

# complexpack user manual

<b>Title</b>	complexpack (VHDL complex arithmetic package).
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<b>Rev. history</b>	
<b>v0.0.0</b>	2009-10-02 First public release.
<b>v0.0.1</b>	2014-02-24 Changed documentation format to RestructuredText. Code has been reorganized into new directory structure.
<b>v0.1.0</b>	2014-03-03 Added <code>get_real</code> , <code>get_imaginary</code> , <code>magnitude</code> , and operators: <code>lt</code> , <code>gt</code> , <code>le</code> , <code>ge</code> , <code>eq</code> , <code>ne</code> . New library dependency: <code>IEEE.math_real</code> .
<b>v0.1.1</b>	2014-03-04 Added support for the <code>"abs"</code> and the negation <code>"-"</code> operators as those are needed by the <code>complexarrpack</code> package project.
<b>v0.1.2</b>	2014-06-17 Changed README to README.rst.

## 1. Introduction

`complexpack` is a simple complex arithmetic package written in VHDL. It is based on a code example present in the RASSP series of VHDL lectures. Compared to the RASSP version, the following have been added:

- conjugate function.
- magnitude function.
- comparison operators.
- get real and get imaginary part functions.

A complex number is defined by the pair (real-part, imaginary-part) where both items of the pair are numbers. A common algebraic representation for complex numbers is:

$$z = a + i*b,$$

where:

- $z$  is the resulting complex number
- $a$  is the real part of the number also written as  $a = \text{Re}(z)$
- $b$  is the imaginary part of the number also written as  $b = \text{Im}(z)$
- $i$  is the imaginary unit and has the value of  $\text{sqrt}(-1)$ .

Currently, the `complepack` package implements the following:

- the constants `re` and `im`, which specify addresses for an array-based representation of a complex number
- type definition for a complex number
- interface and implementation for complex arithmetic functionality

## 1.1. Implemented functions and operators

This is a summary of the currently supported functions, procedures and operators by the `complepack` package.

- `to_complex(real, real)`: form a complex number
- `+`: add two complex numbers
- `-`: subtract one complex number from another
- `-`: negate a complex number
- `*`: multiply two complex numbers
- `/`: divide two complex numbers
- `conjugate(complex)`: return the conjugate of the given complex number

All functions above return an item of the complex data type.

- `get_real(complex)`: get the real part of a complex number
- `get_imaginary(complex)`: get the imaginary part of a complex number
- `magnitude(complex)`: return the magnitude (distance of point 0,0) of the complex number
- `abs(complex)`: alias for magnitude

All functions above return an item of the real data type (a scalar quantity).

- `<`: less than comparison for two complex numbers
- `>`: greater than comparison for two complex numbers
- `<=`: less than or equal comparison for two complex numbers

- `>=`: greater than or equal comparison for two complex numbers
- `=`: equality comparison for two complex numbers
- `/=`: non-equality comparison for two complex numbers

All functions above return an item of the boolean data type (TRUE or FALSE).

The definition of `magnitude` requires a square root computation. For this task, a call to the `sqrt` function found in the `IEEE.math_real` library is used.

`complexpack` is distributed along with a simple VHDL testbench exercising basic functionalities.

## 2. File listing

The `complexpack` distribution includes the following files:

<code>/complexpack</code>	Top-level directory
<code>/bench/vhdl</code>	Benchmarks VHDL directory
<code>complexpack_tb.vhd</code>	A simple testbench.
<code>/doc</code>	Documentation directory
<code>AUTHORS</code>	List of <code>complexpack</code> authors.
<code>BUGS</code>	Bug list.
<code>ChangeLog</code>	A log for code changes.
<code>LICENSE</code>	The LGPL, version 3, governs <code>complexpack</code> .
<code>README.rst</code>	This file.
<code>README.html</code>	HTML version of <code>README.rst</code> .
<code>README.pdf</code>	PDF version of <code>README.rst</code> .
<code>rst2docs.sh</code>	Bash script for generating the HTML and PDF versions.
<code>THANKS</code>	Acknowledgements.
<code>TODO</code>	A list of future enhancements.
<code>VERSION</code>	Current version of the project sources.
<code>/rtl/vhdl</code>	RTL source code directory for the package
<code>complexpack.vhd</code>	The complex arithmetic package.
<code>/sim/rtl_sim</code>	RTL simulation files directory
<code>/sim/rtl_sim/out</code>	RTL simulation output files directory
<code>complexpack_results-.txt</code>	Output generated by the <code>complexpack_tb.vhd</code> test.
<code>/sim/rtl_sim/run</code>	RTL simulation run scripts directory
<code>complexpack.mk</code>	GNU Makefile for running GHDL simulations.
<code>run.sh</code>	A bash script for running the GNU Makefile for GHDL.

## 3. complexpack usage

The `complexpack` package test script can be used as follows:

```
$./run.sh
```

as run from within the `./sim/rtl_sim/run` subdirectory.

After this process, the `complexpack_results.txt` file is generated containing simulation results.

## 4. Prerequisites

- Standard UNIX-based tools (tested on cygwin/x86 and MinGW/x86 and MinGW/x64)
  - make
  - bash
- GHDL simulator (<http://ghdl.free.fr>)

Provides the "ghdl" executable and corresponding simulation environment. Versions throughout 0.26 to 0.31 (mcode) have been used for testing.