



®

# Boruss® CPU Architecture Software Developer's Manual

Volume:  
1

**NOTE:** This document contains Boruss® CPU Architecture Software Developer's Manual.

October 2024

## **Notices & Disclaimers**

Boruss CPU technology require use hardware

# CHAPTER 1

## ABOUT THIS MANUAL

---

The Boruss CPU Architecture Software Developer's Manual, Volume 1 describes the architecture and programming environment of Boruss® CPU architecture processor.

### 1.1 BORUSS® CPU PROCESSORS COVERED IN THIS MANUAL

- BorussCPU "Laibach"

### 1.2 OVERVIEW OF VOLUME 1: BASIC ARCHITECTURE

A description of this manual's content follows:

**Chapter 1 – About This Manual.** Gives an overview of the BorussCPU.

**Chapter 2 - Boruss® Architecture.** Introduces the Boruss CPU architecture and gives overview of the features.

**Chapter 3 – Basic Execution Environment.** Introduces the model of memory organization and describes the register set used by applications.

**Chapter 4 – Instruction Set Summary.** List all BorussCPU instructions

### 1.3 NOTATIONAL CONVENTION

This manual uses typical notation described below.

#### 1.3.1 Bit and Byte Order

- **Bit order** (in byte) specifies how bits are arranged within a single byte
  - **MSB** (Most Significant Bit) leftmost bit is the most significant (bit 7)
  - **LSB** (Least Significant Bit first) leftmost bit is the least significant (bit 0)

MSBO: b7 b6 b5 b4 b3 b2 b1 b0 (bits numbered 7 down to 0, left to right)

LSBO: b0 b1 b2 b3 b4 b5 b6 b7 (bits numbered 0 up to 7, left to right)

|-----8 bits-----|

- **Byte Order** (Endianness)
  - **Big-endian:** Most significant byte first (higher address = less significant)
  - **Little-endian:** Least significant byte first (lower address = less significant)

Memory addresses: 0 1 2 3

Big-endian: [0x12] [0x34] [0x56] [0x78]

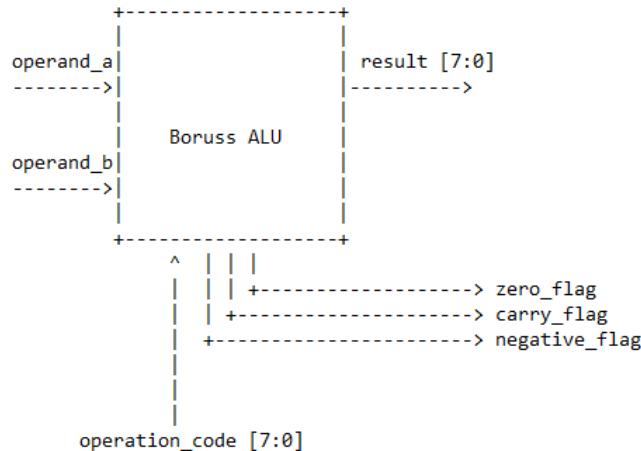
Little-endian: [0x78] [0x56] [0x34] [0x12]

## 2.1 BORUSS® CPU ARCHITECTURE

This chapter describes all BorussCPU components

### 2.1.1 Arithmetic-Logic Unit

Performs arithmetic (adding, subtracting) and logical(AND, OR, XOR) operations based on operation code received from CPU.



*Figure 1 BorussCPU ALU inputs and outputs overview*

#### 2.1.1.1 ALU inputs and outputs

Name	Role	Description	Width
<code>operand_a</code>	Input	operand A	8 bits
<code>operand_b</code>	Input	operand B	8 bits
<code>operation_code</code>	Input	operation code	8 bits

*Table 1 ALU inputs overview*

Name	Role	Description	Width
<code>result</code>	Output	Operation result	8 bits
<code>zero_flag</code>	Output	Set when result is zero	1 bit
<code>carry_flag</code>	Output	Set when carry occurred	1 bit
<code>negative_flag</code>	Output	Set when result is negative (bit 7 is set to 1)	1 bit

*Tabela 2 ALU outputs overview*

#### 2.1.1.2 ALU operation processing

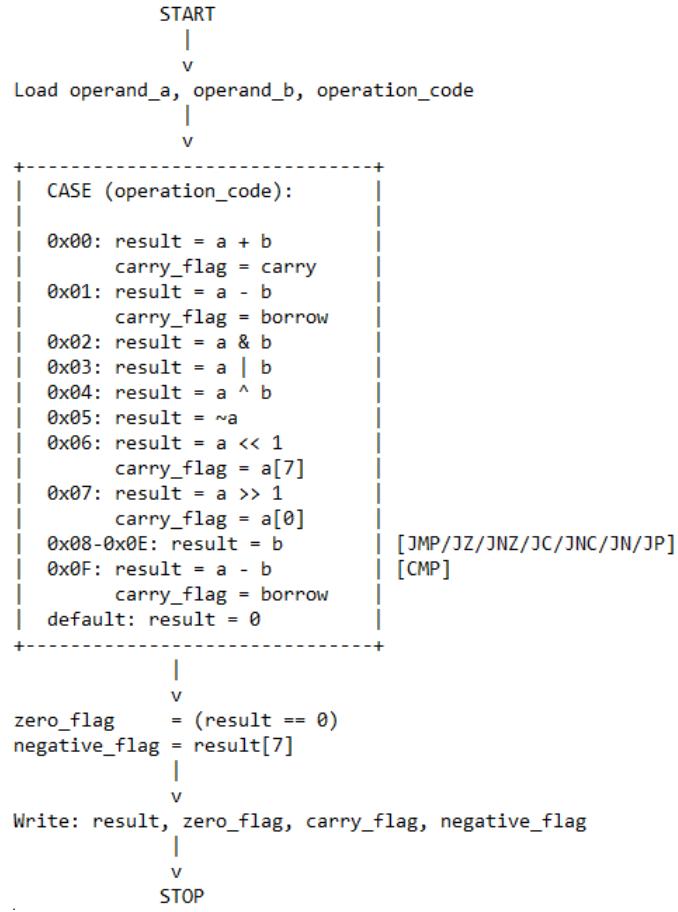


Figure 2 ALU operation processing flow chart

ALU gets the information about what operation is needed to be performed on the 8-bits wide input bus named “operation\_code”. Based on that ALU selects and performs the operation and puts the outcome to the “result” 8-bits wide bus.

Operation name	Code	Used flags
ADD	0x0 (8'b00000000)	carry_flag

When operation code value is 0x0 that means the ADD operation is requested. Operands A and B are added and result can be longer (9 bits) than two input operands because the result can overflow. In that case the oldest bit (MSB) is stored in **carry\_flag** and the rest written to the **result**.

Example:

```

operand_a = 8'11111111 (0xFF, 8`d255, 255)
operand_b = 8'00000001 (0x1, 8'd1, 1)

8'b11111111 + 8'b00000001 = 9'b100000000 (0x100, 9'd256, 255 + 1 = 256)

result = 8'b00000000
carry_flag = 1'b1

```

Operation name	Code	Used flags
SUB	0x0 (8'b00000001)	carry_flag

When operation code value is 0x1 that means the SUB operation is requested. Operands A and B are subtracted and result can be longer (9 bits) than two input operands because the result can borrow. In that case the oldest bit (MSB) is stored in **carry\_flag** and the rest written to the **result**.

**Example:**

```
operand_a = 8'00000101 (0x5, 8'd5, 5)
operand_b = 8'00001000 (0x8, 8'd8, 8)
```

```
8'00000101 - 8'00001000 = 9'b11111101 (0xFFFFD, -8'd3, 5 - 8 = -3)
```

```
result = 8'b11111101
carry_flag = 1'b1
```

Note: When **operand\_a < operand\_b** then carry\_flag is set to 1.