

NPU Unit

Mains decoupling relay

Installation and Operation Instructions



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Written by Libor Šindelář, Milan Vandírek

ComAp s.r.o. Světova 7 , 180 00 Praha 8, Czech Republic

Tel: 00420 2 6679 0611, Fax: 00420 2 6631 6647

WWW: <http://www.comap.cz>

E-mail: info@comap.cz

ELECTRONIC - HYDRAULIC - SYSTEMS

HUEGLI TECH AG 4900 LANGENTHAL SWITZERLAND
TEL. + 41 62 916 50 30 FAX. + 41 62 916 50 35
E - M a i l : sales@huegli-tech.com www.huegli-tech.com

1. Contents

1.	CONTENTS	2
<hr/>		
2.	TECHNICAL SPECIFICATION	3
<hr/>		
2.1.	NPU TECHNICAL SPECIFICATION	4
2.2.	NPU MECHANICAL DESIGN	5
3.	INSTALLATION	6
<hr/>		
3.1.	POWER SUPPLY	6
3.2.	ANALOG INPUTS	6
3.3.	OUTPUT RELAYS	6
3.4.	THE NPU UNIT WIRING DIAGRAM	7
3.4.1.	CONNECTION NPU UNIT TO PHASE-TO-NEUTRAL VOLTAGE	7
3.4.2.	CONNECTION NPU UNIT TO PHASE-TO-PHASE VOLTAGE	8
4.	FUNCTION	9
<hr/>		
4.1.	PROTECTION TYPES	9
4.2.	PHASE SEQUENCE SUPERVISION	9
4.3.	FREQUENCY MEASUREMENT	9
4.4.	INTERNAL WATCHDOG	10
4.5.	OUTPUT RELAYS	10
4.6.	EXAMPLE: EVALUATION OF UNDERVOLTAGE PROTECTION	11
4.7.	VECTOR SHIFT PROTECTION	12
5.	SETTINGS	14
<hr/>		
5.1.	BUTTONS	14
5.2.	DISPLAY AND LEDs	14
5.3.	PARAMETERS SETTINGS	14
6.	DISPLAYED QUANTITIES AND PARAMETERS	15
<hr/>		
	SET A:	15
	SET B:	16
7.	ORDER CODES	17
<hr/>		

2. Technical Specification

The NPU unit is designed for 3-phase mains protection. Operator can switch on/off available protections or adjust limits and time delays for each protection.

Rated voltages are 100 V, 230 V, 400 V selected by order - see order codes. Measuring voltage frequency range is from 44 up to 68 Hz.

NPU power supply voltage can be in the range 90 ÷ 250 VAC or 16 ÷ 110 VDC selected by order - see order codes.

NPU offers following protections:

- Overfrequency protection
- Underfrequency protection
- Overvoltage protection
- Undervoltage protection
- Phase sequence supervision
- Voltage asymmetry protection
- Vector shift supervision

2.1. NPU Technical Specification

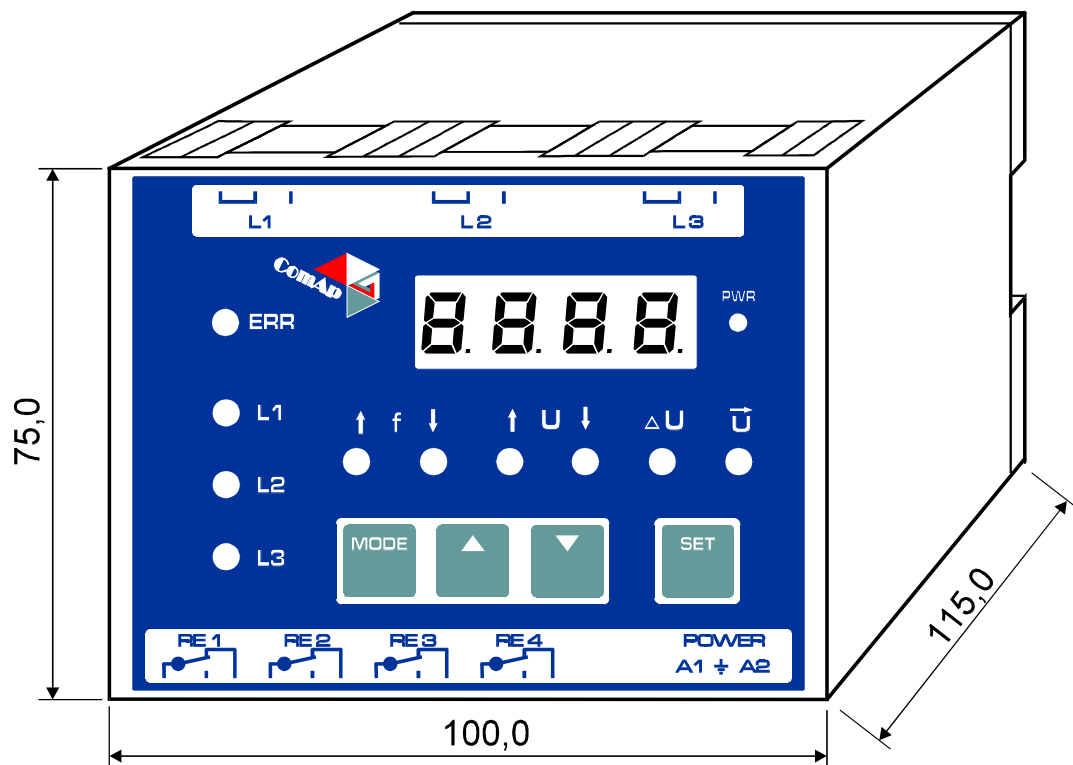
Parameter	Specification
Dimensions	75 x 100 x 115 mm
Power supply NPU XXX/YYY/230VAC NPU XXX/YYY/24VDC	90 ÷ 250 VAC 16 ÷ 110 VDC
Power consumption	c. 3 W
Insulation	4 kV
Elmg. Interference immunity	According to IEC 50082-2
Elmg. Interference	According to IEC 55022
Temperature range	-20 ÷ +70°C
Protection	IP20
Rated voltage	100 V, 230 V, 400 V (<i>by the order</i>)
Maximal voltage range	Rated + 30 %
Rated frequency	50 / 60 Hz
Maximal frequency range	44 – 68 Hz
Accuracy of frequency measuring	0,2% from rated value (<i>from 10% of rated voltage value</i>)
Accuracy of voltage measuring	1% from rated value at rated frequency ± 10% and 25°C 1,5% over whole temperature range
Signal relay contacts - max. switched voltage / current - max. switched power - rated voltage / current - minimum load - lifetime	250 V / 4 A resistive load: 1000 VA AC, 200 W DC inductive load: 500VA AC, 25W DC resistive load: 250V / 4A AC 200V/0,1A DC, 24V 4A DC inductive load: 250V / 2A AC 200V/0,1A DC, 24V 3A DC 1W / 1VA at $U_{min} > 10V$ 1x10 ⁵ cycles
Overtoltage category	Class. III
Time delay accuracy	0.2% +0÷30ms

2.2. NPU Mechanical Design

The NPU is packaged in a plastic box for assembly on a mounting plate TS 35 (DIN rail 35 mm).

NPU could be also mounted with two screws M4 (with span 60mm) to a mounting board. For this alternative it is necessary to take out and turn clamp on the rare side of the box.

NPU has four operating push-buttons. The SET button (for settings) can be protected with cover (fixed by wire with two seals). The NPU has an LED display (four digits) and 10 LEDs for indication. Dimensions are on the figure.



3. Installation

3.1. Power Supply

There are two types of NPU units – see chapter 7 – Order codes:

NPU XXX/YYYY/230VAC power supply is in range 90 ÷ 250 VAC

NPU XX/YYYY/24VDC power supply is in range 16 ÷ 110 VDC

Power supply polarity is not important in the case of DC power. The terminal PE is only as an anti-interference terminal.

3.2. Analog Inputs

The rated voltage (100V, 230V, 400V) is selected by order. Terminals are designed for connection of either phase-to-phase or phase-to-neutral voltage measurement. For connection see wiring diagram.

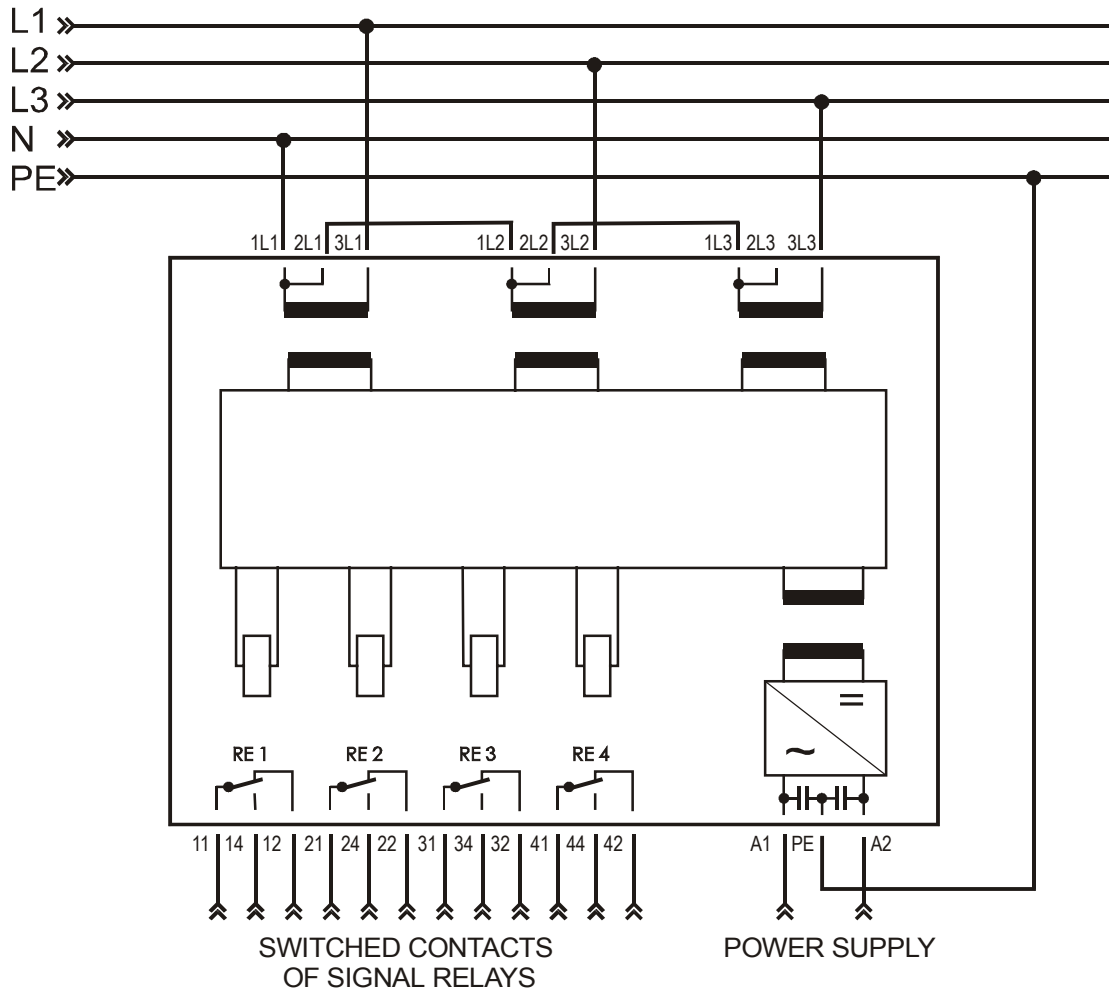
3.3. Output Relays

See wiring diagram. Relays on figure are without supply voltage (failure situation)

3.4. The NPU Unit Wiring Diagram

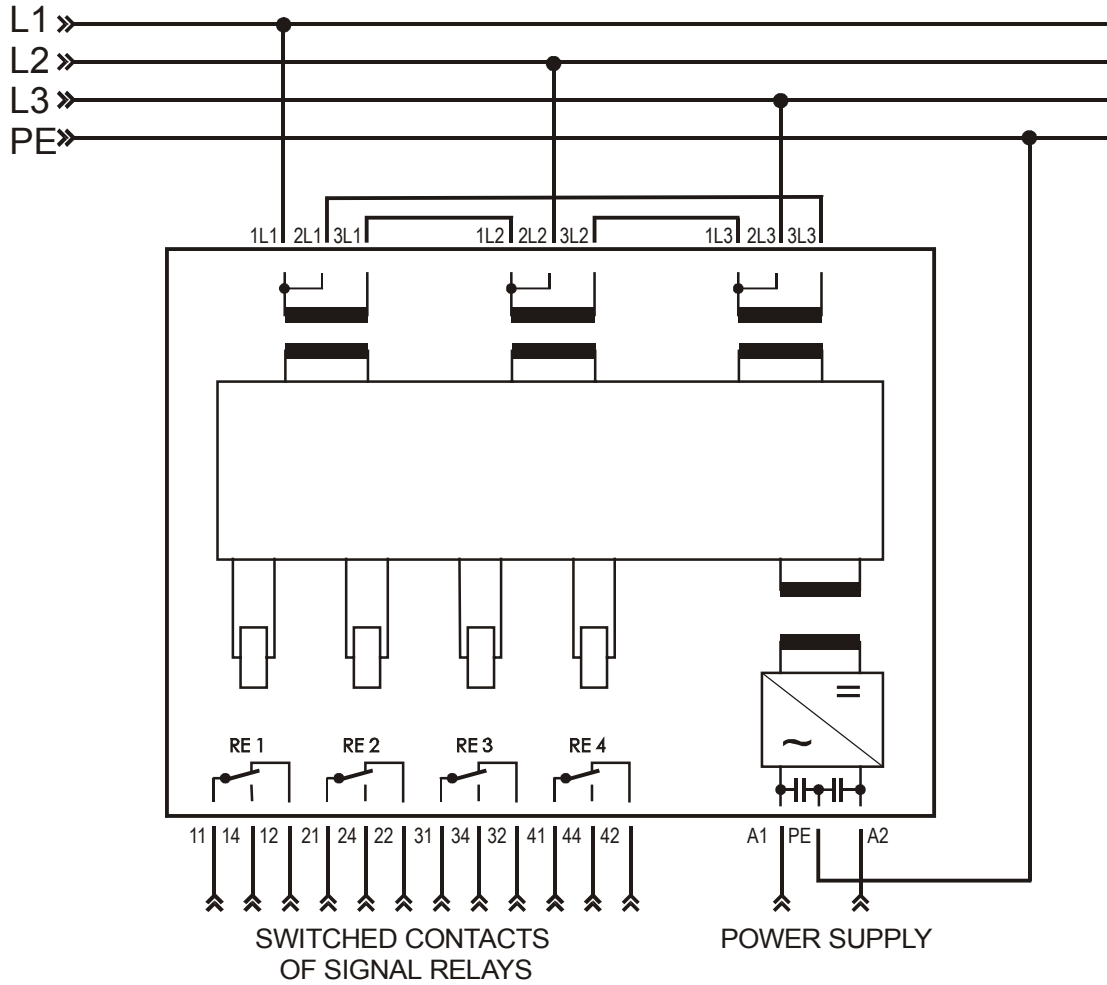
3.4.1. Connection NPU Unit to phase-to-neutral voltage

CONNECTION NPU UNIT TO PHASE-TO-NEUTRAL VOLTAGE



3.4.2. Connection NPU Unit to phase-to-phase voltage

CONNECTION NPU UNIT TO PHASE-TO-PHASE VOLTAGE



4. Function

4.1. Protection types

Overvoltage protection

The protection responds to raising the voltage above set threshold (**A11**, **A12**, **A13**) with it's own delay (**A14**). Limits can be set for any phase extra. By setting zero value the protection is switched off.

Undervoltage protection

The protection responds to voltage drop under set threshold (**A15**, **A16**, **A17**) with it's own delay (**A18**). Limits can be set for any phase extra. By setting zero value the protection is switched off.

Overfrequency protection

The protection responds to raising frequency above set threshold (**A7**) with it's own delay (**A8**). Limit is common for all three phases. By setting zero value the protection is switched off.

Underfrequency protection

The protection responds to fall frequency under set threshold (**A9**) with it's own delay (**A10**). Limit is common for all three phases. By setting zero value the protection is switched off.

Voltage assymetry protection

The protection responds to raising of the voltage difference between any two phases above set threshold (**A19**) with it's own delay (**A20**). By setting zero value the protection is switched off.

Vector shift supervision

The protection (**A21**) responds to voltage vector shift (e.g. this can be caused by jump loading generator). No delay it is possible to adjust. By setting zero value the protection is switched off. The vector shift supervision delay (**A22**) can be set from 0 s to 99.98 s (skip factor 20 ms) only at power supply switch on. It could be used when connecting of asynchronous generators to the mains.

4.2. Phase sequence supervision

Phase sequence supervision checks the right sequence. The angle has to be at interval ($120^\circ \pm 30^\circ$) among voltage vectors. The right phase sequence is L1→L2→L3. The LEDs L1, L2 and L3 are red flashing at wrong phase sequence. If the voltage is too small (approx. <10% of rated voltage value) at any phase then **EEEE** is displayed.

4.3. Frequency measurement

The frequency is measured in one phase. NPU selects the phase where voltage exceeds 10% of rated value. If the voltage is not high enough sufficient in any phase then both LEDs overfrequency/underfrequency are red flashing. The frequency cannot to be measured. In this case zero delayed failure is evaluated.

Hint:

Previous error (red LED) indication is cleared when:

- No phase voltage is sufficient for measuring
- Phase sequence error is detected

4.4. Internal watchdog

To increase the operating safety the internal watchdog and parameters consistency checks are installed. Flashing of LED **ERR** indicates NPU internal failure.

Check all adjusted parameters. If ERR is still flashing, send NPU for repair.

4.5. Output Relays

RE1 and **RE4** are used mainly for proper adjusting and tests of NPU parameters. **RE2** and **RE3** are used mainly for protection.

Relay RE1:

The relay **RE1** opens at any failure without delay. It closes after the time given by parameter **B3**.

Relay RE2:

The relay **RE2** opens at any failure with delay given by active protection (**A8, A10, A14, A18, A20**) see table in the Chapter 6 – Displayed Quantities and Parameters. In example on the following drawing it is Undervoltage delay **A18**. **RE2** closes after the time given by parameter **B4**. The relay doesn't close until all failures are gone. LED ERR copies the state of **RE2**.

Relay RE3:

The relay **RE3** opens at any failure with delay given by active protection (**A8, A10, A14, A18, A20**) see table in the Chapter 6 – Displayed Quantities and Parameters. In example on the following drawing it is Undervoltage delay **A18**. **RE3** closes immediately when no failure is active or with delay **B5** in the case of vector shift protection .

Relay RE4:

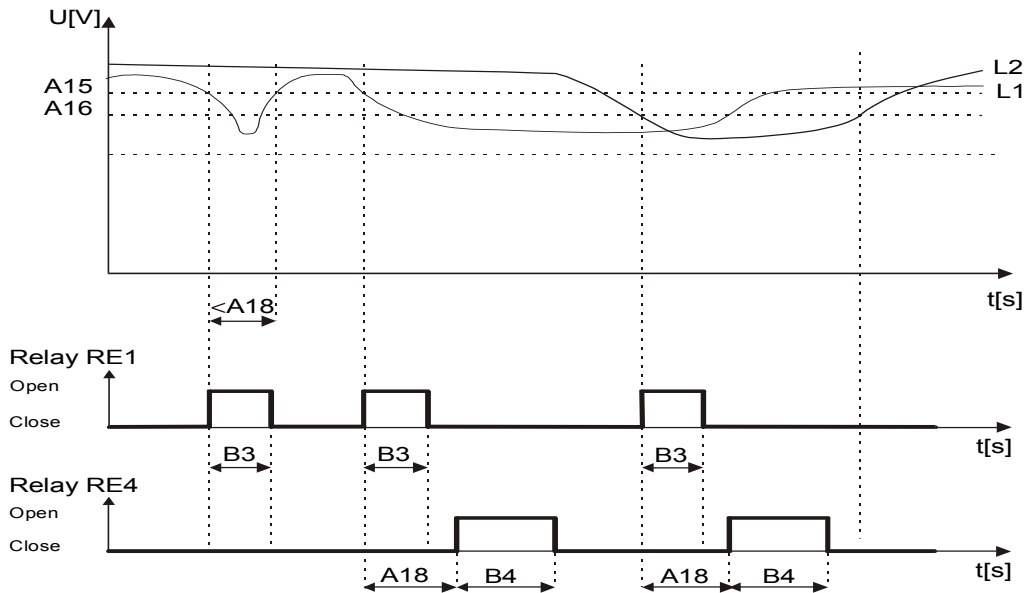
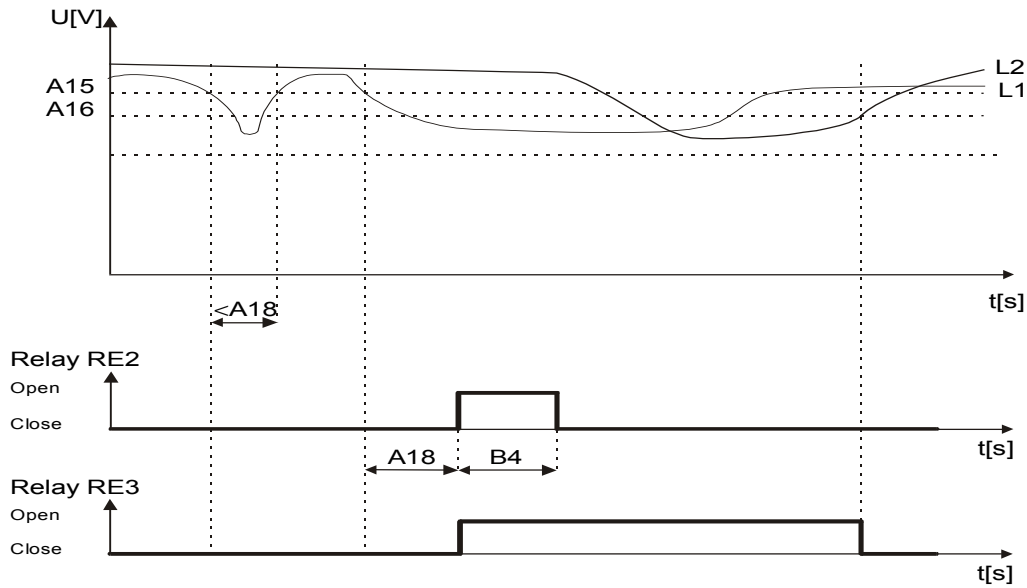
The relay **RE4** opens at any failure with delay given by active protection (**A8, A10, A14, A18, A20**) see table in the Chapter 6 – Displayed Quantities and Parameters. In example on the following drawing it is Undervoltage delay **A18**. **RE4** closes after the time given by parameter **B4**. The relay operates similar as **RE2**, but indicates any new failure.

This feature is available from software version 1.5 (see parameter **B10** to find your software version).

Note:

If there is no power supply, all relays are open.

4.6. Example: Evaluation of undervoltage protection



4.7. Vector Shift Protection

The vector shift protection protects synchronous generator in parallel operation in case of mains failure by very fast opening the coupling breaker. Automatic mains reclosing for synchronous generator is very dangerous. The mains voltage returning after 300 ms can meet the generator in asynchronous mode. There are two main applications for vector protection:

1. parallel mode only (no island mode)

The vector protection controls the generator circuit breaker.

2. parallel and island mode

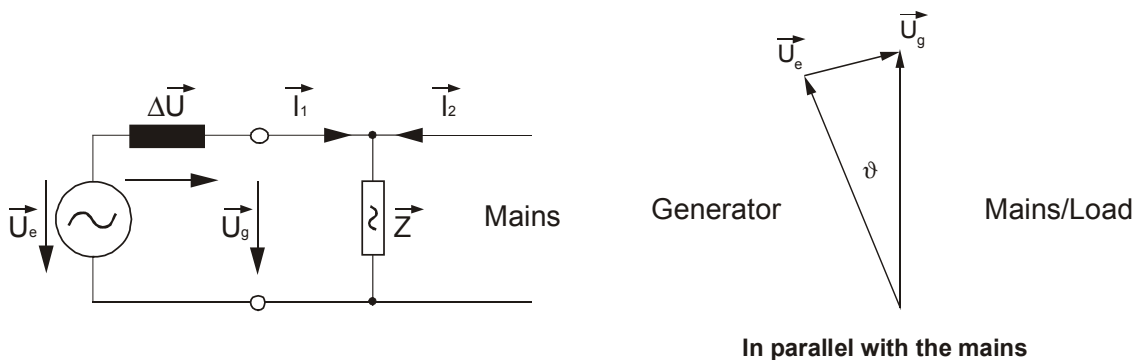
The vector protection controls the mains circuit breaker.

The NPU detects mains failure within 30 ms. The total time of disconnection is shorter than 100 ms including disconnecting time of the circuit breaker.

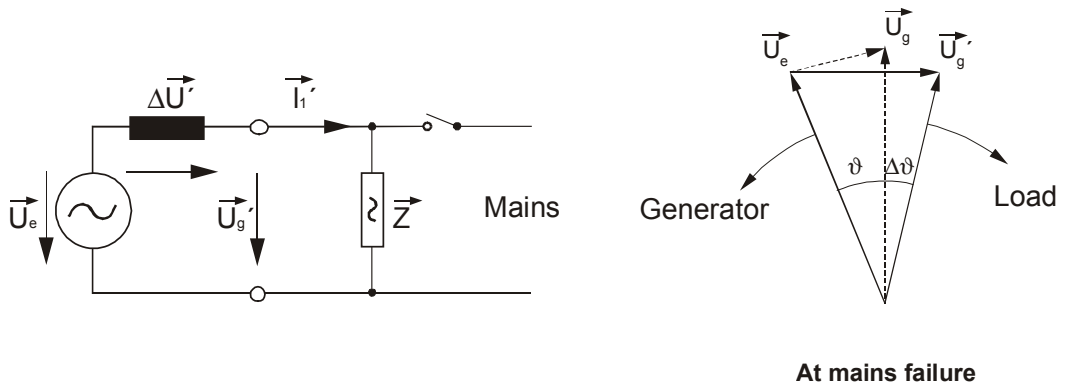
The requirement for generator disconnection comes on power change of more than 15% - 20%. Slow changes of frequency (e.g. governor commands) don't activate the protection.

Measuring principle

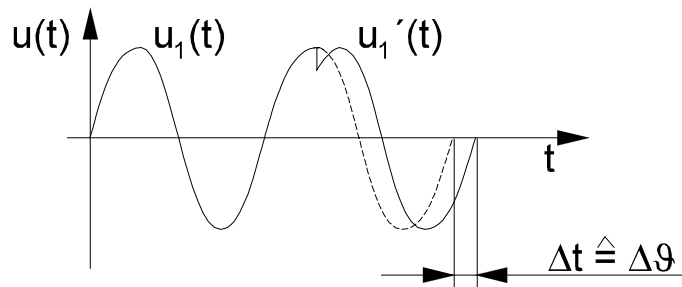
When a synchronous alternator is loaded, the rotor displacement angle ϑ is built between the terminal voltage (mains voltage) \vec{U}_g and the synchronous electromotive force \vec{U}_e . Therefore a voltage difference ΔU is built between \vec{U}_e and \vec{U}_g . The rotor displacement angle ϑ between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



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' .



As shown in the timing diagram the voltage jumps to an other value and the phase position changes. This procedure is named phase or vector surge. NPU continuously measures the cycles, starting each zero up ward slope. The time cycle is internally compared to the quartz table 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.



Measuring principle

5. Settings

5.1. Buttons

Parameters and quantities are divided into two sets. For transfer from one set to the other press **MODE** button for 5 seconds. See tables for these sets. Items (parameters and quantities) in tables are in the same sequence as on display.

If the **SET** button is available (the **SET** button can be protected with panel fixed by two seals), parameters can be adjusted by pressing of **SET** button.

For transfer between items use \uparrow (up arrow) or \downarrow (down arrow).

5.2. Display and LEDs

Parameters or measured quantities are displayed on four digits display.

The display switches on after pressing any button and switches off after the time given by B2. If B2 is 0, than the display never switches off. The display switch off also aborts unfinished parameter settings.

The green LED **PWR** indicates power supply.

Three-colour LEDs **L1**, **L2**, **L3** indicate the phase that corresponds to the data on display (yellow colour) or to a failure LED (red colour).

Three-colour LEDs **f \uparrow** , **f \downarrow** , **U \uparrow** , **U \downarrow** , **Δ U**, **U**, **\vec{U}** indicate failure type (red colour) or data on display (yellow colour).

The three-colour LED **ERR** follows relay **RE2** (red colour id. RE2 is open, switches off if RE2 is closed) and also NPU internal error (red flashing).

Notes:

If any LED shines or flashes red the failure is indicated. The failure indication has always priority to another indications.

The LEDs **L1**, **L2**, **L3**, **f \uparrow** , **f \downarrow** , **U \uparrow** , **U \downarrow** , **Δ U**, **U**, **\vec{U}** shine red immediately after failure (without delay). If RE2 relay opens LED's starts red flashing. The LED flashing is finished by pressing any button or the time given by **B2**. Failures are not indicated by red LED flashing if **B2** is zero.

5.3. Parameters settings

Press the **SET** button and the first digit starts flashing. The flashing digit can be changed by pressing \uparrow (+1) and \downarrow (-1) buttons. The next digit is selected by pressing **MODE** button.

If the required parameter value is displayed press the **SET** button again and the new value is stored. If a new value is out of allowed range the NPU sets it to proximate value.

Caution: a new value is applied immediately.

6. Displayed Quantities and Parameters

Set A:

No.	Quantity (parameter)	Front panel signals	Characters on display	Limits	Step	Unit
A1	Frequency in L1, L2, L3	Green L1,L2,L3			0,01	[Hz]
A2	Voltage L1	Green L1	0.0000		1	[V]
A3	Voltage L2	Green L2	0.0000		1	[V]
A4	Voltage L3	Green L3	0.0000		1	[V]
A5	Max. phase asymmetry		0.0000		1	[V]
A6	Max. vector shift in L1, L2, L3	Yellow L1	0.0000		0,1	[°]
A7	Overfrequency limit	Green f ↑	0.0000	0;45÷65	0,1	[Hz]
A8	Overfrequency delay	Yellow f ↑		0÷99,98	0,02	[s]
A9	Underfrequency limit	Green f ↓	0.0000	0;45÷65	0,1	[Hz]
A10	Underfrequency delay	Yellow f ↓		0÷99,98	0,02	[s]
A11	Overvoltage limit L1	Green L1, U ↑	0.0000	0÷999	1	[V]
A12	Overvoltage limit L2	Green L2, U ↑	0.0000	0÷999	1	[V]
A13	Overvoltage limit L3	Green L3, U ↑	0.0000	0÷999	1	[V]
A14	Overvoltage delay	Yellow U ↑		0÷99,98	0,02	[s]
A15	Undervoltage limit L1	Green L1, U ↓	0.0000	0÷999	1	[V]
A16	Undervoltage limit L2	Green L2, U ↓	0.0000	0÷999	1	[V]
A17	Undervoltage limit L3	Green L3, U ↓	0.0000	0÷999	1	[V]
A18	Undervoltage delay	Yellow U ↓		0÷99,98	0,02	[s]
A19	Voltage asymmetry limit	Green ΔU	0.0000	0÷999	1	[V]
A20	Asymmetry delay	Yellow ΔU		0÷99,98	0,02	[s]
A21	Vector shift limit	Green ↗	0.0000	0÷50	1	[°]
A22	Vector shift evaluation delay on voltage connection	Yellow U		0÷99,98	0,02	[s]

Set B:

No.	Quantity (parameter)	Front panel signals	Characters on display	Limits	Step	Unit
B1	Failure time signalling (red LED's flashing time)	Flashing green L1,L2		0÷9999	1	[min]
B2	Display switch off time	Flashing green L1, L3		0÷9999	1	[min]
B3	Relay RE1 switch off time	Flash. yellow L1, L2		0÷99,98	0,02	[s]
B4	Relay RE2 switch off time	Flash. yellow L1, L3		0÷99,98	0,02	[s]
B5	Relay RE3 switch off time for vector shift protection	Flash. yellow U		0÷99,98	0,02	[s]
B6	Max. vector shift in L1, L2, L3 (from manual reset)	Yellow L1, L2, L3		0÷0		[°]
B7	Angle between L1 and L2	Yellow L1, L2			1	[°]
B8	Angle between L2 and L3	Yellow L2, L3			1	[°]
B9	Display and LED's brightness			0÷9	1	
B10	Software release					
B11	Display and LED's test	All LEDs yellow (no failure) ERR red				

Time delays are set with step 0.02 s (without relay drop out time - c. 0.01 s has to be added).

The Max. vector shift (**A6**) is the highest measured value between data recovery on display. The Max. vector shift (**B6**) is the highest measured value between manual resets. This could be used for a long-term monitoring of the grid's vector shifts. Reset of **B6**: Set zero like in the other parameters.

Setting zero bold typed parameters switches off the appropriate protection.

Exception: **B2** set to zero makes the display shining continuously.

7. Order codes

NPU - XXX / YYY / ZZZ

XXX functions: FU / FUV
 YYY measurement range: 400 / 230 / 100
 ZZZ power supply range: 230VAC / 24VDC

Order code	Frequency protection	Voltage protection	Voltage asymmetry protection	Vector shift supervision	Rated voltage	Power supply voltage
NPU-FU/100/230VAC NPU-FU/100/24VDC	Yes	Yes	Yes	No	100V	230VAC 24VDC
NPU-FU/230/230VAC NPU-FU/230/24VDC	Yes	Yes	Yes	No	230V	230VAC 24VDC
NPU-FU/400/230VAC NPU-FU/400/24VDC	Yes	Yes	Yes	No	400V	230VAC 24VDC
NPU-FUV/100/230VAC NPU-FUV/100/24VDC	Yes	Yes	Yes	Yes	100V	230VAC 24VDC
NPU-FUV/230/230VAC NPU-FUV/230/24VDC	Yes	Yes	Yes	Yes	230V	230VAC 24VDC
NPU-FUV/400/230VAC NPU-FUV/400/24VDC	Yes	Yes	Yes	Yes	400V	230VAC 24VDC