Civil Real-Time operating systems and assembly languages for their programming

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**Abstract.** Real-Time operating systems are usage in many different domains. They can be used in military industries. There are OS for robotics ROS, for drones, for missile system control and for aircraft control system. This paper describes well known real-time OS such as Zephyr OS, FreeRTOS and GNU/Linux.

# Introduction

Real-time operating systems can be used for embedded devices management or for civil or military aviation – for optical devices and weapon controls management. There are different free assembly languages for embedded devices such as: AVR Assembler, PIC Assembler, RISC-V Assembler. Real-time operating system manages devices with that has:

→ limited resources

→ limited time to complete task

→ sensors for communication

Target of the paper is to explore and describe features of well-known RTOS such as: FreeRTOS, Zephyr and Armbian GNU/Linux.

**2. Material and Methods**

Programming languages for real-time os development are C or Assembly language. Usage of assembly language gives more control of current task execution. For every RTOS will be analyzed:

→ Short description

→ Supported virtualizators

→Supported toolchains

→ Supported Instruction set architectures

→ Possible assembly languages that can be used

→ Embedded device witch is supported by the os

1) Zephyr Analysis

Zephyr is real-time operating system written in C programming language. Zephyr is available for different instruction set architectures such as:

→ ARM-64

→ x86

→ MIPS

This OS can be used for different micro-controller boards like NEORV32,KB-2040. There are several options for developing Zephyr applications:

→ using default C-based SDK

→ using standalone assembly language according to instruction set of target device. Zephyr can be used throught QEMU virtualizator.ARM C Toolchain is supported. Cmake can be used for automation of build process of the project. (Zephyr Docs 2024**).**

2) Armbian GNU/Linux Analysis

Armbian is real-time Debian – ported OS for microcontroller modules; SD card can be used for storage. Armbian is available for different instruction set architectures such as:

→ x86\_64

→ RISC

This OS can be used for different micro-controller boards like OrangePi, BananaPi. **(Armbian Docs 2024).**

3) FreeRTOS Analysis

FreeRTOS is open-source real-time operating system that has portable libraries written in C programming language. Libraries provides support for popular communication protocols such as: MQTT, TCP/IP, etc. FreeRTOS is available for different instruction set architectures such as:

→ x86

→ ARM

→ ARM-64

→ PIC

This OS can be used for different micro-controller boards like STM32-based, PIC24-based and SiFive RISC-V – based boards. FreeRTOS can be used for IoT boards witch supports connection to Amazon Web Services-based remote services.

There are several options for developing FreeRTOS applications:

→ using default C-based SDK

→ using inline assembly language in C function

→ using standalone assembly language according to instruction set of target device.Options are shown on *Figure1*.

Applications can be developed on standard x86 computer using virtual environment using QEMU or Virtual-Box – based virtualization. It’s shown onFigure2.

GNU Make, Cmake can be used for automation of build process of the project. Compiled once the project can be deployed to multiple compatible boards using pipelines based on chosen build tool. Build automatization is shown on *Figure3****. (*FreeRTOS Docs ,2024).**

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# mathematics (first level heading) (Use the Microsoft Word template style: *Heading 1*) or (Use Times New Roman Font: 12 pt, Bold, ALL CAPS, Centered)

Here we provide some basic advice for formatting your mathematics, but we do not attempt to define detailed styles or specifications for mathematical typesetting. You should use the standard styles, symbols, and conventions for the field/discipline you are writing about.

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From Word 2007 onwards, Microsoft Word provides two “Equation Editors,” which, for ease of reference, we’ll call “Old Style Equations” and “New Style Equations.”

* **“New Style Equations”** (Word 2007 onwards): With Word 2007 Microsoft introduced a powerful new built-in Equation Editor that enables input of sophisticated mathematics typeset (usually) in the Cambria Math font. You access it from the Insert menu.
* **“Old Style Equations”** (Word 97–Word 2003): For versions of Microsoft Word between Word 97 and Word 2003, mathematical input was created by an add-in: Inserting and editing a “Microsoft Equation 3.0 object,” typically by *Insert* ð *Object* and selecting “Microsoft Equation 3.0.”

Newer versions of Microsoft Word (Word 2007 and onwards) still support the original “Old Style Equations” method of creating mathematics by inserting an equation via *Insert* ð *Object* and selecting “Microsoft Equation 3.0.” Whatever method is used, please make sure the equation is clear and readable.

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## Formatting and Inserting Equations (Second Level Heading) (Use the Microsoft Word template style: *Heading 2*) or (Use Times New Roman Font: 12 pt, Bold, Centered)

Equations should be centered with equation numbers on the right-hand side (flush right). Achieving a pleasing layout of equations can be tricky in Microsoft Word, so here are some tips. You can either:

1. Copy, paste, and edit the sample equation provided (recommended), or
2. Manually insert an equation and equation number

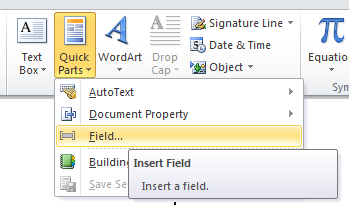
### Copy, Paste, and Edit a Sample Equation (Third Level Heading) (Use the Microsoft Word template style: Heading 3) or (Use Times New Roman Font: 10 pt, Italic, Centered)

To use this “Old Style Equation” as a “template,” highlight the entire line, then use cut and paste to the new location. Note that the equation number will automatically update (increment).

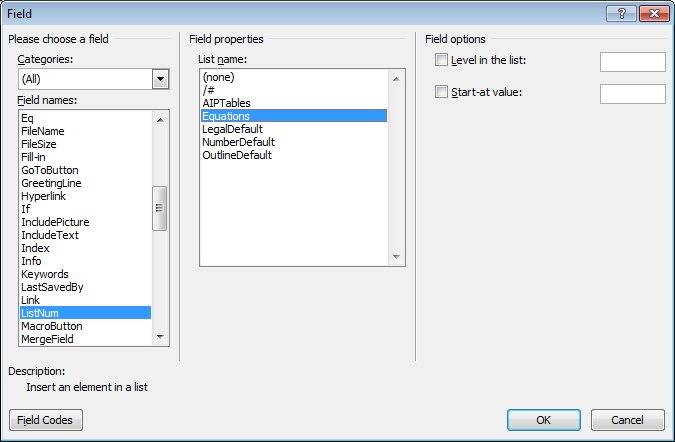
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If you prefer to manually insert and number equations, follow this step-by-step guide:

1. Make sure you can see “hidden characters” by switching on “show invisibles” from the Home menu (it looks like this: ). This allows you to see paragraph markers (¶) and tab characters (à), which are usually hidden from view.
2. Create a blank paragraph by pressing [ENTER].
3. Format your new blank paragraph by applying the Microsoft Word template style: *Equation.* The *Equation* paragraph style sets up the tabs so that you can center the equation and have an equation number appear at the right.
4. Place your cursor at the start of your new paragraph and press the [TAB] key twice.
5. Place your cursor between the tab characters (à) and insert your equation using *Insert* ð *Object* ð *Microsoft Equation 3.0*.
6. To add an equation number, place your cursor at the end of the paragraph (just before the paragraph markers (¶) and after the second tab character (à)).
7. On the *Insert* tab, in the *Text* group, click *Quick Parts* and then click *Field*:



1. A dialog box should appear:



1. From the list of *Field Names* on the left of the dialog box, select *ListNum.*
2. From the list of *Field properties* on the right, select the “Equations” *List name* and click OK. You should now see an equation number in parentheses: e.g., (3).

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|  |  |
| --- | --- |
|  |  |
| (a) | (b) |

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Cite all figures in the text in consecutive order. The word “Figure” should be spelled out if it is the first word of the sentence and abbreviated as “Fig.” elsewhere in the text. Place the figures as close as possible to their first mention in the text at the top or bottom of the page with the figure caption positioned below, all centered. Figures must be inserted in the text and may not follow the Reference section.

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Due to the wide range and complexity of tables, we simply offer an example for guidance. Please follow the style for table (and figure) captions.

|  |  |  |
| --- | --- | --- |
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| **Column Header Goes Here** | **Column Header Goes Here** | **Column Header Goes Here** |
| Row Name Here | x | x |
| Row Name Here | x | x |
| Row Name Here | x | x |

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1. M. P. Brown and K. Austin, *The New Physique* (Publisher Name, Publisher City, 2005), pp. 25–30.
2. M. P. Brown and K. Austin, Appl. Phys. Letters **85**, 2503–2504 (2004).
3. R. T. Wang, “Title of Chapter,” in *Classic Physiques*, edited by R. B. Hamil (Publisher Name, Publisher City, 1999), pp. 212–213.
4. C. D. Smith and E. F. Jones, “Load-cycling in cubic press,” in *Shock Compression of Condensed Matter-2001*, AIP Conference Proceedings 620, edited by M. D. Furnish *et al*. (AIP Publishing, Melville, NY, 2002), pp. 651–654.
5. B. R. Jackson and T. Pitman, U.S. Patent No. 6,345,224 (8 July 2004)
6. D. L. Davids, “Recovery effects in binary aluminum alloys,” Ph.D. thesis, Harvard University, 1998.
7. R. C. Mikkelson (private communication).

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