



RISC-V MC CPU IP - Lattice Propel Builder 2.0

User Guide

FPGA-IPUG-02157-1.0

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Acronyms in This Document

A list of acronyms used in this document.

Acronym	Definition
AHB-L	Advanced High-performance Bus – Lite
CPU	Central Processing Unit
DMIPS	Dhrystone MIPS (Million Instructions per Second)
FPGA	Field Programmable Gate Array
GDB	Gnu Debugger
HDL	Hardware Description Language
IRQ	Interrupt Request
ISA	Instruction Set Architecture
JTAG	Joint Test Action Group
LUT	Lookup-Table
MC	Micro-Controller (RISC-V for Micro-Controller applications)
OpenOCD	Open On-Chip Debugger
PIC	Programmable Interrupt Controller
RISC-V	Reduced instruction set computer-V (five)
RV32IC	RISC-V Integer & Compressed Instruction Sets

1. Introduction

The Lattice Semiconductor RISC-V MC CPU soft IP contains a 32-bit RISC-V processor core and optional submodules – Timer and Programmable Interrupt Controller (PIC). The CPU core is with instruction and data caches, it supports RV32IC instruction set, external interrupts, and debug feature which is JTAG – IEEE 1149.1 compliant. The Timer submodule is a 64-bit real time counter, which compares a real-time register with another register to assert the timer interrupt. The PIC submodule aggregates up to eight external interrupt inputs into one external interrupt. The submodule registers are accessed by the processor core using a 32-bit Advanced High-performance Bus - Lite (AHB-L) interface.

The design is implemented in Verilog HDL, it can be configured and generated using the Lattice Propel™ Builder software. It is targeted to CrossLink™-NX/MachXO3D™/MachXO3™/MachXO2™ FPGA devices and implemented using Lattice Radiant™ software Place and Route tool integrated with the Synplify Pro® synthesis tool.

1.1. Features

The RISC-V MC soft IP has the following features:

- RV32IC instruction set
- Five stages of pipelines
- Support for the AHB-L bus standard for instruction/data port
- Optional caches (for CrossLink-NX device only, 4 KB 2-way instruction cache and 4 KB 2-way data cache)
- Optional debug through GDB and OpenOCD
- Optional PIC module
- Optional Timer module
- Interrupt and exception handling under Machine Mode
- >0.7 DMIPS/MHz performance
- 100 MHz on CrossLink-NX device (tested on the Hello World template provided by Propel)
 - Added optional instruction and data caches

1.2. Conventions

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

2. Functional Descriptions

2.1. Overview

The RISC-V MC CPU IP processes data and instructions while considering the external interrupts. As shown in [Figure 2.1](#), the CPU IP has a 32-bit processor core and optional submodules. It uses one AHB-L interface (Read-Only) for instruction fetch and another AHB-L interface (Read/Write Access) for data access. See [Table 2.5](#) and [Table 2.6](#) for the AHB-L Instruction Fetch and Data Accessing ports definition. The CPU core, PIC, Timer and AHB-L multiplex run in system clock domain. The Core Debug runs in both system clock domain and JTAG clock domain.

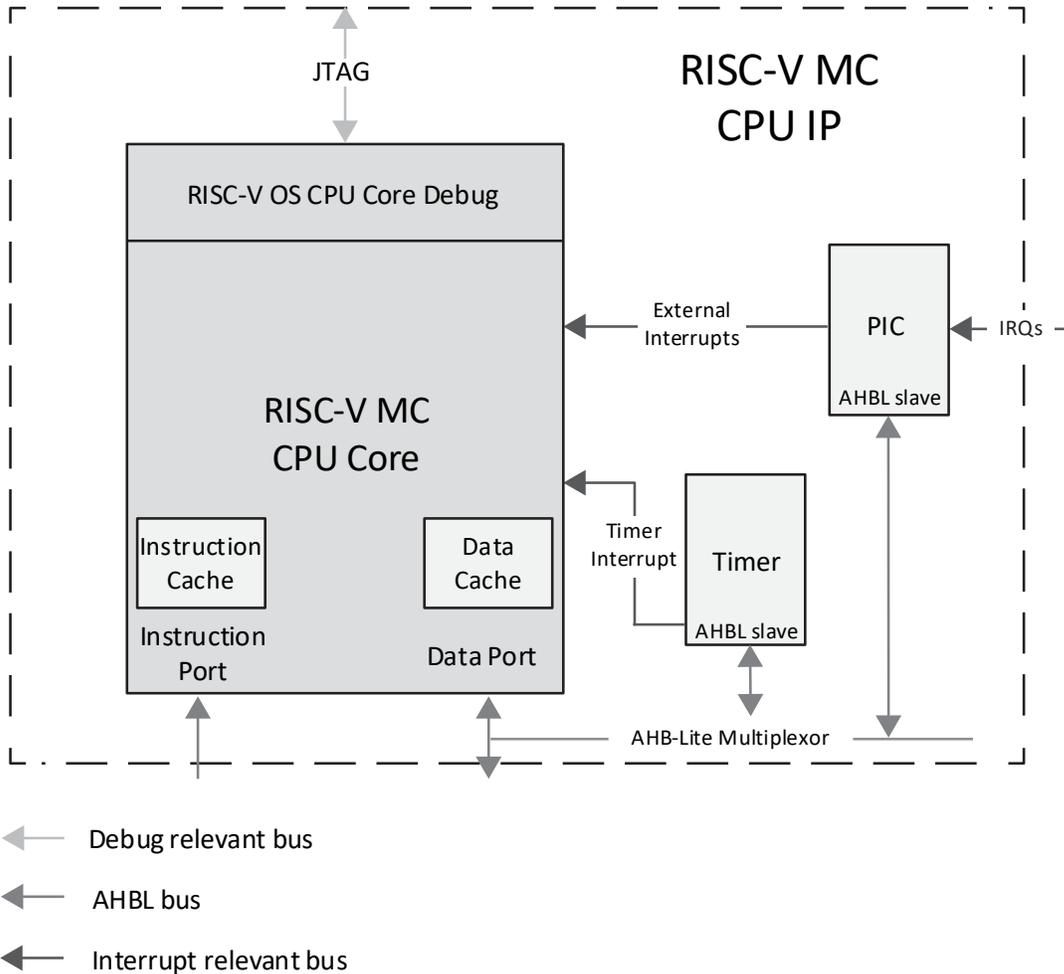


Figure 2.1. RISC-V MC Soft IP Diagram

2.2. Modules Description

2.2.1. RISC-V Processor Core

The processor core follows the RV32I instruction set. [Figure 2.2](#) shows the processor core block diagram.

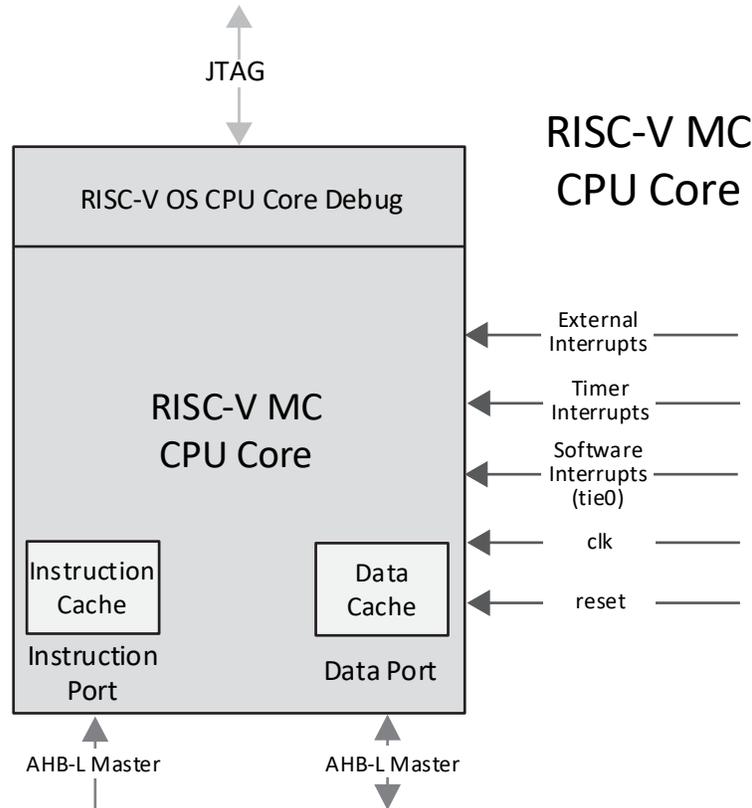


Figure 2.2. RISC-V MC Processor Core Block Diagram

2.2.1.1. Interrupt

Whenever an interrupt occurs, it has to remain in its active level until it is cleared by the processor core interrupt service routine.

If an interrupt occurs before jumping to the interrupt service routine, the processor core stops the prefetch stage and waits for all instructions in the later pipeline stages to complete their execution.

2.2.1.2. Exception

If an exception occurs, the processor core stops the corresponding instruction, flushes all previous instructions, and waits until the terminated instruction reaches the writeback stage before jumping to the exception service routine.

2.2.1.3. Low Power Mode

Processor core enters into low power mode with *WFI* command, PC halts during low power mode, and processor wakes up if there is external/timer interrupt.

2.2.1.4. Debug

The processor core supports the IEEE-1149.1 JTAG debug logic with two hardware breakpoints.

2.2.1.5. Instruction and Data Caches

The processor core supports instruction and data caches.

The instruction and data caches are both 4 KB 2-way set associative, each cache line contains 32 bytes.

The Instruction and data caches can be enabled/disabled together by checking/unchecking the *CACHE_ENABLE* option when instantiating CPU in Propel, and the cacheable address range can be configured by setting the *CACHEABLE_ADDR_LOW* and *CACHEABLE_ADDR_HIGH* parameters.

It should be noted that the instruction and data caches should only be enabled for CrossLink-NX devices, as they have enough resources to support the caches.

2.2.1.6. Control and status registers

The processor core supports the Control and Status Registers (CSRs) listed in [Table 2.1](#).

Table 2.1. RISC-V Processor Core Control and Status Registers

CSR No.	CSR Name	Access	Fields
0x300	mstatus (machine status register)	read/write	bit[12:11]: mpp, privilege mode before entering trap , should always be 2'b11 (machine mode) in this CPU core. bit[7]: mpie, mie before entering trap, updated to mie value when entering to trap. bit[3]: mie, global interrupt enable.
0x304	mie (machine interrupt enable register)	read/write	bit[11]: meie, machine mode external interrupt enable bit[7]: mtie, machine mode timer interrupt enable bit[3]: msie, machine mode software interrupt enable
0x305	mtvec	read/write (initialized to 0x20)	bit[31:2]: trap vector base address, 4-byte aligned. bit[1:0]: trap vector mode, all traps set the program counter to the base address in RISC-V SM CPU core.
0x340	mscratch	read/write	bit[31:0]: dedicated for use by machine mode, it is used to hold a pointer to a machine-mode hart-local context space and swapped with a user register upon entry to an machine mode trap handler.
0x341	mepc (machine exception program counter)	read/write	bit[31:0]: when trap is taken into machine mode, mepc is used to store the address of the instruction that encountered exception.
0x342	mcause (machine cause register)	read only	bit[31]: 1'b1 - interrupt, 1'b0 - exception bit[3:0]: exception code for interrupt : 3 - machine software interrupt 7 - machine timer interrupt 11 - machine external interrupt for exception : 0 - instruction address misaligned 1 - instruction access fault 2 - illegal instruction 4 - load address misaligned 5 - load access fault
0x343	mtval (machine trap value register)	read only	bit[31:0] : When a hardware breakpoint is triggered, or an instruction fetch, load or store address is misaligned or access exception occurs, mtval is written with the fault address. It may also be written with illegal instruction when an illegal instruction occurs.
0x344	mip (machine interrupt pending register)	read/write	bit[11]: meip, machine mode external interrupt pending, read only. bit[7] mtip, machine mode timer interrupt pending, read only. bit[3] msip, machine mode software interrupt pending, readable and writable.

2.2.2. Submodule (PIC/Timer)

The CPU soft IP contains submodules: PIC and Timer. The PIC and Timer share the same start address in memory map and a fixed two KB address range is allocated, if any of PIC or Timer is enabled.

2.2.2.1. PIC

The PIC aggregates up to eight external interrupt inputs (IRQs) into one interrupt output to processor core. The interrupt status register and can be used to read the values of IRQs. Individual IRQs can be configured by programming the corresponding PIC_STATUS, PIC_ENABLE, PIC_SET and PIC_POL registers. All registers can be accessed through an AHB-L interface, as shown in Figure 2.3.

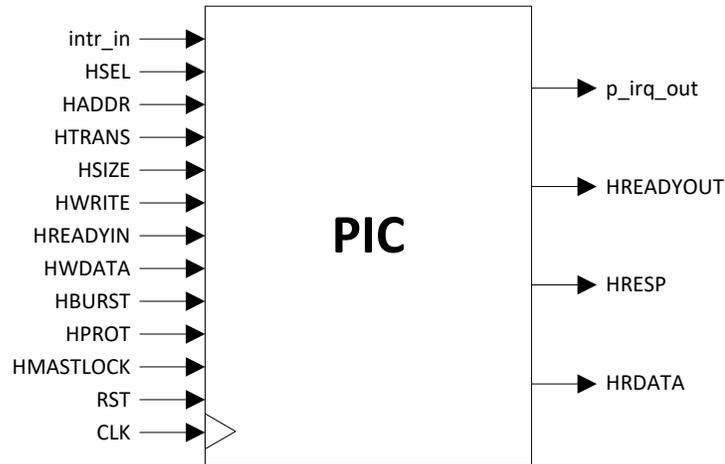


Figure 2.3. PIC Block Diagram

Table 2.2 provides the descriptions of PIC registers.

Table 2.2. PIC Registers

Offset	Name	Description																									
0x000	PIC_STATUS	<p>Interrupt Status Register (read-write) (parameterizable width, min=2, max=8) Indicate the pending interrupt at corresponding interrupt request port(irq[i]).</p> <table border="1"> <thead> <tr> <th>Field</th> <th>Name</th> <th>Access</th> <th>Width</th> <th>Reset</th> </tr> </thead> <tbody> <tr> <td>[N-1]</td> <td>PIC_STATUS [N-1]</td> <td>RW</td> <td>1</td> <td>0x0</td> </tr> <tr> <td>...</td> <td>...</td> <td>...</td> <td>...</td> <td>...</td> </tr> <tr> <td>[1]</td> <td>PIC_STATUS [1]</td> <td>RW</td> <td>1</td> <td>0x0</td> </tr> <tr> <td>[0]</td> <td>PIC_STATUS [0]</td> <td>RW</td> <td>1</td> <td>0x0</td> </tr> </tbody> </table> <p>PIC_STATUS[i]: Read</p> <ul style="list-style-type: none"> 0 – no interrupt at irq[i] 1 – interrupt pending at irq[i] <p>Write</p> <ul style="list-style-type: none"> 0 – no effect 1 – clear interrupt status for irq[i] 	Field	Name	Access	Width	Reset	[N-1]	PIC_STATUS [N-1]	RW	1	0x0	[1]	PIC_STATUS [1]	RW	1	0x0	[0]	PIC_STATUS [0]	RW	1	0x0
Field	Name	Access	Width	Reset																							
[N-1]	PIC_STATUS [N-1]	RW	1	0x0																							
...																							
[1]	PIC_STATUS [1]	RW	1	0x0																							
[0]	PIC_STATUS [0]	RW	1	0x0																							

Offset	Name	Description																									
0x004	PIC_ENABLE	<p>Interrupt Enable Register (read-write) (parameterizable width, min=2, max=8) Enable or Disable the corresponding interrupt request port (irq[i]).</p> <table border="1"> <thead> <tr> <th>Field</th> <th>Name</th> <th>Access</th> <th>Width</th> <th>Reset</th> </tr> </thead> <tbody> <tr> <td>[N-1]</td> <td>PIC_ENABLE[N-1]</td> <td>RW</td> <td>1</td> <td>0x0</td> </tr> <tr> <td>...</td> <td>...</td> <td>...</td> <td>...</td> <td>...</td> </tr> <tr> <td>[1]</td> <td>PIC_ENABLE[1]</td> <td>RW</td> <td>1</td> <td>0x0</td> </tr> <tr> <td>[0]</td> <td>PIC_ENABLE[0]</td> <td>RW</td> <td>1</td> <td>0x0</td> </tr> </tbody> </table> <p>PIC_ENABLE[i]: Read</p> <ul style="list-style-type: none"> 0 – irq[i] disabled 1 – irq[i] enabled <p>Write</p> <ul style="list-style-type: none"> 0 – disable irq[i] 1 – enable irq[i] 	Field	Name	Access	Width	Reset	[N-1]	PIC_ENABLE[N-1]	RW	1	0x0	[1]	PIC_ENABLE[1]	RW	1	0x0	[0]	PIC_ENABLE[0]	RW	1	0x0
Field	Name	Access	Width	Reset																							
[N-1]	PIC_ENABLE[N-1]	RW	1	0x0																							
...																							
[1]	PIC_ENABLE[1]	RW	1	0x0																							
[0]	PIC_ENABLE[0]	RW	1	0x0																							
0x008	PIC_SET	<p>Interrupt Set Register (write-only) (parameterizable width, min=2, max=8) Set the interrupt status for corresponding interrupt request port(irq[i]).</p> <table border="1"> <thead> <tr> <th>Field</th> <th>Name</th> <th>Access</th> <th>Width</th> <th>Reset</th> </tr> </thead> <tbody> <tr> <td>[N-1]</td> <td>PIC_SET [N-1]</td> <td>W</td> <td>1</td> <td>0x0</td> </tr> <tr> <td>...</td> <td>...</td> <td>...</td> <td>...</td> <td>...</td> </tr> <tr> <td>[1]</td> <td>PIC_SET [1]</td> <td>W</td> <td>1</td> <td>0x0</td> </tr> <tr> <td>[0]</td> <td>PIC_SET [0]</td> <td>W</td> <td>1</td> <td>0x0</td> </tr> </tbody> </table> <p>PIC_SET[i]: Read</p> <ul style="list-style-type: none"> Invalid operation gets 0. <p>Write</p> <ul style="list-style-type: none"> 0 – no effect 1 – set interrupt status for irq[i] (set PIC_STATUS[i]) 	Field	Name	Access	Width	Reset	[N-1]	PIC_SET [N-1]	W	1	0x0	[1]	PIC_SET [1]	W	1	0x0	[0]	PIC_SET [0]	W	1	0x0
Field	Name	Access	Width	Reset																							
[N-1]	PIC_SET [N-1]	W	1	0x0																							
...																							
[1]	PIC_SET [1]	W	1	0x0																							
[0]	PIC_SET [0]	W	1	0x0																							
0x00C	PIC_POL	<p>Interrupt Polarity Register (read-write) (parameterizable width, min=2, max=8) Indicates the polarity of corresponding interrupt request (irq[i]) port.</p> <table border="1"> <thead> <tr> <th>Field</th> <th>Name</th> <th>Access</th> <th>Width</th> <th>Reset</th> </tr> </thead> <tbody> <tr> <td>[N]</td> <td>PIC_POL [N]</td> <td>RW</td> <td>1</td> <td>0x0</td> </tr> <tr> <td>...</td> <td>...</td> <td>...</td> <td>...</td> <td>...</td> </tr> <tr> <td>[1]</td> <td>PIC_POL I[1]</td> <td>RW</td> <td>1</td> <td>0x0</td> </tr> <tr> <td>[0]</td> <td>PIC_POL [0]</td> <td>RW</td> <td>1</td> <td>0x0</td> </tr> </tbody> </table> <p>PIC_POL[i]: Read</p> <ul style="list-style-type: none"> 0 – irq[i] is active high 1 – irq[i] is active low <p>Write</p> <ul style="list-style-type: none"> 0 – Set irq[i] active high 1 – Set irq[i] active low 	Field	Name	Access	Width	Reset	[N]	PIC_POL [N]	RW	1	0x0	[1]	PIC_POL I[1]	RW	1	0x0	[0]	PIC_POL [0]	RW	1	0x0
Field	Name	Access	Width	Reset																							
[N]	PIC_POL [N]	RW	1	0x0																							
...																							
[1]	PIC_POL I[1]	RW	1	0x0																							
[0]	PIC_POL [0]	RW	1	0x0																							

Note: The register definition of PIC follows Lattice Interrupt Interface (LINTR) Standard, refer to [Lattice Memory Mapped Interface \(LMMI\)](#) and [Lattice Interrupt Interface \(LINTR\) User Guide](#) for more information.

2.2.2.2. Timer

The Timer module provides a 64-bit real-time counter register (*mtime*) and time compare register (*mtimecmp*). An output interrupt signal notices the RISC-V processor core when the value of *mtime* is greater than or equal to the value of *mtimecmp*. All registers can be accessed through an AHB-L interface, as shown in [Figure 2.4](#).

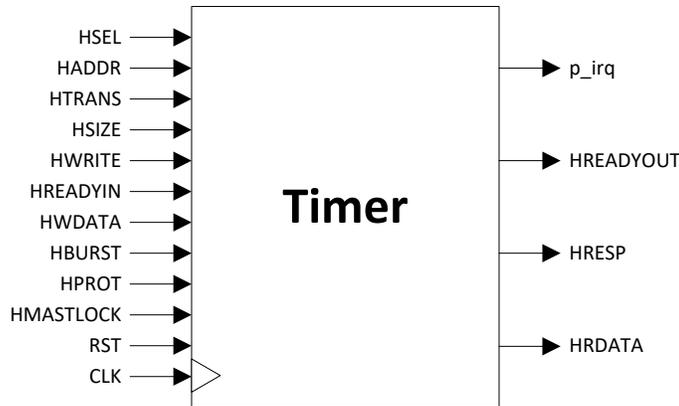


Figure 2.4. Timer Block Diagram

[Table 2.3](#) provides the descriptions of Timer registers.

Table 2.3. Timer Registers

Offset	Name	Description										
0x400	TIMER_CNT_L	Lower 32 bits of Timer counter register <table border="1" style="margin-top: 10px;"> <thead> <tr> <th>Field</th> <th>Name</th> <th>Access</th> <th>Width</th> <th>Reset</th> </tr> </thead> <tbody> <tr> <td>[63:0]</td> <td><i>mtime</i></td> <td>RW</td> <td>64</td> <td>0x0</td> </tr> </tbody> </table> <p><i>mtime</i></p> <p>A 64-bit real-time counter register. You must set the register to a non-zero value to start the counting process.</p>	Field	Name	Access	Width	Reset	[63:0]	<i>mtime</i>	RW	64	0x0
Field	Name	Access	Width	Reset								
[63:0]	<i>mtime</i>	RW	64	0x0								
0x404	TIMER_CNT_H	Higher 32 bits of Timer counter register.										
0x410	TIMER_CMP_L	Lower 32 bits for Timer time compare register. <table border="1" style="margin-top: 10px;"> <thead> <tr> <th>Field</th> <th>Name</th> <th>Access</th> <th>Width</th> <th>Reset</th> </tr> </thead> <tbody> <tr> <td>[63:0]</td> <td><i>mtimecmp</i></td> <td>RW</td> <td>64</td> <td>0x0</td> </tr> </tbody> </table> <p><i>mtimecmp</i></p> <p>This register is used to generate or clear the timer interrupt (<i>mtip</i>). When the value of <i>mtime</i> register is greater than or equal to the value of <i>mtimecmp</i> register, the <i>cpu_mtip_o</i> is asserted and remains asserted until it is cleared by writing to <i>mtimecmp</i> register. Lower 32 bit for Timer time compare register</p>	Field	Name	Access	Width	Reset	[63:0]	<i>mtimecmp</i>	RW	64	0x0
Field	Name	Access	Width	Reset								
[63:0]	<i>mtimecmp</i>	RW	64	0x0								
0x400	TIMER_CNT_L	Higher 32 bits for Timer time compare register										

2.3. Signal Description

Table 2.4 to Table 2.7 list the ports of the CPU soft IP in different categories.

2.3.1. Clock and Reset

Table 2.4. Clock and Reset Ports

Name	Direction	Width	Description
clk_i	In	1	RISC-V soft IP clock
rst_n_i	In	1	Global reset (active low)
system_resefn_o	Out	1	Combined Global reset and Debug Reset from JTAG

2.3.2. Instruction and Data Interface

Table 2.5. Instruction Ports

Name	Direction	Width	Description
AHBL_M0_INSTR - HADDR	Out	32	—
AHBL_M0_INSTR - HWRITE	Out	1	Fixed to 1'b0
AHBL_M0_INSTR - HSIZE	Out	3	Fixed to 3'b010
AHBL_M0_INSTR - HPROT	Out	1	Fixed to 4'b1110 when cache is not enabled
AHBL_M0_INSTR - HTRANS	Out	2	—
AHBL_M0_INSTR - HBURST	Out	3	Fixed to 3'b000
AHBL_M0_INSTR - HMASTLOCK	Out	1	Fixed to 1'b0
AHBL_M0_INSTR - HWDATA	Out	32	—
AHBL_M0_INSTR - HRDATA	In	32	—
AHBL_M0_INSTR - HREADY	In	1	—
AHBL_M0_INSTR - HRESP	In	1	—

Table 2.6. Data Ports

Name	Direction	Width	Description
AHBL_M1_DATA - HADDR	Out	32	—
AHBL_M1_DATA - HWRITE	Out	1	—
AHBL_M1_DATA - HSIZE	Out	3	—
AHBL_M1_DATA - HPROT	Out	1	Fixed to 4'b1111 when cache is not enabled
AHBL_M1_DATA - HTRANS	Out	2	—
AHBL_M1_DATA - HBURST	Out	3	Fixed to 3'b000
AHBL_M1_DATA - HMASTLOCK	Out	1	—
AHBL_M1_DATA - HSEL	Out	1	—
AHBL_M1_DATA - HWDATA	Out	32	—
AHBL_M1_DATA - HRDATA	In	32	—
AHBL_M1_DATA - HREADY	In	1	—

Note: Refer to [AMBA 3 AHB-Lite Protocol V1.0](#) for more information.

2.3.3. Interrupt interface

Table 2.7. Interrupt Ports

Name	Type	Width	Description
IRQ_Sx	In	1~8	Peripheral interrupts
TIMER_IRQ_M0	Out	1	Timer interrupt output, exist only when "TIMER_ENABLE" checked
TIMER_IRQ_S0	In	1	Timer interrupt input, exist only when "TIMER_ENABLE" unchecked

2.4. Attribute Summary

The configurable attributes of the RISC-V MC CPU IP are shown in [Table 2.8](#) and are described in [Table 2.9](#).

The attributes can be configured through the Propel Builder software.

Table 2.8. Configurable Attributes

Attribute	Selectable Values	Default	Dependency on Other Attributes
General			
SIMULATION	Checked, Unchecked	UnChecked	—
ICACHE_ENABLE	Checked, Unchecked	UnChecked	—
DCACHE_ENABLE	Checked, Unchecked	UnChecked	—
ICACHE_RANGE_LOW	0 ~ 0xFFFFFFFF	0	Enabled when ICACHE_ENABLE
ICACHE_RANGE_HIGH	0 ~ 0xFFFFFFFF	0xF0000000	Enabled when ICACHE_ENABLE
DCACHE_RANGE_LOW	0 ~ 0xFFFFFFFF	0	Enabled when DCACHE_ENABLE
DCACHE_RANGE_HIGH	0 ~ 0xFFFFFFFF	0xF0000000	Enabled when DCACHE_ENABLE
DEBUG_ENABLE	Checked, Unchecked	UnChecked	—
TIMER_ENABLE	Checked, Unchecked	UnChecked	—
PIC_ENABLE	Checked, Unchecked	UnChecked	—
PICTIMER_START_ADDR	0 ~ 0xFFFFFB00	0xFFFF0000	Enabled when PIC_ENABLE or TIMER_ENABLE
IRQ_NUM	2 ~ 8	8	Enabled when PIC_ENABLE
C_EXT	Checked, Unchecked	Unchecked	—
JTAG_CHANNEL	14~16	14	Enabled when DEBUG_ENABLE

Table 2.9. Attributes Description

Attribute	Description
SIMULATION	1: simulation mode 0: synthesis mode
ICACHE_ENABLE	1: enable instruction cache 0: disable instruction cache
DCACHE_ENABLE	1: enable data cache 0: disable data cache
ICACHE_RANGE_LOW	Lower limit of cacheable address range for instruction cache, this address itself is included
ICACHE_RANGE_HIGH	Higher limit of cacheable address range for instruction cache, this address itself is included
DCACHE_RANGE_LOW	Lower limit of cacheable address range for data cache, this address itself is included
DCACHE_RANGE_HIGH	Higher limit of cacheable address range for data cache, this address itself is included
DEBUG_ENABLE	1: debug function enable 0: debug function disable
TIMER_ENABLE	1: timer enable 0: timer disable
PIC_ENABLE	1: pic enable 0: pic disable

PICTIMER_START_ADDR	Start address of PIC and Timer
IRQ_NUM	Interrupt number for peripherals
C_EXT	1: support for compressed instruction 0: no support for compressed instruction
JTAG_CHANNEL	JTAG channel select

Note:

“ICACHE_ENABLE” and “DCACHE_ENABLE” should only be enabled when using CrossLink-NX Devices with sufficient resources. For MachXO2, MachXO3L, MachXO3LF and MachXO3D devices, cache features are not supported as their resources are limited.

“ICACHE_RANGE_LOW” should not be larger than “ICACHE_RANGE_HIGH”, and address range between “ICACHE_RANGE_LOW” and “ICACHE_RANGE_HIGH” should not be overlapped with peripheral devices’ address ranges.

Similarly, “DCACHE_RANGE_LOW” should not be larger than “DCACHE_RANGE_HIGH”, and address range between “DCACHE_RANGE_LOW” and “DCACHE_RANGE_HIGH” should not be overlapped with peripheral devices’ address ranges.

3. RISC-V MC CPU IP Generation

This section provides information on how to generate the CPU IP Core module using Propel Builder.

To generate the CPU IP Core module:

1. In Propel Builder, create a new design. Select the CPU package.
2. Enter the component name as shown in [Figure 3.1](#). Click **Next**.

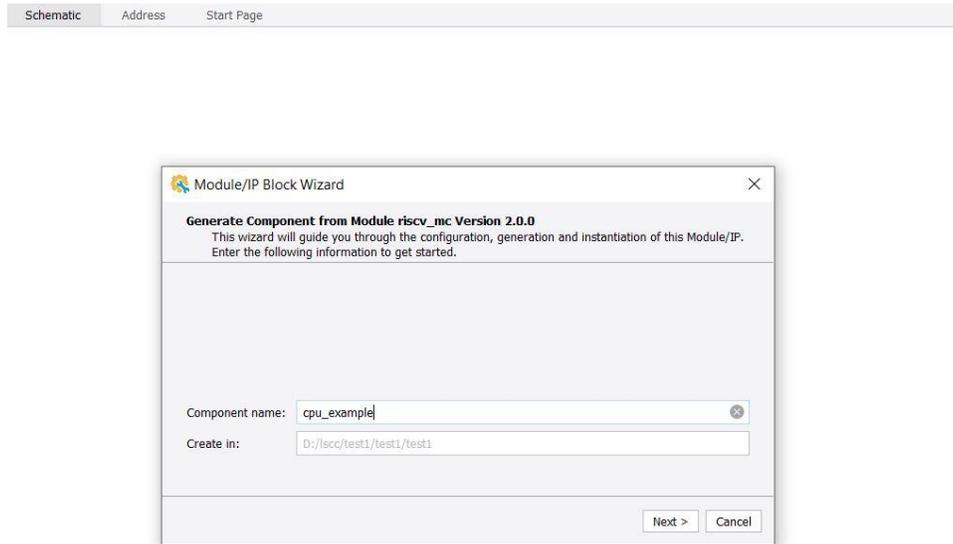


Figure 3.1. Entering Component Name

3. Configure the parameters as shown in [Figure 3.2](#). Click **Generate**.

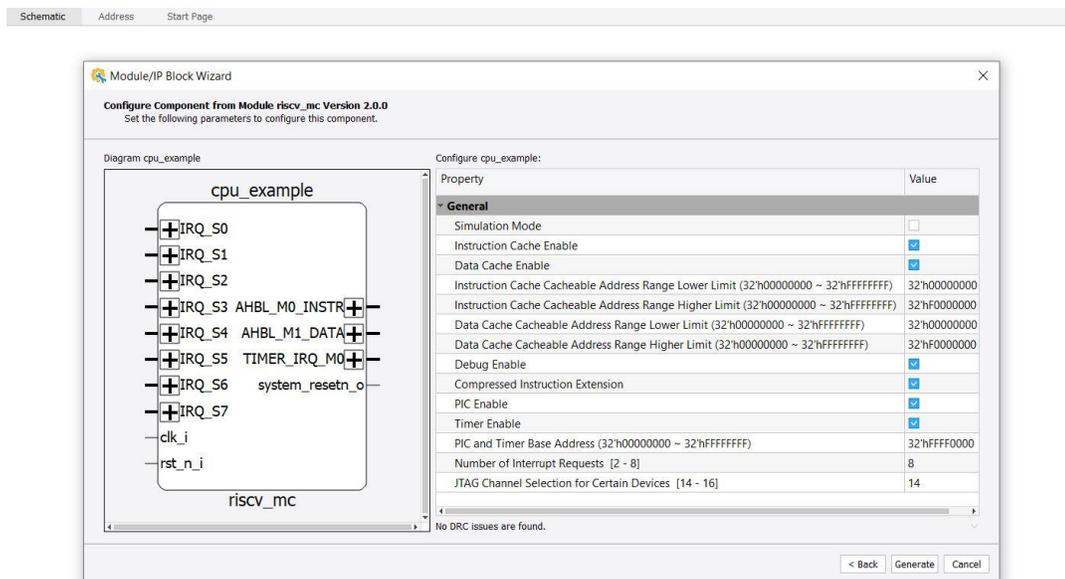


Figure 3.2. Configuring Parameters

4. Verify the information. Click **Finish**.

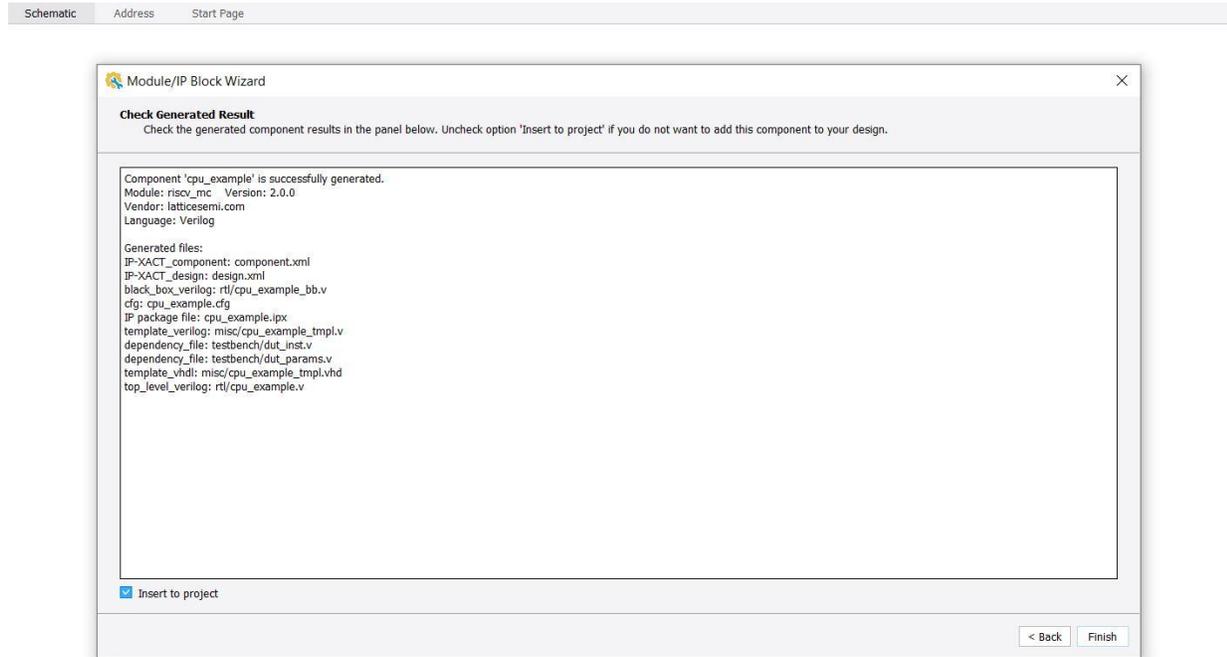


Figure 3.3. Verifying Results

5. Confirm or modify the module instance name. Click **OK**.

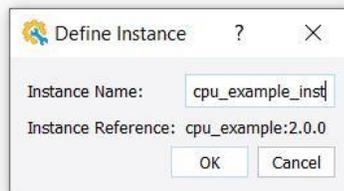
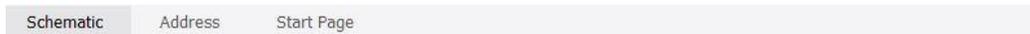


Figure 3.4. Specifying Instance Name

The CPU IP instance is successfully generated as shown in [Figure 3.5](#).

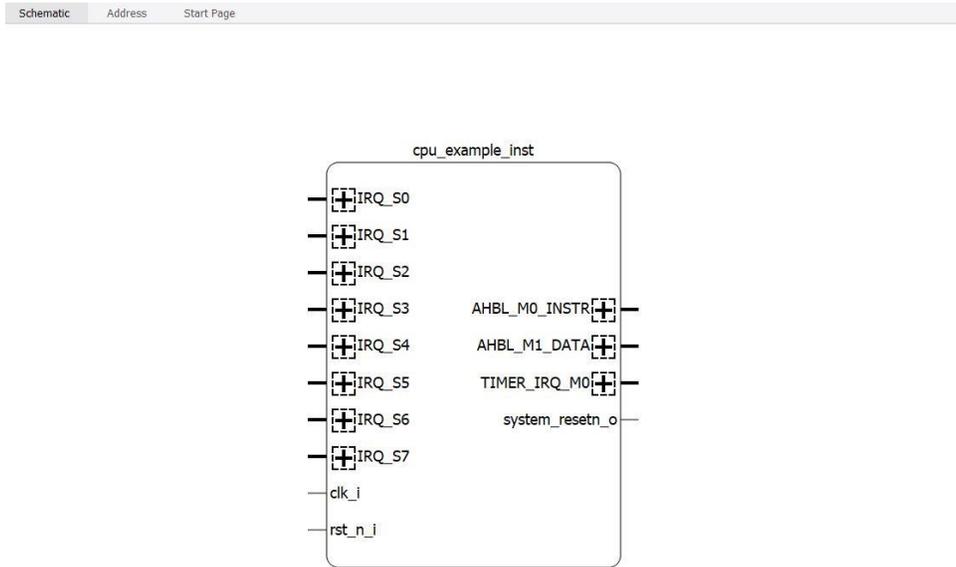


Figure 3.5. Generated Instance

Appendix A. Resource Utilization

Table A.1. Resource Utilization in MachXO3D Device (with Cache Disabled)

Configuration	LUTs	Registers	sysMEM EBRs
Processor core only	1507	809	4
Processor core + PIC	1640	851	4
Processor core + Timer	1857	955	4
Processor core + Debug	1716	1111	4
Processor core + C_EXT	1754	861	4
Processor core + PIC + Timer	1864	965	4
Processor core + PIC + Timer + Debug	2140	1268	4
Processor core + PIC + Timer + Debug + C_EXT	2410	1352	4

Note: Resource utilization characteristics are generated using Lattice Diamond software.

Table A.2. Resource Utilization in CrossLink-NX Device (with Cache Disabled)

Configuration	LUTs	Registers	sysMEM EBRs
Processor core only	1619	807	2
Processor core + PIC	1707	826	2
Processor core + Timer	2099	959	2
Processor core + Debug	1943	1182	2
Processor core + C_EXT	1893	852	2
Processor core + PIC + Timer	2110	963	2
Processor core + PIC + Timer + Debug	2489	1339	2
Processor core + PIC + Timer + Debug + C_EXT	2749	1352	2

Note: Resource utilization characteristics are generated using Lattice Radiant software.

Table A.3. Resource Utilization in CrossLink-NX Device (with Cache Enabled)

Configuration	LUTs	Registers	sysMEM EBRs
Processor core + only	2577	1033	17
Processor core + PIC	2512	1054	17
Processor core + Timer	2959	1181	17
Processor core + Debug	2908	1416	17
Processor core + C_EXT	2857	1103	17
Processor core + PIC + Timer	3063	1195	17
Processor core + PIC + Timer + Debug	3277	1572	17
Processor core + PIC + Timer + Debug + C_EXT	3672	1641	17

Note: Resource utilization characteristics are generated using Lattice Radiant software.

References

- [Lattice Semiconductor CrossLink-NX FPGA Web Page](#)
- [Lattice Semiconductor MachXO3D FPGA Web Page](#)
- [Lattice Semiconductor MachXO3 FPGA Web Page](#)
- [Lattice Semiconductor MachXO2 FPGA Web Page](#)
- [Lattice Propel Builder 2.0 User Guide](#)
- [Lattice Diamond Software 3.12 User Guide](#)
- [Lattice Radiant Software 2.2 User Guide](#)
- [AMBA 3 AHB-Lite Protocol V1.0](#)
- [RISC-V Privileged Specification \(20190608\)](#)
- [RISC-V Instruction Set Manual \(20190608\)](#)
- [Lattice Memory Mapped Interface \(LMMI\) and Lattice Interrupt Interface \(LINTR\) User Guide](#)

Technical Support Assistance

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

Revision History

Revision 1.0, April 2021

Section	Change Summary
All	Initial release



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