

# STEADY-STATE MODE ANALYSIS OF TOMSK ENERGY SYSTEM «VOSTOCHNAYA» SUBSTATION

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Substation (SB) Vostochnaya with installed capacity 526 MV\*A has been put into service at 1963 year. From its reliable operation depends energy supply most of the Tomsk city, peak backup boiler-house, of the "Sibkabel" plant, ball bearing plant and also Sputnik township which has the training reactor Research Institute of Nuclear Physics [1].

Schematic structure of substation includes the following elements: switch-houses (SH); power transformers (T), autotransformers (AT). SB "Vostochnaya" contains HV-SH, MV-SH-1, MV-SH-2, LV-SH in accordance with Figure 1.

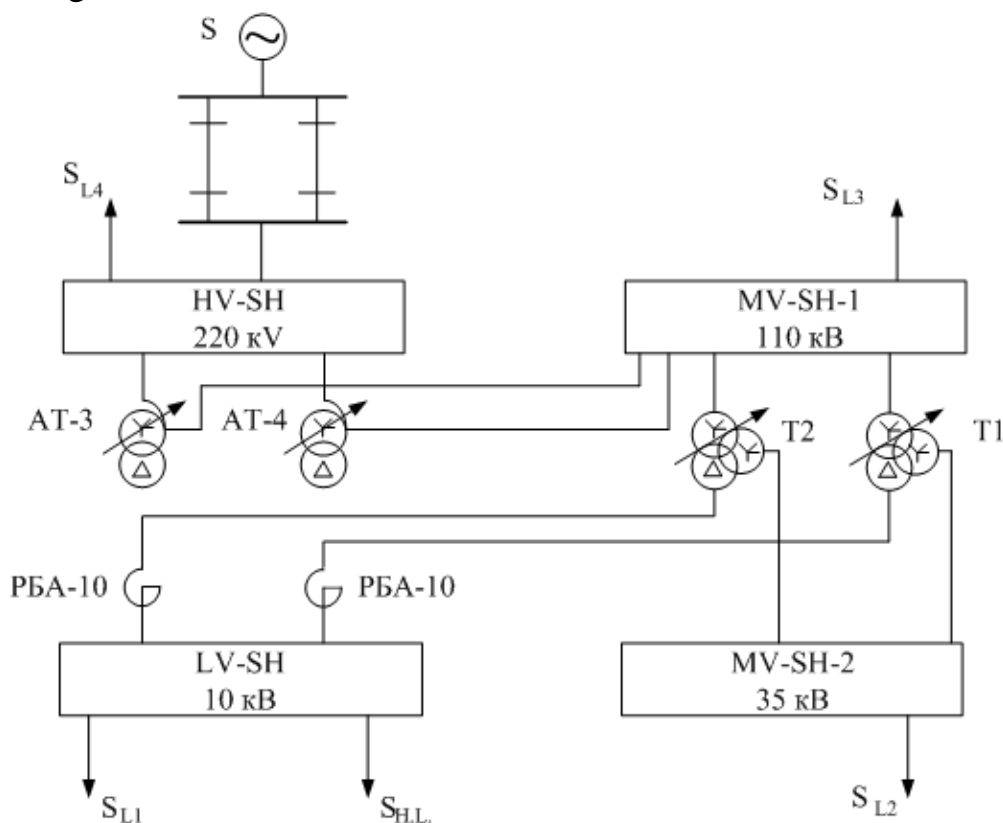


Figure 1 – Schematic structure of «Vostochnaya» substation

It is necessary to make calculations prolonged (steady state) modes (SSM) for the selection and analysis of electrical power equipment.

Some examples of the network calculations in the software packages Mustang and RastrWin3 are given in this paper/

The software package (SP) RastrWin3 are used for decision of problems by calculation, analysis and optimization of steady-state mode of electrical networks and systems.

Set benchmarks for point branches have to be set (Figure 2) with showing all point branches of electrical network. For convenience and clarity, the equivalent circuit has equivalent transformers

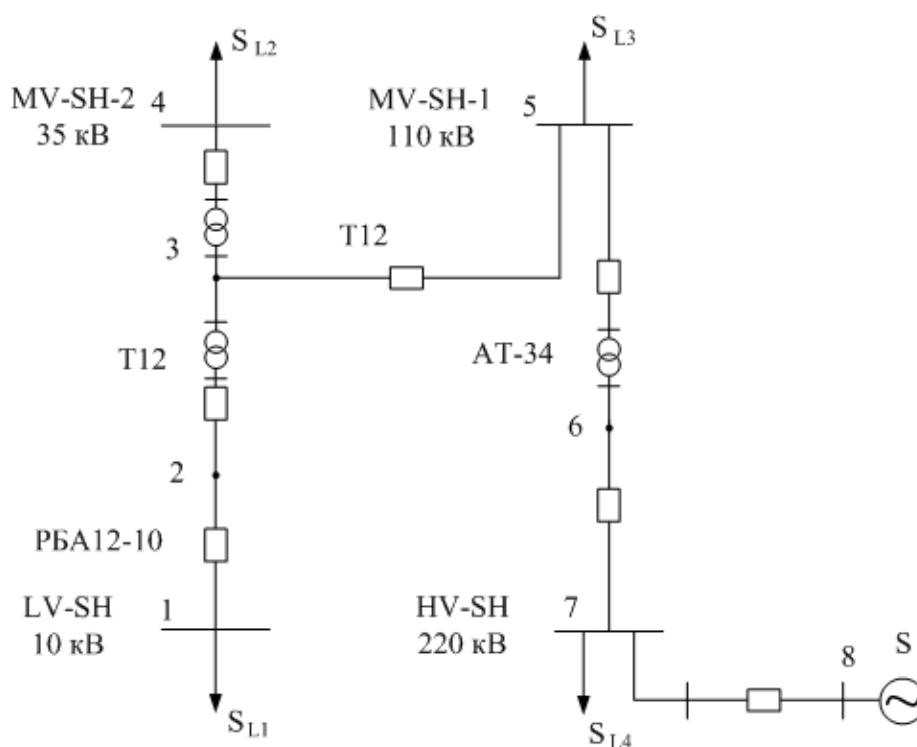


Figure 2 – Scheme SB Vostochnaya for calculate (SSM) in RastrWin3

Some calculate resistance of all branches of the circuit.

Transformer T12, type – ТДТН-63000/110-76Y1

For example,

$$u_{KB} = 0,5 \cdot (u_{KB-C} + u_{KB-H} - u_{KC-H}) = 0,5 \cdot (10,39 + 17,75 - 7,06) = 10,54\%;$$

$$u_{KC} = 0,5 \cdot (u_{KB-C} + u_{KC-H} - u_{KB-H}) = 0,5 \cdot (10,39 + 7,06 - 17,75) = -0,15\%;$$

$$u_{KH} = 0,5 \cdot (u_{KB-H} + u_{KC-H} - u_{KB-C}) = 0,5 \cdot (17,75 + 7,06 - 10,39) = 7,21\%.$$

Autotransformer AT34, type – АТДЦТН-200000/220/110-68Y1

In ratings energy loss  $\Delta P_{KB-C}$  of autotransformers reports toward the transformer capacity, and the value  $\Delta P_{KB-H}$ ,  $\Delta P_{KC-H}$  (denote these ratings

$\Delta P'_{KB-H}$ ,  $\Delta P'_{KC-H}$ ) – to the nominal power LV winding. The values  $\Delta P'_{KB-H}$ ,  $\Delta P'_{KC-H}$  are recalculated to the autotransformer capacity in this way

$$\Delta P_{KB-H} = \frac{\Delta P'_{KB-H}}{\alpha^2} = \frac{382}{0.5^2} = 1528 \text{ kW},$$

$$\Delta P_{KC-H} = \frac{\Delta P'_{KC-H}}{\alpha^2} = \frac{344}{0.5^2} = 1376 \text{ kW},$$

где  $\alpha = \frac{S_{HH}}{S_{HOM}}$  – derating factor,

$$\alpha = \frac{100}{200} = 0,5 \text{ o.e.}$$

$$\Delta P_{KB} = 0,5 \cdot (\Delta P_{KB-C} + \Delta P_{KB-H} - \Delta P_{KC-H}) = 0,5 \cdot (450 + 1528 - 1376) = 301 \text{ kW};$$

$$\Delta P_{KC} = 0,5 \cdot (\Delta P_{KB-C} + \Delta P_{KC-H} - \Delta P_{KB-H}) = 0,5 \cdot (450 + 1376 - 1528) = 149 \text{ kW};$$

Inductive reactance are calculated similarly as for the three-winding transformers. Due to the fact that the low voltage side of the autotransformer decommissioned, calculation do only for the resistance of the windings of higher and secondary voltages.

Current-limiter reactor, type PБА-10-2000-10

Active resistance of single reactor:

$$r_p = \frac{\Delta P}{I_{HOM}^2} \cdot 10^{-3} = \frac{16,9}{2^2} \cdot 10^{-3} = 0,425 \text{ Ohm.}$$

where  $\Delta P$  – nominal energy loss on phase reactor, kW [4],

$I_{HOM}$  – nominal reactor current, kA [4];

$$x_p = 2 \cdot \pi \cdot f \cdot L_{HOM} \cdot 10^{-3} = 2 \cdot 3,14 \cdot 50 \cdot 930 \cdot 10^{-3} = 0,292 \text{ Ohm},$$

where  $L_{HOM}$  – nominal reactor inductance, H [4].

Load: the value power of load got from [4], for e[ample load 10 kV:  $S_1=5 \text{ MV} \cdot \text{A}$ ;  $P=4 \text{ MW}$ ;  $Q=3 \text{ Mvar}$ ;

Then we must complete basic data into SP RastrWin3 in point branches and circuits and calculate the steady state mode.

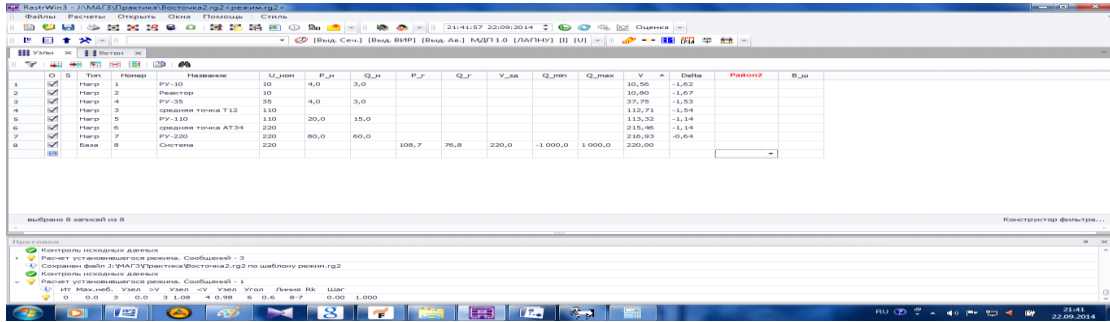


Figure 3 – results table (SSM) in point branches

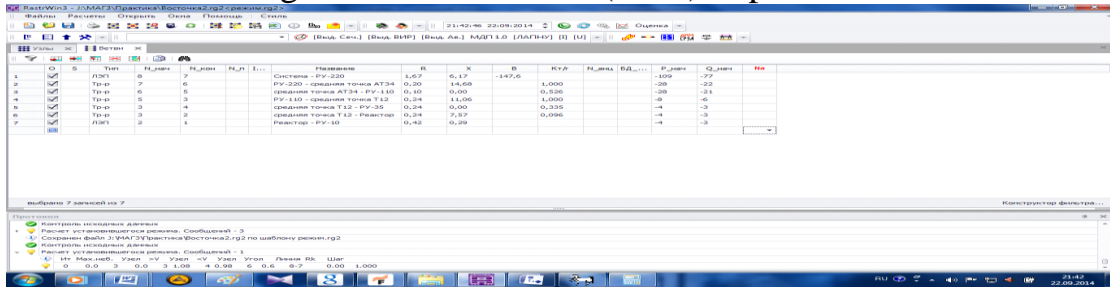


Figure 4 – results table (SSM) in circuits

In RastrWin3 exists a function demonstration of nodes and branches listed in the table in the form of graphical scheme (Figure 5).

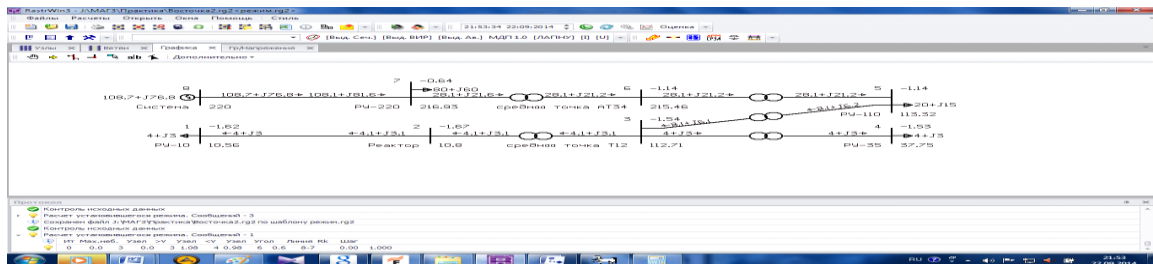


Figure 5 – Schematic structure of «Vostochnaya» substation in RastrWin3

Next, we perform steady-state calculation of the SB " Vostochnaya " in Mustang

Similarly, working with RastrWin3 to calculate SSM Mustang skid all the necessary background information on units and branches and perform calculations. The calculation results are shown in Figures 6 and 7.

| Имя      | Величина | Система | ВНУ | МВТТ м/ч | МВТТ устан | К       | В     | Юг     |
|----------|----------|---------|-----|----------|------------|---------|-------|--------|
| Система  | Шины 220 | 0       | 2   | 1.673    | 6.166      | -147.65 |       |        |
| Шины 220 | АТ-СРТ   | 7       | 6   | 0.149    | 14.680     |         | 1.000 |        |
| АТ-СРТ   | Шины 110 | 6       | 5   | 0.099    | 0.000      |         | 1.001 |        |
| Шины 110 | Т-СРТ    | 5       | 3   | 0.240    | 11.063     |         |       | 1.000  |
| Т-СРТ    | Шины 35  | 3       | 4   | 0.240    | 0.000      |         |       | 0.997  |
| Т-СРТ    | реактор  | 3       | 2   | 0.240    | 7.567      |         |       | 10.455 |
| реактор  | Шины 10  | 2       | 1   | 0.425    | 0.290      |         |       |        |

Figure 6 – results table (SSM) in point branches

| Имя      | Величина | Система | ВНУ | МВТТ м/ч | МВТТ устан | К       | В     | Юг     |
|----------|----------|---------|-----|----------|------------|---------|-------|--------|
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| АТ-СРТ   | Шины 110 | 6       | 5   | 0.099    | 0.000      |         | 1.001 |        |
| Шины 110 | Т-СРТ    | 5       | 3   | 0.240    | 11.063     |         |       | 1.000  |
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| реактор  | Шины 10  | 2       | 1   | 0.425    | 0.290      |         |       |        |

Figure 7 – results table (SSM) in circuits

Comparing voltages at nodes substation of Tables 3 and 6 shows that the calculation and UR configured correctly for further studies may be used as RastrWin3, and the Mustang.

Given our own experience and the reviews have worked in these software systems, we can say that RastrWin3 has an advantage over Mustang in terms of features, and with it a fairly simple interface and its setting.

To date, many students used RastrWin3 universities in Russia to perform projects and dissertations, thanks student license, which allows you to work with any scheme of up to 60 knots without restrictions [5].

## REFERENCES

1. Federal grid company of the power pool system. – [Электронный ресурс]. – Режим доступа: [http://www.fsk-ees.ru/press\\_center/companу\\_news](http://www.fsk-ees.ru/press_center/companу_news) (дата обращения: 04.09.2014).
2. Neklepayev B. N. Electrical part of power plants and substations: Reference materials for course and degree design. – М.: Energoatomizdat, 1989. – 608 pages/
3. Okolovich M.N. Design of power plants: The textbook for higher education institutions. – М.: Energoizdat, 1982. – 400 pages.
4. Passport of "Vostochnaya" PS of 220 kV.
5. RastrWin. – [Электронный ресурс]. – Режим доступа: <http://rastrwin.ru> (дата обращения: 04.09.2014).The scheme and the program of development of power industry of the Tomsk region for 2014-2018 years.