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## Chapter 1

**Bootloader**

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## Chapter 2

**License**

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## Appendix A

**Serial Bootloader Test Application**

## Appendix B

**Serial Bootloader Revision History**
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About This Document
This manual describes the 56F801x Serial Bootloader application.

Audience
This manual targets software developers utilizing the 56F801x Bootloader applications.

Organization
This manual consists of the following sections:

• Chapter 1, Bootloader -- describes the Serial Bootloader.
• Chapter 2, License -- provides the license required to use this product.

Suggested Reading
We recommend that you have a copy of the following references:

• Freescale DSP56800E Reference Manual, DSP56800ERM
• 56F8000 Peripheral Reference Manual, MC56F8000RM
• Inside CodeWarrior: Core Tools, Freescale Inc.
Conventions

This document uses the following notational conventions:

<table>
<thead>
<tr>
<th>Typeface, Symbol or Term</th>
<th>Meaning</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Courier Monospaced Type</td>
<td>Code examples</td>
<td>//Process command for line flash</td>
</tr>
<tr>
<td>Italic</td>
<td>Directory names, project names, calls, functions, statements, procedures, routines, arguments, file names, applications, variables, directives, code snippets in text</td>
<td>...and contains these core directories: applications contains applications software... ...CodeWarrior project, 3des.mcp is... ...the pConfig argument.... ...defined in the C header file, aec.h....</td>
</tr>
<tr>
<td>Bold</td>
<td>Reference sources, paths, emphasis</td>
<td>...refer to the Targeting 56F801x Platform manual.... ...see: C:\Program Files\Motorola\Embedded SDK\help\tutorials</td>
</tr>
<tr>
<td>Blue Text</td>
<td>Linkable on-line</td>
<td>...refer to Chapter 7, License....</td>
</tr>
<tr>
<td>Number</td>
<td>Any number is considered a positive value, unless preceded by a minus symbol to signify a negative value</td>
<td>3V -10 DES⁻¹</td>
</tr>
<tr>
<td>ALL CAPITAL LETTERS</td>
<td># defines/defined constants</td>
<td># define INCLUDE_STACK_CHECK</td>
</tr>
<tr>
<td>Brackets [...]</td>
<td>Function keys</td>
<td>...by pressing function key [F7]</td>
</tr>
<tr>
<td>Quotation marks, &quot;...&quot;</td>
<td>Returned messages</td>
<td>...the message, &quot;Test Passed&quot; is displayed.... ...if unsuccessful for any reason, it will return &quot;NULL&quot;...</td>
</tr>
</tbody>
</table>
Definitions, Acronyms, and Abbreviations

The following list defines the acronyms and abbreviations used in this document. As this template develops, this list will be generated from the document. As we develop more group resources, these acronyms will be easily defined from a common acronym dictionary. Please note that while the acronyms are in solid caps, terms in the definition should be initial capped ONLY IF they are trademarked names or proper nouns.

COP       Computer Operating Properly
DSC       Digital Signal Controller
EVM       Evaluation module
FM        Flash Module
IDE       Integrated Development Environment
PC        Personal Computer
PLL       Phase Locked Loop
RAM       Random Access (read/write) Memory
SCI       Serial Communications Interface

References

The following sources were used to produce this book:

1. Freescale DSP56800E Reference Manual, DSP56800ERM
2. 56F8000 Peripheral Reference Manual, MC56F8000RM
3. Freescale website:
   www.freescale.com
Chapter 1
Bootloader

1.1 Serial Bootloader

All 56F801x family devices are preprogrammed with the Serial Bootloader application. The Serial Bootloader has been developed to load and run a proprietary user application presented as an S-Record file into the Program Memory. The Serial Bootloader is located in the dedicated Program Memory region, called Program Flash. The Serial Bootloader supports the simplest serial protocol, so any standard serial terminal program can be used on the host PC.

The Serial Bootloader application reads the S-Record file of a user application (for example, generated by CodeWarrior) via serial interface, parses this S-Record file, and stores needed data in Program Flash memory. When the processing of the S-Record file is finished, the Bootloader will remain in an infinite loop. Resetting the device will allow the downloaded application to be launched. If any error occurs while loading the S-Record file, the Bootloader outputs an error message via the serial line and will prompt the user to resend the S-Record file. See Figure 1-1.

![Figure 1-1. Programming Flash on a 56F801x Device](image)
1.1.1 Start-up Sequence with Bootloader

The following steps describe the Bootloader’s start-up sequence.

1.1.1.1 Step 1: Power-up/Reset

The 56800E core specifies two reset vectors: Hardware Reset and COP Reset. The reset vectors are each two words wide, and reside in consecutive addresses in the beginning of Program Flash. The Hardware Reset vector identifies the address the processor accesses after a power-on reset, external reset, or software reset. The COP Reset vector is accessed after a watchdog time-out. When the 56F801x Bootloader is present, both reset vectors will contain an entry point to the Serial Bootloader application. Once the Serial Bootloader has begun reprogramming the Flash, the entire Flash will be erased. Since this affects the reset vectors, it is critical that no resets are asserted until the Serial Bootloader application has concluded.

1.1.1.2 Step 2: Transfer Code from Program Flash to RAM

Before the Serial Bootloader application can execute, portions of the software must be moved from Program Flash to RAM. This is necessary because the Program Flash is to be erased and reprogrammed with new data. Only the portions of the Serial Bootloader application used to reprogram Flash with S-record data are transferred. Initialization code used by the Serial Bootloader application will be lost once the application has begun modifying Program Flash.

1.1.1.3 Step 3: Write New Application to Program Flash

Once the Serial Bootloader has processed a valid S0 S-record, it erases the entire Program Flash in anticipation of new data. Program Flash is written with new data each time a valid S3 S-record has been processed. The Serial Bootloader application will not reprogram any RAM locations. In the event of an error, a notification will be sent over the serial port. The application will flush all data associated with the current S-record file and wait for the user to send a new S-record file.

1.1.1.4 Step 4: Switch to New Application

Once the 56F801x Serial Bootloader has reprogrammed the Flash with the data from the S-record file, it enters an infinite loop to prevent further code execution. A hardware reset is necessary to begin executing the downloaded application. The reset causes the processor to begin executing code contained in the Hardware Reset vector (which should now contain a JMP instruction to an address used as the entry point for the new application). The reset also returns all peripheral registers to default values.
1.1.2 Bootloader History

The most current version of the Bootloader is 1.5. When running the Serial Bootloader application, the version number is contained in a message transmitted over the serial port. The Bootloader version history can be seen in the following table; see Appendix B for functionality differences between versions.

Known Issues:

a. A default terminal serial program line-ending character terminator is not supported. Work around through the serial application configuration. See Appendix B for the work-around.

b. XON/XOFF flow control requires 2ms line delays. Work around through the serial application configuration. See Appendix B for the work-around.

c. An odd number of data bytes in S3 Record will hang execution. A work-around PERL script is available on the Freescale FAQ website: http://faqts.freescale.net
FAQ# 25759 contains the script, as well as a detailed explanation of the problem.

<table>
<thead>
<tr>
<th>Version Number</th>
<th>Known Issues</th>
<th>Actions/Resolutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2</td>
<td>a,b,c</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>c</td>
<td>Corrected &quot;a&quot; and &quot;b&quot;</td>
</tr>
<tr>
<td>1.5</td>
<td>c</td>
<td>Corrected &quot;c&quot;</td>
</tr>
</tbody>
</table>

1.1.3 Files

The Serial Bootloader application was developed using CodeWarrior™ with Processor Expert™ (PE) and makes use of the standard files generated for PE projects. Some of the standard PE files were modified, however, to support special functionality needed by the application.
Support

This directory contains run time libraries imported when using the Codewarrior tool. The contents of this directory can not be modified.
**Generated Code**

This directory contains source code generated by the Processor Expert (PE) stationery and beans. Files within this directory may be modified if changes are made to project or bean settings. It should be noted, however, that the linker command file, `smm_pROM_pRAM.cmd`, has been customized for the Serial Bootloader application and, to ensure correct operation of the Bootloader software, should not be modified. When compiling the Bootloader software, do not enable the CPU bean property to build the linker command file, as this will result in overwriting the customized file.

**Start-up Code**

This directory contains the start-up assembly code, `56F80xx_init.asm`, responsible for initializing the core registers and internal memory. This includes the Operating Mode Register (OMR), Stack Pointer (SP), and Hardware Stack (HWS), as well as the on-chip RAM.

**User Modules**

All files within this directory are customized files, not generated by Processor Expert. The `bootloader.c` file contains the `main()` function, which controls the Serial Bootloader application flow. The `bootloader_lib.c` file contains various utilities for achieving the functionality required by the Serial Bootloader application.

**Doc**

This directory contains miscellaneous files generated by the Processor Expert tool, related to project settings and the stationery used.

**Set-up**

This directory contains set-up files used to configure serial communication applications, such as HyperTerminal and Tera Term Pro.

**Test**

This directory contains various S-record files used to test the Serial Bootloader application.

The Serial Bootloader application source code is available on the Freescale website ([http://www.freescale.com](http://www.freescale.com)) and contains the Serial Bootloader application source code and other associated files. To download the Serial Bootloader package, go to:

**Products / Digital Signal Processors and Controllers / 56800/E / 56F8013 / Design Tools / Software / Application Software / 56F801x Bootloader**
1.1.4 Bootloader Hardware Set-up

These requirements must be met to use the Bootloader:

- It must be programmed into Program Flash
- The RS-232 socket must be connected by serial cable with the host PC’s COM serial port (See Figure 1-3)

![Figure 1-3. Loading a User’s Application via Serial Bootloader](image)

1.1.5 Host Terminal Set-up

A host terminal program is used to communicate with the Bootloader. The terminal must be configured to the following mode:

<table>
<thead>
<tr>
<th>Table 1-2. PC Serial Communication Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baud Rate</td>
</tr>
<tr>
<td>Data Format</td>
</tr>
<tr>
<td>Flow Control Protocol</td>
</tr>
</tbody>
</table>

Note: See Appendix B for additional configuration options required by Serial Bootloader versions prior to 1.3.

Once your serial port has been properly configured, the serial communications application should be capable of displaying any 56F801x Serial Bootloader messages. An example of how to obtain this configuration using HyperTerminal follows.
1.1.6 Build

All 56F801x devices should be preprogrammed with the Serial Bootloader application. However, source code is provided in the event it is necessary to reprogram a 56F801x device with the Serial Bootloader application via CodeWarrior (see Section 1.1.3).

To build the Serial Bootloader, first open the bootloader.mcp project file using the CodeWarrior IDE. Although this project uses the 56F8013 CPU bean, it is not necessary to change the target processor when building for other 56F801x devices. This single project generates code executable on all 56F801x devices. Next, select the Project/Make command, which builds and links the Serial Bootloader application.

1.1.7 Download into Program Flash

Load the software onto the 56F801x device by choosing the Project/Debug command in the CodeWarrior IDE. Make sure all hardware has been properly configured before attempting to download the software.
1.1.8 Execute

Once the 56F801x Serial Bootloader has been downloaded, the Bootloader will run automatically after a reset has been asserted on the device. If the terminal program is properly set up and the EVM and the Host PC are properly connected, the terminal program will display the following version number and wait for S-record download:

"MC56F801x Serial Bootloader v1.5"
"Waiting for S-record file ..."

To load the S-Record file using HyperTerminal, use the “Transfer/Send Text File” menu option to select the desired S-Record file. If the download attempt is successful, the following message will be displayed:

"Download complete"

When an error is detected while downloading the S-Record file, the 56F801x Serial Bootloader displays an error message and waits for the transmission of another S-record file. The following example of this scenario appears:

"Error: 3001"
"Waiting for S-record file ..."

Note: Consult Troubleshooting, Section 1.1.13, for information on decoding error messages.

1.1.9 Requirements for a Loaded Program

If the application is to be loaded via the Bootloader, it must meet the following requirements:

- **Application Entry Point** - The hardware reset vector must be present at the beginning of Program Flash
- **Initialized Data** - All variables must be initialized via program code. Although it is possible to generate S-records that contain data used to initialize RAM, this data will be ignored by the Serial Bootloader application.
- **Restricted Resources** - The S-record used for download should not contain any data targeted for RAM. The Serial Bootloader uses this region of memory to execute code used to erase and program Flash, as well as to download and parse S-record data. If data is needed in RAM, it should be loaded into Program Flash and copied into RAM at run time (this is handled automatically when using the Processor Expert stationery).

1.1.10 S-Record Generation

*Figure 1-5* illustrates how a user’s application can be set up within Code Warrior to generate an S-Record needed by the Bootloader to program the user’s application into the 56F801x device’s Flash. The options for S-Record generation are circled in blue.
The “Max Record Length” option gives the maximum number of bytes that can be used to comprise the address and data fields for a given S-Record. To reduce S-Record parsing overhead, this option should be set with a large number. Although the maximum value for this option is “255”, CodeWarrior will use “252” by default.

The “EOL Character” option determines what type of line ending will be used for the S-Record file. To ensure proper parsing of the S-Record file, this option must be set to “DOS”.

1.1.11 Peripheral Usage

The 56F801x Serial Bootloader uses the Flash Module (FM), Interrupt Controller (ITCN), On-Chip Clock Synthesis (OCCS), Phase-Locked Loop (PLL), and Serial Communications Interface (SCI) peripherals. The PLL clock is enabled to allow a 32MHz system clock, and assumes the Internal Relaxation Oscillator input frequency is 8MHz. The FM Clock Divide value used by the application also assumes an 8MHz Internal Relaxation Oscillator input. The SCI Baud Rate value used was calculated to achieve 115,200 baud communication, assuming a
32MHz system clock. After downloading a new application with the Serial Bootloader, a hardware reset is required to run the application. The hardware reset will restore all peripheral registers to default values before running the new application.

### 1.1.12 Performance Data

The Serial Bootloader application consumes 838 words (approximately 1.64 kB) of Program Flash. The Serial Bootloader is capable of programming the entire flash array in under 5 seconds in most cases. Of course, the actual performance will depend on the PC, Operating System, and serial application used. Below are some sample download times for programming the 56F8013 device using HyperTerminal and Tera Term Pro.

#### Table 1-3. Sample Download Times for 16KB Memory

<table>
<thead>
<tr>
<th>Serial Application</th>
<th>PC Type</th>
<th>Windows 2000</th>
<th>Windows XP</th>
</tr>
</thead>
<tbody>
<tr>
<td>HyperTerminal</td>
<td>Pentium-4 1.7 GHz</td>
<td>4.46 seconds</td>
<td>4.75 seconds</td>
</tr>
<tr>
<td>Tera Term Pro</td>
<td>Pentium-3 1.0 GHz</td>
<td>3.75 seconds</td>
<td>4.29 seconds</td>
</tr>
</tbody>
</table>

### 1.1.13 Troubleshooting

The Serial Bootloader application checks for the following error conditions:

- SCI Receiver Error
- Flash Programming Error (Access Error, Protection Violation)
- Flash Verify Error
- Invalid S-Record Checksum
- Invalid S-Record Type

If any of these errors are encountered, the Serial Bootloader application will generate an error message and prompt the user to download the S-Record file again. The following text illustrates what is seen on the PC host terminal in the event of a download error:

```
"MC56F801x Serial Bootloader v1.5"
"Waiting for S-record file ..."
"PROGRAM&DATA***"
"Error: 3002"
"Waiting for S-record file ..."
```

In the progress message, `PROGRAM&DATA***`, each asterisk indicates a successfully processed S-record. This information can be used with the status code, `Error: 3002`, to determine whether or not an S-record file contains bad data. The status code is a 16-bit hexadecimal
number, containing a variety of status and error flags controlled by the Serial Bootloader application; see **Figure 1-6.**

![Serial Bootloader Status Code](image)

**Figure 1-6. Serial Bootloader Status Code**

A description of each bit used in the Serial Bootloader status code is provided in **Table 1-4.** Please consult this table for possible errors and resolutions when troubleshooting the Serial Bootloader application.
### Table 1-4. Bootloader Troubleshooting Guide

<table>
<thead>
<tr>
<th>Status Code</th>
<th>Description</th>
<th>Possible Cause(s)</th>
<th>Solution(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERR_CKSUM</td>
<td>The checksum calculated by the Bootloader does not match the S-record checksum field</td>
<td>S-record file corrupted</td>
<td>Regenerate the S-record by rebuilding the application</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Noisy serial cable</td>
<td>Ensure the serial cable is properly connected and/or replace it with a new cable</td>
</tr>
<tr>
<td>ERR_TYPE</td>
<td>An invalid S-record type was received.</td>
<td>S-record file corrupted</td>
<td>Regenerate the S-record by rebuilding the application</td>
</tr>
<tr>
<td></td>
<td>Only S0, S3 and S7 records are supported by the Serial Bootloader application.</td>
<td>Noisy serial cable</td>
<td>Ensure the serial cable is properly connected and/or replace it with a new cable</td>
</tr>
<tr>
<td>ERR FM_ACCERR</td>
<td>An access error was encountered when programming the Flash</td>
<td>On-chip Flash Module failure</td>
<td>Contact Freescale Technical Support</td>
</tr>
<tr>
<td>ERR FM_PVIOL</td>
<td>A protection violation was encountered when programming the Flash</td>
<td>On-chip Flash Module failure</td>
<td>Contact Freescale Technical Support</td>
</tr>
<tr>
<td>ERR FM_PROG</td>
<td>The Flash program / read verify failed for a word in the Flash array</td>
<td>On-chip Flash Module failure</td>
<td>Contact Freescale Technical Support</td>
</tr>
<tr>
<td>ERR SCI_RX</td>
<td>An SCI receive error was detected when downloading the S-record (e.g., noise, frame, and /or receiver overrun)</td>
<td>Noisy serial cable</td>
<td>Ensure the serial cable is properly connected and/or replace it with a new cable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Incorrect PC host terminal serial program baud rate selected</td>
<td>See Section 1.1.5 for correct configuration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PC host terminal serial program transmitted break character</td>
<td>Do not send break characters</td>
</tr>
<tr>
<td>TX XOFF</td>
<td>APPLICATION STATUS FLAG</td>
<td>The ASCII &quot;XOFF&quot; character (0x13) was sent to the PC terminal to halt transmission</td>
<td>N/A</td>
</tr>
<tr>
<td>RX HEADER</td>
<td>APPLICATION STATUS FLAG</td>
<td>The SO record was received and processed</td>
<td>N/A</td>
</tr>
<tr>
<td>RX EOF</td>
<td>APPLICATION STATUS FLAG</td>
<td>The S7 record was received and processed</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Unshaded rows = Error Indicators

Shaded rows = Status Indicators

---

56F801x Bootloader User Guide, Rev. 1.0
Chapter 2
License

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Appendix A
Serial Bootloader Test Application

A simple test application is provided for the Serial Bootloader application. This application fills the entire Program Flash array with functional code, along with a sequential data pattern. When executed, the application checks for the expected pattern of data in the Program Flash locations not used for storing code. If the data pattern verification was successful, the application blinks a series of LEDs connected to GPIOA[2:0] at 1Hz. Otherwise, the LEDs will remain off to indicate failure.

Versions of the test application are available in S-record format for each 56F801x device (i.e., test_app_56F8013, test_app_56F8014) on the Freescale website (http://www.freescale.com) as part of the 56F801x Serial Bootloader software package. The test application source code is also available on the website. To obtain any desired files, go to:

Products / Digital Signal Processors and Controllers / 56800/E / 56F8013 / Design Tools / Software / Application Software
Appendix B
Serial Bootloader Revision History

This document was targeted for the most recent version of the 56F801x Serial Bootloader. You should reference this section if you are using an older version of the Bootloader software, where some of the differences in functionality of the older revisions will be covered in detail.

• Bootloader Messages

While newer versions of the Bootloader (1.3 and higher) show an error code containing the types of errors encountered, previous versions do not send such a descriptive message. The following block of text is an example of what is seen on a terminal program when an error occurs on a device running Bootloader versions 1.2 and lower:

"MC56F801x Serial Bootloader v1.1"
"Waiting for S-record file ..."
"PROGRAM&DATA***"
"Download Aborted!"
"Waiting for S-record file ..."

• Host Terminal Set-up

Bootloader versions 1.2 and lower require additional terminal configuration options; additional options are highlighted in bold in Table B-1.

Table B-1. PC Serial Communication Settings for Versions 1.2 and Lower

<table>
<thead>
<tr>
<th>Setting</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baud Rate</td>
<td>115200bps</td>
</tr>
<tr>
<td>Data Format</td>
<td>8N1 (8 data bits, no parity, 1 stop bit character format)</td>
</tr>
<tr>
<td>Flow Control Protocol</td>
<td>Xon / Xoff</td>
</tr>
<tr>
<td>Line Delay</td>
<td>2ms</td>
</tr>
<tr>
<td>Line Ending</td>
<td>“\r” (carriage return), followed by “\n” (newline)</td>
</tr>
</tbody>
</table>

Figure B-1 shows how to configure HyperTerminal for use with 56F801x Serial Bootloader Versions 1.2 and lower.
Figure B-1. HyperTerminal Configuration Example for Versions 1.2 and Lower

• S-Record Formatting

Bootloader versions 1.3 and lower are unable to fully process data in S3 records if the S-record data field contains an odd number of bytes. These versions of software assumed that all S3 records would contain an even number of actual data bytes. This assumption was based on the fact the 56800/E is a 16-bit architecture with 16-bit program opcodes.

A PERL script is available to modify S-record files containing odd S3 data. After using the script to convert an S-record file, it should be safe to use on all versions of the Bootloader software. Instructions for use are embedded within the script itself, and can be referenced by executing the script with an “-h” or “-help” option in the command line. Please reference the Freescale FAQ website, http://faqts.freescale.net, to obtain this script; see FAQ #25759.

It is recommended, however, that users take advantage of the 1.5 release. Version 1.5 of the Bootloader handles the odd S3 data field issue in the Bootloader application. It accomplishes this by appending 0xFF to the S3 data if the record contains an odd number of data field bytes. This fix does not affect the S-record checksum calculation. To obtain version 1.5, go to:

Products / Digital Signal Processors and Controllers / 56800/E / 56F8013 / Design Tools / Software / Application Software / 56F801x Bootloader
Symbols
56F8000 Peripheral User Manual Preface-v, Preface-vii

C
Computer Operating Properly
  COP Preface-vii
COP Preface-vii

D
Digital Signal Controller
  DSC Preface-vii
DSC Preface-vii

E
Evaluation Module
  EVM Preface-vii
EVM Preface-vii

F
Flash Module
  FM Preface-vii
FM Preface-vii

I
IDE Preface-vii
Inside CodeWarrior
  Core Tools Preface-v
Integrated Development Environment
  IDE Preface-vii

P
PC Preface-vii
Personal Computer
  PC Preface-vii
Phase Locked Loop
  PLL Preface-vii
PLL Preface-vii

R
RAM Preface-vii
Random Address Memory
  RAM Preface-vii

S
SCI Preface-vii
Serial Communications Interface
  SCI Preface-vii
S-Record file 1-1
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