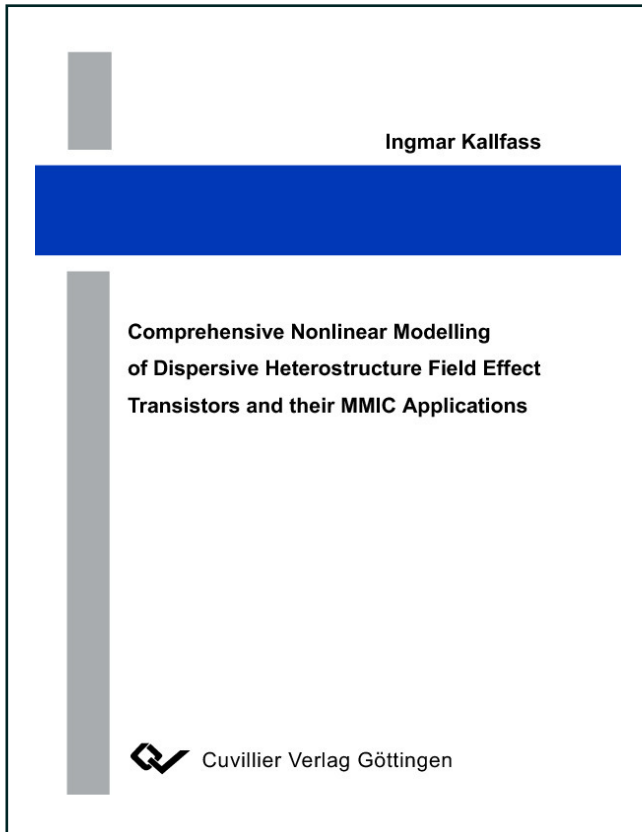




Ingmar Kallfass (Autor)

Comprehensive Nonlinear Modelling of Dispersive Heterstructure Field Effect Transistors and their MMIC Applications



<https://cuvillier.de/de/shop/publications/2147>

Copyright:

Cuvillier Verlag, Inhaberin Annette Jentsch-Cuvillier, Nonnenstieg 8, 37075 Göttingen, Germany

Telefon: +49 (0)551 54724-0, E-Mail: info@cuvillier.de, Website: <https://cuvillier.de>

Contents

| | |
|--|-----------|
| Introduction | 1 |
| 1 Modelled HEMT Technologies | 4 |
| 1.1 Strained-Si/SiGe mHEMT | 4 |
| 1.2 Low Noise- and Power AlGaAs/GaAs pHEMT | 9 |
| 1.3 InGaAs/InP pHEMT | 11 |
| 2 Modelling of Frequency Dispersion in HFETs | 13 |
| 2.1 Physical- Versus Empirical Large-Signal Modelling | 13 |
| 2.2 Effects of Frequency Dispersion in HFET Devices | 16 |
| 2.3 State-of-the-Art Modelling Approaches | 18 |
| 2.3.1 Thermal models | 18 |
| 2.3.2 Static- and Dynamic Current Sources | 19 |
| 2.3.3 Equivalent Voltage Sources | 21 |
| 2.4 Importance of a Dispersion Model in Circuit Design | 22 |
| 2.4.1 Static Analysis | 22 |
| 2.4.2 Small-Signal Circuits | 23 |
| 2.4.3 Large-Signal Frequency Domain Circuits | 24 |
| 2.4.4 Large-Signal Time Domain Circuits | 25 |
| 2.4.5 System Level | 26 |
| 2.5 Obtaining Dynamic IV Characteristics | 26 |
| 2.5.1 Pulsed-IV Characterisation | 27 |
| 2.5.2 Numerical Integration of Dynamic Trans- and Output Conductance . | 28 |
| 3 Universal Large-Signal HFET Model | 33 |
| 3.1 Advanced De-embedding Technique | 33 |
| 3.2 Static Model | 37 |
| 3.2.1 Modified COBRA drain current model | 37 |
| 3.2.2 Gate current model | 43 |
| 3.3 Dynamic Model | 45 |
| 3.3.1 Multi-Bias Small-Signal Model Extraction | 45 |
| 3.4 Nonlinear Capacitance Model | 47 |

| | | |
|----------|---|------------|
| 3.4.1 | A Unified Approach to Charge-Conservative Capacitance Modelling | 48 |
| 3.4.2 | A Universal HFET Capacitance Model | 50 |
| 3.5 | Multiple Time-Constant Dispersion Model | 54 |
| 3.5.1 | Physical Motivation | 54 |
| 3.5.2 | Single Time-Constant Dispersion Model | 55 |
| 3.5.3 | Multiple Time-Constants | 57 |
| 3.5.4 | Determination of Dispersion Time Constants | 58 |
| 3.6 | Parameter Extraction Software FETfit | 66 |
| 3.7 | Model Implementation | 66 |
| 3.7.1 | Implementation of nonlinear capacitance | 69 |
| 3.7.2 | Schematic level parameters | 71 |
| 3.8 | Small- and Large-Signal Model Verification | 72 |
| 4 | MMIC Applications | 78 |
| 4.1 | SiGe mHEMT Travelling-Wave Amplifiers | 78 |
| 4.1.1 | Transmission Line- and Active Device Models | 79 |
| 4.1.2 | Common-Source Stage Distributed Amplifier | 80 |
| 4.1.3 | Cascode Stage Distributed Amplifier | 86 |
| 4.2 | GaAs pHEMT Travelling-Wave Mixer and Variable Gain Amplifier | 89 |
| 4.2.1 | Unit Cell Topology and Operation Principle | 89 |
| 4.2.2 | Circuit Design and Layout | 91 |
| 4.2.3 | VGA Operation | 92 |
| 4.2.4 | Mixer Operation | 98 |
| 5 | Conclusion | 102 |
| | Bibliography | 105 |
| | List of Acronyms and Symbols | 117 |
| A | Dynamic Small-Signal FET Model Equations | 121 |
| B | Model Parameters, Equations and Derivatives | 122 |
| C | Detailed Model Parameters and Verification | 131 |
| C.1 | Strained-Si/SiGe mHEMT | 131 |
| C.2 | Low-noise AlGaAs/GaAs pHEMT | 136 |
| C.3 | Power AlGaAs/GaAs pHEMT | 141 |
| C.4 | InGaAs/InP pHEMT | 145 |
| D | SiGe mHEMT Two Metal Layers Process | 150 |