1 kW three-phase motor control demonstration board featuring L6390 drivers and STGP10NC60KD IGBT

1 Introduction

This document describes the 1 kW three-phase motor control demonstration board featuring the L6390 high and low-side drivers and the STGP10NC60KD IGBT. The demonstration board is an AC/DC inverter that generates a three-phase waveform for driving three or two-phase motors such as induction motors or PMSM motors up to 1000 W with or without sensors.

The main device presented in this user manual is a universal, fully evaluated, and populated design consisting of a three-phase inverter bridge based on the 600 V STMicroelectronics™ IGBT STGP10NC60KD in a TO-220 package mounted on a heatsink, and the L6390 high-voltage high-side and low-side driver featuring an integrated comparator for hardware protection features such as overcurrent and overtemperature. The driver also integrates an operational amplifier suitable for advanced current sensing. Thanks to this advanced characteristic, the system has been specifically designed to achieve an accurate and fast conditioning of the current feedback, therefore matching the typical requirements in field oriented control (FOC).

The board has been designed to be compatible with single-phase mains, supplying from 90 VAC to 285 VAC or from 125 VDC to 400 VDC for DC voltage. With reconfiguration of the input sourcing, the board is suitable also for low-voltage DC applications up to 35 VDC. This document is associated with the release of the STEVAL-IHM023V2 demonstration board (see *Figure 1* below).

Figure 1.   STEVAL-IHM023V2

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2 System introduction

2.1 Main characteristics

The information below lists the converter specification data and the main parameters set for the STEVAL-IHM023V2 demonstration board.

- Minimum input voltage 125 VDC or 90 VAC
- Maximum input voltage 400 VDC or 285 VAC
- With applied input voltage doubler - the range is from 65 VAC to 145 VAC
- Voltage range for low-voltage motor control applications from 18 VDC to 35 VDC
- Possibility to use auxiliary +15 V supply voltage
- Maximum output power for motors up to 1000 W
- Regenerative brake control feature
- Input inrush limitation with bypassing relay
- + 15 V auxiliary power supply based on buck converter with VIPer™16
- IGBT power switch STGP10NC60KD in TO-220 package - compatible with other ST IGBTs or power MOSFETs in TO-220 package
- Fully populated board conception with testing points and isolated plastic safety cover
- Motor control connector for interface with STM3210B-EVAL board and other ST motor control dedicated kits
- Tachometer input
- Hall/encoder inputs
- Possibility to connect BEMF daughterboard for sensorless six-step control of BLDC motors
- PCB type and size:
  - Material of PCB - FR-4
  - Double-sided layout
  - Copper thickness: 60 μm
  - Total dimensions of demonstration board: 127 mm x 180 mm.

2.2 Target applications

- Washing machines
- Home appliances
- Medical applications - rehabilitative beds
- High-power, high-efficiency water pumps for heating applications.

2.3   Safety and operating instructions

2.3.1   General terms

Warning: **During assembly, testing, and operation, the demonstration board poses several inherent hazards, including bare wires, moving or rotating parts, and hot surfaces. There is a danger of serious personal injury and damage to property, if the kit or components are improperly used or installed incorrectly. The kit is not electrically isolated from the AC/DC input. The demonstration board is directly linked to the mains voltage. No insulation has been placed between the accessible parts and the high-voltage. All measurement equipment must be isolated from the mains before powering the board. When using an oscilloscope with the demonstration board, it must be isolated from the AC line. 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. Do not touch the demonstration board after disconnection from the voltage supply, as several parts and power terminals, which contain energized capacitors, need to be allowed to discharge.**

All operations involving transportation, installation and use, as well as maintenance, are to be carried out by skilled technical personnel (national accident prevention rules must be observed). For the purpose of these basic safety instructions, "skilled technical personnel" are suitably qualified people who are familiar with the installation, use and maintenance of powered electronic systems.

2.3.2   Demonstration board intended use

The STEVAL-IHM023V2 demonstration board is a component designed for demonstration purposes only and is not to be used for electrical installation or machinery. The technical data as well as information concerning the power supply conditions should be taken from the documentation and strictly observed.

2.3.3   Demonstration board installation

The installation and cooling of the demonstration kit boards must be in accordance with the specifications and the targeted application.

● The motor drive converters are protected against excessive strain. In particular, no components are to be bent or isolating distances altered during the course of transportation or handling.

● No contact must be made with other electronic components and contacts.

● The boards contain electro-statically sensitive components that are prone to damage through improper use. Electrical components must not be mechanically damaged or destroyed.

2.3.4 Electrical connections

Applicable national accident prevention rules must be followed when working on the main power supply with a motor drive. The electrical installation must be completed in accordance with the appropriate requirements.

2.3.5 Demonstration board operation

A system architecture which supplies power to the demonstration board should be equipped with additional control and protective devices in accordance with the applicable safety requirements (e.g. compliance with technical equipment and accident prevention rules).

3 Board description

3.1 System architecture

A generic motor control system can be basically schematized as the arrangement of four main blocks (see *Figure 2* below).

● **A control block** - its main task is to accept user commands and motor drive configuration parameters and to provide all digital signals to implement the proper motor driving strategy. The ST demonstration board based on the STM32™ microcontroller STM3210B-EVAL can be used as a control block thanks to the motor control connector used on the board.

● **A power block** - makes a power conversion from the DC bus transferring to the motor by means of a three-phase inverter topology. The power block is based on high-voltage (high and low-side) drivers (L6390) and power switches (STGP10NC60KD) in TO-220 packages.

● **The motor itself** - the STEVAL-IHM023V2 demonstration board is able to properly drive any PMSM, but the FOC itself is conceived for sinusoidal-shaped BEMF. The demonstration board is also suitable for driving any three or two-phase asynchronous motor or low-voltage BLDC motors.

● **Power supply block** - able to work from 90 VAC to 285 VAC or from 125 VDC to 400 VDC. With reconfiguration of the power stage with jumpers, the board can also be used for low-voltage applications from 18 VDC to 35 VDC. By supplying the electronic parts on the board through an external + 15 V connector, the board can be used for a wide voltage range up to 400 VDC. Please refer to *Section 4* for detailed settings of the jumpers according to the required application.

Figure 2.   Motor control system architecture
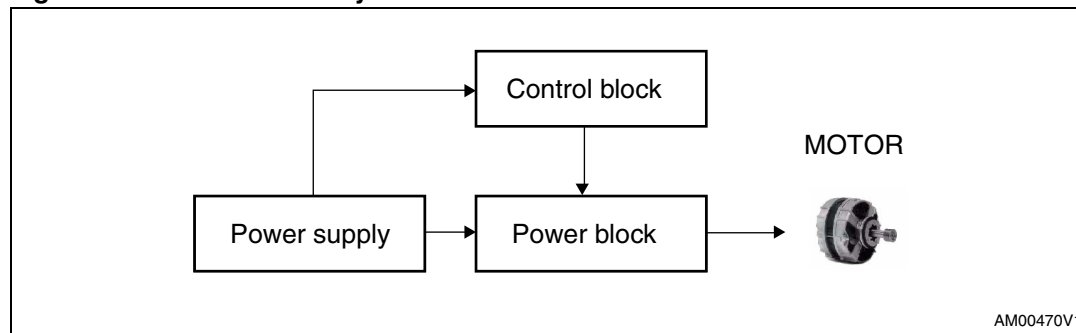
Referring to the above motor control system architecture, the STEVAL-IHM023V2 includes the power supply and the power block hardware blocks.

3.2 The board schematic

Figure 3. STEVAL- IHM023V2 schematic - part 1
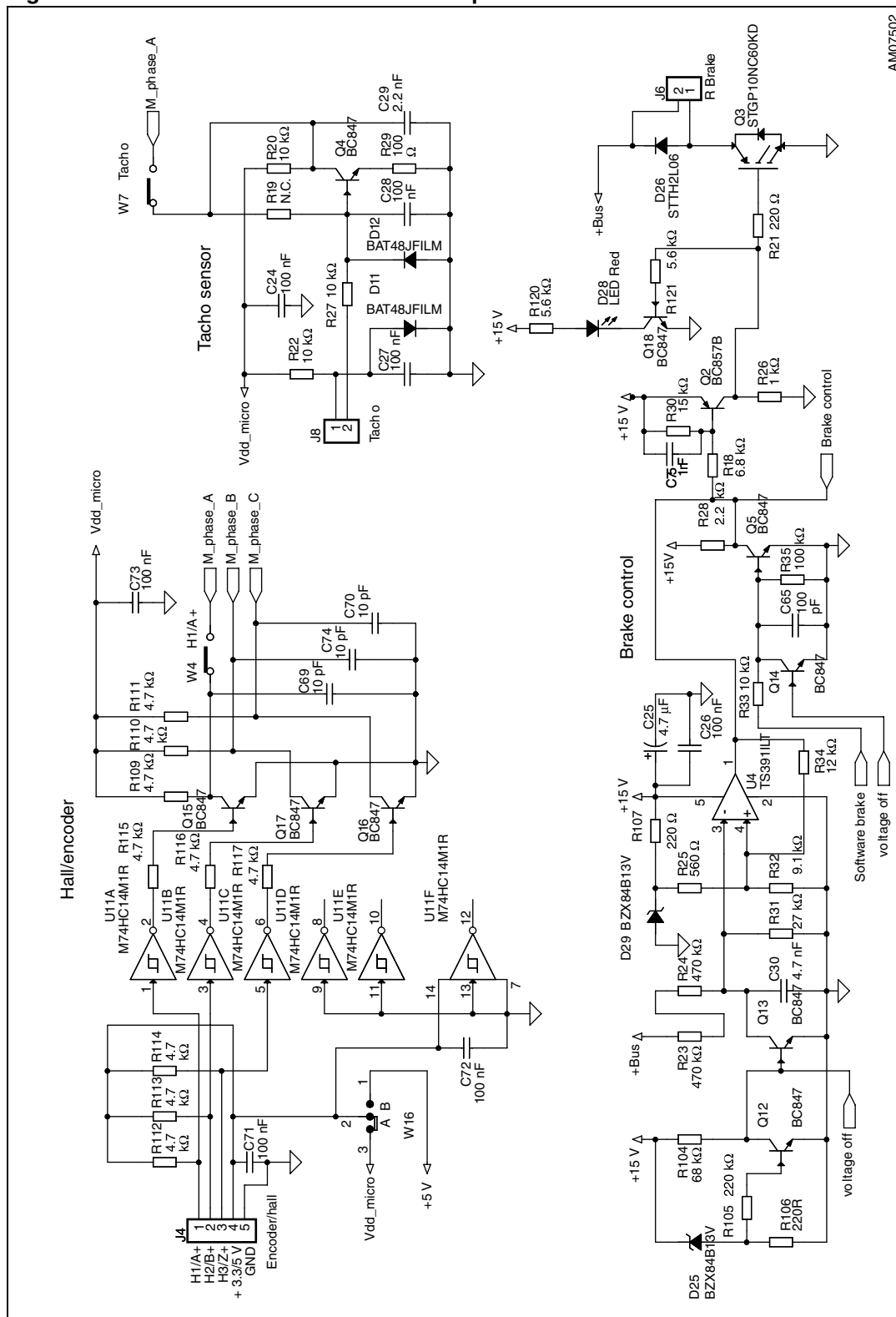
Figure 4. STEVAL- IHM023V2 schematic - part 2
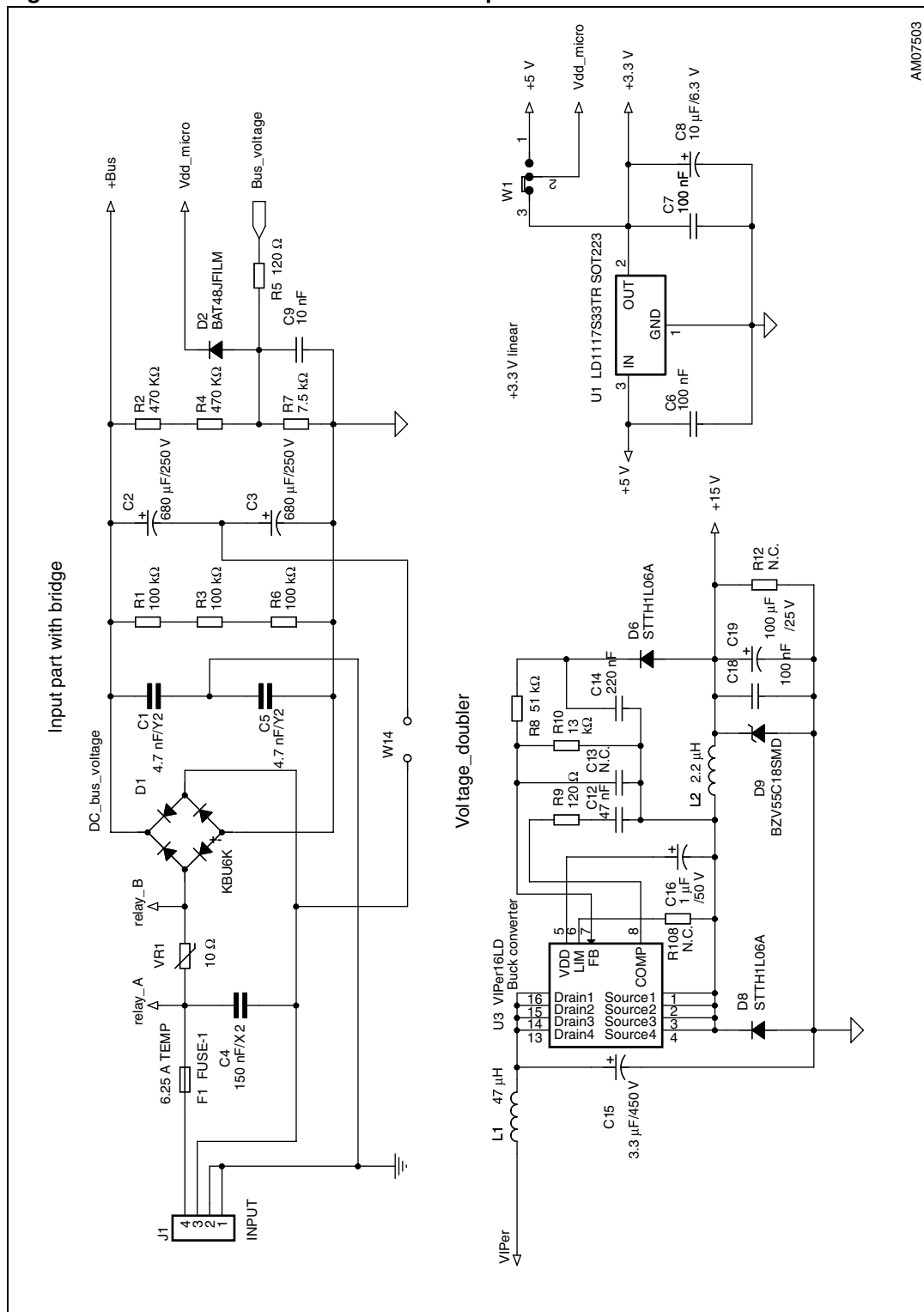
Figure 5.   STEVAL- IHM023V2 schematic - part 3
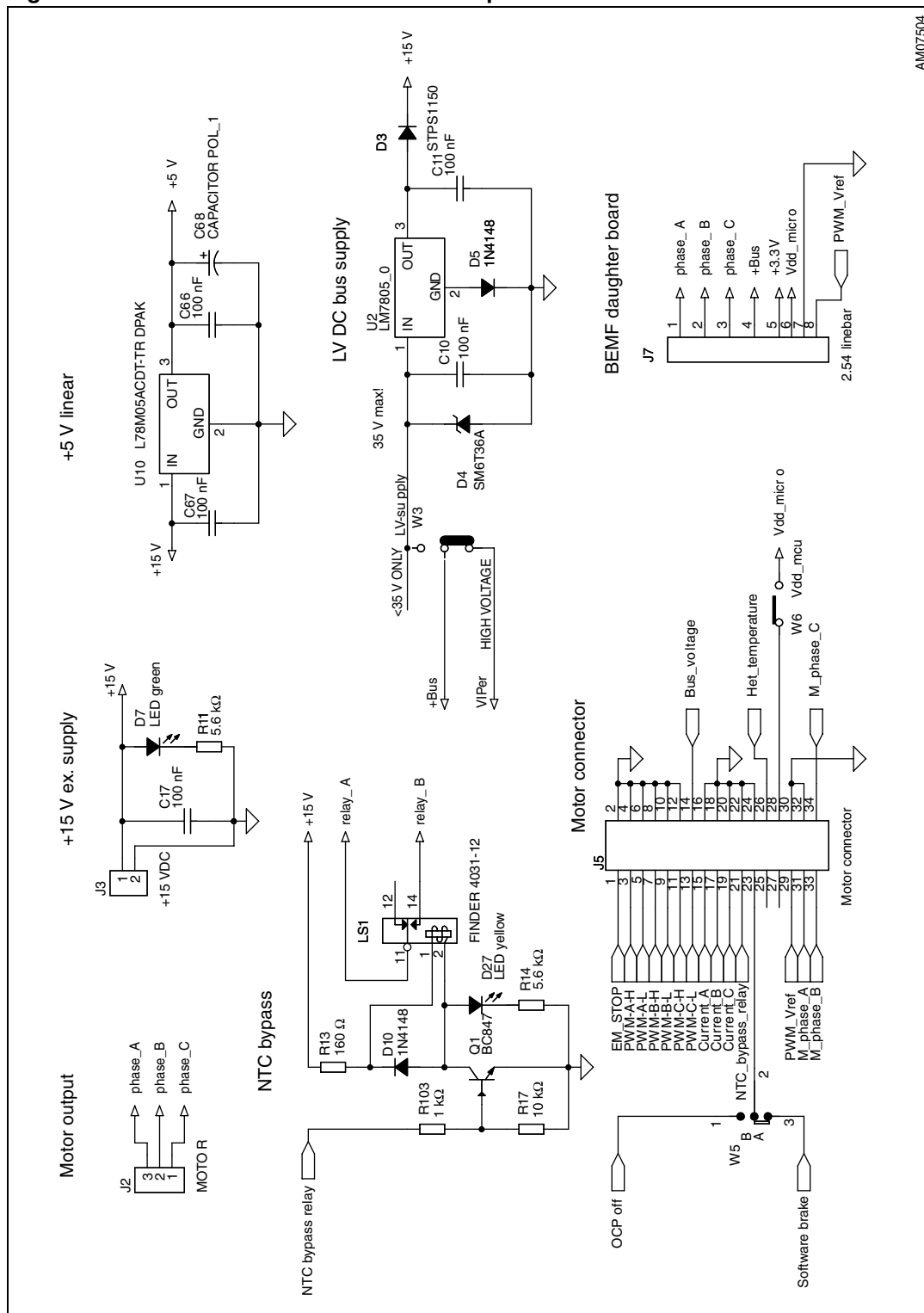
Figure 6. STEVAL- IHM023V2 schematic - part 4
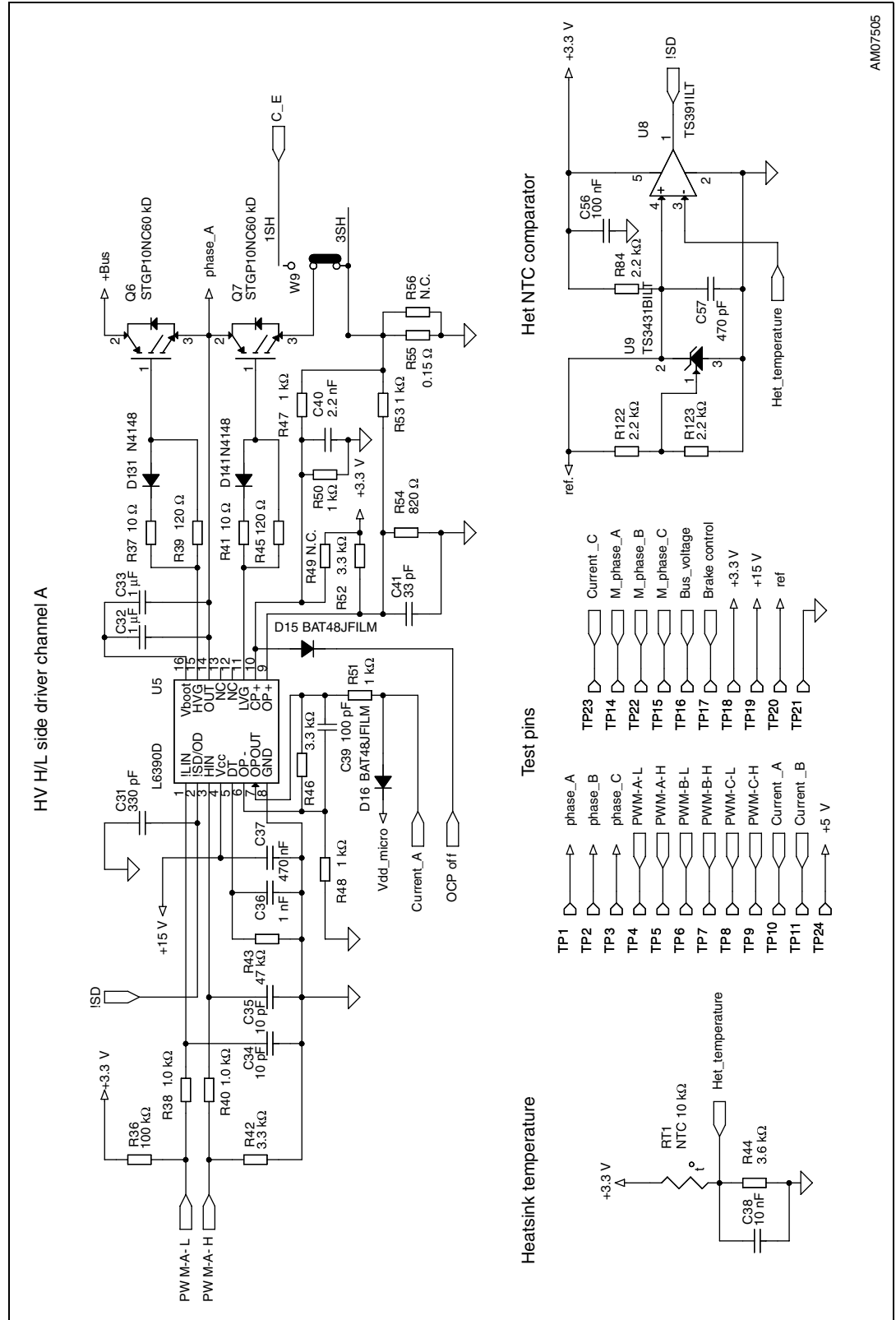
Figure 7.   STEVAL- IHM023V2 schematic - part 5
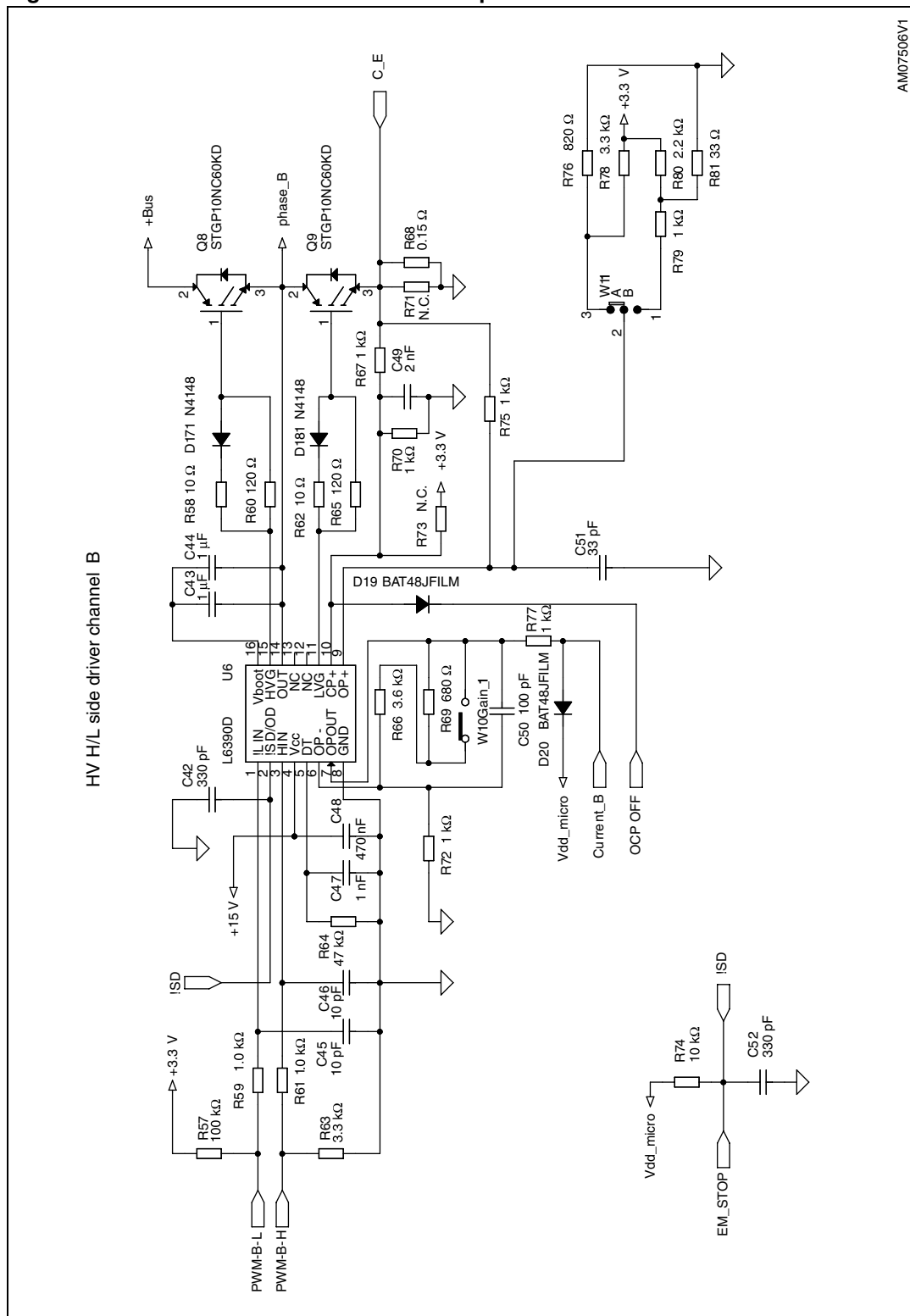
Figure 8.   STEVAL- IHM023V2 schematic - part 6
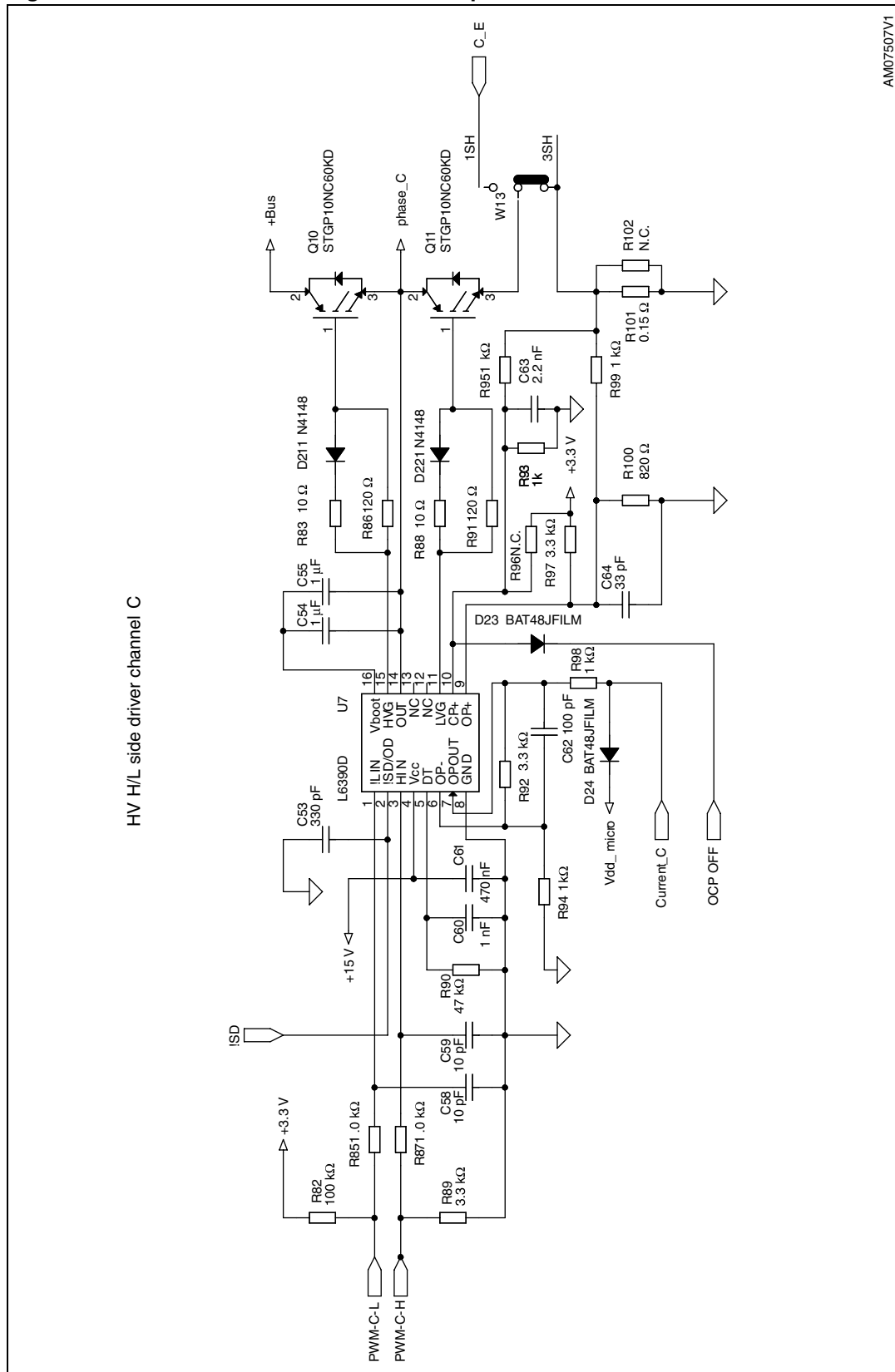
3.3 Circuit description

3.3.1 Power supply

The power supply in the STEVAL-IHM023V2 demonstration board is implemented as a multifunctional block which allows to supply the inverter in all ranges of input voltage up to 285 VAC or 400 VDC. If the input AC voltage does not surpass 145 VAC, it is possible to apply the input voltage doubler, this is done by shorting the W14 jumper. This configuration almost doubles the input AC voltage to a standard level and allows to evaluate the motor control application with a low level of input AC voltage.

For high-voltage applications it is necessary to set W3 jumpers to position "HIGH VOLTAGE", the auxiliary power supply for supplying all active components on the demonstration board is implemented as a buck converter based on the U6 VIPer16L which works with fixed frequency 60 kHz. The output voltage of the converter is +15 VDC voltage which is fed into the L6390 drivers as supply voltage as well as into the linear regulator L78L33ACD and L78M05ACDT. The linear regulator provides +3.3 VDC and +5 VDC for supplying the operational amplifiers and other related parts placed on the demonstration board. The selection of supply voltage for hardware peripherals placed on the board is done with jumper W1. In the "3.3 V" position the supply voltage selected is +3.3 V and in the "5 V" position it is +5 V. Thanks to jumper W6, it is possible to supply the connected MCU driving board with related supply voltage. In this case, the maximal consumptive current of the MCU unit has not overreached 50 mA. Please refer to the ST released VIPer16LD datasheet for further information on this concept.

For low-voltage applications, the step-down converter must be disabled by setting the W3 jumper to position "<35 V ONLY". In this case, the other linear regulator, L7815, is connected directly on the bus line, to provide auxiliary voltage + 15 VDC.

Note: *Please note that the voltage range in this kind of application must be in the range + 18 VDC to + 35 VDC.*

For low-voltage DC motor applications which require a voltage lower than + 18 VDC, a dual supply mode can be used. Voltage on the input connector is normally linked through power switches to the motor and an external auxiliary voltage is fed through the J3 connector from an external power source. The voltage of the external power supply used must be in the range + 14.8 V to + 15.5 V with maximal consumption current 0.5 A.

The information regarding the value of the supply bus voltage on the main filtering capacitors is sensed with the voltage divider built around R2, R4, and R7 and is fed into the dedicated control unit through the J5 connector. The proper voltage partitioning for applied resistors values is 0.0075.

The presence of +15 VDC on the board is indicated with green LED D7. For a better understanding of the concept, *Figure 9* describes the power supply in a block diagram.

Figure 9.   Power supply block diagram
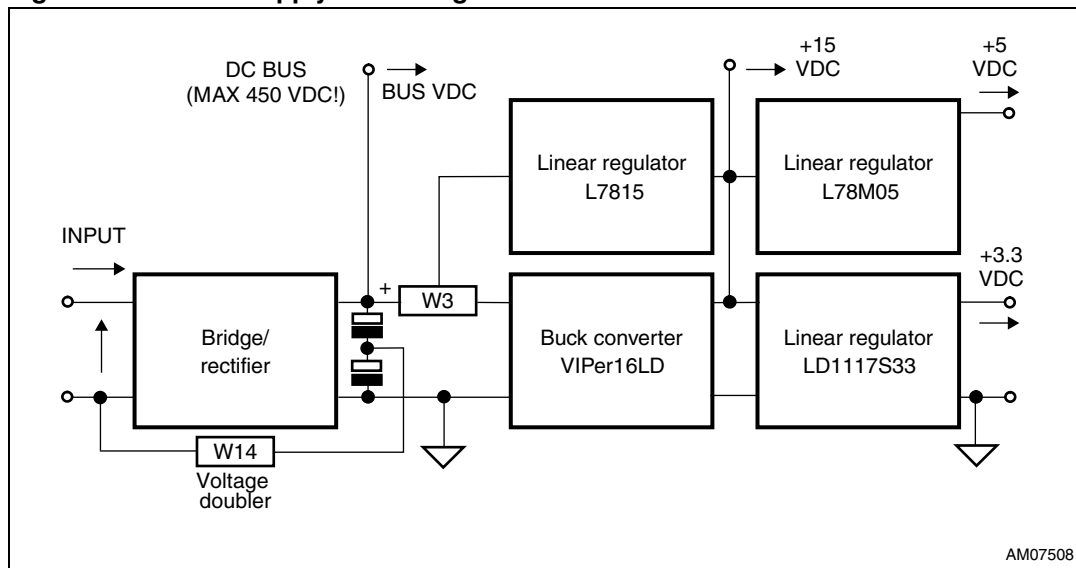
3.3.2   Inrush limitation

The input stage of the demonstration board is provided with the 10 Ω NTC resistor to eliminate input inrush current peak during charging of the bulk capacitors. To achieve a higher efficiency of the inverter, it is possible to bypass the NTC after the startup phase. The NTC bypass signal is provided from the MCU board through the J5 connector. The yellow D27 LED diode is turned off when the inrush NTC is bypassed.

The STEVAL-IHM023V2 demonstration board contains only a basic EMI filter based on X2 and Y2 capacitors. The main function of this demonstration board is as a universal testing platform. For this reason, the EMI filter is not able to absorb EMI distortion coming from the inverter for all ranges of the applications used and the design of the filter is up to the user. The EMI filter must be designed according to the motor and final target applications used. The heatsink itself is connected to the earth pin in the input J1 connector. If the demonstration board is used only with DC voltage, it is recommended to connect the heatsink to a negative voltage potential - common ground.

3.3.3   Brake function

The hardware brake feature has been implemented on the STEVAL-IHM023V2 demonstration board. This feature connects the external resistive load applied to the J6 connector to the bus to eliminate overvoltage generated when the motor acts as a generator. Such a connected load must be able to dissipate all motor generated energy. The brake feature functions automatically in the case of bus overvoltage. Voltage on the bus is sensed through the voltage divider with resistors R23, R24, and R31 and compared to the voltage reference built around the Zener diode D26. The brake dummy load is switched on when voltage on the bus reaches 440 VDC and is switched off when the voltage falls below 420 VDC. This voltage level has been chosen to be fully compliant with the possible use of front-end PFC stage. Another possibility, to activate the brake dummy load, is to use the external signal coming through the J5 motor connector (PWM_Brake signal) from the connected MCU board. This function is active with the jumper W5 in position "R_BRAKE". The brake threshold levels can be modified by calculating R23, R24, and R34 new values. The D28 red LED diode indicates acting brake switch.

3.3.4 Gate driving circuit

The gates of the switches of the IGBT used are controlled by the L6390D drivers. Please refer to the L6390 datasheet for a detailed analysis of the driver parameters.

Figure 10 shows the correct driving of the IGBT. As can be seen, the charging current for the IGBT is different compared to the discharging current due to the diode used. The configuration used provides the best trade-off between efficiency and EMI distortion.

Thanks to the high-performance L6390 driver, the deadtime insertion between the HVG and LVG outputs is hardware-guaranteed. In this case, considering the value of the deadtime resistors used to be 47 kΩ, the DT of about 600 ns is applied on the outputs in case:

● The deadtime is not present on HIN and LIN inputs signals.
● The deadtime present on HIN and LIN inputs is less than hardware-set DT.

On the contrary, the hardware-set deadtime is not the sum of the deadtime present on the outputs between LVG and HVG if the deadtime present on the HIN and LIN inputs signals is higher than the hardware-set deadtime.

Figure 10. Gate driving network
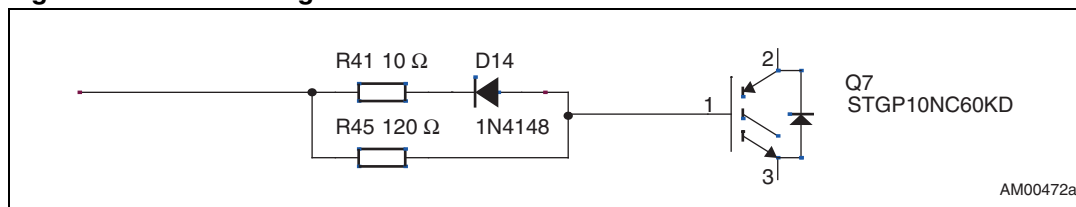
3.3.5 Overcurrent protection

Hardware overcurrent protection (OCP) is implemented on the board. This feature takes full advantage of the L6390 driver where an internal comparator is implemented. Thanks to the internal connection between the comparator output and shutdown block, the intervention time of the overcurrent protection is extremely low, ranging slightly above 200 ns. Please see *Figure 11* below for details of the OCP.

Considering that the overcurrent protection acts as soon as the voltage on the CP+ pin of the L6390 rises above (approximately equal to) 0.53 V, and considering the default value of the shunt resistor, it follows that the default value for the maximum allowed current is equal to:

Equation 1

$$I_{SHUNT\_MAX} = \frac{V_{REF}}{R_{SHUNT}} \times \left(1 + \frac{R1}{R2}\right)$$

with the default values this gives:

$$I_{SHUNT\_MAX} = 7 \text{ A}$$

Figure 11. Overcurrent protection
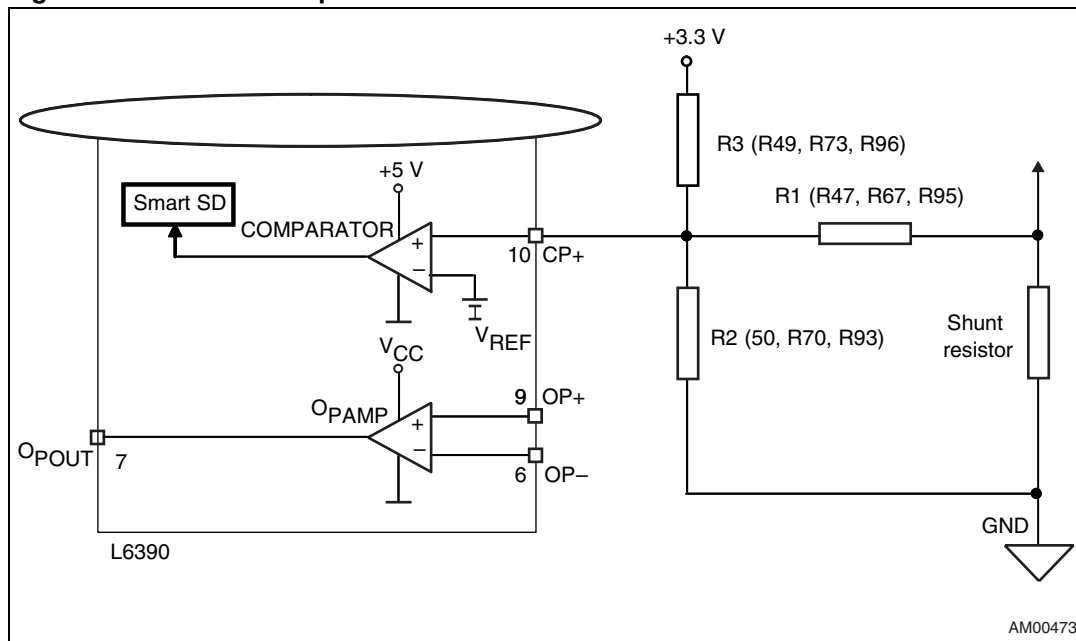
The overcurrent protection can be disabled with software if the W5 jumper is set to the "OCP OFF" position. This may be necessary and is often useful when the user decides to make the brake operate by turning on the three low-side switches. In fact, if the motor acts as a generator, it's necessary to protect the hardware, preventing the bus voltage from exceeding a safety threshold. In addition to dissipating the motor energy on a brake resistor, it's possible to short the motor phases, preventing the motor current from flowing through the bulk capacitors.

Please note that with disabling of the OCP, the demonstration board is not protected against any overcurrent event.

3.3.6 Current sensing amplifying network

The STEVAL-IHM023V2 motor control demonstration board can be configured to run in various current reading configuration modes:

● Three-shunt configuration - suitable for the use of field oriented control (FOC)

● Single-shunt configuration - suitable for the use of FOC in a single-shunt configuration

● Single-shunt six-step configuration - suitable for scalar control

Configuration with a shunt resistor, where voltage amplified with an operational amplifier is sensed, was chosen as the current sensing networks. Single-shunt configuration requires a single op amp, three-shunt configuration requires three op amps. Just for compatibility purposes, one of them is common to both basic configurations.

The configuration jumpers W10 and W11 allow the user to set the common op amp to achieve the compatibility between single-shunt six-step configuration (suitable for scalar control) and three-shunt or single-shunt FOC current reading configuration.

Three-shunt FOC or single-shunt FOC current reading configuration

The details of the three-shunt current sensing reading configuration are shown in *Figure 12*. In this configuration, the alternating signal on the shunt resistor, with positive and negative

values, must be converted to be compatible with the single positive input of the microcontroller A/D converter used to read the current value. This means that the op amp must be polarized in order to obtain a voltage on the output that makes it possible to measure the symmetrical alternating input signal.

The op amp is used in follower mode with the gain of the op amp set by resistor r and R:

Equation 2

$$G = \frac{R + r}{r}$$

It is possible to calculate the voltage on the output of the op amp, OP OUT - V_{OUT}, as the sum of a bias, V_{BIAS}, and a signal, V_{SIGN}, component equal to:

Equation 3

$$V_{OUT} = V_{SIGN} + V_{BIAS}$$

$$V_{BIAS} = \frac{3.3}{\left(\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}\right) \times R3} \times G$$

$$V_{SIGN} = \frac{I \times R_{SHUNT}}{\left(\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}\right) \times R1} \times G$$

Total gain of the circuit including the resistors' divider is equal to:

Equation 4

$$G_{TOT} = \frac{V_{SIGN}}{V_{IN}} = \frac{V_{SIGN}}{R_{SHUNT \times I}}$$

with the default values this gives:

- V_{BIAS} = 1.7 V
- G = 4.3
- G_{TOT} = 1.7
- Maximum current amplifiable without distortion is 6.5 A.

Please observe that the user can modify the max. current value by changing the values of the shunt resistors.

Figure 12. Three-shunt configuration
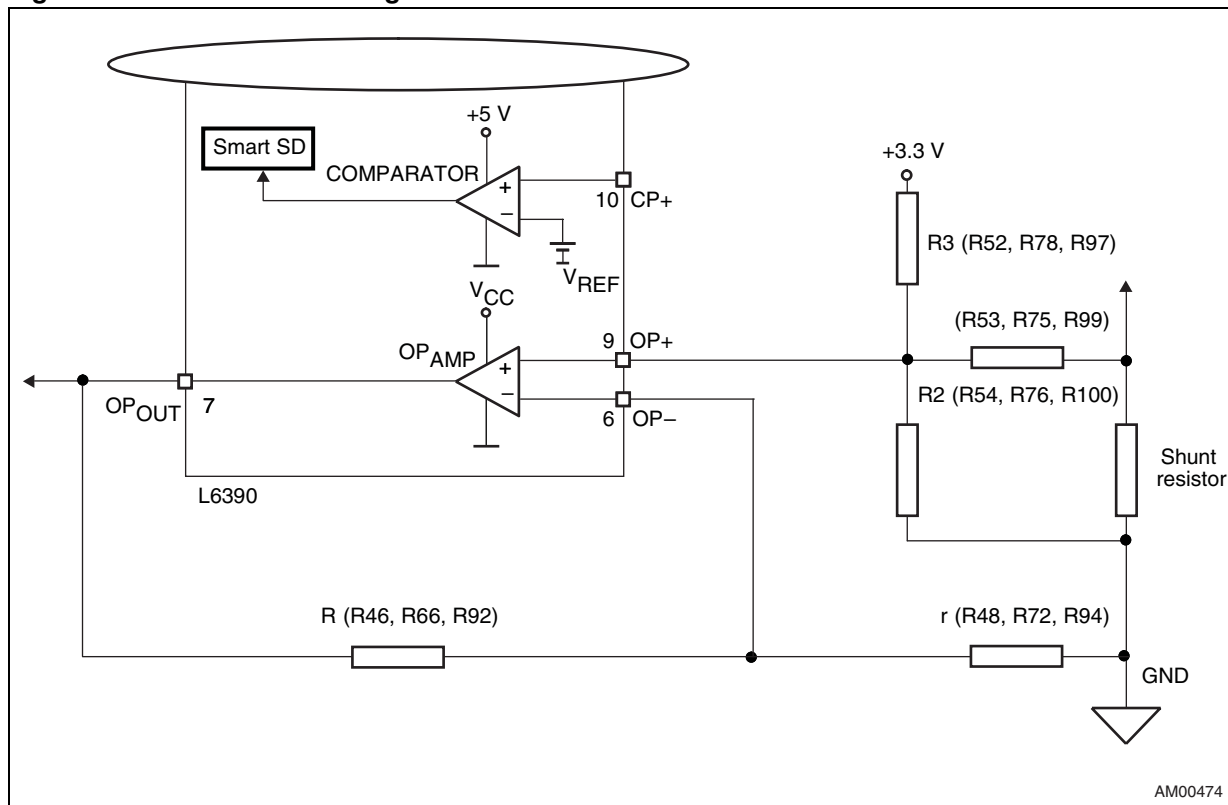
For previously mentioned FOC configurations it is necessary to set the proper gain by applying the W10 jumper and by applying the W11 jumper to the dash marked position.

Six-step (block commutation) current reading configuration

In case of six-step (also called block commutation) current control, only two of the motor phases conduct current at the same time. Therefore, it is possible to use only one shunt resistor placed on the DC link to measure the motor phase current. Moreover, as the current is always flowing on the shunt resistor in the same direction, only positive current must be measured, and in this case, the amplifying network needs to be properly designed. The details of single-shunt current sensing reading configuration are shown in *Figure 13*. In this configuration, the current sampling is done only when the value on the shunt resistor is positive. The only positive value read on the shunt resistor allows the setting of a higher gain for the op amp than the one set in the three-shunt reading mode.

The op amp is used in follower mode with the gain of the op amp set by resistor r and R:

Equation 5

$$G = \frac{R + r}{r}$$

It is possible to calculate the voltage on the output of the op amp, OP OUT V_{OUT}, as the sum of a bias, V_{BIAS}, and a signal, V_{SIGN}, component equal to:

Equation 6

$$V_{OUT} = V_{SIGN} + V_{BIAS}$$

$$V_{BIAS} = \frac{3.3 \times \dfrac{R1}{R1 + R2}}{\left(\dfrac{1}{R3} + \dfrac{1}{R1 + R2} + \dfrac{1}{R4}\right) \times R4} \times G$$

$$V_{SIGN} = \frac{I \times R_{SHUNT} \times R2}{R1 + R2} + \frac{I \times R_{SHUNT} \times R1}{\left(\dfrac{1}{R3} + \dfrac{1}{R1 + R2} + \dfrac{1}{R4}\right) \times (R1 + R2)^2} \times G$$

Total gain of the circuit with the resistors' divider is equal to:

Equation 7

$$G_{TOT} = \frac{V_{SIGN}}{V_{IN}} = \frac{V_{SIGN}}{R_{SHUNT} \times I}$$

with the default values this gives:

- V_{BIAS} = 1.7 V
- G = 4.98
- G_{TOT} = 2.53
- Maximum current amplifiable without distortion is 6.5 A.

Please observe that the user can modify the max. current value by changing the values of the shunt resistors.

Figure 13. Six-step current sensing configuration
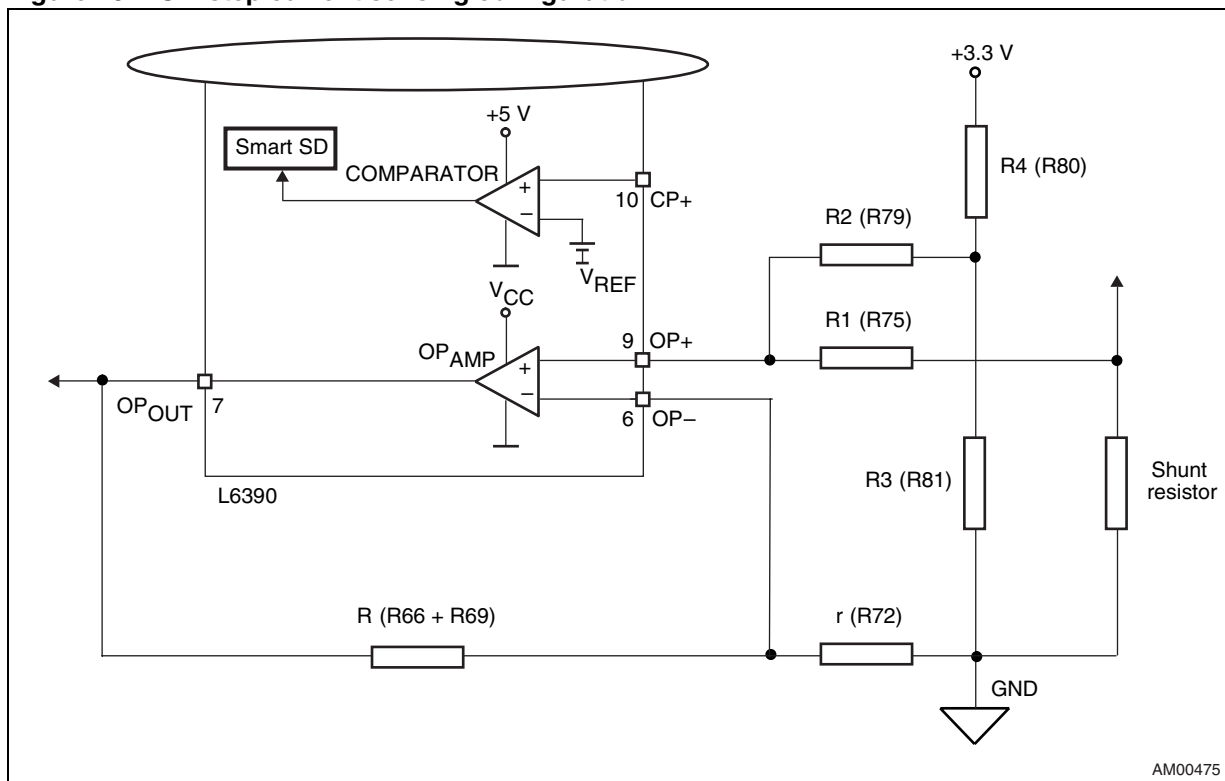
For six-step configurations it is necessary to set the proper gain by removing the W10 jumper and applying the W11 jumper to the not marked position.

In *Table 1* the mentioned setting of gain jumpers, for all possible current reading configurations, is shown.

Table 1.   Current reading configuration

Jumper	Gain configuration	
	Six-step current reading	**FOC current reading**
W10	Not present	Present
W11	Not marked position	"-" position

3.3.7   The tachometer and Hall/encoder inputs

Both the tachometer and Hall/encoder inputs have been implemented on the board. In the case of using a Hall or encoder sensor, the W4 jumper must be connected and the W7 jumper disconnected. The W16 jumper set to dash marked "-" position allows to supply any connected Hall sensor with +5 VDC supply voltage. Setting the W16 jumper to not marked position supplies the Hall sensor with the same supply voltage as other hardware peripherals (+3.3 VDC or +5 VDC depend on the W1 jumper). The U11 Hex Schmitt inverter is used as the voltage level shifter for the connected Hall sensor.

In the case of using a tachometer, the W4 jumper must be disconnected and the W7 jumper connected.This feature allows to test and evaluate a wide spectrum of various motors.

3.3.8   Temperature feedback and overtemperature protection

Hardware overtemperature protection is implemented on the STEVAL-IHM023V2 demonstration board. This feature fully protects the switches against damage when temperature on the junction of the switches overruns a defined value. The temperature is sensed with an NTC resistor placed on the heatsink. The measured signal is fed through the J5 motor connector to the MCU control unit and can be read with an A/D converter. The signal is also fed to comparator U8 where it is compared with a 2.5 V reference voltage which is built around the U9 precision reference Tl431. The output signal of the comparator U8 is fed to the SD pin of the L6390D drivers to stop the commutation of the connected motor. With the value of the NTC resistor used equal to 10 kΩ, and resistor R44 equal to 3.6 kΩ the shutdown temperature is around 70 °C.

Figure 14.   NTC placement on the heatsink
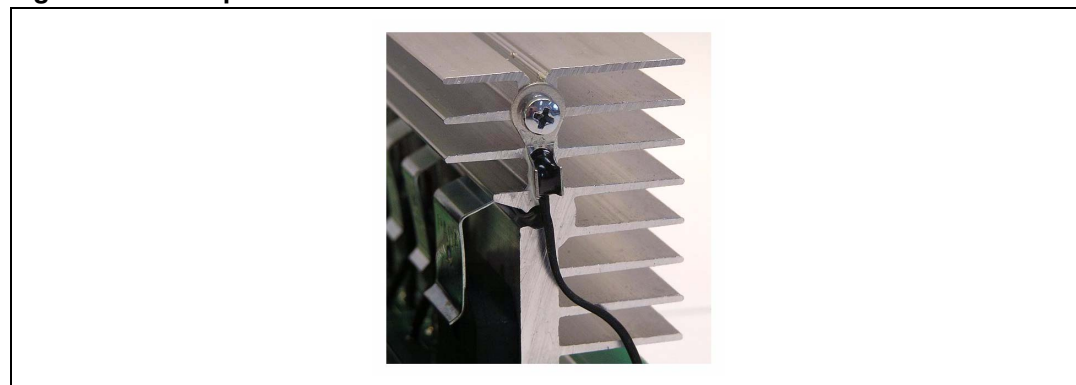
4 Hardware setting of the STEVAL-IHM023V2

The STEVAL-IHM023V2 demonstration board can be driven through the J5 motor control connector by various MCU control units released by STMicroelectronics which feature a unified 34-pin motor connector (STM3210B-EVAL, STM32F100-EVAL, STEVAL-IHM022v1, STM32F10E-EVAL, etc.). The demonstration board is suitable for both field oriented and scalar controls. In particular, it can handle output signal conditioning for different types of speed and/or position feedback sensors (such as tachometer, Hall sensors, and quadrature encoders) and different current sensing topologies (single-shunt resistor placed on DC bus or three-shunt resistors placed in the three inverter legs).

4.1 Hardware settings for six-step (block commutation) control of BLDC motors

To drive any motor, the user must ensure that:

● The motor control demonstration board is driven by a control board that provides the six output signals required to drive the three-phase power stage

● The motor is connected to the J2 motor output connector

● If using an encoder or Hall sensor connection, it is connected to connector J4

● If using a tachometer connection, it is connected to connector J8

● If using the brake control feature, connect a dissipative power load to J6 connector

Table 2 below shows the jumper settings for any BLDC high-voltage motors in six-step (block commutation) control. Please confirm that the demonstration board input voltage is in the range of 125 VDC to 400 VDC or 90 VAC to 285 VAC. If the voltage doubler is applied, the input voltage must be in the range of 65 VAC to 145 VAC.

Table 2.   Jumper settings for high-voltage BLDC motor in six-step control

Jumper	Settings for any HV motor in six-step control
W1	"3.3 V" position for VDD = 3.3 V
	"5 V" position for VDD = 5 V
W3	"HIGH VOLTAGE" position
W4	Present for Hall sensor or encoder
	Not present for connected tachometer
W5	"R_BRAKE" position for software handling of resistive brake (if any)
	"OCP OFF" position for software handling of overcurrent protection disabling
W6	Present for supplying stage from IHM023V2 (max. 50 mA)
W7	Present for connected tachometer
	Not present for connected Hall sensor or encoder
W9	Single-shunt
W10	Not present
W11	Not marked position

Table 2.   **Jumper settings for high-voltage BLDC motor in six-step control (continued)**

Jumper	Settings for any HV motor in six-step control
W13	Single-shunt
W14	Present for voltage doubler
	Not present for standard voltage range
W16	Dash mark position of Hall/encoder with VDD
	Not marked position for supplying Hall/encoder with +5 V

Table 3 shows jumper settings for a low-voltage BLDC motor. Please confirm that the input voltage (mains voltage) of the demonstration board in this case is in the range of 18 VDC to 35 VDC. If it is necessary to supply the motor with a voltage lower than 18 VDC, please remove the W3 jumper and connect the auxiliary voltage to the J3 connector. This configuration is called "dual supply configuration".

In this configuration it may be necessary to modify R2, R4, and R7 resistors according to applied supply voltage.

Table 3.   **Jumper settings for low-voltage BLDC motor in six-step control**

Jumper	Settings for any HV motor in six-step control
W1	"3.3 V" position for V_{DD} = 3.3 V
	"5 V" position for V_{DD} = 5 V
W3	"<35 V ONLY" position
W4	Present for Hall sensor or encoder
	Not present for connected tachometer
W5	"R_BRAKE" position for software handling of resistive brake (if any)
	"OCP OFF" position for software handling of overcurrent protection disabling
W6	Present for supplying stage from IHM023V2 (max. 50 mA)
W7	Present for connected tachometer
	Not present for connected Hall sensor or encoder
W9	Single-shunt
W10	Not present
W11	Not marked position
W13	Single-shunt
W14	Present for voltage doubler
	Not present for standard voltage range
W16	Dash mark position of Hall/encoder with V_{DD}
	Not marked position for supplying of Hall/encoder with +5 V

4.2 Hardware settings for "Field Oriented Control" (FOC) in single-shunt topology current reading configuration

To drive any motor, the user must ensure that:

● The motor control demonstration board is driven by a control board that provides the six output signals required to drive the three-phase power stage
● The motor is connected to the J2 motor output connector
● If using an encoder or Hall sensor connection, it is connected to connector J4
● If using a tachometer connection, it is connected to connector J8
● If using the brake control feature, connect a dissipative power load to J6 connector

Table 4 below shows the jumper settings for any high-voltage motors in single-shunt FOC configuration. Please confirm that the demonstration board input voltage is in the range of 125 VDC to 400 VDC or 90 VAC to 285 VAC. If the voltage doubler is applied, the input voltage must be in the range of 65 VAC to 145 VAC.

Table 4. Jumper settings for high-voltage PMAC or generic AC motor in single-shunt FOC control

Jumper	Jumper settings for FOC of HV PMSM, BLDC or AC IM in single-shunt configuration for current reading
W1	"3.3 V" position for V_{DD} = 3.3 V
	"5 V" position for V_{DD} = 5 V
W3	"HIGH VOLTAGE" position
W4	Present for Hall sensor or encoder
	Not present for connected tachometer
W5	"R_BRAKE" position for software handling of resistive brake (if any)
	"OCP OFF" position for software handling of overcurrent protection disabling
W6	Present for supplying control stage from IHM023v2 connector with V_{DD} (max. 50 mA)
W7	Present for connected tachometer
	Not present for connected Hall sensor or encoder
W9	Single-shunt
W10	Present
W11	Dash mark position
W13	Single-shunt
W14	Not present
W16	Dash marked position for supplying of Hall/encoder with V_{DD}
	Not marked position for supplying of Hall/encoder with +5 V

Table 5 shows jumper settings for a low-voltage BLDC motor in single-phase FOC current control. Please confirm that the input voltage (mains voltage) of the demonstration board in this case is in the range of 18 VDC to 35 VDC. If it is necessary to supply the motor with a voltage lower than 18 VDC, please remove the W3 jumper and connect the auxiliary voltage to the J3 connector.

In this configuration it may be necessary to modify R2, R4, and R7 resistors according to applied supply voltage.

Table 5.   Jumper settings for low-voltage BLDC motor in single-shunt FOC control

Jumper	Settings for any LV BLDC motor in single-shunt FOC control
W1	"3.3 V" position for V_{DD} = 3.3 V
	"5 V" position for V_{DD} = 5 V
W3	"<35 V ONLY" position
W4	Present for Hall sensor or encoder
	Not present for connected tachometer
W5	"R_BRAKE" position for software handling of resistive brake (if any)
	"OCP OFF" position for software handling of overcurrent protection disabling
W6	Present for supplying control stage from IHM023v2 connector with V_{DD} (max. 50 mA)
W7	Present for connected tachometer
	Not present for connected Hall sensor or encoder
W9	Single-shunt
W10	Present
W11	Dash mark position
W13	Single-shunt
W14	Not present
W16	Dash marked position for supplying of Hall/encoder with V_{DD}
	Not marked position for supplying of Hall/encoder with +5 V

4.3   Hardware settings for FOC in three-shunt configuration

To drive any motor, the user must ensure that:

● The motor control demonstration board is driven by a control board that provides the six outputs signals required to drive the three-phase power stage

● The motor is connected to the J4 motor output connector

● If using an encoder or Hall sensor connection, it is connected to connector J5

● If using a tachometer connection, it is connected to connector J6

● If using the brake control feature, connect a dissipative power load to J7 connector

Table 6 below shows the jumper settings for three-shunt based FOC of any high-voltage PMSM, BLDC, or AC IM motor. Please confirm that the demonstration board input voltage is in the range of 125 VDC to 400 VDC or 90 VAC to 285 VAC. If the voltage doubler is applied, the input voltage must be in the range of 65 VAC to 145 VAC.

Table 6.   Jumper settings for FOC of HV PMSM, BLDC, or AC IM in three-shunt configuration for current reading

Jumper	Jumper settings for FOC of HV PMSM, BLDC or AC IM in three-shunt configuration for current reading
W1	"3.3 V" position
W3	"HIGH VOLTAGE" position
W4	Present for Hall sensor or encoder
	Not present for connected tachometer
W5	"R_BRAKE" position for software handling of resistive brake (if any)
	"OCP OFF" position for software handling of overcurrent protection disabling
W6	Present for supplying control stage from IHM023v2 connector with V_{DD} (max. 50 mA)
W7	Present for connected tachometer
	Not present for connected Hall sensor or encoder
W9	Three-shunt
W10	Present
W11	Silk screen marked position
W13	Three-shunt
W14	Not present
W16	Silk screen marked position for supplying Hall/encoder with V_{DD}
	Not marked position for supplying Hall/encoder with +5 V

Table 7 shows jumper settings for three-shunt based FOC of any low-voltage PMSM or BLDC. Please confirm that the input voltage of the demonstration board in this case is in the range of 18 VDC to 35 VDC. If it is necessary to supply the motor with a voltage lower than 18 VDC, please remove the W3 jumper and connect the auxiliary voltage to the J3 connector.

In this configuration it may be necessary to modify R2, R4, and R7 resistors according to the applied supply voltage.

Table 7.   Jumper settings for FOC of LV PMSM or BLDC in three-shunt configuration for current reading

Jumper	Jumper settings for FOC of LV PMSM or BLDC in three-shunt configuration for current reading
W1	"3.3 V" position
W3	"<35 V ONLY" position
W4	Present for Hall sensor or encoder
	Not present for connected tachometer
W5	"R_BRAKE" position for software handling of resistive brake (if any)
	"OCP OFF" position for software handling of overcurrent protection disabling
W6	Present for supplying control stage from IHM023v2 connector with V_{DD} (max. 50 mA)
W7	Present for connected tachometer
	Not present for connected Hall sensor or encoder
W9	Three-shunt
W10	Present
W11	Silk screen marked position
W13	Three-shunt
W14	Not present
W16	Silk screen marked position for supplying Hall/encoder with V_{DD}
	Not marked position for supplying Hall/encoder with +5 V

5   Description of jumpers, test pins, and connectors

The following tables give a detailed description of the jumpers, test pins, and the pinout of the connectors used.

Table 8.   Jumpers description

Jumper	Selection	Description
W1	"3.3 V" position	V_{DD} = 3.3 V
	"5 V" position	V_{DD} = 5 V
W3	"<35 V" ONLY	Linear regulator supplied from DC bus - input supply voltage < 35 VDC
	"HIGH VOLTAGE"	Buck converter supplied from bus
W4	Present	Hall sensor or encoder connected
	Not present	Tachometer connected
W5	"R_BRAKE"	Software brake feature applied
	"OCP OFF"	OCP disabled
W6	Present	Supplying of MCU control board through J5 motor connector with V_{DD}
	Not present	Separated voltage of MCU control board
W7	Present	Tachometer connected
	Not present	Hall sensor or encoder connected
W9	Single-shunt	Any single-shunt configuration
	Three-shunt	Any three-shunt configuration
W10	Present	Gain for any FOC
	Not present	Gain for six-step control
W11	Dash position	Gain for any FOC
	Free position	Gain for six-step control
W13	Single-shunt	Any single-shunt configuration
	Three-shunt	Any three-shunt configuration
W14	Present	Voltage doubler applied (V_{IN} = max. 145 VAC)
	Not present	Standard single-phase range
W16	Dash position	Hall/encoder supplied by V_{DD}
	Free position	Hall/encoder supplied by +5 V

Table 9.   Connector pinout description
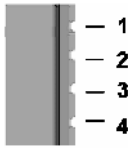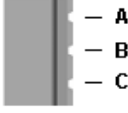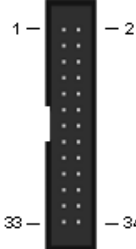
Name	Reference	Description / pinout	
J1		**Supply connector** 1 - PE-earth 2 - PE-earth 3 - L-phase 4 - N-neutral	
J2		**Motor connector** A - Phase A B - Phase B C - Phase C	
J3		**15 V auxiliary supply connector** 1 - GND 2 - +15 VDC	
J4		**Hall sensors/ encoder input connector** 1 - GND 1 - $+V_{DD}$/+5 V 1 - Hall sensor input 1/ encoder A+ 1 - Hall sensor input 2/ encoder B+ 1 - Hall sensor input 3/ encoder Z+	
J5		**Motor control connector**	
		1 - Emergency stop	2 - GND
		3 - PWM-1H	4 - GND
		5 - PWM-1L	6 - GND
		7 - PWM-2H	8 - GND
		9 - PWM-2L	10 - GND
		11 - PWM-3H	12 - GND
		13 - PWM-3L	14 - HV bus voltage
		15 - Current phase A	16 - GND
		17 - Current phase B	18 - GND
		19 - Current phase C	20 - GND
		21 - NTC bypass relay	22 - GND
		23 - Dissipative brake PWM	24 - GND
		25 - +V power	26 - heatsink temperature
		27 - PFC sync.	28 - Vdd_m
		29 - PWM V_{REF}	30 - GND
		31 - Measure phase A	32 - GND
		33 - Measure phase B	34 - measure phase C

Table 9.   Connector pinout description (continued)
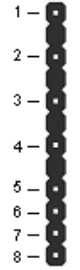
Name	Reference	Description / pinout
J6		**Dissipative brake** 1 - Bus voltage 2 - Open collector
J7		**BEMF daughterboard connector** 1 - Phase A 2 - Phase B 3 - Phase C 4 - Bus voltage 5 - 3.3 VDC 6 - V_{DD}_micro 7 - GND 8 - PWM V_{REF}
J8		**Tachometer input connector for AC motor speed loop control** 1 - Tachometer bias 2 - Tachometer input

Table 10.   Testing pins description

Number	Description
TP1	Output phase A
TP2	Output phase B
TP3	Output phase C
TP4	PWM - phase A - low-side
TP5	PWM - phase A - high-side
TP6	PWM - phase B - low-side
TP7	PWM - phase B - high-side
TP8	PWM - phase C - low-side
TP9	PWM - phase C - high-side
TP10	Current sensed in phase A
TP11	Current sensed in phase B
TP23	Current sensed in phase C
TP13	Sensed tachometer/encoder/Hall signal A
TP14	Sensed encoder/Hall signal B
TP15	Sensed encoder/Hall signal Z
TP16	Voltage on bus divider - bus voltage information
TP17	Brake status - brake active in low state

Table 10.   Testing pins description (continued)

Number	Description
TP18	3.3 VDC
TP19	15 VDC
TP20	Reference voltage 2.5 V for overtemperature protection
TP21	GND
TP24	5 VDC

6   Connector placement

A basic description of the placement of all connectors on the board is visible in *Figure 15*.

Figure 15.   STEVAL-IHM023V2 connectors placement
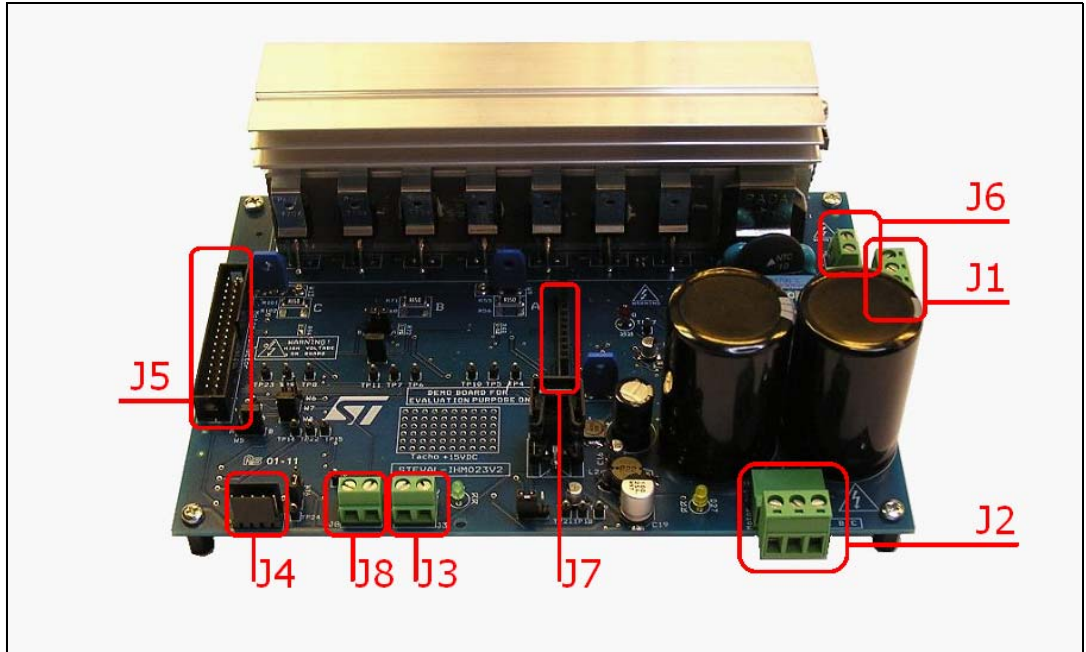
7 Bill of material

A list of components used to build the demonstration board is shown in *Table 11*. The majority of the active components used are available from STMicroelectronics.

Table 11.   Bill of material

Quan-tity	Reference	Value / generic part number	Package / class	Manufacturer
2	C1, C5	2.2 nF/Y1	Y1 safety CAP - 4.7 nF	Murata Manufacturing Co., Ltd.
2	C2, C3	1200 µF/250 V	Elyt. capacitor, RM 10 mm, 30 x 45, 105 °C	Panasonic
1	C13	N.C.		
1	C14	220 nF/25 V	Capacitor, SMD 0805	
1	C15	3.3 µF/450 V		Panasonic
1	C16	1 µF/50 V	Elyt. capacitor, SMD 4 x 4	Panasonic
1	C19	100 µF/25 V	Elyt. capacitor, SMD 8 x 8	Panasonic
9	C66, C67, C71, C72, C73, C26, C24, C27, C28, C6, C7, C17, C18, C10, C11	100 nF/25 V	Capacitor, SMD 0805	
3	C69, C70, C74	10 pF/25 V	Capacitor, SMD 0805	
1	C25	4.7 µF/25 V	Elyt. capacitor, SMD 4 x 4	Panasonic
1	C29	2.2 nF/25 V	Capacitor, SMD 0805	
1	C30	4.7 nF/25 V	Capacitor, SMD 0805	
3	C31, C42, C53	330 pF/25 V	Capacitor, SMD 0805	
6	C32, C33, C43, C44, C54, C55	1 µF/50 V	Capacitor, SMD 1206; 50 V	
6	C34, C35, C45, C46, C58, C59	10 pF/25 V	Capacitor, SMD 0805	
4	C36, C47, C60, C75	1 nF/25 V	Capacitor, SMD 0805	
3	C37, C48, C61	470 nF/25 V	Capacitor, SMD 0805	
3	C39, C50, C62	100 pF/25 V	Capacitor, SMD 0805	
1	C4	150 nF/X2	Foil X2 capacitor, RM 22.5 mm	Arcotronics
3	C40, C49, C63	2.2 nF/25 V	Capacitor, SMD 0805	
3	C41, C51, C64	33 pF/25 V	Capacitor, SMD 0805	
1	C52	330 pF/25 V	Capacitor, SMD 0805	
1	C65	100 pF/25 V	Capacitor, SMD 0805	
1	C56	100 nF/25 V	Capacitor, SMD 0805	
1	C57	470 pF/25 V	Capacitor, SMD 0805	

Table 11.   Bill of material (continued)

Quan-tity	Reference	Value / generic part number	Package / class	Manufacturer
1	C12	47 nF/25 V	Capacitor, SMD 0805	
2	C8, C68	22 µF/6.3 V	Elyt. capacitor, SMD 4 x 4	Panasonic
2	C9, C38	10 nF/25 V	Capacitor, SMD 0805	
1	RT1	10 kΩ	NTC	EPCOS B57703M103G40
1	VR1	10 Ω	NTC	EPCOS B57364S100M
3	R1, R3, R6	100 kΩ	Resistor, SMD 1206	
1	R10	13 kΩ	Resistor, SMD 0805, 1%	
4	R11, R14, R120, R121	5.6 kΩ	Resistor, SMD 0805	
1	R12	N.C.		
1	R13	160 Ω	Resistor, SMD 1206	
9	R112, R113, R114, R115, R116, R117, R109, R110, R111	4.7 kΩ	Resistor, SMD 0805	
1	R18	6.8 kΩ	Resistor, SMD 0805	
2	R19, R108	N.C.		
4	R2, R4, R23, R24	470 kΩ	Resistor, SMD 1206, 1%	
3	R21, R107, R106	220 Ω	Resistor, SMD 0805	
6	R22, R27, R20, R33, R74, R17	10 kΩ	Resistor, SMD 0805	
1	R25	560 Ω	Resistor, SMD 0805	
1	R32	9.1 kΩ	Resistor, SMD 0805, 1%	
1	R26	1 kΩ	Resistor, SMD 0805, 1%	
3	R28, R122, R123	2.2 kΩ	Resistor, SMD 0805	
1	R29	100 Ω	Resistor, SMD 0805	
1	R30	15 kΩ	Resistor, SMD 0805	
1	R31	27 kΩ	Resistor, SMD 0805, 1%	
1	R34	12 kΩ	Resistor, SMD 0805, 1%	
4	R35, R36, R57, R82	100 kΩ	Resistor, SMD 0805	
4	R37, R41, R58, R62	10 Ω	Resistor, SMD 0805	
6	R38, R59, R85, R40, R61, R87	1 kΩ	Resistor, SMD 0805, 1%	
4	R39, R45, R60, R65	120 Ω	Resistor, SMD 0805	
3	R42, R63, R89	3.3 kΩ	Resistor, SMD 0805	
3	R43, R64, R90	47 kΩ	Resistor, SMD 0805, 1%	
1	R44	3.6 kΩ	Resistor, SMD 0805, 1%	

Table 11.   Bill of material (continued)

Quan-tity	Reference	Value / generic part number	Package / class	Manufacturer
3	R46, R66, R92	3.3 kΩ	Resistor, SMD 0805, 1%	
1	R49	N.C.		
2	R5, R9	120 Ω	Resistor, SMD 0805	
3	R52, R97, R78	3.3 kΩ	Resistor, SMD 0805, 1%	
3	R54, R76, R100	820 Ω	Resistor, SMD 0805, 1%	
3	R55, R71, R101	0.15 Ω	Resistor, SMD 2512, 1%, 2 W	
3	R56, R68, R102	N.C.		
6	R67, R70, R75, R79, R50, R53	1 kΩ	Resistor, SMD 0805, 1%	
1	R69	680 Ω	Resistor, SMD 0805, 1%	
1	R7	7.5 Ω	Resistor, SMD 0805, 1%	
6	R72, R48, R47, R77, R51, R98	1 kΩ	Resistor, SMD 0805, 1%	
1	R73	N.C.		
1	R8	51 kΩ	Resistor, SMD 0805, 1%	
1	R80	2.2 kΩ	Resistor, SMD 0805, 1%	
1	R81	33 Ω	Resistor, SMD 0805, 1%	
2	R83, R88	10 Ω	Resistor, SMD 0805	
1	R104	68 kΩ	Resistor, SMD 0805	
1	R84	2.2 kΩ	Resistor, SMD 0805	
2	R86, R91	120 Ω	Resistor, SMD 0805	
5	R93, R95, R99, R94, R103	1 kΩ	Resistor, SMD 0805, 1%	
1	R96	N.C.		
1	R105	220 kΩ	Resistor, SMD 0805, 1%	
1	L1	47 µH	SMD choke, 0.5 A	Panasonic
1	L2	2.2 mH	SMD choke, 0.25 A	Würth Elektronik
1	D1	KBU6K	Diode bridge, 250 VAC, 8 A	
7	D11, D12, D15, D16, D19, D20, D2, D23, D24	BAT48	Diode, SMD, SOD-323	STMicroelectronics
8	D13, D5, D14, D17, D18, D21, D22, D10	1N4148	Universal diode, SMD, SOD80C	
2	D25, D29	BZX84B13V	Zener diode, SOT23, 13 V	
1	D3	STPS1150	Schottky diode, DO-241AC (SMA)	STMicroelectronics
1	D4	SM6T36	Transil™, JEDEC DO-214AA	STMicroelectronics

Table 11. Bill of material (continued)

Quan-tity	Reference	Value / generic part number	Package / class	Manufacturer
2	D6, D8	STTH1L06	HV diode, SMA	STMicroelectronics
1	D7	LED GREEN	Universal LED 3 mm, 2 mA	
1	D9	BZV55C18SMD	Zener diode, SOD80, 18 V	
1	D27	LED YELLOW	Universal LED 3 mm, 2 mA	
1	D28	LED RED	Universal LED 3 mm, 2 mA	
1	D26	STTH2L06	HV diode, SMA	STMicroelectronics
10	Q1, Q4, Q5, Q12, Q13, Q14, Q15, Q16, Q17, Q18	BC847	NPN transistor, SOT23	
7	Q10, Q11, Q3, Q6, Q7, Q8, Q9	STGP10NC60KD	N-channel IGBT, TO220	STMicroelectronics
1	Q2	BC857B	PNP transistor, SOT23	
1	F1	Holder	Fuse holder 5 x 20 mm, KS21 SW	SCHURTER
1	F1	6.25 A	Fuse 6.25 A Slov., FST06.3, 5 x 20 mm	
1	LS1	Finder 4031-12	Relay 12 VDC	Finder
1	U1	LD1117S33	Linear regulator 3.3 V, SOT223	STMicroelectronics
1	U2	L7815	Linear regulator 15 V, TO-220	STMicroelectronics
1	U3	VIPer16	Smart PWM driver, SO-16	STMicroelectronics
2	U4, U8	TS391	Voltage comparator, SOT23-5	STMicroelectronics
3	U5, U6, U7	L6390	HV low and high-side driver, SO-16	STMicroelectronics
1	U9	TS3431	Voltage reference, SOT23-3L	STMicroelectronics
1	U10	L78M05C	Linear regulator 5 V, DPAK	STMicroelectronics
1	U11	M74HC14	Hex Schmitt inverter SOP	STMicroelectronics
3	TP1, TP2, TP3	N.C.		
18	TP4 - TP24	PCB terminal 1 mm	Test pin	
1	J1	Connector 4P	Connector RM 5 mm, 4-pole male horizontal	PHOENIX CONTACT
1		Connector 4P	Connector RM 5 mm, 4-pole female parallel	PHOENIX CONTACT
1	J2	Connector 3P	Connector RM 5 mm, 3-pole male horizontal	PHOENIX CONTACT
1		Connector 3P	Connector RM 5 mm, 3-pole female parallel	PHOENIX CONTACT

Table 11. Bill of material (continued)

Quan-tity	Reference	Value / generic part number	Package / class	Manufacturer
1	J3	Con. 5 mm, 2P	Connector RM 5 mm, 2-pole, screw	PHOENIX CONTACT
1	J4	Connector 5P	Autocom HE14 5-pin	Stelvio Kontek
1	J5	MLW34G	MLW connector 34-pin	Tyco Electronics
1	J6	Con. 5 mm, 2P	Connector RM 5 mm, 2-pole, screw	PHOENIX CONTACT
1	J7	Con. 2.54 mm 12-pin	Pins RM 2.54 mm female, 12-pin	
1	J8	Con. 5 mm, 2P	Connector RM 5 mm, 2-pole, screw	PHOENIX CONTACT
1	W1	Jumper 2.54	Three pins of break way + jumper in position 3.3 V	
1	W10	Jumper 2.54	Two pins of break way + jumper	
1	W11	Jumper 2.54	Three pins of break way + jumper in position 3.3 V	
3	W13	Mounting hole	Three way HV selector, default three-shunt position	
1		Insulated jumper blue	HV insulated jumper, 5.08 mm, default three-shunt position	
3	W3	Mounting hole	Three way HV selector	
1		Insulated jumper blue	HV insulated jumper, 5.08 mm, default "HIGH VOLTAGE" position	
1	W4	Jumper 2.54	Two pins of break way + jumper	
1	W5	Jumper 2.54	Three pins of break way + jumper in position R_BRAKE	
1	W6	Jumper 2.54	Two pins of break way	
1	W7	Jumper 2.54	Two pins of break way	
3	W9	Mounting hole	Three way HV selector, default three-shunt position	
1		Insulated jumper blue	HV insulated jumper, 5.08 mm, default three-shunt position	
1	W14	Wire jumper	Not assembled	
1	W16	Jumper 2.54	Three pins of break way + jumper in position 1	
150 mm	Het 1	Heatsink	150 mm of AL profile 8693	PADA Engineering
1	Het 2	Heatsink	Heatsink for TO-220 with montage pin	PADA Engineering
7		Clip for het	Montage clip PADA 7704, TO-220, 10 mm	PADA Engineering

Table 11.   Bill of material (continued)

Quan-tity	Reference	Value / generic part number	Package / class	Manufacturer
1		Clip for het	Montage clip PADA 7703, TO-220, 15 mm	PADA Engineering
130 mm		Isolation tape	Isolation tape, 24 mm wide; approx. 130 mm long, self adhesive	

8 PCB layout

For this application a standard, double-layer, coppered PCB with a ~60 μm copper thickness was selected. The PCB material is FR-4.

The dimensions of the board are:

Length: 182 mm

Width: 127 mm

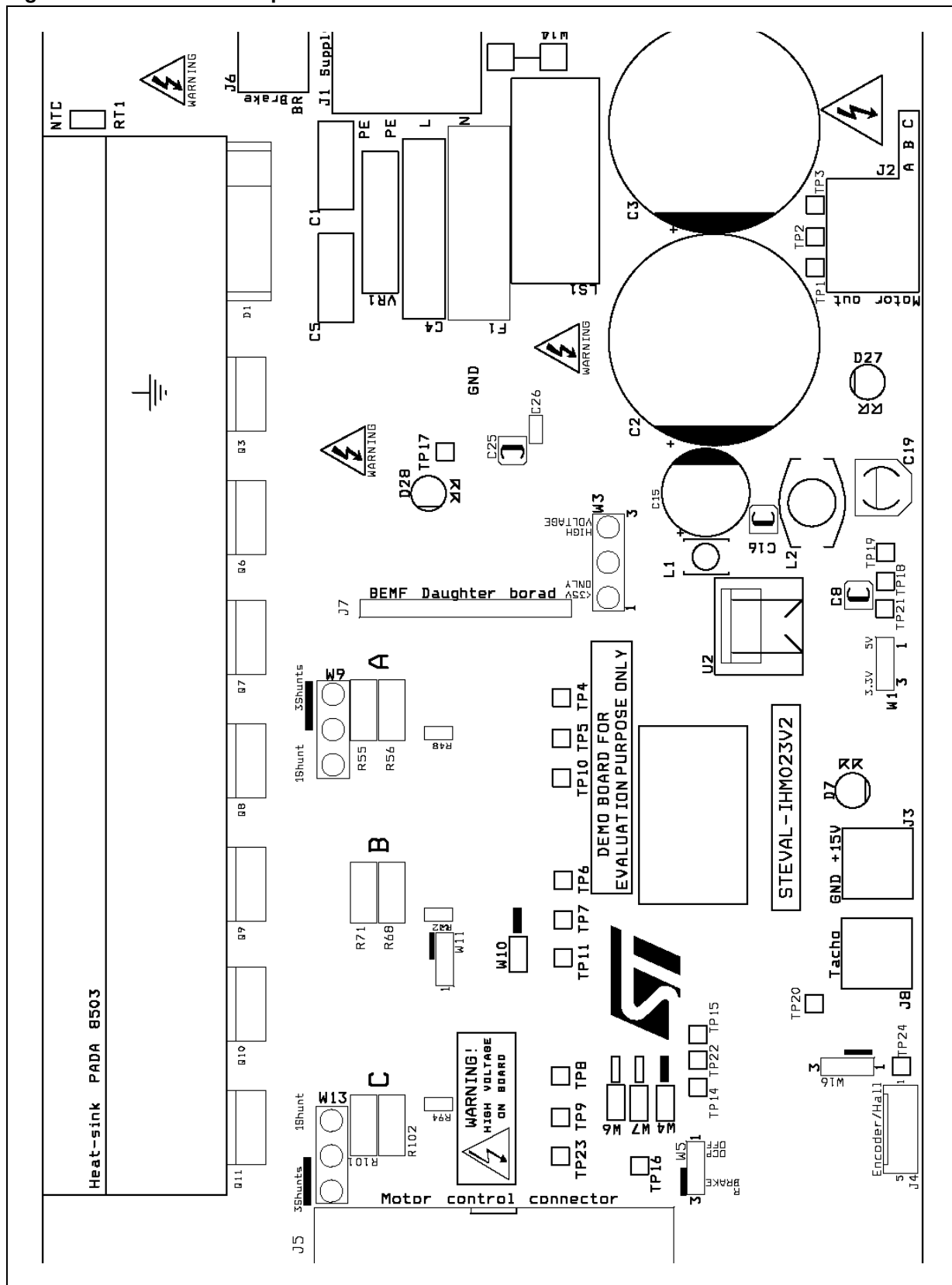PCB thickness: 1.55 mm

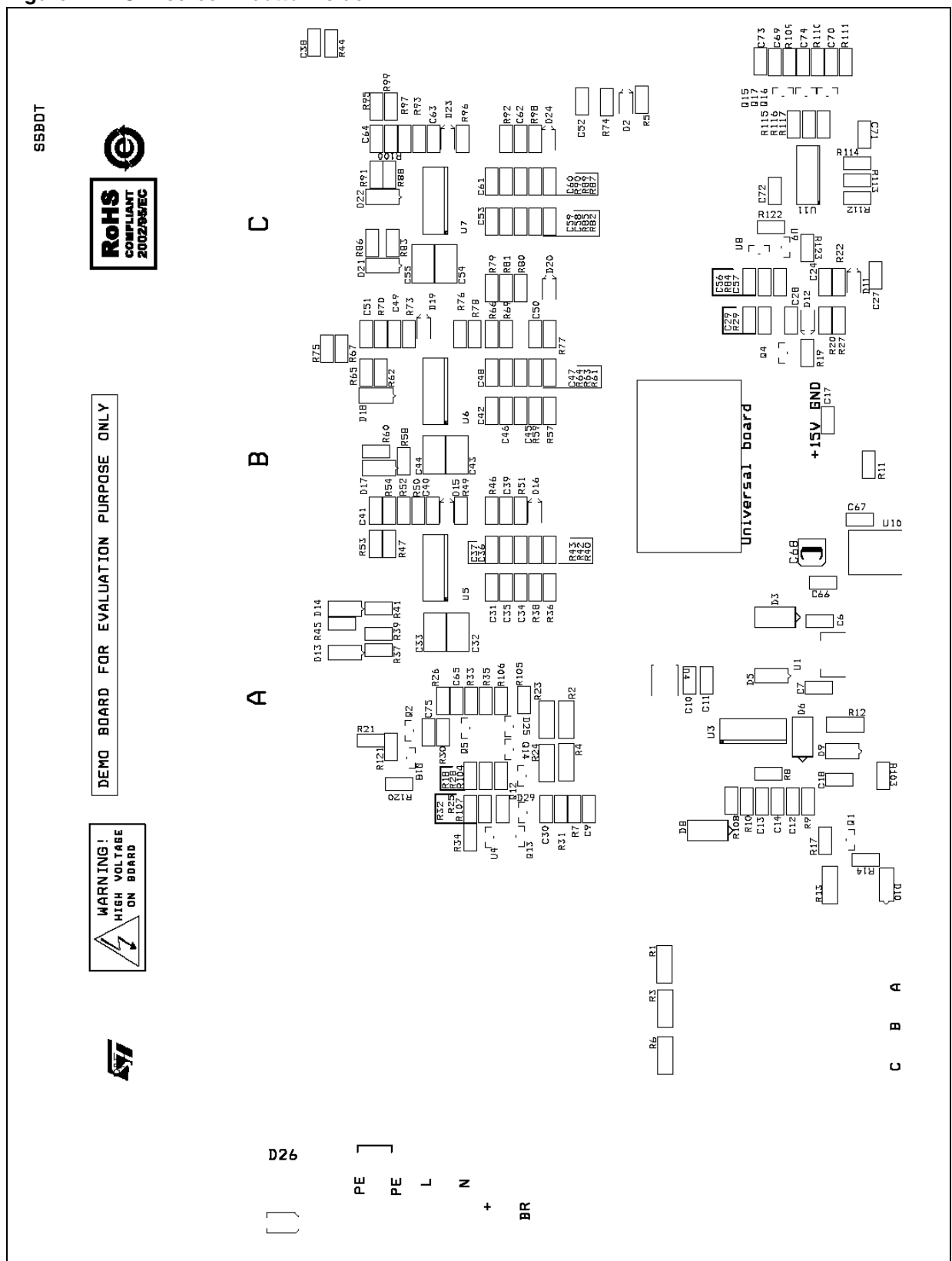**Figure 16. Silk screen - top side**

Figure 17. Silk screen - bottom side
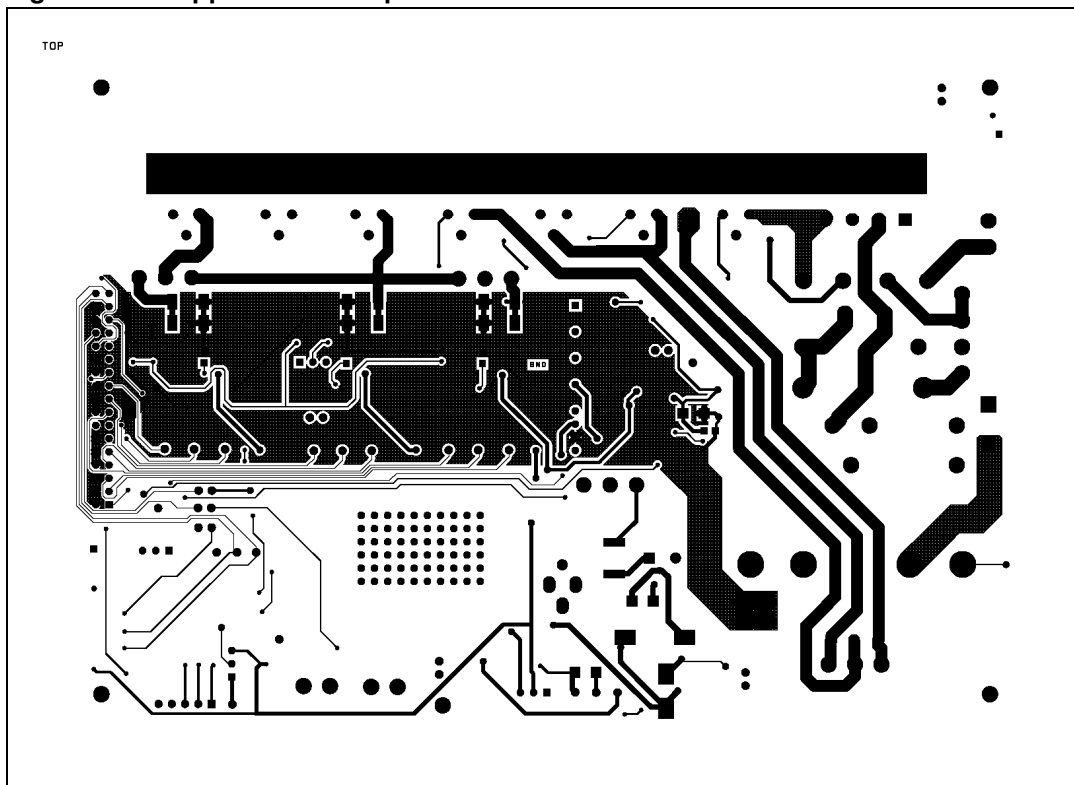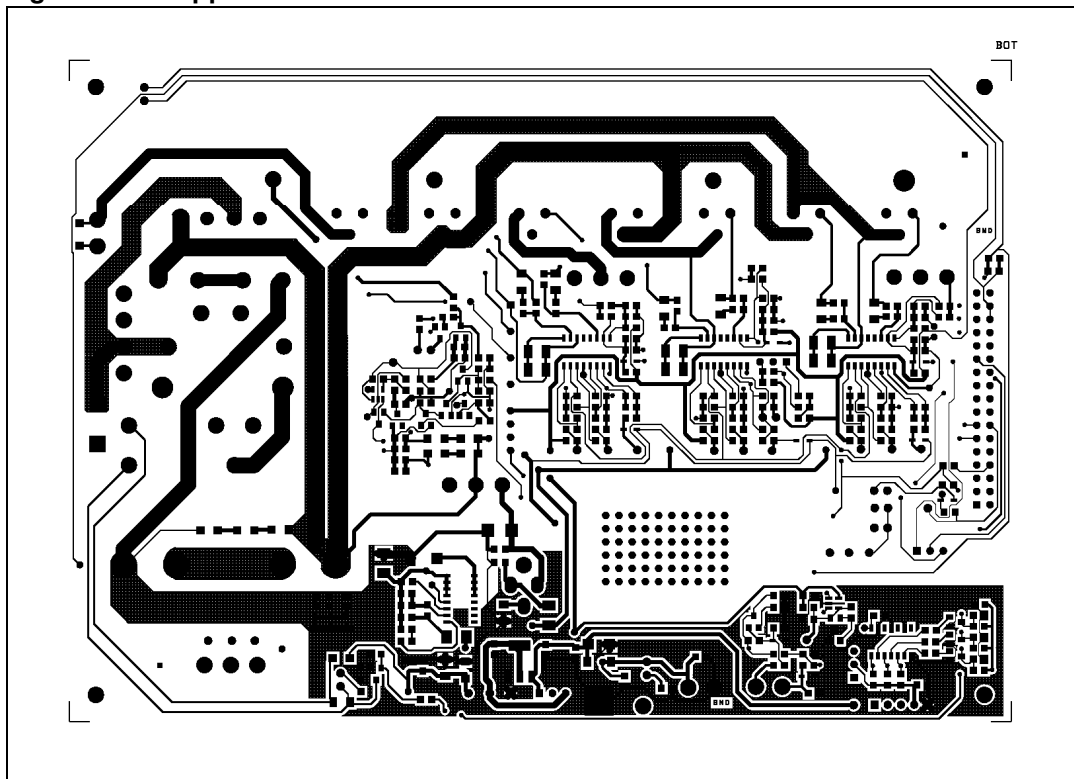
Figure 18.   Copper tracks - top side

Figure 19.   Copper tracks - bottom side

9 Ordering information

The demonstration board is orderable through the standard ordering system, the ordering code is: STEVAL-IHM023V2. The items delivered include the assembled demonstration board, board documentation, PCB fabrication data such as gerber files, assembly files (pick and place), and component documentation.

10 Using STEVAL-IHM023V2 with STM32 PMSM FOC firmware library v3.0

The "STM32 PMSM FOC firmware library v3.0" is part of the STM32 PMSM single/dual FOC SDK v3.0. In particular, it is a firmware library running on any STM32F103x and STM32F100x device which implements the "Field Oriented Control" (FOC) drive of three-phase "Permanent Magnet Synchronous Motors" (PMSM), both "Surface Mounted" (SM-PMSM) and "Internal" (I-PMSM).

This section describes how to customize the firmware library by making use of the PC tool "ST MC Workbench" (STMCWB) downloadable from www.st.com.

10.1 Environmental considerations

Warning: **The STEVAL-IHM023V2 demonstration board 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 DC input. 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: **All measuring 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 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.*

10.2   Hardware requirements

The following items are required to run the STEVAL-IHM023V2 together with the "STM32 PMSM FOC firmware library v3.0".

● Any microcontroller demonstration board with MC connector such as: STEVAL-IHM022V1, STEVAL-IHM033V1, STM3210B-EVAL, STM3210E-EVAL, or STM32100B-EVAL

● A high-voltage insulated AC power supply up to 230 VAC

● A programmer/debugger dongle for control board (not included in the package). Refer to the control board user manual to find a supported dongle. Use of an insulated dongle is always recommended.

● Three-phase brushless motor with permanent magnet rotor (not included in the package)

● An insulated oscilloscope (as necessary)

● An insulated multimeter (as necessary)

10.3   Software requirements

To customize, compile, and download the "STM32 FOC firmware library v3.0", a toolchain must be installed.

10.4   STM32 FOC firmware library v3.0 customization

The ST motor control workbench can be used to customize the STM32 FOC firmware library v.3.0.

The required parameters for the power stage related to the STEVAL-IHM023V2 are reported in *Table 12*.

Table 12.   STEVAL-IHM023V2 motor control workbench parameters

Variable	Value
Rated bus voltage information	
Min. rated voltage (V)	18 or 60 according to W3 position (respectively for "<35 V" and "HIGH VOLTAGE" positions)
Max. rated voltage (V)	32 or 450 according to W3 position (respectively for "<35 V" and "HIGH VOLTAGE" positions)
Nominal voltage (V)	Depends on W3 position and application nominal bus voltage
Bus voltage sensing	Available
Bus voltage divider 1/...	136
Dissipative brake	Available if W5 is set to R_BRAKE position, not available otherwise
Polarity	Active high
Driving signals	

Table 12.   STEVAL-IHM023V2 motor control workbench parameters (continued)

Variable	Value
Phases U, V, W high-side polarity	Active high
Phases U, V, W low-side polarity	Active low
Temperature sensing	Available
V0 (mV)	875
T0 (°C)	25
ΔV/ΔT (mV/°C)	28
Max. working temperature on sensor (°C)	70
Overcurrent protection	Available
Comparator threshold (V)	0.5
Overcurrent network gain (V/A)	0.075
Expected overcurrent threshold (A)	6.25
Overcurrent feedback signal polarity	Active low
Overcurrent protection disabling network	Available if W5 is set to OCP OFF position, not available otherwise
Overcurrent protection disabling network polarity	Active low
Current sensing	
Current reading topology	Configurable
Shunt resistor(s) value (Ω)	0.15
Amplifying network gain	1.7
T-noise (ns)	2000
T-rise (ns)	2000
Power switches	
Min. deadtime (ns)	800
Max. switching frequency (kHz)	50

11 Conclusion

This document describes the 1 kW three-phase motor control STEVAL-IHM023V2 demonstration board as a universal fully evaluated and adaptable motor control platform.

12 References

1. L6390 datasheet
2. VIPer16 datasheet
3. STGP10NC60KD datasheet
4. UM0379 user manual
5. UM0580 user manual

13 Revision history

Table 13.   Document revision history

Date	Revision	Changes
07-Sep-2009	1	Initial release.
27-Nov-2009	2	Changed part number STGF7NC60HD to STGP10NC60KD in *Figure 10*, updated input voltage in *Section 4.2*, step 3 in *Section 10.4*, replaced STEVAL-IHM023V1 by STEVAL-IHM021V1 in point 5 of *Section 12*.
03-May-2011	3	Replaced STEVAL- IHM023V1 by STEVAL-IHM023V2, updated *Section 1*, *Figure 1*, *Section 2.1*, *Section 3.1*, *Figure 3* to *Figure 8*, *Section 3.3*, *Section 4* to *Section 12*, minor text and graphic modifications throughout the document.
28-Jun-2011	4	Updated *Table 12*, corrected typo in *Figure 7* and *Figure 8*.

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