UM1517
User manual

3-phase high voltage inverter power board for FOC and scalar motor control based on the STGIPN3H60 (SLLIMM™-nano)

Introduction

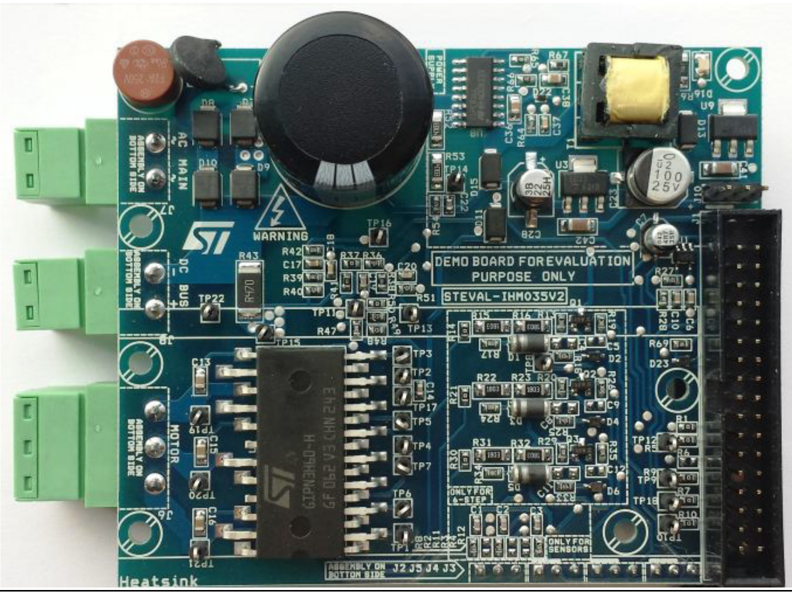
The 3-phase high voltage inverter power board features the STGIPN3H60 (SLLIMM™-nano) for both field-oriented control (FOC) of permanent magnet synchronous motors (PMSM) and trapezoidal scalar control of brushless DC (BLDC) motors. Also referred to by the order code STEVAL-IHM035V2, this 3-phase inverter is designed to perform both the FOC of sinusoidal-shaped back-EMF PMSMs and trapezoidal control of BLDC motors with or without sensors, with nominal power up to 100 W. The flexible, open, high-performance design consists of a 3-phase inverter bridge based on:

- The STGIPN3H60 SLLIMM™-nano (small low-loss intelligent molded module) IPM, 3 A - 600 V 3-phase IGBT inverter bridge
- The VIPer16 fixed frequency VIPer™ plus family

The system is specifically designed to achieve fast and accurate conditioning of the current feedback, thereby matching the requirements typical of high-end applications such as field oriented motor control.

The board is compatible with 110 and 230 Vac mains, and includes a power supply stage with the VIPer16 to generate the +15 V and the +3.3 V (or optionally the +5 V) supply voltage required by the application. Finally, the board can be interfaced with the STM3210xx-EVAL (STM32 microcontroller evaluation board), STEVAL-IHM022V1 (high density dual motor control evaluation board based on the STM32F103ZE microcontroller), and with the STEVAL-IHM033V1 (control stage based on the STM32F100CB microcontroller suitable for motor control), through a dedicated connector.

Figure 1. STEVAL-IHM035V2 evaluation board



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1 Main features

The STEVAL-IHM035V2 inverter power stage board has the following characteristics:

- Compact size
- Wide-range input voltage
- Maximum power up to 100 W at 230 Vac input
- The STGIPN3H60 SLLIMM™-nano (small low-loss intelligent molded module) IPM, 3 A - 600 V 3-phase IGBT inverter bridge
- The VIPer16 fixed frequency VIPer™ plus family
- AC or DC bus voltage power supply connectors
- Connector for interfacing with the STM3210xx-EVAL board, STEVAL-IHM022V1, and STEVAL-IHM033V1 with alternate functions (current reference, current limitation/regulation, method selection, current boost)
- Efficient DC-DC power supply (15 V, 3.3 V, 5 V)
- Suitable both for sinusoidal FOC and trapezoidal BLDC drive
- Single-shunt current reading topology with fast operational amplifier (with offset insertion for bipolar currents)
- Hardware overcurrent protection with boost capabilities
- Temperature sensor
- BEMF detecting network for BLDC drive
- Current regulation/limitation network for BLDC drive
- Hall sensor/quadrature encoder inputs.

1.1 Target application

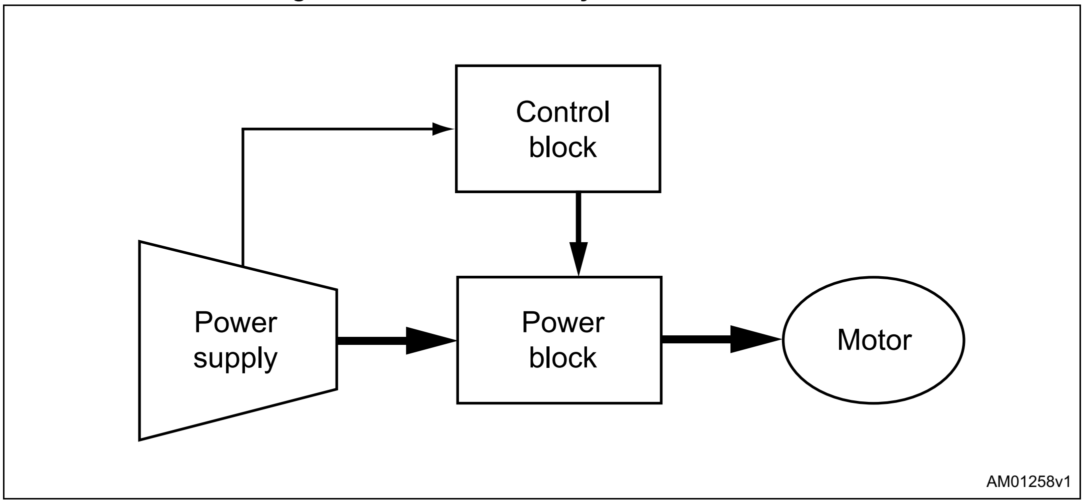
- High efficiency drain pump for home appliance white goods, like dishwashers and washers
- Compressor drives for fridges
- Ceiling fans
- Inverters for high efficiency circulating water pump for heating systems in single-family houses
- High efficiency and reliable solution for small power transfer pumps for waste sludge - sewerage plants in single-family houses, waste piping
- High efficiency transfer pumps for outlet condensation water
- High efficiency extractor hoods and blowers for gas furnace applications.

2 System architecture

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

- Control block: its main tasks are to accept user commands and motor drive configuration parameters, and to provide digital signals to implement the appropriate motor driving strategy
- Power block: it performs the power conversion from the DC bus, transferring it to the motor by means of a 3-phase inverter topology
- The motor: the STEVAL-IHM035V2 board can drive both PMSM and BLDC motors
- Power supply block: it can accept input voltages of 86 to 260 Vac and provides the appropriate levels to supply both the control block and power block devices.

Figure 2. Motor control system architecture



Of the above motor control system architecture, the STEVAL-IHM035V2 includes the power supply and power hardware blocks.

The power block, based on the high voltage STGIPN3H60 (SLLIMM™-nano), converts the signals coming from the control block into power signals capable of correctly driving the 3-phase inverter, and therefore the motor.

The power supply can be fed with 110 or 230 Vac mains, and the maximum allowed input power is 100 W at 230 Vac (refer to *Section 6*).

In the control block, an MC connector is mounted on the STEVAL-IHM035V2 and the STM3210xx-EVAL, STEVAL-IHM022V1, and STEVAL-IHM033V1, which allows the STM32 microcontroller evaluation board to be used as a hardware platform for development.

The “STM32 FOC firmware library” is ready to be used in conjunction with the STM32 MC workbench 1.2 as a software platform for the sensorless control of PMSMs (see *Section 9*).

The required STM32 motor control workbench data is reported in *Table 4*.

3 Safety and operating instructions

3.1 General

Warning: During assembly and operation, the STEVAL-IHM035V2 evaluation board poses several inherent hazards, including bare wires, moving or rotating parts and hot surfaces. Serious personal injury and damage to property may occur if the kit or its components are used or installed incorrectly.

All operations involving transportation, installation and use, as well as maintenance, should be performed by skilled technical personnel (applicable national accident prevention rules must be observed). The term “skilled technical personnel” refers to suitably-qualified people who are familiar with the installation, use and maintenance of electronic power systems.

3.2 Intended use of the evaluation board

The STEVAL-IHM035V2 evaluation board is designed for evaluation purposes only, and must not be used for electrical installations or machinery. Technical data and information concerning the power supply conditions are detailed in the documentation and should be strictly observed.

3.3 Installing the evaluation board

The installation and cooling of the evaluation board must be in accordance with the specifications and target application.

- The motor drive converters must be protected against excessive strain. In particular, components should not be bent or isolating distances altered during transportation or handling.
- No contact must be made with other electronic components and contacts.
- The board contains electrostatically-sensitive components that are prone to damage if used incorrectly. Do not mechanically damage or destroy the electrical components (potential health risk).

3.4 Electronic connections

Applicable national accident prevention rules must be followed when working on the main power supply with a motor drive. The electrical installation must be completed in accordance with the appropriate requirements (for example, cross-sectional areas of conductors, fusing, PE connections, etc.).

3.5 Operating the evaluation board

A system architecture that supplies power to the STEVAL-IHM035V2 evaluation board must be equipped with additional control and protective devices in accordance with the applicable safety requirements (i.e., compliance with technical equipment and accident prevention rules).

Warning: **Do not touch the evaluation board after it has been disconnected from the voltage supply as several parts and power terminals containing possibly-energized capacitors need time to discharge.**

4 STGIPN3H60 characteristics

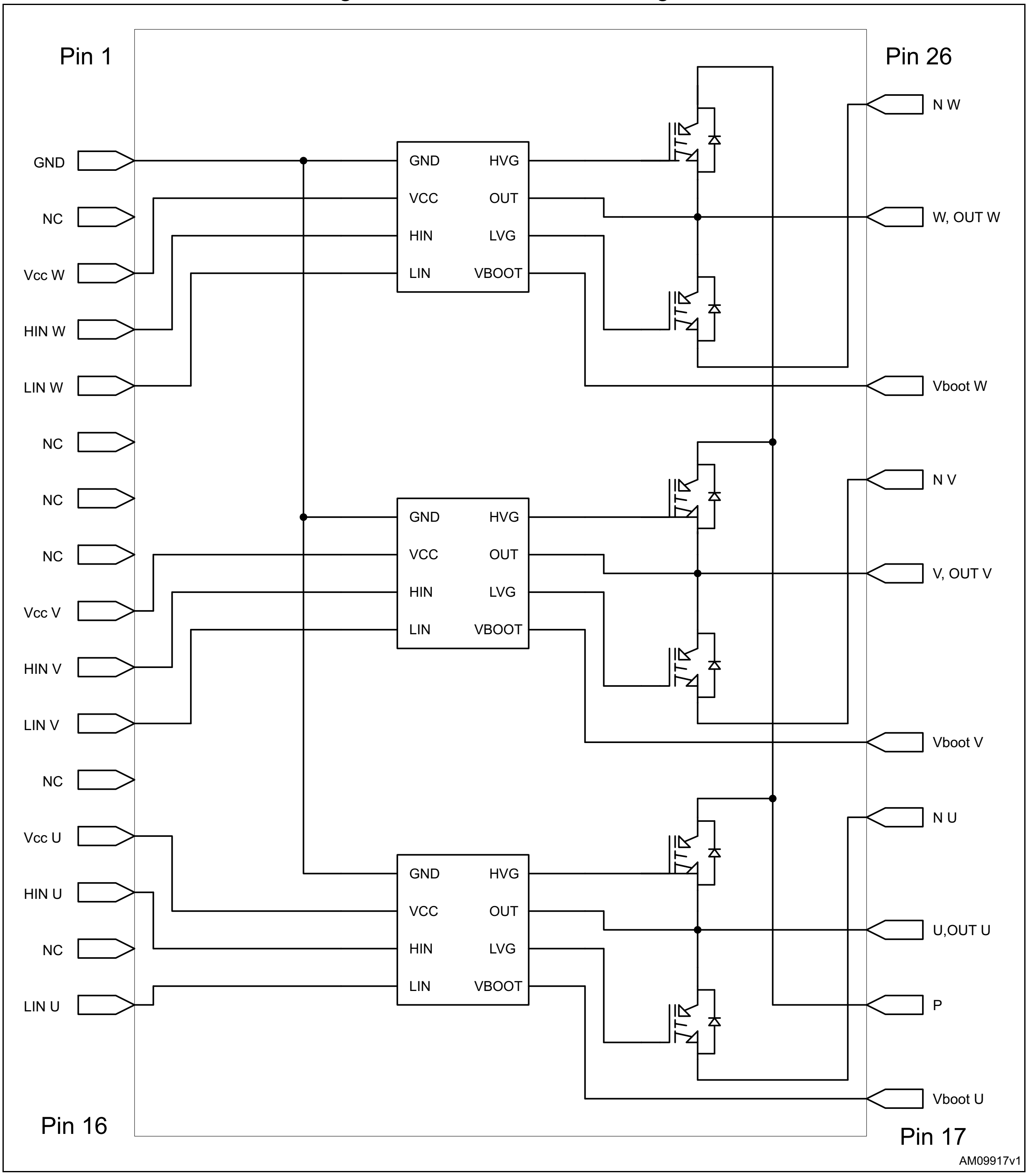
4.1 Main features

- IPM 3 A, 600 V, 3-phase IGBT inverter bridge including control ICs for gate driving and freewheeling diodes
- Optimized for low electromagnetic interference
- VCE(sat) negative temperature coefficient
- 3.3 V, 5 V, 15 V CMOS/TTL input comparators with hysteresis and pull-down/pull-up resistors
- Undervoltage lockout
- Internal bootstrap diode
- Interlocking function
- Shutdown function
- Comparator for fault protection against overtemperature and overcurrent
- Op amp for advanced current sensing
- Optimized pinout for easy board layout.

4.2 Block diagram

Figure 3 shows the block diagram of the L6392 device.

Figure 3. STGIPN3H60 block diagram



5 VIPer16 characteristics

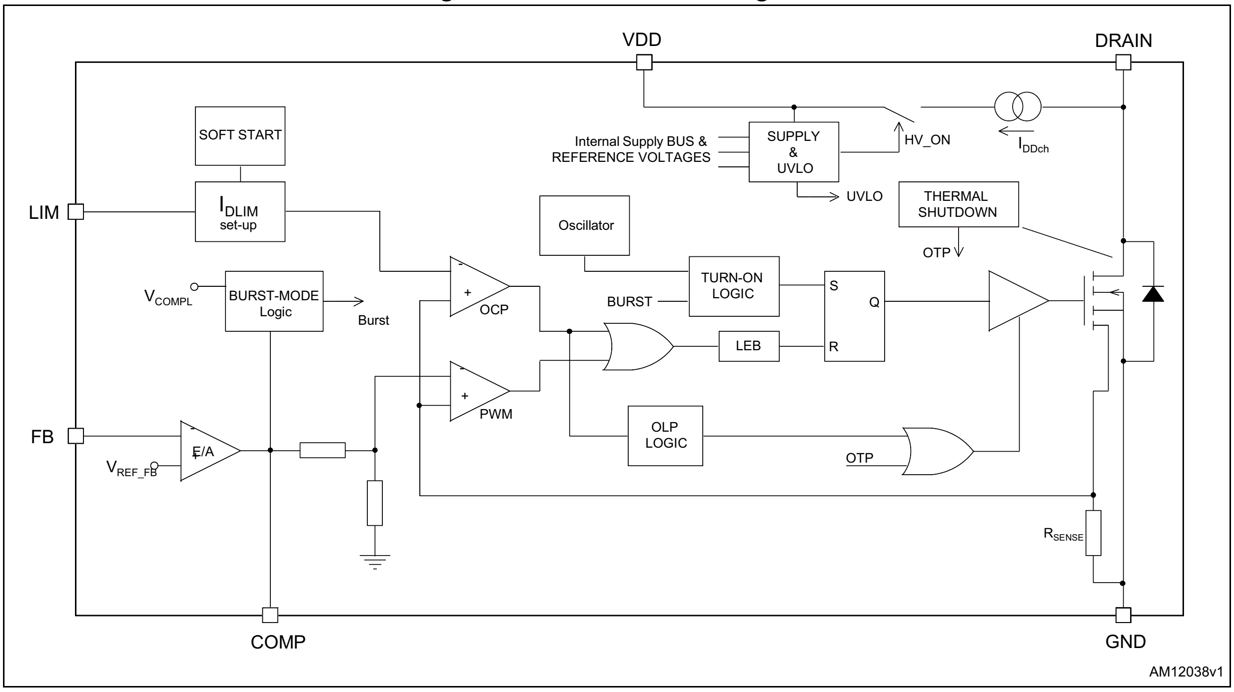
5.1 Main features

- 800 V avalanche rugged power section
- PWM operation with frequency jittering for low EMI
- Operating frequency 60 kHz
- No need of auxiliary winding for low power application
- Standby power < 50 mW at 265 VAC
- Limiting current with adjustable set point
- Onboard soft-start
- Safe auto-restart after a fault condition
- Hysteretic thermal shutdown.

5.2 Block diagram

Figure 4 shows the block diagram of the VIPer16 device.

Figure 4. VIPer16 block diagram



6 Electrical characteristics of the board

Board power is intended to be supplied by an alternate current power supply through connector J7 (AC mains) or optionally by a direct current power supply through connector J8 (DC bus), in which case it is required to respect the correct polarity.

Stresses above the limits shown in *Table 1* may cause permanent damage to the devices present inside the board. These are stress ratings only and functional operation of the device under these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

A bias current measurement may be useful to check the working status of the board. If the measured value is considerably higher than the typical value, some damage has occurred to the board. Supply the board using a 40 V power supply connected to J8, respecting the polarity. When the board is properly supplied, LED D16 is turned on.

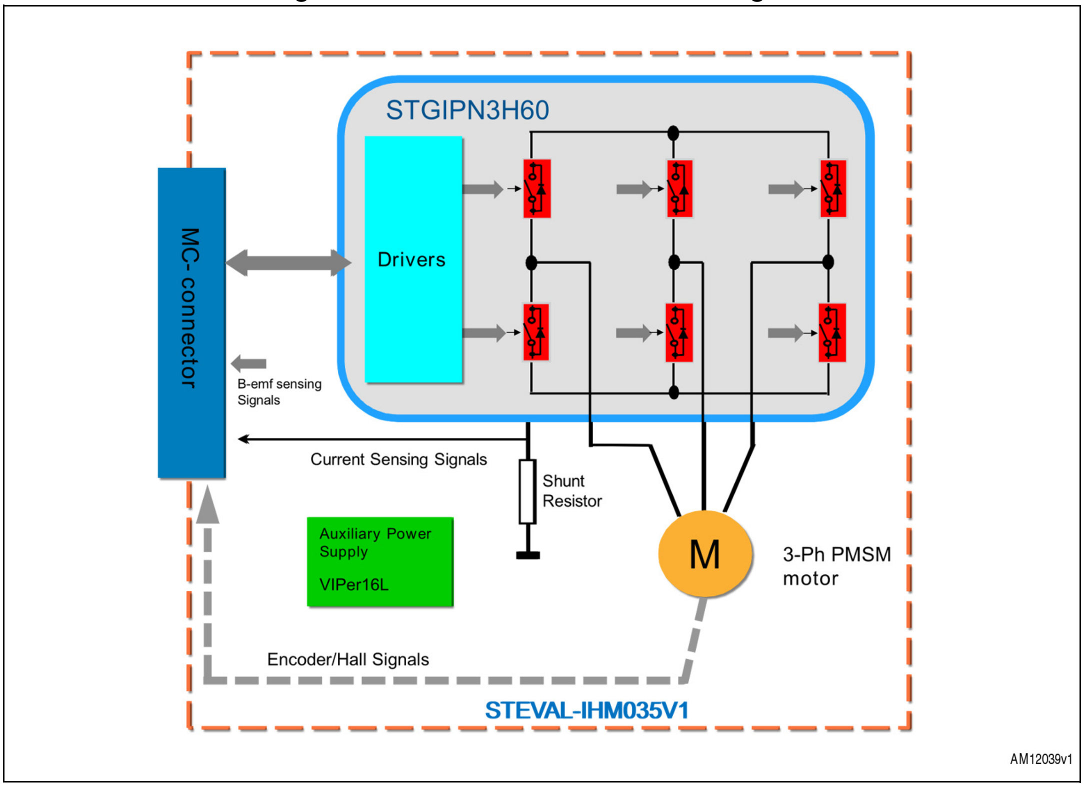
Table 1. Board electrical characteristics

Board parameters	STEVAL-IHM035V2		Unit
	Min.	Max.	
AC mains – J7	30	270	Vrms
DC bus – J8	40	380	V
40 V bias current (typical)	15	25	mA

7 Board architecture

The STEVAL-IHM035V2 can be schematized as shown in *Figure 5*.

Figure 5. STEVAL-IHM035V2 block diagram



7.1 Power supply

The power supply can address an AC input voltage (J7) ranging from 30 Vac up to 270 Vac. The alternating current input is rectified by a diode bridge and a bulk capacitor to generate a direct current bus voltage approximately equal to √2 Vac (neglecting the voltage drop across the diodes and the bus voltage ripple). A VIPer16 is then used in a buck converter configuration to generate the +15 V supply voltage of the gate drivers and to supply the low drop voltage regulators (LD1117S33TR) to generate the 3.3 V and (LD1117S50TR) to generate the 5 V that can be used as Vdd microcontroller reference voltage selecting jumper J10. It is possible to also provide the microcontroller supply voltage to the control board via motor control connector J1.

7.2 Gate driving

As mentioned previously, gate driving of the switches is performed inside the STGIPN3H60 IPM.

7.3 Hardware overcurrent protection

The hardware overcurrent protection is implemented using the fast shutdown feature of U2 (STGIPN3H60).

A fault signal is also fed back to the J1 connector if the overcurrent event is detected.

See *Section 8.1* for more detailed information on hardware current protection.

7.4 Amplifying network for current measurement

The voltages across the shunt resistor are amplified by Aop amplification gains to correctly condition the current feedback signals and optimize the output voltage range for a given phase current range and A-D converter input dynamics. Refer to *Section 8.3* for more detailed information on how to dimension the op amp conditioning network depending on user needs.

To implement the current measurement network, the operational amplifier present in U2 (STGIPN3H60) is used.

7.5 Temperature feedback

Temperature feedback is performed by way of an NTC placed below the package of the STGIPN3H60. It enables the monitoring of the power stage temperature so as to prevent any damage to the inverter caused by overtemperature.

7.6 BEMF zero crossing detection network

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 3-phase BLDC software library v1.0 (UM0708).

7.7 BLDC current limitation/regulation network

The current regulation/regulation network is used to adapt the signal to perform the cycle-by-cycle current control in the BLDC drive. See the STM8S 3-phase BLDC software library v1.0 (UM0708) for more details. To implement the current limitation/regulation network the external comparator U1 (TS3021ILT) is used.

7.8 Overcurrent boost network

On the STEVAL-IHM035V2 board the overcurrent boost network that allows, in run time, a temporary rise of the hardware overcurrent protection threshold is present. See *Section 8.2* for more details.

7.9 Hall sensor/quadrature encoder inputs

The board is easily configurable to run the motor using the Hall sensors or quadrature encoder as position/speed feedback changing the jumpers J3, J4 and J5 and connecting the sensor signals to connector J2.

Note: The Hall sensors or quadrature encoder sensor is not power supplied by STEVAL-IHM035V2.

The default configuration is intended for push-pull sensors. The R8, R11 and R12 resistors are used to limit the current injected into the microcontroller if the sensor high voltage is above $V_{dd\text{-}micro}$.

The maximum current injected should be less than the maximum present in the microcontroller datasheet.

If the sensor has open drain outputs it is possible to mount the pull-up resistors R2, R3 and R4.

8 STEVAL-IHM035V2 schematic diagrams

Figure 6. Inverter schematic

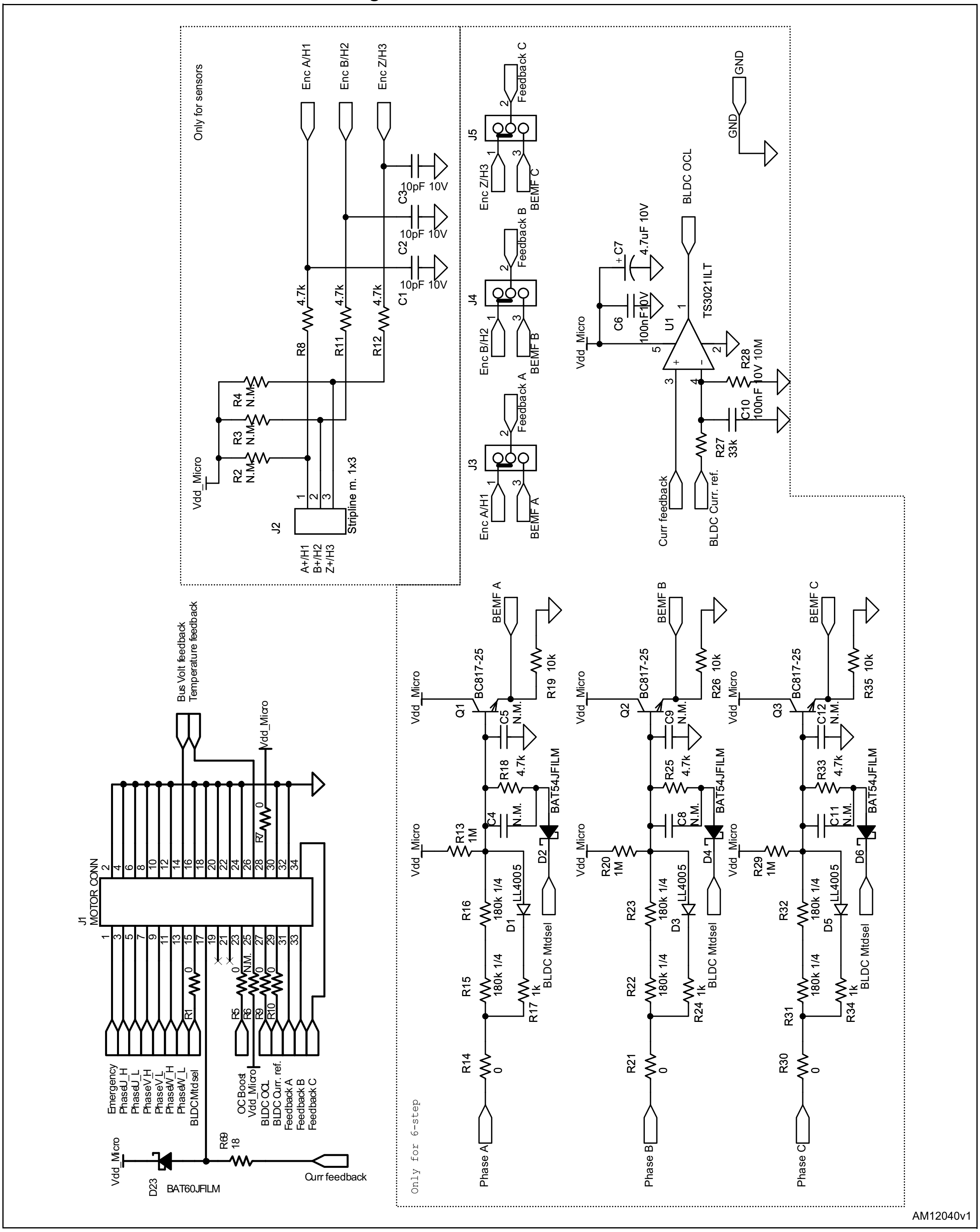


Figure 7. Power supply schematic

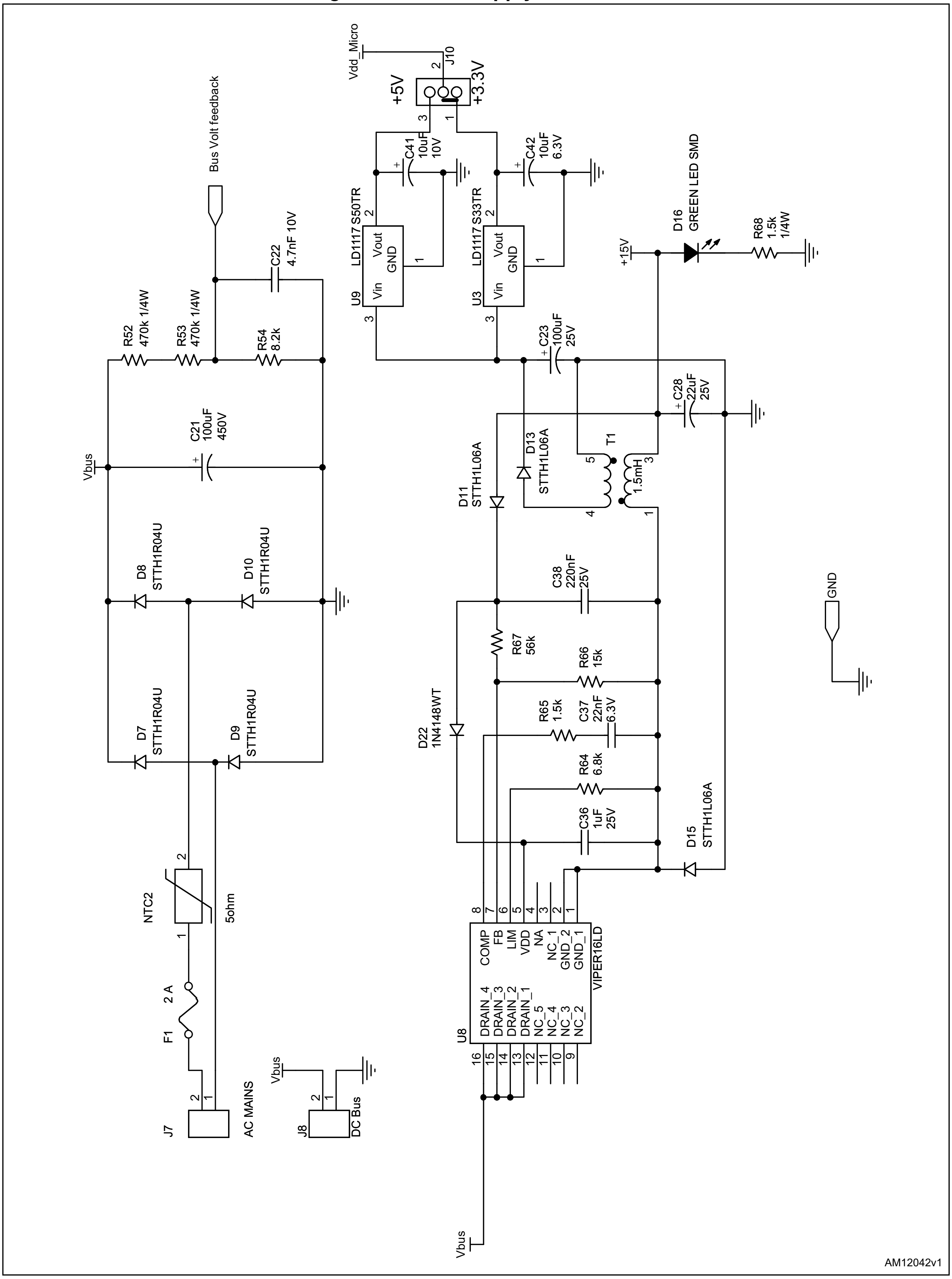
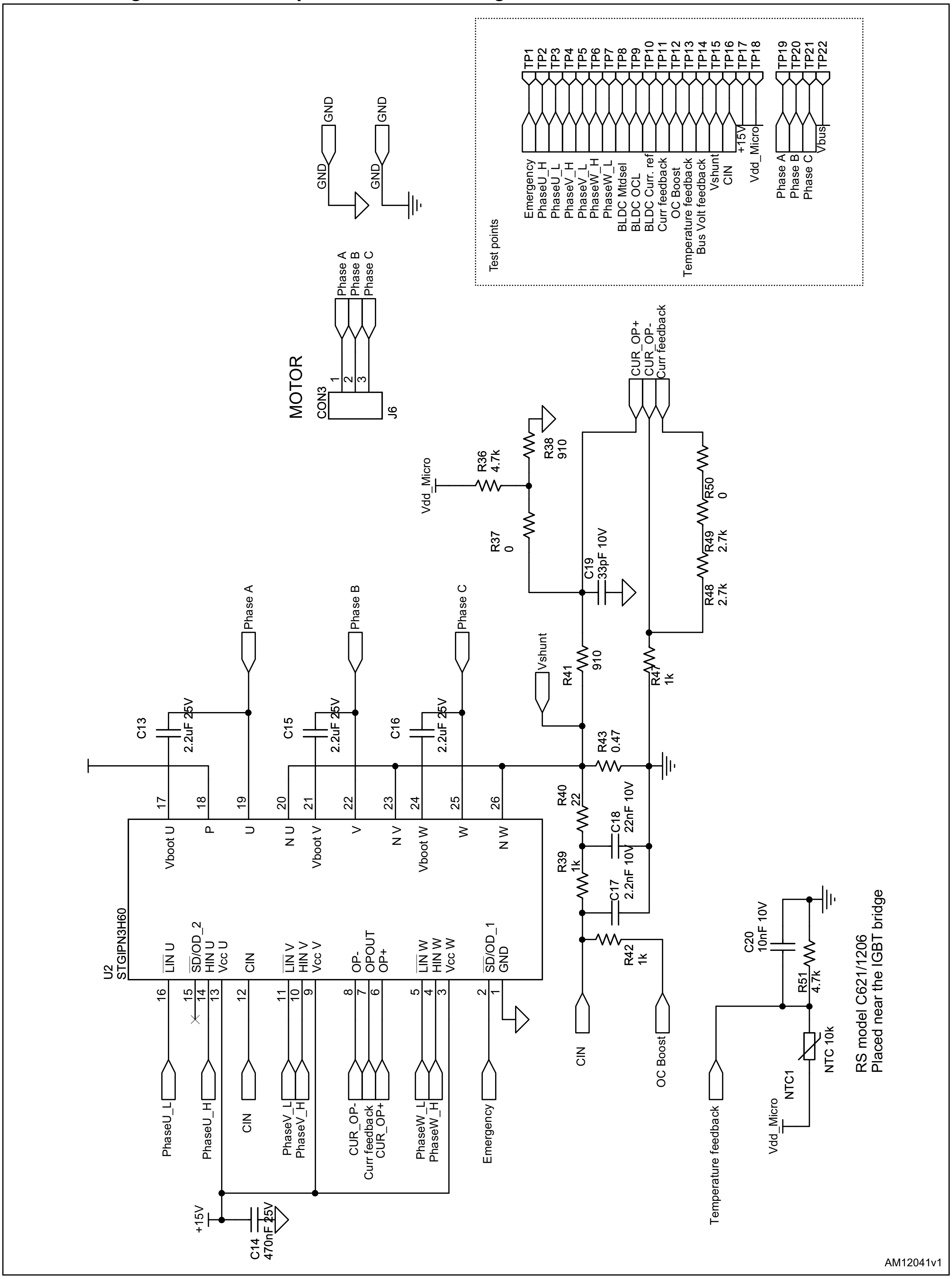


Figure 8. Sensor inputs, BEMF detecting network, motor control connector



8.1 Overcurrent protection

Hardware overcurrent protection has been implemented on the board, taking advantage of the comparator integrated inside the STGIPN3H60. The internal connection between the comparator output and the shutdown block makes the intervention time of the overcurrent protection extremely low, slightly above 100 ns.

Since the overcurrent protection acts as soon as the voltage on CIN rises above the internal reference equal to 0.5 V, and given the default value of the shunt resistors (equal to 0.47 Ω), it follows that the default value for the maximum allowed current (ICP) is equal to:

Equation 1

$$I_{CP} = \frac{V_{Ref}}{R_{shunt}} \cong 1.106$$

If necessary, the overcurrent threshold can be modified changing the value of shunt resistor R43.

8.2 Overcurrent boost

Overcurrent boost can be requested by an application during, for instance, the motor startup or during an active brake. The STEVAL-IHM035V2 includes an overcurrent boost feature, it is possible to increase temporarily the hardware overcurrent protection threshold using the “OC Boost” signal present in the motor control connector J1 (pin 23). This signal is intended to be high impedance when not active while set to GND when active. The default values of the overcurrent threshold and the “OC Boost” signal activation logic are reported in *Table 2*.

Table 2. “OC Boost” signal activation logic and overcurrent threshold

OC boost state	Physical state	Overcurrent threshold	Formula
Not active	High impedance	1.06 A (default)	$I_{CP} = \frac{0.5}{R_{shunt}}$
Active	Grounded	2.15 A (boost)	$\frac{0.5}{R_{shunt}}\left[\frac{R_{42} + R_{39} + R_{40}}{R_{42}}\right]$

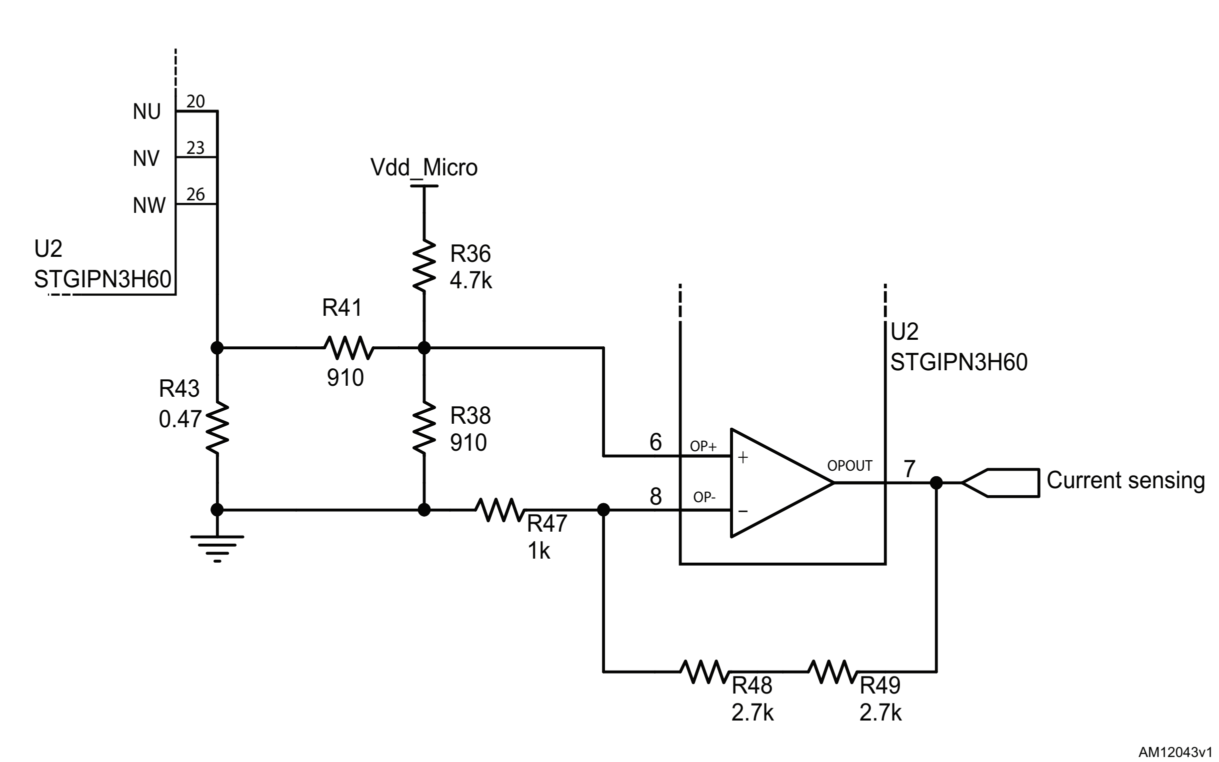
The overcurrent threshold during the boost can be modified changing the values of resistors R39 and/or R42 (see formulas in *Table 2*).

Note: It is possible also to implement an overcurrent protection disabling network if the value of R42 is 0 Ω.

8.3 Current sensing amplification network

Figure 9 shows the current sensing amplification network.

Figure 9. Current sensing amplification network



The voltage at node "Current sensing" can be computed as the sum of a bias and a signal component, respectively equal to:

Equation 2

$$V_{BIAS} = V_{ddMicro} \cdot \frac{(R_{41} \parallel R_{38})}{R_{36} + R_{41} \parallel R_{38}} \cdot \left(1 + \frac{R_{48} + R_{49} + R_{50}}{R_{47}}\right)$$

Equation 3

$$V_{BIASSIGN} = I \cdot R_{Shunt} \cdot \frac{(R_{36} \parallel R_{38})}{R_{41} + R_{36} \parallel R_{38}} \cdot \left(1 + \frac{R_{48} + R_{49} + R_{50}}{R_{47}}\right)$$

With the default values this gives:

- V_{BIAS}=1.86 V
- V_{SIGN}=2.91· R_{Shunt} · I

As such, the maximum current amplifiable without distortion is equal to:

Equation 4

$$I_{MAX} = \frac{3.3 - 186}{2.91 \cdot R_{Shunt}} = \frac{0.495}{R_{Shunt}} = 1.05A$$

Note that the I_{MAX} value can be modified by simply changing the values of the shunt resistors.

8.4 Jumper configuration

This section provides jumper settings for configuring the STEVAL-IHM035V2 board.

Two types of jumpers are used on the board:

- 3-pin jumpers with two possible positions; the possible settings for which are presented in the following sections.
- 2-pin jumpers with two possible settings; fitted if the jumper is closed, and not fitted if the jumper is open.

The STEVAL-IHM035V2 board can also be configured using a set of 0 Ω resistors. These resistors are used as 2-pin jumpers with two possible settings: mounted and not mounted.

8.4.1 Microcontroller supply voltage

The microcontroller supply voltage fed to J1 pin 28 through the R7 resistor is selected using jumper J10:

- J10 between pin 1 and 2 (default setting): select Vdd micro (J1 pin 28) to +3.3 V
- J10 between pin 2 and 3: select V_{dd_micro} (J1 pin 28) to +5 V.

8.4.2 Current sensing network settings

The current sensing network can be configured for bipolar current reading or for unipolar current reading.

In the first case (bipolar current reading), the current flows in the shunt resistor in both directions: to the ground and from the ground. This is sinusoidal control and the current sensing network must make sure to add an offset value in order to measure the negative values.

In the second case (unipolar direction) the current flows only in one direction: to the ground. This is trapezoidal control and the current sensing network is not required to add an offset. Anyhow, it is possible to add a small offset to avoid the saturation of the op amp to the minimum value for low value of motor current.

Resistor R37 is used to select the value of the offset added by the current sensing network.

- R37 mounted (default setting): The current sensing network adds an output offset of 1.86 V (See *Section 8.3*). This configuration should be used for sinusoidal control.
- R37 not mounted: The current sensing network doesn't add any offset.

Resistor R50 can be used to change the amplification gain of the current sensing network, see *Equation 2* and *3*.

- R50 equal to 0 Ω (default setting): The current sensing network amplification gain value is set to 2.91. This configuration should be used for sinusoidal control having a Vdd_micro = 3.3 V.
- R50 equal to 5.6 kΩ: The current sensing network amplification gain is increased by adding a 5.6 kΩ resistor in series to the R48 and R49 (see *Section 8.3*). This configuration can be used for trapezoidal control having a V_{dd_micro} = 5 V. If R37 is not mounted and R50 is 5.6 kΩ, the current sensing network amplification gain value is 12.

8.4.3 Bus voltage divider setting

The default value of the bus voltage divider is sized to scale up to 400 V of DC bus voltage to 3.3 V maximum voltage. By changing resistor R54 it is possible to modify the bus voltage divider.

- R54 equal to 8.2 kΩ (default setting): The bus voltage divider value is 125. This configuration can be used having a V_{dd_micro} = 3.3 V.
- R54 equal to 12 kΩ: The bus voltage divider value is 88. This configuration can be used having a V_{dd_micro} = 5 V.

Note: The value of the bus voltage divider is computed considering the 100 kΩ resistor present in the voltage sensing input of the control stage.

8.4.4 Position feedback jumper setting

On the STEVAL-IHM035V2 board two position feedback networks are present: BEMF zero crossing detecting network and Hall sensors/quadrature encoder sensor conditioning network.

To select which of the two networks is connected with the motor control connector, jumpers J3, J4 and J5 are used.

- J3, J4 and J5 between pin 1 and pin 2 (default setting): The Hall sensors/quadrature encoder sensor conditioning networks are fed into the motor control connector.
- J3, J4 and J5 between pin 2 and pin 3: The BEMF zero crossing detecting networks are fed into the motor control connector. The BEMF zero crossing is possible only in trapezoidal control.

8.4.5 BEMF zero crossing detection network enabling

The BEMF zero crossing detection networks can be disabled removing the following resistors R14, R21 and R30.

- R14, R21 and R30 mounted (default setting): The BEMF zero crossing detection network is enabled. The BEMF zero crossing is possible only in trapezoidal control.
- R14, R21 and R30 not mounted: The BEMF zero crossing detection network is disabled. If not required, it is possible in this way to cut off unwanted power consumption.

8.4.6 Motor control connector extra features enabling

If these extra features are not supported by the control board, it is possible to disable it removing the following resistors; R1, R5, R9 and R10.

- R9 and R10 mounted (default setting): enables the cycle-by-cycle current regulation for trapezoidal control.
- R9 and R10 not mounted: disables the cycle-by-cycle current regulation for trapezoidal control.
- R1 mounted (default setting): enables the dynamic BEMF zero crossing sampling (during T_{ON} or during T_{OFF}) for trapezoidal control.
- R1 not mounted: disables the dynamic BEMF zero crossing sampling (during T_{ON} or during T_{OFF}) for trapezoidal control.
- R5 mounted (default setting): enables the overcurrent boost.
- R5 not mounted: disables the overcurrent boost.

Resistors R6 and R7 are used to supply the control board via the MC connector.

- R6 not mounted (default setting): The V_{dd_micro} is not provided to the control board via pin 25 of MC connector J1.
- R6 mounted: The V_{dd_micro} is provided to the control board via pin 25 of the MC connector J1. Pin 25 of the MC connector can be used to provide the +5 V to the control board.
- R7 mounted (default setting): The Vdd_micro is provided to the control board via pin 28 of the MC connector J1. Pin 25 of the MC connector can be used to provide the +3.3 V to the control board.
- R7 not mounted: The Vdd_micro is not provided to the control board via pin 28 of the MC connector J1.

8.5 Motor control connector J1 pinout

Figure 10. Motor control connector J3 (top view)

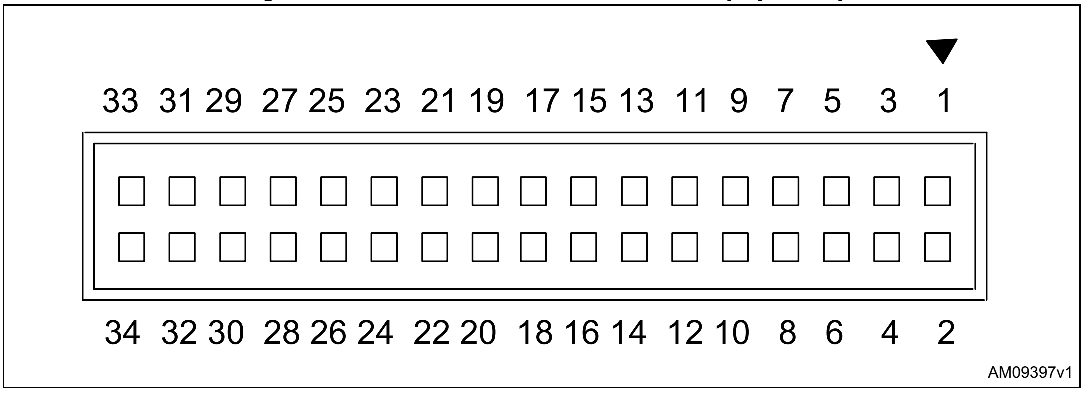


Table 3. Motor control connector J1 pin assignment

J3 Pin	Function	J3 Pin	Function
1	Emergency stop	2	GND
3	PWM-UH	4	GND
5	PWM-UL	6	GND
7	PWM-VH	8	GND
9	PWM-VL	10	GND
11	PWM-WH	12	GND
13	PWM-WL	14	Bus voltage
15	BEMF sampling method selection (see *Section 8.4.6*)	16	GND
17	Phase B current	18	GND
19	Not connected	20	GND
21	Not connected	22	GND

Table 3. Motor control connector J1 pin assignment (continued)

J3 Pin	Function	J3 Pin	Function
23	OCP Boost (see *Section 8.4.6*)	24	GND
25	Not connected (see *Section 8.4.6*)	26	Heatsink temperature
27	6Step - current regulation feedback (see *Section 8.4.6*)	28	VDD ì
29	6Step - current regulation reference (see *Section 8.4.6*)	30	GND
31	H1/Enc A/BEMF A	32	GND
33	H2/Enc B/BEMF B	34	H3/Enc Z/BEMF C

9 Using the STEVAL-IHM035V2 with the STM32 FOC firmware library

The “STM32 FOC firmware library v3.0 or later” provided together with the STM3210B-MCKIT performs the field-oriented control (FOC) of a permanent magnet synchronous motor (PMSM) in both sensor and sensorless configurations.

It is possible to configure the firmware to use the STEVAL-IHM035V2 as power stage (power supply plus power block of *Figure 2*) of the motor control system.

This section describes the customization to be applied to the “STM32 FOC firmware library” in order for the firmware to be compatible with the STEVAL-IHM035V2.

9.1 Environmental considerations

Warning: The STEVAL-IHM035V2 evaluation board must only be used in a power laboratory. The voltage used in the drive system presents a shock hazard.

The kit is not electrically isolated from the DC input. This topology is very common in motor drives. The microprocessor is grounded by the integrated ground of the DC bus. The microprocessor and associated circuitry are hot and MUST be isolated from user controls and communication interfaces.

Warning: Any measurement equipment must be isolated from the main power supply before powering up the motor drive. To use an oscilloscope with the kit, it is safer to isolate the DC supply AND the oscilloscope. This prevents a shock from occurring as a result of touching any single point in the circuit, but does NOT prevent shock when touching two or more points in the circuit.

An isolated AC power supply can be constructed using an isolation transformer and a variable transformer.

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

9.2 Hardware requirements

The following items are required to run the STEVAL-IHM035V2 together with the “STM32 FOC firmware library”.

- The STEVAL-IHM035V2 board and MB525 board (STM32 evaluation board with MC connector) or any other evaluation board with an MC connector, such as the STEVAL-IHM022V1, STEVAL-IHM033V1, MB871, or MB672
- A high voltage insulated AC power supply up to 230 Vac
- A programmer/debugger dongle for the control board (not included in the package). Refer to the control board user manual to find a supported dongle. Use of an insulated dongle is always recommended.
- A 3-phase brushless motor with permanent magnet rotor (not included in the package)
- An insulated oscilloscope (as necessary)
- An insulated multimeter (as necessary).

9.3 Software requirements

To customize, compile and download the “STM32 FOC firmware library”, a toolchain must be installed. Please check the availability on STMicroelectronics website or contact your nearest STMicroelectronics office to obtain documentation relevant to the “STM32F103xx or STM32F100xx PMSM single/dual FOC SDK” and refer to the control board user manual for further details.

9.4 STM32 FOC firmware library customization

To customize the STM32 FOC firmware library the “ST motor control workbench” can be used.

The required parameters for the power stage related to the STEVAL-IHM035V2 are reported in *Table 4*.

Table 4. STEVAL-IHM035V2 motor control workbench parameters

Parameter	STEVAL-IHM035V2 default value	Unit	Parameter
ICL shut-out	Disabled		ICL shut-out
Dissipative brake	Disabled		Dissipative brake
Bus voltage sensing	Enabled		Bus voltage sensing
Bus voltage divider	125		Bus voltage divider
Min. rated voltage	40	V	Min. rated voltage
Max. rated voltage	380	V	Max. rated voltage
Nominal voltage	325	V	Nominal voltage
Temperature sensing	Enabled		Temperature sensing
V0(1)	1055	mV	V0
T0	25	°C	T0

Table 4. STEVAL-IHM035V2 motor control workbench parameters (continued)

Parameter	STEVAL-IHM035V2 default value	Unit	Parameter
$\Delta V/\Delta T$[1]	22	mV/°C	$\Delta V/\Delta T$
Max. working temperature on sensor	70	°C	Max. working temperature on sensor
Overcurrent protection	Enabled		Overcurrent protection
Comparator threshold	0.50	V	Comparator threshold
Overcurrent network gain	0.47	V/A	Overcurrent network gain
Expected overcurrent threshold	1.0638	A	Expected overcurrent threshold
Overcurrent feedback signal polarity	Active low		Overcurrent feedback signal polarity
Overcurrent protection disabling network polarity	Active low		Overcurrent protection disabling network polarity
Current reading topology	One shunt resistor		Current reading topology
Shunt resistor(s) value	0.47	Ω	Shunt resistor(s) value
Amplifying network gain[2]	2.91		Amplifying network gain
T-rise	1000	ns	T-rise
Power switches min. deadtime	1500	ns	Power switches min. deadtime
Power switches max. switching frequency	50	kHz	Power switches max. switching frequency
U,V,W driver high-side driving signal	Active high		U,V,W driver high-side driving signal
U,V,W driver low-side driving signal complemented from high-side	Disabled		U,V,W driver low-side driving signal complemented from high-side
U,V,W driver low-side driving signal polarity	Active low		U,V,W driver low-side driving signal polarity
Overcurrent protection disabling network polarity	Active low		Overcurrent protection disabling network polarity
Current reading topology	One shunt resistor		Current reading topology

1. These values are computed for V_{dd_micro} = 3.3 V, if the V_{dd_micro} = 5 V, the values are V0 = 1600 m V, $\Delta V/\Delta T$= 34 mV/°C.
2. Amplifying network gain = 12 for trapezoidal drive. See *Section 8.4.1*.

10 Using the STEVAL-IHM035V2 with the STM8 3-phase BLDC firmware library

The “STM8 3-phase BLDC firmware library v1.0” provided together with the STM8-MCKIT performs the brushless direct current motor (BLDC) scalar control of a permanent magnet synchronous motor (PMSM) in both sensor and sensorless configurations.

It is possible to configure the firmware to use the STEVAL-IHM035V2 as power stage (power supply plus power block of *Figure 2*) of the motor control system.

This section describes the customization to be applied to the “STM8 3-phase BLDC firmware library v1.0” in order for the firmware to be compatible with the STEVAL-IHM035V2STEVAL-IHM035V2.

10.1 Environmental considerations

Warning: The STEVAL-IHM035V2 evaluation board must only be used in a power laboratory. The voltage used in the drive system presents a shock hazard.

The kit is not electrically isolated from the DC input. This topology is very common in motor drives. The microprocessor is grounded by the integrated ground of the DC bus. The microprocessor and associated circuitry are hot and MUST be isolated from user controls and communication interfaces.

Warning: Any measurement equipment must be isolated from the main power supply before powering up the motor drive. To use an oscilloscope with the kit, it is safer to isolate the DC supply AND the oscilloscope. This prevents a shock from occurring as a result of touching any single point in the circuit, but does NOT prevent shock when touching two or more points in the circuit.

An isolated AC power supply can be constructed using an isolation transformer and a variable transformer.

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

10.2 Hardware requirements

The following items are required to run the STEVAL-IHM035V2 together with the “STM8 3-phase BLDC firmware library v1.0”.

- The STEVAL-IHM035V2 board and MB631 board (STM8 evaluation board with MC connector)
- A high voltage insulated AC power supply up to 230 Vac
- A programmer/debugger dongle for control board (not included in the package). Refer to the control board user manual to find a supported dongle. Use of an insulated dongle is always recommended.
- A 3-phase brushless motor with permanent magnet rotor (not included in the package)
- An insulated oscilloscope (as necessary)
- An insulated multimeter (as necessary).

Note: To make the MB631 board compatible with the BLDC drive, it is necessary to check if the required modifications explained in UM0709 (appendix A.1) have been properly carried out.

The MB843 (BLDC daughterboard) available in the STM8 MC-KIT can be used for BLDC sensing and for the current regulation/limitation, otherwise wire connections on the extension connector present in the MB631 are required to feed the proper signal coming from the MC connector to the right microcontroller inputs/outputs, see *Table 5* for sensorless drive and *Table 6* for sensored drive.

Table 5. MB631 wire connections required for BLDC sensorless drive

Function	Jumper settings and connections
BEMF A	J3 (STEVAL-IHM035V2) open Connect pin 3 of J3 (STEVAL-IHM035V2) with PB2 (MB631)
BEMF B	J4 (STEVAL-IHM035V2) between 2-3 Connect PD4 (MB631) with PF4 (MB631)
BEMF C	J5 (STEVAL-IHM035V2) between 2-3 Connect PA3 (MB631) with PB0 (MB631)
6Step - current regulation feedback	Connect PD2 (MB631) with PH4 (MB631)
6Step - current regulation reference	JP13 (MB631) between 1-2 Connect PD0 (MB631) with PD3 (MB631)
BEMF sampling method selection	Connect pin 15 of J1 (STEVAL-IHM035V2) with PI4, PI5 or PI6 in the MB631
OCP boost	Connect pin 23 of CN10 connector (MB631) with any available GPIO pin of the microcontroller.

Figure 11. MB631 wire connections required for BLDC sensorless drive

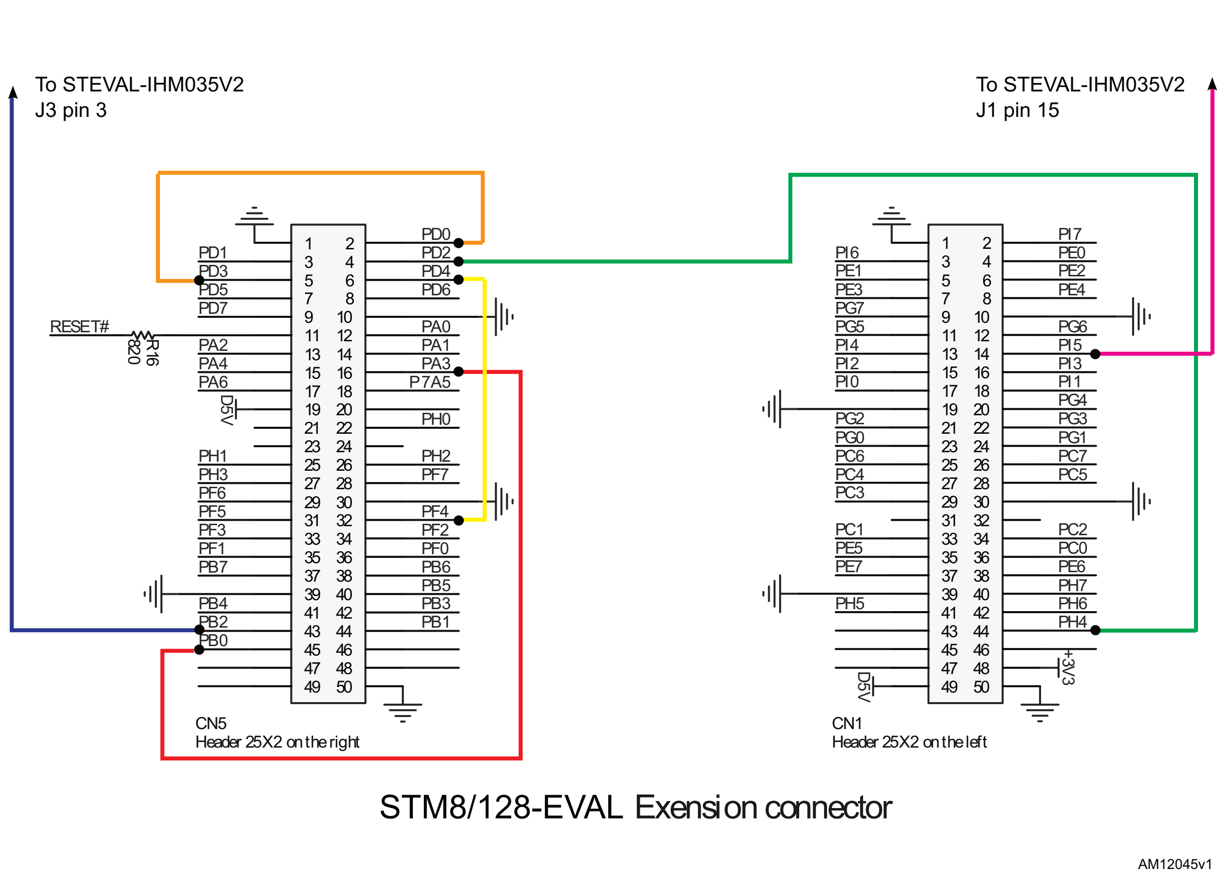
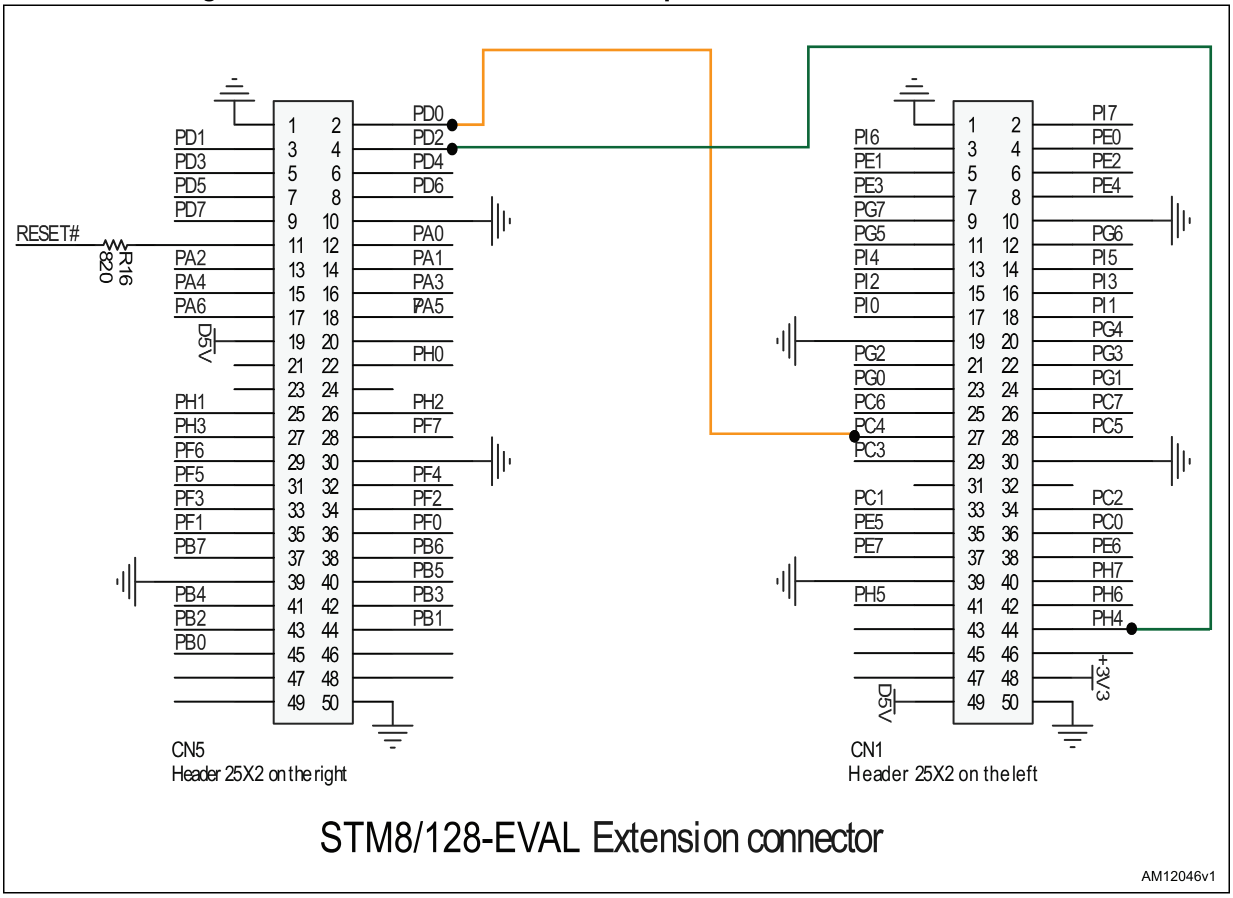


Table 6. MB631 wire connections required for BLDC sensored drive

Function	Jumper settings and connections
BEMF A	J3 (STEVAL-IHM035V2) between 1-2
BEMF B	J4 (STEVAL-IHM035V2) between 1-2
BEMF C	J5 (STEVAL-IHM035V2) between 1-2
6Step - current regulation feedback	Connect PD2 (MB631) with PH4 (MB631)
6Step - current regulation reference	JP13 (MB631) between 1-2 Connect PD0 (MB631) with PC4 (MB631)
BEMF sampling method selection	
OCP boost	Connect pin 23 of CN10 connector (MB631) with any available GPIO pin of the microcontroller.

Figure 12. MB631 wire connections required for BLDC sensored drive



10.3 Software requirements

To customize, compile and download the “STM8 3-phase BLDC firmware library v1.0”, a toolchain must be installed, see the UM0708 and UM0709 user manuals.

10.4 STM8 3-phase BLDC firmware library v1.0 customization

To customize the STM8 3-phase BLDC firmware library v1.0, the “STM8S MC FW library builder” can be used.

The required parameters for the power stage related to the STEVAL-IHM035V2 are reported in *Table 4*.

10.5 Bill of materials

Table 7. BOM (part 1)

Item	Qty	Reference	Part / value	Tolerance%	Voltage current	Watt
1	3	C1,C2,C3	10pF	5%	10V	
2	3	C5,C9,C12	N.M.			
3	1	C6	100nF	5%	10V	
4	1	C10	100nF	5%	10V	
5	1	C14	470nF	5%	25V	
6	1	C17	2.2nF	5%	10V	
7	1	C18	22nF	5%	10V	
8	1	C19	33pF	5%	10V	
9	1	C20	10nF	5%	10V	
10	1	C22	4.7nF	5%	10V	
11	1	C7	4.7uF	20%	25V	
12	3	C13,C15,C16	2.2uF	5%	25V	
13	1	C21	100uF	20%	450V	
14	1	C42	10uF	20%	6.3V	
15	1	C23	100uF	20%	25V	
16	1	C41	10uF	20%	10V	
17	1	C28	22uF	20%	25V	
18	3	C4,C8,C11	N.M.			
19	1	C36	1uF	5%	25V	
20	1	C37	22nF	5%	6.3V	
21	1	C38	220nF	5%	25V	
22	4	R2,R3,R4,R6	N.M			
23	10	R1,R5,R7,R9,R10,R14,R21,R30,R37,R50	0	1%		

Table 7. BOM (part 1) (continued)

Item	Qty	Reference	Part / value	Tollerance%	Voltage Current	Watt
24	8	R8,R11,R12,R18,R25,R33,R36,R51	4.7K	1%		
25	3	R13,R20,R29	1M	1%		
26	6	R15,R16,R22,R23,R31,R32	180K	1%		
27	6	R17,R24,R34,R39,R42,R47	1K	1%		
28	3	R19,R26,R35	10K	1%		
29	1	R27	33K	1%		
30	1	R28	10M	1%		
31	2	R38,R41	910	1%		
32	1	R40	22	1%		
33	1	R43	0.47	1%		2W
34	2	R48,R49	2,7K	1%		
35	2	R52,R53	470K	1%		
36	1	R54	8.2K	1%		
37	1	R68	1.5K	1%		1/4W
38	1	R64	6.8K	1%		
39	1	R65	1.5K	1%		
40	1	R66	15K	1%		
41	1	R67	56K	1%		
42	1	R69	18	1%		
43	22	TP1,TP2,TP3,TP4,TP5,TP6,TP7,TP8,TP9,TP10,TP11,TP12,TP13,TP14,TP15,TP16,TP17,TP18,TP19,TP20,TP 21,TP22				
44	3	D1,D3,D5	LL4005		600V/1A	
45	3	D2,D4,D6	BAT54JFILM			
46	4	D7,D8,D9,D10	STTH1R04U			
47	3	D13,D11,D15	STTH1L06A		600V/1A	
48	1	D22	1N4148WT			
49	1	D16	GREEN LED			
50	1	D23	BAT60JFILM			
51	1	F1	FUSE		2A	
52	1	J1	MOTOR CONNECTOR			
53	4	J2, J3, J4, J5	STRIPLINE1 X3			

Table 7. BOM (part 1) (continued)

Item	Qty	Reference	Part / value	Tollerance%	Voltage Current	WATT
54	1	J10	STRIPLINE1 X3			
55	5		Jumper			
56	1	J6	MOTOR	250V	12A	
57	1		MOTOR			
58	1	J7	AC MAIN	250V	12A	
59	1	J8	DC BUS	250V	12A	
60	2		AC MAIN/DC BUS			
61	1	NTC1	NTC			300mW
62	1	NTC2	NTC		4.2A	
63	3	Q1,Q2,Q3	BC 817-25			
64	1	TR1	SMAJ18A-TR			
65	1	T1	Multiple Inductor 1.41mH 0.17A			
66	1	U1	TS3021ILT			
67	1	U2	STGIPN3H60			
68	1	U3	LD1117S33TR			
69		U9	LD1117S50TR			
70	1	U8	VIPER16LD			
71	1					
72	1					
73	1					
74	6	Screw M3-20 mm				
75	6	Washer M3				
76	2	Screw nut M3				
77	4	Nylon spacer M3 20mm				
78	1	Plastic bag				

Table 8. BOM (part 2)

Item	Tech info	Package	Manufacturer	Manufacturer code	RS/ distrelec/ other code
1	SMD mult.ceramic cap.	0603	Any		
2					
3	SMD mult.ceramic cap.	0603	Any		
4	SMD mult.ceramic cap.	0603	Any		
5	SMD mult.ceramic cap.	0603	Any		
6	SMD mult.ceramic cap.	0603	Any		
7	SMD mult.ceramic cap.	0603	Any		
8	SMD mult.ceramic cap.	0603	Any		
9	SMD mult.ceramic cap.	0603	Any		
10	SMD mult.ceramic cap.	0603	Any		RS:262-2179
11	Aluminium electrolytic capacitor	SMT	Panasonic	EEE1EA4R7SR	RS:536-9916
12	SMD mult.ceramic cap.	0805	Any		
13	Aluminium electrolytic capacitor				RS:706-3297
14	Ceramic SMT capacitor	1206	Murata	GRM31CR60J106KA01L	RS: 653-0541
15	Aluminium electrolytic capacitor	SMT	Panasonic	ECEV1EA101P	RS:628-4024
16	Ceramic SMT capacitor	1206	Murata	GRM31CR61A106KA01L	RS: 723-6524
17	Aluminium electrolytic capacitor	SMT	Panasonic	EEE1EA220SP	RS:536-9893
18		0805	Any		
19	SMD MULT.CERAMIC CAP.	0805	Any		
20	SMD mult.ceramic cap.	0603	Any		
21	SMD mult.ceramic cap.	0805	Any		
22		0603	Any		
23		0603	Any		
24		0603	Any		
25		0603	Any		
26		1206	Any		
27		0603	Any		
28		0603	Any		
29		0603	Any		
30		0603	Any		

Table 8. BOM (part 2) (continued)

Item	Tech info	Package	Manufacturer	Manufacturer code	RS/ distrelec/ other code
31		0603	Any		
32		0603	Any		
33		2512	IRC	LR2512-LF-R470-F	MOUSER:66-LR2512-LF-R470-F
34		0603	Any		
35		1206	Any		
36		0603	Any		
37		1206	Any		
38		0603	Any		
39		0603	Any		
40		0603	Any		
41		0603	Any		
42		0603	Any		
43	Loop terminal assembly, black 1.02mm dia		Vero technologies	20-2137	RS:101-2391
44	Rectifier diode	SMD DO213AB	Taiwan semiconductor	LL 4005G	Distrelec code: 604754
45	Small signal Schottky diodes	SOD-323	ST	BAT54JFILM	
46	Fast recovery rectifier diodes	SMD SMB	ST	STTH1R04U	
47	Turbo 2 ultrafast high voltage rectifier	SMA	ST	STTH1L06A	
48	High conductance fast switching diode	SOD 523F	Fairchild	1N4148WT	
49	Chipled SMT	0805	AVAG	HSMG-C170	RS:435-6767
50	Small signal Schottky diodes	SOD-323	ST	BAT60JFILM	
51	Radial lead microfuse		HOLLY	5RF020HK	RS:611-0664
52	Multiples connector		Tyco electronics	3-1761603-1	RS:461-792
53	Strip line-male 90°		Kontek	4720302140400	RS:423-2857
54	Strip line-male		Molex	90120-0763	RS:360-6320
55	Jumper female		RS		RS:251-8682
56	3 Ways connector male 90° 5.08mm		Phoenix	MSTBA 2.5/ 3-G-5.08	RS:189-6111

Table 8. BOM (part 2) (continued)

Item	Tech info	Package	Manufacturer	Manufacturer code	RS/ distrelec/ other code
57	3 Ways connector female 90° 5.08mm		Phoenix	MSTB 2.5/ 3-ST-5.08	RS:1896026
58	2 Ways connector male 90° 5.08mm		Phoenix	MSTBA 2.5/ 2-G-5.08	RS:189-6105
59	2 Ways connector male 90° 5.08mm		Phoenix	MSTBA 2.5/ 2-G-5.08	RS:189-6105
60	2 Ways connector female 90° 5.08mm		Phoenix	MSTBA 2.5/ 2-G-5.08	189-6105
61	NTC thermistor	1206	Epcos	B57621C103J62	RS:191-2342
62	NTC thermistor		Epcos	B57235S509M	RS:467-614
63	NPN Transistor	SMD SOT23	Any		RS code: 436-7903
64	Transil diode	SMA	ST	SMAJ18A-TR	
65	Multiple inductor 1.41mH 0.17A		Magnetica	2092.0003	
66	Rail-to-rail 1.8V high-speed comparator	SOT23-5	ST	TS3021ILT	
67	Small low-loss intelligent molded module	NDIP-26L	ST	STGIPN3H60	
68	Low drop fixed and adjustable positive voltage regulators	SMD SOT-223	S	LD1117S33TR	
69	Low drop fixed and adjustable positive voltage regulators	SMD SOT-223	ST	LD1117S50TR	
70	Low power OFF-line SMPS primary switcher	SO16N	ST	VIPER16LD	
71	3 Ways connector male 5.08mm		Phoenix	MSTB 2.5/ 3-ST-5.08	RS: 189-6026
72	2 Ways connector male 5.08mm		Phoenix	MSTB 2.5/2-ST-5.08	RS: 189-6010
73	2 Ways connector male 5.08mm		Phoenix	MSTB 2.5/2-ST-5.08	RS: 189-6010
74					RS:528-772
75					RS:560-338
76					RS:189-563
77					RS:325-700
78					RS:287-7852

11 References

This user manual provides information on the hardware features and use of the STEVAL-IHM035V2 evaluation board. For additional information on supporting software and tools, refer to the following:

1. STGIPN3H60 datasheet
2. VIPer16 datasheet

http://www.st.com/mcu/ website, which is dedicated to the complete STMicroelectronics microcontroller portfolio.

12 Revision history

Table 9. Document revision history

Date	Revision	Changes
27-Jul-2012	1	Initial release.
11-Dec-2014	2	Updated: *Figure 6*, *Table 7* and *Table 8*.