Arm® Cortex®-M
32-bit Microcontroller

ICP Programming Tool
User Manual

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1 Overview

1.1 Introduction

Nuvoton ICP Programming Tool is a software that can program Nuvoton Cortex®-M series products, which supports “online” and “offline” programming mode.

“ICP” is the acronym of In-Circuit Programming, which means user can upgrade Flash memory of MCU on board and does not need to unmount it from target PCB.

1.2 Supported Devices

Open the hyperlink to see the table of supported devices: Link of supported devices.

Users can download datasheet of each device from *http://www.nuvoton.com*

1.3 Features

- In-Circuit programming target chip
- Online/offline programming mode
- Backup Flash data of target chip (If the target chip is not Flash protected)
- Backup offline Flash data of Nu-Link dongle (if offline data has been unprotected)
- Write software serials number (SN) to target chip
- Limit the maximum programming count
- Data encryption for online/offline programming
- Batch mode for online/offline programming

2 Preparing for ICP Programming Tool

2.1 System Requirements

The hardware and software requirements for installing the ICP Programming Tool system are as follows:

- PC/AT compatible machine with Pentium or higher CPU
- XVGA(1024*768) color monitor
- At least 512M RAM for best performance
- At least 20M free disk space
- Windows 2000/XP/Vista/7

2.2 Hardware Installation

Step 1: Plug USB cable into the USB port of the ICP Programming Tool board.

Step 2: Connect the ICP Programming Tool board with ICE interface of DEV board.

2.3 Software Installation

Please run the installer package to install the software.

Figure 2-1 shows the selection form at startup of the ICP Programming Tool and Figure 2-2 shows the main window of the ICP Programming Tool.

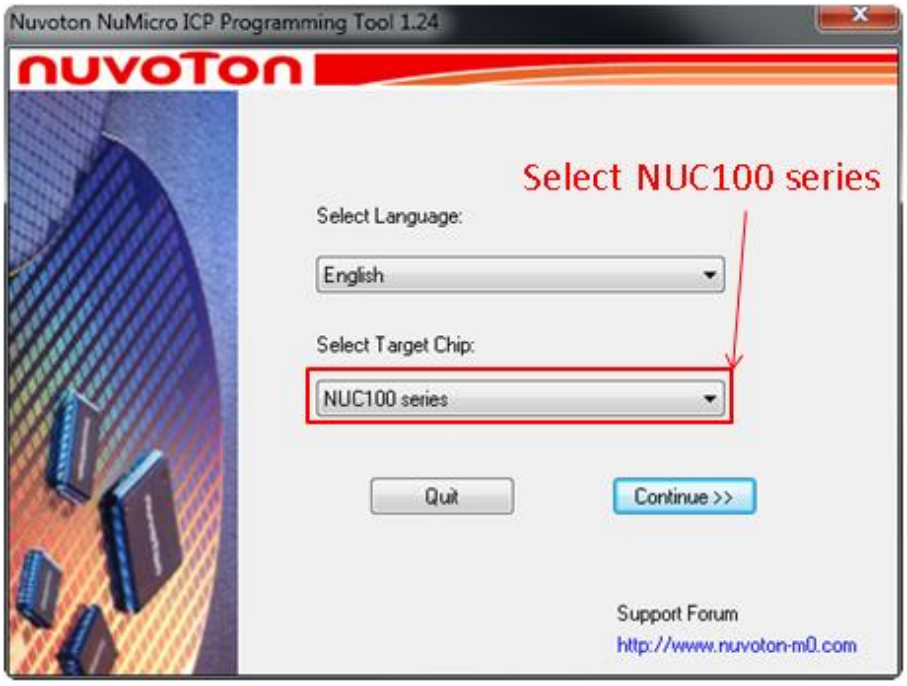

Figure 2-1 Chip Series and Language Selection

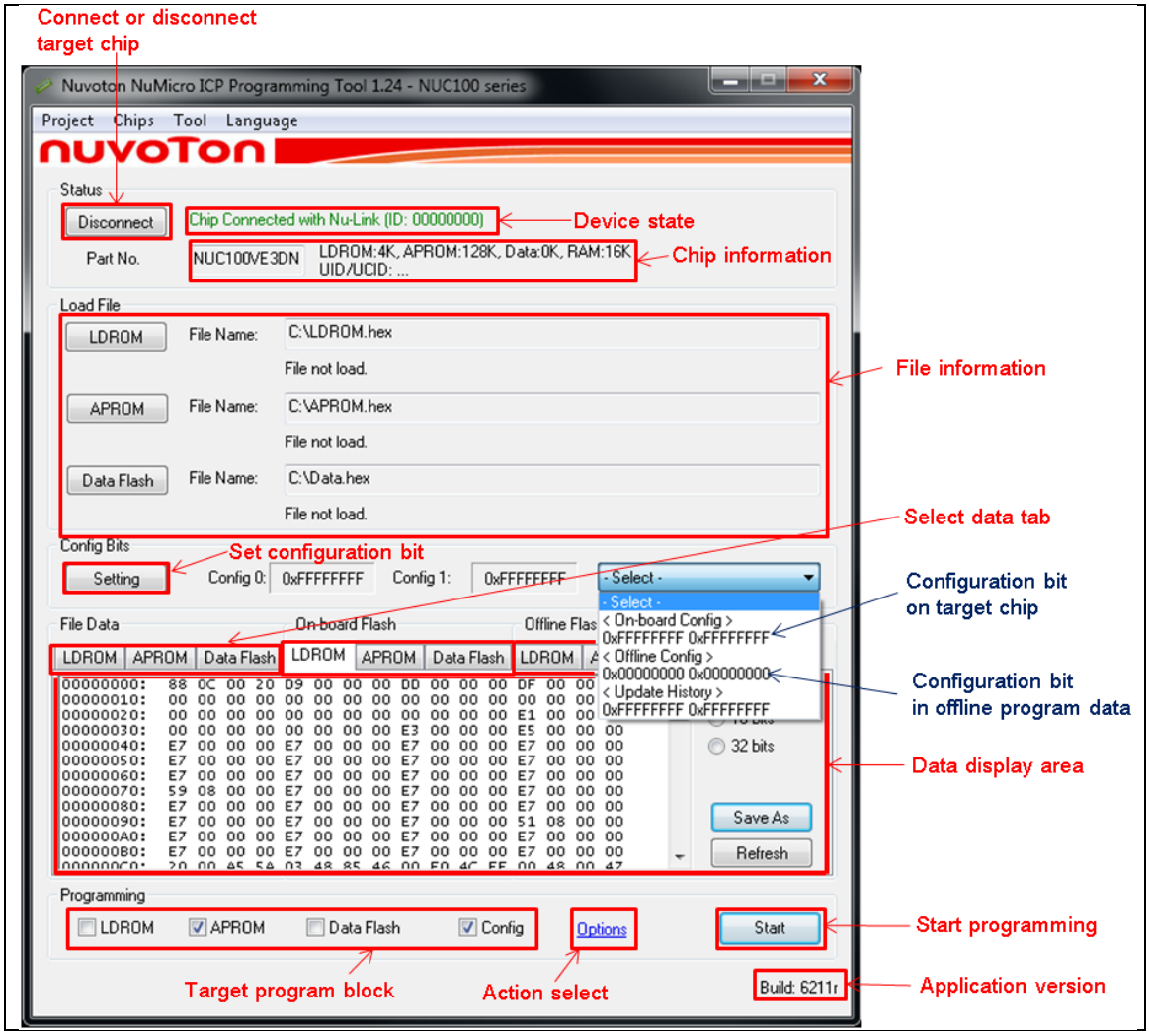

Figure 2-2 Overview of Main Window

3 Operation Modes of ICP Programming Tool and Nu-Link Dongle

This chapter describes operation modes of the ICP Programming Tool and Nu-Link dongle.

3.1 ICP Programming Tool Modes

The ICP tool supports “online” and “offline” programming mode.

3.1.1 Online Programming Mode

If the “**Offline programming mode**” option in Figure 4-14 is unchecked, ICP Programming Tool will program in online programming mode.
Click the “**Start**” button in Figure 2-2 to start to program target device immediately. The target device must be connected to Nu-Link.

3.1.2 Offline Programming Mode

If the “**Offline programming mode**” option in Figure 4-14 is checked, the ICP Programming Tool will program in offline programming mode.
Click the “**Start**” button to save the file data into Nu-Link at first, no matter a target device is connected to Nu-Link or not.

Next, user can program the target devices with this dongle alone (instead of using PC and ICP Programming Tool) by pressing the button on the Nu-Link dongle (red part in Figure 3-1).

Figure 3-1 Offline Programming Button

3.2 Nu-Link Dongle Operation Modes

The Nu-Link dongle also has two modes, ICE mode and Offline Download mode. ICE mode is the default mode of Nu-Link.

Pressing the button on the Nu-Link dongle (red part in Figure 3-1) will switch the Nu-Link to Offline Download mode and start to download the offline data to target chip immediately.

3.2.1 ICE Mode

The ICP Programming Tool AP can be only connected with Nu-Link in ICE mode.

3.2.2 Offline Download Mode

In Offline Download mode, the Nu-Link dongle will try to program the target device. After the programming is finished, Nu-Link will switch back to ICE mode automatically.
PC and the ICP Programming Tool AP are not required for this operation. Please note that the file data must have been saved in Nu-Link through section 3.1.2.

3.3 LED and Keypad of Nu-Link Dongle

Nu-Link Dongle Operation Status	Status LED			
	ICE	ICP	Red	Green
Boot	Flash*3	Flash*3	Flash*3	Flash*3
One Nu-Link dongle selected to connect	Flash*4	Flash*4	Flash*4	On
ICE Online (Not connected with a target chip)	On	Any	-	-
ICE Online (Connected with a target chip)	On	Any	-	On
ICE Online (Failed to connected with a target chip)	On	Any	Flash	On
During Offline Programming	-	On	-	Flash Slowly
Offline Programming Completed	On	-	-	-
Offline Programming Completed (Auto mode)	On	On	-	-
Offline Programming Failed	On	Flash	-	-

Table 3-1 Status LEDs Difference List

4 Starting to Use ICP Programming Tool

This chapter introduces the general operations in ICP Programming Tool. Please refer to Figure 4-1.

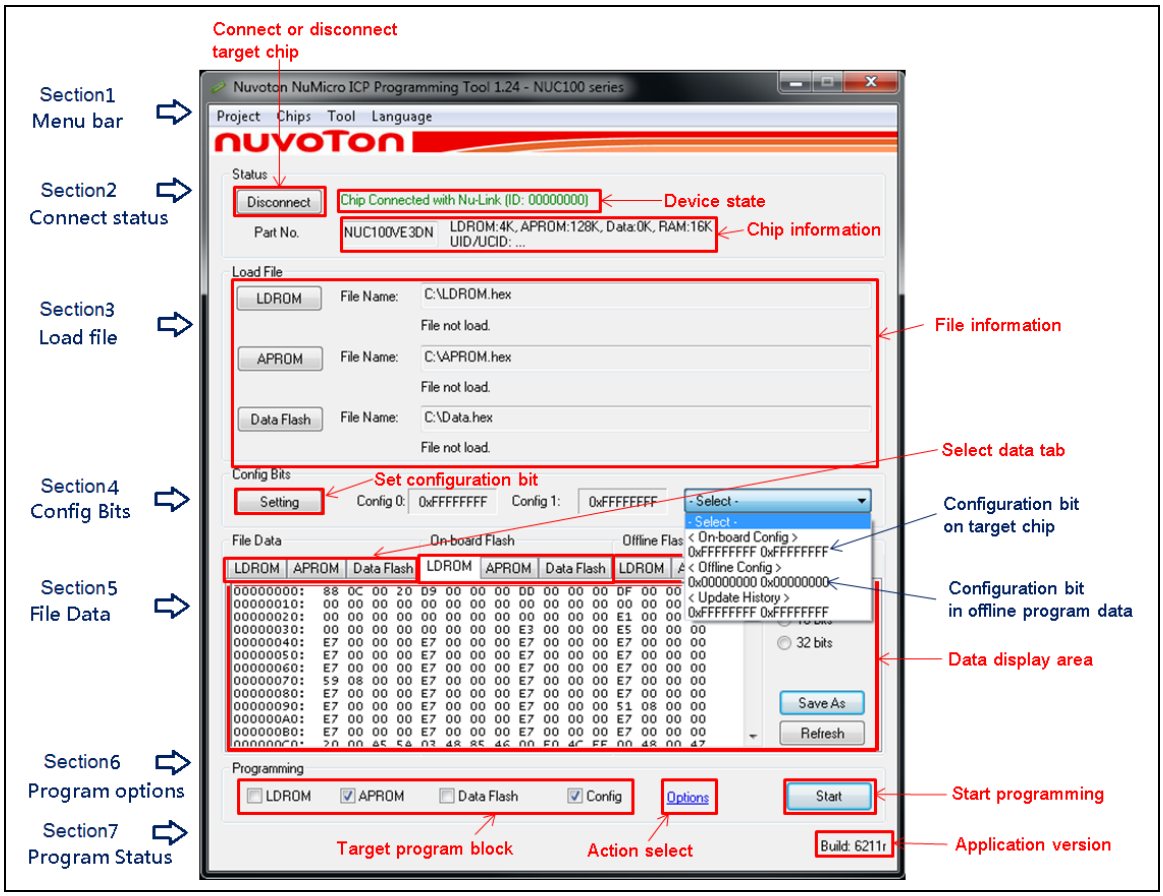

Figure 4-1 ICP Programming Tool User Interface

4.1 Menu Bar

The menu bar is described below.

Figure 4-2 Menu Bar

- **Project**
  - Import and export the ***.icp** project file. This command can not only save and load user settings, but also do binary code protection through exporting with a certificate.

- **Chips**
  - To switch between different chips.

- **Tool**

- **Erase offline data**
  - Erase offline data that saved in NuLink dongle.
- **Create Nu-Link certificate file**
  - For ICP Programming Tool online programming mode, create a certificate file to encrypt program data that saved in .icp project file, and bind this .icp project file to a certain Nu-Link dongle.Please see the "**Binary Code** Protection (Online Programming Mode)" chapter for more details.

- **Language**
  - Switch **between** "English", "Simple Chinese" and "Traditional Chinese".

4.2 Connection Status

- Before connected

The ICP Programming Tool will try to connect target chip once the user clicks the "**Connect**" button.

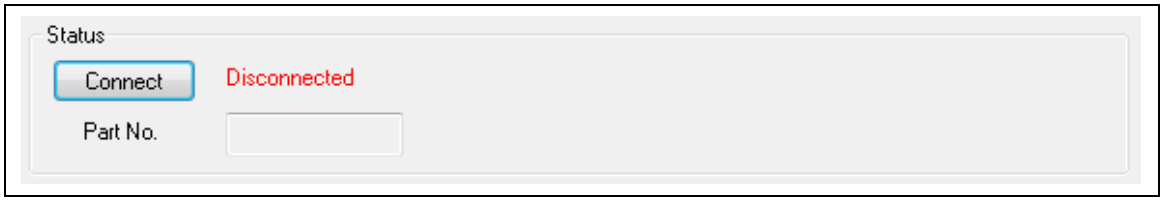

Figure 4-3 before Connected Status

- After USB dongle connected successfully

The ICP Programming Tool shows "ICE Connected".

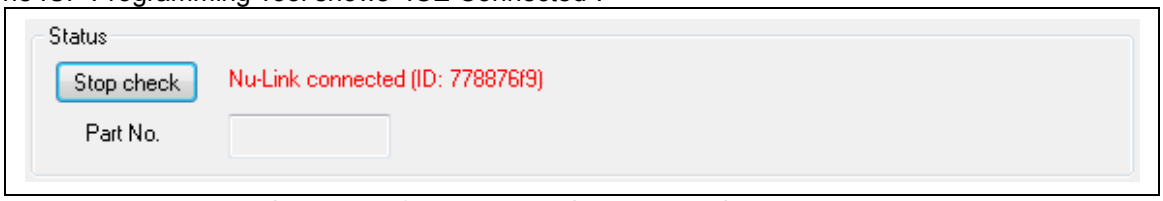

Figure 4-4 after USB Dongle Connected Status

- After target chip connected successfully

The ICP Programming Tool shows chip information.

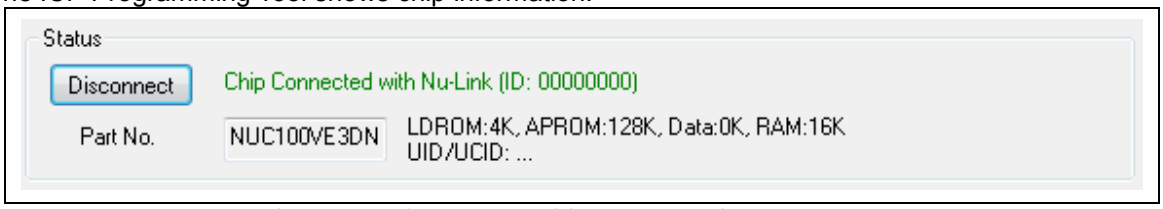

Figure 4-5 after Target Chip Connected Status

4.3 Load File

- Select file for programming

Select a file for programming. Then the file size and checksum information will be displayed.

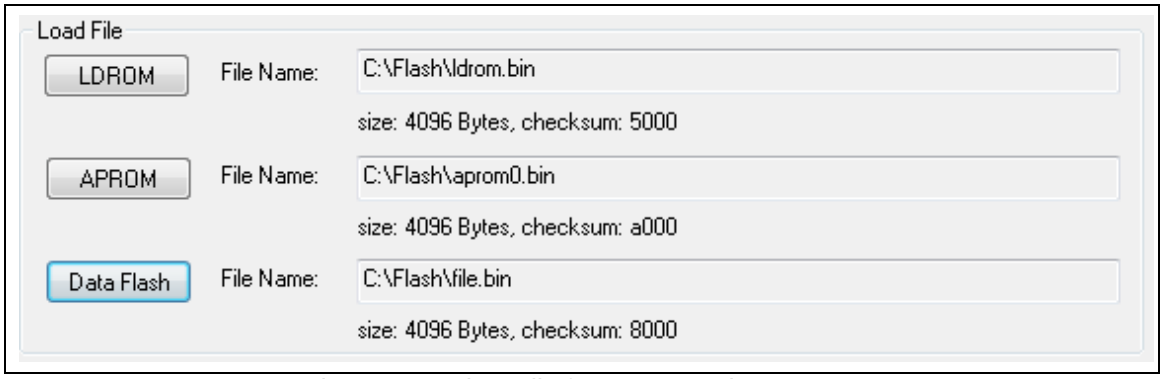

Figure 4-6 Select File for Programming

- Supported file format:

The supported file format includes **bin** or **Intel hex** (Intel 8, 16 and 32) file format.

4.4 Configuration Bits

The Config Bits section is used for configuration bits setting.

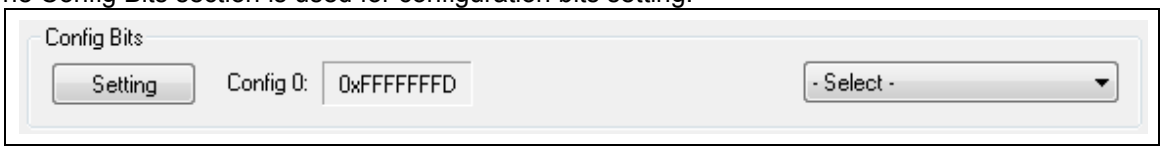

Figure 4-7 User Configuration Status

The Chip Options form will be displayed after clicking the “**Setting**” button.

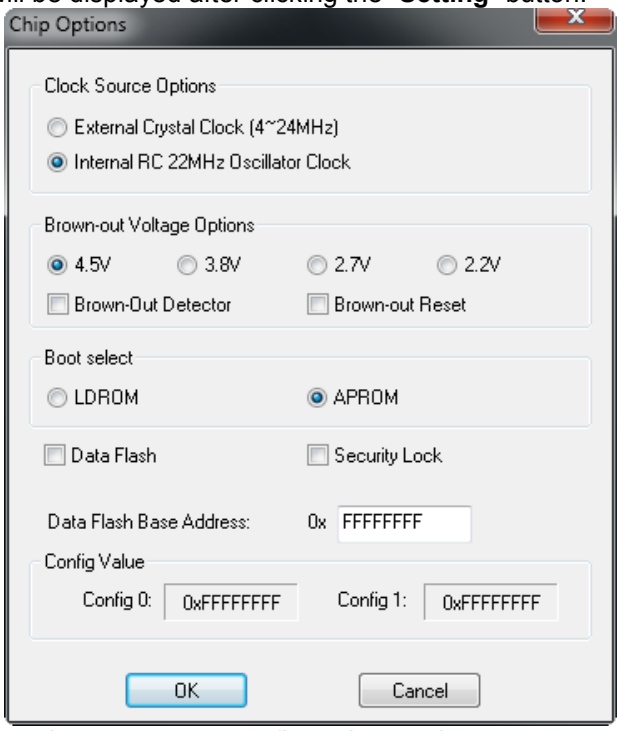

Figure 4-8 User Configuration Settings

- Configuration selection list
  - **"On-board Config"** shows the configuration bit that’s read from target chip;
  - **"Offline Config"** shows the configuration bit read from Nu-Link that’s saved previously for offline programming;
  - **"Update History"** shows the history configuration.

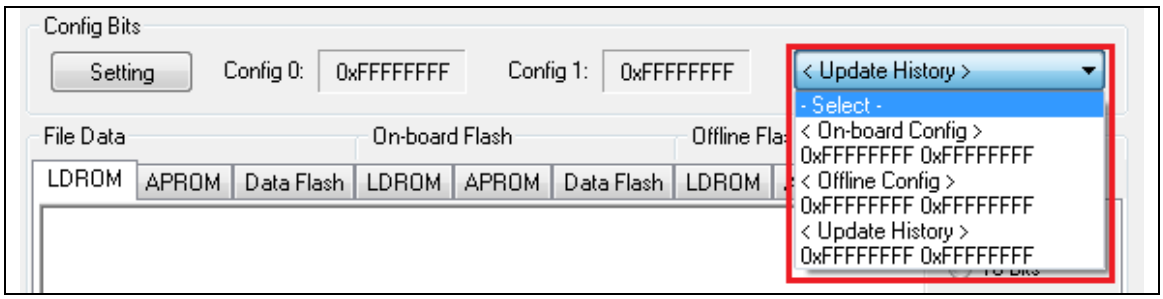

Figure 4-9 User Configuration Setting History

4.5 Dump Data

Once refresh, the data information section will show three parts of Flash data information respectively, including “File Data”, “On-board Flash”, and “Offline Flash”.

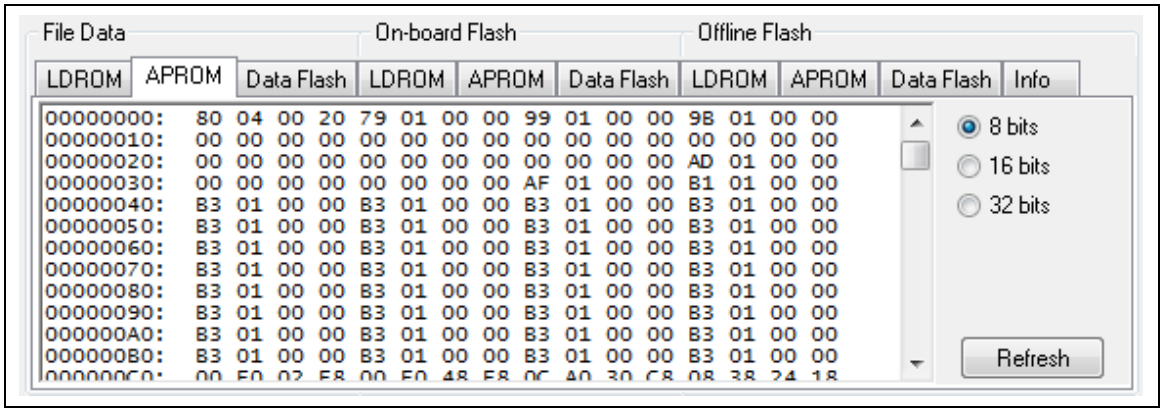

Figure 4-10 Data Information Interface

- File data
  - The file content selected in the “Load file” group.

- On-board Flash
  - The data programmed on built-in Flash of target chip.

- Offline Flash
  - The offline data on SPI Flash of Nu-Link dongle.
  - The info tab will show download information of online and offline programming mode

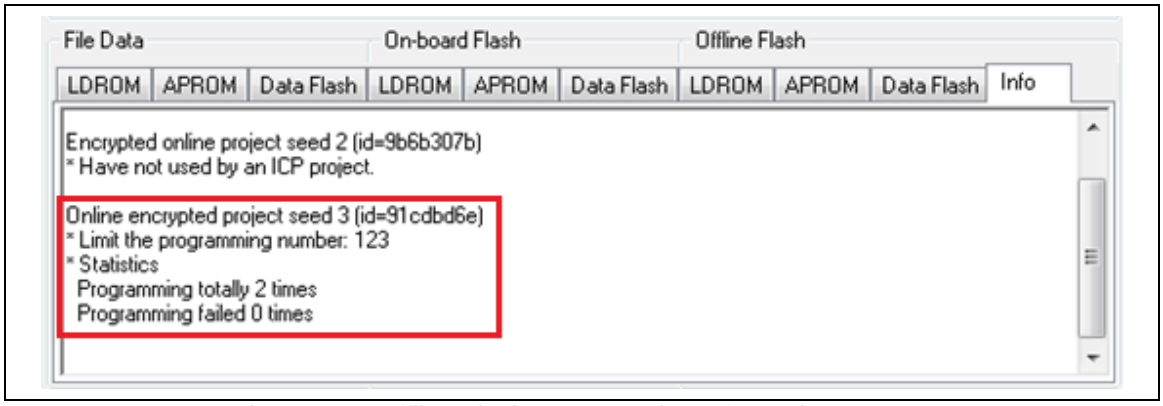

Figure 4-11 Offline Flash Programming Information

4.6 Programming Options

Figure 4-12 Programming Block Options and Start Button

- Target programming block

User can program APROM, Data Flash, or LDROM separately.

In online programming mode, user only needs to set the target programming block as shown in Figure 4-13.

In offline programming mode, besides the target programming block, user also needs to enable the “Program Specific Area” option as shown in Figure 4-14; otherwise, it will erase the whole target chip while offline downloading.

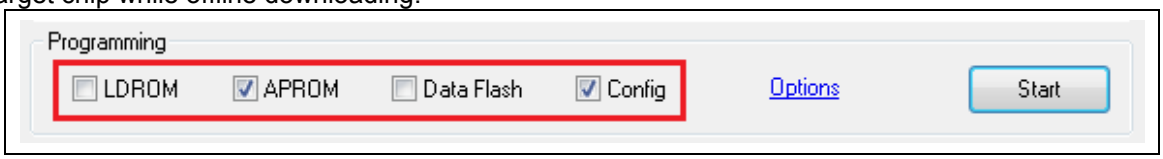

Figure 4-13 Programming Block Options

- Programming Options

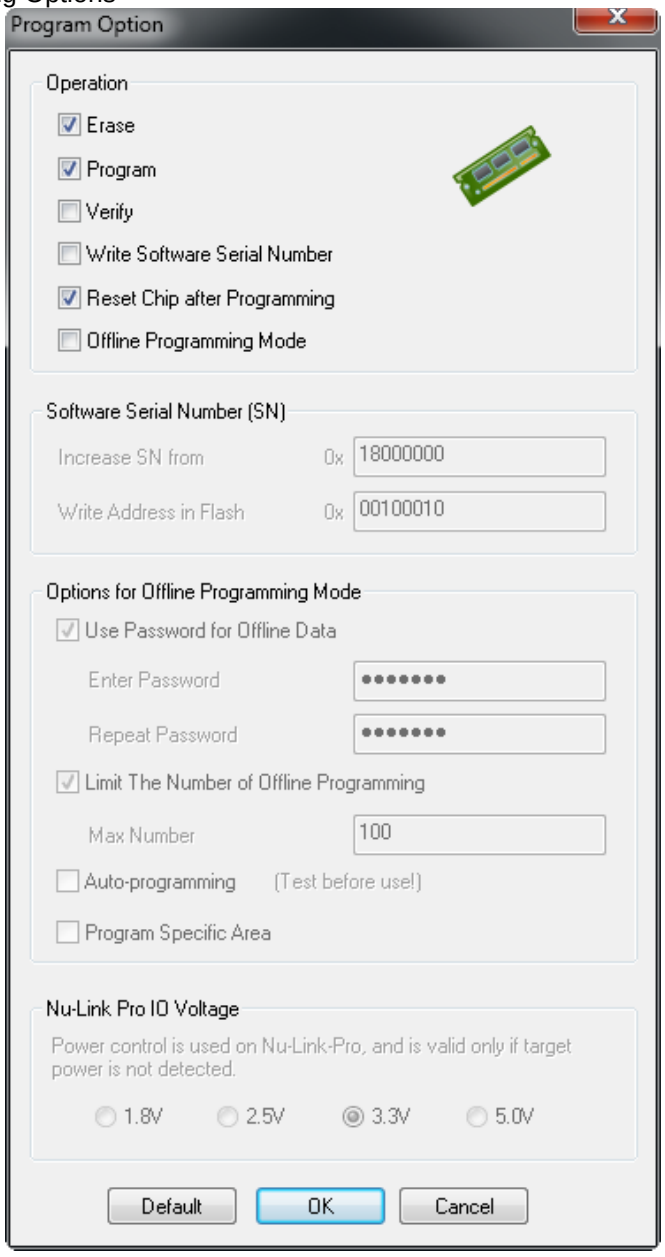

Figure 4-14 Programming Options

- The Operation group contains erase, program, verify, offline programming mode option settings.
- User can enable “Write Software Serials Number”, and assign “SN start value” and “target

Flash address where SN saved".

- User can specify the password for offline programming mode and the limitation of maximum programming count for security issue.

4.7 Programming Status

The ICP Programming Tool contains progress bar and program status. After programming is done, a dialog box will appear to display the success information or any other failed information.

Figure 4-15 Programming Status

5 Binary Code Protection (Online Programming Mode)

This chapter describes the security for ICP Programming Tool in online programming mode.

In data delivery, binary code is encrypted in online programming mode (referring to Figure 5-1).

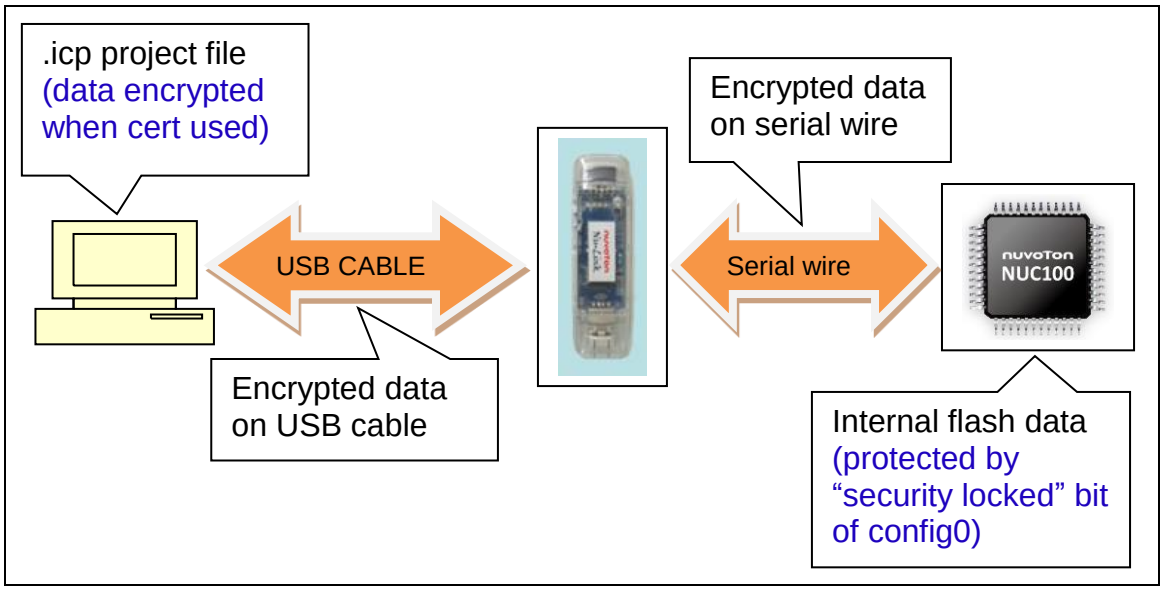

Figure 5-1 Binary Code Protection in Online Programming Mode

5.1 Introduction to Nu-Link Certification

To prevent factory from getting developer's image, developer can protect his binary code by Nu-Link certificate mechanism.

5.2 Procedure of Using Nu-Link Certification

Step 1: Factory creates Nu-Link's certificate file and sends it to developer.

Step 2: Developer encrypts binary file with this certificate file and exports a *.icp project file, and then sends the *.icp file to Factory.

Step 3: The cert-creating Nu-Link updates its certificate information (for example, increased programming count) after Nu-Link successfully decrypts and programs the ICP project to target chips.

The benefits:

- If someone gets your *.icp project file, he cannot program target chips without the cert-creating Nu-Link device.
- The content of exported *.icp project file is encrypted.
- Factory is not allowed to do unlimited mass production without the permission of developer.

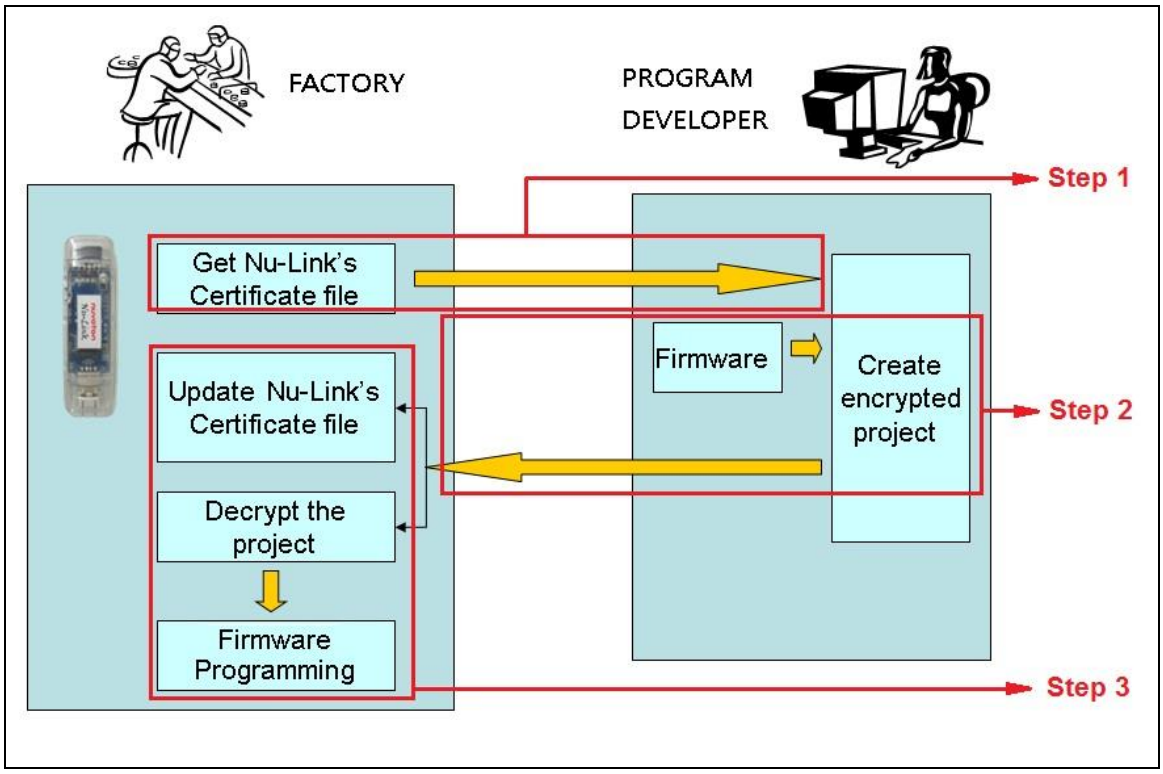

Figure 5-2 Nu-Link Certification Procedure

5.3 Steps of ICPTool

5.3.1 Create Nu-Link Certificate File (Factory Side)

Step 1: Connect Nu-Link.

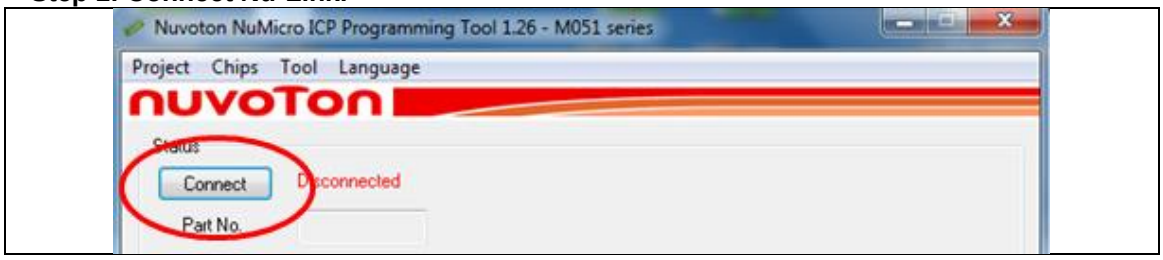

Figure 5-3 Connect Nu-Link

Step 2: Create certificate file.

Figure 5-4 Create Nu-Link Certificate File

Step 3: Save Nu-Link certificate file (*.ict).

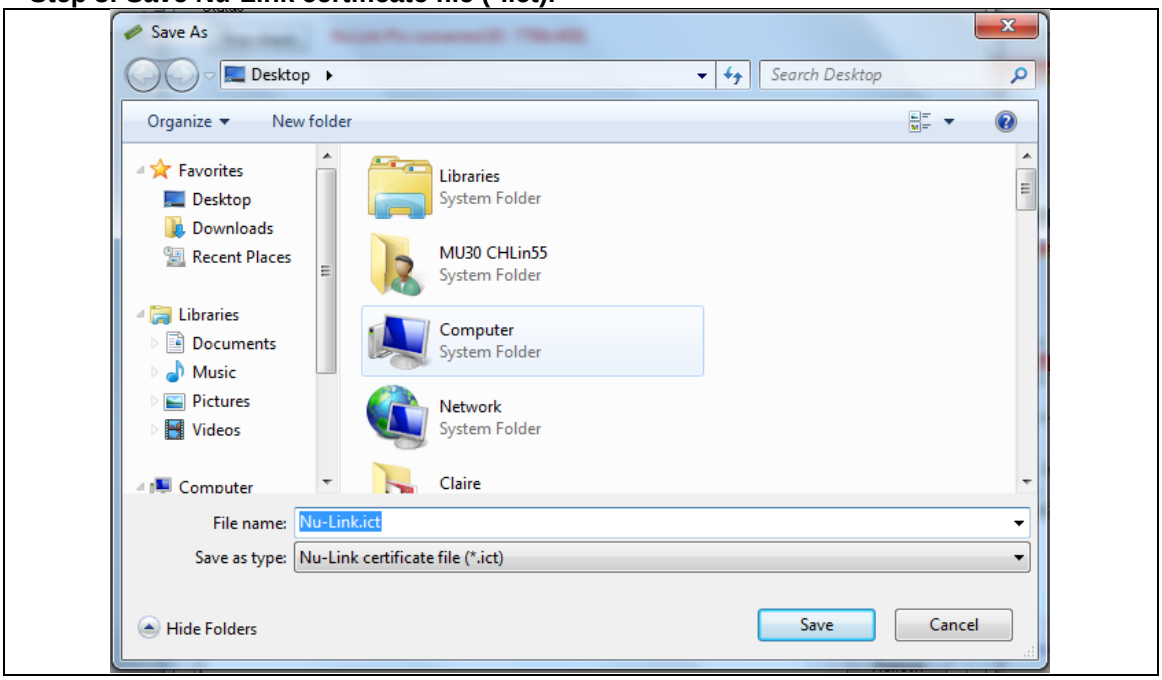

Figure 5-5 Save Nu-Link Certificate File

5.3.2 Bind Certificate File and Program Binary File to Encrypted Project (Developer Side)

Step 1: Export project.

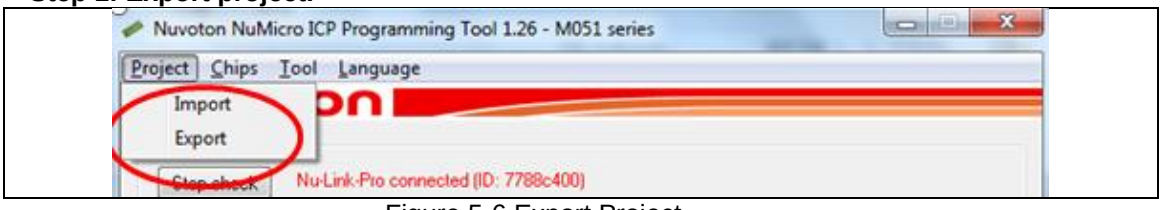

Figure 5-6 Export Project

Step 2: Enable settings.

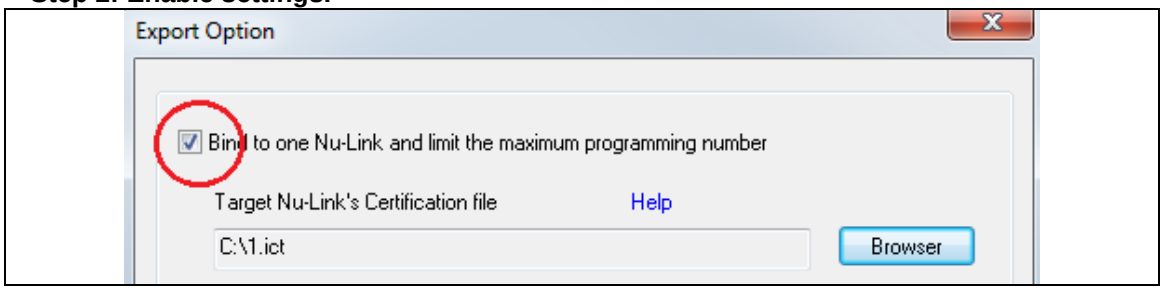

Figure 5-7 Enable Binding Nu-Link Settings

Step 3: Select the Nu-Link certificate file path.

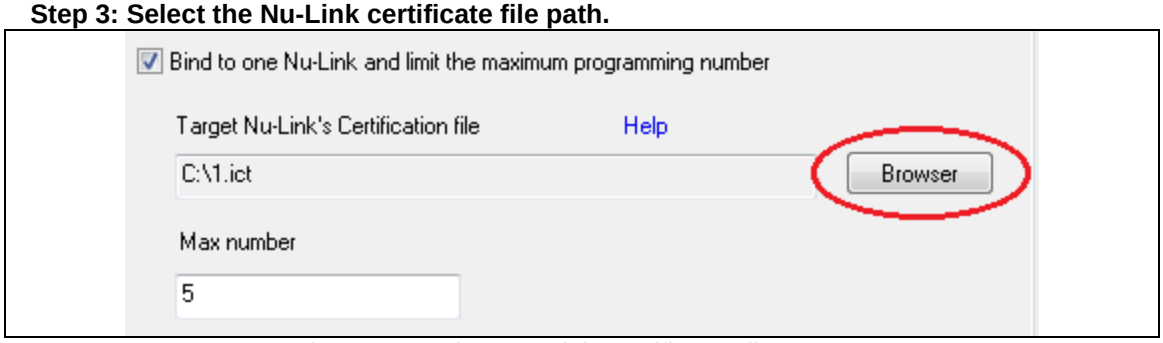

Figure 5-8 Select Nu-Link Certificate File

Step 4: Enter the maximum programming number and start to export the project.

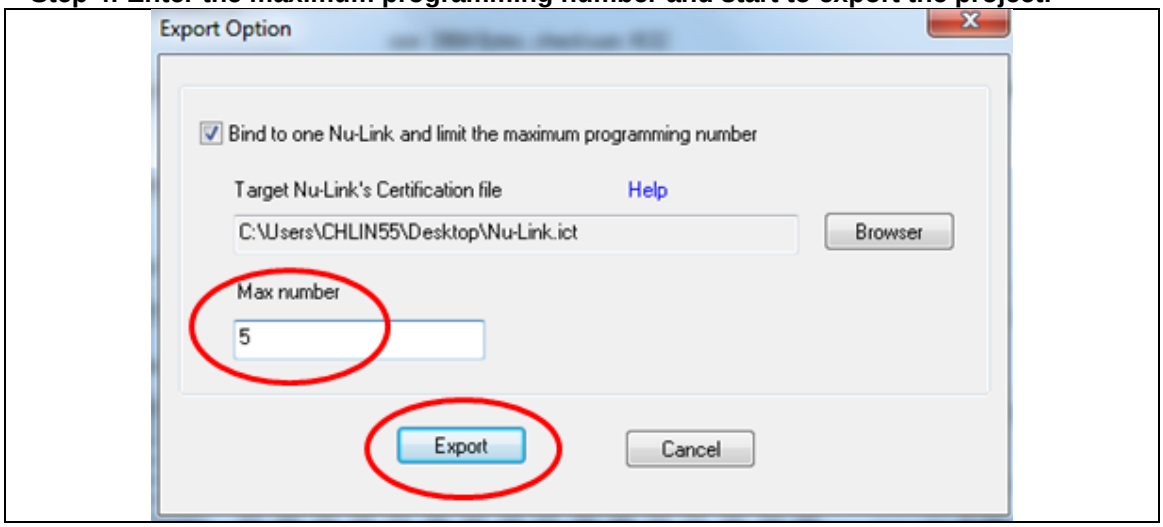

Figure 5-9 Set Max Programming Number

Step 5: Save the ICP project file (*.icp).

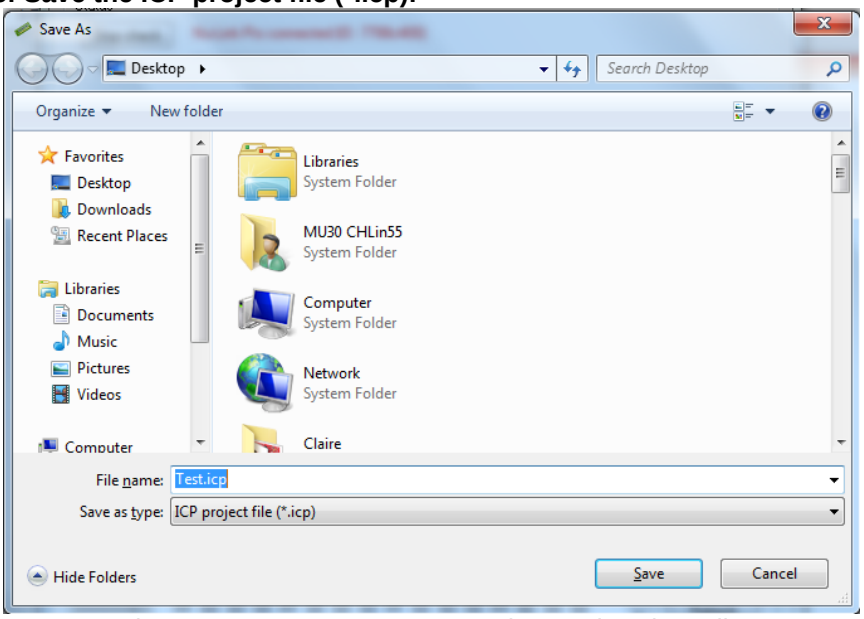

Figure 5-10 Save ICP Programming Tool Project File

Note: Once the project exceeds the maximum programming number, user needs to create a new Nu-Link certification and set the new max programming number.

Note: The maximum programming number is determined at first time when using the certification to create an ICP project file. Even user sets the maximum programming number several times, the maximum programming number is the one set at first time.

- For example:
  - Use B.ict to create an ICP project file and set the maximum programming number to 10.
  - After programming 5 times, use B.ict to create the second ICP project file and set the maximum programming number to 3.
  - The second ICP project file still can program 5 times.
  - Set the maximum programming number carefully at first time and it is better to create different certification for different ICP projects.

6 Binary Code Protection (Offline Programming Mode)

This chapter describes code security for ICP Programming Tool in offline programming mode.
In data delivery, binary code is encrypted in offline programming mode (referring to Figure 6-1).

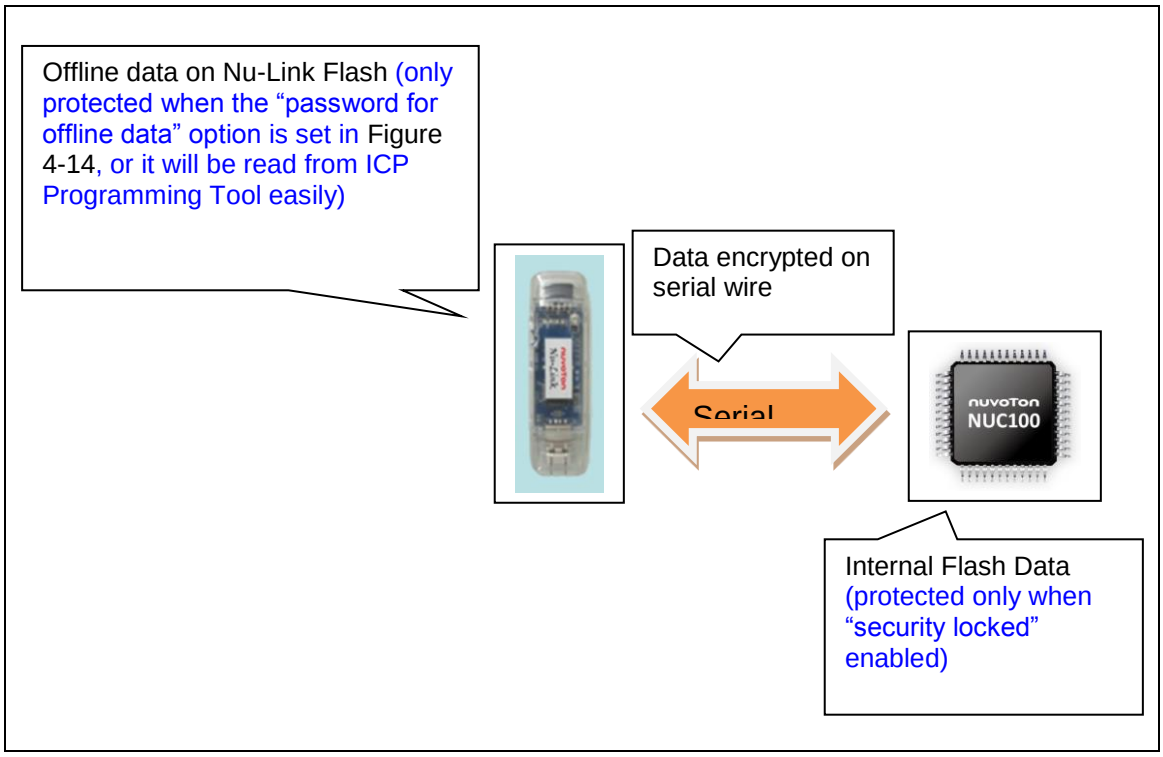

Figure 6-1 Binary Code Protection in Offline Programming Mode

If code security is your concern, it is suggested to set the "**password for offline data**" in Figure 4-14, and enable "**Security lock**" in Figure 4-8.
To limit offline download times for Nu-Link, please enable the "**Limit the number of offline programming**" option as shown in Figure 4-14.

7 Nu-Link Firmware Update

Follow the steps below to update firmware update:

Step 1: Run the ICP Programming Tool. Click ‘Connect' and start to connect to a device. If the firmware version and driver version are not matched, a firmware update dialog will be displayed, as shown in Figure 7-1.

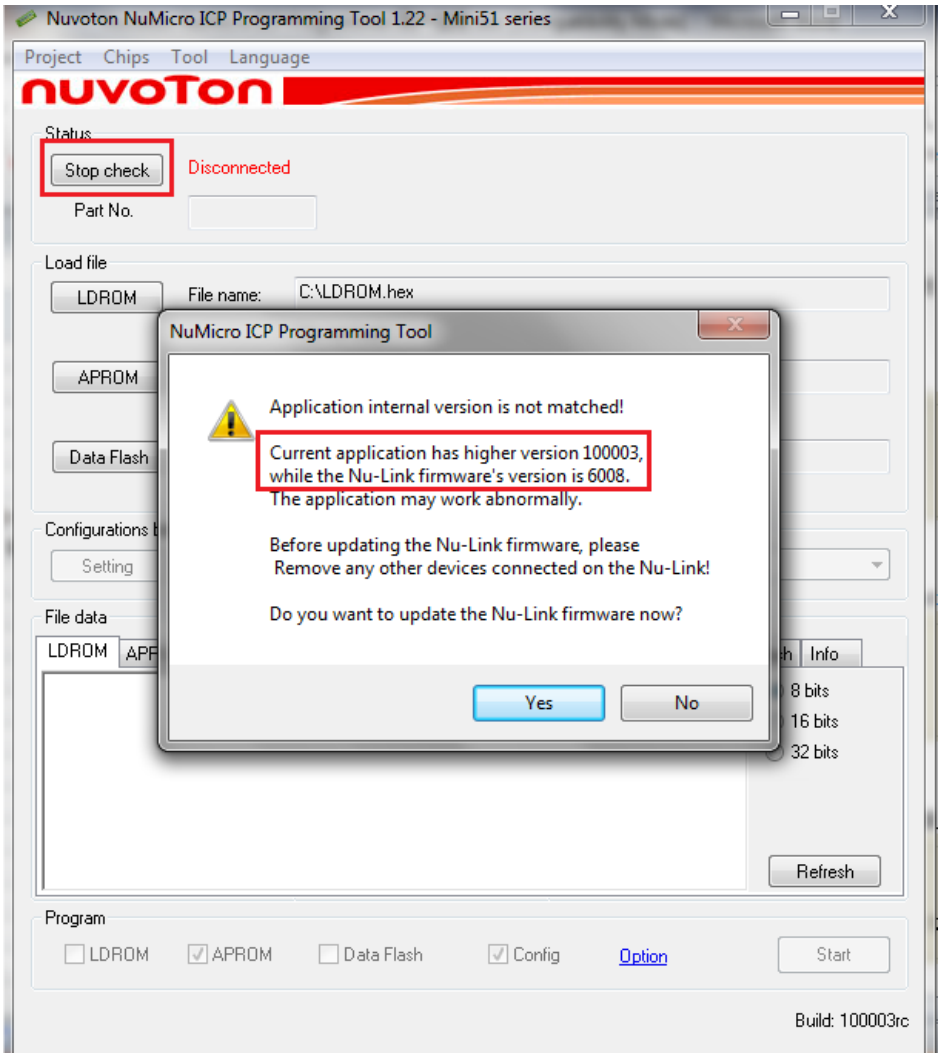

Figure 7-1 Firmware Update Selection Dialog Box

Step 2: Click "**Yes**" to update firmware, as shown in Figure 7-2.

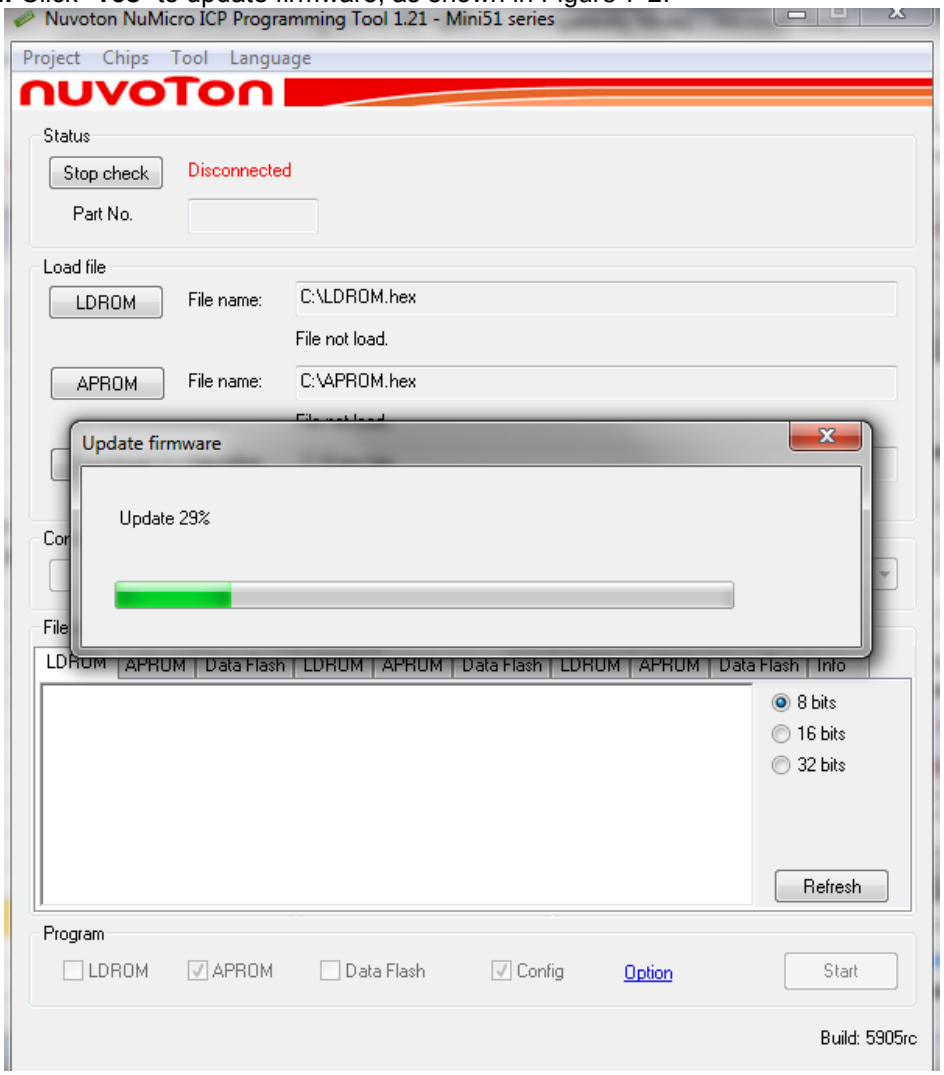

Figure 7-2 Firmware Update Dialog Box

Once the update is completed, user needs to re-connect the Nu-link to PC, as shown in Figure 7-3.

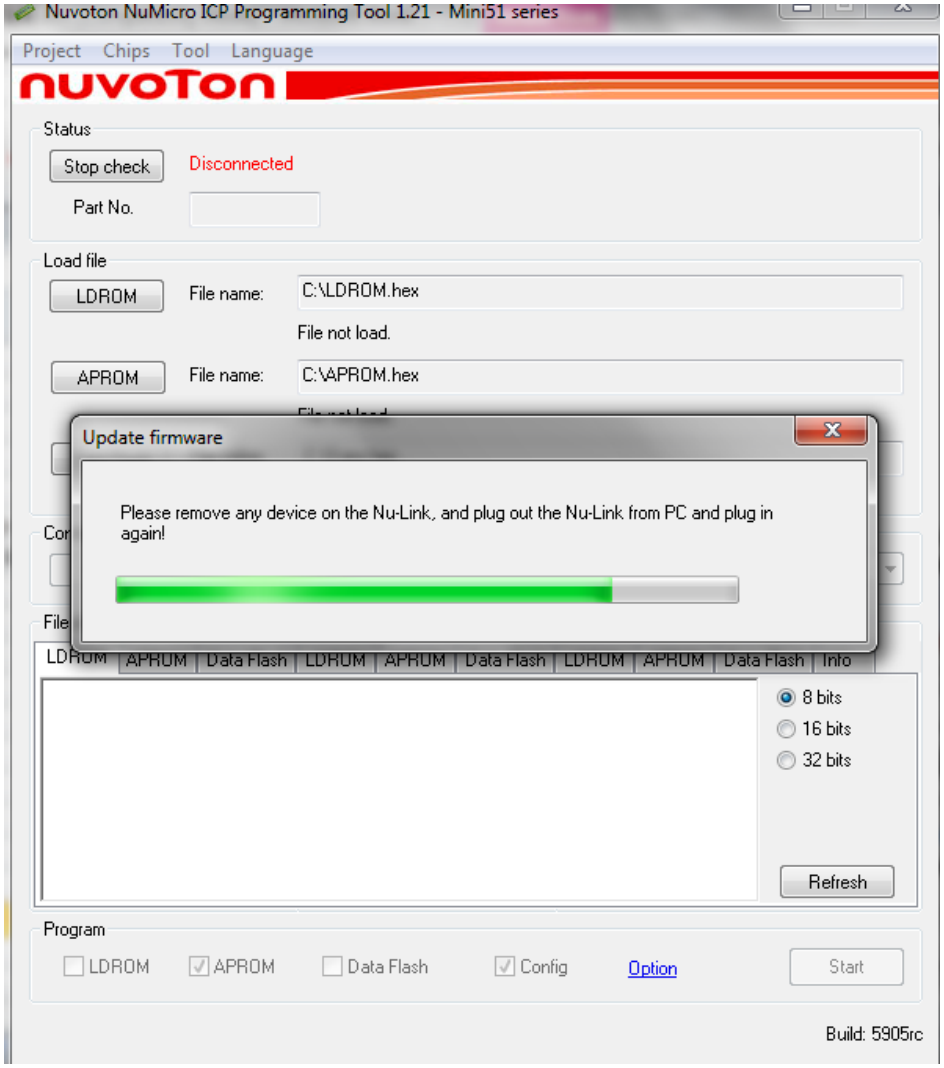

Figure 7-3 Re-connect Nu-Link to Complete Firmware Update

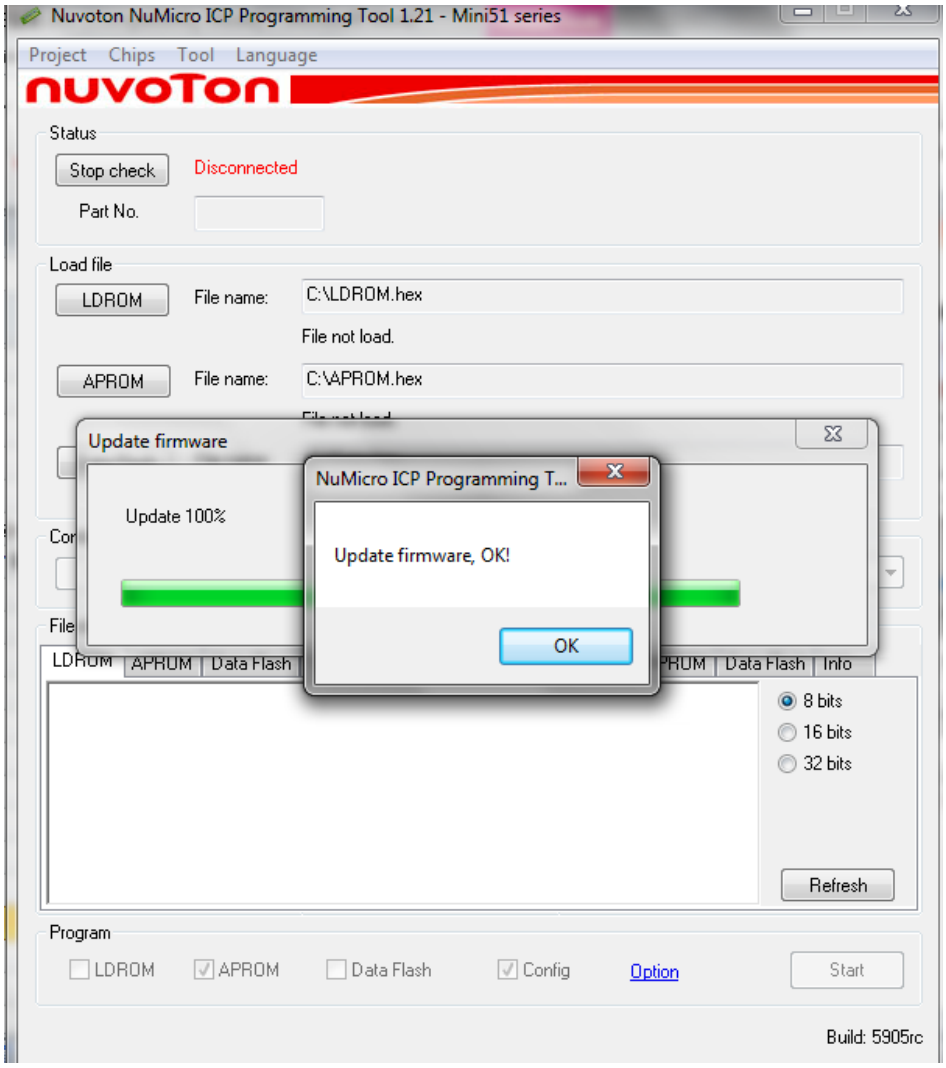

Figure 7-4 Update Firmware Completely

8 Features of Specific Series

8.1 Support for NUC505 Series

8.1.1 Main Window for NUC505 Series

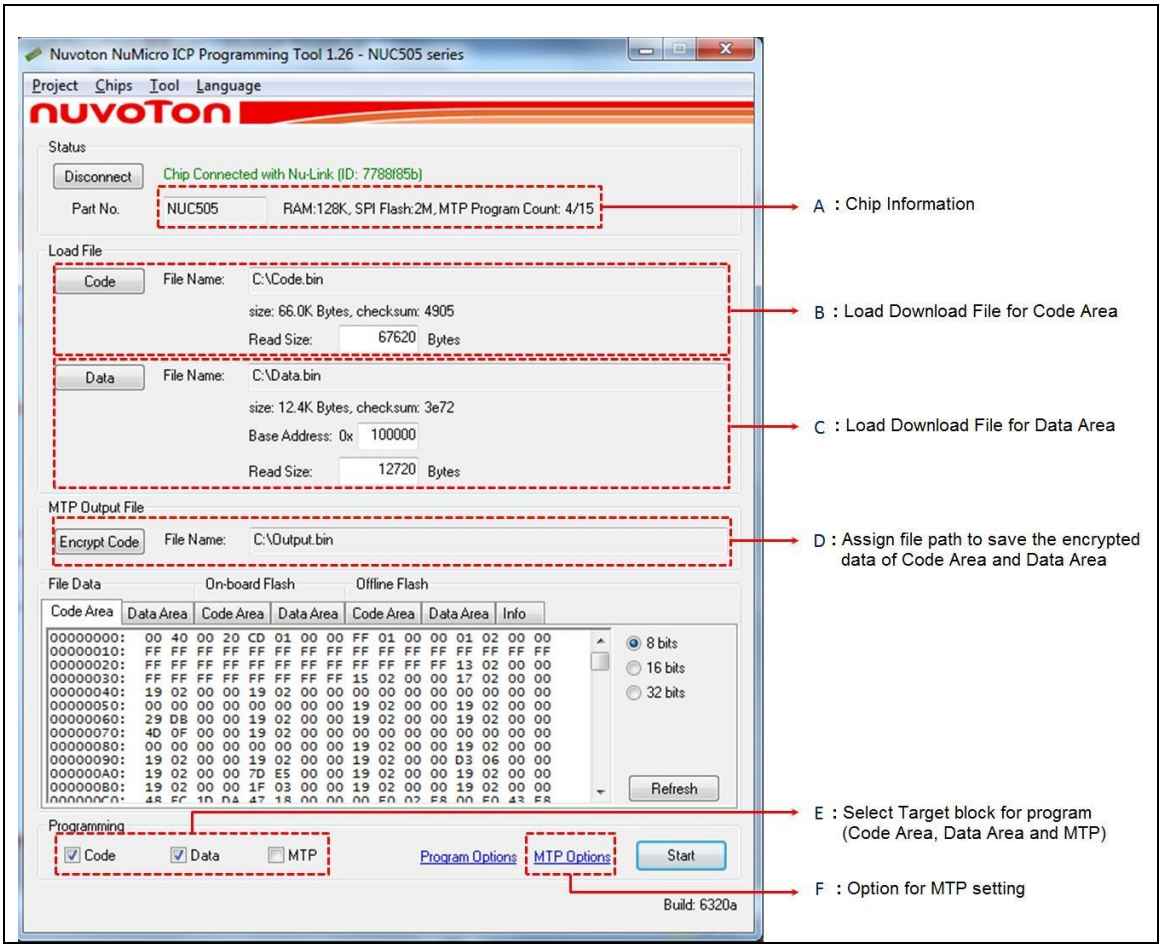

Figure 8-1 Main Window for NUC505 Series

After a target chip is detected, the ICP Tool would read chip information (including Part No., RAM size, SPI Flash size and MTP status) and show the information on section A in Figure 8-1. If MTP is locked, MTP status shows “MTP: Locked” in red and the “MTP” option is also unchecked.

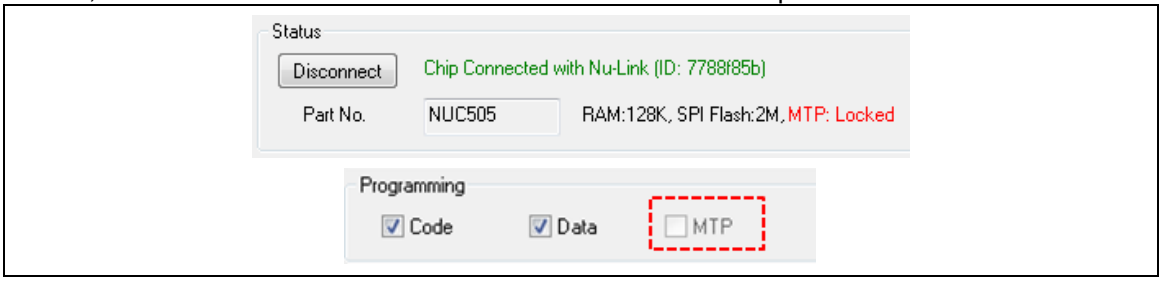

Figure 8-2 NUC505 Chip Information and MTP Status

Due to reading all contents of SPI Flash is time-consuming, partial-read from the assigned base address (Code Area is fixed at 0x0) and read size are provided (referring to section B and C in Figure 8-1). The "**Base Address**" and "**Read Size**" show different input format respectively. The "**Base Address**" is hex-coded, and "**Read Size**" is decimal-coded. User can read any range of SPI Flash by clicking "**Refresh**".

If MTP had ever been programmed or MTP is selected for this program, user can assign the file path (section D in Figure 8-1). When the programming process is ended, the ICP tool would merge the encrypted data of Code Area and Data Area into a binary file and save it to the assigned path. User can use ciphertext/plaintext binary to do ICP online/offline programming, based on whether target chip MTP key has been pre-programmed or not. In General, has to use ciphtertext when MTP has been pre-programmed. For more detail, please refer to http://www.nuvoton.com/resource-files/AN_0010_ICP_Programming_Guide_EN_Rev1.00.pdf

Before starting to program a target board, user can select target blocks for programming (section E in Figure 8-1).

By clicking "**MTP Options**" (section F in Figure 8-1), user can open the MTP Option form and configure MTP related settings.

8.1.2 MTP Options

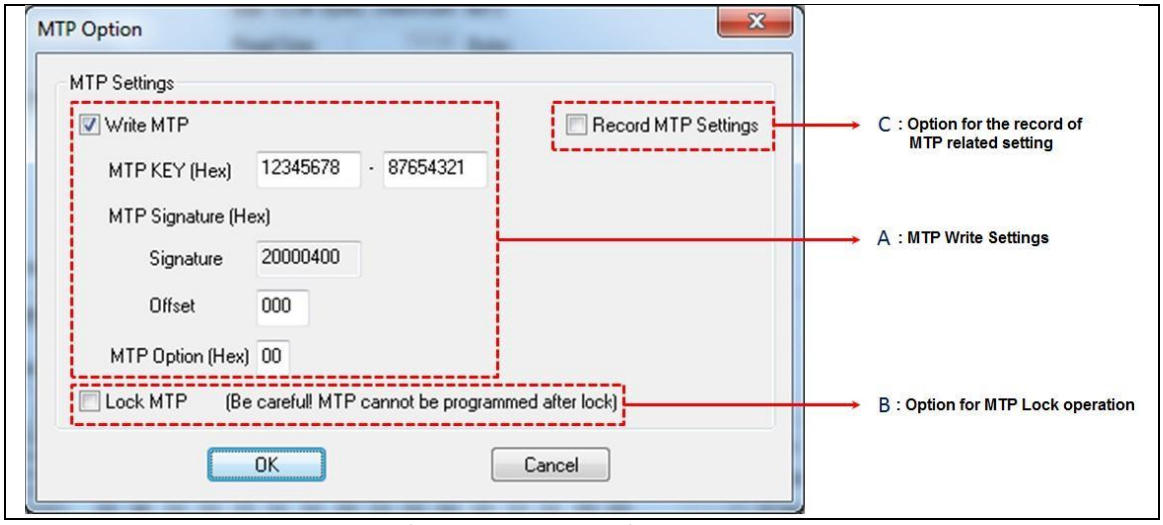

Figure 8-3 MTP Options

On the *MTP Option* form, user can select the desired operation and fill in MTP keys and signature. The options and fields are described below:

- "**Write MTP**": Write 64-bit key, 32-bit Signature, 12-bit Offset, and 1-byte Option with hex-code input format. If the file for Code Area is loaded, Tool will search the corresponding 32-bit value and fill in the "Signature" automatically according to the address of "Offset".

32-bit Signature is used to authenticate programmed binary, if the Signature on SPI Flash is not matched with user's input, system will boot up fail.

It is suggested to locate Signature after the end of interrupt vector table. (e.g. 0x100).

MTP Option (Hex) byte is another method to do authentication and is optional, user can ignore this if there is no special need.

For more details, please refer to http://www.nuvoton.com/resource-files/AN_0010_ICP_Programming_Guide_EN_Rev1.00.pdf

- "**Lock MTP**": Lock MTP. MTP cannot be programmed after lock.
- "**Record MTP Settings**": If this option is checked, the MTP settings including MTP Key and Signature on MTP Option Dialog will be recorded after clicking "**OK**". When the ICP Tool is reopened, the previous MTP settings will be restored.

8.2 Support for M480 Series

8.2.1 Main Window for M480 Series

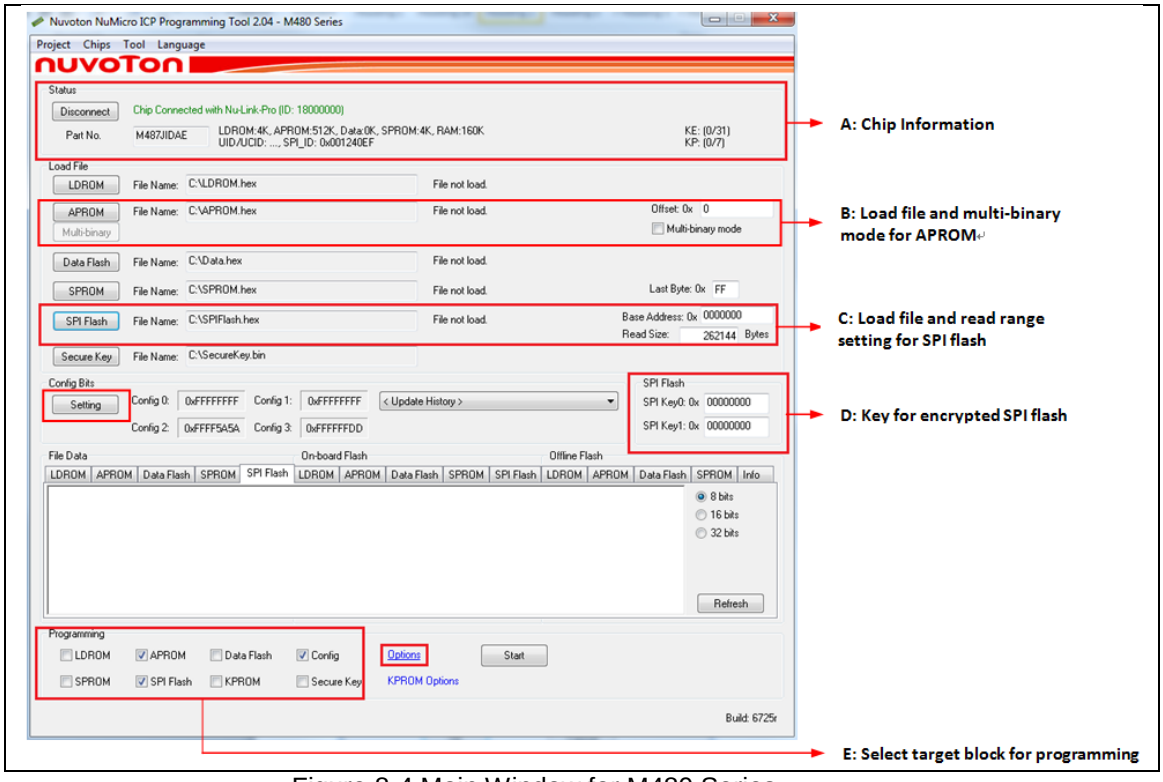

Figure 8-4 Main Window for M480 Series

Section A: Show the part no., LDROM, APROM, data Flash, SPROM, RAM size and SPI Flash ID of target chip information.

Section B: Load programming APROM file path or Load multiple binary file path using multi-binary mode.

Section C: Load programming SPI Flash file path and setting start address and read size for programming or reading SPI Flash. Due to reading all contents of SPI Flash is time-consuming, partial-read from the assigned base address and read size are provided. The "Base Address" and "Read Size" show different input format respectively. The "Base Address" is hex-coded, and "Read Size" is decimal-coded. User can read specific range of SPI Flash by clicking **"Refresh"** button.

Section D: User can assign SPI key0 and key1 to program encrypted file data to SPI Flash. If SPI key0 value is 0 or SPI key1 value is 0, ICP tool will not encrypt file data.

Section E: Select a target chip block for programming.

After clicking the “Connect” button, the ICP Tool would read chip information (including Part No., internal Flash size, RAM size, SPI Flash ID and KPROM status) and show the information. If SPI Flash is not detected, the value is 0xFFFFFFFF and the “SPI Flash” option is also unchecked in Figure 8-5.

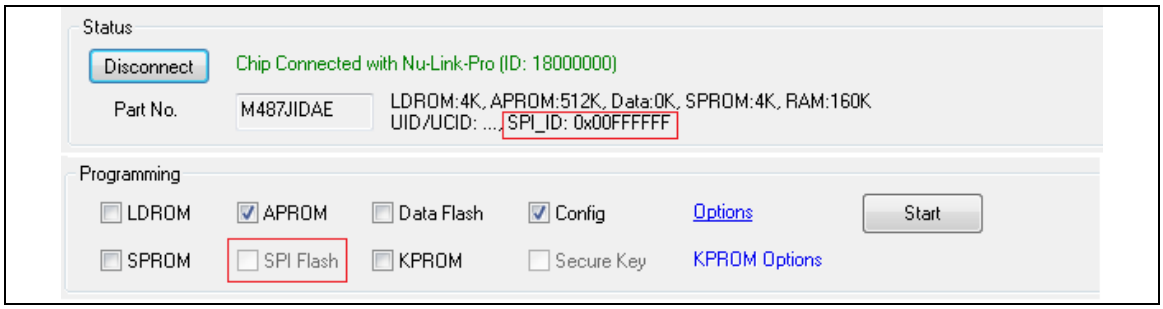

Figure 8-5 SPI Flash Status

Click config bits **“Setting”** button in Figure 8-4 and show the Chip Options form. In Chip Options form, user can select the SPIM multi–function pin option base on SPIM function pin status of target chip in Figure 8-6. After programming config of SPIM setting, ICP tool will detect the valid SPI ID value and enable **“SPI Flash”** option.

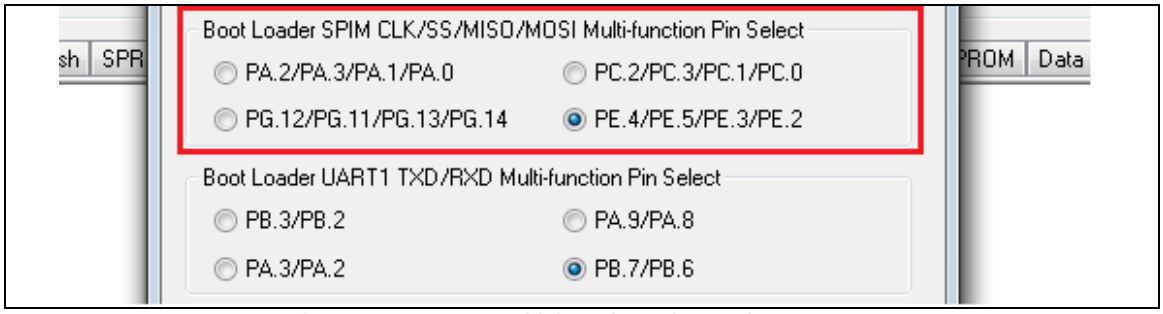

Figure 8-6 SPIM Multi-function Pin Setting

8.2.2 SPI Flash Programming

The ICP tool SPI Flash programming can be ciphertext or plaintext by assigned SPI key. If SPI key0 or key1 value is 0, ICP tool will program data without encrypting binary file to SPI Flash. Due to the SPI Flash data is plaintext , user can verify SPI Flash data by checking the verify SPI option in Program Option form in Figure 8-7.

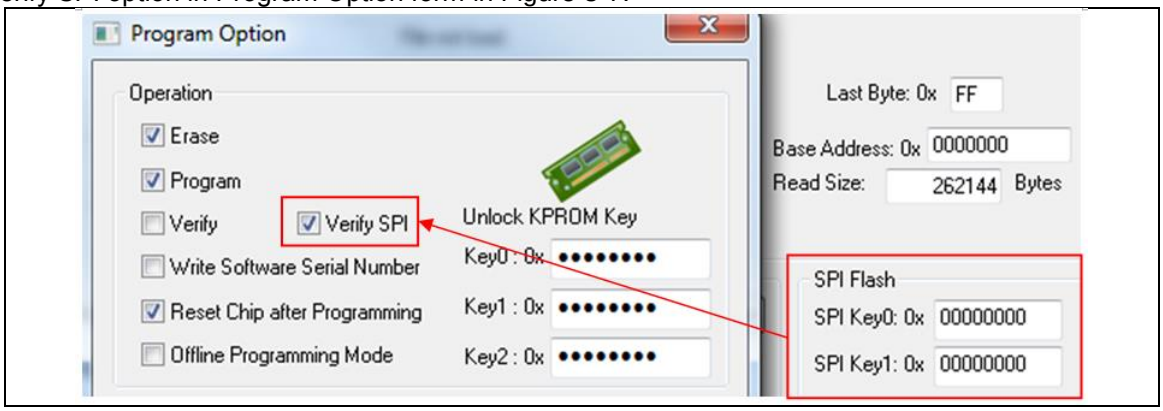

Figure 8-7 Plain Data Setting for SPI Flash Programming

If SPI key0 and key1 value is not 0, ICP tool will use SPI key0 and key1 to encrypt binary file and program to SPI Flash. Due to the SPI Flash data is ciphertext, the **"Verify SPI"** option disable in Program Option form in Figure 8-8.

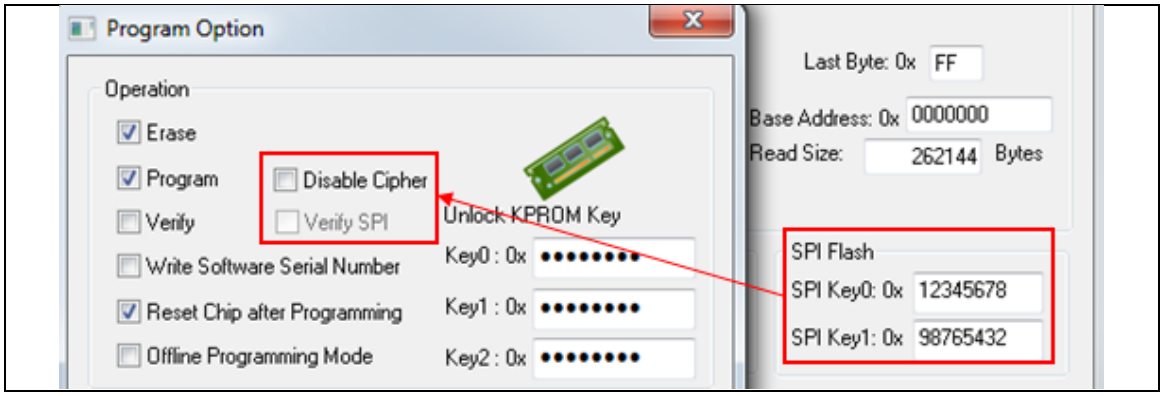

Figure 8-8 Encrypted Data Setting for SPI Flash Programming

User can also keep the SPI key value and program data to SPI Flash without encrypting binary file by checking the **"Disable Cipher"** option in Figure 8-8.

After programming ciphertext data to SPI Flash, User can save the encrypted SPI Flash data to file in Figure 8-9. Follow the steps below:

Step 1: Select "SPI Flash" On-board Flash tab.

Step 2: Click **"Refresh"** button and ICP tool read back the Flash data.

Step 3: Click **"Save As"** button and save ciphertext to binary file.

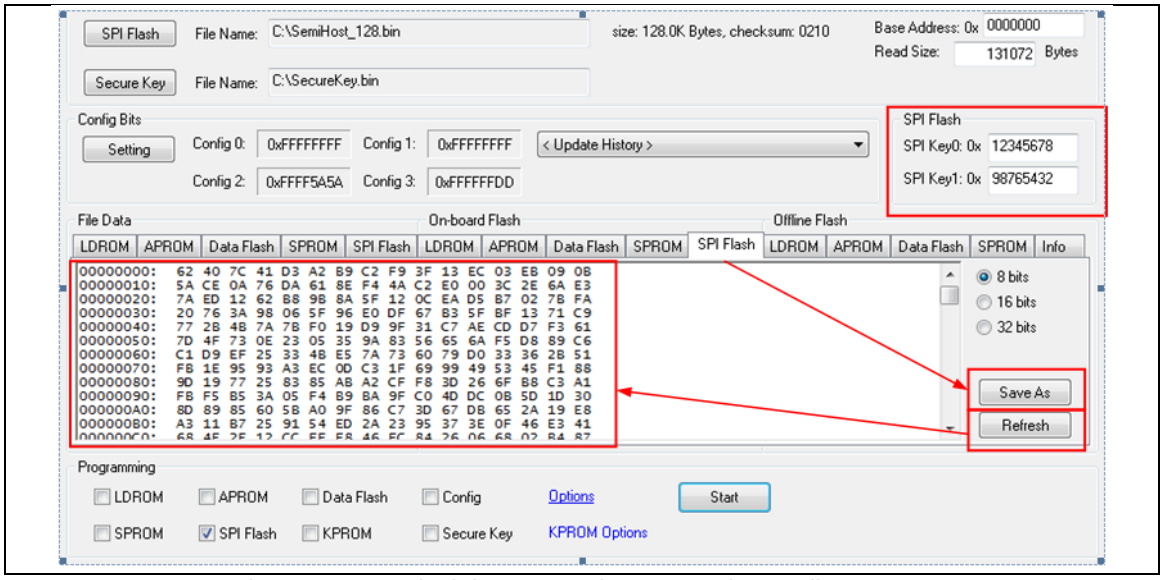

Figure 8-9 Read Ciphertext and Save to Binary File

8.2.3 KPROM Setting

ICP tool provide KPROM programming for writing protection of KPROM and APROM region. Select **"KPROM"** option in programming options and click **"KPROM options"** to set KPROM key setting in Figure 8-10.

Figure 8-10 KPROM Option

On the KPROM Key Setting form, user can select the desired operation and fill in KPROM keys and error key retry counts. KPROM keys are three 32-bit with hex-code input format. User can set the key0 ~ key2, error key retry counts and the optional write-protected region of Config or SPROM in Figure 8-11.

KPROM key setting will be recorded after clicking "OK" button. But the ICP tool is reopened, the previous KPROM key setting will not be recorded. User need to set the KPROM key setting again.

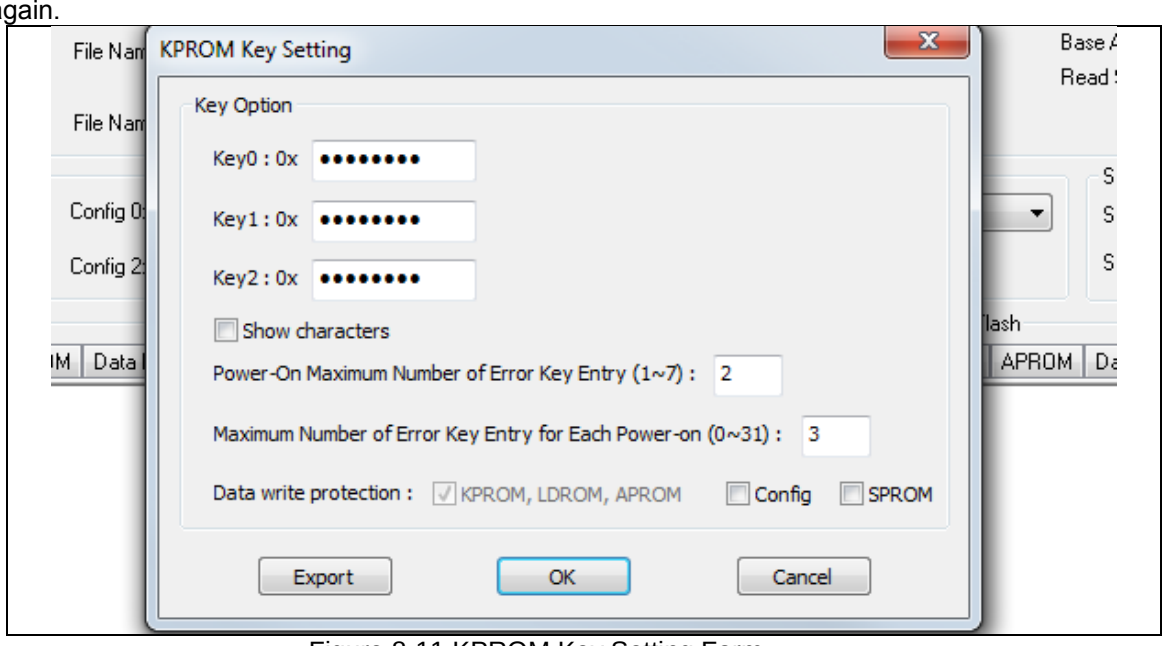

Figure 8-11 KPROM Key Setting Form

8.2.4 Secure Boot Key and Information Block Programming

ICP tool provide secure boot key and information programming. Secure boot key programming need to load secure boot key file, so user can generate secure boot key file by using **"Tool" -> "Create Secure Key File"** menu item in Figure 8-12.

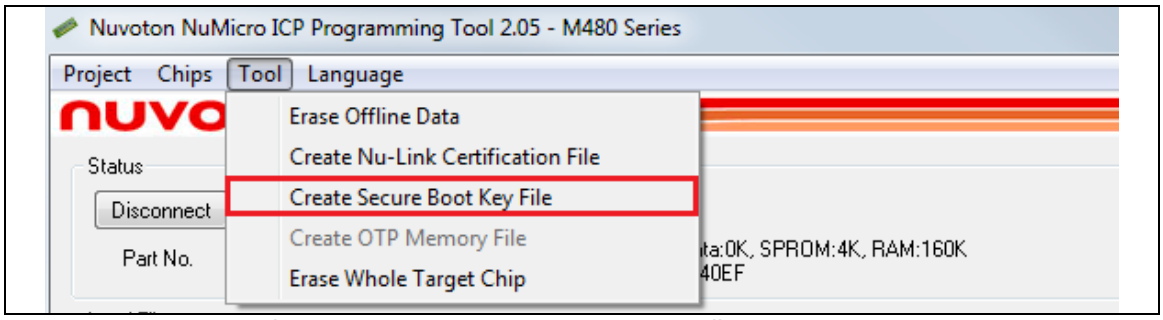

Figure 8-12 Create Secure Boot Key File Menu

On the Create Secure Key File form, user can select the desired operation in Figure 8-13. The options and fields are described below:

- "**Generate**": Random generate a secure boot key. User can also edit the key in key field.
- **"Export":** Save current secure boot key in key field to file.
- **"Import":** Select a secure boot key file and load key in the field.

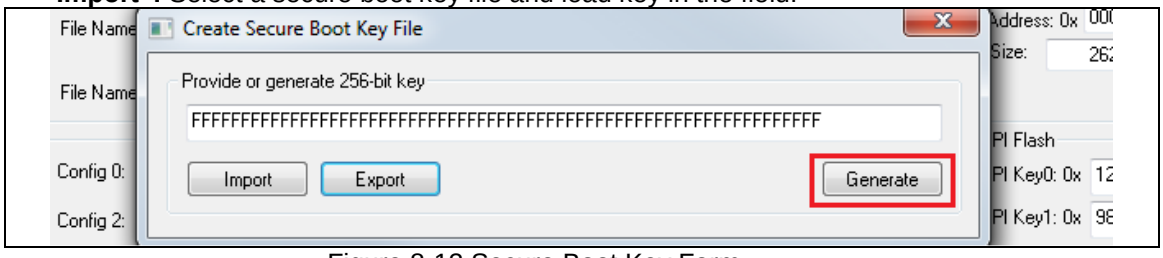

Figure 8-13 Secure Boot Key Form

To program secure boot key and information block, follow the steps below:

Step1: Click **"**Secure **Key"** button to load secure boot key file.

Step2: Select the target block in programming options and load the corresponding binary file of target block (LDROM, APROM or SPI Flash).

Step3: Click **"Setting"** button to enable **"boot Loader"** option in Figure 8-14

Step4: Select **"KPROM"** button and click **"KPROM Options"** to set KPROM key setting.

Step5: Select **"Secure Key"** option in programming options and click **"Start"** button to program in Figure 8-15.

Note: Once the **"Boot Loader"** option is enabled, Config, KPROM and Secure Key options must be enabled in programming options.

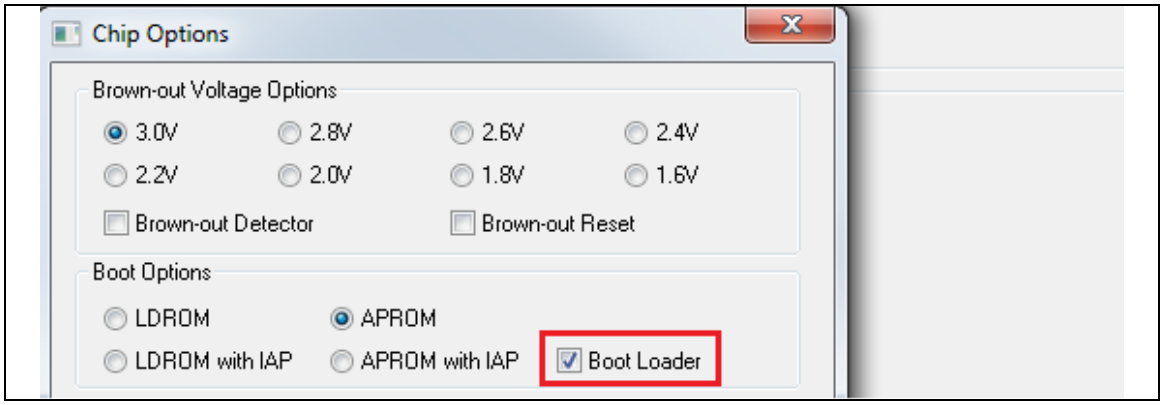

Figure 8-14 Boot Loader Option

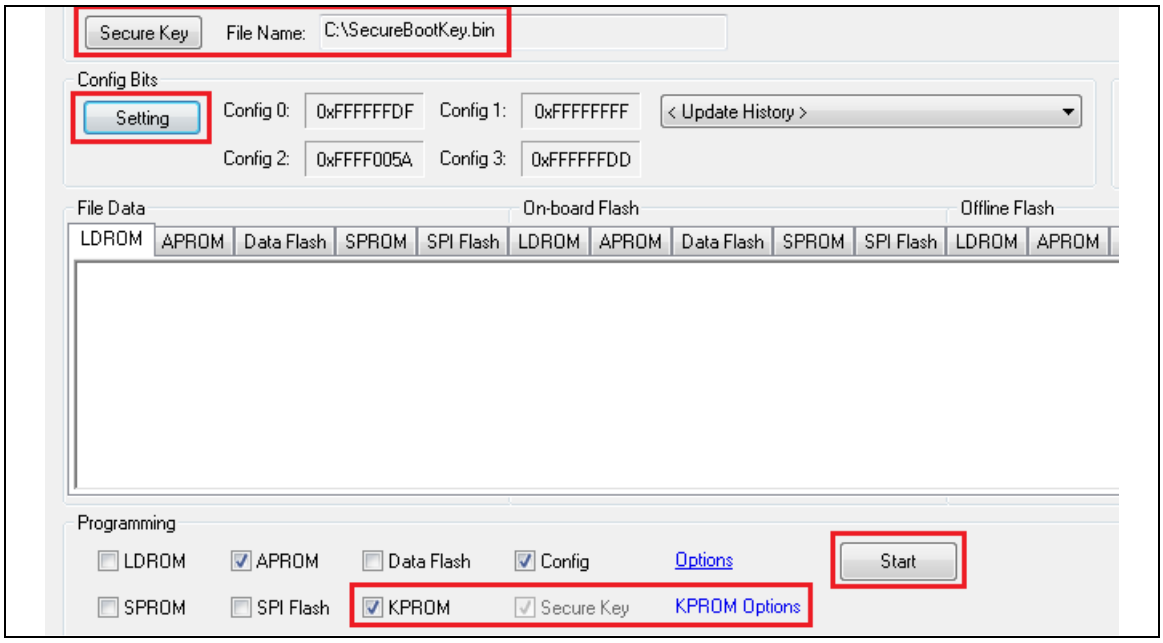

Figure 8-15 Program Secure Boot Key and Information Block

8.2.5 Multi-binary Mode

User can load multiple binary files to program APROM region separately.
In multi-binary mode, user needs to enable the "**Multi-binary mode**" option as shown in Figure 8-16.

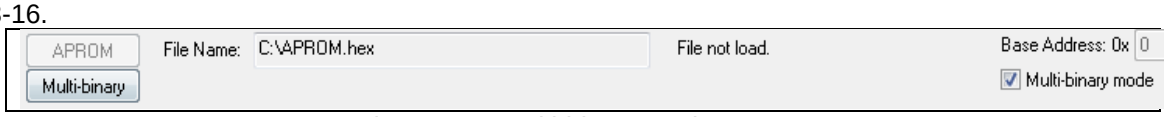

Figure 8-16 Multi-binary Mode

The "**Load Multiple Binary File**" form will be displayed after clicking the "**Multi-binary**" button as shown in Figure 8-17.

In "**Load Multiple Binary File**" form, user can load multiple files and set the start address and protection property.

- Use "**Add**" button to load a file and insert an item to the list.

- Use “**Remove**” button to delete an item from the list.
- Use “**Modify**” button to set offset value and protection column item to the list.
- Set the file programming region as authentication and validation code by selecting “**Protection**” combo box.
- Set the “**Offset**” value to define the start address of file programming.

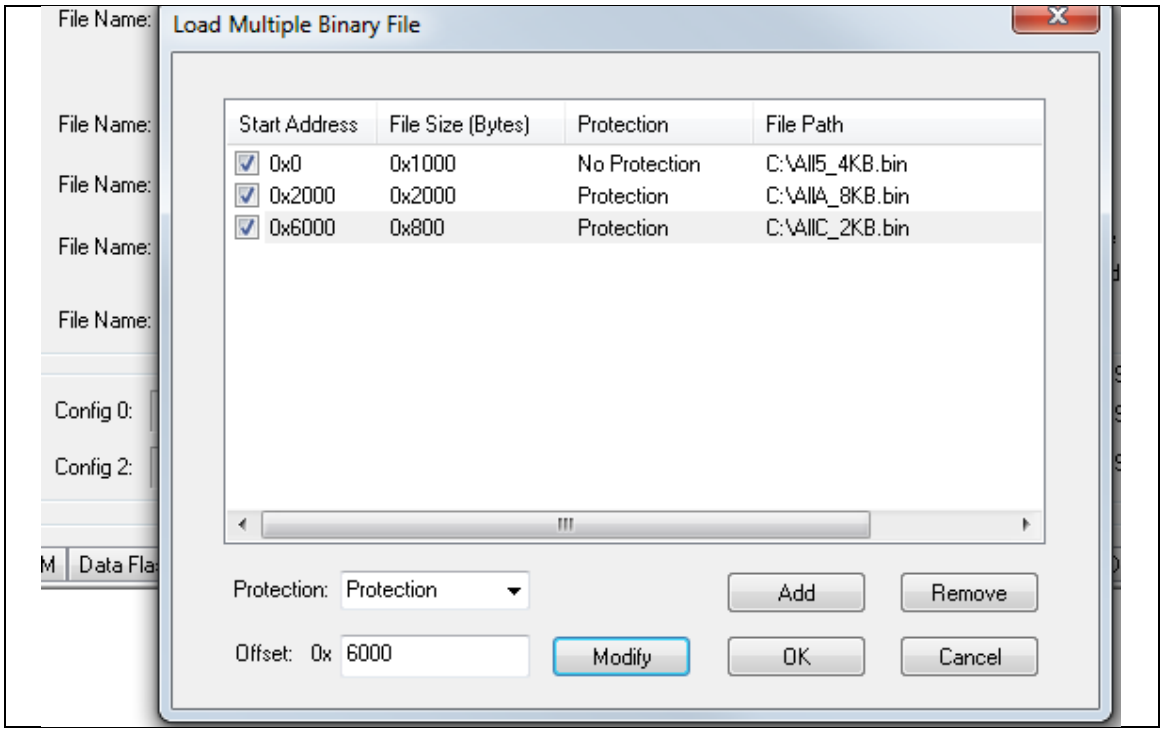

Figure 8-17 Load Multiple Binary Files

9 Revision History

Date	Revision	Description
2010.01.28	1.01.001	First version.
2010.02.24	1.01.002	Added offline programming mode.
2010.06.04	1.01.003	Changed key & LED definition.
2010.06.22	1.02.001	Added chip select and offline security.
2010.07.22	1.03.001	Supported M502x series.
2011.08.03	1.17.001	Supported Mini51/Nano100 series. Added more features in offline programming mode.
2012.08.10	1.19.001	Supported NUC200.
2013.07.01	1.20.001	Supported NUC200 and NUC123 series. Added firmware update and Nuvoton announcement.
2014.02.10	1.21.001	Changed document format.
2014.08.08	1.21.002	Added security chapter and reorganized document.
2014.09.05	1.22.001	Changed document and figure format.
2018.05.24	2.04.001	Added M480 series
2018.12.21	2.06.001	Changed document and figure format.

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