

Contents

1	Introduction	9
1.1	Motivation	10
1.2	Objectives and Structure of the Thesis	12
2	State of the Art	15
2.1	Basic Terms and Definitions	15
2.2	The Aircraft Electrical System	16
2.2.1	Reference Architecture	18
2.2.2	Electrical Load Analysis (ELA) and Network Size Calculation	24
2.3	Electrical Cabin and Cargo Systems	27
2.3.1	In-Service Data	29
2.3.2	Basic Characteristics of Electrical Loads	29
2.4	Safety and Reliability	30
2.4.1	Fault Tree Analysis	31
2.4.2	Operational Reliability	32
2.5	Statistics	33
2.5.1	Binomial Distribution	33
2.5.2	Dependency Analysis	33
2.6	The Knapsack Problem	34
2.7	Electrical Power Management Applications	35
2.7.1	Power Management on Aircraft	36
3	Identifying Limited Network Resources by Extended Fault Tree Analysis	37
3.1	Mean Time Between Under-Capacities (MTBUC)	41
3.1.1	Derivation of Mean Time Between Under-Capacities (MTBUC)	41
3.2	Identifying Limited Resources by Means of MTBUC	43
3.2.1	Identifying Limited Resources with Flexible Configurations	46
3.3	Risk of Under-Capacities in Systems with Limited Resources	49
3.4	Summary of Chapter 3	50
4	Electrical Load Analysis under Limited Network Resources	53
4.1	Data Quality	53
4.2	Systems Dependency Study	54
4.3	Electrical Load Analysis	58
4.4	Benefits and Drawbacks of Network Design with Limited Resources	59
4.5	Summary of Chapter 4	60
5	Power Management on Aircraft	63
5.1	Power Management and the Protective Device	65
5.1.1	Extreme Scenarios, Tripping Curve, and PM Response Times	65
5.1.2	Complex Switching	72

5.1.3	Sub-busbar Limit for ELAs with Over-Installation	77
5.2	Single-Phase Reactive Power Management	78
5.2.1	Load Classification	79
5.2.2	Power Reduction and Restoration	80
5.3	Three-Phase Reactive Power Management	94
5.3.1	Three-Phase Power Reduction and Restoration	96
5.4	Proposal for Final Power Management Realization	99
5.4.1	Power Management with Sheddable Loads	99
5.4.2	Power Management with Sheddable and Steerable Loads	102
5.4.3	Content for Future Considerations	103
5.5	Summary of Chapter 5	105
6	Further Concepts for Electrical Network Weight Reduction	109
6.1	230 VAC Main Power Supply	111
6.1.1	Weight Benefits	111
6.1.2	Safety and Certification	114
6.1.3	Installation, Maintenance Efforts, and Customization	115
6.1.4	Operational Reliability	115
6.1.5	Effects on other Aircraft Systems and Costs	115
6.2	Split Primary Power Center	115
6.2.1	Weight Benefits	117
6.2.2	Safety and Certification	119
6.2.3	Installation, Maintenance Efforts and Customization	119
6.2.4	Operational Reliability	120
6.2.5	Effects on other Aircraft Systems and Costs	120
6.3	Multiple AC Points Of Regulation – Multi AC POR	120
6.3.1	Weight Benefits	120
6.3.2	Safety and Certification	120
6.3.3	Installation, Maintenance Efforts, and Customization	121
6.3.4	Operational Reliability	122
6.3.5	Effects on other Aircraft Systems and Costs	122
6.4	Cross-ATA Chapter Network Design / “Quick Win”	122
6.4.1	Weight Benefits, Safety, Certification, and Operational Reliability	122
6.4.2	Installation, Maintenance Efforts, and Customization	123
6.4.3	Effects on other Aircraft Systems and Costs	123
6.5	Summary of Chapter 6	124
7	Summary and Outlook	127
7.1	Outlook	131
	Bibliography	133
A	Abbreviations	143
B	Supplement to State of the Art	145
B.1	Electrical Network Quality	145
B.1.1	Inrush Currents	145
B.1.2	Voltage Transients	145
B.1.3	Steady State Voltage Range	145
B.1.4	Power Factor Limits	147

B.2	Supplement to Cabin and Cargo Systems	148
B.2.1	Supplement to Failure Rates of AC and DC Sub-busbars	148
C	Supplement to Chapter 3	149
C.1	Usage Factors	149
C.2	Further Results on Convolution	149
D	Supplement to Chapter 4	153
D.1	Data Preparation	153
D.2	Further Results on Systems Dependency	157
E	Supplement to Chapter 5	161
E.1	RCCB Model Validation	161
E.1.1	Model with no Over-Installation ($\alpha = 1$) vs. Extreme Scenarios	164
E.2	Power Management Studies – Further Results and Additional Information	166
E.2.1	Results on Extreme Scenarios and PM Response Time	166
E.2.2	Results on Complex Switching	171
E.2.3	Test Signals and Simulation Model for Single-Phase Power Management	172
E.2.4	Results on Single-Phase Power Management	177
E.2.5	Results on Three-Phase and Final Power Management	182
E.2.6	Mathematical Derivations	191
F	Scientific Work	193
F.1	Publications	193
F.1.1	Authoring	193
F.1.2	Co-authoring	194
F.2	Supervised Student Theses	194
Index		197