

Table of Contents

Chapter 1. Phenomena of Perturbation in Electrical Systems	1
1.1. Electromagnetic perturbations in energy systems.	1
1.1.1. Introduction	1
1.2. Power grid harmonics	6
1.2.1 Presentation	6
1.2.2. Characterization of the quality of electrical energy.	8
1.2.3. Relevant standards for harmonic emissions	10
1.2.4. Classification of appliances	11
1.2.5. The limits of harmonic currents	12
1.2.6. Examples of observations of harmonic currents.	15
1.2.7. Fluorescent lighting scenario	16
1.2.8. Practical scenario of the improvement of the total harmonic distortion generated by a variable-frequency drive	20
1.2.9. Converter with sinusoidal absorption	24
1.3. Common-mode and differential-mode conducted perturbations.	29
1.3.1. Common mode and differential mode.	30
1.3.2. Crosstalk	41
1.4. Measuring electromagnetic perturbations	44
1.4.1. The line impedance stabilization network.	44
1.4.2. Current sensors	46

1.4.3. Antennae	53
1.4.4. Spectrum analyzer.	65
1.5. The standards	72
1.6. Bibliography	73
Chapter 2. Fundamental Principles	75
2.1. Sources of noise: the switching cell and its control . . .	75
2.1.1. Origin of conducted and radiated perturbations in static converters	76
2.2. Modeling.	77
2.2.1. Simple model of the switching cell	77
2.2.2. More complex model of the switching cell.	82
2.3. Characterization of coupling functions and parasitic elements	86
2.3.1. Passive components and differential-mode effects	86
2.3.2. Invisible parasitic elements and common-mode effects	89
2.3.3. Parasitic effects contributing to undesirable couplings.	91
2.4. Electromagnetic compatibility study of a practical scenario: the Buck chopper	103
2.4.1. Description of the case study	104
2.4.2. Influence of the design parameters of the converter	109
2.4.3. Influence of technological parameters and control	111
2.4.4. Other sources of switching noise	112
2.4.5. Other switching modes: soft switching, advantages and constraints	113
2.5. EMC study of an insulated DC-DC fly back power supply.	114
2.5.1. Description of the device.	114
2.5.2. Creation of the circuit model	117
2.5.3. Analysis of switchings in the structure	121
2.5.4. Electric simulation of the complete structure	123

2.6. Corrected exercise number 1: conducted perturbations of a step-up chopper	127
2.7. Answers with comments	130
2.8. Bibliography	141

Chapter 3. EMC of Complex Electrical Energy

Conversion Systems: Electromagnetic Actuators	143
3.1. How to define a complex system?	143
3.2. Qualitative study	145
3.2.1. Description of the conversion chain	145
3.2.2. Reminder of the standards.	147
3.2.3. Propagation methods	149
3.3. Modeling in frequency domain.	152
3.3.1. Linearization of the switching cell.	152
3.3.2. Modeling of the perturbation sources.	157
3.4. Frequency-based representation of an inverter.	173
3.4.1. Equivalent common-mode source – simplified diagram	173
3.4.2. Differential-mode influence	176
3.4.3. Proposed frequency-based diagram	178
3.5. Modeling of the cables and motors	179
3.5.1. Estimation of the primary parameters of the power cables	179
3.5.2. High-frequency model of an asynchronous machine	185
3.6. Connection of the cable and the motor	196
3.6.1. Total impedance read by the variable-speed drive	196
3.6.2. Measuring the total common-mode impedance	197
3.7. Results	198
3.7.1. Time-based simulation and frequency-based simulation	198
3.7.2. Measurement versus simulation	200
3.8. Passing from the time domain to the frequency domain: circuit simulations	201
3.9. Conclusion	204
3.10. Bibliography	205

Chapter 4. Concrete Study of Solutions for the Reduction of Electromagnetic Perturbations	207
4.1. Concrete study of solutions for the reduction of electromagnetic perturbations.	207
4.1.1. Introduction	207
4.2. Filtering conducted emissions: analysis and conceptual design of common-mode filters	212
4.2.1. Introduction	212
4.2.2. Description of a common-mode filter.	214
4.3. Case study: determining a common-mode filter for a variable-speed drive.	221
4.3.1. Equivalent model of the drive	221
4.3.2. Filter simulated using perfect components.	223
4.3.3. Effect of the parasitic elements of components	226
4.4. Design and optimization components.	230
4.4.1. Study of capacitors	230
4.4.2. Study of the common-mode toric inductance	232
4.4.3. Results	237
4.5. Conclusion	239
4.5.1. Corrected exercise: filtering the conducted perturbations of a step-up chopper	239
4.6. Shielding	248
4.6.1. Introduction	248
4.6.2. Breakdown of shielding effects.	249
4.6.3. Materials	252
4.6.4. Wave impedance	257
4.6.5. Expression of attenuations	264
4.6.6. Global attenuation: case study.	269
4.6.7. Shielding issues for magnetic fields in low frequency	273
4.7. Conclusion	275
4.8. Bibliography	276
Index.	279