



RV1 - RISC-V Architecture

This course covers and explains the implementation of the RISC-V CPU

Objective

- Understand the basics of the RISC-V architecture and instruction set.
- Develop proficiency in RISC-V C Programming and be able to write, compile, and run RISC-V C code.
- Learn how to handle interrupts and exceptions in RISC-V.
- Understand the concepts of RISC-V hardware and system design, specifically on FPGA and embedded systems

A more detailed course description is available on request at training@ac6-training.com

Course environment

- Theoretical course
 - PDF course material (in English)
 - Course dispensed using the Teams video-conferencing system
 - The trainer answers trainees' questions during the lectures and provide technical and pedagogical assistance through the Teams video-conferencing system
- Practical activities
 - Practical activities represent from 40% to 50% of course duration
 - The trainer has access to trainees' Online PCs for technical and pedagogical assistance.
 - Course will be using QEMU as the RISC-V emulator.
 - Students will be given access to a shared filesystem to save and share their work.
 - Hands-on labs will include exercises that use QEMU to emulate RISC-V systems and run assembly and C code.
 - The course will provide materials and tutorials for the lab sessions which will be based on QEMU
 - Example code, labs and solutions
- Virtual Machine with System Workbench for STM32 with GNU ARM Eclipse QEMU

Prerequisites

- Familiarity with computer architecture
- Programming skills: Some programming experience, particularly in C or assembly
- Knowledge of digital logic: Understanding of digital logic and basic concepts of computer design would be beneficial for understanding RISC-V CPU implementation and FPGA design
- Basic understanding of operating systems: Familiarity with operating system concepts such as process management, memory management, and interrupts
- The course may use Linux-based development tools and environments

Target Audience

- Any embedded systems engineer or technician with the above prerequisites.

Course Outline

First Day

Introduction to RISC-V

- Overview of RISC-V
 - What is RISC-V and why is it important?
 - History and development of RISC-V
 - RISC-V architecture and instruction set
 - RISC-V implementations and applications
- RISC-V ISA Overview
 - Instruction format
 - Instruction set encoding
 - Privileged architecture
 - Vector instructions
 - Compressed instructions

Exercise: Setting up a RISC-V development environment and running a "Hello World" program on a RISC-V emulator

RISC-V CPU Implementation

- RISC-V 32-bit CPU implementation
 - RISC-V 32-bit instruction set
 - RISC-V 32-bit register set
 - RISC-V 32-bit pipeline
- RISC-V 64-bit CPU implementation
 - RISC-V 64-bit instruction set
 - RISC-V 64-bit register set
 - RISC-V 64-bit pipeline

Exercise: CPU Implementation

Second Day

RISC-V Memory Management

- Introduction to RISC-V memory management
 - Memory management unit
 - Virtual memory
 - Address translation
- Memory-mapped I/O in RISC-V
 - MMIO interface
 - Device drivers
- Virtual memory and address translation in RISC-V
 - Page tables
 - Translation lookaside buffer

RISC-V Interrupt and Exception Handling

- Introduction to RISC-V interrupts and exception handling
 - Interrupts and exceptions
 - Interrupt handling
- Implementing interrupt handlers in RISC-V assembly and C
 - Interrupt service routines
 - Exception handling

- Handling exceptions and errors in RISC-V
 - Exception vectors
 - Trap handling

Exercise: Interrupt and Exception Handling

RISC-V C Programming and Debugging

- Introduction to RISC-V C programming
 - Setting up the C development environment
 - Writing and compiling RISC-V C code
- Debugging and testing C code
 - GDB and OpenOCD
 - Trace

Exercise: C programming and debugging

Third Day

RISC-V Optimization

- Introduction to RISC-V performance optimization
 - Understanding performance metrics
 - Identifying performance bottlenecks
- Profiling and benchmarking RISC-V code
 - Using performance counters
 - Analyzing performance data
- Optimizing RISC-V code for performance
 - Instruction scheduling
 - Loop optimization
 - Register allocation
 - Memory optimization

Exercise: Optimizing RISC-V Code

RISC-V Optimization for FPGA and Embedded Systems

- Introduction to RISC-V on FPGA
 - Overview of FPGA technology
 - RISC-V on FPGA: benefits and challenges
- Synthesis and Implementation
 - Synthesis flow
 - Place and route
 - Power and performance optimization
- Designing RISC-V systems with FPGA
 - SoC design
 - Peripherals and interfaces
 - Interrupts and exception handling
- RISC-V on embedded systems and IoT applications
 - Applications and use-cases
 - Memory and power constraints
 - Security and privacy concerns

Exercise: Implementing a RISC-V system on an FPGA development board