UM0004
User Manual

AT-Link Connector User Manual

Introduction

This user manual is written to give a complete account of AT-Link connector that is designed to make it easier and more convenient for users to carry out MCU programming and configurations.

Applicable products:

Part number	ARTERY MCU family

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1 Overview

1.1 Introduction

Artery AT-Link is an online/offline downloader (referred to as “AT-Link” in this document) that is stable, reliable, portable and easy-to-use. Its main features are shown in Table 1.

Table 1. AT-Link specifications

Main features	EZ	Standard	ISO	Standard plus	ISO plus	Pro
IDE compiling and debugging, such as Keil/IAR	Support	Support	Support	Support	Support	Support
SWD online download	Support	Support	Support	Support	Support	Support
ICP tool online continuous download	Support	Support	Support	Support	Support	Support
USB to UART	Support	Support	Support	Support	Support	Support
User system data programming	Support	Support	Support	Support	Support	Support
Serial number programming	Support	Support	Support	Support	Support	Support
Security library (sLib)	Support	Support	Support	Support	Support	Support
Simultaneous programming of multi-section codes at discontinuous address area	Support	Support	Support	Support	Support	Support
Multiple offline projects storage	-	Support	Support	Support	Support	Support
SWD offline download	-	Support	Support	Support	Support	Support
ISP-UART offline download	-	Support	Support	Support	Support	Support
Machine programming control	-	Support	Support	Support	Support	Support
Offline continuous download	-	Support	Support	Support	Support	Support
Offline programming times restriction	-	Support	Support	Support	Support	Support
Remote file/project encryption	Support	Support	Support	Support	Support	Support
Limit the number of times of using remote project	-	Support	Support	Support	Support	Support
Remote offline project is bound to the only AT-Link	-	Support	Support	Support	Support	Support
Remote file is bound to the only AT-Link	-	Support	Support	Support	Support	Support
Online auto/manual firmware upgrade	Support	Support	Support	Support	Support	Support

Main features	EZ	Standard	ISO	Standard plus	ISO plus	Pro
Download/verify in ciphertext mode	-	Support	Support	Support	Support	Support
Buzzer on	-	Support	Support	Support	Support	Support
LED indicator	Support	Support	Support	Support	Support	Support
Output voltage regulation	-	-	-	-	-	Support
LCD display prompt	-	-	-	-	-	Support
Offline parameter settings	-	-	-	-	-	Support
Multifunctional download interfaces (SPI, I^2C, etc.)	-	-	-	Support	Support	-
Enhanced anti-interference	General	General	Enhanced	General	Enhanced	General

1.2 Glossary

- **AT-Link**

ARTERY AT-Link connector.

- **ICP**

This is an in-circuit programmer software that can be used for various functions by AT-Link.

- **ISP**

This is an in-system programmer that supports write or erase operation to the chip.

- **IDE**

Third-party development programming software, such as Keil, IAR and other compiling and debugging tools.

2 Hardware configuration

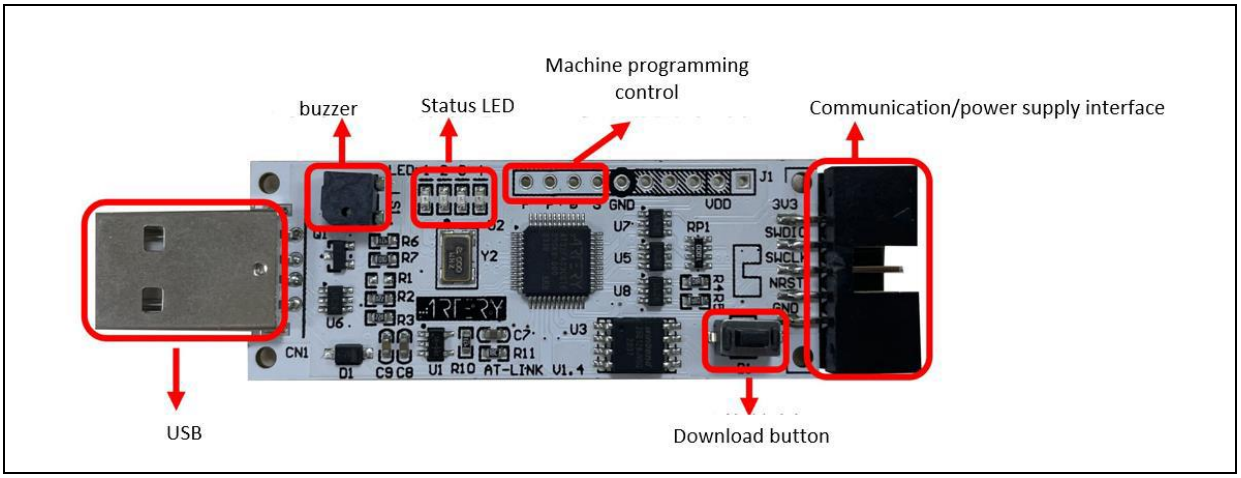
2.1 AT-Link

AT-Link is a basic debugger and programmer that supports IDE online debugging, online/offline programming, USB to serial interface and other functions.

Its hardware configuration includes:

USB interface connected to PC, status LEDs, buzzer, buttons, machine programming control interface, communication interfaces (such as SWD, SWO, serial port, NRST and BOOT0) and power interfaces (3V3 and E5V). Figure 1 shows the appearance of an AT-Link.

Figure 1. AT-Link hardware appearance



2.1.1 USB interface

It is used to communicate with PC during online debugging and download or ICP parameter configuration. It can also serve as AT-Link power supply interface in offline mode.

2.1.2 Communication interface

- **SWD:** A serial wire debug interface including SWCLK and SWDIO can be used for IDE online debugging or ICP online and offline programming.
- **SWO:** It has SWO_UART feature that can be used for print information output in debug mode, baud rate: 1465bps ~ 3Mbps (for AT-Link with hardware V1.3 and above).
- **USB-to-serial port:** Includes TX and RX, connected to the serial interface of the target board for ISP offline download or acts as a general serial interface; baud rate: 1500bps ~6Mbps / 750bps ~ 3Mbps (for firmware V3.0.0 and above).
- **NRST:** It can be connected to the NRST reset pin of the target board to provide a hardware reset signal, and works with BOOT0 pin for auto boot mode switching during ISP download.
- **BOOT0:** It can be connected to the B00T0 pin of the target board, and works with NRST pin for auto boot mode switching during ISP download.

2.1.3 Power supply interface

- **3V3 power supply interface:** it is used as 3.3 V power output port to output 3.3 V.
- **E5V power supply interface:** it is used as 5 V power output or input port.

  As output: when the USB interface is powered, it outputs about 4.7 V;

  As input: the external source can input 4.5V~5.5V via this interface to supply AT-Link.
- **GND:** connected to the GND of the target board.

2.1.4 LED and buzzer

LED1~LED4 are “connected” (red), “running” (green), “USB status” (blue), and “power” (orange), respectively.

- **LED1** is connection status LED that indicates connection state during offline/online operation.
- **LED2** is running status LED that indicates running state during offline/online operation.
- **LED3** indicates the connection state between AT-Link and PC USB. It remains ON after successful connection.
- **LED4** remains ON after power-on, indicating that AT-Link starts working.
- **Buzzer** indicates download status, and can be turned on/off through ICP PC software.

This table below shows the status of LED1 and LED2 during IDE, ICP online and offline operations:

Table 2. AT-Link LED and buzzer status

Working status	LED1-Connected (red)	LED2-Run (Green)	Buzzer status
Power-on initialization	All LEDs blink once		Short beep
Idle state	OFF	OFF	Mute
IDE operation settings	ON	OFF	Mute
IDE debugging stops	ON	OFF	Mute
IDE debugging in progress	ON	ON	Mute
ICP configuration in progress	ON	OFF	Mute
Online/offline download on-going	Blink alternately	Blink alternately	Mute
End of online/offline download: PASS	OFF	Blink slowly	Short beep
End of online/offline download: FAIL	Blink quickly	OFF	Ring quickly for 3s
End of continuous download and remove target	OFF	OFF	Mute
Long press the key 3s to switch to offline download mode: button free download	Blink quickly for 3s	Blink quickly for 3s	Keep ringing for 3s
Long press the key 3s to switch to offline download mode: single download	OFF	Blink quickly for 3s	Ring for 3s intermittently

2.1.5 Machine programming control interface

Machine programming control contains START, BUSY, PASS, FAIL interfaces and 5V-tolerant I/Os. The parameters include machine programming control enable, active level polarity, START active level pulse width and BUSY denounce delay setup time, which can be programmed through ICP PC software and saved after power-off. Refer to *Section 3.5* for more information on the pin

definitions and timing of machine programming control.

- START: Input interface. Download starts when the received active level pulse width is greater than the programmed value.
- BUSY: Output interface, it remains in the active level state during download.
- PASS: Output interface. It remains active until the next operation after a successful download.
- FAIL: Output interface. If download failed, the interface remains active until the next operation.

2.1.6 Buttons

Buttons are mainly used for offline download, and download mode switching.

- Short press 3s and release enables a single offline download.
- Press and hold 3s without release enables switching between button free download or single download, with LED and buzzer indicating the switched mode

Note: Button operation can take effect only when AT-Link is in idle state. If offline download is on-going or the target board is being operated, it will not respond.

2.1.7 Load capacity

Output load capacity:

- 5V@500mA
- 3.3V@300mA

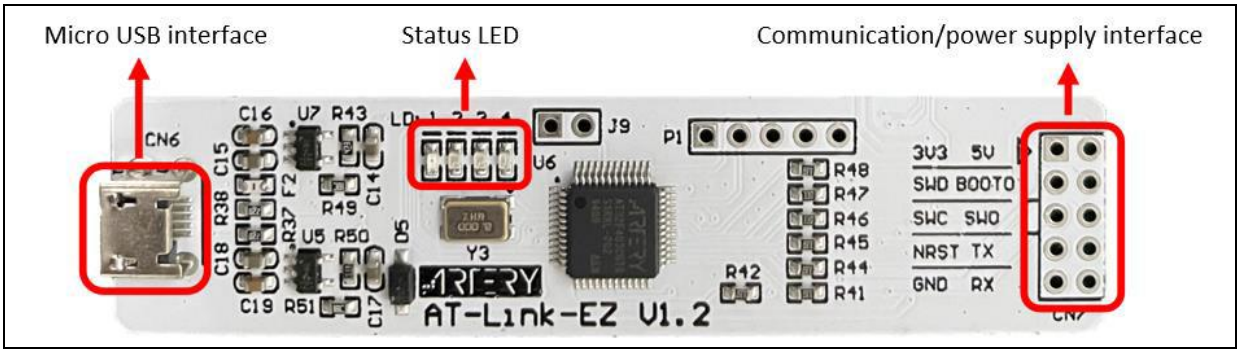
2.2 AT-Link-EZ

AT-Link EZ is a simplified debugger and programmer, which can be used in conjunction with ATSTART get-started board, or works with other circuit boards after being disassembled. It supports IDE online debugging, online programming, USB to serial interface and other functions.

Its hardware configuration includes:

Micro USB interface connected to PC, status LEDs, communication interfaces (such as SWD, SWO, serial port, NRST and BOOT0) and power interfaces (3V3 and E5V). Figure 2 shows the appearance of an AT-Link-EZ.

Figure 2. AT-Link-EZ hardware appearance



2.2.1 USB interface

It is used to communicate with PC during online download and debugging or parameter configuration. It must be connected to the USB port on PC to supply AT-Link EZ.

2.2.2 Communication interfaces

- **SWD:** A serial wire debug interface including SWCLK and SWDIO can be used for IDE online debugging or ICP online programming.
- **SWO:** It has SWO_UART feature that can be used for print information output in debug mode, baud rate: 1465bps ~ 3Mbps (for AT-Link-EZ with hardware V1.1 and above).
- **USB-to-serial port:** Includes TX and RX, connected to the serial interface of the target board as a general serial interface; baud rate: 1500bps ~ 6Mbps / 750bps ~ 3Mbps (for firmware V3.0.0 and above).
- **NRST:** It can be connected to the NRST reset pin of the target board to provide hardware reset signals.
- **BOOT0:** It can be connected to the B00T0 pin of the target board, and works with NRST pin for auto boot mode switching during ISP download.

2.2.3 Power supply interfaces

- **3V3 power supply interface:** it is used as 3.3 V power output port to output 3.3 V.
- **5V power supply interface:** it is used as 5 V power output port to output 4.7 V.
- **GND:** connected to the GND of the target board.

2.2.4 LEDs

LED1~LED4 are “connected” (red), “running” (green), “USB status” (blue), and “power” (orange) respectively.

- **LED1** is connection status LED that indicates connection state during online operation.
- **LED2** is running status LED that indicates running state during online operation.
- **LED3** indicates the connection state between AT-Link-EZ and PC USB. It remains ON after successful connection.
- **LED4** remains ON after power-on, indicating that AT-Link-EZ is working normally.

This table below shows the status of LED1 and LED2 during IDE or ICP online operations:

Table 3. AT-Link-EZ LED status

Working status	LED1-Connected (Red)	LED2-Run (Green)
Power-on initialization	All LEDs blink once	
Idle state	OFF	OFF
IDE operation settings	ON	OFF
IDE debugging stops	ON	OFF
IDE debugging in progress	ON	ON
ICP configuration in progress	ON	OFF
Online download in progress	Blink alternately	Blink alternately
End of online download: PASS	OFF	Blink slowly
End of online download: FAIL	Blink quickly	OFF

2.2.5 Load capacity

Output load capacity:

- 5V@500mA
- 3.3V@300mA

2.3 AT-Link-Pro

AT-Link Pro is a professional debugger and programmer that supports IDE online debugging, online/offline programming, VDD output voltage regulation, offline parameter settings, USB to serial interface and other functions.

Its hardware configuration includes:

USB interface connected to PC, LCD display, status LEDs, buzzer, buttons, machine programming control interface, communication interfaces (such as SWD, SWO, serial port, NRST and BOOT0) and power interfaces (VDD and E5V). Figure 3 shows the appearance of an AT-Link-Pro.

Figure 3. AT-Link-Pro hardware appearance

2.3.1 USB interfaces

It is used to communicate with PC during online download and debugging or ICP parameter configuration. It can also act as a power supply interface for AT-Link-Pro in offline mode.

2.3.2 LCD touch screen

LCD screen is used to display information and for touch operations. Regular settings can be done through the touch screen.

As the screen is a resistive touch screen, it is recommended to use touch pen or other hard objects for more sensitive operation.

2.3.3 Communication interfaces

The voltage status of the pins of communication interfaces depends on VDD input voltage or output configuration.

- **SWD:** A serial wire debug interface including SWCLK and SWDIO can be used for IDE online

debugging or ICP online/offline programming.

- **SWO:** It has SWO_UART feature that can be used for print information output in debug mode, baud rate: 1465bps ~ 3Mbps (for AT-Link-Pro with hardware V1.2 and above).
- **USB-to-serial port:** Includes TX and RX, connected to the serial interface of the target board for ISP offline download, or used as a common serial interface. Baud rate: 1500bps ~ 6Mbps / 750bps ~ 3Mbps (for firmware V3.0.0 and above).
- **NRST:** It is connected to the NRST reset pin of the target board to provide hardware reset signals, and works with BOOT0 pin to achieve auto boot mode switching during ISP offline download.
- **BOOT0:** It is connected to the B00T0 pin of the target board, and works with NRST pin to achieve auto boot mode switching during ISP download.

2.3.4 Power supply interfaces

- **VDD:** used as power output or input port.
  - As output: It outputs 3.0 V, 3.3 V or 1.62 V~5.0 V (customized), depending on the voltage output range configured by ICP host or LCD touch screen;
  - As input: It receives voltage between 1.62 V and 5.5 V to power the AT-Link Pro. In this case, VDD output is invalid.
- **E5V:** used as 5V power input or output port.
  - As output: When the USB interface is powered, the output voltage is close to 4.7 V;
  - As input: The external source inputs 4.5 V~5.5 V via this interface to supply power for AT-Link Pro.
- **GND:** Connected to the GND of the target board.

2.3.5 LEDs and buzzer

LED1-LED2 are “connected” (red) and “running” (green), respectively.

- **LED1** is connection status LED that indicates connection state during online/offline operation.
- **LED2** is running status LED that indicates running state during online/offline operation.
- **Buzzer:** It is used to indicate download status, and can be turned on/off through ICP PC software or LCD touch screen.

This table below shows the status of LED1 and LED2 during IDE, ICP online and offline operations:

Table 4. AT-Link-Pro LED and buzzer status

Working status	LED1-Connected (Red)	LED2-Run (Green)	Buzzer status
Power-on initialization	All LEDs blink once		Short beep
Idle status	OFF	OFF	Mute
IDE operating settings	ON	OFF	Mute
IDE debugging stops	ON	OFF	Mute
IDE debugging in progress	ON	ON	Mute
ICP configuration in progress	ON	OFF	Mute
Online/offline download	Blink alternately	Blink alternately	Mute

on-going			
End of online/offline download: PASS	OFF	Blink slowly	Short beep
End of online/offline download: FAIL	Blink quickly	OFF	Ring quickly for 3s
End of button free download and remove target	OFF	OFF	Mute

2.3.6 Machine programming control interface

Machine programming control contains START, BUSY, PASS, FAIL interfaces and 5V-tolerant I/Os. The parameters include machine programming control signal enable, active level polarity, START active level pulse width and BUSY denounce delay setup time, which can be programmed in ICP PC software or LCD touch screen. These parameters are saved after power-off. Refer to *Section 3.5* for more information on the pin definitions and timing of machine programming control.

- START: Input interface. Download starts when the received active level pulse width is greater than the programmed value.
- BUSY: Output interface, it remains active during download.
- PASS: Output interface, it remains active until the next operation after a successful download.
- FAIL: Output interface. If the download failed, the interface remains active until the next operation.

2.3.7 Buttons

Buttons are mainly used for offline download and other interface operations.

- Short press 3s and release:
  - When the LCD is in the offline programming page/window, it serves as a download key for a single offline download.
  - When the LCD is on other pages/windows, it serves as a return key to the home page; if the LCD is in sleep mode, it can be used to wake up the screen and return it to the home page.
- Long press and hold 3s without release: When AT-Link-Pro is in the online debug mode, it acts as an exit key to exit this mode.

Note: Button operation can take effect only when AT-Link-Pro is in idle state. If offline download is on-going or the target board is being operated, it will not respond.

2.3.8 Load capacity

Output load capacity:

- 5V@500mA
- 3.3V@500mA

2.4 AT-Link-ISO

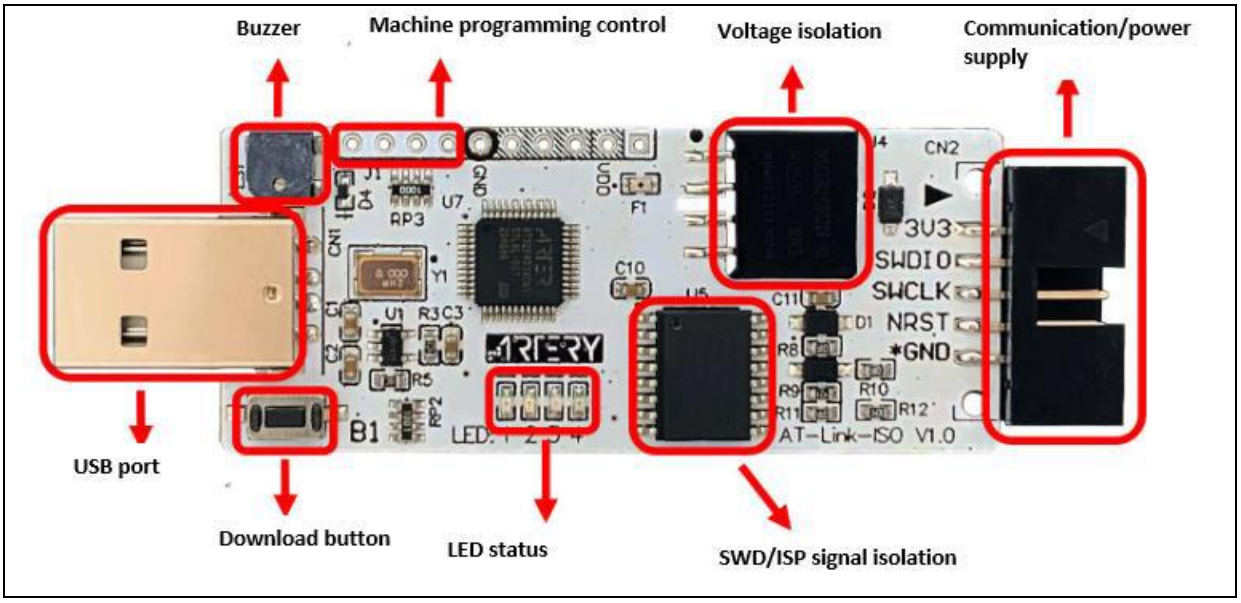
AT-Link-ISO literally refers to the AT-Link with isolation protection feature. Thus, it has the exact same function as that of AT-Link, and shows almost no difference when used in regular scenarios compared to AT-Link.

AT-Link-ISO comes with enhanced isolation protection to ensure it is capable of isolating 1500V power supply and signals. Such design also makes it the best choice for the application development under strong interference environment such as motors, high-power supplies and high voltage. Thus, it is recommended to use AT-Link-ISO in above-mentioned scenarios to get a stable development environment.

Slight differences between AT-Link-ISO and AT-Link are as follows:

- For AT-Link-ISO, E5V pin cannot be used as a power input. It is always powered through USB interface.
- The maximum total power output on the isolation side is around 200 mA, slightly weaker than AT-Link. It is not recommended to exceed this limit.
- The machine programming control interface is not included in the isolation protection part of AT-Link-ISO, so it is recommended that good quality cable is used to connect AT-Link-ISO with the programming machine to ensure good connection and shielding during mass production.

Figure 4. AT-Link-ISO hardware appearance



2.4.1 Load capacity

Output load capacity:

- 5V@200mA
- 3.3V@200mA

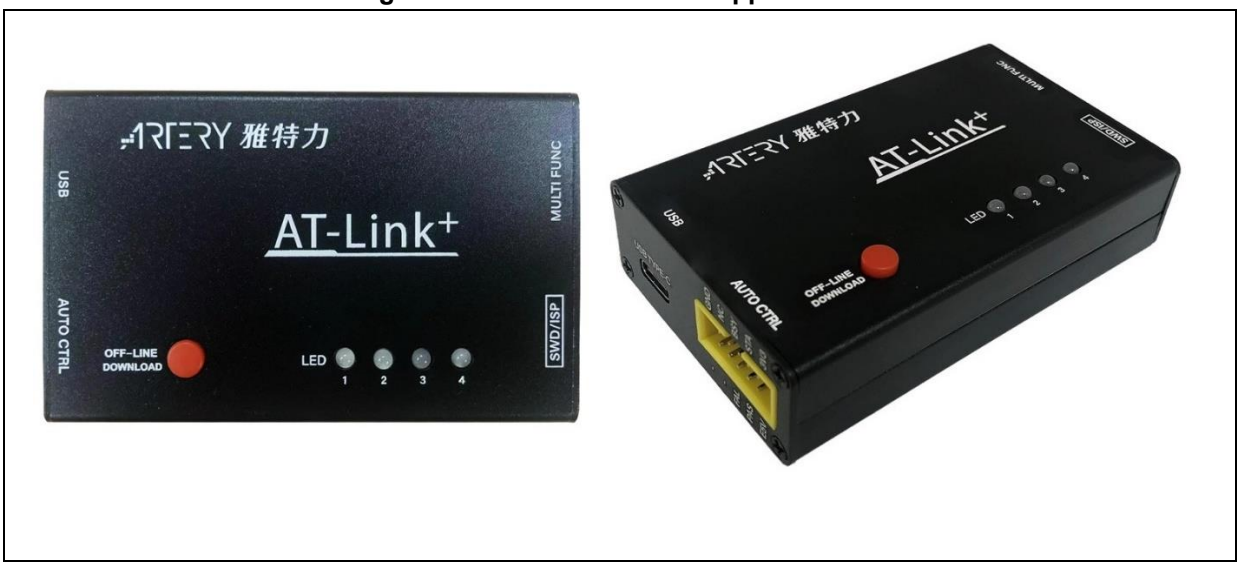
2.5 AT-Link+

AT-Link+ is an enhanced debugger and programmer that supports online/offline programming, IDE online debugging, USB to serial interface and other functions.

Its hardware configuration includes:

USB interface connected to PC, status LEDs, buzzer, buttons, machine programming control interface, communication interfaces (such as SWD, SWO, serial port, MULTI FUNC, NRST and BOOT0) and power interfaces (3V3 and E5V). Figure 5 shows the appearance of an AT-Link+.

Figure 5. AT-Link+ hardware appearance



2.5.1 USB interfaces

It is used to communicate with PC during online debugging and download or ICP parameter configuration. It can also serve as AT-Link+ power supply interface in offline mode.

2.5.2 Communication interfaces

- **SWD:** A serial wire debug interface including SWCLK and SWDIO can be used for IDE online debugging or ICP online and offline programming.
- **SWO:** It has SWO_UART feature that can be used for print information output in debug mode; baud rate: 1465bps ~ 3Mbps.
- **USB-to-serial port:** Includes TX and RX, connected to the serial interface of the target board for ISP offline download or acts as a general serial interface. Baud rate: 1500bps ~6Mbps / 750bps ~ 3Mbps (for firmware V3.0.0 and above)
- **MULTI FUNC:** It is a multifunctional interface consisting of SPI interfaces (MOSI/MISO/SCK/CS) and changeable peripheral interfaces (I^2C/CAN, etc.). The interface can be connected to the target board for online or offline programming through ISP or ICP tool. The USB side adopts CDC communication, which is identified as AT-Link-Bridge device by PC side.
- **NRST:** It can be connected to the NRST reset pin of the target board to provide a hardware reset signal, and works with BOOT0 pin for auto boot mode switching during ISP offline download.
- **BOOT0:** It can be connected to the B00T0 pin of the target board, and works with NRST pin for auto boot mode switching during ISP download.

The specific definitions of communication interfaces depend on the connected microcontroller and corresponding configuration.

Figure 6. SWD interface connected to MCU

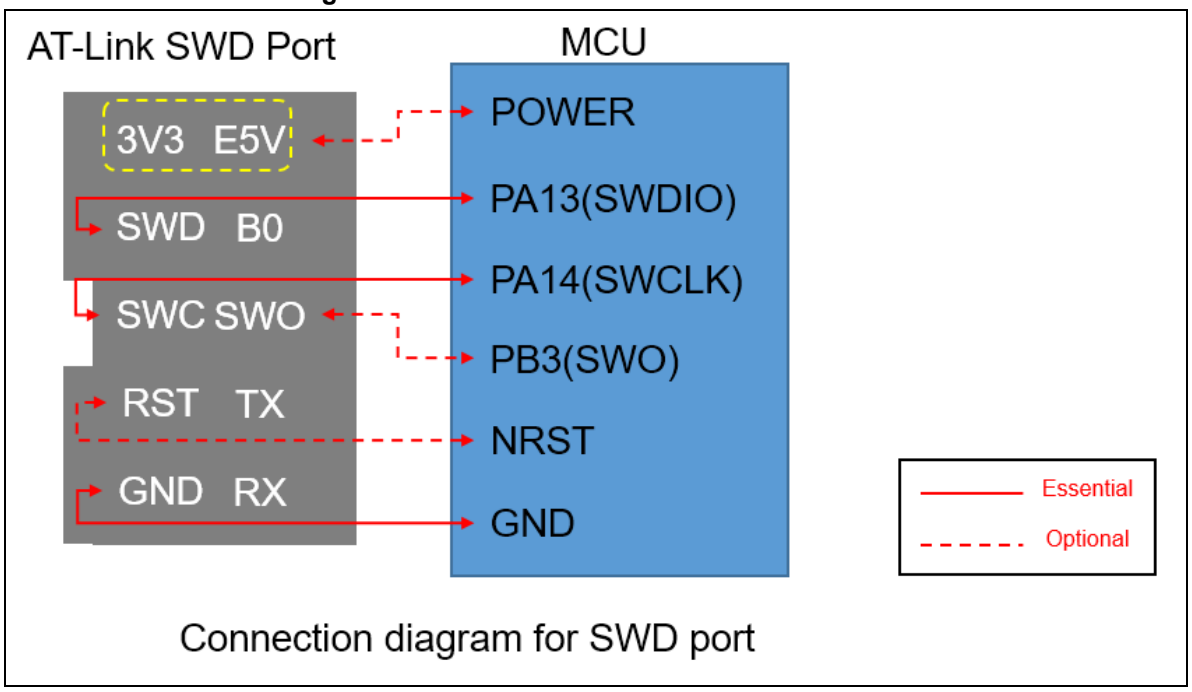


Figure 7. UART interface connected to MCU

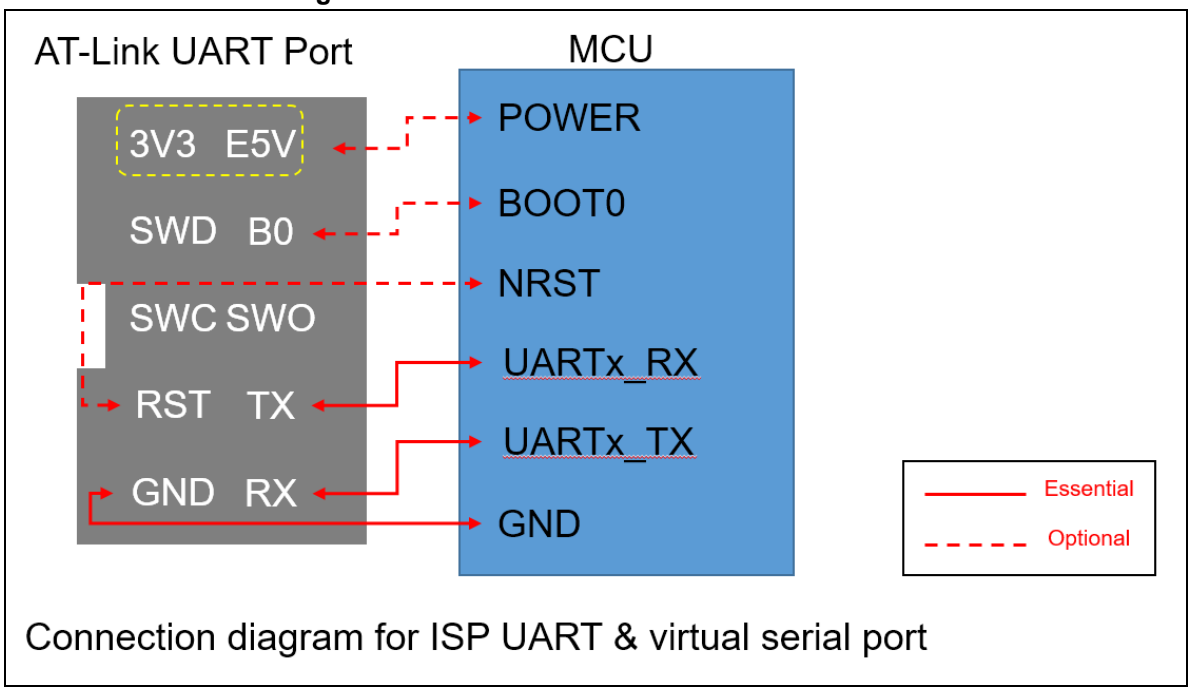


Figure 8. MULTI FUNC interface connected to MCU

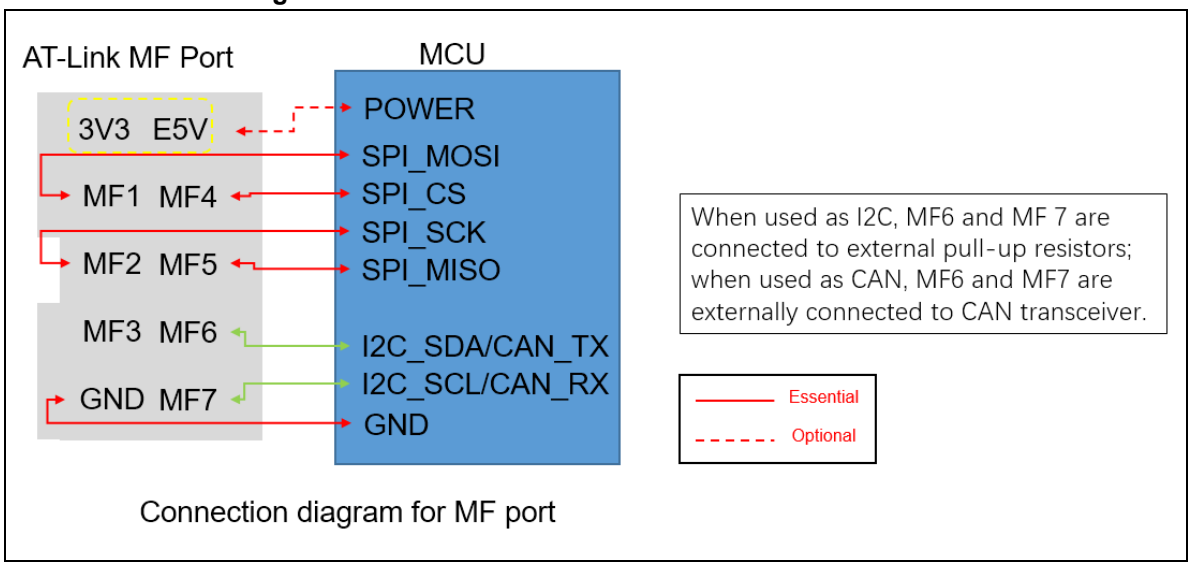
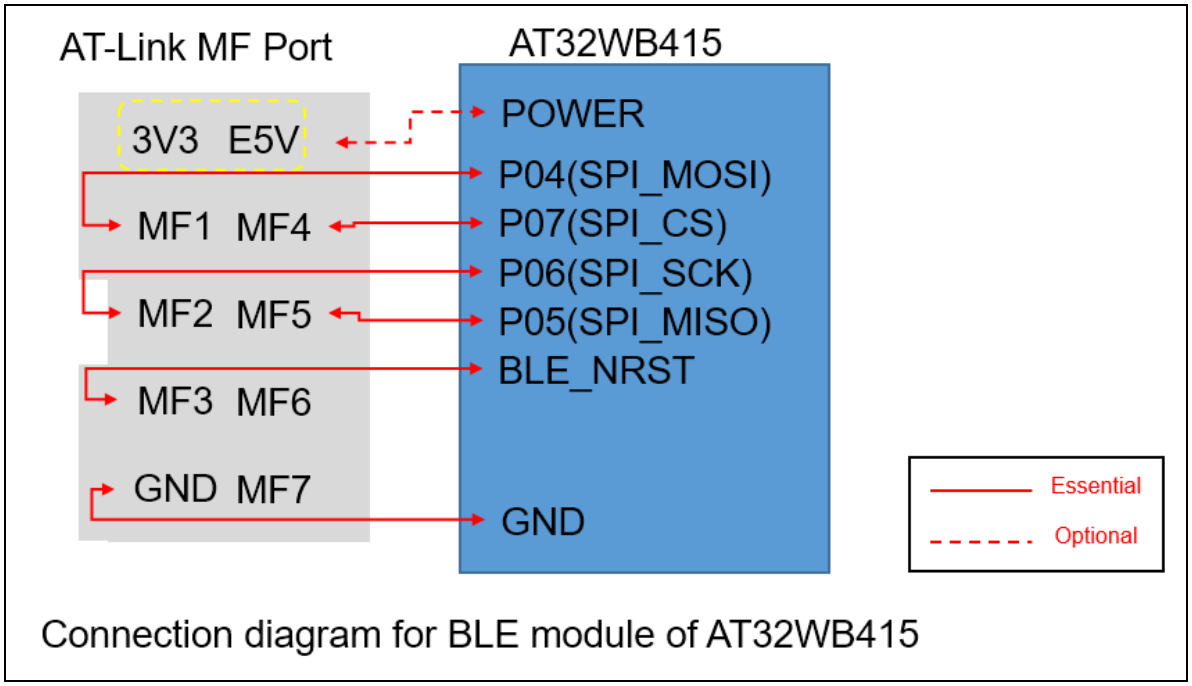


Figure 9. MULTI FUNC interface connected to AT32WB415 BLE module



2.5.3 Power supply interface

- **3V3 power supply interface:** it is used as 3.3 V power output port to output 3.3 V.
- **E5V power supply interface:** it is used as 5 V power output or input port.

  As output: when the USB interface is powered, it outputs about 4.7 V;

  As input: the external source can input 4.5V~5.5V via this interface to supply AT-Link+.
- **GND:** Connected to the GND of the target board.

2.5.4 LEDs and buzzer

LED1~LED4 are “connected/running” (red/green), “USB status” (blue), “power supply” (orange) and “USB to serial interface transceiver” (red/blue) respectively.

- **LED1** is two-color LED that indicates connection/running during offline/online operation.
- **LED2** indicates the connection state between AT-Link+ and PC USB. It remains ON after successful connection.
- **LED3** remains ON after power-on, indicating that AT-Link+ starts working.
- **LED4** is two-color LED. It turns blue when data is sent from USB to serial port, and turns red when data is sent from the serial port to USB.
- **Buzzer** indicates download status, and can be turned on/off through ICP PC software.

This table below shows the status of two-color LED1 during IDE, ICP online and offline operations:

Table 5. AT-Link+ LED1 and buzzer status

Working status	Connected (red)	Run (green)	Buzzer status
Power-on initialization	All LEDs blink once		Short beep
Idle status	OFF	OFF	Mute
IDE operation settings	ON	OFF	Mute
IDE debugging stops	ON	OFF	Mute
IDE debugging in progress	ON	ON	Mute
ICP configuration in progress	ON	OFF	Mute
Online/offline download on-going	Blink alternately	Blink alternately	Mute
End of online/offline download: PASS	OFF	Blink slowly	Short beep
End of online/offline download: FAIL	Blink quickly	OFF	Ring quickly for 3s
End of continuous download and remove target	OFF	OFF	Mute
Long press the key 3s to switch offline download mode: button free download	Quickly blink for 3s	Quickly blink for 3s	Keep ringing for 3s
Long press the key 3s to switch offline download mode: single download	OFF	Quickly blink for 3s	Ring for 3s intermittently

2.5.5 Machine programming control interface

Machine programming control contains START, BUSY, PASS, FAIL interfaces and 5V-tolerant I/Os. The parameters include machine programming control enable, active level polarity, START active level pulse width and BUSY denounce delay setup time, which can be programmed through ICP PC software and saved after power-off. Refer to *Section 3.5* for more information on the pin definitions and timing of machine programming control.

- START: Input interface. Download starts when the received active level pulse width is greater than the programmed value.
- BUSY: Output interface, it remains in the active level state during download.
- PASS: Output interface, it remains active until the next operation after a successful download
- FAIL: Output interface. If download failed, the interface remains active until the next operation.

2.5.6 Buttons

Buttons are mainly used for offline download and download mode switching.

- Short press 3s and release enables a single download operation.
- Long press and hold 3s without release enables switching between button free download or single download, with LED and buzzer indicating the switched mode

Note: Button operation can take effect only when AT-Link+ is in idle state. If offline download is on-going or the target board is being operated, it will not respond.

2.5.7 Load capacity

Output load capacity:

- 5V@500mA
- 3.3V@300mA

2.6 AT-Link-ISO+

AT-Link-ISO+ literally refers to the AT-Link+ with isolation protection feature. Thus it has the exact same function as that of AT-Link+, and shows almost no difference when used in regular scenarios compared to AT-Link.

AT-Link-ISO+ comes with enhanced isolation protection to ensure it is capable of isolating 1500V power supply and signals. Such design also makes it the best choice for the application development under strong interference environment such as motors, high-power supplies and high voltage. Thus it is recommended to use AT-Link-ISO+ in above-mentioned scenarios to get a stable development environment.

Slight differences between AT-Link-ISO+ and AT-Link+ are as follows:

- The E5V pin in SWD/ISP box cannot be used as a power supply input because of isolated chip, but those in AUTO CTRL and MULTI FUNC supports 5V input, and the external source can input 4.5 V-5.5V to supply the AT-Link-ISO+ via this interface.
- The maximum total power output on the isolation side is around 300 mA, slightly weaker than AT-Link+. It is not recommended to exceed this limit.
- The isolated unit of the AT-Link-ISO+ deals with SWD/ISP. The AUTO CTRL and MULTI FUNC interfaces are not included in it. Thus, it is recommended that good quality cable is used to connect AT-Link-ISO+ with AUTO CTRL and MULTI FUNC interfaces to ensure good connection and shielding during mass production.

Figure 10. AT-Link-ISO+ hardware appearance

2.6.1 Load capacity

Output load capacity:

- SWD/ISP interface box 5V@300mA
- SWD/ISP interface box 3.3V@300mA
- AUTO CTRL and MULTI FUNC interface box 5V@500mA
- AUTO CTRL and MULTI FUNC interface box 3.3V@300mA

3 Function overview

3.1 PC connection and driver installation

AT-Link is a USB composite device that integrates HID, WinUSB and CDC device types (V2 and above firmware supports WinUSB). It is connected to PC through a USB cable.

- For win7 and older operating systems, a driver needs to be installed manually. The driver is recognized by device manager as HID, WinUSB and CDC device (AT-Link-USART, AT-Link-Bridge).
- For win10 and newer operating systems, a driver is not required. However, it is still recommended to install a driver so that the device name can be recognized more accurately by the device manager.

3.1.1 How to install a driver

Double click on “Artery_ATLink-USART_DriverInstall.exe” and follow the prompts to install:

Figure 11. Driver installation illustration

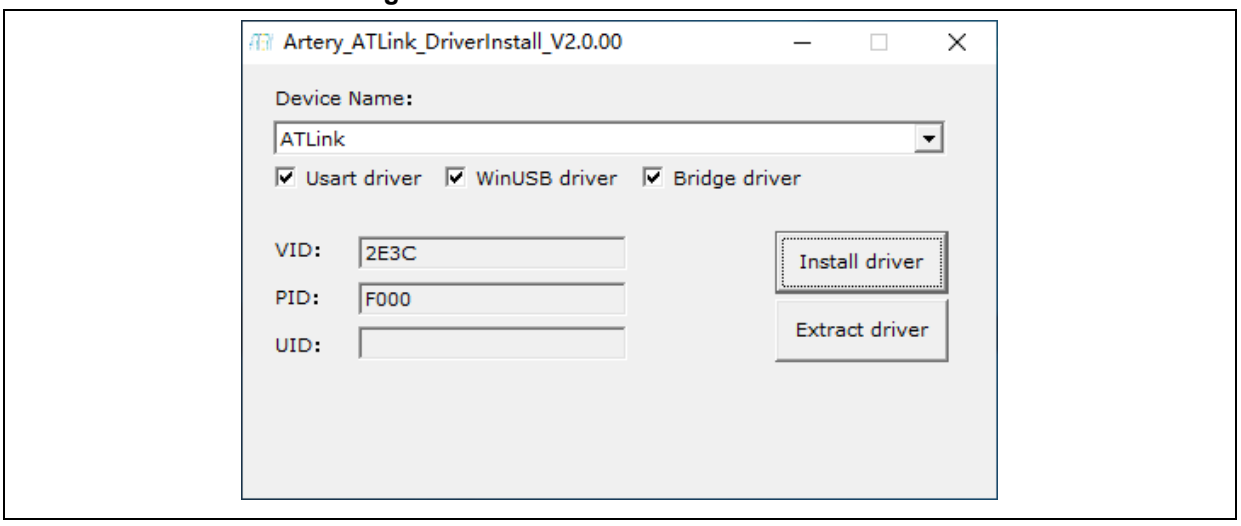


Figure 12. Driver install success

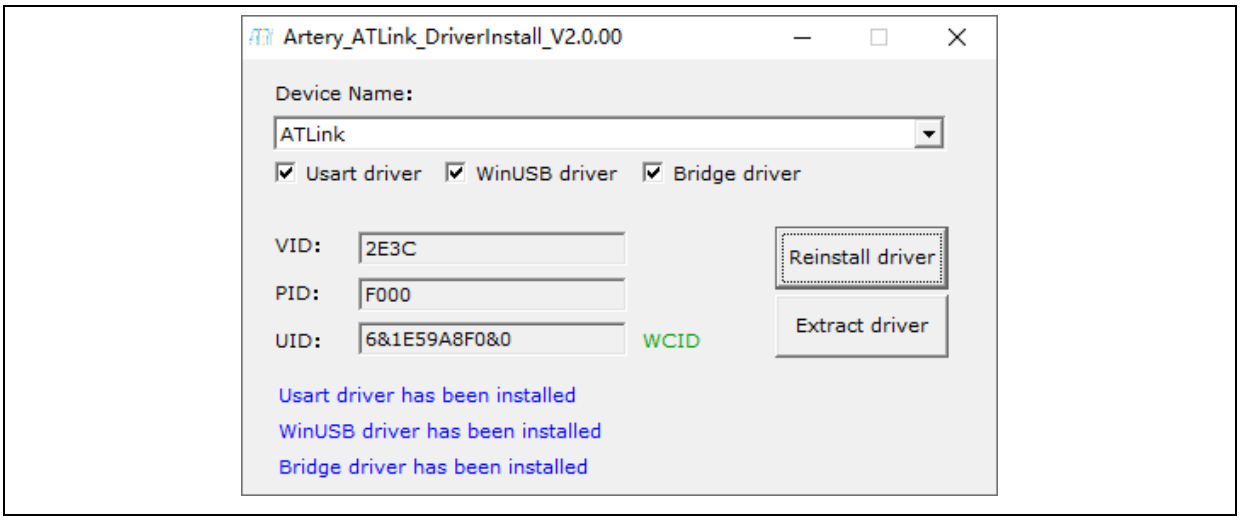
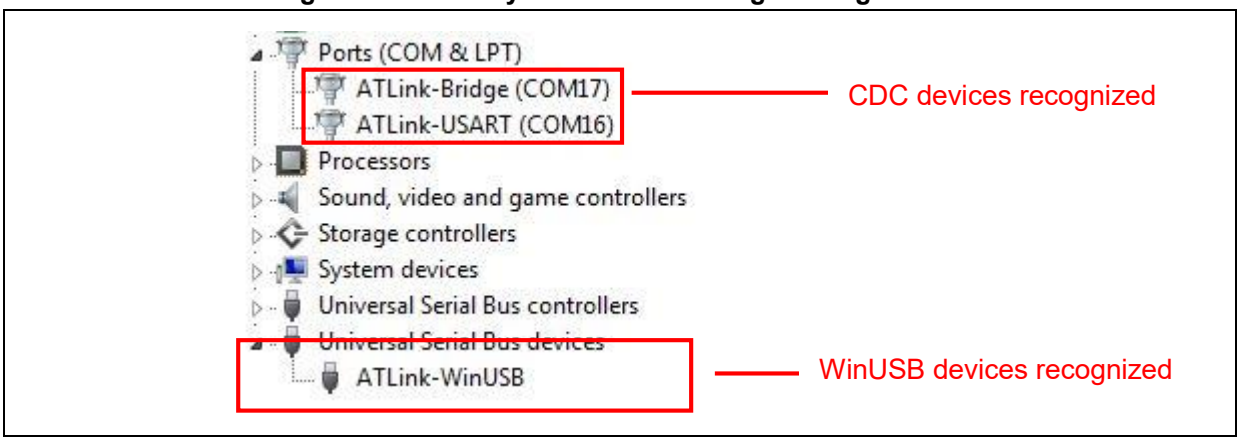


Figure 13. win10 system device manager recognition



3.2 WinUSB communication

For the USB interface on AT-Link, the V1.x.x revision AT-Link supports HID only, while the V2 and above revision supports WinUSB in addition to the HID. The Win 10 and newer operating systems provide better WinUSB support. Thus, it is recommended to use WinUSB for debug and download during the use of IDE tools such as Keil and IAR so as to ensure faster run and better development efficiency. The subsequent sections describe how to select WinUSB in Keil or IAR environment.

Regarding the improved performance, we take the compiled 250KB (ROM size) of bin file as an example to do comparison test. The test compared the download speed of WinUSB vs HID under Win10 operating system in the environment of Keil V5/ IAR V8/ICP.

Table 6. HID/WinUSB download speed comparison test

Download mode	ICP	KEIL	IAR
HID	26s	24s	20s
WinUSB	12s	11s	9.5s

3.3 IDE operation

AT-Link is compatible with standard CMSIS-DAP protocol. It can be used for debugging and download on the development tools such as Keil, IAR and AT32IDE. The AT-Link supports up to 6 hardware breakpoints. The subsequent sections provide the examples based on Keil and IAR.

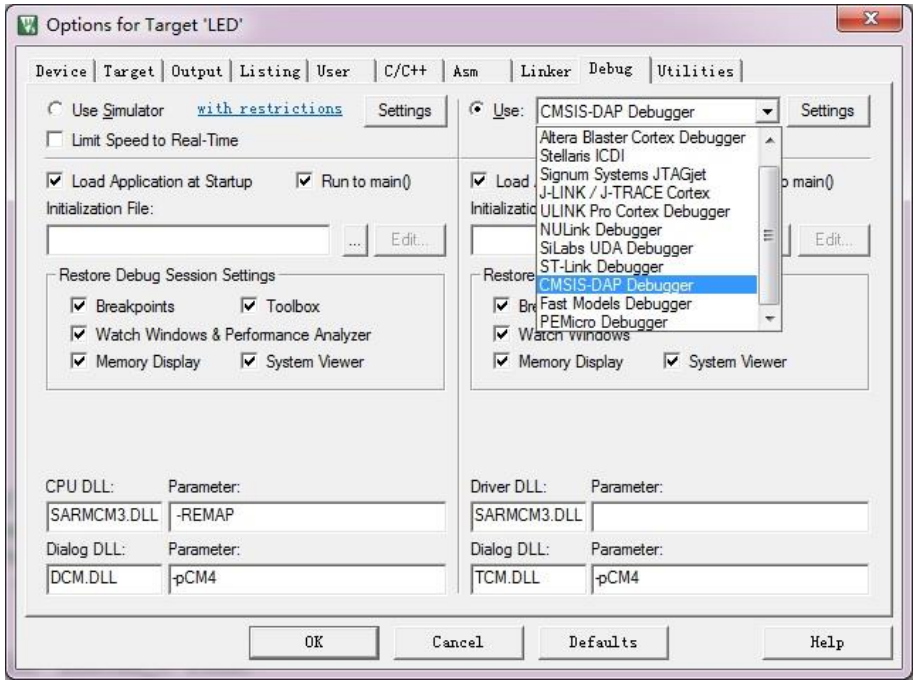
3.3.1 Keil environment

The Keil V5.36.0.0 is used in this document.

- **Initialization**

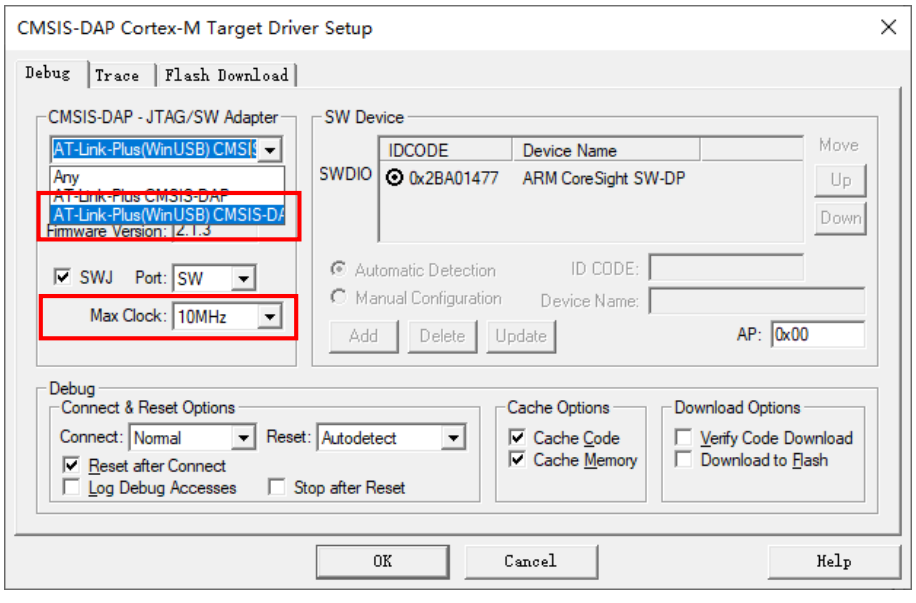
1) Select “CMSIS-DAP Debugger” in “Options-Debug”, as shown in Figure 14:

Figure 14. Select CMSIS-DAP Debugger in Keil



2) Go to Debug Settings, you would see two “AT-Link” devices in the “Adapter” box, and select “WinUSB” device. In “Port” drop-down list, select “SW “. In “Max Clock”, select 5 MHz and above to get the best AT-Link performance, as shown in Figure 15:

Figure 15. Debug settings in Keil

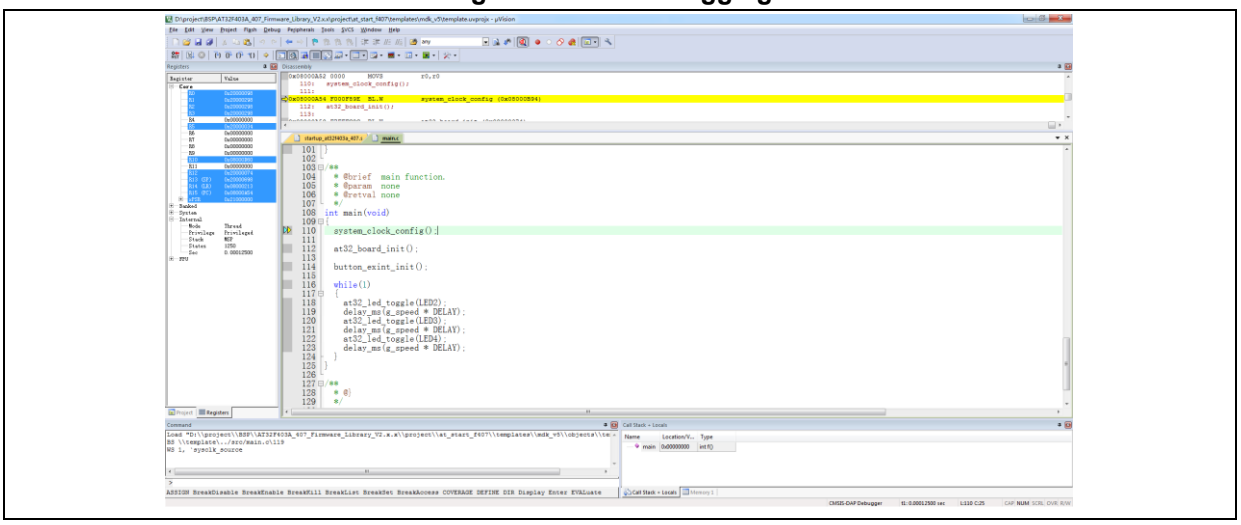


Note: As the V5.29 and above Keil supports WinUSB, for old versions, following ARM official guideline, replace the file of the same time under Keil_v5\ARM\BIN with the CMSIS_DAP.dll which is available on the ARM official website (developer.arm.com/documentation/ka003663/1-0/?lang=en).

- **Debugging**

Click on “Debug” button on the software to enter the debug mode, and follow Keil window for various operations.

Figure 16. Keil debugging



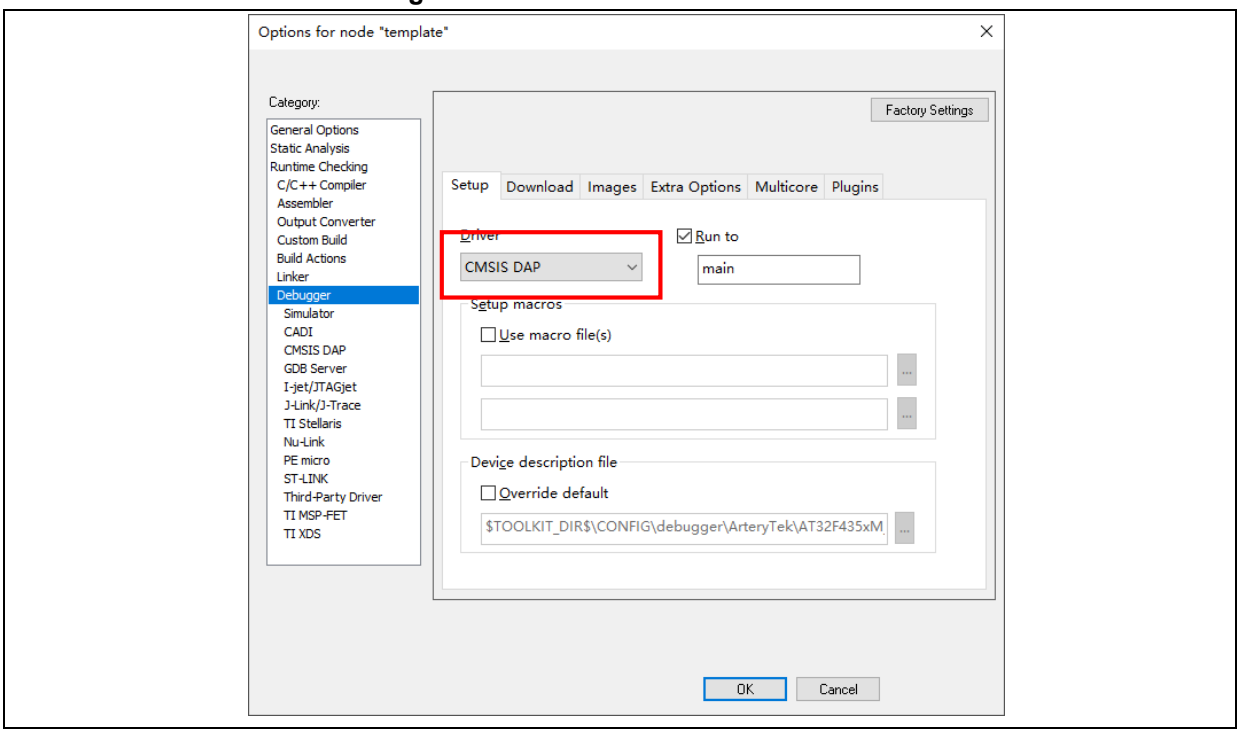
3.3.2 IAR environment

AT-Link is applicable to IAR V7.10 and above only. Take IAR V8.3 as an example here.

- **Initialization**

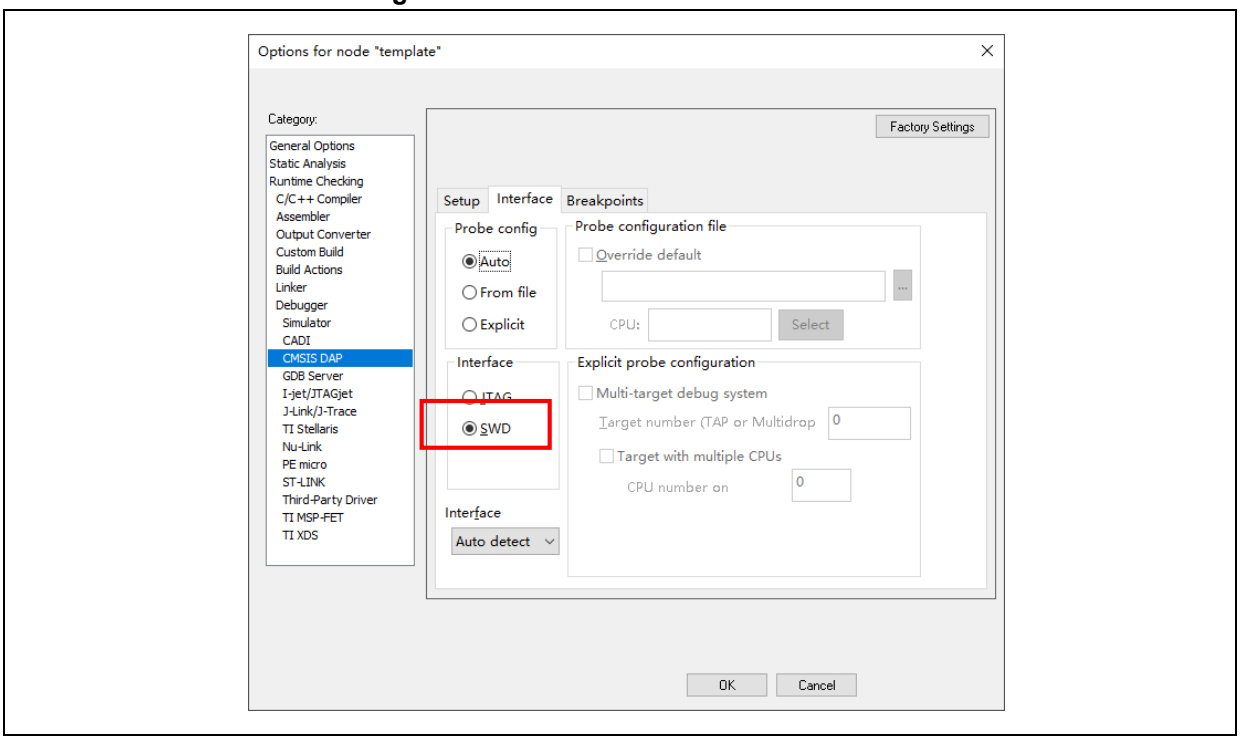
1) Select “CMSIS DAP” in “Options-Debugger-Setup-Driver”, as shown in Figure 17:

Figure 17. Select CMSIS DAP in IAR



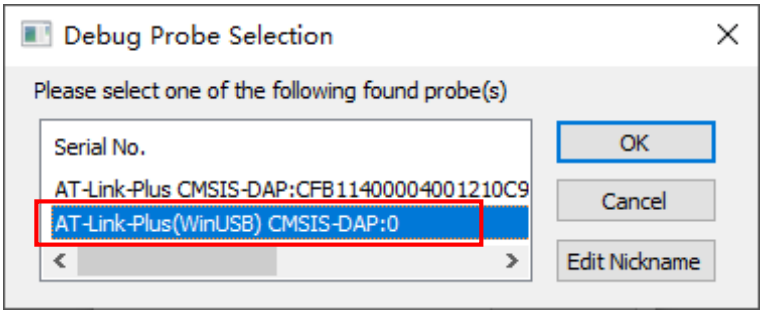
2) Select “SWD Interface” in “Options-Debugger-CMSIS DAP”, as shown in Figure 18:

Figure 18. Select SWD interface in IAR



- **Debug configuration**

For initial debug and download operation, a device dialog box would pop out (as shown below). In this window, there are two AT-Link devices available. Select WinUSB device.

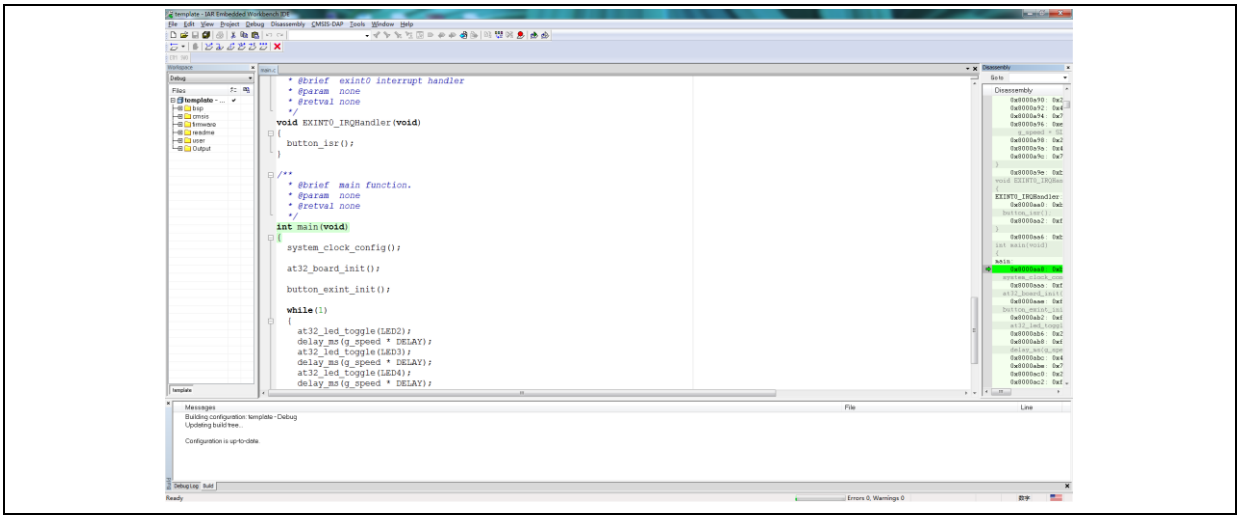


Note: The WinUSB is supported in the V8.3 and above IAR only.

- **Debugging**

Click on “Debug” to enter the debug mode, and follow IAR window for various operations.

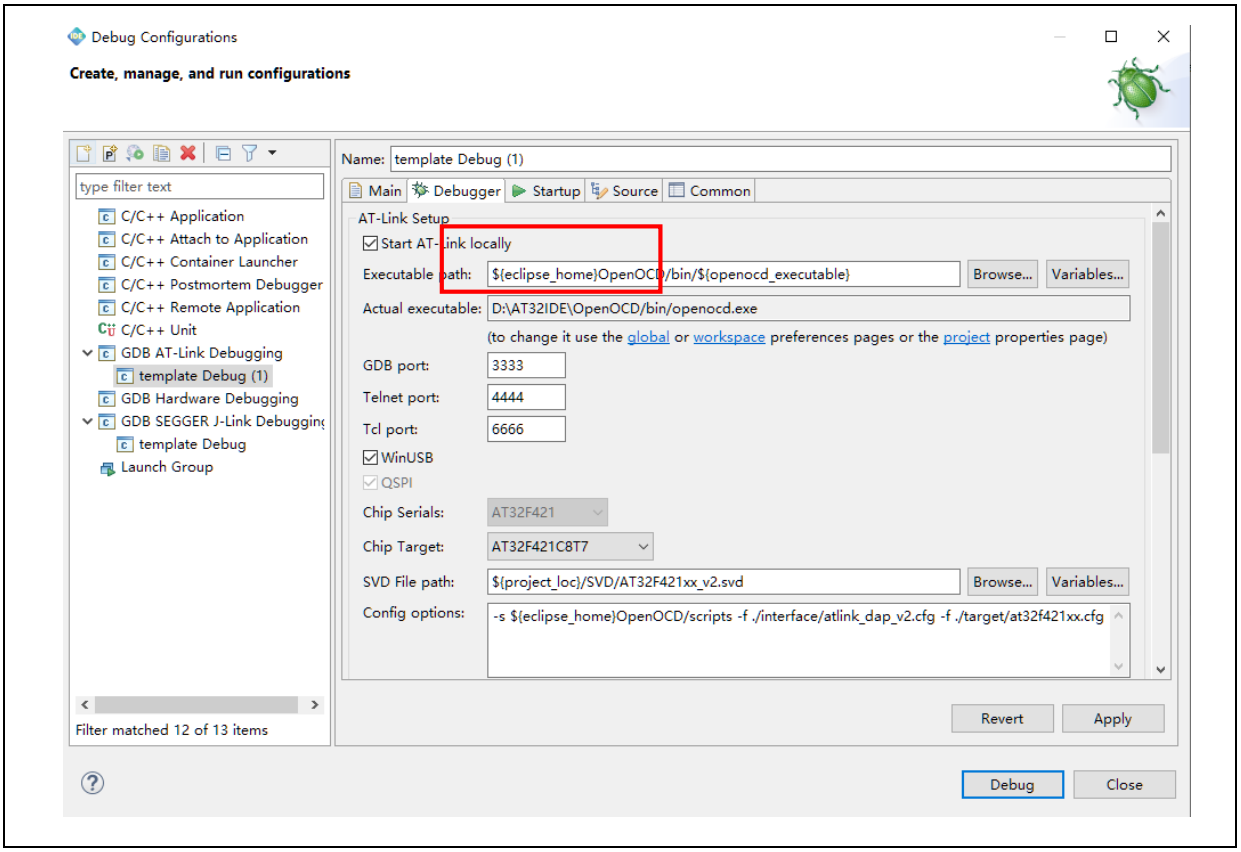
Figure 19. IAR debugging



3.3.3 AT32 IDE

AT32 project configuration is completed, by default. Users only need to create a new GDB AT-Link. Tick “WinUSB” to improve performance, as shown below.

Figure 20. AT32 IDE debugging interface



3.4 ICP tool operation

ICP PC software can be used to perform online operations such as memory download/read and

parameter configurations on Artery MCUs, and to encrypt AT-Link files, as well as support online/offline configuration and monitoring, firmware upgrade, among others.

Note: The V3 and above ICP supports WinUSB. The version is automatically selected while connecting to MCU, so it is recommended to download the latest ICP software.

3.4.1 How to use encryption files

- To protect files against leakage and copy during remote transfers, the contents of firmware can be encrypted into corresponding benc/henc/senc files to allow encryption download;
- The encryption key must be the same as that of the target AT-Link;
- Each AT-Link has its unique serial number, which is the initial factory default encryption key.

The steps for using encryption files are as follows:

1) Obtain the encryption key of the target AT-Link

   The factory default encryption key is AT-Link serial number, which is available on the ICP homepage by connecting to the target AT-link. Users can also customize the encryption key according to their needs, modify and save it in the “AT-Link setting-parameter setting” of ICP.

Figure 21. Encryption key location

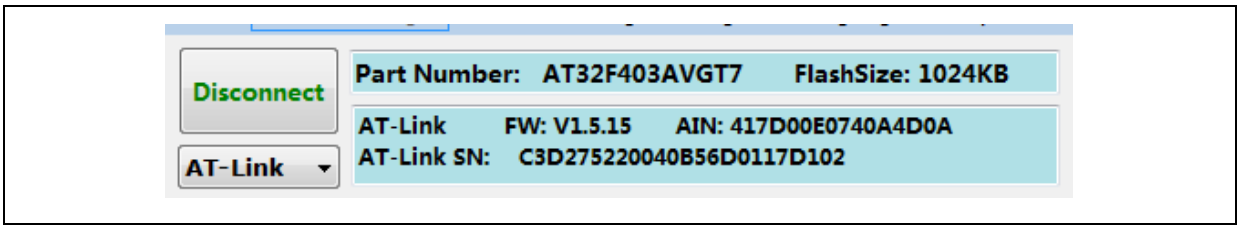
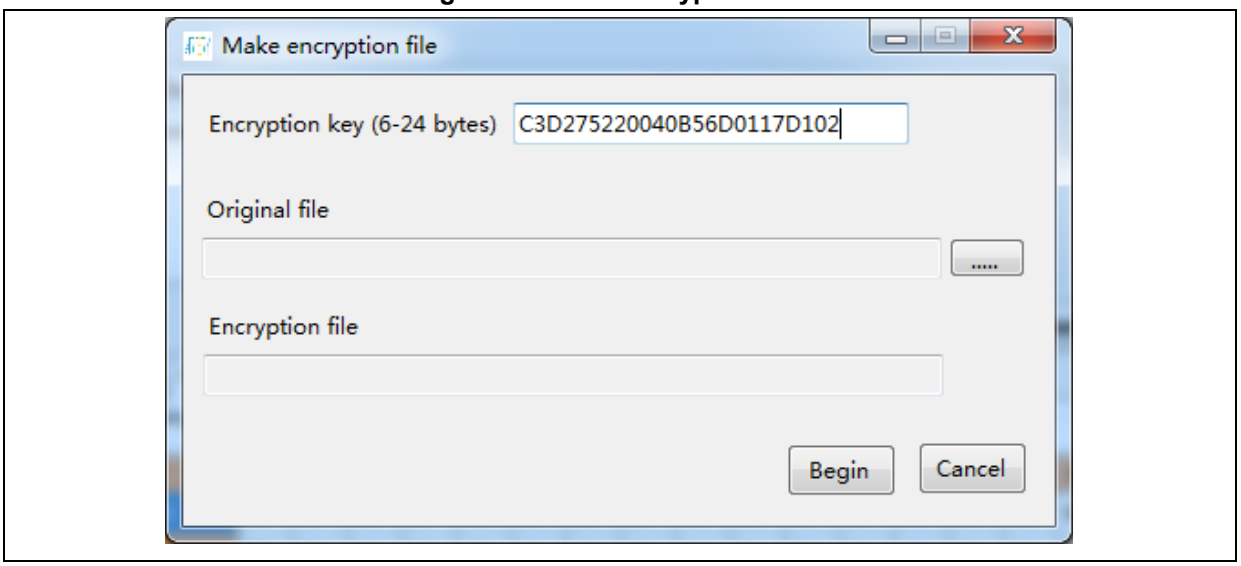


Figure 22. Customize the encryption key

2) In ICP, click on “file-make encryption file”, enter the encryption key, then the firmware contents in the format of bin/hex/srec/s19 generated by tools such as Keil and IAR are translated into encrypted files in the format of benc/henc/senc.

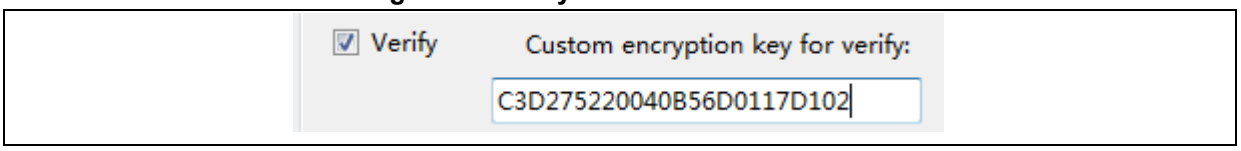
Figure 23. Make encryption file



3) Encrypted files are transferred remotely to the corresponding AT-Link for online/offline download.

– Online download: Add encrypted files to the download file box and click on “Begin”. If “Verify” box is ticked, you need to input an encryption key.

Figure 24. Verify after online download

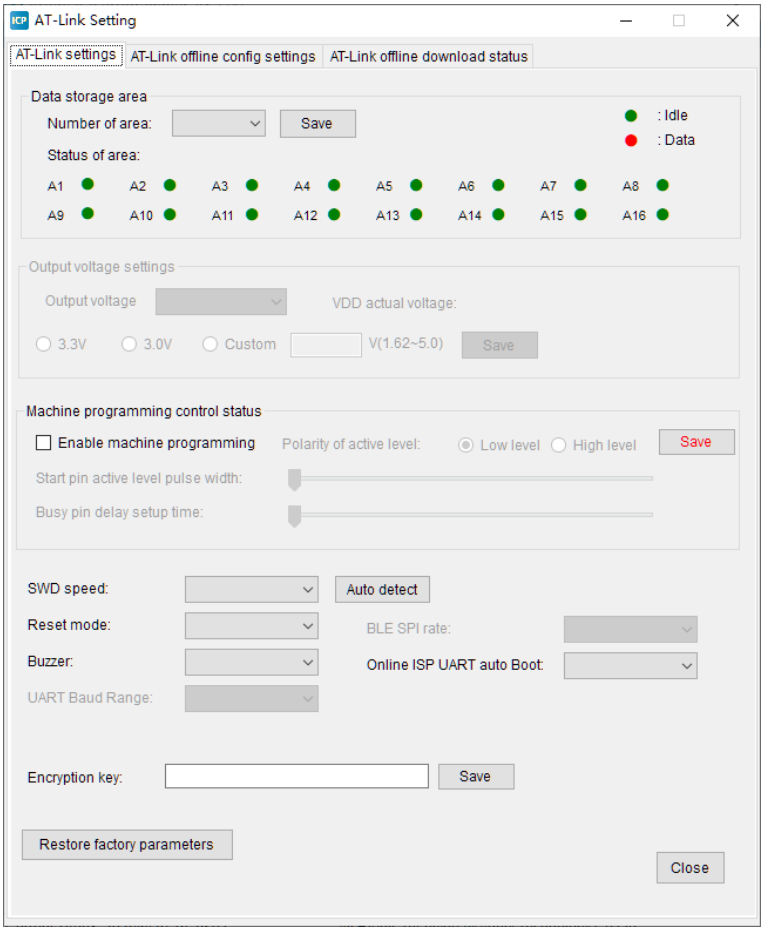


– Offline download: Add encrypted files to the offline project configuration, and save them to the corresponding AT-Link for offline download.

3.4.2 Parameter settings

This section describes how to configure AT-Link parameters.

Figure 25. Parameter settings window



- **Number of data storage area:** This indicates the number of codes stored offline, which can be configured as 1/2/4/8/16, with their individual maximum capacity being 16/8/4/2/1 MB respectively. Offline download also supports downloading several code files (up to 5) at a time, which occupy multiple storage areas.

  Note: Modifying this option will clear all offline stored data.

- **Output voltage settings:** For AT-Link-Pro only, used to regulate voltage level and enable output.

- **Machine programming control:**
  - Machine programming control enable: Tick it and click on “Save “to enable machine programming control.
  - Polarity of active level: Select low level or high level.
  - START pin active level pulse width: 20-1000 ms
  - BUSY pin denounce delay setup time: 20-1000 ms

- **SWD speed:** This is used to configure the SWD transfer speed for online/offline operation in non-IDE operating mode. It is recommended to click on “Auto detect “to let AT-Link automatically obtain the best SWD speed according to the actual circuit. Users can also select SWD speed from the drop-down list. Depending on the line length (distance) between AT-Link and the target board, it is advised to reduce the SWD speed if the distance is long. To take into account the programming quality, it is recommended to connect AT-Link and target board using

a flat cable thicker than AWG28. Measuring at AWG28 cable, the line length is around 10 meters for 1MHz SWD, 5 meters for 2 MHz SWD, and 3 meters for 5 MHz SWD.

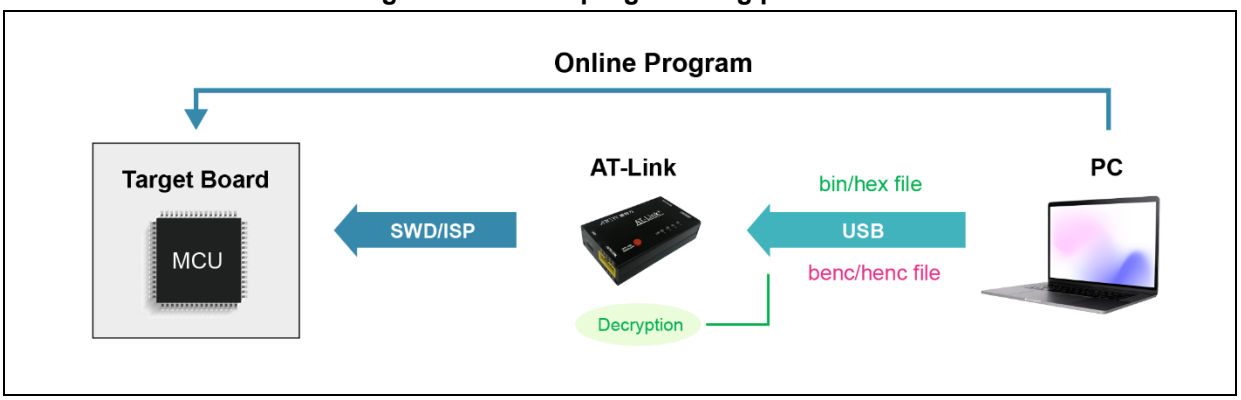
- **Reset mode:** It contains software system reset and hardware NRST pin reset, which is used to select the reset type after the target board is connected and offline programming is completed.
- **Buzzer:** Buzzer enable/disable. When it is disabled, all other operations are mute except for power-on initialization.
- **BLE module SPI rate:** It is used to configure the SPI communication speed for downloading MCU BLE module.
- **Online ISP USRT auto Boot:** It is used for auto boot mode switching during ISP download.
- **UART baud range:** It is used to set USB-to-serial port baud rate range.
- **Encryption key:** Supports the combination of 6-24 bytes of letters or numbers, which is customized by AT-Link users. Its initial default value is a 24-byte AT-Link serial number.

  Note: Modifying this option will clear all existing offline stored data.
- **Restore factory parameters:** Clear all AT-Link parameters and stored data, and return to factory default values.

3.4.3 Online operations

AT-Link supports online programming. The data transferred can be the original bin/hex/srec/s19 data or encrypted benc/henc/senc data. For encrypted benc/henc/senc data, the encryption key to generate data must be the same as that of AT-Link during programming.

Figure 26. Online programming process



Online download

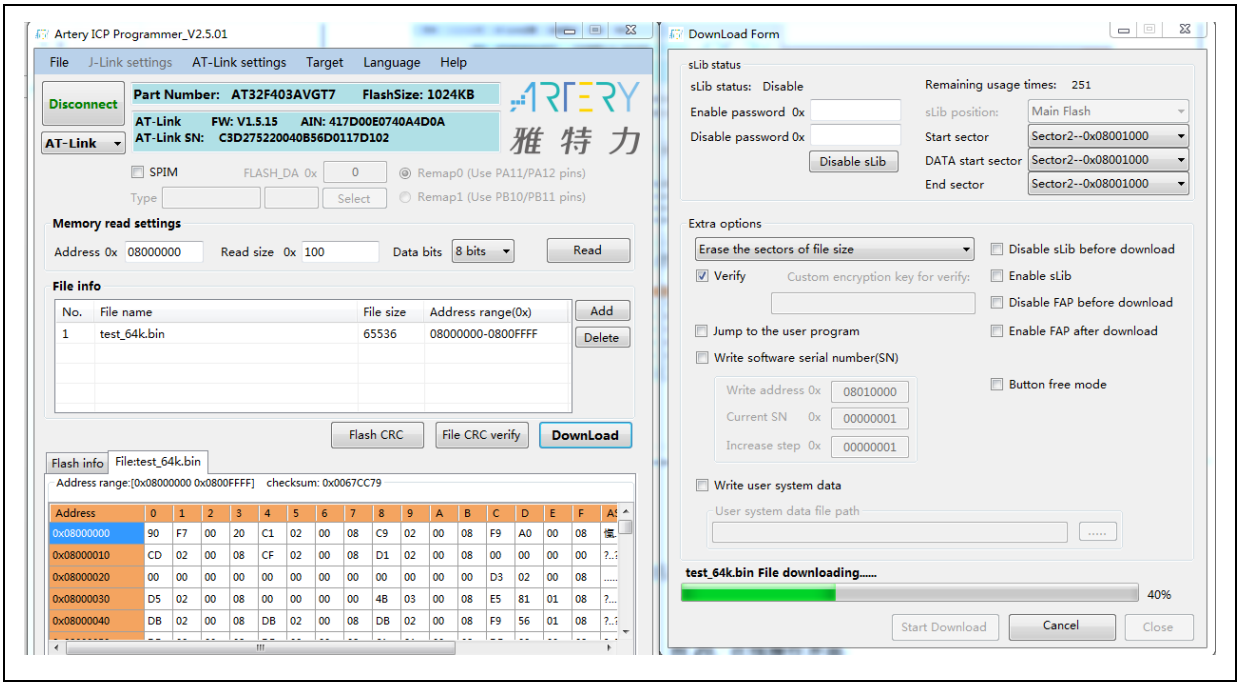
Select AT-Link and connect. If the connection is successful, the information such as model, serial number and firmware version will be displayed, and each AT-Link has its unique serial number. If the target board is connected successfully, its MCU part number and Flash size will be shown, and will halt the target board MCU. If failed, related online operations cannot be performed.

- Supports downloading multi-section files (up to five) at a time, in the format of original bin, hex, srec, s19 or encrypted benc, henc, senc.
- Some MCUs have SPIM feature. If the downloaded file address goes beyond SPIM address (0x0840_0000), users need to tick “SPIM”, and select the correct external Flash part number, I/Os multiplexed or not, external memory encryption range and other parameters according to the needs.

- Download Form allows users to set various options, where the user system data files support bin or hex format only.

Note: If the downloaded files are encrypted, the encryption key is required to enable verify after download.

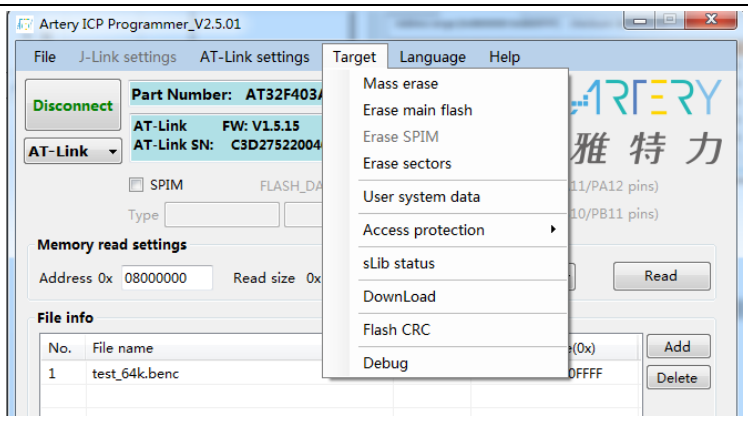
Figure 27. Online download window



Online configurations

This page describes online MCU configurations such as erase, user system data, access protection, sLib, bootloader AP mode.

Figure 28. Online operation



3.4.4 Offline operations

AT-Link supports also offline download, and works with the Hex Encryption function of Artery MCU to enable encrypted data transfer during offline programming.

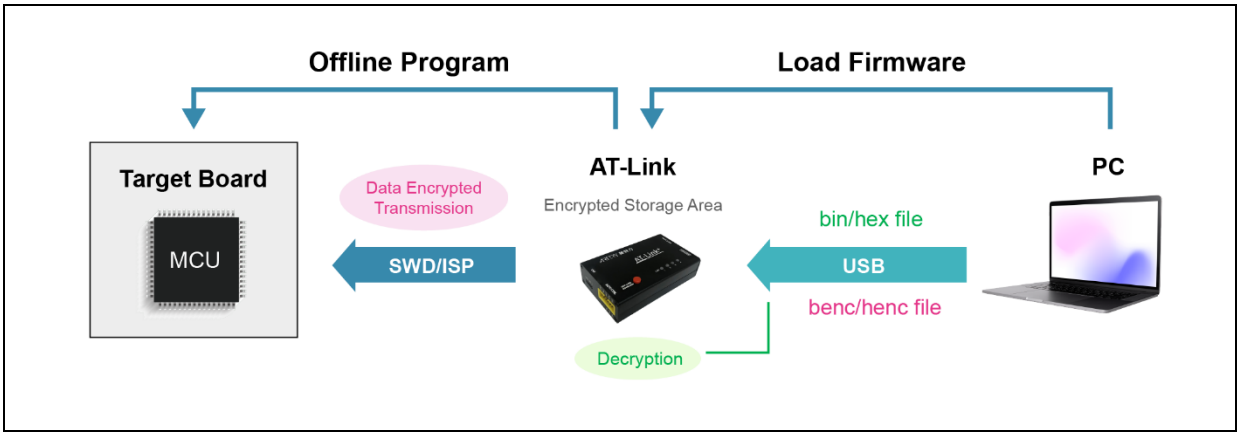
- Data transfer can be original bin/hex/srec/s19 format or encrypted benc/henc/senc format;
- For encrypted benc/henc/senc data, the encryption key to generate data must be the same as

that of AT-Link used during programming.

- For AT-Link that has saved offline projects, offline programming mode is supported.

Note: All AT-Link parameters can be saved after power-off.

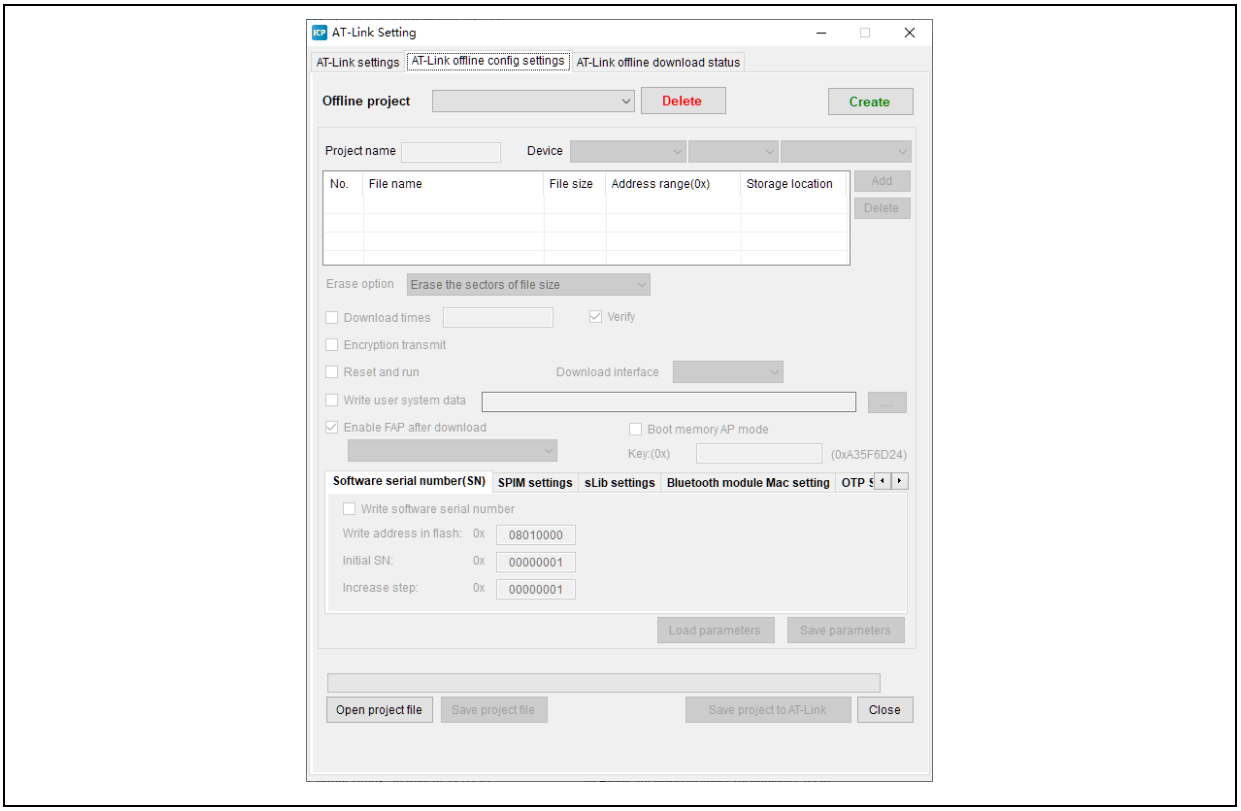
Figure 29. Offline programming process



Offline project configuration

This page describes how to configure offline download, including configuration information, user system data and code. All the configuration contents are collectively referred to as an offline project.

Figure 30. Offline project configuration window



- **Offline project:** Indicates the saved offline projects, and select a project from the drop-down list to view its configuration parameters (V3.0.0 above version supports project files in the more secure *.atcpe format).

- **Delete/Create:** Delete the selected project or create a new one in the drop-down list;
- **Project name:** When creating a project, the project name can be customized, supporting up to 16 bytes.
- **Device:** When creating a new project, users can select “Only download the target board of a specific MCU” or “All MCU boards under a MCU series”. For example, if the AT32F413 Universal-1Kbytes/sector is selected, it means that all 1KB MCUs/sector under F413 series can be downloaded;
- **Add/Delete:** When creating a new project, add/delete the code file to be downloaded. The format can be original bin/hex/ srec/s19 or encrypted benc/henc/senc. Multiple code files can be configured, but their storage addresses cannot be on the same Flash page. The maximum length of a file name is 32 bytes;
- **Erase option:** Configure as required. Perform various erase operations before downloading.
- **Download interface:** Select SWD or ISP interface for offline download.
- **Download times:** If this option is ticked, it means that the total number of download times is limited between 1 and 4000000. Both successes and failures are counted. If the total number is exceeded, no more downloads are allowed.
- **Reset and run:** Reset and run after the completion of download. This option and *Enable Access Protection* after download cannot be enabled at the same time.
- **Encryption transmit:** The encrypted transfer is done through the Hex Encryption feature of Artery MCU to ensure data security.
- **Verify:** Verify whether the downloaded data is correct. The hardware CRC is used during transfer encryption to ensure data security.
- **Enable access protection after download:** Access protection is enabled for the downloaded project. This option and *Reset and Run* cannot be enabled at the same time.
- **Bluetooth erase:** This applies to the MCUs featuring Bluetooth module. It is used for erase operation prior to download.
- **Enable Bluetooth module access protection after download:** The Bluetooth module access protection is enabled for the downloaded project.
- **Bootloader AP mode**: For some MCUs, their boot memory can be configured as an extended user code area to store user code. To avoid misuse, users need to enter the encryption key 0xA35F6D24 to make it effective.

  Note: This mode setting is irreversible and can only be modified once.
- **Write user system data:** Users can choose to download user system data files. The format can only be either bin or hex.
- **Program serial number:** This is a 32-bit data. The programming address can be customized. This address and code address cannot be on the same flash page.

  Serial number value = initial serial number + number of successful download x each incremented value. If overflow occurs, the upper bits will be cleared and the lower 32 bits reserved.
- **SPIM:** When there are files with their address range in SPIM (including code or serial number),

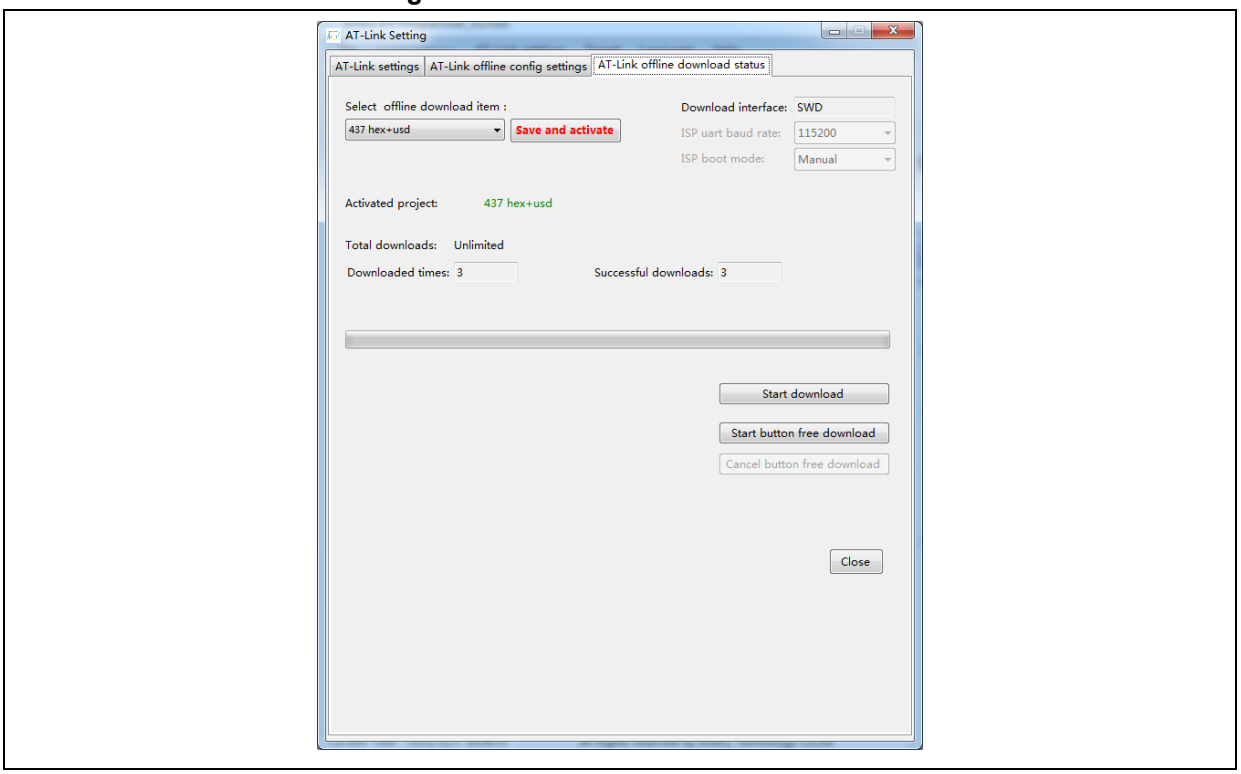
users need to select the corresponding external Flash model, I/Os multiplexed or not, external memory encryption range and other information.

- **sLib settings:** Configure sLib-related parameters, including disabling sLib before download or enabling sLib when download, the sLib password and sLib range must be programmed;
- **Program MAC address:** It is used for MAC address programming for AT32 MCU devices with Bluetooth module.
- **OTP settings:** It is used to program OTP data and OTP lock information for AT32 MCU devices supporting OTP.
- **Save project file:** After the completion of all configurations, they can be packaged to generate an encrypted *.atcp project file for remote transfer or local storage. When saving, it is up to the user to tick the option “This project is only used at the specified AT-Link” (AT-Link SN is required) or “This project is only used once” (AT-Link AIN is required)
- **Open project:** Open an existing atcp. format project file and load its content into software for viewing.
- **Save project to AT-Link:** Save the configured project or open project into the AT-Link through a dynamic encryption algorithm for the purpose of offline download.

Offline download status monitoring

This page describes AT-Link offline download status monitoring and related configuration.

Figure 31. Offline download window



- **Select offline download item:** Because AT-Link can store multiple offline projects, users need to select one project to activate and download. If the activated project is deleted, users need to select it again.
- **Download interface:** It only indicates the interface corresponding to the current project and

cannot be changed. If it is an ISP interface, the baud rate and boot mode can be modified according to the target board circuit.

- **Total downloads:** It only indicates the total number of downloads of the activated project.
- **Download times:** It indicates the number of times the active project has been downloaded, including the successes and failures. When the total downloads are reached, the file can no longer be downloaded so as to prevent download times control function from being maliciously cracked.
- **Successful downloads:** It indicates the number of times the active project has been downloaded successfully.
- **Start download:** Start a single offline download, and the corresponding prompt message will be displayed according to the download progress. If it fails, error message will be displayed.
- **Start/Cancel button free download:** Once started, there is no need to operate ICP interface, just need to replace the target board MCU according to the prompts to complete automatic continuous download. The switching of Start/Cancel can be allowed only when AT-Link is in idle state.

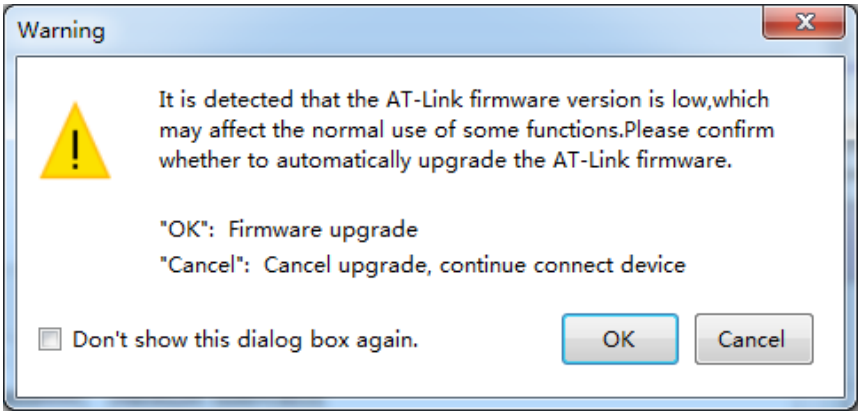
  Note: Other operations are not allowed in button free download mode. Users must cancel button free download mode before operation.

3.4.5 Firmware update

AT-Link supports auto networking and manual upgrade, which is shown in the “Help” menu. This is used to upgrade various functions and support more MCU models.

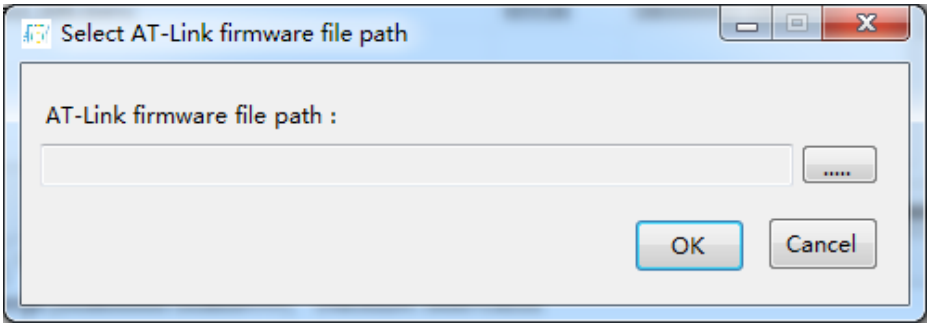
- **Auto upgrade:** When connecting, the ICP software starts to detect the current connected AT-Link version. If it is lower than the latest version on the internet or the firmware version embedded in ICP, users are prompted to perform auto upgrade.

Figure 32. Auto firmware upgrade



- **Manual upgrade:** Users can download the latest firmware in benc format on Artery official website, and select a firmware and upgrade it.

Figure 33. Firmware manual upgrade



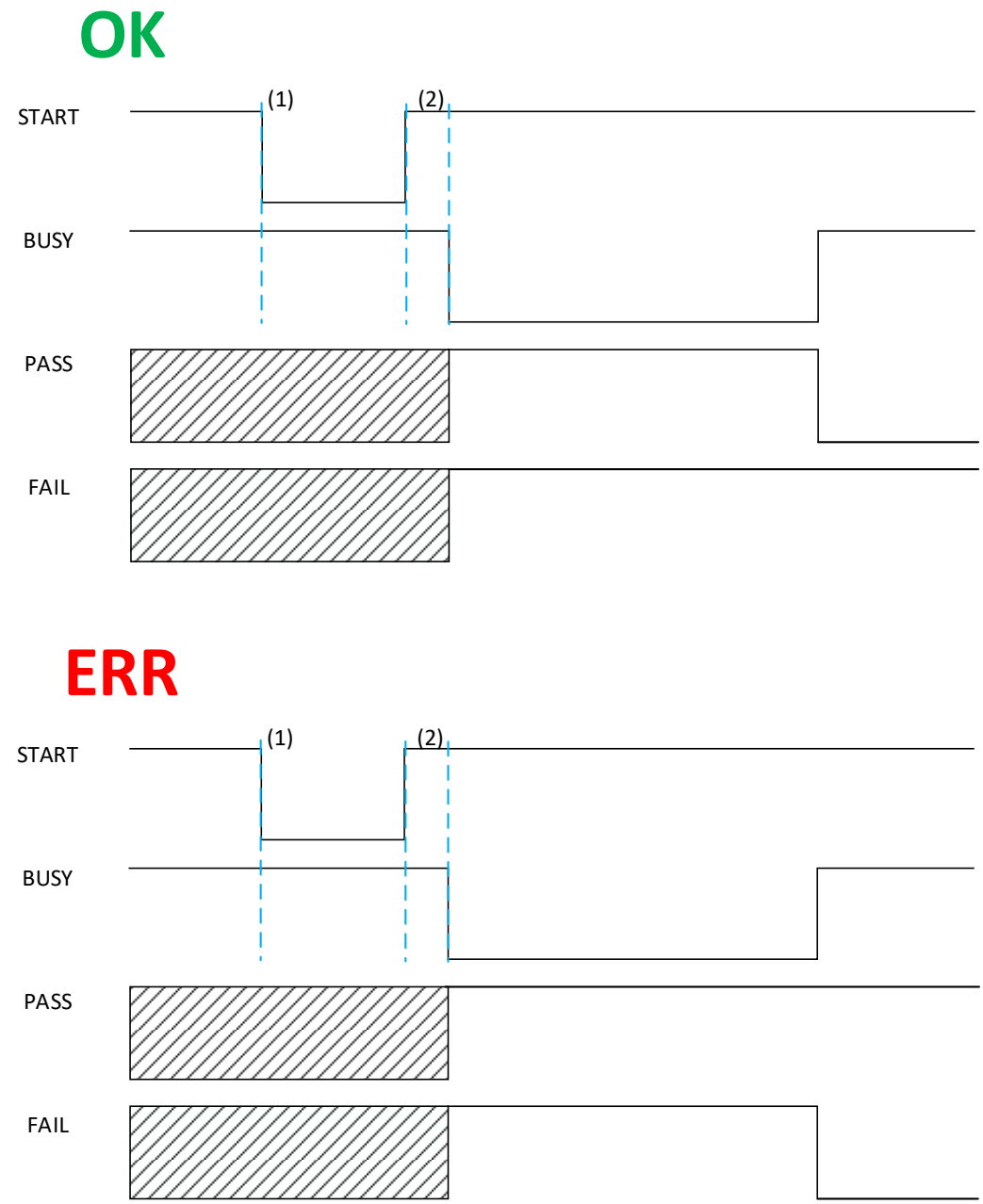
3.5 Machine programming control

After offline project configurations are saved, select a project for offline download through a machine programming control interface, without the need of ICP software.

The auto programming machine sends a sufficient active level pulse width to the START pin and calculates the debounce time so that the AT-Link starts programming to the target board. In this case, the BUSY pin will output active level and toggle at the end of programming. Then the auto programming machine can read PASS/FAIL pin to judge whether the programming is OK or ERR.

The parameters of machine programming control can be customized in AT-Link parameter settings according to the needs.

Figure 34. Typical timing diagram of machine programming control



(1) START active level pulse width
(2) BUSY denounce delay setup time
(3) Active low level

3.6 Button operations

After the offline project configurations are saved, select a project for offline download through buttons, without the need of ICP software.

When AT-Link is in idle state, press and hold the key for 3s to switch between button free download mode and single download mode.

- **Single download:** In a single download mode, short press the key enables an offline download. The download result is indicated through LCD, LED or buzzer.
- **Button free download:** In button free mode, when the download is completed, the target

board is directly replaced to continue downloading. The download result is indicated through LCD, LED or buzzer.

3.7 LCD touch operations

To facilitate mass programming, users can directly configure AT-Link parameters offline on the LCD screen using AT-Link-Pro, such as output voltage, machine programming, SWD speed, offline project file operation, switching single/button free download mode, etc. All configurations, similar to ICP Tool operations, can be saved after power-off.

Besides, it is possible to perform special operations through LCD display:

- **Online debugging:** Once it is enabled, the LCD screen operation and offline download is disabled temporarily, and the AT-Link-Pro is used as an online debugger.
- **Low-power consumption mode:** To address the problem of insufficient USB power supply in some circumstances, after this mode is enabled, when the LCD is in idle state for more than 30s, the screen will be OFF to reduce power consumption. The screen can be waken up temporarily through touching.

3.8 Offline programming procedures

For mass programming, offline programming mode can be used to significantly shorten the programming time and save cost. This section describes how to create and use offline project files.

A. Create offline project

Go to offline project configuration window, tick “Create offline project”, select a MCU part number to be programmed, enter offline project name, add the corresponding code, and set other parameters according to the needs (user system data, sLib settings, download times, etc.).

B. Save offline project (two methods)

- Save the configured offline project to PC (it is up to the user to tick the option “This project is only used for the specified AT-Link” or “This project is only used once”), and send to the programming factory, who will open the project and save it to the connected AT-Link.
- Directly save the configured offline project to the currently connected AT-Link.

C. Activate offline project

AT-Link can save up to 16 offline projects. Access to offline download page of ICP software, select an offline project to be programmed, save and activated it (For AT-Link-Pro, the user can select the offline project through touch operation on offline programming window).

4 FAQ

4.1 Device cannot be recognized by PC

Check the USB connection status LED of AT-Link device (for AT-Link-Pro, check the USB icon in the lower left corner of the home page; for other versions, check the blue LED). If the LED is ON, it indicates successful enumeration on PC; otherwise, unplug and reconnect the AT-Link or replace with a new USB cable. After successful enumeration, if the device is still not recognized, use ICP tools for follow-up operation as instructed.

4.2 AT-Link-Pro displays data error

When LCD displays “data error”, it indicates that the data has been corrupted. This may be caused by disconnection during LCD upgrade or unexpected or unknown error. It is recommended to operate as follows:

1) When the device is not found through ICP connection, hold the button and plug in USB to power on, and keep for 3s until both LEDs blink simultaneously;
2) Use ICP tool (V3.0.4 and above) for connection, and a prompt indicating ATLINK firmware upgrade pops up; click OK to upgrade;
3) Plug in USB for power on and wait for seconds; then use ICP tool (V3.0.4 and above) for connection, and a prompt indicating ATLINK firmware upgrade pops up; click OK to upgrade.

When the version of AT-Link-Pro to be restored is V2.1.4 and above, perform step 3).

4.3 ISP interface offline download fails

The prompt of connection failure (DETECT_FAIL) may occur in one of the following conditions:

1. The boot mode of the target MCU is not correct.

Solution: For ISP downloading, the boot mode should be switched to “boot from boot memory”, which requires downloading through the embedded bootloader and then set boot from boot memory.

2. The FAP of the target MCU is enabled, and the SWD interface is used for connection (for example, the MCU that uses ICP for connection, with FAP enabled).

Solution: The bootloader fails to run. Power on to reset the bootloader, and do not use SWD interface in follow-up operations.

5 Revision history

Table 7. Document revision history

Date	Version	Revision note
2021.9.2	2.0.0	Initial release.
2022.7.22	2.1.0	1. Added AT-Link+ and AT-Link-ISO+ descriptions. 2. Added WinUSB description in the section of AT-Link.
2022.9.1	2.1.1	Added FAQs and solutions.
2024.1.2	2.1.2	1. Added IO level description in the machine programming control interface sections. 2. Updated online/offline programming flowchart.
2024.7.20	2.1.3	Added schematic diagrams of AT-Link+ communication interface connection.
2025.6.9	2.1.4	1. Added USB-to-USRT baud rate range settings. 2. Improved offline project file security. 3. Updated description of new features.

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