

## A

### Adaptive filters

- benchmarks 202
- implementations 167
- testing shell for adaptive filters 199
- uses of 158, 159, 160

### Arctangent

- implementation 27
- subroutine 29

## B

### Bit block transfer

- transfer of image data 253

### Bit-reversal 210, 211

### Bresenham line drawing

- pixels 257
- set\_pixel 257

## C

### Cascaded\_biquad 104

### Convolution equation 90

### Cosine approximation

- sine/cosine approximation subroutine 18

### Cosine functions 15

### Cubic B-spline polynomial evaluation

- control points 248
- curves 248
- knots 248
- surfaces 248

### Cubic bexier polynomial evaluation

- control points 244
- knots 244
- parametric equations 244
- three-dimensional curved surfaces 244

# Index

## D

- Decimation filters 113
- Decimation-in frequency (DIF) FFT 207
- Decimation-in-time (DIT) FFT 207
- Digit-reversal 213
- Digital filtering 89
- Discrete fourier transform (DFT) 205
  - computation of the DFT 206
  - frequency bins 206
  - twiddle factors 206
- Divide operation
  - division subroutine 44
  - implementation 44
  - iterative convergence algorithm 44
- Division 44

## E

- EPROM
  - how to make 316
- Exponential approximation
  - exponential function 52
  - exponential subroutine 55
  - implementation 53

## F

- Fast fourier transform (FFT) 205
  - architectural features for FFTs 210
  - benchmarks 216
  - bit-reversal 210, 211
  - butterfly calculations 208
  - complex input radix-2 FFT 211
  - complex input radix-4 FFT 211
  - decimation-in frequency (DIF) FFT 207
  - decimation-in-time (DIT) FFT 207
  - derivation of the fast fourier transform 207
  - digit-reversal 213
  - groups 210
  - inverse complex FFTs 215
  - radix-2 FFT 205, 207, 212
  - radix-4 FFT 205, 207, 213
  - stages 210
  - twiddle factor 206, 212, 214
- Filter structures
  - lattice filter 163
  - symmetric transversal structure 162
  - transversal FIR filter 161

# Index

Finite Impulse Response filter (FIR) 90, 114  
FIR filters 90, 114  
    buffer operation 94  
    convolution equation 90  
    example calling routine 96  
    implementation 91  
    TAPS 91  
Frequency bins 206

## G

Gauss-Jordan algorithm 81  
Graphic line accept/reject-3D  
    clipline 239  
    display device 237  
    trivial acceptance 238  
    trivial rejection 238  
    view volume 237  
Graphics algorithms 71  
Graphics translation, rotation, & scaling-3D  
    4×4 transformation matrix 262  
    multifunction operations 264  
    x, y, and z coordinates 263  
    x, y, z, and w coordinates 263

## H

Histogram equalization  
    gain and offset 288  
    pixel intensity 288  
    pixels 288  
    register pipelining 289

## I

Image processing 71  
Infinite Impulse Response (IIR) filter 119  
    advantages 100  
    canonical form 100  
    cascaded\_biquad 104  
    code listings 106  
    direct form II 100  
    implementation 101  
Interpolation filters 113  
Inverse complex FFTs 215  
Iterative convergence algorithm 44

# Index

## J

### JTAG

- definition 299
- instruction register (IR) 306
- pins 300
- signals 300
- test access port operations 305

### JTAG downloader

- block diagram 302
- code listings 320
- downloader operations 307
- hardware 300
- parts list 304
- prototype board layout 304
- prototype schematic 303
- reference 336
- software 310
- software example 313
- state diagram 305
- system diagram 301
- timing considerations 308
- timing diagram 309
- TMS & TDI bit generation 311

## L

### Least Mean Square (LMS) filters

- algorithm 164
- benchmarks 202
- code listing 169
- gradient lattice-ladder 189
- implementation 168
- lattice filter LMS with joint process estimation 189
- leaky LMS algorithm 171
- normalized LMS algorithm 173
- sign-data LMS 179
- sign-error LMS 176
- sign-sign LMS 183
- symmetric transversal filter implementation LMS 185

### Logarithm approximations 46

- implementation 47
- logarithm approximation subroutine 49

# Index

## M

Matrices 71

Matrix functions

- inverse of a matrix 71

- matrix inversion 81, 84

- multiplication 73, 77

- multiplying 71

- $M \times N$  by  $N \times 0$  multiplication 79

- $M \times N$  by  $N \times 1$  multiplication 75

- $M \times N$  matrix by a  $N \times 0$  matrix 77

- $M \times N$  matrix by an  $N \times 1$  vector 73

- rolling the loop 74

- row major order 72

- storing a matrix 72

Matrix inversion 81

Median filtering (3×3)

- comp (compare) 285

- delay line 292

- image blurring 292

- impulse noise 285

- macros 285

- middle sorting 292

- shot noise 285

Multiply 4×4 by 4×1 matrices (3D graphics transformation)

- graphics transformation 267

- w coordinate 267

Multirate filters

- decimation filter listing 117

- decimation filters 113

- interpolation filter listing 124

- interpolation filters 113

- multirate systems 113

- rational rate changer (external interrupt-based) 138

- rational rate changer (timer-based) 129

- rational rate changer listing 133

- single-stage decimation filter 114

- single-stage interpolation filter 122

- two-stage decimation filter 143

- two-stage interpolation filter 150

# Index

## N

Newton-Raphson iteration 34

## P

Polynomial approximation 61

Power function

    hidden scaling factor 59

    implementation 59

    power subroutine 62

    pseudo extended-precision product 61

## R

Recursive Least Square (RLS) filters

    algorithm 165

    benchmarks 203

    forgetting factor 166

    implementation 194

    Kalman Gain Vector 166

    Z-matrix 194

## S

Sine approximation

    sine/cosine approximation subroutine 18

Sine/cosine approximation 15

Square root

    code listings 35

    implementation 34

    Newton-Raphson iteration 34

Square root & inverse square root approximations 33

## T

Table lookup with interpolation 270

Tangent

    implementation 22

    min-max polynomial approximation 22

    tangent subroutine 24

Tangent approximation 22

Twiddle factor 206, 212, 214

Two-dimensional convolution

    convolution sum 279

    FIR filters 280

    impulse response function 279

    linear time-invariant system 279

    transfer function matrix 280

    two-dimensional convolution sum 279

# Index

## V

- Vector cross product
  - 3D graphics 274
  - back-face culling 274
  - illumination 274