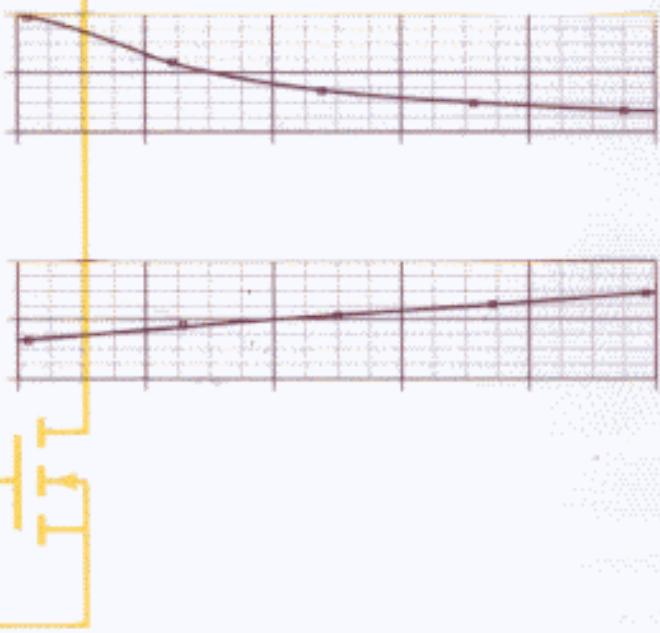


Introduction to PSpice® Using OrCAD® for Circuits and Electronics

Third Edition



Muhammad H. Rashid



CD-ROM
Included

Contents

Preface

xiii

About the Author

xvii

| | | |
|------------------|---|-----------|
| CHAPTER 1 | Introduction | 1 |
| 1.1 | Introduction | 1 |
| 1.2 | Descriptions of Spice | 2 |
| 1.3 | Types of Spice | 2 |
| 1.4 | Types of Analysis | 3 |
| 1.5 | Descriptions of Simulation Software Tools | 5 |
| 1.6 | PSpice Platform | 6 |
| 1.6.1 | PSpice A/D | 6 |
| 1.6.2 | PSpice Schematics | 6 |
| 1.6.3 | OrCAD Capture | 7 |
| 1.7 | PSpice Schematic Versus OrCAD Capture | 7 |
| 1.8 | Limitations of PSpice | 9 |
| 1.9 | SPICE Resources | 9 |
| References | | 12 |
| CHAPTER 2 | Circuit Descriptions | 14 |
| 2.1 | Introduction | 14 |
| 2.2 | Input Files | 14 |
| 2.3 | Element Values | 16 |
| 2.4 | Nodes | 17 |
| 2.5 | Circuit Elements | 18 |
| 2.6 | Sources | 20 |
| 2.7 | Types of Analysis | 22 |
| 2.8 | Output Variables | 22 |
| 2.9 | PSpice Output Commands | 23 |
| 2.10 | Format of Circuit Files | 23 |
| 2.11 | Format of Output Files | 25 |
| 2.12 | Examples of SPICE Simulations | 26 |

| | | |
|--------------------------------------|---|-----------|
| 2.13 | OrCAD Capture | 32 |
| 2.13.1 | OrCAD Capture Layout | 32 |
| 2.13.2 | PSpice A/D | 35 |
| 2.13.3 | Probe | 37 |
| 2.14 | Importing Microsim Schematic in OrCAD Capture | 37 |
| | References | 37 |
| | Problems | 38 |
| CHAPTER 3 DC Circuit Analysis | | 39 |
| 3.1 | Introduction | 39 |
| 3.2 | Resistors | 40 |
| 3.3 | Modeling of Elements | 41 |
| 3.4 | Operating Temperature | 43 |
| 3.5 | Independent DC Sources | 44 |
| 3.5.1 | Independent DC Voltage Source | 44 |
| 3.5.2 | Independent DC Current Source | 45 |
| 3.5.3 | Schematic Independent Sources | 45 |
| 3.6 | Dependent Sources | 45 |
| 3.6.1 | Polynomial Source | 45 |
| 3.6.2 | Voltage-Controlled Voltage Source | 48 |
| 3.6.3 | Voltage-Controlled Current Source | 49 |
| 3.6.4 | Current-Controlled Current Source | 50 |
| 3.6.5 | Current-Controlled Voltage Source | 51 |
| 3.6.6 | Schematic Dependent Sources | 52 |
| 3.7 | DC Output Variables | 52 |
| 3.7.1 | Voltage Output | 52 |
| 3.7.2 | Current Output | 54 |
| 3.8 | Types of Output | 56 |
| 3.8.1 | .PRINT (Print Statement) | 56 |
| 3.8.2 | .PLOT (Plot Statement) | 56 |
| 3.8.3 | .PROBE (Probe Statement) | 57 |
| 3.8.4 | Probe Output | 57 |
| 3.8.5 | .WIDTH (Width Statement) | 60 |
| 3.9 | Types of DC Analysis | 61 |
| 3.9.1 | .OP (Operating Point) | 61 |
| 3.9.2 | .TF (Small-Signal Transfer Function) | 64 |
| 3.9.3 | .DC (DC Sweep) | 68 |
| 3.9.4 | .PARAM (DC Parametric sweep) | 75 |
| | Summary | 79 |
| | References | 80 |
| | Problems | 80 |

| | |
|---|------------|
| CHAPTER 4 Transient Analysis | 84 |
| 4.1 Introduction | 84 |
| 4.2 Capacitors and Inductors | 85 |
| 4.2.1 Capacitor | 85 |
| 4.2.2 Inductor | 87 |
| 4.3 Modeling of Transient Sources | 90 |
| 4.3.1 Exponential Source | 90 |
| 4.3.2 Pulse Source | 91 |
| 4.3.3 Piecewise Linear Source | 93 |
| 4.3.4 Single-Frequency Frequency Modulation | 93 |
| 4.3.5 Sinusoidal Source | 95 |
| 4.4 Transient Sources | 96 |
| 4.4.1 Independent Voltage Source | 97 |
| 4.4.2 Independent Current Source | 97 |
| 4.5 Transient Output Variables | 98 |
| 4.6 Transient Output Commands | 99 |
| 4.7 Transient Response | 99 |
| 4.7.1 .IC (Initial Transient Conditions) | 100 |
| 4.7.2 .TRAN (Transient Analysis) | 101 |
| 4.8 Switches | 112 |
| 4.8.1 Voltage-Controlled Switch | 112 |
| 4.8.2 Current-Controlled Switch | 117 |
| 4.8.3 Time-Dependent Switches | 119 |
| Summary | 122 |
| References | 124 |
| Problems | 124 |
| CHAPTER 5 AC Circuit Analysis | 131 |
| 5.1 Introduction | 131 |
| 5.2 AC Output Variables | 132 |
| 5.2.1 Voltage Output | 132 |
| 5.2.2 Current Output | 133 |
| 5.3 Independent AC Sources | 134 |
| 5.4 AC Analysis | 135 |
| 5.5 Magnetic Elements | 145 |
| 5.6 Transmission Lines | 149 |
| 5.7 Multiple Analyses | 152 |
| Summary | 154 |
| References | 154 |
| Problems | 155 |

| | |
|---|------------|
| CHAPTER 6 Advanced SPICE Commands and Analysis | 159 |
| 6.1 Introduction | 159 |
| 6.2 Behavioral Modeling | 160 |
| 6.2.1 Value | 160 |
| 6.2.2 Table | 162 |
| 6.2.3 Laplace | 163 |
| 6.2.4 FREQ | 164 |
| 6.3 .SUBCKT (Subcircuit) | 164 |
| 6.4 .ENDS (End of Subcircuit) | 165 |
| 6.5 .FUNC (Function) | 166 |
| 6.6 .GLOBAL (Global) | 167 |
| 6.7 .INC (Include File) | 167 |
| 6.8 .LIB (Library File) | 168 |
| 6.9 .NODESET (Nodeset) | 169 |
| 6.10 Options | 169 |
| 6.11 .PARAM (Parameter) | 172 |
| 6.12 Fourier Analysis | 174 |
| 6.13 Noise Analysis | 177 |
| 6.14 .SENS (Sensitivity Analysis) | 180 |
| 6.15 .STEP (Parametric Analysis) | 182 |
| 6.16 .DC (DC Parametric Sweep) | 186 |
| 6.17 Monte Carlo Analysis | 189 |
| 6.18 DEV/LOT Device and Lot Tolerances | 191 |
| 6.19 Sensitivity/Worst-Case Analysis | 195 |
| Summary | 197 |
| References | 198 |
| Problems | 199 |
| CHAPTER 7 Semiconductor Diodes | 203 |
| 7.1 Introduction | 203 |
| 7.2 Diode Characteristics | 203 |
| 7.2.1 Forward-Bias Region | 205 |
| 7.2.2 Reverse-Bias Region | 205 |
| 7.2.3 Breakdown Region | 206 |
| 7.3 Analysis of Diode Circuits | 206 |
| 7.3.1 DC Analysis | 206 |
| 7.3.2 Small-Signal AC Analysis | 208 |
| 7.4 Diode Model | 209 |
| 7.5 Diode Statement | 211 |
| 7.6 Diode Parameters | 212 |
| 7.7 Examples of DC Analysis | 215 |
| 7.8 Examples of Transient and AC Analysis | 223 |

| | |
|--|------------|
| Summary | 232 |
| References | 232 |
| Problems | 233 |
| CHAPTER 8 Bipolar Junction Transistors | 237 |
| 8.1 Introduction | 237 |
| 8.2 BJT Model | 237 |
| 8.3 BJT Statements | 240 |
| 8.4 BJT Parameters | 242 |
| 8.5 Examples of BJT Circuits | 248 |
| Summary | 283 |
| References | 283 |
| Problems | 284 |
| CHAPTER 9 Field-Effect Transistors | 289 |
| 9.1 Introduction | 289 |
| 9.2 Junction Field-Effect Transistors | 289 |
| 9.3 JFET Parameters | 293 |
| 9.4 Examples of JFET Amplifiers | 295 |
| 9.5 Metal Oxide Silicon Field-Effect Transistors | 307 |
| 9.6 MOSFET Parameters | 312 |
| 9.7 Examples of MOSFET Amplifiers | 318 |
| 9.8 Gallium Arsenide MESFETs | 329 |
| Summary | 334 |
| References | 334 |
| Problems | 335 |
| CHAPTER 10 Op-Amp Circuits | 340 |
| 10.1 Introduction | 340 |
| 10.2 DC Linear Models | 340 |
| 10.3 AC Linear Model | 341 |
| 10.4 Nonlinear Macromodel | 342 |
| 10.5 Examples of OP-AMP Circuits | 344 |
| References | 367 |
| Problems | 368 |
| CHAPTER 11 Difficulties | 373 |
| 11.1 Introduction | 373 |
| 11.2 Large Circuits | 374 |
| 11.3 Running Multiple Circuits | 374 |
| 11.4 Large Outputs | 375 |
| 11.5 Long Transient Runs | 375 |

| | | |
|-------------------|---|------------|
| 11.6 | Convergence Problems | 376 |
| 11.6.1 | DC Sweep | 376 |
| 11.6.2 | Bias Point | 378 |
| 11.6.3 | Transient Analysis | 379 |
| 11.7 | Analysis Accuracy | 380 |
| 11.8 | Negative Component Values | 381 |
| 11.9 | Power-Switching Circuits | 382 |
| 11.10 | Floating Nodes | 385 |
| 11.11 | Nodes with Less than two Connections | 389 |
| 11.12 | Voltage Source and Inductor Loops | 389 |
| 11.13 | Running A PSpice File on Spice | 390 |
| 11.14 | Running a Spice File on PSpice | 390 |
| 11.15 | Running an Earlier Version of Schematic | 391 |
| | References | 391 |
| | Problems | 392 |
| Appendix A | Drawing in PSpice Schematics | 393 |
| A.1 | Learning Objectives | 393 |
| A.2 | Installing the Software | 393 |
| A.3 | Overview | 393 |
| A.4 | The Circuit Analysis Process | 395 |
| A.5 | Drawing the Circuit | 395 |
| A.6 | Copying and Capturing Schematics | 405 |
| Appendix B | Drawing in OrCAD Capture Lite | 406 |
| B.1 | Learning Objectives | 406 |
| B.2 | Installing the Software | 406 |
| B.3 | Overview | 408 |
| B.4 | The Circuit Analysis Process | 409 |
| B.5 | Drawing the Circuit | 410 |
| B.6 | Copying and Capturing Schematics | 422 |
| Appendix C | Creating Input Circuit File | 424 |
| Appendix D | DOS Commands | 427 |
| Appendix E | Noise Analysis | 429 |
| E.1 | Thermal Noise | 429 |
| E.2 | Shot Noise | 429 |
| E.3 | Flicker Noise | 430 |
| E.4 | Burst Noise | 430 |
| E.5 | Avalanche Noise | 431 |

| | | |
|---------------------|--|------------|
| E.6 | Noise in Diodes | 431 |
| E.7 | Noise in Bipolar Transistors | 432 |
| E.8 | Noise in Field-Effect Transistors | 432 |
| E.9 | Equivalent Input Noise | 433 |
| Appendix F | Nonlinear Magnetic Model | 437 |
| Appendix G | PSpice Default Symbol Libraries | 440 |
| Bibliography | | 442 |
| Index | | 444 |