

AN00168: Interfacing FlashRunner with Texas Instruments Stellaris LM3S3000 Devices using Serial Wire Debug (SWD) Interface

FlashRunner is a Universal In-System Programmer, which uses the principles of In-Circuit Programming to program Texas Instruments Stellaris LM3S3000 family microcontrollers. This Application Note describes how to properly set up and use FlashRunner to program Stellaris LM3S3000 family Flash devices.

This Application Note assumes that you are familiar with both FlashRunner and the main features of the Stellaris LM3S3000 family devices. Full documentation about these topics is available in the FlashRunner user's manual and in device-specific datasheets.

1. Introduction

In-system programming of Stellaris LM3S3000 microcontrollers is performed through Serial Wire Debug (SWD) interface/protocol.

In order to use FlashRunner to perform in-system programming, you need to implement the appropriate in-circuit programming hardware interface on your application board.

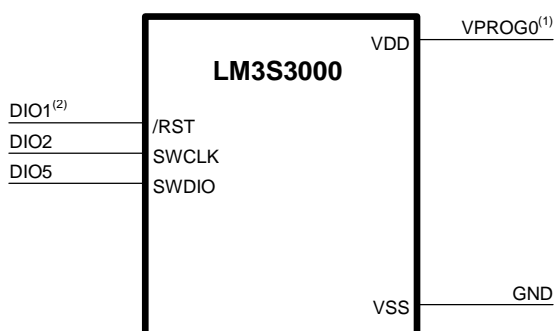
Thanks to its in-system programming capabilities, FlashRunner allows you to program or update the content of the Flash memory when the chip is already plugged on the application board.

2. Hardware Configuration

The microcontroller's lines needed to program a LM3S3000 device are the following:

- **/RST**: System reset (Optional).
- **SWCLK**: Serial wire clock.
- **SWDIO**: Serial wire debug input/output.
- **VDD**: Device power supply voltage.
- **VSS**: Device power supply ground.

The lines mentioned above must be connected to the FlashRunner's "ISP" connector according to the following diagram:



⁽¹⁾ Connect this line if you want FlashRunner to automatically power the target device

⁽²⁾ Optional

3. Specific TCSETPAR Programming Commands

Overview

TCSETPAR commands set device-specific and programming algorithm-specific parameters. These commands must be sent after the **TCSETDEV** command and before a **TPSTART** / **TPEND** command block.

All of the following parameters must be correctly specified through the relative **TCSETPAR** commands (although the order with which these parameters are set is not important):

- VDD voltage;
- VDD_AUX voltage
- Power Up time;
- Power Down time;
- Reset Up time;
- Reset Down time;
- Reset Drive mode;
- SWCLK Serial Wire clock frequency;
- FCPU CPU clock frequency.
- FOSC External clock source frequency

TCSETPAR VDD

Command syntax:

TCSETPAR VDD <voltage mV>

Parameters:

voltage mV: Target device supply voltage, expressed in millivolts.

Description:

This command is used to properly generate the voltage level of the ISP lines. Additionally, the specified voltage is routed to the VPROG0 line of the FlashRunner's "ISP" connector, which can be used as a supply voltage for the target board.

TCSETPAR VDD_AUX

Command syntax:

TCSETPAR VDD_AUX <voltage mV>

Parameters:

voltage mV: Auxiliary supply voltage, expressed in millivolts, in the range 3000-14500mV.

Description:

This command is used to generate an optional, auxiliary voltage level for user purposes. The specified voltage is routed to the VPROG1 line of the FlashRunner "ISP" connector.

A value of 0 drives the VPROG1 line to GND. If the **TCSETPAR VDD_AUX** is not sent, the VPROG1 line is driven to HiZ.

TCSETPAR PWUP

Command syntax:

TCSETPAR PWUP <time ms>

Parameters:

time ms: Power rising time, expressed in milliseconds.

Description:

This command is necessary because, to enter the programming mode, FlashRunner must properly drive the V_{DD} line during the power-on reset.

The V_{DD} rising time (PWUP) is expressed in milliseconds and depends on the features of your target board. Make sure to choose a value large enough to ensure that the V_{DD} signal reaches the high logic level within the specified time. Note that, if the V_{DD} line has a high load, a longer time is required for the V_{DD} signal to reach the high logic level. If PWUP is not long enough, FlashRunner could not be able to enter the programming mode.

TCSETPAR PWDOWN

Command syntax:

TCSETPAR PWDOWN <time ms>

Parameters:

time ms: Power falling time, expressed in milliseconds.

Description:

The V_{DD} falling time (PWDOWN) is expressed in milliseconds and depends on the features of your target board. Make sure to choose a value large enough to ensure that the V_{DD} signal reaches the low logic level within the specified time. Note that, if the V_{DD} line has a high load, a longer time is required for the V_{DD} signal to reach the low logic level.

TCSETPAR RSTUP

Command syntax:

TCSETPAR RSTUP <time μ s>

Parameters:

time μ s: Reset rising time, expressed in microseconds.

Description:

The Reset rising time (RSTUP) is expressed in microseconds and depends on the features of your target board. Make sure to choose a value large enough to ensure that the Reset signal reaches the high logic level within the specified time. Note that, if the Reset line has a high load, a longer time is required for the Reset signal to reach the high logic level.

TCSETPAR RSTDOWN

Command syntax:

TCSETPAR RSTDOWN <time μ s>

Parameters:

time μ s: Reset falling time, expressed in microseconds.

Description:

The Reset falling time (RSTDOWN) is expressed in microseconds and depends on the features of your target board. Make sure to choose a value large enough to ensure that the Reset signal reaches the low logic level within the specified time. Note that, if the Reset line has a high load, a longer time is required for the Reset signal to reach the low logic level.

TCSETPAR RSTDRV

Command syntax:

TCSETPAR RSTDRV <mode>

Parameters:

mode: Reset drive mode.

Options:

OPENDRAIN

PUSHPULL

Description:

Sets the Reset line driving mode

TCSETPAR SWCLK

Command syntax:

TCSETPAR SWCLK <Hz>

Parameters:

Hz: serial wire debug clock frequency in Hertz

Description:

This parameter is used to set up the speed of clock signal on SWD interface. Value must be less than 10.000.000.

The effective frequency of the SWD clock signal driven by FlashRunner is the higher value less or equal to this parameter that can be obtained from the following formula:

$\text{SWD Clock} = 12.500.000 / \text{div.}$ (where *div* is an integer value).

The maximum clock speed is 6.250.000 Hz.

TCSETPAR FCPU

Command syntax:

TCSETPAR FCPU <Hz>

Parameters:

Hz: CPU core frequency in Hertz

Description:

This parameter is used to enable the microcontroller's PLL and speed up the programming performance. This command sets the system clock frequency to its maximum value. This parameter must be set in conjunction with the FOSC parameter.

TCSETPAR FOSC

Command syntax:

TCSETPAR FOSC <Hz>

Parameters:

Hz: External clock source frequency in Hertz

Description:

This parameter sets the main oscillator as the clock source for the system clock. This parameter must be set in conjunction with the FCPU parameter to enable the PLL.

4. Specific TPCMD Programming Commands

Overview

TPCMD commands perform a programming operation (i.e. mass erase, program, verify, etc.) These command must be sent within a **TPSTART** / **TPEND** command block.

LM3S3000 specific target programming commands are the following:

- **TPCMD MASSERASE;**
- **TPCMD ERASE;**
- **TPCMD BLANKCHECK;**
- **TPCMD PROGRAM;**
- **TPCMD VERIFY;**
- **TPCMD READ;**
- **TPCMD RUN;**

TPCMD MASSERASE

Command syntax:

TPCMD MASSERASE F

Command options:

F Specifies that this command refer to Flash memory (**F**).



Description:

It erases all the device Flash memory (**F**).

TPCMD ERASE

Command syntax:

```
TPCMD ERASE F <tgt start addr> <len>
```

Command parameters and options:

- F:** Specifies Flash (**F**) memory.
- tgt start address:** Device memory location from where the erase operation will start.
- len:** Number of locations to be erased.
It must be a multiple of 1KB page size

Description:

It erases Flash memory pages. Erase **len** locations starting from the address specified by **tgt start address**. The start address is the logical address specified in each single device datasheet or User's Guide under "Memory" chapter.

TPCMD BLANKCHECK

Command syntax:

```
TPCMD BLANKCHECK F <tgt start addr> <len>
```

Command parameters and options:

- F:** Specifies Flash (**F**) memory.
- tgt start address:** Device memory location from where the blankcheck operation will start.



len: Number of locations to be blankchecked.

Description:

It blankchecks Flash memory. Blankchecks **len** locations starting from the address specified by **tgt start addr**. The start address is the logical address specified in each single device datasheet or User's Guide under "Memory" chapter.

TPCMD PROGRAM

Command syntax:

TPCMD PROGRAM F <src offset> <tgt start addr> <len>

Command parameters and options:

F: Specifies Flash (**F**) memory.

src offset: Offset from the beginning of the source memory.

tgt start addr: Device memory location from where the program operation will start.

len: Number of locations to be programmed.

Description:

It programs **len** locations of Flash memory starting from the **tgt start addr** address.

len specifies the number of locations to be programmed. **tgt start addr** is the logical address specified in each single device datasheet or User's Guide under "Memory" chapter.

TPCMD VERIFY

Command syntax:

```
TPCMD VERIFY F R|S <src offset> <tgt start addr> <len>
```

Command parameters and options:

F:	Specifies Flash (F) memory.
R	Specifies Readout (R) method.
S	Specifies Checksum (s) method.
src offset:	Offset from the beginning of the source memory.
tgt start addr:	Device memory location from where the verify operation will start.
len:	Number of locations/option bytes to be verified

Description:

It verifies **len** locations of Flash memory starting from the **tgt start addr** address. **len** specifies the number of locations to be verified.

TPCMD READ

Command syntax:

```
TPCMD READ F <tgt start addr> <len>
```

Command parameters and options:

F:	Specifies Flash (F) memory.
tgt start addr:	Device memory location from where the read operation will start.
len:	Number of locations to be read.



Description:

It reads **len** locations of Flash memory starting from the **tgt start addr** address. **len** specifies the number of locations to be read.

TPCMD RUN

Command syntax:

TPCMD RUN

Command parameters:

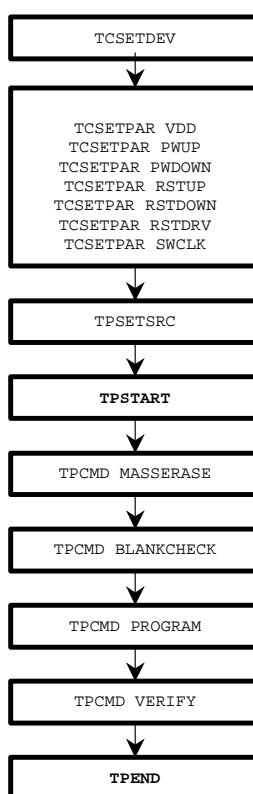
None.

Description:

It runs the target application.

5. Typical Programming Flow

The following flow chart illustrates typical steps to help you write your own script file.



6. Script Example

The example below shows a typical programming flow for a LM3S3000 device.

```
;
; FLASHRUNNER SCRIPT EXAMPLE FOR TI LM3S3739
;
; Use this example as a starting point for your specific programming needs
;
; -----
;
; Hardware connections
;
; DIO1/AO1      (/RST - optional)
; DIO2          (SWCLK)
; DIO5          (SWDIO)
;
; Turns off logging
#LOG_OFF
; Halt on errors
#HALT_ON FAIL
; Sets device
TCSETDEV TI LM3S3739 TI_ARM
;-----
; FLASHRUNNER I/O Settings
;-----

; Target voltage, mV (change as needed)
TCSETPAR VDD 3600

; VPROG1 voltage, mV (from 3000 to 14500, 0 to disable)(change as needed)
TCSETPAR VDD_AUX 0

; Clock oscillator frequency driven by FlashRunner, Hz
; Possible frequencies are: 25000000, 12500000, 6250000, 0 (DISABLED)
TCSETPAR CLKOUT 0

; RESET down time (from 0 us to 65535 us)
TCSETPAR RSTDOWN 1000
; RESET up time (from 0 us to 65535 us)
TCSETPAR RSTUP 1000
```



```
; RESET driving mode (PUSHPULL or OPENDRAIN)
TCSETPAR RSTDRV OPENDRAIN

; Power down time (from 0 ms to 65535 ms)
TCSETPAR PWDOWN 10

; Power up time (from 0 ms to 65535 ms)
TCSETPAR PWUP 10

;-----
; TI_ARM ALGO Settings
;-----

; Set the frequency of the SWD channel, Hz (change as needed)
; Max frequency allowed: 6250000 Hz
TCSETPAR SWCLK 1000000

;External clock source frequency, Hz (change as needed)
;Set this parameter if you want the main oscillator to be the clock source for the System Clock
;Leave it commented to use the internal oscillator (default)
;Note: This parameter must be set if you enable the PLL
;TCSETPAR FOSC 1000000

;PLL enable
;Set the maximum system clock frequency, Hz
;Set this parameter in conjunction with the FOSC parameter if you want the System Clock to be derived from the PLL output
;Leave it commented to use the internal oscillator (default)
;TCSETPAR FCPU 50000000

;-----
; Start Programming operation
;-----

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

; Starts programming block
TPSTART

;-----
; FLASH commands
;-----

; Mass erases Flash memory
TPCMD MASSERASE F
```



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```
; Blank checks Flash memory (change address and length as needed)
TPCMD BLANKCHECK F $0 $0 $20000

; Programs Flash memory (change source, target address and length as needed)
TPCMD PROGRAM F $0 $0 $20000

; Verifies Flash memory (change source, target address and length as needed)
; If you want you can choose between two type of verify:
; 1) Read-Out method (R). Slow but secure
; 2) CheckSum method (S). Fast but not secure
TPCMD VERIFY F R $0 $0 $20000

; Ends programming block
TPEND
```

The FlashRunner's system software setup will install script examples specific for each device of the LM3S3000 family on your PC.



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7. TI Stellaris LM3S3000 Specific Errors

TI Stellaris LM3S3000 -Specific Errors	
\$5000	TCSETDEV command: manufacturer not supported
\$5001	TCSETDEV command: algorithm not found on card
\$5002	TCSETDEV command: device not supported
\$5003	TCSETDEV command: internal hardware configuration error
\$5004	TCSETDEV command: corrupted algorithm file
\$5005	TCSETDEV command: programming algorithm requires FlashRunner firmware version 01.01.00.00 or newer
\$5006	TCSETPAR command: parameter not supported
\$5007	TCSETPAR CLKOUT command: missing, invalid or out of range parameter
\$5008	TCSETPAR RSTDOWN command: missing, invalid or out of range parameter
\$5009	TCSETPAR RSTUP command: missing, invalid or out of range parameter
\$500A	TCSETPAR RSTDRV command: missing or invalid command option
\$500B	TCSETPAR PWDOWN command: missing, invalid or out of range parameter
\$500C	TCSETPAR PWUP command: missing, invalid or out of range parameter
\$500D	TCSETPAR VDD command: missing, invalid or out of range parameter
\$500E	TCSETPAR VDD_AUX command: missing, invalid or out of range parameter
\$5017	TCSETPAR FOSC command: missing, invalid or out of range parameter
\$500F	TCSETPAR FCPU command: missing, invalid or out of range parameter
\$5010	TCSETPAR SWCLK command: missing, invalid or out of range parameter
\$5011	TPCMD command: missing parameter
\$5012	TPCMD command: parameter not supported
\$5013	TPCMD RUN command: execution error
\$5014	TPCMD MASSERASE command: missing parameter
\$5015	TPCMD MASSERASE command: invalid parameter
\$5016	TPCMD MASSERASE command: Flash masserase error
\$5018	TPCMD ERASE command: missing parameter
\$5019	TPCMD ERASE command: invalid parameter
\$501A	TPCMD ERASE command: Flash erase error
\$501C	TPCMD BLANKCHECK command: missing parameter
\$501D	TPCMD BLANKCHECK command: invalid parameter
\$501E	TPCMD BLANKCHECK command: Flash blankcheck error
\$5020	TPCMD PROGRAM command: missing parameter
\$5021	TPCMD PROGRAM command: invalid parameter
\$5022	TPCMD PROGRAM command: source offset parameter out of range
\$5023	TPCMD PROGRAM command: Flash program error
\$5025	TPCMD VERIFY command: missing parameter
\$5026	TPCMD VERIFY command: invalid parameter
\$5027	TPCMD VERIFY command: source offset parameter out of range
\$5028	TPCMD VERIFY command: Flash verify error
\$502A	TPCMD READ command: missing or invalid parameter
\$502B	TPCMD READ command: Flash read error
\$502F	TPSTART command: execution error
\$5030	TPSTART command: one or more required TCSETPAR commands have not been sent
\$5031	TPEND command: execution error

8. Programming Times

The following table shows programming times for selected TI Stellaris LM3S3000 device.



Device	Mem. Size	Conditions	Operations	Time
Stellaris LM3S3739	128 KB	FR01LAN	Masserase+Blank Check+Program+Verify (Read out) PLL enabled	4,35 s

Programming times depend on Programming Algorithm version, target board connections, communication mode, target microcontroller mask, and other conditions. Programming times for your actual system may therefore be different than the ones listed here. SMH Technologies reserves the right to modify Programming Algorithms at any time.

9. References

FlashRunner User's Manual.

Microcontroller-specific Datasheets and User's Guides.