CEC1702 Quick Start Guide

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Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.

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INTRODUCTION

This chapter contains general information that will be useful to know before using the CEC1702 Quick Start Guide. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the CEC1702 Efuse Generator Tool as a development tool for CEC1702 Efuse Programming and the CEC1702 SPI Image Generator Utility for programing a binary image into a SPI flash device. The manual layout is as follows:

- **Chapter 1. "Introduction"** – This chapter provides an introduction to programming the Efuse using the CEC1702 Efuse Generator Tool and programming a SPI device using the CEC1702 SPI Image Generator Utility.
- **Chapter 2. "CEC1702 Efuse Generator Tool Procedure"** – This chapter refers to the CEC1702 Efuse Generator Tool User's Guide, reference 2 in **Appendix B. "References"**, which contains a step by step procedure.
- **Chapter 3. "CEC1702 SPI Image Generator Utility Procedure"** – This chapter describes the procedure.
- **Appendix A. "CEC1702 SPI Flash Layout"** – This appendix contains details of the SPI Flash Image.
- **Appendix B. "References"** – This appendix includes helpful references.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

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- **Emulators** – The latest information on Microchip in-circuit emulators.This includes the MPLAB REAL ICE and MPLAB ICE 2000 in-circuit emulators.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debuggers. This includes MPLAB ICD 3 in-circuit debuggers and PICkit 3 debug express.
- **MPLAB IDE** – The latest information on Microchip MPLAB IDE, the Windows Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB IDE Project Manager, MPLAB Editor and MPLAB SIM simulator, as well as general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers. These include production programmers such as MPLAB REAL ICE in-circuit emulator, MPLAB ICD 3 in-circuit debugger and MPLAB PM3 device programmers. Also included are nonproduction development programmers such as PICSTART Plus and PIC-kit 2 and 3.

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Technical support is available through the web site at:
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DOCUMENT REVISION HISTORY

Revision	Section/Figure/Entry	Correction
DS50002665A (08-24-17)	Preliminary Release	

Chapter 1. Introduction

1.1 CEC1702 QUICK START GUIDE

1.1.1 Purpose

This document is intended for software engineers to program the Efuse in a blank CEC1702 device and to program a blank SPI device for use with the CEC1702.

This procedure includes generating public and private keys for authentication and/or encryption, generating custom Efuse data and creating a signed and/or encrypted SPI image for the CEC1702 to support a secure boot process for their system.

This document gives the steps involved in CEC1702 Efuse programming as well as the hardware and software requirements for the custom Efuse programming of a blank CEC1702 part from Microchip.

This document also gives the steps involved in creating a binary image to load into the SPI flash, including encrypting the image as well as generating the signature that is used by the CEC1702 to authenticate the image.

1.1.2 Introduction

The CEC1702 loads application EC firmware from an external SPI flash device into its internal SRAM, verifies its authenticity and/or decrypts it before launching the application firmware. The image is authenticated using the standard ECDSA signature protocol and may be decrypted using an AES key.

The CEC1702 utilizes private and public keys located in its Efuse and the SPI device to authenticate and decrypt the SPI image.

There are two utilities that are used to create the Efuse data and SPI image:

- CEC1702 Efuse Generator Tool
- CEC1702 SPI Image Generator Utility.

1.1.2.1 SECURITY CAPABILITIES

The CEC1702 supports the following security options for the SPI flash image:

- Authentication
  - If Authentication is enabled, the CEC1702 SPI Image Generator Utility computes a digital signature that is appended to both the Image Header and Binary Image in the SPI. The CEC1702 performs an Signature Verification of both the Image Header and Binary Image that it reads from the SPI.
  - If Authentication is disabled, a hash digest is used to verify the integrity of the image.
- Encryption
  - If Encryption is enabled, the CEC1702 SPI Image Generator Utility encrypts the firmware image in the SPI. A Key Header containing a Public key is appended to the image. The CEC1702 decrypts the firmware image that it reads from the SPI.
  - If Encryption is disabled, the image that is loaded into the SPI is not encrypted and therefore no decryption is done by the CEC1702.

1.1.2.2 CEC1702 EFUSE GENERATOR TOOL

The CEC1702 Efuse Generator Tool is used to generate private/public key pairs and generate the Efuse programming values. The output of the tool is a binary file for programming the CEC1702 part on the Clicker board using a JTAG programming tool.

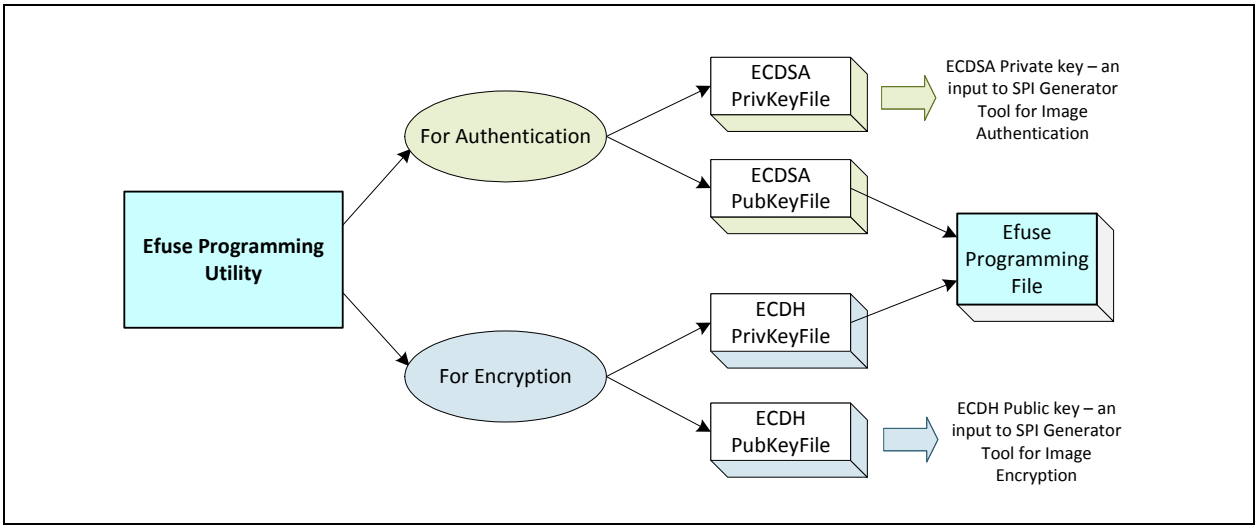
The CEC1702 Efuse Generator Tool also writes the private and public key in an output file protected with the password set by the user while entering the parameters. The keys generated by the CEC1702 Efuse Generator Tool are also used by the CEC1702 SPI Image Generator Utility.

This document refers to the CEC1702 Efuse Generator Tool User's Guide, which gives step by step information on programming the Efuse.

See **Chapter 2. "CEC1702 Efuse Generator Tool Procedure"**.

Figure 1-1 illustrates the flow of the CEC1702 Efuse Generator Tool.

FIGURE 1-1: CEC1702 EFUSE GENERATOR TOOL FLOW



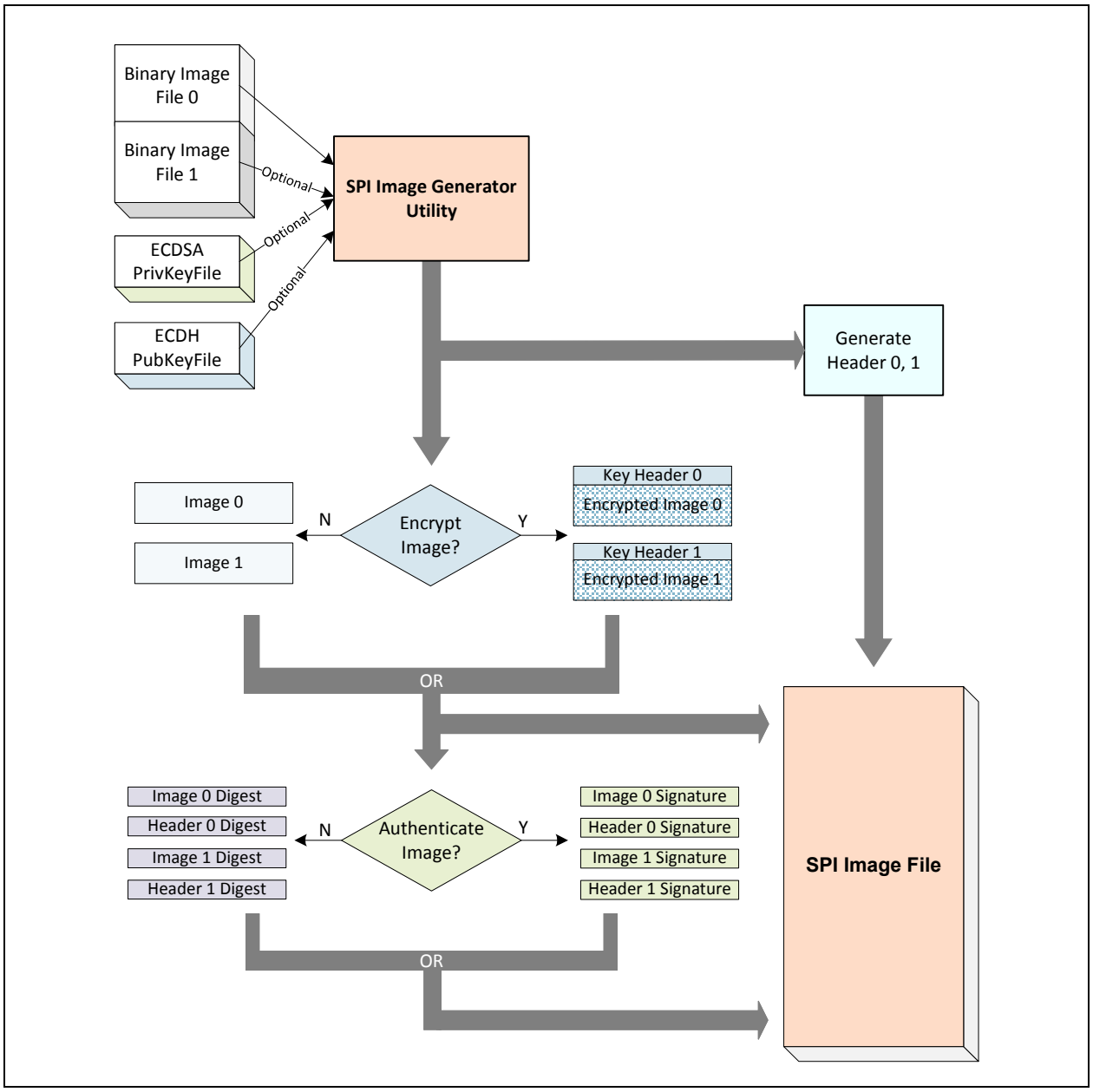
1.1.2.3 CEC1702 SPI IMAGE GENERATOR UTILITY

The CEC1702 SPI Image Generator Utility is used to create the binary image for the SPI flash. The output from the utility is a binary file that will be loaded into the SPI flash device on a Clicker board using a SPI Flash Programmer.

This document gives step by step information on generating the SPI Image using the CEC1702 SPI Image Generator Utility. This process involves generating the required keys and performing the steps necessary for encrypting the binary image and creating a digital signature for the image and its associated header.

See **Chapter 3. "CEC1702 SPI Image Generator Utility Procedure"**. Figure 1-2 illustrates the flow of the CEC1702 SPI Image Generator Utility.

FIGURE 1-2: SPI IMAGE GENERATOR UTILITY FLOW



1.1.3 Introduction to Hardware

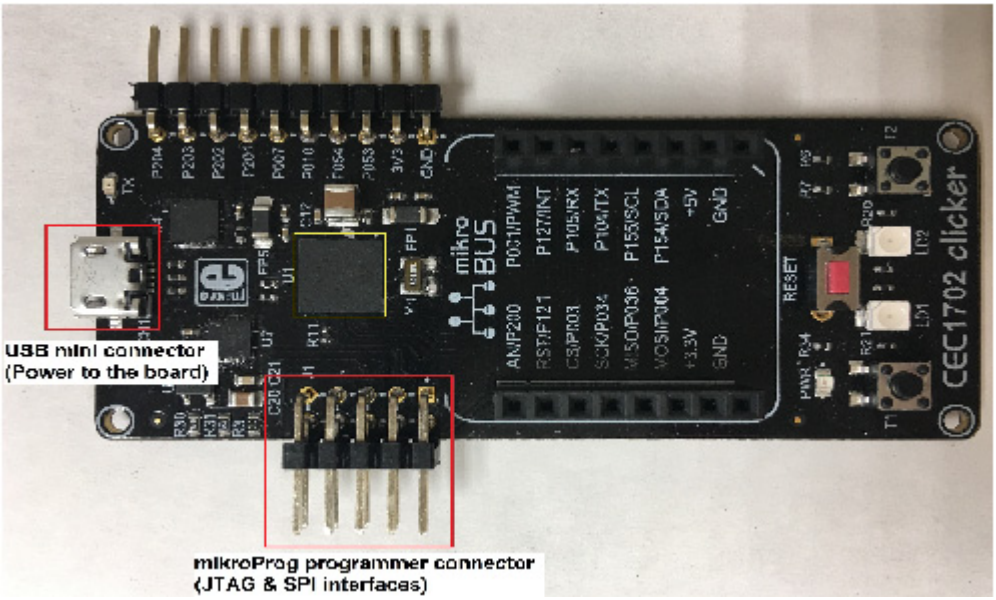
The board used for programming the eFuse in the CEC1702 and the SPI flash device is the “CEC1702 Clicker board”.

The Clicker Board consists of following interfaces

1. USB mini Connector (Power to the board)
2. MikroProg Programmer connector (JTAG and SPI)

Figure 1-3: “CEC1702 Clicker Board Interface Details” shows the Clicker Board and the location of the various interfaces listed above:

FIGURE 1-3: CEC1702 CLICKER BOARD INTERFACE DETAILS



1.1.4 Prerequisites

The following are prerequisites for programming the eFuse in the CEC1702 and programming the SPI device:

1. Clicker Board with blank CEC1702 and blank SPI Flash device should be available.
2. The hardware board must have proper input circuitry for providing 1.59V Efuse programming voltage.
3. PC should have Windows7/8/10. See Note 1.
4. The user is expected to have downloaded and installed openssl version 1.0.1e. See Note 2.
5. The user is expected to have downloaded the CEC1702 Efuse Generator Tool on a PC. If the user is using mikroProg tool for programming the Clicker Board, this utility is part of the tool package.
6. The user is expected to have any JTAG programmer tool installed on their PC for programming the Efuse hex / binary file in CEC1702 on the Clicker Board.
7. The user is expected to have downloaded the CEC1702 SPI Image Generator Utility on a PC.
8. The user is expected to have read the CEC1702 data sheet and know all the authentication and encryption modes planned to be used in their system.
9. The user is expected to know which keys need to be generated for their system and application.

Note 1:	CEC1702 Efuse Generator Tool is only supported for Windows at this time.
2:	Openssl may be downloaded from https://www.openssl.org/source/old/1.0.1/. Version number is openssl-1.0.1e.tar.gz or later.
3:	Please refer to CEC1702 Clicker board documentation for other requirements for executing step 2.

Chapter 2. CEC1702 Efuse Generator Tool Procedure

2.1 CEC1702 EFUSE PROGRAMMING PROCEDURE

The CEC1702 Efuse Generator Tool generates private/public key pairs and Efuse programming values. The output from the tool is a binary file for programming the CEC1702 part on the Clicker board using any JTAG programmer tool. The tool also writes the private and public keys into an output file protected with the password set by the user while entering the parameters.

The CEC1702 Efuse Generator Tool is described in the CEC1702 Efuse Generator Tool User's Guide (reference 2 in **Appendix B. "References"**). This document gives step by step information on programming the Efuse.

> **Note:** The keys generated by the CEC1702 Efuse Generator Tool are also used by the CEC1702 SPI Image Generator Utility. See **Chapter 3. "CEC1702 SPI Image Generator Utility Procedure"**.

Chapter 3. CEC1702 SPI Image Generator Utility Procedure

3.1 SPI IMAGE GENERATION PROCEDURE

The CEC1702 may authenticate and decrypt one of two images from a SPI flash as part of a secure boot process. The layout of these images in the SPI is described below.

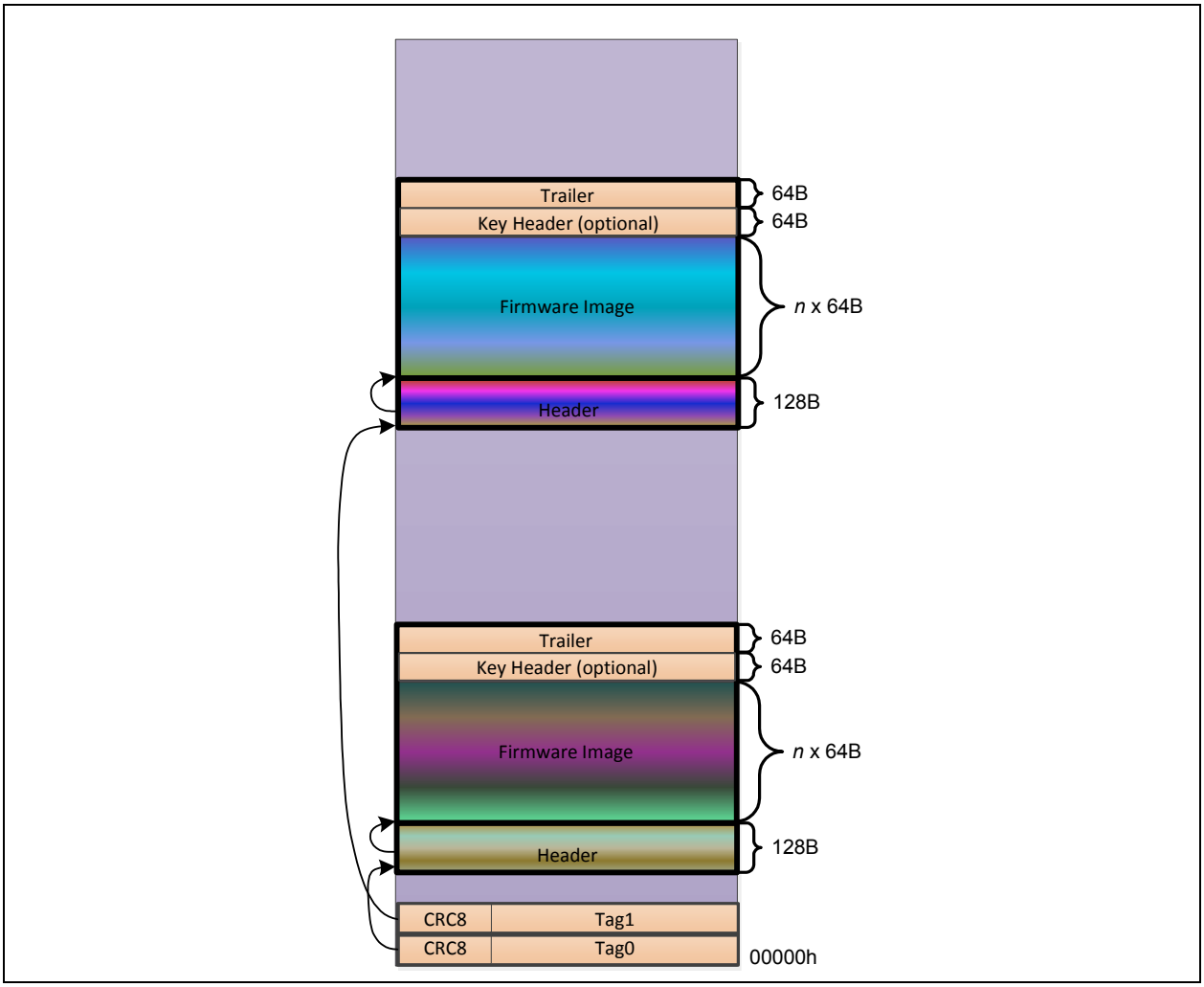
3.1.1 SPI Image Layout

The CEC1702 SPI Image Generator Utility creates a SPI image containing two firmware images. These images can be created from different files by the utility.

The boot ROM in the CEC1702 will attempt to locate a valid image in two locations in the SPI Flash. The locations are searched in the order Tag0 first, then Tag1.

The SPI image that is generated by the CEC1702 SPI Image Generator Utility is shown in **Figure 3-1: "SPI Image Layout Example"**.

FIGURE 3-1: SPI IMAGE LAYOUT EXAMPLE



Detailed information about the SPI Image is contained in **Appendix A. "CEC1702 SPI Flash Layout"**.

3.1.2 Key Generation

Prior to running the CEC1702 SPI Image Generator Utility, the CEC1702 Efuse Generator Tool must be executed to generate key files as described in the next section.

3.1.2.1 OUTPUT KEY FILES

The output directory for the output files generated from the CEC1702 Efuse Generator Tool may be defined by the user.

On program execution the tool generates two folders in the output directory "Output Dir". The ECDH private key (AES Encrypted), self signed certificate, ECDSA private key (AES Encrypted), ECDSA Self Signed Certificate and their corresponding certificate requests are stored in the "keys" directory. This is represented below:

```
<efuse_generator>
 |
 +---efuse
     +--efuse_<YYYYMMDD>_<WHHMMSS>   -> Output Dir self generated
       +---keys                      -> Contains all the keys
       |     <ECDH>.pem              -> ECDH Private key AES Encrypted
       |     <ECDH>_crt.pem          -> ECDH Self Signed Certificate
       |     <ECDH>_csr.pem          -> ECDH Certificate Request
       |     <ECDSA>.pem             -> ECDSA Private key AES Encrypted
       |     <ECDSA>_crt.pem         -> ECDSA Self Signed Certificate
       |     <ECDSA>_csr.pem         -> ECDSA Certificate Request
       |     keys_info.txt           -> Generated Key details
       |     key_file.bin            -> key_file.bin extracted key output
       |
```

3.1.2.2 KEY GENERATION STEPS

See the CEC1702 Efuse Generator Tool User's Guide for the steps required for key generation. The result of these steps are the following files used by the CEC1702 SPI Image Generator Utility.

- <"ECDSA Key filename">.pem
- <"ECDSA Key filename">_crt.pem
- <"ECDH Key filename">.pem
- <"ECDH Key filename">_crt.pem

Note that the <XXXX>_crt.pem files are used as the "Public Key Files" by the utilities.

3.1.3 SPI Image Generation

Running the executable file "mec2016_spi_gen.exe" from the command prompt will utilize a configuration file as an input and generate the output binary image file to be written to the SPI flash device.

The configuration file provides the filename and location of the key files and binary image files as well as other parameters used in the generation of the image.

By default, running "mec2016_spi_gen.exe" from the command prompt will take "spi_cfg.txt" as a default configuration file and generate the output file "spi_image.bin".

The file can have several options as follows:

mec2016_spi_gen.exe -i <cfg_file_name> -o <output_spi_file_name> -m <merge_-file>

Where:

-i cfg_file_name

Specifies the text config file for the SPI chip & images. Defaults to spi_cfg.txt.

-o output_spi_file_name

Specifies the SPI binary output file name. Defaults to spi_image.bin.

-m merge_file

Read merge file as an existing SPI binary image and create FW images inside it. No default value.

The user is required to fill in the required information in the configuration file, including the filename and location of the key files, binary image files and other parameters. See the “release.txt” file and “spi_cfg.txt” file for more information.

The required information includes the Size of SPI flash device and the following information for each binary image (Image 0 and Image 1):

- Location of the Header in the SPI (“ImageLocation”)
- SPI interface settings
- Filename of Application Binary File (“FwBinFile”). See Note 1.
- Offset of Binary File from end of Header - number of 64B offsets (“FwOffset”)
- Application firmware load address in SRAM (“FwLoadAddress”)
- Application firmware entry address in SRAM (“FwEntryAddress”)
- Enable/disable ECDSA Authentication of Header and Image
- Filename for the key pair used to sign and verify/authenticate the Header and Image (“ECDSAPrivKeyFile”). See Note 1.
- Password for the key pair used to sign and verify/authenticate the Header and Image (“ECDSAPrivKeyPassword”)
- Enable/disable Encryption of Image
- Filename of Public Key used to Generate the AES-256 Key/IV for encryption (“AesGenECPubKeyFile”). See Note 1. Note: this is the ECDH Public key.
- The voltage level of the three VTRx regions of the CEC1702. See the data sheet for more information.

Note 1: If the "mec2016_spi_gen.exe" executable file is not run in the same directory as the key files and binary file, then this filename must also contain the directory path of the file.

The output file from the utility is a binary file that will be used to program the SPI flash device on a Clicker board using a SPI programmer tool.

3.1.3.1 GENERATING SPI IMAGE USING MICROE TOOL

If the MikroElektronika tool will be used to generate and program the SPI device, refer to the CEC1702 Efuse Generator Tool User’s Guide, reference 2 in **Appendix B. “References”**. See **Appendix B. “Programming Steps For MikroE Tool”** in the CEC1702 Efuse Generator Tool User’s Guide. Specifically, section **B.2 “Firmware Image Encryption and Authentication”** shows the steps for enabling encryption and authentication. Note that the MicroE tool does not have all the same options that the CEC1702 SPI Image Generator Utility provides.

3.1.4 Programming the SPI Flash Device on a Board

If the MikroElektronika tool will be used to program the SPI device, refer to the CEC1702 Efuse Generator Tool User's Guide, reference 2 in **Appendix B. "References"**. See **Appendix B. "Programming Steps For MikroE Tool"** in the CEC1702 Efuse Generator Tool User's Guide. Specifically, section **B.2 "Firmware Image Encryption and Authentication"** shows the steps for programming the SPI image.

The SPI device may also be programmed as follows:

a) The Image may be loaded into the SPI device before putting it on the board
b) The Image may be programmed into the SPI device with a tool such as Ded-iProg SPI Flash Programmer.

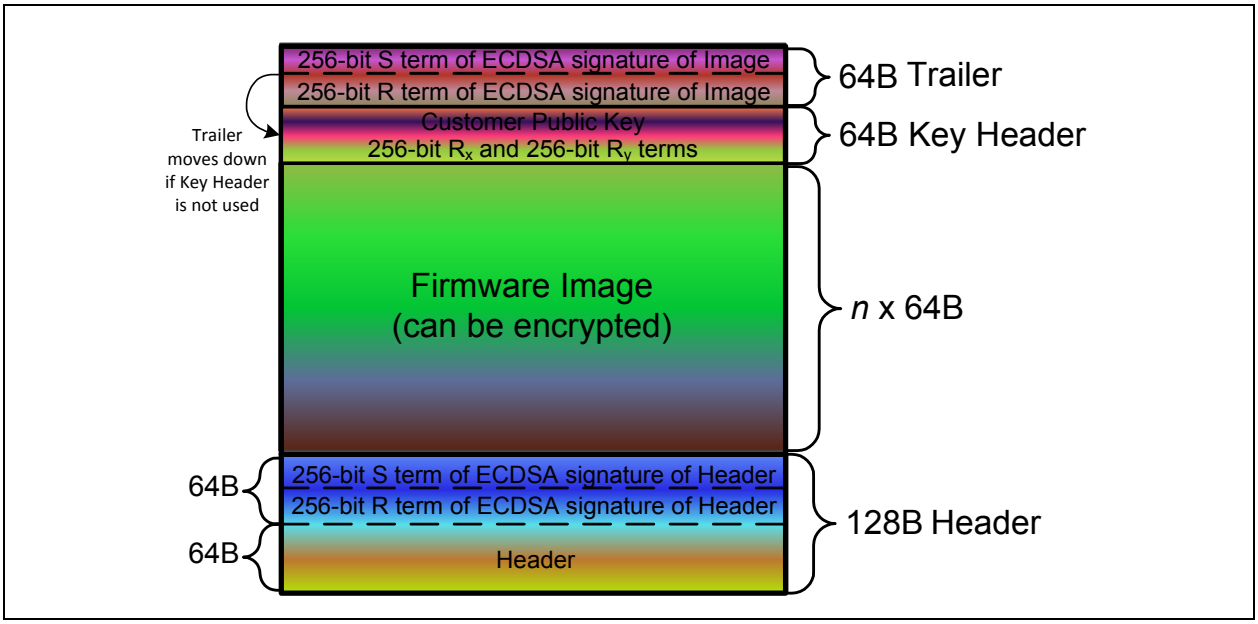
Appendix A. CEC1702 SPI Flash Layout

A.1 SPI IMAGE

The SPI image that is generated by the CEC1702 SPI Image Generator Utility is shown in **Figure 3-1: "SPI Image Layout Example"**.

The header and image region is shown in expanded form in **Figure A-1: "SPI Image Details"**.

FIGURE A-1: SPI IMAGE DETAILS



A.1.1 SPI FLASH REGIONS

The SPI Flash has the following defined regions:

1. Two 8-byte Tags, each of which identify the position of one of the two load regions in the Flash. Each of the load regions consists of the following four regions.
2. A 128-byte Header
3. The EC Runtime FW body (Firmware Image), an integral multiple of 64 bytes
4. An optional 64-byte Key Header
5. A 64-byte Trailer

A.1.1.1 TAG

The Tag contains a pointer to the EC code image header. The Load Sequence first checks for TAG 0, which is located at offset 0x00 in the SPI flash.

If the data stored in TAG 0 fails the Tag validation, the FW Image Header validation, or the EC Runtime FW Binary Image validation, the Load Sequence then checks for TAG 1, which is located at offset 0x04.

A.1.1.2 FIRMWARE IMAGE HEADER

The FW Image Header is located in the SPI Flash as determined by the Tag. The Header is located at an offset in the SPI Flash that is on a 256-byte boundary. The header contains SPI interface settings and information about the image, including

- Offset of Binary File from end of Header
- Application firmware load address in SRAM
- Encryption of Image enabled/disabled

AUTHENTICATING THE HEADER

If Authentication is enabled, the Header is signed by a standard ECDSA digital signature, using SHA-256.

Using the CEC1702 Efuse Generator Tool, a customer generates a P- 256 private key, which is retained by the customer and kept a secret, and the corresponding public key, which is stored in the CEC1702 eFuse One Time Programmable (OTP) memory. The Header is signed by the CEC1702 SPI Image Generator Utility as part of the SPI image generation process.

The ECDSA verification is performed with the public key. If the ECDSA verification procedure returns an error, the load terminates.

A.1.1.3 EC RUNTIME FW BINARY IMAGE

The EC Runtime FW Binary Image contains three contiguous components as originally illustrated in **Figure 3-1: “SPI Image Layout Example”**.

1. Firmware Image

The Firmware image contains the application code that is loaded into SRAM.

The Firmware image will start on a 64-byte boundary in the SPI Flash, and consists of an integral number of 64-byte blocks. If the firmware image does not end on a 64-byte boundary, it will be padded with zero's. The number of 64-byte blocks in the Firmware Image is defined by the "FW Binary Length" field in the Header, n.

2. Key Header (Optional), Used for Encryption

The 64 bytes immediately appended to the end of the Firmware Image are used for Encryption feature.

- If Encryption is disabled in the SPI flash header, the Key Header is not used. The ROM code loads *n*X64 bytes from the Flash into SRAM.
- If Encryption is enabled in the SPI flash header, the Key Header is used to store the 64 Byte Diffie-Hellman public key used by the boot ROM Diffie-Hellman key exchange to derive the AES256-CBC decryption key. The ROM code loads *(n+1)*X64 bytes from the Flash into SRAM.

3. Trailer, Used for Authentication

The Trailer refers to the 64 bytes in the SPI Flash appended to the end of the Firmware Image.

- If Authentication is enabled, the trailer contains the ECDSA signature used to authenticate the Firmware Image.

  The signature is over the Firmware Image and, if encryption is enabled, the Key Header as well. The signature block is 64 bytes long.

  a) If Encryption is disabled, the size of the image signed is n x 64.
  b) If Encryption is enabled, the size of the image signed is (n+1) x 64.

- If Authentication is disabled, The trailer contains a SHA-256 digest used to validate the Firmware Image has been loaded without error.
  a) If Encryption is disabled, the ROM code loads *n* x 64 bytes from the Flash into SRAM.
  b) If Encryption is enabled, the ROM code loads (*n*+1) x 64 bytes from the Flash into SRAM.

Appendix B. References

B.1 REFERENCE LIST

1. CEC1702 Data Sheet is available at www.microchip.com/cec1702.
2. CEC1702 Efuse Generator Tool User's Guide is available at the link in item 1.
3. Documentation and details of CEC1702 Clicker Board.
4. Documentation and details of CEC1702 Clicker 2 Board.
5. Openssl installable package openssl-1.0.1e.tar.gz.
6. Latest mikroC compiler is available at mikroC for ARM v5.0.0.

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