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

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ELECTROTECHNICAL
COMMISSION

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Contents

1.	Overview of this standard	1
1.1	Scope.....	1
1.2	Purpose.....	1
1.3	Structure and terminology of this standard.....	2
2.	Normative references	5
3.	Design entities and configurations.....	7
3.1	General.....	7
3.2	Entity declarations	7
3.3	Architecture bodies	10
3.4	Configuration declarations.....	13
4.	Subprograms and packages.....	19
4.1	General.....	19
4.2	Subprogram declarations	19
4.3	Subprogram bodies	23
4.4	Subprogram instantiation declarations.....	26
4.5	Subprogram overloading.....	26
4.6	Resolution functions	29
4.7	Package declarations.....	30
4.8	Package bodies.....	31
4.9	Package instantiation declarations	33
4.10	Conformance rules.....	34
5.	Types.....	35
5.1	General.....	35
5.2	Scalar types	36
5.3	Composite types.....	44
5.4	Access types.....	53
5.5	File types.....	55
5.6	Protected types	58
5.7	String representations	61
6.	Declarations	63
6.1	General.....	63
6.2	Type declarations	64
6.3	Subtype declarations	64
6.4	Objects	66
6.5	Interface declarations	73
6.6	Alias declarations.....	89
6.7	Attribute declarations.....	92
6.8	Component declarations	93
6.9	Group template declarations	93
6.10	Group declarations	93
6.11	PSL clock declarations.....	94

7.	Specifications	95
7.1	General	95
7.2	Attribute specification	95
7.3	Configuration specification	98
7.4	Disconnection specification	103
8.	Names	107
8.1	General	107
8.2	Simple names	108
8.3	Selected names	108
8.4	Indexed names	111
8.5	Slice names	112
8.6	Attribute names	112
8.7	External names	113
9.	Expressions	117
9.1	General	117
9.2	Operators	118
9.3	Operands	131
9.4	Static expressions	139
9.5	Universal expressions	142
10.	Sequential statements	145
10.1	General	145
10.2	Wait statement	145
10.3	Assertion statement	147
10.4	Report statement	148
10.5	Signal assignment statement	149
10.6	Variable assignment statement	160
10.7	Procedure call statement	163
10.8	If statement	164
10.9	Case statement	164
10.10	Loop statement	166
10.11	Next statement	167
10.12	Exit statement	167
10.13	Return statement	168
10.14	Null statement	168
11.	Concurrent statements	169
11.1	General	169
11.2	Block statement	169
11.3	Process statement	170
11.4	Concurrent procedure call statements	172
11.5	Concurrent assertion statements	173
11.6	Concurrent signal assignment statements	174
11.7	Component instantiation statements	176
11.8	Generate statements	182

12.	Scope and visibility	185
	12.1 Declarative region	185
	12.2 Scope of declarations	185
	12.3 Visibility	187
	12.4 Use clauses	191
	12.5 The context of overload resolution	192
13.	Design units and their analysis	195
	13.1 Design units	195
	13.2 Design libraries	195
	13.3 Context declarations	197
	13.4 Context clauses	197
	13.5 Order of analysis	198
14.	Elaboration and execution	199
	14.1 General	199
	14.2 Elaboration of a design hierarchy	199
	14.3 Elaboration of a block, package, or subprogram header	202
	14.4 Elaboration of a declarative part	205
	14.5 Elaboration of a statement part	210
	14.6 Dynamic elaboration	213
	14.7 Execution of a model	214
15.	Lexical elements	225
	15.1 General	225
	15.2 Character set	225
	15.3 Lexical elements, separators, and delimiters	227
	15.4 Identifiers	229
	15.5 Abstract literals	230
	15.6 Character literals	231
	15.7 String literals	231
	15.8 Bit string literals	232
	15.9 Comments	234
	15.10 Reserved words	235
	15.11 Tool directives	237
16.	Predefined language environment	239
	16.1 General	239
	16.2 Predefined attributes	239
	16.3 Package STANDARD	254
	16.4 Package TEXTIO	268
	16.5 Standard environment package	274
	16.6 Standard mathematical packages	275
	16.7 Standard multivalued logic package	276
	16.8 Standard synthesis packages	277
	16.9 Standard synthesis context declarations	283
	16.10 Fixed-point package	283
	16.11 Floating-point package	284

17.	VHDL Procedural Interface overview	285
	17.1 General	285
	17.2 Organization of the interface	285
	17.3 Capability sets	286
	17.4 Handles	288
18.	VHPI access functions	291
	18.1 General	291
	18.2 Information access functions	291
	18.3 Property access functions	293
	18.4 Access by name function	294
19.	VHPI information model	295
	19.1 General	295
	19.2 Formal notation	295
	19.3 Class inheritance hierarchy	296
	19.4 Name properties	297
	19.5 The stdUninstantiated package	310
	19.6 The stdHierarchy package	313
	19.7 The stdTypes package	320
	19.8 The stdExpr package	322
	19.9 The stdSpec package	325
	19.10 The stdSubprograms package	327
	19.11 The stdStmts package	329
	19.12 The stdConnectivity package	335
	19.13 The stdCallbacks package	340
	19.14 The stdEngine package	340
	19.15 The stdForeign package	341
	19.16 The stdMeta package	341
	19.17 The stdTool package	343
	19.18 Application contexts	344
20.	VHPI tool execution	345
	20.1 General	345
	20.2 Registration phase	345
	20.3 Analysis phase	351
	20.4 Elaboration phase	351
	20.5 Initialization phase	353
	20.6 Simulation phase	353
	20.7 Save phase	353
	20.8 Restart phase	354
	20.9 Reset phase	354
	20.10 Termination phase	355
21.	VHPI callbacks	357
	21.1 General	357
	21.2 Callback functions	357
	21.3 Callback reasons	359

22.	VHPI value access and update	371
	22.1 General	371
	22.2 Value structures and types	371
	22.3 Reading object values	374
	22.4 Formatting values	375
	22.5 Updating object values	377
	22.6 Scheduling transactions on drivers	381
23.	VHPI function reference	385
	23.1 General	385
	23.2 vhpi_assert	385
	23.3 vhpi_check_error	386
	23.4 vhpi_compare_handles	388
	23.5 vhpi_control	389
	23.6 vhpi_create	390
	23.7 vhpi_disable_cb	392
	23.8 vhpi_enable_cb	393
	23.9 vhpi_format_value	394
	23.10 vhpi_get	396
	23.11 vhpi_get_cb_info	396
	23.12 vhpi_get_data	397
	23.13 vhpi_get_foreignf_info	399
	23.14 vhpi_get_next_time	400
	23.15 vhpi_get_phys	401
	23.16 vhpi_get_real	402
	23.17 vhpi_get_str	402
	23.18 vhpi_get_time	403
	23.19 vhpi_get_value	404
	23.20 vhpi_handle	405
	23.21 vhpi_handle_by_index	406
	23.22 vhpi_handle_by_name	408
	23.23 vhpi_is_printable	410
	23.24 vhpi_iterator	411
	23.25 vhpi_printf	412
	23.26 vhpi_protected_call	413
	23.27 vhpi_put_data	415
	23.28 vhpi_put_value	417
	23.29 vhpi_register_cb	418
	23.30 vhpi_register_foreignf	419
	23.31 vhpi_release_handle	421
	23.32 vhpi_remove_cb	422
	23.33 vhpi_scan	422
	23.34 vhpi_schedule_transaction	423
	23.35 vhpi_vprintf	426
24.	Standard tool directives	429
	24.1 Protect tool directives	429
	Annex A (informative) Description of accompanying files	447
	Annex B (normative) VHPI header file	451

Annex C (informative) Syntax summary	477
Annex D (informative) Potentially nonportable constructs	501
Annex E (informative) Changes from IEEE Std 1076-2002	503
Annex F (informative) Features under consideration for removal	511
Annex G (informative) Guide to use of standard packages	513
Annex H (informative) Guide to use of protect directives	551
Annex I (informative) Glossary	557
Annex J (informative) Bibliography	585
Annex K (informative) IEEE List of participants	587
Index	589

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BEHAVIOURAL LANGUAGES –

Part 1-1: VHDL Language Reference Manual

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The text of this standard is based on the following documents:

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IEEE Standard VHDL Language Reference Manual

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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, VHDL

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IEEE introduction

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 1076-2008, is a revision of IEEE Std 1076-2002 as amended by IEEE Std 1076c™-2007. Initial work on gathering requirements and developing language extensions was undertaken by the IEEE VHDL Analysis and Standardization Group (VASG), otherwise known as the 1076 Working Group. Subsequently, Accellera^a sponsored an effort to complete that work and draft a revised Language Reference Manual. That draft was returned to IEEE for final revision and approval, resulting in this document and the associated machine-readable files. 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, both in the IEEE committees and the Accellera effort, and encourages the participation of all interested parties in future language revisions.^b

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^aMore information is available at www.accellera.org.

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

1. Overview of this standard

1.1 Scope

This standard revises and enhances the VHDL language reference manual (LRM) by including a standard C language interface specification; specifications from previously separate, but related, standards IEEE Std 1164TM-1993 [B16],¹ IEEE Std 1076.2TM-1996 [B11], and IEEE Std 1076.3TM-1997 [B12]; and general language enhancements in the areas of design and verification of electronic systems.

1.2 Purpose

The VHDL language was defined for use in the design and documentation of electronics systems. It is revised to incorporate capabilities that improve the language's usefulness for its intended purpose as well as extend it to address design verification methodologies that have developed in industry. These new design and verification capabilities are required to ensure VHDL remains relevant and valuable for use in electronic systems design and verification. Incorporation of previously separate, but related standards, simplifies the maintenance of the specifications.

¹The numbers in brackets correspond to those of the bibliography in Annex J.

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.

Finally, each clause may end with examples, notes, and references to other pertinent clauses.

1.3.2 Syntactic description

The form of a VHDL description is described by means of context-free syntax using a simple variant of the Backus-Naur form (BNF); in particular:

- a) Lowercase words in roman font, some containing embedded underlines, are used to denote syntactic categories, for example:

`formal_port_list`

Whenever the name of a syntactic category is used, apart from the syntax rules themselves, spaces take the place of underlines [thus, “formal port list” would appear in the narrative description when referring to the syntactic category in item a)].

- b) Boldface words are used to denote reserved words, for example:

array

Reserved words shall be used only in those places indicated by the syntax.

- c) A *production* consists of a *left-hand side*, the symbol “`::=`” (which is read as “can be replaced by”), and a *right-hand side*. The left-hand side of a production is always a syntactic category; the right-hand side is a replacement rule. The meaning of a production is a textual-replacement rule: any occurrence of the left-hand side may be replaced by an instance of the right-hand side.
- d) A vertical bar (|) separates alternative items on the right-hand side of a production unless it occurs immediately after an opening brace, in which case it stands for itself, as follows:

`letter_or_digit ::= letter | digit`
`choices ::= choice { | choice }`

In the first instance, an occurrence of “letter_or_digit” can be replaced by either “letter” or “digit.” In the second case, “choices” can be replaced by a list of “choice,” separated by vertical bars [see item f) for the meaning of braces].

- e) Square brackets [] enclose optional items on the right-hand side of a production; thus, the following two productions are equivalent:

`return_statement ::= return [expression] ;`
`return_statement ::= return ; | return expression ;`

Note, however, that the initial and terminal square brackets in the right-hand side of the production for signatures (see 4.5.3) are part of the syntax of signatures and do not indicate that the entire right-hand side is optional.

- f) Braces { } enclose a repeated item or items on the right-hand side of a production. The items may appear zero or more times; the repetitions occur from left to right as with an equivalent left-recursive rule. Thus, the following two productions are equivalent:

```
term ::= factor { multiplying_operator factor }
term ::= factor | term multiplying_operator factor
```

- g) If the name of any syntactic category starts with an italicized part, it is equivalent to the category name without the italicized part. The italicized part is intended to convey some semantic information. For example, *type_name* and *subtype_name* are both syntactically equivalent to name alone.
- h) The term *simple_name* is used for any occurrence of an identifier that already denotes some declared entity.

1.3.3 Semantic description

The meaning and restrictions of a particular construct are described with a set of narrative rules immediately following the syntactic productions. In these rules, an italicized term indicates the definition of that term, and identifiers appearing entirely in uppercase letters refer to definitions in package STANDARD (see 16.3).

The following terms are used in these semantic descriptions with the following meanings:

erroneous: The condition described represents an ill-formed description; however, implementations are not required to detect and report this condition. Conditions are deemed erroneous only when it is impossible in general to detect the condition during the processing of the language.

error: The condition described represents an ill-formed description; implementations are required to detect the condition and report an error to the user of the tool.

illegal: A synonym for “error.”

legal: The condition described represents a well-formed description.

1.3.4 Front matter, examples, notes, references, and annexes

Prior to this subclause are several pieces of introductory material; following Clause 24 are some annexes and an index. The front matter, annexes (except Annex B), and index serve to orient and otherwise aid the user of this standard, but are not part of the definition of VHDL; Annex B, however, is normative.

Some clauses of this standard contain examples, notes, and cross-references to other clauses of the standard; these parts always appear at the end of a clause. Examples are meant to illustrate the possible forms of the construct described. Illegal examples are italicized. Notes are meant to emphasize consequences of the rules described in the clause or elsewhere. In order to distinguish notes from the other narrative portions of this standard, notes are set as enumerated paragraphs in a font smaller than the rest of the text. Cross-references are meant to guide the user to other relevant clauses of the standard. Examples, notes, and cross-references are not part of the definition of the language.

1.3.5 Incorporation of Property Specification Language

VHDL incorporates the simple subset of the Property Specification Language (PSL) as an embedded language for formal specification of the behavior of a VHDL description. PSL is defined by IEEE Std 1850™-2005.² All PSL constructs that appear in a VHDL description shall conform to the

²Information on references can be found in Clause 2.

VHDL flavor of PSL. Within this standard, reference is made to syntactic rules of PSL. Each such reference has the italicized prefix *PSL_* and corresponds to the syntax rule in IEEE Std 1850-2005 with the same name but without the prefix.

2. Normative references

The following referenced documents are indispensable for the application 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.

IEC 62531:2007, Standard for Property Specification Language (PSL)¹
IEEE Std 1850TM-2005, IEEE Standard for Property Specification Language (PSL)

NOTE—IEEE Std 1850-2005 was adopted as IEC 62531:2007

IEEE Std 754TM-1985 (Reaff 1990), IEEE Standard for Binary Floating-Point Arithmetic.^{3, 4}

IEEE Std 854TM-1987 (Reaff 1994), IEEE Standard for Radix-Independent Floating-Point Arithmetic.

ISO/IEC 8859-1:1998, Information technology—8-bit single-byte coded graphic character sets—Part 1: Latin alphabet No. 1.⁵

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ISO/IEC 9899:1999/Cor 1:2001, Programming languages—C, Technical Corrigendum 1.

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³IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

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⁵ISO/IEC publications are available from the ISO Central Secretariat, Case Postale 56, 1 chemin de la Voie-Creuse, CH-1211 Genève 20, Switzerland/Suisse (<http://www.iso.ch/>) and from the IEC Central Office, Case Postale 131, 3 rue de Varembe, CH-1211 Genève 20, Switzerland/Suisse (<http://www.iec.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/>).