



# KTFRDMHB2000ESEVMUG

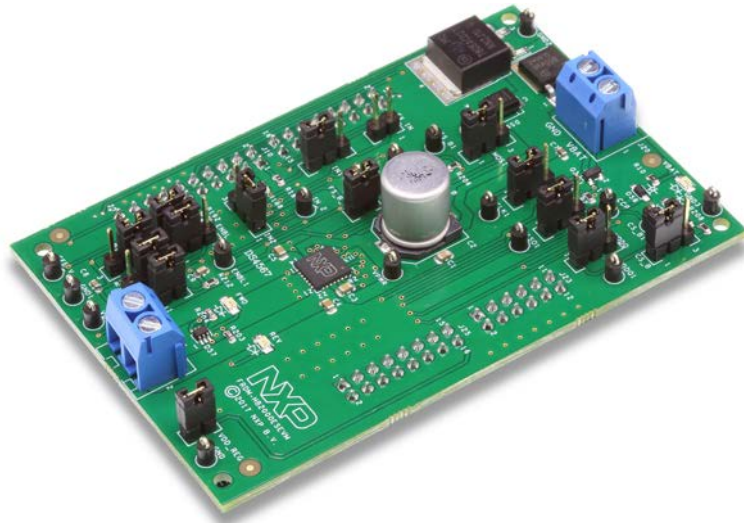
FRDM-HB2000ESEVM evaluation board

Rev. 2 — 11 June 2018

User guide

## 1 FRDM-HB2000ESEVM

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## 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.

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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 Getting started

The NXP analog product development boards provide an easy-to-use platform for evaluating NXP products. These development boards support a range of analog, mixed-signal, and power solutions. These boards 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-HB2000ESEVM is at <http://www.nxp.com/FRDM-HB2000ESEVM>. The overview tab on this page provides an overview of the device, a list of device features, a description of the kit contents, links to supported devices and a **Get Started** section.

The **Get Started** section provides information applicable to using the FRDM-HB2000ESEVM.

1. Go to <http://www.nxp.com/FRDM-HB2000ESEVM>.
2. On the **Overview** tab, locate the **Jump To** navigation feature on the left side of the window.
3. Select the **Get Started** link.
4. Review each entry in the **Get Started** section.
5. Download an entry by clicking the linked title.

After reviewing the **Overview** tab, visit the other 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.

### 3.1 Kit content/packing list

The FRDM-HB2000ESEVM content includes:

- Assembled and tested evaluation board/module in anti-static bag
- FRDM-KL25Z
- Quick start guide

### 3.2 Required equipment

This kit requires the following items:

- 3/16-inch blade screwdriver for connecting the cables
- DC power supply: 5.0 V to 40 V with up to 20 A current handling capability, depending on motor requirements
- USB standard A (male) to mini-B (male) cable
- Typical loads (brushed DC motor, power resistors, or inductive load with up to 5.0 A and 28 V operation)
- Function generator (optional)
- FRDM-KL25Z Freedom development platform for serial peripheral interface (SPI) communication (included in KIT)
- SPIGen software (for using FRDM-KL25Z based SPI Dongle)

### 3.3 System requirements

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

- USB-enabled computer with Windows XP or newer

## 4 Getting to know the hardware

### 4.1 Board overview

The FRDM-HB2000ESEVM evaluation kit exercises all the functions of the MC33HB2000 H-Bridge device. Lab equipment or any microcontroller unit (MCU) with general-purpose input/output (GPIOs) can control the parallel inputs to provide pulse width modulation (PWM) control to the inputs.

The board can be used with a FRDM-KL25Z board connected to a USB port of a PC. Configure, control, and monitor the status of MC33HB2000 by using the SPI communication capabilities of the board.

### 4.2 Board features

The FRDM-HB2000ESEVM board evaluates the NXP part MC33HB2000, including all functions. The board features the following:

- Built-in reverse battery protection
- Test points that allow signal probing
- Built-in voltage regulator to supply logic level circuitry
- Current feedback network for real-time load current monitoring by MCU analog-to-digital converter (ADC)
- LEDs to indicate the supply status and the direction of the motor
- Low equivalent series resistance (ESR) capacitor to reduce ripple in the power supply
- Transient voltage suppressor to handle system level transients

### 4.3 Block diagram

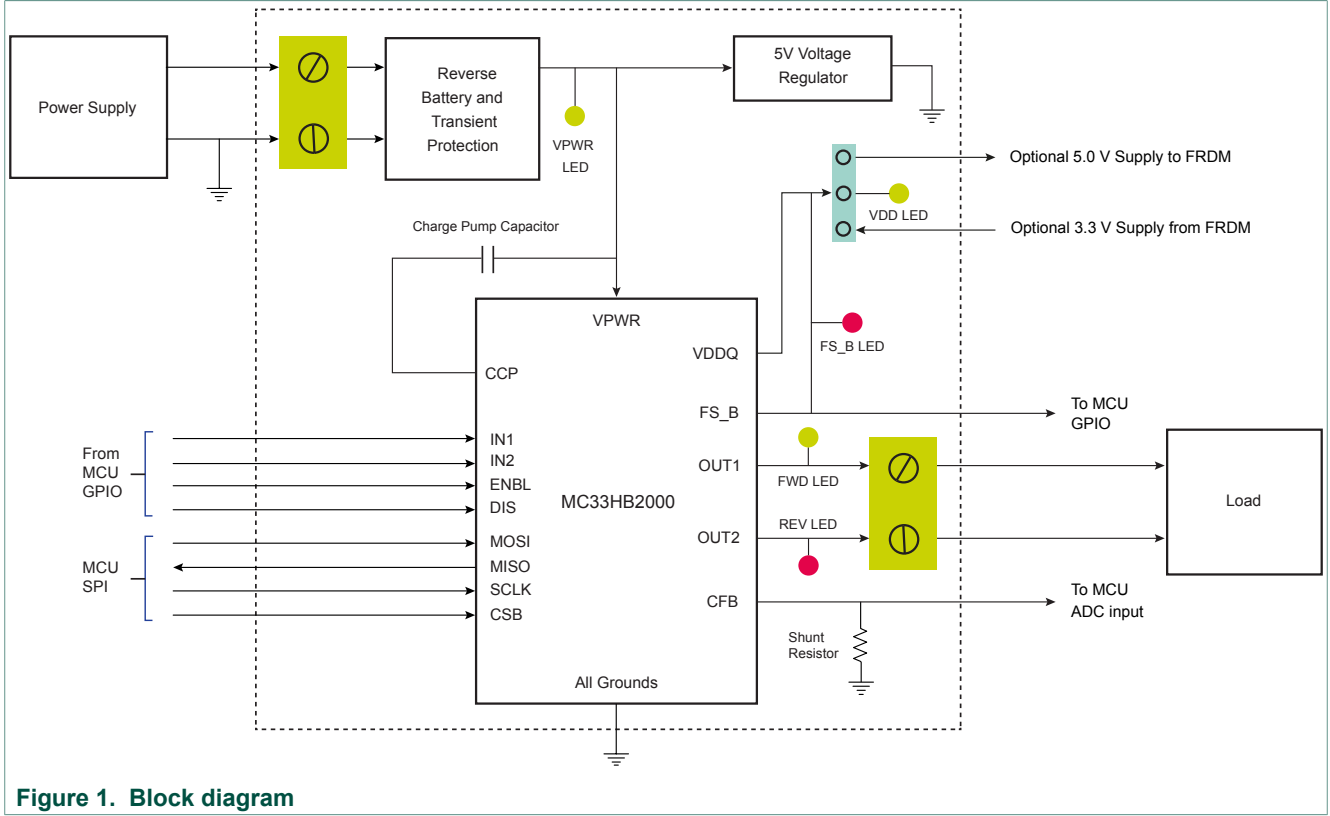


Figure 1. Block diagram

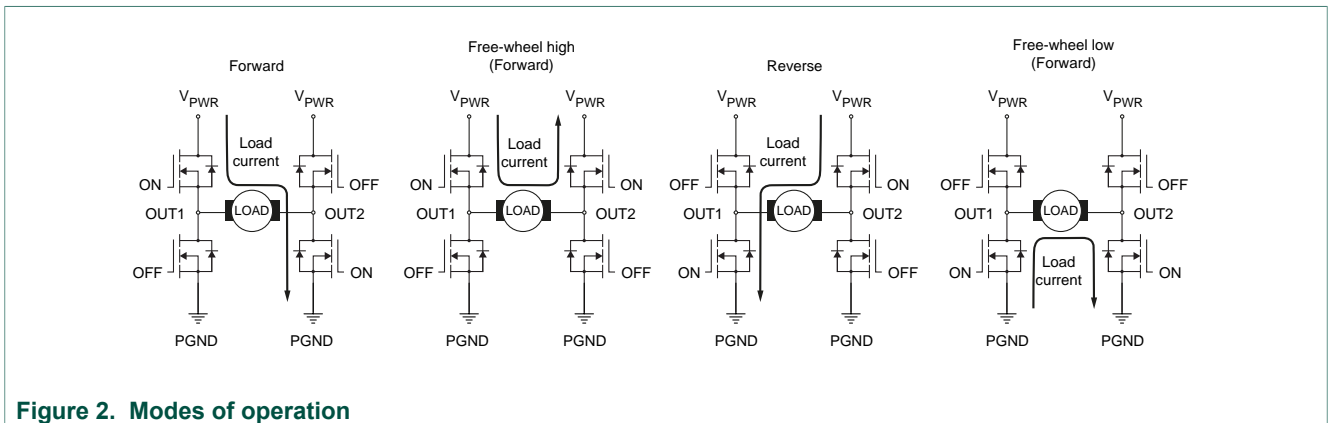
**4.3.1 Device features**

This evaluation board features the following NXP product:

**Table 1. Device features**

| Device     | Description   | Features   |
|------------|---|--|
| MC33HB2000 | The MC33HB2000 is a monolithic H-Bridge power IC, enhanced with SPI configurability, and diagnostic capabilities. | <ul style="list-style-type: none"> <li>Advanced diagnostic reporting via a serial peripheral interface (SPI): charge pump undervoltage on VPWR, short to ground and short to VPWR for each output, open load, temperature warning, and overtemperature shutdown</li> <li>Thermal management: excellent thermal resistance of &lt; 1.0 °C/W between junction and case (exposed pad)</li> <li>Eight selectable slew rates via the SPI: 0.25 V/μs to more than 16 V/μs for electromagnetic interference (EMI) and thermal performance optimization</li> <li>Four selectable current limits via the SPI: 5.4 A, 7.0 A, 8.8 A, 10.7 A, covering a wide range of applications</li> <li>Can be operated without the SPI with a default slew rate of 2.0 V/μs and a 7.0 A current limit threshold</li> <li>Highly accurate real-time current feedback through a current mirror output signal with less than 5.0 % error</li> <li>Drives inductive loads in a full H-Bridge or Half-Bridge configuration</li> <li>Overvoltage protection places the load in high-side recirculation (braking) mode with notification in H-Bridge mode</li> <li>Wide operating range: 5.0 V to 28 V operation</li> <li>Low R<sub>DS(on)</sub> integrated metal-oxide-semiconductor field-effect transistors (MOSFETs): Maximum of 235 mΩ (T<sub>J</sub> = 150 °C) for each MOSFET</li> <li>Internal protection for overtemperature, undervoltage, and short-circuit by signaling the error condition and disabling the outputs</li> <li>I/O pins can withstand up to 36 V</li> </ul> |

**4.3.2 Modes of operation**



**Figure 2. Modes of operation**

### 4.3.3 Architecture

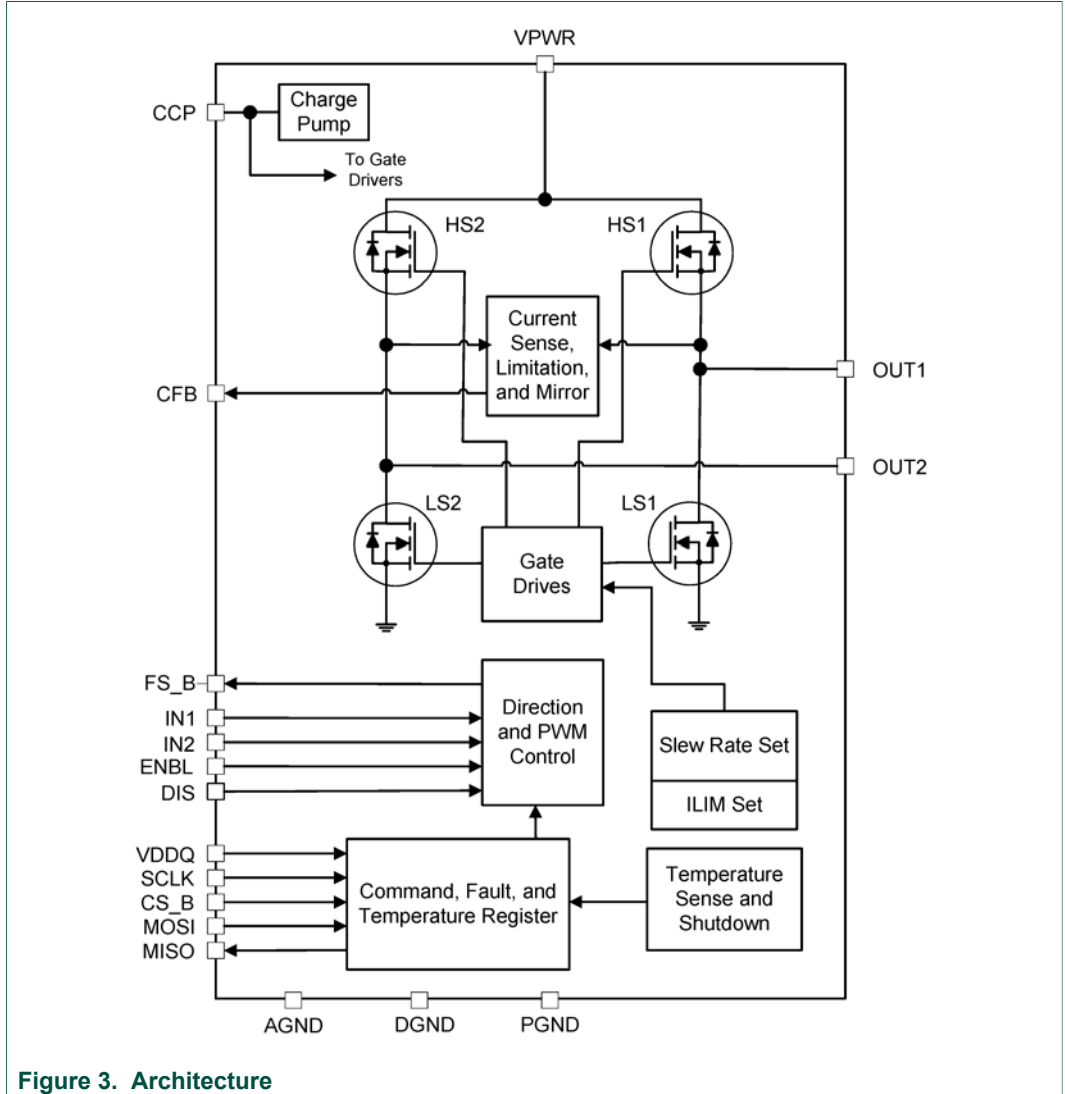


Figure 3. Architecture

4.3.4 Thermal management

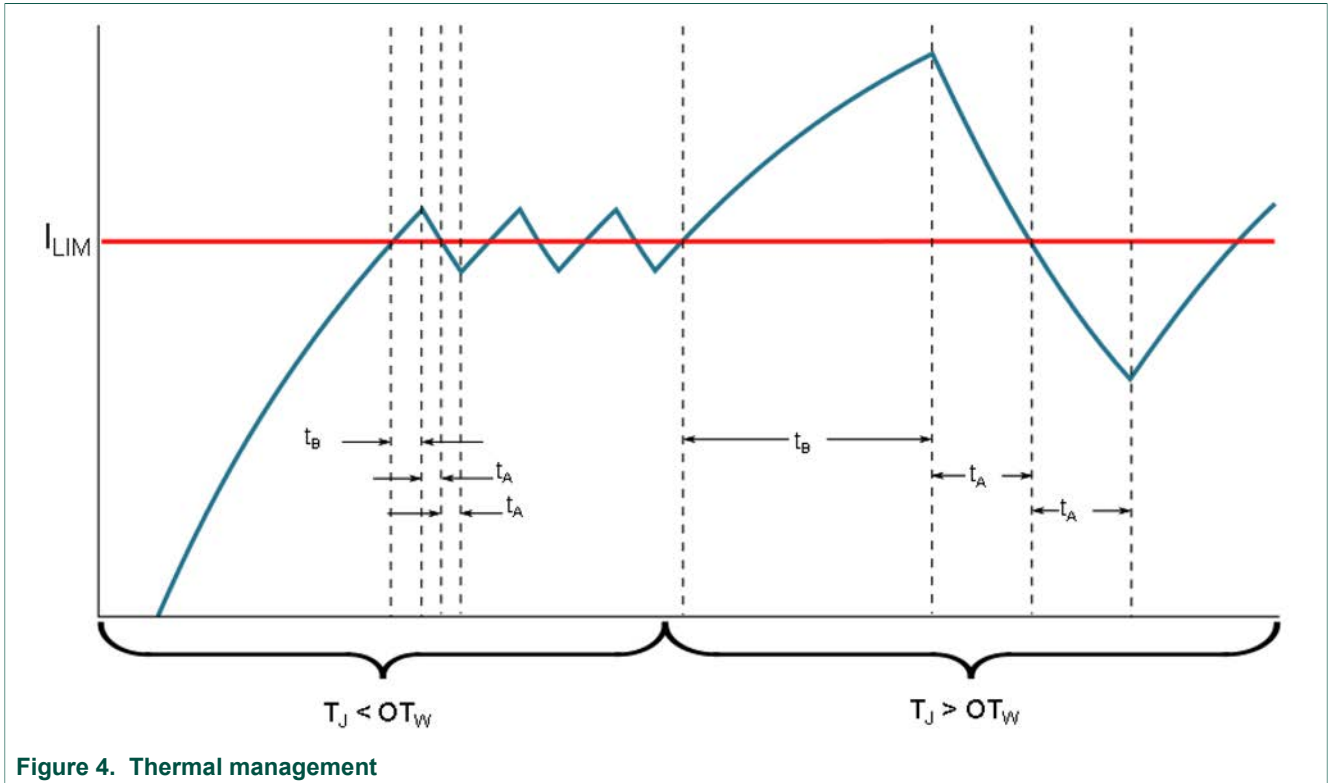


Figure 4. Thermal management



**4.4 Board description**

Figure 5 describes the main elements on the FRDM-HB2000ESEVM.

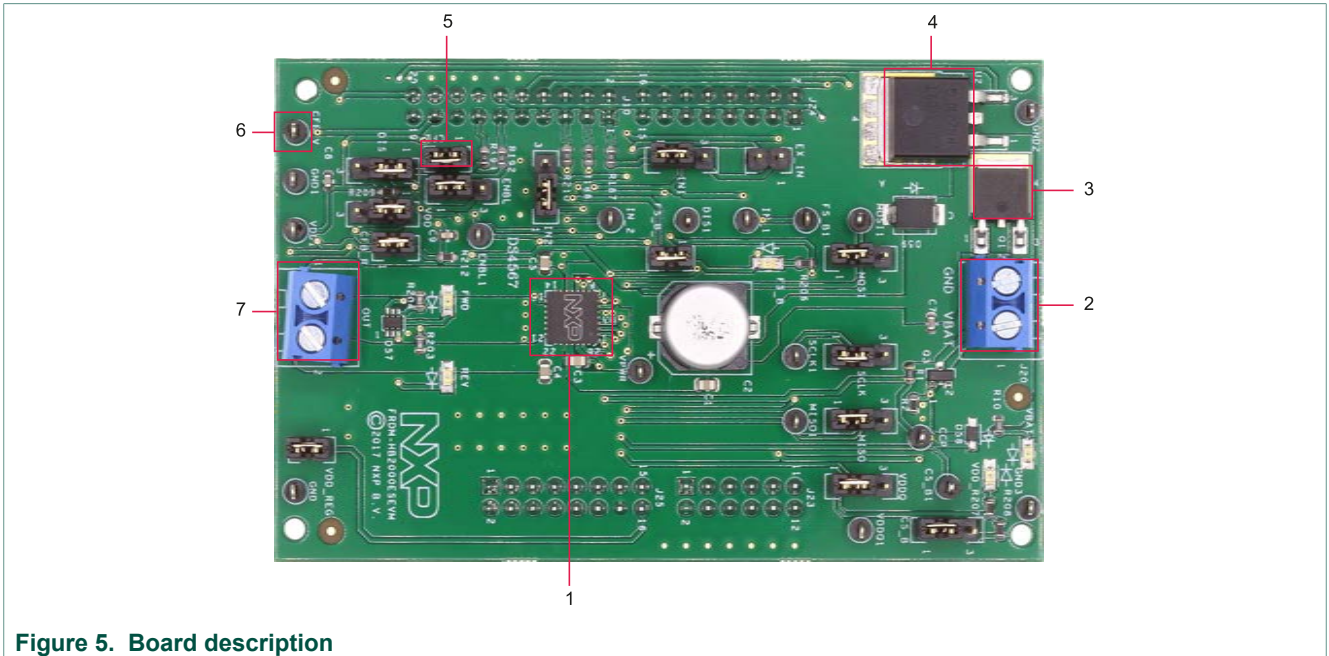


Figure 5. Board description

Table 2. Board description

| Number | Name                       | Description   |
|--------|----------------------------|---|
| 1      | MC33HB2000ES               | monolithic H-Bridge motor driver IC in a robust, thermally enhanced 28-pin HVQFN (6 × 6 mm) package |
| 2      | power and ground inputs    | power supply terminal to connect the battery/power supply with the board                            |
| 3      | reverse battery protection | MOSFET for protecting MC33HB2000 in reverse battery condition                                       |
| 4      | 5.0 V regulator            | 5.0 V regulator for VDD and supply  |
| 5      | jumpers                    | jumpers for configuring the board for different modes of operation                                  |
| 6      | test points                | test points to probe different signals  |
| 7      | output terminal            | output connector to connect a load to the MC33HB2000 output   |

### 4.5 LED description

The following LEDs are provided as visual output devices for the evaluation board:

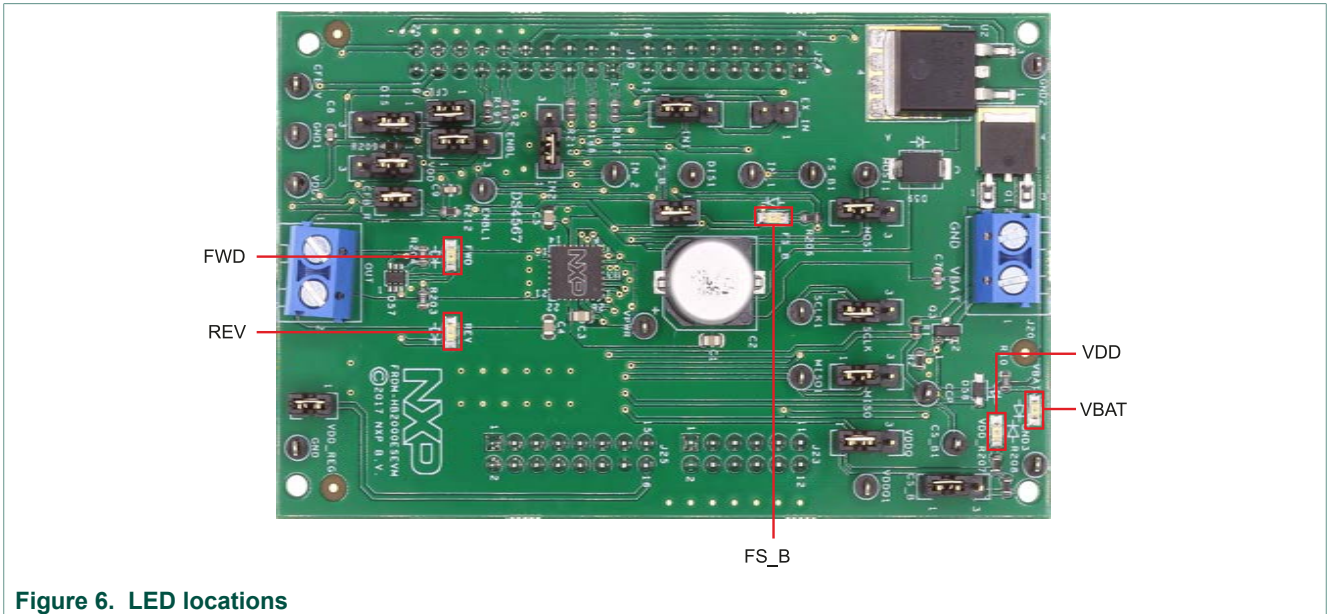


Figure 6. LED locations

Table 3. LED description

| LED ID | Description  |
|--------|--|
| VBAT   | green LED, indicates when main/battery supply is connected                         |
| VDD    | green LED, indicates when +5.0 V supply is connected                               |
| FS_B   | red LED, illuminates when the H-Bridge detects a fault                             |
| FWD    | green LED, indicates output current in forward direction ( $V_{OUT1} > V_{OUT2}$ ) |
| REV    | red LED, indicates output current in reverse direction ( $V_{OUT2} > V_{OUT1}$ )   |

## 4.6 Jumper definitions

Figure 7 illustrates the evaluation board jumper locations. Table 4 explains the function of each position. Bold fonts in the jumper position column indicate the default settings for use with the FRDM-KL25Z.

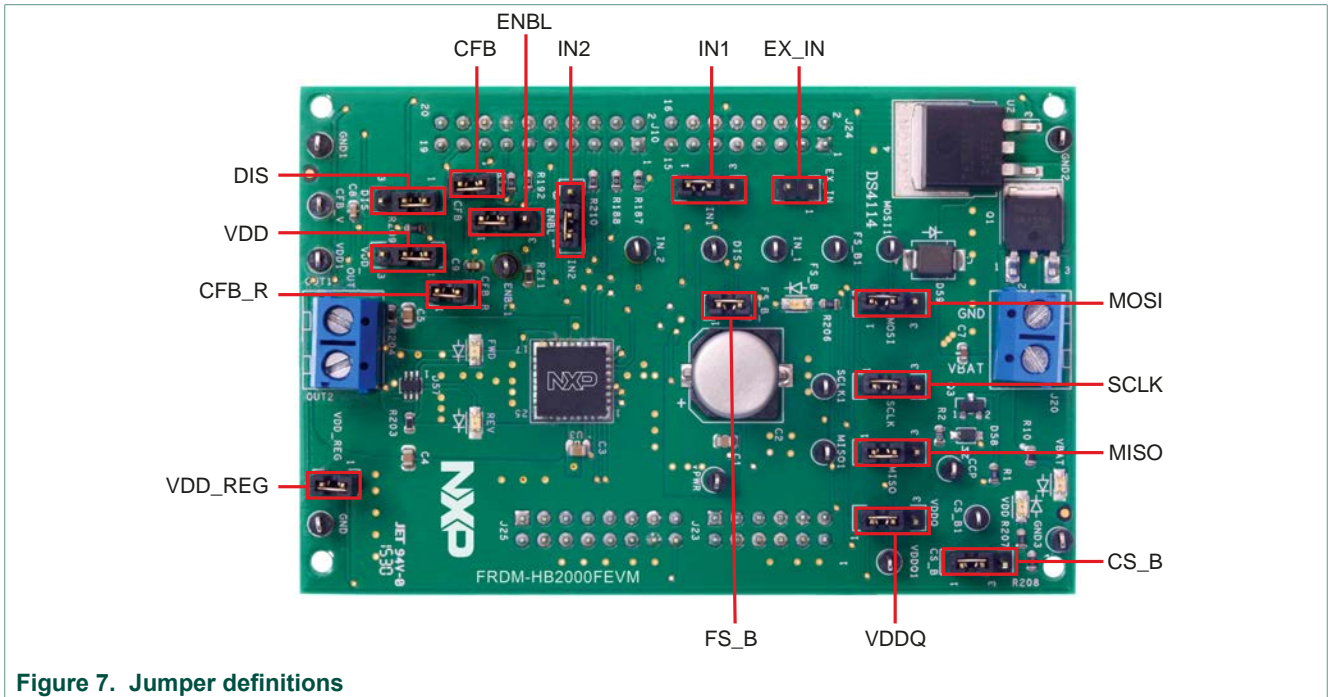


Table 4. Jumper locations

| Name | Signal | Jumper position | Connection  |
|------|--------|-----------------|---|
| J1   | IN1    | <b>1-2</b>      | IN1 control through MCU parallel output on J10 pin 1 (DATA0)  |
|      |        | 2-3             | IN1 control through external input on J15 pin 1               |
| J2   | DIS    | <b>1-2</b>      | DIS control through MCU parallel output on J10 pin 13 (CTRL1) |
|      |        | 2-3             | DIS connected to GND to keep the outputs enabled              |
| J3   | IN2    | <b>1-2</b>      | IN2 control through MCU parallel output on J10 pin 3 (DATA1)  |
|      |        | 2-3             | IN2 control through external input on J15 pin 2               |
| J4   | CS_B   | <b>1-2</b>      | CS_B control through MCU SPI output J10 pin 6 (SPI_CS_B)      |
|      |        | 2-3             | CS_B pulled up to VDD for operation without SPI               |
| J5   | ENBL   | <b>1-2</b>      | ENBL control through MCU parallel output J10 pin 11 (CTRL0)   |
|      |        | 2-3             | ENBL pulled up to VDD to keep the outputs enabled             |
| J6   | SCLK   | <b>1-2</b>      | SPI clock SCLK from MCU J10 pin 12 (SPI_SCLK)                 |
|      |        | 2-3             | SCLK connected to GND for operation without SPI               |
| J7   | MOSI   | <b>1-2</b>      | MOSI control through MCU SPI output J10 pin 8 (SPI_MOSI)      |
|      |        | 2-3             | MOSI connected to GND for operation without SPI               |

| Name | Signal  | Jumper position | Connection  |
|------|---------|-----------------|---|
| J8   | MISO    | 1-2             | MISO control through MCU SPI output J10 pin 10 (SPI_MISO) |
|      |         | 2-3             | MISO not connected for operation without SPI              |
| J11  | CFB     | 1-2             | CFB connected to 200 $\Omega$ resistor                    |
| J14  | VDDQ    | 1-2             | VDD connected to VDDQ                                     |
|      |         | 2-3             | VDDQ not connected  |
| J17  | VDD     | 1-2             | V <sub>DD</sub> supply from regulator U2                  |
|      |         | 2-3             | V <sub>DD</sub> supply from FRDM board                    |
| J18  | CFB_R   | 1-2             | CFB connected to MCU ADC input J10 pin 17 (CFB_READ)      |
| J19  | FS_B    | 1-2             | FS_B connected to the pull-up resistor                    |
| J26  | VDD_REG | 1-2             | V <sub>DD</sub> to FRDM board                             |
| J15  | EX_IN   | open            | IN1 and IN2 external inputs                               |

The FRDM-HB2000ESEVM, with a FRDM-KL25Z board (shipped with the kit), can evaluate the design with a GUI, any MCU with GPIO or with simple lab equipment. A FRDM-KL25Z compatible GUI and MCU program are available online at the following link: <http://www.nxp.com/FRDM-HB2000ESEVM>.

The FRDM-HB2000ESEVM is compatible with any Arduino platform board. However, if a board other than the FRDM-KL25Z is used, MCU code must be written to work with the board.

## 4.7 Input signal definitions

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

**Table 5. Input signal definitions**

| Input name | Description   |
|------------|---|
| DIS        | disable signal to 3-state the outputs                               |
| ENBL       | disable signal to 3-state the output and put the part in Sleep mode |
| IN1        | logic input to control OUT1   |
| IN2        | logic input to control OUT2   |
| MOSI       | master output slave input for the SPI                               |
| CS_B       | chip select bar input for the SPI                                   |
| SCLK       | clock for the SPI   |

## 4.8 Output signal definitions

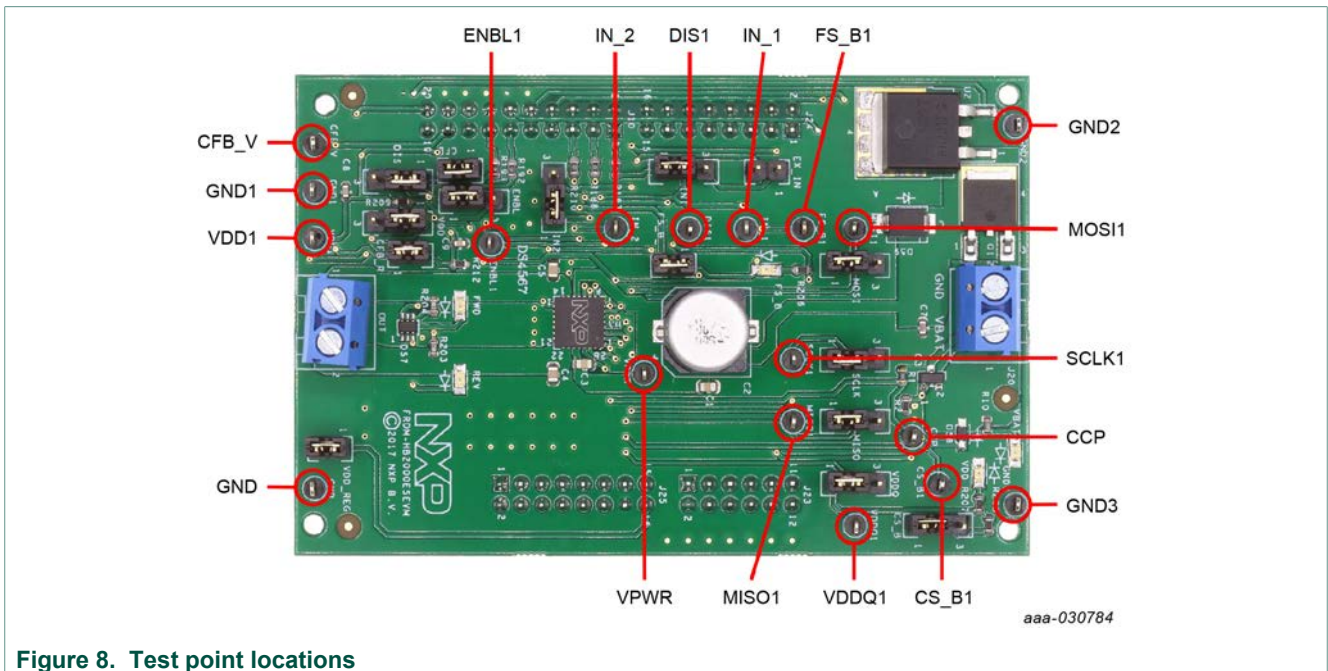
The FRDM-HB2000ESEVM uses the following output signals to drive a load such as a brushed DC motor. The board provides an analog output for real-time load current monitoring. This signal allows closed-loop control of the load.

**Table 6. Output signal definitions**

| Output name | Description   |
|-------------|---|
| OUT1        | output 1 of H-Bridge  |
| OUT2        | output 2 of H-Bridge  |
| FS_B        | open-drain active LOW status flag output to indicate fault  |
| CFB         | current mirror output for real-time load current monitoring |
| MISO        | master input slave output for SPI                           |

### 4.9 Test point definitions

The following test points provide access to various signals to and from the board.



**Figure 8. Test point locations**

**Table 7. Test point definitions**

| Test point name | Signal name | Description  |
|-----------------|-------------|--|
| CFB_V           | CFB_READ    | CFB pin voltage going to ADC   |
| CCP             | CCP         | charge pump voltage  |
| ENBL1           | ENBL        | enable/disable signal to activate/3-state the outputs and put the device to Sleep mode |
| DIS1            | DIS         | enable/disable signal to activate/3-state the outputs                                  |
| IN_1            | IN1         | direction control in H-Bridge mode and OUT1 control in Half-Bridge mode                |
| IN_2            | IN2         | PWM control in H-Bridge mode and OUT2 control in Half-Bridge mode                      |
| VPWR            | VPWR        | system voltage   |
| VDDQ1           | VDDQ        | VDDQ digital output supply voltage   |
| FS_B1           | FSB         | fault status monitoring pin  |
| VDD1            | VDD         | V <sub>DD</sub> supply for the part  |

| Test point name | Signal name | Description                      |
|-----------------|-------------|----------------------------------|
| CS_B1           | CS_B        | chip select bar                  |
| SCLK1           | SCLK        | clock for SPI                    |
| MOSI1           | MOSI        | master output slave input signal |
| MISO1           | MISO        | master input slave output signal |
| GND             | GND         | ground signal                    |
| GND1            | GND         | ground signal                    |
| GND2            | GND         | ground signal                    |
| GND3            | GND         | ground signal                    |

### 4.10 Screw terminal connections

The board has the following screw terminal connections to connect the power supply and the load.

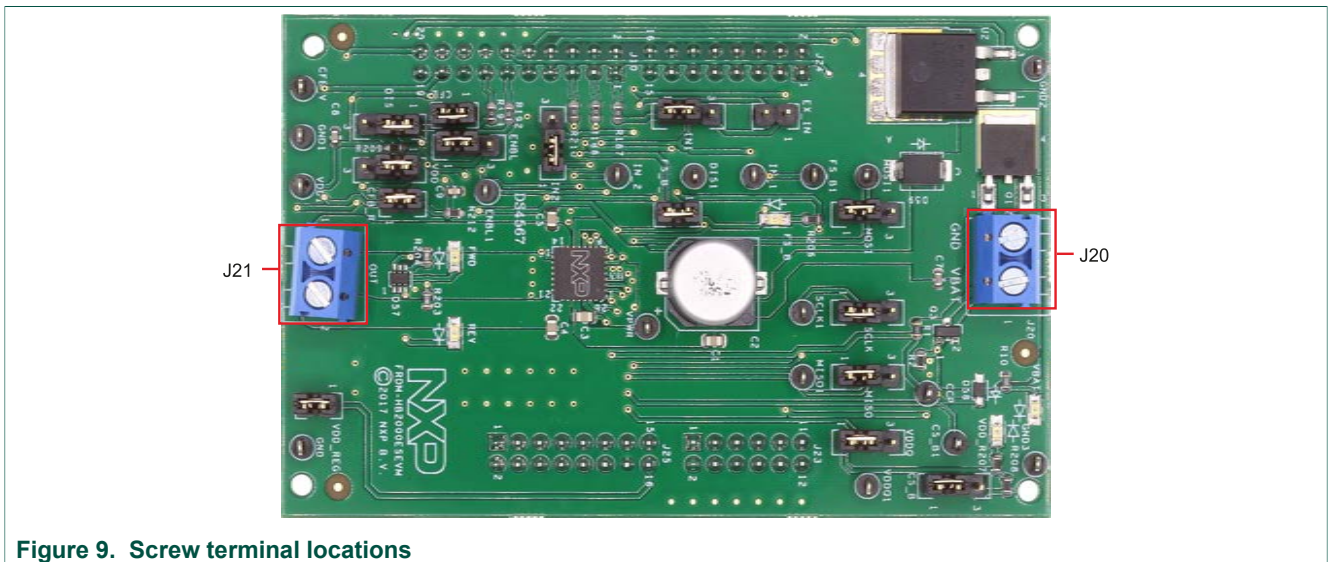


Figure 9. Screw terminal locations

Table 8. Screw terminal connections

| Screw terminal name | Description                               |
|---------------------|---|
| J20                 | power supply connector for the MC33HB2000 |
| J21                 | output connector to connect load          |

## 5 FRDM-KL25Z Freedom SPI dongle

The NXP Freedom development platform is a set of software and hardware tools supporting evaluation and development. It is ideal for rapid prototyping of microcontroller-based applications. The NXP Freedom KL25Z hardware, FRDM-KL25Z, is a simple, yet sophisticated design featuring a Kinetis L series microcontroller, the first microcontroller of the industry built on the arm Cortex-M0+ core.

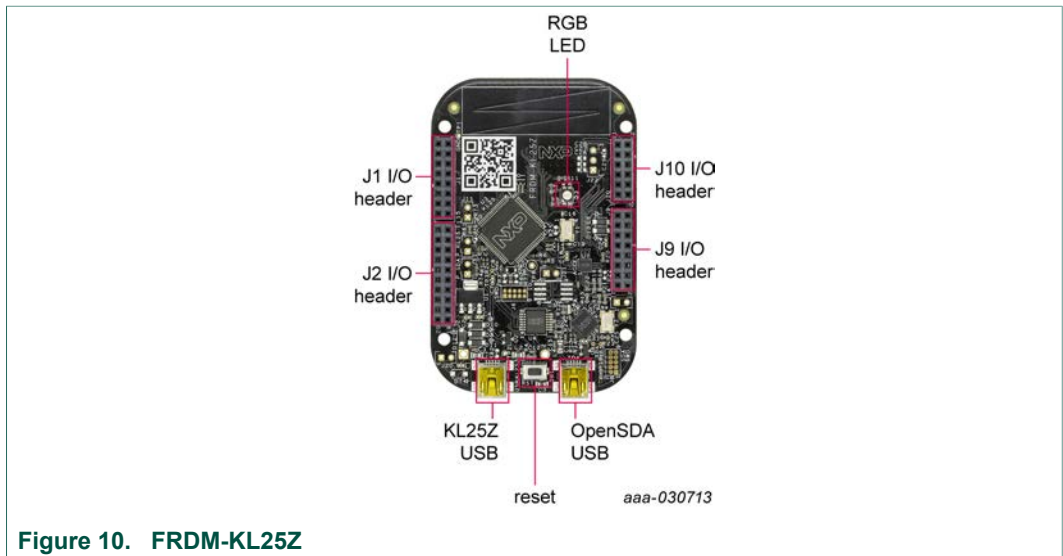


Figure 10. FRDM-KL25Z

## 5.1 Connecting the FRDM-KL25Z to the board

The FRDM-KL25Z evaluation board was chosen specifically to work with the FRDM-HB2000ESEVM kit because of its low cost and features. The FRDM-KL25Z board uses the USB, built-in LEDs, and I/O ports available with NXP's Kinetis KL2x family of microcontrollers.

The FRDM-KL25Z connects to a PC through a USB port, which permits the user to interact with the motor driver per the evaluation board inputs. The FRDM-KL25Z also monitors the SPI registers, by that facilitating the use of safety and advanced diagnostic functions.

The FRDM-HB2000ESEVM connects to the FRDM-KL25Z using the four dual row Arduino R3 connectors on the bottom of the board (see [Table 9](#), [Figure 11](#), and [Figure 12](#)). The board contains GPIO and SPI pin inputs to control and operate a brushed DC motor.

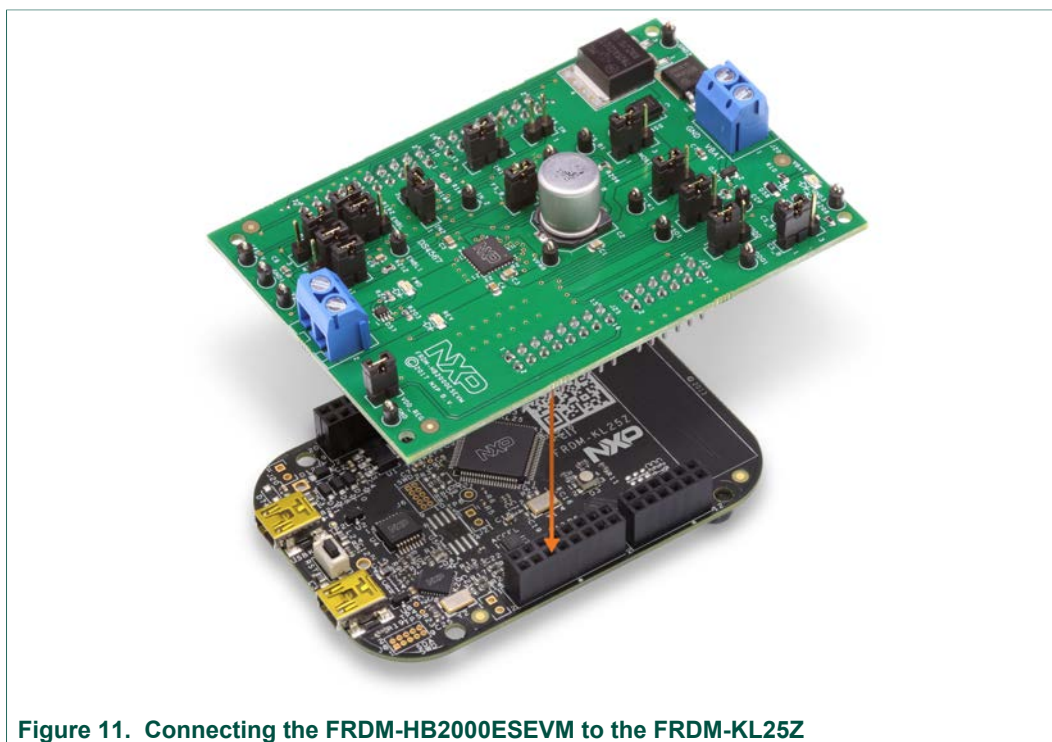


Figure 11. Connecting the FRDM-HB2000ESEVM to the FRDM-KL25Z



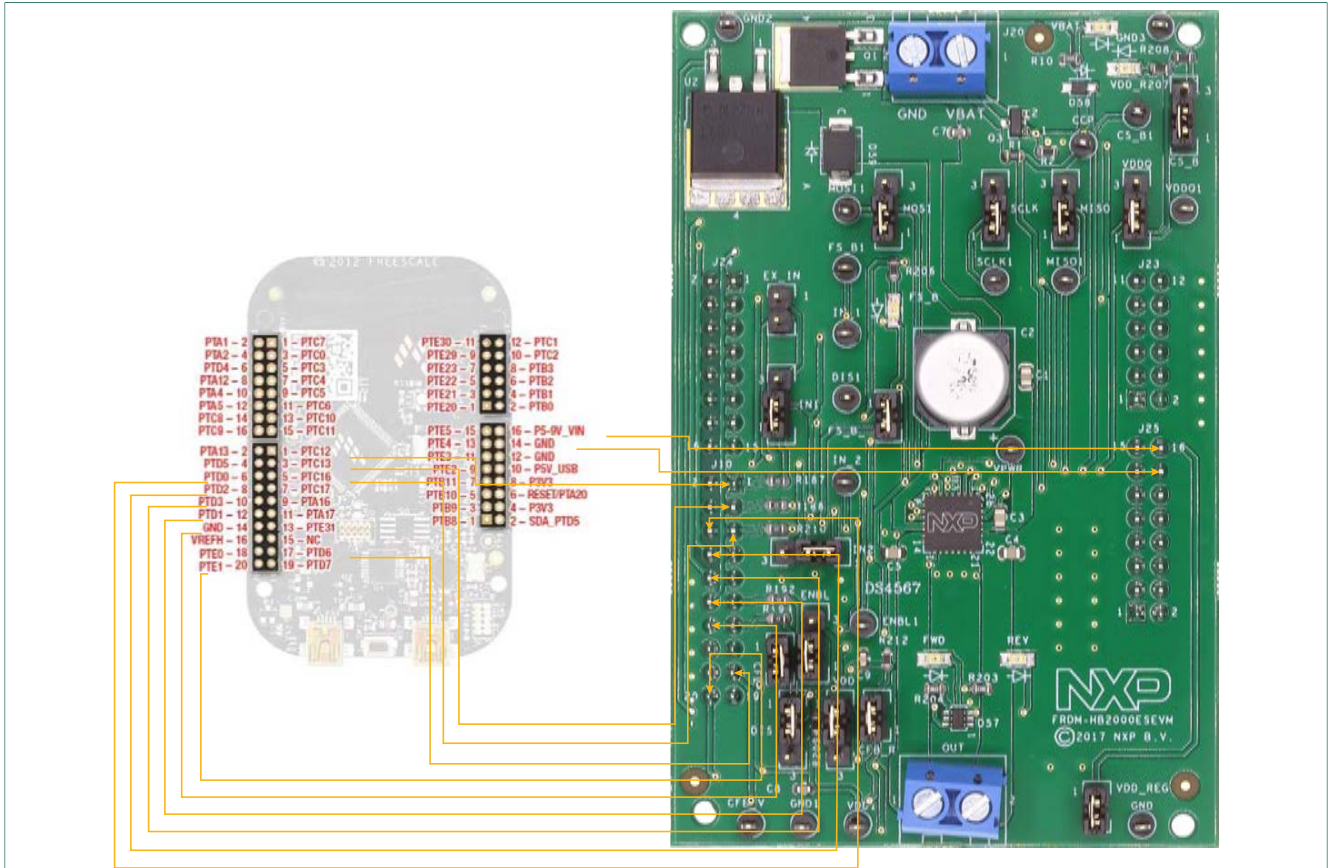


Figure 12. FRDM-KL25Z to FRDM-HB2000ESEVM connections

Table 9. FRDM-HB2000ESEVM to FRDM-KL25Z connections

| FRDM-HB2000ESEVM |     | FRDM-KL25Z |     | Pin hardware name |            | Description   |
|------------------|-----|------------|-----|-------------------|------------|---------------|
| Header           | Pin | Header     | Pin | FRDM-HB2000ESEVM  | FRDM-KL25Z |               |
| J24              | 1   | J1         | 1   | n.c.              | PTC7       | not connected |
| J24              | 2   | J1         | 2   | n.c.              | PTA1       | not connected |
| J24              | 3   | J1         | 3   | n.c.              | PTC0       | not connected |
| J24              | 4   | J1         | 4   | n.c.              | PTA2       | not connected |
| J24              | 5   | J1         | 5   | n.c.              | PTC3       | not connected |
| J24              | 6   | J1         | 6   | n.c.              | PTD4       | not connected |
| J24              | 7   | J1         | 7   | n.c.              | PTC4       | not connected |
| J24              | 8   | J1         | 8   | n.c.              | PTA12      | not connected |
| J24              | 9   | J1         | 9   | n.c.              | PTC5       | not connected |
| J24              | 10  | J1         | 10  | n.c.              | PTA4       | not connected |
| J24              | 11  | J1         | 11  | n.c.              | PTC6       | not connected |
| J24              | 12  | J1         | 12  | n.c.              | PTA5       | not connected |
| J24              | 13  | J1         | 13  | n.c.              | PTC10      | not connected |
| J24              | 14  | J1         | 14  | n.c.              | PTC8       | not connected |


| FRDM-HB2000ESEVM |     | FRDM-KL25Z |     | Pin hardware name |            | Description  |
|------------------|-----|------------|-----|-------------------|------------|--|
| Header           | Pin | Header     | Pin | FRDM-HB2000ESEVM  | FRDM-KL25Z |  |
| J24              | 15  | J1         | 15  | n.c.              | PTC11      | not connected  |
| J24              | 16  | J1         | 16  | n.c.              | PTC9       | not connected  |
| J10              | 1   | J2         | 1   | DATA0/IN1         | PTC12      | IN1 signal for the H-Bridge  |
| J10              | 2   | J2         | 2   | n.c.              | PTA13      | not connected  |
| J10              | 3   | J2         | 3   | DATA1/IN2         | PTC13      | IN2 signal for the H-Bridge  |
| J10              | 4   | J2         | 4   | n.c.              | PTD5       | not connected  |
| J10              | 5   | J2         | 5   | FS_B              | PTC16      | fault status pin to report fault   |
| J10              | 6   | J2         | 6   | CS_B              | PTD0       | chip select bar pin  |
| J10              | 7   | J2         | 7   | n.c.              | PTC17      | not connected  |
| J10              | 8   | J2         | 8   | MOSI              | PTD2       | master output serial input   |
| J10              | 9   | J2         | 9   | n.c.              | PTA16      | not connected  |
| J10              | 10  | J2         | 10  | MISO              | PTD3       | master input serial output   |
| J10              | 11  | J2         | 11  | n.c.              | PTA17      | not connected  |
| J10              | 12  | J2         | 12  | SCLK              | PTD1       | clock for SPI  |
| J10              | 13  | J2         | 13  | n.c.              | PTE31      | not connected  |
| J10              | 14  | J2         | 14  | GND               | GND        | not connected  |
| J10              | 15  | J2         | 15  | n.c.              | n.c.       | not connected  |
| J10              | 16  | J2         | 16  | n.c.              | VREFH      | not connected  |
| J10              | 17  | J2         | 17  | CFB_READ          | PTD6       | ADC input for monitoring the CFB pin   |
| J10              | 18  | J2         | 18  | n.c.              | PTE0       | disable signal to 3-state the output and put the part in Sleep mode (active LOW) |
| J10              | 19  | J2         | 19  | n.c.              | PTD7       | not connected  |
| J10              | 20  | J2         | 20  | FRDM_VDD          | PTE1       | not connected  |
| J23              | 1   | J10        | 1   | n.c.              | PTE20      | not connected  |
| J23              | 2   | J10        | 2   | n.c.              | PTB0       | not connected  |
| J23              | 3   | J10        | 3   | n.c.              | PTE21      | not connected  |
| J23              | 4   | J10        | 4   | n.c.              | PTB1       | not connected  |
| J23              | 5   | J10        | 5   | n.c.              | PTE22      | not connected  |
| J23              | 6   | J10        | 6   | n.c.              | PTB2       | not connected  |
| J23              | 7   | J10        | 7   | n.c.              | PTE23      | not connected  |
| J23              | 8   | J10        | 8   | n.c.              | PTB3       | not connected  |
| J23              | 9   | J10        | 9   | n.c.              | PTE29      | not connected  |
| J23              | 10  | J10        | 10  | n.c.              | PTC2       | not connected  |
| J23              | 11  | J10        | 11  | n.c.              | PTE30      | not connected  |
| J23              | 12  | J10        | 12  | n.c.              | PTC1       | not connected  |

| FRDM-HB2000ESEVM |     | FRDM-KL25Z |     | Pin hardware name |             | Description   |
|------------------|-----|------------|-----|-------------------|-------------|---|
| Header           | Pin | Header     | Pin | FRDM-HB2000ESEVM  | FRDM-KL25Z  |   |
| J25              | 1   | J9         | 1   | n.c.              | PTB8        | not connected   |
| J25              | 2   | J9         | 2   | n.c.              | SDA_PTD5    | not connected   |
| J25              | 3   | J9         | 3   | n.c.              | PTB9        | not connected   |
| J25              | 4   | J9         | 4   | n.c.              | P3V3        | not connected   |
| J25              | 5   | J9         | 5   | n.c.              | PTB10       | not connected   |
| J25              | 6   | J9         | 6   | n.c.              | RESET/PTA20 | not connected   |
| J25              | 7   | J9         | 7   | n.c.              | PTB11       | not connected   |
| J25              | 8   | J9         | 8   | n.c.              | P3V3        | not connected   |
| J25              | 9   | J9         | 9   | n.c.              | PTE2        | not connected   |
| J25              | 10  | J9         | 10  | n.c.              | P5V_USB     | not connected   |
| J25              | 11  | J9         | 11  | n.c.              | PTE3        | not connected   |
| J25              | 12  | J9         | 12  | GND               | GND         | ground  |
| J25              | 13  | J9         | 13  | n.c.              | PTE4        | not connected   |
| J25              | 14  | J9         | 14  | GND               | GND         | not connected   |
| J25              | 15  | J9         | 15  | n.c.              | PTE5        | not connected   |
| J25              | 16  | J9         | 16  | VDD_REG           | P5-9V_VIN   | 5.0 V logic input to FRDM-KL25Z board from FRDM-HB2000ESEVM |

## 6 Installing the software and setting up the hardware

### 6.1 Configuring the hardware

The FRDM-HB2000ESEVM consists of an H-Bridge, a parallel and SPI interface, power conditioning circuitry and a FRDM-KL25Z board. The board can be configured for use with a FRDM-KL25Z board or a function generator.

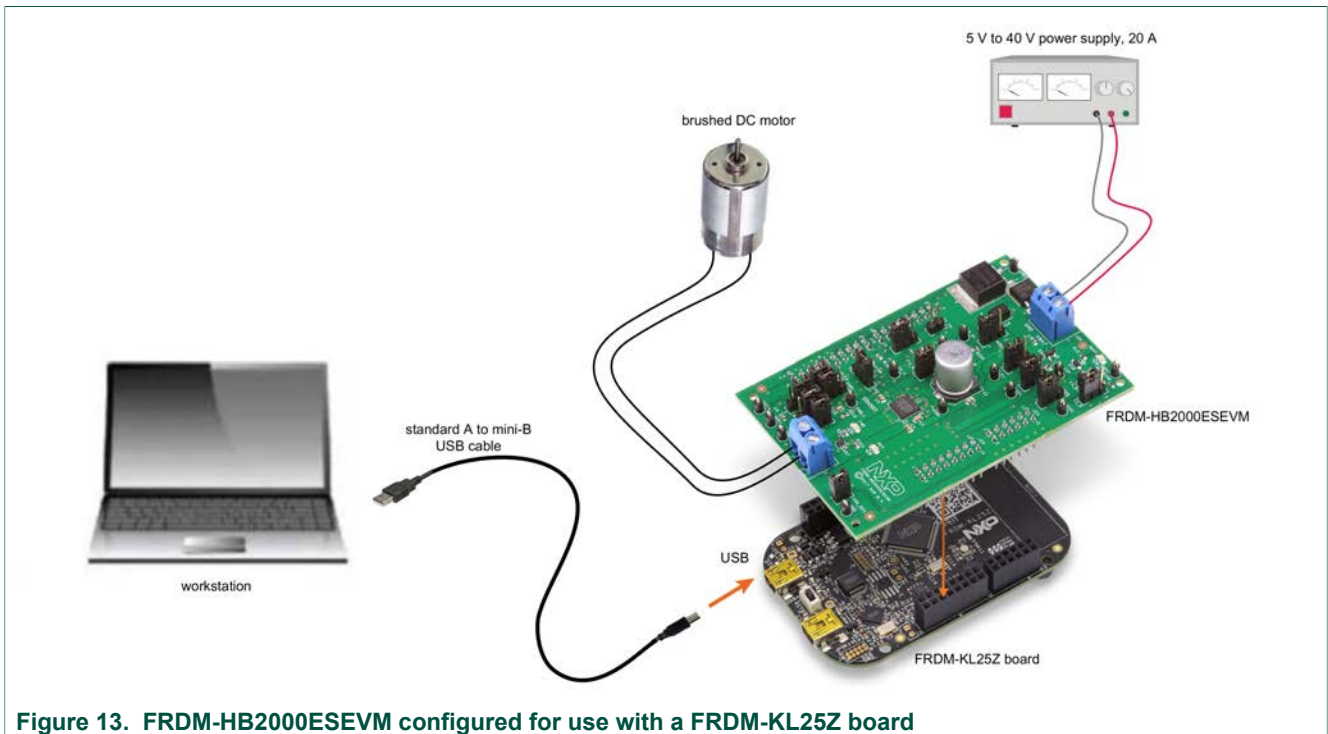
|   |  |
|---|--|
|  | <b>Caution</b>   |
|   | <p>When using the FRDM-HB2000ESEVM, make sure that the maximum motor supply voltage (VPWR) stays within the 5.0 V to 40 V range. Operating outside this range may cause damage to the board.</p> |

#### 6.1.1 Step-by-step instructions for setting up the hardware for use with a FRDM-KL25Z

To configure the FRDM-HB2000ESEVM for use with the FRDM-KL25Z do the following:

1. Connect the FRDM-HB2000ESEVM to the FRDM-KL25Z using the Arduino connectors on each board.
2. Connect the USB cable (not supplied with the kit) between the PC and the KL25Z USB port on the FRDM-KL25Z board.
3. With the power switched off, attach the DC power supply to the VBAT and GND screw connector terminal (J20) on the evaluation board.
4. Connect the load to the screw terminal (J21).

[Figure 13](#) illustrates the hardware configuration using a FRDM-KL25Z.



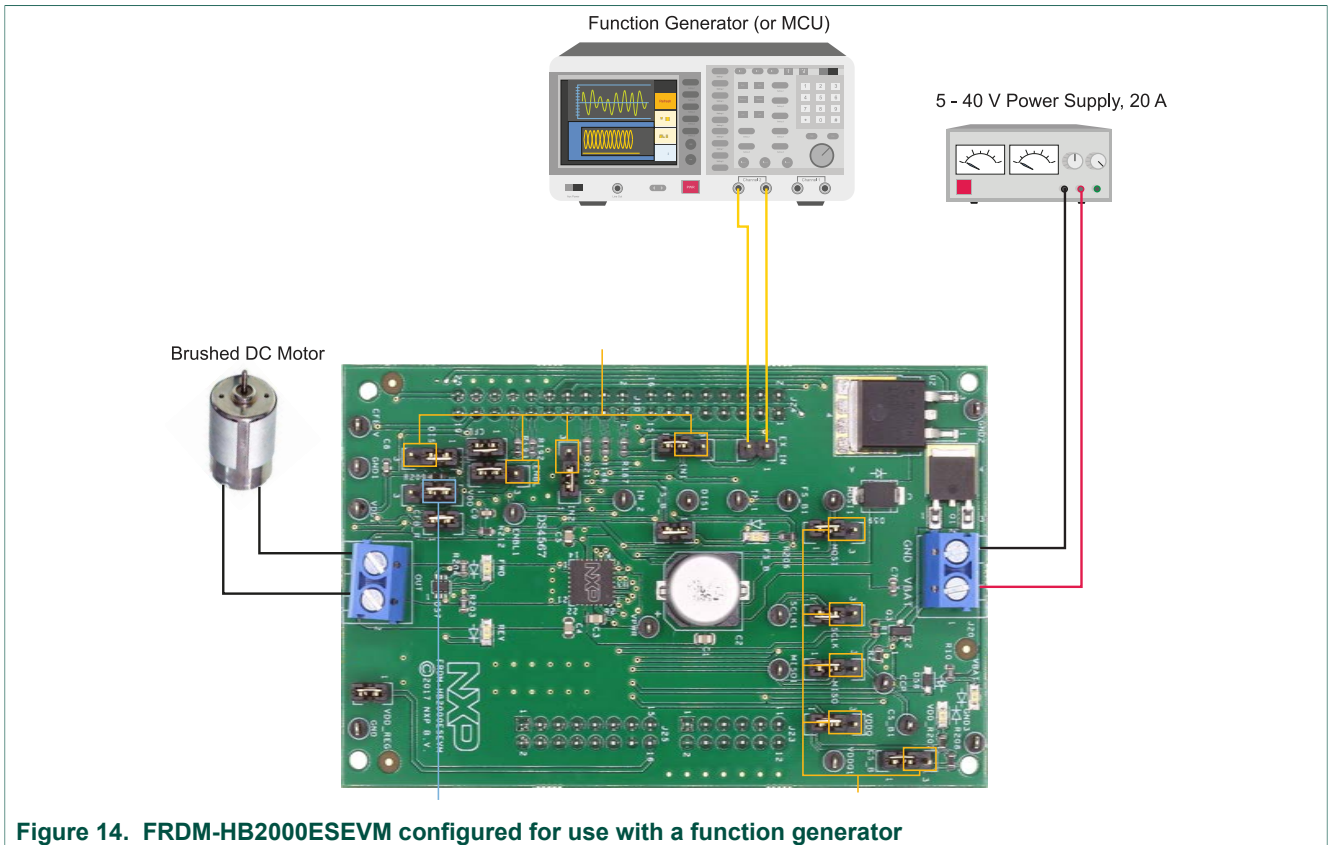
**Figure 13. FRDM-HB2000ESEVM configured for use with a FRDM-KL25Z board**

**6.1.2 Step-by-step instructions for setting up the hardware for use with a function generator**

This section describes how to configure the FRDM-HB2000ESEVM for use with a function generator. The same connections apply if the board is connected to a microcontroller instead of a function generator. To configure the board for use in a specific environment, see [Section 4.4](#), [Section 7](#), and the MC33HB2000 data sheet.

1. Connect the function generator to the EX\_IN jumper, with one channel attached to each pin.
2. Change the board jumper connections, as shown in [Figure 14](#).
3. With the power switched off, attach the DC power supply to the VBAT and GND screw connector terminal (J20) on the evaluation board.
4. Connect the load to the screw terminal (J21).

[Figure 14](#) illustrates the hardware configuration.



**Figure 14. FRDM-HB2000ESEVM configured for use with a function generator**

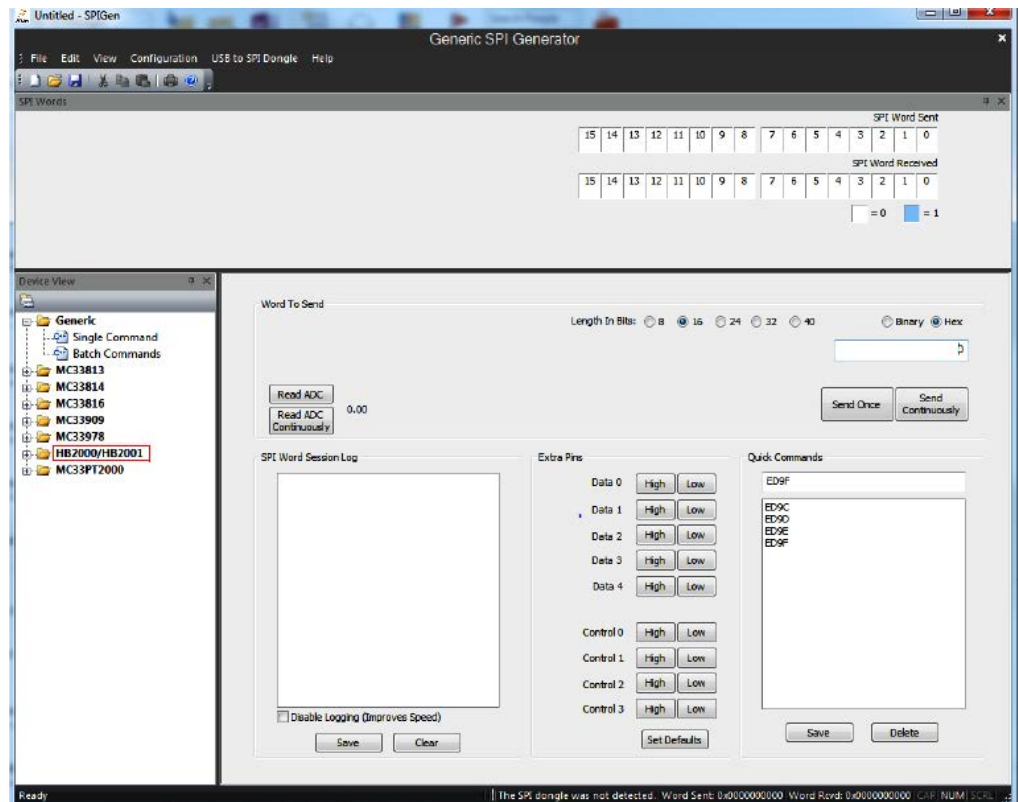
**6.2 Installing and using SPIGen**

The latest version of SPIGen supports the MC33HB2000 and is designed to run on any Windows 10, Windows 8, Windows 7, Vista, or XP-based operating system. To install the software, do the following:

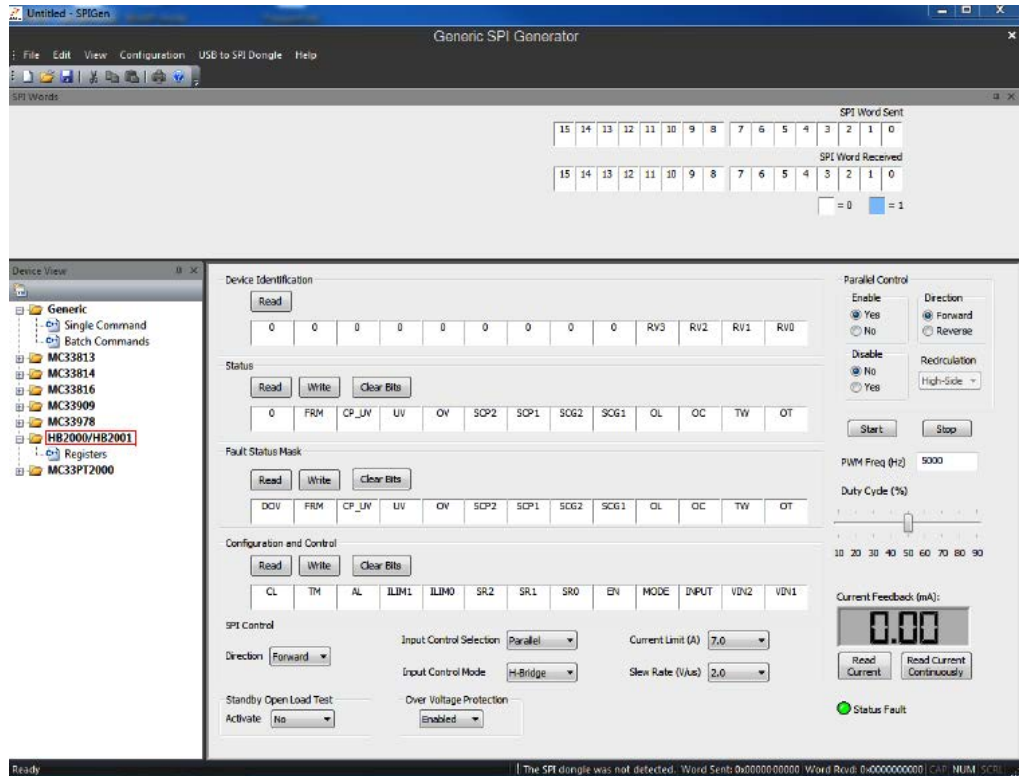
1. Go to [www.nxp.com/SPIGen](http://www.nxp.com/SPIGen) and click **Download**.
2. When the SPIGEN: SPI Generator (SPIGen) Software page appears, go to the **Lab and Test Software** section and click **Download** associated with the description of the selected environment. A wizard guides the user through the process.
3. If instructed for the SPIGen wizard to create a shortcut, a SPIGen icon appears on the desktop. By default, the SPIGen executable file is installed at **C:\Program Files\SPIGen**.

Installing the device drivers overwrites any previous SPIGen installation and replaces it with a current version containing the MC33HB2000 drivers. However, configuration files (.spi) from the previous version remain intact.

4. Launch SPIGen. The HB2000/HB2001 device appears in the **Device View** panel.

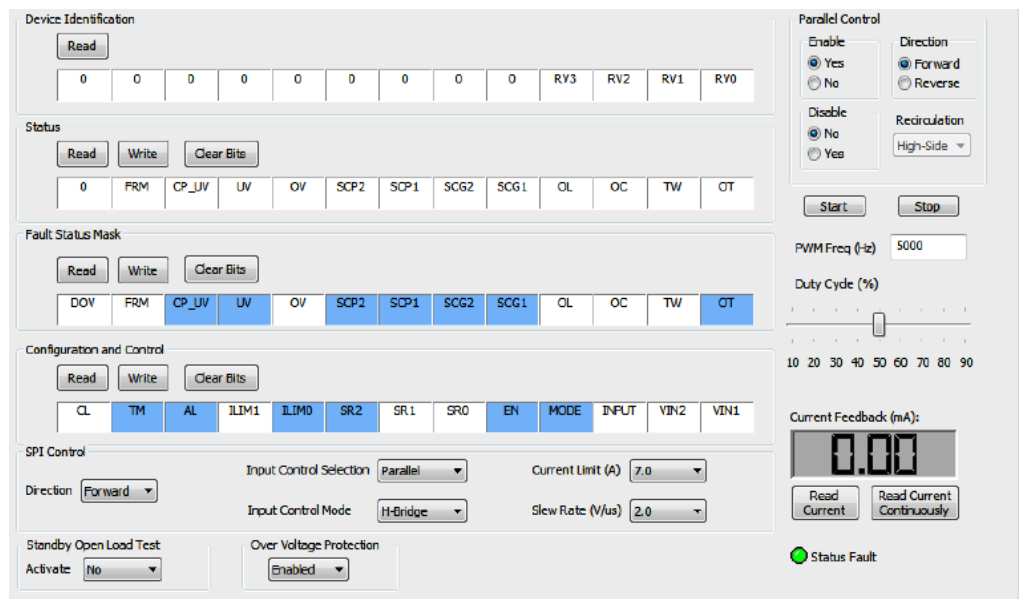


5. To access the HB2000/HB2001 tab in the SPIGen window, expand the HB2000/HB2001 folder in the Device View. Then click **Registers** icon.

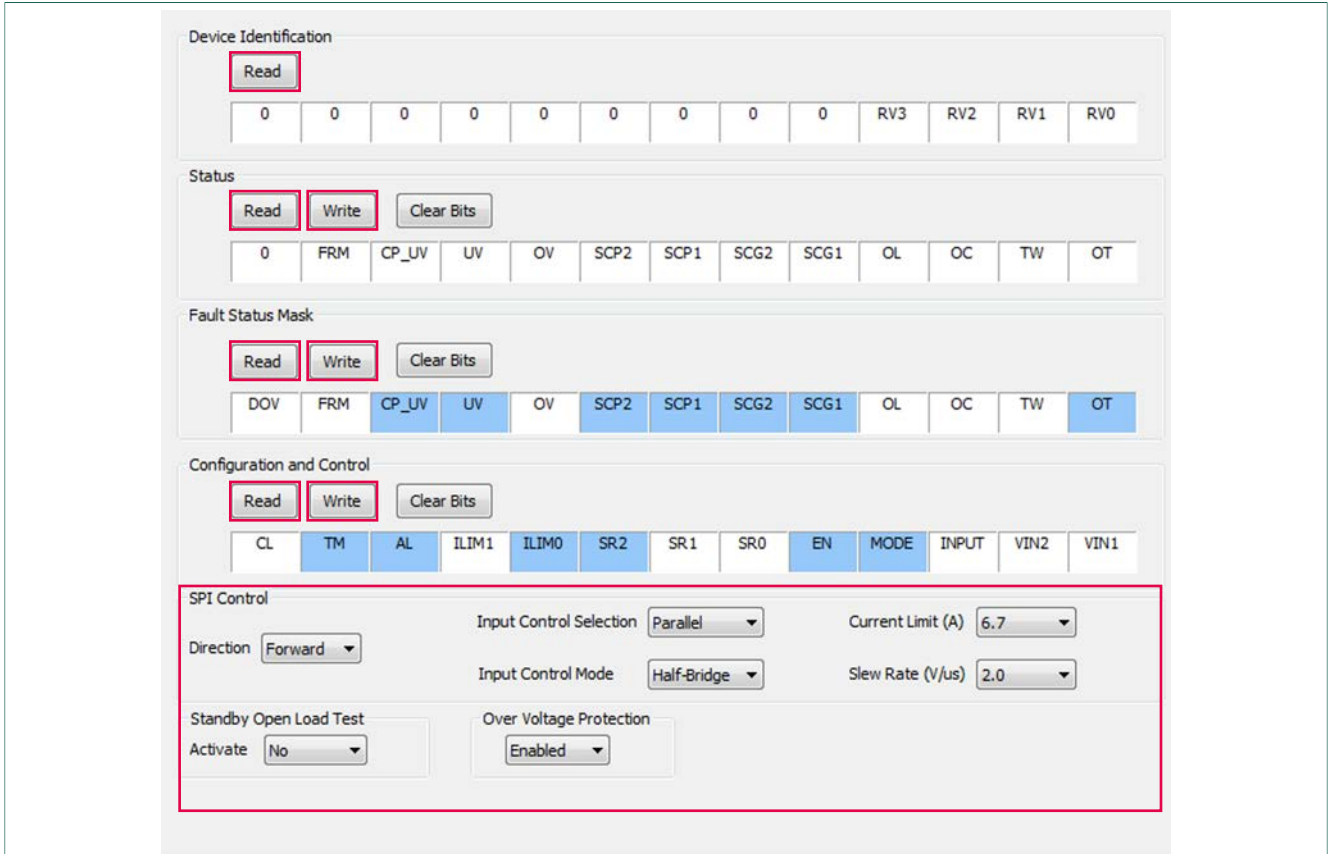


If the pre-programmed code on FRDM-KL25Z is accidentally erased, download "UsbSpiDongleKL25Z\_HB2000\_HB2001\_v512.srec" from the following link: [www.nxp.com/Usb-Spi-Dongle-firmware-KL25Z-HB2000-1](http://www.nxp.com/Usb-Spi-Dongle-firmware-KL25Z-HB2000-1). The .srec file is a configuration file for the FRDM-KL25Z MCU kit (to be uploaded via the OpenSDA port), containing the KL25Z pin definitions, SPI/PWM generation code, and mapping to interface with the HB2000ESEVB.

6. Reading all the SPI Registers displays the following default status.



**6.2.1 SPI control**



**Figure 15. SPI control description**

**Table 10. SPI control description**

| Name        | Description  |
|-------------|--|
| Read        | To read the content of each register, click the read button on top of each register.   |
| Write       | Click individual bits of any register and then press the corresponding write button to write into the register.  |
| SPI control | This section is designed for ease of use. Each dropdown menu sets or resets appropriate bits in the registers for a selected configuration. However, after configuration selection, press the write button of the corresponding register to be able to configure the part. |



## 6.2.2 Parallel control

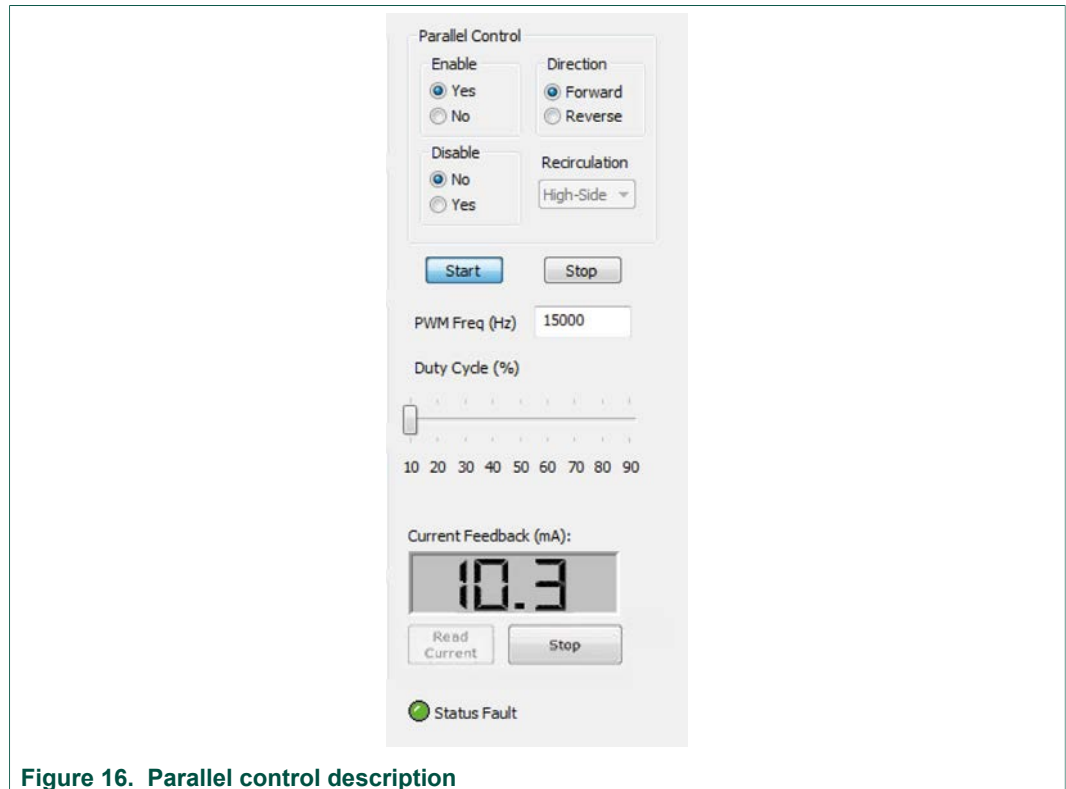


Figure 16. Parallel control description

### Direction:

- **Forward:** Current flowing through OUT1 to OUT2
- **Reverse:** Current flowing through OUT2 to OUT1

### Recirculation:

- **High-side:** Freewheel-High (both high-side FETs turned on) during PWMing
- **Low-side:** Freewheel-Low (both low-side FETs turned on) during PWMing (only valid for Half-Bridge mode)

### ENBL:

- **Yes:** ENBL is logic HIGH, the H-Bridge is operational
- **No:** ENBL is logic LOW, the H-Bridge outputs are 3-stated and placed in Sleep mode

### DIS:

- **Yes:** DIS is logic HIGH, both OUT1 and OUT2 are 3-stated
- **No:** DIS is logic LOW, both OUT1 and OUT2 are enabled

### PWM Freq:

- Enter PWM frequency up to 20000 Hz

### Duty Cycle:

- Select PWM duty cycle from 10 % to 90 %

### Start:

- After selection of parallel control configuration, press **Start** to activate the outputs

**Stop:**

- Press **Stop** to deactivate the outputs

**Current Feedback:**

- Shows current through the high-side FET using the current recopy feature as interpreted by the KL25Z microcontrollers ADC

**Status Fault:**

- Shows any fault condition in Sleep mode

**Table 11. Logic behind direction control with high-side versus low-side recirculation**

| Direction                     | Recirculation           | Input signal (INx) generated                            |
|-------------------------------|-------------------------|---|
| Half-Bridge mode (MODE = 0)   |                         |   |
| Forward                       | high-side recirculation | IN1 = 1   |
|                               |                         | IN2 = PWM signal with selected duty cycle and frequency |
| Reverse                       | high-side recirculation | IN1 = PWM signal with selected duty cycle and frequency |
|                               |                         | IN2 = 1   |
| Forward                       | low-side recirculation  | IN1 = PWM signal with selected duty cycle and frequency |
|                               |                         | IN2 = 0   |
| Reverse                       | low-side recirculation  | IN1 = 0   |
|                               |                         | IN2 = PWM signal with selected duty cycle and frequency |
| Full H-Bridge mode (MODE = 1) |                         |   |
| Forward                       | high-side recirculation | IN1 = 1   |
|                               |                         | IN2 = PWM signal with selected duty cycle and frequency |
| Reverse                       | high-side recirculation | IN1 = 0   |
|                               |                         | IN2 = PWM signal with selected duty cycle and frequency |

## 7 Schematic

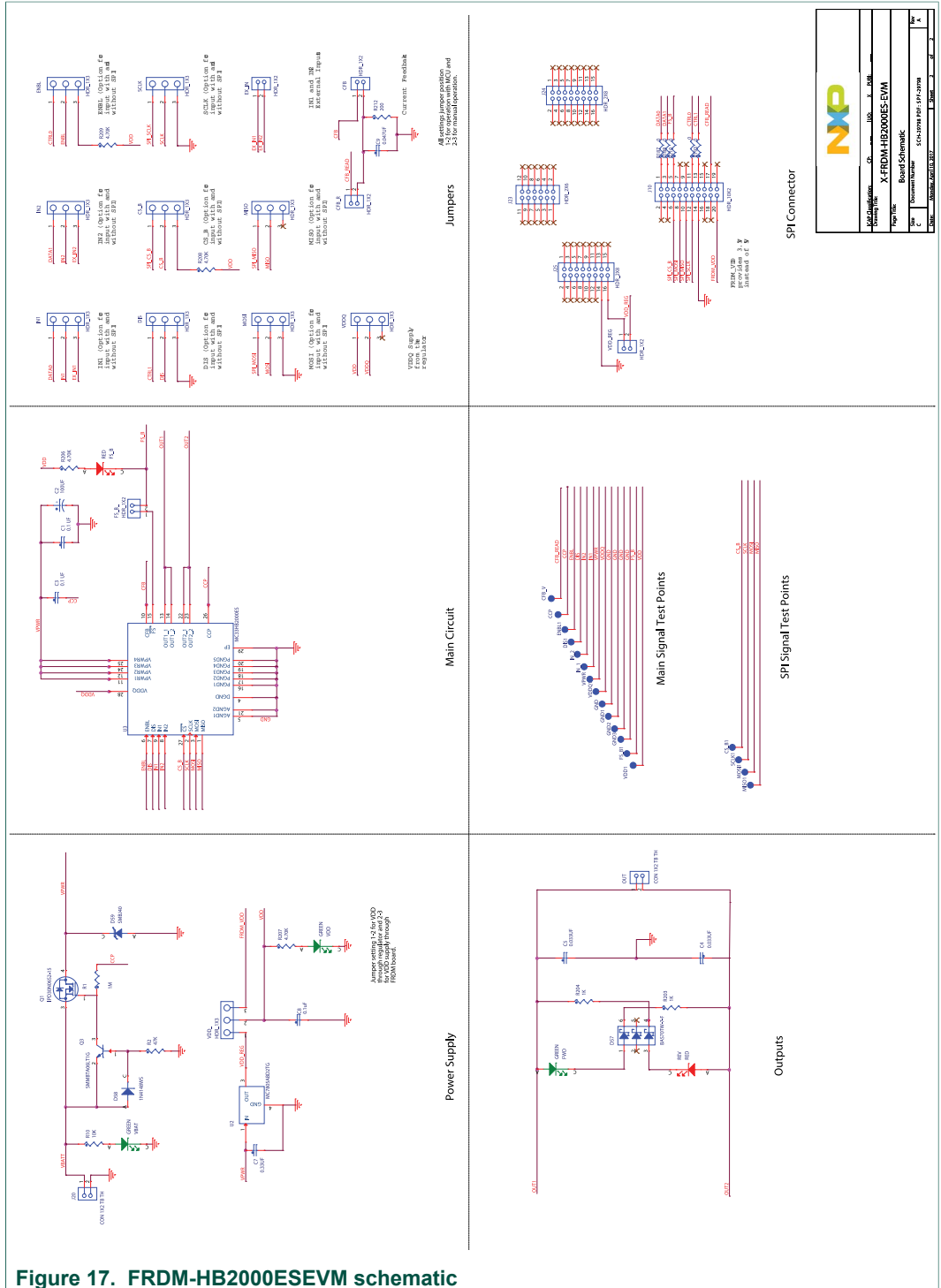


Figure 17. FRDM-HB2000ESEVM schematic

## 8 Board layout

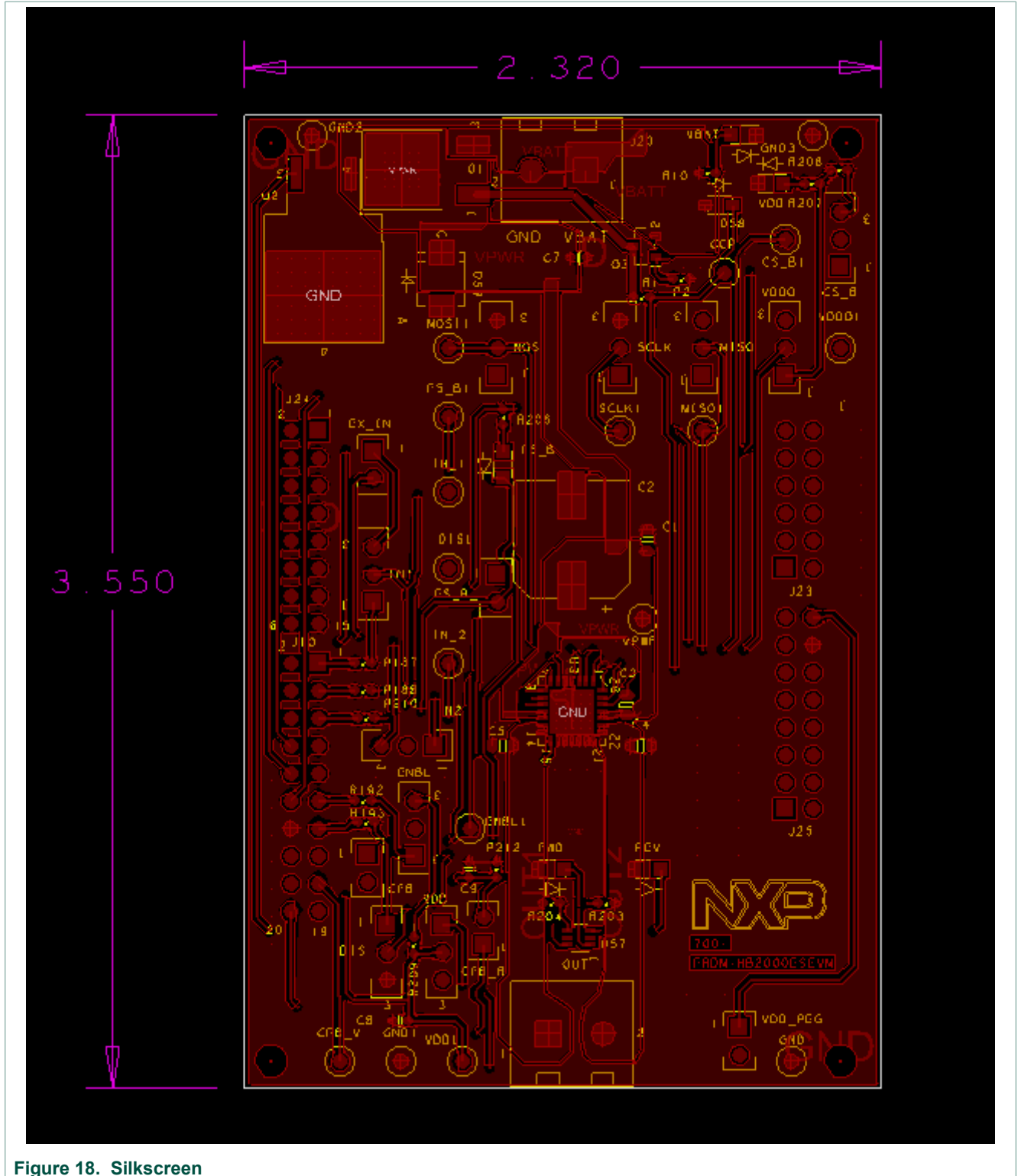


Figure 18. Silkscreen

## 9 Bill of materials

Table 12. Bill of materials

| Item                             | Qty | Schematic label              | Value    | Description  | Part number         | Assy opt |
|----------------------------------|-----|------------------------------|----------|--|---------------------|----------|
| Active components <sup>[1]</sup> |     |                              |          |  |                     |          |
| 1                                | 1   | U1                           |          | IC DRV H-BRIDGE MOTOR 3.0 A 5.0 V to 28 V HVQFN28 – NXP    | HB2000ES            | [2]      |
| 2                                | 1   | U2                           |          | IC VREG 5.0 V 1.0 A 5.0 V to 18 V D2PAK – ON Semiconductor | MC7805ABD2TG        | [2]      |
| Diodes <sup>[1]</sup>            |     |                              |          |  |                     |          |
| 3                                | 1   | D2                           | 24 V     | DIODE TVS UNIDIR 600 W 24 V AEC-Q101 SMB                   | SMBJ24AHE3/52       |          |
| 4                                | 1   | D57                          | 70 V     | DIODE SCH TRIPLE 70 mA 70 V 200 mW SOT363                  | BAS70TW-7-F         |          |
| 5                                | 1   | D58                          | 75 V     | DIODE SW 150 mA 75 V SOD323                                | 1N4148WS-7-F        |          |
| 6                                | 2   | D59, D64                     | 25 mA    | LED RED SGL 25 mA 0805                                     | 598-8110-107F       |          |
| 7                                | 3   | D60, D61, D63                | 25 mA    | LED GRN SGL 25 mA 0805                                     | 598-8170-107F       |          |
| Capacitors <sup>[1]</sup>        |     |                              |          |  |                     |          |
| 8                                | 2   | C1, C13                      | 0.1 µF   | CAP CER 0.1 µF 50 V 10 % X7R 0805                          | C0805C104K5RAC      |          |
| 9                                | 1   | C2                           | 100 µF   | CAP ALEL 100 µF 50 V 20 % AEC-Q200 RADIAL SMT              | MAL214699104E3      |          |
| 10                               | 2   | C4, C5                       | 0.033 µF | CAP CER 0.033 µF 50 V 10 % X7R 0805                        | 08055C333KAT2A      |          |
| 11                               | 1   | C7                           | 0.33 µF  | CAP CER 0.33 µF 50 V 10 % X7R 0603                         | C1608X7R1H334K080AC |          |
| 12                               | 1   | C8                           | 0.1 µF   | CAP CER 0.1 µF 16 V 10 % X7R AEC-Q200 0603                 | GCM188R71C104KA37D  |          |
| 13                               | 1   | C9                           | 0.047 µF | CAP CER 0.047 µF 25 V 10 % X7R 0603                        | C0603X7R250-473KNE  |          |
| Resistors <sup>[1]</sup>         |     |                              |          |  |                     |          |
| 14                               | 1   | R1                           | 1.0 MΩ   | RES 1 MΩ 1/4 W 1 % AEC-Q200 0603                           | CRCW06031M00FKEAHP  |          |
| 15                               | 1   | R2                           | 47 kΩ    | RES MF 47 kΩ 1/10 W 1.0 % AEC-Q200 0603                    | CRCW060347K0FKEA    |          |
| 16                               | 1   | R10                          | 10 kΩ    | RES MF 10 kΩ 1/10 W 5 % AEC-Q200 0603                      | ERJ-3GEYJ103V       |          |
| 17                               | 5   | R187, R188, R192, R193, R210 | 0 Ω      | RES MF 0 Ω 1/10 W 0603                                     | CRCW06030000Z0EA    |          |
| 18                               | 1   | R212                         | 200 Ω    | RES MF 200 Ω 1/10 W 1 % 0603                               | RK73H1JT2D2000F     |          |
| 19                               | 2   | R203, R204                   | 1.0 kΩ   | RES MF 1.0 kΩ 1/10 W 1 % 0603                              | AR03FTNX1001        |          |
| 20                               | 4   | R206, R207, R208, R209       | 4.70 kΩ  | RES MF 4.70 kΩ 1/10 W 1 % 0603                             | RK73H1JT2D4701F     |          |

| Item  | Qty | Schematic label   | Value | Description                                   | Part number        | Assy opt |
|---|-----|---|-------|---|--------------------|----------|
| Switches, connectors, jumpers, and test points <sup>[1]</sup> |     |   |       |   |                    |          |
| 21  | 18  | IN1, GND1, IN2, GND2, GND3, VPWR, VDDQ, VDD, SCLK, MOSI, MISO, GND, FS_B, ENBL, DIS, CS_B, CFB_V, CCP |       | TEST POINT BLACK 40 MIL DRILL 180 MIL TH 109L | 5001               |          |
| 22  | 10  | J1, J2, J3, J4, J5, J6, J7, J8, J14, J17  |       | HDR 1X3 TH 100 MIL SP 374H AU                 | 826629-3           |          |
| 23  | 1   | J10   |       | HDR 2X10 TH 100 MIL CTR 330H AU 100L          | TSW-110-07-S-D     |          |
| 24  | 5   | J11, J15, J18, J19, J26   |       | HDR 1X2 TH 100 MIL SP 378H AU 130L            | 826629-2           |          |
| 25  | 2   | J20, J21  |       | CON 1X2 TB TH 5.08 MM 543H SN 138L            | 20020316-H021B01LF |          |
| 26  | 1   | J23   |       | HDR 2X6 TH 100 MIL CTR 330H AU                | TSW-106-07-S-D     |          |
| 27  | 2   | J24, J25  |       | HDR 2X8 TH 100 MIL CTR 330H AU                | TSW-108-07-G-D     |          |
| 28  | 1   | Q1  |       | TRAN NMOS PWR 30 A 55 V AEC-Q101 TO252        | IPD30N06S2-15      |          |
| 29  | 1   | Q3  |       | TRAN NPN DRIVER 500 mA 80 V AEC-Q101 SOT23    | SMMBTA06LT1G       |          |

[1] NXP does not assume liability, endorse, or warrant components from external manufacturers are referenced in circuit drawings or tables. While NXP offers component recommendations in this configuration, it is the responsibility of the customer to validate their application.

[2] Critical components. For critical components, it is vital to use the manufacturer listed.

## 10 Accessory item bill of materials

Table 13. Accessory item bill of materials

| Item | Qty | Part Number               | Description  |
|------|-----|---------------------------|--|
| 1    | 1   | FRDM-KL25Z <sup>[1]</sup> | NXP Freedom development platform for Kinetis KL14, KL15, KL24, KL25 MCUs |

[1] NXP does not assume liability, endorse, or warrant components from external manufacturers are referenced in circuit drawings or tables. While NXP offers component recommendations in this configuration, it is the responsibility of the customer to validate their application.

## 11 References

Following are URLs where you can obtain information on related NXP products and application solutions:

| Support page     | Description            | URL   |
|------------------|------------------------|---|
| FRDM-HB2000ESEVM | tool summary page      | <a href="http://www.nxp.com/FRDM-HB2000ESEVM">http://www.nxp.com/FRDM-HB2000ESEVM</a> |
| MC33HB2000       | product summary page   | <a href="http://www.nxp.com/HB2000">http://www.nxp.com/HB2000</a>                     |
| FRDM-KL25Z       | tool summary page      | <a href="http://www.nxp.com/FRDM-KL25Z">http://www.nxp.com/FRDM-KL25Z</a>             |
| SPIGen           | SPI generator software | <a href="http://www.nxp.com/SPIGEN">http://www.nxp.com/SPIGEN</a>                     |

## 12 Revision history

| Rev | Date     | Description  |
|-----|----------|--|
| 2   | 20180611 | <ul style="list-style-type: none"> <li>• <a href="#">Table 2</a>: updated MC33HB2000ES part number and package description</li> <li>• <a href="#">Table 3</a>: updated naming and reflect current direction</li> <li>• <a href="#">Table 7</a>: correct test point name</li> <li>• <a href="#">Table 9</a>: updated, reflect EVB name</li> <li>• <a href="#">Figure 13</a>: updated, reflect EVB name</li> <li>• <a href="#">Table 11</a>: changed layout for readability</li> <li>• <a href="#">Table 12</a>: updated, reflect board layout and part numbers</li> </ul> |
| 1.0 | 9/2017   | initial release  |

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