# **KTFRDMHB2001FEVMUG** FRDM-HB2001FEVM evaluation board Rev. 1.0 – 25 May 2016

User guide

# 1 FRDM-HB2001FEVM





FRDM-HB2001FEVM evaluation board

### 2 Important notice

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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-theshelf 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 Getting started

### 3.1 Kit contents/packing list

The FRDM-HB2001FEVM contents includes:

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

### 3.2 Jump start

NXP's 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 ICs and system-in-package devices that use proven high-volume SMARTMOS 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.

- 1. Go to <u>www.nxp.com/FRDM-HB2001FEVM</u>.
- 2. Review your Tools Summary Page.
- 3. Locate and click:

# Jump Start Your Design

4. Download the documents, software and other information.

Once the files are downloaded, review the user guide in the bundle. The user guide includes setup instructions, BOM and schematics. Jump start bundles are available on each tool summary page with the most relevant and current information. The information includes everything needed for design.

### 3.3 Required equipment

This kit requires the following items:

- 3/16" 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 SPI communication (included in KIT)
- SPIGen software (for using FRDM-KL25Z based SPI Dongle)

### 3.4 System requirements

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

· USB enabled computer with Windows XP or newer

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### 4 Getting to know the hardware

### 4.1 Board overview

The FRDM-HB2001FEVM evaluation kit exercises all the functions of the MC33HB2001 H-Bridge device. The parallel input can be easily controlled by lab equipment or any MCU with GPIOs.

The board can be used in conjunction with a FRDM-KL25Z board connected to a PC's USB port. Configure, control and monitor the status of MC33HB2001 by using the board's SPI communication capabilities.

### 4.2 Board features

The FRDM-HB2001FEVM board evaluates the NXP part MC33HB2001, including all functions. The board features the following:

- Built-in reverse battery protection
- Test points allows probing its signals
- · Built-in voltage regulator to supply logic level circuitry
- · 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

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### 4.3 Block diagram

### 4.3.1 Device features

This evaluation board features the following NXP product:

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#### Table 1. Device features

Device	Description	Features
Device MC33HB2001	Description The 33HB2001 is a monolithic H-Bridge Power IC, enhanced with SPI configurability and diagnostic capabilities.	<ul> <li>Features</li> <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 EMI and thermal performance optimization</li> <li>Four selectable current limits via the SPI: 5.4/7.0/8.8/10.7 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> </ul>
		<ul> <li>Wide operating range: 5.0 V to 28 V operation</li> <li>Low R<sub>DS(on)</sub> integrated MOSFETs: Maximum of 125</li> </ul>
		<ul> <li>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</li> </ul>
		<ul> <li>I/0 pins can withstand up to 36 V</li> </ul>

### 4.3.2 Modes of operation



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### 4.3.4 Thermal management

### 4.4 Board description

Figure 5 describes the main elements on the FRDM-HB2001FEVM.

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#### Table 2. Board description

Number	Name	Descrioption
1	MC33HB2001	Monolithic H-Bridge Power IC in a robust thermally enhanced 32 lead PQFN 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 MC33HB2001 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 MC33HB2001 output

### 4.4.1 LED display

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

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#### Table 3. LED locations

	T
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 current flowing in forward direction
REV	Red LED, indicates current flowing in reverse direction

### 4.4.2 Jumper definitions

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

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#### Table 4. Jumper locations

Name	Signal	Jumper position	Connection
14	1014	1-2	IN1 control through MCU parallel output on J10 Pin 1 (DATA0)
JI		2-3	IN1 control through MCU parallel output on J10 Pin 1 (DATA0)
12	פוס	1-2	DIS control through MCU parallel output on J10 Pin 13 (CTRL1)
JZ	DIS	2-3	DIS connected to GND to keep the outputs enabled
12	IND	1-2	IN2 control through MCU parallel output on J10 Pin 3 (DATA1)
13	J3 IN2		IN2 control through external input on J15 Pin 2
И		1-2	CS_B control through MCU SPI output J10 Pin 6 (SPI_CS_B)
54	С3_В	2-3	CS_B pulled up to VDD for operation without SPI
15		1-2	ENBL control through MCU parallel output J10 Pin 11 (CTRL0)
JO ENBL	2-3	ENBL pulled up to VDD to keep the outputs enabled	
16	SCI K	1-2	SPI clock SCLK from MCU J10 Pin 12 (SPI_SCLK)
<b>J</b> 0	SULK	2-3	SCLK connected to GND for operation without SPI
17	MOSI	1-2	MOSI control through MCU SPI output J10 Pin 8 (SPI_MOSI)
57	MOSI	2-3	MOSI connected to GND for operation without SPI
10	MISO	1-2	MISO control through MCU SPI output J10 Pin 10 (SPI_MISO)
90	WISO	2-3	MISO not connected for operation without SPI
J11	CFB	1-2	CFB connected to 200 $\Omega$ resistor

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Name	Signal	Jumper position	Connection
114	νρρο	1–2	VDD connected to VDDQ
514	VDDQ	2-3	VDDQ not connected
J17 VDD	חחע	1-2	V <sub>DD</sub> supply from regulator U2
	VDD	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-HB2001FEVM, in conjunction with a FRDM-KL25Z board (shipped with the kit), can evaluate the design by means of 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: <u>http://www.nxp.com/FRDM-HB2001FEVM</u>.

The FRDM-HB2001FEVM is compatible with any Arduino<sup>™</sup> platform board. However, if a board other than the FRDM-KL25Z is used, MCU code must be written to work with the board.

### 4.4.3 Input signal definitions

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

Table	5.	Input	signal	definitions
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Input name	Description
DIS	Disable signal to tri-state the outputs
ENBL	Disable signal to tri-state the output and put the part in Sleep mode
IN1	Logic input to control OUT1
IN2	Logic input to control OUT2
MOSI	Master out slave input for the SPI
CS_B	Chip select bar input for the SPI
SCLK	Clock for the SPI

### 4.4.4 Output signal definitions

The FRDM-HB2001-FEVM 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. Out	tput signal	definitions
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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	

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Output name	Description
CFB	Current mirror output for real time load current monitoring
MISO	Master input slave output for SPI

### 4.4.5 Test point definitions

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



#### Table 7. Test point definitions

Test point name	Signal name	Description
CFB_V	CFB_READ	CFB pin voltage going to ADC
ССР	ССР	Charge pump voltage
ENBL1	ENBL	Enable/disable signal to activate/tri- state the outputs and put the device to Sleep mode
DIS1	DIS	Enable/disable signal to activate/tri- 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

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Test point name	Signal name	Description
FSB1	FSB	Fault status monitoring pin
VDD1	VDD	$V_{DD}$ supply for the part
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

### 4.4.6 Screw terminal connections

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



Screw terminal name	Description
J20	Power supply connector for the MC33HB2001
J21	Output connector to connect load

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### 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 microcontrollerbased applications. The NXP Freedom KL25Z hardware, FRDM-KL25Z, is a simple, yet sophisticated design featuring a Kinetis L Series microcontroller, the industry's first microcontroller built on the ARM<sup>®</sup> Cortex<sup>™</sup>-M0+ core.



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### 5.1 Connecting the FRDM-KL25Z to the board

The FRDM-KL25Z evaluation board was chosen specifically to work with the FRDM-HB2001FEVM kit because of its low cost and features. The FRDM-KL25Z board makes use of 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 control a DC brushed motor and to drive the evaluation board inputs in order to operate the motor via the GPIOs and SPI pins. The FRDM-KL25Z also monitors the SPI registers, thereby facilitating the use of safety and advanced diagnostic functions.

The FRDM-HB2001FEVM connects to the FRDM-KL25Z using the four dual row Arduino<sup>TM</sup> R3 connectors on the bottom of the board (see <u>Table 9</u>, <u>Figure 11</u> and <u>Figure 12</u>).



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#### Figure 12. FRDM-KL25Z to FRDM-HB2001FEVM connections

#### Table 9. FRDM-HB2001FEVM to FRDM-KL25Z connections

FRDM-HB2001FEVM		FRDM-I	KL25Z	Pin hardwa	Description	
Header	Pin	Header	Pin	FRDM-HB2001FEVM	FRDM-KL25Z	Description
J24	1	J1	1	N/C	PTC7	No Connection
J24	2	J1	2	N/C	PTA1	No Connection
J24	3	J1	3	N/C	PTC0	No Connection
J24	4	J1	4	N/C	PTA2	No Connection
J24	5	J1	5	N/C	PTC3	No Connection
J24	6	J1	6	N/C	PTD4	No Connection
J24	7	J1	7	N/C	PTC4	No Connection
J24	8	J1	8	N/C	PTA12	No Connection
J24	9	J1	9	N/C	PTC5	No Connection
J24	10	J1	10	N/C	PTA4	No Connection
J24	11	J1	11	N/C	PTC6	No Connection
J24	12	J1	12	N/C	PTA5	No Connection

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### FRDM-HB2001FEVM evaluation board

FRDM-HB	FRDM-HB2001FEVM		KL25Z	Pin hardwa	Description		
Header	Pin	Header	Pin	FRDM-HB2001FEVM	FRDM-KL25Z	Description	
J24	13	J1	13	N/C	PTC10	Not Connected	
J24	14	J1	14	N/C	PTC8	No Connection	
J24	15	J1	15	N/C	PTC11	Not Connected	
J24	16	J1	16	N/C	PTC9	C9 No Connection	
J10	1	J2	1	DATA0/IN1	PTC12	IN1 signal for the H- Bridge	
J10	2	J2	2	N/C	PTA13	No Connection	
J10	3	J2	3	DATA1/IN2	PTC13	IN2 signal for the H- Bridge	
J10	4	J2	4	N/C	PTD5	No Connection	
J10	5	J2	5	FS_B	PTC16	Fault status pin to report fault	
J10	6	J2	6	CS_B	CS_B PTD0		
J10	7	J2	7	N/C	PTC17	No Connection	
J10	8	J2	8	MOSI	PTD2	Master output serial input	
J10	9	J2	9	N/C	PTA16	No Connection	
J10	10	J2	10	MISO	PTD3	Master input serial output	
J10	11	J2	11	N/C	PTA17	No Connection	
J10	12	J2	12	SCLK	PTD1	Clock for SPI	
J10	13	J2	13	N/C	PTE31	No Connection	
J10	14	J2	14	GND	GND	No Connection	
J10	15	J2	15	N/C	N/C	No Connection	
J10	16	J2	16	N/C	VREFH	No Connection	
J10	17	J2	17	CFB_READ	PTD6	ADC input for monitoring the CFB pin	
J10	18	J2	18	N/C	PTE0	Disable signal to tri- state the output and put the part in Sleep mode (Active Low)	
J10	19	J2	19	N/C	PTD7	No Connection	
J10	20	J2	20	FRDM_VDD	PTE1	No Connection	
J23	1	J10	1	N/C	PTE20	No Connection	
J23	2	J10	2	N/C	PTB0	No Connection	
J23	3	J10	3	N/C	PTE21	No Connection	
J23	4	J10	4	N/C	PTB1	No Connection	
J23	5	J10	5	N/C	PTE22	No Connection	
J23	6	J10	6	N/C	PTB2	No Connection	
J23	7	J10	7	N/C	PTE23	No Connection	
J23	8	J10	8	N/C	PTB3	No Connection	
J23	9	J10	9	N/C	PTE29	No Connection	
J23	10	J10	10	N/C	PTC2	No Connection	
J23	11	J10	11	N/C	PTE30	No Connection	
J23	12	J10	12	N/C	PTC1	No Connection	
J25	1	J9	1	N/C	PTB8	No Connection	
J25	2	J9	2	N/C	SDA_PTD5	No Connection	
J25	3	J9	3	N/C	PTB9	No Connection	

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FRDM-HB2001FEVM		FRDM-I	KL25Z	Pin hardwa	Description	
Header	Pin	Header	Pin	FRDM-HB2001FEVM	FRDM-KL25Z	Description
J25	4	J9	4	N/C	P3V3	No Connection
J25	5	J9	5	N/C	PTB10	No Connection
J25	6	J9	6	N/C	RESET/PTA20	No Connection
J25	7	J9	7	N/C	PTB11	No Connection
J25	8	J9	8	N/C	P3V3	No Connection
J25	9	J9	9	N/C	PTE2	No Connection
J25	10	J9	10	N/C	P5V_USB	No Connection
J25	11	J9	11	N/C	PTE3	No Connection
J25	12	J9	12	GND	GND	Ground
J25	13	J9	13	N/C	PTE4	No Connection
J25	14	J9	14	GND	GND	No Connection
J25	15	J9	15	N/C	PTE5	No Connection
J25	16	9C	16	VDD_REG	P5-9V_VIN	5.0 V logic input to FRDM-KL25Z board from FRDM- HB2001FEVM

### 6 Installing the software and setting up the hardware

### 6.1 Configuring the hardware

The FRDM-HB2001FEVM consists of an H-Bridge, a parallel and SPI interface, power conditioning circuitry and an FRDM-KL25Z board. The board can be configured for use in conjunction with a FRDM-KL25Z board or a function generator.



#### Caution

When using the FRDM-HB2001FEVM, 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.

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

To configure the FRDM-HB2001FEVM for use with the FRDM-KL25Z do the following:

- 1. Connect the FRDM-HB2001FEVM to the FRDM-KL25Z using the Arduino<sup>™</sup> 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.

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# 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-HB2001FEVM for use with a function generator. The same connections apply if the board is connected to a microcontroller instead of a function generator. See the board description (<u>Section 4.4 "Board</u> <u>description"</u>), the schematic (<u>Section 7 "Schematic"</u>) and the MC33HB2001 datasheet, to configure the board for use in a specific environment.

- 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.

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### 6.2 Installing and using SPIGen

The latest version of SPIGen supports the MC33HB2001 and is designed to run on any Windows 8, Windows 7, Vista, or XP-based operating system. To install the software, do the following:

- 1. Go to <u>www.nxp.com/SPIGen</u> and click **Download**.
- 2. When the SPIGEN: SPI Generator (SPIGen) Software page appears, go to the **Device Drivers** 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 MC33HB2001 drivers. However, configuration files (.spi) from the previous version remain intact.

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

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	Generic	SPI Generator	
e Edit View Configuration	USB to SPI Dongle Help		
Vords			
		15 14 13 12 11 1	SPL Word Sent 10 9 8 7 6 5 4 3 2 1 0
			SPI Ward Received
		15 14 13 12 11 1	10 9 8 7 6 5 4 3 2 1 0
			= 0 = 1
Generk	Word To Send	Length în <del>Billa</del> : 🔿 a 🔘 1	16 🖗 24 💮 32 🔿 40 💮 Binary 🖲 Hex
- All Single Command			<b>N</b>
- 🖼 Batch Commands			5 <b>1</b>
MC33813			
MC33813 MC33814 MC33814 MC33816	Read ADC Read ADC 0.00		Send Once Send Continuously
	Read ADC Read ADC Continuously		Send Once Continuously
-91 Batch Commands 7 MC33613 9 MC33614 7 MC33616 9 MC33909 7 MC33978 9 HB2000/HB2001 9 MC33P72000	Read AOC Read AOC Continuoudy SPI Word Session Log	Extra Pine	Send Once Send Continuously Quick Commands
••••••••••••••••••••••••••••••••••••	Read ADC Read ADC Carifixuaudy SPE Word Session Log	Extra Pres Data 0 High Lo	Send Once Send Continuously Quick Commands ED9F
••••••••••••••••••••••••••••••••••••	Read ADC Read ADC Confinuaudy SPT Word Section Log	Extre Pres Data 0 High Loo , Data 1 High Loo	Quick Commands ED9F BD9C BD9C BD9C
••••••••••••••••••••••••••••••••••••	Read ADC Confinuaudy SPT Word Session Log	Extra Pins Data 0 High Loo , Data 1 High Loo Data 2 High Loo	Quick Commands Quick Commands ED9F ED9E ED9E ED9E ED9E ED9E ED9E ED9E
<ul> <li>Elch Commands</li> <li>MC3813</li> <li>MC3814</li> <li>MC3816</li> <li>MC3909</li> <li>MC33978</li> <li>HB2000/HB2001</li> <li>MC33PT2000</li> </ul>	Read ACC Read ACC Confinencial SPT Word Session Log	Extra Pins Data 0 High Lo Data 1 High Lo Data 2 High Lo Data 3 High Lo	Quick Commands Quick Commands ED96 ED96 ED96 ED96 ED96 ED96 ED96 ED96
<ul> <li>Bitch Commands</li> <li>MC3813</li> <li>MC3814</li> <li>MC3816</li> <li>MC3809</li> <li>MC3978</li> <li>HB2000/HB2001</li> <li>MC39712000</li> </ul>	Read ACC Read ACC Confinencial SPT Word Session Log	Extra Pins Data 0 High Lo Data 1 High Lo Data 2 High Lo Data 3 High Lo Data 4 High Lo	Quick Commands ED9F B700 B700 B700 B700 B700 B700 B700 B70
••••••••••••••••••••••••••••••••••••	Read ACC Read ACC Confinemely SPT Word Session Log	Extra Pins Data 0 Figh Lo Data 1 High Lo Data 2 High Lo Data 4 High Lo Control 0 High Lo	Quick Commands ED9F BD9C BD9C BD9E BD9E BD9E BD9E BD9E BD9E BD9E BD9E
● Back Commands ● MG3813 ■ MG3814 ■ MG3816 ■ MG3909 ■ MG3978 ■ HB2000/H82001 ■ MG3972000	Read ACC Read ACC Confinemely SPT Word Session Log	Extra Pins Data 0 Figh Lo Data 1 Hgh Lo Data 2 Hgh Lo Data 3 Figh Lo Data 4 Hgh Lo Control 0 Hgh Lo Control 1 Hgh Lo	Quick Commands ED9F BD0 BD0 BD0 BD0 BD0 BD0 BD0 BD0
••••••••••••••••••••••••••••••••••••	Read ACC Read ACC Confinually SPT Word Session Log	Extra Pins Data 0 Figh Lo Oata 1 Hgh Lo Oata 2 Hgh Lo Data 4 Hgh Lo Control 0 Hgh Lo Control 0 Hgh Lo Control 1 Figh Lo	Quick Commands  Quick Commands  ED9F  ED9C ED9C ED9F  Proce ED9F
••••••••••••••••••••••••••••••••••••	Read ADC       0.00         Deartificationally       0.00         SPI Word Session Log       Image: Comparison Log         Disable Logging (Improves Speed)       Improves Speed)	Extra Pins Data 0 Figh Loo Data 1 High Loo Data 1 High Loo Data 4 High Loo Control 0 High Loo Control 1 Figh Loo Control 1 High Loo Control 3 High Loo	Send Once Send Continuously Dark Commands ED9F ED9E ED9E ED9E ED9E ED9E ED9E ED9E

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

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🔏 Untitled - SPIGen		= 🗆 X								
:File Edit View Configuration U	Generic SPI Generator USE to SPI Dongle Help	×								
SPI Words	CT Mark Court	a x								
	SPI Word Sent									
	SPI Word Received									
	15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0									
	= 0 = 1									
Device View 0 ×										
2	Device Identification Parallel Control	Direction								
🔁 🦢 Generic	Read @ Yes	Forward								
- Single Command	0 0 0 0 0 0 0 0 0 RV3 RV2 RV1 RV0 ON0	C Revense								
m - MC33813	Disable	Rediroulation								
👜 🔤 MC33814	Status @ No	High-Side x								
H	Read Write Clear Bits © Yes	(ingrised)								
E MC33909	0 FRM CP_UV UV OV SCP2 SCP1 SCG2 SCG1 OL OC TW OT	(								
HB2000/HB2001	Start									
- 😁 Registers	Fault Status Mask PWM Freg (Hz)									
E - MC33P12000	Read Write Clear Bits									
	Duty Cyde (%)									
		2010 St. 101 1								
	Configuration and Control									
	Read Write Clear Bits									
	CL TM AL ILIM1 ILIM0 SR2 SR1 SR0 EN MODE DAPUT VIN2 VIN1									
	Current Peedao	t (mA):								
	991 Cantrol									
	Direction Research v									
	Input Control Mode H-Bridge  Slew Rate (Vius) 2.0  Current C	Continuously								
	Stanthu Open Load Test Over Initiane Protection									
	Activate No T Enabled T									
Ready	The SPI dongle was not detected. Word Sent: 0x000000000 Word Royd: 0x00000000	00 CAR NUM SCRUM								

If the pre-programmed code on FRDM-KL25Z is accidentally erased, download "UsbSpiDongleKL25Z\_SPIDrive\_v512.srec" from the following link: <u>www.nxp.com/Usb-Spi-Dongle-firmware-KL25Z-HB2000-1</u>.

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

Device Identification	Parallel Control
Read	Enable Direction
0 0 0 0 0 0 0 0 0 0 RY3 RV2 RV1 RY0	Yes     Yes     Forward     No     Reverse
Status	Disable Recirculation
Read         Write         Clear bite           0         FRM         CP_UV         UV         OV         SCP2         SCP1         SCG2         SCG1         OL         OC         TW         OT	Start Stop
Fault Status Mask	PWM Freq (Hz) 5000
Read Write Clear Bits	Duty Cyde (%)
DOV FRM CP_UV UV OV SCP2 SCP1 SCG2 SCG1 OL OC TW OT	
Configuration and Control Read Write Clear Bits	10 20 30 40 50 60 70 80 90
CL TM AL 1LIM1 1LIM0 SR2 SR1 SR0 EN MODE INFUT VIN2 VIN1	Current Feedback (mA):
SPI Control	8.88
Direction Forward  Input Control Mode H-Bridge  Slew Rate (V/us) 2.0	Read Current Current Continuously
Standby Open Load Test Over Voltage Protection Activate No	O Status Fault

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### 6.2.1 SPI control

	0	0	0	0	0	0	0	0	0	RV3	RV2	RV1	RV0
Stat	JS												
	Read	Write	Clei	ar Bits									
	0	FRM	CP_UV	UV	OV	SCP2	SCP1	SCG2	SCG1	OL	OC	TW	OT
Fault	t Status Ma	ask											
	Read	Write	Clea	ar Bits									
	DOV	FRM	CP_UV	UV	OV	SCP2	SCP1	SCG2	SCG1	OL	ос	TW	OT
Conf	iguration a	nd Contro		7			d		ka - A				h
	Read	Write	Clea	ar Bits									
	CL	тм	AL	ILIM1	ILIMO	SR2	SR1	SR0	EN	MODE	INPUT	VIN2	VIN1
SPIC	Control												- -
Direc	tion Forv	vard 🔻		Inp	ut Control	Selection	Parallel	•	(	Current Lin	nit (A) 6.	7 .	•
				Inp	ut Control	Mode	Half-Brid	ge 🔻	S	Slew Rate	(V/us) 2.	0.	•
Stan	dby Open	Load Test		Ov	er Voltage	Protectio	n						
Activ	ate No	-			Enabled	-							

### Figure 15. SPI control description

### Table 10. SPI control description

Name	Description
Read	Click the read button on top of each register to read the content 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.

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	Parallel Control
	Enable Direction
	Yes     Forward
	O No O Reverse
	Disable
	No     High-Side x
	© Yes
	Start Stop
	PWM Freq (Hz) 15000
	Duty Cycle (%)
	10 20 30 40 50 60 70 80 90
	Current Feedback (mA):
	Rend
	Current Stop
	G Statuc Fault
Figure 16. Parallel control descri	ption

### 6.2.2 Parallel control

#### 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 tri-stated and placed in Sleep mode **DIS**:

- DIS is logic HIGH, both OUT1 and OUT2 are tri-stated
- 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

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#### Stop:

• Press Stop to deactivate the outputs

### **Current Feedback:**

• Shows current through the high-side FET using the current recopy feature

### Status Fault:

· Shows any fault condition in Sleep mode

# Table 11. Logic behind direction control with High-side versus Low-side recirculation

Half-Bridge Mode	
	Forward - High-side Recirculation
1	IN1 = 1 IN2 = PWM signal with selected duty cycle and frequency
	Reverse - High-side Recirculation
2	IN1 = PWM signal with selected duty cycle and frequency IN2 = 1
	Forward - Low-side Recirculation
3	IN1 = PWM signal with selected duty cycle and frequency IN2 = 0
4	Reverse - Low-side Recirculation
	IN1 = 0 IN2 = PWM signal with selected duty cycle and frequency

H-Bridge Mode	
	Forward - High-side Recirculation
1	IN1 = 1
	IN2 = PWM signal with selected duty cycle and frequency
	Reverse - High-side Recirculation
2	IN1 = 0
	IN2 = PWM signal with selected duty cycle and frequency

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# 7 Schematic



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# 8 Board layout



Figure 18. Silkscreen

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# 9 Bill of materials

Item	Qty	Schematic label	Value	Description	Part number	Assy opt
Active co	mponer	nts <sup>[1]</sup>			I	
1	1	U1		IC DRV H-BRIDGE MOTOR 3.0 A 5.0 to 28 V SOIC32 – NXP	MC33HB2001FK	[2]
2	1	U2		IC VREG 5.0 V 1.0 A 5.0 to 18 V D2PAK – ON Semiconductor	MC7805ABD2TG	[2]
Diodes <sup>[1]</sup>			1	1	l	
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 SOD-323	1N4148WS-7-F	
6	2	D59, D64	150 mA	LED RED SGL 25 mA 0805	598-8110-107F	
7	3	D60, D61, D63	25 mA	LED RED SGL 25 mA 0805	598-8110-107F	
Capacito	rs <sup>[1]</sup>		1		l	
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	[1]			1	I	
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	4	R18, R188, R192, R193	0 Ω	RES MF 0 Ω 1/10 W – 0603	CRCW06030000Z0EA	
18	1	R211	200 Ω	RES MF 200 Ω 1/10 W 1 % 0603	RK73H1JTTD2000F	
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	RK73H1JTTD4701F	
Switches	, connec	ctors, jumpers a	and test p	oints <sup>[1]</sup>		

### FRDM-HB2001FEVM evaluation board

ltem	Qty	Schematic label	Value	Description	Part number	Assy opt
21	16	IN1, GND1,IN2, GND2, GND3, VPWR, VDDQ, VDD, SCLK, MOSI, MISO, GND, FS_B, ENBL, DIS, CS_B		TEST POINT BLACK 40 MIL DRILL 180 MIL TH 109L	5001	
22	11	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	4	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	

NXP does not assume liability, endorse, or warrant components from external manufacturers are referenced in circuit drawings or tables. While NXP [1] offers component recommendations in this configuration, it is the customer's responsibility to validate their application. Critical components. For critical components, it is vital to use the manufacturer listed.

[2]

# 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 KL14/15/24/25 MCUs

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### **11 References**

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

NXP.com support pages	Description	URL
FRDM-HB2001FEVM	Tool summary page	http://www.nxp.com/FRDM- HB2001FEVM
MC33HB2001	Product summary page	http://www.nxp.com/MC33HB2001
FRDM-KL25Z	Tool summary page	http://www.nxp.com/FRDM-KL25Z
SPIGen	SPI generator software	http://www.nxp.com/SPIGEN

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# **12 Revision history**

Revision	Date	Description of changes
1.0	5/2016	Initial release

### **13** Contact information

Visit <u>http://www.nxp.com/support</u> for a list of phone numbers within your region. Visit <u>http://www.nxp.com/warranty</u> to submit a request for tool warranty.

#### FRDM-HB2001FEVM evaluation board

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User guide

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