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## STM3210B-MCKIT motor control starter kit

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### Introduction

The STM3210B-MCKIT starter kit is an integrated system designed to provide a complete, ready-to-use motor control application developed around the STMicroelectronics STM32 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 STM32 microcontrollers can be used in real-world motor control applications.

Drive is based on sensored field oriented control (FOC) for three-phase motors using the single- or three-shunt resistor current measurement method for closed loop torque control. Position measurement is implemented using Encoder sensor or Tachometer. The inverter is driven using the space vector PWM modulation technique.

You can run the STM3210B-MCKIT starter kit in several ways:

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

However, the main advantage of the STM3210B-MCKIT is that you can use it to create your own applications and re-program the STM32 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.

#### **In this manual, you will find information on:**

- The STM3210B-MCKIT starter kit components, and how to set up the hardware to run the provided PMSM motor or an AC induction motor
- How to run the STM3210B-MCKIT starter kit in standalone mode
- How to re-program the STM32 microcontroller to run your own application

For information on the features of the STM32 microcontroller, refer to the datasheet. The STM32 evaluation board features, peripherals, and connectors are described in the STM3210B-EVAL user manual (UM0426).

For information on the PMSM and AC induction motor software libraries and how to use them in motor control application development projects, refer to the PMSM field oriented control software library user manual (UM0492) and the AC induction motor IFOC software library user manual (UM0483) respectively. You will find these manuals, and all related documentation on the STM3210B-MCKIT CD-ROM.

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## Safety warnings

### General

In operation, the STM3210B-MCKIT starter kit has noninsulated 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 motor control 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 STM3210B-MCKIT starter kit contains electrostatic sensitive components which may be damaged through improper use.

### Intended use

The STM3210B-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 STM3210B-MCKIT starter kit must be strictly observed.

### 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.

### Important notice to users

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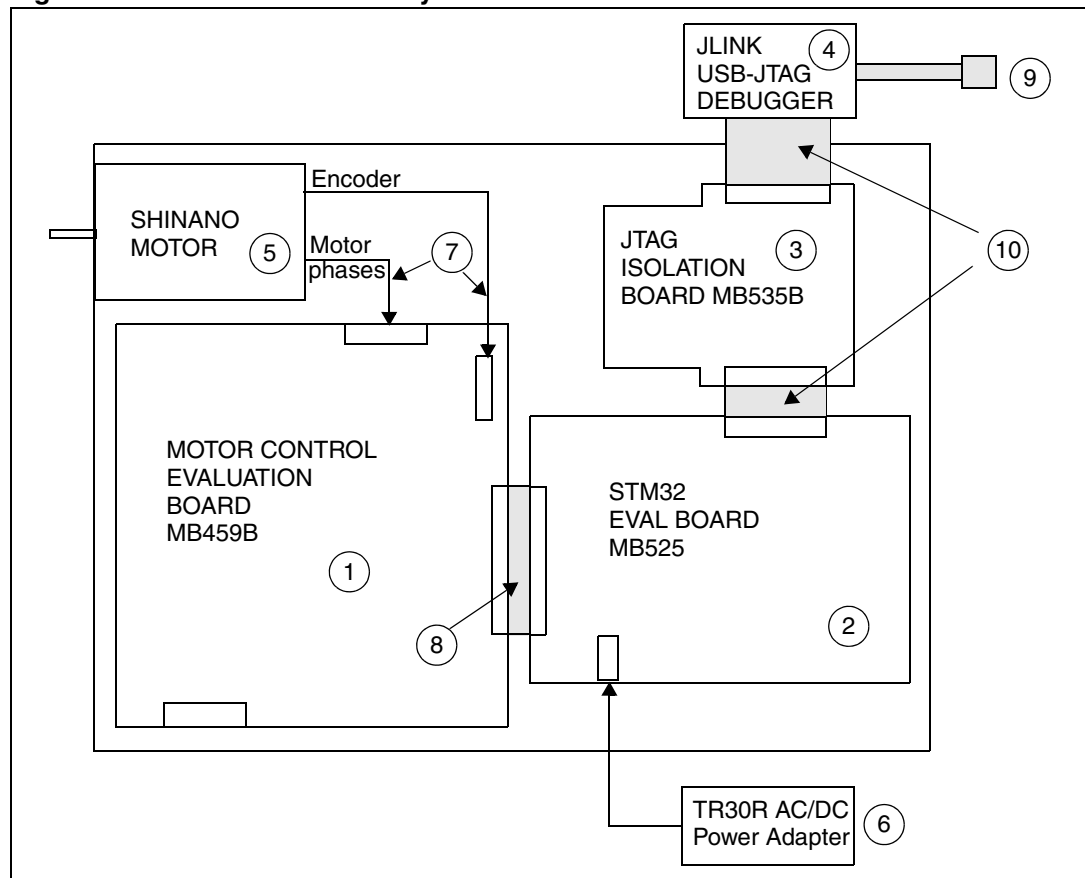
# 1 STM3210B-MCKIT hardware setup

This section provides a detailed description of the components included in the STM3210B-MCKIT starter kit. It also describes the default settings for a permanent magnet sensed motor (PMSM), and explains how to change them to use an AC induction motor.

## 1.1 Package checklist

Figure 1 shows the layout and connections of the major components of the STM3210B-MCKIT starter kit.

Figure 1. STM3210B-MCKIT layout



### 1.1.1 Hardware

The STM3210B-MCKIT starter kit includes the following items:

- The MB459B motor control evaluation board (1)  
This board is described in the MB459B motor control board user manual (UM0379) provided on the STM3210B-MCKIT CD-ROM.
- The MB525 STM32 evaluation board (2)  
This board is described in the STM3210B-EVAL user manual (UM0426) provided on the STM3210B-MCKIT CD-ROM.

- An MB535B opto-isolation JTAG board (3)  
This board is described in the JTAG opto-isolation board user manual (UM0378) provided on the STM3210B-MCKIT CD-ROM.  
The purpose of the JTAG opto-isolation board is to provide galvanic isolation between the J-link debugger/programmer and the STM32 evaluation board. It helps to prevent accidental damage to the PC in the event of a catastrophic failure on the motor control board. This isolation barrier also solves the problem of the PC, JTAG debugger and motor control board being at different ground potentials.
- A J-link USB–JTAG debugger (4)  
The SEGGER J-link USB-JTAG debugger allows you to reprogram the Flash memory of the STM32 microcontroller and to debug the software before using the application in standalone mode.
- A 24V DC SHINANO PMSM motor (5)  
The motor included in the STM3210B-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 STM3210B-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)
  - Two JTAG cables (10)
- A bag with three 0.1ohm resistors are included to configure the MB459B board for driving an AC induction motor.
- The STM3210B-MCKIT CD-ROM

### 1.1.2 Software

The STM3210B-MCKIT CD-ROM includes the following software: PMSM and AC induction motor software libraries.

When you receive the STM3210B-MCKIT, the STM32 microcontroller is programmed by default with the PMSM sensorless FOC firmware.

### 1.1.3 Documentation

The STM3210B-MCKIT CD-ROM also includes the following product documentation in PDF format:

- STM32F103xx high-, medium- and low-density datasheets
- STM32F10xxx reference manual
- STM3210B-MCKIT motor control kit user manual (UM0486, the present manual)
- STM32F103xx permanent-magnet synchronous motor FOC software library V2.0 (UM0492)
- STM32F103xx AC induction motor IFOC software library V2.0 (UM0483)
- STM3210B-EVAL user manual (UM0426)
- MB459B motor control evaluation board user manual (UM0379)
- JTAG opto-isolation board user manual (UM0378)

In the box with the STM3210B-MCKIT, you will also find:

- A startup color poster which summarizes the main steps for running the motor control kit
- The MCD product finder
- Product flyers and brochures
- The MCD miniROM
- A guarantee record card

### 1.1.4 Components not provided

The STM3210B-MCKIT starter kit does not include:

- A power supply  
To use the STM3210B-MCKIT starter kit with the provided PMSM motor, you need a 24V-3A minimum power supply. You can order the SPU65-108 (24V - 3.3A - 80W) with S&T Type connector (code P00) from SINPRO ([www.trcelectronics.com/Sinpro](http://www.trcelectronics.com/Sinpro)).
- An AC induction motor  
The STM3210B-MCKIT can operate with an AC induction motor. The provided graphical user interface 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 STM3210B-MCKIT starter kit with the Selni AC induction motor, you need a 42V DC or 32V<sub>eff</sub> AC power supply (polarity not important, GND recommended).

### 1.1.5 Permanent magnet synchronous motor (PMSM)

The PM synchronous motor is a rotating electric machine where the stator is a classic three phase stator like that of an induction motor and the rotor has surface-mounted permanent magnets. In this respect, the PM synchronous 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 PM motors.

A PM synchronous motor is driven by sine wave voltage 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 sine wave voltage output 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 PM synchronous motor, a standard 3-phase power stage is used. The same power stage is used for AC induction and PMSM motors. The power stage utilizes six power transistors with independent switching. The power transistors are switched in the complementary mode. The sine wave output is generated using the space vector PWM technique.

### 1.1.6 AC induction motor

The AC induction motor is a rotating electric machine designed to operate from a three-phase source of alternating voltage. The stator is a classic three 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 three-phase voltage waves are shifted  $120^\circ$  to each other and thus a three-phase motor can be supplied.

## 1.2 Hardware configuration for PMSM motor (default)

This section describes the procedure for operating the STM3210B-MCKIT with a PMSM motor. The default settings that are present on the STM32 evaluation board and on the motor control evaluation board when you receive the STM3210B-MCKIT starter kit are intended for a PMSM motor.

When you are running the PMSM motor, follow these steps:

1. Verify that all the jumpers on the motor control board (MB459B) are in their default position.  
Refer to [Table 1](#) for information on jumper settings, and if necessary, to the MB459B Motor Control Board User Manual for the location of the jumpers on the board.
2. Verify that all of the STM32 evaluation board (MB525) jumpers are in their default position.  
Refer to [Table 2](#) for information on jumper settings, and if necessary, to the STM3210B-EVAL board User Manual for the location of jumpers on the board.
3. Verify that the PMSM motor cables are correctly plugged into the motor control board's "MOTOR" connectors (J5 and J8).  
The motor control board (MB459B), the STM32 evaluation board (MB525), the opto-isolation JTAG board (MB535B), and the provided PMSM motor are already assembled together over a metal support when you receive the kit.
4. Verify that the STM32 evaluation board and the JTAG opto-isolation board (MB535B) are connected with the provided 20-pin JTAG cable.  
In this way, the STM32 evaluation board automatically supplies the opto-isolation board.
5. Power up the STM32 evaluation board with the auxiliary power supply block TR30R.
6. Power up the motor control board by connecting the output terminals of your DC power supply to the "MAINS" connector (J3).  
The provided voltage must be 24V DC and your power supply must be able to provide a current of 3A.  
The STM3210B-MCKIT is ready to run with the PMSM 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 1. MB459B motor control board jumper settings for a PMSM motor (default)**

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

**Table 2. STM32 evaluation board jumper settings for a PMSM motor (default)**

| Jumper   | Description   |
|----------|---|
| JP4      | Set to <b>PSU</b> position to supply the STM32 evaluation board through the jack (CN3). |
| JP12     | Not fitted (tachogenerator signal filtering for AC induction motor)                     |
| JP10     | Not fitted: TRST (JTAG) and NRESET (MCU) do not need to be connected                    |
| SW1, SW2 | Both set to "0" position to boot from embedded user flash.                              |

*Note:* In order to increase the motor control performance (especially when the motor is not loaded), it is suggested to replace capacitor C77 by a 470 nF capacitor on the STM3210B-EVAL evaluation board. Please refer to the STM3210B-EVAL evaluation board user manual (UM0488) to know more about the location of C77.

## 1.3 Hardware configuration for AC induction motor

This section describes the procedure for operating the STM3210B-MCKIT with an AC induction motor. You must change the default settings that are present on the STM32 evaluation board and on the motor control evaluation board when you receive the STM3210B-MCKIT starter kit because they are intended for a PMSM motor.

When you are running the AC induction motor, follow these steps:

1. Change the jumpers on the motor control board (MB459B) to the settings required for running with an AC induction motor.  
Refer to [Table 3](#) for information on jumper settings, and if necessary, to the MB459B Motor Control Board User Manual for the location of the jumpers on the board.
2. Replace the three shunt resistors (R3, R4 and R5) on the motor control board (MB459B) by the 0.1ohm resistors included in the bag delivered with the kit.
3. Verify that the jumpers on the STM3210B-EVAL evaluation board (MB469B) are in their default position.  
Refer to [Table 4](#) for information on jumper settings, and if necessary, to the STM3210B-EVAL board user manual for the location of jumpers on the board.
4. Disconnect the PMSM motor from the motor control board's "MOTOR" connectors (J5 and J8).  
The motor control board (MB459B), the STM3210B-EVAL evaluation board (MB469B), the opto-isolation JTAG board (MB535B), and the provided PMSM motor are already assembled together over a metal support when you receive the kit.
5. Connect your AC induction motor to the motor control board by connecting the three-phases to the J5 connector, and the tachometer cables to the J6 connector.
6. Verify that the STM3210B-EVAL evaluation board and the JTAG opto-isolation board (MB535B) are connected with the provided 20-pin JTAG cable.  
In this way, the STM3210B-EVAL evaluation board automatically supplies the opto-isolation board.
7. Power up the STM3210B-EVAL evaluation board with the auxiliary power supply block TR30R.
8. Power up the motor control board by connecting the output terminals of your DC power supply to the "MAINS" connector (J3).  
The provided voltage must not be higher than 42V DC or 32V<sub>eff</sub> AC (GND recommended).

The STM3210B-MCKIT is 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 3. MB459B motor control board jumper settings for an AC induction motor**

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

**Table 4. STM3210B-EVAL evaluation board jumper settings for an AC induction motor**

| Jumper   | Description   |
|----------|---|
| JP4      | Set to <b>PSU</b> position to supply the STM32 evaluation board through the jack (CN4). |
| JP12     | Fitted (tachogenerator signal filter for AC induction motor)                            |
| JP10     | Not fitted: TRST (JTAG) and NRESET (MCU) do not need to be connected                    |
| SW1, SW2 | Both set to "0" position to boot from embedded user flash.                              |

- Note:**
- 1 To use the STM3210B-EVAL evaluation board with an AC induction motor, the three shunt resistors (R3, R4 and R5) of the motor control board (MB459B) must be replaced by the 0.1ohm resistors included in the bag delivered with the kit.
  - 2 In order to increase the motor control performance (especially when the motor is not loaded), it is suggested to replace capacitor C77 by a 470 nF capacitor on the STM3210B-EVAL evaluation board. Please refer to the STM3210B-EVAL evaluation board user manual (UM0488) to know more about the location of C77.

## 1.4 Power supply connections

J1 connector provides a completely independent control of the DC bus voltage (power) and the +15V 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 having gate drivers operating with their nominal supply.

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

1. No jumpers are connected on Jumper W1.
2. The shortcircuit replacing the D3 diode footprint must be open. This is to avoid having reverse current in the L7815 voltage regulator.

## 2 Running the starter kit

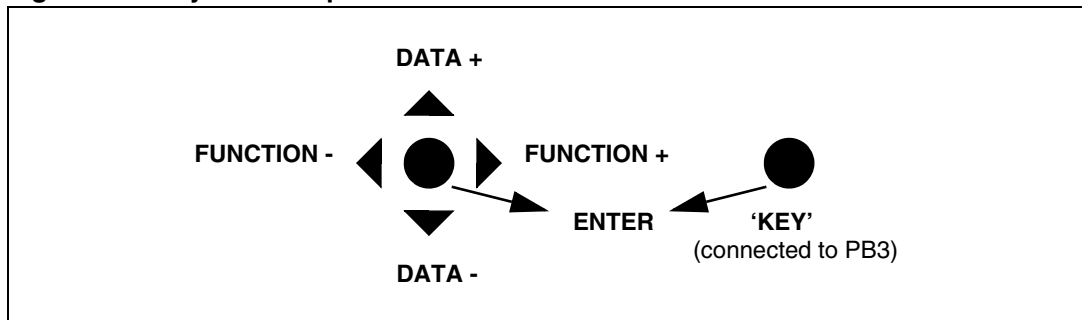
When you receive the STM3210B-MCKIT starter kit, the STM32 microcontroller is already programmed with the PMSM sensorless FOC firmware, allowing to immediately run the PMSM motor included in the kit. [Section 2.1](#) explains how to do this.

The STM3210B-MCKIT can also run an AC induction motor. To do this, you must first reconfigure the hardware, and load the AC induction motor standalone firmware into the flash memory of the STM32 microcontroller. [Section 2.2](#) explains how to do this.

For both types of motors, once you have checked the motor connections and jumper settings on the motor control board, you can use the joystick, push button and LCD display on the STM3210B-EVAL evaluation board to monitor and change parameters of the motor.

The joystick and the button labelled **Key** are used to navigate between the different menus (see [Figure 2](#)).

**Figure 2. Joystick and push-button**

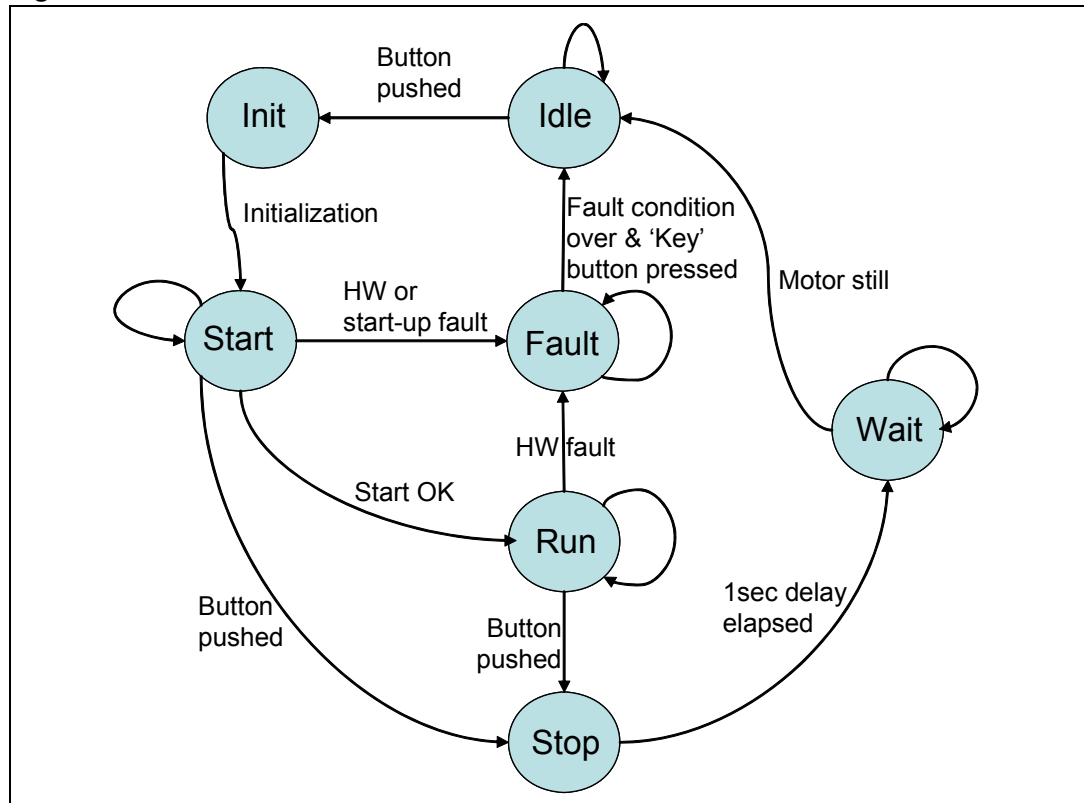


The conventions for actions on the **Key** push-button and the joystick are as follows:

1. The **Function** concerned by a setting is displayed in red on the LCD.
2. **Right/Left** movement of the joystick allows:
  - a) Inside a given screen to pass from one function to another,
  - b) to pass from one screen to the other using a circular path.
3. **Up/Down** movement of the joystick changes the data for the selected function.

A simple state machine handles the motor control tasks in the main loop, and monitors the power stage. This state machine is described in [Figure 3](#); it does not differentiate speed control from torque control demos.

Figure 3. PMSM and AC induction motor main state machine



The power stage is monitored using the A/D converter and the PWM peripheral Emergency Stop (Break in) input. These peripherals check for the following conditions:

- Heatsink over-temperature
- DC bus over-voltage (or under-voltage)
- Over-current protection

Any of these three conditions will cause the PWM to be stopped and the state machine to go into FAULT state for 2 seconds before going back to IDLE state. Depending on the source of the fault, an error message is also displayed on the LCD for the duration of the FAULT condition.

## 2.1 Running the PMSM motor

The PMSM firmware allows you to run the motor in torque or speed control mode, and to monitor and change various parameters on the fly. This section provides a summary of the screen displays and settings. The active parameter (the one that is selected to be modified with the joystick) is displayed in red.

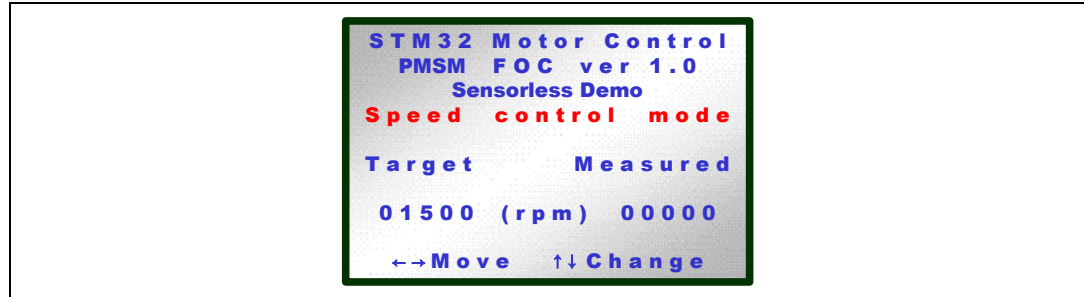
For more information on how the demo works and on how a PMSM can be controlled with the STM32, refer to the UM0492, “STM32F103xx permanent-magnet synchronous motor FOC software library V2.0”.

### Starting the motor

- Once you have checked the hardware configuration and connected the power supply as explained in [Section 1.2 on page 8](#), press the **Reset** push-button.

*Figure 4* shows the main screen of the PMSM demo.

**Figure 4. PMSM main screen**

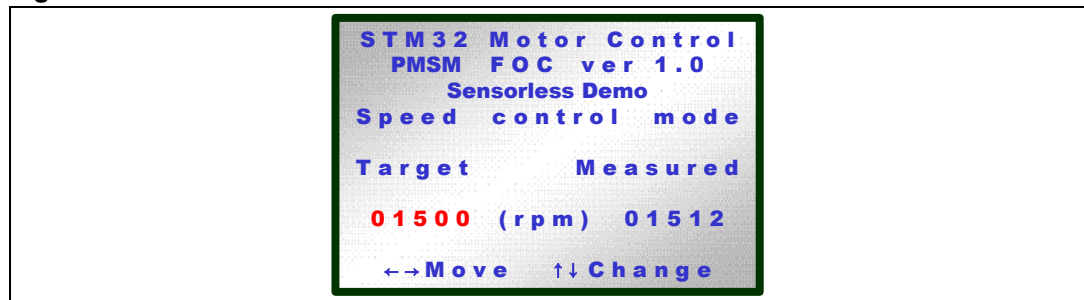


- Press the **Key** push-button to start the motor. Pressing the **Key** push-button again will stop the motor.

### 2.1.1 LCD display in speed control mode

In Speed control mode, the firmware allows modifying in real time the speed set-point.

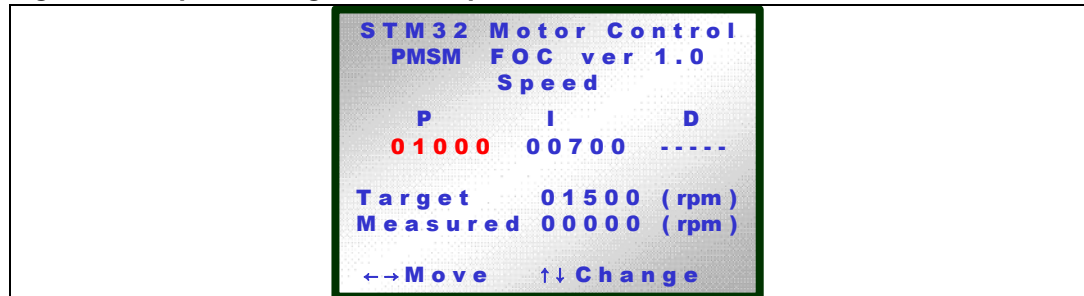
**Figure 5. Main screen in run state**



When the motor is running, the LCD indicates the target as well as the measured speed. Pressing the joystick up/down increases (or decreases) the speed set point respectively.

Pressing the joystick to the right enters the Speed PI regulator set-up screen.

**Figure 6. Speed PI regulator set-up screen**

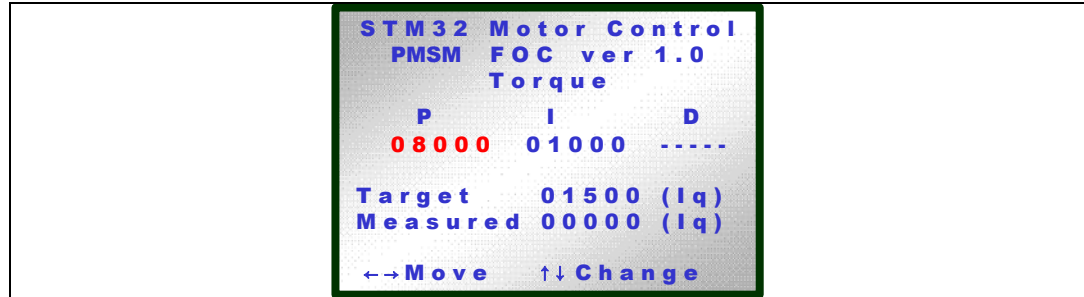


The P (proportional) coefficient is active by default; pressing the joystick up/down increases (or decreases) its value respectively. This can be done while the motor is running.

Pressing the joystick to the right a second time allows you to modify the I (integral) coefficient.

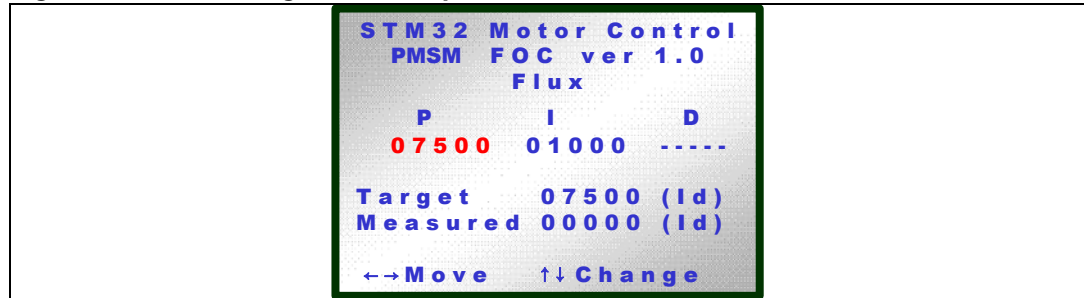
Pressing the joystick to the right another time enters the Torque PI regulator set-up screen.

**Figure 7. Torque PI regulator set-up screen**



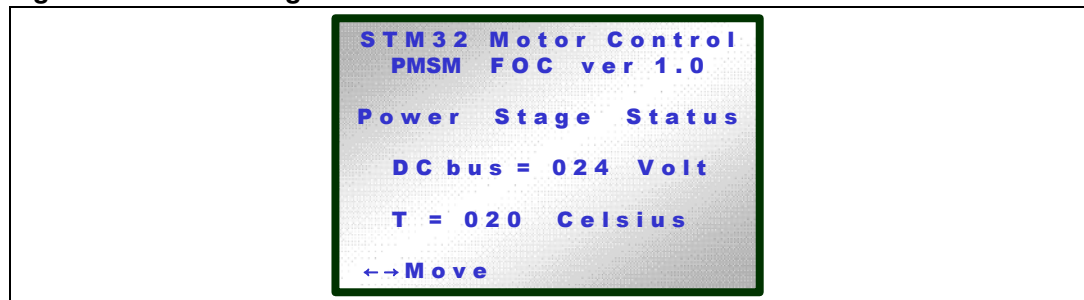
This regulator can be tuned in the same way as the speed regulator. Pushing the joystick twice to the right enters the Flux regulator settings screen.

**Figure 8. Flux PI regulator set-up screen**



Pushing the joystick twice to the right enters the Power stage status screen, giving the current heat sink temperature and DC bus voltage.

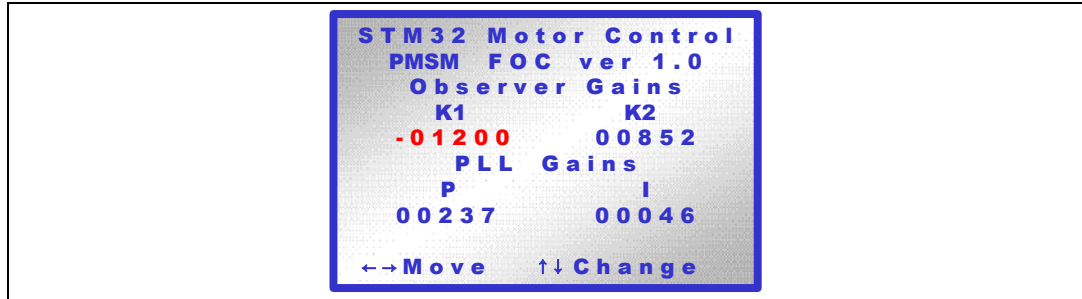
**Figure 9. Power stage status screen**



Pushing the joystick on the right enters the Sensorless control settings screen, to modify the rotor position observer gains K1 and K2, as well as the PLL gains (this PLL provides the speed feedback for the speed regulator, using the rotor angle computed by the observer).

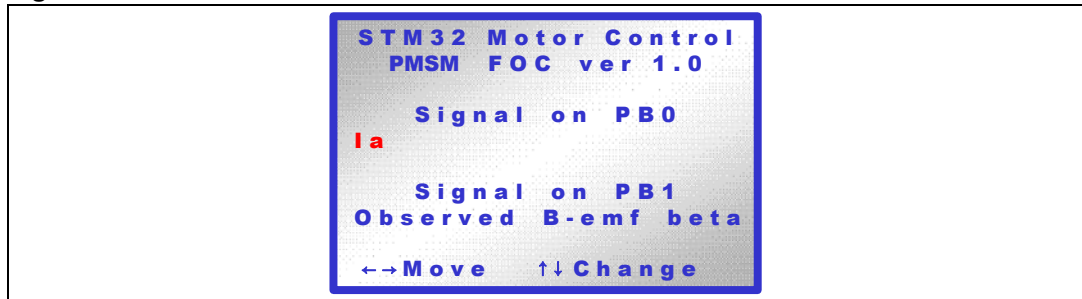


Figure 10. Sensorless screen



After 4 consecutive pushes, the last settings screen is entered: it allows the I/Os of the micro (PB0 and PB1) to be used as DACs, to monitor internal variables in real-time with an oscilloscope. These outputs provide PWM signals with a duty cycle proportional to the value of the variable: it must be low-pass filtered by a 6.8K/47nF low pass filter to remove all high frequency components due to the PWM fundamental frequency.

Figure 11. DAC screen



You can select the following internal variables to be monitored:

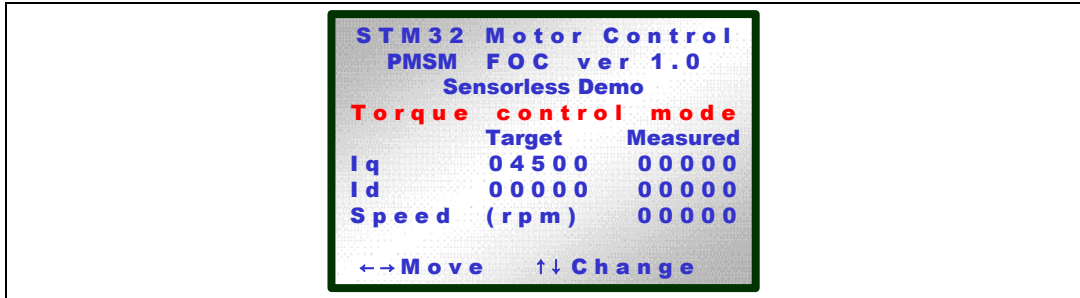
- Ia, Ib: Phase a and b currents (from ADC reading results)
- I alpha, I beta: outputs of the clarke transformation
- Iq, Id: direct and quadrature currents, output of the park transformation
- Iq ref, Id ref: direct and quadrature current components set-points
- Vq, Vd: direct and quadrature voltage commands
- V alpha, V beta: output voltages from the reverse park transform
- Measured El(ectrical) angle: rotor position computed from the encoder (if connected)
- Measured rotor speed: speed measured with the encoder (if connected)
- Observed El(ectrical) angle: output of the rotor position estimator
- Observed rotor speed: output of the speed reconstruction PLL
- Observed I alpha, I beta, B-emf alpha, B-emf beta: rotor position estimator internal variables

A last push to the right returns to the very 1st screen.

### 2.1.2 LCD display in torque control mode

In torque control mode, the firmware allows modifying in real time the torque and flux set-points (for constant torque operation). From the speed control menu, an up or down push enters this demo mode.

Figure 12. Torque Control demo



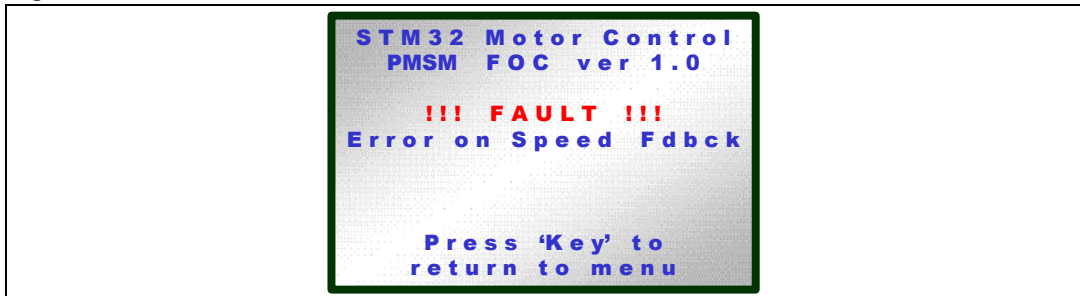
When the motor is running, the LCD indicates the target Id and Iq current components set-points, as well as the measured values. Pressing the joystick up/down increases (resp. decreases) these settings. Actual speed is also reported.

Pressing the joystick on the right enters the same screen than for speed control mode, at the exception of Speed PI regulator settings.

### 2.1.3 PMSM motor fault messages

During the demo, you can potentially get error messages, as shown in [Figure 13](#).

Figure 13. Fault screen



“Press 'Key' to return to menu” is displayed only if the cause of the fault is no longer present. Pressing the 'Key' button causes the main state machine to switch from FAULT to IDLE state. Six different fault sources are monitored during operation. Refer to the UM0492 “STM32F103xx permanent-magnet synchronous motor FOC software library V2.0” user manual for more implementation details.

**Table 5. PMSM motor faults**

| Error message        | Description   |
|----------------------|---|
| Overcurrent          | This occurs if a low level triggers the emergency stop on the PWM peripheral dedicated input pin BKIN (on pin1 of motor control connector CN14). It means that either the hardware over temperature protection or the hardware over current protection was triggered. Over-current trip is defined by the L6386 gate driver's comparators level (0.5V) and the shunt resistors:<br>3.3A for 0.22 ohm shunt resistor (default PMSM configuration)<br>7A for 0.1 ohm shunt resistor |
| Overheating          | This occurs if the power stage heat sink temperature goes above 60°C. This is monitored by reading the voltage value on a NTC resistor, with the STM32 ADC (on pin26 of motor control connector CN14).  |
| Bus Overvoltage      | This occurs if the DC bus voltage goes above 350Vdc. This value is read using the STM32 ADC (pin14 of the motor control connector CN14) and a resistor network in parallel with the power stage bulk capacitors.  |
| Bus Undervoltage     | This occurs if the bus voltage is below 20V DC.   |
| Start-up failed      | This indicates that the correct start-up criteria were not met during the motor start-up sequence.  |
| Error on speed fdbck | This returns an error on the speed / position estimation by the sensorless algorithm (the quality of the speed measurement expressed in terms of distribution around the mean value is not satisfactory). This typically means that either the observer is not properly tuned or that the speed is so low that a good observation of the induced B-emf is not possible (e.g. rotor is locked).  |

### 2.1.4 Running your own PMSM motor

To run your own motor using the standalone PMSM firmware, follow the indications given in the *Getting Started with the Library* section of the UM0492 user manual "STM32F103xx permanent-magnet synchronous motor FOC software library V2.0".

Based on your own motor parameters and hardware configuration, you must edit and update the following files:

- STM32F10x\_conf.h (configuration header file)
- MC\_Control\_Param.h
- MC\_encoder\_Param.h
- MC\_PMSM\_param.h
- MC\_State\_Observer\_param.h
- MC\_hall\_param.h

Users are assisted in customizing their PMSM application firmware by a parameter file generation tool (FOCGUI) which, starting from system parameters, automatically generates everything that is needed by the MC firmware library to quickly run the motor, thus saving time and easing the development phase.

This tool can be downloaded from: <http://www.st.com/mcu/>

Using a third-party IDE and C compiler, you must then rebuild the project and load it onto the STM32 microcontroller.

## 2.2 Running an AC induction motor

The AC induction motor firmware allows you to run the motor in torque or speed control mode, and to monitor and change various parameters on the fly. This section provides a summary of the screen displays and settings.

Before you can use the STM3210B-MCKIT with an AC induction motor, you must re-program the STM32 microcontroller to use the AC induction motor firmware. To do this you must:

1. Set up the hardware as described in [Section 1.3 on page 10](#).
2. Connect the J-link debugger to the opto-isolation board with the 20-pin JTAG cable.
3. Connect the J-link debugger to the host PC with the USB cable provided. The "POWER LED" on the instrument turns on.
4. Power up the motor control kit.
5. Load the AC induction motor firmware into the flash memory of the STM32 microcontroller using a third-party IDE and C compiler.
6. Disconnect the PC from the motor control kit.

### Starting the motor

1. To initialize the system, press the **Reset** push-button.
2. Press the **Key** push-button to start the motor.

Pressing the **Key** push-button again will stop the motor.

At this stage, the joystick and the **Key** push-button can be used to navigate between the different menus as described at the beginning of this section.

### 2.2.1 LCD display in speed control mode

Figure 14. AC motor screens (speed control)



Pressing the joystick or the **Key** push-button starts the motor.

During the Speed control demo start-up, a linear torque ramp is applied to the motor until it reaches the minimum speed allowing to enter closed loop operation for torque and flux. Then, the speed PID regulator is enabled and takes over control of the torque reference.

The final torque reference value is applied until the motor reaches the target speed, or until a 3 seconds period is elapsed.

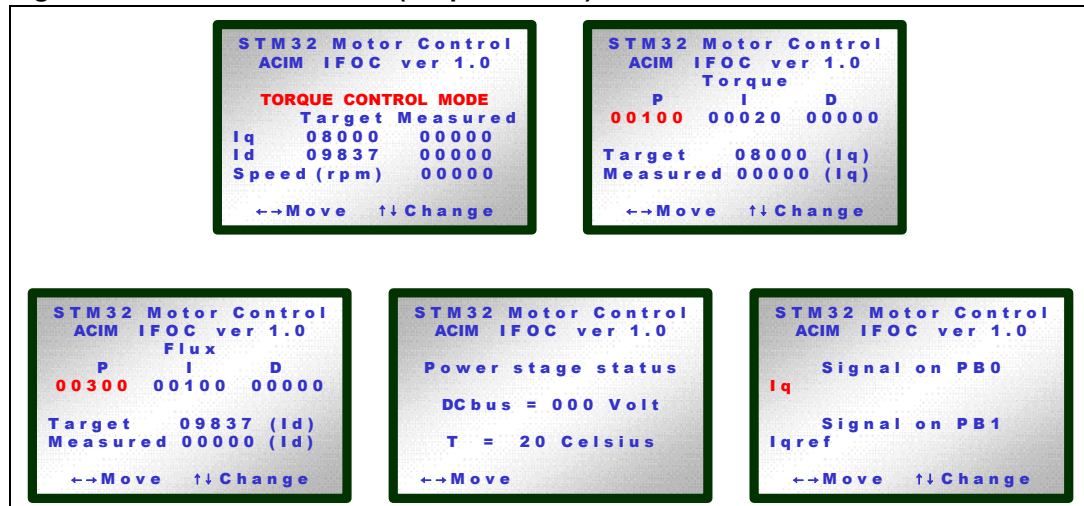
If the target speed is not reached after 3 seconds, the state machine goes into FAULT state for two seconds and the “Start-up failed” error message is displayed on the LCD. If this happens, you are strongly advised to check the speed sensor feedback connections first and, if this is not sufficient, to increase the STARTUP\_FINAL\_TORQUE parameter because the load torque is probably too high. This parameter cannot be modified using the LCD interface. It is necessary to rebuild the firmware library and re-flash the STM32 to change the value.

Note that the STARTUP\_FINAL\_TORQUE and STARTUP\_TIMEOUT parameters are fully configurable so that you can customize the start-up phase to adapt it to the motor you are using and to load conditions.

For more information about driving an AC induction motor, refer to the UM0483 user manual: STM32F103xx AC induction motor IFOC software library V2.0.

### 2.2.2 LCD display in torque control mode

Figure 15. AC motor screens (torque control)



When you press the **Key** push-button or the joystick, the motor starts (the main state machine goes from IDLE to START state).

After startup, following a linear ramp, if valid information from the speed sensor (tachometer or encoder) is detected, you can adjust the torque reference on the fly using the joystick.

However, if no valid information from the speed sensor is detected, due to a problem with speed sensor connections or because the load torque is higher than the defined value for example, then the final torque reference remains constant for 3 seconds.

Finally, if there's no valid information coming from the motor after 3 seconds, the main state machine goes into FAULT state for two seconds and the “Start-up failed” error message is displayed on the LCD. If this happens, you are strongly advised to check the speed sensor feedback connections first and, if this is not sufficient, to increase the final ramp torque reference because the load torque is probably too high.

**Caution:** In torque control mode operation, a constant torque reference is produced. Depending on the applied load torque, this could lead to a constant acceleration of the motor, making the speed rise up to the physical limits of the motor.

For more information about driving an AC induction motor, refer to the UM0483 **user manual**: STM32F103xx AC induction motor IFOC software library V2.0.

### 2.2.3 AC motor control variables that can be monitored

You can select the following internal variables to be monitored:

- Ia, Ib: Phase a and b currents (from ADC reading results)
- I alpha, I beta: outputs of the clarke transformation
- Iq, Id: direct and quadrature currents, output of the park transformation
- Iq ref, Id ref: direct and quadrature current components set-points
- Vq, Vd: direct and quadrature voltage commands
- V alpha, V beta: output voltages from the reverse park transform
- Measured El(ectrical) angle: rotor position computed from speed feedback
- Measured rotor speed: speed measured with the tachogenerator

### 2.2.4 AC induction motor fault messages

[Table 6](#) gives the list of fault messages that can be displayed using the demo firmware.

**Table 6. AC induction motor faults**

| Error Message        | Description   |
|----------------------|---|
| Overcurrent          | This occurs if a low level triggers the emergency stop on the PWM peripheral dedicated input pin BKIN (on pin1 of motor control connector CN14). It means that either the hardware over temperature protection or the hardware over current protection was triggered. Over-current trip is defined by the L6386 gate driver's comparators level (0.5V) and the shunt resistors:<br>3.3A for 0.22 ohm shunt resistor (default PMSM configuration)<br>7A for 0.1 ohm shunt resistor |
| Overheating          | This occurs if the power stage heat sink temperature goes above 60°C. This is monitored by reading the voltage value on a NTC resistor, with the STM32 ADC (on pin26 of motor control connector CN14).  |
| Bus Overvoltage      | This occurs if the DC bus voltage goes above 350Vdc. This value is read using the STM32 ADC (pin14 of the motor control connector CN14) and a resistor network in parallel with the power stage bulk capacitors.  |
| Bus Undervoltage     | This occurs if the bus voltage is below 20V DC.   |
| Start-up failed      | This indicates that the correct start-up criteria were not met during the motor start-up sequence.  |
| Error on speed fdbck | This indicates a time out on tachogenerator feedback signal: it can be either a cable disconnection or a motor stall (because of an insufficient torque reference or supply voltage for instance).  |

### 2.2.5 Running your own AC motor

To run your own motor using the AC firmware, follow the indications given in the *Getting Started* section of the UM0483 user manual: “STM32F103xx AC induction motor IFOC software library V2.0”.

Based on your own motor parameters and hardware configuration, you must edit and update the following files:

- STM32F10x\_conf.h (configuration header file)
- MC\_Control\_Param.h
- MC\_encoder\_Param.h
- MC\_acmotor\_prm.h
- MC\_tacho\_prm.h

Using a third-party IDE and C compiler, you must then rebuild the project and load it onto the STM32 microcontroller.

### 3 Creating your custom application

The main benefit of the STM3210B-MCKIT starter kit is that you can use it to create your own applications and reprogram the STM32 microcontroller. In the toolkit, you will find the source files for PMSM and AC induction motors, and the STM32 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 IAR EWARM v. 5.20, KEIL RVMDK v. 3.22 and Green Hills MULTI v. 5.0.3 workspaces. Exhaustive validation was performed using IAR, while simple functional validation was done with the other toolchains. You can set up your workspace manually for any other toolchain.



## Appendix A Additional information

### A.1 Recommended reading

This documentation describes how to use the STM3210B-MCKIT Starter Kit. Additional information can be found in the following documents:

- STM32F103xx low-, medium- and high-density datasheets
- STM32F10xxx reference manual (RM0008)
- STMicroelectronics motor control application notes.
- STM3210B-EVAL evaluation board user manual (UM0426).
- Motor control evaluation board user manual (UM0379)
- JTAG opto-isolation board user manual (UM0378)
- STM32F103xx AC induction motor IFOC software library V2.0 user manual (UM0483)
- STM32F103xx permanent-magnet synchronous motor FOC software library V2.0 user manual (UM0492)

Most of the above documents are present on the STM3210B-MCKIT CD-ROM.

### A.2 Software upgrades

The latest versions of the STM32 motor control libraries are available free of charge, from our sales offices.

### A.3 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   |
|-------------|----------|---|
| 13-Dec-2007 | 1        | Initial release.  |
| 26-Sep-2008 | 2        | STM3210B-MCKIT starter kit upgraded.<br>“Open and closed loop modes” replaced by “torque and speed modes” throughout the document.<br>The starter kit supports several other third-party IDE and C compilers in addition to the EWARM KickStart Edition from IAR software.<br><a href="#">1.1.2 Firmware</a> section removed.<br><a href="#">Section 1.1.2: Software</a> and <a href="#">Section 1.1.3: Documentation</a> updated.<br>A customization assistant is also provided (see <a href="#">Section 2.1.4: Running your own PMSM motor</a> ).<br><a href="#">Section 3: Creating your custom application</a> updated (Sections <a href="#">3.1</a> and <a href="#">3.2</a> removed).<br><a href="#">A.1: Recommended reading</a> updated. |
| 06-Nov-2008 | 3        | Note added to <a href="#">Section 1.2: Hardware configuration for PMSM motor (default)</a> and <a href="#">Section 1.3: Hardware configuration for AC induction motor</a> .   |

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