

Contents

1	Introduction	1
1.1	Motivation	1
1.2	Goal of this Work	2
1.3	Comparison with State-of-the-Art	2
1.3.1	Technology Comparison	2
1.3.2	Device Comparison	3
1.3.3	Conclusions	4
1.3.4	State-of-the-art Mobile Communication Base Station Devices	4
1.3.5	State-of-the-art C-Band Devices	5
2	Theoretical Consideration of Micro-System Broad-Band High-Power Amplifier	9
2.1	Requirements for Broad-Band High-Power Amplifier	9
2.1.1	Distinction between Narrow-Band and Broad-Band	9
2.1.2	Broad-Band Requirements for Devices	9
2.2	Limitations for Broad-Band High-Power Amplifier	11
2.2.1	Theoretical Limitation for Broad-Band Matching Networks	12
2.2.2	Broad-Band Impedance Transformation	12
2.3	Stability Issue for Multiple Finger Devices	14
2.3.1	Types of Oscillations	14
2.3.2	Stability Analysis Methods	15
3	Field Theoretical Analysis	17
3.1	Complex Micro-System Broad-Band High-Power Amplifier	17
3.1.1	Description of Micro-System	17
3.1.2	Interface Definition	18
3.1.3	Stability Issue of Micro-Systems	19
3.2	Modeling of Micro-System	19
3.2.1	Gate Finger Module	19
3.2.2	Slice Model for a Power Cell	21
3.2.3	Verification of the Slice Model	21
3.2.4	Conclusions	23
3.3	First Layout $8 \times 400 \mu\text{m}$ Coplanar Waveguide Power Cell	23
3.3.1	Description of Coplanar Waveguide Power Cell	23
3.3.2	Stability Issue at Higher Drain Voltage for the Coplanar Waveguide Power Cell	23
3.3.3	Conclusions	26

3.4	Proposal for Stable $6 \times 400 \mu\text{m}$ Coplanar Waveguide Power Cell	27
3.4.1	Analysis of Gate Bus Structure of the Coplanar Waveguide Power Cell	27
3.4.2	Stability Simulation of $6 \times 400 \mu\text{m}$ Coplanar Waveguide Power Cell	28
3.4.3	Discussion of the Results from Stability Simulation of $6 \times 400 \mu\text{m}$ Coplanar Waveguide Power Cell	29
3.4.4	Conclusions	29
3.5	Frequency Scaling up to 6 GHz	29
3.5.1	Relation between HEMT Layout Dimensions and Small-Signal Elements	30
3.5.2	Analysis of Layout Changes of the Micro-Strip Line Power Cell	31
3.5.3	Investigation of Gate Module Parameters on Input Path of HEMT	35
3.5.4	Consequence for Power Bar Design	38
3.6	Introduction of New Layout Concept for the Power Cell	39
3.6.1	Small-Signal Comparison of Micro-Strip Line and Individual Source Via Power Cell	40
3.6.2	Conclusions	41
4	Synthesis of Multiple Power Cells	43
4.1	Modeling of Multiple Power Cell Devices	43
4.1.1	Introduction of Different Multiple Power Cell Setup	43
4.1.2	Example Modeling of Power Bar	45
4.1.3	Modeling Approach	45
4.2	Analysis of Power Bar Environment	47
4.2.1	Introduction	47
4.2.2	Simple Modeling Approach for Odd-Mode Oscillation Analysis of a Mono-mos with n Unit Cells	50
4.2.3	Parallel Connection of n Power Cells	56
4.2.4	Hybrid-Mos Approach	57
4.2.5	Conclusions	62
4.3	Design of Coplanar Waveguide Power Bar for Mobile Communication	62
4.3.1	Stability Simulation of Coplanar Waveguide Power Bar without Package	63
4.3.2	Stability Simulation of Coplanar Waveguide Power Bar in Package RF3410	66
4.3.3	Large-Signal Measurement Results	68
4.3.4	Investigation of Gain Reduction of a Coplanar Waveguide Power Bar in Package RF3410	68
4.3.5	Conclusions	72
4.4	Design of Micro-Strip Line Power Bar for Operating Frequency up to 6 GHz	73
4.4.1	Analysis of Gain Improvement of Micro-Strip Line Power Bar	73
4.4.2	Stability Analysis of Micro-Strip Line Power Bar	75
4.4.3	Influence of Stability Resistors on Performance	76

4.4.4	Large-Signal Measurement Results at 4 GHz and 6 GHz	79
4.4.5	Conclusions	80
4.5	The Individual Source Via Approach Advances	81
4.5.1	Mobile Communication Application	81
4.5.2	Broad-Band and C-Band Application	83
5	Demonstrators	87
5.1	Power Bar with MMIC Approach	87
5.1.1	Design Goal	88
5.1.2	Simulation Results of the Input Matching Network	88
5.1.3	Measurement Results	88
5.1.4	Conclusions	89
5.2	Broad-Band Power Amplifier with MMIC Approach	90
5.2.1	Design Goal	90
5.2.2	Simulation Results for the Input and Output Matching Network	91
5.2.3	Measurement Results	92
5.2.4	Conclusions	94
5.3	Narrow-Band High-Power Amplifier in Hybrid Approach at 6 GHz	94
5.3.1	Design Goal	94
5.3.2	Phase Distribution Analysis	95
5.3.3	Simulation Results of the Amplifier	96
5.3.4	Measurement Results	97
5.3.5	Discussion of the Measurement Results	98
5.3.6	Conclusions	100
5.4	Demonstrators Based on Presented Power Bars	100
5.4.1	Dual-Band Class-ABJ High-Power Amplifier	100
5.4.2	Broad-Band Class-J High-Power Amplifier	101
5.4.3	Class-E High-Power Amplifier	103
5.4.4	Conclusion	104
6	Conclusion and Outlook	105
6.1	Conclusion	105
6.2	Outlook	106
	Bibliography	109
	Publications	119
	Acknowledgments	123
	List of Tables	125
	List of Figures	127