

УДК 621.315.1

К 78

Рецензенты:

д-р техн. наук, доцент *A. Г. Русина*

д-р техн. наук, профессор *B. Г. Сальников*

Красильникова Т. Г.

К 78 Технико-экономические вопросы дальних электропередач переменного тока : монография / Т. Г. Красильникова, Г. И. Самородов. – Новосибирск : Изд-во НГТУ, 2021. – 331 с. – (Монографии НГТУ).

ISBN 978-5-7782-4539-6

В книге рассмотрен широкий круг вопросов, таких как надежность дальних электропередач и пути ее повышения, оптимизация конструктивных параметров и минимизация потерь мощности в линиях сверхвысокого напряжения, экологическое и техногенное воздействие дальних линий. Вниманию читателя представлены перспективы развития дальних электропередач.

Книга может представлять интерес для специалистов в области разработки, проектирования и эксплуатации дальних электропередач СВН, студентов, аспирантов и преподавателей электроэнергетических специальностей.

УДК 621.315.1

ISBN 978-5-7782-4539-6

© Красильникова Т. Г.,
Самородов Г. И., 2021

© Новосибирский государственный
технический университет, 2021

УДК 621.315.1

К 78

Reviewers:

Associate professor A.G. Rusina, D.Sc. (Eng.)
Professor V.G. Salnikov, D.Sc. (Eng.)

Krasilnikova T. G.

К 78 Technical and economic issues of long-distance power transmission : monograph / T. G. Krasilnikova, G. I. Samorodov. – Novosibirsk : NSTU Publisher, 2021. – 331p. – (NSTU Monographs).

ISBN 978-5-7782-4539-6

The book discusses a wide range of issues such as the reliability of long-distance power transmission and ways to improve it, optimization of design parameters and minimization of power losses in ultra-high voltage lines, as well as environmental and man-made effects of long-distance lines. The reader is presented with the prospects for the development of long-distance power transmission.

The book may be of interest to specialists in the field of development, design and operation of long-distance power transmission lines, as well as to teachers, students, and postgraduates majoring in electric power engineering.

УДК 621.315.1

ISBN 978-5-7782-4539-6

© Krasilnikova T.G., Samorodov G.I., 2021

© Novosibirsk State
Technical University, 2021

CONTENS

Preface	7
CHAPTER 1. RELIABILITY OF LONG-DISTANCE POWER TRANSMISSION AND WAYS TO IMPROVE IT	9
1.1. General analysis of reliability indicators	9
1.2. Ways to ensure the reliability of EHV and UHV power transmission	16
1.2.1. General provisions.....	16
1.2.2. Double-circuit lines	18
1.2.3. SPAR as an effective way to increase reliability	19
1.2.4. Application of two-phase modes	20
1.2.5. The use of redundant phase lines.....	22
1.2.6. Four-phase power transmission	23
1.2.7. Lines with parallel semi-phases.....	24
1.3. A criterion for assessing the level of operational reliability.....	25
1.3.1. A probabilistic criterion of operational reliability in the sim- plest case	26
1.3.2. A probabilistic criterion of operational reliability with due regard for changes in power transmission loads.....	30
1.3.3. A probabilistic criterion of operational reliability in general for the network	32
1.4. A criterion for assessing the level of adequacy reliability.....	37
1.4.1. Calculation of reliability of a concentrated power system.....	37
1.4.2. An effect of power transmission accidents on the indicators of power system reliability	44
1.4.3. Regard for the accident rate of various types of power transmission in their comparative analysis	46
1.5. SPAR and characteristic features of its implementation in EHV lines	47
1.5.1. General provisions.....	47
1.5.2. Analysis of HV and SAC under ideal transposition.....	50



1.6. SPAR in transposed OH lines using four-beam reactors.....	55
1.6.1. General provisions.....	55
1.6.2. An algorithm for determining HV and SAC in lines with real transposition	56
1.6.3. HV and SAC analysis under real transposition.....	63
1.7. SPAR in transposed HV lines using automatic phase bypass	74
1.7.1. General provisions.....	74
1.7.2. An algorithm for determining HV and SAC in lines with real transposition	76
1.7.3. HV and SAC analysis under real transposition of lines.....	77
1.8. Characteristic features of SPAR implementation in nontransposed lines	81
1.8.1. General provisions.....	81
1.8.2. An algorithm for determining HV and SAC in nontransposed lines	81
1.8.3. HV and SAC analysis.....	85
1.9. Improvement of adaptive SPAR.....	88
1.9.1. General provisions.....	88
1.9.2. An intermediate system scheme	90
1.9.3. A scheme that includes a line connecting a station and a power system or two power systems	92
CHAPTER 2.PERFORMANCE INDICATORS.....	95
2.1. A criterion of economic performance of PT versions	95
2.2. Cost indicators of the main power transmission units	101
2.2.1. Cost indicators of OH lines	101
2.2.2. Cost indicators of substations	105
2.2.3. Cost indicators of reactive power units.....	108
2.3. Power and electrical energy losses.....	108
2.3.1. Heating losses.....	110
2.3.2. Corona losses.....	113
2.3.3. Total losses of electrical energy in LDT.....	118
2.4. The main technical and economic tasks to be solved as applied to LDT	118
2.4.1. Optimization of the line design parameters	118



2.4.2. Selection of an optimal scheme and parameters of long-distance power transmission with a given transmission capacity	134
2.4.3. Minimization of active power losses in EHV lines	156
2.4.4. Optimization of adequacy reliability when combining two power systems	168
2.4.5. Comparison of LDT and DCT	186
CHAPTER 3. ENVIRONMENTAL ASPECTS OF EHV AND UHV POWER TRANSMISSION.....	193
3.1. General provisions.....	193
3.2. Classification of the power transmission effect on the environment.....	195
3.3. Land transfer and land use constraint.....	196
3.4. Requirements for the aesthetic perception of power transmission	201
3.5. An electric field effect.....	205
3.5.1. A regulatory framework for the electric field	205
3.5.2. Assessment of electric fields in the OH line passage zone	206
3.6. Magnetic field effect	215
3.7. Corona discharge effect on the environment.....	222
3.7.1. Radio interference from OH lines.....	222
3.7.2. TV interference.....	225
3.7.3. Acoustic noise	228
3.8. Effect of power transmission lines on wire lines.....	230
CHAPTER 4. PROSPECTS FOR LDT DEVELOPMENT.....	233
4.1. Three-phase power transmission	234
4.1.1. PT over conventional ultra-high voltage overhead lines (UHF).....	235
4.1.2. PT over compact overhead lines.....	238
4.1.3. PT with a backup phase of the OH line	243
4.1.4 PT with parallel semi-phase OH.....	246
4.1.5. PT with combined compensation of the capacity parameters of overhead lines.....	247
4.1.6. Adaptive power transmission (FACTS)	249
4.2. Nonconventional AC power transmission.....	256
4.2.1. Six-phase PT.....	257
4.2.2. PT with controlled self-compensating overhead lines	261
4.2.3. Four-phase PT	265



4.3. DC transmission	270
4.4. Exotic power transmission	277
4.4.1. Wireless power transmission	278
4.4.2. Gas power transmission	288
4.4.3. Cryogenic power transmission	290
4.4.4. Resonant single-wire power transmission	292
4.5. Ultra-long distance PT	294
4.5.1. General characteristics of the problem of ultra-long-distance power transmission.....	294
4.5.2. Ultra-long-distance half-wave power transmission	299
4.5.3. Comparison of reliability and performance indicators of HWT and DCT	303
References.....	313