MainsPro

Mains Decoupling Protection Relay

Comprehensive Guide

SW version 1.0, May 2010

Installation and Operation Guide
Application Guide
Reference Guide

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Purpose of the MainsPro manuals

Installation and Operation Guide

The Installation and Operation Guide serves for the personnel, providing installation of the MainsPro unit. It contains wiring and setting instructions, needed for service and commissioning of the unit. It also contains introduction of the user interface and necessary procedures to perform setting and operating of the unit. Though MainsPro is very simple and intuitive for the operating personnel, we recommend to keep one copy of this manual available permanently at the installation site, where MainsPro unit is installed, to facilitate the necessary service and operation tasks.

Application Guide

The Application Guide serves for the designers and engineers, who process the necessary documentation and implementation procedures on the installation site, where MainsPro is installed. It contains detailed description of MainsPro functionalities and practical application of MainsPro functionalities.

Reference Guide

The Reference Guide contains library of setpoints, inputs and outputs functionalities and technical data for the purpose of detailed technical information. This information is referenced in the Installation and Operation Guide and Application Guide.

MainsPro

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Installation and Operation Guide

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Table of contents

Introduction

Congratulations to your purchase of ComAp MainsPro unit! MainsPro is a microprocessor-based protective relay, providing a comprehensive set of protective and supplementary functionalities. The basic protective functions are:

- Voltage
- Frequency
- Loss of mains

This covers the basic requirements for mains-decoupling (inter-tie, „G59/2“) protection, but allows also usage in many applications where benefits of the unit's unique functionality is needed.

Purpose of this manual

The Installation and Operation Guide serves for the personnel, providing installation of the MainsPro unit. It contains wiring and setting instructions, needed for service and commissioning of the unit. It also contains introduction of the user interface and necessary procedures to perform setting and operating of the unit. Though MainsPro is very simple and intuitive for the operating personnel, we recommend keeping one copy of this manual available permanently at the installation site, where MainsPro unit is installed, to facilitate the necessary service and operation tasks.

Conformity declaration

CE

Following described machine complies with the appropriate basic safety and health requirement of the EC Low Voltage Directive No: 73/23 / EEC and EC Electromagnetic Compatibility Directive 89/336 / EEC based on its design and type, as brought into circulation by us.

Warnings

Be aware that the relay outputs can change state during and after the unit setting (before the unit is used again ensure that the proper setting is done)!!!

Be aware that the devices connected to binary outputs of the unit may operate upon disconnection of power supply, measurement inputs and/or binary inputs!!!

!!! CAUTION !!!

Dangerous voltage

In no case touch the terminals of voltage measurement!

Adjust set points

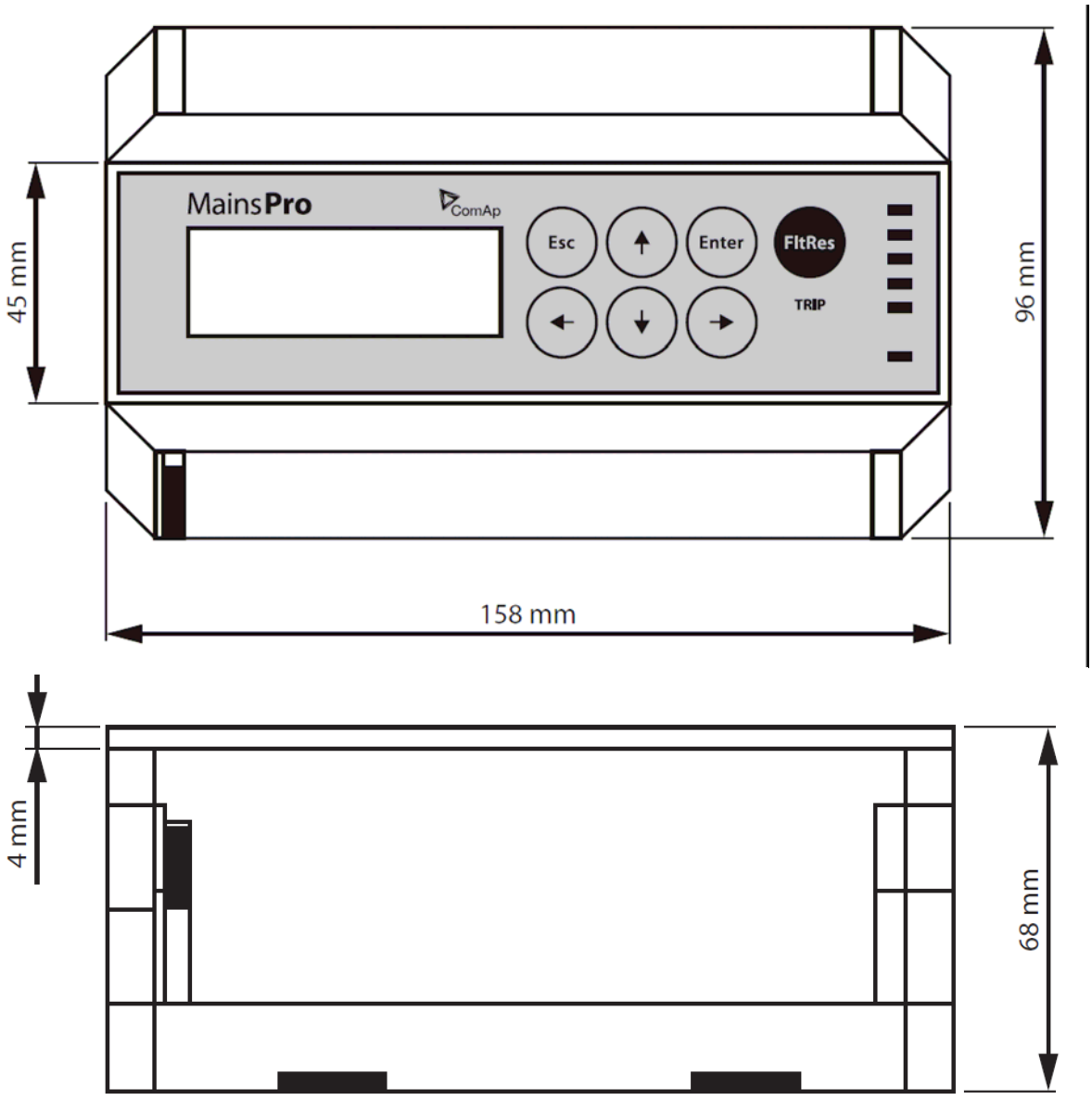
All setpoints are pre-adjusted to their typical values. Before putting into operation, the setpoints must be checked and/or adjusted to the required values.

Installation may be done by qualified personnel only.
To avoid personal injury do not perform any action not specified in this guide!!!

Note:
ComAp believes that all information provided herein is correct and reliable and reserves the right to update at any time. ComAp does not assume any responsibility for its use unless otherwise expressly undertaken.

Installation data

Dimensions



List of terminals

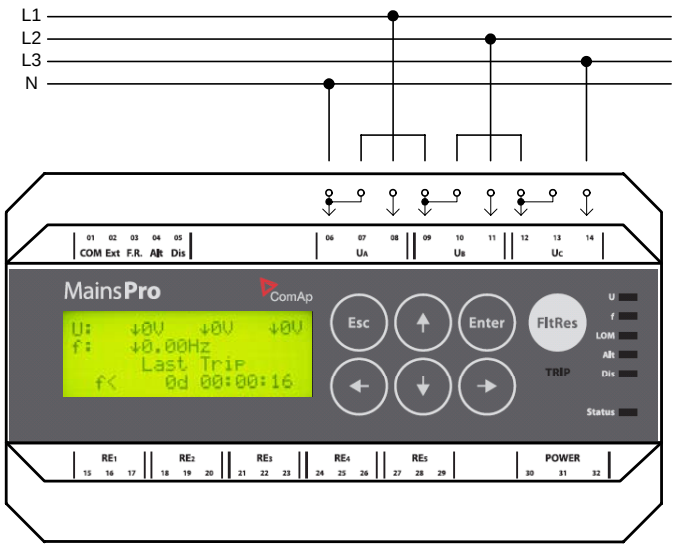
BI0	Binary switches – COM terminal
BI1	External trip binary switch
BI2	Remote Fault reset binary switch
BI3	Alternative settings binary switch
BI4	Disable binary switch
UA1 to 3	First set of voltage measurement terminals (Ua). Terminals UA1 and UA2 are internally interconnected
UB1 to 3	Second set of voltage measurement terminals (Ub). Terminals UB1 and UB2 are internally

	interconnected
UC1 to 3	Third set of voltage measurement terminals (Uc). Terminals UC1 and UC2 are internally interconnected
12, 22, 32, 42, 52	RE1-5 relay contact – common
14, 24, 34, 44, 54	RE1-5 relay contact – normally closed (during fault-free conditions maintained in open position)
11, 21, 31, 41, 51	RE1-5 relay contact – normally open (during fault-free conditions maintained in closed position)
AC2	Power supply – high range 85-265 VAC / 110 – 370 VDC.
+	Power supply – low range 8 – 40 VDC. Connect + pole to this terminal.
AC1/-	Common terminal for power supply. In case of DC supply, connect – pole to this terminal.

Wiring

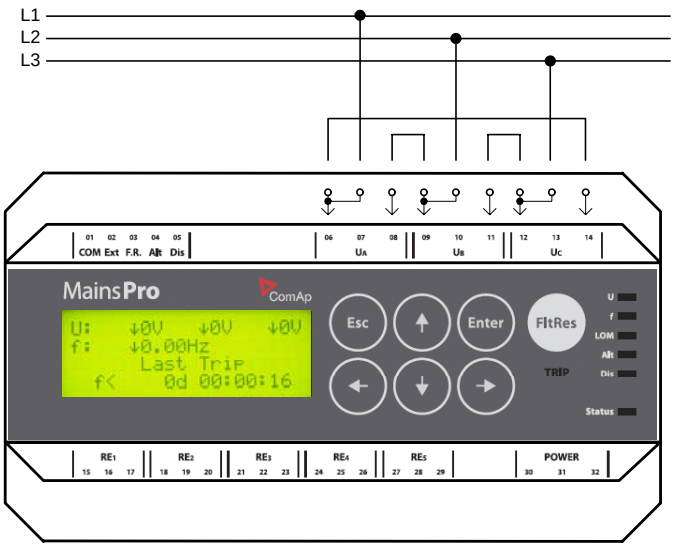
"Wye" connection

If used for rated voltage 230 VAC ph-ground, set the setpoint Basic: Uin is to **230/**400V, for systems with rated voltage 120VAC ph-ground, set the setpoint Basic: Uin is to **120V**. No additional setting is necessary for indication of "Wye" connection - MainsPro provides automatic detection of phase-ground voltage measurement. MainsPro provides over-range to 130% of the rated voltage, i.e. 300 VAC for 230 V system and 156 V for 120 V system with no change of measurement accuracy.



"Delta" connection:

In this arrangement, MainsPro is rated for 400 VAC ph-ph with over-range to 130% = 520 VAC with no change of measurement accuracy. Setpoint Basic: Uin is to be set to **230/400V**, no additional setting is necessary for indication of "Wye" connection. MainsPro provides automatic detection of phase-phase voltage measurement.

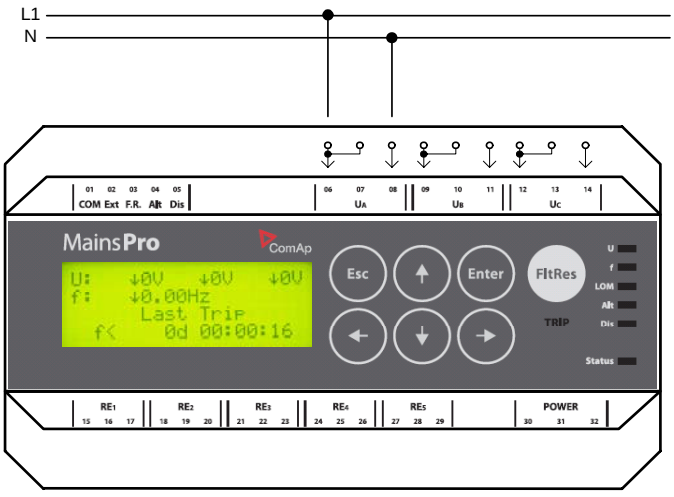


Connection with voltage transformers

MainsPro allows to connect HV or other measurement transformers with secondary rated voltage 100V. Provide the "Wye" or "Delta" arrangement on the primary windings of the transformers and connect the secondary 100 V to the MainsPro measurement inputs. Setpoint Basic: Uin is to be set to **120V**. This setting provides the guaranteed measurement accuracy for the 100V inputs with over-range to 120V * 130% = 156 VAC.

Single-phase connection

MainsPro provides support for single-phase applications. Use the U_A terminals to connect the measured voltage to the unit and set the setpoint Basic: System to **1ph**. Use the same setting of rated voltage selection as mentioned above.

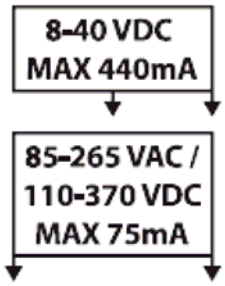


Power supply range

MainsPro provides set of 3 terminals for the purpose of dual power supply range:

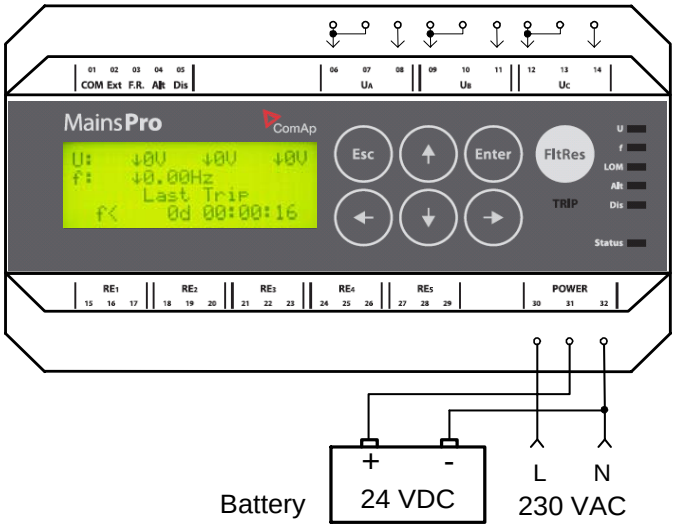
- 8 - 40 VDC: use the terminals + and AC1/-
- 8 - 265 VAC / 110-370 VDC: use the terminals AC2 and AC1/-. The unit accepts both polarities of the DC power supply.

For proper connection of the power supply, see also the printed sign on the MainsPro unit:



Note:

It is possible to connect both power supply ranges at the same time. Any DC or AC voltage may be applied to the higher power supply voltage range. Appropriate attention has to be paid to the potential interconnection of the independent power supply circuits. If the lower range DC power supply is below 30 V DC, no current is consumed on the terminal +, and it serves as a redundant backup power supply in case of the high-range power supply failure. This arrangement may be used for higher reliability of the unit operation. For wiring in this arrangement, follow the diagram below:



Relay outputs connection

For safety purposes, all MainsPro relay outputs use the inverse logic for failures trips and signaling. This means that in case of fault-free state all contacts are kept in energized position. In trip or out-of-range signaling state, the contacts de-energize. In case of power-supply fail, the unit automatically moves to fault-signaling by de-energizing the output relays, assuring safety disconnection of the controlled devices.

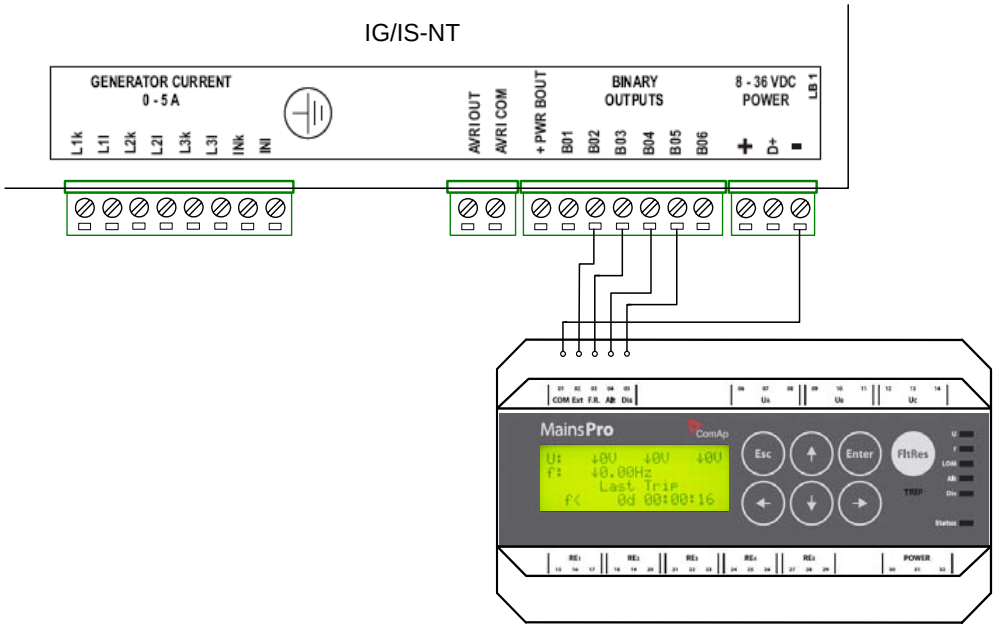
Relay outputs in MainsPro are freely assignable by the setpoints f(RE).

- In default configuration, RE1 serves as the permanently energized common trip output contact (ComTrpPer). Use this contact to operate the connector devices with permanently energized inputs.
- In default configuration, RE2 serves as an impulse common trip contact (Com Trp Imp). Use this contact to operate e.g. opening or UV coil of circuit breakers.
- Remaining 3 relay outputs serve for signaling of any sensed failure.
- The arrangement of RE1 to 4 outputs in default configuration corresponds to the functionality of the previous NPU-FUV unit outputs.

Binary switches connection

MainsPro provides 4 galvanically isolated binary switches with fixed functionality. These inputs allow connection of any voltage free contact between the common terminal BI0 and the appropriate functional contact. Due to galvanic isolation, open collector contacts may also be connected to the binary switches, with the COM terminal connected to the common high or low potential of the connected switches, depending on the technology of the connected device.

On the picture below, see the example of interconnection of MainsPro binary switches to IG-IS-NT controller. The IG/IS-NT outputs technology switches the output terminal to negative power supply potential when activated. For this reason the (-) terminal has to be interconnected with MainsPro BIC terminal. Please note that this is just a principle example. The appropriate logical functions have to be implemented and configured at the controller terminals.

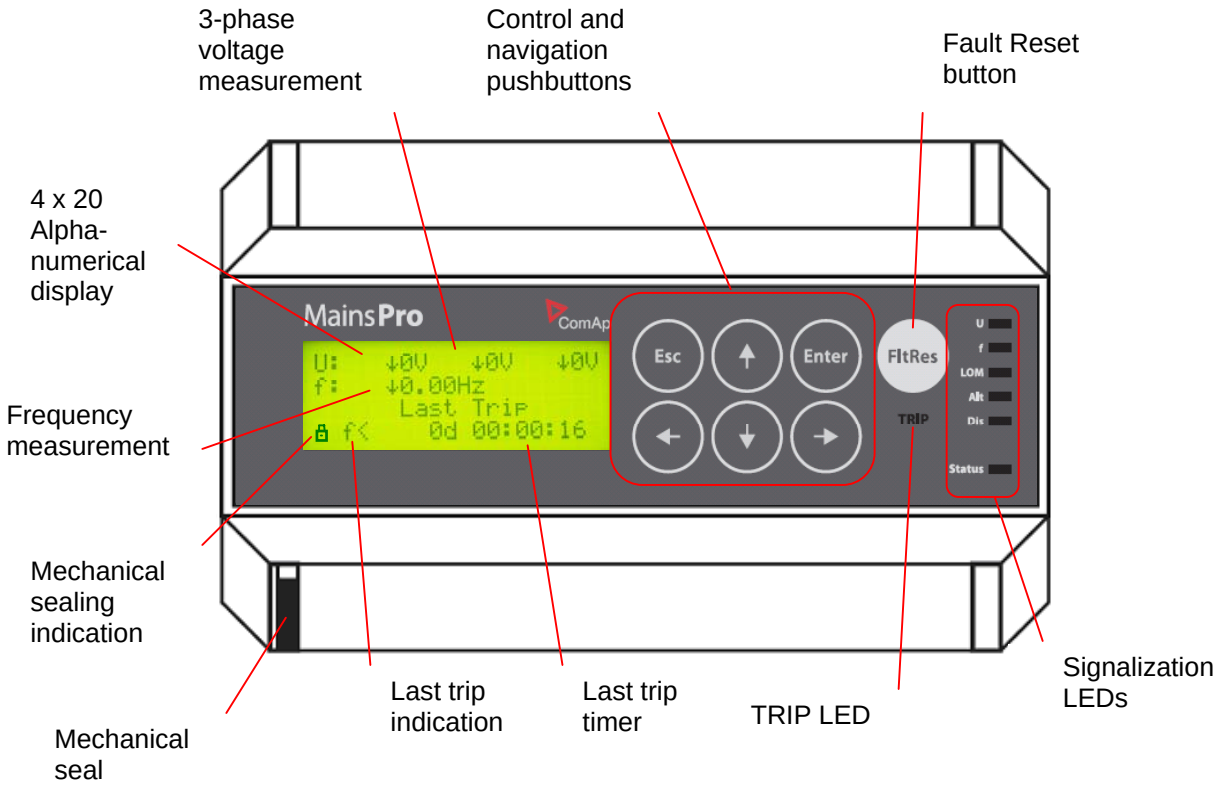


Measurement range

MainsPro allows using multiple voltage ranges on the measurement inputs with unchanged measurement accuracy. The following ranges are applicable:

- 230 V - this range applies in case of "star" connection of the 3-phase system using nominal 230V phase to neutral. It may be also used for single-phase applications 230V phase to neutral. Overshoot by 30% up to 290V is possible for this measurement range. For this case, set the setpoint Basic: Uin to 230/400V. MainsPro will adjust automatically the measurement method, to assure the defined accuracy for the measured voltage 230 V.
- 400 V - this range applies in case of "delta" connection of the 3-phase system using nominal 400V phase to phase. Overshoot by 30% up to 520V is possible for this measurement range. For this case, set the setpoint Basic: Uin to 230/400V. MainsPro will adjust automatically the measurement method, to assure the defined accuracy for the measured voltage 400 V.
- 120 V - this range is applicable in countries using 120 V nominal voltage phase to neutral. Another application is for the high-voltage and other applications, using voltage transformers from rated voltage to 100 V. The guaranteed accuracy applies to both ranges 100 and 120 V. Overshoot by 30% up to 156V is possible for this measurement range. For this case, set the setpoint Basic: Uin to 120V.

User interface



Control and navigation Pushbuttons - basic operation

- In the measurement screens, use the  and  arrow buttons to browse through the measured values as displayed on the 4x20 alphanumerical display. See the chapter Measurement screens to get the basic orientation.
- To enter the setpoints menu, Push the  button. For setpoints change, see the following chapter.
- To enter the init screen, perform factory default reset, reset statistics or enter the Test mode, push the  and  at the same time. Together with the init screen display, the nit performs lamp test by simultaneous cycling of all LEDs through all indication colors.
- For confirmation of any value change or query, use the  button.
- For leaving any value change or query screen without change, use  button.
- From any screen, press and fold the  button for 2 seconds to return back to the main measurement screen (homepage).

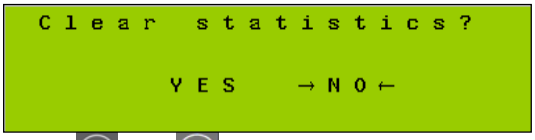
Setpoints change:

1. Push the  button to open the setpoints menu.
2. By buttons  and  browse through the menu. The setpoint groups are displayed in the cycling order, i.e. from the last setpoint group by button  , the cursor moves to the first group and vice versa.

3. By button or , enter the setpoint group, by button , move one level up in the setpoint tree. The setpoints are displayed in the cycling order, i.e. from the last setpoint by button , the cursor moves to the first one and vice versa.
4. If standing on a setpoint, the setpoint change screen opens by pressing or . In the screen, see the setpoint limits at the lowest row of the screen.
5. The change is done by orders, starting form the least important digit. Use the buttons and to move between the digits. Use the buttons and to edit the digit. Please note, that the value is not limited by the parameters limits during editing, but if an out-of-limits value is set-up, it will not be allowed to store in the unit memory (the change may not be confirmed).
6. After the setpoint change is done, press to confirm the set value, or to leave the setpoint change screen without saving the changes.
7. **Please note**: the unit allows mechanical sealing of the setpoints by the black switch in left-bottom corner of the unit. If locked, the icon of closed padlock will appear on the position of setpoint change and the setpoints may not be changed. Also, the padlock icon will be seen on the "homepage" measurement screen. Once the setpoint change screen is entered and afterwards the sealing position is changed, the padlock indication is not changed, but the internal lock is applied immediately.

Reset trip counters

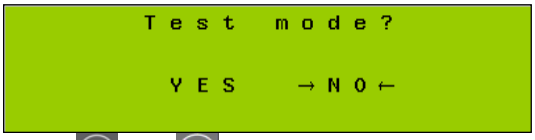
1. Enter the init screen, by pushing the and at the same time.
2. Press to enter the Clear Statistics dialog screen:



3. Using and do your selection. By selecting YES, all trip counters will be reset. Press to confirm your selection.
4. By selecting NO and pressing or by pressing , return to the measurement screens with no change.

TEST mode activation

1. Enter the init screen, by pushing the and at the same time.
2. Press and to enter the Test mode activation screen:

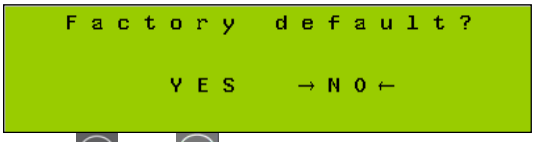


3. Using and do your selection. By selecting YES, you will activate the TEST mode - see the chapter TEST mode in Application Guide. Press to confirm your selection.
4. By selecting NO and pressing or by pressing , return to the measurement screens with no change.

Factory default

MainsPro contains a default set of all setpoints, which corresponds to the typical requirement of distribution network operator in some countries.

1. Enter the init screen, by pushing the and at the same time.
2. Press and to enter the Factory default activation screen:



3. Using ◄ and ► do your selection. By selecting YES, you will return all previously done setting to the default values. **Please note that by this selection, you will loose all setting done prior to this operation!** Press Enter to confirm your selection.
4. By selecting NO and pressing Enter or by pressing Esc, return to the measurement screens with no change.

Mechanical sealing

MainsPro allows to mechanically prevent the setting changes by securing the mechanical seal in locked position by sealing wire. The locked position is indicated at the MainsPro side-print and on the alphanumerical display.

Signalization LEDs

- There are 7 LEDs for indication of MainsPro status with the meaning indicated in the table below:
- In case of signaling different statuses by one LED, the following priorities apply, i.e. the higher priority signal is provided by the LED:
    1. Red flashing
    2. Red
    3. Orange flashing
    4. Orange
    5. Green
- **Please note:** the U and f signalization is immediate at detection of fault conditions, regardless of the set delay for the unit trip. After the conditions get back to the fault-free state, the LEDs may move back to green color, regardless of whether the unit is currently in TRIP status.
- Indication of LED LOM is immediate at detection of the particular protection stage (Vector shift or ROCOF) and fault indication remains active for the period of time, set by the setpoint Basic: Imp Len Del.
- TRIP signalization is delayed according to the particular delay of the appropriate protective stage.

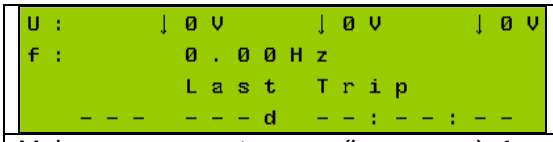
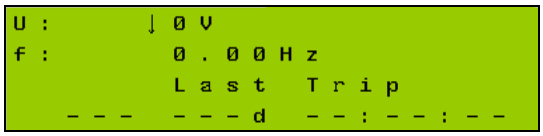
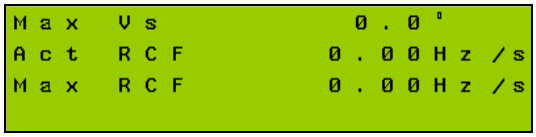
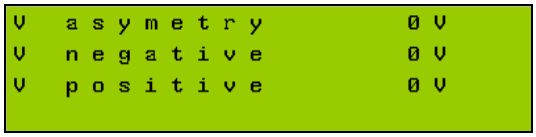
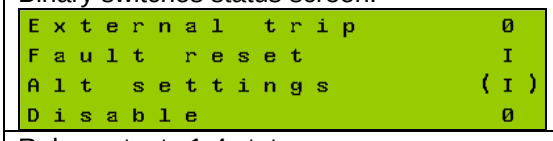
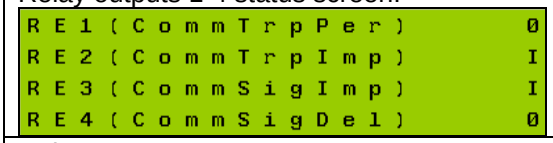
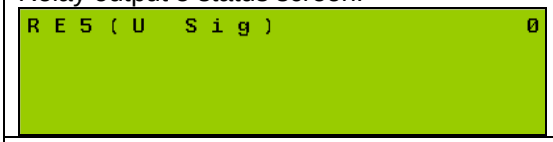
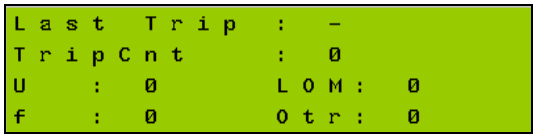
Meaning of signaling LEDs		
LED	**Color**	**Meaning**
TRIP	Red	The unit has the appropriate outputs in TRIP position and the unit is sensing a fault situation
	Red flashing	The unit has the appropriate outputs in TRIP position, but the unit is sensing fault-free situation. Fault reset is possible.
	Nothing	The unit has no output in TRIP position
U	Red flashing	Voltage of any phase is above threshold for 1st or 2nd stage overvoltage
	Red	Voltage of any phase is under threshold for 1st or 2nd stage undervoltage
	Orange flashing	Voltage unbalance (amplitude) is indicated.
		If activated together with LED f and LOM, indicates incorrect phase rotation
	Orange	Negative sequence overvoltage or Positive sequence undervoltage is indicated.

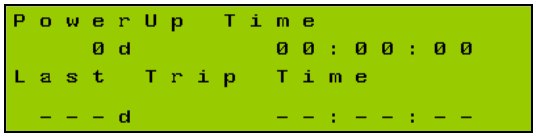
Meaning of signaling LEDs		
LED	**Color**	**Meaning**
		If activated together with LED f and LOM, indicates incorrect polarity of one phase
	Green	All voltages are in fault-free state
	Nothing	Over/under voltage protections are not enabled by setpoint and no other voltage failure is sensed
f	Red flashing	Frequency as sensed on terminals Ua is above threshold for 1st or 2nd stage overfrequency
	Red	Frequency as sensed on terminals Ua is under threshold for 1st or 2nd stage underfrequency
	Orange flashing	Together with LED U and LOM, indicates incorrect phase rotation
	Orange	Together with LED U and LOM, indicates incorrect polarity of one phase
	Green	Frequency, rotation and phases polarity are in fault-free state
	Nothing	Over/under frequency is protections are not enabled by setpoint and no other indicated failure is sensed
LOM	Red	Vector shift or ROCOF protection was indicated and Fault reset was not yet done
	Orange flashing	Together with LED U and f, indicates incorrect phase rotation
	Orange	Together with LED U and f, indicates incorrect polarity of one phase
	Nothing	None of Vector shift or ROCOF failure is detected or neither Vector shift nor ROCOF protections are not enabled by setpoint and no other indicated failure is sensed
Status	Red flashing	Indication of severe internal failure. Contact ComAp technical support!
	Orange flashing	Indication of internal failure. Contact ComAp technical support!
	Orange	Indication of internal failure. Contact ComAp technical support!
	Green	The unit is in operation with no internal problems.
	Nothing	The unit is not in operation
Alt	Orange	The function Alternative setting is activated by means of binary switch Alt setting.
	Nothing	The function Alternative setting is not activated
Dis	Orange	The unit is disabled by means of binary switch Disable
	Nothing	The unit is not disabled by means of binary switch Disable

Measurement screens

Following are the examples of the measurement screens, showing values measured and evaluated by the unit:

Main measurement screen (homepage), 3-phase application:	- U: measured voltages on terminal sets Ua, Ub and Uc. If overvoltage or undervoltage is detected on a particular phase, arrow symbol is displayed left of the particular voltage value. - f: measured frequency on terminal set Ua. If overfrequency or underfrequency is detected, arrow

	symbol is displayed left of the frequency value. - Last Trip: indication of the latest event, which caused trip by the MainsPro unit. See the following chapter for trip messages explanation.
Main measurement screen (homepage), 1-phase application (setpoint System set to 1ph): 	- U: measured voltage on terminal set Ua. If overvoltage or undervoltage is detected, arrow symbol is displayed left of the voltage value. - f: measured frequency on terminal set Ua. If overfrequency or underfrequency is detected, arrow symbol is displayed left of the frequency value. - Last trip: indication of the latest event, that caused trip by the MainsPro unit
Loss of mains (LOM) measurement screen: 	- Max Vs: maximum value of measured Vector shift since unit power-up or since the last reset Vector shift trip. - Act RCF: actual measured value of ROCOF protection - Max RCF: maximum value of measured ROCOF protection since unit power-up or since the last reset ROCOF trip.
Voltage asymmetry measurement screen: 	- V asymmetry: actual value of asymmetry of effective values measured on terminals Ua, Ub, Uc - V negative: actual value of negative sequence voltage - V positive: actual value of positive sequence voltage *Negative sequence overvoltage and positive sequence undervoltage are methods of evaluation of angle asymmetry of the 3-phase voltage system. See more in the chapter Voltage unballance and angle asymmetry*
Binary switches status screen: 	Status of the 4 MainsPro binary switches. If any of the switches is not enabled by the appropriate setpoint, its status is not internally processed and it is displayed in brackets on the display screen.
Relay outputs 1-4 status screen: 	Status of the first 4 MainsPro relay outputs. Name in parenthesis marks the function assigned by the setpoints in group f(RE).
Relay output 5 status screen: 	Status of the 5th MainsPro relay output. Name in parenthesis marks the function assigned by the setpoints in group f(RE).
Trip counters and indication screen: 	- Last Trip: indication of the latest event, which caused trip by the MainsPro unit. See the following chapter for trip messages explanation. - TripCnt: total counter of MainsPro trips since the MainsPro unit counters reset - U: counter of overvoltage and undervoltage -related trips - f: counter of overfrequency and underfrequency -related trips - LOM: counter of Loss-of-Mains - related trips (Vector shift and ROCOF) - Otr: counter of trips with other reason then the above mentioned: External trip, voltage asymmetry, phase sequence or inverse phase polarity

Time measurement screen: 	- PowerUp Time: time from MainsPro unit power-up. - Last Trip Time: time from the latest trip by the MainsPro unit. *Please note that the time information on the MainsPro unit is not measured by a calibrated RTC device and may serve for orientation purposes only. Find more in Technical data chapter.*

Alarm messages

One of these indications appears on the homepage screen in case of the unit trip. It indicates the first protective stage, which issued the trip event:

f>	Overfrequency, 1st stage
f>>	Overfrequency, 2nd stage
f<	Underfrequency, 1st stage
f<<	Underfrequency, 2nd stage
U>	Overvoltage, 1st stage
U>>	Overvoltage, 2nd stage
U<	Undervoltage, 1st stage
U<<	Undervoltage, 2nd stage
Vs	Vector shift
RCF	ROCOF
Vunb	Voltage (amplitude) unbalance
Vneg	Negative sequence overvoltage
Vpos	Positive sequence undervoltage
Rot	Wrong phase rotation
Pol	Wrong polarity of one phase
Ext	External trip

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Application Guide

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Table of contents

Purpose of this manual

The Application Guide serves for the designers and engineers, who process the necessary documentation and implementation procedures on the installation site, where MainsPro is installed. It contains detailed description of MainsPro functionalities and practical application of MainsPro functionalities.

MainsPro typical usage

MainsPro is a mains protective relay protecting operation of parallel-to mains generators or other electrical resources of distributed generation of electricity. The main purpose is to prevent unwanted interaction between the generator and mains in case of its abnormal state (e.g. mains failure):

- Specific situations may occur, causing e.g. the utility network to momentarily disconnect part of the network and connect it back by automatic-recloser. During this fault-clearing period, the generators may move away from synchronism and their eventual re-connection may cause severe damage to the property of the generator operator, or to the utility equipment.
- The sole operation of a generator into an unintentionally islanded part of electricity network provides potentially dangerous situation. The load of the area may exceed the generator capacity and cause instability of the voltage, delivered to the consumers connected in the islanded area.
- Severe hazards may occur to the working personnel on the grid equipment in the area, where the mains is presumed as failed, but there are still generators delivering power into this area without central control of their operation.

These are some of the situations, leading the utilities to strictly require that any parallel connection to the mains is approved and protection devices with required protective features are installed.

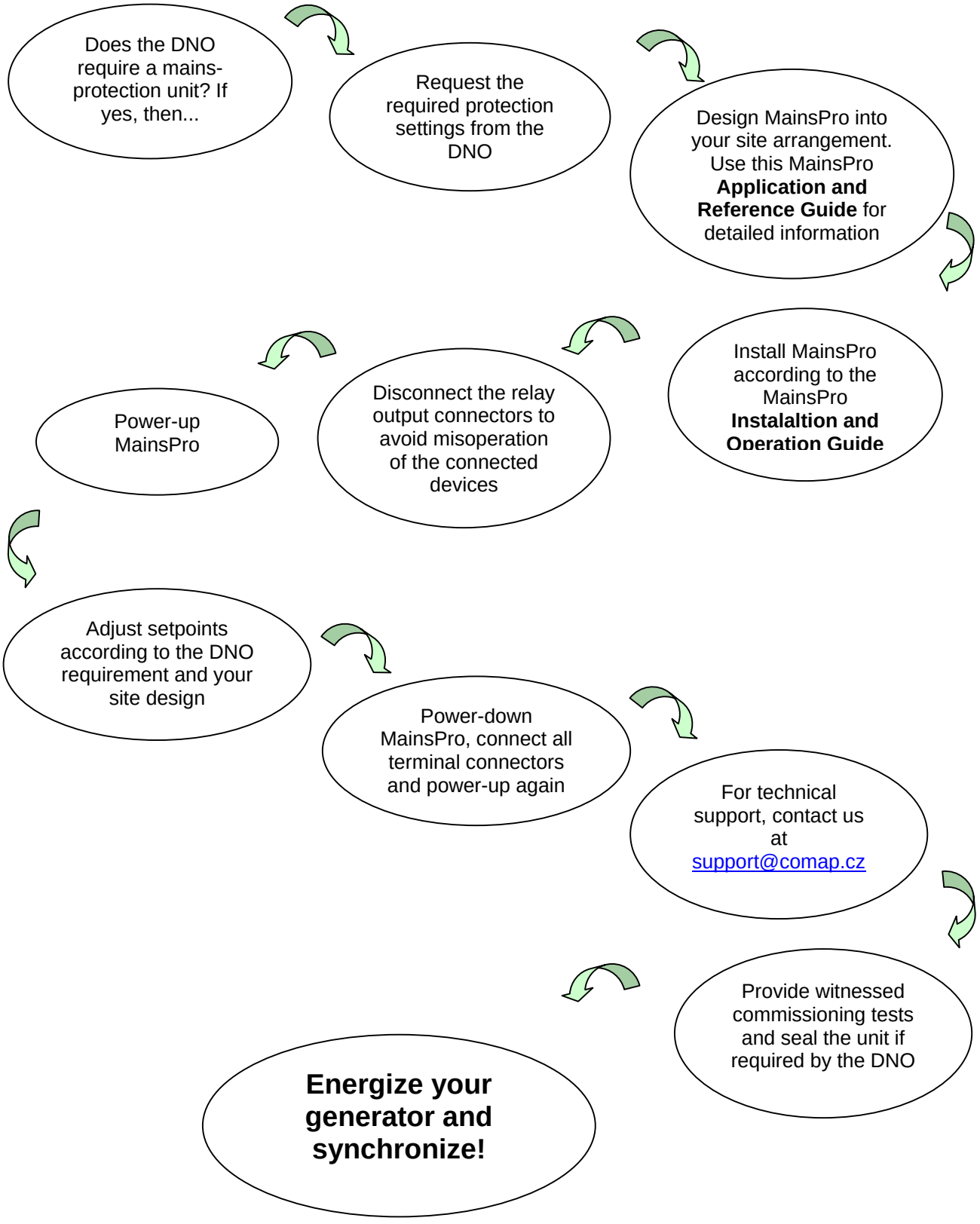
Typical applications of MainsPro protection relay

These are installations of any sources of electrical energy. For example:

- Cogeneration
- Peak-lopping power stations
- Stand-by generators with soft return/short-time parallel operation with mains
- Microturbines
- Small hydro power-plant
- Photovoltaic power plant
- Windmills

Important Steps of MainsPro utilization

This process describes a typical decisions and technical steps to follow in case of MainsPro utilization, if required by the distribution network operator (DNO).



TRIP and Fault Reset description

TRIP

TRIP may be considered as event or status of the unit:

TRIP event:
- Starts in the moment of terminating the count-down of any protective function with delay, or in the moment of activation of any immediate protective function.
- As a result of the trip event, are e.g. the following consequences:
  - Immediate deactivation of outputs CommTrpPer and CommTrpImp
  - LED TRIP goes to red
  - The appropriate counter in the statistics screen increments
  - The Last Trip Time timer starts to count time and the last trip indication is set

TRIP status:
- Starts at the moment of TRIP event
- During this status, the CommTrpPer output keeps in the fault position
- During this status, it is not possible to perform Fault reset
- TRIP status is active until a successful Fault reset. This may not be done before all measured and evaluated values are within preset limits.
- If during the TRIP status, caused by some value, another value overreached its limits for TRIP evaluation, this second overreach is not considered as TRIP. It does not cause a second TRIP event. However, as a consequence of this, the TRIP duration may be prolonged until the moment when both (all) values are within limits.

Fault reset

Fault reset is an event, caused by either of the following reasons:
- FltRes button is pressed
- Binary switch Fault reset is activated
- Automatic fault reset timer set by setpoint Basic: Auto FR Del, has count down. The counter is started in the moment when all evaluated values are back within their limits. If during the count-down another fault status appears, the timer is reset and started no sooner than after all evaluated values are back within limits again.
- By activation and following deactivation of binary switch Disable.

The abovementioned reasons are a trigger to provide Fault reset, however, it is successfully done only in case that the TRIP status is activated and all evaluated values have returned back into limits. If the TRIP status is not activated, or it is activated, but any of the values is still out of limits, Fault reset is not done and any of the mentioned triggers is forgotten. I.e., the unit may not be „provisionally“ fault-reset.
By a successful Fault reset, the TRIP status is terminated.

Protective features

The following protective functionalities, referred also by their ANSI number, are available in MainsPro unit:

59 Overvoltage, 27 Undervoltage

The RMS value of measured voltage is compared with the preset limit of overvoltage or undervoltage. When any of the preset limits is over/underreached, the appropriate LED signal is issued by LED U and the output U Sig moves to fault-indicating position immediately. If voltage of in the given phase keeps out of limits for the delay of the appropriate stage, TRIP is issued. As the voltage returns back within limits in all measured phases, the LED and U Sig output stop to signal the fault state immediately, regardless of whether TRIP was issued or not or Fault reset was performed or not.
Both overvoltage and undervoltage protective stages provide possibility of setting 2 levels with independent delay assigned to each level.

81H Overfrequency, 81L Underfrequency

The frequency value measured on phase L1 is compared with the preset limit of overfrequency or underfrequency. When any of the preset limits is over/underreached, the appropriate LED signal is issued by LED f and the output f Sig moves to fault-indicating position immediately. If the frequency keeps out of limits for the delay of the appropriate stage, TRIP is issued. As the frequency returns back within limits, the LED and f Sig output stop to signal the fault state immediately, regardless of whether TRIP was issued or not or Fault reset was performed or not.
Both overfrequency and underfrequency protective stages provide possibility of setting 2 levels with independent delay assigned to each level.

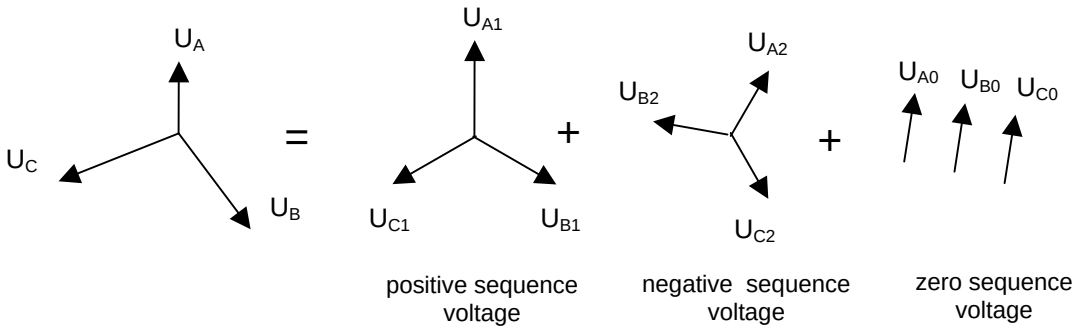
47 Voltage unbalance and angle asymmetry

MainsPro provides 3 independent methods for evaluation of voltage symmetry failures. All of these protections are only active in case that 3-phase system is selected by the setpoint Basic: System.

Voltage unbalance
In further text, this term refers to the state, when amplitude difference between any 2 phases overreaches the preset limit dU: V unb. I.e., it refers to the amplitude unbalance of the measured voltage.

Positive sequence undervoltage, Negative sequence overvoltage
These two methods provide very good sensitivity also to angle asymmetry of the measured voltages. The evaluation is based on the mathematical principle of evaluation of the symmetrical components of measured voltage. Any 3-phase system in any asymmetrical arrangement may be decomposed to 3 perfectly symmetrical components:

- positive sequence - system of 3 phases with 120° phase-shift between the system vectors and the same phase-order as the original system.
- negative sequence - system of 3 phases with 120° phase-shift between the system vectors and opposite phase-order as the original system.
- zero sequence - system of 3 conphase vectors (with 0° phase-shift between the phases).



Picture 2: decomposition of a generic 3-phase voltage to symmetrical components

MainsPro provides positive and negative sequence voltage evaluation and compares the measured values with V> neg and V< pos thresholds. In the perfectly symmetrical arrangement, negative sequence voltage is zero and positive sequence voltage equals to the measured voltage. If the asymmetry situation occurs, non-zero negative sequence voltage is calculated and positive sequence voltage drops. When any of the preset limits is over/underreached, the appropriate LED signal is issued by LED U and the output dU Sig moves to fault-indicating position immediately. If the calculated values keep out of limits for the delay dU del, TRIP is issued. As the calculated values of voltage asymmetry return back within limits, the LED and dU Sig output stop to signal the fault state immediately, regardless of whether TRIP was issued or not or Fault reset was performed or not.
Some utilities strictly require in their regulations that symmetrical components are evaluated in the mains-decupling relay and appropriate trip is provided. However, the method may also be used in the areas, where no such requirement is in place, to minimize non-detection zones of detection of 1-phase mains failures. In case that the generator, connected to the mains is operated close to equity-state, i.e. power delivered to the mains is close to zero, it may be difficult to sense loss of one phase further in

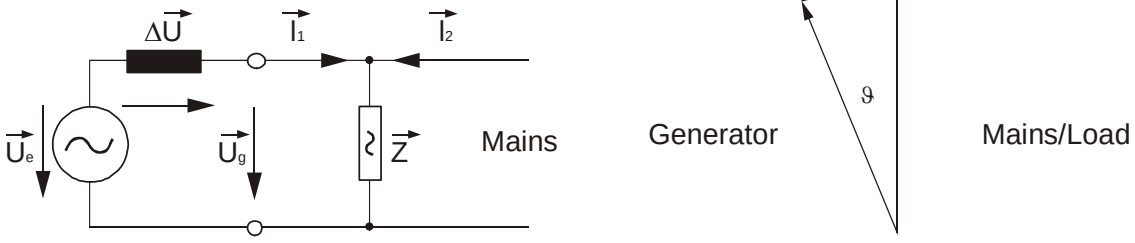
the system. The only change seen in such situation may be movement of the failed phase by a certain angle with small or no voltage drop in the absolute values. This may not be detected by undervoltage or unbalance protection stage. Symmetrical components provide very good and sensitive method to detect such a situation and trip the generator in case of this situation.
Typical setting of the V< pos vary from 0,65 to 0,85 of the rate voltage value. The exact values are delivered by the mains operator or may be set-up during commissioning after experimental verification of the protection stage sensitivity to the single-phase failures in equity state of the generator (e.g. by opening one fuse on the mains transformer).

78 Vector shift

The vector shift is one of the fast "Loss of Mains" protection stages. The principle is based on the fact that if a generator works into an islanded area of the electricity network, its voltage and frequency depend strongly on the load size, remaining in the islanded area. Decrease of the generator speed due to overload may not be fast enough to assure e.g. trip by underfrequency stage. The mains may be equipped with auto-reclosing mechanisms and in case that the generator is not disconnected within the auto-reclosing delay, the area may be reconnected back to the grid by this mechanism. This reconnection may meet the generator in asynchronous state, imposing severe risk of damage to the generator, its feeder equipment as well as equipment of the mains operator. Vector shift provides fast protective function for this situation.

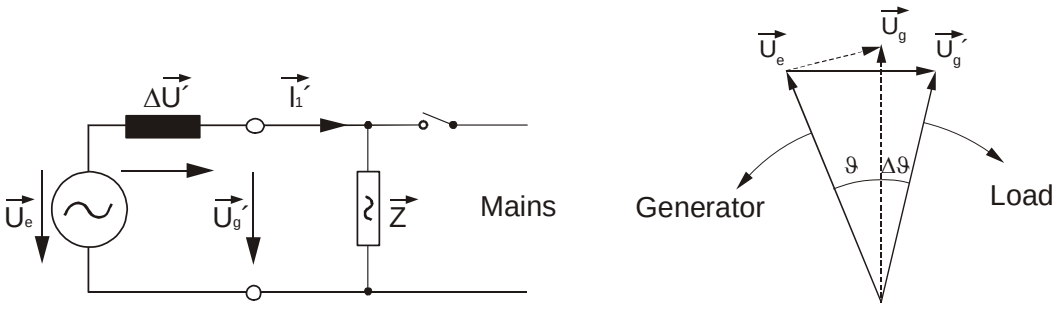
Measuring principle

When synchronous alternator is loaded, the rotor displacement angle ϑ is build between the terminal voltage (mains voltage) $\vec{U}g$ and the synchronous electromotive force $\vec{U}e$. Therefore a voltage difference ΔU is built between $\vec{U}e$ and $\vec{U}g$. The rotor displacement angle ϑ between stator and rotor is depending on mechanical moving torque of the generator shaft. The mechanical shaft power is balanced with the electrical feeder mains power and therefore the synchronous speed keeps constant.



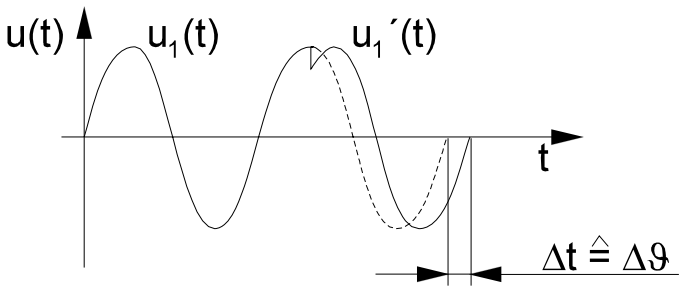
In parallel with the mains

In case of mains failure or auto reclosing the generator suddenly feeds a very high consumer load.
The rotor displacement angle is decreased repeatedly and the voltage vector $\vec{U}g$ changes its direction to $\vec{U}g'$.



At mains failure

As shown in the timing diagram the voltage jumps to another value and the phase position changes. This procedure is called phase or vector surge. MainsPro continuously measures the cycles, starting each zero up ward slope. The time cycle is internally compared to the reference time. In case of vector surge the zero up ward is delayed and the device trips instantaneously. The trip angle $\Delta\vartheta$ and consequently the sensitivity of the vector surge detection is adjustable by the setpoint LOM: Vs lim.



Proper setting of Vector shift limit has to be examined at the field tests, especially at very low setting of the protection limit (under 3°). Vector shift is very fast method and may be sensitive to disturbances, naturally present in the electricity grid.
Note:
Due to high sensitivity, Vector shift protection is not evaluated in the transient states, e.g. when Alt settings functionality is turned on or off, fault reset is performed or Vector shift limit is being set. Functionality is blocked in the sine wave period, when such an event occurs.

81R Rate Of Change Of Frequency (ROCOF)

ROCOF is another fast "Loss of Mains" protection stages provided in MainsPro. It is based on the similar principle as Vector shift, i.e. dependence of the generator speed and voltage on the load size. The variations of frequency delivered by the gen-set depend on the load fluctuations and speed of the compensated fuel inlet. In case of operation in parallel with large network, these changes are absorbed in the network and frequency is stable. When the connected area disconnects from the mains into island operation, the frequency becomes instable. MainsPro ROCOF stage provides fast evaluation of the frequency instability and TRIPS immediately in case of fast frequency changes. The threshold is set by the setpoint LOM: ROCOF. As the ROCOF stage provides very sensitive protection, software filter may be set using the LOM: ROCOF filt setpoint. By appropriate setting of those two setpoints, perfect ratio between sensitivity and speed of reaction of ROCOF protection may be established at the field tests.

Phase rotation, incorrect phase polarity

MainsPro provides check of the phase sequence and polarity. The correct connection is indicated in the wiring instructions e.g. on MainsPro box or in Wiring chapter, where clockwise rotation system is expected on the mains side. It may happen, that e.g. by redesign in the mains or generator site installation, the phase rotation changes. MainsPro ensures in such case, that this state is indicated and it prevents incorrect closing of the circuit breaker by its standard protective functionality. To allow phase sequence or incorrect phase polarity check, the phase angle between the 3 voltage vectors is expected in range 120° +/- 30°. If wrong phase arrangement is detected, TRIP is issued and the appropriate LED signalization is given. The reconnection of measurement terminals is necessary to ensure further proper functionality of the unit.

Application tips

Auto Fault reset

Appropriate setting of automatic fault reset by setpoint Basic: Auto FR Del timer allows setting the waiting time reserved for mains parameters to settle in their fault-free conditions after a TRIP. This

state is indicated by flashing red signal of the TRIP LED. If during this time any measured value reaches out of the preset limits, MainsPro terminates the automatic fault reset count-down and goes back into fault indication state. The automatic fault reset is reset and started again in the moment when all measured values are back in limits again. After automatic fault reset is count down to zero, the unit performs automatic fault reset and terminates the TRIP status.

Binary switches application

MainsPro allows basic remote operation by means of binary signals wired from an external logic to MainsPro binary switches. The signals may be also provided remotely, e.g. through radio or GSM communicator devices. As an example for the many similar devices on the market, see the uGATE communicator below. Ask for more information about this product at protections@comap.cz.

This way, MainsPro functionality may be simply controlled by a mobile telephone commands. All four binary switches may be enabled or disabled by the appropriate setpoints in the group Basic.

External trip

- In case that a specific protective function is requested and this function is not supported in MainsPro, it may be provided in an external device. Wire the output of this device to Ext binary switch to allow tripping by this external device.
- Use the External trip also for forced disconnection of the generator if such command is for example evaluated in a superior system or transmitted through remote communication device.
- External trip functionality may be also used for intertripping method of protection system topology. This method is required by the mains operator for bigger generators.

Fault reset

- Use this switch in case that complex conditions are to be evaluated before the generator is connected back to mains. These conditions may be processed in an external system and the result may be sent to this switch.
- External fault reset may be also provided in case that locked button is used for performing the fault reset operation by authorized personnel only. In this case, MainsPro is to be secured inside of the locked switchboard and external fault reset only made possible.
- Remote fault reset via GSM communicator may also be a useful feature for the remote sites.

Alternative settings

- Alt settings binary switch may be used in case that a specific setting of the protection relay is required by the mains operator when exceptional conditions occur. After deactivation, the unit immediately switches to the default groups of setpoints.

Disable

- The Disable switch may be used for blocking the MainsPro protective functions, e.g. in case that the generator is not running in parallel operation with mains, or any other blocking conditions are fulfilled.

Counters

Keeping a track of the most frequent trips may provide valuable information for the generator as well as distribution network operator. Use the counters indication on the MainsPro screen for keeping track of the most frequent failures detected in the point of your connection. For example, in case that the MainsPro counters show significantly higher rate of a certain failure types (e.g. overvoltage or Vector shift), it may be a good signal to perform a detailed evaluation of the voltage quality in the point of connection or start discussions with the DNO to allow for wider limits of the protection setting to minimize down-times of the generator.

Timer

MainsPro provides two time counters: since the unit power-up and since the last TRIP. Use these timers for investigation of failures that were detected by MainsPro unit. Please note that MainsPro does not provide RTC clock and after each power-up of the unit, the time and date is lost. For this reason only indication of days / hh : mm : ss is used. The accuracy of the time measurement may also not be fully guaranteed. During internal tests, the measurement error of 4 seconds per 24 hours was recorded.

TEST mode

MainsPro provides the TEST mode, in which phase-by-phase testing of 3-phase protective features by single-phase power source is supported.

- The test mode may be activated by entering the init screen (entered by pressing the  and  at the same time). Follow by  button and then  button. This will open the Test mode activation screen.
- Select Y to enter the TEST mode.
- The voltage asymmetry protections are deactivated.
- The following functions are fix-assigned to the appropriate relay outputs, regardless of their actual assignment:
    - Comm Trp Per to RE3
    - f Sig to RE4
    - U Sig to RE5
- In TEST mode, the setpoint group TEST becomes visible. This group contains only one setpoint Phase - by setting this setpoint to the appropriate measurement input (U_A, U_B or U_C). Use this setting to assign, to which input is the 1-phase measurement voltage source connected.
- All relevant protections are evaluated only in that phase, which is selected:
    - If TEST/Phase = Ua, the following protective functions are evaluated:
        - Overvoltage and undervoltage on the U_A terminals, with dual stage setting, including the Alt parameters possibility
        - Overfrequency and underfrequency on the U_A terminals, with dual stage setting, including the Alt parameters possibility
        - Loss OF Mains protections on the U_A terminals, with the Alt parameters possibility
    - If TEST/Phase = Ub or Uc, the following protective functions are evaluated:
        - Overvoltage and undervoltage on the appropriate terminals, with dual stage setting, including the Alt parameters possibility
        - **Please note: When testing on the terminals Ub and Uc, it is always necessary, that the same measurement voltage as applied on terminals Ub or Uc is also present at the terminals Ua. It is not used for testing purposes, but serves for the internal synchronization of the measurement process of the unit.**
- On the first measurement screen (homepage), the sign !!!TEST!!! is displayed in the bottom line instead of the last trip information.
- If any TRIP is performed during the TEST mode, no counters are incremented and the last trip indication and timer is not affected.
- In the TEST mode, it is possible to change setpoints, but some functionality, which is disabled in the TEST mode (e.g. voltage asymmetry setting or assignment of f(RE)) is not applicable.
- After return from the TEST mode, the unit goes back to its original setting including the outputs assignment and the setpoint group TEST is hidden.

To return from the TEST mode:

- Go to Test mode activation screen and select NO, or
- Turn the unit off and on again, or
- The unit goes back to the standard operation after 10 minutes from the last keyboard activity.

MainsPro

Mains Decoupling Protection Relay

Application and Reference guide

SW version 1.0, May 2010

Reference Guide

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Table of contents

Purpose of this manual

The Reference Guide contains library of setpoints, inputs and outputs functionalities and technical data for the purpose of detailed technical information. This information is referenced in the Installation and Operation Guide and Application Guide.

Library of setpoints

MainsPro provides the possibility of dual setting of the protection functions setpoints. This setting may be used in case that the installation is running in exceptional conditions with different requirements for protections setting. Some groups of setpoints have their alternative setpoints identified by the same name, but with latter “A.” at the beginning (e.g. V<>, A.V<> etc.). By activating the binary switch Alt settings, the unit is immediately switched to the setting, done in the “A.xx” group. See more in the chapter Library of binary switches.

Basic

Uin

Selection of the measurement range in order to adjust the HW for maximum accuracy.

230/400V	the unit measures 230 VAC phase-ground or 400V phase-phase with max over-range 130% (300/520 VAC)
120V	the unit measures 120 VAC phase-ground or on the secondary winding of the VT with max over-range 130% (156 VAC)

Default setting: 230/400V

System

Selection of single phase or 3-phase application. In case of single phase setting, the voltage on last two phases and voltage asymmetry are not measured.

3ph	the unit measures 3-phase system
1ph	the unit measures single-phase system

Default setting: 3ph

DispT [min]

Setting of display backlight timeout since the last button activity.

Range: 1..60 min
0 min = OFF, display is set to permanent backlight

Default setting: 10 min

Auto FR del [s]

Automatic fault reset delay. The timer starts to count in the moment when TRIP is detected, but the fault conditions are cleared. After the Auto FR del time, the Fault reset is done automatically to allow automatic reconnection.

Range: 1..6000 s
0 = OFF, automatic fault reset function is disabled

Default setting: 0 s

Imp Len [s]

Impulse length in case of activation of various impulse outputs of the protection. The setpoint is reverenced in the appropriate outputs description.

Range: 0..60 s

Default setting: 1 s

Ext

Enabled or disables the functionality of the External trip binary switch.

ENABLED	the binary switch is enabled
DISABLED	the binary switch is disabled

Default setting: ENABLED

F.R.

Enabled or disables the functionality of the Fault reset binary switch.

ENABLED the binary switch is enabled
DISABLED the binary switch is disabled

Default setting: ENABLED

Alt

Enabled or disables the functionality of the Alternative settings binary switch.

ENABLED the binary switch is enabled
DISABLED the binary switch is disabled

Default setting: ENABLED

Disable

Enabled or disables the functionality of the Disable binary switch.

ENABLED the binary switch is enabled
DISABLED the binary switch is disabled

Default setting: ENABLED

V <>, A.V <>

V>, V>>, V<, V<<, A.V>, A.V>>, A.V<, A.V<< [V]

Threshold of 1st and 2nd stage overvoltage and 1st and 2nd stage undervoltage protection respectively.

Range: 1..999 V
0 = OFF, the appropriate stage of voltage protection is not enabled

Default setting:

- V>, V>> 253 V
- V<, V<< 196 V

V> del, V>> del, V< del, V<< del [s]

Delay of the appropriate stage of the voltage protection.

Range: 0,00..600,00 s

Default setting: 2,50 s

dU, A.dU

V unb, A.V unb [V]

Threshold of the voltage unbalance (amplitude asymmetry). The value corresponds to the maximum difference between highest and lowest RMS phase voltage of the 3-phase system.

Range: 0..999 V
0 = OFF, the amplitude asymmetry is disabled

Default setting: 15 V

V unb del, A.V unb del [s]

Delay of the voltage unbalance (amplitude asymmetry) protection.

Range: 0,00..600,00 s

Default setting: 2,5 s

V< pos, A.V< pos[V]

Threshold of the positive sequence undervoltage (angle asymmetry method).

Range: 0..999 V
0 = OFF, the positive sequence undervoltage is disabled

Default setting: 0 V

V> neg, A.V> neg[V]

Threshold of the negative sequence overvoltage (angle asymmetry method).

Range: 0..999 V
0 = OFF, the negative sequence overvoltage is disabled

Default setting: 0 V

dU del, A.dU del [s]

Delay of the voltage unbalance (amplitude asymmetry) protection.

Range: 0,00..600,00 s

Default setting: 2,5 s

f <>, A.f <>

f>, f>>, f<, f<<, A.f>, A.f>>, A.f<, A.f<< [Hz]

Threshold of 1st and 2nd stage overfrequency and 1st and 2nd stage underfrequency protection respectively.

Range: 45..65 Hz
0 = OFF, the appropriate stage of frequency protection is not enabled

Default setting:

- f>, f>> 52 Hz
- f<, f<< 48 Hz

f> del, f>> del, f< del, f<< del, A.f> del, A.f>> del, A.f< del, A.f<< del [s]

Delay of the appropriate stage of the frequency protection.

Range: 0,00..600,00 s

Default setting: 2,50 s

LOM, A.LOM

VS lim, A.VS lim [°]

Threshold at which the Vector shift protection is activated.

Range: 1..50°
0 = OFF, the Vector shift protection is not enabled

Default setting: 20°

ROCOF, A.ROCOF [Hz/s]

Threshold at which the Rate of change of frequency (ROCOF) protection is activated.

Range: 0,1..10,0 Hz/s
0 = OFF, the ROCOF protection is not enabled

Default setting: 0 Hz/s

ROCOF filt, A.ROCOF filt [-]

Number of periods considered for evaluating ROCOF protection. Higher number means lower sensitivity and longer evaluation time. Lower number means increased sensitivity and shorter evaluation time.

Range: 1..100

Default setting: 5 Hz/s

LOM Init Del, A. LOM Init Del [s]

Delay for what the Loss of Mains (LOM, i.e. Vector shift and ROCOF) protection is disabled after sensing the valid voltage on measurement terminals (stepping into the operational area of voltage and frequency).

Range: 0..600

Default setting: 3 s

LOM Trip Del, A.LOM Trip Del [s]

Duration of Loss of Mains (LOM, i.e. Vector shift and ROCOF) protection trip. After this delay, the fault is considered as terminated and Fault reset is possible. In case of automatic fault reset, the timer is started.

Range: 0..3600

Default setting: 3 s

f(RE)

f(RE1-5)

Function, assigned to the appropriate relay output 1 to 5. For description, see chapter „Relay outputs“.

CommTrpPer
CommTrpImp
CommSigImp
CommSigDel
U Sig
f Sig
LOM Sig
dU Sig
Other Sig

Default setting:

- RE1: CommTrpPer
- RE2: CommTrpImp
- RE3: CommSigImp
- RE4: CommSigDel
- RE5: U Sig

Library of binary switches

Ext Trip

Activation of this input causes immediate trip of the protection. The trip conditions are active throughout the activation of this input.

Fault Reset

Activation of this switch causes fault reset. The input has the same effect as pushing the button FltRes. If permanently activated, every 100ms an impulse to fault reset the unit is done internally.

Alt Settings

Activation of this switch causes immediate switching to the setting, done in the setpoint groups marked as „A.xx. In case that the switchover comes in the moment when a delay of some of the protection stage is being count-down (the unit is about to trip), the timer setting is kept as before the switch. However, if the trip conditions change during the delay run (e.g. by changing the protection threshold), the trip is not performed.

Disable

Activation of this switch disables immediately all protective features of the unit. The switch may be used e.g. in case that the generator is not yet in parallel-to-mains operation, and so the mains parameters do not have to be evaluated. In this case, the unit does not trip on any fault conditions.

Library of relay outputs

The standard logic of MainsPro corresponds to the standard of protective relays. I.e. the relay contacts are used, with fault-free position maintained in energized state. This is for safety reasons – in case of power supply fail, the unit goes to “fault” indication position. For this reason, any signaling or trip activation is described in this manual as “the output relay deactivates”, what means, it goes to “fault indication” position.

CommTrpPer

Common trip permanent relay. The relay opens at any failure with delay given by appropriate parameter. Relay opens immediately in case of LOM protection (Vector shift or ROCOF), External trip, incorrect phase rotation or wrong phase polarity. Relay closes in fault free state after a successful fault reset. In case of LOM protection, the delay LOM: LOM Trip Del is timed out and after this time it is possible to perform Fault reset.

CommTrpImp

Common trip impulse relay. The relay opens at any failure with delay given by appropriate parameter. Relay opens immediately in case of LOM protection (Vector shift or ROCOF), External trip, incorrect phase rotation or wrong phase polarity. Relay closes after Basic: Imp Len has timed out, his closing however does not mean end of trip state! Trip is terminated in fault free state after a successful fault reset. In case of LOM protection, the delay LOM: LOM Trip Del is timed out and after this time it is possible to perform Fault reset. During trip status, the relay does not react on any new failure.

CommSigImp

Impulse signaling relay – immediate. Relay opens immediately at any failure. Relay closes after Basic: Imp Len since its opening. Any other detected fault-state during run of this timer has no effect. Fault reset has no influence on this output.

CommSigDel

Impulse signaling relay delayed. Relay opens at any failure with delay given by appropriate parameter. Relay opens immediately in case of LOM protection (Vector shift or ROCOF), External trip, incorrect phase rotation or wrong phase polarity. Relay closes after Basic: Imp Len since its opening. Any other detected fault-state during run of this timer causes a new activation of this relay or extends timing of Basic: Imp Len by the new impulse length from the moment of the failure detection. Fault reset has no influence on this output

U Sig

Immediate signaling relay – voltage. Relay opens immediately in case of voltage failure (over or under voltage). Relay closes in case that all parameters are back within limits, but no sooner than after Basic: Imp Len from its activation. If the relay is open during trip activation, it closes no sooner than Basic: Imp Len since trip status activation. Fault reset has no influence on this output. If any voltage protection is disabled by setpoint (limit set to 0), the output does not signal activation of this protection stage.

f Sig

Immediate signaling relay – frequency. Relay opens immediately in case of frequency failure (over or under frequency). Relay closes in case that all parameters are back within limits, but no sooner than after Basic: Imp Len from its activation. If the relay is open during trip activation, it closes no sooner than Basic: Imp Len since trip status activation. Fault reset has no influence on this output. If any

frequency protection is disabled by setpoint (limit set to 0), the output does not signal activation of this protection stage.

LOM Sig

Immediate signaling relay – loss of mains. Relay opens immediately in case of loss of mains failure (Vector shift or ROCOF). Relay closes after LOM: LOM Trip Del since the last LOM protection activation. Fault reset has no influence on this output. If any LOM protection is disabled by setpoint (limit set to 0), the output does not signal activation of this protection stage.

dU Sig

Immediate signaling relay – asymmetry. Relay opens immediately in case of voltage (amplitude) unbalance, positive sequence undervoltage or negative sequence overvoltage. failure (over or under frequency). Relay closes in case that all three methods of voltage asymmetry are in fail-free state, but no sooner than after Basic: Imp Len from its activation. If the relay is open during trip activation, it closes no sooner than Basic: Imp Len since trip status activation. Fault reset has no influence on this output. If any asymmetry protection is disabled by setpoint (limit set to 0), the output does not signal activation of this protection stage.

Other Sig

Immediate signaling relay – other failures. Relay opens immediately in case of incorrect phase rotation, wrong polarity of one phase or External trip. Relay closes in case that all observed failures are not active, but no sooner than after Basic: Imp Len from its activation. If the relay is open during trip activation, it closes no sooner than Basic: Imp Len since trip status activation. Fault reset has no influence on this output.

Certifications

The MainsPro unit is certified according to the following standards:

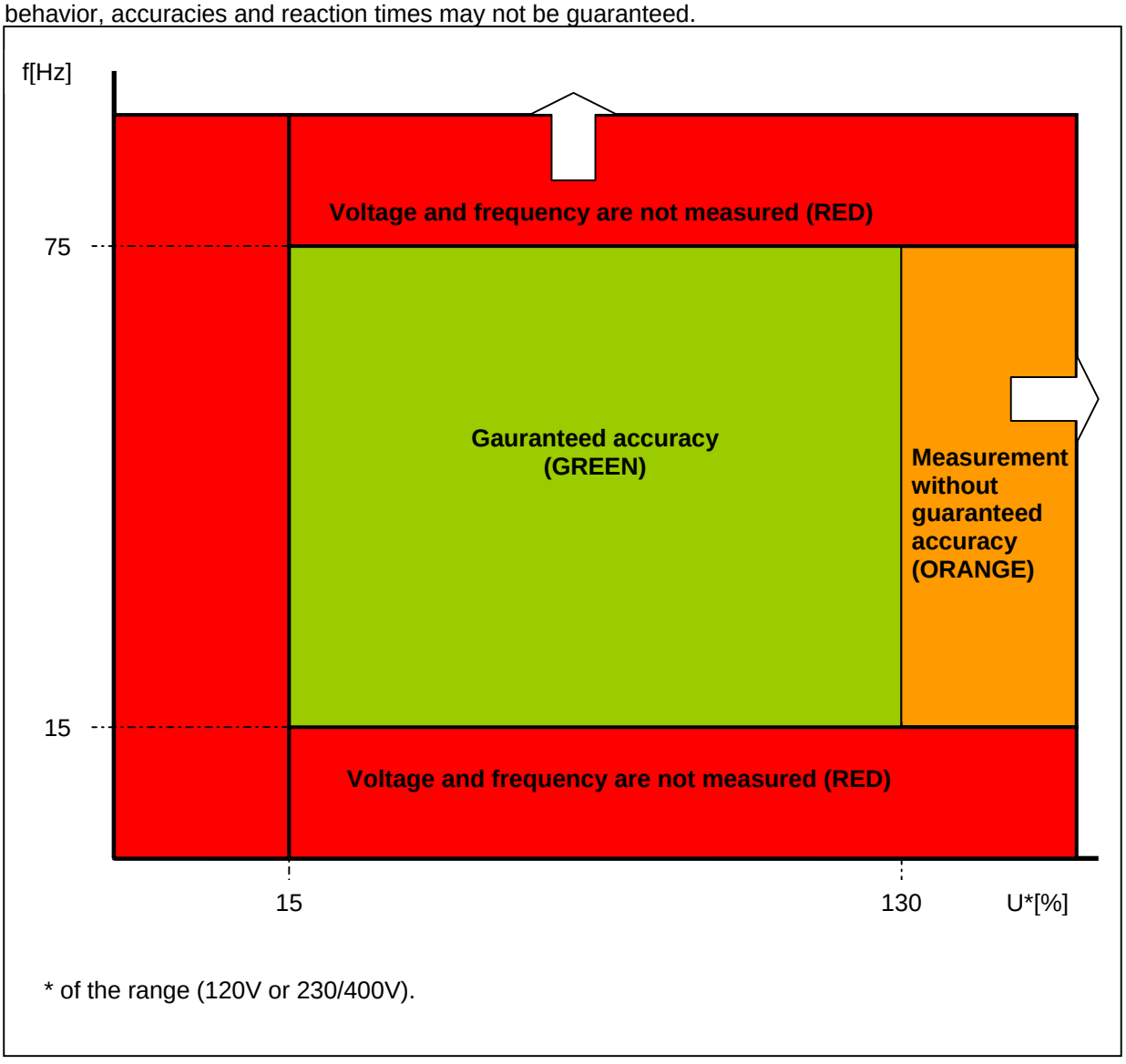
According to standard	Test type	*Tested acc. to conditions*
Electromagnetic field tests - EMC:		
IEC 60255 part 11	Voltage dips, short interruptions, variations and ripple on auxiliary power supply power	IEC 61000-4-11 (AC power) IEC 61000-4-17 (voltage ripple) IEC 61000-4-29 (DC power)
IEC 60255 part 22-2	Electrostatic discharge tests	IEC 61000-4-2
IEC 60255 part 22-3	Radiated electromagnetic field immunity tests	IEC 61000-4-3
IEC 60255 part 22-4	Electrical fast transient/burst immunity tests	IEC 61000-4-4
IEC 60255 part 22-5	Surge immunity test	IEC 61000-4-5
IEC 60255 part 22-6	Immunity to conducted disturbances induced by radio frequency fields	IEC 61000-4-6
IEC 60255 part 22-7	Power frequency immunity tests	IEC 61000-4-16
IEC 61000-4-8	Power frequency magnetic field immunity tests	
IEC 60255 part 25	Electromagnetic emission tests	
IEC 60255 part 22-1	100kHz burst immunity tests	IEC 61000-4-12 (100kHz)
	1 MHz burst immunity tests	IEC 61000-4-18 (1MHz)
Environmental tests:		
IEC 60068-2-1	Cold	
IEC 60068-2-2	Dry heat	
IEC 60068-2-3	Damp heat	
IEC 60068-2-30	Damp heat, cyclic	
Others:		
IEC 60255-5	Insulation coordination for measuring relays and protection equipment	
IEC 60255-21-1	Vibration tests (sinusoidal)	
IEC 60255-21-2	Shock and bump tests	
IEC 60255-21-3	Seismic tests	
IEC 61010-1	Safety requirements for electrical equipment for measurement, control and laboratory use	

Technical data

Accuracies and reaction times

Operating area

MainsPro provides the below mentioned accuracies and reaction times in case that the measured voltage is within the green area on the picture below. Outside of the green area, MainsPro provides the expected performance (i.e. trips in case of voltage overreaching the green area border), but the behavior, accuracies and reaction times may not be guaranteed.



* of the range (120V or 230/400V).

Voltage measurement

- Voltage measurement accuracy is 1% of the nominal value at frequency 50 Hz ± 10% and temperature 25°C.
- The accuracy is 1,5% within the complete temperature range and in the green operational area. See the picture below.
- Maximum reaction time for voltage failures (in case of the delay set to 0,00 s) is 2 periods of measured voltage + 15 ms. This is valid at nominal frequencies 50 Hz ± 10% and 60 Hz ± 10%.

Frequency measurement

- Frequency measurement is 0,1 Hz in the complete green operating area.
- Maximum reaction time for frequency failures (in case of the delay set to 0,00 s) is 1 period of measured signal + 5 ms. This is valid in complete green operating area.

Time delays accuracy

- The unit allows to set the time delays with step 10 ms.
- Accuracy of the unit timing is ± 1%.

Loss of Mains reaction times

- Reaction time of Vector shift protection is 1 period of measured signal + 5 ms in case of detection on terminals Ua.
- Reaction time of Vector shift protection is 2,5 periods of measured signal + 5 ms in case of detection on terminals Ub and Uc.

Technical parameters

Power supply:	
8 - 40 VDC:	Maximum consumption 600 mA
85 - 265 VAC / 110 - 370 VDC	Maximum consumption 60 mA
Operating temperature range	-20°C TO +70°C
Protection:	IP20
Dimensions	158 x 96 x 68 mm
Rated voltage	120 V / 230 V ph-n / 400 V ph-ph
Maximal voltage range	Rated + 30%
Rated frequency	50/60 Hz
Signal relay contacts:	
Max switched voltage/current	250 V / 4A
Max switched power	resistive load: 1000 VA AC, 200 W DC
	inductive load: 50 VA AC, 25 W DC
Rated voltage/current	resistive load: 250 V / 4 A AC
	200 V / 0,1 A DC, 24 V / 4A DC
	inductive load: 250 V / 2 A AC
	200 V / 0,1 A DC, 24 V 3A DC
Minimum load	1 W / 1VA at U_{min} > 10 V
Lifetime	1 x 10^5 cycles
Terminal tightening torque	0,4 Nm