RISC-V MCU development boards

Table of contents

Introduction

"How do I get my feet wet with RISC-V?" is a very common question, which is often answered "Buy a RISC-V development board, and practice bare metal development."

This document provides guidance on part selection, as well as pointers to useful resources. It is not a comprehensive guide of RISC-V MCU, but rather a short list of easily approachable parts. To be listed in this guide, parts **must** meet several criteria:

- have decent English documentation,
- have open-source or freely downloadable supporting software,
- be easily available from anywhere in the world, e.g. through AliExpress or LCSC,
- have cheap development boards as easily available as the chips,
- not require a Chinese mobile phone number to download software and documentation.

License

Manufacturer selection

MCU manufacturers have different product strategies, leading to different product ranges. An easy and efficient method is to select a manufacturer whose strategy matches your needs, and then see which of their parts best suits your project.

Manufacturer	*Wide supply voltage range*	*Wide package choice*	*Lots of I/O pins*	*WiFi*	*BLE*	*802.15.4*
BouffaloLab				x	x	x
Espressif				x	x	x
GigaDevice			x			
WCH	x	x	x		x	

Note: manufacturers are sorted in alphabetical order.

BouffaloLab

BouffaloLab only manufactures RISC-V chips, so they're undoubtedly committed to this platform. They have a wide range of IoT-oriented MCU, some with SiFive IP, others with T-Head IP. The documentation is good, but their SDK and code examples are a bit chaotic.

However, Pine64 has released a well-documented development board (PineCone) and a module (PineNut), both based on the BL602 MCU, and Lee Lup Yuen has produced excellent training material on this board, which comes in complement to the community built by Pine64 around their products.

It is highly recommended to become quite familiar with the PineCone/BL602's ecosystem before attempting to use other chips from BouffaloLab (e.g. BL702, BL616), with which you will be left a bit on your own.

The following table presents the main differences between BouffaloLab's RISC-V SoC (not the modules):

Part	*MHz*	*RAM*	*CPU*	*WiFi*	*BT*	*BLE*	*802.15.4*	*USB*	*Ethernet*	*Camera*	*AI NPU*
BL602	192	276K	RV32IMAFC	b/g/n	no	yes	no	no	no	no	no
BL702	144	132K	RV32IMAFC	no	no	yes	yes	yes	no	no	no
BL706	144	132K	RV32IMAFC	no	no	yes	yes	yes	yes	yes	no
BL616	320	480K	RV32IMAFCP	b/g/n/ax	yes	yes	yes	yes	yes	yes	no
BL808	480	64M	RV32IMAFCP + RV64IMAFCV +RV32EMC	b/g/n/ax	yes	yes	yes	yes	yes	yes	yes

I chose to include the BL808 because it is exceedingly powerful for an MCU, but very limited for a Linux-capable SoC, so it makes sense to include it in both documents.

Finally, the BL604, is a higher pin count version of the BL602, and the BL618, a higher pin count version of the BL616, not included above because otherwise identical.

Documentation, SDK and tools

Data sheets & reference manuals: https://github.com/bouffalolab/bl_docs

SDK:

> https://github.com/bouffalolab/bl_mcu_sdk
> https://github.com/bouffalolab/bl_iot_sdk
> https://dev.bouffalolab.com/download

Flashing tool (BlDevCube): https://github.com/bouffalolab/flash_tools

GitHub: https://github.com/bouffalolab

Developer forum: https://bbs.bouffalolab.com/t/english-forum

Interesting information not found in BouffaloLab documents: https://github.com/pine64/

BL602

Third-party development board: PineCone

Purchase link: https://pine64.com/product/pinecone-bl602-evaluation-board/

Documentation: https://wiki.pine64.org/wiki/PineCone

Review: https://lupyuen.github.io/articles/pinecone

Tutorials: https://lupyuen.github.io/articles/book

Third-party development board: Ai-WB2-32S

Purchase link: https://www.aliexpress.com/item/1005004904931700.html

Documentation: https://docs.ai-thinker.com/en/wb2

GitHub: https://github.com/Ai-Thinker-Open/Ai-Thinker-WB2

Third-party development board: DT-BL10 or XT-BL12

Purchase links:

> https://www.aliexpress.com/item/1005005083839351.html
> https://www.aliexpress.com/item/1005003695650307.html

Documentation: https://xzrnllk27j.k.topthink.com/@xgr3x6lrjy/BL602.html

BL702

Third-party development board: M0 Sense

Purchase links:

> https://www.aliexpress.com/item/1005005373072135.html
> https://www.aliexpress.com/item/1005005012406688.html

Documentation: https://dl.sipeed.com/shareURL/Maix-Zero/M0sense

GitHub: https://github.com/sipeed/M0sense_BL702_example

Third-party development board: XT-ZB1

Purchase links:

> https://www.aliexpress.com/item/1005004134568356.html
> https://www.aliexpress.com/item/1005003747200098.html

Documentation: https://xzrnllk27j.k.topthink.com/@xgr3x6lrjy/BL702.html

BL616

Third-party development board: M0S Dock

Purchase links:

https://www.aliexpress.com/item/1005005373075939.html
https://www.aliexpress.com/item/1005005142466936.html

Documentation: https://dl.sipeed.com/shareURL/Maix-Zero/M0S

GitHub: https://github.com/sipeed/M0S_BL616_example

Third-party development board: Ai-M62-12F

Purchase links:

https://www.aliexpress.com/item/1005005407942430.html
https://www.aliexpress.com/item/1005005438854506.html

Documentation: https://docs.ai-thinker.com/ai_m62

BL618

Third-party development board: M0P Dock

Purchase link: https://www.aliexpress.com/item/1005005461103465.html

Documentation: https://dl.sipeed.com/shareURL/Maix-Zero/M0P

GitHub: https://github.com/sipeed/M0P_BL618_examples

Third-party development board: Ai-M61-32S

Purchase links:

https://www.aliexpress.com/item/1005005407539968.html
https://www.aliexpress.com/item/1005005407935386.html

Documentation: https://docs.ai-thinker.com/ai_m61

BL808

Third-party development board: Ox64

Purchase link: https://pine64.com/product-category/ox64/

Documentation: https://wiki.pine64.org/wiki/Ox64

Third-party development board: M1S Dock

Purchase links:

https://www.aliexpress.com/item/1005004996668405.html
https://www.aliexpress.com/item/1005004970779483.html

Documentation: https://dl.sipeed.com/shareURL/MAIX/M1s

GitHub:

https://github.com/sipeed/M1s_BL808_example
https://github.com/sipeed/M1s_BL808_SDK
https://github.com/sipeed/M1s_BL808_Linux_SDK

Espressif

Espressif is famous for their Xtensa-based ESP32 and ESP32-S3 modules, but they also announced their new developments would be made on RISC-V, so interesting things are to be expected from them. Like BouffaloLab, they focus on IoT-oriented MCU.

Their current RISC-V product range includes the ESP32-C2/ESP8684, ESP32-C3/ESP8685, ESP32-C6, and ESP32-H2.

The following table presents the main differences between Espressif's RISC-V SoC (not the modules):

Part	*Pins*	*Freq.*	*RAM*	*Flash*	*WiFi*	*BLE*	*802.15.4*	*Notes*
ESP8684	24	120MHz	272KB	1/2/4MB	b/g/n	yes	no	
ESP32-C3	32	160MHz	400KB	0/4MB	b/g/n	yes	no	
ESP8685	28	160MHz	400KB	2/4MB	b/g/n	yes	no	
ESP32-C6	40	160MHz	512KB	0/4MB	a/x	yes	yes	Has 2 CPU (one low power)
ESP32-H2	32	96MHz	320KB	2/4MB	a/x	yes	yes	Low-power applications

GitHub: https://github.com/espressif

The SDK for all Espressif products is called **ESP-IDF**. It is available from GitHub, or can be downloaded from there: https://www.espressif.com/en/support/download/all?keys=&field_type_tid%5B%5D=785

ESP8684 (ESP32-C2)

Official development board: ESP8684-DevKitM-1

Purchase link: https://www.aliexpress.com/item/1005004436990376.html

Documentation: https://docs.espressif.com/projects/espressif-esp-dev-kits/en/latest/esp8684/esp8684-devkitm-1/index.html

Third-party development board: ESPC2-12

Purchase links:

> https://www.aliexpress.com/item/1005004861021167.html
> https://www.aliexpress.com/item/1005004708803007.html

Documentation: http://bbs.doit.am/forum.php?mod=viewthread&tid=489&extra=page%3D1

Documentation

https://www.espressif.com/en/support/documents/technical-documents?keys=&field_type_tid%5B%5D=956

Relevant documents are *ESP8684 Datasheet*, *ESP8684 Technical Reference Manual*.

ESP32-C3 and ESP8685

Official development board: ESP32-C3-DevKitM-1

Purchase link: https://www.aliexpress.com/item/1005003989099547.html

Documentation: https://docs.espressif.com/projects/esp-idf/en/latest/esp32c3/hw-reference/esp32c3/user-guide-devkitm-1.html

Third-party development board: ESP32-C3FH4

Purchase link: https://www.aliexpress.com/item/1005004960064227.html

Documentation: https://github.com/WeActStudio/WeActStudio.ESP32C3CoreBoard

Third-party development board: YD-ESP32-C3

Purchase links:

> https://www.aliexpress.com/item/1005004639250865.html
> https://www.aliexpress.com/item/1005003613170790.html

Documentation: http://www.vcc-gnd.com/

Breaks the ESP32-C3's USB interface out and provides a separate USB-to-serial interface.

Third-party development board: XIAO ESP32C3

Purchase link: https://www.aliexpress.com/item/33011482127.html

Documentation: https://wiki.seeedstudio.com/XIAO_ESP32C3_Getting_Started/

Third-party development board: ESP32C3-MINI-DK

Purchase links:

> https://www.aliexpress.com/item/1005004994621831.html
> https://www.aliexpress.com/i/1005004945580114.html
> https://www.aliexpress.com/item/1005004945500567.html

Has similar features as the ESP32-C3-DevKitC-02 except uses ESP32-C3-MINI-1 instead of ESP32-C3-WROOM-02 and CH340 instead of CP2102, and costs half the price.

Documentation

https://www.espressif.com/en/support/documents/technical-documents?keys=&field_type_tid%5B%5D=785

Relevant documents are *ESP32-C3 Datasheet*, *ESP32-C3 Technical Reference Manual*, and *ESP32-C3 Series SoC Errata*.

ESP32-C6

Official development board: ESP32-C6-DevKitC-1

Purchase link: https://www.aliexpress.com/item/1005005087160183.html

Documentation: https://docs.espressif.com/projects/espressif-esp-dev-kits/en/latest/esp32c6/esp32-c6-devkitc-1/index.html

Documentation

Data sheets & reference manuals:

https://www.espressif.com/en/support/documents/technical-documents?keys=&field_type_tid%5B%5D=1177

Relevant documents are *ESP32-C6 Datasheet*, *ESP32-C6 Technical Reference Manual*.

ESP32-H2

Official development board: ESP32-H2-DevKitM-1

Purchase link: https://www.aliexpress.com/item/1005005252175587.html

Documentation: https://docs.espressif.com/projects/espressif-esp-dev-kits/en/latest/esp32h2/esp32-h2-devkitm-1/index.html

Documentation

ESP32-H2 SoC documentation is not available yet as of 2023-05-16.

GigaDevice

While GigaDevice have largely developed their ARM MCU portfolio in the past years, the GD32VF103 is still their only one RISC-V MCU. It's a very interesting part, but unfortunately out-of-stock to date (Feb. 2023), and GigaDevice not being committed to RISC-V doesn't bode well of its future. Anyway, there are still development boards available for the GD32VF103 and plenty of articles and tutorials can be found on the web, so you might want to give it a try.

Official development board: GD32VF103C-START

Purchase link: https://www.lcsc.com/product-detail/C432220.html

Note: this evaluation board includes GigaDevice's GDLink programmer.

Third-party development board: Longan Nano

Purchase links:

> https://www.aliexpress.com/item/1005002542610332.html
> https://www.aliexpress.com/item/1005003467064600.html

Documentation: https://github.com/sipeed/Longan-DOC

Downloads: https://dl.sipeed.com/shareURL/LONGAN/Nano

Note: an additional JTAG adapter is needed to program the chip. If you don't already have one (e.g. JLink), you can buy Sipeed's USB-JTAG/TTL.

Purchase link: https://www.aliexpress.com/item/1005002714665888.html

Documentation, SDK and tools

Download URL: https://www.gd32mcu.com/en/download?kw=GD32VF1

Data sheets & reference manuals: relevant documents are *GD32VF103xx Datasheet* and *GD32VF103 User Manual*.

SDK: relevant archive is *GD32VF103 Firmware Library*.

WCH

WCH provides a much wider range of RISC-V MCU than any other manufacturer. For this reason, each chip has its own section below.

WCH's offer is divided in 2 families, the general purpose CH32V*xxx* series, which are the RISC-V equivalents of their ARM CH32F*xxx* series, and the more specialised CH*xxx* series, which use a slightly different peripheral set.

An interesting thing to note is the CH32V003 doesn't have an ARM equivalent, which could be a hint that, like Espressif, WCH will continue to concentrate their efforts on their RISC-V products.

The following table presents the main differences between WCH's RISC-V MCU:

Part	*Features*	*Max. frequency*	*Supply voltage*	*Notes*
CH32V003	RV32EC	48 MHz	2.7-5.5V	Low pin count (8, 16, 20)
CH32V103	RV32IMAC	80 MHz	2.7-5.5V	
CH32V203	RV32IMAC	144 MHz	2.4-3.6V	CH32V203RBT6 has Ethernet
CH32V208	RV32IMAC	144 MHz	2.4-3.6V	BLE + Ethernet
CH32V30*x*	RV32IMAFC	144 MHz	2.4-3.6V	CH32V307 has Ethernet
CH582	RV32IMAC	80 MHz	2.3-3.6V	BLE, ultra low power

WCH also makes the CH573 which is comparable to but, in my opinion, less interesting than the CH582, and the CH569, which is specifically intended for communication applications and supports USB 3.0.

For further details, here is a selection table covering the whole WCH offer: https://special.wch.cn/en/mcu/

Note: all WCH MCU SDK include the schematics of the official evaluation boards as reference design.

GitHub: https://github.com/openwch

Programmer / debugger

A proprietary programmer / debugger is needed to flash WCH chips, the WCH-LinkE.

Purchase link: https://www.aliexpress.com/item/1005004881582037.html

One is already included with the official evaluation kit for the CH32V003, and the CH32V003 + CH32V203 evaluation kit combo.

The flashing software, WCHISPTool, is unfortunately Windows-only and doesn't work under Wine.

Download link: http://wch-ic.com/downloads/WCHISPTool_Setup_exe.html

There's also a portable command-line flashing tool, but it uses configuration files generated by WCHISPTool...

MounRiver IDE

MounRiver Community Edition is an Eclipse-based IDE supporting all RISC-V and ARM WCH MCU, available for Windows, Linux and Mac. It includes a portable flashing tool, which is convenient if you don't use Windows (see above), particularly to unlock the flash write protection to be able to program your chip.

WCH provides modified versions of OpenOCD and GCC with MounRiver, but these toolchains can also be downloaded separately, e.g. for installation on a continuous integration server.

Download link: http://www.mounriver.com/

CH32V003

Official development board

Purchase link: https://www.aliexpress.com/item/1005004895791296.html

Third-party development board: nanoCH32V003

Purchase link: https://www.aliexpress.com/item/1005005221751705.html

Documentation: https://github.com/wuxx/nanoCH32V003

Documentation and SDK

Data sheet: http://wch-ic.com/downloads/CH32V003DS0_PDF.html

Reference manual: http://wch-ic.com/downloads/CH32V003RM_PDF.html

Processor manual: http://wch-ic.com/downloads/QingKeV2_Processor_Manual_PDF.html

SDK: https://www.wch.cn/downloads/CH32V003EVT_ZIP.html

CH32V103

Official development board

Purchase links:

https://www.lcsc.com/product-detail/C2943983.html
https://www.lcsc.com/product-detail/C2943982.html
https://www.aliexpress.com/item/1005004607642695.html

Documentation and SDK

Data sheet: http://wch-ic.com/downloads/CH32V103DS0_PDF.html

Reference manual: http://wch-ic.com/downloads/CH32xRM_PDF.html

Processor manual: http://wch-ic.com/downloads/QingKeV3_Processor_Manual_PDF.html

SDK: https://www.wch.cn/downloads/CH32V103EVT_ZIP.html

CH32V203

Official development board

Purchase link: https://www.aliexpress.com/item/1005004493040662.html

Third-party development board: BluePill+ CH32V203

Purchase link: https://www.aliexpress.com/item/1005001474741936.html

Documentation: https://github.com/WeActStudio/WeActStudio.BluePill-Plus-CH32

Note: this board initially shipped with a CH32V103C8T6, but now uses a CH32V203C8T6.

Third-party development board: nanoCH32V203

Purchase link: https://www.aliexpress.com/item/1005004908206775.html

Documentation: https://github.com/wuxx/nanoCH32V203

Documentation and SDK

Data sheet: http://wch-ic.com/downloads/CH32V203DS0_PDF.html

Reference manual: http://wch-ic.com/downloads/CH32FV2x_V3xRM_PDF.html

Processor manual: http://wch-ic.com/downloads/QingKeV4_Processor_Manual_PDF.html

SDK: https://www.wch.cn/downloads/CH32V20XEVT_ZIP.html

CH32V208

Official development board

Purchase link: https://www.aliexpress.com/item/1005004924242063.html

Documentation and SDK

Data sheet: http://wch-ic.com/downloads/CH32V208DS0_PDF.html

Reference manual: http://wch-ic.com/downloads/CH32FV2x_V3xRM_PDF.html

Processor manual: http://wch-ic.com/downloads/QingKeV4_Processor_Manual_PDF.html

SDK: https://www.wch.cn/downloads/CH32V20XEVT_ZIP.html

CH32V303

Official development board

Purchase link: https://www.aliexpress.com/item/1005005444077007.html

Documentation and SDK

Data sheet: http://wch-ic.com/downloads/CH32V307DS0_PDF.html

Reference manual: http://wch-ic.com/downloads/CH32FV2x_V3xRM_PDF.html

Processor manual: http://wch-ic.com/downloads/QingKeV4_Processor_Manual_PDF.html

SDK: https://www.wch.cn/downloads/CH32V307EVT_ZIP.html

CH32V305

Third-party development board: nanoCH32V305

Purchase link: https://www.aliexpress.com/item/1005005033298927.html

Documentation: https://github.com/wuxx/nanoCH32V305

Documentation and SDK

Data sheet: http://wch-ic.com/downloads/CH32V307DS0_PDF.html

Reference manual: http://wch-ic.com/downloads/CH32FV2x_V3xRM_PDF.html

Processor manual: http://wch-ic.com/downloads/QingKeV4_Processor_Manual_PDF.html

SDK: https://www.wch.cn/downloads/CH32V307EVT_ZIP.html

CH32V307

Official development board

Purchase link: https://www.lcsc.com/product-detail/C2943980.html

Third-party development board: YD-CH32V307VC

Purchase link: https://www.aliexpress.com/item/1005004367173443.html

Documentation: http://www.vcc-gnd.com/

Third-party development board: CH32V307RCT6 MINI

Purchase link: https://www.aliexpress.com/item/1005005175678285.html

Documentation and SDK

Data sheet: http://wch-ic.com/downloads/CH32V307DS0_PDF.html

Reference manual: http://wch-ic.com/downloads/CH32FV2x_V3xRM_PDF.html

Processor manual: http://wch-ic.com/downloads/QingKeV4_Processor_Manual_PDF.html

SDK: https://www.wch.cn/downloads/CH32V307EVT_ZIP.html

CH582

Official development board

Purchase links:

> https://www.lcsc.com/product-detail/C2943981.html
>
> https://www.aliexpress.com/item/1005005060737000.html

Third-party development board: YD-CH58x

Purchase links:

> https://www.aliexpress.com/item/1005005305938011.html
> https://www.aliexpress.com/item/1005004787513484.html
> https://www.aliexpress.com/item/1005004794466027.html

Documentation: http://www.vcc-gnd.com/

Can be programmed and debugged using OpenOCD and a WCH-Link or WCH-LinkE programmer, so is suitable for use with Linux.

Third-party development board: 303CH582M01

Purchase links:

> https://www.aliexpress.com/item/1005005458836770.html
> https://www.aliexpress.com/item/1005005467071580.html
> https://www.aliexpress.com/item/1005005456987838.html

Similar to YD-CH58x. After ordering, ask the seller for schematic diagram. Uses the USB C connector for programming, which at the moment only works under Windows.

Documentation and SDK

Data sheet: http://wch-ic.com/downloads/CH583DS1_PDF.html

Processor manual: http://wch-ic.com/downloads/QingKeV4_Processor_Manual_PDF.html

SDK: https://www.wch.cn/downloads/CH583EVT_ZIP.html

Alternatives to WCH tools

If you would like to use mainstream GCC instead of WCH's, or to try an open-source flashing tool, the following Reddit thread will be of interest to you:
https://www.reddit.com/r/RISCV/comments/115u6i9/comment/j94xvpq/