

# Index

## Symbols

- ! (negation) 174
  - != (inequality) 174
  - !== (not identical) 174
  - # delay 166, 216
    - not in analog process 196
  - \$abstime 83, 175
  - \$bound\_step 77, 190
  - \$discontinuity 69, 79, 80, 191
  - \$display 192
  - \$driver\_... functions 144, 145
  - \$fclose 193
  - \$fdisplay 193
  - \$finish 191
  - \$fopen 193
  - \$fstrobe 194
  - \$limexp 57, 188
  - \$monitor 193
  - \$random 194
  - \$rdist\_... functions 194
  - \$realtime 176
  - \$stop 191
  - \$strobe 84, 192
  - \$temperature 57, 177
  - \$vt 57, 177
  - \$write 193
  - % (modulus) 173
  - & (bitwise and) 173
  - && (logical and) 174
  - (—§—p—) (cross reference) 35
  - \* (multiplication) 173
  - + (addition) 173
  - .model 238, 241, 244
  - .subckt 238, 245
  - / (division) 173
  - < (less than) 174
  - << (shift left) 174
  - <= (less than or equal to) 174
  - == (equality) 174
  - === (identical) 174
  - > (greater than) 174
  - > (trigger named event) 174, 217
  - >= (greater than or equal to) 174
  - >> (shift right) 174
  - ?: (inline conditional) 174, 200
  - @ event 216
    - different in analog process 196
    - restrictions 178
  - ^ (bitwise exclusive or) 173
  - ^~ (bitwise exclusive nor) 173
  - \_ (in numbers) 153
  - \_\_VAMS\_ENABLE\_\_ 151
  - {,} concatenate and replicate 154
  - | (bitwise or) 173
  - || (logical or) 174
  - ~ (bitwise invert) 173
  - ~& (bitwise nand) 173
  - ~^ (bitwise exclusive nor) 173
  - ~| (bitwise nor) 173
  - 'default\_transition 80, 180
  - 'define 151
  - 'ifdef 151
  - 'include 36, 151
  - 'M\_... (math constant) 65, 153
  - 'P\_... (physical constant) 65, 153
  - 'resetall 152
  - 'timescale 152
  - 'undef 151
  - 'b binary constant 153
  - 'd decimal constant 153
  - 'h hexadecimal constant 153
  - 'o octal constant 153
- ## A
- a (atto) 154
  - above event 120, 207
    - restrictions 178

- absdelay filter 181
  - absolute tolerance (abstol) 52, 72, 95, 159, 162, 168
  - abstime function 83, 175
  - AC analysis 66, 177, 189
  - ac\_stim stimulus 66, 189
  - Acceleration nature 159
  - access function 38, 52, 159, 168
  - access on demand
    - analog values in discrete process 118, 225
    - discrete values in analog process 115, 223
  - ADC model 84, 118
  - always process 103, 209
  - AMS Designer ix, x
    - compatibility 248–258
  - analog event 67, 72, 78, 204
    - restrictions 178
  - analog functions 204
  - analog operators 177
    - restrictions 177, 178
  - analog process 38, 196
    - accessing discrete values 115, 223
    - sensitive to discrete events 115, 225
    - variable capture 57, 114, 198, 223
    - versus event-driven processes 199
  - analog to digital connect module 131
  - analog to digital converter model 84, 118
  - analysis
    - AC 66, 189
    - noise 66, 189
    - small signal 65
    - transient 242
  - analysis function 175
  - angle natures 159
  - arithmetic operators 173
  - array 157
    - bit select 105, 157, 166
    - branch 167
    - constants 154
    - instance 229
    - net 164
    - part select 157, 166
    - port 84, 166
    - see bus
  - assignment 59, 198
    - blocking 107, 213
    - continuous 102, 213
    - delayed 109, 219
    - contribution 38, 60, 169, 198
    - delayed 107, 218
      - continuous 109, 219
    - discrete event 212
    - indirect 170, 172
      - multiple 171
    - net 214
    - non-blocking 108, 213
    - procedural 212, 213
      - continuous 214
    - register 212, 214
    - wreal 111
  - associated reference directions 50
  - autonomous events 78, 206
- B**
- barrier model 71
  - base nature 53
  - begin-end block 106, 196, 209
  - behavioral description 227
  - behavioral module 45
  - bi-directional connect module 135
  - binary constant 153
  - bit select 105, 157, 166
  - bit stream generator model 206
  - bit variable 103, 156
  - bitwise operators 173
  - block
    - concurrent 106, 211
    - disable 210
    - named 197, 210
    - parallel, see concurrent block
    - procedural 106, 196, 209
    - sequential, see procedural block
  - blocking assignment 107, 213
  - bottom-up design methodology 17
  - bottom-up verification 28
  - bound\_step function 77, 190
  - branch 47, 167
    - declaration 56, 167
    - named or explicit 56, 167
    - port 168
    - probe 61
    - signal access 168
    - source 62
    - switch 62
    - unnamed or implicit 38, 167
    - vector 167

- breakdown warning model 208
- bus 84, 102, 105, 165, 229
  - bit select 105, 157, 166
  - part select 157, 166
- C**
- capacitor model 39
- captured variable 57, 114, 198, 223
- case sensitivity 149
  - Spectre 245
  - SPICE 237
- case statement 201
- charge conservation 54
- Charge nature 159
- circular integrator 75, 179
- clock model 103, 209
- comment 36, 149
- compact model 9
- comparator model 121, 226, 227
- compatibility
  - AMS Designer 248–258
  - Spectre 241–247
  - SPICE 236–241
  - Verilog-HDL 235
- component 46
- concatenate operator 106, 154
- concurrent block 106, 211
- conditional
  - case statement 201
  - if-else statement 68, 200
  - inline 174, 200
- conductor model 39
- configuration 256
- connect module 131–145
  - analog to digital 131
  - automatic insertion 128, 253
  - bi-directional 135
  - digital to analog 135
- connect statement 125, 129, 163
- connectrules 125, 129, 163
- conservative
  - discipline 160
  - system 46
- constant 152
  - expression 172
  - integer 152
  - logic 152
  - mathematical 155
  - physical 155
  - real 153
  - strings 154
  - vector 154
- constants.vams file 65, 153
- continuous assignment 102, 213
  - delayed 109, 219
  - wreal 111
- continuous domain 160
- continuous-time kernel 196
- contribution statement 38, 60, 169, 198
  - and indirect assignment 172
  - and simultaneous solution 199
  - restrictions 178
- counter model 109, 210, 211
- cross event 67, 72, 206
  - restrictions 178
  - tolerance 81
- current discipline 161
- Current nature 159
- current source model 41
- current, see flow
- D**
- d flip flop model 104, 207, 214, 217
- DAC model 87, 111, 223, 224
- DC analysis 177
- ddt operator 40, 179
  - restrictions 178
- ddt\_nature 96
- decade counter model 210
- decimal constant 153
- define statement 151
- defparam statement 233
- delay
  - # 103, 166, 216
    - not allowed in analog process 196
  - @ 104, 216
  - analog (absdelay) 181
  - gate 230
  - inter-assignment 107, 218
  - net 166
  - wait 105, 218
    - not allowed in analog process 196
- delay function (absdelay) 181
- delay measurement model 80
- derivative (ddt) 40, 179
- derived nature 53

- design 2
  - design methodology
    - bottom up 17
    - primitive top down 17
    - rigorous top down 24
    - top down design principles 19
  - difference equations 187
  - digital functions 221
  - digital signal 3
  - digital to analog connect module 135
  - digital to analog converter model 87, 111, 223, 224
  - diode
    - ideal 73
    - junction 54
  - disable statement 210
  - discipline 36, 51, 100, 160
    - resolution 123–128
      - basic 124
      - compatible disciplines 124, 162
      - detailed 127
      - specifying 252
  - disciplines.vams file 37, 159
  - discontinuity function 69, 79, 80, 191
  - discrete domain 160
  - discrete process
    - accessing analog values 118, 225
    - sensitive to analog events 119, 225
    - variable capture 114, 223
  - discrete-event kernel 209
  - discrete-event signal 3
  - display function 192
  - distributions, random 194
  - domain 160
  - driver/receiver segregation 137
  - driver\_... functions 144, 145
- E**
- e (exponent) 154
  - edge triggered 67, 80, 104, 217
  - electrical discipline 161
  - elements of style 96
  - environment functions 175
  - equality operators 174
  - escaped identifiers 149
  - event
    - above 120, 207
    - analog 67, 72, 78, 204
    - in discrete process 119, 225
    - restrictions 178
  - cross 67, 72, 81, 206
  - delayed assignment 107, 218
  - different in analog process 196
  - discrete 216
    - in analog process 115, 225
  - expression 217
  - final\_step 83, 205
  - initial\_step 78, 92, 205
  - named 217
  - restrictions 83
  - timer 78, 206
  - exclude keyword 55, 158
  - executable specification 23
  - explicit branch 56
  - expression 172
- F**
- f (femto) 154
  - fclose function 193
  - fdisplay function 193
  - file
    - constants.vams 153
    - disciplines.vams 159
  - file inclusion 36, 151
  - filter 177
    - absdelay 181
    - ddt 40, 179
    - idt 179
    - idtmod 75, 179
    - laplace 92, 182
    - restrictions 83, 177
    - sampled data 184
    - slew 181
    - transition 79, 180
    - z 184
  - final verification 29
  - final\_step event 83, 205
  - finish function 191
  - finite-state machines 2, 13
  - FIR filter 187
  - fixed-point formulation 169
  - flicker\_noise stimulus 66, 189
  - flow 47, 161, 168
    - probe 61
    - source 62
  - Flux nature 159

fopen function 193  
for loop 93, 202  
Force nature 159  
forever loop 220  
fork-join block 106, 211  
formal specification 23  
frequency measurement model 110  
from keyword 55, 158  
fstrobe function 194  
function  
    \$abstime 83, 175  
    \$bound\_step 77, 190  
    \$discontinuity 69, 79, 80, 191  
    \$display 192  
    \$driver\_... 144, 145  
    \$fclose 193  
    \$fdisplay 193  
    \$finish 191  
    \$fopen 193  
    \$fstrobe 194  
    \$limexp 57, 188  
    \$monitor 193  
    \$random 194  
    \$rdist\_... 194  
    \$realtime 176  
    \$stop 191  
    \$strobe 84, 192  
    \$temperature 57, 177  
    \$vt 57, 177  
    \$write 193  
    above 120, 207  
    absdelay 181  
    ac\_stim 66, 189  
    analog 204  
    analysis 175  
    cross 67, 72, 81, 206  
    ddt 40, 179  
    digital 221  
    environment 175  
    final\_step 83, 205  
    flicker\_noise 66, 189  
    idt 63, 179  
    idtmod 75, 179  
    initial\_step 78, 92, 205  
    laplace\_... 92, 182  
    last\_crossing 81, 188  
    logical 175  
    mathematical 172, 175

noise\_table 66, 189  
restrictions 83  
slew 181  
timer 78, 206  
transition 79, 180  
user defined 190  
    analog 204  
    digital 221  
versus task 220  
white\_noise 66, 189  
zi\_... 184

## **G**

G (giga) 154  
gate-level descriptions 229  
generate loop 203  
genvar 84  
    expression 178, 201, 203  
    restricted for loop 84  
    variables 157  
ground 49  
    statement 43, 166

## **H**

hardware description language 1  
hexadecimal constant 153  
hierarchical name 72, 232  
    discipline 124

## **I**

IC analysis 177  
ideal diode model 73  
ideal opamp model 171  
identifier 149  
identity operators 174  
idt operator 63, 179  
    restrictions 178  
idt\_nature 96  
idtmod operator 75, 179  
    restrictions 178  
ifdef statement 151  
if-else statement 68, 200  
IIR filter 187  
implicit branch 38, 167  
implicit formulation 59, 169  
Impulse nature 159  
include statement 36, 151  
index, vector 105, 157  
indirect assignment 170

- and contribution 172
- multiple 171
- inductor model 40
  - lossy 88
- initial process 103, 209
- initial\_step event 78, 92, 205
- inout statement 37, 164
- input statement 37, 164
- instantiation 43, 227
- integer
  - constants 152
  - variables 156
- integral (idt) 179
- integral (idtmod) 75, 179
- inter-assignment delay 107, 218
- interface component 99, 131–145
  - automatic insertion 128, 253
- interval measurement model 80
- inverter model 100
- IP reuse 31
- iterator 202, 220

**J**

- join-fork block 106, 211
- junction diode model 54

**K**

- k (kilo) 154
- kernel 5
  - continuous-time 196
  - discrete-event 209
- keywords 150
- kinematic disciplines 161
- Kirchhoff's laws 47, 95

**L**

- laplace filters 92, 182
  - restrictions 178
- last\_crossing function 81, 188
  - restrictions 178
- latch model 105, 230
- level triggered 105, 218
- limexp function 57, 188
  - restrictions 179
- logic
  - constants 152
  - discipline 100, 161
  - functions 175
  - operators 174

- values 102, 156
- variables 103, 156
- loop 202, 220
  - analog operator restrictions 178
  - for 93, 202
  - forever 220
  - generate 203
  - genvar 84
  - repeat and while 202
- lossy inductor 88
- lossy transmission line 245

**M**

- M (mega) 154
- m (milli) 154
- M\_... (math constant) 65, 153
- macro 151
- macromodule 226
- magnetic discipline 161
- Magneto\_Motive\_Force nature 159
- mathematical constants 155
- mathematical functions 172, 175
- mechanical stop model 71
- methodology
  - bottom-up design 17
  - primitive top-down design 17
  - principles of top-down design 19
  - rigorous top-down design 24
- mixed-level simulation 21, 27
- mixed-signal
  - behavior 111
  - netlist 121–145
  - simulators 5
- model
  - ADC 84, 118
  - barrier 71
  - bit stream generator 206
  - breakdown warning 208
  - capacitor 39
  - clock 103, 209
  - comparator 121, 226, 227
  - conductor 39
  - connect module
    - analog to digital 131
    - bi-directional 141, 146
    - digital to analog 135
  - counter 109, 210, 211
  - d flip flop 104, 207, 214, 217

- DAC 87, 111, 223, 224
  - frequency measurement 110
  - ideal diode 73
  - ideal opamp 171
  - independent source 41
  - inductor 40
    - lossy 88
  - inverter 100
  - junction diode 54
  - latch 105, 230
  - mechanical stop 71
  - motor 50
  - port 65
  - quantizer 243
  - relay 67, 115
  - resistor 35
  - RLC 63
  - sample and hold 77, 225
  - skin effect 88
  - Spectre 244, 257
  - SPICE 238, 241, 244, 257
  - structural 41–50, 121–145, 226–233
  - switch (controlled) 67, 115
  - time interval measurement 80
  - tristate buffer 224
  - VCO 73, 118
  - modeling plan 22, 24
  - modeling style 96
  - module 37, 226
    - SPICE 239
  - monitor function 193
  - motor model 50
  - multiple indirect assignment 171
  - multiple instantiation 229
  - multiplicity factor 241
- N**
- n (nano) 154
  - name, hierarchical 232
    - discipline 124
  - named block 197, 210
  - named branch 56, 167
  - named event 217
  - names, SPICE 239
  - nature 36, 51, 95, 159
  - negedge 105, 217
  - net 164
    - assignment 214
    - delay 166
      - rules of use vs. resistors 215
      - signal access 168
      - types 165
      - vector 164
      - versus node 162
    - netlist 41–50, 121–145, 226–233
      - definition 45
    - node 47, 164
      - versus net 162
    - nodeset analysis 177
    - noise analysis 66, 177, 189
    - noise\_table stimulus 66, 189
    - non-blocking assignment 108, 213
    - number 152
- O**
- octal constant 153
  - OOMR 233
    - discipline 124
  - opamp, ideal 171
  - operator 172
    - analog 177
    - concatenate 106, 154
    - ddt 40, 179
    - idt 63, 179
    - idtmod 75, 179
    - replicate 154
    - restrictions 83, 177
  - out of module reference (OOMR) 233
    - discipline 124
  - output statement 37, 164
  - override, absolute tolerance (abstol) 159
- P**
- p (pico) 154
  - P\_... (physical constant) 65, 153
  - parallel block, see concurrent block
  - parameter 37, 55, 75, 157, 228
  - part select 157, 166
  - physical constants 155
  - pin, see port
  - plan, verification and modeling 22, 24
  - port 37, 46, 164, 228
    - branch 168
    - direction 37, 164
    - model 65
    - signal access 168
    - vector 84, 166

posedge 105, 217  
 Position nature 159  
 potential 47, 161, 168  
   probe 61  
   source 62  
 primitive  
   Spectre 244, 257  
   SPICE 239, 257  
 probe branch 61  
 procedural assignment 212  
 procedural block 106, 196, 209  
 procedural continuous assignment 214  
 process 38, 103, 196, 209  
   analog 38, 196  
   initial and always 209  
   variable capture 57, 114, 198, 223  
 pseudo-random bit stream generator 206

**Q**

quantizer model 243

**R**

random function 194  
 range limit 55  
 rdist\_... functions 194  
 real  
   constants 153  
   variables 157  
 realtime function 176  
 real-valued event driven nets 164  
 reduction operators 173  
 reference directions 50  
 reference node 43, 49, 166  
 reg, see register  
 register 103, 156  
   assignment 212, 214  
   captured 198, 223  
   rules of use vs. nets 215  
 register-transfer level 2, 13  
 relational operators 174  
 relative tolerance (reltol) 95  
 relay model 67, 115  
   non ideal 69, 115  
 repeat loop 202  
 replicate operator 154  
 resetall statement 152  
 resistive port model 65  
 resistor model 35  
 resistor noise 66, 189

resolveto statement 125, 163  
 restricted for loop 84, 203  
 reuse 31  
 RLC model 63  
 rotational disciplines 161  
 rules of scope 230

**S**

sample and hold 186  
   model 77, 225  
 scaled 166  
 scale factors 43, 153  
 scaling 96  
 scope rules 230  
 sequential block, see procedural block  
 shift operators 174  
 signal 167  
   attributes, accessing 168  
 signal flow 75  
   discipline 160  
   port 166  
 simulation 1  
   mixed level 21, 27  
   plan 22, 24  
 simultaneous solution 199  
 skin effect model 88  
 slew filter 181  
   restrictions 178  
 small-signal analysis 65  
 source branch 62  
 specification, executable 23  
 Spectre ix, x  
   case sensitivity 245  
   compatibility 241–247  
   from AMS Designer 257  
   model 244  
   subcircuit 245  
   with Verilog-A 241  
 SPICE 8  
   case sensitivity 237  
   compatibility 236–241  
   from AMS Designer 257  
   model 238, 241, 244  
   multiplicity factor 241  
   names 239  
   primitive 239  
   subcircuit 238  
 spontaneous events 78, 206



- state equations 171
  - state variable 79
  - static analysis 177
  - stimulus, ac and noise 66, 189
  - stop function 191
  - stop, mechanical 71
  - string
    - as argument 208
    - constant 154
  - strobe function 84, 192
  - structural module 41–50, 121–145, 226–233
    - definition 45
  - style, modeling 96
  - subcircuit
    - Spectre 245, 257
    - SPICE 238, 257
  - supply0, supply1 wire types 165
  - switch (controlled) model 67, 115
    - non ideal 69, 115
  - switch branch 62, 169
  - synchronization
    - analog event in discrete process 120
    - discrete event in analog process 116
  - synthesis 1, 13
  - system 46
  - system function, see function
  - system-level verification 26
  - SystemVerilog ix, 249
- T**
- T (tera) 154
  - task 221
    - versus function 220
  - temperature function 57, 177
  - Temperature nature 159
  - terminal, see port
  - test 30
  - test bench 10
  - thermal discipline 161
  - thermal noise 66, 189
  - thermal voltage (vt) function 177
  - time function 83, 175, 176
  - time interval measurement model 80
  - time unit 152, 176, 216, 218
  - timer event 78, 206
  - timescale 152
  - timing control 104, 216
  - tolerance 94
    - see absolute tolerance
    - see relative tolerance
  - top-down design methodology
    - primitive 17
    - principles 19
    - rigorous 24
  - top-level module 227
  - torque nature (Angular\_Force) 52, 159
  - transient analysis 177, 242
  - transition filter 79, 180
    - restrictions 178
  - transmission line 245
  - tri, triand, trior, tri0, tri1, trireg wire
    - types 165
  - triggered
    - edge 67, 80, 104, 217
    - level 105, 218
  - tristate buffer model 224
- U**
- u (micro) 154
  - unary reduction operators 173
  - undef statement 151
  - units 52, 159
  - unnamed branch 38, 167
  - user-defined functions 190
    - analog 204
    - digital 221
- V**
- variable 57, 155
    - captured 57, 114, 198, 223
    - genvar 157
    - initialization 57
    - integer 156
    - logic 103, 156
    - real 157
    - register 103, 156
    - vector 105
    - vectors 157
  - VCO model 73, 118
  - vector 157
    - access 105, 157
    - bit select 105, 157, 166
    - branch 167
    - constants 154
    - instance 229
    - net 164
    - part select 157, 166

- port 84, 166
  - see bus
  - variables 105, 157
- vectored 166
- Velocity nature 159
- verification
  - bottom up 28
  - final 29
  - mixed level 21, 27
  - plan 22, 24
  - system level 26
- Verilog languages 2
- Verilog-A 35–98
  - with Spectre 241
- Verilog-HDL compatibility 235
- VHDL-AMS 2, 257
- voltage discipline 161
- Voltage nature 159
- voltage source model 41
- voltage, see potential
- VPI 234
- vt function 57, 177

## **W**

- wait 218
  - not allowed in analog process 196
- wait statement 105
- wand (wired and) wire type 165
- while loop 202
- white\_noise stimulus 66, 189
- wire 101, 165
- wor (wired or) wire type 165
- wreal wire type 164
- write function 193

## **X**

- x logic value 101, 102, 153, 156
  - accessing in analog process 223, 224

## **Z**

- z filters 184
  - restrictions 178
- z logic value 101, 102, 153, 156
  - accessing in analog process 223, 224