

CH552 USB Multi-Protocol Programmer User Guide and Technical Reference

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Department of Research, Innovation, and Development

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Note: This documentation is actively evolving. For the latest updates and revisions, please visit the project's GitHub repository.

CH552 USB Multi-Protocol Programmer

The **CH552 USB Multi-Protocol Programmer** is a compact and cost-effective device designed for embedded systems development, testing, and debugging. It supports multiple hardware architectures including **AVR**, **ARM Cortex-M (CMSIS-DAP)**, and **CPLD (MAX II)**, making it ideal for a wide range of applications such as firmware development, educational labs, and low-volume production environments.

This programmer is built around the **CH552 microcontroller**, which is based on the enhanced **8051 architecture**. It offers native USB support and a range of digital interfaces (GPIO, SPI, I2C, UART), enabling seamless communication between the host system and the target hardware.

Microcontroller Core

The programmer integrates a **CH552 microcontroller** with the following characteristics:

- 8051-based enhanced core, up to 24 MHz.
- Native USB 2.0 Full-Speed device.
- Multiple GPIO pins for signal control and mapping.
- SPI, I2C, and UART interfaces for protocol bridging.
- Low power consumption and small form factor.

Features

- **Multi-architecture support:** Compatible with AVR (ISP), ARM Cortex-M (CMSIS-DAP), and CPLD (JTAG).
- **In-System Programming (ISP):** Flash microcontrollers without desoldering.
- **Real-time debugging:** Step-through and breakpoint debugging with OpenOCD and PyOCD.
- **JTAG boundary-scan:** For CPLD configuration and board testing.
- **Configurable GPIOs:** Adaptable for use as JTAG, SWD, or ISP lines.
- **USB 2.0 interface:** Direct connection to host PC using USB CDC or HID.
- **Toolchain compatibility:** Works with avrdude, OpenOCD, PyOCD, urJTAG, and others.

- **Cross-platform support:** Compatible with Linux and partially supported on Windows.

Advantages

- **Compact design:** Suitable for breadboards and embedded setups.
- **Versatility:** One device for multiple programming and debugging protocols.
- **Open-source firmware:** Fully customizable and community-supported.
- **Cost-effective:** Inexpensive alternative to commercial debuggers and programmers.
- **Linux-friendly:** No need for proprietary drivers on Linux systems.
- **Ideal for education:** Can be used in microcontroller courses and workshops.

Limitations

- **External power required:** Cannot supply power to high-current target boards.
- **Learning curve:** Requires knowledge of protocols like CMSIS-DAP, JTAG, or AVR ISP.
- **Firmware updates:** May require reflashing to support new features or targets.
- **Partial Windows support:** Some tools may require manual setup or driver adjustments.

Compatibility

CMSIS-DAP (ARM Cortex-M)

- Fully compatible with CMSIS-DAP v2.0 protocol.
- Supported by OpenOCD and PyOCD.
- Tested with:
 - STM32F0
 - RP2040 (Raspberry Pi Pico)
 - PY32 series
 - Other Cortex-M0/M3/M4 devices

AVR ISP

- Works with avrdude using USBasp-like interface.
- Supports:
 - ATmega328P
 - ATTiny85
 - ATmega2560
 - Other classic 8-bit AVR microcontrollers

CPLD JTAG

- Supports Intel (formerly Altera) MAX II series.
- Compatible with JTAG tools like urJTAG or openFPGALoader.
- JTAG signals exposed via GPIO (TDI, TDO, TCK, TMS).

Use Cases

- Firmware flashing and in-system programming.
- Debugging embedded applications with CMSIS-DAP.
- Educational labs and training environments.
- Low-cost production line programming.
- Boundary-scan tests for hardware bring-up.
- CPLD configuration and prototyping.

Resources

- Firmware: [https://github.com/wagiminator/CH552-DAPLink{}](https://github.com/wagiminator/CH552-DAPLink)
- CH552 Datasheet: Available from WCH official website.
- Tools:
 - OpenOCD, PyOCD
 - avrdude
 - urJTAG, openFPGALoader
- Community support: GitHub issues, Reddit, Hackaday, forums.

TERMS, ACKNOWLEDGMENTS, AND LICENSES

1.1 Terms and Conditions

By using, modifying, or distributing the documentation, firmware, or hardware designs included in this repository, you agree to the following terms:

- All materials are provided “**as-is**”, without warranty of any kind.
- The authors and contributors shall not be held responsible for **any damages**, data loss, or legal issues arising from the use of these materials.
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- When redistributing or reusing any part of this project, you must **retain attribution** and comply with the corresponding license terms of each component.

1.2 Acknowledgments and Contributors

This project builds upon the work of several open-source developers and projects:

1.2.1 CMSIS-DAP (DAPLink Firmware for CH552)

- **Stefan Wagner** Project: [CH552-DAPLink](#) License: Creative Commons BY-SA 3.0 Description: CMSIS-DAP firmware and hardware design
- **Ralph Doncaster** Source: [nerdralph/ch554_sdcc](#) Description: Original CMSIS-DAP firmware implementation for CH554 (SDCC)
- **Deqing Sun** Source: [CH55xduino](#) Description: CH552/CH554 Arduino-compatible toolchain

1.2.2 USB-Blaster Firmware (CH552G)

- **Vladimir Duan** Project: [CH55x-USB-Blaster](#) License: MIT Description: USB-Blaster JTAG emulation for CH55x
- **Blinkinlabs** SDK Source: [ch554_sdcc](#) Description: SDK for CH552/CH554 (SDCC)
- **Doug Brown** Blog: [Fixing a Knockoff Altera USB Blaster](#) Description: Insights into compatibility and firmware flashing

1.3 Hardware License

All hardware designs (schematics, layouts, and design files) in this repository are released under the **MIT License**, allowing unrestricted use, modification, and distribution, provided the original license and attribution are retained.

1.4 Resources and References

Table 1.1: Source URLs

Project / Tool	Source URL
CH552	https://github.com/wagiminator/CH552-DAPLink
picoDAP	https://github.com/wagiminator/CH552-picoDAP
CH55xDuino	https://github.com/DeqingSun/ch55xduino
CMSIS-DAP Handbook	https://os.mbed.com/handbook/CMSIS-DAP
CH55x USB-Blaster	https://github.com/VladimirDuan/CH55x-USB-Blaster
SDCC Compiler	https://sdcc.sourceforge.net/
CH554 SDK	https://github.com/Blinkinlabs/ch554_sdcc

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1.5.1 Documentation & Visual Content

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1.5.2 Firmware Projects

- **CH552-DAPLink:** Creative Commons BY-SA 3.0 — © Stefan Wagner
- **CH55x-USB-Blaster:** MIT License — © Vladimir Duan
- **CH55x SDK / Tools:** MIT License — © Blinkinlabs

1.5.3 Hardware Repository

- All PCB designs and schematics are released under the **MIT License**.

Note: If you distribute this product with third-party firmware (e.g., CMSIS-DAP), you are responsible for ensuring license compliance. Only firmware developed by Unit Electronics and released under the MIT license is supported for commercial redistribution.

1.5.4 Preloaded USB-Serial Firmware

This product may include preloaded firmware based on the project by **Kongou Hikari**: “USB to Serial Converter firmware for CH552T”. Original source: [https://github.com/diodep/ch55x_dualserial/tree/master] License: MIT

Under the terms of the MIT License, users are free to modify or replace the firmware. Unit Electronics provides this firmware for convenience only and does not offer performance guarantees.

CH55X UNIT SDK DOCKER

Note: Portable SDK for CH552 firmware development using SDCC in Docker containers. Includes a cross-platform command-line tool (*spkg*) to simplify compilation on both Linux and Windows.

2.1 Project Structure

```
ch552-docker-sdk/
├── spkg/                                # Standalone
│   ├── CLI build system
│   │   ├── spkg                # CLI launcher
│   │   └── (bash script)
│   └── Dockerfile               # SDCC-based
│       └── build environment
│           └── docker-compose.yml # Container
└── configuration
    └── template/              # CH552
        └── example projects
            └── Blink/          # Blink
            └── example (main.c, src/, tools/, Makefile)
└── README.md
```

2.2 Main Features

- Unified command-line tool: “*spkg*” available on Linux and Windows (using Git Bash).
- No manual installation of SDCC or other toolchains required.
- Uses Docker containers to provide a completely isolated build environment.
- Based on a project system with a Makefile, compatible with CH552/CH55x microcontrollers.
- Includes an example project located in the *template/* directory.

2.3 Requirements

2.3.1 Common (All Platforms)

- Docker Desktop

2.3.2 Linux/macOS

- Git
- Python 3
- Bash shell
- Superuser privileges required to run Docker

2.3.3 Windows

- Git Bash
- Docker Desktop with WSL2 or Hyper-V backend enabled
- MinGW64 (included with Git Bash) for the *make* command

Note: Running *spkg* on Linux might require *sudo* if the user is not part of the *docker* group. You can add your user with: *sudo usermod -aG docker \$USER && newgrp docker*

2.4 Installation

2.4.1 Linux

Clone the repository:

```
git clone git@github.com:UNIT-Electronics-
    ↵MX/unit_ch55x_docker_sdk.git
cd ch552-docker-sdk/spkg
chmod +x spkg
```

(Optional) Install it globally:

```
sudo ln -s "$(pwd)/spkg" /usr/local/bin/  
↳ spkg
```

Now you can run spkg from any location.

2.4.2 Windows

Clone the repository:

```
git clone git@github.com:UNIT-Electronics-  
↳ MX/unit_ch55x_docker_sdk.git  
cd ch552-docker-sdk
```

2.4.3 Building the Docker Image

On Linux:

```
spkg compose
```

On Windows:

```
./spkg/spkg.bat compose
```

Warning: Ensure Docker is running and that your user has permission to execute it. You can verify by running `docker ps`. If no errors appear, Docker is running correctly.

2.4.4 Creating a New Project

Note: This command will create a new directory with the specified name.

On Linux:

```
./spkg/spkg init template/project
```

On Windows:

```
./spkg/spkg.bat init template/project
```

2.4.5 Showing Help

On Linux:

```
spkg --help
```

On Windows:

```
./spkg/spkg.bat --help
```

2.4.6 Compiling a Project

On Linux:

```
spkg -p ./template/Blink
```

On Windows:

```
./spkg/spkg.bat -p ./template/Blink
```

2.4.7 Execute make clean, all, hex, etc.

On Linux:

```
spkg -p ./template/Blink clean  
spkg -p ./template/Blink all  
spkg -p ./template/Blink hex
```

On Windows:

```
spkg.bat -p ./template/Blink clean  
spkg.bat -p ./template/Blink all  
spkg.bat -p ./template/Blink hex
```

2.5 Output

The compiled binary will be generated at:

```
template/Blink/build/main.bin
```

You can flash it using:

- tools/chprog.py
- WCHISPTool

GENERAL INFORMATION

The **CH552 USB Multi-Protocol Programmer** is a compact and versatile development tool designed for high-precision embedded system applications. It supports a broad range of protocols and device architectures, including **AVR**, **ARM (CMSIS-DAP)**, and **CPLD (MAX II)**. Its USB connectivity enables direct interfacing with standard development environments, enabling:

- In-system programming (ISP)
- Step-through debugging
- Boundary-scan testing (JTAG)
- Flash memory operations

Compatible with popular platforms such as **STM32**, **RP2040**, and **PY32**, this programmer integrates configurable GPIO lines, multi-protocol headers, and streamlined power delivery—making it ideal for rapid prototyping and field diagnostics.

3.1 Supported Architectures

- **AVR** — via ISP (SPI configuration)
- **ARM Cortex-M** — via CMSIS-DAP and SWD
 - **RP2040**
 - **PY32**
 - **STM32**
- **CPLD/FPGA (MAX II)** — via JTAG

All protocols are exposed via labeled headers or JST connectors, allowing fast, solderless prototyping.

This device connects to a host system via USB and allows the user to program and debug various microcontrollers and programmable logic devices.

3.2 Supported Interfaces

- **JTAG**, for full-chip debugging and boundary scan
- **SWD**, for ARM Cortex-M series
- **SPI**, for flash and peripheral programming
- **UART**, for serial bootloaders and communication
- **GPIO**, for bit-banging or peripheral testing

Table 3.1: Interface and Signal Overview

Interface	Description	Signals / Pins	Typical Use
JTAG	Standard boundary-scan and debug interface	TCK, TMS, TDI, TDO, nTRST	Full chip programming, in-circuit test, debug
SPI	High-speed serial peripheral interface	MOSI, MISO, SCK, CS	Flash memory programming, peripheral data exchange
SWD	ARM's two-wire serial debug and programming interface	SWCLK, SWDIO	Cortex-M programming and step-through debugging
JST Header	Compact connector for power and single-wire debug signals	SWC (SWCLK), SWD (SWDIO), VCC, GND	Quick-connect to target board for SWD and power

3.3 Sections GPIO Pin Distribution

The CH552 USB Multi-Protocol Programmer features a set of GPIO pins that can be configured for various protocols, including JTAG, SWD, and ISP. These GPIOs are mapped to specific functions in the firmware, allowing users to adapt the programmer for different applications.

The GPIO pin distribution is defined within the CH552 firmware, supporting flexible assignment for various protocols. The firmware configures the specific mapping of GPIOs to protocols, such as SPI, JTAG, or SWD, based on the loaded configuration. Users can alter the pin distribution by modifying the firmware source code to suit their application requirements.

3.3.1 Protocol ISP – In-System Programming

Compatible with **AVR** microcontrollers, this protocol allows programming and debugging via the SPI interface. The programmer can be used to flash firmware directly into the target device's memory.

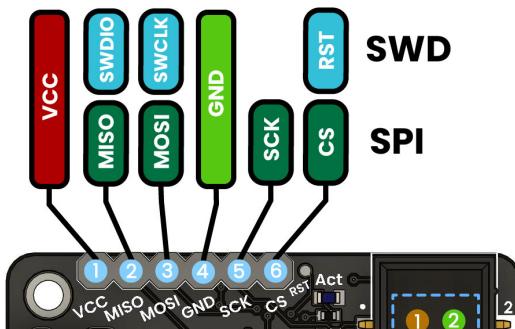


Table 3.2: Pinout

PIN	GPIO	I/O
MOSI	1.5	MOSI/PWM1
MISO	1.6	MISO/RXD1
CS	3.0	PWM1/TXD0
SCK	1.7	SCK/TXD1

3.4 Protocol JTAG

Compatible with **CPLD** and **FPGA** devices, this protocol allows programming and debugging via the JTAG interface. The programmer can be used to flash firmware directly into the target device's memory.

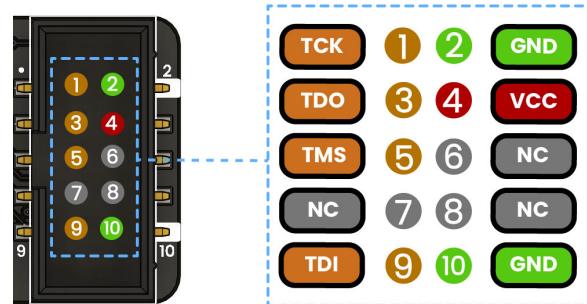


Fig. 3.1: Pinout diagram for CH552 Programmer (JTAG interface)

Table 3.3: Pinout

PIN	GPIO	I/O
TCK	1.7	SCK/TXD1
TMS	3.2	TXD1 /INT0/VBUS1/AIN3
TDI	1.5	/MOSI/PWM1/TIN3/UCC2/AIN2
TDO	1.6	6/MISO/RXD1/TIN4

Table 3.4: Pinout NC - Not Connected

PIN	GPIO	I/O
NC 6	3.4	PWM2/ RXD1 /T0
NC 7	3.3	INT1
NC 8	1.4	T2 / CAP1 /SCS/TIN2/UCC1/AIN

3.5 Protocol SWD

Compatible with **ARM Cortex-M** microcontrollers, this protocol allows programming and debugging via the SWD interface. The programmer can be used to flash firmware directly into the target device's memory.

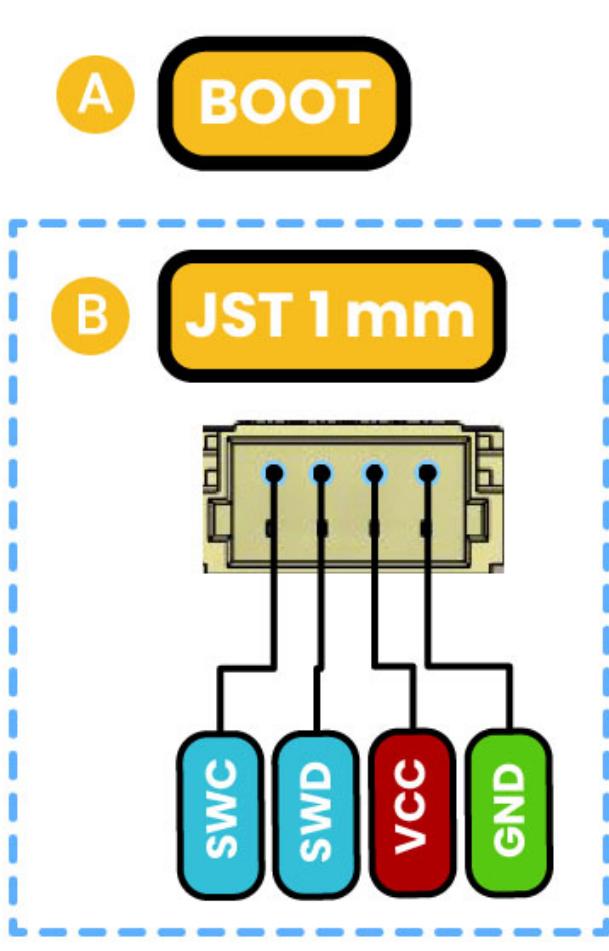


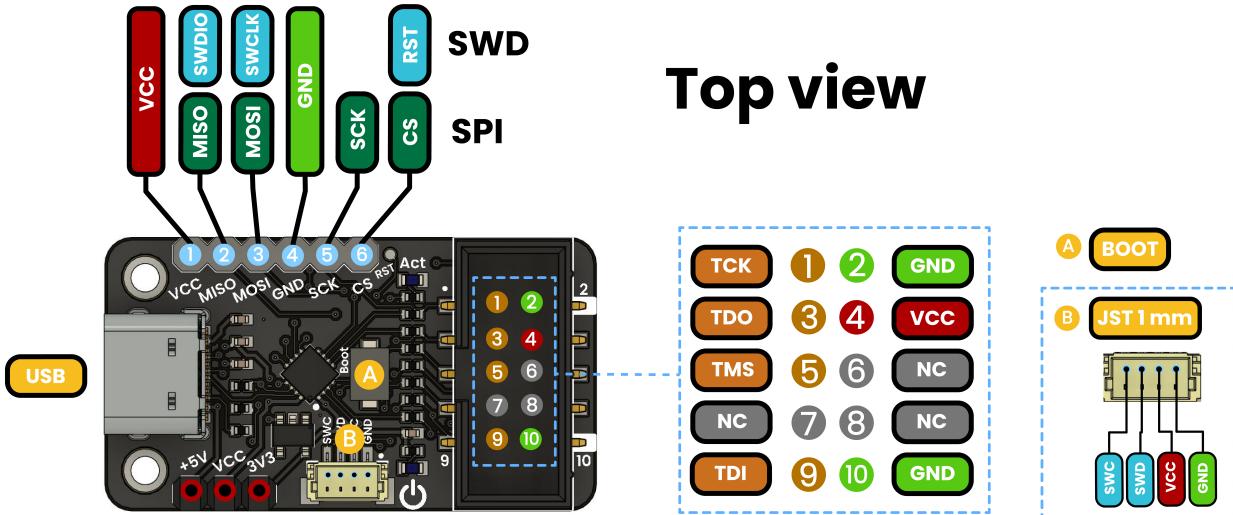
Fig. 3.2: SWD Pinout(JTAG interface)

Table 3.5: Pinout

PIN	GPIO	I/O
SWCLK	1.7	SCK/TXD1/TIN5
SWDIO	1.6	MISO/RXD1/TIN4

Note: GPIO numbers refer to the CH552 internal ports. Ensure correct firmware pin mapping before connecting external devices.

Multi-Protocol Programmer



**VCC depends on the supply voltage
of the microcontroller (3V3 or 5V) to be programmed**



Description:

- Supply voltage
- GND
- Components
- No connection
- SPI
- JTAG
- SWD

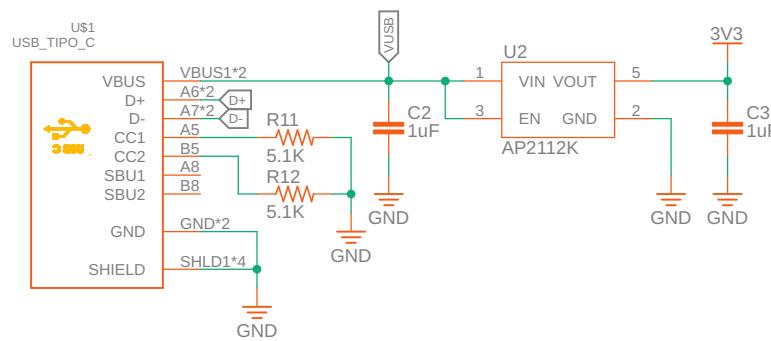
APPENDIX A: SCHEMATICS

1 2 3 4 5 6 7 8

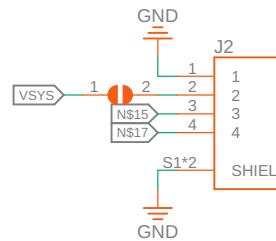
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PROPRIETARY

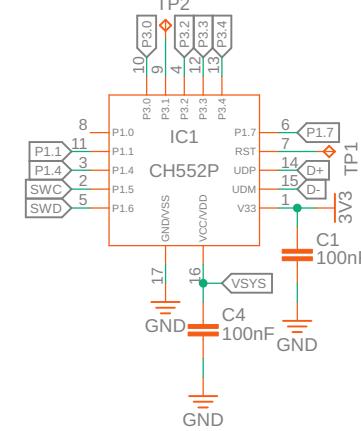
Voltage Regulator



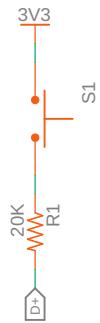
JST



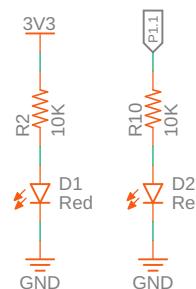
Microcontroller



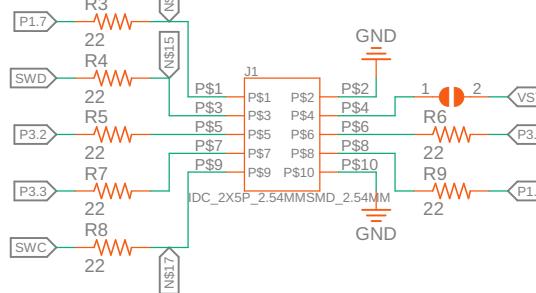
Boot



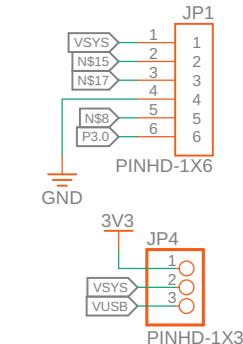
LEDS



IDC Connector



Headers



Mounting Holes



Title: CH552 USB Multi-Protocol Programmer

SKU: UE0090 REV1.0

Last date time: 02/05/2025 11:40 a.m. SHEET 1 of 1

File: Sheet description:

UNIT
ELECTRONICS

1 2 3 4 5 6 7 8

Author: Alberto Villanueva

AVR: GETTING STARTED

4.1 Introduction to AVR Microcontrollers

AVR (Advanced Virtual RISC) is a family of microcontrollers originally developed by Atmel, now part of Microchip Technology. Renowned for their simplicity, low power consumption, and ease of use, AVR microcontrollers are widely adopted in embedded systems, including Arduino boards and other DIY electronics projects.

The AVR family spans a variety of models with differing specifications—such as flash memory capacity, I/O pin count, and integrated peripherals. Common examples include the **ATmega** series (e.g., ATmega328P, ATmega2560) and the **ATtiny** series (e.g., ATtiny85, ATtiny2313).

4.2 Architecture Overview

AVR microcontrollers are based on a **modified Harvard architecture**, which separates instruction and data memory. This design allows for simultaneous access and contributes to faster instruction execution and efficient memory usage.

Developers typically write code for AVR devices using **AVR Assembly** or higher-level languages like **C/C++**, supported by environments such as **Atmel Studio** or the **Arduino IDE**.

4.3 Programming with the CH552 Multi-Protocol Programmer

The **CH552 USB Multi-Protocol Programmer** provides robust support for AVR microcontrollers via the **In-System Programming (ISP)** interface. This method enables direct programming of the target microcontroller's **flash memory** and **EEPROM** without removing it from the circuit.

4.3.1 Key Advantages:

- **Non-intrusive:** Program the MCU without desoldering or removing it from the board.
- **Efficient workflow:** Ideal for development, testing, and field updates.
- **Wide compatibility:** Supports common AVR chips used in educational and commercial projects.

4.3.2 Supported Operations:

- Flash memory writing
- EEPROM access
- Fuse and lock bit configuration
- Signature verification

4.4 Getting Started

To program AVR microcontrollers using the CH552 programmer:

1. Connect the ISP header to the target board (MISO, MOSI, SCK, RESET, VCC, GND).
2. Use compatible software such as avrdude or the Arduino IDE with custom programmer settings.
3. Ensure proper voltage levels (typically 5V or 3.3V depending on the target device).
4. Run the programming command to flash the firmware or configure the device.

```
avrdude -p m328p -c ch552 -U  
→flash:w:firmware.hex
```

NOTES

AVR FIRMWARE OVERVIEW

The CH552 Multi-Protocol Programmer relies on the PICO-AVR firmware to operate correctly. This firmware works with the CH552 USB-to-ISP bridge and is a critical part of the programmer's functionality. The CH55x-based picoAVR acts as a combined ISP, TPI, and UPDI programmer for AVR microcontrollers. It is compatible with both USBasp and SerialUPDI interfaces and integrates seamlessly with the Arduino IDE (accessible via Tools → Programmer → USBasp or Tools → Programmer → SerialUPDI).

Warning: The PICO-AVR firmware is available under the [Creative Commons Attribution-ShareAlike 3.0 Unported License](#).

Additional resources:

- Github: [wagiminator](#)
- EasyEDA: [wagiminator at EasyEDA](#)
- License details: [Creative Commons Attribution-ShareAlike 3.0 Unported License](#)

5.1 Resources

1. EasyEDA Design Files
2. WCH: CH552 Datasheet
3. SDCC Compiler
4. Blinkinlabs: CH55x SDK for SDCC
5. Thomas Fischl: USBasp
6. Ralph Doncaster: USBasp
7. Deqing Sun: CH55xduino

AVR: COMPILE AND UPLOAD CODE

6.1 Toolchain Overview

To compile and upload code to an AVR microcontroller, you'll need the **AVR-GCC** toolchain. This includes essential components such as the compiler, assembler, linker, and utilities like `avr-objcopy`.

6.2 Installation

You can download and install the AVR-GCC toolchain from the official Microchip website:

Windows

Download the installer from the Microchip website and follow the installation instructions.

- AVR-GCC Compiler for Microchip Studio

Linux

You can install the AVR-GCC toolchain using your package manager. For example, on Ubuntu:

```
sudo apt-get install avr-gcc avr-binutils
↪avr-libc
```

macOS

You can use Homebrew to install the AVR-GCC toolchain:

```
brew tap osx-cross/avr
brew install avr-gcc
```

Ensure the toolchain is added to your system's PATH environment variable for global access.

6.3 Example: Compiling a Blink Program

This example demonstrates how to compile a basic blink program for two common AVR microcontrollers:

- ATtiny88
- ATmega328P

The program toggles an LED connected to **pin PB0** every second.

6.3.1 Source File

```
#define F_CPU 16000000UL
#include <avr/io.h>
#include <util/delay.h>

int main(void) {
    DDRB |= (1 << PB0); // Set PB0 as
↪output
    while (1) {
        PORTB ^= (1 << PB0); // Toggle PB0
        _delay_ms(1000);
    }
}
```

6.3.2 Compilation Commands

Use the following commands to compile and generate the HEX file:

```
# For ATtiny88
avr-gcc -mmcu=attiny88 -Os -o blink.elf
↪blink.c
avr-objcopy -O ihex blink.elf blink.hex

# For ATmega328P
avr-gcc -mmcu=atmega328p -DF_
↪CPU=16000000UL -Os -o blink.elf blink.c
avr-objcopy -O ihex blink.elf blink.hex
```

Explanation of flags:

- `-mmcu=` specifies the target microcontroller.
- `-Os` enables size optimization.
- `-DF_CPU` sets the clock frequency used for timing functions.

6.4 Uploading with AVRDUDE

Once the .hex file is generated, you can upload it to the AVR microcontroller using **AVRDUDE**.

6.4.1 Upload Command

```
avrdude -p m328p -c usbas -U  
flash:w:blink.hex
```

Explanation:

- `-p m328p` specifies the target device (ATmega328P).
- `-c usbas` sets the programmer to the CH552 USB Multi-Protocol Programmer.
- `-U flash:w:blink.hex` uploads the hex file to flash memory.

Replace `m328p` with the appropriate identifier for your specific AVR device (e.g., `t88` for ATtiny88). A full list of supported devices is available in the [AVRDUDE user manual](#).

AVR: ARDUINO IDE BOOTLOADER

7.1 Installing the Bootloader on ATMEGA328P

This guide explains how to flash the Arduino-compatible bootloader onto an **ATMEGA328** microcontroller using the **UNIT USB Multi-Protocol Programmer**. By following these steps, your ATMEGA328 can function as an **ATMEGA328P**, fully compatible with the Arduino IDE.

7.2 Required Materials

1. **UNIT Multi-Protocol Programmer**
2. **ATMEGA328P Microcontroller**

7.3 Hardware Connection

1. Use the FC cable to connect one end to the UNIT Multi-Protocol Programmer and the other to the ICSP interface of the ATMEGA328P.
2. Make sure the **MISO** pin of the programmer is aligned with **pin 1** of the ICSP header on the ATMEGA328P.

7.4 Driver Setup with Zadig

To allow USB communication between your PC and the programmer, install the required drivers using **Zadig**.

7.4.1 Step 1: Identify the COM Port

Connect the programmer to your PC and open the **Device Manager**. Under **Ports (COM & LPT)**, identify the COM port assigned to the device.

7.4.2 Step 2: Open Zadig

Launch Zadig. You should see a window like the following:

Click **Options → List All Devices** to display all USB interfaces:

7.4.3 Step 3: Install Drivers

Install the following two drivers:

- **picoASP Interface 0:** Install the **libusbK** driver by clicking **Replace Driver**.
- **SerialUPDI Interface 1:** Install the **USB Serial (CDC)** driver by clicking **Upgrade Driver**.

Once both drivers are installed, your UNIT Multi-Protocol Programmer is ready to flash the bootloader.

7.5 Bootloader Installation Using Arduino IDE

Open the **Arduino IDE** and follow these steps to burn the bootloader onto your ATMEGA328P.

1. Select the Target Board

Navigate to **Tools → Board** and choose **ATMEGA328P**.

2. Choose the Correct Port

Under **Tools → Port**, select the COM port corresponding to your programmer.

3. Select the Programmer

Under **Tools → Programmer**, select the programmer (e.g., **USBasp** or your custom driver name).

4. Burn the Bootloader

Finally, go to **Tools → Burn Bootloader**.

Success! Your ATMEGA328P now has a compatible Arduino bootloader installed and is ready for development.

ARM CORTEX-M

ARM Cortex-M microcontrollers—such as those found in the STM32, RP2040, PY32, and similar families—are built on ARMv6-M, ARMv7-M, or ARMv8-M architectures. These cores target low-power, high-performance embedded applications.

8.1 Core Families

- Cortex-M0 / M0+ (ARMv6-M): Ultra-low power, suitable for simple tasks.
- Cortex-M3 / M4 / M7 (ARMv7-M): Higher performance; some models (like M4 and M7) support floating-point operations.
- Cortex-M23 / M33 (ARMv8-M): Introduce enhanced security features, such as TrustZone.

8.2 Additional Notes

- The RP2040 uses dual Cortex-M0+ cores (ARMv6-M).
- The PY32 series (e.g., PY32F003) typically uses a Cortex-M0+ core (ARMv6-M).
- The STM32 family spans a wide range—from Cortex-M0 to M7 and even M33 in newer models.

8.2.1 OpenOCD (Open On-Chip Debugger)

OpenOCD is an open-source software tool that facilitates debugging, in-system programming, and boundary-scan testing of embedded devices. It supports a diverse range of microcontrollers including STM32, RP2040, and PY32. Through interfaces such as JTAG or SWD, OpenOCD provides a command-line interface for effective interaction with the target devices.

8.2.2 PyOCD: A Python Interface to OpenOCD

PyOCD simplifies the use of OpenOCD by providing a Python-based high-level interface. It offers a Python API that abstracts the complexities of the OpenOCD command-line interface, making it easier to program and debug microcontrollers. PyOCD is user-friendly, flexible, and designed to be extensible for various microcontroller interactions.

Tool	Functionality
OpenOCD	Provides a command-line interface for debugging and programming microcontrollers.
PyOCD	Offers a Python API for seamless interaction with microcontrollers via OpenOCD.

8.3 ARM Cortex-M Debug Capabilities

8.3.1 Debugging Interface of ARM Cortex-M

The ARM Cortex-M architecture includes a comprehensive debug interface that allows external tools to access the microcontroller core for debugging and programming tasks. This interface includes a suite of registers and commands that empower debuggers to halt the core, access memory, and manage the execution of programs.

8.3.2 Connection Through Debug Pins

Access to the debug interface is facilitated through specific pins on the microcontroller, such as SWDIO, SWCLK, and nRESET. These are linked to a debug adapter like the ST-Link or CMSIS-DAP, which forms the physical bridge between the host computer and the target device.

8.4 CMSIS-DAP: A Standardized Debug Adapter

8.4.1 Overview of CMSIS-DAP

CMSIS-DAP (Cortex Microcontroller Software Interface Standard - Debug Access Port) serves as a standardized debug adapter for ARM Cortex-M devices. It is endorsed by OpenOCD and provides a cost-effective solution compared to proprietary debug adapters.

8.5 SWD Communication Protocols

8.5.1 Signals and Operations

The SWDIO (Serial Wire Debug Input/Output) and SWCLK (Serial Wire Clock) signals are integral for communication over the SWD interface. SWDIO is a bidirectional line used for transmitting debug commands and data, while SWCLK is a clock signal that ensures synchronized data transfer between the host and the target.

8.5.2 Advantages of SWD Over JTAG

Utilizing a two-wire connection, the SWD interface minimizes the pin count required compared to the traditional JTAG interface. This reduction is particularly beneficial for microcontrollers where pin availability is limited.

**CHAPTER
NINE**

ARM FIRMWARE

RP2040: AN INTRODUCTION

The RP2040 is an efficient, cost-effective microcontroller developed by Raspberry Pi. It boasts a dual-core ARM Cortex-M0+ processor, versatile I/O options, and a comprehensive set of peripherals, making it perfect for both hobbyist and professional projects.

Note: This documentation is continually updated and adapts key concepts from the official Raspberry Pi Pico SDK documentation.

Tip: It is recommended to use a Linux operating system, as the Pico-SDK is primarily developed and tested on Linux. However, it can also be configured for Windows and macOS with some additional steps.

10.1 Getting Started with RP2040 and Pico-SDK

This guide provides an in-depth look at working with the RP2040 microcontroller using the Pico-SDK. It covers everything from setting up your development environment to installing the necessary software and writing your first RP2040-based projects.

**CHAPTER
ELEVEN**

RP2040 FIRMWARE

STM32: GETTING STARTED

STMicontrollers is a family of 32-bit microcontrollers designed and manufactured by STMicroelectronics. They are widely used in embedded systems and IoT applications due to their low power consumption, high performance, and rich peripheral set. STM32 microcontrollers are based on the ARM Cortex-M architecture and are available in a wide range of series, each tailored to specific applications and requirements.

12.1 Getting Started with STM32

This documentation provides a comprehensive guide to getting started with STM32 microcontrollers. It includes information on setting up the development environment, installing the necessary software, and writing code for STM32 microcontrollers.

This technical documentation is a work in progress and is an adaptation of documentation from the STM32CubeIDE and STM32CubeMX software tools. It uses the [ARM-GCC](#) compiler and visual studio code as the IDE.

CH552 Multi-Protocol Programmer is a versatile tool that supports programming and debugging of STM32 microcontrollers. It provides a simple and efficient way to program STM32 devices using the SWD (Serial Wire Debug) interface.

12.2 Programming STM32 with CH552 Multi-Protocol Programmer

Currently, the CH552 Multi-Protocol Programmer supports programming STM32 microcontrollers using the SWD interface. This allows for direct programming of the target microcontroller's flash memory and debugging capabilities STM32f10x series and STM32f4xx series.

**CHAPTER
THIRTEEN**

STM32 FIRMWARE

USING OPENOCD

To program your microcontroller using OpenOCD, use the following command:

```
openocd -f interface/cmsis-dap.cfg -f
↪target/rp2040.cfg \
    -c "init" -c "reset init" \
    -c "flash write_image erase blink.
↪bin 0x10000000" \
    -c "reset run" -c "shutdown"
```

14.1 Supported Microcontrollers

This guide supports the following microcontrollers:

Micro- con- troller	Description
RP2040	Low-cost microcontroller with a dual-core ARM Cortex-M0+ processor.
STM32F1	Budget-friendly microcontroller with an ARM Cortex-M3 processor.
STM32F4	Cost-effective microcontroller with an ARM Cortex-M4 processor.

14.1.1 Selecting Your Microcontroller Target

Each microcontroller requires a specific configuration file. This file is a script that instructs OpenOCD on how to communicate with the microcontroller. The configuration file is tailored to the microcontroller and the debugger interface.

Microcon- troller	Configuration File
RP2040	<code>rp2040.cfg</code>
STM32F103C8	<code>stm32f103c8t6.cfg</code>
STM32F411	<code>stm32f411.cfg</code>

PYOCD

```
pyocd erase -t py32f003x6 --chip --config .
~/Misc/pyocd.yaml
```


CPLD/FPGA

This firmware is not an official programmer from Altera or Intel. Instead, it is a JTAG programmer for CPLD/FPGA devices based on the WCH CH552 USB microcontroller. It supports the Intel (formerly Altera) MAX II series and is compatible with Quartus Prime Lite.

Warning: This firmware is a third-party implementation and **is not affiliated with or endorsed by Altera or Intel**. It is intended for educational, development, prototyping, and other lawful purposes only.

Ensure that you comply with all applicable laws and regulations when using this firmware. **Use is at your own risk.** The user assumes all responsibility for any consequences, including potential legal implications. The author and distributor of this firmware **are not liable** for any damage, misuse, or legal issues arising from its use.

Proceed with caution and discretion.

It is also compatible with:

- CPLD (MAX3000, MAX7000, MAX9000, and MAX II)
- FPGA (Stratix, StratixII, Cyclone, CycloneII, ACEX1K, APEX20K, and FLEX 10K)
- Active configuration devices (EPCS1, EPCS4, EPCS16)

The ALTERA CPLD/FPGA programmer includes a USB cable and a 2.10 Core JTAG data line.

For programming Altera FPGA and CPLD devices, the Quartus software is used. A free version, Quartus Lite, is available. Quartus is the suite from Altera (now Intel) for programming, configuring, and using its products, and it fully supports the USB Blaster programmer and all its features.

16.1 Quick installation

Note: To download the Intel Quartus Prime software, visit [Quartus Prime Installer](#).

1. Open the file .exe

- a. In the 24.1 version, add your devices
- b. Check the option “Agree to Intel License Agreement”
- c. Click on “Download and Install”
- d. Wait until the installation has completed successfully

16.2 Create a new project in Quartus

Once installed the software and the driver for your CH552, we can create a new project. It's necessary that you've connected your device to your computer.

In the upper left, you will find the File > New Project Wizard tab.

- a. You will see the New Project Wizard window
- b. Select the option “Next”.
- c. Choose an appropriate name to start the project.
- d. In the project type, select the option empty project as shown above:
- e. Afterwards, click Next.
- f. For this example, it is not necessary to add additional files.
- g. Afterwards, click Next.
- h. This is where you can select your device, package, pin count, core speed grade.

- i. EDA Tools Settings.

Note: These options do not define the device family (e.g., MAX II, Cyclone IV, etc.); rather, they specify how Quartus will connect to third-party tools (ModelSim, Synopsys, etc.). If you do not have any external EDA tools, you may leave all options set to <None>, and Quartus will use its internal functionality to compile and generate programming files.

- j. In this window, you will be able to see a summary of your settings.
- k. Afterwards, click Finish.

**CHAPTER
SEVENTEEN**

CPLD FIRMWARE

HOW TO GENERATE AN ERROR REPORT

This guide explains how to generate an error report using GitHub repositories.

18.1 Steps to Create an Error Report

1. Access the GitHub Repository

Navigate to the [GitHub](#) repository where the project is hosted.

2. Open the Issues Tab

Click on the “Issues” tab located in the repository menu.

3. Create a New Issue

- Click the “New Issue” button.
- Provide a clear and concise title for the issue.
- Add a detailed description, including relevant information such as:
 - Steps to reproduce the error.
 - Expected and actual results.
 - Any related logs, screenshots, or files.

4. Submit the Issue

Once the form is complete, click the “Submit” button.

18.2 Review and Follow-Up

The development team or maintainers will review the issue and take appropriate action to address it.