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ELECTRICAL ENERGY DISTRIBUTION

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ELECTRICAL ENERGY DISTRIBUTION

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PREFACE

Electrical energy distribution in regulated and de-regulated power utility presents a particular technical and organizational part of the chain between the supplier and the consumer of electrical energy. The particularity of power distribution companies, compared to other parts of the power utility is in direct contracting relationship with qualified tariff consumers and in the necessity of considering the Law of large numbers upon deciding about technical solutions and characteristics of the electrical distribution system elements.

The basic concepts of the book are theoretical explanations for concrete technical solutions for all areas of electrical energy distribution that are mostly based on many decade positive experiences for exploitation of distribution systems in Serbia. Therefore, the book is dedicated to all engineers dealing in various ways with electrical energy distribution as well as to power engineering students.

The author have classified the electrical energy distribution subjects into nine chapters.

Chapter one presents the historical development and position of power distribution company in traditionally regulated power utility, some important aspects of technology development, functions and organization forms of de-regulated power utility, as well as the basic technical requirements for joint operation of generation, transmission and electrical distribution systems.

Chapter two treats symmetrical and asymmetrical short circuits in distribution system, criteria for sizing of the distribution transformer substation (TS) grounding system and fulfilling of safety conditions inside and outside TS, overhead line pole grounding, as well as the specific issues concerning cable and overhead line contribution to TS grounding system.

Chapter three deals with concept solutions for all types of distribution TS stressing the neutral point earthing, lightning and commutation overvoltages, as well as the insulation coordination. The special place in this chapter is taken by: standardization of basic characteristics of power distribution transformers (ET) of all transformation ratios, as well as by the relay protection of lines and power transformers (ET). At the end of this chapter the detailed description of TS 110/X kV, TS 35/10 kV and TS X/0, 4 kV stations standardized in ED Serbia is given.

Chapter four gives the selection of power cables that are used in 1 kV, 10 kV, 20 kV and 35 kV distribution systems, technical solutions for cable laying, including approaching to and crossing with other objects. Particularly are considered: thermal processes in cable in normal operation and in short circuit, testing of power cables and accessories, as well as the occurrence of circulation currents in electrical protections of single core cables in normal operation.

Chapter five deals with the issues of design and building of overhead lines made of aluminium conductors steel reinforced (ACSR), covered conductors (CC) or aerial bundle conductors (ABC), also it deals with the problem of telecommunication cable

installation on overhead line poles. Particular attention is given to the mechanical calculation of overhead line: calculation of sags, permissible conductor distances and safety altitudes, forces, selection of concrete pole foundation - the specific user programs are developed for these calculations. Practical guidelines are given for the foundation of poles and installation (tensioning) of conductors, as well as the requirements concerning approaching and crossing of overhead line with other objects. Thermal calculation of overhead line is specially given for normal and short circuit operation, as well as the testing of overhead line elements.

Chapter six presents consumer categories and consumers groups, it deals with the calculation of consumers peak load, particularly in household category. The connection of consumers to the grid is given in more details (the realization of the connection, standardization of metering cabinets, metering of electrical energy, load management). Due to exceptional importance, in this chapter the protection of connection and electrical installations of residential buildings from unpermitted loads, indirect touch and lightning overvoltages are given in detail.

Chapter seven deals with the quality of service to the customers, quality of the supply and quality of delivered electrical energy (frequency, magnitude and wave shape of the voltage). Within the consideration of distribution system reliability the reliability indexes and indexes of damage due to interruption of electrical energy supply are given.

Chapter eight deals with electrical distribution system development planning. The classification of development plans is given, the necessary data and bases for making the development studies and plans, technical and economy criteria for the conception of distribution system are given, certain methods for the forecast of needs for electrical power and energy are presented as well as the principles for the shaping of distribution grid.

Chapter nine gives the conceptual solutions and technical requirements for the connection of small generating sources, with the special emphasis on application of renewable electrical energy sources (Sun, wind, water and biomass). The required technical criteria (maximum permissible power, flickers, higher harmonics) that should be fulfilled for the connection of small generating sources to the grid are given in detail.

Chapters **2**, **4** and **8** were prepared by Miladin Tanasković, and chapters **3**, **5** and **9** by Tomislav Bojković. The same authors have prepared together the Chapters **1** and **6**. Dragoslav Perić has prepared the Chapter **7**.

For the efforts in doing many calculations for Chapter 2, the author Miladin Tanasković thanks to Mr. Vladimir Balkovoj. Also, the authors Tomislav Bojković and Miladin Tanasković thank to Mr. Dragan Tasić for numerical determination of coefficients for the calculation of current load of overhead lines carried out with ACSR conductors, CC and SKS.

On this occasion authors would like to thank to the reviewers Prof. dr Jovan Nahman and Prof. dr Dragan Tasić on their efforts and useful suggestions.

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COMMENT ON THE BOOK:

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The authors of the book are experienced professionals involved in the various aspects of distribution system planning, exploitation and maintenance. During their permanent activities in this area lasting more than a decade they have considerably contributed to many technical solutions and technical normative in this field.

Among other important issues the book treats in depth the grounding of distribution systems and corresponding safety conditions by taking into account the effects of the underground cables as ground electrodes and/or ties connecting various installations building a grounding system. A special chapter is devoted to a detailed description of transformer stations coupling 110 kV, 35 kV, 10 kV and 0.4 kV networks with specified technical solutions concerning the apparatus implemented, protection and control devices and systems applied. Two chapters consider the methods of selection of the conductor sizes and types of cables and overhead lines with regard to their electrical, thermal and mechanical properties including the overvoltage protection. In a separate chapter are considered the methods for planning the peak loads of different types of consumers, ways of measuring the load consumed and low voltage installations in consumer buildings. The quality of supply is discussed including the availability aspects and the cost of the energy not delivered due to failures, based upon a comprehensive survey conducted among the consumers in authors' country. A chapter is devoted to the issues associated with planning of distribution systems of various types and voltage levels including technical and economy aspects. The last chapter discusses the technical aspects of distributed generation with detailed presentation of recommendable solutions and constructive and operational constraints concerning both the distribution network and the small generating sources.

The book considers in a detailed way various aspects of the planning and operation of nowadays distribution systems in the range from 0.4 kV up to 110 kV and presents good technical solutions based not only upon the theoretical work but also upon the practical experience acquired during a long period. As such, the book could be of interest for those that are involved in management, planning and operation of distribution and industrial electrical power systems as well as for students of associated faculties.

Belgrade, 02.09.2008

Prof. Dr. Jovan Nahman, Dipl.Eng.

