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Securing the debug interface of your devices

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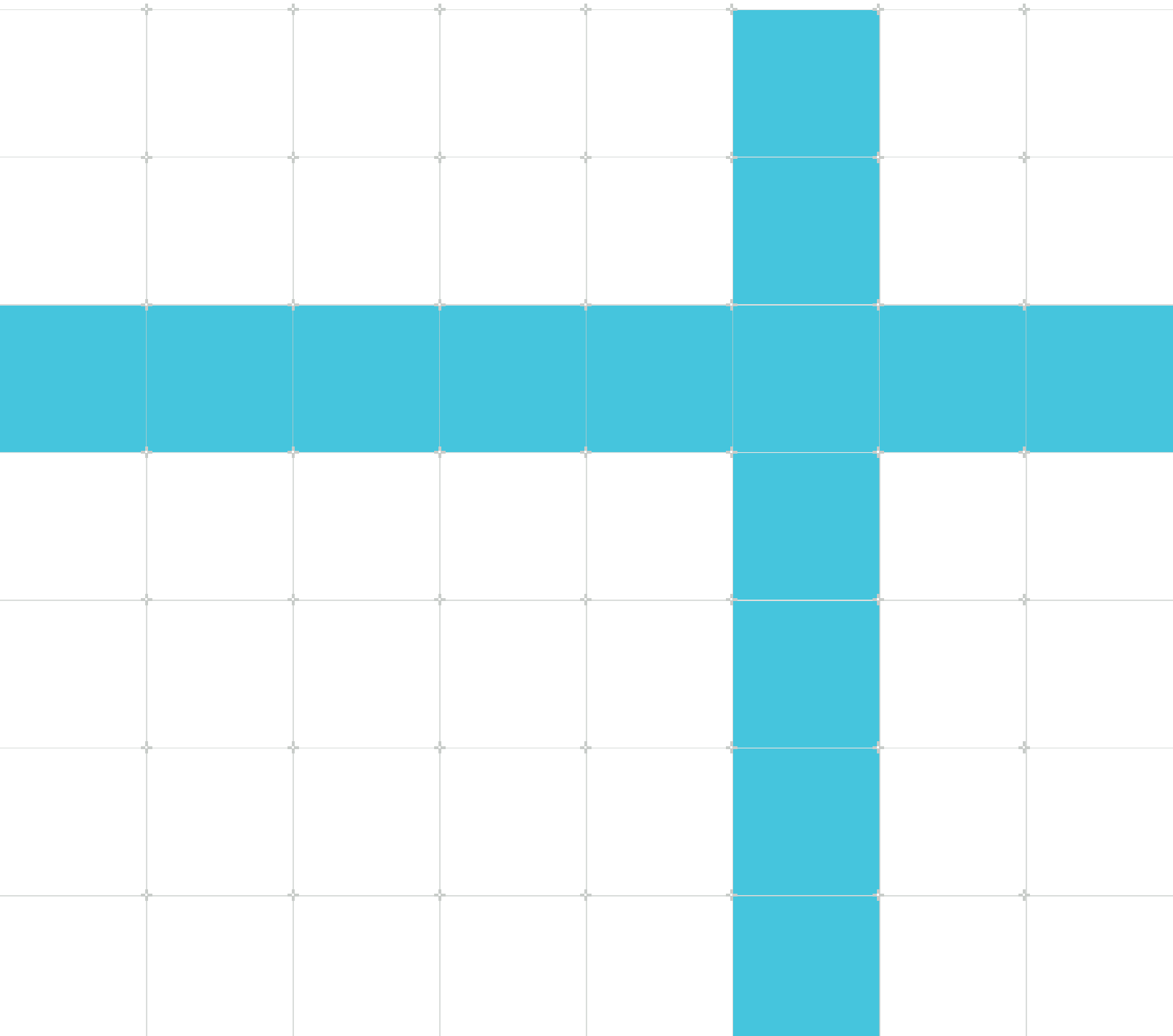

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Contents

1. Overview

To debug software on a System on Chip (SoC) system like Cortex-M-based microcontrollers, the debugger needs low-level access to the SoCs hardware. This can be a security risk under the right circumstances, as it allows a software developer, which can also be a hacker to access System registers, memories. This includes Secure and normal memories if TrustZone security technology is implemented, and sometimes, the program codes stored in the device. Without proper protection in place for the debug interface, third parties can potentially perform various attacks like:

- Copy firmware and steal valuable software assess for example, algorithms
- Access to cryptography keys or other security sensitive information stored in the system
- Modify the firmware of the device without permission
- Using a compromised device to attack other systems connected to it

To minimize security risks, many silicon providers integrate security measures in their products to disable unauthorized debug accesses. When such protection is enabled, an authorized software developer must unlock the device first before connecting the debugger to the processor system. For modern embedded systems, the authentication process involves a challenge-response mechanism, which is carried out using a communication channel.

To enable debug authentication, a processor system requires several elements:

- Communication interface: This element is required for the communication of challenge-response process. To reduce the total number of pins required for debug, Arm provide CoreSight SDC-600 Secure Debug Channel components. These components provide a communication channel using existing Joint Test Action Group (JTAG) or Serial Wire Debug (SWD) connection. In silicon products that do not have SDC-600, a dedicated communication interface could be used.
- A processing element to process the authentication: This element can be a standalone processor such as Secure Enclave in advanced SoC products, or can be the embedded processor that runs the applications itself. During debug authentication, the processor runs debug authentication firmware to process the authentication messages. Depending on the security requirement, the processor used in a Secure enclave could be specialized processors that provide anti-tampering and features. Arm SecurCore processors (SC300 and SC000) and Cortex-M35P processors are suitable for such scenarios.
- Debug authentication support on the processors – Arm processors provide debug authentication interface to allow debug and trace operations to be enabled or disabled. The processor or a Secure enclave controls these signals, if such subsystem is implemented. For Arm processors that support TrustZone Security Extension, there are separate debug authentication control signal to allow separated Secure and Non-secure debug or trace permission settings.

To make it hard for the attacker to gain debug access, modern debug authentication solutions use cryptographic based techniques. The cryptographic operations can be accelerated using crypto accelerator if available on the SoC. Instead of using cryptographic based authentication, some legacy systems use simple password-based processes to unlock debug access. This process is considered inadequate in modern IoT era.

The disadvantage of having debug authentication is that software developers must undertake extra steps when connecting their debug tools to the development board. In Arm Development Studio - when Platform Configuration Editor (PCE) runs and detects an **UNKNOWN** device, it is possible that the device is a Secure device. If the board does contain a Secure locked device, consult the board designer, manufacturer, or documentation to learn how to unlock the Secure device. You must add an unlock sequence to the platform configurations `.sdf` file. See the KBA How do I add pre-connect JTAG scans to enable target connection? to learn how to unlock the device.

To allow software developers to handle the debug authentications, typically silicon vendors provide software packages for generating or delivering the authentication tokens. The generation of authentication tokens could be handled as a cloud-based service so that only authorized software developers can use. To make the process easier for software developers, the software used by software developers could:

- Connect to the cloud-based authentication service to generate authentication tokens on demand.
- Interface with debug tools directly to send the authentication tokens to the development board directly through the debug interface.

Development tools might also offer extra features to make debug authentication easier. Please note many application processor systems might provide software-based debug (for example, GDB in a Linux environment) for application development. In such scenarios the application being debugged is sandboxed through the security measure of the execution environment and software developers do not have low-level access to hardware resources. Therefore, debug authentication might not be required.

2. Platform Security Architecture Authenticated Debug Access Control

To enable best practices for Secure debug and enable software developers to deal with debug authentication easily, there is a strong demand for standardization of debug authentication technologies. As a result, the Platform Security Architecture (PSA) initiative in Arm has been working on the standardization of Secure debug technology to enable:

- Consistence debug authentication protocols
- Consistence interface between IDEs from tool vendors and authentication software from silicon vendors
- Choices of modern cryptographic based authentication schemes
- Scalability to different systems, for example: multiple processors
- Reference firmware implementation available as open-source software

The PSA ADAC project is supported by multiple silicon vendors and debug tool vendors. When Authenticated Debug Access Control (ADAC) enabled products reach the market, software developers can utilize Secure debug features with a range of debug tools that have PSA ADAC support. This market appearance is expected to be in the second half of 2022.

3. Related information

Here are some resources related to material in this guide:

Platform Security Architecture (PSA):

- Arm PSA security main page
- PSA Authenticated Debug Access Control Specification
- Reference software

SDC-600 Secure Debug Channel:

- Legacy software example based on CryptoCell API (superseded by PSA ADAC)
  - Code on Github
  - Documentation
- Product page

The following resources are related to this guide:

Arm Development Studio:

- Detecting and unlocking the Arm Secure Debug Channel
- Help with connecting to new targets
- Help with debugging and tracing targets
- How PCE identifies the CoreSight components on the target board
- What is lock device?