UM0379
User manual

STM3210B-MCKIT and STR750-MCKIT 3-phase motor control power stage

Introduction

This manual describes the MB459B motor control evaluation board. The MB459B is an AC/AC power converter that generates a three-phase waveform for driving three-phase motors such as induction motors or PMSM motors.

It includes:

- An input power stage with voltage rectification and auxiliary power supply,
- A 7A three-phase inverter based on IGBT and level shifter,
- A motor connector for linking with the control board,
- A connector for motors with Hall/encoder and tachometer input.

The MB459B motor control evaluation board can be supplied in two ways:

- From a single power supply for motors requiring a voltage greater than 18 V;
- From a dual power supply for motors requiring a voltage less than 18 V.

This manual describes where the various components are located on the motor control board, and the appropriate settings for driving a PMSM motor or an AC induction motor.

The MB459B board is delivered with the STM3210B-MCKIT and STR750-MCKIT motor control kits. For more information on these kits, refer to www.st.com.

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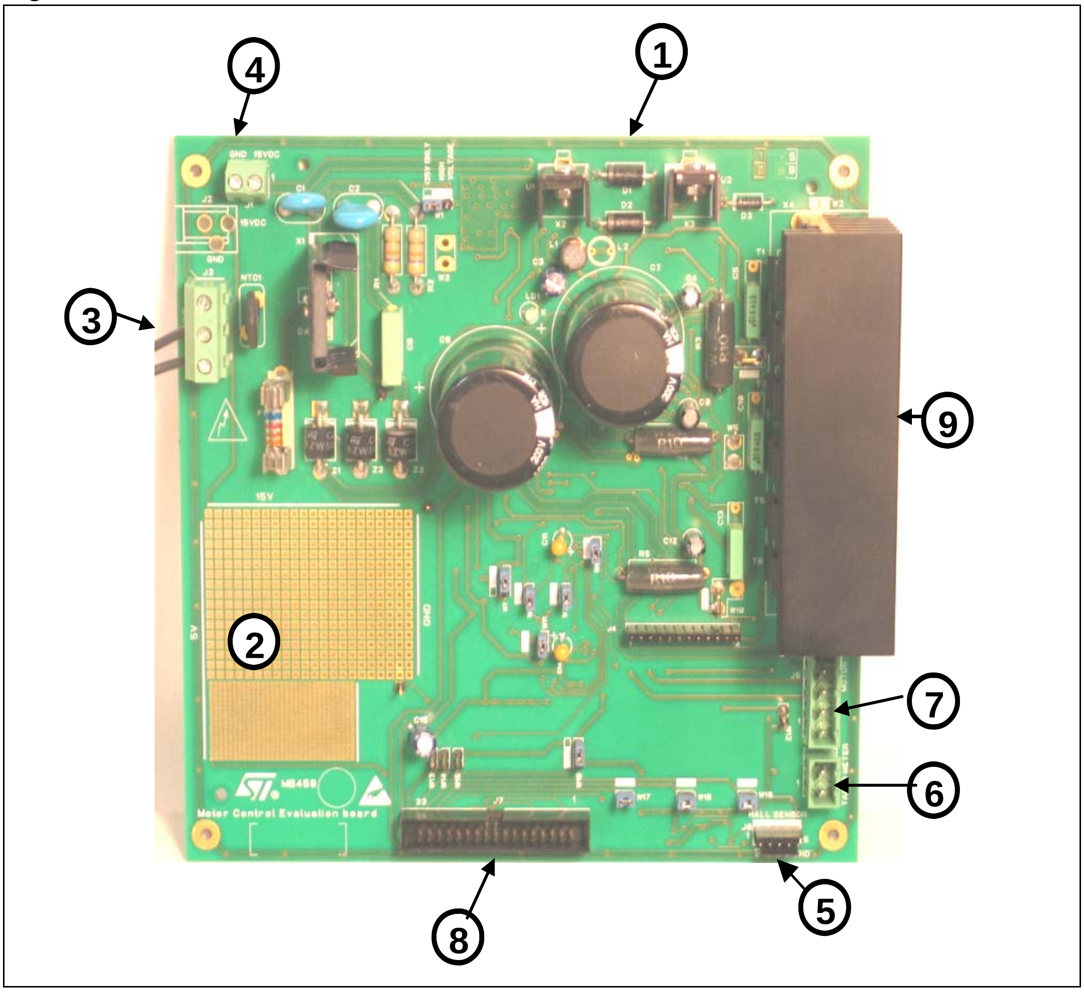
1 Hardware layout

This section illustrates the main connectors of the MB459B motor control board (see *Figure 1*), and describes their function.

Figure 1. MB459B connectors



1. Motor and board input power stage, auxiliary power supply, and voltage rectification
2. Prototype area
3. J3 connector: power supply input
4. J1 connector: auxiliary supply input
5. J8 connector: Hall sensors / encoder input
6. J6 connector: tachometer input for closed-loop controlled AC motors
7. J5 connector: Three-phase output to motor
8. J7 motor connector: link to STR75x and to STM3210B-EVAL evaluation board, or other control board
9. 7A inverter and level shifter

2 Power supply

The MB459B motor control evaluation board can be supplied from a single power supply or from a dual power supply.

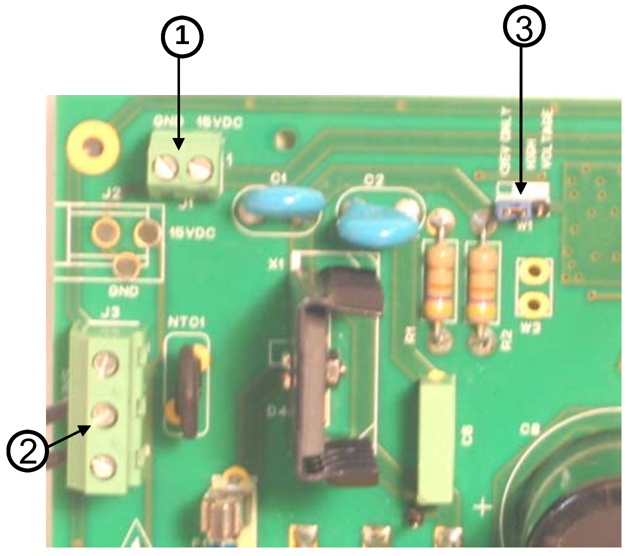
- **Single power supply for motors requiring a voltage greater than 18 V**
  The power is supplied to the J3 connector. The voltage must not exceed 42V DC or $30V_{eff}$ AC. It supplies both the motor and the motor control board. A 15V DC voltage is automatically generated for the motor control board logic. However, depending on the voltage supplied, two cases are possible:
  – If the supplied voltage is greater than 35V DC, the W1 jumper must be set in "HIGH VOLTAGE" position;
  – If the supplied voltage is between 18V and 35V DC, the W1 jumper must be set in the "<35V ONLY" position.
- **Dual power supply for motors requiring a voltage less than 18 V**
  The power for the motor is supplied to the J3 connector, while a separate power supply for the motor control board logic must be applied to the J1 connector (15V DC, 0.5 A).

Caution: In the case of dual power supply, the W1 jumper must be removed and the D3 short-circuit must be unsoldered (this is to avoid having reverse current in the linear voltage regulator).

Note: On the J3 connector, the polarity of DC input is not important.

Figure 2 shows where the power supply connectors are located on the board.

Figure 2. MB459B power supply connectors



1. **J1** connector: 15V DC, 0.5 A power supply input (used in dual power supply mode to supply the motor control board logic).
2. **J3** connector: motor power supply (in dual power supply mode) or motor plus motor control board power supply (in single power supply mode). Up to 42V DC or $30V_{eff}$ AC.
3. **W1** jumper. In single power supply mode, selects the motor voltage; in dual power supply mode, it must be removed.

3 Operational amplifier configuration

The MB459B motor control evaluation board can be configured to run in two current reading configuration modes:

- Three-shunt configuration
- Single-shunt configuration

Single-shunt configuration requires a single op-amp, three-shunt configuration requires three op-amps, and for compatibility purposes, one of them must be common to the two configurations.

Jumpers W7, W8 and W9 allow you to set the common op-amp to achieve the compatibility between single-shunt and three-shunt current reading mode.

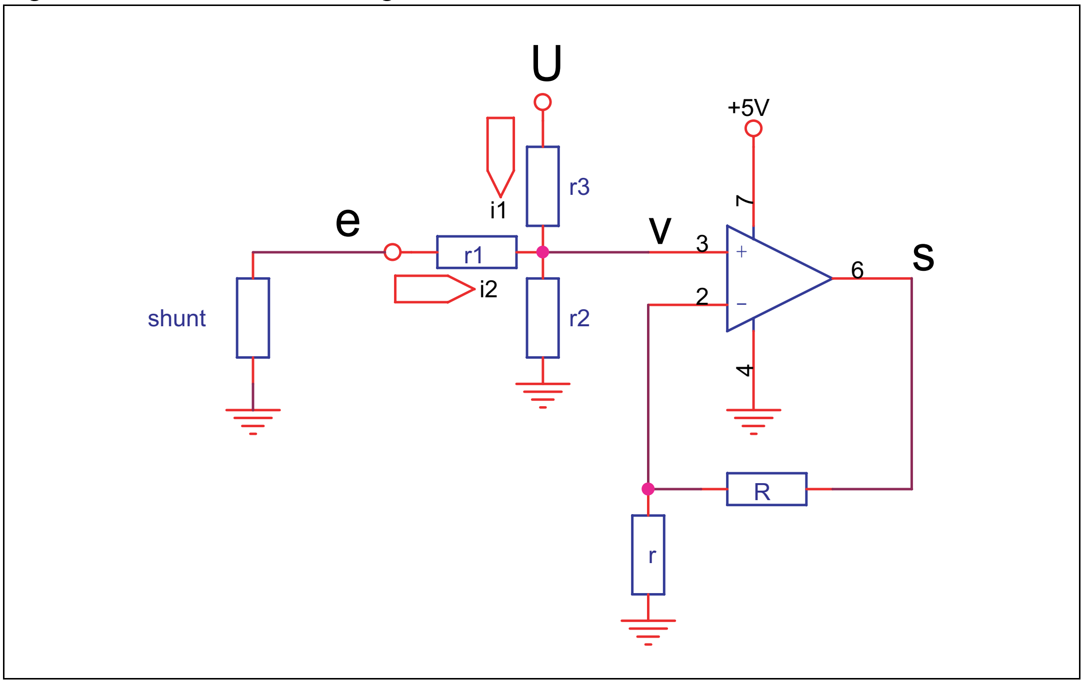
The TSV994 used on the motor control board has a 20MHz gain bandwidth and operates with a single positive supply.

3.1 Three-shunt current reading configuration

Figure 3 gives the op-amp configuration for the three-shunt current reading mode. In this configuration, the alternating signal on the shunt resistor, with positive and negative values, must be translated to be compatible with the single positive input voltage of the microcontroller's analog-to-digital converter used to read the current value.

This means that the op-amp must be polarized in order to obtain on the output a voltage that makes it possible to measure the symmetrical alternating input signal.

Figure 3. Three-shunt configuration



The op-amp is used in follower mode with a gain set by resistors r and R.

$G = s / v = (R + r)/r$

The relation between the input signal **e** and the signal **v** on the positive input of the follower is:

$v = (U/(k*r3) + e/(k*r1))$

where $k = (1/r1+1/r2+1/r3)$

The resistor values implemented on the MB549B board are:

R=5400Ω \ r=1000Ω \ r1=660Ω \ r2=560Ω \ r3=4700Ω

and

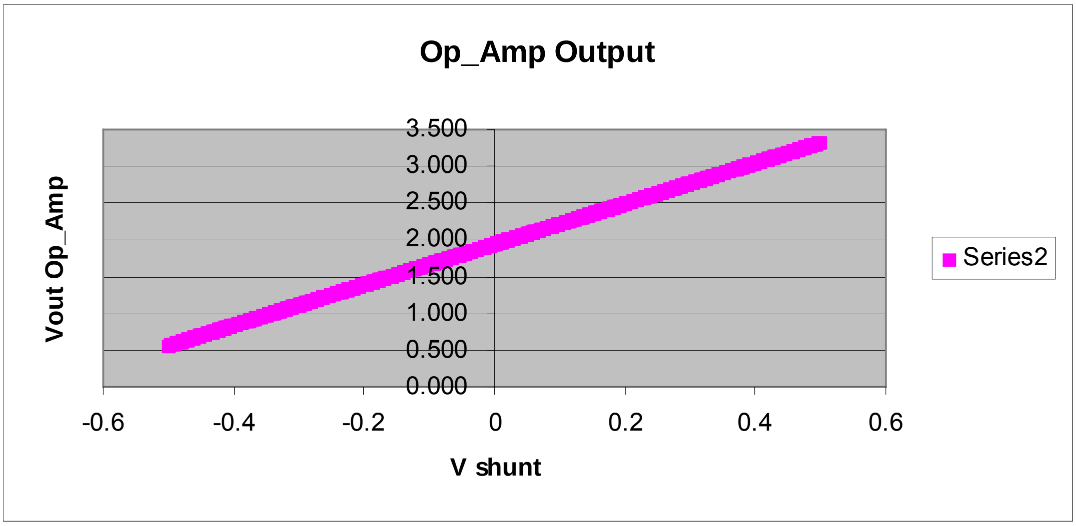
U=5V

Therefore, the gain is:

G = 6.4

The response of the op-amp is represented in *Figure 4*.

Figure 4. Voltage response in three-shunt configuration



With these settings, the output voltage of the op-amp is equal to 1.94V for a nil current.

The peak current that can be measured in this configuration is:

+/- 5A for R_shunt = 0.1ohms

+/- 2.3A for R_shunt = 0.22 ohms

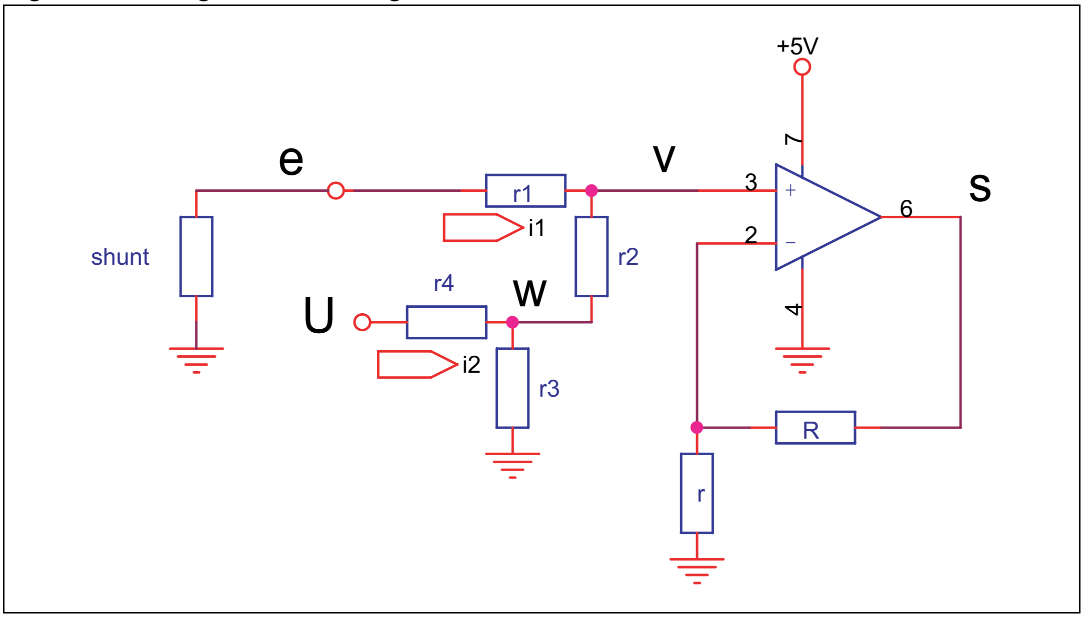
3.2 Single-shunt current reading configuration

In the single-shunt current reading configuration, the current sampling is done only when the value on the shunt resistor is positive.

The only positive value read on the shunt resistor allows to set a higher gain for the op-amp than the one set in three-shunt mode. However, because the input of the op-amp is not rail-to-rail, in this configuration also, it is necessary to polarize ~~the~~ it to compensate for this limitation.

Figure 5 shows the op-amp configuration used in single-shunt configuration.

Figure 5. Single-shunt configuration



The op-amp is used in follower mode with a gain set by resistors r and R.

G = s/v = (R + r)/r

The relation between the input signal **e** and the signal **v** on the positive input of the follower is:

v = ((U*h)/(k*r4) + f(e))

with:

k =(1/r3+1/(r1+r2)+1/r4)

h=r1/ (r1 +r2)

f(e)=(e*r2)/ (r1 + r2) + (e*r1)/((k*(r1+r2)*(r1+r2))

The resistor values implemented on the MB549B board are:

R=11000Ω \ r=1000Ω \ r1=1130Ω \ r2=1000Ω \ r3=22Ω \ r4=2200Ω

and

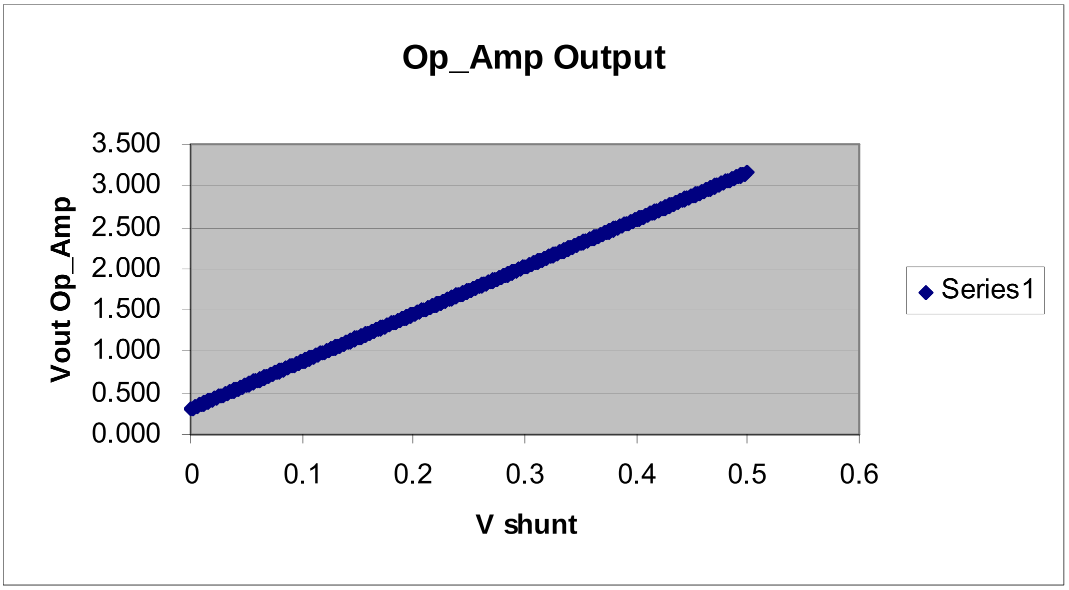
U=5V

Therefore, the gain is:

G = 12

The response of the op-amp is shown in *Figure 6*.

Figure 6. Voltage response in single-shunt configuration



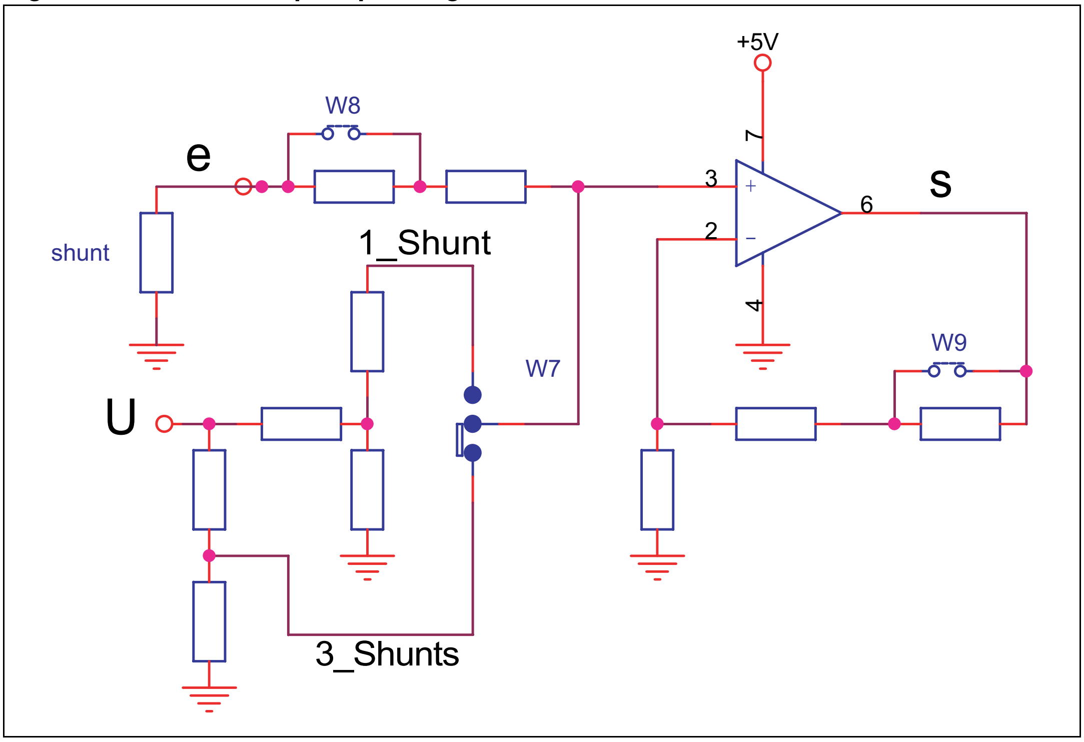
In this configuration, the output voltage of the op-amp is equal to 3.16V when the maximum peak current that is measured in R_shunt is reached:

+ 5A for R_shunt = 0.1Ω or + 2.3A for R_shunt = 0.22Ω

3.3 Jumper configuration

Based on the two current reading configurations for single-shunt and three-shunt, the final configuration of the common op-amp is summarized in *Figure 7*.

Figure 7. Common op-amp configuration



4 Electrical specifications

Table 1 provides the maximum ratings for the MB459B motor control board.

Table 1. Motor control evaluation board electrical specifications

Parameter	Maximum ratings
Motor types	Three-phase PMSM or AC motor
Main input voltage (J3)	42V DC or 30 V_{eff} AC
Auxiliary input voltage (J1)	15V DC, 0.5A
Maximum output current on motor phases (J5)	7A

The maximum current allowed on the motor phases is mainly dependent on the shunt resistor value and op-amp gain. For further information, see *Section 3: Operational amplifier configuration on page 5*.

5 Hardware settings for driving PMSM motors

To drive the PMSM motor, you must simply ensure that the MB459B motor control board is driven by a control board that outputs the six signals required to drive the three-phase power stage. The MB469B STR75x evaluation board provided in the STR750-MCKIT or the STM3210B-EVAL evaluation board provided with the STM3210B-MCKIT are perfectly suited for this task.

To drive any other generic high voltage PMSM motor, you must ensure that:

- your PMSM motor is connected on the motor control board in place of the PMSM motor provided, on the J5 and J8 connectors,
- the motor phases are connected to the board on the J5 connector,
- the encoder from the PMSM motor is connected to the board on the J8 connector

For example, for the Shinano PMSM motor provided with the STR750-MCKIT and the STM3210B-MCKIT the connections are listed in *Table 2*.

Table 2. Jumper settings for a PMSM motor (default settings)

Jumper	Settings for the supplied SHINANO 24V PMSM motor	Settings for a generic high voltage PMSM motor
W1	“< 35V Only”	“< 35V Only” or “ HIGH VOLTAGE”
W4	Present	
W5	Not present	
W6	Present	
W7	Present and set to default position of silk-screen printing	
W8	Present	
W9	Present	
W10	Present	
W11	Present	
W12	Not present	
W13	Not present	
W14	Not present	
W15	Not present	
W16	Present and set to reverse position of silk-screen printing	
W17	Present	
W18	Present	
W19	Present	

6 Hardware settings for driving AC induction motors

To drive an AC induction motor, you must ensure that:

- The motor control evaluation board is driven by an adapted control board that outputs the six signals required to drive the three-phase power stage,
- The AC induction motor is connected on the motor control board in place of the PMSM motor,
- The AC induction motor phases are connected to the board on the J5 connector,
- The tacho generator is connected to the board on the J6 connector.

Table 3. Jumper settings for an AC Induction motor

Jumper	Settings for a generic AC motor with tachometer feedback
W1	"< 35V Only" or " HIGH VOLTAGE"
W4	Present
W5	Not present
W6	Present
W7	Present and set to default position of silk-screen printing
W8	Present
W9	Present
W10	Present
W11	Present
W12	Present
W13	Not present
W14	Not present
W15	Not present
W16	Present - any position
W17	Not present
W18	Not present
W19	Not present

7 Description of jumper and connector settings

Table 4. Jumper descriptions

Jumper	Selection	Description
W1	" HIGH VOLTAGE"	Motor supply is greater than 35V DC or $25V_{eff}$ AC.
	"< 35V Only"	Motor supply is less than 35V DC or $25V_{eff}$ AC.
	Not present	Power motor supply is separate from motor control circuit.The motor control circuit must be supplied with 15V DC (0.5A) on J1 connector. In this case, the D3 short-circuit must be removed (unsoldered) from the PCB. Refer to *Section 2: Power supply* for details.
W4	Present	Connects R3 shunt resistor to T2 IGBT source for the three shunt configuration.
	Not present	Disconnects R3 from T2 IGBT source for the single shunt configuration.
W5	Present	Connects the T2 IGBT source to R4 shunt resistor for the single shunt configuration.
	Not present	Disconnects the T2 IGBT source from R4 shunt resistor for the three shunt configuration.
W6	Present	Connects the output of thermal comparator on shut-down to the pin 2 input of the L6386 MOS-driver. In such cases, the thermal protection can also generate an emergency stop forcing the Fault signal to low.
	Not present	Disables feedback of thermal comparator on L6386 MOS-driver.
W7	Set to default position of silk-screen printing	Selects the input polarization of Phase B current op-amp for the three shunt configuration.
	Set to reverse position of silk-screen printing	Selects the input polarization of Phase B current op-amp for the single shunt configuration.
W8	Present	Sets the input resistor of Phase B current op-amp for three shunt configuration.
	Not present	Sets the input resistor of Phase B current op-amp for single shunt configuration.
W9	Present	Sets the gain resistor of Phase B current op-amp for three shunt configuration.
	Not present	Sets the gain resistor of Phase B current op-amp for single shunt configuration.
W10	Set to default position of silk-screen printing	Connects R5 shunt resistor to T6 IGBT source for the three shunt configuration.
	Set to reverse position of silk-screen printing	Connects the T6 IGBT source to R4 shunt resistor for the single shunt configuration.

Table 4. Jumper descriptions (continued)

Jumper	Selection	Description
W11	Present	Connects the output of diagnostic comparator to the Fault/MC EMGCY input of microcontroller pin P1.10
	Not present	Disconnects the output of diagnostic comparator from the Fault/MC EMGCY input of microcontroller pin P1.10
W12	Present	Connects the tachometer signal to Measure Phase A / TIM2_TI1 input P0.03. In that case, W17 is not present (removed).
	Not present	Disconnects the tachometer signal from Measure Phase A / TIM2_TI1 input P0.03.
W13	Present	The 3.3V Pow supply connected to Vdd_m is used to supply the microcontroller board connected on pin 26 of the motor control connector J7.
	Not present	Vdd_m is not connected to the 3.3V Pow of power board.
W14	Present	The 5V supply connected to Vdd_m, is used to supply the microcontroller board connected on pin 26 of the motor control connector J7.
	Not present	Vdd_m is not connected to the 5V of the power board.
W15	Present	Uses the 5V of the microcontroller board to supply the power board via the motor control connector J7.
	Not present	The 5V of the power board is not supplied by the microcontroller board.
W16	Set to default position of silk-screen printing	The +Vdd_m is used to supply the Hall sensor or encoder
	Set to reverse position of silk-screen printing	The +5V is used to supply the Hall sensor or encoder
W17	Present	Enables Hall1/A+ on Measure Phase A/ TIM2_TI1 input P0.03
	Not present	Disables Hall1/A+ for Measure Phase A/ TIM2_TI1 input P0.03
W18	Present	Enables Hall2/B+ on Measure Phase B/ TIM2_TI2 input P1.03
	Not present	Disables Hall2/B+ for Measure Phase B/ TIM2_TI2 input P1.03
W19	Present	Enables Hall3/Z+ on Measure Phase C/ TIM0_TI1 input P0.01
	Not present	Disables Hall3/Z+ for Measure Phase C/ TIM0_TI1 input P0.01

Table 5. Connector pinout descriptions

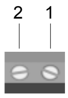
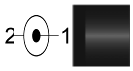
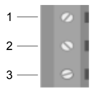
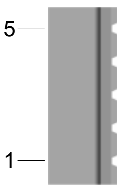
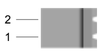
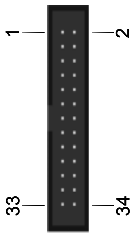
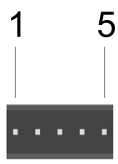
Name	Reference	Description/pinout
J1		Optional 15V DC, 0.5A input connector to supply the motor control board logic separately from the motor power stage. 1) 15V DC power supply 2) Vss power
J2		15V DC output connector to supply auxiliary board. This connector is not mounted. 1) 15 V DC power supply 2) VSS power
J3		Up to 42V DC or 30V_{eff} AC power supply input connector. 1) Earth/ground 2) Power input (AC/DC) 3) Power input (AC/DC)
J4		BEMF daughter board connector 1) Phase A 2) Not connected 3) Phase B 4) Not connected 5) Phase C 6) Not connected 7) Bus voltage 8) Not connected 9) +5V 10) +Vdd_m 11) Vss board 12) PWM V_{ref}
J5		Motor three-phase output. 1) Motor phase C 2) Motor phase A 3) Motor phase B 4) DC bus middle point (may be used for two-phase motors) 5) Earth
J6		Tachometer input connector for AC motor speed loop control. 1) Tachometer bias (0.6 V) 2) Tachometer input

Table 5. Connector pinout descriptions (continued)

Name	Reference	Description/pinout
J7		Motor control connector 1) EMERGENCY STOP ---------------- 2) GND 3) PWM-1H ---------------------------------- 4) GND 5) PWM-1L ---------------------------------- 6) GND 7) PWM-2H ---------------------------------- 8) GND 9) PWM-2L -------------------------------- 10) GND 11) PWM-3H ------------------------------- 12) GND 13) PWM-3L ------------------------------ 14) HV BUS VOLTAGE 15) Current PHASE A ---------------- 16) GND 17) Current PHASE B----------------- 18) GND 19) Current PHASE C----------------- 20) GND 21) NTC BYPASS RELAY ---------- 22) GND 23) DISSIPATIVE BRAKE PWM - 24) GND 25) +V Power ---------------------------- 26) Heatsink temperature 27) PFC Sync -------------------------- 28) Vdd_m 29) PWM Vref -------------------------- 30) GND 31) Measure Phase A ---------------- 32) GND 33) Measure Phase B ---------------- 34) Measure Phase C
J8		Hall sensors/ encoder input connector 1) Hall sensor input 1 / encoder A+ 2) Hall sensor input 2 / encoder B+ 3) Hall sensor input 3 / encoder Z+ 4) 5V DC power supply 5) VSS board

8 Schematic diagrams

The MB459B motor control evaluation board schematics are split into two sheets:

- Sheet 1/2 Current Measurement (*Figure 8*), shows the op-amp wiring and configuration, the encoder/ Hall sensor adaptation, the tacho input stage and the motor control connector wiring.
- Sheet 2/2 Power Switch (*Figure 9*), shows the power converter with its associated level shifter and all auxiliary power supplies.

The version of the board described in this manual is MB459-B01. The board version information can be found on a sticker on the component side of the PCB (the visible one), on the bottom left edge of the board when reading the serigraphy.

The changes on this version of the board compared with the previous version MB459-B00 are summarized below:

- Operational amplifiers have changed, TSV994 replacing TSH24.
- The value of capacitors C37, C42, and C47 has increased from 10pF to 100pF.
- The value of resistors R13, R23 and R52 has decreased from 2.2kΩ to 1.8kΩ.
- The D3 diode is now short-circuited.
- The board can also be driven by the STM3210B-EVAL board.

Figure 8. Schematics sheet 1/2: current measurement

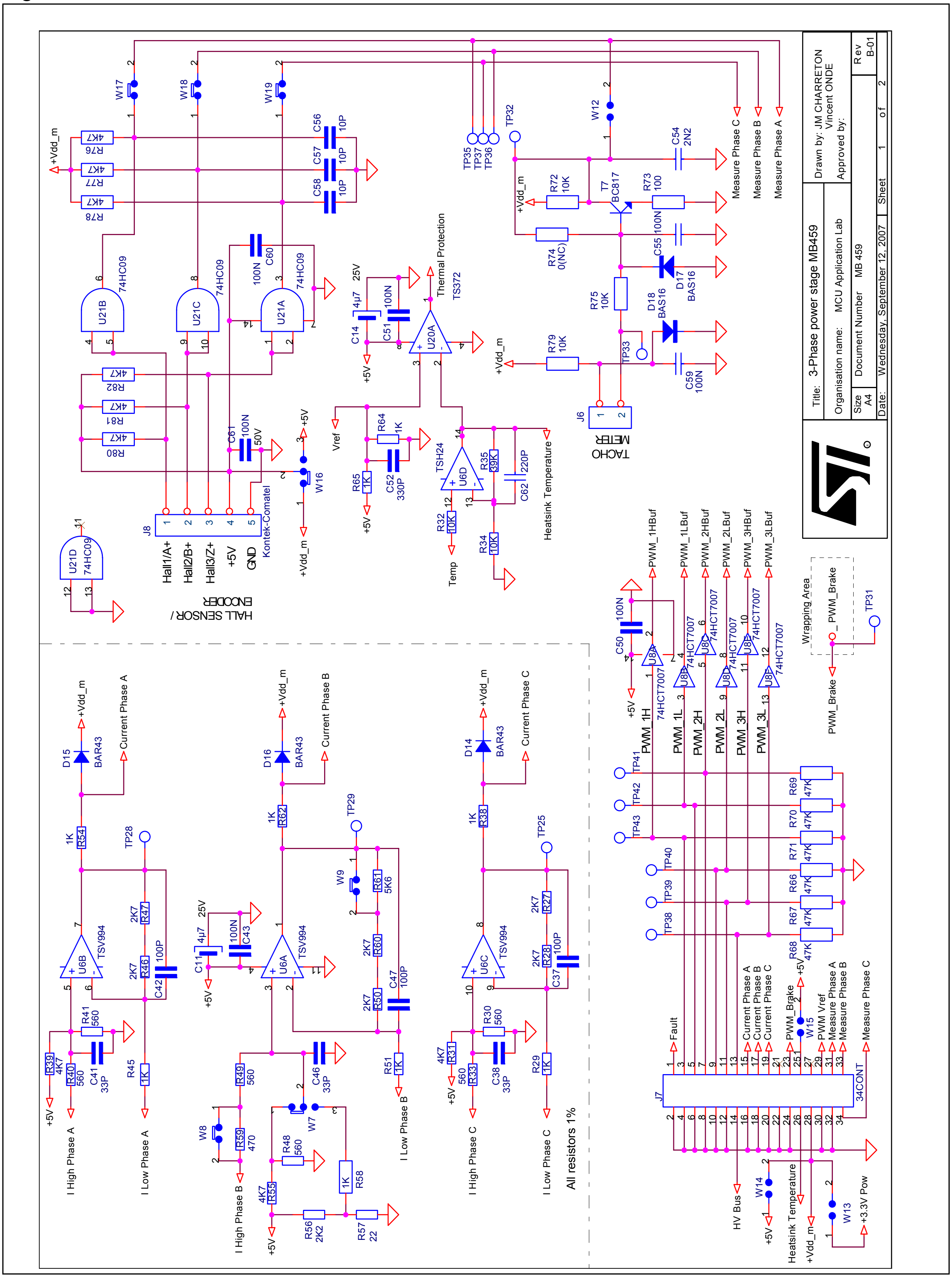
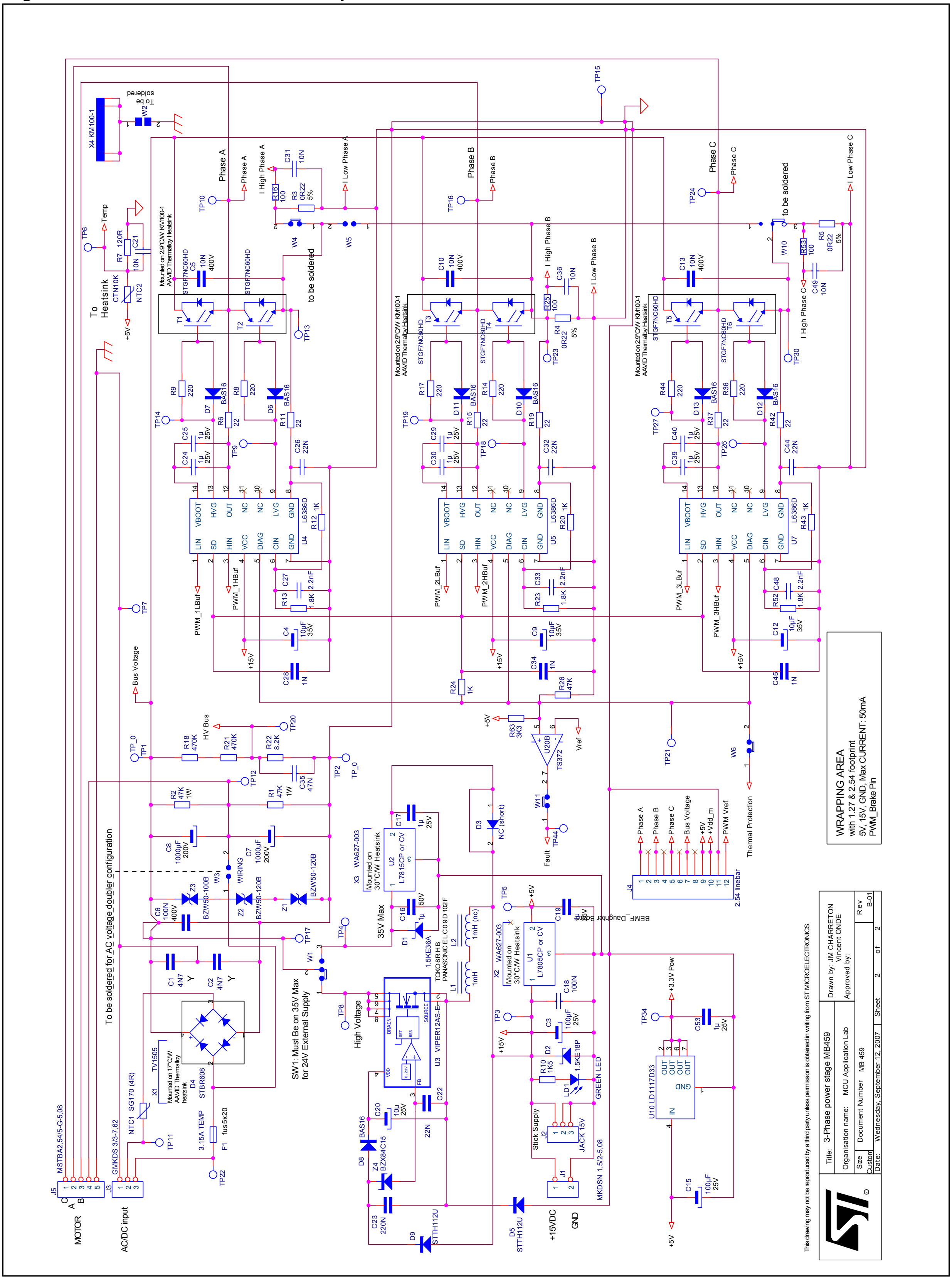


Figure 9. Schematics sheet 2/2: power switch



9 Revision history

Table 6. Document revision history

Date	Revision	Changes
7-Feb-2007	1	Initial release.
17-Dec-2007	2	Added list of changes to the MB459B board compared with the previous version in *Section 8: Schematic diagrams*. Update for release of STM32B-MCKIT motor control kit.