Contents

Preface v

Notation system vii

1. Fundamentals of Energy Conversion

   1.1. Power and Energy Flow 1

   1.2. Representation of Sinusoidal Signals by means of Complex Numbers 5

   1.3. Apparent, Active and Reactive Power 8

   1.4. Equivalent RL Circuit 12

2. Electromagnetic Fields and Forces

   2.1. Governing Equations 15

   2.2. Magnetic Properties of Materials 17

   2.3. Integral Identities in Electromagnetism 21

   2.4. Magnetic Energy Stored and Permanent Magnets 24

   2.5. Magnetic Forces 28

3. Transformers

   3.1. Ideal Transformer - Principle of Operation 33

   3.2. Power Losses 40

   3.3. Transformer Ratings 47

   3.4. Autotransformer 49

   3.5. Three-phase Transformers 51

4. DC Machines

   4.1. Ideal DC Machine - Principle of Operation 61

   4.2. Commutator Machines 64

   4.3. Brushless Machines 68

4.4. Exploitation Properties 71

4.5. Self-excited DC Shunt Generator 77

4.6. DC Traction Motor 79

5. Rotating Field Concept

5.1. Rotor DC Field 81

5.2. Back Electromotive Force 83

5.3. Armature Field and Voltage 90

5.4. Power of Rotating Field 96

6. Synchronous Machines

6.1. Types and Basic Properties of Synchronous Machines 101

6.2. Operation on Network with Constant Voltage and Frequency 109

6.3. Supply from Network with Variable Voltage and Frequency 114

7. Asynchronous Machines

7.1. Types and Basic Properties of Asynchronous Machines 121

7.2. Equivalent Circuit 130

7.3. Exploitation Properties 137

7.4. Single-Phase Motors 143

Further Reading 147