IEEE P1076.1 Working Group
Requirements for Matrix/Vector Support

History:

v0.1	Zhichao Deng / June 7, 2010	Initial draft.
v0.2	Zhichao Deng / Aug 18, 2010	Updated to include changes from two meetings.
v0.3	Zhichao Deng / Sep 29, 2010	Updated to include changes from meeting.
v0.4	Zhichao Deng / Oct 24, 2010	The final draft version.

IEEE recommendations on word usage
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shall	means	is required to
should	means	is recommended that
may	means	is permitted to
can	means	is able to

Purpose

Matrix/Vector operations allow models with equations with a pre-defined matrix/vector operator. Such support allows all the frequently used operators envolving matrix/vector.

Scope

To develop VHDL-AMS package(s) and/or new language constructs that support the required functionality.

General Requirements

MVS-R1 [shall]

Matrix/vector operations are defined as reference in a standard package.

The package will only cover 2-D matrix or vector since the multi-dimension matrix seem not being used quite often in the modeling world.

Matrix Definition

MVS-R2 [shall]

The package(s) shall provide the ability to describe matrix of real and complex type.

MVS-R3 [shall]

The package(s) shall provide the ability to describe matrix of non-floating type such as integer, boolean, physical type.

Matrix/vector Construction/access

MVS-R4 [shall]

The package(s) shall provide the ability to get sub-matrices out of and put sub-matrices into a matrix (support block matrix manipulation). For example, matrix/vector slicing.

MVS-R5 [shall]

The package(s) shall provide the ability to construct a diagonal matrix with a vector of the diagonal element. Example: identity matrix construction

The package(s) shall provide the ability to construct a matrix with all the elements to be the same element specified by the user. Example: zero or unity matrix construction

Matrix/vector Operations

MVS-R7 [shall]

The package(s) shall provide the addition, subtraction, multiplication, division, exponentiation operators of matrix elements.

MVS-R8 [shall]

The package(s) shall provide dot product between matrix-matrix and matrix-vector.

$$\mathbf{a} \cdot \mathbf{b} = \mathbf{a}^{\mathrm{T}} \mathbf{b},$$

The package(s) shall provide cross product between two 3-vectors.

$$\mathbf{a} \times \mathbf{b} = ab \sin\theta \, \mathbf{n}$$

MVS-R9 [shall]

The package(s) shall provide transpose, conjugate transpose (complex), complex conjugate (complex) for matrix and vector.

MVS-R10 [shall]

The package(s) shall provide determinant computation for matrix and vector.

MVS-R11 [shall]

The package(s) shall provide matrix power operation.

Example: MatrixPower(A, 3) = A * A * A A is a matrix

MVS-R12 [shall]

The packages(s) shall provide matrix exponential operation.

Example: MatrixExponential(A) = exp(A) A is a matrix

MVS-R13 [shall]

The package(s) shall provide vector norm operation for 1, 2, and infinite norm.

MVS-R14 [shall]

The package(s) shall provide matrix 1-norm operation.

Rationale: the matrix 1 norm performs the same operation as Matlab.

MVS-R15 [should]

The package(s) should provide matrix trace operation.

MVS-R16 [should]

The package(s) should provide the Kronecker product of matrix.

$$\mathbf{A} \otimes \mathbf{B} = \begin{bmatrix} a_{11}B & \cdots & a_{1n}B \\ \vdots & \ddots & \vdots \\ a_{m1}B & \cdots & a_{mn}B \end{bmatrix}.$$

For example, outer product, a special case of Kronecker product, is used in performing transform operations in DSP. It is also useful in statistical analysis for computing the covariance matrices.

$$\mathbf{u} \otimes \mathbf{v} = \mathbf{A} = \begin{bmatrix} u_1v_1 & u_1v_2 & \dots & u_1v_n \\ u_2v_1 & u_2v_2 & \dots & u_2v_n \\ \vdots & \vdots & \ddots & \vdots \\ u_mv_1 & u_mv_2 & \dots & u_mv_n \end{bmatrix}.$$

MVS-R17 [shall]

The standard shall perform the check for matrix dimension/size during all the matrix operations.

MVS-R18 [may]

The package(s) may provide the matrix inverse operation. But the result from the package definition is not enforced as the correct result by the standard.

Rationale: Due to the nature of numerical accuracy limitiation during matrix inverse, the correctness of the matrix inverse is difficult to be defined by the standard.

MVS-R19 [may]

The package(s) may provide a function for calculating a system of linear equations. But the result from the package definition is not enforced as the correct result by the standard.

Rationale: Due to the nature of numerical accuracy limitiation during matrix inverse, the correctness of solving a system of linear equation is difficult to be defined by the standard.

Ax = b, where A is a known matrix and b is a known vector. X is the unknown vector to be solved.