

CONTENTS

LIST OF SYMBOLS	6
I MECHANICAL PROPERTIES OF ELECTRIC DRIVES	7
1.1 Definition of electric drive.....	7
1.2 Motion equation	8
1.3 Mechanical characteristics of load.....	10
1.4 Mechanical characteristics of motors	12
1.5 Relationship of motor mechanical characteristics and load.....	14
2 LOSSES, THERMAL PROPERTIES AND DIMENSIONING OF ELECTRIC MOTORS	17
2.1 Losses and efficiency of electric motors.....	17
2.2 Dimensioning and thermal properties of electric motors.....	18
2.3 Methods of thermal equivalence.....	20
3 EXTERNALLY EXCITED ELECTRIC DRIVES WITH DC MOTORS	24
3.1 Use, principle and construction of DC machines.....	24
3.2 Properties of externally excited DC motors	27
3.3 Starting of externally excited drives with DC motors	30
3.3.1 Starting by inserting ballast resistance in rotor.....	30
3.3.2 Starting with reduced rotor voltage	31
3.4 Braking of externally excited DC motors	31
3.4.1 Regenerative braking	31
3.4.2 Resistance braking.....	32
3.4.3 Counter-current braking	32
3.5 Reversal of externally excited DC motors	33
3.6 Controlling drives with externally excited DC motors.....	33
3.6.1 Controlling by inserting ballast resistance.....	33
3.6.2 Controlling by rotor voltage change.....	33
3.6.3 Controlling by magnetic flux change.....	34
4 ELECTRIC DRIVES WITH DC AND AC COMMUTATOR SERIES MOTORS	36
4.1 Use and properties of DC series motors.....	36
4.2 Starting drives with DC series motors	37
4.2.1 Starting by inserting ballast resistance.....	38
4.2.2 Starting with reduced voltage.....	38
4.3 Braking of DC series motors.....	38
4.3.1 Regenerative braking	38
4.3.2 Resistance braking.....	39
4.3.3 Counter-current braking	39
4.4 Reversing speed of DC series motors	40
4.5 Controlling drives with DC series motors	40

4.5.1	Controlling by inserting ballast resistance	40
4.5.2	Controlling speed by supply voltage change	40
4.5.3	Controlling speed by field weakening	41
4.6	Advantages of DC series motors for traction.....	42
4.7	Drives with single-phase commutator series motors.....	43
5	DRIVES WITH ASYNCHRONOUS MOTORS	46
5.1	Rotating magnetic field	46
5.2	Use, construction and principle of function of asynchronous motors	48
5.3	Properties of asynchronous motors in steady state	52
5.3.1	Alternative diagram of an asynchronous motor.....	52
5.3.2	Power balance and mechanical properties of asynchronous motors.....	53
5.4	Starting of asynchronous motors.....	56
5.4.1	Starting of asynchronous motors by direct connection to network.....	56
5.4.2	Starting with reduced voltage	57
5.4.3	Starting with variable supply frequency	58
5.5	Braking of drives with asynchronous motors	58
5.5.1	Generating braking	58
5.5.2	Counter-current braking	58
5.5.3	Direct current braking.....	58
5.6	Reversing and controlling of drives with asynchronous motors.....	59
5.6.1	Controlling by supply voltage change	59
5.6.2	Controlling by supply frequency change	60
6	DRIVES WITH SYNCHRONOUS MOTORS	64
6.1	Classification and use of synchronous machines.....	64
6.2	The principle of functioning and basic properties of synchronous machines	64
6.3	Construction of synchronous machines with permanent magnets	68
6.4	Comparing synchronous motors with other drive units	70
6.5	Starting, braking and controlling synchronous motors with permanent magnets	71
7	INTRODUCTION TO CONVERTER TECHNOLOGY	73
7.1	Power semiconductor converters.....	73
7.2	Overview of power semiconductor components	74
7.2.1	Power diodes.....	74
7.2.2	Power thyristors	75
7.2.3	Power unipolar transistors.....	76
7.2.4	GTO.....	77
7.2.5	IGCT	78
7.2.6	IGBT.....	78
7.2.7	Losses and cooling of power semiconductor components	78
7.3	Choppers.....	81
7.4	Three-phase inverters	86
7.5	Pulse-width modulation of inverters.....	88
7.6	Indirect frequency converters	90
7.7	Compatible rectifiers	91

8	COMMENTS ON SOLVING ELECTRICAL CIRCUITS	93
8.1	Basic electrical quantities.....	93
8.2	Circuits with harmonics of current and voltage	94
8.3	Magnetic quantities.....	96
8.4	Basic relationships between magnetic and electrical quantities	97
8.5	Electrical power	98