Low voltage motor control demo kit

Introduction

The evaluation board STEVAL-IHM015V1 is a complete development platform for low voltage motor control applications. Based on a cost effective, flexible and open design, it allows easy demonstration of ST7MC capabilities to drive low voltage synchronous motors. It includes an ST7MC 8-bit microcontroller with 16 Kbyte internal flash memory. The STEVAL-IHM015V1 features complete hardware for developing motor control applications based on ST7MC peripherals including motor control peripheral (MTC), and Serial Communication Interface (SCI). The STEVAL-IHM015V1 uses an In-Circuit Communication (ICC) standard interface to connect to the host PC via In-circuit debuggers/programmers such as the inDART-STX board from Softec. The power stage of the board is designed to support up to 25 A and up to 50 V. It is possible to use the STS8DNH3LL devices which are included or replace them with different devices in the SO-8 package (dual or single devices for chip) or DPAK. Power supply stages can be easily configured for a wide range of bus voltages.

Figure 1.   STEVAL-IHM015V1

Features

■ Voltage range from 5 V to 48 V

■ Current up to 25 A

■ Power MOSFET STS8DNH3LL (dual device) 8 A 30 V included

■ Compatible with Power MOSFET in SO-8 and DPAK

■ 10 V auxiliary power supply connector

■ Serial Communication Interface connector

■ Programming and debug support via 10-pin ICC connector

■ Onboard 2 K-bit (256 byte) serial memory

■ Four potentiometers for runtime settings

■ Start/stop button

■ Reset button

■ Debug pins available

Contents

List of tables

List of figures

1 System architecture

The generic motor control system can be schematized as the arrangement of four blocks (see *Figure 2*):

● Control block

● Power block

● Motor

● Power supply

Figure 2. Motor control system architecture
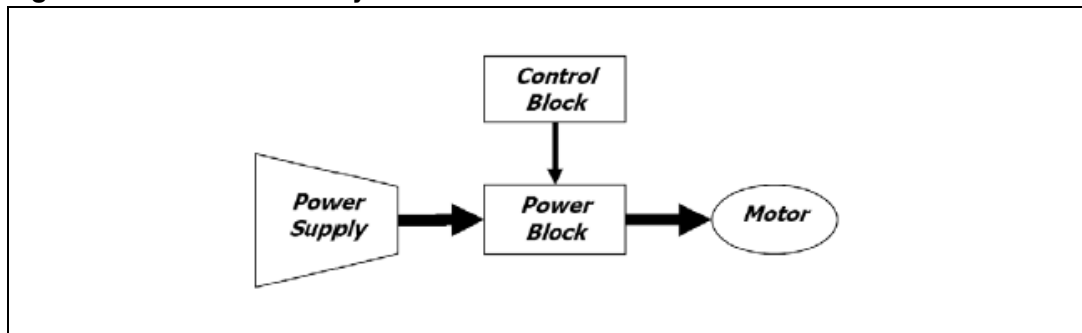
The system proposed for the low voltage motor control demo kit is composed of one board STEVAL-IHM015V1 (containing control and power block), one motor and the power supply.

The control block is a microcontroller (ST7MC) based block that provides the driving signals related to the motor selected and the diving strategies. synchronized with sensor signal (if it is required).

Driving signals are constituted of 6 PWM signals in the range of 0-5 V paired in High side/low side pairs of one pair for each leg. In the system proposed, three legs are present (three-phase inverter).

The power block is based on the gate drivers L6387 and Power MOSFET (STS8DNH3LL) that convert the control signal to power signals in order to drive the motor.

The low voltage motor control demo kit is able to drive following kinds of motors:

● Brushless permanent magnet motor (trapezoidal driven), sensored or sensorless

● Brushless permanent magnet motor (sinusoidal driven), sensored.

The board is supplied by low voltage DC power supply from 5 up to 48 V with the capability to generate current up to 25 A. *Section 6: Board architecture*.

With the included Power MOSFET device STS8DNH3LL, the maximum rating of voltage is 30 V and the maximum rating current is 8 A.

2 Safety and operating instructions

2.1 General

Warning: During assembly and operation, the low voltage motor
control demo kit poses several inherent hazards, including
bare wires, moving or rotating parts, and hot surfaces. There
is danger of serious personal injury and damage to property,
if the kit or its components are improperly used or installed
incorrectly.

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 purposes of these basic safety instructions, "skilled technical personnel"
are suitably qualified people who are familiar with the installation, use, and maintenance of
power electronic systems.

2.2 Demo kit board intended use

The low voltage motor control demo kit boards are components designed for demonstration
purposes only, and shall not be used for electrical installation or machinery. The technical
data as well as information concerning the power supply conditions shall be taken from the
documentation and strictly observed.

2.3 Demo kit board installation

The installation and cooling of the demo kit boards shall be in accordance with the
specifications and the targeted application (see *Section 7: Motor control demonstration*).

●   The motor drive converters shall be 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 shall be made with other electronic components and contacts.

●   The boards contain electrostatically sensitive components that are prone to damage
     through improper use. Electrical components must not be mechanically damaged or
     destroyed (to avoid potential health risks).

2.4 Electronic connections

Applicable national accident prevention rules must be followed when working on the main
power supply with a motor drive. The electrical installation shall be completed in accordance
with the appropriate requirements (e.g., cross-sectional areas of conductors, fusing, PE
connections; for further information, see *Section 7: Motor control demonstration*).

2.5   Demo kit board operation

A system architecture which supplies power to the low voltage motor control demo kit boards shall 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).

Warning: **Do not touch the board after disconnection from the voltage supply, as several parts and power terminals which contain possibly energized capacitors need to be allowed to discharge.**

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3   ST7FMC2S4T6 microcontroller functions

3.1   Main features

● TQFP44 package
● 16 Kbyte dual voltage FLASH program memory with read-out protection capability
● 768 bytes RAM (256 stack bytes)
● Clock, Reset And Supply Management with:
    – enhanced reset system
    – enhanced low voltage supervisor (LVD) for main supply and auxiliary voltage detector (AVD) with interrupt capability
    – clock sources: crystal/ceramic resonator oscillators and bypass for external clock, clock security system
    – four power saving modes: halt, active-halt, wait and slow
● configurable window watchdog timer
● nested interrupt controller with 14 interrupt vectors
● two 16-bit timers
● one 8-bit auto-reload timer
● Serial Peripheral Interface (SPI)
● Serial Communication Interface (LINSCI™)
● Motor Controller (MTC) peripheral with:
    – 6 high sink Pulse Width Modulator (PWM) output channels
    – asynchronous emergency stop
    – analog inputs for rotor position detection
    – permanent magnet motor coprocessor including: multiplier, programmable filters, blanking windows and event counters
    – Op Amp and comparator for current limitation
● 10-bit Analog-to-Digital Converter (ADC) with 11 inputs
● In-circuit Communication Interface (ICC, debug)

Table 1.   ST7FMC2S4T6 functions

Function	I/o name	Description (depends on embedded software)
MTC	MCO0	PWM outputs high side phase A
	MCO1	PWM outputs low side phase A
	MCO2	PWM outputs high side phase B
	MCO3	PWM outputs Low Side Phase B
	MCO4	PWM outputs high side phase C
	MCO5	PWM outputs low side phase C
	MCIA, MCIB, MCIC	Analog or digital input for position sensor or B.E.M.F. detection
	MCV_{REF}	B.E.M.F. detection comparator reference
	NMCES	Emergency stop
	OAP	Operational amplifier positive input
	OAN	Operational amplifier negative input
	OAZ	Operational amplifier output
	MCC_{REF}	Current limitation reference
	MCPWMV	PWM Output V user for current reference
	MCZEM	Debug pin C/Z event
	MCDEM	Debug pin C/D event
SPI	MISO	Master in/slave out data
	MOSI	Master out/slave in data
	SCK	Serial clock
LINSCI™	RDI	Received data input
	TDO	Transmit data output
10-bit ADC	AIN0	Temperature sensor input
	AIN1	Bus voltage sensing input
	AIN13	Trimmer P1 reading input
	AIN11	Trimmer P2 reading input
	AIN7	Trimmer P3 reading input
ICC	ICCCLK	Output serial clock
	ICCDATA	Input/Output serial data
	ICCSEL/Vpp	Programming voltage input
Other I/O	PE0	GPIO_A for GE method of BEMF detection
	PE1	GPIO_B for GE method of BEMF detection
	PE2	GPIO_C for GE method of BEMF detection
	PE3	Start/stop pushbutton
	PB7	LED management

4 STS8DNH3LL characteristics

The STS8DNH3LL is a dual N-channel Power MOSFET in the SO-8 package (30 V - 0.018 Ω - 8 A) low gate charge, STripFET™ III.

Figure 3. STS8DNH3LL
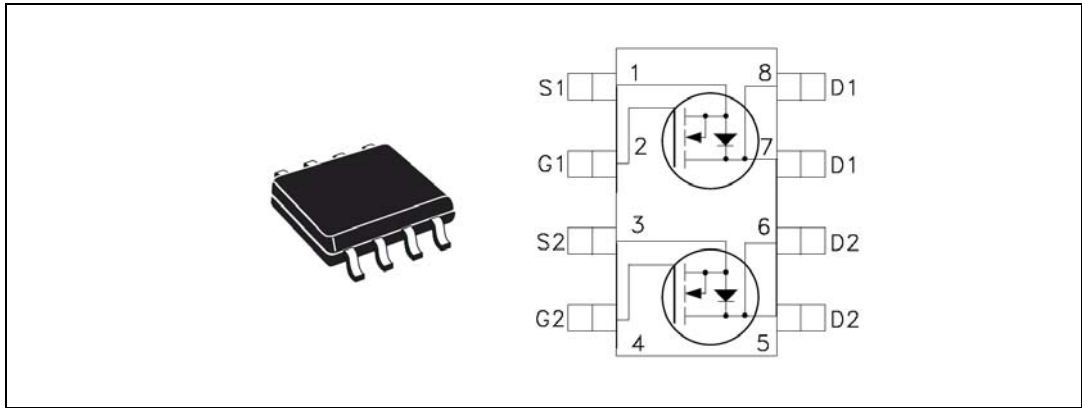
- V_{DSS} = 30 V
- $R_{DS(on)}$ = 0.018 Ω
- I_D = 8 A

Table 2. STS8DNH3LL absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{DS}	Drain-source voltage(V_{GS} = 0)	30	V
V_{DGR}	Drain-gate voltage (R_{GS} = 20 kΩ)	30	V
V_{GS}	Gate- source voltage	± 16	V
I_D	Drain current (continuous) at T_C = 25 °C	8	A
I_D	Drain current (continuous) at T_C = 100 °C	5	A
I_{DM}[1]	Drain current (pulsed)	32	A
P_{tot}	Total dissipation at T_C = 25 °C	2	W

1. Pulse width limited by safe operating area.

Stresses above the limit shown in *Table 2* may cause permanent damage to the device.

5 Board electrical characteristics

Stresses above the limit shown in *Table 3* may cause permanent damage to the devices present inside the board. This is a stress rating only and functional operation of the device under these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

10 V Bias Current measurement can be useful to check the working status of the board. If measured value is considerably greater than typical value, it means that some damage has occurred in the board. See the power supply configuration for 10 V auxiliary supply.

Table 3.   Control board electrical characteristics

Control board parameters	STEVAL-IHM015V1		Unit
	Min	Max	
10 V auxiliary supply range – J6	5	15	V
10 V bias current (typical)	30	70	mA
V_{BUS} – J5 (low voltage configuration)[1]	5	6.5	V
V_{BUS} – J5 (medium voltage configuration)[1]	6.5	9	V
V_{BUS} – J5 (high voltage configuration)[1]	9	48	V

1.   See power supply configuration

6   Board architecture

The STEVAL-IHM015V1 can be schematized as in *Figure 4*.

Figure 4.   Board architecture
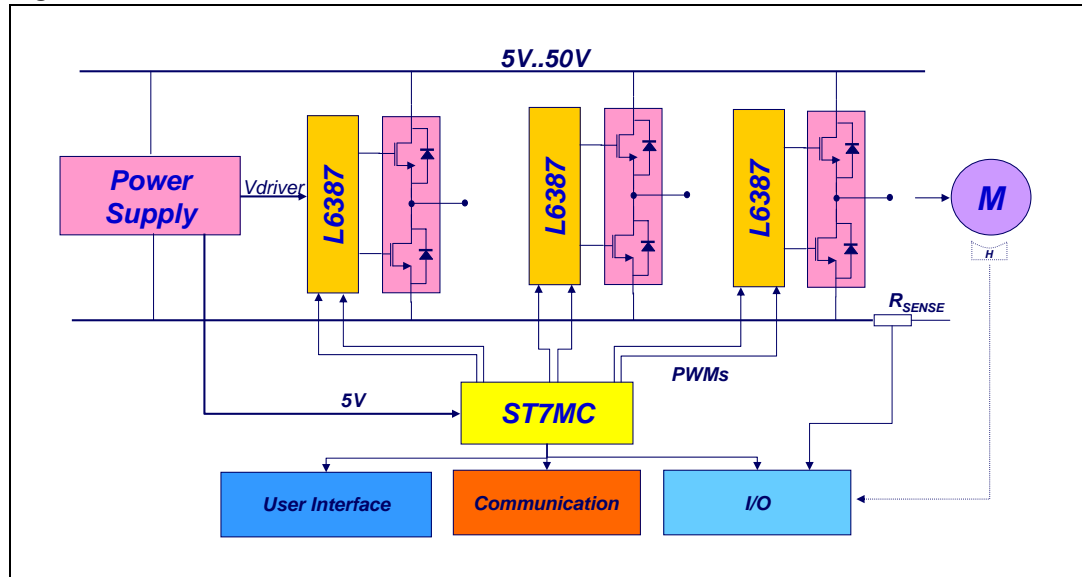
The heart of the control board is the ST7MC microcontroller with a dedicated peripheral included to drive the three-phase brushless motor.

The user interface is constituted of four potentiometers (P1, P2, P3, P4) used to set parameters related to the specific drive. See *Section 7: Motor control demonstration*.

Two push buttons are also present:

– Reset button for a "hardware reset".
– Start/stop button used to start and stop the motor driving. *Section 7: Motor control demonstration*.

Two LEDs (green/red) are used to get information about the status of the system. Their behavior is related to the specific drive. See *Section 7: Motor control demonstration*.

In normal functionality it is expected that the board is supplied by V_{BUS} connector J5 but an auxiliary supply connector J6 is included on the board to feed the drivers and the microcontroller.

The board is supplied with 2 Kbit EEPROM (M95020) connected to the micro by the SPI bus. To enable the onboard EEPROM memory, the jumper J2 must be closed and the debug feature must be disabled inside the firmware. J4 can be set by the user connecting a jumper between pin 1-2 or 2-3. This setting is related to a specific drive (see *Section 7: Motor control demonstration*).

Two communication systems can be established with the microcontroller:

– ICC used for Programming/Debugging purposes
– SCI used for data exchange through the SDI connector

● Power supply

The power supply has been designed to address a wide range of DC bus voltages from 5V to 48 V. Three configurations of power supply have been designed:

– Low voltage: 5 V - 6.5 V based on boost converter L5970.

– Medium voltage: 6.5 V - 9 V direct connection to the bus.

– High voltage: 9 V - 48 V based on buck converter L4976 (for V_{BUS} > 28 V the Power MOSFET must be replaced with the STD20NF06LT4 or STS7NF60L).

Figure 5.   Power supply architecture
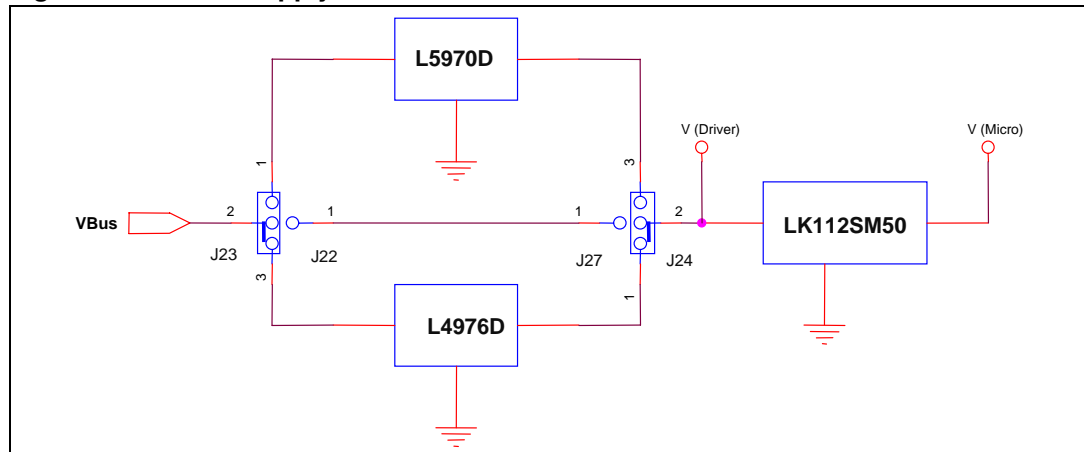
Table 4.   Power supply jumper settings

Configuration	V_{BUS} range	V Driver	Jumper configuration
Low voltage	5 V - 6.5 V	7 V	J23 between 1-2 J24 between 2-3
Medium voltage	6.5 V - 9 V	V_{BUS}	J23 pin2 – J22 J24 pin 2 – J27
High voltage	9 V -4 8 V	8 V	J23 between 2-3 J24 between 1-2

The following can be used to supply the 5 V to the micro:

- the Vref signal of the L4976D regulator if it is used (High voltage setting in *Table 4*) or

- the LK112SM50TR

The first setting can be configured by putting J8 between pins 2-3 and the second configuration by putting J8 between pins 1-2

Using the Vref signal of the L4976D, it is possible to provide the microcontroller with up to 20 m A. Using the LK112SM50TR it is possible to provide up to 200 m A.

● Power stage

The power stage is based on six Power MOSFETs in full three-phase bridge configuration. In the board there are three STS8DNH3LLs in an SO-8 package, each one containing two devices. The maximum driving current is 8 A, and the suggested maximum driving voltage is 24 V.

It is possible to use different Power MOSFET devices replacing U15, U17 and U18 with other devices. Compatible devices are Power MOSFETs in an SO-8 package containing single or dual devices and Power MOSFETs in a DPAK package. The board is designed to work up to 25 A and 48 V.

Figure 6.   **Power devices footprint selection**
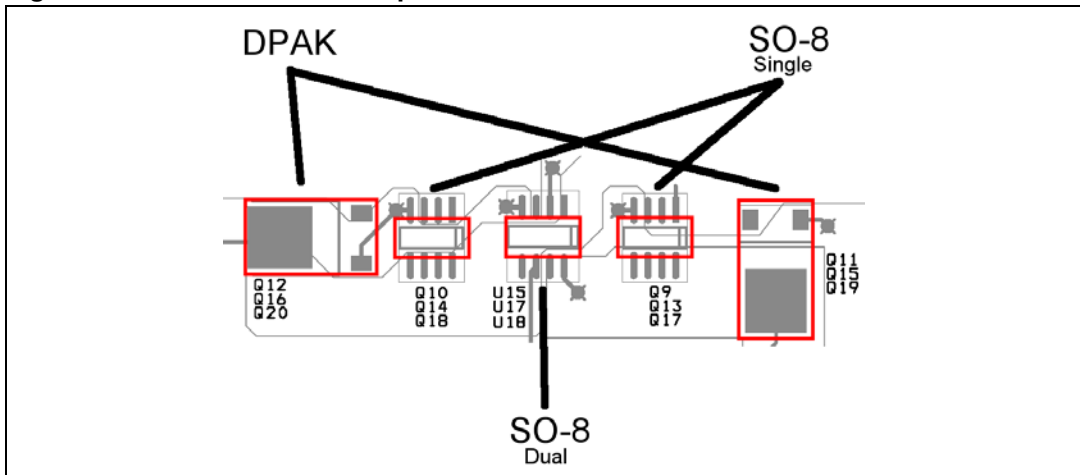
Figure 6 shows one of the three legs of the bridge where it is possible to mount one of the three kinds of devices. *Table 5* indicates a list of compatible devices.

Table 5.   **Compatible devices**

Place holder	Packages	Type	Compatible devices
U15, U17, U18	SO-8	Dual	STS8DNH3LL[1]
Q9, Q10, Q13, Q14, Q17, Q18	SO-8	Single	STS20NHS3LL[1] STS7NF60L[1]
Q11, Q12, Q15, Q16, Q19, Q20	DPAK	Single	STD20NF06LT4[1]

1. These devices are only examples of compatible devices. See the Power MOSFET Selection guide for a complete list of devices.

Figure 7. Board layout
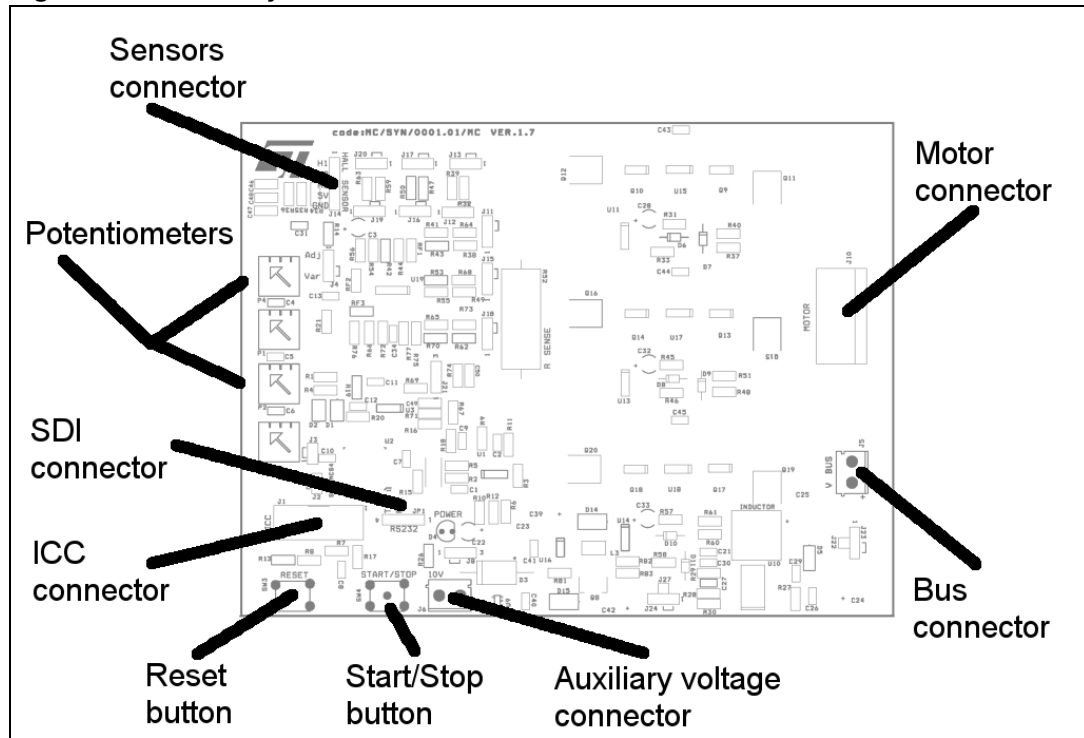
6.1 ICC connector

The ICC connector (J1) is used to establish ICC communication for programming/debugging purposes. The pin-out is shown in *Figure 8*. This connector is compatible with Softec's inDART-STX board (not included in the package).

Figure 8. ICC connector
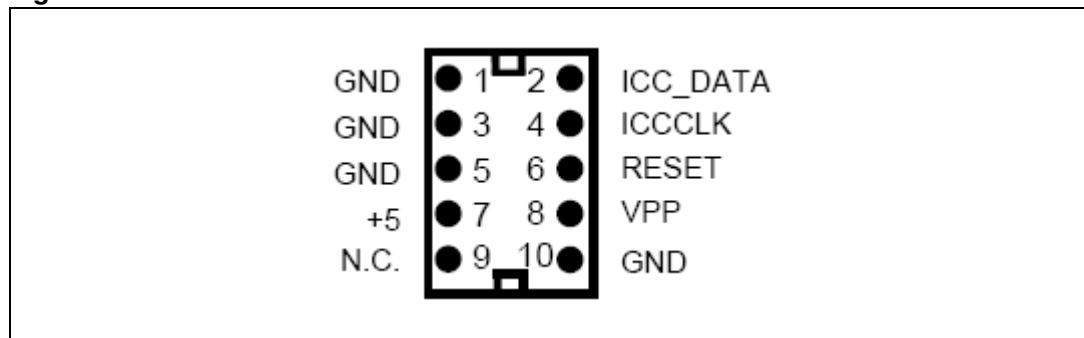
6.2 SDI Interface (Serial Data Interface)

The board is provided with an SDI interface (JP1) able to establish SCI communication with external devices. We suggest using an isolation board between the SDI Interface and the external devices. The pin-out is shown in *Figure 9*.

Figure 9.   SDI connector
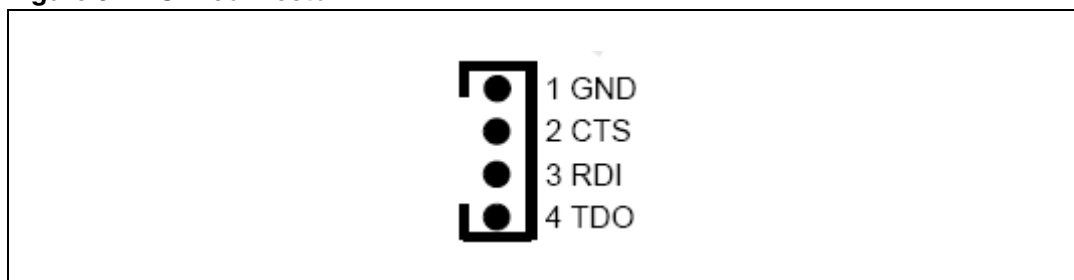
6.3 Board schematic

Figure 10. Board schematic - control block
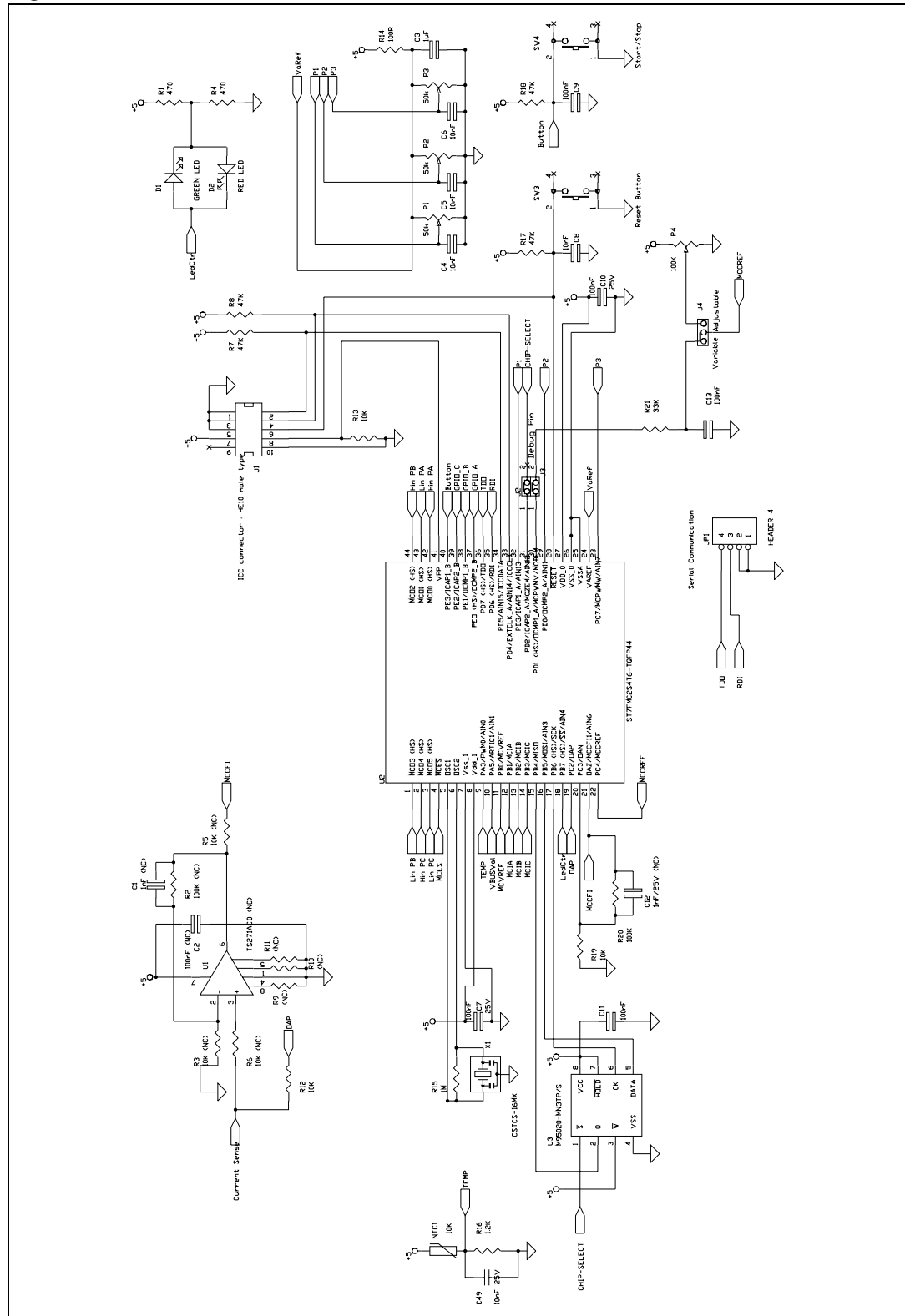
Figure 11.   Board schematic - power block
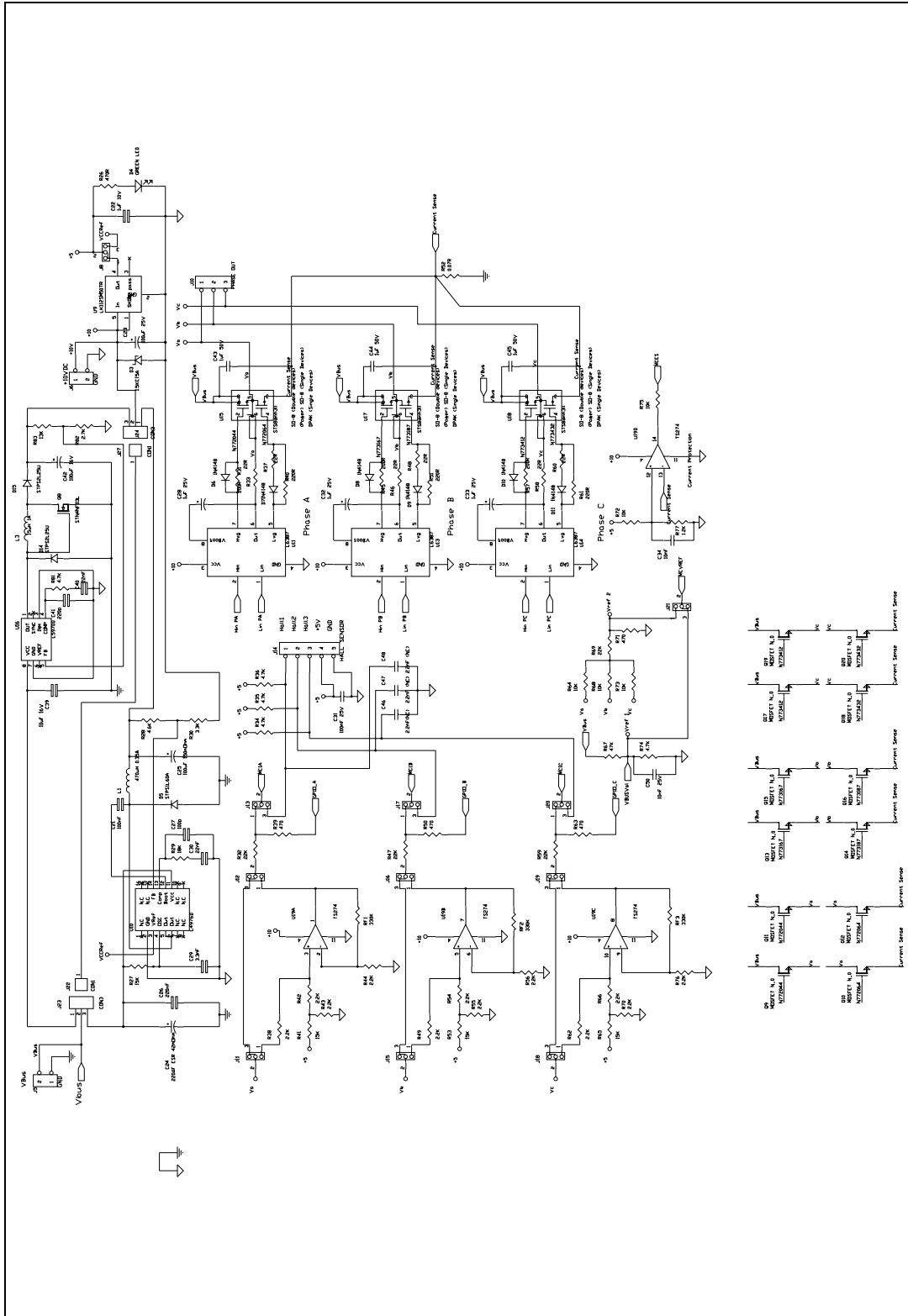
7 Motor control demonstration

7.1 Environmental considerations

Warning: **The low voltage motor control demo kit 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 serial 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 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 DC power supply can be constructed using an isolation transformer and a variable transformer. A schematic of this DC power supply is in the application note, "AN438, TRIAC + Microcontroller: safety precautions for development tools." (Although this Application Note was written for TRIAC, the isolation constraints still apply for switching semiconductor devices such as MOFSETs.)

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

7.2 Hardware requirements

To set up the low voltage motor control demo kit system, the following items are required:
● The board: STEVAL-IHM015V1
● Insulated DC power supply up to 24 V 8 A
● Softec inDART-STX (not included in the package)
● Softec ICC isolation board (not included in the package)
● Two 10-pin flat cables (not included in the package)
● Brushless PM motor Ametek (not included in the package)
● Insulated oscilloscope (as needed)
● Insulated multimeter (as needed)

7.3   Software requirements

To customize, compile, and download the motor control firmware, the following software must be installed:

● "LV ST7MC - GUI" (included in the CD-ROM)

● STVD7 for inDART-STX V.3.11 (also called "ST7 Toolset" downloadable from Softec's website: www.softecmicro.com)

● Cosmic compiler - ST7 C compiler 16 Kbyte free version - 4.5c (downloadable from Cosmic's website: www.cosmic-software.com).

7.3.1   Installing the software

● LV ST7MC - GUI installation

Insert the CD-ROM provided with the kit and execute Setup.exe.

● 3rd party software installation

Follow the instructions of the related software to install and configure STVD7 for inDART-STX and cosmic compiler.

● Installation note

1. Install the Cosmic compiler first. Use the default installation folder: "C:\Program Files\COSMIC\CXST7_16Kbite". Registration is required before using the product. You can perform this procedure at any time by running the "lmreg16k.exe" file inside Cosmic's installation folder. Complete the form and click on the "Register by email" button. You will receive a license file "license.lic" that must be copied inside the installation folder under the "license" folder.

2. Then install STVD7 for inDART-STX. During the first run of the software after installation, a prompt for the configuration of the toolset should appear. The toolset can be configured at any time by opening "tools →options" inside STVD7. To do this, click "toolset", and select the "toolset" menu tab, select "ST7Cosmic" and configure as in *Figure 12*.

Figure 12.   STVD7 for InDART-STX Toolset configuration
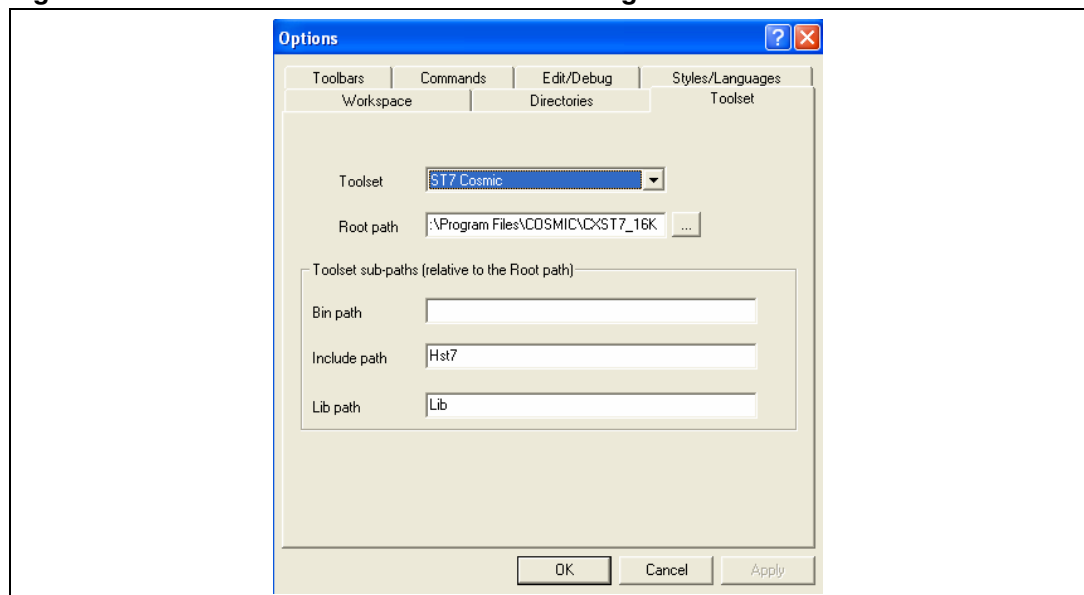
7.4 Board setup

7.4.1 Choosing the right firmware

Motor control firmwares are arranged according to the kind of motor to be driven and according to the driving strategy. See *Table 6* to choose which firmware should be used.

Together with the installation of "LV ST7MC - GUI" the firmware source code is installed on the PC inside the installation folder under the "LVK_Firm" folder.

Each firmware is stored inside working folder under the same name as the firmware itself. The following files are present inside each working folder:

– ".stw" file - STVD7 workspace file
– ".stp" file - STVD7 project file
– "source" folder - containing all .c and .h files required

Table 6. Firmware libraries arranged according to driving strategy

Firmware name	Description
BLAC_3PH_SR	to drive sensored PM brushless motor sinusoidal driven
BLDC_3PH_SL	to drive sensorless PM brushless motor trapezoidal driven
BLDC_3PH_SR	to drive sensored PM brushless motor trapezoidal driven

Note: *We suggest making a backup copy of the original working folder for each firmware. The following procedure modifes the original content of the workspace folder without leaving the possibility to return to a previous step.*

7.4.2 Configuring the firmware using GUI

Before "using" the firmware, it must be configured. The term "configure" indicates the act of selecting a specific driving strategy, such as open or closed loop, voltage or current mode and so on. The setting of customized parameters such as current limitation, motor settings, driving related parameters and so on is also indicated.

Configuring the firmware is performed by compiling a set of .h files inside the source folder and writing a series of values as fields of #define statements. To do this configuration, solid knowledge of the hardware and the architecture of the firmware is required. Otherwise, the configuration tool provided inside the CD-ROM called "LV ST7MC - GUI" can be used. This allows the user to choose and set all required parameters visually and the software automatically generates the ".h" files required (refer to the ".h" files that constitute the configurations related to the firmware in *Table 7*).

Table 7.   **Configuration ".h" files**

Firmware name	Configuration files
BLAC_3PH_SR	PMACparam.h
	config.h
	Mainparam.h
	MTCparam.h
BLDC_3PH_SL	MTC_Settings_Sensorless.h
	spec_settings.h
	version.h
BLDC_3PH_SR	MTC_Settings_Sensor.h
	spec_settings.h
	version.h

For a detailed description of the configuration files and how to manually customize the related parameters see AN1905, AN1947.

7.4.3   Motor type selection

● After "LV ST7MC - GUI" is started, the motor type choice dialog box appears (see *Figure 13*). In this window the user can choose the kind of motor (PM Brushless) and the driving strategy (sinusoidal or trapezoidal).

● The two options are:

● "3-Phase BLAC/DC (trapezoidal)" to select PM brushless motor trapezoidal driven, or

● "3-Phase PMAC Motor (sinewave)" to select PM brushless motor sinusoidal driven.

Figure 13.   Motor type choice window
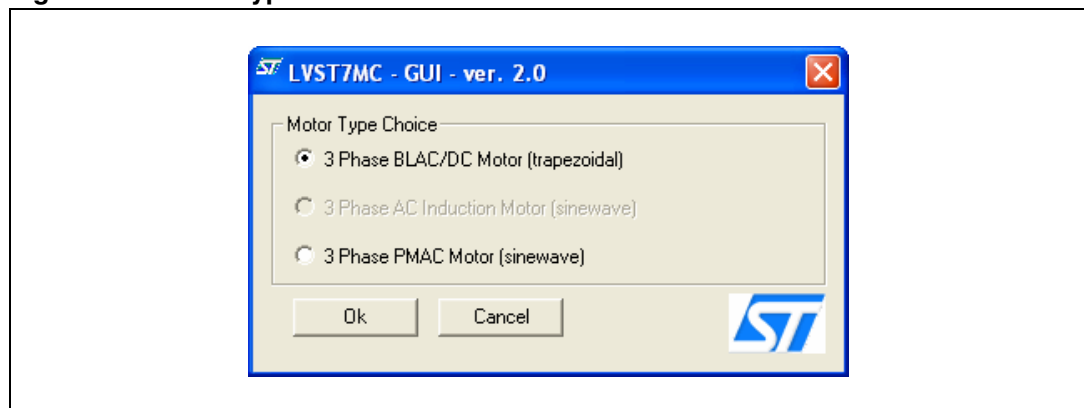
The user must select the desired value and press OK.

7.4.4 "3-Phase BLAC/DC (trapezoidal)" settings

Figure 14. "3-Phase BLAC/DC (trapezoidal)" basic parameters window

Table 8. "3-Phase BLAC/DC (trapezoidal)" basic parameters

Parameter name	Description
Poles pairs	the number of pole (north/south) pairs in the motor
Speed regulation	the manner in which to run the motor, either open loop (without speed regulation) or closed loop (with speed regulation)
Driving mode	the motor driving mode, current mode or voltage mode
Current bus limitation	the software current limitation value (only in voltage mode), if the current flowing inside one (of three) phases of the motor reach this value overcurrent is not generated but the pwm is managed to limit the current at this level.
Detection mode	the Back EMF (BEMF) detection mode (rotor position), either sensorless, hall (effect) sensor 60°, or hall (effect) sensor 120°
Alignment phase (only for sensorless mode)	
Final duty cycle	the percentage of final duty cycle applied at the end of alignment phase (only in voltage mode)
Final current	the value of current flowing inside the motor at the end of the *"alignment phase"* (only in current mode)
Alignment duration	the duration of the *"alignment phase"* in milliseconds (ms)
Acceleration phase (only for sensorless mode)	
Mechanical acceleration rate	the mechanical acceleration rate of the rotor during the ramp UP in RPMs (or Hz) per second (alternate between RPM and Hz settings by clicking on the "RPM" button)

Table 8.   "3-Phase BLAC/DC (trapezoidal)" basic parameters (continued)

Parameter name	Description
Duty cycle	the duty cycle percentage during the ramp Up (only in voltage mode)
Current reference	the value of current flowing inside one (of three) phases of the motor at the end of the *"acceleration phase"* (only in current mode)
Number of Z events before auto-switched mode	the number of consecutive Z events that occur before the microcontroller runs the motor in autoswitched mode
Electrical frequency	
Minimum	the Minimum target rotor frequency in closed loop, expressed in Hz
Maximum	the Maximum target rotor frequency in closed loop, expressed in Hz
Run settings	
From RV1	when the "From RV1" checkbox is selected: Duty cycle value is defined by the RV1 potentiometer (only for voltage mode), or Current reference is defined by the RV1 potentiometer (only for current mode), or Target speed is defined by the RV1 potentiometer (only for closed loop) If this box is unchecked, the above parameters are set by the user.
Duty cycle	the duty cycle percentage when the motor is run in "open loop" "voltage mode"
Current reference	The value of current flowing inside one (of three) phases of the motor at run time in "open loop" "current mode"
Target speed	the target mechanical (rotor) Speed in RPMs (or Hz) if speed regulation is set to "closed loop" (alternate between RPM and Hz settings by clicking on the "RPM" button)
Delay coefficient from RV2-RV3	When the "From RV2 - RV3" checkbox is selected, the value of rising delay is defined by the RV2 potentiometer and the value of falling delay is defined by the RV3 potentiometer. If this box is unchecked, the above parameters are set by the user.
B-emf rising edge	the B-EMF Rising Edge delay coefficient value (from 0 to 255)
B-emf falling edge	the B-EMF Falling Edge delay coefficient value (from 0 to 255)
Closed loop parameter (only in closed loop)	
Integral coefficient (Ki)	the value of the Integral Coefficient (Ki) of the Proportional Integrative (PI) regulator
Proportional coefficient (KP)	the value of the proportional coefficient (Kp) of the PI regulator
Sampling time	the regulation sampling time (in milliseconds)
Change motor type	the "change motor type" button enables the user to change the motor type (see *Figure 13*)
Advanced settings	the "advanced settings" button enables the user to set the advanced parameters (see *Section 7.4.5: "3-Phase BLAC/DC (trapezoidal)" advanced settings*)
Generate source files	the "generate source files" button enables the user to generate the configuration ".h" files shown in *Table 7* - configuration ".h" files. A "save" dialog window appears, where the user can select in which folder to create the file. User must choose the right "Source" directory in the firmware working folder (see *Section 7.4.1: Choosing the right firmware*).

7.4.5 "3-Phase BLAC/DC (trapezoidal)" advanced settings

Clicking the "advanced settings" button (see *Figure 14*) opens the "advanced settings" dialog box (see *Figure 15*). This is where the advanced "3-Phase BLAC/DC (trapezoidal)" motor type parameters are set.

Figure 15. "3-Phase BLAC/DC (trapezoidal)" advanced parameters window
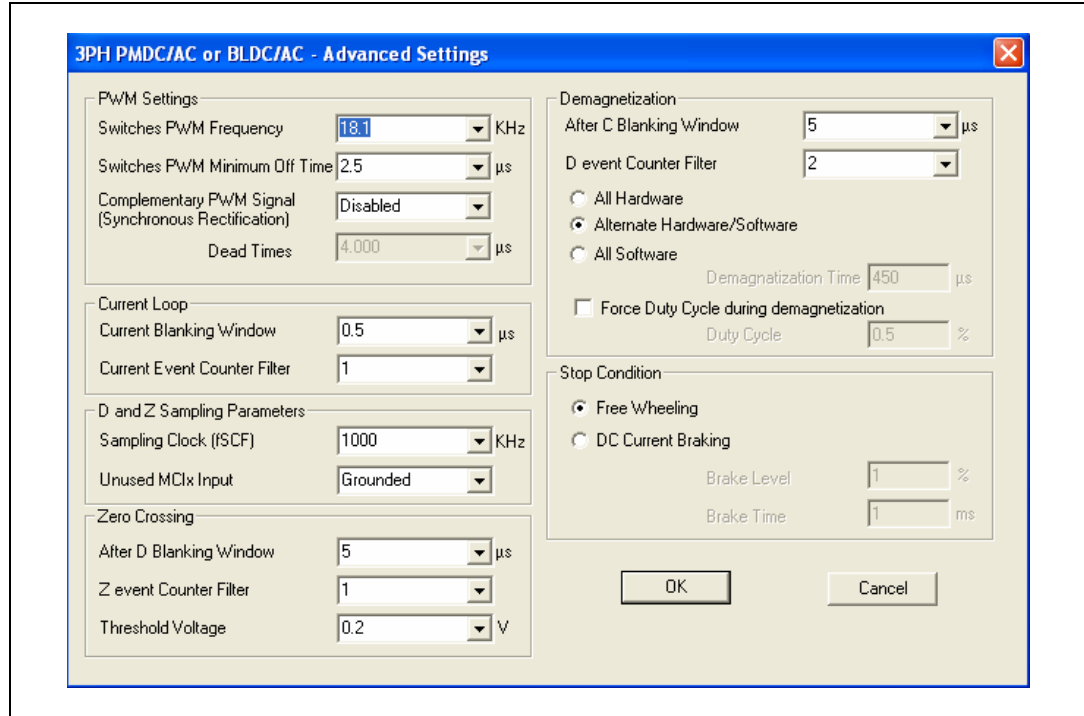
Table 9. "3-Phase BLAC/DC (trapezoidal)" advanced parameters

Parameter name	Description
Switches PWM frequency	Pulse Width Modulation (PWM) frequency in kHz
Switches PWM minimum off time	PWM minimum off time in microseconds (µs) to detect the BEMF
Complementary PWM signal	if synchronous rectification it is enable or not
Dead time	value of dead time in µs (only if Complementary PWM enabled)
Current loop	
Current blanking window	time window filter in milliseconds to prevent erroneous sampling of the current after the PWM is turned ON
Current event counter filter	defines the number of counter events required to validate a current limitation event
D and Z sampling parameters	
Sampling clock	sets the frequency of the sampling clock for D and Z events in kHz
Unused MCIx input	defines in which state the unused MCI input is fixed, either "Grounded" or "Hi-Z

Table 9.   **"3-Phase BLAC/DC (trapezoidal)" advanced parameters (continued)**

Parameter name	Description
Zero crossing	
After D Blanking Window	sets the blanking window after a D event in microseconds (µs)
Z Event Counter Filter	defines the number of counter events required to validate a Z event
Threshold Voltage	voltage set (in Volts) for Z detection
Demagnetization	
After C blanking window	sets the blanking window after a C event in microseconds (µs)
D event counter filter	defines the number of counter events required to validate a D event
Demagnetization method	Three methods are available: "all hardware", "alternate hardware/software" or "all software"
Demagnetization time	fixed demagnetization time in microseconds (µs) (only with demagnetization methods "all software")
Force duty cycle during demagnetization	allows using a different value of duty cycle rather than the one in run time setting
Duty cycle	value of duty cycle percentage forced during demagnetization
Stop condition	
Free wheeling	after stopping, the motor continues to spin freely
DC current braking	active brake obtained injected dc current into the motor
Brake level	value of duty cycle percentage of PWM brake signal
Brake time	duration in milliseconds of the active brake

7.4.6 ”3-Phase PMAC motor (sinewave)" settings

Figure 16. "3-Phase PMAC motor (sinewave)" basic parameters window

Table 10. "3-Phase PMAC motor (sinewave)" basic parameters

Parameter name	Description
Poles pairs	the number of pole (north/south) pairs in the motor
Speed regulation	the manner in which to run the motor, either open loop (without speed regulation) or closed loop (with speed regulation)
Sensor configuration	the number of Hall sensors on the motor – One sensor – Two sensors – Three sensors
Synchronous speed	
Min	sets the target minimum stator frequency in Hz for closed loop mode
Max	sets the target maximum stator frequency in Hz for closed loop mode
V/F (Voltage vs. Frequency) curve limitation	
Min voltage	sets the voltage level (expressed as a part of the 255th of the bus voltage) in the first corner of the V/F curve
Low frequency	sets the frequency of the first corner of the V/F curve in Hz
High frequency	sets the frequency of the second corner of the V/F curve in Hz

Table 10.   "3-Phase PMAC motor (sinewave)" basic parameters (continued)

Parameter name	Description
Start-up settings	
Voltage slew rate	affects the slew rate of the voltage during the motor start-up phase before reaching the potentiometer set value (only in open loop)
Start-Up stator frequency	sets the stator frequency during the start-up sequence (only in closed loop)
Max duration	sets the maximum duration of the start-up sequence in milliseconds (ms) (only in closed loop)
Min rotor frequency to validate closed loop	sets the rotor speed or frequency to validate the closed loop mode (only in closed loop)
Regulator settings	
Integral coefficient (Ki)	sets the value of the integral coefficient (Ki) of the Proportional Integrative (PI) regulator
Proportional Coefficient (Kp)	sets the value of the Proportional Coefficient (Kp) of the PI regulator
Sampling Time	sets the regulator sampling frequency in milliseconds (ms)
Phase shift	
Set phase shift according to Ph/F Curve	software sets (in run time) the actual phase shift from the Ph/F curve defined in the advanced settings (based on the rotor speed).
Set phase shift according by P3	manual setting of the phase shift using potentiometer P3; the maximum CCW position is 0° of phase shift and the maximum CW position is 360° of phase shift.
Change motor type	the "Change Motor Type" button enables the user to change the motor type (see *Figure 13*)
Advanced settings	the "advanced settings" button enables the user to set the advanced parameters (see *Section 7.4.7: "3-Phase PMAC motor (sinewave)" advanced settings*)
Generate source files	the "generate source files" button enables the user to generate the configuration ".h" files shown in *Table 7* - Configuration ".h" files. A "save" dialog window appears, where the user can select in which folder to create the file. User must choose the right "Source" directory in the firmware working folder (see *Section 7.4.1: Choosing the right firmware*).

7.4.7   "3-Phase PMAC motor (sinewave)" advanced settings

Clicking the "advanced settings" button (see *Figure 16*) opens the "advanced settings" dialog box (see *Figure 17*). This is where the advanced "3-phase PMAC motor (sinewave)" motor type parameters are set.

Figure 17. "3-Phase PMAC motor (sinewave)" advanced parameters window
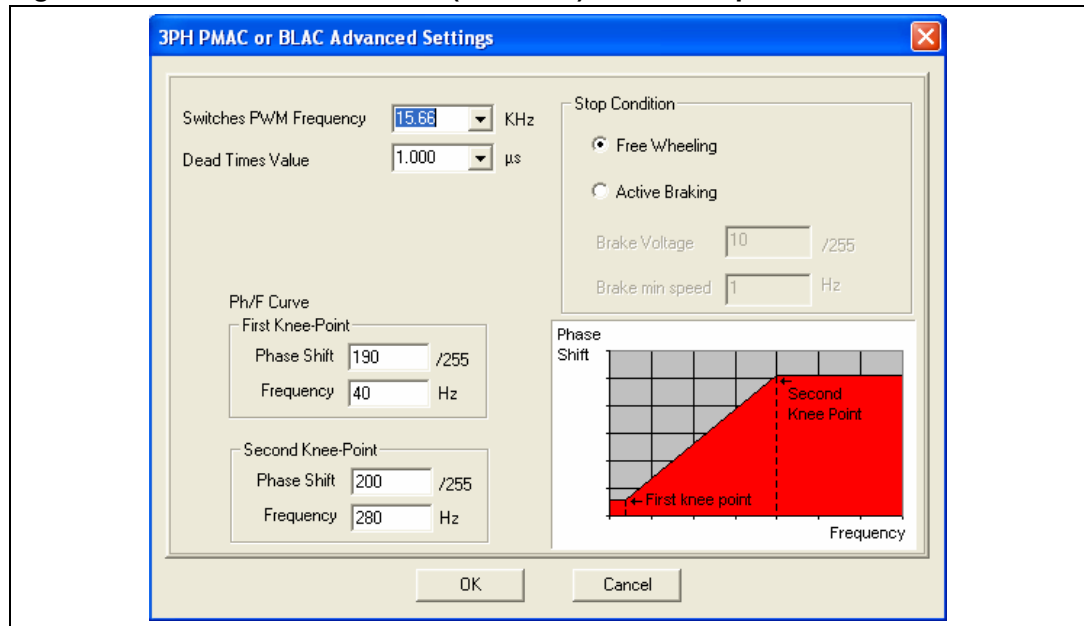
Table 11. "3-Phase PMAC motor (sinewave)" advanced parameters

Parameters name	Description
Switches PWM frequency	Pulse Width Modulation (PWM) frequency in kHz
Dead times value	selects from available preset dead time duration values in microseconds (µs)
Ph/F curve	Software uses this curve to set the value of the phase shift based on the actual value of the rotor frequency when the "set phase shift according to Ph/F curve" option is set in the main window. The curve is a linear interpolation between two knee-points.
First knee-point	
Phase shift	sets the value of phase shift of the first knee-point of the curve
Frequency	sets the value of frequency of the first knee-point of the curve
Second knee-point	
Phase shift	sets the value of phase shift of the second knee-point of the curve
Frequency	sets the value of frequency of the second knee-point of the curve
Stop condition	
Free wheeling	after stopping, the motor will continue to spin freely
Active braking	the motor will be braked generating a stator field 90° in advance respect the rotor field
Brake voltage	voltage level (expressed as a part of the 255th of the bus voltage) of the active braking stator field
Brake min speed	brake stays active until the motor it is brought below this rotor frequency

7.4.8 Changing the maximum current allowed by GUI

The maximum current allowed by GUI has been set to 8 A. This value may be changed by modifying the file "gui.ini" inside the folder where the "LVST7MC - GUI" file is installed.

Open the "gui.ini" file using the notepad and change the value of the following line:

MAX_CURRENT = 8

Replace the value 8 with the desired value of current limitation expressed in ampere.

Remember that also the hardware current limitation must be changed accordingly, see *Section 7.4.16: Changing the maximum current level allowed* to know how to modify this limitation.

7.4.9 Compiling the firmware

Once the configuration files have been produced (manually or using the GUI), the binary executable file (.s19) must be compiled and produced.

To do this, the STVD7 for inDART-STX is used with the Cosmic compiler (see *Section 7.3: Software requirements*)

1. Run the STDV7 for inDART-STX and choose "file > open workspace".
2. Select the workspace file under the "firmware working folder" depending on the motor type (see *Section 7.4.1: Choosing the right firmware*).
3. The default project in use is opened by the environment and is shown on the left side of the window below the opened ".stw" file.
4. Make sure that "Release" is set as the active project configuration (see *Figure 18*).

Figure 18. ST7VD active project configuration
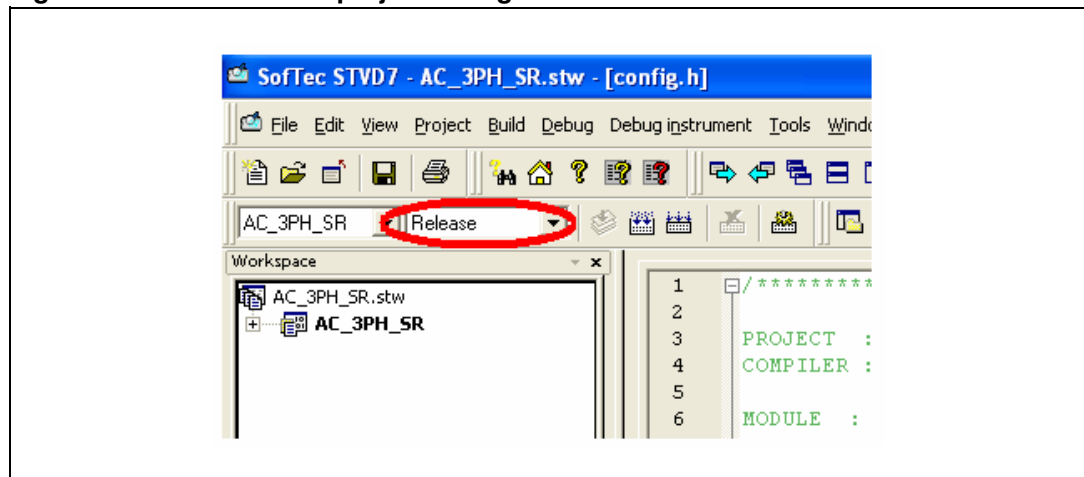
5. Use the "build" pull-down menu to display and select the "rebuild all" command. The project will be compiled and built, and an executable file "<firmware name>.s19" will be generated inside "release" folder under the workspace.

1 Make sure that the following string: "<firmware name>.elf - 0 error(s), 0 warning(s)" is displayed inside the output pane after the building of the executable.

2 After the building of the executable, please ensure that the file "<firmware name>.s19" generated inside the "release" folder under the workspace has been created. To do this, show the properties and check the creation date.

7.4.10 Programming the firmware

Before programming the firmware, the board must be supplied and connected to the PC using the inDART board. We suggest setting up the system as described in *Figure 19*.

Figure 19. System setup for programming phase
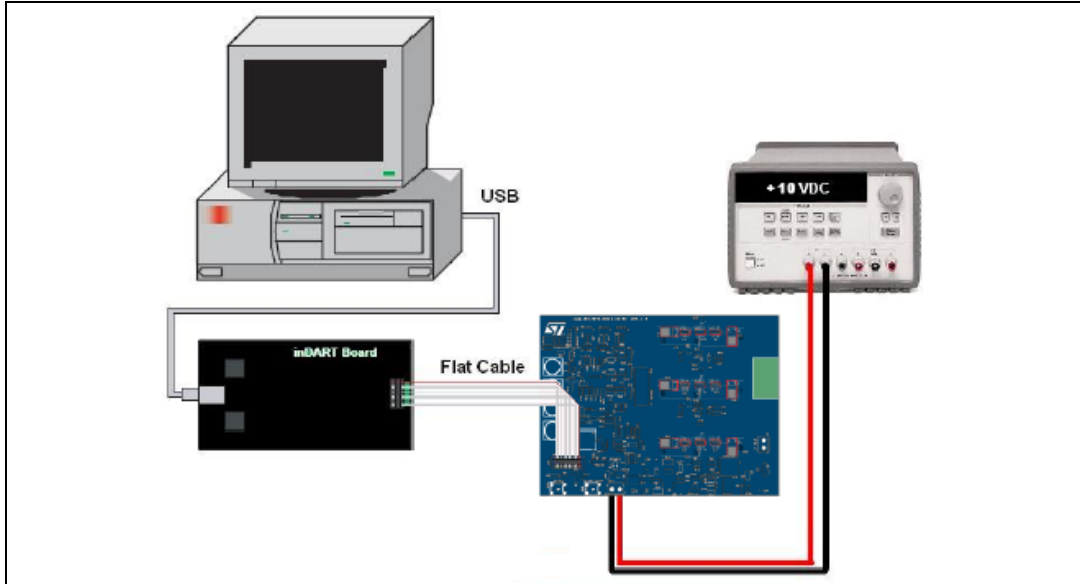
1. Use the USB cable to connect the inDART-STX board to the PC. The green LED on the inDART-STX Board turns on. The Windows® operating system automatically detects the new hardware and loads the appropriate USB and inDART-STX drivers.

3 Windows 2000® and Windows XP® may issue a warning the first time the inDART-STX power board is connected to the PC. The USB driver used by inDART-STX is not digitally signed by Microsoft, however, the user may safely ignore the warning since every kind of compatibility and security test has been carried out by Softec Microsystems.

2. Connect the inDART board with the J1 connector using the 10-pin flat cable.

3. Before supplying the board, remove J23 and J24. Check that J8 is connected between pin 1 and 2.

4. Supply the Control Board using a 10 V power supply connected to J6 observing the polarity.

Once the ST7VD for inDART has been installed, the "datablaze programmer" utility that can be used to program the firmware using the inDART-STX is automatically installed.

5. Run the Softec datablaze programmer utility.

6. Click the "select device" button on the toolbar.

7. In the "select device" window, select "inDART-STX" in the "programmer hardware" box, and "ST7FMC2S4" as the device code, and press OK.

4 If an error occurs, make sure that the inDART-STX board is connected to the PC. A green LED lights up if the board is connected.

8. Click on the file pull-down menu, select "load", then "code buffer".

9. In the "load file to code buffer" dialog box format menu, select "Motorola S-Rec" settings.

10. Click the button near "name" box and select the binary code (.S19) to download into the microcontroller, and press "OK" (to know which binary code to select, see *Section 7.4.9: Compiling the firmware*).

7.4.11 Setup option byte

11. Press the "option byte" button in the toolbar and select the value as shown in the "option configuration" window (see *Figure 20*), and press "OK".

Figure 20.   Option byte settings
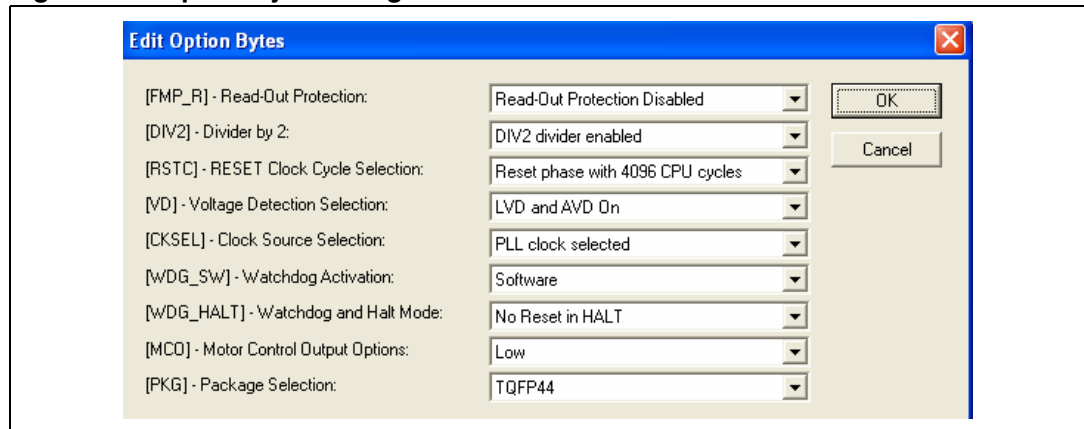
12. Press the "auto" button in the toolbar and select the programming options as shown in *Figure 21*.

Figure 21.   Programming option auto window

13. Press "start" to program the device.

If an error window appears, make sure that the inDART-STX board is connected to the ControlBDST7MC2 control board and that the control board is well supplied.
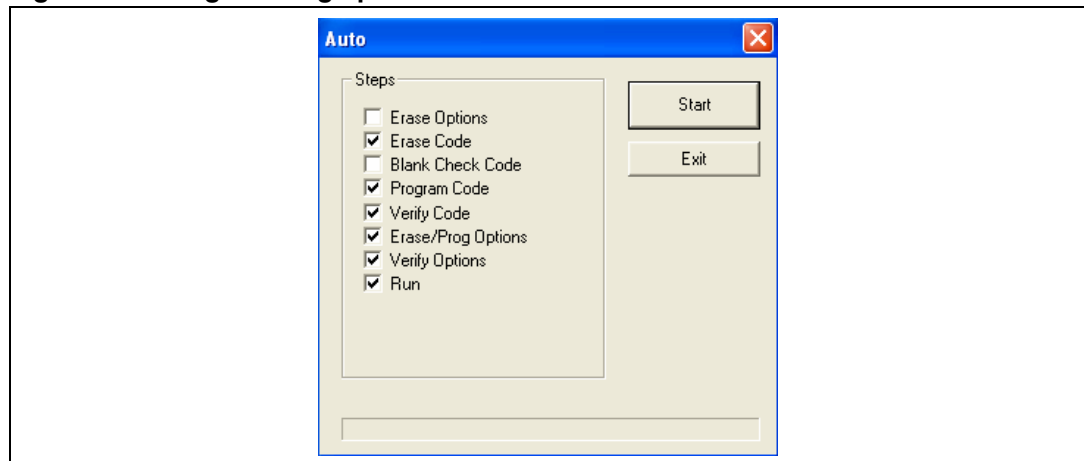
14. After programming check LED behavior to verify that the firmware has been correctly downloaded (see *Section 7.5.3*, *Section 7.6.3*, and *Section 7.7.3: LED behavior after power on*).

7.4.12 Configuring DC input range

Before supplying the board with bus voltage, it must be configured by setting the jumper J22, J23, J24, J27 and J8 in the proper position. Follow *Table 4* to configure the jumper based on the DC input range and keep the J8 jumper between 1-2.

7.4.13 Jumper settings table

Table 12.   Jumper settings table

Name	Selection	Description
J2	Open	Disable the auxiliary flash memory. Debug feature can be enabled.
	Closed(*)	Enable the auxiliary flash memory. Debug feature cannot be enabled.
J3	Open	Disable the current reference generated by PWMV. Debug feature can be enabled (this setting is not allowed driving BLDC trapezoidal)
	Closed(*)	Enable the current reference generated by PWMV. Debug features cannot be enabled.
J4	Between 1-2	Adjustable – The current reference value (MCCREF) is set by potentiometer P4 – Only for BLDC (trapezoidal) driving.
	Between 2-3(*)	Variable – The current reference value (MCCREF) is driven by the microcontroller PWM-V - Only for BLDC (trapezoidal) driving.
	Open	No current reference is required – For PMAC Motor (sinewave) driving.
J21	Open(*)	Threshold voltage used for BEMF detecting is set internally by the microcontroller firmware. This option should be selected for ST BEMF detecting strategy.
	Between 1-2	Threshold voltage used for BEMF detecting is derived from phases voltage value. This option should be selected for GE BEMF detecting strategy.
	Between 2-3	Threshold voltage used for BEMF detecting is derived from Bus voltage. This option should be selected for GE BEMF detecting strategy.

Note: The default configuration is indicated with (*) in Table 12.

7.4.14 Board connection

After the board has been programmed, the system can be configured as shown in *Figure 22*. This configuration is called a "running configuration". Remove the ICC flat cable from the board if present.

1. Connect the insulated DC power supply to the J5 connector of STEVAL-IHM015V1, following the serigraphy for polarity.
2. Connect the phases of the motor to the J10 connector of the board and if required, connect the sensor signal to the hall sensor connector J14.

Figure 22. System setup for running phase
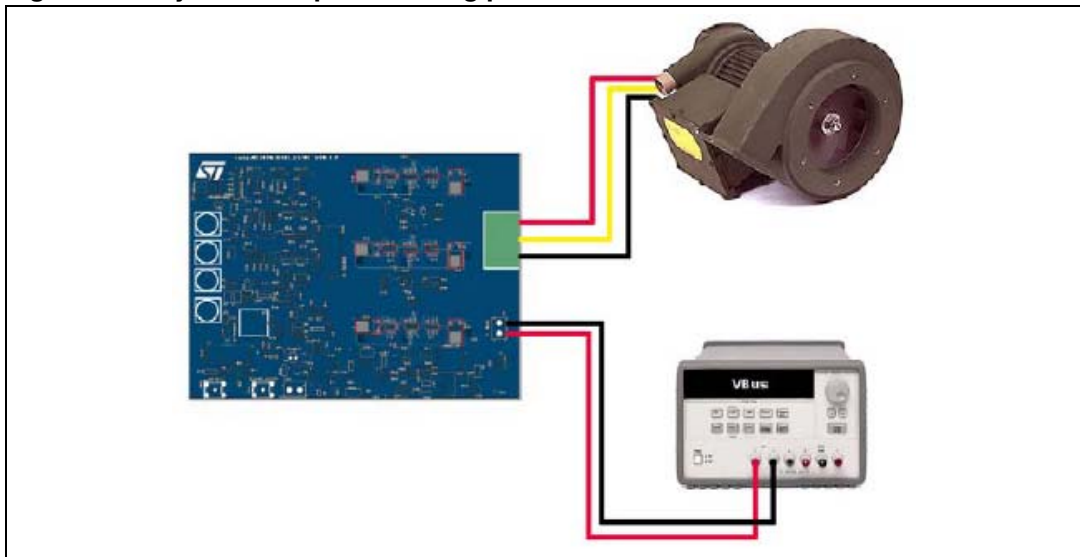
7.4.15 Changing the maximum bus voltage level allowed

Inside the board an over voltage protection mechanism is included that protects the system, preventing the motor from starting if the bus voltage it is greater than a certain voltage. If this occurs, the red LED starts blinking.

This threshold value is coded inside the firmware and is fixed at 29 V as the default value. To change this value, one parameter inside the source code must be modified and the executable must be rebuilt. To do this find the following definition inside the adc.c source file.

```
#define HVBUS_THRESHOLD  539       // bus voltage reference (29 V)
```

See *Table 13* to get the value relative to the desired bus voltage threshold and replace the number 539 in the statement above with this value.

Table 13. Bus voltage threshold parameter

Bus threshold	HVBUS_threshold value
6 V	112
12 V	223
18 V	335
24 V	446
30 V	558
36 V	670
42 V	781
48 V	893

7.4.16 Changing the maximum current level allowed

An over current protection mechanism is included inside the board that protects the system, disabling all the power switches if current that flows inside the motor is greater than a certain

threshold. If this occurs, the red LED starts blinking. This mechanism is called "hardware current protection".

This threshold value is fixed by the hardware to 7.65 A.

To change this threshold to I_{MAX}, resistor R77 must be modified according to *Equation 1* (Changing hardware current protection threshold).

Equation 1

$$R_{77} = \frac{10K}{\left[\dfrac{5}{0.07 \bullet I_{MAX}} - 1\right]}$$

When the BLDC (trapezoidal) driving strategy is used, there is another current protection mechanism called "software current limitation" which regulates the current that flows inside the motor. In "current mode" the current is regulated to a certain value, and in "voltage mode" the current is limited to a maximum value.

The maximum current allowed by this mechanism is related to the hardware and is fixed at 6.5 A.

To change this threshold, resistor R20 must be modified as follows.

First the amplification factor called AMP must be calculated using *Equation 2* (Amplification factor).

Equation 2

$$AMP = \frac{5}{0.07 \bullet I_{MAX}}$$

Then the value of R_{20} can be calculated using *Equation 3* (Changing the maximum current allowed).

Equation 3

$$R_{20} = (AMP - 1) \bullet 10K$$

After this modification the "gui.ini" file must be modified. This file is inside the same folder as the "LVST7MC - GUI" file.

Open the "gui.ini" file using the notepad and change the value of the following line:

```
MAX_CURRENT = 8
```

…

```
AMP_SENS = 11
```

Replace the value 8 with I_{MAX} expressed in amps and 11 with the AMP value calculated by *Equation 2*.

Remember to close and re-open "LVST7MC - GUI" to activate this modification and follow the instructions in *Section 7.4.2: Configuring the firmware using GUI*.

7.5 Driving the BLDC motor (trapezoidal - sensorless)

Let's start the demonstration driving the brushless permanent magnet motor sensorless, so at this point please check that the board has been set up for sensorless driving (See *Section 7.4.4: "3-Phase BLAC/DC (trapezoidal)" settings*.

7.5.1 Specific connection (sensor)

To drive the motor also in closed loop mode, it is not required that the motor include any position or speed sensor. For this demonstration we suggest using one Ametek BLDC Blower motor (voltage max 30 Vdc).

7.5.2 Specific jumper settings

Set up the board following the instructions in *Section 7.4.12: Configuring DC input range* (Bus voltage between 9 V - 28 V) and *Section 7.4.13: Jumper settings table*.

Table 14.   BLDC SL jumpers setting

Driving mode	Jumpers setting
BLDC_3PH_SL	J11 between 2-3, J12 between 2-3, J13 between 1-2
	J15 between 2-3, J16 between 2-3, J17 between 1-2
	J18 between 2-3, J19 between 2-3, J20 between 1-2
	J3 Closed, J4 variable (2-3)

Set up the board as in *Table 14*.

7.5.3 LED behavior after power on

Turn on the power supply. For this demonstration the power supply output voltage should be set to 20 Vdc and the current limitation of the power supply should be set to 4 A.

After power on the Control board LED behavior should be the following:

● Red LEDs blink signaling that the firmware has started to run.

● After a while a green LED stays on to indicate "idle state"

7.5.4 Setting the potentiometers

Before running the motor, the three potentiometers P1, P2, P3 must be set up (see *Table 15: Potentiometer functionality based on open/closed loop driving strategy* for the correct configuration.

7.5.5 Running the motor (LED behavior)

Push the start/stop button. After pushing the button the LEDs toggle from green to red to indicate "run state" The motor starts to run.

During any state: idle, start, run or brake, blinking of the red LED together with the brake of the motor indicates a fault condition. A fault condition can be obtained is due to one of the following conditions:

● Hardware overcurrent: current flowing inside motor reaches a value greater than max current allowed 7.65 A (see *Section 7.4.16: Changing the maximum current level allowed*)

● Over voltage: bus voltage reaches a value greater than 29 Vac.

● Over temperature: onboard temperature sensor measures a temperature greater than 110°.

● Start-up failed: start-up phase ends without getting a sufficient number of valid zero crossing events.

● Motor stalled: during the running of the motor no more zero crossing events have been observed.

5 *Blinking of the red LED during the running of the motor indicates that software current limitation is in action.*

7.5.6 Changing real-time parameters

The real-time parameters can be changed using the potentiometers of the control board. *Table 15* explains the potentiometer functionality based on the driving strategy.

Table 15. Potentiometer functionality based on open/closed loop driving strategy

Voltage mode		
	Open loop	**Closed loop**
P1	sets the duty cycle percentage from 0% to the maximum duty cycle allowed.	sets the target rotor frequency value from minimum value to maximum value configured (see *Section 7.4.4: "3-Phase BLAC/DC (trapezoidal)" settings*)
P2	sets the value of rising delay coefficient from 0 to 255	
P3	sets the value of falling delay coefficient from 0 to 255	
P4	not used	
Current mode		
	Open loop	**Closed loop**
P1	sets the current reference value from 0 A to maximum current allowed.	sets the target rotor frequency value from minimum value to maximum value configured (see *Section 7.4.4: "3-Phase BLAC/DC (trapezoidal)" settings*)
P2	sets the value of rising delay coefficient from 0 to 255	
P3	sets the value of falling delay coefficient from 0 to 255	
P4	not used	

If during the configuration using GUI, the "from RV1" control has been unchecked, then the value of the duty cycle (or the value of current reference) is not set by P1 but has a fixed value.

If during the configuration using GUI, the "from RV2 - RV3" control has been unchecked, then the value of the rising delay coefficient and the value of the falling delay coefficient are not set by P2 and P3 but have fixed values.

The maximum duty cycle allowed in voltage mode depends on the value of PWM frequency and the value of PWM min off time set by the GUI.

The maximum current allowed by GUI has been set to 8A. (see *Section 7.4.8: Changing the maximum current allowed by GUI*).

7.5.7 Stopping the motor (LED behavior)

Push the Start/Stop button to stop the motor. The LEDs toggle from green to red to indicate "idle state".

7.5.8 Configuring the system for BEMF amplification

It is possible to configure the system to enable a BEMF amplification network. This configuration can be useful for any circumstance in which the BEMF signal is very low such as low speed for instance. This network is able also to compensate the freewheeling diode voltage drop that can not be negligible in case of low value bus voltage. See AN1103 "Improved B-EMF detection for low-speed and low-voltage applications". Use the settings in *Table 16* to enable this feature.

Table 16.   BLDC SL with BEMF amplification jumper settings

Driving mode	Jumper setting
BLDC_3PH_SL	J11 between 2-3, J12 between 2-3, J13 between 1-2
	J15 between 2-3, J16 between 2-3, J17 between 1-2
	J18 between 2-3, J19 between 2-3, J20 between 1-2
	J3 Closed, J4 variable (2-3)

7.6 Driving the BLDC motor (trapezoidal - sensored)

Let's start the demonstration driving the brushless permanent magnet motor with three Hall sensors 60°. At this point please check that the board has been set up for BLDC sensor 60° driving (See *Section 7.4.4: "3-Phase BLAC/DC (trapezoidal)" settings*).

7.6.1 Specific connection (sensor)

To drive the motor, it must have three position sensors, in this case three Hall sensors. For this demonstration, we suggest using one Ametek BLDC Blower motor (voltage max 30 Vdc).

Use the connections described in *Table 17* to connect the motor to the power board.

Table 17. "BLDC Sensored" motor connections

Motor	Power board
Phase A (red)	J10 pin 1
Phase B (yellow)	J10 pin 2
Phase C (black)	J10 pin 3
Hall sensor 1 (white)	J14 pin 1
Hall sensor 2 (green)	J14 pin 2
Hall sensor 3 (blue)	J14 pin 3
Hall sensor +5V (red)	J14 pin 4
Hall ground (black)	J14 pin 5

7.6.2 Specific jumper settings

Set up the board following the instructions in *Section 7.4.12: Configuring DC input range* (bus voltage between 9 V - 28 V) and *Section 7.4.13: Jumper settings table*.

Table 18. BLDC SR jumper settings

Driving mode	Jumper setting
BLDC_3PH_SR	J11 open, J12 open, J13 between 2-3
	J15 open, J16 open, J17 between 2-3
	J18 open, J19 open, J20 between 2-3
	J3 Closed, J4 Variable (2-3)

Set up the board as in *Table 18*.

7.6.3 LED behavior after power on

Turn on the power supply. For this demonstration the power supply output voltage should be set to 20 Vdc and the current limitation of the power supply should be set to 4 A.

After power on the control board LED behavior should be the following:

● Green LEDs blink signaling that the firmware has started to run.
● After a while a green LED stays on to indicate "idle state".

7.6.4 Setting the potentiometers

Before running the motor, the three potentiometers P1, P2, P3 must be set up (see *Table 19: Potentiometer functionality based on open/closed loop driving strategy* for the correct configuration.

7.6.5 Running the motor (LED behavior)

Push the start/stop button. After pushing the button the LEDs toggle from green to red to indicate "run state"

The motor starts to run.

During any state: idle, start, run or brake, a red LED that stays on together with the brake of the motor indicates a fault condition.

A fault condition is due to one of the following conditions:

● Hardware overcurrent: current flowing inside motor reaches a value greater than the max current allowed 7.65 A (see *Section 7.4.16: Changing the maximum current level allowed*.)

● Over voltage: bus voltage reaches a value greater than 29 Vac.

● Over temperature: onboard temperature sensor measures a temperature greater than 110°.

● Start-up Failed: Start-up phase ends without getting a sufficient number of valid zero crossing events.

● Motor stalled: during the running of the motor no more zero crossing events have been observed.

6   Blinking of the red LED during the running of the motor indicates that software current limitation is in action.

7.6.6   Changing real-time parameters

The real-time parameters can be changed using the potentiometers of the control board. *Table 19* explains the potentiometer functionality based on the driving strategy.

Table 19.   Potentiometer functionality based on open/closed loop driving strategy

Voltage mode		
	Open Loop	**Closed loop**
P1	sets the duty cycle percentage from 0% to 100%.	sets the target rotor frequency value from Minimum value to Maximum value configured (see *Section 7.4.4: "3-Phase BLAC/DC (trapezoidal)" settings*)
P2	sets the value of rising delay coefficient from 0 to 255	
P3	sets the value of falling delay coefficient from 0 to 255	
P4	not used	
Current mode		
	Open loop	**Closed loop**
P1	sets the current reference value from 0 A to maximum current allowed.	sets the target rotor frequency value from Minimum value to Maximum value configured (see *Section 7.4.4: "3-Phase BLAC/DC (trapezoidal)" settings*)
P2	sets the value of rising delay coefficient from 0 to 255	
P3	sets the value of falling delay coefficient from 0 to 255	
P4	not used	

If during the configuration using GUI, the "from RV1" control has been unchecked, then the value of the duty cycle (or the value of current reference) is not set by P1 but has a fixed value.

If during the configuration using GUI, the "from RV2 - RV3" control has been unchecked, then the value of the rising delay coefficient and the value of the falling delay coefficient are not set by P2 and P3 but have fixed values.

The maximum current allowed by GUI has been set to 8A. (see *Section 7.4.8: Changing the maximum current allowed by GUI*.)

7.6.7 Stopping the motor (LED behavior)

Push the start/stop button to stop the motor. The LEDs toggle from green to red to indicate "idle state".

7.7 Driving the BLAC motor

Let's start the demonstration driving the brushless permanent magnet motor. At this point please check that the board has been set up for BLAC driving (See *Section 7.4.6: "3-Phase PMAC motor (sinewave)" settings*).

7.7.1 Specific connection (sensor)

To drive the motor it must have three position sensors, in this case three Hall sensors. For this demonstration we suggest using one Ametek BLDC Blower motor (voltage max 30 Vdc). Refer to the connections in *Table 20* to connect the motor to the power board.

Table 20.   "PMAC Sensored" motor connections

Motor	Power board
Phase A (red)	J10 pin 1
Phase B (yellow)	J10 pin 2
Phase C (black)	J10 pin 3
Hall sensor 1 (white)	J14 pin 1
Hall sensor 2 (green)	J14 pin 2
Hall sensor 3 (blue)	J14 pin 3
Hall sensor +5 V (red)	J14 pin 4
Hall ground (black)	J14 pin 5

7.7.2 Specific jumper settings

Set up the board following the instructions in *Section 7.4.12: Configuring DC input range* (Bus voltage between 9 V - 28 V) and *Section 7.4.13: Jumper settings table*.

Table 21.   PMAC SR jumper settings

Driving mode	Jumper setting
PMAC_3PH_SR	J11 open, J12 open, J13 between 2-3
	J15 open, J16 open, J17 between 2-3
	J18 open, J19 open, J20 between 2-3

Set up the board as in *Table 21*.

7.7.3   LED behavior after power on

Turn on the power supply. For this demonstration the power supply output voltage should be set to 30 Vdc and the current limitation of the power supply should be set to 4 A. After power on, the Control board LED behavior should be the following:

● Green and red LEDs blink alternatingly signaling that the firmware has started to run.

● After a while a green LED stays on to indicate "idle state"

7.7.4   Setting the potentiometers

Before running the motor the two potentiometers P1, P3 must be set up (see *Table 22: Potentiometer functionality based on open/closed loop driving strategy* for the correct configuration).

7.7.5   Running the motor (LED behavior)

Push the Start/Stop button. After pushing the button the LEDs toggle from green to red to indicate "run state". Turn P1 in clockwise direction. Keeping P1 fixed, turn P3 in a clockwise direction until the motor runs.

7   Turning the P3 potentiometer modifies the "phase shift" parameter. To optimize driving, the right value of this parameter must be set. Finding the optimum value of "phase shift" can be useful to monitor the DC current provided by the power supply. The user should try to fine tune the P3 potentiometer to minimize the current absorption. When this parameter has been found, the potentiometer P3 can be left at this value for all future tests.

During any state: idle, start, run or brake, blinking of the red LED indicates a fault condition. A fault condition is due to one of the following conditions:

● Hardware overcurrent: current flowing inside motor reaches a value greater than max current allowed 7.65 A (see *Section 7.4.16: Changing the maximum current level allowed*.)

● Over voltage: bus voltage reaches a value greater than 29Vac.

● Over temperature: onboard temperature sensor measures a temperature greater than 110°.

● Start-up failed: no signal from sensors is present at the end of start-up.

● Motor stalled: during the running of the motor no sensor signal has been observed.

7.7.6   Changing real-time parameters

The real-time parameters can be changed using the potentiometers of the control board.

Table 22 explains the potentiometer functionality based on the driving strategy.

Table 22.   Potentiometer functionality based on open/closed loop driving strategy

	Open loop	Closed loop
P1	sets the voltage modulation index from 0% to 100% of bus voltage.	sets the target rotor frequency value from minimum value to Maximum value configured (see *Section 7.4.6: "3-Phase PMAC motor (sinewave)" settings*)
P2	not used	
P3	manual setting of the phase shift; the maximum CCW position is 0° of phase shift and the maximum CW position is 360° of phase shift	
P4	not used	

If during the configuration using GUI, the "Set Phase Shift according to Pf/F curve" control has been checked, then the value of "phase shift" is not set by P3 but is calculated run time based on the Pf/F curve (see *Section 7.4.7: "3-Phase PMAC motor (sinewave)" advanced settings*).

The maximum current allowed by GUI has been set to 8A (see *Section 7.4.8: Changing the maximum current allowed by GUI*).

7.7.7   Stopping the motor (LED behavior)

Push the start/stop button to stop the motor. The LEDs toggle from green to red to indicate "idle state".

8   Bill of materials

Table 23.   Bill of materials

Item	Reference	Part
1	C1	1 nF (NC)
2	C2	100 nF (NC)
3	C3	1 µF/25 V
4	C4,C5,C6,C8,C34	10 nF/50 V
5	C7,C9,C10,C11,C21	100 nF/50 V
6	C12	1 nF/50 V (NC)
7	C13,C31	100 nF/25 V
8	C22	1 µF/10 V
9	C23	100 µF/25 V
10	C24	330 µF ESR 42 mΩ
11	C25	100 µF 150 mΩ
12	C26	220 nF/50 V
13	C43, C44, C45	1 µF/50 V
14	C27	100 pF/50 V
15	C28,C32	1 µF/25 V
16	C29	3.3 nF/50 V
17	C30,C40	22 nF/50 V
18	C33	1 µF 25 V
19	C39	10 µF 16 V
20	C41	220 pF/50 V
21	C42	100 µF 16 V
22	C46,C47,C48	2.2 nF 25 V (NC)
23	C49,C50	10 nF/25 V
24	D1	Green LED
25	D2	Red LED
26	D4	Green LED
27	D3	1.5KE15A
28	D5	STPS1L60A
29	D6,D7,D8,D9,D10,D11	1N4148
30	D14,D15	STPS2L25U
31	JP1	CON4
32	J1	ICC connector: HE10 male type

Table 23.   Bill of materials (continued)

Item	Reference	Part
33	J2,J3	CON2
34	J4,J8,J11,J12,J13,J15, J16,J17,J18,J19,J20,J21	CON3
35	J5	V_{BUS}
36	J6	+10 V
37	J10	Phase OUT
38	J14	CON5
39	J22,J27	CON1
40	J23,J24	CON3
41	L1	470 µH 0.35 A
42	L3	15 µH 1 A
43	NTC1	10 kΩ
44	R12,R13,R19,R64,R68, R72,R73,R75	10 kΩ
45	P1,P2,P3	50 kΩ - trimmer
46	P4	100 kΩ - trimmer
47	R20	100 kΩ - 1/4 W
48	Q8	STN4NF03L
49	Q9,Q10,Q11,Q12,Q13,Q14,Q15,Q16,Q17,Q18,Q19,Q20	(NC)
50	RF1,RF2,RF3	330 kΩ - 1/4 W
51	R1, R4, R39, R50, R63, R71	470 Ω - 1/4 W
52	R2	100 kΩ (NC)
53	R3,R5,R6	10 kΩ (NC)
54	R7, R8, R17, R18, R67	47 kΩ - 1/4 W
55	R9,R10,R11	(NC)
56	R14	100 Ω - 1/4 W
57	R15	1 MΩ 1/4 W
58	R16	1.2 kΩ - 1/4 W
59	R21	33 KΩ -1/4 W
60	R26	470 Ω - 1/4 W
61	R27,R41,R53,R65	15 kΩ - 1/4 W
62	R28	4.6 kΩ - 1/4 W
63	R29	18 kΩ - 1/4 W
64	R30	3.3 kΩ - 1/4 W
65	R31,R45,R57	200 R - 1/4 W
66	R32,R47,R59,R69	22 kΩ - 1/4 W
67	R38,R42,R44,R49,R54,R56,R62,R66,R76	2.2 kΩ - 1/4 W

Table 23.   Bill of materials (continued)

Item	Reference	Part
68	R33,R37,R46,R48,R58,R60	22 Ω - 1/4 W
69	R34,R35,R36,R74,R81	4.7 kΩ - 1/4 W
70	R40,R51,R61	220 Ω - 1/4 W
71	R43, R55,R70	2.2 kΩ - 1/4 W
72	R52	0.07 Ω - 5 W
73	R77	1.2 kΩ - 1/4 W
74	R82	2.7 KΩ - 1/4 W
75	R83	13 kΩ - 1/4 W
76	SW3	Reset button
77	SW4	Start/stop
78	U1	TS271ACD (NC)
79	U2	ST7FMC2S4T6-TQFP44
80	U3	M95020-MN3TP/S
81	U9	LK112SM50TR
82	U10	L4976D
83	U11,U13,U14	L6387
84	U15,U17,U18	STS8DNH3LL
85	U16	L5970D
86	U19	TS274
87	X1	CSTCS-16MX

9 References

This user manual provides information about using the STEVAL-IHM015V1 and its hardware features. For additional information about supporting software and tools, please refer to:

ST7MC Datasheet: complete information about microcontroller features and peripherals.

ST7MC Motor Control related application notes: complete information about motor control libraries developed for the ST7MC microcontroller.

STS8DNH3LL Datasheet: complete information about the Power MOSFET devices included.

Website http://mcu.st.com/ which is dedicated to the complete STMicroelectronic's microcontroller portfolio.

Motor Control forum:

http://mcu.st.com/mcu/modules.php?mop=modload&name=Splatt_Forums&file=viewforum &forum=13.

10 Revision history

Table 24. Revision history

Date	Revision	Changes
24-Jul-2007	1	First issue

Please Read Carefully: