

Contents

Introduction	1
1. Unbalance in three-phase systems.....	2
1.1 Unbalance calculations	2
Example 1.1.1.....	3
Example 1.1.2.....	4
Example 1.1.3.....	5
Example 1.1.4.....	7
Example 1.1.5.....	7
Example 1.1.6.....	7
Example 1.1.8.....	8
Example 1.1.9.....	8
Example 1.1.10.....	11
Example 1.1.11.....	11
1.2 Powers in unbalance loaded lines.....	11
Example 1.2.1.....	12
Example 1.2.2.....	14
Example 1.2.3.....	14
Example 1.2.4.....	16
1.3 Symmetrization of unbalance load	16
Example 1.3.1.....	17
Example 1.3.2.....	19
2. Power factor compensation.....	20
2.1 Series compensation	20
Example 2.1.1	20
2.2 Parallel compensation.....	22
Example 2.2.1	22
Example 2.2.2.....	24
Example 2.2.3.....	24
Example 2.2.4.....	26
2.3 Protected compensation devices.....	28
Example 2.3.1	30
Example 2.3.2.....	31
Example 2.3.3.....	34
Example 2.3.4.....	36
Example 2.3.5.....	38
Example 2.3.7.....	39
3. Harmonics components	41
3.1 Fundamental definitions	41
Example 3.1.1	42
Example 3.1.2.....	43
Example 3.1.3.....	43
3.2 Harmonics in industrial network	46

Example 3.2.1.....	46
Example 3.2.2.....	50
Example 3.2.3.....	50
Example 3.2.4.....	52
Example 3.2.5.....	53
Example 3.2.7.....	56
Example 3.2.8.....	58
Example 3.2.9.....	58
Example 3.2.10.....	59
4. Flicker-effect	63
Example 4.1.....	63
5. Laboratory Measurements.....	71
5.1 Power Factor Compensation.....	72
Measurement 5.1.1 Power Factor Compensation of an Induction Motor.....	72
Measurement 5.1.2 Power Factor Compensation of an ASM on 22 kV Power Line Model	74
5.2 Harmonic Components of Current and Voltage	76
Measurement 5.2.1 Measurement of Harmonics Caused by Various Types of Lighting sources.	76
Measurement 5.2.2 Operation of Digital Protection with Respect to Distortion of the Drawn Current.....	78
Measurement 5.2.3 Measurement of Harmonic Flow on 22 kV Power Line Model for Various Operating States of a 3-phase Diode Rectifier	78
Measurement 5.2.4 Measurement of Harmonic Flow on 22 kV Power Line Model	80
5.3 Voltage sags.....	83
Measurement 5.3.1 Voltage Sags and their Spread on 22 kV Power Line Model	83
Measurement 5.3.2 Measurement of the Device's Resistance to Voltage Sags.....	84
References	87