



## STM8/128-MCKIT motor control starter kit

### 1 Introduction

The STM8/128-MCKIT starter kit is an integrated system designed to provide a complete, ready-to-use motor control application developed around the STMicroelectronics STM8 microcontroller.

This starter kit is particularly suited to drive 3-phase brushless motors (either AC induction or permanent magnet types) and demonstrates how effectively the STM8 microcontrollers can be used in real-world motor control applications.

- Drive is based on scalar control (BLDC or ACIM) for three-phase motors.
- Position and/or speed measurement is implemented using Hall sensors or a tachometer.
- Sensorless control is also implemented.
- The inverter is driven using the PWM modulation technique.

The STM8/128-MCKIT starter kit can be run in various ways:

- As a plug-and play demo, out of the box, with the provided BLDC motor, in sensorless speed control mode.
- With an AC induction motor, after reprogramming the microcontroller, in open loop or in speed control mode.

However, the main advantage of the STM8/128-MCKIT is that you can use it to create your own applications and re-program the STM8 microcontroller. You can develop your own applications using the dedicated software libraries provided in the starter kit in conjunction with a third-party IDE and C compiler.

This manual describes:

- The STM8/128-MCKIT starter kit components, and how to set up the hardware to run the provided BLDC motor or an AC induction motor.
- How to run the STM8/128-MCKIT starter kit in standalone mode.
- The BLDC daughterboard (MB843).

For information about the STM8 microcontroller features, refer to the datasheet. The STM8 evaluation board features, peripherals, and connectors are described in the STM8/128-EVAL user manual (UM0482).

For information on the BLDC and AC induction motor software libraries and how to use them in motor control application development projects, refer to the STM8S three-phase BLDC software library (UM0708) and the STM8S three-phase AC induction motor software library user manual (UM0712) respectively. You will find these manuals, and all related documentation on the STM8/128-MCKIT CD-ROM.

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## 2 Safety warnings

### 2.1 General

In operation, the STM8/128-MCKIT starter kit has non-insulated wires, moving or rotating parts (when connected to a motor), as well as hot surfaces. In case of improper use, incorrect installation or misuse, there is danger of serious personal injury and damage to property. All operations, installation and maintenance are to be carried out by skilled technical personnel (applicable accident prevention rules must be observed).

When the power board is supplied with voltages greater than 30 V AC/DC, all of the board and components must be considered “hot”, and any contact with the board must be avoided. The operator should stay away from the board as well (risk of projection of material in case of components destruction, especially when powering the board with high voltages).

The rotating parts of motors are also a source of danger.

The STM8/128-MCKIT starter kit contains electrostatic sensitive components which may be damaged through improper use.

*Note: The board's power supply must be electrically insulated **before** connecting any cables that link the PC to the board, such as the STX-RLINK or a serial cable. Otherwise an earth/ground loop would occur, as there is no insulation board.*

### 2.2 Intended use

The STM8/128-MCKIT starter kit is made of components designed for demonstration purposes and must not be included in electrical installations or machinery. Instructions about the setup and use of the STM8/128-MCKIT starter kit must be strictly observed.

### 2.3 Operation

After disconnecting the board from the voltage supply, several parts and power terminals must not be touched immediately because of possible energized capacitors or hot surfaces.

### 2.4 Important notice to users

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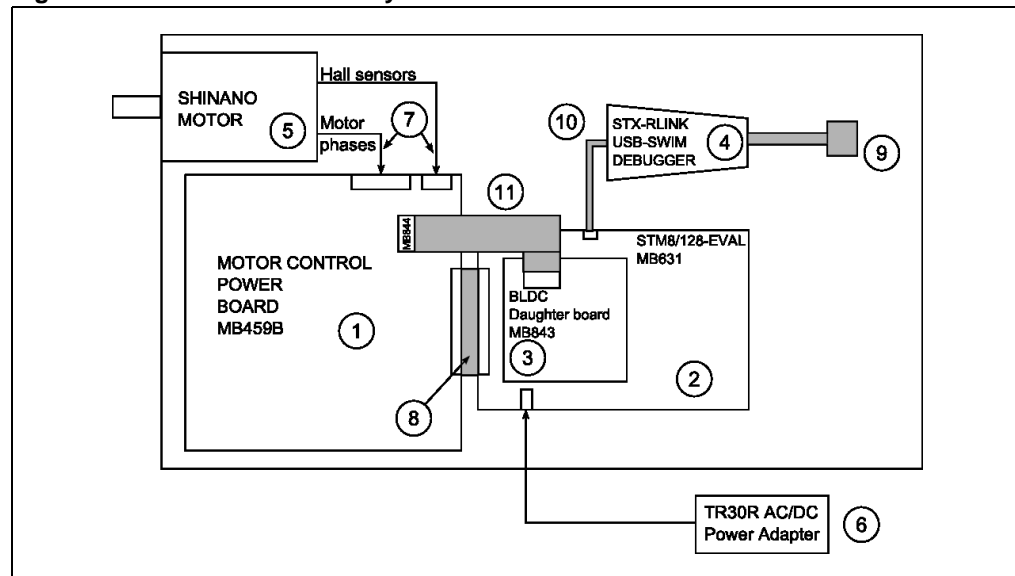
### 3 STM8/128-MCKIT hardware setup

This section provides a detailed description of the components included in the STM8/128-MCKIT starter kit. It also describes the default settings for a brushless DC motor (BLDC), and explains how to change them to use an AC induction motor.

#### 3.1 Package checklist

*Figure 1* shows the layout and connections of the major components of the STM8/128-MCKIT starter kit.

**Figure 1. STM8/128-MCKIT layout**



##### 3.1.1 Hardware

The STM8/128-MCKIT starter kit includes the following items:

- The MB459B power board (1): This board is described in the MB459B power board user manual (UM0379) provided on the STM8/128-MCKIT CD-ROM.
- The MB631 STM8 evaluation board (2): This board is described in the STM8/128-EVAL user manual (UM0482) provided on the STM8/128-MCKIT CD-ROM.
- An MB843 BLDC daughterboard (3): This board is described in the chapter BLDC daughterboard MB843. The purpose of the BLDC daughterboard is to implement the BEMF detecting network and the current regulation/limitation network.
- An STX-RLink USB–SWIM debugger (4): The RAISONANCE STX-RLink USB-JTAG debugger allows you to reprogram the Flash memory of the STM8 microcontroller and to debug the software before using the application in standalone mode.
- A 24V DC SHINANO BLDC motor (5): The motor included in the STM8/128-MCKIT starter kit is a SHINANO inner rotor type 4-pole brushless DC motor with Hall sensor and encoder. For electrical specifications and mechanical dimensions, refer to the SHINANO datasheets on the STM8/128-MCKIT CD-ROM.

- An auxiliary power supply block TR30R (6)
- The following cables:
  - Motor cables (7)
  - A motor connector HE10 34-pin cable (8)
  - A USB cable (9)
  - One SWIM cable and the related adapter (10)
  - An auxiliary connector for BLDC sensorless HE10 20-pin cable (11)
- A bag with three 0.1 ohm resistors is included to configure the MB459B board to increase the maximum motor nominal current level up to 5 amps.
- The STM3210B-MCKIT CD-ROM.

### 3.1.2 Software

The STM8/128-MCKIT CD-ROM includes the BLDC and AC induction motor software libraries.

When you receive the STM8/128-MCKIT, the STM8 microcontroller is programmed by default with the BLDC sensorless firmware.

### 3.1.3 Documentation

The STM8/128-MCKIT CD-ROM also includes the following product documentation in PDF format:

- STM8Sxxx access line and performance line datasheets
- STM8Sxxx reference manual
- STM8/128-MCKIT motor control kit user manual (UM0709, the present manual)
- STM8S three-phase BLDC software library v1.0 user manual (UM0708)
- STM8S three-phase AC induction motor software library v1.0 user manual (UM0712)
- STM8/128-EVAL user manual (UM0482)
- MB459B power board user manual (UM0379)
- SHINANO motor datasheet.

In the box with the STM8/128-MCKIT, there is also:

- The MCD product finder
- Product flyers and brochures
- The MCD miniROM
- A guarantee record card

### 3.1.4 Components not provided

The STM8/128-MCKIT starter kit does not include:

- A power supply: To use the STM8/128-MCKIT starter kit with the provided BLDC motor, you need a 24V-3A minimum power supply.
- An AC induction motor: The STM8/128-MCKIT can operate with an AC induction motor. The provided firmware is designed to operate with the SELNI induction motor. It can be ordered as an accessory with the following order code: ST7MC-MOT/IND. To use the STM8/128-MCKIT starter kit with the Selni AC induction motor, you need a 42 V DC or 32 Veff AC power supply (polarity not important, earth connection recommended).

## 3.2 Brushless DC motor (default)

The brushless DC motor (BLDC) is a rotating electric machine where the stator is a classic 3-phase stator like that of an induction motor and the rotor has surface-mounted permanent magnets. In this respect, the BLDC motor is equivalent to an induction motor where the air gap magnetic field is produced by a permanent magnet. The use of a permanent magnet to generate a substantial air gap magnetic flux makes it possible to design highly efficient motors.

A BLDC motor is driven by trapezoidal currents coupled with the given rotor position. The generated stator flux together with the rotor flux, which is generated by a rotor magnet, defines the torque, and thus speed, of the motor. The trapezoidal currents have to be applied to the 3-phase winding system in a way that angle between the stator flux and the rotor flux is kept close to  $90^\circ$  to get the maximum generated torque. To meet this criterion, the motor requires electronic control for proper operation.

For a common 3-phase BLDC motor, a standard 3-phase power stage is used.

The same power stage is used for AC induction and BLDC motors. The power stage utilizes six power transistors with independent switching. The power transistors are switched in the also called six step operation.

## 3.3 AC induction motor

The AC induction motor is a rotating electric machine designed to operate from a 3-phase source of alternating voltage.

The stator is a classic 3-phase stator with the winding displaced by  $120^\circ$ .

The most common type of induction motor has a squirrel cage rotor in which aluminum conductors or bars are shorted together at both ends of the rotor by cast aluminum end rings. When three currents flow through the three symmetrically placed windings, a sinusoidally distributed air gap flux generating the rotor current is produced. The interaction of the sinusoidally distributed air gap flux and induced rotor currents produces a torque on the rotor. The mechanical angular velocity of the rotor is lower than the angular velocity of the flux wave by so called slip velocity.

In adjustable speed applications, AC induction motors are powered by inverters. The inverter converts DC power to AC power at the required frequency and amplitude. The inverter consists of three half-bridge units where the upper and lower switches are controlled complementarily. As the power device's turn-off time is longer than its turn-on time, some dead-time must be inserted between the turn-off of one transistor of the half bridge and turn-on of its complementary device.

The output voltage is mostly created by a pulse width modulation (PWM) technique. The 3-phase voltage waves are shifted  $120^\circ$  to each other and thus a 3-phase motor can be supplied.

### 3.4 Hardware configuration for a BLDC motor (default)

This section describes the procedure for operating the STM8/128-MCKIT with a BLDC motor.

The default settings that are present on the STM8 evaluation board and on the power board when you receive the STM8/128-MCKIT starter kit are intended for a BLDC motor.

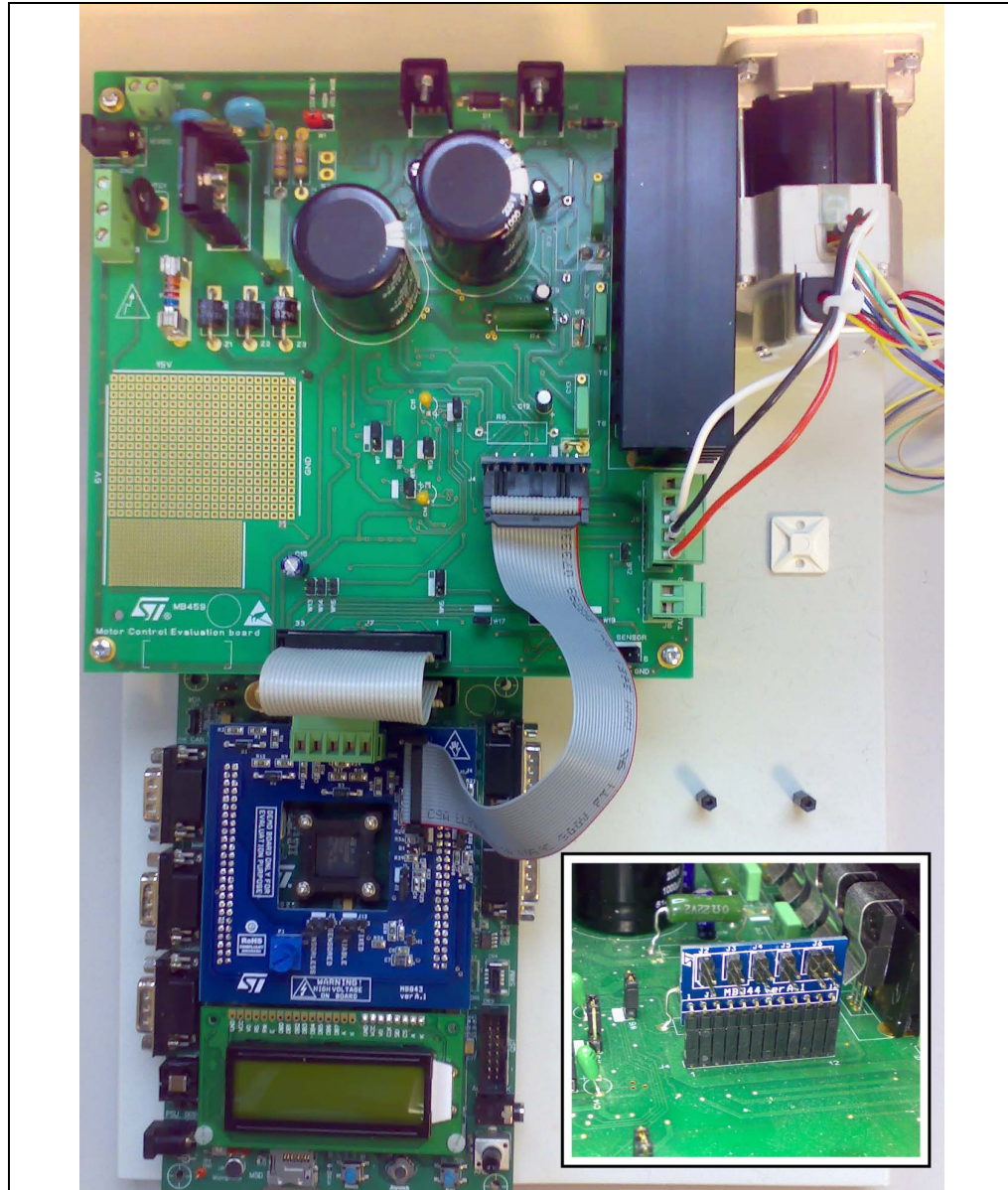
When you are using the BLDC motor, follow these steps:

1. Verify that all the jumpers on the power board (MB459B) are in their default position. Refer to [Table 1: MB459B power board jumper settings for a BLDC motor \(default\)](#) for information on jumper settings, and if necessary, to the MB459B power board User Manual for the location of the jumpers on the board.
2. Verify that all of the STM8 evaluation board (MB631) jumpers are in their default position. Refer to [Table 2: STM8 evaluation board jumper settings for a BLDC motor \(default\)](#) for information on jumper settings, and if necessary, to the STM8/128-EVAL board User Manual for the location of jumpers on the board.
3. Verify that all of the BLDC daughterboard (MB843) jumpers are in their default position. Refer to [Table 3: BLDC daughterboard MB843 jumper settings for a BLDC motor \(default\)](#) for information on jumper settings.
4. Verify that the BLDC daughterboard (MB843) is fitted on top of STM8/128-EVAL board through the CN1 and CN5 connectors (see [Figure 2](#)).
5. Verify that the adapter board (MB844) is fitted on top of power board (MB459B) through the J4 connector (see [Figure 2](#)).
6. Verify that the BLDC daughterboard (MB843) and the adapter board (MB844) are connected with the provided 20-pin auxiliary connector cable for BLDC sensorless (see [Figure 2](#)).
7. Verify that the BLDC motor cables are correctly plugged into the power board's MOTOR connectors (J5 and J8). The power board (MB459B), the STM8 evaluation board (MB631), and the provided BLDC motor are already assembled together over a metal support when you receive the kit.
8. Power up the STM8 evaluation board with the auxiliary power supply block TR30R.
9. Power up the power board by connecting the output terminals of your DC power supply to the MAINS connector (J3). The provided voltage must be 24 V DC and your power supply must be able to provide a current of 3 A.

The STM8/128-MCKIT is now ready to run with the BLDC motor.



Figure 2. STM8/128-MCKIT assembly



**Caution:** Before supplying the board, double check proper connections, make sure that there are no metal parts on, below or around the PCB and that there are no undesired earth/ground loops due to measuring equipment such as an oscilloscope.

**Caution:** Be sure that the STM8/128-EVAL used is marked with (MB631/2) or with (MB631); in the second case you must also check the required modifications reported in the Appendix [Section A.1: Modification of MB631 for BLDC drive](#).

**Note:** Not all the default positions of the jumper are coincident with the silk-screen printing. The jumper settings that are different from the silk-screen printing are highlighted in the [Table 1: MB459B power board jumper settings for a BLDC motor \(default\)](#) and [Table 2: STM8 evaluation board jumper settings for a BLDC motor \(default\)](#).

**Table 1. MB459B power board jumper settings for a BLDC motor (default)**

Jumper	Setting for the SHINANO 24V BLDC motor provided	Setting for a high-voltage BLDC motor
W1	"<35V only"	"<35V only" or "HIGH VOLTAGE"
W4	Not present	
W5	Present	
W6	Present	
W7	Not present	
W8	Not present	
W9	Not present	
W10	Present and soldered on reverse position of silk-screen printing	
W11	Present	
W12	Not present	
W13	Not present	
W14	Present	
W15	Not present	
W16	Present and set on reverse position of silk-screen printing	
W17	Not present	
W18	Not present	
W19	Not present	

**Table 2. STM8 evaluation board jumper settings for a BLDC motor (default)**

Jumper	Setting
JP1	Present between 1-2
JP2	Present
JP3	Set to PSU position to supply the STM8 evaluation board through the jack (CN6) And set to DTB position to supply the BLDC daughterboard (MB843)
JP4	Present
JP5	Not present
JP6	Present between 1-2
JP7	Not present
JP8	Present
JP9	Not present
JP10	Present
JP11	Present between 2-3
JP12	Present between 1-2
JP13	Present between 1-2 to configure the HW for the DAC functionality Or present between 2-3 to configure the HW for the dissipative brake
JP14	Not present

**Table 3. BLDC daughterboard MB843 jumper settings for a BLDC motor (default)**

Jumper	Setting
J1	Present and set on default position of silk-screen printing
J2	Present and set on default position of silk-screen printing
J3	Present and set on default position of silk-screen printing
J4	Present and set on default position of silk-screen printing
J5	Present and set on default position of silk-screen printing (SENSORLESS)
J13	Present and set on default position of silk-screen printing (VARIABLE)

### 3.5 Hardware configuration for an AC induction motor

This section describes the procedure for operating the STM8/128-MCKIT with an AC induction motor. You must change the default settings that are present on the STM8 evaluation board and on the power board when you receive the STM8/128-MCKIT starter kit because they are intended for a PMSM motor. When you are running the AC induction motor, follow these steps:

1. Remove the BLDC daughterboard (MB843) from the STM8/128-EVAL evaluation board (MB631).
2. Remove the adapter board (MB844) from the power board (MB459B).
3. Change the jumpers on the power board (MB459B) to the settings required for running with an AC induction motor. Refer to [Table 4: MB459B power board jumper settings for an AC induction motor](#) for information on jumper settings, and if necessary, to the MB459B power board user manual for the location of the jumpers on the board.
4. If the peak value of the motor phase current should be greater than 3 ampere, replace the R4 shunt resistor on the power board (MB459B) by the 0.1 ohm resistor included in the bag delivered with the kit.
5. Verify that the jumpers on the STM8/128-EVAL evaluation board (MB631) are in their default position. Refer to [Table 5: STM8 eval board jumper settings for an AC induction motor](#) for information on jumper settings, and if necessary, to the STM8/128-EVAL board user manual for the location of jumpers on the board.
6. Disconnect the PMSM motor from the power board's MOTOR connectors (J5 and J8). The power board (MB459B), the STM8/128-EVAL evaluation board (MB631), and the provided PMSM motor are already assembled together over a metal support when you receive the kit.
7. Connect your AC induction motor to the power board by connecting the three phases to the J5 connector, and the tachometer cables to the J6 connector.
8. Power up STM8/128-EVAL evaluation board with auxiliary power supply block TR30R.
9. Power up the power board by connecting the output terminals of your DC power supply to the MAINS connector (J3). The provided voltage must not be higher than 42 V DC or 32 Veff AC (GND recommended).

After re-programming the STM8S microcontroller with the ACIM motor control firmware, the STM8/128-EVAL is now ready to run with your AC induction motor.

**Caution:** Before supplying the board, double check proper connections, make sure that there are no metal parts on, below or around the PCB and that there are no undesired earth/ground loops due to measuring equipment such as an oscilloscope.

**Table 4. MB459B power board jumper settings for an AC induction motor**

Jumper	Settings for AC induction motor with tachometer feedback
W1	"<35V only" or "HIGH VOLTAGE"
W4	Not present
W5	Present
W6	Present
W7	Not present
W8	Not present
W9	Not present
W10	Present and soldered on reverse position of silk-screen printing
W11	Present
W12	Present
W13	Not present
W14	Not Present
W15	Not present
W16	Present and set on reverse position of silk-screen printing
W17	Not present
W18	Not present
W19	Not present

**Table 5. STM8 eval board jumper settings for an AC induction motor**

Jumper	Setting
JP1	Present between 1-2
JP2	Present
JP3	Set to PSU position to supply the STM8 evaluation board through the jack (CN6)
JP4	Present
JP5	Not present
JP6	Present between 1-2
JP7	Not present
JP8	Present
JP9	Present, if required to filter the noise from the tachogenerator signal
JP10	Present
JP11	Present between 2-3
JP12	Present between 1-2
JP13	Present between 1-2 to configure the HW for the DAC functionality Or present between 2-3 to configure the HW for the dissipative brake
JP14	Not present

*Note:* The jumper settings that are different from the silk-screen printing are highlighted in the [Table 4: MB459B power board jumper settings for an AC induction motor](#) and [Table 5: STM8 eval board jumper settings for an AC induction motor](#).

### 3.6 Power supply connections

J1 connector of power board (MB459B) provides a completely independent control of the DC bus voltage (power) and the +15 V supply for the gate drivers. This is interesting for development purposes, when one needs to smoothly increase the motor's operating voltage from zero, while the gate drivers are operating with their nominal supply.

When supplying the power stage with an external +15 V power supply using the J1 connector, special care must be taken that:

1. No jumpers are connected on jumper W1.
2. The short circuit that replaces the D3 diode footprint must be open. This is to avoid having reverse current in the L7815 voltage regulator.

## 4 BLDC daughterboard MB843

### 4.1 Features

The BLDC daughterboard MB843 is an extension of the STM8/128-EVAL evaluation board MB631 required to implement the BLDC drive.

It includes:

- A BEMF detection network,
- A current regulation/regulation network,
- A neutral voltage reconstruction network.

The board has been designed to be compatible with the voltage level applicable to the power board MB459B (“<35V only” or “HIGH VOLTAGE”).

The BEMF detection network allows the following strategies of BEMF sampling:

- BEMF sampling during off time (ST patented method),
- BEMF sampling during on time,
- Dynamic method based on the duty cycle applied.

For more details see the STM8S three-phase BLDC software library v1.0 (UM0708).

*Note: For applications that require a limited range of motor speed, for example if the ratio between maximum and minimum speed is below 4, it is possible to replace the BEMF detecting network with a simple resistive voltage divider.*

The current regulation/regulation network is used to adapt the signal to perform the current control in the BLDC drive. Control is made possible by a special characteristic of the STM8 microcontroller. See for more details the STM8S three-phase BLDC software library v1.0 (UM0708).

The neutral voltage reconstruction network is used to reconstruct the neutral voltage (also called star point) of the motor in order to perform the BEMF sampling during the on time. Two strategies of the neutral point reconstruction are implemented by the board:

- Bus voltage partitioning,
- Star point reconstruction starting from the motor phases.

*Note: It is possible to configure either method (see [Section 4.3: Jumper configuration](#)) but only the first is implemented by the firmware.*

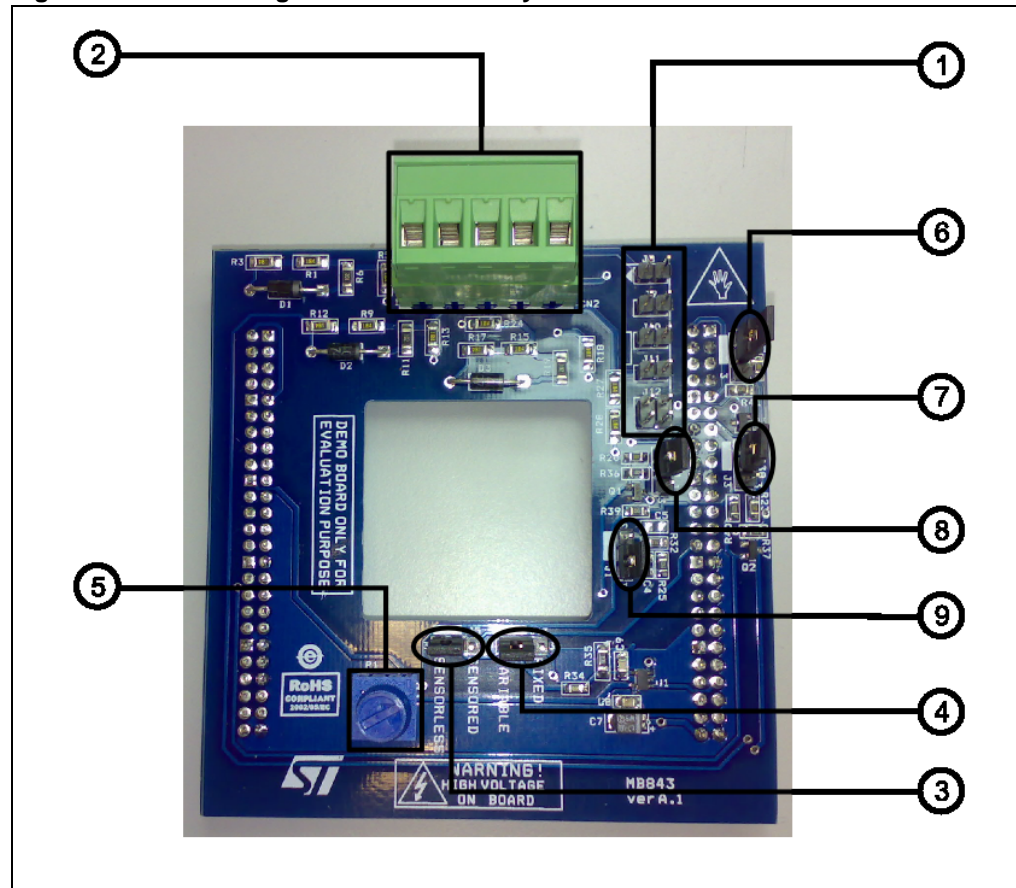
*Note: Even if bus partitioning is also performed in the power board MB459B, the partitioning performed by the MB843 makes use of a voltage partitioning that allows a better resolution in the neutral voltage reconstruction.*

The board is easily configurable to run the BLDC drive in sensorless mode, or to use the Hall sensors as position/speed feedback.



## 4.2 Layout

Figure 3. BLDC daughterboard MB843 layout



1. J8-J12 connector for the 20-pin auxiliary connector cable for BLDC sensorless. This is used to provide the three motor phase voltage signals and the bus voltage signal to the daughterboard MB843.
2. Auxiliary phase voltage connector CN2 (optional input). It can be used alternatively to the J8-J12 connecting directly the motor phase voltage signals using custom wire connections. Using that connector you can tighten the cables with a screwdriver connecting motor phase A in the pin 1, motor phase B in the pin 2, motor phase C in pin 3, the DC bus voltage in pin 4 and the ground in pin 5.
3. Jumper J5 sets sensorless or sensed configuration.
4. Jumper J13 sets the current reference or limitation.
5. Potentiometer P1 sets the fixed current limitation.
6. Jumper J4
7. Jumper J3
8. Jumper J2
9. Jumper J1

### 4.3 Jumper configuration

*Table 6* describes the jumpers.

**Table 6. BLDC daughterboard MB843 jumper settings**

Jumper	Setting	Description
J1	Selects the motor neutral voltage reconstruction network	
	Set to default position of silk-screen printing	Bus voltage partitioning
	Set to reverse position of silk-screen printing	Star point reconstruction starting from the motor phases
J2,J3,J4	Configures the BEMF attenuation network	
	Set to default position of silk-screen printing	Three GPIOs perform the dynamic attenuation of the BEMF signal this allows the sampling during off time, during on time and the dynamic selection of the two methods.
	Set to reverse position of silk-screen printing	Fixes the BEMF signals attenuation and frees the three GPIOs
	Not present	Removes the attenuation of the BEMF signals
J5	Sets sensorless or sensed configuration	
	Set to default position of silk-screen printing	Sets the sensorless configuration
	Set to reverse position of silk-screen printing	Sets the Hall sensor configuration
J13	Sets the current reference or limitation	
	Set to default position of silk-screen printing	With this setting the current reference or limitation is dynamically selected by the microcontroller using a filtered PWM signal. Is the only configuration that allows the current regulation.
	Set to reverse position of silk-screen printing	The current limitation is fixed and the potentiometer P1 is used to set this value. In this case is possible to free the microcontroller PWM resource.





## **5        Running the starter kit**

### **5.1       Running the BLDC motor**

See STM8S three-phase BLDC software library v1.0 (UM0708) Chapter 2: Running the demo program.

### **5.2       Running the AC induction motor**

See STM8S three-phase AC induction motor software library v1.0 (UM0712) Chapter 2: Running the demo program.

## 6 Creating your custom application

The main benefit of the STM8/128-MCKIT starter kit is that you can use it to create your own applications and reprogram the STM8 microcontroller. In the toolkit, you have the source files for BLDC and AC induction motors, and the STM8 standard library. They are intended to provide a sound basis for your own application developments. Do not hesitate to fine-tune them to suit your specific requirements.

These libraries are provided with ST Visual Develop v.4.1.1 workspaces compatible with Cosmic compiler v. 4.2.7. You can set up your workspace manually for any other toolchain.

## Appendix A Additional information

### A.1 Modification of MB631 for BLDC drive

It is possible to assemble the system of STM8/128-MCKIT by acquiring separately the various parts described in [Chapter 3: STM8/128-MCKIT hardware setup](#) or by replacing it with compatible hardware.

The control board released with the STM8/128-MCKIT (marked with MB631/2) has been modified to work with the BLDC firmware.

It is possible to use a standard STM8 evaluation board marked with MB631 with the BLDC firmware after performing the following modifications:

- Remove R21, R30, R58, R59, R75, R99 and R103.
- Remove pins 15, 19 and 28 on the CN10 connector.

### A.2 Recommended reading

This documentation describes how to use the STM8/128-MCKIT starter kit. Additional information can be found in the following documents:

- STM8Sxxx access line and performance line datasheets
- STM8Sxxx reference manuals
- STMicroelectronics motor control application notes
- STM8S three-phase BLDC software library v1.0 (UM0708)
- STM8S three-phase AC induction motor software library v1.0 (UM0712)
- STM8/128-EVAL user manual (UM0482)
- MB459B power board user manual (UM0379)
- Most of the above documents are present on the STM3210B-MCKIT CD-ROM

### A.3 Software upgrades

The latest versions of the STM8 motor control libraries are available free of charge, from our sales offices.

### A.4 Getting technical support

Technical assistance is provided free to all customers. For technical assistance, documentation and information about products and services, please refer to your local STMicroelectronics partner.

## Revision history

Table 7. Document revision history

Date	Revision	Changes
12-Jun-2009	1	Initial release.
22-Jun-2009	2	Added note to <a href="#">Section 2.1</a> .

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