Demonstration Design for the TMCM-AC-840 Motor Control Daughter Board

for the Actel SmartFusion™ Development Kit (A2F-DEV-KIT)

and the Actel SmartFusion™ Evaluation Kit (A2F-EVAL-KIT)

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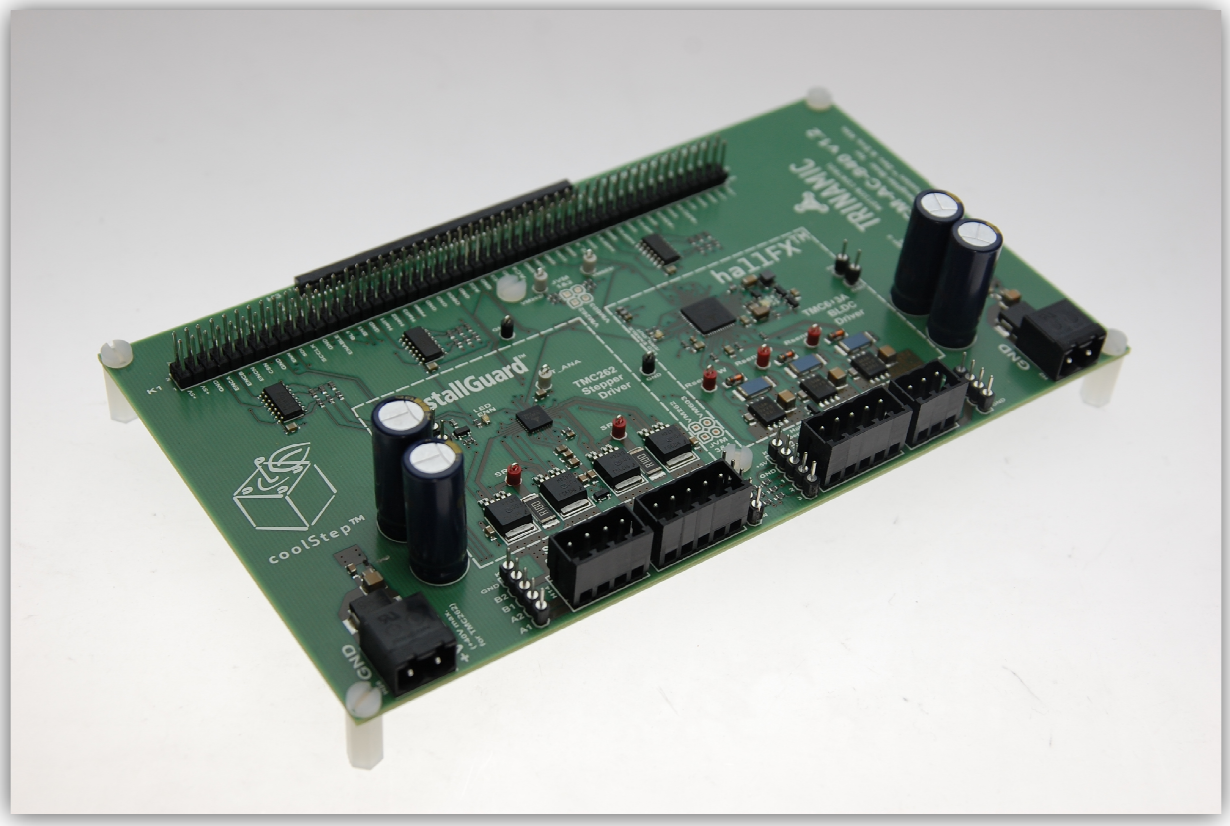

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1 Introduction

SmartFusion™ FPGA fit well to motion control applications. Due to the combination of hardware, software, and additional analog components complex systems can be integrated within a single chip. This drastically reduces the number of required components to realize a motion control unit. Real time critical tasks can be implemented in hardware. Complex - but less real time critical tasks - can be realized in software. Real Time critical tasks are commutation of fast rotating BLDC motors or processing of high resolution encoder signals. Processing of analog signals, e.g., voltage and current measurement is a typical task in motion control applications. Therefore, the SmartFusion's™ analog I/Os and processing functionality can be used.
Together with Trinamic's integrated BLDC motor gate driver TMC603A (or with the integrated stepper motor driver TMC262), one can realize a power stage with a couple of components as demonstrated with the TMCM-AC-840 Daughter Board Kit for direct plug to the ACTEL SmartFusion™ Evaluation Kit boards or Development Kit boards.

The TRINAMIC TMCM-AC-840 Daughter Board Kit is a power driver for brushless DC motors (BLDC) as well as stepper motors. The TMCM-AC-840 Daughter Board Kit incorporates one TMC603A BLDC motor driver IC and one TMC262 coolStep™ stepper motor driver IC as well as two motors (one BLDC and one stepper motor) to start right away.

The TMCM-AC-840 is designed to operate with the ACTEL SmartFusion™ Development Kit (Revision C and later) as well as the ACTEL SmartFusion™ Evaluation Kit as both boards are pin-compatible regarding their Mixed Signal Expansion Header (see the ACTEL user guides for both boards). When using the TMCM-AC-840 in combination with an ACTEL SmartFusion™ Development Kit that is equipped with the larger A2F500 SmartFusion™ FPGA, some additional analog I/Os are available on the Mixed Signal Header. All signals of the Mixed Signal Expansion Header are easily accessible via pin headers on the TMCM-AC-840 daughter board.

The TMCM-AC-840 daughter board requires at least one DC supply voltage of $+V_M$ = 12V to 40V. We recommend driving the board with two independent DC supply voltages – one for each driver IC: **$+VM_{262}$ = 12V to 40V and $+VM_{603}$ = 12V to 48V**!

The TMCM-AC-840 daughter board and the driver stages support **maximum motor currents** of up to 2A for stepper driver block and up to 4A (5A with good cooling) for the BLDC driver block.

For more information on the board itself, how to hook up the board, the motors and the drivers, we refer to the official manual documents available for download from the websites of Trinamic and Actel.

Also use the Trinamic support forum (http://www.trinamic.com/ttdg/phpBB3/) or contact Trinamic directly using aspp.tech@trinamic.com.

2 Demo Designs

Demo designs are available under free license from Trinamic Motion Control GmbH & Co. KG.

The projects and the source code (VHDL and C) is provided AS IS and without any warranty.
You are free to use and/or modify the demo designs and source code.

Also refer to the comments directly inside the VHDL/C code of the demo projects.

For more information or questions contact us using the contact information given on the Actel Solution Partner Website [7].

The most recent version of the demo design(s) is available from our website and the Actel Solution Partner Program website:

- **http://www.trinamic.com/tmc/render.php?sess_pid=478**
- **http://www.actel.com/products/partners/solution/ip/trinamic.aspx**

3 Demonstration Design for Actel SmartFusion™ Development and Evaluation Kits

This demonstration is made for the Actel SmartFusion Development Kit Revision C and Evaluation Kits with an A2F200 SmartFusion device.
When using the newer version of the development kit (including an A2F500), the project needs to be recompiled accordingly.

As a first test application for the ACTEL SmartFusion™ device, TRINAMIC realized a control block for BLDC and stepper motor commutation. The commutation units are realized as functional blocks coded in VHDL. These blocks have interfaces for control via register access from the ARM Cortex-M3 subsystem using the AHB/APB3 bus matrix.

3.1 Requirements

For this demonstration design, you need the following:

- Actel SmartFusion Evaluation or Development Kit (Revision C or later)
- Trinamic TMCM-AC-840 daughter board kit (including 2 motors)
- 2 USB cables for programming and UART connection to your workstation
- Actel Libero tool chain
- FlashPro programming software
- 2 power supply units
    - For each motor block (stepper or BLDC) you need a separate power supply unit
    - With only one power supply you can only drive one motor at the same time

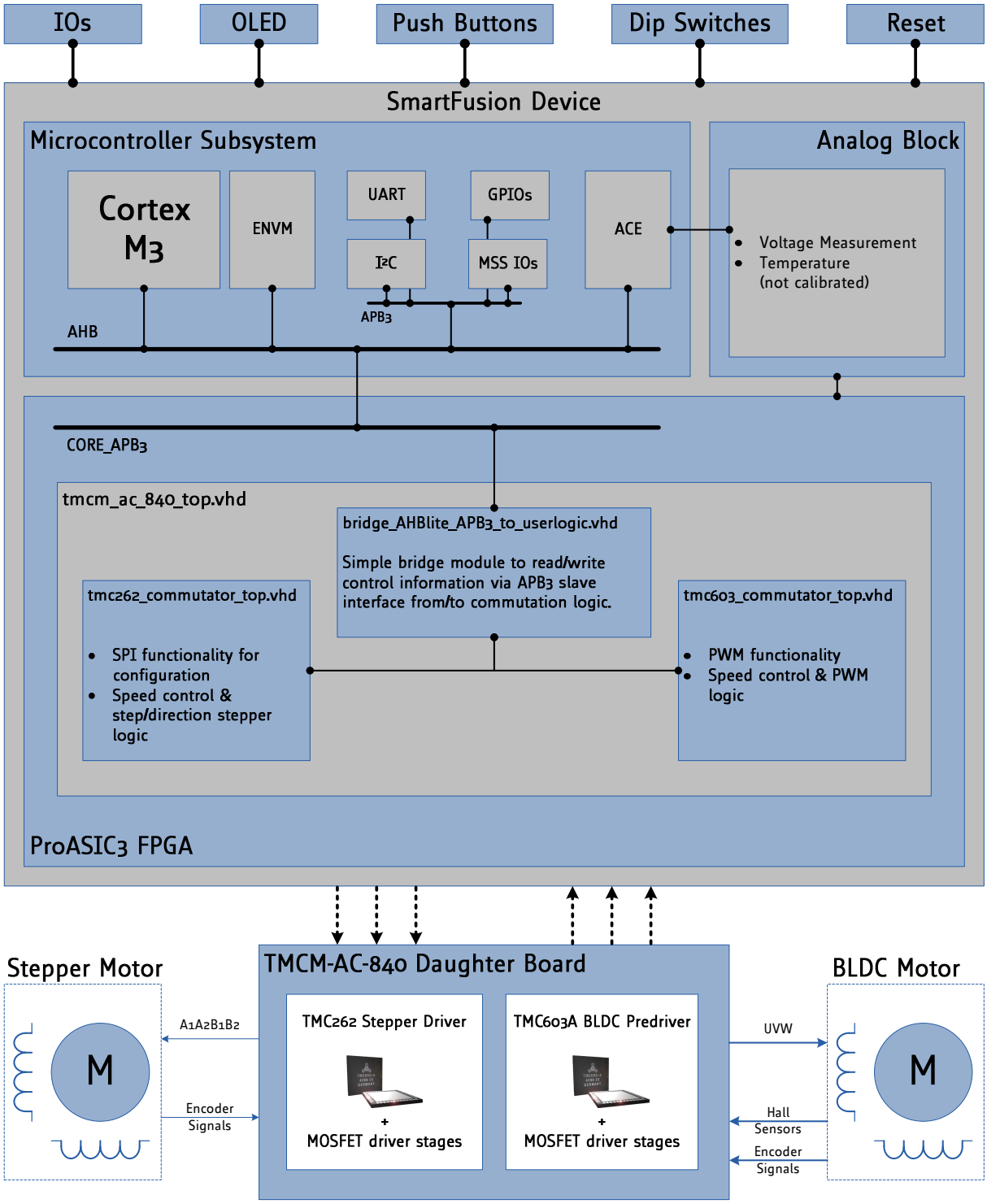
3.2 Basic design structure

The following block diagram shows the coarse structure of the demo design inside the SmartFusion™ FPGA and together with the TMCM-AC-840 board.

The TMC603A BLDC driver is controlled using a simple PWM-block. The PWM value and the motor voltage supply have influence on the motor speed.

The TMC262 stepper driver is configured via SPI and set to step/direction mode. Motor speed and direction are the controlled via the step/direction interface of the TMC262.

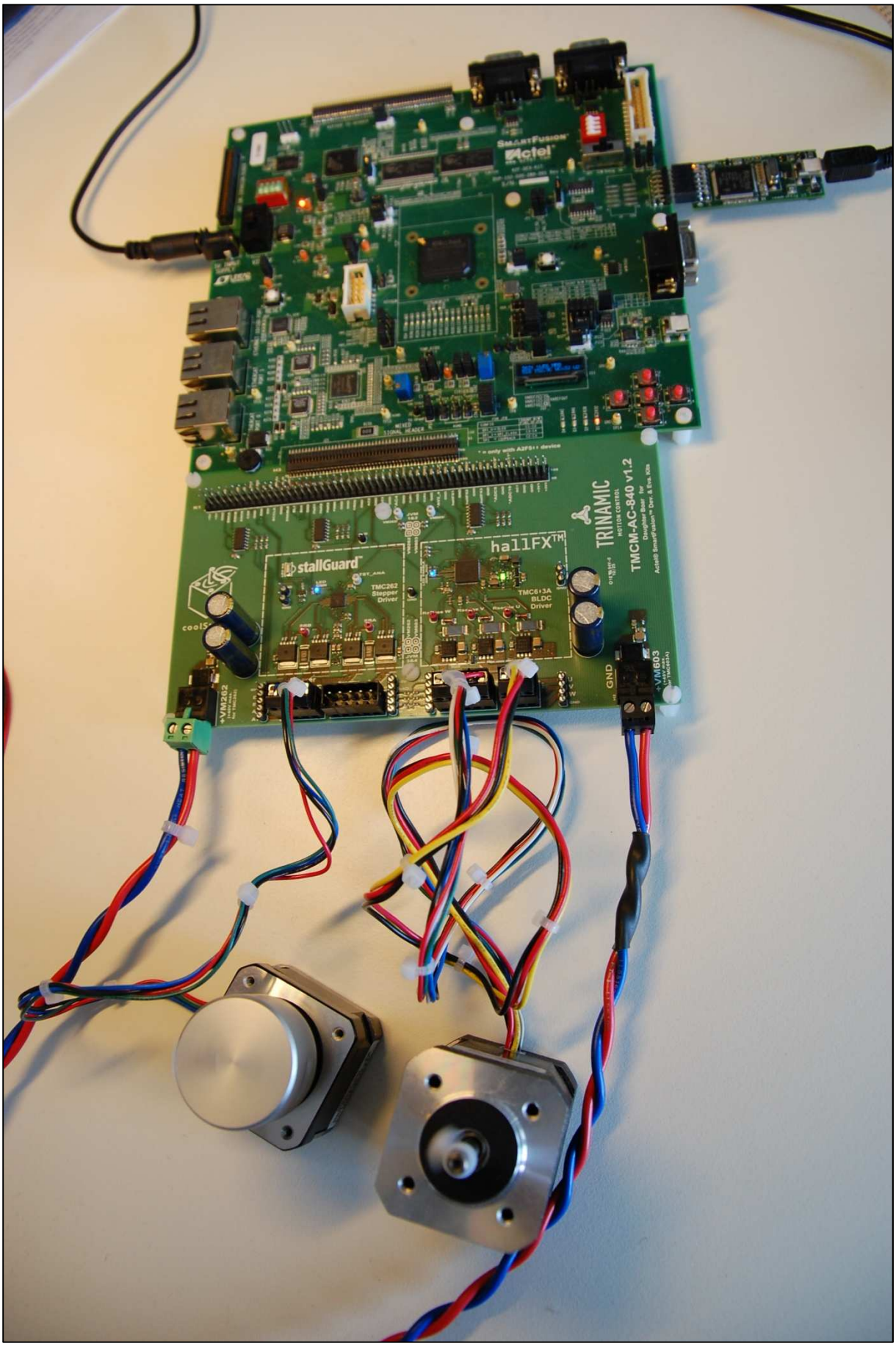
Both driver blocks are tested only with free running motors without any load attached to the shaft. If used with additional application load, configuration should be modified accordingly.



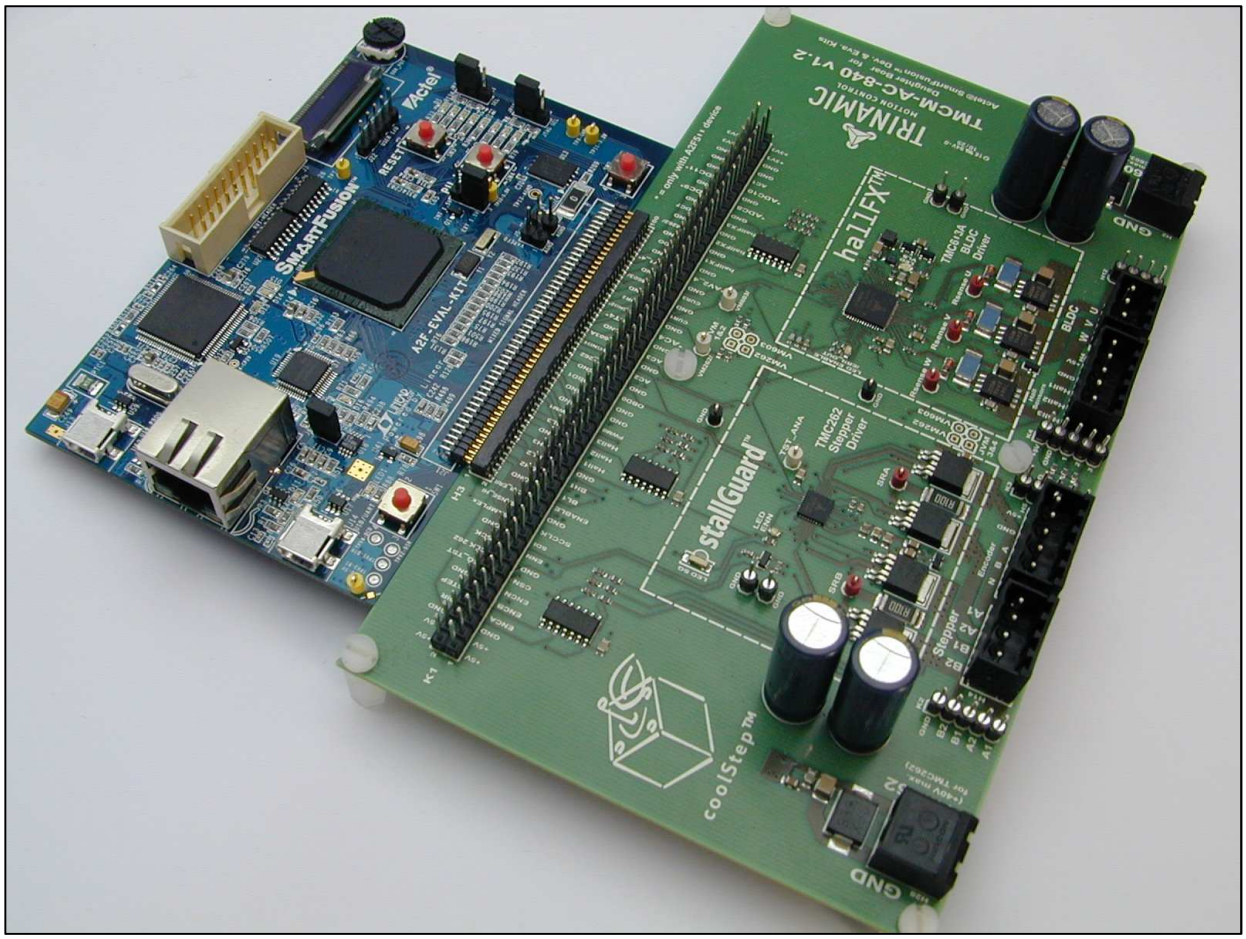
3.1 : Basic block diagram of the BLDC and stepper demo design for the SmartFusion™ Development Kit

3.3 Hooking up the board

The following picture shows a complete setup for running this demonstration project using the SmartFusion development kit. You need two supplies for the motors, two motors, the Actel SmartFusion™ Development Kit with programmer and USB cable and supply, and the Trinamic TMCM-AC-840 daughter board. Connect everything as described in the TMCM-AC-840 user guide.



The next picture shows the TMCM-AC-840 connected to the SmartFusion Evaluation Kit. Connect the cables and motors in the same manner as with the Development Kit.



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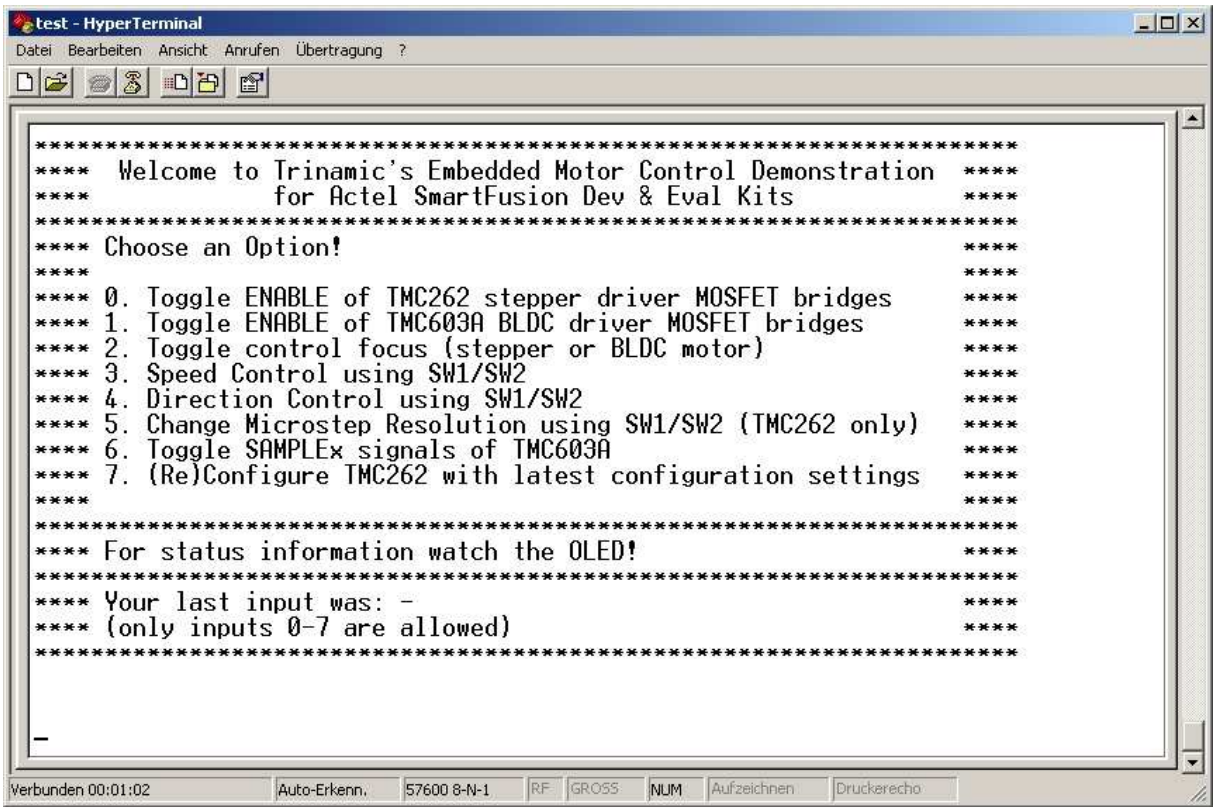
3.4 UART Interface

The complete demo design is controlled using UART0 of the SmartFusion MSS. Therefore connect the USB2Serial USB cable to you workstation and start your hyper-terminal application.

Select the appropriate interface.

The configuration for this UART is 57600 baud, 1 stop bit, no flow control, no parity bit, 8 data bits.

After resetting the system, the following menu should be visible in your terminal application:



Although the available options are quite self-explanatory, the following table lists the available functions:

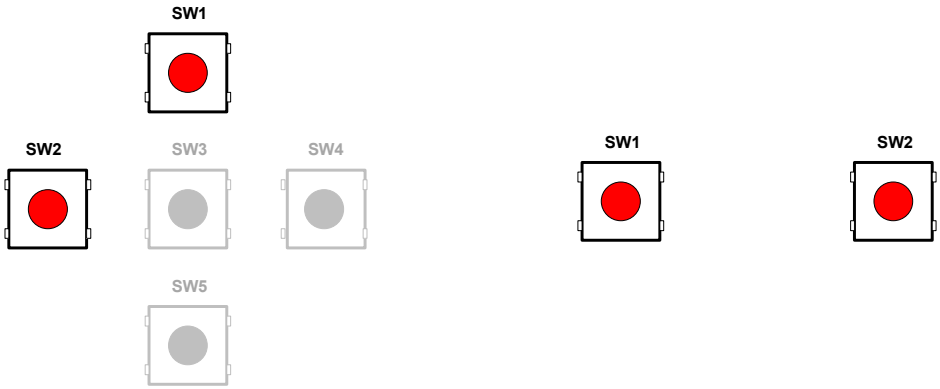
Input Key	Function	Result/Effect on the board/motors
0	Enables/disables MOSFET bridges of TMC262 stepper driver block	The blue onboard LED for the TMC262 stepper driver block is on if the MOSFET bridges are enabled. The TMC262 driver IC is active and can be configured, even if the MSOFET bridges are off. The MOSFET bridges can also be switched off if the motor is currently in use and running.
1	Enables/disables MOSFET bridges of TMC603A BLDC driver block	The blue onboard LED for the TMC603A stepper driver block is on if the MOSFET bridges are enabled. The TMC603A driver IC is active and can be configured, even if the MSOFET bridges are off. The MOSFET bridges can also be switched off if the motor is currently in use and running.
2	Toggles the control focus	Only one of the motors can be controlled at a time. By choosing this option, you switch between the motor that is currently controlled. As a result, the OLED display will switch as well and show the information related to the respective motor driver block.
3	Selects speed control	After choosing this option, the speed of the motor that is currently in the focus can be increased and decreased using the onboard switches SW1/SW2 of the SmartFusion Board.
4	Selects direction control	After choosing this option, the rotation direction of the motor that is currently in the focus can be changed using the onboard switches SW1/SW2 of the SmartFusion Board.

5	Selects control of the microstep resolution of the TMC262 stepper driver	This option only works, if the stepper motor is currently in the control focus. Using the onboard switches SW1/SW2 of the SmartFusion Board, the resolution of the microstep engine can be modified. There are nine (9) options to choose from 0 to 8. 0 = 256 microsteps (highest resolution) 1 = 128 2 = 64 3 = 32 4 = 16 5 = 8 6 = 4 microsteps 7 = half stepping 8 = full stepping The currently chosen resolution is visible on the OLED in the first line if the stepper motor is currently in the control focus (see section 3.7) To configure the new microstep resolution, you have to choose option seven (7) next, to start the (re)configuration of the TMC262 stepper driver IC. After reconfiguration, the new microstep resolution setting becomes active.
6	Toggles the SAMPLEx signals of the TMC603A BLDC driver	Choosing this option you can toggle between sample state and hold state of the CURx output signals of the TMC603A BLDC driver IC. In hold state, the voltages shown on the OLED should be stable (if the TMC603 BLDC motor driver is currently in the control focus).
7	Trigger (re)configuration of the TMC262 stepper driver IC	Choosing this option starts/restarts the configuration engine for the TMC262 stepper driver. The actual configuration vectors are sent via SPI to the TMC262. **After reset and power up, this must be done one time to configure the stepper driver IC. Otherwise, it will not start operation.** You have to restart configuration after choosing a different microstep resolution. See also option 5 above.

3.5 Switches SW1/SW2

Some functions of the switches are different depending on the driver that is currently controlled and what option has been chosen from the hyperterminal window menu. See the table before for more details.

Only two switches are used on the development board (the other ones are drawn in gray below).
On the Evaluation board the two available switches are used.



3.2 : Used push-buttons on the development kit (right) and evaluation kit (left)

3.6 LED D1-D4

The demo uses 4 LEDs on the SmartFusion Development and Evaluation kits.

When the TMC603A is currently in the control focus, the LEDs show the lower nibble of the 8-bit PWM signal of the PWM unit.

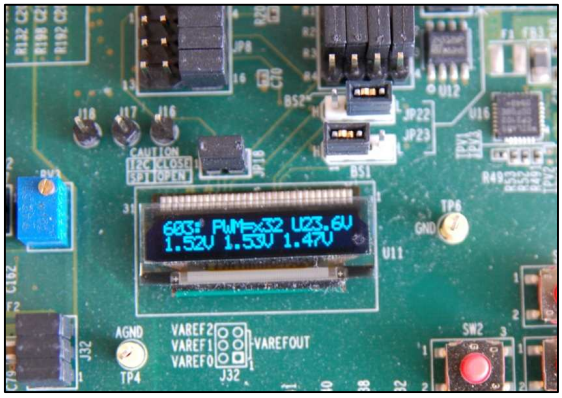
When the TMC263 is currently in the control focus, the LEDs show the lower nibble of the 8-bit velocity value.

3.7 OLED

Various parameters are shown on the OLED.

When TMC603A is in the control focus, the OLED shows data related to the TMC603A…the actual speed value of the PWM in hex numbers (PWM), the supply voltage VM_{603} in Volts (U), and the voltages of the three CURx pins in the second display line.

When TMC262 is in the control focus, the OLED shows data related to the TMC262…the momentary speed value in hex numbers (V), the actual number of wait cycles between consecutive steps in hex numbers (WC), the supply voltage VM_{262} in Volts (U), and the actual microstep resolution (MR).



4 References

[1] Actel SmartFusion™ Development Kit:
http://www.actel.com/products/hardware/devkits_boards/smartfusion_dev.aspx

[2] Actel SmartFusion™ Evaluation Kit:
http://www.actel.com/products/hardware/devkits_boards/smartfusion_eval.aspx

[3] TMC603A Information: http://www.tmc603.com http://www.trinamic.com

[4] TMC262 Information: http://www.trinamic.com/tmc/render.php?sess_pid=468

[5] Stepper motor Qmot QSH4218-35-10-027 manual and datasheet:
http://www.trinamic.com/tmc/render.php?sess_pid=261

[6] BLDC motor Qmot QBL4208-41-04-006 manual and datasheet:
http://www.trinamic.com/tmc/render.php?sess_pid=391

[7] Actel Solution Partner Websites:
http://www.actel.com/products/partners/solution/ip/specialization.aspx