

CONTENTS

LIST OF IMPORTANT SYMBOLS.....	7
1. INTRODUCTION	9
2. POWER BALANCE UNDER NORMAL AND EMERGENCY CONDITIONS .	12
2.1. Data preparation	12
2.2. Calculation of power flows under normal conditions	14
2.3. Calculation of power flows under emergency conditions.....	16
2.4. Calculations of power flows including losses in transformers and power lines	19
2.5. Power flow calculations using computer programs	20
3. SELECTION OF POWER TRANSFORMERS	24
3.1. Selection of transformers in 400/110 kV/kV substations	26
3.2. Selection of transformers in 400/220 kV/kV substations	28
3.3. Determination of power losses in transformers	28
4. SELECTION OF OVERHEAD POWER LINES	29
4.1. Basic criteria for power line selection.....	29
4.1.1. Long-term capacity criterion	29
4.1.2. Corona criterion	31
4.1.3. Economic current density criterion	32
4.2. Unification criterion and summary of power line selection	33
4.3. Calculation of line equivalent parameters	35
5. FAULT CALCULATIONS	39
5.1. Model parameterization and simulative calculations	40
5.1.1. Short-circuit calculations in OeS program	43
5.1.2. Development of fault calculations results	47
5.2. Checking the line conductor cross-section for short-circuit strength	47
5.3. Calculations of fault transients	50
5.3.1. Remarks for sources modeling	54
5.3.2. Remarks for power transformers modeling	55
5.3.3. Remarks for overhead power lines modeling	55
5.3.4. Faults simulations in PSCAD/EMTDC	57

6. GENERAL CHARACTERISTICS OF PROTECTION AND AUTOMATION SYSTEMS	64
6.1. Generator – transformer protection	65
6.2. Transformer protection	69
6.3. Busbar protection in HV and EHV substations	72
6.4. HV and EHV lines protection	73
6.5. General remarks for automation systems	76
7. PROTECTION SCHEME DESIGN – CHOSEN ISSUES	78
7.1. Selection of current transformers	78
7.2. Selection of voltage transformers.....	85
7.3. Selection of circuit breakers and disconnectors	86
7.4. Calculation of settings for chosen protective criteria	88
7.4.1. Transformer protection settings	89
7.4.2. Transmission line protection settings.....	95
7.4.3. Fault resistance consideration	104
7.4.4. HV cable and overhead-cable line protection	105
7.4.5. Examples of distance protection settings calculation	110
8. FINAL REMARKS	118
8.1. Computation results elaboration.....	118
8.2. Summary	121
BIBLIOGRAPHY	123
APPENDICES	130
Abstract	151