PREFACE

A design represents each process by which a goal or group of goals is reached. The realization of a design is inconceivable without the use of a computer. Computer-Aided Design in Power Engineering represents a vital engineering discipline which has been studied at the Faculty of Electrical Engineering at the University of Belgrade for nearly two decades. The use of computers in power engineering is elaborated upon through the aspects of calculation, development of technical documentation and project management.

Within the reformed studies at the Faculty of Electrical Engineering at the University of Belgrade, the aspects of design and application of software tools are taught within the basic studies of the Power Systems Department in the courses *Computer-Aided Design in Power Engineering*, *Workshop for Software Tools in Power Engineering* and *Computer-Aided Design in Power Engineering Project*, or within the power systems doctoral studies program in the course, *The Application of Software Tools in Power Engineering.*

A continuation of the previously realized monographic work – "Computer-Aided Design in Power Engineering – Software Tools" is the monographic work "Computer-Aided Design in Power Engineering – Application of Software Tools". This work relates to the application of existing and independently developed software tools in solving a series of problems from the field of designing power engineering structures and systems. The material is presented in four chapters.

The first chapter relates to computer-aided modeling and simulation in power engineering. The complex problems from the mentioned area are displayed in an original and illustrative manner. By working through eleven original examples, the reader is led through all the phases necessary in the procedures of computer-aided modeling and simulation. The concepts of computer-aided modeling and simulation are explained in the practical design examples along with the methods for model development, the principles of carrying out computer-aided simulation and the possible limitations. The entire procedure is shown in a concise way, step by step, from the formulation and analysis of the engineering problem, to the formation of the mathematical model, selection of computer methods, formation of the program and execution

of the simulation. Special attention is given to the reasons for possible errors in calculations.

With consideration of fact that engineers from the field of power systems often develop software tools in practice, the required documentation which a software tool must contain has been displayed along with the procedure for its testing. This chapter displays a software tool for the analysis of grounding systems during the effects of impulse current as an example of a software tool with all the necessary characteristics to make it user friendly. This software tool was created using the MATLAB® technical computing software and the program Visual C++.

Calculations represent an integral part of the design and are necessary for the selection and verification of the characteristics of power engineering equipment. The application of software tools in power engineering calculations is elaborated upon in the second chapter. The most significant programs used today in power engineering calculations have been singled out from the multitude of what is available. These programs are organized into four sections: MATLAB®, EMTP/ATP, MS Excel & MS Access and AutoCAD.

The first section elaborates upon MATLAB® which represents a software tool for solving mathematical problems, analysis of data and visualizations. This technical computing software dominates in university centers, scientific research institutions and design firms throughout the entire world and is useful in solving a multitude of engineering problems. The application of this software tool is illustrated through three examples from the engineering practice. In the first example, the characteristic values of the fault current, necessary for equipment selection, have been calculated using the additional Simulink® software. The application of this software is displayed on a part of an equivalent circuit of a power system. The obtained results are discussed and compared with the results obtained from the application of the classic procedure of calculation. The second example displays the independently developed software tool SPLCAD (Software Power Line Computer-Aided Design) for designing medium-voltage overhead lines. The tool was developed using the MATLAB® technical computing software as the development platform for creating the user interface. Creating and working with databases was achieved using software tools MS Access and MS Excel. The third example presents a Simulink® model of the turbine regulator within the "Kokin Brod" hydroelectric power plant. A section of the comparative analysis of the numerically and experimentally determined results for the elaborated turbine regulator is presented.

Problems during the designing of power systems and problems related to the planning and exploitation of power systems are often solved through the application of the software tool EMTP (Electromagnetic Transient Program) / ATP (Alternative Transient Program), which is described in the second section of the second chapter. The use of the software tool ATP is illustrated in the examples of calculation of transient phenomena in metal-enclosed SF_6 gas insulated switchgears (GIS). The first example relates to the numerically and experimentally determined electromagnetic transient processes in the secondary circuits of the measurement transformers of the 123 kV three-phase enclosed, SF_6 GIS Karlsruhe-Oberwald. The second example illustrates the procedure for calculating the increase of potential of the metal enclosure of the 420 kV single-phase enclosed, SF_6 GIS within the "Višegrad" hydroelectric power plant.

The third section of the second chapter explains the use of the software tools MS Excel and MS Access and contains three parts. In the first part of the third section, some possibilities for the use of databases in the design of high-voltage substations are displayed. The characteristic values of the fault current, as an integral part of the criteria for the selection of high-voltage equipment, have been calculated using the programming languages Visual Basic for Applications (VBA) and Visual Basic (VB). Different types of databases with elements of high-voltage equipment have been developed using the software tools MS Excel and MS Access. The basic principles of the architecture of databases and formation of filtering criteria are discussed based on the use of the program MS Query and VBA. The main elements for the proper creation of relational databases in MS Access are also illustrated. The use of databases is presented in the examples of selection of high-voltage circuit breakers and disconnectors.

Modern design in power engineering entails the automation of calculations through the use of macros. In the second part of the third section, the procedure for forming a macro as a VBA procedure is presented. The use of macros is illustrated in the examples of calculation of the total electricity and thermal impulse of injected impulse current into the tested structure and the automation of work with databases. In the third part of the third section, the use of the Microsoft Office software package in the design of a power supply for the telecommunications equipment of a control-commutation center is demonstrated. The technical calculations and corresponding selection of the aforementioned devices were completely automated using MS Excel and VB, which is

illustrated in the examples of the selection of accumulator batteries and rectifiers.

The fourth section of the second chapter is dedicated to AutoCAD as a powerful software tool for computer-aided design. This section presents some of the aspects of advanced use of AutoCAD in computer-aided design of power system substations and structures. The first example illustrates an effective technique of 3D modeling of some of the most complex structures, such as a turbogenerator. The calculation of the physical characteristics of a 3D model is executed in the example of the inertia moment of a U-profile busbar. The developed software tool for designing lightning protection for general and special purpose structures was realized using the programs AutoLISP, Visual LISP and VBA. By using this software tool, calculations were made for the zone of protection from lightning discharge for a residential structure, special purpose structure, substation and overhead line.

The graphical documentation represents an integral part of the design. The application of software tools in the development of graphical documentation is the subject of the third chapter. The most frequently used types of electrical diagrams are described along with examples of how they are formed. Electrotechnical graphic symbols and markings of devices and connections in installations are presented. The application of the software tool AutoCAD, as the basic tool for development of graphical documentation in power engineering, is clearly presented in the examples of the different types of electrical diagrams of a concrete transformer station. The elements of the program EPLAN, which enables the efficient formation of wiring diagrams and connection diagrams, are also considered. Application of the version R.6.1 of the program SIMARIS SIVACON for design and installation of 8PT SIEMENS SIVACON low-voltage switchgear is displayed in the example of a transformer station with a single-pole diagram created using the program SIMARIS DESIGN.

In that way the collection of software tools which enable the complete automation of the development of graphical documentation of a power engineering design is presented, through which efficiency in work is greatly increased.

In the fourth chapter, the application of software tools within project management in power engineering is discussed. In the first section, the basic elements of a design and the participants in its realization are analyzed. In the second section, the basics of project management are presented, while in the third section examples are presented which

illustrate the management of a concrete design of technological development through the application of the software tools MS Excel and MS Project.

Literature is provided in each chapter. A list of abbreviations and index of key words are provided at the end of the monographic work.

This monographic work has an educative, engineering and scientific aspect. Considering that it contains a series of examples from the direct application of software tools in the practice of design in the field of power engineering, the monographic work may be of some benefit to experts who are involved in power engineering design. The educative and scientific aspects have been confirmed by the publishing of a large number of works in journals from various categories, as well as at conferences. For that reason, the material is also intended as an educational resource in the area of design of power systems and structures for all levels of study.

Dr. Zlatan Stojković, Full Professor

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Stojkovic, Z.
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