PROPOSAL FOR A STANDARD VHDL MATHEMATICAL PACKAGE

Jose A. Torres  
Synopsys Inc.  
700 E Middlefield Road # C  
Mountain View, CA 94043  
Phone: (415)694-4335  
FAX: (415)694-4331  
Email: jose@synopsys.com

Donald F. Hanson  
Department of Electrical Engineering  
University of Mississippi  
University, MS 38677  
Phone: (601)232-5389  
FAX: (601)232-7231  
Email: EEHANSON@olemiss.edu

Abstract

As part of the VHDL standardization activities, an IEEE working group has been created to gather information and put together a proposal for a set of standard VHDL Mathematical Packages that include most often used real and complex elementary functions with floating point real and complex arguments.

This type of functionality can be supported by IEEE 1076, but there is not a set of standard definitions provided in IEEE 1076 for this purpose.

The idea behind this effort is to provide a set of standard definitions that can help increase the portability and interoperability of models that make use of this type of functionality.

This paper will present the status of the working group, the intended schedule, as well as the current proposal for the contents of these packages.
Proposal for a Standard
VHDL Mathematical Package

October 20, 1992

Jose A. Torres
Synopsys Inc.
700 E. Middlefield Road # C
Mountain View, CA 94043
Phone: (415)994-4330
Fax: (415)994-4331
Email: jose@synopsys.com

Donald F. Hanson
Department of Electrical Engineering
University of Mississippi
University, MS 38677
Phone: (601)232-5389
Fax: (601)232-7231
Email: EEHANSON@olemiss.edu

Agenda

- Objectives
- Motivation
- Working Group
- Design Process
- Plans
- Status and Schedule
- Deliverables
- Strawman Proposal
- Concluding Remarks
Objectives

A set of standard VHDL Mathematical Packages that include:

- most often used real and complex elementary functions, and
- required data types and type conversion functions

Motivation

- Lack of a set of standard definitions in IEEE 1076 for this purpose
- Need for portability and interoperability of models that use this functionality
- Need for efficient implementation for simulation
Handouts

Working Group

- An IEEE working subgroup has been created
- Current active group members are
  - Jose A. Torres (chair), Synopsys, Inc.
  - Donald F. Hanson, University of Mississippi
  - Charles Swart, Mentor Graphics Corp.
  - Alex Zamfirescu, Vantage
  - Others are welcome!
- First meeting took place on June 13, 1992

Design Process

1) Set General Scope and Objectives
2) Gather Requirements
3) Design the Package's Definition and Body
4) Document
5) Validate
6) Ballot
7) Negative Ballot Review
8) Publish Finalized/Approved Standard
Handouts

Plans

- Broadcast information and look for participants
- Review work done for other languages (e.g., ADA, C) for same functionality
- Get par number(s) for the package(s)
- Collect information from VHDL community
- Study 1992 changes impact (e.g., global var. & priv. types)
- Put together proposal
- Distribute proposal for feedback

Status and Schedule

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gather Requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Get IEEE Par Numbers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ballot Constituency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysis of Requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package(s) Definition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package Pre-Ballot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Documentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ballot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Ballot Review</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Get IEEE Approval</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Handouts

Deliverables

- Two or more VHDL packages with basic functionality from which other functions can be built:
  -- All in standard VHDL
  -- An implementation may modify the package body, as long as the functionality is preserved as documented.

- Documentation for the packages

- Set of test benches to validate simulation results:
  -- Not part of the standard

Package Names

- Library: IEEE

- MATH_REAL for real elementary functions. XXXX_STD when par number gets assigned.

- MATH_COMPLEX for complex elementary functions. YYYY_STD when par number gets assigned.
Handouts

Straw Proposal -- Data Types for MATH_Real

- Floating point type name: REAL
- Package where is defined: STD.STANDARD
- Valid REAL ranges: minimum -1.0E38 to +1.0E38
- Representation precision: minimum 6 fractional digits
- Arithmetic operations predefined (+, -, *, /)
- Comparison operations predefined (=, <, >, <=, >=, /=)
- Detection of invalid parameters for out of range or overflow conditions is required

Straw Proposal -- Constants for MATH_Real

constant CNST_E : real := 2.718281_828469;  -- value of e
constant CNST_PI : real := 3.141592_653589;  -- value of pi
constant LOG_OF_2 : real := 0.693147_180559;  -- natural log of 2
constant LOG_OF_10 : real := 2.302585_092994;  -- natural log of 10
constant SQRT_OF_2 : real := 1.414213_562373;  -- sqrt of 2

NOTE: Requirement is to support at least 6 fractional digits
Handouts

Straw Proposal -- Functions for MATH_Real I

function SIGN (X: real; Y: real) return real;
-- returns value of X with sign of Y

function MAX MIN (X: real) return real;

function ABS (X: real) return integer;

function ROUND CEILING FLOOR

Straw Proposal -- Functions for MATH_Real II

function INIT_SEED (seed: natural) return natural;
-- set value of seed for sequence of pseudo-random numbers.
-- The seed value (a global variable) -- as per LCS46 in VHDL 1992
-- is used and modified by the function RANDOM.
-- Returns previous seed value.

function RANDOM () return real;
-- Returns pseudo-random number uniformly distributed between 0 & 1
-- Use global for seed set by the init_seed() function, as per LCS44 in
-- VHDL 1992

synopsys
U. of Mississippi
Straw Proposal -- Functions for MATH_Real III

function \(\text{SQRRT}(X: \text{real})\) return \(\text{real}\);
function \(\text{LOG}(X: \text{real})\) return \(\text{real}\);
function \(\text{LOG10}(X: \text{real})\) return \(\text{real}\);
function \(\text{EXP}(X: \text{real})\) return \(\text{real}\);
function \(\text{SIN}(X: \text{real})\) return \(\text{real}\);
function \(\text{COS}(X: \text{real})\) return \(\text{real}\);
function \(\text{TAN}(X: \text{real})\) return \(\text{real}\);
function \(\text{ASIN}(X: \text{real})\) return \(\text{real}\);
function \(\text{ACOS}(X: \text{real})\) return \(\text{real}\);
function \(\text{ATAN}(X: \text{real})\) return \(\text{real}\);
function \(\text{SINH}(X: \text{real})\) return \(\text{real}\);
function \(\text{COSH}(X: \text{real})\) return \(\text{real}\);
function \(\text{TANH}(X: \text{real})\) return \(\text{real}\);
function \(\text{ASINH}(X: \text{real})\) return \(\text{real}\);
function \(\text{ACOSH}(X: \text{real})\) return \(\text{real}\);
function \(\text{ATANH}(X: \text{real})\) return \(\text{real}\);

Straw Proposal -- Data Types for MATH_Complex

subtype RADIANS is real range -\(\text{CNST}\_\text{PI}\) to \(\text{CNST}\_\text{PI}\);

type COMPLEX is record
  CREAL, CIMAG: real;
end record;

type COMPLEX_VECTOR is array (integer range \(\langle\rangle\)) of COMPLEX;

type COMPLEX_POLAR is record
  CMAG: real; CANG: real;
end record;
Straw Proposal -- Functions for MATH_Complex I

function (CV: complex) return complex;
"-" CONJ CEXP

function (CV: complex) return real;
CHEAL CIMAG CABS

function CANG (CV:complex) return radians;
function CMPLX (X, Y: real) return complex;
function CSQRT (CV: complex) return complex_vector;

function (L: complex; R: complex) return boolean:
= < > <= >= /=

Straw Proposal -- Functions for MATH_Complex II

function (L: complex; R: complex) return complex;
+ - * /

function (L: complex; R: real) return complex;
+ - * /

function (L: real; R: complex) return complex;
+ - * /
Current Discussion Topics

- Accuracy and Digits of Precision
- Portability and Platform Independence
- Overlaps with IEEE 1076-1992
- Error Detection
- Floating Point Comparisons for Equality
- Use of foreign functions (non-VHDL) or customized VHDL bodies by an implementation
- Quality of random number generator
- Additional Requirements

Concluding Remarks

- An overview of the VHDL Mathematical Package work has been presented
- The design work has just started and is in the process of gathering requirements
- Work on the VHDL Mathematical Package will continue through March 1993
- Active participants and submission of requirements is highly desired and needed!