

Software Solution of Technical Losses of the Transmission Network System Line

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Abstract—The paper deals with the calculation of technical losses of the transmission network system line. There are presented calculations of Joule losses, corona losses and leakage losses. The main role plays a special software. This software enables to evaluate results in the form of the graph and the tab for following analysis. One of the possibilities of technical losses evaluation in transmission network system is application of the real database in a company that keeps the transmission network system.

Keywords—Software solution, technical losses, transmission network system, database, calculation.

1. INTRODUCTION

The paper deals with a software solution of technical losses calculation of the transmission network system line. There are presented calculations of Joule losses, corona losses and leakage losses. The input data for software are parameters of all lines of the transmission network system and 15 minutes samples of measured quantities of active and reactive power, voltage and current from the energy control system. These values make input database in MS Excel. With this software there is possible to do calculations of technical losses of the transmission network system line during chosen days and in various time periods. Software enables to evaluate results by graphs and tabs that can be printed. One of possibilities for evaluation of technical losses of the transmission network system is software that is applied in the real database in a company keeping the transmission network system.

1.1 Technical losses of the transmission network system line

The technical losses of the transmission network system line have a big economic impact that is why we have to know their magnitude as well as possible. In each transmission system there are losses of electric energy in all elements and components. There is not possible to remove them at all, it is possible to reduce them. The costs for reducing do not have to exceed savings. Stated calculation program solves technical losses of EHV lines. These losses present a part of produced electric energy that is not used and brings additional costs.

Losses:

- Joule losses – a result of pure resistance of a conductor material R
- corona losses – a result of imperfect electric isolation among conductors
- leakage losses – a result of imperfect electric isolation of the line towards the ground

Mature power companies use a high quality IT for the electric system control. They work with measured quantities (voltage, current, active energy, temperature etc.), estimated quantities and state quantities. All this information is processed by the control system of the power control room and they are used for the electric system control. The methodology of calculation of technical losses has to be based on mathematical relations and physical rules. The calculation of the technical losses is important for their mathematical quantification and evaluation. Software is a part of the program called “Losses of the transmission network system line” and it enables to calculate and evaluate the technical losses of the line.

2. USE OF SOFTWARE FOR CALCULATION OF LOSSES OF THE TRANSMISSION NETWORK SYSTEM LINE

This software is an independent program that needs a static database of measured values and parameters of a line. This database is made of a set of voltage and current values samples, active power and reactive power. It is processed in MS Excel and each of them takes 15 minutes. The measured values are downloaded from the control system of the CEPS, plc. Software itself works in the program environment MS Visual Basic. It uses a database of the whole transmission network system line and input data are loaded from the control system of the power control room. The database is static, in MS Excel. All is shown in Fig. 3.

2.1 Program “Losses of the transmission network system line” and results of electric losses

The important indicators during right line running are electric losses. On the base of done calculations it is possible to apply these results i.e. during the program switching off and transmission system running. The results can serve for preparation of the network running and control service. Suggested measures lead to a better economy. The demonstration of the opening panel is stated in Fig. 1. On the base of long term calculations it is possible to require a change of destroyed insulator suspensions or other destroyed devices that have increased leakage losses and corona losses. For the right function of the program it is necessary to define formulas where physical rules that take account of results are preserved. The results can be displayed at the screen for processing them into graphs or numbers. The demonstration of the graphical output of the leakage losses magnitude is in Fig. 2. We can see there longer time of changes of chosen losses magnitudes.

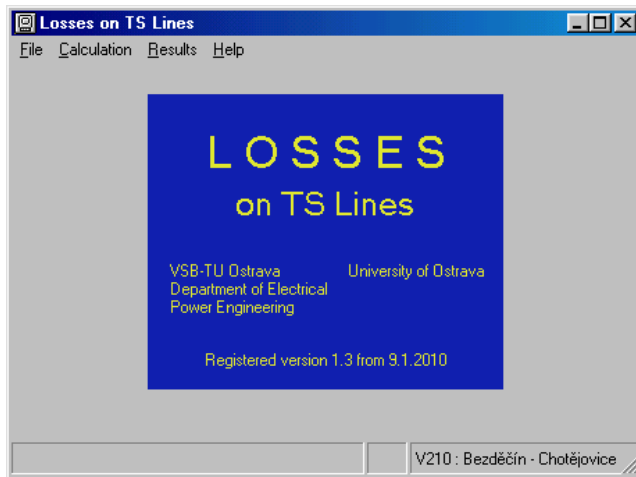


Fig. 1 Demonstration of the opening panel of the program “Losses of the transmission network system line”

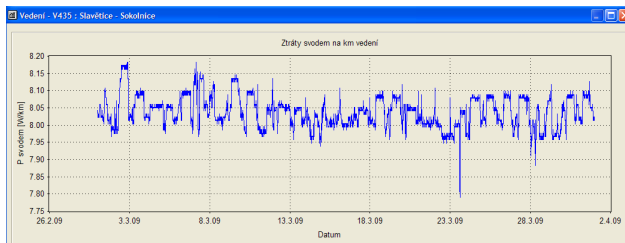


Fig. 2 View of progress of leakage losses of the line of 400kV: V435: Slavětice – Sokolnice

2.2 Physically adapted formulas for the calculation of losses

In this chapter there are adapted relations for software which calculates technical losses of the transmission network system line. Result formulas are stated in a form that is followed by the input database of necessary values for quantification of individual technical losses.

• modified formula for the calculation of Joule losses

This relation comes out of an alternate schema of the line. The alternate circuit makes π item. The result formula for calculation of Joule losses is stated in the form (1). This equation is valid in case of a null leakage. Calculated results of losses are compared to measured values [6] in a control system of CEPS, plc.

A mathematical expression for the calculation of Joule losses:

$$\Delta P = 3 \cdot R \cdot I^2 = 3 \cdot R \cdot \left[\frac{P^2 + \left(Q - \frac{U^2 \cdot B}{2} \cdot 10^{-6} \right)^2}{\sqrt{3} \cdot U} \right]^2 \quad (1)$$

Where:

ΔP	[MW]	total Joule losses of the whole line
P	[MW]	active power of the line
Q	[Mvar]	reactive power of the line
U	[kV]	delta voltage
R	[Ω]	effective resistance
B	[μS]	susceptance of the line

G [μS] leakage of the line if considered to be null

• modified formula for calculation of corona losses

In literature there is possible to find a lot of methods for calculations of corona losses that are described in [1], [6], [7]. No method is universal. Atmospheric conditions have a big impact on the magnitude of these losses. The most suitable method for the measuring and real calculations is the Russian method [1], [6]. The Peterson formula was chosen for calculation of the corona losses. This formula is suitable for definition of mathematical relation and it was simplified in the software. The modified formula is (2):

$$\Delta P_{k/km} = k_{kor} \cdot \left(\frac{U_s}{\sqrt{3}} \right)^2 \cdot F_U \quad (2)$$

Where:

k_{kor} coefficient allowing factors that have impact on cancer creation

F_U coefficient, relation of the phase voltage and effective intensity of the field. Used coefficients for individual levels of voltage were chosen on the measurement base

U_s delta voltage of the line

Modified formulas for calculation of leakage losses

Leakage losses in practice are measured mainly at the built lines. In [3] there are derived result relations for calculation of leakage currents and leakage losses. In literature [4], [5] and [7] there is stated an analysis of the insulator pollution impact on the leakage magnitude.

$$I_{leak} = \sqrt{3} \cdot U_s \cdot c \quad (3)$$

$$\Delta P_{leak} = U_s^2 \cdot c \quad (4)$$

$$\Delta P_{leak/km} = \frac{U_s^2 \cdot c}{L} \quad (5)$$

Where:

I_{leak}	[A]	leakage current in the whole line
P_{leak}	[W]	leakage losses of the whole line
c	[S]	coefficient that respects a pollution coat at insulators, type, structure and number of EHV insulator suspensions [4]
U_s	[V]	delta voltage
L	[km]	length of the line
$P_{leak/km}$	[W.km ⁻¹]	leakage losses per kilometre of the line

3. DATABASE OF THE INPUT DATA FOR THE CALCULATION SOFTWARE

A structure of software for calculation of technical losses is designed for the system of databases to be open and to react to changes. The program is able to calculate with the exports of statistic databases that come from the controlling system of energy control room [5].

Input database is made of files in three categories:

- tabs with names of lines and abbreviations of distributing substations (Tab.1)
- tabs with values of the line parameters (Tab.2)

- samples in the length of 15 minutes – active power (P), reactive power (Q), voltage (U), and current (I) (Tab.3)

Database of the tabs is in Microsoft Excel. MS Excel was chosen for its possibility to extend tabs. It is possible to fill in the databases or combine them. It is not necessary to modify these experts for this software. In practice this program could be connected to the database of the control room. The technical losses could be evaluated on-line. The magnitude of input databases is limited just by the format of MS Excel. The demonstration of necessary values is stated in Tabs 1, 2 and 3.

For the right functioning, there have to be fulfilled:

- abbreviations of distributing substations and numbers must have valid names
- 15 minutes samples have to be from the same interval
- database can contain redundant information, all necessary values are searched there and it their fixed structure is not essential

TABLE I.
DEMONSTRATION OF NAMES AND ABBREVIATIONS OF DISTRIBUTING SUBSTATIONS WITH VOLTAGE FOR CAMERA-READY PAPERS

Abbreviation	Substation	Voltage
PRN2	Prosenice	220 kV
CHT2	Chotějovice	220 kV
CST2	Čechy Sřfed	220 kV
HRA2	Hradec	220 kV
LIS2	Lískovec	220 kV

TABLE II.
DEMONSTRATION OF A PART OF THE DATABASE (PARAMETERS OF THE LINE)

Number line	I_{\max} [A]	Length [km]	R [Ω]	X [Ω]	B [μS]
V400	1740	46,221	1,39	14,1	173
V401	1740	103,816	3,12	31,68	375
V402	1740	87,571	2,57	26,5	354
V403	1740	79,416	2,28	23,87	280

TABLE III.
A PART OF DATABASE FOR MEASUREMENT OF ACTIVE ENERGY AND REACTIVE POWER AT A CHOSEN LINE

Time	Hour	cALB4:V443:P	cALB4:V443:Q
		[MW]	[Mvar]
1.3.2009	0:00:00	125,69	6,6
1.3.2009	0:15:00	152,17	2,57
1.3.2009	0:30:00	163,06	2,54
1.3.2009	0:45:00	155,47	3,68
1.3.2009	1:00:00	160,24	2,39

4. PROGRAM „LOSSES OF THE TRANSMISSION NETWORK SYSTEM LINE”

Software works in the program MS Visual Basic Professional. There is possible to create graphs very easy and quickly. It supports all used program technologies, it contains modules for the work with MS files and it is fully functioning in all operating systems of the Microsoft Company. The conception was chosen for intuitive work with it. Individual steps are logically connected and their

number is minimized. It is optimized from the point of view of calculations and loading input databases. The program enables displaying results in tabs and graphs. The demonstration of the output is in Fig. 7. Results are possible to save and print for the following work.

4.1 Description of the program for calculation of technical losses

Program runs according the block diagram in Fig. 3. In the start of the work there is necessary to upload all essential input databases in menu File – see Fig. 4. There are possibilities of uploading individual databases. The demonstration of the file of these databases is in Fig. 4. An order of databases is in Fig. 5.

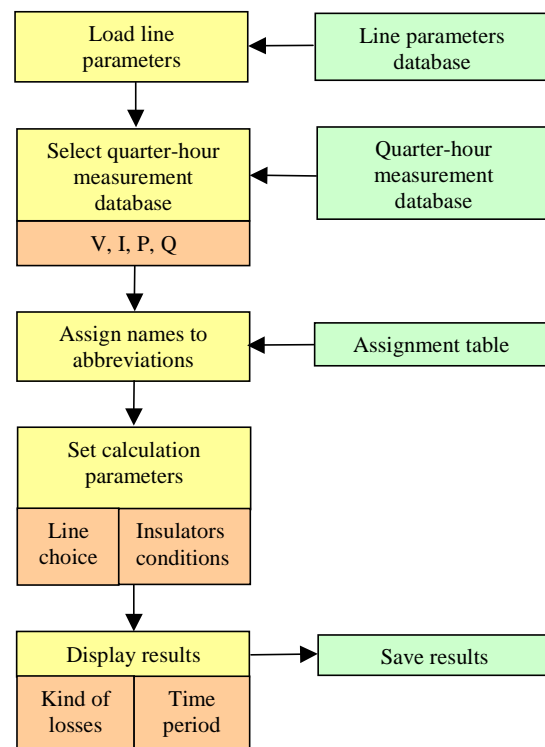


Fig. 3: A block diagram for running of the program “Losses of the transmission network system line”

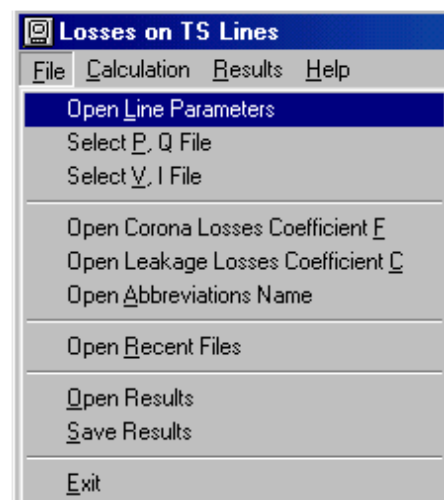


Fig. 4: Menu “File” for the choice of databases

Upload of databases:

- parameters of the line
- 15 minutes samples P, Q, U, I
- coefficients F_u , c , k_{kor}
- abbreviations of distributing centres

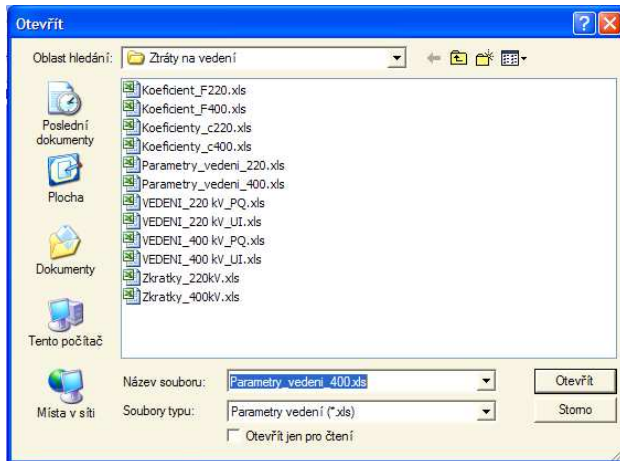


Fig. 5: Screen of the program for uploading of databases

In the beginning the databases of parameters are uploaded. The tabs with 15 minutes samples are matched with the databases. The names of distributing centres are matched with the abbreviations of lines and also the coefficients c and F_u are uploaded. The names of opened files are saved in the register of the system Windows. For the acceleration of all essential files there is possible to use an option "Načti vše z naposledy otevřených souborů" (Upload all from the last opened files).

The concrete line and corresponding state of pollution of insulators are chosen before calculation. The choice of relevant line is stated in the demonstration of the 400 kV line signed V435 and by the choice of the state of pollution of insulators, see Fig. 6.

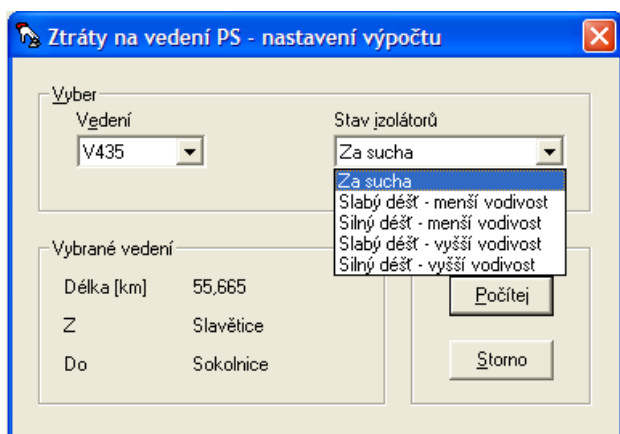


Fig. 6: Demonstration - the choice of the line and the state of pollution of insulators

Legend:

- choice of the line
- choice of the insulator states

Choice of the type of losses for evaluation:

- Joule losses
- corona losses
- leakage losses
- display of results
- saving of results

4.2 Program control for calculation of technical losses

It is possible to display results in a graph and in a tab – see Fig. 7. as first the whole time period from the set of 15 minutes samples is displayed. It is possible to enlarge it and analyse it in detail. Next switch enables to select which one of technical losses to display. Another choice is to re-calculate results per kilometre of the line length. The last switch displays results in neutral 1 or 2 or their average value. The graph is possible to print. If we want to repeat calculation for another line there is not necessary to upload all input databases but we just choose a required line and let run the calculation. This process can be applied at all lines in the database. The results of each calculation can be saved in menu "File". The file with results contains all calculated technical losses in both neutrals and their average. The part of the file is a list where all parameters that were used in calculation are. Software enables to calculate technical losses of the whole distributing system if we have a database of essential parameters (lines, voltage, current, active power, reactive power). Calculated values of technical losses can serve for another processing in administration of electric network and for evaluation and preparation of the process, for control service or another activity in the transmission network system. Software was authorized and now there are preparations made for its next expansion and possibilities of use in practice.

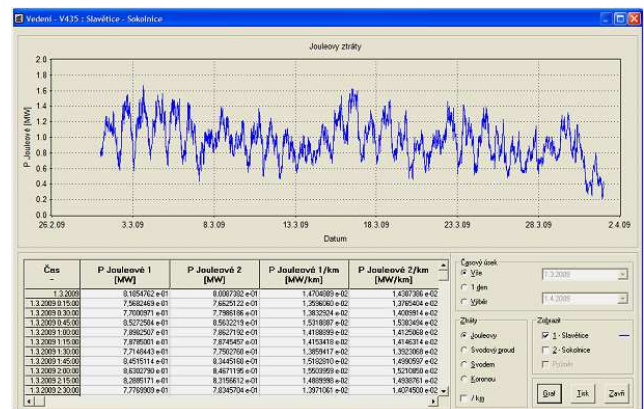


Fig. 7: Demonstration of the result – calculation of Joule losses of the line 400kV number V435

5. PROGRAM "LOSSES OF THE TRANSMISSION NETWORK SYSTEM LINE" AND ITS USE IN EDUCATION AND TECHNICAL PRACTICE

At present we speak about the use of information technologies in education and in technical practice. Connection of IT and practice is ideal for the application and use of software. Possibility of this special software using leads students to a bigger imagination of operation of transmission networks system lines and the magnitude of

changing losses of lines. In the subject Electro-energetics students are informed about the theory of transmission networks and their operation. Students can choose in computer lines, technical losses by themselves and evaluate them by graphs. The best solution is cooperation of ČEPS, plc. with a university when using this software. This software was made in cooperation of the University of Ostrava and the VŠB - Technical University of Ostrava. The opening panel is in Fig. 1. The calculated losses were compared to measured values in the beginning of testing a program creation. Empiric formulas were simplified for the need of software. Some results and calculations of individual types of technical losses are stated in a literature [5].

6. CONCLUSION

The paper deals with using of applied software for calculations of technical losses of a transmission network system line in the Czech Republic. The program software was created in the environment of MS Visual Basic and input data are in a form of MS Excel. The program solves Joule losses, corona losses and leakage losses. The way of uploading the chosen line is demonstrated in Fig. 6. Software was applied in the real database in the control system of ČEPS, plc. and results are used in practice. There are statistic databases that are imported from the control system. During the final evaluation of software using in practice and in education there is possible to tell that no software can work without input data. In case of good cooperation of schools and industrial companies there is no problem and the solution is suitable as for school as for the company.

Every kind of software needs to be updated. Modernization of software means implementation of more functions and elimination of possible mistakes during processing. These requirements can be fulfilled in the best if there is some cooperation between a school and a company. This cooperation leads teachers and students to better knowledge of practical and real results. The students can imagine how losses are changeable during various transmission magnitudes in lines. At the end we can claim that high-quality software enables quick gaining results for other processing in practice. These results can indicate failures – that could be electric devices that are in connection with electric network operation. The exchange and the repair of diagnosed devices lead to cost savings because there are reduced technical losses. Applied software is a big benefit for the technical practice.

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