SELF-MANAGING VOLTAGE REGULATORS



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INTRODUCTION

DESCRIPTION

The self-managing voltage regulator is designed for voltage management and control in low-voltage networks. It balances the load along the line where it is installed, as well as reduce the return current through a neutral conductor for consumers connected downstream of the VROT-* device, thereby improving protection operating conditions and protection selectivity, while also protecting consumers from overvoltage in the event of short circuits between the phase and neutral conductors. It features a high transfer rate of maximum power along the low-voltage line.

The primary components are: a fuse box, a special galvanically isolated dry-type power transformer, and a control box.

Fuse Box

It is equipped with an automatic, high-interrupting-capacity fuse.

The cover is transparent, allowing for visual verification of the status of the switching and protective element.

Control box

It is made of top-quality PVC material with an IP 54 protection rating. It is equipped with electronic circuitry driving the transformer, galvanically isolated from the low-voltage network.

Via a special actuator, the electronics issue the command for the transformer to enter regulation mode. The electronic assembly also features a self-test function.

Dry-type power transformer

This is a special type of self-managing transformer whose operation is based on the principle of controlling the variable structure of a galvanically isolated circuit, and it does not belong to the autotransformer family.

The primary insulation is made of cycloaliphatic epoxy resins for outdoor/indoor mounting, with dimensions optimized relative to the rated power and installation site.

Utmost attention has been given to the design, mechanical, and electrical characteristics regarding thermodynamic and dielectric loads, as well as losses (iron and copper losses), making it highly efficient, reliable, and aesthetically appealing.

PROTECTION AGAINST DIRECT CONTACT

All live parts of the device are fully enclosed.

PRINCIPLE OF OPERATION

Electronics, galvanically isolated from the low-voltage network, monitor the parameters of the low-voltage line at the installation site and execute control according to the pre-programmed software. By installing the device at the designated point on the low-voltage feeder, identical parameters to those on the busbars of the associated 10(20)/0.4 kV substation are achieved, thus implementing a method that mirrors the 10(20)/0.4 kV substation at the installation site.

INSTALLATION METHOD AND LOCATION

The self-managing voltage regulator is mounted on a specially designed, stainless steel console.
It is installed at a height of 1 m below the lowest conductor of the low-voltage network. The connection to the low-voltage network is established by connecting the primary conductors to the line-to-line voltage of the grid, while the secondary side is connected to the phase and neutral conductors.

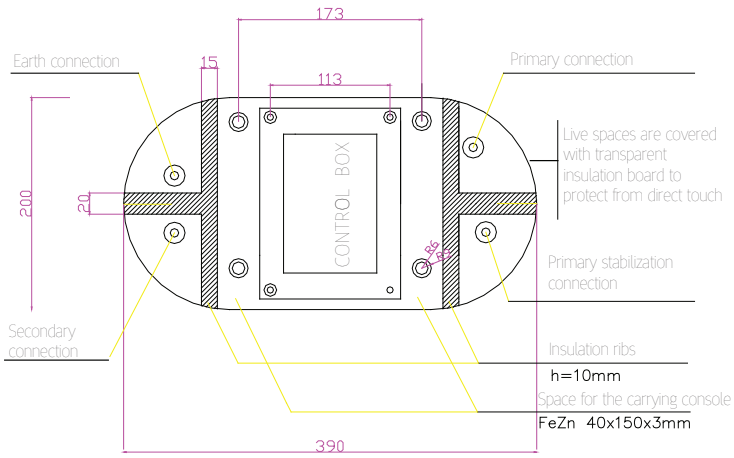
A combined grounding system must be implemented at the installation site.
One power transformer is used per phase, and each has its own fuse box and control box.
The self-managing voltage regulator regulates the voltage independently for each phase.

Bočna strana 1.

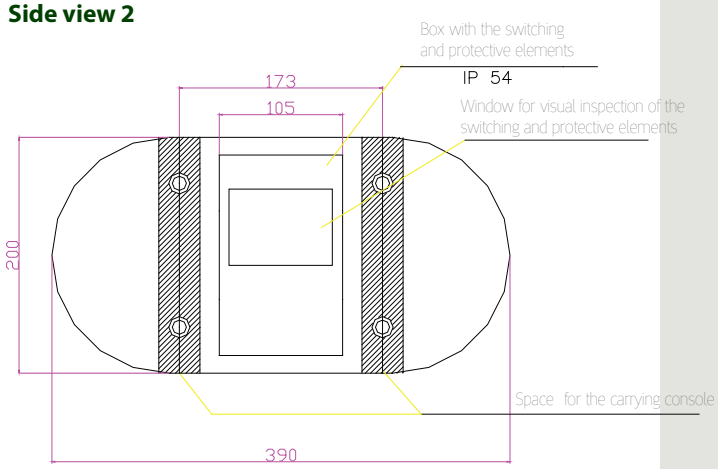
VROT-X



Side view 1



Side view 2



CHARACTERISTICS OF SELF-MANAGING VOLTAGE REGULATORS

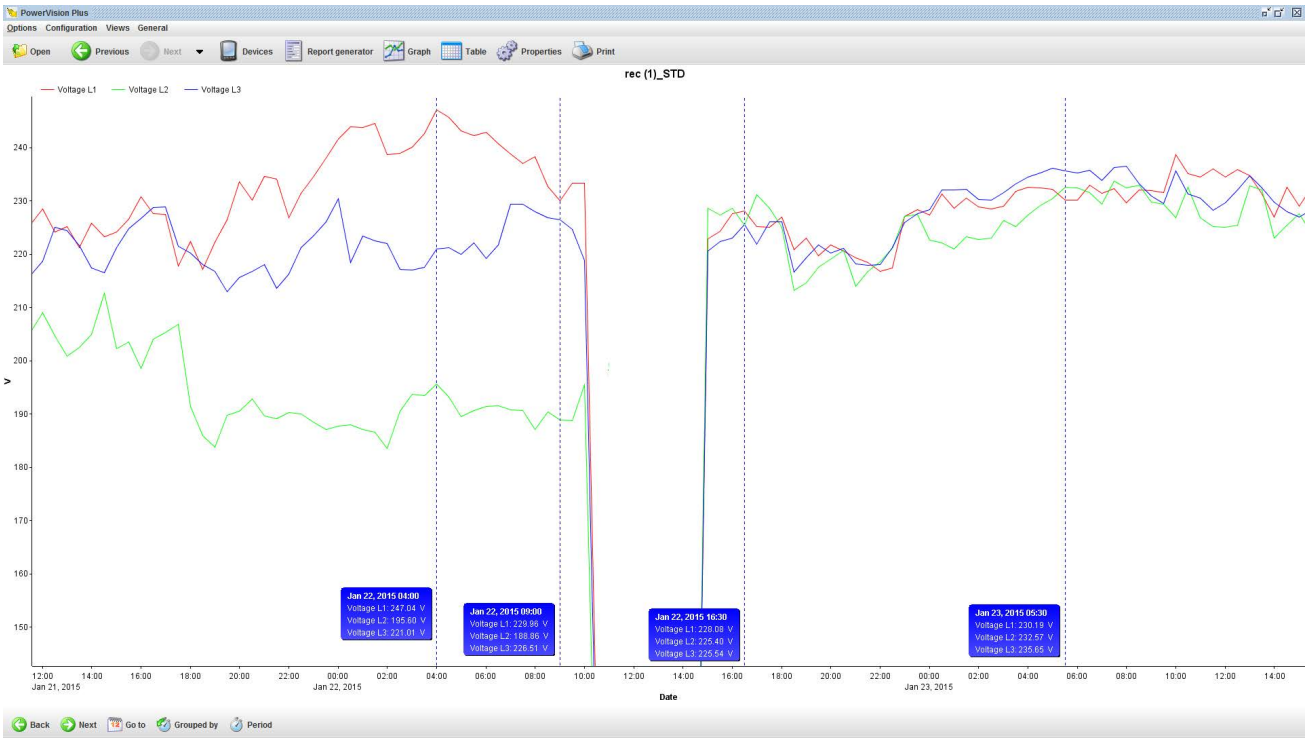
TECHNICAL DATA	VROT-10	VROT-18
Rated power (kVA)	10	18
Rated network voltage (V)	400/231	
Output voltage (V)	230 ± 10%	
Rated insulation level (kV)	1	
Rated power-frequency withstand voltage, 1min (kV)	3	
Rated impulse withstand voltage 1.2/50μs [kV]	6	
Rated output current [A]	44	80
Power losses (in transformer) P_{cun} (W)/P_{fe}(W)	310/50	500/80
Transformer power factor cos φ	0.95	
Degree of mechanical protection	IP 54	
Temperature range	-30°C do +45°C	
Mounting	in any position on the pole	

CONTENTS

ADVANTAGES OF UTILIZING THIS SYSTEM

- **Simple and fast installation**;
- **Low investment costs** during network reconstruction/retrofitting;
- **Significantly higher system efficiency** during power transmission along the low-voltage (LV) line;
- **Reduced energy losses** during transmission to consumers;
- **Capability to transmit significantly higher power over longer distances** while maintaining continuous voltage profiles along the low-voltage line within the limits defined by the IEC 60038 / EN 50160 standards;
- **Eliminated impact of higher harmonics** due to galvanic isolation;
- **Eliminated neutral conductor loading** in the substation during severe unbalances, as I0 = 0 at the installation site;
- **Improved protection operating conditions** for TN-C-S systems;
- **Consumer protection against overvoltage** in the event of a phase-to-neutral short circuit or a neutral conductor breakage (open neutral);
- **Load balancing** across phase conductors;
- **Achieved selectivity and sensitivity of protection operations** along the low-voltage line;
- **Zero-maintenance feeder operation** when combined with aerial bundled cables (ABC), particularly if the power line passes through areas with dense/high vegetation;
- **Highly suitable as a replacement for 10/0.4 kV substations up to 50 kVA** when supplying small consumer loads;
- **Reduced number of outages on the main 10(20) kV lines** (if used as a replacement for 10/0.4 kV substations up to 50 kVA) caused by faults on high-voltage lines that pass through dense vegetation to feed low-capacity 10/0.4 kV substations;
- **Highly suitable for a ring network configuration** consisting of a 10/0.4 kV 250 kVA substation with 5 outgoing feeders of 50 kVA each, specifically for the VROT-18 device type;
- **Highly suitable for application in industrial facilities, large buildings, and commercial centers** for a ditributed power supply system to remote consumers.

THE EFFECT OF VROT INSTALLATION



Effects achieved by installing self-managing voltage regulators in the low-voltage networks

WITH VROT 18 ISNTALLED IN THE 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 an aerial bundled cable (ABC) TABLE 1.0

WITHOUT VROT 18 ISNTALLED IN THE 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

To transmit higher power from the beginning to the end of the line, as well as for distances greater than those shown in "TABLE 1.0", larger conductor cross-sections must be used.

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EFFECTS OF INSTALLING A SINGLE-PHASE VROT INTO A 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

The problem of continuously maintaining voltage within the limits defined by the IEC 60038 / EN 50160 standard along a low-voltage power line – stretching from the associated 10/0.4 kV substation to the very last consumer under operating conditions ranging from unbalanced to balanced loads – is not easy to solve.

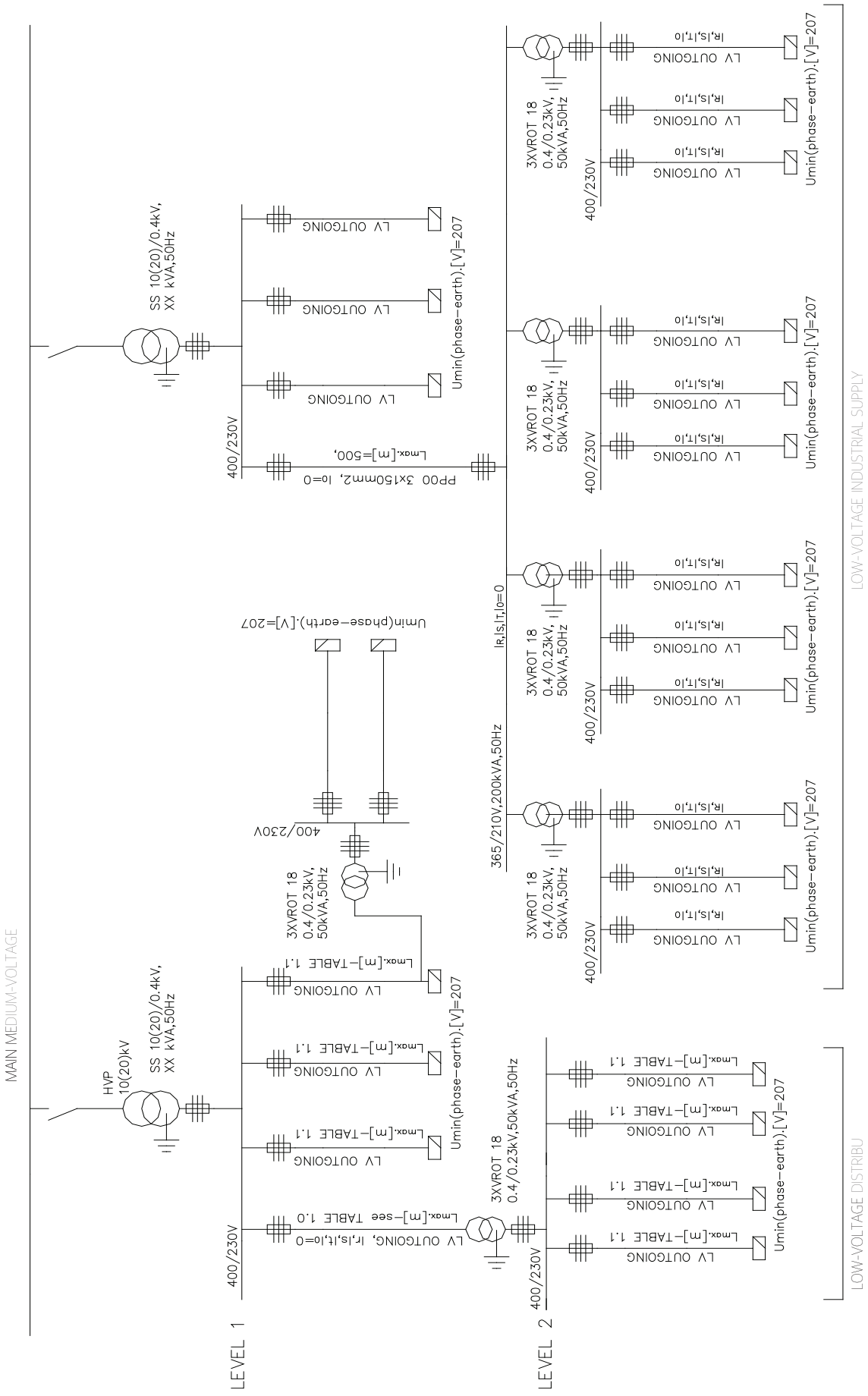
It has been proven that changing the conductor cross-section or increasing the voltage at the associated 10/0.4 kV substation is not an effective method. This is evident from the comparative analysis of the results with and without the VROT-* installation according to Tables 1.0 and 1.1, especially when supplying power to a single-phase consumer, as shown in Table 2.

If the development concept of the medium-voltage and low-voltage network is based on a ring supply via 10/0.4 kV, 250 kVA substations with 5 feeders, then at least one feeder could always be used to supply remote consumers. This is achieved by combining an appropriate conductor cross-section with the VROT-X device, depending on the required load demand in accordance with the presented Table 1.0.

By implementing the aforementioned system for supplying small consumer loads up to 50 kVA, compared to conventional solutions (power transmission via a 10(20) kV power line, 10(20)/0.4 kV, 50 kVA substation), we achieve:

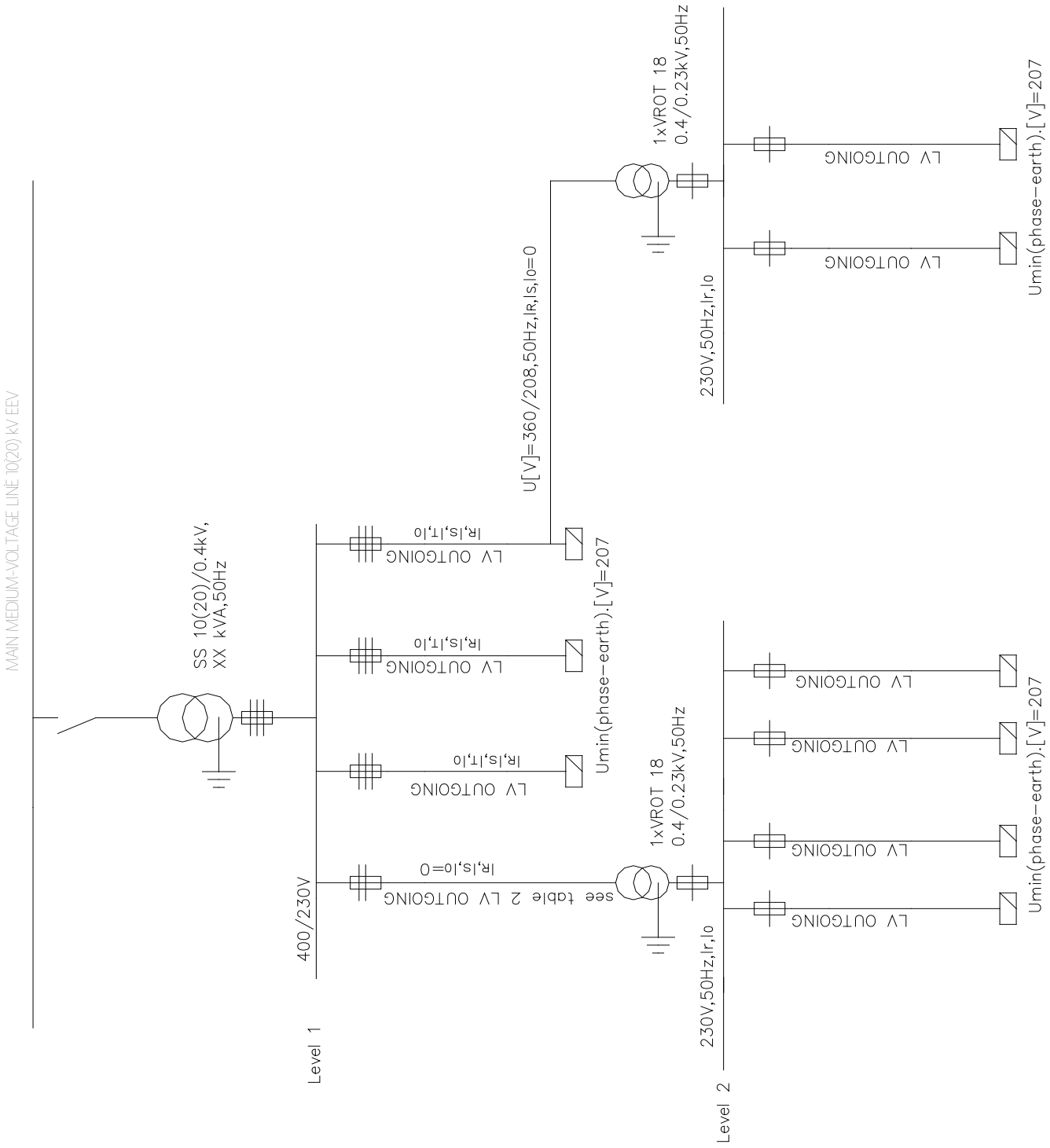
- Lower maintenance costs, especially if the power line passes through areas with dense/high vegetation where right-of-way (corridor) maintenance is required, or when utilizing a high-voltage aerial bundled cable system;
- Faster, cheaper, and easier network maintenance when a low-voltage aerial bundled cable combined with the VROT-X device is used as the primary feeder for supplying small consumer loads, rather than a high-voltage aerial bundled cable system;
- A reduced number of outages on the main 10(20) kV line when bare ACSR (Al/Fe) conductors are used as primary conductors and the line passes through areas with high/dense vegetation.

APPLICATION OF THE THREE-PHASE VROT-18 IN DISTRIBUTION AND INDUSTRIAL NETWORKS

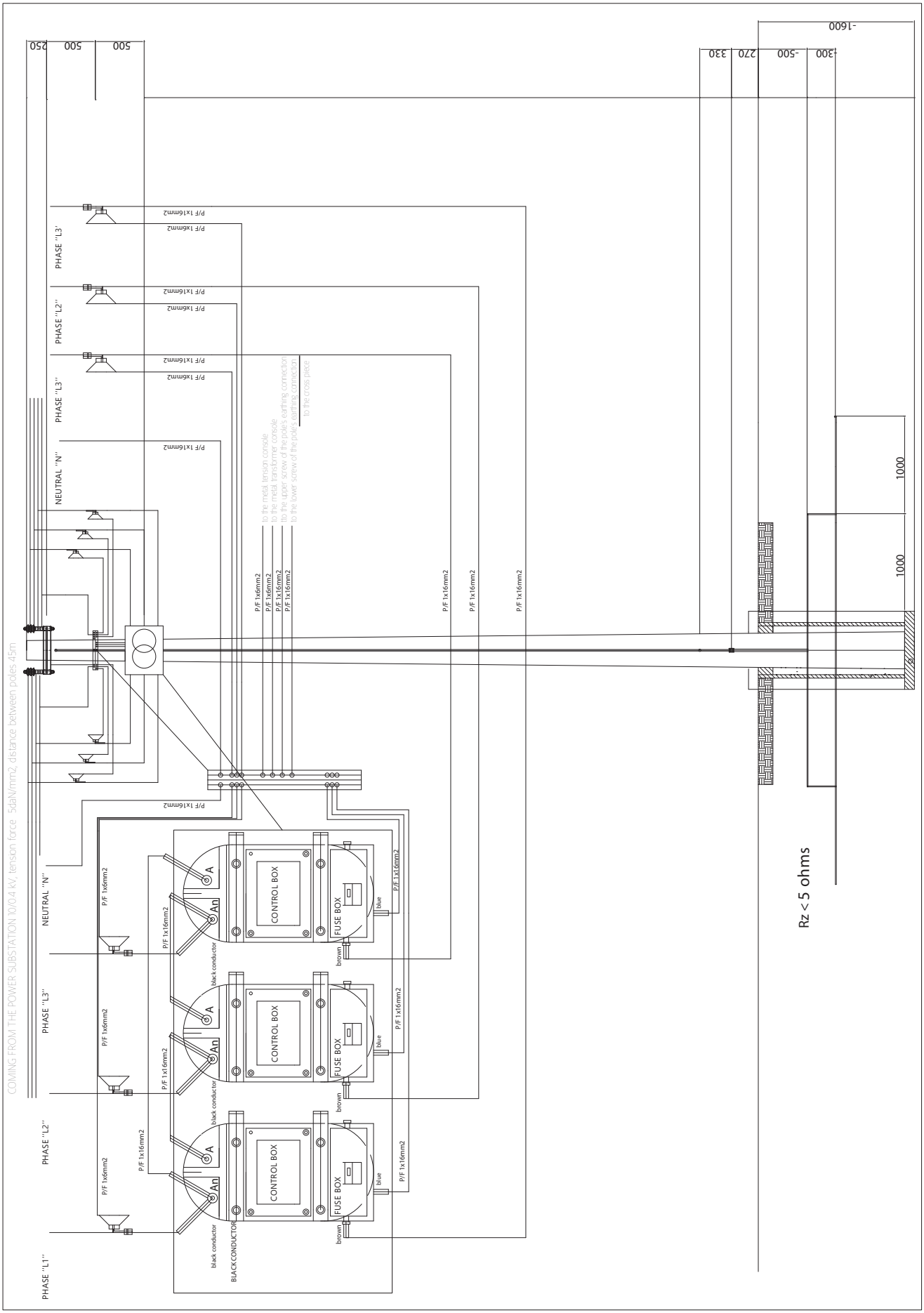


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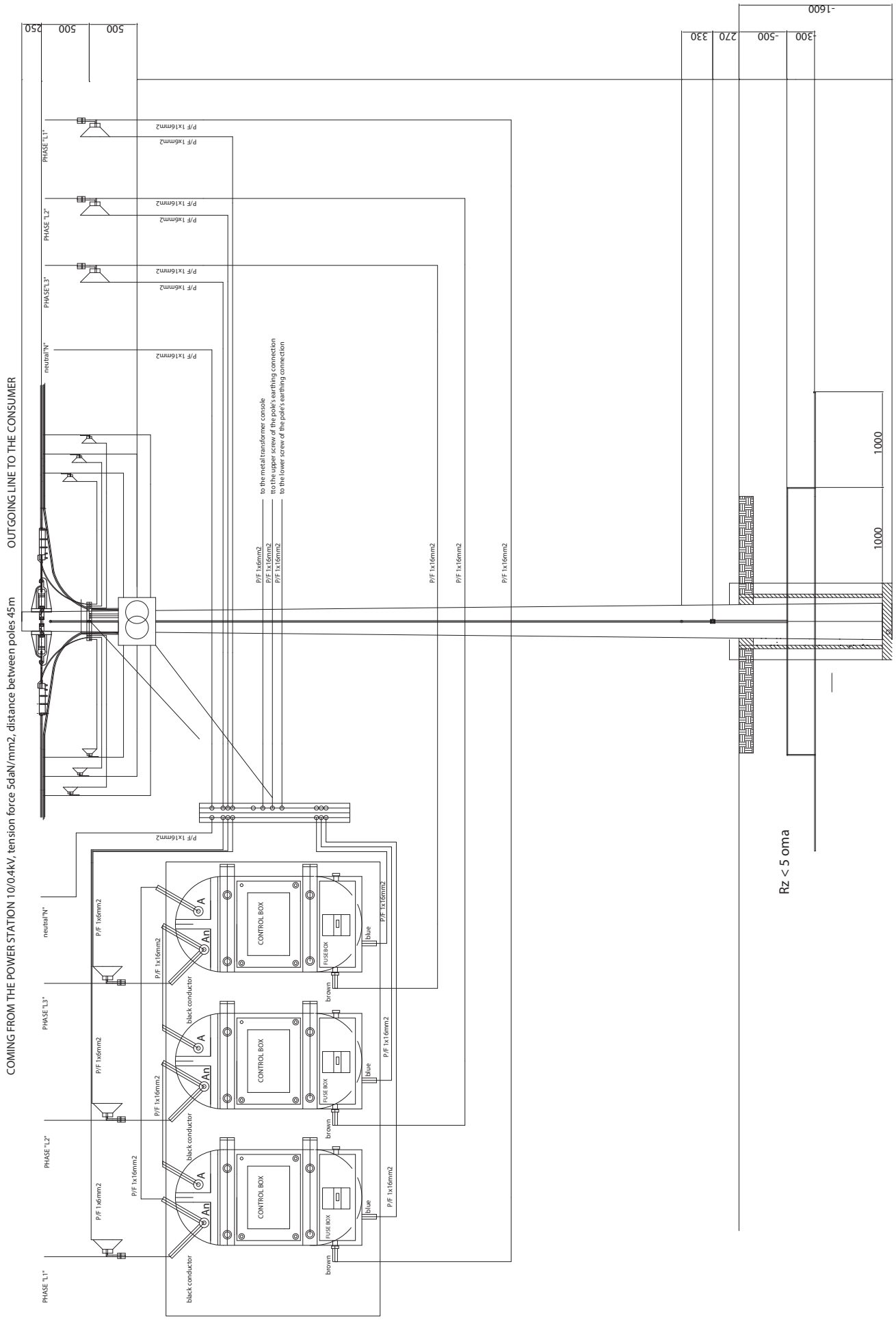
APPLICATION OF THE SINGLE-PHASE VROT-18 IN DISTRIBUTION NETWORKS



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

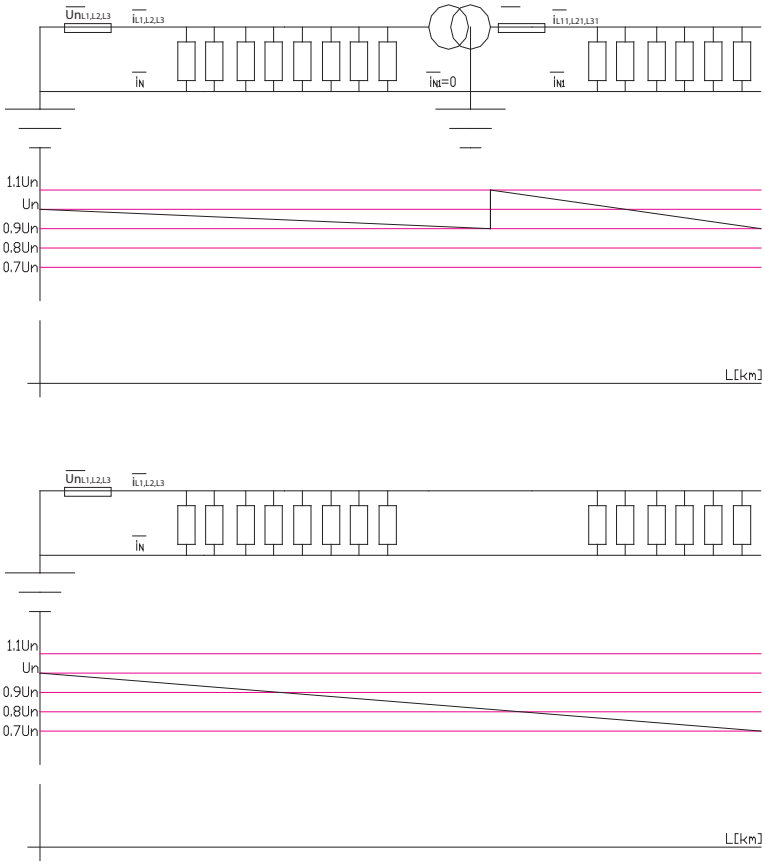
CONTENTS


COMING FROM THE POWER STATION 10/0.4kV, tension force 5daN/mm2, distance between poles 45m
OUTGOING LINE TO THE CONSUMER
PHASE "L1"
PHASE "L2"
PHASE "L3"
neutral "N"
P/F 1x16mm2
P/F 1x6mm2
P/F 1x16mm2
to the metal transformer 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
black conductor
brown
blue
A
An
250
500
500
330
270
500
300
1600
1000
1000
Rz < 5 oma

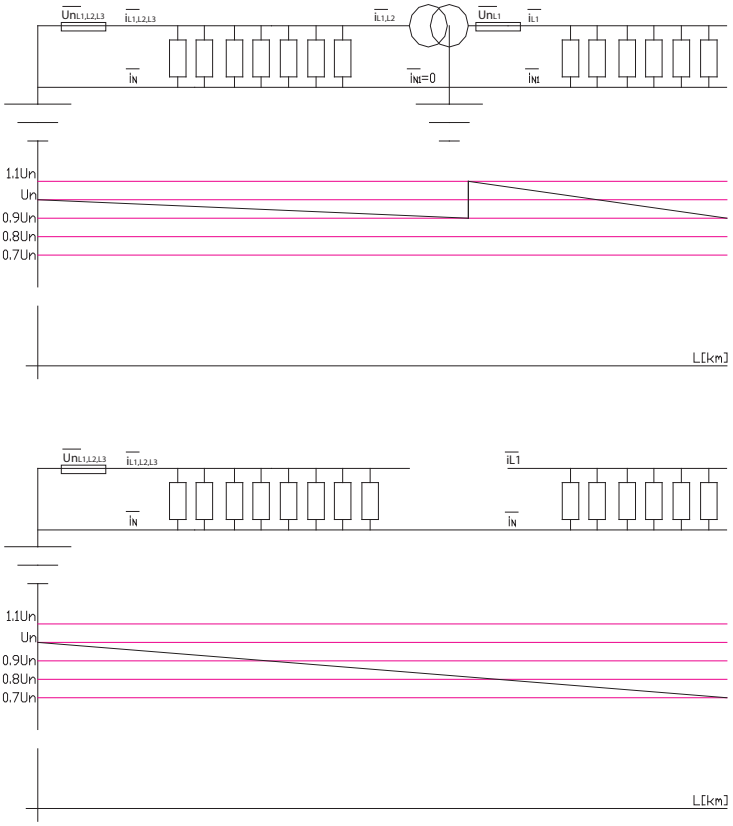
CONTENTS

Characteristics of voltage profiles along a low-voltage line

Application of the three-phase VROT for a three-phase consumer load at the end of the line

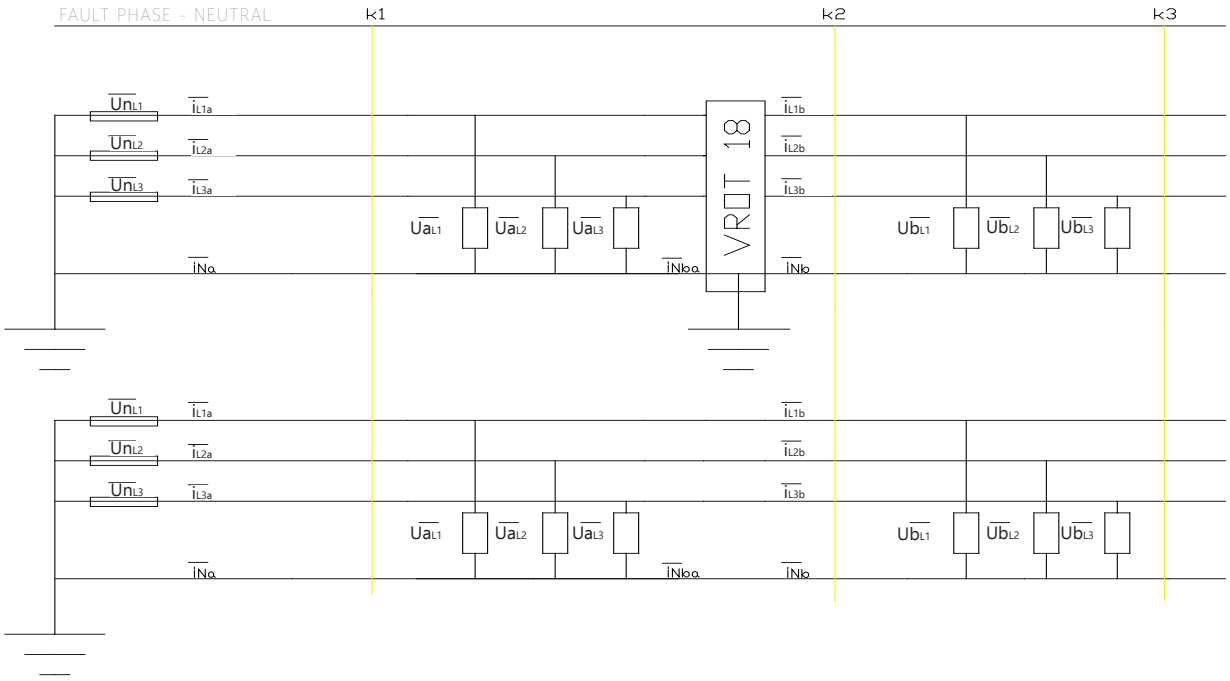


Application of the single-phase VROT for a single-phase consumer load at the end of the line



CONTENTS

Consumer protection against overvoltage in a low-voltage distribution network during faults caused by a phase-to-neutral short circuit.



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

CONTENTS

Appearance of the device installed in a single-phase low-voltage network:



The VROT 18 device supplies a single-phase consumer area located 1,500 m away from the associated substation (10(20)/0.4 kV, 250 kVA TS).

Prior to the installation of the VROT 18, the consumer area had a consumption of 750 kWh/month.

Following the installation of the VROT 18, the consumer area achieved a consumption of 3,048 kWh/month—with voltage quality in full compliance with the IEC 60038 / EN 50160 standards.



3VROT-18 installed in a three-phase network

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Installation photos





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

CONTENTS

TYPE TEST CERTIFICATE FROM AN INDEPENDENT INTERNATIONAL LABORATORY

RESEARCH, DEVELOPMENT AND TESTING
NATIONAL INSTITUTE FOR
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Matriculation certificate: J 16/312/1999; Fiscal code: RO3871599
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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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