



1D Filter Module - Lattice Radiant Software

User Guide

FPGA-IPUG-02099-1.5

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Acronyms in This Document

A list of acronyms used in this document.

Acronym	Definition
FPGA	Field Programmable Gate Array
IP	Intellectual Property
LSB	Least Significant Bit
MSB	Most Significant Bit
RTL	Register Transfer Level

1. Introduction

The 1D Filter Module has three modes: 1D Symmetry, 1D Asymmetry Serial, and 1D Asymmetry Parallel, which support configurable number of taps each with its own coefficient.

1.1. Features

The key features of 1D Filter Module include:

- Supports the following modes:
 - 1D Symmetry
 - 1D Asymmetry Serial
 - 1D Asymmetry Parallel
- Configurable number of taps
- Supports both Positive and Negative Symmetry for 1D Symmetry Mode only
- Configurable Reset Mode
- Configurable data width and sign representation for Data A and B
- Configurable Bus Ordering

1.2. Conventions

1.2.1. Nomenclature

The nomenclature used in this document is based on Verilog HDL.

1.2.2. Signal Names

Signal names that end with:

- `_n` are active low
- `_i` are input signals
- `_o` are output signals

1.2.3. Attribute Names

Attribute names in this document are formatted in title case and italicized (*Attribute Name*).

2. Functional Description

The 1D Filter Module filters the input data according to the following general equation:

$$result = \sum_{n=0}^{NUM_OF_TAPS-1} (A_n * B_n)$$

The following sections provides information on the 1D Filter Module modes:

- 1D Asymmetry Serial
- 1D Asymmetry Parallel
- 1D Symmetry

2.1. 1D Asymmetry Serial Mode

data_a_i width = DATAA Width,

data_b_i width = Number of Taps * DATAB Width

A is a data input that is provided serially, B is an input for coefficients which is provided in a parallel way.

For this mode, the output data is calculated as follows:

$$result = \sum_{n=0}^{NUM_OF_TAPS-1} (A_n * B[(n + 1) * DATAB - 1 : n * DATAB])$$

2.2. 1D Asymmetry Parallel Mode

data_a_i width = Number of Taps * DATAA Width,

data_b_i width = Number of Taps * DATAB Width,

A is a data input, B is an input for coefficients; both are provided in a parallel way.

For this mode, the output data is calculated as follows:

$$result = \sum_{n=0}^{NUM_OF_TAPS-1} (A[(n + 1) * DATAA - 1 : n * DATAA] * B[(n + 1) * DATAB - 1 : n * DATAB])$$

2.3. 1D Symmetry Mode

data_a_i width = DATAA Width,

data_b_i width:

- when the Number of Taps is odd, data_b_i width = $\frac{\text{Number of Taps} + 1}{2} * \text{DATAB Width}$,
- when the Number of Taps is even, data_b_i width = $\frac{\text{Number of Taps}}{2} * \text{DATAB Width}$.

For this mode, the output data is calculated as follows:

$$result = \sum_{n=0}^{K-1} (A_n + A_{(K-n)}) * B[(n + 1) * DATAB - 1 : n * DATAB]),$$

where

- $K = \frac{\text{Number of Taps} + 1}{2}$, when Number of Taps is odd, and
- $K = \frac{\text{Number of Taps}}{2}$, when Number of Taps is even.

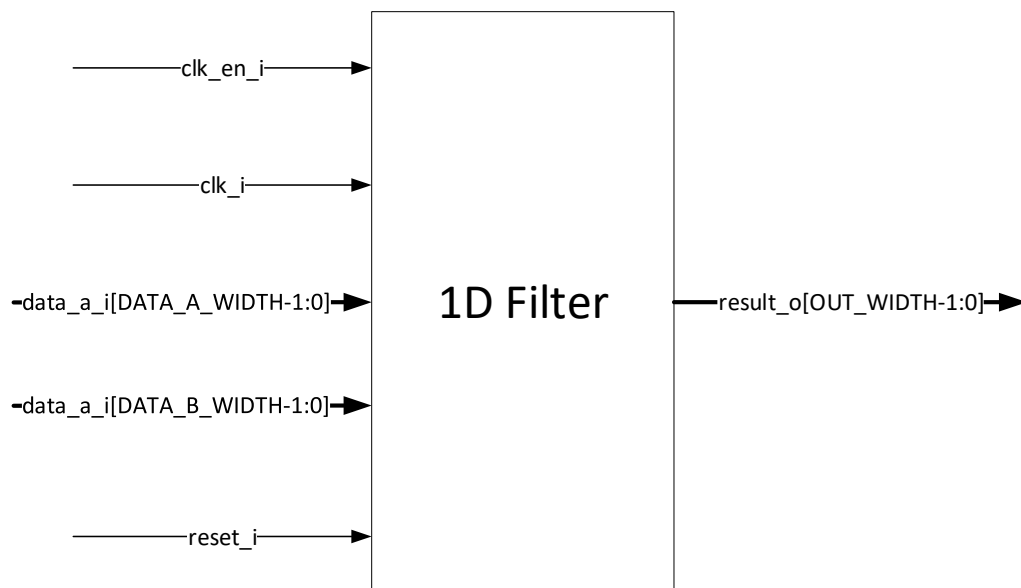


Figure 2.1. 1D Filter Block Diagram

2.4. Signal Descriptions

Table 2.1. 1D Filter Module Signal Description

Port Name	I/O	Width	Description
Clock and Reset Ports			
clk_i	In	1	System clock input.
reset_i	In	1	Reset input.
User Interface Ports			
clk_en_i	In	1	Clock enable input.
data_a_i	In	DATAA Width ¹	Input data for port A.
data_b_i	In	DATAB Width ¹	Input data for port B.
result_o	Out	OUT_WIDTH ²	Output data result.

Note:

The bit width of some signals is set by the attribute. Refer to [Table 2.2](#) for the description of these attributes.

1. If DATAA Width ≤ 9 and DATAB Width ≤ 9, then OUT_WIDTH = DATAA Width + DATAB Width + 6;
2. If at least one of DATAA Width or DATAB Width > 9, then OUT_WIDTH = DATAA Width + DATAB Width + 18.

2.5. Attribute Summary

The configurable attributes of the 1D Filter Module are shown in [Table 2.2](#) and are described in [Table 2.3](#). The attributes can be configured through the IP Catalog's Module/IP wizard of the Lattice Radiant™ software.

Table 2.2. Attributes Table

Attribute	Selectable Values	Default	Dependency on Other Attributes
Configuration			
Mode	1D Symmetry, 1D Asymmetry Serial, 1D Asymmetry Parallel	1D Asymmetry Serial	—
Number of Taps	2–N	2	For <i>Mode</i> == 1D Symmetry: If Device Type LIFCL-17, N = 48 else N = 55.
Symmetry	Positive, Negative	Positive	Active if <i>Mode</i> == 1D Symmetry
Reset Mode	Sync, Async	Sync	—
DATAA Sign	Signed, Unsigned	Signed	Active if <i>Symmetry</i> == Positive
DATAA Width	2–18	18	—
DATAB Sign	Signed, Unsigned	Signed	Active if <i>Symmetry</i> == Positive
DATAB Width	2–18	18	—
Bus Ordering Style	Big Endian [MSB : LSB], Little Endian [LSB : MSB]	Big Endian [MSB : LSB]	—

Table 2.3. Attributes Descriptions

Attribute	Description
Configuration	
Mode	Specifies the mode of 1D Filter Module. Refer to Functional Description section for more details.
Number of Taps	Specifies the number of taps.
Symmetry	Specifies the Symmetry of the 1D Filter Module. Selectable values are Positive and Negative Symmetry.
Reset Mode	Specifies the mode of reset that is used.
DATAA Sign	Specifies the sign representation for port data_a_i.
DATAA Width	Specifies the data width for port A. The exact value of this attribute can be calculated depending on the type of <i>Mode</i> . Refer to Functional Description section for more details.
DATAB Sign	Specifies the sign representation for port data_b_i.
DATAB Width	Specifies the data width for port B. The exact value of this attribute can be calculated depending on the type of <i>Mode</i> . Refer to Functional Description section for more details.
Bus Ordering Style	Specifies the bus ordering of input and output data ports. Big Endian: the data_a_i, data_b_i and result_o busses ordering is from MSB to LSB. Little Endian: the data_a_i, data_b_i and result_o busses ordering is from LSB to MSB;

3. IP Generation, Synthesis, and Validation

This section provides information on how to generate and synthesize this module using the Lattice Radiant software. For more on Lattice Radiant software, refer to the Lattice Radiant software user guide and relevant tutorials.

3.1. Licensing the IP

No license is required for this module.

3.2. Generating and Synthesizing the IP

The Lattice Radiant software allows you to customize and generate modules and IPs and integrate them into the device's architecture. The procedure for generating the 1D Filter Module in Lattice Radiant software is described below.

To generate the 1D Filter Module:

1. Create a new Lattice Radiant software project or open an existing project.
2. In the IP Catalog tab, double-click on **1D_Filter** under **Module, DSP_Arithmetic_Modules** category.
3. The **Module/IP Block Wizard** opens as shown in [Figure 3.1](#). Enter values in the **Component name** and the **Create in** fields and click **Next**.

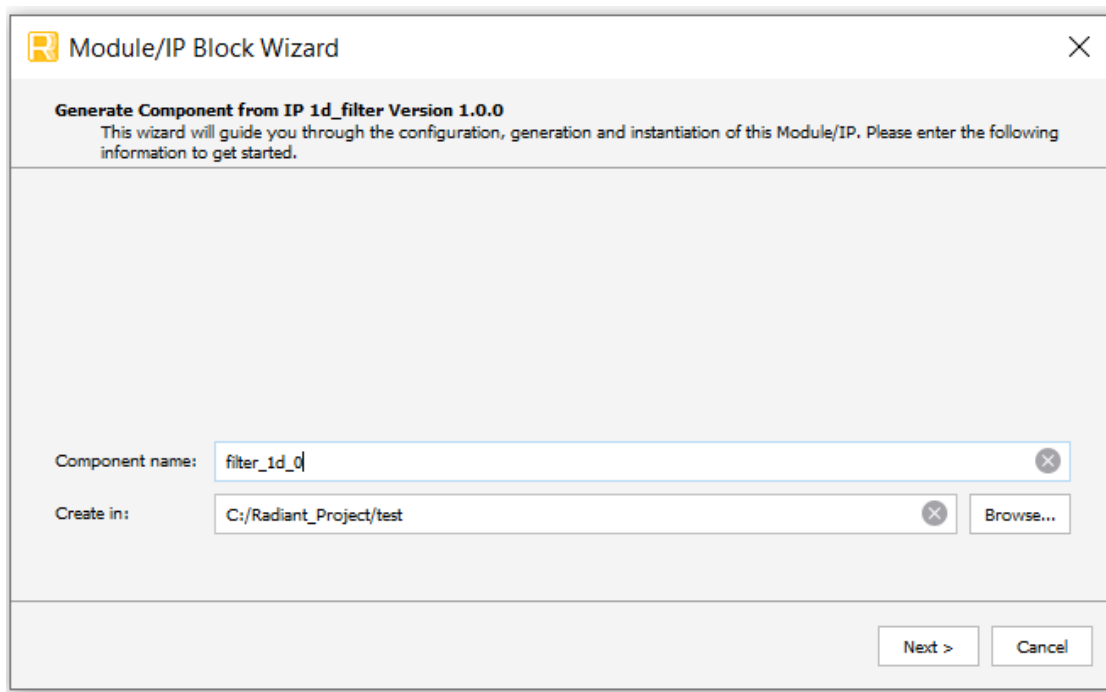


Figure 3.1. Module/IP Block Wizard

- In the module's dialog box of the **Module/IP Block Wizard** window, customize the selected 1D Filter Module using drop-down menus and check boxes. As a sample configuration, see [Figure 3.2](#). For configuration options, see the [Attribute Summary](#) section.

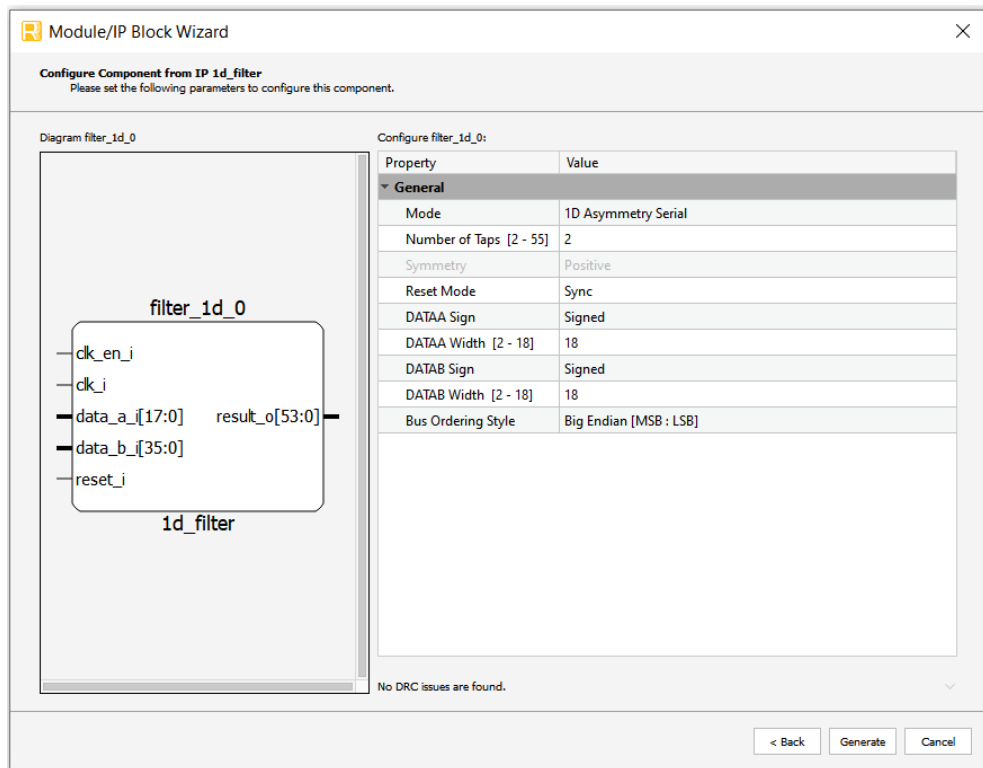


Figure 3.2. Configure User Interface of 1D Filter Module

- Click **Generate**. The **Check Generating Result** dialog box opens, showing design block messages and results as shown in [Figure 3.3](#).

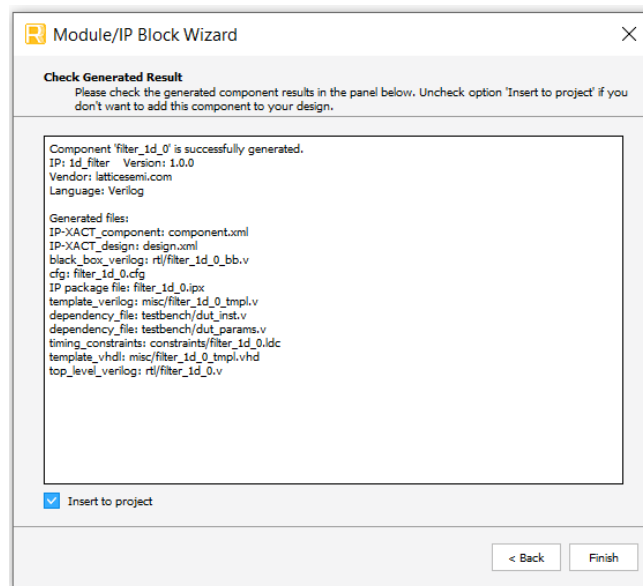


Figure 3.3. Check Generating Result

- Click **Finish**. All the generated files are placed under the directory paths in the **Create in** and the **Component name** fields shown in [Figure 3.1](#).

The generated 1D Filter Module package includes the black box (<Instance Name>_bb.v) and instance templates (<Instance Name>_tmpl.v/vhd) that can be used to instantiate the module in a top-level design. An example RTL top-level reference source file (<Instance Name>.v) that can be used as an instantiation template for the module is also provided. You may also use this top-level reference as the starting template for the top-level for their complete design. The generated files are listed in [Table 3.1](#).

Table 3.1. Generated File List

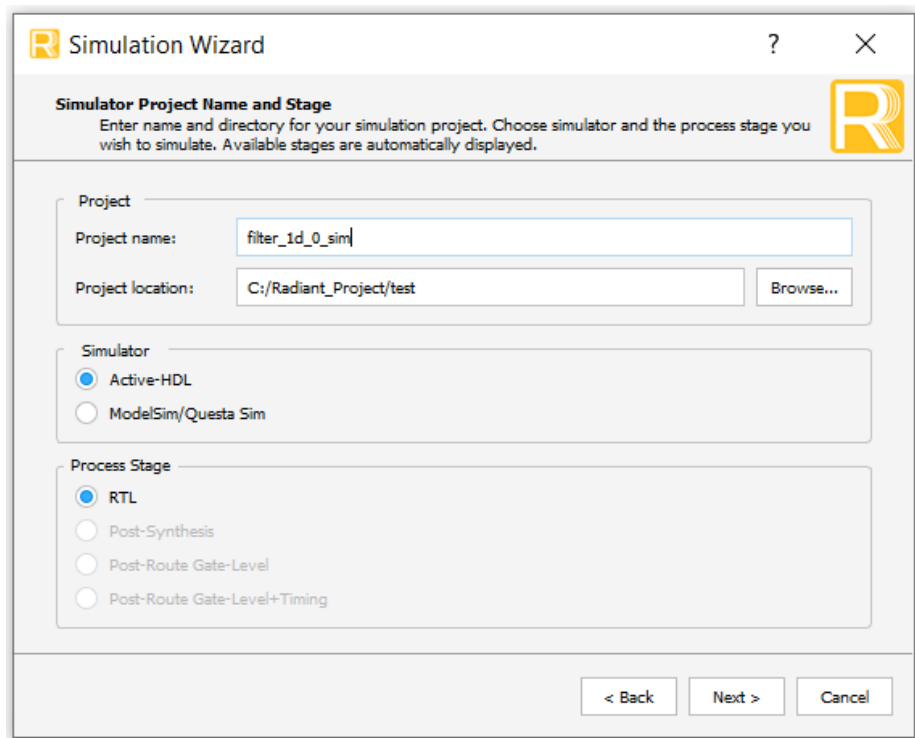
Attribute	Description
<Instance Name>.ipx	This file contains the information on the files associated to the generated IP.
<Instance Name>.cfg	This file contains the attribute values used in IP configuration.
component.xml	Contains the ipxact:component information of the IP.
design.xml	Documents the configuration attributes of the IP in IP-XACT 2014 format.
rtl/<Instance Name>.v	This file provides an example RTL top file that instantiates the module.
rtl/<Instance Name>_bb.v	This file provides the synthesis black box.
misc/<Instance Name>_tmpl.v misc /<Instance Name>_tmpl.vhd	These files provide instance templates for the module.

3.3. Running the Functional Simulation

Running functional simulation can be performed after the IP is generated.

To run functional simulation:

- Click the  button located on the **Toolbar** to initiate the **Simulation Wizard** shown in [Figure 3.4](#).



The **Simulation Wizard** dialog box is shown. It has a title bar with a question mark and a close button. The main content area is titled **Simulator Project Name and Stage** with a subtitle: "Enter name and directory for your simulation project. Choose simulator and the process stage you wish to simulate. Available stages are automatically displayed." Below this, there are three sections: **Project** with fields for "Project name:" (containing "filter_1d_0_sim") and "Project location:" (containing "C:/Radiant_Project/test" and a "Browse..." button); **Simulator** with two radio buttons: "Active-HDL" (selected) and "ModelSim/Questa Sim"; and **Process Stage** with four radio buttons: "RTL" (selected), "Post-Synthesis", "Post-Route Gate-Level", and "Post-Route Gate-Level+Timing". At the bottom right, there are three buttons: "< Back", "Next >", and "Cancel".

Figure 3.4. Simulation Wizard

- Click **Next** to open the **Add and Reorder Source** window as shown in Figure 3.5.

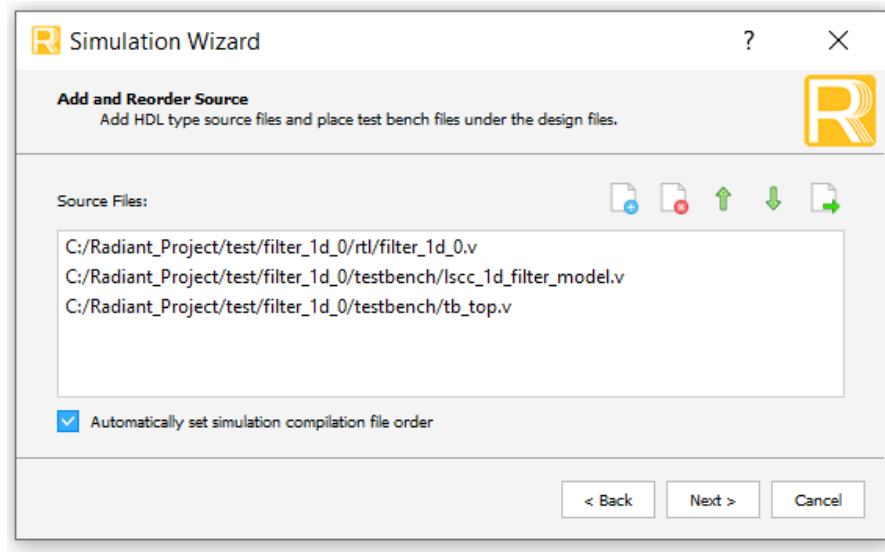


Figure 3.5. Adding and Reordering Source

- Click **Next**. The **Summary** window is shown.
- Click **Finish** to run the simulation.

Note: It is necessary to follow the procedure above until it is fully automated in the Lattice Radiant software suite. The results of the simulation in our example are provided in Figure 3.6.

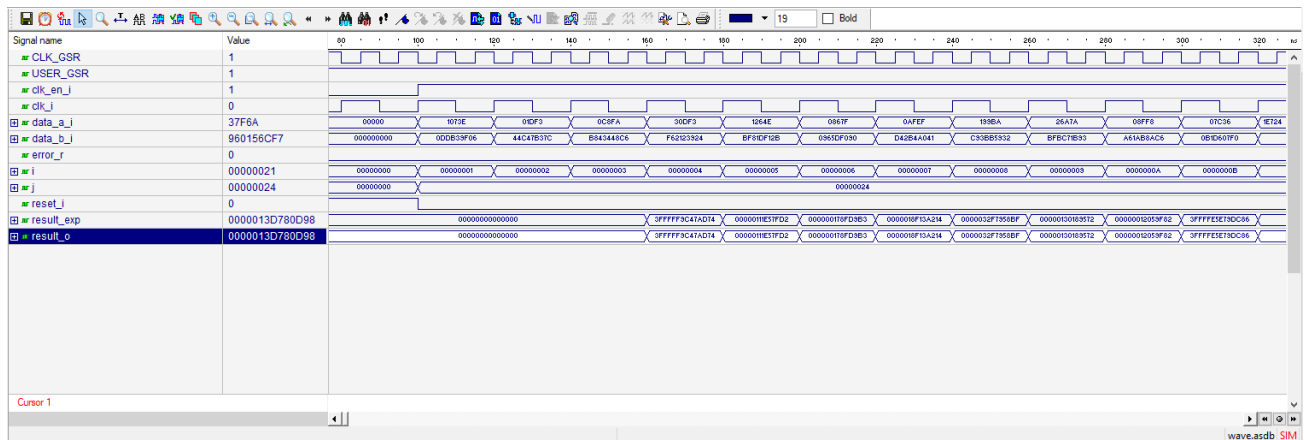


Figure 3.6. Simulation Waveform

Appendix A. Resource Utilization

Table A.1 and Table A.2 show the resource utilization of the 1D Filter Module for the LIFCL-40-9BG400I, and LFCPNX-100-9LFG672I device, using Lattice Synthesis Engine of Lattice Radiant software. Default configuration is used and some attributes are changed from the default value to show the effect on the resource utilization.

Table A.1. Resource Utilization (LIFCL)

Configuration	Clk Fmax (MHz)*	Registers	LUTs	DSP
Default	200 MHz	0	1	2
DATAA Width = 2, DATAB Width = 2, Others = Default	200 MHz	0	1	2
Mode = 1D Symmetry, Symmetry = Negative, Others = Default	200 MHz	0	1	2
Number of taps = 5, Others = Default	200 MHz	0	1	6

*Note: Fmax is generated when the FPGA design only contains 1D Filter Module and the target frequency is 200 MHz. These values may be reduced when user logic is added to the FPGA design.

Table A.2. Resource Utilization (LFCPNX)

Configuration	Clk Fmax (MHz)*	Registers	LUTs	DSP
Default	250 MHz	0	1	2
DATAA Width = 2, DATAB Width = 2, Others = Default	250 MHz	0	1	2
Mode = 1D Symmetry, Symmetry = Negative, Others = Default	250 MHz	0	1	2
Number of taps = 5, Others = Default	250 MHz	0	1	6

*Note: Fmax is generated when the FPGA design only contains 1D Filter Module and the target frequency is 250 MHz. These values may be reduced when user logic is added to the FPGA design.

References

For complete information on Lattice Radiant Project-Based Environment, Design Flow, Implementation Flow and Tasks, as well as on the Simulation Flow, see the Lattice Radiant software user guide.

Technical Support Assistance

Submit a technical support case through www.latticesemi.com/techsupport.

Revision History

Document Revision 1.5, Lattice Radiant SW version 3.2, May 2022

Section	Change Summary
Functional Description	Updated dependency of Number of Taps in Table 2.2 .

Document Revision 1.4, Lattice Radiant SW version 3.1, November 2021

Section	Change Summary
Appendix A. Resource Utilization	Added Table A.1. Resource Utilization (LIFCL) and updated Table A.2. Resource Utilization (LFCPNX) .

Document Revision 1.3, Lattice Radiant SW version 3.0, June 2021

Section	Change Summary
Introduction	Removed Quick Facts section.
Functional Description	Updated equations in this section.
References	Updated reference to Lattice Radiant software user guide.

Document Revision 1.2, Lattice Radiant SW version 2.3, December 2020

Section	Change Summary
Functional Description	Updated dependency of <i>Number of Taps</i> in Attribute Summary.
References	Updated this section.

Document Revision 1.1, Lattice Radiant SW version 2.1, June 2020

Section	Change Summary
Introduction	Updated Table 1.1. - Added support to Certus-NX - Added LFD2NX-40 as targeted device. - Updated Lattice Implementation to Lattice Radiant 2.1.
Functional Description	Updated dependency of <i>Number of Taps</i> to support LFD2NX-40 in Attributes Summary.
Appendix A. Resource Utilization	Updated device to LIFCL-40-9BG400I.

Document Revision 1.0, Lattice Radiant SW version 2.0, February 2020

Section	Change Summary
All	Initial release.



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