FABRIKA MERNIH TRANSFORMATORA ZAJEČAR

SELF-MANAGEABLE VOLTAGE REGULATORS

1969
ZAJEČAR
FMT

2024.

TÜV NORD

CERTIFICATE

Management system as per
ISO 9001 : 2015

The Certification Body TÜV NORD CERT GmbH hereby confirms as a result of the audit, assessment and certification decision according to ISO/IEC 17021-1:2015, that the organization

Fabrika mernih transformatora Zaječar
Stražilovska 57
19000 Zaječar
Republic of Serbia

operates a management system in accordance with the requirements of ISO 9001 : 2015 and will be assessed for conformity within the 3 year term of validity of the certificate.

Scope

Design, production and sale of voltage transformers, measuring transformers, current and voltage sensors, insulators of epoxy resins, earthing resistors and reactor

Certificate Registration No. 44 100 22430235
Audit Report No. 10022818

End of validity of previous certificate: 2022-12-12
Valid from 2023-01-13
Valid until 2025-12-12
Initial certification 2016

Certification Body
at TÜV NORD CERT GmbH

Essen, 2023-01-13

TÜV NORD CERT GmbH Am TÜV 1 45307 Essen www.tuev-nord-cert.com

IAF DAkkS Deutsche Akkreditierungsstelle D-ZM-12007-01-00

TÜV NORD

CERTIFICATE

Management system as per
ISO 14001 : 2015

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Fabrika mernih transformatora Zaječar
Stražilovska 57
19000 Zaječar
Republic of Serbia

operates a management system in accordance with the requirements of ISO 14001 : 2015 and will be assessed for conformity within the 3 year term of validity of the certificate.

Scope

Design, production and sale of voltage transformers, measuring transformers, current and voltage sensors, insulators of epoxy resins, earthing resistors and reactor

Certificate Registration No. 44 104 22430235
Audit Report No. 10422345

Valid from 2023-01-13
Valid until 2026-01-12
Initial certification 2016

Certification Body
at TÜV NORD CERT GmbH

Essen, 2023-01-13

TÜV NORD CERT GmbH Am TÜV 1 45307 Essen www.tuev-nord-cert.com

IAF DAkkS Deutsche Akkreditierungsstelle D-ZM-12007-01-00

TÜV NORD

CERTIFICATE

Management system as per
ISO 45001 : 2018

The Certification Body TÜV NORD CERT GmbH hereby confirms as a result of the audit, assessment and certification decision according to ISO/IEC 17021-1:2015, that the organization

Fabrika mernih transformatora Zaječar
Stražilovska 57
19000 Zaječar
Republic of Serbia

operates a management system in accordance with the requirements of ISO 45001 : 2018 and will be assessed for conformity within the 3 year term of validity of the certificate.

Scope

Design, production and sale of voltage transformers, measuring transformers, current and voltage sensors, insulators of epoxy resins, earthing resistors and reactor

Certificate Registration No. 44 126 22430235
Audit Report No. 12622189

End of validity of previous certificate: 2022-12-09
Valid from 2023-01-13
Valid until 2025-12-09
Initial certification 2016

Certification Body
at TÜV NORD CERT GmbH

Essen, 2023-01-13

TÜV NORD CERT GmbH Am TÜV 1 45307 Essen www.tuev-nord-cert.com

IAF DAkkS Deutsche Akkreditierungsstelle D-ZM-12007-01-00

VROT-X

INTRODUCTION

DESCRIPTION

The self-manageable voltage regulator is intended for managing voltage conditions in the low voltage network, balancing the load along the line where it is installed, eliminating return current through a neutral conductor for consumers connected behind the VROT - * device, improving protection conditions and protection selectivity, and protecting the consumers from the higher voltage at the short-circuit faults between phase and neutral conductor. It has high degree of transmission of maximum power over low voltage line. The basic elements are: fuse box, special galvanic isolated dry-type power transformer and control box.

FUSE BOX

It is equipped with high-performance fuses. The cover of the fuse box is transparent so the status of fuse can be seen.

DRY POWER TRANSFORMER

It is special type of self-manageable transformer whose operation is based on the control of the changing structure of the galvanically separated circuit. It has been made of highest quality epoxy resins for outdoor-indoor mounting with optimized dimensions considering rated power and place of mounting. Special attention has been given to design, mechanical and electrical characteristics, dielectric and thermodynamic stresses and power losses which makes it very efficient and reliable.

CONTROL BOX

Control box has been made of highest quality PVC materials with degree of mechanical protection IP 54, equipped with galvanically separated electronics which controls the transformer. The electronics issue an order to the special executive body for the transformer to enter the regulation. The electronics also has self testing function.

BASIC WORKING PRINCIPLE

It is based on the fact that the electronics that are galvanically separated from the low-voltage network monitors the state of the parameters of the low-voltage line at the installation site and performs control according to the entered program. By installing the device at the projected point at the low voltage outlet at the installation site, identical parameters are obtained as on the busbars of the transformer station 10(20)/0.4kV, so that the method of mapping the transformer station TS 10(20)/0.4kV to the installation point of the device is realized.

MOUNTING

The self-manageable voltage regulator is intended for mounting on the stainless steel console at the height 1m below the lowest conductor of the low voltage network. Connection has been made by connecting the primary winding on the network lines and secondary winding between phase and neutral line. Joint grounding must be done at the installation site. One transformer has been used per one phase.

PROTECTION AGAINST DIRECT CONTACT VOLTAGE

It has been done by covering all parts which are connected to voltage.

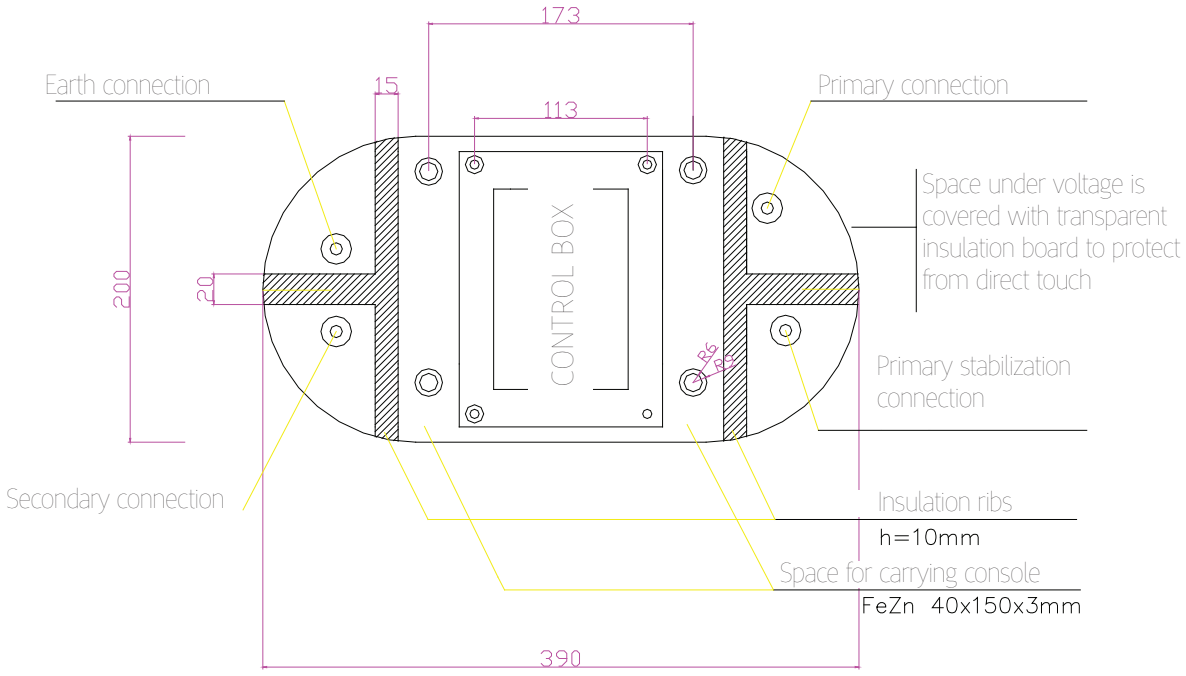
TECHNICAL CHARACTERISTICS OF THE SELF-MANAGEABLE REGULATING TRANSFORMERS

TYPE OF THE TRANSFORMER	VROT-3	VROT-5	VROT-10	VROT-18
Rated power [kVA]	3	5	10	18
Rated network voltage [V]	400/231			
Output voltage [V]	230 ± 10%			
Rated insulation level [kV]	1			
Rated power-frequency withstand voltage, 1min [kV]	3			
Rated impulse withstand voltage 1.2/50μs [kV]	6			
Rated output current [A]	13	22	44	80
Power losses P_{cun} (W)/P_{fe}(W)	120/22	160/30	310/50	500/80
Power factor cos φ	0.95			
Degree of mechanical protection	IP 54			
Temperature range	-35^{0}C to 80^{0}C			
Mounting	In any position on the pole			

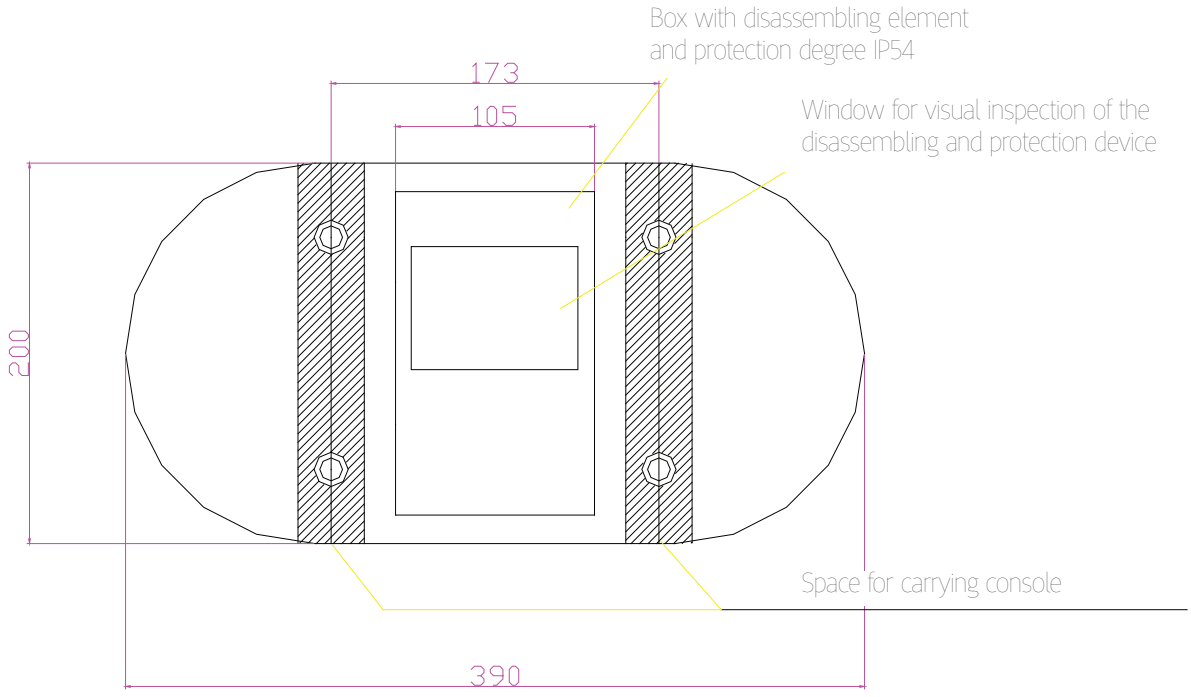
Advantages:

- Easy mounting;
- Low investment costs;
- Considerably higher efficiency for power transmission along the low-voltage lines;
- Reduced power losses along the line;
- Ability to transmit much greater power to larger distances with maintaining voltage value along the low voltage lines between the limits defined in standards IEC 60038/EN 50160;
- Eliminated influence of the higher harmonics due to galvanic separation;
- Eliminated burden of the neutral line caused by large asymmetry, because at the mounting place I0 = 0;
- Improved protection conditions in TNC-S systems;
- protection of consumers from excessive voltage in case of short-circuit of phase and neutral conductor or interruption of neutral conductor;
- load balancing by phase conductors;
- achieved selectivity and sensitivity of the protection action along the low voltage line;
- in combination with a self-supporting cable bundle does not require maintenance of that outlet from the transformer station, especially if the power line passes through areas with high vegetation;
- Very suitable for replacing the power substations 10/0.4 kV, power up to 50 kVA when supplying small consumption;
- When replacing the power substations 10/0.4 kV, power up to 50 kVA there are less outages of the main line 10(20) kV caused by high vegetation to supply small power substation 10/0.4 kV;
- Very suitable for ring networks power substations 10/0.4 kV 250 kVA with 5 output lines, each one 50 kVA, speaking of type VROT-18;
- Very suitable for industrial objects, high buildings and market malls for distribution systems for distant consumers.

Side 1.


173
15
113
Earth connection
Primary connection
Space under voltage is covered with transparent insulation board to protect from direct touch
200
20
CONTROL BOX
Primary stabilization connection
Secondary connection
Insulation ribs
h=10mm
Space for carrying console
FeZn 40x150x3mm
390

Side 2.


Box with disassembling element and protection degree IP54
173
105
Window for visual inspection of the disassembling and protection device
200
Space for carrying console
390

The effects of putting self-manageable regulating transformers in the low voltage network:

WITH VROT 18 IN LOW VOLTAGE NETWORK

Rated voltage at power substation 10(20)/0.4kV, 250 kVA Level 1	Used conductor in the low voltage network Level 1 to Level 2	Lenght of the low voltage line [m]	Rated power / Line voltage / Phase voltage at the end of the line LEVEL 2	
			Symmetrical 3 phase	Not symmetrical 1 phase
231/400V	AlFe 3x 25/4mm or X00-A-3x25mm^2	800	16kW/400/230V	7.8kW/230V
		450	30kW/400/230V	13.8kW/230V
		250	50kW/400/230V	18kW/230V
	AlFe 3x 35/6mm or X00-A-3x35mm^2	1100	16kW/400/230V	7.8kW/230V
		500	30kW/400/230V	13.8kW/230V
		300	50kW/400/230V	18kW/230V
	AlFe 3x 50/8mm or X00-A-3x50mm^2	1500	16kW/400/230V	7.8kW/230V
		800	30kW/400/230V	13.8kW/230V
		500	50kW/400/230V	18kW/230V
	X00-A-3x70mm^2	2000	16kW/400/230V	7.8kW/230V
		1000	30kW/400/230V	13.8kW/230V
		600	50kW/400/230V	18kW/230V

X00-A is self-supporting cable assembly. TABLE 1.0

WITHOUT VROT 18 IN LOW VOLTAGE NETWORK

Rated voltage at power substation 10(20)/0.4kV, 250 kVA Level 1	Used conductor in the low voltage network Level 1 to Level 2	Lenght of the low voltage line [m]	Rated power / Line voltage / Phase voltage at the end of the line LEVEL 2	
			Symmetrical 3 phase	Not symmetrical 1 phase
231/400V	AlFe 4x 25/4mm or X00-A-4x25mm^2	400	16kW/376/217V	5.00kW/207V
		225	30kW/376/217V	8.66kW/207V
		125	50kW/376/217V	15.4kW/207V
	AlFe 4x 35/6mm or X00-A-4x35mm^2	550	16kW/377/218V	5.00kW/207V
		320	30kW/377/218V	8.66kW/207V
		180	50kW/377/218V	15.4kW/207V
	AlFe 4x 50/8mm or X00-A-4x50mm^2	770	16kW/377/218V	5.00kW/207V
		450	30kW/377/218V	8.66kW/207V
		260	50kW/377/218V	15.4kW/207V
	X00-A-3x70+71.5 mm^2	1000	16kW/377/218V	5.00kW/207V
		600	30kW/377/218V	8.66kW/207V
		340	50kW/377/218V	15.4kW/207V

TABLE 1.1

For transmission of the larger power and for longer distances from the ones shown in the "TABLE 1.0" larger cross-section conductors should be used.

THE EFFECTS OF PUTTING SINGLE PHASE SELF-MANAGEABLE REGULATING TRANSFORMER VROT-18 IN THE SINGLE PHASE LOW VOLTAGE NETWORK:

	Method	With VROT 18		Without VROT 18	
Level 2	Phases on the consumer	R	N	R	N
	Power on the consumer	12.70kW		7.61kW	
	Current through the consumer	55.5 A	55.5 A	42.52 A	42.52 A
	Voltage on the consumer	230.00 V		179.00 V	
	Consumer gets the supply via	VROT 18		Al/Fe -2 x 50/8mm^2	
	Connection towards power substation	R	S	R	N
Low voltage power line 1000m	Used conductor	Al/Fe -2 x 50/8mm^2		Al/Fe -2 x 50/8mm^2	
	Current that runs through the line towards power substation	36.60 A	36.60A	42.52 A	42.52 A
	Losses in the low voltage power line [kW]	0.80	0.80	1.08	1.08
TS 10(20)/0.4kV Level 1	Rated voltage at the power substation	230V			

TABLE 2

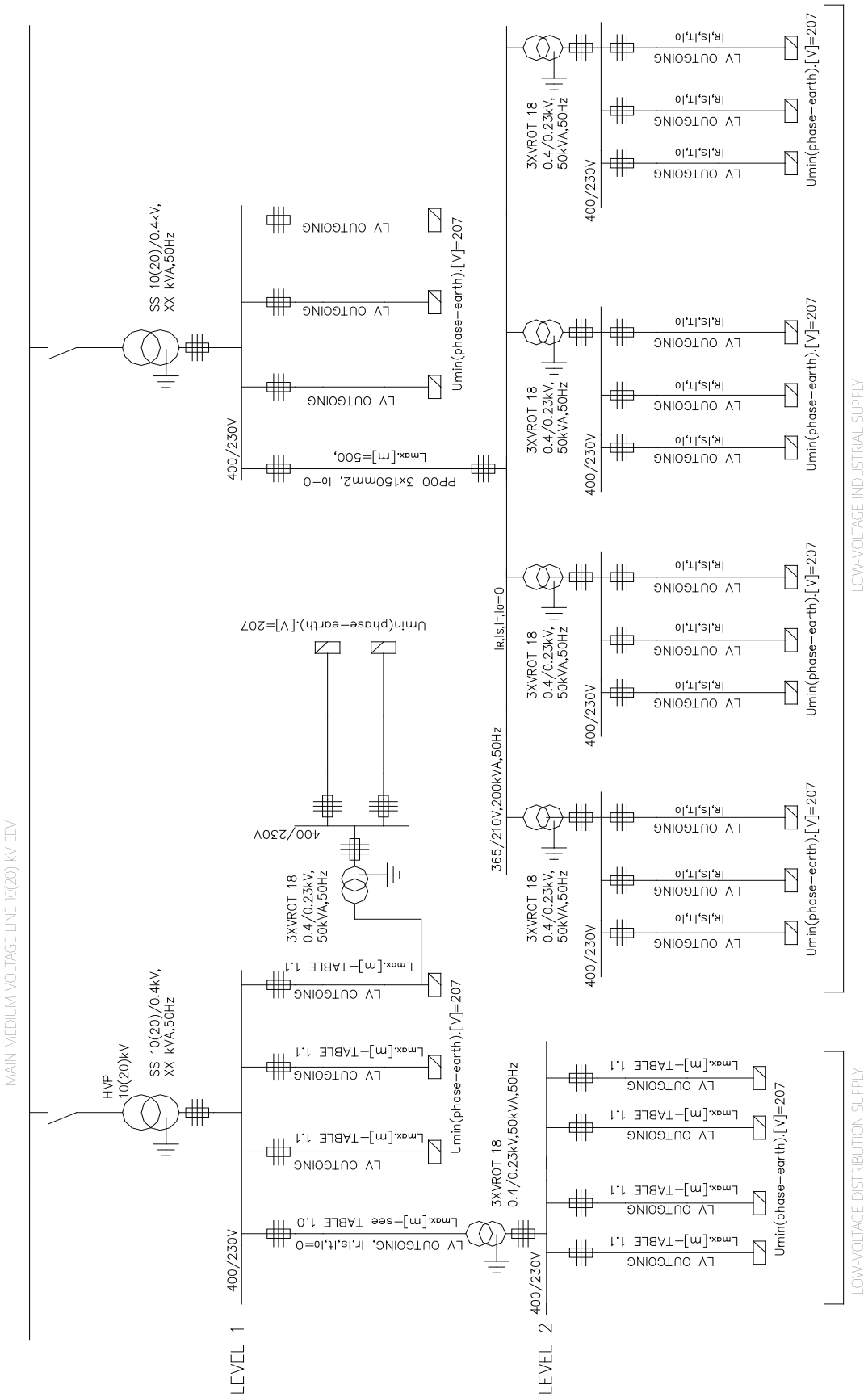
Solving the problem of maintaining the voltage continuous between the limits defined in standard IEC 60038/EN 50160 along the low voltage power line from the power substation 10/0.4 kV to the last consumer for asymmetrically and symmetrically load, influencing only on the conductor's cross section or by increasing the voltage in the sub station is not an efficient method which can be seen through the analysis according to the Tables 1.0 and 1.1, especially if the power supply of single-phase consumption is performed, which can be seen in the Table 2.

If the development concept of the medium and low voltage network is based on a ring type of supply via power substations 10/0.4 kV, 250 kVA with 5 outputs, than minimum 1 output could be used to supply distant consumers, using the combination of conductor with appropriate cross section and the device VROT-X depending of the required power of the consumer according to the Table 1.0.

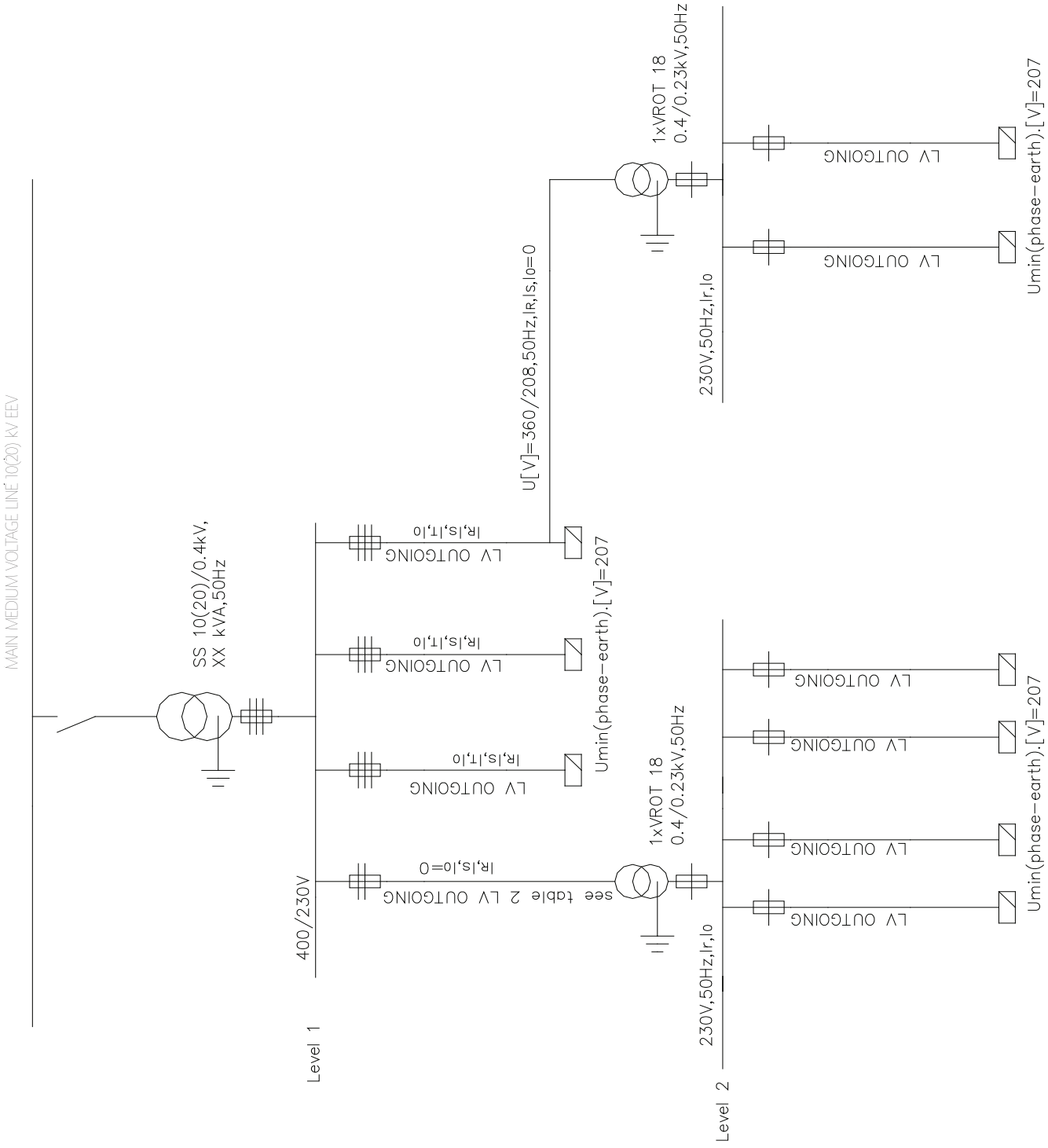
This system of supply the consumer up to 50 kVA has the following advantages comparing to classic solutions (power distribution through the 10(20) kV power line, power substation 10(20)/0.4 kV, 50 kVA):

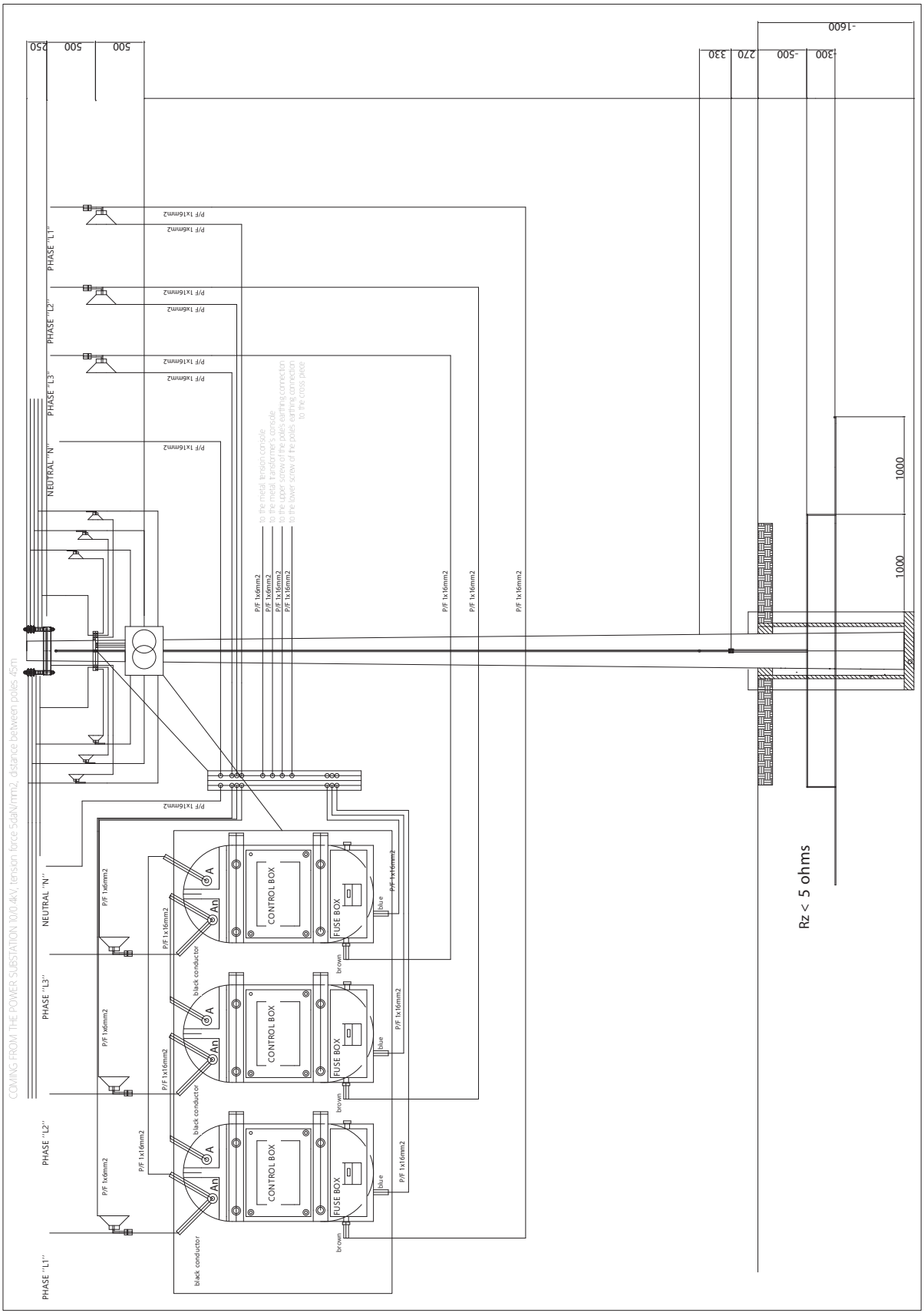
- Less maintaining expenses especially if the power line passes through the areas with high vegetation which requires maintaining of the track or using the high voltage cable harness;
- Faster, cheaper and easier network maintenance, when supplying small power consumer with low voltage cable harness and device VROT-X than with high voltage cable harness;
- smaller number of outages of the main power line 10(20) kV when primary conductors are uninsulated Al/Fe conductors passing through the high vegetation.

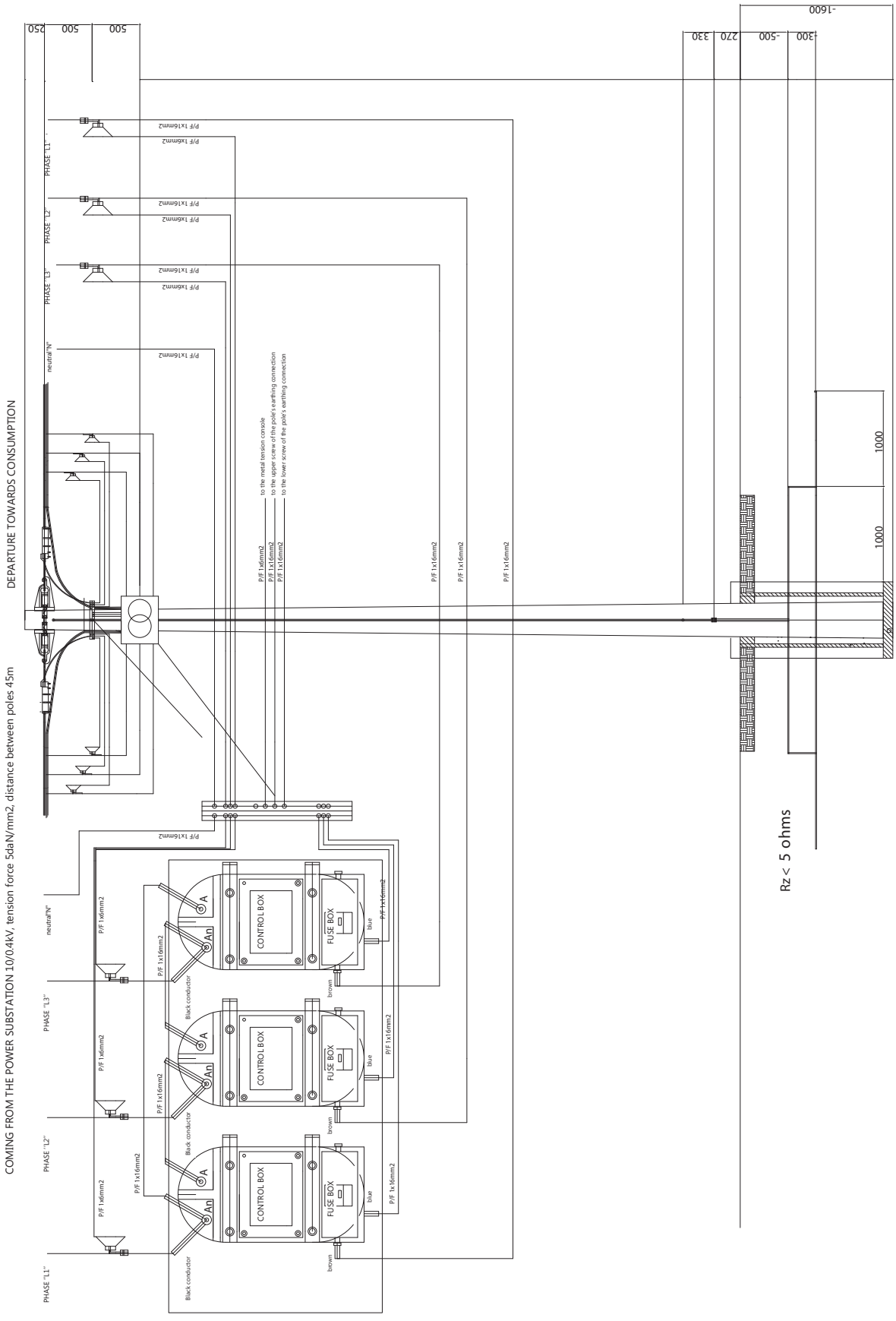
APPLYING THE THREE PHASE VROT-18 IN DISTRIBUTION AND INDUSTRIAL NETWORK



APPLYING THE SINGLE PHASE VROT-18 IN DISTRIBUTION NETWORK

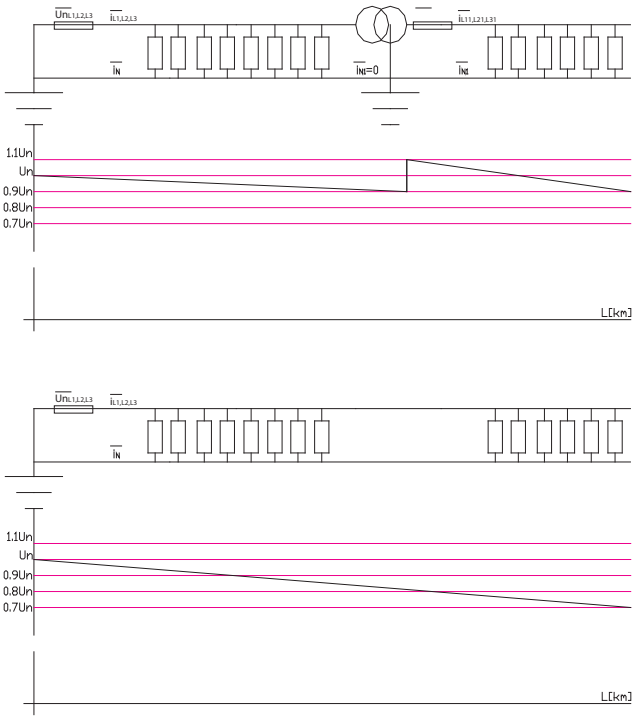



COMING FROM THE POWER SUBSTATION 10/0.4kV, tension force 5daN/mm2, distance between poles 45m
PHASE "L1"
PHASE "L2"
PHASE "L3"
NEUTRAL "N"
P/F 1x16mm2
P/F 1x6mm2
P/F 1x16mm2
to the metal tension console
to the metal transformer's console
to the upper screw of the poles earthing connection
to the lower screw of the poles earthing connection
to the cross piece
CONTROL BOX
FUSE BOX
blue
brown
black conductor
1000
1000
1600
300
500
270
330
250
500
500
Rz < 5 ohms

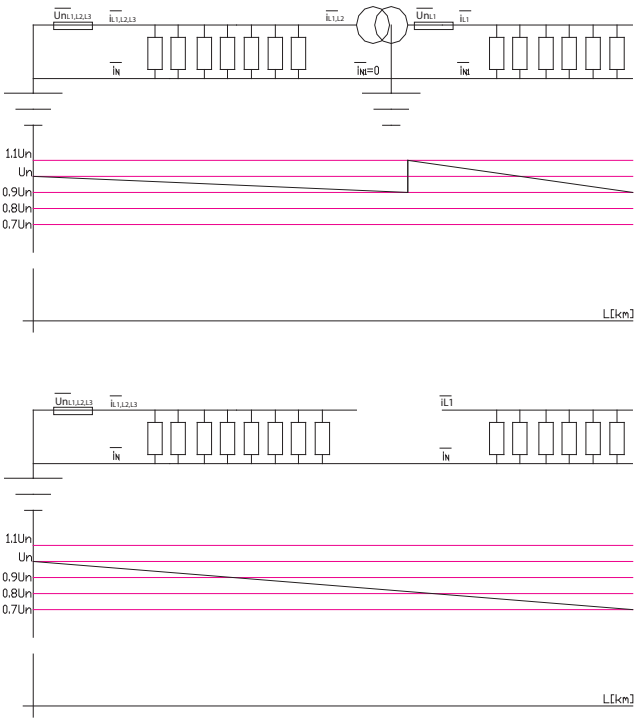

COMING FROM THE POWER SUBSTATION 10/0.4kV, tension force 5daN/mm2, distance between poles 45m
DEPARTURE TOWARDS CONSUMPTION
PHASE "L1"
PHASE "L2"
PHASE "L3"
neutral"N"
P/F 1x16mm2
P/F 1x6mm2
to the metal tension console
to the upper screw of the pole's earthing connection
to the lower screw of the pole's earthing connection
CONTROL BOX
FUSE BOX
blue
brown
Black conductor
Rz < 5 ohms
1000
1600
300
500
270
330
250

Characteristics of the voltage occasions along the low voltage power line

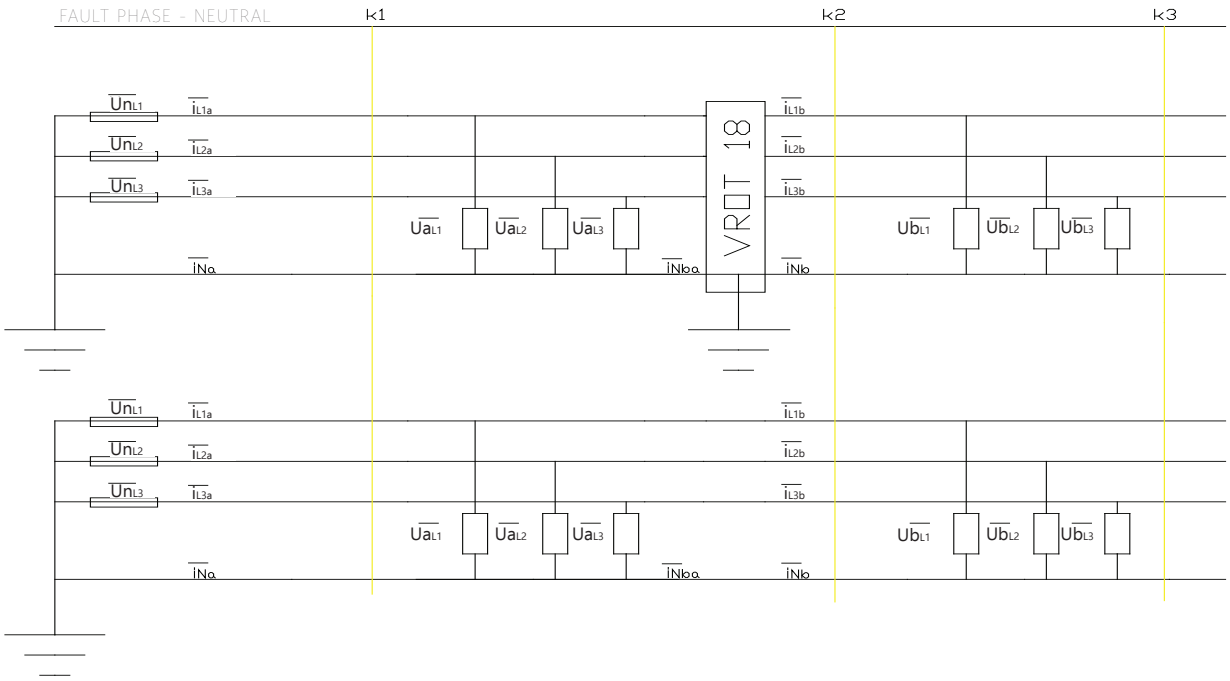
Applying the three phase VROT for three phase consumer at the end of the line



Applying the single phase VROT for single phase consumer at the end of the line



Protection of the consumer from the too high voltage in the low voltage distribution network when the short-circuit fault occurs between phase and neutral conductor.



Simulation of the short-circuit fault	WITH VROT 18			WITHOUT VROT 18		
	k_1	k_2	k_3	k_1	k_2	k_3
Conductor	X00- 3x70+71.5mm^2					
Distance from the power substation [m]	200	600	1000	200	600	1000
i_{Ra} [A] U_{RA} [V]	1224.04 12.18	709.81 117.30	757.60 117.98	1241.04 12.41	483.38 14.46	516.42 15.45
i_{Sa} [A] U_{SaA} [V]	39.18 297.36	710.18 117.15	758.00 117.80	61.40 293.42	58.45 279.35	58.70 280.51
i_{Ta} [A] /U_{TA} [V]	67.71 293.54	57.07 212.74	57.35 213.91	67.40 292.63	63.90 277.41	64.19 278.69
i_{Na} [A]	1163.54	14.24	14.4	1145.04	393.64	426.24
i_{Nab} [A]	0	0	0	43.42	442.91	475.65
i_{Rb} [A] U_{RB} [V]	0 136.12	1176.73 16.90	1256.00 3.38	0 23.10	482.03 7.29	514.98 2.19
i_{Sb} [A] U_{SB} [V]	29.08 234.36	24.37 196.46	24.50 195.21	36.40 275.85	34.66 281.05	34.80 277.39
i_{Tb} [A] U_{TB} [V]	12.40 135.07	13.42 196.60	13.48 198.22	19.97 280.88	18.94 279.53	19.02 278.49
i_{Nb} [A]	23.26	1173.43	1252.49	43.42	442.91	475.65

Look of the mounted device in the single line network:

Device VROT 18 supply single phase consumers area up to the distance 1500m from the belonging power substation (TS 10(20)/0.4kV, 250kVA).
Consumers area before mounting VROT 18- had the consumption 750 kWh/month.
Consumers area after mounting VROT 18- had the consumption 3.048 kWh/month with maintaining voltage quality in accordance with IEC 60038/EN 50160.

Mounting procedure:

Additional accessories delivered with the device

The device has been delivered to the end user together with all necessary mounting equipment so the mounting can be done directly without any adjustments.

RESEARCH, DEVELOPMENT AND TESTING
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HIGH VOLTAGE DIVISION - HVD
LOW VOLTAGE LABORATORY
Phone: 0351 – 402425; e-mail: ljt@icmet.ro

TEST REPORT
Nr. 20093 / 23.03.2010

1. CUSTOMER: Fabrika Mernih Transformatora Zajecar A.D.
Paracinski put bb, 19000 Zajecar, SERBIA

2. MANUFACTURER: Fabrika Mernih Transformatora Zajecar A.D.
Paracinski put bb, 19000 Zajecar, SERBIA

ENERGO-GROUP D.O.O
Petra Milosevica 7, 71123 I. Sarajevo, B&H

3. TESTED PRODUCT: Power low voltage transformer, type VROT 18, 400 V, 18 kVA, serial no. 2/10

4. REFERENCE STANDARD: IEC 60076-11:2004

5. TEST PERFORMED:
I. Separate-source AC withstand voltage test
II. Induced AC withstand voltage test
III. Lightning impulse test

6. TEST DATE: 23.03.2010

7. TEST RESULT: The product PASSED the test.

This report contains 7 pages and it is edited in 4 copies from which 3 copies for customer and one copy for laboratory.

HEAD OF HV DIVISION,
Eng. Ion PĂTRU

ICMET CRAIOVA DIVIZIA DE ÎNALTĂ TENSIUNE

HEAD OF LABORATORY,
Eng. Aurelia SCORNEA

Issue date: 25.03.2010

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d. All signatures from the present report are originals.
e. The product was presented to be tested by the customer.

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