

Index

6

64-bit addition, 203
 64-bit logic shift left, 206
 64-bit multiplication, 208
 64-bit operations, 203
 64-bit shifted right, 207
 64-bit sign extension, 205
 64-bit signed division, 211
 64-bit subtraction, 204

A

ABI, 167
 access C variables, 231
 accumulator-based instruction set, 61
 ACK, 50, 496, 499, 500, 501, 508
 ADC, 443
 continuous mode, 450
 digital quantization, 444
 DMA, 460
 external trigger, 452
 freeze mode, 453
 quantization error, 448
 sample-and-hold amplifier, 446
 sampling time, 446
 scan mode, 450
 single mode, 450
 software trigger, 452
 trigger, 452
 add, 80
 add with carry, 67, 80
 ADSR, 477
 advanced high-performance bus, 59
 advanced peripheral bus, 59
 AHB, 59, 251, 435
 ALIGN, 218
 aligned memory accesses, 221
 alignmefor, 217
 alignment
 double-word alignment, 217
 halfword alignment, 217
 word alignment, 217

alternative functions, 335
 ALU, 20, 24, 25, 59, 61, 62, 75, 78
 always, 112
 AMBA, 435
 analog watchdog, 451
 APB, 59, 435
 application binary interface, 173, 191, 215
 application program status register, 75, 111
 APSR, 75, 92, 93, 111
 arithmetic
 add, 80
 add with carry, 80
 multiply and subtract, 80
 reverse subtract, 80
 subtract, 80
 subtract with carry, 80
 arithmetic logic unit, 59
 ARM EABI, 169
 ARM state, 57
 ARM32, 55, 56, 57, 73
 ARM64, 55, 56, 73
 Armstrong numbers, 151
 ASCII, 49
 assembly function in C programs, 228
 assembly instruction, 66
 assembly program, 2
 asynchronous transmission, 483
 AT commands, 493
 atoi, 154
 audio, 535
 AVRCP, 493

B

Barrel shifter, 64, 78, 83
 base, 29, 265
 BASEPRI, 14, 92, 249
 baud rate, 485
 BCD encodes, 427
biased exponent, 277
 big endianness, 100
 binary executable, 1
 binary interface, 167

- binary numbers, 29, 31
- binary search, 155
- bipolar, 389
- bit*, 27
 - bit mask, 86
 - check a bit, 86
 - clear a bit, 87
 - set a bit, 87
 - toggle a bit, 87
- bit mask, 86
- bit order, 89
- bit stuffing, 523
- bitwise logic
 - AND, 85
 - bit clear, 85
 - move not, 85
- BL, 116
- Bluetooth, 492
 - address, 492
 - AT commands, 493
 - HC-05, 493
 - HC-06, 493
 - paring, 493
- BLX, 116
- boot loader, 19
- branch
 - branch if equal, 114
 - branch if negative, 114
 - branch if not equal, 114
 - branch if overflow set, 114
 - branch if positive or zero, 114
 - branch if signed greater or equal, 114
 - branch if signed greater than, 114
 - branch if signed less than, 114
 - branch if signed less than or equal, 114
 - branch if unsigned higher, 114
 - branch if unsigned higher or same, 114
 - branch if unsigned lower, 114
 - branch if unsigned lower or same, 114
 - branch label, 114
 - table branch byte, 127
 - table branch halfword, 128
- branch and exchange, 68, 116, 162
- branch and link, 68, 116, 162
- branch indirect with link, 116
- branch instruction, 114
- branch with link and exchange, 68
- break statement, 126

- bubble sort, 157
- buffered output, 467
- bulk transfers, 524
- bus, 4, 59
- bus matrix, 58
- BX, 116
- byte, 27
- byte order, 89

C

- calendar time, 425
- call a C function from assembly, 232
- call an assembly subroutine from C, 230
- caller, 9, 162, 166, 173, 175, 190
- calloc, 8
- carry flag, 36, 37, 42, 75
- CBNZ, 116
- CBZ, 116
- CDC, 535
- change processor state, 249
- change-on-zero, 523
- check a bit, 86
- circular right rotate, 98
- clear a bit, 87
- clock arbitration, 498
- clock phase, 516
- clock polarity, 516
- clock synchronization, 498
- CMAR, 439
- CNDTR, 439
- collector, 340
- comment, 2, 21, 63, 64, 65
- compare and branch on non-zero, 116
- compare and branch on zero, 116
- compare and capture register, 365, 371
- compare negative, 68, 77, 91
- compound Boolean expression, 119
- compound logical expression, 120
- compwithnd Boolean expression, 119
- condition flags, 111, 117
- conditional branch instruction, 114
- conditional execution, 117
- context switch, 549, 552, 554, 555
- continue statement, 125
- control register, 466, 508, 543, 545
- control structures, 133
- coordinated universal time, 425

Cortex-A, 56
Cortex-M, 56
Cortex-M0, 57, 317
Cortex-M1, 57
Cortex-M4, 57, 73, 317
Cortex-R, 56
 count digits, 146
 counter overflow, 387
 counter underflow, 387
 CPACR, 295, 297, 298
 CPAR, 439
 CPS, 249
 CPSID, 249
 CPSIE, 68, 249, 546, 548, 556
 CRC, 526

D

DAC, 463
 buffered output, 467
 control register, 467
 data output register, 466
 resolution, 464
 sampling rate, 464
 trigger, 466
 Darlington array, 400
 data alignment, 217
 data comparison, 91
 data memory, 5, 7, 8, 9, 18, 19, 20, 21, 22, 23, 24, 25,
 58, 73, 138, 139, 171, 202, 223, 364, 408, 411, 482
 data memory barrier, 68
 data minus, 522
 data plus, 522
 data structure padding, 219
 data symbols, 1
 data synchronization barrier, 68
DCB, 71
DCD, 71
DCQ, 71
DCW, 71
 De Morgan's laws, 120
 debouncing, 350
 decimal, 29, 265
 decode, 324
 default NaN, 299
 deformatized, 282
 delay, 256
 differential signals, 522

digital input filter, 376
 digital quantization, 444
 direct memory access, 435
 directives, 2, 65, 66, 69, 70, 72
 dividing by zero, 261
 DMA, 435, 460
 DMA and interrupt enable register, 378
double precision, 277
double-word, 27
 do-while loop, 124
 DSP, 559
 digital filtering, 579
 extension and add, 573
 finite impulse response, 580
 fixed-point DSP, 559, 560
 floating-point DSP, 559
 multiply, 577
 multiply and accumulate, 580, 584, 585, 586
 overflow, 561
 Q flag, 563
 saturation, 561
 vector absolute value, 593
 vector dot product, 602
 vector mean, 598
 vector min and max, 603
 vector negate, 592
 vector offset with saturation, 595
 vector shift with saturation, 597
 wrap-around, 561
 duty cycle, 368
 duty ratio, 403

E

EABI, 178, 230, 232
 electromagnetic interference, 344
 ELF, 3, 25, 628
 embedded assembly in C programs, 229
 EMI, 344
 END, 70
 end of packet, 526
 endianness, 89
 endianness, 100, 129, 243
 ENDP, 70
 endpoint, 521, 524, 526, 527, 528, 530, 533, 536
 enumeration, 531
 EOP, 525, 526, 527
 EPSR, 75, 92, 93

EQU, 71, 348
 equal, 112
 event generation register, 370
 exception, 240
 exception handling, 261
 executable and linkable format, 3
 executable file, 1
 executable interface, 3
 execution program status register, 75
 execution view, 4
 export, 175, 230
 extern, 231, 233
 external trigger, 453
 external voltage reference, 449

F

factorial numbers, 141, 194
 FAULTMASK, 14, 92, 249
 FHSS, 492
FILL, 71
 find maximum, 144
 fixed-point numbers, 266
 accuracy, 270
 addition, 272
 division, 274
 multiplication, 273
 Qm.n format, 267
 range, 270
 resolution, 270
 subtraction, 272
 flash memory, 7
 floating-point numbers, 275
 addition, 289
 biased exponent, 277
 double precision, 277
 fraction field, 277
 half precision, 277
 IEEE 754, 275
 normalized notation, 275
 overflow, 281
 range, 283
 rounding rules, 285
 rounding to even, 286
 rounding up, 287
 sign bit, 277
 single precision, 277
 special values, 280

 subnormal numbers, 282
 truncation, 287
 underflow, 281
 floating-point register, 295
 floating-point unit, 266
 flowcharts, 136
 for loop, 122
 FPCAR, 295, 300, 301, 310, 315
 FPCCR, 295, 301, 302, 310
 FPSCR, 295, 298, 299, 300, 303, 305, 306, 308, 309, 310, 609
 FPU, 295, 468
 alternative half-precision, 299
 arithmetic instructions, 304
 comparison, 305
 conversion, 306
 copy, 303
 CPACR, 297
 default NaN mode, 299
 divide-by-zero exception, 300
 exception handling, 308
 exceptions, 299, 308
 flushing-to-zero, 299
 FPCAR, 300
 FPCCR, 301
 FPSCR, 298
 inexact exception, 299
 input denormal cumulative exception, 300
 invalid operation exception, 299
 load and store, 302
 N, Z, C, V flags, 298
 overflow exception, 299
 registers, 295
 rounding, 298
 underflow exception, 299
 fraction field, 277
 freeze mode, 453
 frequency hopping, 492
 FT232R, 487
 full stepping, 391, 392, 393, 394, 395, 397
 function, 161

G

GAVDP, 493
 GCD, 177
 GE flags, 590
 general-purpose integer registers, 13

- get, 72
- global, 230
- global static variable, 222
- goto, 133
- goto statement, 135
- GPIO, 335
 - data input register, 347
 - data output register, 347
 - input data register, 336
 - open drain, 342
 - output data register, 336
 - pull down, 336
 - pull up, 336
 - push pull, 340
 - slew rate, 343
 - strong pull down, 337
 - strong pull up*, 337
 - weak pull down, 337
 - weak pull up*, 337
- greatest common divisor, 177

H

- half precision, 277
- half stepping, 395
- halfword*, 27
- Hamming distance, 142
- harmonics, 344, 476
- Harvard architecture, 4, 7, 10, 18, 24
- HD44780, 416
- heap, 8, 158, 171, 223
- hexadecimal, 29
- HID, 535, 536
- HID descriptor, 537, 539
- HSI, 385

I

- I²C, 495
 - ACK, 496
 - NACK, 496
 - open drain, 495
 - SCL, 495
 - SDA, 495
 - start, 496
 - stop, 496
- ICPSC, 377
- if-then statement, 118
- if-then-else statement, 121
- immediate number, 61, 64, 81, 93, 97, 98, 99, 319, 324, 325, 326, 327, 546
- import, 175, 231
- include, 72
- initialized data segment, 8
- injected channel, 456
- inline assembly, 228
- input capture, 375
 - prescaler, 377
- instruction memory, 5, 7, 8, 14, 15, 19, 20, 25, 56, 58, 59, 318
- instruction synchronization barrier, 68
- interface class, 528
- internal reference voltage, 449
- interrupt*, 237
 - active bit register, 242
 - clear pending register, 242
 - controller type register, 242
 - enable and disable, 243
 - external interrupt, 240, 258
 - interrupt levels, 246
 - interrupt number, 242
 - pending bit, 243
 - preemption priority, 245
 - priority*, 239
 - set enable register, 242
 - set pending register, 242
 - software interrupts, 261
 - software trigger, 243
 - stacking, 241
 - unstacking, 241
- interrupt clear enable register, 242
- interrupt priority, 245
- interrupt priority register, 245
- interrupt program status register, 75
- interrupt service routine*, 237
- interrupt transfers, 524
- intra-procedure-call register, 167
- Intra-Procedure-Call register, 168
- Inverting Schmitt trigger, 338
- IP, 245
- IPSR, 75, 92, 93
- ISER, 242, 243, 245, 433
- isochronous transfers, 524, 530, 535
- itoa, 182

J

J state, 523
 Java executables, 1
 JEOC, 456

K

K state, 523
 keypad reverse scanning, 356
 keypad scanning algorithm, 353

L

label, 2, 63, 65, 127, 136
 last-in-first-out, 164
 LCD
 4-bit bus mode, 417
 8-bit bus mode, 417
 bias, 403, 404
 commands, 420
 common terminals, 407
 data bus, 417
 data memory, 409
 display memory, 409
 duty ratio, 403
 encoding, 412, 419
 function set, 421
 initialization, 421
 nibble, 417
 programming fonts, 423
 register select, 417
 size, 419
 LDM
 LDMDA, 106, 165
 LDMDB, 68, 106, 165
 LDMIA, 106, 108, 165, 166
 LDMIB, 106, 165
 LDR, 98
 LDRB, 68, 103, 109, 126, 152, 153, 154, 176, 179, 180,
 183, 186, 196, 216, 217, 229, 230, 236, 617, 618
 LDRSB, 68, 103, 104, 109, 216, 217, 617
 leap second, 425
 LIFO, 164
 linkable interface, 3
 little endianness, 100, 243
 load
 load byte, 103

 load halfword, 103
 load multiple words, 103
 load signed byte, 103
 load signed halfword, 103
 load word, 103
 load constant into registers, 97
 load register exclusive, 68
 load register with byte, 109, 216, 217
 load register with double-word, 217
 load register with signed byte, 109, 216
 load register with signed halfword, 109, 217
 loading effects, 467
 loading view, 3
 load-store instruction set, 61, 62
 local static variable, 222, 224
 logic shift left, 67, 321
 logic shift right, 67, 207
 lookup table, 468
 loop structure, 134

M

machine program, 1, 3, 4, 18
 main stack, 14, 238, 242, 262, 315, 543, 553, 554, 556,
 557
 major opcode, 321
 malloc, 8
 mask, 86
 matrix transpose, 184
 memory
 data memory, 4
 instruction memory, 4
 main memory, 4
 memory address modes, 101
 memory addressing modes, 101
 pre-index, 102
 memory mapped I/O, 10
 micro-stepping, 397
 minor opcode, 320, 321
 MISO, 513
 mnemonic, 2, 63, 64, 77
 MOSI, 513
 move 16-bit immediate value to bottom halfword,
 97
 move 16-bit immediate value to top, 97
 move from general register to special register, 93
 move from special register to general register, 93
 move not, 92

move the bitwise inverse of 8-bit immediate value,
97
MSC, 535
MSP, 238
multiply and accumulate, 580, 584, 585, 586
multiply and subtract, 80
multiply-accumulate, 67
multiply-subtract, 67
musical
ADSR, 477
amplitude, 476
duration, 477
pitch, 476
timbre, 476
tone, 476

N

NACK, 496, 501
NaN, 280
negative, 112
negative flag, 75
nibble, 417
NMI, 14, 249
noise filtering, 376
non-preemptive, 237
non-return-to-zero inverted, 523
non-static variable, 223
non-system interrupts, 242
non-volatile, 4, 7, 227
normalized presentation, 282
NOT, 93
not any number, 280
note equal, 112
NRZI, 523
NULL, 49, 50, 51, 54, 153, 159, 176, 180, 183, 235,
492
NULL terminator, 50
NVIC, 59, 238, 241, 242, 243, 244, 245, 247, 249, 251,
259, 489, 520, 554
Nyquist frequency, 559

O

object codes, 3
OCM, 363
OCREF, 363
octal, 29

one's complement, 34
opcode, 63, 319, 320, 321, 325, 326, 327
open collector, 495
open drain, 340, 341, 342, 347, 349, 352, 356, 366,
495
operands, 2, 11, 24, 33, 39, 45, 46, 47, 49, 55, 59, 61,
62, 63, 64, 65, 81, 83, 92, 99, 203, 267, 274, 294,
318, 319, 320, 321, 325
output compare mode, 363
over-capture flag, 377
overflow, 39, 42
overflow on subtraction, 40
overflow clear, 112, 114
overflow flag, 36, 75
overflow set, 112

P

pack two halfwords, 588
packed, 221
packed data structure, 219
padding, 219
palindrome string, 152
parity, 147
even parity, 147
odd parity, 147
parity bit, 485
part per million, 522
pass arguments, 169
pass by reference, 170, 171
pass by value, 170, 171, 176
PC-relative addressing, 99, 104, 105, 332
perfect number, 149
peripheral interrupt, 242, 243, 244, 245, 247, 248
permutation, 197
PHDC, 535
piconet, 492
plus, 112, 114
polling, 238, 240, 351, 357
positive or zero, 112
post-index format, 101
pot, 455
potentiometer, 455
power dissipation, 443
PPM, 522
preempt priority, 246
preemptive, 237
prescaler, 362

PRIMASK, 14, 92, 249, 548, 556
 privileged state, 543, 545, 548
 PROC, 70
 procedure, 161
 process stack, 14, 242, 543, 553, 554, 556, 557
 processor exception, 242
 program counter, 15
 program status register, 75
 pseudo instruction, 19, 66, 98, 99, 105, 153
 PSR, 75, 92, 93, 241, 257, 262, 315, 548, 551, 553, 555, 556
 pull down, 336, 337
 pull up, 336, 337
 push button, 350
 push pull, 340, 341, 342, 344, 347, 349, 352, 356, 365, 381
 PVD output, 260
 PWM, 367
 control register, 370
 mode, 370

Q

Q15, 560
 Q31, 560
 Q7, 560
 QNaN, 280
 quantization error, 448
 Quiet NaN, 280

R

radio frequency interference, 344
 radix, 265
 read-only section, 3
 read-write section, 3
 real number, 27, 265, 270, 278, 313
 real-time clock, 425
recursive function, 192
register allocation, 13
 registers, 11
 general purpose registers, 11
 live range, 138
 register reuse, 138
 scratch registers, 167, 173
 special purpose registers, 11
 virtual registers, 229
 regular channel, 456

resolution, 443
 reverse bits, 89
 reverse byte order, 89
 reverse subtract, 67, 80
 RFCOMM, 493
 RFI, 344
 rise time, 502
 ROR, 215
 rotate
 rotate right, 67, 79
 rotate right with extend, 79
 rotate right with extend, 67
 round to even, 286
 round to the nearest, 285
 round toward negative infinity, 285
 round toward plus infinity, 285
 round toward zero, 285
 rounding up, 287
 round-robin scheduler, 549, 557
 routine, 161
 RRX, 215
 RS-232, 486
 RS-422, 486
 RS-485, 486
 RTC, 260, 411, 425, 426, 428, 429, 430, 431, 432, 433, 434
 alarm time comparison, 431
 RTC alarm, 431
 RTC alarm event, 260
 RTC tamper and time stamp events, 260

S

S suffix, 77, 88, 324, 327
 sample-and-hold amplifier, 444, 446
sampling rate, 443
 sampling time, 446
 saturation, 83
 saturation flag, 75
 scanning algorithm, 354
 SCB, 246, 247, 248, 261
 Schmitt trigger, 337
 SCLK, 513
 SE0, 523
 SE1, 523
 selection structure, 134
 Separated Operand Scanning, 586
 sequence structure, 134

- servo motor, 389
- set a bit, 87
- shift
 - arithmetic shift right, 67, 79
 - logical shift left, 78
 - logical shift right, 78
- shift and rotate, 78
- SHP, 246
- sign and magnitude, 33
- sign and zero extension, 90
- sign extension, 216, 451
- Signaling NaN, 280
- signed division, 48, 79
- signed greater or equal, 112
- signed greater than, 112
- signed integer, 31
- signed less than, 112
- signed less than or equal, 112
- signed long multiply-accumulate, 67
- signed saturate, 80, 83
- SIMD, 560, 563, 564, 565, 567, 571, 588, 590, 595, 601
 - add, 565, 566
 - byte selection, 591
 - GE flags, 590
 - saturating add, 568
 - saturating subtract, 568
 - signed extension, 589
 - subtract, 565
 - unsigned extension, 589
- single precision*, 277
- single-ended signal, 523
- sinusoidal, 476
- slave select line, 513
- slew rate, 343
- SNaN, 280
- SOF, 526
- software trigger, 452
- software trigger interrupt register, 242, 243
- SPACE**, 71
- SPI, 513
- SPI mode, 516
- SSAT, 68, 75, 80, 83
- stack, 7, 8, 9, 13, 61, 68, 162, 163, 164, 166, 167, 168, 169, 173, 178, 190, 191, 194, 201, 202, 215, 228, 229, 241, 250, 263, 316, 470, 543, 544, 545, 546, 547, 548, 549, 551, 552, 553, 554, 555, 556, 557
 - ascending stack, 164
 - descending stack, 164
 - full stack, 164
- stack frame pointer, 552
- stack-based instruction set, 61, 62
- stacking, 241
- start-of-frame, 526
- static variable, 222
- statically-allocated, 4
- step angle, 391
- stepper motor, 389
 - full stepping*, 393
 - half stepping, 395
 - micro-stepping, 397
 - wave stepping, 393
- stepwise refinement, 135
- STIR, 242, 243
- STM
 - STMDA, 106, 165
 - STMDB, 68, 106, 108, 165, 166, 555, 556
 - STMIA, 106, 108, 165
 - STMIB, 106, 165
- store
 - store lower byte, 104
 - store lower halfword, 104
 - store multiple words, 104
 - store register byte, 217
 - store register halfword, 217
 - store word, 104
- strcat, 179, 197, 198, 234
- string
 - itoa, 182
 - remove a character, 186
 - reverse a string, 196
 - string comparison, 51, 180
 - string concatenation, 179
 - string permutation, 197
 - strlen, 230, 232
- strong pull down, 337, 353
- strong pull up*, 337, 353
- strchr, 54
- strstr, 54
- structured programming, 133, 134, 135
- subroutine, 161
 - pass arguments through stack, 190
 - pass by reference, 170
 - pass by value, 170
 - passing arguments, 169
- subtract, 80

subtract with carry, 67, 80
 successive-approximation, 443
 suffix S, 117
 supervisor call, 262
 swap, 176, 196
 switch statement, 126
 synchronous protocol, 514
 system control block, 247, 248
 system exception, 242
 system handler priority, 246
 system interrupt, 242
 system tick timer, 250
 SysTick, 71, 226, 227, 250, 251, 252, 255, 257, 262, 263, 315, 554

T

table branch halfword, 128
 TBB, 127
 TBH, 128
 temporal locality, 12
 test, 91
 test equivalence, 91
 test equivalent, 68
 Thumb, 55, 56, 57, 73, 317, 318, 319, 320, 617, 619
 Thumb state, 57
 Thumb-2, 55, 73, 317, 318
 time division duplex, 492
 timer, 359

- center-aligned counting, 360
- compare and capture register, 365
- downcounting, 360
- input capture, 375
- output compare mode, 363
- overflow, 360
- prescaler, 362
- PWM, 370
- underflow, 360
- upcounting, 360

 toggle a bit, 87
 token packet, 526
 transmission bus, 4, 7
 trap, 261
 truncation, 287
 two's complement, 35

U

UART, 483
 UEV, 370
 ULN2803, 400
 ultrasonic distance sensor, 382
 ultrasonic waves, 383
 unaligned memory accesses, 221
 unaligned memory layout, 221
 unconditional branch instruction, 114
 uninitialized data segment, 8
 uninitialized variables, 4
 unipolar, 390
 unique numbers, 187
 Unix Epoch, 425, 434
 unprivileged state, 543, 545
 unsigned decimal, 31
 unsigned division, 48, 78, 212
 unsigned higher, 112
 unsigned higher or same, 112
 unsigned long multiply-subtract, 67
 unsigned lower, 112
 unsigned lower or same, 112
 unsigned numbers, 30
 unsigned saturate, 80, 83
 unstacking, 241
 update event, 370, 386, 387, 453, 472
 update interrupt flag bit, 370
 USAT, 68, 75, 80, 83
 USB, 521

- address field, 525
- bulk transfers, 524
- bus layer, 522
- class layer, 535
- CRC, 526
- data field, 525
- descriptors, 527
- device layer, 524
- differential signals, 522
- endpoint, 524, 530
- enumeration, 531
- functions layer, 527
- GET_DESCRIPTOR requests, 533
- HID, 536
- interrupt transfers, 524
- isochronous transfers, 524
- J state, 523
- K state, 523

NRZI, 523
packet identification field, 525
power supply, 528
product ID, 528
SET_ADDRESS request, 533
speed, 522
start-of-frame, 526
SYNC, 525
transfer type, 524
vendor ID, 528
UTC, 425, 426

V

variable live range, 13
video, 535
virtual decimal place, 266
volatile, 4, 5, 7, 222, 226, 227
volatile variable, 226
von Neumann, 4, 24

W

wait for event, 68
wait for interrupt, 68
wave stepping, 392, 393
weak, 231, 232, 233
weak pull down, 337
weak pull up, 337
while loop, 123
word, 27

X

xPSR, 14

Y

year 2038 problem, 425

Z

zero flag, 75
zero-initialized data section, 4, 7