

# AN1268: Authenticating Silicon Labs Devices Using Device Certificates



This application note describes how to authenticate a device as a genuine Silicon Labs product at any time during its life. The digital certificates for secure identity are stored in the device and the Silicon Labs Server.

This secure identity feature is only available on Secure Vault High devices.

## KEY POINTS

- Secure identity on Secure Vault High devices
- Device certificate options
- Remote authentication process
- Examples for certificate chain verification and remote authentication

## 1. Series 2 Device Security Features

Protecting IoT devices against security threats is central to a quality product. Silicon Labs offers several security options to help developers build secure devices, secure application software, and secure paths of communication to manage those devices. Silicon Labs' security offerings were significantly enhanced by the introduction of the Series 2 products that included a Secure Engine. The Secure Engine is a tamper-resistant component used to securely store sensitive data and keys and to execute cryptographic functions and secure services.

On Series 1 devices, the security features are implemented by the TRNG (if available) and CRYPTO peripherals.

On Series 2 devices, the security features are implemented by the Secure Engine and CRYPTOACC (if available). The Secure Engine may be hardware-based, or virtual (software-based). Throughout this document, the following abbreviations are used:

- HSE - Hardware Secure Engine
- VSE - Virtual Secure Engine
- SE - Secure Engine (either HSE or VSE)

Additional security features are provided by Secure Vault. Three levels of Secure Vault feature support are available, depending on the part and SE implementation, as reflected in the following table:

Level (1)	SE Support	Part (2)
Secure Vault High (SVH)	HSE only (HSE-SVH)	EFR32xG2yB (3)
Secure Vault Mid (SVM)	HSE (HSE-SVM)	EFR32xG2yA (3)
"	VSE (VSE-SVM)	EFR32xG2y, EFM32PG2y (4)
Secure Vault Base (SVB)	N/A	MCU Series 1 and Wireless SoC Series 1

**Note:**

1. The features of different Secure Vault levels can be found in <https://www.silabs.com/security>.
2. The x is a letter (B, F, M, or Z).
3. At the time of this writing, the y is a digit (1 or 3).
4. At the time of this writing, the y is a digit (2).

Secure Vault Mid consists of two core security functions:

- Secure Boot: Process where the initial boot phase is executed from an immutable memory (such as ROM) and where code is authenticated before being authorized for execution.
- Secure Debug access control: The ability to lock access to the debug ports for operational security, and to securely unlock them when access is required by an authorized entity.

Secure Vault High offers additional security options:

- Secure Key Storage: Protects cryptographic keys by "wrapping" or encrypting the keys using a root key known only to the HSE-SVH.
- Anti-Tamper protection: A configurable module to protect the device against tamper attacks.
- Device authentication: Functionality that uses a secure device identity certificate along with digital signatures to verify the source or target of device communications.

A Secure Engine Manager and other tools allow users to configure and control their devices both in-house during testing and manufacturing, and after the device is in the field.

## 1.1 User Assistance

In support of these products Silicon Labs offers whitepapers, webinars, and documentation. The following table summarizes the key security documents:

Document	Summary	Applicability
AN1190: Series 2 Secure Debug	How to lock and unlock Series 2 debug access, including background information about the SE	Secure Vault Mid and High
AN1218: Series 2 Secure Boot with RTSL	Describes the secure boot process on Series 2 devices using SE	Secure Vault Mid and High
AN1247: Anti-Tamper Protection Configuration and Use	How to program, provision, and configure the anti-tamper module	Secure Vault High
AN1268: Authenticating Silicon Labs Devices using Device Certificates (this document)	How to authenticate a device using secure device certificates and signatures, at any time during the life of the product	Secure Vault High
AN1271: Secure Key Storage	How to securely “wrap” keys so they can be stored in non-volatile storage.	Secure Vault High
AN1222: Production Programming of Series 2 Devices	How to program, provision, and configure security information using SE during device production	Secure Vault Mid and High

## 1.2 Key Reference

Public/Private keypairs along with other keys are used throughout Silicon Labs security implementations. Because terminology can sometimes be confusing, the following table lists the key names, their applicability, and the documentation where they are used.

Key Name	Customer Programmed	Purpose	Used in
Public Sign key (Sign Key Public)	Yes	Secure Boot binary authentication and/or OTA upgrade payload authentication	AN1218 (primary), AN1222
Public Command key (Command Key Public)	Yes	Secure Debug Unlock or Disable Tamper command authentication	AN1190 (primary), AN1222, AN1247
OTA Decryption key (GBL Decryption key) aka AES-128 Key	Yes	Decrypting GBL payloads used for firmware upgrades	AN1222 (primary), UG266
Attestation key aka Private Device Key	No	Device authentication for secure identity	AN1268

## 2. Device Compatibility

This application note supports Series 2 device families (HSE-SVH), and some functionality is different depending on the device.

Wireless SoC Series 2 families (HSE-SVH) consist of:

- EFR32BG21B/EFR32MG21B
- EFR32FG23B/EFR32ZG23B

### 3. Introduction

One of the biggest challenges for connected devices is post-deployment authentication. Silicon Labs' factory trust provisioning service with optional secure programming provides a secure device identity certificate, analogous to a birth certificate, for each individual silicon die during integrated circuit (IC) manufacturing. This enables post-deployment security, authenticity, and attestation-based health checks. The device certificate guarantees the authenticity of the device for its lifetime. When the certificate is checked, a digital signature confirms that the certificate received has not been tampered with.

Certificates can now be used to authenticate Internet of Things (IoT) devices as well as Internet servers, now that Silicon Labs' HSE-SVH devices have both cryptographic acceleration in hardware and tamper-resistant storage to handle digital certificate operations.

The digital signature and certificates are major cryptographic tools to verify the device is authentic. These tools are described in the following sections.

#### 3.1 Digital Signature

The digital signature is used to protect integrity and authenticity of an electronic message.

##### Digital Signature Example:

Alice wants to give data to Bob, and Bob wants to make sure that the data came from Alice and has not been tampered with. Alice has a private/public key pair, and has previously given Bob her public key.

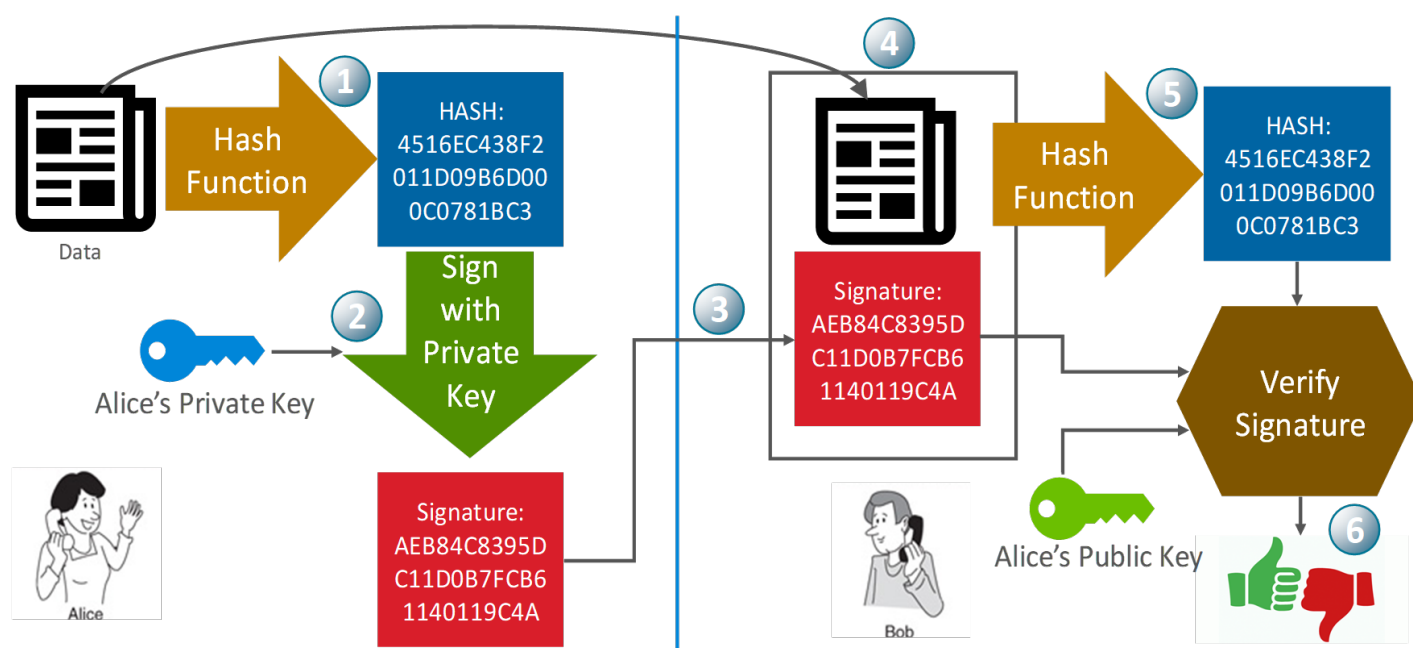


Figure 3.1. Digital Signature

1. Alice generates the hash (for example SHA256) of the data.
2. Alice's private key is used to sign the hash to create a signature. The hash is signed instead of the data itself because the signing operation is slow. Therefore it is more efficient to sign the hash instead of the arbitrarily large data.
3. The signature is attached to the end of the data.
4. The data and signature are given to Bob.
5. Bob independently generates the hash of the data.
6. The signature is verified with the hash and Alice's public key, which results in a true or false outcome indicating if the data is valid.

**Note:** This scheme requires distribution of Alice's public key.

### 3.2 Digital Certificates and Chain of Trust

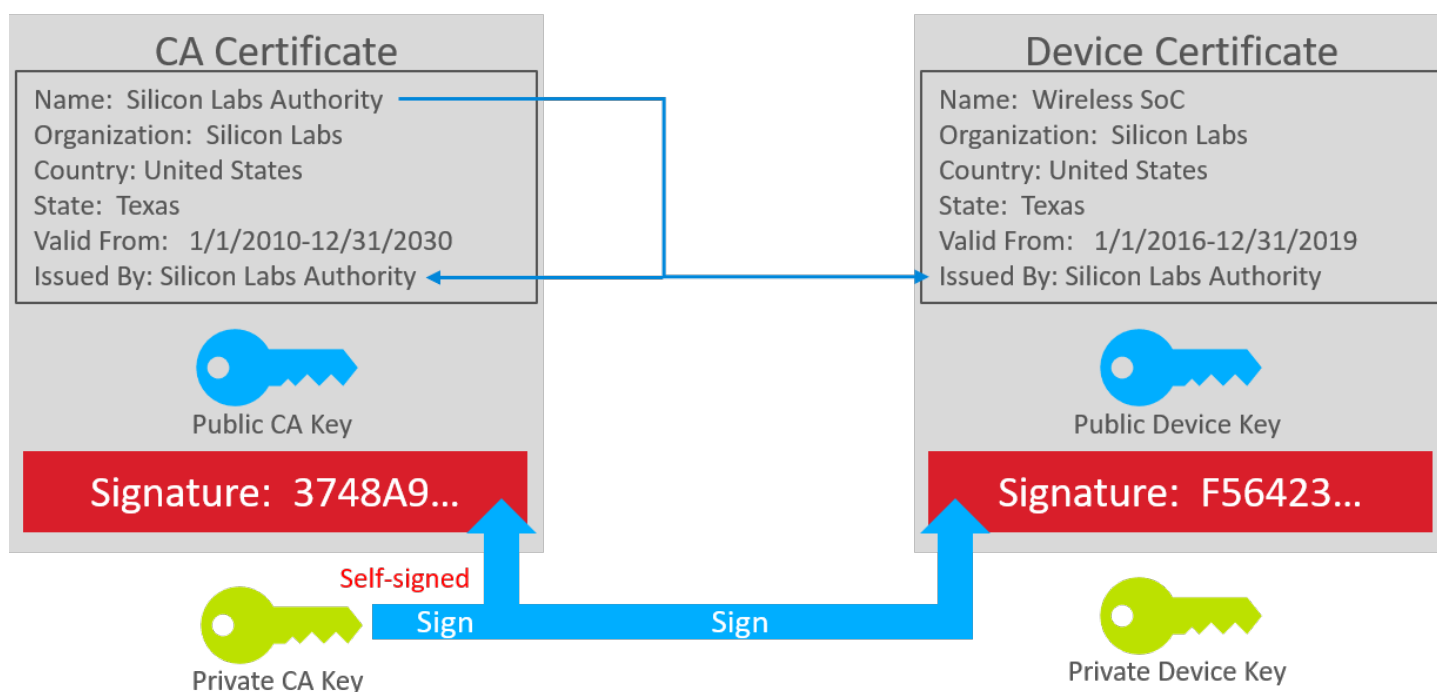
In [Figure 3.1 Digital Signature on page 5](#), Bob already had access to Alice's public key, which he trusted. However, it is not always feasible to pre-share a public key with everyone for secure identity verification, and no mechanism exists to revoke or inactivate the public key in case it gets stolen.

A digital certificate is simply a small, verifiable data file that contains identity credentials and a public key. That data is then signed either with the corresponding private key, or a different private key. The digital certificate can be used to prove the ownership of a public key.

- If it is signed using the corresponding private key, it is called a self-signed certificate.
- If it is signed by another private key, the owner of that private key is acting as a Certificate Authority (CA).
- A Certificate Authority (CA) is a trusted third party by both the owner and party relying on the certificate.

Concatenation of digital certificates builds a chain of trust.

- At the root of the chain is a self-signed certificate called a root certificate or a CA certificate.
- The root or CA certificate can be used to sign another certificate.



**Figure 3.2. Digital Certificates and Chain of Trust**

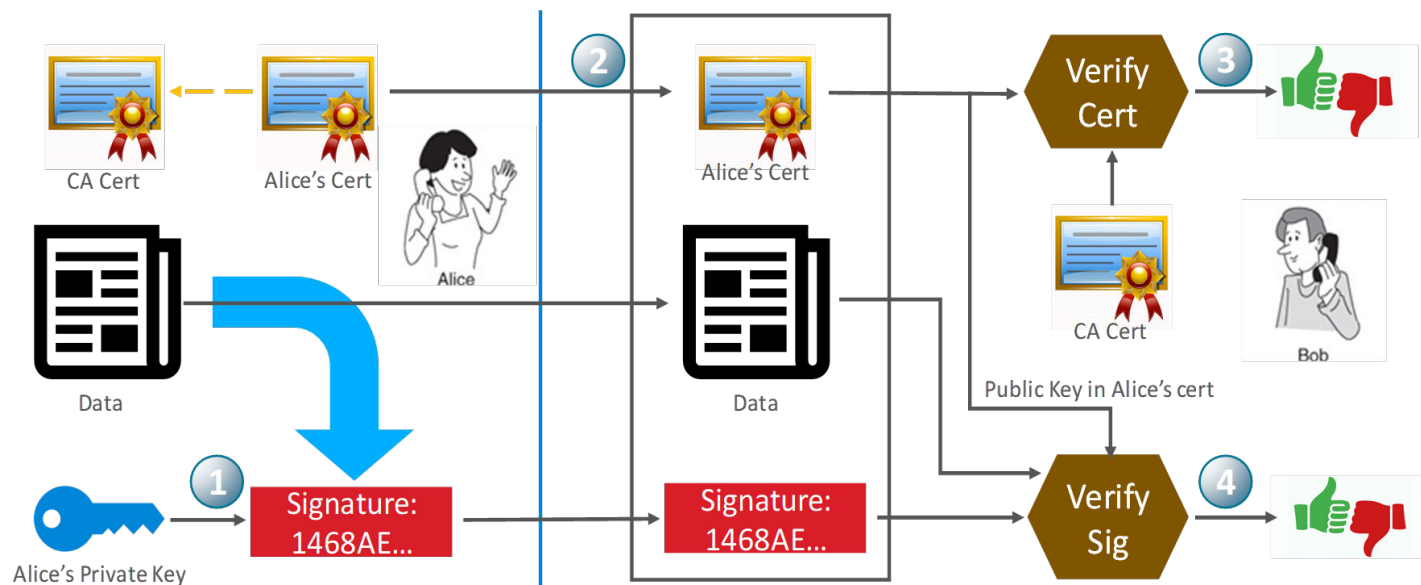
**Note:** The private key is never included as part of the certificate – it must be stored separately and kept private. The security of the scheme relies on protecting the private keys.

### 3.3 Digital Certificates Verification

This section illustrates the process shown in [Figure 3.1 Digital Signature on page 5](#), but using digital certificates.

#### Digital Certificates Verification Example:

Alice wants to give data to Bob, signed with her private key. Alice has a digital certificate signed by a trusted third party (CA) in addition to her private key. Bob has a certificate from the trusted CA but nothing else is previously shared.



**Figure 3.3. Digital Certificate Verification**

1. Alice uses her private key to sign the data.
2. Alice gives the data, signature, and her certificate to Bob.
3. Bob first verifies that Alice's certificate is valid, to prove Alice is the owner of the certificate's public key. This is done by verifying that Alice's certificate contains a valid signature created by the CA.
4. Bob then verifies the signature of the data using the public key in Alice's certificate.

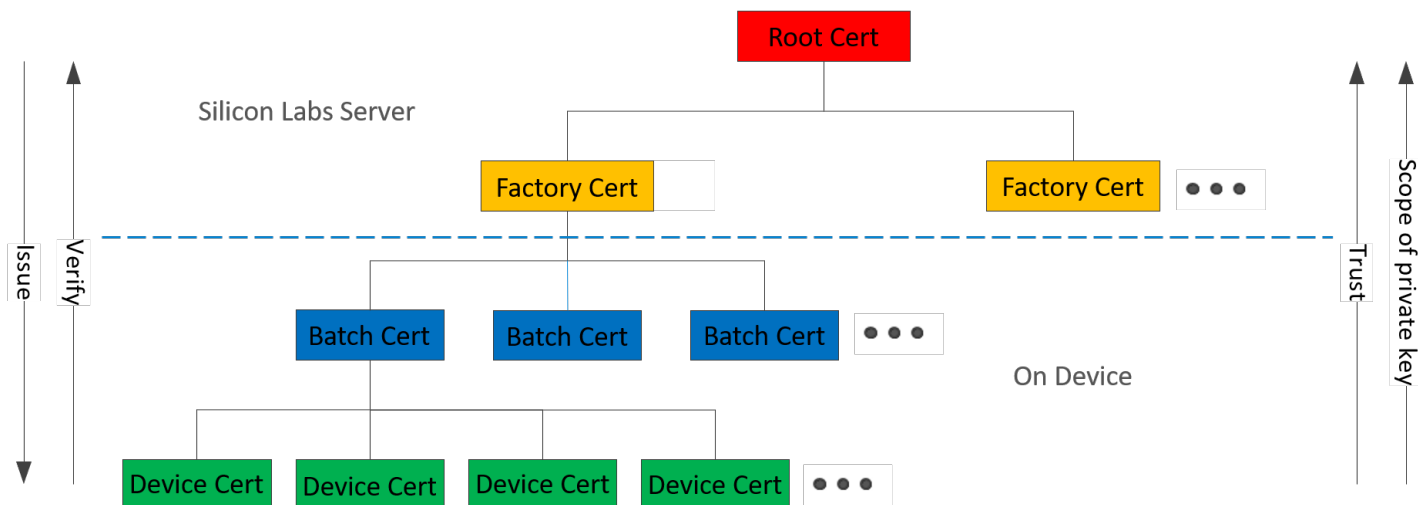
**Note:** The hash process in [Figure 3.1 Digital Signature on page 5](#) is skipped in this example.

## 4. Secure Identification on HSE-SVH Devices

The goal of secure identification is to prove the ownership of a device's unique public key to an external service. It enables the external service to identify the device as legitimate and to authenticate device-generated data or messages.

### 4.1 Chain of Trust

The chain of trust on HSE-SVH devices is illustrated in the following figure.



**Figure 4.1. Chain of Trust**

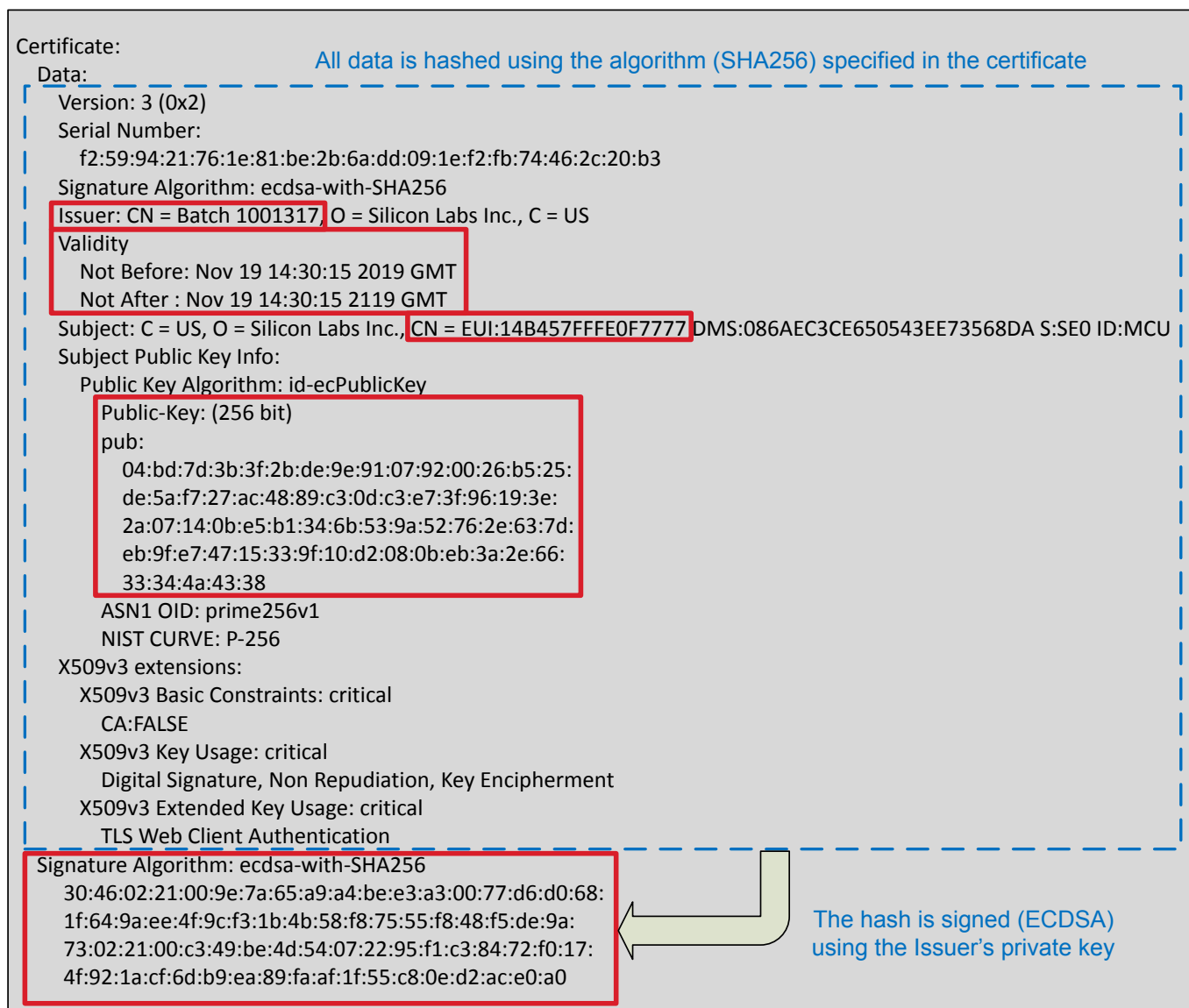
- Silicon Labs is a Certificate Authority (CA).
- The root certificate and factory certificate are stored in the Silicon Labs Server.
- The factory certificate is static per factory.
- The batch certificate and device certificate are stored on the device.
- The batch certificate is rolled per production batch.
- The [device certificate](#) is a unique cryptographic identity.
- All certificates are X.509 standard format.
  - TLS-compliant: Standard endpoint authentication methods are used in internet communications
  - Signature algorithm: ECDSA-prime256v1 with SHA256
- Each certificate in the chain is signed by the certificate above it ([Figure 4.3 Signing for Certificates on page 10](#)).

**Note:** A certificate can be revoked if needed, for instance if security issues arise. The certificate revocation lists are stored in the Silicon Labs Server.



## 4.2 Device Certificate

The device certificate example is described in the following figure.



**Figure 4.2. Device Certificate Example**

- The device certificate is in X.509 DER format (~0.5 kB).
- The device certificate is stored in HSE one-time programmable memory (OTP). It cannot be modified once programmed.
- The batch number (Issuer: CN = Batch field) identifies the factory and batch in which the device was produced.
- The validity period is 100 years from device manufacture date.
- The device 64-bit hard-coded unique ID (EUI) is encoded in the Subject: CN field, which blinds this certificate to the device.
- The device-specific public key is embedded in the device certificate and the corresponding private key is securely stored in the Secure Key Storage on the chip.
- The Issuer's private key is used to sign the hash of the certificate data to create a device certificate signature.

### 4.3 Signing and Verification

Signing and verification for certificates on HSE-SVH devices are described in the following figures.

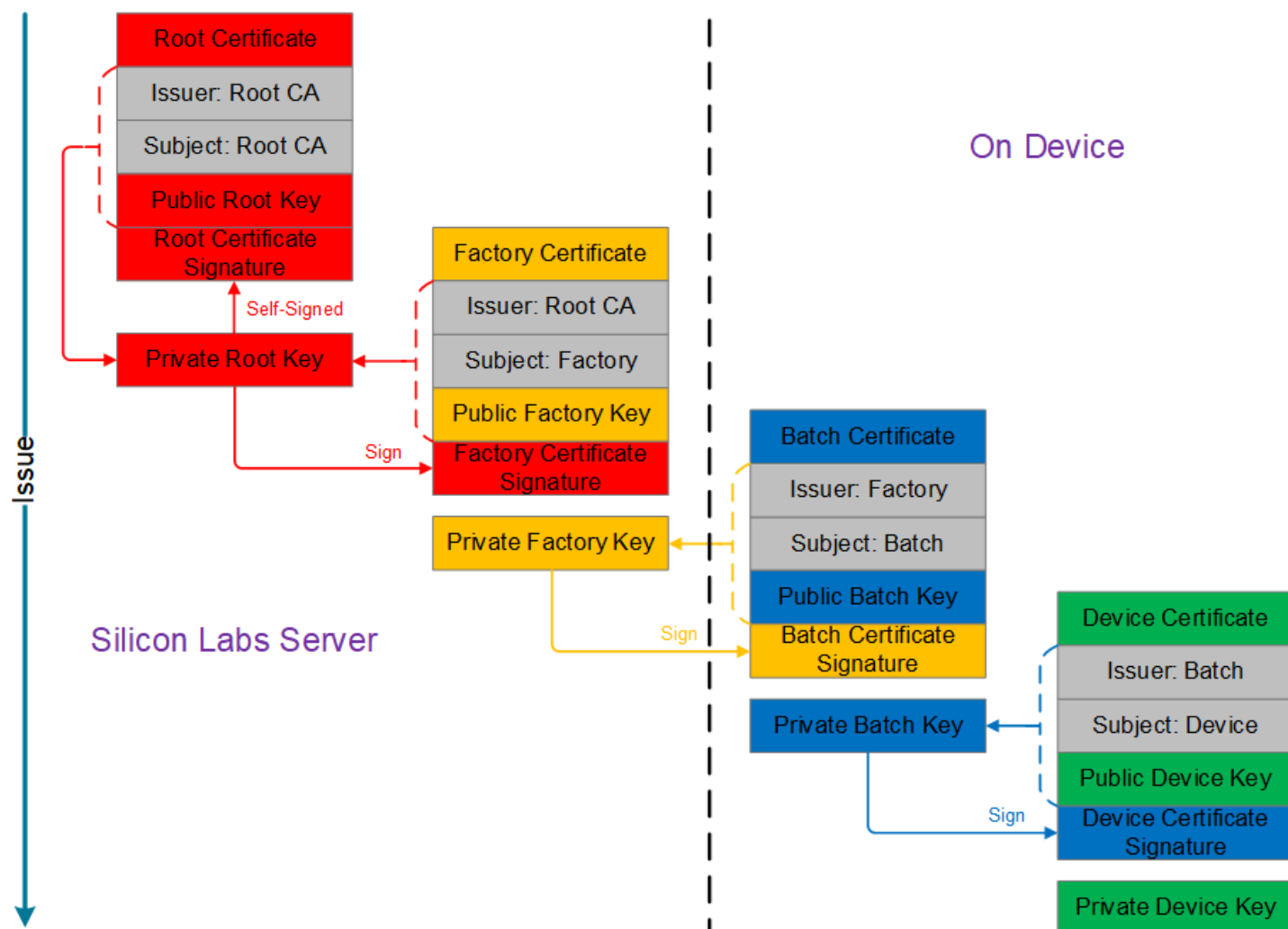


Figure 4.3. Signing for Certificates

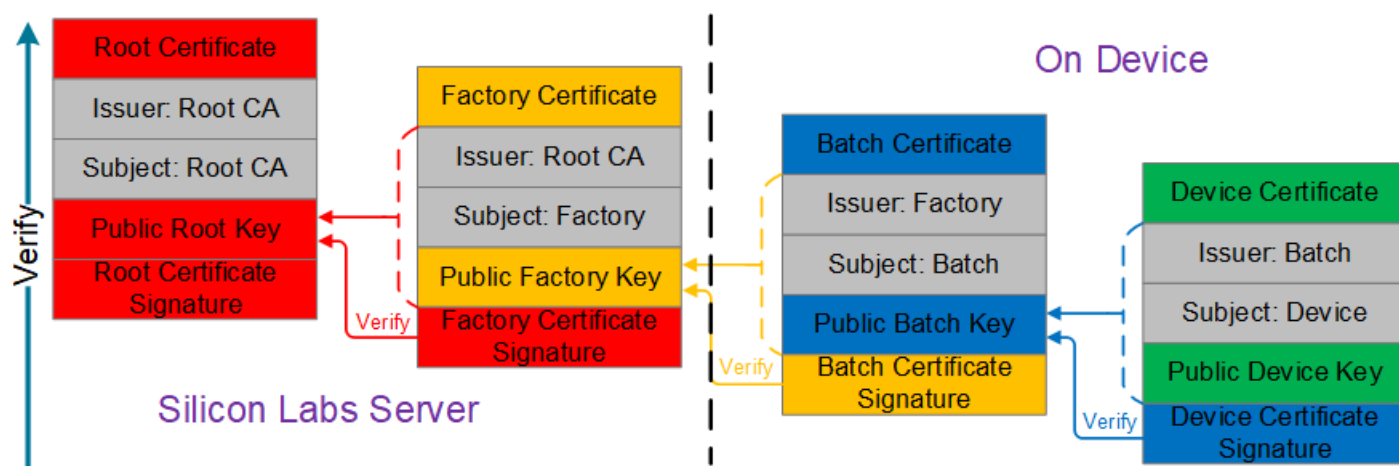


Figure 4.4. Verification for Certificates

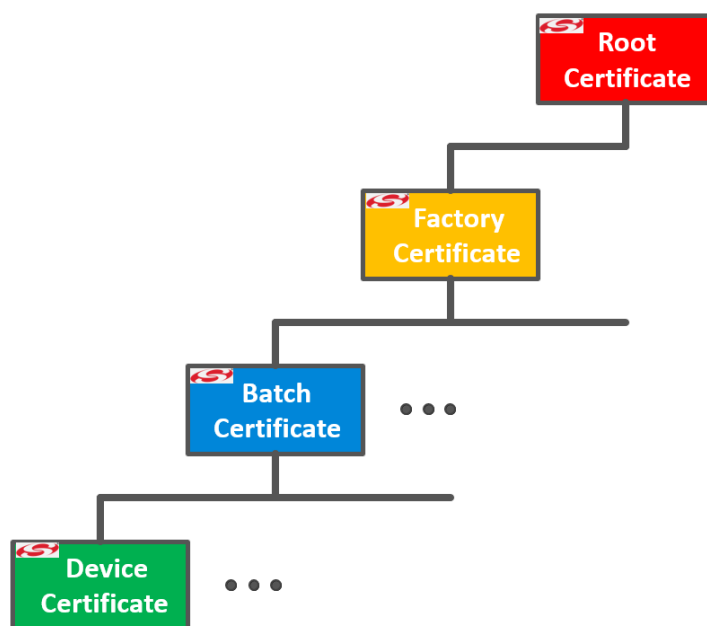
## 5. Device Certificate Options

The HSE-SVH devices are each programmed with a device certificate during IC production. The device certificate is signed with a Public Device Key, using a Private Batch Key that can be validated against a Silicon Labs certificate chain (Figure 4.4 Verification for Certificates on page 10 and 8.2 Certificate Chain Verification). The device private key never leaves the Secure Key Storage on the chip. Customers can create their own device certificates during their production.

Three device certificate options (standard, modified, and external) are provided to meet different requirements. The modified and external options are subject to an additional cost. For these options, contact your local sales representative (<http://www.silabs.com/buysample/pages/contact-sales.aspx?view=map>).

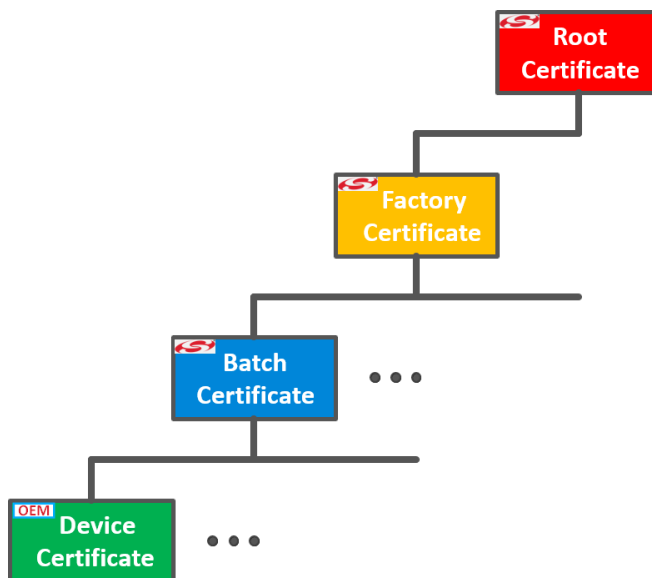
### Standard Device Certificate:

- Comes standard with HSE-SVH devices.
- Cryptographically proves the device is an authentic Silicon Labs device.
- Does not protect against overproduction or counterfeit products that are built with authentic Silicon Labs devices.
- Signed to a Silicon Labs Certificate Authority (CA).
- The device can prove that it possesses the private key associated with the public key in its certificate by signing the response to a given challenge (Figure 6.1 Remote Authentication Process on page 13 and 8.3 Certificate Chain Verification and Remote Authentication).



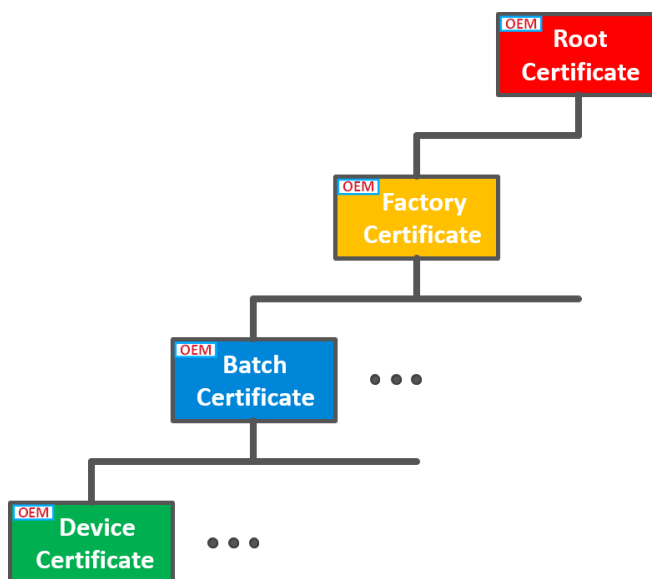
### Modified Device Certificate:

- Available as a customization service on HSE-SVH devices (OEM custom part number).
- Cryptographically proves the device is an authentic Silicon Labs device that was produced for a specific OEM.
- Protects against overproduction by Contract Manufacturer (CM).
- Device Certificate X.509 fields can be specified, with restrictions.
- Signed to a Silicon Labs Certificate Authority (CA).



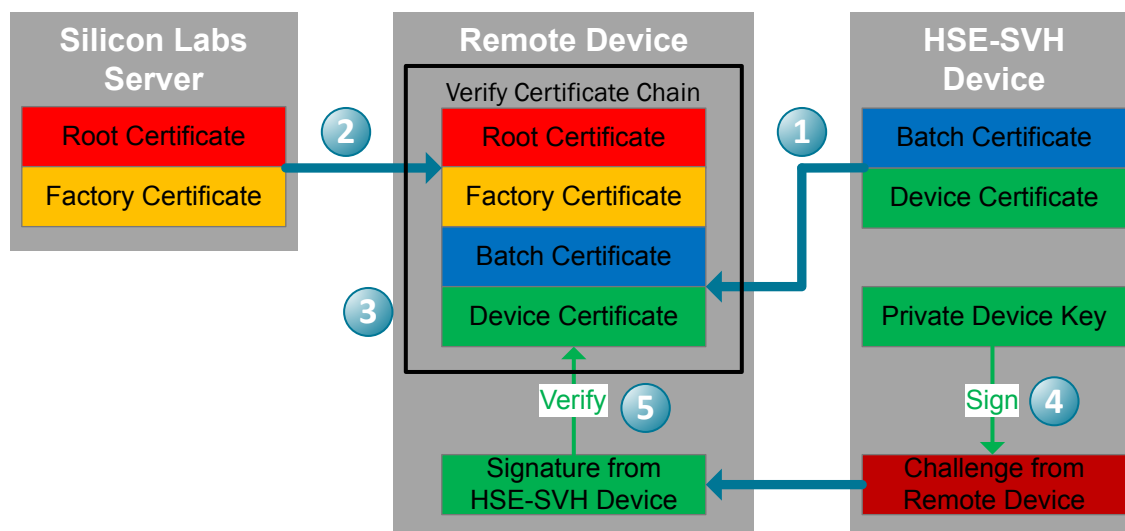
### External Device Certificate:

- Available as a customization service on HSE-SVH devices (OEM custom part number).
- Cryptographically proves the device is an authentic Silicon Labs device that was produced for a specific OEM.
- Protects against overproduction by Contract Manufacturer (CM).
- Factory Certificate is custom for each OEM.
- Device Certificate and Factory Certificate X.509 fields can be specified, with restrictions.
- Signed to a OEM Certificate Authority (CA).
- Root Certificate Authority is OEM-specified and is optional.
- Electronic delivery of all batch and device certificates signed under this OEM factory certificate is supported.



## 6. Remote Authentication Process

Remote authentication is used to manage attestation by requesting that the device sign a challenge based on its secure identity.



**Figure 6.1. Remote Authentication Process**

1. The remote device requests the device certificate and batch certificate from the HSE-SVH device.
2. The remote device looks up the factory certificate and root certificate from the Silicon Labs Server.
3. The remote device validates each certificate in the chain using the public key of each Issuer ([Figure 4.4 Verification for Certificates on page 10](#)).
4. The remote device then sends an attestation challenge (random number) to the HSE-SVH device. The HSE-SVH device uses the Private Device Key in the Secure Key Storage on the chip to sign the challenge and sends the signature to the remote device.
5. The remote device validates the signature using the Public Device Key in the device certificate.

## 7. Secure Engine Manager

The Secure Engine Manager provides thread-safe APIs for the SE's mailbox interface. The following table lists the SE Manager APIs related to secure identity. The SE Manager API document can be found at <https://docs.silabs.com/gecko-platform/latest/service/api/group-sl-se-manager>.

For the SE's mailbox interface, see section "*Secure Engine Subsystem*" in [AN1190: Series 2 Secure Debug](#).

**Table 7.1. SE Manager API for Security Identity**

SE Manager API	Usage
sl_se_read_pubkey	Read stored Public Device Key in the HSE-SVH device.
sl_se_read_cert	Read stored certificates (DER format) in the HSE-SVH device.
sl_se_read_cert_size	Read the size of stored certificates in the HSE-SVH device.

## 8. Examples

### 8.1 Overview

The secure device authentication examples are described in the following table.

**Table 8.1. Secure Device Authentication Examples**

Example	Device (Radio Board)	HSE Firmware	Tool
Certificate chain verification	EFR32MG21B010F1024IM32 (BRD4181C)	Version 1.2.9	Simplicity Commander and OpenSSL
"	EFR32MG21B010F1024IM32 (BRD4181C)	Version 1.2.9	Simplicity Commander
"	EFR32MG21B010F1024IM32 (BRD4181C)	Version 1.2.9	Simplicity Studio 5
Certificate chain verification & Remote authentication	EFR32MG21B010F1024IM32 (BRD4181C)	Version 1.2.9	SE Manager and Mbed TLS

**Note:** Unless specified in the example, these examples can apply to other [HSE-SVH devices](#).

Users can download the device root certificate (`Device-Root-CA-chain.pem`) and factory certificate (`Factory-chain.pem`) from <https://www.silabs.com/certificate-authority>.



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# Certificate Practice Statement

## Active Public Certificates:

- [Device Root Certificate](#)
- [Factory Certificate](#)
- [Zentri DMS Certificate](#)

## CRL Links:

- [Device Root Certificate Revocation List](#)
- [Factory Certificate Revocation List](#)
- [Zentri DMS Certificate Revocation List](#)

For more information contact: [certificateauthority@silabs.com](mailto:certificateauthority@silabs.com)

### 8.1.1 Using Simplicity Commander

1. This application note uses Simplicity Commander v1.11.2. The console output may be different on the other version of Simplicity Commander. The latest version of Simplicity Commander can be downloaded from <https://www.silabs.com/developers/mcu-programming-options>.

```
commander --version
```

```
Simplicity Commander 1v11p2b998
```

```
JLink DLL version: 6.94d
Qt 5.12.1 Copyright (C) 2017 The Qt Company Ltd.
EMDLL Version: 0v17p18b581
mbed TLS version: 2.6.1
```

```
DONE
```

2. The Simplicity Commander's Command Line Interface (CLI) is invoked by `commander.exe` in the Simplicity Commander folder. The location for Simplicity Studio 5 in Windows is `C:\SiliconLabs\SimplicityStudio\v5\developer\adapter_packs\commander`. For ease of use, it is highly recommended to add the path of `commander.exe` to the system PATH in Windows.
3. If more than one Wireless Starter Kit (WSTK) is connected via USB, the target WSTK must be specified using the `--serialno <J-Link serial number>` option.
4. If the WSTK is in debug mode OUT, the target device must be specified using the `--device <device name>` option.

For more information about Simplicity Commander, see [UG162: Simplicity Commander Reference Guide](#).

### 8.1.2 Using an External Tool

The [certificate chain verification](#) example uses the **OpenSSL** to validate the certificate chain. The Windows version of OpenSSL can be downloaded from <https://slproweb.com/products/Win32OpenSSL.html>. This application note uses OpenSSL Version 1.1.1h (Win64).

```
openssl version
```

```
OpenSSL 1.1.1h 22 Sep 2020
```

The OpenSSL's Command Line Interface (CLI) is invoked by `openssl.exe` in the OpenSSL folder. The location in Windows (Win64) is `C:\Program Files\OpenSSL-Win64\bin`. For ease of use, it is highly recommended to add the path of `openssl.exe` to the system PATH in Windows.

### 8.1.3 Using a Platform Example

Simplicity Studio 5 includes the [SE Manager platform example](#) for secure identity. This application note uses platform example of GSDK v3.2.2. The console output may be different on the other version of GSDK.

Refer to the corresponding `readme.html` file for details about each SE Manager platform example. This file also includes the procedures to create the project and run the example.

## 8.2 Certificate Chain Verification

Certificate chain verification is the process of making sure a given certificate chain is well-formed, valid, properly signed, and trustworthy. The certificate signature is verified using the public key in the issuer certificate ([Figure 4.4 Verification for Certificates on page 10](#)).



## 8.2.1 Simplicity Commander and OpenSSL

1. Run the `security readcert batch` command to save the batch certificate in PEM format.

```
commander security readcert batch -o batch.pem --serialno 440030580
```

```
Writing certificate to batch.pem...
DONE
```

2. Run the `security readcert mcu` command to save the device certificate in PEM format.

```
commander security readcert mcu -o device.pem --serialno 440030580
```

```
Writing certificate to device.pem...
DONE
```

3. Run the DOS `copy` command to merge the root certificate (`Device-Root-CA-chain.pem`) and factory certificate (`Factory-chain.pem`) into a certificate chain file (`chain.pem`).

```
copy Device-Root-CA-chain.pem+Factory-chain.pem chain.pem
```

```
Device-Root-CA-chain.pem
Factory-chain.pem
      1 file(s) copied.
```

4. Use OpenSSL to display the certificate information (e.g. `device.pem`).

```
openssl x509 -in device.pem -text -noout
```

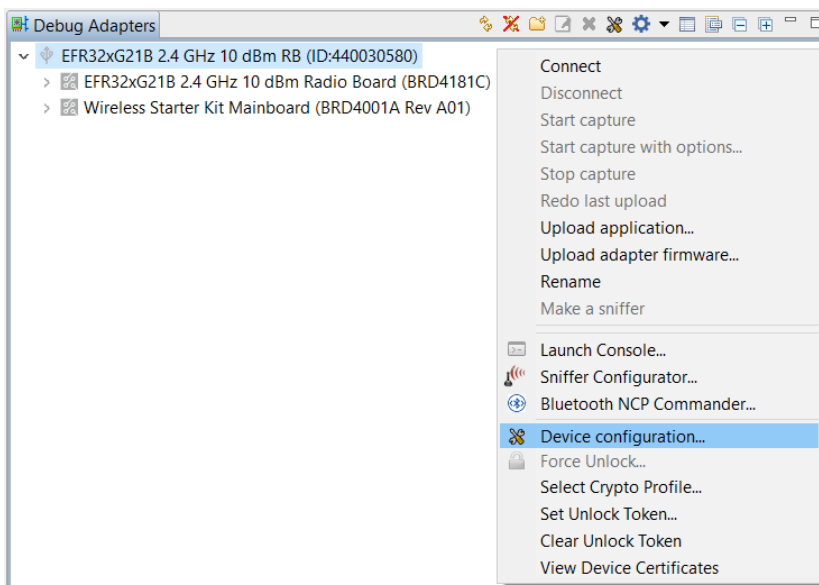
```
Certificate:
  Data:
    Version: 3 (0x2)
    Serial Number:
      66:f8:5a:e6:b4:ef:6e:49:d3:36:95:63:c9:c3:99:13:e4:71:93:f6
    Signature Algorithm: ecdsa-with-SHA256
    Issuer: CN = Batch 1001317, O = Silicon Labs Inc., C = US
    Validity
      Not Before: Nov 19 15:10:33 2019 GMT
      Not After : Nov 19 15:10:33 2119 GMT
    Subject: C = US, O = Silicon Labs Inc., CN = EUI:14B457FFFE0F77CE DMS:086AEC3C645836BFB04D312F S:SE0 ID:MCU
    Subject Public Key Info:
      Public Key Algorithm: id-ecPublicKey
      Public-Key: (256 bit)
      pub:
        04:5c:4b:c9:b0:b3:ff:fa:99:81:c5:99:be:ff:ae:
        77:74:1a:f4:30:f1:1e:0e:2d:df:96:4b:ff:d2:46:
        fa:fa:e7:23:4b:79:cb:0a:c7:71:13:fa:7c:39:5f:
        e2:18:9e:4e:06:43:88:a7:9c:65:53:f3:a3:a1:06:
        81:e6:06:f2:11
      ASN1 OID: prime256v1
      NIST CURVE: P-256
    X509v3 extensions:
      X509v3 Basic Constraints: critical
        CA:FALSE
      X509v3 Key Usage: critical
        Digital Signature, Non Repudiation, Key Encipherment
      X509v3 Extended Key Usage: critical
        TLS Web Client Authentication
    Signature Algorithm: ecdsa-with-SHA256
      30:44:02:20:57:12:a4:84:d8:37:b8:c0:44:8f:16:ac:c1:a3:
      be:a9:f1:16:38:9f:b9:a2:57:e6:12:49:bf:96:a9:a9:d2:b8:
      02:20:5f:ae:22:f5:00:05:49:b1:da:ee:4a:84:48:70:27:97:
      1c:40:2d:85:5f:f2:12:b3:8b:4a:d7:9a:ee:60:81:7c
```



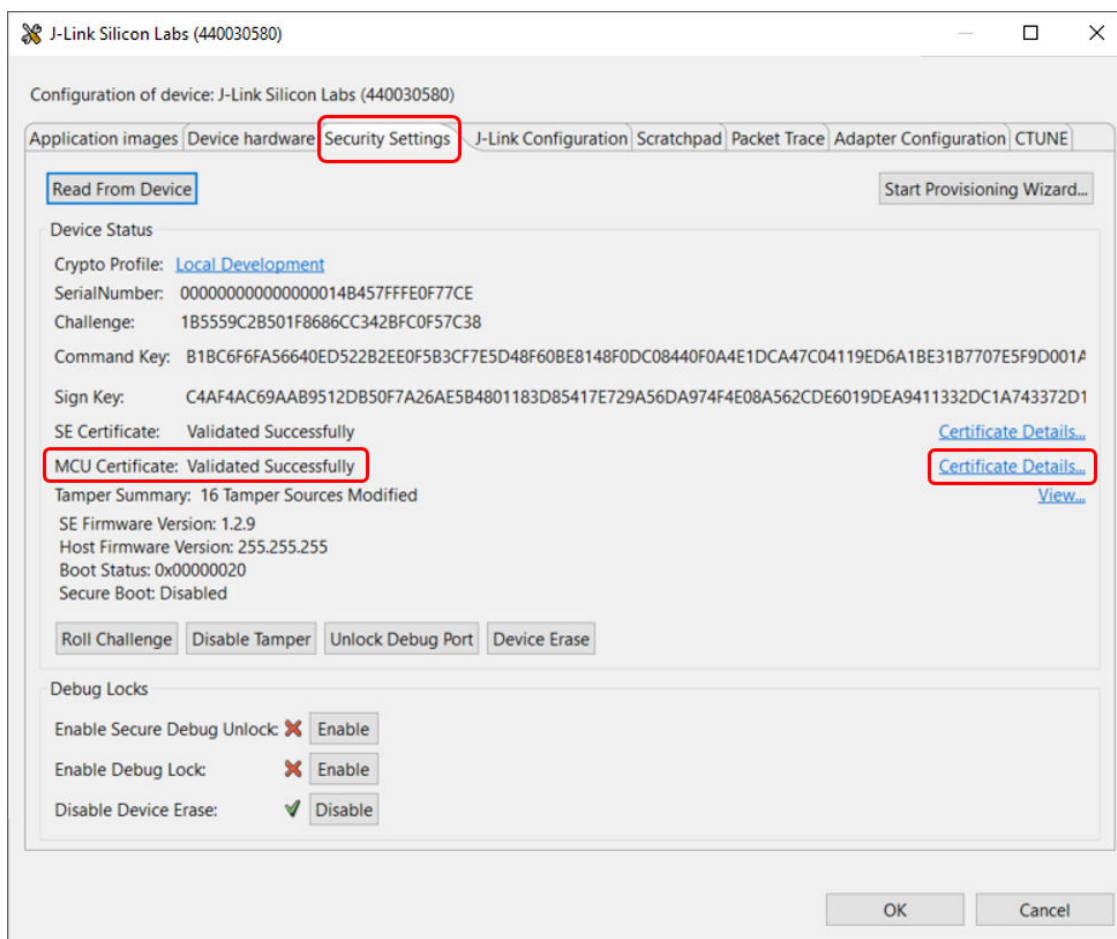
### 8.2.3 Simplicity Studio

This application note uses Simplicity Studio v5.2.1.1. The procedures and pictures may be different on the other version of Simplicity Studio 5.

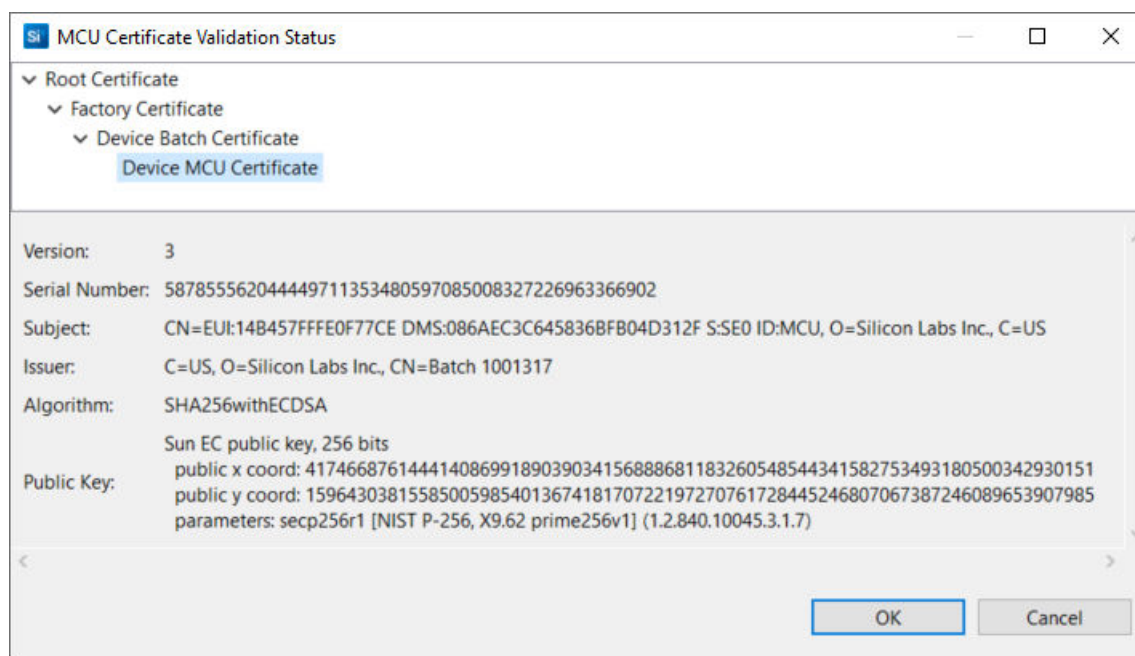
1. Right-click the selected debug adapter **RB (ID:J-Link serial number)** to display the context menu.



2. Click **Device configuration...** to open the **Configuration of device: J-Link Silicon Labs (serial number)** dialog box. Click the **Security Settings** tab to get the selected device configuration.
3. The **MCU Certificate:** will display **Validated Successfully** if it passed the certificate chain verification process.



4. Click **Certificate Details...** to browse the details of different certificates (e.g. Device MCU Certificate in the figure below).



### 8.3 Certificate Chain Verification and Remote Authentication

The SE Manager Secure Identity platform example uses APIs in SE Manager and Mbed TLS to emulate the processes in [Figure 6.1 Remote Authentication Process on page 13](#).

Click the [View Project Documentation](#) link to open the `readme.html` file.

#### Platform - SE Manager Secure Identity

This example project demonstrates the secure identity of Secure Vault device.

[View Project Documentation](#)

file:/C:/SiliconLabs/SimplicityStudio/v5/developer/sdks/gecko\_sdk\_suite/v3.2/app/common/example/se\_manager\_secure\_identity/readme.html

CREATE

The HSE-SVH device simulates the operations in the remote device to eliminate the communications between different parties in this example. The factory certificate and root certificate are hard-coded in the `app_mbedtls_x509.c` file.

The Private Device Key in the Secure Key Storage on the chip is used to sign the challenge from the remote device. Therefore this example can only run on a chip with the [Standard Device Certificate](#).

#### Step 1 in the Remote Authentication Process:

```
SE Manager Secure Identity Example - Core running at 38000 kHz.
. SE manager initialization... SL_STATUS_OK (cycles: 6 time: 0 us)

. Secure Vault High device:
+ Read size of on-chip certificates... SL_STATUS_OK (cycles: 5296 time: 139 us)
+ Read on-chip device certificate... SL_STATUS_OK (cycles: 5138 time: 135 us)
+ Parse the device certificate (DER format)... SL_STATUS_OK (cycles: 167043 time: 4395 us)
+ Get the public device key in device certificate... OK
+ Read on-chip batch certificate... SL_STATUS_OK (cycles: 5080 time: 133 us)
+ Parse the batch certificate (DER format)... SL_STATUS_OK (cycles: 173151 time: 4556 us)
```

#### Steps 2 and 3 in the Remote Authentication Process (certificate chain printout is disabled):

```
. Remote device:
+ Parse the factory certificate (PEM format)... SL_STATUS_OK (cycles: 5373122 time: 141 ms)
+ Parse the root certificate (PEM format)... SL_STATUS_OK (cycles: 5448802 time: 143 ms)
+ Verify the certificate chain with root certificate... SL_STATUS_OK (cycles: 958730 time: 25229 us)
```

**Steps 2 and 3 in the Remote Authentication Process (certificate chain printout is enabled):**

```
. Remote device:
+ Parse the factory certificate (PEM format)... SL_STATUS_OK (cycles: 5373935 time: 141 ms)
+ Parse the root certificate (PEM format)... SL_STATUS_OK (cycles: 5449622 time: 143 ms)
+ Verify requested for (Depth 3) ... OK
  cert. version      : 3
  serial number      : 12:E6:A2:A5:9C:AA:27:F9
  issuer name        : CN=Device Root CA, O=Silicon Labs Inc., C=US
  subject name       : CN=Device Root CA, O=Silicon Labs Inc., C=US
  issued on          : 2018-10-10 17:32:00
  expires on         : 2118-09-16 17:32:00
  signed using       : ECDSA with SHA256
  EC key size        : 256 bits
  basic constraints  : CA=true, max_pathlen=2
  key usage          : Digital Signature, Key Cert Sign, CRL Sign
+ Verify requested for (Depth 2) ... OK
  cert. version      : 3
  serial number      : 24:DC:7B:40:0C:32:9C:0A
  issuer name        : CN=Device Root CA, O=Silicon Labs Inc., C=US
  subject name       : CN=Factory, O=Silicon Labs Inc., C=US
  issued on          : 2018-10-10 17:33:00
  expires on         : 2118-09-16 17:32:00
  signed using       : ECDSA with SHA256
  EC key size        : 256 bits
  basic constraints  : CA=true, max_pathlen=1
  key usage          : Digital Signature, Key Cert Sign, CRL Sign
+ Verify requested for (Depth 1) ... OK
  cert. version      : 3
  serial number      : 23:09:DA:39:B4:78:05:AA
  issuer name        : CN=Factory, O=Silicon Labs Inc., C=US
  subject name       : CN=Batch 1001317, O=Silicon Labs Inc., C=US
  issued on          : 2019-10-17 21:20:20
  expires on         : 2118-09-16 17:32:00
  signed using       : ECDSA with SHA256
  EC key size        : 256 bits
  basic constraints  : CA=true, max_pathlen=0
  key usage          : Digital Signature, Key Cert Sign
+ Verify requested for (Depth 0) ... OK
  cert. version      : 3
  serial number      : 66:F8:5A:E6:B4:EF:6E:49:D3:36:95:63:C9:C3:99:13:E4:71:93:F6
  issuer name        : CN=Batch 1001317, O=Silicon Labs Inc., C=US
  subject name       : C=US, O=Silicon Labs Inc., CN=EUI:14B457FFFE0F77CE DMS:086AEC3C645836BFB04D312F S:SE0 ID:MCU
  issued on          : 2019-11-19 15:10:33
  expires on         : 2119-11-19 15:10:33
  signed using       : ECDSA with SHA256
  EC key size        : 256 bits
  basic constraints  : CA=false
  key usage          : Digital Signature, Non Repudiation, Key Encipherment
  ext key usage      : TLS Web Client Authentication
+ Verify the certificate chain with root certificate... SL_STATUS_OK (cycles: 9703861 time: 255 ms)
```

**Note:** The longer processing time (255 ms) is due to the certificate chain printout.

**Steps 4 and 5 in the Remote Authentication Process:**

```
. Remote authentication:
+ Create a 16 bytes challenge (random number) in remote device for signing... SL_STATUS_OK (cycles: 3700 time: 97 us)
+ Sign challenge with private device key in Secure Vault High device... SL_STATUS_OK (cycles: 221983 time: 5841 us)
+ Get public device key in Secure Vault High device... SL_STATUS_OK (cycles: 199788 time: 5257 us)
+ Verify signature with public device key in Secure Vault High device... SL_STATUS_OK (cycles: 229054 time: 6027 us)
+ Verify signature with public device key in remote device... SL_STATUS_OK (cycles: 230442 time: 6064 us)

. SE manager deinitialization... SL_STATUS_OK (cycles: 6 time: 0 us)
```

## 9. Revision History

### Revision 0.2

September 2021

- Formatting updates for source compatibility.
- Added revised terminology to [1. Series 2 Device Security Features](#) and use this terminology throughout the document.
- Updated [2. Device Compatibility](#).
- Added [7. Secure Engine Manager](#).
- Added the URL to retrieve the root and factory certificates to [8. Examples](#).
- Added [8.2.3 Simplicity Studio](#) to [8. Examples](#).
- Revised [8. Examples](#) to the latest Simplicity Studio and Simplicity Commander version, updated the content.

### Revision 0.1

September 2020

- Initial Revision.



# Simplicity Studio

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