BILLING METERING ASSEMBLIES FOR POLE-MOUNTED SUBSTATIONS



1969
ZAJEČAR
FMT

www.fmt.rs

INTRODUCTION 2

ASSEMBLY ELEMENTS 3

SUPPOTING STRUCTURE 3

FUSE HOLDERS 3

VOLTAGE TRANSFORMERS 4

CURRENT TRANSFORMERS 5

CORRECT INSTRUMENT TRANSFORMER SELECTION 5

INDIRECT THREE-SYSTEM METERING UNIT 6

CONNECTION DIAGRAMS FOR THREE-SYSTEM METERING 7

SMST-V1 8

SMST-V2 12

SMST-V3 15

POLE INSTALLATION OF THE THREE-SYSTEM ASSEMBLY 18

INTRODUCTION

In accordance with the EPS (Elektroprivreda Srbije) Tariff System, prices are determined for the active and reactive electrical energy taken, as well as for the maximum active power, which differ depending on the voltage level at which the billing metering is performed.

For connections at higher voltage levels, the consumer's share of the costs for the construction of power facilities (per 1 kW) is higher, but the prices for the active and reactive energy consumed and for the maximum active power are lower.

The consumer has the right to choose the voltage level for billing, according to their specific needs.

From a long-term perspective, it is more cost-effective for the consumer to pay at a higher voltage level, provided that the maintenance of the power facility does not present an undue burden.

From the perspective of the electricity supplier, delivery at a higher voltage level is preferable for at least two reasons:

- The bill includes losses in the power transformer and in transmission up to the metering point;
- There is no obligation to maintain the facility since, according to legal regulations, the supplier's jurisdiction extends up to the metering point (including the metering point itself).

Investors who wish to retain ownership of the pole-mounted substation would not, formally, be able to achieve this without such a solution, due to the provisions of the Law on Energy stating that the boundary of jurisdiction is the metering point.

Until 15 years ago, the application of revenue metering at 10 kV, 20 kV, and 35 kV levels was only possible in indoor transformer substations, where the instrument transformers were installed in metal-enclosed metering (and connecting-metering) cubicles within the 10 kV, 20 kV, or 35 kV switchgear.

Given that the proposer of this solution – the Instrument Transformer Factory Zaječar – has in its production program all the elements necessary for outdoor billing metering, the idea for this project was born, with the aim of offering a mutually beneficial solution to both interested power distribution companies and investors.

The solution offered by this project is the SMST BILLING METERING ASSEMBLY (hereinafter referred to as SMST) for outdoor installation. It can be installed primarily on pole-mounted transformer substations, but also at points of separation from the 10 kV, 20 kV, or 35 kV overhead lines (cables, 10 kV, 20 kV, or 35 kV aerial bundled cables - ABC) to supply consumers at the 10 kV, 20 kV, and 35 kV levels.

This project provides for three variants of the SMST assembly for **three-system indirect metering** on pole-mounted substations:

- **SMST V1** - Consists of 3 current and 3 voltage measuring transformers with high-voltage high-rupturing-capacity (HV HRC) fuses that protect the supply lines and the power transformer from short circuits;
- **SMST V2** - Consists of 3 current and 3 voltage measuring transformers with HV HRC (VVC) fuses that protect the voltage measuring transformers and other elements from short circuits;
- **SMST V3** - Consists of 3 current and 3 voltage measuring transformers with appropriate connections (without HV fuses).

ELEMENTS

The THREE-SYSTEM BILLING METERING ASSEMBLY basically consists of:

- **A supporting structure**;
- **3 single-pole HV fuse holders with HV fuses** (except for variant 3);
- **3 single-pole insulated voltage measuring transformers** 10/√3 kV/kV, 20/√3, or 35/√3 kV/kV;
- **3 current measuring transformers** of insulation level 20 kV or 35 kV;
- **1 resistor** for protecting voltage measuring transformers from ferroresonance, which is connected in series into the tertiary circuit of 3 single-pole voltage measuring transformers in networks with an isolated neutral point (isolated star point);
- **A complete indirect three-system metering unit** in a separate cabinet on the pole-mounted substation itself **(not an integral part of the SMST assembly).**

NOTE: For the 35 kV voltage level, 2 metering groups are provided - one for billing metering and the other for quality control. Both should be bidirectional so that the assembly can be used with solar power plants.

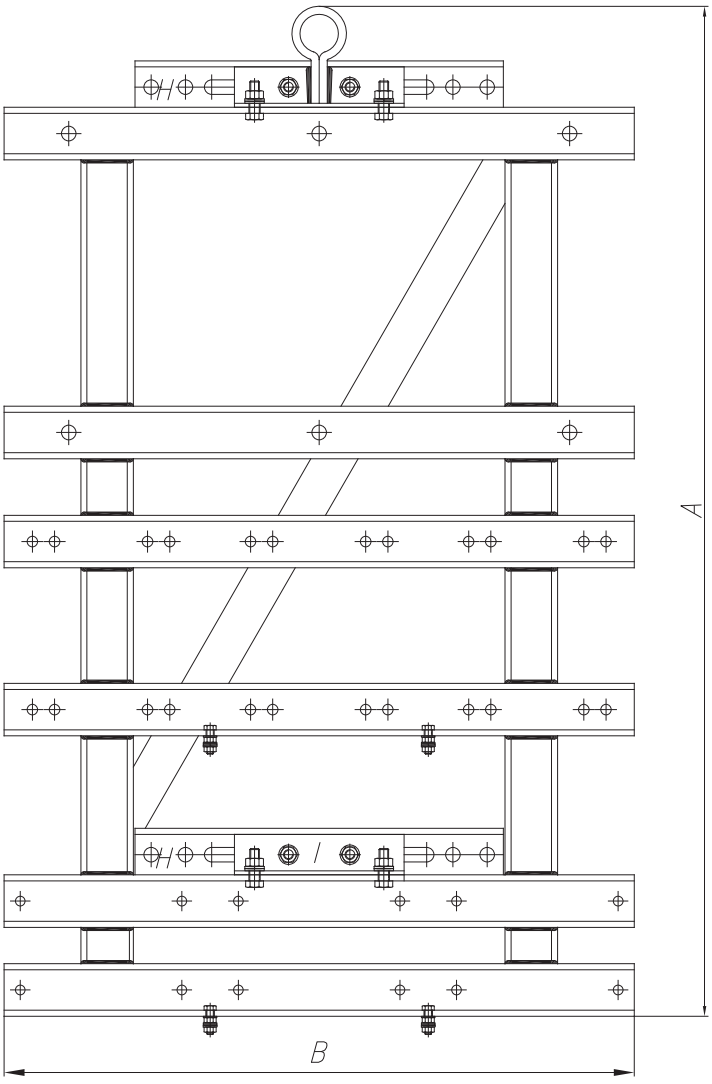
Metering groups are not an integral part of the SMST assembly. On request, we can also make an assembly for two-system billing metering, which is covered in a separate brochure material.

Supporting Structure

The supporting structure is metal, composed of welded aluminum profiles 60x40mm.

It is intended for mounting on a round utility pole stem of an overhead network, via 2 general-purpose brackets, which are made of standard steel channel profile NP U6.5, with U-bolts adapted to the installation height. The supporting structure connects to the general-purpose brackets using 2 connectors, made of standard angle profile NP L 5.

Steel parts are protected from corrosion by the hot-dip galvanizing process.



Supporting structure

HV Fuse Holders

The applied fuse holders are on apparatus post insulators of type C4-125, which are certified for an operating voltage of 20 kV, respectively C4-170d for an operating voltage of 35 kV.

The fuse clips (grips) for the HV fuses are made of hard copper, protected against corrosion by electrolytic tin plating.

Mechanical safety latches for protecting the HV fuse links from falling out are steel, galvanized.

CONTENTS

Voltage measuring transformers

For three-system metering, dry-insulated single-pole voltage transformers are used, cast in cycloaliphatic resin and intended for outdoor installation, for vertical and horizontal placement.

The magnetic cores of these transformers are of the laminated type, and the windings are made of copper, executed as layered. This ensures a rational distribution of radial and axial stresses, as well as good endurance against power-frequency overvoltages and impulse overvoltages.

Since the transformers are completely cast, a body with a smooth surface is obtained, made of one piece, whose homogeneity ensures high dielectric strength and mechanical endurance.

They are connected between phase and earth and are harmonized with standards: IEC, CSA, VDE, ANSI, BS, GOST, and SRPS.

Characteristics of Dry Voltage Measuring Transformers:

- These transformers cannot catch fire, and the insulation cannot leak out;
- They are of smaller dimensions because they have special electromagnetic field absorbers;
- The insulation does not change characteristics at extreme temperatures from -50°C to +50°C;
- It is possible to place the transformers anywhere and in any position;
- There is no need for maintenance;
- They do not pollute the environment;
- They are quiet during operation – they do not produce noise;
- The outer surface is smooth and rounded and does not retain dust;
- Their service life is longer under operating conditions – they are highly reliable;
- They are of smaller dimensions, cost less, and installation is easier and cheaper.

Technical characteristics of voltage measuring transformers

Type	JNT SM-12	JNTm2 SM-24	JNT SM36-6R
Highest voltage for equipment (kV)	12	24	38(36)
Rated primary voltage (kV)	10/√3	20/√3	35/√3
Rated secondary voltage (V)	100/√3	100/√3	100/√3
Power-frequency withstand voltage 50 Hz, 1 min. (kV)	28	50	70
Impulse withstand voltage 1.2/50μs (kV)	75	125	170
Rated frequency (Hz)	50/60		
Rated accuracy class	0,5	0,5	0,5 (0,2)
Rated poser (VA)	30	30	30 (15)
Creepage distance (mm)	500	535	920
Mass(kg)	26	28	43
Thermal insulation class	E/B		
Type of main insulation	Cycloaliphatic resin		
Mounting	Outdoor		
Operating temperature range	-50°C to +50°C		
Valid standards	IEC 61869-1, IEC 61869-3		

Resistor

In case the assembly is used in networks with an isolated neutral point, the voltage measuring transformers are protected from ferroresonance via resistors (25 Ω, 400 W for 10 and 20 kV, respectively 16.6 Ω, 600 W for 35 kV), which are located in the open-delta circuit of the residual windings of the 3 voltage transformers.

Current measuring transformers

They can be placed in vertical and horizontal positions.

Technical characteristics of current measuring transformers:

Technical data	ATMS-2411	ATM-3820h (ATM-3821h)
Rated voltage (kV)	20	35
Highest voltage for equipment (kV)	24	38(36)
Power-frequency withstand voltage 50 Hz, 1 min. (kV)	50	70
Impulse withstand voltage 1.2/50μs (kV)	125	170
Rated frequency (Hz)	50/60	
Rated primary current (A)	2x5 do 2x600	
Rated secondary current (A)	5 (or 1)	
Rated short-time thermal current, 1s	I_{th}=(100-200)In	
Rated dynamic current	$I_{dyn}=2,5I_{th}$	
Rated continuous thermal current	$I_{cth}=1,2I_n$	
Instrument security factor	FS5	
Rated burden (VA)	10	15/15
Rated accuracy class	0,5	0,2; 0,5 (0,2s; 0,5s)
Number of cores	1	2
Creepage distance (mm)	570	1296
Mass kg)	~15	~54
Thermal insulation class	E/B	
Type of main insulation	Cycloaliphatic resin	
Mounting	Outdoor	
Operating temperature range	-50°C to +50°C	
Valid standards	IEC 61869-1, IEC 61869-2	

CORRECT SELECTION OF MEASURING TRANSFORMERS FOR THE ASSEMBLY

For three-system metering, 3 current and 3 **voltage measuring transformers** for outdoor mounting are required, of the rated voltage level of the network on which the metering is performed. It is important that the transformation ratio and power of the measuring transformers are determined as accurately as possible, so that the metering is as precise as possible.
The primary voltage of the voltage measuring transformers is the phase voltage of the network (for three-pole assemblies 10/√3, 20/√3, or 35/√3 kV, and for two-pole 10, 20, or 35 kV). The secondary voltage of the voltage measuring transformers is 100//√3 V or 110/√3 V.
The rated power of the secondary and/or tertiary windings should include the consumption of the connected measuring or protective devices supplied in that circuit plus the Joule power losses in the lines themselves, which are given in the table below.

Consumer	Power consumption per system (W/m)
Cu conductor 1m 2,5mm² at 5A	0.18
Cu conductor 1m 4mm² at 5A	0.11
Cu conductor 1m 1,5mm² at 1A	0.012
Cu conductor 1m 2,5mm² at 1A	0.007
Cu conductor 1m 4mm² at 1A	0.0044

The primary current of current measuring transformers is the line current calculated according to the power of the power transformer in front of which the assembly is placed and is rounded to the nearest higher standard value. Since the power transformer itself is not always loaded with the rated power, it is necessary to determine as realistically as possible the rated primary current of the current transformers, which is calculated according to the formula:

$$I(A) = \frac{Sn(kVA)}{\sqrt{3}\,Un(kV)}$$

The rated values of primary currents I_{1n} are 5 - 7.5 - 10 - 12.5 - 15 - 20 - 25 - 30 - 40 - 50 - 60 - 75 A or their integer decimal multiples.

The secondary current of current measuring transformers can be 5 A or 1 A. The rated power of each secondary winding of the current measuring transformer should include the consumption of all measuring or protective devices connected to the secondary terminals of that secondary winding plus the Joule power losses in the lines themselves according to the given table.
Standard powers of the secondary windings of voltage measuring transformers are 5, 10, 25, and 50 VA, and of the measuring cores in current measuring transformers are 2.5, 5, 10, 15, and 30 VA.

CONTENTS

Indirect metering unit

The metering of consumed electrical energy and peak (maximum reached 15-minute power in the billing period) is provided using a three-system metering group for indirect metering, on the 10 kV, 20 kV, or 35 kV side, located in a separate cabinet, which is placed on the pole stem.

A metering group with a multi-functional digital meter for three-system metering is recommended.

Through the meter, the following are also performed:

- Metering of consumed active electrical energy in 2 tariffs, Class 1;
- Metering of consumed reactive electrical energy in 2 tariffs, Class 3;
- Metering of the reached maximum of 15-minute active power, in 2 tariffs, Class 1;
- Reception of MTK (ripple control) telegrams;
- Memorizing the state of the power maximum for the 12 last reading cycles.

The meter should be approved for use by the Federal Bureau of Measures and Precious Metals and accepted for use in the consumption area.

For networks of rated voltage 35 kV, the installation of two metering groups is provided. One is a metering group for bidirectional metering (intended for measuring electrical energy in both directions in solar power plants), and the second metering group is intended for measuring the quality of electrical energy.

The factory does not supply the metering unit and the cabinet as part of the SMST, but if customers wish, they can order them separately.

The cabinet also contains:

- A metering connection box with 3 automatic circuit breakers 6 A and a sealed transparent cover;
- Conductors for wiring, small materials, and accessories.

The connection between the voltage measuring transformers and the metering group is established using a 1 kV cable, type PP, cross-section 4x1.5 mm^2, and between the current measuring transformers and the metering group using a 1 kV cable, type PP, cross-section 6x2.5 mm^2.

The number of cables going to the electrical energy meter depends on the number of metering groups.
All cables are individually placed in flexible galvanized steel conduits, and all connection points are sealed.
The conduits are fastened to the pole with straps made of stainless material, at a distance of 1 m.

EARTHING OF EQUIPMENT

All provided equipment is insulated.
The secondary circuits of current measuring transformers are earthed directly on the terminals of the current measuring transformers and connect to the supporting metal structure.
The same applies to the secondary circuits (windings) of voltage measuring transformers.

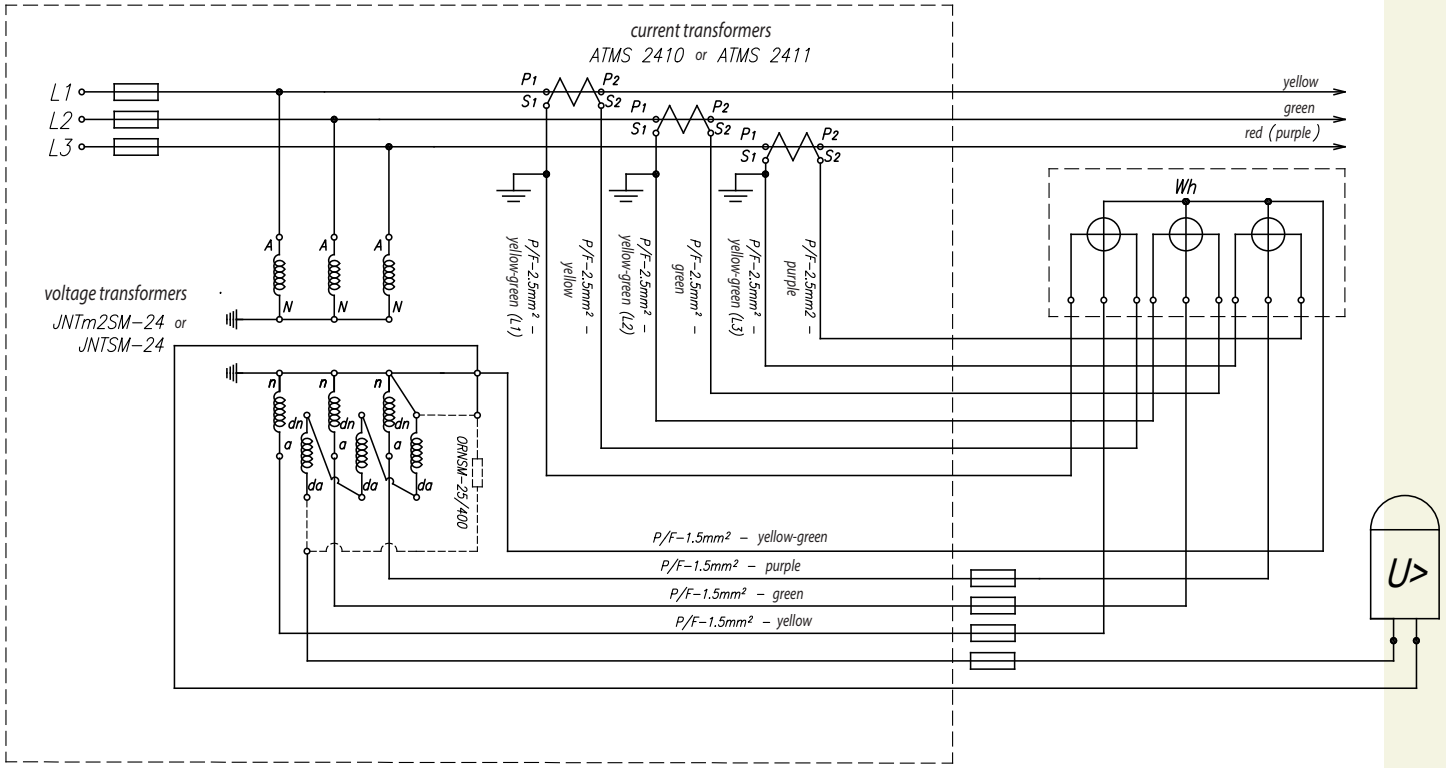
The supporting structure connects to the collective earth conductor of the pole using the ELDS kit, which is not an integral part of the SMST but can be ordered specially.
For this purpose, a hole with an opening of 13mm is provided on the upper bar of the structure. As the supporting structure has a profile cross-section greater than 100 mm^2, it is used as part of the earth conductor for connecting the earthing of the equipment it carries.

PROTECTION AGAINST HAZARDOUS TOUCH VOLTAGE

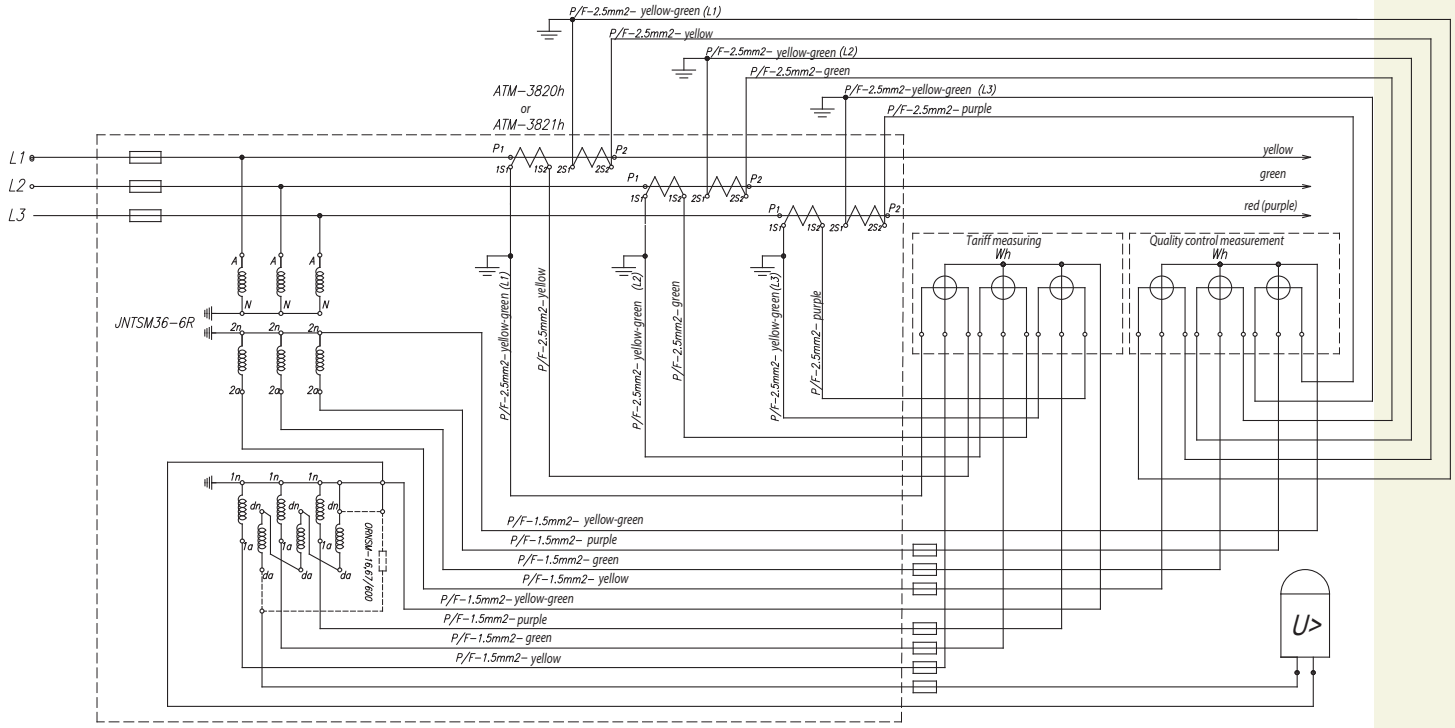
The height from the ground to the unprotected live parts of the equipment is greater than 5 m, and all cables up to a height of at least 2 m have mechanical protection, earthed to the earth conductor of the pole-mounted substation.

All provided supply lines are of appropriate construction and supplied with the necessary insulations or placed in protective pipes, and their correct entry into cabinets and protective housings of electrical equipment is also provided.

CONNECTING DIAGRAMS FOR THREE-SYSTEM METERING



Three-pole connecting diagram for three-system metering for 20 kV



Three-pole wiring diagram for three-system metering for 35 kV

ASSEMBLY FOR THREE-SYSTEM BILLING METERING SMST-V1



SMST - VARIANT 1

In the direction of power flow, the SMST connects directly behind (below) the switch-disconnector with surge arresters, and in front of the power transformer, as shown in the attached drawings.

In the case of mounting the SMST on existing pole-mounted transformer substations, the HV HRC fuses located above the power transformer should be removed, thereby achieving the necessary protection and freeing up space to accommodate the SMST.

Protection of all elements of the SMST (and the power transformer) is primarily via HV HRC fuses (25 A or 31.5 A), and secondarily (on the 100 V side), the metering group is protected via 3 automatic fuses 6 A, in the connection box.

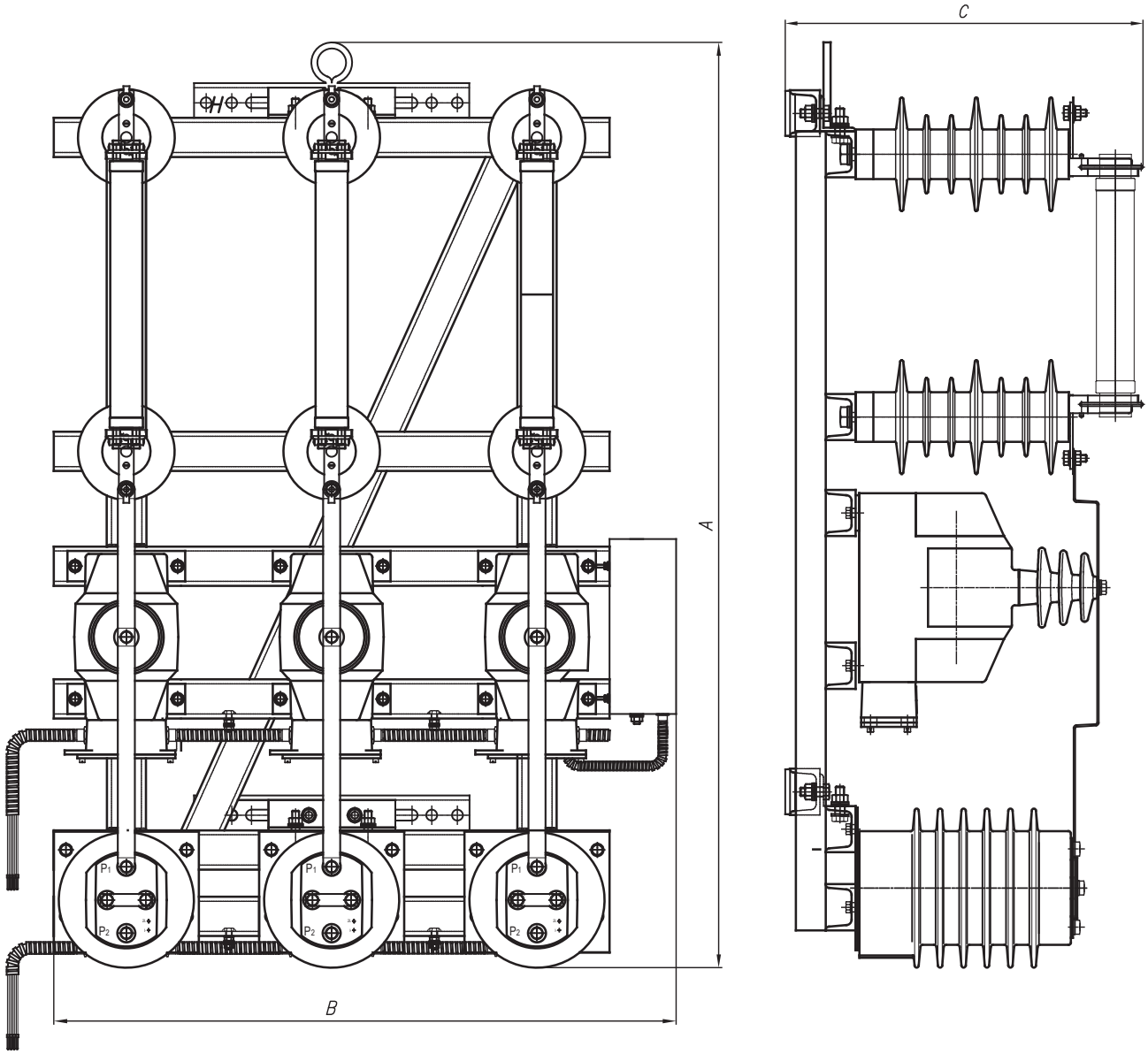
Special protection (against overload and short circuit) of the voltage measuring transformers is not provided. The reason should be sought in the facts that special HV HRC fuses for this purpose require an increased envelope size of the equipment, that failures on voltage measuring transformers are very rare, and even if they happen – due to the circumstance that the primary current values are very small (below 1 mA), and the primary windings of the voltage measuring transformer are of a very small cross-section, the eventual failure is interrupted locally without consequences.

In case the assembly is used in networks with an isolated neutral point, the voltage measuring transformers are protected from ferroresonance via resistors (25 Ω, 400 W for 10 and 20 kV, respectively 16.6 Ω, 600 W for 35 kV), which are located in the open-delta circuit of the residual windings of the 3 voltage transformers.

This protection is provided in case the assembly is used in isolated networks, but it does not interfere if it is installed in other networks. The SMST can be placed on the side opposite to the placement of the power transformer or on the same side, and the connection between the SMST and the power transformer is executed with single-core cables X00-A, 1×35 mm^2 (from a 10, 20, or 35 kV aerial bundled cable - ABC), with cable terminations for outdoor mounting on both sides. The cable is attached to the end of the SMST on one side, and on the other directly to the 10 kV (20 kV or 35 kV) insulators on the power transformer.

SMST-V1 is also often used when technical conditions provide for the assembly to be placed on a pole before the pole carrying the pole-mounted substation. In that case, the fuses protect the supply line supplying the pole-mounted substation from short circuits as well, and the technical conditions provide for a disconnector and the SMST-V1 assembly to be placed on a special pole.

CONTENTS



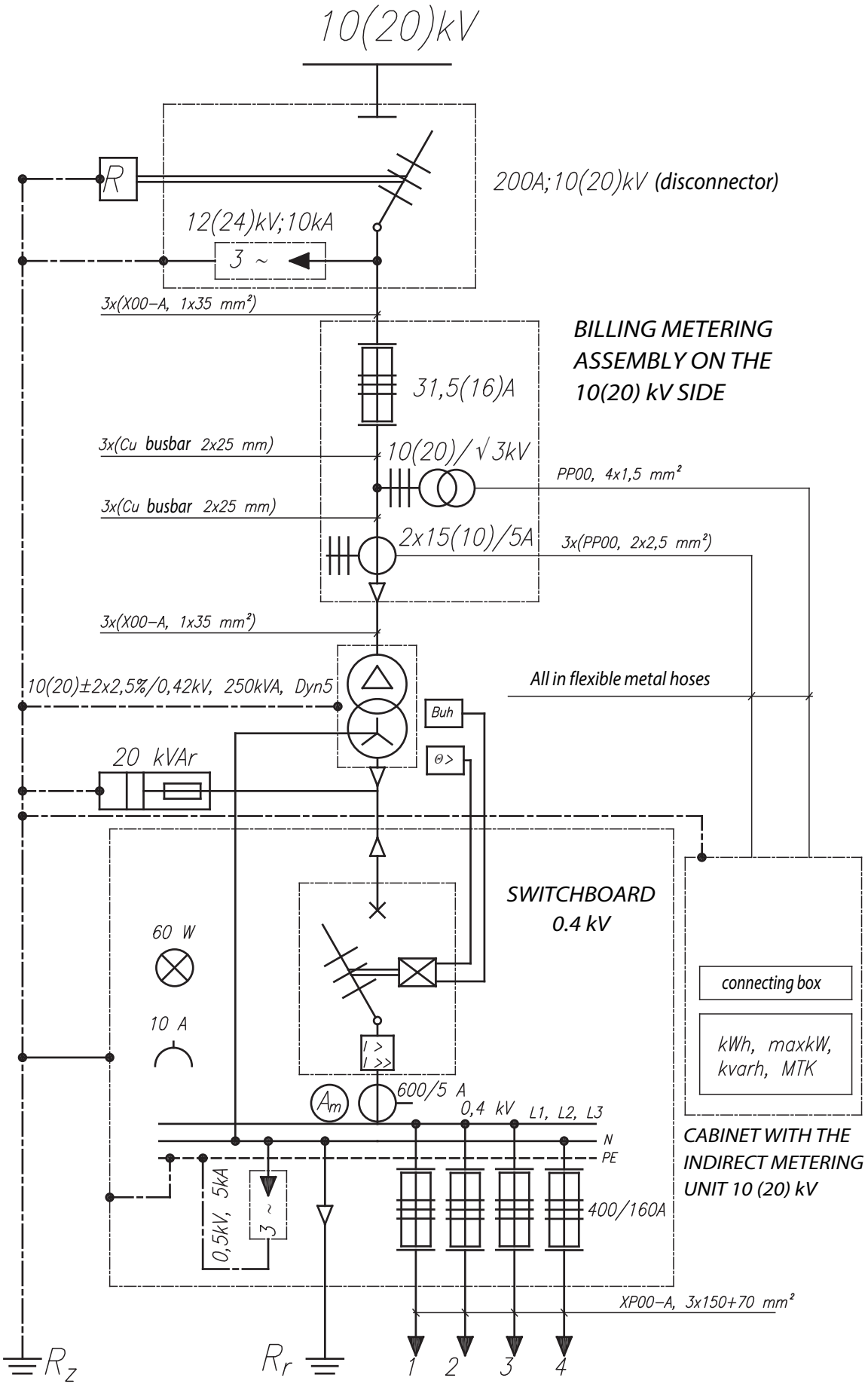
ASSEMBLY FOR THREE-SYSTEM BILLING METERING ON THE 10 kV, 20 kV and 35 kV SIDE

Item No.	Description	Designation*	Dimensions AxBxC (mm)	Dimensions of the supporting structure (mm)	Current transformer	Voltage transformer	Fuse base	Mass (kg)
1	Assembly for three-system billing metering on 10 kV side	SMST-12-3-V1	1302.5x970x503.5	1125x860x80	ATMS-2411	JNT SM-12	PVOs-12	182
2	Assembly for three-system billing metering on 20 kV side	SMST-24-3-V1	1532.5x1030x503.5	1382,5x920x80	ATMS-2411	JNTm2 SM-24	PVOs-24	221
3	Assembly for three-system billing metering on 35 kV side	SMST-36-3-V1	1812x1230x635	1687x1120x85	ATM-3821h	JNT SM-36-6R	PVOs-38	390

NOTE: Dimensions and weights of the assembly may deviate from those given in the table above depending on the characteristics of the assembly. We reserve the right to make modifications.

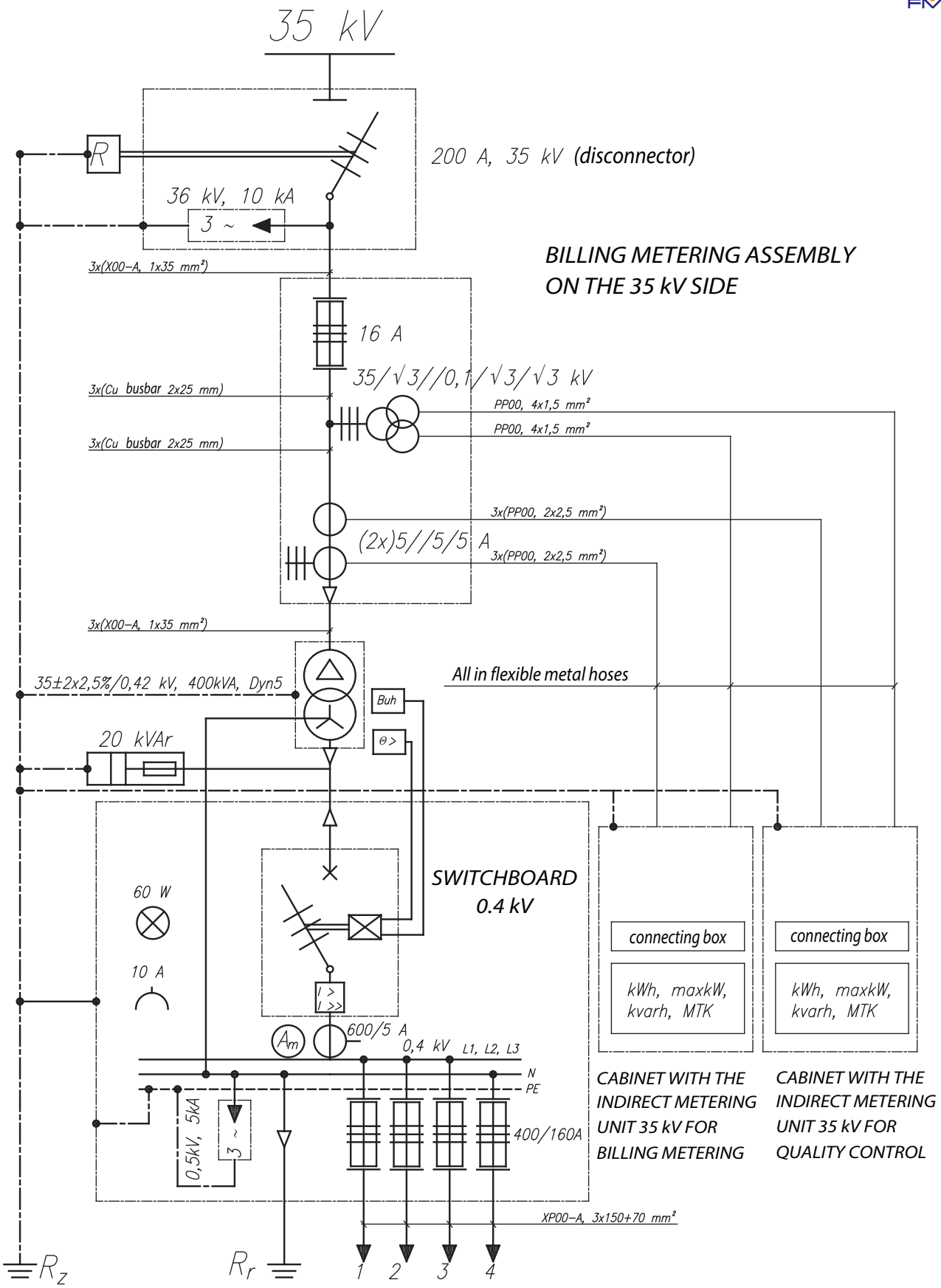
* • **Designation interpretation:** SMST-Um-3-V1(V2/V3) - assembly for three-system indirect metering on pole-mounted substations for maximum voltage Um(kV).

CONTENTS



Single-pole connecting scheme for three-system measuring at 10(20) kV side, SMST-12-3-V1 (SMST-24-3-V1)

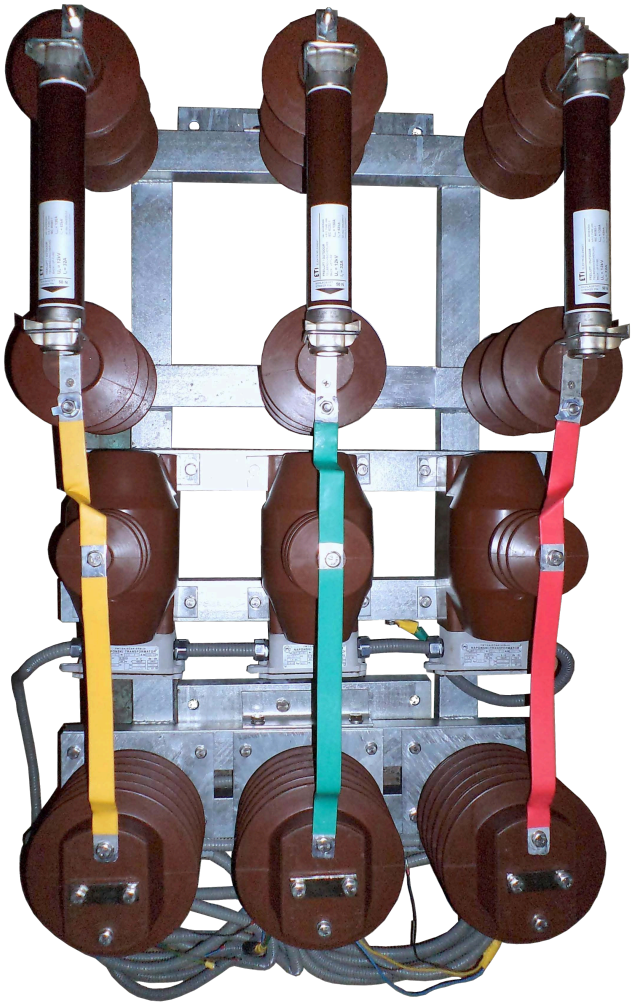
CONTENTS



Single-pole connecting scheme for three-system measuring on the 35 kV side,
SMST-35-3-V1

CONTENTS

ASSEMBLY FOR THREE-SYSTEM BILLING METERING SMST-V2



SMST - VARIANT 2

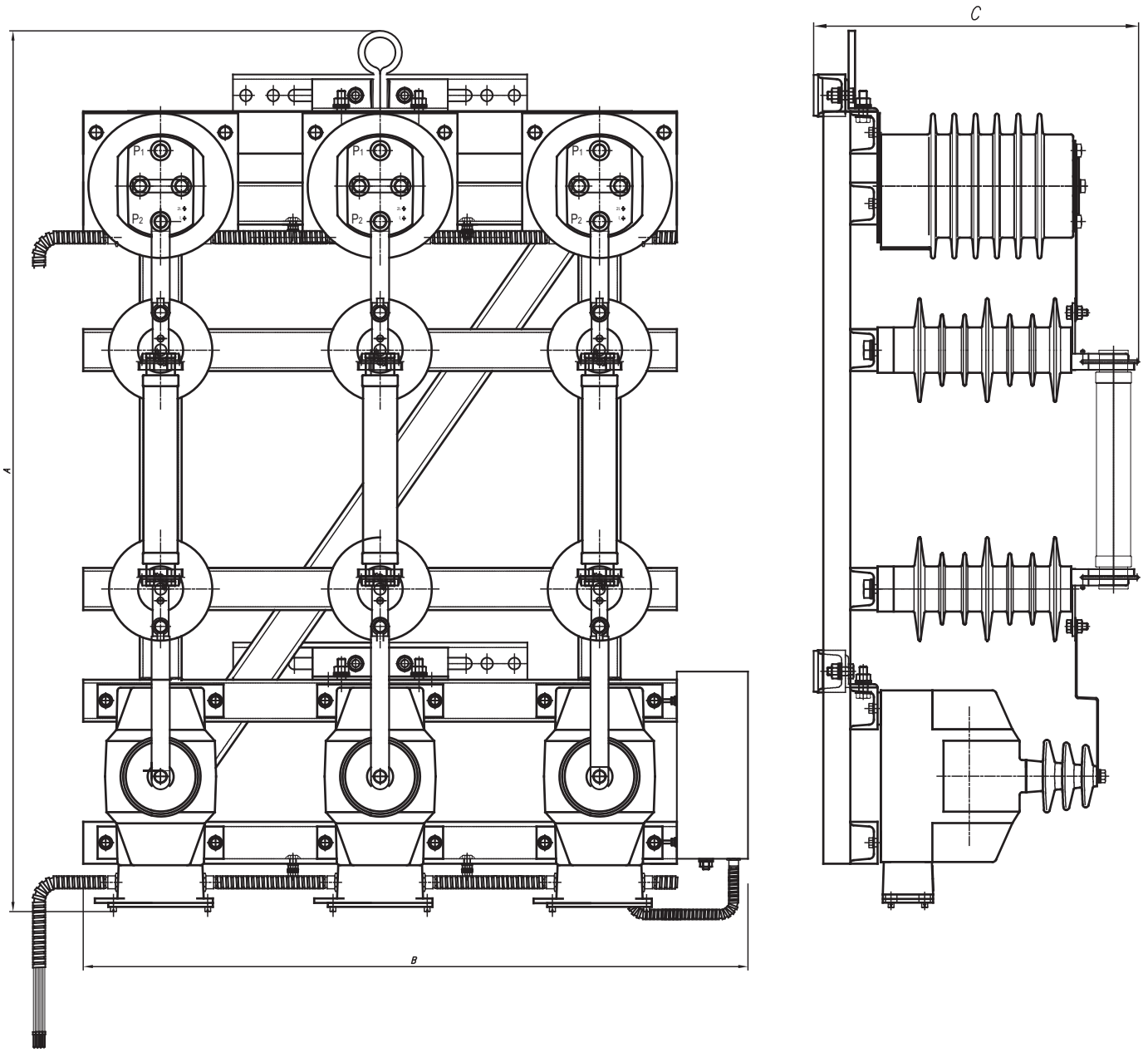
In this variant, protection of the voltage measuring transformers is executed using special HV HR fuses 10 kV (20 or 35 kV), 2 A.

This variant is most often executed at the request of customers who wish to meet the condition of protecting voltage transformers against the occurrence of ferroresonance when the assembly is used in isolated networks.

The SMST can be placed on the side opposite to the placement of the power transformer or on the same side.

In case the assembly is used in networks with an isolated neutral point, the voltage measuring transformers are protected from ferroresonance via resistors (25 Ω, 400 W for 10 and 20 kV, respectively 16.6 Ω, 600 W for 35 kV), which are located in the open-delta circuit of the residual windings of the 3 voltage transformers.

The connection between the SMST and the power transformer is with single-core cables X00-A, 1x35 mm^2 (from a 10 kV, 20 kV, or 35 kV aerial bundled cable - ABC), with cable terminations for outdoor mounting on both sides. The cable is attached to the SMST on one side, between the current measuring transformers and the HV fuses, and on the other directly to special HV fuses (for protection of the power transformer), placed on the 10 kV (20 or 35 kV) insulators on the power transformer.



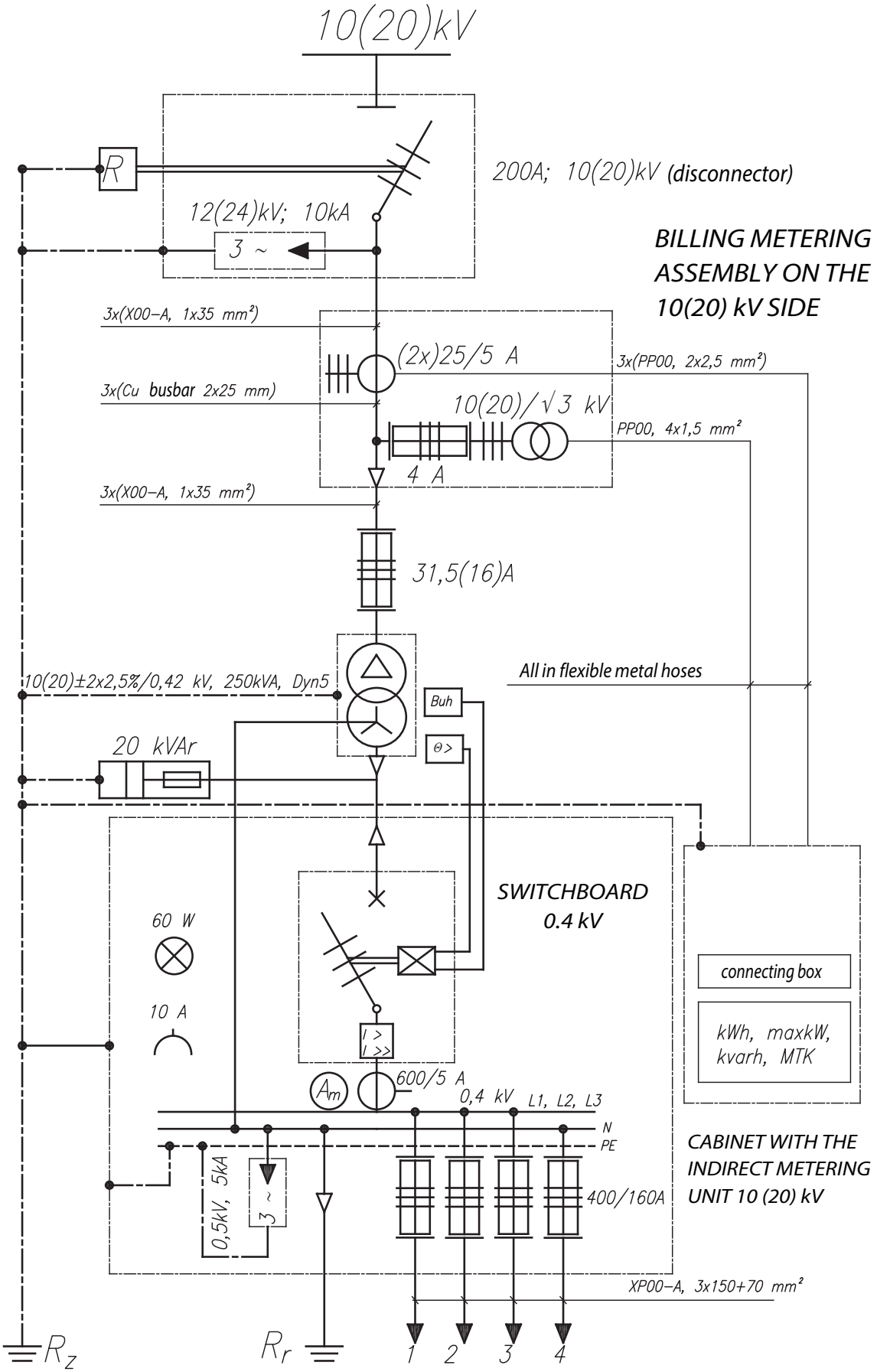
ASSEMBLY FOR THREE-SYSTEM BILLING METERING ON THE 10 kV, 20 kV and 35 kV SIDE

Item No.	Description	Designation*	Dimensions AxBxC (mm)	Dimensions of the supporting structure (mm)	Current transformer	Voltage transformer	Fuse base	Mass (kg)
1	Assembly for three-system billing metering on the 10 kV side	SMST-12-3-V2	1450x890x500	1267,5x780x80	ATMS-2411	JNT SM-12	PVOs-12	182
2	Assembly for three-system billing metering on the 20 kV side	SMST-24-3-V2	1364,5x1030x500	1165x920x80	ATMS-2411	JNTm2 SM-24	PVOs-24	221
3	Assembly for three-system billing metering on the 35 kV side	SMST-36-3-V2	1889x1230x635	1697x1120x85	ATM-3821h	JNT SM-36-6R	PVOs-38	390

NOTE: Dimensions and weights of the assembly may deviate from those given in the table above depending on the characteristics of the assembly. We reserve the right to make modifications.

*** Designation interpretation**: SMST-Um-3-V2 - assembly for three-system indirect metering on pole-mounted substations for maximum voltage Um(kV).

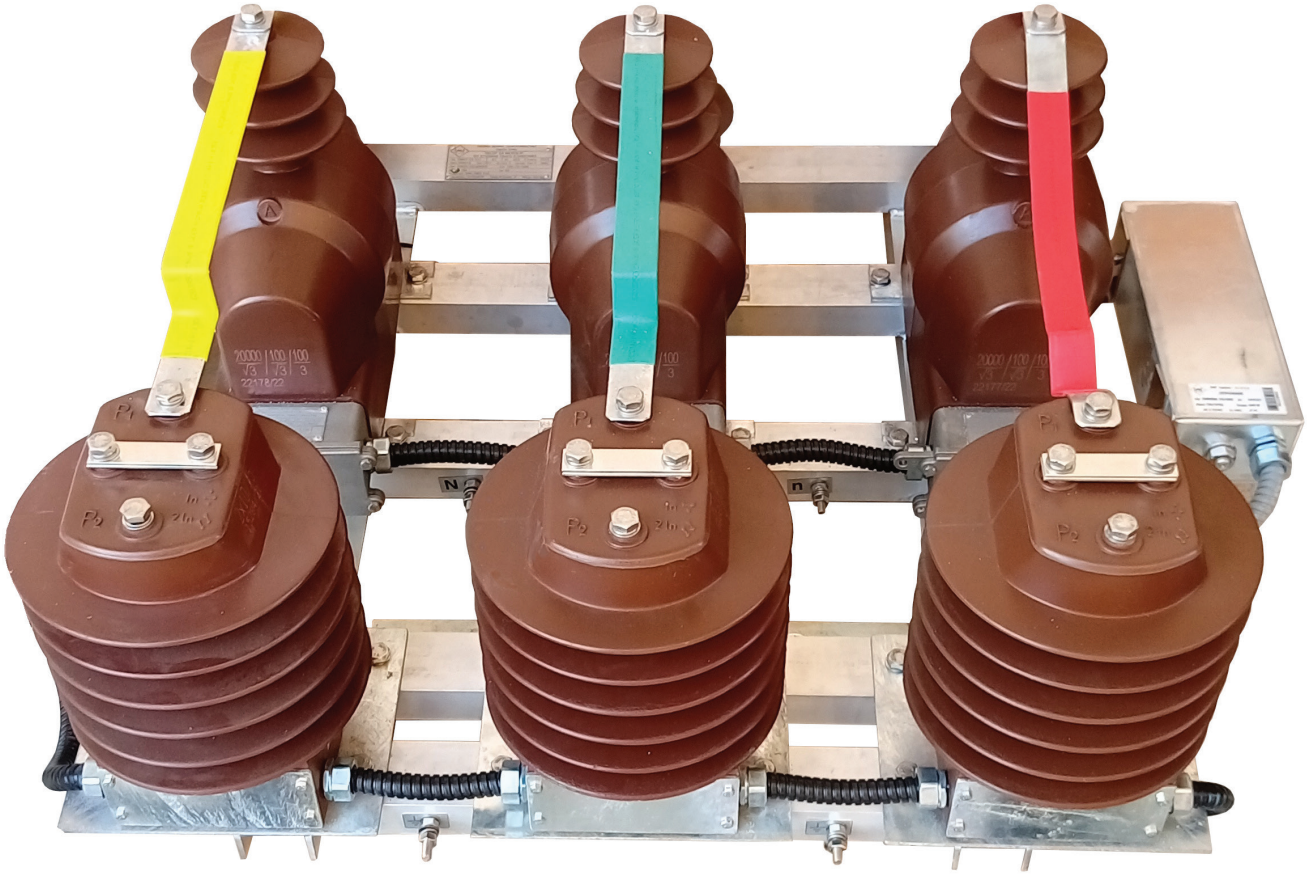
CONTENTS



Single-pole connecting scheme for three-system billing metering on the 10(20) kV side, SMST-12-3-V2 (SMST-24-3-V2)

CONTENTS

ASSEMBLY FOR THREE-SYSTEM BILLING METERING SMST-V3

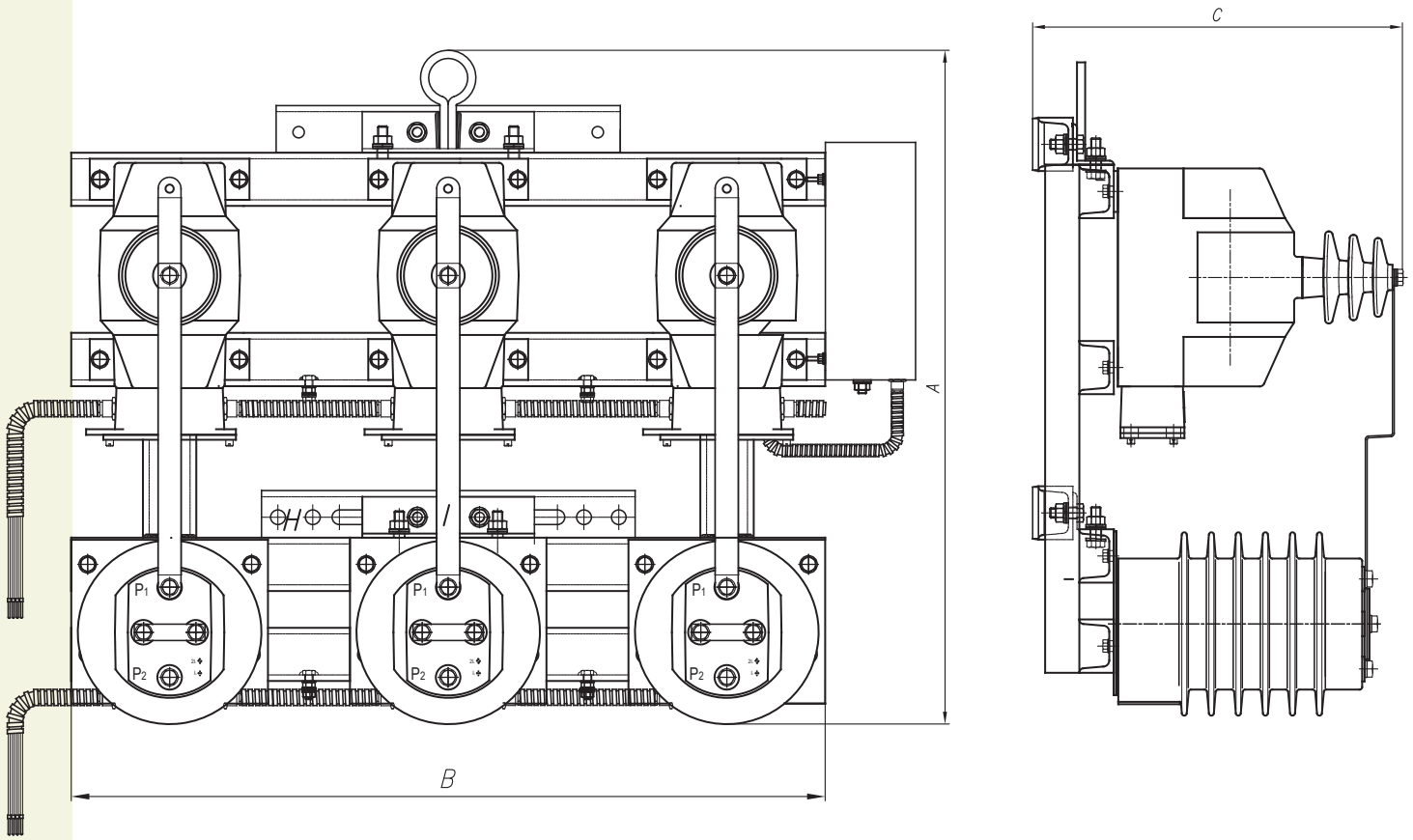


SMST - VARIANT 3

In this variant, the SMST does not possess fuses for protection, so during mounting, it is not necessary to remove the HV fuses located on the power transformer itself. The SMST basically consists only of a supporting structure with 3 current and 3 voltage transformers.

In case the assembly is used in networks with an isolated neutral point, the voltage measuring transformers are protected from ferroresonance via resistors (25 Ω, 400 W for 10 and 20 kV, respectively 16.6 Ω, 600 W for 35 kV), which are located in the open-delta circuit of the residual windings of the 3 voltage transformers.

CONTENTS

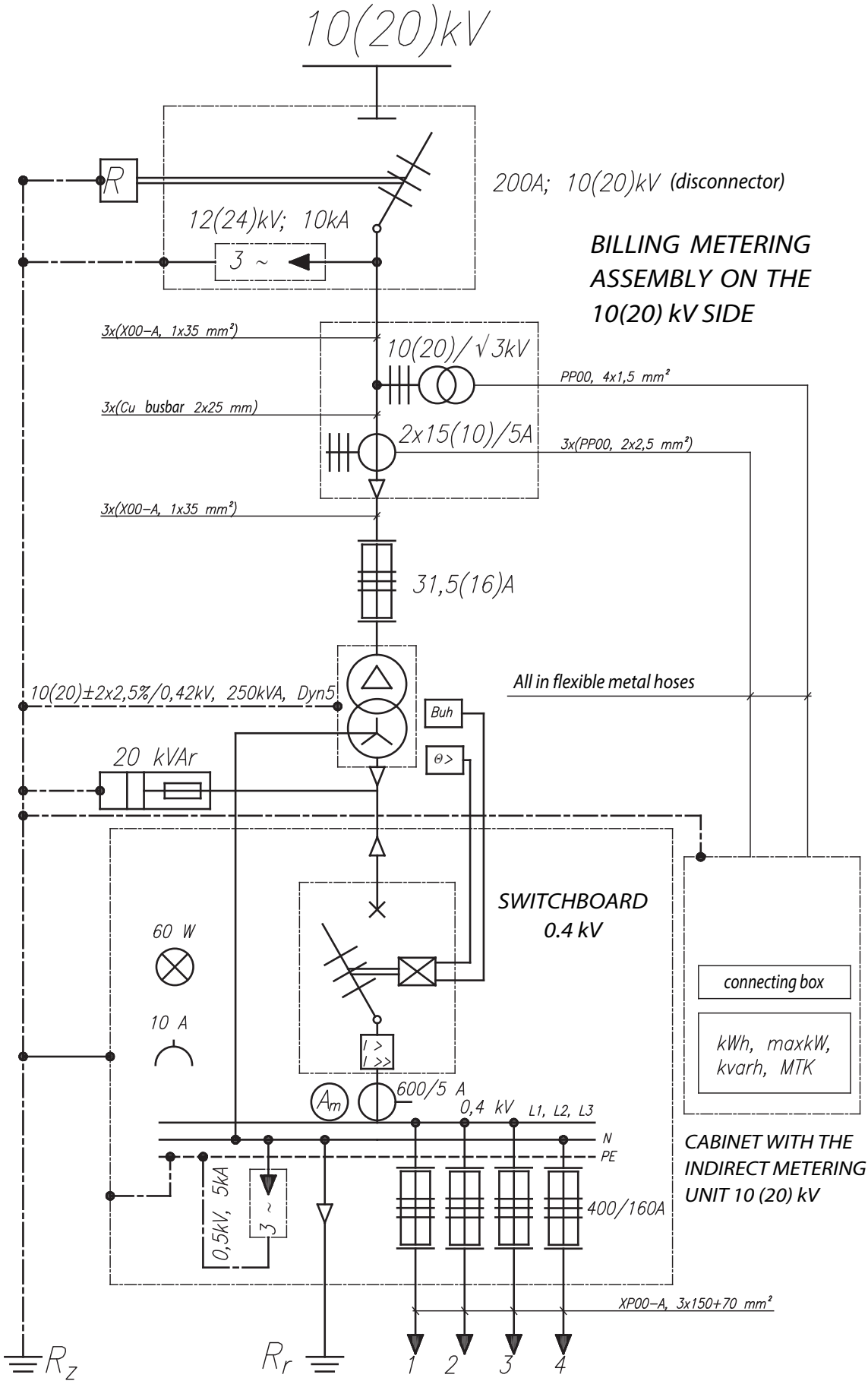


ASSEMBLY FOR THREE-SYSTEM BILLING METERING ON THE 10 kV, 20 kV and 35 kV SIDE

Item No.	Description	Designation*	Dimensions AxBxC (mm)	Dimensions of the supporting structure (mm)	Current transformer	Voltage transformer	Mass (kg)
1	Assembly for three-system billing metering on the 10 kV side	SMST-12-3-V3	797,5x970x446	620x860x80	ATMS-2411	JNT SM-12	150
2	Assembly for three-system billing metering on the 20 kV side	SMST-24-3-V3	825x1030x466	645x920x80	ATMS-2411	JNTm2 SM-24	167
3	Assembly for three-system billing metering on the 35 kV side	SMST-36-3-V3	1015x1230x635	890x1120x85	ATM-3821h	JNT SM-36-6R	336

NOTE: Dimensions and weights of the assembly may deviate from those given in the table above depending on the characteristics of the assembly. We reserve the right to make modifications.

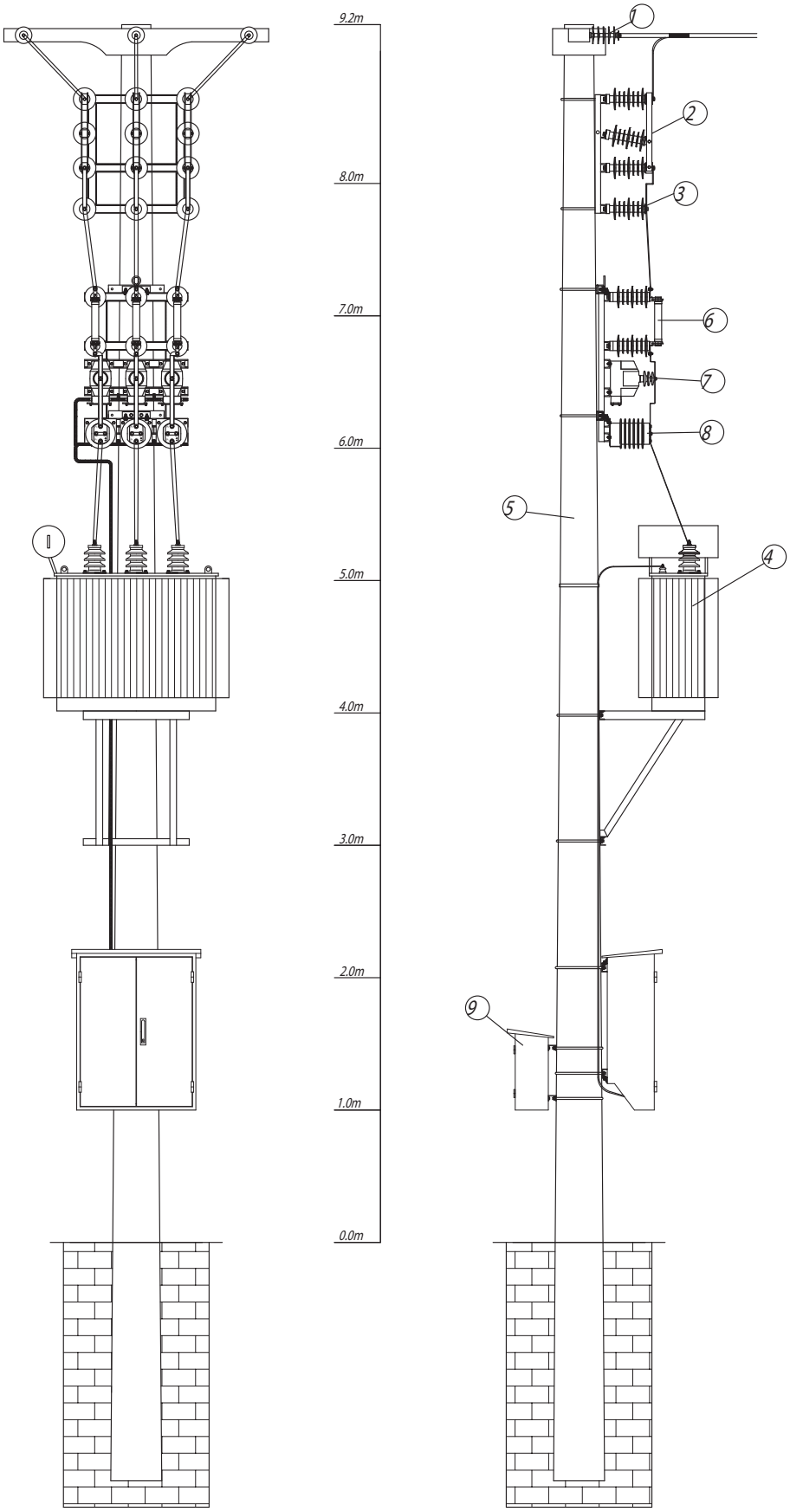
***• Designation interpretation**: SMST-Um-3-V3 - assembly for three-system indirect metering on pole-mounted substations for maximum voltage Um(kV).



Single-pole connecting scheme for three-system billing metering on the 10(20) kV side, SMST-12-3-V3 (SMST-24-3-V3)

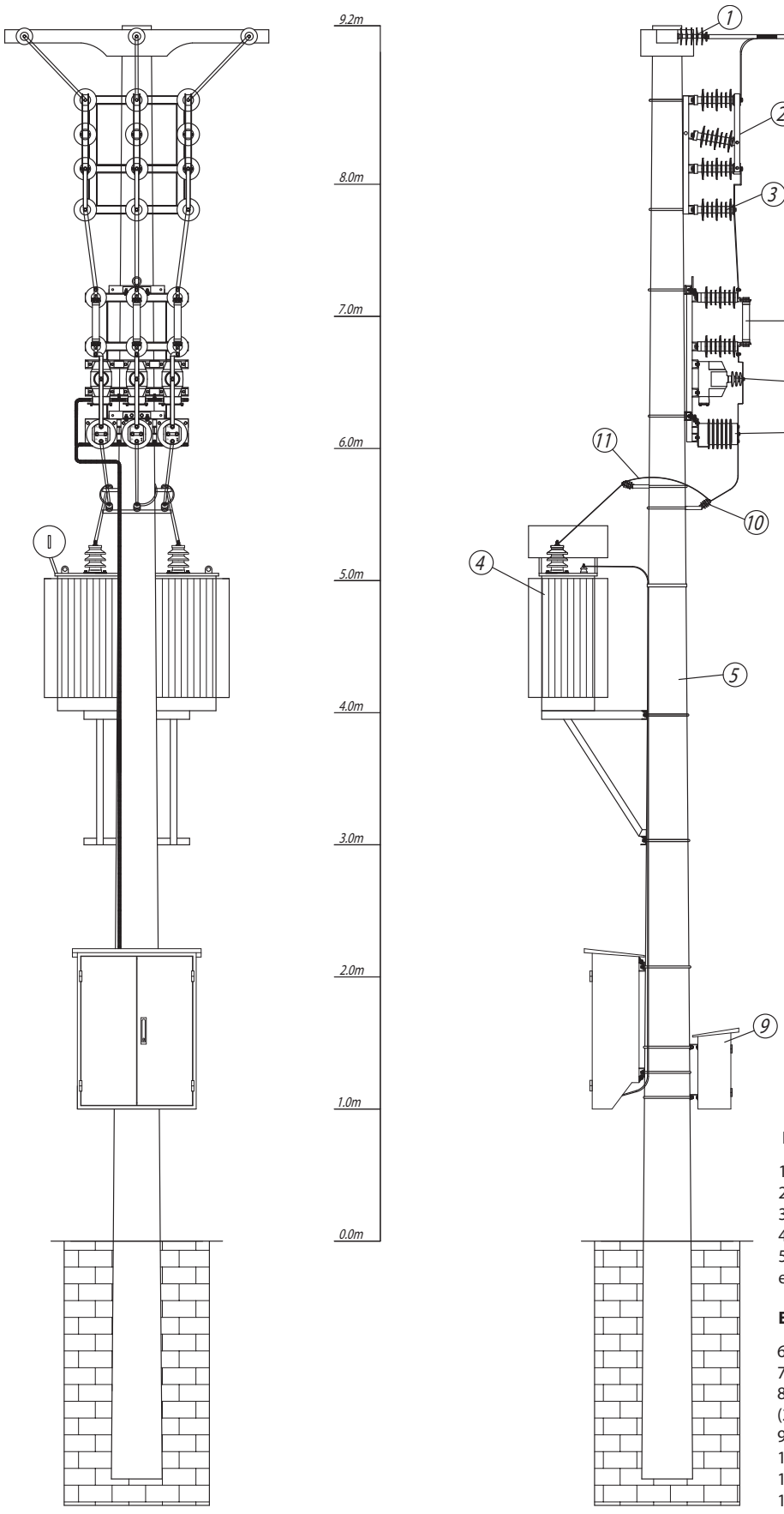
CONTENTS

POLE INSTALLATION OF THE THREE-SYSTEM ASSEMBLY



Mounting of the assembly on a pole with the power transformer and the assembly on the same side of the pole

POLE INSTALLATION OF THE THREE-SYSTEM ASSEMBLY



LEGEND

Equipment of the pole-mounted substation:

1. Tension clamping 10 kV or 20 kV, ACSR (Al/Če)
2. Disconnector 10 kV or 20 kV
3. Surge arrester 12 kV, 10 kA or 24 kV, 20 kA
4. Power transformer 10/0.4 kV or 20/0.4 kV
5. Utility pole for carrying pole substation equipment

Equipment for metering on the 10 kV or 20 kV side

6. HV fuse 10 kV or 20 kV with fuse base
7. Voltage measuring transformer 10/√3 kV or 20/√3 kV
8. Current measuring transformer (2x)15/5 A/A or (2x)10/5 A/A
9. Cabinet for housing the indirect metering group
10. Cable head (termination) for outdoor mounting for 10 kV or 20 kV cable
11. Cable 10 kV or 20 kV, XHE 48A, 1x50 mm^2

Mounting of the assembly on a pole with the power transformer on the opposite side from the assembly.

CONTENTS

FMT - Factory of measuring transformers d.o.o.
Zajecar 19000, Strazilovska 57, Serbia

Central phones: +381 19 3413 122; +381 19 3413 222; +381 19 3413 111
General manager: +381 19 31 5555 1
Sales: +381 19 31 5555 5; +381 19 31 5555 6;
+381 19 31 5555 8; +381 19 3413 111
komercijala@fmt.rs
Supply: +381 19 31 5555 7
Development: +381 19 31 5555 3
Finance: +381 19 31 5555 2
www.fmt.rs • office@fmt.rs

1969

ZAJEČAR

FMT

MINEL FEPO d.o.o.
Zeleznicka 3
23101 Zrenjanin, Serbia
tel: +381 23 544 902
tel: +381 23 545 529
office@minelfepo.com