TS-LIB is an extensive, hand-optimized assembly language library for the TigerSHARC DSP. Designed to complement Analog Devices’ run-time library (included within the VisualDSP++ tool-chain) it contains over 400 functions for signal and image processing applications. TS-LIB is operating system independent and can be used ‘as is’ in any C-applications - single-threaded or under operating systems such as VSPworks or OSE.

**Features**

- Over 400 critical DSP functions
- Up to 400% Speed Improvement over existing libraries
  - 1024 pt complex FFT: 41 µS
  - 50 tap FIR filter on 1024 pt array: 116 µS
  - 3x3 convolution on 256x256 array: 1.2 mS
  - 5x5 convolution on 256x256 array: 20 mS
- Individually hand crafted for the TigerSHARC DSP
- Uses a logical and intuitive naming convention
- Maintains a consistent calling interface
- Execution flag indicators
- Uses latest algorithm theory

Designed by

in association with

www.transtech-dsp.com
Functions Summary

Power Routines
Scalar, Vector, Complex Scalar Power, Complex Vector

Trigonometric Routines
Scalar & Vector Trigonometric, Scalar & Vector Hyperbolic

Vector Mathematic Routines
2-input term Vector & complex Vector, 3-input term Vector & Complex Vector, 4-input term Vector

Matrix Mathematic Routines
Matrix Vector & Scalar, Complex Matrix-Vector & Scalar

Simple Operations
Scalar, Vector, Complex Scalar, Complex Vector

Logic-Test-Sort Operations
Vector Test, Threshold, Logic, Shift, Sorting, Matrix Check

Statistic Operations
Vector Sum/Average, Vector Max/Min, Matrix Max/Min, Probability, Vector Gather/Scatter, Histogram, Integration, Interpolation

Filter Routines
Convolution, Correlation, Filtering, Windowing

Transform Routines
Conversion, Complex FFTs, Real FFTs, FFT Operator, DCT Routines, Compander, Coordinate Transform, Accumulating Spectrum

Matrix/Vector Creation & Moving Routines
Create Matrix / Vector, Complex Vector Creation, Distribution and Pseudo-Random Number Generation, Memory Move, Matrix/Vector

Other Routines
Doppler, Cholesky, Signal-Noise, Sub-matrix

Example Performance Increase (ADSP-TS101 Cycles)

<table>
<thead>
<tr>
<th>Routine</th>
<th>Input Length</th>
<th>Visual DSP Run-time</th>
<th>TS-Lib</th>
<th>% Faster</th>
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</thead>
<tbody>
<tr>
<td>Real Vector and Scalar Addition.</td>
<td>1000</td>
<td>900</td>
<td>527</td>
<td>70.8</td>
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<tr>
<td>Real Vector and Scalar Multiplication</td>
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<td>900</td>
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<tr>
<td>Real Vector and Vector Addition</td>
<td>1000</td>
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<td>Real Vector and Vector Multiplication</td>
<td>1000</td>
<td>1273</td>
<td>776</td>
<td>64.0</td>
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<tr>
<td>Complex Vector Addition</td>
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<td>1526</td>
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<td>Complex Vector Multiplication</td>
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<tr>
<td>Complex Vector Dot Product</td>
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<td>3022</td>
<td>2039</td>
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<tr>
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<td>(100,100)</td>
<td>12533</td>
<td>10043</td>
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<tr>
<td>Real Matrix Scalar Addition</td>
<td>(100,100)</td>
<td>8785</td>
<td>7542</td>
<td>16.5</td>
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<tr>
<td>Complex Matrix Addition</td>
<td>(100,100)</td>
<td>25030</td>
<td>12713</td>
<td>96.9</td>
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<tr>
<td>Real Vector Mean</td>
<td>1000</td>
<td>1431</td>
<td>1045</td>
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<tr>
<td>Real Vector Root Mean of Squares</td>
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<td>1134</td>
<td>1065</td>
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<tr>
<td>FIR</td>
<td>20 &amp; 10000</td>
<td>202534</td>
<td>104420</td>
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<tr>
<td>Real Cross Correlation</td>
<td>1000 &amp; 1000</td>
<td>1145056</td>
<td>260821</td>
<td>339.0</td>
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<tr>
<td>Real Convolution</td>
<td>1000 &amp; 1000</td>
<td>2513531</td>
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Power Routines

Scalar Power Routines
- Scalar Exponential
- Scalar Base 10 Exponential
- Scalar Base 2 Exponential
- Scalar Natural Logarithm
- Scalar Base 10 Logarithm
- Scalar Base 2 Logarithm
- Scalar Power
- Scalar Reciprocal Square Root
- Scalar Square Root
- Scalar Cube Root
- Scalar Cube

Vector Power Routines
- Vector Cube Root
- Vector Cube
- Vector Distance
- Vector Exponential
- Vector Base 10 Exponential
- Vector Base 2 Exponential
- Vector Logarithm
- Vector Base 10 Logarithm
- Vector Base 2 Logarithm
- Vector Power
- Vector Pythagoras
- Vector Reciprocal Square Root
- Vector Square Root
- Vector Signed Square

Complex Scalar Power Routines
- Complex Scalar Exponential
- Complex Scalar Square Root
- Complex Scalar Reciprocal

Complex Vector Power Routines
- Complex Vector Exponential
- Complex Vector Exponential & Multiply
- Complex Vector Square Root
- Complex Vector Reciprocal

Trigonometric Routines

Scalar Trig Routines
- Scalar Cosine
- Scalar Sine
- Scalar Tangent
- Scalar Sin(x) / x
- Scalar Inverse Cosine
- Scalar Inverse Sine
- Scalar Inverse Tangent
- Scalar Inverse Tangent 2

Vector Trig Routines
- Vector Cosine
- Vector Cotangent
- Vector Cosecant
- Vector Secant
- Vector Sine
- Vector Tangent
- Vector Sin(x) / x
- Vector Inverse Cosine
- Vector Inverse Sine

Vector Hyperbolic Routines
- Vector Hyperbolic Cosine
- Vector Hyperbolic Sine
- Vector Hyperbolic Tangent
- Vector Inverse Hyperbolic Cosine
- Vector Inverse Hyperbolic Sine
- Vector Inverse Hyperbolic Tangent

Vector Mathematic Routines

2-input term vector Math Routines
- Vector Dot Product
- Vector Scalar Add
- Vector Scalar Divide
- Vector Scalar Multiply
- Vector Scalar Subtract
- Vector Vector Add
- Vector Vector Divide
- Vector Vector Multiply
- Vector Vector Subtract

Complex Vector Math Routines

2-input term Complex Vector Math Routines
- Complex Vector Dot Product
- Complex Vector Dot Product By Conjugate
- Complex Vector Multiply & Add
- Complex Vector Multiply
- Complex Vector Subtract
- Complex Vector Vector Add With Real Vector
- Complex Vector Divided By Real Vector
- Complex Vector Multiplied By Real Vector
- Complex Vector Subtracted By Real Vector
- Complex Vector Scalar Add
- Complex Vector Scalar Divide
- Complex Vector Scalar Multiply
- Complex Vector Scalar Subtract

3-input term Complex Vector Math Routines
- Complex Vector Conjugate, Multiply & Add
- Complex Vector Conjugate & Multiply
- Complex Vector Scalar Multiply & Add Complex Vector

3-input term vector Math Routines
- Vector Scalar Add & Scalar Multiply
- Vector Scalar Add & Scalar Subtract
- Vector Scalar Multiply & Scalar Add
- Vector Scalar Multiply & Scalar Subtract
Vector Scalar Subtract & Scalar Add
Vector Scalar Subtract & Scalar Multiply
Vector Add & Scalar Multiply
Vector Multiply & Scalar Subtract
Vector Multiply & Scalar Add
Vector Multiply & Scalar Subtract
Vector Scalar Multiply & Vector Add
Vector Subtract & Scalar Add
Vector Scalar Multiply & Vector Subtract
Vector Subtract & Scalar Multiply
Vector Add & Multiply
Vector Multiply & Add
Vector Multiply & Subtract
Vector Subtract & Multiply

4-input term vector Math Routines
Vector Add, Add & Multiply
Vector Add, Subtract & Multiply
Vector Multiply, Multiply & Add
Vector Multiply, Multiply & Subtract
Vector Multiply By Scalar Added to Vector Multiplied By Scalar
Vector Subtract, Subtract & Multiply

Matrix Mathematic Routines
Matrix Math Routines
Matrix Add
Matrix Determinant
Matrix Multiply
Matrix Subtract
Matrix Transpose
Determinant of 2x2 Matrix
Determinant of 3x3 Matrix
Kronecker Product
Matrix LU Decomposition
Matrix-Vector Math Routines
Vector-Matrix Multiply
Matrix Vector Multiply
Matrix Vector Multiply 2 by 2
Matrix Vector Multiply 3 by 3
Matrix Vector Multiply 4 by 4
Vector Matrix Multiply 2 by 2
Vector Matrix Multiply 3 by 3
Vector Matrix Multiply 4 by 4

Matrix-Scalar Math Routines
Matrix Scalar Multiply
Matrix Scalar Subtract
Matrix Scalar Addition
Matrix Scalar Division
Matrix Multiply 2 by 2
Matrix Multiply 3 by 3
Matrix Multiply 4 by 4

Complex Matrix Math Routines
Multiply Complex Matrix By Complex Conjugate Matrix
Multiply Complex Scalar By Complex Conjugate Matrix

Simple Operations
Scalar Simple Routines
Scalar Absolute Value
Scalar Floating-Point Remainder
Scalar Get Mantissa & Exponent
Scalar Multiply By A Power of 2
Scalar Get Fraction & Integer
Truncate To Next Higher Whole - Ceil
Round Down To Next Lower - Floor

Vector Simple Routines
Vector Absolute Value
Vector Clear
Vector Fill
Vector Move
Vector Move Program Memory to Data Memory
Vector Move Program Memory to Program Memory
Vector Negate Absolute Value
Vector Negate
Vector Reverse Order
Vector Swap
Vector Truncate To Next Higher Whole Number
Vector Floating-Point To Integer Conversion
Vector Integer To Floating-Point Conversion
Vector Truncate To Next Lower Whole Number
Vector Floating-Point to Integer Round
Vector Floating-Point To Integer Conversion for Positive Numbers
Vector Truncate To Fraction
Vector Get Mantissa and Exponent
Vector Scale By Raising to Power of 2
Vector Split Into Floating-Point & Integer Portions
Vector Floating-Point To Integer Conversion for Negative Numbers
Vector Floating-Point To Nearest Integer Conversion
Vector Integer To Floating-Point Conversion of Short Word

Complex Scalar Simple Routines
Complex Absolute Value
Complex Conjugate

Complex Vector Simple Routines
Complex Absolute Value
Complex Vector Fill
Complex Vector Move
Complex Vector Move From Data Memory To Program Memory
Complex Vector Move From Program Memory to Data Memory
Complex Vector Negate
Complex Vector Conjugate

Logic-Test-Sort Operations
Vector Test
Vector Compress
Vector Compressed Merge
Vector Envelope
Logical Vector Equal
Logical Vector Greater Than or Equal
Logical Vector Greater Than
Logical Vector Less Than or Equal
Logical Vector Less Than
Vector Not Equal
Vector Logical Merge
Vector Negative Merge
Vector Positive Merge
Vector Tapered Merge

Threshold Operations
Vector Clip
Vector Inverse Clip
Vector Limit
Vector Lower Threshold
Vector Threshold Normalized
Vector Threshold, Zero Fill
Vector Threshold, Signed Constant
Vector Upper Threshold

Logic Operations
Vector Logical And
Vector Logical Or
Vector Logical Exclusive Or
Vector Not Exclusive Bitwise Or
Vector Logical And Followed By And
Vector Logical Or Followed By Complement
Vector Logical Complement

Shift Operations
Vector Arithmetic Shift
Vector Logical Shift
Vector Rotate Left
Vector Rotate Right
Vector Rotate

Sorting Operations
Vector Bubble Sort

Matrix Check Operations
Check Matrix Orthogonal
Partial Matrix Pivoting
Check Matrix Skew
Check Matrix Symmetry
Matrix Trace

Statistic Operations
Vector Sum / Average
Moving Average
Vector Range
Mean Value of Vector Elements
Mean Value of Vector Element Magnitudes
Mean Value of Vector Element Squares
Mean Value of Vector Element Signed Squares
Root Mean Square of Vector Elements
Sliding Window Summation
Vector Summation
Sum of Vector Element Magnitudes
Sum of Vector Element Squares
Sum of Vector Element Signed Squares
Vector Exponential Average
Vector Linear Average
Vector Running Sum

Vector Max/Min
Maximum Magnitude
Maximum Magnitude with Index
Maximum Element of a Vector
Maximum Element of a Vector With Index
Minimum Magnitude
Minimum Magnitude with Index

Minimum Element of a Vector
Minimum Element of a Vector With Index
Vector Maximum of 3 Vectors
Vector Minimum of 3 Vectors

Matrix Max/Min
Maximum Value of a Matrix
Maximum Value of a Matrix w/ Coordinates
Minimum Value of a Matrix
Minimum Value of a Matrix w/ Coordinates
Maximum Value of 2 Matrices
Minimum Value of 2 Matrices

Probability Routines
Combination
Factorial
Least Square Regression Fit
Mean Deviation
Mean Squared Error
Permutation
Standard Error of Estimate
Standard Deviation Function
Variance
Weighted Mean

Vector Gather/Scatter
Vector Gather
Vector Index
Vector Scatter

Histogram Routines
Vector Histogram
Vector Integer Histogram

Integration Routines
Vector Polynomial Evaluation
Vector Build Ramp
Simpson’s Integration
Trapezoidal Integration

Interpolation Routines
Linear Interpolation Using Reference Grid of Points
Vector Linear Interpolate
Vector Generation By Linear Interpolation and Extrapolation
Vector Quadratic Interpolation

Filter Routines
Convolution Routines
Convolution
2-Dimensional Convolution

Correlation Routines
Auto-Correlation Time
Complex Auto-Correlation Time Domain
Complex Correlation Time Domain
Cross-Correlation Time Domain
Correlation
2-Dimensional Correlation

Filtering Routines
Bi-Quad IIR Filter
Complex Decimating FIR Filter
Complex FIR Filter
Direct Form Decimating FIR Filter
Compute FIR of 2 Vectors w/ Decimation & Delay Memory
5-Tap Finite Impulse Response Filter
Direct Form FIR Filter
Direct Form LMS FIR Filter
Windowing Routines
Hamming Window Multiply
Blackman Window Multiply
Kaiser-Bessel Window Shape Function
Bartlett Window Multiply
Blackman-Harris Window Multiply
Hanning Window Multiply
Kaiser-Bessel Window Multiply
Welch Window Multiply

Transform Routines

Conversion Routines
Rectangular to Polar Conversion
Polar to Rectangular Conversion
Vector Convert Decibels to Linear Amplitude
Vector Convert Decibels to Linear Power
Vector Convert Radians to Degrees
Vector Convert Linear Volt Units to Decibels Amplitude
Vector Convert Linear Power to Decibels
Vector Convert Degrees to Radians

Complex FFTs
Complex FFT
Complex 2-Dimensional
8-Point Complex FFT
16-Point Complex FFT
Inverse Complex FFT

Real FFTs
Real FFT
Real FFT In Place
Real FFT (Sorenson Algorithm)
8-Point Real FFT
16-Point Real FFT
32-Point Real FFT

FFT Operator Routines
FFT Weights Array
Window Cosine/Sine Weights Array
Sort rfft( ) Data for rfft( )
Sort rffts( ) Data for rfft( )

DCT Routines
8x8 Discrete Cosine Transform

Compressor Routines
a-Law Compression
a-Law Expansion
µ-Law Compression
µ-Law Expansion

Coordinate Transform Routines
2-Dimensional Coordinate Transformation
3-Dimensional Coordinate Transformation

Accumulating Spectrum Routines
Accumulating Autospectrum
Accumulating Cross-Spectrum

Matrix / Vector Creation and Moving Routines

Create Matrix / Vector
Null Matrix
Unity Matrix
Complex Vector Create From Real
Complex Vector Create From Integer
Create Vector From Imaginary Components
Create Vector From Real Components
Extract Real & Imaginary Components From Complex Vector

Complex Vector Creation Routines
Vector Magnitude Squared
Power Spectra
Vector Transfer Function
Vector Multiply By Cosine and Sine Function

Distribution and Pseudo-Random Number Generation Routines
Vector Build Normal Distribution
Vector Build Uniform Distribution
Vector Pseudo-Random Number (PRN) Generator

Memory Move Matrix / Vector
Matrix Move
Matrix Move From Data Memory to Program Memory
Matrix Move From Program Memory to Data Memory
Move a Source Complex Matrix to a Destination Complex Matrix
Unpack Integer Matrix to IQ Matrices
Pack Floating-Point Vector
Pack Integer Vector
Unpack into Floating-Point Vector
Unpack into Integer Vector

Other Routines
Generate Doppler Signal
Endian Order
Integral Non-Linearity
Linear Magnitude
Log Based Magnitude
Monopulse Function
Monopulse Function (Program Memory)
Compute NCO Values
Compute NCO Table Values
Signal to Noise Density
Compute NCO Table Values
Zero Crossing Detector
Complex Vector Phase
Complex Vector Magnitude Squared
Complex Vector Magnitude Squared & Add
Choleski Matrix Decomposition
Constant Matrix
Complete Matrix Pivot
Extract a Sub Matrix
Matrix Identity
Insert a Sub Matrix
Matrix Forward-Back Substitution