IEC 61691-1-1

Edition 3.0 2023-10

INTERNATIONAL STANDARD

IEEE Std 1076™

Behavioural languages –
Part 1-1: VHDL Language Reference Manual



IEC 61691-1-1:2023-10(en) IEEE Std 1076-2019

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2019 IEEE

All rights reserved. IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by the Institute of Electrical and Electronics Engineers, Inc. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the IEC Central Office. Any questions about IEEE copyright should be addressed to the IEEE. Enquiries about obtaining additional rights to this publication and other information requests should be addressed to the IEC or your local IEC member National Committee.

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue
New York, NY 10016-5997
United States of America
stds.info@ieee.org
www.ieee.org

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC 61691-1-1

Edition 3.0 2023-10

INTERNATIONAL STANDARD

IEEE Std 1076™

Behavioural languages – Part 1-1: VHDL Language Reference Manual

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 25.040.01, 35.060

ISBN 978-2-8322-7517-7

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

Contents

1. Overview ... 14

1.1 Scope ... 14
1.2 Purpose ... 14
1.3 Structure and terminology of this standard ... 14
1.4 Word usage ... 16

2. Normative references ... 18

3. Design entities and configurations ... 19

3.1 General ... 19
3.2 Entity declarations ... 19
3.3 Architecture bodies ... 22
3.4 Configuration declarations ... 25

4. Subprograms and packages ... 32

4.1 General ... 32
4.2 Subprogram declarations ... 32
4.3 Subprogram bodies ... 37
4.4 Subprogram instantiation declarations ... 39
4.5 Subprogram overloading ... 40
4.6 Resolution functions ... 43
4.7 Package declarations ... 44
4.8 Package bodies ... 45
4.9 Package instantiation declarations ... 47
4.10 Conformance rules ... 48

5. Types ... 49

5.1 General ... 49
5.2 Scalar types ... 50
5.3 Composite types ... 58
5.4 Access types ... 68
5.5 File types ... 70
5.6 Protected types ... 75
5.7 String representations ... 79
5.8 Unspecified types ... 81

6. Declarations ... 85

6.1 General ... 85
6.2 Type declarations ... 86
6.3 Subtype declarations ... 86
6.4 Objects ... 88
6.5 Interface declarations ... 96
6.6 Alias declarations ... 119
6.7 Attribute declarations ... 122
6.8 Component declarations ... 123
6.9 Group template declarations ... 123

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

6.10 Group declarations 124
6.11 PSL clock declarations 124

7. Specifications 126

7.1 General 126
7.2 Attribute specification 126
7.3 Configuration specification 129
7.4 Disconnection specification 135

8. Names 138

8.1 General 138
8.2 Simple names 139
8.3 Selected names 140
8.4 Indexed names 142
8.5 Slice names 143
8.6 Attribute names 143
8.7 External names 144

9. Expressions 148

9.1 General 148
9.2 Operators 149
9.3 Operands 163
9.4 Static expressions 172
9.5 Universal expressions 175

10. Sequential statements 176

10.1 General 176
10.2 Wait statement 176
10.3 Assertion statement 178
10.4 Report statement 179
10.5 Signal assignment statement 180
10.6 Variable assignment statement 189
10.7 Procedure call statement 191
10.8 If statement 192
10.9 Case statement 193
10.10 Loop statement 195
10.11 Next statement 196
10.12 Exit statement 196
10.13 Return statement 196
10.14 Null statement 197
10.15 Sequential block statement 197

11. Concurrent statements 199

11.1 General 199
11.2 Block statement 199
11.3 Process statement 200
11.4 Concurrent procedure call statements 202
11.5 Concurrent assertion statements 203
11.6 Concurrent signal assignment statements 204

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

11.7 Component instantiation statements 206
11.8 Generate statements 212

12. Scope and visibility 216

12.1 Declarative region 216
12.2 Scope of declarations 216
12.3 Visibility 218
12.4 Use clauses 222
12.5 The context of overload resolution 223

13. Design units and their analysis 225

13.1 Design units 225
13.2 Design libraries 225
13.3 Context declarations 227
13.4 Context clauses 227
13.5 Order of analysis 228

14. Elaboration and execution 229

14.1 General 229
14.2 Elaboration of a design hierarchy 229
14.3 Elaboration of a block, package, subprogram or protected type header 232
14.4 Elaboration of a declarative part 235
14.5 Elaboration of a statement part 241
14.6 Dynamic elaboration 244
14.7 Execution of a model 245

15. Lexical elements 256

15.1 General 256
15.2 Character set 256
15.3 Lexical elements, separators, and delimiters 258
15.4 Identifiers 260
15.5 Abstract literals 261
15.6 Character literals 262
15.7 String literals 262
15.8 Bit string literals 263
15.9 Comments 266
15.10 Reserved words 266
15.11 Tool directives 268

16. Predefined language environment 269

16.1 General 269
16.2 Predefined attributes 269
16.3 Package STANDARD 287
16.4 Package TEXTIO 305
16.5 Standard environment package 311
16.6 Standard mathematical packages 325
16.7 Standard multivalue logic package 326
16.8 Standard synthesis packages 326
16.9 Standard synthesis context declarations 332

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

16.10 Fixed-point package ... 333
16.11 Floating-point package ... 333
16.12 Reflection package ... 334

17. VHDL Procedural Interface overview ... 355

17.1 General ... 355
17.2 Organization of the interface ... 355
17.3 Capability sets ... 356
17.4 Handles ... 358

18. VHPI access functions ... 360

18.1 General ... 360
18.2 Information access functions ... 360
18.3 Property access functions ... 362
18.4 Access by name function ... 363

19. VHPI information model ... 364

19.1 General ... 364
19.2 Formal notation ... 364
19.3 Class inheritance hierarchy ... 365
19.4 Name properties ... 366
19.5 The stdUninstantiated package ... 379
19.6 The stdHierarchy package ... 382
19.7 The stdTypes package ... 388
19.8 The stdExpr package ... 391
19.9 The stdSpec package ... 394
19.10 The stdSubprograms package ... 396
19.11 The stdStmts package ... 398
19.12 The stdConnectivity package ... 404
19.13 The stdCallbacks package ... 409
19.14 The stdEngine package ... 409
19.15 The stdForeign package ... 410
19.16 The stdMeta package ... 410
19.17 The stdTool package ... 412
19.18 Application contexts ... 413

20. VHPI tool execution ... 414

20.1 General ... 414
20.2 Registration phase ... 414
20.3 Analysis phase ... 420
20.4 Elaboration phase ... 420
20.5 Initialization phase ... 422
20.6 Simulation phase ... 422
20.7 Save phase ... 422
20.8 Restart phase ... 423
20.9 Reset phase ... 423
20.10 Termination phase ... 424

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

21. VHPI callbacks 425

21.1 General 425
21.2 Callback functions 425
21.3 Callback reasons 427

22. VHPI value access and update 439

22.1 General 439
22.2 Value structures and types 439
22.3 Reading object values 442
22.4 Formatting values 443
22.5 Updating object values 445
22.6 Scheduling transactions on drivers 449

23. VHPI function reference 452

23.1 General 452
23.2 vhpi_assert 452
23.3 vhpi_check_error 453
23.4 vhpi_compare_handles 456
23.5 vhpi_control 457
23.6 vhpi_create 459
23.7 vhpi_disable_cb 462
23.8 vhpi_enable_cb 462
23.9 vhpi_format_value 464
23.10 vhpi_get 465
23.11 vhpi_get_cb_info 466
23.12 vhpi_get_data 467
23.13 vhpi_get_foreignf_info 469
23.14 vhpi_get_next_time 470
23.15 vhpi_get_phys 472
23.16 vhpi_get_real 472
23.17 vhpi_get_str 473
23.18 vhpi_get_time 474
23.19 vhpi_get_value 475
23.20 vhpi_handle 476
23.21 vhpi_handle_by_index 477
23.22 vhpi_handle_by_name 481
23.23 vhpi_is_printable 483
23.24 vhpi_iterator 484
23.25 vhpi_printf 485
23.26 vhpi_protected_call 486
23.27 vhpi_put_data 490
23.28 vhpi_put_value 492
23.29 vhpi_register_cb 493
23.30 vhpi_register_foreignf 496
23.31 vhpi_release_handle 499
23.32 vhpi_remove_cb 499
23.33 vhpi_scan 500
23.34 vhpi_schedule_transaction 501
23.35 vhpi_vprintf 506

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

24. Standard tool directives 507

24.1 Protect tool directives 507
24.2 Conditional analysis tool directives 523

Annex A (informative) VHPI definitions file 525

Annex B (normative) VHPI header file 527

Annex C (informative) Syntax summary 530

Annex D (informative) Potentially non-portable constructs 557

Annex E (informative) Changes from IEEE Std 1076-2008 558

Annex F (informative) Features under consideration for removal 559

Annex G (informative) Guide to use of standard packages 560

Annex H (informative) Guide to use of protect directives 597

Annex I (informative) Glossary 605

Annex J (informative) Bibliography 632

Annex K (informative) Participants 633

Index 634

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

BEHAVIOURAL LANGUAGES –

Part 1-1: VHDL 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* https://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.

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

IEC 61691-1-1/IEEE Std 1076 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
1076 (2019)	91/1871/FDIS	91/1885/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, or
- revised.

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

IEEE Std 1076™-2019
(Revision of
IEEE Std 1076-2008)

IEEE Standard for VHDL Language Reference Manual

Developed by the

Design Automation Standards Committee
of the
IEEE Computer Society

Approved 5 September 2019

IEEE SA Standards Board

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

Abstract: VHSIC Hardware Description Language (VHDL) is defined. VHDL is a formal notation intended for use in all phases of the creation of electronic systems. Because it is both machine readable and human readable, it supports the development, verification, synthesis, and testing of hardware designs; the communication of hardware design data; and the maintenance, modification, and procurement of hardware. Its primary audiences are the implementors of tools supporting the language and the advanced users of the language.

Keywords: computer languages, electronic systems, hardware, hardware design, IEEE 1076™, VHDL

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

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 Notices and Disclaimers Concerning IEEE Standards Documents." They can also be obtained on request from IEEE or viewed at http://standards.ieee.org/ipr/disclaimers.html.

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. IEEE Standards are documents developed through scientific, academic, and industry-based technical working groups. Volunteers in IEEE working groups 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 Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers and users of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

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.

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

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 US 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.

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

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, non-commercial 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 10 years. When a document is more than 10 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 IEEE Xplore at http://ieeexplore.ieee.org/ or contact IEEE at the address listed previously. For more information about the IEEE SA or IEEE's standards development process, visit the IEEE SA Website at http://standards.ieee.org.

Errata

Errata, if any, for IEEE standards can be accessed via https://standards.ieee.org/standard/index.html. Search for standard number and year of approval to access the web page of the published standard. Errata links are located under the Additional Resources Details section. Errata are also available in IEEE Xplore: https://ieeexplore.ieee.org/browse/standards/collection/ieee/. Users are encouraged to periodically check for errata.

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 https://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.

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

IEEE Introduction

This introduction is not part of IEEE Std 1076-2019, IEEE Standard for VHDL Language Reference Manual.

The VHSIC Hardware Description Language (VHDL) is a formal notation intended for use in all phases of the creation of electronic systems. Because it is both machine readable and human readable, it supports the development, verification, synthesis, and testing of hardware designs; the communication of hardware design data; and the maintenance, modification, and procurement of hardware.

This document, IEEE Std 1076-2019, is a revision of IEEE Std 1076-2008. The IEEE VHDL Analysis and Standardization Group (VASG), otherwise known as the 1076 Working Group, gathered the requirements, developed language extensions, and completed a draft of this revised Language Reference Manual. That draft was returned to IEEE for final revision and approval, resulting in this document. This revision incorporates numerous enhancements, both major and minor, to previously existing language features and several new language features. The changes are summarized in Annex E. In addition, several VHDL library packages that were previously defined in separate standards are now defined in this standard, ensuring that they are treated as integral parts of the language. Finally, this revision incorporates the IEEE Property Specification Language (PSL) as part of VHDL. The combination of these changes significantly improves VHDL as a language for specification, design, and verification of complex electronic systems.

The maintenance of the VHDL language standard is an ongoing process. The chair of the VHDL Analysis and Standardization Group extends his gratitude to all who have participated in this revision and encourages the participation of all interested parties in future language revisions.[1]

Acknowledgments

Material in clause titled “Protect Tool Directives” is derived from the document titled “A Mechanism for VHDL Source Protection” © 2004, Cadence Design Systems Inc. Used, modified, and reprinted by permission of Cadence Design Systems Inc.

The packages FIXED_GENERIC PKG, FIXED_PKG, FLOAT_GENERIC_PKG, FLOAT_PKG, and FIXED_FLOAT_TYPES were modified and used with permission from Eastman Kodak Company © 2006. Material in annex clauses titled “Using the fixed-point package” and “Using the floating-point package” is derived from the documents titled “Fixed Point Package User’s Guide” and “Floating Point Package User’s Guide” by Eastman Kodak Company © 2006. Used, modified, and reprinted by permission of Eastman Kodak Company.

The package STD_LOGIC_TEXTIO was modified and used with permission of Synopsys Inc. © 1990, 1991, and 1992.

[1]If interested in participating, please contact the VASG at vhdl-200x@LISTSERV.IEEE.ORG or http://www.eda-twiki.org/cgi-bin/view.cgi/P1076/WebHome.

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.

IEEE Standard for VHDL Language Reference Manual

1. Overview

1.1 Scope

This standard defines the syntax and semantics of the VHSIC Hardware Description Language (VHDL). The acronym VHSIC (Very High Speed Integrated Circuits) in the language's name comes from the U.S. government program that funded early work on the standard.

1.2 Purpose

VHDL is a formal notation intended for use in all phases of the creation of electronic systems. Since it is both machine and human readable, it supports the design, development, verification, synthesis, and testing of hardware designs; the communication of hardware design data; and the maintenance, modification, and procurement of hardware. This document is intended for the implementers of tools supporting the language and for advanced users of the language.

1.3 Structure and terminology of this standard

1.3.1 General

This standard is organized into clauses, each of which focuses on some particular area of the language. Within each clause, individual constructs or concepts are discussed in each subclause.

Each subclause describing a specific construct begins with an introductory paragraph. Next, the syntax of the construct is described using one or more grammatical *productions*.

A set of paragraphs describing the meaning and restrictions of the construct in narrative form then follow.

In this document, the word *shall* is used to indicate a mandatory requirement. The word *should* is used to indicate a recommendation. The word *may* is used to indicate a permissible action. The word *can* is used for statements of possibility and capability.

Machine readable elements that are normatively referenced are available in the IEEE 1076 Open Source Repository (see Clause 2).

Published by IEC under licence from IEEE. © 2019 IEEE. All rights reserved.