EUROPROT +

Automatic tap changer controller for parallel transformers; Function block description

PROTECTA HUNGARY

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User's manual version information

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Preliminary	24.11.2010	Preliminary version, without technical information	Petri
V1.0	13.12.2010	First edition for single transformers	Petri
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V1.1	20.12.2012	Corrected formula for complex compensation	Petri
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CONTENTS

1 Automatic tap changer controller

1.1 Application

One of the most important criteria for power quality is to keep the voltage of selected points of the network 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.

Depending on the selected mode of operation this version of the controller can be applied to regulate a single transformer or to control parallel transformers.

When transformers are connected parallel, i.e. they are connected to the same busbar section on the primary side and also on the secondary side of the transformer, then these transformers must be regulated together to avoid circulating current among the transformers. This circulating current causes additional losses, and the generated additional heat could overstress the transformers.

The “Operation” parameter for selection of the operating mode has several choices:

- Off, for disabling the control function;
- Single, for regulation a single transformer only;
- CircCurrMin, for operating the controllers of the parallel connected transformers to minimize the circulating current;
- Master, for selection one of the controllers of the parallel connected transformers to be the master, to transmit commands to the slave controllers;
- SlaveCmd, for selection the controller to operate in slave mode, and follow the UP and DOWN commands;
- SlaveTap for selection the controller to operate in slave mode, and drive the tap changer to the same position as the transformer assigned to the master controller.

In any of the active modes of operation the controllers can be set to the “Manual” or to “Automatic” control command generation.

1.2 Mode of operation to control a single transformer

This mode of operation is selected if the “Operation” parameter is set to “Single”.

1.2.1 The scheme of the function block

Figure 1-1 shows the scheme of the function block, simplified for single mode of operation.

1.2.2 Analog inputs of the controller function

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.

1.2.3 Internal checks before control operation

In Figure 1-1 the block “U-I BLOCK” performs the following checks before control operation:

- If the voltage of the controlled side UL1L2 is above the value set by the parameter “U High Limit”, then control command 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 command 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 the 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.

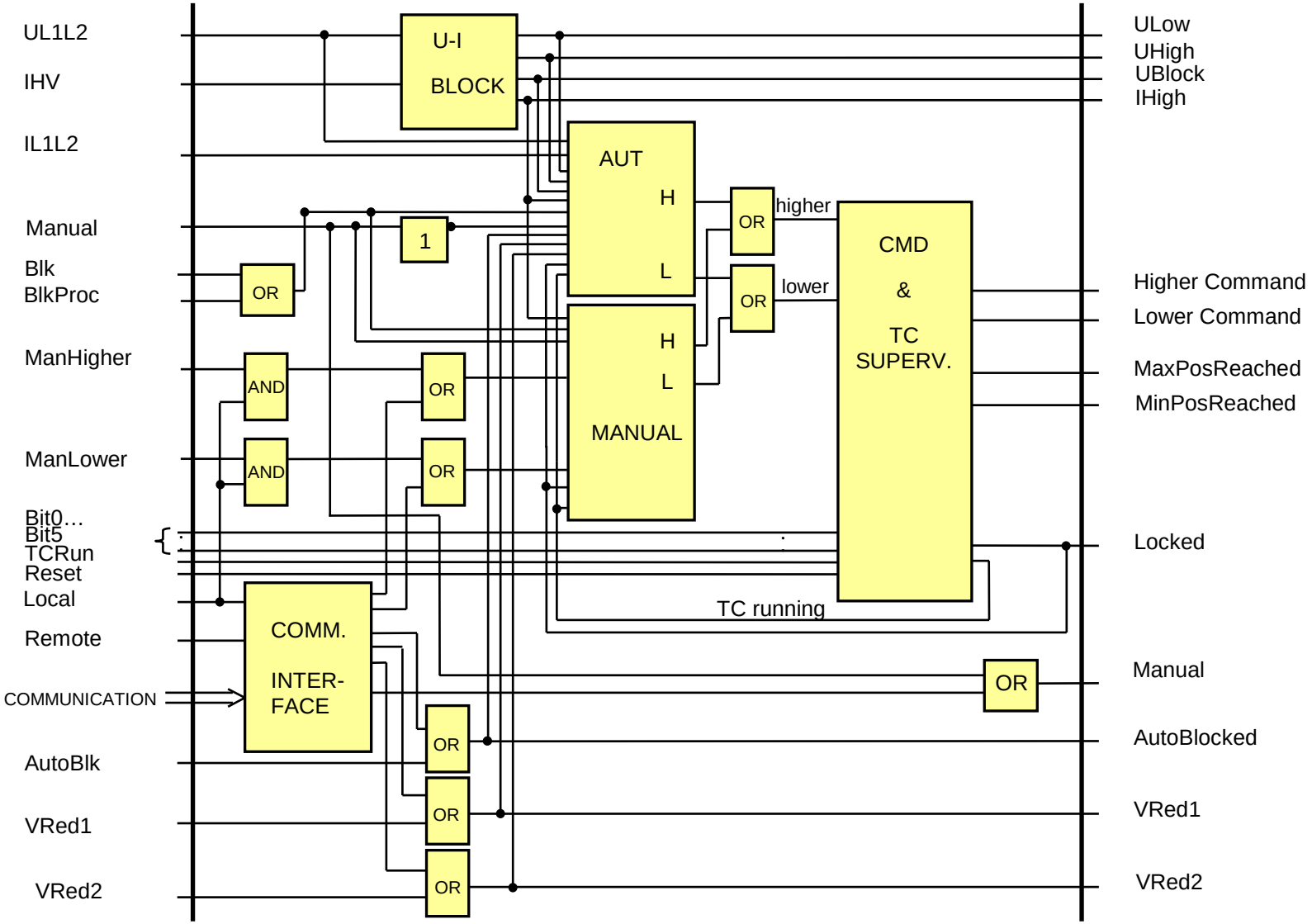


Figure 1-1 The logic schema of the automatic tap changer controller

1.2.4 Automatic control mode

Voltage compensation in automatic control mode

The module “AUT” in Figure 1-1 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 by setting the “Compensation” parameter: “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:

$$\begin{aligned} |Ucontrol| = |Ubus - Udrop| &\approx |Ubus| - |Udrop| \\ &\approx |Ubus| - |I| * (R)CompoundFactor \end{aligned}$$

Where

(R) Compound Factor	is a parameter value.

If the “|I|” 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.

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

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

In this 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.)

$$\begin{aligned} |Ucontrol| = |&Ubus \\ &- [(IL1L2_{Re} + jIL1L2_{Im}) * ((R)CompoundFactor \\ &+ jXCompoundFactor)]| \end{aligned}$$

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.

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 “Voltage Reduction 1” or “Voltage Reduction 2” enter into active state. These inputs must be programmed graphically by the user.

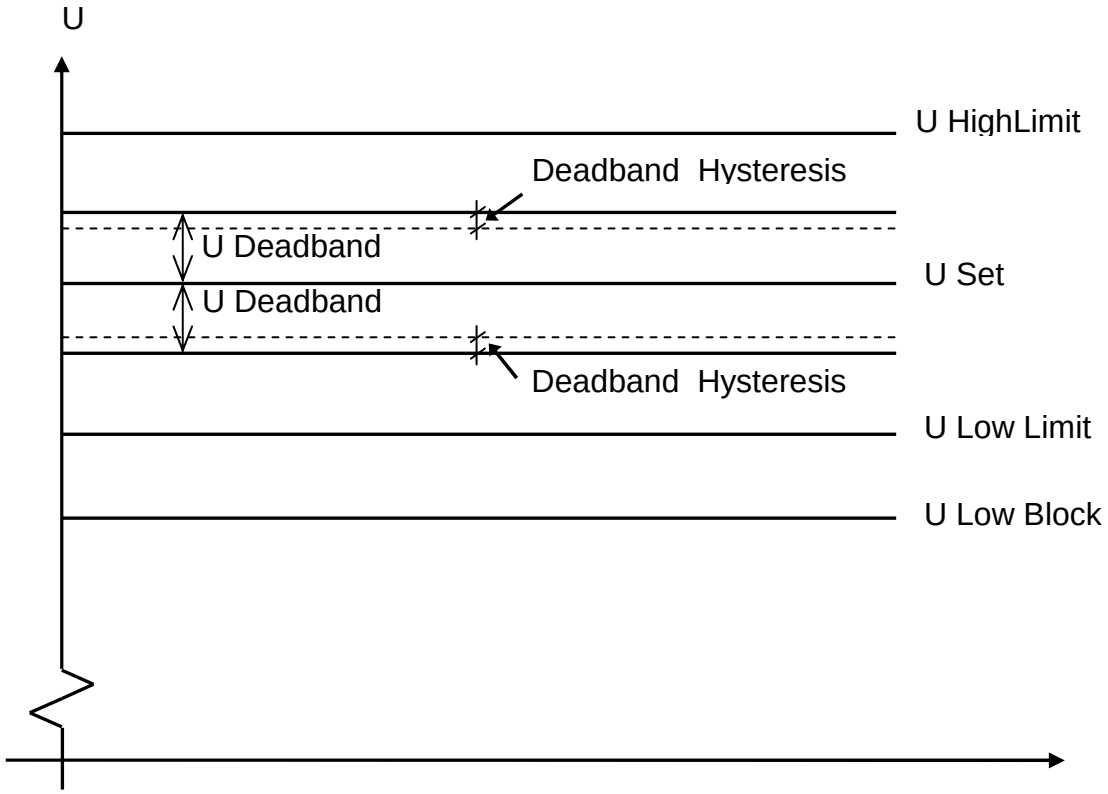


Figure 1-2 Voltage level settings

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, then 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

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

- “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 need for regulation with the same direction is detected within the “Reclaim time” defined by 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)”

1.2.5 Manual control mode

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.

1.2.6 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.

1.2.7 Error codes

The On-line information includes a variable "ErrorCode" (ATCC_ErrCode_ISt_), indicating different error states. These states are binary coded; any of them causes “Locked” state of the controller function. The explanation of the individual bits in the code value is explained in the Table below.

Bit	Value	Explanation
0	1	Drive started without control command
1	2	Drive did not start after control command
2	4	Drive did not stop in due time
3	8	Invalid position signal
4	16	Position signal did not change value

In case of multiple error states the values are added in the "ErrorCode".

1.3 Mode of operation to control parallel transformers

This mode of operation is selected if the “Operation” parameter is set to one of the following values:

- CircCurrMin, for operating the controllers of the parallel connected transformers to minimize the circulating current;
- Master, for selection one of the controllers of the parallel connected transformers to be the master, to transmit commands to the slave controllers;
- SlaveCmd, for selection the controller to operate in slave mode, and follow the UP and DOWN commands;
- SlaveTap for selection the controller to operate in slave mode, and drive the tap changer to the same position as the transformer assigned to the master controller.

Up to 4 transformers may be involved. Individual EuroProt+ controllers are assigned to each of them, and these devices co-operate with each other. The method of co-operation depends on the selected mode, as set by the “Operation” parameter.

Usually the devices must be connected to the same Ethernet communication network, characterized with the same “GroupID”. This must be selected by parameter setting, identical for the co-operating devices. The “Device Address” must be set unique for the devices within the group, for two transformers “0” and “1”, etc. The “GroupID” can be applied also for VLAN identifier. To do this, the parameter “UseVLAN” must be set to logic “1”.

The messages sent via Ethernet network are similar multicast messages to the GOOSE messages according to the IEC 61850 communication standard, but they are device specific commands. The MAC address of these multicast messages is 01-0C-CD-07-“GroupID”.

1.3.1 Minimizing the circulating currents

This mode of operation is selected if the “Operation” parameter is set to “CircCurrMin”.

To perform the related algorithm, communication is needed among the controllers. The co-operating controllers must be identified by each device, by checking the parameters “Address 0 InUse”, “Address 1 InUse”, “Address 2 InUse”, “Address 3 InUse”. For minimizing the circulating current, the following information is needed from each co-operating devices:

- Calculated voltage drop (U_{di} see below),
- Current real and imaginary components (relative to the common bus voltage),
- Sn/Drop, calculated internally from parameters “Transformer Sn” and “Transformer Drop”.
- Connected or disconnected state of the transformer to the busbar of the regulated voltage level.

Based on this information the current vectors are transformed into a common coordinate system defined by the common voltage vector. The sum of these currents is the total load current:

$$I_L = \sum_i I_{Ti}$$

The transformers disconnected from the busbar of the regulated voltage level are not involved in this calculation.

The current, according to the impedance relationship is calculated by:

$$I_{Li} = \frac{\frac{S_{ni}}{\varepsilon_i}}{\sum_j \frac{S_{nj}}{\varepsilon_j}} I_L$$

The difference of the measured I_{Ti} current and the current I_{Li} due to the current division is the circulating current:

$$I_{CCi} = I_{Ti} - I_{Li}$$

This circulating current causes a voltage drop, which is equivalent to the voltage difference caused by the tap changer position:

$$U_{di} = Im(I_{CCi}) * \frac{\varepsilon_{iContr}}{100} \frac{U_{ni}^2}{S_{ni}}$$

In this formula a special drop value is applied: $\varepsilon_{iContr,}$, called “control drop”, and can be set as parameter “Control Drop”. If this value is set different as compared with the setting value of the parameter “Transformer Drop” then the calculated effect of the circulating current can be influenced.

With this U_{di} voltage drop, the measured busbar voltage U_B to be controlled is modified:

$$U'_B = U_B - U_{di}$$

This modified busbar voltage is applied as the $Ubus$ voltage in paragraph 1.2.4, and using this value, the controller perform the task as if the transformer would be alone (see “Single” mode of “Operation”, in Paragraph 1.2). The result of this mode of operation is that additionally to the required control of the load center voltage, the circulating current is minimized.

Based on the calculated U_{di} voltage drops, the controller with the highest U_{di} calculated value starts generating the required control command, the operation of all other controllers are delayed. This method prevents the possibility to regulate quickly up and down subsequently, due to the mutual influence of tap-changer operations.

1.3.2 Master slave mode of operation

This mode of operation is selected if the “Operation” parameter of one of the co-operating devices is set to “Master” and for all other devices it is set either to “SlaveCmd” or to “SlaveTap”. (The not consistent setting is signaled as setting error.)

In this mode of operation the master is controlling the assigned transformer, as if it would be alone, and transmits the HIGHER and LOWER commands and the tap changer position to the slaves.

The slave devices react according to the parameter setting.

Operation in “SlaveCmd” mode

If all slave’s “Operation” parameter is set to “SlaveCmd” mode then the slave device transmits the HIGHER or LOWER commands, received via Ethernet connection from the master, without comparing the tap changer position. If the initial state of all tap-changers assures the operation of the system without any circulating currents, and the appropriate tap steps generate the same voltage regulation then this mode can be applied. If there is a single failure in the operation of any of the tap-changers then the error is not corrected automatically.

Operation in “SlaveTap” mode

If all slave’s “Operation” parameter is set to “SlaveTap” mode, then the master device transmits the own tap position as the required tap position for all co-operating controllers. The slave devices generate the appropriate commands until this required position is reached. If the tap position of a slave is identical with that of the master then the subsequent operation is performed according to the rule of the “SlaveCmd” mode.

There is a correction possibility for tap position adjustment, if the tap-changers are not of the same type: the parameter setting “Tap Offset” can match the parallel running of the individual tap-changers.

1.3.3 Irregular modes of operation

In case of certain errors the algorithm can override the mode of operation defined by parameter setting as follows:

- Forced “Single mode”
  The mode of operation is changed to “Single mode” and at the same time the operation is disabled in case of any of the following errors:
  - Contradiction in addresses
  - Topology error
  - If the device set to “Master” mode finds another master with higher priority connected to the same bus section
  - In “Master” mode or in “CircCurrMin” mode the voltage measurement is missing
- Forced “Master” mode
  The slave with the highest priority can enter to this mode of operation, if the “MTO” input is active and the former Master is not available.

The device displays the actual mode of operation in the “On-line” menu of the LCD and also in the WEB interface.

1.3.4 Operation in case of errors

For correct operation the following conditions must be fulfilled:

- The devices to control parallel transformers must be connected to the same Ethernet network,
- The status signals indicating the busbar configuration must be correct, and
- Also the parameter setting of the co-operating controllers must be correct.

In case of any errors the “On-line” window of the controller function shows an error code. The configured code vales of the “Parallel error” field are summarized in the Table below:

Error code (Decimal)	Error code (Hexa)	Explanation
0	Ox0	No error
1	Ox1	There is no interconnection with the device on address 0
2	Ox2	There is no interconnection with the device on address 1
4	Ox4	There is no interconnection with the device on address 2
8	Ox8	There is no interconnection with the device on address 3
256	Ox100	Invalid address
512	Ox200	Master error (indicated by the slave device)
1024	Ox400	Error in the topology (e.g. a transformer seems to be connected to more than one bus section)
2048	Ox800	There is another master with higher priority in the system (indicated by the master device)
4096	Ox1000	Address error (more then one device with the same address)

In case of multiple error the assigned code values are added

Table 1-1 *“Parallel error” code values*

1.3.5 Disabled state

The devices are blocked in “CircCurrMin” mode if the communication fails with any of the co-operating devices, or any of them is blocked.

1.4 Manual mode of operation

When programming the graphic logic, there are some important inputs to select the mode of operation:

Binary status signal	Title	Explanation
ATCC_Local_GrO_	Local	Local state of the manual operation
ATCC_Remote_GrO_	Remote	Remote state of the manual operation
ATCC_Blk_GrO_	Blk	Blocking of the function
ATCC_AutoBlk_GrO_	AutoBlk	Blocking of the automatic function
ATCC_Manual_GrO_	Manual	Manual mode of operation
ATCC_ManHigher_GrO_	ManHigher	Manual command for increasing the voltage
ATCC_ManLower_GrO_	ManLower	Manual command for decreasing the voltage

Table 1-2 Inputs to select the mode of operation

If the input “Manual” is programmed by the user and set to logic “1”, then the automatic modes are disabled, and the device transmits the commands from the inputs “ManHigher” or “ManLower” to the tap-changer.

Manual commands can be generated using the local means, or they can be received from the communication channels.

If in manual mode the input “Local” is programmed by the user and set to logic “1”, then the local LCD of the device can be the source of the command. If the input “Remote” is programmed by the user and set to logic “1”, then the communication channels can deliver the manual commands.

The function can be blocked by binary signal if the input “Blk” is programmed by the user and set to logic “1”. The input “AutoBlk” can block the automatic control functions only.

1.5 Technical summary

1.5.1 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 % < ΔU < 25%	<5%
	25 % < ΔU < 50%	<2% or ±20 ms, whichever is greater

Table 1-3 Technical data of the automatic tap changer controller function

1.5.2 Summary of the 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 defining the mode of operation of the function			
ATCC_Oper_EPar_	Operation	Off,Single*, CircCurrMin*, Master, SlaveCmd*, SlaveTap*	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

** Selection range extension for parallel transformers*

Table 1-4 Enumerated parameters of the automatic tap changer controller function

Boolean parameters

Parameter name	Title	Default	Explanation
ATCC_FastHigh_BPar_	Fast Higher Enable	0	Enabling fast higher control command
ATCC_FastLow_BPar_	Fast Lower Enable	0	Enabling fast lower control command
Extension for parallel transformers			
ATCC_ChInUse1_BPar_	Address0 InUse	0	0 priority level is used in the system
ATCC_ChInUse2_BPar_	Address1 InUse	0	1 priority level is used in the system
ATCC_ChInUse3_BPar_	Address2 InUse	0	2 priority level is used in the system
ATCC_ChInUse4_BPar_	Address3 InUse	0	3 priority level is used in the system
ATCC_UseVLAN_BPar_	UseVLAN	1	VLAN identifier is used for the communication

Table 1-5 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
Extension for parallel transformers						
VLAN Identifier for the group of cooperating controllers						
ATCC_VLAN_IPar_	GroupID		0	4095	1	0
Device address within the group of cooperating controllers						
ATCC_Addr_IPar_	Device Address		0	3	1	3
Setting the tap offset position in master-slave “SlaveTap” mode						
ATCC_Offset_IPar_	Tap Offset	tap	-5	5	1	0

Table 1-6 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
There are no additional timer parameters for extension with parallel transformers						

Table 1-7 Timer parameters of the automatic tap changer controller function

Float 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. See Chapter 1.2.4						
ATCC_URinc_FPar_	(R) Compound Factor	%	0.0	15.0	1	5.0
Parameter for the current compensation. See Chapter 1.2.4						
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. See Chapter 1.2.4						
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. See Chapter 1.2.4						
ATCC_VRed2_FPar_	Voltage Reduction 2	%	0.0	10.0	1	5.0
Maximum current value to be considered in current compensation formulas. See Chapter 1.2.4						
ATCC_ICompLim_FPar_	I Comp Limit	%	0.00	150	0	1
Current upper limit to disable all operation. See Chapter 1.2.3.						
ATCC_IHVOC_FPar_	I Overload	%	50	150	0	100
Voltage upper limit to disable step up. See Chapter 1.2.3.						
ATCC_UHigh_FPar_	U High Limit	%	90.0	120.0	1	110.0
Voltage lower limit to disable step down. See Chapter 1.2.3						
ATCC_ULow_FPar_	U Low Limit	%	70.0	110.0	1	90.0
Voltage lower limit to disable all operation. See Chapter 1.2.3.						
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
Extension for parallel transformers						
Transformer drop for the circulating current mode of operation						
ATCC_Drop_FPar_	Transformer Drop	%	1.0	30		5.0
Transformer rated power for the circulating current mode of operation						
ATCC_Sn_FPar_	Transformer Sn	MVA	1.0	500		40.0
Drop for weighting the influence of the circulating current for the circulating current mode of operation						
ATCC_ControlDrop_FPar_	Control Drop	%	1.0	50		10.0

Table 1-8 Float parameters of the automatic tap changer controller function

1.5.3 Summary of the generated output signals

The **binary output status signals** of the breaker failure protection function are listed in the table below.

Binary status signal	Title	Explanation
ATCC_AutoBlocked_GrI_	Auto Blocked (ext)	Automatic control blocked
ATCC_Manual_GrI_	Manual	Signaling the manual mode of operation
ATCC_HigherCmd_GrI_	Higher Command	Command for increasing the voltage
ATCC_LowerCmd_GrI_	Lower Command	Command for decreasing the voltage
ATCC_MaxReached_GrI_	Max Pos Reached	Signaling the maximal position
ATCC_MinReached_GrI_	Min Pos Reached	Signaling the minimal position
ATCC_UHigh_GrI_	U High	Voltage is high
ATCC_ULow_GrI_	U Low	Voltage is low
ATCC_UBlock_GrI_	U Block	Blocked state for too low voltage
ATCC_IHigh_GrI_	I High	Blocked because of current limit
ATCC_Locked_GrI_	Locked	The supervision detected tap changer error, the blocking can be released exclusively by the Reset impulse
ATCC_VRed1_GrI_	Voltage Reduction 1	Controlling to reduced voltage 1
ATCC_VRed2_GrI_	Voltage Reduction 2	Controlling to reduced voltage 2
ATCC_HigherTimer_GrI_	HigherTimer	Timer before generation “Higher” command is running
ATCC_LowerTimer_GrI_	LowerTimer	Timer before generation “Lower” command is running
Extension for parallel transformers		
ATCC_RemHigher_GrI_	Remote Higher	Signal of the slave, indicating execution of the master command
ATCC_RemLower_GrI_	Remote Lower	Signal of the slave, indicating execution of the master command
ATCC_ComFail_GrI_	Communication Error	No connection with at least one of the configured devices
ATCC_MasterError_GrI_	Master Error	The slave device can not follow the master

Table 1-9 Binary output status signals of the breaker failure protection function

1.5.4 Summary of the input signals

Binary status signals

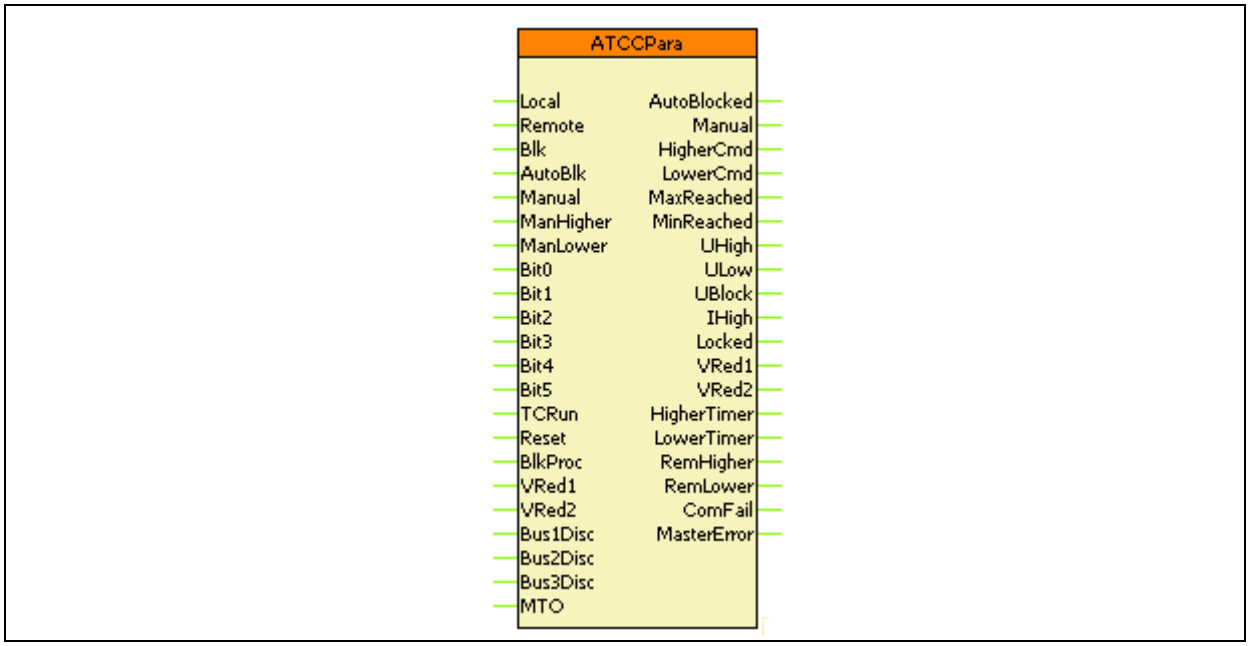
The automatic tap changer controller function has binary input status signals**. The conditions are defined by the user applying the graphic equation editor.**

The **binary input status signals** of the automatic tap changer controller function are listed in the table below.

Binary status signal	Title	Explanation
ATCC_Local_GrO_	Local	Local state of the manual operation
ATCC_Remote_GrO_	Remote	Remote state of the manual operation
ATCC_Blk_GrO_	Blk	Blocking of the function
ATCC_AutoBlk_GrO_	AutoBlk	Blocking of the automatic function
ATCC_Manual_GrO_	Manual	Manual mode of operation
ATCC_ManHigher_GrO_	ManHigher	Manual command for increasing the voltage
ATCC_ManLower_GrO_	ManLower	Manual command for decreasing the voltage
ATCC_Bit0_GrO_	Bit0	Bit 0 of the position indicator
ATCC_Bit1_GrO_	Bit1	Bit 1 of the position indicator
ATCC_Bit2_GrO_	Bit2	Bit 2 of the position indicator
ATCC_Bit3_GrO_	Bit3	Bit 3 of the position indicator
ATCC_Bit4_GrO_	Bit4	Bit 4 of the position indicator
ATCC_Bit5_GrO_	Bit5	Bit 5 of the position indicator
ATCC_TCRun_GrO_	TCRun	Running state of the tap changer
ATCC_Reset_GrO_	Reset	Reset to release from blocked state
ATCC_BlkProc_GrO_	BlkProc	Blocking signal from the tap changer
ATCC_VRed1_GrO_	VRed1	Reduced voltage 1 is required
ATCC_VRed2_GrO_	VRed2	Reduced voltage 2 is required
Extension for parallel transformers		
ATCC_Bus1Disc_GrO_	Bus1Disc	Disconnector closed for Bus1
ATCC_Bus2Disc_GrO_	Bus2Disc	Disconnector closed for Bus2
ATCC_Bus3Disc_GrO_	Bus3Disc	Disconnector closed for Bus3
ATCC_MTO_GrO_	MTO	Slave is enabled to take over the master role

Table 1-10 Binary input signals of the breaker failure protection function

1.5.5 The symbol of the function block in the graphic editor



The names of the input and output signals are parts of the “Binary status signal” names listed in the previous paragraph.