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**Free Assembly Languages for developing real-time operating system for  
embedded devices**

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**Abstract:** Free assembly languages will become popular because of open-source instruction set architecture – RISC-V. Features of assembly languages such as: AVR Assembler, RISC-V assembler will be analyzed. The paper performs the Critical analysis of available assembly languages task of PhD thesis.

**Keywords:** risc-v assembly, avr assembly, operating system, micro-controller modules

**1. Introduction**

Usage of assembly languages is most natural way to program embedded devices. There are several types of instruction-set architectures. x86, RISC, CISC and RISC-V instruction-set architectures are the most known. There are different free assembly languages for different devices. For x86 based devices Netwide assembler or Yarn assembler can be used. For devices based on RISC based devices there are GNU assembler, AVR assembler. For RISC-V based devices can be used RISC-V assembler. This paper describes process of finding best assembler to design real-time operating system.

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<sup>1</sup> PhD Theme: Methods and Tools to develop a assembly-based operating system for embedded devices

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## **2. Material and Methods**

There are different free assembly languages for embedded devices such as: AVR Assembler, PIC Assembler, RISC-V Assembler. For each assembler will be analyzed:

- Types of available instructions
- Supported micro-controllers
- Compilation process of target assembler

### **1) AVR assembler**

AVR assembler is free and open-source assembly language. It supports several types of instructions such as:

- arithmetical-logic operations
- control flow branch instructions
- bite control instructions
- byte control instructions

This assembler is used for range of RISC-based device families such as:

- Raspberry Pi-based
- Atmega and Attiny-based boards
- RISC-based single board computers. Compilation steps for AVR assembler are shown

on Figure1.

### **2) PIC assembler**

PIC assembler is free and open-source assembly language. It supports several types of instructions such as:

- control flow branch instructions
- bite control instructions

This assembler is used for range of PIC-based device families such as:

- PIC10-based
- PIC20-based
- PIC-based single board computers. Compilation steps for PIC assembler are shown on

Figure2.

RTOS Development scheme is shown on Figure3. (Attiny85 PIC10F320 Datasheet, 2023).

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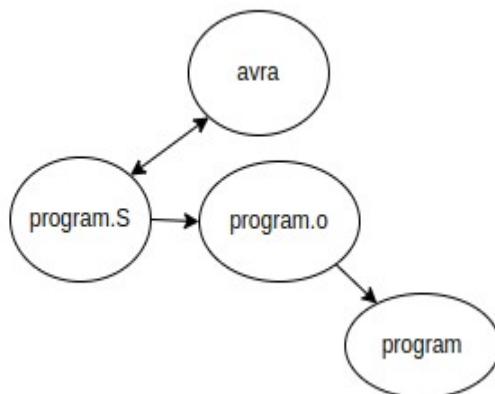


Figure1. AVR assembler compilation

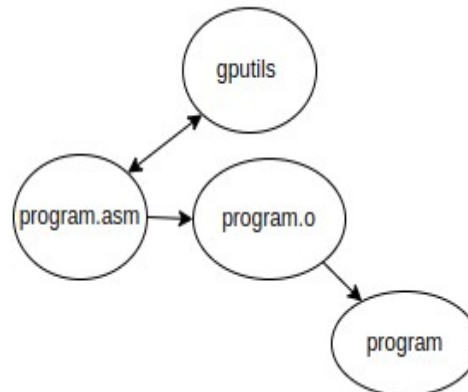


Figure2. PIC assembler compilation

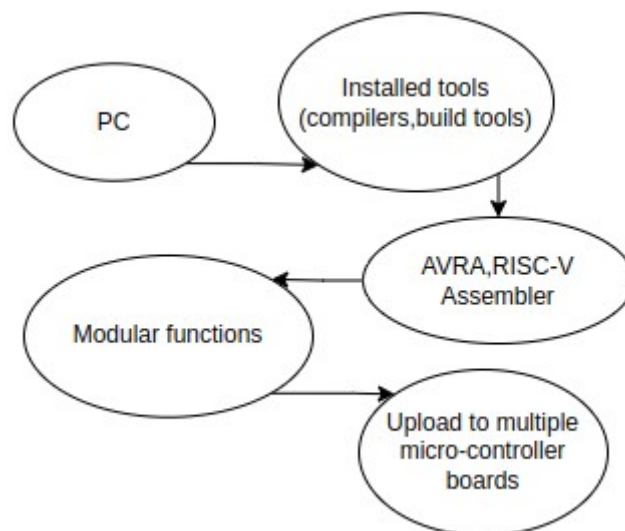


Figure3. RTOS Development

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3) RISC-V assembler

RISC-V assembler is free and open-source assembly language. It supports several types of instructions such as:

- arithmetical-logic operations
- control flow branch instructions
- floating point instructions

This assembler is used for range of PIC-based device families such as:

- Atmega-based devices
- SiFive-based devices

### 3. Results

Free assembly languages for different instruction sets are compared. RTOS Development scheme is demonstrated. Compilation process for AVR / PIC assemblers is shown.

### 4. Conclusions and future work

According to Free assembly languages overview that can be used and AVR PIC instruction analys the conclusion of the paper: AVR assembly language and RISC-V assembly languages will be best choice to design real-time operating system. AVR and PIC assembly languages are used in Master Degree project of the author.

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