KTFRDM32XSGEVBUG

FRDM-32XSG-EVB evaluation board

Rev. 2.0 — 16 February 2018 User guide

1 FRDM-32XSG-EVB

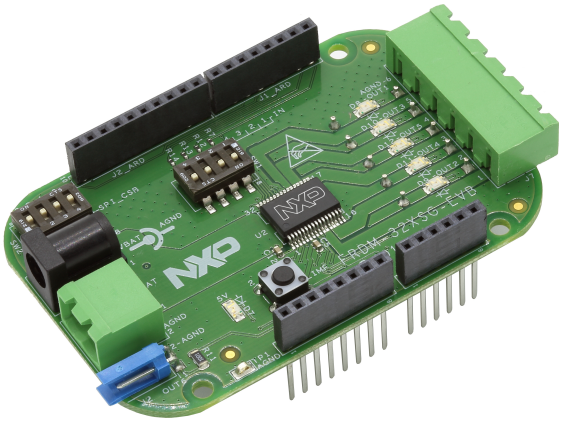

Figure 1. FRDM-32XSG-EVB

2 Important notice

NXP provides the enclosed product(s) under the following conditions:

This evaluation kit is intended for use of ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY. It is provided as a sample IC pre-soldered to a printed circuit board to make it easier to access inputs, outputs, and supply terminals. This evaluation board may be used with any development system or other source of I/O signals by simply connecting it to the host MCU or computer board via off-the-shelf cables. This evaluation board is not a Reference Design and is not intended to represent a final design recommendation for any particular application. Final device in an application will be heavily dependent on proper printed circuit board layout and heat sinking design as well as attention to supply filtering, transient suppression, and I/O signal quality.

The goods provided may not be complete in terms of required design, marketing, and or manufacturing related protective considerations, including product safety measures typically found in the end product incorporating the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge. In order to minimize risks associated with the customers applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards. For any safety concerns, contact NXP sales and technical support services.

Should this evaluation kit not meet the specifications indicated in the kit, it may be returned within 30 days from the date of delivery and will be replaced by a new kit.

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3 Overview

The FRDM-32XSG-EVB is an evaluation platform for developing designs based on NXP's MC17XSG500 high-side switch power IC. The board allows external components such as fans, lights, pumps and DC motors to be connected to the MC17XSG500's high-side switches.

The FRDM-32XSG-EVB requires a companion board to manage communications between the evaluation board and a host PC. There are two options for providing that functionality. This user guide will only focus on the first option that are Arduino boards.

Arduino boards

Arduino boards (sold separately) enable users with a minimal knowledge of electronics to create simple systems that control external components. The boards act as a communication link between a host PC and an attached shield board (in this case, the FRDM-32XSG-EVB.) User's download the Arduino Software IDE to develop code that exercises the functionality of the attached shield board. NXP makes available a compatible eSwitch library of FRDM-32XSG-EVB-specific functions that are imported into the Arduino Software. The eSwitch library functions have all the capabilities needed to access and control the MC17XSG500.

NXP Freedom boards

The FRDM-32XSG-EVB is also compatible with a wide range of Kinetis Freedom boards from NXP, thanks to the Arduino connectors. In this configuration, the Freedom board serves primarily as the SPI communication link between the evaluation board and the host PC. The software interface is through NXP's CodeWarrior IDE (Integrated Design Environment) or Kinetis Design Studio and the CodeWarrior Gen4XtremeSwitch component. A CodeWarrior and KDS example project, available as a .zip file on NXP's website, incorporates the Gen4XtremeSwitch component and demonstrates a typical implementation using the FRDM-32XSG-EVB associated with FRDM-KL25Z. Designers can connect components to the evaluation board and modify the code in the example to suit their development needs.

For more details, please consult this tool summary page:

www.nxp.com/products/:GEN4-EXTREMESWITCH-PEXPERT

4 Getting started

The NXP analog product development boards provide an easy-to-use platform for evaluating NXP products. The boards support a range of analog, mixed-signal and power solutions. They incorporate monolithic integrated circuits and system-in-package devices that use proven high-volume technology. NXP products offer longer battery life, a smaller form factor, reduced component counts, lower cost and improved performance in powering state-of-the-art systems.

The tool summary page for FRDM-32XSG-EVB is located at http://www.nxp.com/FRDM-32XSG-EVB. The overview tab provides an overview of the device, product features, a description of the kit contents, a list of (and links to) supported devices, list of (and links to) any related products and a **Get Started** section.

The **Get Started** section provides links to everything needed to start using the device and contains the most relevant, current information applicable to the FRDM-32XSG-EVB.

- Go to http://www.nxp.com/FRDM-32XSG-EVB.

- On the **Overview** tab, locate the **Jump To** navigation feature on the left side of the window.
- Select either the **Get Started** link or scroll in the main window of the **Overview** tab until the **Get Started** section is visible.
- Review each entry in the **Get Started** section.
- Download an entry by clicking on the title.
- After reviewing the **Overview** tab, visit the other product related tabs for additional information:
  - **Documentation**: download current documentation
  - **Software & Tools**: download current hardware and software tools
  - **Buy/Parametrics**: purchase the product and view the product parametrics

After downloading files, review each file, including the user guide which includes setup instructions. If applicable, the bill of materials (BOM) and supporting schematics are also available for download in the **Get Started** section of the **Overview** tab.

4.1 Kit contents/packing list

The FRDM-32XSG-EVB kit contents include:

- Assembled and tested evaluation board in an anti-static bag
- Power connectors
- Quick start guide

4.2 Required equipment

This kit requires the following items:

- 3/16" blade screwdriver for connecting the loads
- DC Power supply: 7.0 V to 30 V with up to 20 A current handling capability, depending on motor requirements
- USB Standard A (male) to B (male) cable
- Typical loads (brushed DC motor, power resistors or inductive load with up to 5.0 A and 28 V operation)
- Development board for SPI communication
  - Arduino Uno (All revisions)
  - Arduino Due
  - Arduino Leonardo

4.3 System requirements

The kit requires the following to function properly with the software:

- USB enabled computer running Windows XP or newer

5 Getting to know the hardware

5.1 Board overview

The FRDM-32XSG-EVB evaluation kit exercises all the functions of the MC17XSG500 high-side switch. The onboard device provides five power outputs.

The evaluation board can be used in conjunction with a FRDM-KL25Z board or an Arduino development board connected to a PC's USB port.

These development boards support SPI communication with the FRDM-32XSG-EVB board and enable configuration, control and status monitoring of the MC17XSG500.

5.2 Board features

The board features are as follows:

The FRDM-32XSG-EVB provides a platform for evaluating the functionality of NXP's MC17XSG500 high-side switch IC. The board features the following:

- Five configurable power outputs with current, voltage and overtemperature protection
- Power connectors to control various types of external loads
- 5.0 V voltage regulator
- LEDs to indicate supply and output status
- Low Equivalent Series Resistance (ESR) capacitor to reduce ripple in the power supply
- SPI Chip Select switch capable of addressing up to four stacked FRDM-32XSG-EVB boards, see Table 8
- Freewheeling diodes on all power channels

5.3 Block diagram

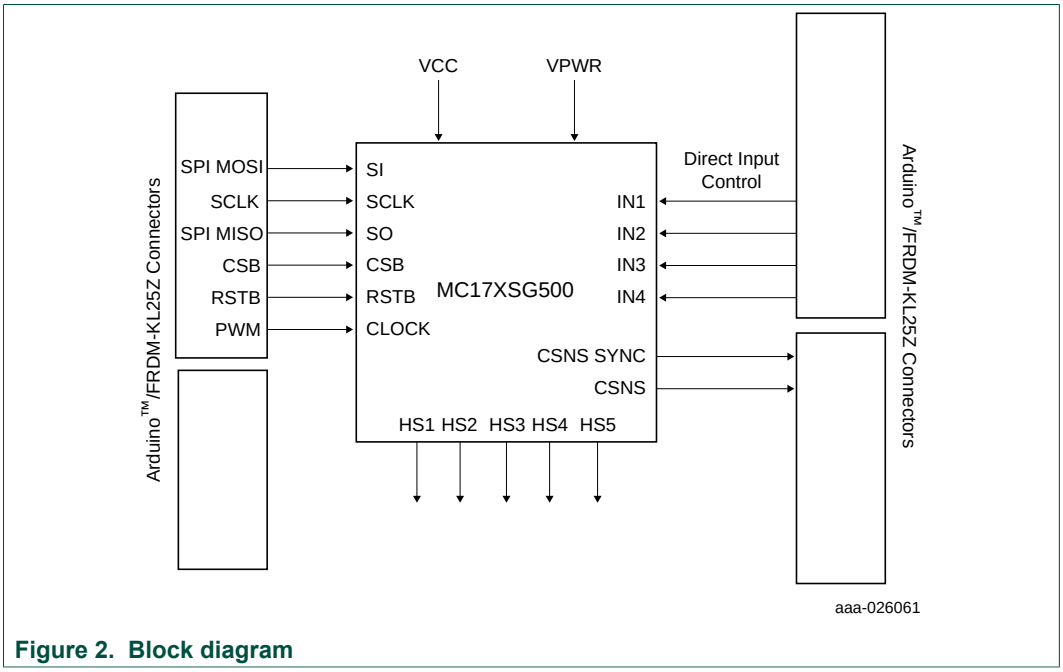


Figure 2. Block diagram

5.4 Device features

Table 1. Device features

Device	Description	Features
MC17XSG500	The MC17XSG500 is a penta 17 mΩ smart high-side switch power IC, enhanced with SPI configuration, protection and diagnostic capabilities	• Normal operating range: 7.0 V to 30 V • Extended operating range: 6.0 V to 32 V • 5.5 A steady-state current per channel • Analog feedback pin providing supply voltage, temperature monitoring and channel current sensing • Advanced current sense mode for LED usage • 16-bit 5.0 MHz SPI communication for channel control, including PWM duty cycles, OpenLoad detection, thermal shutdown and fault reporting • Overload, overtemperature, overvoltage and undervoltage protections • –16 V reverse polarity and ground disconnect protections

5.5 Application diagram

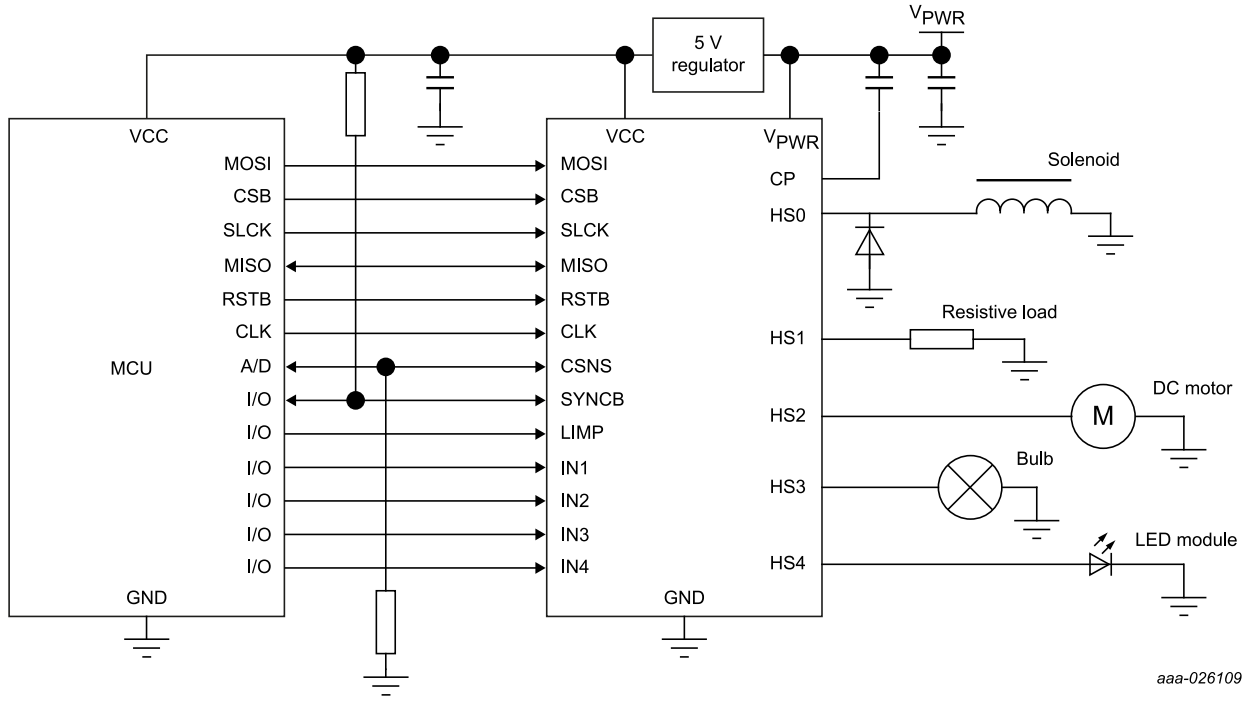
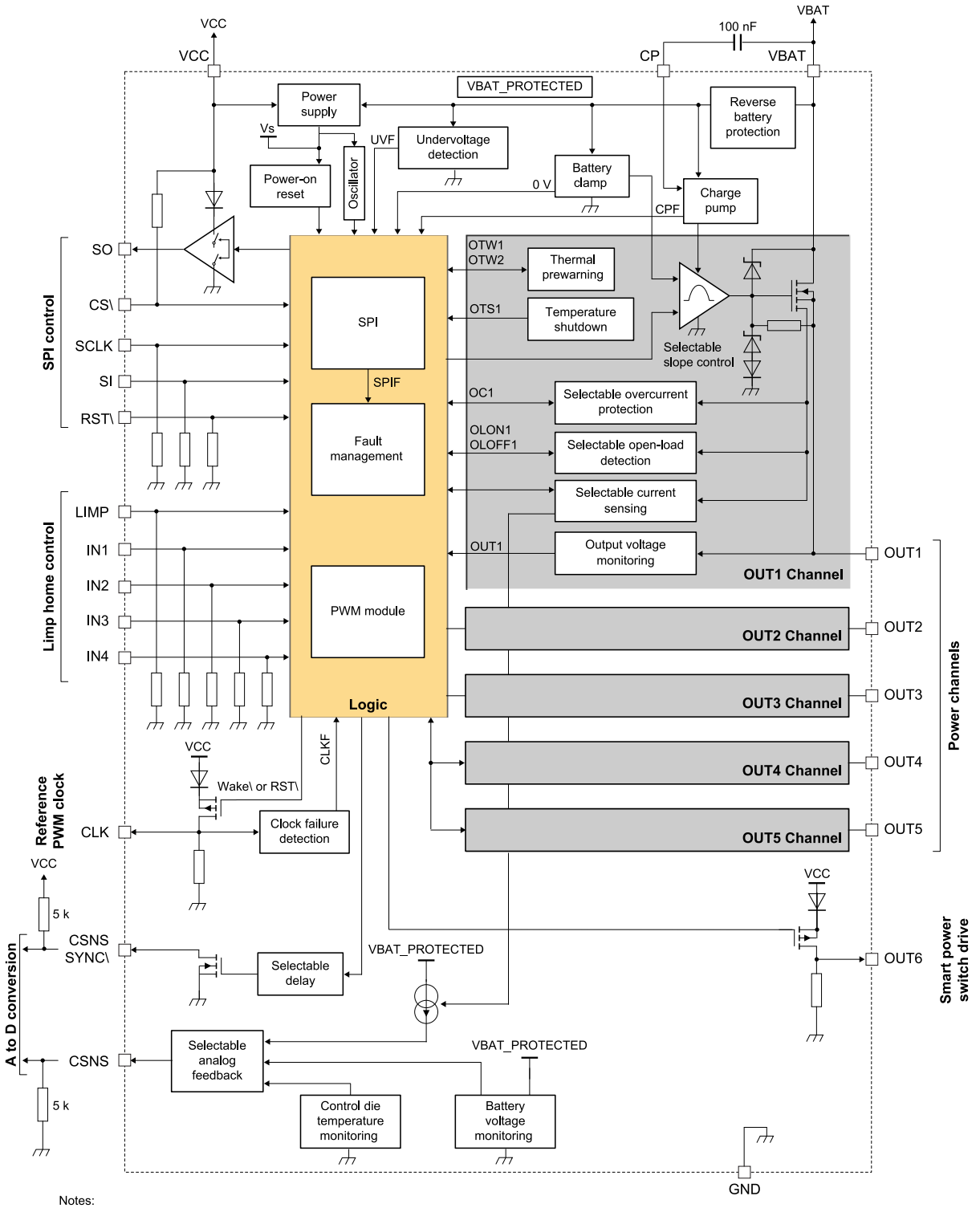


Figure 3. Application diagram

5.6 Internal block diagram



Notes:
- Blocks shaded gray have been implemented independently for each channel.
- Red outlined blocks indicate safety mechanisms.

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Figure 4. Internal block diagram

5.7 Board description

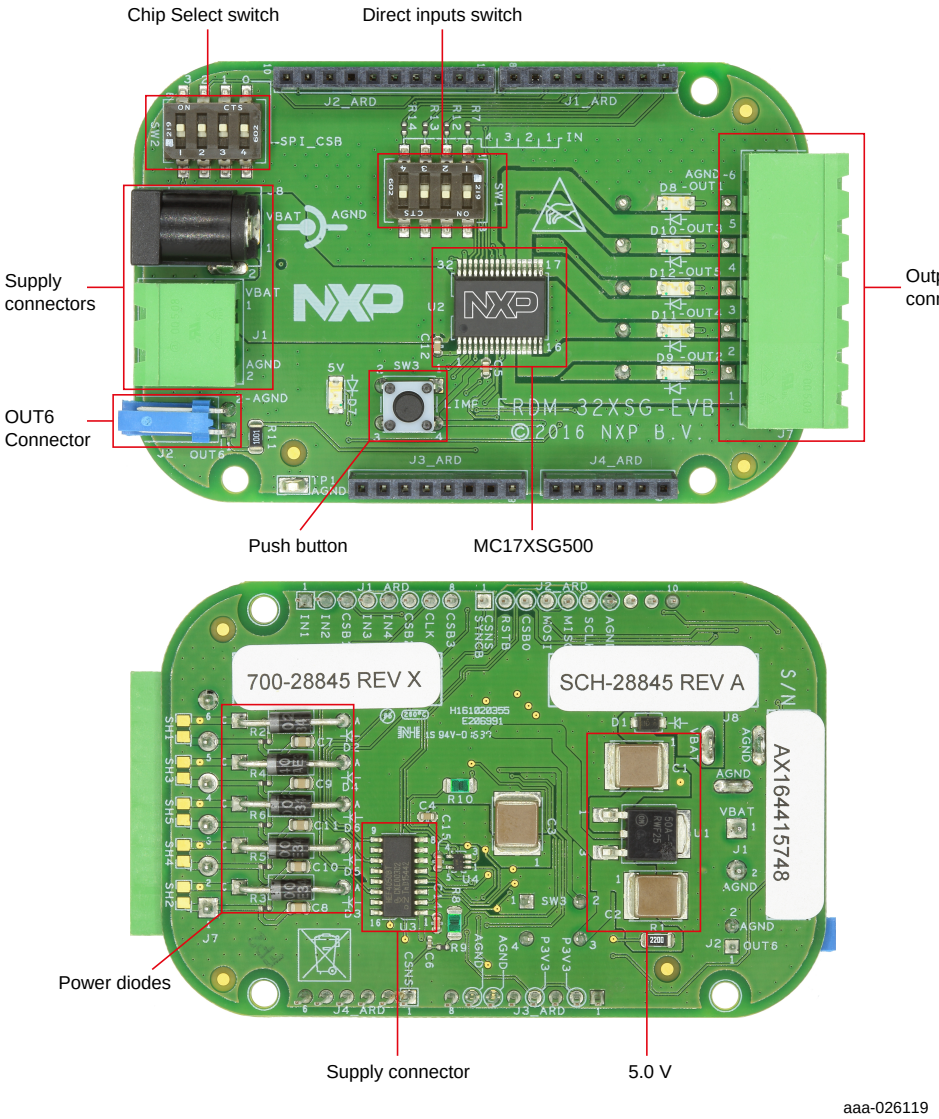


Figure 5. Board description

Table 2. Board description

Name	Description
Output connector	Power connection for outputs HS1 through HS5 and ground
MC17XSG500	Penta high-side smart switch
Push button	LIMP mode button
OUT6 connector	External smart power switch driver
Supply connectors	Jack and 2-pin power connectors
Chip Select switch	Switch used to select CS signal when stacking boards
Direct inputs switch	Switch used to set the state of an input in LIMP mode
Power diodes	Freewheeling diodes for inductive loads

Name	Description
Supply connector	Power connection for V_{PWR} and ground
5.0 V	5.0 V supply for V_{DD}

5.8 Input signal definition

The following input signals control the outputs or functions inside the circuit.

Table 3. Input signal definitions

Input name	Description
D0, D1, D3, D4	Logic input to control the output state of HS1..4
MOSI	Master Out Slave In signal for the SPI
CSB0 through CSB3	Chip select signals for different boards
SCLK	Clock for the SPI
RSTB	Reset of devices. Active Low
CLOCK	External clock for PWM

5.9 Output signal definitions

The FRDM-32XSG-EVB uses the following output signals to reflect the fault and device status as well as to drive a load. The board provides an analog output for real-time load current monitoring.

Table 4. Output signal definitions

Output name	Description
HS1 through HS4	Power outputs of both devices
MISO	Master In Slave Out signal for the SPI
CSNS	Analog monitoring of output current and ICs temperature
SYNC	Trigger signal for measurements on CSNS pin

5.10 LED display

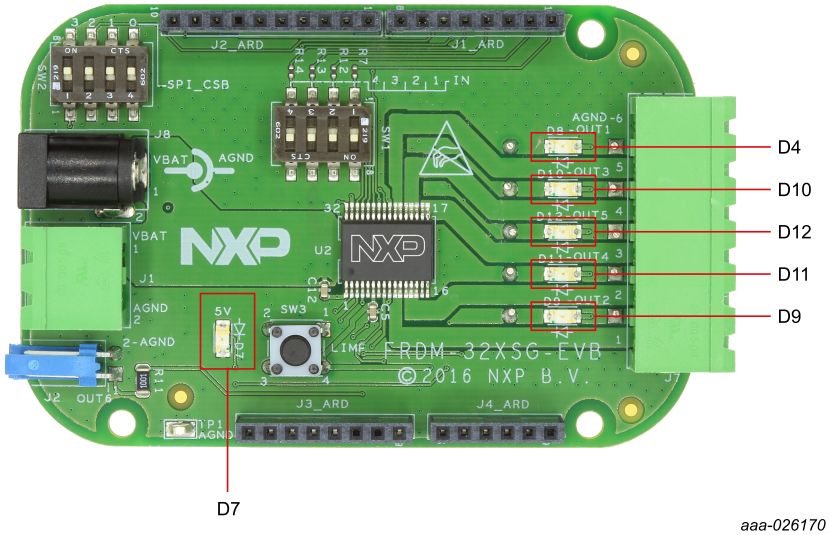


Figure 6. LED locations

Table 5. LED locations

LED ID	Description
D4	LED Green. Indicates power to OUT_1
D7	LED Green. Indicates 5.0 V supply
D9	LED Green. Indicates power to OUT_2
D10	LED Green. Indicates power to OUT_3
D11	LED Green. Indicates power to OUT_4
D12	LED Green. Indicates power to OUT_5

5.11 Test points

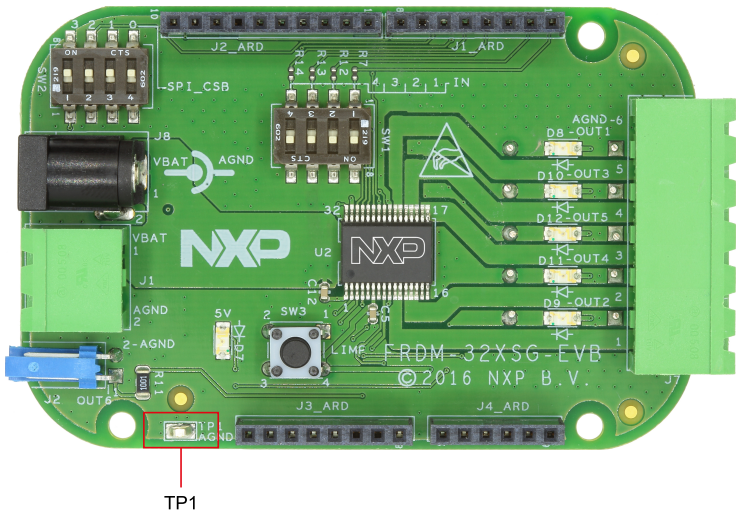


Figure 7. Test point locations

Table 6. Test point definitions

Label	Description
TP1	Ground test point

5.12 Connectors

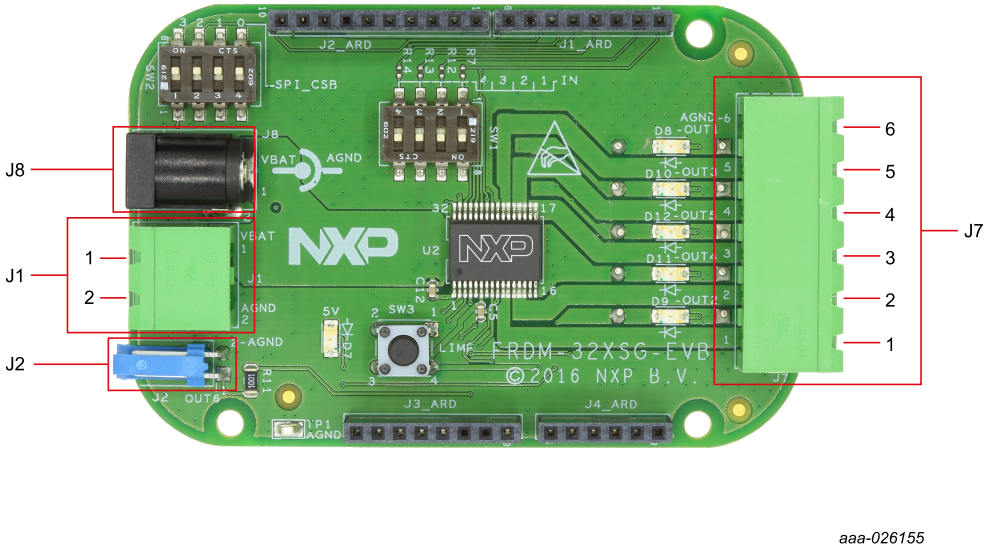


Figure 8. Connectors

Table 7. Connector definitions

Label	Description	Number	Name	Function
J1	Two-pin power supply	1	VBAT	DC power
		2	AGND	DC ground
J2	OUT6		OUT_6	External smart power switch driver
J7	HSx Power/Ground	1	OUT_2	Power connection for HS2
		2	OUT_4	Power connection for HS4
		3	OUT_5	Power connection for HS5
		4	OUT_3	Power connection for HS3
		5	OUT_1	Power connection for HS1
		6	AGND	HSx Ground
J8	Jack power supply		VBAT/AGND	DC power jack

5.13 Switches

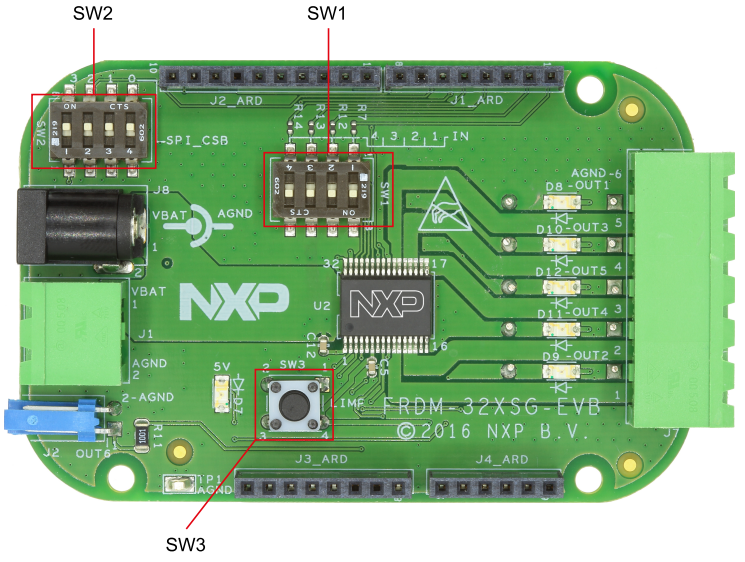


Figure 9. Switches

Table 8. Switch descriptions

Label	Name	Position	Function
SW1	Direct input switches	1	Selects 5.0 V supply to IN1
		2	Selects 5.0 V supply to IN2
		3	Selects 5.0 V supply to IN3
		4	Selects 5.0 V supply to IN4

Label	Name	Position	Function
SW2[1]	Chip select switch	1	Selects connection from J1 pin8 to SPI0_CSB_FRDM
		2	Selects connection from J1 pin6 to SPI0_CSB_FRDM
		3	Selects connection from J1 pin3 to SPI0_CSB_FRDM
		4	Selects connection from J2 pin3 to SPI0_CSB_FRDM
SW3	LIMP mode button	—	Selects LIMP mode

[1] SW2 acts as an address switch that allows stacking of up to four boards.

6 Operating with Arduino Uno and the Arduino software

The FRDM-32XSG-EVB supports the following Arduino boards:

- The Arduino Uno R3 is based on the Atmel ATmega328 8-bit microcontroller with 32 Kb of flash memory. The board contains fourteen GPIO pins (six of which are PWM enabled) and six analog inputs.
- The Arduino Due is based on the Atmel SAM3X8E ARM Cortex-M3 CPU, a 32-bit ARM core microcontroller with 256 Kb of flash memory. The board contains 54 GPIO pins (13 of which are PWM enabled) and 12 analog inputs. The Arduino Due also offers an USB OTG capable connection, two DAC (digital to analog converters), two TWI connectors, a SPI header and a JTAG header.
- The Arduino Leonardo is based on the Atmel ATmega32U4 8-bit microcontroller with 32 Kb of flash memory. It has 20 GPIO pins (seven of which are PWM enabled) and 12 analog inputs. The board also offers a micro USB connection and an ICSP header.

This section describes operating with the Arduino Uno R3. The procedures are similar for the Arduino Due and the Arduino Leonardo.

6.1 Connecting the FRDM-32XSG-EVB to an Arduino board

The Arduino board connects to a PC through a USB port, which allows the user to program it using the Arduino Software.

The Arduino board controls the power outputs and sets the features of the FRDM-32XSG-EVB's MC17XSG500 smart high-side switch power IC. The Arduino board also monitors the SPI registers, thereby facilitating the use of safety and advanced diagnostic functions.

The FRDM-32XSG-EVB connects to the Arduino Uno using the four single-row Arduino connectors on the bottom of the board (see Figure 10).

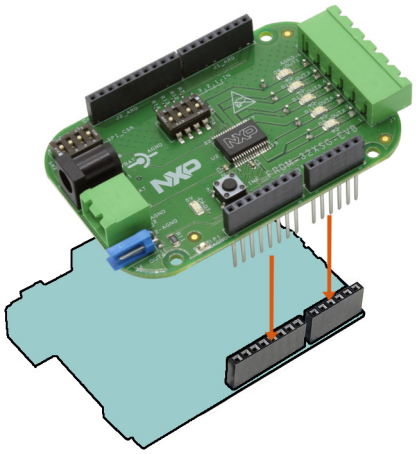


Figure 10. Connecting the FRDM-32XSG-EVB to an Arduino board

Table 9 shows the connections between the FRDM-32XSG-EVB and an Arduino board.

Table 9. FRDM-32XSG-EVB to Arduino board connections

Header	Pin	Arduino board hardware name	Freedom board hardware name	Description
Digital	0	D0	IN1	IN1 signal for HS1
	1	D1	IN2	IN2 signal for HS2
	2	D2	CSB1	SPI chip Select 1
	3	D3	IN3	IN3 signal for HS3
	4	D4	IN4	IN4 signal for HS4
	5	D5	CSB2	SPI Chip Select 2
	6	D6	CLK	Output PWM clock reference
	7	D7	CSB3	SPI Chip Select 3
	8	D8	CSNS SYNC	CSNS trigger signal
	9	D9	RSTB	MC17XSG500 reset signal
	10	D10	CSB0	SPI Chip Select 0
	11	D11	MOSI	SPI Data OUT
	12	D12	MISO	SPI Data IN
	13	D13	SCLK	SPI clock
	14	GND	AGND	Ground
Analog	1	A0	CSNS	No connection
	2	A1	N/C	No connection
	3	A2	N/C	No connection
	4	A3	N/C	No connection
	5	A4	N/C	No connection
	6	A5	N/C	No connection

Header	Pin	Arduino board hardware name	Freedom board hardware name	Description
Power	1	Vin	N/C	No connection
	2	GND	AGND	Ground
	3	GND	AGND	Ground
	4	5V	N/C	No connection
	5	3.3V	P3V3	3.3 V supply
	6	RESET	N/C	No connection
	7	IOREF	P3V3	3.3 V supply

6.2 Configuring the hardware

The FRDM-32XSG-EVB consists of five high-side power channels driven through a SPI interface. The board can be configured for use with an Arduino development board or a FRDM-KL25Z board and the *Gen4XtremeSwitch* Processor Expert component.

Caution: When using the FRDM-32XSG-EVB, make sure that the maximum supply voltage (VPWR) stays within the 5.0 V to 32 V range. Operating outside this range may damage the board.

The procedure for configuring the FRDM-32XSG-EVB for use with an Arduino board is as follows:

1. Connect the FRDM-32XSG-EVB to the Arduino Uno using the Arduino connectors on each board.
2. Connect the USB cable (not supplied with the kit) between the PC and the Arduino Uno board.
3. With the power switched off, connect the power supply to the jack connector (J8) or attach the DC power supply to the VBAT and GND screw connector terminal (J1) on the evaluation board.
4. Screw the wires of each load to the 6-pin power connector (J7) provided. Ground is on pin 6.
5. Switch the power supply on. The green LEDs adjacent to connector J7 will light when a channel is set to ON, either by the SW1 switch or with SPI commands.

Figure 11 illustrates the hardware configuration using an Arduino board.

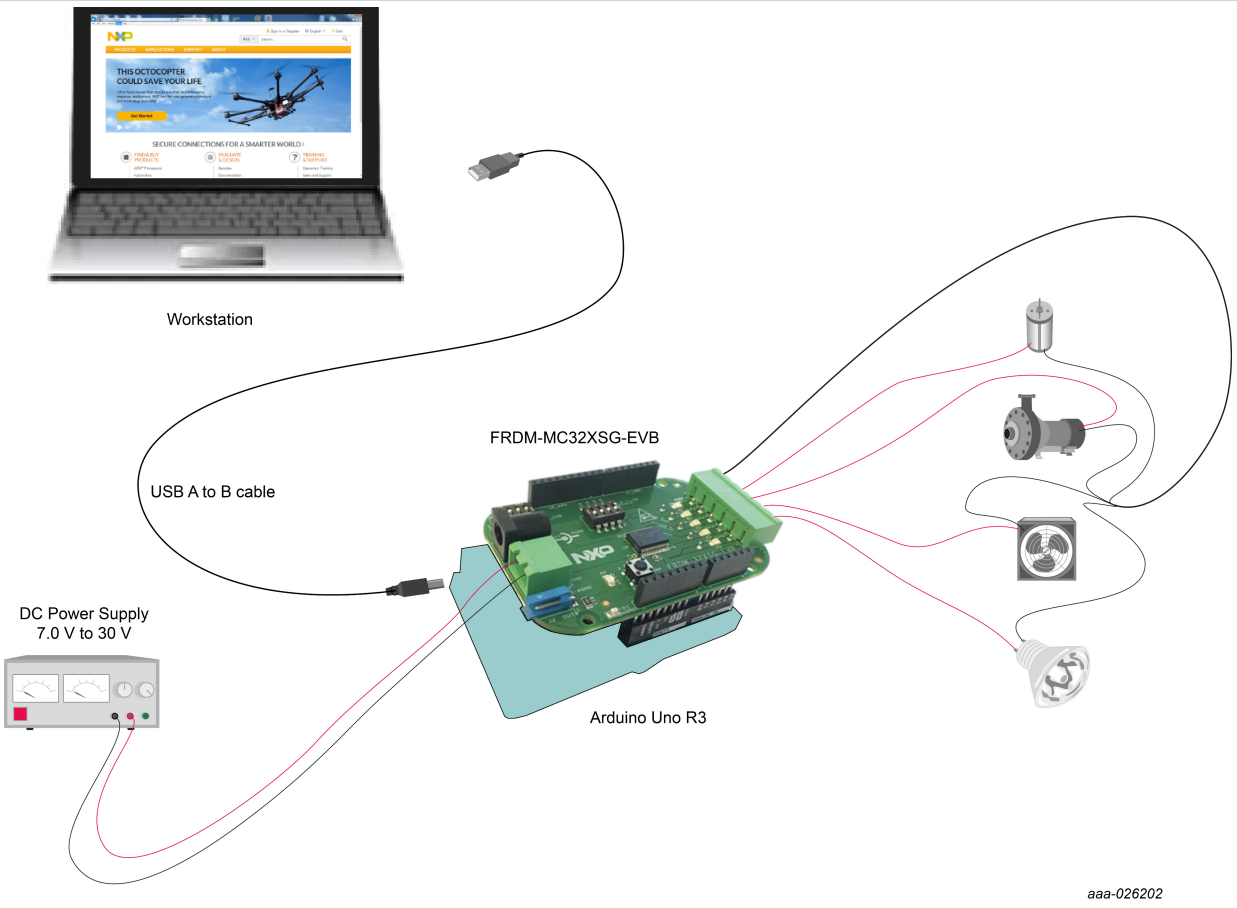


Figure 11. FRDM-32XSG-EVB configured for use with an Arduino board

For more details on setting up the Arduino board, see www.arduino.cc/en/Guide/HomePage.

6.3 Setting up the software

Prior to any evaluation on the FRDM-32XSG-EVB board, the following Arduino software must be installed:

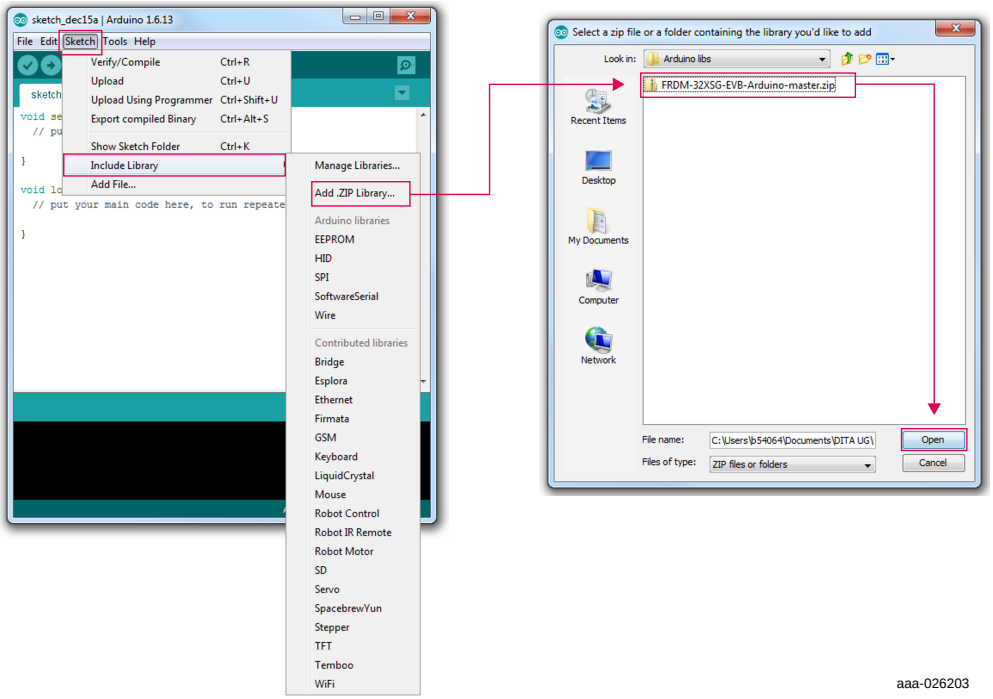
- The Arduino software (IDE)
  www.arduino.cc/en/Main/Software
- The FRDM-32XSG-EVB eSwitch library
  https://source.codeaurora.org/external/32xsg_ino.
  The eSwitch library contains drivers that make device operations easier to implement. To download the library, open a 'Git' invite command on your computer (installation link: https://git-scm.com/book/en/v2/Getting-Started-Installing-Git) and clone the library with the following command: **git clone https://source.codeaurora.org/external/32xsg_ino/eswitch**. The library folder is now downloaded in the repository selected with Git.

For more details on Arduino installation and its configuration and usage, review the Arduino tutorials at www.arduino.cc/en/Tutorial/HomePage.

6.4 Importing the eSwitch library into the Arduino software

Prior to using the Arduino Software (IDE) for development, the FRDM-32XSG-EVB eSwitch library downloaded in Section 6.3 "Setting up the software" must be imported into the software. The procedure is as follows:

1. Open the Arduino software.
2. From the menu bar, click **Sketch->Include Library**. When the **Select a zip file...** window opens, browse for the location of the eSwitch library that was downloaded in Section 6.3 "Setting up the software".
3. Select the library, and then click **Open**.



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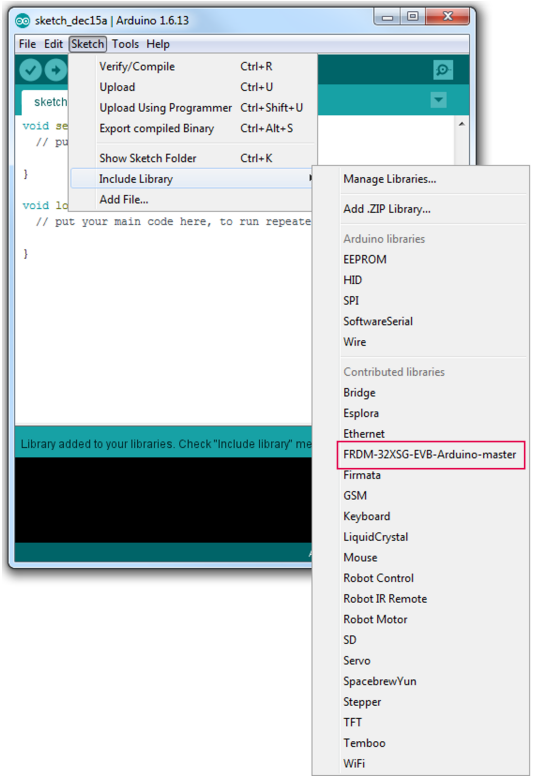
4. Verify that the library has been imported. Click **Sketch->Include Library** and then confirm that **FRDM-32XSG-EVB-Arduino-master** appears as a menu item.



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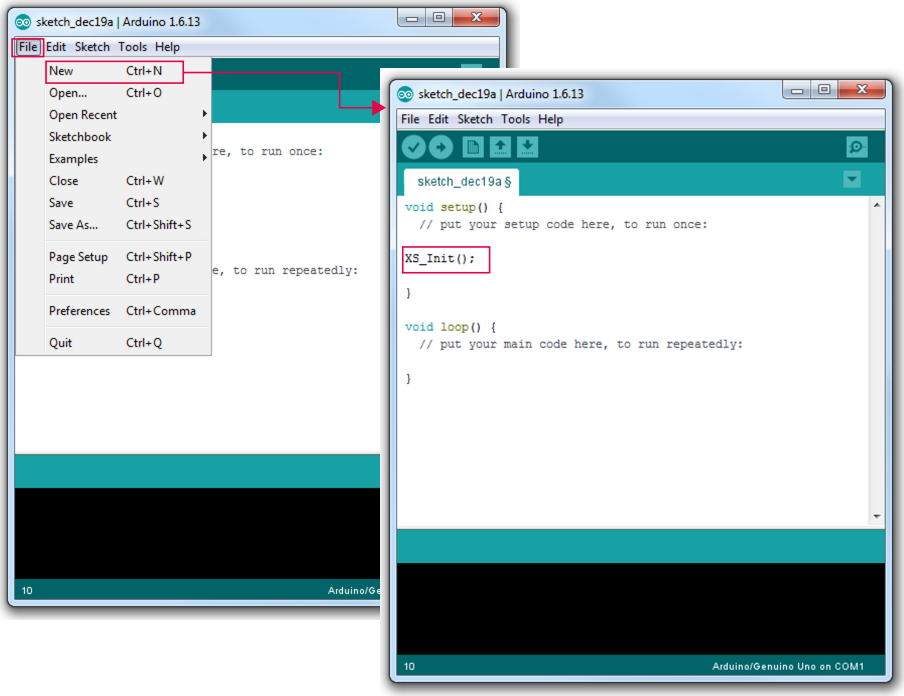
6.5 Creating a new project

To create a new FRDM-32XSG-EVB project in the Arduino software, do the following:

1. Open the Arduino software (IDE).
2. From the **File** menu, click **New**. A new Sketch window opens.
3. Within the open and close brackets of the **setup()** function, enter **XS-Init();** to invoke a function that initializes the FRDM-32XSG-EVB board and enables all of the library functions.



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XS_Init initializes the SPI bus, allowing the Arduino Uno board to communicate with the FRDM-32XSG-EVB board. It also sets the current sense pin, the PWM clock and the RSTB pin. At runtime, a function within XS_Init executes every 10 ms to toggle the Watchdog value, thereby preventing the MC17XSG500 from entering Fail mode.

6.6 Function descriptions

The eSwitch library contains eight functions that provide a means of controlling the FRDM-32XSG-EVB board.

6.6.1 WriteRegister

Writes 16-bits of data to the specified SPI register.

```
WriteRegister(reg_addr, data)
   reg_addr  byte              address of the SPI register
   data      unsigned integer  data to be sent
Return  void
```

6.6.2 ReadRegister

Returns the 16-bit contents of the SPI output register. (For SPI output register bit descriptions, see the MC32XSG datasheet here: www.nxp.com/files/analog/doc/data_sheet/MC32XSG.pdf.

```
ReadRegister(reg_addr)
   reg_addr  byte          address of the SPI output register
```

```
Return  unsigned integer    Contents of the SPI output register
```

6.6.3 SetOutputState

Toggles the ON/OFF state of the specified high-side switch power output (HS1 through HS5).

```
SetOutputState(output, state)

   output  byte     The number id of the high-side switch to be
                    toggled (1=HS1, 2=HS2...5=HS5)
   state   boolean  The specified ON/OFF state (0=OFF, 1=ON)
Return  void
```

6.6.4 SetPWMDuty

Changes the PWM duty cycle for the specified high-side switch power output (HS1 through HS5).

```
SetPWMDuty(output, state)
   output  byte    The number id of the high-side switch to be
                   toggled (1=HS1, 2=HS2...5=HS5)
   value   byte    The duty cycle specified as a number between
 0 to 255
Return  void
```

6.6.5 SetMonitoring

Changes the type of feedback provided by the MC17XSG500 CSNS pin. (The CSNS pin provides selectable analog feedback on output current per high-side switch, power supply voltage or temperature.

```
SetMonitoring(mux_value)
   mux_value  byte    A number indicating the type of feedback
                      CSNS outputs. Allowable values are:
                      • 0 = Off
                      • 1 = Output1 (HS1) current
                      • 2 = Output2 (HS2) current
                      • 3 = Output3 (HS3) current
                      • 4 = Output4 (HS4) current
                      • 5 = Output5 (HS5) current
                      • 6 = VPWR
                      • 8 = Temperature
Return  void
```

6.6.6 GetOutputCurrent

Reads the MC17XSG500's CSNS pin and returns the current flowing through the specified high-side switch power output (HS1 through HS5). The desired high-side switch must be selected by the SetMonitoring function prior to invoking GetOutputCurrent.

```
GetOutputCurrent( )
   void        No input parameters
```

```
Return  float  The output current in amps on the
               selected high-side switch
```

6.6.7 GetVPWR

Reads the MC17XSG500's CSNS pin and returns the power supply voltage in volts. V_{PWR} output must be selected by the SetMonitoring function prior to invoking GetOutputCurrent.

```
GetOutputCurrent( )
   void       No input parameters
Return float  The power supply voltage in volts
```

6.6.8 GetTemperature

Reads the MC17XSG500's CSNS pin and returns the temperature of the device in degrees Centigrade. Temperature output must be selected by the SetMonitoring function prior to invoking GetOutputCurrent.

```
GetOutputCurrent( )
   void  No input parameters
Return float  The temperature in degrees Centigrade
                  of the MC17XSG500 on the FRDM32XSGEVB
```

6.7 Code example

The following section of code illustrates a typical implementation of the FRDM-32XSG-EVB being used with an Arduino Uno board. The code sets the MC17XSG500 CSNS pin to output power supply voltage and later reads the voltage into a variable. It turns ON the high-side switch output 2 (HS2) and sets the PWM duty cycle on the high-side switch output 3 (HS3) to 50 %. Finally, diagnostic information in the MC17XSG500 Quick Status register is read into a variable.

```
#include <Arduino.h>
#include <eSwitch.h>

float voltage;
float temperature;
float current;
unsigned int diagnostic;

void setup(){
  XS_Init();
  Serial.begin(9600); //Initialize the Serial communication through USB

  SetMonitoring(6); //CSNS pin feeds back the Power supply voltage
}

void loop(){

  SetOutputState(2,1); //Set output 2 fully ON

  /*
  * Put the voltage value sent by the CSNS pin in voltage variable
  */
  voltage = GetVPWR();
  Serial.println("Vpwr :" + voltage);//Print the voltage variable into the
//Serial Monitor
```

```
  SetPWMDuty(3, 127); //Set output 3 to 50% pwm duty cycle

  /*
  * Read Quick Status register of the product
  * For more information about the product refer to MC17XSG500 datasheet
  * in SPI Output Register and Bit Descriptions
  */
  diagnostic = ReadRegister(1);
}
```

7 Schematics, board layout and bill of materials

The board schematics, board layout and bill of materials are available at http://www.nxp.com/FRDM-32XSG-EVB on the Overview tab under Get Started.

8 References

The following URLs reference related NXP products and application solutions:

NXP.com support pages	Description	URL
FRDM-32XSG-EVB	Tool summary page	www.nxp.com/FRDM-32XSG-EVB
MC32XSG	Product summary page	www.nxp.com/MC32XSG

9 Revision history

Revision	Date	Description
1.0	20170227	• Initial version of the document
2.0	20180216	• Updated the software drivers download link for Arduino in Section 6.3 "Setting up the software" • Added description to download the library files from Code Aurora in Section 6.3 "Setting up the software" • Updated Section 4 "Getting started" • Deleted Jump start

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Tables

Figures

Contents

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