MODELING THE PERMANENT REGIME OF 220/110/20 kV SARDANESTI POWER SUBSTATION

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Abstract: The calculations of permanent regimes of high and very high voltage power substations are performed to predetermine the optimal operation of the analyzed power substation and the energy system from a technical point of view and economic. This paper presents the behavior of the 220/110/20 kV Sardanesti power substation for the current operating conditions, if the electricity consumption increases or decreases, checking the stability of the system in the Oltenia area and developing a strategy on the safety and security of the National Energy System.

Keywords: Modeling, permanent regime, power substation.

1. INTRODUCTION

The calculation of the permanent regime of an power system consists, in determining the values of all state quantities that define the regime, starting from certain primary information regarding the passive and active elements of the analyzed system. This information allows the elaboration of the mathematical permanent regime in the form of a system of algebraic equations, generally nonlinear, which describes the operation of the equivalent single-phase direct sequence scheme. System elements – generators, consumers, power lines, transformers, etc. and their connections conventionally represent a monofilament scheme. The equivalent single-phase equivalent connections of the elements form the equivalent scheme of the whole system a complex circuit, in which the neutral point, common to all component schemes, is chosen a reference node. The other nodes are independent nodes. They

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always appear explicitly and in the monofilament scheme.The calculation of the permanent regime is the most common CAD application both in design (planning of the development of power grid) and in operation (dispatcher). An power system includes all the equipment necessary for the transformation of " non-electrical energy " into electricity as well as its transport to consumption points. Specifically, the power system comprises the multitude of power plants, power substations (with the role of interconnection or transformation of the voltage level), transmission elements (transport or distribution) and means of adjustment and compensation.

The permanent regime, or *operating stationary* of the system is described by the following two categories of electrical quantities:

- *the powers introduced, or consumed, in the nodes of the power grid;*
- *the voltages of these nodes (measured from the reference node – earth), the distribution of powers and power losses through the transmission elements.*

The calculations of permanent regimes are performed to predetermine the optimal operation of the system from a technical and economic point of view. The main uses of the results of these calculations concern:

- *determining the development strategy of the system, as a result of the foreseeable increases of consumption;*
- *finding the optimal solution of operation, under normal conditions;*
- *analysis of the effects of decommissioning some elements in the system* [1], [3] [4].

2. DESCRIPTION OF THE PERMANENT REGIME MODELING PROGRAM

Paladin DesignBase 7.0. is a comprehensive power systems simulation platform for modeling, analyzing and optimizing power system performance. Regardless of the complexity of electrical infrastructure, Paladin DesignBase provides the technological richness to perfect infrastructure for superior system performance: 800-component library with more than 100,000 device-specific manufacturers' specifications; *a comprehensive range of integrated analysis modules; easy-to-navigate CAD-like user interface, allowing unprecedented ease of use; personal and team-based productivity features and data management tools.*

Paladin DesignBase 7.0. includes a family of 42 design and simulation features including: *Power Flow; Voltage Stability; Short Circuit; Arc Flash; Protective Device Coordination; Wire Sizing; Generator Sizing; Load Forecasting; Transmission Line Parameters; Cable Ampacity.*

Paladin DesignBase 7.0. offers users an unparalleled range of features and functions designed to increase their engineering capabilities, without adding technical complexity:

- *Rich-Object Component Library:* This comprehensive library of frequently-used design components allows users to easily "drag and drop" pre-defined symbols on their design workspace. Each Paladin DesignBase symbol is an intelligent object that is instructed to connect itself to the desired object, and to stay anchored once connected. If two branches are connected by the user, then the program automatically generates a physical node;

- *Complex Components:* This feature allows Paladin DesignBase users to save any part of a model as an object… no matter how many objects are contained within it. This allows sophisticated grouping of objects – say a collection of buses or equipment – to be saved as a single custom component… and used over and over in downstream design projects;
- *User-Customizable Symbols Catalog:* Paladin DesignBase has incorporated Autodesk's "ActiveShapes® Editor," allowing users to design the layout of any new catalog component, such as a new bus symbol or branch symbol;
- *Project Layout Management:* Paladin DesignBase users can organize the project layout as a single drawing model, as a multiple-page model, or as multiple drawings model. The drawings are electrically interconnected and operate on a single project database;
- *User-Customizable Working Environment Layout:* Paladin DesignBase users can customize the displayed tools, features and application, as well as customize the toolbars and the associated commands.
- *Comprehensive Library:* Paladin DesignBase has a comprehensive, verified and validated library with protective devices, control systems, battery data, transformers, cables, motors, generators, transmission lines, relays, etc.

This feature allows Paladin DesignBase 7.0. users to connect any Windows-based application to their Paladin. DesignBase project, including any website. This is a powerful feature that allows users to organize their Paladin DesignBase projects – stored in a single project database – as multiple page or multiple drawings project. For a given project, the hyperlink feature is a search, find, open the drawing model and locate the network component on the drawing.

Key Benefits: *DesignBase models become boundary-less, extending wherever necessary; Models are not constrained to CAD-only elements, but to all business applications; A single project database ensures manageability over the extended design model* [2], [5], [6].

3. MODELING OF 220/110/20 kV SARDANESTI POWER SUBSTATION

3.1. Description of the power substation

The 220/110/20 kV Sardanesti power substation is located in Plopsoru commune, Gorj county, belonging to the Center for the Exploitation of Electricity Transmission Networks Târgu-Jiu – Craiova Electricity Transport Unit [4], [5].

3.1.1. 220 kV Power Substation

The 220 kV power substation is of the external type and is equipped with simple bussbar systems, to which the following power cells (switchgears) are connected: *220/110 kV – 200 MVA AT (autotransformer); 220 kV Urechesti OHL* *(overhead power line); 220 kV Craiova Nord OHL (overhead power line); 220 kV Measures 1, according to fig.1*. [7], [8], [9].

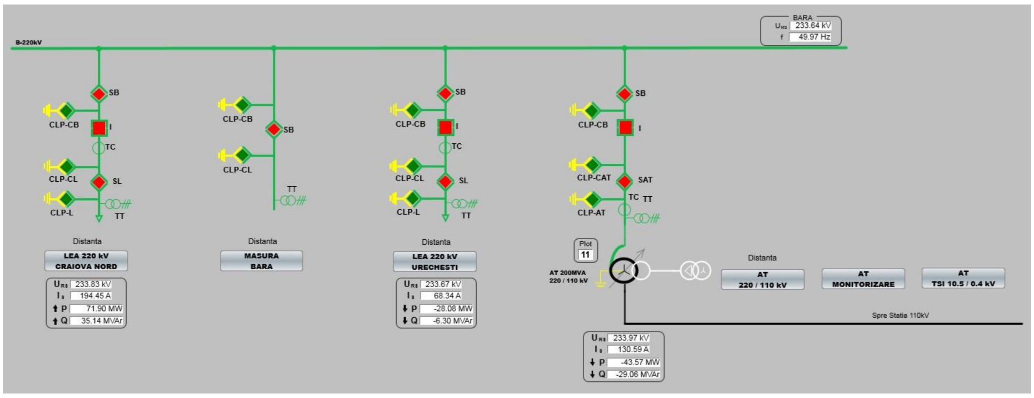

Fig.1. Scheme of the 220 kV Sardanesti power substation – SCADA

3.1.2. 110 kV Power Substation

The 110 kV power substation is of the external type and is equipped with double bussbar systems, with connection by transversal couple, to which the following power cells (switchgears) are connected: *220/110 kV – 200 MVA AT 1 (autotransformer); 220/110 kV – 200 MVA AT 2 (autotransformer); 110 kV Jilt OHL (overhead power line); 110 kV Dragotesti OHL (overhead power line); 110 kV Pinoasa OHL (overhead power line); 110 kV Rosia – Pesteana OHL (overhead power line); 110 kV SRA - Pesteana OHL (overhead power line); 110 kV Plopsoru – CFR 1 OHL (overhead power line); 110 kV Turceni T01 OHL (overhead power line); 110 kV Turceni T03 OHL (overhead power line); 110 kV Turceni T05 OHL (overhead power line); 110 kV Transversal couple, 110 kV Measure 1, 110 kV Measure 2, according to fig.2* [10], [11].

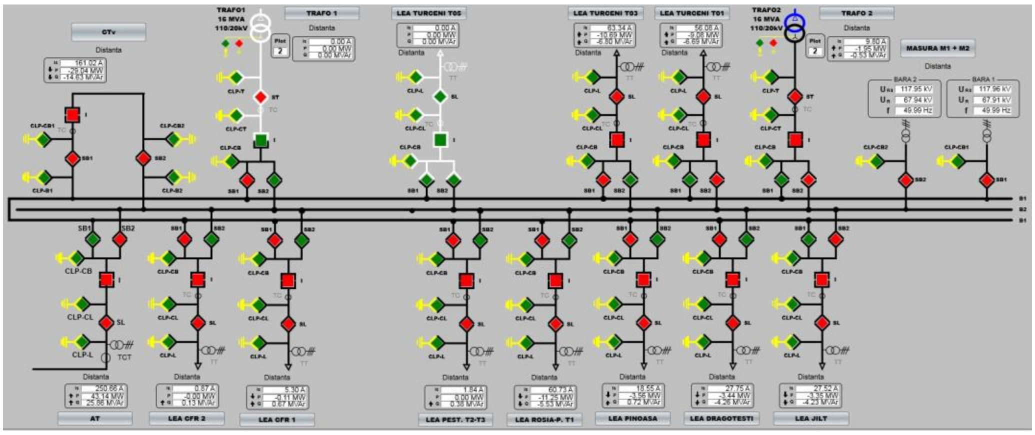

Fig.2. Scheme of the 110 kV Sardanesti power substation – SCADA

3.1.3. 20 kV Power Substation

The 20 kV power substation is of the internal type and is equipped with 2 simple bussbar systems conected with transversal couple, to which the following power cells (switchgears) are connected: *220/20 kV – 16 MVA AT 1 (autotransformer); 220/20 kV – 16 MVA AT 2 (autotransformer); 20 kV Turceni OHL (overhead power line); 20 kV Cocoreni OHL (overhead power line); 20 kV MHC 1 OHL (overhead power line); 20 kV MHC 2 OHL (overhead power line); 20 kV SI CHE OHL (overhead power line); 20 kV Transversal couple; 20 kV Measure 1; 20 kV Measure 2; 20 kV TSI 1 (intern services); 20 kV TSI 2 (intern services), according to fig. 3* [12].

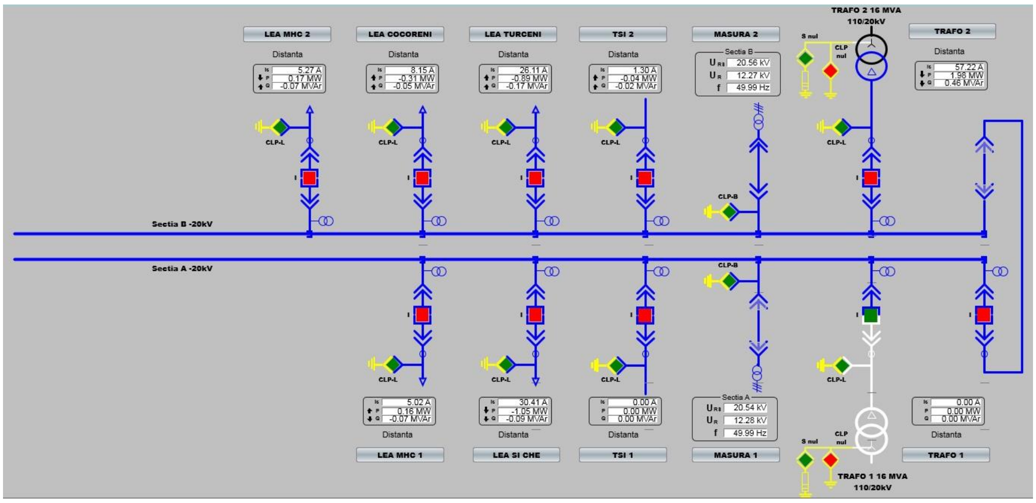

Fig.3. Scheme of the 20 kV Sardanesti power substation – SCADA

3.2. Modeling of permanent regime

3.2.1. Active and reactive losses

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a)   Scenario 1    Power injection:           220 kV Craiova Nord OHL and
                                              110 kV Turceni T01;
                   Equilibrium connection:    220 kV Urechesti OHL;
                   Consumers:                 110  kV  Plopsoru  –  CFR  1  OHL,  110
                                              kV  Plopsoru  –  CFR  2  OHL,  110  kV
                                              Rosia-Pesteana  1  OHL,  110  kV  SRA-
                                              Pesteana  2  OHL,  110  kV  Dragotesti
                                              OHL,  110  kV  Jilt  OHL,  OHL  00  kV
                                              Pinoasa  OHL,  110  kV  Turceni  T03
                                              OHL, 110 kV Turceni T05 OHL.
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Summary of Total Generation and Demand:
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                     P(MW)              Q(MVAR)              S(MVA)
PF(%)
Swing Bus(es):       5.283              -36.911              36.666
14.17
Generators:         -5.000              -16.000              17.482
15.00
```

Shunt:	0.000	-44.973	99.973	0.00
Static Load:	0.000	0.000	0.000	0.00
Motor Load:	0.000	0.000	0.000	0.00
Total Loss:	**0.283**	**-97.884**		

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b) Scenario 2

Power injection: 220 kV Urechesti OHL and 110 kV Turceni T03 OHL;

Equilibrium connection: 220 kV Craiova Nord OHL;

Consumers: 110 kV Pinoasa OHL, 110 kV Plopsoru – CFR 2 OHL, 110 kV Rosia-Pesteana 1 OHL, 110 kV SRA-Pesteana 2 OHL, 110 kV Dragotesti OHL, 110 kV Jilt OHL, 110 kV Turceni T01 OHL, 100 kV Plopsoru 1 OHL, 110 kV Turceni T05 OHL.

Summary of Total Generation and Demand:
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	P(MW)	Q(MVAR)	S(MVA)	PF(%)
Swing Bus(es):	5.132	-36.912	36.666	14.17
Generators:	-5.000	-16.000	17.482	15.00
Shunt:	0.000	-45.973	98.977	0.00
Static Load:	0.000	0.000	0.000	0.00
Motor Load:	0.000	0.000	0.000	0.00
Total Loss:	**0.132**	**-98.885**		

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c) Scenario 3

Power injection: 220 kV Urechesti OHL and 110 kV Turceni T05 OHL;

Equilibrium connection: 220 kV Craiova Nord OHL;

Consumers: 110 kV Pinoasa OHL, 110 kV Plopsoru – CFR 1 OHL, 110 kV Plopsoru – CFR 2 OHL, 110 kV Rosia-Pesteana 1 OHL, 110 kV SRA-Pesteana 2 OHL, 110 kV Jilt OHL, 110 kV Turceni T01 OHL, 110 kV Turceni T03 OHL, 110 kV Dragotesti OHL.

Summary of Total Generation and Demand:
===============================

	P(MW)	Q(MVAR)	S(MVA)	PF(%)
Swing Bus(es):	5.131	-36.912	35.667	14.17
Generators:	-5.000	-16.000	17.482	15.00
Shunt:	0.000	-45.973	98.977	0.00
Static Load:	0.000	0.000	0.000	0.00
Motor Load:	0.000	0.000	0.000	0.00

Total Loss: 0.131 -96.888

3.2.2. Voltage drops (surges)

Bus Voltage Results

Bus Name	Type	V (KVOLTS)	DROP (%)	ANG (DEG)	P (MW)	Q (MVAR)	PF (%)
Urechesti OHL	Swing	232.821	0.00	-10000.0	-98.07	-168.64	50.27
Craiova Nord OHL	Gen	231.831	-5.83	79.8	-10.00	-7.00	81.92
Dragotesti OHL	Gen	112.831	-5.83	79.8	-10.00	-7.00	81.92
Pinoasa OHL	Gen	115.773	-0.94	79.7	40.00	26.00	83.84
Plopsoru - CFR 1 OHL	Gen	110.366	-1.09	79.6	60.00	39.00	83.84
Plopsoru - CFR 2 OHL	Gen	110.152	-5.98	79.7	20.00	10.00	89.44
Rosia-Pesteana 1 OHL	None	110.715	-0.68	79.8	0.00	0.00	
SRA-Pesteana 2 OHL	None	112.932	-5.88	79.8	19.98	15.50	79.00
Jilt OHL	None	112.634	-0.66	79.8	0.00	101.30	0.00
Turceni T01 OHL	None	112.675	-0.67	79.8	0.00	101.31	0.00
Turceni T03 OHL	None	110.594	-0.65	79.8	0.00	101.29	0.00
Turceni T05 OHL	None	110.922	-5.87	79.7	10.00	1.70	98.58
AT 220/110 - 200 MVA	ShuntR	231.554	-0.64	79.8	0.00	-101.28	0.00
AT 110/20 (1) - 16 MVA	ShuntR	231.554	-0.64	79.8	0.00	-101.28	0.00
AT 110/20 (2) - 16 MVA	ShuntR	231.554	-0.64	79.8	0.00	-101.28	0.00
0012	None	232.821	-0.70	79.8	39.81	83.61	42.99
0013	None	232.821	-0.64	79.7	99.31	95.13	72.21
0014	None	232.821	-0.69	79.8	39.81	83.60	43.00
0015	None	232.821	-0.68	79.8	0.11	11.27	0.93
0016	None	232.821	-0.67	79.7	99.33	95.17	72.21
0019	None	232.821	-0.68	79.8	0.00	0.00	
0020	None	232.821	-0.68	79.8	0.00	0.00	
0025	None	112.932	-5.87	79.7	0.03	12.09	0.24
0026	None	232.917	-5.87	79.7	0.03	12.09	0.24
0027	None	112.932	-5.87	79.8	0.03	12.09	0.24
0028	None	232.926	-5.88	79.8	19.98	15.50	79.01
0029	None	232.929	-5.88	79.8	19.98	15.50	79.01
0030	None	112.932	-5.87	79.7	10.00	1.70	98.58
0032	None	232.922	-5.87	79.7	10.00	1.70	98.58
0036	None	232.921	-5.87	79.7	10.00	1.70	98.58
0048	None	232.939	-5.88	79.8	19.98	15.50	79.00
0049	None	112.932	-0.69	79.8	59.62	101.67	50.58
0050	None	112.932	-0.70	79.8	59.62	101.68	50.58
0051	None	232.946	-5.88	79.8	19.98	15.51	79.00
0052	None	232.949	-5.89	79.8	19.98	15.51	79.00
0053	None	112.932	-0.71	79.8	59.62	101.70	50.57
0059	None	112.932	-0.70	79.8	39.81	83.60	43.00
0064	None	112.932	-0.65	79.7	99.31	95.15	72.21
100014	None	112.932	-0.68	79.8	0.11	11.27	0.93
100015	None	232.921	-0.68	79.8	0.11	11.27	0.93
100205	None	232.921	-5.87	79.7	10.00	1.70	98.58
100206	None	232.922	-5.87	79.7	10.00	1.70	98.58

3.2.3. Current flow

Branch Current Flow Values

Branch Name	C#	Type	Library CodeName	Current (KA)	Angle (Deg)	Ampacity (KA)	Loading (%)
Urechesti OHL	1	Breaker	L-V 1600 A ITR	0.133	195.2	1.600	8%

Craiova Nord OHL	1	Breaker	L-V 1600 A ITR	0.016	-10.8	1.600	1%
AT 220/110 - 200 MVA	1	Switch	1600 SME 220KV	0.000	79.8	0.000	
Dragotesti OHL	1	Switch	1600 SME 220KV	0.063	41.9	0.000	
Pinoasa OHL	1	Breaker	L-V 1600 A ITR	0.145	-10.2	1.600	9%
Plopsoru-CFR 1 OHL	1	Breaker	L-V 1600 A ITR	0.197	36.0	1.600	12%
Plopsoru-CFR 2 OHL	1	Feeder	AL1600HIAMP-GF-I	0.145	169.8	1.600	9%
Rosia-Pesteana 1 OHL	1	Breaker	L-V 1600 A ITR	0.000	79.8	1.600	0%
SRA-Pesteana 2 OHL	1	Breaker	L-V 1600 A ITR2	0.063	221.9	1.600	4%
Jilt OHL	1	Breaker	L-V 1600 A ITR2	0.169	200.1	1.600	11%
Turceni T01 OHL	1	Breaker	L-V 1600 A ITR2	0.030	169.6	1.600	2%
Turceni T03 OHL	1	Feeder	AL1600HIAMP-GF-H	0.025	70.1	0.644	4%
Turceni T05 OHL	1	Feeder	AL1600HIAMP-GF-H	0.025	70.1	0.644	4%
AT 110/20 (1)-16 MVA	1	Feeder	AL1600HIAMP-GF-H	0.068	46.6	0.644	11%
AT 110/20 (2)-16 MVA	1	Feeder	AL1600HIAMP-GF-I	0.282	-9879.8	0.644	44%
SB-AT 220/110	1	Switch	1600 SME 220KV	0.030	-10.4	1.600	2%
SB-Urechesti OHL	1	Switch	1600 SME	0.016	169.2	1.600	1%
SB-Craiova Nord OHL	1	Switch	1600 SME 220KV	0.025	70.1	1.600	2%
SB-Dragotesti OHL	1	Switch	1600 SME 220KV	0.025	70.1	1.600	2%
SB-Pinoasa OHL	1	Switch	1600 SME	0.145	169.8	1.600	9%
SB-Plopsoru-CFR 1 OH	1	Switch	1600 SME 220KV	0.063	41.9	1.600	4%
SB-Plopsoru-CFR 2 OH	1	Switch	1600 SME	0.133	15.2	1.600	8%
SL-Rosia-Pesteana 1	1	Switch	1600 SME	0.197	216.0	1.600	12%
SL-SRA-Pesteana 2 OH	1	Switch	1600 SME 220KV	0.063	41.9	1.600	4%
SL-Jilt OHL	1	Switch	1600 SME	0.000	79.8	1.600	0%
SL-Turceni T01 OHL	1	Switch	1600 SME 220KV	0.063	221.9	1.600	4%
SL-Turceni T03 OHL	1	Switch	1600 SME	0.000	79.8	1.600	0%
SB2-Turceni T05 OHL	1	Switch	1600 SME 220KV	0.169	20.1	1.600	11%
SL-AT 110/20 (1)-16	1	Switch	1600 SME 220KV	0.030	-10.4	1.600	2%
SL-AT 110/20 (1)-16	1	Switch	1600 SME	0.145	169.8	1.600	9%
SL-AT 220/110 - 200	1	Switch	1600 SME 220KV	0.025	70.1	1.600	2%

Branch Name	C#	Type	Library CodeName	Current (KA)	Angle (Deg)	Ampacity (KA)	Loading (%)
AT 220/110 - 200 MVA	1	Breaker	L-V 1600 A ITR2	0.025	250.1	1.600	2%
AT 110/20 (1)-16 MVA	1	Breaker	L-V 1600 A ITR2	0.063	41.9	1.600	4%
AT 110/20 (2)-16 MVA	1	Breaker	L-V 1600 A ITR2	0.063	41.9	1.600	4%

3.2.4. Power flow

Branch Power Flow Values

Branch Name	C#	Type	Library CodeName	From -> To Flow (MW)	(MVAR)	To -> From Flow (MW)	(MVAR)	Losses (MW)	(MVAR)
AT 220/110 -	1	Breaker	L-V	-39.81	-83.60	39.81	83.60	0.00	0.01
AT 110/20 (1)-1	1	Breaker	L-V	-20.81	-43.60	19.81	43.60	0.00	0.01
AT 110/20 (2)-1	1	Breaker	L-V	-19.81	-43.60	19.81	43.60	0.00	0.01
Urechesti OHL	1	Switch	1600 SME	0.00	0.00	0.00	0.00	0.00	0.00
Craiova Nord OHL	1	Switch	1600 SME	0.00	0.00	0.00	0.00	0.00	0.00
Dragotesti OHL	1	Breaker	L-V 1600 A IT	0.00	101.31	0.00	-101.30	0.00	0.01
Pinoasa OHL	1	Breaker	L-V 1600 A IT	99.33	95.17	-99.31	-95.15	0.02	0.02
Plopsoru-CFR 1 OHL	1	Feeder	AL1600HIAMP-GF	0.00	-101.28	0.00	101.29	0.00	0.01
Plopsoru-CFR 2 OHL	1	Feeder	AL1600HIAMP-GF	0.00	-101.28	0.00	101.29	0.00	0.01
Rosia-Pesteana 1 OHL	1	Breaker	L-V 1600 A	0.00	0.00	0.00	0.00	0.00	0.00

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SRA-Pesteana 2 OHL    1 Breaker  L-V 1600 A  -19.98   -15.50    19.98    15.51
0.00   0.00
Jilt OHL              1 Breaker  L-V 1600 A    0.03   -12.09    -0.03    12.09
0.00   0.00
Turceni T01 OHL       1 Feeder   AL1600HIAMP   10.00   1.70   -10.00    -7.00
0.00  -5.30
Turceni T03 OHL       1 Feeder   AL1600HIAMP    10.00   1.70    -10.00    -7.00
0.00 -5.30
Turceni T05 OHL       1 Feeder   AL1600HIAMP    40.00   26.00   -39.82   -83.61
0.19-57.61
SB1-AT 220/110-200 MVA1 Switch   1600 SME       -0.03   12.09     0.03   -12.09
0.00  0.00
SB1-AT 110/20(1)-16 MVA 1 Switch 1600 SME        0.11  -11.27    -0.11    11.27
0.00  0.00
SB1-AT 110/20(2)-16 MVA 1 Switch 1600 SME       10.00    1.70   -10.00    -1.70
0.00  0.00
SB2-Urechesti OHL       1 Switch 1600 SME       10.00    1.70   -0.00     -1.70
0.00  0.00
SB2-Craiova Nord OHL    1 Switch 1600 SME      -19.98  -15.50   19.98     15.50
0.00  0.00
SB2-COUPLE              1 Switch 1600 SME        0.00    0.00    0.00      0.00
0.00  0.00
SB-Dragotesti OHL       1 BreakerL-V 1600 A ITR  0.00  101.31    0.00   -101.30
0.00  0.01
SB-Pinoasa OHL          1 BreakerL-V 1600 A IT  99.33   95.17  -99.31    -95.15
0.02  0.02
SL-SB-Plopsoru-CFR1 OHL 1 Feeder AL1600HIAMP-GF  0.00 -101.28    0.00    101.29
0.00  0.01
SL-Plopsoru-CFR 2 OHL   1 Feeder AL1600HIAMP-GF  0.00  -101.28   0.00    101.29
0.00  0.01
SL-Rosia-Pesteana 1 OHL 1 Breaker L-V 1600 A     0.00     0.00   0.00      0.00
0.00  0.00
SL-SRA-Pesteana 2 OHL   1 Breaker  L-V 1600 A  -19.98   -15.50  19.98     15.51
0.00  0.00
SL-Jilt OHL             1 Breaker  L-V 1600 A    0.03   -12.09  -0.03     12.09
0.00  0.00
SL-AT 220/110-200 MVA   1 Switch   1600 SME     -0.03    12.09   0.03    -12.09
0.00  0.00
SL-AT 110/20(1)-16 MVA  1 Switch   1600 SME      0.11   -11.27  -0.11     11.27
0.00  0.00
SL-AT 110/20(2)-16 MVA  1 Switch   1600 SME     10.00     1.70 -10.00     -1.70
0.00  0.00
SL-Urechesti OHL        1 Switch   1600 SME     -0.03    12.09   0.03    -12.09
0.00  0.00
SL-Craiova Nord OHL     1 Switch   1600 SME      -0.00  -101.29  0.00    101.30
0.00  0.01
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3.2.5. Voltage violation

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                            Voltage Violation Report
                            ========================
 Bus Name            Type     Bus Voltage  UpperLim  LowerLim  Violation
                               (kvolts)      (pu)      (%)       (%)
----------------------- ------ -------- -------- -------- -------- ---------


Urechesti OHL         Gen       232.831    1.0582    105.0%     95.0%    over
Craiova Nord OHL      Gen       232.831    1.0584    105.0%     95.0%    over
Dragotesti OHL        Gen       232.832    1.0583    105.0%     95.0%    over
Pinoasa OHL           Gen       232.836    1.0581    105.0%     95.0%    over
Plopsoru-CFR 1 OHL    Gen       232.831    1.0583    105.0%     95.0%    over
Plopsoru-CFR 2 OHL    Gen       232.833    1.0583    105.0%     95.0%    over
Rosia-Pesteana 1 OHL  Gen       232.835    1.0583    105.0%     95.0%    ove
SRA-Pesteana 2 OHL    Gen       232.831    1.0589    105.0%     95.0%    over
```

```
Jilt OHL              Gen      232.839    1.0586    105.0%     95.0%    over
Turceni T01 OHL       Gen      232.838    1.0583    105.0%     95.0%    over
Turceni T03 OHL       Gen      232.833    1.0587    105.0%     95.0%    over
```

3.2.6. AutoTransformers loading:

```
                AutoTransformers Loading
                ========================

Branch Name               C#   Type Library CodeName  Capacity   Loading
F_Tap T_Tap
                                                        (MVA)     (MVA)    (%)
PU)  (PU)
------------------------ -- -------- ---------------- ---------- ---------- ----
- ----- -----

AutoTransformator          1         AT 220/110       200.00      12.22    3%
AutoTransformator          1         AT 110/20 (1)     16.00      11.12    3%
AutoTransformator          2         AT 110/20 (2)     16.00      10.27    3%
```

3.2.7. Total losses

```
                   Summary of Total Generation and Demand
                   ======================================
                        P(MW)        Q(MVAR)         S(MVA)        PF(%)
    Swing Bus(es):     -98.070      -168.641        195.083        50.27
    Generators   :     100.000        61.000        117.137        85.37
    Shunt        :       0.000      -101.281        101.281         0.00
    Static Load  :       0.000         0.000          0.000         0.00
    Motor Load   :       0.000         0.000          0.000         0.00
    Total Loss   :       1.935      -208.922
                    ----------    ----------
    Mismatch     :      -0.005        -0.000
```

4. CONCLUSIONS

This paper illustrate the functioning of 220/110/20 kV Sardanesti power substation during the permanent regime.

After simulation of 220/110/20 kV Sardanesti power substation by EDSA programme, the results is next:

a) Active and reactive power losses:

- Scenario 1 – 0.283 MW and 97.884 MVA;
- Scenario 2 – 0.132 MW and 97.885 MVA;
- Scenario 3 – 0.131 MW and 96.888 MVA.

b) Voltage drops (surges):

- Urechesti 220 kV OHL: 0.00 %;
- Craiova Nord 220 kV OHL: – 5.83 %;
- AT 220/110 – 200 MVA: 0.64 %;
- Dragotesti 110 kV OHL: – 5,83 %;
- Pinoasa 110 kV OHL: – 0.94 %;
- Plopsoru – CFR 1 110 kV OHL: – 1.09 %;
- Plopsoru – CFR 2 110 kV OHL: – 5.98 %;
- Rosia-Pesteana 1 110 kV OHL: – 0.68 %;
- SRA-Pesteana 2 110 kV OHL: – 5.88 %;

- Jilt 110 kV OHL: – 0.66 %;
- Turceni T01 110 kV OHL: – 0.67 %;
- Turceni T03 110 kV OHL: – 0.65 %;
- Turceni T05 110 kV OHL: – 5.87 %;
- AT 110/20 (1) – 16 MVA: – 0.64 %;
- AT 110/20 (2) – 16 MVA: – 0.64 %.

c) ***Current flow:***

- AT 220/110 kV – 200 MVA: 0.025 kA – 2 % loading;
- AT 110/20 (1) – 16 MVA: 0.063 kA – 4 % loading;
- AT 110/20 (2) – 16 MVA: 0.063 kA – 4 % loading.

d) ***Power flow:***

- AT 220/110 – 200 MVA: – 39.81 MW; 0.01 losses;
- AT 110/20 (1)–16 MVA: – 20.81 MW; 0.01 losses;
- AT 110/20 (2)–16 MVA: – 19.81 MW; 0.01 losses;
- Urechesti 220 kV OHL: 0.00 MW; 0.00 losses;
- Craiova Nord 220 kV OHL: 0.00 MW; 0.00 losses;
- Dragotesti 110 kV OHL: 0.00 MW; 0.01 losses;
- Pinoasa 110 kV OHL: 99.33 MW; 0.02 losses;
- Plopsoru–CFR 1 110 kV OHL: 0.00 MW; 0.01 losses;
- Plopsoru–CFR 2 110 kV OHL: 0.00 MW; 0.01 losses;
- Rosia-Pesteana 1 110 kV OHL: 0.00 MW; 0.00 losses;
- SRA-Pesteana 2 110 kV OHL: – 19.98 MW; 0.00 losses;
- Jilt 110 kV OHL: 0.03 MW; 0.00 losses;
- Turceni T01 110 kV OHL: 10.00 MW; – 5.30 losses;
- Turceni T03 110 kV OHL: 0.00 MW; – 5.30 losses;
- Turceni T05 110 kV OHL: 40.00 MW; – 57.61 losses.

e) ***Voltage violation:***

- Urechesti 110 kV OHL: 95.0% over;
- Craiova Nord 110 kV OHL: 95.0% over;
- Dragotesti 110 kV OHL: 95.0% over;
- Pinoasa 110 kV OHL: 95.0% over;
- Plopsoru–CFR 1 110 kV OHL: 95.0% over;
- Plopsoru–CFR 2 110 kV OHL: 95.0% over;
- Rosia-Pesteana 1 110 kV OHL: 95.0% over;
- SRA-Pesteana 2 110 kV OHL: 95.0% over;
- Jilt 110 kV OHL: 95.0% over;
- Turceni T01 110 kV OHL: 95.0% over;
- Turceni T03 110 kV OHL: 95.0% over.

f) ***AutoTransformers loading:***

- AT 220/110 – 200 MVA: 12.22 – 3%;

- AT 110/20 (1) – 16 MVA: 11.12 – 3%;
- AT 110/20 (2) – 16 MVA: 10.27 – 3%.

g) Total losses:

- 1.935 MW and – 208.922 MVAR.

Following the simulation of the permanent regime of the 220/110/20 kV Sardanesti power substation, it can be seen that the power substation falls within normal operating parameters, but it is proposed to modify the 220 kV power substation from a simple collector bussbar system, in a double collector bussbars, thus increasing the reliability of the 220 kV power substation.

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