IEC 61691-8

Edition 1.0 2021-07

INTERNATIONAL STANDARD

IEEE Std 1666.1™

Behavioural languages – Part 8: Standard SystemC® Analog/Mixed-Signal Extensions Language Reference Manual

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 25.040.01; 35.060

ISBN 978-2-8322-9951-7

Contents

Behavioural languages – Part 8: Standard SystemC® Analog/Mixed-Signal Extensions Language Reference Manual

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC document(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation.

   IEEE Standards documents are developed within IEEE Societies and Standards Coordinating Committees of the IEEE Standards Association (IEEE SA) Standards Board. IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of IEEE and serve without compensation. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards. Use of IEEE Standards documents is wholly voluntary. *IEEE documents are made available for use subject to important notices and legal disclaimers (see* http://standards.ieee.org/ipr/disclaimers.html *for more information).*

   IEC collaborates closely with IEEE in accordance with conditions determined by agreement between the two organizations. This Dual Logo International Standard was jointly developed by the IEC and IEEE under the terms of that agreement.

2) The formal decisions of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees. The formal decisions of IEEE on technical matters, once consensus within IEEE Societies and Standards Coordinating Committees has been reached, is determined by a balanced ballot of materially interested parties who indicate interest in reviewing the proposed standard. Final approval of the IEEE standards document is given by the IEEE Standards Association (IEEE SA) Standards Board.

3) IEC/IEEE Publications have the form of recommendations for international use and are accepted by IEC National Committees/IEEE Societies in that sense. While all reasonable efforts are made to ensure that the technical content of IEC/IEEE Publications is accurate, IEC or IEEE cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications (including IEC/IEEE Publications) transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC/IEEE Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC and IEEE do not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC and IEEE are not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or IEEE or their directors, employees, servants or agents including individual experts and members of technical committees and IEC National Committees, or volunteers of IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE SA) Standards Board, for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC/IEEE Publication or any other IEC or IEEE Publications.

8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that implementation of this IEC/IEEE Publication may require use of material covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. IEC or IEEE shall not be held responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patent Claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

IEC 61691-8/IEEE Std 1666.1 was processed through IEC technical committee 91: Electronics assembly technology, under the IEC/IEEE Dual Logo Agreement. It is an International Standard.

The text of this International Standard is based on the following documents:

IEEE Std	FDIS	Report on voting
1666.1 (2016)	91/1712/FDIS	91/1724/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

The IEC Technical Committee and IEEE Technical Committee have decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IEEE Std 1666.1™-2016

IEEE Standard for Standard SystemC® Analog/Mixed-Signal Extensions Language Reference Manual

Sponsor

Design Automation Standards Committee
of the
IEEE Computer Society

Approved 29 January 2016

IEEE-SA Standards Board

Abstract: The SystemC® Analog/Mixed-Signal (AMS) extensions are defined in this standard. SystemC AMS is an ANSI standard C++ class library for electronic system-level design and modeling for use by system architects and engineers who need to address complex heterogeneous systems that are a hybrid between analog, digital and software components. This standard provides a precise and complete definition of the SystemC AMS class library so that a SystemC AMS implementation can be developed with reference to this standard alone. The primary audiences for this standard are the implementors of the SystemC AMS class library, the implementors of tools supporting the class library, and the users of the class library.

Keywords: analog mixed signal, behavioral modeling, C++, computer languages, data flow simulation, digital systems, discrete event simulation, electronic design automation, electronic system level, electronic systems, electrical networks, hardware description language, hardware design, hardware verification, IEEE 1666™, IEEE 1666.1™, mixed-signal modeling, SystemC, SystemC AMS, signal flow modeling, system modeling, system-on-chip

Acknowledgment: Grateful acknowledgment is made to the Accellera Systems Initiative for the permission to use the following source material: Standard SystemC® AMS extensions 2.0 Language Reference Manual.

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Standards Documents."

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association ("IEEE-SA") Standards Board. IEEE ("the Institute") develops its standards through a consensus development process, approved by the American National Standards Institute ("ANSI"), which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied "AS IS" and "WITH ALL FAULTS."

Use of an IEEE standard is wholly voluntary. The existence of an IEEE standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854 USA

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under U.S. and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, noncommercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE-SA Website at http://ieeexplore.ieee.org/expel/standards.jsp or contact IEEE at the address listed previously. For more information about the IEEE-SA or IOWA's standards development process, visit the IEEE-SA Website at http://standards.ieee.org.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: http://standards.ieee.org/findstds/errata/index.html. Users are encouraged to check this URL for errata periodically.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at http://standards.ieee.org/about/sasb/patcom/patents.html. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Introduction

This introduction is not part of IEEE Std 1666.1™-2016, IEEE Standard for Standard SystemC® Analog/Mixed-Signal Extensions Language Reference Manual.

This document defines the SystemC Analog/Mixed-Signal (AMS) extensions, which is a C++ class library.

As the electronics industry builds more complex heterogeneous systems involving large numbers of components including analog, digital and software, there is an increasing need for a modeling language that can manage the complexity, heterogeneity, and size of these systems. SystemC AMS provides a mechanism for managing this complexity with its facility for modeling hardware and software together at multiple levels of abstraction. This capability is not available in traditional hardware description languages.

Stakeholders in SystemC AMS include Electronic Design Automation (EDA) companies who implement SystemC AMS class libraries and tools, integrated circuit (IC) suppliers who extend those class libraries and use SystemC AMS to model their intellectual property, and end users who use SystemC AMS to model their systems.

This standard is not intended to serve as a user's guide or to provide an introduction to SystemC AMS. Readers requiring a SystemC AMS tutorial or information on the intended use of SystemC AMS should consult the Accellera Systems Initiative Web site (http://www.accellera.org) to locate the supplemental material and training classes available.

IEEE Standard for Standard SystemC® Analog/Mixed-Signal Extensions Language Reference Manual

1. Overview

1.1 Scope

This standard defines the Analog/Mixed-Signal extensions for SystemC®[1], as an ANSI standard C++ class library based on SystemC for system and hardware design including analog/mixed-signal elements.

1.2 Purpose

The general purpose of the SystemC AMS extensions is to provide a C++ standard for designers and architects, who need to address complex heterogeneous systems that are a hybrid between hardware and software. This standard is built on the IEEE Std 1666™-2011[2] (SystemC Language Reference Manual) and extends it to create analog/mixed-signal, multi-disciplinary models to simulate continuous-time, discrete-time, and discrete-event behavior simultaneously.

The specific purpose of this standard is to provide a precise and complete definition of the AMS class library, so that a SystemC AMS implementation can be developed with reference to this standard alone. This standard is neither intended to serve as a user's guide nor to provide an introduction to AMS extensions in SystemC, but does contain useful information for end users.

[1] SystemC® is a registered trademark of the Accellera Systems Initiative.
[2] Information on references can be found in Clause 2.

1.3 Subsets

It is anticipated that tool vendors will create implementations that support only a subset of this standard or that impose further constraints on the use of this standard. Such implementations are not fully compliant with this standard but may nevertheless claim partial compliance with this standard and may use the name SystemC AMS extensions.

1.4 Relationship with C++

This standard is closely related to the C++ programming language and adheres to the terminology used in ISO/IEC 14882:2003. This standard does not seek to restrict the usage of the C++ programming language; an application using the SystemC AMS extensions may use any of the facilities provided by C++, which in turn may use any of the facilities provided by C. However, where the facilities provided by this standard are used, they shall be used in accordance with the rules and constraints set out in this standard.

This standard defines the public interface to the SystemC AMS class library and the constraints on how those classes may be used. The SystemC AMS class library may be implemented in any manner whatsoever, provided only that the obligations imposed by this standard are honored.

A C++ class library may be extended using the mechanisms provided by the C++ language. Implementors and users are free to extend SystemC AMS extensions in this way, provided that they do not violate this standard.

NOTE—It is possible to create a well-formed C++ program that is legal according to the C++ programming language standard but that violates this standard. An implementation is not obliged to detect every violation of this standard.[3]

1.5 Relationship with SystemC

This standard is built on IEEE Std 1666-2011 and extends it using the mechanisms provided by the C++ language, to provide an additional layer of analog/mixed-signal constructs. Consequently, an implementation and application may use the SystemC core language and predefined channels defined in the namespace **sc_core** and the SystemC data types defined in the namespace **sc_dt**, unless stated otherwise.

Any SystemC compliant application shall behave the same in the presence of the SystemC AMS extensions.

1.6 Guidance for readers

Readers who are not entirely familiar with the SystemC AMS extensions should start with Annex A, which provides a brief informal summary of the subject intended to aid in the understanding of the normative definitions. Such readers may also find it helpful to scan the examples embedded in the normative definitions and to see Annex B.

Readers should pay close attention to Clause 3. An understanding of the terminology and conventions defined in that clause is necessary for a precise interpretation of this standard.

The semantic definitions given in the subsequent clauses detailing the individual classes are built upon the foundations laid in Clause 4.

Clause 5, Clause 6 and Clause 7 define the public interface to the SystemC AMS class library defining the predefined models of computation.

[3]Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

The following information is listed for each class:

a) A brief class description.

b) A C++ source code listing of the class definition.

c) A statement of any constraints on the use of the class and its members.

d) A statement of the semantics of the class and its members.

e) For certain classes, a description of functions, typedefs, macros, and template parameters associated with the class.

For each predefined model of computation, the execution semantics for elaboration and simulation are defined.

Readers should bear in mind that the primary obligation of a tool vendor is to implement the abstract semantics defined in Clause 5, Clause 6, and Clause 7, using the framework and constraints provided by the class definitions starting in Clause 4.

Annex A is intended to aid the reader in the understanding of the structure and intent of the SystemC AMS class library.

Annex B is giving informal descriptions of the terms used in this standard.

2. Normative references

The following referenced documents are indispensable for the applications of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained) For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

This standard shall be used in conjunction with the following publications:

ISO/IEC 14882:2003, Programming Languages—C++[4]

IEEE Std 1666™-2011: IEEE Standard for Standard SystemC Language Reference Manual[5,6]

[4]ISO/IEC publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iso.ch/). ISO/IEC publications are also available in the United States from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (http://global.ihs.com/). Electronic copies are available in the United States from the American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

[5]The IEEE standards or products referred to in this clause are trademarks of The Institute of Electrical and Electronics Engineers, Inc.

[6]IEEE publications are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).