

Contents

1	Introduction	1
2	Fundamentals	7
2.1	Osteosynthesis	7
2.1.1	Bone Fractures	8
2.1.2	Osteosynthesis Plates	9
2.1.3	Electronically Instrumented Osteosynthesis Implants	11
2.1.4	Hexapod Fixators	13
2.1.5	Electronically Instrumented Hexapod Fixators	15
2.2	Medical Instrumentation Systems	16
2.2.1	Sensors	18
2.2.2	Amplifiers	26
2.2.3	Analog-to-Digital Converters	29
2.2.4	Control Units and Data Storage	31
2.2.5	Power Supply	32
2.2.6	Wireless Data Transmission	43
2.3	CMOS Analog Integrated Circuit Design	46
2.3.1	CMOS Transistor Modeling	47
2.3.2	Two-stage Operational Amplifier	52
3	Electronic Osteosynthesis Implant	57
3.1	Requirements	57
3.2	I. Demonstrator	60
3.2.1	Strain Measurements	62
3.2.2	Wireless Power Transfer	64
3.2.3	Wireless Data Transmission	74
3.2.4	Design of the Implantable Electronics Module	77
3.2.5	External Devices	80

3.2.6	Results	82
3.3	ASIC Design for the Analog Front-End	88
3.3.1	Differential Difference Amplifier	91
3.3.2	Voltage Reference for the Virtual Ground	94
3.3.3	Analog Front-End	96
3.3.4	Results	98
3.4	II. Demonstrator	101
3.4.1	Implantable Electronics	102
3.4.2	Encapsulation of the Implantable Electronics Module	104
3.4.3	Results	105
4	Electronic Hexapod Fixator	111
4.1	System Design	112
4.2	Fixator Electronics	114
4.3	Results	117
5	Conclusion and Outlook	121
	Bibliography	125
	List of Symbols and Acronyms	143
	Latin Symbols	143
	Greek Symbols	144
	Acronyms	145
A	Appendix	147
A.1	Schematics of the Electronic Osteosynthesis Implant	147
A.2	Schematics of the Electronic Hexapod Fixator	156