shimmer
DISCOVERY IN MOTION

Shimmer3

JTAG Developer Board

User Guide

Revision 1.3

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3

Legal Notices and Disclaimer

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3

Table of Contents

1. Introduction

This document is an accompaniment to the *Shimmer3 JTAG Developer Board* whose aim is to aid the user in getting started with the product.

The *Shimmer3 JTAG Developer Board* enables users to incorporate additional functionality to the *Shimmer3* by providing access to develop their specific application to their own user requirements. It facilitates in-system programming and debugging of the *Shimmer3* - via a standard JTAG connection - to aid in the development of custom firmware solutions.

In addition, the *Shimmer3 JTAG Developer Board* allows for prototyping of 3rd party sensors or custom sensing solutions with the *Shimmer3* by facilitating access to each of the pins from the *Shimmer3* external connector, thus enabling an Analog Output Sensor, a Digital Output Sensor, a Serial UART or a Parallel Bus Interface to connect to the *Shimmer3*.

The *Shimmer3 JTAG Developer Board* is normally connected in-line between the external connector of a *Shimmer3* and the *Shimmer Dock*. An on-board mode selection switch allows the user to easily switch between the standard Bootstrap loading functionality of the *Shimmer Dock* or JTAG Programming Mode. Alternatively, the board can be powered directly via a built-in Mini-USB connector, for use without a *Shimmer Dock*.

2. General Information

2.1. Pre-Requisites

- A *Shimmer3* device programmed with appropriate firmware, either stock or custom built. The *Shimmer3* stock firmware solutions of *LogAndStream* (which can be used to stream data over Bluetooth and/or log data to the SD card) and *SDLog* (which can be used to log data to the SD card) are both available for download from https://github.com/ShimmerResearch/. The latest version of stock firmware should always be used.
- A *Shimmer3 JTAG Developer Board*.
- An MSP430 flash emulation tool (FET), such as the Texas Instruments MSP-FET430UIF or equivalent from another manufacturer (*e.g.*, Elpotronic).
- Code compiling software which supports the MSP430F5437A microcontroller (*e.g.*, Code Composer Studio™).
- A *Shimmer Dock* or Mini-USB power cable.

2.2. Expansion Board Features

- Full JTAG programming and in-system debugging capabilities.
- Easy access to multiple *Shimmer3* microcontroller signals using through-hole solder pads.
- Connection with an auxiliary power supply.
- A hard-wired *Shimmer3* reset push button.

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3

2.3. Basic Overview

The *Shimmer3 JTAG Developer Board*, shown in Figure 2-1, can be used by firmware developers for debug and programming purposes. It can also be used to provide access to several input/output pins in the Shimmers microcontroller for peripheral prototyping. The board can be installed in-line with the *Shimmer Dock* to enable use of 3rd party JTAG programming and debugging tools.
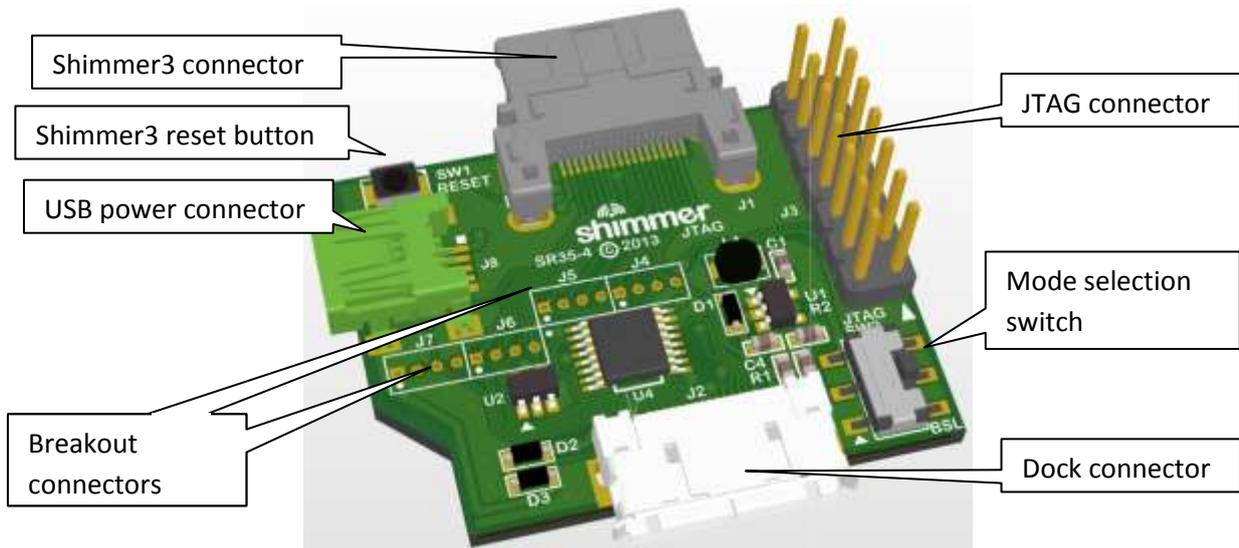
Figure 2-1: The main features of the Shimmer3 JTAG Developer Board.

(a) Shimmer Dock powered   (b) Mini-USB powered

Figure 2-2: The Shimmer3 JTAG Developer Board should be powered by either the (a) Shimmer Dock or (b) the on-board Mini-USB connector.

4

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3

The *Shimmer3 connector*, see Figure 2-1, should be inserted into the *Shimmer3* external connector and the *Dock connector* should be connected directly to the *Shimmer Dock*, see Figure 2-2 (a). Alternatively, the board can be powered directly via the USB power-only connector, for use without a *Shimmer Dock*, as shown in Figure 2-2 (b). Please note that when undertaking firmware development involving microSD card access (as is the case with *SDLog* development), the developer board must be powered by the on-board USB connector and not through the *Shimmer Dock*.

## 2.4.	Mode selection switch

When used in conjunction with a *Shimmer Dock*, the mode selection switch on the *Shimmer3 JTAG Developer Board* (as shown in Figure 2-3) facilities fast switching between normal docking mode operations (such as microSD card access or Bootstrap loading) and JTAG programming mode. When the mode-selection slide switch is down (*i.e.*, towards the "BSL" PCB label), the device is in normal dock operation with the JTAG operation and connector disabled. When the switch is up, JTAG operation is enabled and the *Shimmer Dock* is only utilised to power the JTAG developer board.
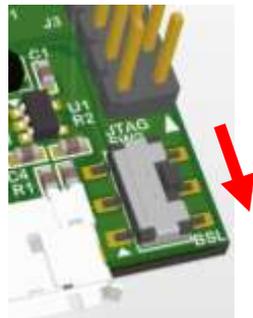
(a) Normal Dock Mode	(b) JTAG Programming Mode
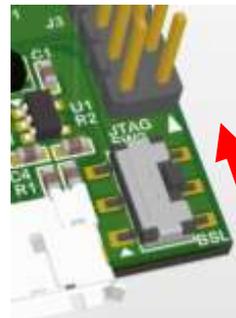
Figure 2-3: Mode selection switch actions - (a) Normal Dock Mode for and (b) JTAG Programming Mode

If the JTAG developer board is powered by the Mini-USB instead of the *Shimmer Dock*, the mode selection switch need just be placed in the JTAG programming mode position.

2.5.   Board Layout
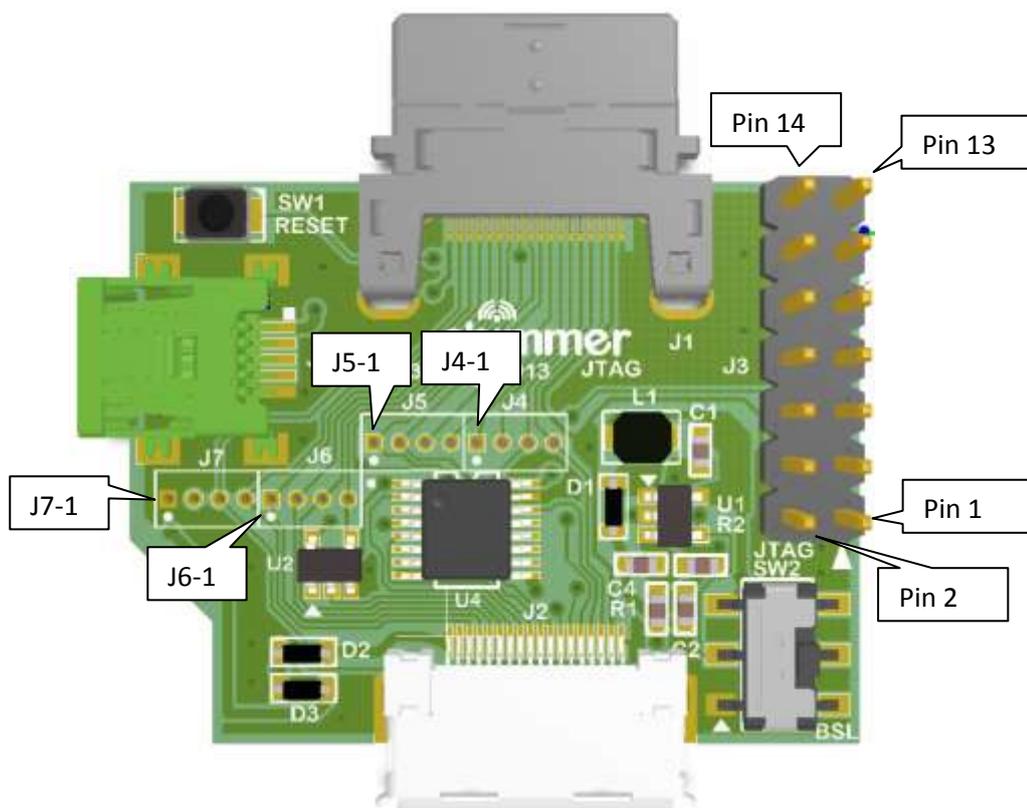
Figure 2-4: Shimmer3 JTAG Developer Board Top View
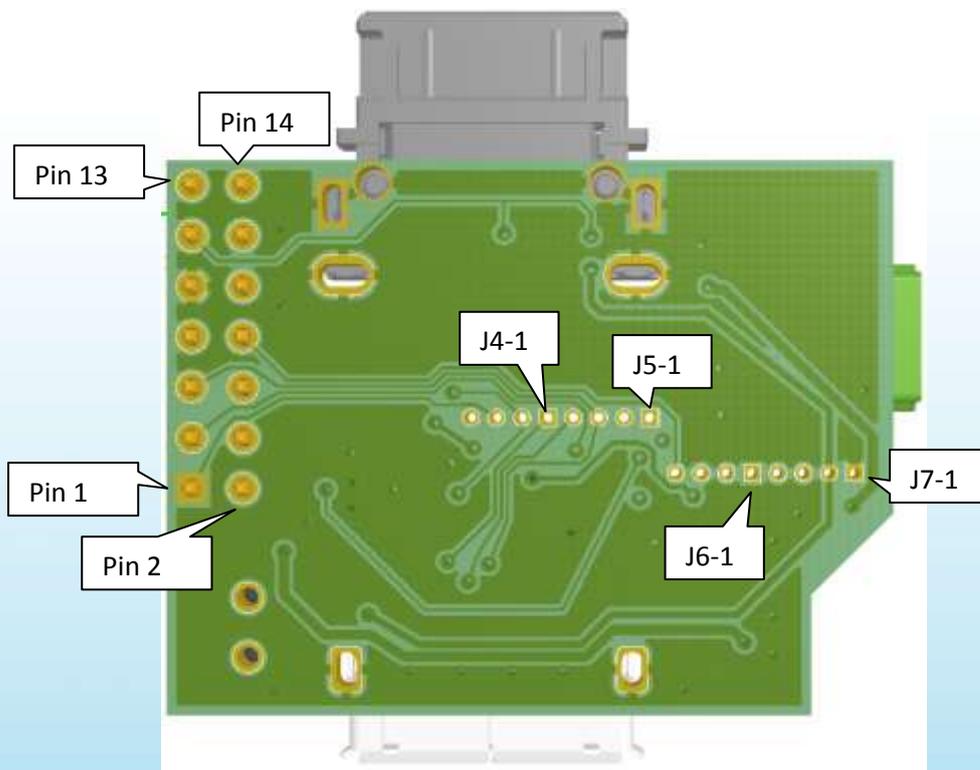
Figure 2-5: Shimmer3 JTAG Developer Board Bottom View

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3

2.6. Prototyping Pin Connections

The MSP430F5437A microprocessor inside the *Shimmer3* has multifunctional pins - some of which are accessible via the *Shimmer3* external connector. The functionality of the pin depends on firmware configuration. The *Shimmer3 JTAG Developer Board* provides users with access to several of *Shimmer3* external connector pins via a standard JTAG connection and four sets of on-board through-hole connector locations. Each of the 4-way through-hole header pin locations (as illustrated as J4 to J7 in Figure 2-4) have a pitch of 1.27 mm and the function of each is listed below in Table 1. Note that the 1st pin of each header pin set has a square shape as opposed to a round shape for pins 3 to 4.

Connector	MSP430 Pin / Label	Interruptible?	*Shimmer3* Function
J7-1	GND	N	Board Ground
J7-2*	PV_PROG	N	Board post-regulation voltage. With mode selection switch set to JTAG Programming Mode, the voltage on this pin will be approximately 5.85 V. With mode selection switch set to Normal Dock Mode, the voltage on this pin will be low.
J7-3	P3.5 / SA_SOMI_RXD	N	USART A0 SOMI or Serial RXD or GPIO. A level shifter is required to interface with an RS-232 cable
J7-4	P3.4 / SA_SIMO_TXD	N	USART A0 SIMO or Serial TXD or GPIO. A level shifter is required to interface with an RS-232 cable
J6-1	FLASH_SCLK_EXT	N	USART B1 SPI CLK or GPIO (wired to microSD)
J6-2	P5.4 / FLASH_SOMI	N	USART B1 SPI SOMI or GPIO (wired to microSD)
J6-3	P3.7 / FLASH_SIMO	N	USART B1 SPI SIMO or GPIO (wired to microSD)
J6-4	SBWTCK	N	BSL programming
J5-1*	PJ.1 / JTAG_TDI (P6.0 / DETECT_N)	N	JTAG TDI signal (Card detect output signal to flash controller)
J5-2	P1.5 / GPIO_EXTERNAL_RADIO_DD	Y	GPIO.
J5-3*	PJ.2 / JTAG_TMS (P2.2 /BSL_RX_LED_BLU)	N/A	JTAG TMS signal (BSL programming RX, BLU LED SIGNAL) **Do not use this pin for GPIO.**
J5-4	P6.6 / ADC6_FLASHDAT2	N	Analog ADC input 6 or GPIO (wired to microSD)
J4-1	P6.7 / ADC7_FLASHDAT1	N	Analog ADC input 7 or GPIO (wired to microSD)
J4-2*	PJ.3 / JTAG_TCK (P1.1 / BSL_TX_LED_GR1)	Y	JTAG_TCK signal (BSL Programming TX, LED signal)
J4-3*	PJ.0 / JTAG_TDO (P4.0 /	Y	JTAG TDO Signal (Flash CS or SD Mode DAT3 line)

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3

	FLASH_CS_N_FLASHDAT3)		
J4-4	P7.7 / ADC_15_RADIO_DC	Y	ADC Input 15 or GPIO Alternate function is reserved for coprocessor Spy-Bi-Wire

Table 1 Test Pad Connections for Shimmer3 JTAG Developer Board. As listed in order of left to right when looking at Figure 2-4. N/A = not applicable.

* Note that the JTAG connections on J5-1, J5-3, J4-2 and J4-3 are only available when the mode selection switch is switched to JTAG Programming Mode. In this mode, the on-board voltage regulator is powered by either the *Shimmer Dock* or the Mini-USB connector. In this case, the necessary >5.7V is applied to the PV_CHG pin of the *Shimmer3* which activates DEBUG mode. When the JTAG Programming Mode is disabled (by either changing the state of the mode selection switch or removing external power to the *Shimmer3 JTAG Developer Board*), the function of these pins reverts to the function that is listed in brackets in their respective sections in the table above.

2.7.   JTAG Connections

The JTAG connector is a 14-pin (2 row by 7 way) header with 2.54 mm pitch spacing. As with the prototyping pin connections, the JTAG functions of pins 1, 3, 5 and 7 are only enabled when the mode selection switch is in the JTAG programming position (see note from previous table).

Connector Pin	MSP430 Pin / Label	Interruptible?	*Shimmer3* Function
1*	PJ.0 / JTAG_TDO (P4.0 / FLASH_CS_N_FLASHDAT3)	Y	JTAG TDO Signal (Flash CS or SD Mode DAT3 line)
2	PV_TOOL	N/A	FET programmer voltage
3*	PJ.1 / JTAG_TDI (P6.0 / DETECT_N)	N	JTAG TDI signal (Card detect output signal to flash controller)
4	PV_SHIMMER	N/A	+3.0V regulated voltage from *Shimmer3*
5*	PJ.2 / JTAG_TMS (P2.2 /BSL_RX_LED_BLU)	N/A	JTAG TMS signal (BSL programming RX, Blue LED signal) **Do not use this pin for GPIO.**
6	N/C	N/A	N/A
7*	PJ.3 / JTAG_TCK (P1.1 / BSL_TX_LED_GR1)	Y	JTAG_TCK signal (BSL Programming TX, Green1 LED signal)
8	TEST	N	JTAG TEST signal
9	GND	N	Ground connection
10	N/C	N/A	N/A
11	MSP_RESET_N		Global Reset
12	N/C	N/A	N/A
13	N/C	N/A	N/A
14	N/C	N/A	N/A

Table 2 JTAG connections for Shimmer3. N/C = not connected, N/A = not applicable.

8

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3

3. Mode of Operation

Normal Dock Mode

1. Connect the *Shimmer3 JTAG Developer Board* in-line between the *Shimmer3* and the *Shimmer Dock* - as shown in Figure 2-2 (a).

2. Connect the *Shimmer Dock* to a computer via the provided USB cable. If the *Shimmer Dock* has not previously been installed, please refer to the *Shimmer User Manual for further information.*

3. Switch the mode selection switch to the normal dock mode position (*i.e.*, towards the "BSL" PCB label).

4. Ensure that the *Shimmer3* is turned on. It should be noted that when the developer board is in normal dock mode, the *Shimmer3* will not be charged via the dock. As such, ensure that there is sufficient battery life in the *Shimmer3* for programming to occur.

5. Finally, operate the *Shimmer3* as normal with the *Shimmer3 Bootstrap Loader* application or with microSD card access, as appropriate with your application.

JTAG Programming Mode

1. Connect a third party MSP FET into the *Shimmer3 JTAG Developer Board* - as shown in Figure 3-1. For installation procedures of an individual MSP FET, please refer to the device specific user manual.

2. Connect the *Shimmer3 JTAG Developer Board* into *Shimmer3* external connector.

3. Power the *Shimmer3 JTAG Developer Board* by either a *Shimmer Dock* or Mini-USB cable plugged into the on-board Mini-USB socket - as shown in Figure 2-2 (a) and (b). Please note that when performing development involving the microSD card, the developer board must be powered by the on-board USB connector and not through the *Shimmer Dock*.

4. Switch the mode selection switch to the JTAG programming mode position (*i.e.*, towards the JTAG connector).

5. Ensure that the *Shimmer3* is turned on.

6. The hardware setup is now ready for programming and debugging with the chosen compiler - see Section 4 for more information on this topic.

9

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3
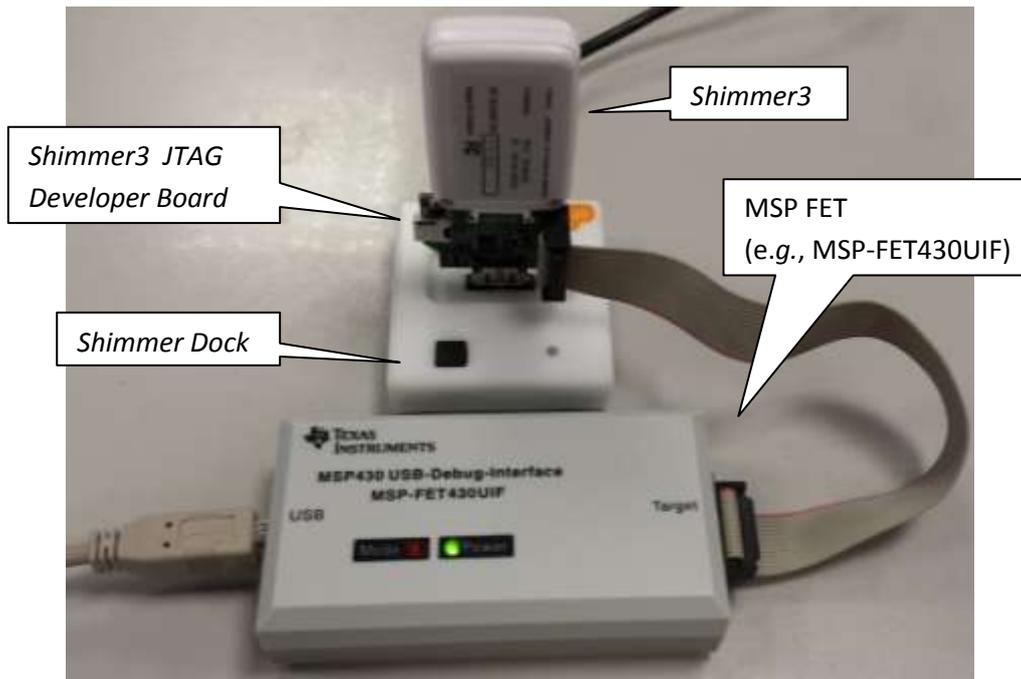
Figure 3-1: Typical hardware configuration for programming and debugging a Shimmer3.

4. Firmware Development

It is recommended that design, implementation, testing and validation of Shimmer embedded software (firmware) is done in Code Composer Studio™ from Texas Instruments. Alternatively, any compiler that supports the MSP430F5437A can be used (e.g. IAR embedded workbench, Rowley Crossworks, MSP430GCC). Shimmer application code examples for Code Composer Studio™ are actively maintained at https://github.com/ShimmerResearch/shimmer3.

Current functionality includes:

- microSD flash storage.
- FAT file system.
- Bluetooth configuration, connection management and streaming data transfer.
- Time and clock configuration.
- Peripheral control and configuration.
- Power supply monitoring.

4.1. Setting up a build environment

To develop firmware for *Shimmer3*, you will need the Code Composer Studio™ IDE from Texas Instruments or another compiler that supports MSP430F5437A (examples listed above). Furthermore, a FET, such as the MSP-FET430UIF, or equivalent from Elpotronic or another manufacturer, and a Shimmer Developer Board are recommended for developers but not essential unless debug capability is needed.

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3

4.2. Getting and updating the Shimmer source code

All Shimmer source code is hosted in a Git repository. Git is an open source version control system that facilitates software configuration management. It is used by many software developers to manage changes within their source code tree and provides the means to store, not only, the current version of a source code element (e.g. a *.c source file) but, also, a record of all changes that have occurred to that source code. For further details on Git, follow the documentation link at http://git-scm.com; a download link can be found on the same website.

To clone a copy of the *Shimmer3* repository to a new directory, use the following command:

```
git clone https://github.com/ShimmerResearch/shimmer3
```

To update the repository, navigate to the appropriate folder and run the following two commands:

```
git fetch origin
```

```
git pull origin
```

In the *Shimmer3* repository, you will find the source code for all of the stock firmware solutions described in the *Shimmer User Manual*.

4.3. Getting started with Code Composer Studio™

The programming language for the *Shimmer3* is *C*. Texas Instruments provide training material helping new users to get up-to-speed with Code Composer Studio on their Wiki[1].

Code Composer Studio can be configured to create an output flash image that can be loaded to a *Shimmer3* using Consensys and a *Shimmer Dock*. To ensure this option is selected, follow the following steps:

1. Firstly, with the project selected in Code Composer Studio, go to the *"Project"* menu and select *"Properties"*.
2. As shown in Figure 4-3, select the *"Build"* menu in the left panel and then select the "Steps" panel on the right.
3. Ensure that *"Create flash image TI-TXT"* is listed in the *"Description"* box. If this is not the case, select it from the *"Apply Predefined Step"* drop down menu as shown.
4. Finally press the *"Apply"* button to save the changes.

An output TXT file with the same name as the project will then be created within the *"Debug"* directory of the project when the project is built. This is the file that can be loaded to the *Shimmer3* through the *Consensys* application.

---

[1] http://processors.wiki.ti.com/index.php/Category:CCS_Training.

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3
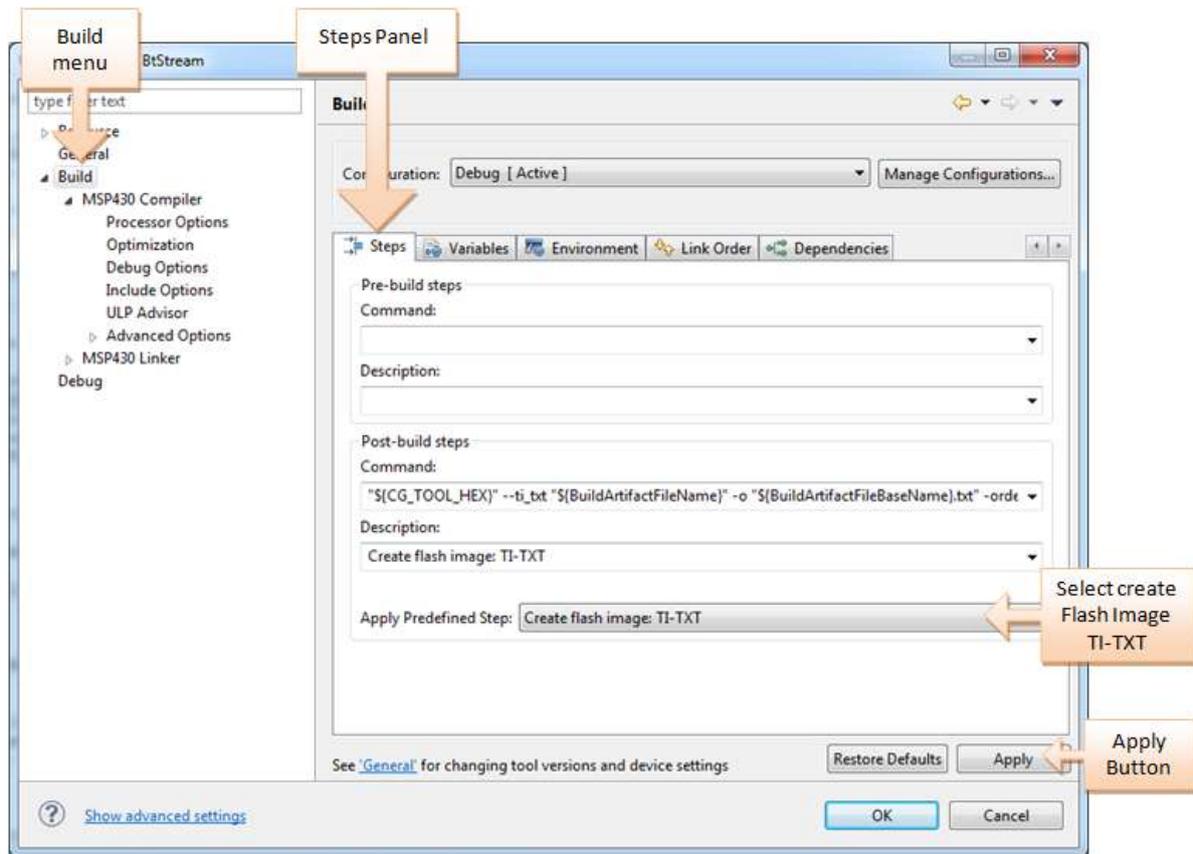
Figure 4-1: Creating an output TXT file using Code Composer for custom firmware programming with Consensys.

5. Possible Prototyping Applications

When designing custom firmware for the *Shimmer3*, as would be the case in the applications discussed in this section, particular care must be taken to verify the configuration of any *Shimmer3* pins in the Shimmer application code.

5.1. Connecting an Analog Output Sensor

Using the sensor specification, chose either the *Shimmer3* +3V (PV_SHIMMER - JTAG pin 4) or another external source as the power supply connections to the sensor. The output of the sensor should be tied to either the A6, A7 or A15 ADC inputs as appropriate. If the sensor output is outside of the range of the Shimmer ADC (+ 3 V max) an attenuator must be added.

If the sensor uses the bipolar power supply, the output must be AC-coupled via a series capacitor to an appropriate DC bias resistor network connected to the ADC input pin.

Any unused GPIO pins can be used to configure control pins on the sensor. Verify the configuration of any of these pins in the Shimmer application code.

12

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3

5.2. Connecting a Digital Output Sensor using the SPI interface

When using the *Shimmer3 JTAG Developer Board* with *Shimmer3*, the SPI bus is shared with the microSD, making the interface much more complicated than that for the *PROTO3 Deluxe Expansion Board*, which uses the dedicated internal bus. For that reason, Shimmer recommends use of *PROTO3 Deluxe Expansion Board* wherever possible. Furthermore, Shimmer recommends that the *Shimmer3 JTAG Developer Board* should not be used in cases where microSD is used, noting that this use case will receive only limited support from Shimmer.

If connecting a digital sensor to the *Shimmer3* via the *Shimmer3 JTAG Developer Board*, attention must be given to the required master-slave relationship in your application (Shimmer is usually master). To create the digital interface, connect up the SPI SI,SO, and CLK pins with an additional GPIO pin as a Chip Select. The USART B1 module of the MSP430 will need to be configured for SPI mode - as is the default case in the *SDLog* stock firmware. For power supply connections, chose either the *Shimmer3* on-board + 3 V or an external power supply connection to the sensor as appropriate. A level shift IC may be required if the sensor output voltages exceeds the *Shimmer3* voltage supply level.

The application must ensure that the bus is correctly multiplexed using the SPI chip-select signals. Any remaining GPIO pins can be used to configure control pins on the sensor. Verify the configuration of any of these pins in the Shimmer application code.

5.3. Connecting to a Serial UART

Similar to the SPI directions above, the USART A0 module must be configured for UART operation. The output signals will be digital at a + 3V reference. A level shifter IC or RS-232 level shifter may be used to interface with instrumentation or other computers.

5.4. Connecting a Parallel Bus interface

To use a parallel bus interface, most pins will need to be configured as GPIO instead of the default functionality. Up to an 11-pin bus can be configured.

5.5. Connecting an External Power Battery Pack

There are two options available if an external power supply is required. The first is to connect an external source via the on-board Mini-USB socket. In this case, the *Shimmer3 JTAG Developer Board* mode selection switch must be in the JTAG programming mode position. The *Shimmer3* will think that it is in DEBUG mode and the respective JTAG pins on the JTAG header and breakout connectors will be in JTAG functionality mode (as described in Table 1).

The second is to solder an external battery pack or power supply to the PV_PROG (J7-2) and GND (J7-1) breakout pins of the *Shimmer3 JTAG Developer Board*. In this case, it is recommended to isolate this power supply with a Schottky diode when the Shimmer battery is also in use. As before, if the voltage on PV_PROG is > 5.7 V, the Shimmer3 will think it is DEBUG mode and the JTAG pin functions will be activated. If it is < 5.7 V, the alternative pin functions (as listed in Table 1) will be enabled.

Note: Both of these options will charge the Shimmer battery.

13

Copyright © Shimmer 2016
Realtime Technologies Ltd
All rights reserved

Shimmer3 JTAG
Developer Board User Guide
Rev 1.3

Note: Do not exceed 5.5 VDC on PV_PROG or 5 V on the USB V+ connection.

Note: Do not exceed 200 mA input.