

## Low voltage 3-phase power stage for electric traction with MC connector

### Introduction

The STEVAL-IEM003V1 demonstration board is designed to drive a low voltage/high current 3-phase brushless synchronous or asynchronous motor up to 3 kW. This kit can be typically used for battery powered traction system applications or high power tools.

The demonstration board is made up of two stacked boards:

- Power board where the power devices are mounted on a dedicated IMS layer
- Board with gate driving, current sensing, and power supply sections

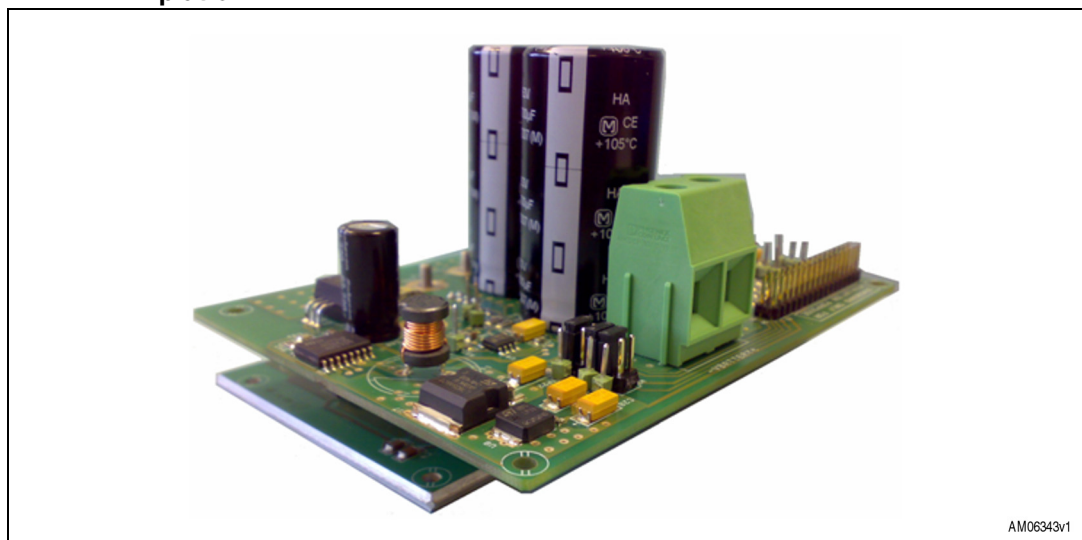
It provides a compact solution in terms of size and efficient power dissipation thanks to the power MOSFET mounted on the dedicated IMS layer.

Thanks to the onboard MC-connector, the STEVAL-IEM003V1 can be easily interfaced with any ST MCU control board equipped with a dedicated connector (MC connector) in order to control several kinds of 3-phase motors (asynchronous, PMSM brushless DC, brushless AC).

This document describes the features of the STEVAL-IEM003V1 demonstration board and gives information on using it.

The demonstration board, shown in [Figure 1](#), can be ordered using the STEVAL-IEM003V1 order code.

**Figure 1. Low voltage 3-phase power stage for electric traction demonstration platform**



## Contents

<b>1</b>	<b>STEVAL-IEM003V1 main features</b> .....	<b>4</b>
1.1	Main devices .....	4
<b>2</b>	<b>Getting started</b> .....	<b>5</b>
2.1	System architecture .....	5
2.2	Power up .....	5
<b>3</b>	<b>Hardware and connectors</b> .....	<b>6</b>
3.1	Driving board .....	6
3.1.1	Power supply .....	7
3.1.2	Motor connections .....	8
3.1.3	Heatsink temperature sensing .....	8
3.1.4	Motor control connector .....	9
3.1.5	DC BUS current and voltage monitoring section .....	10
3.1.6	Gate driving .....	10
3.2	Power board .....	10
<b>4</b>	<b>Schematic diagrams and BOM</b> .....	<b>12</b>
4.1	Gate driving, sensing, and power supply section .....	12
4.2	Power section .....	13
4.3	Bill of material .....	14
<b>5</b>	<b>Revision history</b> .....	<b>17</b>

## List of figures

Figure 1.	Low voltage 3-phase power stage for electric traction demonstration platform . . . . .	1
Figure 2.	Block diagram . . . . .	5
Figure 3.	Gate driving, sensing, and power supply board layout description (top view) . . . . .	6
Figure 4.	Gate driving, sensing, and power supply board layout description (bottom view mirrored) .	7
Figure 5.	Power supply section . . . . .	8
Figure 6.	Motor control connector J5 . . . . .	9
Figure 7.	Gate driving network . . . . .	10
Figure 8.	Power board layout . . . . .	11
Figure 9.	Gate driving, sensing, and power supply section . . . . .	12
Figure 10.	Power section . . . . .	13

# 1 STEVAL-IEM003V1 main features

- BUS voltage up to 48 V and up to 3 kW
- 3-phase full bridge inverter topology
- Efficient power dissipation with power MOSFETs mounted on a dedicated IMS layer
- Motor current feedback via ICS
- Security functions:
  - Bus overcurrent detection
  - Bus voltage monitoring
  - Power stage temperature sensing

## 1.1 Main devices

The main onboard devices are:

- Power MOSFETs in PowerSO (automotive grade):
  - STV240N75F3: MOSFET N-channel 75 V- 2.3 m $\Omega$  - 240 A, for applications up to 48 V
  - STV250N55F3: MOSFET N-channel 55 V- 1.5 m $\Omega$  - 250 A, for applications up to 24 V
  - STV270N4F3: MOSFET N-channel 40 V- 1.25 m $\Omega$  - 270 A, for applications up to 12 V.

Refer to the relevant datasheets on ST.com for more information

*Note: The board is equipped by default with STV250N55F3, other devices can be easily mounted with no additional changes to the board*

- L4976D: the L4976D is a step-down switching regulator capable of delivering up to 1 A at output voltages from 0.5 V to 50 V.  
Refer to the L4976D datasheet for more information.
- L6388E: the L6388E is a high-voltage high side and low side driver.  
Refer to the L6388 datasheet for more information.
- STS01DTP06: The STS01DTP06 is a dual NPN-PNP complementary bipolar transistor.

## 2 Getting started

This section gives information on system architecture and hardware configuration to power up the board.

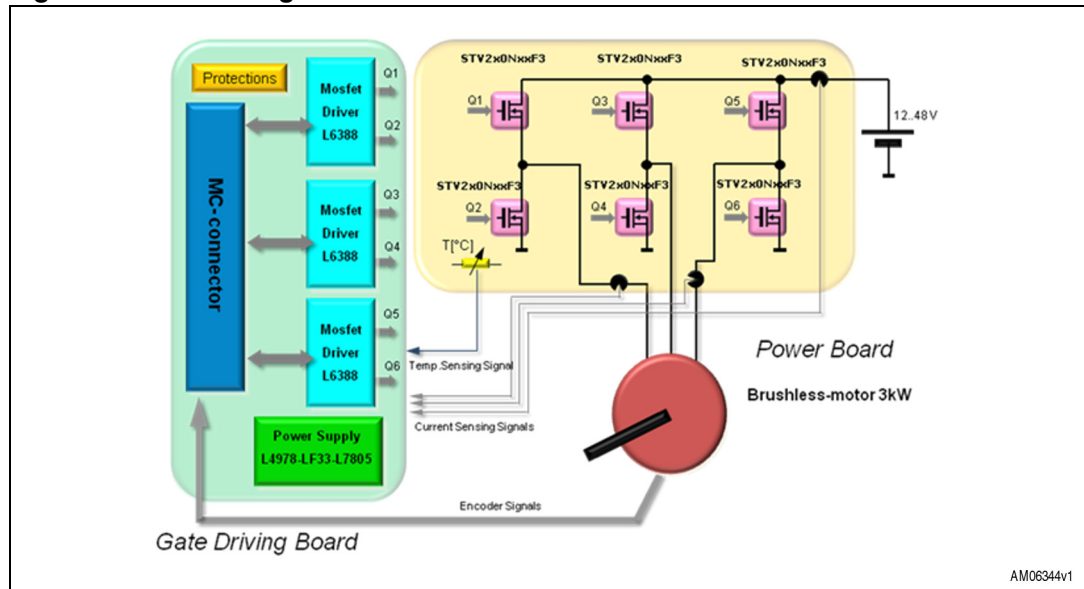
### 2.1 System architecture

The STEVAL-IEM003V1 demonstration board consists of 2 separate boards:

- Gate driving, sensing, and power supply board
- Power board

Note that, for a complete platform, a control board with an MCU and an MC-connector is requested in order to perform the motor control.

Figure 2. Block diagram



### 2.2 Power up

The system is powered by a battery voltage ranging from 12 V up to 48 V (note that the actual maximum voltage rate depends on the power MOSFETs mounted). The battery connector is described in the following section.

### 3 Hardware and connectors

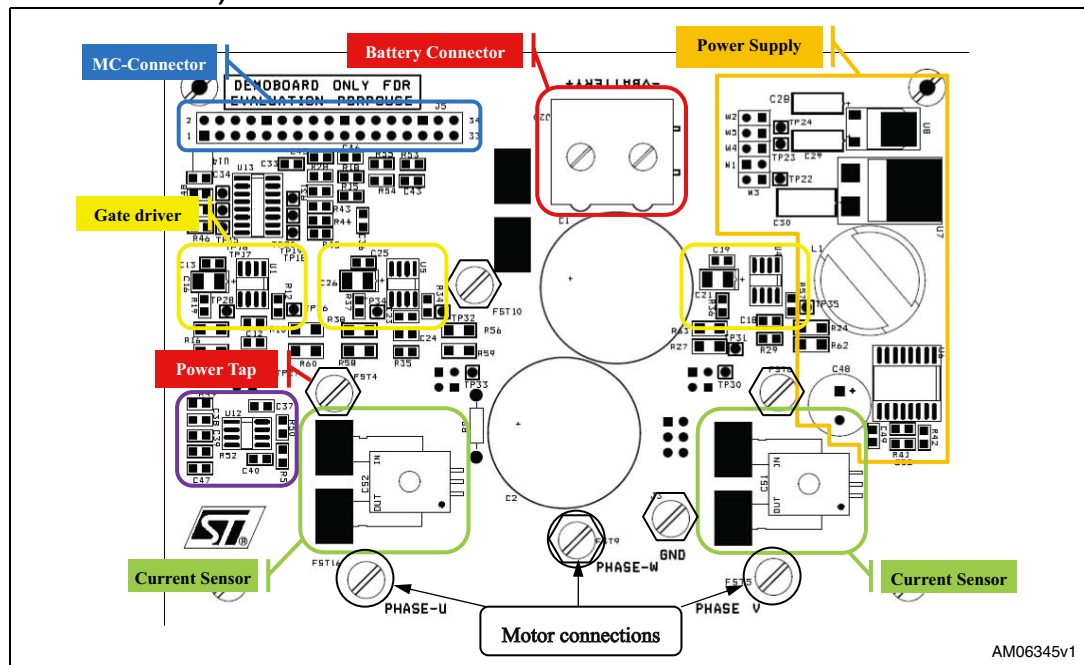
#### 3.1 Driving board

The main blocks of the driving board are:

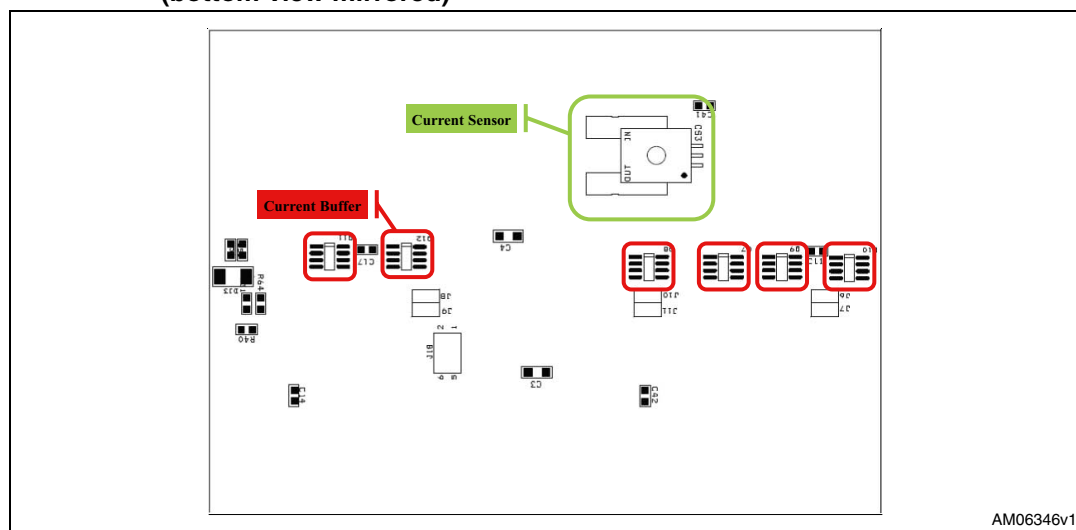
- Power supply
- Motor connections
- Battery connector
- Overcurrent and voltage monitoring sections
- Gate drivers

In [Figure 3](#) and [4](#) the top and the bottom view of the gate driving, sensing, and power supply board layout are shown.

**Figure 3. Gate driving, sensing, and power supply board layout description (top view)**



**Figure 4. Gate driving, sensing, and power supply board layout description (bottom view mirrored)**



### 3.1.1 Power supply

The whole system requires an input voltage from 17 V up to 55 V (note that the actual maximum voltage rate depends on the power MOSFETs mounted) that can be provided by a battery voltage. The battery input is labeled -VBATTERY+ (refer to [Figure 3](#)). Because different voltage levels are needed for the whole system a power supply section has been designed on the board.

The gate driver section requires a 15 V power supply, which is generated by the IC L4976D step-down switching regulator, fed by the battery voltage. The L4976D is a step-down monolithic power switching regulator capable of delivering up to 1 A at output voltages from 3.3 V to 50 V. In this application it is configured to deliver a 15 V output voltage.

In the next stage an L7805, linear voltage regulator, is necessary to obtain a 5 V input voltage and in the last stage an LF33, low drop linear voltage regulator, is necessary to obtain a 3.3 V input voltage.

On the board there is the possibility to disconnect the system powered by 15 V, 5 V, and 3.3 V respectively (see [Table 1](#) below).

**Table 1. Control board jumper configuration**

Jumper configuration	Description	
	W1	If fitted the 5 V is delivered to the MC-connector
	W2	If fitted the 3.3 V is delivered to the MC-connector
	W3	If fitted the 15 V is delivered to the related system
	W4	If fitted the 5 V is delivered to the related system
	W5	If fitted the 3.3 V is delivered to the related system

The W1 and W2 jumpers allow the connecting of 5 V and/or 3.3 V to the MC-connector.



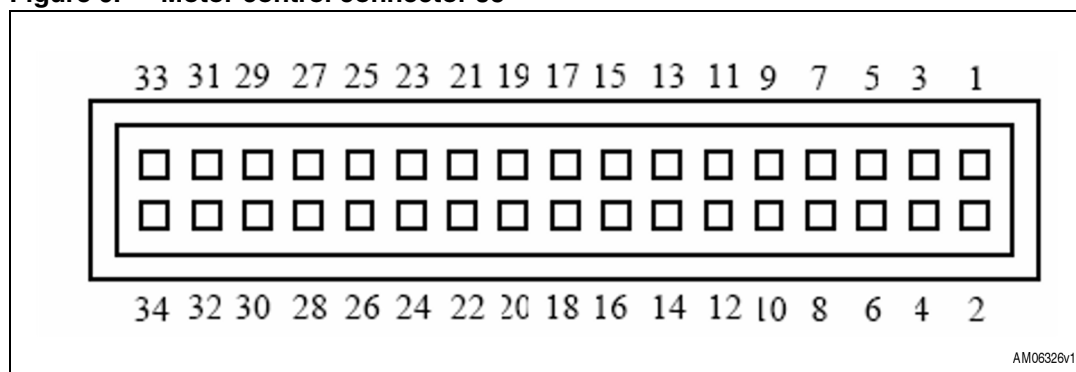


### 3.1.4 Motor control connector

The STEVAL-IEM003V1 demonstration board supports a 3PH (phase) brushless motor control via a 34-pin connector J5 (MC\_Connector) providing all required control and feedback signals to and from the motor power-driving board. Available signals include emergency stop/fault condition, two motor phase currents, bus voltage monitoring, bus current monitoring, power board heatsink temperature sense, and 6 channels of PWM control signals going to the motor driving circuit.

Two voltage levels, 5 V and 3.3 V, are available through two jumpers (W1 and W2) to supply a control board if necessary.

**Figure 6. Motor control connector J5**



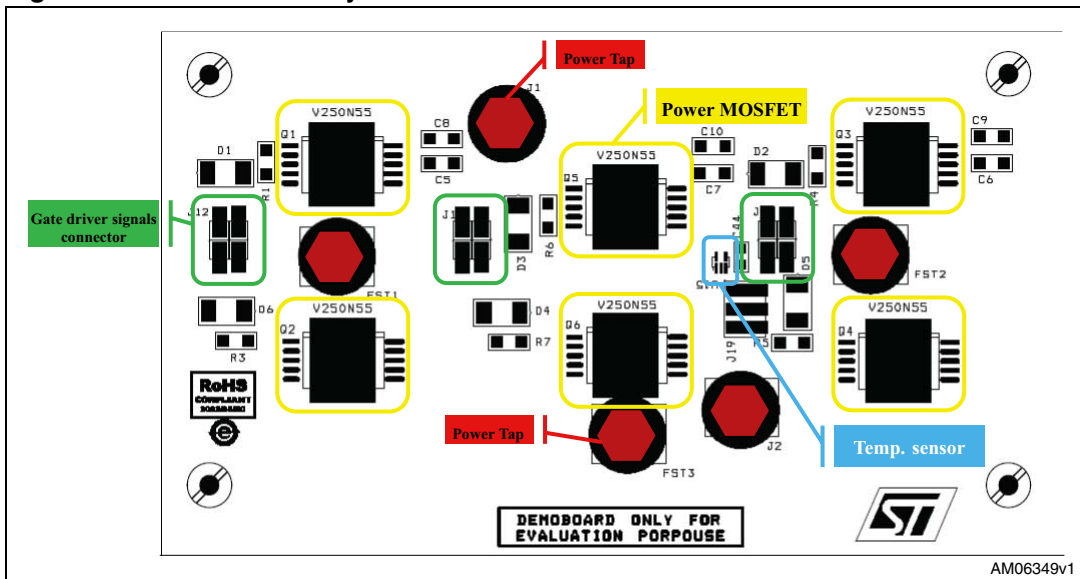
**Table 2. Motor control connector J6 (top view)**

Description	Pin number	Pin number	Description
Emergency stop/fault	1	2	GND
PWM-UH	3	4	GND
PWM-UL	5	6	GND
PWM-VH	7	8	GND
PWM-VL	9	10	GND
PWM-WH	11	12	GND
PWM-WL	13	14	Bus voltage monitor
Phase current U	15	16	GND
Phase current W	17	18	GND
N.C.	19	20	GND
N.C.	21	22	GND
N.C.	23	24	GND
+5 V power	25	26	Heatsink temperature
N.C.	27	28	+3.3 V power
N.C.	29	30	GND
N.C.	31	32	GND
N.C.	33	34	N.C.



The board layout is shown in [Figure 8](#):

**Figure 8. Power board layout**



The insulated metal substrate (IMS) minimizes the thermal impedance and conducts heat more effectively.

The power board is connected with the gate driving, sensing, and power supply board by five power taps for the high current connections (battery and motor connections) and standard connectors for gate driver and temperature sensing signals.

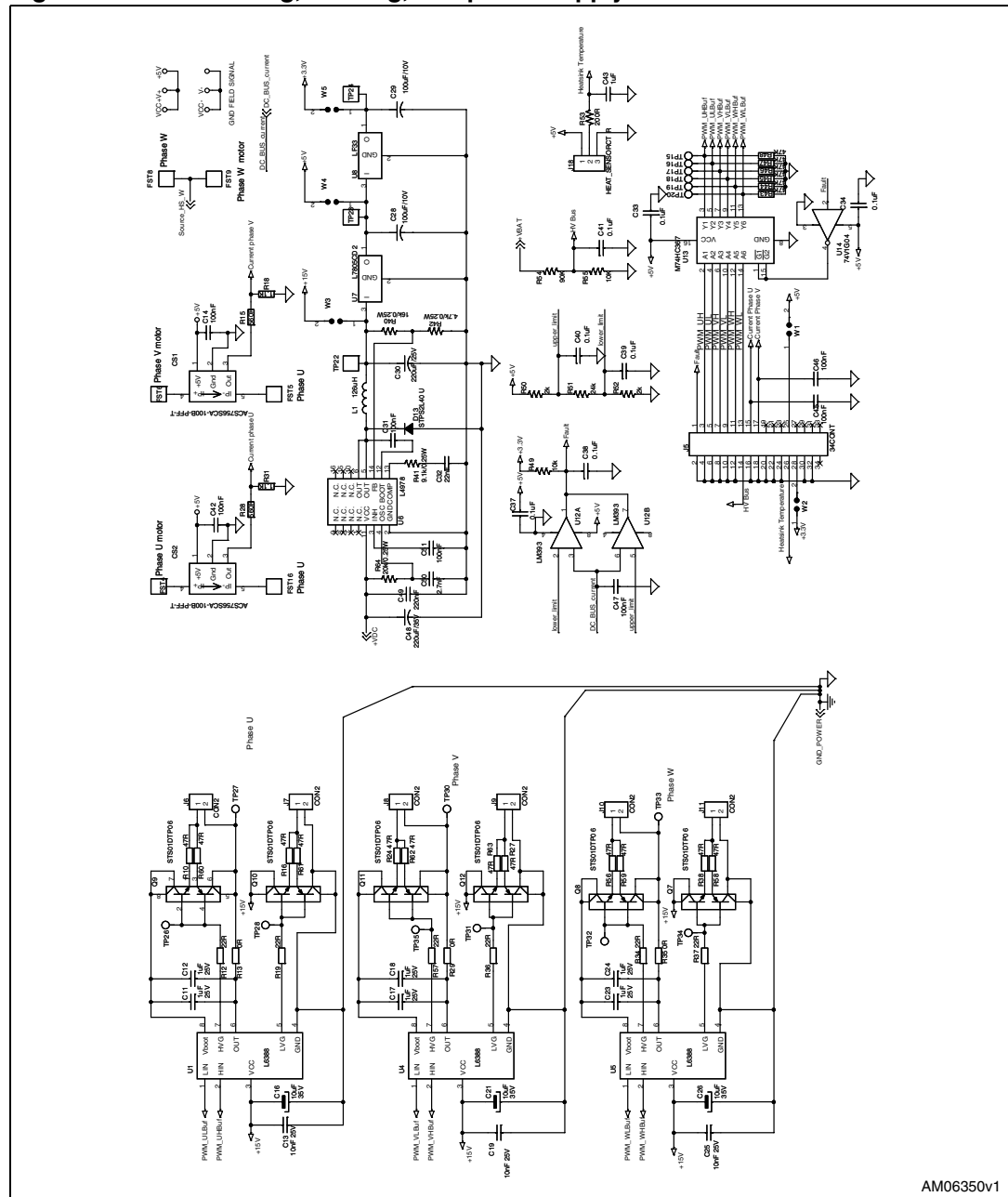
# 4 Schematic diagrams and BOM

This section gives the design schematics for the STEVAL-IEM003V1 board key features, to help implement these features in applications. Schematics are provided for:

- Driving board: gate driving, sensing, and power supply board
- Power board on IMS layer

## 4.1 Gate driving, sensing, and power supply section

Figure 9. Gate driving, sensing, and power supply section

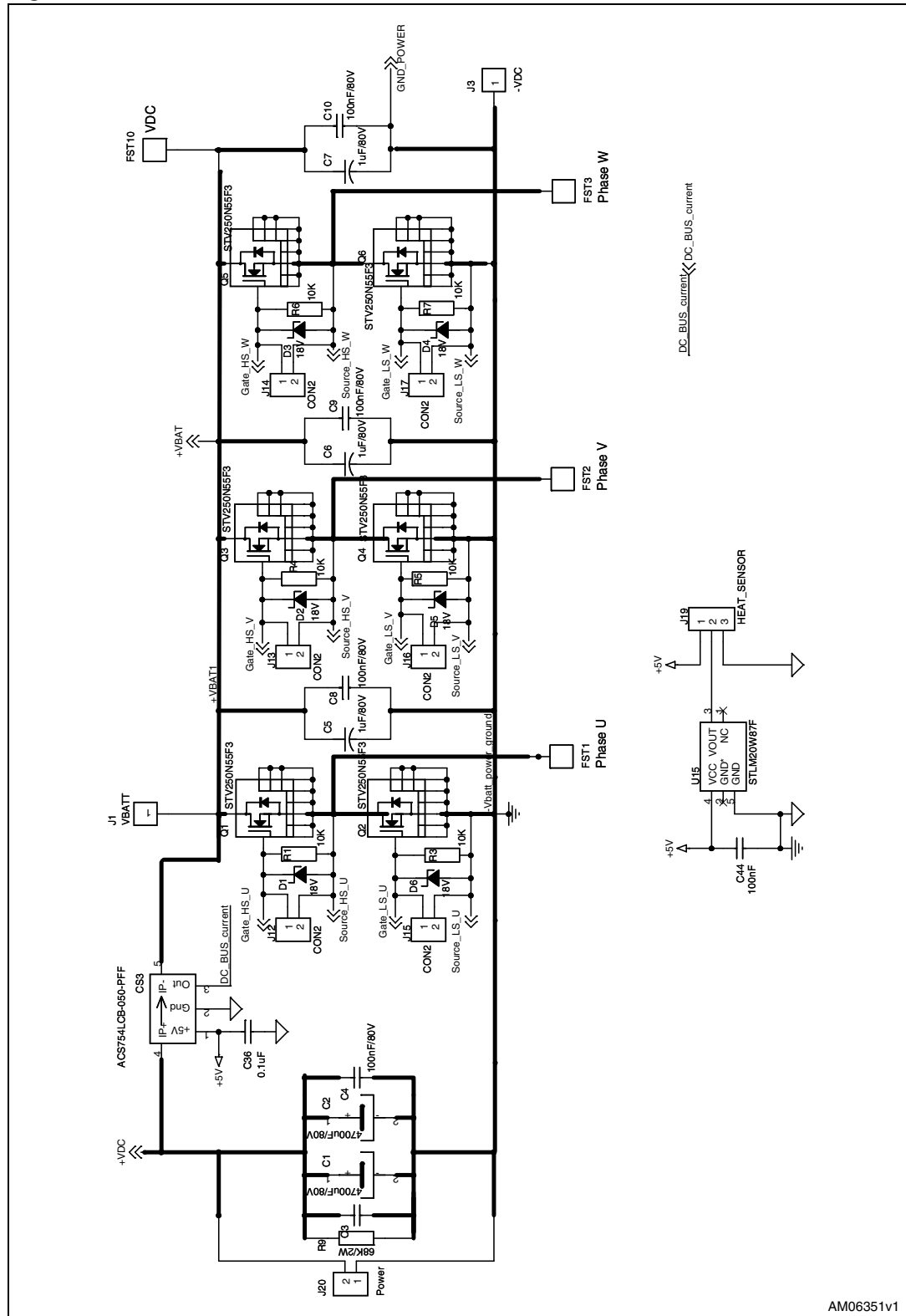


AM06350V1



## 4.2 Power section

Figure 10. Power section



## 4.3 Bill of material

Table 3. BOM

Reference	Value / generic part number	Package	Manufacturer	Manufacturer's ordering code / orderable part number	Supplier	Supplier's ordering code
CS1,CS2	ACS756SCA-100B-PFF-T		Allegro	ACS756SCA-100B-PFF-T		
CS3	ACS754LCB-050-PFF		Allegro	ACS754LCB-050-PFF		
C1,C2	4700 $\mu$ F/63 V	CEL25				127-824
C3,C4,	100 nF/63 V	SMC1206				
C8,C9,C10	100 nF/63 V	SMC1206				
C5,C6,C7	1 $\mu$ F/63 V	SMC1206				
C11,C12,C17,C18,C23,C24,C43	1 $\mu$ F	SMC0805				
C13,C19,C25	10 nF 50 V	SMC0805				
C14,C31,C33,C34,C36,C37,C38,C39,C40,C41,C42,C45,C46,C47,C51	100 nF 50 V	SMC0805				
C16,C21,C26	10 $\mu$ F 25 V	SMC1210				464-9306
C28,C29	100 $\mu$ F/10 V	Tantalio_C				464-7877
C30	220 $\mu$ F/25 V	Tantalio_Dii				547-9603
C32	22 nF 25 V	SMC0805				
C44	100 nF 50 V	SMC0805				
C48	220 $\mu$ F/63 V	Cel10				191-7943
D1,D2,D3,D4,D5,D6	SM6T18CA	sm/do213ab_21	STMicroelectronics	SM6T18CA	STMicroelectronics	
D13	STPS2L40U	sm/do213ab_21	STMicroelectronics	STPS2L40U	STMicroelectronics	

**Table 3. BOM (continued)**

Reference	Value / generic part number	Package	Manufacturer	Manufacturer's ordering code / orderable part number	Supplier	Supplier's ordering code
FST1,FST2,FST3,J1,J2,			Distrelec	340676		
FST16,FST9,FST5			Distrelec	340676		
J5	2X17	BLCCON.100/VH/T M20E/W.200/34				
J6,J7,J8,J9,J10,J11		SIP/TM/L.200/2				
J12,J14,J16		BLCCON.100/VH/T M20E/W.200/4				528-6322
J18	2X3	BLCCON.100/VH/T M20E/W.200/6				
J19	2X3	BLCCON.100/VH/T M20E/W.200/6				528-6338
J20	Connector	Mor10mm_S				314-9861
L1	100 µH	CEL10				233-5140
Q1,Q2,Q3,Q4,Q5,Q6	STV250N55F3	SOG.050/10/WG55 0/L.370	STMicroelectronics	STV250N55F3	STMicroelectronics	
Q7,Q8,Q9,Q10,Q11,Q12	STS01DTP06	SOG.050/8/WG.24 4/L.200	STMicroelectronics	STS01DTP06	STMicroelectronics	
R1,R3,R4,R5,R6,R7	10 kΩ	SMR1206				
R49,R55	10 kΩ	SMR0805				
R9	68 kΩ/1 W	TRUE Hole				
R10,R16,R24,R27,R38, R56,R58,R59,R60,R61, R62,R63	47 Ω	SMR1206				
R12,R19,R34,R36,R37, R39,R57	22 Ω	SMR0805				
R13,R29,R35	22 Ω	SMR0805				
R15,R28	560 Ω	SMR0805				

Doc ID 17061 Rev 2

15/18

UM0904

Schematic diagrams and BOM



Table 3. BOM (continued)

Reference	Value / generic part number	Package	Manufacturer	Manufacturer's ordering code / orderable part number	Supplier	Supplier's ordering code
R18,R31	1.1 k $\Omega$	SMR0805				
R40	16 k $\Omega$	SMR0805				
R41	9.1 k $\Omega$	SMR0805				
R42	4.7 k $\Omega$	SMR0805				
R43,R44,R45,R46,R47, R48	47 k $\Omega$	SMR0805				
R50,R52	2 k $\Omega$	SMR0805				
R51	24 k $\Omega$	SMR0805				
R53	200 $\Omega$	SMR0805				
R54	90 k $\Omega$	SMR0805				
R64	20 k $\Omega$	SMR0805				
TP15,TP16,TP17,TP18, TP19,TP_0,TP20,TP26, TP27,TP28,TP30,TP31, TP32,TP33,TP34,TP35, TP22,TP23,TP24,TP25						
U1,U4,U5	L6388E	SO8	STMicroelectronics	L6388E	STMicroelectronics	
U6	L4978D	SO16	STMicroelectronics	L4978D	STMicroelectronics	
U7	L7805CD2	D2PACK	STMicroelectronics	L7805CD2	STMicroelectronics	
U8	LF33CDT	DPACK	STMicroelectronics	LF33CDT	STMicroelectronics	
U12	LM393AD	SO8	STMicroelectronics	LM393AD	STMicroelectronics	
U13	M74HC367M1R	SO16	STMicroelectronics	M74HC367M1R	STMicroelectronics	
U14	74V1G04CTR	SOT323-5L	STMicroelectronics	74V1G04CTR	STMicroelectronics	
U15	STLM20W8	SOT323-5L	STMicroelectronics	STLM20W8	STMicroelectronics	
W1,W2,W3,W4,W5	JUMP1	SIP/TM/L.200/2				



## 5 Revision history

**Table 4. Document revision history**

Date	Revision	Changes
05-Jul-2010	1	Initial release.
02-Aug-2010	2	Minor text changes

**Please Read Carefully:**

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

**UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.**

**UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.**

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2010 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

[www.st.com](http://www.st.com)