In	
Operate time	Injected currents > 2.0 x start current:	
	internal time < 32 ms	
	total time < 40 ms	
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)	
Reset ratio, typically	0.95	
Retardation time	< 45 ms	
Operate time accuracy in DT mode	±2% of set value or ±20 ms	

8.1.3. Io>-->, Io>>--> and Io>>>-->

The directional earth-fault protection function blocks Io>-->, Io>>--> and Io>>>--> are designed to be used for directional or non-directional earth-fault protection whenever the DT characteristic or, as concerns Io>-->, the IDMT (Inverse Definite Minimum Time) characteristic is appropriate. Suppression of harmonics is possible.

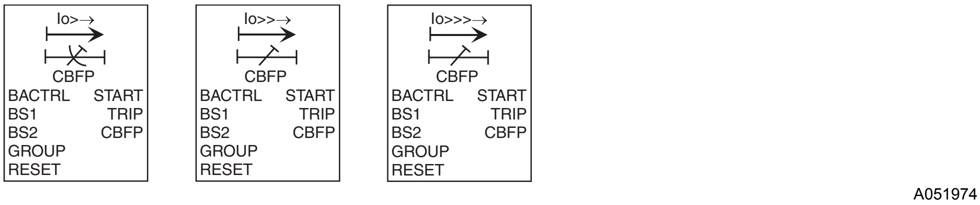


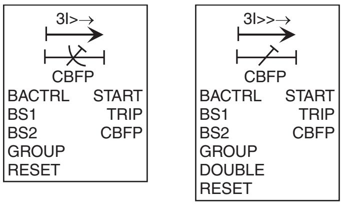
Fig. 8.1.3.-1 Function block symbols of Io>-->, Io>>--> and Io>>>-->

Directional earth-fault protection, low-set stage, Io>--> (67N-1)		
Start current	1.0…500.0% of In	
Start voltage	2.0…100.0% of Un	
Operate time in DT mode	0.1…300.0 s	
Time multiplier in IDMT mode	0.05…1.00	
Operation mode	Not in use	Very inverse
	Definite time	Normal inverse
	Extremely inverse	Long time inverse
Operation criteria	Basic angle & Uo	IoSin/Cos
	Basic angle	Non-directional Io
	IoSin/Cos & Uo	Non-directional Uo
Operation direction	Forward	
	Reverse	
Basic angle φ_b	-90°... 60°	
Operation characteristic	IoSin(φ)	
	IoCos(φ)	
Intermittent E/F	Not active	
	Active	
Measuring mode	Peak-to-peak	
	Fundamental frequency	
Drop-off time of the operate time counter	0...1000 ms	
	Note! The values below apply when f/fn = 0.95...1.05	
Operation accuracy	±2.5% of set value + 0.0005 x In	
	±2.5% of set value or + 0.01 x Un	
	Phase angle ±2°	
Start time	Injected neutral current > 2.0 x start current and residual voltage > 2.0 x start voltage:	
	internal time < 72 ms	
	total time < 80 ms	
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)	
Reset ratio, typically	0.95	
Retardation time	< 50 ms	
Operate time accuracy in DT mode	±2% of set value or ±20 ms	
Accuracy class index E in IDMT mode	Class index E = 5.0 or ±20 ms	

Directional earth-fault protection, high-set stage, Io>>--> (67N-2) and instantaneous stage, Io>>>--> (67N-3)		
Start current	1.0…500.0% of In	
Start voltage	2.0…100.0% of Un	
Operate time	0.1…300.0 s	
Operation mode	Not in use Definite time	Instantaneous
Operation criteria	Basic angle & Uo Basic angle IoSin/Cos & Uo	IoSin/Cos Non-directional Io Non-directional Uo
Operation direction	Forward Reverse	
Basic angle φ_b	-90°...60°	
Operation characteristic	IoSin(φ) IoCos(φ)	
Intermittent E/F	Not active Active	
Measuring mode	Peak-to-peak Fundamental frequency	
Drop-off time of the operate time counter	0...1000 ms	
	Note! The values below apply when f/fn = 0.95...1.05	
Operation accuracy	±2.5% of set value + 0.0005 x In ±2.5% of set value or + 0.01 x Un Phase angle ±2°	
Start time	Injected neutral current > 2.0 x start current and residual voltage > 2.0 x start voltage: internal time < 72 ms total time < 80 ms	
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)	
Reset ratio, typically	0.95	
Retardation time	< 50 ms	
Operate time accuracy in DT mode	±2% of set value or ±20 ms	

8.1.4. 3I>--> and 3I>>-->

The directional overcurrent function blocks are designed for directional single-phase, two-phase and three-phase overcurrent and short-circuit protection whenever the DT characteristic or, as concerns 3I>-->, the IDMT (Inverse Definite Minimum Time) characteristic is appropriate. Suppression of harmonics is possible.



A051975

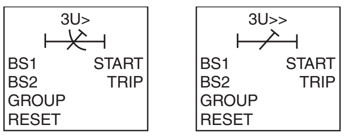
Fig. 8.1.4.-1 Function block symbols of 3I>--> and 3I>>-->

Three-phase directional overcurrent protection, low-set stage, 3I>--> (67-1)	
Start current	0.05…40.00 x In
Operate time	0.05…300.00 s
Operation mode	Not in use Definite time Extremely inv Very inverse Normal inverse Long-time inv. RI-type inverse RD-type inverse
Time multiplier	0.05...1.00
Basic angle φ_b	0°...90°
Oper. Direction	Forward Reverse
earth-fault pr.	Disabled Enabled
Measuring mode	Mode1 (Phase-to-phase voltages/Peak-to-peak currents) Mode2 (Phase-to-phase voltages/Fund. freq. Currents) Mode3 (Phase-to-earth voltages/Peak-to-peak currents) Mode4 (Phase-to-earth voltages/Fund. freq. Currents)
Drop-off time of the operate time counter	0...1000 ms
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	Current: 0.1...10 x In: ±2.5% of set value or ±0.01 x In 10...40 x In: ±5.0% of set value Voltage: ±2.5% of measured value or ±0.01 x Un Phase angle: ±2°
Start time	Injected currents > 2.0 x start current: internal time < 42 ms total time < 50 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	< 45 ms
Operate time accuracy in DT mode	±2% of set value or ±20 ms
Accuracy class index E at IDMT mode	Class index E = 5.0 or ±20 ms

Three-phase directional overcurrent protection, high-set stage, 3I>>--> (67-2)	
Start current	0.05…40.00 x In
Operate time	0.05…300.00 s
Operation mode	Not in use Definite time Instantaneous
Basic angle φ_b	0°...90°
Oper. Direction	Forward Reverse
earth-fault pr.	Disabled Enabled
Nondir. operat.	Disabled Enabled
Measuring mode	Mode1 (Phase-to-phase voltages/Peak-to-peak currents) Mode2 (Phase-to-phase voltages/Fund. freq. Currents) Mode3 (Phase-to-earth voltages/Peak-to-peak currents) Mode4 (Phase-to-earth voltages/Fund. freq. Currents)
Drop-off time of the operate time counter	0...1000 ms
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	Current: 0.1...10 x In: ±2.5% of set value or ±0.01 x In 10...40 x In: ±5.0% of set value Voltage: ±2.5% of measured value or ±0.01 x Un Phase angle: ±2°
Start time	Injected currents > 2.0 x start current: internal time < 42 ms total time < 50 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	< 45 ms
Operate time accuracy in DT mode	±2% of set value or ±20 ms

8.1.5. 3U> and 3U>>

Abnormal busbar voltages can be caused by faults in the network or a faulty tap changer or voltage regulator of a power transformer. The function blocks are designed for the single-phase, two-phase and three-phase overvoltage protection whenever the DT characteristic or, as concerns 3U>, the IDMT (Inverse Definite Minimum Time) characteristic is appropriate. Suppression of harmonics is possible.



A051976

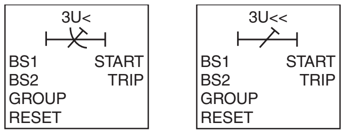
Fig. 8.1.5.-1 Function block symbols of 3U> and 3U>>

Three-phase overvoltage protection, low-set stage, 3U> (59-1)	
Start voltage	0.10...1.60 x Un
Operate time	0.05...300.00 s
Operation mode	Not in use Definite time A curve B curve
Time multiplier	0.05...1.00
Measuring mode	Mode 1 (Phase-to-phase voltages / Peak-to-peak meas.) Mode 2 (Phase-to-phase voltages / Fundam.freq.) Mode 3 (Phase-to-earth voltages / Fundam.freq.)
Operation hysteresis	1.0...5.0%
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of the set value with Measuring Mode 3 ±1,0% of the set value with Measuring Modes 1 and 2
Start time	Injected voltages > 1.1 x start voltage: internal time < 42 ms total time < 50 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	Default 0.96 (range 0.95...0.99) (Depends on the value of the Oper. hysteresis parameter, refer to the manual of the Three-phase Overvoltage protection function, 1MRS752322-MUM, chapters 2.3.1. and 3.2.4.)
Retardation time	< 50 ms
Operate time accuracy in DT mode	±2% of set value or ±20 ms
Accuracy class index E in inverse-time mode	± 20 ms or the accuracy appearing when the measured voltage varies ±2.5%

Three-phase overvoltage protection, high-set stage, 3U>> (59-2)	
Start voltage	0.10...1.60 x Un
Operate time	0.05...300.00 s
Operation mode	Not in use Definite time
Measuring mode	Mode 1 (Phase-to-phase voltages / Peak-to-peak meas.) Mode 2 (Phase-to-phase voltages / Fundam.freq.) Mode 3 (Phase-to-earth voltages / Fundam.freq.)
Operation hysteresis	1.0...5.0%
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of the set value with Measuring Mode 3 ±1.0% of the set value with Measuring Modes 1 and 2
Start time	Injected voltages > 1.1 x start voltage: internal time < 42 ms total time < 50 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	Default 0.96 (range 0.95...0.99) (Depends on the value of the Oper. hysteresis parameter, refer to the manual of the Three-phase Overvoltage protection function, 1MRS752322-MUM, chapters 2.3.1. and 3.2.4.)
Retardation time	< 50 ms
Operate time accuracy in DT mode	±2% of set value or ±20 ms

8.1.6. 3U< and 3U<<

Abnormal busbar voltages can be caused by faults in the network or a faulty tap changer or voltage regulator of a power transformer. The function blocks are designed for the single-phase, two-phase and three-phase undervoltage protection whenever the DT characteristic or, as concerns 3U<, the IDMT (Inverse Definite Minimum Time) characteristic is appropriate. Suppression of harmonics is possible.



A051976

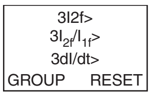
Fig. 8.1.6.-1 Function block symbols of 3U< and 3U<<

Three-phase undervoltage protection, low-set stage, 3U< (27-1)	
Start voltage	0.10...1.20 x Un
Operate time	0.1...300.0 s
Operation mode	Not in use Definite time C curve
Time multiplier	0.1...1.0
Measuring mode	Mode 1 (Phase-to-phase voltages / Peak-to-peak meas.) Mode 2 (Phase-to-phase voltages / Fundam.freq.) Mode 3 (Phase-to-earth voltages / Fundam.freq.)
Operation hysteresis	1.0...5.0%
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of the set value with Measuring Mode 3 ±1,0% of the set value with Measuring Modes 1 and 2
Start time	Injected voltages < 0.5 x start voltage: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	1.04 (range 1.01...1.05) (depends on the value of the Oper. hysteresis parameter, refer to the manual of the Three-phase Undervoltage Protection function, 1MRS752333-MUM, chapters 2.3.1. and 3.2.4.)
Retardation time	< 60 ms
Operate time accuracy in DT mode	±2,5% of set value
Accuracy class index E in inverse-time mode	± 35 ms or the accuracy appearing when the measured voltage varies ±2.5%

Three-phase undervoltage protection, high-set stage, 3U<< (27-2)	
Start voltage	0.10...1.20 x Un
Operate time	0.1...300.0 s
Operation mode	Not in use Definite time C curve
Measuring mode	Mode 1 (Phase-to-phase voltages / Peak-to-peak meas.) Mode 2 (Phase-to-phase voltages / Fundam.freq.) Mode 3 (Phase-to-earth voltages / Fundam.freq.)
Operation hysteresis	1.0...5.0%
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2,5% of the set value with Measuring Mode 3 ±1,0% of the set value with Measuring Modes 1 and 2
Start time	Injected voltages < 0.5 x start voltage: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	1.04 (range 1.01...1.05) (depends on the value of the Oper. hysteresis parameter, refer to the manual of the Three-phase Undervoltage Protection function, 1MRS752333-MUM, chapters 2.3.1. and 3.2.4.)
Retardation time	< 60 ms
Operate time accuracy in DT mode	±2,5% of set value

8.1.7. 3I2f>

The function block 3I2f> can be used for doubling the set start current of overcurrent protection in a transformer magnetizing inrush situation, or at motor start-up, or for blocking (stabilizing) overcurrent protection in a transformer magnetizing inrush situation.



A051978

Fig. 8.1.7.-1 Function block symbol of 3I2f>

Three-phase transformer inrush and motor start-up current detector 3I2f> (68)	
Ratio I 2f/I 1f	5...50%
Start current	0.10...5.00 x In
Operation mode	Not in use Inrush mode Start-up mode
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	Current meas.: ±2.5% of set value or ±0.01 x In Ratio I2f/I1f measurement: ±5.0% of set value
Start time	Internal time <32 ms Total time <40 ms

8.1.8. Iub>

The phase discontinuity protection function block Iub> is designed to be used for protection against broken phase conductors in distribution networks. Definite-time (DT) characteristic is always used.

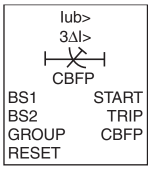


Fig. 8.1.8.-1 Function block symbol of Iub>

Phase discontinuity protection, Iub> (46)	
Start unbalance	10.0…95.0%
Operate time	1.0…300.0 s
Operation mode	Not in use Definite time
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of set value or ±1% unit
Start time	internal time < 95 ms total time < 100 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	Total time for blocking: < 25 ms Total time when current drops below start value: < 50 ms
Operate time accuracy in DT mode	±2% of set value or ±50 ms

8.1.9. 3Ith>

The three-phase thermal overload protection function block 3Ith> is designed for the thermal protection of three-phase power cables and overhead lines.

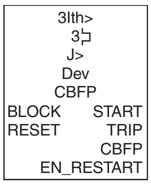


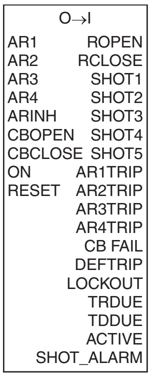
Fig. 8.1.9.-1 Function block symbol of 3Ith>

Three-phase thermal overload protection for cables, 3Ith> (49F)	
Time constant for the cable	1…999 min
Maximum load current for the cable	1.0…5000.0 A
Maximum temperature of conductor	40.0…150.0°C
Reference temperature	-50.0…100.0°C
Trip temperature	80.0…120.0%
Prior alarm temperature	40.0…100.0%
Reclose temperature	40.0…100.0%
Ambient temperature	-50.0…100.0°C
Operation mode (principle of ambient temperature compensation)	Not in use No sensors; the set ambient temperature 1 sensor used 2 sensors used
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±1.0%, I = 0.1...10.0 x In
Reset ratio	Trip: (Calculated temp. rise - 0.1) / Trip temperature Start: (Calculated temp. rise - 0.1) / Prior alarm temperature

8.1.10. O-->I

The majority (about 80...85%) of MV overhead line faults are transient and are automatically cleared by momentarily de-energizing the line, whereas the rest of the faults (15...20%) can be cleared by longer interruptions. The de-energization of the fault place for a desired period of time is implemented by autoreclose (AR) relays or functions. The autoreclosers are capable of clearing most of the faults. At a permanent fault, the autoreclosing is followed by final tripping. A permanent fault has to be located and cleared before the fault location can be re-energized.

The autoreclose function O-->I can be used for autoreclosing together with any circuit breaker that has the characteristics required for autoreclosing. The function block provides five programmable AR shots which can perform one to five successive autoreclosures of desired type and duration, such as one high-speed and one delayed autoreclosure. When the reclosing is initiated by the start of a protection function, the AR function is capable of executing the final trip of the circuit breaker in a short operate time in case the fault still persists when the last reclosure selected has been carried out.



A051981

Fig. 8.1.10.-1 Function block symbol of O-->I

Autoreclose function, O-->I (79)	
Number of reclosures	0…5
Initiation mode	Trip Start
AR1, AR2, AR3, AR4 starting line operation mode	No operation AR shot initiated Initiation of AR shot blocked
AR1 AR2, AR3, AR4 start delay	0…10.00 s
Dead time	0.20…300.00 s
Synchro-check	Not in use; ARSYNC in use
Discriminating time td	0…30.00 s
Operation accuracy	±1% of setting value or ±30 ms

The AR function is initiated internally from the protection functions or externally with the digital inputs. The initiation signals are selected in the input SWGRP. Activation and alarm signals can be routed to the output relays via the output SWGRP selection.

The re-open (ROPEN) signal is connected directly to the HSPO1. The reclose signal is routed to the close signal which can be connected to the output relays. The reclose signal is depended on the interlocking scheme chosen for the control (COCB) function. (See Fig. 8.1.10.-2.) Note that the open and the trip signal always overrides the reclose and the close signal.

Sometimes it can be useful to get indications on the display cleared after a successful autoreclosing. This can be done by selecting O-->I in input SWGRP Reset indication. By default this option is disabled.

CB open and CB close via the AR function are disabled in REX 521.

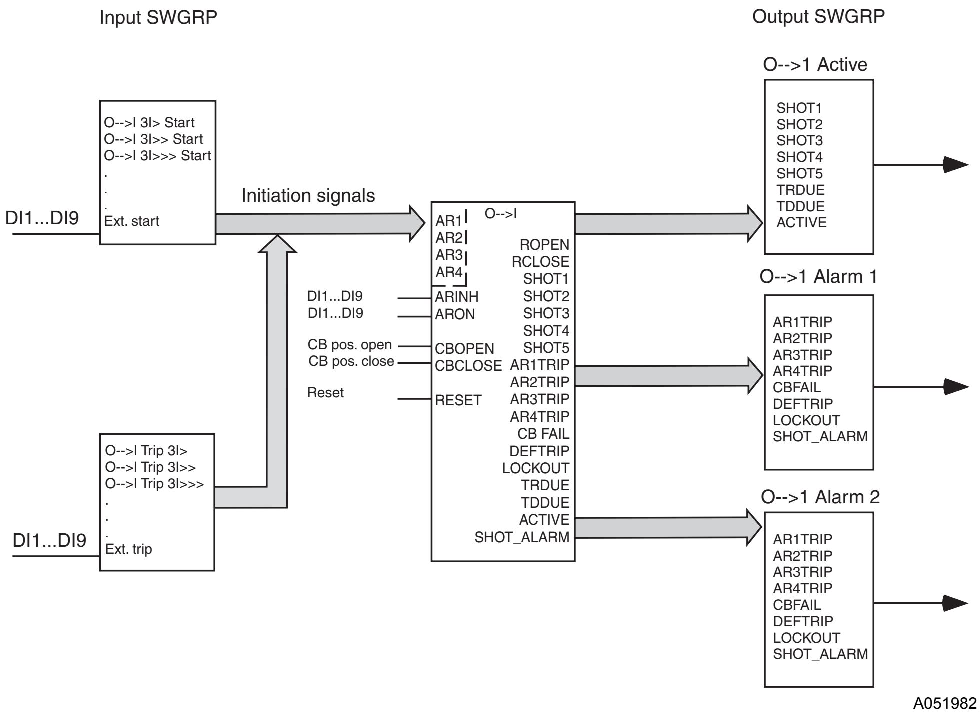


Fig. 8.1.10.-2 Input and output signal overview for the autoreclose function

8.1.10.1. Autoreclose in H50

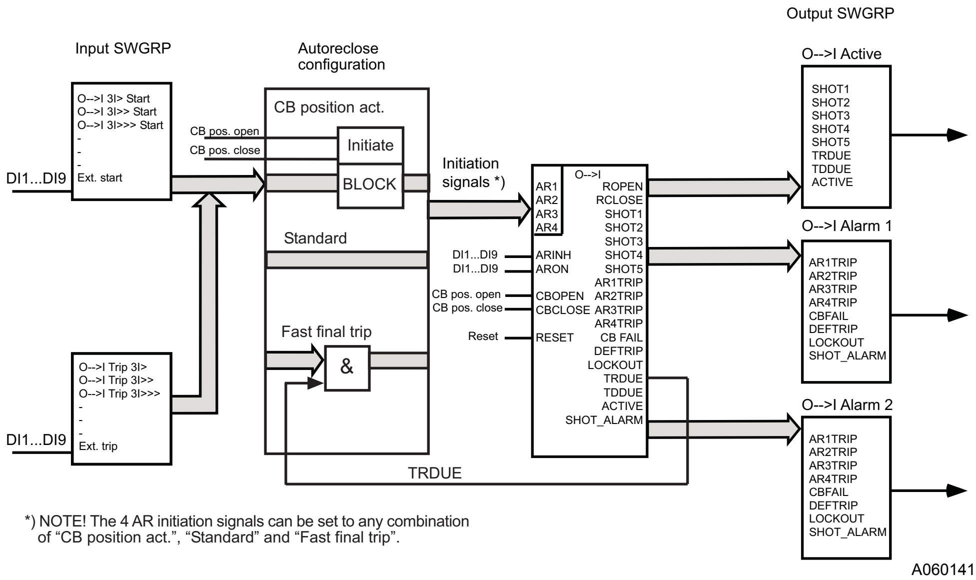


Fig. 8.1.10.-3 Input and output signal overview for the AR function in H50

Table 8.1.10-1 Settings of the autoreclose configuration in H50

Settings of the autoreclose configuration	Functional description
CB position act.	CB position OPEN activates the reclose sequence. Input SWGRP determines which start or trip signal blocks O-->I.
Fast final trip	After the first reclose or manual close, the Trip is carried out by a Start signal, ignoring the operate time set within the protection block. The input SWGRP determines which function blocks use this feature.
Standard	Input SWGRP determines which start or trip signal activates O-->I.

The autoreclose configuration settings are found in `Configuration/Input SWGRP/Special settings/AR1 conf ... /AR4 conf`.

These features requires correct settings inside the AR function block.

CB position act.

Opening a CB manually does not start the O-->I sequence. The selected signals in the Input SWGRP are used to block the initiation of the O-->I sequence.

In order to allow the `Master trip` input signal to initiate the O-->I sequence, `O-->I INH` must have a different DI selected than the `Master trip` input signal. Both signals are found in `Configuration/Input signals/`. Both the `Master trip` and the `O-->I INH` signals are by default configured to DI8.

Fast final trip

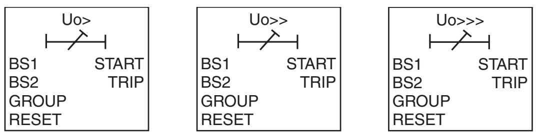
Fast final trip is used when a specific start signal is used to open the breaker faster if an error still exists after an autoreclose or a manual close. After the first reclose or manual close, the TRDUE signal is set to TRUE. If a start signal triggers the AR during the time the TRDUE signal is TRUE (called reclaime time), the circuit breaker is opened by the AR function. In this way the operate time of the protection block is bypassed. The input SWGRP sets the start signals of the function blocks which initiate this functionality.

Standard

The input SWGRP determines the initiate signals that activates the O-->I sequence. AR works like in other configurations where it is used.

8.1.11. Uo>, Uo>> and Uo>>>

The residual overvoltage protection function blocks are designed for sensitive earth-fault protection whenever the DT characteristic is appropriate. Suppression of harmonics is possible.



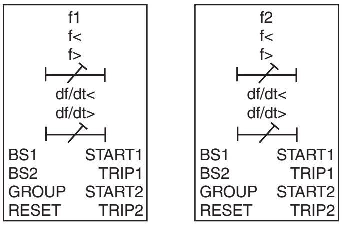
A051983

Fig. 8.1.11.-1 Function block symbol of Uo>, Uo>> and Uo>>>

Residual overvoltage protection, low-set stage, Uo> (59N-1), high-set stage, Uo>> (59N-2) and instantaneous stage, Uo>>> (59N-3)	
Start voltage	2.0...100.0% Un
Operate time	0.05...300.00 s
Operation mode	Not in use Definite time
Measuring mode	Peak-to-peak Fundamental frequency
	Note! The values below apply when f/fn = 0.95...1.05
Operation accurcy	±2.5% of set value or ±0.01 x Un
Start time	Injected voltages > 2.0 x start voltage: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (Depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	Total time for blocking: < 25 ms Total time when voltage drops below start value: < 50 ms
Operate time accuracy in DT mode	±2% of set value or ±20 ms

8.1.12. f1 and f2

The frequency function blocks operate as either underfrequency or overfrequency protection depending on whether the set operate value is above or below the rated frequency of the relay. The operation is insensitive to harmonics and the DC component.



A051984

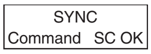
Fig. 8.1.12.-1 Function block symbol of f1 and f2

System frequency protection, f1 (81-1) and f2 (81-2)	
Undervoltage limit for blocking	0.30...0.90 x Un
Start value for under-/overfrequency prot.	25.00...75.00 Hz
Operate time for under-/overfrequency prot.	0.10...300.00 s
Start value for df/dt protection	0.2...10.0 Hz/s
Operate time for df/dt protection	0.12...300.00 s
Operation mode	Not in use f</f> 1 timer f</f> 2 timers f</f> OR df/dt> f</f> AND df/dt> f</f> OR df/dt< f</f> AND df/dt< Accuracy for the f</f> function is defined in the setting range 25...75 Hz.
Operation accuracy	Frequency function (f</f>): ± 10 mHz Frequency rate of change function (df/dt): real df/dt < ± 5 Hz/s: accuracy ±100 mHz/s real df/dt < ± 15 Hz/s: accuracy ±2.0% of the real df/dt Undervoltage blocking: ±1.0% of set value
Start time	Total start times at rated freq. fn = 50 Hz: Frequency measurement: < 100 ms df/dt measurement: < 120 ms Note! The operate times and start times are specified for the set rated frequencies 50 Hz and 60 Hz.
Reset time	140...1000 ms (Depends on the minimum pulse width set for the trip output)
Operate time accuracy	±2.0% of set value or ±30 ms

8.1.13. SYNC1

The function block is designed to be used for checking the conditions for circuit-breaker closing. The function can be used for closing ring mains, interconnecting busbars and connecting generators to the network. The harmonics are suppressed.

In sensor standard configurations (H01S and H03S) the parameter `Control settings\Voltage combine` must be enabled and in transformer standard configuration (H03) it must be disabled. The parameter is by default in the correct mode.



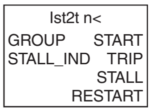
A051985

Fig. 8.1.13.-1 Function block symbol of SYNC1

Synchro-check, SYNC1 (25-1)	
Umax (Upper threshold voltage)	0.50...1.00 x Un
Umin (Lower threshold voltage)	0.10...0.80 x Un
dU (Voltage difference)	0.02...0.50 x Un
dphase (Phase angle difference)	5...90°
df (Frequency difference)	0.02...5.00 Hz
Energizing mode	Not in use U1->U2 or U2->U1 U1->U2 U2->U1 U1->U2 or U2->U1 or both “cold”
Operation mode	Command mode Continuous mode
Synchro mode	Not in use Asynchronous Mode Synchronous Mode
Operate time	0.10...20.0 s
Check time	0.05...300.0 s
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	Voltage measurement: ±2.5% of set value or ± 0.01 x Un Frequency measurement: ±10 mHz Phase angle measurement: ±2°
Reset time	< 50 ms
Reset ratio (typically)	0.975 x Un (range 0.96...0.98)
Operate time accuracy	±2% of set value or ±20 ms

8.1.14. Is2t n<

The motor start-up supervision protection function block Is2t n< is designed to monitor thermal stress during a single motor start-up.



A051986

Fig. 8.1.14.-1 Function block symbol of Is2t n<

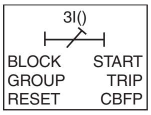
Three-phase start-up supervision for motors, Is2t n< (48)	
Operation mode	Not in use I^2t I^2t & stall
Start current	1.0...10.0 x In
Start time	0.3...250.0 s
Time limit	1.0...500.0 s
Countdown rate	2.0...250.0 s/h
Stall time	2.0...120.0 s

Three-phase start-up supervision for motors, Is2t n< (48) (Continued)		
	Note! The values below apply when f/fn = 0.95...1.05:	
Operation accuracies	Current measurement: ±2.5% of set value or ±0.01 x In	
Stall time accuracy	±2% of set value or ±20 ms	
Start time	f/fn = 0.95...1.50:	Internal time <22 ms Total time <30 ms[1]
	f/fn = 0.50...0.95	Internal time <32 ms Total time <40 ms[1]
Reset ratio	Typical 0.95 (range 0.95...0.98)	
Retardation time	Total retardation time when current drops below the start value <50 ms [2]	
Frequency dependence of settings and operating times	Frequency dependence is described above	

[1] Includes the delay of signal relay
[2] Includes the delay of heavy-duty output relay

8.1.15. 3I()

The function block 3I() is designed for phase-reversal protection of motors



A051987

Fig. 8.1.15.-1 Function block symbol of 3I()

Phase-reversal protection, 3I() (46R)	
Operation mode	Not in use 2-phase 3-phase
Operate time	0.1...10.00 s
Rotation direction	Forward Reverse
	Note! The values below apply when f/fn = 0.95...1.05:
Operation accuracies	Phase angle difference ±2° Current ±0.01 x In
Start time	Start time when phase order is wrong and the injected currents = 1.0 < In: Internal time <72 ms Total time <80 ms [1]
Reset time	40...1000 ms (depending on the minimum pulse width set for the TRIP output)
Reset ratio	Reset value for phase angle difference: 3°
Retardation time	Total retardation time when correct phase order is restored: <60 ms [2]
Operate time accuracy	Depends on the frequency of the current measured: ±2% of set value or ±20 ms [2]
Frequency dependence of the settings and operate times (see above)	Suppression of harmonics: -50 dB at f = n x fn, where n = 2, 3, 4, 5,...

[1] Includes the delay of the signal relay
[2] Includes the delay of the heavy-duty output relay

8.1.16. I2> and I2>>

The function blocks I2> and I2>> are designed for negative phase sequence protection whenever the operating characteristic is appropriate. The function blocks are applied in protecting power generators or synchronous motors against thermal stress and damage

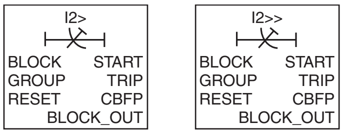


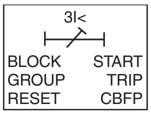
Fig. 8.1.16.-1 Function block symbols of I2> and I2>>

Negative phase sequence (NPS) protection, low-set stage I2> (46-1) and high-set stage I2>> (46-2)	
Operation mode	Not in use Definite time Inverse time
Start value	0.01...0.50 x I_n
Operate time	0.1...120.0 s
K	5.0...100.0 s
Start delay	0.1...60.0 s
Minimum time	0.1....120.0 s
Maximum time	500...10000 s
Cooling time	5...10000 s
Number of phases	2...3
	Note! The values below apply when f/fn = 0.95...1.05:
Operation accuracies	±2.5% of set value or ±0.01 x In
Start time	Injected negative-sequence current = 2.00 x start value: internal time <32 ms total time <40 ms [1]
Reset time	40...1000 ms (depending on the minimum pulse width set for TRIP output)
Reset ratio	Typical 0.96 (range 0.96...0.98) in definite-time mode
Retardation time	Total retardation time when negative-sequence current drops below the start value <45 ms [2]
Operate time accuracy in definite-time mode	Depends on the frequency of the current measured: ±2% of set value or ±20 ms [2]
Accuracy class index E in inverse-time mode	Depends on the frequency of the current measured: ±2% of the calculated ideal operate time or ±20 ms [2]

[1] Includes the delay of the signal relay.
[2] Includes the delay of the heavy-duty output relay.

8.1.17. 3I<

The undercurrent function block is designed to be used for non-directional three-phase undercurrent protection. Usually the undercurrent function block indicates loss of load for pumps, fans and conveyors. Protection is important if the pump is cooled by the liquid it pumps, or if a broken conveyor belt may cause damage for the process. Also a broken main circuit, problems with measuring devices, and loss of supply can be indicated.



A051989

Fig. 8.1.17.-1 Function block symbol of 3I<

Non-directional undercurrent protection, 3I< (37-1)		
Operation mode	Not in use Alarm Trip	
Operation criteria	1-, 2-, 3-phase 3-phase	
Start current	0.10...0.99 x In	
Operate time	0.1...600.0 s	
Internal blocking	Disabled Enabled	
Blocking time	0...7200 s	
Measuring mode	Peak-to-peak Fundamental frequency	
Drop-off time	0.00...60.00 s	
	Note! The values below apply when f/fn = 0.95...1.05:	
Operation accuracies	±2.5% of set value or ±0.01 x In	
Start time	Injected currents = 0.5 x start current: internal time <112 ms total time <120 ms [1]	
Reset time	40...1000 ms (depends on the minimum pulse width set for TRIP output)	
Reset ratio (typically)	1.02 (range 1.02...1.06)	
Retardation time	Total retardation time when the current exceeds the start value: <80ms [2]	
Operate time accuracy	±2% of set value or ±25 ms [2]	
Frequency dependence of settings and operate times	Measuring mode 0 1	Suppression of harmonics No suppression -50dB at f = n x fn, where n = 2, 3, 4, 5,...

[1] Includes the delay of the signal relay
[2] Includes the delay of the heavy-duty output relay

8.1.18. FUSEF

Some voltage-based protection functions may mal-operate if a voltage measurement circuitry is damaged or if the miniature circuit breaker (MCB) of the measurement circuitry has opened for example due to an operation of the short-circuit protection.

A failure in the voltage measurement circuitry should, however, be repaired as soon as possible to restore the blocked protection functions into use.

A051990

Fig. 8.1.18.-1 Function block symbol of FUSEF

Fuse failure supervision, FUSEF (60)	
Ratio U2/U1>	10...50%
Ratio I2/I1>	10...50%
FuseFail	Not in use In use
Operation accuracies	Depends on the frequency of the current and voltage measured: f/fn = 0.98...1.02: ±2.0% of Ratio U2/U1> and Ratio I2/I1< f/fn = 0.95...1.05: ±4.0% of Ratio U2/U1> and Ratio I2/I1<
BSOUT activation time (when task interval is 10 ms) [1]	Injected negative-sequence voltage = 2.00 x Ratio U2/U1>: f/fn = 0.98...1.02: <35 ms (within the same task)
Reset time (when task interval is 10 ms) [2]	20 ms (within the same task)
Reset ratio	0.8...0.96 (for Ratio U2/U1>) 1.04...1.2 (for Ratio I2/I1<)

[1] When BSOUT output is used for blocking function blocks that are executed in a slower task interval than FuseFail, an additional delay has to be included in the block activation time

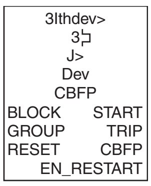
[2] When BSOUT output is used for blocking function blocks that are executed in a slower task interval than FuseFail, an additional delay has to be included in the reset time

8.1.19. 3Ithdev>

The function block protects a motor both from short- and long-duration overloads. The start situation is a good example of short-duration overload since particularly at start-up the rotor is in danger to be overloaded by the starting current. The starting current can be in the range of five to seven times the rated current of the motor.

The motor start-ups also load stator windings. Especially when a warm motor is restarted, the stator may constitute a limitation regarding thermal protection.

Because the function block calculates the temperature rise both for the stator and the rotor individually, the motor can be fully protected by proper settings. Furthermore, the thermal model of two-time constants enables detecting both short-time and long-time overloadings.



A051991

Fig. 8.1.19.-1 Function block symbol of 3Ithdev>

Three-phase thermal overload protection for devices, 3Ithdev (49M/G/T)		
Short time constant for stator	0.1...999.0 min	
Long time constant for stator	0.1...999.0 min	
Weighting factor of stator's short time-constant	0.00...1.00	
Temperature rise when In for stator	50.0...350.0°C	
Maximum temperature for stator	50.0...350.0°C	
Short time constant for rotor	0.1...999.0 min	
Long time constant for rotor	0.1...999.0 min	
Weighting factor of rotor's short time constant	0.00...1.00	
Temperature rise when In for rotor	50.0...350.0°C	
Maximum temperature for rotor	50.0...350.0°C	
Starting current	0.10...10.00 x I_n	
Starting time	0.1...120.0 s	
Number of starts	1...3	
Device type	MOTOR I MOTOR II MOTOR III MOTOR IV	GENERATOR I GENERATOR II TRANSFORMER
Trip temperature	80.0...120.0%	
Prior alarm	40.0...100.0%	
Restart inhibit	40.0...100.0%	
Ambient temperature	-50.0...100.0°C	
Cooling time constant	1.0...10.0 x τ	
Gen&Trafo heating time constant	1...999 min	
Operation accuracies	Current measurement: f/fn = 0.95...1.05: ±1.0%, I = 0.1...10.0 x In	
Operate time accuracy	±2% or ±0.5 s	
Reset ratio	TRIP: (TEMP(%) -0.1)/Trip temperature START: (TEMP(%) -0.1)/Prior alarm EN_RESTART: (TEMP(%) -0.1)/Restart inhibit	

8.1.20. U1U2<>_1

The positive-sequence undervoltage function U1< is designed to be used to protect small generating plant from asynchronous reclosure with the rest of the network, and to protect the plant from loss of synchronism.

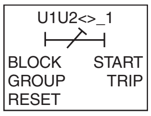
The function block is also used to protect against unwanted isolation of small generating plant during one- or two-phase network unbalance. The level of positive sequence voltage is found to be a good criteria when determining the criticality of the network fault from the generating plant's point of view.

Additionally, the function block can be used in unsuccessful reclosure protection in cases where a small generating plant with a faulted feeder supplies fault current which is too small to be detected by the current relays, but high enough to maintain the arc.

The negative-sequence overvoltage function U2> is designed to be used to protect motors against failure on one or more phases (single phasing), to protect against excessive imbalance between phases, and to protect machines against reversal of phase sequence both in forward and reverse rotation direction.

A faulty voltage transformer or sensor, as well as a wrong connection of voltage measuring devices causes apparent voltage unbalance. The U2> function can also be used for monitoring the condition of measuring circuits.

The positive-sequence overvoltage function U1> can be used in various applications instead of an ordinary three-phase overvoltage protection.



A051992

Fig. 8.1.20.-1 Function block symbol of U1U2<>_1

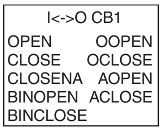
Phase sequence voltage protection, U1U2<>_1 (47-1)	
Operation mode	Not in use U1< & U2> & U1> U1< & U2> U2> & U1> U1< & U1> U2> U1< U1>
Start value U2>	0.01...1.00 x Un
Start value U1<	0.01...1.20 x Un
Start value U1>	0.80...1.60 x Un
Operate time U2>	0.04...60.00 s
Operate time U1<	0.04...60.00 s
Operate time U1>	0.04...60.00 s
	Note! The values below apply when f/fn = 0.95...1.05:
Operation accuracies	±2.5% of set value or ±0.01 x Un
Start time, U2> operation	Injected negative sequence voltage = 1.1 x start value: internal time <42 ms total time <50 ms [1]
Start time, U1< operation	Injected positive sequence voltage = 0.50 x start value: internal time <32 ms total time <40 ms [1]
Start time, U1> operation	Injected positive sequence voltage = 1.1 x start value: internal time <42 ms total time <50 ms [1]
Reset time	70...1030 ms (depends on the minimum pulse width set for TRIP output)
Reset ratio U2> operation	Typical 0.96 (range 0.90...0.98)
Reset ratio U1< operation	Typical 1.04 (range 1.02...1.10)
Reset ratio U1> operation	Typical 0.99
Retardation time	Total retardation time when negative-/positive-sequence voltage passes the start value: <45 ms [2]
Operate time accuracy	Depends on the frequency of the current measured: f/fn = 0.95...1.05: ±2% of set value or ±20 ms

[1] Includes the delay of the signal relay
[2] Includes the delay of the heavy-duty output relay

8.2. Control

8.2.1. I<->O CB1

The circuit-breaker function block is used for controlling the open and close positions of a circuit breaker. The function block also takes care of the user-defined interlocking logics and has guaranteed opening and closing pulse widths and forced open control operations for protection purposes. The open, close and undefined states of an object can be indicated remotely by the function block. Since the function block is mainly designed for circuit breakers, it will issue specific alarm signals based on the condition monitoring features.



A051993

Fig. 8.2.1.-1 Function block symbol of I<->O CB1

8.2.2. I<->O IND1 and I<->O IND2

The object indication function blocks I<->O IND1 and I<->O IND2 indicate the open, close and undefined states of a disconnector or an earthing switch.

8.2.3. I<->O IND3

The object indication function block I<->O IND3 indicates the state of the motor (running/stopped) in H07 and H51.

8.2.4. I<->O POS

The function block for logic control position selector, I<->O POS, makes it possible to choose remote or local position via the input Remote, which facilitates the flexible selection of control position. The Remote input can be found in `Main menu\Configuration\Input Signals\Remote`.

In remote position, the circuit breaker can only be controlled via remote communication and, accordingly, the local position only enables operation via the HMI and the digital inputs.

A051994

Fig. 8.2.4.-1 Function block symbol of I<->O POS

8.2.5. ALARM1-8

The alarm indicating functions are used for controlling alarm LEDs. The following configuration-specific signals can be connected to the alarm indicating functions:

Table 8.2.5-1 Basic B01

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io> Start	Iub> Start	DI1	DI1	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3I> Trip	Io> Trip	Iub> Trip	DI2	DI2	DI2	MEAS HI ALARM	TCS1
3I>> Start	Io>> Start	3Ith> Start	DI3	DI3	DI3	DI3	MCS 3I
3I>> Trip	Io>> Trip	3Ith> Trip	DI4	DI4	DI4	DI4	DI4
3I>>> Start	Io>>> Start		DI5	DI5	DI5	DI5	DI5
3I>>> Trip	Io>>> Trip		DI6	DI6	DI6	DI6	DI6
			DI7	DI7	DI7	DI7	DI7
			DI8	DI8	Interlocking	Lockout	DI8

Table 8.2.5-2 Basic B02

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io> Start	Iub> Start	DI1	DI1	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3I> Trip	Io> Trip	Iub> Trip	DI2	DI2	DI2	MEAS HI ALARM	TCS1
3I>> Start	Io>> Start	3Ith> Start	DI3	DI3	DI3	DI3	MCS 3I
3I>> Trip	Io>> Trip	3Ith> Trip	DI4	DI4	DI4	DI4	DI4
3I>>> Start	Io>>> Start	O-->I OPEN	DI5	DI5	DI5	DI5	DI5
3I>>> Trip	Io>>> Trip	O-->I ACTIVE	DI6	DI6	DI6	DI6	DI6
		O-->I ALAR1	DI7	DI7	DI7	DI7	DI7
		O-->I ALAR2	DI8	DI8	Interlocking	Lockout	DI8

Table 8.2.5-3 Medium M01

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io>--> Start	Iub> Start	DI1	DI1	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3I> Trip	Io>-->Trip	Iub> Trip	DI2	DI2	DI2	MEAS HI ALARM	TCS1
3I>> Start	Io>>--> Start	3Ith> Start	DI3	DI3	DI3	DI3	MCS 3I
3I>> Trip	Io>>--> Trip	3Ith> Trip	DI4	DI4	DI4	DI4	DI4
3I>>> Start	Io>>>--> Start		DI5	DI5	DI5	DI5	DI5
3I>>> Trip	Io>>>--> Trip		DI6	DI6	DI6	DI6	DI6
			DI7	DI7	DI7	DI7	DI7
			DI8	DI8	Interlocking	Lockout	DI8

Table 8.2.5-4 Medium M02

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io>--> Start	Iub> Start	DI1	DI1	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3I> Trip	Io>--> Trip	Iub> Trip	DI2	DI2	DI2	MEAS HI ALARM	TCS1
3I>> Start	Io>>--> Start	3Ith> Start	DI3	DI3	DI3	DI3	MCS 3I
3I>> Trip	Io>>--> Trip	3Ith> Trip	DI4	DI4	DI4	DI4	DI4
3I>>> Start	Io>>>--> Start	O-->I OPEN	DI5	DI5	DI5	DI5	DI5
3I>>> Trip	Io>>>-->Trip	O-->I ACTIVE	DI6	DI6	DI6	DI6	DI6
		O-->I ALAR1	DI7	DI7	DI7	DI7	DI7
		O-->I ALAR2	DI8	DI8	Interlocking	Lockout	DI8

Table 8.2.5-5 High/Sensor H01

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I>--> Start	Io>--> Start	Iub> Start	DI1	DI1	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3I>--> Trip	Io>--> Trip	Iub> Trip	DI2	DI2	DI2	MEAS HI ALARM	TCS1
3I>>--> Start	Io>>--> Start	3Ith> Start	DI3	DI3	DI3	DI3	MCS 3I
3I>>--> Trip	Io>>--> Trip	3Ith> Trip	DI4	DI4	DI4	DI4	MCS 3U
3I>>> Start	Io>>>--> Start	O-->I OPEN	DI5	DI5	DI5	DI5	DI5
3I>>> Trip	Io>>>--> Trip	O-->I ACTIVE	DI6	DI6	DI6	DI6	DI6
		O-->I ALAR1	DI7	DI7	DI7	DI7	DI7
		O-->I ALAR2	DI8	DI8	Interlocking	Lockout	DI8

Table 8.2.5-6 High/Sensor H02

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io>--> Start	f1 Start 1	O-->I OPEN	DI1	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3I> Trip	Io>--> Trip	f1 Trip 1	O-->I ACTIVE	DI2	DI2	MEAS HI ALARM	TCS1
3I>> Start	Io>>--> Start	f1 Start 2	O-->I ALAR1	DI3	DI3	DI3	MCS 3I
3I>> Trip	Io>>--> Trip	f1 Trip 2	O-->I ALAR2	DI4	DI4	DI4	MCS 3U
3I>--> Start	Io>>>--> Start	Iub> Start	DI1	DI5	DI5	DI5	DI5
3I>--> Trip	Io>>>--> Trip	Iub> Trip	DI2	DI6	DI6	DI6	DI6
3I>>--> Start		3Ith> Start	DI3	DI7	DI7	DI7	DI7
3I>>--> Trip		3Ith> Trip	DI4	DI8	Interlocking	Lockout	DI8

Table 8.2.5-7 High/Sensor H03

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io>--> Start	Iub> Start	DI1	DI1	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3I> Trip	Io>--> Trip	Iub> Trip	DI2	DI2	DI2	MEAS HI ALARM	TCS1
3I>> Start	Io>>--> Start	3Ith> Start	DI3	DI3	DI3	DI3	MCS 3I
3I>> Trip	Io>>--> Trip	3Ith> Trip	DI4	DI4	DI4	DI4	MCS 3U
3I>>> Start	Io>>>--> Start	O-->I OPEN	DI5	DI5	DI5	DI5	DI5
3I>>> Trip	Io>>>-->Trip	O-->I ACTIVE	DI6	DI6	DI6	DI6	DI6
		O-->I ALAR1	DI7	DI7	DI7	DI7	DI7
		O-->I ALAR2	DI8	DI8	Interlocking	Lockout	DI8

Table 8.2.5-8 High/Sensor H04

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io>--> Start	Io> Start	f1 Start 1	O-->I OPEN	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3I> Trip	Io>--> Trip	Io> Trip	f1 Trip 1	O-->I ACTIVE	DI2	MEAS HI ALARM	TCS1
3I>> Start	Io>>--> Start	Io>> Start	f1 Start 2	O-->I ALAR1	DI3	DI3	MCS 3I
3I>> Trip	Io>>--> Trip	Io>> Trip	f1 Trip 2	O-->I ALAR2	DI4	DI4	MCS 3U
3I>>> Start	Io>>>--> Start	Io>>> Start	Iub> Start	DI1	DI5	DI5	DI5
3I>>> Trip	Io>>>-->Trip	Io>>> Trip	Iub> Trip	DI2	DI6	DI6	DI6
3I>--> Start			3Ith> Start	DI3	DI7	DI7	DI7
3I>--> Trip			3Ith> Trip	DI4	Interlocking	Lockout	DI8

Table 8.2.5-9 High/Sensor H05

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io> Start	3U> Start	Uo> Start	DI1	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3I> Trip	Io> Trip	3U> Trip	Uo> Trip	DI2	DI2	MEAS HI ALARM	TCS1
3I>> Start	Io>> Start	3U>> Start	Uo>> Start	DI3	DI3	DI3	MCS 3I
3I>> Trip	Io>> Trip	3U>> Trip	Uo>> Trip	DI4	DI4	DI4	MCS 3U
3I>>> Start	Io>>> Start	3U< Start	Uo>>> Start	DI5	DI5	DI5	DI5
3I>>> Trip	Io>>> Trip	3U< Trip	Uo>>> Trip	DI6	DI6	DI6	DI6
	3Ithdev> Start	3U<< Start	DI1	DI7	DI7	DI7	DI7
	3Ithdev> Trip	3U<< Trip	DI2	DI8	Interlocking	Lockout	DI8

Table 8.2.5-10 High/Sensor H06

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3U> Start	Uo> Start	f1 Start 1	3I> Start	DI1	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3U> Trip	Uo> Trip	f1 Trip 1	3I> Trip	DI2	DI2	MEAS HI ALARM	TCS1
3U>> Start	Uo>> Start	f1 Start 2	3I>> Start	DI3	DI3	DI3	MCS 3I
3U>> Trip	Uo>> Trip	f1 Trip 2	3I>> Trip	DI4	DI4	DI4	MCS 3U
3U< Start	Uo>>> Start	f2 Start 1	DI1	DI5	DI5	DI5	DI5
3U< Trip	Uo>>>Trip	f2 Trip 1	DI2	DI6	DI6	DI6	DI6
3U<< Start		f2 Start 2	DI3	DI7	DI7	DI7	DI7
3U<< Trip		f2 Trip 2	DI4	DI8	Interlocking	Lockout	DI8

Table 8.2.5-11 High/Sensor H07

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io>--> Start	3U> Start	I2> Start	I2> Trip	U1U2<>_1 Start	MEAS LO ALARM	CB wear1
3I> Trip	Io>--> Trip	3U> Trip	I2>> Start	I2>> Trip	Restart Disabled	MEAS HI ALARM	TCS1
3I>> Start	Io>>--> Start	3U>> Start	3Ithdev> Start	3Ithdev> Trip	MEAS HI ALARM	DI3	MCS 3I
3I>> Trip	Io>>--> Trip	3U>> Trip	Is2t n< Start	Is2t n< Trip	DI1	DI4	MCS 3U
3I>>> Start	Io> Start	3U< Start	3I< Start	3I< Trip	DI2	DI5	TIME1
3I>>> Trip	Io> Trip	3U< Trip	3I() Start	3I() Trip	DI3	DI6	Motor Runs
	Io>> Start	3U<< Start	f1 Start 1/2	f1 Trip 1/2	DI4	DI7	DI7
	Io>> Trip	3U<< Trip	FUSEF	U1U2<>_1 Trip	Interlocking	Lockout	DI8

Table 8.2.5-12 High H08

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io> Start	3U> Start	Uo> Start	DI1	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3I> Trip	Io> Trip	3U> Trip	Uo> Trip	DI2	DI2	MEAS HI ALARM	TCS1
3I>> Start	Io>> Start	3U>> Start	Uo>> Start	DI3	DI3	DI3	MCS 3I
3I>> Trip	Io>> Trip	3U>> Trip	Uo>> Trip	DI4	DI4	DI4	MCS 3U
3I>>> Start	Io>>> Start	3U< Start	Uo>>> Start	DI5	DI5	DI5	DI5
3I>>> Trip	Io>>> Trip	3U< Trip	Uo>>> Trip	DI6	DI6	DI6	DI6
	3Ithdev> Start	3U<< Start	DI1	DI7	DI7	DI7	DI7
	3Ithdev> Trip	3U<< Trip	DI2	DI8	Interlocking	Lockout	DI8

Table 8.2.5-13 High H09

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io> Start	3U> Start	Uo> Start	DI1	MEAS HI ALARM	MEAS LO ALARM	CB wear1
3I> Trip	Io> Trip	3U> Trip	Uo> Trip	DI2	DI2	MEAS HI ALARM	TCS1
3I>> Start	Io>> Start	3U>> Start	Uo>> Start	DI3	f2 Start1/2	f2 Trip1/2	MCS 3I
3I>> Trip	Io>> Trip	3U>> Trip	Uo>> Trip	DI4	DI4	DI4	MCS 3U
3I>>> Start	Io>>> Start	3U< Start	Uo>>> Start	DI5	DI5	DI5	O-->I OPEN
3I>>> Trip	Io>>> Trip	3U< Trip	Uo>>> Trip	DI6	DI6	DI6	O-->I ACTIVE
		3U<< Start	f1 Start1/2	f1 Trip1/2	DI7	DI7	O-->I ALARM1
		3U<< Trip	DI2	DI8	Interlocking	Lockout	O-->I ALARM2

Table 8.2.5-14 High H50

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io> Start	3U> Start	Uo> Start	f1 Start 1/2	U1U2<>_1 Start	MEAS_LO ALARM	CB wear1
3I> Trip	Io> Trip	3U> Trip	Uo> Trip	f1 Trip 1/2	MEAS_HI ALARM	MEAS_HI ALARM	TCS1
3I>> Start	Io>> Start	3U>> Start	Uo>> Start	f2 Start1/2	DI1	DI4	MCS 3I
3I>> Trip	Io>> Trip	3U>> Trip	Uo>> Trip	f2 Trip 1/2	DI2	DI5	MCS 3U
3I>>> Start	Io>--> Start	3U< Start	3I>--> Start	f prot.	DI3	DI6	O-->I OPEN
3I>>> Trip	Io>--> Trip	3U< Trip	3I>--> Trip	U1U2<>_1 Trip	DI4	DI7	O-->I ACTIVE
	Io>>--> Start	3U<< Start	3I>>--> Start		DI5	DI8	O-->I ALARM1
	Io>>--> Trip	3U<< Trip	3I>>--> Trip		Interlocking	Lockout	O-->I ALARM2

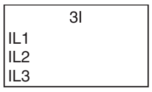
Table 8.2.5-15 High H51

LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
3I> Start	Io>--> Start	3U> Start	I2> Start	I2> Trip	U1U2<>_1Start	MEAS_LO ALARM	CB wear1
3I> Trip	Io>--> Trip	3U> Trip	3Ithdev> Start	3Ithdev> Trip	Restart Disabled	MEAS_HI ALARM	TCS1
3I>> Start	Io>>--> Start	3U>> Start	Is2t n< Start	Is2t n< Trip	MEAS_HI ALARM	f prot.	MCS 3I
3I>> Trip	Io>>--> Trip	3U>> Trip	3I() Start	3I() Trip	DI1	DI5	MCS 3U
3I>>> Start	Io> Start	3I>>--> Start	FUSEF	U1<U1U2> Trip	DI2	DI6	TIME1
3I>>> Trip	Io> Trip	3I>>--> Trip	f1 Start 1/2	f2 Start 1/2	DI3	DI7	Motor Runs
	Io>> Start	Uo> Start	f1 Trip 1/2	f2 Trip1/2	DI4	DI8	DI7
	Io>> Trip	Uo> Trip			Interlocking	Lockout	DI8

8.3. Measurement

8.3.1. 3I

The measurement function block 3I measures the true RMS phase currents, that is, harmonics are not suppressed. The current values are updated once a fundamental frequency cycle, that is, the integration time for the true RMS calculation is one fundamental cycle.



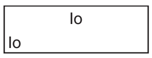
A051995

Fig. 8.3.1.-1 Function block symbol of 3I

Three-phase current measurement, 3I	
IL1	0.0…20000.0 A
IL2	0.0…20000.0 A
IL3	0.0…20000.0 A
IL1	0.0…1000.0% In
IL2	0.0…1000.0% In
IL3	0.0…1000.0% In
IL1 demand	0.0…20000.0 A
IL2 demand	0.0…20000.0 A
IL3 demand	0.0…20000.0 A
IL1 demand	0.0…1000.0% In
IL2 demand	0.0…1000.0% In
IL3 demand	0.0…1000.0% In

8.3.2. Io

The neutral current measurement function block Io measures the true RMS neutral current, that is, harmonics are not suppressed. The current values are updated once a fundamental frequency cycle, that is, the integration time for the true RMS calculation is one fundamental cycle



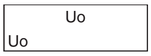
A051996

Fig. 8.3.2.-1 Function block symbol of Io

Neutral current measurement, Io	
Io (A)	0.0…20000.0 A
Io (%)	0.0…80.0% In

8.3.3. Uo

The function block Uo measures either the true RMS residual voltage, that is, harmonics are not suppressed, or the numerically calculated fundamental component amplitude of the residual voltage. A HMI parameter or a serial communication parameter can be used for selecting the measuring mode. The voltage value is updated once a fundamental frequency cycle, that is, the integration time for the true RMS calculation, is one fundamental cycle.



A051997

Fig. 8.3.3.-1 Function block symbol of Uo

Residual voltage measurement, Uo	
Uo Uo	0…440000 V 0.0…120.0% Un

8.3.4. DREC

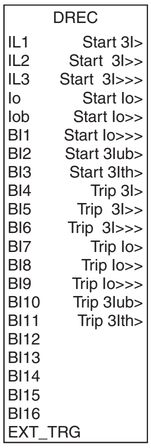
The transient disturbance recorder DREC is used for recording current waveforms and, when available, voltage waveforms. Furthermore, start and trip signals from the protection functions are recorded. The amount of recorded signals is standard configuration specific; refer to the block diagram of the standard configuration.

The default setting for the analogue channels recorded in DREC does not include I_{0b} measurement. When I_{0b} is in use and it is wanted to record data, the used analogue channel setting has to be changed in `Main menu\Measurement\DREC\General info\AI chs used`.

Recording can be triggered on the rising or falling edge of any or several of the digital inputs, on an adjustable level of overcurrent, overvoltage or undervoltage, or the recording can be triggered manually via the HMI, via serial communication or a parameter, or using a periodic triggering.

Notice that the recordings will be cleared if setting some of the parameters which cause the device to reset.

Refer to Technical Reference Manual, General, chapter "Relay Setting Tool view" (see Section 1.3. Related documents).



A051998

Fig. 8.3.4.-1 Function block symbol of DREC

Transient disturbance recorder, DREC	
Operation mode	Saturation Overwrite Extension
Pre-trg time	0…100%
Over limit ILx	0.00…40.00 x In
Over limit Io	0.00…40.00 x In
Over limit Uo	0.00…2.00 x Un
AI filter time	0.000…60.000 s

The recording can be triggered by any (or several) of the alternatives listed below:
• triggering on the rising or falling edge of any (or several) of the digital inputs
• triggering on undercurrent, undervoltage
• triggering via serial communication or a parameter
• periodic triggering
The recording length depends on the number of recordings and inputs used. For example, the following combination of recording length, number of recordings and number of inputs is available at 50 Hz (in parentheses the total recording time at 60 Hz):

# **recordings \ # inputs**	**1**	**2**	**3**	**4** [a]	**5**	**6**	**7** [b]
1	1066 cyc. 21.3 s (17.8 s)	581 cyc. 11.6 s (9.7 s)	399 cyc. 8.0 s (6.7 s)	304 cyc. 6.1 s (5.1 s)	246 cyc. 4.9 s (4.1 s)	206 4.1 s (3.4 s)	177 cyc. 3.5 s (3.0 s)
5	212 cyc. 4.2 s (3.5 s)	116 cyc. 2.3 s (1.9 s)	79 cyc. 1.6 s (1.3 s)	60 cyc. 1.2 s (1.0 s)	49 cyc. 1.0 s (0.8 s)	41 0.8 s (0.7 s)	35 cyc. 0.7 s (0.6 s)
10	106 cyc. 2.1 s (1.8 s)	57 1.1 s (1.0 s)	39 cyc. 0.8 s (0.7 s)	30 cyc. 0.6 s (0.5 s)	24 cyc. 0.5 s (0.4 s)	20 cyc. 0.4 s (0.3 s)	17 cyc. 0.34 s (0.28 s)

a. Used in Basic and Medium configurations
b. Used in High and Sensor configurations

Table 8.3.4-1 DREC digital inputs (Trip 1...5 are Output SWGRP signals.)

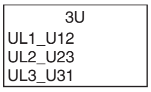
Input	B01/B02	M01/M02	H01 [a]	H02	H03	H04
BI1	Start 3I>	Start 3I>	Start 3I>-->	Start 3I>-->	Start 3I>	Start 3I>
BI2	Start 3I>>	Start 3I>>	Start 3I>>-->	Start 3I>>-->	Start 3I>>	Start 3I>>
BI3	Start 3I>>>	Start 3I>>>	Start 3I>>>	Start 3I>	Start 3I>>>	Start 3I>>>
BI4	Start Io>	Start Io>-->	Start Io>-->	Start 3I>>	Start Io>-->	Start Io>-->
BI5	Start Io>>	Start Io>>-->	Start Io>>-->	Start Io>-->	Start Io>>-->	Start Io>>-->
BI6	Start Io>>>	Start Io>>>-->	Start Io>>>-->	Start Io>>-->	Start Io>>>-->	Start Io>>>-->
BI7	Start Iub>	Start Iub>	Start Iub>	Start Io>>>-->	Start Iub>	Start Io>
BI8	Start 3Ith>	Start 3Ith>	Start 3Ith>	Start Iub>	Start 3Ith>	Start Io>>
BI9	Trip 3I>	Trip 3I>	Trip 3I>-->	Start 3Ith>	Trip 3I>	Start Io>>>
BI10	Trip 3I>>	Trip 3I>>	Trip 3I>>-->	Start1 f1	Trip 3I>>	Start Iub>
BI11	Trip 3I>>>	Trip 3I>>>	Trip 3I>>>	Start2 f1	Trip 3I>>>	Start 3Ith>
BI12	Trip Io>	Trip Io>-->	Trip Io>-->	Trip1	Trip Io>-->	Start 3I>-->
BI13	Trip Io>>	Trip Io>>-->	Trip Io>>-->	Trip2	Trip Io>>-->	Start1 f1
BI14	Trip Io>>>	Trip Io>>>-->	Trip Io>>>-->	Trip3	Trip Io>>>-->	Start2 f1
BI15	Trip Iub>	Trip Iub>	Trip Iub>	Trip4	Trip Iub>	Trip1
BI16	Trip 3Ith>	Trip 3Ith>	Trip 3Ith>	Trip5	Trip 3Ith>	Trip2

Input	H05/H08 [b]	H06	H07	H09 [b]	H50 [b]	H51 [b]
BI1	Start 3I>	Start 3I>	Start 3I>	Start 3I>	Start 3I>	Start 3I>
BI2	Start 3I>>	Start 3I>>	Start 3I>>	Start 3I>>	Start 3I>>	Start 3I>>
BI3	Start 3I>>>	Start 3U>	Start 3I>>>	Start 3I>>>	Start 3I>>>	Start 3I>>>
BI4	Start Io>	Start 3U>>	Start Io>-->	Start Io>	Start Io>	Start Io>-->
BI5	Start Io>>	Start 3U<	Start Io>>-->	Start Io>>	Start Io>>	Start Io>>-->
BI6	Start Io>>>	Start 3U<<	Start Io>	Start Io>>>	Start Io>-->/Io>>-->	Start Io>/Io>>
BI7	Start 3U>	Start Uo>	Start Io>>	Start 3U>	Start 3I>-->/3I>>-->	Start 3U</3U>
BI8	Start 3U>>	Start Uo>>	Start 3Ithdev>	Start 3U>>	Start 3U>/3U>>	Start 3Ithdev>
BI9	Start 3U<	Start Uo>>>	Start I2>/I2>>	Start 3U<	Start 3U</3U<<	Start I2>
BI10	Start 3U<<	Start 1 f1	Start Is2t n<	Start 3U<<	Start 1/Start 2 f1	Start Is2t, n<
BI11	Start Uo>	Start 2 f1	Start 3I<	Start Uo>	Start 1/Start 2 f2	Start 1/Start 2 f1
BI12	Start Uo>>	Start 1 f2	Start 3U>/3U>>	Start Uo>>	Start Uo>	Start 1/Start 2 f2
BI13	Start Uo>>>	Start 2 f2	Start 3U</3U<<	Start Uo>>>	Start Uo>>	Start 3I>>-->
BI14	Trip 1	Trip 1	Start1/Start2 f1	Start1/Start2 f1	Start U1<U1U2>	Start Uo>
BI15	Trip 2	Trip 2	Trip1	Start1/Start2 f2	f prot.	f prot.
BI16	Trip 3	Trip 3	Trip2	Trip1	Trip1	Trip1

a. H01 not available with transformers
b. H08, H09, H50, H51 not available with sensors

8.3.5. 3U

The measurement function block 3U measures true RMS phase-to-earth or phase-to-phase voltages. If voltage dividers are used, as in configurations H01S-H07S, only phase-to-earth voltages can be measured. If voltage transformers are used, as in configurations H02-H07, H50 and H51 only phase-to-phase voltages can be measured. As an exception from these, in configurations H08 and H09, voltage transformers are used and phase-to-earth voltage is measured. The voltage values are updated once per fundamental frequency cycle, that is, the integration time for true RMS calculation is one fundamental cycle.



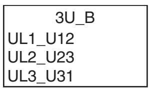
A051999

Fig. 8.3.5.-1 Function block symbol of 3U

Three-phase voltage measurement, 3U			
UL1_U12	0.00...999.99 kV	UL1_U12 average	0.00...999.99 kV
UL2_U23	0.00...999.99 kV	UL2_U23 average	0.00...999.99 kV
UL3_U31	0.00...999.99 kV	UL3_U31 average	0.00...999.99 kV
UL1_U12	0.00...2.00 x Un	UL1_U12 average	0.00...2.00 x Un
UL2_U23	0.00...2.00 x Un	UL2_U23 average	0.00...2.00 x Un
UL3_U31	0.00...2.00 x Un	UL3_U31 average	0.00...2.00 x Un

8.3.6. 3U_B

The measurement function block 3U_B measures true RMS phase-to-earth or phase-to-phase voltages. In configurations H08 and H09, 3U_B measures the calculated phase-to-phase voltage. The voltage values are updated once per fundamental frequency cycle, that is, the integration time for true RMS calculation is one fundamental cycle.



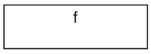
A052000

Fig. 8.3.6.-1 Function block symbol of 3U_B

Three-phase voltage measurement, 3U_B			
UL1_U12	0.00...999.99 kV	UL1_U12 average	0.00...999.99 kV
UL2_U23	0.00...999.99 kV	UL2_U23 average	0.00...999.99 kV
UL3_U31	0.00...999.99 kV	UL3_U31 average	0.00...999.99 kV
UL1_U12	0.00...2.00 x Un	UL1_U12 average	0.00...2.00 x Un
UL2_U23	0.00...2.00 x Un	UL2_U23 average	0.00...2.00 x Un
UL3_U31	0.00...2.00 x Un	UL3_U31 average	0.00...2.00 x Un

8.3.7. f

The measurement function block f measures the frequency of the network.



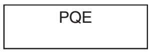
A052001

Fig. 8.3.7.-1 Function block symbol of f

System frequency measurement, f	
Frequency	10.00...75.00 Hz
Average Freq.	10.00...75.00 Hz
Voltage U	0.0...2.0 x Un

8.3.8. PQE

The measurement function block PQE measures fundamental frequency three-phase power and energy.



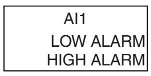
A052002

Fig. 8.3.8.-1 Function block symbol of PQE

Three-phase power and energy measurement, PQE			
P3 (kW)	-999999...999999 kW	Q3 demand (kVAr)	-999999...999999 kVAr
Q3 (kVAr)	-999999...999999 kVAr	Energy kWh	0...999999999 kWh
Power factor DPF	-1.00...1.00	Reverse kWh	0...999999999 kWh
Power factor PF	-1.00...1.00	Energy kvarh	0...999999999 kVArh
P3 demand (kW)	-999999...999999 kW	Reverse kvarh	0...999999999 kVArh

8.3.9. AI1

The analog measuring block is used for supervising current limits and for determining the state of the motor (running/stopped) in H07 and H51.



A052003

Fig. 8.3.9.-1 Function block symbol of AI1

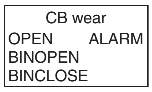
Analog input, AI1			
Limit selection	Not in use	High alarm	-10000.00000...10000.00000
	HW, HA, LW, LA	Low alarm	-10000.00000...10000.00000
	HW, HA	HA start delay	1.0...300.0 s
	LW, LA	HA reset delay	1.0...300.0 s
	HW, LW	LA start delay	1.0...300.0 s
	HA, LA	LA reset delay	1.0...300.0 s
	HW		
	HA		
	LW		
	LA		

8.4. Condition monitoring

8.4.1. CB wear1

In the circuit-breaker wear function block CB wear1, calculating the electrical wear of the circuit breaker is based on the current in each phase before opening. The breaker wear is calculated for each phase separately and when the accumulated breaker wear has reached the setting value, the function block will issue an alarm signal.

The function block uses a 16-point setting table (`Main menu\Cond.Monit.\CB wear1\ Control settings`) for the current and the corresponding breaker wear value. The calculation is based on linear interpolation using the table. Typically, the breaker wear increases in proportion to the square of the current. However, the interpolation table solution provides a close match and facilitates the configuration.

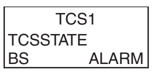


A052004

Fig. 8.4.1.-1 Function block symbol of CB wear1

8.4.2. TCS1

The trip-circuit supervision function block TCS1 does not perform the supervision itself but it is used as an aid for configuration. The functional part belongs mainly to the self-supervision tasks of the PS_ card.



A052005

Fig. 8.4.2.-1 Function block symbol of TCS1

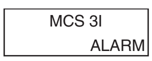
8.4.3. MCS 3I

The supervision function block MCS 3I detects interruptions in energizing current circuits. The function block supervises the energizing circuits by comparing the measured phase currents. If one or two phase currents exceed the setting “High limit”, while the measured phase current in the remaining one or two phases is below the setting “Low limit”, the output ALARM is activated after the adjustable alarm delay.

The function block is disabled if all input currents are below the setting “Low limit”.

The ALARM output will reset automatically when the fault disappears.

The phase current supervision function block operates on the numerically calculated fundamental frequency component of the phase currents.



A052006

Fig. 8.4.3.-1 Function block symbol of MCS 3I

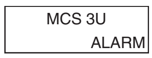
8.4.4. MCS 3U

The supervision function block MCS 3U detects interruptions in energizing voltage circuits. The user can select three-phase or two-phase operation. The function block can also be set out of use by means of the parameter.

The function block supervises the energizing circuits by comparing the measured voltages. If one or two voltages exceed the setting “High limit”, while the measured values of the remaining one or two voltages are below the “Low limit”, the output ALARM is activated after the set alarm delay.

The function block is disabled if all input voltages are below the setting “Low limit”.

The ALARM output resets automatically when the fault disappears.

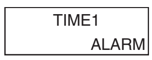


A052007

Fig. 8.4.4.-1 Function block symbol of MCS 3U

8.4.5. TIME1

The time measuring block TIME1 is used for measuring the motor running time in H07 and H51.



A052008

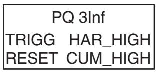
Fig. 8.4.5.-1 Function block symbol of TIME1

8.5. Power quality

8.5.1. PQ 3Inf

The current waveform distortion measurement function block PQ 3Inf is used for measuring the harmonics and monitoring the power quality in distribution networks. Although the European Standard EN 50160 concerns voltage distortion, the same standard is applied to current distortion measurements in PQ 3Inf. Measuring principles for individual harmonics and THD are adapted from the International standard IEC 61000-4-7. The American standard IEEE Std 1159 is also partly supported.

The function block measures quasi-stationary (slowly varying) harmonics up to 13th. Distortion measurement does not include rapidly changing harmonics, interharmonics or other spurious components.



A052009

Fig. 8.5.1.-1 Function block symbol of PQ 3Inf

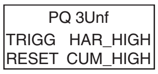
Current waveform distortion measurement, PQ 3Inf	
Measuring modes	Not in use; L1; L2; L3; Worst phase
Measurement activation	Triggering by: setting parameter, binary input, date & time setting
Triggering mode	Single; Continuous; Periodic
Distortion factor	THD; TDD
Monitored values	
THD (3 sec and 10 min mean values)	0.0... 1000.0%
Harmonic components from 1st to 13th (3 sec mean values)	0.0... 1000.0% In
Harmonic components from 2nd to 13th (10 min mean values)	0.0... 1000.0% In
Statistics	
Observation times for statistics	1 hour; 12 hours; 1 day; 2 days; 3 days; 4 days; 5 days; 6 days; 1 week
Percentile setting	90.0... 99.5%
Percentiles for each harmonic and THD	0.0... 1000.0% In
Five fixed percentiles (1,5,50,95,99) for one selectable harmonic or THD	0.0... 1000.0% In
Maximum values for each harmonic and THD	0.0... 1000.0% In
Recorded data	One data set for updating; One data set from the previous observation period
Harmonic limit supervision	
Limit for THD	0.0... 60.0%
Limits for each harmonic	0.0... 40.0% In
Recorded data	If any limit should be exceeded, the whole harmonic set will be recorded during the maximum THD (3 sec values)
Operation criteria	
Fundamental frequency	0.9... 1.1 Fn
Frequency deviation	≤ 0.5 Hz (difference between max. and min. values within 1s)
Amplitude of the fundamental wave	≥ 1% In
Measurement accuracy	
Measured harmonic Im = 1st,...,10th	In accordance with IEC 61000-4-7
Measured harmonic Im = 11th,..,13th	± 1.0% In, if Im < 10% In; ± 10% In, if Im ≥ 10% In

8.5.2. PQ 3Unf

The function block PQ 3Unf is used for measuring the harmonics and monitoring the power quality in distribution networks. Power quality measurements carried out by the function block PQ 3Unf follow the European Standard EN 50160. Data collection and analysis is done according to EN 50160. Measuring principles for individual harmonics and THD are adapted from the International standard IEC 61000-4-7. The American standard IEEE Std 1159 is also partly supported.

The function block measures quasi-stationary (slowly varying) harmonics up to 13th.

Distortion measurement does not include rapidly changing harmonics, interharmonics or other spurious components.



A052010

Fig. 8.5.2.-1 Function block symbol of PQ 3Unf

Voltage waveform distortion measurement, PQ 3Unf	
Measuring modes	Not in use, L1, L2, L3, Worst phase, L1-L2, L2-L3, L3-L1 Worst main
Measurement activation	Triggering by: setting parameter, binary input, date & time setting
Triggering mode	Single, Continuous, Periodic
Monitored values	
THD (3 sec and 10 min mean values)	0.0... 120.0%
Harmonic components from 1st to 13th (3 sec mean values)	0.0... 120.0% Un
Harmonic components from 2nd to 13th (10 min mean values)	0.0... 120.0% Un
Statistics	
Observation times for statistics	1 hour; 12 hours; 1 day; 2 days; 3 days; 4 days; 5 days; 6 days; 1 week
Percentile setting	90.0... 99.5%
Percentiles for each harmonic and THD	0.0... 120.0% Un
Five fixed percentiles (1,5,50,95,99) for one selectable harmonic or THD	0.0... 120.0% Un
Maximum values for each harmonic and THD	0.0... 120.0% Un
Recorded data	One data set for updating; One data set from the previous observation period
Harmonic limit supervision	
Limit for THD	0.1... 30.0%
Limits for each harmonic	0.0... 20.0% Un
Recorded data	If any limit should be exceeded, the whole harmonic set will be recorded during the maximum THD (3 sec values)
Operation criteria	
Fundamental frequency	0.9... 1.1 Fn
Frequency deviation	≤ 0.5 Hz (difference between max. and min. values within one second)
Amplitude of the fundamental wave	≥ 0.7 Un
Measurement accuracy	
Measured harmonic Im = 1st,..., 10th	In accordance with IEC 61000-4-7
Measured harmonic Im = 11th,..., 13th	± 0.3% Un, if Um < 3% Un; ± 10% Un, if Um ≥ 3% Un

8.6. Standard functions

8.6.1. Switchgroups (SWGRP)

The switchgroups are used for changing the functionality of the standard configuration via the HMI or using the Relay Setting Tool.

8.6.2. Selectors

The selectors are used for routing signals and connecting inputs. Every digital input can be connected to an input signal (for example Blocking 1, Master trip) via a selector. Likewise, an output signal can be connected to an output relay (Trip1, Alarm 1) via a selector.

9. Example substations

All the application examples are designed for typical HV/MV substations like below.

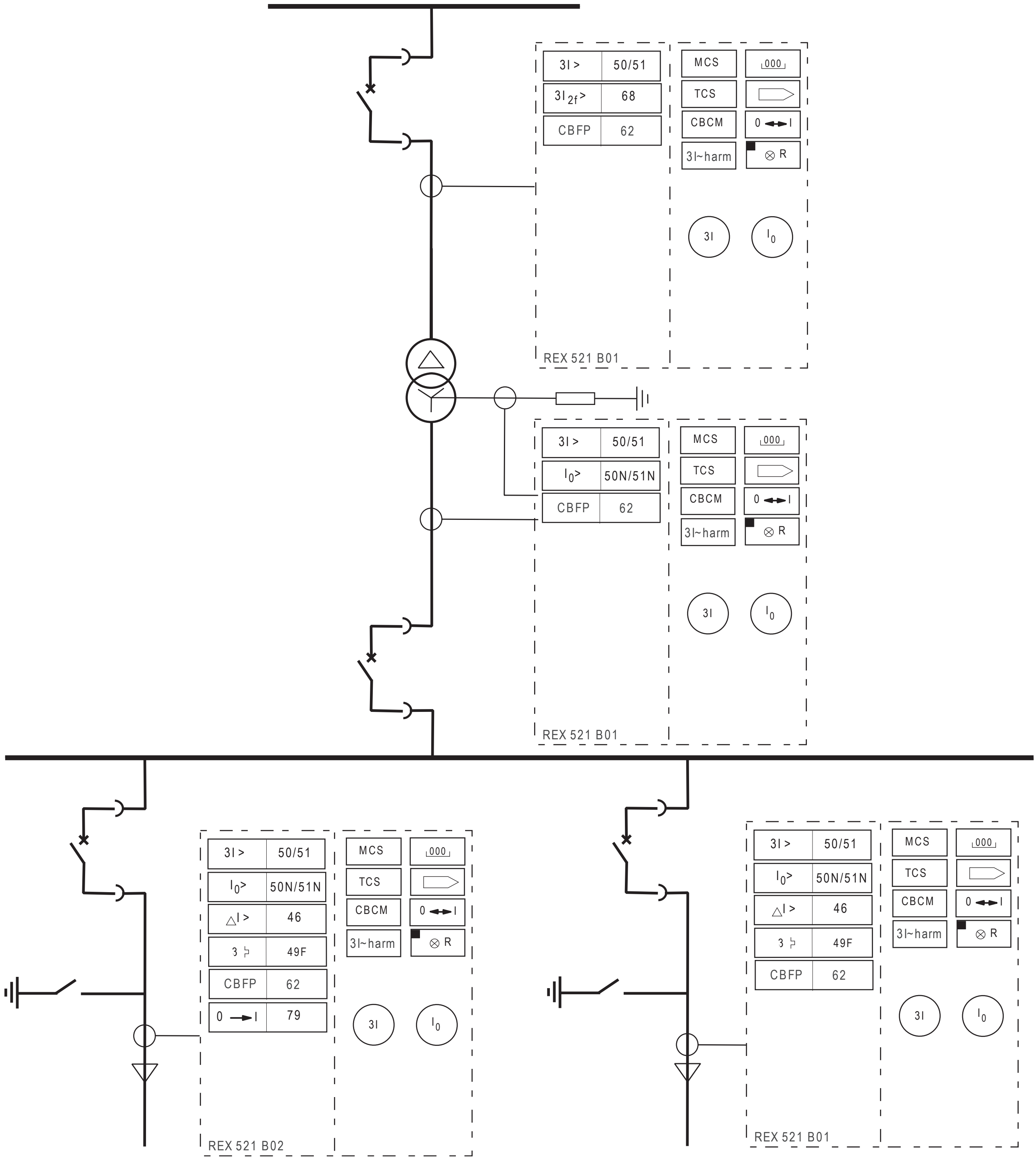


Fig. 9.-1 Typical HV/MV substation 1

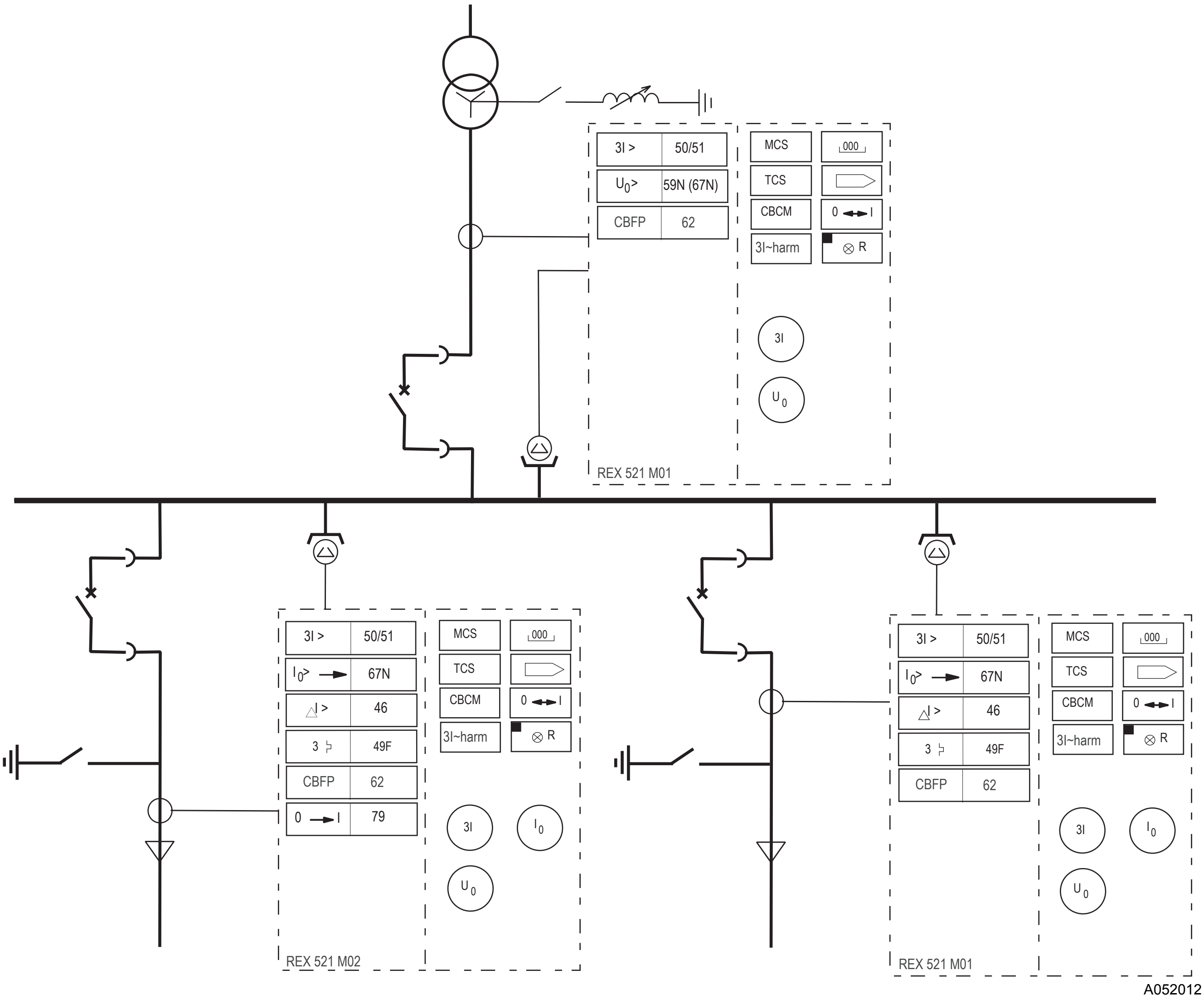


Fig. 9.-2 Typical HV/MV substation 2

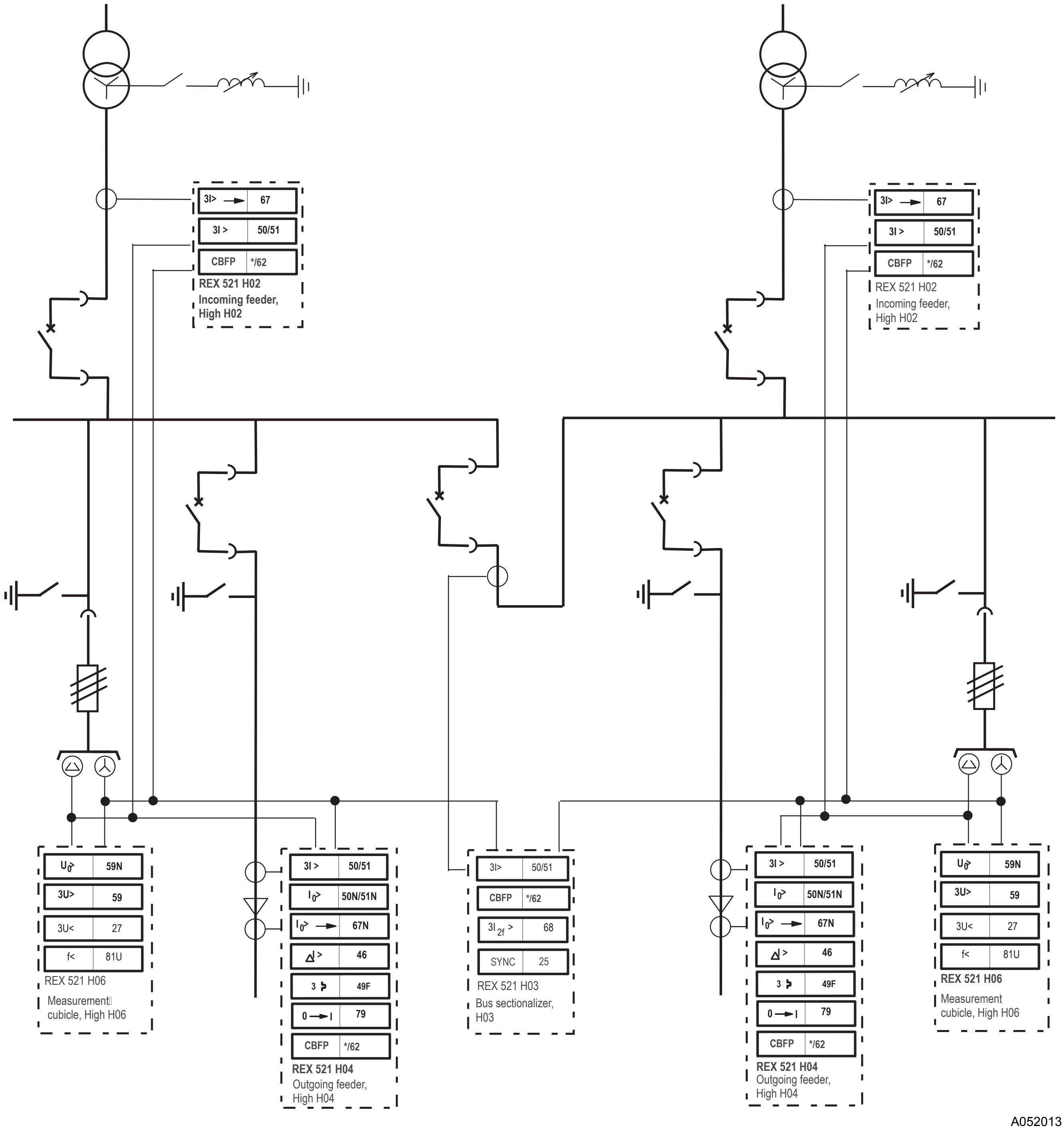


Fig. 9.-3 Typical HV/MV substation 3

10. Application examples, Basic

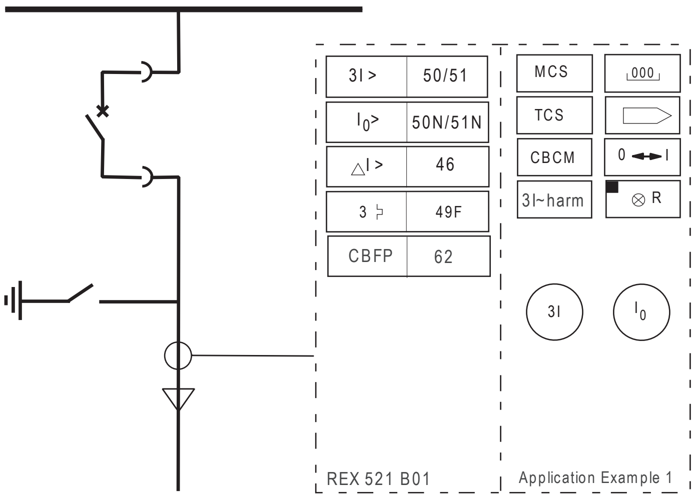
10.1. Outgoing feeder, Basic B01

10.1.1. Features

This application example describes an outgoing feeder of a single busbar including:

- Overcurrent protection
- Non-directional earth-fault protection
- Phase discontinuity protection
- Thermal overload protection for cable/line

The network is either resistance or solidly earthed. The three-phase current measurement is established with a set of current transformers. The neutral current is measured in a residual connection.



A052014

Fig. 10.1.1.-1 B01 is used for protection, measuring and supervision on an outgoing feeder in a single busbar system. The supplying network is either solidly or resistance earthed.

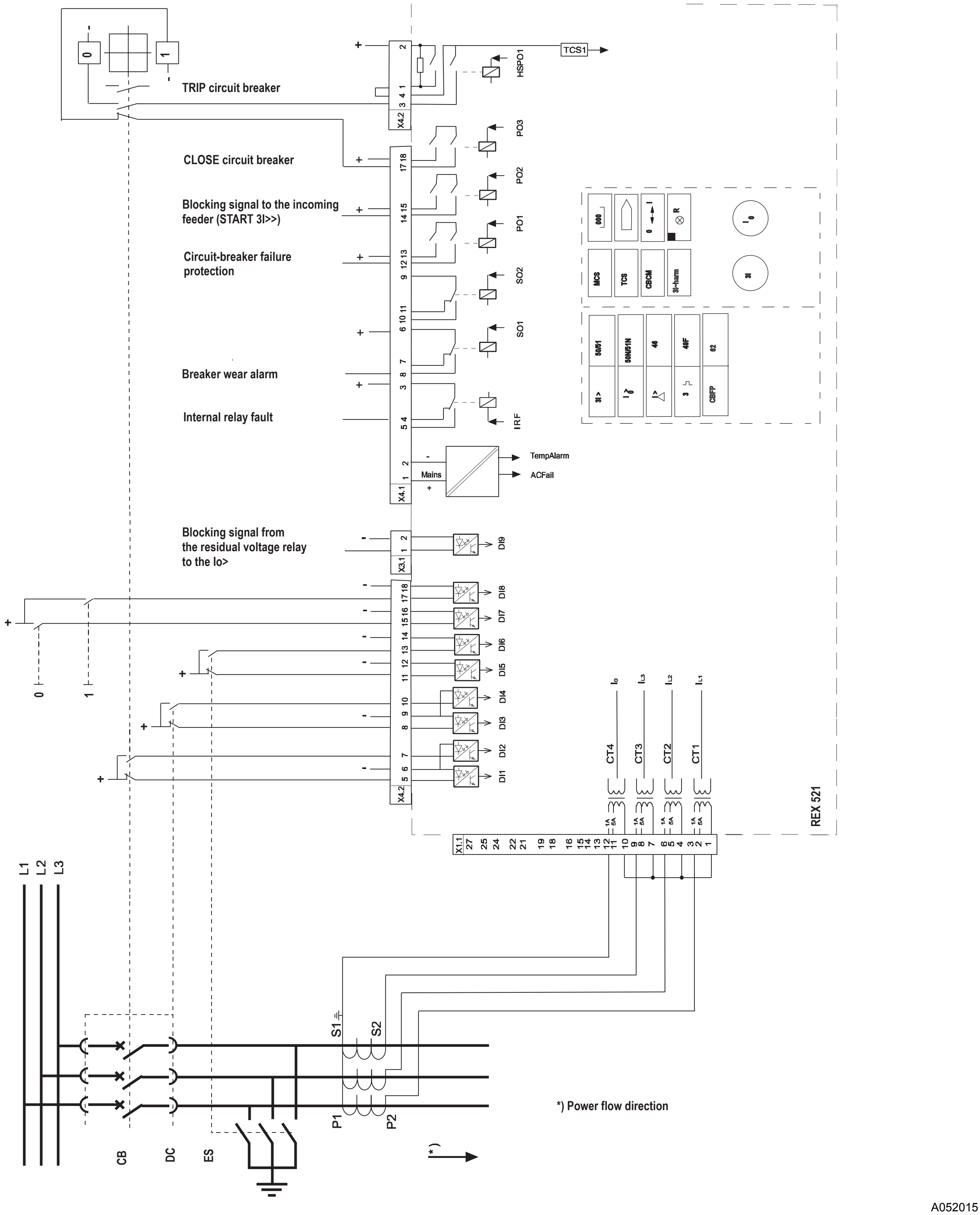


Fig. 10.1.1.-2 Connection overview diagram of the outgoing feeder

10.1.2. Measurement connections

The three-phase current transformers are connected to the connector X1.1 on the rear panel. The rated currents of the measuring input are 1 A and 5 A.

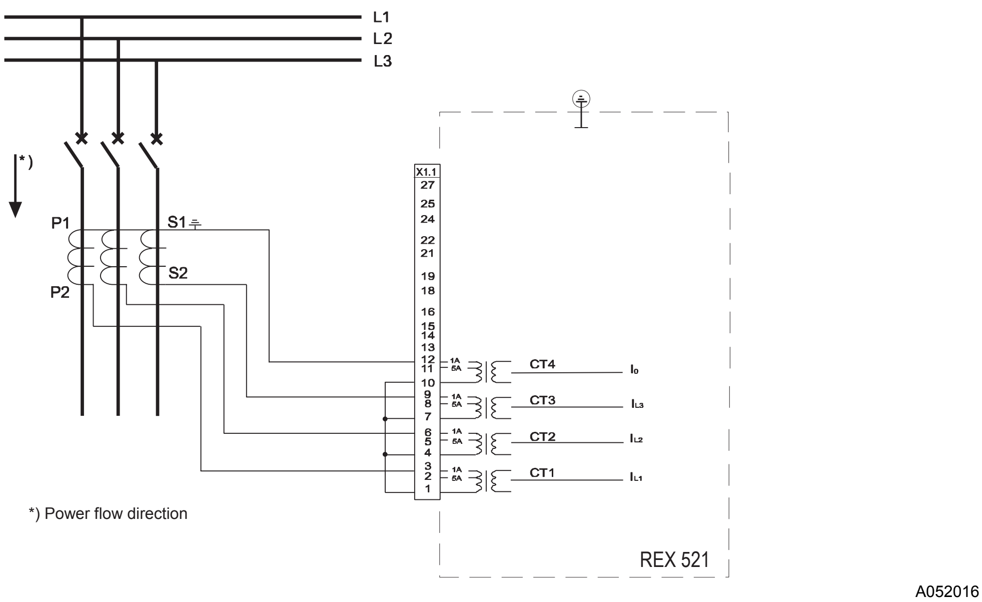


Fig. 10.1.2.-1 Connection diagram of the standard configuration B01 with three CTs in a residual connection

The technical data of the current transformers are set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Configuration\Meas. devices\`. Refer to Technical Reference Manual, General (see Section 1.3. Related documents) for further information about how to set the rated currents.

10.1.3. Protection

All the necessary settings for the protection functions can be set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

10.1.3.1. Phase overcurrent protection

The phase overcurrent protection includes three stages. By using all the three stages and giving each overcurrent stage its own start value and operate time, good selectivity with short operate times can be obtained.

Normally, a two-stage overcurrent protection is sufficient. However, when the short-circuit protection is based on blocking between the successive protection relays, the high-set stage 3I>> can be used for blocking purpose. As this stage (3I>>) is not used for tripping purposes, the blocking level can be freely set. This means that when the 3I>> overcurrent stage of the outgoing feeder starts, a blocking signal is provided to the 3I>>> overcurrent stage of the incoming feeder. When no blocking signal is received, the overcurrent protection of the incoming feeder perceives the fault as being within its own protection zone and trips the circuit breaker.

For more information about the phase overcurrent blocking signals between the first and the third application example, refer to the overview diagram on Fig. 10.3.5.-1.

The operation of the low-set overcurrent stage 3I> of the relay can be based on a definite- or on an inverse-time characteristic. The operation characteristic is selected within the settings of the low-set overcurrent function block. When the definite time characteristic has been selected, the operate time of the relay is current independent. On the contrary, when the inverse-time characteristic is in use, the operate time is a function of the fault current level: the greater the fault current, the shorter the operate time. Therefore, the operate time is short at close faults. The definite-time characteristic can be used for obtaining the time grading steps over a wide current range and it offers faster tripping times than the inverse time protection at low multiples of the current settings.

The settings for the over current protections can be found in: `Main menu\Protection\3I>\ … \3I>>>\Setting group 1\`. The parameters `Operation mode`, `Start current`, `Operate time` and `Time multiplier` for the function can be set in this setting group.

For example, in `Main menu\Protection\3I>\ … \3I>>>\Control setting\` the `Drop-off time` and the length of the trip signal, `Trip pulse`, can be set.

The data of the three last operations, start or trip, are recorded and the values of the most recent operation can be found in: `Main menu\Protection\3I>\ … \3I>>>\Recorded data1\…3\`.

10.1.3.2. Earth-fault protection

The neutral current can be measured either via a set of three-phase current transformers in a residual connection, like in this example, or via a core-balance current transformer. The residual connection can be used in the cases of high earth-fault currents and moderate sensitivity requirements. In solidly earthed networks or in networks earthed via a low-resistance resistor or low-impedance coil, the earth-fault current is high enough to guarantee the sufficient accuracy of the residual current connection for measuring the earth-fault current. The accuracy of the residual current connection depends on electrical similarity of the current transformers. To secure selectivity and stability at high fault current levels, current transformers with sufficient repeatability are recommended, especially, if the high-set stage is to operate instantaneously.

The earth-fault protection includes three stages. In the application two stages are in use, the low-set Io> stage and the high-set Io>> stage. The low-set stage fulfills the sensitivity requirements of the earth-fault protection and can be given definite-time or inverse-time characteristic. The high-set stage fulfills the operate-time requirements and can be used for instantaneous operation.

Alternatively the high-set stages Io>> and Io>>> can be used instead of Io> and Io>> in the example above, then the Io> stage can be an alarming stage for high resistance faults. Note that in this application example the CBFP signal has to be taken out of use for this stage. With the default settings, the CBFP is in use.

While using the sensitive non-directional earth fault it is recommended to secure the earth-fault functionality by using the start signal from a residual voltage relay to release blocking of the earth-fault protection. By doing this, unnecessary trips are avoided due to disturbances in the measured earth-fault current.

The settings for the earth-fault current protections can be found in `Main menu\Protection\Io>\ … \Io>>>\`.

10.1.3.3. Phase discontinuity protection

The phase discontinuity stage Iub> has a tripping function when used for protecting overhead lines. In cable networks, where phase discontinuity does not cause dangerous situations, the Iub> stage can give an alarm signal. The phase discontinuity protection can be used irrespective of the earthing principle.

An example of a phase discontinuity fault is a broken phase wire that has fallen down on such a place that the resistance towards earth, the specific soil resistivity, is very high. The earth-fault protection alone is not able to detect the fault and thus the feeder is not disconnected. The phase discontinuity protection is specially important in overhead lines and particularly in overhead lines with insulated phase wires. Another example of a phase discontinuity fault is a line breakdown and a one-phase earth fault on the load side. Note that a fault in the end of a long feeder behind several loads may result in a very low unbalance and thus the phase discontinuity protection may not operate.

The unbalance of the network is detected by monitoring the highest (IL_{max}) and the lowest (IL_{min}) phase currents. The unbalance is calculated according to the following formula:

$$\Delta I = 100\% \times \frac{IL_{max} - IL_{min}}{IL_{max}}$$

Full unbalance (100%) occurs when a phase conductor is broken before the first load on the phase. Due to asymmetrical load in the network, the normal unbalance has to be considered when defining the start value. Since this type of protection cannot be graded with other systems, it is confined to a supplementary role by the use of a long time delay, adjustable from 1s up to 300 s.

The settings for the phase discontinuity protection can be found in `Main menu\Protection\Iub>\Setting group 1\`, where the parameters `Operation mode`, `Start unbalance` and `Operate time` for the protection function can be set.

For example, the pulse length for the trip and the start signal can be set in `Main menu\Protection\Iub>\Control setting\`.

10.1.3.4. Thermal overload protection

The thermal overload protection 3Ith> is designed for protection of three-phase power cables and overhead lines. The calculation of the thermal model is based on the TRUE RMS measuring principle. The thermal load is calculated by means of the highest phase current value. The 3Ith> applies the thermal model of one time-constant for temperature measurement, which means that both the temperature rise and the cooling follow an exponential curve.

The following set values have to be defined for the 3Ith>: the time constant for the rise and cooling of the cable, the maximum rated load current for the cable, the maximum temperature allowed for the cable and the reference temperature in which the rated current has been defined.

The Start output becomes active when the calculated conductor temperature exceeds the setting of the `Prior alarm` parameter that can be given a value in the range 40% to 100%. The trip output is activated if the conductor temperature-rise measured in per cents exceeds the value of the `Trip temperature` parameter that can be set in the range 80% to 120%. The delayed trip is set into use by giving the `Trip temperature` parameter a value higher than 100% and the `Trip delay` parameter one higher than 0. For example, the trip temperature can be set to 120% and the trip delay to 60 min, in which case the function block trips when the cable load remains above 100% for 60 minutes but does not exceed 120%.

The CU_ALARM output alarms when the measured current has exceeded the level where, if it remains the same, the cable temperature will reach the maximum temperature set for the cable.

After the thermal overload protection has tripped, reclosing is not possible until the calculated conductor temperature falls below the value set for the `Reclosure temp` parameter, because the function block holds the trip output active. If the reclosing inhibit is chosen not to be used, the parameter is set to 100%.

In the initializing stage, that is, when the auxiliary voltage is connected to the relay, the function block assumes that the cable temperature has risen to 50% of the difference between the parameter values `Maximum temp` and `Ambient temp`. For example, if the maximum temperature has been set to +90°C (cable with PEX insulation) and the ambient temperature is set to +20°C, the relay assumes a temperature of +55°C for the cable.

The necessary settings for the thermal overload protection can be found in:
`Main menu\Protection\3Ith>\Setting group 1\`.

The calculated temperatures of the conductor can be viewed in:
`Main menu\Protection\3Ith>\Output data\`.

10.1.4. Connections and signal routings

All the necessary settings for the connected signals can be set via the Relay Setting Tool or the local HMI.

10.1.4.1. Protection signal routing

The protection trip signal, Trip 1, is routed to the high-speed power output HSPO1, (x4.2.1/2/3/4) as well as the control-open signal to the circuit breaker. The trip signals from the protection functions are routed to the output relay via the output switchgroups. These settings can be found in
`Main menu\Configuration\Output SWGRP\`.

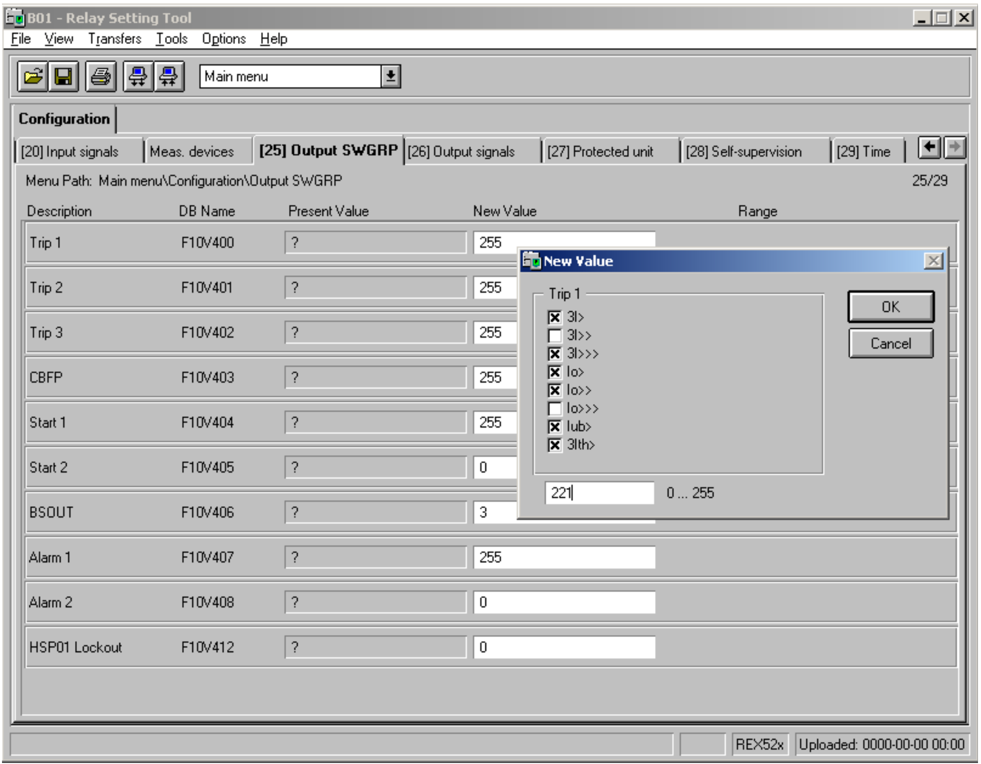
As the HSPO1 is always routed to the “Trip 1” output signal, the settings are made directly in `Main menu\Configuration\Output SWGRP\Trip 1` where the checksum for the settings is displayed (255 by default).

Using HMI:

To change the settings for the Trip 1, go to `Configuration\Output SWGRP\Trip 1` and press the [E]-button. The different protection functions are displayed one at a time. By pressing the [→] or [←] navigation push button, it is possible to scroll between the different protections. By pressing the [↑] or [↓] navigation push button, the specific protection function trip signal can be connected or disconnected. When the two-stage overcurrent (3I> and 3I>>>), two-stage earth fault (Io> and Io>>), the unbalance and thermal overload protection are selected, the checksum for the Trip 1 is 221.

Using Relay Setting Tool:

To change the settings for the Trip 1, go to the `Configuration` in config view and `Output SWGRP` and select the “New value” on Trip 1. Press backspace to change the value. In the “New value” window the protection functions that are used can be marked or unmarked. The checksum can also be changed directly. Finally, the new setting has to be sent to the relay with the Download  button. For more information about the tool, refer to Tools for Relays and Terminals, User’s Guide (see Section 1.3. Related documents).



A052018

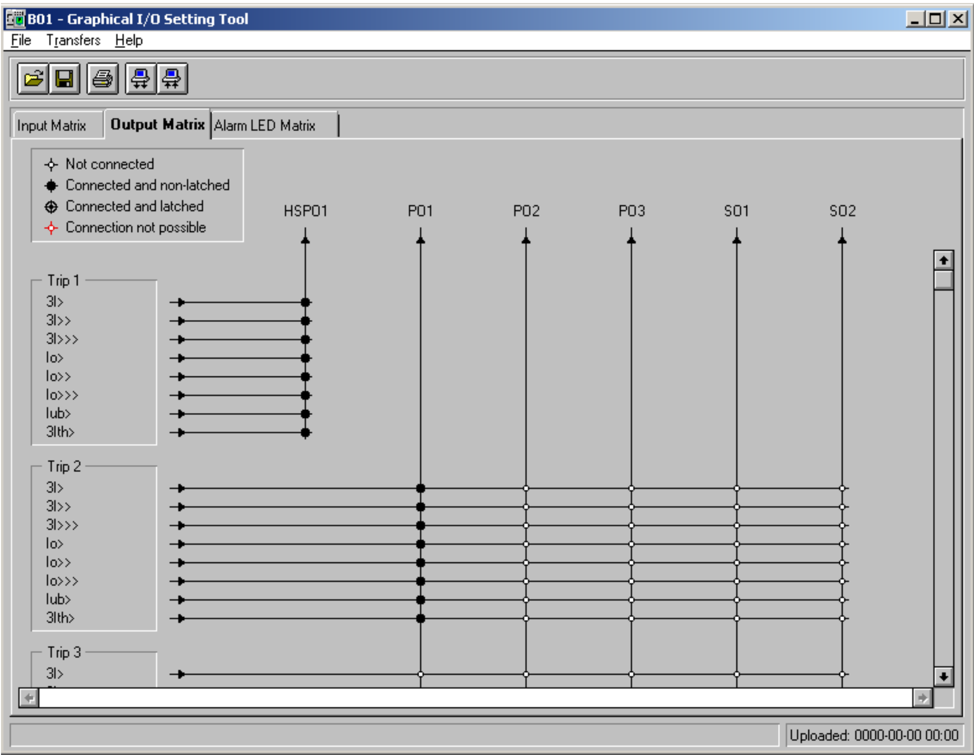
Fig. 10.1.4.1.-1 Changing the checksum value for the Trip 1 in the Relay Setting Tool

Using Graphical I/O Setting Tool

To change settings for Trip 1, go to the `Output Matrix`. Route the Trip 1 signals to HSPO1 with a mouse-click in the graphical matrix.

There are three connection options for each signal: “Not connected”, “Connected and non-latched” and “Connected and latched”. You can change the connection option by clicking the symbol with the mouse (see Fig. 10.1.4.1.-2).

Finally, the new setting has to be sent to the relay by using the Download button. For more information about the tool, refer to Tools for Relays and Terminals User's Guide (see Section 1.3. Related documents).



A052019

Fig. 10.1.4.1.-2 Setting Trip 1 signal in the Graphical I/O Setting Tool

10.1.4.2. Indication and control connections

The output signals can be routed to any of the output relays and in this example the circuit breaker close-signal is connected to the power output 3, PO3 (X4.1.17/18). The status indications from the circuit breaker can also be connected to any of the digital inputs DI1…DI9. In this example DI1 (X4.2.5/6), has been used for open indication and DI2 (X4.2.6/7), for close indication, mainly because these two inputs have a common ground.

The close signal can be connected to the output relay PO3 like this. In `Main menu\Configuration\Output Signals\`, scroll down to the PO3 output and select the close signal.

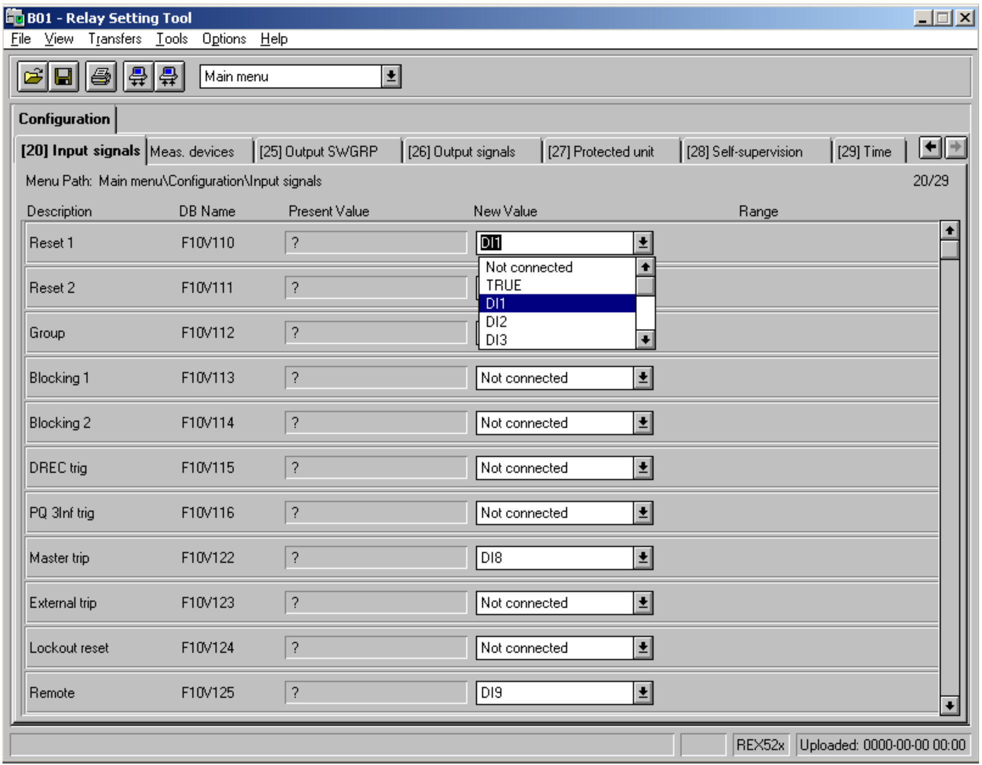
The status-indication signals are also routed from the digital inputs to the circuit breaker function (I<->O CB1) via the input signal selectors. These settings can be found in: `Main menu\Configuration\Input Signals\`, where the different input signal names are displayed and the specific inputs selected. The status-indication signals are named as “CB pos. open” and “CB pos. close”.

Using the HMI:

To change the settings for “CB pos. open” go to the `Configuration\Input Signals\` and scroll with the [↑] or [↓] navigation push button to “CB pos. open” and press the [E]-button. The different digital inputs are displayed one at a time by selecting with the [↑] or [↓] navigation push button. Select DI1 and press the [E]-button to confirm. Scroll to the “CB pos. close” and select the DI2 input.

Using Relay Setting Tool:

To change the settings for the CB pos. open go to the Configuration/Input Signals and find CB pos. open. Select DI1 in the pull-down menu. For more information, refer to Tools for Relays and Terminals, User’s Guide (see Section 1.3. Related documents).



A052020

Fig. 10.1.4.2.-1 Selecting the digital input for the status indication of the breaker in the Relay Setting Tool

In this application example the open and close push buttons are connected to the digital inputs DI7 and DI8. Normally these buttons are connected directly to the open or close circuits of the breaker. By including these to the relay, it is possible to monitor the whole opening and closing time of the breaker and it is also possible to define the pulse width for the open and close pulse. The manual opening and closing via push buttons are also disabled when the relay is set to remote mode, and vice versa when the relay is in local mode, the remote control is disabled. If the breaker is interlocked and the interlocking scheme is used with one or more digital inputs configured to the "CLOSEENA" input signal, no close pulse will be sent from the relay. The open and close input signals have to be selected via the `Configuration\Input Signals\` menu in the same way as for the breaker status indication signals.

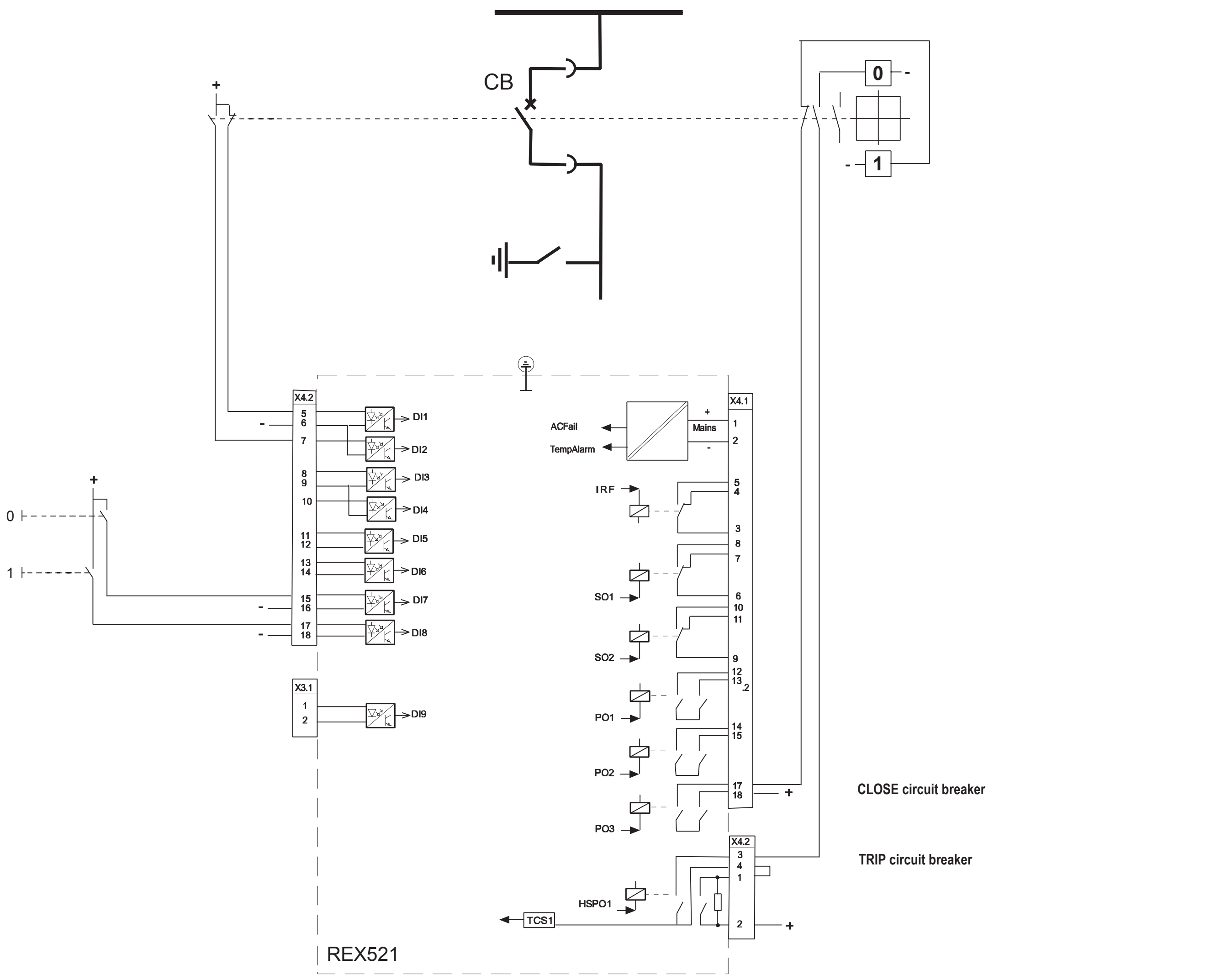


Fig. 10.1.4.2.-2 Connection diagram for the standard configuration B01 with the breaker status indication and the control signals for opening and closing of the circuit breaker

10.1.5. Implementations

In the sections below a few implementation examples for the standard configuration B01 are presented.

10.1.5.1. Outgoing blocking signal to the incoming feeder

The start signals from any protection function can be routed to an output relay to provide a blocking signal to the incoming feeder. The overcurrent stages 3I>> and 3I>>> have also a separate BSOUT signal for blocking purpose.

To use the start signal from a protection function the signal has to be routed via the `Main menu\Configuration\Output SWGRP\Start 1` or `\Start 2`. When the start signals have been routed, the output relay has to be selected in the `Main menu\Configuration\Output Signals`. In this example, the overcurrent stage 3I>> is routed via Start 1 and then connected to the power output 2, PO2. In this application example, the checksum for the Start 1 is 2.

10.1.5.2. Blocking signal received from the residual voltage relay

To release blocking, the start signals from a residual voltage relay can be connected to the earth-fault stages in the outgoing feeder. There are two input blocking signals, Blocking 1 and Blocking 2, which can have different functions depending on the different protections.

The Blocking 1 input signal is connected to the BS1 input and the Blocking 2 input signal is connected to the BS2 input of the earth-fault stages Io>, Io>> and Io>>>. The BS1 in this application example will stop the DT (Definite time) or the IDTM (Inverse Definite Time) timer and the BS2 will block the trip signal. Refer to the CD-ROM Technical Descriptions of Functions (see Section 1.3. Related documents) for more information.

In this application example, the digital input DI9 is connected to the input signal Blocking 1 and then routed to the BS1 input of the earth-fault stage Io>. The Blocking 1 signal can be found in `Main menu\Configuration\Input Signals\Blocking 1\` where the DI9 is selected. The checksum for the switchgroup in `Main menu\Configuration\Input SWGRP\Blocking 1\` is 8 to block Io>.

Normally the Blocking 1 signal is set to release the Io> blocking when the residual voltage relay starts, and give the Io> protection a permission to start and further execute trip after the set time delay has elapsed. For instance, this can be established by inverting the digital input DI9 and use the start signal from the residual relay for permission.

10.1.5.3. Circuit-breaker failure protection

Every protection function in the standard configuration B01 provides a delayed trip signal CBFP after the trip signal unless the fault has not disappeared during the set CBFP time delay. In circuit-breaker failure protection, the CBFP output can be used for operating an upstream circuit-breaker.

The settings for the breaker failure are set separately for each protection function. For example, to set the CBFP time for the 3I>> go to Main menu\Protection\3I>>\Control settings, where it is possible to set the CBFP time from 100 ms to 1000 ms. The control parameter Trip pulse sets the width of the trip output signal, but also of the CBFP output signal.

The CBFP signals from the protection functions are routed to the output signals via the output switchgroups. These settings can be found in Main menu\Configuration\Output SWGRP\CBFP. When the three-stage overcurrent, the two-stage earth fault, the unbalance and thermal overload protection are selected the checksum for the CBFP is 223.

The CBFP signal is then connected to any of the output relays, via Main menu\Configuration\Output Signals\. In this example, the circuit-breaker failure signal is connected to the power output 1, PO1.

10.1.5.4. Trip-circuit supervision

The trip-circuit supervision is available for the HSPO1 relay. If the resistance of the trip circuit exceeds a certain limit, for instance due to a bad contact or oxidation, the supervision function will be activated and a trip-circuit supervision alarm signal is provided after an adjustable delay time. The settings for the function can be found in Main menu\Cond. monit.\TCS1\.

To avoid unnecessary alarms, the trip-circuit supervision can be blocked by the BS signal, which disables the supervision output when the circuit breaker is open. The BS signal is configured to be operated by the “CB pos. open” status from the selected digital input. The BS signal can be connected via the switchgroup in Main menu\Configuration\Input SWGRP\TCS1\. The default setting of the parameter is ”Not in use”.

Another solution is to use an external resistor to prevent the TCS1 alarm. Refer to Technical Reference Manual, General (see Section 1.3. Related documents) for more information about the trip-circuit supervision.

10.1.5.5. Condition monitoring of the breaker wear

Calculating the electrical wear of the circuit breaker is based on the current in each phase before opening. The breaker wear is calculated for each phase separately and when the accumulated breaker-wear has reached the setting value, the function block will issue an alarm signal.

When the circuit breaker is in the close state, the rising edge of the Open pulse will trigger the function, which again ends when the circuit breaker enters from the undefined state to the open state. The function finds the maximum current peak-value in each phase and uses the obtained values as a reference when interpolating the breaker wear for each phase by means of the 16-point setting table. The settings for the breaker-wear function can be found in Main menu\Cond. monit.\CB wear1\.

The status indications “CB pos. open” and “CB pos. close” are automatically used for the breaker-wear function. The open pulse for the HSPO1 also triggers the function.

The alarm signal from the breaker wear function is routed via Main menu\Configuration\Output SWGRP\Alarm 1\ or \Alarm 2\ to the output signal together with the other available alarm signals from the relay. If the CB wear1 alarm alone is selected in Alarm 1, the checksum is 128.

The Alarm 1 signal is then connected to an output relay via Main menu\Configuration\Output Signals\, and in this example, the breaker wear alarm signal is connected to the signal output 1, SO1.

10.1.5.6. Disconnector and earth-switch indication

If the status indication signals are available from the disconnector or the earth switch, they can be connected to the digital inputs for indication sent as events to a monitoring system or to include in the interlocking scheme for close-operation of the breaker. These settings can be found in: Main menu\Configuration\Input Signals\.

The status indication signals for the disconnector are named as “DC pos. open” and “DC pos. close” and for the earth switch as “ES pos. open” and “ES pos. close”. In this example, the disconnector indication signals are connected to the inputs DI3 (open) and DI4 (close). The earth-switch indication is connected to the inputs DI5 (open) and DI6 (close).

With these indication signals, it is possible to prevent or give permission for the closing of the breaker. The different interlocking options are described in Section 6.2. Interlocking. In this example, the interlocking option “Interlocking_B” is used. This option allows closing of the breaker only when the disconnector is closed and the earth switch is open. The different interlocking options can be set in Main menu\Configuration\Input Signals\Close enable.

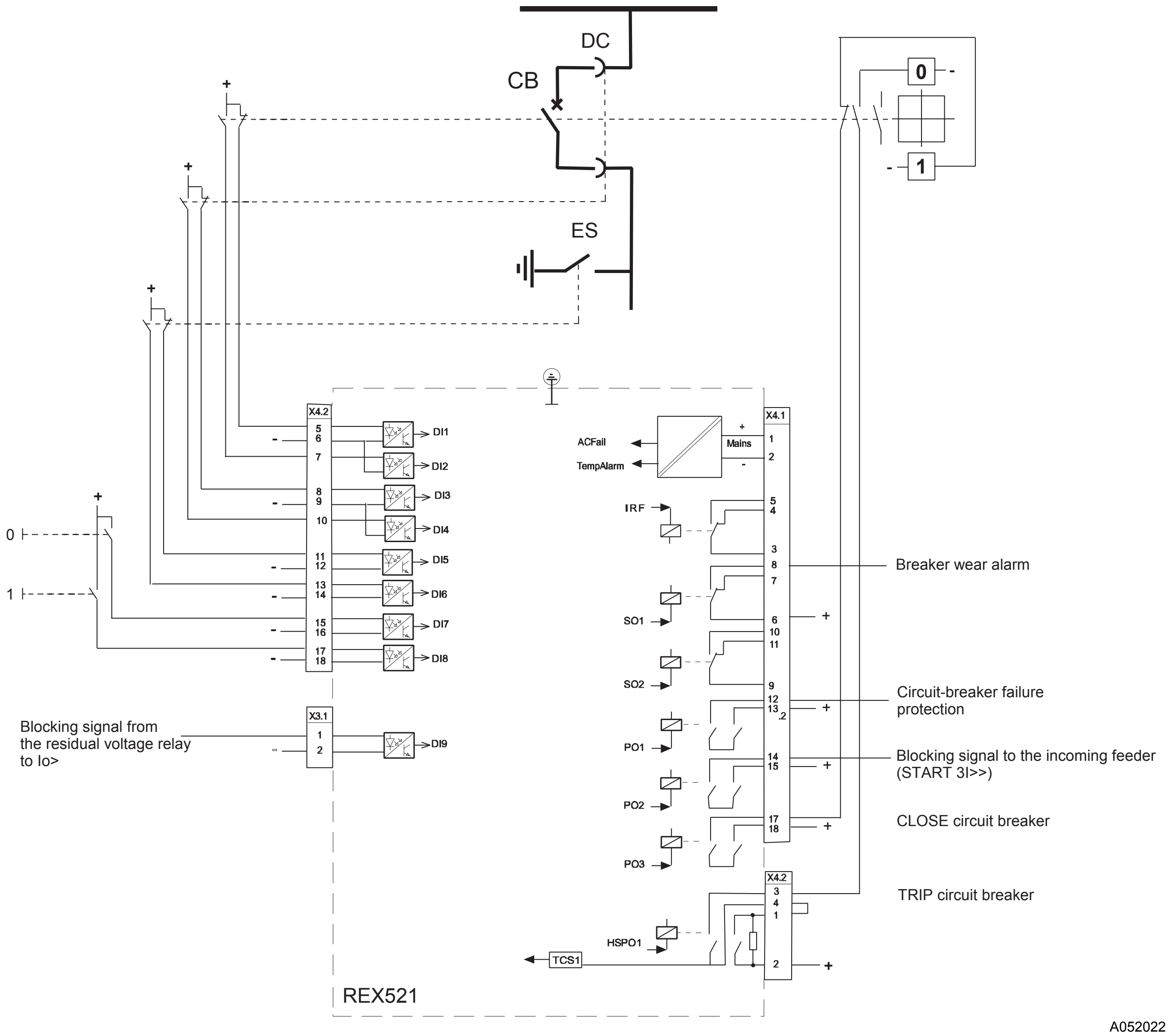


Fig. 10.1.5.-1 Connection diagram for the standard configuration B01 with the breaker status indication, the control and alarm signals.

10.2. Incoming feeder, Basic B01

10.2.1. Features

This application example describes an incoming feeder to a single busbar including:

- Overcurrent protection
- Non-directional earth-fault protection

The network is resistance or solidly earthed. The three-phase current measurement is established with current transformers. The neutral current is measured via a current transformer located in the neutral earthing circuit on the LV side of the power transformer.

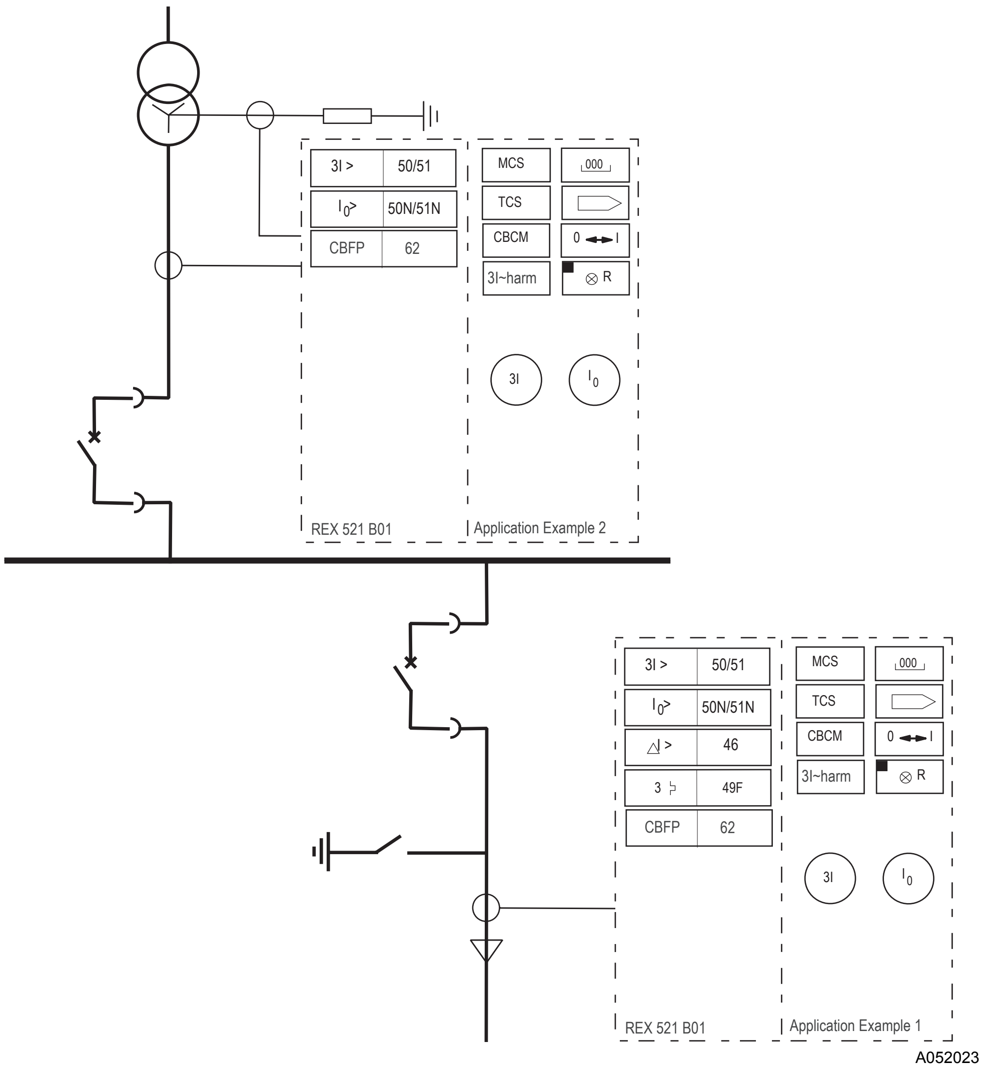


Fig. 10.2.1.-1 B01 is used for protection, measuring and supervision on both an incoming and an outgoing feeder in a single busbar system. The supplying network is either solidly or resistance earthed

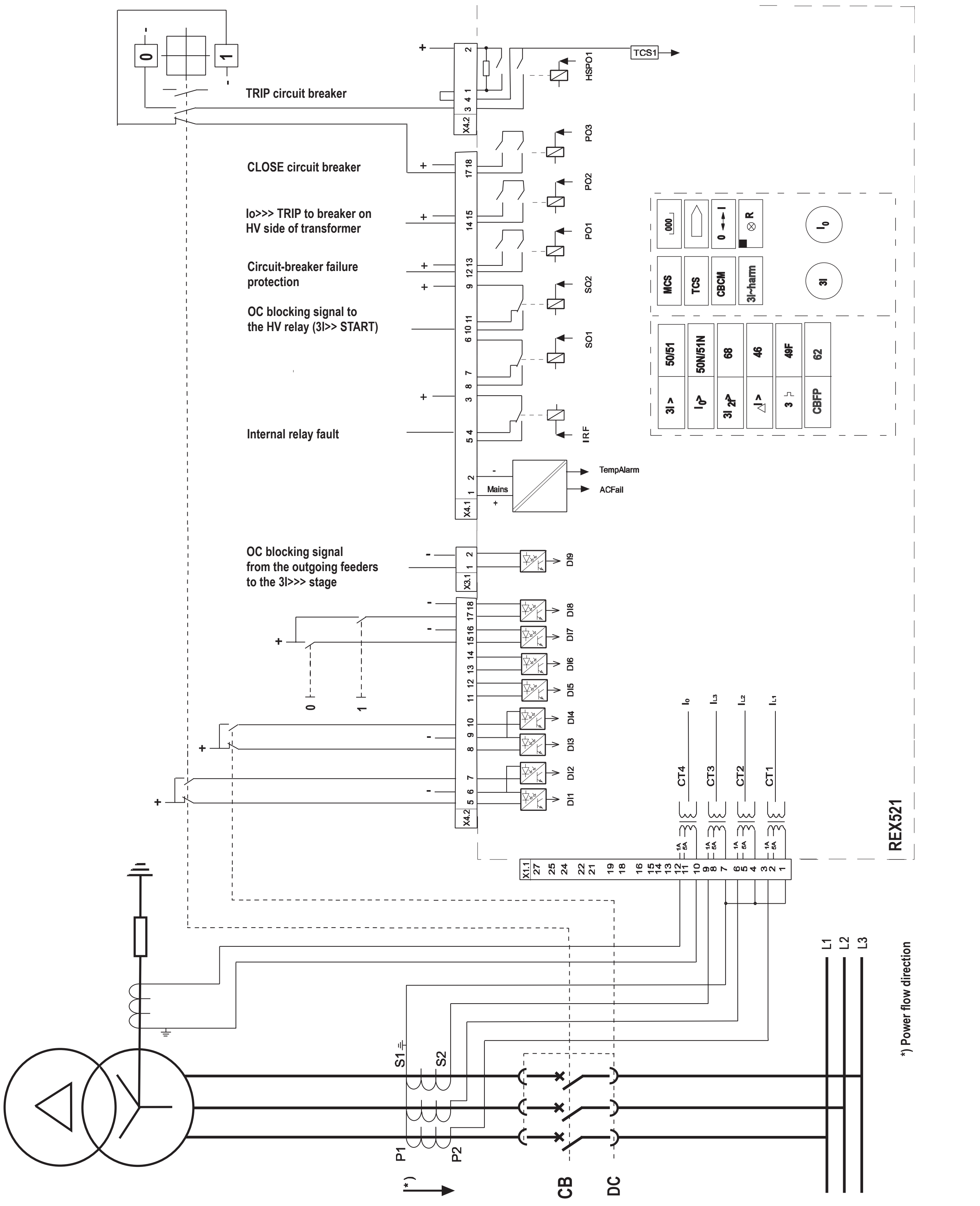


Fig. 10.2.1.-2 Connection overview diagram of the incoming feeder

10.2.2. Measurement connections

The three-phase current transformers are connected to the connector X1.1 on the rear panel. The rated currents of the measuring input are 1 A and 5 A.

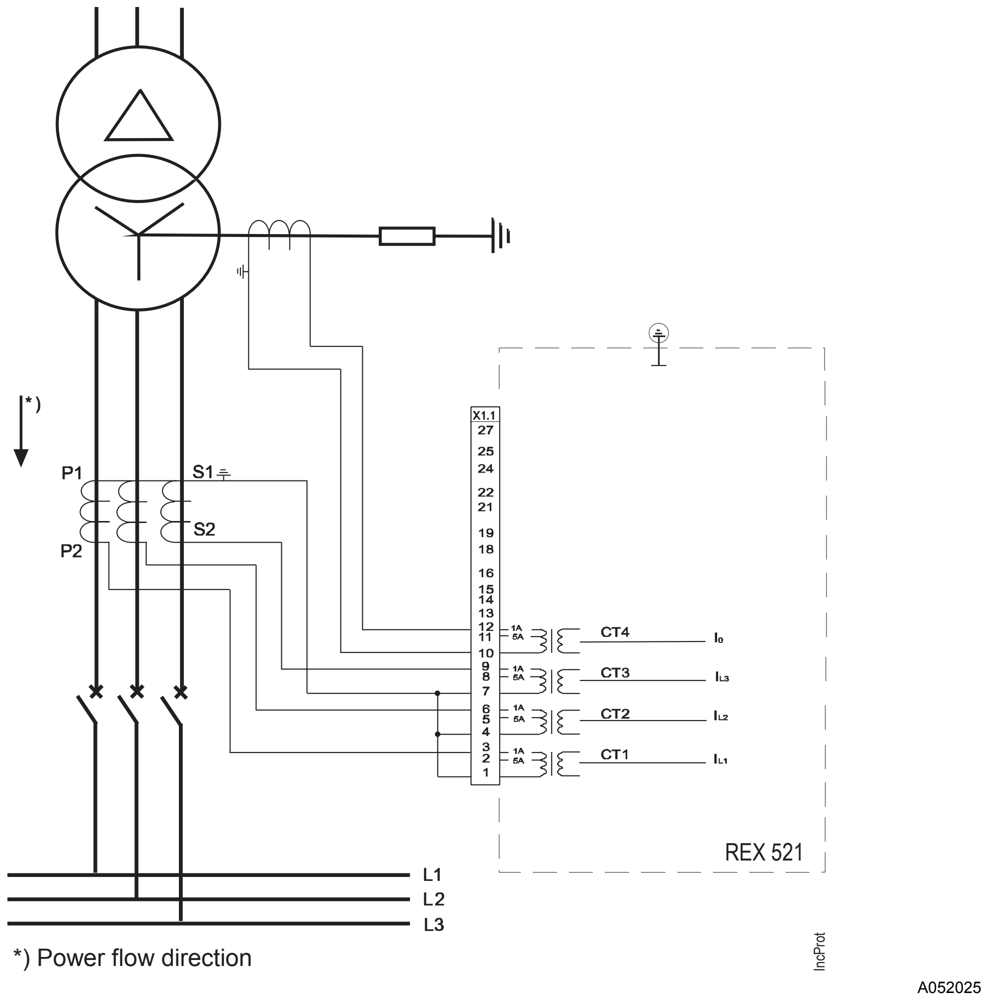


Fig. 10.2.2.-1 Connection diagram of the B01 for protection of an incoming feeder and as back-up protection of the outgoing feeders

The technical data of the current transformers are set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Configuration\Meas. devices\`. Refer to Technical Reference Manual, General (see Section 1.3. Related documents) for further information about how to set the rated currents.

10.2.3. Protection

All the necessary settings for the protection functions can be set by means of the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

10.2.3.1. Phase overcurrent protection

In the example of the incoming feeder application, the stages 3I> and 3I>> of the overcurrent protection operate time selectively as a back-up protection of the outgoing feeders. The 3I>>> stage is used for the short-circuit protection of the busbar system. The set operate time of a back-up protection stage can be calculated as follows:

Time grading	+	Operate time of the protection relay of the outgoing feeder

The time grading includes (definite time):

2 X Tolerance of the relays' operate times	+	Operation time of the CB	+	Retardation time of the relay	+	Saturation and delay margin

If a fault occurs in the feeder, the overcurrent protection relay of the outgoing feeder provides a blocking signal to the overcurrent protection relay of the incoming feeder. If the fault should occur in the busbar system, no blocking signal is issued and the 3I>>> stage of the overcurrent protection of the in-feeder provides a trip signal to the in-feeder circuit breaker. Therefore, when no auxiliary relay is used, it is possible to use a minimum operate time of 100 ms when a fault in the busbar system occurs.

The needed time for blocking includes:

Start time of the relay (40 ms)	+	Input delay on the relay to be blocked (10 ms)	+	Retardation time (30 ms)	+	Margin (20 ms)

The blocking arrangement can be extended to include the HV side overcurrent protection of the main transformer. For example, the start signal of the high-set stage 3I>> can be routed as blocking to the high-set stage 3I>> of the HV relay.

The busbar protection and the co-operation of the relays between the different protection levels can be arranged in many ways and they vary in different applications. A few examples of how the described application can be changed using some of the features of REX 521 are described below.

The back-up protection can be made with the circuit-breaker failure protection function of the protection relay of the outgoing feeder. A fast back-up function can be achieved because the safety margin can be omitted when setting the CBFP time. Furthermore, the different time settings in the outgoing feeders do not affect the operation because each relay has a separate CBFP function. The CBFP function requires external wiring from the protection relays of the outgoing feeders to the relay of the in-feeder.

If an operate time of less than 100 ms is required in the busbar protection system and the non-selective operation is allowed, one possibility is to use the instantaneous stage 3I>>> with an instantaneous operate time. Then the start current value has to be set to such a level that the fault most probably is in the busbar system. It is of advantage if a fault in the busbar system does not cause serious damage due to the instantaneous trip of the busbar system. On the other hand, it is difficult to find the right setting value since a close-up fault in a feeder can cause the circuit breaker of the in-feeder to trip instead of the feeder protection relay.

In a double busbar system where the busbar circuit breaker is closed and two main transformers are connected in parallel, the breaking capacity of the circuit breakers of the outgoing feeders may not be sufficient and so tripping should be carried out by the circuit breaker of the in-feeder. Then the current setting of the outgoing instantaneous stage 3I>>> is set to the same level as the breaking capacity of the feeders. This means that if the fault current exceeds the breaking capacity of the outgoing feeders, the tripping is performed by the protection of the in-feeder. An external control signal can be used for shifting to the second settings when the transformers are used in parallel operation. Then the stage 3I>>> is active in parallel operation and inhibited or has other settings when the parallel operation is not used.

The settings for the overcurrent protections can be found in: `Main menu\Protection\3I>\ … \3I>>>\Setting group 1\` where the parameters `Operation mode`, `Start current` and `Operate time` for the function can be set. In `Main menu\Protection\3I>\Control setting\` can for example the `Drop-off time` and the length of the trip signal `Trip pulse` be set. The data of the three last operations, start or trip, are recorded and the values of the most recent operation can be found in `Main menu\Protection\3I>\Recorded data1\…3\`.

10.2.3.2. Earth-fault protection

The earth-fault stages can be used in different ways depending on the used earthing principle. In this example with a low-resistance earthed network, the two stages are used as back-up earth-fault protection and as earth-fault protection of the busbar system. The low-set Io> stage of the earth-fault protection serves as back-up protection of the outgoing feeders and the high-set stage Io>> as the primary earth-fault protection of the busbar system. The instantaneous stage Io>>> is configured to trip the breaker on the HV side of the transformer.

The settings for the earth-fault current protections can be found in `Main menu\Protection\Io>\ … \Io>>>\`.

10.2.3.3. Protection signal routing

The trip signal (Trip 1) of the protection functions are routed to the high speed power output HSPO1 (x4.2.1/2/3/4) as well as the control-open signal for the circuit breaker. The trip signals from the protection functions are routed to the output relay via the output switchgroups. These settings can be found in `Main menu\Configuration\Output SWGRP\`.

As the HSPO1 is always routed to the “Trip 1” output signal, the settings are made directly in `Main menu\Configuration\Output SWGRP\Trip 1` where the checksum of the settings is displayed (255 by default).

Using the HMI:

To change the settings for Trip 1 go to `Output SWGRP\Trip 1` and press the [E]-button. The different protection functions are displayed one at a time. By pressing the [→] or [←] navigation push button, it is possible to scroll between the different protections. By pressing the [↑] or [↓] navigation push button, the specific protection function trip signal can be connected or disconnected. When the three-stage overcurrent (3I> 3I>> and 3I>>>), two-stage earth fault (Io> and Io>>) protection is selected the checksum for Trip 1 is 31.

10.2.3.4. Indication and control connections

All the necessary settings for the indication and control signals of the circuit breaker and the disconnector for the incoming feeder can be set as described in the first application example on Section 10.1. Outgoing feeder, Basic B01 onwards for the outgoing feeder (except for the earth switch). The settings are made by means of the Relay Setting Tool or the local HMI. The settings can be found in:

```
Main menu\Configuration\Input Signals\
Main menu\Configuration\Input SWGRP\
Main menu\Configuration\Output Signals\
Main menu\Configuration\Output SWGRP\.
```

10.2.4. Implementations

In the sections below a few implementation examples for the standard configuration B01 are presented.

10.2.4.1. Blocking signal received from the outgoing feeder

The start signals from the overcurrent protection of the outgoing feeder can be connected in order to block the overcurrent protection stages on the incoming feeder. There are two input blocking signals, Blocking 1 and Blocking 2, which can have different functions depending on the different protections.

The Blocking 1 input signal is connected to the BS1 input and the Blocking 2 input signal is connected to the BS2 input of the overcurrent stages 3I>, 3I>> and 3I>>>. The BS1 in this application example will stop the DT or IDTM timer and the BS2 will block the trip signal. Refer to the CD-ROM Technical Descriptions of Functions (see Section 1.3. Related documents) for more information.

In this application example, the digital input DI9 is connected to the input signal Blocking 1 and then routed to the BS1 input of the overcurrent stage 3I>>>. The Blocking 1 signal can be found in `Main menu\Configuration\Input Signals\Blocking 1\` where the DI9 is selected. The checksum for the switchgroup in `Main menu\Configuration\Input SWGRP \Blocking 1\` should be 4 to block 3I>>>.

10.2.4.2. Outgoing blocking signal to the overcurrent relay on the HV side

The start signals from the overcurrent protection function can be routed to an output relay to provide a blocking signal. The overcurrent stages 3I>> and 3I>>> have also a separate BSOUT signal for blocking purpose.

As mentioned above the start signal from the high-set overcurrent stage 3I>> can be routed to the high-set stage 3I>> of the HV relay. To use the start signal of a protection function, the signal has to be routed via `Main menu\Configuration\Output SWGRP\Start 1` or `\Start 2`. When the start signal has been routed, the output relay has to be selected in `Main menu\Configuration\Output Signals`. In this example, the overcurrent start signal from the 3I>> stage is routed via Start 1 and then connected to the signal output 2, SO2. The checksum in this application example for Start 1 is 2.

10.2.4.3. Earth-fault stage Io>>> used to trip the breaker on the HV side of the transformer

The trip signal from the earth-fault instantaneous stage can be routed to an output relay to trip the breaker on the HV side of the transformer. To use the trip signal from the earth-fault function, the signal has to be routed via `Main menu\Configuration\Output SWGRP\Trip 2 or \Trip 3`. When the trip signal has been routed, the output relay has to be selected in `Main menu\Configuration\Output Signals`.

In this example, the trip signal of the earth-fault stage Io>>> is routed via Trip 2 and then connected to the power output 2, PO2. The checksum in this application example for Trip 2 is 32.

10.2.4.4. Circuit-breaker failure protection

All of the protection functions in the standard configuration B01 provide a delayed trip signal CBFP after the trip signal unless the fault has not disappeared during the set CBFP time delay. In the circuit-breaker failure protection, the CBFP output can be used for operating an upstream circuit breaker.

The settings for the breaker failure are set separately for each protection function. For example, to set the CBFP time for 3I>>, go to `Main menu\Protection\3I>>\Control setting`, where it is possible to set the `CBFP time` from 100 ms to 1000 ms. The control parameter `Trip pulse` sets the width of the trip output signal, but also of the CBFP output signal.

The CBFP signals from the protection functions are routed to the output signals via the output switchgroups. These settings can be found in `Main menu\Configuration\Output SWGRP\CBFP`. When the three-stage overcurrent and the two-stage earth-fault protection are selected the checksum for CBFP is 31.

The CBFP signal is then connected to any of the output relays, via `Main menu\Configuration\Output Signals\`. In this example, the circuit-breaker failure signal is connected to the power output 1, PO1.

10.2.4.5. Disturbance recorder

The disturbance recorder (DREC) can be found in `Main menu\Measurement\DREC\`. All of the measured current signals as well as all of the start signals from the protection functions are connected to the DREC in the B01 standard configuration.

The recording can be triggered by any of the alternatives listed below:

- Triggering on the rising or falling edge of the protective start signals
- Triggering on current measurement
- Manual triggering via the HMI or with the external input signal
- Triggering via communication by a parameter
- Periodic triggering

Regardless of the triggering type, each recording generates the event E31. The triggering time and reason are included in the recording. Number of recordings can be viewed in `Main menu\Measurements\DREC\Control setting\# records`.

External triggering can be made by means of the reserved input signal “DREC trig” connected to one of the digital inputs. The settings can be found in `Main menu\Configuration\Input Signals\DREC trig`.

Refer to the CD-ROM Technical Descriptions of Functions (MEDREC16) for more information about the disturbance recorder.

10.2.4.6. Power quality

The power quality function (PQ 3Inf) can be found in `Main menu\Power Quality\PQ 3Inf`. The function is used for measuring the harmonics and monitoring the power quality in distribution networks.

The power quality function can be triggered by any of the alternatives listed below:

- Manual triggering via the HMI
- With the external input signal
- Triggering via communication parameter
- Preset time and date

External triggering can be made by means of the reserved input signal “PQ 3Inf trig” connected to one of the digital inputs. The settings can be found in `Main menu\Configuration\Input Signals\PQ 3Inf trig`.

The function can deliver the alarm signals “PQ 3Inf cum”, an output signal for exceeding a setting limit for cumulative probability of a harmonic and the “PQ 3Inf har”, an output signal for exceeding a setting limit for a harmonic. The alarm signals can be routed to the output contacts via the switchgroups. The connection settings can be made in `Main menu\Configuration\Output SWGRP\Alarm 1\ or \Alarm 2\`. The “Alarm 1” or “Alarm 2” output signal can be then connected to an output relay and the settings are done in `Main menu\Configuration\Output Signals\`.

Refer to the CD-ROM Technical Descriptions of Functions (PQCU3H) for more information about the power quality function.

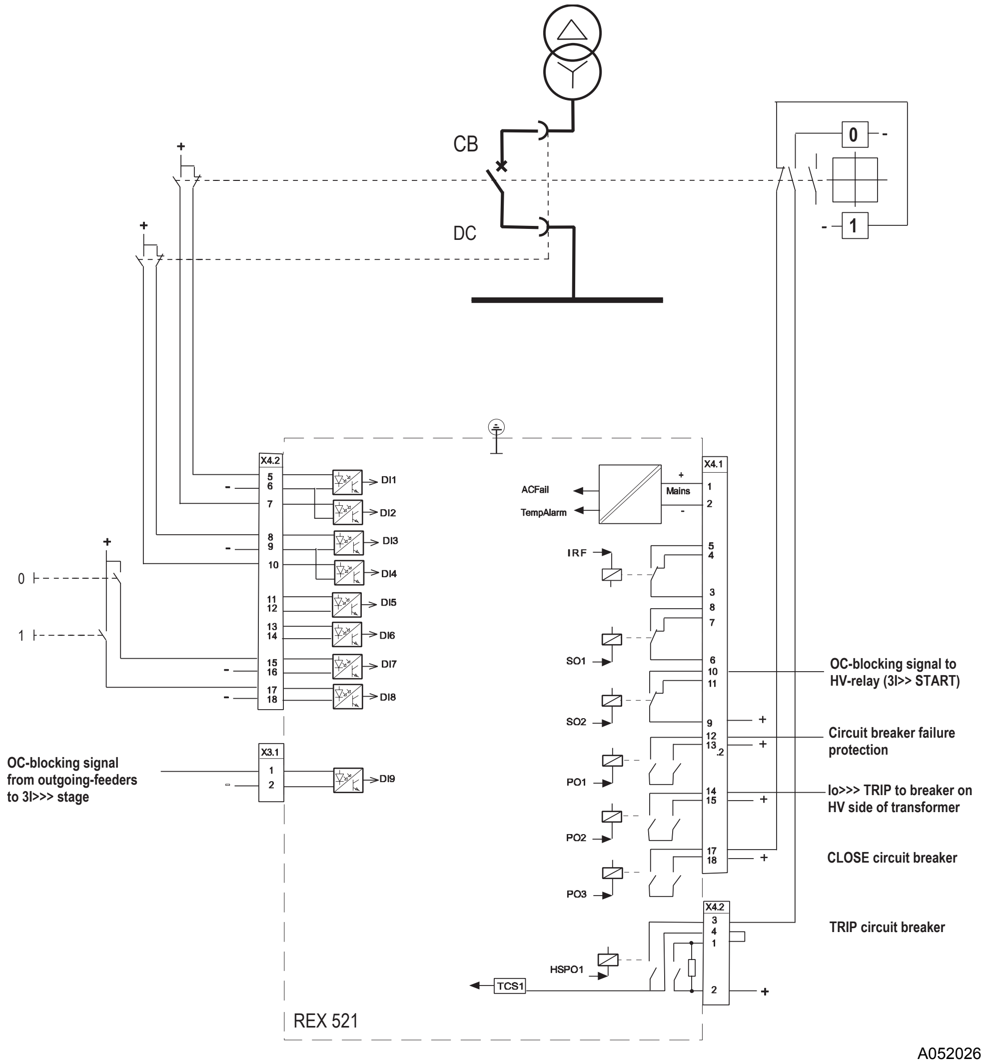


Fig. 10.2.4.6.-1 Connection diagram for the standard configuration B01 with the breaker-status indication, blocking-, control- and breaker failure signals.

10.3. Transformer feeder, Basic B01

10.3.1. Features

This application example describes a transformer feeder including:

- Overcurrent protection
- Inrush protection

The application described in this example can serve as a backup protection for a differential protection of the transformer or as main protection for smaller transformers.

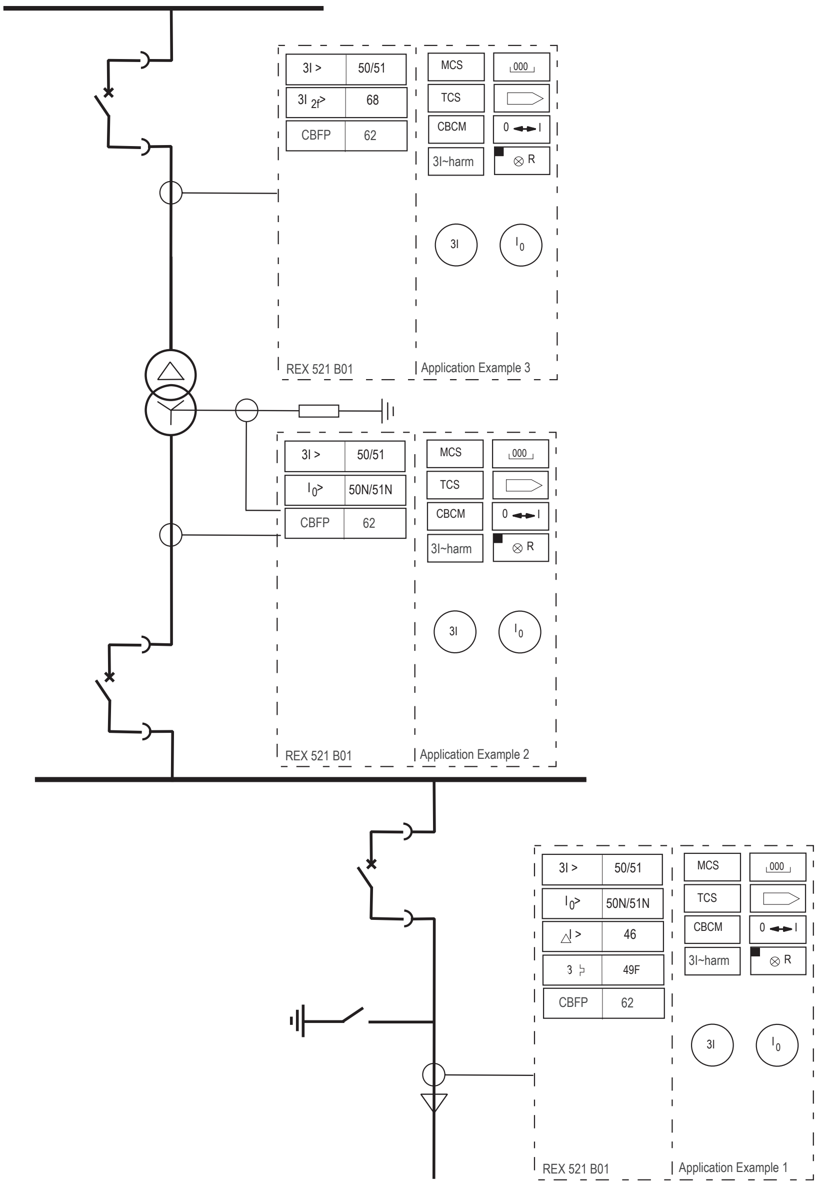


Fig. 10.3.1.-1 B01 is used for protection, measuring and supervision on an outgoing, an incoming and a transformer feeder in a single busbar system.

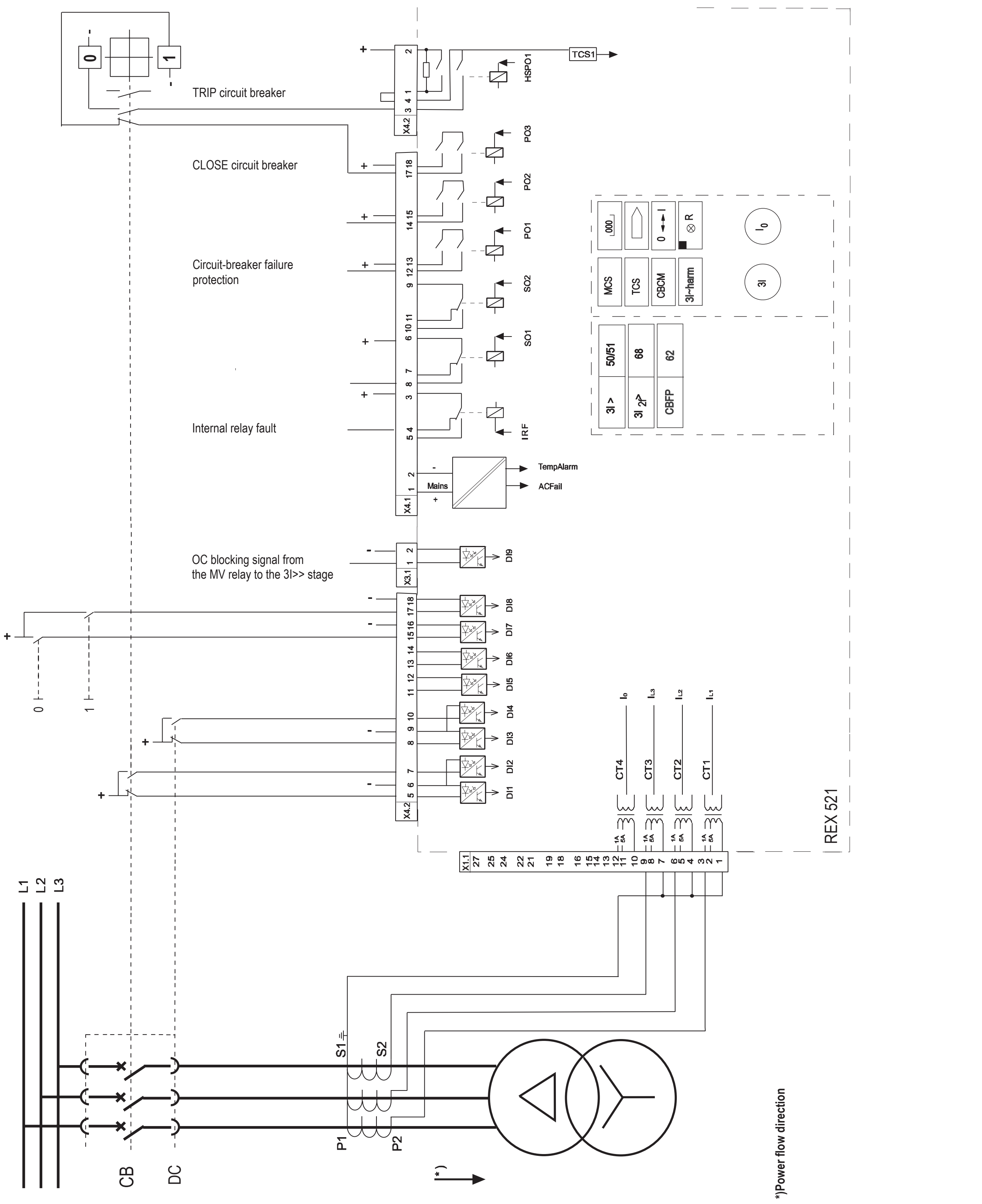


Fig. 10.3.1.-2 Connection overview diagram of the incoming feeder

10.3.2. Measurement connections

The three phase current transformers are connected to the connector X1.1 on the rear panel. The rated currents of the measuring input are 1 A and 5 A.

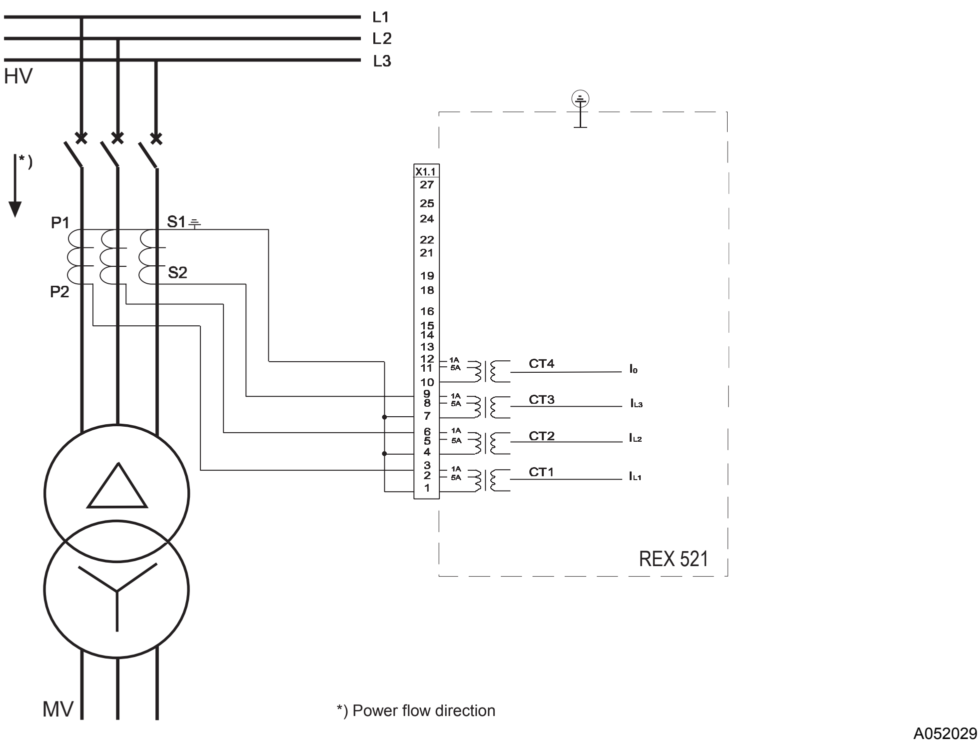


Fig. 10.3.2.-1 Connection diagram for the standard configuration B01 with three current transformers

The technical data of the current transformers are set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Configuration\Meas. devices\`. Refer to Technical Reference Manual, General (see Section 1.3. Related documents) for further information about how to set the rated currents.

10.3.3. Protection

All the necessary settings for the protection functions can be set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

10.3.3.1. Phase overcurrent protection

The overcurrent protection includes three stages. The relay measures the phase currents on the HV side. The definite-time instantaneous overcurrent stage 3I>>> is set to operate on short circuits occurring on the primary side of the transformer and most of the transformer winding. The fault currents are limited by the impedance of the transformer so it does not detect faults on the secondary side of the transformer. The 3I>>> is current selective and it is set to a minimum operate time or instantaneous.

The high-set overcurrent stage 3I>> is configured to operate in case of a short-circuit in the poles of the LV side. The stage serves also as back-up at short-circuits in the MV busbar system. The protection method for the stage is based on blocking and the blocking signal is delivered from the high-set stage 3I>> of the relay on the MV side.

The low-set overcurrent stage 3I> of the relay is employed as definite time overcurrent back-up protection for the MV feeders. The stage is time-graded with the down-stream relay. In this case where this application example is used together with the second application example (chapter Section 10.2. Incoming feeder, Basic B01), the operate time will be the operate time of the low-set stage 3I> in the second example plus time grading. The start current setting and the inrush current and its duration may have to be considered.

The settings for the overcurrent protections can be found in `Main menu\Protection\3I>\ … \3I>>>\Setting group 1\` where the parameters `Operation mode`, `Start current` and `Operate time` can be set for the function. In `Main menu\Protection\3I>\Control setting\` the `Drop-off time` and the length of the trip signal, `Trip pulse`, for example, can be set.

The data of the three last operations, start or trip, are recorded and the values of the most recent operation can be found in `Main menu\Protection\3I>\Recorded data1\…3\`.

10.3.3.2. Transformer inrush

The Inrush 3I2f> function is used for doubling the set start-current of overcurrent protection in a transformer magnetizing inrush situation or at motor start-up. The operation of the overcurrent stages 3I>> and 3I>>> can be inhibited by the inrush function.

Transformer magnetizing inrush currents occur when energizing the transformer. The inrush current may be many times the rated current and the halving time may be up to several seconds. The inrush current that may arise, would cause the relay to start practically always when the transformer is connected to the network. Typically, the inrush current contains a large amount of the second harmonic. Doubling the operation of the overcurrent stage of the relay at magnetizing inrush current is based on the ratio of the amplitudes of the second harmonic digitally filtered from the current and the fundamental frequency.

The overcurrent stage is doubled once the numerically derived ratio I2f/I1f between the amplitudes of the second harmonic and the fundamental frequency current in one phase exceeds the value set for the `Ratio I2f/I1f>` parameter. Thus a set start current value below the connection inrush current level may be selected for the overcurrent stages. The doubling can be activated only if the amplitude of the fundamental frequency current of the corresponding phase is above 2.0% In. A control parameter is used for setting the minimum pulse width of the doubling signal. However, the signal remains active until the ratio I2f/I1f drops below the value set for the `Ratio I2f/I1f>` parameter in all phases, that is, until the inrush situation is over, even if the pulse counter has elapsed earlier.

The settings for the inrush protection can be found in `Main menu\Protection\3I2f>\`.

The signal from the inrush function is configured as an input signal to the standard configuration and has to be routed to the overcurrent functions when taken into use. The settings, for which overcurrent stage to double, are made in `Main menu\Input SWGRP\Double\`.

10.3.3.3. Protection signal routing

The trip signal of the protection, Trip 1, is routed to the high speed power output HSP01 (x4.2.1/2/3/4) as well as the control-open signal for the circuit breaker. The trip signals from the protection functions are to be routed to the output relay via the output switchgroups. These settings can be found in `Main menu\Configuration\Output SWGRP\`.

As the HSPO1 is always named as the “Trip 1” output signal, the settings are made directly in `Main menu\Configuration\Output SWGRP\Trip 1` where the checksum of the settings is displayed (255 by default).

Using the HMI:

To change the settings for Trip 1 go to `Output SWGRP\Trip 1` and press the [E]-button. The different protection functions are displayed one at a time. By pressing the [→] or [←] navigation push button, it is possible to scroll between the different protections. By pressing the [↑] or [↓] navigation push button, the specific protection function trip signal can be connected or disconnected. When the three-stage overcurrent (3I> 3I>> and 3I>>>) is selected the checksum for Trip 1 is 7.

10.3.3.4. Indication and control connections

All the necessary settings for the indication and the control signals of the circuit breaker and the disconnector for the incoming feeder can be set as described above in the first application example on Section 10.1. Outgoing feeder, Basic B01. The settings are made by means of the Relay Setting Tool or the local HMI. The settings can be found in

```
Main menu\Configuration\Input Signals\
Main menu\Configuration\Input SWGRP\
Main menu\Configuration\Output Signals\
Main menu\Configuration\Output SWGRP\.
```

10.3.4. Implementations

In the section below a few implementation examples for the standard configuration B01 are presented.

10.3.4.1. Blocking signal from the MV relay on the secondary side of the transformer

The start signal from the high-set overcurrent stage 3I>> of the MV relay (incoming feeder) can be routed to the high-set stage 3I>> of the HV relay to block the overcurrent protection stage. There are two input blocking signals, Blocking 1 and Blocking 2, which can have different functions depending on the different protections.

On the overcurrent stages 3I>, 3I>> and 3I>>>, the Blocking 1 input signal is connected to the BS1 input and the Blocking 2 input signal is connected to the BS2 input of the function. The BS1 in this application example will stop the DT or IDTM timer and the BS2 will block the trip signal. Refer to the CD-ROM Technical Descriptions of Functions (see Section 1.3. Related documents) for more information about the different protection function blocks.

In this application example the digital input DI9 is connected to the input signal Blocking 1 and then routed to the BS1 input of the overcurrent stage 3I>>. The Blocking 1 signal can be found in `Main menu\Configuration\Input Signals\Blocking 1\` where DI9 is selected. The checksum for the switchgroup in `Main menu\Configuration\Input SWGRP\Blocking 1\` should be 2 to block the 3I>>.

10.3.4.2. Circuit-breaker failure protection

All of the protection functions in the standard configuration B01 provide a delayed trip signal CBFP after the trip signal unless the fault has not disappeared during the set CBFP time delay. In the circuit-breaker failure protection, the CBFP output can be used for operating an upstream circuit breaker.

The settings for breaker failure are set separately for each protection function. For example, to set the CBFP time for 3I>>, go to `Main menu\Protection\3I>>\Control setting`, where it is possible to set the `CBFP time` from 100 ms to 1000 ms. The control parameter `Trip pulse` sets the width of the trip output signal, but also of the CBFP output signal.

The CBFP signals from the protection functions are routed to the output signals via the output switchgroups. These settings can be found in `Main menu\Configuration\Output SWGRP\CBFP`. When the three-stage overcurrent and two-stage earth-fault protection are selected the checksum for CBFP will be 31.

The CBFP signal is then connected to any of the output relays, via `Main menu\Configuration\Output Signals\`. In this example, the circuit-breaker failure signal is connected to the power output 1, PO1.

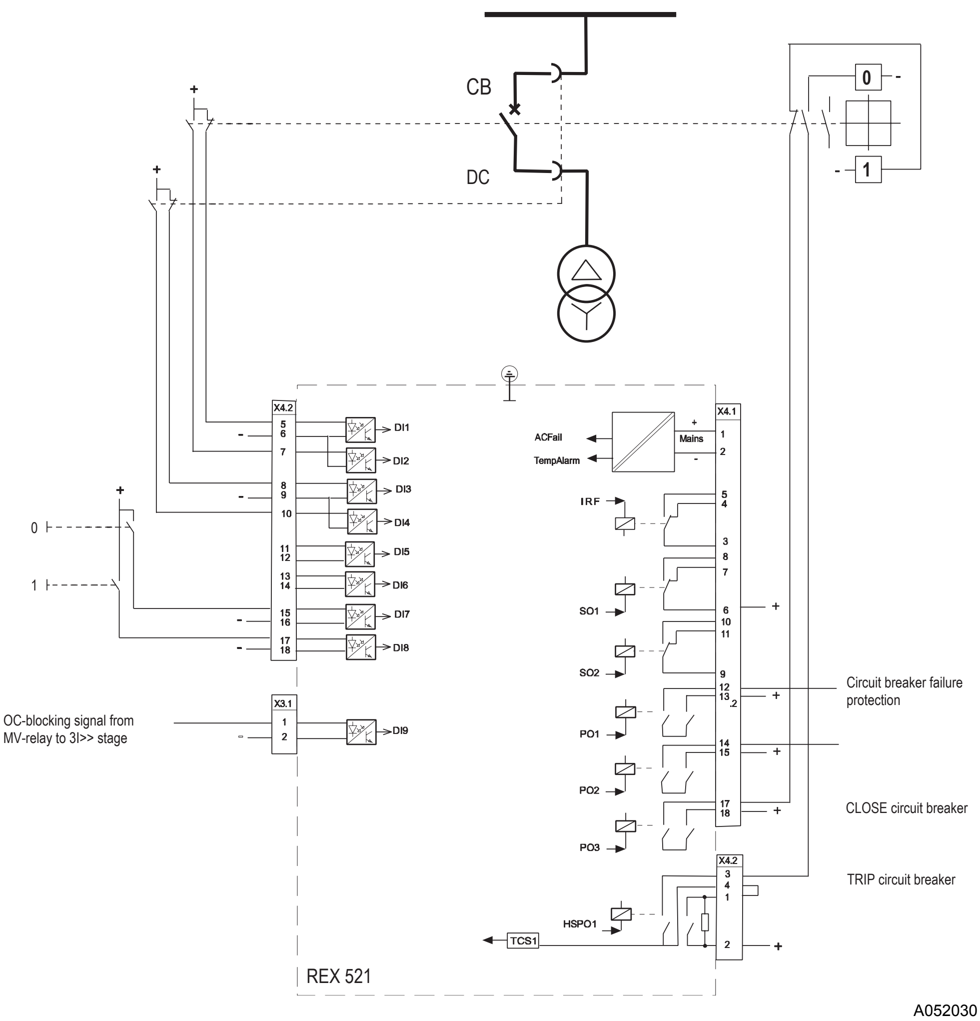


Fig. 10.3.4.2.-1 Connection diagram for the standard configuration B01 with breaker status indication, blocking, control and breaker failure signals.

10.3.5. Blocking signal overview

To clarify the blockings between the different levels in the first three application examples (Section 10.1. Outgoing feeder, Basic B01, Section 10.2. Incoming feeder, Basic B01 and Section 10.3. Transformer feeder, Basic B01) the signals are presented in the following figure.

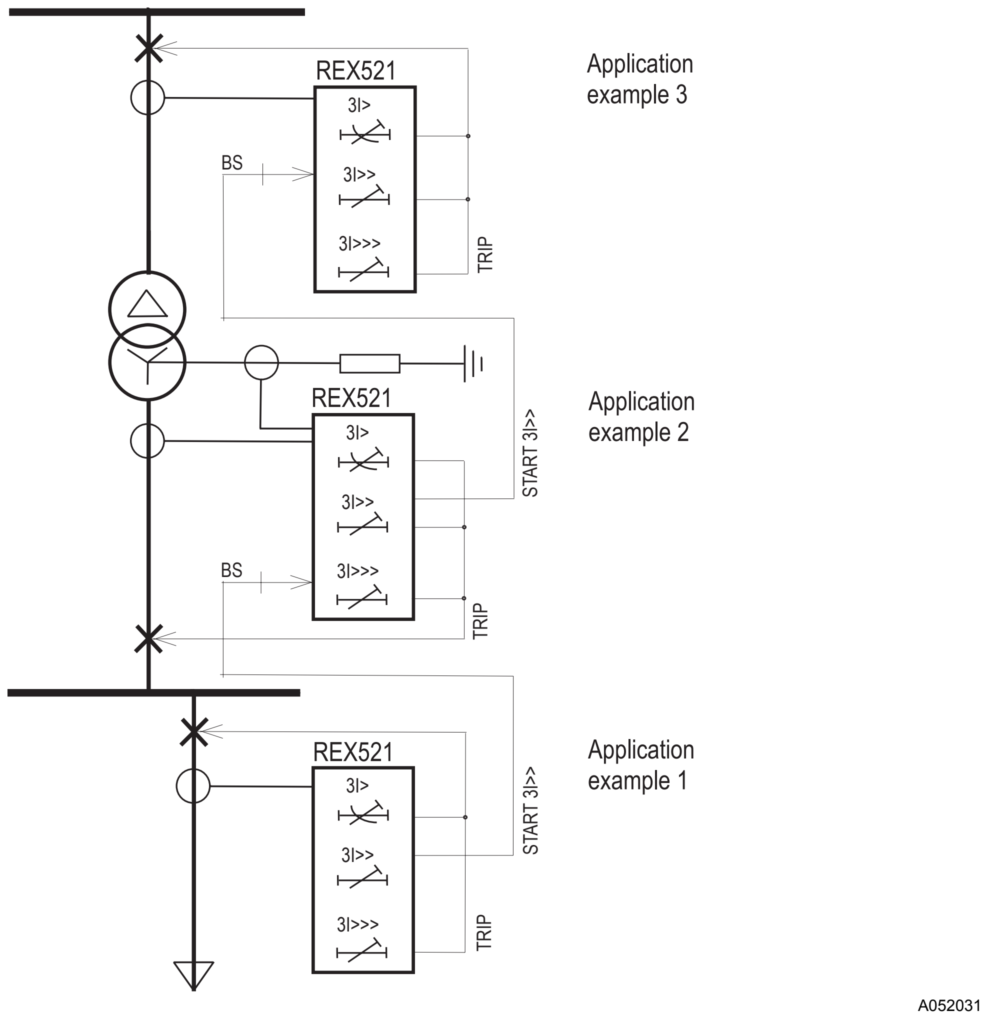


Fig. 10.3.5.-1 Phase overcurrent blocking signal overview diagram for the first three application examples with trip signals from the different overcurrent stages

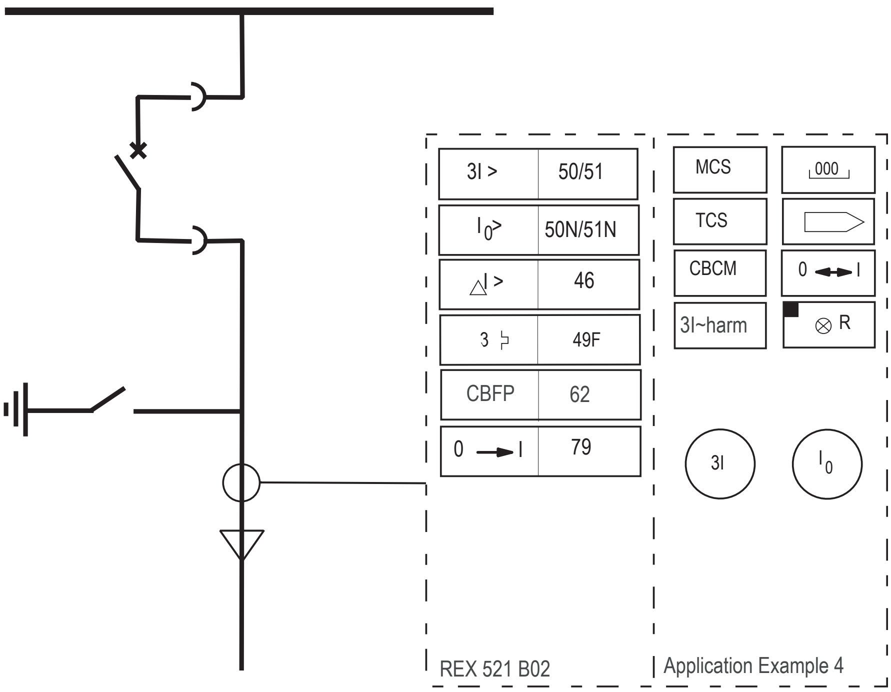
10.4. Outgoing feeder, Basic B02

10.4.1. Features

This application example describes an outgoing feeder of a single busbar including:

- Autoreclose function
- Overcurrent protection
- Non-directional earth-fault protection
- Phase discontinuity protection
- Thermal overload protection for cable/line

The network is either resistance or solidly earthed. Three-phase current measurement is established with a set of current transformers and the neutral current is measured in a residual connection.



A052032

Fig. 10.4.1.-1 B02 is used for protection, measuring and supervision on an outgoing feeder in a single busbar system. The supplying network is either solidly or resistance earthed.

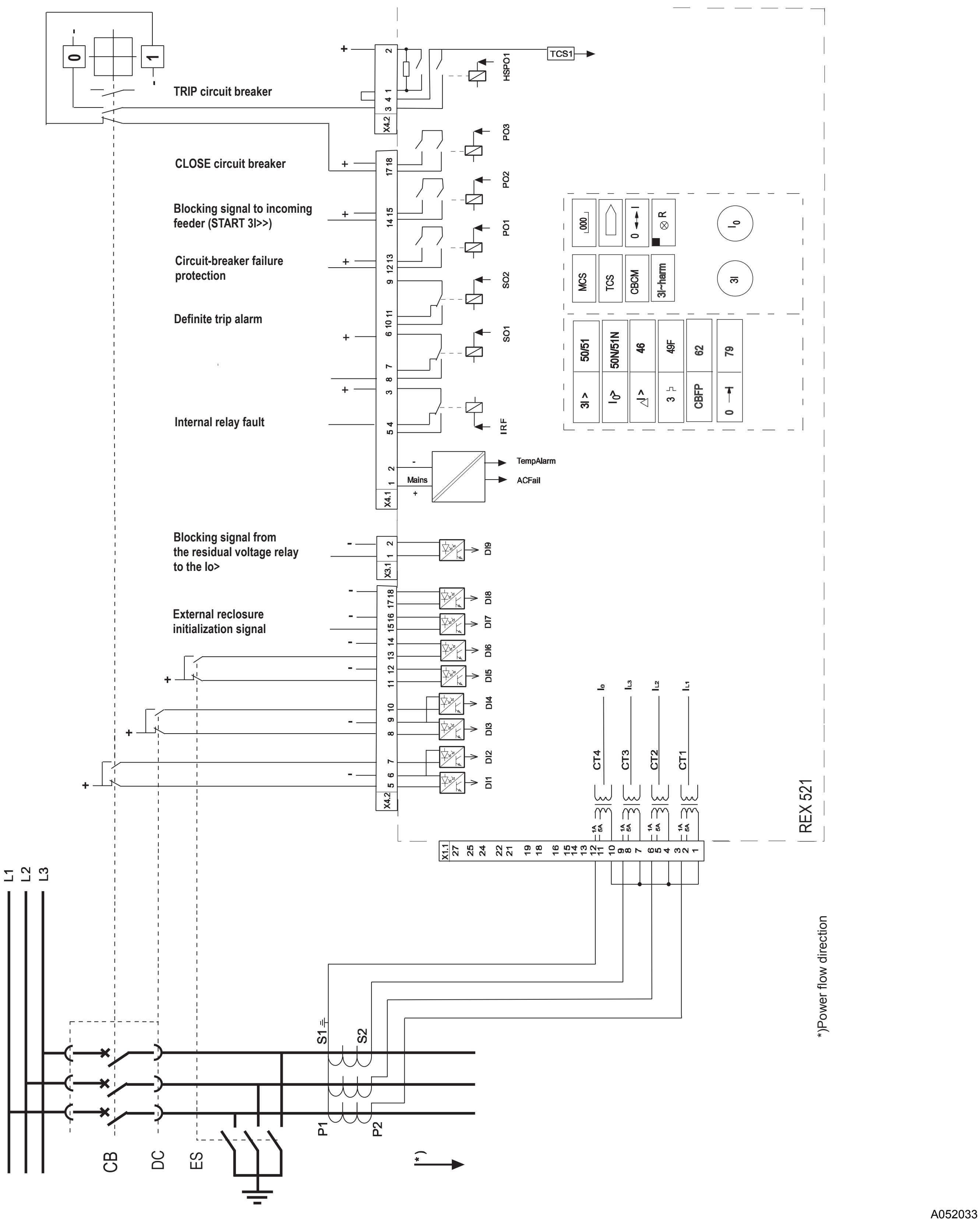


Fig. 10.4.1.-2 Connection overview diagram of the outgoing feeder

10.4.2. Measurement connections

The three-phase current and neutral current transformers are connected to the connector X1.1 on the rear panel. The rated currents of the measuring input are 1 A and 5 A.

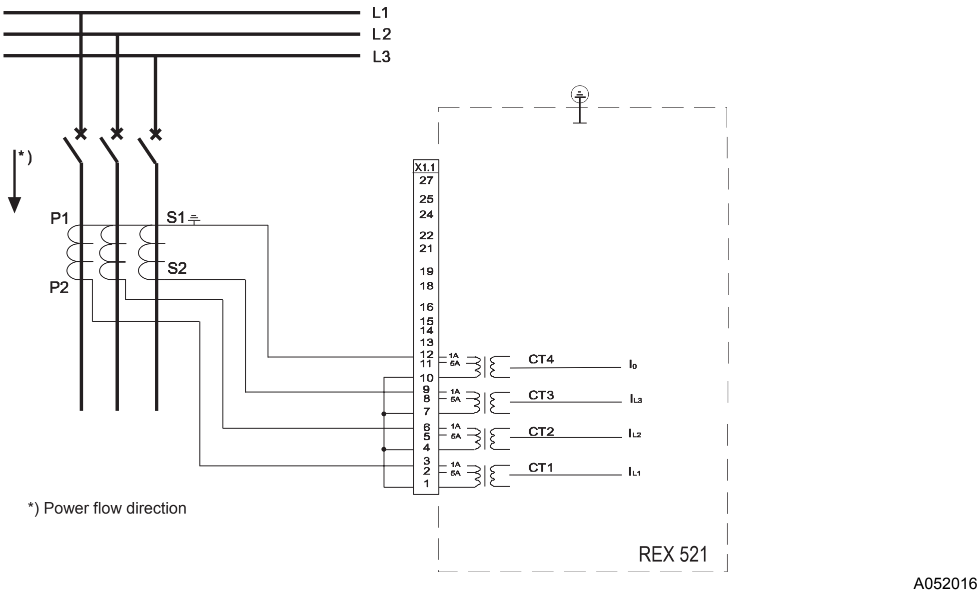


Fig. 10.4.2.-1 Connection diagram for the standard configuration B02 with three CTs in a residual connection

The technical data of the current transformers are set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Configuration\Meas. devices\`. Refer to REX 521 Technical Reference Manual, General (see Section 1.3. Related documents) for further information about how to set the rated currents.

10.4.3. Protection

All the necessary settings for the protection functions can be set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

The following protection functions can be implemented in the same way as in the first application example (see Section 10.1. Outgoing feeder, Basic B01):

- Overcurrent protection
- Earth-fault protection
- Phase discontinuity protection
- Thermal overload protection

10.4.3.1. Autoreclose function

The autoreclose function (O-->I) enables different types of auto-reclosing. An autoreclose sequence is initiated either by a start signal or by a trip signal.

In the following example two auto-reclosures initiated by the start of the protection are carried out. The auto-reclosures are subject to a preset start-delay time initiated from the start signal of the protection.

The first auto-reclosure (see Fig. 10.4.3.1.-1) is delayed only slightly to avoid unwanted auto-reclosures (100 ms). Shot 1 is a high-speed auto-reclosure (short dead-time 300 ms) mainly used for extinguishing the arc at the fault place. Before the second shot is initiated, a longer start delay time is used to attempt to burn the fault (300 ms). The dead time of the Shot 2 is long, a so called delayed auto-reclosure, that typically lasts minutes (in this case 2 min). Should the fault still persist when Shot 2 has been performed (after 200 ms), a final circuit-breaker tripping will follow and a DEFTRIP alarm signal is activated and it can be routed to an output contact if needed.

The operate time of the protection is longer than the operate times of the autoreclose function and the final trip time. Therefore the protection operates as a back-up for the autoreclose function, if the tripping carried out by the autoreclose function fails.

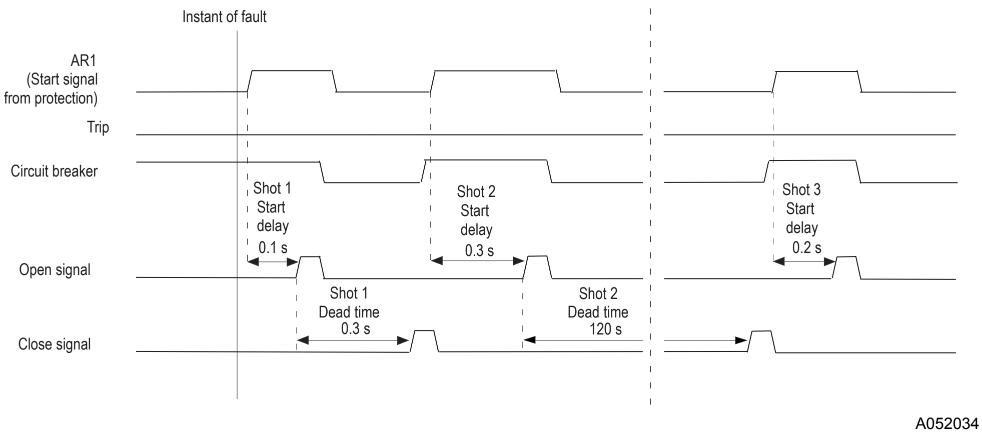


Fig. 10.4.3.1.-1 Autoreclose sequence, when AR is initiated by the start signal.

An autoreclose sequence can also be initiated by the trip signal of a protection function (see Fig. 10.4.3.1.-2). The trip signal from the protection trips the breaker after the set start-time of the protection function.

When the set dead-time of the autoreclose function elapses, the function closes the circuit breaker and a discriminating time (TDDUE output signal) is started. If one of the initiation signals is activated during the discriminating time, and if the short circuit current or the earth-fault current increases and the operate time of the protection function shortens at inverse-time operation, the AR shots are prevented and a definite tripping will follow. The discriminating time (td) can be set out of use by selecting the value 0. Normally, this discriminating time is shorter than the operate time of the protection function, so the sequence is allowed to continue with the second shot, the third shot, and so on, until the selected sequence has been completed or the fault has disappeared.

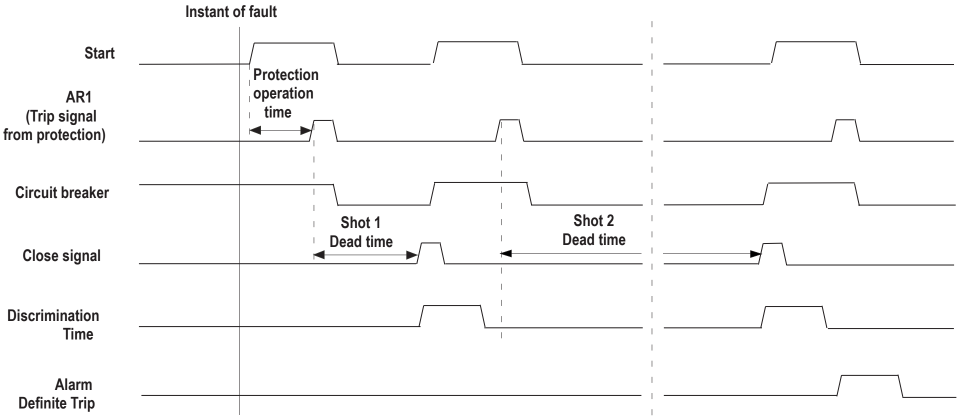


Fig. 10.4.3.1.-2 Autoreclose sequence, when AR is initiated by the trip signal.

The reclaim time is always started or restarted at a circuit breaker close operation. A new initiation signal during the reclaim time will perform the next shot if such has been selected. When all shots have been executed, the autorecloser is locked out. When the reclaim time has elapsed, the lock-out function of the autorecloser ends, if lock-out mode for the autoreclose function has been set to "automatic".

To be able to initiate the autoreclose function with the start or trip signal from a protection function, a few settings must be prepared. The initiation signals from the different protections can be found in `Main menu\Configuration\Input SWGRP\`, where for example the overcurrent initiation signals are named as `O-->I \3I>...3I>>>`.

To select the high overcurrent stage (3I>>) in order to initiate the autoreclose function, choose `O-->I\3I>>`. Press [E] push button and scroll the different initiation signal methods with the [→] and [←] navigation push buttons. The specific initiation method can be enabled or disabled with the [↑] and [↓] push buttons. The checksum will be 1 if “3I>> Start AR1” is set and 2 if “3I>> Trip AR1” is set.

After the initiation method is chosen, the settings for the autoreclose function has to be made. In `Main menu\Protection\O-->I\General setting\` the operation is taken in use when the `AR operations` is set to ON and the `Reclaim time` can be set.

The different shot settings are given in `Main menu\Protection\ O-->I\Shot1...5 settings`. To set the first shot as in the example above with the initiation from the start:

1. Go to the Shot 1 setting.
2. Select `Initiation mode` as “Start”.
3. Select `AR1 oper. mode` as “Init Shot”.
4. Set the `AR1 start delay` to 0.1 s.
5. Set the `Dead time` to 0.3 s.

Proceed with the Shot 2 setting in the same way and with the start delay and dead-time settings as in the example or as the functionality requires.

To make the initiation by the trip signal:

1. Go to the Shot 1 setting, select `Initiation mode` as “Trip”.
2. Select `AR1 oper. mode` as “Init Shot”.
3. Set the first `Dead time` as the requirements.

The Shot 2 and the ongoing shots are made in the same way.

The open signal from the autorecloser is connected as the trip directly to the HSPO1 and the close signal is connected to the same output signal as the close signal from the circuit breaker function. The reclose signal is depended on the interlocking method chosen for closing of the breaker. If the trip is activated during the close-pulse period, the close signal is deactivated.

Alarms and action signals are available as three different signals from the autorecloser. The signals can be found in `Main menu\Configuration\Output SWGRP\` and are named as O-->I ACTIVE, O-->I Alarm 1 and O-->I Alarm 2.

Refer to the CD-ROM Technical Descriptions of Functions for more information about the auto-reclosing function.

10.4.4. Protection signal routing

The settings for the protection signal routing can be implemented as described in the first application example (see Section 10.1. Outgoing feeder, Basic B01).

10.4.5. Indication and control connections

The connections for indication and control can be implemented as described in the first application example (see Section 10.1. Outgoing feeder, Basic B01), except the signals for the open and close buttons that in this example are disconnected to free the digital inputs for other functionality. Local control can be executed via the HMI according to the instructions in REX 521 Operator’s Manual (see Section 1.3. Related documents).

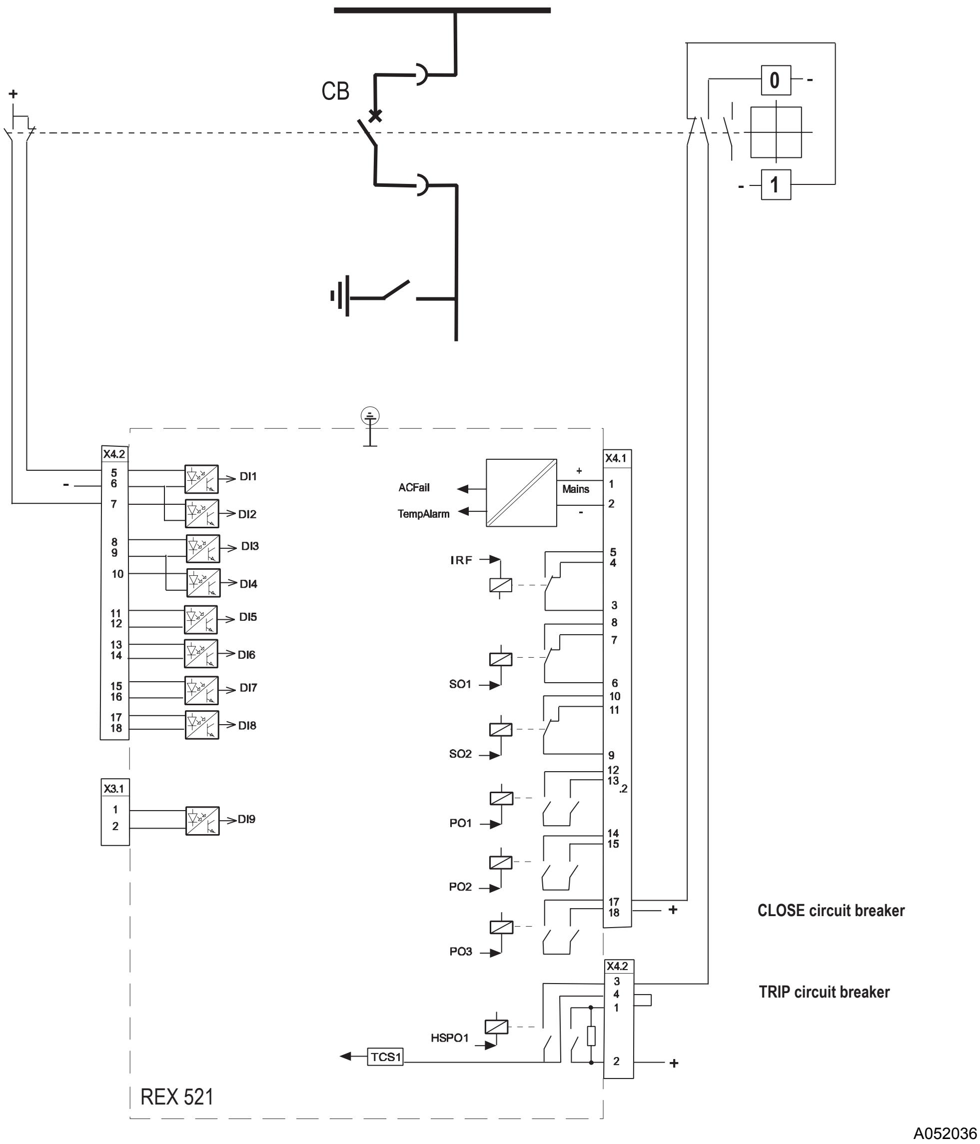


Fig. 10.4.5.-1 Connection diagram for the standard configuration B02 with breaker status indication and the control signals for opening and closing of the circuit breaker

10.4.6. Implementations

In the section below a few implementation examples for the standard configuration B02 are presented.

10.4.6.1. Definite Trip alarm to output relay

To get the DEFTRIP signal to activate an output contact go to `Main menu\Configuration\Output SWGRP\O-->I Alarm 1`, press the [E]-button and scroll to DEFTRIP and take it in to use with the help of the [↑] and [↓] push buttons. The checksum for O-->I Alarm 1 will then be 32. The O-->I Alarm 1 signal can then be routed to an output contact, in this example SO2, in `Main menu\Configuration\Output Signals\`.

10.4.6.2. Digital input to initiate auto-reclosing function

If an external start or trip signal is available for initializing the autorecloser, the signal can be connected to a digital input of the relay. Set the digital input, in this example DI7, to the `O-->I Ext. start` or `O-->I Ext. trip` in `Main menu\Configuration\Input Signals\`.

Further in `Main menu\Configuration\Input SWGRP\`, the external initiation signal is named as `O-->I External`. The initiation method is chosen and in this example Trip AR1 or Start AR1 can be used depending on the signal available and the methods parametrized within the autoreclose function.

The rest of the settings are made in the settings for the autorecloser in the same way as mentioned above.

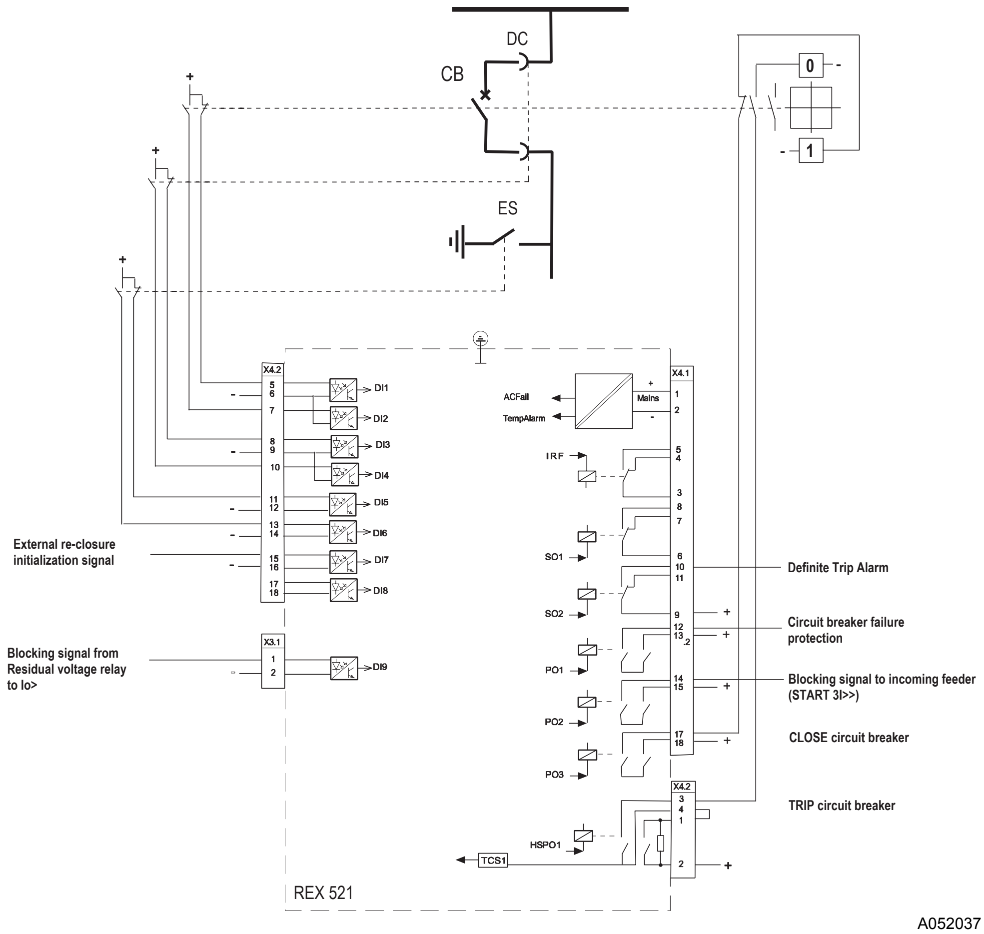


Fig. 10.4.6.2.-1 Connection diagram for the standard configuration B02 with the breaker status indication, control and alarm signals.

11. Application examples, Medium

11.1. Outgoing feeder, Medium M01

11.1.1. Features

This application example describes an outgoing feeder of a single busbar including:

- Overcurrent protection
- Directional earth-fault protection
- Phase discontinuity protection
- Thermal overload protection for cable/line

The network is compensated earthed or isolated. Three-phase current measurement is established with a set of current transformers and the neutral current is measured with a cable transformer. The residual voltage is measured with a set of voltage transformers in an open-delta connection.

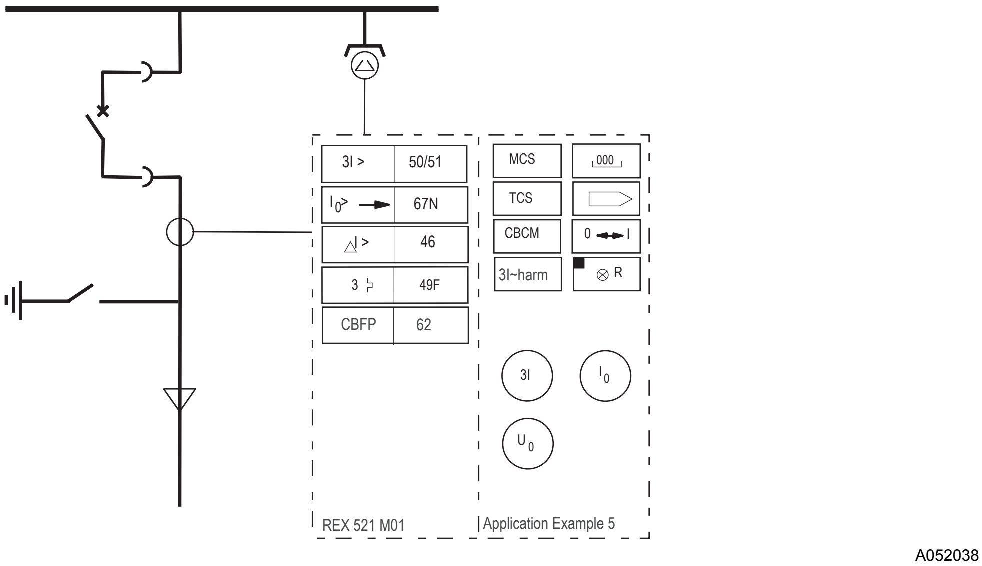
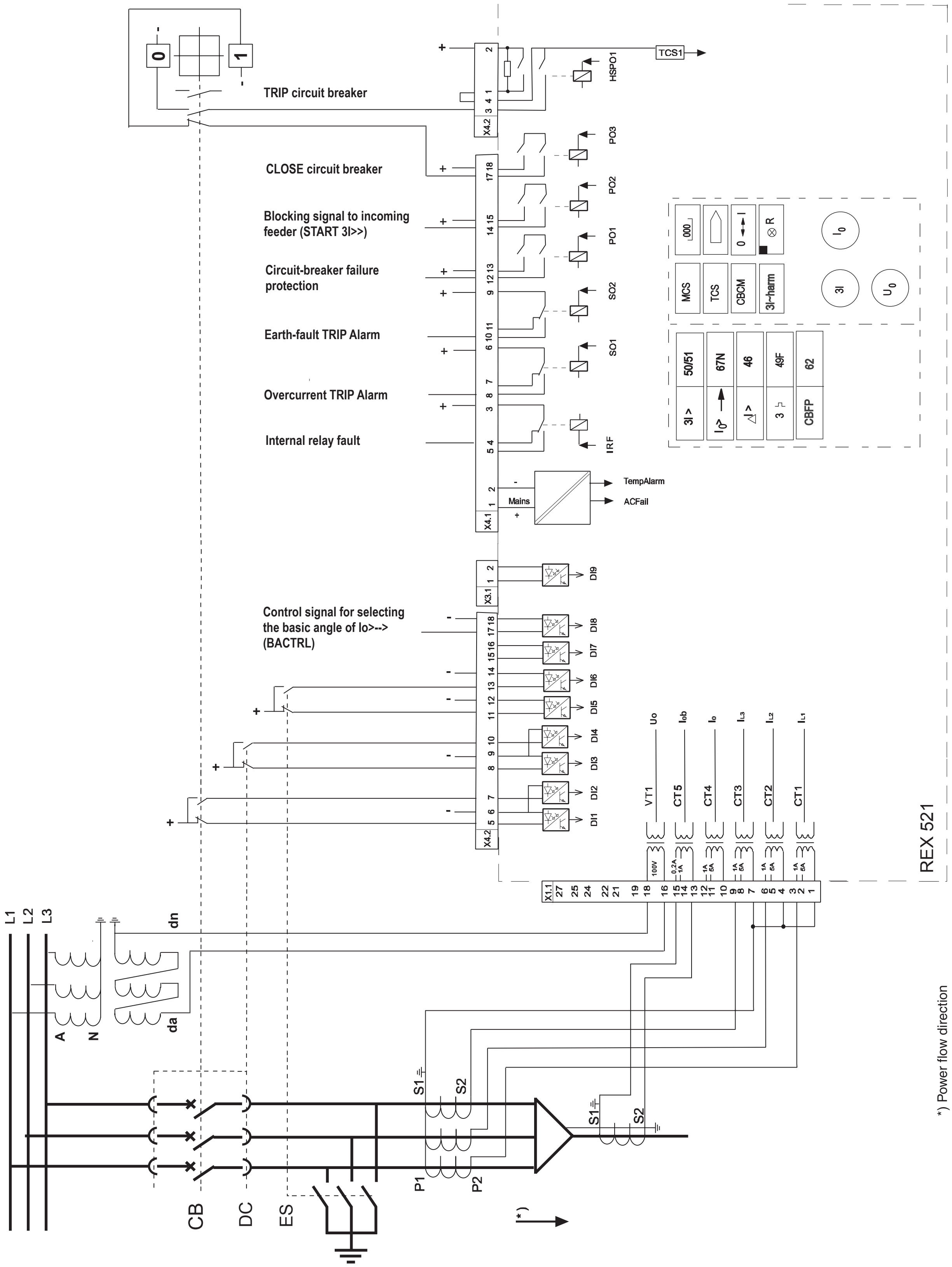


Fig. 11.1.1.-1 REX 521 M01 used for protection, measuring and supervision on an outgoing feeder in a single busbar system. The system earthing of the supplying network is either compensated or isolated.



A052039

Fig. 11.1.1.-2 Connection overview diagram of the outgoing feeder

11.1.2. Measurement connections

The three-phase current, neutral current transformers and residual voltage transformer are connected to the connector X1.1 on the rear panel. The rated currents of the measuring input are 1 A and 5 A and additionally, for earth fault, 0.2 A and 1 A. The rated values for voltage are 100 V, 110 V, 115 V and 120 V.

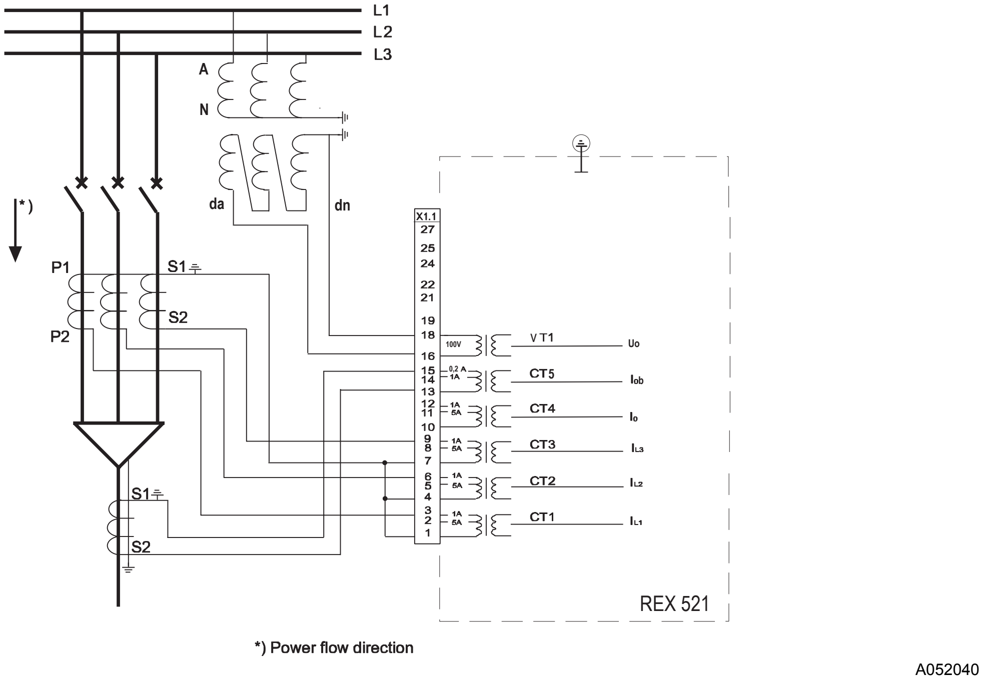


Fig. 11.1.2.-1 Connection diagram for the standard configuration M01

The technical data of the current transformers and the voltage transformer are set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Configuration\Meas. devices\`. Refer to REX 521 Technical Reference Manual, General (see Section 1.3. Related documents) for further information about how to set the rated currents and voltage.

11.1.3. Protection

All the necessary settings for the protection functions can be set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

The following protection functions can be implemented in the same way as in the first application example (see Section 10.1. Outgoing feeder, Basic B01).

- Overcurrent protection
- Phase discontinuity protection
- Thermal overload protection

11.1.3.1. Directional earth-fault protection

The neutral current can be measured with a cable current transformer and the residual voltage can be measured with a set of voltage transformers in a open-delta connection. In the REX 521 M01 it is suitable to use the directional earth-fault protection with the sensitive current input. The rated values are 0.2 A/1 A.

In most cases, in compensated and isolated networks the directional earth fault is used if the sensitive requirements are high and the configuration of the network is varying a lot.

The directional earth-fault function includes three protection stages: a low stage Io>--> a high stage Io>>--> and an instantaneous stage Io>>>-->. The protection is based on measuring the neutral current Io, the residual voltage Uo and the phase angle between these. An earth-fault stage starts if the neutral current and the residual voltage exceeds the set values and the phase angle is within the specified operating sector. The earth-fault function can also be configured to operate as a three-stage residual voltage protection.

The basic angle of the function can be set to 0°, -30°, -60° or -90°. If the network to be protected is compensated, the basic angle is normally set to 0°. When an isolated neutral system is protected the basic angle is set to -90°. It is also possible to use an external control signal BACTRL for selecting the basic angle (0°/-90°) to be automatically determined by the earthing situation of the network. The operation direction, forward or reverse, can be individually selected for the three stages.

The start value of the low stage Io>--> of the earth-fault protection should be set low enough to fulfil the sensitivity requirements of the safety regulations. The requirements regarding operate times are mainly fulfilled by the operation of the high stage Io>>--> and instantaneous operation by the third stage Io>>>-->. The directional earth-fault protection in this example is configured with two stages, Io>--> and Io>>-->.

The settings for the earth-fault current protections can be found in `Main menu\Protection\Io>-->\ … \Io>>>-->\`.

11.1.3.2. Protection signal routing

The settings for the protection signal routing can be implemented as described in the first application example (see Section 10.1. Outgoing feeder, Basic B01).

11.1.3.3. Indication and control connections

The connections for indication and control can be implemented as described in the first application example (see Section 10.1. Outgoing feeder, Basic B01), except the signals for the open and close buttons that in this example are disconnected to free the digital inputs for other functionality. Local control can be executed via the HMI according to the instructions in REX 521 Operator’s Manual (see Section 1.3. Related documents).

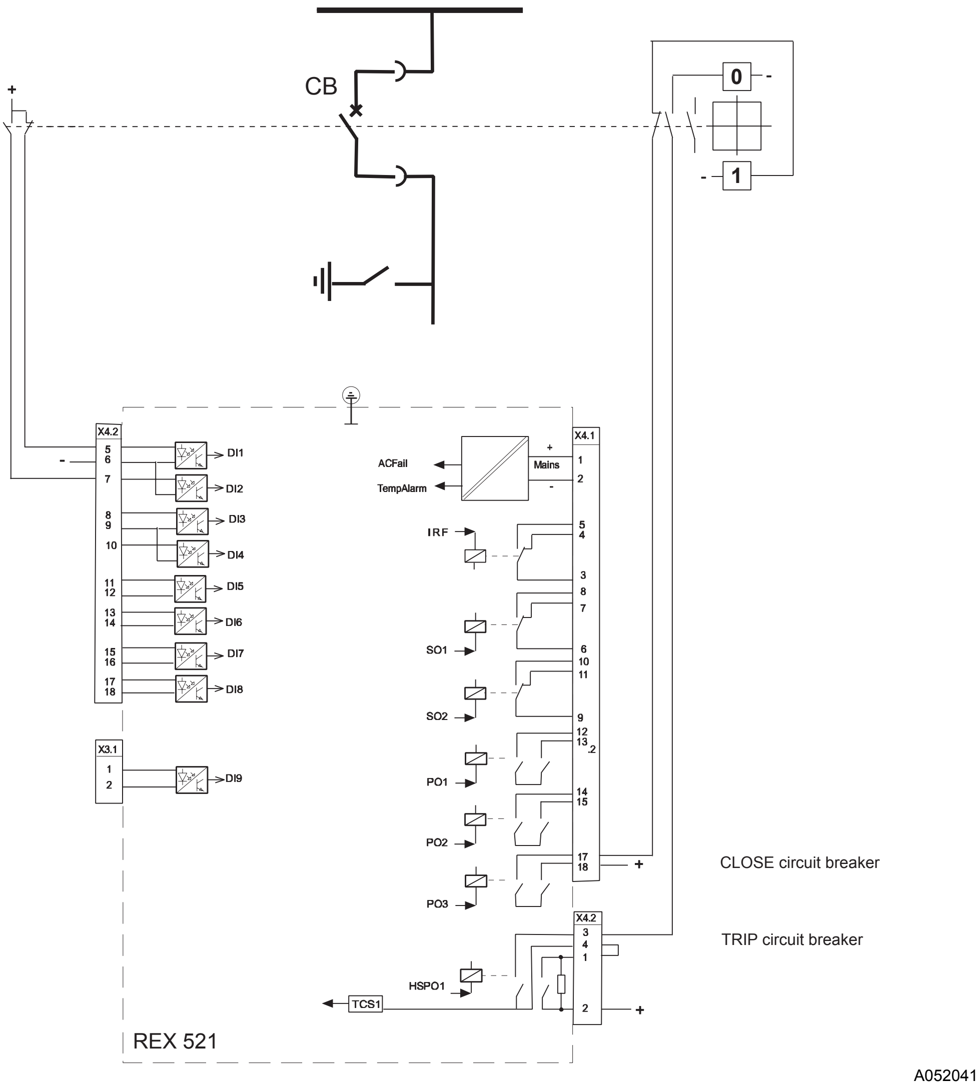


Fig. 11.1.3.3.-1 Connection diagram for the standard configuration M01 with breaker status indication and control signals for opening and closing of the circuit breaker

11.1.4. Implementations

In the section below a few implementation examples for the standard configuration M01 are presented.

11.1.4.1. Basic angle control by digital input

If an external control signal determined from the earthing situation of the network is available, it can be used for changing the settings for the basic angle of the directional earth-fault protection. The angle can be switched in between 0° and –90°. The usage of basic angle control is useful as compensated network is normally set to 0° and an isolated network is set to -90°.

In this example the digital input DI8 is connected to the input signal BACTRL and then routed to the BACTRL input of the directional earth-fault functions. The BACTRL signal can be found in Main menu\Configuration\Input Signals\BACTRL\ where DI8 is selected. The checksum for the switchgroup in Main menu\Configuration\Input SWGRP\BACTRL\ should be 3 to change the angle on Io>--> and Io>>-->. Refer to the CD-ROM Technical Descriptions of Functions (see Section 1.3. Related documents) for more information about the basic angle control (directional earth-fault function).

11.1.4.2. Outgoing blocking signal to the incoming feeder

The start signals from any protection function can be routed to an output relay to provide a blocking signal to the incoming feeder. The overcurrent stages 3I>> and 3I>>> have also a separate BSOUT signal for blocking purpose.

To use the start signal from a protection function, the signal has to be routed via `Main menu\Configuration\Output SWGRP\Start 1 or \Start 2`. When the start signals have been routed, the output relay has to be selected in `Main menu\Configuration\Output Signals`. In this example the overcurrent stage 3I>> is routed via Start 1 and then connected to power output 2, PO2. The checksum in this application example for Start 1 is 2.

11.1.4.3. Trip-alarm signals from overcurrent and earth fault

The trip signals from any protection function can be routed to an output relay in order to provide an alarm signal to indicate which protection has tripped.

To use the trip signal from a protection function, the signal has to be routed via `Main menu\Configuration\Output SWGRP\Trip 2` or `\Trip 3`. When the trip signals have been routed, the output relay has to be selected in `Main menu\Configuration\Output Signals`.

In this example, the overcurrent stages 3I> and 3I>>> are routed via Trip 2, then connected to the signal output 1, SO1. The earth-fault stages Io>--> and Io>>--> are routed via Trip 3, then connected to signal output 2, SO2. The checksum in this application example for Trip 2 is 5 and 24 for Trip 3.

11.1.4.4. Circuit-breaker failure protection

All of the protection functions in the standard configuration M01 provide a delayed trip signal CBFP after the trip signal unless the fault has not disappeared during the set CBFP time delay. In the circuit-breaker failure protection, the CBFP output can be used for operating an upstream circuit breaker.

The settings for breaker failure are set separately for each protection function. For example, to set the CBFP time for 3I>> go to `Main menu\Protection\3I>>\Control settings` where it is possible to set the `CBFP time` from 100 ms to 1000 ms. The control parameter `Trip pulse` sets the width of the trip output signal, but also of the CBFP output signal.

The CBFP signals from the protection functions are routed to the output signals via the output switchgroups. These settings can be found in `Main menu\Configuration\Output SWGRP\CBFP`. When the two-stage overcurrent, the two-stage directional earth fault, the unbalance and thermal overload protection are selected the checksum for CBFP will be 221.

The CBFP signal is then connected to any of the output relays via `Main menu\Configuration\Output Signals\`, and in this example the circuit-breaker failure signal is connected to power output 1, PO1.

11.1.4.5. Trip-circuit supervision

The trip-circuit supervision is available for the HSPO1 relay. If the resistance of the trip circuit exceeds a certain limit, for instance due to a bad contact or oxidation, the supervision function will be activated and a trip-circuit supervision alarm signal is provided after an adjustable delay time. The settings for the function can be found in `Main menu\Cond. monit.\TCS1\`.

To avoid unnecessary alarms the trip-circuit supervision can be blocked by the BS signal, which disables the supervision output when the circuit breaker is open. The BS signal is configured to be operated by the `CB pos. open` status from the selected digital input. The BS signal can be connected via the switchgroup in `Main menu\Configuration\Input SWGRP\TCS1\`. The default setting of the parameter is ”Not in use”.

Another solution is to use an external resistor to prevent the TCS1 alarm. Refer to REX 521 Technical Reference Manual, General (see Section 1.3. Related documents) for more information about the trip-circuit supervision.

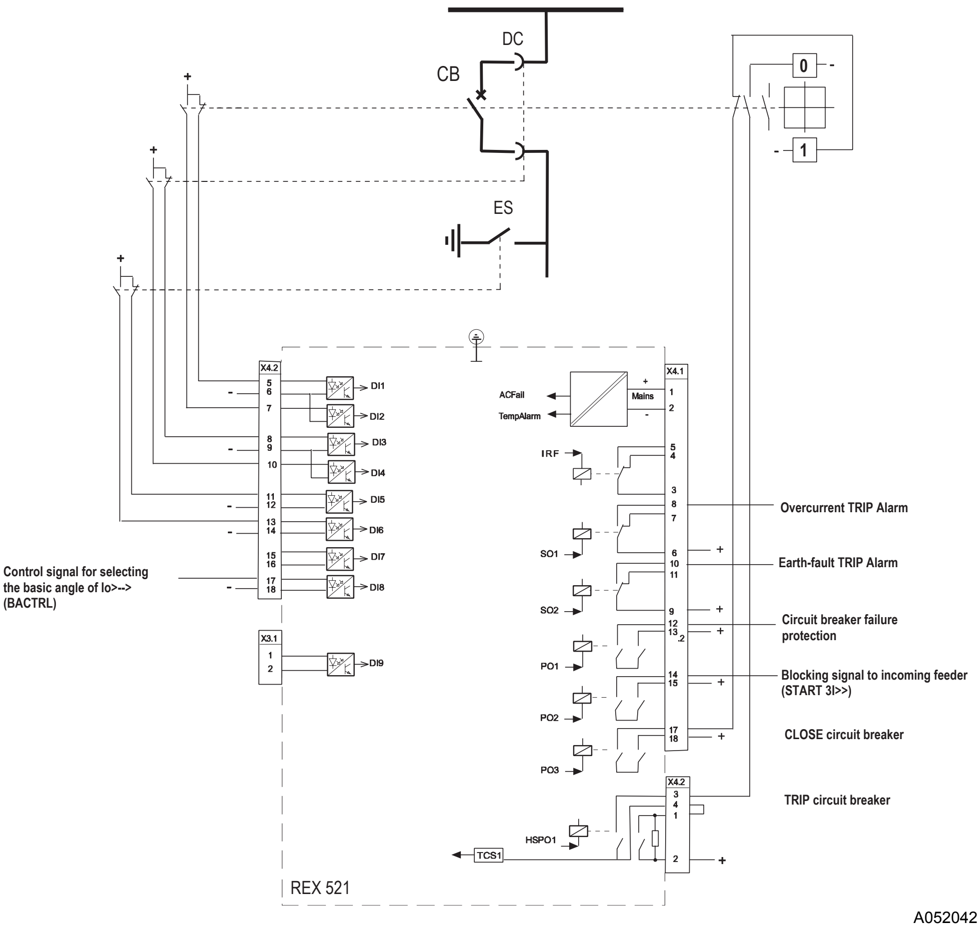


Fig. 11.1.4.5.-1 Connection diagram for the standard configuration M01 with breaker status indication, control and alarm signals.

11.2. Incoming feeder, Medium M01

11.2.1. Features

This application example describes an incoming feeder to a single busbar including:

- Overcurrent protection
- Residual voltage protection

The network is either compensated earthed or isolated. The three-phase current measurement is established with current transformers and the residual voltage is measured with a set of voltage transformers in an open-delta connection.

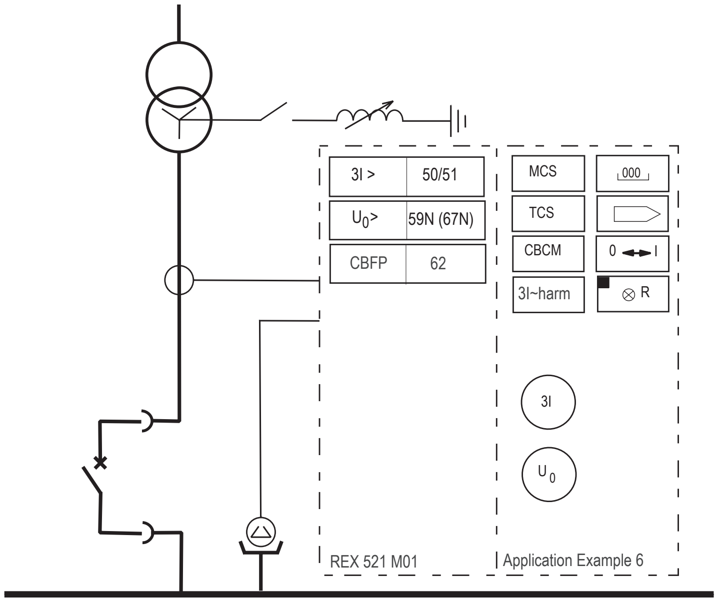


Fig. 11.2.1.-1 REX 521 M01 used for protection, measuring and supervision on an incoming feeder in a single busbar system. The system earthing on the supplying network is compensated or isolated.

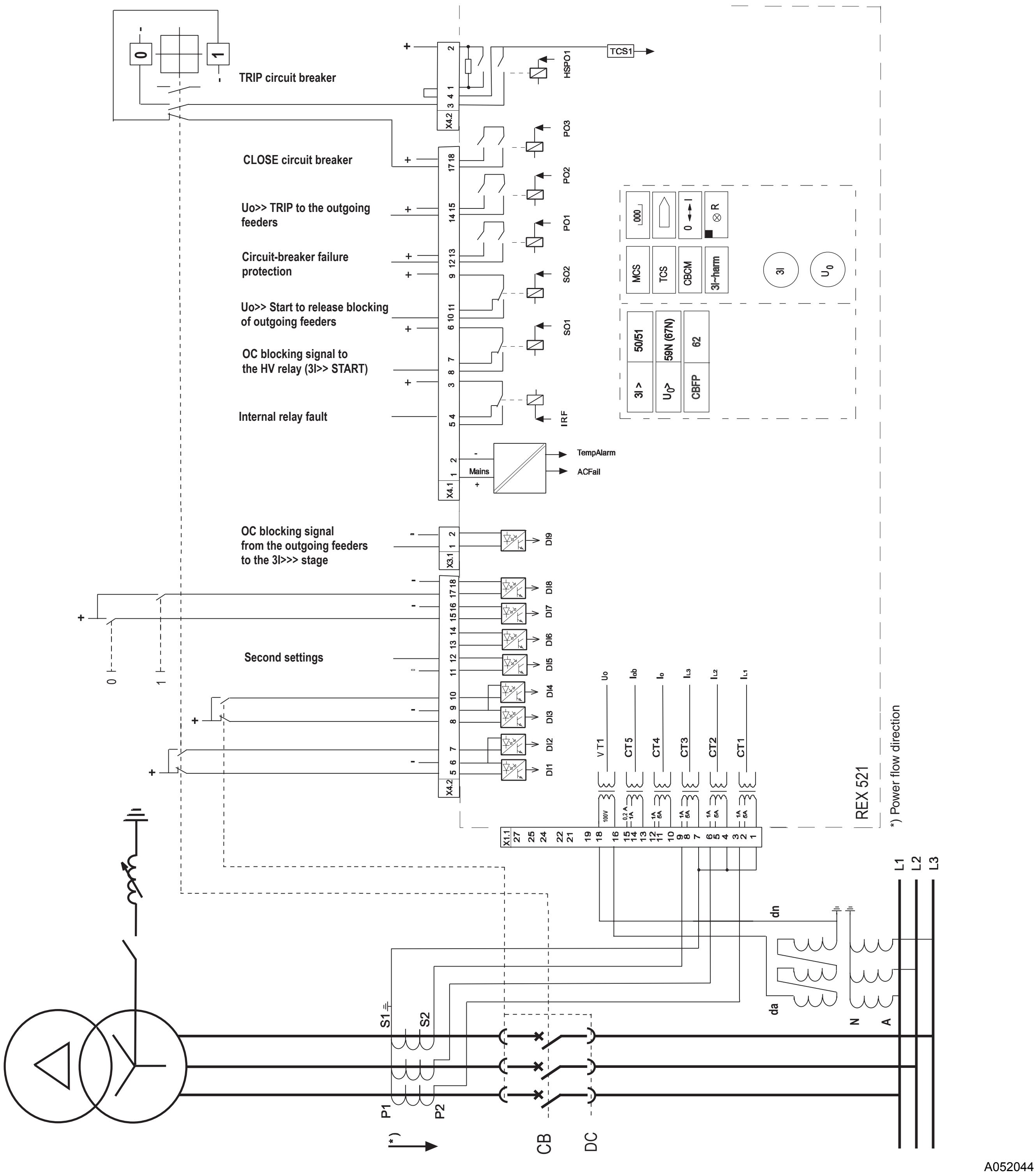
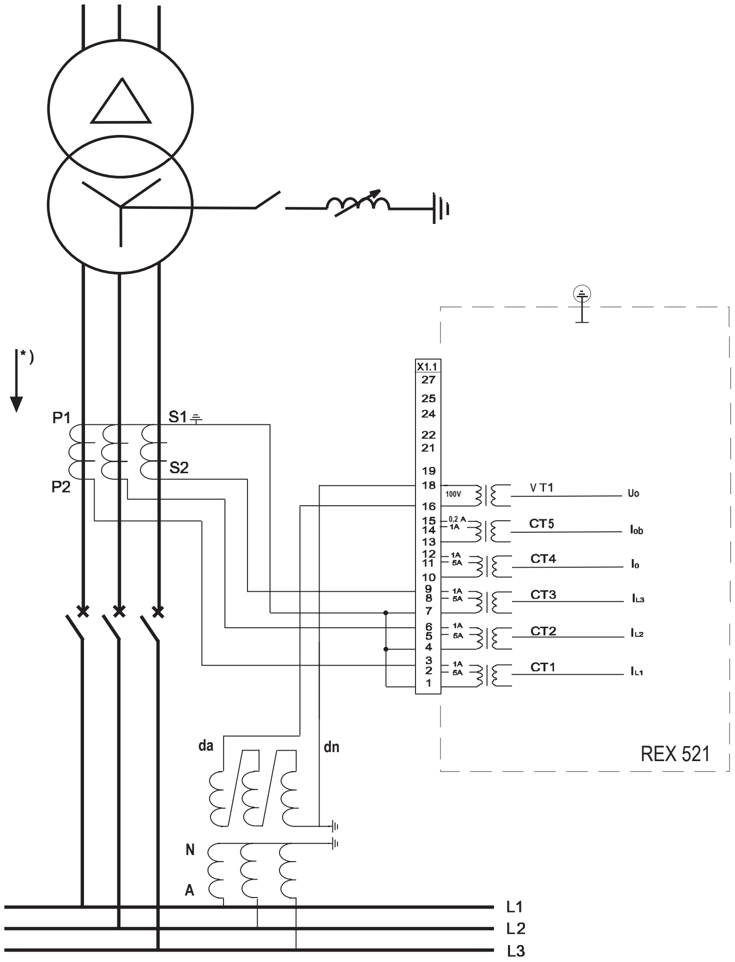


Fig. 11.2.1.-2 Connection overview diagram of the incoming feeder

11.2.2. Measurement connections

The three-phase current transformers and residual voltage transformers are connected to the connector X1.1 on the rear panel. The rated currents of the measuring input are 1 A and 5 A. The rated values for the voltage are 100 V, 110 V, 115 V and 120 V.



*) Power flow direction

A052045

Fig. 11.2.2.-1 Connection diagram for the standard configuration M01 for protection of an incoming feeder and as back-up protection of the outgoing feeders

The technical data of the current transformers and the voltage transformer are set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Configuration\Meas. devices\`. Refer to REX 521 Technical Reference Manual, General (see Section 1.3. Related documents) for further information about how to set the rated currents and voltage.

11.2.3. Protection

All the necessary settings for the protection functions can be set via the Relay Setting Tool or the local HMI. The settings can be found in
`Main menu\Protection\`.

11.2.3.1. Overcurrent protection

The overcurrent protection can be implemented as described in the second application example (see Section 10.2. Incoming feeder, Basic B01).

11.2.3.2. Residual voltage protection

On the busbar, the residual voltage can be measured with a set of voltage transformers in an open-delta connection.

In this example, the directional earth-fault functions are configured to operate as three-stage residual voltage protection. The directional earth-fault functions include three protection stages: a low stage Io>-->, a high stage Io>>--> and an instantaneous stage Io>>>-->. The protection is based on measuring the neutral current Io, the residual voltage Uo and the phase angle between these. In this application example the stages are set to residual protection (Uo).

In an isolated network, a three-stage residual overvoltage protection can be used for the main earth-fault protection of the busbar system and for the back-up protection of the network. The low stage can be given a sensitive setting and have an alarming function. Note that in this application example the CBFP signal has to be taken out of use for this stage. With the default settings, the CBFP is in use.

The high stage can work as back-up for the network and perform trip on the outgoing feeders. Further, the start signal from the high-set stage can be routed to an output contact to release the blocking for the non-directional earth-fault protection stages of the outgoing feeders (see also application example 9.1. for the outgoing feeder). The instantaneous stage can be configured as busbar protection and provide trip to the incoming feeder.

The settings for the residual voltage protection are made in the settings for the directional earth-fault current functions and can be found in
`Main menu\Protection\Io>-->\ … \Io>>>-->\`.
In `Main menu\Protection\Io>-->\Setting group 1`, the operation criteria is set to `Non.dir.Uo`.

11.2.4. Connections

All the necessary settings for the connections and signal routings can be set via the Relay Setting Tool or the local HMI.

11.2.4.1. Protection signal routing

The settings for the protection signal routing (except the settings for the earth-fault protection) can be implemented as described in the second application example (see Section 10.2. Incoming feeder, Basic B01).

11.2.4.2. Indication and control connections

The connections for the indication and the control signals of the circuit breaker and the disconnector for the incoming feeder can be set as described in the first application example on Section 10.2. Incoming feeder, Basic B01 onwards. Settings are made via the Relay Setting Tool or the local HMI. The settings can be found in:

```
Main menu\Configuration\Input Signals\
Main menu\Configuration\Input SWGRP\
Main menu\Configuration\Output Signals\
Main menu\Configuration\Output SWGRP\.
```

11.2.5. Implementations

In the sections below a few implementation examples for the standard configuration M01 are presented.

11.2.5.1. Start signal from the second residual voltage stage to release blocking

The start signal from the residual voltage high stage can be routed to an output relay to release the blocking signal for the non-directional earth-fault stages on the outgoing feeders of the network. To use the start signal from the residual protection function, the signal has to be routed via `Main menu\Configuration\Output SWGRP\Start 1` or `\Start 2`. When the start signal has been routed, the output relay has to be selected in `Main menu\Configuration\Output Signals`.

In this example, the directional earth-fault stage Io>>--> is configured as a Uo>> protection and the start signal is routed via Start 1 and then connected to the signal output 2, SO2. The checksum in this application example for Start 1 is 16.

11.2.5.2. Blocking signal received from the outgoing feeder

The start signals from the overcurrent protection of the outgoing feeder can be connected to block the overcurrent protection stages on the incoming feeder. There are two input blocking signals, Blocking 1 and Blocking 2, which can have different functions depending on the different protections.

On the overcurrent stages 3I>, 3I>> and 3I>>>, the Blocking 1 input signal is connected to the BS1 input and the Blocking 2 input signal is connected to the BS2 input of the function. In this application example, the BS1 will stop the DT or IDTM timer and the BS2 will block the trip signal. Refer to the CD-ROM Technical Descriptions of Functions (see Section 1.3. Related documents) for more information about the different protection function blocks.

In this application example the digital input DI9 is connected to the input signal Blocking 1 and then routed to the BS1 input of the overcurrent stage 3I>>>. The Blocking 1 signal can be found in `Main menu\Configuration\Input Signals\Blocking 1\` where DI9 is selected. The checksum for the switchgroup in `Main menu\Configuration\Input SWGRP\Blocking 1\` should be 4 to the block 3I>>>.

11.2.5.3. Outgoing blocking signal to the overcurrent relay on the HV side

The start signals from the overcurrent protection function can be routed to an output relay to provide a blocking signal. The overcurrent stages 3I>> and 3I>>> have also a separate BSOUT signal for blocking purpose.

As mentioned above, the start signal from the first high-set overcurrent stage 3I>> can be routed to the first high-set stage 3I>> of the HV relay. To use the start signal from a protection function the signal has to be routed via `Main menu\Configuration\Output SWGRP\Start 1` or `\Start 2`. When the start signal has been routed, the output relay has to be selected in `Main menu\Configuration\Output Signals`. In this example, the overcurrent start signal from the 3I>> stage is routed via Start 1 and then connected to the signal output 1, SO1. The checksum in this application example for Start 1 is 2.

11.2.5.4. Trip signal from second residual voltage stage

The trip signal from the residual voltage high stage can be routed to an output relay to provide a back-up trip signal to the outgoing feeders of the network.

To use the trip signal from the residual voltage protection function, the signal has to be routed via the `Main menu\Configuration\Output SWGRP\Trip 2 or \Trip 3`. When the trip signal has been routed, the output relay has to be selected in `Main menu\Configuration\Output Signals`.

In this example, the directional earth-fault stage Io>>--> is configured as a Uo>> protection and is routed via Trip 2 and then connected to the power output 2, PO2. The checksum in this application example for Trip 2 is16.

Note also that the events (for example start and trip) for the residual overvoltage protection will be sent from the directional earth-fault stages.

11.2.5.5. Second settings for residual voltage protection

If an external control signal determined from the earthing situation of the network is available, it can be used for changing to the second settings of the residual voltage protection. The usage of different settings can be useful when switching between a compensated network and an isolated network which results in changes in the level of the neutral voltage during earth fault.

In this example, the digital input DI5 is connected to the input signal Group and then routed to the group input of the directional earth-fault functions, which in this example is configured as residual protection. The Group signal can be found in `Main menu\Configuration\Input Signals\GROUP\` where DI5 is selected. The checksum for the switchgroup in `Main menu\Configuration\Input SWGRP\GROUP\` should be 2 to change to the second settings for earth fault. In the control settings for the directional earth-fault functions, the group input has to be chosen for the group selection. Refer to the CD-ROM Technical Descriptions of Functions (see Section 1.3. Related documents) for more information about the directional earth-fault function.

11.2.5.6. Circuit-breaker failure protection

All of the protection functions in the standard configuration M01 provide a delayed trip signal CBFP after the trip signal unless the fault has not disappeared during the set CBFP time delay. In the circuit-breaker failure protection, the CBFP output can be used for operating an upstream circuit breaker.

The settings for breaker failure are set separately for each protection function. For example, to set the CBFP time for 3I>> go to `Main menu\Protection\3I>>\Control setting` where it is possible to set the `CBFP time` from 100 ms to 1000 ms. The control parameter `Trip pulse` sets the width of the trip output signal, but also of the CBFP output signal.

The CBFP signals from the protection functions are routed to the output signals via the output switchgroups. These settings can be found in `Main menu\Configuration\Output SWGRP\CBFP`. When the two-stage overcurrent, the two-stage directional earth fault, the unbalance and thermal overload protection are selected, the checksum for CBFP will be 221.

The CBFP signal is then connected to any of the output relays via `Main menu\Configuration\Output Signals\`, and in this example the circuit-breaker failure signal is connected to the power output 1, PO1.

11.2.5.7. Trip-circuit supervision

The trip-circuit supervision is available for the HSPO1 relay. If the resistance of the trip circuit exceeds a certain limit, for instance due to a bad contact or oxidation, the supervision function will be activated and a trip-circuit supervision alarm signal will be provided after an adjustable delay time. The settings for the function can be found in `Main menu\Cond. monit.\TCS1\`.

To avoid unnecessary alarms the trip-circuit supervision can be blocked by the BS signal, which disables the supervision output when the circuit breaker is open. The BS signal is configured to be operated by the “CB pos. open” status from the selected digital input. The BS signal can be connected via the switchgroup in `Main menu\Input SWGRP\TCS1\`. The default setting of the parameter is ”Not in use”.

Another solution is to use an external resistor to prevent the TCS1 alarm. Refer to REX 521 Technical Reference Manual, General (see Section 1.3. Related documents) for more information about the trip-circuit supervision.

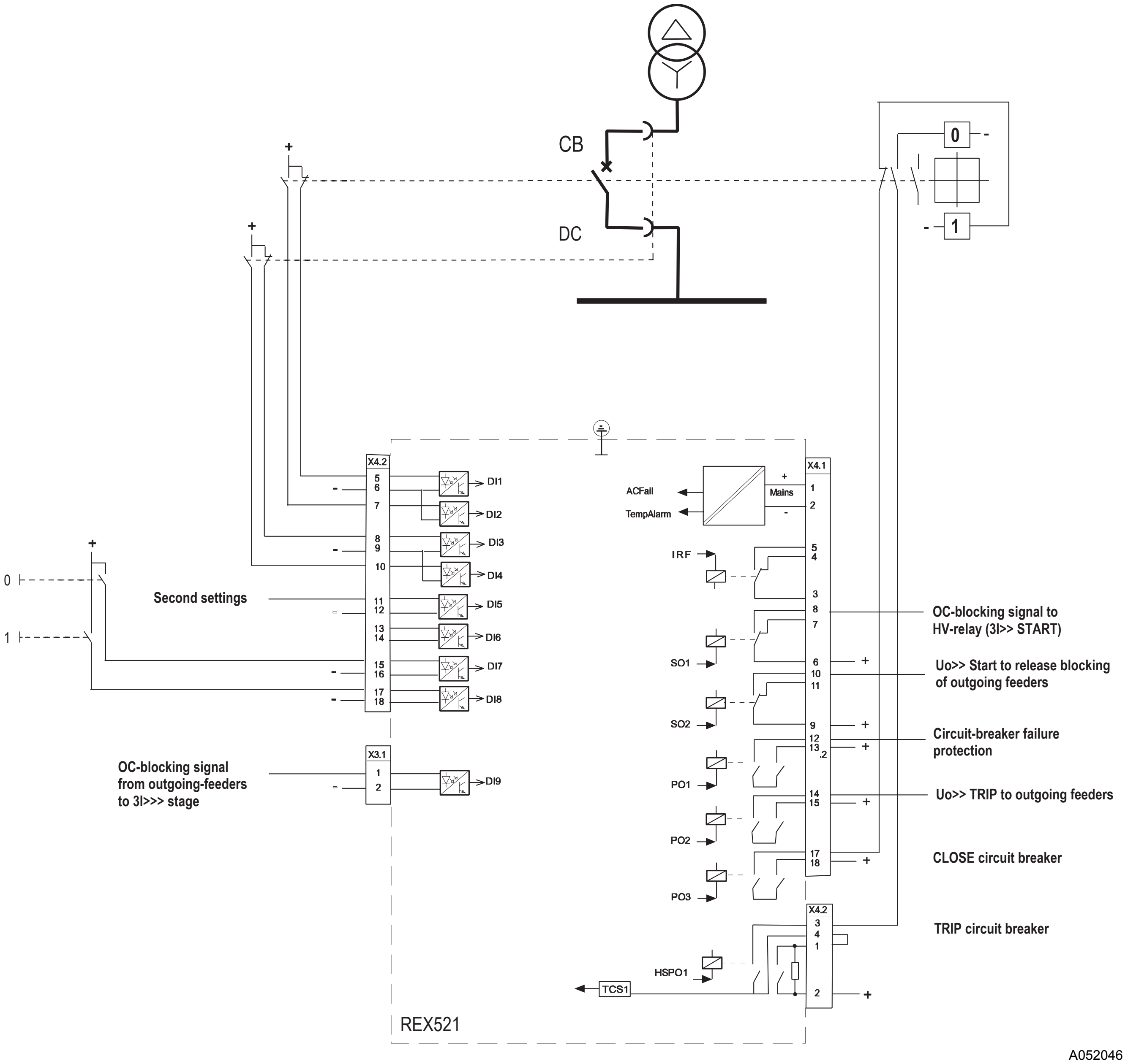


Fig. 11.2.5.7.-1 Connection diagram for the standard configuration M01 with breaker status indication, control and alarm signals.

11.3. Outgoing feeder, Medium M02

11.3.1. Features

This application example describes an outgoing feeder of a single busbar including:

- Autoreclose function
- Overcurrent protection
- Directional earth-fault protection
- Phase discontinuity protection
- Thermal overload protection for cable/line

The network is either compensated or isolated. Three-phase current measurement is established with a set of current transformers and the neutral current is measured with a cable transformer. The residual voltage is measured with a set of voltage transformers in an open-delta connection.

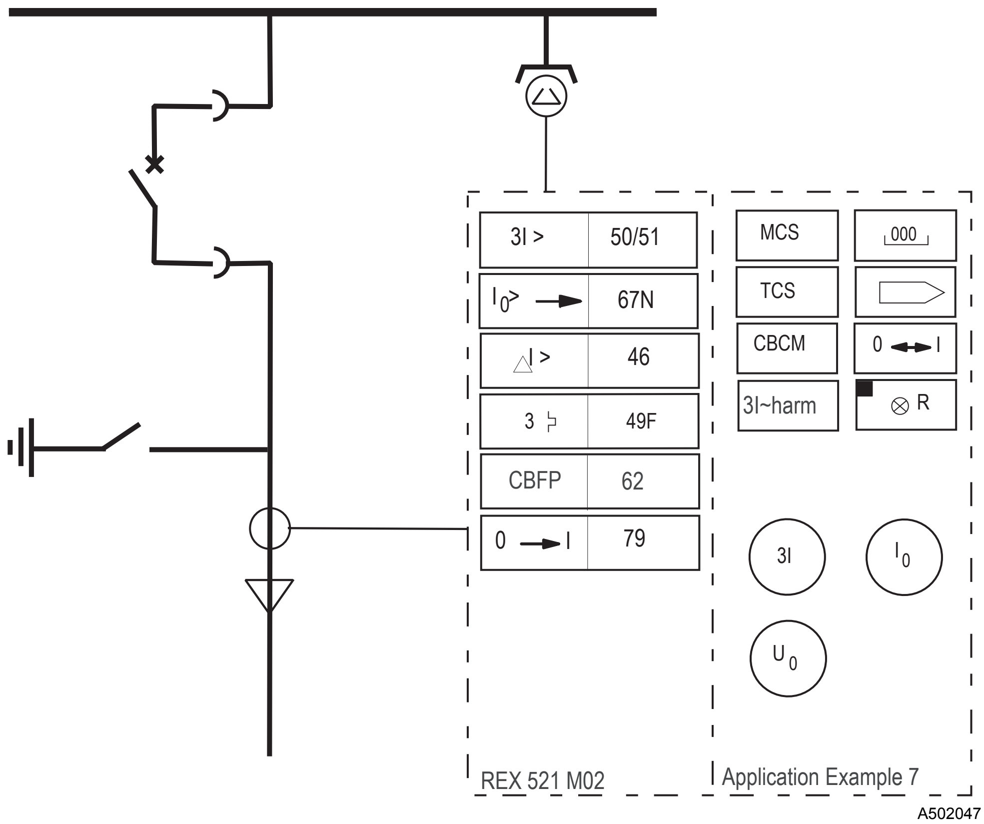


Fig. 11.3.1.-1 REX 521 M02 used for protection, measuring and supervision on an outgoing feeder in a single busbar system. The supplying network is either compensated or isolated.

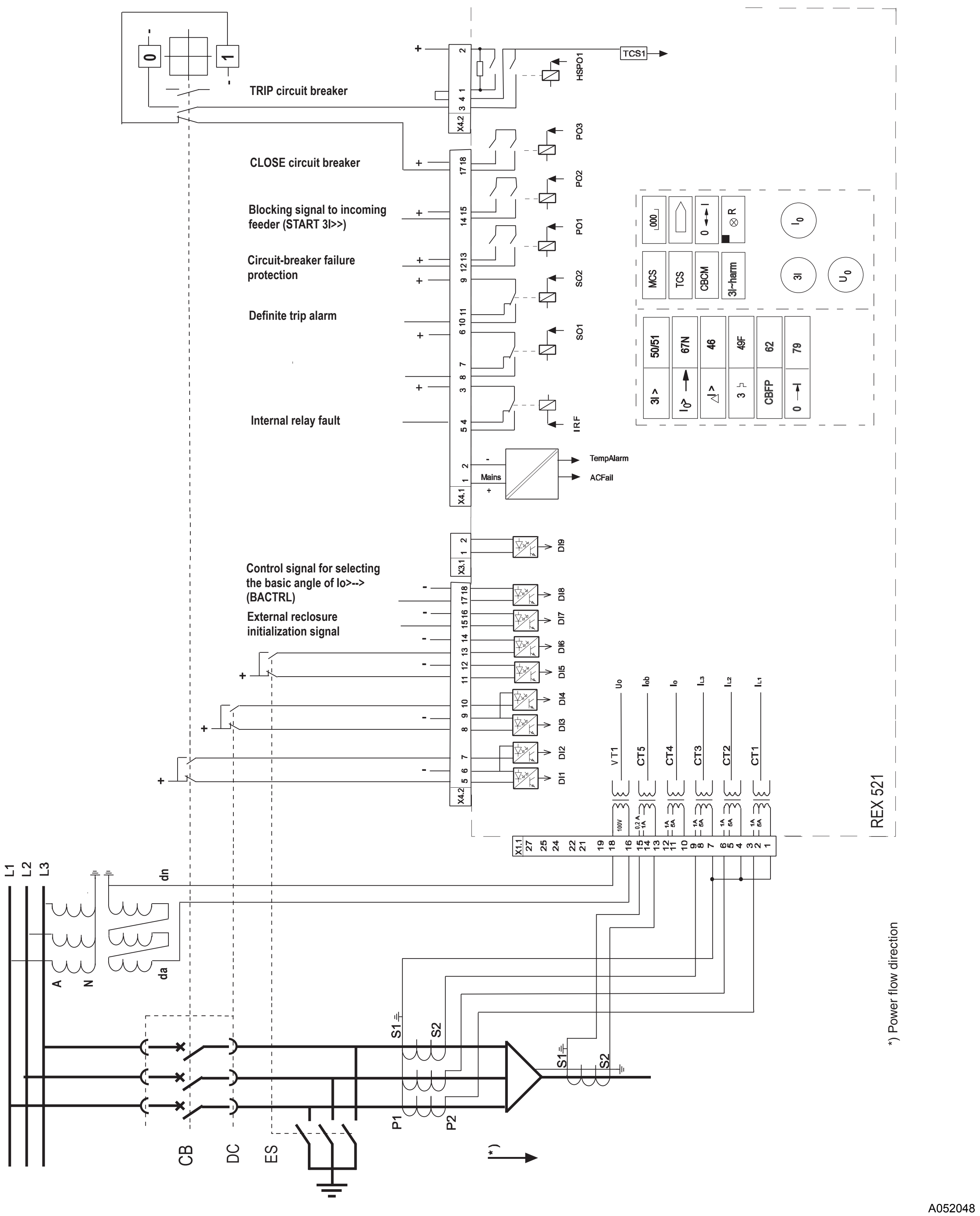


Fig. 11.3.1.-2 Connection overview diagram of the outgoing feeder

11.3.2. Measurement connections

The three-phase current, neutral current transformers and residual voltage transformer are connected to the connector X1.1 on the rear panel. The rated currents of the measuring input are 1 A and 5 A and additionally, for earth fault, 0.2 A and 1 A. The rated values for voltage are 100 V, 110 V, 115 V and 120 V.

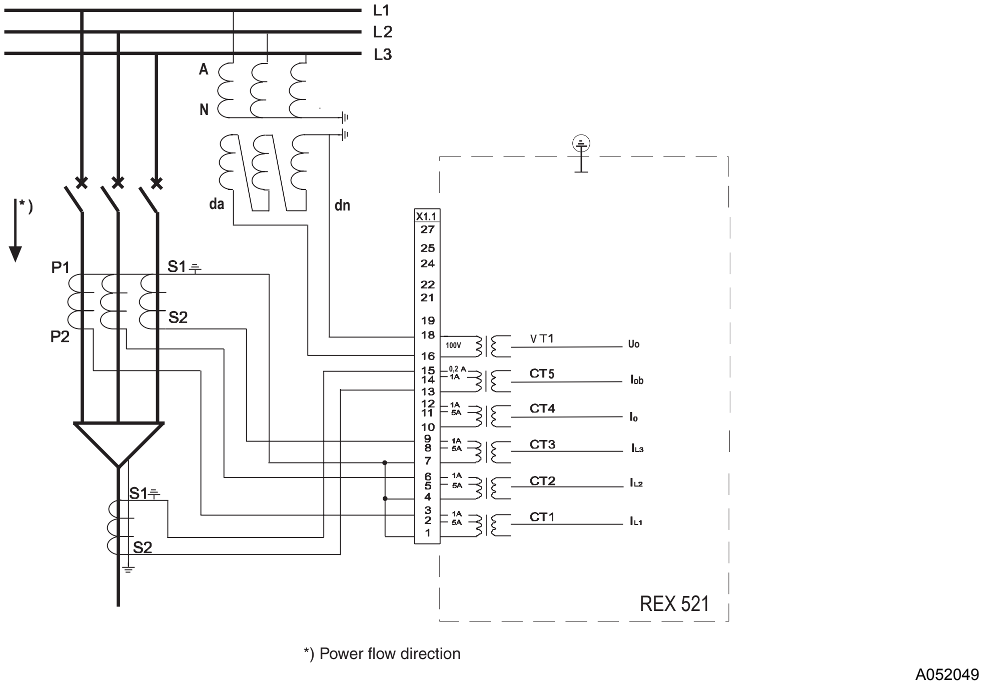


Fig. 11.3.2.-1 Connection diagram for the standard configuration M02

The technical data of the current transformers and the voltage transformer are set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Configuration\Meas. devices\`.

Refer to REX 521 Technical Reference Manual, General (see Section 1.3. Related documents) for further information about how to set the rated currents and voltage.

11.3.3. Protection

All the necessary settings for the protection functions can be set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

The overcurrent, the phase discontinuity and thermal overload protection can be implemented in the same way as in the first application example (see Section 10.1. Outgoing feeder, Basic B01) and the directional earth-fault protection as in the fifth application example (seec Section 11.1. Outgoing feeder, Medium M01).

11.3.3.1. Autoreclose function

The autoreclose function (O-->I) enables different types of auto-reclosing. An autoreclose sequence is initiated either by a start signal or by a trip signal.

In the following example two auto-reclosures initiated by the start of the protection are carried out. The auto-reclosures are subject to a preset start-delay time initiated from the start signal of the protection. The first auto-reclosure is delayed only slightly to avoid unwanted auto-reclosures (100 ms). Shot 1 is a high-speed auto-reclosure (short dead time 300 ms) mainly used for extinguishing the arc at the fault place. Before the second shot is initiated, a longer start delay time is used to attempt to burn the fault (300 ms). The dead time of Shot 2 is long, a so called delayed autoreclose, that typically lasts minutes, (in this case 2 min). Should the fault still persist when Shot 2 has been performed (after 200 ms), the final circuit-breaker tripping will follow and a DEFTRIP alarm signal is activated and can be routed to an output (contact if needed).

The operate time of the protection is longer than the operate times of the autoreclose function and the final trip-time. Thus the protection operates as a back-up for the autoreclose function, if the tripping carried out by the autoreclose function fails.

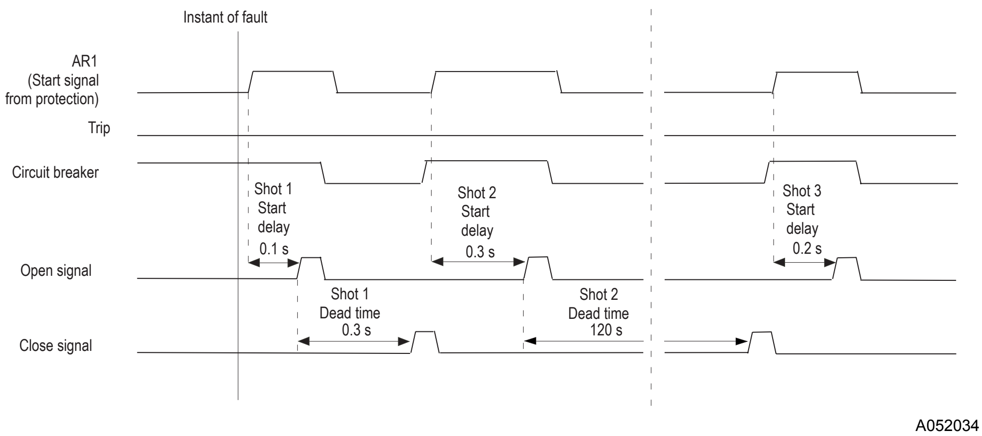


Fig. 11.3.3.1.-1 An autoreclose sequence, when AR is initiated by the start signal

An autoreclose sequence can also be initiated by the trip signal of a protection function. The trip signal from the protection trips the breaker after the set start-time of the protection function.

When the set dead-time of the autoreclose function elapses, the function closes the circuit breaker and a discriminating time (TDDUE output signal) is started. If one of the initiation signals is activated during the discriminating time, and if the short circuit current or the earth-fault current increases and the operate time of the protection function shortens at inverse-time operation, the AR shots are prevented and definite tripping will follow. The discriminating time, usually called td, can be set out of use by selecting the value 0. Normally, this discriminating time is shorter than the operate time of the protection function, so the sequence is allowed to continue with the second shot, the third shot, and so on, until the selected sequence has been completed or the fault has disappeared.

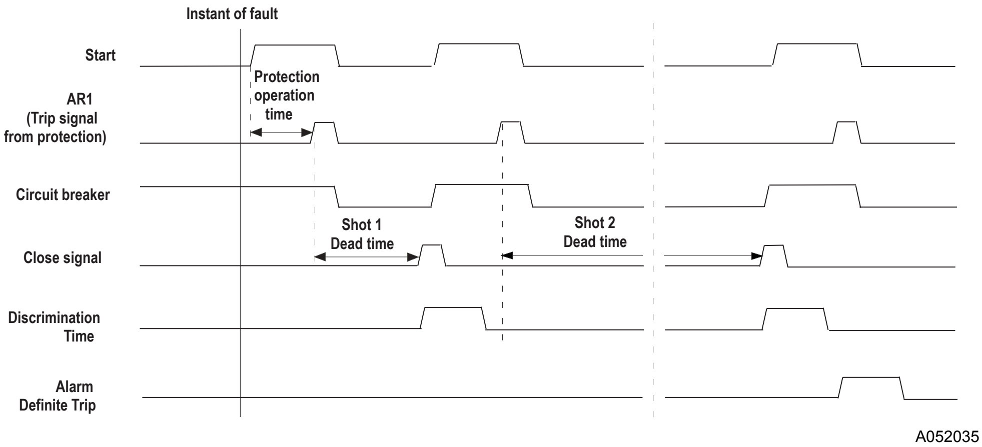


Fig. 11.3.3.1.-2 An autoreclose sequence, when AR is initiated by the trip signal

The reclaim time is always started or restarted at a circuit breaker close operation. A new initiation signal during the reclaim time will perform the next shot if one has been selected. When all shots have been executed, the autorecloser is locked out. When the reclaim time has elapsed, the lock-out function of the autorecloser ends, if lock-out mode for the autoreclose function has been set to "automatic".

To be able to initiate the autoreclose function with the start or trip signal from a protection function a few settings must be prepared. The initiation signals from the different protections can be found in `Main menu\Configuration\Input SWGRP\` where for example the overcurrent initiation signals are named as `O-->I\3I>...3I>>>`.

To select the high overcurrent stage (3I>>) to initiate the autoreclose function, choose the `O-->I/3I>>`, press [E], scroll the different initiation signal methods with the [→] and [←] navigation push buttons and the specific initiation method can be enabled or disabled with the [↑] and [↓] push buttons. The checksum will be 1 if the `3I>> Start AR1` is set, and 2 if the `3I>> Trip AR1` is set.

After the initiation method is chosen, the settings for the autoreclose function has to be done. In `Main menu\Protection\O-->I\General setting\` the operation is taken in use with the `AR-operation` set to ON and the `Reclaim time` can be set.

The different shot settings are given in `Main menu\Protection\O-->I\Shot1...5 settings`. To set the first shot as earlier in this section with initiation from the start, go to the Shot 1 settings, select `Initiation mode` as "Start", select `AR1 oper. mode` as "Init. shot", set `AR1 start delay` to 0.1 s and set `Dead time` to 0.3 s. Proceed with the Shot 2 settings in the same way and with the start-delay and dead-time settings as the example or as the functionality requires.

To make the initiation by the trip signal, go to the Shot 1 settings, select `Initiation mode` as "Trip", select `AR1 oper. mode` as "Init. shot" and set the first `Dead time` according to the requirements. The Shot 2 and the ongoing shots are made in the same way.

The open signal from the autorecloser is connected as the trip directly to the HSPO1 and the close signal is connected to the same output signal as the close signal from the circuit breaker function. The reclose signal is depended on the interlocking method chosen for closing of the breaker. If the trip is activated during the close-pulse period, the close signal is deactivated. Alarms and action signals are available as three different signals from the autorecloser. The signals can be found in `Main menu\Configuration\Output SWGRP\` and they are named as `O-->I ACTIVE`, `O-->I Alarm1` and `O-->I Alarm2`. Refer to the CD-ROM Technical Descriptions of Functions (see Section 1.3. Related documents) for more information about the auto-reclosing function.

11.3.4. Protection signal routing

The settings for the protection signal routing can be implemented as described in the first application example (see Section 10.1. Outgoing feeder, Basic B01).

11.3.5. Indication and control connections

The connections for indication and control can be implemented as described in first application example (see Section 10.1. Outgoing feeder, Basic B01), except the signals for the open and close buttons that in this example are disconnected to free the digital inputs for other functionality. Local control can be executed via the HMI according to the instructions in REX 521 Operator’s Manual (see Section 1.3. Related documents).

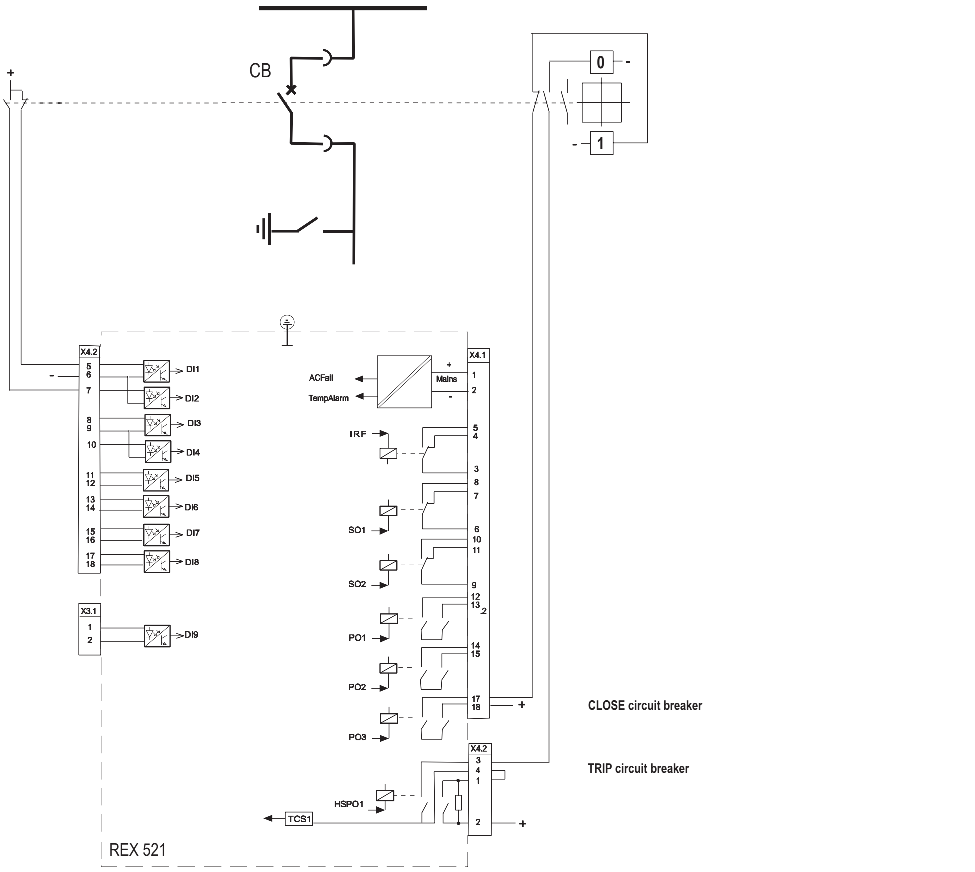


Fig. 11.3.5.-1 Connection diagram for the standard configuration M02 with breaker status indication and control signals for opening and closing of the circuit breaker

11.3.6. Implementations

In the sections below a few implementation examples for the standard configuration M02 are presented.

11.3.6.1. Definite trip alarm to output relay

To receive the DEFTRIP signal on an output contact go to `Main menu\Configuration\Output SWGRP\O-->I Alarm 1`, press the [E]-button and scroll to the DEFTRIP and take it in to use with the help of the [↑] and [↓] push buttons. The checksum for O-->I Alarm 1 is then 32. The O-->I Alarm1 signal can then be routed to an output contact, in this example SO2, in `Main menu\Configuration\Output signals\`.

11.3.6.2. Digital input to initiate auto-reclosing function

If an external start or trip signal is available for initializing the autorecloser, the signal can be connected to a digital input of the relay. Set the digital input, in this example DI7, for the `O-->I Ext. start`, or `O-->I Ext. trip` in `Main menu\Configuration\Input signals\`. Further, in `Main menu\Configuration\Input SWGRP\` the external initiation signal is named as `O-->I External`. The initiation method is chosen and in this example Trip AR1 or Start AR1 can be used depending on the signal available and the methods parametrized within the autoreclose function.

The rest of the settings are made in the settings for the autorecloser in the same way as mentioned above.

11.3.6.3. Basic angle control by digital input

If an external control signal determined from the earthing situation of the network is available, it can be used for changing the settings for the basic angle of the directional earth-fault protection. The angle can be switched in between 0° and –90°. The usage of basic angle control is useful when compensated network is set to 0° and an isolated network is set to -90°.

In this example, the digital input DI8 is connected to the input signal BACTRL and then routed to the BACTRL input of the directional earth-fault functions. The BACTRL signal can be found in `Main menu\Configuration\Input Signals\BACTRL\` where the DI8 is selected. The checksum for the switchgroup in `Main menu\Configuration\Input SWGRP\BACTRL\` should be 3 in order to change the angle on Io>--> and Io>>-->. Refer to the CD-ROM Technical Descriptions of Functions (see Section 1.3. Related documents) for more information about the basic angle control.

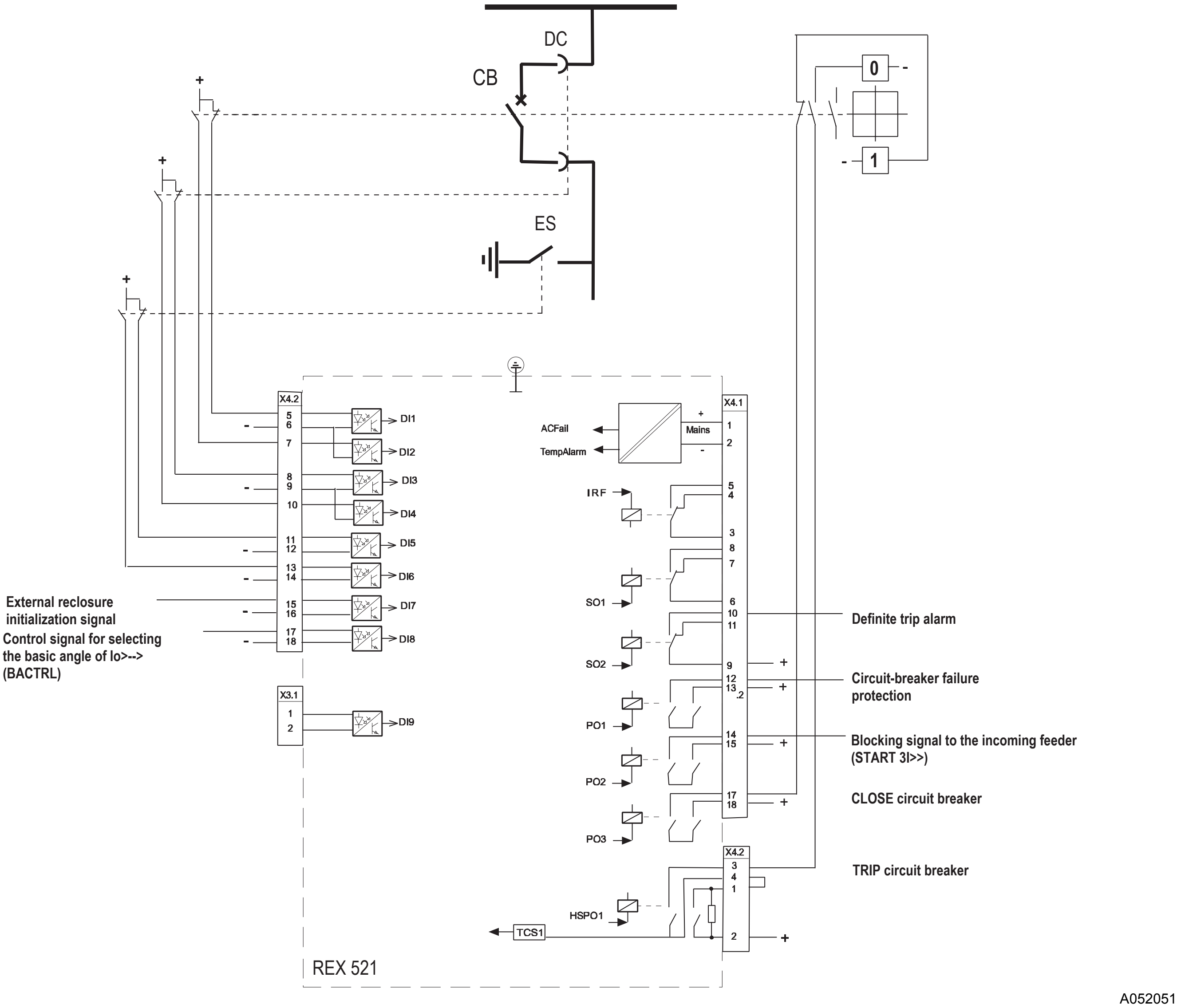


Fig. 11.3.6.3.-1 Connection diagram for the standard configuration M02 with breaker status indication, control and alarm signals.

12. Application examples, High

12.1. Incoming feeder, High H01

12.1.1. Features

This application example describes an incoming feeder to a single busbar with parallel feeders including:

- Directional overcurrent protection
- Non-directional overcurrent protection
- Synchro-check and voltage-check

This application example is an optional solution for the application example 9 (see Section 12.2. Incoming feeder, High H02), if there is a parallel generator feeder connected to the same busbar.

The network is either compensated earthed or isolated. The directional overcurrent protection is used because of the parallel feeders. There is no earth-fault protection included in this application example, because residual voltage-based protection can be located on the measurement cubicle of the busbar.

The three-phase current measurement is established with Rogowski sensors and the residual voltage is calculated from phase-to-earth voltages which are measured by the voltage dividers. Phase-to-phase voltage of the busbar for synchro- and voltage-check is measured by the voltage transformer.

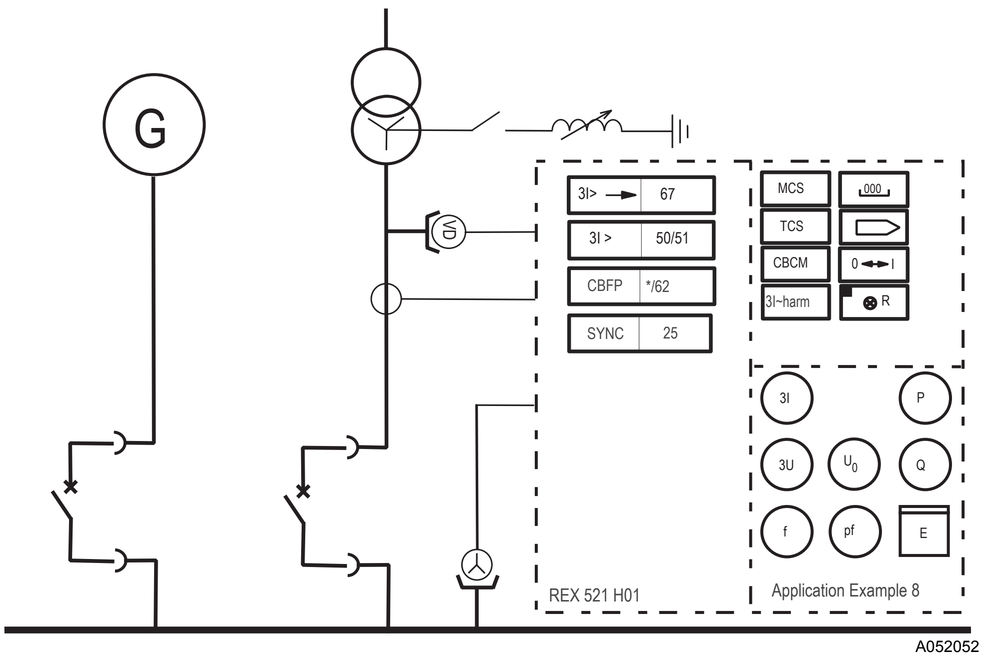


Fig. 12.1.1.-1 REX 521 High H01 used for protection, measuring and supervision on an incoming feeder in a single busbar system with parallel generator feeder. The system earthing on the supplying network is compensated or isolated.

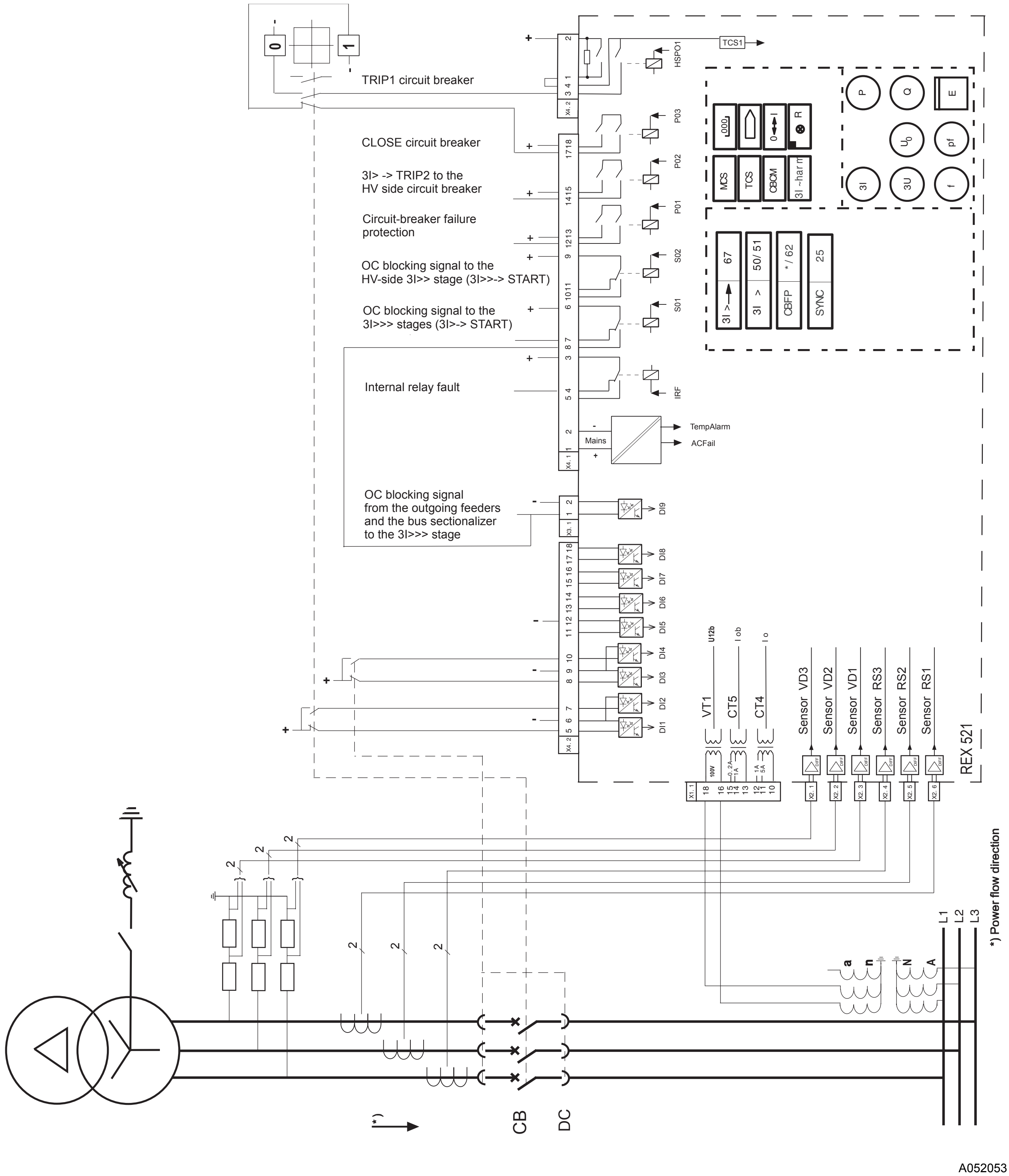


Fig. 12.1.1.-2 Connection overview diagram of the incoming feeder

12.1.2. Measurements

Following measurements are supported in this application example:

- True RMS measurement of phase currents
- True RMS measurement of phase-to-earth voltages
- True RMS measurement of residual voltage (calculated value from phase-to-earth voltages)
- Fundamental frequency active power [kW]
- Fundamental frequency reactive power [kVAr]
- Fundamental frequency displacement power factor cos (ϕ)
- Power factor PF including the harmonics
- Fundamental frequency active energy [kWh]
- Fundamental frequency reactive energy [kvarh]
- System frequency measurement

12.1.3. Protection

All the necessary settings for the protection functions can be set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

12.1.3.1. Overcurrent protection

The basic overcurrent protection principles presented in the application example Section 12.2. Incoming feeder, High H02 are applicable, but different overcurrent protection stages have been used.

In the example of the incoming feeder application, the stage 3I>>--> of the overcurrent protection of the incoming feeder operate time-selectively as a directional overcurrent back-up protection of the outgoing feeders. The stage 3I> -> is used for the directional overcurrent protection of the parallel incoming feeders to disconnect faulty feeder from the network. The stage 3I>>> is used for the non-directional short-circuit protection of the busbar system.

12.1.3.2. Synchro-check function

In this application example the synchro-check function is used for checking the conditions for the closing of incoming feeders circuit-breaker. The synchro-check function does not allow the circuit breaker to be closed if the criteria are not fulfilled.

The synchro-check function can be used for two different operating conditions. The most typical case is the one where both sides of the circuit breaker to be closed are live and thus the synchronism is always checked before the circuit breaker is given the permission to close. In the other situation one or both sides of the circuit breaker to be closed are dead and, consequently, the frequency and phase differences cannot be measured, in which case the relay checks the energizing direction.

Operation criteria of the function are:

- Voltages must be in accordance with the energizing direction.
- In cases “Live-Dead”, “Dead-Live” and “Dead-Dead” no other conditions are checked.
- In the case “Live-Live” also the following must be fulfilled:
  - $\Delta U <$ dU setting
  - $\Delta f <$ df setting
  - $\Delta \varphi <$ dphi setting

Before the function block allows the CB closing, it ensures that the phase difference will remain within the setting range until the CB closes.

The command mode is used as a basic control principle of the synchro-check function. In command mode, the synchro-check function directly uses the output signal to close the circuit breaker. The close command for example from the HMI is connected to the synchro-check function. When the close command is activated, the synchro-check function checks the closing criteria and if they are fulfilled, it will route the command to the output relay of the protection relay. In this application example the close signal is connected to the power output PO3.

The command mode principle means that the interlocking logic related to the control functionality will affect the synchro-check function as well. If blocking is needed it can be carried out by using the ready-made interlocking logic, for example in a case where the phase-to-phase voltage is missing from either side of the circuit breaker because of the open miniature circuit breaker (MCB) of the measurement circuit.

12.1.4. Connections

All the necessary settings for the connections and signal routings can be set via the Relay Setting Tool or the local HMI.

12.1.4.1. Protection signal routing

The settings for the protection signal routing can be implemented as described in the second application example (see Section 10.2. Incoming feeder, Basic B01). In this application two different trip signals are used: Trip 1 for opening of the circuit breaker of the incoming feeder and Trip 2 for opening of the circuit breaker of the transformer feeder. In this application separate power output relays are used for Trip 2 and CBFP (circuit breaker failure protection) function.

12.1.4.2. Indication and control connections

The connections for indication and control can be implemented as described in first application example (see Section 10.1. Outgoing feeder, Basic B01), except the signals for the open and close buttons that in this example are disconnected. Local control can be executed by HMI according to the instructions in REX 521 Operator’s Manual (see Section 1.3. Related documents).

12.1.5. Implementations

In the sections below a few implementation examples for the standard configuration H01 are presented.

12.1.5.1. Blocking principles

The blocking principles presented in the application example Section 12.2. Incoming feeder, High H02 are applicable, but different overcurrent protection stages have been used.

12.1.5.2. Circuit-breaker failure protection

All of the current-based protection functions in the standard configuration H01 provide a delayed trip signal CBFP after the trip signal unless the fault has not disappeared during the set CBFP time delay. In the circuit-breaker failure protection, the CBFP output can be used for operating an upstream circuit breaker.

The settings for breaker failure are set separately for each protection function. For example, to set the CBFP time for 3I>> -> go to `Main menu\Protection\3I>> ->\Control setting` where it is possible to set the `CBFP time` from 100 ms to 1000 ms. The control parameter `Trip pulse` sets the width of the trip output signal, but also of the CBFP output signal.

The CBFP signals from the protection functions are routed to the output signals via the output switchgroups. These settings can be found in `Main menu\Configuration\Output SWGRP\CBFP`. The CBFP signal is then connected to any of the output relays via `Main menu\Configuration\Output Signals\`, and in this example the circuit-breaker failure signal is connected to the power output 1, PO1.

12.1.5.3. Trip-circuit supervision

The trip-circuit supervision is available for the HSPO1 relay. If the resistance of the trip circuit exceeds a certain limit, for instance due to a bad contact or oxidation, the supervision function will be activated and a trip-circuit supervision alarm signal will be provided after an adjustable delay time. The settings for the function can be found in `Main menu\Cond. monit.\TCS1\`.

To avoid unnecessary alarms, trip-circuit supervision can be blocked by the BS signal, which disables the supervision output when the circuit breaker is open. The BS signal is configured to be operated by the “CB pos. open” status from the selected digital input. The BS signal can be connected via the switchgroup in `Main menu\Input SWGRP\TCS1\`. The default setting of the parameter is “Not in use”.

Another solution is to use an external resistor to prevent the TCS1 alarm. Refer to REX 521 Technical Reference Manual, General (see Section 1.3. Related documents) for more information about the trip-circuit supervision.

12.2. Incoming feeder, High H02

12.2.1. Features

This application example describes an incoming feeder to a single busbar with parallel incoming feeders including:

- Directional overcurrent protection
- Non-directional overcurrent protection

The network is either compensated earthed or isolated. The directional overcurrent protection is used because of the parallel incoming feeders. There is no earth-fault protection included in this application example because residual voltage-based protection can be located on the measurement cubicle of the busbar.

The three-phase current measurement is established with current transformers and the residual voltage is measured with a set of voltage transformers in an open-delta connection. Phase-to-phase voltage measurements are established with voltage transformers.

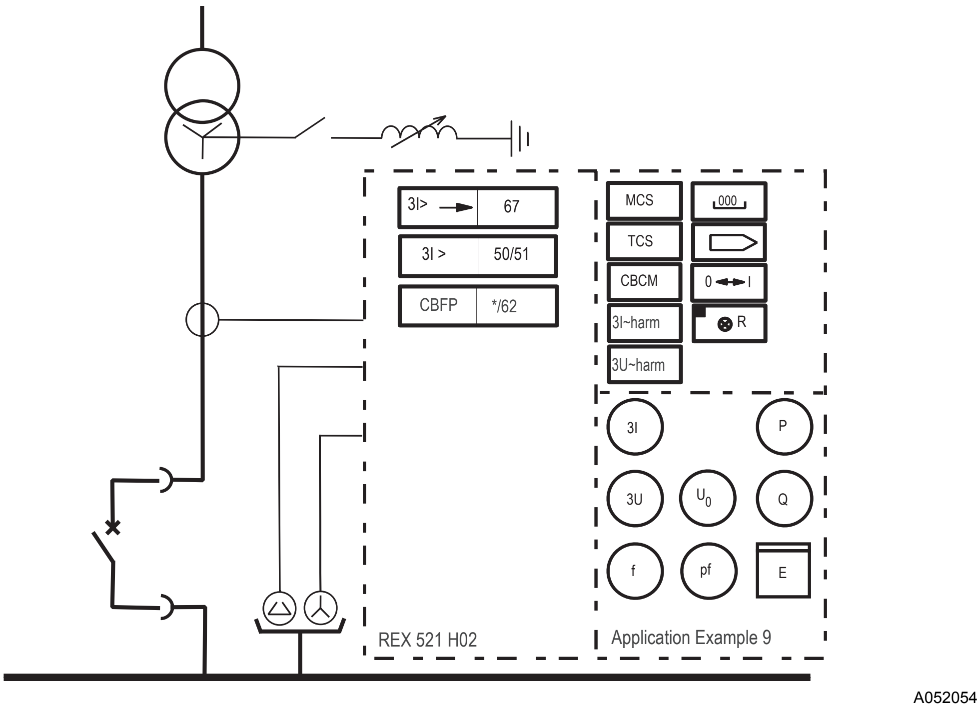


Fig. 12.2.1.-1 H02 used for protection, measuring and supervision on an incoming feeder in a single busbar system with parallel feeders. The system earthing on the supplying network is compensated or isolated.

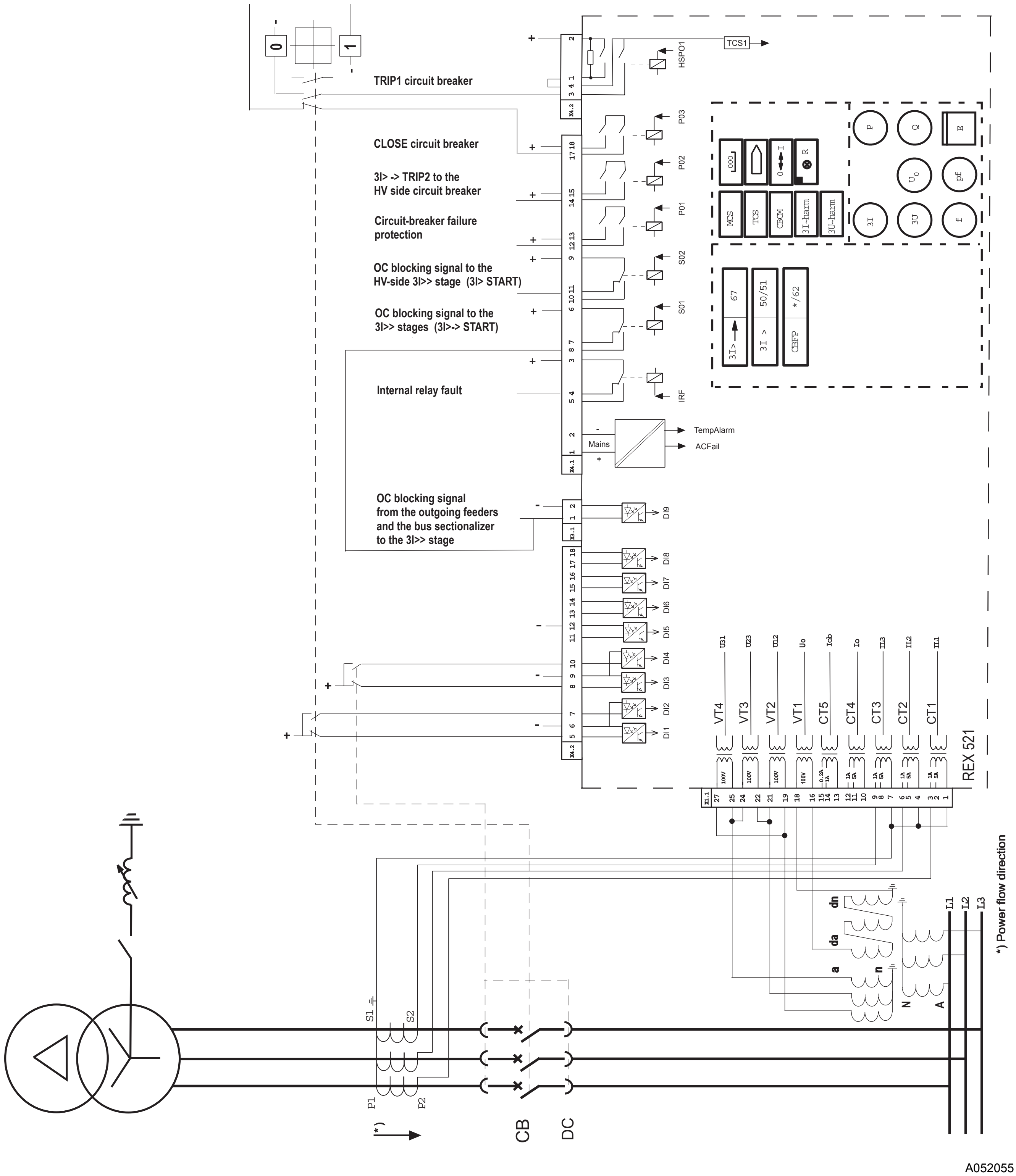


Fig. 12.2.1.-2 Connection overview diagram of the incoming feeder

12.2.2. Measurement connections

Following measurements are supported in this application example:

- True RMS measurement of phase currents
- True RMS measurement of phase-to-phase voltages
- True RMS measurement of residual voltage
- Fundamental frequency active power [kW]
- Fundamental frequency reactive power [kVAr]
- Fundamental frequency displacement power factor cos (ϕ)
- Power factor PF including harmonics
- Fundamental frequency active energy [kWh]
- Fundamental frequency reactive energy [kvarh]
- System frequency measurement

12.2.3. Protection

All the necessary settings for the protection functions can be set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

12.2.3.1. Overcurrent protection

In the example of the incoming feeder application, the stage 3I> of the overcurrent protection of the incoming feeder operate time selectively as a non-directional overcurrent back-up protection of the outgoing feeders. The stage 3I>--> is used for the directional overcurrent protection of the parallel incoming feeders to disconnect faulty feeder from the network. The stage 3I>> is used for the non-directional short-circuit protection of the busbar system.

The directional low-set stage 3I>--> is set to look into the protected line. This means it is set to operate in reverse direction. The definite time or IDMT mode can be used.

The directional stage 3I>--> of the incoming feeder provides blocking signal to the 3I>>> stage of the bus sectionalizer. Also it will provide blocking signal for the 3I>> stages of the parallel incoming feeders. The current setting of the directional stage looking in reverse direction can be 50% of the normal full load of the protected circuit.

If the fault should occur in the busbar system, the stage 3I>> of the bus sectionalizer provides blocking signal to the incoming feeders and the 3I>>> stage of the overcurrent protection of the bus sectionalizer provides a trip signal to the bus sectionalizer. When the fault is limited to the one busbar sector the 3I>> stage of the overcurrent protection of the incoming feeder provides a trip signal to the circuit breaker of the incoming feeder.

If a fault occurs in the feeder, the overcurrent protection relay of the outgoing feeder provides a blocking signal to the overcurrent protection relays of the bus sectionalizer and incoming feeders. Therefore it is possible to use a minimum operate time of 100 ms for the overcurrent protection 3I>>> stage of the bus sectionalizer and for the 3I>> stage of the incoming feeders when a fault in the busbar system occurs.

The needed time for blocking includes:

Start time of the relay (40 ms)	+	Input delay on the relay to be blocked (10 ms)	+	Retardation time (30 ms)	+	Margin (20 ms)

The set operate time of a back-up protection stage 3I> of the incoming feeder can be calculated as follows:

Time grading	+	Operate time of the protection relay of the bus sectionalizer

The time grading includes (definite time):

2 X Tolerance of the relays' operate times	+	Operation time of the CB	+	Retardation time of the relay	+	Saturation and delay margin

As an example the time grading can be:

2 x 25 ms + 50 ms + 30 ms + 20 ms = 150 ms

Back-up protection can be realized with the circuit-breaker failure protection function of the protection relay. A fast back-up function can be achieved because the safety margin can be omitted when setting the CBFP time. The CBFP function requires external wiring from the protection relay of the LV-side incoming feeder to the relay of the HV-side in-feeder. Notice that in this application example the CBFP function is only operating in the HV side of the transformer, but fault current will be fed from the other direction as well if the fault is between the LV- and the HV-side circuit breakers of the transformer feeder.

The settings for the overcurrent protections can be found in: `Main menu\Protection\3I>-->\ 3I> \3I>>\Setting group 1\` where the parameters `Operation mode`, `Start current` and `Operate time` for the function can be set. In `Main menu\Protection\3I_\Control setting\` can, for example, the `Drop-off time` and the length of the trip signal, `Trip pulse`, be set. The data of the three last operations, start or trip, are recorded and the values of the most recent operation can be found in `Main menu\Protection\3I>_\Recorded data1\…3\`.

12.2.4. Connections

All the necessary settings for the connections and signal routings can be set via the Relay Setting Tool or the local HMI.

12.2.4.1. Protection signal routing

The settings for the protection signal routing can be implemented as described in the second application example (see Section 10.2. Incoming feeder, Basic B01). In this application example two different trip signals are used: Trip 1 for opening the circuit breaker of the incoming feeder and Trip 2 for opening the circuit breaker of the transformer feeder. In this application example separate power output relays are used for Trip 2 and CBFP (circuit-breaker failure protection) function.

12.2.4.2. Indication and control connections

The connections for indication and control can be implemented as described in the first application example (see Section 10.1. Outgoing feeder, Basic B01), except the signals for the open and close buttons that in this example are disconnected. Local control can be executed via HMI according to the instructions in REX 521 Operator's Manual (see Section 1.3. Related documents).

12.2.5. Implementations

In the sections below a few implementation examples for the standard configuration H02 are presented.

12.2.5.1. Blocking signal received from the outgoing feeder and the bus sectionalizer

The start signals from the overcurrent protection of the outgoing feeder and bus sectionalizer can be connected in order to block the overcurrent protection stage on the incoming feeder. There are two input blocking signals, Blocking 1 and Blocking 2, which can have different functions depending on the different protections. See Fig. 12.2.5.1.-1.

On the overcurrent stages 3I>-->, 3I> and 3I>>, the Blocking 1 input signal is connected to the BS1 input and the Blocking 2 input signal is connected to the BS2 input of the function. In this application example, the BS1 will stop the DT or IDTM timer and the BS2 will block the trip signal. Refer to the CD-ROM Technical Descriptions of Functions (see Section 1.3. Related documents) for more information about the different protection function blocks.

In this application example the digital input DI9 is connected to the input signal Blocking 1 and then routed to the BS1 input of the overcurrent stage 3I>>. The Blocking 1 signal can be found in `Main menu\Configuration\Input Signals\Blocking 1\` with DI9 is selected. The checksum for the SWGRP in `Main menu\Configuration\Input SWGRP\Blocking 1\` should be 8 to the block 3I>>.

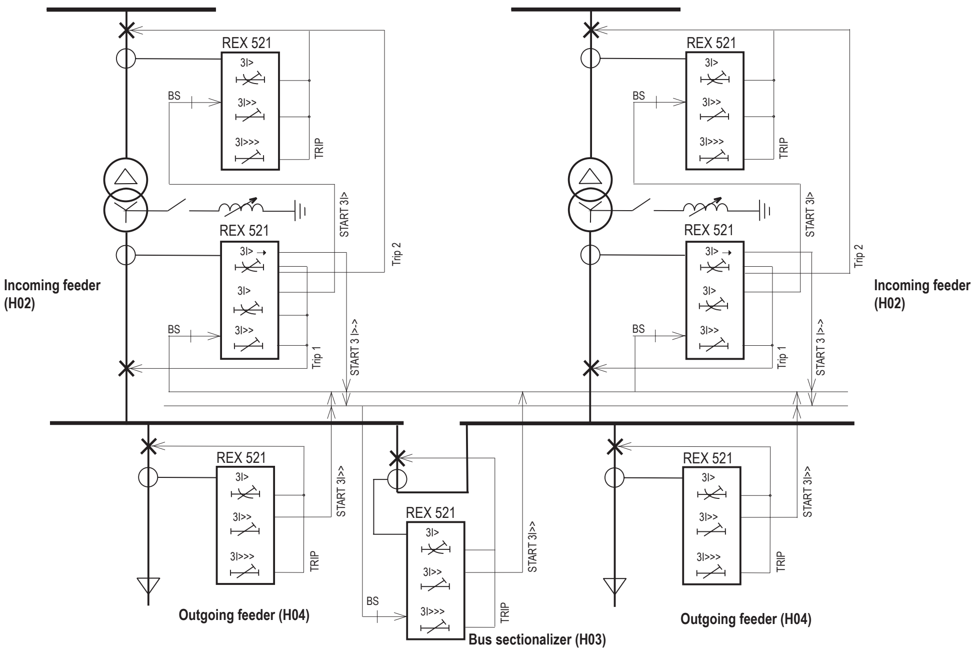


Fig. 12.2.5.1.-1 Overcurrent blocking diagram

12.2.5.2. Blocking signal from 3I>--> stage to 3I>> stage

In addition to the blocking described in Section 11.2.5.1. Start signal from the second residual voltage stage to release blocking the blocking signal from the directional overcurrent stage 3I>--> can be used for blocking the 3I>> stage of the same relay. With this arrangement we can set the operating time of the 3I>> shorter. External wiring is needed for this blocking. The start signal of the 3I>--> is routed to the signal output SO1. The output is connected to the input DI9 which is routing blocking signal to the BS1 input of the overcurrent stage 3I>> as described in Section 11.2.5.1. Start signal from the second residual voltage stage to release blocking.

12.2.5.3. Circuit-breaker failure protection

All of the current-based protection functions in the standard configuration H02 provide a delayed trip signal CBFP after the trip signal unless the fault has not disappeared during the set CBFP time delay. In the circuit-breaker failure protection, the CBFP output can be used for operating an upstream circuit breaker.

The settings for breaker failure are set separately for each protection function. For example, to set the CBFP time for 3I>>--> go to `Main menu\Protection\3I>>-->\Control setting` where it is possible to set the `CBFP time` from 100 ms to 1000 ms. The control parameter `Trip pulse` sets the width of the trip output signal, but also of the CBFP output signal.

The CBFP signals from the protection functions are routed to the output signals via the output switchgroups. These settings can be found in `Main menu\Configuration\Output SWGRP\CBFP`. The CBFP signal is then connected to any of the output relays via Main menu\Configuration\Output Signals\, and in this example the circuit-breaker failure signal is connected to the power output 1, PO1.

12.2.5.4. Trip-circuit supervision

The trip-circuit supervision is available for the HSPO1 relay. If the resistance of the trip circuit exceeds a certain limit, for instance due to a bad contact or oxidation, the supervision function will be activated and a trip-circuit supervision alarm signal will be provided after an adjustable delay time. The settings for the function can be found in Main menu\Cond. monit.\TCS1\.

To avoid unnecessary alarms, trip-circuit supervision can be blocked by the BS signal, which disables the supervision output when the circuit breaker is open. The BS signal is configured to be operated by the “CB pos. open” status from the selected digital input. The BS signal can be connected via the switchgroup in Main menu\Input SWGRP\TCS1\. The default setting of the parameter is “Not in use”.

Another solution is to use an external resistor to prevent the TCS1 alarm. Refer to REX 521 Technical Reference Manual, General (see Section 1.3. Related documents) for more information about the trip-circuit supervision.

12.3. Bus sectionalizer, High H03

12.3.1. Features

This application example describes a bus sectionalizer of a single busbar including:

- Overcurrent protection
- Synchro-check and
- Voltage-check function

The network can be compensated, isolated, resistance or solidly earthed. Three-phase current measurement is established with a set of current transformers. Phase-to-phase voltage measurements are established with voltage transformers in both sections of the busbar.

The High H03 variant of REX 521 is selected to be used in this application because of the synchro-check and voltage-check functionality. This selection makes it possible to extend the automatic supervision functionality in the substation. The synchro-check function does not allow closing of the bus sectionalizer if the operation criteria are not fulfilled.

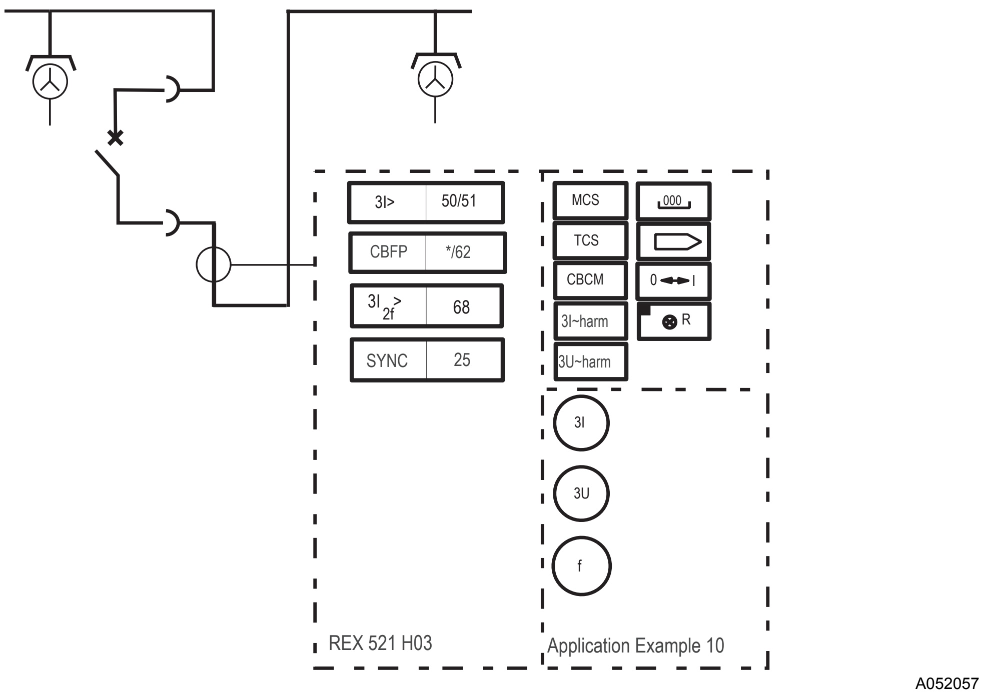


Fig. 12.3.1.-1 H03 is used for protection, measuring and supervision on a bus sectionalizer in a single busbar system. The supplying network can be compensated, isolated, solidly or resistance earthed.

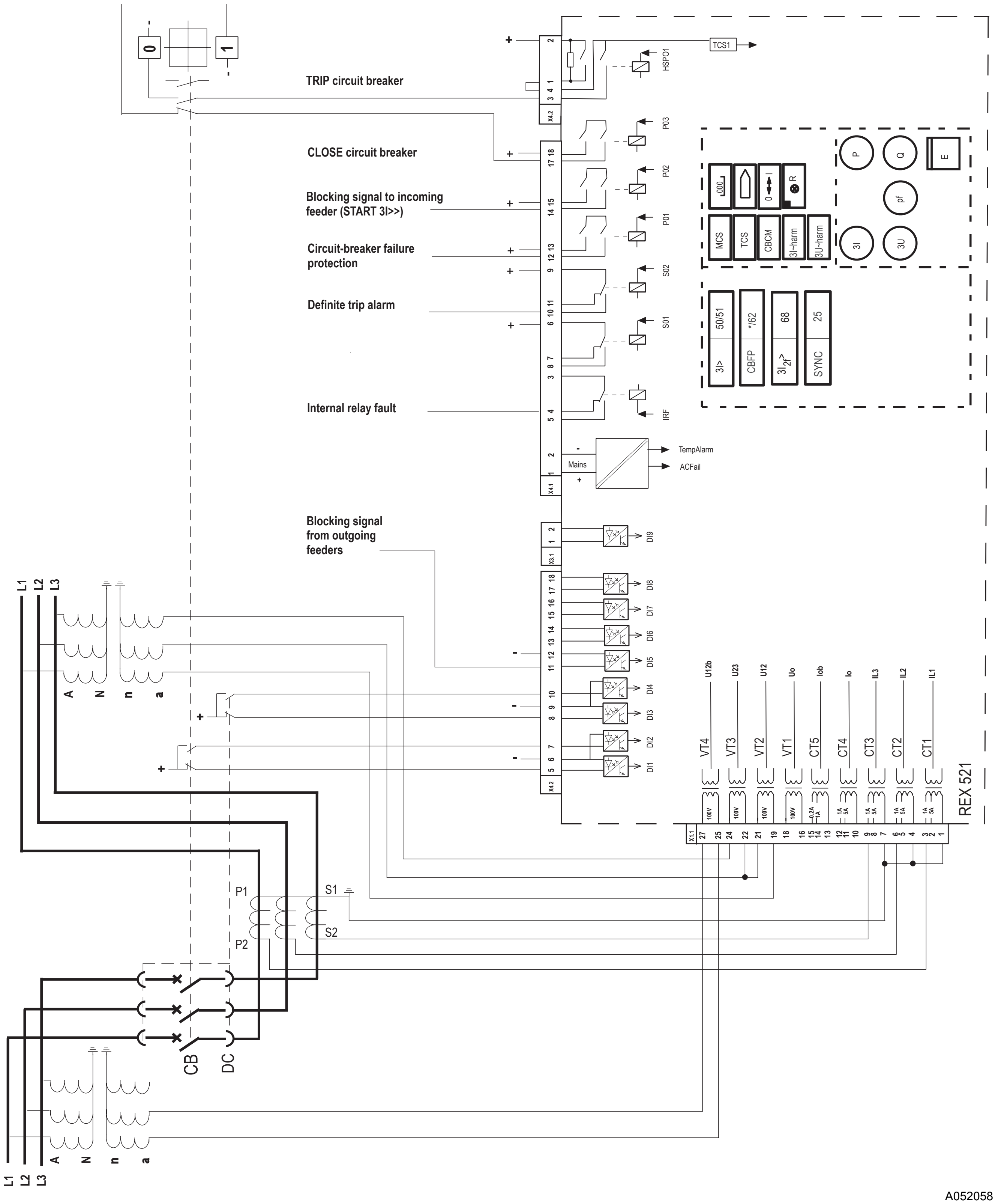


Fig. 12.3.1.-2 Connection overview diagram of the bus sectionalizer

12.3.2. Measurements

Following measurements are supported in this application example:

- True RMS measurement of phase currents
- True RMS measurement of phase-to-phase voltages
- System frequency measurement

12.3.3. Protection

All the necessary settings for the protection functions can be set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

12.3.3.1. Overcurrent protection

Overcurrent protection of the bus sectionalizer is used for disconnecting the faulty sector of the busbar from the healthy sector to minimize disturbances in distribution of electrical energy.

In the example of the bus sectionalizer application, the stage 3I> of the overcurrent protection of the bus sectionalizer and incoming feeder operate time selectively as a back-up protection of the outgoing feeders. The stage 3I>> is used for blocking of the incoming feeders. The stage 3I>>> is used for short-circuit protection of the busbar system.

If a fault should occur in the busbar system, the stage 3I>> of the bus sectionalizer provides blocking signal to the 3I>> stage of the incoming feeders. Also, the 3I>>> stage of the overcurrent protection of the bus sectionalizer provides a trip signal to the bus sectionalizer circuit breaker.

When a fault is limited to one busbar sector, the blocking from the 3I>> stage of the bus-sectionalizer overcurrent protection disappears and the 3I>> stage of the overcurrent protection of the incoming feeder provides a trip signal to the circuit breaker of the incoming feeder.

If a fault occurs in the feeder, the overcurrent protection relay of the outgoing feeder provides a blocking signal to the overcurrent protection relays of the bus sectionalizer and incoming feeders. Therefore, it is possible to use a minimum operate time of 100 ms for the overcurrent protection 3I>>> stage of the bus sectionalizer and for the 3I>> stage of the incoming feeders when a fault in the busbar system occurs.

The needed time for blocking includes:

Start time of the relay (40 ms)	+	Input delay on the relay to be blocked (10 ms)	+	Retardation time (30 ms)	+	Margin (20 ms)

The set operate time of a back-up protection stage 3I> of the bus sectionalizer can be calculated as follows:

Time grading	+	Operate time of the protection relay of the outgoing feeder

The time grading includes (definite time):

2 X Tolerance of the relays' operate times	+	Operation time of the CB	+	Retardation time of the relay	+	Saturation and delay margin

As an example the time grading can be:

2 x 25 ms + 50 ms + 30 ms + 20 ms = 150 ms

Back-up protection can be realized with the circuit-breaker failure protection function of the protection relay. A fast back-up function can be achieved because the safety margin can be omitted when setting the CBFP time. The CBFP function requires external wiring from the protection relay of the bus sectionalizer to the relay of the in-feeder.

The settings for the overcurrent protections can be found in: `Main menu\Protection\3I>\ … \3I>>>\Setting group 1\` where the parameters `Operation mode`, `Start current` and `Operate time` for the function can be set. In `Main menu\Protection\3I>\Control setting\` can for example the `Drop-off time` and the length of the trip signal `Trip pulse` be set. The data of the three last operations, start or trip, are recorded and the values of the most recent operation can be found in `Main menu\Protection\3I>\Recorded data1\…3\`.

12.3.3.2. Synchro-check function

In this application example where the synchro-check function is used for ensuring the condition between two busbar sections fed by own transformers, the voltage difference between busbar sections is the most important criterion. The synchro-check function does not allow the circuit breaker to be closed if the voltage difference is too high. If the voltage difference is high, the inrush current between the busbar sectors can be too high. In an application where a generator is connected to one of the busbar sectors other criteria are also important and the need for the synchro-check functionality is unavoidable.

The synchro-check function can be used in two different operating conditions. The most typical case is one where both sides of the circuit breaker to be closed are live and thus the synchronism is always checked before the circuit breaker is given the permission to close. In an other situation one or both sides of the circuit breaker to be closed are dead and, consequently, the frequency and phase differences cannot be measured, in which case the relay checks the energizing direction.

Operation criteria of the function are:

- Voltages must be in accordance with the energizing direction.
- In cases “Live-Dead”, “Dead-Live” and “Dead-Dead” no other conditions are checked.
- In the case “Live-Live” also the following must be fulfilled:
  - $\Delta U <$ dU setting
  - $\Delta f <$ df setting
  - $\Delta \varphi <$ dphi setting

Before the function block allows the closing of the CB, it ensures that the phase difference remains within the setting range until the CB closes.

The command mode is used as a basic control principle of the synchro-check function. In command mode, the synchro-check function directly uses the output signal to close the circuit breaker. The close command for example from the HMI is connected to the synchro-check function. When the close command is activated, the synchro-check function checks the closing criteria and if they are fulfilled, it will route the command to the output relay of the protection relay. In this application example the close signal is connected to the power output PO3.

The command mode principle means that the interlocking logic related to the control functionality will affect the synchro-check function as well. If blocking is needed it can be carried out by using the ready-made interlocking logic, for example in a case where the phase-to-phase voltage is missing from either side of the circuit breaker because of the open miniature circuit breaker (MCB) of the measurement circuit.

12.3.4. Connections

All the necessary settings for the connections and signal routings can be set via the Relay Setting Tool or the local HMI.

12.3.4.1. Protection signal routing

The settings for the protection signal routing can be implemented as described in the first application example (see Section 10.1. Outgoing feeder, Basic B01).

12.3.4.2. Indication and control connections

The connections for indication and control can be implemented as described in the first application example (see Section 10.1. Outgoing feeder, Basic B01), except the signals for the open and close buttons that in this example are disconnected. Local control can be executed via the HMI according to the instructions in REX 521 Operator’s Manual (see Section 1.3. Related documents).

12.4. Outgoing feeder, High H04

12.4.1. Features

This application example describes an outgoing feeder of a single busbar including:

- Autoreclose function
- Overcurrent protection
- Directional and non-directional earth-fault protection
- Phase discontinuity protection
- Thermal overload protection for cable or line

This application example is an optional solution for the seventh application example (chapter 10.3), if extended earth-fault protection against a cross-country fault is required or wider range of measurements is needed.

The network is either compensated or isolated. Three-phase current measurement is established with a set of current transformers. The neutral current I_{0b} is measured with a cable current transformer and the neutral current I_0 is measured with the sum connection of the phase current transformers. The residual voltage is measured with a set of voltage transformers in an open-delta connection. Phase-to-phase voltage measurements are established with voltage transformers.

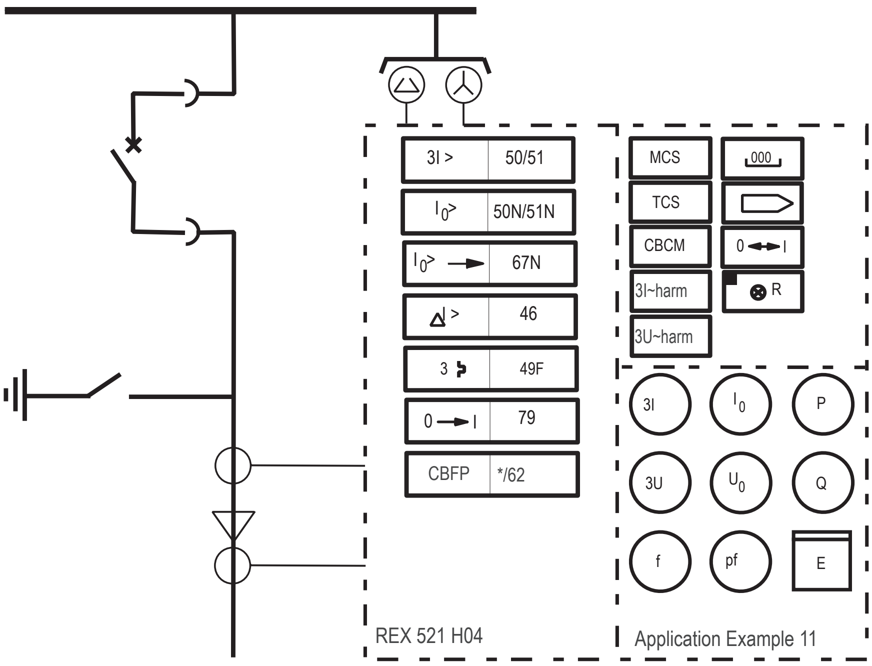
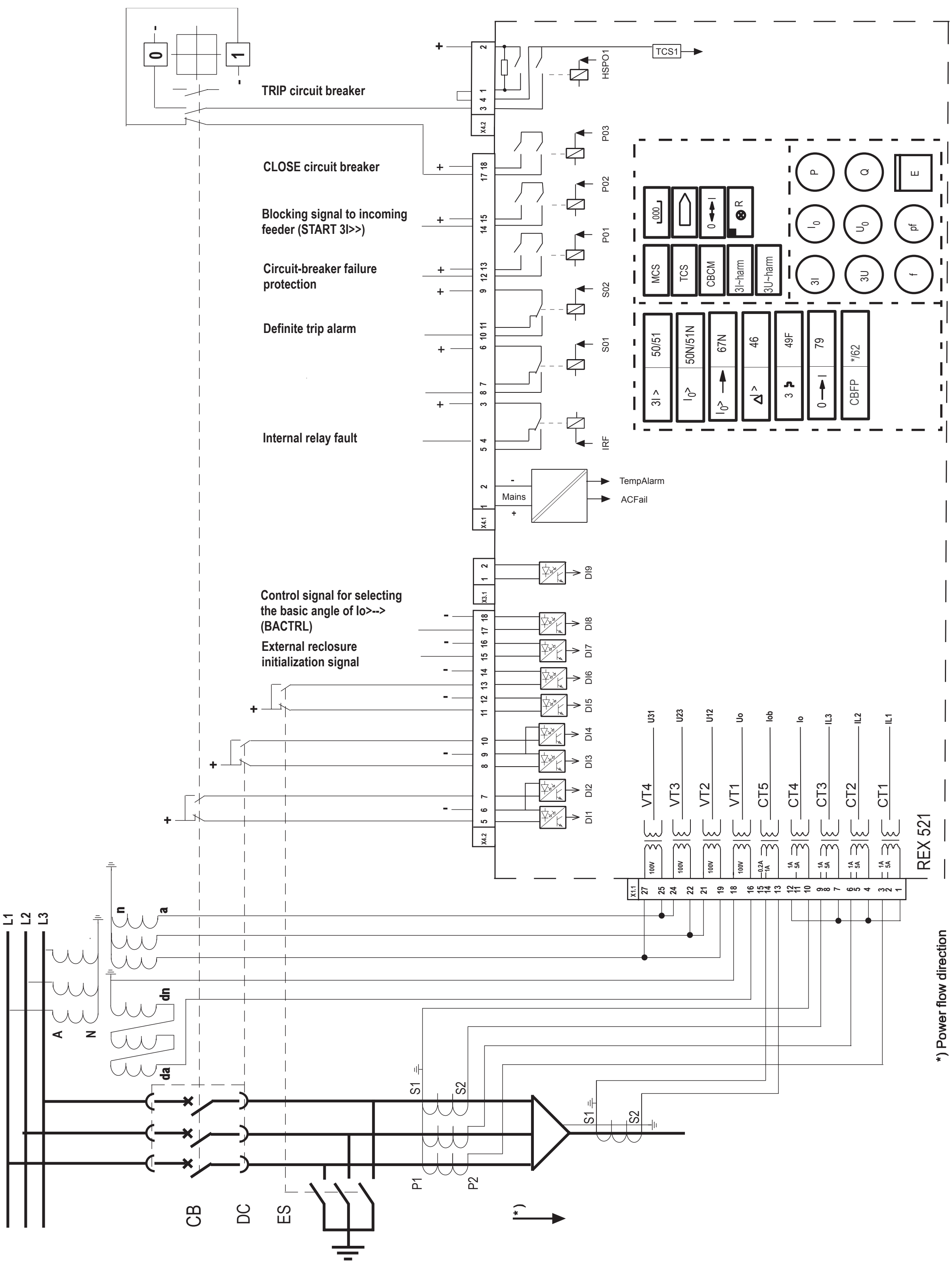


Fig. 12.4.1.-1 REX 521 H04 used for protection, measuring and supervision on an outgoing feeder in a single busbar system. The supplying network is either compensated or isolated.



A052060

Fig. 12.4.1.-2 Connection overview diagram of the outgoing feeder

12.4.2. Measurements

Following measurements are supported in this application example:

- True RMS measurement of phase currents
- True RMS measurement of neutral current
- True RMS measurement of phase-to-phase voltages
- True RMS measurement of residual voltage
- Fundamental frequency active power [kW]
- Fundamental frequency reactive power [kVAr]
- Fundamental frequency displacement power factor cos (ϕ)
- Power factor PF including harmonics
- Fundamental frequency active energy [kWh]
- Fundamental frequency reactive energy [kvarh]
- System frequency measurement

12.4.3. Measurement connections

The three-phase current, neutral current transformers and residual voltage transformer are connected to the connector X1.1 on the rear panel. The rated currents of the measuring input are 1 A and 5 A and additionally, for earth fault, 0.2 A and 1 A. The rated values for voltage are 100 V, 110 V, 115 V and 120 V.

In this application two neutral current measurements are used. The neutral current I_{0b} measured by a cable transformer is used for directional earth-fault protection and the neutral current I_0 measured by the sum connection of the phase current transformers is used for non-directional earth-fault protection.

The technical data of the current transformers and the voltage transformer are set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Configuration\Meas. devices\`.

Refer to REX 521 Technical Reference Manual, General (see Section 1.3. Related documents) for further information about how to set the rated currents and voltage.

12.4.4. Protection

All the necessary settings for the protection functions can be set via the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

The overcurrent, the phase discontinuity and thermal overload protection can be implemented in the same way as in the first application example Section 10.1. Outgoing feeder, Basic B01, and the directional earth-fault protection as in the fifth application example Section 11.1. Outgoing feeder, Medium M01.

12.4.4.1. Non-directional earth-fault protection

A double earth fault occurs when two phase-conductors get in galvanic connection with the earth. This can occur in the same line or between two lines when the fault current has to flow through the earth. This fault type is also known as a cross-country fault.

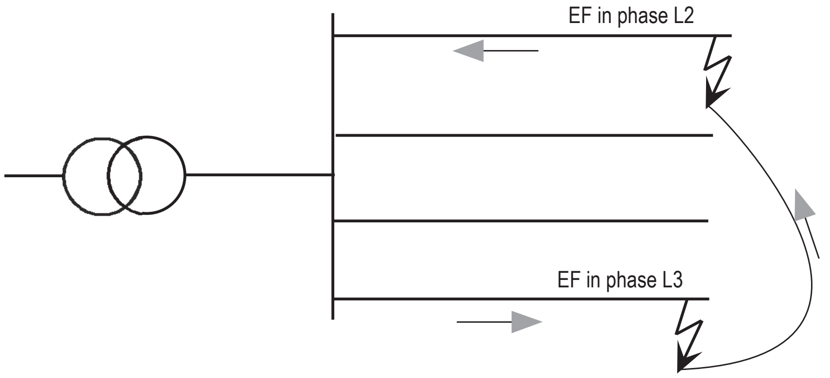


Fig. 12.4.4.1.-1 Cross-country fault

Detection of a cross-country fault can be implemented by non-directional earth-fault protection. In a case where the fault current is lower than the start current level of the overcurrent protection because of the fault resistance, the separated non-directional high-set earth-fault stage I_0>> can be used for detecting the fault. With this arrangement it is also possible to get clear indication of the fault type if the settings are selected so that this protection stage will operate only in double earth fault situations.

In H04 standard configuration the measurement channel I_0 for earth-fault current measurement is fixedly connected to the non-directional earth-fault stages.

12.4.4.2. Autoreclose function

The autoreclose function can be implemented as described in the seventh application example (Section 11.3. Outgoing feeder, Medium M02)

12.4.5. Connections

All the necessary settings for the connections and signal routings can be set via the Relay Setting Tool or the local HMI.

12.4.5.1. Protection signal routing

The settings for the protection signal routing can be implemented as described in the first application example (refer to Section 10.1. Outgoing feeder, Basic B01).

12.4.5.2. Indication and control connections

The connections for indication and control can be implemented as described in the first application example (Section 10.1. Outgoing feeder, Basic B01), except the signals for the open and close buttons that in this example are disconnected to free the digital inputs for other functionality. Local control can be executed via the HMI according to the instructions in REX 521 Operator's Manual (see Section 1.3. Related documents).

12.4.6. Implementations

The implementations for the seventh application example (see Section 11.3. Outgoing feeder, Medium M02) are also applicable for this application example.

12.5. Incoming feeder, High H05/H50

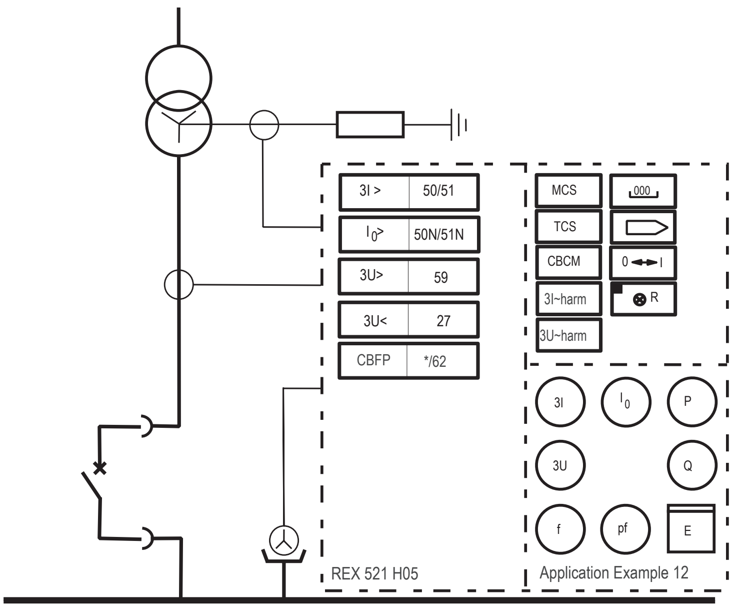
12.5.1. Features

This application example describes an incoming feeder to a single busbar including:

- Overcurrent protection
- Non-directional earth-fault protection
- Overvoltage protection
- Undervoltage protection

This application example is an optional solution for the second application example (Section 10.2. Incoming feeder, Basic B01), if overvoltage and undervoltage protection is required or wider range of measurements is needed.

The network is resistance or solidly earthed. The three-phase current measurement is established with current transformers. The neutral current is measured via a current transformer located in the neutral earthing circuit on the LV side of the power transformer. Phase-to-phase voltage measurements are established with voltage transformers.



A052062

Fig. 12.5.1.-1 H05 and H50 are used for protection, measuring and supervision on an incoming feeder in a single busbar system. The supplying network is either solidly or resistance earthed

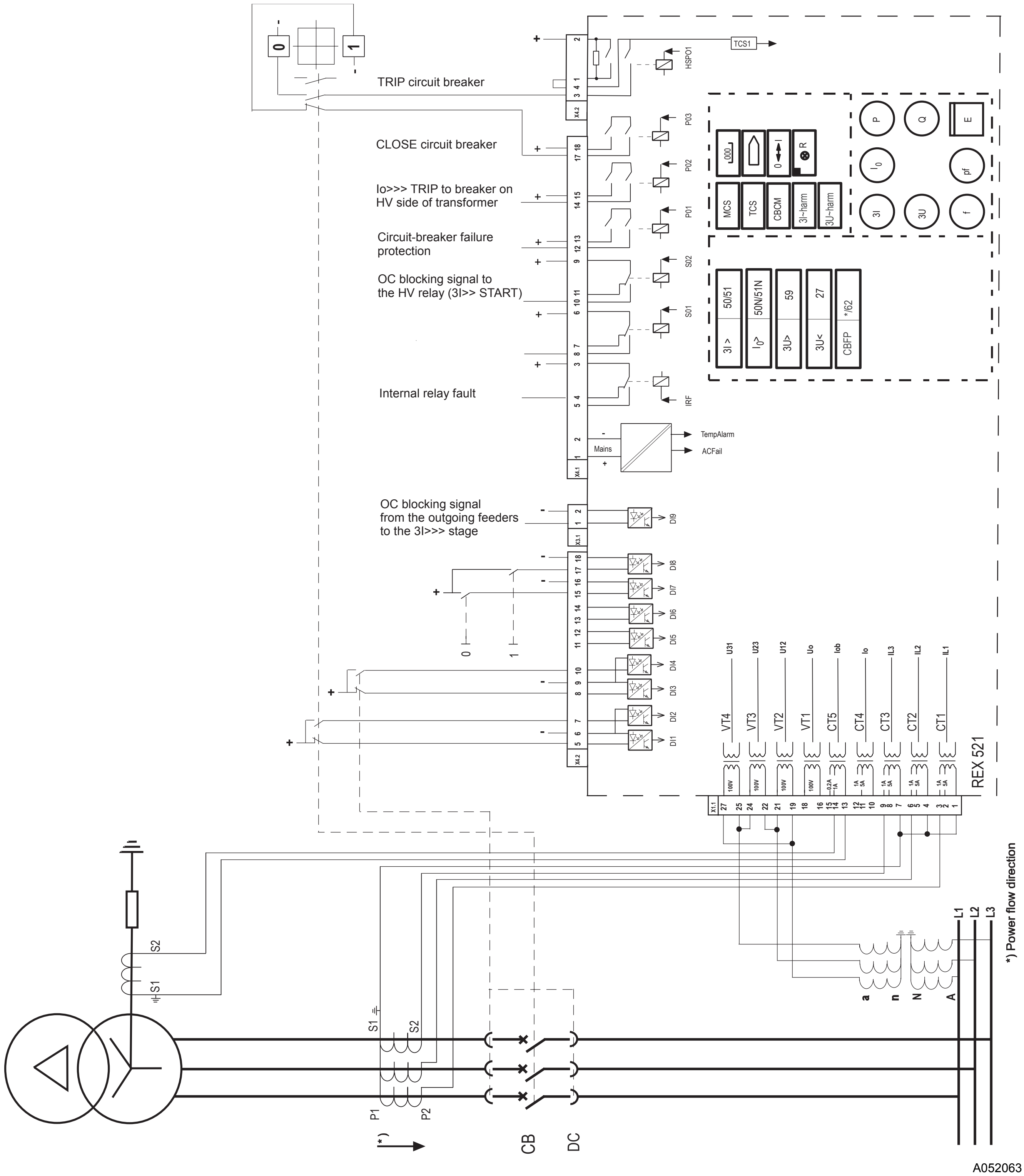


Fig. 12.5.1.-2 Connection overview diagram of the incoming feeder

12.5.2. Measurements

Following measurements are supported in this application example.

- True RMS measurement of phase currents
- True RMS measurement of neutral current
- True RMS measurement of phase-to-phase voltages
- Fundamental frequency active power [kW]
- Fundamental frequency reactive power [kVAr]
- Fundamental frequency displacement power factor cos (ϕ)
- Power factor PF including harmonics
- Fundamental frequency active energy [kWh]
- Fundamental frequency reactive energy [kvarh]
- System frequency measurement

12.5.3. Protection

All the necessary settings for the protection functions can be set by means of the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

12.5.3.1. Phase overcurrent protection

The overcurrent protection can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01)

12.5.3.2. Earth-fault protection

The earth-fault protection can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01)

12.5.3.3. Overvoltage and undervoltage protection

Faults in the network or a faulty tap changer or voltage regulator of a power transformer may cause abnormal busbar voltages. The overvoltage and undervoltage protection is used for preventing possible damages to the devices connected to the network.

In this application the overvoltage and undervoltage protection is included in the functionality of the protection relay of the incoming feeder. In the overvoltage or undervoltage situation the circuit breaker of the incoming feeder will be opened.

The overvoltage protection includes two protection stages: a low stage U> and a high stage U>>. The low stage can be set to the definite-time or inverse-time operation. The definite-time operation is used with the high-set stage.

Similarly, the undervoltage protection includes two protection stages: a low stage U< and a high stage U<<. The low stage can be set to the definite-time or inverse-time operation. The definite-time operation is used with the high set stage.

An operational characteristic example on overvoltage and undervoltage protection is presented in the picture below (Fig. 12.5.3.-1).

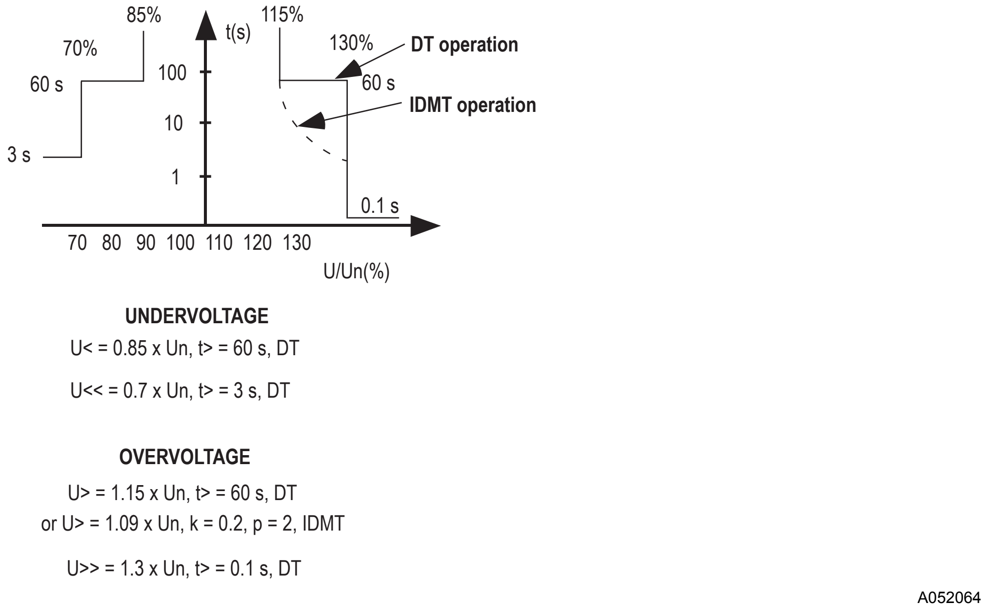


Fig. 12.5.3.-1 Example on overvoltage and undervoltage protection

12.5.4. Connections

All the necessary settings for the connections and signal routings can be set via the Relay Setting Tool or the local HMI.

12.5.4.1. Protection signal routing

The trip signal (Trip 1) of the protection functions is routed to the high speed power output HSPO1 (x4.2.1/2/3/4) as well as the control-open signal for the circuit breaker. The trip signals from the protection functions are routed to the output relay via the output switchgroups. These settings can be found in `Main menu\Configuration\Output SWGRP\`.

As the HSPO1 is always routed to the “Trip 1" output signal, the settings are made directly in `Main menu\Configuration\Output SWGRP\Trip 1`, where the checksum of the settings is displayed (255 by default).

Using the HMI:

To change the settings for Trip 1 go to `Output SWGRP\Trip 1` and press the [E]-button. The different protection functions are displayed one at a time. By pressing the [→] or [←] navigation push button, it is possible to scroll between the different protections. By pressing the [↑] or [↓] navigation push button, the specific protection function trip signal can be connected or disconnected. When the three-stage overcurrent (3I> 3I>> and 3I>>>), two-stage earth fault (I_0> and I_0>>), two-stage overvoltage (U> and U>>) and two-stage undervoltage (U< and U<<) protection is selected the checksum for Trip 1 is 991. When the earth-fault protection stage Io>>> is selected the checksum for Trip 2 is 32.

12.5.4.2. Indication and control connections

All the necessary settings for the indication and control signals of the circuit breaker and the disconnector for the incoming feeder can be set as described in the first application example on Section 10.1. Outgoing feeder, Basic B01 onwards for the outgoing feeder (except for the earth switch). The settings are made by means of the Relay Setting Tool or the local HMI. The settings can be found in:

```
Main menu\Configuration\Input Signals\
Main menu\Configuration\Input SWGRP\
Main menu\Configuration\Output Signals\
Main menu\Configuration\Output SWGRP\.
```

12.5.5. Implementations

In the sections below a few implementation examples for the standard configurations H05 and H50 are presented.

12.5.5.1. Blocking signal received from the outgoing feeder

The blocking signal received from the outgoing feeder can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01).

12.5.5.2. Outgoing blocking signal to the overcurrent relay on the HV side

The outgoing blocking signal to the overcurrent relay on the HV side can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01).

12.5.5.3. Earth-fault stage Io>>> to trip the breaker on the HV side of the transformer

The earth-fault stage Io>>> to trip the breaker on the HV side of the transformer can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01). The earth-fault stage Io>>> is not found in H50.

12.5.5.4. Circuit-breaker failure protection

The circuit-breaker failure protection can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01). CBFP function is not available for the overvoltage and undervoltage protection.

12.5.5.5. Disturbance recorder

The disturbance recorder (DREC) can be found in `Main menu\Measurement\DREC\`. All of the measured current and voltage signals as well as all of the start signals from the protection functions and the Trip 1..3 signals are connected to the DREC in the H05 standard configuration. In H50 all measured current and voltage signals, all start signals from the protection functions as well as the Trip 1 signal are connected to the DREC.

The recording can be triggered by any of the alternatives listed below:

- Triggering on the rising or falling edge of the protective start signals
- Triggering on current or voltage measurement
- Manual triggering via the HMI or with the external input signal
- Triggering via communication parameter
- Periodic triggering

Regardless of the triggering type, each recording generates the event E31. The triggering time and reason are included in the recording. Number of recordings can be viewed in `Main menu\Measurements\DREC\Control setting\# records`.

External triggering can be made by means of the reserved input signal “DREC trig” connected to one of the digital inputs. The settings can be found in `Main menu\Configuration\Input Signals\DREC trig`.

Refer to the CD-ROM Technical Descriptions of Functions (MEDREC16) for more information about the disturbance recorder.

12.5.5.6. Power quality

The power quality functions (PQ 3Inf and PQ 3Unf) can be found in `Main menu\Power Quality\PQ 3Inf` and `Main menu\Power Quality\PQ 3Unf`. The functions are used for measuring the harmonics and monitoring the power quality in distribution networks.

The power quality function can be triggered by any of the alternatives listed below:

- Manual triggering via the HMI
- With the external input signal
- Triggering via communication parameter
- Preset time and date

External triggering can be made by means of the reserved input signals “PQ 3Inf trig” and “PQ 3Unf trig” connected to the digital inputs. The settings can be found in `Main menu\Configuration\Input Signals\PQ 3Inf trig` and `Main menu\Configuration\Input Signals\PQ 3Unf trig`.

The functions can deliver the alarm signals “PQ 3Inf cum” and “PQ 3Unf cum”, an output signal for exceeding a setting limit for cumulative probability of a harmonic and the “PQ 3Inf har” and “PQ 3Unf har”, an output signal for exceeding a setting limit for a harmonic. The alarm signals can be routed to the output contacts via the switchgroups. The connection settings can be made in

Main menu\Configuration\Output SWGRP\Alarm 1\ or \Alarm 2\. The “Alarm 1” or “Alarm 2" output signal can be then connected to an output relay and the settings are done in Main menu\Configuration\Output Signals\.

Refer to the CD-ROM Technical Descriptions of Functions (PQCU3H) for more information about the power quality function.

12.6. Measurement cubicle, High H06

12.6.1. Features

This application example describes a measurement cubicle in a single busbar system including:

- Overvoltage protection
- Undervoltage protection
- Residual voltage protection
- Underfrequency protection with two stages

The network is either compensated or isolated. The residual voltage is measured with a set of voltage transformers in an open-delta connection. Phase-to-phase voltage measurements are established with voltage transformers.

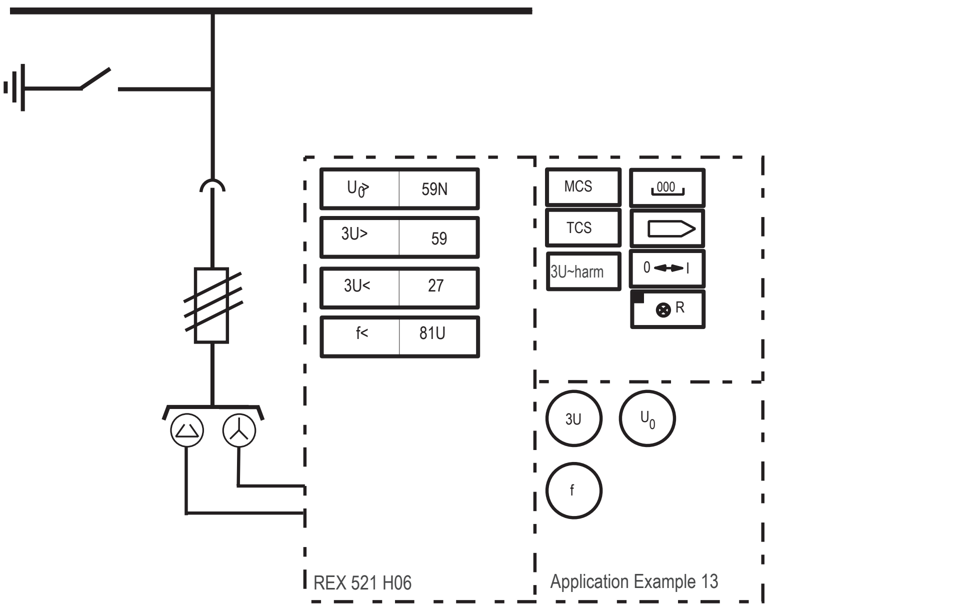


Fig. 12.6.1.-1 H06 is used for protection, measuring and supervision in a measurement cubicle in a single busbar system. The supplying network is either compensated or isolated.

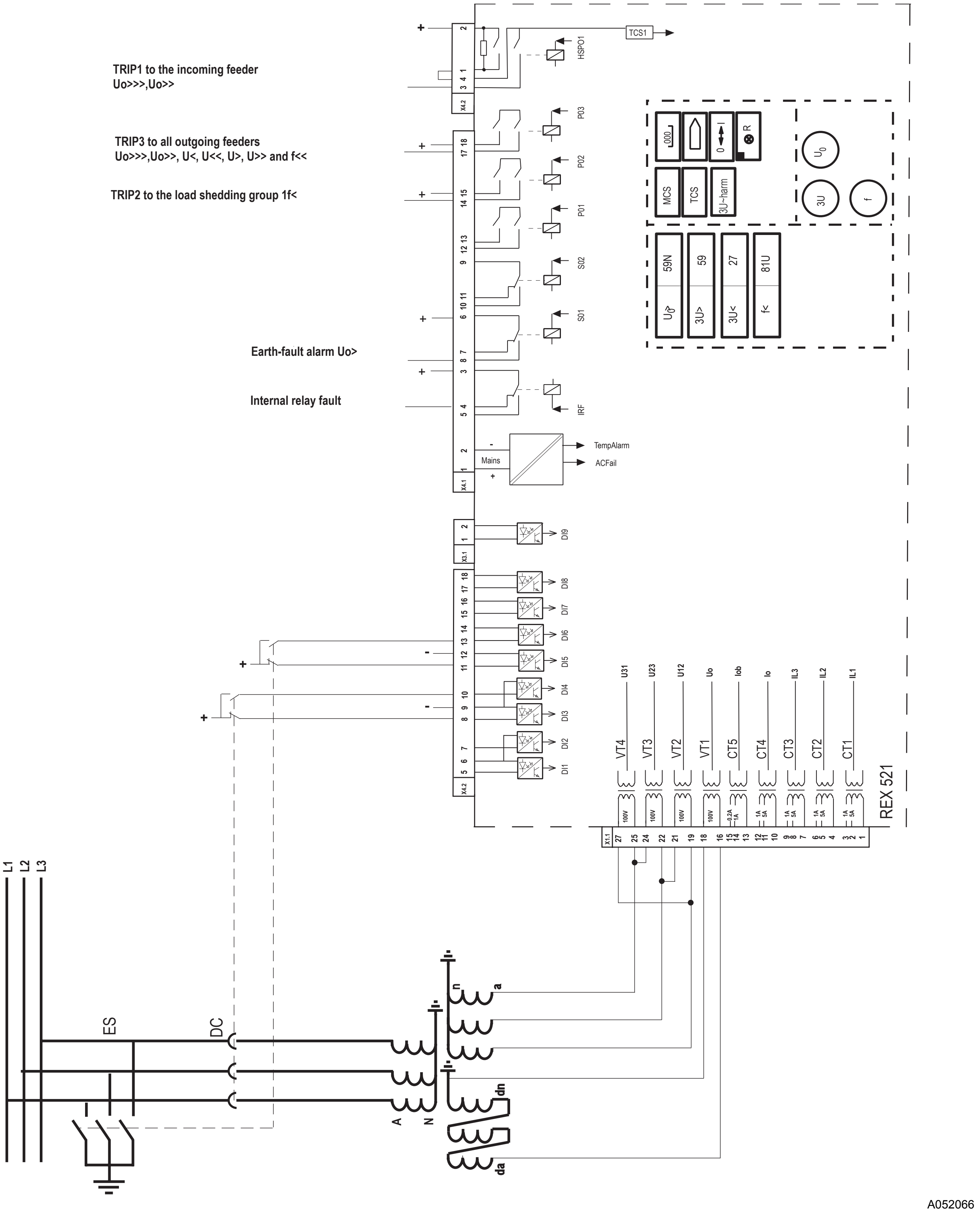


Fig. 12.6.1.-2 Connection overview diagram of the measurement cubicle

12.6.2. Measurements

Following measurements are supported in this application example:

- True RMS measurement of phase-to-phase voltages
- True RMS measurement of residual voltage
- System frequency measurement

12.6.3. Protection

All the necessary settings for the protection functions can be set by means of the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

12.6.3.1. Residual voltage protection

In a compensated or isolated network, a three-stage residual overvoltage protection can be used for the main earth-fault protection of the busbar system and for the back-up protection of the network. On the busbar, the residual voltage can be measured with a set of voltage transformers in an open-delta connection.

The low stage Uo> can be given a sensitive setting and have an alarming function. The high stage Uo>> can work as back-up for the outgoing feeders and perform trip on the incoming feeder and outgoing feeders. The instantaneous stage Uo>>> can be configured as busbar protection and provide trip to incoming feeder and outgoing feeders.

The settings for the residual voltage protection are made in the settings for the residual overvoltage functions and can be found in `Main menu\Protection\Uo>\ … \Uo>>>\`.

12.6.3.2. Overvoltage and undervoltage protection

Faults in the network or a faulty tap changer or voltage regulator of a power transformer may cause abnormal busbar voltages. The overvoltage and undervoltage protection is used to prevent possible damages to the devices connected to the network.

In this application the overvoltage and undervoltage protection is included to the functionality of the protection relay of the measurement cubicle. In the overvoltage or undervoltage situation the circuit breakers of the outgoing feeders will be opened.

The overvoltage protection includes two protection stages: a low stage U> and a high stage U>>. The low stage can be set to the definite-time or inverse-time operation. The definite-time operation is used with the high set stage.

Similarly, the undervoltage protection includes two protection stages: a low stage U< and a high stage U<<. The low stage can be set to the definite-time or inverse-time operation. The definite-time operation is used with the high set stage.

An operational characteristic example for overvoltage and undervoltage protection is presented in the following picture.

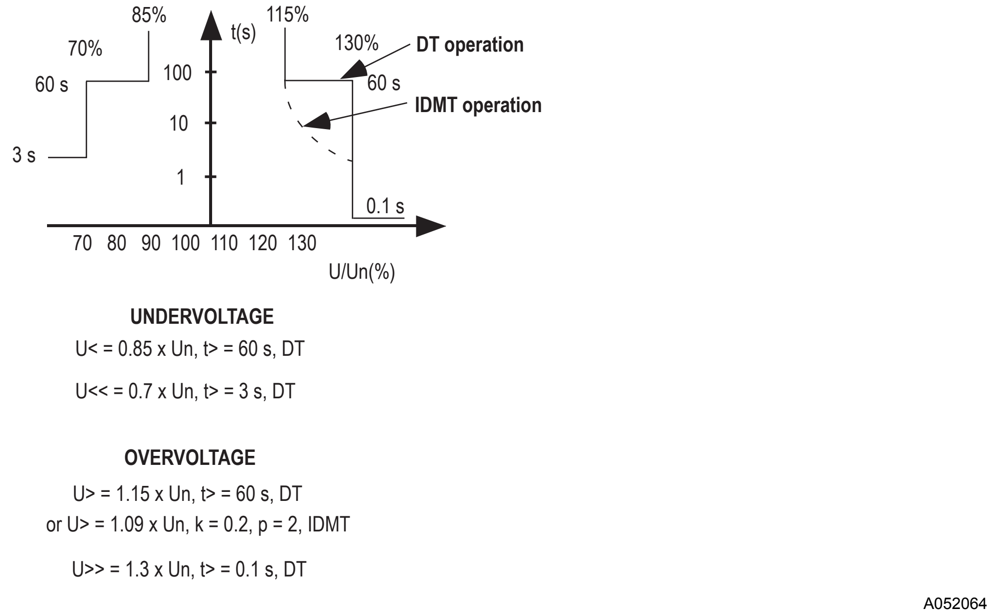


Fig. 12.6.3.2.-1 Example on overvoltage and undervoltage protection

12.6.3.3. Underfrequency protection

The underfrequency protection is included in the functionality of the protection relay of the measurement cubicle. The underfrequency protection includes two protection stages: a low stage f< and a high stage f<<.

In this application two load shedding groups are used. The low stage f< is used for disconnecting the load shedding group 1. The high stage f<< is used for disconnecting the load shedding group 2.

The trip signal of the f< stage is connected to the power output relay PO2 via Trip 2 signal. This trip signal is used for disconnecting the outgoing feeders of the first load shedding group.

The trip signal of the f<< stage is connected to the power output relay PO3 via Trip 3 signal. Also the residual voltage stage Uo>>, under- and overvoltage protection trips are connected to this power output and those signals have to be connected to all outgoing feeders. Therefore the trip signal of the high stage f<< will be connected to all circuit breakers of the outgoing feeders. All outgoing feeders are included in the load shedding group 2.

12.6.4. Connections

All the necessary settings for the connections and signal routings can be set via the Relay Setting Tool or the local HMI.

12.6.4.1. Protection signal routing

The trip signal (Trip 1) of the residual voltage stages Uo>> and Uo>>> protection function are routed to the high speed power output HSPO1 (x4.2.1/2/3/4).

The trip signal (Trip 2) of the underfrequency stage f< protection function is routed to the power output PO2 (x4.2.14/15).

The trip signals (Trip 3) of the residual voltage stages Uo>>> and Uo>>, undervoltage, overvoltage and underfrequency stage f<< protection function are routed to the power output PO3 (x4.2.17/18).

The trip signals from the protection functions are routed to the output relay via the output switchgroups. These settings can be found in `Main menu\Configuration\Output SWGRP\`.

As the HSPO1 is always named as the “Trip 1" output signal, the settings are made directly in `Main menu\Configuration\Output SWGRP\Trip 1` where the checksum of the settings is displayed (255 by default).

The Trip 2 has to be set to PO2 and the Trip 3 to PO3 in `Main menu\Configuration\Output Signals\`. The trip signals from the protection functions can be set to the correct trip group in `Main menu\Configuration\Output SWGRP\Trip 2…3` where the checksum of the settings is displayed (255 by default).

Using the HMI:

To change the settings for Trip 1 go to `Output SWGRP\Trip 1` and press the [E]-button. The different protection functions are displayed one at a time. By pressing the [→] or [←] navigation push button, it is possible to scroll between the different protections. By pressing the [↑] or [↓] navigation push button, the specific protection function trip signal can be connected or disconnected.

To change the settings for PO2 and PO3 go to `Output Signals\PO2…PO3` and press the [E]-button. The different signals (Trip 2, Trip 3, CBFP, etc.) are displayed one at a time. By pressing the [→] or [←] navigation push button, it is possible to scroll between the different signals. By pressing the [↑] or [↓] navigation push button, the specific signal can be selected. Select the Trip 2 for the PO2 and Trip 3 for the PO3.

To define settings for Trip 2 and Trip 3 the same principle as shown above for the Trip1 can be used.

When the residual voltage stages Uo>>> and Uo>> are selected the checksum for Trip 1 is 384.

When the underfrequency protection stage f< is selected for the load shedding group 1, the checksum for Trip 2 is 512.

When the residual voltage stages Uo>>> and Uo>>, two-stage overvoltage (U> and U>>), two-stage undervoltage (U< and U<<) and underfrequency protection stage f<< are selected the checksum for Trip 3 is 2492.

12.6.4.2. Indication and control connections

All the necessary settings for the alarm signals and indication signals of the disconnector for the measurement cubicle can be set as described in the first application example on Section 10.1. Outgoing feeder, Basic B01 onwards for the outgoing.

The settings are made by means of the Relay Setting Tool or the local HMI. The settings can be found in:

`Main menu\Configuration\Input Signals\`
`Main menu\Configuration\Input SWGRP\`
`Main menu\Configuration\Output Signals\`
`Main menu\Configuration\Output SWGRP\.`

12.6.5. Implementations

In the sections below a few implementation examples for the standard configuration H06 are presented.

12.6.5.1. Disturbance recorder

The disturbance recorder (DREC) can be found in `Main menu\Measurement\DREC\`. All of the measured voltage signals as well as all of the start signals from the protection functions and the Trip 1, Trip 2 and Trip 3 signals are connected to the DREC in the H06 standard configuration.

The recording can be triggered by any of the alternatives listed below:

- Triggering on the rising or falling edge of the protective start signals
- Triggering on voltage measurement
- Manual triggering via the HMI or with the external input signal
- Triggering via communication parameter
- Periodic triggering

Regardless of the triggering type, each recording generates the event E31. The triggering time and reason are included in the recording. Number of recordings can be viewed in `Main menu\Measurements\DREC\Control setting\# records`.

External triggering can be made by means of the reserved input signal “DREC trig” connected to one of the digital inputs. The settings can be found in `Main menu\Configuration\Input Signals\DREC trig`.

Refer to the CD-ROM Technical Descriptions of Functions (MEDREC16) for more information about the disturbance recorder.

12.6.5.2. Power quality

The power quality function (PQ 3Unf) can be found in `Main menu\Power Quality\PQ 3Unf`. The function is used for measuring the harmonics and monitoring the power quality in distribution networks.

The power quality function can be triggered by any of the alternatives listed below:

- Manual triggering via the HMI
- With the external input signal
- Triggering via communication parameter
- Preset time and date

External triggering can be made by means of the reserved input signal "PQ 3Unf trig" connected to digital input. The settings can be found in `Main menu\Configuration\Input Signals\PQ 3Unf trig`.

The function can deliver the alarm signal "PQ 3Unf cum", an output signal for exceeding a setting limit for cumulative probability of a harmonic and the "PQ 3Unf har", an output signal for exceeding a setting limit for a harmonic. The alarm signals can be routed to the output contacts via the switchgroups. The connection settings can be made in `Main menu\Configuration\Output SWGRP\Alarm 1\` or `\Alarm 2\`. The "Alarm 1" or "Alarm 2" output signal can be then connected to an output relay and the settings are done in `Main menu\Output Signals\`.

Refer to the CD-ROM Technical Descriptions of Functions (PQCU3H) for more information about the power quality function.

12.7. Motor protection, High H07/H51

12.7.1. Features

This application example describes a single busbar motor feeder including:

- Non-directional overcurrent protection
- Negative phase sequence (NPS) protection
- Motor start-up supervision
- Thermal protection for motors
- Non-directional undercurrent protection (only in H07)
- Phase reversal protection
- Fuse fail protection

Three-phase current measurement is established with current transformers, and residual voltage is measured with a set of voltage transformers in an open-delta connection. Phase-to-phase voltage measurements are established with voltage transformers.

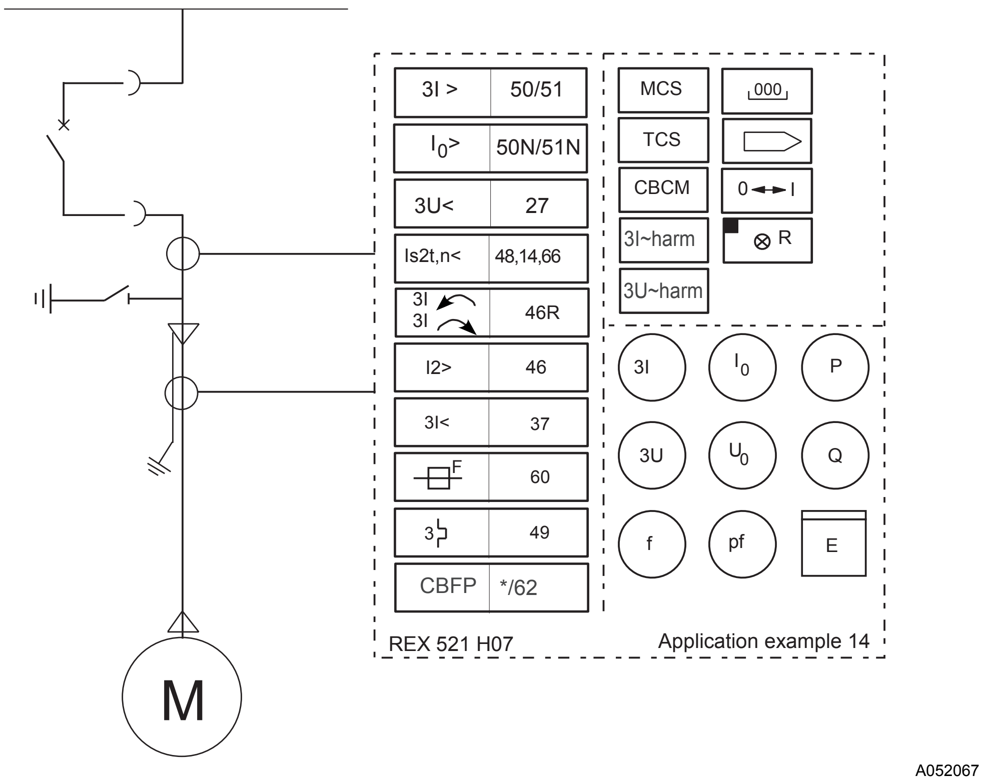


Fig. 12.7.1.-1 H07 and H51 are used for protection, measuring, and supervision of a single busbar motor feeder

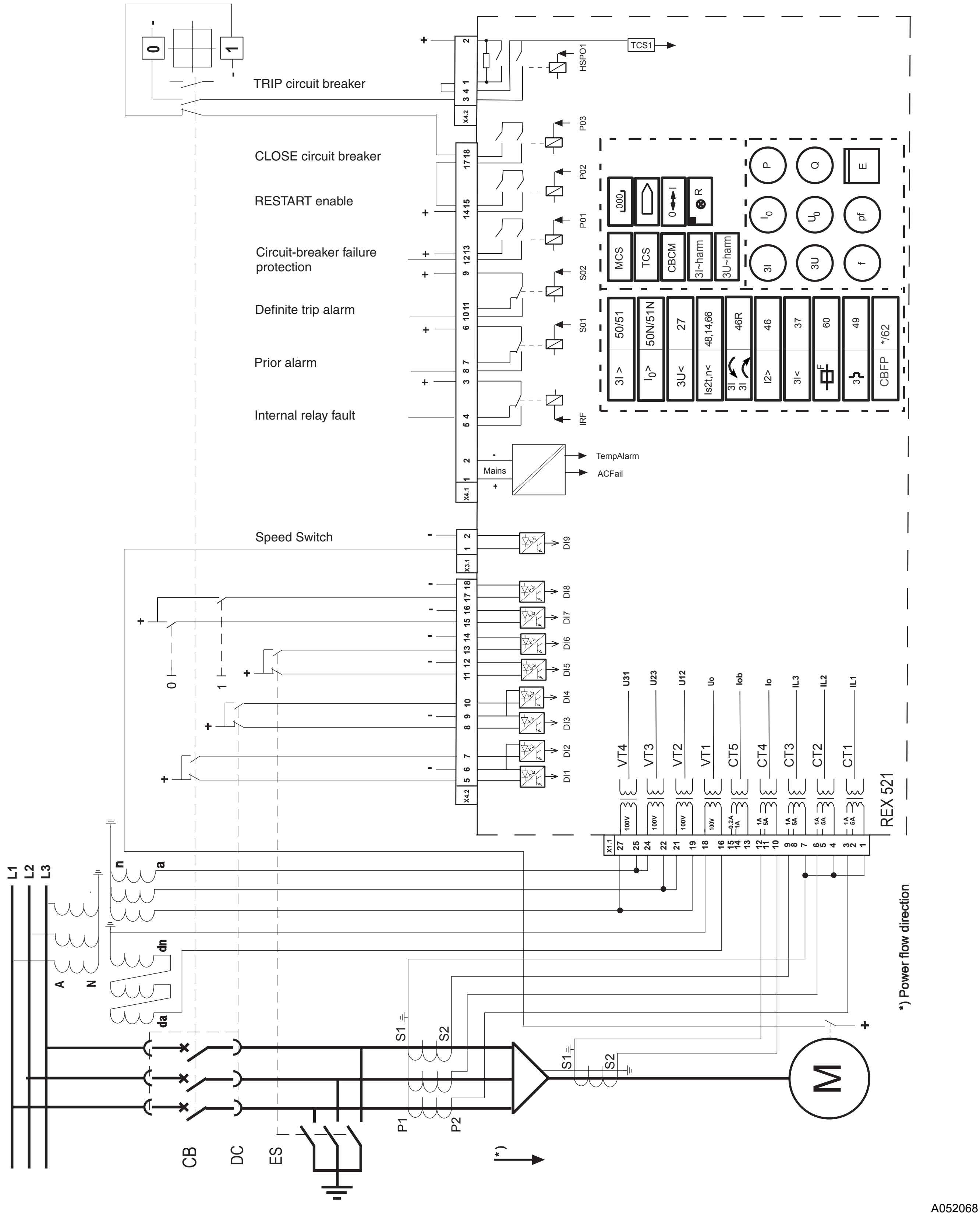


Fig. 12.7.1.-2 Connection overview diagram of the single busbar motor feeder

12.7.2. Measurements

The following measurements are supported in this application example:

- True RMS measurement of phase currents
- True RMS measurement of phase-to-phase voltages
- True RMS measurement of neutral current
- True RMS measurement of residual voltage
- Fundamental frequency active power [kW]
- Fundamental frequency reactive power [kVAr]
- Fundamental frequency displacement power factor cos (ϕ)
- Power factor PF including the harmonics
- Fundamental frequency active energy [kWh]
- Fundamental frequency reactive energy [kvarh]
- System frequency measurement

12.7.3. Protection

All the necessary settings for the protection functions can be set via Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

12.7.3.1. Thermal overload protection

Thermal Overload Protection (3Ithdev>) constitutes a full three-phase thermal overload protection. When applied to motor protection, the thermal unit forms an overload protection with two time-constants, separately for both the stator and the rotor.

Two setting groups (basic settings and advanced settings) are available. Normally, the user sets the motor data only to the basic settings, and the relay automatically calculates the advanced settings.

- The type of the motor to be protected is selected by means of the Device type setting.
- The Starting current setting is the ratio of the motor starting current to full load current.
- The Starting time setting is the maximum permitted starting time for motor.
- No of starts setting specifies how many times the motor is allowed to be started from cold condition state (assuming the motor has the ambient temperature).
- Cooling factor setting determines how slowly (compared to running condition) the motor cools down in case the motor is stopped. It can be defined also as a ratio of cooling constant (for a stopped motor) to heating constant. ($\tau_{cooling}$ / $\tau_{heating}$) A normal, totally enclosed motor cooled by a fan on the rotor shaft generally has the setting of 4...6.
- By means of Ambient temp. setting, the thermal protection can be given a standard temperature reference level (typically 40°C).
- For other basic setting parameters, the factory default values can be used as a starting point. The Gen&Trafo τ setting applies only if the Device type setting is set to be a generator or transformer.

12.7.3.2. Start-up supervision (stall protection)

The thermal stress during any single start-up condition is monitored by the start-up supervision (Is2t n<), which monitors the thermal stress equivalent product I^2xt.

The Start current setting is set directly to motor starting current value, whereas the Start time setting is set about 10% above the normal start-up time in order to give a safety margin for the operation.

For example, if the motor starting current is 6.2 x FLC and the starting time is 11 seconds, the Start current setting = 6.2 and Start time setting =11 s x 1.1 ≈ 12 seconds.

Check-up of the need of speed switch

In case the start-up time of the motor is smaller than the maximum stall time for cold condition, no speed switch information is needed for protection.

In many applications, for example in ExE-type drives, the motor is not allowed to be in a stalled condition as long as its own start-up time, that is, the maximum stall time is shorter than the start-up time. To find out whether the motor is speeding up or not, a speed switch on the motor shaft is used. Refer to Fig. 12.7.1.-2 for an example of speed switch connection to the inputs of REX 521.

The speed switch information is used to control the stall protection (the operation mode of Is2t n< is set to “I^2t & stall”). In case the motor starts accelerating, the speed switch will inhibit the stall protection trip and leave the protection to the thermal unit. If the motor does not speed up, tripping will be carried out after the Stall time.

12.7.3.3. Cumulative start-up counter

A motor manufacturer may give a statement of how many times a motor may be restarted within a certain time interval. The totalling check of start-up time acts as a backup to the thermal protection by ensuring that restarts cannot be made too frequently, in other words that the manufacturer recommendations are not exceeded.

The start-up time counting possibility is integrated in the function of Is2t n< so that no extra timers are needed. To use the start-up time counter, you have to determine two settings.

Firstly, you have to define the restart inhibit level (`Time limit` setting) in start seconds. Secondly, the module has to be told how rapidly the accumulated amount of start seconds should be counted down.

The equation for restart inhibit level is:

$$\text{Time limit} = (n - 1) \times t - \text{margin}$$

where

n	= required number of starts
t	= starting time of the motor (in seconds)
margin	= safety margin, about 10...20%

The equation for Countdown rate setting is:

$$= \frac{t}{t_{reset}}$$

where

t = starting time (in seconds)

t_{reset} = time (in hours) to reset one start-up stress

If it is assumed that the motor is recommended to be started at most three times within eight hours, and that the start-up time is 20 seconds each, the situation described in the diagram (see Fig. 12.7.3.3.-1) occurs if all the allowed three starts in a row are made:.

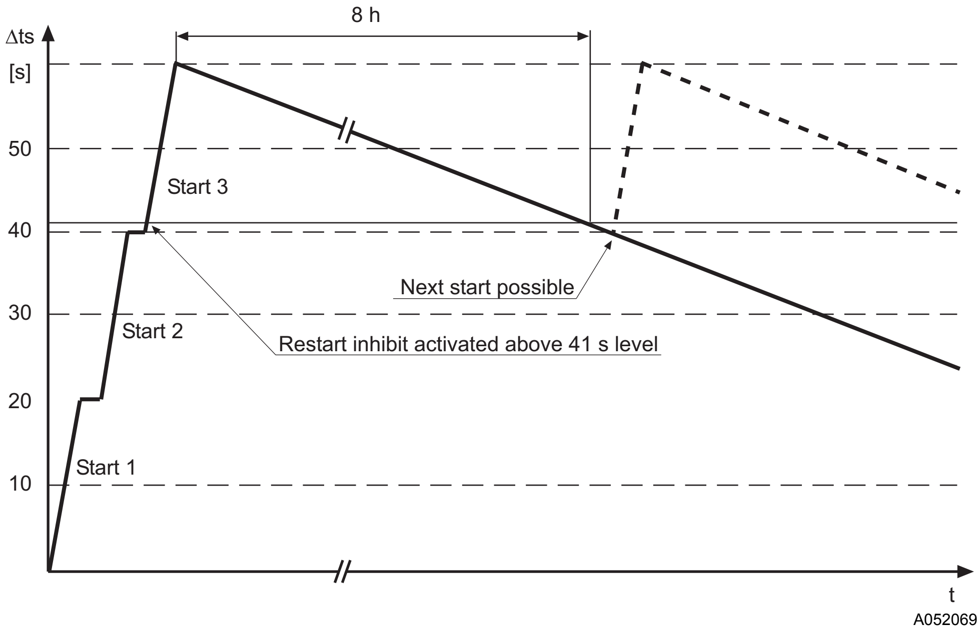


Fig. 12.7.3.3.-1 Operation of start-up time counter

The three 20 second starts add up to a total of 60 seconds. Right after the third start has been initiated, the inhibit should be activated, and the fourth start attempt is therefore not allowed. This means that the setting of the `Time limit` in this case is set to 41 seconds. Note that the start sequence still proceeds even though the inhibit is activated. The inhibit is only interrupting the close path to the circuit-breaker, and thereby preventing further start-ups.

Furthermore, the recommendation of at most three starts within eight hours means that the count-down should reach the inhibit level after 8 hours in order for it to allow a single new start. In this example it means that it should be counted down 20 seconds in 8 hours, that is, the `Countdown rate` setting is 20 s/8 h = 2.5 s/h.

For readability reasons the time scaling in the diagram is not the same for start-up versus cooling-down sequences.

12.7.3.4. Short-circuit (high-set overcurrent) protection

The high-set overcurrent protection (3I>> or 3I>>>) constitutes an interwinding short-circuit protection for the motor and a phase-to-phase short circuit protection for the feeder cable.

It is recommended to use doubling function which automatically doubles the high-set overcurrent setting during start-up. Thus, the current setting can be given a value lower than the motor starting current. Normally, the setting can be chosen to 0.70...0.90 times the motor starting current. With a suitable operating time set, this feature enables the high-set overcurrent unit to operate in case the motor is jammed while the motor is running. Generally, a setting value as low as 75% gives good results but if the inrush current causes trippings during start-up, choose a higher setting.

The doubling is controlled by the Is2t n< function block. The checksum for the switchgroup in `Main menu\Configuration\Input SWGRP\Double` should be 1 to double the 3I>> settings, and 2 to double the 3I>>> settings.

12.7.3.5. Unbalance protection

The negative phase sequence protection (I2> and I2>>) monitors the current asymmetry of the network and protects the motor against heavy network unbalance or single-phasing. Typically, the operating time of the protection follows an inverse time characteristic.

Selecting Start value -setting

The `Start value` -setting is the negative phase sequence (NPS) current, which the machine is able to continuously withstand without damage. The setting is selected as instructed by the machine manufacturer.

In case the maximum permitted negative phase sequence voltage is known (instead of NPS current), the NPS current is approximately equal to the product of the NPS voltage and the ratio of starting current to full load current.

Example:

Motor start-up current is 6 x FLC, the highest permitted NPS voltage is 4% and thereby the estimated NPS current is 6 x 4% = 24%.

Selecting K-setting

The machine constant K is equal to the I_2^2 x t capability of the machine, as stated by the machine manufacturer. It defines the rotor capability of accepting additional heating caused by negative sequence current.

A conservative estimate is calculated as:

$$K_2 = \frac{175}{(I_{LR})^2}$$

where

I_{LR} = locked-rotor current (times the Full Load Current of the motor

Example:

Motor start-up current is 5.2 x FLC and thereby the estimated K-setting is $175/(5.2)^2 = 6.5\%$.

The most severe unbalance is caused by an broken phase. It should be checked that in case of broken (open) phase the operation time of the unbalance protection is shorter than the permissible locked-rotor jam time.

12.7.3.6. Phase reversal protection

The separate phase-reversal protection (3I()) checks for phase reversal conditions based on the phase order of currents. The protection operates within a set definite time after detecting wrong phase sequence.

Alternatively, the phase-sequence voltage protection (U1U2<>_1) can be used for phase-reversal protection if it is set to trip at high negative phase sequence voltage. Because the protection is based on voltage instead of current, this protection can be used to inhibit the starting of the motor on wrong phase sequence.

The phase-reversal protections should be taken out of use for a motor which is used also with a reversed direction of rotation.

12.7.3.7. Undercurrent protection

The undercurrent protection (3I<) operates upon a sudden loss of load. The protection is used, for example, for submersible pumps where the cooling is based on a constant flow of liquid. If this flow is interrupted, the cooling capacity of the motor is reduced. This condition is detected by the undercurrent unit, which trips the motor. This function block is only found in H07.

12.7.3.8. Fuse fail protection

If an undervoltage or phase sequence voltage protection is used, the fuse failure supervision (FUSEF) should be used to block these protections. This will prevent disruptive tripping (for example fuse blow) in case of failure in the voltage measuring circuits.

12.7.4. Condition monitoring

12.7.4.1. Operation time counter

Operation time counting (in hours) is necessary for some motors. The TIME1 function block uses the motor runs-indication for counting the operate time. Refer to Section 12.7.5.3. Indication of motor status on how to enable motor status indication. The cumulative counting value is recorded.

The ALARM output of the TIME1 function block can be connected to Alarm 1 or Alarm 2 output signal (`Main menu\Configuration\Output SWGRP\`). The operate time alarm can also be connected to the Alarm LED 8 (`Main menu\Configuration\Alarm LEDs\`).

12.7.5. Connections

All the necessary settings for the connections and signal routings can be set by using Relay Setting Tool or a local HMI.

12.7.5.1. Protection signal routing

The settings for the protection signal routing can be implemented as described in Section 10.2.3.3. Protection signal routing.

12.7.5.2. Indication and control connections

The connections for indication and control can be implemented as described in Section 10.2.3.4. Indication and control connections with the exception of the signals for the open and close buttons that are disconnected in this example. Local control can be executed via HMI according to the instructions in REX 521 Operator's Manual (see Section 1.3. Related documents).

If the TOL3Dev or MotStart block are not in use, they should be disconnected from the Restart Enable signal by the SWGRP (10V325).

12.7.5.3. Indication of motor status

The motor statuses “Stop” and “Runs” can be indicated both remotely and locally by the function block I<->O IND3. Indication can be based on the measured current level, and/or on the state of the speed switch binary input, or on the measured current level and circuit breaker state. The open indication of I<->O IND3 function block corresponds to “Stop” status and close indication corresponds to “Runs” status of the motor.

The basis for the motor status indication can be selected in `Main menu\Configuration\Input SWGRP\Motor status`. The different options are the following:

Table 12.7.-1 Motor status indication options

Option	Description	Checksum
STOP:CB & I	Motor stop indication by current limit (low alarm) and circuit breaker open status input	1
STOP:I	Motor stop indication by current limit (low alarm)	2
STOP:I & Ind.	Motor stop indication by current limit (low alarm) and motor status input	4
STOP:Ind.	Motor stop indication by speed switch input	8
RUNS:Ind.	Motor runs indication by speed switch input	16
RUNS:I & Ind.	Motor runs indication by current limit (high alarm) and speed switch input	32
RUNS:I	Motor runs indication by current limit Motor runs indication by current limit (high alarm)	64
RUNS:CB & I	Motor runs indication by current limit (high alarm) and circuit breaker close status input	128

For logical operation of motor status indication, the “Stop” and “Runs” indications must be selected in pairs and the corresponding checksums must be added together, for example:
STOP:Ind. and RUNS:Ind. checksum = 24.

The high and low alarm signals of the function block `AI1` are used when the measured current level is selected for indicating motor statuses “Stop” and “Runs”. The settings for the `AI1` can be made in
`Main menu\Measurements\AI1\Control setting\`.

The function block is set in use by using the `Limit Selection` parameter.

12.8. Incoming feeder, High H08/H09

12.8.1. Features

This application example describes an incoming feeder to a single busbar including:

- Overcurrent protection
- Non-directional earth-fault protection
- Overvoltage protection
- Undervoltage protection

This application example is an optional solution for the second application example (Section 10.2. Incoming feeder, Basic B01), if overvoltage and undervoltage protection is required or wider range of measurements is needed.

The network is resistance or solidly earthed. The three-phase current measurement is established with current transformers. The neutral current is measured via a current transformer located in the neutral earthing circuit on the LV side of the power transformer. Phase-to-earth voltage measurements are established with voltage transformers.

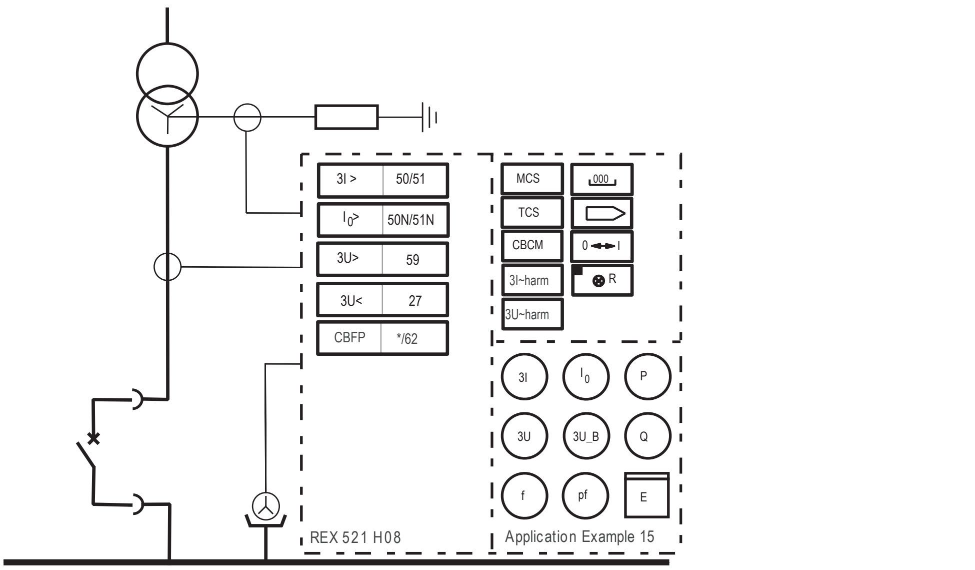


Fig. 12.8.1.-1 H08/H09 is used for protection, measuring and supervision on an incoming feeder in a single busbar system. The supplying network is either solidly or resistance earthed

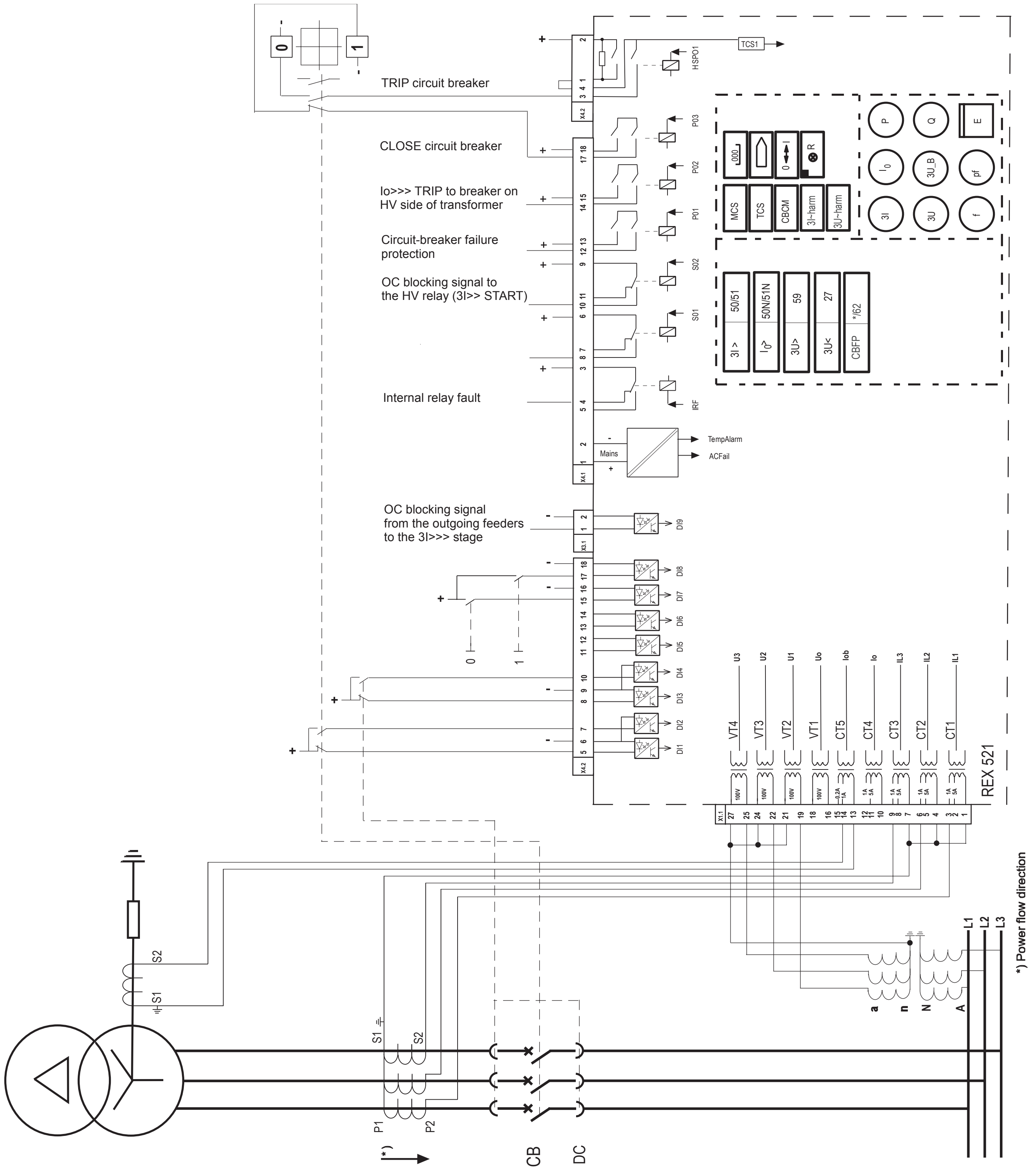


Fig. 12.8.1.-2 Connection overview diagram of the incoming feeder

12.8.2. Measurements

The following measurements are supported in this application example.

- True RMS measurement of phase currents
- True RMS measurement of neutral current
- True RMS measurement of phase-to-earth voltages
- True RMS measurement of calculated phase-to-phase voltages
- Fundamental frequency active power [kW]
- Fundamental frequency reactive power [kVAr]
- Fundamental frequency displacement power factor cos (ϕ)
- Power factor PF including harmonics
- Fundamental frequency active energy [kWh]
- Fundamental frequency reactive energy [kvarh]
- System frequency measurement

12.8.3. Protection

All the necessary settings for the protection functions can be set by means of the Relay Setting Tool or the local HMI. The settings can be found in `Main menu\Protection\`.

12.8.3.1. Phase overcurrent protection

The overcurrent protection can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01)

12.8.3.2. Earth-fault protection

The earth-fault protection can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01)

12.8.3.3. Overvoltage and undervoltage protection

Faults in the network or a faulty tap changer or voltage regulator of a power transformer may cause abnormal busbar voltages. The overvoltage and undervoltage protection is used to prevent possible damages to devices connected to the network.

In this application the overvoltage and undervoltage protection is included in the functionality of the protection relay of the incoming feeder. In the overvoltage or undervoltage situation the circuit breaker of the incoming feeder will be opened.

The overvoltage protection includes two protection stages: a low stage U> and a high stage U>>. The low stage can be set to definite-time or inverse-time operation. Definite-time operation is used with the high-set stage.

Similarly, the undervoltage protection includes two protection stages: a low stage U< and a high stage U<<. The low stage can be set to definite-time or inverse-time operation. Definite-time operation is used with the high set stage.

An operational characteristic example on overvoltage and undervoltage protection is presented in the following picture (Fig. 12.5.3.-1).

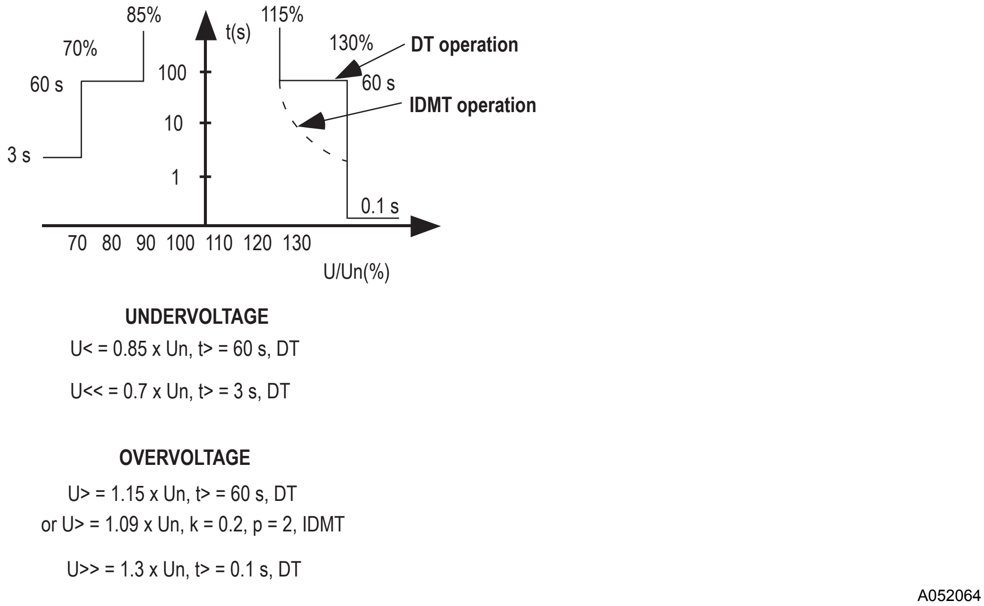


Fig. 12.8.3.-1 Example on overvoltage and undervoltage protection

12.8.4. Connections

All the necessary settings for the connections and signal routings can be set via the Relay Setting Tool or the local HMI.

12.8.4.1. Protection signal routing

The trip signal (Trip 1) of the protection functions is routed to the high speed power output HSPO1 (x4.2.1/2/3/4) as well as the control-open signal for the circuit breaker. The trip signals from the protection functions are routed to the output relay via the output switchgroups. These settings can be found in `Main menu\Configuration\Output SWGRP\`.

As the HSPO1 is always named as the “Trip 1" output signal, the settings are made directly in `Main menu\Configuration\Output SWGRP\Trip 1`, where the checksum of the settings is displayed (255 by default).

Using the HMI:

To change the settings for Trip 1 go to `Output SWGRP\Trip 1` and press the [E]-button. The different protection functions are displayed one at a time. By pressing the [→] or [←] navigation push button, it is possible to scroll between the different protections. By pressing the [↑] or [↓] navigation push button, the specific protection function trip signal can be connected or disconnected. When the three-stage overcurrent (3I> 3I>> and 3I>>>), two-stage earth fault (I_0> and I_0>>), two-stage overvoltage (U> and U>>) and two-stage undervoltage (U< and U<<) protection is selected the checksum for Trip 1 is 991. When the earth-fault protection stage Io>>> is selected the checksum for Trip 2 is 32.

12.8.4.2. Indication and control connections

All the necessary settings for the indication and control signals of the circuit breaker and the disconnector for the incoming feeder can be set as described in the first application example on Section 10.1. Outgoing feeder, Basic B01 onwards for the outgoing feeder (except for the earth switch). The settings are made by means of the Relay Setting Tool or the local HMI. The settings can be found in:

```
Main menu\Configuration\Input Signals\
Main menu\Configuration\Input SWGRP\
Main menu\Configuration\Output Signals\
Main menu\Configuration\Output SWGRP\.
```

12.8.5. Implementations

In the sections below a few implementation examples for the standard configurations H08 and H09 are presented.

12.8.5.1. Blocking signal received from the outgoing feeder

The blocking signal received from the outgoing feeder can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01)

12.8.5.2. Outgoing blocking signal to the overcurrent relay on the HV side

The outgoing blocking signal to the overcurrent relay on the HV side can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01)

12.8.5.3. Earth-fault stage Io>>> to trip the breaker on the HV side of the transformer

The earth-fault stage Io>>> to trip the breaker on the HV side of the transformer can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01)

12.8.5.4. Circuit-breaker failure protection

The circuit-breaker failure protection can be implemented as described in the second application example (Section 10.2. Incoming feeder, Basic B01). CBFP function is not available for the overvoltage and undervoltage protection.

12.8.5.5. Disturbance recorder

The disturbance recorder (DREC) can be found in `Main menu\Measurement\DREC\`. All of the measured current and voltage signals as well as all of the start signals from the protection functions and the Trip 1 and Trip 2 signals are connected to the DREC in the H08 and H09 standard configurations.

The recording can be triggered by any of the alternatives listed below:

- Triggering on the rising or falling edge of the protective start signals
- Triggering on current or voltage measurement
- Manual triggering via the HMI or with the external input signal
- Triggering via communication parameter
- Periodic triggering

Regardless of the triggering type, each recording generates the event E31. The triggering time and reason are included in the recording. Number of recordings can be viewed in `Main menu\Measurements\DREC\Control setting\# records`.

External triggering can be made by means of the reserved input signal “DREC trig” connected to one of the digital inputs. The settings can be found in `Main menu\Configuration\Input Signals\DREC trig`.

Refer to the CD-ROM Technical Descriptions of Functions (MEDREC16) for more information about the disturbance recorder.

12.8.5.6. Power quality

The power quality functions (PQ 3Inf and PQ 3Unf) can be found in `Main menu\Power Quality\PQ 3Inf` and `Main menu\Power Quality\PQ 3Unf`. The functions are used for measuring the harmonics and monitoring the power quality in distribution networks.

The power quality function can be triggered by any of the alternatives listed below:

- Manual triggering via the HMI
- With the external input signal
- Triggering via communication parameter
- Preset time and date

External triggering can be made by means of the reserved input signals “PQ 3Inf trig” and “PQ 3Unf trig” connected to the digital inputs. The settings can be found in `Main menu\Configuration\Input Signals\PQ 3Inf trig` and `Main menu\Configuration\Input Signals\PQ 3Unf trig`.

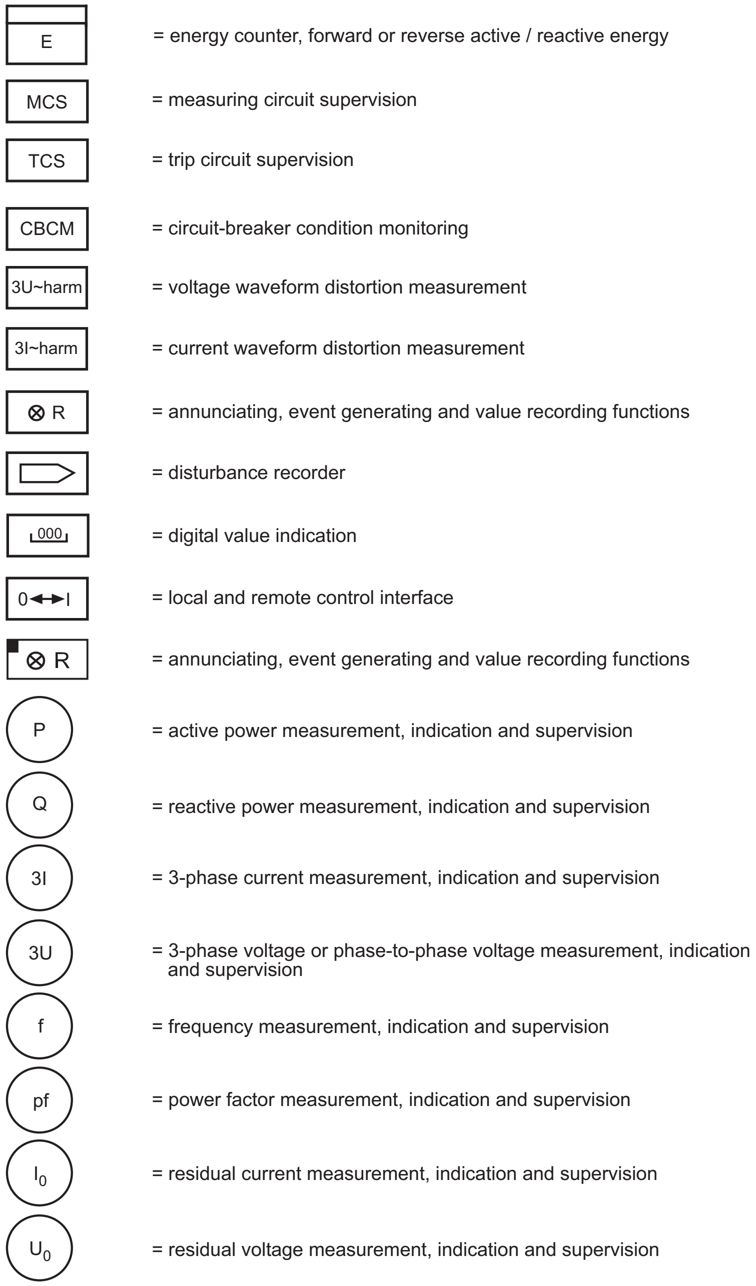
The functions can deliver the alarm signals “PQ 3Inf cum” and “PQ 3Unf cum”, an output signal for exceeding a setting limit for cumulative probability of a harmonic and the “PQ 3Inf har” and “PQ 3Unf har”, an output signal for exceeding a setting limit for a harmonic. The alarm signals can be routed to the output contacts via the switchgroups. The connection settings can be made in `Main menu\Configuration\Output SWGRP\Alarm 1\ or \Alarm 2\`. The Alarm 1 or Alarm 2 output signal can be then connected to an output relay and the settings are done in `Main menu\Configuration\Output Signals\`.

Refer to the CD-ROM Technical Descriptions of Functions (PQCU3H) for more information about the power quality function.

13. Symbol notations

3I >	50/51	= multiple-stage three-phase overcurrent protection, low-set, high-set and instantaneous stage available
3I> →	67	= multiple-stage three-phase directional overcurrent protection, low-set, high-set and instantaneous stage available
I_0>	50N/51N	= multiple-stage earth-fault protection, low-set, high-set and instantaneous stage available
I_0> →	67N	= multiple-stage directional earth-fault protection, low-set, high-set and instantaneous stage available
3U >	59	= three-phase overvoltage protection, low-set and high-set stage available
3U <	27	= three-phase undervoltage protection, low-set and high-set stage available
U_0>	59N	= multiple-stage residual overvoltage protection, low-set, high-set and instantaneous stage available
$3I_{2f}$ >	68	= inrush detection based on the 2nd harmonic content of phase currents, applied for preventing possible unnecessary operation of overcurrent or earth-fault protection during transformer switching-in or to start cold load pick-up logic
DI>	46	= phase discontinuity protection
3	49F	= thermal overload protection for feeders
f </f>	81U/81O	= under/overfrequency protection/load shedding scheme
0 → I	79	= multiple-shot auto-recloser
SYNC	25	= circuit breaker synchro-check/direction of energizing check function
CBFP	* /62	= circuit-breaker failure protection
LO	86	= lockout (Refer to chapter “Lockout function” in this manual)
I_s^2t, n<	48,14,66	= start-up supervision for motors (MotStart)
3I↶ 3I↷	46R	= phase reversal protection (PREV3)
I_2 >	46	= negative phase-sequence protection, low-set and high-set stages available (NPS3_)
3I<	37	= three-phase non-directional undercurrent protection, stages 1 and 2 available (NUC3St2)
F	60	= fuse failure supervision (FuseFail)
3	49	= three-phase thermal overload protection for motors, generators and transformers (TOL3Dev)

A052072


E = energy counter, forward or reverse active / reactive energy
MCS = measuring circuit supervision
TCS = trip circuit supervision
CBCM = circuit-breaker condition monitoring
3U~harm = voltage waveform distortion measurement
3I~harm = current waveform distortion measurement
⊗ R = annunciating, event generating and value recording functions
= disturbance recorder
000 = digital value indication
0 I = local and remote control interface
⊗ R = annunciating, event generating and value recording functions
P = active power measurement, indication and supervision
Q = reactive power measurement, indication and supervision
3I = 3-phase current measurement, indication and supervision
3U = 3-phase voltage or phase-to-phase voltage measurement, indication and supervision
f = frequency measurement, indication and supervision
pf = power factor measurement, indication and supervision
I0 = residual current measurement, indication and supervision
U0 = residual voltage measurement, indication and supervision

A052073

14. Abbreviations

AR	Auroreclose
ASCII	American Standard Code for Information Interchange
CB	Cicuit breaker
CBFP	Circuit creaker failure protection function
CRC	Cyclic redundancy check
CT	Current transformer
DC	Disconnector
DI	Digital input
ES	Earth switch
HMI	Human-machine interface
HSPO	High-speed power output
IDMT	Inverse definite minimum time
IRF	Internal relay fault
LCD	Liquid crystal display
LED	Light-emitting diode
MCB	Miniature circuit breaker
MMI	Man-machine interface
NC	Normally closed
NO	Normally open
NPS	Negative phase sequence
PO	Power output
RS	Rogowski sensor
RTC	Real-time clock
RTU	Remote terminal unit
SA	Substation automation
SO	Signalling output
TCS	Trip-circuit supervision
VD	Voltage divider
VT	Voltage transformer

ABB Oy
Distribution Automation
P.O. Box 699
FI-65101 Vaasa
FINLAND
Tel. +358 10 22 11
Fax. +358 10 224 1094
www.abb.com/substationautomation

1MRS751802-MUM EN 09.2006