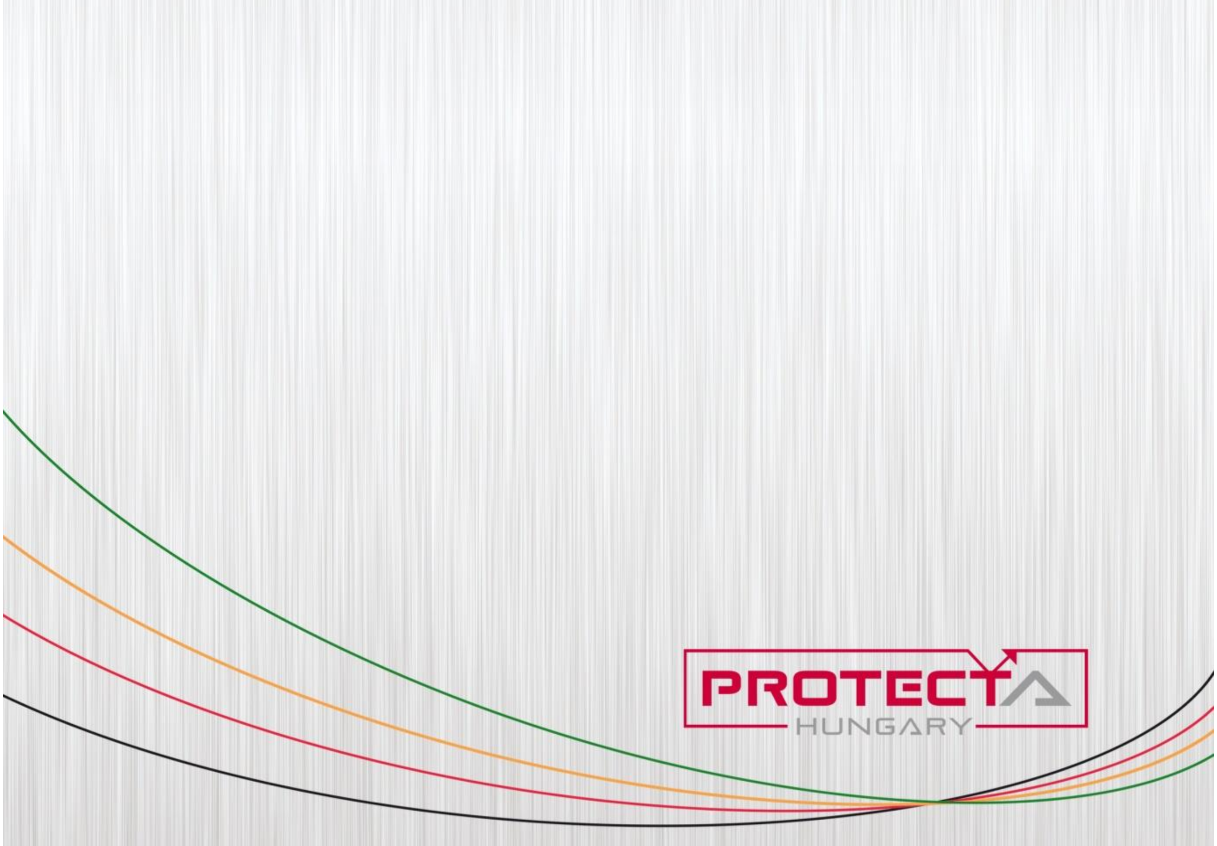
EUROPROT +

DV7500
configuration description
(Type: DTRV)



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User’s manual version information

Version	Date	Modification	Compiled by
V1.0		First edition	Tóth
V1.1			
V1.2	2017-02-14	**Added**: • 3 Mounting of the device Modified: • Minor formatting	Seida
V1.3	2021-06-29	Connection diagram is added Module arrangement is replaced	

CONTENTS

1 Configuration description

The DV7500 protection device is a member of the ***EuroProt+*** product line, made by Protecta Co. Ltd. The ***EuroProt+*** type complex protection in respect of hardware and software is a modular device. The modules are assembled and configured according to the requirements, and then the software determines the functions. This manual describes the specific application of the DV7500 factory configuration.

1.1 Application

The members of the DTRV product line are configured to protect and control high voltage/medium voltage transformers.

1.1.1 Protection functions

The DV7500 configuration measures three phase currents, the zero sequence current component from both sides of a two winding, three-phase transformer and additionally three phase voltages and the zero sequence voltage component. These measurements allow, in addition to the current- and voltage-based functions, directionality extension of the residual overcurrent function.

The main protection functions are transformer differential protection and restricted earth-fault protection functions.

Based on the voltage measurement also the frequency is evaluated to realize frequency-based protection functions.

The realized current-based and voltage-based protection functions, including thermal replica protection function, frequency functions and differential functions, are listed in the Table below.

This configuration is extended also with tap-changer controller function.

Protection functions	**IEC**	**ANSI**	**DV7500**
Three-phase instantaneous overcurrent protection	I >>>	50	**X**
Three-phase time overcurrent protection	I >, I >>	51	**X**
Residual instantaneous overcurrent protection	Io >>>	50N	**X**
Residual time overcurrent protection	Io >, Io >>	51N	**X**
Residual directional overcurrent protection	Io Dir > >, Io Dir >>	67N	**X**
Negative sequence overcurrent protection	I_2 >	46	**X**
Thermal protection	T >	49	**X**
Transformer differential	$3I_dT$ >	87T	**2w**
Restricted earth fault	REF	87N	**X**
Definite time overvoltage protection	U >, U >>	59	**X**
Definite time undervoltage protection	U <, U <<	27	**X**
Residual overvoltage protection	Uo >, Uo >>	59N	**X**
Negative sequence overvoltage protection	U_2 >	47	**X**
Overexcitation	V/Hz	24	**X**
Current unbalance protection		60	**X**
Breaker failure protection	CBFP	50BF	**X**

Table 1 The protection functions of the DV7500 configuration

The configured functions are drawn symbolically in the Figure below.

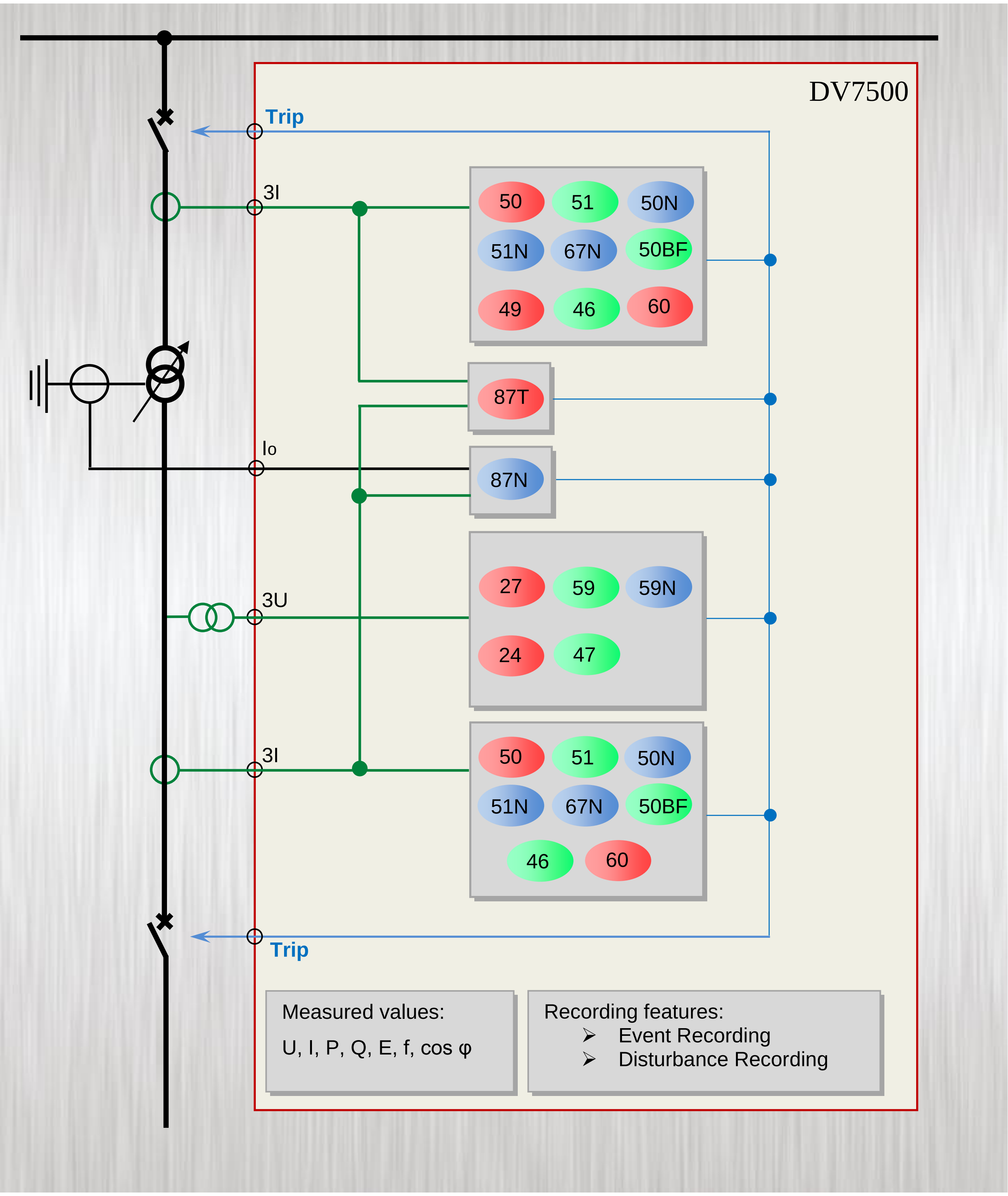


Figure 1 Implemented protection functions

1.1.2 Measurement functions

Based on the hardware inputs the measurements listed in Table below are available.

Measurement functions	DV7500
Current (I1, I2, I3, Io)	X
Voltage (U1, U2, U3, U12, U23, U31, Uo, Useq) and frequency	X
Supervised trip contacts (TCS)	X

Table 2 The measurement functions of the DV7500 configuration

1.1.3 Hardware configuration

The module arrangement of the DV7500 configuration is shown below.

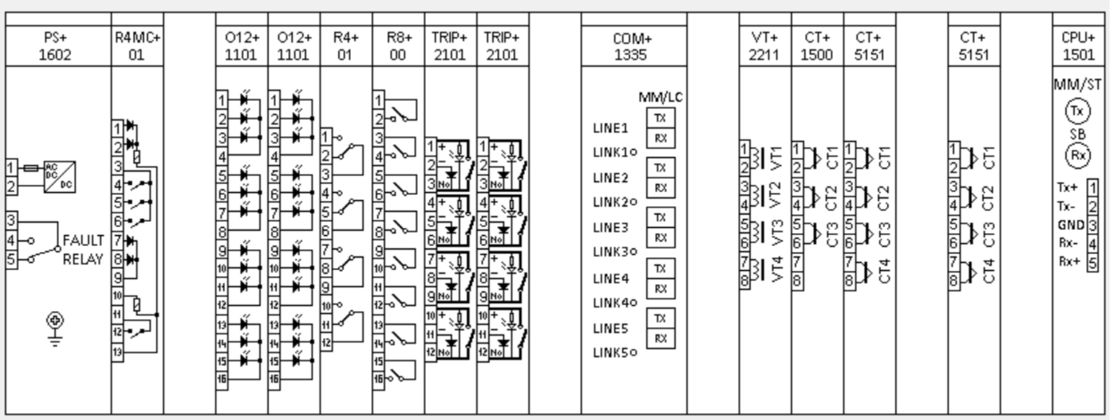


Figure 2 Basic module arrangement of the DV7500 configuration (rear view)

1.1.4 The applied hardware modules

The applied modules are listed in Table 3.

The technical specification of the device and that of the modules are described in the document "***Hardware description***".

Module identifier	Explanation
PS+ 1602	Power supply unit
R4MC+01	Signal relay output module
O12+ 1101	Binary input module
R4+ 01	Signal relay output module
R8+ 00	Signal relay output module
TRIP+ 2101	Trip relay output module
COM+1335	Remote I/O (RIO) server host module
VT+ 2211	Analog voltage input module
CT + 5151	Analog current input module
CT + 1500	Analog current input module
CPU+ 1101	Processing and communication module

Table 3 The applied modules of the DV7500 configuration

1.1.4.1 Connector allocation

"A" "B" PS+/1602

No.	Name	Term.
1	AuxPS+	
2	AuxPS-	
3	Fault Relay Common	
4	Fault Relay NO	
5	Fault Relay NC	

"E" O12+/1101

No.	Name	Term.
1	Open position of 52HV	
2	Closed position of 52HV	
3	Open position of 52MV	
4	Opto-(1-3)	
5	Closed position of 52MV	
6	DPX	
7	27VSC	
8	Opto-(4-6)	
9	SNI	
10	SNC	
11	Inib_Vo	
12	Opto-(7-9)	
13	K/K'	
14		
15	BIn_E12	
16	Opto-(10-12)	

"F" O12+/1101

No.	Name	Term.
1	Local HV Open command	
2	Local HV Close command	
3	Local MV Open command	
4	Opto-(1-3)	
5	Local MV Close command	
6	Local control mode DC	
7	TC reset	
8	Opto-(4-6)	
9	AR disable	
10	Local mode	
11	Remote mode	
12	Opto-(7-9)	
13	Man Voltage up	
14	Man Voltage down	
15	Man TC Comm Enable	
16	Opto-(10-12)	

"G" R4+/01

No.	Name	Term.
1	Local HV/MV Open NO	
2	Local HV/MV Open NC	
3	Local HV/MV Open Common	
4	BOut_G02 NO	
5	BOut_G02 NC	
6	BOut_G02 Common	
7	BOut_G03 NO	
8	BOut_G03 NC	
9	BOut_G03 Common	
10	BOut_G04 NO	
11	BOut_G04 NC	
12	BOut_G04 Common	

"H" R8+/00

No.	Name	Term.
1	BOut_H01 Common	
2	BOut_H01 NO	
3	BOut_H02 Common	
4	BOut_H02 NO	
5	BOut_H03 Common	
6	BOut_H03 NO	
7	BOut_H04 Common	
8	BOut_H04 NO	
9	BOut_H05 Common	
10	BOut_H05 NO	
11	BOut_H06 Common	
12	BOut_H06 NO	
13	BOut_H07 Common	
14	BOut_H07 NO	
15	BOut_H08 Common	
16	BOut_H08 NO	

"I" TRIP+/2101

No.	Name	Term.
1	Trip MV +	
2	Trip MV -	
3	Trip MV NO	
4	Close MV +	
5	Close MV -	
6	Close MV NO	
7	LowDC Trip3 MV +	
8	LowDC Trip3 MV -	
9	LowDC Trip3 MV NO	
10	BOut_I08 +	
11	BOut_I08 -	
12	BOut_I08 NO	

"J" TRIP+/2101

No.	Name	Term.
1	Trip HV +	
2	Trip HV -	
3	Trip HV NO	
4	Close HV +	
5	Close HV -	
6	Close HV NO	
7	Trip2 HV +	
8	Trip2 HV -	
9	Trip2 HV NO	
10	LowDC Trip3 HV +	
11	LowDC Trip3 HV -	
12	LowDC Trip3 HV NO	

"O" VT+/2211

No.	Name	Term.
1	phase voltage 4 MV->	
2	phase voltage 4 MV<-	
3	phase voltage 8 MV->	
4	phase voltage 8 MV<-	
5	phase voltage 12 MV->	
6	phase voltage 12 MV<-	
7	U4 MV->	
8	U4 MV<-	

"P" CT+/1500

No.	Name	Term.
1	phase current 4 MV meas->	
2	phase current 4 MV meas<-	
3	phase current 8 MV meas->	
4	phase current 8 MV meas<-	
5	phase current 12 MV meas->	
6	phase current 12 MV meas<-	
7	NU	
8	NU	

"R" CT+/5151

No.	Name	Term.
1	phase current 4 MV->	
2	phase current 4 MV<-	
3	phase current 8 MV->	
4	phase current 8 MV<-	
5	phase current 12 MV->	
6	phase current 12 MV<-	
7	I4 MV->	
8	I4 MV<-	

"T" CT+/5151

No.	Name	Term.
1	phase current 4 HV->	
2	phase current 4 HV<-	
3	phase current 8 HV->	
4	phase current 8 HV<-	
5	phase current 12 HV->	
6	phase current 12 HV<-	
7	I4 HV->	
8	I4 HV<-	

1.2 Meeting the device

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

*Figure 3 The 84 inch rack of **EuroProt+** family*

1.3 Software configuration

1.3.1 Protection and control functions

The implemented protection and control functions are listed in Table 4. The function blocks are described in details in separate documents. These are referred to also in this table.

Name	Title	Document
IOC50	3ph Instant.OC	***Three-phase instantaneous overcurrent protection function block description***
TOC51D_HV1 TOC51D_HV2 TOC51D_MV1 TOC51D_MV2	3ph Overcurr	***Three-phase definite time overcurrent protection function block description***
IOC50N	Residual Instant.OC	***Residual instantaneous overcurrent protection function block description***
TOC51N_low TOC51N_high	Residual TOC	***Residual overcurrent protection function block description***
TOC67N_low TOC67N_high	Dir.Residual TOC	***Directional residual overcurrent protection function block description***
TOC46_HV	Neg. Seq. OC	***Negative sequence overcurrent protection function block description***
TTR49L_HV	Thermal overload	***Line thermal protection function block description***
DIF87_2w	Transformer Differential	***Transformer differential protection function block description***
INR68	Inrush detection	***Inrush current detection function block description***
DIF87N_MV	Restricted EF	***Restricted Earth Fault protection function block description***
TOV59_MV1 TOV59_MV2	Overvoltage	***Definite time overvoltage protection function block description***
TUV27_MV1 TUV27_MV2	Undervoltage	***Definite time undervoltage protection function block description***
TOV59N_V	Overvoltage	***Definite time zero sequence overvoltage***

TOV59N_W TOV59N_U4		***protection function block description***
VPH24	Overexcitation	***Overexcitation protection function block description***
VCB60	Current Unbalance	***Current unbalance function block description***
BRF50	Breaker failure	***Breaker failure protection function block description***
TRC94	Trip Logic	***Trip logic function block description***
PD	Pole discordance	***Pole discordance detection function block description***
DLD	Dead line detection	***Dead line detection protection function block description***
VTS	VoltageSupervision	***Voltage transformer supervision and dead line detection function block description***
REC79MV	MV autoreclosing	***Automatic reclosing function for medium voltage networks, function block description***
ATCCIT	Tap Change Control	***Automatic tap-changer controller function block description***

Table 4 Implemented protection and control functions

1.3.1.1 Three-phase instantaneous overcurrent protection function (IOC50)

The three-phase instantaneous overcurrent protection function (IOC50) operates immediately if the phase currents are higher than the setting value.

The setting value is a parameter, and it can be doubled by graphic programming of the dedicated input binary signal defined by the user.

The function is based on peak value selection or on the RMS values of the Fourier basic harmonic calculation, according to the parameter setting. The fundamental Fourier components are results of an external function block.

Parameter for type selection has selection range of Off, Peak value and Fundamental value. When Fourier calculation is selected then the accuracy of the operation is high, the operation time however is above one period of the network frequency. If the operation is based on peak values then fast sub-cycle operation can be expected, but the transient overreach can be high.

The function generates trip commands without additional time delay if the detected values are above the current setting value.

The function generates trip commands for the three phases individually and a general trip command as well.

The instantaneous overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function		**Accuracy**
Using peak value calculation		
Operating characteristic	Instantaneous	<6%
Reset ratio	0.85	
Operate time at 2*I_S	<15 ms	
Reset time *	< 40 ms	
Transient overreach	90 %	
Using Fourier basic harmonic calculation		
Operating characteristic	Instantaneous	<2%
Reset ratio	0.85	
Operate time at 2* I_S	<25 ms	
Reset time *	< 60 ms	
Transient overreach	15 %	

**Measured with signal contacts*

Table 5 Technical data of of the instantaneous overcurrent protection function

Parameters

Enumerated parameter

Parameter name	**Title**	**Selection range**	**Default**
Parameter for type selection			
IOC50_Oper_EPar_	Operation	Off, Peak value, Fundamental value	Peak value

Table 6 The enumerated parameter of the instantaneous overcurrent protection function

Integer parameter

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Starting current parameter:						
IOC50_StCurr_IPar_	Start Current	%	20	3000	1	200

Table 7 The integer parameter of the instantaneous overcurrent protection function

1.3.1.2 Three-phase time overcurrent protection function (TOC51)

The definite (independent) time characteristic has a fixed time delay when the current is above the starting current I_s previously set as a parameter.

The binary output status signals of the three-phase overcurrent protection function are starting signals of the three phases individually, a general starting signal and a general trip command.

The overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	Value	Accuracy
Operating characteristic accuracy	DT	< 2 %
Reset ratio	0,95	
Operating time accuracy		< 5% or ±15 ms, whichever is greater
Reset time	16-25ms	

Table 8 Technical data of of the definite time overcurrent protection function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Parameter for type selection			
TOC51D_Oper_EPar_	Operation	Off, On	On

Table 9 The enumerated parameters of the definite time overcurrent protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Starting current parameter:						
TOC51D_StCurr_IPar_	Start Current	%	20	1000	1	200

Table 10 The integer parameter of the definite time overcurrent protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Definite time delay:						
TOC51D_DefDel_TPar_	Definite Time Delay	msec	0	60000	1	100

Table 11 The timer parameters of the definite time overcurrent protection function

1.3.1.3 Residual instantaneous overcurrent protection function (IOC50N)

The residual instantaneous overcurrent protection function (IOC50N) block operates immediately if the residual current (3Io) is above the setting value. The setting value is a parameter, and it can be doubled by a dedicated binary input signal defined by the user applying the graphic programming.

The function is based on peak value selection or on the RMS values of the Fourier basic harmonic component of the residual current, according to the parameter setting. The fundamental Fourier component calculation is not part of the IOC50N function.

Parameter for type selection has selection range of Off, Peak value and Fundamental value.

The function generates a trip commands without additional time delay if the detected values are above the current setting value.

The residual instantaneous overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function		**Accuracy**
Using peak value calculation		
Operating characteristic (I>0.1 In)	Instantaneous	<6%
Reset ratio	0.85	
Operate time at 2*I_S	<15 ms	
Reset time *	< 35 ms	
Transient overreach	85 %	
Using Fourier basic harmonic calculation		
Operating characteristic (I>0.1 In)	Instantaneous	<3%
Reset ratio	0.85	
Operate time at 2*I_S	<25 ms	
Reset time *	< 60 ms	
Transient overreach	15 %	

**Measured with signal contacts*

Table 12 Technical data of the residual instantaneous overcurrent protection function

Parameters

Enumerated parameter

Parameter name	**Title**	**Selection range**	**Default**
Parameter for type selection			
IOC50N_Oper_EPar_	Operation	Off, Peak value, Fundamental value	Peak value

Table 13 The enumerated parameter of the residual instantaneous overcurrent protection function

Integer parameter

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Starting current parameter:						
IOC50N_StCurr_IPar_	Start Current	%	10	400	1	200

Table 14 The integer parameter of the residual instantaneous overcurrent protection function

1.3.1.4 Residual overcurrent protection function (TOC51N)

The residual delayed overcurrent protection function can realize definite time or inverse time characteristics according to IEC or IEEE standards, based on the RMS value of the fundamental Fourier component of a single measured current, which can be the measured residual current at the neutral point (3Io) or the calculated zero sequence current component. The characteristics are harmonized with IEC 60255-151, Edition 1.0, 2009-08.

The definite (independent) time characteristic has a fixed time delay when the current is above the starting current I_S previously set as a parameter.

The standard operating characteristics of the inverse time overcurrent protection function are defined by the following formula:

$$t(G) = TMS\left[\frac{k}{\left(\frac{G}{G_S}\right)^{\alpha} - 1} + c\right] \quad \text{when } G > G_S$$

where

t(G)(seconds)	theoretical operate time with constant value of G,
k, c	constants characterizing the selected curve (in seconds),
α	constant characterizing the selected curve (no dimension),
G	measured value of the characteristic quantity, Fourier base harmonic of the residual current (INFour),
G_S	preset value of the characteristic quantity (Start current),
TMS	preset time multiplier (no dimension).

	IEC ref		**k_r**	**c**	**α**
1	A	IEC Inv	0,14	0	0,02
2	B	IEC VeryInv	13,5	0	1
3	C	IEC ExtInv	80	0	2
4		IEC LongInv	120	0	1
5		ANSI Inv	0,0086	0,0185	0,02
6	D	ANSI ModInv	0,0515	0,1140	0,02
7	E	ANSI VeryInv	19,61	0,491	2
8	F	ANSI ExtInv	28,2	0,1217	2
9		ANSI LongInv	0,086	0,185	0,02
10		ANSI LongVeryInv	28,55	0,712	2
11		ANSI LongExtInv	64,07	0,250	2

The end of the effective range of the dependent time characteristics (G_D) is:

$$G_D = 20 * G_S$$

Above this value the theoretical operating time is definite:

$$t(G) = TMS\left[\frac{k}{\left(\frac{G_D}{G_S}\right)^{\alpha} - 1} + c\right] \quad \text{when } G > G_D = 20 * G_S$$

Additionally a minimum time delay can be defined by a dedicated parameter (Min. Time Delay). This delay is valid if it is longer than t(G), defined by the formula above.

Resetting characteristics:

- for IEC type characteristics the resetting is after a fix time delay,
- for ANSI types however according to the formula below:

$$t_r(G) = TMS\left[\frac{k_r}{1-\left(\frac{G}{G_S}\right)^{\alpha}}\right] \text{ when } G < G_S$$

where

$t_r(G)$(seconds)	theoretical reset time with constant value of G,
k_r	constants characterizing the selected curve (in seconds),
α	constant characterizing the selected curve (no dimension),
G	measured value of the characteristic quantity, Fourier base harmonic of the residual current,
G_S	preset value of the characteristic quantity (Start current),
TMS	preset time multiplier (no dimension).

	IEC ref		**k_r**	**α**
1	A	IEC Inv	Resetting after fix time delay, according to preset parameter TOC51_Reset_TPar_ “Reset delay”	
2	B	IEC VeryInv		
3	C	IEC ExtInv		
4		IEC LongInv		
5		ANSI Inv	0,46	2
6	D	ANSI ModInv	4,85	2
7	E	ANSI VeryInv	21,6	2
8	F	ANSI ExtInv	29,1	2
9		ANSI LongInv	4,6	2
10		ANSI LongVeryInv	13,46	2
11		ANSI LongExtInv	30	2

The binary output status signals of the residual overcurrent protection function are the general starting signal and the general trip command if the time delay determined by the characteristics expired.

The residual overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	**Value**	**Accuracy**
Operating accuracy *	$20 \le G_S \le 1000$	< 3 %
Operate time accuracy		±5% or ±15 ms, whichever is greater
Reset ratio	0,95	
Reset time * Dependent time char. Definite time char.	 Approx 60 ms	< 2% or ±35 ms, whichever is greater
Transient overreach		2 %
Pickup time	≤ 40 ms	
Overshot time Dependent time char. Definite time char.	 30 ms 50 ms	
Influence of time varying value of the input current (IEC 60255-151)		< 4 %

* *Measured in version In = 200 mA*

Table 15 *The technical data of the residual overcurrent protection function*

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Parameter for type selection			
TOC51N_Oper_EPar_	Operation	Off, DefinitTime, IEC Inv, IEC VeryInv, IEC ExtInv, IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv	Definite Time

Table 16 The enumerated parameters of the residual overcurrent protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Starting current parameter:						
TOC51N_StCurr_IPar_	Start Current *	%	5	200	1	50
TOC51N_StCurr_IPar_	Start Current **	%	10	1000	1	50

* *In = 1 A or 5 A*
** *In = 200 mA or 1 A*

Table 17 The integer parameter of the residual overcurrent protection function

Float point parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time multiplier of the inverse characteristics (OC module)						
TOC51N_Multip_FPar_	Time Multiplier	sec	0.05	999	0.01	1.0

Table 18 The float parameter of the residual overcurrent protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Minimal time delay for the inverse characteristics:						
TOC51N_MinDel_TPar_	Min Time Delay*	msec	0	60000	1	100
Definite time delay:						
TOC51N_DefDel_TPar_	Definite Time Delay**	msec	0	60000	1	100
Reset time delay for the inverse characteristics:						
TOC51N_Reset_TPar_	Reset Time*	msec	0	60000	1	100

**Valid for inverse type characteristics*
***Valid for definite type characteristics only*

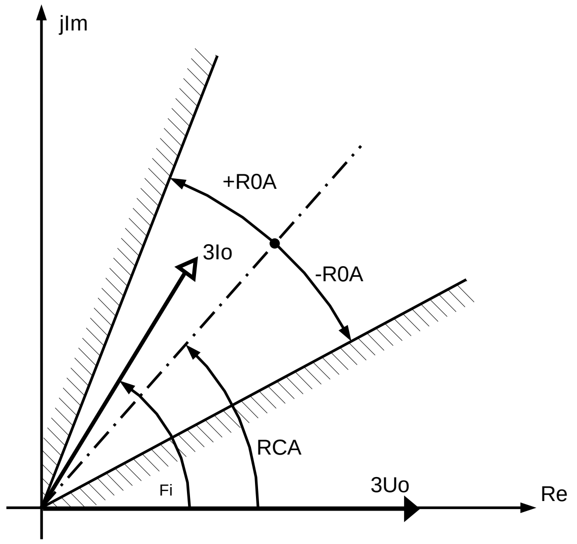
Table 19 The timer parameters of the residual overcurrent protection function

1.3.1.5 Residual directional overcurrent protection function (TOC67N)

The main application area of the directional residual delayed overcurrent protection function is an earth-fault protection.

The inputs of the function are the RMS value of the Fourier basic harmonic components of the zero sequence current (IN=3Io) and those of the zero sequence voltage (UN=3Uo).

The block of the directional decision generates a signal of TRUE value if the UN=3Uo zero sequence voltage and the IN=3Io zero sequence current are above the limits needed for correct directional decision, and the angle difference between the vectors is within the preset range. The decision enables the output start and trip signal of an overcurrent protection function block (TOC51N). This non-directional residual overcurrent protection function block is described in a separate document.



The directional decision module calculates the phase angle between the residual voltage and the residual current. The reference signal is the residual voltage according to the *Figure.*

The output of the directional decision module is OK, namely it is TRUE if the phase angle between the residual voltage and the residual current is within the limit range defined by the preset parameter OR if non-directional operation is selected by the preset parameter (Direction=NonDir).

Technical data

Function	**Value**	**Accuracy**
Operating accuracy		< ±2 %
Operate time accuracy		±5% or ±15 ms, whichever is greater
Accuracy in minimum time range		±35 ms
Reset ratio	0,95	
Reset time	Approx 50 ms	±35 ms
Transient overreach	<2 %	
Pickup time	25 – 30 ms	
Angular accuracy Io ≤ 0.1 In 0.1 In < Io ≤ 0.4 In 0.4 In < Io		 < ±10° < ±5° < ±2°
Angular reset ratio Forward and backward All other selection	 10° 5°	

Table 20 The technical data of the residual directional overcurrent protection function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Directionality of the function			
TOC67N_Dir_EPar_	Direction	NonDir,Forward-Angle,Backward-Angle,Forward-I*cos(fi),Backward-I*cos(fi),Forward-I*sin(fi),Backward-I*sin(fi),Forward-I*sin(fi+45),Backward-I*sin(fi+45)	Forward-Angle
Operating characteristic selection of the TOC51N module			
TOC67N_Oper_EPar_	Operation	Off,DefiniteTime,IEC Inv,IEC VeryInv,IEC ExtInv,IEC LongInv,ANSI Inv,ANSI ModInv,ANSI VeryInv,ANSI ExtInv,ANSI LongInv,ANSI LongVeryInv,ANSI LongExtInv	DefiniteTime

Table 21 The enumerated parameters of the residual directional overcurrent protection function

Short explanation of the enumerated parameter "Direction"

Selected value	Explanation
NonDir,	Operation according to non-directional TOC51N
Forward-Angle	See *Figure*, set RCA (Characteristic Angle) and ROA (Operating Angle) as required
Backward-Angle	RCAactual=RCAset+180°, set RCA (Characteristic Angle) and ROA (Operating Angle) as required
Forward-I*cos(fi)	RCA=0°fix, ROA=85°fix, the setting values RCA and ROA are not applied
Backward-I*cos(fi)	RCA=180°fix, ROA=85°fix, the setting values RCA and ROA are not applied
Forward-I*sin(fi)	RCA=90°fix, ROA=85°fix, the setting values RCA and ROA are not applied
Backward-I*sin(fi)	RCA=–90°fix, ROA=85°fix, the setting values RCA and ROA are not applied
Forward-I*sin(fi+45)	RCA=45°fix, ROA=85°fix, the setting values RCA and ROA are not applied
Backward-I*sin(fi+45)	RCA=–135°fix, ROA=85°fix, the setting values RCA and ROA are not applied

Table 22 The short explanation of the enumerated parameters of the residual directional overcurrent protection function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
The threshold value for the 3Uo zero sequence voltage, below which no directionality is possible. % of the rated voltage of the voltage transformer input						
TOC67N_UoMin_IPar_	URes Min	%	1	10	1	2
The threshold value for the 3Io zero sequence current, below which no operation is possible. % of the rated current of the current transformer input						
TOC67N_IoMin_IPar_	IRes Min	%	1	50	1	5
Operating angle (See *Figure*)						
TOC67N_ROA_IPar_	Operating Angle	deg	30	80	1	60
Characteristic angle (See *Figure*)						
TOC67N_RCA_IPar_	Characteristic Angle	deg	-180	180	1	60
Start current (TOC51N module)						
TOC67N_StCurr_IPar_	Start Current	%	5	200	1	50

Table 23 The integer parameters of the residual directional overcurrent protection function

Float point parameter

Parameter name	**Title**	**Unit**	**Min**	**Step**	**Step**	**Default**
Time multiplier of the inverse characteristics (TOC51N module)						
TOC67N_Multip_FPar_	Time Multiplier	sec	0.05	999	0.01	1.0

Table 24 *The float point parameter of the residual directional overcurrent protection function*

Timer parameters

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Minimal time delay for the inverse characteristics (TOC 51N module):						
TOC67N_MinDel_TPar_	Min Time Delay	msec	50	60000	1	100
Definite time delay (TOC 51N module):						
TOC67N_DefDel_TPar_	Definite Time Delay	msec	0	60000	1	100
Reset time delay for the inverse characteristics (TOC 51N module):						
TOC67N_Reset_TPar_	Reset Time	msec	0	60000	1	100

Table 25 *The timer parameters of the residual directional overcurrent protection function*

1.3.1.6 Negative sequence overcurrent protection function (TOC46)

The negative sequence overcurrent protection function (TOC46) block operates if the negative sequence current is higher than the preset starting value.

In the negative sequence overcurrent protection function, definite-time or inverse-time characteristics are implemented, according to IEC or IEEE standards. The function evaluates a single measured current, which is the RMS value of the fundamental Fourier component of the negative sequence current. The characteristics are harmonized with IEC 60255-151, Edition 1.0, 2009-08.

The definite (independent) time characteristic has a fixed delaying time when the current is above the starting current G_S previously set as a parameter.

The standard dependent time characteristics of the negative sequence overcurrent protection function are as follows.

$$t(G) = TMS\left[\frac{k}{\left(\frac{G}{G_S}\right)^{\alpha} - 1} + c\right] \quad \text{when } G > G_S$$

where

t(G)(seconds)	theoretical operate time with constant value of G,
k, c	constants characterizing the selected curve (in seconds),
α	constant characterizing the selected curve (no dimension),
G	measured value of the characteristic quantity, Fourier base harmonic of the negative sequence current (INFour),
G_S	preset starting value of the characteristic quantity,
TMS	preset time multiplier (no dimension).

	IEC ref		**k_r**	**c**	**α**
1	A	IEC Inv	0,14	0	0,02
2	B	IEC VeryInv	13,5	0	1
3	C	IEC ExtInv	80	0	2
4		IEC LongInv	120	0	1
5		ANSI Inv	0,0086	0,0185	0,02
6	D	ANSI ModInv	0,0515	0,1140	0,02
7	E	ANSI VeryInv	19,61	0,491	2
8	F	ANSI ExtInv	28,2	0,1217	2
9		ANSI LongInv	0,086	0,185	0,02
10		ANSI LongVeryInv	28,55	0,712	2
11		ANSI LongExtInv	64,07	0,250	2

Table 26 The constants of the standard dependent time characteristics

A parameter (Operation) serves for choosing overcurrent function of independent time delay or dependent one with type selection above.

Time multiplier of the inverse characteristics (TMS) is also a parameter to be preset.

The end of the effective range of the dependent time characteristics (G_D) is:

$$G_D = 20 * G_S$$

Above this value the theoretical operating time is definite. The inverse type characteristics are also combined with a minimum time delay, the value of which is set by user parameter TOC46_MinDel_TPar_ (Min. Time Delay).

The negative phase sequence components calculation is based on the Fourier components of the phase currents.

The binary output status signals of the negative sequence overcurrent protection function are the general starting and the general trip command of the function.

The negative sequence overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	Value	Accuracy
Operating accuracy	$10 \le G_S$ [%] ≤ 200	< 2 %
Operate time accuracy		±5% or ±15 ms, whichever is greater
Reset ratio	0,95	
Reset time * Dependent time charact. Definite time charact.	 approx. 60 ms	<2 % or ±35 ms, whichever is greater
Transient overreach		< 2 %
Pickup time at 2* G_S	<40 ms	
Overshot time Dependent time charact. Definite time charact.	 25 ms 45 ms	
Influence of time varying value of the input current (IEC 60255-151)		< 4 %

* *Measured with signal contacts*

Table 27 Technical data of the negative sequence overcurrent protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for type selection			
TOC46_Oper_EPar_	Operation	Off, DefinitTime, IEC Inv, IEC VeryInv, IEC ExtInv, IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv	Definit Time

Table 28 The enumerated parameter of the negative sequence overcurrent protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Starting current parameter:						
TOC46_StCurr_IPar_	Start Current	%	5	200	1	50

Table 29 The integer parameter of the negative sequence overcurrent protection function

Timer parameters

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Minimal time delay for the inverse characteristics:						
TOC46_MinDel_TPar_	Min Time Delay*	msec	0	60000	1	100
Definite time delay:						
TOC46_DefDel_TPar_	Definite Time Delay**	msec	0	60000	1	100
Reset time delay for the inverse characteristics:						
TOC46_Reset_TPar_	Reset Time*	msec	0	60000	1	100
Time multiplier for the inverse characteristics:						
TOC46_Multip_TPar_	Time Multiplier*	msec	100	60000	1	100

**Valid for inverse type characteristics*

***Valid for definite type characteristics only*

Table 30 *The timer parameter of the negative sequence overcurrent protection function*

1.3.1.7 Line thermal protection function (TTR49L)

Basically, line thermal protection measures the three sampled phase currents. RMS values are calculated and the temperature calculation is based on the highest RMS value of the phase currents.

The temperature calculation is based on the step-by-step solution of the thermal differential equation. This method yields “overtemperature”, meaning the temperature above the ambient temperature. Accordingly, the temperature of the protected object is the sum of the calculated “overtemperature” and the ambient temperature.

If the calculated temperature (calculated “overtemperature”+ambient temperature) is above the threshold values, alarm, trip and restart blocking status signals are generated.

For correct setting, the following values must be measured and set as parameters: rated load current is the continuous current applied for the measurement, rated temperature is the steady state temperature at rated load current, base temperature is the temperature of the environment during the measurement and the time constant is the measured heating/cooling time constant of the exponential temperature function.

When energizing the protection device, the algorithm permits the definition of the starting temperature as the initial value of the calculated temperature. The parameter Startup Term. is the initial temperature above the temperature of the environment as compared to the rated temperature above the temperature of the environment

The ambient temperature can be measured using e.g. a temperature probe generating electric analog signals proportional to the temperature. In the absence of such measurement, the temperature of the environment can be set using the dedicated parameter TTR49L_Amb_IPar_ (Ambient Temperature). The selection between parameter value and direct measurement is made by setting the binary Boolean parameter.

The problem of metal elements (the protected line) exposed to the sun is that they are overheated as compared to the „ambient” temperature even without a heating current; furthermore, they are cooled mostly by the wind and the heat transfer coefficient is highly dependent on the effects of the wind. As the overhead lines are located in different geographical environments along the tens of kilometers of the route, the effects of the sun and the wind cannot be considered in detail. The best approximation is to measure the temperature of a piece of overhead line without current but exposed to the same environmental conditions as the protected line itself.

The application of thermal protection of the overhead line is a better solution than a simple overcurrent-based overload protection because thermal protection “remembers” the preceding load states of the line and the setting of the thermal protection does not need so a high security margin between the permitted current and the permitted continuous thermal current of the line. In a broad range of load states and in a broad range of ambient temperatures this permits the better exploitation of the thermal and consequently current carrying capacity of the line.

The thermal differential equation to be solved is:

$$\frac{d\Theta}{dt}=\frac{1}{T}\left(\frac{I^2(t)R}{hA}-\Theta\right)$$, and the definition of the heat time constant is: $$T=\frac{cm}{hA}$$

In this differential equation:

I(t) (RMS)	heating current, the RMS value usually changes over time;
R	resistance of the line;
c	specific heat capacity of the conductor;
m	mass of the conductor;
θ	rise of the temperature above the temperature of the environment;
h	heat transfer coefficient of the surface of the conductor;
A	area of the surface of the conductor;
t	time.

The solution of the thermal differential equation for constant current is the temperature as the function of time (the mathematical derivation of this equation is described in a separate document):

$$\Theta(t) = \frac{I^2 R}{hA}\left(1 - e^{-\frac{t}{T}}\right) + \Theta_o e^{-\frac{t}{T}}$$

where

Θ_o is the starting temperature.

Remember that the calculation of the measurable temperature is as follows:

Temperature(t) = Θ(t)+Temp_ambient

where

Temp_ambient is the ambient temperature.

In a separate document it is proven that some more easily measurable parameters can be introduced instead of the aforementioned ones. Thus, the general form of equation above is:

$$H(t) = \frac{\Theta(t)}{\Theta_n} = \frac{I^2}{I_n^2}\left(1 - e^{-\frac{t}{T}}\right) + \frac{\Theta_o}{\Theta_n} e^{-\frac{t}{T}}$$

where:

H(t)	is the „thermal level” of the heated object, this is the temperature as a percentage of the Θ_n reference temperature**.** (This is a dimensionless quantity but it can also be expressed in a percentage form.)
Θ_n	is the reference temperature above the temperature of the environment, which can be measured in steady state, in case of a continuous I_n reference current.
I_n	is the reference current (can be considered as the nominal current of the heated object). If it flows continuously, then the reference temperature can be measured in steady state.
$\frac{\Theta_o}{\Theta_n}$	is a parameter of the starting temperature related to the reference temperature

The *RMS calculations modul* calculate the RMS values of the phase currents individually. The sampling frequency of the calculations is 1 kHz; therefore, theoretically, the frequency components below 500Hz are considered correctly in the RMS values. This module is not part of the thermal overload function; it belongs to the preparatory phase.

The *Max selection module* selects the maximal value of the three RMS phase currents.

The *Thermal replica module* solves the first order thermal differential equation using a simple step-by-step method and compares the calculated temperature to the values set by parameters. The temperature sensor value proportional to the ambient temperature can be an input (this signal is optional, defined at parameter setting).

The function can be disblaed by parameter, or generates a trip pulse if the calculated temperature exceeds the trip value, or generates a trip signal if the calculated temperature exceeds the trip value given by a parameter but it resets only if the temperature cools below the “Unlock temperature”.

The line thermal protection function has two binary input signals. The conditions of the input signal are defined by the user, applying the graphic equation editor. One of the signals can block the line thermal protection function, the other one can reset the accumulated heat and set the temperature to the defined value for the subsequent heating test procedure.

Technical data

Function	Accuracy
Operate time at I>1.2*Itrip	<3 % or <+ 20 ms

Table 31 Technical data of the line thermal protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for mode of operation			
TTR49L_Oper_EPar_	Operation	Off, Pulsed, Locked	Pulsed

Table 32 The enumerated parameter of the line thermal protection function

The meaning of the enumerated values is as follows:

Off	the function is switched off; no output status signals are generated;
Pulsed	the function generates a trip pulse if the calculated temperature exceeds the trip value
Locked	the function generates a trip signal if the calculated temperature exceeds the trip value. It resets only if the temperature cools below the “Unlock temperature”.

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Alarm Temperature						
TTR49L_Alm_IPar_	Alarm Temperature	deg	60	200	1	80
Trip Temperature						
TTR49L_Trip_IPar_	Trip Temperature	deg	60	200	1	100
Rated Temperature						
TTR49L_Max_IPar_	Rated Temperature	deg	60	200	1	100
Base Temperature						
TTR49L_Ref_IPar_	Base Temperature	deg	0	40	1	25
Unlock Temperature						
TTR49L_Unl_IPar_	Unlock Temperature	deg	20	200	1	60
Ambient Temperature						
TTR49L_Amb_IPar_	Ambient Temperature	deg	0	40	1	25
Startup Term.						
TTR49L_Str_IPar	Startup Term	%	0	60	1	0
Rated Load Current						
TTR49L_Inom_IPar_	Rated Load Current	%	20	150	1	100
Time constant						
TTR49L_pT_IPar_	Time Constant	min	1	999	1	10

Table 33 The integer parameters of the line thermal protection function

Boolean parameter

Boolean parameter	Signal title	Selection range	Default
Parameter for ambient temperature sensor application			
TTR49L_Sens_BPar_	Temperature Sensor	No, Yes	No

Table 34 The boolean parameter of the line thermal protection function

1.3.1.8 Transformer differential protection function (DIF87_2w)

The differential protection function provides main protection for transformers, generators or large motors, but it can also be applied for overhead lines and cables of solidly grounded networks or for the protection of any combination of the aforementioned objects.

Version DIF87_3w can be applied to protect three-winding transformers. The simpler version DIF87_2w does not process analogue inputs from the tertiary side.

The three-phase power transformers transform the primary current to the secondary side according to the turns ratio and the vector group of the transformers. The Y (star), D (delta) or Z (zig-zag) connection of the three phase coils on the primary and secondary sides causes the vector shift of the currents. The numerical differential protection function applies matrix transformation of the directly measured currents of one side of the transformer to match them with the currents of the other side.

In Protecta’s transformer differential protection the target of the matrix transformation is the delta (D) side. Thus the problem of zero sequence current elimination in case of an external ground fault is also solved.

The method of the matrix transformation is defined by the „Code” parameter identifying the transformer vector group connection.

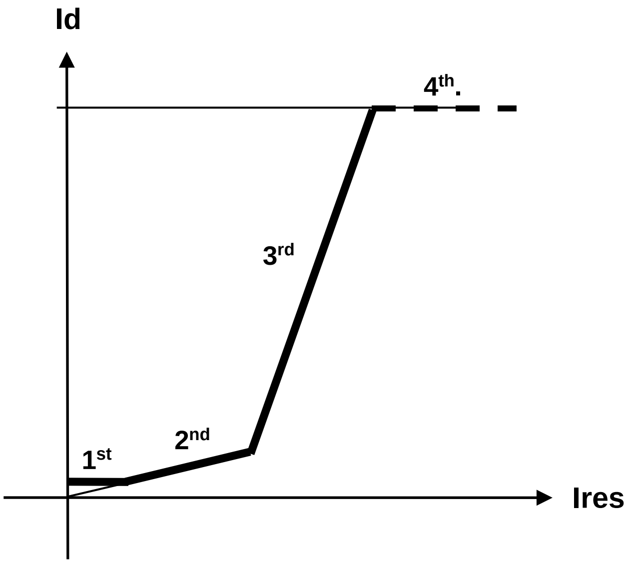
The differential current can be high during the transients of transformer energizing (inrush current) due to the current distortion caused by the transformer iron core asymmetrical saturation. In this case, the second harmonic content of the differential current is applied to disable the false operation of the differential protection function.

The differential current can be high in case of the over-excitation of the transformer due to the current distortion caused by the transformer iron core symmetrical saturation. In this case, the fifth harmonic content of the differential current is applied to disable the false operation of the differential protection function.

The harmonic analysis calculates the basic Fourier components of the three differential currents. These results are needed for the high-speed differential current decision and for the second and fifth harmonic restraint calculation.

The software modules evaluate and compare the result with the parameter values set for the second and fifth harmonic. If the harmonic content relative to the basic harmonic component of the differential currents is high, a restraint signal is generated immediately and a timer is started at the same time. If the duration of the active status is at least 25 ms, then the resetting of the restraint signal is delayed by an additional 15 ms.

The decision logic module decides if the differential current of the individual phases is above the characteristic curve of the differential protection function. It compares the magnitudes of the differential currents and those of the restraint currents for evaluation of the “percentage differential characteristics”. This curve is the function of the restraint current, which is calculated based on the sum of the magnitude of the phase-shifted phase currents (see Figure below).



The characteristic curve has four sections. The first section is the base sensitivity, the second one serves to compensate the turns ratio deviation e.g. due to the operation of the on-load tap changer, the third is to eliminate false operation caused by the CT saturation and the fourth one is the unrestricted differential function. The slope of the third section is constant, it is 2.

The differential protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user applying the graphic equation editor.

Measured values

Measured value	**Dim.**	**Explanation**
Idiff. L1	In %	The calculated differential current in phase L1 (after vector group compensation)
Idiff. L2	In %	The calculated differential current in phase L2 (after vector group compensation)
Idiff. L3	In %	The calculated differential current in phase L3 (after vector group compensation)
Ibias L1	In %	The calculated restraint current in phase L1 (after vector group compensation)
Ibias L2	In %	The calculated restraint current in phase L2 (after vector group compensation)
Ibias L3	In %	The calculated restraint current in phase L3 (after vector group compensation)

Remark: The evaluated basic harmonic values of the measured input phase currents (without vector group compensation) help the commissioning of the differential protection function. These evaluations however are performed by an independent software measuring module, so this chapter excludes the description of these measurements.

Table 35 *The measure values of the transformer differential protection function*

Enumerated parameters

Parameter name	**Title**	**Selection range**	**Default**
Parameter to enable the differential protection function:			
DIF87_Op_EPar_	Operation	Off, On	On
Parameter to select connection group of the transformer coils in primary-secondary relation:			
DIF87_VGrSec_EPar_	Pri-Sec VGroup*	Dy1,Dy5,Dy7,Dy11,Dd0,Dd6,Dz0,Dz2,Dz4, Dz6,Dz8,Dz10,Yy0,Yy6,Yd1,Yd5,Yd7,Yd11, Yz1,Yz5,Yz7,Yz11	Dd0
Parameter to select connection group of the transformer coils in primary-tertiary relation:			
DIF87_VGrTer_EPar_	Pri-Ter VGroup*	Dy1,Dy5,Dy7,Dy11,Dd0,Dd6,Dz0,Dz2,Dz4, Dz6,Dz8,Dz10,Yy0,Yy6,Yd1,Yd5,Yd7,Yd11, Yz1,Yz5,Yz7,Yz11	Dd0

* If the connection of the primary winding in primary-secondary and primary tertiary relation is selected in contradiction then the protection function is automatically disabled, and the function generates a warning signal.

Table 36 *The enumerated parameters of the transformer differential protection function*

Boolean parameter

Parameter name	**Title**	**Default**	**Explanation**
DIF87_0Seq_BPar_	Zero Seq Elimination	True	See Chapter **Error! Reference source not found.**

Table 37 *The boolean parameter of the transformer differential protection function*

Integer parameters

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Parameters for the current magnitude compensation:						
DIF87_TRPr_IPar_	TR Primary Comp	%	20	500	1	100
DIF87_TRSec_IPar_	TR Secondary Comp	%	20	500	1	100
DIF87_TRTer_IPar_	TR Tertiary Comp	%	20	200	1	100
Parameter of the second harmonic restraint:						
DIF87_2HRat_IPar_	2nd Harm Ratio	%	5	50	1	15
Parameter of the fifth harmonic restraint:						
DIF87_5HRat_IPar_	5th Harm Ratio	%	5	50	1	25
Parameters of the percentage characteristic curve:						
Base sensitivity:						
DIF87_f1_IPar_	Base Sensitivity	%	10	50	1	20
Slope of the second section of the characteristics:						
DIF87_f2_IPar_	1st Slope	%	10	50	1	20
Bias limit of the first slope:						
DIF87_f3_IPar_	1st Slope Bias Limit	%	200	2000	1	200
Unrestrained differential protection current level:						
DIF87_HCurr_IPar_	UnRst Diff Current	%	800	2500	1	800

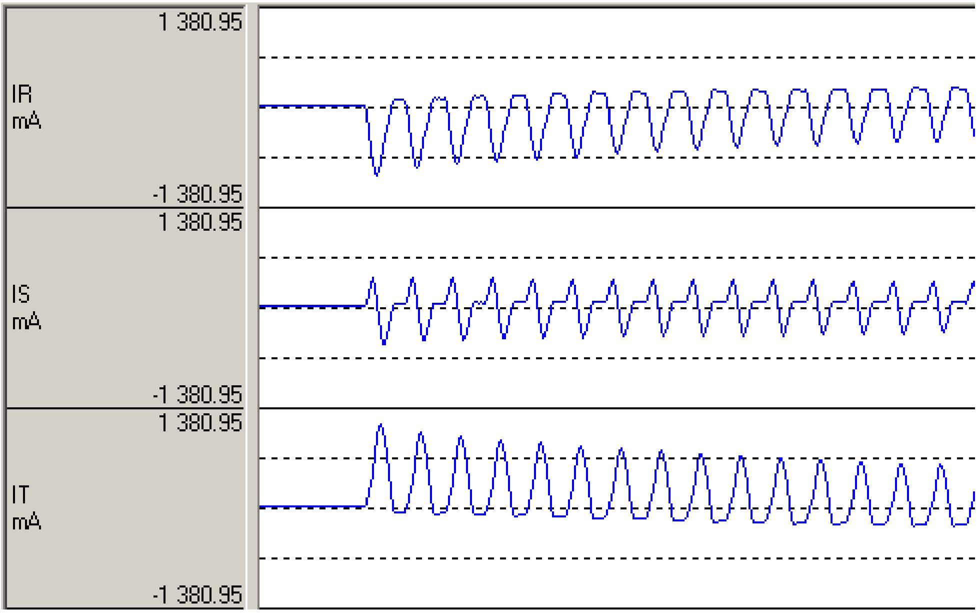
Table 38 *The integer parameters of the transformer differential protection function*

Function	**Value**	**Accuracy**
Operating characteristic	2 breakpoints	
Reset ratio	0,95	
Characteristic accuracy		<2%
Operate time, unrestrained	Typically 20 ms	
Reset time, unrestrained	Typically 25 ms	
Operate time, restrained	Typically 30 ms	
Reset time, restrained	Typically 25 ms	

Table 39 *The functions of the transformer differential protection function*

1.3.1.9 Inrush detection function (INR2)

When an inductive element with an iron core (transformer, reactor, etc.) is energized, high current peak values can be detected. This is caused by the transient asymmetric saturation of the iron core as a nonlinear element in the power network. The sizing of the iron core is usually sufficient to keep the steady state magnetic flux values below the saturation point of the iron core, so the inrush transient slowly dies out. These current peaks depend also on random factors such as the phase angle at energizing. Depending on the shape of the magnetization curve of the iron core, the detected peaks can be several times above the rated current peaks. Additionally, in medium or high voltage networks, where losses and damping are low, the indicated high current values may be sustained at length. Figure below shows a typical example for the inrush current shapes of a three-phase transformer.



A typical inrush current

As a consequence, overcurrent relays, differential relays or distance relays may start, and because of the long duration of the high current peaks, they may generate an unwanted trip command.

The inrush current detection function can distinguish between high currents caused by overload or faults and the high currents during the inrush time.

The operating principle of the inrush current detection function is based on the special shape of the inrush current.

The typical inrush current in one or two phases is asymmetrical to the time axis. For example, in IT of the Figure above the positive peaks are high while no peaks can be detected in the negative domain.

The theory of the Fourier analysis states that even harmonic components (2^{nd}, 4^{th} etc.) are dominant in waves asymmetrical to the time axis. The component with the highest value is the second one.

Typical overload and fault currents do not contain high even harmonic components.

The inrush current detection function processes the Fourier basic harmonic component and the second harmonic component of the three phase currents. If the ratio of the second harmonic and the base Fourier harmonic is above the setting value of the parameter *2nd Harm Ratio*, an inrush detection signal is generated.

The signal is output only if the base harmonic component is above the level defined by the setting of the parameter *IPh Base Sens.* This prevents unwanted operation in the event that low currents contain relatively high error signals.

The function operates independently using all three phase currents individually, and additionally, a general inrush detection signal is generated if any of the phases detects inrush current.

The function can be disabled by the binary input *Disable*. This signal is the result of logic equations graphically edited by the user.

Using the inrush detection binary signals, other protection functions can be blocked during the transient period so as to avoid the unwanted trip.

Some protection functions use these signals automatically, but a stand-alone inrush detection function block is also available for application at the user's discretion.

Technical data

Function	Range	Accuracy
Current accuracy	20 … 2000% of In	±1% of In

Table 40 Technical data of the inrush detection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Disabling or enabling the operation of the function			
INR2_Op_EPar_	Operation	Off,On	On

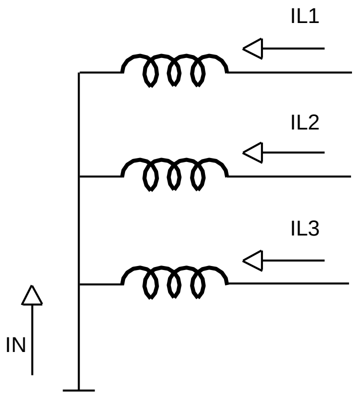
Table 41 The enumerated parameter of the inrush detection function

Integer parameters

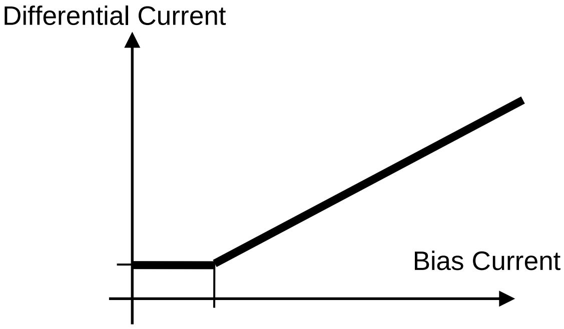
Parameter name	Title	Unit	Min	Max	Step	Default
Ratio of the second and basic harmonic Fourier components						
INR2_2HRat_IPar_,	2nd Harm Ratio	%	5	50	1	15
Basic sensitivity of the function						
INR2_MinCurr_IPar_	IPh Base Sens	%	20	100	1	30

Table 42 The integer parameter of the inrush detection function

1.3.1.10 Rectricted earth fault protection function (DIF87N)



The restricted earth-fault protection function is basically a low-impedance differential protection function based on zero sequence current components. It can be applied to protect one side winding of transformers with grounded neutral against single-phase-to-earth fault (see Figure). The function compares the measured neutral current at the star point (IN) and the calculated zero sequence current component of the phase currents (IL1, IL2, IL3) and generates a trip command if the difference of these currents is above the characteristics.

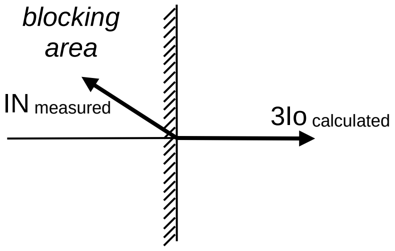


The function performs the necessary calculations for the evaluation of the “percentage differential characteristics”, and decides to trip if the differential current is above the characteristic curve of the zero sequence differential protection function. This curve is the function of the restraint (Bias) current, which is the maximum of the phase currents and the current of the neutral point.

$$Differential\ Current = IL1Four + IL2Four + IL3Four + INFour$$
$$Bias\ Current = MAX(IL1Four, IL2Four, IL3Four, INFour)$$

Note: Four = Fourier

Additionally the function compares the direction of the neutral current and that of the calculated zero sequence current. In case of small zero sequence component of the high fault currents in the phases, this decision improves the stability of the function.



In this system, if the angle between the calculated zero sequence current 3Io and the measured neutral current IN is out of the range of ±90 degrees, then the restricted earth fault protection can be blocked (see the Figure). For the directional decision, the positive directions are drawn in Figure above. The output signal of the directional decision module can block the restricted earth-fault protection function.

A Boolean parameter of the restricted earth-fault protection function serves to enable the directional checking of the measured and calculated zero sequence currents.

The restricted earth-fault protection function generates a trip signal if the differential current as the function of the bias current is above the differential characteristic lines and the function is not blocked by the directional decision. Additionally the operation of the function is enabled by parameter setting. The conditions of enabling are defined by the user applying the graphic equation editor.

Technical data

Function	Value	Accuracy
Operating characteristic	1 breakpoint	
Reset ratio	0,95	
Characteristic accuracy		<2%
Operate time, restrained	typically 20 ms	
Reset time, restrained	typically 25 ms	

Table 43 The technical data of the restricted earth fault protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter to enable the zero sequence differential protection function:			
DIF87N_Oper_EPar_	Operation	Off, On	On

Table 44 The enumerated parameter of the restricted earth fault protection function

Boolean parameter

Parameter name	Title	Default	Explanation
DIF87N_DirCheck_BPar_	Directional check	True	Enabling the directional checking of the measured and calculated zero sequence currents

Table 45 The boolean parameter of the restricted earth fault protection function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Parameters for the current magnitude compensation:						
DIF87N_TRPri_IPar_	Io Primary Match	%	20	500	1	100
DIF87N_TRNeut_IPar_	Neutral Match	%	100	1000	1	500
Base sensitivity:						
DIF87N_f1_IPar_	Base Sensitivity	%	10	50	1	30
Slope of the second section of the characteristics:						
DIF87N_f2_IPar_	Slope	%	50	100	1	70
Break point of the characteristic line:						
DIF87N_f2Brk_IPar_	Base Sens Bias Limit	%	100	200	1	125

Table 46 The integer parameters of the restricted earth fault protection function

1.3.1.11 Definite time overvoltage protection function (TOV59)

The definite time overvoltage protection function measures three voltages. The measured values of the characteristic quantity are the RMS values of the basic Fourier components of the phase voltages.

The Fourier calculation inputs are the sampled values of the three phase voltages (UL1, UL2, UL3), and the outputs are the basic Fourier components of the analyzed voltages (UL1Four, UL2Four, UL3Four). They are not part of the TOV59 function; they belong to the preparatory phase.

The function generates start signals for the phases individually. The general start signal is generated if the voltage in any of the three measured voltages is above the level defined by parameter setting value.

The function generates a trip command only if the definite time delay has expired and the parameter selection requires a trip command as well.

The overvoltaget protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	Value	Accuracy
Pick-up starting accuracy		< ± 0,5 %
Blocking voltage		< ± 1,5 %
Reset time U< → Un U< → 0	 60 ms 50 ms	
Operate time accuracy		< ± 20 ms
Minimum operate time	50 ms	

Table 47 Technical data of the definite time overvoltage protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Enabling or disabling the overvoltage protection function			
TOV59_Oper_EPar_	Operation	Off, On	On

Table 48 The enumerated parameter of the definite time overvoltage protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Voltage level setting. If the measured voltage is above the setting value, the function generates a start signal.						
TOV59_StVol_IPar_	Start Voltage	%	30	130	1	63

Table 49 The integer parameter of the definite time overvoltage protection function

Boolean parameter

Parameter name	Title	Default
Enabling start signal only:		
TOV59_StOnly_BPar_	Start Signal Only	FALSE

Table 50 The boolean parameter of the definite time overvoltage protection function

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay of the overvoltage protection function.						
TOV59_Delay_TPar_	Time Delay	ms	0	60000	1	100

Table 51 The timer parameter of the definite time overvoltage protection function

1.3.1.12 Definite time undervoltage protection function (TUV27)

The definite time undervoltage protection function measures the RMS values of the fundamental Fourier component of three phase voltages.

The Fourier calculation inputs are the sampled values of the three phase voltages (UL1, UL2, UL3), and the outputs are the basic Fourier components of the analyzed voltages (UL1Four, UL2Four, UL3Four). They are not part of the TUV27 function; they belong to the preparatory phase.

The function generates start signals for the phases individually. The general start signal is generated if the voltage is below the preset starting level parameter setting value and above the defined blocking level.

The function generates a trip command only if the definite time delay has expired and the parameter selection requires a trip command as well.

The operation mode can be chosen by the type selection parameter. The function can be disabled, and can be set to “1 out of 3”, “2 out of 3”, and “All”.

The overvoltage protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	Value	Accuracy
Pick-up starting accuracy		< ± 0,5 %
Blocking voltage		< ± 1,5 %
Reset time U> → Un U> → 0	 50 ms 40 ms	
Operate time accuracy		< ± 20 ms
Minimum operate time	50 ms	

Table 52 Technical data of the definite time undervoltage protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for type selection			
TUV27_Oper_EPar_	Operation	Off, 1 out of 3, 2 out of 3, All	1 out of 3

Table 53 The enumerated parameter of the definite time undervoltage protection function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Starting voltage level setting						
TUV27_StVol_IPar_	Start Voltage	%	30	130	1	52
Blocking voltage level setting						
TUV27_BlkVol_IPar_	Block Voltage	%	0	20	1	10

Table 54 The integer parameters of the definite time undervoltage protection function

Boolean parameter

Parameter name	Title	Default
Enabling start signal only:		
TUV27_StOnly_BPar_	Start Signal Only	FALSE

Table 55 The boolean parameter of the definite time undervoltage protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay of the undervoltage protection function.						
TUV27_Delay_TPar_	Time Delay	ms	0	60000	1	100

Table 56 The timer parameter of the definite time undervoltage protection function

1.3.1.13 Residual definite time overvoltage protection function (TOV59N)

The residual definite time overvoltage protection function operates according to definite time characteristics, using the RMS values of the fundamental Fourier component of the zero sequence voltage (UN=3Uo).

The Fourier calculation inputs are the sampled values of the residual or neutral voltage (UN=3Uo) and the outputs are the RMS value of the basic Fourier components of those.

The function generates start signal if the residual voltage is above the level defined by parameter setting value.

The function generates a trip command only if the definite time delay has expired and the parameter selection requires a trip command as well.

The residual overvoltage protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	Value	Accuracy
Pick-up starting accuracy	2 – 8 % 8 – 60 %	< ± 2 % < ± 1.5 %
Reset time U> → Un U> → 0	 60 ms 50 ms	
Operate time	50 ms	< ± 20 ms

Table 57 Technical data of the residual definite time overvoltage protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for enabling/disabling:			
TOV59N_Oper_EPar_	Operation	Off, On	On

Table 58 The enumerated parameter of the residual definite time overvoltage protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Starting voltage parameter:						
TOV59N_StVol_IPar_	Start Voltage	%	2	60	1	30

Table 59 The integer parameter of the residual definite time overvoltage protection function

Boolean parameter

Parameter name	Title	Default
Enabling start signal only:		
TOV59N_StOnly_BPar_	Start Signal Only	FALSE

Table 60 The boolean parameter of the residual definite time overvoltage protection function

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Definite time delay:						
TOV59N_Delay_TPar_	Time Delay	ms	0	60000	1	100

Table 61 The time parameter of the residual definite time overvoltage protection function

1.3.1.14 Current unbalance function (VCB60)

The current unbalance protection function (VCB60) can be applied to detect unexpected asymmetry in current measurement.

The applied method selects maximum and minimum phase currents (RMS value of the fundamental Fourier components). If the difference between them is above the setting limit, the function generates a start signal. It is a necessary precondition of start signal generation that the maximum of the currents be above 10 % of the rated current and below 150% of the rated current.

The Fourier calculation modules calculate the RMS value of the basic Fourier current components of the phase currents individually. They are not part of the VCB60 function; they belong to the preparatory phase.

The analog signal processing module processes the RMS value of the basic Fourier current components of the phase currents to prepare the signals for the decision. It calculates the maximum and the minimum value of the RMS values and the difference between the maximum and minimum of the RMS values of the fundamental Fourier components of the phase currents as a percentage of the maximum of these values (ΔI>). If the maximum of the currents is above 10 % of the rated current and below 150% of the rated current and the ΔI> value is above the limit defined by the preset parameter (Start Current Diff) an output is generated to the decision module.

The decision logic module combines the status signals to generate the starting signal and the trip command of the function.

The trip command is generated after the defined time delay if trip command is enabled by the Boolean parameter setting.

The function can be disabled by parameter setting, and by an input signal programmed by the user with the graphic programming tool.

Technical data

Function	Value	Accuracy
Pick-up starting accuracy at In		< 2 %
Reset ratio	0.95	
Operate time	70 ms	

Table 62 Technical data of the current unbalance function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Selection of the operating mode			
VCB60_Oper_EPar_	Operation	Off, On	On

Table 63 The enumerated parameter of the current unbalance function

Boolean parameter

Parameter name	Title	Explanation	Default
Selection for trip command			
VCB60_StOnly_BPar_	Start Signal Only	0 to generate trip command	0

Table 64 The boolean parameter of the current unbalance function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Phase difference current setting						
VCB60_StCurr_IPar_	Start Current Diff	%	10	90	1	50

Table 65 The integer parameter of the current unbalance function

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay						
VCB60_Del_TPar_	Time Delay	msec	100	60000	100	1000

Table 66 The timer parameter of the current unbalance function

1.3.1.15 Breaker failure protection function (BRF50)

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

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

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

The starting signal of the breaker failure protection function is usually the trip command of any other protection function assigned to the protected object. The user has the task to define these starting signals using the graphic equation editor, or if the operation of the individual phases is needed, then the start signals for the phases individually.

Two dedicated timers start at the rising edge of the start signals at the same time, one for the backup trip command and one for the repeated trip command, separately for operation in the individual phases. During the running time of the timers the function optionally monitors the currents, the closed state of the circuit breakers or both, according to the user’s choice. The selection is made using an enumerated parameter.

If current supervision is selected by the user then the current limit values must be set correctly. The binary inputs indicating the status of the circuit breaker poles have no meaning.

If contact supervision is selected by the user then the current limit values have no meaning. The binary inputs indicating the status of the circuit breaker poles must be programmed correctly using the graphic equation editor.

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

If at the end of the running time of the backup timer the currents do not drop below the pre-defined level, and/or the monitored circuit breaker is still in closed position, then a backup trip command is generated.

If repeated trip command is to be generated for the circuit breakers that are expected to open, then the enumerated parameter Retrip must be set to “On”. In this case, at the end of the retrip timer(s) a repeated trip command is also generated in the phase(s) where the retrip timer(s) run off.

The pulse duration of the trip command is not shorter than the time defined by setting the parameter Pulse length.

The breaker failure protection function can be disabled by setting the enabling parameter to “Off”.

Dynamic blocking (inhibition) is possible using the binary input Block. The conditions are to be programmed by the user, using the graphic equation editor.

Technical data

Function	**Effective range**	**Accuracy**
Current accuracy		<2 %
Retrip time	approx. 15 ms	
BF time accuracy		± 5 ms
Current reset time	20 ms	

Table 67 Technical data of the breaker failure protection function

Parameters

Enumerated parameters

Parameter name	**Title**	**Selection range**	**Default**
Selection of the operating mode			
BRF50_Oper_EPar_	Operation	Off, Current, Contact, Current/Contact	Current
Switching on or off of the repeated trip command			
BRF50_ReTr_EPar_	Retrip	Off, On	On

Table 68 The enumerated parameters of the breaker failure protection function

Integer parameters

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Phase current setting						
BRF50_StCurrPh_IPar_	Start Ph Current	%	20	200	1	30
Neutral current setting						
BRF50_StCurrN_IPar_	Start Res Current	%	10	200	1	20

Table 69 The integer parameters of the breaker failure protection function

Timer parameters

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Time delay for repeated trip command generation						
BRF50_TrDel_TPar_	Retrip Time Delay	msec	0	10000	1	200
Time delay for trip command generation for the backup circuit breaker(s)						
BRF50_BUDel_TPar_	Backup Time Delay	msec	60	10000	1	300
Trip command impulse duration						
BRF50_Pulse_TPar_	Pulse Duration	msec	0	60000	1	100

Table 70 The timer parameters of the breaker failure protection function

1.3.1.16 Dead line detection function (DLD)

The “Dead Line Detection” (DLD) function generates a signal indicating the dead or live state of the line. Additional signals are generated to indicate if the phase voltages and phase currents are above the pre-defined limits.

The task of the “Dead Line Detection” (DLD) function is to decide the Dead line/Live line state.

> Criteria of “Dead line” state: all three phase voltages are below the voltage setting value AND all three currents are below the current setting value.
>
> Criteria of “Live line” state: all three phase voltages are above the voltage setting value.

The details are described in the document ***Dead line detection protection function block description.***

Technical data

Function	Value	Accuracy
Pick-up voltage		1%
Operation time	<20ms	
Reset ratio	0.95	

Table 71 Technical data of the dead line detection function

Parameters

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Integer parameters of the dead line detection function						
DLD_ULev_IPar_	Min. Operate Voltage	%	10	100	1	60
DLD_ILev_IPar_	Min. Operate Current	%	2	100	1	10

Table 72 The integer parameters of the dead line detection function

1.3.1.17 Pole discordance detection function

In high voltage networks pole discordance is usually not allowed as a continuous mode of operation. It means that a trip command for the circuit breaker is to be generated if the circuit breaker is closed only in one phase, or if the circuit breaker is open only in one phase.

The pole discordance protection function receives status signals from the poles of the circuit breaker. From each pole, the open and closed state is received. Pole discordance is detected based on these status signals. Pole discordance can be either single phase open or double phase open state. Separate time delays (Delay 1ph, Delay 2ph) can be set for the two states and the operation of the function for the two modes can be enabled or disabled separately. If the dedicated timer expires, the function generates a trip command

The single pole open state detection is enabled by parameter “Trip 1ph” and the single pole closed detection is by parameter “Trip 2ph”.

Additionally, in some applications an external device processes the status signals of the circuit breaker poles. In the event of pole discrepancy, the output signal of that external device (Common) is received by this function. If this external (common) mode of operation is enabled by Boolean parameter (Common Input) setting, a trip command of the specified duration is generated. If the dedicated timer (Delay Comm.) expires, the function generates a trip command.

For these three modes of operation, the duration of the trip command is defined by parameter setting, and the application of the common “Blk” input signal disables operation.

The output signals of the function are:

- single phase open state after a specified time delay,
- single phase closed state after a specified time delay,
- general trip command of a given duration after a specified time delay.

Technical data

Function	**Accuracy**
Timer accuracy	±5% or ±15 ms, whichever is greater

Parameters

Enumerated parameter

Parameter name	**Title**	**Selection range**	**Default**
Parameter for enabling/disabling			
PD_Op_EPar_	Operation	Off, On	On

Boolean parameters

Parameter name	**Title**	**Default**	**Explanation**
PD_**1ph**_BPar_	Trip 1ph	True	Enabling operation if single phase is open
PD_**2ph**_BPar_	Trip 2ph	True	Enabling operation if two phases are open
PD_**ComInp**_BPar_	Common Input	False	Enabling the application of the common input

Timer parameters

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Time delay if the common input is applied						
PD_DelCom_TPar_	Delay Comm.	msec	100	60000	1	500
Time delay for operation if single phase is open						
PD_Del1ph_TPar_	Delay 1ph	msec	100	60000	1	500
Time delay for operation if two phases are open						
PD_Del2ph_TPar_	Delay 2ph	msec	100	60000	1	1000

1.3.1.18 Trip logic (TRC94)

The simple trip logic function operates according to the functionality required by the IEC 61850 standard for the “Trip logic logical node”. This simplified software module can be applied if only three-phase trip commands are required, that is, phase selectivity is not applied.

The function receives the trip requirements of the protective functions implemented in the device and combines the binary signals and parameters to the outputs of the device.

The trip requirements are programmed by the user, using the graphic equation editor. The aim of the decision logic is

- to define a minimal impulse duration even if the protection functions detect a very short-time fault.

Technical data

Function		Accuracy
Impulse time duration	Setting value	<3 ms

Table 73 Technical data of the simple trip logic function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Selection of the operating mode			
TRC94_Oper_EPar_	Operation	Off, On	On

Tables 74 The enumerated parameter of the decision logic

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Minimum duration of the generated impulse						
TRC94_TrPu_TPar_	Min Pulse Duration	msec	50	60000	1	150

Table 75 Timer parameter of the decision logic

1.3.1.19 Auto-reclose protection (REC79MV)

The MV automatic reclosing function can realize up to four shots of reclosing for medium-voltage networks. The dead time can be set individually for each reclosing and separately for earth faults and for multi-phase faults. All shots are of three phase reclosing.

The starting signal of the cycles can be generated by any combination of the protection functions or external signals of the binary inputs.

The automatic reclosing function is triggered if as a consequence of a fault a protection function generates a trip command to the circuit breaker and the protection function resets because the fault current drops to zero or the circuit breaker's auxiliary contact signals open state. According to the preset parameter values, either of these two conditions starts counting the dead time, at the end of which the MV automatic reclosing function generates a close command automatically. If the fault still exits or reappears, then within the "Reclaim time" the protection functions picks up again and the subsequent cycle is started. If the fault still exists at the end of the last cycle, the MV automatic reclosing function trips and generates the signal for final trip. If no pickup is detected within this time, then the MV automatic reclosing cycle resets and a new fault will start the procedure with the first cycle again.

At the moment of generating the close command, the circuit breaker must be ready for operation, which is signaled via the binary input "CB Ready". The preset parameter value "CB Supervision time" decides how long the MV automatic reclosing function is allowed to wait at the end of the dead time for this signal. If the signal is not received during this dead time extension, then the MV automatic reclosing function terminates.

Depending on binary parameter settings, the automatic reclosing function block can accelerate trip commands of the individual reclosing cycles. This function needs user-programmed graphic equations to generate the accelerated trip command.

The duration of the close command depends on preset parameter value "Close command time", but the close command terminates if any of the protection functions issues a trip command.

The MV automatic reclosing function can control up to four reclosing cycles. Depending on the preset parameter values "EarthFaults Rec,Cycle" and "PhaseFaults Rec,Cycle", there are different modes of operation, both for earth faults and for multi-phase faults:

Disabled	No automatic reclosing is selected,
1. Enabled	Only one automatic reclosing cycle is selected,
1.2. Enabled	Two automatic reclosing cycles are activated,
1.2.3. Enabled	Three automatic reclosing cycles are activated,
1.2.3.4. Enabled	All automatic reclosing cycles are activated.

The function can be switched Off /On using the parameter "Operation".

The user can also block the MV automatic reclosing function applying the graphic equation editor. The binary status variable to be programmed is "Block".

Depending on the preset parameter value "Reclosing started by", the MV automatic reclosing function can be started either by resetting of the TRIP command or by the binary signal indicating the open state of the circuit breaker.

If the reset state of the TRIP command is selected to start the MV automatic reclosing function, then the conditions are defined by the user applying the graphic equation editor. The binary status variable to be programmed is "AutoReclosing Start".

If the open state of the circuit breaker is selected to start the MV automatic reclosing function, then additionally to programming the "AutoReclosing Start" signal, the conditions for detecting the open state of the CB are defined by the user applying the graphic equation editor.

For all four reclosing cycles, separate dead times can be defined for line-to-line faults and for earth faults. The dead time counter of any reclosing cycle is started by the starting signal but starting can be delayed.

Reclosing is possible only if the conditions required by the “synchro-check” function are fulfilled. The conditions are defined by the user applying the graphic equation editor. The HV automatic reclosing function waits for a pre-programmed time for this signal. This time is defined by the user. If the “SYNC Release” signal is not received during the running time of this timer, then the “synchronous switch” operation is started. If no synchronous switching is possible, then the MV automatic reclosing function resets.

In case of a manual close command which is assigned to the binary input “Manual Close“ using graphic equation programming, a preset parameter value decides how long the MV automatic reclosing function should be disabled after the manual close command.

The MV automatic reclosing function can be blocked by a binary input. The conditions are defined by the user applying the graphic equation editor.

Technical data

Function	Accuracy
Operating time	±1% of setting value or ±30 ms

Table 76 Technical data of the auto-reclosing protection function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Switching ON/OFF the MV automatic reclosing function			
REC79_Op_EPar_	Operation	Off, On	On
Selection of the number of reclosing sequences in case of earth faults			
REC79_EFCycEn_EPar_	EarthFault RecCycle	Disabled, 1. Enabled, 1.2. Enabled, 1.2.3. Enabled, 1.2.3.4. Enabled	1. Enabled
Selection of the number of reclosing sequences in case of line-to-line faults			
REC79_PhFCycEn_EPar_	PhaseFault RecCycle	Disabled, 1. Enabled, 1.2. Enabled, 1.2.3. Enabled, 1.2.3.4. Enabled	1. Enabled
Selection of triggering the dead time counter (trip signal reset or circuit breaker open position)			
REC79_St_EPar_	Reclosing Started by	Trip reset, CB open	Trip reset

Table 77 The enumerated parameters of the auto-reclosing protection function

Timer parameters

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Dead time setting for the first reclosing cycle for line-to-line fault						
REC79_PhDT1_TPar_	1. Dead Time Ph	msec	0	100000	10	500
Dead time setting for the second reclosing cycle for line-to-line fault						
REC79_PhDT2_TPar_	2. Dead Time Ph	msec	10	100000	10	600
Dead time setting for the third reclosing cycle for line-to-line fault						
REC79_PhDT3_TPar_	3. Dead Time Ph	msec	10	100000	10	700
Dead time setting for the fourth reclosing cycle for line-to-line fault						
REC79_PhDT4_TPar_	4. Dead Time Ph	msec	10	100000	10	800
Dead time setting for the first reclosing cycle for earth fault						
REC79_EFDT1_TPar_	1. Dead Time EF	msec	0	100000	10	1000
Dead time setting for the second reclosing cycle for earth fault						
REC79_ EF DT2_TPar_	2. Dead Time EF	msec	10	100000	10	2000
Dead time setting for the third reclosing cycle for earth fault						
REC79_ EF DT3_TPar_	3. Dead Time EF	msec	10	100000	10	3000
Dead time setting for the fourth reclosing cycle for earth fault						
REC79_ EF DT4_TPar_	4. Dead Time EF	msec	10	100000	10	4000
Reclaim time setting						
REC79_Rec_TPar_	Reclaim Time	msec	100	100000	10	2000
Impulse duration setting for the CLOSE command						
REC79_Close_TPar_	Close Command Time	msec	10	10000	10	100
Setting of the dynamic blocking time						
REC79_DynBlk_TPar_	Dynamic Blocking Time	msec	10	100000	10	1500
Setting of the blocking time after manual close command						
REC79_MC_TPar_	Block after Man Close	msec	0	100000	10	1000
Setting of the action time (max. allowable duration between protection start and trip)						
REC79_Act_TPar_	Action Time	msec	0	20000	10	1000
Limitation of the starting signal (trip command is too long or the CB open signal received too late)						
REC79_MaxSt_TPar_	Start Signal Max Time	msec	0	10000	10	1000
Max. delaying the start of the dead-time counter						
REC79_DtDel_TPar_	DeadTime Max Delay	msec	0	100000	10	3000
Waiting time for circuit breaker ready to close signal						
REC79_CBTO_TPar_	CB Supervision Time	msec	10	100000	10	1000
Waiting time for synchronous state signal						
REC79_SYN1_TPar_	SynCheck Max Time	msec	500	100000	10	10000
Waiting time for synchronous switching signal						
REC79_SYN2_TPar_	SynSW Max Time	msec	500	100000	10	10000

Table 78 The timer parameters of the auto-reclosing protection function

Boolean parameters

Parameter name	**Title**	**Default**	**Explanation**
REC79_CBState_BPar_	CB State Monitoring	0	Enable CB state monitoring for “Not Ready” state
REC79_Acc1_BPar_	Accelerate 1.Trip	0	Accelerate trip command at starting cycle 1
REC79_Acc2_BPar_	Accelerate 2.Trip	0	Accelerate trip command at starting cycle 2
REC79_Acc3_BPar_	Accelerate 3.Trip	0	Accelerate trip command at starting cycle 3
REC79_Acc4_BPar_	Accelerate 4.Trip	0	Accelerate trip command at starting cycle 4
REC79_Acc5_BPar_	Accelerate FinTrip	0	Accelerate final trip command

Table 79 The boolean parameters of the auto-reclosing protection function

1.3.1.20 Voltage transformer supervision function (VTS60)

The voltage transformer supervision function generates a signal to indicate an error in the voltage transformer secondary circuit. This signal can serve, for example, as a warning, indicating disturbances in the measurement, or it can disable the operation of the distance protection function if appropriate measured voltage signals are not available for a distance decision.

The voltage transformer supervision function is designed to detect faulty asymmetrical states of the voltage transformer circuit caused, for example, by a broken conductor in the secondary circuit.

(Another method for detecting voltage disturbances is the supervision of the auxiliary contacts of the miniature circuit breakers in the voltage transformer secondary circuits. This function is not described here.)

The user has to generate graphic equations for the application of the signal of this voltage transformer supervision function.

This function is interconnected with the “dead line detection function”. Although the dead line detection function is described fully in a separate document, the explanation necessary to understand the operation of the VT supervision function is repeated also in this document.

The voltage transformer supervision function can be used in three different modes of application:

> Zero sequence detection (for typical applications in systems with grounded neutral): “VT failure” signal is generated if the residual voltage (3Uo) is above the preset voltage value AND the residual current (3Io) is below the preset current value.
>
> Negative sequence detection (for typical applications in systems with isolated or resonant grounded (Petersen) neutral): “VT failure” signal is generated if the negative sequence voltage component (U2) is above the preset voltage value AND the negative sequence current component (I2) is below the preset current value.
>
> Special application: “VT failure” signal is generated if the residual voltage (3Uo) is above the preset voltage value AND the residual current (3Io) AND the negative sequence current component (I2) are below the preset current values.

The voltage transformer supervision function can be activated if “Live line” status is detected for at least 200 ms. This delay avoids mal-operation at line energizing if the poles of the circuit breaker make contact with a time delay. The function is set to be inactive if “Dead line” status is detected.

If the conditions specified by the selected mode of operation are fulfilled (for at least 4 milliseconds) then the voltage transformer supervision function is activated and the operation signal is generated. (When evaluating this time delay, the natural operating time of the applied Fourier algorithm must also be considered.)

NOTE: For the operation of the voltage transformer supervision function the “ Dead line detection function” must be operable as well: it must be enabled by binary parameter setting, and its blocking signal may not be active.

If, in the active state, the conditions for operation are no longer fulfilled, the resetting of the function depends on the mode of operation of the primary circuit:

- If the “Live line” state is valid, then the function resets after approx. 200 ms of time delay. (When evaluating this time delay, the natural operating time of the applied Fourier algorithm must also be considered.)
- If the “Dead line” state is started and the “VTS Failure” signal has been continuous for at least 100 ms, then the “VTS failure” signal does not reset; it is generated continuously even when the line is in a disconnected state. Thus, the “VTS Failure” signal remains active at reclosing.
- If the “Dead line” state is started and the “VTS Failure” signal has not been continuous for at least 100 ms, then the “VTS failure” signal resets.

Technical data

Function	Value	Accuracy
Pick-up voltage Io=0A I2=0A		 <1% <1%
Operation time	<20ms	
Reset ratio	0.95	

Table 80 Technical data of the voltage transformer supervision function

Parameters

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Integer parameters of the dead line detection function						
DLD_ULev_IPar_	Min Operate Voltage	%	10	100	1	60
DLD_ILev_IPar_	Min Operate Current	%	2	100	1	10
Starting voltage and current parameter for residual and negative sequence detection:						
VTS_Uo_IPar_	Start URes	%	5	50	1	30
VTS_Io_IPar_	Start IRes	%	10	50	1	10
VTS_Uneg_IPar_	Start UNeg	%	5	50	1	10
VTS_Ineg_IPar_	Start INeg	%	10	50	1	10

Table 81 The integer parameters of the voltage transformer supervision function

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for type selection			
VTS_Oper_EPar_	Operation	Off, Zero sequence, Neg. sequence, Special	Zero sequence

Table 82 The enumerated parameter of the voltage transformer supervision function

1.3.1.21 Automatic tap-changer controller function (ATCC)

One criterion for power quality is to keep the voltage of selected points of the networks within the prescribed limits. The most common mode of voltage regulation is the application of transformers with on-load tap changers. When the transformer is connected to different taps, its turns ratio changes and supposing constant primary voltage, the secondary voltage can be increased or decreased as required.

Voltage control can take the actual load state of the transformer and the network into consideration. As a result, the voltage of a defined remote point of the network is controlled assuring that neither consumers near the busbar nor consumers at the far ends of the network get voltages out of the required range.

The voltage control function can be performed automatically or, in manual mode of operation, the personnel of the substation can set the network voltage according to special requirements.

The automatic tap changer controller function can be applied to perform this task.

The automatic tap changer controller function receives the following analog inputs:

UL1L2	Line-to-line voltage of the controlled secondary side of the transformer
IL1L2	Difference of the selected line currents of the secondary side of the transformer for voltage drop compensation
IHV	Maximum of the phase currents of the primary side of the transformer for limitation purposes

The parameter “U Correction” permits fine tuning of the measured voltage.

The function performs the following internal checks before control operation (see Figure below):

- If the voltage of the controlled side UL1L2 is above the value set by the parameter “U High Limit”, then control to increase the voltage is disabled.
- If the voltage of the controlled side UL1L2 is below the value set by the parameter “U Low Limit”, then control to decrease the voltage is disabled.
- If the voltage of the controlled side UL1L2 is below the value set by the parameter “U Low Block”, then the transformer is considered to be de-energized and automatic control is completely disabled.
- If the current of the supply side IHV is above the limit set by the parameter “I Overload”, then both automatic and manual controls are completely disabled. This is to protect the switches inside the tap changer.

Automatic control mode

Voltage compensation in automatic control mode

The function gets the Fourier components of the busbar voltage and those of the current:

- $UL1L2_{Re}$ and $UL1L2_{Im}$
- $IL1L2_{Re}$ and $IL1L2_{Im}$

In automatic control mode the voltage of the controlled side *UL1L2* is compensated by the current of the controlled side *IL1L2*. This means that the voltage of the “load center” of the network is controlled to be constant, in fact within a narrow range. This assures that neither the voltage near to the busbar is too high, nor the voltage at far-away points of the network is too low. The voltage of the “load center”, i.e. the controlled voltage is calculated as:

$$|Ucontrol| = |Ubus - Udrop|$$

There are two compensation modes to be selected: “AbsoluteComp” and “ComplexComp”.

- If the parameter “Compensation” is set to **“AbsoluteComp”,** the calculation method is as follows:

In this simplified method the vector positions are not considered correctly, the formula above is approximated with the magnitudes only:

$$|Ucontrol| = |Ubus - Udrop| \approx |Ubus| - |Udrop| \approx |Ubus| - |I| * (R)CompoundFactor$$

where

(R) Compound Factor	is a parameter value.

If the current is above the value defined by the parameter “I Comp Limit”, then in the formulas above this preset value is considered instead of the higher values measured.

The method is based on the experiences of the network operator. Information is needed: how much is the voltage drop between the busbar and the “load center” if the load of the network is the rated load. The parameter “(R) Compound Factor” means in this case the voltage drop in percent.

- If the parameter “Compensation” is set to **“ComplexComp”,** the calculation method is as follows:

In this simplified method the vector positions are partly considered. In the formula above the voltage drop is approximated with the component of the voltage drop, the direction of which is the same as the direction of the bus voltage vector. (This is “length component” of the voltage drop; the “perpendicular component” of the voltage drop is neglected.)

$$|Ucontrol| = |Ubus - [IL1L2_{Re} * (R)CompoundFactor - IL1L2_{Im} * XCompoundFactor]|$$

where

(R) Compound Factor	is a parameter value
X Compound Factor	is a parameter value

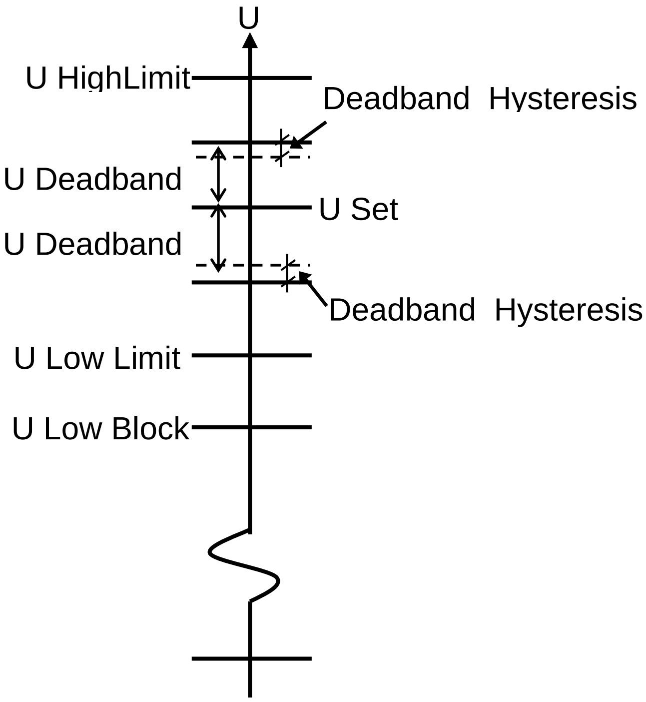
The voltage of the “load center” of the network is controlled to be within a narrow range. This assures that neither the voltage near to the busbar is too high, nor the voltage at far-away points of the network is too low.

The method is based on the estimated complex impedance between the busbar and the “load center”.

The parameter *“(R) Compound Factor*” means in this case the voltage drop in percent, caused by the real component of the rated current.

The parameter *“X Compound Factor”* means in this case the voltage drop in percent, caused by the imaginary component of the rated current.

NOTE: if the active power flows from the network to the busbar then in “AbsoluteComp” mode no compounding is performed.



Voltage checking in automatic control mode

In automatic control mode the calculated | *Ucontrol* | voltage is checked to see if it is outside the limits. The limits are defined by parameter values:

U Set	is the setting value defining the centre of the permitted range
U Deadband	is the width of the permitted range in both + and – directions
Deadband Hysteresis	is the hysteresis decreasing the permitted range of the „U Deadband” after the generation of the control command.

If the calculated | *Ucontrol* | voltage is outside the limits, then timers are started.

In an emergency state of the network, when the network elements are overloaded, the Uset value can be driven to two lower values defined by the parameters “Voltage Reduction 1” and “Voltage Reduction 2”. “U Set” is decreased by the parameter values if the binary inputs “VRed 1” or “VRed 2” enter into active state. These inputs must be programmed graphically by the user.

Time delay in automatic control mode

In automatic control mode the first and every subsequent control command is processed separately.

For the first control command:

The voltage difference is calculated:

$$Udiff = |Ucontrol - Uset|$$

If this difference is above the U Deadband value, and depending on the setting of parameter “T1 Delay Type”, three different timing modes can be selected:

- “Definite” this definite time delay is defined by parameter T1
- “Inverse” standard IDMT characteristic defined by the parameters:
  - T1 maximum delay defined by the parameter
  - U Deadband is the width of the permitted range in both + and – directions
  - Min Delay minimum time delay

$$Tdelay = \frac{T1}{\left(\frac{Udiff}{Udeadband}\right)}, but\ minimum\ Min\ Delay$$

- “2powerN”

$$Tdelay = T1 * 2^{\left(1-\frac{Udiff}{Udeadband}\right)}$$

The binary parameters “Fast Lower Enable” and/or “Fast Higher Enable” enable fast command generation if the voltage is above the parameter value “U High Limit” or below the “U Low Limit”. In this case, the time delay is a definite time delay defined by parameter “T2”.

For subsequent control commands:

In this case, the time delay is always a definite time delay defined by parameter “T2” if the subsequent command is generated within the „Reclaim time” defined by a parameter.

The automatic control mode can be blocked by a binary signal received via binary input „AutoBlk” and generates a binary output signal “AutoBlocked (ext)”

<u>Manual control mode</u>

In manual mode, the automatic control is blocked. The manual mode can be “Local” or “Remote”. For this mode, the input “Manual” needs to be in active state (as programmed by the user).

In the local mode, the input “Local” needs to be in active state. The binary inputs “ManHigher” or “ManLower” must be programmed graphically by the user.

In the remote mode, the input “Remote” needs to be in active state as programmed by the user. In this case manual commands are received via the communication interface.

Command generation and tap changer supervision

The software module “CMD&TC SUPERV” is responsible for the generation of the “HigherCmd” and “LowerCmd” command pulses, the duration of which is defined by the parameter “Pulse Duration”. This is valid both for manual and automatic operation.

The tap changer supervision function receives the information about the tap changer position in six bits of the binary inputs “Bit0 to Bit5”. The value is decoded according to the enumerated parameter “CodeType”, the values of which can be: Binary, BCD or Gray. During switchover, for the transient time defined by the parameter “Position Filter”, the position is not evaluated.

The parameters “Min Position” and “Max Position” define the upper and lower limits. In the upper position, no further increasing command is generated and the output “Max Pos Reached” becomes active. Similarly, in the lower position, no further decreasing command is generated and the output “Min Pos Reached” becomes active.

The function also supervises the operation of the tap changer. Depending on the setting of parameter “TC Supervision”, three different modes can be selected:

- TCDrive the supervision is based on the input “TCRun”. In this case, after command generation the drive is expected to start operation within one quarter of the value defined by the parameter “Max Operating Time” and it is expected to perform the command within “Max Operating Time”
- Position the supervision is based on the tap changer position in six bits of the binary inputs “Bit0 to Bit5”. It is checked if the tap position is incremented in case of a voltage increase, or the tap position is decremented in case of a voltage decrease, within the “Max Operating Time”.
- Both in this mode the previous two modes are combined.

In case of an error detected in the operation of the tap changer, the “Locked” input becomes active and no further commands are performed. To enable further operation, the input “Reset” must be programmed for an active state by the user.

Technical data

Function	Range	Accuracy
Voltage measurement	50 % < U < 130 %	<1%
Definite time delay		<2% or ±20 ms, whichever is greater
Inverse and “2powerN” time delay	12 % < U < 25%	<5%
	25 % < U < 50%	<2% or ±20 ms, whichever is greater

Table 83 Technical data of the automatic tap-changer controller function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Control model, according to IEC 61850			
ATCC_ctlMod_EPar_	ControlModel	Direct normal, Direct enhanced, SBO enhanced	Direct normal
Select before operate class, according to IEC 61850			
ATCC_sboClass_EPar_	sboClass	Operate-once, Operate-many	Operate-once
Parameter for general blocking of the function			
ATCC_Oper_EPar_	Operation	Off,On	Off
Parameter for time delay mode selection			
ATCC_T1Type_EPar_	T1 Delay Type	Definite, Inverse, 2powerN	Definite
Selection for compensation mode			
ATCC_Comp_EPar_	Compensation	Off, AbsoluteComp, ComplexComp	Off
Tap changed supervision mode selection			
ATCC_TCSuper_EPar_	TC Supervision	Off, TCDrive, Position, Both	Off
Decoding of the position indicator bits			
ATCC_CodeType_EPar	CodeType	Binary, BCD, Gray	Binary

Table 84 The enumerated parameters of the automatic tap-changer controller function

Boolean parameters

Parameter name	Title	Explanation	Default
ATCC_FastHigh_BPar_	Fast Higher Enable	Enabling fast higher control command	0
ATCC_FastLow_BPar_	Fast Lower Enable	Enabling fast lower control command	0

Table 85 The boolean parameters of the automatic tap-changer controller function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Code value of the minimum position						
ATCC_MinPos_Ipar_	Min Position		1	32	1	1
Code value of the maximum position						
ATCC_MaxPos_Ipar_	Max Position		1	32	1	32

Table 86 The integer parameters of the automatic tap-changer controller function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Time limit for tap-change operation						
ATCC_TimOut_TPar_	Max Operating Time	msec	1000	30000	1	5000
Command impulse duration						
ATCC_Pulse_TPar_	Pulse Duration	msec	100	10000	1	1000
Time overbridging the transient state of the tap changer status signals						
ATCC_MidPos_TPar_	Position Filter	msec	1000	30000	1	3000
Select before operate timeout, according to IEC 61850						
ATCC_SBOTimeout_TPar_	SBO Timeout	msec	1000	20000	1	5000

Table 87 The timer parameters of the automatic tap-changer controller function

Float point parameters

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Digits**	**Default**
Factor for fine tuning the measured voltage:						
ATCC_Ubias_FPar_	U Correction	-	0.950	1.050	3	1.000
Set-point for voltage regulation, related to the rated voltage (valid at I=0):						
ATCC_USet_FPar_	U Set	%	80.0	115.0	1	100.0
Dead band for voltage regulation, related to the rated voltage:						
ATCC_UDead_FPar_	U Deadband	%	0.5	9.0	1	3.0
Hysteresis value for the dead band, related to the dead band:						
ATCC_DeadHyst_FPar_	Deadband Hysteresis	%	60	90	0	85
Parameter for the current compensation:						
ATCC_URinc_FPar_	(R) Compound Factor	%	0.0	15.0	1	5.0
Parameter for the current compensation:						
ATCC_UXinc_FPar_	X Compound Factor	%	0.0	15.0	1	5.0
Reduced set-point 1 for voltage regulation (priority), related to the rated voltage:						
ATCC_VRed1_FPar_	Voltage Reduction 1	%	0.0	10.0	1	5.0
Reduced set-point 2 for voltage regulation, related to the rated voltage:						
ATCC_VRed2_FPar_	Voltage Reduction 2	%	0.0	10.0	1	5.0
Maximum current value to be considered in current compensation formulas:						
ATCC_ICompLim_FPar_	I Comp Limit	%	0.00	150	0	1
Current upper limit to disable all operation:						
ATCC_IHVOC_FPar_	I Overload	%	50	150	0	100
Voltage upper limit to disable step up:.						
ATCC_UHigh_FPar_	U High Limit	%	90.0	120.0	1	110.0
Voltage lower limit to disable step down:						
ATCC_ULow_FPar_	U Low Limit	%	70.0	110.0	1	90.0
Voltage lower limit to disable all operation:						
ATCC_UBlock_FPar_	U Low Block	%	50.0	100.0	1	70.0
Time delay for the first control command generation:						
ATCC_T1_FPar_	T1	sec	1.0	600.0	1	10.0
Definite time delay for subsequent control command generation or fast operation (if it is enabled):						
ATCC_T2_FPar_	T2	sec	1.0	100.0	1	10.0
In case of dependent time characteristics, this is the minimum time delay						
ATCC_MinDel_FPar_	Min Delay	sec	1.0	100.0	1	10.0
After a control command, if the voltage is out of the range within the reclaim time, then the command is generated after T2 time delay						
ATCC_Recl_FPar_	Reclaim Time	sec	1.0	100.0	1	10.0

Table 88 *The float point parameters of the automatic tap-changer controller function*

1.3.2 Measuring functions

The measured values can be checked on the touch-screen of the device in the “On-line functions” page, or using an Internet browser of a connected computer. The displayed values are secondary voltages and currents, except the blocks MXU_IT; MXU_C; ATCCIT”. This specific block displays the measured values in primary units, using CT and VT primary value settings.

VT4 module MV	
Voltage Ch - U1	RMS value of the Fourier fundamental harmonic voltage component in phase L1
Angle Ch - U1	Phase angle of the Fourier fundamental harmonic voltage component in phase L1*
Voltage Ch - U2	RMS value of the Fourier fundamental harmonic voltage component in phase L2
Angle Ch - U2	Phase angle of the Fourier fundamental harmonic voltage component in phase L2*
Voltage Ch - U3	RMS value of the Fourier fundamental harmonic voltage component in phase L3
Angle Ch - U3	Phase angle of the Fourier fundamental harmonic voltage component in phase L3*
Voltage Ch - U4	RMS value of the Fourier fundamental harmonic voltage component in Channel U4
Angle Ch - U4	Phase angle of the Fourier fundamental harmonic voltage component in Channel U4*
CT4 module HV	
Current Ch - I1	RMS value of the Fourier fundamental harmonic current component in phase L1
Angle Ch - I1	Phase angle of the Fourier fundamental harmonic current component in phase L1*
Current Ch - I2	RMS value of the Fourier fundamental harmonic current component in phase L2
Angle Ch - I2	Phase angle of the Fourier fundamental harmonic current component in phase L2*
Current Ch - I3	RMS value of the Fourier fundamental harmonic current component in phase L3
Angle Ch - I3	Phase angle of the Fourier fundamental harmonic current component in phase L3*
Current Ch - I4	RMS value of the Fourier fundamental harmonic current component in Channel I4
Angle Ch - I4	Phase angle of the Fourier fundamental harmonic current component in Channel I4*
CT4 module MV	
Current Ch - I1	RMS value of the Fourier fundamental harmonic current component in phase L1
Angle Ch - I1	Phase angle of the Fourier fundamental harmonic current component in phase L1*
Current Ch - I2	RMS value of the Fourier fundamental harmonic current component in phase L2
Angle Ch - I2	Phase angle of the Fourier fundamental harmonic

	current component in phase L2*
Current Ch - I3	RMS value of the Fourier fundamental harmonic current component in phase L3
Angle Ch - I3	Phase angle of the Fourier fundamental harmonic current component in phase L3*
Current Ch - I4	RMS value of the Fourier fundamental harmonic current component in Channel I4
Angle Ch - I4	Phase angle of the Fourier fundamental harmonic current component in Channel I4*
CT4 module HV Meas.	
Current Ch - I1	RMS value of the Fourier fundamental harmonic current component in phase L1
Angle Ch - I1	Phase angle of the Fourier fundamental harmonic current component in phase L1*
Current Ch - I2	RMS value of the Fourier fundamental harmonic current component in phase L2
Angle Ch - I2	Phase angle of the Fourier fundamental harmonic current component in phase L2*
Current Ch - I3	RMS value of the Fourier fundamental harmonic current component in phase L3
Angle Ch - I3	Phase angle of the Fourier fundamental harmonic current component in phase L3*
Current Ch - I4	RMS value of the Fourier fundamental harmonic current component in Channel I4
Angle Ch - I4	Phase angle of the Fourier fundamental harmonic current component in Channel I4*
CT4 module MV Meas.	
Current Ch - I1	RMS value of the Fourier fundamental harmonic current component in phase L1
Angle Ch - I1	Phase angle of the Fourier fundamental harmonic current component in phase L1*
Current Ch - I2	RMS value of the Fourier fundamental harmonic current component in phase L2
Angle Ch - I2	Phase angle of the Fourier fundamental harmonic current component in phase L2*
Current Ch - I3	RMS value of the Fourier fundamental harmonic current component in phase L3
Angle Ch - I3	Phase angle of the Fourier fundamental harmonic current component in phase L3*
Current Ch - I4	RMS value of the Fourier fundamental harmonic current component in Channel I4
Angle Ch - I4	Phase angle of the Fourier fundamental harmonic current component in Channel I4*
Differential 2w	
I Diff L1	The calculated differential current in phase L1 (after vector group compensation)
I Diff L2	The calculated differential current in phase L2 (after vector group compensation)
I Diff L3	The calculated differential current in phase L3

	(after vector group compensation)
I Bias L1	The calculated restraint current in phase L1 (after vector group compensation)
I Bias L2	The calculated restraint current in phase L2 (after vector group compensation)
I Bias L3	The calculated restraint current in phase L3 (after vector group compensation)
Restricted EF MV	
Diff Current	The calculated differential current
Bias Current	The calculated restraint current
Thermal Overload HV	
Calc Temperature	Calculated temperature
Power Supply	
Auxiliary voltage	Auxiliary voltage
Voltage Control (here the displayed information means primary value)	
U Bus	True RMS value of the voltage between phases L1 L2 on MV bus
U Controlled	
Uset actual	Setting voltage
Transformer meas (here the displayed information means primary value) (Secondary side of the transformer)	
Active Power - P	Three-phase active power
Reactive Power - Q	Three-phase reactive power
Current L1	True RMS value of the current in phase L1
Current L2	True RMS value of the current in phase L2
Current L3	True RMS value of the current in phase L3
Voltage L12	True RMS value of the voltage between phases L1 L2
Voltage L23	True RMS value of the voltage between phases L2 L3
Voltage L31	True RMS value of the voltage between phases L3 L1
Current measurementHV (here the displayed information means primary value) (Primary side of the transformer)	
Current L1	True RMS value of the current in phase L1
Current L2	True RMS value of the current in phase L2
Current L3	True RMS value of the current in phase L3
Residual Current	True RMS value of the residual current

* *The refernce angle is the phase angle of “Voltage Ch - U1”*

1.3.2.1 Voltage input function (VT4)

If the factory configuration includes a voltage transformer hardware module, the voltage input function block is automatically configured among the software function blocks. Separate voltage input function blocks are assigned to each voltage transformer hardware module.

A voltage transformer hardware module is equipped with four special intermediate voltage transformers. (See Chapter 6 of the EuroProt+ hardware description document.) As usual, the first three voltage inputs receive the three phase voltages (UL1, UL2, UL3), the fourth input is reserved for zero sequence voltage or for a voltage from the other side of the circuit breaker for synchron switching. All inputs have a common parameter for type selection: 100V or 200V.

Additionally, there is a correction factor available if the rated secondary voltage of the main voltage transformer (e.g. 110V) does not match the rated input of the device.

The role of the voltage input function block is to
- set the required parameters associated to the voltage inputs,
- deliver the sampled voltage values for disturbance recording,
- perform the basic calculations
    - Fourier basic harmonic magnitude and angle,
    - True RMS value;
- provide the pre-calculated voltage values to the subsequent software modules,
- deliver the basic calculated values for on-line displaying.

Operation of the voltage input algorithm

The voltage input function block receives the sampled voltage values from the internal operating system. The scaling (even hardware scaling) depends on parameter setting. See the parameter VT4_Type_EPar_ (Range). The options to choose from are 100V or 200V. This parameter influences the internal number format and, naturally, accuracy. (A small voltage is processed with finer resolution if 100V is selected.)

The connection of the first three VT secondary winding must be set to reflect actual physical connection. The associated parameter is VT4_Ch13Nom_EPar_ (Connection U1-3). The selection can be: Ph-N, Ph-Ph or Ph-N-Isolated.

The Ph-N option is applied in solidly grounded networks, where the measured phase voltage is never above 1.5-Un. In this case the primary rated voltage of the VT must be the value of the rated PHASE-TO-NEUTRAL voltage.

The Ph-N option is applied in compensated or isolated networks, where the measured phase voltage can be above 1.5-Un even in normal operation. In this case the primary rated voltage of the VT must be the value of the rated PHASE-TO-PHASE voltage.

If phase-to-phase voltage is connected to the VT input of the device, then the Ph-Ph option is to be selected. Here, the primary rated voltage of the VT must be the value of the rated PHASE-TO-PHASE voltage. This option must not be selected if the distance protection function is supplied from the VT input.

The fourth input is reserved for zero sequence voltage or for a voltage from the other side of the circuit breaker for synchron switching. Accordingly, the connected voltage must be identified with parameter setting VT4_Ch4Nom_EPar_ (Connection U4). Here, phase-to-neutral or phase-to-phase voltage can be selected: Ph-N,Ph-Ph

If needed, the phase voltages can be inverted by setting the parameter VT4_Ch13Dir_EPar_ (Direction U1-3). This selection applies to each of the channels UL1, UL2 and UL3. The fourth voltage channel can be inverted by setting the parameter VT4_Ch4Dir_EPar_ (Direction U4). This inversion may be needed in protection functions such as distance protection, differential protection or for any functions with directional decision, or for checking the voltage vector positions.

Additionally, there is a correction factor available if the rated secondary voltage of the main voltage transformer (e.g. 110V) does not match the rated input of the device. The related parameter is VT4_CorrFact_IPar_ (VT correction). As an example: if the rated secondary voltage of the main voltage transformer is 110V, then select Type 100 for the parameter "Range" and the required value to set here is 110%.

These sampled values are available for further processing and for disturbance recording.

The performed basic calculation results the Fourier basic harmonic magnitude and angle and the true RMS value of the voltages. These results are processed by subsequent protection function blocks and they are available for on-line displaying as well.

The function block also provides parameters for setting the primary rated voltages of the main voltage transformer. This function block does not need that parameter setting. These values are passed on to function blocks such as displaying primary measured values, primary power calculation, etc. Concerning the rated voltage, see the instructions related to the parameter for the connection of the first three VT secondary winding.

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Rated secondary voltage of the input channels. 100 V or 200V is selected by parameter setting, no hardware modification is needed.			
VT4_Type_EPar_	Range	Type 100,Type 200	Type 100
Connection of the first three voltage inputs (main VT secondary)			
VT4_Ch13Nom_EPar_	Connection U1-3	Ph-N, Ph-Ph, Ph-N-Isolated	Ph-N
Selection of the fourth channel input: phase-to-neutral or phase-to-phase voltage			
VT4_Ch4Nom_EPar_	Connection U4	Ph-N,Ph-Ph	Ph-Ph
Definition of the positive direction of the first three input channels, given as normal or inverted			
VT4_Ch13Dir_EPar_	Direction U1-3	Normal,Inverted	Normal
Definition of the positive direction of the fourth voltage, given as normal or inverted			
VT4_Ch4Dir_EPar_	Direction U4	Normal,Inverted	Normal

Table 89 The enumerated parameters of the voltage input function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Voltage correction						
VT4_CorrFact_IPar_	VT correction	%	100	115	1	100

Table 90 The integer parameter of the voltage input function

Floating point parameters

Parameter name	Title	Dim.	Min	Max	Default
Rated primary voltage of channel1					
VT4_PriU1_FPar	Rated Primary U1	kV	1	1000	100
Rated primary voltage of channel2					
VT4_PriU2_FPar	Rated Primary U2	kV	1	1000	100
Rated primary voltage of channel3					
VT4_PriU3_FPar	Rated Primary U3	kV	1	1000	100
Rated primary voltage of channel4					
VT4_PriU4_FPar	Rated Primary U4	kV	1	1000	100

Table 91 The floating point parameters of the voltage input function

NOTE: The rated primary voltage of the channels is not needed for the voltage input function block itself. These values are passed on to the subsequent function blocks.

Function	Range	Accuracy
Voltage accuracy	30% … 130%	< 0.5 %

Table 92 Technical data of the voltage input

Measured values

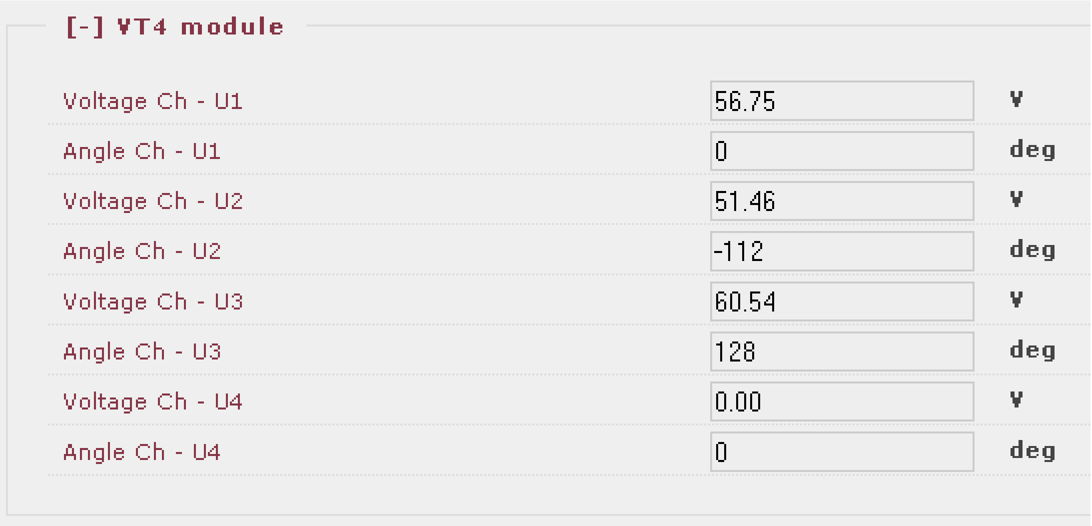
Measured value	Dim.	Explanation
Voltage Ch - U1	V(secondary)	Fourier basic component of the voltage in channel UL1
Angle Ch - U1	degree	Vector position of the voltage in channel UL1
Voltage Ch – U2	V(secondary)	Fourier basic component of the voltage in channel UL2
Angle Ch – U2	degree	Vector position of the voltage in channel UL2
Voltage Ch – U3	V(secondary)	Fourier basic component of the voltage in channel UL3
Angle Ch – U3	degree	Vector position of the voltage in channel UL3
Voltage Ch – U4	V(secondary)	Fourier basic component of the voltage in channel U4
Angle Ch – U4	degree	Vector position of the voltage in channel U4

Table 93 The measured analogue values of the voltage input function

NOTE1: The scaling of the Fourier basic component is such if pure sinusoid 57V RMS of the rated frequency is injected, the displayed value is 57V. (The displayed value does not depend on the parameter setting values “Rated Secondary”.)

NOTE2: The reference vector (vector with angle 0 degree) is the vector calculated for the first voltage input channel of the first applied voltage input module.

The figure below shows an example of how the calculated Fourier components are displayed in the on-line block. (See the document EuroProt+ “Remote user interface description”.)



[-] VT4 module

Voltage Ch - U1	56.75	V
Angle Ch - U1	0	deg
Voltage Ch - U2	51.46	V
Angle Ch - U2	-112	deg
Voltage Ch - U3	60.54	V
Angle Ch - U3	128	deg
Voltage Ch - U4	0.00	V
Angle Ch - U4	0	deg

1.3.2.2 Current input function (CT4)

If the factory configuration includes a current transformer hardware module, the current input function block is automatically configured among the software function blocks. Separate current input function blocks are assigned to each current transformer hardware module.

A current transformer hardware module is equipped with four special intermediate current transformers. (See Chapter 5 of the EuroProt+ hardware description document.) As usual, the first three current inputs receive the three phase currents (IL1, IL2, IL3), the fourth input is reserved for zero sequence current, for the zero sequence current of the parallel line or for any additional current. Accordingly, the first three inputs have common parameters while the fourth current input needs individual setting.

The role of the current input function block is to

- set the required parameters associated to the current inputs,
- deliver the sampled current values for disturbance recording,
- perform the basic calculations
    - Fourier basic harmonic magnitude and angle,
    - True RMS value;
- provide the pre-calculated current values to the subsequent software modules,
- deliver the basic calculated values for on-line displaying.

Operation of the current input algorithm

The current input function block receives the sampled current values from the internal operating system. The scaling (even hardware scaling) depends on parameter setting. See parameters CT4_Ch13Nom_EPar_ (Rated Secondary I1-3) and CT4_Ch4Nom_EPar_ (Rated Secondary I4). The options to choose from are 1A or 5A (in special applications, 0.2A or 1A). This parameter influences the internal number format and, naturally, accuracy. (A small current is processed with finer resolution if 1A is selected.)

If needed, the phase currents can be inverted by setting the parameter CT4_Ch13Dir_EPar_ (Starpoint I1-3). This selection applies to each of the channels IL1, IL2 and IL3. The fourth current channel can be inverted by setting the parameter CT4_Ch4Dir_EPar (Direction I4). This inversion may be needed in protection functions such as distance protection, differential protection or for any functions with directional decision.

These sampled values are available for further processing and for disturbance recording.

The performed basic calculation results the Fourier basic harmonic magnitude and angle and the true RMS value. These results are processed by subsequent protection function blocks and they are available for on-line displaying as well.

The function block also provides parameters for setting the primary rated currents of the main current transformer. This function block does not need that parameter setting. These values are passed on to function blocks such as displaying primary measured values, primary power calculation, etc.

Technical data

Function	Range	Accuracy
Current accuracy	20 – 2000% of In	±1% of In

Table 94 Technical data of the current input

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Rated secondary current of the first three input channels. 1A or 5A is selected by parameter setting, no hardware modification is needed.			
CT4_Ch13Nom_EPar_	Rated Secondary I1-3	1A,5A	1A
Rated secondary current of the fourth input channel. 1A or 5A is selected by parameter setting, no hardware modification is needed.			
CT4_Ch4Nom_EPar_	Rated Secondary I4	1A,5A (0.2A or 1A)	1A
Definition of the positive direction of the first three currents, given by location of the secondary star connection point			
CT4_Ch13Dir_EPar_	Starpoint I1-3	Line,Bus	Line
Definition of the positive direction of the fourth current, given as normal or inverted			
CT4_Ch4Dir_EPar_	Direction I4	Normal,Inverted	Normal

Table 95 *The enumerated parameters of the current input function*

Floating point parameters

Parameter name	Title	Dim.	Min	Max	Default
Rated primary current of channel1					
CT4_PriI1_FPar_	Rated Primary I1	A	100	4000	1000
Rated primary current of channel2					
CT4_PriI2_FPar	Rated Primary I2	A	100	4000	1000
Rated primary current of channel3					
CT4_PriI3_FPar_	Rated Primary I3	A	100	4000	1000
Rated primary current of channel4					
CT4_PriI4_FPar_	Rated Primary I4	A	100	4000	1000

Table 96 *The floating point parameters of the current input function*

NOTE: The rated primary current of the channels is not needed for the current input function block itself. These values are passed on to the subsequent function blocks.

The **measured values** of the current input function block.

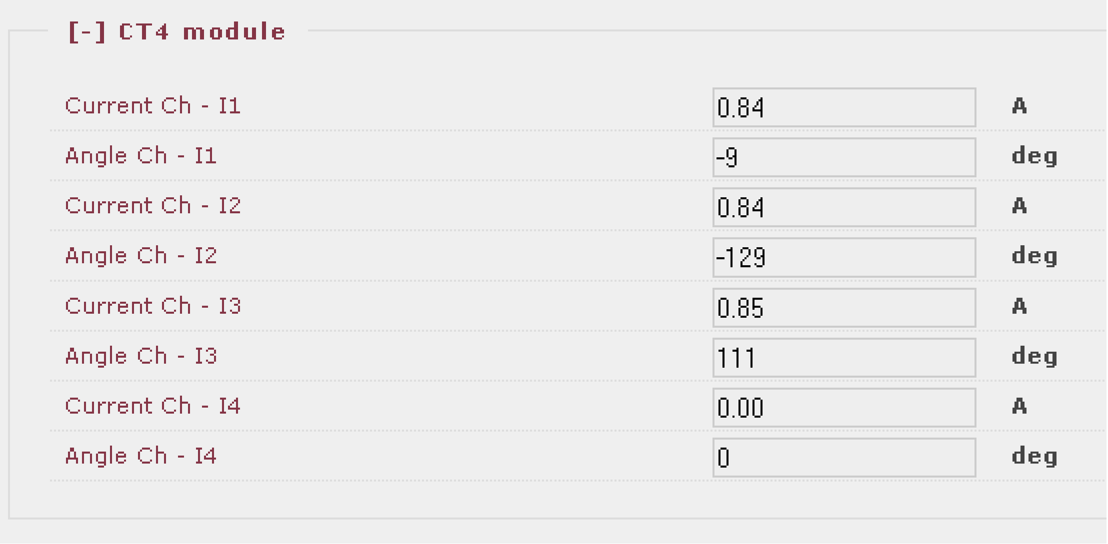
Measured value	Dim.	Explanation
Current Ch - I1	A(secondary)	Fourier basic component of the current in channel IL1
Angle Ch - I1	degree	Vector position of the current in channel IL1
Current Ch – I2	A(secondary)	Fourier basic component of the current in channel IL2
Angle Ch – I2	degree	Vector position of the current in channel IL2
Current Ch – I3	A(secondary)	Fourier basic component of the current in channel IL3
Angle Ch – I3	degree	Vector position of the current in channel IL3
Current Ch – I4	A(secondary)	Fourier basic component of the current in channel I4
Angle Ch – I4	degree	Vector position of the current in channel I4

Table 97 *The measured analogue values of the current input function*

NOTE1: The scaling of the Fourier basic component is such that if pure sinusoid 1A RMS of the rated frequency is injected, the displayed value is 1A. (The displayed value does not depend on the parameter setting values “Rated Secondary”.)

NOTE2: The reference of the vector position depends on the device configuration. If a voltage input module is included, then the reference vector (vector with angle 0 degree) is the vector calculated for the first voltage input channel of the first applied voltage input module. If no voltage input module is configured, then the reference vector (vector with angle 0 degree) is the vector calculated for the first current input channel of the first applied current input module.

Error! Reference source not found. shows an example of how the calculated Fourier c omponents are displayed in the on-line block. (See the document “EuroProt+ Remote user interface description”.)



[-] CT4 module

Current Ch - I1	0.84	A
Angle Ch - I1	-9	deg
Current Ch - I2	0.84	A
Angle Ch - I2	-129	deg
Current Ch - I3	0.85	A
Angle Ch - I3	111	deg
Current Ch - I4	0.00	A
Angle Ch - I4	0	deg

1.3.2.3 Line measurement function (MXU)

The input values of the EuroProt+ devices are the secondary signals of the voltage transformers and those of the current transformers.

These signals are pre-processed by the “Voltage transformer input” function block and by the “Current transformer input” function block. These function blocks are described in separate documents. The pre-processed values include the Fourier basic harmonic components of the voltages and currents and the true RMS values. Additionally, it is in these functions that parameters are set concerning the voltage ratio of the primary voltage transformers and current ratio of the current transformers.

Based on the pre-processed values and the measured transformer parameters, the “Line measurement” function block calculates – depending on the hardware and software configuration – the primary RMS values of the voltages and currents and some additional values such as active and reactive power, symmetrical components of voltages and currents. These values are available as primary quantities and they can be displayed on the on-line screen of the device or on the remote user interface of the computers connected to the communication network and they are available for the SCADA system using the configured communication system.

It is usual for the SCADA systems that they sample the measured and calculated values in regular time periods and additionally they receive the changed values as reports at the moment when any significant change is detected in the primary system. The “Line measurement” function block is able to perform such reporting for the SCADA system.

The inputs of the line measurement function are

- the Fourier components and true RMS values of the measured voltages and currents,
- frequency measurement,
- parameters.

The outputs of the line measurement function are

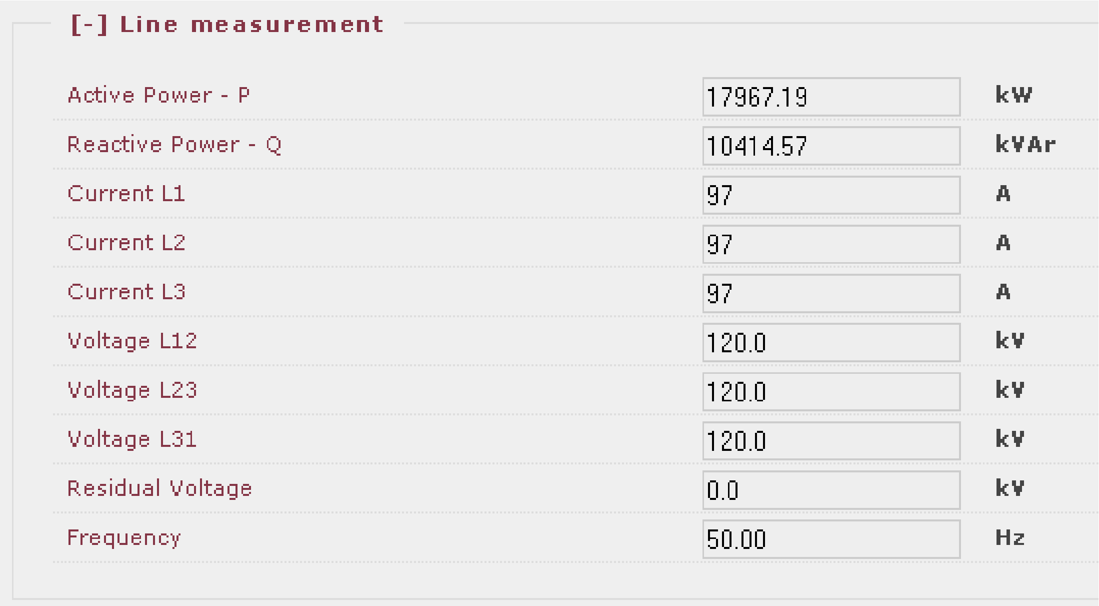
- displayed measured values,
- reports to the SCADA system.

NOTE: the scaling values are entered as parameter setting for the “Voltage input” function block and for the “Current input” function block.

The measured values of the line measurement function depend on the hardware configuration.

The available quantities are described in the relevant configuration description documents.

As an example, the Figure below shows the list of the measured values available in a configuration for compensated networks.



[-] Line measurement

Active Power - P	17967.19	kW
Reactive Power - Q	10414.57	kVAr
Current L1	97	A
Current L2	97	A
Current L3	97	A
Voltage L12	120.0	kV
Voltage L23	120.0	kV
Voltage L31	120.0	kV
Residual Voltage	0.0	kV
Frequency	50.00	Hz

For reporting to the SCADA**,** additional information is needed, which is defined in parameter setting. As an example in a configuration for solidly grounded the following parameters are available:

Parameters

Enumerated parameters

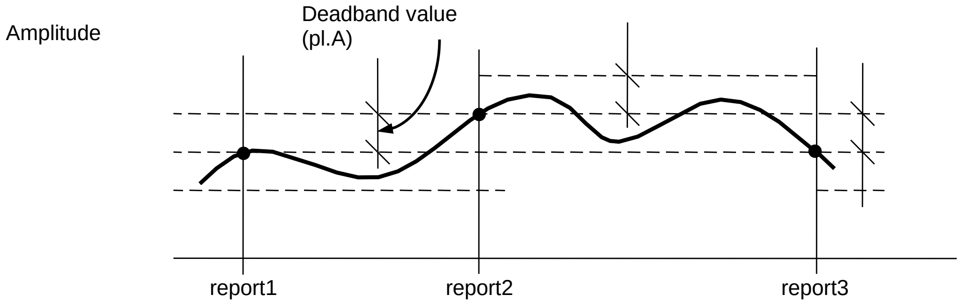
Parameter name	**Title**	**Selection range**	**Default**
Selection of the reporting mode for active power measurement			
MXU_PRepMode_EPar_	Operation ActivePower	Off, Amplitude, Integrated	Amplitude
Selection of the reporting mode for current measurement			
MXU_IRepMode_EPar_	Operation Current	Off, Amplitude, Integrated	Amplitude

Table 98 *Enumerated parameters of the line measurement function*

Floating point parameters

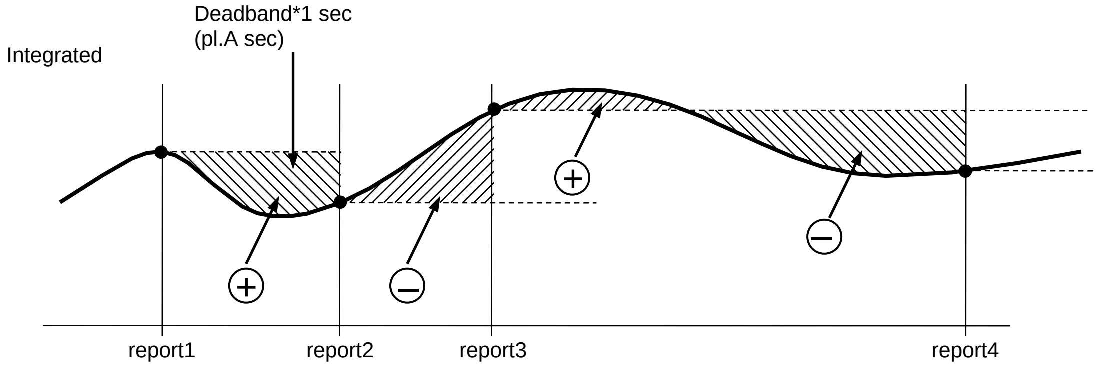
Parameter name	**Title**	**Dim.**	**Min**	**Max**	**Step**	**Default**
Deadband value for the active power						
MXU_PDeadB_FPar_	Deadband value - P	MW	0.1	100000	0.01	10
Range value for the active power						
MXU_PRange_FPar_	Range value - P	MW	1	100000	0.01	500
Deadband value for the current						
MXU_IDeadB_FPar_	Deadband value - I	A	1	2000	1	10
Range value for the current						
MXU_IRange_FPar_	Range value - I	A	1	5000	1	500

Table 99 *Floating point parameters of the line measurement function*



If the “Amplitude” mode is selected for reporting, a report is generated if the measured value leaves the deadband around the previously reported value. As an example, Figure above shows that the current becomes higher than the value reported in “report1” plus the deadband value, this results “report2”, etc.

The “Range” parameters in Table above are needed to evaluate a measurement as “out-of-range”.



If the “Integrated” mode is selected for reporting, a report is generated if the time integral of the measured value since the last report becomes larger, in the positive or negative direction, then the [deadband*1sec] area. As an example, Figure above shows that the integral of the current in time becomes higher than the Deadband value multiplied by 1sec, this results “report2”, etc.

Periodic reporting is generated independently of the changes of the measured values when the defined time period elapses. As an example, the required parameter setting is shown in Table below.

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Reporting time period for the active power						
MXU_PIntPer_IPar_	Report period P	sec	0	3600	1	0
Reporting time period for the current						
MXU_IIntPer_IPar_	Report period I	sec	0	3600	1	0

Table 100 *Integer parameters of the line measurement function*

If the reporting time period is set to 0, then no periodic reporting is performed for this quantity.

All reports can be disabled for a quantity if the reporting mode is set to “Off” by the Selection parameter.

Technical data

Function	Range	Accuracy
Current accuracy		
with CT/5151 or CT/5102 modules	0,2 In – 0,5 In	±2%, ±1 digit
	0,5 In – 20 In	±1%, ±1 digit
with CT/1500 module	0,03 In – 2 In	±0,5%, ±1 digit
Voltage accuracy	5 – 150% of Un	±0.5% of Un, ±1 digit
Power accuracy	I>5% In	±3%, ±1 digit
Frequency accuracy	U>3.5%Un 45Hz – 55Hz	2mHz

Table 101 *Technical data of the line measurement function*

1.3.3 Disturbance recorder

The DV7500 configuration contains a disturbance recorder function. The details are described in the document shown in Table 102.

Name	Title	Document
DRE	Disturbance Rec	***Disturbance recorder function block description***

Table 102 Implemented disturbance recorder function

The recorded analog and digital channels:

Recorded analog signal	**Channel source signal**
phase current 4 HV	MAn_T01 (phase current 4 HV)
phase current 8 HV	MAn_T02 (phase current 8 HV)
phase current 12 HV	MAn_T03 (phase current 12 HV)
phase current 4 MV	MAn_R01 (phase current 4 MV)
phase current 8 MV	MAn_R02 (phase current 8 MV)
phase current 12 MV	MAn_R03 (phase current 12 MV)
Io current MV	MAn_R04 (I4 MV)
phase voltage 4 MV	MAn_O01 (phase voltage 4 MV)
phase voltage 8 MV	MAn_O02 (phase voltage 8 MV)
phase voltage 12 MV	MAn_O03 (phase voltage 12 MV)
Uo voltage MV	MAn_O04 (U4 MV)
Recorded binary signal	**Channel source signal**
General Trip HV	TRC94_GenTr_GrI_HV (General Trip)
General Trip MV	TRC94_GenTr_GrI_MV (General Trip)
Differential Trip	DIF87_GenSt_GrI_ (General Start)
Restricted EF Trip	DIF87N_GenTr_GrI_MV (General Trip)
Inrush	INR2_2HBlk_GrI_HV (Inrush)
PoleDis Trip	PD_GenTr_GrI (General Trip)
Neg.Seq OC Trip	TOC46_GenTr_GrI_HV (General Trip)
Overcurrent Trip C1	TOC51D_GenTr_GrI_C1 (General Trip)
Overcurrent Trip C2	TOC51D_GenTr_GrI_C2 (General Trip)
Overcurrent Trip HV1	TOC51D_GenTr_GrI_HV1 (General Trip)
Overcurrent Trip HV2	TOC51D_GenTr_GrI_HV2 (General Trip)
Overcurrent Trip MV1	TOC51D_GenTr_GrI_MV1 (General Trip)
Overcurrent Trip MV2	TOC51D_GenTr_GrI_MV2 (General Trip)
Overvoltage Trip MV1	TOV59_GenTr_GrI_MV1 (General Trip)
Overvoltage Trip MV2	TOV59_GenTr_GrI_MV2 (General Trip)
Res OV Trip V	TOV59N_GenTr_GrI_V (General Trip)
Res OV Trip W	TOV59N_GenTr_GrI_W (General Trip)
Undervoltage Trip MV1	TUV27_GenTr_GrI_MV1 (General Trip)
Undervoltage Trip MV2	TUV27_GenTr_GrI_MV2 (General Trip)
Rec Close	REC79_Close_GrI_ (Close command)

Table 103 Disturbance recorder, recorded analog and digital channels

Enumerated parameter

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

Table 104 The enumerated parameter of the disturbance recorder function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Pre-fault time:						
DRE_PreFault_TPar_	PreFault	msec	100	1000	1	200
Post-fault time:						
DRE_PostFault_TPar_	PostFault	msec	100	1000	1	200
Overall-fault time limit:						
DRE_MaxFault_TPar_	MaxFault	msec	500	10000	1	1000

Table 105 The timer parameters of the disturbance recorder function

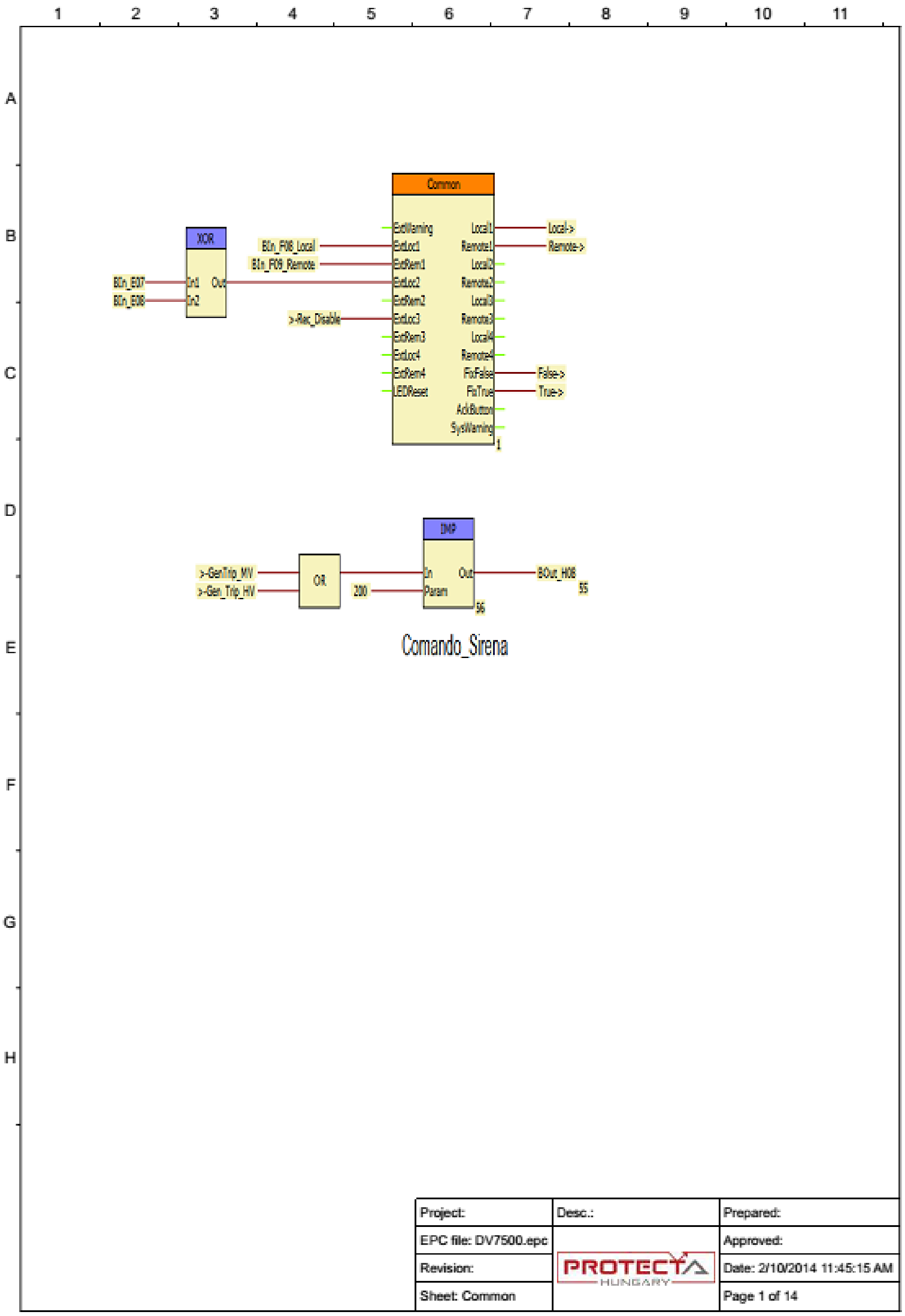
1.3.4 LED assignment

On the front panel of the device there are “User LED”-s with the “Changeable LED description label” (See the document “***Quick start guide to the devices of the EuroProt+ product line***”).

LED title	LED source signal
51_S1_AT e 51_S2_AT	TOC51D_GenTr_Grl_HV1 (General Trip)
51_S1_MT e 51_S2_MT	TOC51D_GenTr_Grl_MV1 (General Trip)
59Vo_V e 59Vo_W	TOV59N_GenTr_Grl_V (General Trip)
59V_S2	TOV59_GenTr_Grl_MV2 (General Trip)
Scatto Differenziale	DIF87N_GenTr_Grl_MV (General Trip)
Scatti TR	Trip_HV_MV_gen ()
Avv_Gen	GenStartMV (General Start MV)
Locale	BIn_F08_Local (Local mode)
79 Esclusa	Common_Local3_Grl_ (Local 3)
79 Inclusa	REC_enable ()
79 x CRC	REC79_InProg_Grl_ (AR in progress)
90 Manuale	ATCC_Man ()
90 Automatico	ATCC_Aut (Automatic mode)
C AX Tensione	ATCC_HigherCmd_Grl_ (Higher Command)
C DX Tensione	ATCC_LowerCmd_Grl_ (Lower Command)
SN	Common_Local2_Grl_ (Local 2)

Table 106 LED assignment of the DV7500

2 Logic editor sheets



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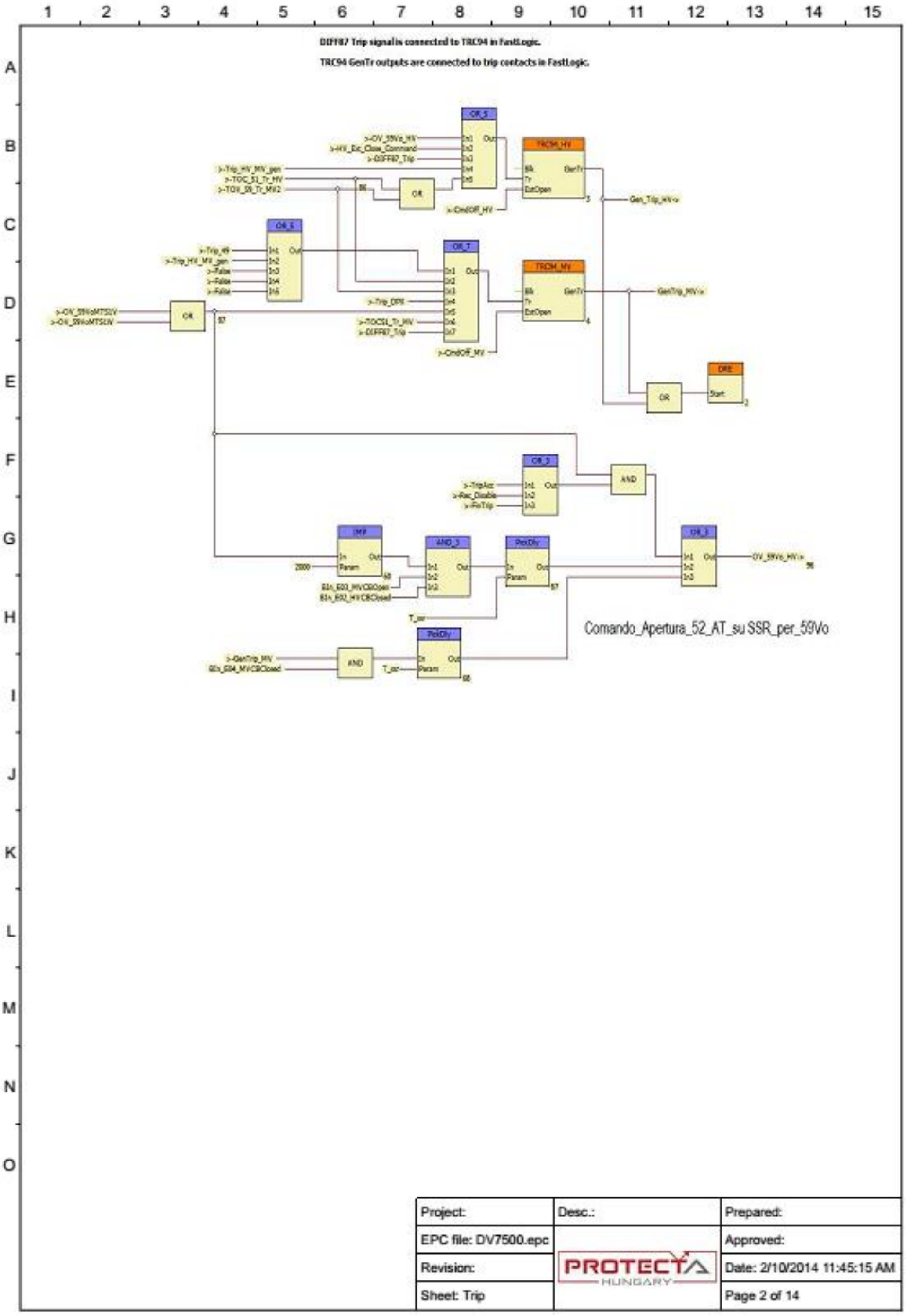
DIFF87 Trip signal is connected to TRC94 in FastLogic.
TRC94 GenTr outputs are connected to trip contacts in FastLogic.
OR_5
>-OV_59Vo_HV
>-HV_Ext_Close_Command
>-DIFF87_Trip
>-Trip_HV_MV_gen
>-TOC_51_Tr_HV
>-TOV_59_Tr_MV2
OR
TRC94_HV
Blk
Tr
ExtOpen
GenTr
>-CmdOff_HV
Gen_Trip_HV<
OR_5
>-Trip_49
>-Trip_HV_MV_gen
>-False
>-False
>-False
OR_7
>-Trip_DPR
>-TOC51_Tr_MV
>-DIFF87_Trip
>-CmdOff_MV
TRC94_MV
GenTrip_MV<
>-OV_59VoMTS2V
>-OV_59VoMTS1N
OR
OR
DRE
Start
OR_3
>-TripAcc
>-Rec_Disable
>-FinTrip
AND
IMP
In
Param
Out
2000
AND_3
BIn_E03_MVCBOpen
BIn_E02_HVCBClosed
PickDly
T_ar
OR_3
OV_59Vo_HV<
Comando_Apertura_52_AT_su SSR_per_59Vo
>-GenTrip_MV
BIn_E04_MVCBClosed
AND
PickDly
T_ar
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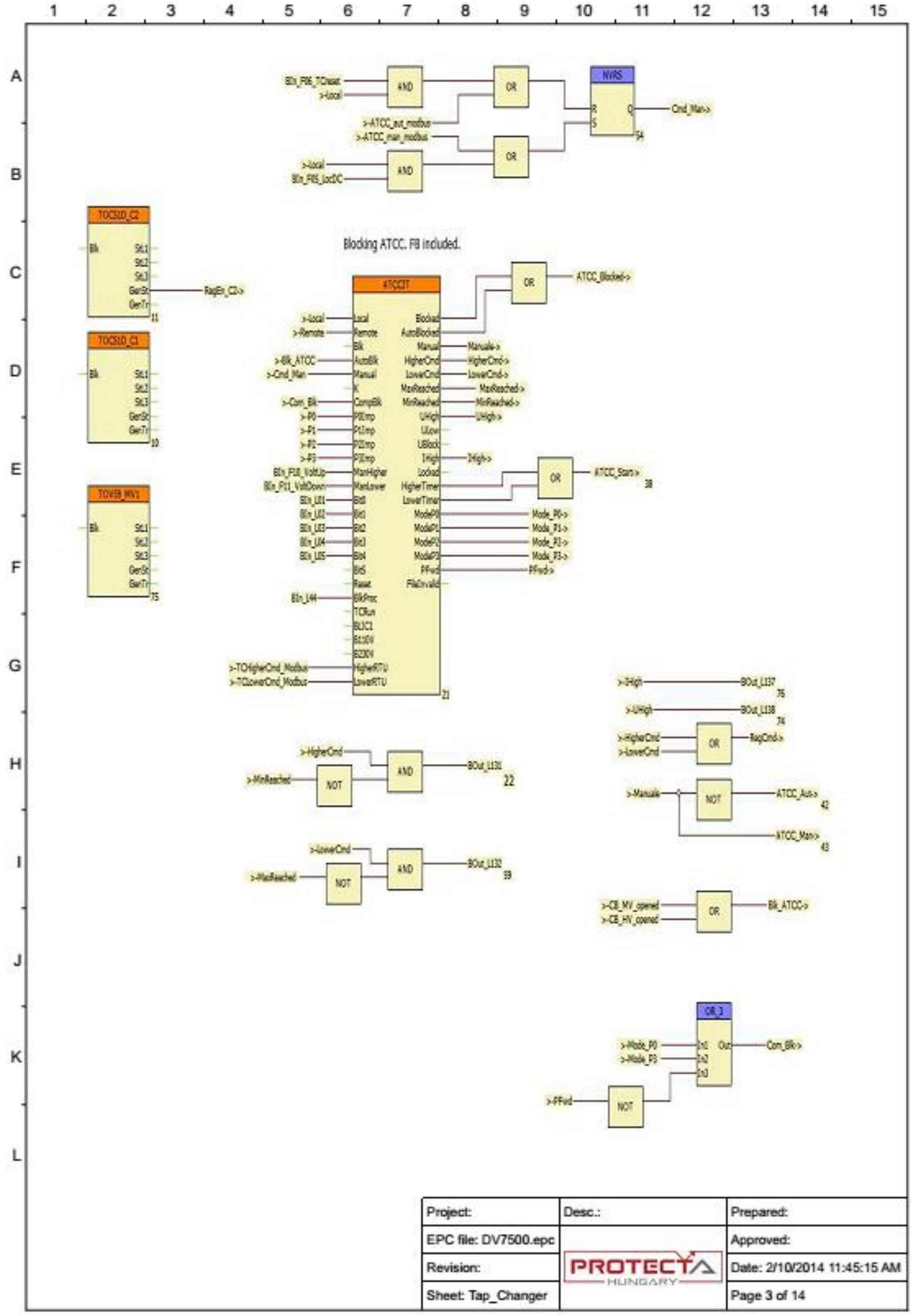
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L
BIn_F06_TCreset
>-Local
AND
OR
NVRS
R
S
Q
Cmd_Man->
54
>-ATCC_aut_modbus
>-ATCC_man_modbus
>-Local
BIn_F05_LocDC
AND
OR
TOC51D_C2
Blk
St1
St2
St3
GenSt
GenTr
11
RegEn_C2->
TOC51D_C1
Blk
St1
St2
St3
GenSt
GenTr
10
TOV59_MV1
Blk
St1
St2
St3
GenSt
GenTr
75
Blocking ATCC. FB included.
ATCCIT
>-Local
>-Remote
>-Blk_ATCC
>-Cmd_Man
>-Com_Blk
>-P0
>-P1
>-P2
>-P3
BIn_F10_VoltUp
BIn_F11_VoltDown
BIn_U01
BIn_U02
BIn_U03
BIn_U04
BIn_U05
BIn_L44
>-TCHigherCmd_Modbus
>-TCLowerCmd_Modbus
Local
Remote
Blk
AutoBlk
Manual
K
CompBlk
P0Imp
P1Imp
P2Imp
P3Imp
ManHigher
ManLower
Bit0
Bit1
Bit2
Bit3
Bit4
Bit5
Reset
BlkProc
TCRun
B1IC1
B110V
B230V
HigherRTU
LowerRTU
Blocked
AutoBlocked
Manual
HigherCmd
LowerCmd
MaxReached
MinReached
UHigh
ULow
UBlock
IHigh
Locked
HigherTimer
LowerTimer
ModeP0
ModeP1
ModeP2
ModeP3
PFwd
FileInvalid
21
OR
ATCC_Blocked->
Manuale->
HigherCmd->
LowerCmd->
MaxReached->
MinReached->
UHigh->
IHigh->
OR
ATCC_Start->
38
Mode_P0->
Mode_P1->
Mode_P2->
Mode_P3->
PFwd->
>-IHigh
BOut_L137
76
>-UHigh
BOut_L138
74
>-HigherCmd
>-LowerCmd
OR
RegCmd->
>-Manuale
NOT
ATCC_Aut->
42
ATCC_Man->
43
>-HigherCmd
>-MinReached
NOT
AND
BOut_L131
22
>-LowerCmd
>-MaxReached
NOT
AND
BOut_L132
59
>-CB_MV_opened
>-CB_HV_opened
OR
Blk_ATCC->
OR_3
>-Mode_P0
>-Mode_P3
In1
In2
In3
Out
Com_Blk->
>-PFwd
NOT
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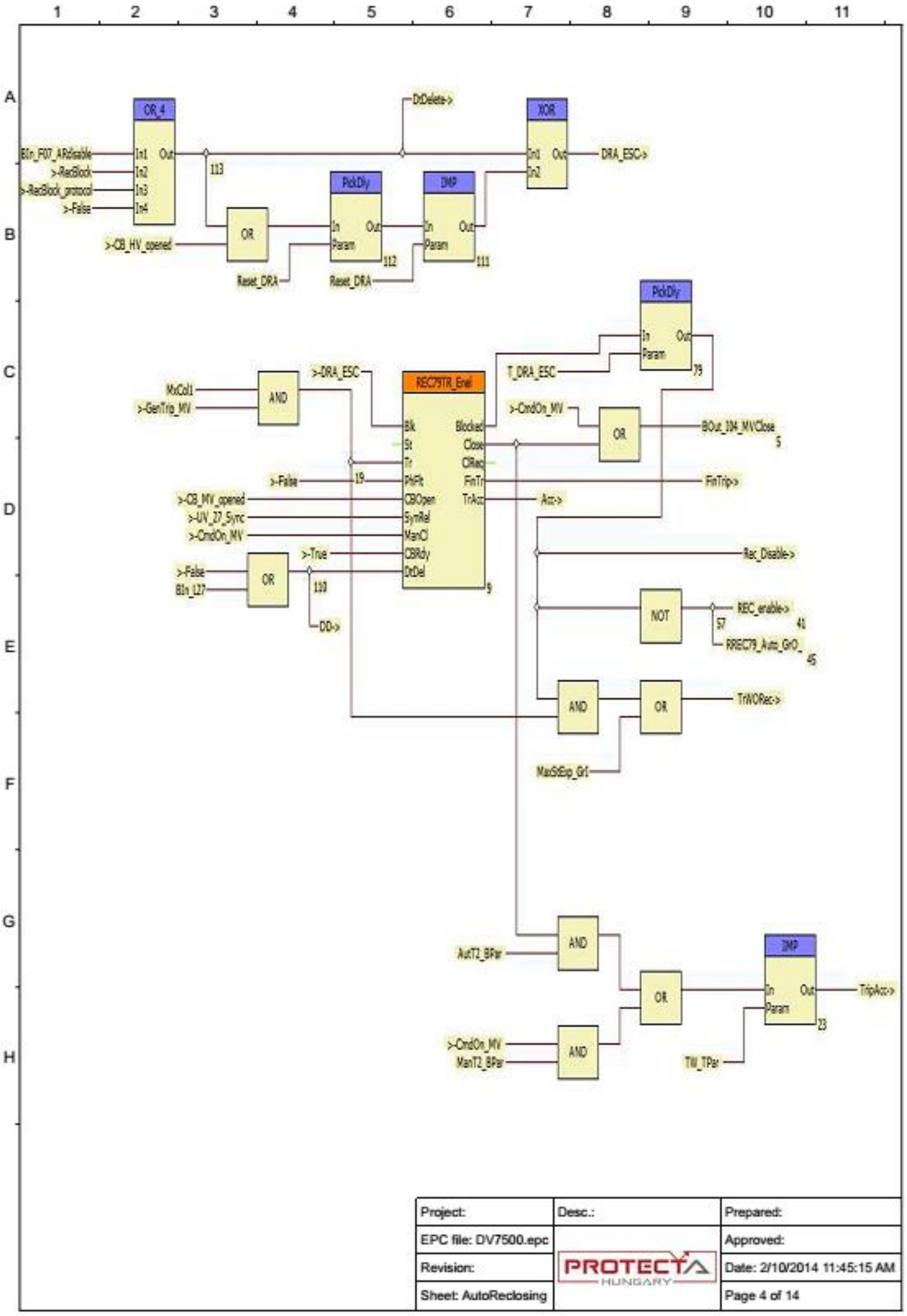
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OR_4
BIn_F07_ARdisable
>-RecBlock
>-RecBlock_protocol
>-False
In1
In2
In3
In4
Out
113
DrDelete->
XOR
In1
In2
Out
DRA_ESC->
OR
>-CB_HV_opened
PickDly
In
Param
Out
112
Reset_DRA
DMP
In
Param
Out
111
Reset_DRA
PickDly
In
Param
Out
79
T_DRA_ESC
MxCol1
>-GenTrip_MV
AND
>-DRA_ESC
REC79TR_Enel
Blk
St
Tr
PhFlt
CBOpen
SynRel
ManCl
CBRdy
DrDel
Blocked
Close
ClRec
FinTr
TrAcc
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19
>-False
>-CB_MV_opened
>-UV_27_Sync
>-CmdOn_MV
>-True
>-False
BIn_L27
OR
110
DD->
>-CmdOn_MV
OR
BOut_104_MVClose
5
FinTrip->
Acc->
Rec_Disable->
NOT
REC_enable->
57
41
RREC79_Auto_GrO_
45
AND
OR
TrWORec->
MaxStExp_Gr1
AND
AutT2_BPar
OR
AND
>-CmdOn_MV
ManT2_BPar
DMP
In
Param
Out
23
TW_TPar
TripAcc->
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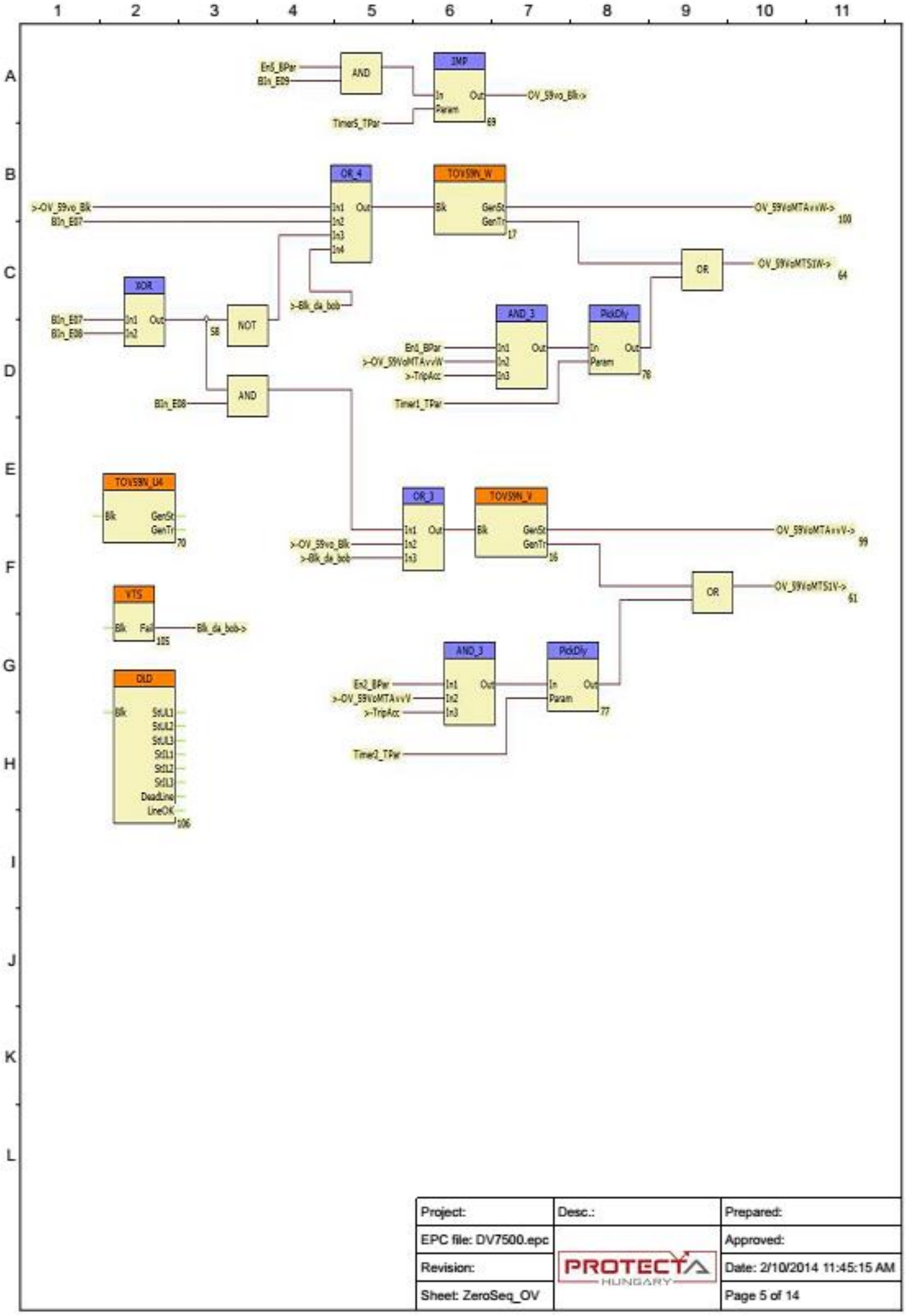
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En5_BPar
BIn_E09
AND
Timer5_TPar
IMP
In
Param
Out
69
OV_59vo_Blk->
>-OV_59vo_Blk
BIn_E07
OR_4
In1
In2
In3
In4
Out
TOV59N_W
Blk
GenSt
GenTr
17
OV_59VoMTAvvW->
100
OR
OV_59VoMTS1W->
64
XOR
BIn_E07
BIn_E08
In1
In2
Out
58
NOT
>-Blk_da_bob
AND_3
En1_BPar
>-OV_59VoMTAvvW
>-TripAcc
In1
In2
In3
Out
PickDly
In
Param
Out
78
Timer1_TPar
AND
BIn_E08
TOV59N_U4
Blk
GenSt
GenTr
70
OR_3
>-OV_59vo_Blk
>-Blk_da_bob
In1
In2
In3
Out
TOV59N_V
Blk
GenSt
GenTr
16
OV_59VoMTAvvV->
99
OR
OV_59VoMTS1V->
61
VTS
Blk
Fail
105
Blk_da_bob->
AND_3
En2_BPar
>-OV_59VoMTAvvV
>-TripAcc
In1
In2
In3
Out
PickDly
In
Param
Out
77
Timer2_TPar
DLD
Blk
StUL1
StUL2
StUL3
StIL1
StIL2
StIL3
DeadLine
LineOK
106
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Revision:
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Prepared:
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Date: 2/10/2014 11:45:15 AM
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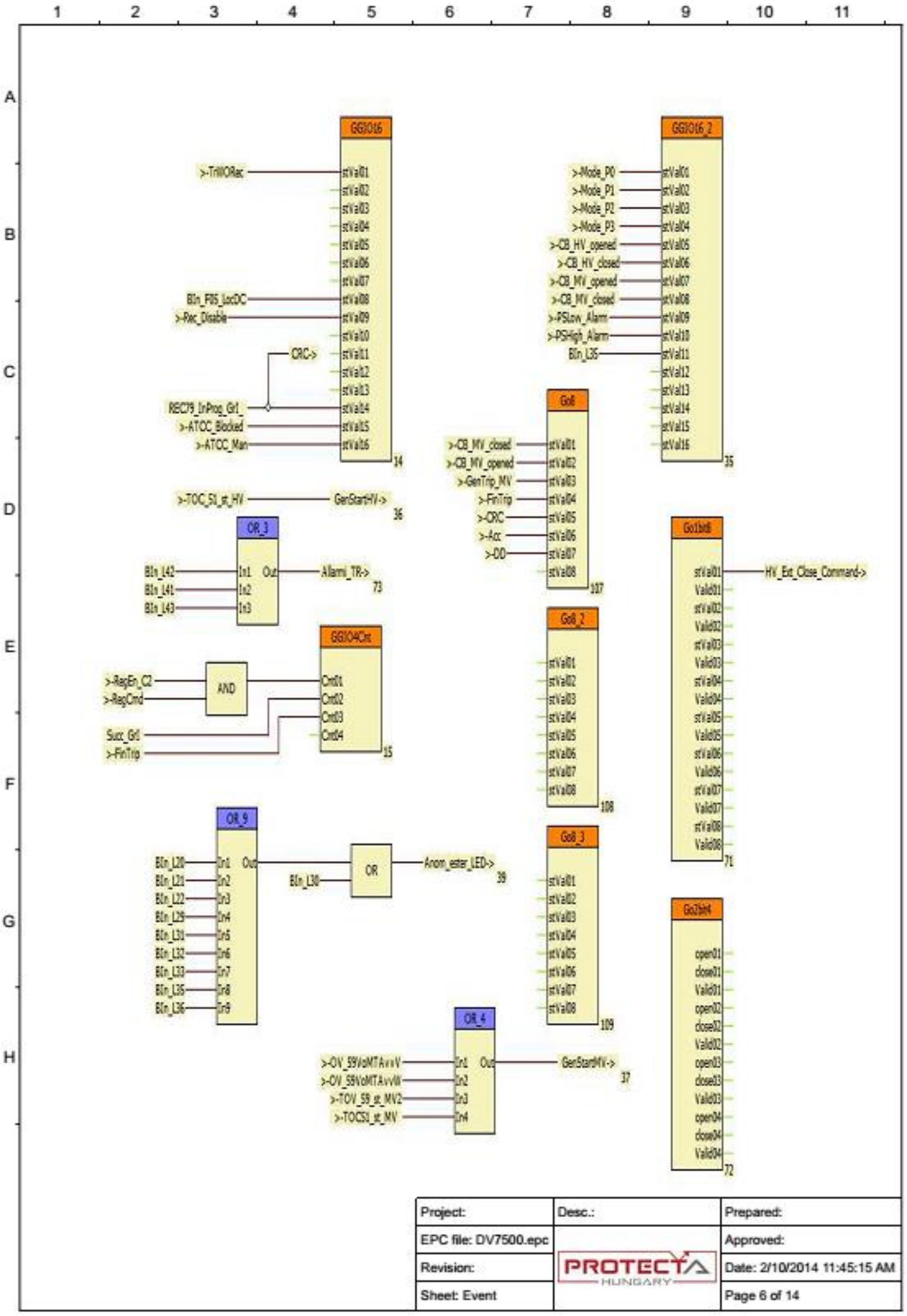
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GGIO16
>-TrWORec
stVal01
stVal02
stVal03
stVal04
stVal05
stVal06
stVal07
BIn_F05_LocDC
stVal08
>-Rec_Disable
stVal09
stVal10
CRC->
stVal11
stVal12
stVal13
REC79_InProg_Gr1_
stVal14
>-ATOC_Blocked
stVal15
>-ATOC_Man
stVal16
14
GGIO16_2
>-Mode_P0
stVal01
>-Mode_P1
stVal02
>-Mode_P2
stVal03
>-Mode_P3
stVal04
>-CB_HV_opened
stVal05
>-CB_HV_closed
stVal06
>-CB_MV_opened
stVal07
>-CB_MV_closed
stVal08
>-PSLow_Alarm
stVal09
>-PSHigh_Alarm
stVal10
BIn_L35
stVal11
stVal12
stVal13
stVal14
stVal15
stVal16
35
Go8
>-CB_MV_closed
stVal01
>-CB_MV_opened
stVal02
>-GenTrip_MV
stVal03
>-FinTrip
stVal04
>-CRC
stVal05
>-Acc
stVal06
>-DD
stVal07
stVal08
107
>-TOC_51_st_HV
GenStartHV->
36
OR_3
BIn_L42
BIn_L41
BIn_L43
In1
In2
In3
Out
Allarmi_TR->
73
GGIO4Cnt
>-RegEn_C2
>-RegCmd
AND
Succ_Gr1
>-FinTrip
Cnt01
Cnt02
Cnt03
Cnt04
15
Go8_2
stVal01
stVal02
stVal03
stVal04
stVal05
stVal06
stVal07
stVal08
108
Go1bit8
stVal01
HV_Ext_Close_Command->
Valid01
stVal02
Valid02
stVal03
Valid03
stVal04
Valid04
stVal05
Valid05
stVal06
Valid06
stVal07
Valid07
stVal08
Valid08
71
OR_9
BIn_L20
BIn_L21
BIn_L22
BIn_L29
BIn_L31
BIn_L32
BIn_L33
BIn_L35
BIn_L36
In1
In2
In3
In4
In5
In6
In7
In8
In9
Out
BIn_L30
OR
Anom_ester_LED->
39
Go8_3
stVal01
stVal02
stVal03
stVal04
stVal05
stVal06
stVal07
stVal08
109
Go2bit4
open01
close01
Valid01
open02
close02
Valid02
open03
close03
Valid03
open04
close04
Valid04
72
OR_4
>-OV_59VoMTAvvV
>-OV_59VoMTAvvW
>-TOV_59_st_MV2
>-TOC51_st_MV
In1
In2
In3
In4
Out
GenStartMV->
37
Project:
Desc.:
Prepared:
EPC file: DV7500.epc
Approved:
Revision:
PROTECTA
HUNGARY
Date: 2/10/2014 11:45:15 AM
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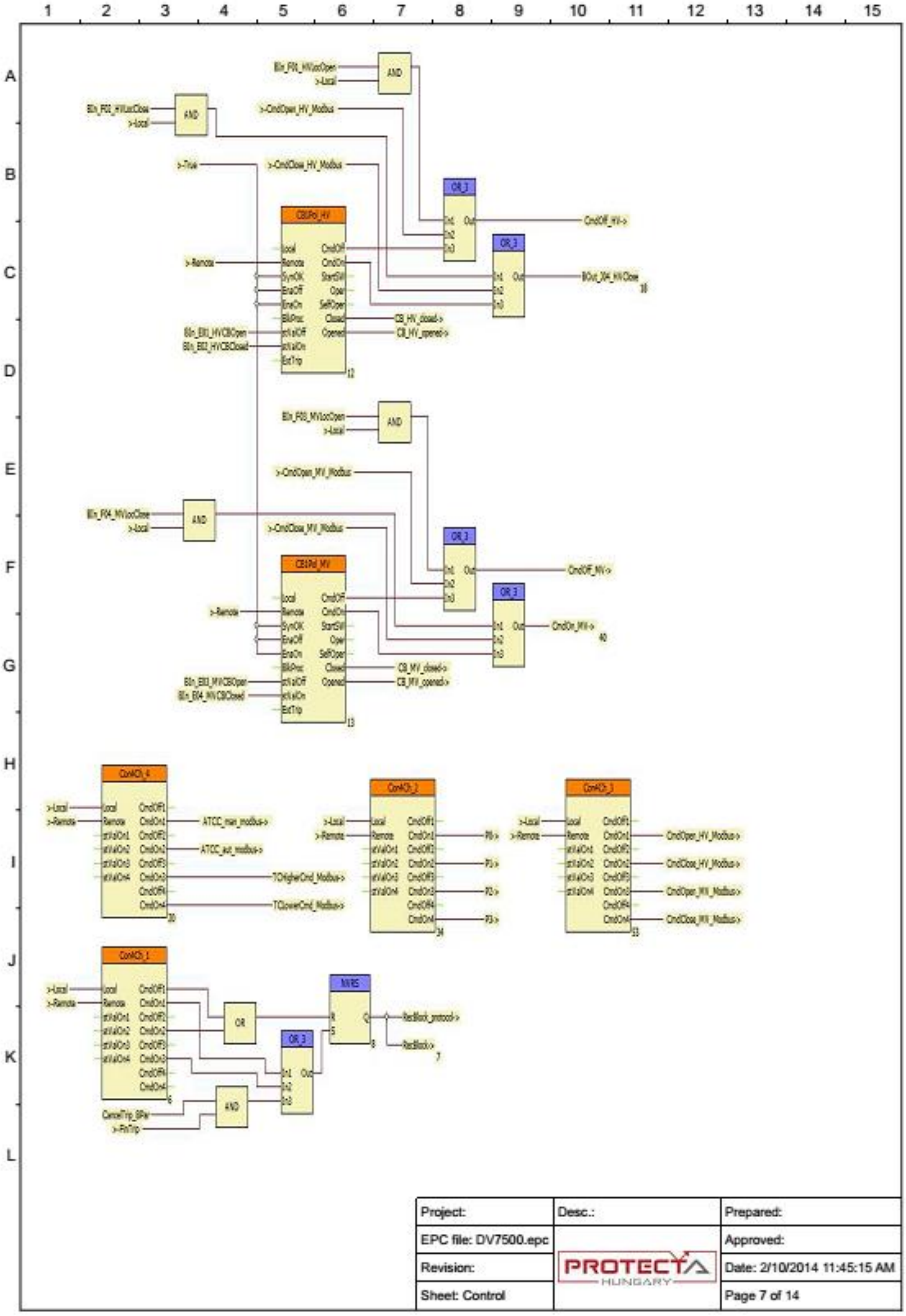
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I
J
K
L
BIn_F01_HVLocOpen
>-Local
AND
BIn_F02_HVLocClose
>-Local
AND
>-CmdOpen_HV_Modbus
>-True
>-CmdClose_HV_Modbus
OR_3
In1
In2
In3
Out
CmdOff_HV->
OR_3
BOut_X04_HVClose
18
CB1Pol_HV
Local
Remote
SynOK
EnaOff
EnaOn
BlkProc
stValOff
stValOn
ExtTrip
CmdOff
CmdOn
StartSW
Oper
SelfOper
Closed
Opened
12
>-Remote
BIn_E01_HVCBOpen
BIn_E02_HVCBClosed
CB_HV_closed->
CB_HV_opened->
BIn_F03_MVLocOpen
>-Local
AND
>-CmdOpen_MV_Modbus
BIn_F04_MVLocClose
>-Local
AND
>-CmdClose_MV_Modbus
OR_3
CmdOff_MV->
OR_3
CmdOn_MV->
40
CB1Pol_MV
>-Remote
BIn_E03_MVCBOpen
BIn_E04_MVCBClosed
CB_MV_closed->
CB_MV_opened->
13
ConACh_4
>-Local
>-Remote
stValOn1
stValOn2
stValOn3
stValOn4
CmdOff1
CmdOn1
CmdOff2
CmdOn2
CmdOff3
CmdOn3
CmdOff4
CmdOn4
ATCC_man_modbus->
ATCC_aut_modbus->
TCHigherCmd_Modbus->
TCLowerCmd_Modbus->
30
ConACh_2
>-Local
>-Remote
P0->
P1->
P2->
P3->
34
ConACh_3
>-Local
>-Remote
CmdOpen_HV_Modbus->
CmdClose_HV_Modbus->
CmdOpen_MV_Modbus->
CmdClose_MV_Modbus->
33
ConACh_1
>-Local
>-Remote
6
OR
OR_3
NVRS
R
S
Q
8
RecBlock_protocol->
RecBlock->
7
CancelTrip_BPar
>-FinTrip
AND
Project:
Desc.:
Prepared:
EPC file: DV7500.epc
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Revision:
PROTECTA HUNGARY
Date: 2/10/2014 11:45:15 AM
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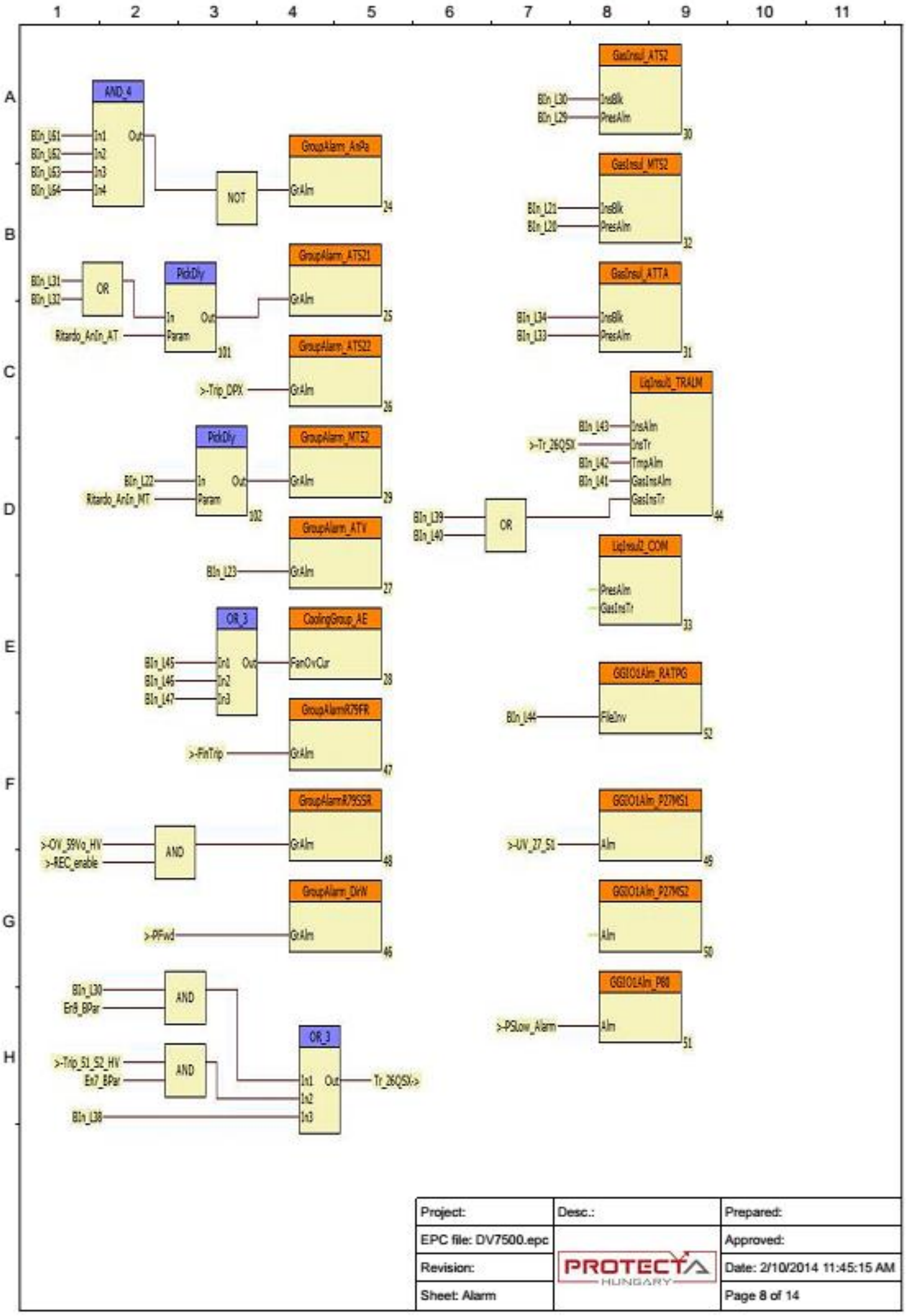

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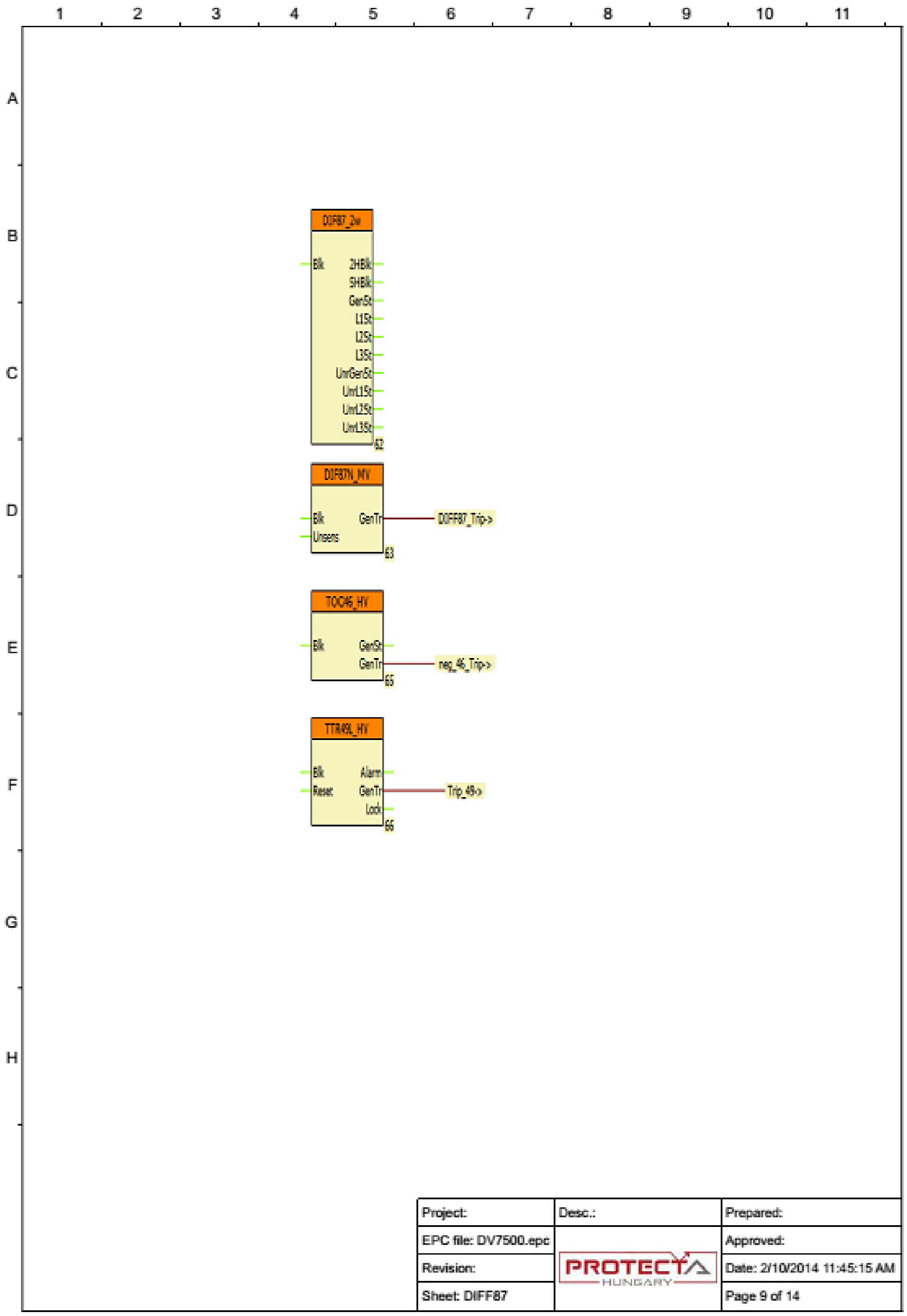
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DIF87_2w
Blk
2HBlk
5HBlk
GenSt
L1St
L2St
L3St
UnrGenSt
UnrL1St
UnrL2St
UnrL3St
62
DIF87N_MV
Blk
Unsens
GenTr
DIFF87_Trip->
63
TOC46_HV
Blk
GenSt
GenTr
neg_46_Trip->
65
TTR49L_HV
Blk
Reset
Alarm
GenTr
Lock
Trip_49->
66
Project:
EPC file: DV7500.epc
Revision:
Sheet: DIFF87
Desc.:
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Prepared:
Approved:
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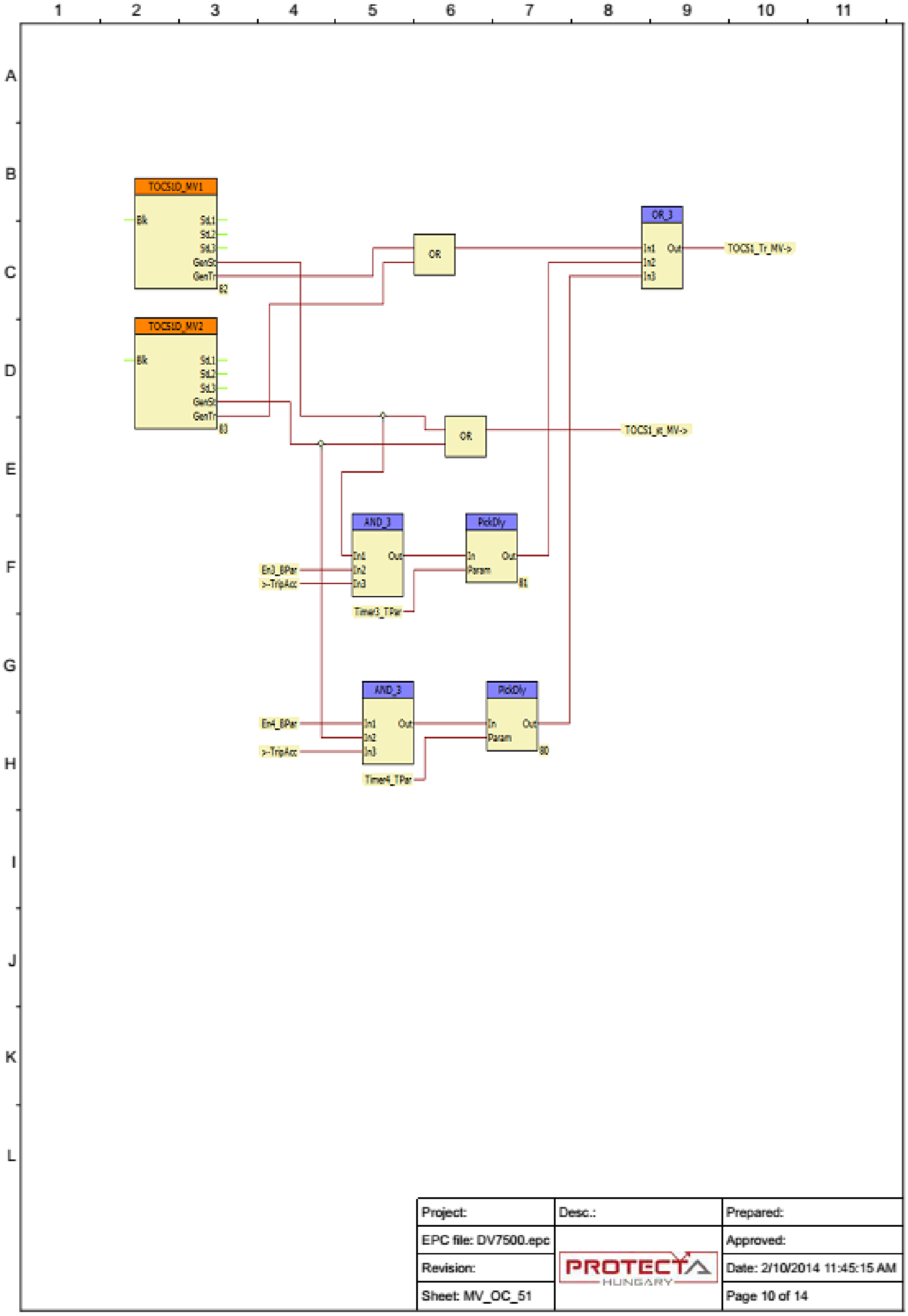
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I
J
K
L
TOC51D_MV1
Blk
St.L1
St.L2
St.L3
GenSt
GenTr
82
TOC51D_MV2
Blk
St.L1
St.L2
St.L3
GenSt
GenTr
83
OR
OR
OR_3
In1
In2
In3
Out
TOC51_Tr_MV->
TOC51_st_MV->
AND_3
In1
In2
In3
Out
En3_BPar
>-TripAcc
Timer3_TPar
PickDly
In
Param
Out
81
AND_3
In1
In2
In3
Out
En4_BPar
>-TripAcc
Timer4_TPar
PickDly
In
Param
Out
80
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Prepared:
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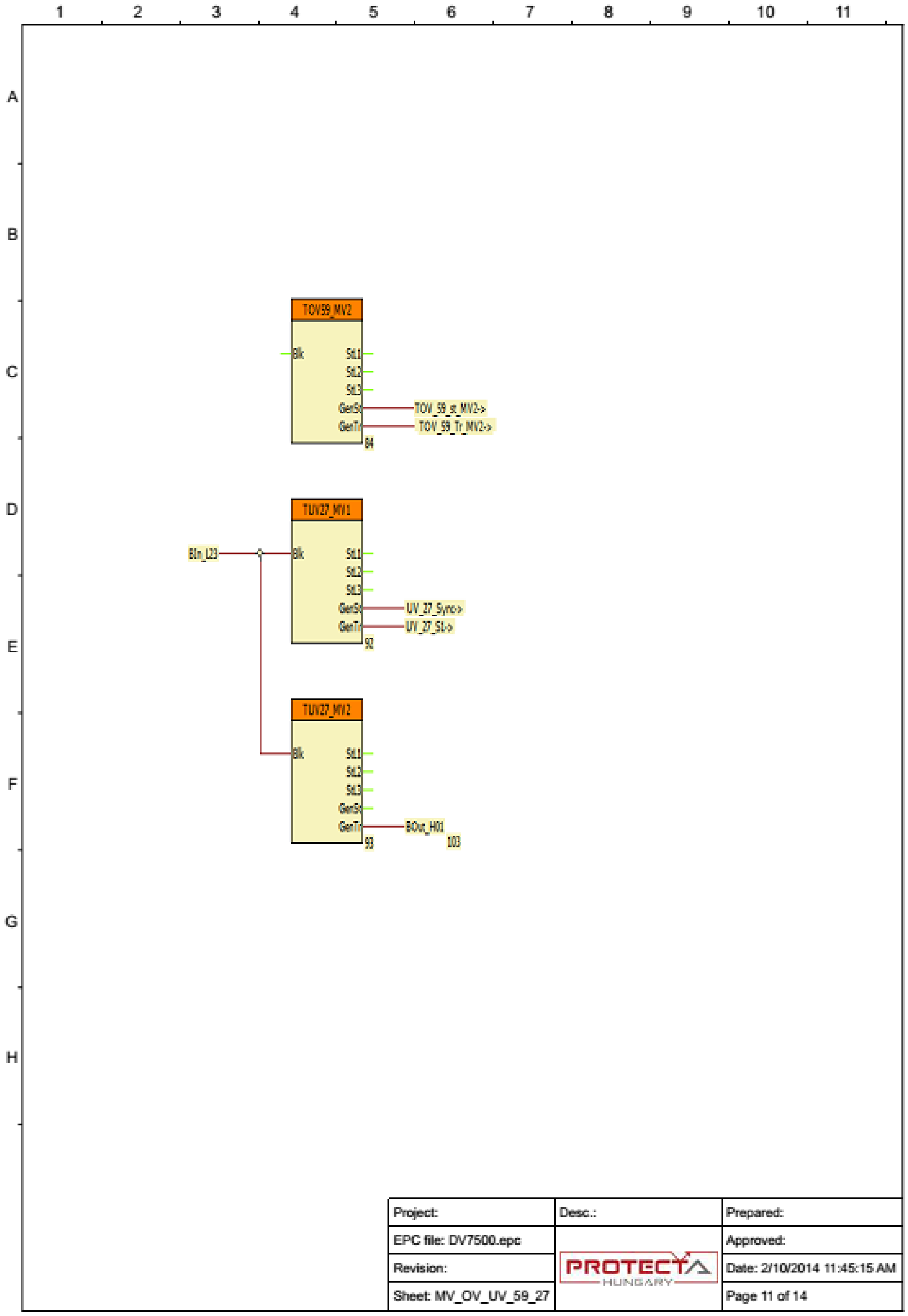
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A
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TOV59_MV2
Blk
StL1
StL2
StL3
GenSt
GenTr
TOV_59_st_MV2->
TOV_59_Tr_MV2->
84
TUV27_MV1
BIn_L23
Blk
StL1
StL2
StL3
GenSt
GenTr
UV_27_Sync->
UV_27_St->
92
TUV27_MV2
Blk
StL1
StL2
StL3
GenSt
GenTr
BOut_H01
103
93
Project:
Desc.:
Prepared:
EPC file: DV7500.epc
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Revision:
Date: 2/10/2014 11:45:15 AM
Sheet: MV_OV_UV_59_27
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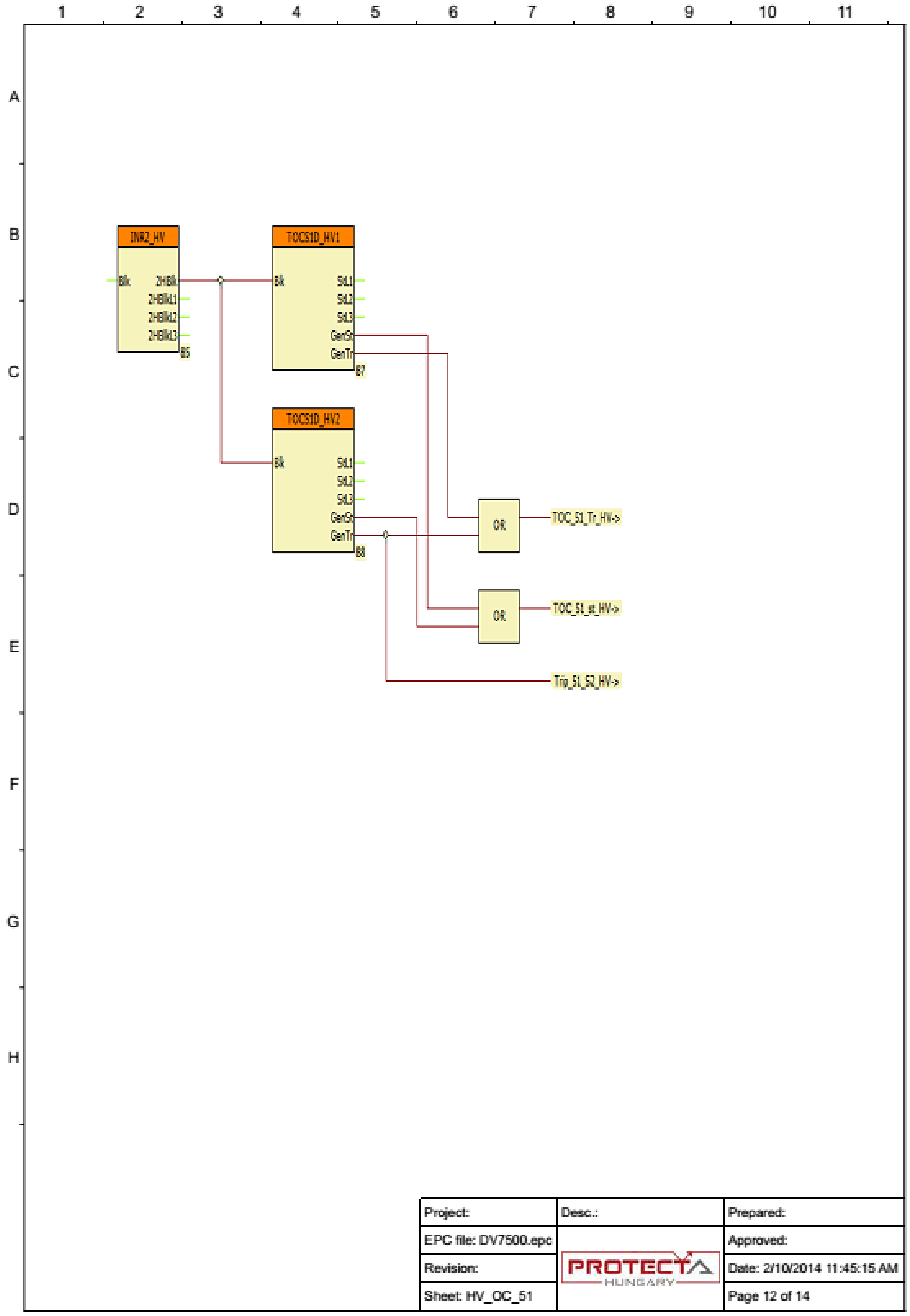
PROTECTA
HUNGARY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INR2_HV
Blk
2HBlk
2HBlkL1
2HBlkL2
2HBlkL3
85
TOC51D_HV1
Blk
StL1
StL2
StL3
GenSt
GenTr
87
TOC51D_HV2
Blk
StL1
StL2
StL3
GenSt
GenTr
88
OR
OR
TOC_51_Tr_HV->
TOC_51_st_HV->
Trip_51_52_HV->
Project:
Desc.:
Prepared:
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Approved:
Revision:
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Sheet: HV_OC_51
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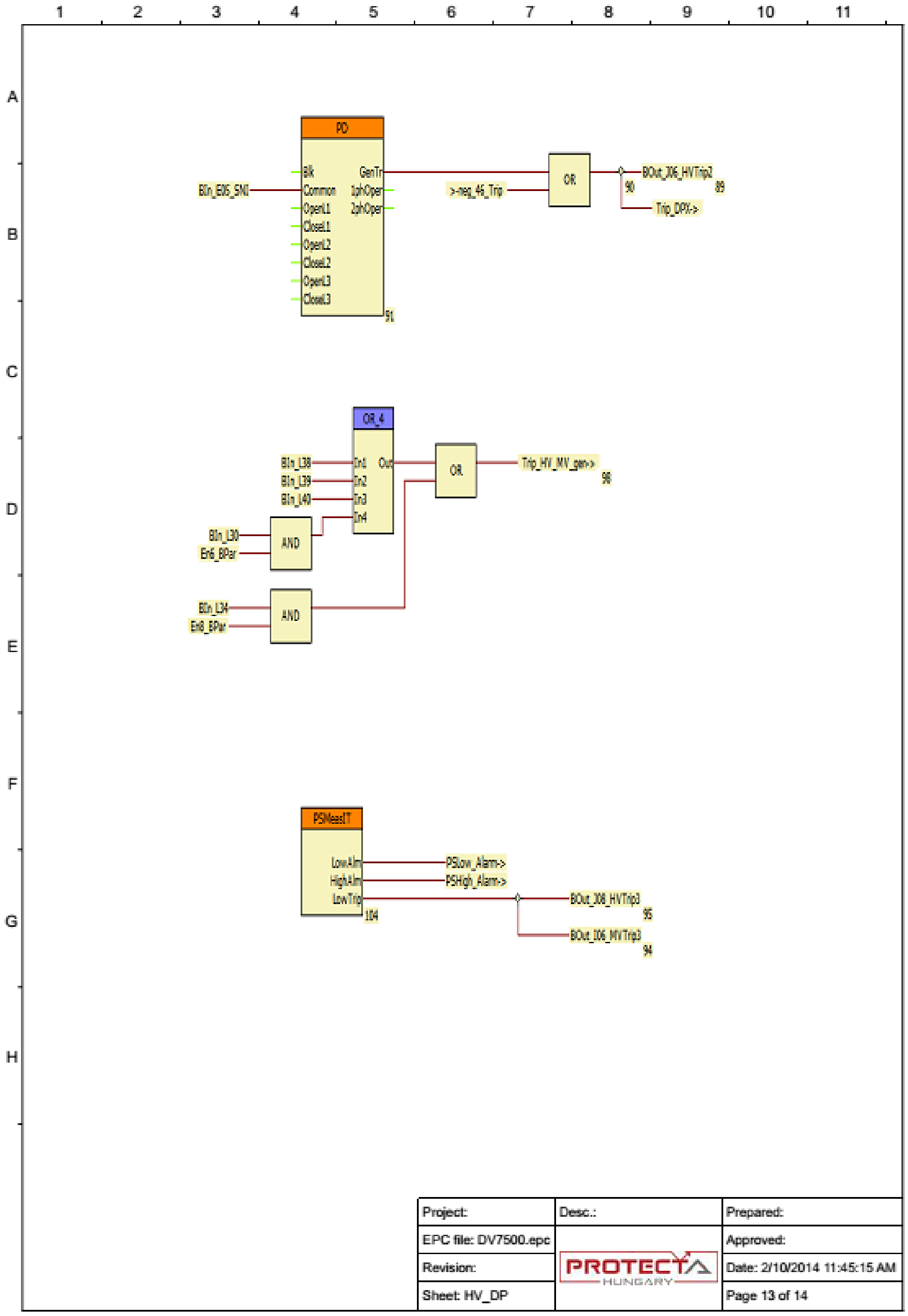
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A
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PD
BIn_E06_SMI
Blk
Common
OpenL1
CloseL1
OpenL2
CloseL2
OpenL3
CloseL3
GenTr
1phOper
2phOper
91
>-neg_46_Trip
OR
BOut_J06_HVTrip2
90
89
Trip_DPX->
OR_4
BIn_L38
BIn_L39
BIn_L40
In1
In2
In3
In4
Out
OR
Trip_HV_MV_gen->
98
BIn_L30
En6_BPar
AND
BIn_L34
En8_BPar
AND
PSMeasIT
LowAlm
HighAlm
LowTrip
104
PSLow_Alarm->
PSHigh_Alarm->
BOut_J08_HVTrip3
95
BOut_I06_MVTrip3
94
Project:
Desc.:
Prepared:
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Approved:
Revision:
PROTECTA HUNGARY
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Sheet: HV_DP
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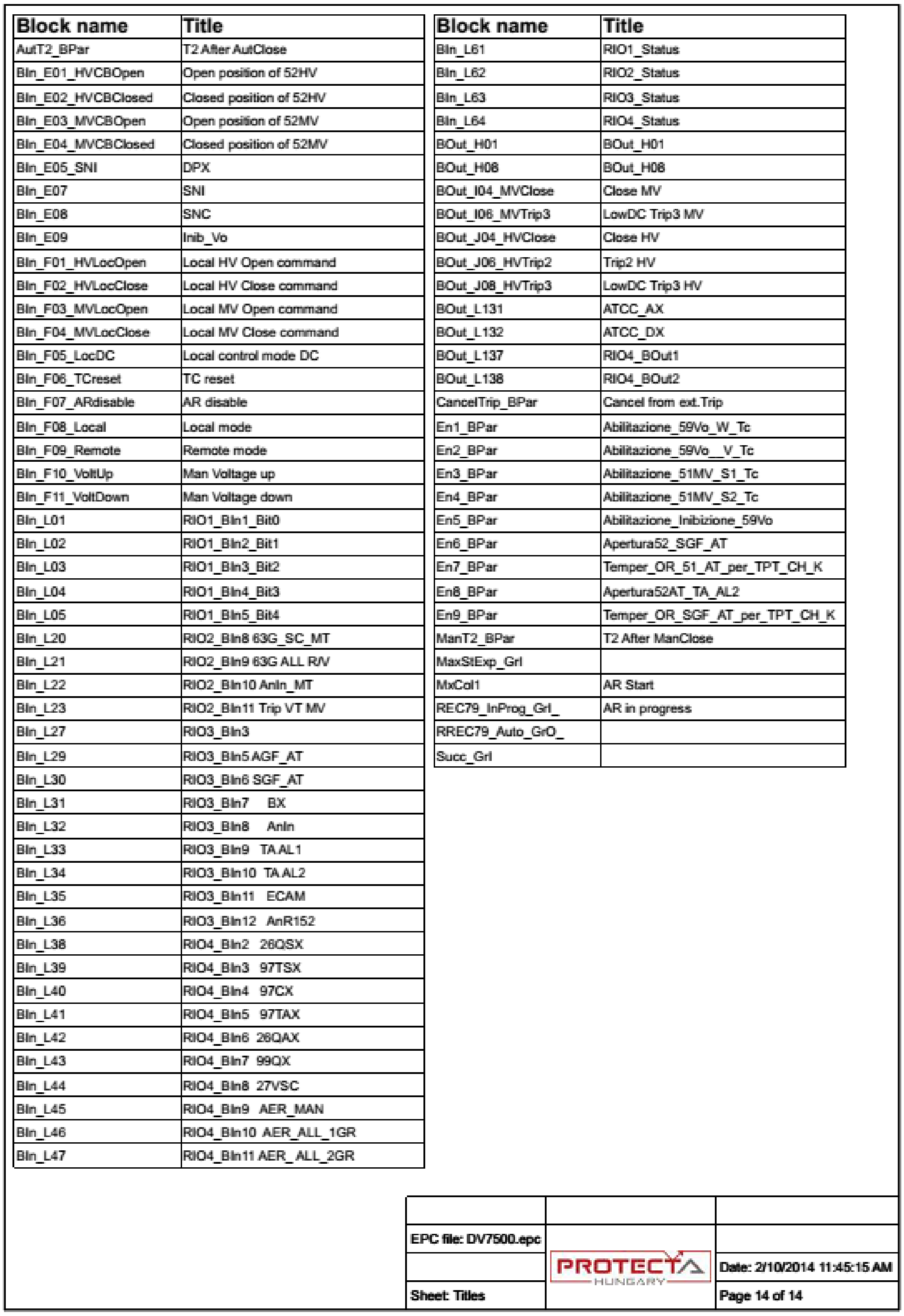

Block name	Title
AutT2_BPar	T2 After AutClose
BIn_E01_HVCBOpen	Open position of 52HV
BIn_E02_HVCBClosed	Closed position of 52HV
BIn_E03_MVCBOpen	Open position of 52MV
BIn_E04_MVCBClosed	Closed position of 52MV
BIn_E05_SNI	DPX
BIn_E07	SNI
BIn_E08	SNC
BIn_E09	Inib_Vo
BIn_F01_HVLocOpen	Local HV Open command
BIn_F02_HVLocClose	Local HV Close command
BIn_F03_MVLocOpen	Local MV Open command
BIn_F04_MVLocClose	Local MV Close command
BIn_F05_LocDC	Local control mode DC
BIn_F06_TCreset	TC reset
BIn_F07_ARdisable	AR disable
BIn_F08_Local	Local mode
BIn_F09_Remote	Remote mode
BIn_F10_VoltUp	Man Voltage up
BIn_F11_VoltDown	Man Voltage down
BIn_L01	RIO1_BIn1_Bit0
BIn_L02	RIO1_BIn2_Bit1
BIn_L03	RIO1_BIn3_Bit2
BIn_L04	RIO1_BIn4_Bit3
BIn_L05	RIO1_BIn5_Bit4
BIn_L20	RIO2_BIn8 63G_SC_MT
BIn_L21	RIO2_BIn9 63G ALL R/V
BIn_L22	RIO2_BIn10 AnIn_MT
BIn_L23	RIO2_BIn11 Trip VT MV
BIn_L27	RIO3_BIn3
BIn_L29	RIO3_BIn5 AGF_AT
BIn_L30	RIO3_BIn6 SGF_AT
BIn_L31	RIO3_BIn7 BX
BIn_L32	RIO3_BIn8 AnIn
BIn_L33	RIO3_BIn9 TA AL1
BIn_L34	RIO3_BIn10 TA AL2
BIn_L35	RIO3_BIn11 ECAM
BIn_L36	RIO3_BIn12 AnR152
BIn_L38	RIO4_BIn2 26QSX
BIn_L39	RIO4_BIn3 97TSX
BIn_L40	RIO4_BIn4 97CX
BIn_L41	RIO4_BIn5 97TAX
BIn_L42	RIO4_BIn6 26QAX
BIn_L43	RIO4_BIn7 99QX
BIn_L44	RIO4_BIn8 27VSC
BIn_L45	RIO4_BIn9 AER_MAN
BIn_L46	RIO4_BIn10 AER_ALL_1GR
BIn_L47	RIO4_BIn11 AER_ ALL_2GR

Block name	Title
BIn_L61	RIO1_Status
BIn_L62	RIO2_Status
BIn_L63	RIO3_Status
BIn_L64	RIO4_Status
BOut_H01	BOut_H01
BOut_H08	BOut_H08
BOut_I04_MVClose	Close MV
BOut_I06_MVTrip3	LowDC Trip3 MV
BOut_J04_HVClose	Close HV
BOut_J06_HVTrip2	Trip2 HV
BOut_J08_HVTrip3	LowDC Trip3 HV
BOut_L131	ATCC_AX
BOut_L132	ATCC_DX
BOut_L137	RIO4_BOut1
BOut_L138	RIO4_BOut2
CancelTrip_BPar	Cancel from ext.Trip
En1_BPar	Abilitazione_59Vo_W_Tc
En2_BPar	Abilitazione_59Vo__V_Tc
En3_BPar	Abilitazione_51MV_S1_Tc
En4_BPar	Abilitazione_51MV_S2_Tc
En5_BPar	Abilitazione_Inibizione_59Vo
En6_BPar	Apertura52_SGF_AT
En7_BPar	Temper_OR_51_AT_per_TPT_CH_K
En8_BPar	Apertura52AT_TA_AL2
En9_BPar	Temper_OR_SGF_AT_per_TPT_CH_K
ManT2_BPar	T2 After ManClose
MaxStExp_GrI	
MxCol1	AR Start
REC79_InProg_GrI_	AR in progress
RREC79_Auto_GrO_	
Succ_GrI	

EPC file: DV7500.epc

Date: 2/10/2014 11:45:15 AM

Sheet: Titles

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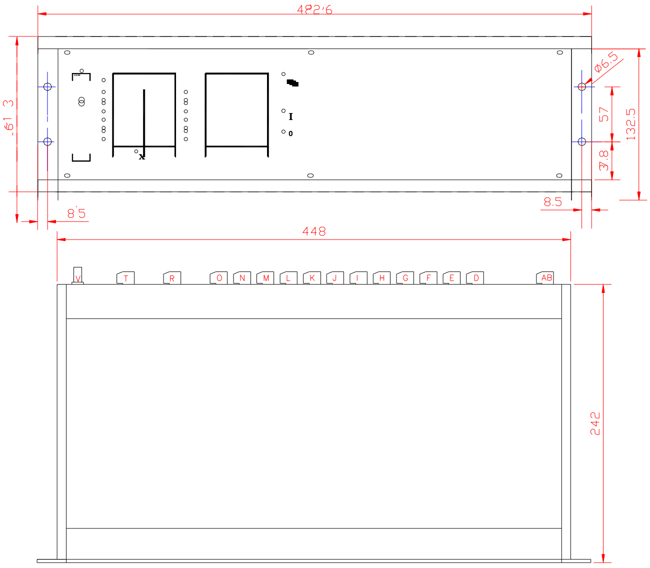
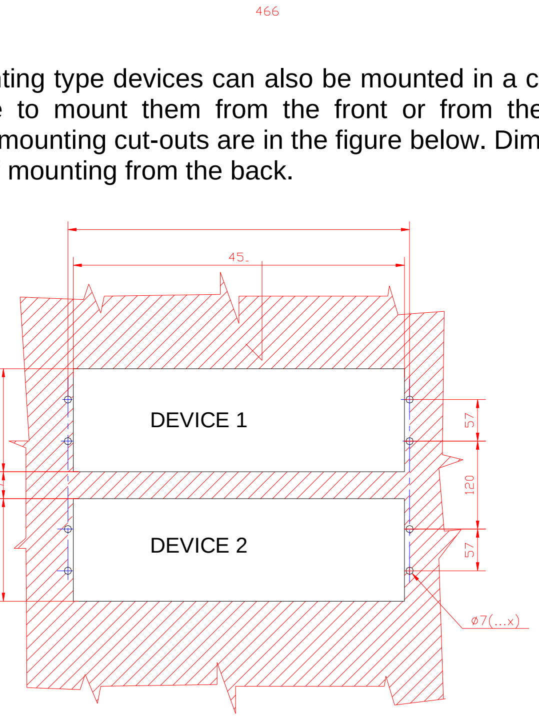
3 Mounting of the device

The DV7500 devices are 84HP wide and intended to be mounted into racks. The dimensions of them are shown in the drawings below.



PANEL CUT-OUT



Note that rack mounting type devices can also be mounted in a cut-out (e.g. on a switchgear door). It is possible to mount them from the front or from the back of the cut-out. The dimensions for rack mounting cut-outs are in the figure below. Dimensions in brackets are applicable in case of mounting from the back.

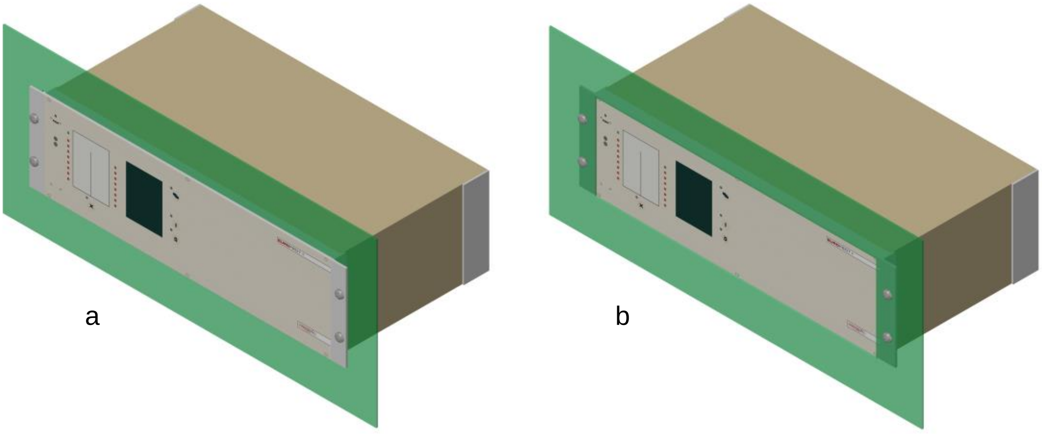
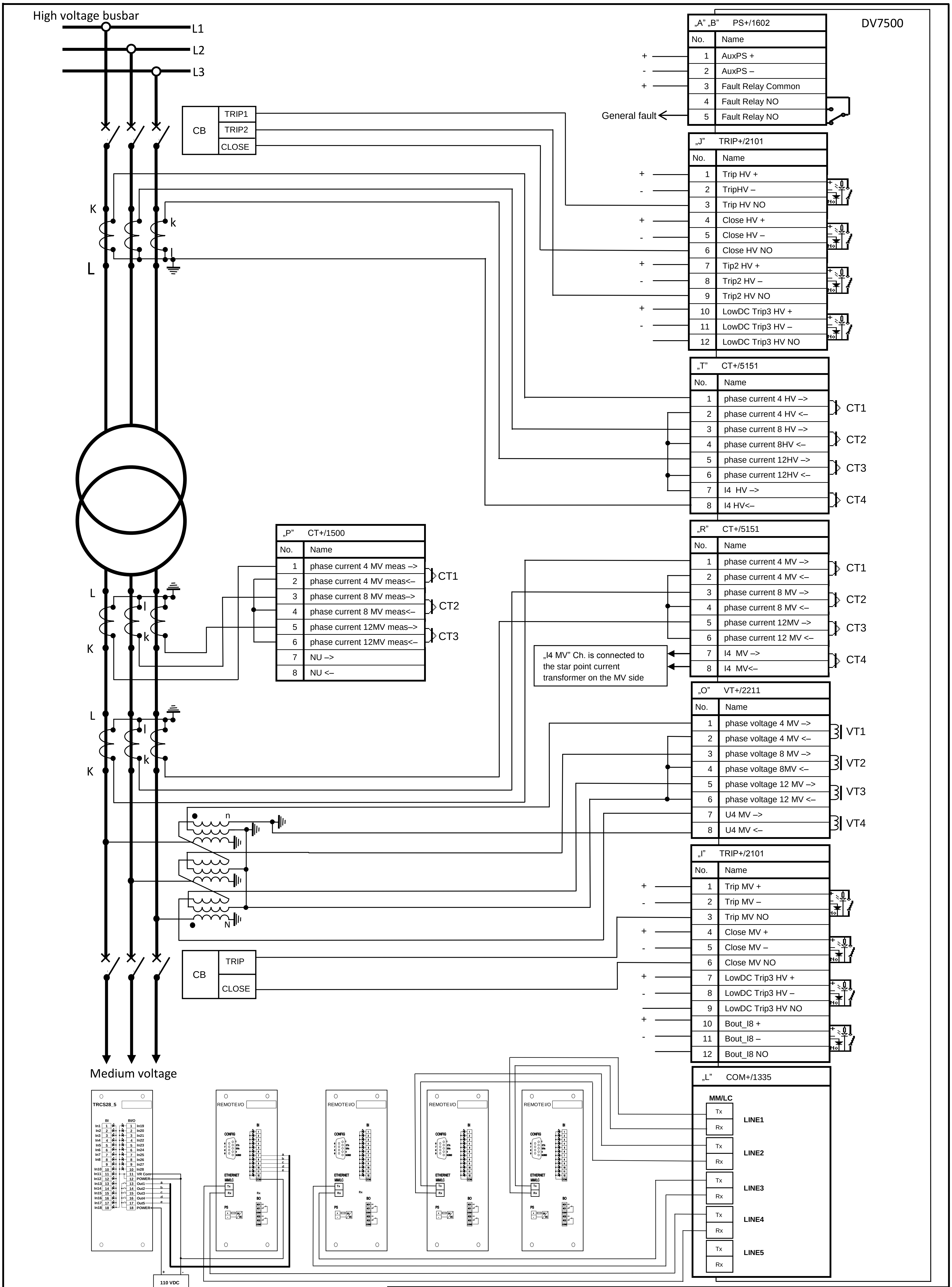


Figure 4 3D illustration for rack mounting of 84 HP device
(a - from the front; b - from the back)

4 Connection diagram



„A" „B" PS+/1602

No.	Name
1	AuxPS +
2	AuxPS –
3	Fault Relay Common
4	Fault Relay NO
5	Fault Relay NO

„J" TRIP+/2101

No.	Name
1	Trip HV +
2	TripHV –
3	Trip HV NO
4	Close HV +
5	Close HV –
6	Close HV NO
7	Tip2 HV +
8	Trip2 HV –
9	Trip2 HV NO
10	LowDC Trip3 HV +
11	LowDC Trip3 HV –
12	LowDC Trip3 HV NO

„T" CT+/5151

No.	Name
1	phase current 4 HV –>
2	phase current 4 HV <–
3	phase current 8 HV –>
4	phase current 8HV <–
5	phase current 12HV –>
6	phase current 12HV <–
7	I4 HV –>
8	I4 HV<–

„P" CT+/1500

No.	Name
1	phase current 4 MV meas –>
2	phase current 4 MV meas<–
3	phase current 8 MV meas–>
4	phase current 8 MV meas<–
5	phase current 12MV meas–>
6	phase current 12MV meas<–
7	NU –>
8	NU <–

„R" CT+/5151

No.	Name
1	phase current 4 MV –>
2	phase current 4 MV <–
3	phase current 8 MV –>
4	phase current 8 MV <–
5	phase current 12MV –>
6	phase current 12 MV <–
7	I4 MV –>
8	I4 MV<–

„O" VT+/2211

No.	Name
1	phase voltage 4 MV –>
2	phase voltage 4 MV <–
3	phase voltage 8 MV –>
4	phase voltage 8MV <–
5	phase voltage 12 MV –>
6	phase voltage 12 MV <–
7	U4 MV –>
8	U4 MV <–

„I" TRIP+/2101

No.	Name
1	Trip MV +
2	Trip MV –
3	Trip MV NO
4	Close MV +
5	Close MV –
6	Close MV NO
7	LowDC Trip3 HV +
8	LowDC Trip3 HV –
9	LowDC Trip3 HV NO
10	Bout_I8 +
11	Bout_I8 –
12	Bout_I8 NO

„L" COM+/1335

MM/LC

Tx Rx	LINE1
Tx Rx	LINE2
Tx Rx	LINE3
Tx Rx	LINE4
Tx Rx	LINE5

Edit by	Balogh N	Platform Type Config	IED-EP+ DTRV DV7500
Checked	Tóth J.		
Approved by	Günthner R.		
Prod.manager		Subject	CONNECTION DIAGRAM
Data	21.11.2018.		

ID PP-14-20920-02

Pages: