

Contents

Abstract	vii
Kurzfassung	ix
1 Introduction	3
1.1 Organization of the Thesis	5
1.2 Contributions	6
1.3 Notation	7
2 Fundamentals	9
2.1 Signal Representation	9
2.2 FMCW Radar	9
2.3 Chirp Sequence Radar	11
2.4 Radar Range Equation	13
2.5 Multiple-Input Multiple-Output	14
2.6 Resolution	14
2.7 Far-Field Condition	16
2.8 Beamforming	16
2.9 Movement Compensation	18
2.10 Array Factor and Radiation Pattern	19
2.11 Array Factor using FFT	22
2.12 Side Lobe Level	23
2.13 Synthetic Aperture Radar	24
2.14 Mono-static Virtual Aperture	25
2.15 Cell-Averaging CFAR	28
3 Large Aperture Automotive Radar	29
3.1 State of the Art	29
3.1.1 Radar Systems	29
3.1.2 Array Pattern Synthesis	31
3.2 Requirements	34
3.3 Array Design	35
3.3.1 Array Topology	35
3.3.2 Optimization Algorithm	36
3.3.3 Final Design	45
3.4 Array Analysis	47
3.5 Link-Budget	49
3.6 Signal Processing Flow	50
3.7 Summary	51

4	Synchronization Demonstrator	53
4.1	Hardware and Concept	53
4.1.1	Radar Chips	54
4.1.2	Module Hardware	56
4.1.3	Module Synchronization	58
4.1.4	Antenna Elements and Array	61
4.2	Calibration	64
4.3	System Parameters, Software and Signal Processing	73
4.4	Simulations, Measurements and Results	76
4.5	Summary	79
5	SAR Demonstrator	81
5.1	Concept and Hardware	81
5.1.1	Synthetic Virtual Aperture	81
5.1.2	Radar Module	82
5.1.3	XY-Table	84
5.2	Software and Signal Processing	85
5.3	Measurements	85
5.3.1	Synchronization Demonstrator Scenario	85
5.3.2	Outdoor Scenario	86
5.4	Summary	88
6	Module Position Tolerance Compensation	93
6.1	Causes and Displacement Estimates	93
6.2	Impact on the System	94
6.3	Calibration Algorithm	98
6.4	Simulation	101
6.5	Summary	103
7	Conclusions and Future Work	105
8	Appendices	107
Appendix 8.A	Antenna Element Positions	107
Appendix 8.B	Antenna Element Weights	109
Appendix 8.C	Synchronization Demonstrator Components	113
Appendix 8.D	HPBW of a Corner Reflector	114
8.D.1	Analytical Comparison to a Plate	114
8.D.2	Simulation and Fitting	114
	List of References	117
	List of Symbols	123
	List of Publications	129