Using FlashRunner^{TM} FR03TXI0 for Standalone Programming of UCD3020/UCD3028/UCD3040 & UCD3138 Digital Power Controllers

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Scope of this Document

This document from Texas Instruments provides step by step information about Hardware and Software setup of FlashRunner FR03TXI0 required for standalone programming UCD30xx and UCD3138 digital controllers.

Additional documentation available from SMH Technologies (www.smh-tech.com) regarding generic FlashRunner FR03 topics include:

- FlashRunner FR03 – User's Manual
- FlashRunner FR03 – Programmer's Manual

Additional documentation available from SMH Technologies (www.smh-tech.com) regarding programming UCD3020/3028/3040 & UCD3138 controllers using FlashRunner FR03:

- AN00153: Interfacing FlashRunner with TI UCD30XX Devices (DC10496.pdf)

Additional documentation available from Texas Instruments regarding UCD30xx and UCD3138 controllers:

- UCD3040/20/28 Device Datasheet, Literature # - SLU868
- UCD30xx Flash Application Note

- UCD3138 Device Datasheet, Literature # - SLUSAP2
- UCD3138 ARM and Digital System Programmer's Manual

For the most up to date product specifications please visit www.ti.com.

1. Introduction

1.1 FlashRunner FR03 Overview

FlashRunner FR03 is a high-performance, standalone In-System Programmer from SMH Technologies specific for Flash-based microcontrollers and serial memories. FlashRunner FR03 is targeted at production environments, easily interfaces to a programming system or Automatic Test Equipment (ATE) and can work either in full standalone mode or controlled by a host system.

FlashRunner FR03TXI0 is capable of programming Texas Instruments digital controller devices UCD3020, UCD3028, UCD3040 and UCD3138. PMBUS protocol (at 400kHz operating frequency) is used to program these devices.

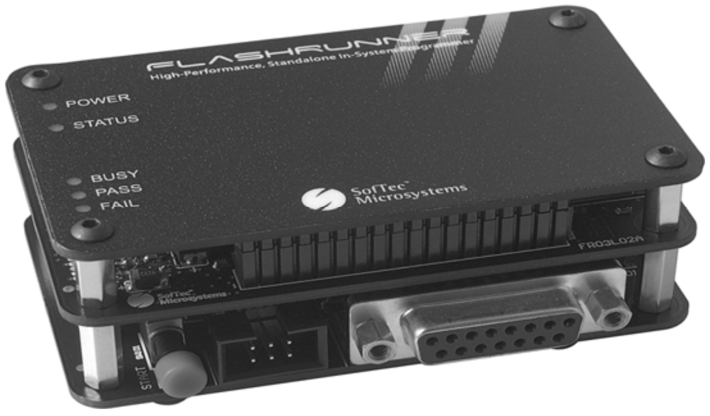


Figure 1: FlashRunner FR03 from SMH Technologies

1.2 Features

Key attributes of FlashRunner FR03 include:

- Standalone operation with Start button (projects and code images stored on a memory card)
- Controllable by any host system via RS-232, also can be integrated with ATE
- Supports ISP (in-system programming) protocols
- LED indicators for Power, Instrument Status & Programming Status (Busy/pass/Fail)

1.2.1 Hardware Features

- ISP connector with I/O ports for communication with target device that is to be programmed
  - Five digital I/O lines
  - Two digital I/O or analog output lines
  - One programmable output voltage (0 to 5.5V, 0.5A)
  - One programmable clock output
- Secure Digital memory card (up to 2 GB)
- One command input button (START)
- Three programming status LED indicators (FAIL, PASS, BUSY)
- RS-232 channel communication with host system
- 7.5V DC power supply input

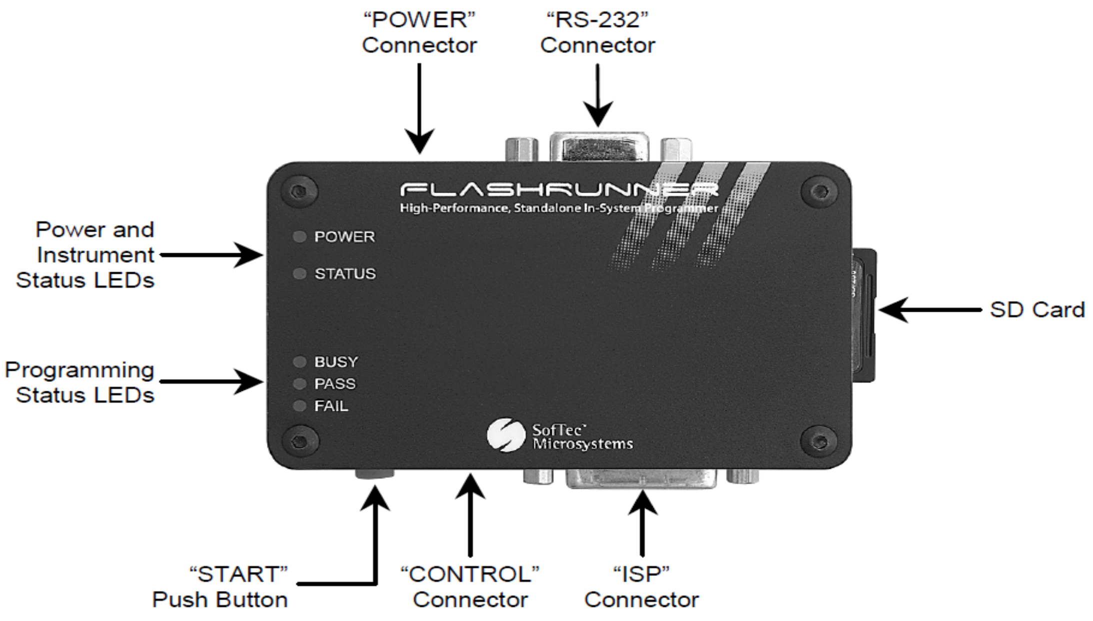


Figure 2: FlashRunner Hardware Features

1.2.2 Software Features

- Fully autonomous standalone mode (based on SD memory card)
- Controllable by any host system through a terminal utility and simple ASCII protocol.
- One hardware-selectable project (script)
- Unlimited software-selectable projects (scripts)
- Erase, blank check, program, read, verify, oscillator trimming, etc.

1.2.3 FR03TXI0 Package

Key items in the FR03TXI0 package include:

- FlashRunner FR03 unit, including SD card pre-installed with the programming algorithm and licences for UCD3020/UCD3028/UCD3040/UCD3138 devices
- 9-pin Serial cable for connection between FlashRunner and host PC
- FlashRunner "System Software" CD-ROM, containing the FlashRunner Control Panel utility installation files and FlashRunner documentation

AC/DC Power Supply (7.5V DC output) must be provided by user to power up FlashRunner.

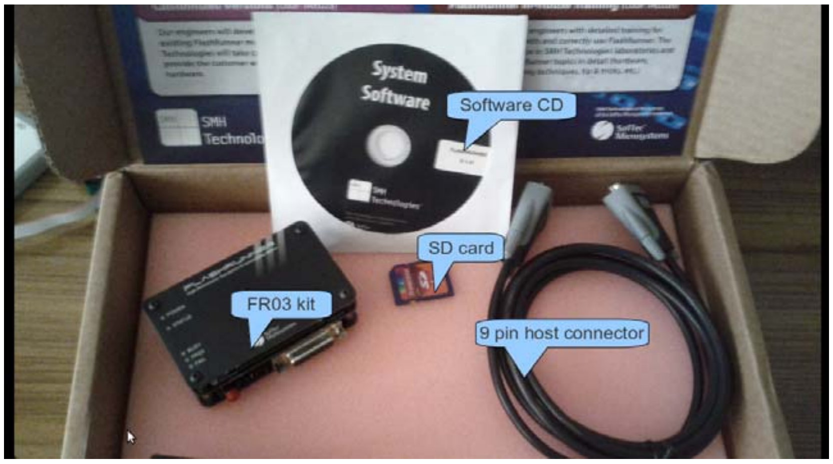


Figure 3: FlashRunner FR03TXI0 package contents

2. System Set-Up for Successful Programming

2.1 Overview

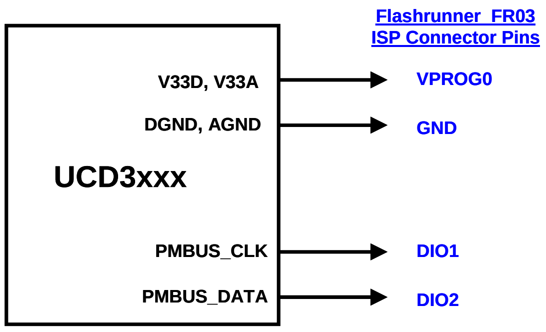
The following steps are necessary in order to use FlashRunner FR03 to achieve standalone programming of the UCD3xxx devices:

1. Hardware Preparations
    a) Develop hardware interface between FR03 and Target board with the UCD3xxx device
2. Software preparations
    a) Generate Image file for programming the target device
    b) Generate script file SCRIPT0.FRS for standalone operation
    c) Install Image file and script files in SD card using FlashRunner FR03 Utility

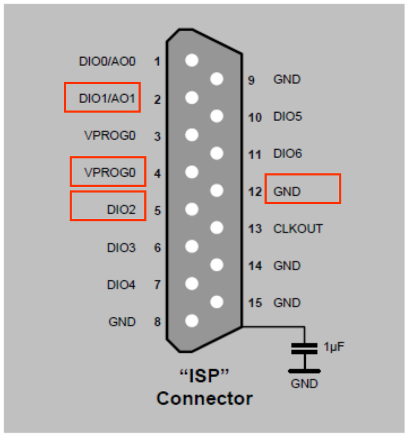
2.2 Hardware Preparations

A Connector is necessary to interface between the target UCD3xxx device and FR03. UCD3xxx devices are programmed using PMBUS/I2C communication interface. It is possible to power the UCD3xxx device using the VDD/GND connectors available from FR03.

The UCD3xxx device I/O ports involved in programming are as follows:
PMBUS_CLK : PMBUS Clock frequency
PMBUS_DATA : PMBUS Data line
V33A & V33D : Device Bias supply
DGND & AGND : Device ground
These UCD3xxx I/O lines must be connected to the FlashRunner's "ISP" connector according to Figure 8.



(a): UCD3xxx & FlashRunner FR03 ISP connector pins involved in programming



(b) FlashRunner FR03 ISP connector pins involved in programming (to be interfaced with UCD3xxx target device)
Figure 8. Hardware Interface requirement between UCD3xxx target device and FR03 ISP connector

For example, if the target device is located on the UCD3138CC64EVM-030 EVM from Texas Instruments (http://www.ti.com/tool/ucd3138cc64evm-030), then a connector cable must be prepared between the FlashRunner ISP connector and the PMBUS connector J1 in UCD3138CC64-030 EVM. This is illustrated in

Figure 9. The target device can be biased directly from the PMBUS line coming from the FlashRunner ISP connector (jumper J2 in Figure 9-1).

NOTE: It is necessary to insert a high-frequency capacitor, C_{HF} between the PMBUS_DATA and GND line to support 400kHz data transfer. The exact value of capacitor depends on the cable length and the programming environment. 47pF is a good starting point for a 20cm (approximately 8" cable). A higher value may be needed for longer cable lengths and different board configurations. As an example, Table 1 summarizes the capacitance value needed with different cable lengths in tests conducted at TI. This capacitor can be installed close to the ISP connector as shown in Figure 10.

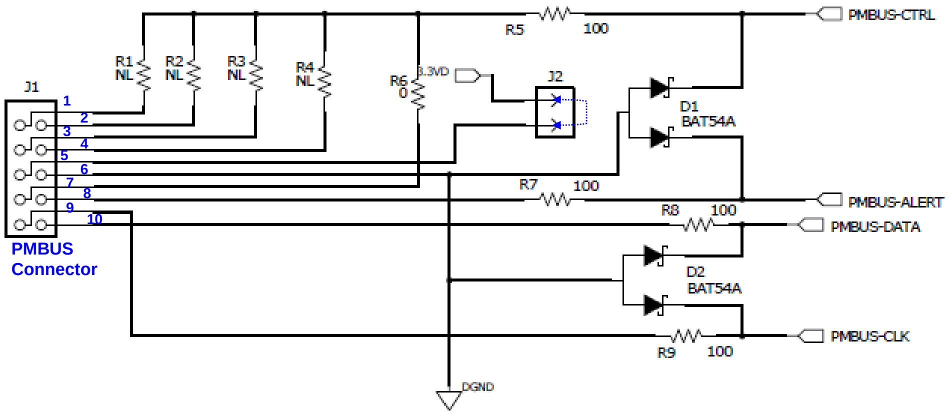


Figure 9-1. UCD3138CC64EVM-030 PMBUS Connector (J1)

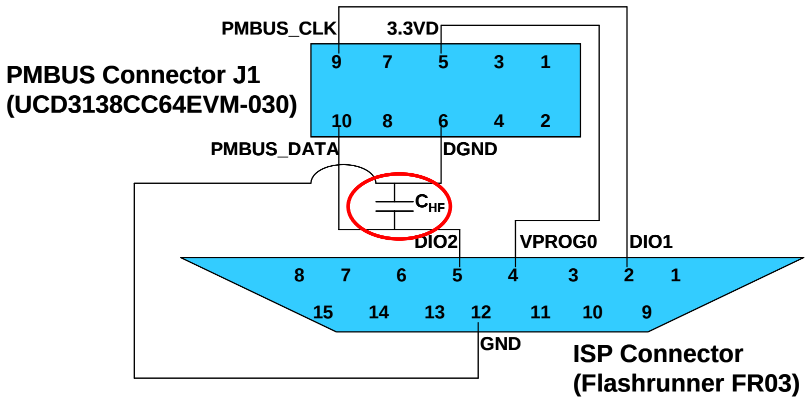


Figure 9-2. Cable (with high-frequency capacitor) for interfacing FR03 ISP Connector to UCD3138CC64EVM-030 PMBUS Connector (J1) for in system programming

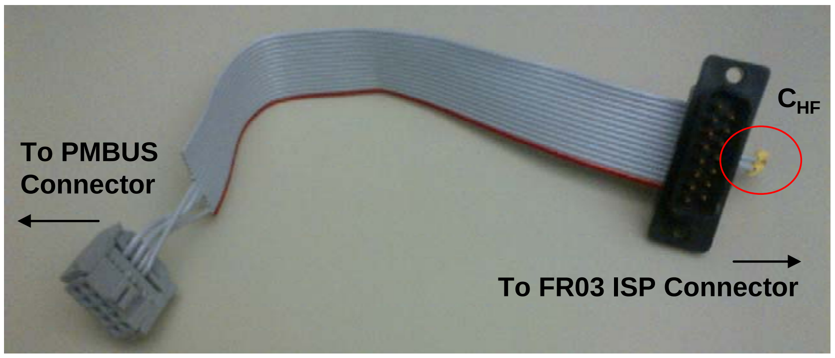


Figure 9-3. Cable (with high-frequency capacitor) for interfacing FR03 ISP connector with UCD3138CC64EVM-030 PMBUS Connector (J1)

Table 1: C_{HF} capacitor needed between PMBUS_DATA and GND lines for successful programming with

different cable lengths (actual capacitor value will vary based on programming environment)

Cable length	**C_{HF} Capacitor value needed in TI Test Set-up**	
	At 100 KHz operating frequency	At 400 KHz operating frequency
20 cm	No capacitor needed	47pF
50 cm	18pF	94pF
100 cm	47pF	127pF

2.3 Software Preparations

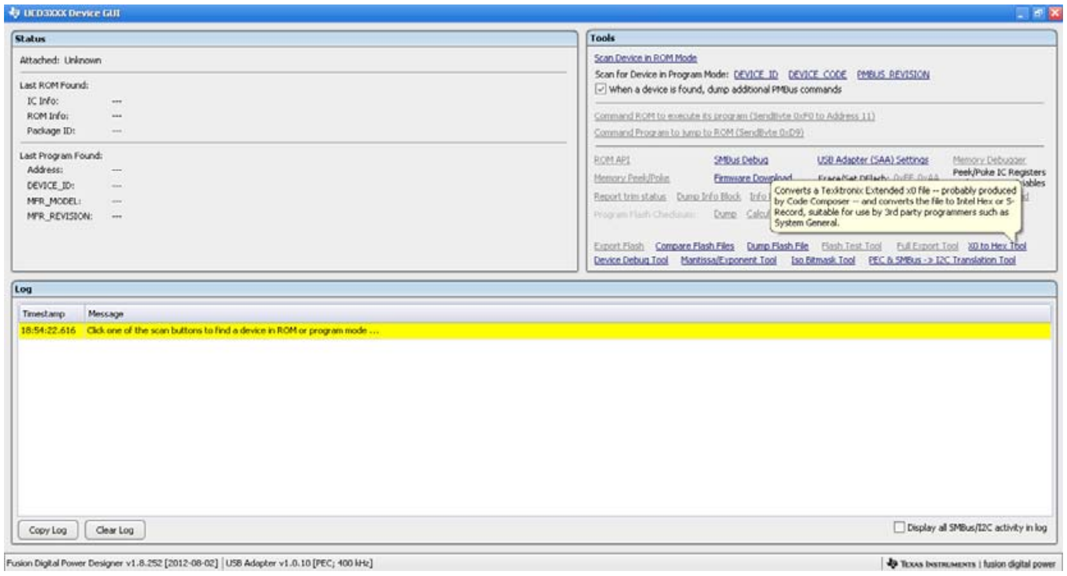
2.3.1 Generating Firmware Image (.Hex file)

In order to enable the UCD30xx/UCD3138 device to transfer control from ROM mode to Flash mode after programming, the firmware image must be generated with a valid Checksum, according to the steps below:

a) Compile the *.c Source file using Code Composer Studio V3.3 and obtain *.x0 file.

b) Using Texas Instruments UCD3XXX Device GUI (in FUSION_DIGITAL_POWER_DESIGNER http://www.ti.com/tool/fusion_digital_power_designer) create Intel Hex file by following the 3 steps below:

i. Select “**x0 to Hex Tool”** option in the GUI as shown below



Attached: Unknown

Last ROM Found:
IC Info: ---
ROM Info: ---
Package ID: ---

Last Program Found:
Address: ---
DEVICE_ID: ---
MFR_MODEL: ---
MFR_REVISION: ---

Scan for Device in Program Mode: DEVICE_ID DEVICE_CODE PMBUS_REVISION

☑ When a device is found, dump additional PMBus commands

Peek/Poke IC Registers

Converts a Texktronix Extended x0 file -- probably produced by Code Composer -- and converts the file to Intel Hex or S-Record, suitable for use by 3rd party programmers such as System General.

```
Timestamp     Message
18:54:22.616  Click one of the scan buttons to find a device in ROM or program mode ...
```

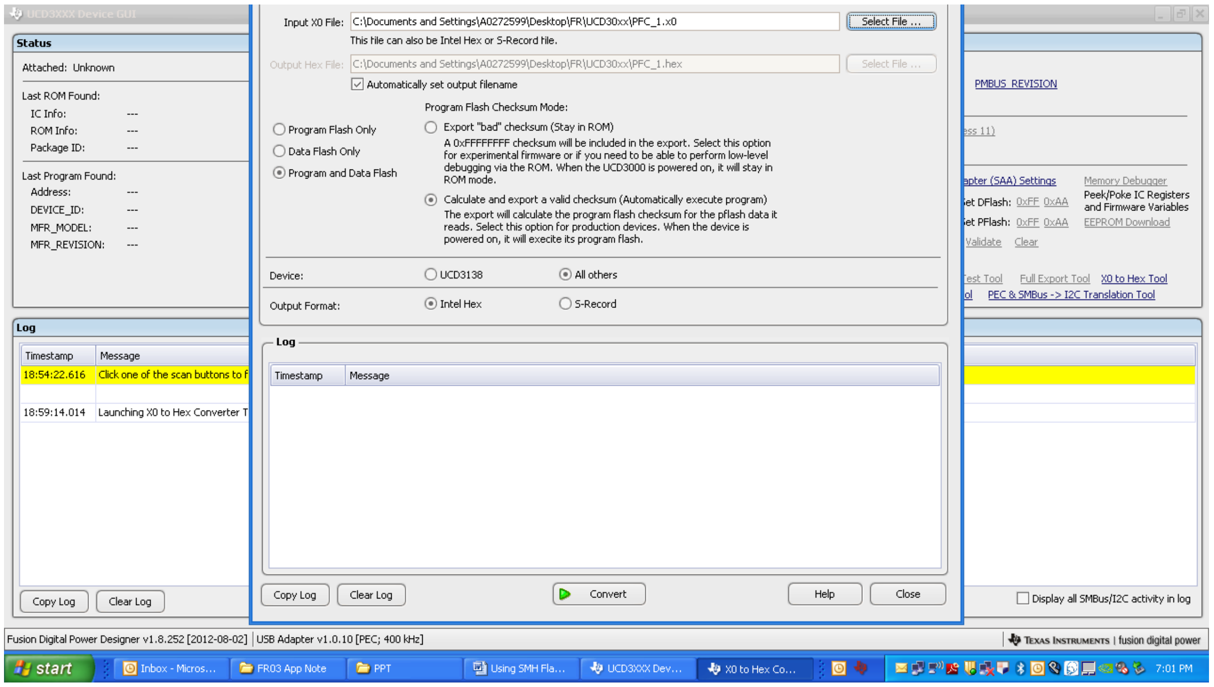
☐ Display all SMBus/I2C activity in log

Fusion Digital Power Designer v1.8.252 [2012-08-02] | USB Adapter v1.0.10 [PEC; 400 kHz] | Texas Instruments | fusion digital power

Figure 10: “X0 to Hex Tool” option of FUSION_DIGITAL_POWER_DESIGNER Device GUI

ii. Browse and locate the .xo file on the PC

iii. Select radio button indicating **“Calculate and export valid checksum”** option. This will put the device in Flash mode after successful programming with FlashRunner (however, if for any reason, it is desired to retain the device in ROM mode after successful programming, then select the “Export bad Checksum (Stay in ROM)” option)



Input X0 File: C:\Documents and Settings\A0272599\Desktop\FR\UCD30xx\PFC_1.x0
This file can also be Intel Hex or S-Record file.
Output Hex File: C:\Documents and Settings\A0272599\Desktop\FR\UCD30xx\PFC_1.hex
[✓] Automatically set output filename

Program Flash Checksum Mode:
- Export "bad" checksum (Stay in ROM)
  A 0xFFFFFFFF checksum will be included in the export. Select this option for experimental firmware or if you need to be able to perform low-level debugging via the ROM. When the UCD3000 is powered on, it will stay in ROM mode.
- [✓ Calculate and export a valid checksum (Automatically execute program)]
  The export will calculate the program flash checksum for the pflash data it reads. Select this option for production devices. When the device is powered on, it will execite its program flash.

Program Flash Only / Data Flash Only / [✓ Program and Data Flash]

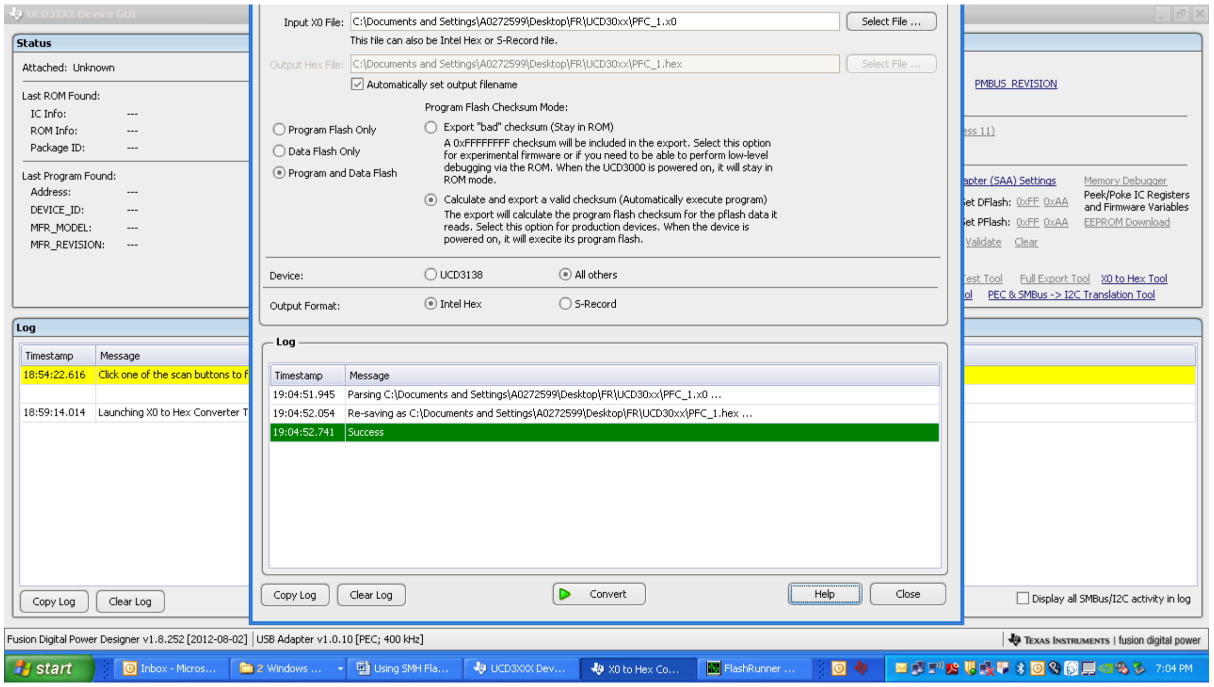
Device: UCD3138 [✓ All others]
Output Format: [✓ Intel Hex] S-Record

```
Timestamp     Message
18:54:22.616  Click one of the scan buttons to f
18:59:14.014  Launching X0 to Hex Converter T
```

Select File ...
Copy Log
Clear Log
Convert
Help
Close
Fusion Digital Power Designer v1.8.252 [2012-08-02]
USB Adapter v1.0.10 [PEC; 400 kHz]

Figure 11: Intel Hex file creation with **"Calculate and export valid checksum"** option

iv. Click "Convert". The Intel .Hex file will be created at the same location as the .xo file and the following screen will be displayed upon successful conversion



Input X0 File: C:\Documents and Settings\A0272599\Desktop\FR\UCD30xx\PFC_1.x0
Output Hex File: C:\Documents and Settings\A0272599\Desktop\FR\UCD30xx\PFC_1.hex
[✓] Automatically set output filename

Program Flash Checksum Mode: [✓ Calculate and export a valid checksum (Automatically execute program)]

[✓ Program and Data Flash]

Device: [✓ All others]
Output Format: [✓ Intel Hex]

```
Timestamp     Message
19:04:51.945  Parsing C:\Documents and Settings\A0272599\Desktop\FR\UCD30xx\PFC_1.x0 ...
19:04:52.054  Re-saving as C:\Documents and Settings\A0272599\Desktop\FR\UCD30xx\PFC_1.hex ...
19:04:52.741  Success
```

Figure 12. Intel Hex file creation with **"Calculate and export valid checksum"** option

2.3.2 Installing FlashRunner Control Panel Utility

Please review Section 7 FlashRunner Control Panel in FlashRunner Programmer's Manual for detailed information regarding use of FlashRunner Control Panel Utility.

Using the CD-ROM provided, install the FlashRunner system software on the PC. The software setup installs all of the required components on the hard drive. These components include:

- The FlashRunner Control Panel utility (GUI)
- Script examples
- Documentation in PDF format

The FlashRunner Control Panel utility is used for the following purposes:

1. To create and set up the necessary files and licenses in SD card for Stand-alone programming
2. To send commands from host PC to instruct FR03 to program target devices

In this document, only the requirements and procedures related to stand-alone programming are covered.

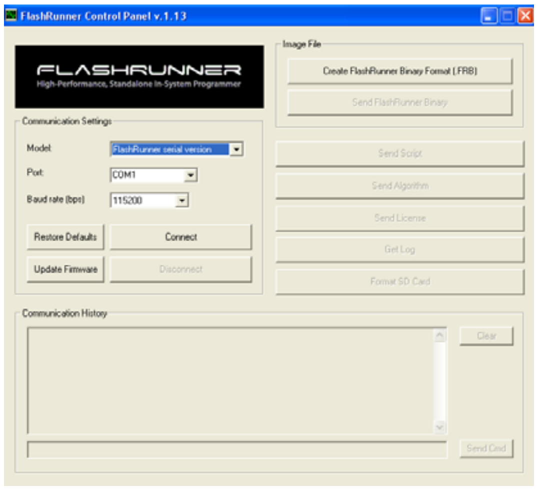
2.3.3 Generating Binary File for programming using FlashRunner

Please review Section 7.1.3 Creating FlashRunner Binary Files in FlashRunner Programmer's Manual for detailed information regarding subject covered in this section.

FlashRunner accepts the firmware image files in a .FRB (FlashRunner Binary) format. In order to generate the .frb image file from the Intel Hex file the following steps must be executed.

i. Connect the FlashRunner unit to host PC using the 9-pin serial cable and provide 7.5VDC power input

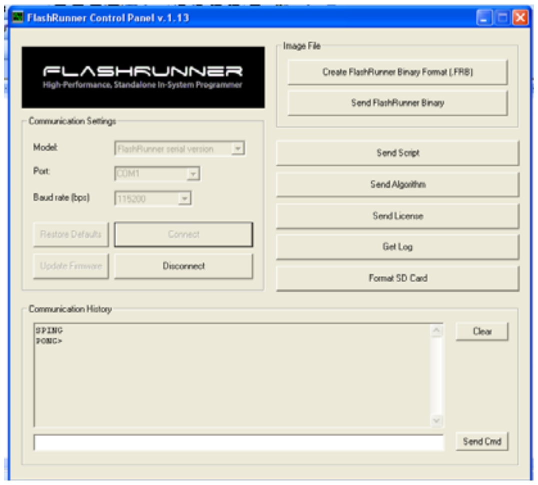
ii. Launch the FlashRunner Control Panel utility. Select Start > Programs > SofTec Microsystems > FlashRunner > Control Panel. The Control Panel utility will open.



Model: FlashRunner serial version
Port: COM1
Baud rate (bps): 115200

Figure 13. FrashRunner Control Panel utility upon launch

iii. To establish a connection with FlashRunner, on the "Communication Settings" section, select "FlashRunner serial version", and specify the COM port you are using and the baud rate (by default, FlashRunner communicates at 115200 bps). Then click "Connect". After successful connection is made, the Control Panel responds with "PONG>" message, as shown below.

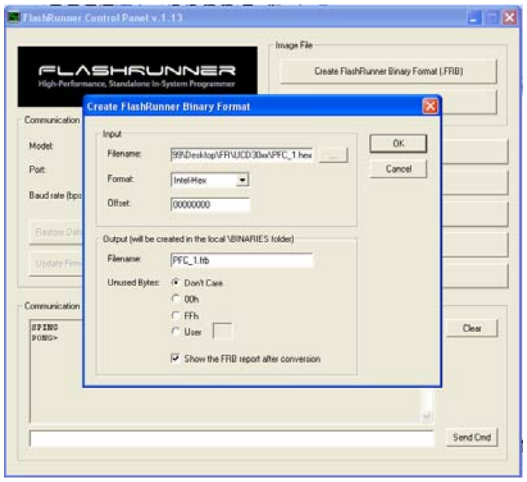


Model: FlashRunner serial version
Port: COM1
Baud rate (bps): 115200

```
SPING
PONG>
```

Figure 14. FlashRunner Control Panel utility after communication with host PC

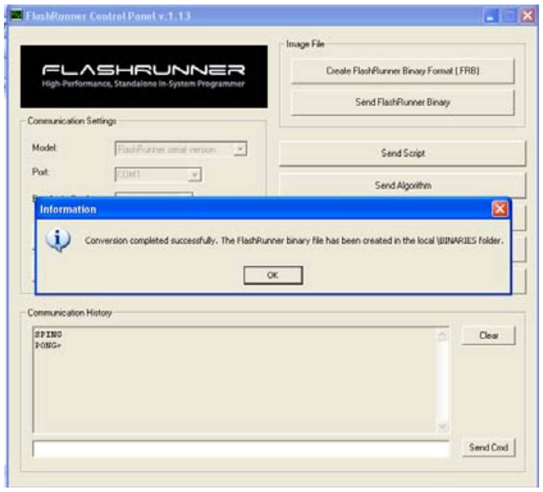
iv. Next, click “Create FlashRunner Binary Format (.FRB)”. In the pop up window that opens, browse and locate the .Hex file created in Section 2.3.1 (select Intel Hex option from the dropdown menu in Format field). Then click OK. In the example below the PFC_1.xo file was chosen.


FlashRunner Control Panel v.1.13
Image File
Create FlashRunner Binary Format (.FRB)
Create FlashRunner Binary Format
Input
OK
Cancel
Output (will be created in the local \BINARIES folder)
Clear
Send Cmd

Filename: 99\Desktop\FR\UCD30xx\PFC_1.hex
Format: Intel-Hex
Offset: 00000000
Filename: PFC_1.frb
Unused Bytes: (●) Don't Care ( ) 00h ( ) FFh ( ) User
[✓] Show the FRB report after conversion

Figure 15. Creating .FRB file using FlashRunner Control Panel

v. A .FRB file with the specified file name (by default, same name as .Hex file) is created and a message is displayed.



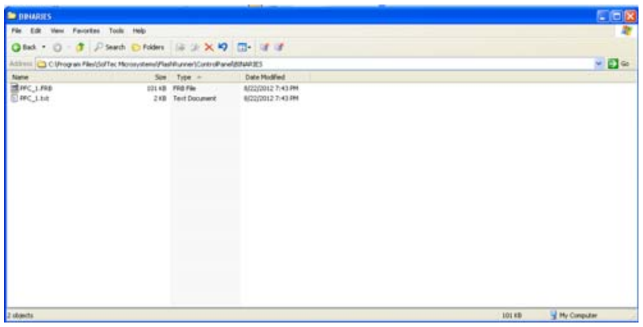
Model: FlashRunner serial version
Port: COM1

Conversion completed successfully. The FlashRunner binary file has been created in the local \BINARIES folder.

```
SPING
PONG>
```

Figure 16. Successful creation of .FRB file using FlashRunner Control Panel

vi. The .FRB file is located in the PC at C:\Program Files\SofTec Microsystems\FlashRunner\ControlPanel\BINARIES. A .txt creation report is also created at the same location. In the example below, a .FRB file named PFC_1.FRB was generated.



Address: C:\Program Files\SofTec Microsystems\FlashRunner\ControlPanel\BINARIES

Name	Size	Type	Date Modified
PFC_1.FRB	101 KB	FRB File	8/22/2012 7:43 PM
PFC_1.txt	2 KB	Text Document	8/22/2012 7:43 PM

2 objects 101 KB My Computer

Figure 17. .FRB file created at C:\Program Files\SofTec Microsystems\FlashRunner\ControlPanel\BINARIES

2.3.4 Generating Script File for Standalone Programming

Please review Section.3 Scripts in FlashRunner Programmer's Manual for detailed information regarding subject covered in this section.

Standalone mode operation of the FlashRunner is enabled by the use of Script files. Script files are text files, stored in the SD card, which contain a sequence of FlashRunner commands. With FlashRunner FR03, for standalone programming, the filename SCRIPT0.FRS' must be used for the script file. The automatic execution of the sequence of commands in the SCRIPT0.FRS script file is triggered when the red 'START' push-button on the FlashRunner FR03 is depressed.

When FlashRunner begins executing the script file, the "BUSY" LED turns on. During script file execution FlashRunner will not answer host commands. Script file execution ends either after FlashRunner has executed the last command in the script, or immediately after the first command in the script that is not successful. When script file execution ends, the "BUSY" LED turns off and either the "PASS" or "FAIL" LED turns on, depending on whether the last command executed was successful or not.

The flowchart below summarizes the typical sequence of commands executed in the script file for standalone operation.

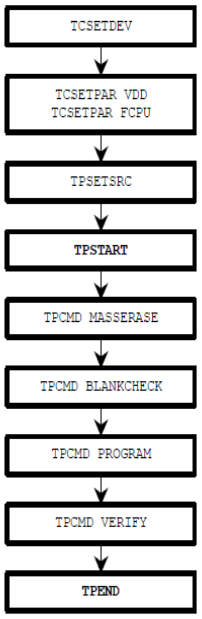


Figure 18. FlashRunner Script development

Please review Section.2 FlashRunner Commands in FlashRunner Programmer's Manual for detailed information regarding command statements executed by FlashRunner.

TI has partnered with SMH Technologies to develop sample scripts that can be used for fast and reliable programming of UCD3xxx devices, from ROM mode as well as Flash mode (Firmware Update). The example scripts provided in the next 2 sections can be used for programming the UCD3xxx devices.

2.3.4.1 Sample Script for Programming UCD3xxx device in ROM Mode

A sample script for programming of UCD30xx devices from ROM mode is provided below. This script programs all 32kB of the program flash and 2kB of data flash in UCD3xxxx devices and performs verification. In verification step, the FlashRunner performs Checksum calculation on the .FRB image file independently and FlashRunner also instructs the UCD3xxx ROM to perform Checksum calculation on the downloaded firmware image in the device. By comparing these 2 calculations, the FlashRunner determines whether a valid programming has been executed or not.

;

```
; FLASHRUNNER SCRIPT EXAMPLE FOR TI UCD3020
;
; Use this example as a starting point for your specific programming needs
;
;
; --------------------
; HARDWARE CONNECTIONS
; --------------------
; DIO1 (SCLK)
; DIO2 (SDATA)
;

; Turns off logging
#LOG_OFF
; Halt on errors
#HALT_ON FAIL

; Sets device
TCSETDEV TI UCD3020 TI_D

; ----------------------------------------------------------------------------------------------------------
; ATTENTION: for more information on the available commands and parameter tuning
; please visit our website: http:\www.smh-tech.com, click on 'Support & download' menu, Download Area
section and
; 'Application Note' subsection and download the document related to the specific programming algorithm
; ----------------------------------------------------------------------------------------------------------

;----------
; SETTINGS
;----------
; Target voltage, mV (change as needed)
TCSETPAR VDD 3300

; VDD Rise-Time, ms (change as needed)
TCSETPAR PWUP 1

; VDD Fall-Time, ms (change as needed)
TCSETPAR PWDOWN 1

; I2C clock frequency, Hz (change as needed)
; For this device the maximum clock frequency is 400000 Hz
TCSETPAR SCLK 400000

; Image file to be programmed (must be placed in the \BINARIES directory)
TPSETSRC FILE FLASH.FRB

;---------------------------
; START PROGRAMMING SESSION
;---------------------------
TPSTART

; Mass erases complete Flash Memory, Program memory, Data memory (C/F/E)
TPCMD MASSERASE C

; Erase Program/Data page (F/E) (change address and length as needed)
;TPCMD ERASE F $10000 $8000

; Blank checks Program/Data (F/E) memory (change address and length as needed)
; TPCMD BLANKCHECK F $10000 $8000

; Programs Program/Data (F/E) memory (change addresses and length as needed)
```

```
TPCMD PROGRAM F $10000 $10000 $8000

TPCMD PROGRAM E $18800 $18800 $800

; Verifies Program/Data (F/E) memory (change source, target address and length as needed)
; If you want you can choose between two types of verification:
; 1) CheckSum method (S) (Recommended)
; 2) Read-Out method (R)

TPCMD VERIFY F S $10000 $10000 $8000

TPCMD VERIFY E S $18800 $18800 $800

; Run program.
; Works only if issued in the same session as PROGRAM command.
; TPCMD RUN

; Ends programming block
TPEND
```

Additional points to note:

- **In the TCSETDEV command, only the following device name options are allowed: UCD3020, UCD3028, UCD3040 and UCD3138**
  Examples:
  ```
  TCSETDEV TI UCD3020 TI_D
  TCSETDEV TI UCD3028 TI_D
  TCSETDEV TI UCD3040 TI_D
  TCSETDEV TI UCD3138 TI_D
  ```

- The TCSETPAR SCLK 400000 command sets the clock frequency (in Hz) for PMBUS protocol. Either 100kHz or 400kHz can be used. 400kHz is recommended for fast programming. **A high-frequency capacitor (C_{HF} in Figure.9) may be necessary to support data transfer at 400kHz.**

- **In the TPSETRC command, the name of the FlashRunner Binary file (.FRB) must match the name of the .FRB file that was generated in section 2.3.3**
  Example:
  ```
  TPSETSRC FILE PFC_1.FRB
  ```

- The actual programming of the device is executed by the TPCMD PROGRAM command with F option for programming the Program flash and E option for programming the Data flash in UCD3xxx devices. Additionally, parameters must be specified in this command to specify the exact starting address and length (# of bytes) that need to programmed in the UCD3xxx device.

- The VERIFY command (with S option) implements the Checksum calculation described earlier, for the memory locations specified by the starting address and length (# of bytes).

- **For Standalone programming with FR03, the script file must be named as SCRIPT0.FRS**

2.3.4.2 Sample Script for Programming UCD3xxx device in Flash Mode (Firmware Update)

For updating the firmware in UCD3xxx device i.e. for re-programming the firmware image, it is necessary to first send the device back to the ROM mode. This is accomplished by adding one more command, known as 'ROMBACK' command, to the script used for programming in ROM mode. The ROMBACK command is inserted immediately after the TPSTART command in the script. All other commands in the ROM mode programming script are retained for Flash mode programming as well.

The ROMBACK statement in the script sends a PMBUS command to the UCD3xxx device forcing it to enter the ROM mode. It is also possible to implement a password requirement in this step in order to avoid accidental re-programming or for added data security. The pre-existing firmware in the device must be capable of recognizing and implementing this PMBUS function.

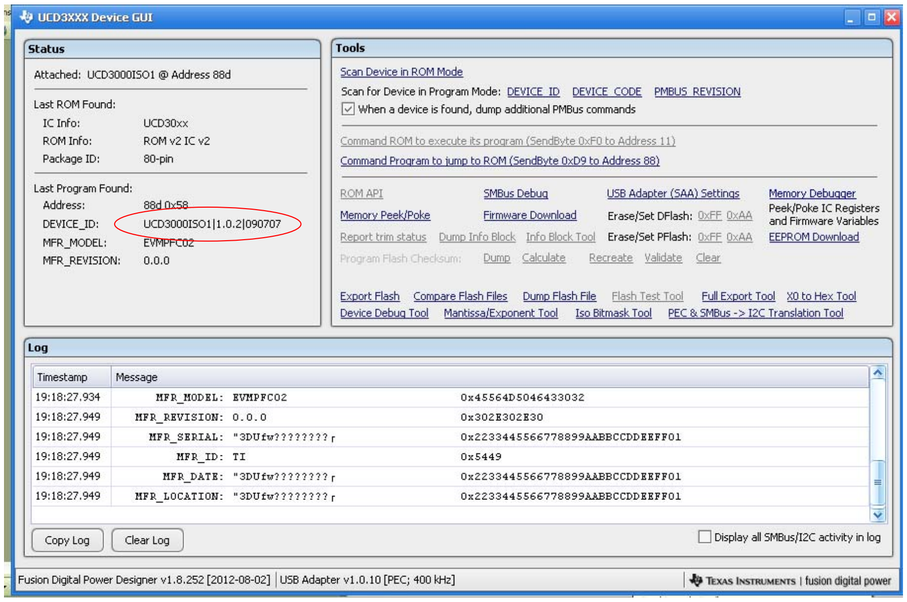
Command syntax:

`TPCMD ROMBACK <command> <delay> <device_id> <pw_length> <pw>`

`command` Command to return to ROM mode
`delay` Delay [msec] before a new boot ROM command.
`device_ID` UCD3XXX device ID code
`pw_length` If pw_length IS '0' no password will be sent, otherwise **`pw_length`** byte will be transmitted
`pw` User defined password

ROMBACK command is used to send device back to ROM mode when a customer firmware is running on the device. The **`command`**, **`device_ID`** and **`pw`** are user definable. Moreover **`pw`** is optional and if no password protection is desired then the requirement for **`pw`** is ignored by assigning the '0' value to **`pw_length`**.

Example for non-password implementation of ROMBACK command:
TPCMD ROMBACK $D9 100 UCD3000ISO1|1.0.2|090707 0
where,
- the 'D9' command resets the device without the need for a password (this command must be defined in the source code of the pre-existing firmware)
- 100 ms is the delay time to allow device to enter ROM mode
- UCD3000ISO1|1.0.2|090707 is the Device ID of the pre-existing firmware on the device (obtained from UCD3xxx Device GUI as shown below)



Attached: UCD3000ISO1 @ Address 88d

Last ROM Found:

IC Info:	UCD30xx
ROM Info:	ROM v2 IC v2
Package ID:	80-pin

Last Program Found:

Address:	88d 0x58
DEVICE_ID:	UCD3000ISO1|1.0.2|090707
MFR_MODEL:	EVMPFC02
MFR_REVISION:	0.0.0

Scan for Device in Program Mode: DEVICE_ID DEVICE_CODE PMBUS_REVISION
[✓] When a device is found, dump additional PMBus commands

Erase/Set DFlash: 0xFF 0xAA
Erase/Set PFlash: 0xFF 0xAA
Peek/Poke IC Registers and Firmware Variables
Program Flash Checksum:

```
Timestamp     Message
19:18:27.934      MFR_MODEL: EVMPFC02                  0x45564D5046433032
19:18:27.949   MFR_REVISION: 0.0.0                     0x302E302E30
19:18:27.949     MFR_SERIAL: "3DUfw????????┌           0x2233445566778899AABBCCDDEEFF01
19:18:27.949         MFR_ID: TI                        0x5449
19:18:27.949       MFR_DATE: "3DUfw????????┌           0x2233445566778899AABBCCDDEEFF01
19:18:27.949   MFR_LOCATION: "3DUfw????????┌           0x2233445566778899AABBCCDDEEFF01
```

[ ] Display all SMBus/I2C activity in log

Fusion Digital Power Designer v1.8.252 [2012-08-02] | USB Adapter v1.0.10 [PEC; 400 kHz] | Texas Instruments | fusion digital power

Figure 19. Reading UCD3xxx Device ID using UCD3xxx Device GUI

Examples of ROMBACK command with 1, 2 or 4-byte password implementation shown in table below:
TPCMD ROMBACK $26 100 UCD3000ISO1|1.0.2|090707 4 $34129078
TPCMD ROMBACK $25 100 UCD3000ISO1|1.0.2|090707 2 $3456
TPCMD ROMBACK $24 100 UCD3000ISO1|1.0.2|090707 1 $12
where,

Password Byte Option	Command Code	Password			
		Byte 1	Byte 2	Byte 3	Byte 4
1	0x24	0x12			
2	0x25	0x56	0x34		
4	0x26	0x78	0x90	0x12	0x34

NOTE: In order to implement the ROMBACK command successfully:
- **The Device ID of the <u>pre-existing</u> firmware image of the device must be known**
- **The <u>pre-existing</u> firmware image on the UCD3xxx device MUST be capable of recognizing the PMBUS command (such as a standard D9 command for non-password option and specific user-defined commands for password option) called by the ROMBACK statement to force the device to enter ROM mode. This requires the PMBUS command to be properly defined in the source code of the pre-existing firmware image.**

- **Also, in all the examples above, a delay time of 100ms is used. Special functions MUST be included in the source code of the pre-existing firmware image in order to allow the device to return to ROM mode reliably within 100ms. If these methods are not implemented then a delay time of at least 3000ms will be necessary for UCD3020/3028/3040 and a delay time of at least 2000ms will be necessary for UCD3138.**

Section 4 of this document provides a detailed discussion regarding source code requirements for implementing the ROMBACK command examples listed above.

The complete example script file for programming in Flash mode is provided below and the ROMBACK command needed is highlighted in boldface. In this script example, the ROMBACK command is implemented with non-password option (to implement password security simply comment out the ROMBACK statement shown below and uncomment the ROMBACK statement for the desired password option).

```
;
; FLASHRUNNER SCRIPT EXAMPLE FOR TI UCD3020
;
; Use this example as a starting point for your specific programming needs
;
;
; --------------------
; HARDWARE CONNECTIONS
; --------------------
; DIO1 (SCLK)
; DIO2 (SDATA)
;

; Turns off logging
#LOG_OFF
; Halt on errors
#HALT_ON FAIL

; Sets device
TCSETDEV TI UCD3020 TI_D

; ----------------------------------------------------------------------------------------------------------
; ATTENTION: for more information on the available commands and parameter tuning
; please visit our website: http:\www.smh-tech.com, click on 'Support & download' menu, Download Area section and
; 'Application Note' subsection and download the document related to the specific programming algorithm
; ----------------------------------------------------------------------------------------------------------

;----------
; SETTINGS
;----------
; Target voltage, mV (change as needed)
TCSETPAR VDD 3300

; VDD Rise-Time, ms (change as needed)
TCSETPAR PWUP 1

; VDD Fall-Time, ms (change as needed)
TCSETPAR PWDOWN 1

; I2C clock frequency, Hz (change as needed)
; For this device the maximum clock frequency is 400000 Hz
TCSETPAR SCLK 400000

; Image file to be programmed (must be placed in the \BINARIES directory)
TPSETSRC FILE FLASH.FRB

;--------------------------
```

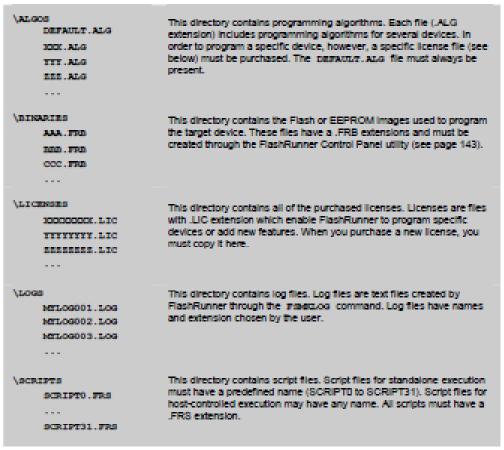
```
; START PROGRAMMING SESSION
;---------------------------
TPSTART

; This instruction is needed only for re-programming of device (Firmware UPDATE)
; This instruction permits to restore ROM mode from Flash mode (change command, delay, Device ID as needed, password length, password as needed)
; If you don't have a password put '0' in password length field, otherwise indicate password length (max 4 bytes) and then put it on password field (refer TI Application Note for related firmware requirements)

TPCMD ROMBACK $D9 100 UCD3000ISO1|1.0.2|090707 0
; TPCMD ROMBACK $26 100 UCD3000ISO1|1.0.2|090707 4 $34129078
; TPCMD ROMBACK $26 100 UCD3000ISO1|1.0.2|090707 4 $34129078
; TPCMD ROMBACK $26 100 UCD3000ISO1|1.0.2|090707 4 $34129078

; Mass erases complete Flash Memory, Program memory, Data memory (C/F/E)
TPCMD MASSERASE C

; Erase Program/Data page (F/E) (change address and length as needed)
;TPCMD ERASE F $10000 $8000

; Blank checks Program/Data (F/E) memory (change address and length as needed)
; TPCMD BLANKCHECK F $10000 $8000

; Programs Program/Data (F/E) memory (change addresses and length as needed)

TPCMD PROGRAM F $10000 $10000 $8000

TPCMD PROGRAM E $18800 $18800 $800

; Verifies Program/Data (F/E) memory (change source, target address and length as needed)
; If you want you can choose between two types of verification:
; 1) CheckSum method (S) (Recommended)
; 2) Read-Out method (R)

TPCMD VERIFY F S $10000 $10000 $8000

TPCMD VERIFY E S $18800 $18800 $800

; Run program.
; Works only if issued in the same session as PROGRAM command.
; TPCMD RUN

; Ends programming block
TPEND
```

NOTE: For standalone programming with FlashRunner FR03, the file name of the script file MUST be 'SCRIPT0.FRS'.

2.3.5 Sending Binary (.FRB) & Script (SCRIPT0.FRS) files to SD card in FlashRunner

Please review Section.5 SD Card File Structure in FlashRunner Programmer's Manual for detailed information regarding the subject covered in this section.

The FlashRunner unit is provided with a pre-formatted SD card with the file structure shown in Figure 20.

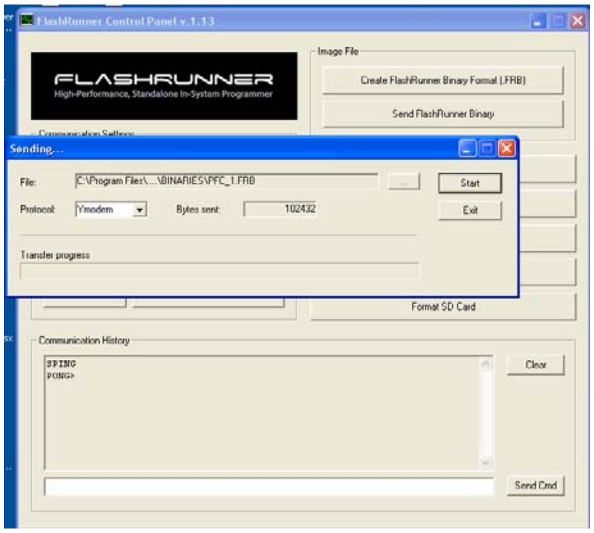


\ALGOS DEFAULT.ALG XXX.ALG YYY.ALG ZZZ.ALG ...	This directory contains programming algorithms. Each file (.ALG extension) includes programming algorithms for several devices. In order to program a specific device, however, a specific license file (see below) must be purchased. The DEFAULT.ALG file must always be present.
\BINARIES AAA.FRB BBB.FRB CCC.FRB ...	This directory contains the Flash or EEPROM images used to program the target device. These files have a .FRB extensions and must be created through the FlashRunner Control Panel utility (see page 143).
\LICENSES XXXXXXXX.LIC YYYYYYYY.LIC ZZZZZZZZ.LIC ...	This directory contains all of the purchased licenses. Licenses are files with .LIC extension which enable FlashRunner to program specific devices or add new features. When you purchase a new license, you must copy it here.
\LOGS MYLOG001.LOG MYLOG002.LOG MYLOG003.LOG ...	This directory contains log files. Log files are text files created by FlashRunner through the FSMKLOG command. Log files have names and extension chosen by the user.
\SCRIPTS SCRIPT0.FRS ... SCRIPT31.FRS	This directory contains script files. Script files for standalone execution must have a predefined name (SCRIPT0 to SCRIPT31). Script files for host-controlled execution may have any name. All scripts must have a .FRS extension.

Figure 20. SD Card file structure after formatting by FlashRunner

The final preparation step for standalone programming with FR03 involves installing the .FRB file created in section 2.3.3 and the SCRIPT0.FRS script file created in section 2.3.4 at the appropriate locations in the SD card. In order to accomplish this, the following steps need to be performed:

i. Insert the SD card provided into the FlashRunner unit.
ii. Click “Send FlashRunner Binary”. In the pop-up window, browse and locate the .FRB file created in section 2.3.3. at the location C:\Program Files\SofTec Microsystems\FlashRunner\ControlPanel\BINARIES. Click “Start”.

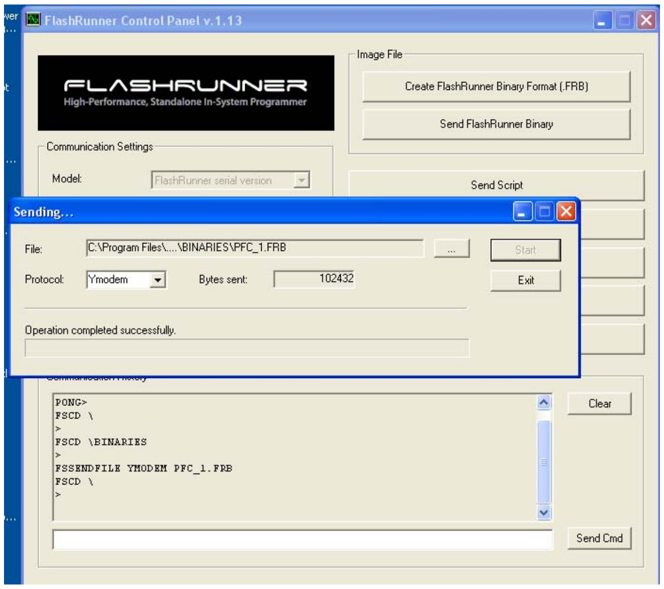


File: C:\Program Files\....\BINARIES\PFC_1.FRB
Protocol: Ymodem
Bytes sent: 102432

```
$PING
PONG>
```

Figure 21. Sending .FRB file to SD card using FlashRunner Control Panel

After successful execution of this step, a message is displayed. Click “Exit”. In this example the PFC_1.FRB file was installed in the BINARIES folder in the SD card.


FlashRunner Control Panel v.1.13
FLASHRUNNER
High-Performance, Standalone In-System Programmer
Image File
Create FlashRunner Binary Format (.FRB)
Send FlashRunner Binary
Communication Settings
Send Script
Sending...
Start
Exit
Clear
Send Cmd

Model: FlashRunner serial version

File: C:\Program Files\....\BINARIES\PFC_1.FRB

Protocol: Ymodem   Bytes sent: 102432

Operation completed successfully.

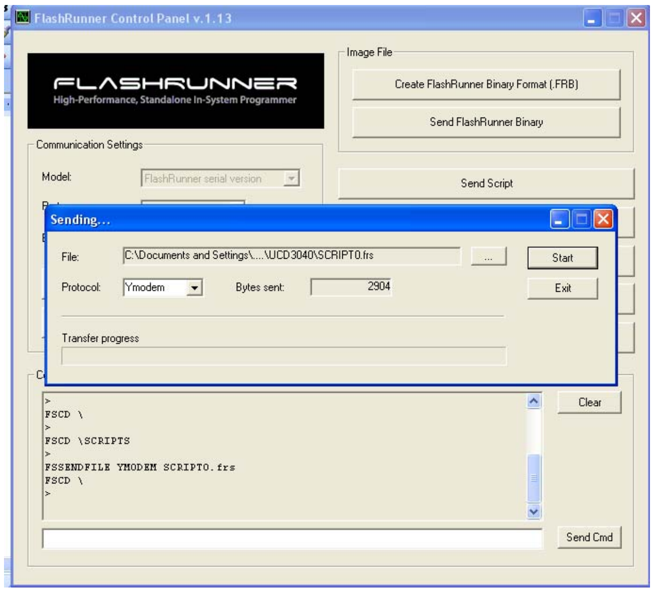
```
PONG>
FSCD \
>
FSCD \BINARIES
>
FSSENDFILE YMODEM PFC_1.FRB
FSCD \
>
```

Figure 22. FlashRunner Control Panel after successfully sending .FRB file to SD

Note: The filename of .FRB file installed in the SD card must be the same as the filename specified in the TPSETRC command line of the SCRIPT0.FRS script file.
Example:

```
TPSETSRC FILE PFC_1.FRB
```

iii Next, Click “Send Script”. In the pop-up window, browse and locate the SCRIPT0.FRS script file created in section 2.3.4 and click “Start”.


FlashRunner Control Panel v.1.13
FLASHRUNNER
High-Performance, Standalone In-System Programmer
Image File
Create FlashRunner Binary Format (.FRB)
Send FlashRunner Binary
Communication Settings
Send Script
Sending...
Start
Exit
Clear
Send Cmd

Model: FlashRunner serial version

File: C:\Documents and Settings\....\UCD3040\SCRIPT0.frs

Protocol: Ymodem   Bytes sent: 2904

Transfer progress

```
>
FSCD \
>
FSCD \SCRIPTS
>
FSSENDFILE YMODEM SCRIPT0.frs
FSCD \
>
```

Figure 23. Sending script file SCRIPT0.FRs file to SD card using FlashRunner Control Panel

Once again, after successful execution of this step, a message is displayed. Click “Exit”.

After this, the FlashRunner unit with the SD card is ready to perform Standalone programming of UCD3xxx devices.

2.3.6 Additional Notes

The FlashRunner unit is provided with all the licenses and algorithm files related to programming UCD3xxx devices pre-installed in the SD card at the appropriate locations.

- TI_D.ALG and DEFAULT.ALG files must be present inside the ALGOS directory inside the SD card
- Type "FSCD ALGOS" command in Control Panel and enter the ALGOS directory of SD card. Next type "FSLS**"** command to list the files and verify the required files are available. Enter "**FSCD \**" to return to the root directory
- If these files are not present then save DEFAULT.ALG and TI_D.ALG files (provided by SMH technologies) in local path "C:\Program Files\SofTec Microsystems\FlashRunner\ControlPanel\ALGOS" and install them inside the SD card using "Send Algorithm" option of Control Panel
- In a similar manner, ensure that all required licence files are installed inside the LICENSES directory of the SD card. If not, the save all the license files (.LIC) in local path "C:\Program Files\SofTec Microsystems\FlashRunner\ControlPanel\LICENSES" and install the files in the SD card using "Send Licences" option of Control Panel.
- The licence files (.LIC) are exclusive to the FlashRunner FR03 unit serial # being used for programming and also the UCD3xxx programming algorithm.

3. FlashRunner FR03 Standalone Programming Procedure

Programming the FlashRunner involves the following steps:

1. Power up the FlashRunner FR03
2. Insert SD card with all the requisite files installed inside. Use Checklist below:
    - Ensure SCRIPT0.FRS script file & firmware image (.FRB) file are installed in SD card at correct location
    - Ensure that the correct Device name is used in the TCSETDEV statement in the script file
    - Ensure that the filename of the firmware image file (.FRB) in the SD card matches the file name specified in the TPSETSRC statement in the script file
    - Ensure that correct Device ID of the pre-existing firmware is used in the ROMBACK statement in the script file (for firmware update)
    - Ensure that the pre-existing firmware can support the PMBUS commands in ROMBACK statement (for firmware update)
    - Ensure the correct password is used in ROMBACK statement (if desired, for firmware update)
    - Ensure that all licenses of the FR03 unit being used are installed in SD card at correct location
    - Ensure that TI_D.ALG and DEFAULT.ALG algorithm files are loaded in the SD card at correct location
3. Connect interface cable between the DUT board (with the device to be programmed) and the FR03 unit ISP connector
    - Ensure that the C_{HF} capacitor is properly installed on the interface cable to support high-frequency PMBUS protocol during programming
4. Provide 3.3V bias to the target Device (can be biased either with external power supply or directly from the VPROG0 line from FlashRunner ISP connector)
5. Press the red START button on the FR03 unit

The response from the status LEDs is summarized below:

Scenario	**LED status**
During programming	the yellow BUSY status LED is lit up
After successful programming and verification[1] by FR03	the green PASS status LED is lit up
If programming is unsuccessful[2]	the red FAIL status LED is lit up

[1] - In verification step, the FlashRunner performs Checksum calculation on the .FRB image file independently and FlashRunner also instructs the UCD3xxx ROM to perform Checksum calculation on the downloaded firmware image in the device. By comparing these 2 calculations, the FlashRunner determines whether a valid programming has been executed or not. If a valid Checksum was written during .xo file generation step, then the device will be put in Flash-mode after successful programming. If an invalid Checksum was written during .xo file generation step, then the device will stay in ROM mode after successful programming.

[2] – There are several reasons related to set-up which can cause programming to be unsuccessful. A checklist is provided in table below for trouble-shooting purpose:

Reason for unsuccessful programming	**Troubleshooting Guideline**
ROMBACK command Password is incorrect	Use correct password, according to definition in pre-existing firmware in the device
Delay time parameter in ROMBACK command is insufficient	Increase delay time or add additional code to implement faster reset according to Section 4.1 in this document
ROMBACK command is not included in script file when device to be programmed is in Flash mode	Add ROMBACK statement in SCRIPT0.FRS file
DEVICE ID in ROMBACK statement is incorrect	Use correct DEVICE ID according to pre-existing firmware in the device in ROMBACK statement
Invalid Device name is used in TCSETDEV statement	Use only valid Device names (UCD3020, UCD3028, UCD3040 and UCD3138) in TCSETDEV statement.
Script file name is not SCRIPT0.FRS	Change Script file name to 'SCRIPT0.FRS'
The .FRB file name in SD card does not match .FRB file name in script file TPSETRC statement	Change .FRB file name in TPSETRC statement of script file to match .FRB file installed in SD card
C_{HF} capacitor is not properly installed or is too small value to support 400khz PMBUS protocol	Check C_{HF} capacitor installation or increase C_{HF} capacitor value
PMBUS command in ROMBACK statement is not recognized by the pre-existing firmware on the device	Pre-existing firmware in device must support PMBUS command in ROMBACK statement. Firmware update feature cannot be used if this condition is not met.

4. Source Code Requirements for Successful ROMBACK Command Implementation in Flash Mode Programming

If Firmware Update feature using FlashRunner is desired, then it is important to ensure that the pre-existing firmware image on the device has the capability to recognize the PMBUS command in the ROMBACK statement and to send the device back to the ROM mode, from where it can be re-programmed. This means that the PMBUS command must be properly defined in the source code of the pre-existing image in the device.

ROMBACK Command syntax:
`TPCMD ROMBACK <command> <delay> <device_id> <pw_length> <pw>`

`command` Command to return to ROM mode
`delay` Delay [msec] before a new boot ROM command
`device_ID` UCD3XXX device ID code
`pw_length` If pw_length IS ‘0’ no password will be sent, otherwise **`pw_length`** byte will be transmitted
`pw` User defined password

Command parameters:
This command is used to go back to ROM mode when a customer firmware is running on the device. The **`command`**, **`device_ID`** and **`pw`** parameters are user definable. Moreover **`pw`** is optional and if no password protection is desired then the requirement for **`pw`** is ignored by assigning the ‘0’ value to **`pw_length`**.

4.1 Implementing Fast Device Re-programming

The PMBUS command in the ROMBACK statement will deliberately reset the device and force invalid checksum to send it back to ROM mode. A delay time has to be specified in the ROMBACK command, allowing enough time for the device to enter ROM mode. However, this delay time must be kept to a minimum to enable fast re-programming. There are 2 methods recommended to enable delay time of less than 100ms:

1. One method to force a quick reset in less than 100ms is by pointing the device to an illegal memory location during the PMBUS command execution. This is easily implemented by adding the code highlighted in boldface in the ‘interrupts.c’ file:

```
case 12: //zero_integrity_word();
 DecRegs.PFLASHILOCK = 0x42DC157E;// Write key to Program Flash Interlock Register

 {
   register Uint32 * program_index = (Uint32 *) 0x19000;  //store destination address for erase checksum
program
   register Uint32 * source_index = (Uint32 *)zero_integrity_word; //Set source address of PFLASH;
    register Uint32 zoiw_size = (Uint32 *)zoiw_end - (Uint32 *)zero_integrity_word;//Calculate lenght
    register Uint32 counter;

     for(counter=0; counter < zoiw_size; counter++) //Copy program from PFLASH to RAM
        {
              *(program_index++)=*(source_index++);
        }
 {
     register FUNC_PTR func_ptr;
     func_ptr=(FUNC_PTR)0x19000;//Set function to 0x19000
     func_ptr();
     //now jump out into space and force a reset
     func_ptr=(FUNC_PTR)0x200000;//Set function to 0x200000
     func_ptr();
 } //execute erase checksum
return;
```

2. Another method to force a quick reset in less than 100ms is by implementing a software reset using the

system exception control register SYSECR bit in the 'clear_program_flash.c' file, highlighted in boldface below:

```
void zero_out_integrity_word(void)
{
    DecRegs.FLASHILOCK.all = 0x42DC157E;// Write key to Program Flash Interlock Register
    DecRegs.MFBALR1.all = MFBALRX_BYTE0_BLOCK_SIZE_32K; //enable program flash write
    program_flash_integrity_word = 0;
    DecRegs.MFBALR1.all = MFBALRX_BYTE0_BLOCK_SIZE_32K + //expand program flash out to 4x real
size
                                                  MFBALRX_BYTE0_RONLY;
    while(DecRegs.PFLASHCTRL.bit.BUSY != 0)
    {
          ; //do nothing while it programs
    }
    SysRegs.SYSECR.bit.RESET = 2; //reset device
    return;
}
```

NOTE: One of these reset methods described above must be implemented in the source code of pre-existing firmware on the device in order to be able to use a delay time of 100ms in the ROMBACK command. If these methods are not implemented then a delay time of 3000ms will be necessary for UCD3020/3028/3040 and a delay time of 2000ms will be necessary for UCD3138.

4.2 Implementing Password Protection during Firmware Update

FlashRunner also offers the user the option to implement password protection during firmware update. The password can be 1 byte, 2 bytes or 4 bytes long and is defined by the user. The code highlighted in boldface below illustrates examples of how to implement the 1, 2, and 4 bit passwords and related PMBUS commands (shown in table below). One of the password options may be chosen and the related code should be included in 'pmbus.c' in the source code of pre-existing firmware on the device. The user has flexibility to define the exact command code.

Password Byte Option	Command Code	Password			
		Byte 1	Byte 2	Byte 3	Byte 4
1	0x24	0x12			
2	0x25	0x56	0x34		
4	0x26	0x78	0x90	0x12	0x34

```
// look at command byte from a write perspective
int32 pmbus_write_message(void)
{
    switch (pmbus_buffer[0])
    {
          case PMBUS_CMD_ROM_MODE:
                return pmbus_write_rom_mode();
          case 0x24:

                if((pmbus_buffer[1] == 0x12) && (pmbus_number_of_bytes == 3)) //1 byte password
                {
                        return pmbus_write_rom_mode();
                }
                else
                {
                        return 0;
                }
          case 0x25:
                if((pmbus_buffer[2]    ==    0x34)    &&    (pmbus_buffer[1]    ==    0x56)    &&
(pmbus_number_of_bytes == 4)) //1 word password
                {
                        return pmbus_write_rom_mode();
                }
                else
```

```
                    {
                            return 0;
                    }
            case 0x26:
                    if((pmbus_buffer[1] == 0x4) && (pmbus_buffer[2] == 0x78) &&
                    (pmbus_buffer[3] == 0x90) && (pmbus_buffer[4] == 0x12) &&
                    (pmbus_buffer[5] == 0x34) && (pmbus_number_of_bytes == 7)) //4 byte password
                    {
                            return pmbus_write_rom_mode();
                    }
                    else
                    {
                            return 0;
                    }

         case PMBUS_CMD_MFR_PARM_INFO:
            return pmbus_write_parm_info();
            case PMBUS_CMD_MFR_PARM_VALUE:
                    return pmbus_write_parm_value();
            default:
                    break;
     }
     return 0;
}
```

5. UCD3xxx Device Programming Time using FlashRunner FR03

Programming Time

The table below provides time taken for programming 32kB program flash and 2kB data flash and verification by FlashRunner FR03 in Standalone mode, for a UCD3040 device:

	400KHz PMBUS	**100kHz PMBUS**
ROM Mode	3.4 sec	6.2 sec
Flash Mode (firmware update)	3.6 sec	6.4 sec

The measurements above were generated from:
- UCD3040 PR799A Control Card, biased using the PMBUS line VPROG0 from FlashRunner ISP connector
- Using script examples provided in this document, with 100ms delay time in ROMBACK command for Flash mode programming

6. References

1. FlashRunner FR03 – User’s Manual
2. FlashRunner FR03 – Programmer’s Manual
3. AN00153: Interfacing FlashRunner with TI UCD30XX Devices (DC10496.pdf)
4. UCD3040/20/28 Device Datasheet, Literature # - SLU868
5. UCD30xx Flash Application Note
6. UCD3138 Device Datasheet, Literature # - SLUSAP2
7. UCD3138 ARM and Digital System Programmer’s Manual – SLUU994

Products	**Applications**
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DLP® Products www.dlp.com	Consumer Electronics www.ti.com/consumer-apps
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Interface interface.ti.com	Medical www.ti.com/medical
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RFID www.ti-rfid.com	OMAP Mobile Processors www.ti.com/omap
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Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		