UM1077
User manual

Control stage based on STM32F100CB microcontroller dedicated for motor control with user interface via serial communication

Introduction

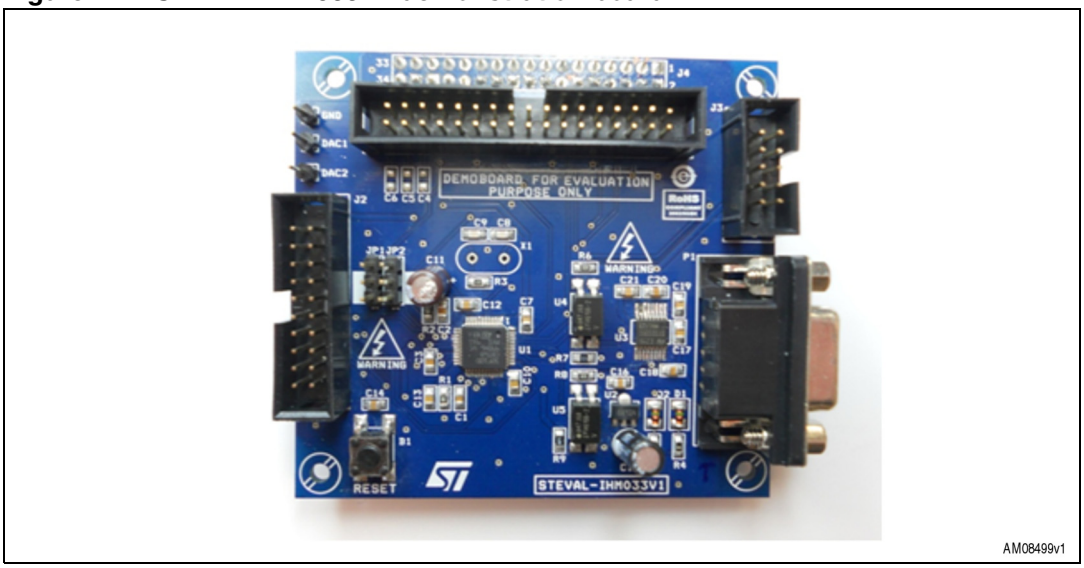
The STEVAL-IHM033V1 is a control stage based on STMicroelectronics' ARM™ Cortex-M3 core-based STM32F100CB microcontrollers dedicated for motor control. It is designed as an evaluation environment for motor control applications using STM32F100CB microcontrollers with full-speed I^2C channels, SPI channels, insulated USART channels, internal 8 KB SRAM, and 128 KB Flash, and SWD debugging.

With dedicated hardware evaluation features, the STEVAL-IHM033V1 board is designed to help developers evaluate the device and to develop their own applications.

The STEVAL-IHM033V1 can be used together with the STM32 PMSM single/dual FOC SDK v3.0 and an STMicroelectronics demonstration powerboard equipped with an MC connector (such as the STEVAL-IHM032V1) for a complete motor control evaluation and development platform.

This user manual provides information on using the STEVAL-IHM033V1 board and its hardware features.

Figure 1. STEVAL-IHM033V1 demonstration board



Contents

1 **Main features** 5

2 **Hardware layout and configuration** 6

2.1 Power supply 7

2.2 Boot option 7

2.3 Clock source 7

2.4 Reset source 7

2.5 Insulated RS232 7

2.6 16-pin SPI/I^{2}C/SCI interface 7

2.7 Motor control 8

2.8 Development and debug support 8

3 **Connectors** 9

3.1 Motor control connector J1 (J4) 9

3.2 Insulated RS232 connector P1 10

3.3 16-pin SPI, I^{2}C, SCI interface J3 parameters 11

3.4 Serial wire debugging connector J2 11

4 **Schematics** 13

5 **STEVAL-IHM033V1 IO assignments** 16

6 **Using the STEVAL-IHM033V1 with the STM32 FOC firmware library** . 18

6.1 Environmental considerations 18

6.2 Hardware requirements 19

6.3 Software requirements 19

6.4 STM32 FOC firmware library v3.0 customizing 19

7 **Bill of material** 21

8 **References** 22

9 **Revision history** 23

List of tables

Table 1. Motor control jumpers JP1, JP2 8
Table 2. Motor control connector J1 (J4) pin assignments 9
Table 3. Insulated RS232 connector P1 pin assignments 10
Table 4. 16-pin SPI, I^2C, SCI interface J3 pin assignments 11
Table 5. Serial wire debugging connector J2 pin assignments. 12
Table 6. STEVAL-IHM033V1 IO assignments 16
Table 7. STEVAL-IHM033V1 motor control workbench parameters 19
Table 8. Bill of material 21
Table 9. Document revision history 23

List of figures

Figure 1. STEVAL-IHM033V1 demonstration board 1
Figure 2. STEVAL-IHM033V1 block diagram 6
Figure 3. STEVAL-IHM033V1 board layout 6
Figure 4. Motor control connector J1/J4 (top view) 9
Figure 5. Insulated RS232 connector P1 (front view) 10
Figure 6. 16-pin SPI, I^2C, SCI interface J3 11
Figure 7. Serial wire debugging connector J2 11
Figure 8. Motor control connector 13
Figure 9. MCU connections 14
Figure 10. Serial communication 15

1 Main features

The STEVAL-IHM033V1 control stage has the following characteristics:

- Compact size
- STMicroelectronics ARM™ Cortex-M3 core-based STM32F100CB microcontroller
- Connector for interfacing with any STMicroelectronics demonstration powerboard equipped with an MC connector (such as the STEVAL-IHM032V1) with alternate functions (current reference, current limitation/regulation, method selection, current boost)
- The board is compatible with sinusoidal and trapezoidal control
- Insulated USART communication interface
- Non insulated UUSCI interface (see STEVAL-PCC009V4)
- External oscillator
- Reset button
- SWD for programming/debugging
- DAC outputs test points

2 Hardware layout and configuration

The STEVAL-IHM033V1 board is designed around an STM32F100CB microcontroller in a 48-pin LQFP package.

The hardware block diagram in *Figure 2* shows the connections between the STM32F100CB microcontroller and peripherals (USART, UUSCI, motor control).

Figure 3 shows these features on the demonstration board.

Figure 2. STEVAL-IHM033V1 block diagram

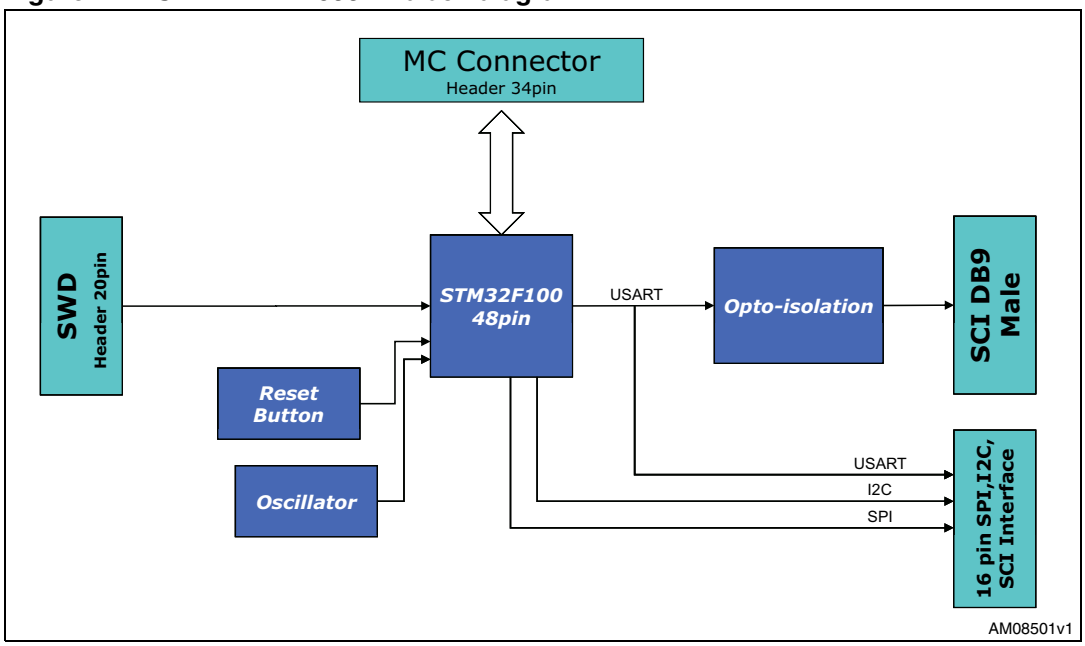
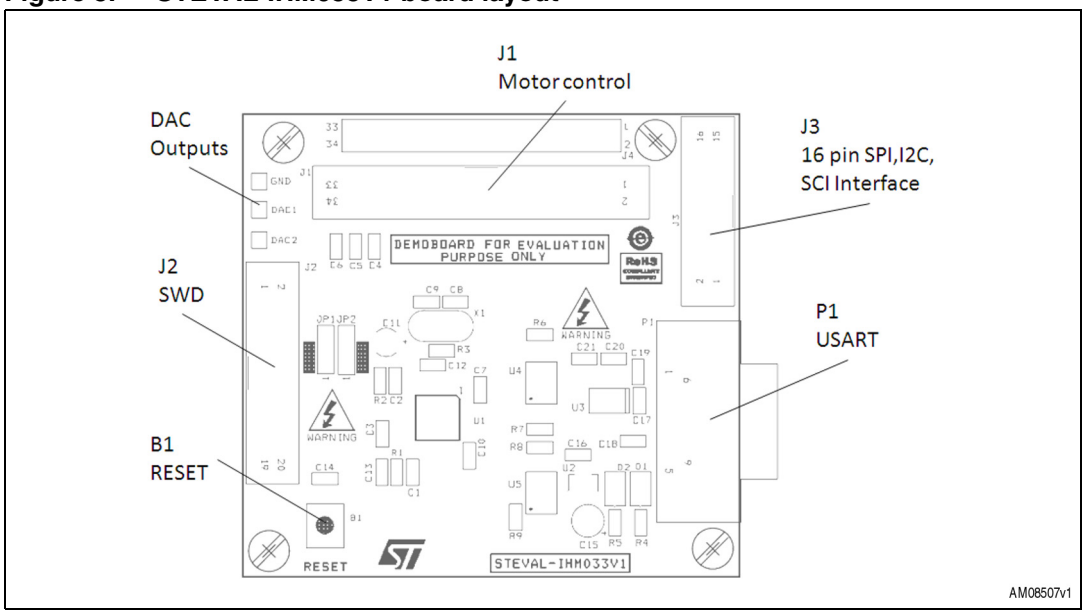


Figure 3. STEVAL-IHM033V1 board layout



Two 3-pin jumpers with two possible positions are present on the STEVAL-IHM033V1 board, the possible settings for which are presented in *Table 1*.

2.1 Power supply

The STEVAL-IHM033V1 board is designed to be powered via J1 or J4 (MC connector). See *Section 3.1*.

2.2 Boot option

The STEVAL-IHM board allows boot only from embedded user Flash.

2.3 Clock source

The STM32F100CB microcontroller present on the STEVAL-IHM033V1 board is intended to be used in conjunction with an external high speed clock (HSE) 8 MHz crystal, X1 reference in the schematic.

2.4 Reset source

The reset signal of the STEVAL-IHM033ve board is active low and the reset sources include:

- Reset button B1
- Debugging tools from connector J2

2.5 Insulated RS232

One type-D 9-pin connector, P1 (USART1), is available on the STEVAL-IHM033V1 board. The USART1 connector is connected to the RS232 transceiver U3. The RS232 transceiver U3 is connected to the microcontroller via optocouplers U4 and U5 which perform the electrical insulation of the board.

2.6 16-pin SPI/I^{2}C/SCI interface

Using this interface, it is possible to connect a device which can communicate using I^{2}C, SPI, and UART.

For instance, the STEVAL-PCC009V4 is an STM32 based universal USB to serial communication interface (UUSCI). In the UUSCI demonstration board, the STM32 microcontroller is used as the interface between the PC and the end device.

2.7 Motor control

The STEVAL-IHM033V1 board supports motor control via a 34-pin connector, J1 or J4, which provides all required control and feedback signals to and from a motor power-drive board. Available signals on this connector include emergency stop, speed or position feedbacks, 3-phase motor current, bus voltage sensor, heatsink temperature sensor coming from the motor drive board, and 6 channels of PWM control signals going to the motor drive circuit.

It is possible to use the J1 connector 34-way boxed header placed in the top side, or alternatively, the J4 connector 32-way double row female stripline placed in the bottom side to connect the STEVAL-IHM033V1 with one of STMicroelectronics' demonstration powerboards equipped with an MC connector (such as STEVAL-IHM032v1). For the latter option it is possible to directly plug in the J4 connector to the MC connector of the powerboard respecting the polarity.

Special motor control operation is enabled by setting jumpers JP1, JP2 (see *Table 1*).

Table 1. Motor control jumpers JP1, JP2

Jumper	Position	Description
JP1	Between pin 1 and 2 (Default setting)	Connect pin 27 of the J1 (J4) MC connector to the STM32F100CBT6B microcontroller pin PB11 (TIM2_CH4) used as PFC Synch
	Between pin 2 and 3	Connect pin 27 of the J1 (J4) MC connector to the STM32F100CBT6B microcontroller pin PA12 (TIM1_ETR) used as BLDC ETR
JP2	Between pin 1 and 2 (Default setting)	Connect pin 29 of the J1 (J4) MC connector to the STM32F100CBT6B microcontroller pin PB10 (TIM2_CH3) used as PFC PWM
	Between pin 2 and 3	Connect pin 29 of the J1 (J4) MC connector to the STM32F100CBT6B microcontroller pin PA4 (DAC1_OUT) used as Curr. Ref.

2.8 Development and debug support

The following debug connector is available on the STEVAL-IHM033V1 board:

- J2, an industry standard 20-pin SWD interface connector for connection of debugging/programming tools for ARM core-based devices.

3 Connectors

3.1 Motor control connector J1 (J4)

Figure 4. Motor control connector J1/J4 (top view)

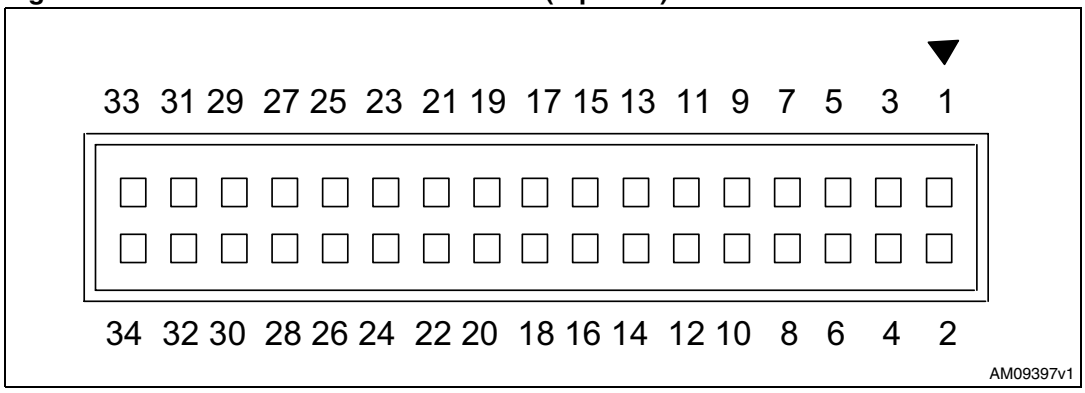


Table 2. Motor control connector J1 (J4) pin assignments

J1/J4 pin	Function	Pin of STM32F100CB	J1/J4 pin	Function	Pin of STM32F100 CB
1	Emergency stop	PB12	2	GND	
3	PWM-UH	PA8	4	GND	
5	PWM-UL	PB13	6	GND	
7	PWM-VH	PA9	8	GND	
9	PWM-VL	PB14	10	GND	
11	PWM-WH	PA10	12	GND	
13	PWM-WL	PB15	14	Bus voltage	PA3
15	Phase A current, BEMF sampling method selection	PA6	16	GND	
17	Phase B current	PA7	18	GND	
19	Phase C current	PB0	20	GND	
21	NTC bypass	PB2	22	GND	
23	Dissipative brake, OCP Boost	PB9	24	GND	
25	Not connected		26	Heatsink temperature	PB1
27	PFC synch, 6Step - current regulation feedback	PB11 or PA12 (see *Table 1*)	28	VDD µ (required 3.3 V)	

Table 2. Motor control connector J1 (J4) pin assignments

J1/J4 pin	Function	Pin of STM32F100CB	J1/J4 pin	Function	Pin of STM32F100 CB
29	PFC PWM, 6Step - current regulation reference	PB10 or PA4 (see *Table 1*)	30	GND	
31	H1/Enc A/BEMF A	PA0	32	GND	
33	H2/Enc B/BEMF B	PA1	34	H3/Enc Z/BEMF C	PA2

3.2 Insulated RS232 connector P1

Figure 5. Insulated RS232 connector P1 (front view)

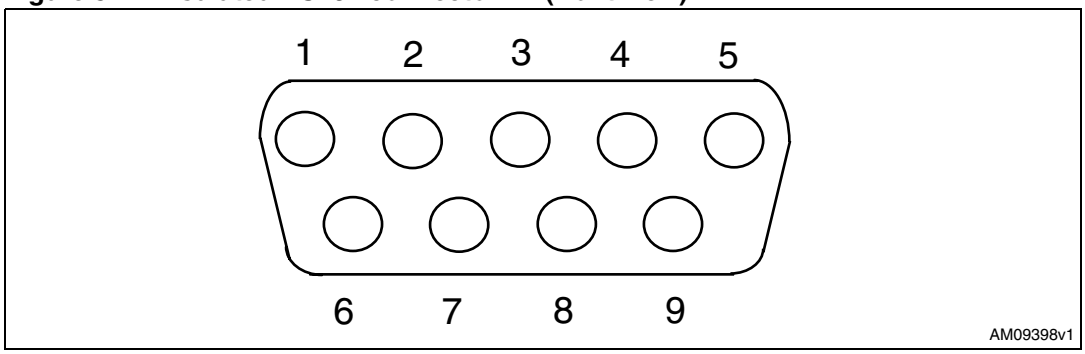


Table 3. Insulated RS232 connector P1 pin assignments

Pin number	Description	Pin number	Description
1	NC	6	NC
2	Insulated RXD connected to USART1_RXD via optocoupler	7	RTS used as insulated power supply
3	Insulated TXD connected to USART_TXD via optocoupler	8	NC
4	DTR used as insulated power supply	9	NC
5	Insulated GND		

Note: The insulated section is power supplied via P1 connector pins 4 and 7. To supply the insulated section it is required to bring up DTR and RTS before establishing the communication.

3.3 16-pin SPI, I²C, SCI interface J3 parameters

Figure 6. 16-pin SPI, I²C, SCI interface J3

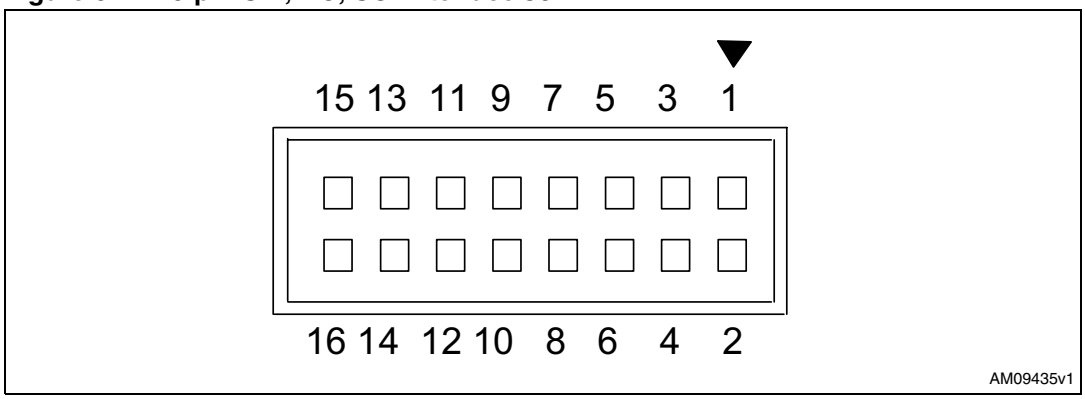


Table 4. 16-pin SPI, I²C, SCI interface J3 pin assignments

J3 pin	Description	Pin of STM32F100CB	J3 pin	Description	Pin of STM32F100CB
1	VDD µ		2	Not connected	
3	USART1_RX	PB7	4	USART1_TX	PB6
5	SPI1_NSS	PB8	6	SPI1_SCK	PB3
7	SPI1_MISO	PB4	8	SPI1_MOSI	PB5
9	I2C1_SDA	PB7	10	I2C1_SCL	PB6
11	Not connected		12	Not connected	
13	Not connected		14	Not connected	
15	VDD µ		16	Ground	

Note: The J3 connector is not insulated so please ensure that the instructions in Section 6.1 are strictly followed.

3.4 Serial wire debugging connector J2

Figure 7. Serial wire debugging connector J2

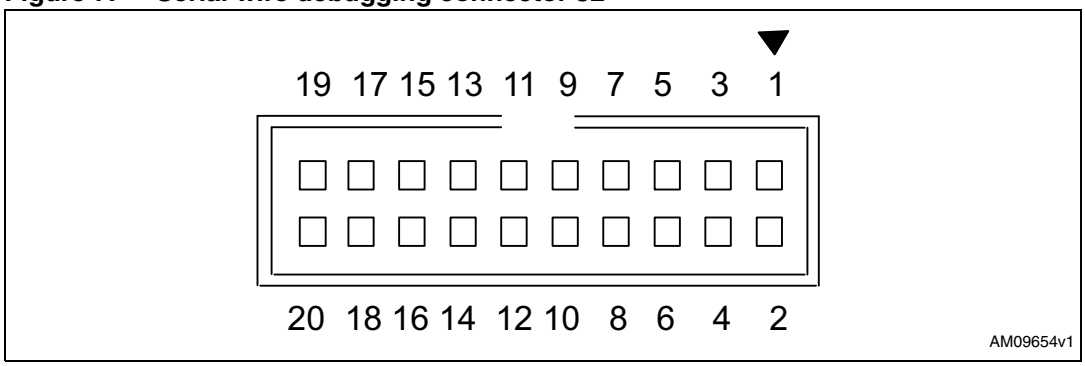


Table 5. Serial wire debugging connector J2 pin assignments

Pin number	Description	Pin number	Description
1	3.3 V power	2	Not connected
3	Not connected	4	GND
5	Not connected	6	GND
7	SWDIO/PA13	8	GND
9	SWCLK/PA14	10	GND
11	Not connected	12	GND
13	SWO/PB3	14	GND
15	RESET#	16	GND
17	Not connected	18	GND
19	Not connected	20	GND

4 Schematics

This section provides design schematics for the STEVAL-IHM033V1.

This section includes:

- Motor control connector (see*Figure 8*)
- MCU connections (see *Figure 9*)
- Serial communication (see *Figure 10*)

Figure 8. Motor control connector

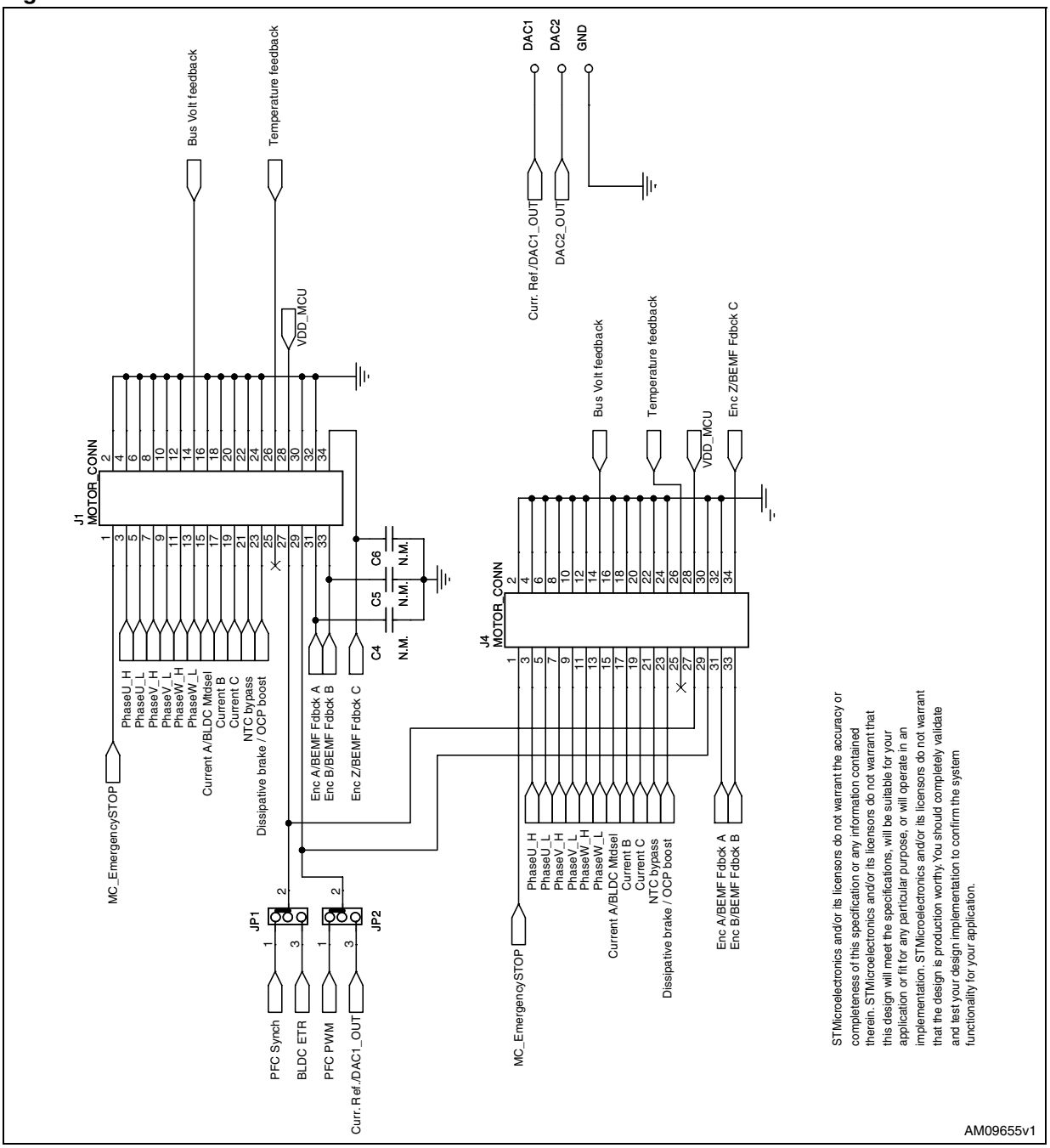


Figure 9. MCU connections

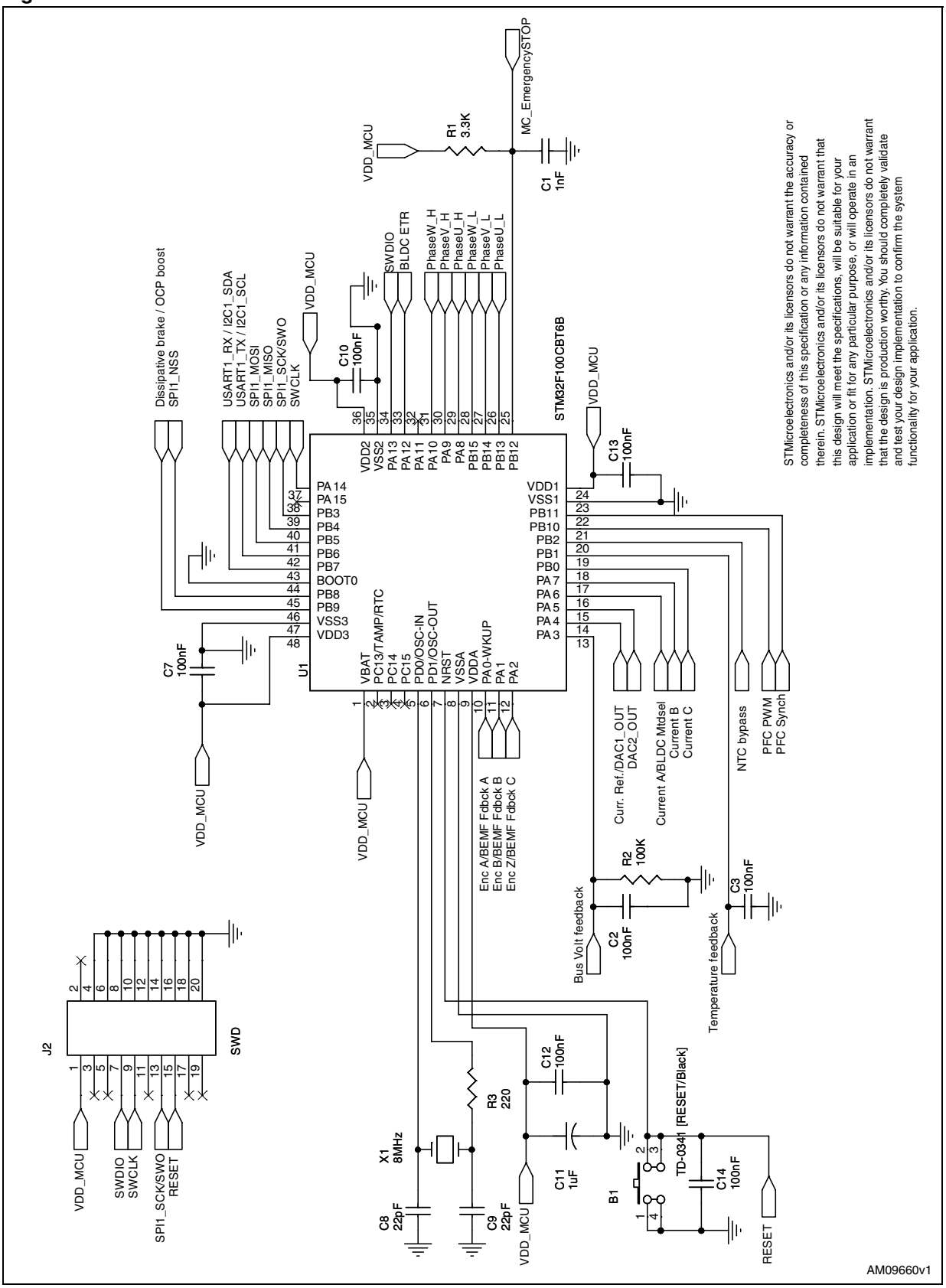
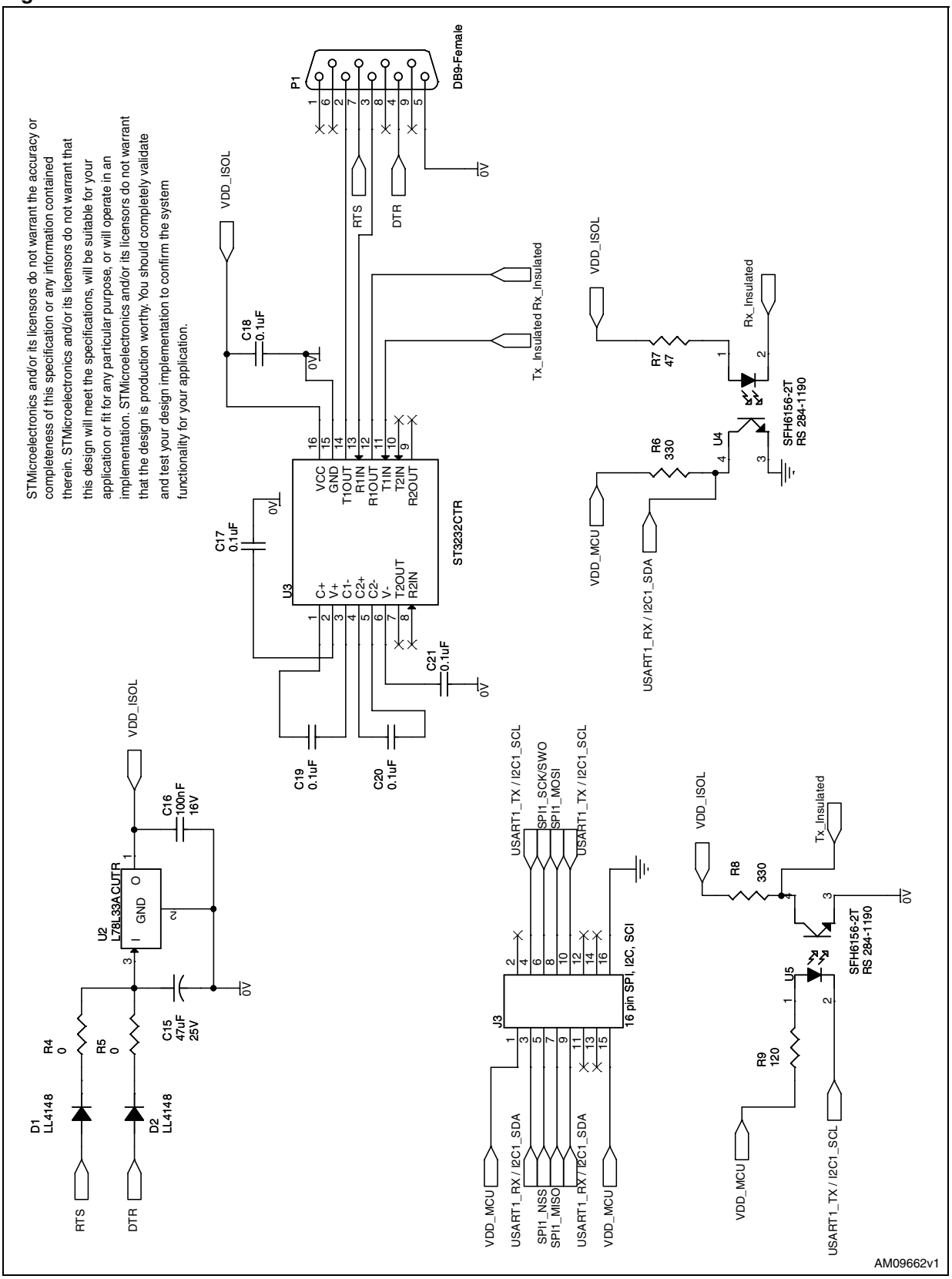


Figure 10. Serial communication



5 STEVAL-IHM033V1 IO assignments

Table 6. STEVAL-IHM033V1 IO assignments

LQFP48	Pin name	Type	I/O level input	EVAL board IO assignment
1	V_{BAT}	S		
2	PC13			Not connected
3	PC14			Not connected
4	PC15			Not connected
5	OSC_IN			Crystal oscillator 8 MHz
6	OSC_OUT			Crystal oscillator 8 MHz
7	NRST	I/O		RESET#
8	V_{SSA}	S		
9	V_{DDA}	S		
10	PA0	I		Enc A/BEMF Fdbck A
11	PA1	I		Enc B/BEMF Fdbck B
12	PA2	I		Enc Z/BEMF Fdbck C
13	PA3	I		Bus Volt feedback
14	PA4	O		Curr. Ref./DAC1_OUT
15	PA5	O		DAC2_OUT
16	PA6	I		Current A/BLDC Mtdsel
17	PA7	I		Current B
18	PB0	I		Current C
19	PB1	I		Temperature feedback
20	PB2	O	FT	NTC bypass
21	PB10	O	FT	PFC PWM
22	PB11	I	FT	PFC Synch
23	V_{SS_1}	S		
24	V_{DD_1}	S		
25	PB12	I	FT	MC_EmergencySTOP
26	PB13	O	FT	PhaseU_L
27	PB14	O	FT	PhaseV_L
28	PB15	O	FT	PhaseW_L
29	PA8	O	FT	PhaseU_H
30	PA9	O	FT	PhaseV_H
31	PA10	O	FT	PhaseW_H
32	PA11			Not connected

Table 6. STEVAL-IHM033V1 IO assignments (continued)

LQFP48	Pin name	Type	I/O level input	EVAL board IO assignment
33	PA12	I	FT	BLDC ETR
34	PA13	I/O	FT	SWDIO
35	V_{SS_2}	S		
36	V_{DD_2}	S		
37	PA14	O	FT	SWCLK
38	PA15			Not connected
39	PB3	I/O	FT	SPI1_SCK/SWO
40	PB4	I/O	FT	SPI1_MISO
41	PB5	I/O		SPI1_MOSI
42	PB6	I/O	FT	USART1_TX / I2C1_SCL
43	PB7	I/O	FT	USART1_RX / I2C1_SDA
44	BOOT0			GND
45	PB8	I/O	FT	SPI1_NSS
46	PB9	O	FT	Dissipative brake / OCP boost
47	V_{SS_3}	S		
48	V_{DD_3}	S		

- FT = 5 V tolerant
- S = supply

6 Using the STEVAL-IHM033V1 with the STM32 FOC firmware library

The “STM32 FOC firmware library v3.0” provided along with the STM3210B-MCKIT performs the field-oriented control (FOC) of a permanent magnet synchronous motor (PMSM) in both sensor and sensorless configurations.

It is possible to configure the firmware to use the STEVAL-IHM033V1 as the control stage of the motor control system.

This section describes the customizing to be applied to the “STM32 FOC firmware library V3.0” in order for the firmware to be compatible with the STEVAL-IHM033V1.

6.1 Environmental considerations

Warning: The STEVAL-IHM033V1 demonstration board is not electrically insulated; if it is connected to a high voltage powerboard, it must only be used in a power laboratory; the voltage used in the drive system presents a shock hazard.

The kit is not electrically isolated from the powerboard. This topology is very common in motor drives. The microprocessor is grounded by the integrated ground of the DC bus. The microprocessor and associated circuitry are hot and MUST be isolated from user controls and communication interfaces.

Warning: Any measurement equipment must be isolated from the main power supply before powering up the motor drive. To use an oscilloscope with the kit, it is safer to isolate the DC supply AND the oscilloscope. This prevents a shock from occurring as a result of touching any single point in the circuit, but does NOT prevent shocks when touching two or more points in the circuit.

An isolated AC power supply can be constructed using an isolation transformer and a variable transformer.

Note: Isolating the application rather than the oscilloscope is highly recommended in any case.

6.2 Hardware requirements

The following items are required to run the STEVAL-IHM033V1 together with the “STM32 FOC firmware library”.

- The STEVAL-IHM033V1 board or MB459B board (powerboard present in the STM32 MC kit) or any other demonstration board with MC connector.
- A high-voltage insulated AC power supply up to 230 Vac
- A programmer/debugger dongle for the control board (not included in the package). To program/debug the STEVAL-IHM033V1, a dongle with single wire debugging capabilities (SWD) is required. Use of an insulated dongle is always recommended.
- A 3-phase brushless motor with permanent magnet rotor (not included in the package)
- An insulated oscilloscope (as necessary)
- An insulated multimeter (as necessary)

6.3 Software requirements

To customize, compile, and download the “STM32 FOC firmware library v3.0”, a toolchain must be installed. Please refer to the UM1052 user manual for complete details on how to set up the proper toolchain and refer to the control board user manual for further details.

6.4 STM32 FOC firmware library v3.0 customizing

To customize the STM32 FOC firmware library v.3.0, the “ST motor control workbench”, as described in the UM1052 user manual, can be used.

The required parameters for the control stage related to the STEVAL-IHM033V1 are given in *Table 7*.

Table 7. STEVAL-IHM033V1 motor control workbench parameters

Block	Parameter	STEVAL-IHM033V1 default value	Unit
MCU and clock frequency	STM32 sub-family	Value line medium density	
	CPU frequency	24	MHz
	Nominal MCU supply voltage	3.30	V
Analog input	ADC channel selection for phase U	ADC1_IN6	
	ADC channel selection for phase V	ADC1_IN7	
	ADC channel selection for phase W	ADC1_IN8	
	ADC channel for current reading (1sh)	ADC1_IN7	
	Bus voltage – ADC channel	ADC1_IN3	
	Temp. feedback – ADC channel	ADC1_IN9	
DAC functionality	DAC functionality peripheral	DAC	
Digital I/O	Timer	TIM1	
	TIM1 remapping	No remap	

Table 7. STEVAL-IHM033V1 motor control workbench parameters (continued)

Block	Parameter	STEVAL-IHM033V1 default value	Unit
	Encoder interface - timer	TIM2	
	Encoder interface – timer remap	No remap	
	Hall sensor interface - timer	TIM2	
	Hall sensor interface – timer remap	No remap	
	Serial communication – channel	USART1	
	Serial communication – USART1 remapping	Remap	
	Dissipative brake output	Port:B Pin:9	
	In-rush current limiter	Port:B Pin:2	
	Overcurrent protection disabling	Port:B Pin:9	

Note: In the "Drive management" section "User Interface Add-on" the "Joystick, LCD, button" check box must be unchecked because the feature is not supported by the STEVAL-IHM033V1.

Note: To program/debug the board, it is necessary to configure the IAR workbench for the SWD interface. Go to the "User project" option. Click on "J-Link/J-Trace". Select the "Connection" tab and check the SWD radio button.

7 Bill of material

Table 8. Bill of material

Reference	Part / value	Manufacturer	Manufacturer code
B1	TD-0341 [RESET/black]	Any	
C1	1 nF		
C2,C3,C7,C10,C12,C13, C14,C16,C17,C18,C19, C20,C21	100 nF		
C4,C5,C6	N.M.	Do not fit	Do not fit
C8,C9	22 pF		
C11	1 µF	Any	
C15	47 µF	Any	
TP_CH4	Test point	Test point	Test point
DAC1,DAC2,GND	Test point	Any	
D1,D2	LL4148	any	
JP1,JP2	Jumper	Any	
J1	MOTOR_CONN	Any	
J4 (place on bottom layer)	MOTOR_CONN	Any	
J2	SWD	Any	
J3	16-pin SPI, I^2C, SCI	Any	
P1	DB9-female	Any	
R1	3.3 kΩ		
R6,R8	330 Ω		
R2	100 kΩ		
R3	220 Ω		
R4,R5	0		
R7	47 Ω		
R9	120 Ω		
U1	STM32F100CBT6B	STMicroelectronics	STM32F100CBT6B
U2	L78L33ACUTR	STMicroelectronics	L78L33ACUTR
U3	ST3232CTR	STMicroelectronics	ST3232CTR
U4,U5	SFH6156-2T	Vishay Semiconductors	SFH6156-2T
X1	8 MHz	Any	
Jumper			

8 References

This user manual provides information on the hardware features and use of the STEVALIHM033V1 demonstration board. For additional information on supporting software and tools, refer to the following:

- STM32F100xx datasheet
- RM0041 reference manual
- UM1052 user manual
- UM1053 user manual
- TN0516 technical note
- http://www.st.com/mcu/ web site, which is dedicated to the complete STMicroelectronics microcontroller portfolio.

Please contact the nearest ST sales office or support team to obtain the required documentation if it is not included in the software package received or available on the ST web site (www.st.com).

9 Revision history

Table 9. Document revision history

Date	Revision	Changes
24-May-2011	1	Initial release.
28-Oct-2011	2	Minor text changes to improve readability, no technical changes.

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries (“ST”) reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST’s terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST’S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY TWO AUTHORIZED ST REPRESENTATIVES, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER’S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com