C2Prog User Manual

Version 2.0

May 27, 2023

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Contents

1 Introduction

C2Prog consists of a collection of tools for programming TI C2000™ MCUs.

Besides reflashing over JTAG, C2Prog also supports reflashing over RS-232, RS-485, TCP/IP and Controller Area Network (CAN). It is, therefore, well suited for deployment in the field where the JTAG port is typically not accessible.

Some salient features of C2Prog are:

- Ease of use and reliable operation.
- Support for multiple communication interfaces and protocols.
- Smart flash erase, or manual sector section selection.
- Automatic 32-bit CRC generation for flash integrity verification at MCU bootup.
- "Extended Hex" file format for firmware distribution (encapsulates all settings for programming, including the secondary bootloader).
- Firmware password protection.
- Firmware encryption.
- Fast serial communication protocol that works reliably with USB-to-RS-232 converters.
- Communication protocol compatible with multidrop networks (RS-485).
- Support for Texas Instruments XDS JTAG emulators.
- CAN communications based on ISO-14229/15765.
- GNU debug (GDB) server stub.
- Command-line and DLL interface for batch programming and integration of C2Prog functionality into other applications (requires "professional" or "integration" license for C2Prog –- see our `CodeShop`).
- JSON-RPC server for using C2Prog from a CI/CD pipeline.
- Flexible and modular design allowing for customer specific solutions.
- Small footprint application.
- Cross-platform (Windows, macOS, Linux) binaries for Intel and ARM.

C2Prog includes the following modules:

- **C2Prog** — graphical user interface
- **c2p-cli** — headless command line interface
- **c2p-server** — JSON-RPC server
- **c2p-gdb** — GDB client with support for scripting

2 Quick Start

2.1 Installation

The most recent version of the programmer can be downloaded from the C2Prog website:

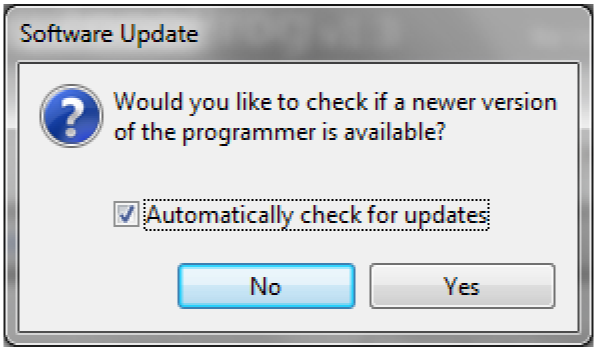
`https://c2prog.com/download/`

For Windows, an installer executable is provided. C2Prog can also be uninstalled from the control panel similar to other Windows software.

For macOS, the C2Prog application is distributed as a disk image. Simply mount the image and copy the application to a location of your choosing.

For Linux, the application files are contained in a self-extractable **makeself** shell script.

When the programmer is launched for the first time, an option is presented to check if a newer version is available. It is highly recommended that the most recent version be installed.



Software Update

Would you like to check if a newer version of the programmer is available?

☑ Automatically check for updates

If the **Automatically check for updates** option is enabled, the programmer will periodically query the update-server to check if a newer version of the application is available.

☞ **Privacy:** When communicating with the CodeSkin update-server, C2Prog will transmit the C2Prog version number and installation ID. The web server will further have access to the public IP address of the network from which the request is made. CodesSkin may use this data for compiling anonymous statistics. However, no proprietary or personally identifiable data is ever transmitted or collected.

2.2 Supported Binary Files

C2Prog supports all binary files generated by the TI codegen tools, including COFF/ELF (*.out) files and Intel hex (.hex) files.

If you want to use hex files with C2Prog, then you must generate them as follows:

C2400 Tools:

```
dsphex -romwidth 16 -memwidth 16 -i -o .\Debug\code.hex .\Debug\code.out
```

C2000 Tools:

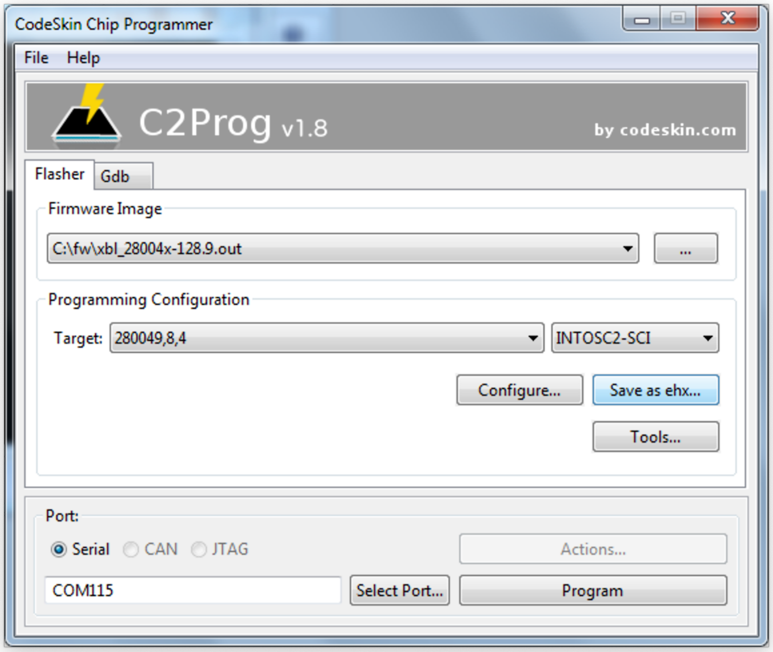
```
hex2000 -romwidth 16 -memwidth 16 -i -o .\Debug\test.hex .\Debug\test.out
```

ARM Tools:

```
armhex -romwidth 8 -memwidth 8 -i -o .\Debug\test.hex .\Debug\test.out
```

2.3 Programming (over RS-232)

This section demonstrates the use of C2Prog in conjunction with TI's SCI bootloader. Please refer to the TI Boot ROM Reference Guides for information on how to configure your target for SCI programming. In order to operate with the C2Prog default settings, the serial link must be capable of full duplex communication at 115200 baud. Slower links are supported, but will require custom settings.



Firmware Image: C:\fw\xbl_28004x-128.9.out

Programming Configuration

Target: 280049,8,4 INTOSC2-SCI

Port: ● Serial ○ CAN ○ JTAG

COM115

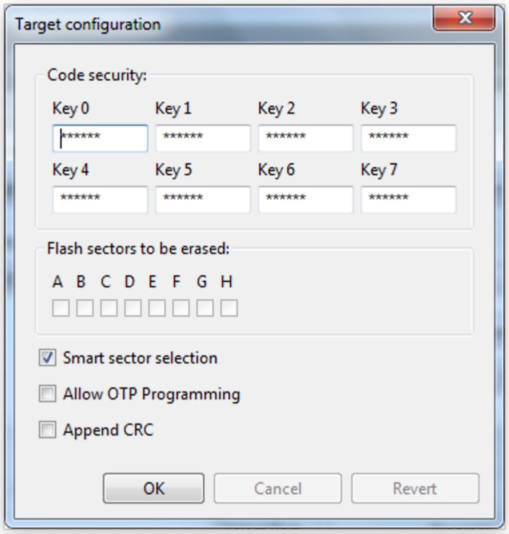
Activate the **Flasher** tab and select the **Firmware Image** (binary file) by means of the **...** popup menu.

Raw binary files do not define any target specific programming information such as the type of MCU to be flashed, the oscillator frequency, the communication protocol to be used, etc. You must therefore configure this information in the **Programming Configuration** section by choosing the appropriate MCU part-name and option (e.g. clock frequency and communication interface - see Section 3.11 on page 20). Contact CodeSkin at info@codeskin.com if no match is found for your hardware.

Next click on **Configure...** to open the configuration dialog.

For programming a locked C2000™ MCU, valid CSM keys (passwords) must be provided as 4 digit hex numbers (with ’0x’ or ’$’ prefix). In the case of 32-bit keys, each key is split into two 16-bit keys in big endian (BE) order. Note that contrary to the other fields, keys are not remembered as defaults.

Now you must select which flash sectors should be erased prior to programming. This is either done manually by checking the individual boxes, or by choosing **Smart Sector Selection**. The smart sector feature automatically detects which sectors require erasing by parsing the contents of the binary file.



Target configuration

Code security:

Key 0 ****** Key 1 ****** Key 2 ****** Key 3 ******

Key 4 ****** Key 5 ****** Key 6 ****** Key 7 ******

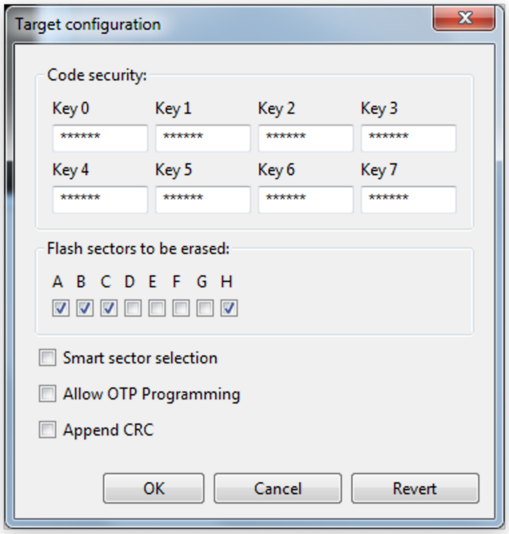
Flash sectors to be erased:

A □ B □ C □ D □ E □ F □ G □ H □

☑ Smart sector selection

□ Allow OTP Programming

□ Append CRC



Target configuration

Code security:

Key 0 ****** Key 1 ****** Key 2 ****** Key 3 ******

Key 4 ****** Key 5 ****** Key 6 ****** Key 7 ******

Flash sectors to be erased:

A ☑ B ☑ C ☑ D □ E □ F □ G □ H ☑

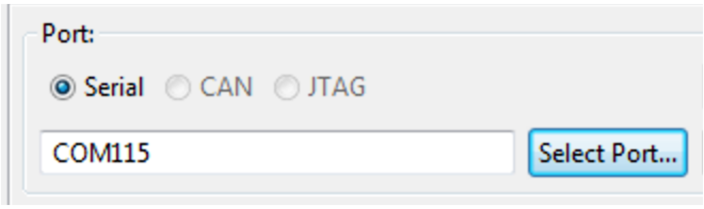
□ Smart sector selection

□ Allow OTP Programming

□ Append CRC

As a further option, **Append Checksum** can be selected, which instructs the programmer to append a 32-bit CRC checksum to the hex data. This checksum can be used by the MCU to verify the integrity of the flash data, as described later in this document.

Once all the programming configurations are made, configure the COM port, either by typing its name directly into the text-field, or clicking on the **Select Port...** button. Valid entries for the serial port on the windows platform are COM1, COM2, etc.



Port:

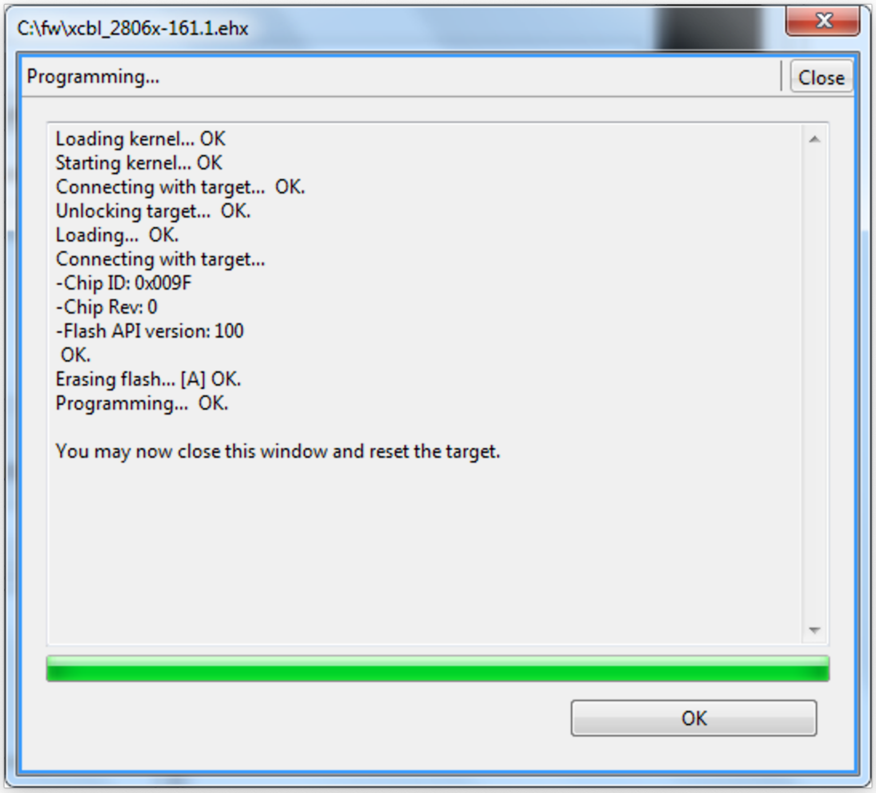
● Serial ○ CAN ○ JTAG

COM115

The **Scan Ports** button in the port selection dialog automatically scans for all available serial ports. Please note that on some computers this feature can take some time to execute, especially if Bluetooth COM ports are present.

Now the reflashing process can be started by clicking the **Program** button. This will open a new window which displays status information while the programming progresses, as shown below.

⚠ Do not power-cycle or reset the target during programming.



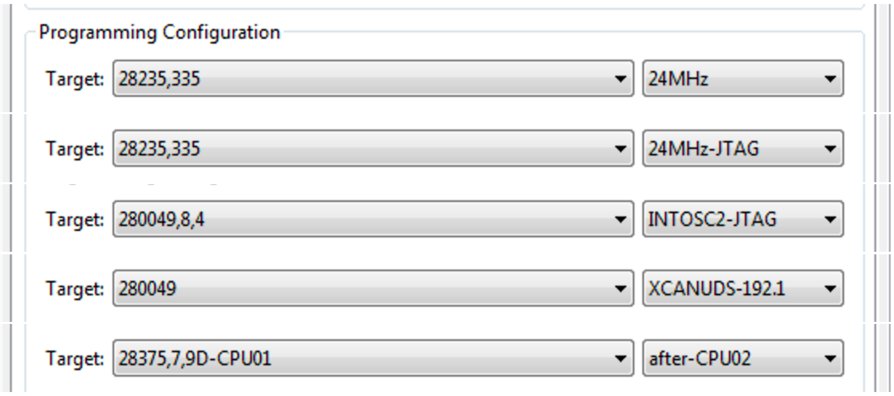
```
Loading kernel... OK
Starting kernel... OK
Connecting with target...  OK.
Unlocking target...  OK.
Loading...  OK.
Connecting with target...
-Chip ID: 0x009F
-Chip Rev: 0
-Flash API version: 100
 OK.
Erasing flash... [A] OK.
Programming...  OK.

You may now close this window and reset the target.
```

Finally, you may save the programming configuration combined with the firmware image to an Extended Hex file by clicking on the **Save as ehx...** button. When this file is subsequently selected in C2Prog, all programming settings are automatically configured. This format is thus recommended for distributing firmware images.

3 Detailed Description

3.1 Communication Protocols

C2Prog supports a number of communication protocols and interfaces. Originally designed with a focus on serial communication (RS-232/485), C2Prog also supports TCP/IP, Controller Area Network (CAN) and JTAG. The communication protocol is selected by means of drop-down fields in the **Programming Configuration**. Shown below are some examples:



Programming Configuration

Target: 28235,335 | 24MHz

Target: 28235,335 | 24MHz-JTAG

Target: 280049,8,4 | INTOSC2-JTAG

Target: 280049 | XCANUDS-192.1

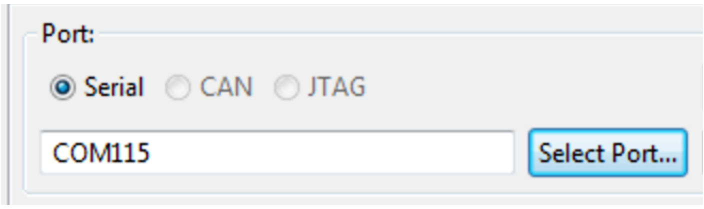
Target: 28375,7,9D-CPU01 | after-CPU02

A few comments about target options:

- Frequency values, e.g. **24MHz**, specify the external clock/crystal frequency.
- Options without explicit frequency value use the internal oscillator of the MCU.
- **INTOSC** also refers to the internal oscillator.
- The qualifier after the frequency parameter specifies the communication interface, e.g. **SCI**, **CAN**. The default interface is SCI, i.e. **24MHz** stands for SCI communication with an external clock of 24 MHz.
- Options can also refer to customer specific configurations, such as in the **XCANUDS-192.1** example.

3.2 Programming over Serial Link

The serial interface can be used with TI's SCI bootloader as well as customer specific bootloaders developed by CodeSkin. Please refer to the TI Boot ROM Reference Guides for information on how to configure your target for SCI programming. In order to operate with the C2Prog default settings, the serial link must be capable of communicating at 115200 baud and support full duplex-transmission. Slower links and half-duplex operation are supported, but will require custom settings.



Port:

● Serial ○ CAN ○ JTAG

COM115

C2Prog works most reliably with converters that utilize the FTDI chipset. A good choice, for example, is the Parallax USB to Serial Adapter. The serial port of TI's evaluation hardware is also proven to work well with C2Prog.

3.3 Programming over JTAG

C2Prog supports TI XDS emulators for flash programming and in conjunction with the GDB server (see Section 3.13 on page 23).

When you install C2Prog on Windows, an option is given to also install TI's XDS drivers and EmuPack. Alternatively, you may point C2Prog to an existing installation of the EmuPack, for example within Code Composer Studio (CCS) or UniFlash.

The manual configuration is done by means the **c2p-cli** executable:

```
c2p-cli set ccs-base-path C:\ti\ccs<version>\ccs\ccs_base
```

If you are using CCS for code development, it may be desirable that C2Prog use the same EmuPack version. Referring to an existing installation of the EmuPack can also save disk space.

On non-Windows machines, the manual configuration is required to enable programming over JTAG.

3.3.1 Port configuration

⚠ It is extremely important that the correct external clock/crystal frequency is selected, as C2Prog has no means of verifying the frequency when using JTAG. Selecting the wrong frequency may damage the MCU.

The port configuration must be formatted as follows:

- xds100v<v>:<sn>:<pid>
- xds110:<sn>

- xds110-2w:<sn>

- xds2xx

where <v> must be equal to ”1”, ”2”, etc, <sn> is the serial number of the emulator (if several are connected), and <pid> is the USB PID of the emulator hardware in hex notation. The “2w” postfix specifies use of the 2-pin cJTAG mode. Both the <sn> and <pid> parameters are optional. The default value for <pid> is 0xa6d0. Some examples for valid configuration strings include:

- “xds100v1”, “ xds100v2”, “ xds100v3”, “ xds110”, “ xds110-2w”,

- “xds100v2:TIUDCI83”

- “xds100v2:TIUDCI83:6010”

- “xds100v2::6010”

The serial number of a particular unit can be determined by means of the command-line utility stored in the `ccs_base\common\uscif\ftdi\utility` directory.

3.3.2 XDS110 Considerations

C2Prog can be configured to automatically upgrade/downgrade the firmware of XDS110 emulators. This feature is disabled by default but may be enabled by means of the **c2p-cli** executable as follows:

```
c2p-cli set xds110-auto-update on
```

The firmware update process is not always 100% reliable. Should your XDS110 emulator become unresponsive, open a command-line prompt, navigate to the `ccs_base\common\uscif\xds110` folder and execute the following sequence of commands to restore the firmware.

```
xdsdfu -m
xdsdfu -f firmware.bin
```

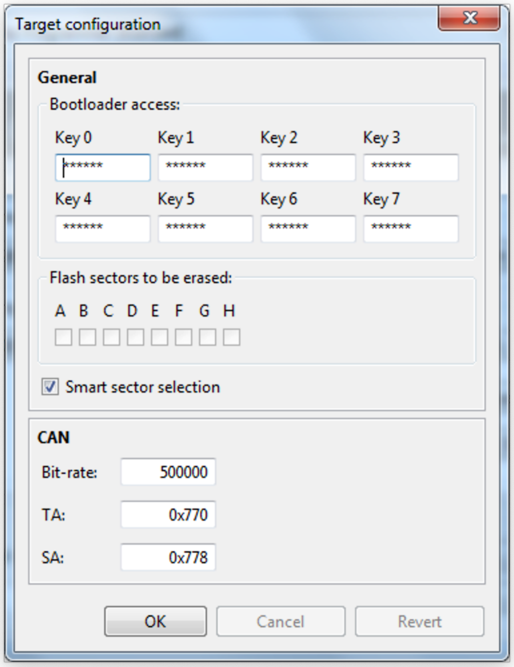
The location of the EmuPack used by C2Prog can be queried as follows:

```
c2p-cli get ccs-base-path
```

3.4 Programming over CAN

C2Prog allows programming over CAN using the “Unified Diagnostics Protocol” as defined in ISO-14229/15765 (requires custom CodeSkin CAN bootloader).

A special convention is used to allow for the configuration of custom bit-timings. In lieu of a normal baudrate, e.g. “250000”, it is possible to specify the BTR0 and BTR1 values directly as “0x8000<BTR1><BTR0>”, where BTRx stands for the bit-timing registers of the SJA1000 (or compatible) CAN controller, assuming a clock frequency of 16 MHz. For example, a value of 0x80001C03 specifies 87.5% sampling at 125 kbit/s.



General

Bootloader access:

Key 0: ******
Key 1: ******
Key 2: ******
Key 3: ******
Key 4: ******
Key 5: ******
Key 6: ******
Key 7: ******

Flash sectors to be erased:

A □ B □ C □ D □ E □ F □ G □ H □

☑ Smart sector selection

CAN

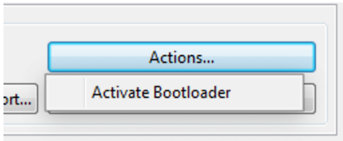
Bit-rate: 500000

TA: 0x770

SA: 0x778

When configuring CAN identifiers in the **Configure...** dialog, they can be entered as hex numbers (with ’0x’ or ’$’ prefix) or decimal numbers. An ’X’ postfix specifies an extended CAN identifier.

CodeSkin’s custom CAN bootloaders offer a mechanism to recover from unresponsive application code. This **Activate Bootloader** feature can be accessed from the **Actions...** menu.



See notes on bootloaders in the Appendix B on page 28 for more information regarding CAN bootloaders. We also encourage our users to contact CodeSkin for custom solutions.

3.4.1 CAN Adapters on Windows

On Windows, CAN hardware from Vector, Kvaser, Lawicel, NI, and PEAK-System is supported. The syntax for the port configuration is as follows:

- Lawicel: “canlw:0” – only one port supported
- Kvaser: “cankv:<n>” – where <n> is the port number (0 or 1)
- Vector: “canvec:<n>” – where <n> is the port number (0 or 1)
- NI-XNET: “canxnet:<n>” – where <n> is the port assigned to the adapter
- Peak CAN: “canpk:<n>” – where <n> is the device number as configured in PCAN-View, e.g. 255; other channels on the same device are identified as “255B”, “255C”, etc

3.4.2 CAN Adapters on Linux

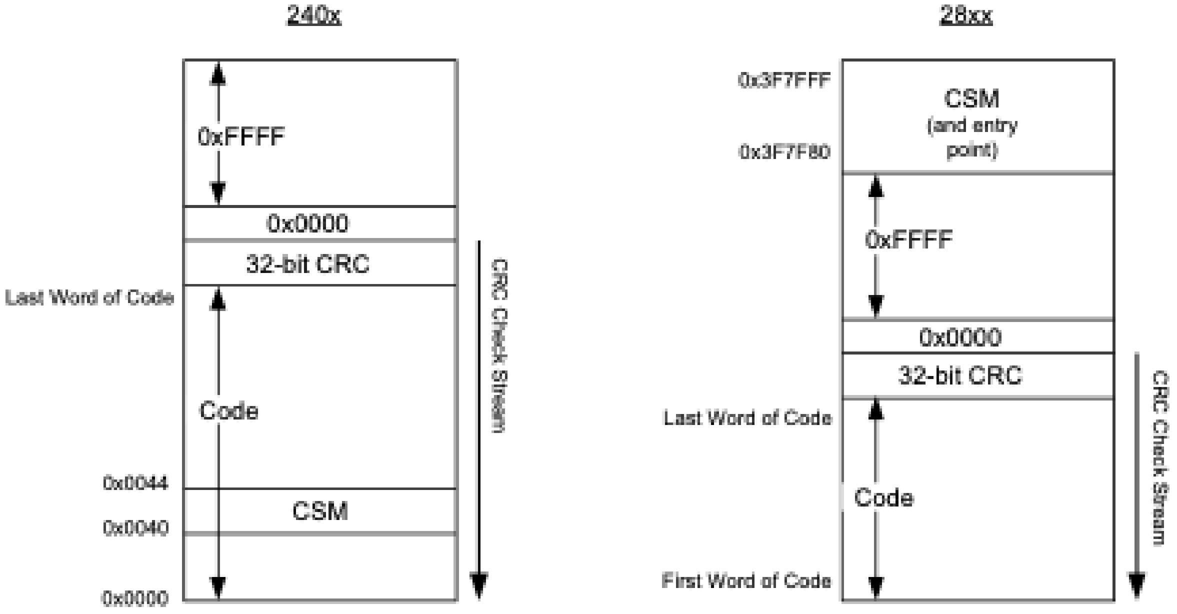
On Linux, SocketCAN is used for accessing a wide range of supported CAN hardware. The port configuration is done according to the name of the device, i.e. the netdev name, as reported by `ifconfig -a` or `ip link show`, for example ”can0”.

SocketCAN interfaces must be configured (requires root privileges) from the command line before starting a programming session.

```
sudo ip link set can0 type can bitrate 500000
sudo ip link set up can0
```

3.5 CRC Checksum

C2Prog can be configured to automatically append a 32-bit CRC to the code being programmed into flash. This allows for the embedded application to verify the flash integrity at each powerup or even periodically during operation.



If the **Append CRC** box is checked, or the "−−crc" command line option is used, C2Prog will first parse the binary-file and determine the lowest and highest address to be programmed. For a 240x MCU, this includes the CSM zone (4 keys), for a 28xx MCU, the CSM zone is ignored (including keys, reserved words, and program entry point). Next, the 32-bit CRC is calculated and appended at the top of the memory, i.e. at the two addresses above the highest address of the hex-file determined before. In addition, a CRC delimiter, one zero word (0x0000), is placed above the two CRC words.

The 32-bit CRC algorithm used has the following parameters:

- Polynomial: 0x04c11db7
- Endianess: big-endian
- Initial value: 0xFFFFFFFF
- Reflected: false
- XOR out with: 0x00000000

Test stream: 0x0123, 0x4567, 0x89AB, 0xCDEF results in CRC = 0x612793C3. Please refer to Appendix C on page 29 of this manual for a CRC32 implementation example.

In contrast to a typical data-stream with the CRC transmitted at the end, the C2Prog CRC must be verified by processing the flash data starting with the CRC, i.e. one memory address below the CRC delimiter (0x0000). A successful data-verify results in a CRC register value of zero (0x00000000).

A typical flash verification algorithm running at MCU powerup executes as follows:

1. Set a memory pointer to the highest possible program address.
2. Decrement the pointer until it points to the CRC delimiter (0x0000), skipping all 0xFFFF values.
3. Decrement the counter by one more address (at which time it points to the first CRC word).
4. Initialize the CRC register to 0xFFFFFFFF.
5. Update the register with the value addressed by the memory pointer (CRC polynomial: 0x04C11DB7).
6. Decrement memory pointer.
7. Repeat 5-6 until the memory pointer reaches the lowest program address.

8. If, at this point, the register holds 0x00000000, then the data integrity has been successfully verified.

Sample Code for 28xx with code in flash sector A:

```
#define FLASH_TOP (const uint16_t*)(0x3F7F7FL)
#define FLASH_BOT (const uint16_t*)(0x3F6000L)

const uint16_t* FlashPtr;
uint32_t CRCRegister;

FlashPtr = FLASH_TOP;
// search for CRC delimiter
while((*FlashPtr != 0x0000) && (FlashPtr > FLASH_BOT)){
  FlashPtr--;
}
// process stream, CRC first
CRCRegister = 0xFFFFFFFFL;
while(FlashPtr > FLASH_BOT){
  FlashPtr--;
  // each CRC32Step() shifts one byte into the CRC register
  CRCRegister = CRC32Step1(((*FlashPtr >> 8) & 0xFF), CRCRegister);
  CRCRegister = CRC32Step(((*FlashPtr >> 0) & 0xFF), CRCRegister);
}
// at this point CRCRegister should be reading zero
```

3.6 Code Security

C2Prog will unlock the code security module (CSM) using the keys provided with the ”−−keys” command-line option or **Configure...** dialog. In the case of 32-bit keys, each key is split into two 16-bit keys in big endian (BE) order.

For older C2000 MCUs with the keys located at a fixed locations in erasable flash memory, C2Prog will extract the keys from the firmware image if default keys of all 0xFFFF are provided.

If the MCUs has the PSWDLOCK mechanism, specifying all 0x0000 in C2Prog (−−keys, **Configure...**) will instruct C2Prog to unlock the CSM by reading the unprotected password locations in OTP.

⚠ The security zone will not be truly protected until the corresponding PWDLOCK is set. Please make sure that you review the relevant documentation from TI.

3.6.1 DCSM

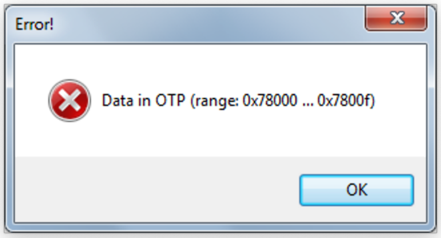
In case of MCUs with dual code security module (DCSM), C2Prog will automatically determine which zone must be unlocked in order to program a particular firmware image.

☞ It is only possible to program one security zone at a time.

⚠ Do not set the PWDLOCK of a zone unless the sector assignment for that zone has been fully configured by either explicitly requesting, or not requesting, the zone for each sector. See TI technical documentation of GRABSECT and GRABRAM registers.

3.7 OTP

C2Prog helps prevent unintentional writing to one-time programmable (OTP) memory. Unless the user generates the Extended Hex file with the ”−−allow-otp” option or checks the **Allow OTP Programming** box, C2Prog will not permit the programming of OTP locations.



Data in OTP (range: 0x78000 ... 0x7800f)

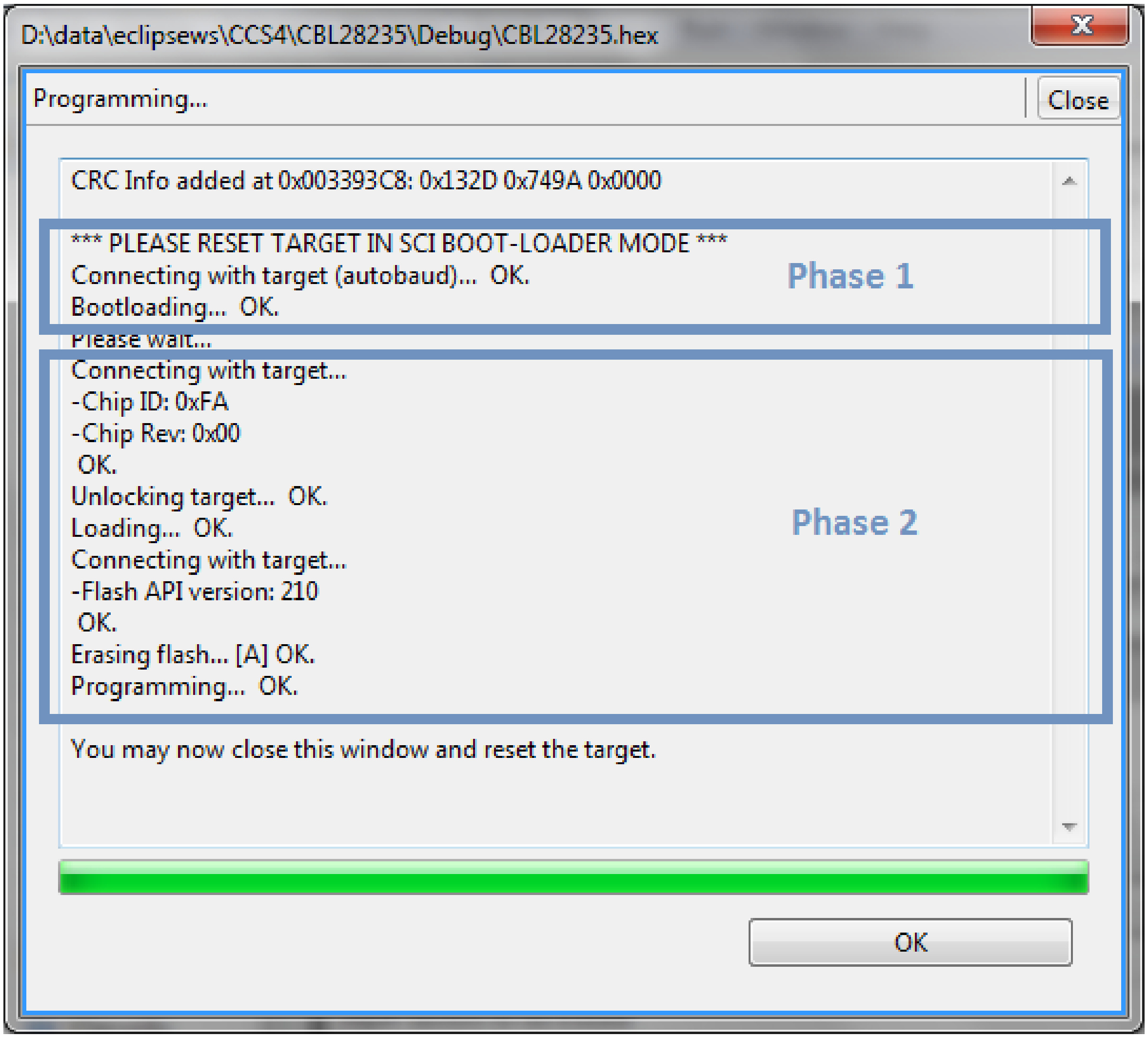
3.8 Programming Sequence

The reflashing process is typically divided into two phases:

- Phase 1: Download of secondary bootloader (SBL)
- Phase 2: Execution of SBL, erasing of flash, download of application / flash programming

☞ The programming of some targets may require additional download stages to deal with memory restrictions.

The screen capture below further illustrates the programming sequence for the serial mode in conjunction with TI's SCI bootloader. Please refer to the Appendix B on page 28 for more information on bootloaders.



```
CRC Info added at 0x003393C8: 0x132D 0x749A 0x0000

*** PLEASE RESET TARGET IN SCI BOOT-LOADER MODE ***
Connecting with target (autobaud)...  OK.
Bootloading...  OK.
Please wait...
Connecting with target...
-Chip ID: 0xFA
-Chip Rev: 0x00
 OK.
Unlocking target...  OK.
Loading...  OK.
Connecting with target...
-Flash API version: 210
 OK.
Erasing flash... [A] OK.
Programming...  OK.

You may now close this window and reset the target.
```

3.9 Extended Hex Files

The programming configuration, secondary bootloader, and contents of the binary file can be combined and saved as an "Extended Hex File" (*.ehx). This format is preferable over the raw binary file as it allows programming without requiring any manual configuration of the programmer options. An Extended Hex file can also be password protected. Thus, it is the ideal format for distributing programming files while also avoiding unauthorized use.

From the graphical user interface of the programmer an ehx file can be generated by clicking on the **Save as ehx...** button. The same can be done by calling C2Prog via its command line options, as below:

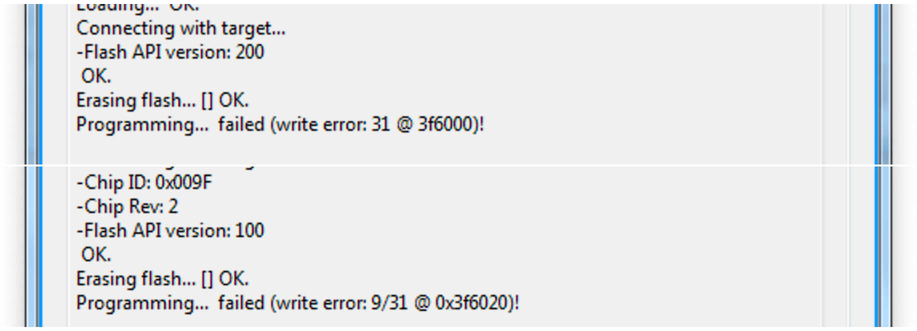
```
c2p-cli mkehx --target=28335_30MHz test.out
```

The target name corresponds to the concatenation of the target name and option, separated by an underscore (see page 28). It is recommended that this command be configured as a post-build step in Code Composer Studio:

```
"C:\Users\joe\AppData\Local\Programs\C2Prog 2.x\c2p-cli.exe" mkehx --target
   ↪ =28335_30MHz ${BuildArtifactFileBaseName}.out
```

3.10 Error Codes

If an error occurs during programming, either a single error code or a pair of primary/secondary codes is displayed.



```
Loading... OK.
Connecting with target...
-Flash API version: 200
 OK.
Erasing flash... [] OK.
Programming...  failed (write error: 31 @ 3f6000)!
```

```
-Chip ID: 0x009F
-Chip Rev: 2
-Flash API version: 100
 OK.
Erasing flash... [] OK.
Programming...  failed (write error: 9/31 @ 0x3f6020)!
```

A singe number, or the primary code of a pair must be interpreted based on the type of MCU that is being programmed.

In case of 240x, 280x, 2802x, 2803x, 2805x, 2806x, 2823x and 2833x devices, the value corresponds to the error code reported by the TI flash API. Please refer to the relevant technical documentation for details.

For all other processors, and custom bootloaders licensed from CodeSkin, the single number, or primary code of a pair, indicates the following:

- 1: Unknown error
- 2: Feature not supported
- 3: Unlock error
- 4: Invalid size or alignment
- 5: Buffer overflow
- 6: Invalid address
- 7: Illegal sector
- 8: Erase error
- 9: Write error

- 10: Flash pump error
- 11: Flash FSM error
- 12: OTP ECC write error
- 13: OTP data write error

The secondary code of a pair identifies the flash API specific error code. When the primary code reads ”Flash FSM error”, the secondary code corresponds to the value of the FSM status. Please review the TI technical documentation for more details or contact CodeSkin for assistance.

3.11 Command Line Options

C2Prog can be launched from a command prompt (shell) with command-line options. This feature is available to facilitate the creation of ehx files as part of the code generation (for example, as a “final build step” in Code Composer Studio™). Users with a “professional” or “integration” C2Prog license can also program MCUs via the command line and extract hex files from ehx files.

The corresponding executable is **c2p-cli**.

c2p-cli accepts the following primary commands and options:

c2p-cli −−help	Display help
c2p-cli −−version	Display version information
c2p-cli mkehx [options]	Create ehx file
c2p-cli load [options]	Program ehx file (licensed users only)
c2p-cli extract [options]	Extract hex file form ehx file (licensed users only)

The command for creating an ehx file is

```
c2p-cli mkehx --target=<target> [options] <binary file> [<ehx file>]
```

The <target> parameter corresponds to the concatenation of the target name and option, separated by an underscore (see page 28).

For example, the following command creates an extended hex file that is protected by a passphrase. All keys to unlock the flash are specified as 0x1234 and the sectors selected to be erased are A,B,C and D (hex 0xF = binary 1111).

```
c2p-cli mkehx --target=2811_30MHz c:\test.out --keys
    ↪ =1234,1234,1234,1234,1234,1234,1234,1234 --sector-mask=F --append-
    ↪ crc --passphrase="very secret"
```

The command for programming an ehx file is

```
c2p-cli load --port=<port> [options] <ehx file>
```

For example

```
c2p-cli load --port=COM5 test.ehx
```

The command for extracting a hex file is

```
c2p-cli extract [options] <ehx file> [<hex file>]
```

mkehx options	
−−target=TARGET_ID	Selects the target – the target ID is composed of the target name, followed by an underscore "_" and the target option, for example "2812_30MHz".
−−keys=KEY1,KEY2,...	Configures keys for unlocking flash (optional), KEYn is in 16-bit hex notation without '0x' prefix. In the case of 32-bit keys, each key is split into two 16-bit keys in big endian (BE) order. E.g. keys 0x01234567, 0x89ABCDEF, 0x11112222, 0x33334444 are specified as −−keys= 0123,4567,89AB,CDEF,1111,2222,3333,4444.
−−sector-mask=SECTOR_MASK	Configures which flash sectors are erased, where SECTOR_MASK is a hex number: −−sector-mask=1: sector A −−sector-mask=2: sector B −−sector-mask=3: sectors A & B −−sector-mask=A: sectors B & D If the "−−sector-mask" option is not used, then sectors to be erased are automatically detected.
−−append-crc	Enables addition of CRC checksum (optional)
−−allow-otp	Allows OTP programming (optional)
−−passphrase=PASS_PHRASE	Passphrase for extended hex-file
−−bitrate=BIT_RATE	Bit-rate for some protocols (such as CAN)
−−ta=TARGET_ADDRESS	Target-address for multidrop protocols (such as CAN)
−−sa=SOURCE_ADDRESS	Source address for multidrop protocols (such as CAN)

load options	
−−port	Specifies communication port
−−passphase=PASS_PHRASE	Passphrase for extended hex-file
−−print-progress	Enables the display of progress information

extract options	
−−passphase=PASS_PHRASE	Passphrase for extended hex-file

3.12 JSON RPC Interface

The C2Prog functionality can be accessed via `JSON RPC`, a lightweight remote procedure call protocol.

The executable for launching the JSON RPC server is **c2p-server**.

```
  c2p-server --rpc-port=<port>
```

For example

```
  c2p-server --rpc-port=8080
```

A JSON RPC client can then connect to the C2Prog server and issue remote procedure requests.

3.12.1 Load command

The `load` method initiates a programming session.

```
{
  "method": "load",
  "params": {
    "file":"<ehx file path>",
    "port":"<port>",
    "passphrase":"<passphrase>"
  },
  "jsonrpc": "2.0",
  "id": 0
}
```

For example:

```
  {
    "method": "load",
    "params": {
      "file":"c:\test.ehx",
      "port":"COM5",
      "passphrase":"very secret"
    },
    "jsonrpc": "2.0",
    "id": 0
  }
```

The server response to the `load` command is formatted as follows:

```
  {
    "result": {
      "info":"",
      "error":"<error description>",
      "progress":0.0
    },
    "jsonrpc": "2.0",
    "id": 0
  }
```

A non-empty `error` string signals that the `load` command failed.

3.12.2 Get Status command

The `get_status` method can be used to query the status of on ongoing flashing session.

```
{
  "method": "get_status",
  "jsonrpc": "2.0",
  "id": 0
}
```

The response to `get_status` is identical to the `load` method response:

```
{
  "result": {
    "info":"<status description>",
    "error":"<error description>",
    "progress":<[0.0-1.0]>
  },
  "jsonrpc": "2.0",
  "id": 0
}
```

The programming session is complete once `progress` reaches `1.0`. If an error occurs, it is indicated my means of the `error` field.

3.12.3 Shutdown command

The server can be shut down by means of the `shutdown` method.

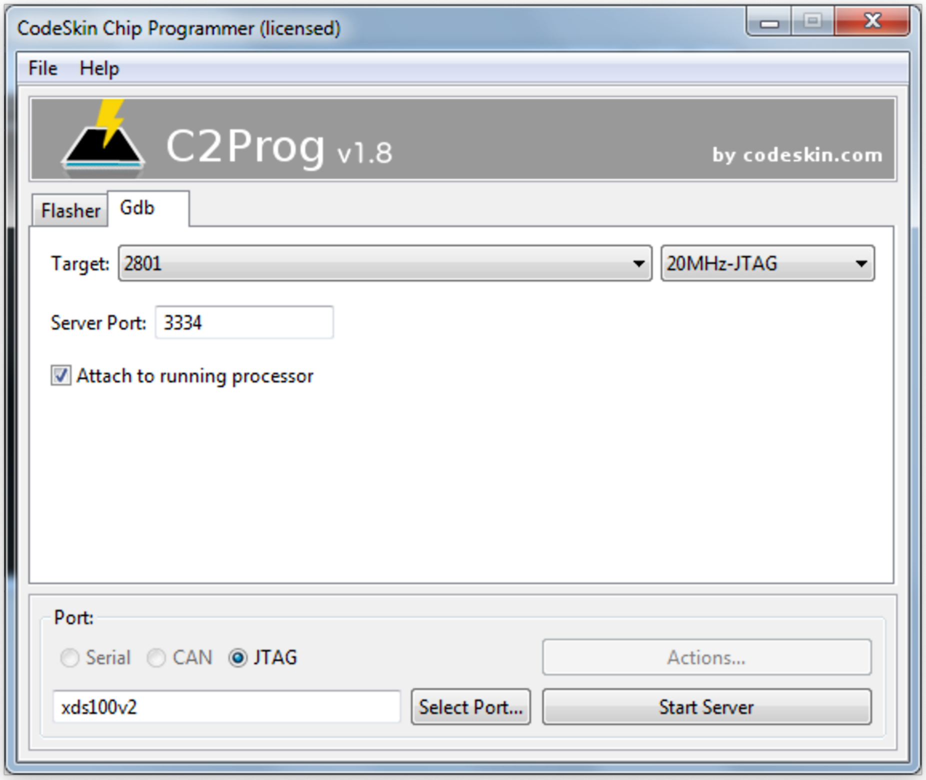
```
{
  "method": "shutdown",
  "jsonrpc": "2.0",
  "id": 0
}
```

3.13 GNU Debug Server

For *primarily experimental* purposes, C2Prog includes a rudimentary GNU Debug Server stub.

A few notes about the server implementation:

- C28 cores have a 16-bit wide architecture. Memory access must therefore be made with an even number of bytes, where each pair of bytes is interpreted as a little endian 16-bit value.
- The server accepts multiple connections. This allows issuing a a blocking 'continue' command and subsequently accessing the MCU, while it is running, through a second connection.


CodeSkin Chip Programmer (licensed)

Target: 2801 | 20MHz-JTAG

Server Port: 3334

☑ Attach to running processor

Port: ○ Serial ○ CAN ● JTAG

xds100v2

☞ The functionality of the Gdb server is still subject to change without notice. Please contact us if you wish to use this feature for important work.

3.14 GDB Client

C2Prog includes a GDB client **c2p-gdb** that can be used to interact with a GDB server, such as the C2Prog GDB stub, Segger J-Link GDB Server or `OpenOCD`.

c2p-gdb accepts the following primary commands and options:

c2p-gdb −−help	Display help
c2p-gdb script [options] <filename>	Run Lua script
c2p-gdb load [options] <filename>	Load binary file

c2p-gdb options	
−−endian=[big]/[little]	Target endianess
−−lausize=<lau size>	Size of least addressable unit
−−url=<server url>	Server URL
−−port=<server port>	Server port
−−nvic=<nvic base>	NVIC base address (ARM only)
−−server-cmd=”<cmd>”	GDB server launch command
−−server-start-delay=<delay>	Server startup delay [ms]

The following command connects to port 3333 of a GDB server and executes the script contained in **my_script.lua**:

```
./c2p-gdb script --port 3333 my_script.lua
```

Scripts are written in the Lua programing language using **gdb** methods to interact with the Gdb server. See the `<c2prog-installation-path>/scripts` folder for examples.

```
-- reset target
gdb.restart()
-- configure boot from flash
gdb.write_memory(0xD00, {0x55aa, 0x0b}, 2)
-- start application
gdb.cont()
```

The next command connects to port 3333 of a GDB server and programs a target with the binary file **my_firmware.elf**. Note that providing the `--nvic` option for ARM processors will run the application automatically after it has been programmed.

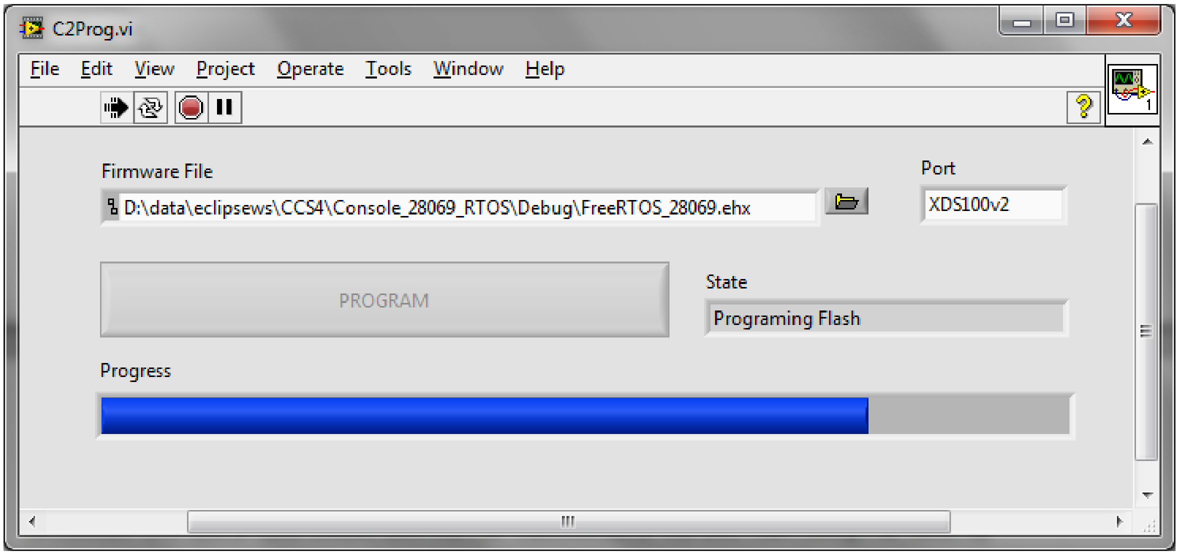
```
./c2p-gdb load --port 3333 --nvic 0x8000000 ~/Desktop/my_firmware.elf
```

With the `--server-cmd` and `--server-start-delay` options it is possible to automatically launch the GDB server for the duration of the interaction with the GDB client.

```
./c2p-gdb load --server-cmd="~/opt/openocd/bin/openocd -s ~/opt/openocd/
   ↪ share/openocd/scripts -f board/stm32g431.cfg" --server-start-delay
   ↪ 1000 --port 3333 --nvic 0x8000000 ~/Desktop/my_firmware.elf
```

3.15 DLL Interface

The C2Prog programming functionality is being exported via a Dynamic-Link Library (DLL) for use by other applications, such as end-of-line (EOL) test-stands or field support tools [1]. With the ”c2p” C2Prog DLL, flash programming capability can easily be added to custom applications generated by virtually any toolchain, including NI LabView.



Firmware File: D:\data\eclipsews\CCS4\Console_28069_RTOS\Debug\FreeRTOS_28069.ehx

Port: XDS100v2

State: Programing Flash

Progress

Below is a list of the function calls that are exposed by the C2Prog DLL. Please refer to the Appendix D on page 30 for a more detailed description of the API.

- **c2pInitializeLibrary** — initializes the C2Prog environment
- **c2pProgram** — starts programming session (programs flash)
- **c2pGetStatus** — retrieves information about the progress of the flash programming
- **c2pGetErrorDescription** — retrieves a textual description (string) for a given error code
- **c2pCloseProgrammingSession** — terminates a programming session.

The function **c2pProgram** can be called as “blocking” or “non-blocking”. In blocking mode, the function will not return until the programming has completed (successfully, or with an error). In the non-blocking mode, the function returns immediately, and the progress of the programming (and its success) must be polled by means of the **c2pGetStatus** call. This allows the application using the C2Prog DLL, to display progress information while the programming takes place.

[1] The DLL interface is only available with the professional license of C2Prog.

The C2Prog DLL is implemented as a wrapper around the **c2p-cli** executable. Therefore, the DLL must be able to locate **c2p-cli**. On Windows, the DLL will read the entry in the Windows registry that the C2Prog installer creates.

An alternate mechanism for specifying the location of the **c2p-cli** executable is the use of a **c2p.config** configuration file, located in the same directory as the DLL itself.

The **c2p.config** must contain a single line with a quoted string. Several options exist for how to provide the path:

1. Specification of an absolute path
2. Specification of a relative path
3. Specification of a registry key, which contains the absolute path (Windows only)

The example below illustrates the first option, specifying an absolute path. Note how the path has to be provided as a quoted string.

```
"/home/user/opt/c2prog_v2.x"
```

Alternatively, a relative path can be specified by using the “$”-prefix. The path is then interpreted to be relative to the “c2p.config” file (and, hence, the C2Prog DLL). This is shown in the next example.

```
"$/C2Prog"
```

The third option specifies a Windows HKCU registry key that contains the absolute path to the **c2p-cli** binary. The special character “@” is used to identify this option, as shown below. The DLL will then read the value named ”InstallPath” at the provided registry path.

```
"@\SOFTWARE\MyApp\C2Prog"
```

The DLL binaries and header file are located in the `{C2Prog}\api` folder. Examples for how to use the API from different programming languages can be found in `{C2Prog}\api\examples`.

Appendices

A License

C2Prog is governed by the licensing agreement as stated in the file `C2Prog-License.pdf` available for download at `https://c2prog.com/license` and also located in the `data` folder of the C2Prog installation.

BY USING THIS SOFTWARE YOU AGREE TO BE BOUND BY THE TERMS OF THIS AGREEMENT. PLEASE READ IT CAREFULLY.

Except where otherwise noted, all of the documentation and software included in the C2Prog package is copyrighted by CodeSkin, LLC.

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C2Prog is using several open source software packages. For a comprehensive list of the libraries used, and their respective license conditions, please refer to **Help→About C2Prog**.

B About Bootloaders

When programming, C2Prog is interacting with a so called “bootloader” running on the target. This bootloader is often divided into two components:

- **Primary Bootloader (PBL)**: The primary bootloader is a small piece of code that is permanently programmed into the target and called immediately after reset. The primary bootloader can branch to the application code (if present) or receive the secondary bootloader (SBL) into RAM over the communication link and execute it. The primary bootloader typically also includes a security algorithm for unlocking the chip before the secondary bootloader can be loaded.

- **Secondary Bootloader (SBL)**: Contrary to the primary bootloader, the secondary bootloader is not permanently stored in the target. Instead, it is being loaded via the primary bootloader when needed. The SBL contains the flash programming algorithms. It erases the flash, receives the application code over the communication link, and programs the flash memory. Upon completion, the secondary bootloader can reset the chip.

Almost all C2000™ MCUs ship with a primary bootloader programmed into the boot-ROM. While this bootloader supports several communication interfaces, only the SCI mode (RS-232) is of practical use in the field (the CAN implementation is too limited). CodeSkin has developed secondary RS-232 bootloaders for most C2000™ MCUs and distributes them with the C2Prog programming tool. The compiled versions of the secondary bootloaders are free; if so desired, the source code can be licensed for a fee.

CodeSkin also develops custom primary bootloaders that can be used in lieu of the TI version. They are licensed as source code, and allow for the implementation of customer specific features, such as servicing an external watchdog, and proprietary security/encryption algorithms. The CodeSkin primary bootloaders also support communication protocols other than RS-232. For example half-duplex RS-485, TCP/IP and CAN bus. Along with the primary bootloader, the source code of a matching secondary bootloader is provided.

C 32-bit CRC Algorithm

A basic implementation of a 32-bit CRC algorithm, optimized for code space, is provided in the listing below.

```
// 32-bit CRC lookup table (poly = 0x04c11db7)
uint32_t CRC32Lookup[16]={
0x00000000L, 0x04c11db7L, 0x09823b6eL, 0x0d4326d9L,
0x130476dcL, 0x17c56b6bL, 0x1a864db2L, 0x1e475005L,
0x2608edb8L, 0x22c9f00fL, 0x2f8ad6d6L, 0x2b4bcb61L,
0x350c9b64L, 0x31cd86d3L, 0x3c8ea00aL, 0x384fbdbdL
};

uint32_t CRC32StepNibble(uint16_t nibbleIn, uint32_t crc){
  uint16_t index;
  index = (uint16_t)(crc >> 28);
  crc = ((crc << 4) | (uint32_t)(nibbleIn)) ^ CRC32Lookup[index];
  return(crc);
}

uint32_t CRC32Step(uint16_t byteIn, uint32_t crc){
  uint16_t nibble;

  // first nibble
  nibble = (byteIn >> 4) & 0x0F;
  crc = CRC32StepNibble(nibble, crc);

  // second nibble
  nibble = (byteIn) & 0x0F;
  crc = CRC32StepNibble(nibble, crc);
  return(crc);
}
```

D C2Prog API

The following functions are provided by the C2Prog DLL. All API calls return a status information c2pStatus of type int. Use **c2pGetErrorDescription** to obtain an error description.

c2pStatus **c2pInitializeLibrary()**

Initializes the programming environment. Must be called by the application prior to using any other API functions.

Returns:

- zero (0), if call successful,
- error code, otherwise – use **c2pGetErrorDescription** for description of error

c2pStatus **c2pProgram**
(char* fileName, char* password, char* protocol, char* port, short wait)

Initiates flash programming. Note that only one flash programming session can be active at any time.

Parameters:

- fileName: Full path and name of ehx file
- password: Password to decrypt ehx file. If no password is used, provide an empty string (“”).
- protocol: Reserved for future use. The string “default” is recommended.
- port: Name of communication port
- wait: If set to 0, the function launches the programming session and returns immediately. Otherwise, the call blocks until the programming session terminates.

Returns:

- zero (0), if call successful,
- error code, otherwise – use **c2pGetErrorDescription** for description of error

Example:

```
    c2pProgram("D:\\data\\Firmware.ehx", "", "default", "XDS100v2", 1);
```

c2pStatus **c2pGetStatus**
(int *state, double *progress, char* stateInfo, int infoStringMaxLen)

Obtains status information while programming session is active. This function is typically used after a non-blocking call to c2pProgram to display progress, status and error information. If a fault occurred during programming, the function returns an error code and the value of state indicates in which state the error occurred.

Parameters:

- state
  0. Idle
  1. Active
  2. Done
  3. Failed
- progress: Completion rate (0.5 = 50%, 1.0 = 100%)
- stateInfo: String describing state – memory allocated by caller
- infoStringMaxLen: Number of bytes allocated by caller to stateInfo string

Returns:

- zero (0), if call successful,
- error code, otherwise – use **c2pGetErrorDescription** for description of error

c2pStatus **c2pCloseProgrammingSession()**

Stops active programming session.

Returns:

- zero (0), if call successful,
- error code, otherwise – use **c2pGetErrorDescription** for description of error

c2pStatus **c2pGetErrorDescription**
(c2pStatus error, char* errorDescription, int errorStringMaxLen)

Obtains description for error code.

Parameters:

- error: Status returned by any of the API calls
- errorDescription: String describing error – memory allocated by caller
- errorStringMaxLen: Number of bytes allocated by caller to the errorDescription string

Returns:

- zero (0) if call successful,
- error code, otherwise

c2pStatus **c2pGetProgressInfo**
(int *state, double *progress, char* stateInfo, int infoStringMaxLen)

This function is deprecated and only provided for backward compatibility .

Obtains status information while programming session is active. This function is typically used after a non-blocking call to c2pProgram to display progress, status and error information. If a fault occurred during programming, the function returns an error code and the value of state indicates in which state the error occurred.

Parameters:

- state
  0. Idle / Done
  1. Running
- progress: Completion rate (0.5 = 50%, 1.0 = 100%)
- stateInfo: String describing state – memory allocated by caller
- infoStringMaxLen: Number of bytes allocated by caller to stateInfo string

Returns:

- zero (0), if call successful,
- error code, otherwise – use **c2pGetErrorDescription** for description of error