Troubleshooting Guide for HT32 MCU SWD Interface Usage Problems

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Introduction

Holtek HT32 series of MCUs are based on an Arm® Cortex®-M core. The core contains integrated Serial Wire Debug (SWD) ports namely SW-DP/SWJ-DP, which makes development, programming and debugging more convenient. However, during hardware design when using the SWD, users may encounter some abnormal situations, which affect project development. This application note provides users with a comprehensive troubleshooting guide for SWD interface problems and includes possible errors which may occur during connection, communication and other conditions. This guide will assist users to use the SWD interface more easily, saving development time to make the project more efficient.

Holtek has released a USB debugging tool named e-Link32 Pro/Lite, which has been developed based on the Arm® CMSIS-DAP reference design. By connecting the target board to the PC's USB port, users can program and debug the program on the target MCU via the SWD under the development environment or with a programming tool. The following figure shows the connection relations. This text will take the e-Link32 Pro/Lite as an example to introduce the SWD, common error messages and troubleshooting steps. The SWD related instructions and debug information are also used for a common USB debug adapter such as ULINK2 or J-Link.
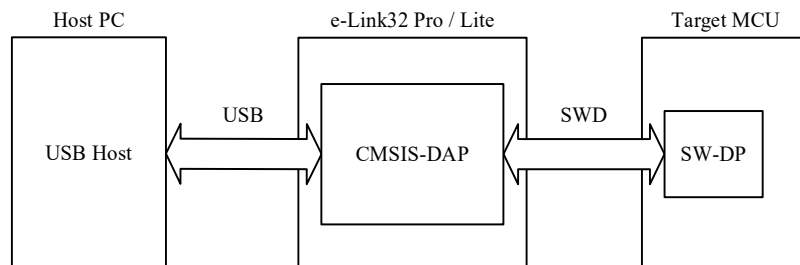

Figure 1. SWD Connection Diagram

Abbreviation description:

SWD: Serial Wire Debug

SW-DP: Serial Wire Debug Port

SWJ-DP: Serial Wire and JTAG Debug Port

CMSIS: Common Microcontroller Software Interface Standard

DAP: Debug Access Port

IDE: Integrated Development Environment

SWD Introduction

The SWD is a hardware interface widely used with the Arm® Cortex-M® series of MCUs for programming and debugging. The following section will illustrate the Holtek e-Link32 Pro and e-Link32 Lite. The e-Link32 Pro has approximately the same architecture as the e-Link32 Lite, the main difference is that the e-Link32 Pro supports ICP offline programming. The following is a brief description:

- e-Link32 Pro: this is a Holtek standalone USB debug adapter, which supports In-Circuit Programming, offline programming and debugging. Refer to the e-Link32 Pro User Guide for details.

- e-Link32 Lite: this is a Holtek Starter Kit internal USB Debug adapter, which can directly program or debug on the target MCU without additional connections. Refer to the Starter Kit User Manual for details.
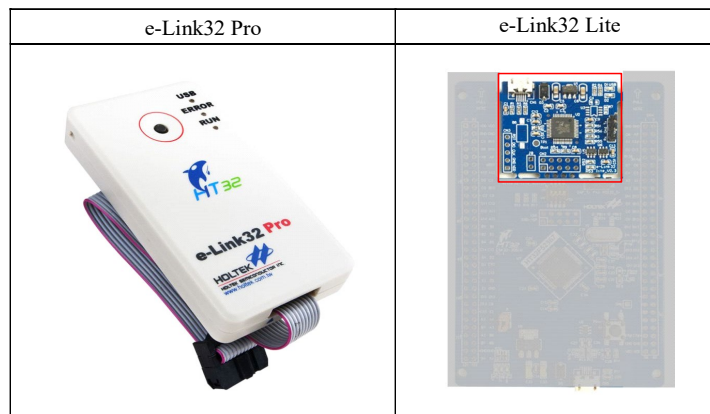

Figure 2. e-Link32 Pro and e-Link32 Lite

SWD Pin Description

There are two SWD communication pins:

- SWDIO (Serial Wire Data Input/Output): a bidirectional data line for debug information transmission and code/data programming between the debug adapter and the target MCU.

● SWCLK (Serial Wire Clock): a clock signal from the debug adapter for synchronous data transmission.

A traditional Joint Test Action Group (JTAG) interface requires four connection pins, while the SWD only requires two pins to communicate. Therefore, the SWD requires fewer pins and is more convenient to use.

Connection Description/PCB Design

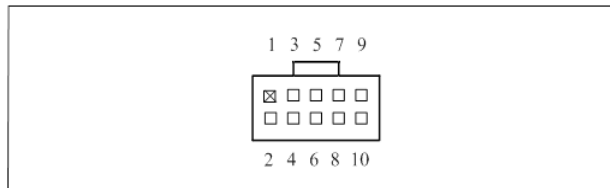The following figure shows the e-Link32 Pro/Lite interfaces.

Figure 3. SWD 10-Pin Connector

Pin No.	Name	Description
1	VCC	Debug adapter SWD interface Level Shift power supply by default, must be connected to the target MCU power supply
2	SWDIO	Data signal, must be connected to the target MCU SWDIO pin
3	GND	Ground
4	SWCLK	Clock signal, must be connected to the target MCU SWCLK pin
5	GND	Ground
6	Reserved	Reserved pin, no connection required
7	VCOM_RXD	The e-Link32 Pro/Lite provides two Virtual COM ports for serial communication. This is independent of the SWD. The connection is determined based on the development environment and hardware requirements
8	VCOM_TXD	
9	GND	Ground
10	Reset	Used to control the target board reset signal - must be connected to the target MCU nRST pin

Table 1. SWD 10-Pin Description

If users need to design their own board, it is recommended to reserve an SWD connector, as shown in the following figure. The SWD interface must contain VDD, GND, SWDIO, SWCLK and nRST of the target MCU and which can then be connected to e-Link32 Pro/Lite via this connector for programming or debugging.
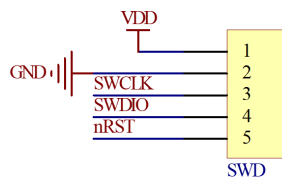

Figure 4. SWD 5-Pin Connector

Debug Adapter Level Shift Description

As the MCU may have different operating voltages in practical applications, the I/O logic voltage levels may also be different. The e-Link32 Pro/Lite provides a Level Shift circuit to adapt to different voltages. If the SWD Pin 1 VCC is used as a reference voltage in the above circuit, then the SWD pin input/output voltage on the e-Link32 Pro/Lite can be automatically adjusted according to the target MCU operating voltage, thus making it compatible with different MCU hardware board designs. Most debug adapters such as ULINK2 or J-Link have a similar design.

As can be seen from the above description, when the debug adapter is connected to the MCU hardware board under a preset condition, it should be noted that the MCU hardware board will provide power to the SWD VCC pin on the debug adapter, as shown in the following figure. This means that the MCU hardware board must be connected to a power supply separately and the SWD VCC pin on the debug adapter has no power output by default.
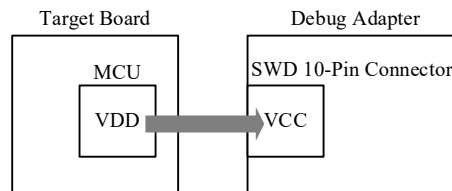

Figure 5. Target Board & Debug Adapter Power Supply Direction

The e-Link32 Pro/Lite Pin 1 VCC can also be set to output 3.3V to power the target MCU hardware board. However, it is important to pay attention to current and power supply limitations. Refer to the e-Link32 Pro User Guide for details.

Check whether the debug adapter USB is correctly connected

When the e-Link32 Pro/Lite is connected to the PC, check whether it is correctly connected using the following two methods.

1. Check whether the D1 USB LED of the e-Link32 Pro/Lite remains illuminated.

2. Press the "Win +R" buttons to call "Run" and enter "control printers" to run. When a "Printers & scanners" window appears, click on "Devices" and find "Other devices" from the drop-down menu. Then check whether a device named "CMSIS-DAP" or "Holtek CMSIS-DAP" appears, as shown in the following figure. It should be noted that different computer systems may have slightly different displays. Users can refer to this step to find and check whether this device appears.
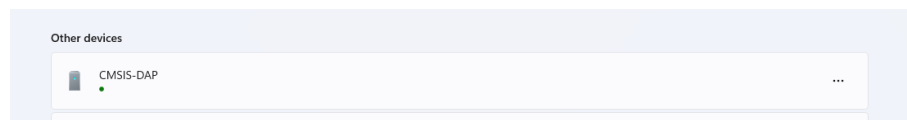

Figure 6. CMSIS-DAP Device

If the USB debug adapter fails to connect to the PC, refer to "Troubleshooting Step 2".

Keil Debug Settings

This section will take e-Link32 Pro/Lite as an example to illustrate the debug settings under the Keil development environment. Use the following steps to check step by step whether the settings are correct. First click on "Project → Options for Target".

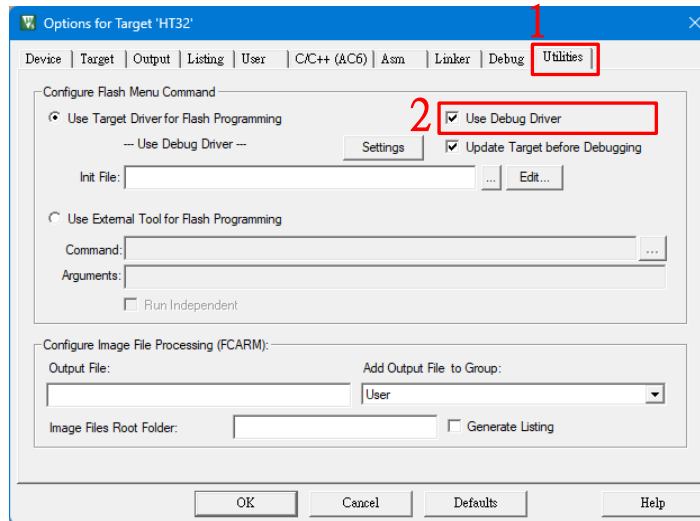1. Click on the "Utilities" tab

2. Check "Use Debug Driver"

Figure 7. Keil - Options for Target - Utilities

3. Click on the "Debug" tab

4. Use "CMSIS-DAP Debugger"

5. Check "Load Application at Startup"

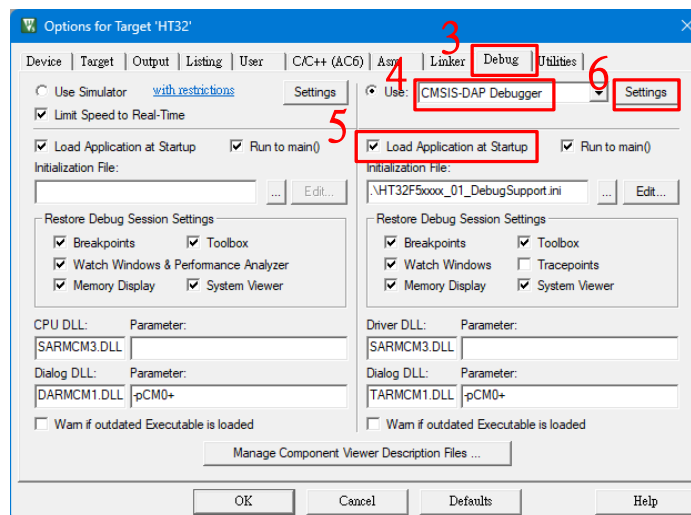6. Click "Settings" on the right to open the "Options for Target" dialog box

Figure 8. Keil - Options for Target - Debug

7. If the debug adapter has connected to the PC successfully, "Serial No" will display. If not then refer to" Troubleshooting Step 2"

8. Check "SWJ" and select "SW" as Port

9. If the debug adapter has connected to the MCU successfully, the SWDIO table will display "IDCODE" and "Device Name". Otherwise, refer to "Troubleshooting Step 3" and check each item sequentially from there.
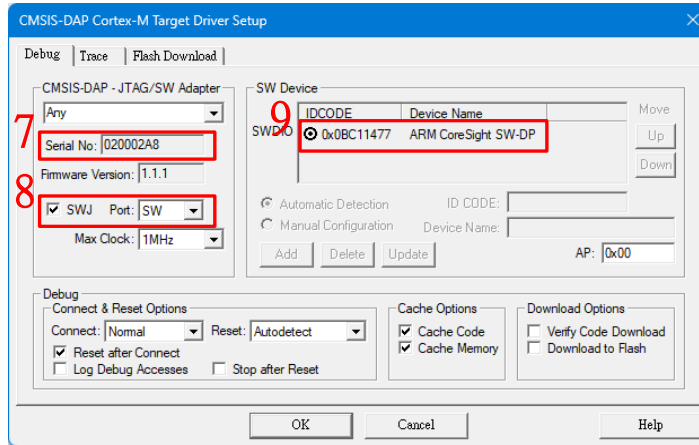

Figure 9. Keil - Target Driver Setup - Debug

10. Click on the "Flash Download" tab

11. Select "Erase Full Chip" or "Erase Sectors" as Download Function, then check "Program" and "Verify"

12. Check whether the HT32 Flash Loader exists in the Programming Algorithm. The following shows the HT32 Flash Loader.

- HT32 Series Flash

- HT32 Series Flash Options

If the HT32 Flash Loader does not exist, click "Add" to manually add it. If the HT32 Flash Loader cannot be found, install the Holtek DFP. Click on "Project - Manage - Pack Installer…" to find the Holtek DFP and install. Refer to the Arm Developer website or download the HT32 Firmware Library. Find "Holtek.HT32_DFP.latest.pack"in the root directory and install.
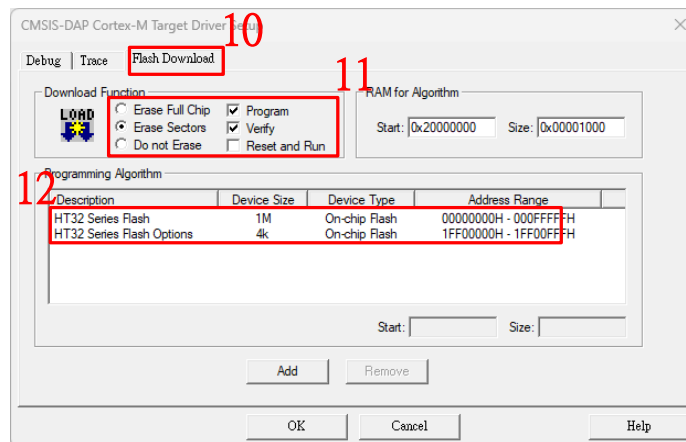

Figure 10. Keil - Target Driver Setup - Flash Download

IAR Debug Settings

This section will take the e-Link32 Pro/Lite as an example to illustrate the debug settings under the IAR development environment. Follow the following steps to check step by step whether the settings are correct. First click on "Project → Options".

1. Click "General Options → Target" and select the target MCU as the Device. If the corresponding MCU cannot be found, download the "HT32_IAR_Package_Vx.x.x.exe" from the Holtek official website to install the IAR Support Package.
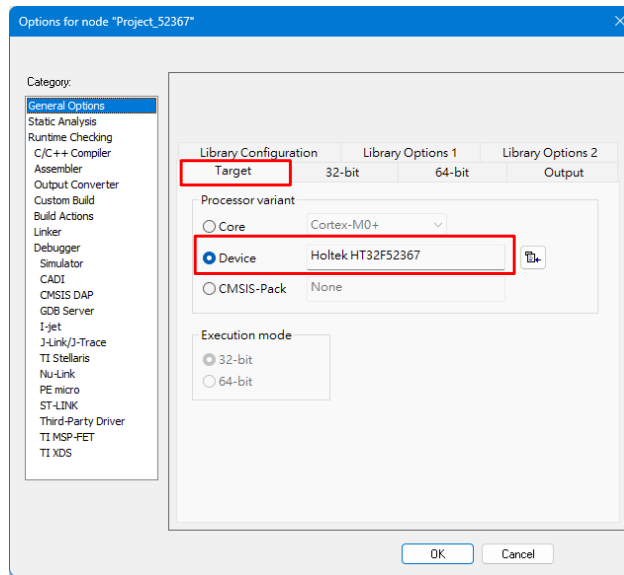

Figure 11. IAR - General Options

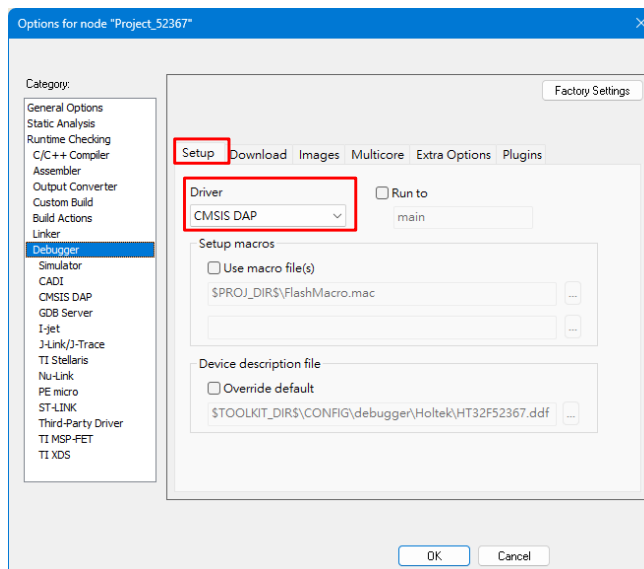2. Select the "Setup" tab in "Debugger" and select "CMSIS DAP" as Driver

Figure 12. IAR – Debugger

3. Select the "Interface" tab in "CMSIS DAP" and select "SWD" as Interface
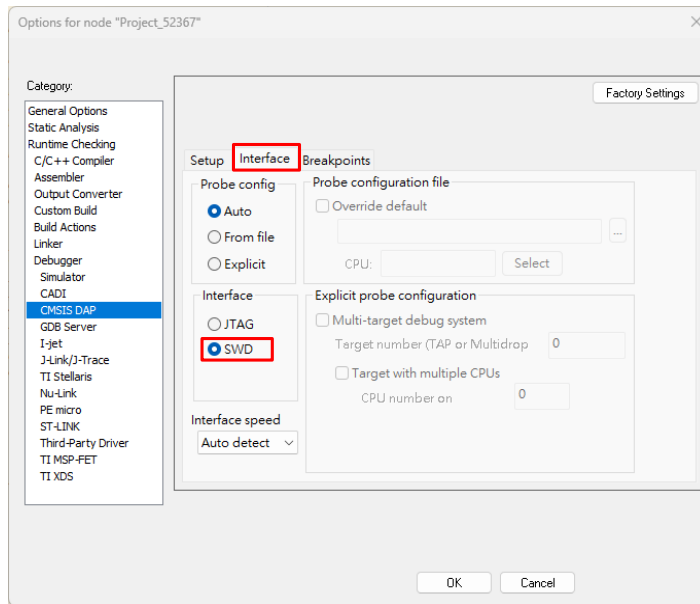

Figure 13. IAR - CMSIS DAP

Check whether the SWD is correctly connected

When taking Keil as an example, click on "Project → Options for Target" to select the "Debug" tab and click "Settings" on the right.
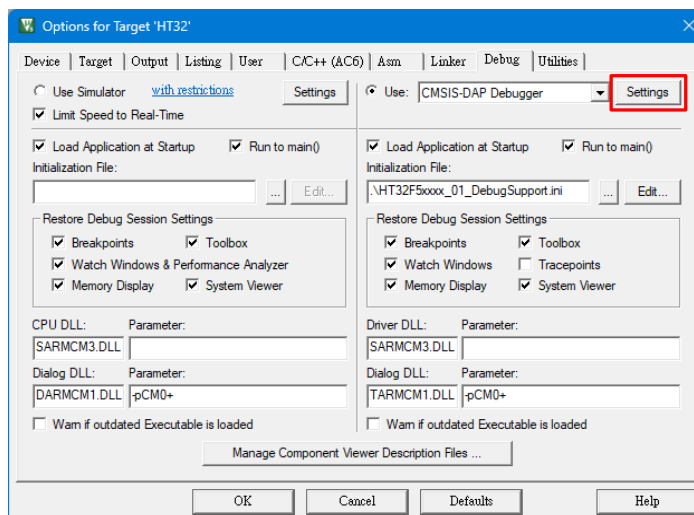

Figure 14. Keil - Options for Target - Debug

If the IDCODE and Device Name are displayed in the SWDIO table as shown in the following figure, it indicates that the SWD is correctly connected. Otherwise, if an error occurs, refer to the instructions in the "Connect Under Reset" section, or refer to the troubleshooting steps to check.
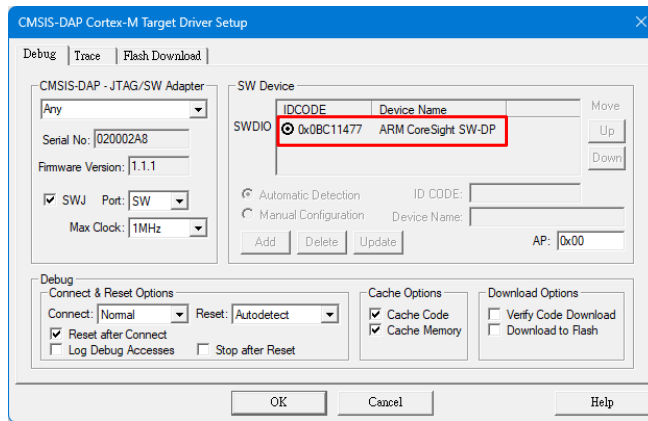
Figure 15. Keil - Target Driver Setup - Debug

Connect Under Reset

Connect Under Reset is a feature of the MCU core and SW-DP to pause the system before the program is executed. If a program behavior causes the SWD to be inaccessible, users can resolve the problem using this method. The common reasons why the SWD is inaccessible are as follows.

1. When the SWDIO/SWCLK pin-shared function is selected to have another function, such as GPIO, the I/O will not be used for SWD communication.

2. When the MCU enters the Deep-Sleep mode or Power-Down mode, the MCU core will stop. Therefore, it is not possible to communicate with the MCU core via the SWD for programming or debugging.

Refer to Connect Under Reset settings below when using Keil. "Project" → "Options for Target" → "Debug" → click "Settings" → select "under Reset" as the Connect method, as shown in the following figure. Refer to "Troubleshooting Step 9" for the detailed Keil setting steps.
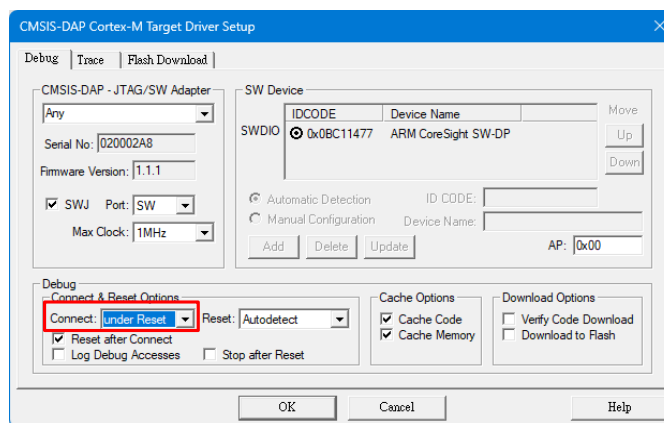

Figure 16. Keil - Connect Under Reset Setting

Common Error Messages

The following table shows a summary of common error messages between Keil and IAR.

IDE	Error Message	Troubleshooting
Keil	"No Debug Unit Device found"	Refer to "Troubleshooting Step 2"
	"SWD/JTAG Communication Failure"	Check one by one from "Troubleshooting Step 3"
	"Error: Flash Download failed - Cortex-Mx"	(1) Check whether the image size exceeds the specification (2) Check the Keil - Flash Download setting (3) Refer to "Troubleshooting Step 10 and Step 11"
	"Cannot Load Flash Programming Algorithm!"	Refer to "Troubleshooting Step 4 and Step 5"
	"Flash Timeout. Reset the Target and try it again."	Check whether the image size exceeds the specification
IAR	"Fatal error: Probe not found"	Refer to "Troubleshooting Step 2 and Step 13"
	"Fatal error: Failed to connect to CPU"	(1) Check the IAR-MCU model (2) Check one by one from "Troubleshooting Step 3"
	"Failed to load flash loader:…. "	Refer to "Troubleshooting Step 4 and Step 5"

Table 2. Error Message Summary

Keil - Message "No Debug Unit Device found"

Figure 17. Keil - Message "No Debug Unit Device found"

When the debug adapter fails to connect to the PC, refer to "Troubleshooting Step 2".
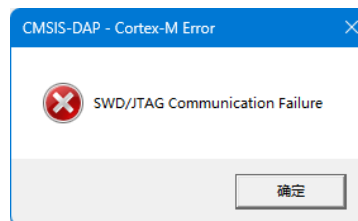
Keil - Message "SWD/JTAG Communication Failure"

Figure 18. Keil - Message "SWD/JTAG Communication Failure"

When the SWD communication fails, it means that the debug adapter has failed to connect to the MCU. Check one by one from "Troubleshooting Step 3".

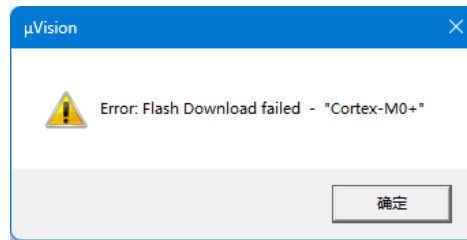**Keil - Message "Error: Flash Download failed - "Cortex-Mx" "**

Figure 19. Keil - Message "Error: Flash Download failed - "Cortex-Mx" "

1. First check whether the compiled "Code Size + RO-data + RW-data Size" exceeds the target MCU specifications.

2. Check whether the Flash Loader settings in the Keil Programming Algorithm are correct. Refer to the "Keil Debug Settings" section for details.

3. Check whether the Page Erase/Program or Security protection is enabled. Refer to "Troubleshooting Step 10 and Step 11" for details.

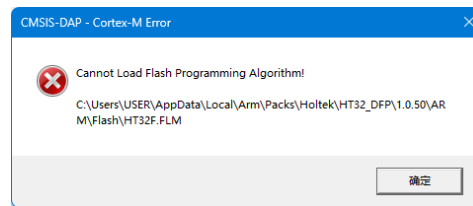**Keil - Message "Cannot Load Flash Programming Algorithm!"**

Figure 20. Keil - Message "Cannot Load Flash Programming Algorithm!"

Check whether the VCC and GND pins on the debug adapter are connected to that of the target MCU. Refer to "Troubleshooting Step 4" and "Step 5".

Keil - Message "Flash Timeout. Reset the Target and try it again."
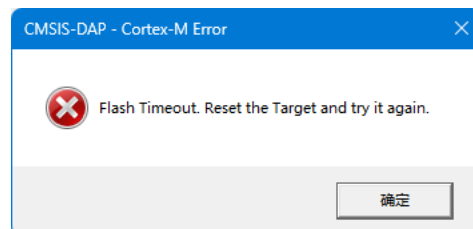

Figure 21. Keil - Message "Flash Timeout. Reset the Target and try it again."

Check whether the compiled "Code Size + RO-data + RW-data Size" exceeds the target MCU specifications.
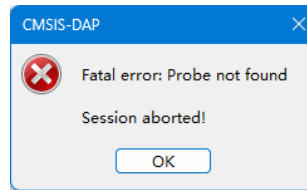
IAR - Message "Fatal error: Probe not found"

Figure 22. IAR- Message "Fatal error: Probe not found"

When the debug adapter is not connected to the PC, refer to "Troubleshooting Step 2" and "Step 13".

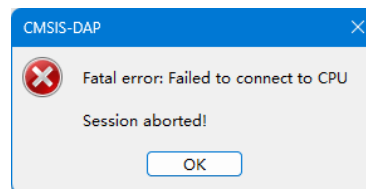### IAR - Message "Fatal error: Failed to connect to CPU"

Figure 23. IAR- Message "Fatal error: Failed to connect to CPU"

When the SWD communication fails, it means that the debug adapter has failed to connect to the MCU. The following shows the possible reasons:

1. The target MCU model of the Device in "General Options" may be incorrect, refer to the "IAR Debug Settings" section for details about how to modify this.

2. If the MCU cannot respond to the host via the SWD, check one by one from "Troubleshooting Step 3".

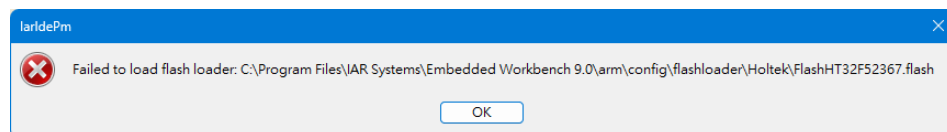### IAR - Message "Failed to load flash loader:…."

Figure 24. IAR- Message "Failed to load flash loader:…."

Check whether the VCC and GND pins on the debug adapter are connected to that of the target MCU. Refer to "Troubleshooting Step 4" and "Step 5".

Troubleshooting

If users encounter problems when using the SWD, use the following steps to check in sequence.

Step 1. Whether multiple USB debug adapters are connected to the system?

If multiple USB debug adapters such as e-Link32 Pro/Lite or ULINK2 are connected to the system simultaneously, remove them and retain only one group. This prevents misjudgment caused by simultaneous access of multiple debug adapters. Users can also select the debug adapter with a specific connection under the development environment.

Step 2. Check whether the debug adapter USB port is successfully connected?

If the D1 USB LED on the e-Link32 Pro/Lite is not illuminated or the corresponding device "CMSIS-DAP" is not found in "Printers & scanners", try to troubleshoot the error using the following method.

1. Re-plug the e-Link32 Pro/Lite USB port.

2. Check whether the USB cable is undamaged and can communicate with the PC.

3. Check whether the e-Link32 Pro/Lite USB port is not loose.

4. Check whether the PC USB Port can operate correctly or replace the connected USB Port.

5. Restart the PC and reconnect the USB port.

Step 3. Check whether the SWDIO/SWCLK/ nRST pins are connected?

Check whether the MCU SWDIO, SWCLK and nRST pins are actually connected to the debug adapter. Check whether the cable is not broken or the connection is disconnected. If the Holtek ESK32 Starter Kit is used, ensure that the Switch-S1 on the board is switched to "On".

Step 4. Check whether the SWDIO/SWCLK wire is too long?

Shorten the wire to less than 20cm.

Step 5. Check whether the SWDIO/SWCLK connect to protection components?

The serial protection components can cause SWD high-speed signal distortion, therefore the SWD transmission rate must be reduced. Adjust the transmission rate as follows:

Keil: "Project → Options for Target" select the "Debug" tab, and click "Settings" to adjust the Max Clock, as shown in the following figure.
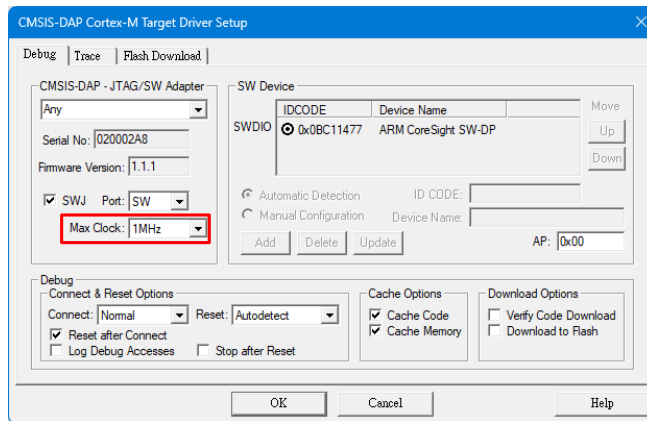
Figure 25. Keil - Target Driver Setup - Max Clock

IAR: click "CMSIS DAP" in "Project → Options" and click the "Interface" tab to adjust the interface speed, as shown in the following figure.
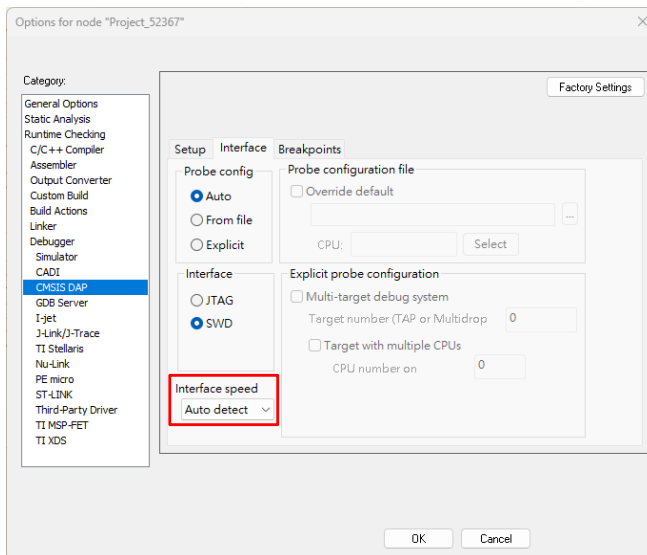

Figure 26. IAR - CMSIS DAP - Interface speed

Step 6. Check whether the power supply is normal?

Check the following power supply conditions:

1. Check whether all the GND pins are connected together to ensure the same reference voltage

2. Check whether the power supply of the debug adapter such as the e-Link32 Lite Pro is normal (USB VBUS 5V).

3. Check whether the target board is correctly connected to the power supply

4. Check whether the SWD Pin 1 VCC on the debug adapter is powered by the target board. Pin 1 VCC on the debug adapter connects to the VDD pin on the target MCU and should have an appropriate voltage.

Step 7. Check whether the Boot pin setting is correct？

If the programming operation has been successful but the program does not execute, check whether the BOOT pin has been externally pulled-low. If yes, then remove this external signal. After a power-on or reset, the BOOT pin must be kept at a high level, after which the program in the Main Flash memory can execute normally. Refer to the MCU Datasheet for details on the BOOT pin position or the required level.

Step 8. Check whether the MCU configures SWDIO/SWCLK pin as GPIO or other functions?

If the SWDIO/SWCLK pin-shared function is selected to have a different function such as a GPIO by the MCU firmware, then when the program has executed to "AFIO switch SWDIO/SWCLK", the MCU will no longer respond to any SWD communication. This will make the target board present a state that cannot be programmed. In such cases, it can be restored by setting Connect under Reset. Refer to the Method 1 or Method 2 in Step 9 for details.

Step 9. Check whether the MCU has entered the power saving mode?

If the MCU has entered the Deep-Sleep mode or Power-Down mode by firmware, the registers in the MCU Cortex-M core cannot be accessed via the SWD. This makes the programming or debugging functions unavailable. Refer to the following two methods to restore this. The main principle here is to prevent the firmware in the Main Flash from operating, thus allowing the SWD communication to operate normally.

- Method 1 - Set the Connect Under Reset

    Take Keil as an example for the IDE settings. Click on "Project → Options for Target" to select the "Debug" tab, and then click on "Settings".
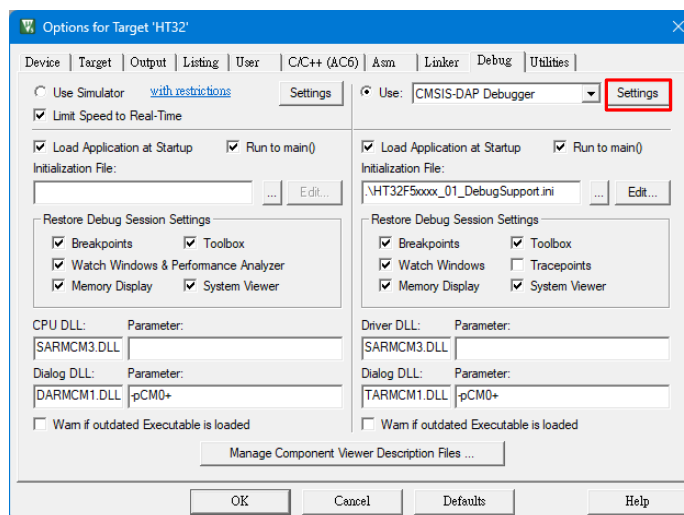

Figure 27. Keil - Options for Target – Debug

Select Connect "under Reset", as shown in the following figure. Now the IDE can then program using the SWD normally. It is recommended to first erase the firmware in the Main Flash (refer to "Step 11" for the erase operation) to prevent from the SWDIO/SWCLK AFIO Switch or entering the power saving mode by the firmware.
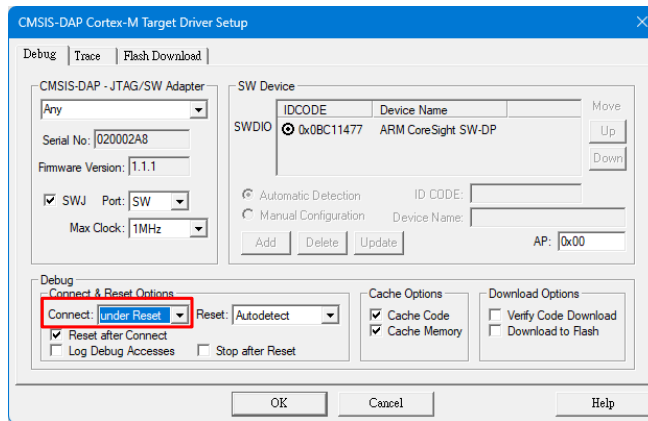

Figure 28. Keil - Connect under Reset Setting

- Method 2

  Pull-down the PA9 BOOT pin, reset or power it on again and execute an MCU Flash Erase. After the Erase has completed, release the PA9 pin. Refer to Step 11 for instructions on how to perform an erase via the IDE.

Step 10. Check whether the MCU has enabled Memory Page Erase/Write protection?

If the MCU has enabled Memory Page Erase protection, the protected memory page cannot be erased or modified. During an SWD page erase, when an error occurs because the protected page cannot be erased, a mass erase operation is required to resolve this problem. Here the MCU memory will be completely erased and removed from memory protection by a Mass Erase. Refer to "Step 11" for details.

Step 11. Check whether the MCU has enabled Security protection?

If the MCU has enabled Security protection, when an error occurs during an SWD page erase, a Mass Erase operation must be executed to erase the Option Byte to remove the memory protection. After a Mass Erase has completed, the MCU must reset or be powered on again.
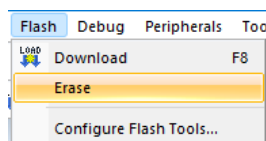
- Keil: "Flash → Erase"

Figure 29. Keil - Mass Erase Method

● IAR: "Project → Download → Erase memory"

Figure 30. IAR - Mass Erase Method

Step 12. Check whether to reset the system after completing the programming?

After the program has been updated via the debug adapter, an MCU reset must be triggered before the system can start the program. The MCU reset can be triggered by either the nRST pin or by powering on again.

Step 13. Check whether the e-Link32 Pro/Lite firmware is the latest version?

If users still cannot program or debug using the SWD after completing the above troubleshooting steps, it is recommended to update the e-Link32 Pro/Lite firmware to the latest version. Download the new e-Link32 Pro ICP Tool from the Holtek official website and click on "Connect". If the e-Link32 Pro Lite version is older, an update message will automatically pop up, then click on "OK" to update the firmware.
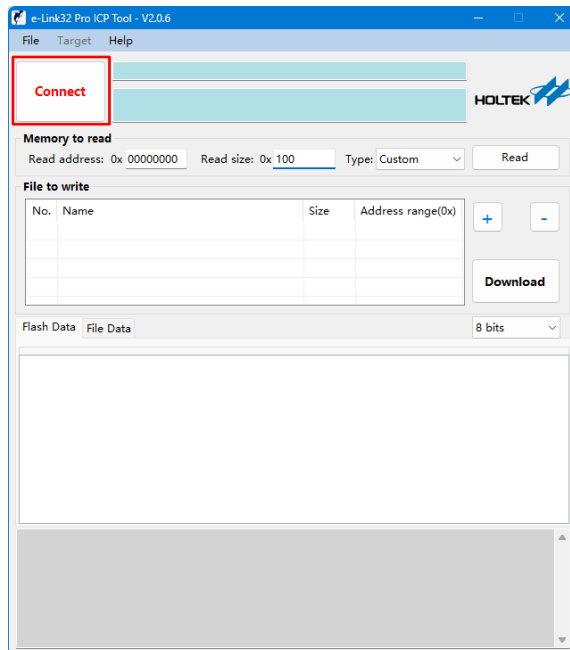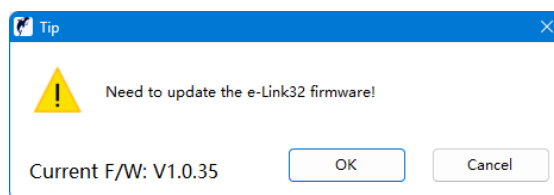

Figure 31. e-Link32 Pro ICP Tool

Figure 32. e-Link32 Pro/Lite Firmware Update Prompt Window

Reference Material

For more information, consult the Holtek official website: https://www.holtek.com.

Revision and Modification Information

Date	Author	Issue	Modification Information
2024.01.09	王宏綸	V1.00	First Version

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