ZAZ-En

DESCRIPTION OF CONFIGURATION FUNCTIONS

iZAZ

CONTENTS

EMPTY PAGE

1. INTRODUCTION

This document describes the iZAZ family of devices, based on a homogeneous software and hardware platform. The operation of the devices is based on a configuration file, represented in graphical mode via the dedicated iZAZ Tools software.
The configuration file can be saved on the disk with the .izaz extension; it includes the complete configuration of the device along with the settings of individual protection functions. It consists of functions linked by logic-time dependencies.
The iZAZ Tools program allows to view/edit the configuration saved in graphical mode, making the device's operation interpretation intuitive and user-friendly.
The configuration scheme is presented on sheets that allow functional division of configuration fragments.

When a specific variant is selected, the Manufacturer prepares the device with a specific configuration file. In most cases, there must be an adaptation of the configuration to a specific design or connection circuit in terms of:

- two-state inputs
- relay outputs (control and signaling)
- LEDs
- other logic-time dependencies required in a given circuit
- protection settings and logic functions

These signals are pre-configured by default, but the user can use the iZAZ Tools maintenance program to modify the configuration according to the system needs.

Note: It is possible to rename each function in the configuration. It increases the readability of the configuration and facilitates navigation between the various functions.

Each function can set the level of access permission to edit the function, its input connections and settings independently.
At the standard access level (EDIT), the user can edit protection settings and logical-time functions. Changes related to the connections of the functions of binary inputs, relay outputs, LEDs and creating additional logic connections using basic logic functions (AND, OR, NOT) and the editing of the connections of analog channels functions, estimates, protection are normally secured with a higher level of authorization - configuration (CONFIGURATION).

The following sections first describe the protection and automation functions, then the other functions available in the iZAZ devices.
The availability of functions may be limited depending on the types of iZAZ devices - in such case, an additional symbol appears.

2. DESCRIPTION OF PROTECTION

2.1. General description

Protection functions are implemented as functions with specific input and output parameters.

Each protection function has the following settings by default:

ON/OFF – function activity – the setting enabling the deactivation of the function; when set to OFF, the function is not performed.

W – Trip – the setting allows to set the protection operation for emergency shutdown of the breaker (ON). Each function has a dedicated "W" – shutdown binary output which, via correct connection in the scheme, performs the shutdown. For the OFF setting, despite the protection being tripped, the "W" output will not be active.

OR/AND – logic of the function phase activations – the setting available only for three-phase functions, allows to change the method of detecting the activation in particular phases. For the OR setting, activation in one of the phases causes activation of the entire function and tripping after the set time. For the AND setting, activation of the entire function will be performed only with activation in all phases simultaneously.

Additionally, the protection functions are equipped with analog inputs (in the example below, phase currents I1, I2, I3) required for the implementation of the algorithm of the implemented protection and other additional binary inputs (obligatory interlock and test status to enable the function testing).

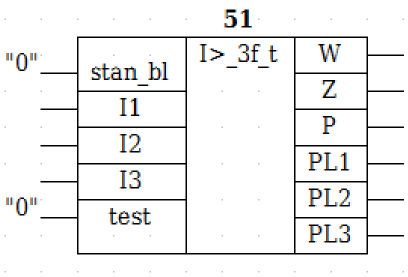


Fig. 1. Protection function example (three-phase overcurrent)

Each function is equipped with dedicated binary outputs:
W – shutdown state – active with the W = ON setting after the function tripping.
Z – operating state – active after meeting the conditions for the function tripping.
P activation state – active after meeting the conditions for the function activation.
Optionally PL1, PL2, PL3 as independent activations of particular phases, only for three-phase functions

Moreover, the function can be equipped with other binary inputs/outputs resulting from the specificity of its operation. Some functions enable the output of an analog signal (measurement) in order to analyze internal states, e.g. count states in the case of time-dependent functions.

The configuration must include the appropriate connection of inputs and outputs of the protection functions, starting from the implementation of physical channels, estimates required by protection and measurements via output signals, such as activations and operations used in recorders, up to the control of signaling relays, emergency control and optical signaling by LEDs on the front panel and texts on the display.

The applicability of the function is presented in the table under the name of the function (e.g. availability in iZAZ400, iZAZ600, and no applicability in iZAZ200, iZAZ300)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

2.2. I1f> – single-phase overcurrent function, time independent (51/50)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Basic overcurrent protection for overcurrent and short circuit protection functions. The function enables the implementation of the overcurrent criterion for overload protection as well as its use for other purposes, e.g. automation control (detection of the load threshold).

Operation description
The protection function is designed as a single-phase variant (I1f>).

The function uses the fundamental current component estimate for overcurrent and short circuit protection.
The function uses the RMS current estimate for overload protection.

After exceeding the start-up value, the function is activated and after a set time it is tripped according to the $I > I_r$ criterion.
The function allows to derive the tripping and activation state (e.g., information to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.05÷30.00) In in 0.01 In increments	5.00 In
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Own time $t_w < 30$ ms
Permissible error $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.3. I> – three-phase overcurrent function, time independent (51/50)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application

Basic overcurrent protection for overcurrent and short circuit protection functions. The function enables the implementation of the overcurrent criterion for overload protection as well as its use for other purposes, e.g. automation control (detection of the load threshold).

Operation description

The protection function is made in the three-phase variant.

The function uses the estimates of fundamental components of phase currents for overcurrent and short circuit protection.
The function uses the estimates of the effective phase currents for overload protection.
After exceeding the start-up value, the function is activated and after a set time it is tripped according to the $I > I_r$ criterion.
The function analyzes the criterion in all phases simultaneously and enables the output of information about activation from each phase independently (e.g. information to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.05÷30.00) In in 0.01 In increments	5.00 In
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:
Own time $t_w < 30$ ms
Permissible error $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.4. I>blh – three-phase overcurrent function, time independent, with a interlock on the second harmonic (51/50)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Basic overcurrent protection for the implementation of the short circuit current protection function for objects where current surges may occur under normal operating conditions of the object, e.g. when switching on a transformer or a line supplying a group of transformers.

Operation description
The protection function is made in the three-phase variant.

The function uses estimates of fundamental components of phase currents for short circuit protection and estimates of the harmonic content.

After exceeding the start-up value, the function is activated and after the set time t it is tripped according to the $I > I_r$ criterion, if there is no interlocking due to the second harmonic content in the measured current. An additional criterion is unconditional function tripping after exceeding the set start-up value of unconditional operation Ir>>. It is possible to disable the operation of the unconditional operation criterion (Setting I>>_ON/OFF = OFF).

For the fundamental current below the unconditional operation value (or with the unconditional operation function deactivated), if the rms of the second harmonic in relation to the rms of the fundamental component is greater than the set factor k_{bl}, the protection operation is interlocked.

The interlocking conditions determine the dependencies: $$\frac{I_{2h}}{I_{1h}} > k_{bl}$$

The interlock lasts until the second harmonic content is lowered, according to the interlocking criterion, but not longer than the setting of the interlocking activity time t_{bl}, counting from the time of the short circuit. After the set time, if the current criterion is still activated with the simultaneous interlocking from the second harmonic, the function is unblocked and the system shuts down.
It is possible to remove the interlocking of the function from the content of the second harmonic (Setting bl_h_ON/OFF = OFF).
The function analyzes the criterion in all phases simultaneously and enables the output of information about activation and possible interlocking state from each phase independently (e.g. information to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.05÷30.00) In in 0.01 In increments	5.00 In
k_{bl}	Relative second harmonic content interlocking operation	(0.01÷0.50) in 0.01 increments	0.10
$I_{r>>}$	Operate current unconditional criterion	(0.05÷30.00) In in 0.01 In increments	10.00 In
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
t_z	Delay time	(0.00÷300.00) s in 0.01 s increments	1.00 s
t_{bl}	The time of the interlocking operation from the short circuit occurrence	(0.00÷300.00) s in 0.01 s increments	0.50 s
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR
Bl_h_ON/OFF	Interlock of higher harmonics in the fault current	(ON / OFF)	ON
I>>_ON/OFF	Trip unconditional	(ON / OFF)	ON

Parameters:

Own time	$t_w < 30$ ms
Permissible error	$\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.5. I1f< – single-phase undercurrent function, time independent (37)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application
A function that allows the loss of load by the engine or other load to be detected. Used, for example, to protect the engine against the effects of idling.

Operation description
Protection function made in single-phase variant.
The function uses an estimate of the fundamental current component.
After lowering the value below the start-up value, the function is activated and after a set time it is tripped according to the $I < I_r$ criterion.
The function enables the output of information on activation and operation (e.g. to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.05÷30.00) In in 0.01 In increments	0.40 In
t_z	Delay time	(0.00÷10,000.00) s in 0.01 s increments	300.00 s
k_p	Reset ratio	(1.01÷1.20) in 0.01 increments	1.02
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:

Own time	$t_w < 30$ ms
Permissible error	$\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.6. I< – three-phase undercurrent function, time independent (37)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application
A function that allows the loss of load by the engine or other load to be detected. Used, for example, to protect the engine against the effects of idling.

Operation description
The protection function is made in the three-phase variant.

The function uses estimates of fundamental components of phase currents.
After lowering the value below the start-up value, the function is activated and after a set time it is tripped according to the $I < I_r$ criterion.
The function analyzes the criterion in all phases simultaneously and enables the output of information about activation from each phase independently (e.g. information to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.05÷30.00) In in 0.01 In increments	0.40 In
t_z	Delay time	(0.00÷10,000.00) s in 0.01 s increments	300.00 s
k_p	Reset ratio	(1.01÷1.20) in 0.01 increments	1.02
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	AND

Parameters:
Own time $t_w < 30$ ms
Permissible error $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.7. Im> – three-phase peak overcurrent function, time independent (51/50)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Overcurrent protection for the implementation of the object protection function (e.g. generator, engine) against the effects of short circuit or overload in the event of a frequency start, or when the receiver is supplied by an inverter. The function works in a wide range of frequency changes (10 ÷ 300) Hz.

Operation description
The protection function is made in a full three-phase version.

The function uses dedicated phase current estimates that control the actual frequency of the measured current.

After exceeding the start-up value, the function is activated and after a set time it is tripped according to the $I > I_r$ criterion.
The function analyzes the criterion in all phases simultaneously and enables the output of information about activation from each phase independently (e.g. information to the event/disturbance recorder).

Due to the fact that the self-operation time of the protection is extended for signals with a reduced frequency, an additional accelerating criterion was applied, based on the comparison of the instantaneous current values with the appropriate number of repetitions.

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.05÷30.00) In in 0.01 In increments	5.00 In
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:

Own time	t_w <30 ms (not less than 1 period of measured current)
Permissible error	$\delta_{\%} = \pm 5\%$

2.8. IK> – three-phase directional overcurrent function, time independent (67)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Directional short circuit protection, enabling selective operation in feeders with double-sided power supply.

Operation description
The function monitors the value of the currents in three phases and the direction for I_{L1} – U_{L2L3}, I_{L2} – U_{L3L1} and I_{L3} – U_{L1L2}.

The protection uses estimates of fundamental components of phase currents and phase-to-phase voltages.
The activation condition is the exceeding of the current above the start-up value with the set operating direction FROM BUS-BAR, TO BUS-BAR, according to the $I > I_r$ and $\varphi_m - 90^o < \varphi < \varphi_m + 90^o$ criteria. After the set time has elapsed, it is tripped.

For the FROM BUS-BAR direction setting, the activation will occur when the short circuit current flows from the bus towards the outflow, while the tripping will not occur for the short circuit on the bus and the short circuit current flows from the outlet towards the bus.
For the TO BUS-BAR direction setting, the activation will occur when the short circuit current will flow from the outlet towards the bus, while the tripping will not occur for the short circuit on the outflow and the short circuit current will flow from the bus towards the outlet.
To correctly determine the direction of the current flow, it is necessary to measure the voltage with a value at least higher than the setting U_{akt}.

The function analyzes the criterion in all phases simultaneously and enables the output of activation information from each phase independently (e.g. information to the event/disturbance recorder).

For short circuits, there is a risk that the measured voltage will drop to a value that prevents the correct determination of the short circuit direction. For this reason, a voltage memory is additionally used, with an independently settable start-up level and the time of generating the voltage from the memory.

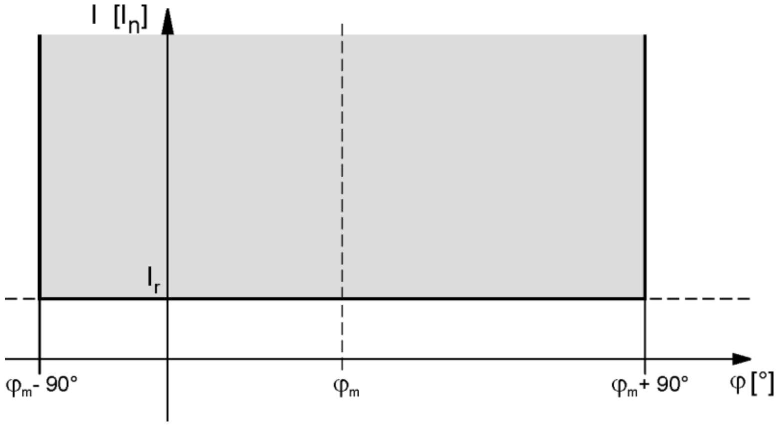


Fig. 2. Start-up characteristics of the three-phase directional overcurrent function

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.05÷30.00) In in 0.01 In increments	2.00 In
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
U_{akt}	Protection activation voltage	(0.010÷1.000) U_n in 0.001 U_n increments	0.050 U_n
φ_m	Maximum sensitivity angle	(0÷90)°ind in 1 °ind increments	0 °ind
dir	Action direction	(FROM BUS-BAR / TO BUS-BAR)	(FROM BUS-BAR)
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR
Additional settings for the voltage memory function			
U_{akt}	Memory chip activation voltage	(0.001÷0.010) U_n in 0.001 U_n increments	0.005 U_n
t_z	Time to generate voltage from memory	(0.10÷5.00) s in 0.01 s increments	1.00 s

Parameters:
Own time $t_w < 30$ ms
Permissible error $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.9. Ip>inv – overcurrent function, time dependent (49)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
The function is implemented as overload or time dependent short circuit protection.

Operation description
The three-phase protection function, implemented in accordance with the PN-EN 60255-3 standard, detects an increase in the rms of the fundamental current component (for use as a short circuit protection) or the rms of the current (for use as an overload protection).

The function is activated according to the dependence: $I_{max} > I_r$, and the tripping time is determined according to the following dependence:

$$t = \frac{k}{\left(\frac{I}{I_r}\right)^c - 1} \; [s]$$

where: $I = \max(I_{L1}, I_{L2}, I_{L3})$ – rms from max-selector of three-phase currents / estimate
I_r - operate current value / setting
k - factor determining the type of characteristics / setting
c - power exponent determining the type of the characteristics / setting

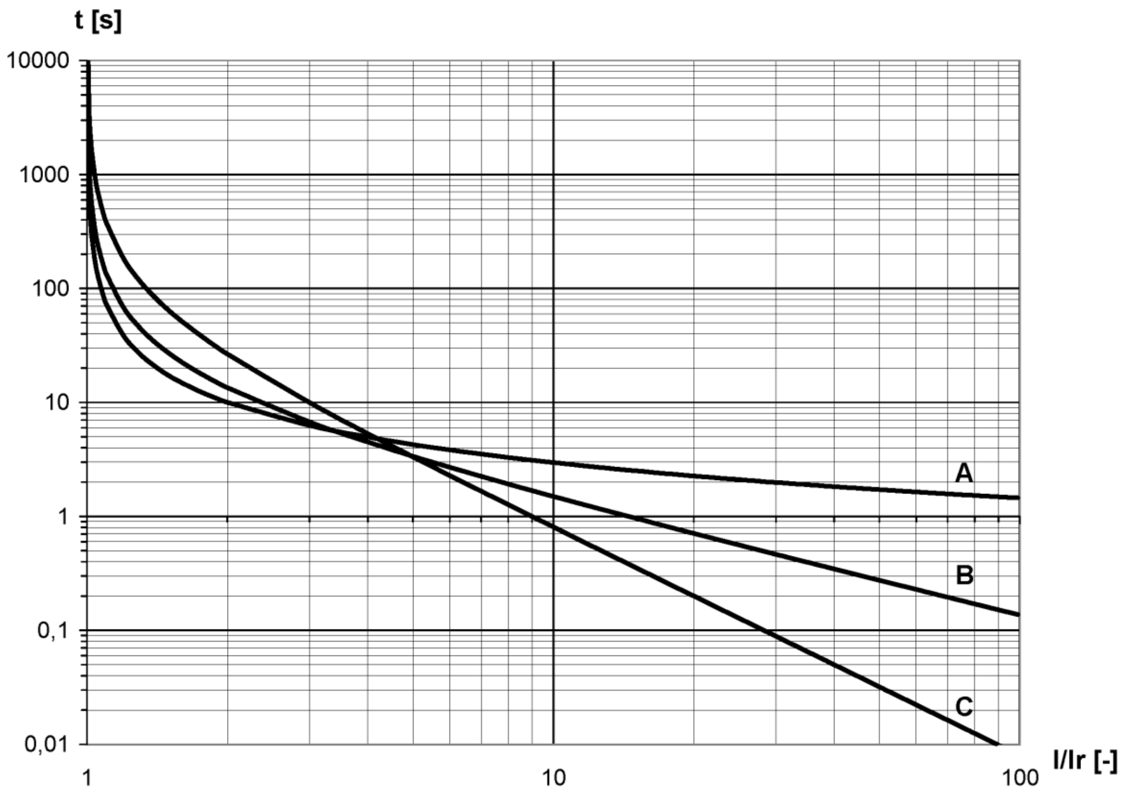


Fig. 3. Start-up characteristics of the time dependent overcurrent function according to types A, B, C.

The function enables the introduction of any shape of the time dependent characteristic; below is an example of types A, B, C according to the standard:

type A - time dependent, normal characteristics (k1 = 0.14 s; c = 0.02)
type B - very time dependent characteristics (k1 = 13.5 s; c = 1)
type C - extremely time dependent characteristics (k1 = 80 s; c = 2)

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.05÷5.00) In in 0.01 In increments	1.10 In
c	power exponent determining the characteristics type	(0.02÷2.00) in 0.01 increments	1.00
k	factor determining the characteristics type	(0.01÷200.00) s in 0.01 s increments	13.50 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Own time $t_w < 30$ ms
Permissible error of current measurement $\delta_{\%} = \pm 2.5\% \pm 0.01$ In
Permissible error of the time measurement according to PN-EN 60255-3, respectively for the error of the current measurement.

2.10. IA>inv – negative sequence component overcurrent function, time dependent (46)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Protection against load asymmetry with operation time depending on the value of the measured asymmetry. Most often used for generators as a switching module after exceeding the permissible short-term asymmetrical load.

Typically implemented as two-stage, where the tripping after deduction of the time dependent characteristics causes the generator to shut down as the second stage 46.2.

The first stage 46.1, as signaling, is implemented by an additional time delay tz – tripping delay (section 4.9.10 on page 216) connected to the function activation signal.

Operation description

The protection function is made in a three-phase variant, based on the current negative sequence component estimate, calculated on the basis of the measurement of phase currents.

Protection function according to PN-EN 60255-3.

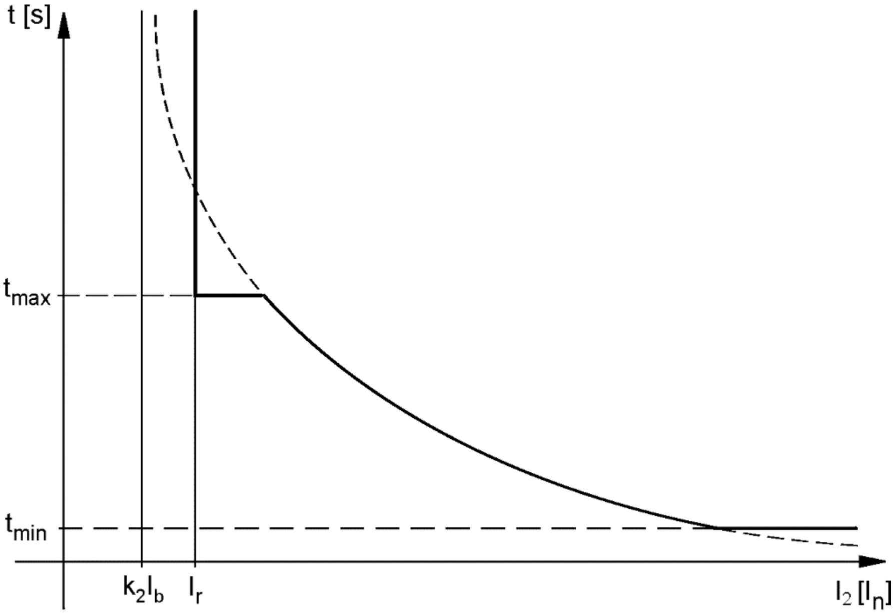


Fig. 4. Start-up characteristics of the time dependent negative sequence component overcurrent function

The tripping time is determined according to the following dependence:

$$t = \frac{k_1}{\left(\frac{I_2}{I_b}\right)^2 - k_2^2} \ [s]$$

where:
- I_2 - current negative sequence component / estimate
- k_1 - factor determined by the generator manufacturer, which is a measure of the short-term permissible load asymmetry / setting
- k_2 - factor determined by the generator manufacturer, which is a measure of the permanently permissible load asymmetry / setting
- I_b - base current (generator rated current) / setting

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.05÷1.00) In in 0.01 In increments	0.10 In
I_b	Base current	(0.50÷2.00) In in 0.01 In increments	1.00 In
t_{min}	Minimum time	(1.00÷60.00) s in 0.01 s increments	5.00 s
t_{max}	Maximum time	(100.00÷6,000.00) s in 0.01 s increments	300.00 s
t_{pow}	Return time	(1.00÷600.00) s in 0.01 s increments	1.00 s
k_1	factor – short-term permissible load asymmetry	(1.00÷100.00) s in 0.01 s increments	10.00 s
k_2	factor – permanent permissible unbalance of the load	(0.01÷1.00) in 0.01 increments	0.10
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
Additional setting when implementing the signaling stage 46.1			
t_z	Stage 1 signaling delay time	(0.00÷100.00) s in 0.01 s increments	10.00 s

Parameters:

Own time $t_w < 30$ ms

Permissible error of negative sequence component current measurement $\delta_{\%} = \pm 2.5\% I_n$ (for $I_{L1}=I_{L3}=I_{L2} = I_n$)

Permissible error of the time measurement according to PN-EN 60255-3, respectively for the error of the current measurement.

2.11. Ic>inv – overcurrent function based on a thermal model, time dependent (49M)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Protects the engine winding against the thermal effects of operational overloads, with the operation time depending on the value of the measured current, based on the two-exponential thermal model of the machine heating.

Operation description
The protection function is made in a three-phase variant, according to the PN-EN 60255-8 standard. Based on the mathematical model, according to the following dependencies, the object temperature is calculated based on the maximum effective value of the current, determined by the max selector from the phase currents.

Thermal model algorithm – heating state:

The phenomenon of heating the entire engine – time constant T_1 including the iron (Fe) constant:

For $I < 2I_b$

$$\vartheta_M = \vartheta_n \cdot \frac{I^2}{I_b^2} \cdot \left(1 - e^{\frac{-t}{T_1}}\right)$$

The phenomenon of heating the engine windings – time constant T_2 including the copper (Cu) constant:

For $I \geq 2I_b$

$$\vartheta_M = \vartheta_n \cdot \frac{I^2}{I_b^2} \cdot \left(1 - e^{\frac{-t}{T_2}}\right)$$

Thermal model algorithm – cooling state:

$$\vartheta_M = \vartheta_n \cdot \frac{I^2}{I_b^2} + \left(\vartheta_{styg} - \vartheta_n \cdot \frac{I^2}{I_b^2}\right) \cdot e^{\frac{-t}{k\ T_1}}$$

where:
- I – maximum engine load current; (I_{L1}, I_{L2}, I_{L3}) max value / estimate
- I_b – base current (rated engine current) / setting
- ϑ_M – current engine temperature mapped in the model / setting
- ϑ_{styg} – engine temperature when it starts to cool down / setting
- t – current time from the moment the breaker is closed (with the engine is running) / setting

engine manufacturer data:
- ϑ_n – temperature increase of the engine for the rated load current ($I = I_b$) / setting
- T_1, T_2 – engine thermal time constants (T_1 for $I<2I_b$ i T_2 $I\geq2I_b$) / setting
- k – factors of elongation of the time constant for currentless cooling / setting

In the currentless cooling state (detected via current measurement, when $I < 0.1I_b$), the k factor causes the extension of the cooling time constant according to the implemented setting. For $I \geq 0{,}1I_b$ (currentless cooling) k = 1.

The current engine temperature ϑ is the result of the model temperature ϑ_M and the current ambient temperature ϑ_o.

$$\vartheta = \vartheta_M + \vartheta_o$$

The function provides the possibility of including the measurement from the ambient temperature sensor - if the signal is not connected or the data is unreliable (e.g. broken 4–20 mA loop), the ambient temperature is assumed in accordance with the setting.

Settings table

Setting	Description	Setting range	Default value
I_b	Base current	(0.50÷2.00) In in 0.01 In increments	1.00 In
ϑ_n	engine temperature increase at rated load current	(40÷120)°C in 1°C increments	100°C
ϑ_o	ambient temperature	(-20÷55)°C in 1°C increments	20°C
ϑ_b	start-up temperature of the interlock	(20÷160)°C in 1°C increments	80°C
ϑ_s	start-up temperature of the signaling element	(60÷160)°C in 1°C increments	90°C
ϑ_z	start-up temperature of the tripping unit	(60÷160)°C in 1°C increments	100°C
k	factors of elongation of the time constant for currentless cooling (k = 1 for current cooling, i.e. for $I > 0{,}1I_b$)	(1÷20) in 1 increments	5
T_1	Time constant for $I<2I_b$ (Fe)	(1÷99) min in 1 min increments	20 min
T_2	Time constant for $I\geq 2I_b$ (Cu)	(1÷99) min in 1 min increments	5 min
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Permissible error of current measurement $\delta_{\%} = \pm 2.5\% \pm 0.01$ In
Permissible error of the time measurement according to PN-EN 60255-8, corresponding to the error of the current measurement.

2.12. IR>inv – thermal overcurrent function, time dependent (49R)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Protects the rotor winding against thermal effects of operational overloads, with time depending on the value of the measured current.

Operation description
The protection function is made in a three-phase variant, implemented in accordance with the PN-EN 60255-3 standard, detecting an increase in the rms of the summed current from the three phases. The function performs the criterion of permissible short-term overload, determined by the generator manufacturer, according to the dependence: $I_{\Sigma}^2 = \frac{I_{L1}^2 + I_{L2}^2 + I_{L3}^2}{3}$

The function is activated according to the dependence: $I_{\Sigma} > I_r$, and the tripping time is determined according to the following dependence:

$$t = \frac{k}{\frac{I_{\Sigma}^2}{I_b^2} - 1} \quad [s]$$

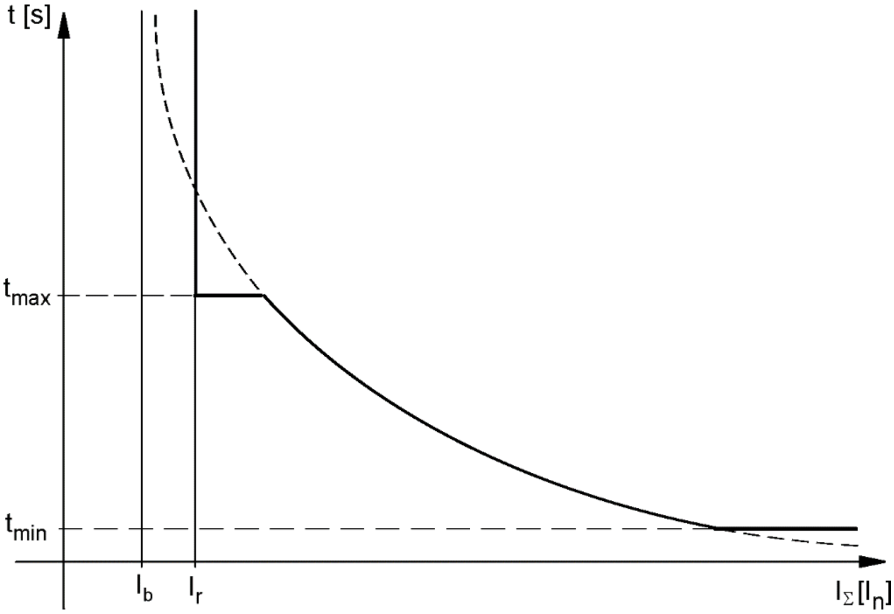


Fig. 5. Start-up characteristics of the time dependent thermal overcurrent function

where: I_{L1}, I_{L2}, I_{L3} – effective values of currents in individual phases / estimates
k - factor determined by the generator manufacturer, which is a measure of the short-term permissible rotor overload / setting
I_b - base current (rotor rated current) / setting

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.10÷1.50) Ib in 0.01 Ib increments	1.00 Ib
I_b	Base current	(0.50÷2.00) In in 0.01 In increments	1.00 In
t_{min}	Minimum time	(1.00÷60.00) s in 0.01 s increments	5.00 s
t_{max}	Maximum time	(100.00÷6,000.00) s in 0.01 s increments	300.00 s
t_{pow}	Return time	(1.00÷100.00) s in 0.01 s increments	1.00 s
k	factor – short-term permissible load asymmetry	(1.00÷100.00) s in 0.01 s increments	10.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Own time $t_w < 30$ ms
Permissible error of current measurement $\delta_{\%} = \pm 2.5\% \pm 0.01$ In
Permissible error of the time measurement according to PN-EN 60255-3, respectively for the error of the current measurement.

2.13. DM – engine operation diagnostics function

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Function enabling the detection of the engine operating state. It is used to implement protection functions where information about the start-up or operation state is necessary.

Operation description
The function is made in single-phase variant. It controls the rms of the current obtained from the phase current max-selector.

Start-up criterion

The current measurement allows the correct recognition of the engine start-up state (significant current flow after the engine is turned on and the gradual reduction of the start-up current along with the duration of the engine rotor acceleration process) and the transition to steady operation, according to the following conditions specified in the set:

- ***STOP*** - *engine standstill state*, for a minimum of 5 s, the maximum value of the engine load current meets the $I < I_{rp}$ condition (typically $0.1I_b$)
- ***START-UP*** (dynamic increase of the load current in the ***STOP*** state) - in the time not longer than t < 30 ms, the current value increases to the level of $I > 2.5I_b$,
- ***OPERATION*** - after meeting the above conditions, the current value drops to the level of $I < 1.5I_b$, but not less than $I > I_{rp}$ (typically $I_{rp} = 0.1I_b$)
- ***PLAY*** – engine idling state, detected after lowering the current below the set value of $I < I_{rbj}$ (typically $I_{rbj} = 0.15I_b$) after meeting the above conditions, the current value drops to the level not less than $I > I_{rp}$ (typically $I_{rp} = 0.1I_b$)

The DM function contains a base current setting according to which the start-up values of some functions are recalculated.

Settings table

Setting	Description	Setting range	Default value
I_b	Base current	(0.05÷2.00) In in 0.01 In increments	1.00 In
I_{rp}	Operate current of stop relay	(0.05÷0.50) Ib in 0.01 Ib increments	0.10 Ib
I_{rbj}	Operate current of load-loss relay	(0.05÷0.50) I_b in 0.01 Ib increments	0.15 Ib
ON/OFF	Function activity	(ON / OFF)	ON

Parameters:
Permissible error of current measurement $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.14. IR>0 – overcurrent function, from starting the engine on to a interlocked rotor (51LR)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Engine protection that detects an abnormal start-up state indicating an interlocked rotor.

Operation description
The protection function is made in the three-phase variant. It detects an increase in the rms of the current obtained from the max-selector of the phase currents.

The function requires the connection of binary information about the start-up, controlled by the DM – engine operation diagnostics function (page 28).

The condition for activating the function is recognition of the start-up state and no reduction of the operate current to the value of 0.8 I_{max} (maximum initial start-up value) after the set time $t_{80\%}$.

For the BL_Z = ON setting, after the protection is tripped, the activation of the interlock output is activated for the set t_{reg} time, which enables the thermal regeneration of the engine after an unsuccessful start-up. Engine activation interlock time $t_{regItR0}$ measurement counts down the set time needed for the thermal regeneration of the engine.

Settings table

Setting	Description	Setting range	Default value
$t_{80\%}$	Time for the operate current to drop to 0.8 of the maximum value.	(1.00÷100.00) s in 0.01 s increments	10.00 s
t_{reg}	Engine thermal regeneration time after unsuccessful start-up (starting interlocking time)	(1.00÷180.00) min in 0.01 min increments	60.00 min
BL_Z	Activation of the starting interlock output for the t_{reg} time	(ON / OFF)	ON
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Permissible error of current measurement $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.15. IR>1 –overcurrent function, extended engine start-up (48)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Engine protection that detects an abnormal start-up state that is abnormal for an extended (hard) start-up.

Operation description
The protection function is made in the three-phase variant. It detects the inrush energy increase as a value proportional to the maximum RMS current obtained from the phase current max selector.

The function requires the connection of binary information about the start-up, controlled by the DM – engine operation diagnostics function (page 28).

The condition for activating the function is to recognize the start-up state and to exceed the single start-up energy resulting from the t_6 setting.

$$E = \int \left(\frac{I}{I_b} \right)^2 dt$$

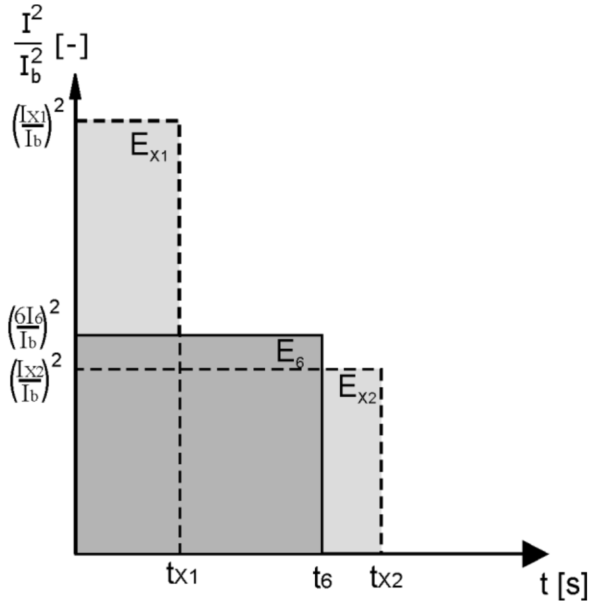


Fig. 6. Interpretation of the ItR1 protection operation time

The energy value is proportional to the square of the current flowing. The higher the current value, the shorter the start-up time required (for I_{X1} - t_{X1}) and similarly, the lower the start-up current value, the longer the start-up time is possible (for I_{X2} - t_{X2}).
In the shown cases $E_{X1} = E_{X2} = E_6$

The energy setting of a single start-up results from the current flow $I = 6I_b$ for the t_6 time.
If the engine manufacturer specifies the permissible start-up time t_x for the current value I_x, it should be recalculated according to the formula:

$$t_6 = t_x \cdot \left(\frac{I_x}{6 \cdot I_b} \right)^2$$

where: t_x – permissible start-up duration for the operate current I_x / setting
I_x – operate current as a parameter to define the permissible start-up time / setting
I_b – base current (rated engine current) / setting

For the BL_Z = ON setting, after the protection is tripped, the activation of the interlock output is activated for the set t_{reg} time, which enables the thermal regeneration of the engine after an unsuccessful start-up. Measurement of the engine starting interlock time $t_{regItR1}$ counts down the set time needed for the thermal regeneration of the engine.
The function has an independent input for canceling the interlock (clearing the interlocking time).

The current function state is defined as an $ItR1_{\%}$ measurement signaling the percentage of use of the rated single start-up energy; when 100% is reached, it is tripped.

Settings table

Setting	Description	Setting range	Default value
I_b	Base current	(0.50÷2.00) In in 0.01 In increments	1.00 In
t_6	permissible duration of the start-up for $I= 6I_b$	(1.00÷100.00) s in 0.01 s increments	10.00 s
t_{reg}	Engine thermal regeneration time after unsuccessful start-up (starting interlocking time)	(1.00÷180.00) min in 0.01 min increments	60.00 min
BL_Z	Activation of the starting interlock output for the t_{reg} time	(ON / OFF)	ON
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Permissible error of current measurement $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.16. IR>2 – overcurrent function, multiple engine start-ups (66)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Engine protection against a sequence of multiple start-ups that controls the start-up current proportional to the start-up energy.

Operation description
The protection function is made in the three-phase variant. It controls the start-up energy as a value proportional to the maximum value of the current from the phase current max selector.

The function requires the connection of binary information about the start-up, controlled by the DM – engine operation diagnostics function (page 28).
The protection controls a value proportional to the start-up energy and interlocks the starting when the calculated E_{pom} energy value exceeds the value:

$$E_{pom} > (R - 1) \cdot E_6$$

where: E_6 – energy value of a single start-up resulting from the flow of the inrush current $6I_b$ for the t_6 time / setting
R – number of permissible rated start-ups / setting

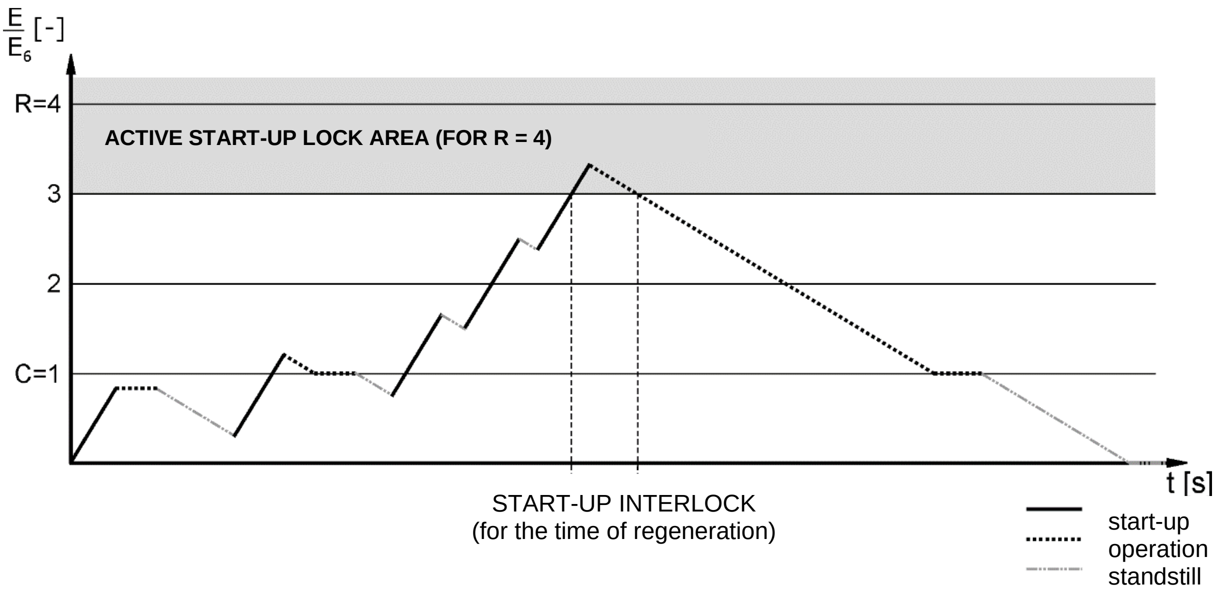


Fig. 7. Interpretation of the ItR2 protection start-up interlock from multiple starts

The R setting determines the permissible number of nominal start-ups from a cold state, not always the same as the number of actual starts-ups.
The energy setting of a single start-up results from the current flow $I = 6I_b$ for the t_6 time.
The C setting determines the energy level assumed to be the warm state of the engine. This setting is important for engine cooling and start-ups from the hot state.

E_{pom} energy calculation occurs only in the start-up state. When the engine is at standstill (for $I < 0.1I_b$), the calculated energy decreases (thermal regeneration state) always with the same time constant, resulting from the t_{reg} regeneration time setting; during this time the value will decrease by one E_6 level.
For the engine operation state ($I \geq 0.1I_b$) the E_{pom} value will also decrease, but only to the heated level according to the $E_{pom} = RE_6$ setting.
Note that for a hot engine, if there was no standstill long enough to drop the E_{pom} energy level below the C setting (for the case above C = 1), the available energy range of the permissible number of start-ups is limited by the C setting value:

RC-1 (for the case above $2E_6$). However, the actual start-up energy is usually lower than the rated energy E_6, because when this value is exceeded, the ItR1 protection is tripped. Hence, in most cases, the number of actual permissible start-ups is greater than that resulting from the set value.
The function has an independent input for canceling the interlock (resetting the E_{pom} energy level).
The current function state is defined as an ItR2 measurement that indicates a relative count of the rated energy proportional to the individual start-ups. The interlock will occur when the value reaches R-1 (for example above 3.00).

Settings table

Setting	Description	Setting range	Default value
I_b	Base current	(0.50÷2.00) In in 0.01 In increments	1.00 In
t_6	permissible duration of the start-up for $I= 6I_b$	(1.00÷100.00) s in 0.01 s increments	10.00 s
t_{reg}	Engine thermal regeneration time after unsuccessful start-up (starting interlocking time)	(1.00÷180.00) min in 0.01 min increments	60.00 min
R	Permissible number of rated start-ups	(1 ÷ 5) in 1 increments	4
C	Number of energy levels of the rated start-up E_6 corresponding to the hot state (<R)	(1 ÷ 5) in 1 increments	1
ON/OFF	Function activity	(ON / OFF)	ON

Parameters:
Permissible error of current measurement $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.17. IU> – overcurrent function, engine stall (51LR)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application
Engine protection against stall current increases.

Operation description
The protection function is made in the three-phase variant. It detects an increase in the maximum rms of the fundamental current component from the max selector of the phase currents.
For technological reasons, the protection is interlocked during the engine start-up.

The function requires the connection of binary information about the start-up, controlled by the DM – engine operation diagnostics function (page 28).

After exceeding the start-up value, the function is activated, and after a set time, it is tripped, according to the $I > I_r$ criterion.

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.60÷6.00) Ib in 0.01 Ib increments	5.00 Ib
I_b	Base current	(0.50÷2.00) In in 0.01 In increments	1.00 In
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Own time $t_w < 90$ ms
Permissible error of current measurement $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.18. ΔI> – stabilized residual current function with the second and fifth harmonics interlocking (87G, 87B, 87TB, 87TO)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function can be performed using one of the two available configuration interlocks: **ΔI>typ1** or **ΔI>typ2.** In the typ2 function, an option to select the method of calculating the braking current has been added.

Application

Stabilized residual current protection enables selective detection of phase-to-phase faults in the area it operates. With active interlock, the second harmonic of the residual current is insensitive to surges of the magnetizing current of the transformer; with active interlock, the fifth harmonic is insensitive to overmagnetization of the transformer.

The function enables the implementation of differential protection of:

- generator (87G),
- generator-engine hydro unit (87G/M),
- engine (87M),
- transformer with two and three windings (87TB, 87TO),
- block (87B).

In the case of generator (engine) differential protection, it is possible to disable the interlock from higher harmonics, although leaving the interlock from the second harmonic enables improvement of selectivity in case of external short circuits during saturation of current transformers.

Operation description

The criterion values are the residual and braking currents, based on which, in accordance with the start-up characteristics, the algorithm of the protection operation is calculated.
The measured values are three-phase currents measured in two, three or four branches of the protected object.
The figure below shows examples of applications of differential protection for a generator (or engine), for a unit with a tap for auxiliary purposes (three-branch differential protection) and with two taps (four-branch differential protection).

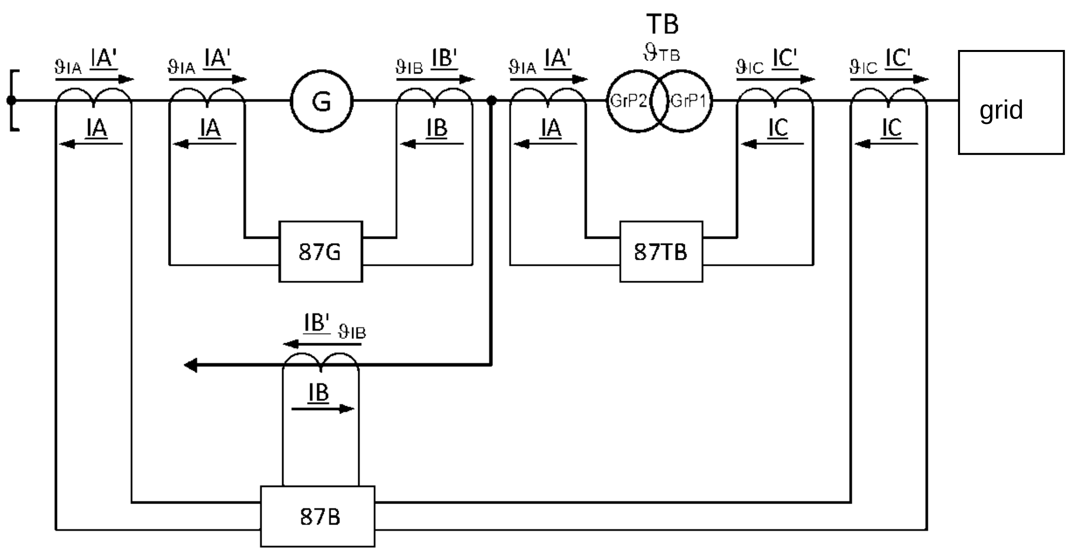


Fig. 8. Examples of differential protections within a interlock: 87G – generator differential protection, 87TB – interlock transformer differential protection, 87B – block differential protection (three-branch) (Tr_zas=DN)

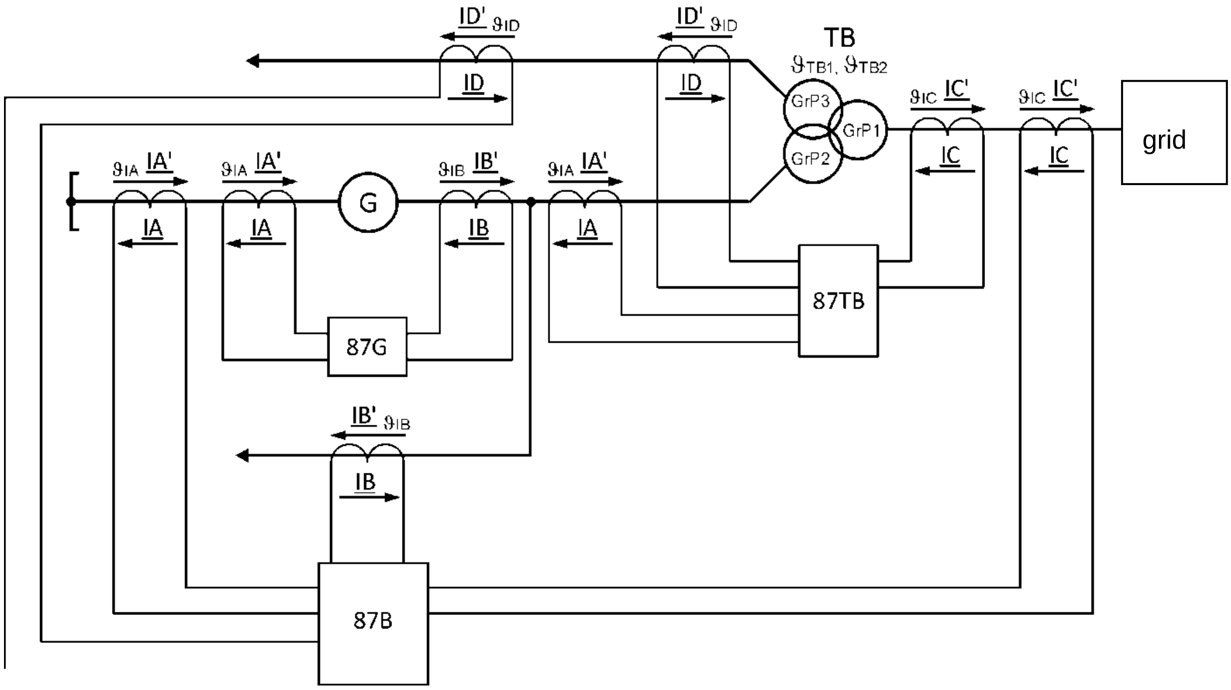


Fig. 9. Examples of differential protections within a interlock: 87G – generator differential protection, 87TB – interlock transformer differential protection, 87B – block differential protection (four-branch) (Tr_zas=DN)

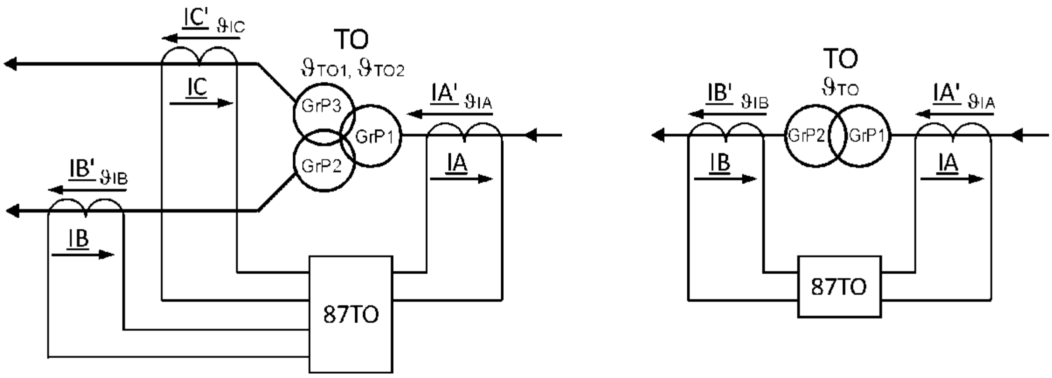


Fig. 10. Example of differential protection: 87TO – tap transformer differential protection (three-winding and two-winding variant) (Tr_zas=GN)

The correct operation of the differential protection is based on the introduction of the amplitude and phase correction of the measured currents, so that in its normal operation state, the value of the residual current is close to zero.
This correction is made for each phase of the measurement circuit. It includes the transformer ratio in the differential protection zone, as well as the connection group (phase shift) and the current transformer ratio values.

The group of connections of the protected transformer is selected for the function using GrP1, GrP2, GrP3 parameters, where:
GrP1 – winding connection group 1 (on the GN side of the transformer),
GrP2, GrP3 - winding connection groups 2, 3 (on the DN side of the transformer).

The GrP2 or GrP3 = OFF setting means that the transformer winding is missing, while the GrP2 = GrP3 = OFF parameters setting means differential protection with a range not including the transformer, i.e. differential protection of a generator, engine or gland.

In such case, the input currents I3, I4 will not be included in the calculations.

An additional setting parameter that determines the method of calculating the criteria is the setting of the supply side of the differential protection system (Tr_zas).
This is because the calculation of the residual and braking current values based on the corrections refers to the level of the current value marked in the I1 schemes. It is the supply side current, from which the remaining leakage currents of the measurement system are subtracted.
In the case of differential protection, including the Tr_zas = DN block transformer, the conversion of the criteria, i.e. the residual and braking currents, is relative to the current from the generator side (power supply). However, in the case of differential protection of tap transformers, where the typical supply direction of the system is from the upper voltage side, the setting is Tr_zas = GN and in this system the criteria values are recalculated according to the current from the upper voltage side of the tap transformer.
This setting is important due to the reference level of the setting, expressed in current ratings.
Equally important is the correct connection of measurement signals to the analog inputs of the functions labeled IA, IB, IC, ID.

The start-up characteristics of the differential protection are shown below.

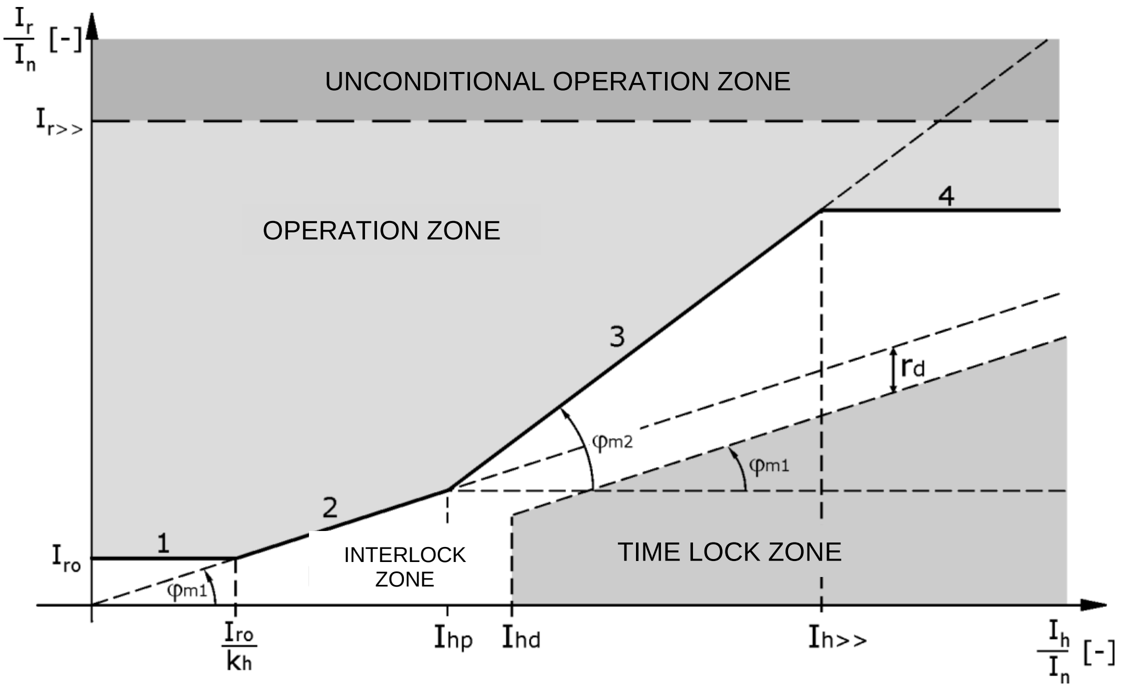


Fig. 11. Start-up characteristics of the stabilized residual current function

The criterion values of the differential protection are the amplitudes of the:

- fundamental harmonic of the residual current (I_r),
- fundamental harmonic of the braking current (I_h),
- second harmonic of the residual current (I_{r2}),
- fifth harmonic of the residual current (I_{r5}).

The amplitude of the fundamental harmonic of the residual current is assumed to be the amplitude of the fundamental harmonic of the geometric difference of the currents.

For generator protection:

$$I_r = \underline{I1} - \underline{I2}$$

For a four-branch interlock differential protection system:

$$I_r = \underline{I1} - (\underline{I2} + \underline{I3} + \underline{I4})$$

The amplitude of the fundamental harmonic of the stabilization current is understood as the amplitude of the fundamental harmonic of the result of the operation of the following relations for the corresponding set value:

Function	Tryb_Ih setting	For generator protection I_h	For a four-branch interlock differential protection system I_h
ΔI>typ1	Not applicable	$\frac{\underline{I1} + \underline{I2}}{2}$	$\frac{\underline{I1} + \underline{I2} + \underline{I3} + \underline{I4}}{2}$
ΔI>typ2	0	$\frac{\underline{I1} + \underline{I2}}{2}$	$\frac{\underline{I1} + \underline{I2} + \underline{I3} + \underline{I4}}{2}$
ΔI>typ2	1	$abs(\max(\lvert I1\rvert, \lvert I2\rvert) - \frac{\lvert I_r\rvert}{2})$	$abs(\max(\lvert I1\rvert, \lvert I2\rvert, \lvert I3\rvert, \lvert I4\rvert) - \frac{\lvert I_r\rvert}{2})$
ΔI>typ2	2	$\frac{\lvert I1\rvert + \lvert I2\rvert}{3}$	$\frac{\lvert I1\rvert + \lvert I2\rvert + \lvert I3\rvert + \lvert I4\rvert}{3}$
ΔI>typ2	3	$\frac{\lvert I1\rvert + \lvert I2\rvert}{2}$	$\frac{\lvert I1\rvert + \lvert I2\rvert + \lvert I3\rvert + \lvert I4\rvert}{2}$
ΔI>typ2	4	$\lvert I1\rvert + \lvert I2\rvert$	$\lvert I1\rvert + \lvert I2\rvert + \lvert I3\rvert + \lvert I4\rvert$

The calculations in the algorithm of the protection function include the values of the current transformer ratios and the transformer's gear and winding connection group located in the differential protection zone.
Phase compensation is achieved by subtracting the corresponding phase currents depending on the group of connections. For this purpose, the following transformations will be presented via matrix operations on three-phase waveforms.

For residual current reference to the lower voltage side (Tr_zas=DN setting):

	IA	IB	IC
Yy0	$\frac{1}{\sqrt{3}}\cdot(IA_{L1}-IA_{L3})$	$\frac{1}{\sqrt{3}}\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IB_{L1}-IB_{L3})$	$\frac{1}{\sqrt{3}}\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IC_{L1}-IC_{L3})$
Yy6	$\frac{1}{\sqrt{3}}\cdot(IA_{L1}-IA_{L3})$	$\frac{1}{\sqrt{3}}\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IB_{L1}-IB_{L3})$	$-\frac{1}{\sqrt{3}}\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IC_{L1}-IC_{L3})$
Yd1	IA_{L1}	$\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot IB_{L1}$	$\frac{1}{\sqrt{3}}\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IC_{L1}-IC_{L3})$
Yd5	$-IA_{L1}$	$-\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot IB_{L1}$	$\frac{1}{\sqrt{3}}\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IC_{L1}-IC_{L2})$
Yd7	$-IA_{L1}$	$-\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot IB_{L1}$	$\frac{1}{\sqrt{3}}\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IC_{L1}-IC_{L3})$
Yd11	IA_{L1}	$\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot IB_{L1}$	$\frac{1}{\sqrt{3}}\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IC_{L1}-IC_{L2})$
Dd0	IA_{L1}	$\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot IB_{L1}$	$\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot IC_{L1}$
Dd6	IA_{L1}	$\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot IB_{L1}$	$-\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot IC_{L1}$
Dy1	$\frac{1}{\sqrt{3}}\cdot(IA_{L1}-IA_{L2})$	$\frac{1}{\sqrt{3}}\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IB_{L1}-IB_{L2})$	$\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot IC_{L1}$
Dy5	$\frac{1}{\sqrt{3}}\cdot(IA_{L1}-IA_{L3})$	$\frac{1}{\sqrt{3}}\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IB_{L1}-IB_{L3})$	$-\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot IC_{L1}$
Dy7	$\frac{1}{\sqrt{3}}\cdot(IA_{L1}-IA_{L2})$	$\frac{1}{\sqrt{3}}\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IB_{L1}-IB_{L2})$	$-\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot IC_{L1}$
Dy11	$\frac{1}{\sqrt{3}}\cdot(IA_{L1}-IA_{L3})$	$\frac{1}{\sqrt{3}}\frac{\vartheta_{iB}\cdot I_{nB}}{\vartheta_{iA}\cdot I_{nA}}\cdot(IB_{L1}-IB_{L3})$	$\frac{\vartheta_{TB1-2}\cdot\vartheta_{iC}\cdot I_{nC}}{\vartheta_{iA}\cdot I_{nA}}\cdot IC_{L1}$

For three-winding transformers, the method of calculating the compensation of connection groups depends on the combination of each winding. Relationships for a system with a transformer on the GN side connected in a star (**GrP1=Y**) are shown in the table below:

GrP1=Y		Side 3 connection group – GrP3					
		y0	y6	d1	d5	d7	d11
Side 2 connection group – GrP2	y0	L1-L3 L1-L3 L1-L3	L1-L3 L1-L3 L3-L1	L1-L3 L1-L3 L1	L1-L2 L1-L2 -L1	L1-L3 L1-L3 -L1	L1-L2 L1-L2 L1
	y6	L1-L3 L3-L1 L1-L3	L1-L3 L3-L1 L3-L1	L1-L3 L3-L1 L1	L1-L2 L2-L1 -L1	L1-L3 L3-L1 -L1	L1-L2 L2-L1 L1
	d1	L1-L3 L1 L1-L3	L1-L3 L1 L3-L1	L1-L3 L1 L1	L1-L2 -L2 -L1	L1-L3 L1 -L1	L1-L2 -L2 L1
	d5	L1-L2 -L1 L1-L2	L1-L2 -L1 L2-L1	L1-L2 -L1 -L2	L1-L2 -L1 -L1	L1-L2 -L1 L2	L1-L2 -L1 L1
	d7	L1-L3 -L1 L1-L3	L1-L3 -L1 L3-L1	L1-L3 -L1 L1	L1-L2 L2 -L1	L1-L3 -L1 -L1	L1-L2 L2 L1
	d11	L1-L2 L1 L1-L2	L1-L2 L1 L2-L1	L1-L2 L1 -L2	L1-L2 L1 -L1	L1-L2 L1 L2	L1-L2 L1 L1

Configuration to recalculate side 1 Tr_zas=DN – IC, Tr_zas=GN - IA

Configuration to recalculate side 2 Tr_zas=DN – IA, IB, Tr_zas=GN - IB

Configuration to recalculate side 3 Tr_zas=DN – ID, Tr_zas=GN - IC

Relationships for a system with a transformer on the GN side connected in a triangle (**GrP1=D**) are shown in the table below:

GrP1=D		Side 3 connection group – GrP3					
		y1	y5	y7	y11	d0	d6
Side 2 connection group – GrP2	y1	L1 L1-L2 L1-L2	L1 L1-L2 L3-L1	L1 L1-L2 L2-L1	L1 L1-L2 L1-L3	L1 L1-L2 L1	L1 L1-L2 -L1
	y5	L1 L3-L1 L1-L2	L1 L3-L1 L3-L1	L1 L3-L1 L2-L1	L1 L3-L1 L1-L3	L1 L3-L1 L1	L1 L3-L1 -L1
	y7	L1 L2-L1 L1-L2	L1 L2-L1 L3-L1	L1 L2-L1 L2-L1	L1 L2-L1 L1-L3	L1 L2-L1 L1	L1 L2-L1 -L1
	y11	L1 L1-L3 L1-L2	L1 L1-L3 L3-L1	L1 L1-L3 L2-L1	L1 L1-L3 L1-L3	L1 L1-L3 L1	L1 L1-L3 -L1
	d0	L1 L1 L1-L2	L1 L1 L3-L1	L1 L1 L2-L1	L1 L1 L1-L3	L1 L1 L1	L1 L1 -L1
	d6	L1 -L1 L1-L2	L1 -L1 L3-L1	L1 -L1 L2-L1	L1 -L1 L1-L3	L1 -L1 L1	L1 -L1 -L1

First line of each cell: Configuration to recalculate side 1 Tr_zas=DN – IC, Tr_zas=GN - IA

Second line of each cell: Configuration to recalculate side 2 Tr_zas=DN – IA, IB, Tr_zas=GN - IB

Third line of each cell: Configuration to recalculate side 3 Tr_zas=DN – ID, Tr_zas=GN - IC

In addition, the following multipliers must be included to recalculate the transformer ratios and current transformer compensation factor:
For Tr_zas=DN:

Tr_zas	IA	IB	IC	ID
DN	$r \cdot IA_{tab}$	$r \frac{\vartheta_{iB} \cdot I_{nB}}{\vartheta_{iA} \cdot I_{nA}} \cdot IB_{tab}$	$r \frac{\vartheta_{TB1\text{-}2} \cdot \vartheta_{iC} \cdot I_{nC}}{\vartheta_{iA} \cdot I_{nA}} \cdot IC_{tab}$	$r \frac{1}{\sqrt{3}} \frac{\vartheta_{TB1\text{-}2} \cdot \vartheta_{iD} \cdot I_{nD}}{\vartheta_{TB1\text{-}3} \cdot \vartheta_{iA} \cdot I_{nA}} \cdot ID_{tab}$
GN	$r \cdot IA_{tab}$	$r \frac{\vartheta_{iB} \cdot I_{nB}}{\vartheta_{TB1\text{-}2} \cdot \vartheta_{iA} \cdot I_{nA}} \cdot IB_{tab}$	$r \frac{\vartheta_{iC} \cdot I_{nC}}{\vartheta_{TB1\text{-}3} \cdot \vartheta_{iA} \cdot I_{nA}} \cdot IC_{tab}$	---------------------------

where:

$r = \frac{1}{\sqrt{3}}$ I_{tab} is a difference of two currents according to the table

$r = 1$ I_{tab} is a single phase current

ϑ_{iX} X = A, B, C or D transformer ratio

I_{nX} rated current of the secondary side of the transformer X = A, B, C or D

$\vartheta_{TB1\text{-}X}$ transformer ratio in the differential protection zone $\vartheta_{TB1\text{-}2} = PT1\text{-}2$; $\vartheta_{TB1\text{-}3} = PT1\text{-}3$

Example for the Yy0d11 transformer for Tr_zas=DN:

$$I_{rL1} = \frac{1}{\sqrt{3}}(IA_{L1} - IA_{L2}) - \left[\frac{1}{\sqrt{3}} \frac{\vartheta_{iB} \cdot I_{nB}}{\vartheta_{iA} \cdot I_{nA}} \cdot (IB_{L1} - IB_{L2}) + \frac{1}{\sqrt{3}} \frac{\vartheta_{TB1\text{-}2} \cdot \vartheta_{iC} \cdot I_{nC}}{\vartheta_{iA} \cdot I_{nA}} \cdot (IC_{L1} - IC_{L2}) + \frac{\vartheta_{TB1\text{-}2} \cdot \vartheta_{iD} \cdot I_{nD}}{\vartheta_{TB1\text{-}3} \cdot \vartheta_{iA} \cdot I_{nA}} \cdot ID_{L1} \right]$$

$$I_{rL3} = \frac{1}{\sqrt{3}}(IA_{L3} - IA_{L1}) - \left[\frac{1}{\sqrt{3}} \frac{\vartheta_{iB} \cdot I_{nB}}{\vartheta_{iA} \cdot I_{nA}} \cdot (IB_{L3} - IB_{L1}) + \frac{1}{\sqrt{3}} \frac{\vartheta_{TB1\text{-}2} \cdot \vartheta_{iC} \cdot I_{nC}}{\vartheta_{iA} \cdot I_{nA}} \cdot (IC_{L3} - IC_{L1}) + \frac{\vartheta_{TB1\text{-}2} \cdot \vartheta_{iD} \cdot I_{nD}}{\vartheta_{TB1\text{-}3} \cdot \vartheta_{iA} \cdot I_{nA}} \cdot ID_{L3} \right]$$

The following areas (zones) of the start-up characteristics of the differential protection can be distinguished:

INTERLOCK ZONE – this area contains the operating point under normal conditions, the protection function is not activated.

TIME LOCK ZONE – this area contains the operating point for external short circuits when the braking current exceeds the $I_h > I_{hd}$ setting and the residual current is relatively low. When the operating point is in this zone, the set time delay t_{bld} is activated, the countdown of which occurs after leaving the time interlock zone. This allows increased selectivity for cases of strong external short circuits. If the operating point is temporarily moved from the time interlock zone to the operation zone for a period of time no longer than the set delay t_{bld} will not cause a shutdown. The exception is when the residual current exceeds the $I_{r>>}$, setting limit, which trips the function immediately.
It is possible to set aside the operation of this zone (N_{SBC} = OFF).

OPERATION ZONE – area of conditional activation of the function when there is no interlocking from the content of higher harmonics in the residual current.
If the value of the second or fifth harmonic with regard to the fundamental component of the residual current is greater than the set value of the corresponding k_{b2}, k_{b5} interlocking factor then the operation of the protection is interlocked.

The interlocking conditions determine the dependencies: $\frac{I_{2r}}{I_r} > k_{b2}$ or $\frac{I_{5r}}{I_r} > k_{b5}$

Interlocking is implemented on a cross-checking basis, which means that the interlocking condition is checked between the maximum value of the second and fifth components from all phases, up to the value of the residual current from the phase where it is maximum. This approach improves the selectivity of the interlock and avoids incorrect shutdowns.
It is possible to set aside interlocking independently of the second harmonic and/or the fifth harmonic (N_{2r} = OFF, N_{5r} = OFF settings).
In the **ΔI>typ2** function it is possible to "set aside" the cross-checking. Then the interlock condition is checked between the value of the second and fifth components of each phase.

UNCONDITIONAL OPERATION ZONE – the area of activation of the function when the primary component of the residual current exceeds the setting value of the limit residual current $I_{r>>}$. In this area, the protection operates without implementing the start-up characteristics and without interlocking from higher harmonics. This area also ignores the time interlock resulting from the displacement of the work point from the time interlock zone.
This allows additional acceleration of the protection operation in case of a strong internal short circuit.
It is possible to set aside the operation of this zone ($N_{r>>}$ = OFF).

Description of the implementation of the ΔI> differential function:

<u>Section 1</u> – limitation with the initial residual current, regardless of the braking current level.

$$for\ I_h \le \frac{I_{ro}}{k_h} \Rightarrow I_r > I_{ro}$$

<u>Section 2</u> – according to the characteristics, slope based on the k_{h1} setting.

$$for\ \frac{I_{ro}}{k_h} < I_h \le I_{hp} \Rightarrow I_r > k_{h1} I_h$$

<u>Section 3</u> – according to the characteristics, slope based on the k_{h2} setting.

$$for\ I_{hp} < I_h \le I_{h>>} \Rightarrow I_r > k_{h2} I_h$$

<u>Section 4</u> – only for $N_{h>>}$ = ON, additional stabilization after exceeding the $I_{h>>}$ setting by braking current. Characterization by horizontal line according to the calculation of the point according to the $I_{h>>}$ setting.

$$for\ I_h > I_{h>>} \Rightarrow I_r > k_{h2} I_{h>>}$$

where: I_r - the primary component of the inrush (residual) current / estimate
I_{2r} - the second harmonic of inrush (residual) current / estimate
I_{5r} - the fifth harmonic of inrush (residual) current / estimate
I_h - the primary component of the stabilizing (braking) current / estimate
I_{ro} - initial inrush (residual) current / setting
$I_{r>>}$ - limit inrush (residual) current / setting
$I_{h>>}$ - limit stabilizing (braking) current / setting
I_{hp} - bias stabilizing current / setting
I_{hd} - stabilizing current time interlock start-up value / setting
t_{bld} - time of operation interlock after leaving the time interlock zone / setting
r_d - shift of the time interlock zone from the operation zone / setting
k_{h1} - stabilization factor determining the slope of the characteristics of the start-up characteristics (section 2) to the abscissa axis according to the formula $k_{h1} = tg(\varphi_{m1})$ / setting
k_{h2} - stabilization factor determining the slope of the characteristics of the start-up characteristics (section 3) to the abscissa axis according to the formula $k_{h2} = tg(\varphi_{m2})$ / setting

NOTE:

Through the settings, it is possible to disable the time interlock zone, 2 h and 5 h harmonics interlock, limit stabilization and to disable the unconditional operation zone, where:

N_{2r} - the second harmonic interlock on / bit setting
N_{5r} - the fifth harmonic interlock on / bit setting
N_{SBC} - time interlock zone on / bit setting
$N_{h>>}$ - limit stabilization on / bit setting
$N_{r>>}$ - unconditional shutdown zone on / bit setting

Settings table

Setting	Description	Setting range	Default value
I_{ro}	Initial differential current.	(0.05÷2.00) In in 0.01 In increments	0.50 In
$I_{r>>}$	Boundary differential starting current	(1.00÷20.00) In in 0.01 In increments	5.00 In
$I_{h>>}$	Boundary restraining current	(1.00÷20.00) In in 0.01 In increments	10.00 In
I_{hp}	Bias stabilizing current	(1.00÷20.00) In in 0.01 In increments	3.00 In
I_{hd}	time interlock of the stabilizing current start-up value	(1.00÷20.00) In in 0.01 In increments	20.00 In
t_{bld}	operation interlock time after leaving the time interlock zone	(0.01÷1.00) s in 0.01 s increments	0.08 s
r_d	shift of the time interlock zone from the operation zone	(0.00÷5.00) In in 0.01 In increments	0.50 In
k_{h1}	stabilization factor determining the slope of the characteristics of the start-up characteristics (section 2) to the abscissa axis according to the formula $k_{h1} = tg(\varphi_{m1})$	(0.10÷0.80) in 0.01 increments	0.20
k_{h2}	stabilization factor determining the slope of the characteristics of the start-up characteristics (section 3) to the abscissa axis according to the formula $k_{h2} = tg(\varphi_{m2})$	(0.10÷0.80) in 0.01 increments	0.50
k_{b2}	blocking factor from the second content in the residual current	(0.01÷0.50) in 0.01 increments	0.10
k_{b5}	blocking factor from the fifth content in the residual current	(0.01÷0.30) in 0.01 increments	0.10
t_z	Delay time	(0.00÷0.10) s in 0.01 s increments	0.00 s
k_p	Reset ratio	(0.60÷0.99) in 0.01 increments	0.80
Tr_zas	supply side of the differential protection system	(DN, GN)	DN

Setting	Description	Setting range	Default value
GrP1*)	factory group of transformer winding connections for GN winding (1)	(Y, D)	Y
GrP2*)	factory group of transformer winding connections for SN winding (2)	(OFF, y0, y1, y5, y6, y7, y11, d0, d1, d5, d6, d7, d11)	y0
GrP3*)	factory group of transformer winding connections for SN winding (3)	(OFF, y0, y1, y5, y6, y7, y11, d0, d1, d5, d6, d7, d11)	OFF
Tryb_Ih	Method of calculating the braking current (only for the ΔI>typ2 version)	(S(i)/2,Imax-Ir/2, S(|I|),S(|I|)/2,S(|I|)/3)	Imax-Ir/2
PT1-2	transformer winding connection ratio for winding 1-2	(1.00÷100.00) in 0.01 increments	17.46
PT1-3	transformer winding connection ratio for winding 1-3	(1.00÷100.00) in 0.01 increments	1.00
ON/OFF	Function activity	(ON / OFF)	ON
BL_ON	Interlock input activation	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
N_{2r}	the second harmonic interlock on	(ON / OFF)	ON
N_{5r}	the fifth harmonic interlock on	(ON / OFF)	OFF
N_{SBC}	time lock zone on	(ON / OFF)	OFF
$N_{h>>}$	Boundary restraining ON	(ON / OFF)	ON
$N_{r>>}$	unconditional trip zone ON	(ON / OFF)	ON
TrybBlh	Interlock operation from higher harmonics mode (only for the ΔI>typ2 version)	(max z faz / fazowy) (max from phase / phased)	fazowy (phased)

*) **NOTE:** The function supports the following settings of connection groups (GrP1, GrP2, GrP3):

Yy0, Yy6, Yd1, Yd5, Yd7, Yd11
Dd0, Dd6, Dy1, Dy5, Dy7, Dy11

Other combinations of transformer winding system are not supported (no calculation of residual and brake currents).

Parameters:

Own time	$t_w < 10$ ms	for $I_r > 2I_{r>>}$ (reed relay)
	$t_w < 15$ ms	for $I_r > 2I_{r>>}$ (RM executive relay)
	$t_w < 30$ ms	for $I_r < I_{r>>}$

Own time includes the algorithm time and the response time of the executive relay contact $t_w=t_{wa}+t_{wp}$
The own time of the algorithm when the limit operate current is exceeded twice is
t_{wa}= 4 ms. For the reed relay t_{wp}= 3 ms, while for the RM executive relay t_w= 8 ms.

Permissible measurement error of input currents $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.19. ΔIL – Line differential protection. Stabilized differential function with second harmonic braking (87L, 87TL)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function is implemented using the configuration interlock: **ΔIL.** The operation requires two iZAZ400s connected by a fiber optic cable (two half-complexes)

Application
Stabilized residual current protection enables selective detection of phase-to-phase faults in the area it operates. With active interlock, the second harmonic of the residual current is insensitive to the surges of the transformer magnetizing current.

The function enables the implementation of differential protection of:

- line (87L),
- line ending with a double-winding transformer (87TL).

Operation description
The criterion values are the residual and braking currents, based on which, in accordance with the start-up characteristics, the algorithm of the protection operation is calculated.
The measured values are three-phase currents measured in two half-complexes.
The correct operation of the differential protection is based on the introduction of the amplitude and phase correction of the measured currents, so that in its normal operation state, the value of the residual current is close to zero.
This correction is made for each phase of the measurement circuit. It includes the transformer ratio in the differential protection zone, as well as the connection group (phase shift) and the current transformer ratio values.

The connection group of the protected transformer is selected for the function using the parameters GrP1, GrP2, where:
GrP1 – winding connection group 1 (on the GN side of the transformer),
GrP2 – winding connection group 2 (on the DN side of the transformer).

The GrP2 = OFF setting means no transformer.

The performance characteristics of the protection are shown in Fig.11 in section 2.18.

The criterion values of the differential protection are the amplitudes of the:

- fundamental harmonic of the residual current (I_r),
- fundamental harmonic of the braking current (I_h),
- second harmonic of the residual current (I_{r2}),

The amplitude of the fundamental harmonic of the residual current is assumed to be the amplitude of the fundamental harmonic of the geometric difference of the currents.

$$I_r = \underline{I1} - \underline{I2}$$

The amplitude of the fundamental harmonic of the stabilization current is understood as the amplitude of the fundamental harmonic of the result of the operation of the following relations for the corresponding set value:

$$I_h = \frac{\underline{I1} + \underline{I2}}{2}$$

The calculations in the algorithm of the protection function include the values of the current transformer ratios and the transformer's gear and winding connection group located in the differential protection zone.
Phase compensation is achieved by subtracting the corresponding phase currents depending on the group of connections. The conversion method for the corresponding transformer is shown in section 2.18.

The following areas (zones) of the start-up characteristics of the differential protection can be distinguished:

INTERLOCK ZONE – this area contains the operating point under normal conditions, the protection function is not activated.

TIME LOCK ZONE – this area contains the operating point for external short circuits when the braking current exceeds the $I_h > I_{hd}$ setting and the residual current is relatively low. When the operating point is in this zone, the set time delay t_{bld} is activated, the countdown of which occurs after leaving the time interlock zone. This allows increased selectivity for cases of strong external short circuits. If the operating point is temporarily moved from the time interlock zone to the operation zone for a period of time no longer than the set delay t_{bld} will not cause a shutdown. The exception is when the residual current exceeds the $I_{r>>}$, setting limit, which trips the function immediately.
It is possible to set aside the operation of this zone (N_{SBC} = OFF).

OPERATION ZONE – area of conditional activation of the function when there is no interlocking from the content of higher harmonics in the residual current.
If the second harmonic value based on the fundamental component of the residual current is greater than the set value of the corresponding k_{b2} interlocking factor, the protection operation is interlocked.

The interlocking conditions determine the dependencies: $\frac{I_{2r}}{I_r} > k_{b2}$

Interlocking is implemented on a cross-checking basis, which means that the interlocking condition is checked between the maximum value of the second and fifth components from all phases, up to the value of the residual current from the phase where it is maximum. This approach improves the selectivity of the interlock and avoids incorrect shutdowns.
It is possible to set aside (N_{2r} = settings).

UNCONDITIONAL OPERATION ZONE – the area of activation of the function when the primary component of the residual current exceeds the setting value of the limit residual current $I_{r>>}$. In this area, the protection operates without implementing the start-up characteristics and without interlocking from higher harmonics. This area also ignores the time interlock resulting from the displacement of the work point from the time interlock zone.
This allows additional acceleration of the protection operation in case of a strong internal short circuit.
It is possible to set aside the operation of this zone ($N_{r>>}$ = OFF).

Description of the implementation of the ΔI> differential function:

Section 1 – limitation with the initial residual current, regardless of the braking current level.

$$for\ I_h \leq \frac{I_{ro}}{k_h} \Rightarrow I_r > I_{ro}$$

Section 2 – according to the characteristics, slope based on the k_{h1} setting.

$$for\ \frac{I_{ro}}{k_h} < I_h \leq I_{hp} \Rightarrow I_r > k_{h1} I_h$$

Section 3 – according to the characteristics, slope based on the k_{h2} setting.

$$for\ I_{hp} < I_h \leq I_{h>>} \Rightarrow I_r > k_{h2} I_h$$

Section 4 – only for $N_{h>>}$ = ON, additional stabilization after exceeding the $I_{h>>}$ setting by braking current. Characterization by horizontal line according to the calculation of the point according to the $I_{h>>}$ setting.

$$for\ I_h > I_{h>>} \Rightarrow I_r > k_{h2} I_{h>>}$$

where:
- I_r - the primary component of the inrush (residual) current / estimate
- I_{2r} - the second harmonic of inrush (residual) current / estimate
- I_h - the primary component of the stabilizing (braking) current / estimate
- I_{ro} - initial inrush (residual) current / setting
- $I_{r>>}$ - limit inrush (residual) current / setting
- $I_{h>>}$ - limit stabilizing (braking) current / setting
- I_{hp} - bias stabilizing current / setting
- I_{hd} - stabilizing current time interlock start-up value / setting
- t_{bld} - time of operation interlock after leaving the time interlock zone / setting
- r_d - shift of the time interlock zone from the operation zone / setting
- k_{h1} - stabilization factor determining the slope of the characteristics of the start-up characteristics (section 2) to the abscissa axis according to the formula $k_{h1} = tg(\varphi_{m1})$ / setting
- k_{h2} - stabilization factor determining the slope of the characteristics of the start-up characteristics (section 3) to the abscissa axis according to the formula $k_{h2} = tg(\varphi_{m2})$ / setting

NOTE:

The settings allow to disable the time interlock zone, interlock from the 2 h harmonic, limit stabilization and to disable the unconditional operation zone, where:
- N_{2r} - the second harmonic interlock on / bit setting
- N_{SBC} - time interlock zone on / bit setting
- $N_{h>>}$ - limit stabilization on / bit setting
- $N_{r>>}$ - unconditional shutdown zone on / bit setting

Settings table

Setting	Description	Setting range	Default value
I_{ro}	Initial residual current.	(0.05÷2.00) In in 0.01 In increments	0.50 In
$I_{r>>}$	limit (residual) operate current	(1.00÷20.00) In in 0.01 In increments	5.00 In
$I_{h>>}$	limit stabilizing (braking) current	(1.00÷20.00) In in 0.01 In increments	10.00 In
I_{hp}	bias stabilizing current	(1.00÷20.00) In in 0.01 In increments	3.00 In
I_{hd}	time interlock of the stabilizing current start-up value	(1.00÷20.00) In in 0.01 In increments	20.00 In
t_{bld}	operation interlock time after leaving the time interlock zone	(0.01÷1.00) s in 0.01 s increments	0.08 s
r_d	shift of the time interlock zone from the operation zone	(0.00÷5.00) In in 0.01 In increments	0.50 In
k_{h1}	stabilization factor determining the slope of the characteristics of the start-up characteristics (section 2) to the abscissa axis according to the formula $k_{h1} = tg(\varphi_{m1})$	(0.10÷0.80) in 0.01 increments	0.20
k_{h2}	stabilization factor determining the slope of the characteristics of the start-up characteristics (section 3) to the abscissa axis according to the formula $k_{h2} = tg(\varphi_{m2})$	(0.10÷0.80) in 0.01 increments	0.50
k_{b2}	blocking factor from the second content in the residual current	(0.01÷0.50) in 0.01 increments	0.10
t_z	Delay time	(0.00÷0.10) s in 0.01 s increments	0.00 s
k_p	Reset ratio	(0.60÷0.99) in 0.01 increments	0.80
GrP1*)	factory group of transformer winding connections for GN winding (1)	(Y, D)	Y

Setting	Description	Setting range	Default value
GrP2*)	factory group of transformer winding connections for SN winding (2)	(OFF, y0, y1, y5, y6, y7, y11, d0, d1, d5, d6, d7, d11)	OFF
PT1-2	transformer winding connection ratio for winding 1-2	(1.00÷100.00) in 0.01 increments	1.00
ON/OFF	Function activity	(ON / OFF)	ON
BL_ON	Interlock input activation	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
N_{2r}	the second harmonic interlock on	(ON / OFF)	ON
N_{SBC}	time interlock zone on	(ON / OFF)	OFF
$N_{h>>}$	limit stabilization on	(ON / OFF)	ON
$N_{r>>}$	unconditional shutdown zone on	(ON / OFF)	ON
Tryb (Mode)	Second side connection mode	SLAVE, MASTER	MASTER
dł_poł	The length of the connection between the two assemblies	(0÷40,000) in 1 increments	1,000

*) **NOTE:** The function supports the following settings of connection groups (GrP1, GrP2):

Yy0, Yy6, Yd1, Yd5, Yd7, Yd11
Dd0, Dd6, Dy1, Dy5, Dy7, Dy11

Other combinations of transformer winding system are not supported (no calculation of residual and brake currents).

Parameters:

Own time	$t_w < 10$ ms	for $I_r > 2I_{r>>}$ (reed relay)
	$t_w < 15$ ms	for $I_r > 2I_{r>>}$ (RM executive relay)
	$t_w < 30$ ms	for $I_r < I_{r>>}$

Own time includes the algorithm time and the response time of the executive relay contact $t_w=t_{wa}+t_{wp}$
The own time of the algorithm when the limit operate current is exceeded twice is
t_{wa}= 4 ms. For the reed relay t_{wp}= 3 ms, while for the RM executive relay t_w= 8 ms.

Permissible measurement error of input currents $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.20. Io> – zero-sequence component overcurrent function, time independent (51N)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application
Basic non-directional earth fault protection, used in grids where the overcurrent criterion is sufficient to selectively identify an earth fault.

Operation description
Protection function made in the single-phase variant, using the estimation of the zero current primary component ($3I_0$). Typically, the signal from a Ferranti transformer is used. It is possible to connect transformers in the Holmgreen system, and to introduce an estimate of the zero component, calculated from three phase currents.

When the start-up value is exceeded, the function is activated and, after a set time, tripped, according to the $3I_0 > I_{0r}$ criterion.

The protection also works correctly and reliably in the event of an intermittent short circuit. The durations of the activation pulses and the durations of the pauses between these pulses are controlled. Tripping will occur after a time that is derived from the duration of the activations and the intervals between activation pulses.
In this connection, it should be borne in mind that an intermittent earth short circuit causes an additional delay in tripping the protection, related to the time required to correctly identify the phenomenon.
When the activation is stable, the tripping delay time is in accordance with the set time.

In the case of both stable and intermittent short circuits, the protection operates with a delayed dropout. After the disappearance of the signal causing activation of the protection, the dropout occurs after 280 ms. The delayed dropout of the protection is due to the characteristics of the measurement algorithm, not to the use of an additional timing circuit.

Settings table

Setting	**Description**	**Setting range**	**Default value**
I_{or}	Operate current	(5÷5,000) mA in 1 mA increments	20 mA
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	0.10 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Own time $t_w < 100$ ms (for uninterruptible short circuits)
Return time $t_p < 280$ ms
Permissible error $\delta_{\%} = \pm 2.5\% \pm 1$ mA

2.21. Io>inv – zero-sequence component overcurrent function, time dependent (51N)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Non-directional earth fault protection with time dependent characteristics, used in grids where the overcurrent criterion is sufficient to selectively identify an earth fault.

Operation description
Protection function using the zero current primary component estimate ($3I_0$). Typically, the signal from a Ferranti transformer is used. It is possible to connect transformers in the Holmgreen system, and to introduce an estimate of the zero component, calculated from three phase currents.

When the start-up value is exceeded, the function is activated according to the $3I_0 > I_{0r}$ criterion.

The protection also works correctly and reliably in the event of an intermittent short circuit. The durations of the activation pulses and the durations of the pauses between these pulses are controlled. Tripping will occur after the calculated time according to the following formula, plus any interval times between activation pulses.
In this connection, it should be borne in mind that an intermittent earth short circuit causes an additional delay in tripping the protection, related to the time required to correctly identify the fault.
If the activation is stable, the tripping delay time is in accordance with the time calculated by the formula.

In the case of both stable and intermittent short circuits, the protection operates with a delayed dropout. After the disappearance of the signal causing activation of the protection, the dropout occurs after 280 ms. The delayed dropout of the protection is due to the characteristics of the measurement algorithm, not to the use of an additional timing circuit.

The time-current characteristics of the protection is determined by the formula:

$$t = 2t_2 \cdot \left(\frac{I_{or}}{3I_o} \right)$$

where: $3I_o$ - zero-sequence current / estimate
I_{or} - operate current setting value / setting
t_2 - settable tripping time for $3I_o=2I_{or}$ / setting

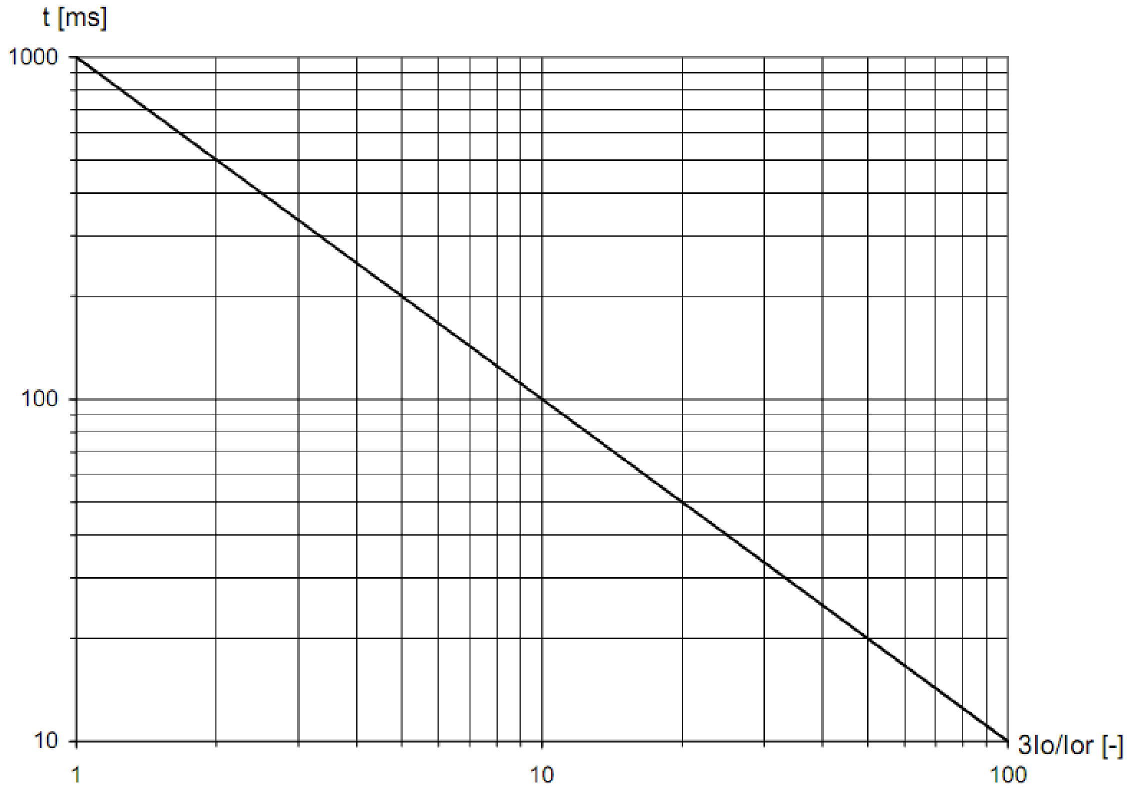


Fig. 12. Time-current characteristics of the Io>inv protection (for the t_2 = 0.50 s setting)

Settings table

Setting	Description	Setting range	Default value
I_{or}	Operate current	(5÷1,000) mA in 1 mA increments	10 mA
t_2	Delay time for $3I_o=2I_{or}$	(0.00÷100.00) s in 0.01 s increments	0.10 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:

Own time $t_w < 100$ ms (for uninterruptible short circuits)

Return time $t_p < 280$ ms

Permissible error $\delta_{\%} = \pm 2.5\% \pm 1$ mA

2.22. IoKs> – zero-sequence component directional function, delayed independent (59N/67N)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Directional earth fault protection, used in grids where the non-directional overcurrent criterion is insufficient to selectively identify an earth fault.

Operation description

A protection function using an estimate of the zero current ($3I_0$) and zero voltage ($3U_0$) primary component. Typically, the signal from a Ferranti transformer is used. It is possible to connect transformers in the Holmgreen system, and to introduce an estimate of the zero component, calculated from three phase currents. To determine the direction of the short circuit, an estimate of the phase shift angle between the current and voltage zero-sequence component is calculated.

The protection also works correctly and reliably in the event of an intermittent short circuit. The durations of the activation pulses and the durations of the pauses between these pulses are controlled. Tripping will occur after a set time, plus any interval times between activation pulses.
In this connection, it should be borne in mind that an intermittent earth short circuit causes an additional delay in tripping the protection, related to the time required to correctly identify the fault.
When the activation is stable, the tripping delay time is in accordance with the set time.

In the case of both stable and intermittent short circuits, the protection operates with a delayed dropout. After the disappearance of the signal causing activation of the protection, the dropout occurs after 280 ms. The delayed dropout of the protection is due to the characteristics of the measurement algorithm, not to the use of an additional timing circuit.

The start-up characteristics of the protection are determined by the following formula, with the additional consideration of the condition for the minimum value of zero voltage $3U_o > U_{akt:}$

$$3Io > \frac{I_{or}}{|\cos(\varphi - \varphi_m)|}$$ /setting dir: NO DIRECTION

$$3Io > \frac{I_{or}}{\cos(\varphi - \varphi_m)}$$ /setting dir: FROM BUS-BAR

$$3Io > \frac{I_{or}}{-\cos(\varphi - \varphi_m)}$$ /setting dir: TO BUS-BAR

where:
- $3I_o$ - zero-sequence current / estimate
- $3U_o$ - zero-sequence voltage / estimate
- φ - phase shift angle between the zero-sequence component voltage and current / estimate
- I_{or} - operate current setting value / setting
- U_{akt} - protection activation voltage / setting
- φ_m - maximum sensitivity angle / setting

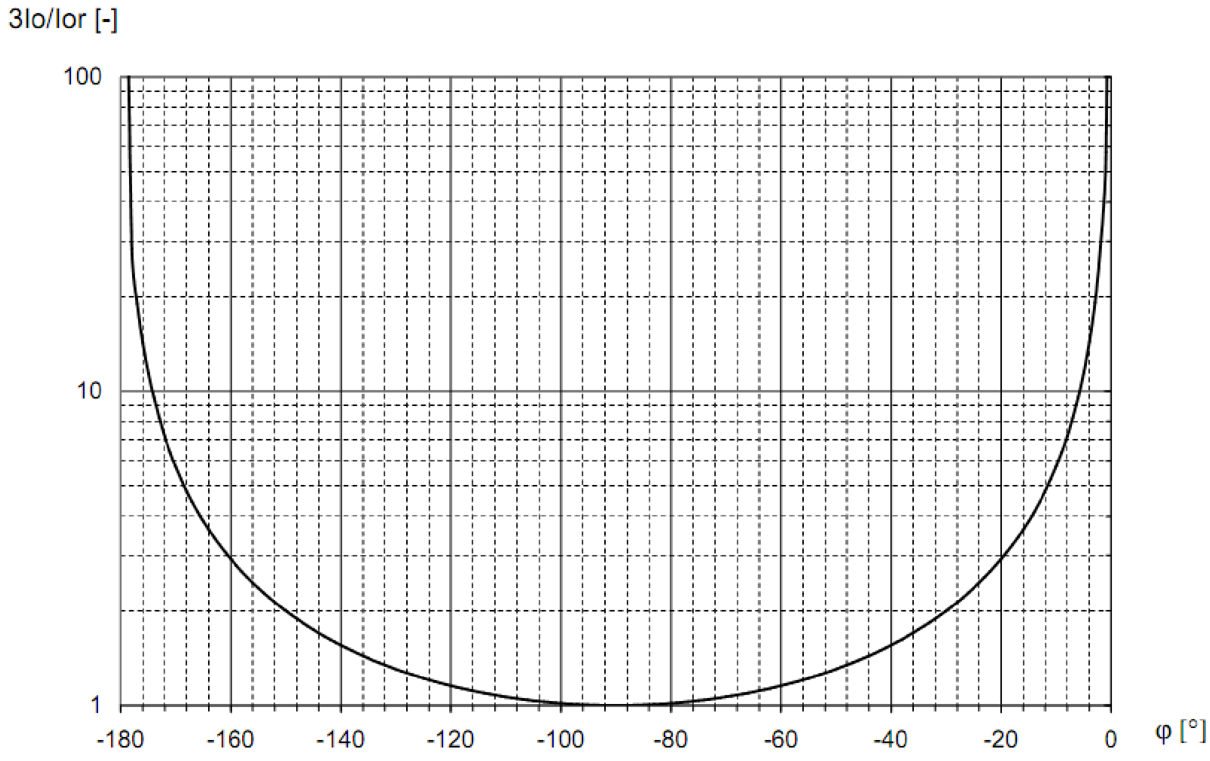


Fig. 13. Start-up characteristics of the IoKs> (dir=OD SZYN; φ_m = 90cap°) protection

Settings table

Setting	Description	Setting range	Default value
I_{or}	Operate current	(5÷5,000) mA in 1 mA increments	20 mA
U_{akt}	Protection activation voltage	(0.010÷1.000) U_n in 0.001 U_n increments	0.100 U_n
φ_m	maximum sensitivity angle	(0.0÷90.0)cap ° in 0,1 ° increments	0cap °
dir	Action direction	(FROM BUS-BAR / TO BUS-BAR / NO DIRECTION)	(FROM BUS-BAR)
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	0.50 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:

Own time $t_w < 100$ ms (for uninterruptible short circuits)

Return time $t_p < 280$ ms

Permissible error $\delta_{\%} = \pm 2.5\% \pm 1$ mA

2.23. IoKw> – zero-sequence component directional function, delayed independent (59N/67N)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Directional earth fault protection, used in grids where the non-directional overcurrent criterion is insufficient to selectively identify an earth fault. Used in HV grids with a directly earthed neutral point.

Operation description

A protection function using an estimate of the zero current ($3I_0$) and zero voltage ($3U_0$) primary component. Typically, the connected signal from the transformers in the Holmgreen system or the zero-sequence component estimate is calculated from the three phase currents. To determine the direction of the short circuit, an estimate of the phase shift angle between the voltage and current zero-sequence component is calculated.

The start-up characteristics of the protection are determined by the following formula, with the additional consideration of the condition for the minimum value of zero voltage $3U_o > U_{akt}$:

$$3Io > \frac{I_{or}}{|\cos(\varphi - \varphi_m)|}$$ /setting dir: NO DIRECTION

$$3Io > \frac{I_{or}}{\cos(\varphi - \varphi_m)}$$ /setting dir: FROM BUS-BAR

$$3Io > \frac{I_{or}}{-\cos(\varphi - \varphi_m)}$$ /setting dir: TO BUS-BAR

where:
- $3I_o$ - zero-sequence current / estimate
- $3U_o$ - zero-sequence voltage / estimate
- φ - phase shift angle between the zero-sequence component voltage and current / estimate
- I_{or} - operate current setting value / setting
- U_{akt} - protection activation voltage / setting
- φ_m - maximum sensitivity angle / setting

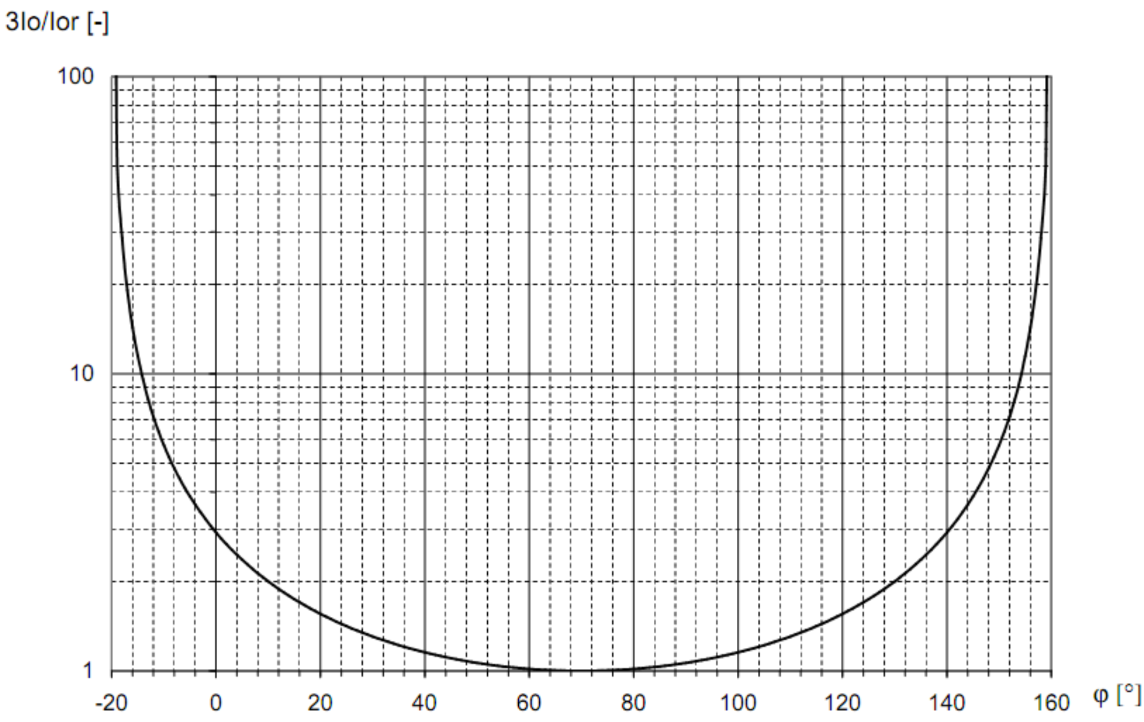


Fig. 14. Start-up characteristics of the IoKw> (dir=OD SZYN ; φ_m = 70ind°) protection

Settings table

Setting	Description	Setting range	Default value
I_{or}	Operate current	(0.05÷30.00) In in 0.01 In increments	2.00 In
U_{akt}	Protection activation voltage	(0.010÷1.000) U_n in 0.001 U_n increments	0.100 U_n
φ_m	Maximum sensitivity angle	(0.0÷90.0)ind ° in 0.1 ° increments	70 ind °
dir	Action direction	(FROM BUS-BAR / TO BUS-BAR)	(FROM BUS-BAR)
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:

Own time $t_w < 30$ ms

Permissible error $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.24. Io_kal – earth fault protection function with current calibration

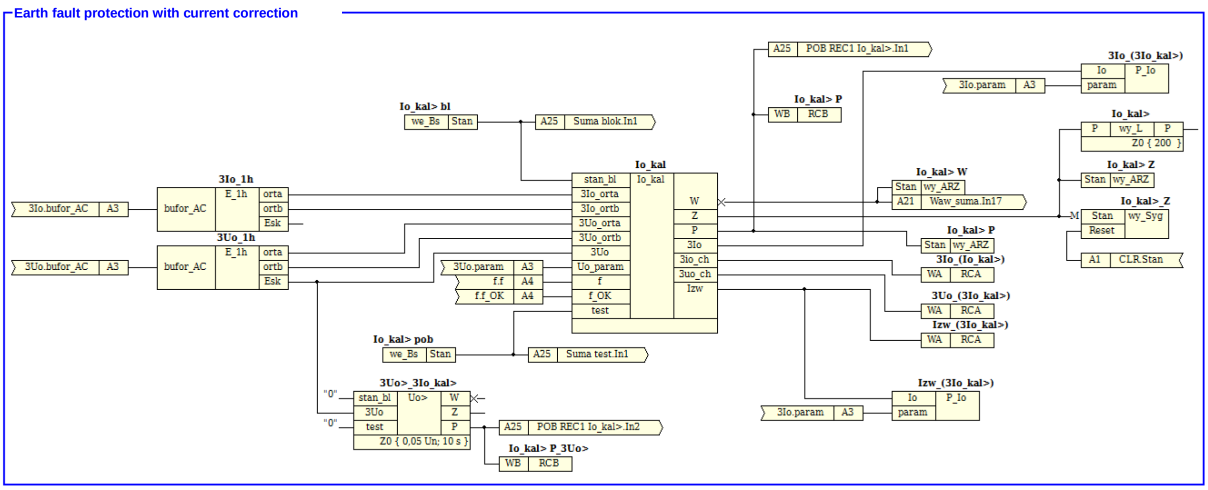
iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Earth fault protection dedicated for MV grid switchgear with small capacitive currents. Directional protection with current calibration.

Operation description
The entire function is configured from several pre-processing function interlocks and the actual function interlock (earth fault relay with current calibration).
From the input signals, pre-processing functions (configurable) calculate:

- vector of the current zero-sequence component (orthogonal components)
- vector of the voltage zero-sequence component (orthogonal components and rms)
- grid frequency

Calculations of criterion values and corrections are made based on the signal vectors of the fundamental harmonic calculated using a pair of digital filters (SOI) with full-period sine and cosine windows.
The relay consists of two basic parts: a current correction circuit and a criterion relay. An example configuration of the function is shown in the following scheme:



The current of the zero-sequence component is continuously monitored, and if the zero-sequence component of the voltage appears (the rms exceeds the set value of 3Uor), the current flowing before the short circuit is treated as a disturbance. An additional condition for activating the correction is the observation of a step change in the earth fault current. The pitch size can be adjusted with the "**kkal**" setting. Once these conditions are met, the current zero-sequence component is then calculated as the vector difference of the current value and the value before the short circuit. To avoid transients, the entire calculation is delayed by 20 to 40 ms, and depending on the recognized state, the correction is activated or not. The correction vector (the current before the moment of short circuiting) is further corrected as a function of frequency (phase shift in the case of frequency deviation from 50Hz).
The relay can operate without frequency correction (e.g., no measurement of line voltage), but it should be noted that the accuracy of correction will decrease over time, until with large frequency deviations it can cause undesirable effects (increase instead of decrease in error).
The function is equipped with a time relay to turn off correction after a set time. In this case, the relay's main algorithm operates on the total current without any correction.

The criterion value of the earth fault relay is the current calculated from the formula:

$$I_{zw} = \left| 3\underline{I}_0 - j \cdot 3B_3 \cdot \underline{U}_0 \right|$$

where:

- I_{zw} – criterion value
- $3I_o$ – the current zero-sequence component vector corrected by the vector of the current before the moment of short circuit.
- $3U_o$ – voltage zero-sequence component vector
- $3B_3$ – susceptance value of the protected object (settable)

After exceeding the start-up value (the 3Iorz setting), the relay is activated, and after the set time has elapsed, it is tripped.

Settings table

Setting	Description	Setting range	Default value
3Uor	Limit voltage	(0.010÷0.500) U_n in 0.001 U_n increments	0.050 U_n
3B	Object susceptance value	(0.05÷500.00) ms in 0.01 ms increments	0.10 ms
3Iorz	Inrush value of the short circuit current	(1.0÷1,000.0) mA in 0.1 mA increments	10 mA
kp	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
tz	Delay time	(0.00÷100.00) s in 0.01 s increments	0.50 s
tkal	Calibration time	(0.00÷10.00) s in 0.01 s increments	5.00 s
kkal	Calibration condition safety factor	(0.50÷4.00) in 0.01 increments	2.00
ON/OFF	Relay active/inactive	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
Bl_ON	Interlock on/off	(włączona/wyłączona) (on/off)	włączona (on)

Parameters:

Own time $t_w < 100$ ms

Permissible error $\delta_{\%} = \pm 5\% \pm 0.01$ In

2.25. Yo> – non-directional earth fault admittance function, delayed independent (21N)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Typically used as earth fault protection, in grids with an isolated neutral point or in compensated grids and in grid configurations with the neutral point earthed through a resistor (parallel lines, ring grid), when the measurement of the current zero-sequence component is not a sufficient criterion for the correct identification of a short circuit. The protection can also be used in compensated grids equipped with active component forcing devices.

The advantage of admittance protection, compared to zero-current protection, is the greatly increased sensitivity of earth fault detection when the earthing resistor is damaged (possibly disconnected).

A characteristic feature of admittance protection is the matching of sensitivity to earth fault conditions. For high short circuit impedance and low Uo voltage values, the protection works already at a low current value.

Operation description

A protection function that uses an estimate of the zero current ($3I_0$) and zero voltage ($3U_0$) primary component to determine the admittance modulus. Typically connected signal from Ferranti transformer and open triangle voltage transformers.

Admittance is determined on the secondary side of the transformers, so the start-up value should be recalculated by the transformers' ratios to the secondary side.

The protection also works correctly and reliably in the event of an intermittent short circuit. The durations of the activation pulses and the durations of the pauses between these pulses are controlled. Tripping will occur after a set time, plus any interval times between activation pulses.

In this connection, it should be borne in mind that an intermittent earth short circuit causes an additional delay in tripping the protection, related to the time required to correctly identify the phenomenon.

When the activation is stable, the trip time delay is in accordance with the set time.

In the case of both stable and intermittent short circuits, the protection operates with a delayed dropout. After the disappearance of the signal causing activation of the protection, the dropout occurs after 280 ms. The delayed dropout of the protection is due to the characteristics of the measurement algorithm, not to the use of an additional timing circuit.

The start-up characteristics of the protection are determined by the following formula, with the additional consideration of the condition for the minimum value of zero voltage $3U_o > U_{akt}$:

$$Y \geq Y_{or}$$

$$Y = \left| \frac{3I_o}{3U_o} \right|$$

where: Y - zero-sequence component admittance modulus / estimate
$3I_o$ - zero-sequence current / estimate
$3U_o$ - zero-sequence voltage / estimate
Y_{or} - start-up admittance setting value (secondary side) / setting
U_{akt} - protection activation voltage / setting

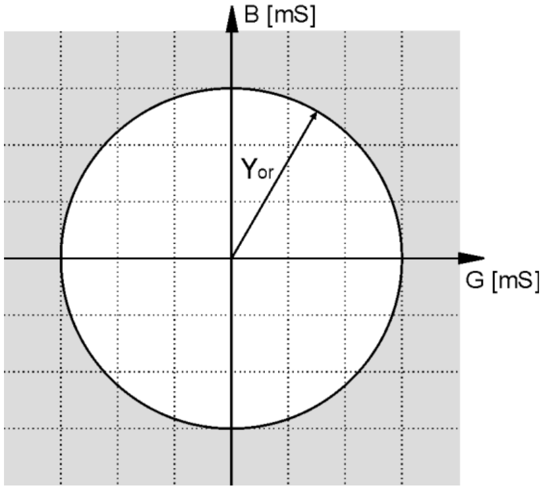


Fig. 15. Start-up characteristics of the Yo> protection

Settings table

Setting	Description	Setting range	Default value
Y_{or}	Start-up admittance (secondary side)	(0.05÷500.00) ms in 0.01 ms increments	0.10 ms
U_{akt}	Protection activation voltage	(0.010÷1.000) U_n in 0.001 U_n increments	0.100 U_n
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	0.50 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Own time $t_w < 100$ ms (for uninterruptible short circuits)
Return time $t_p < 280$ ms
Permissible error $\delta_{\%} = \pm 2.5\% \pm 0.01$mS

2.26. YoK> – directional earth fault admittance function, delayed independent (21N)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application

Typically used as an earth fault protection, in grids with an isolated neutral point or in compensated grids and in grid configurations with the neutral point earthed through a resistor (parallel lines, ring grid), when the measurement of the current zero-sequence component is not a sufficient criterion for the correct identification of a short circuit. The protection can also be used in compensated grids equipped with active component forcing devices.
The advantage of admittance protection, compared to zero-current protection, is the greatly increased sensitivity of earth fault detection when the earthing resistor is damaged (possibly disconnected).
A characteristic feature of admittance protection is the matching of sensitivity to earth fault conditions. For high short circuit impedance and low Uo voltage values, the protection works already at a low current value.
The ability to set the direction of operation enables the implementation of conductance (for $\varphi_m = 0°$) or susceptance (for $\varphi_m = 90°$) directional or non-directional protection.

Operation description

A protection function that uses an estimate of the zero current ($3I_0$) and zero voltage ($3U_0$) primary component to determine the admittance vector. Typically connected signal from Ferranti transformer and open triangle voltage transformers.
Admittance is determined on the secondary side of the transformers, so the start-up value should be recalculated by the transformers' ratios to the secondary side.

The protection also works correctly and reliably in the event of an intermittent short circuit. The durations of the activation pulses and the durations of the pauses between these pulses are controlled. Tripping will occur after a set time, plus any interval times between activation pulses.
In this connection, it should be borne in mind that an intermittent earth short circuit causes an additional delay in tripping the protection, related to the time required to correctly identify the fault.
When the activation is stable, the trip time delay is in accordance with the set time.

In the case of both stable and intermittent short circuits, the protection operates with a delayed dropout. After the disappearance of the signal causing activation of the protection, the dropout occurs after 280 ms. The delayed dropout of the protection is due to the characteristics of the measurement algorithm, not to the use of an additional timing circuit.

The start-up characteristics of the protection are determined by the following formula, with the additional consideration of the condition for the minimum value of zero voltage $3U_o > U_{akt:}$

$$Y \geq \frac{Y_{or}}{|\cos(\varphi_m - \varphi)|}$$ /setting dir: NO DIRECTION

$$Y \geq \frac{Y_{or}}{\cos(\varphi_m - \varphi)}$$ /setting dir: FROM BUS-BAR

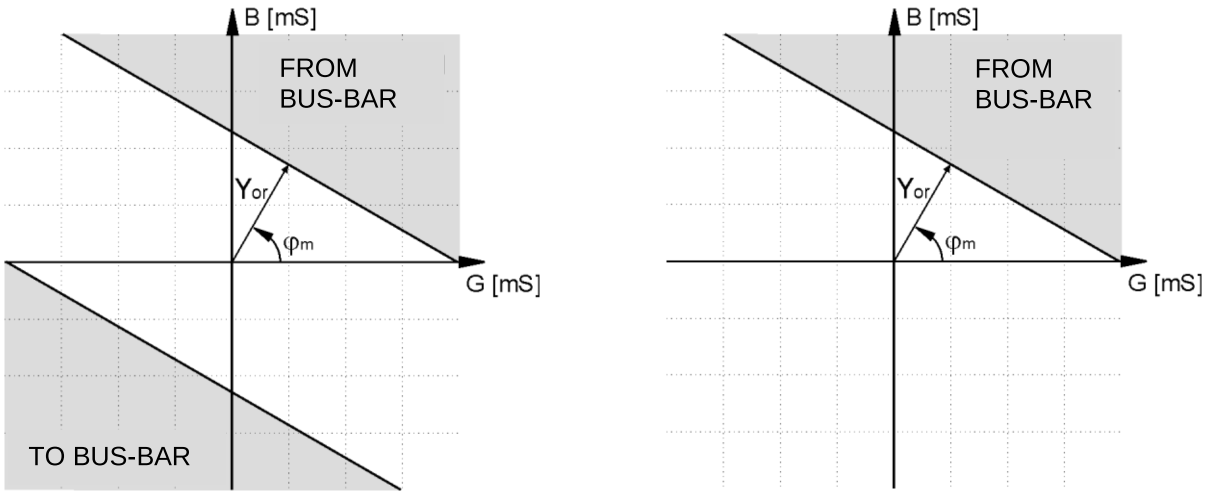
$$Y \geq \frac{Y_{or}}{-\cos(\varphi_m - \varphi)}$$ /setting dir: TO BUS-BAR

for $$Y = \frac{3I_o}{3U_o}$$

$$Y = \frac{3I_o}{3U_o}$$

where: Y - zero-sequence admittance vector / estimate
$3I_o$ - zero-sequence current / estimate
$3U_o$ - zero-sequence voltage / estimate
Y_{or} - start-up admittance setting value (secondary side) / setting
U_{akt} - protection activation voltage / setting

φ_m - maximum sensitivity angle /
setting



dir: NO DIRECTION setting **dir: FROM BUS-BAR setting**

Fig. 16. Start-up characteristics of the YoK> (for φ_m = 60 cap °) protection

Settings table

Setting	**Description**	**Setting range**	**Default value**
Y_{or}	Start-up admittance (secondary side)	(0.05÷500.00) ms in 0.01 ms increments	0.10 ms
U_{akt}	Protection activation voltage	(0.010÷1.000) U_n in 0.001 U_n increments	0.100 U_n
φ_m	maximum sensitivity angle	(0.0÷90.0)cap ° in 0,1 ° increments	0 cap °
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	0.50 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:

Own time	t_w < 100 ms (for uninterruptible short circuits)
Return time	t_p < 280 ms
Permissible error	$\delta_{\%} = \pm 2.5\% \pm 0.01mS$

2.27. U1f> – single-phase overvoltage function, time independent (59)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Basic overvoltage protection to perform the function of protecting the object (e.g., generator, block transformer) from the effects of excessive voltage increase.

Operation description
Protection function made in single-phase variant.

The function uses an estimate of the phase or phase-to-phase voltage primary component.

After exceeding the start-up value, the function is activated, and after a set time it is tripped, according to the $U > U_r$ criterion.

Settings table

Setting	Description	Setting range	Default value
U_r	Inrush voltage	(0.010÷1.500) Un in 0.001 Un increments	1.10 Un
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Own time $t_w < 30$ ms

Permissible error (1.21 ÷ 1.50) Un $\delta_{\%} = \pm 1.0\%$
Permissible error (0.45 ÷ 1.20) Un $\delta_{\%} = \pm 0.5\%$
Permissible error (0.21 ÷ 0.45) Un $\delta_{\%} = \pm 1.0\%$
Permissible error (0.01 ÷ 0.20) Un $\delta_{\%} = \pm 2.5\% \pm 0.1$ V

2.28. U1f>(3h) – 100% stator earth fault protection function based on the difference of neutral voltages third harmonics (64S)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Supplementary protection of the stator earth fault protection system, protecting the part of the windings near the star point of the generator, not covered by the 59N protection based on the appearance of the voltage zero-sequence component.

Operation description

Protection function made in single-phase variant.
The function uses estimates of the zero voltages third harmonics from the transformer side of the generator's neutral point and from the power output side of the open-triangle system.
The protection is based on the presence of the third harmonic component in the generator voltage under normal operating conditions.
The algorithm is based on the difference of these values, which, in the event of a circuit earthing from the side of the star point, causes the appearance of the difference of these voltages.
After exceeding the start-up value, the function is activated, and after a set time it is tripped, according to the $Ua_{3h} - Ub_{3h} > U_r$ criterion.
In generator-transformer interlock systems equipped with a generator breaker, where there is the possibility of generator operation for captive use, two levels of protection are used due to the need to select different 3h voltage compensation factors, due to the different nature of the system capacitance, depending on the position of the block breaker.

Settings table

Setting	Description	Setting range	Default value
U_r	Inrush voltage	(0.001÷0.300) Un in 0.001 Un increments	0.010 Un
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:

Own time	$t_w < 30$ ms
Permissible error	$\delta_{\%} = \pm 2.5\% \pm 0.1$ V

2.29. U> – three-phase overvoltage function, time independent (59)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application
Basic overvoltage protection to perform the function of protecting the object (e.g., generator, block transformer) from the effects of excessive voltage increase.

Operation description
The protection function is made in the three-phase variant.

The function uses primary component estimates of phase or phase-to-phase voltages.

After exceeding the start-up value, the function is activated, and after a set time it is tripped, according to the $U > U_r$ criterion.
The function analyzes the criterion in all phases simultaneously and enables the output of activation information from each phase independently (e.g. information to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
U_r	Inrush voltage	(0.010÷1.500) Un in 0.001 Un increments	1.10 Un
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:

Own time	$t_w < 30$ ms
Permissible error (1.21 ÷ 1.50) Un	$\delta_{\%} = \pm1.0\%$
Permissible error (0.45 ÷ 1.20) Un	$\delta_{\%} = \pm0.5\%$
Permissible error (0.21 ÷ 0.45) Un	$\delta_{\%} = \pm1.0\%$
Permissible error (0.01 ÷ 0.20) Un	$\delta_{\%} = \pm2.5\% \pm 0.1$ V

2.30. U>inv – overvoltage function, time dependent (59)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Protects the generator and block transformer from the effects of excessive voltage rise.

Operation description
The criterion value of the function is the amplitude of the largest voltage primary component, selected via max selector.

The tripping time of the function, as time-dependent (N_{ZAL} = ON), according to the dependence:

$$t = \frac{k_1}{\left(\frac{U}{U_r}\right)^C - k_2^C} \quad [s]$$

At the (N_{ZAL} = OFF), the function operates as time independent, with a settable delay time t_z.

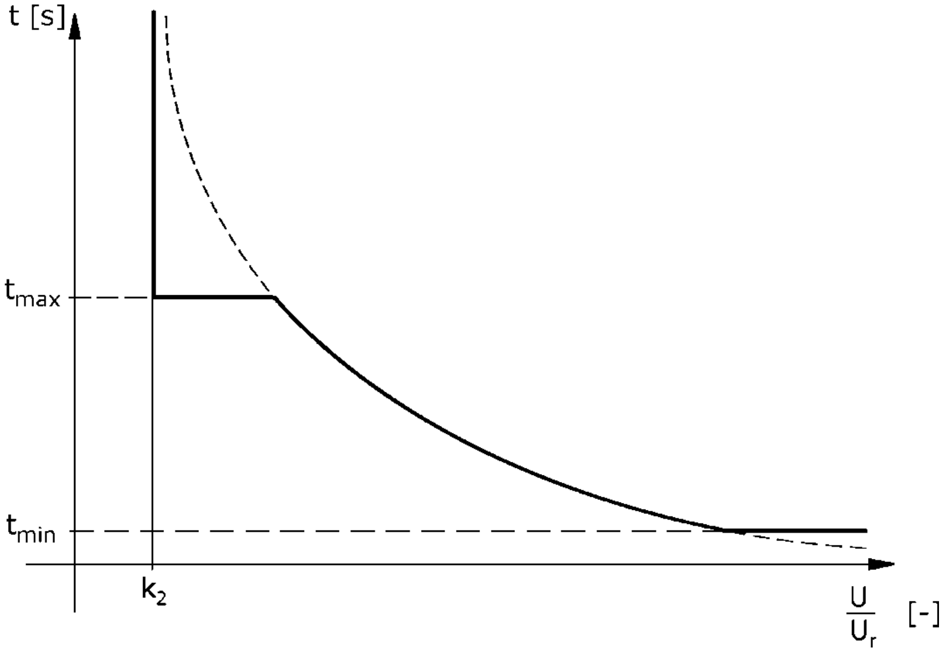


Fig. 17. Time dependent characteristics of the overvoltage function.

Settings table

Setting	Description	Setting range	Default value
U_r	Inrush voltage	(1.010 ÷ 1.500) U_n in 0.001 U_n increments	1.100 U_n
k_1	Factor proportional to the delay	(0.00÷10,000.00) s in 0.01 s increments	60.00 s
k_2	Characteristics shift factor	(0.01÷1.00) in 0.01 increments	1.00
c	Exponent	(0.01÷10.00) in 0.01 increments	2.00
t_{min}	Minimum delay time	(0.00÷60.00) s in 0.01 s increments	5.00 s
t_{max}	Maximum delay time	(100.00÷6,000.00) s in 0.01 s increments	300.00 s
k_p	Reset ratio	(0.80÷0.99) in 0.01 increments	0.95
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
N_{ZAL}	time dependent characteristics on	(ON / OFF)	ON
t_z	Delay time (N_{ZAL} = OFF)	(0.00÷300.00) s in 0.01 s increments	10.00 s

Parameters:

Own time	$t_w < 30$ ms
Permissible error (1.21 ÷ 1.50) Un	$\delta_{\%} = \pm 1.0\%$
Permissible error (0.45 ÷ 1.20) Un	$\delta_{\%} = \pm 0.5\%$
Permissible error (0.21 ÷ 0.45) Un	$\delta_{\%} = \pm 1.0\%$
Permissible error (0.01 ÷ 0.20) Un	$\delta_{\%} = \pm 2.5\% \pm 0.1$ V

Permissible time measurement error according to PN-EN 60255-3 for voltage measurement error, respectively.

2.31. U1f< – single-phase undervoltage function, time independent (27)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application
A function to implement, for example, undervoltage protection of a generator. Other possibilities of use - an auxiliary criterion for automation systems.

Operation description
Protection function made in single-phase variant.
The function uses an estimate of the phase or phase-to-phase voltage primary component.
When the start-up value is reduced below the start-up value, the function is activated, and after a set time it is tripped, according to the $U < U_r$ criterion.

Settings table

Setting	Description	Setting range	Default value
U_r	Inrush voltage	(0.010÷1.200) Un in 0.001 Un increments	0.800 Un
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(1.00÷1.20) in 0.01 increments	1.02
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:

Own time	$t_w < 30$ ms
Permissible error (0.45 ÷ 1.20) Un	$\delta_{\%} = \pm 0.5\%$
Permissible error (0.21 ÷ 0.45) Un	$\delta_{\%} = \pm 1.0\%$
Permissible error (0.01 ÷ 0.20) Un	$\delta_{\%} = \pm 2.5\% \pm 0.1$ V

2.32. U< – three-phase undervoltage function, time independent (27)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
A function that enables the implementation of undervoltage protection, such as for the generator protection. In addition, the possibility of using as an auxiliary criterion in automation systems.

Operation description
The protection function is made in the three-phase variant.
The function uses primary component estimates of phase or phase-to-phase voltages.
When the start-up value is reduced below the start-up value, the function is activated, and after a set time it is tripped, according to the $U < U_r$ criterion
The function analyzes the criterion in all phases simultaneously and enables the output of activation information from each phase independently (e.g. information to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
U_r	Inrush voltage	(0.010÷1.200) Un in 0.001 Un increments	0.800 Un
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(1.00÷1.20) in 0.01 increments	1.02
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	AND

Parameters:
Own time $t_w < 30$ ms
Permissible error (0.45 ÷ 1.20) Un $\delta_{\%} = \pm 0.5\%$
Permissible error (0.21 ÷ 0.45) Un $\delta_{\%} = \pm 1.0\%$
Permissible error (0.01 ÷ 0.20) Un $\delta_{\%} = \pm 2.5\% \pm 0.1$ V

2.33. Usp> – control of incorrect order of rotation of engine phases function (47)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Protection to detect the opposite direction of rotation of the supply voltage phases.

Operation description
Protection function based on the measurement of the value of the positive sequence component and negative sequence component measurement voltage. Detection of the opposite direction of phase rotation is based on the analysis of two criteria:

$$U_2 > U_{r2} \text{ and } U_1 < U_{r1}.$$

where: U_2 - voltage negative sequence component / estimate
U_1 - voltage positive sequence component / estimate
U_{r2} - negative sequence component inrush voltage / setting
U_{r1} - positive sequence component inrush voltage / setting

If the value of the opposite voltage component U_2 is greater than the set start-up value U_{r2}, while meeting the condition for the value of the voltage component in accordance with U_1 (U_1 < Ur1), the protection is tripped after the set delay time.

Settings table

Setting	Description	Setting range	Default value
U_{r2}	Negative sequence component inrush voltage	(0.300÷1.000) Un in 0.001 Un increments	0.800 Un
U_{r1}	Positive sequence component inrush voltage	(0.050÷1.000) Un in 0.001 Un increments	0.100 Un
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Own time $t_w < 30$ ms
Permissible error $\delta_{\%} = \pm1.0\%U_n$ (for $U_{L1}=U_{L2}=U_{L3} = U_n$)

2.34. Uf>inv – single or three-phase frequency-voltage function, time dependent or independent (24)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Protects a transformer, operating in a interlock with a generator, excited by a thyristor system, from excessive increases in magnetic induction.

Operation description
The criterion values of the function are voltage amplitude and frequency. The protection measurement system implements the frequency-voltage function, which is a measure of induction in iron

$$B = c\frac{U}{f}$$

As a criterion for the protection operation, the transformer's overexcitation factor, or the relative value of the quotient, was used. The start-up characteristics, shown in the figure below, are determined by the dependence

$$\frac{U}{f}\frac{f_n}{U_n} > Uf_r$$

where: U_n – transformer rated voltage
f_n – rated frequency

Voltage and frequency values below which the function operation is interlocked:
Interlock voltage $U < U_{akt}$
Interlock frequency $f < f_{akt}$

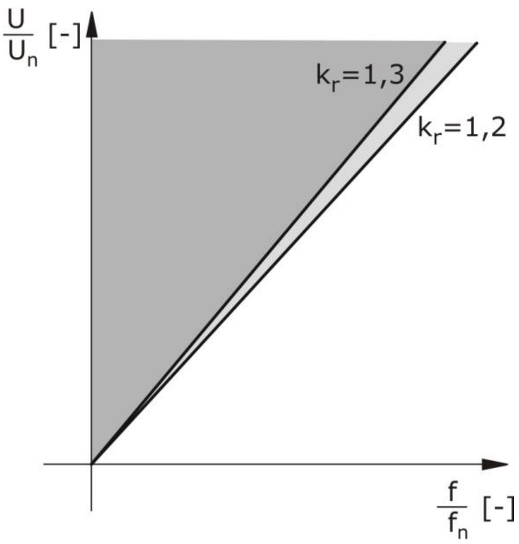


Fig. 18. Start-up characteristics of the frequency-voltage function.

The tripping time of the function, as time-dependent (the N_{ZAL} = ON setting), is determined by the dependence:

$$t = \frac{k_1}{\left(\frac{U}{f}\frac{f_n}{U_n}\right)^C - k_2^C} \quad [s]$$

For the N_{ZAL} = OFF setting, the function operates as a time independent, with a settable delay time t_z.

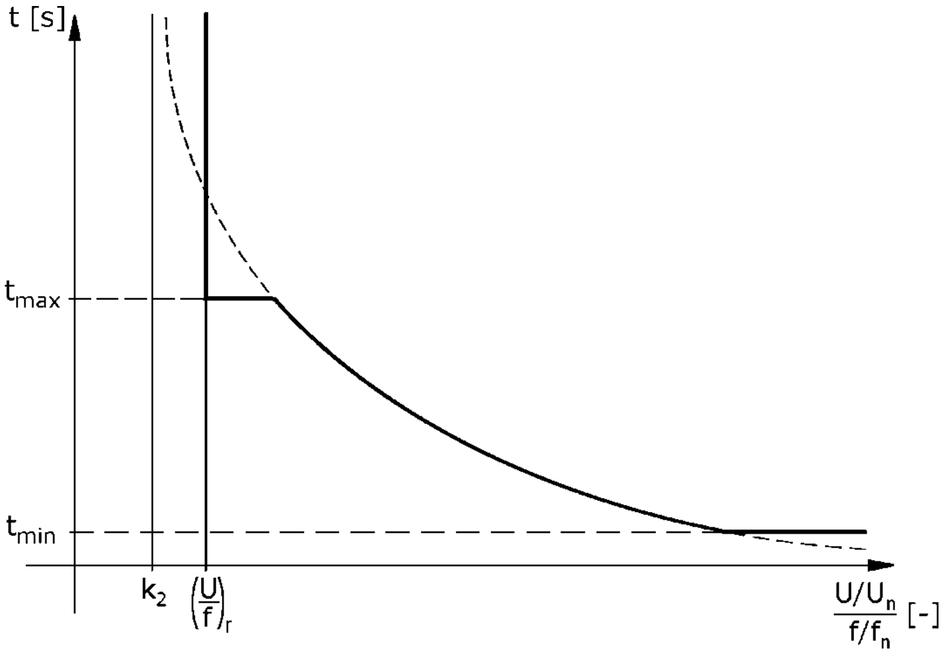


Fig. 19. Time dependent characteristics of the frequency-voltage function (N_{ZAL} = ON).

Settings table

Setting	Description	Setting range	Default value
$(U/f)_r$	Start-up overexcitation factor	(1.01 ÷ 1.50) U_n/f_n in 0.01 U_n/f_n increments	1.30 U_n/f_n
U_{akt}	Protection activation voltage	(0.010÷1.000) U_n in 0.001 U_n increments	0.200 U_n
f_{akt}	Frequency of protection activation	(0.100÷1.000)f_n in 0.001 f_n increments	0.300 f_n
t_z	Delay time (N_{ZAL} = OFF)	(0.00÷300.00) s in 0.01 s increments	10.00 s
k_p	Reset ratio	(0.80÷0.99) in 0.01 increments	0.95
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR
N_{ZAL}	time dependent characteristics on	(ON / OFF)	ON
k_1	Factor proportional to the delay	(0.00÷10,000.00) s in 0.01 s increments	60.00 s
k_2	Characteristics shift factor	(0.01÷1.00) in 0.01 increments	1.00
c	Exponent	(0.01÷10.00) in 0.01 increments	2.00
t_{min}	Minimum operate time delay	(0.00÷20.00) s in 0.01 s increments	1.00 s
t_{max}	Maximum operate time delay	(0.00÷10,000.00) s in 0.01 s increments	300.00 s

Parameters:

Own time $t_w < 100$ ms

Permissible error $\delta_{\%} = \pm 2.5\%$

2.35. Uo> – zero-sequence component overvoltage function, time independent (59N)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
The function is used as a protection signaling the occurrence of earthing in grids with a neutral point not directly earthed. In addition, it is used to force the active component of the earth current in AWSC automation for selective detection of the earthed portion of the system.

Operation description
Protection function made in a single-phase variant, using the zero voltage (3Uo) fundamental component estimate. Typically used signal from the open triangle of voltage transformers. It is possible to introduce an estimate of the voltage zero component, calculated from three phase voltages.

The protection also works correctly and reliably in the event of an intermittent short circuit. The durations of the activation pulses and the durations of the pauses between these pulses are controlled. Tripping will occur after a set time, plus any interval times between activation pulses.
In this connection, it should be borne in mind that an intermittent earth short circuit causes an additional delay in tripping the protection, related to the time required to correctly identify the phenomenon.
When the activation is stable, the trip time delay is in accordance with the set time.

In the case of both stable and intermittent short circuits, the protection operates with a delayed dropout. After the disappearance of the signal causing activation of the protection, it is dropped after 280 ms. The delayed dropout of the protection operation is due to the characteristics of the measurement algorithm, not to the use of an additional timing circuit.

After exceeding the start-up value, the function is activated, and after a set time it is tripped, according to the $3Uo > U_{0r}$ criterion.

Settings table

Setting	Description	Setting range	Default value
U_{or}	Inrush voltage	(0.010÷1.000) Un in 0.001 Un increments	0.100 Un
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	10.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Own time $t_w < 100$ ms
Permissible error (0.45 ÷ 1.00) Un $\delta_{\%} = \pm 0.5\%$
Permissible error (0.21 ÷ 0.45) Un $\delta_{\%} = \pm 1.0\%$
Permissible error (0.01 ÷ 0.20) Un $\delta_{\%} = \pm 2.5\% \pm 0.1$ V

2.36. Z< – full-impedance circular function (21)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Used as reserve protection for primary differential protection. It replaces the previously used overcurrent protections with voltage interlock.

Operation description

The function made in the three-phase variant.
The function is implemented on the impedance plane, where the criterion values are the resistance (R) and reactance (X) components of the impedance vector on the secondary side of the transformers, so the start-up value should be recalculated by the transformers' ratios to the secondary side.

The start-up characteristics are defined by the dependence:

$$R^2 + X^2 < Z_r^2 \quad i \quad I > I_{akt}$$

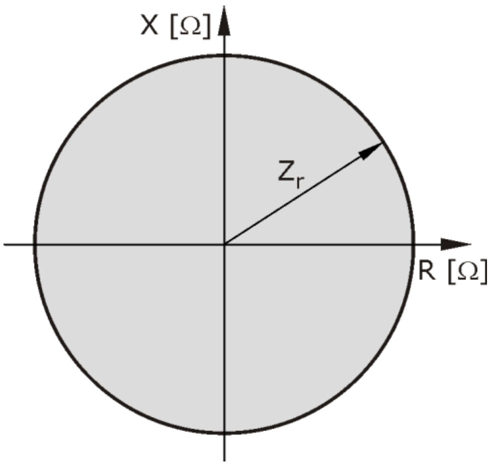


Fig. 20. Start-up characteristics of the full-impedance circular function.

To avoid measurement errors, an additional condition was introduced to activate the protection for current values above the set value of I_{akt}, in each phase independently.

Settings table

Setting	Description	Setting range	Default value
I_{akt}	Protection activation current	(0.05÷1.00) In in 0.01 In increments	0.10 In
Z_r	inrush impedance (secondary side)	(0.10 ÷ 99.00)Ω in 0.01 Ω increments	2.00 Ω
t_z	Delay time	(0.00÷30.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(1.01÷1.20) in 0.01 increments	1.02
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:

Own time $t_w < 30$ ms

Permissible error $\delta_{\%} = \pm 2.5\%$

2.37. Z<inv – full-impedance circular function, time dependent (21)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Used as reserve protection for primary differential protection. It replaces the previously used overcurrent protection with voltage interlock, but additionally equipped with a time dependent module depending on the degree of exceeding

Operation description
The function made in the three-phase variant.
The function is implemented on the impedance plane, where the criterion values are the resistance (R) and reactance (X) components of the impedance vector on the secondary side of the transformers, so the start-up value should be recalculated by the transformers' ratios to the secondary side.
The start-up characteristics are defined by the dependence:

$$R^2 + X^2 < Z_r^2 \quad i \quad I > I_{akt}$$

The tripping time is determined according to the following dependence:

$$t = \frac{k_1}{\left(\frac{Z_r}{Z}\right)^C - k_2^C} \quad [s]$$

where: Z - impedance rms / estimate
k_1 - time constant extension factor / setting
k_2 - asymptote shift factor / setting
Z_r - impedance start-up value (secondary side) / setting

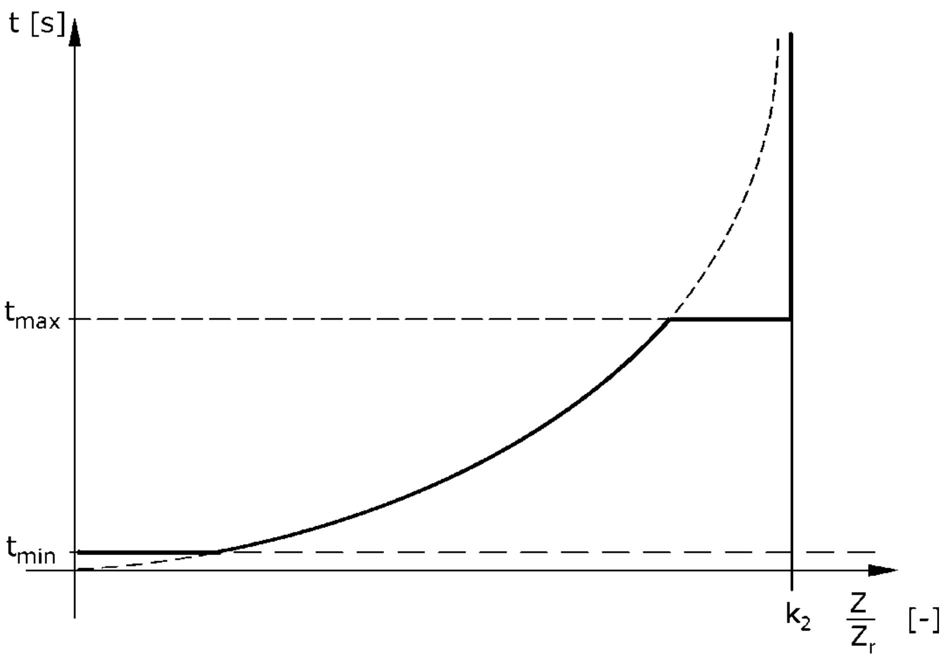


Fig. 21. Start-up characteristics of the time dependent full-impedance circular function

To avoid measurement errors, an additional condition was introduced to activate the protection for current values above the set value of I_{akt}, in each phase independently.

Settings table

Setting	Description	Setting range	Default value
I_{akt}	Protection activation current	(0.05÷1.00) In in 0.01 In increments	0.10 In
Z_r	inrush impedance (secondary side)	(0.10 ÷ 99.00)Ω in 0.01 Ω increments	2.00 Ω
t_{min}	Minimum time	(1.00÷60.00) s in 0.01 s increments	5.00 s
t_{max}	Maximum time	(100.00÷6,000.00) s in 0.01 s increments	300.00 s
t_{pow}	Return time	(1.00÷600.00) s in 0.01 s increments	1.00 s
k_1	time constant extension factor	(1.00÷100.00) s in 0.01 s increments	10.00 s
k_2	asymptote shift factor	(0.01÷1.00) in 0.01 increments	0.10
c	Exponent	(0.01÷10.00) in 0.01 increments	2.00
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:
Own time $t_w < 30$ ms
Permissible error $\delta_{\%} = \pm 2.5\%$

2.38. Zuw< – reactance function with rectilinear cutoff from loss of excitation (40/27)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Protects the generator from asynchronous operation and the effects of unstable interaction with the grid due to complete or partial loss of excitation.

Operation description

The function is implemented on the impedance plane, where the criterion values are the resistance (R) and reactance (X) components of the impedance vector on the secondary side of the transformers, so the start-up values must be recalculated by the transformers' ratios to the secondary side. The generator's moving impedance measurement enables detection of a loss-of-excitation state. In the normal operating state, the impedance vector is located in the first quadrant of the system, while during loss of excitation, the motion impedance vector moves to the inside of the circle, representing the start-up characteristics of the protection. The cutoff line for the upper part of the circle is selected so that the protection does not work when short circuits occur in the interlock main circuits.

In addition, the function of the three-phase undervoltage relay (27), described in section 3.26. is implemented, which, upon detecting a decrease in the phase-to-phase voltage below the set point, accelerates the tripping of the underreactance function (40). Due to the possibility of power swings, the undervoltage relay is also equipped with a system for summing excitation times, with control of the interval time between excitations (reset time).

The start-up characteristics of the underreactance relay (40), are determined by the dependencies:

$$R^2 + \left(X - \frac{X_1 + X_3}{2} \right)^2 < \left(\frac{X_1 - X_3}{2} \right)^2 \quad i \quad X < X_2$$

where: X_1 - upper limiting reactance (secondary side) ($X_1 = X_T$),

X_2 - cutoff reactance (secondary side) ($X_2 = \frac{-X_d^{'}}{2}$),

X_3 - lower limiting reactance (secondary side) ($X_3 = -X_d$),

X_d - generator synchronous reactance in the longitudinal axis,

X_T - block transformer reactance,

$X_d^{'}$ - generator reactance in the transition state.

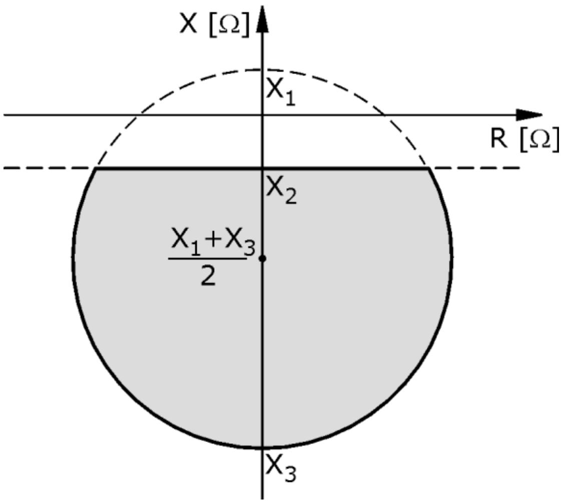


Fig. 22. Start-up characteristics of the reactance function with rectilinear cutoff.

To avoid measurement errors, an additional condition was introduced to activate the protection for current values above the set value of I_{akt}, in each phase independently.

Settings table

Setting	Description	Setting range	Default value
I_{akt}	Protection activation current	(0.05÷1.00) In in 0.01 In increments	0.10 In
X_1	upper limiting reactance ($X_1 = X_T$),	(-200.00 ÷ 200.00)Ω in 0.01 Ω increments	2.00 Ω
X_2	cutoff reactance ($X_2 = \frac{-X_d'}{2}$),	(-100.00 ÷ 100.00)Ω in 0.01 Ω increments	-2.00 Ω
X_3	lower limiting reactance ($X_3 = -X_d$),	(-200.00 ÷ 200.00)Ω in 0.01 Ω increments	-30.00 Ω
t_s	Excitation adding time	(0.00÷10.00) in 0.01 increments	2.00 s
t_r	Adder reset time	(0.00÷10.00) in 0.01 increments	2.00 s
t_z	Delay time	(0.00÷30.00) in 0.01 increments	5.00 s
k_p	Reset ratio	(1.01÷1.20) in 0.01 increments	1.10
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

The table above includes only the settings of the underreactance module of the protection (set on the secondary side of the transformers). Additional settings, resulting from the use of the undervoltage module, are in accordance with the type of protection function used (U<) and the logic circuits, primarily the pulse adder (ts) - described in section 5.7.13.

Parameters:

Own time $t_w < 100$ ms

Permissible error $\delta_{\%} = \pm 2.5\%$

2.39. Zpb< – pole slipping function (78)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function consisting of the following start-up characteristics:
- S1 impedance module (signaling - first level)
- S2 impedance module (signaling - second level)
- W impedance module (shutdown)
- K directional module
- Z directional module

Application

A function used to detect a state in which the power grid source voltages are out of phase with the generator voltages. A set of functions allows to determine the state and nature of power sway (generator rotor angle increase, pole slipping, location of the center of power swing within or outside the interlock).

Operation description

The criterion values are the R, X components of the impedance vector and the amplitude of the generator phase current primary component. Estimates of R, X are calculated based on the symmetrical components of the compatible three-phase voltage and current on the secondary side of the transformers, so the start-up values need to be recalculated by the transformers' ratios to the secondary side.

The start-up characteristics are shown in the figure below:

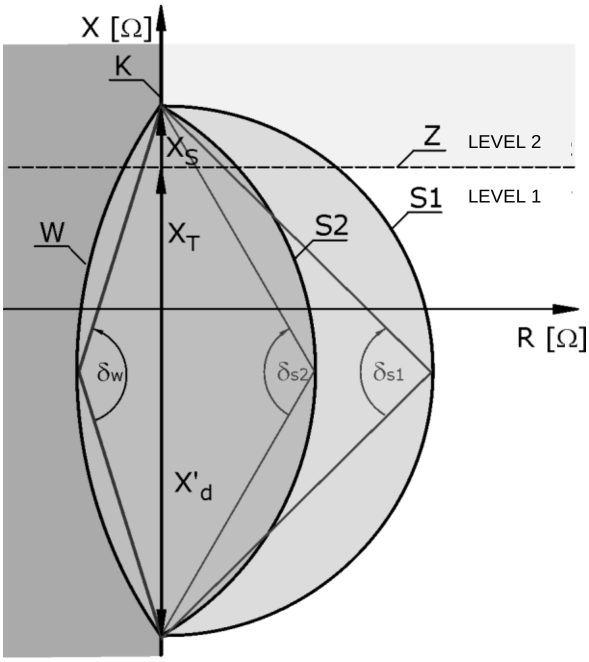


Fig. 23. Start-up characteristics of the pole slipping function.

The criterion for the function activation is the movement of the impedance vector through the S2 zone into the W zone. An additional condition is that after the vector enters the S2 zone, the transition to the W zone should not take longer than the t_{imp} set counted from the moment the S2 zone is activated. If the vector transition time is longer, the function will not be activated. The S1 zone has a signaling role.

When implementing the protection function from pole slippings, the setting of the number of slippings is included. If the setting is Ps1 = 1, the counter will be activated and tripped when one slipping is detected (Ps1_P = Ps1_Z = 1). For the Ps2 = 2 setting, when one slipping is detected, the counter is activated - the signaling output Ps2_P, typically directed to the warning signal), while when another slipping is detected, the counter Ps2_Z is tripped. The two-state reset input (KAS) allows resetting of counters and possible signaling of the slipping.

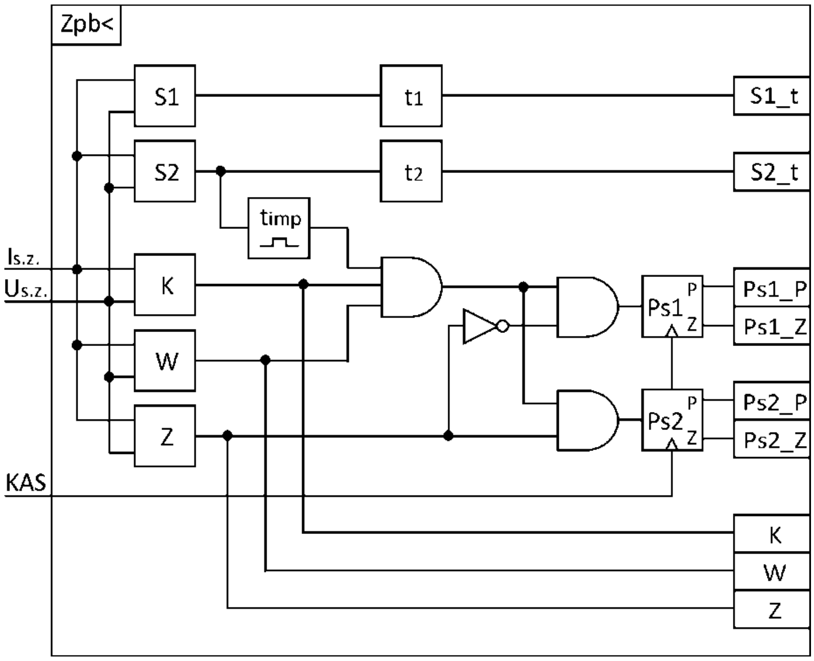


Fig. 24. Zpb< pole slipping protection operation logic circuit

Settings table

Setting	Description	Setting range	Default value
I_{akt}	Protection activation current	(0.05÷1.00) In in 0.01 In increments	0.10 In
X_T	Block transformer reactance (secondary side)	(0.00÷100.00) in 0.01 Ωincrements	2.00 Ω
X_S	System equivalent reactance (secondary side)	(0.00÷100.00) in 0.01 Ωincrements	1.00 Ω
X'_d	Generator transient reactance (secondary side)	(1.00÷200.00) in 0.01 Ω increments	4.00 Ω
δ_{S1}	Angle between the grid and generator source voltages for the S1 signal module	(0.1÷179.9)° in 0.1° increments	90.0°
δ_{S2}	Angle between the grid and generator source voltages for the S2 signal module	(0.1÷179.9)° in 0.1° increments	120.0°
δ_W	Angle between the grid source voltages and the generator for the W shutdown module	(0.1÷179.9)° in 0.1° increments	150.0°
t_{imp}	Pulse duration after the vector enters the S2 zone.	(0.00÷300.00) s in 0.01 s increments	20.00 s
t_1	Signaling delay time after the vector enters the S1 zone.	(0.00÷300.00) s in 0.01 s increments	1.00 s
t_2	Signaling delay time after the vector enters the S2 zone.	(0.00÷300.00) s in 0.01 s increments	1.00 s
Ps1	Permissible slippings, level 1	(1÷2) in 1 increments	1
Ps2	Permissible slippings, level 2	(1÷2) in 1 increments	2
k_p	Reset ratio	(1.01÷1.20) in 0.01 increments	1.05
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:

Own time $t_w < 100$ ms

Permissible error $\delta_{\%} = \pm 2.5\%$

2.40. Zw< – impedance function from earthing in the excitation system (64R)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application

Protection responding to single earth short circuits in excitation circuits and to lowering the insulation resistance of excitation circuits of a synchronous machine. Two protection levels are provided for in the algorithm:

- 64R.1 - signaling module,
- 64R.2 - shutdown module.

In addition, the function implements the 64R.3 measurement circuit continuity check using a full-impedance function to detect discontinuity in the measurement circuit.

Operation description

The function is implemented on the impedance plane, where the criterion values are the resistance (R) and reactance (X) components of the impedance vector.

The criterion value is the insulation resistance of the rotor winding and the galvanically connected circuits. Measurement of earth insulation resistance is carried out in the measurement system, in which the current flow is forced by 50 Hz AC voltage from an external source using the iZAZ-FRC filter and two voltage paths in the iZAZ protection assembly (iZAZ200 / iZAZ300 / iZAZ400 / iZAZ600).

The algorithm includes compensation for the excitation circuit capacitance, thus allowing resistance monitoring.

In applications where there are a limited number of analog voltage paths, it is possible to use a single voltage path. In such a solution, the measurement circuit is not able to eliminate the influence of the measurement circuit capacitance and the measurement accuracy decreases at higher resistance values. However, for many cases such a system is sufficient and will properly detect earth faults in excitation circuits.

The function enables the detection of a measurement voltage loss, signaled in the system and also allows the derivation of resistance and reactance measurements after considering the compensation algorithm.

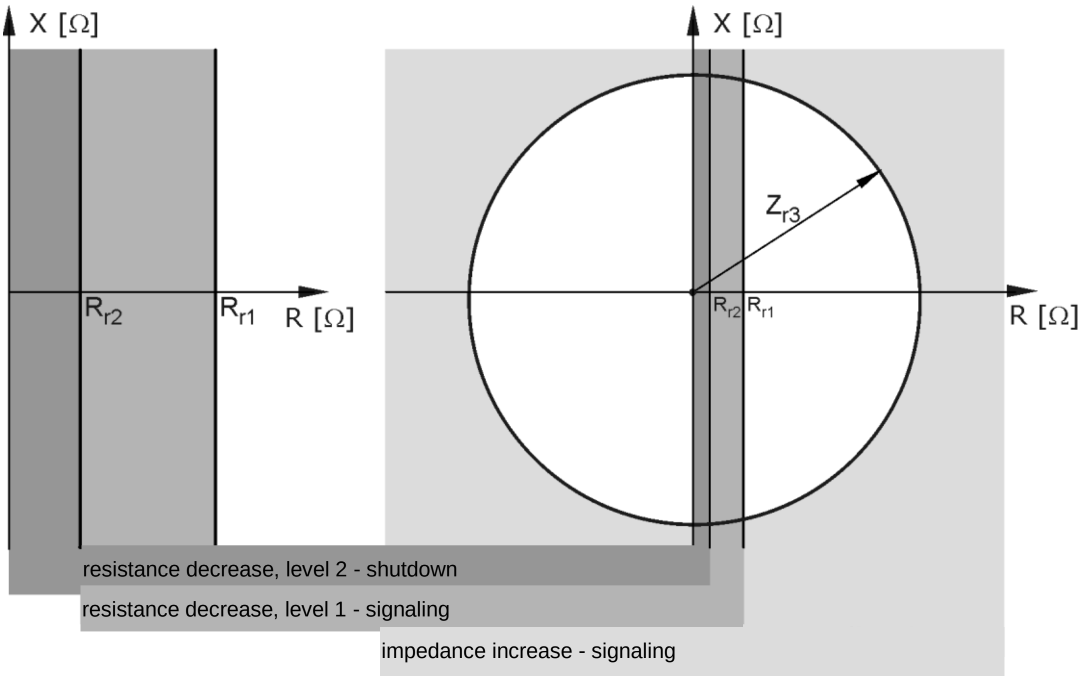


Fig. 25. Start-up characteristics of the function from earthing in the excitation system

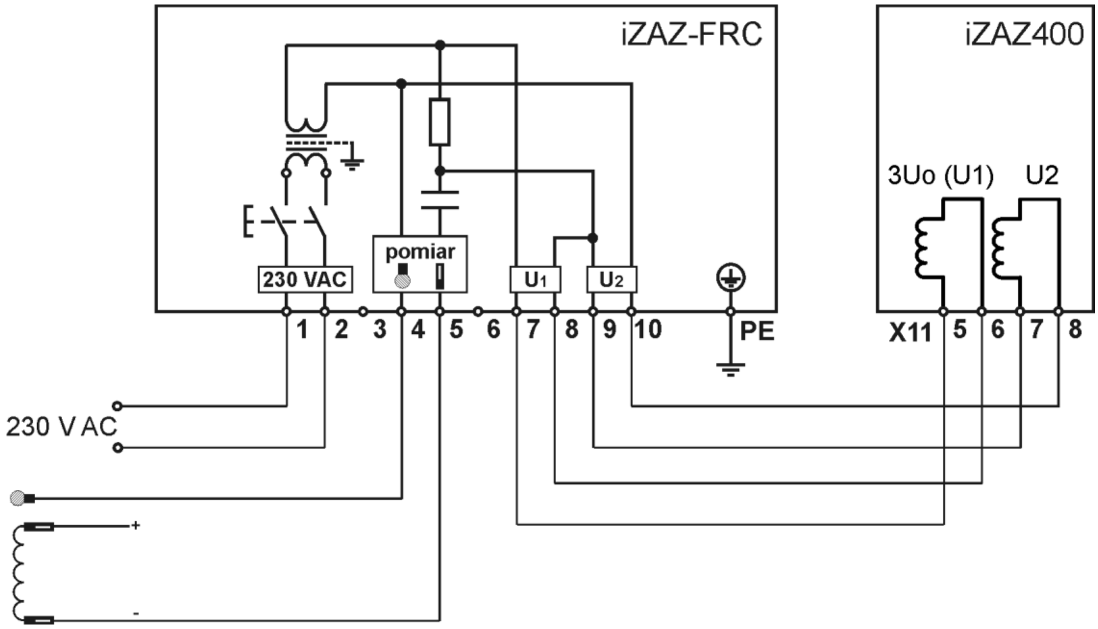


Fig. 26. Example wiring scheme of the excitation circuit earth fault protection measurement system – two measurement paths system

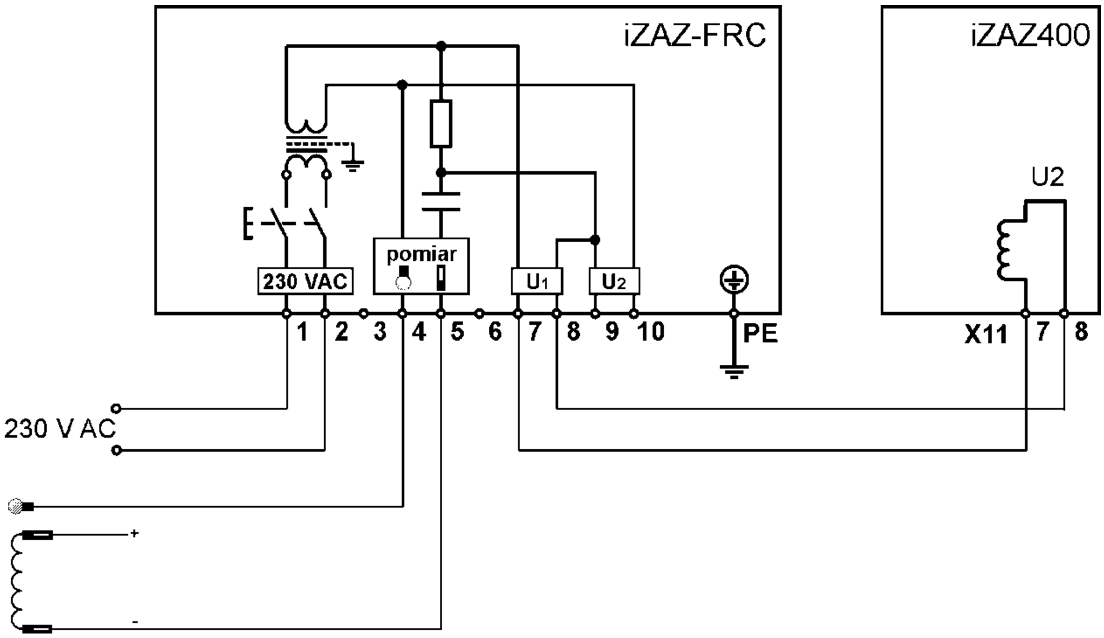


Fig. 27. Example wiring scheme of the excitation circuit earth fault protection measurement system – one measurement path system

Settings table

Setting	Description	Setting range	Default value
R_{r1}	Signaling level start-up resistance	(50÷ 15,000)Ω in 1 Ω increments	5,000 Ω
R_{r2}	Shutdown level start-up resistance	(50÷ 15,000)Ω in 1 Ω increments	1,000 Ω
Z_{r3}	Start-up impedance of signaling discontinuity in the measurement circuit	(15,000 ÷ 50,000)Ω in 1 Ω increments	30,000 Ω
t_1	Signaling module time delay	(0.00÷300.00) s in 0.01 s increments	10.00 s
t_2	Tripping module time delay	(0.00÷300.00) s in 0.01 s increments	1.00 s
t_3	Delay time of the continuity check module in the measurement circuit	(0.00÷300.00) s in 0.01 s increments	10.00 s
k_p	Reset ratio	(1.01÷1.20) in 0.01 increments	1.10
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:

Own time $t_w < 100$ ms

Permissible error $\delta_{\%} = \pm 2.5\%$ (for the 1μF capacity, additional error ± 2.5%)

2.41. Z2w< – protection from second earth fault in rotor circuits (64R2)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

If the generator is allowed to operate with a single earth fault in the excitation system, protection is required to detect a second earth fault that is dangerous to the generator excitation system.
The protection is implementable as standard on iZAZ600 assemblies. However, if this protection is required for other hardware versions (iZAZ200, iZAZ300, iZAZ400), the analog voltage inputs need to be adjusted to measure DC voltage. Such a solution is possible, but requires arrangements at the stage of protection assembly implementation.

Operation description

The protection requires two measurement signals to be connected to the assembly, i.e. the positive and negative potentials of the excitation voltage referenced to the earth potential (from the brush on the generator shaft).
In this case, until the first earth fault is detected, the protection system against the second earth fault is interlocked.
After detecting an earth fault by the 64R.2 protection, the procedure of digital calibration of the measurement signals U13, U12 is performed and the protection module from the second earth fault is started automatically. By monitoring both voltages, the iZAZ600 is able to detect the occurrence of a second earth fault and shut down the generator.
The protection measurement circuit from the first earth fault, by virtue of the fact that it operates on a 50 Hz AC signal, is constantly on and keeps pace with the status of a single earth fault. In case of spontaneous disappearance of the earth fault cause, the protection from the second earth fault will be automatically interlocked.

The circuit wiring scheme from single and double earth fault in the excitation system is shown below.

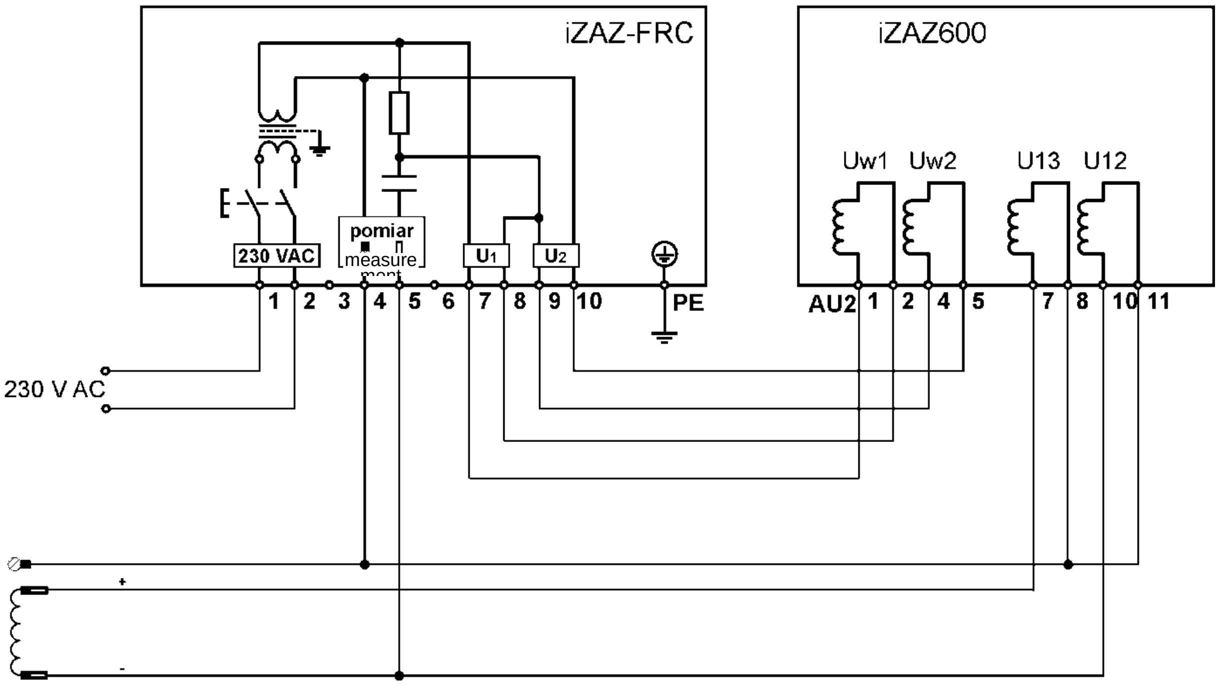


Fig. 28. Connection circuit of protection from the second earth fault in the excitation system

The algorithm is based on controlling two excitation voltages in relation to the system's earthing point.

The function controls the rms values of both voltages. Under normal conditions, the reference potentials will be closed only by capacitances. The sum of these voltages should produce the excitation voltage.
After the occurrence of an earth fault, which is detected by the Zw< function (64R1.2 - the signal should be brought to the activation input), the function is calibrated. It involves checking that each voltage is stable over a set calibration time period.
If, after the set time, the difference in signal fluctuations is below the set value, the function starts operating.
The sum of the measured voltages is controlled - through the undervoltage criterion. If there is a decrease of the set percentage, the function will be activated, and after a delay time, tripped according to the $U < U_r$ criterion.

Settings table

Setting	Description	Setting range	Default value
U_{gr}	Minimum excitation voltage value	(0.010÷1.000) Un in 0.001 Un increments	0.060 Un
U_r	Inrush voltage (percentage change in calibration distribution)	(0.1÷30.0)% in 0.1% increments	2.0%
U_{kalib}	Calibration precision	(0.010÷0.200) Un in 0.001 Un increments	0.050 Un
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
t_{kalib}	Calibration time (voltage distribution values determination time)	(0.01÷10.00) s in 0.01 s increments	0.50 s
k_p	Reset ratio	(1.00÷1.20) in 0.01 increments	1.10
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Own time $t_w < 100$ ms
Permissible error $\delta_{\%} = \pm 2.5\%$

2.42. 64S2 – 100% stator earth fault protection function based on injection of 20 Hz sinusoidal measurement signal

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Supplementary protection of the stator earth fault protection system, protecting the part of the windings near the star point of the generator, not covered by the 59N protection based on the appearance of the voltage zero-sequence component.

Protection requires the use of an external additional measurement signal generator circuit, which is injected from the zero side of the generator earthed through a resistor.

Two protection levels are provided for in the algorithm:

- 64S.1 - signaling module,
- 64S.2 - shutdown module.

Also, the function implements continuity control of the measurement circuit, control of injected voltage fade and 3Io overcurrent at 50 Hz.

Operation description

The function uses estimates of the current measured at the neutral point and the source voltage of the measurement system.

The measurement is made considering the 20 Hz estimates and the measurement resistance of the system is determined from the signals.

Under normal conditions, considering the capacitance of the generator winding system, the function is able to control the continuity of the measurement system and signal a fault in the measurement circuits (Ifail output). If the voltage generation system is damaged, a warning signal (Ufail output) is generated. If an earth fault occurs at the power lead or at the buses, the function detects this state by measuring the 3Io current at 50 Hz, which clearly indicates an earth fault in the system. This state prevents the correct operation of the 20 Hz measurement system, hence the 64S function is interlocked, and the overrun is output at the P_Io50 output. This output can be used to signal the occurrence of an earth fault in the system, or as a reserve module to shut down the system if the protections of the primary system do not tripping after settable time delays.

Settings table

Setting	Description	Setting range	Default value
R_{r1}	Signaling level start-up resistance	(0÷ 15,000)Ω in 1 Ω increments	10,000 Ω
R_{r2}	Shutdown level start-up resistance	(0÷ 15,000)Ω in 1 Ω increments	1,000 Ω
t_1	Signaling module trip time delay	(0.00÷300.00) s in 0.05 s increments	10.00 s
t_2	Shutdown module trip time delay	(0.00÷300.00) s in 0.05 s increments	1.00 s
k_p	Reset ratio	(1.01÷1.20) in 0.01 increments	1.05
U_{wg}	Limit forcing voltage to control the efficiency of the generation system	(0.0÷100.0) Un in 0.1 V increments	0.5 V
Z_{og}	Limit impedance of discontinuity in the measurement circuit	(10.0 ÷100.0) kΩ in 0.1 k incrementsΩ	30 kΩ
I_{ogr}	3Io 50 Hz current limit	(500÷2,000) mA in 1 mA increments	1,000 mA
R	Neutral point earthing resistor resistance	(1,000÷ 5,000)Ω in 1 incrementsΩ	1,000 Ω
Rz	Generator source resistance	(0÷ 1,000)Ω in 1 incrementsΩ	100 Ω
Xz	Generator source reactance	(-1,000÷ 1,000)Ω in 1 incrementsΩ	100 Ω
Kor_50Hz	Correction factor for the 50 Hz component	(0.800÷1.200) in 0.001 increments	1.000
ON/OFF	Function activity	(ON / OFF)	ON
W	Action on shutdown from the second level	(ON / OFF)	ON

Parameters:

Own time $t_w < 750$ ms
Permissible error $\delta_{\%} = \pm 5\% \pm 100\Omega$ in the range of (0÷ 10,000)Ω
$\delta_{\%} = \pm 10\%$ in the range of (10,000÷ 30,000)Ω

2.43. P> – three-phase reverse power function - overpower (32R)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application
Used, at the (φ_m = 180°) setting, as a reverse power flow-responsive protection to protect the generator from the effects of engine operation. Due to the need to maintain high accuracy in measurement of small power values, it is advisable to use currents from measurement transformers.

Operation description
The criterion values are the generator's active and reactive powers, calculated from estimates of three currents and three voltages. The start-up characteristics are shown in the figure below. Due to the possibility of power swings, the relay is equipped with logic-timing circuits, allowing the summation of activation times and control of the interval time between activations (ts - pulse adder). Incorporating information about the turbine shut-off valves state, or the generator drive state, into the logic allows the introduction of graded operation times. In the event of the emergence of reverse power due to the closure of the valves, the duration of the protection is short, around a few seconds. If there is no information about the closure of the turbine valves, but there are activation pulses, the tripping time of the short circuit protection can be longer, around tens of seconds.

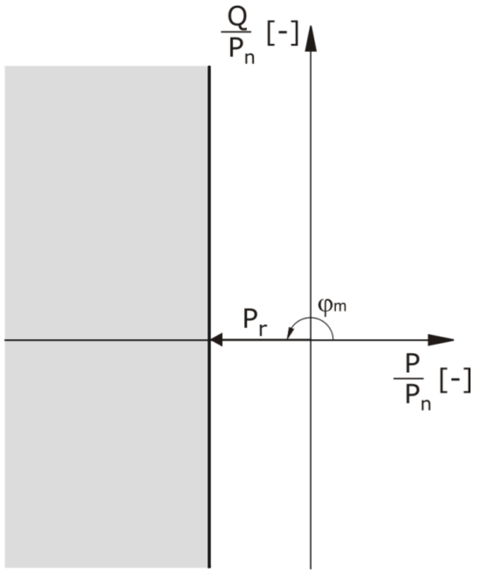


Fig. 29. Start-up characteristics of the reverse power function (φ_m = 180°).

Settings table

Setting	Description	Setting range	Default value
P_r	Start-up power	(0.000 ÷ 1.300) P_n in 0.001 P_n increments	0.005 P_n
φ_m	Maximum sensitivity angle	(0.0÷360.0) ° in 0.1 ° increments	180 °
t_z	Delay time	(0.00÷300.00) s in 0.01 s increments	30.00 s
k_p	Reset ratio	(0.60÷0.99) in 0.01 increments	0.80
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

The table above does not include the settings resulting from the use of additional logic and time circuits in the functional protection scheme.

Parameters:

Own time	$t_w < 80$ ms
Permissible error	$\delta_{\%} = \pm 2.5\%$

2.44. P< – three-phase function from power shedding - underpower (32L)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
It is used, at the (φ_m = 0°) setting, as a protection that responds to the detection of the power shedding phenomenon, i.e. a reduction in the value of the generator's produced power over a short period of time. The protection can work with the automation of the interlock or boiler.

Operation description
The criterion values are the generator's active and reactive powers, calculated from estimates of three currents and three voltages. The start-up characteristics are shown in the figure below.
To implement power shedding protection, two underpower functions 32L.1 and 32L.2 are used as standard to detect power reduction and an overpower function, which is a condition for activating the protection operation system.

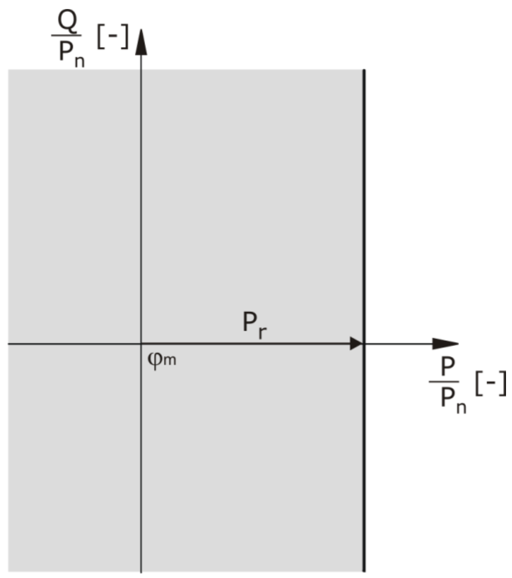


Fig. 30. Start-up characteristics of the underpower function (φ_m = 0°).

Settings table

Setting	Description	Setting range	Default value
P_r	Start-up power	(0.000 ÷ 1.300) P_n in 0.001 P_n increments	0.800 P_n
φ_m	Maximum sensitivity angle	(0.0÷360.0) ° in 0.1 °increments	0 °
t_z	Delay time	(0.00÷300.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(1.40÷1.01) in 0.01 increments	1.20
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

The table above shows the settings of one function of the underpower protection and does not include the settings resulting from the use of additional logic and time circuits in the protection functional scheme.

Parameters:
Own time $t_w < 80$ ms
Permissible error $\delta_{\%} = \pm 2.5\%$

2.45. f – frequency function, time independent (81H, 81L)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Frequency protection used to protect frequency-sensitive objects (e.g., generators), or in multi-stage SCO and SPZ automation after SCO.

Operation description
Protection function made in single-phase, two-phase or full three-phase variants.

The function implemented based on the estimation of frequency calculated from phase voltages, phase-to-phase voltages or phase currents. The correct measurement, and also the operation of the protection depends on the signal level. The function therefore has settable values for voltage (U_{akt}) or current (I_{akt}) levels, below which its operation is interlocked.
The over / undercriteria setting allows the implementation of either overfrequency or underfrequency protection.

For overfrequency protection (the TRYB = NADCZĘSTOTLIWOŚCIOWY setting), when the measured value increases above the start-up value, the function is activated, and after a settable time it is tripped, according to the $f > f_r$ criterion.

For underfrequency protection (the TRYB = PODCZĘSTOTLIWOŚCIOWY setting), when the measured value decreases below the start-up value, the function is activated, and after a settable time it is tripped, according to the $f < f_r$ criterion.

By changing the setting of the T_{spr} parameter, it is possible to additionally stabilize (filter) the frequency measurement accuracy. Increasing the setting by 1 increases the own time by about 10 ms, which is due to the estimate implementation methodology. If there is no need for very fast protection it is advisable to increase this setting, achieving an improvement in measurement accuracy while increasing the protection's own time.

Settings table

Setting	Description	Setting range	Default value
f_r	Start-up frequency	(40.00÷60.00) Hz in 0.01 Hz increments	50.00 Hz
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
df_p	Frequency difference for return	(0.00÷0.20) Hz in 0.01 Hz increments	0.10 Hz
T_{spr}	Extension of the time window for frequency checking	(0÷20) in 1 increments	4
Tryb (Mode)	Operating mode	(podczęstotliwościowy/nadczęstotliwościowy)(underfrequency/overfrequency)	podczęstotliwościowy (underfrequency)
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
Additional settings when implementing functions based on voltage estimates			
U_{akt}	Protection activation voltage	(0.100÷1.000) U_n in 0.001 U_n increments	0.200 U_n
Additional settings when implementing functions based on current estimates			
I_{akt}	Protection activation current	(0.05÷1.00) In in 0.01 In increments	0.10 In

Parameters:
Own time $t_w < 70$ ms + T_{spr} x 10ms
Permissible error $\Delta = \pm 0.01$ Hz

2.46. df – frequency steepness function, time independent (81S)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Frequency steepness protection used to protect frequency-sensitive objects (e.g., generators), or in SCO automation systems with a criterion for detecting the rate of frequency change (derivative of frequency change over time).

Operation description
Protection function made in single-phase, two-phase or full three-phase variants.

The function implemented based on the frequency derivative estimate calculated from phase voltages, phase-to-phase voltages or phase currents. The correct measurement, and also the operation of the protection depends on the signal level. For signal values smaller than the settings: U_{akt} or I_{akt} function operation is interlocked.

In the case of the TRYB = SPADEK setting, activation of the function occurs for a decreasing frequency, according to the $-df/dt > (df/dt)_r$ criterion, and tripping occurs after a set delay time.

In the case of the TRYB = WZROST setting, activation of the function occurs for an increasing frequency, according to the $df/dt > (df/dt)_r$ criterion, and tripping occurs after a set time.

Changing the setting of the T_{spr} parameter allows additional stabilization (filtering) of the accuracy of the frequency derivative measurement. Increasing the setting by 1 increases the own time by about 10 ms, which is due to the estimate implementation methodology. If there is no need for very fast protection, then it is advisable to increase this setting for an increase in accuracy with an increase in the protection's own time.

Settings table

Setting	Description	Setting range	Default value
$(df/dt)_r$	Start-up frequency derivative	(0.10÷20.00) Hz/s in 0.05 Hz/s increments	0.30 Hz/s
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	0.00 s
Δdf_p	Difference of the frequency derivative for the return	(0.00÷0.20) Hz/s in 0.01 Hz/s increments	0.10 Hz/s
T_{spr}	Extension of the time window for checking the frequency derivative	(0÷20) in 1 increments	1
Tryb (Mode)	Direction of frequency changes	(decrease/increase)	decrease
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
Additional settings when implementing functions based on voltage estimates			
U_{akt}	Protection voltage	(0.100÷1.000) U_n in 0.001 U_n increments	0.200 U_n
Additional settings when implementing functions based on current estimates			
I_{akt}	Protection activation current	(0.05÷1.00) In in 0.01 In increments	0.10 In

Parameters:
Own time for (0.10 ÷ 0.19) Hz/s $t_w <$ 170 ms + T_{spr} x 10 ms
Own time for (0.20 ÷ 0.29) Hz/s $t_w <$ 120 ms + T_{spr} x 10 ms
Own time for (0.30 ÷ 0.49) Hz/s $t_w <$ 90 ms + T_{spr} x 10 ms
Own time for (0.50 ÷ 0.99) Hz/s $t_w <$ 80 ms + T_{spr} x 10 ms
Own time for (1.00 ÷ 20.00) Hz/s $t_w <$ 70 ms + T_{spr} x 10 ms

Permissible error $\Delta = \pm 2.5\% \pm 0.02$ Hz/s

2.47. fdf – frequency steepness function with frequency condition, time independent (81S)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Frequency steepness protection used to protect frequency-sensitive objects (e.g., generators), as well as in the implementation of SCO automation with a criterion for detecting the rate of change of frequency (derivative of frequency change over time), considering the exceeding of the set level of frequency values.

Operation description

Protection function made in single-phase, two-phase or full three-phase variants.

The function implemented based on the frequency estimate and frequency derivative, calculated from phase voltages, phase-to-phase voltages or phase currents. The correct measurement, and also the operation of the protection depends on the signal level. For measurement signal values lower than the U_{akt} or I_{akt} settings, the function operation is interlocked.

In the case of the TRYB = DECREASE setting, activation of the function occurs for decreasing frequency, according to the $-df/dt > (df/dt)$ and $f < f_r$ criterion, and tripping occurs after the set time.

In the case of the TRYB = INCREASE setting, activation of the function occurs for increasing frequency, according to the $df/dt > (df/dt)$ and $f > f_r$ criterion, and tripping occurs after the set time.

By setting the T_{spr} parameter, it is possible to additionally stabilize (filter) the accuracy of the frequency and frequency derivative measurement result. Increasing the setting by 1 increases the own time by about 10 ms, which is due to the estimate implementation methodology. If there is no need for very fast protection, it is advisable to increase this setting, which allows to improve the accuracy while increasing the own time of protection.

Settings table

Setting	Description	Setting range	Default value
$(df/dt)_r$	Start-up frequency derivative	(0.10÷20.00) Hz/s in 0.05 Hz/s increments	0.30 Hz/s
Δdf_p	Difference of the frequency derivative for the return	(0.00÷0.20) Hz/s in 0.01 Hz/s increments	0.10 Hz/s
f_r	Start-up frequency	(40.00÷60.00) Hz in 0.01 Hz increments	50.00 Hz
Δf_p	Frequency difference for return	(0.00÷0.20) Hz in 0.01 Hz increments	0.10 Hz
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	0.00 s
T_{spr}	Extension of the time window for checking the frequency derivative	(0÷20) in 1 increments	1
Tryb (Mode)	Direction of frequency changes	(decrease/increase)	decrease
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
Additional settings when implementing functions based on voltage estimates			
U_{akt}	Protection activation voltage	(0.100÷1.000) U_n in 0.001 U_n increments	0.200 U_n
Additional settings when implementing functions based on current estimates			
I_{akt}	Protection activation current	(0.05÷1.00) In in 0.01 In increments	0.10 In

Parameters:

Own time for (0.10 ÷ 0.19) Hz/s $t_w <$ 170 ms + T_{spr} x 10 ms

Own time for (0.20 ÷ 0.29) Hz/s $t_w <$ 120 ms + T_{spr} x 10 ms

Own time for (0.30 ÷ 0.49) Hz/s $t_w <$ 90 ms + T_{spr} x 10 ms

Own time for (0.50 ÷ 0.99) Hz/s $t_w <$ 80 ms + T_{spr} x 10 ms

Own time for (1.00 ÷ 20.00) Hz/s $t_w <$ 70 ms + T_{spr} x 10 ms

Permissible error $\Delta = \pm 2.5\% \pm 0.02$ Hz/s
Permissible error f $\Delta = \pm 0.01$ Hz

2.48. Δf – incremental frequency function, time independent (81SA)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Incremental frequency protection that considers the average value of the change in frequency over a set time, based on the measurement of the voltage or current frequency difference.

Operation description
Protection function made in single-phase, two-phase or full three-phase variants.

The function implemented based on the estimate of the averaged frequency increment calculated from phase or phase-to-phase voltages or phase currents, according to the set measurement window T. Correct measurement, and also the operation of the protection depends on the set U_{akt} or I_{akt} signal level. Below these values, the function operation is interlocked.

In the case of the TRYB = DECREASE setting, the function is tripped for decreasing frequency, according to the $-\Delta f/\Delta T > (\Delta f/\Delta T)_r$ criterion.

In the case of the TRYB = INCREASE setting, the function is tripped for increasing frequency, according to the $\Delta f/\Delta T > (\Delta f/\Delta T)_r$ criterion.

By setting the T_{spr} parameter, it is possible to additionally stabilize (filter) the accuracy of the frequency derivative measurement result. Increasing the setting by 1 increases the own time by about 10 ms, which is due to the estimate implementation methodology. If there is no need for very fast protection, then it is advisable to increase this setting, which allows to improve accuracy at the expense of increasing the own time of protection.

Settings table

Setting	Description	Setting range	Default value
$(\Delta f/\Delta T)_r$	Start-up frequency increment	(0.20÷20.00) Hz/s in 0.05 Hz/s increments	1.00 Hz/s
T	Measurement period	(0.02÷2.00) s in 0.01 s increments	1.00 s
Δf_p	Difference in frequency increment for return	(0.00÷0.20) Hz/s in 0.01 Hz/s increments	0.10 Hz/s
T_{spr}	Extension of the time window for checking the frequency derivative	(0÷20) in 1 increments	1
Tryb (Mode)	Direction of frequency changes	(decrease/increase)	decrease
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
Additional settings when implementing functions based on voltage estimates			
U_{akt}	Protection activation voltage	(0.100÷1.000) U_n in 0.001 U_n increments	0.200 U_n
Additional settings when implementing functions based on current estimates			
I_{akt}	Protection activation current	(0.05÷1.00) In in 0.01 In increments	0.10 In

Parameters:
Own time for (0.10 ÷ 0.60) Hz/s $t_w < T + 40$ ms $+ T_{spr} \times 10$ ms

Permissible error $\Delta = \pm 2.5\% \pm 0.1$Hz/s

2.49. dU – voltage steepness function, time independent (59S/27S)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application
Voltage steepness protection, used to implement the SNO self-voltage relief automation, allowing the output of voltage dip.

Operation description
The protection function is made in the three-phase variant.

The function implemented based on the voltage derivative estimate calculated from phase or phase-to-phase voltages. The correct measurement, and also the operation of the protection depends on the signal level. For $U < U_{akt}$ the function operation is interlocked.

Function activation and, after a set time, operation, follows the $dU/dt > (dU/dt)_r$ criterion.

The function analyzes the criterion in all phases simultaneously and enables the output of activation information from each phase independently (e.g. information to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
$(dU/dt)_r$	Start-up voltage derivative	(-10.00÷10.00) Un/s in 0.002 Un/s increments	0.100 Un/s
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	0.00 s
kp	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
U_{akt}	Protection activation voltage	(0.100÷1.000) U_n in 0.001 U_n increments	0.200 U_n
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:
Own time for (0.10 ÷ 0.19) Un/s $t_w <$ 130 ms
Own time for (0.20 ÷ 0.49) Un/s $t_w <$ 90 ms
Own time for (0.50 ÷ 10.00) Un/s $t_w <$ 65 ms

Permissible error $\Delta = \pm 0.2$ V/s

2.50. ΔU – incremental voltage function, time independent (59SA/27SA)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Incremental voltage protection, used for the implementation of the SNO automatic voltage-relief automation, which enables the output of voltage collapse.

Operation description
The protection function is made in the three-phase variant.
The function implemented based on the estimate of the averaged voltage increment calculated from phase or phase-to-phase voltages. The correct measurement, and also the operation of the protection depends on the signal level. For $U < U_{akt}$ the function operation is interlocked.

Function activation follows the following criterion, within the set measurement period.

$$\Delta U/\Delta T > (\Delta U/\Delta T)_r$$

where: $\Delta U/\Delta T$ – voltage difference over the set period T / estimate
$(\Delta U/\Delta T)_r$ – averaged voltage increase over the set time T / setting

The function analyzes the criterion in all phases simultaneously and enables the output of activation information from each phase independently (e.g. information to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
$(\Delta U/\Delta T)_r$	Start-up voltage increase	(-0.100÷0.100) Un in 0.001 Un increments	0.020 Un
T	Measurement period	(5÷30) s in 1 s increments	5 s
U_{akt}	Protection activation voltage	(0.100÷1.000) U_n in 0.001 U_n increments	0.200 U_n
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:
Own time for (0.10 ÷ 0.60)Hz/s $t_w < T + 40$ ms
Permissible error $\delta_{\%} = \pm 0.5\%$

2.51. CU – integral voltage function, time independent (59SI/27SI)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Integral voltage protection, used for the implementation of the SNO self-voltage relieving automation, allowing the detection of, or exit from, a voltage dip.

Operation description
The protection function is made in the three-phase variant.

The function implemented based on the integral estimate of the change in voltage relative to the rated value, calculated from phase or phase-to-phase voltages, at a set integration time T. The correct measurement, and also the protection operation, depend on the signal level.
For U < U_{akt} the function operation is interlocked.

The function is tripped according to the following criterion

$$\frac{\int_0^T \frac{U - U_n}{U_n} dt}{T} > U_{Cr}$$

where: $\frac{U - U_n}{U_n}$ – difference between measured and rated voltage, related to the rated voltage / estimate

T – integration measurement period / setting
δU_{Cr} – voltage integral setting value / setting

The function analyzes the criterion in all phases simultaneously and enables the output of activation information from each phase independently (e.g. information to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
δU_{Cr}	Start-up value of relative average voltage change	(-0.100÷0.100) Un in 0.001 Un increments	0.020 Un
T	Integration period	(1.0÷30.0) s in 0.1 s increments	10.0 s
U_{akt}	Protection activation voltage	(0.100÷1.000) U_n in 0.001 U_n increments	0.200 U_n
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:
Own time $t_w < T + 40$ ms
Permissible error $\Delta = \pm 0.0005$ Un

2.52. Um>– three-phase peak overvoltage function, time independent (59)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Overvoltage protection to protect the object (e.g., generator, engine) from the effects of excessive voltage rise, operating over a wide range of frequency changes (10 ÷ 300) Hz, used in the case of frequency start-up, or when powering the load through an inverter.

Operation description
The protection function is made in a full three-phase version.

The function uses dedicated phase or phase-to-phase voltage estimates to control the current frequency of the measured signal.

After exceeding the start-up value, the function is activated, and after a set time it is tripped, according to the $U > U_r$ criterion.
The function analyzes the criterion in all phases simultaneously and enables the output of activation information from each phase independently (e.g. information to the event/disturbance recorder).

Due to the extension of the protection's own time for signals with reduced frequency, an additional criterion was used to speed up the operation, based on the comparison of instantaneous voltage values with an appropriate number of repetitions.

Settings table

Setting	Description	Setting range	Default value
U_r	Inrush voltage	(0.050÷1.500) Un in 0.001 Un increments	1.100 Un
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:
Own time $t_w < 50$ ms
Permissible error $\delta_{\%} = \pm 5.0\%$

2.53. Um<– three-phase peak undervoltage function, time independent (27)

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application
Undervoltage protection that allows detection of residual voltage generated by rotating engines. The function enables the implementation of protection from strokes, resulting from the application of power to rotating engines.
The function works in a wide range of frequency changes (10 ÷ 300) Hz.

Operation description
The protection function is made in a full three-phase version.

The function uses dedicated phase-to-phase voltage estimates to control the current frequency of the measured voltage.

When the start-up value is reduced below the start-up value, the function is activated, and after a set time it is tripped, according to the $U < U_r$ criterion.
The function analyzes the criterion in all phases simultaneously and enables the output of activation information from each phase independently (e.g. information to the event/disturbance recorder).

Due to the extension of the protection's own time for reduced-frequency signals, an additional speed-up criterion was used, based on the comparison of instantaneous voltage values with an appropriate number of repetitions.

Settings table

Setting	**Description**	**Setting range**	**Default value**
U_r	Inrush voltage	(0.050÷1.200) Un in 0.001 Un increments	0.950 Un
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(1.00÷1.20) in 0.01 increments	1.02
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functionss ***(only for U<3f)***	(OR/AND)	OR

Parameters:
Own time $t_w < 50$ ms

Permissible error $\delta_{\%} = \pm 5\%$

2.54. tg> – tgφ power factor control function (55)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

The function implements control of the tgφ power factor typically in the field of the HV/SN transformer. It enables to derive a signal when the power factor obtains an undesirable value, or it is possible to derive a signal to control the capacitor battery system for reactive power compensation.

Operation description

Power factor measurement is carried out in a three-phase system based on three phase current and phase voltage estimates.

Measurement of the tgφ power factor is carried out according to the dependence:

$$tg\varphi = \frac{Q}{P}$$

The function is implemented as a two-stage, with the possibility of deriving signaling and control independently.
Each level has an independent minimum and maximum setting, which determine the area of operation, according to the following dependencies:

$$tg\varphi < tg\varphi_{min} \quad \text{or} \quad tg\varphi > tg\varphi_{max}$$

An additional criterion is to meet the condition of minimum apparent energy $S > S_{min}$.

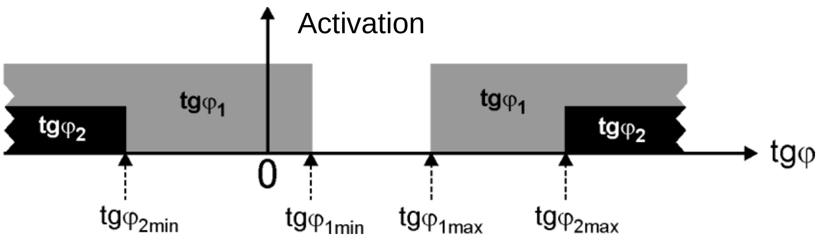


Fig. 31. Graphic interpretation of the tgφ function activation

Settings table

Setting	Description	Setting range	Default value
$tg\varphi_{1min}$	Minimum power factor start-up value for the first level	(-1.00÷1.00) in 0.01 increments	0.10
$tg\varphi_{1max}$	Maximum power factor start-up value for the first level	(-1.00÷1.00) in 0.01 increments	0.40
t_{z1}	Delay time for the first level	(0.00÷100.00) s in 0.01 s increments	5.00 s
$tg\varphi_{2min}$	Minimum power factor start-up value for the second level	(-1.00÷1.00) in 0.01 increments	0.00
$tg\varphi_{2max}$	Maximum power factor start-up value for the second level	(-1.00÷1.00) in 0.01 increments	0.60
t_{z2}	Delay time for the second level	(0.00÷100.00) s in 0.01 s increments	10.00 s
S_{min}	Minimum apparent power of function activation	(0.05÷1.00) S_n in 0.01 S_n increments	0.10 S_n
ON/OFF	Function activity	(ON / OFF)	ON
W1	Action to shut down the first level	(ON / OFF)	OFF
W2	Action to shut down the second level	(ON / OFF)	OFF

Parameters:
Own time $t_w < 100$ ms
Permissible error $\delta_{\%} = \pm 2.5\%$

2.55. DMkl – diagnostic function for induction engine cages

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
The function enables diagnostics of an induction engine cage by analyzing the current supplied to the machine during the start-up period.

Operation description
The criterion value of the function are the supply currents during the start-up. The diagnostics involves the estimation of the current component that results from the effect of the asymmetry of the damaged induction engine cage on the deformation of the magnetic field in the air gap.
The value of the estimated current is proportional to the degree of damage to the engine cage and provides sensitivity at the level of damage to a single rod. The output value of the diagnostic function algorithm is the percentage of the estimated current in the primary component of the supply current. This value is stored in the tripping recorder during engine start-up.
The settable delay time for diagnosing the engine cage (top) allows the engine to stand off from transients that appear during the initial phase of start-up. The typical setting is 2 s. This time should be as small as possible - it should not exceed 40% of the start-up time. If the diagnostics delay time is set too short, the results of subsequent measurements are characterized by a large variance. The value should be chosen experimentally so that subsequent measurements are repeatable.
The analysis of the engine cage state is based on a comparison of measurements, obtained from successive start-ups, using the records of the tripping recorder. In normal state, with no damage, the level of recorded values should be repeatable within 0.0÷1.0 %. An upward trend appearing in the measurements, during the operation of the engine, indicates an increase in asymmetry, which may indicate possible damage to the cage.
Exceeding the set level of cage damage, signaled via text message, an event or any other arbitrary action in programmable logic, provides the basis for analyzing the tripping recorder's records from subsequent start-ups.

Settings table

Setting	Description	Setting range	Default value
N_r	Cage failure signaling level	(0.0÷20.0) in 0.1% increments	6.0%
t_{op}	Diagnostic delay time	(0.00÷300.00) s in 0.01 s increments	2.00 s
ON/OFF	Function activity	(ON / OFF)	ON

Parameters:
Permissible error $\delta_{\%} = \pm 10\%$

2.56. Ioi – cable insulation damage detection function

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
The function enables the detection of progressive damage to the insulation of the HV cable, by detecting pulses appearing in the earth current (current zero-sequence component).

Operation description

Short-duration pulses (with durations in the range of 0.66ms ≤ t ≤ 1ms) are counted within a measurement window of settable duration. When the set threshold of the pulse count is exceeded, the function is activated.

In order to de-energize during intermittent (arc) earth faults, pulse count interlocks are used from activation of earth fault functions.

The function uses the primary component estimate of the zero current ($3I_0$) and the calculated zero-sequence component estimate of the three phase currents ($3I'_0 = I_{L1} + I_{L2} + I_{L3}$) to increase the measurement range of the function.

It is possible to derive a measurement of the counted pulses to enable ongoing diagnostics of the cable insulation state, and it is also possible to delete the current pulse counter.

Settings table

Setting	Description	Setting range	Default value
Ni	Limit number of pulses in earth current	(1÷10,000) in 1 increments	100
Io>i	Pulse threshold value in earth current	(10÷20,000) mA in 1 mA increments	2000 mA
t_z	The width of the measurement window in which the pulses are counted	(1÷65,000) min in 1 min increments	120 min
k_p	Reset ratio	(0.50÷1.00) in 0.01 increments	0.80
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:
Permissible error $\delta_{\%} = \pm 2.5\% \pm 1$ mA

2.57. Δφ – time vector voltage function

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
The function detects the angle difference of two waveforms. It can be used to detect the transition of part of a system with a local source to island operation.

Operation description

The function works based on the voltage vectors of two potential power sources (e.g., the system and a local generator) by controlling the voltage levels and the angle between them.
If both voltages are higher than the set value then exceeding the angle difference of the set value triggers activation, and after a set time the function is tripped.

Settings table

Setting	Description	Setting range	Default value
U_{1r}	Start-up voltage, side 1	(0.100÷1.000) Un in 0.001 increments	0.350 Un
U_{2r}	Start-up voltage, side 2	(0.100÷1.000) Un in 0.001 increments	0.350 Un
φ_r	Start-up angle	(1÷75)° in 1° increments	5°
t_z	Delay time	(1÷65,000) min in 1 min increments	120 min
k_{pU}	Voltage relay reset ratio	(0.80÷1.00) in 0.01 increments	0.98
$k_{p\varphi}$	Angle relay reset ratio	(0.1÷1)°	0.1°
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON

Parameters:

Own time $t_w < 100$ ms

Permissible voltage relays error (1.21 ÷ 1.50) Un $\delta_{\%} = \pm 1.0\%$
Permissible voltage relays error (0.45 ÷ 1.20) Un $\delta_{\%} = \pm 0.5\%$
Permissible voltage relays error (0.21 ÷ 0.45) Un $\delta_{\%} = \pm 1.0\%$
Permissible voltage relays error (0.01 ÷ 0.20) Un $\delta_{\%} = \pm 2.5\% \pm 0.1$ V

Permissible angle relay error $\delta_{\%} = \pm 1°$

2.58. VSS – protection function from voltage phase angle incremental change

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
The function is designed to detect the transition to "island operation."

Operation description

The function controls the change of voltage phase angle in the interval of 2 waveform periods. Tripping of the protection occurs if the angle exceeds the set value at a voltage higher than the set value. The monitoring is performed separately for each of the three input voltages and the result, depending on the setting, can be a sum or a log product.

Voltage value monitoring protects against activation in case of short circuits in the system.

The function uses a voltage primary component estimate.

Settings table

Setting	Description	Setting range	Default value
U_{akt}	Protection activation voltage	(0.800÷1.200) Un in 0.001 Un increments	0.850 Un
φr	Start-up angle change	(5°÷50°) in 1° increments	5°
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	AND

Parameters:
Own time $t_W < 50$ ms
Permissible voltage error (0.45 ÷ 1.20) Un $\delta_{\%} = \pm 0.5\%$
Permissible angle error $\delta_{\%} = \pm 0.5°$

2.59. I>st – stabilized overcurrent function with 2nd and 5th harmonics interlocks

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Relay used for earth differential current protection.

Operation description
Protection function made in single-phase variant.

The relay is activated:

- when the operate current and stabilization current meet the conditions specified by the characteristics (Fig.) and there is no interlock from exceeding the content in the input current
- when the instantaneous value of the input current exceeds the limit value (I_r>>) (activated by setting).

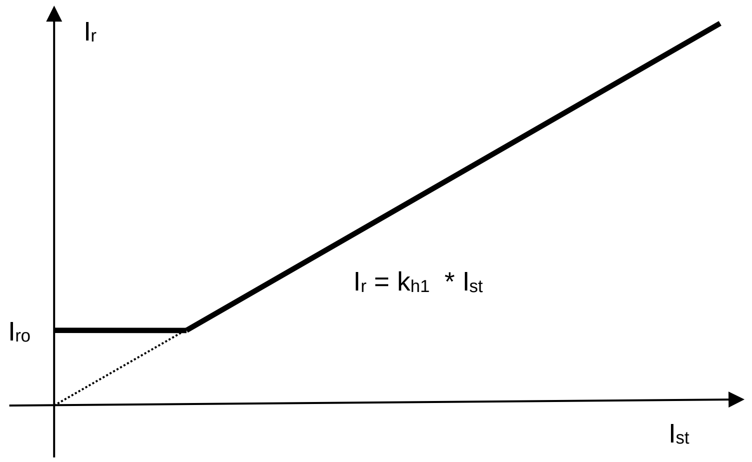


Fig. 32. Operating characteristics of the I>st function

The stabilized function uses an estimate of the current's primary component. The current limit criterion works based on the instantaneous values of the input current
The function allows to derive the tripping and activation state (e.g., information to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
I_{ro}	Initial operate current	(0.05÷2.00) In in 0.01 In increments	0.50 In
k_{h1}	Stabilization factor	(0.10÷0.80) in 0.01 increments	0.20
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_{b2}	Second-harmonic content interlocking factor	(0.01÷0.50) in 0.01 increments	0.10
k_{b5}	Fifth-harmonic content interlocking factor	(0.01÷0.30) in 0.01 increments	0.10
I_r>>	Limit operate current	(1÷20.00) In in 0.01 In increments	5.00 In
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
N_{2r}	Second harmonic interlocking shutdown	(ON / OFF)	OFF
N_{5r}	Fifth harmonic interlocking shutdown	(ON / OFF)	OFF
N_r>>	Unconditional shutdown zone on	(ON / OFF)	ON

Parameters:

Own time	$t_w < 30$ ms
Permissible error	$\delta_{\%} = \pm 2.5\% \pm 0.01$ In

2.60. Uma> – peak differential overvoltage function

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Relay designed for use in a protection system responding to an asymmetrical load on a frequency converter.

Operation description
The protection function is made in the three-phase variant.

The function uses RMS estimates (E_RMS(1T)) of phase-to-phase voltages. The criterion value is the voltage differences between all pairs of inputs.

After exceeding the start-up value, the function is activated, and after a set time it is tripped, according to the $U > U_r$ criterion.
The function analyzes the criterion in all pairs at the same time and enables the derivation of activation information from each pair independently (e.g., information to the event/disturbance recorder).

Settings table

Setting	Description	Setting range	Default value
U_r	Inrush voltage	(0.010÷1.500) Un in 0.001 Un increments	1.10 Un
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	1.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Function activations logic	(OR/AND)	OR

Parameters:

Own time	$t_w < 30$ ms
Permissible error (1.21 ÷ 1.50) Un	$\delta_{\%} = \pm1.0\%$
Permissible error (0.45 ÷ 1.20) Un	$\delta_{\%} = \pm0.5\%$
Permissible error (0.21 ÷ 0.45) Un	$\delta_{\%} = \pm1.0\%$
Permissible error (0.01 ÷ 0.20) Un	$\delta_{\%} = \pm2.5\% \pm 0.1$ V

2.61. Distance protection functions

Version 1:
Zdist< – distance protection impedance relay
Zdist<_cd – distance protection function, part 2

Version 2:
Zdist<_w2 – distance protection function, version 2
Zdist<_w2_cd – supplementing the settings of the distance protection function

Version 3:
Zdist<SN – MV grid distance protection function

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Note:
The function is available in 3 versions and divided into two parts for functional reasons in version 1 and 2. Correct operation requires configuring both functions and connecting them to each other.

Application
The set of the above two functions implements a complete five-zone distance protection characteristics designed to detect phase-to-phase and earth faults. All versions are based on the criteria described below, and the differences are outlined in section2.61.8
Examples of configured characteristics are shown in the figure below.

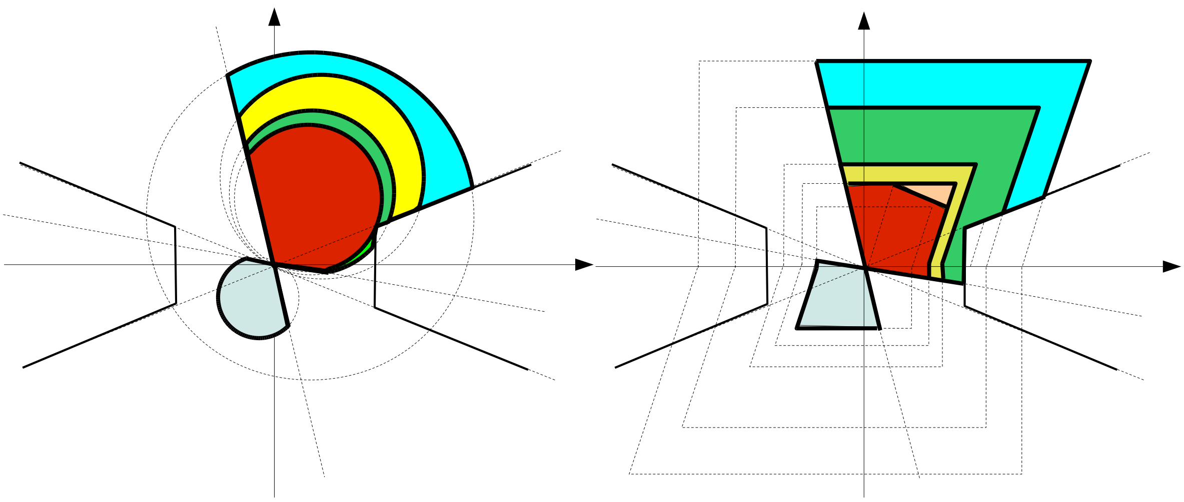


Fig. 33. Examples of distance protection characteristics

Operation description

2.61.1. Criterion value.

The relay was made in a full-schematic circuit. The impedances (on the secondary side) of all possible short circuit loops are analyzed simultaneously in real time. The function output is the state of the impedance vector position of each short circuit loop relative to the characteristics for the zone and type of short circuit.

The criterion value is the short circuit loop impedance calculated from the formulas:

- For phase-to-phase short circuits:

$Z_1 = (U_{L1} – U_{L2}) / (I_{L1} – I_{L2})$
$Z_2 = (U_{L2} – U_{L3}) / (I_{L2} – I_{L3})$
$Z_3 = (U_{L3} – U_{L1}) / (I_{L3} – I_{L1})$

where:
Z – R + jX impedance vector
U_{L123} – Re{U} + jIm{U} phase voltage vector
I_{L123} – Re{I} + jIm{I} conduction current vector

- For single-phase short circuits to earth:

$Z_1 = U_{L1} / (I_{L1} – k * I_o)$
$Z_2 = U_{L2} / (I_{L2} – k * I_o)$
$Z_3 = U_{L3} / (I_{L3} – k * I_o)$

where:
Z – R + jX impedance vector
U_{L123} – Re{U} + jIm{U} phase voltage vector
I_{L123} – Re{I} + jIm{I} conduction current vector
I_o – Re{I_o} + jIm{I_o} current vector of the zero-sequence component
k – Re{k} + jIm{k} earth fault compensation factor vector. The factor is independently settable for zone one and for the other protection zones

- For three-phase short circuits:

The start-up values can be calculated from the formulas
(The actual protection operation results from the analysis of all possible short circuit loops calculated as described above):

$Z = U_{LE} / I_{LE}$

where:
Z – R + jX impedance vector
U_{LE} – Re{U} + jIm{U} phase voltage vector
I_{LE} – Re{I} + jIm{I} conduction current vector

2.61.2. Operating characteristics.

The protection is equipped with two shape options of operating characteristics for each zone (polygonal or circular). Together with additional performance criteria such as direction criteria (see below), they form an arrangement of zone operating characteristics.

2.61.2.1. Polygonal characteristics.

The shape of the polygonal characteristics is shown below.

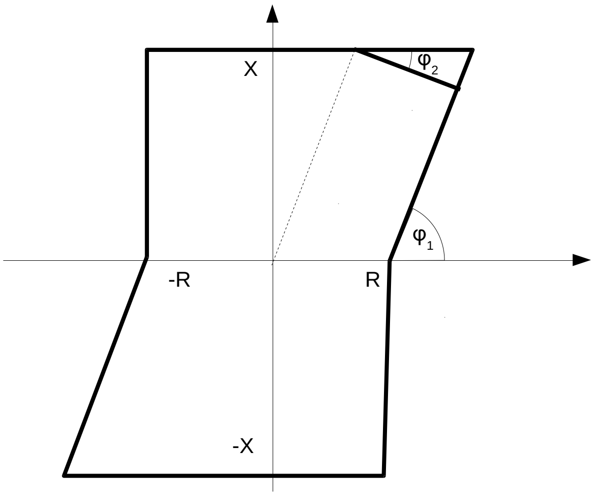


Fig. 34. Polygonal characteristics.

Notes:

- Correction of the characteristics in the first quadrant with a straight angle φ_2 only in the first zone for single-phase short circuits with earth.
- R, X and φ_1 parameters are set independently for single-phase-to-earth and phase-to-phase short circuits for each zone.
- The setting parameters with value ranges are shown below.

2.61.2.2. Circular characteristics

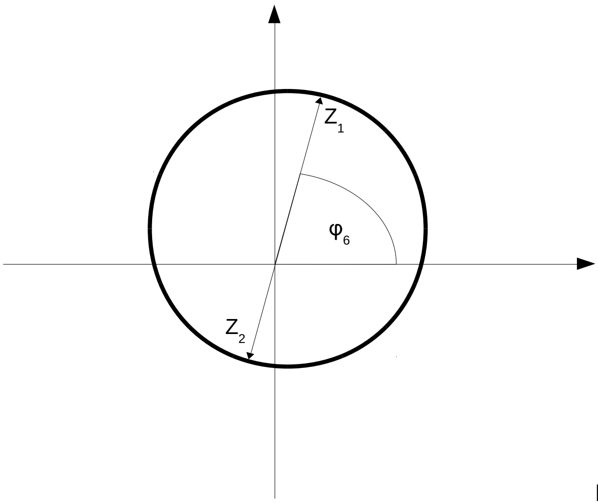


Fig. 35. Circular characteristics

Notes:

- Z1, Z2 and φ_6 parameters are set independently for single-phase-to-earth and phase-to-phase short circuits for each zone
- The setting parameters with value ranges are shown below.

2.61.3. Impedance direction criterion.

Depending on the zone setting, the criterion determines the direction of operation (to the lines, to the buses, in both directions) of each protection zone. The criterion operation is identical for both shapes of operating characteristics.

2.61.3.1. Criterion value

The relay was made in a full-schematic circuit. Real-time impedances of all possible short circuit loops are analyzed simultaneously.
The criterion value is the short circuit loop impedance (secondary side) calculated as above.
The setting parameters with value ranges are shown below.

2.61.3.2. Operating characteristics

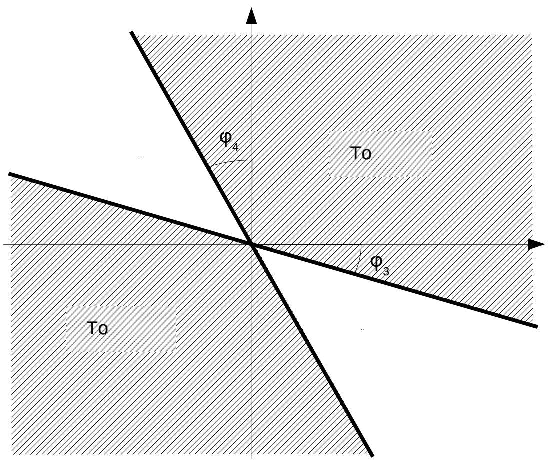


Fig. 36. Characteristics of impedance directional criterion

2.61.4. Operation interlock relay in the area of load currents.

Each protection zone can be interlocked (depending on the setting) if the impedance vector is in the area predicted for the load impedance. The setting ranges are defined separately for single-phase and phase-to-phase loops for each direction.

2.61.4.1. Criterion value

The relay was made in a full-schematic circuit. Real-time impedances of all possible short circuit loops are analyzed simultaneously.
The criterion value is the short circuit loop impedance (secondary side) calculated according to the formulas described above.
The setting parameters with value ranges are shown below.

2.61.4.2. Operating characteristics

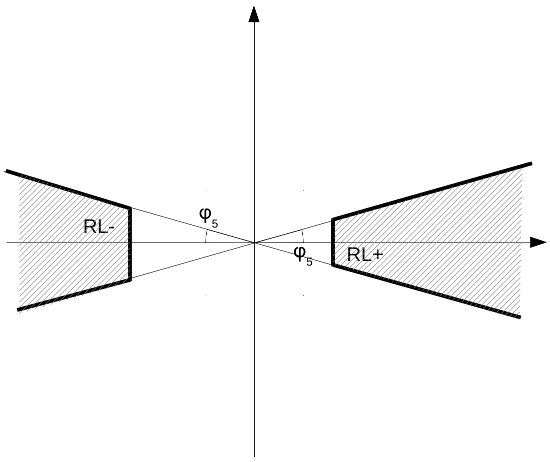


Fig. 37. Characteristics of operation interlock in the area of operating currents.

2.61.5. Additional directional relay

2.61.5.1. Criterion value.

Relay based on currents and voltages symmetrical components. Two independent directional relays: one determining direction based on analysis of opposite components, the other determining direction based on positive sequence components.
For asymmetric short circuits, the short circuit direction is determined from the criterion of negative sequence components. For a three-phase short circuit, the direction is determined by the criterion of positive sequence components. For close symmetrical short circuits, when the voltage drops to values close to zero the reference voltage becomes the voltage from the voltage memory (from before the moment of the short circuit).
The setting parameters with value ranges are shown below.

2.61.5.2. Operating characteristics

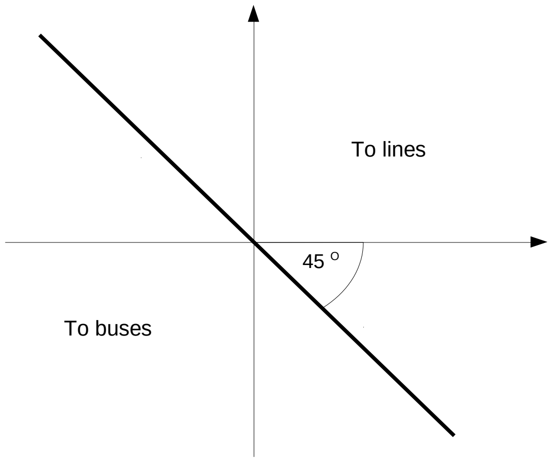


Fig. 38. Characteristics of the additional directional criterion.

2.61.6. Very close short circuits identification relay

2.61.6.1. Criterion value.

For very close short circuits, the short circuit loop voltage can drop below the "distinguishable" value for measurement systems. In this case, the direction impedance criteria may not work properly (determined by the rules described above).
The relay identifies short circuits with an impedance or voltage value lower than that required for unambiguous direction determination by impedance criteria. Activation of this relay results in a determination that the impedance criterion is met in all zones for a given short circuit loop (it interlocks the operation of the impedance direction criterion).
If a short circuit occurs in this area, only an additional criterion determines the identification of the direction.
The relay was made in a full-schematic circuit. Real-time impedances of all possible short circuit loops are analyzed simultaneously.
The criterion value is the short circuit loop impedance (secondary side) calculated as described above and the corresponding short circuit voltage for the loop.
The start-up value is 0.1 Ω (for I_n = 1 A).

2.61.6.2. Operating characteristics of the underimpedance relay

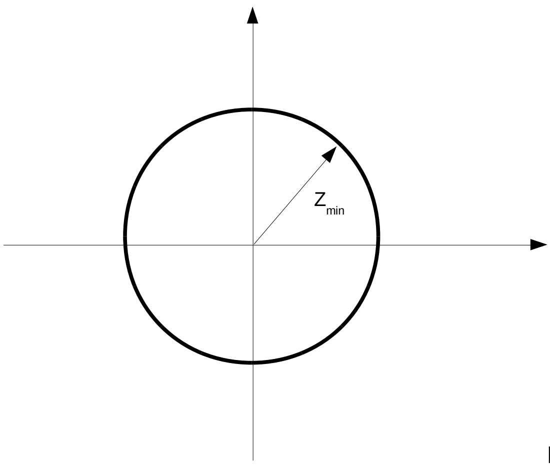


Fig. 39. Operating characteristics of the impedance criterion for identifying close short circuits.

Operation criterion:

$$Z < Z_{min} \text{ or } U < U_{min}$$

where:

Z - short circuit loop impedance (secondary side)
Z_{min} - minimum impedance of 0.1 Ω (for I_n = 1 A)
U_{min} - minimum voltage of 0.01 U_n

2.61.7. Earth fault identification relay

2.61.7.1. Criterion value.

The criterion value is the current zero-sequence component, and conduction currents.
For large-current phase-to-phase short circuits, a certain value of zero current appears in the secondary circuits resulting, for example, from errors in current transformers. The impedance criterion can misleadingly determine the short circuit type in such circumstances.
To further clarify the determination of the short circuit type, an additional zero-sequence current component overcurrent relay was used with characteristics stabilized by the conduction current (maximum of the three phases). An additional criterion is to check the presence of zero voltage.
The setting parameters with value ranges are shown below.

2.61.7.2. Operating characteristics

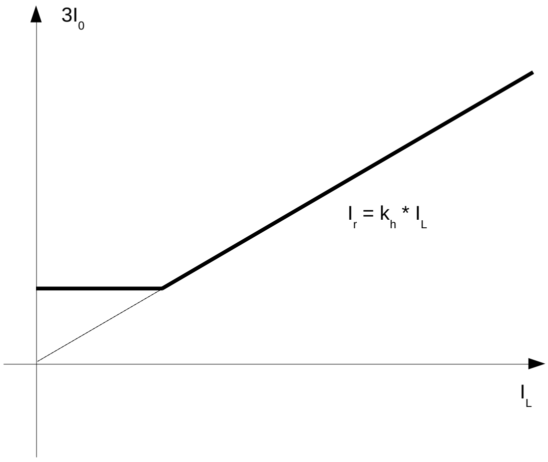


Fig. 40. Operating characteristics of the current part of the relay for identification of short circuits involving earth

Operation criterion (for each phase):

$(3I_0 > kh * I_L)$ AND $(3I_0 > I_{min})$ AND $(3U_0 > U_{min})$

where:

$3I_0$	-	current zero-sequence component
$3U_0$	-	voltage zero-sequence component
I_L	-	conductor current (maximum of three phases)
k_h	-	stabilization factor (setting)
I_{min}	-	minimum required zero current value (setting)
U_{min}	-	minimum required zero voltage value (setting)

2.61.8. Configuring and setting.

The use of the methods of operation described above is possible by configuring in three independent functional interlocks.

2.61.8.1. Version 1.

Two functions **Zdist<** and **Zdist<_cd** with settings as below implement the algorithms described above. Adapted to work with the **ZdistL** logic interlock (section2.66). Altogether, it realizes complete distance protection with single-phase SPZ and two types of operating characteristics.

2.61.8.1.1. Settings table

Settings in the *Zdist*< function

Setting	Description	Setting range	Default value
ON/OFF	Function activity	(ON / OFF)	ON
Bl_Load1	Interlock in the area of load currents for zone 1	(ON / OFF)	OFF
Bl_Load2	Interlock in the area of load currents for zone 2	(ON / OFF)	OFF
Bl_Load3	Interlock in the area of load currents for zone 3	(ON / OFF)	OFF
Bl_Load4	Interlock in the area of load currents for zone 4	(ON / OFF)	OFF
Bl_Load5	Interlock in the area of load currents for zone 5	(ON / OFF)	OFF
Typ1	Characteristics type, zone 1	(poligonalna/kołowa) (polygonal/circular)	poligonalna (polygonal)
Typ2	Characteristics type, zone 2	(poligonalna/kołowa) (polygonal/circular)	poligonalna (polygonal)
Typ3	Characteristics type, zone 3	(poligonalna/kołowa) (polygonal/circular)	poligonalna (polygonal)
Typ4	Characteristics type, zone 4	(poligonalna/kołowa) (polygonal/circular)	poligonalna (polygonal)
Typ5	Characteristics type, zone 5	(poligonalna/kołowa) (polygonal/circular)	poligonalna (polygonal)
K1	Operation direction, zone 1	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K2	Operation direction, zone 2	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K3	Operation direction, zone 3	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K4	Operation direction, zone 4	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K5	Operation direction, zone 5	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do szyn (to buses)
I_{min}	Current limit value	(0.20÷1.00) In in 0.01 In increments	0.20 In
Kk1	Earth fault compensation factor, zone 1	(0.00÷3.00) in 0.01 increments	1.00
Kk1_kąt	Earth fault compensation vector angle, zone 1	(-30.0÷30.0)° in 0.1° increments	0.0°
KkC	Earth fault compensation factor, zone 2, 3, 4, 5	(0.00÷3.00) in 0.01 increments	1.00
KkC_kąt	Earth fault compensation vector angle, zone 2, 3, 4, 5	(-30.0÷30.0)° in 0.1° increments	0.0°
φ1	Line angle	(0.0÷90.0)° in 0.1° increments	75.0°
φ2	The straight correction angle of zone one for single-phase short circuits with earth	(0.0÷45.0)° in 0.1° increments	0.0°
R1W / Zf1W_LE	1W zone. L-E short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.65 Ω
R1W / Zf1W_LL	1W zone. L-L short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.65 Ω
R1 / Zf1_LE	Zone 1. L-E short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
R1 / Zf1_LL	Zone 1. L-L short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω

Setting	Description	Setting range	Default value
R2 / Zf2_LE	Zone 2. L-E short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.70 Ω
R2 / Zf2_LL	Zone 2. L-L short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.70 Ω
R3 / Zf3_LE	Zone 3. L-E short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	1.00 Ω
R3 / Zf3_LL	Zone 3. L-L short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	1.00 Ω
R4 / Zf4_LE	Zone 4. L-E short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
R4 / Zf4_LL	Zone 4. L-L short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
R5 / Zf5_LE	Zone 5. L-E short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
R5 / Zf5_LL	Zone 5. L-L short circuit (setting for the phase on the secondary side) Resistance range for polygonal characteristics / "Forward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
X1W / Zr1W_LE	1W zone. L-E short circuit (setting for the phase on the secondary side) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.65 Ω
X1W / Zr1W_LL	1W zone. L-L short circuit (setting for the phase on the secondary side) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.65 Ω
X1 / Zr1_LE	Zone 1. L-E short circuit (setting for the phase on the secondary side) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
X1 / Zr1_LL	Zone 1. L-L short circuit (setting for the phase on the secondary side) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
X2 / Zr2_LE	Zone 2. L-E short circuit (setting for the phase on the secondary side) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.70 Ω
X2 / Zr2_LL	Zone 2. L-L short circuit (setting for the phase on the secondary side) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.70 Ω
X3 / Zr3_LE	Zone 3. L-E short circuit (secondary side setting) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	1.00 Ω
X3 / Zr3_LL	Zone 3. L-L short circuit (setting for the phase on the secondary side) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	1.00 Ω

Setting	Description	Setting range	Default value
X4 / Zr5_LE	Zone 4. L-E short circuit (setting for the phase on the secondary side) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
X4 / Zr4_LL	Zone 4. L-L short circuit (setting for the phase on the secondary side) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
X5 / Zr5_LE	Zone 5. L-E short circuit (setting for the phase on the secondary side) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
X5 / Zr5_LL	Zone 5. L-L short circuit (setting for the phase on the secondary side) Reactance range for polygonal characteristics / "Backward" range for circular characteristics	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
k_p	Reset ratio	(1.01÷1.20) in 0.01 increments	1.03

Settings in the *Zdist<_cd* function

Setting	Description	Setting range	Default value
U_{min}	Minimum voltage value	(0.010÷0.050) Un in 0.001 Un increments	0.002 Un
φ3	Directional angle from the X axis of the impedance direction criterion	(0.0÷45.0)° in 0.1° increments	15.0°
φ4	Directional angle from the R axis of the impedance direction criterion	(0.0÷45.0)° in 0.1° increments	15.0°
R_{Lf}	"Forward" range of operation interlock criterion in the range of load currents (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
R_{Lr}	"Backward" range of operation interlock criterion in the range of load currents (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
φ5	Directional angle of operation interlock in the range of load currents	(0.0÷60.0)° in 0.1° increments	20.0°
$3I_{omin}$	Minimum start-up value of the earth fault identification relay zero current	(0.10÷20.00) In in 0.01 In increments	1.00 In
$3I_{okh}$	Relay characteristics stabilization factor for identification of short circuits involving earth	(0.00÷1.00) in 0.50 increments	1.00 In
$3U_{omin}$	Minimum value of the zero-sequence component voltage	(0.010÷1.000) Un in 0.001 Un increments	0.050 Un

2.61.8.2. Version 2.

Two functions **Zdist<_w2** and **Zdist<_wd_cd** with settings as below implement the algorithms described above. They implement the function of distance protection with polygonal characteristics and have a logic and time interlock with the following functions:

2.61.8.2.1. Timing relays and shut down.

Each zone has a separately settable shutdown delay time different for single-phase short circuits and for phase-to-phase short circuits. Each zone has a operation mode setting. There are three modes:

- "odstawiona" (deactivated) – zone not working
- "na wyłączenie" (on shutdown) - tripping the zone activated both the outputs labeled "Zadziałanie" (Tripping) and "Wyłączenie" (Shutdown). The shutdown is common to all zones.
- "na sygnalizację" (on signaling) - tripping the zone activates the output labeled "Zadziałanie" (Tripping).

The protection operation is interlocked if a fault is detected in the voltage circuits described in section2.64.
The operation of each zone, depending on the setting, can be interlocked by the power swing identification relay described in section2.63.
When the location of the short circuit loop impedance in the area of extended zone one (1W) is found, tripping (shutdown) from zone 1 occurs only in the following cases:

- if activation of SPZ from zone 1W is set (see section2.66.3). The shutdown occurs only as the first shutdown in the SPZ cycle.
- if the collaboration of zone 1W with the telecommunication link is set (see section3.2.) Shutdown then occurs in a mode that depends on the setting of the link automation function.

2.61.8.2.2. System of collaboration with SPZ automation.

The interlock is adapted to work with SPZ automation (section3.3). A high state at the PDZ input causes activation in zones set to collaborate with SPZ to disable tw_SPZ and activation of the SPZ automation (wyjście P_SPZ) with settable time.

2.61.8.2.3. Automated shutdown on short circuit switching.

If a short circuit is detected when the line is switched on, the protection zone selected (in the settings) shuts down the line non-directionally and immediately.
Criteria for identifying short circuit switching:

- Two-state input status. The signal appearing on the input indicating that the line switching pulse has been sent activates the automation for the set time.
- Status of auxiliary contacts of the breaker status. Determination of the breaker's open status via normally closed auxiliary contacts activates the automation during the opening time and for a set time after the breaker is closed. This is activated with the appropriate setting.

Automation can be shut down through the appropriate setting.

2.61.8.2.4. Settings table

Settings in the *Zdist_w2*< function

Setting	Description	Setting range	Default value
ON/OFF	Function activity	(ON / OFF)	ON
Bl_Load1	Interlock in the area of load currents for zone 1	(ON / OFF)	OFF
Bl_Load2	Interlock in the area of load currents for zone 2	(ON / OFF)	OFF
Bl_Load3	Interlock in the area of load currents for zone 3	(ON / OFF)	OFF
Bl_Load4	Interlock in the area of load currents for zone 4	(ON / OFF)	OFF
Bl_Load5	Interlock in the area of load currents for zone 5	(ON / OFF)	OFF
SPZ_s1	SPZ activation from zone 1	(YES/NO)	NO
SPZ_s2	SPZ activation from zone 2	(YES/NO)	NO
SPZ_s3	SPZ activation from zone 3	(YES/NO)	NO
SPZ_s4	SPZ activation from zone 4	(YES/NO)	NO
SPZ_s5	SPZ activation from zone 5	(YES/NO)	NO
Bl_PS_str1	Interlocking from power swings, zone 1	(YES/NO)	Tak (Yes)
Bl_PS_str2	Interlocking from power swings, zone 2	(YES/NO)	Tak (Yes)
Bl_PS_str3	Interlocking from power swings, zone 3	(YES/NO)	NO
Bl_PS_str4	Interlocking from power swings, zone 4	(YES/NO)	NO
Bl_PS_str5	Interlocking from power swings, zone 5	(YES/NO)	NO
ZZw_ON	Activation of short circuit switching automation	(YES/NO)	Tak (Yes)
PZzw_od_W	Activation of the short circuit switching automation from an open breaker	(YES/NO)	Tak (Yes)
K1	Operation direction, zone 1	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K2	Operation direction, zone 2	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K3	Operation direction, zone 3	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K4	Operation direction, zone 4	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K5	Operation direction, zone 5	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do szyn (to buses)
Strefa1	Zone 1 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa2	Zone 2 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa3	Zone 3 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa4	Zone 4 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa5	Zone 5 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
ZZw	Collaboration zone with short circuit switching automation	(1W / 1 / 2 / 3 / 4 / 5)	1W
I_{min}	Current limit value	(0.20÷1.00) In in 0.01 In increments	0.20 In

Setting	Description	Setting range	Default value
φ1	Line angle	(0.0÷90.0)° in 0.1° increments	75.0°
Kk1	Earth fault compensation factor, zone 1	(0.00÷3.00) in 0.01 increments	1.00
Kk1_kąt	Earth fault compensation vector angle, zone 1	(-30.0÷30.0)° in 0.1° increments	0.0°
KkC	Earth fault compensation factor, zone 2, 3, 4, 5	(0.00÷3.00) in 0.01 increments	1.00
KkC_kąt	Earth fault compensation vector angle, zone 2, 3, 4, 5	(-30.0÷30.0)° in 0.1° increments	0.0°
φ2	The straight correction angle of zone one for single-phase short circuits with earth	(0.0÷45.0)° in 0.1° increments	0.0°
R1W_LE	1W zone. Resistance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.65 Ω
R1W_LL	1W zone. Resistance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.65 Ω
X1W_LE	1W zone. Reactance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.65 Ω
X1W_LL	1W zone. Reactance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.65 Ω
R1_LE	Zone 1. Resistance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
R1_LL	Zone 1. Resistance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
X1_LE	Zone 1. Reactance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
X1_LL	Zone 1. Reactance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
R2_LE	Zone 2. Resistance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
R2_LL	Zone 2. Resistance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
X2_LE	Zone 2. Reactance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
X2_LL	Zone 2. Reactance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
R3_LE	Zone 3. Resistance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	3.00 Ω
R3_LL	Zone 3. Resistance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	3.00 Ω
X3_LE	Zone 3. Reactance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	3.00 Ω
X3_LL	Zone 3. Reactance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	3.00 Ω
R4_LE	Zone 4. Resistance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	5.00 Ω

Setting	Description	Setting range	Default value
R4_LL	Zone 4. Resistance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	5.00 Ω
X4_LE	Zone 4. Reactance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	5.00 Ω
X4_LL	Zone 4. Reactance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	5.00 Ω
R5_LE	Zone 5. Resistance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	1.00 Ω
R5_LL	Zone 5. Resistance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	1.00 Ω
X5_LE	Zone 5. Reactance range, single-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	1.00 Ω
X5_LL	Zone 5. Reactance range, phase-to-phase short circuit (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	1.00 Ω
k_p	Reset ratio	(1.01÷1.20) in 0.01 increments	1.03

Settings in the *Zdist<_w2_cd* function

Setting	Description	Setting range	Default value
φ3	Directional angle from the X axis of the impedance direction criterion	(0.0÷45.0)° in 0.1° increments	15.0°
φ4	Directional angle from the R axis of the impedance direction criterion	(0.0÷45.0)° in 0.1° increments	15.0°
R_{Lf}	"Forward" range of operation interlock criterion in the range of load currents (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
R_{Lr}	"Backward" range of operation interlock criterion in the range of load currents (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
φ5	Directional angle of operation interlock in the range of load currents	(0.0÷60.0)° in 0.1° increments	20.0°
$3I_{omin}$	Minimum start-up value of the earth fault identification relay zero current	(0.10÷20.00) In in 0.01 In increments	1.00 In
$3I_{okh}$	Relay characteristics stabilization factor for identification of short circuits involving earth	(0.00÷1.00) in 0.50 increments	1.00 In
$3U_{omin}$	Minimum value of the zero-sequence component voltage	(0.010÷1.000) Un in 0.001 Un increments	0.050 Un
ts1LE	Zone 1 shutdown time, single-phase short circuits to earth	(0.00÷300.00) s in 0.01 s increments	0.00
ts1LL	Zone 1 shutdown time, phase-to-phase short circuits	(0.00÷300.00) s in 0.01 s increments	0.00
ts2LE	Zone 2 shutdown time, single-phase short circuits to earth	(0.00÷300.00) s in 0.01 s increments	0.50
ts2LL	Zone 2 shutdown time, phase-to-phase short circuits	(0.00÷300.00) s in 0.01 s increments	0.50
ts3LE	Zone 3 shutdown time, single-phase short circuits to earth	(0.00÷300.00) s in 0.01 s increments	1.20
ts3LL	Zone 3 shutdown time, phase-to-phase short circuits	(0.00÷300.00) s in 0.01 s increments	1.20
ts4LE	Zone 4 shutdown time, single-phase short circuits to earth	(0.00÷300.00) s in 0.01 s increments	2.00
ts4LL	Zone 4 shutdown time, phase-to-phase short circuits	(0.00÷300.00) s in 0.01 s increments	2.00
ts5LE	Zone 5 shutdown time, single-phase short circuits to earth	(0.00÷300.00) s in 0.01 s increments	0.50
ts5LL	Zone 5 shutdown time, phase-to-phase short circuits	(0.00÷300.00) s in 0.01 s increments	0.50
tw_SPZ	First shutdown time to SPZ cycle	(0.00÷300.00) s in 0.01 s increments	0.00
ZZw_ta	Operation time of the short circuit switching function when the breaker is closed	(0.00÷300.00) s in 0.01 s increments	5.00

2.61.8.3. Version 3.

The **Zdist<SN** function with settings as below implements the algorithms described above with restriction to only phase-to-phase short circuit loops with polygonal operating characteristics. It has a logic and timing interlock with the following functions:

2.61.8.3.1. Timing relays and shut down.

Each zone has a separately settable delay time. Each zone has a operation mode setting. There are three modes:

- "odstawiona" (deactivated) – zone not working
- "na wyłączenie" (on shutdown) - tripping the zone activated both the outputs labeled "Zadziałanie" (Tripping) and "Wyłączenie" (Shutdown). The shutdown is common to all zones.
- "na sygnalizację" (on signaling) - tripping the zone activates the output labeled "Zadziałanie" (Tripping).

The protection operation is interlocked if a fault is detected in the voltage circuits described in section2.64.
The operation of each zone, depending on the setting, can be interlocked by the power swing identification relay described in section2.63.
When the location of the short circuit loop impedance in the area of extended zone one (1W) is found, tripping (shutdown) from zone 1 occurs only in the following cases:

- if activation of SPZ from zone 1W is set (see section2.66.3). The shutdown occurs only as the first shutdown in the SPZ cycle.
- if the collaboration of zone 1W with the telecommunication link is set (see section3.2.) Shutdown then occurs in a mode that depends on the setting of the link automation function.

2.61.8.3.2. System of collaboration with SPZ automation.

The interlock is adapted to work with SPZ automation (section3.3). A high state at the PDZ input causes activation in zones set to collaborate with SPZ to disable tw_SPZ and activation of the SPZ automation (wyjście P_SPZ) with settable time.

2.61.8.3.3. Automated shutdown on short circuit switching.

If a short circuit is detected when the line is switched on, the protection zone selected (in the settings) shuts down the line non-directionally and immediately.
Criteria for identifying short circuit switching:

- Two-state input status. The signal appearing on the input indicating that the line switching pulse has been sent activates the automation for the set time.
- Status of auxiliary contacts of the breaker status. Determination of the breaker's open status via normally closed auxiliary contacts activates the automation during the opening time and for a set time after the breaker is closed. This is activated with the appropriate setting.

Automation can be shut down through the appropriate setting.

Criteria for identification of short circuit switching

- Two-state input status. The signal appearing on the input indicating that the line switching pulse has been sent activates the automation for the set time.
- Status of auxiliary contacts of the breaker status. Determination of the breaker's open status via normally closed auxiliary contacts activates the automation during the opening time and for a set time after the breaker is closed. This is activated with the appropriate setting.

Automation can be shut down through the appropriate setting.

2.61.8.3.4. Settings table

Settings in the *Zdist_w2*< function

Setting	Description	Setting range	Default value
ON/OFF	Function activity	(ON / OFF)	ON
Bl_Load1	Interlock in the area of load currents for zone 1	(ON / OFF)	OFF
Bl_Load2	Interlock in the area of load currents for zone 2	(ON / OFF)	OFF
Bl_Load3	Interlock in the area of load currents for zone 3	(ON / OFF)	OFF
Bl_Load4	Interlock in the area of load currents for zone 4	(ON / OFF)	OFF
Bl_Load5	Interlock in the area of load currents for zone 5	(ON / OFF)	OFF
SPZ_s1	SPZ activation from zone 1	(YES/NO)	NO
SPZ_s2	SPZ activation from zone 2	(YES/NO)	NO
SPZ_s3	SPZ activation from zone 3	(YES/NO)	NO
SPZ_s4	SPZ activation from zone 4	(YES/NO)	NO
SPZ_s5	SPZ activation from zone 5	(YES/NO)	NO
Bl_PS_str1	Interlocking from power swings, zone 1	(YES/NO)	Tak (Yes)
Bl_PS_str2	Interlocking from power swings, zone 2	(YES/NO)	Tak (Yes)
Bl_PS_str3	Interlocking from power swings, zone 3	(YES/NO)	NO
Bl_PS_str4	Interlocking from power swings, zone 4	(YES/NO)	NO
Bl_PS_str5	Interlocking from power swings, zone 5	(YES/NO)	NO
ZZw_ON	Activation of short circuit switching automation	(YES/NO)	Tak (Yes)
PZzw_od_W	Activation of the short circuit switching automation from an open breaker	(YES/NO)	Tak (Yes)
K1	Operation direction, zone 1	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K2	Operation direction, zone 2	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K3	Operation direction, zone 3	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K4	Operation direction, zone 4	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do linii (to lines)
K5	Operation direction, zone 5	(bez kierunku / do linii / do szyn) (no direction / to lines / to buses)	do szyn (to buses)
Strefa1	Zone 1 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa2	Zone 2 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa3	Zone 3 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa4	Zone 4 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa5	Zone 5 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
ZZw	Collaboration zone with short circuit switching automation	(1W / 1 / 2 / 3 / 4 / 5)	1W
I_{min}	Current limit value	(0.20÷1.00) In in 0.01 In increments	0.20 In
φ1	Line angle	(0.0÷90.0)° in 0.1° increments	75.0°

Setting	Description	Setting range	Default value
R1W	1W zone. Resistance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.65 Ω
R1	Zone 1. Resistance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
R2	Zone 2. Resistance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
R3	Zone 3. Resistance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	3.00 Ω
R4	Zone 4. Resistance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	5.00 Ω
R5	Zone 5. Resistance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	1.00 Ω
X1W	1W zone. Reactance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.65 Ω
X1	Zone 1. Reactance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	0.50 Ω
X2	Zone 2. Reactance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
X3	Zone 3. Reactance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	3.00 Ω
X4	Zone 4. Reactance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	5.00 Ω
X5	Zone 5. Reactance range (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	1.00 Ω
φ3	Directional angle from the X axis of the impedance direction criterion	(0.0÷45.0)° in 0.1° increments	15.0°
φ4	Directional angle from the R axis of the impedance direction criterion	(0.0÷45.0)° in 0.1° increments	15.0°
R_{Lf}	"Forward" range of operation interlock criterion in the range of load currents (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
R_{Lr}	"Backward" range of operation interlock criterion in the range of load currents (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
φ5	Directional angle of operation interlock in the range of load currents	(0.0÷60.0)° in 0.1° increments	20.0°
k_p	Reset ratio	(1.01÷1.20) in 0.01 increments	1.03
ts1	Zone 1 shutdown time	(0.00÷300.00) s in 0.01 s increments	0.00
ts2	Zone 2 shutdown time	(0.00÷300.00) s in 0.01 s increments	0.50
ts3	Zone 3 shutdown time	(0.00÷300.00) s in 0.01 s increments	1.20
ts4	Zone 4 shutdown time	(0.00÷300.00) s in 0.01 s increments	2.00
ts5	Zone 5 shutdown time	(0.00÷300.00) s in 0.01 s increments	0.50
tw_SPZ	First shutdown time to SPZ cycle	(0.00÷300.00) s in 0.01 s increments	0.00
ZZw_ta	Operation time of the short circuit switching function when the breaker is closed	(0.00÷300.00) s in 0.01 s increments	5.00

2.61.9. Parameters for all versions.

Own time $t_w < 35$ ms

Permissible error in impedance measurement (for $U_z > 0.1$ Un and $I_z > 0.5$ In) $\delta_{\%} = \pm 2.5\%$
Permissible error in impedance measurement (for $U_z > 0.05$ Un and $I_z > 0.5$ In) $\delta_{\%} = \pm 5\%$

Permissible error in impedance measurement (for $U_z > 0.1$ Un and $I_z > 0.1$ In)	$\delta_{\%} = \pm 5\%$
Permissible error in voltage measurement	$\delta_{\%} = \pm 1.0\% \pm 0.001$ Un
Permissible error in current measurement	$\delta_{\%} = \pm 1.0\% \pm 0.01$ In
Permissible error in angle measurement	$\delta_{\%} = \pm 2°$

2.62. LMZ – short circuit site locator function

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
The function calculates, based on the recorded short circuit values, the distance to the short circuit site and provides it in km. The prerequisite for correct operation is the active operation of the ***Zdist<*** distance protection function.

Operation description

The function, after the short circuit is detected by the Zdist< function, records the values of current and voltage waveforms, and then calculates the distance to the short circuit site after shutting down the short circuit. For double-path lines, the function allows the effect of parallel path interaction to be included in the distance calculation. It is then required to connect a parallel path to the zero current assembly.

Settings table

Setting	Description	Setting range	Default value
R1	Unit resistance for the positive sequence component (primary side)	(0.000÷10.0000) Ω/km in 0.001 Ω/km increments	0.100
X1	Unit reactance for the positive sequence component (primary side)	(0.000÷10.0000) Ω/km in 0.001 Ω/km increments	0.400
R0	Unit resistance for the zero-sequence component (primary side)	(0.000÷10.0000) Ω/km in 0.001 Ω/km increments	0.100
X0	Unit reactance for the zero-sequence component (primary side)	(0.000÷10.0000) Ω/km in 0.001 Ω/km increments	1.200
Rm	Unit resistance for the mutual component (primary side)	(0.000÷10.0000) Ω/km in 0.001 Ω/km increments	0.000
Xn	Unit reactance for the mutual component (primary side)	(0.000÷10.0000) Ω/km in 0.001 Ω/km increments	0.000
ON/OFF	Function activity	(ON / OFF)	ON
L2T	Double-path line	(YES/NO)	NO

Parameters:

Permissible error $\delta_{\%} = \pm 2.5\%$

2.63. PS – power swing detection function

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application

The function detects power swings (synchronous and asynchronous) occurring in the power system and, depending on the setting, can either interlock protection (e.g., distance) or shut down the object.

Operation description

The criterion value is the change in the value of the positive sequence component of the impedance on the secondary side of the transformers, so the start-up values should be recalculated by the transformers' ratios to the secondary side. The relay measures the transition time of the impedance vector between the two impedance zones (characteristics on the complex plane are shown below). If the transition time is exceeded, it issues a signal used to interlock the distance protection, or used for other purposes such as shutting down the object.

The interlock deactivates immediately if:

- The interlock signal is active for longer than the set time.
- The impedance exits zone 1.
- Depending on the setting - with activation of current zero-sequence component relay (overcurrent stabilized by the positive sequence component current - characteristics shown below),
- Depending on the setting - with activation of the current negative component relay (overcurrent stabilized by the negative sequence component current - characteristics shown below).

The function also enables (depending on the setting) to shut down the object if the number of asynchronous activations (transitions through the characteristics) exceeds the set value during the set time.

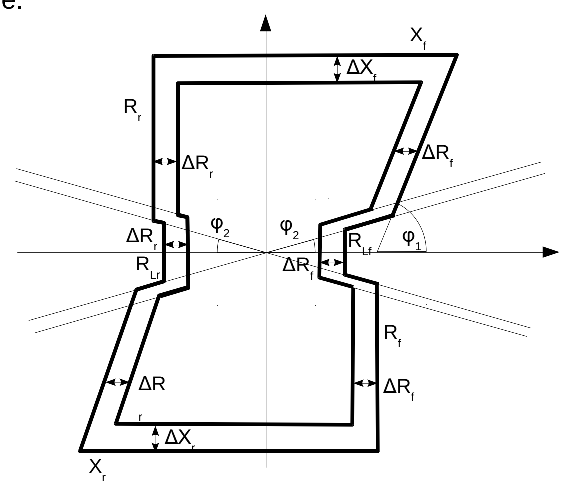


Fig. 41. Characteristics of the impedance criterion.

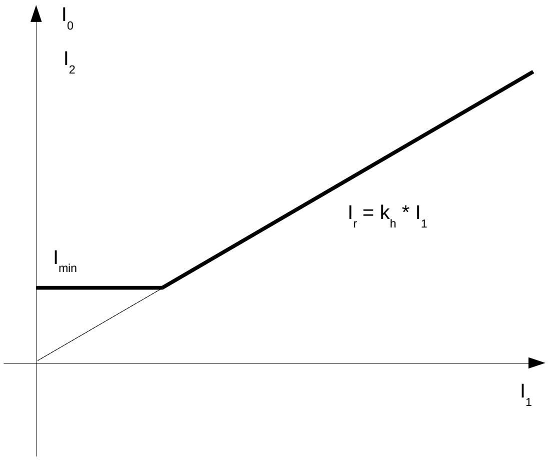


Fig. 42. Characteristics of the current criterion.

Settings table

Setting	Description	Setting range	Default value
R_f	Resistance range forward of the outer zone (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
X_f	Reactance range forward of the outer zone (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
R_r	Resistance range backward of the outer zone (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
X_r	Reactance range backward of the outer zone (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
ΔR_f	Difference defining the resistance range of the internal zone forward (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
ΔX_f	Difference defining the reactance range of the internal zone forward (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
ΔR_r	Difference defining the resistance range of the internal zone backward (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
ΔX_r	Difference defining the reactance range of the internal zone backward (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	2.00 Ω
φ1	Characteristics slope angle	(0.0÷90.0)° in 0.1° increments	70°
R_{Lf}	"Forward" range of operation interlock criterion in the range of load currents (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
R_{Lr}	"Backward" range of operation interlock criterion in the range of load currents (setting for the phase on the secondary side)	(0.10÷500.00) Ω in 0.01 Ω increments	10.00 Ω
φ2	Directional angle of operation interlock in the range of load currents	(0.0÷60.0)° in 0.1° increments	20°
I_{omin}	Minimum start-up value of the zero-sequence current component relay	(0.10÷20.00) In in 0.01 In increments	1.00 In
I_{okh}	Stabilization factor of the zero-sequence current component relay	(0.00÷1.00) in 0.01 increments	0.50
I_{2min}	Minimum start-up value of the negative sequence component relay current	(0.10÷20.00) In in 0.01 In increments	1.00 In
I_{2kh}	Stabilization factor of the negative sequence component relay current	(0.00÷1.00) in 0.01 increments	0.50
t_{pass}	Minimum impedance transition time between zones resulting in relay start-up	(0.04÷3.00) s in 0.01 s increments	0.06 s
t_{dbl}	Activation time of protection deblocking when power swing is detected	(0.10÷300.00) s in 0.01 s increments	2.00 s
t_{PS}	Operation time of the shutdown function from the power swing	(0.00÷300.00) s in 0.01 s increments	10.00 s
I_{PS}	Number of swing repetitions during tPS causing shutdown	(1÷10) in 1 increments	2

Setting	Description	Setting range	Default value
I_{min}	Minimum value of operation current (positive sequence component)	(0.20÷1.00) In in 0.01 In increments	0.20 In
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
D3Io	Deblocking from zero-sequence current component level	(ON / OFF)	ON
D3I2	Deblocking from current negative sequence component level	(ON / OFF)	ON

Parameters:

Permissible error in impedance measurement (for $U_z > 0.1$ Un and $I_z > 0.5$ In) $\delta_{\%} = \pm 2.5\%$
Permissible error in impedance measurement (for $U_z > 0.05$ Un and $I_z > 0.5$ In) $\delta_{\%} = \pm 5\%$
Permissible error in impedance measurement (for $U_z > 0.1$ Un and $I_z > 0.1$ In) $\delta_{\%} = \pm 5\%$
Permissible error in voltage measurement $\delta_{\%} = \pm 1.0\% \pm 0.001$ Un
Permissible error in current measurement $\delta_{\%} = \pm 1.0\% \pm 0.01$ In
Permissible error in angle measurement $\delta_{\%} = \pm 2°$

2.64. Ufail – interlock function from faults in voltage circuits

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

The function detects a fault in voltage circuits and, for example, by interlocking the operation of the distance protection, prevents unnecessary shutdown of the object.

Operation description

2.64.1. Criterion value.

The operation algorithm is based on the analysis of the presence of current and voltage symmetrical components, as well as the breaker state and the state of the auxiliary contacts of the high-speed breaker in voltage circuits. The final decision to identify the damage is based on the state of the following criteria (described in the following paragraphs):

- Zero-sequence component relay *3IU0 (if activated in the settings)*
- Positive sequence component relay *3IU1 (if activated in the settings)*
- Negative sequence component relay *3IU2 (if activated in the settings)*
- Opening of a fast breaker in voltage circuits

Fulfillment of one of the above conditions results in the output of the *Bl_Ufail* signal used, for example, to interlock distance protection. If this state lasts longer than the set time, the *Syg_Ufail* signal is also output. The interlock system's operation is interlocked if the breaker is open.

2.64.2. Zero-sequence component relay.

The relay is used to detect asymmetrical faults in voltage circuits. It works according to the principle that if the presence of zero-sequence component of voltage is found, and there is no current zero-sequence component, the situation is the result of a fault in voltage circuits. If this state lasts longer than the set time, the relay is de-energized only after the voltage zero-sequence component disappears and the positive sequence component appears. Until then, the appearance of the current zero-sequence component will de-energize the relay and remove the interlock. The zero-sequence current component relay has characteristics stabilized by the positive sequence component current according to the following figure.

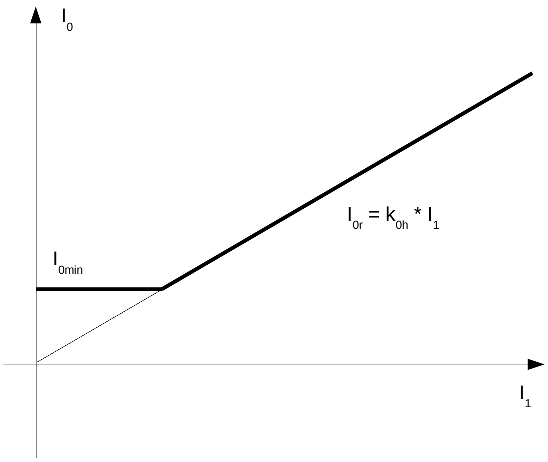


Fig. 43. Characteristics of the current criterion.

2.64.3. Negative sequence component relay.

The relay is used to detect asymmetrical faults in voltage circuits. It works according to the principle that if the presence of the voltage negative sequence component is found, and the current negative sequence component is absent, then the situation is the result of a fault in the voltage circuits. If this state lasts longer than the set time, the relay is de-energized only after the voltage negative sequence component disappears and the positive sequence component appears. Until then, the appearance of the current negative sequence component causes the relay to de-energize. The current negative sequence component relay has characteristics stabilized by the positive sequence component current according to the following figure.

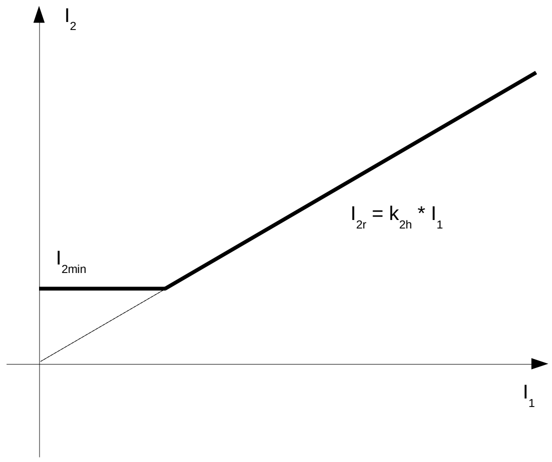


Fig. 44. Characteristics of the current criterion.

2.64.4. Positive sequence component relay.

The relay is used to detect symmetrical (three-phase) faults in voltage circuits. The system generates an interlock signal if the voltage positive sequence component abruptly changes by the set value. The interlock is lifted if:

- During the set time:
  - The current positive sequence component will change in increments greater than the set value. The difference in current is calculated in a vector (considering the current phase change).
  - The current positive sequence component will exceed the specified limits
  - The voltage positive sequence component above the set value will appear
  - The voltage negative sequence component above the set value will appear
  - The voltage zero-sequence component above the set value will appear
- After the set time:
  - The voltage positive sequence component will return to a value above the set point

Settings table

Setting	Description	Setting range	Default value
I_{omin}	Minimum start-up value of zero-sequence component relay current	(0.10÷20.00) In in 0.01 In increments	1.00 In
I_{okh}	Stabilization factor of zero-sequence component relay characteristics	(0.00÷1.00) in 0.01 increments	0.50
U_{omit}	Start-up value of voltage zero-sequence component	(0.010÷1.000) Un in 0.001 Un increments	0.500
I_{2min}	Minimum start-up value of negative sequence component relay current	(0.10÷20.00) In in 0.01 In increments	1.00 In
I_{2kh}	Stabilization factor of negative sequence component relay characteristics	(0.00÷1.00) in 0.01 increments	0.50
U_{2min}	Start-up value of voltage negative sequence component	(0.010÷1.000) Un in 0.001 Un increments	0.500
ΔU1	Incremental voltage change of the positive sequence component	(0.010÷1.000) Un in 0.001 Un increments	0.500
ΔI1	Incremental current change	(0.10÷5.00) In in 0.01 In increments	0.50 In
I_{1max}	Positive sequence component value of the deblocking current	(0.10÷5.00) In in 0.01 In increments	2.00 In
U_{odbl}	Zero-sequence component value of the deblocking voltage	(0.010÷1.000) Un in 0.001 Un increments	0.300
U_{1dbl}	Positive sequence component value of the deblocking voltage	(0.010÷1.000) Un in 0.001 Un increments	0.050
U_{2dbl}	Negative sequence component value of the deblocking voltage	(0.010÷1.000) Un in 0.001 Un increments	0.300
t_{bl}	Time after which the deblocking criterion changes	(0.10÷300.00) s in 0.01 s increments	8.00 s
ON/OFF	Function activity	(ON / OFF)	ON
IU0	Zero-sequence component relay activity	(ON / OFF)	ON
IU1	Positive sequence component relay activity	(ON / OFF)	ON
IU2	Negative sequence component relay activity	(ON / OFF)	ON

Parameters:

Permissible error $\delta_{\%} = \pm 2.5\%$

2.65. Ifail – fault identification function in current circuits

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
The function detects faults in the current circuits of protections and, through the ability to interlock functions (such as differential), prevents unnecessary shutdowns of objects.

Operation description

The analysis uses the phase currents of the protection and an additional current (current zero-sequence component) supplied from a different source than the primary signals (reference current).
The primary criterion for identification is the determination that the set value is exceeded by the vector difference of the zero-sequence component currents (calculated from the phase currents) and the reference current. To stave off errors due to inaccuracies in the analog paths (current transformers, low-pass filter, etc.), the start-up value is stabilized by the maximum value of the phase current. The operation of this criterion is shown in the following characteristics:

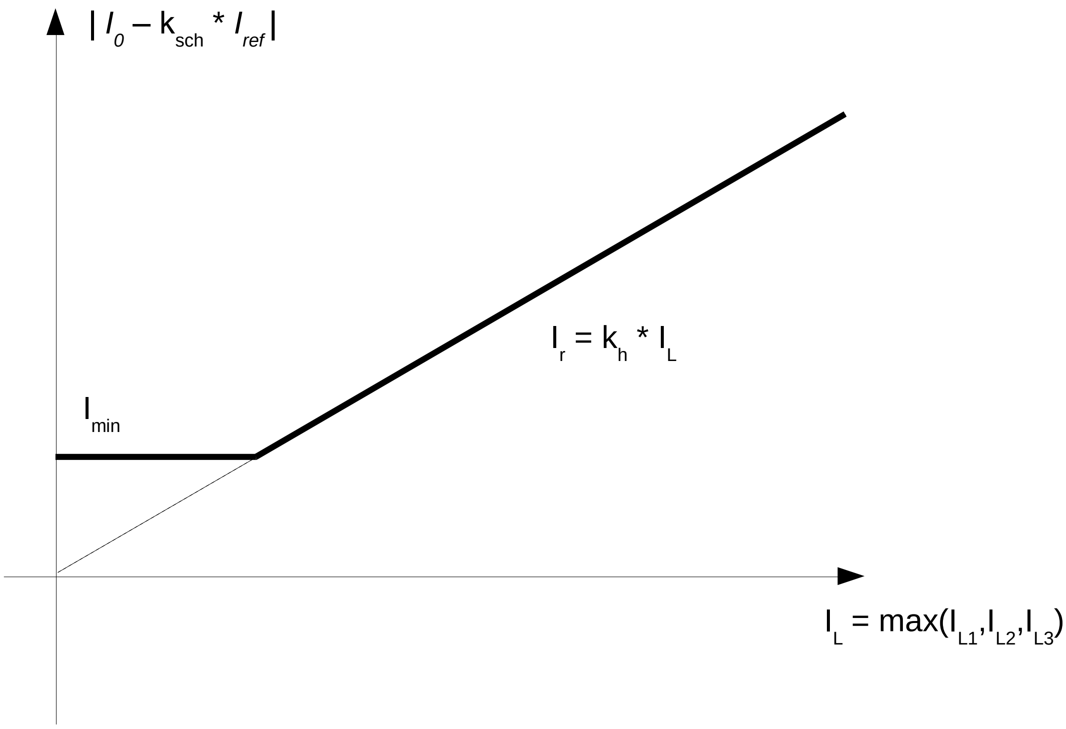


Fig. 45. Characteristics of the differential criterion.

Labels:
- I_o – rms of the control current zero-sequence component (calculated from the phase currents)
- I_{ref} – rms of the reference current
- k_{sch} – schematic factor (considering gears of measurement transformers, and input path)
- I_r – criterion start-up value
- I_{min} – settable initial value of the operating characteristic
- k_h – settable stabilization factor of operating characteristics
- I_L – maximum rms of the three controlled phase currents
- I_{L1},I_{L2},I_{L3} – controlled phase currents

Exceeding the above criterion activates the operation of the circuit and results in the derivation of an interlock (if program-activated). Before the expiration of the set time t_{dbl}, the interlock is " lifted" immediately if:

- The maximum current from the controlled three phases will exceed the set value
- The voltage zero-sequence component above the set value will appear.

The above deblocking conditions can be deactivated by programming with the appropriate setting.
After the set time t_{dbl} is counted down, the fault indication is activated, and the interlock is maintained until the activation of the differential criterion ceases.

Settings table

Setting	Description	Setting range	Default value
I_{min}	Characteristics initial value	(0.10÷1.00) In in 0.01 In increments	0.10
kh	Characteristics stabilization factor	(0.10÷2.00) in 0.01 increments	0.20
ksch	Current matching factor	(0.100÷100.000) in 0.001 increments	0.333
t_{dbl}	Deblocking operation time	(0.00÷300.00) s in 0.01 s increments	5.00 s
I_{dbl}	Deblocking current start-up value	(0.20÷2.00) In in 0.01 In increments	1.50
U_{dbl}	Deblocking voltage start-up value	(0.050÷1.200) Un in 0.001 Un increments	0.100 Un
ON/OFF	Function activity	(ON / OFF)	ON
WyBl	Interlock output activity	(ON / OFF)	ON
Idbl	Interlock activity from phase currents	(ON / OFF)	ON
Udbl	Interlock activity from zero voltage	(ON / OFF)	ON

Parameters:

Permissible error $\delta_{\%} = \pm 2.5\%$

2.66. ZdistL – function of logic-time dependencies of distance protection

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

The function implements the logic and time dependencies of line distance protection. Based on the analog states of the criteria contained in other functions, it decides on the operation of the protection (shutdowns, activations, collaboration with other logic).

Operation description

The primary inputs of the function are the impedance relay states specified in the Zdist< function.
The use of individual functions requires the connection of appropriate input signals.

2.66.1. Timing relays and shut down.

Each zone (defined in the Zdist< function) has a separately settable shutdown delay time different for single-phase short circuits and different for phase-to-phase short circuits. Each zone has a operation mode setting. There are three modes:

- "odstawiona" (deactivated) – zone not working
- "na wyłączenie" (on shutdown) - tripping the zone activated both the outputs labeled "Zadziałanie" (Tripping) and "Wyłączenie" (Shutdown). The shutdown is common to all zones with a distinction between three-phase shutdown (activated by tripping any zone in any short circuit loop) and separately for each phase breaker.
- "na sygnalizację" (on signaling) - tripping the zone activates the output labeled "Zadziałanie" (Tripping).

The protection operation is interlocked if a fault is detected in the voltage circuits described in section2.64.
The operation of each zone, depending on the setting, can be interlocked by the power swing identification relay described in section2.63.
When the location of the short circuit loop impedance in the area of extended zone one (1W) is found, tripping (shutdown) from zone 1 occurs only in the following cases:

- if activation of SPZ from zone 1W is set (see section2.66.3). The shutdown occurs only as the first shutdown in the SPZ cycle.
- if the collaboration of zone 1W with the telecommunication link is set (see section3.2.) Shutdown then occurs in a mode that depends on the setting of the link automation function.

2.66.2. Automated shutdown on short circuit switching.

If a short circuit is detected when the line is switched on, the protection zone selected (in the settings) shuts down the line non-directionally and immediately.
Criteria for identifying short circuit switching:

- Two-state input status. The signal appearing on the input indicating that the line switching pulse has been sent activates the automation for the set time.
- Status of auxiliary contacts of the breaker status. Determination of the breaker's open status via normally closed auxiliary contacts activates the automation during the opening time and for a set time after the breaker is closed. This is activated with the appropriate setting.
- The state of currents and voltages on the line. If the voltage of all phases and the current of all phases is lower than the set values for a time longer than the set value, the automation is activated for the duration of this state and for the set time after the aforementioned conditions cease. This method of activation is inactive when one of the settings (current or voltage) is set to 0.

Automation can be shut down through the appropriate setting.

2.66.3. SPZ automation.

The function includes five-stage SPZ automation.
When SPZ automation is activated, non-definitive (cycle-boosting) shutdown is carried out with separately set time.
Depending on the setting, level 1 can be:

- Three-phase - SPZ cycle shutdown and definitive shutdown are three-phase
- Single-phase - SPZ cycle shutdown for single-phase short circuits with earth is single-phase, for other short circuits three-phase definitive shutdown only. Definitive shutdown is three-phase only.
- Three-phase/single-phase - shutdown in the SPZ cycle for single-phase short circuits to earth is single-phase, for the rest it is three-phase, definitive shutdown is three-phase. The relay is equipped with the ability to separately set the voltage-free interval time for single-phase and three-phase shutdown.

Other SPZ levels three-phase only.
The single-phase SPZ is equipped with a developmental short circuit response function. If a short circuit occurs in the non-shutdown phases during the de-energized interval, a three-phase de-energization occurs without delay and proceeds to the metering of a separately set de-energized interval time.
SPZ automation can be activated:

- By any zone of distance protection. For zone 1, the first shutdown is generated from 1W activation, the definitive shutdown from zone 1 exits only if the impedance is within zone 1 (without extension).
- By an external input: by an external two-state input or by earth fault protection.
- From the telecommunication link automation.

Automation generates the sending of a switching pulse of settable duration after measuring the time of the voltage-free interval.
The time of the voltage-free interval is measured from the moment of opening the breaker, the state of which is controlled by two binary inputs corresponding to the position of the auxiliary contacts of the breaker (two-position).
If the breaker does not open for the set time after sending an off pulse, the SPZ automation stops the program and generates an error signal.
Sending an on pulse can be interlocked by:

- Two-state input of SPZ operation interlock
- Two-state input of switch drive not ready
- Depending on the setting, the state of switching interlock from the synchronism control system

Failure to allow a switching that lasts longer than the set time causes the cycle to be interrupted and an SPZ error indication is generated.
Each time after sending a switching pulse, a settable time is measured during which the appearance of the next activation pulse is treated as a cycle continuation. After this time has elapsed, the automation generates information about the cycle completion in the established state and returns to the activation-ready state.

Settings table

Setting	Description	Setting range	Default value
SPZ_{akt}	SPZ automation activity	(YES/NO)	Tak (Yes)
SPZ_s1	SPZ activation from zone 1	(YES/NO)	NO
SPZ_s2	SPZ activation from zone 2	(YES/NO)	NO
SPZ_s3	SPZ activation from zone 3	(YES/NO)	NO
SPZ_s4	SPZ activation from zone 4	(YES/NO)	NO
SPZ_s5	SPZ activation from zone 5	(YES/NO)	NO
SPZ_zew	Activation from external input	(YES/NO)	NO
Bl_SCK	Activation of SPZ interlock from synchronism control	(YES/NO)	NO
Bl_PS_s1	Interlocking from power swings, zone 1	(YES/NO)	Tak (Yes)
Bl_PS_s2	Interlocking from power swings, zone 2	(YES/NO)	Tak (Yes)
Bl_PS_s3	Interlocking from power swings, zone 3	(YES/NO)	NO
Bl_PS_s4	Interlocking from power swings, zone 4	(YES/NO)	NO
Bl_PS_s5	Interlocking from power swings, zone 5	(YES/NO)	NO
ZZw_akt	Activation of short circuit switching automation	(YES/NO)	Tak (Yes)
PZzw_od_W	Activation of the short circuit switching automation from an open breaker	(YES/NO)	Tak (Yes)
Strefa1	Zone 1 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa2	Zone 2 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa3	Zone 3 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa4	Zone 4 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
Strefa5	Zone 5 operation	(odstawiona / na sygnalizacje / na wyłączenie) (deactivated / on signaling / on shutdown)	na wyłączenie (on shutdown)
SPZst1	Operation mode of SPZ automation level 1	w(1fazowy / 3fazowy / 1/3fazowy) (1-phase / 3-phase / 1/3-phase)	3fazowy (3-phase)
ZZw	Collaboration zone with short circuit switching automation	(1W / 1 / 2 / 3 / 4 / 5)	1W
ts1LE	Zone 1 shutdown time, single-phase short circuits to earth	(0.00÷300.00) s in 0.01 s increments	0.00
ts1LL	Zone 1 shutdown time, phase-to-phase short circuits	(0.00÷300.00) s in 0.01 s increments	0.00
ts2LE	Zone 2 shutdown time, single-phase short circuits to earth	(0.00÷300.00) s in 0.01 s increments	0.50
ts2LL	Zone 2 shutdown time, phase-to-phase short circuits	(0.00÷300.00) s in 0.01 s increments	0.50
ts3LE	Zone 3 shutdown time, single-phase short circuits to earth	(0.00÷300.00) s in 0.01 s increments	1.20
ts3LL	Zone 3 shutdown time, phase-to-phase short circuits	(0.00÷300.00) s in 0.01 s increments	1.20
ts4LE	Zone 4 shutdown time, single-phase short circuits to earth	(0.00÷300.00) s in 0.01 s increments	2.00

Setting	Description	Setting range	Default value
ts4LL	Zone 4 shutdown time, phase-to-phase short circuits	(0.00÷300.00) s in 0.01 s increments	2.00
ts5LE	Zone 5 shutdown time, single-phase short circuits to earth	(0.00÷300.00) s in 0.01 s increments	0.50
ts5LL	Zone 5 shutdown time, phase-to-phase short circuits	(0.00÷300.00) s in 0.01 s increments	0.50
SPZilst	SPZ automation levels	(1÷5) in 1 increments	1
SPZtW	Non-definitive shutdown time in the SPZ cycle	(0.00÷300.00) s in 0.01 s increments	0.00
SPZt1f	Voltage-free interval time for single-phase shutdown	(0.00÷300.00) s in 0.01 s increments	0.50
SPZt3f	Voltage-free interval time for three-phase shutdown	(0.00÷300.00) s in 0.01 s increments	0.50
SPZtzr	Voltage-free interval time for a developmental short circuit	(0.00÷300.00) s in 0.01 s increments	0.50
SPZtst2	Voltage-free interval time, attempt 2	(0.00÷300.00) s in 0.01 s increments	0.50
SPZtst3	Voltage-free interval time, attempt 3	(0.00÷300.00) s in 0.01 s increments	0.50
SPZtst4	Voltage-free interval time, attempt 4	(0.00÷300.00) s in 0.01 s increments	0.50
SPZtst5	Voltage-free interval time, attempt 5	(0.00÷300.00) s in 0.01 s increments	0.50
SPZtow	Waiting time for the breaker to open	(0.00÷300.00) s in 0.01 s increments	1.00
SPZtSCK	Waiting time for interlock to be lifted from synchronism control	(0.00÷300.00) s in 0.01 s increments	1.00
SPZtok	Waiting time for the cycle to continue	(0.00÷300.00) s in 0.01 s increments	8.00
ZZw_ta	Operation time of the short circuit switching function when the breaker is closed	(0.00÷300.00) s in 0.01 s increments	5.00
ZZw_Ir	Breaker opening identification current	(0.10÷1.00) In in 0.01 In increments	0.10 In
ZZw_Ur	Breaker opening identification voltage	(0.300÷1.000) Un in 0.001 Un increments	0.450 Un
ZZw_to	Breaker opening identification time	(0.00÷300.00) s in 0.01 s increments	2.00
ON/OFF	Function activity	(ON / OFF)	ON
WyBl	Interlock output activity	(ON / OFF)	ON
Idbl	Interlock activity from phase currents	(ON / OFF)	ON
Udbl	Interlock activity from zero voltage	(ON / OFF)	ON

Parameters:

Permissible error in current and voltage measurement $\delta_{\%} = \pm 2.5\%$
Permissible error in time measurement $\delta_{\%} = \pm 0.1\% \pm 10$ ms

2.67. IoLWN – HV line earth fault protection function.

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

The function implements protection to detect single-phase short circuits to earth in lines with a directly earthed neutral point. It can be used as reserve protection in HV grids.

Operation description

The relay analyzes the waveforms of the voltage (e.g., open delta) and current (e.g., Holmgreen circuit) zero-sequence components. The tripping conditions are:

- Exceeding the minimum value by the voltage zero-sequence component
- Meeting the current criterion described below. The criterion is analyzed independently for each protection level
- Phase shift angle within the range defined by the characteristics described below. The protection direction is set independently for each level.
- The content of the second harmonic in the zero current is lower than the set value.
- No protection interlock (e.g., from single-phase SPZ).
- The conditions arising from the mode of operation set in the teletechnical link function (in the case of activated link collaboration function) are met. Link automation works with the first protection level.

2.67.1. Stabilized overcurrent relay.

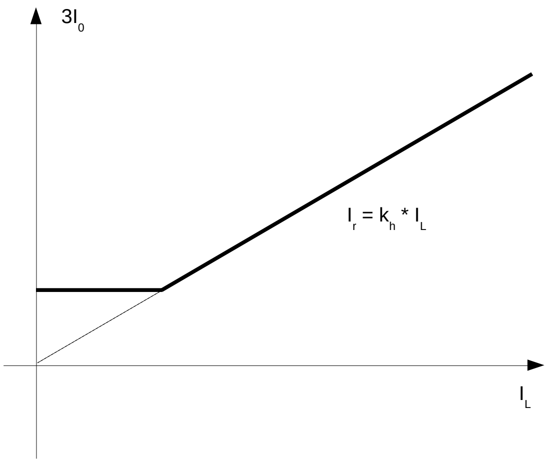


Fig. 46. Operating characteristics

Operation criterion (for each phase):

$(3I_0 > kh * I_L)$ AND $(3I_0 > I_{min})$ AND $(3U_0 > U_{min})$

where:

$3I_0$	-	current zero-sequence component
$3U_0$	-	voltage zero-sequence component
I_L	-	conductor current (maximum of three phases)
k_h	-	stabilization factor (setting)
I_{min}	-	minimum required zero current value (setting)
U_{min}	-	minimum required zero voltage value (setting)

2.67.2. Directional relay

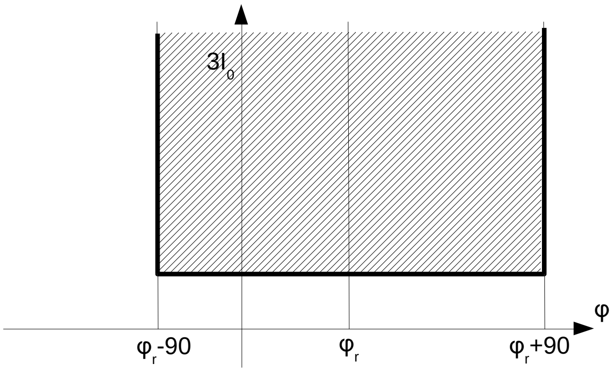


Fig. 47. Angle characteristics

Operation criterion (for each phase):

$$\varphi_r - 90 < \varphi < \varphi_r + 90$$

where:

$3I_0$	-	current zero-sequence component
φ	-	angle between zero-sequence component voltage and current
φ_r	-	characteristic angle (settable)

Settings table

Setting	Description	Setting range	Default value
U_{akt}	Protection activation voltage	(0.001÷1.000) Un in 0.001 Un increments	0.030 Un
φ_{ch}	Characteristic angle	(1÷90 ind)º in 1º increments	70º
$3I_{omin}1$	Current start-up value, level 1	(0.20÷30.00) In in 0.01 In increments	0.50 In
$3I_{omin}2$	Current start-up value, level 2	(0.20÷30.00) In in 0.01 In increments	2.50 In
kh_1	Characteristics stabilization factor, level 1	(0.00÷1.00) in 0.01 increments	0.50
kh_2	Characteristics stabilization factor, level 2	(0.00÷1.00) in 0.01 increments	0.70
t1	Operation time, level 1	(0.00÷300.00) s in 0.01 increments	1.20 s
t2	Operation time, level 2	(0.00÷300.00) s in 0.01 increments	0.50 s
k2h	Second harmonic content factor in current	(0.01÷0.30) in 0.01 increments	0.10
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
STAN1	Level 1 activity	(ODSTAWIONY / OD SZYN / DO SZYN / BEZ KIERUNKU) (DEACIVATED / FROM BUSES / TO BUSES / NO DIRECTION)	OD SZYN (FROM BUSES)
STAN2	Level 2 activity	(ODSTAWIONY / OD SZYN / DO SZYN / BEZ KIERUNKU) (DEACIVATED / FROM BUSES / TO BUSES / NO DIRECTION)	OD SZYN (FROM BUSES)
ON/OFF	Function activity	(ON / OFF)	ON
W1	Trip, level 1	(ON / OFF)	ON
W2	Trip, level 2	(ON / OFF)	ON
Bl_2h1	Interlock on from the second harmonic in level 1	(ON / OFF)	OFF
Bl_2h2	Interlock on from the second harmonic in level 2	(ON / OFF)	OFF

Parameters:

Permissible error in current and voltage measurement $\delta_{\%} = \pm 2.5\%$
Permissible error in angle measurement $\delta_{\%} = \pm 5^{o}$

3. AUTOMATION DESCRIPTION

3.1. SCK – SYNCHROCHECK synchronism control function

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application
The function controls the presence and state of voltages on both sides of an open breaker. The function can be used to interlock switching in the SPZ cycle or (using the state of the relay output) to interlock operational switchings.

Operation description

The function enables, through an appropriate setting, to select one voltage to be analyzed from among all phase or phase-to-phase voltages. The condition for correct operation is to select the voltage corresponding to the reference voltage connected to the assembly.
The system is equipped with the following measurement relays:

- The **Ua<** undervoltage relay to identify the absence of voltage on the line side
- The **Ua>** overvoltage relay to identify the presence of voltage on the line side
- The **Ub<** undervoltage relay to identify the absence of voltage on the bus side
- The **Ub>** undervoltage relay to identify the presence of voltage on the bus side
- The **ΔU<** voltage differential relay. The voltage differential is calculated in a vector.
- **Δφ<** angle difference relay between Ua and Ub
- **Δf<** voltage frequency difference relay between Ua and Ub

The user can allow the following situations for which it is allowed to send a pulse to switch the breaker:

- No voltage on either side (Ua< and Ub< relays activated)
- No voltage on the bus side and voltage present on the line side (Ub< and Ua> relays activated)
- No voltage on the line side and voltage present on the bus side (Ua< and Ub> relays activated)
- Voltage present on both sides (Ua> and Ub> relays activated). In this situation, three criteria (voltage difference, angle difference, frequency difference) are additionally checked. The function allows switching only when all these conditions are met (Δφ<, Δf<, ΔU< relays activated).

Settings table

Setting	Description	Setting range	Default value
ΔUr	Permissible voltage vector difference	(0.020 ÷ 0.500) U_n in 0.001 U_n increments	0.050 U_n
Δf	Permissible frequency difference	(0.005 ÷ 0.300) Hz in 0.005 Hz increments	0.02 Hz
Δφr	Permissible angle difference	(1.0 ÷ 30.0)° in 0.1° increments	5.0°
Uar<	Lower voltage detection limit for Ua	(0.020 ÷ 1.000) U_n in 0.001 U_n increments	0.300 U_n
Uar>	Upper voltage detection limit for Ua	(0.500 ÷ 1.200) U_n in 0.001 U_n increments	0.700 U_n
Ubr<	Lower voltage detection limit for Ub	(0.020 ÷ 1.000) U_n in 0.001 U_n increments	0.300 U_n
Ubr>	Upper voltage detection limit for Ub	(0.500 ÷ 1.200) U_n in 0.001 U_n increments	0.700 U_n
k_p	Reset ratio	(0.80÷0.99) in 0.01 increments	0.95
SCKakt	Function activity	(ON / OFF)	ON
N00	switching without voltage on both sides	(ON / OFF)	ON
N01	switching without voltage on the U1 side and live on the U2 side	(ON / OFF)	ON
N10	switching live on U1 side and without voltage on U2 side	(ON / OFF)	ON
N11	switching live on both sides	(ON / OFF)	ON
Ub	Reference voltage	(L1, L2, L3, L12, L23, L31)	L12

Parameters:

Own time	t_w < 30 ms (for the voltage comparison modules and for the AMP(Ua,Ub) voltage function and the φ(Ua)- φf(Ub) phase shift function).
Own time	t_w < 100 ms (for the f(Ua)-f(Ub) frequency difference function)
Permissible error	$\delta_{\%} = \pm 5\%$

3.2. Ł – teletechnical link function

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
The function allows two assemblies of HV line protection placed at the two ends of the line to collaborate in order to accelerate and synchronize shutdowns at both ends of the line. The function is adapted to work with the Zdist< or 67N_LWN function.

Operation description
For communication with the other end, there are two two-state inputs (reception of the command from the other end and the link efficiency signal) and one output (the command transmission signal). The function works in a three-phase shutdown system.
The function can send, via relay output (transmit signal), information about the activation of any zone of distance protection, or level 1 earth fault protection. The duration of the pulse is settable. The pulse can be used in the logic of the other end's protection link.

The function has a two-state input of information from the other end and a link standby input.
Depending on the setting, the system can perform one of the following functions:

- Zezwalająca (Enabling). Activation of the protection zone (depending on the setting, e.g., the first extended zone) causes immediate operation of this zone if an enabling signal is set on the input from the other side of the line.
- Blokująca (Interlocking). Activation of the protection zone (depending on the setting, e.g., the first extended zone) causes immediate operation of this zone if an interlocking signal is set on the input from the other side of the line.
- Bezwarunkowa (Unconditional). The command signal appearing from the other end causes the breaker to open unconditionally and without delay. Depending on the setting, activation of the SPZ automation may occur simultaneously.

Additional elements (triggered in the settings) are:

- Reverse current logic. When working with a teletechnical link on a parallel line, in order to protect against unnecessary shutdown of the "healthy" line resulting from the reversal of the short circuit current during a short circuit, caused by the opening of the breaker on the faulty line, the above-mentioned logic must be activated. The operation involves generating, through the zone set as a reverse, a pulse interlocking the opening of the breaker for a period of time to update information about the activation states at both ends of the line.
- ECHO function. The function works when activated only if permissive or unconditional collaboration is selected. It is used to effectively eliminate short circuits in lines with "weak" power supply to one end. When information about a short circuit is received from the other end of the line and the absence of activation of any of the protection zones and undervoltage relay activation is detected, the function causes the breaker to open without delay and sends a feedback signal to the other end of the line. Depending on the setting, activation of the SPZ automation may occur simultaneously.
- Link efficiency control function. Selecting a particular zone to work with a link makes its operation conditional on the state of that automation. If the efficiency signal (two-state external input) is absent, the system shuts down all automation functions and activates the operation of distance protection in the deactivated link automation state. All protection zones operate according to their individual settings.

The shutdown timing can be individually set in the link collaboration system.

Settings table

Setting	Description	Setting range	Default value
$Ł_{akt}$	Link automation activity	(ON / OFF)	OFF
CRL_{akt}	Reverse current logic activity	(ON / OFF)	OFF
$ECHO_{akt}$	Echo logic activity	(ON / OFF)	OFF
WD_SPZ_{akt}	SPZ activation in unconditional operation	(ON / OFF)	OFF
$ECHO\_SPZ_{akt}$	SPZ activation at ECHA logic	(ON / OFF)	OFF
Typ	Automation operation program	(Zezwalająca/Blokująca/Bezwarunkowa) (Enabling/Interlocking/Unconditional)	Zezwalająca (Enabling)
Nad	Signal transmission	(1W / 1 / 2 / 3 / 4 / 5)	1W
Odb	Signal received for collaboration	(1W / 1 / 2 / 3 / 4 / 5)	1W
Str_rev	Zone number of collaboration with reverse current logic	(1W / 1 / 2 / 3 / 4 / 5)	5
t_Nad	Transmission pulse length	(0.01÷300) s in 0.01 s increments	0.05 s
t_CRL	Interlock time in reverse current logic	(0.01÷300) s in 0.01 s increments	0.05 s
t_W	Shutdown pulse time from the link	(0.01÷300) s in 0.01 s increments	0.30 s
Ur	Voltage value for the ECHO function condition	(0.010÷1.000) Un in 0.001 Un increments	0.5 Un

Parameters:

Permissible error in voltage measurement $\delta_{\%} = \pm 2.5\%$

3.3. SPZ – automatic restart function (79)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
SPZ automation is used for power supply line fields to restore power after detection and shutdown of a transient short circuit.

Operation description
The function consists of complex operation logic that implements the full functionality of SPZ automation.

It is equipped with the following two-state inputs:

P - automation activation - the sum of protection activations, which are provided for tripping the SPZ automation, e.g. short circuit overcurrent protection, earth fault protection or any other protection or an external signal, is entered into this input.

BL - SPZ automation interlock signal, to which the following signals are typically connected:

- large-current short circuit protection, if the implementation of SPZ is not envisaged after exceeding the set value of short circuit currents due to the risk of damage to the breaker,
- signal indicating that the actuator has not been armed, or signals about the incorrect information on the position of the shutdown contacts (contact position mismatch signal)
- local or remote SPZ automation interlock control signal state
- any other logic signal
- information on the start of the operational control on switching on, which should interlock the automation

W ON - information about the breaker position indicating that the breaker is closed (on).

W OFF - information about the breaker position indicating that the breaker is open (off).

KAS_SYG - signal that cancels the SPZ automation signaling state, after the cycle is completed.

The function equipped with the following two-state outputs:

SPZ - active state during the SPZ automation cycle.

Z - command to switch on the breaker, after measuring the voltage-free intervals in successive SPZ cycles. The signal input into the assembly's switching logic, including pulse formation interlocks for breaker switching.

PDZ - signal issued before the start of the next SPZ cycle, allowing to shorten the delay time, according to the PW1–PW6 settings. Typically, the signal applied to the protections that activate the SPZ automation and in the logic of the product with the activation of the protection controlling directly to the emergency shutdown or after an added delay time.

WZ - output indicating the form of termination of the SPZ cycle by successful engagement of the breaker.

WZW - output indicating the form of termination of the SPZ cycle by unsuccessful engagement of the breaker terminated by a definitive shutdown.

attempt 1÷5 – outputs indicating the number of SPZ cycles attempted.

err_SPZ - output indicating interruption of the SPZ cycle implementation as a result of failure to change the position of the breaker within the set t_o waiting time after sending the command to switch on or waiting to shut down, as well as with the occurrence of SPZ automation interlock (BL input) during the SPZ cycle implementation.

When the breaker is switched on, SPZ automation is triggered. At the moment of tripping the protection (detection of a disturbance on the line) connected to the activation input of the SPZ, the waiting time is counted down to change the position of the breaker state (in this case W ON -> W OFF). If the breaker is not shut down, the SPZ automation will abort the cycle and issue an err_SPZ error.
If the acceleration setting before the 1st tripping is active (PW1=active), the breaker is shut down immediately, otherwise the automation waits for the shutdown with the set time of the activated protection.

After the breaker is shut down, the waiting time of the first de-energized interval tp1 is counted down, after which the breaker is attempted to be switched on (switching on is possible only if there are no switching interlocks). After sending the command to switch on, the waiting time is counted down to change the breaker position and start counting down the interlock time tb of a given SPZ level. If the short circuit was transient in nature, after the time tb is counted down, the automation will issue WZ signaling (successful shut down - switch on cycle) and information about the number of attempts carried out (attempt 1).

If, during the interlock time tb, the protection is activated again, then, depending on the maximum number of attempts set, there will be another attempt to shut down and switch on (for the L.PRÓB > 1 setting) or termination of the SPZ (L.PRÓB = 1) and signaling of an unsuccessful WZW cycle.

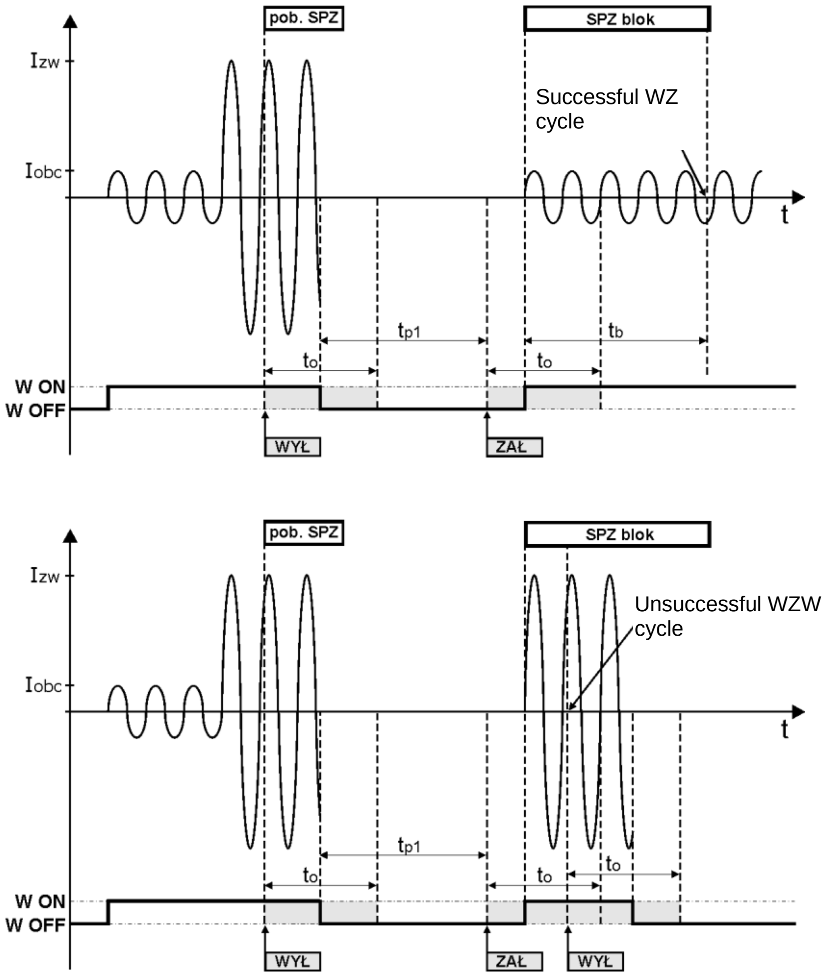


Fig. 48. Functioning of SPZ automation for 1 attempt: successful WZ cycle and unsuccessful WZ cycle.

Settings table

Setting	Description	Setting range	Default value
L.PRÓB	Maximum number of switching attempts	(1 ÷ 5) in 1 increments	1
tp1	Time of the first voltage-free interval	(0.10÷300.00) s in 0.01 s increments	1.00 s
tp2	Time of the second voltage-free interval	(0.10÷300.00) s in 0.01 s increments	5.00 s
tp3	Time of the third voltage-free interval	(0.10÷300.00) s in 0.01 s increments	10.00 s

tp4	Time of the fourth voltage-free interval	(0.10÷300.00) s in 0.01 s increments	20.00 s
tp5	Time of the fifth voltage-free interval	(0.10÷300.00) s in 0.01 s increments	60.00 s
to	Waiting time	(0.10÷300.00) s in 0.01 s increments	0.20 s
tb	Interlock time	(0.00÷300.00) s in 0.01 s increments	1.00 s
ON/OFF	Function activity	(ON / OFF)	ON
PW1	Acceleration before the 1st shutdown	(aktywne/wyłączone) (active/disabled)	wyłączone (off)
PW2	Acceleration after the 1st shutdown	(aktywne/wyłączone) (active/disabled)	wyłączone (off)
PW3	Acceleration after the 2nd shutdown	(aktywne/wyłączone) (active/disabled)	wyłączone (off)
PW4	Acceleration after the 3rd shutdown	(aktywne/wyłączone) (active/disabled)	wyłączone (off)
PW5	Acceleration after the 4th shutdown	(aktywne/wyłączone) (active/disabled)	wyłączone (off)
PW6	Acceleration after the 5th shutdown	(aktywne/wyłączone) (active/disabled)	wyłączone (off)

3.4. SNO – automatic voltage-relief automation

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Automation preventing voltage avalanche phenomenon, protecting the power system from voltage failure by reducing the load.

Operation description
SNO automation effectively identifies a voltage fault state through a set of appropriate voltage protection and timing logic. A set of the following three-phase protections was used to implement the three-stage SNO automaton:

- undervoltage protection 27 (U< - section 2.32, page 66)
- voltage steepness protection, responding to the derivative of voltage against time, acting on signaling 27S (dU - section 91, page 91)
- voltage incremental protection, responding to voltage increment over time, acting on signaling 27SA (ΔU - section 2.50, page 92)
- integral voltage protection, acting on shutdown 27SI (CU - section 2.51, page 93)

Level number of each function depends on the automation concept, typically 3 levels of each function can be envisaged. If necessary, the number of functions can be changed (decreased/increased).

3.5. SCO and SPZ after SCO – automatic frequency de-energization and automatic re-energization after frequency de-energization automation.

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
Automation preventing the loss of stability of the power system by responding to frequency reduction. It works by disconnecting loads when the frequency drops below the set value of the SCO automation level, in order to equalize the balance of active power.
After the shutdown from SCO, this information is stored in the device and SPZ automation can be activated after SCO. In this case, the field is automatically switched on when the frequency value return state is detected (overfrequency function or two-state input) and after a delay time (groups of receivers can be switched on gradually).

Operation description
Through frequency functions, the device can implement the SCO and SPZ automation measurement system after SCO, installed in the voltage measurement field. The 5 stages of SCO automation can be implemented by outputting contact information of five different frequency levels and an additional one for SPZ after SCO.
The device can also perform an executive function with its own frequency measurement or by accepting information with a two-state input from the circular buses.

SCO automation is implemented through f frequency functions, while a separate function is provided to implement SPZ automation after SCO.

The function inputs are:

- Logical state corresponding to the pulse sent off from SCO automation; ***"W"***
- Logical state of the voltage relay output indicating that the voltage level condition is met; ***"U"***.
- Logical state of the frequency relay output indicating that the frequency restoration condition is met; ***"f"***
- Logical state of the breaker auxiliary contacts; ***"W_ON"*** and ***"W_OFF"***
- Command to abort the cycle; ***"Kas_P"***
- Command to clear action signaling ***"Kas_Syg"***.

When the high state appears at the "W" input and the breaker opens, the cycle starts, signaled by setting the high state at the "SPZ" output.
In the activation state, the appearance of high states at the input "U" and "f" after the waiting time for the confirmation of the restoration of the power supply parameters (***"to"*** setting) causes, after the delay

time for sending the switching impulse (***"tz"*** setting), sending a pulse on the breaker with a duration according to the ***"ti"*** setting.
The cycle can be interrupted by:

- Closing the breaker (e.g., operational)
- Appearance of a high state at the Kas_P input
- Exceeding the waiting time for restoring power supply parameters (***"to"*** setting). This condition requires activation with the ***"tp_ON"*** setting.

A successful cycle of SPZ automation after SCO is signaled by the high state of the ***"WZ"*** output.
Unexpected interruption of the cycle is signaled by the high state of the ***"err_SPZ"*** output.
The operation signaling is with the state being sustained. Clearing of signaling is triggered by the high state of the ***"Kas_Syg"*** input.

Settings table

Setting	Description	Setting range	Default value
SPZpoSCOakt	Activation of SPZ automation after SCO	(ON / OFF)	ON
tp_ON	Waiting time limitation activity for restoration of power supply parameters	(ON / OFF)	OFF
tp	Maximum waiting time for restoration of power supply parameters	(0÷65,000) min in 1 min increments	300 min
to	Waiting time to consolidate restored power supply parameters	(0÷65,000) s in 1 s increments	10 s
tz	Delay time for sending the switching pulse	(0÷300.00) s in 0.01 s increments	10.00 s
ti	Switching pulse duration	(0÷300.00) s in 0.01 s increments	0.30 s

3.6. LRW – local breaker reserve automation

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
LRW automation enables the mitigation of unreliable breakers in the power system. The LRW automation system monitors the opening of the breaker at a set time. If the breaker is not shut down after the set delay time, counted from the start of the shutdown, the LRW automation detects this abnormality and generates a control signal for shutting down the breaker in either the coupling field or the supply field.

Operation description
The LRW automation algorithm is shown below. A breaker criterion is implemented in all outflow fields to control the emergency control and the breaker position.
If, after the occurrence of emergency control, the breaker contacts are not switched within the set time, the output relay (one of the configurable relay outputs, e.g. Wy08) will be activated, applying potential to the LRW circle buses of the corresponding section.

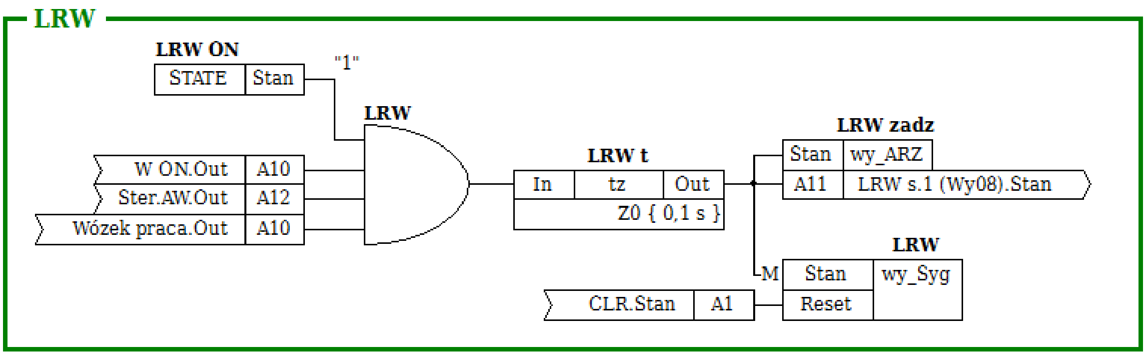


Fig. 49. LRW automation logic scheme - outflow field

Settings table

Setting	Description	Setting range	Default value
LRW t	LRW Delay time	(0.00÷0.50) s in 0.01 s increments	0.10 s
LRW ON	LRW automation activity	ON/OFF	ON

Instead of emergency control, automation can be activated only from selected protection functions, such as short circuit functions.

The LRW automation executive module is implemented in the power supply field and the bus coupler field.
Usually based on two criteria - current, with independent setting of the start-up value, as confirmation of the flow of short circuit current and activation of the circular bus input from the outflow fields.
If the LRW operation is to be extended in terms of eliminating other causes of outages other than short circuits - it is possible to perform LRW without using the current criterion - only unconditional shutdown of the field at activation of the LRW automation circle buses.
Additional emergency control delay from the LRW automation is provided for de-tuning from disturbances in the circular bus circuits.

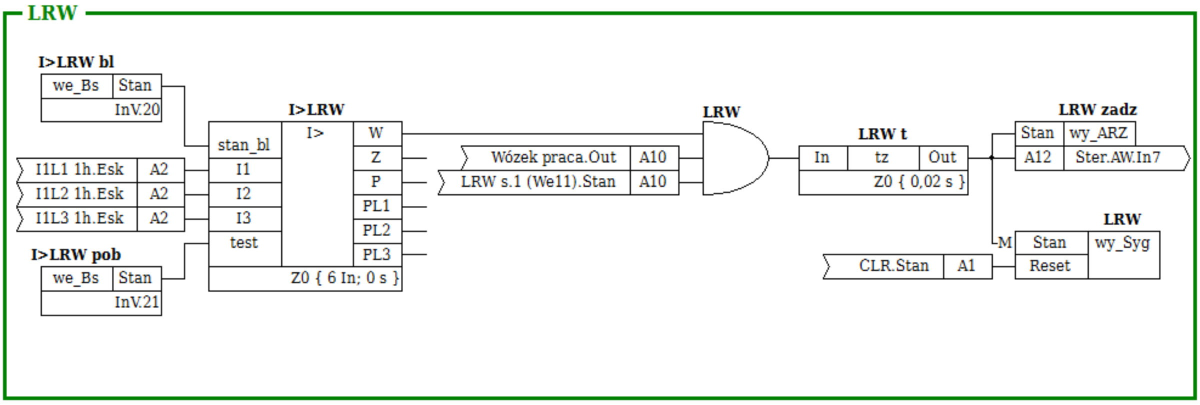


Fig. 50. LRW automation logic scheme – feeder

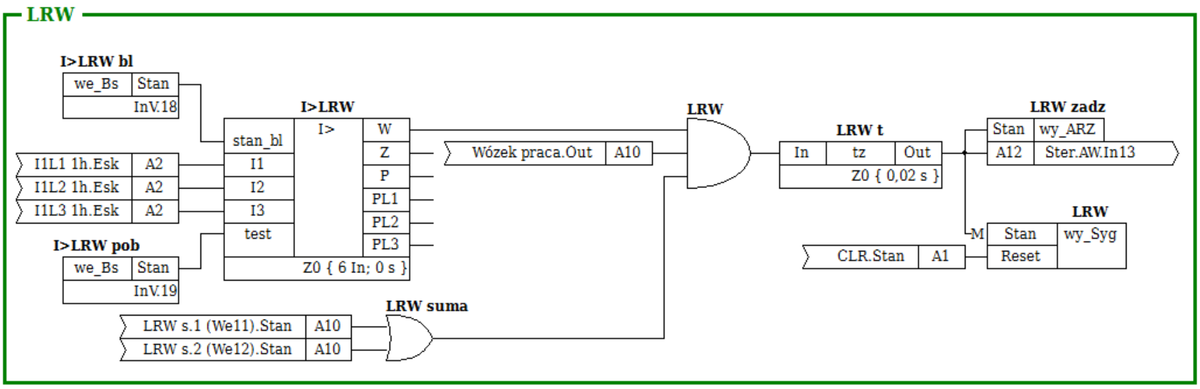


Fig. 51. LRW automation logic scheme - bus coupler field

Settings table

Setting	Description	Setting range	Default value
LRW t	LRW time delay	(0.00÷0.50) s in 0.01 s increments	0.02 s
I_r	Operate current	(0.05÷30.00) In in 0.01 In increments	6.00 In
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	0.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:

Own time	$t_W < 30$ ms
Permissible error	$\delta_{\%} = \pm 2.5\% \pm 0.01$ In

3.7. ZS – bus protection

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Protection of busbars of medium-voltage switchgear is implemented based on the collaboration of protection assemblies in the outflow and feeders. It allows to reduce the delay time in the feeder overcurrent protection, thereby reducing the time of occurrence of short circuits within the switchgear busbars.

Operation description

In typical switchgear short circuit protection systems, time grading is used to achieve selectivity in shutting down the outflow fields and the power supply field. Bus protection helps to reduce the short circuit shutdown time in the busbar zone. If a short circuit occurs in one of the outflows, the protection assembly immediately issues a bus protection interlock signal, which results in interlocking the protection operation in the power supply field and enabling selective shutdown in the outflow field. If, on the other hand, the short circuit occurs on the busbars, then none of the outflow protectors will issue an interlock signal for the protection, and there will be a shutdown in the feeder.
Considering the time to detect the short circuit current flow, the time to close the contacts of the executive relay that activates the circular buses of the bus protection interlock, and the time required to detect the activation of the two-state input, the delay in the protection operation in the feeder should be about 40–100 ms.
In addition, for sectional switchgear, a two-stage delay in the protection operation of the bus coupler field AND the feeder is used to allow the section with a short circuit to be shut down first by shutting down the bus coupler field.

In the outflow field, activation of the BL_ZS(Wy04) bus protection interlock buses is carried out with the State ZS ON automation, with the breaker closed and the cart in the operation mode (to avoid irregularities in protection tests) AND activation of the I>t.P overcurrent protection. Alternatively, the current condition can be implemented as a separate I>ZS overcurrent function or the sum of activations of several levels of the I>> I I> protection.

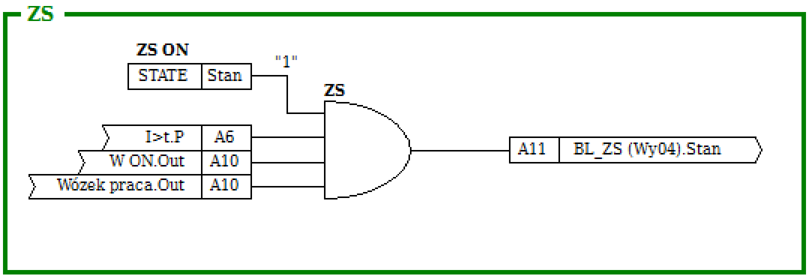


Fig. 52. ZS automation logic scheme – outflow field

Settings table

Setting	Description	Setting range	Default value
ZS ON	ZS automation activity	(ON / OFF)	ON

In the coupling field (bus coupler), executive automation is implemented - the breaker shutdown in its own field of the coupling.
The current criterion dedicated to I>ZS bus protection is interlocked by the interlock from the circular buses activated in the outflow fields of any section BL ZS.s.1(We07) and BL ZS.s.2(We08) section.
If a short circuit occurs on the buses (no interlock from the circular buses), a shutdown occurs with a set delay time. With the coupling breaker open, the bus protection in this field is interlocked.
When the coupling field breaker is closed, the circular interlocking buses of the two sections are connected via one of the executive relays, for example BL ZSs.1-2(Wy10).
Activation of the current criterion, in the absence of interlocks from the section, results in the immediate issue of an interlock signal to the feeders - for example, BL ZSs.PZ(Wy11).

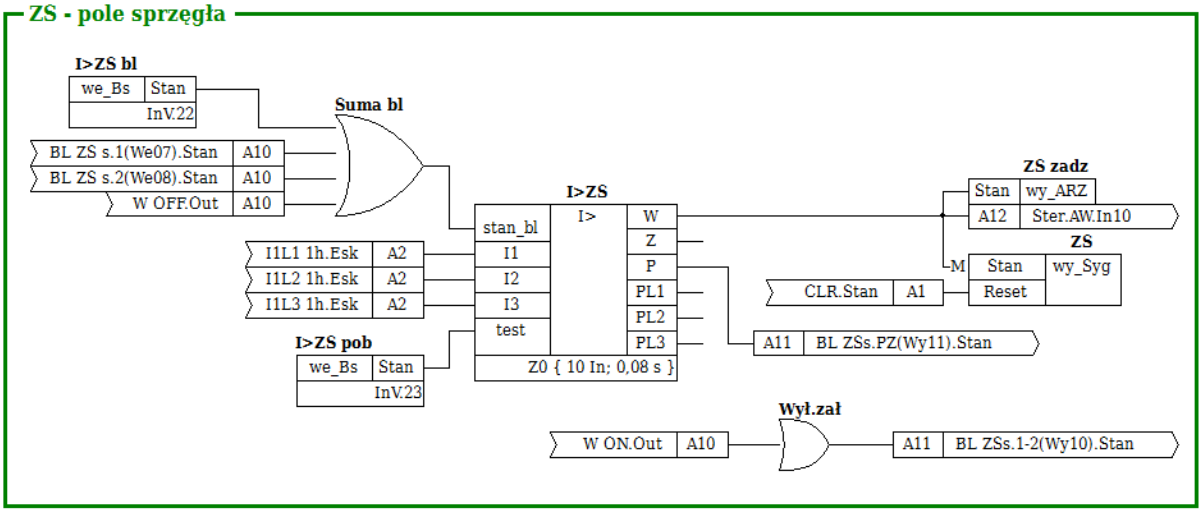


Fig. 53. ZS automation logic scheme - coupling field

Settings table

Setting	Description	Setting range	Default value
I_r	Operate current	(0.05÷30.00) In in 0.01 In increments	10.00 In
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	0.08 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:
Own time $t_w < 30$ ms
Permissible error $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

In the feeder, executive automation is implemented - feeder breaker shutdown.
The current criterion dedicated to I>ZS bus protection is interlocked by the interlock from the circular buses stimulated in the outflow fields of the energized section BL ZS.s.1(We07) and from the bus coupler field BL ZS s.PZ(We08).
If a short circuit occurs on the buses of the directly energized section (in this case, s.1), a shutdown occurs with a set delay time, with no interlock from the outflow fields and the bus coupler field. This is the first level of ZS1 bus protection operation.
The delay time ZS1 t should allow tripping the current criterion in the outflow fields or the bus coupler and in time to interlock the operation in the feeder (for external short circuits).
The second level of ZS2 bus protection is not interlocked by a signal from the bus coupler field, with a set time longer than the operating time in the bus coupler field, it is a reserve in the absence of disabling the fault in this field. In this case, in the event of short circuits on the second section, in which there should be a shutdown in the bus coupler field, the feeder will be shut down after the ZS2 t delay.

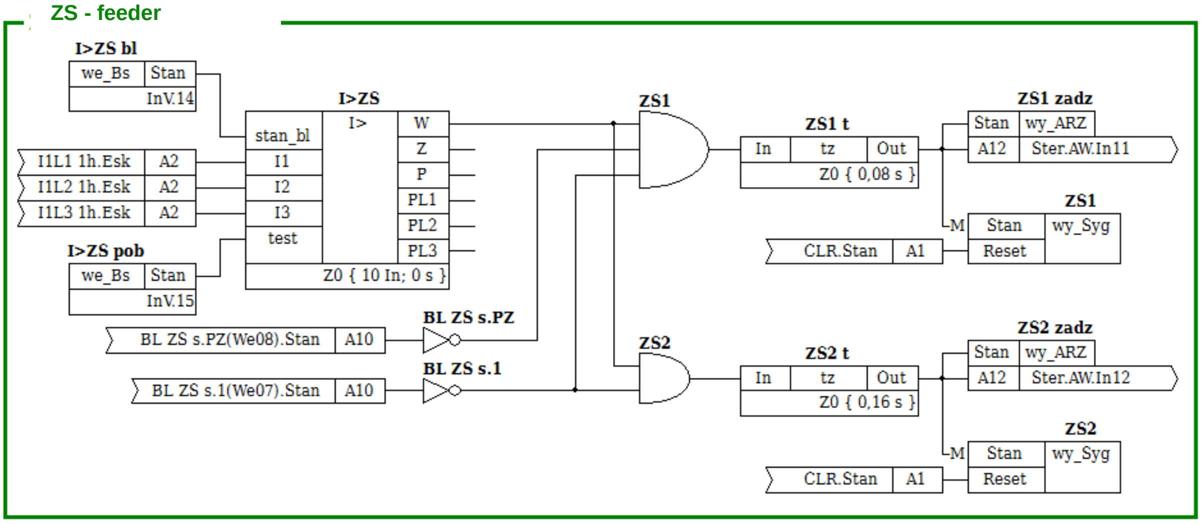


Fig. 54. ZS automation logic scheme - feeder

Settings table

Setting	Description	Setting range	Default value
ZS1 t	ZS1 Delay time	(0.00÷0.50) s in 0.01 s increments	0.08 s
ZS2 t	ZS2 Delay time	(0.00÷0.50) s in 0.01 s increments	0.16 s
I_r	Operate current	(0.05÷30.00) In in 0.01 In increments	10.00 In
t_z	Delay time	(0.00÷100.00) s in 0.01 s increments	0.00 s
k_p	Reset ratio	(0.80÷1.00) in 0.01 increments	0.98
ON/OFF	Function activity	(ON / OFF)	ON
W	Trip	(ON / OFF)	ON
OR/AND	Pickup logic phase functions	(OR/AND)	OR

Parameters:
Own time $t_w < 30$ ms
Permissible error $\delta_{\%} = \pm 2.5\% \pm 0.01$ In

3.8. CLK – timer function

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application
The function allows time control of devices in automation systems according to the individual time control mode resulting from the device specifics.
The timer can be used, for example, in the automation of switching capacitor batteries (AZBK), control of pump systems, fans, engines where cyclic control is required.

Operation description
The function implements cyclic switching and shutting down according to settings based on the real-time clock. Hence, it is important to consider the requirement for time synchronization if high precision control is required.
When the manual mode is set by setting, or by an external logic state, the function sets aside the automatic control resulting from the timer settings and responds only to external Z and W control signals.

Settings table

Setting	Description	Setting range	Default value
Z_h	Switching hour	(00÷23) h in 1 h increments	7
Z_min	Switching minute	(00÷59) min in 1 min increments	10
Zsh	Switching second	(00÷59) s in 1 s increments	0
W_h	Shutdown hour	(00÷23) h in 1 h increments	14
W_min	Shutdown minute	(00÷59) min in 1 min increments	55
W_s	Shutdown second	(00÷59) s in 1 s increments	0
timp	Control pulse duration	(0.10÷300.00) s in 0.01 s increments	0.30 s
Poniedziałek (Monday)	Control selection on Monday	(ZW / Z / W / OFF)	OFF
Wtorek (Tuesday)	Control selection on Tuesday	(ZW / Z / W / OFF)	OFF
Środa (Wednesday)	Control selection on Wednesday	(ZW / Z / W / OFF)	OFF
Czwartek (Thursday)	Control selection on Thursday	(ZW / Z / W / OFF)	OFF
Piątek (Friday)	Control selection on Friday	(ZW / Z / W / OFF)	OFF
Sobota (Saturday)	Control selection on Saturday	(ZW / Z / W / OFF)	OFF
Niedziela (Sunday)	Control selection on Sunday	(ZW / Z / W / OFF)	OFF
ON/OFF	Function activity	(ON / OFF)	ON

3.9. SZR(1) – automatic reserve switching function

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

The function enables the implementation of automatic reserve switching (ARS) and automatic reverse switching (RRS), as well as scheduled power switching (PSC).

Operation description

The function inputs are the supply voltages of the feeders (up to 4) and two section voltages.

Two-state inputs:
U<L1 – L1 power supply voltage loss
U<L2 – L2 power supply voltage loss
U<S1 – section 1 voltage loss
U<S2 – section 2 voltage loss
WL1 Z – L1 power supply breaker on
WL1 W –L1 power supply breaker off
WL2 Z – L2 power supply breaker on
WL2 W –L2 power supply breaker off
WS Z – coupling breaker on
WS W –coupling breaker off
GP_L1 – L1 power supply field standby input
GP_L2 – L2 power supply field standby input
GP_S – coupling field standby input
SZR_OFF – deactivation of the SZR automation
BL-TRW – permanent SZR interlock
BL-PRZ – transient SZR interlock
Kas – input of clearing the interlock of the ABP automation

Two-state outputs:
Pod – system in basic power state
Rez – system in reserve power state
Przeł – system in the switching cycle state
ZL1 – control to switching the L1 power supply breaker
WL1 – control to shut down the L1 power supply breaker
ZL2 – control to switching the L2 power supply breaker
WL2 – control to shut down the L2 power supply breaker
ZS – control to switching the coupling breaker
WS – control to shut down the coupling breaker
G_SZR - ready to perform SZR operations
err_SZR – error in the SZR cycle
err_Bl – external SZR interlock
err_GP - field not ready
err_U – no power voltage
err_STER – error when switching couplers
err_PRZ – coupler manual switching
SPPakt – automatic reverse switching function activity
SZRakt – automatic reserve power-up function activity

Analog output (Measurement):
tp % – advance time countdown (in percent) to the power switch start

Depending on the switching priority settings, automation controls the presence of voltages of both sections, power supplies and the readiness of couplers for switching.
Depending on the UPN setting, the SZR automation implements switchings to the reserve power supply and after the power supply returns to the primary supply.

UPN= L1-L2

In the normal state, the coupling is open when the line breakers powering each section are switched on. In case of one of the section 1 (active inputs U<L1, U<S1) or section 2 (active inputs U<L2, U<S2) voltage loss, the set switching delay time tprz is counted down and the power supply breaker, which is affected by the loss, is shut down - confirmed by a change in the inputs status (WL1 Z, WL1 W,WL2 Z, WL2 W) during the waiting time for the tozw switching. Once the shutdown is confirmed, the coupling breaker is switched on. Also, after tozw time, there should be confirmation of the switching of the coupling breaker and the activation of the U<S1 (or U<S2) input should disappear. At this point, the switching cycle can be considered successful and the REZ state can be issued at the output.

In this system of operation on reserve power supply, depending on the setting of SPPakt, the automation will aim to return to the system of normal operation, if there is a voltage return that caused the switch to reserve power supply.
After the delay time tpow, the coupling is shut down and the power supply is switched on. Operations must be confirmed by switching binary inputs at the set time for switching.

In the case of SPPakt=OFF setting, after the basic voltage returns, the automation does not make a return switching, provided that there is no voltage loss in the second power supply. In such a case, the power supply is switched, after the second power supply is first shut down.

UPN= L1-S(L2-S)

In the normal state, the L1(L2) power line and the coupling are closed with the L2(L1) line in reserve shut down.
In case of voltage loss of the power supply and section 1, 2 - active inputs U<L1(U<L2), U<S1, U<S2, there is a countdown of the set delay time for switching to reserve power supply tprz and shutdown of the power supply breaker L1(L2), which is affected by the loss - confirmed by a change in the inputs status (WL1 Z, WL1 W,WL2 Z, WL2 W) during the switching waiting time tozw. Once the shutdown is confirmed, the L2(L1) reserve line breaker is switched on. Also, after tozw time, the breaker switching should be confirmed and the activation of the U<S1 U<S2 input should disappear. At this point, the switching cycle can be considered successful and the REZ state can be issued at the output.

In this system of operation on reserve power supply, depending on the setting of SPPakt, the automation will aim to return to the system of normal operation, if there is a voltage return that caused the switch to reserve power supply.
After the delay time tpow, the reserve line is shut down and the primary power supply is switched on. Operations must be confirmed by switching binary inputs at the set time for switching.

In the case of the setting SPPakt=OFF, after the return of the basic voltage, the automation does not perform return switching, provided that there is no voltage loss in the reserve power supply. In such a case, the power is switched to the primary power supply, after the second power supply is shut down first.

Settings table

Setting	Description	Setting range	Default value
SZRakt	Automatic standby function activity	(ON / OFF)	ON
SPPakt	Automatic reverse function activity	(ON / OFF)	ON
UPN	Normal operation system	(L1-L2 / L1-S / L2-S)	L1-L2
tprz	Reserve power supply switching delay time	(0.00÷3600.00) s in 0.01 s increments	2.00 s
tpow	Primary power supply switching delay time, after return of primary voltage	(0.00÷100.00) s in 0.01 s increments	2.00 s
tozw	Waiting time to switch the breaker	(0.00÷30.00) s in 0.01 s increments	1.00 s
tster	Duration of control pulse for switching on or shutdown	(0.10÷10.00) s in 0.01 s increments	1.00 s

Detailed description of operating algorithms.

- **"Start" process** (triggered each time the assembly is restarted, e.g., after supply voltage is applied or settings are changed).

  After restarting, the program performs the following steps:

  - recognition of automation state.
    Based on the state of the binary inputs resetting the position of the auxiliary contacts of the field couplers
    (WL1Z,WL1W) - power switch 1
    (WL2Z,WL2W) - power switch 2
    (WSZ,WSW) - coupling switch
    the function determines the power supply operation configuration.
    The switch position is determined by two bits **(W ^ Z)**.
    At the same time, the presence of voltage on the sections is checked.
    ((U<S1) - no voltage on section 1
    ((U<S2) - no voltage on section 2.
    One of three possible states is determined:
    (Pod) - power supply in the primary system
    (Rez) - power supply in the reserve system
    (err_SZR) - error – system not compatible. There are following states of the incompatible system:
    (err_PRZ) - coupler error (mismatch in position of auxiliary contacts, unidentifiable breaker position configuration)

    (err_U) - no voltage on at least one section,
  - transition to "ON-LINE" operation.
    Based on the state specified above, the function transitions to one of three states:
    (Pod) - baseline control
    (Rez) - reserve control
    (err_SZR) - operation error. The procedure waits for a recognizable state to be set for **tozw** time, after which it transitions to the error state.

- **"Pod" process** (performed after the "Start" procedure or after the successful execution of the return from the state in the reserve power mode)

  The operating status in this process is indicated by the output of the "1" state at the **Pod** output.
  In this state, the program performs:

  - status verification (whether, for example, a manual switching has not been performed)
    Checking and reactions are performed exactly as in the start (point 1).

  - checking the readiness to perform the transition to reserve power. The inputs state is controlled:
    (U<L1) - no supply voltage 1
    (U<L2) - no supply voltage 2.
    (GP_L1) - feeder 1 ready
    (GP_L2) - feeder 2 ready.
    (GP_S) - coupling field ready
    Depending on the primary system setting **(UPN)**, the function checks the inputs for the possibility of switching to reserve power supply. If the required criterion is met, the function signals this state by setting the G_SZR output to "1".

  - checking the presence of supply voltages
    (U<L1) - no supply voltage 1
    (U<L2) - no supply voltage 2.
    If any of the primary supply voltages is lost, the function transitions to a switching to reserve power status program. This fact is signaled by switching the state at the output **(Pod)** to the "0" state.

  - checking the presence of voltages on the station buses. Inputs are controlled
    ((U<S1) - no voltage on buses, section 1
    ((U<S2) - no voltage on buses, section 2
    (U<L1) - no supply voltage 1
    (U<L2) - no supply voltage 2.
    auxiliary contacts breaker position
    In case of:
    - no voltage on the buses (the **(U<S1)** or **(U<S2)** inputs),
    - presence of an appropriate supply voltage (the **(U<L1), (U<L2)** inputs)

- correct position of breakers (for a given state and setting)

for longer than the set time **"tozw"** the procedure transitions to the **"error"** procedure.

- **"Rez" process** (performed after a successful switching to reserve power supply state or after the "Start" procedure if reserve power supply is recognized)

The operating state in this process is indicated by the "1" state at the **Rez** output.
In this state, the program performs:

- status verification (whether, for example, a manual switching has not been performed)
  Checking and reactions are performed exactly as in the start (point 1).

- checking the readiness to perform the transition to the primary power supply. The inputs state is controlled:
  (U<L1) - no supply voltage 1
  (U<L2) - no supply voltage 2.
  (GP_L1) - feeder 1 ready
  (GP_L2) - feeder 2 ready.
  (GP_S) - coupling field ready
  Depending on the primary system setting **(UPN)**, the function checks the inputs for the possibility of switching to reserve power supply. If the required criterion is met, the function signals this state by setting the output **(G_SZR)** to "1"

- initiation of the process of returning to the primary power supply state:
  Controlling the presence of supply voltages through the inputs state:
  (U<L1) - no supply voltage 1
  (U<L2) - no supply voltage 2.
  and in case of the **(SPPakt)** setting in the**"ON"** state (which is signaled by the "1" state on the **(SPPakt)** output) function initiates the process of switching to the primary power supply

- Initiating the process of switching supply voltages (for **(UPN=L1-L2))** in the case of a deactivated **PPZ** option (setting "**SPPakt" = "0"**) and the disappearance of the voltage currently supplying the switchgear
  Controlling the presence of supply voltages through the corresponding inputs state:
  (U<L1) - no supply voltage 1
  (U<L2) - no supply voltage 2.
  (GP_L1) - feeder 1 ready
  (GP_L2) - feeder 2 ready.
  (GP_S) - coupling field ready
  If the currently supplying voltage disappears, and the conditions for making the transition to the voltage of the other source are met:
  - presence of input voltage **(U<L1), (U<L2)**, respectively
  - corresponding input fields **"GP_L1", "GP_L2"** ready

  function initiates the power switching. The switching procedure is identical to the switching of voltages from primary to reserve at the **(UPN = L1-S or L2-S)** setting.

- checking the presence of voltages on the station buses. Inputs are controlled
  ((U<S1) - no voltage on buses, section 1
  ((U<S2) - no voltage on buses, section 2
  (U<L1) - no supply voltage 1
  (U<L2) - no supply voltage 2.
  auxiliary contacts breaker position
  In case of:
  - no voltage on the buses (**(U<S1)** or **(U<S2)**),
  - presence of an appropriate supply voltage (the **(U<L1), (U<L2)** inputs)
  - correct position of breakers (for a given state and setting)

  for longer than the set time **"tozw"** the procedure transitions to the **"error"** procedure.

- **"Prze" process** (triggered by the **"Pod"** and **"Rez"** processes to perform power switching)

The operating state in this process is indicated by the "1" at the **Prze** output.
The operations performed depend on the primary system setting **(UPN)** and the current state

- Switching from the primary system to the reserve system.

  - For **(UPN) = L1-L2**, the switching is performed in the following starting steps after the absence of voltage on one of the supplies (**(U<L1)** and **(U<L2)** input status):

- Step 1 - measuring the delay time to switching (**tprz)** setting)
  inputs are monitored during the countdown and the system returns to the initial state
if the power returns.
  The **"tp%"** output shows the advanced countdown of the waiting time (as a percentage of the set time).
- Step 2 - sending a pulse to open the power switch of the faulty side if:
  - there is no transition interlock – the **"BL_PRZ"** input
  - coupling field is ready for switching – the **"GP_S"** input
  - there is voltage on the second supply line – the **(U<L1)** or **(U<L2)** input

  If for the set time **"tozw"** these conditions are not met, the function transitions to the **"error"** process.
  The impulse to open the breaker lasts for a settable time **"tster"**
- Step 3 - sending the coupling breaker closure pulse if:
  - there was an opening of the faulty side breaker
  - the reserve line breaker is closed
  - there is no voltage on the faulty section (the **(U<S1),(U<S2)** inputs, respectively),
  - there is voltage on the reserve section (the **(U<S1), (U<S2)** inputs, respectively),
  - there is no transition interlock – the **"BL_PRZ"** inputs
  - the coupling field is ready – the **"GP_S"** input

  If for the time set **"tozw"** these conditions are not met the function transitions to the **"error"** process. The breaker positions are controlled "two-bit".
  The control pulse lasts for a settable time **"tster"**
- Step 4 - verification of the switching effectiveness:
  - the coupling breaker is closed
  - the current supply side breaker is closed
  - there is voltage on both sections (the **(U<S1), (U<S2)** inputs)

  If for the time set **"tozw"** these conditions are not met the function transitions to the **"error"** process. The breaker positions are controlled "two-bit".

- For **(UPN) = L1-S, L2-S**, the switching is performed in the following starting steps after the absence of the primary power source voltage is detected (the **(U<L1)** and **(U<L2)** input state, respectively):
  - Step 1 - measuring the delay time to switching (**tprz)** setting)
    inputs are monitored during the countdown and the system returns to the initial state
if the power returns.
    The **"tp%"** output shows the advanced countdown of the waiting time (as a percentage of the set time).
  - Step 2 - sending a pulse to open the power switch of the faulty side if:
    - there is no transition interlock – the **"BL_PRZ"** input
    - the reserve feeder is ready for operation – the **"GP_L1", "GP_L2"** input, respectively
    - there is voltage on the reserve power line – the **(U<L1)** or **(U<L2)** input

    If for the set time **"tozw"** these conditions are not met, the function transitions to the **"error"** process.
    The impulse to open the breaker lasts for a settable time **"tster"**
  - Step 3 - sending a pulse to close the reserve line breaker if:
    - there was an opening of the faulty side breaker
    - the coupling breaker is closed
    - there is no voltage on the faulty section (the **(U<S1),(U<S2)** inputs, respectively),
    - there is voltage on the reserve section (the **(U<L1), (U<L2)** inputs, respectively),
    - there is no transition interlock – the **"BL_PRZ"** input
    - the reserve path field is ready (the **"GP_L1", "GP_L2"** inputs, respectively)

    If for the time set **"tozw"** these conditions are not met the function transitions to the **"error"** process. The breaker positions are controlled "two-bit".
    The control pulse lasts for a settable time **"tster"**
  - Step 4 - verification of the switching effectiveness:
    - the coupling breaker is closed
    - the current supply side breaker is closed
    - there is voltage on both sections

    If for the time set **"tozw"** these conditions are not met the function transitions to the **"error"** process. The breaker positions are controlled "two-bit".

- Switching from the reserve system to the primary system
  Process performed only in case of the **"SPPakt" = "1"** setting.

  - For **(UPN) = L1-L2**, the switching is performed in the following starting steps after the presence of both voltages is detected (the **(U<L1)** and **(U<L2)** inputs state):

- Step 1 - measuring the delay time to switching (the (**tpow)** setting)
  during the countdown, the inputs are monitored and in the event of a power failure, the system returns to the initial state.
  The **"tp%"** output shows the advanced countdown of the waiting time (as a percentage of the set time).
- Step 2 - sending a pulse to open the coupling breaker if:
  - there is no transition interlock – the **"BL_PRZ"** input
  - power return breaker fields are ready for operation – the **"GP_L1"** or **"GP_L1"** input, respectively
  - both supply voltages are present – the **(U<L1)** or **(U<L2)** input

  If for the set time **"tozw"** these conditions are not met, the function transitions to the **"error"** process.
  The impulse to open the breaker lasts for a settable time **"tster"**
- Step 3 - sending the coupling breaker closure pulse if:
  - the coupling breaker has been opened
  - the return power line breaker is open
  - there is no voltage on the buses of the section returning to the primary power supply (the **(U<S1), (U<S2)** inputs, respectively),
  - both supply voltages are present (the **(U<L1), (U<L2)** inputs, respectively),
  - there is no transition interlock
  - the breaker field of the path returning to the primary power supply is ready

  If for the time set **"tozw"** these conditions are not met the function transitions to the **"error"** process. The breaker positions are controlled "two-bit".
  The control pulse lasts for a settable time **"tster"**
- Step 4 - verification of the switching effectiveness:
  - the coupling breaker is open
  - power path breakers are closed
  - there is voltage on both sections (the **(U<S1), (U<S2)** inputs)

  If for the time set **"tozw"** these conditions are not met the function transitions to attempt to restore reserve power (Step 5)**.** If the verification is successful the unction transitions to the **"Pod"** process.
  The breaker positions are controlled "two-bit".
- Step 5 - attempt to return to reserve power. The function sends a control pulse to close the bus coupler if the following conditions are met:
  - the coupling field is ready – the **"GP_S"** input
  - there is no voltage on one bus section (the **(U<S1)** and **(U<S2)** inputs)
  - one feeder breaker is open

  In each case, the function transitions to the **"error"** process
  The breaker positions are controlled "two-bit".
  The control pulse lasts for a settable time **"tster"**

◦ For **(UPN) = L1-S and L2-S**, the switching is performed in the following starting steps after the presence of both voltages is detected (the **(U<L1)** and **(U<L2)** inputs state):

- Step 1 - measuring the delay time to switching (the (**tpow)** setting)
  during the countdown, the inputs are monitored and in the event of a power failure, the system returns to the initial state.
  The **"tp%"** output shows the advanced countdown of the waiting time (as a percentage of the set time).
- Step 2 - sending the opening pulse of the reserve power line field breaker:
  - there is no transition interlock – the **"BL_PRZ"** input
  - power return breaker fields are ready for operation – the **"GP_L1"** or **"GP_L2"** input, respectively
  - there is primary supply voltage – the **(U<L1)** or **(U<L2)** input, respectively

  If for the set time **"tozw"** these conditions are not met, the function transitions to the **"error"** process.
  The impulse to open the breaker lasts for a settable time **"tster"**
- Step 3 - sending a pulse to close the primary power breaker if:
  - the reserve power breaker has been opened
  - the return power line breaker is open
  - the bus coupler breaker is closed
  - there is no voltage on the buses of the section returning to the primary power supply (the **(U<S1), (U<S2)** inputs, respectively),
  - there is primary supply voltage (the **(U<L1), (U<L2)** inputs, respectively),
  - there is no transition interlock – the **"BL_PRZ"** input
  - the breaker field of the path returning to the primary power supply is ready

  If for the time set **"tozw"** these conditions are not met the function transitions to

the **"error"** process. The breaker positions are controlled "two-bit".
The control pulse lasts for a settable time **"tster"**

- Step 4 - verification of the switching effectiveness:
  - the coupling breaker is closed
  - the primary power supply breaker is closed
  - there is voltage on both sections (the **(U<S1), (U<S2)** inputs)

If for the time set **"tozw"** these conditions are not met the function transitions to attempt to restore reserve power (Step 5)**.** If the verification is successful the unction transitions to the **"Pod"** process.
The breaker positions are controlled "two-bit".

- Step 5 - attempt to return to reserve power. The function sends a control pulse to close the bus coupler if the following conditions are met:
  - the reserve path field is ready (the **"GP_L1"** or **"GP_L2**" input, respectively)
  - there is no voltage on both bus sections (the **(U<S1)** and **(U<S2)**inputs)

In each case, the function transitions to the **"error"** process
The breaker positions are controlled "two-bit".
The control pulse lasts for a settable time **"tster"**

- **"BL_TRW"** process
  If the "1" state appears on the **"Bl_TRW"** input, the function transitions to the **"error"** process.

- **"error"**process (when an error is found in the SZR operation)
  The procedure can be triggered in all modes of operation. The exact places where the process is triggered are shown in the description of each procedure.
  The function state being in the **"error"** process is indicated by a "1" on the output.
  The function remains to be deleted in the process.
  The function is cleared by applying the "1" state to the **"KAS"** input. After clearing, the function transitions to the **"Start"** process.

  The operation state in this process is indicated by the "1" state at the **"err_SZR"** output.
  Also, in this state, the function signals the cause of the error by setting the "1" state on the corresponding output:
  - **"err_Bl"** - error caused by the appearance of an interlock on the **"BL_TRW"** or **"BL_PRZ"** input
  - **"err_GP"** - error caused by the breaker field not being ready as required for a specific connecting operation
  - **"err_U"** - error caused by incorrect configuration of voltages required for a specific connecting operation
  - **"err_STER"** - error caused by failure of the breaker to respond to the repositioning command
  - **"err_PRZ"** - error caused by unrecognizable breaker position configuration

- **"SZR_OFF"** process
  If the state "1" appears on the "SZR_OFF" input, the function suspends operation (the state is identical to the operation with the **"SZRakt" = "0"** setting).
  The status of this process is indicated by the "1" setting on the **"SZRakt"** output.

- List of function inputs/outputs

List of inputs	
Label	Meaning in the high state "1"
U<L1	No supply voltage 1
U<L2	No supply voltage 2
U<S1	No voltage on buses, section 1
U<S2	No voltage on buses, section 2
WL1 Z	Power breaker 1 on
WL1 W	Power breaker 1 off
WL2 Z	Power breaker 2 on
WL2 W	Power breaker 2 off
WS Z	Coupling breaker on
WS W	Coupling breaker off
GP_L1	Feeder 1 ready
GP_L2	Feeder 2 ready
GP_S	Coupling field ready
SZR_OFF	Deactivation of the SZR automation
BL_TRW	Activation of the permanent interlock of the SPZ automation
BL_PRZ	Activation of the transient interlock of the SPZ automation
KAS	Clearing of SPZ automation error signaling

List of outputs	
Label	Meaning in the high state "1"
Pod	SZR automation in the primary power supply state
Rez	SZR automation in the reserve power supply state
Przeł	SZR automation during power switching
Z L1	Control output to switch on power breaker 1
W L1	Control output to shut down power breaker 1
Z L2	Control output to switch on power breaker 2
W L2	Control output to shut down power breaker 2
ZS	Control output to switch on coupling breaker
WS	Control output to shut down coupling breaker 1
tp%	Countdown progress to the start of power switching (in percentage)
G_SZR	Readiness to perform power switching (from primary to reserve in the "Pod" state and vice versa in the "Rez" state)
err_SZR	Error during performance or unrecognized switchboard state. Automation deactivated. Requires clearing with the "KAS" input.
err_Bl	Error caused by the appearance of the "BL_TRW" or "BL_PRZ" operation interlock.
err_GP	Error caused by field required for switching not being ready
err_U	Voltage error preventing the SZR operation
err_STER	Error during switching (no expected response of the breaker to the command)
err_PRZ	Breaker configuration error preventing proper switching of power supplies
SPPakt	Active automatic switching back to primary supply automation
SZRakt	Active SZR automation

3.10. TRU – Transformer tap changer automation

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Application

Automation enables the transformer voltage to be regulated by switching its taps. It can be used for two- and three-winding transformers. Through the use of configuration capabilities, automation can be supplemented with additional functions, such as overload, voltage and limit switch control.

Operation description

Based on an analysis of the transformer output voltages, possibly corrected for voltage drop at the receiver inflows, the system decides whether to switch the tap. The automation is equipped with interlocks, preventing the transformer's tap from switching after reaching limit values or voltage or current limits. The function, through the appropriate setting, can be set to "automatic" or "manual" control mode or deactivated. In automatic mode, the start of the switching process depends on the rules described below, and in manual mode the switching is initiated by a logical state. The use of a dedicated logic input enables switching from automatic to manual control mode.

3.10.1. Automatic mode input criterion values.

The decision function is based on measuring the following signals:

- U1 voltage (outflow 1),
- I1 current (outflow 1),
- U2 voltage (outflow 2),
- I2 current (outflow 2).

For a two-winding transformer, it is enough to connect one set of inputs (U1, I1).

If no algorithms are envisioned to be used that consider the voltage drop at the receiver's inflows, then a power connection is not needed.

It is advisable to use symmetrical components of positive voltages and currents in the circuit, as far as the device's capabilities (available number of analog inputs) allow. In the minimum configuration, it is possible to operate the regulator based on a single voltage and phase current (if correction is considered) or a single voltage (phase or phase-to-phase) when operating without correction.

Depending on the ***" Compensation type "*** setting, the voltage of each tap entering the criterion can be formed according to the following formulas:

- With no load correction $U_k = |U|$
- With amplitude correction $U_k = |U| - |I| * |Z|$.
- With vector correction $U_k = |u – (R+jX) * i|$

The calculated voltage is averaged over a period of time, depending on the ***" Voltage value averaging period "*** setting.

3.10.2. Start-up criterion for automatic operation.

For a 2-winding transformer, the decision to start the tap changer switching process is made based on the formula

$$U_k – U > \Delta U$$

where:
U_k – voltage calculated according to the rule described above
U – the ***" Expected voltage "***setting
ΔU – the ***" Voltage regulation increment "*** setting

For a 3-winding transformer, the decision to switch the taps is made based on the formula, depending on the " Criterion source voltage " setting:

- Setting = U1

$$U_{k1} – U > \Delta U$$

where:
U_{k1} – voltage calculated according to the rule described above for outflow 1
U – the ***" Expected voltage "*** setting
ΔU – the ***" Voltage regulation increment "*** setting

- Setting = U2

$$U_{k2} - U > \Delta U$$

where:
U_{k2} – voltage calculated according to the rule described above for outflow 2
U – the ***" Expected voltage "*** setting
ΔU – the ***" Voltage regulation increment "*** setting

- Setting = max (U1;U2)

$$U_k = \max (U_{k1}; U_{k2})$$
$$U_k - U > \Delta U$$

where:
U_{k1} – voltage calculated according to the rule described above for outflow 1
U_{k2} – voltage calculated according to the rule described above for outflow 2
U_k – criterion voltage - the maximum of the two input voltages
U – the ***" Expected voltage "*** setting
ΔU – the ***" Voltage regulation increment "*** setting

- Setting = min (U1; U2)

$$U_k = \min (U_{k1}; U_{k2})$$
$$U_k - U > \Delta U$$

where:
U_{k1} – voltage calculated according to the rule described above for outflow 1
U_{k2} – voltage calculated according to the rule described above for outflow 2
U_k – criterion voltage - the minimum of the two input voltages
U – the ***" Expected voltage "*** setting
ΔU – the ***" Voltage regulation increment "*** setting

- Setting = a*U1+b*U2

$$U_k = a * U_{k1} + b * U_{k2}$$
$$U_k - U > \Delta U$$

where:
a – share factor for outflow 1
b – share factor for outflow 2
U_{k1} – voltage calculated according to the rule described above for outflow 1
U_{k2} – voltage calculated according to the rule described above for outflow 2
U_k – criterion voltage
U – the ***" Expected voltage "*** setting
ΔU – the ***" Voltage regulation increment "*** setting

3.10.3. Tap changer position input.

The tap changer position and activation of the interlock when the end positions are reached is determined by the value given to the **" tap_number "** input. The iZAZ assembly is equipped with functions that recalculate the position code into a number. For example, when using BCD encoding, use the BCD logic function according to section 4.9.20. The tap number, once decoded, can also be presented in **" Measurements "**, on the LCD display, and is available for remote reading via communications.

3.10.4. Automatic mode operation algorithm.

The algorithm operation in the automatic mode is shown below.

- The operation is initiated when the criteria described above are exceeded (section 3.10.2). The result, depending on the voltage value, is the appearance of a **"1"** on the corresponding function output - **"P+"**, when a voltage increase will be required, and **"P-"** if a voltage decrease is necessary.
- At the same time, the countdown process begins, confirming the need for adjustments. The time value depends on the degree of deviation of the measured voltage from the expected value according to the characteristics shown in the figure below. If during the countdown, the voltage returns to the expected value (±ΔU) for more than 0.5 s, the function returns to the initial state.
- After the countdown, confirming the need for adjustment, if the switch position has not reached the limit level (***"Tapmin"/"Tapmax"*** setting) and the measured voltage (U1, U2) does not exceed the limit value (***"Umin"/"Umax"*** setting), the function generates a switching command pulse. If the tap changer or voltage limits are found to be reached, the function signals a control error **("1"** on the **" ERR_range "** output). The function continues to control the voltage and is ready to make adjustments when the voltage returns to the adjustment range. The operation error indication persists until any successful adjustment operation is performed.
- The switch control impulse involves setting the **"1"** state on the **"Contr+"/"Contr-"** outputs, depending on whether an increase or decrease in voltage is required, and depending on the ***" Change method"*** setting. The ***"increase"*** setting causes, when the voltage needs to be increased, an increase in the tap number (**"Contr+"**output control), while the ***" decrease "*** setting causes, when the voltage needs to be increased, a decrease in the tap number **" Contr -"** output control).
- Simultaneously with the start of the control process (the appearance of the corresponding pulse with a duration that depends on the ***"tster"*** setting), the waiting time countdown for the tap switching begins (the ***"timeout"*** setting).
- The switching process monitoring is implemented by the **"tap_number"** input. If the tap is found to be switched to the expected one, the function generates a signal of successful switching - signaling **"1"** on the **"Ster_OK"** output for 0.1 s, and returns to the initial position.
- If there is no confirmation of the tap switch to the expected number, the function transitions to the **"ERR_ster"** state and interlocks further operation. The error is indicated by the **"1"** state on the **"ERR_ster"** output.
- If the automation is interlocked after an **ERR_ster** error is detected in its operation, it is required to clear the ERROR state by applying **"1"** to the **"Kas_ERR"** input. The function then returns to its initial state.

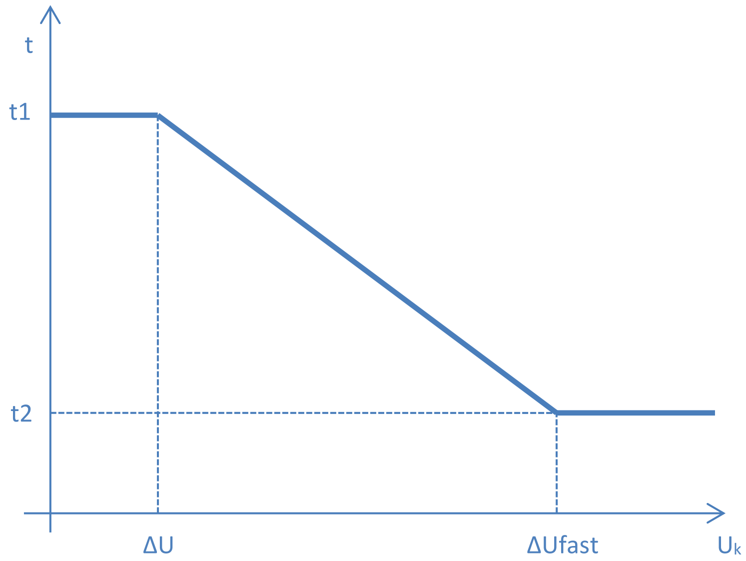


Fig. 55. Characteristics of the time to confirm the need to change the tap in the TRU.

The ready state of the control is signaled by issuing the **"1"** state on the **"TRU_ active"** output, when the following conditions are met:
- no function deactivation,
- no external interlocks (general, from overcurrent, undercurrent and undervoltage functions),
- no ERR_ster control error.

3.10.5. Manual mode operation algorithm.

The function operation can be switched from automatic mode to manual control by changing the ***"A/R"*** setting, or by applying the **"1"** state to the **"M/A"** input. In such a case, automation does not perform any actions on its own. Switching of the taps is possible by applying the **"1"** state to the **"Tap+"** input for achieving voltage increase and **"Tap-"** input for achieving voltage decrease, respectively. The function then works according to the algorithm:

- When the control signal is received at the inputs, if the switch position has not reached the limit level (the **"Tapmin"/"Tapmax"** setting). If a limitation is encountered, the function signals an adjustment error (**"1"** on the **" ERR_range"** output). The function is still ready to implement operations in the permissible range. The error signaling persists until a successful switching operation is performed.
- The control is based on setting the **"1"** state on the ***" Contr+/Contr- "*** outputs, depending on the required increase or decrease in voltage and according to the ***" Change method "*** setting. The ***" increase"*** setting causes, when it is necessary to increase the voltage, to increase the tap number (control of the ***" Contr+ "*** output), while the ***" decrease "*** setting causes, when it is necessary to increase the voltage, to decrease the tap number (control of the ***" Contr- "*** output).
- Simultaneously with the start of the control process (the appearance of the corresponding pulse with a duration that depends on the ***"tster"*** setting), the waiting time countdown for the tap switching begins (the ***"timeout"*** setting).
- The switching process monitoring is implemented by the ***" tap_number "*** input. If the tap is found to be switched to the expected one, the function generates a signal of successful switching - signaling **"1"** on the **"Ster_OK"** output for 0.1 s, and returns to the initial position.
- If there is no confirmation of the tap switch to the expected number, the function transitions to the **"ERR_ster"** state and interlocks further operation. The error is indicated by the **"1"** state on the **"ERR_ster"** output.
- If the automation is interlocked after an **ERR_ster** error is detected in its operation, it is required to clear the ERROR state by applying **"1"** to the **"Kas_ERR"** input. The function then returns to its initial state.

3.10.6. Automation interlock functions.

The automation operation can be interlocked by additional functions that control transformer currents and voltages. The automation module is equipped with 4 interlocking inputs:

- **"BL"** – general interlock, typically used to operationally interlock automation.
- **"BL_I>"** – input designed to interlock the ability to switch taps with an overload on the outflows. Such protection can be built based on overcurrent functions according to the section 2.3 for currents from outflows, or use the binary input as an external input, performing an interlock function in another protection.
- **"BL_I<"** – input designed to interlock the operation of automation when the **transformer is in idle state**. Such protection can be built based on the undercurrent function according to the section 2.6 for the current of the top side of the transformer, or use the binary input as an external input, performing the interlock function in another protection.
- **"Bl_U<"** –input designed to interlock switching capability when transformer top side voltage is reduced or shut down. Such protection can be built based on the undervoltage function (section 2.32).

The interlock functions can be used freely, choosing only those that can be implemented on the basis of the available analog signals, or omitting them all in simplified systems - their absence does not affect the automation operation.
If they are used, the appearance of any interlock is indicated by the **"Bl.Zew"** output state.

3.10.7. Outputs test.

Automation is equipped with control output test inputs. In the iZAZ "TEST_REL" operating mode, the increasing edge at the **"Test+"** / **"Test-"** input generates a single control pulse at the ***" Contr+/Contr- "*** output, respectively.

Settings table

Setting	Description	Setting range	Default value
ON/OFF	Active/non-active automation	ON/OFF	ON
Change method	Direction of voltage change with increasing tap number	increase/decrease	increase
A/R	Control method	(Automatic/Manual)	Automatic
Usrc	Criterion source voltage	U1, U2, max (U1; U2), min (U1; U2), a*U1+b*U2	U1
Comp_type	Compensation type	none |U|+|Z|*|I|, u+(R+jX)*i	none
U	Expected voltage	(0.900÷1.200) Un in 0.001 Un increments	1.050 Un
ΔU	Voltage regulation increment	(0.001÷0.050) Un in 0.001 Un increments	0.010 Un
a	Share factor a for the Usrc = aU1+bU2 setting	(0.00÷1.00) in 0.01 increments	1.00
b	Share factor b for the Usrc = aU1+bU2 setting	(0.00÷1.00) in 0.01 increments	0.00
T	Voltage averaging period	(0.0÷1.0) s in 0.1 s increments	0.5 s
Tapmin	Minimum tap number	(00÷39) in 1 increments	0
Tapmax	Maximum tap number	(00÷39) in 1 increments	15
Umin	Minimum permissible voltage	(0.900÷1.200) Un in 0.001 Un increments	1.050 Un
Umax	Maximum permissible voltage	(0.900÷1.200) Un in 0.001 Un increments	1.150 Un
t1	Maximum confirmation time for voltage dissipation	(1.0÷3,000.0) s in 0.1 s increments	40.0 s
T2	Minimum confirmation time for voltage dissipation	(1.0÷3,000.0) s in 0.1 s increments	5.0 s
ΔUfast	Voltage difference for the minimum confirmation time value (t2)	(0.010÷0.200) Un in 0.001 Un increments	0.050 Un
timeout	Waiting time to switch the tap	(1.0÷3,000.0) s in 0.1 s increments	10.0 s
tster	Control pulse length	(1.0÷3,000.0) s in 0.1 s increments	1.0 s
Z1_komp	Modular compensation impedance, outflow 1	(0.00÷1,000.00) Ω in 0.1 Ω increments	1.00 Ω
R1_komp	Vector compensation resistance, outflow 1	(0.00÷1,000.00) Ω in 0.1 Ω increments	1.00 Ω
X1_komp	Vector compensation reactance, outflow 1	(0.00÷1,000.00) Ω in 0.1 Ω increments	1.00 Ω
Z2_komp	Modular compensation impedance, outflow 2	(0.00÷1,000.00) Ω in 0.1 Ω increments	1.00 Ω
R2_komp	Vector compensation resistance, outflow 2	(0.00÷1,000.00) Ω in 0.1 Ω increments	1.00 Ω
X2_komp	Vector compensation reactance, outflow 2	(0.00÷1,000.00) Ω in 0.1 Ω increments	1.00 Ω

Parameters:

Permissible error in voltage measurement $\delta_{\%} = \pm 0.5\% \pm 0.001$ Un
Permissible error in current measurement $\delta_{\%} = \pm 1.0\% \pm 0.01$ In
Permissible error in impedance measurement (for $U_z > 0.1$ Un and $I_z > 0.5$ In) $\delta_{\%} = \pm 2.5\%$
Permissible error in impedance measurement (for $U_z > 0.05$ Un and $I_z > 0.5$ In) $\delta_{\%} = \pm 5\%$
Permissible error in impedance measurement (for $U_z > 0.1$ Un and $I_z > 0.1$ In) $\delta_{\%} = \pm 5\%$

3.11. ASG – Automatic generator synchronizer

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Application
Function based on the analysis of voltages on both sides of the breaker implements the generator synchronization function. It can also be used to control the breaker closure at other locations in the power system.

List of function inputs/outputs

List of inputs		
Label	Description	Input type
stan_bl	Interlocking activation of function	Binary input
orta_Ua	Orthogonal a of the Ua input voltage	Analog input
ortb_Ua	Orthogonal b of the Ua input voltage	Analog input
Ua	Ua input voltage	Analog input
fa	Ua voltage frequency	Analog input
fa_OK	Ua frequency measurement correct	Binary input
orta_Ub	Orthogonal a of the Ub input voltage	Analog input
ortb_Ub	Orthogonal b of the Ub input voltage	Analog input
Ub	Ub input voltage	Analog input
fb	Ub voltage frequency	Analog input
fb_OK	Ub frequency measurement correct	Binary input
Start	Command to start the process	Binary input
Stop	Command to stop the process	Binary input
WZ	Breaker closed	Binary input
KasSyg	Signaling clearing	Binary input
test	Activation in the TEST_R state	Binary input

List of outputs		
Label	Description	Output type
Akt	Active function - in synchronization	Binary output
P_ΔU	Voltage difference criterion state	Binary output
P_Δf	Frequency criterion state	Binary output
P_Δφ	Angle criterion state	Binary output
ΔU	Current voltage difference state	Analog output - Measurement
Δφ	Phase angle difference value	Analog output - Measurement
Δf	Frequency difference value	Analog output - Measurement
f_OK	Frequency measurement correct	Binary output
U_UP	Control on voltage increase	Binary output
U_DOWN	Control on voltage decrease	Binary output
f_UP	Control on frequency increase	Binary output
f_DOWN	Control on frequency decrease	Binary output
ZW	Close the breaker	Binary output
ERROR	Failed synchronization attempt	Binary output
Ua<<	No voltage at the a input	Binary output
Ub<<	No voltage at the b input	Binary output
Ua<>	Ua voltage in the permissible range	Binary output
Ub<>	Ub voltage in the permissible range	Binary output

Operation description

The function operation is started with the "Start" command on the input. This results in the sending of a command to close the breaker after the relevant conditions resulting from the settings and the state of the analog and binary inputs are met. When the "Start" signal appears, the function, depending on the settings, starts the following processes:

- N00 setting in "ON" state.
  Closing the breaker with no voltage on either side.
  The process is triggered by the appearance of the "Start" input when the breaker is open (the "WZ" input in the "0" state). Activity is signaled by the "Akt" output. If the voltage on both sides of the breaker is lower than the set value ("Uar<<", "Ubr<<", respectively), the function sends a command to close the breaker. The process ends (the "Akt" output changes state to "0") when:
    - "WZ" input state changes to "1",
    - "1" signal appears on the "Stop" input,
    - after sending the command to close the breaker, the time "t_pow" was counted down. If the breaker is open in spite of sending the shutdown command, the function issues a "1" state on the "ERROR" output (cleared by the "KasSyg" input).

- N01 setting in "ON" state.
  Closing the breaker when there is no Ua voltage.
  The process is triggered by the "Start" input when the breaker is open. Activity is signaled by the "Akt" output. The function sends a close command if:
    - the breaker is open ("0" on the "WZ" input),
    - Ua voltage is lower than the set value ("Ubr<<"),
    - voltage amplitude Ub is in the range specified by the "Ubr>" and "Ubr<" settings,
    - voltage frequency Ub is in the range specified by the "fbr<" and "fbr>" settings.

The process ends (the "Akt" output changes state to "0") when:
  - "WZ" input state changes to "1",
  - "1" signal appears on the "Stop" input,
  - after sending the command to close the breaker, the time "t_pow" was counted down. If the breaker is open in spite of sending the shutdown command, the function issues a "1" state on the "ERROR" output (cleared by the "KasSyg" input).

- N10 setting in "ON" state.
  Closing the breaker when there is no Ub voltage.
  The process is triggered by the "Start" input when the breaker is open. Activity is signaled by the "Akt" output. The function sends a close command if:
  - the breaker is open ("0" on the "WZ" input),
  - Ub voltage is lower than the set value ("Uar<<"),
  - voltage amplitude Ua is in the range specified by the "Uar>" and "Uar<" settings,
  - voltage frequency Ua is within the range specified by the "far<" and "far>" settings.

  The process ends (the "Akt" output changes state to "0") when:
  - "WZ" input state changes to "1",
  - "1" signal appears on the "Stop" input,
  - after sending the command to close the breaker, the time "t_pow" was counted down. If the breaker is open in spite of sending the shutdown command, the function issues a "1" state on the "ERROR" output (cleared by the "KasSyg" input).

- N11 setting in "ON" state.
  Closing the breaker when both voltages are present without adjustment.
  The process is triggered by the "Start" input when the breaker is open. Activity is signaled by the "Akt" output. The function sends a close command if:
  - the breaker is open ("0" on the "WZ" input),
  - voltage amplitude Ua is in the range specified by the "Uar>" and "Uar<" settings,
  - voltage frequency Ua is within the range specified by the "far<" and "far>" settings.
  - voltage amplitude Ub is in the range specified by the "Ubr>" and "Ubr<" settings,
  - voltage frequency Ub is in the range specified by the "fbr<" and "fbr>" settings.
  - the permissible voltage difference for Ua > Ub does not exceed the "ΔUr1" set value,
  - the permissible voltage difference for Ua < Ub does not exceed the "ΔUr2" set value,
  - the permissible frequency difference for fa < fb does not exceed the "Δf2" set value and the "Ster_f<" = "ON" setting,
  - the permissible frequency difference for fa > fb does not exceed the "Δf1" set value and the "Ster_f>" = "ON" setting,
  - the permissible angle difference does not exceed the "Δφr" set value.

  After the process starts, the function waits for the aforementioned conditions to be met.
  The process ends (the "Akt" output changes state to "0") when:
  - "WZ" input state changes to "1",
  - "1" signal appears on the "Stop" input,
  - after sending the command to close the breaker, the time "t_pow" was counted down. If the breaker is open in spite of sending the shutdown command, the function issues a "1" state on the "ERROR" output (cleared by the "KasSyg" input).

- N11r setting in "ON" state.
  Synchronization function of the generator with the system.
  The process is triggered by the "Start" input when the breaker is open.
  The purpose of performing the procedure is to send a command to close the breaker when the following conditions are met:
  - the breaker is open ("0" on the "WZ" input),
  - voltage amplitude Ua is in the range specified by the "Uar>" and "Uar<" settings,
  - voltage frequency Ua is within the range specified by the "far<" and "far>" settings.
  - voltage amplitude Ub is in the range specified by the "Ubr>" and "Ubr<" settings,
  - voltage frequency Ub is in the range specified by the "fbr<" and "fbr>" settings.
  - the permissible voltage difference for Ua > Ub does not exceed the "ΔUr1" set value,
  - the permissible voltage difference for Ua < Ub does not exceed the "ΔUr2" set value,
  - the permissible frequency difference for fa < fb does not exceed the "Δf2" set value and the "Ster_f<" = "ON" setting,

- the permissible frequency difference for fa > fb does not exceed the "Δf1" set value and the "Ster_f>" = "ON" setting,
- the permissible angle difference does not exceed the "Δφr" set value,
- the angle difference decreases and, considering the expected time for closing the breaker determined by the "t_out" setting, the breaker is predicted to close at the compatibility of the positions of the voltage vectors of both sides of the breaker.

In order to achieve the aforementioned parameters, the function is equipped with a generator control interlock. The function analyzes the generator voltage and frequency (Ua voltage) and sends control signals:

- "U_UP" - command to increase the voltage,
- "U_DOWN" - command to decrease the voltage,
- "f_UP" - command to increase the generator speed,
- "f_DOWN" - command to decrease the generator speed.

The controls are in the following order:

- The start of regulation is conditioned by the application of voltages with "measurable" parameters - the "fa_OK" and "fb_OK" input state. The function does not take any action to meet this condition,
- Checking if the voltage frequency Ua is within the range specified by the "Δfu" setting. If the condition is not met, the function takes a frequency adjustment action. The outputs are given control signals to increase or decrease as needed and set. The control consists of pulsing at a frequency depending on the frequency difference but the minimum interval is the "t_pow" setting time, up to 5 s. The pulse time is determined by the "t_ster" setting,
- After meeting the conditions above, the function checks and, if necessary, adjusts the generator voltage by feeding the control outputs. The control consists of pulsing at the frequency specified by the "t_pow" setting. The pulse time is determined by the "t_ster" setting,
- When the voltage is controlled, the function again adjusts the frequency in the same way as above, and when the conditions for the frequency-voltage compatibility are met, it switches to controlling the angle difference.
- While waiting for the angular condition (described above) to be met, the function constantly checks the voltage-frequency difference condition and sends correction commands if necessary.
- If the angle does not change for a long time (frequency matching with a large voltage phase difference) the function can perform a targeted "unsynchronization" to about 20 mHz.
- After all conditions (described above) are met, the command to close the breaker is generated.

The process ends (the "Akt" output changes state to "0") when:

- "WZ" input state changes to "1",
- "1" signal appears on the "Stop" input,
- after sending the command to close the breaker, the time "t_pow" was counted down. If the breaker is open in spite of sending the shutdown command, the function issues a "1" state on the "ERROR" output (cleared by the "KasSyg" input).

Settings table

Setting	Description	Setting range	Default value
ΔUr1	Permissible voltage difference for Ua > Ub	(0.005 ÷ 0.500) U_n in 0.001 U_n increments	0.01 U_n
ΔUr2	Permissible voltage difference for Ua < Ub	(0.005 ÷ 0.500) U_n in 0.001 U_n increments	0.01 U_n
Δf1	Permissible frequency difference for fa > fb	(0.005 ÷ 0.300) Hz in 0.005 Hz increments	0.05 Hz
Δf2	Permissible frequency difference for fa < fb	(0.005 ÷ 0.300) Hz in 0.005 Hz increments	0.05 Hz
Δφr	Permissible angle difference	(1.0 ÷ 30.0)° in 0.1° increments	5.0°
Uar<<	Voltage detection lower limit Ua (no power supply)	(0.020 ÷ 1.000) U_n in 0.001 U_n increments	0.300 U_n
Ubr<<	Voltage detection lower limit Un (no power supply)	(0.020 ÷ 1.000) U_n in 0.001 U_n increments	0.300 U_n
Uar>	Minimum switching voltage at Ub<	(0.500 ÷ 1.200) U_n in 0.001 U_n increments	0.700 U_n
Ubr>	Minimum switching voltage at Ua<	(0.500 ÷ 1.200) U_n in 0.001 U_n increments	0.700 U_n
Uar<	Maximum switching voltage at Ub<	(0.500 ÷ 1.200) U_n in 0.001 U_n increments	1.100 U_n
Ubr<	Maximum switching voltage at Ua<	(0.500 ÷ 1.200) U_n in 0.001 U_n increments	1.100 U_n
far>	Minimum switching frequency at Ub<	(45.000 ÷ 55.000) Hz in 0.001 Hz increments	48.000 Hz
fbr>	Minimum switching frequency at Ua<	(45.000 ÷ 55.000) Hz in 0.001 Hz increments	48.000 Hz
far<	Maximum switching frequency at Ub<	(45.000 ÷ 55.000) Hz in 0.001 Hz increments	52.000 Hz
fbr<	Maximum switching frequency at Ua<	(45.000 ÷ 55.000) Hz in 0.001 Hz increments	52.000 Hz
t_wyp	Control pulse advance time for the breaker	(0.00 ÷ 1.00) s in 0.01 s increments	0.20 s
t_ster	Control pulse length	(0.10 ÷ 10.00) s in 0.01 s increments	0.30 s
t_pow	Time between successive control pulses	(0.10 ÷ 10.00) s in 0.01 s increments	1.00 s
Δfu	Permissible frequency difference for voltage adjustment	(0.005 ÷ 0.300) Hz in 0.005 Hz increments	0.200 Hz
ON/OFF	Function activity	(ON / OFF)	ON
Ster_f<	Permitting control of breaker closure "from below" fa<fb	(ON / OFF)	ON
Ster_f>	Permitting control of breaker closure "from above" fa>fb	(ON / OFF)	ON
N00	switching without voltage on both sides	(ON / OFF)	OFF
N01	switching with no voltage on the Ua side and live on the Ub side	(ON / OFF)	OFF
N10	switching live on the Ua side and with no voltage on the Ub side	(ON / OFF)	OFF
N11	switching live on both sides	(ON / OFF)	OFF
N11r	switching live on both sides with adjustment	(ON / OFF)	ON

Parameters:

Permissible error

t_pow $\delta_{\%} = \pm 100$ ms

t_sster $\delta_{\%} = \pm 20$ ms

3.12. SZR(2) – automatic reserve switching function, version 2

iZAZ200	iZAZ300	iZAZ400	iZAZ600

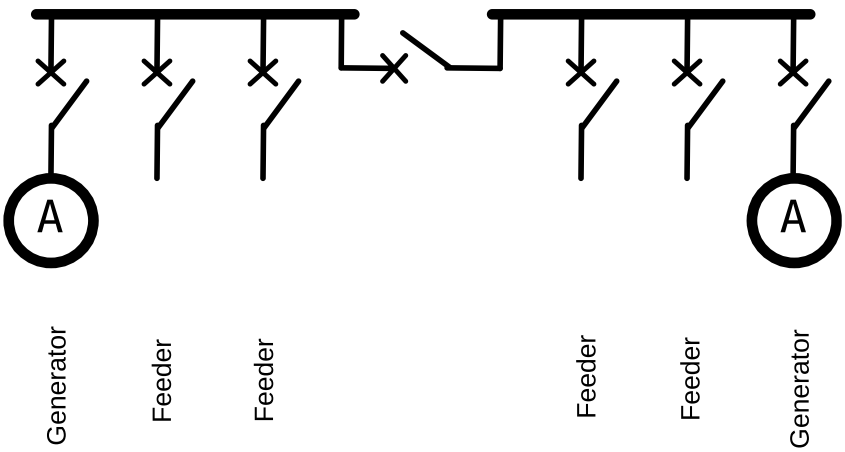
Application

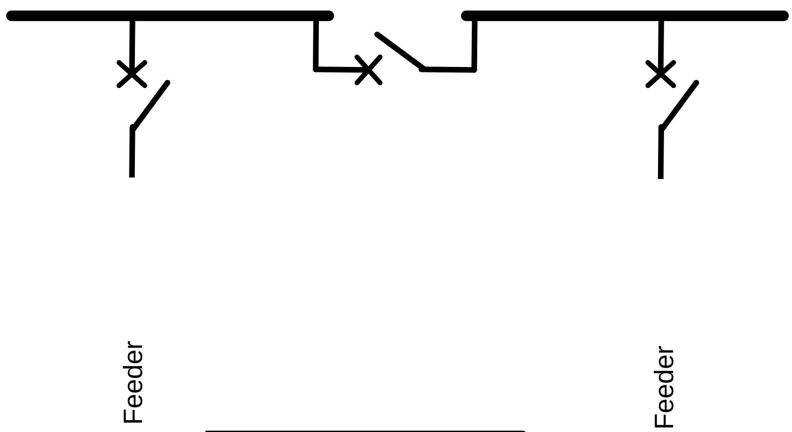
The function allows the implementation of automatic reserve power switching (SZR) and automatic reversing (SPP).

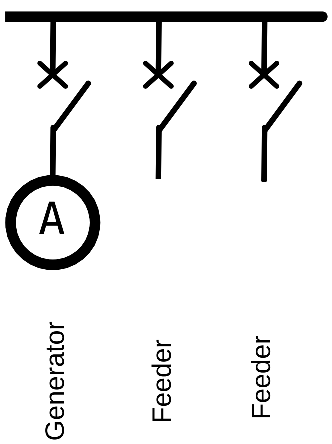
Operation description

The function is adapted to control a two-section switchgear connected by a coupling, with two supply inflows and a connected generator in each section.

It is possible to use this function to control any combination of the above-mentioned elements. The maximum configuration scheme and simplified (feasible) examples are shown in the figures below.







Automation is based on the use of two configuration functions: "**SW-serwis**" (SW-service) and "**SZR(2)".**

3.12.1. SW-serwis – I/O configuration function of the SZR automation power source.

The function defines:

- the parameter inputs describing the power source state
- the outputs controlling the power source breaker.

The function implements switching operations in the field according to the commands from the SZR(2) function considering the breaker state and the state of voltages on both sides of the breaker (synchronism monitoring). Signaling at the **Zzw** output - permission to switch. The breaker closure operation is interlocked if:

- the drive is not ready (the **Wył_OK** (OFF_OK) input)
- there is no permission from the synchronism control system. The system permits switching if there is no voltage on one side of the breaker, or the synchronization conditions (voltage difference, angle difference, frequency difference) are met.

List of inputs - the SW_serwis (SW_service) function		
Label	Description	Comment
Poł_zw	Coupler position, normally open contact	Breaker state in the field (external inputs)
Poł_roz	Coupler position, normally closed contact	
Wył_OK	Coupler ready for switching operations	
orta_Ua	Orthogonal a of the Ua input voltage	Voltage parameters on the power supply side. (Voltage and frequency calculated in preprocessing estimates) Any phase or phase-to-phase voltage
ortb_Ua	Orthogonal b of the Ua input voltage	
Ua	Ua input voltage	
fa	Ua voltage frequency	
fa_OK	Ua frequency measurement correct	
orta_Ub	Orthogonal a of the Ub input voltage	Voltage parameters on the bus side. (Voltage and frequency calculated in preprocessing estimates)
ortb_Ub	Orthogonal b of the Ub input voltage	
Ub	Ub input voltage	
fb	Ub voltage frequency	
fb_OK	Ub frequency measurement correct	

List of outputs - the SW_serwis (SW_service) function		
Label	Description	Comment
Struct	Coupler data structure	Structure of data exchange between the SZR(2) and SW_serwis (SW_service) functions
W	Coupler shutdown command	Breaker control
Zzw	Permission for synchronous coupler closure	
Z	Coupler closure command	
WZ	Coupler closed	Breaker state
WO	Coupler open	
W_ERR	Mismatch in position of coupler contacts	
P_ΔU	Voltage difference criterion state	Synchronism control criterion relay state
P_Δφ	Angle criterion state	
P_Δf	Frequency criterion state	
ΔU	Current voltage difference state	Synchronism control criterion measurement values
Δφ	Phase angle difference value	
Δf	Frequency difference value	
fb_OK	Frequency measurement correct	

The function does not have any settings, and the limits of criteria operation are determined by the settings in the **SZR(2)** function interlock.

3.12.2. SZR(2) – SZR automation implementation function.

3.12.2.1. SZR(2) – inputs/outputs.

The function controls the switching of power supplies, and the switching on and off of generators. The algorithm of automation operation depends on the state of inputs defining the power supply state, and settings.
The function interlock has the following inputs/outputs:

List of inputs - the SZR(2) function		
Label	Description	Comment
Bl_stała	Permanent automation deactivation	High state control interlocks all automation functions. The end requires clearing with the "Kas_ERR" input.
Bl_temp	Temporary automation deactivation	The high state interlocks all automation functions.
Struct_s1w1	Data structure of power connection 1, section 1	
Struct_s1w2	Data structure of power connection 2, section 1	
Struct_s1a	Data structure of generator connection, section 1	
S1_A_got	Section 1 generator ready	
UL1_s1	Bus voltage, section 1, phase 1	
UL2_s1	Bus voltage, section 1, phase 2	
UL3_s1	Bus voltage, section 1, phase 3	
Struct_s	Coupling data structure	
Struct_s1w1	Data structure of power connection 1, section 1	
Struct_s2w2	Data structure of power connection 2, section 2	
Struct_s2a	Data structure of generator connection, section 2	
S2_A_got	Section 2 generator ready	
UL1_s2	Bus voltage, section 2, phase 1	
UL2_s2	Bus voltage, section 2, phase 2	
UL3_s2	Bus voltage, section 2, phase 3	
Kas_ERR	Automation clearing (zeroing)	

List of outputs - the SZR(2) function		
Label	Description	Comment
Akt	Automation ready for operation	Outputs indicating the function operating state
Bl_temp	Transient operation interlock	
BL_stala	Permanent interlock	
S1_A_Z	Switch on the generator, section 1	Commands controlling the generators operation
S2_A_Z	Switch on the generator, section 2	
S1_A_W	Command to shut down the generator, section 1	
S2_A_W	Command to shut down the generator, section 2	
U_s1_OK	Voltage in section 1 OK	Voltage state on switchgear buses
U_s2_OK	Voltage in section 2 OK	
Pod._S1	Primary power supply, section 1	Outputs indicating the switchgear power supply state
Rez._S1	Reserve power supply, section 1	
ERROR_S1	Automation operation error in section 1	
Pod._S2	Primary power supply, section 2	
Rez._S2	Reserve power supply, section 2	
ERROR_S2	Automation operation error in section 2	

3.12.2.1. SZR (2) - Operation description

When the auxiliary voltage is applied, its operation starts. In the first step, the function recognizes the steady state of switchgear power supplies. Analyzing the breakers position and the presence of voltages, it recognizes the steady state and, depending on the settings, takes the following actions:

Automation operation after iZAZ activation

"U..OK" – voltage state on the buses of each section
"Pod" – primary power supply signaling
"Rez" – reserve power supply signaling
"ERROR" – power system error signaling
"ON/OFF" – function activity setting
"APz" – setting the option of automatic power on
"Ppw" – setting the option of automatic return to the primary supply

Signaling		Settings		Automation operation
U..OK	NO	ON/OFF	OFF	Inactivity
Pod..	NO	APz	XXX	
Rez..	NO	Ppw	XXX	
ERROR	NO			
U..OK	NO	ON/OFF	ON	Inactivity. Activation of automatic power switching will occur when the power supplies are manually set to the "recognizable" position (primary, or reserve power supply)
Pod..	NO	APz	OFF	
Rez..	NO	Ppw	XXX	
ERROR	NO			
U..OK	NO	ON/OFF	ON	Automation starts the power-up process. Depending on the power supply priority setting for the section, it opens and closes the corresponding breakers. When there is no voltage in the feeders, the process of switching on the generator is started (in the case of the set option with the generator present).
Pod..	NO	APz	ON	
Rez..	NO	Ppw	XXX	
ERROR	NO			
U..OK	TAK (YES)	ON/OFF	ON	Automation ready to operate according to the settings
Pod..	XXX	APz	XXX	
Rez..	XXX	Ppw	XXX	
ERROR	NO			
U..OK	TAK (YES)	ON/OFF	ON	The couplers position is inconsistent with the set power supply rule, or there are no available power sources. Automation will begin to function after manual reconfiguration of power supplies in the switchgear to a recognizable state and resetting the error signaling.
Pod..	NO	APz	NO	
Rez..	NO	Ppw	XXX	
ERROR	TAK (YES)			
U..OK	TAK (YES)	ON/OFF	ON	The couplers position is inconsistent with the set power supply rule, or there are no available power sources. If there is any set-allowed power source the function will automatically transition to the reconfiguration process to a position consistent with the set priority.
Pod..	NO	APz	TAK (YES)	
Rez..	NO	Ppw	XXX	
ERROR	TAK (YES)			

During normal operation, the function, depending on the settings and the current state of automation, can perform one of the following processes:

- Switching the power supply to a reserve from the primary, or from a reserve to another reserve. If there is no voltage on the buses (voltage below the "Us<" set parameter for a time longer than "tz_startU<"), or if all section power supply breakers are open (the breakers open for a time longer than "tz_startOW"). The automation attempts to turn on the power supplies from the inflows according to the order specified by the "SX_prio" priority setting. The process is performed in the following order:
    - Sending a breaker opening pulse to all inflows
    - Waiting for breakers to open. No confirmation for more than "towy" time causes "ERROR" signaling.
    - Sending a pulse to close the selected breaker.
    - Waiting for the breaker to close and the voltage to return to the buses. No confirmation for more than "towy" time causes "ERROR" signaling.

- Switching power to the generator. If there is no voltage on the buses (voltage below the "Us<" set parameter for a time longer than "tz_startU<"), or if all the section power supply breakers are open (the breakers open for a time longer than "tz_startOW") and no other power supply is available, and in the settings the operation with the generator is enabled, the automation performs the following process:
    - Sending a breaker opening pulse to all inflows. Control of the coupling breaker depends on the "S_A" setting. If the setting is not "OFF", the command to open the breaker is sent.
    - Waiting for breakers to open. No confirmation for more than "towy" time causes "ERROR" signaling.
    - Turning on the generator. After the "tz_startA" set time, it sends a pulse to switch on the generator.
    - Waiting for the generator to be ready. Not being ready for longer than "to_A" causes "ERROR" signal to appear
    - Sending a pulse to close the breaker. If there are two generators in the switchgear (one in each section), and it is allowed to operate them with the coupling breaker closed, the breaker closure does not depend on the synchronization of the two generators.
    - Waiting for the breaker to close and the voltage to return to the buses. No confirmation for more than "towy" time causes "ERROR" signaling.

- Return to primary from reserve power supply. If the basic voltage (according to the "S1_prio/S2_prio" priority setting) is restored to the correct state (voltage within the range specified by the "U<", "U>" settings), if the "Ppw" setting is "ON" the automation performs the following process:
    - Checking if the primary power supply breaker is ready. If the input state "Wył_OK" (Off_OK) is not high "1" the process is aborted.
    - Countdown of the delay time according to the "t_APP" setting. If the voltage does not change during this time, a voltage switching attempt is made.
    - Closing the primary power supply breaker. Closing of the breaker is implemented in uninterruptible mode with synchronism control. The shutdown command is sent only when the conditions are met: voltage difference (the "ΔUr" setting), frequency difference (the "Δf" setting), angle difference (the "Δφr" setting).
    - Section power supply reconfiguration. If the reserve power supply was from the second voltage of the section, a pulse is sent to open this power supply breaker.
    - Updating the power supply configuration from section two. After the "t_APP" set time, the power supplies are switched according to the priority of the section (the "S1_prio"/"Sa_prio" setting, respectively). Then either the current power supply breaker is opened or the coupling breaker is opened.
    - In each connection operation, the breaker state is checked. No confirmation for more than "towy" time causes "ERROR" signaling.

- Return to primary from generator power supply. If any of the voltages supplying the section returns, if the "Ppw" setting is turned "ON" the automation performs the following process:
    - Checking if the power supply breaker is ready. If the input state "Wył_OK" (Off_OK) is not high "1" the process is aborted.
    - Countdown of the delay time according to the "t_APP" setting. If the voltage does not change during this time, a voltage switching attempt is made.
    - Opening the generator and coupling breaker. The automation opens the generator and coupling breaker, if closed.
    - Sending a command to close the power supply inflow breaker (the voltage is checked in the order resulting from the priority setting for each section "S1_prio / S2_prio", respectively).
    - Second section power supply reconfiguration. After the breaker is closed in the section where the voltage has returned, the power supply in the other section is also reconfigured to the state resulting from the priority setting. If the generator was on in the second section, the switching is done in the same way as in the first section.
    - Shutting down the generators. When the generator breaker is opened, the delay time starts the countdown according to the "tz_W_A" setting. After this time, a pulse is sent to shut down the generator.
    - In each connection operation, the breaker state is checked. No confirmation for more than "towy" time causes "ERROR" signaling.

- Automatic power on. Automation activated by the "APz" setting. When this option is active, depending on the state, certain processes are started:
    - When iZAZ is switched on, or the automation function is enabled (unlocked), the determination of no power supply on the buses leads to the start of the power switching process according to the set priorities.
    - When the switching process fails and the function is in the "ERROR" state, the process of attempting to restore the power system to the state according to the set priorities is started.
    - If the breakers are found to be in a state incompatible with the system predicted by the priority setting, the system attempts to switch the power supplies to a compatible state depending on the priority setting.

List of settings:

Setting	Description	Setting range	Default value
ON/OFF	Function activity	(ON / OFF)	ON
PPw	Return switch	(YES/NO)	YES
APz	Automatic power on	(YES/NO)	NO
S_A	Coupling state with the generator on	(ON / OFF)	ON
S1_prio	Power supply order for section 1	none, L1L2, L1S, L1L2S, L1SL2, L1L2A, L1SA, L1L2SA, L1SL2A, L2L1, L2S, L2L1S, L2SL1, L2L1A, L2SA, L2L1SA, L2SL1A, SL1, SL2, SL1L2, SL2L1, SL1A, SL2A, SL1L2A, SL2L1A	L1S
S2_prio	Power supply order for section 2	none, L1L2, L1S, L1L2S, L1SL2, L1L2A, L1SA, L1L2SA, L1SL2A, L2L1, L2S, L2L1S, L2SL1, L2L1A, L2SA, L2L1SA, L2SL1A, SL1, SL2, SL1L2, SL2L1, SL1A, SL2A, SL1L2A, SL2L1A	L1S
Us<	Minimum permissible bus voltage	(0.000÷1.000) Un in 0.001 Un increments	0.900 Un
U<	No voltage detection limit	(0.000÷0.800) Un in 0.001 Un increments	0.300 Un
U>	Efficient power supply detection limit	(0.800÷1.200) Un in 0.001 Un increments	0.950 Un
ΔUr	Permissible voltage vector difference	(0.02÷0.50) Un in 0.01 Un increments	0.05 Un
Δf	Permissible frequency difference	(0.005÷0.300) Hz in 0.001 Hz increments	0.200 Hz
Δφr	Permissible angle difference	(1.0÷30.0)° in 0.1° increments	5.0°
tz_startOW	Delay time for automation start when the breaker is open	(0.00÷300.00) s in 0.01 s increments	0.10 s
tz_startU<	Delayed automation start from the detection of voltage loss on the buses	(0.00÷300.00) s in 0.01 s increments	1.00 s
towy	Waiting time for breaker response	(0.00÷300.00) s in 0.01 s increments	3.00 s
tz_startA	Delay in sending the generator start pulse	(0.00÷300.00) s in 0.01 s increments	3.00 s
to_A	Waiting time for the generator to be ready	(0.00÷3,000.00) s in 0.01 s increments	60.00 s
tz_W_A	Delay time for shutting down the generator after voltage restoration	(0.00÷3,000.00) min in 0.01 min increments	10.00 min
t_APP	Delay time to return to primary configuration	(0.00÷300.00) min in 0.01 min increments	10.00 min
tz_AZZ	Delayed start of the automatic power up process	(0.00÷300.00) min in 0.01 min increments	10.00 min
t_ERROR	Delay time of automation error signaling	(0.00÷300.00) s in 0.01 s increments	10.00 s

4. LIST OF CONFIGURATION FUNCTIONS

4.1. Binary inputs

Configuration binary inputs. The function output state depends on the function type, such as the physical application of Upn voltage to the terminals or the control of commands from the iZAZ Tools operating program or from the host system via the communication protocol.

4.1.1. we_B – binary input

Two-state inputs implemented in various hardware configurations with galvanic isolation against specific potential groups. Numeration in the scheme: In.1, In.2, In.3, ...

Various versions of IO modules are available for the iZAZ400. For iZAZ600 there is one version of the module with separated inputs. The total amount depends on the hardware variant.

For iZAZ200, iZAZ300 the number of inputs is constant: iZAZ200 = 2; iZAZ300 = 9.

These inputs are user-configurable and each can act as an input for interfacing with external protection, for external clearing of internal signaling, for external interlocking of selected protection, or any other arbitrary use according to the layout of configured logic-timing connections.

The Akt.st.we setting allows to change the input polarity. For the Akt.st.we= high setting, the application of Upn voltage to the external terminals is interpreted as the "1" function state and no voltage is interpreted as "0". However, for the Akt.st.we= low setting, the application of Upn voltage to the external terminals is interpreted as the "0" function state and no voltage is interpreted as "1"

Settings table

Setting	Description	Setting range	Default value
Akt.st.we	Active input state	(high/low)	high

4.1.2. we_Bs – virtual input (with support)

Virtual inputs, the state of which is set either through the communication protocol or through the operator panel. It is possible to configure up to 128 virtual inputs with support. Numeration in the scheme: InV.1 ÷ InV.128.

These inputs are user-configurable and each can act as a test of individual protections, interlock of individual protections, and activation/deactivation of an additional interlock of programmable logic or automation.

The state change is done by command and is saved in the device. When the auxiliary voltage is lost, the device starts up with the virtual input states according to the state before the shutdown.

The function has no additional settings.

4.1.3. we_Bi – control input (pulse)

Virtual inputs, the state of which as a pulse is generated through the communication protocol or through the operator panel. It is possible to configure up to 32 pulse control inputs. Numeration in the scheme: InS.1 ÷ InS.32.

These inputs are user-configurable and each can act as an on/off control for a breaker or other coupler.

Generating a command causes a pulse to appear in the logic. For this reason, the state is not saved.

The function has no additional settings.

4.1.4. we_Bd – dedicated input

Inputs used to control dedicated internal states of the device (including changing the assembly state, clearing signaling, clearing the event recorder and the disturbance recorder). They are configured by the manufacturer and the user is not allowed to change these states.

Numeration in the scheme: InS2.2÷...

The function has no additional settings.

The list and description of the states depends on the iZAZ type and can be found in the DTR of each device.

4.1.5. we_Bw – internal control input

Inputs used to control dedicated internal states of the device (including changing the assembly state, clearing signaling, clearing the event recorder and the disturbance recorder). They are configured by the manufacturer and the user is not allowed to change these states.

Numeration in the scheme: OutS.2÷...

The function has no additional settings.

The list and description of the states depends on the iZAZ type and can be found in the DTR of each device.

4.2. Binary outputs

Configuration binary outputs. Functions to control outputs in the configuration, such as output relays, LEDs on the operator panel, signaling outputs via messages on the display.

4.2.1. wy_P – relay output

Programmable relay outputs are derived as normally open, normally closed and changeover contacts in various configurations with galvanic isolation in separated sections (2 kV optoisolation). For the pinout, refer to the external wiring scheme provided in the User Manuals or Data Sheets of each device.

Numeration in the scheme: Out.1, Out.2, Out.3, ...

The function has two inputs: Stan (State) and Reset. Stan (State) is used to control the relay activation, while Reset is used to clear the supported activation.

The Out.negation setting allows to negate the output state. For the Negacja.wy=OFF (Out.negation=OFF) setting, the application of a logical state "1" to the Stan (State) input activates the relay. However, for the Negacja.wy=ON (Out.negation=ON) setting, applying a logical state "0" to the Stan (State) input activates the relay.

For the Podtrz.=wyłączone (Supp.=off) setting, the relay will be de-energized after the loss of the activation signal. However, for the Podtrz.=aktywne (Supp.=active) setting, after the activation signal disappears, the relay will be activated until a pulse appears at the Reset input.

Settings table

Setting	Description	Setting range	Default value
Out.neg.	Negation of relay activation state	ON/OFF	OFF
Sus.	Supporting output operation	(active/disabled)	off

Activation support is used when the signaling of tripping protections or automations is derived via relay outputs to an external signaling device that does not have the internal capability to support signaling for clearing. In such a case, clearing the signaling will depend on the signal connected to the Reset input - most often it is the CLR_SIGNAL (St2.9) dedicated signal. Alternatively, any other logic state (e.g., switch-on information or an external two-state input) can be used to clear the signaling.

4.2.2. wy_LED – single color LED control output (iZAZ200,300)

The function is available only on iZAZ200, iZAZ300 devices.

Eight programmable LEDs on the operator panel (yellow).

Numeration in the scheme: D.1 ÷ D.8.

The function has four inputs: Stan1 (State1), Stan2 (State2), Stan3 (State3) and Reset. Stan (State) is used to control the activation of the LED, while Reset is used to clear the supported activation of the light.

The function allows three modes of light:

Stan1 (State1) – flashing light with a frequency of 1 Hz (every 1 s - slow blinking)

Stan2 (State2) – flashing light with a frequency of 4 Hz (every 0.25 s - fast blinking)

Stan3 (State3) – continuous light

Stan3 (State3) has the highest priority, followed by Stan2 (State2) and the lowest Stan1 (State1).

The Negacja.wyX (Out.negationX) setting for each state (X = 1, 2, 3) allows the output state to be negated independently. For the Negacja.wyX=OFF (Out.negationX=OFF) setting, the application of the logical state "1" to the StanX (StateX) input causes activation of the LED light in the specified mode. However, for the Negacja.wyX=ON (Out.negationX=ON) setting, the application of a logical state "0" to the Stan (State) input causes activation of the LED light in the specified mode.

For the Pod.wyX=wyłączone (Out.suppX=off) setting, the LED will turn off after the activation signal is lost. However, for the Pod.wyX=aktywne (Out.suppX=active) setting, after the activation signal is lost, the LED will light up in the specified mode until a pulse appears at the Reset input (common to all three modes).

Settings table

Setting	Description	Setting range	Default value
Out.neg1	Negation of LED activation state in 1 Hz flashing mode	ON / OFF	OFF
Out.neg2	Negation of LED activation state in 4 Hz flashing mode	ON / OFF	OFF
Out.neg3	Negation of LED activation state in continuous mode	ON / OFF	OFF
Out.sus.1	LED light support in 1 Hz flashing mode	(active/disabled)	active
Out.sus.2	LED light support in 4 Hz flashing mode	(active/disabled)	active
Out.sus.3	LED light support in continuous mode	(active/disabled)	active

Supporting the activation of the lighted LED is used in the case of derivation of tripping signaling of protection or automation. In such a case, a flashing light can be used to signal the protection activation.

Clearing the supported signaling will depend on the connected signal to the Reset input - most often it is the CLR_SIGNAL (St2.9) dedicated signal. Alternatively, any other logic state (e.g., switch-on information or an external two-state input) can be used to clear the signaling.

4.2.3. wy_LED – two-color LED control output (iZAZ400,600)

The function is available only on iZAZ400, iZAZ600 devices.

Sixteen programmable LEDs on the operator panel (green or red).

Numeration in the scheme: D.1 ÷ D.16.

The function has seven inputs: Stan1 (State1), Stan2 (State2), Stan3 (State3), Stan4 (State4), Stan5 (State5), Stan6 (State6) and Reset. Status is used to control the LEDs activation, while Reset is used to clear the supported light activation.

The function allows three modes of light:

Stan1 (State1) – green light flashing with a frequency of 1 Hz (every 1 s - slow blinking)

Stan2 (State2) – green light flashing with a frequency of 4 Hz (every 0.25 s - fast blinking)

Stan3 (State3) – continuous green light

Stan4 (State4) – red light flashing with a frequency of 1 Hz (every 1 s - slow blinking)

Stan5 (State5) – red light flashing with a frequency of 4 Hz (every 0.25 s - fast blinking)

Stan6 (State6) – continuous red light

Stan6 (State6) has the highest priority and Stan1 (State1) has the lowest.

The Negacja.wyX (Out.negationX) setting for each state (X = 1, 2, 3, 4, 5, 6) allows the output state to be negated independently. For the Negacja.wyX=OFF (Out.negationX=OFF) setting, the application of the logical state "1" to the StanX (StateX) input causes activation of the LED light in the specified mode. However, for the Negacja.wyX=ON (Out.negationX=ON) setting, the application of a logical state "0" to the Stan (State) input causes activation of the LED light in the specified mode.

For the Pod.wyX=wyłączone (Out.suppX=off) setting, the LED will turn off after the activation signal is lost. However, for the Pod.wyX=aktywne (Out.suppX=active) setting, after the activation signal is lost, the LED will light up in the specified mode until a pulse appears at the Reset input (common to all three modes).

Settings table

Setting	Description	Setting range	Default value
Neg.wy1 (Out.neg1)	Negation of the activation state of the green LED in 1 Hz flashing mode	ON / OFF	OFF
Neg.wy2 (Out.neg2)	Negation of the activation state of the green LED in 4 Hz flashing mode	ON / OFF	OFF
Neg.wy3 (Out.neg3)	Negation of the activation state of the green LED in continuous mode	ON / OFF	OFF
Neg.wy4 (Out.neg4)	Negation of the activation state of the red LED in 1 Hz flashing mode	ON / OFF	OFF
Neg.wy5 (Out.neg5)	Negation of the activation state of the red LED in 4 Hz flashing mode	ON / OFF	OFF
Neg.wy6 (Out.neg6)	Negation of the activation state of the red LED in continuous mode	ON / OFF	OFF
Pod.wy1 (Out.supp1)	Green LED light support in 1 Hz flashing mode	(active/disabled)	active
Pod.wy2 (Out.supp2)	Green LED light support in 4 Hz flashing mode	(active/disabled)	active
Pod.wy3 (Out.supp3)	Green LED light support in continuous mode	(active/disabled)	active
Pod.wy4 (Out.supp4)	Red LED light support in 1 Hz flashing mode	(active/disabled)	active
Pod.wy5 (Out.supp5)	Red LED light support in 4 Hz flashing mode	(active/disabled)	active
Pod.wy6 (Out.supp6)	Red LED light support in continuous mode	(active/disabled)	active

Supporting the activation of the lighted LED is used in the case of derivation of tripping signaling of protection or automation. In such a case, a flashing light can be used to signal the protection activation.

Clearing the supported signaling will depend on the connected signal to the Reset input - most often it is the CLR_SIGNAL (St2.9) dedicated signal. Alternatively, any other logic state (e.g., switch-on information or an external two-state input) can be used to clear the signaling.

4.2.4. wy_Syg – signaling output

Signaling outputs with a text message of up to 16 characters with an optional comment of up to 64 characters. It is possible to configure up to 64 functions (iZAZ200, iZAZ300) or up to 255 functions (iZAZ400, iZAZ600). Numeration in the scheme: S.1÷S.255.

The function has two inputs: Stan (State) and Reset. Stan (State) is used to control the signaling activation, while Reset is used to clear the supported activation.

The Out.negation setting allows to negate the signaling output state. For the Negacja.wy=OFF (Out.negation=OFF) setting, the application of a logical state "1" to the Status input results in the signaling display. However, for the Negacja.wy=ON (Out.negation=ON) setting, applying a logical state "0" to the Status input results in the signaling display.

For the Podtrz.=wyłączone (Supp.=off) setting, the signaling will be cleared after the activation signal is lost. However, for the Podtrz.=aktywne (Supp.=active) setting, after the activation signal is lost, the signaling will be displayed until a pulse appears at the Reset input.

Settings table

Setting	Description	Setting range	Default value
Out.negation	Negation of signal activation state	ON/OFF	OFF
Sus.	Supporting the signaling operation	(active/disabled)	active

The activation support is used in the case of derivation of text signaling of protection or automation tripping. Clearing the signaling will depend on the signal connected to the Reset input - most often it is the CLR_SIGNAL (St2.9) dedicated signal. Alternatively, any other logic state (e.g., switch-on information or an external two-state input) can be used to clear the signaling.

4.2.5. wy_St – status output

Status outputs, auxiliary signals in the operation logic, used to output the logic state for viewing by the operation program or operator panel and for reading by the host system through the communication protocol. It is possible to configure up to 128 functions.

Numeration in the scheme: St.1÷St.128.

The function has two inputs: Stan (State) and Reset. Stan (State) is used to control the signaling activation, while Reset is used to clear the supported activation.

The Out.negation setting allows to negate the status output state. For the Negacja.wy=OFF (Out.negation=OFF) setting, applying a logical state "1" to the Stan (State) input causes status activation. However, for the Negacja.wy=ON (Out.negation=ON) setting, applying a logical state "0" to the Stan (State) input activates the status.

For the Podtrz.=wyłączone (Supp.=off) setting, the status will be de-energized after the activation signal is lost. However, for the Podtrz.=aktywne (Supp.=active) setting, after the activation signal is lost, the status will be activated until a pulse appears at the Reset input.

Settings table

Setting	Description	Setting range	Default value
Out.negation	Negation of status activation state	ON/OFF	OFF
Sus.	Sustain status operation	(active/disabled)	disabled

Most often, statuses work without supporting operation, as internal logic states, such as the sum of active protection test activations or the sum of protection virtual interlock activations.

The state of such statuses is used as information for the user.

When using status operation support, the reset will depend on the signal connected to the Reset input - most often it is the CLR_SIGNAL (St2.9) dedicated signal. Alternatively, any other logic state (e.g., switch-on information or an external two-state input) can be used to clear the signaling.

4.2.6. wy_Std – dedicated outputs

Dedicated outputs informing about the device internal states (including assembly state, active set of settings, clearing the signaling). The statuses are derived to the logic, in order to allow the user to use these logic states to implement additional logic-time dependencies. For example, output to a relay for signaling the protection test state or for signaling an active reserve protection set.

Numeration in the scheme: Std.1÷...

The function has no additional settings.

The list and description of dedicated outputs depends on the iZAZ type and can be found in the DTR of each device.

4.3. Channels

Functions of analog measurement inputs (currents, voltages) from the A/C converter. These channels are directly related to the device hardware variant. The user is not allowed to edit these functions except for setting the value of the primary side of the transformer.

4.3.1. we_I – current measurement input

The number of current channels is based on the hardware variant.

The connection layout can be found in the external connection scheme, which is included in the DTR of each device.

Numeration in the scheme: K.1÷ ... (numeration common for all analog channels)

The function has three outputs: próbka (sample), AC_buffer, param.

próbka (sample) – information about the current sample value from the converter, most often used for the disturbance recorder (connecting the function of the RCA analog recording channel).

bufor_AC (AC_buffer) – a set of samples for the entire period used to connect digital filters (e.g., primary component estimates)

param – additional channel information (measurement range, transmission ratio), used for measurement functions, in order to correctly display values in nominal, primary and secondary modes.

Settings table

Setting	Description	Setting range	Default value
In	Rated current value	1 A / 5 A	1 A
Ipn	Primary side rated current value	(1÷6,000) A in 1 A increments	1,200 A

The user is not allowed to edit the In setting, there is only a preview option. It results from the hardware variant and is set by the manufacturer as ordered.

4.3.2. we_Ir – current measurement input, reversible

The number of current channels is based on the hardware variant.

The connection layout can be found in the external connection scheme, which is included in the DTR of each device.

Numeration in the scheme: K.1÷ ... (numeration common for all analog channels)

The function has one DIR input for reversing the analog signal direction.

The function has three outputs: próbka (sample), AC_buffer, param.

próbka (sample) – information about the current sample value from the converter, most often used for the disturbance recorder (connecting the function of the RCA analog recording channel).

bufor_AC (AC_buffer) – a set of samples for the entire period used to connect digital filters (e.g., primary component estimates)

param – additional channel information (measurement range, transmission ratio), used for measurement functions, in order to correctly display values in nominal, primary and secondary modes.

Settings table

Setting	Description	Setting range	Default value
In	Rated current value	1 A / 5 A	5 A
Ipn	Primary side rated current value	(1÷6,000) A in 1 A increments	1,200 A
DIR	Reversing direction	(YES/NO)	NO

The user is not allowed to edit the In setting, there is only a preview option. It results from the hardware variant and is set by the manufacturer as ordered.

4.3.3. we_U – voltage measurement input

The number of voltage channels is based on the hardware variant.

The connection layout can be found in the external connection scheme, which is included in the DTR of each device.

Numeration in the scheme: K.1÷ ... (numeration common for all analog channels)

The function has three outputs: próbka (sample), AC_buffer, param.

próbka (sample) – information about the current sample value from the converter, most often used for the disturbance recorder (connecting the function of the RCA analog recording channel).

bufor_AC (AC_buffer) – a set of samples for the entire period used to connect digital filters (e.g., primary component estimates)

param – additional channel information (measurement range, transmission ratio), used for measurement functions, in order to correctly display values in nominal, primary and secondary modes.

Settings table

Setting	Description	Setting range	Default value
Un	Rated voltage value	100 V / 400 V	100 V
Upn	Primary side rated voltage value	(0÷400,000) V in 1 V increments	6,300 V

the user is not allowed to edit the Un setting, there is only a preview option. It results from the hardware variant and is set by the manufacturer as ordered.

4.3.4. we_Ur – voltage measurement input, reversible

The number of voltage channels is based on the hardware variant.

The connection layout can be found in the external connection scheme, which is included in the DTR of each device.

Numeration in the scheme: K.1÷ ... (numeration common for all analog channels)

The function has one DIR input for reversing the analog signal direction.

The function has three outputs: próbka (sample), AC_buffer, param.

próbka (sample) – information about the current sample value from the converter, most often used for the disturbance recorder (connecting the function of the RCA analog recording channel).

bufor_AC (AC_buffer) – a set of samples for the entire period used to connect digital filters (e.g., primary component estimates)

param – additional channel information (measurement range, transmission ratio), used for measurement functions, in order to correctly display values in nominal, primary and secondary modes.

Settings table

Setting	Description	Setting range	Default value
Un	Rated voltage value	100 V / 400 V	100 V
Upn	Primary side rated voltage value	(0÷400,000) V in 1 V increments	6,300 V
DIR	Reversing direction	(YES/NO)	NO

the user is not allowed to edit the Un setting, there is only a preview option. It results from the hardware variant and is set by the manufacturer as ordered.

4.3.5. we_Io – earth fault current measurement input

The use of the earth fault current channel is based on the hardware variant.

The connection layout can be found in the external connection scheme, which is included in the DTR of each device.

Numeration in the scheme: K.1÷ ... (numeration common for all analog channels)

The function has three outputs: próbka (sample), AC_buffer, param.

próbka (sample) – information about the current sample value from the converter, most often used for the disturbance recorder (connecting the function of the RCA analog recording channel).

bufor_AC (AC_buffer) – a set of samples for the entire period used to connect digital filters (e.g., primary component estimates)

param – additional channel information (measurement range, transmission ratio), used for measurement functions, in order to correctly display values in nominal, primary and secondary modes.

Settings table

Setting	Description	Setting range	Default value
In	Rated current value	0.1 A	0.1 A
N	PP transmission	(50÷200) in 1 increments	100

The user is not allowed to edit the In setting, there is only a preview option. It results from the hardware variant and is set by the manufacturer as ordered.

4.3.6. we_Ior – earth fault current measurement input, reversible

The use of the earth fault current channel is based on the hardware variant.

The connection layout can be found in the external connection scheme, which is included in the DTR of each device.

Numeration in the scheme: K.1÷ ... (numeration common for all analog channels)

The function has one DIR input for reversing the analog signal direction.

The function has three outputs: próbka (sample), AC_buffer, param.

próbka (sample) – information about the current sample value from the converter, most often used for the disturbance recorder (connecting the function of the RCA analog recording channel).

bufor_AC (AC_buffer) – a set of samples for the entire period used to connect digital filters (e.g., primary component estimates)

param – additional channel information (measurement range, transmission ratio), used for measurement functions, in order to correctly display values in nominal, primary and secondary modes.

Settings table

Setting	Description	Setting range	Default value
In	Rated current value	0.1 A	0.1 A
N	PP transmission	(50÷200) in 1 increments	100
DIR	Reversing direction	(YES/NO)	NO

The user is not allowed to edit the In setting, there is only a preview option. It results from the hardware variant and is set by the manufacturer as ordered.

4.4. Temperature sensor channels

4.4.1. we_ϑ(4-20mA) – temperature measurement input with 4–20 mA sensor

The use of the 4–20 mA current loop sensor channel for temperature measurement is based on the hardware variant.

Numeration in the scheme: Kϑ.1÷ ... (numeration common for all temperature sensor channels).

The function has two outputs: ϑ, ϑ_OK

- ϑ – information about the current temperature value, used for disturbance recorder, measurement or protection.
- ϑ_OK – information about the correct temperature measurement result. If the 4–20 mA loop current measurement is out of the measurement range, this output will signal an invalid result (0).

Settings table

Setting	Description	Setting range	Default value
ϑmin	temperature corresponding to 4 mA at the channel input	(-200÷1,000)°C in 1 °C increments	40°C
ϑmax	temperature corresponding to 20 mA at the channel input	(-200÷1,000)°C in 1 °C increments	300°C

The ϑmin and ϑmax settings scale the input channel adapting it to the temperature measurement transmitter used.

4.4.2. we_PT100 – temperature measurement input with PT100 sensor

The use of the PT100 type sensor channel for temperature measurement connected in a three-wire system.

Numeration in the scheme: Kϑ.1÷ ... (numeration common for all temperature sensor channels).

The function has two outputs: ϑ, ϑ_OK, param.

- ϑ – information about the current temperature value, used for disturbance recorder, measurement or protection.
- ϑ_OK – information about the correct temperature measurement result. If the 4–20 mA loop current measurement is out of the measurement range, this output will signal an invalid result (0).

4.4.3. we_ϑ(0-3.5V) – temperature measurement input with 0–3.5 V sensor

The use of a temperature sensor channel to measure the protected object surface temperature.

Numeration in the scheme: Kϑ.1÷ ... (numeration common for all temperature sensor channels).

The function has two outputs: ϑ, ϑ_OK

- ϑ – information about the current temperature value, used for disturbance recorder, measurement or protection.
- ϑ_OK – information about the correct temperature measurement result. If the temperature measurement is out of the measurement range, this output will signal an invalid result (0).

Settings table

Setting	Description	Setting range	Default value
ϑmin	temperature corresponding to 0.1V at the channel input	(-200÷1,000)°C in 1 °C increments	40°C
ϑmax	temperature corresponding to 1.5V at the channel input	(-200÷1,000)°C in 1 °C increments	150°C

The ϑmin and ϑmax settings scale the input channel adapting it to the temperature measurement transmitter used.

4.5. 4..20 mA current loop outputs

4.5.1. wy_ϑ– output nominated in temperature units

The signal output of the 4–20 mA current loop system is based on the hardware variant.

Numeration in the scheme: Wy_ϑ.1÷ ... (numeration common for all 4..20 mA output channels)

The function has one input ϑ - temperature value

The function has three outputs: ERROR, OverTemp, OpenLoop

ERROR – input channel error – missing or failure
OverTemp – output temperature exceeded
OpenLoop – output circuit failure (open loop)

Settings table

Setting	Description	Setting range	Default value
4mA	Temperature value for a 4 mA current	(-50÷100)°C in 0.1 °C increments	0°C
20mA	Temperature value for a 20 mA current	(0÷200)°C in 0.1 °C increments	150°C

The 4mA and 20mA settings scale the output channel adjusting it to the requirements of the system that reads the measurement within the specified required range.

4.5.2. wy_zn– output nominated in multiples of the rated value

The signal output of the 4–20 mA current loop system is based on the hardware variant.

Numeration in the scheme: Wy_Zn.1÷ ... (numeration common for all 4..20 mA output channels)

Function has one input: Wartość (Value) - measurement value in multiples of the nominal value

The function has three outputs: ERROR, OverTemp, OpenLoop

ERROR – input channel error – missing or failure
OverTemp – output temperature exceeded
OpenLoop – output circuit failure (open loop)

Settings table

Setting	Description	Setting range	Default value
4mA	Value corresponding to a 4 mA current	(0.000÷1.000) n C in 0.001 n increments	0.000 n
20mA	Value corresponding to a 20 mA current	(0.1÷40.0) n C in 0.1 n increments	2.0 n

The 4mA and 20mA settings scale the output channel adjusting it to the requirements of the system that reads the measurement within the specified required range.

4.6. Estimates

Functions dedicated to analog signals, allowing analog signals to be recalculated appropriately to produce the values required for protection functions.
The basic function is a primary component estimate (F_1h) for short circuit protection.
The estimate library provides a variety of options for recalculating vector signals, calculating higher harmonics, estimating dedicated signals for specific protection functions (e.g., signal derivative, mean value, rms, etc.).
Also included in this group of functions is the memory system estimate, used for directional short circuit protection to correctly determine the direction of short circuit power flow when the voltage decreases.

4.6.1. E_1h – primary component estimate

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The primary component allows filtering of the source signal first harmonic. This is the most commonly used estimate, based on which the short circuit overcurrent, overvoltage, undervoltage functions operate.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has three outputs: orta, ortb, Esk.

orta – estimate a orthogonal
ortb – estimate b orthogonal
Esk – calculated rms of the primary component

The orta, ortb output signals are used for further recalculations (e.g., estimates of symmetrical components, power and energy, etc.), while Esk is a criterion value connected to protection and measurement functions.

4.6.2. E_1h(40ms) – primary component estimate, two-period

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The primary component allows filtering of the source signal first harmonic.

Compared to F_1h, this estimate is slower but the effect of filtering calculations is more preferable. The F_1h(40ms) estimate is used for earth fault protection, for which the time to obtain the result is not deterministic and the source signal is often heavily distorted.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has three outputs: orta, ortb, Esk.

orta – estimate a orthogonal
ortb – estimate b orthogonal
Esk – calculated rms of the primary component

The orta, ortb output signals are used for further recalculations (e.g., estimates of symmetrical components, power and energy, etc.), while Esk is a criterion value connected to protection and measurement functions.

4.6.3. E_2h – second harmonic estimate

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The estimate allows filtering the source signal second harmonic.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has three outputs: orta, ortb, Esk.

orta – estimate a orthogonal

ortb – estimate b orthogonal
Esk – calculated rms of the primary component

The orta, ortb output signals are used for further recalculations (e.g., estimates of symmetrical components, power and energy, etc.), while Esk is a criterion value connected to protection and measurement functions.

4.6.4. E_3h – third harmonic estimate

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The estimate allows filtering the source signal third harmonic.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has three outputs: orta, ortb, Esk.

orta – estimate a orthogonal
ortb – estimate b orthogonal
Esk – calculated rms of the primary component

The orta, ortb output signals are used for further recalculations (e.g., estimates of symmetrical components, power and energy, etc.), while Esk is a criterion value connected to protection and measurement functions.

4.6.5. E_5h – fifth harmonic estimate

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The estimate allows filtering the source signal fifth harmonic.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has three outputs: orta, ortb, Esk.

orta – estimate a orthogonal
ortb – estimate b orthogonal
Esk – calculated rms of the primary component

The orta, ortb output signals are used for further recalculations (e.g., estimates of symmetrical components, power and energy, etc.), while Esk is a criterion value connected to protection and measurement functions.

4.6.6. E_RMS – rms estimate

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The rms calculated based on a 20 ms filter window, used for calculations where the "whole" signal including the content of higher harmonics is important, such as for thermal protection or PKW cumulative current meter.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has one output: Erms - the calculated signal rms including higher harmonics considering a measurement window of 20 ms.

4.6.7. E_RMS(1T) – rms estimate according to the actual waveform period

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The rms calculated based on the actual period of the source signal, according to successive transitions through zero, used for calculations where the "whole" signal including the content of higher harmonics is important, such as for thermal protection or PKW accumulated current meter. It is mainly used when larger deviations of the measurement signal period from 20 ms (50 Hz) can be expected.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has one output: Erms - the calculated signal rms including higher harmonics according to the actual measurement signal period.

4.6.8. E_AVR – average value estimate

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The average value calculated based on a 20 ms filter window, used for calculations where the average value of the "whole" signal including the content of higher harmonics is significant.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has two outputs: AVR and sAVR

AVR – calculated rectified signal average value

sAVR – calculated square of the rectified signal average value

4.6.9. E_RMS(10min) – 10-minute rms estimate

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The rms (TRUE RMS) calculated based on a 10-minute measurement window. The output value is refreshed every 3 seconds and provides the calculated rms of the waveform for the last 10 minutes.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has one output: Esk - the calculated TRUE RMS rms for the last 10 minutes.

4.6.10. E_AVR(1T) – average value estimate

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The average value calculated based on the actual source signal period, according to successive transitions through zero, used for calculations where the average value of the "whole" signal including the content of higher harmonics is significant.

It is mainly used when larger deviations of the measurement signal period from 20 ms (50 Hz) can be expected.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has one output: AVR/T - calculated average rectified value of the signal including higher harmonics according to the actual measurement signal period.

4.6.11. E_AVR(Δt) – average value estimate over a set time period

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Average value calculated over a set Δt time period.

Used when calculation of the average value over several primary component periods is required.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has one output: AVR/Δt – the calculated average rectified value of the signal over the set time period.

Settings table

Setting	Description	Setting range	Default value
Δt	averaging time	(0.020÷0.200) s in 0.001 s increments	0.020 s

4.6.12. E_SC0 – zero order symmetric component estimate

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The estimate allows the zero component to be calculated from a three-phase signal.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has 6 inputs: ortaL1, orbL1, ortaL2, orbL2, ortaL3, orbL3 to connect the orthogonal components of the three-phase signal according to the inputs description. Orthogonal signals are connected from the primary component estimates outputs with analogous names.

The function has three outputs: orta, ortb, Esk.

- orta – estimate a orthogonal
- ortb – estimate b orthogonal
- Esk – calculated rms of the zero order symmetrical component

The orta, ortb output signals are used for further recalculations or the recorder, while Esk is a criterion value connected to protection and measurement functions.

The function allows to calculate the zero voltage/current signal based on three-phase signals. It can be used as an alternative when measurement signals that directly measure zero voltage (open voltage triangle) or zero current (Holmgreen circuit or Ferranti transformer) are not available.

NOTE: The function reports back the rms of the symmetrical component, while the physical measurement always provides a value multiplied by three: 3Uo and 3Io. Hence, when using this estimate for protection, it is important to consider the appropriate recalculation of the start-up value, as the designer usually recalculates the value according to $3I_{or}$ and $3U_{or}$.

4.6.13. E_SC1 – positive order symmetric component estimate

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The estimate allows the calculation of the positive sequence component from a three-phase signal.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has 6 inputs: ortaL1, orbL1, ortaL2, orbL2, ortaL3, orbL3 to connect the orthogonal components of the three-phase signal according to the inputs description. Orthogonal signals are connected from the primary component estimates outputs with analogous names.

The function has three outputs: orta, ortb, Esk.

- orta – estimate a orthogonal
- ortb – estimate b orthogonal
- Esk – calculated rms of the positive order symmetric component

The orta, ortb output signals are used for further recalculations or the recorder, while Esk is a criterion value connected to protection and measurement functions.
The function allows to calculate the positive sequence component voltage/current signal based on three-phase signals.

4.6.14. E_SC2 – negative order symmetric component estimate

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The estimate allows the calculation of the negative sequence component from a three-phase signal.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has 6 inputs: ortaL1, orbL1, ortaL2, orbL2, ortaL3, orbL3 to connect the orthogonal components of the three-phase signal according to the inputs description. Orthogonal signals are connected from the primary component estimates outputs with analogous names.

The function has three outputs: orta, ortb, Esk.

- orta – estimate a orthogonal
- ortb – estimate b orthogonal
- Esk – calculated rms of the zero order symmetrical component

The orta, ortb output signals are used for further recalculations or the recorder, while Esk is a criterion value connected to protection and measurement functions.
The function allows to calculate the negative sequence component voltage/current signal based on three-phase signals. It is most commonly used to implement protection from asymmetry and to detect a break state in voltage circuits.

4.6.15. E_MEM – voltage memory chip

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function allows generating a voltage signal from memory, if this signal is decreased below the set value.

It is mainly used for the function of determining the direction for short circuit protection, where in strong short circuits the voltage signal may be too small to unambiguously determine the short circuit power flow direction. In such cases, when the voltage is decreased below the generation switching limit, the current voltage waveform is replaced by the signal before the short circuit. The memory signal generation time is limited and is based on the setting.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has three inputs: orta, ortb, Esk, to which signals from the phase voltage estimate are connected.

- orta – estimate a orthogonal
- ortb – estimate b orthogonal
- Esk – calculated rms of the primary component

The function has five outputs: orta, ortb, Esk, memory_OK, memory_ON:

- memory_OK – output active when the memory buffer is full, when the function is ready to generate a signal from memory.
- memory_ON – output active when generating signal from memory
- orta – estimate a orthogonal
- ortb – estimate b orthogonal
- Esk – calculated rms of the primary component

For a signal with an rms above the setting, the orta, ortb, Esk outputs are transcribed directly from the inputs. However, for rms below the setting, they are generated from the voltage memory (in this case, the active memory_ON output - waveform generation from memory).

Settings table

Setting	Description	Setting range	Default value
U_r	Limit value for switching on voltage generation from memory	(0.001÷0.100) Un in 0.001 Un increments	0.030 Un
t	Maximum generation time	(0.10÷5.00) s in 0.01 s increments	1.00 s

4.6.16. E_MEM(AVR) – averaged voltage rms values memory

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

An auxiliary function to save the averaged rms values of voltages for CU and ΔU protection functions in memory.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has one input: E - the signal rms.

The function has one output: bufor_E (buffer_E) - rms memory

4.6.17. E_MAX – max selector

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The function allows determining the maximum value from three signals connected to the inputs.

It is mainly used for single-input relay functions whose operating criterion is based on maximum value detection.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has three inputs: E1, E2, E3, to which the signals from the three-phase rms signal estimate are connected.

The function has one output: E - maximum value based on the input signal comparison.

4.6.18. E_MIN – mini selector

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The function allows determining the minimum value from three signals connected to the inputs.

It is mainly used for single-input relay functions whose operating criterion is based on minimum value detection.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has three inputs: E1, E2, E3, to which the signals from the three-phase rms signal estimate are connected.

The function has one output: E - minimum value based on the input signal comparison.

4.6.19. E_COM(2) – submission of samples of two signals S = S1-S2

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function allows the signals to be submitted by subtracting the instantaneous input signal values according to the formula: S = S1-S2

It is used to determine the phase-to-phase voltage based on the phase voltage source channels.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has two inputs: S1, S2, to which sample buffers of the submitted signals are connected.

The function has two outputs: S, bufor_AC (AC_buffer):

S – current sample value
bufor_AC (AC_buffer) – sample buffer

The current sample (S) allows the signal to be output after submission to the disturbance recorder, while the sample buffer is used for further recalculations (e.g., primary component estimate, followed by protection)

Settings table

Setting	Description	Setting range	Default value
ΔS	Submitted signal amplitude correction	(0.000÷2.000) in 0.001 increments	1.000
Δφ	Submitted signal phase correction	(0.0÷360.0)° in 0.1° increments	0.0°

4.6.20. E_COM(8) – submission of samples of eight signals S = C1(S1-S2)-C2(S3-S4)-C3(S5-S6)-C4(S7-S8)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function allows the signals to be submitted by subtracting the instantaneous input signal values according to the formula: S = C1(S1-S2)-C2(S3-S4)-C3(S5-S6)-C4(S7-S8).

It is used to determine the differential signal, inhibiting for estimates used for differential protection.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has eight inputs: S1÷S8, to which sample buffers of the submitted signals are connected.

The function has two outputs: S, bufor_AC (AC_buffer):

S – current sample value
bufor_AC (AC_buffer) – sample buffer

The current sample (S) allows the signal to be output after submission to the disturbance recorder, while the sample buffer is used for further recalculations (e.g., primary component estimate, followed by protection)

Settings table

Setting	Description	Setting range	Default value
ΔS	Submitted signal amplitude correction	(0.000÷2.000) in 0.001 increments	1.000
Δφ	Submitted signal phase correction	(0.0÷360.0)° in 0.1° increments	0.0°
C1	Submission factor (S1-S2)	(-3.000÷3.000) in 0.001 increments	1.000
C2	Submission factor (S3-S4)	(-3.000÷3.000) in 0.001 increments	1.000
C3	Submission factor (S5-S6)	(-3.000÷3.000) in 0.001 increments	1.000
C4	Submission factor (S7-S8)	(-3.000÷3.000) in 0.001 increments	1.000

4.6.21. E_E1+E2 – geometric sum of vectors

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function for assembling the estimates of two vectors, based on orthogonal signals according to the formula: $\vec{E} = \overrightarrow{E1} + \overrightarrow{E2}$

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has four inputs: orta1, ortb1, orta2, ortb2 to which the outputs of the signal estimates whose vectors will be added are connected.

The function has three outputs: orta, ortb, Esk:

orta – a orthogonal of the resultant vector estimate
ortb – b orthogonal of the resultant vector estimate
Esk – calculated resultant vector rms

4.6.22. E_E1-E2 – geometric difference of vectors

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The function for assembling the estimates of two vectors, based on orthogonal signals according to the formula: $\vec{E} = \overrightarrow{E1} - \overrightarrow{E2}$

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has four inputs: orta1, ortb1, orta2, ortb2 to which the signal estimate outputs are connected, the vector of which will be multiplied by a set constant value.

The function has three outputs: orta, ortb, Esk:

orta – a orthogonal of the resultant vector estimate
ortb – b orthogonal of the resultant vector estimate
Esk – calculated resultant vector rms

4.6.23. E_a*E1 – product of vector and constant

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The function for multiplying the input signal vector by a constant value (constant vector, with amplitude and angle settings) according to the formula: $\vec{E} = \vec{a} \cdot \overrightarrow{E1}$

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has two inputs: orta1, ortb1, to which the outputs from the signal estimates whose vectors will be subtracted are connected.

The function has three outputs: orta, ortb, Esk:

orta – a orthogonal of the resultant vector estimate
ortb – b orthogonal of the resultant vector estimate
Esk – calculated resultant vector rms

Settings table

Setting	Description	Setting range	Default value
Ampl	a multiplier vector amplitude value	(0.00÷10.00) in 0.01 increments	1.00
Kąt (Angle)	Submitted signal phase correction	(0.0÷360.0)° in 0.1° increments	0.0°

4.6.24. E_E1*E2 – product of vectors

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function for assembling the estimates of two vectors, based on orthogonal signals according to the formula: $\vec{E} = \vec{E1} \times \vec{E2}$

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has four inputs: orta1, ortb1, orta2, ortb2 to which the signal estimates outputs are connected, whose vectors will be multiplied.

The function has three outputs: orta, ortb, Esk:

- orta – a orthogonal of the resultant vector estimate
- ortb – b orthogonal of the resultant vector estimate
- Esk – calculated resultant vector rms

4.6.25. E_E1/E2 – quotient of vectors

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function for assembling the estimates of two vectors, based on orthogonal signals according to the formula: $\vec{E} = \frac{\vec{E1}}{\vec{E2}}$

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has five inputs: orta1, ortb1, orta2, ortb2, Esk2 to which the signal estimate outputs are connected, whose vectors will be divided.

The function has three outputs: orta, ortb, Esk:

- orta – a orthogonal of the resultant vector estimate
- ortb – b orthogonal of the resultant vector estimate
- Esk – calculated resultant vector rms

Settings table

Setting	Description	Setting range	Default value
Wr	Denominator limit value	(0.00÷1.00) n in 0.01 n increments	0.01 n

4.6.26. E_MUX(A) – analog channel multiplexer

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function that allows switching of analog channels.

It can be used to switch the input signal of the overcurrent protection as the primary component or the rms.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has six inputs: In.1.1, In1.2, In1.3, In2.1, In2.2, In2.3, to which two switchable sets of analog signals are connected, e.g. orta, ortb, Esk

The function has three outputs: Wy1 (Out1), Wy2 (Out2), Wy3 (Out3):

- Out1– adopts the value of In1.1 (for the InActive=In1 setting) or In2.1 (for the InActive=In2 setting)
- Out2– adopts the value of In1.2 (for the InActive=In1 setting) or In2.2 (for the InActive=In2 setting)
- Out3– adopts the value of In1.3 (for the InActive=In1 setting) or In2.3 (for the InActive=In2 setting)

4.6.27. E_MUX(S) – analog channel structure multiplexer

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The function allows to switch the analog channel structure parameter.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has two inputs: We1 (In1), We2 (In2), to which data structures are connected, such as a sample buffer from source channels or frequency.

The function has one output: Out – adopts the value of In1 (for the InActive=In1 setting) or In2 (for the InActive=In2 setting)

4.6.28. E_f(I) – frequency estimation from current signal

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The function allows to determine the frequency from the current source signal.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has one output: f - frequency value buffer.

Settings table

Setting	Description	Setting range	Default value
I_{akt}	Frequency calculation activation current	(0.10÷0.50) In in 0.01 In increments	0.20 In

4.6.29. E_f(U) – frequency estimation from voltage signal

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The function allows to determine the frequency from a voltage source signal.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function's input is a sample AC_buffer, to which the output from the analog channel (K) is connected.

The function has one output: f - frequency value buffer.

Settings table

Setting	Description	Setting range	Default value
U_{akt}	Frequency calculation activation voltage	(0.10÷0.80) Un in 0.01 Un increments	0.50 Un

4.6.30. E_f – frequency estimate from three measurements

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The function allows to determine the frequency from a three-phase signal.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has three inputs:

f1 – L1 phase frequency value buffer,
f2 – L2 phase frequency value buffer,
f3 – L3 phase frequency value buffer.

Frequency buffers calculated with E_f(I) or E_f(U) estimates are connected to the inputs.

The function has two outputs: f, f_OK

f – frequency estimate
f_OK – determined frequency correct state

The output signals are used for protection or measurement functions.

4.6.31. E_df/dt – frequency derivative estimate

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function allows to determine the frequency derivative from a three-phase signal.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has three inputs:

- f1 – L1 phase frequency value buffer,
- f2 – L2 phase frequency value buffer.
- f3 – L3 phase frequency value buffer.

Frequency buffers calculated with E_f(I) or E_f(U) estimates are connected to the inputs.

The function has two outputs: df/dt, df_OK

- df/dt – frequency derivative estimate
- df_OK – determined frequency derivative correct state

The output signals are used for protection or measurement functions.

4.6.32. E_Δf/Δt(1f) – frequency difference over a set time period (single-phase)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function allows to determine the frequency difference from a single-phase signal over a set period of time.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has one input:

- f – frequency value buffer.

A frequency buffer calculated with E_f(I) or E_f(U) estimates is connected to the inputs.

The function has two outputs: Df/Dt, Df/Dt_OK

- Df/Dt – frequency difference over a set time period
- Df/Dt_OK – sample result correct state

The output signals are used for protection or measurement functions.

Settings table

Setting	Description	Setting range	Default value
T	Measurement period	(0.02÷2.00) s in 0.01 s increments	1.00 s

4.6.33. E_Δf/Δt – frequency difference over a set time period

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function allows to determine the frequency difference from the three-phase signal during the set period of time.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has three inputs:

- f1 – L1 phase frequency value buffer,
- f2 – L2 phase frequency value buffer.
- f3 – L3 phase frequency value buffer.

Frequency buffers calculated with E_f(I) or E_f(U) estimates are connected to the inputs.

The function has two outputs: Df/Dt, Df/Dt_OK

- Df/Dt – frequency difference over a set time period
- Df/Dt_OK – sample result correct state

The output signals are used for protection or measurement functions.

Settings table

Setting	Description	Setting range	Default value
T	Measurement period	(0.02÷2.00) s in 0.01 s increments	1.00 s

4.6.34. E_dU/dt – voltage derivative estimate

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function allows to determine the voltage derivative.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has one input: Esk - primary component rms

A phase or phase-to-phase voltage estimate output with an analogous name is connected to the input.

The function has an output: dU/dt - voltage derivative estimate

4.6.35. E_PQ(1f) – power estimate (single-phase)

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The estimate allows to calculate single-phase active and reactive power.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has 4 inputs: I_orta, I_ortb, U_orta, U_ortb to connect the orthogonal current and voltage components according to the description of the inputs. Orthogonal signals are connected from the primary component estimates outputs with analogous names.

The function has two outputs: P, Q.

P – instantaneous active power estimate

Q – instantaneous reactive power estimate

The active and reactive power output signals are used for power protection, measurement functions or the recorder.

4.6.36. E_PQ(A) – Aron circuit power estimate

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The estimate allows to calculate active and reactive power calculated in the Aron circuit for a grid with an isolated neutral point.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has 8 inputs: I1_orta, I1_ortb, I2_orta, I2_ortb, U1_orta, U1_ortb, U2_orta, U2_ortb to connect the orthogonal current and voltage components according to the description of the inputs. Orthogonal signals are connected from the primary component estimates outputs with analogous names.

The function has two outputs: P, Q.

P – instantaneous active power estimate

Q – instantaneous reactive power estimate

The active and reactive power output signals are used for power protection, measurement functions or the recorder.

4.6.37. E_PQ – power estimate

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The estimate allows to calculate active and reactive power in a full three-phase system.

Numeration in the scheme: Est.1÷ ... (numeration common to all estimates)

The function has 12 inputs: I1_orta, I1_ortb, I2_orta, I2_ortb, I3_orta, I3_ortb, U1_orta, U1_ortb, U2_orta, U2_ortb, U3_orta, U3_ortb to connect the orthogonal current and voltage components according to the description of the inputs. Orthogonal signals are connected from the primary component estimates outputs with analogous names.

The function has two outputs: P, Q.

P – instantaneous active power estimate

Q – instantaneous reactive power estimate

The active and reactive power output signals are used for power protection, measurement functions or the recorder.

4.7. Measurements

Functions to read the values of measured analog signals after filtering. These include: measurements of rms of current, voltage, admittance, conductance, susceptance, resistance, reactance, impedance, active power, reactive power (instantaneous and fifteen-minute), apparent power, power factor, phase shift, as well as frequency and the degree of time-dependent characteristics calculation.
Measurements can be accessed via operator panel and through the communication protocol with the iZAZ Tools program or the host system.

Selecting a specific display unit for the primary and secondary sides causes the displayed measurement (P) to be scaled according to the following conversion factors:
nX 10^{-9} (P x 1,000,000,000 nX)
μX 10^{-6} (P x 1,000,000 μX)
mX 10^{-3} (P x 1,000 mX)
X 10^{0} (P x 1 X)
kX 10^{3} (P x 0.001 kX)
MX 10^{6} (P x 0.000001 MX)
GX 10^{9} (P x 0.000000001 GX)
where X - unit depending on the measurement type: A, V, Ω, S, W, var, VA

4.7.1. P_I – current value measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of the primary component, higher harmonics or symmetrical current components values.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has two inputs: Ip and param. The Esk output of the estimate function (Est) is connected to the Ip input. However, the output with an analogous name from the source channel should be connected to the param input, in order to correctly interpret all parameters for displaying the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Current display precision on the PP primary side	(0÷3) in 1 increments	2
Dim_p	Current display unit on the PP primary side	(nA, μA, mA, A, kA, MA, GA)	kA
Prec_w	Current display precision on the PP secondary side	(0÷3) in 1 increments	2
Dim_w	Current display unit on the PP secondary side	(nA, μA, mA, A, kA, MA, GA)	A
Prec_n	Current display precision in relative values referenced to In	(0÷3) in 1 increments	3

4.7.2. P_U – voltage value measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of the phase voltage, phase-to-phase voltage or symmetrical components values.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has two inputs: Up and param. The Esk output of the estimate function (Est) is connected to the Ip input. However, the output with an analogous name from the source channel should be connected to the param input, in order to correctly interpret all parameters for displaying the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Voltage display precision on the PN primary side	(0÷3) in 1 increments	2
Dim_p	Voltage display unit on the PN primary side	(nV, µV, mV, V, kV, MV, GV)	kV
Prec_w	Voltage display precision on the PN secondary side	(0÷3) in 1 increments	2
Dim_w	Voltage display unit on the PN secondary side	(nV, µV, mV, V, kV, MV, GV)	V
Prec_n	Voltage display precision in relative values referenced to Un	(0÷3) in 1 increments	3

4.7.3. P_Io – earth fault current value measurement

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Measurement of earth fault current from Ferranti transformer or Holmgreen circuit.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has two inputs: Io and param. The Esk output from the estimate function (Est) is connected to the Io input. However, the output with an analogous name from the source channel should be connected to the param input, in order to correctly interpret all parameters for displaying the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Current display precision on the PP primary side	(0÷3) in 1 increments	1
Dim_p	Current display unit on the PP primary side	(nA, µA, mA, A, kA, MA, GA)	A
Prec_w	Current display precision on the PP secondary side	(0÷3) in 1 increments	0
Dim_w	Current display unit on the PP secondary side	(nA, µA, mA, A, kA, MA, GA)	mA
Prec_n	Current display precision in relative values referenced to In	(0÷3) in 1 increments	2

4.7.4. P_Yo – admittance value measurement

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Measurement of admittance calculated from earth fault current and voltage.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has four inputs: Io, paramI and Uo, paramU. To the Io and Uo inputs are connected the Esk outputs of the estimate function (Est) of the earth fault current and voltage, respectively. However, the outputs with the analogous name from the source channels of earth fault current and voltage should be connected to the param inputs, in order to correctly interpret all parameters to display the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Admittance display precision on the primary side	(0÷3) in 1 increments	0
Dim_p	Admittance display unit on the primary side	(nS, µS, ms, S, kS, ms, GS)	mS
Prec_w	Admittance display precision on the secondary side	(0÷3) in 1 increments	2
Dim_w	Admittance display unit on the secondary side	(nS, µS, ms, S, kS, ms, GS)	mS
Prec_n	Admittance display precision in relative values	(0÷3) in 1 increments	3

4.7.5. P_Go – conductance value measurement

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Measurement of conductance calculated from earth fault current and voltage.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has six inputs: Io_orta, Io_ortb, paramI and Uo_orta, Uo_ortb, paramU. The orta and ortb outputs from the estimate function (Est) of the earth fault current and voltage, respectively, are connected to the Io and Uo inputs. However, the outputs with the analogous name from the source channels of earth fault current and voltage should be connected to the param inputs, in order to correctly interpret all parameters to display the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Conductance display precision on the primary side	(0÷3) in 1 increments	0
Dim_p	Conductance display unit on the primary side	(nS, µS, ms, S, kS, ms, GS)	mS
Prec_w	Conductance display precision on the secondary side	(0÷3) in 1 increments	2
Dim_w	Conductance display unit on the secondary side	(nS, µS, ms, S, kS, ms, GS)	mS
Prec_n	Conductance display precision in relative values	(0÷3) in 1 increments	3

4.7.6. P_Bo – susceptance value measurement

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Measurement of susceptance calculated from earth fault current and voltage.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has six inputs: Io_orta, Io_ortb, paramI and Uo_orta, Uo_ortb, paramU. The orta and ortb outputs from the estimate function (Est) of the earth fault current and voltage, respectively, are connected to the Io and Uo inputs. However, the outputs with the analogous name from the source channels of earth fault current and voltage should be connected to the param inputs, in order to correctly interpret all parameters to display the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Susceptance display precision on the primary side	(0÷3) in 1 increments	0
Dim_p	Susceptance display unit on the primary side	(nS, µS, ms, S, kS, ms, GS)	mS
Prec_w	Susceptance display precision on the secondary side	(0÷3) in 1 increments	2
Dim_w	Susceptance display unit on the secondary side	(nS, µS, ms, S, kS, ms, GS)	mS
Prec_n	Susceptance display precision in relative values	(0÷3) in 1 increments	3

4.7.7. P_Z – impedance value measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of impedance calculated from current and voltage.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has four inputs: I, paramI and U, paramU. The Esk outputs of the current and voltage estimate (Est) functions, respectively, are connected to the I and U inputs. However, the outputs with the analogous name from the current and voltage source channels should be connected to the param inputs, in order to correctly interpret all parameters to display the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Impedance display precision on the primary side	(0÷3) in 1 increments	0
Dim_p	Impedance display unit on the primary side	(nΩ, µΩ, mΩ, Ω, kΩ, MΩ, GΩ)	Ω
Prec_w	Impedance display precision on the secondary side	(0÷3) in 1 increments	2
Dim_w	Impedance display unit on the secondary side	(nΩ, µΩ, mΩ, Ω, kΩ, MΩ, GΩ)	Ω
Prec_n	Impedance display precision in relative values	(0÷3) in 1 increments	2

4.7.8. P_R – resistance value measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of resistance calculated from current and voltage.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has six inputs: I_orta, I_ortb, paramI and U_orta, U_ortb, paramU. The orta and ortb outputs from the current and voltage estimate (Est) functions, respectively, are connected to the I and U inputs. However, the outputs with the analogous name from the current and voltage source channels should be connected to the param inputs, in order to correctly interpret all parameters to display the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Resistance display precision on the primary side	(0÷3) in 1 increments	0
Dim_p	Resistance display unit on the primary side	(nΩ, µΩ, mΩ, Ω, kΩ, MΩ, GΩ)	Ω
Prec_w	Resistance display precision on the secondary side	(0÷3) in 1 increments	2
Dim_w	Resistance display unit on the secondary side	(nΩ, µΩ, mΩ, Ω, kΩ, MΩ, GΩ)	Ω
Prec_n	Resistance display precision in relative values	(0÷3) in 1 increments	2

4.7.9. P_X – reactance value measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of reactance calculated from current and voltage.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has six inputs: I_orta, I_ortb, paramI and U_orta, U_ortb, paramU. The orta and ortb outputs from the current and voltage estimate (Est) functions, respectively, are connected to the I and U inputs. However, the outputs with the analogous name from the current and voltage source channels should be connected to the param inputs, in order to correctly interpret all parameters to display the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Reactance display precision on the primary side	(0÷3) in 1 increments	0
Dim_p	Reactance display unit on the primary side	(nΩ, μΩ, mΩ, Ω, kΩ, MΩ, GΩ)	Ω
Prec_w	Reactance display precision on the secondary side	(0÷3) in 1 increments	2
Dim_w	Reactance display unit on the secondary side	(nΩ, μΩ, mΩ, Ω, kΩ, MΩ, GΩ)	Ω
Prec_n	Reactance display precision in relative values	(0÷3) in 1 increments	2

4.7.10. P_Zi – insulation impedance measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Impedance measurement calculated based on the function of the rotor earth fault protection relay, based on the voltages of the system in connection with iZAZ-FRC.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has one input: Zi, to which the 64R Rw and Xw function outputs are connected.

Settings table

Setting	Description	Setting range	Default value
Prec	Display precision on the primary side	(0÷3) in 1 increments	2

4.7.11. P_P – active power value measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of active power calculated from power estimate.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has three inputs: P, paramI, paramU. The P output from the power estimate function is connected to the P input. However, the outputs with the analogous name from the current and voltage source channels should be connected to the param inputs, in order to correctly interpret all parameters to display the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Active power display precision on the primary side	(0÷3) in 1 increments	1
Dim_p	Active power display unit on the primary side	(nW, μW, mW, W, kW, MW, GW)	MW

Prec_w	Active power display precision on the secondary side	(0÷3) in 1 increments	1
Dim_w	Active power display unit on the secondary side	(nW, µW, mW, W, kW, MW, GW)	W
Prec_n	Active power display precision in relative values	(0÷3) in 1 increments	2

4.7.12. P_Q – reactive power value measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of reactive power calculated from power estimate.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has three inputs: Q, paramI, paramU. The Q input is connected to the Q output from the power estimate function. However, the outputs with the analogous name from the current and voltage source channels should be connected to the param inputs, in order to correctly interpret all parameters to display the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Reactive power display precision on the primary side	(0÷3) in 1 increments	1
Dim_p	Reactive power display unit on the primary side	(nvar, µvar, mvar, var, kvar, Mvar, Gvar)	Mvar
Prec_w	Reactive power display precision on the secondary side	(0÷3) in 1 increments	1
Dim_w	Reactive power display unit on the secondary side	(nvar, µvar, mvar, var, kvar, Mvar, Gvar)	var
Prec_n	Reactive power display precision in relative values	(0÷3) in 1 increments	2

4.7.13. P_S – apparent power value measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of apparent power calculated from power estimate.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has four inputs: P, Q, paramI, paramU. The P, Q output from the power estimate function is connected to the P, Q inputs. However, the outputs with the analogous name from the current and voltage source channels should be connected to the param inputs, in order to correctly interpret all parameters to display the measurement.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Apparent power display precision on the primary side	(0÷3) in 1 increments	1
Dim_p	Apparent power display unit on the primary side	(nVA, µVA, mVA, VA, kVA, MVA, GVA)	MVA
Prec_w	Apparent power display precision on the secondary side	(0÷3) in 1 increments	1
Dim_w	Apparent power display unit on the secondary side	(nVA, µVA, mVA, VA, kVA, MVA, GVA)	VA
Prec_n	Apparent power display precision in relative values	(0÷3) in 1 increments	2

4.7.14. P_P15 – fifteen minute active power value measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of fifteen minute active power calculated from power estimate.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has three inputs: P, paramI, paramU. The P output from the power estimate function is connected to the P input. However, the outputs with the analogous name from the current and voltage source channels should be connected to the param inputs, in order to correctly interpret all parameters to display the measurement.

The measurement result is averaged for a period of 15 minutes.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Fifteen minute active power display precision on the primary side	(0÷3) in 1 increments	1
Dim_p	Fifteen minute active power display unit on the primary side	(nW, µW, mW, W, kW, MW, GW)	MW
Prec_w	Fifteen minute active power display precision on the secondary side	(0÷3) in 1 increments	1
Dim_w	Fifteen minute active power display unit on the secondary side	(nW, µW, mW, W, kW, MW, GW)	W
Prec_n	Fifteen minute active power display precision in relative values	(0÷3) in 1 increments	2

4.7.15. P_Q15 – fifteen minute reactive power value measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of fifteen minute reactive power calculated from power estimate.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has three inputs: Q, paramI, paramU. The Q input is connected to the Q output from the power estimate function. However, the outputs with the analogous name from the current and voltage source channels should be connected to the param inputs, in order to correctly interpret all parameters to display the measurement. The measurement result is averaged for a period of 15 minutes.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Fifteen minute reactive power display precision on the primary side	(0÷3) in 1 increments	1
Dim_p	Fifteen minute reactive power display unit on the primary side	(nvar, µvar, mvar, var, kvar, Mvar, Gvar)	Mvar
Prec_w	Fifteen minute reactive power display precision on the secondary side	(0÷3) in 1 increments	1
Dim_w	Fifteen minute reactive power display unit on the secondary side	(nvar, µvar, mvar, var, kvar, Mvar, Gvar)	var
Prec_n	Fifteen minute reactive power display precision in relative values	(0÷3) in 1 increments	2

4.7.16. P_cosφ – power factor value measurement

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Power factor measurement calculated from power estimate.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has two inputs: P, Q. The P, Q outputs from the power estimate function are connected to the P, Q inputs.

Settings table

Setting	Description	Setting range	Default value
Prec_n	Power factor display precision	(0÷3) in 1 increments	2

4.7.17. P_tgφ – power factor value measurement

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

Power factor measurement calculated from power estimate.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has two inputs: P, Q. The P, Q outputs from the power estimate function are connected to the P, Q inputs.

Settings table

Setting	Description	Setting range	Default value
Prec_n	Power factor display precision	(0÷3) in 1 increments	2

4.7.18. P_φ° – phase shift value measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Phase shift measurement calculated between two signals.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has four inputs: orta1, ortb1, orta2, ortb2. The orthogonal components of the signals between which the phase shift is to be calculated are connected to these inputs.

The most common is phase voltage and current.

Settings table

Setting	Description	Setting range	Default value
Prec_n	Phase shift display precision	(0÷3) in 1 increments	1

4.7.19. P_f – frequency measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Frequency measurement calculated from the frequency estimate function.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has two inputs: f, f_OK. Outputs with analogous names from the frequency estimate function are connected to these inputs.

Settings table

Setting	Description	Setting range	Default value
Prec_n	Frequency display precision	(0÷3) in 1 increments	3

4.7.20. P_ϑ°C – temperature measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Temperature measurement calculated from the temperature estimate function.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has an ϑ input, to which the output from either the temperature measurement source channel or the thermal model function is connected.

Settings table

Setting	Description	Setting range	Default value
Prec_n	Temperature display precision	(0÷3) in 1 increments	1

4.7.21. P_tz% – advancement of time characteristics measurement, %

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of the advancement of time characteristics calculated from time dependent protection functions. It allows visualization of the tripping time calculation level in percentage.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has a t(%) input, to which the output from the time dependent protection function is connected.

Settings table

Setting	Description	Setting range	Default value
Prec_n	Advancement of time characteristics display precision	(0÷3) in 1 increments	1

4.7.22. P_L – advancement of calculated start-up energy measurement or the number of discharges in the cable insulation measurement

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of the advancement of the start-up energy meter calculated from the function of protection from multiple start-ups ItR2. It allows to visualize the filling level of the multiple start-ups energy meter.

The measurement of the number of discharges in the cable insulation is determined from the failure detection function and indicates the sum of the counted discharges in the current period.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has a Lr input, to which the output from the ItR2 protection function is connected.

Settings table

Setting	Description	Setting range	Default value
Prec	Advancement of characteristics display precision	(0÷3) in 1 increments	2

4.7.23. P_tbl – remaining maximum tripping interlock time

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The measurement allows to display the time of engine protection interlock, considering the longest time of the ongoing thermal interlock.
Based on the calculated interlock times of the protection functions, the function will calculate the maximum interlock time displaying it in hh:mm:ss format in the measurements group.
The output bits will indicate the function from which the maximum interlock time is derived.

Settings table

Setting	Description	Setting range	Default value
Ic>	Setting to consider interlock from thermal model protection	(ON / OFF)	ON
IR>0	Setting to consider interlock from tripping to interlocked rotor	(ON / OFF)	ON
IR>1	Setting to consider interlock from extended start-up	(ON / OFF)	ON
IR>2	Setting to consider interlock from multiple start-ups	(ON / OFF)	ON

4.7.24. P_Δφ-SCK – frequency difference measurement over a set time period

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Shift measurement determined from the synchronism control function.

Numeration in the scheme: P.1÷ ... (numeration common for all measurements). It is possible to configure up to 64 measurement functions.

The function has one input: Δφ, to which the angle difference at the open synchronism control breaker is connected.

Settings table

Setting	Description	Setting range	Default value
Prec_n	Angle value display precision	(0÷3) in 1 increments	1

4.7.25. P_THD – harmonics analyzer

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Measurement of the higher harmonic content (up to 15 h) in relation to the analog channels (currents and voltages) primary component amplitude values.

Numeration in the scheme: THD.1÷ ... (numeration common for THD channels). It is possible to configure up to 8 THD measurement functions.

The function has one input: AC_buffer, to which a set of samples for the entire period used to connect digital filters (e.g., the primary component estimates) is connected.

4.8. Relays

In this group there are protection functions, which implement protections based on the established criterion signals, i.e. currents, voltages, power, impedance, admittance, etc.
The resultant effect of these functions is usually binary information: activation, tripping and shutdown. These signals are used to output information to the recorders and to perform message signaling and output signaling to the output relay. The most important function is to perform emergency breaker control.
Based on the available function library, multi-level protection is implemented.

Numeration in the scheme: R.1÷ ... (numeration common for all relay functions). It is possible to configure up to 64 measurement functions.

For a detailed list of functions with descriptions, see section 2 DESCRIPTION OF PROTECTION (page 10).

4.9. Logic

Functions to implement additional logic-time dependencies. These allow, based on all available logic signals, the development of additional states required in the implemented application. These include functions such as negation (NOT) sum (OR), product (AND), symmetric difference (XOR), state-memory flip-flop elements (SR and RS) and time elements.

4.9.1. NOT – negation

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with one input (In) and one output (Out). The function is implemented according to the following table:

In	Out
0	1
1	0

If there is a "1" logic state at the input, the output adopts a "0" state. For the "0" input state, it is the "1" logic state at the output.
The function has no settings.

4.9.2. AND – logical product

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with two to eight inputs (In) and one output (Out). The function is implemented according to the following table:

In1	In2	Out
0	0	0
1	0	0
0	1	0
1	1	1

If there is a "0" logic state on at least one input, the output adopts a "0" state. Only for the state where there is a "1" logic state on all inputs is there a "1" logic state on the output.

The function has no settings.

4.9.3. OR – logical sum

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with two to eight inputs (In) and one output (Out). The function is implemented according to the following table:

In1	In2	Out
0	0	0
1	0	1
0	1	1
1	1	1

If there is a "1" logic state on at least one input, the output adopts a "1" state. Only for the state where there is a "0" logic state on all inputs is there a "0" logic state on the output.
The function has no settings.

4.9.4. OR32 – logical sum, 32 inputs

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with two to thirty-two inputs (In) and one output (Out). The function is implemented according to the following table:

In1	In2	Out
0	0	0
1	0	1
0	1	1
1	1	1

If there is a "1" logic state on at least one input, the output adopts a "1" state. Only for the state where there is a "0" logic state on all inputs is there a "0" logic state on the output.

The function has no settings.
This function is used where there are more than eight input signals and the OR function is insufficient to implement a logical sum.

4.9.5. XOR – alternative

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

A function with two inputs (In) and one output (Out). The function is implemented according to the following table:

In1	In2	Out
0	0	0
1	0	1
0	1	1
1	1	0

If the inputs have different logical states, "0, 1" or "1, 0", the output adopts the "1" state. For cases where the inputs have the same logic states, "0, 0" or "1, 1" the output is a "0" logic state.

The function has no settings.

4.9.6. SR – bistable element – dominant setting

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

A function with two inputs (S1, R) and one output (Q1). The function implements the memory by setting the input with the S1 (set) control pulse. In such a case, the Q1 output will be in the "1" state until cleared by applying a control pulse to the clear the R (reset) input.

When both S1 and R inputs are active, the output adopts the "1" state - due to the dominant nature of the setting input (S1).

The SR function output states are saved when the power is shut down. These functions can be used to control automation circuits or other logic states.

The function has no settings.

4.9.7. RS – bistable element – dominant clearing

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

A function with two inputs (S, R1) and one output (Q1). The function implements the memory by setting the input with a control pulse S (set). In such a case, the Q1 output will be in the "1" state until cleared by applying a control pulse to the clear input R1 (reset).

When both S and R1 inputs are active, the output adopts the "0" state - due to the dominant nature of the clearing input (R1).

The RS function output states are saved when the power is shut down These functions can be used to control automation circuits or other logic states.

The function has no settings.

4.9.8. R_TRIG – increasing slope detector

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with one input (CLK) and one output (Q). The function detects a change in the CLK input state from "0" to "1". In this state, a pulse is generated at the output (Q).

The function has no settings.

4.9.9. F_TRIG – decreasing slope detector

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with one input (CLK) and one output (Q). The function detects a change in the CLK input state from "1" to "0". In this state, a pulse is generated at the output (Q).

The function has no settings.

4.9.10. tz – tripping delay

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with one input (In) and one output (Out). The function implements a time delay of the increasing slope. When the "1" state is applied to the input (In) after the set time t counts down, the "1" state appears on the output (Out) and persists until the input (In) state changes to "0".

If the input state changes to "0" during the countdown of the delay time, the counting circuit is cleared and the delay time is counted anew when the input is set to "1" again.

Settings table

Setting	Description	Setting range	Default value
t	Trip delay	(0.00÷100.00) s in 0.01 s increments	1.00 s

4.9.11. tp – return delay

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with one input (In) and one output (Out). The function implements a time delay of the decreasing slope. When the "1" state is applied to the input (In), the "1" state appears on the output (Out) and the change to "0" will occur after the set time t counts down after the input state changes to "0".

If the input state changes to "1" during the countdown of the delay time, the counting circuit is cleared and the clearance delay time is counted anew when the input is set to "0" again.

Settings table

Setting	Description	Setting range	Default value
t	Return delay	(0.00÷100.00) s in 0.01 s increments	1.00 s

4.9.12. ti – pulse generator

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with one input (In) and one output (Out). The function implements a "1" pulse at the output with a duration according to the t setting after the occurrence of an increasing slope at the input.

The duration of input driving has no effect on the pulse at the output with a duration according to the t setting.

Settings table

Setting	Description	Setting range	Default value
t	Pulse duration	(0.00÷100.00) s in 0.01 s increments	1.00 s

4.9.13. ts – pulse adder

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with one input (In) and two outputs (Out and t(%)). The function counts the durations of "1" states on the input (In) with the condition that the interval between consecutive activations does not exceed the tr set value. If the interval between consecutive activations is longer than the tr setting time, the adder counter is cleared and the input activations are counted anew.

When the total activations exceed the tz setting, the "1" state appears on the output (Out).

It should be noted that after the output is controlled, the de-energization will occur only after the tr time is counted down, after the state on the input changes to "0", which means that the function will act like a return delay with the tr setting.

The t(%) output allows to derive a measurement of the counting state of the summation time by connecting the P_tz% measurement function - measuring the advancement of the % time characteristics.

Settings table

Setting	Description	Setting range	Default value
tz	Trip delay	(0.00÷100.00) s in 0.01 s increments	1.00 s
tr	Reset time	(0.00÷100.00) s in 0.01 s increments	1.00 s

4.9.14. MULTI – input branching to outputs selected by the setting

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with one input (In) and eight outputs (Out). The function allows to duplicate (output) the input state (In) to the outputs (Out) selected by the "podłączone" (connected) setting.

Settings table

Setting	Description	Setting range	Default value
OUT1_ON/OFF	Output 1 state setting	(disconnected/connected)	disconnected
OUT2_ON/OFF	Output 2 state setting	(disconnected/connected)	disconnected
OUT3_ON/OFF	Output 3 state setting	(disconnected/connected)	disconnected
OUT4_ON/OFF	Output 4 state setting	(disconnected/connected)	disconnected
OUT5_ON/OFF	Output 5 state setting	(disconnected/connected)	disconnected
OUT6_ON/OFF	Output 6 state setting	(disconnected/connected)	disconnected
OUT7_ON/OFF	Output 7 state setting	(disconnected/connected)	disconnected
OUT8_ON/OFF	Output 8 state setting	(disconnected/connected)	disconnected

4.9.15. SW_OUT – switching the input to the output selected by the setting

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with one input (In) and eight outputs (Out). This function allows to redirect the input state (In) to the output (Out) selected by the nr_OUT (OUT_number) setting.

Settings table

Setting	Description	Setting range	Default value
nr_OUT (OUT_number)	Active output selection	(In->Out1÷8)	In->Out1

4.9.16. SW_IN – transcription of the state from the input selected by the setting

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A feature with eight inputs (In) and one output (Out). The function allows to redirect the input state (In) according to the nr_IN (IN_number) setting to the output (Out).

Settings table

Setting	Description	Setting range	Default value
nr_IN (IN_number)	Active input selection	(In1÷8->Out)	In1->Out

4.9.17. UGATE – setting-modified AND / OR gate

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A feature with eight inputs (In) and one output (Out). The function allows the implementation of logical functions of OR sum or AND product according to the OR/AND setting based on the inputs for which the setting is IN_ON/OFF=podłączone (IN_=connected).

Settings table

Setting	Description	Setting range	Default value
IN1_ON/OFF	Input 1 connection	(disconnected/connected)	disconnected
IN2_ON/OFF	Input 2 connection	(disconnected/connected)	disconnected
IN3_ON/OFF	Input 3 connection	(disconnected/connected)	disconnected
IN4_ON/OFF	Input 4 connection	(disconnected/connected)	disconnected
IN5_ON/OFF	Input 5 connection	(disconnected/connected)	disconnected
IN6_ON/OFF	Input 6 connection	(disconnected/connected)	disconnected
IN7_ON/OFF	Input 7 connection	(disconnected/connected)	disconnected
IN8_ON/OFF	Input 8 connection	(disconnected/connected)	disconnected
OR/AND	function type	(OR/AND)	OR

4.9.18. STATE – state setting

iZAZ200	iZAZ300	iZAZ400	iZAZ600

Function without input, with a Stan (State) output. The function allows to enable/disable the state through the Stan (State) setting.

Settings table

Setting	Description	Setting range	Default value
Stan (State)	output state	(ON / OFF)	OFF

The function allows to enter the state setting with the possibility of individual name in the configuration. It can be used to switch on/off logic circuits.

4.9.19. CHB – changing the set of settings

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with one input. The "1" state on the input immediately switches the set of settings to the number established by the setting. It is possible to change the primary, reserve, or current set (depending on the setting).

Settings table

Setting	Description	Setting range	Default value
P/R/B	Edited set	(primary, reserve, current	current
Nr (No.)	Target set number	(0÷8) in 1 increments	0

4.9.20. BCD - BCD decoder

iZAZ200	iZAZ300	iZAZ400	iZAZ600

A function with 8 logic inputs ("bit.0..7) and one analog output ("Wynik" (Result)). The output is the value calculated from decoding the input state bit record in BCD code. The next input state counted from the first corresponds to the states of the next bits of the byte counted from bit 0.

4.10. Automation

A group of functions implementing various automations, such as SPZ, SPZpoSCO, SCK, SZR, or LRW. Based on internal logic signals, automation functions calculate output states in the form of binary outputs.

Numeration in the scheme: A.1÷ ... (numeration common for all automation functions).

For a detailed list of functions with descriptions, see section 3 (page 126).

4.11. Meters

Functions for counting binary or analog states with a memory chip. They allow counting a variety of binary states based on all available logic signals. In addition, the group includes energy meters, breaker cumulative currents meter and a timer.

4.11.1. wy_L - counter

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The function responds to the slope of the logic function output states assigned to the input of a given counter.
In a typical configuration, the counters are used to count the number of trippings of protection functions, automations, activations of binary inputs (e.g., as external protections, or as a change in the breaker position), as well as the number of emergency controls for breaker shutdown.

Numeration in the scheme: C.1 ÷ C.64.

The function has one input: P to connect a binary signal, the increasing slope of which will cause the counter to be calculated.

The function has one output: P – exceeding the set start-up value Lr, which is activated for the of the active threshold function relay = ON setting.

Settings table

Setting	Description	Setting range	Default value
Lr	Signaling start-up value	(0÷65000) in 1 increments	200
ON/OFF	Threshold function relay activity	(ON / OFF)	ON

When the set value is exceeded, the relay function output is activated, which is typically configured for the event recorder. Signaling can be expanded by lighting an LED, controlling an output relay and displaying a text message on the display.

4.11.2. wy_E - electricity meters

iZAZ200	iZAZ300	iZAZ400	iZAZ600

The device provides meters for measuring energy based on estimates of measured currents and voltages. Measurement is typically made based on three currents and three phase voltages. It is possible to implement measurement in the Aron circuit (two phase currents and two phase-to-phase voltages), and it is also possible to configure single-phase power measurement (phase current and voltage). The measurement choice is based on the power determination estimate function used.

Numeration in the scheme: E.1 ÷ E.4.

The function has four inputs: P, Q, param_I, param_U to which the outputs of the power determination estimate are connected, as well as the outputs of the source channels conveying information about the parameters of the channels enabling correct energy conversions.

Settings table

Setting	Description	Setting range	Default value
Prec_p	Energy display precision - primary side	(0, 1, 2, 3)	1
Dim_p	Energy display unit - primary side	(W(var)h, kW(var)h, MW(var)h, GW(var)h)	MWh
TRYB (MODE)	Meter activity	(Counting/Stopped)	Counting

The display precision determines the accuracy with which the energy measurement is made:

For Prec_p = 0 - meter in 9999999 format
For Prec_p = 1 - meter in 999999.9 format
For Prec_p = 2 - meter in 99999.99 format
For Prec_p = 3 - meter in 9999.999 format
The measurement format depends primarily on the Dim_p setting, through which the order of the measurement value is set.

The energy meter is represented by the following values:
- inflowing active energy value (Ec+),
- outflowing active energy value (Ec-),
- inflowing reactive energy value - inductive (Eb+),
- outflowing reactive energy value - capacitive (Eb+)

4.11.3. wy_PKW - breaker cumulative current meter

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The function allows summing the operating load currents and short circuit currents, shut down in each phase by the breaker. The PKW meters function allows diagnostics of the breaker operation. The meter value is given in multiples of the assembly's rated current. Counting is done with an accuracy of 0.01 In. The state of exceeding the set value is indicated by a text message and an event. Signaling can be expanded by lighting up the LED and by controlling the output relay.

Numeration in the scheme: PKW.1 ÷ PKW.16.

The function has two inputs: P, I to which are connected the information about the breaker shutdown (P) and the output of the current rms estimate, which will be counted when the breaker opens.

The function has one output: P – exceeding the set start-up value Lr, which is activated for the of the active threshold function relay = ON setting.

Settings table

Setting	Description	Setting range	Default value
In	Signaling start-up value	(1÷100,000) In in 1 In increments	200 In
ON/OFF	Function activity	(ON / OFF)	ON

4.11.4. wy_M - timer

iZAZ200	*iZAZ300*	*iZAZ400*	*iZAZ600*

The function allows counting the time of operation, for example, engine or power on.

Numeration in the scheme: M.1 ÷ M.8.

The function has one input: Pob - timer activation. During an active input, the function counts the counter time.

The function has one output: P - exceeding the set threshold value tr, which is activated for the setting of the active threshold function relay = ON.

Settings table

Setting	Description	Setting range	Default value
tr	Signaling start-up value	(1÷100,000) h in 1 h increments	1,000 h
ON/OFF	Function activity	(ON / OFF)	ON

4.12. Events

Functions in this group allow to output a signal to the event recorder and create groups of events to give additional attribute to selected (e.g. most important) events.

For a detailed description of the event recorder, see the DTR of each device.

4.12.1. zb_ARZ – set of events

The function provides the ability to specify an attribute in the events used in the configuration.

Numeration in the scheme: zb_ARZ.1 ÷ zb_ARZ.32.

The function has no settings, inputs or outputs.

4.12.2. zd_ARZ – event

The function provides the ability to record the logic state change at a selected location of the device's operation logic.

Numeration in the scheme: zd_ARZ.1 ÷ zd_ARZ.128.

The function has a Stan (State) input, which connects to any logic node in the configuration to enable recording a change in logic state at a selected logic location.

Assigning any function name, when the logical state changes, a time-stamped event with an accuracy of 1 ms is generated with the entered custom name and description:

"0" -> "1": ON

"1" -> "0": OFF

Most often, the function is used to record events from tripping, activation and deactivation of protection functions, as well as to change the binary input state or automation function operation logic.

4.13. Disturbance recorder

It is possible to configure two disturbance recorders in the iZAZ200, iZAZ300, iZAZ400, iZAZ600 assemblies.
To enable the analog and binary channels recording, there are corresponding functions, which placed in the logic provide the ability to configure the recorders settings.

For a detailed description of the settings and operation of the recorder, see the DTR of each device type.

4.13.1. REC – multifunctional disturbance recorder

The disturbance recorder function allows analog and binary signals to be recorded at any activation, such as from emergency control or breaker opening.

Numeration in the scheme: REC.1, REC.2

The function has two inputs: P, R.

P – recorder activation

Q – recorder dilution

Recorder activation is usually implemented by connecting an emergency control signal to the P input for breaker shutdown. There are no contraindications to the use of other signals for recorder activation, such as the protection activation or change in the state of two-state inputs or the automation tripping.

Nevertheless, it is important to consider the nature of the expected duration of the activation signal, so as not to obtain a state of continuous recording of the recorder (such as continuous function activation). Hence, for signals that may exist as an active state longer than the expected record of the recorder, the logical slope function R_TRIG should be used.

Settings table

Setting	Description	Setting range	Default value
tp	Pre-run time	(0.00÷100.00) s in 0.01 s increments	0.10 s
tw	Run-out time	(0.00÷100.00) s in 0.01 s increments	0.20 s
tmax	Maximum recording time	(0.00÷100.00) s in 0.01 s increments	2.00 s
kr	Dilution level	(0 ÷ 24) in 1 increments	3
ofs	Signaling overflow threshold	(50÷100)% in 1% increments	80%
ofa	Operation when memory is full	(overwriting/stopping)	overwriting
ON/OFF	Function activity	(ON / OFF)	ON

4.13.2. RCA – analog output for recording

Analog channel recording function that allows to select a particular function in the REC recorder settings for recording.

Numeration in the scheme: RCA.1, RCA.256

The function has one input: WA - analog signal for recording, to which outputs from the source channel function (sample) or estimate (orta or Esk) are usually connected.

It is possible to record not only source signals of currents, voltages but also recalculated estimates, e.g. power, frequency.

The function inherits the settings from the connected channel for registration, however, it is possible to correct the channel settings.

Settings table

Setting	Description	Setting range	Default value
pri	rated value on the primary side	according to parameters of connected channel	
sec	rated value on the primary side	according to parameters of connected channel	
REC1	Activity in recorder 1	(ON / OFF)	ON
REC2	Activity in recorder 2	(ON / OFF)	ON

4.13.3. RCB – binary output for recording

Binary channel recording function, which allows to select a particular function in the REC recorder settings for recording.

Numeration in the scheme: RCB.1, RCB.512

The function has one input: WB - a binary signal for recording, to which outputs from protection functions are most often connected: activations, tripping and states of binary inputs or automation actions.

Settings table

Setting	Description	Setting range	Default value
REC1	Activity in recorder 1	(ON / OFF)	ON
REC2	Activity in recorder 2	(ON / OFF)	ON

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RELATED DOCUMENTS:

5000.51.02.00.Fx.009 iZAZ200 technical and operating documentation

5000.51.03.00.Fx.009 iZAZ300 technical and operating documentation

5000.51.04.00.Fx.009 iZAZ400 technical and operating documentation

5000.51.06.00.Fx.009 iZAZ600 technical and operating documentation

Questions regarding the operation of iZAZ family devices and this description should be sent to the manufacturer's address:

ZAZ-En sp. z o.o. , ul. Marii Konopnickiej 13, 41-100 Siemianowice Śląskie, Poland
tel. +48 32 726 69 23, fax +48 32 494 48 85
biuro@zaz-en.pl, http://zaz-en.pl

http://zaz-en.pl

ZAZ-En sp. z o.o. , ul. Marii Konopnickiej 13, 41-100 Siemianowice Śląskie
tel. +48 32 726 69 23, faks +48 32 494 48 85
biuro@zaz-en.pl