UM2074
User manual

EVAL-L9907-H

Introduction

The EVAL-L9907-H is an evaluation board designed to provide the user a platform for the L9907, a FET driver for 3 phase BLDC motor. The board offers all the main input/output capabilities needed to drive a BLCD motor properly and to provide diagnostic functionalities.

Full diagnostic is available through SPI. By using SPI communication, it is possible to program L9907 while the application is running (e.i. set the gain of the current sense amplifier).

A dedicated pin array allows connecting easily a SPC5 discovery+ board and the EVAL-L9907-H. In association with the discovery board SPC560P-DISP a dedicated SW allows controlling a motor control application by using a PC via a USB port.

L9907 device is able to control the six pre-driver channels independently and all pre-drivers have dedicated connections with the output MOSFETs; this feature gives the user the possibility to implement all kinds of electric motor control strategy. All gate driver outputs are protected against short circuit and L9907 is protected against over-temperature condition.

Three terminal blocks are dedicated to connect the three wires of a BLDC Motor (3-phases), moreover, specific connectors are present to connect the feedback signals from the motor to the gate driver and to the microcontroller.

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1 Hardware description

The EVAL-L9907-H is an evaluation board designed to allow the whole hardware configuration flexibility, giving the user total access to all pins of the L9907.

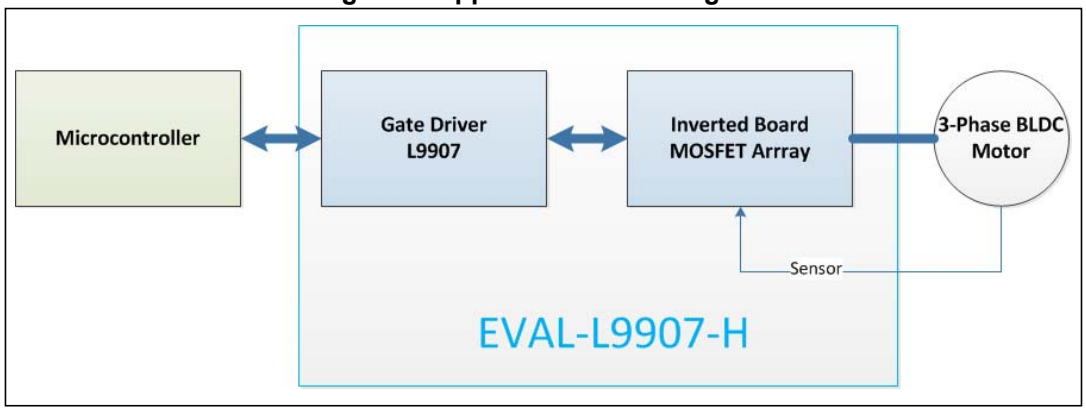
Standard connectors connect the gate driver board (L9907) and Inverter Power MOSFET output stage; this solution allows simplifying the evaluation procedure and it increases the flexibility of the HW environment.

The main features are:

- Total accessibility to all device pins (both L9907 and the Inverter MOSFET board).
- Two separated boards: gate driver with L9907 and Inverter Power MOSFET boards with the MOSFET array. This HW architecture allows the user to evaluate the application with different HW configurations.
- Output power board current capability up to 120 A.
- Full HW compatibility with the SPC56 discovery boards through the standard SPC56 Discovery+ connector, 0.1” - 4x36 pin.
- Possibility to connect generic microcontroller boards[(a)] by using a customized adapter.

1.1 Application block diagram

Figure 1. Application block diagram



a. A dedicated connector allows plugging the EVAL-L9907-H in a SCP5 Discovery+ board easily. Further microcontroller boards can be connected to drive the evaluation boards by using an adaptor.

2 EVAL-L9907-H: Board description

2.1 EVAL-L9907-H: gate driver board

Figure 2. Gate driver board - top view

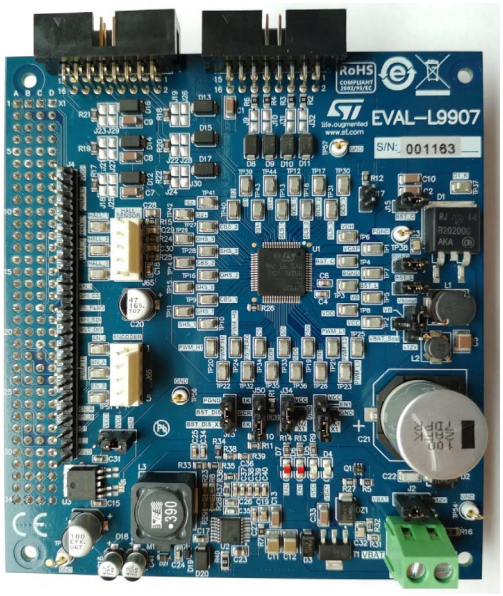


Figure 3. Gate driver board – bottom view

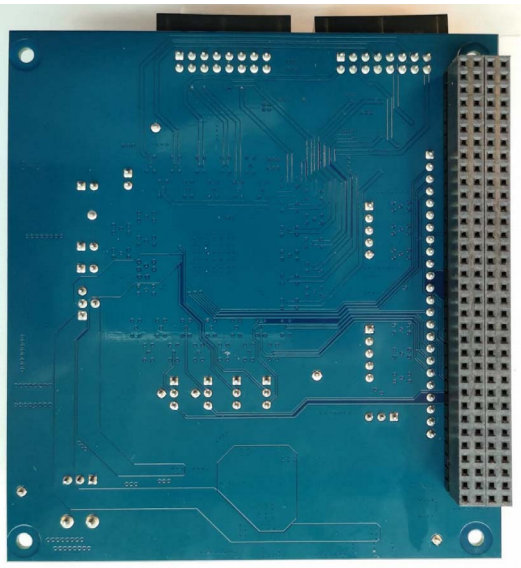


Figure 4. Gate driver board (L9907) - components and connectors - top view

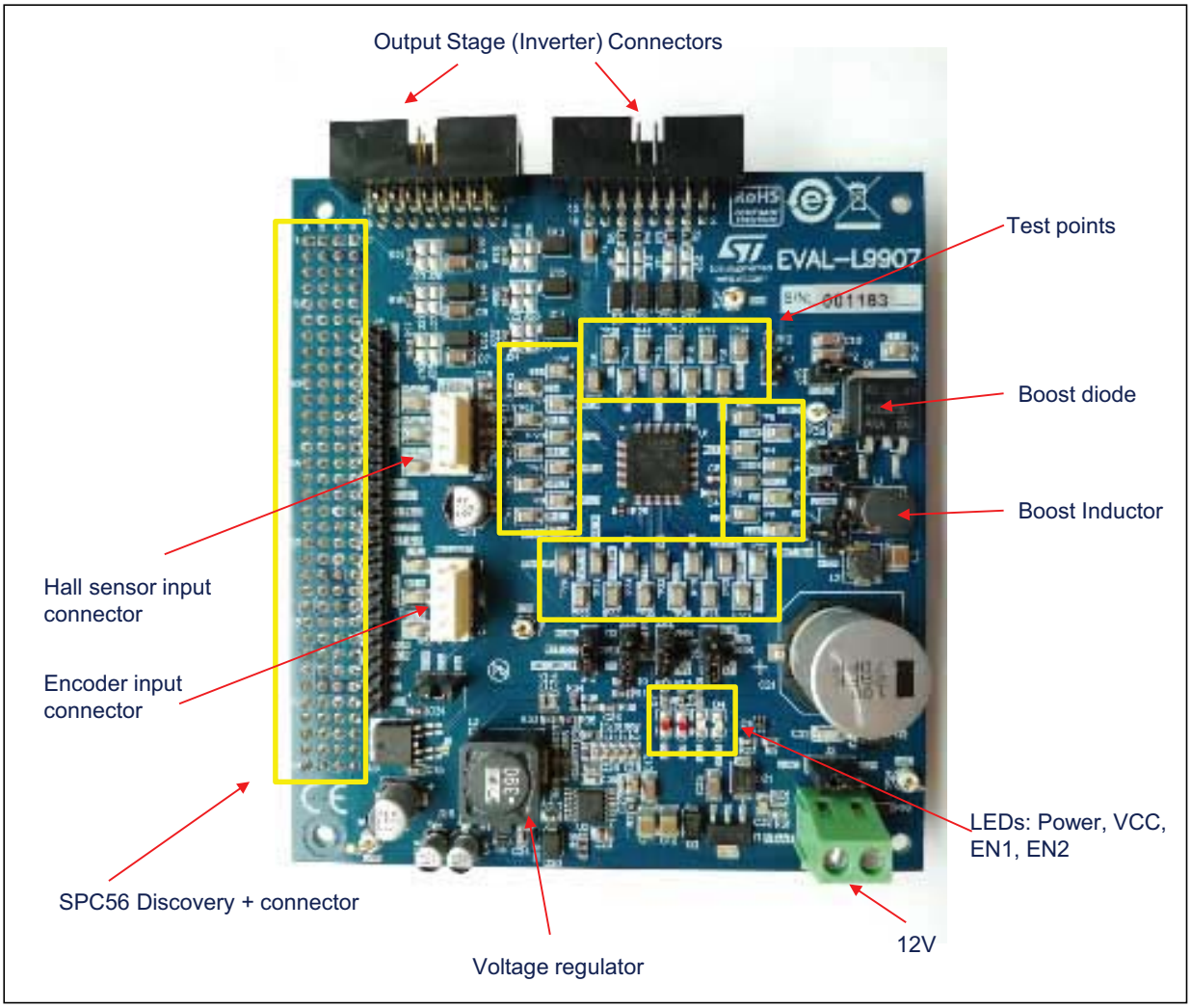
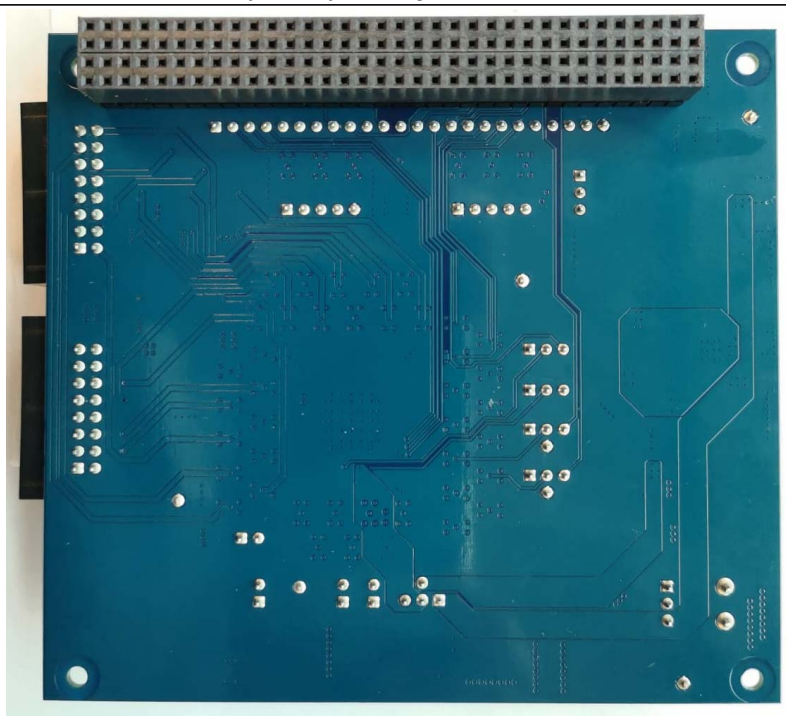


Figure 5. Gate driver board (L9907) - components and connectors - bottom view



2.2 EVAL-L9907-H: Output power board (Inverter)

Figure 6. Output Power Board – top view

Figure 7. Output Power Board – bottom view

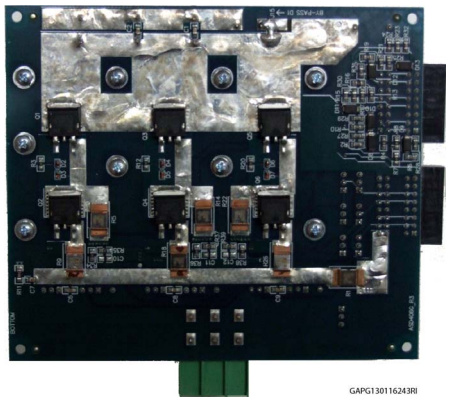


Figure 8. Output Power Board - Components and connectors (Top view)

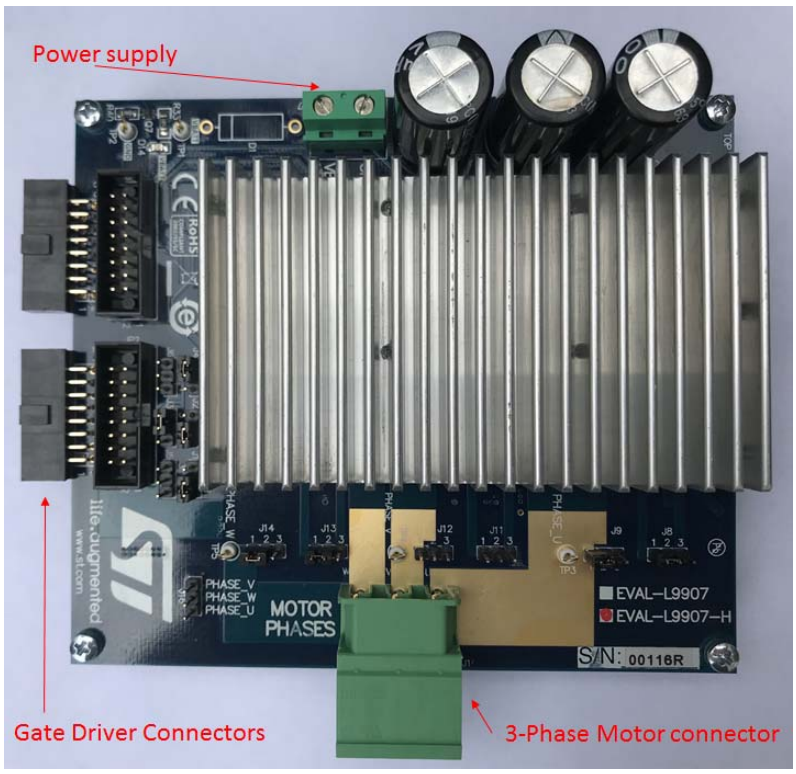
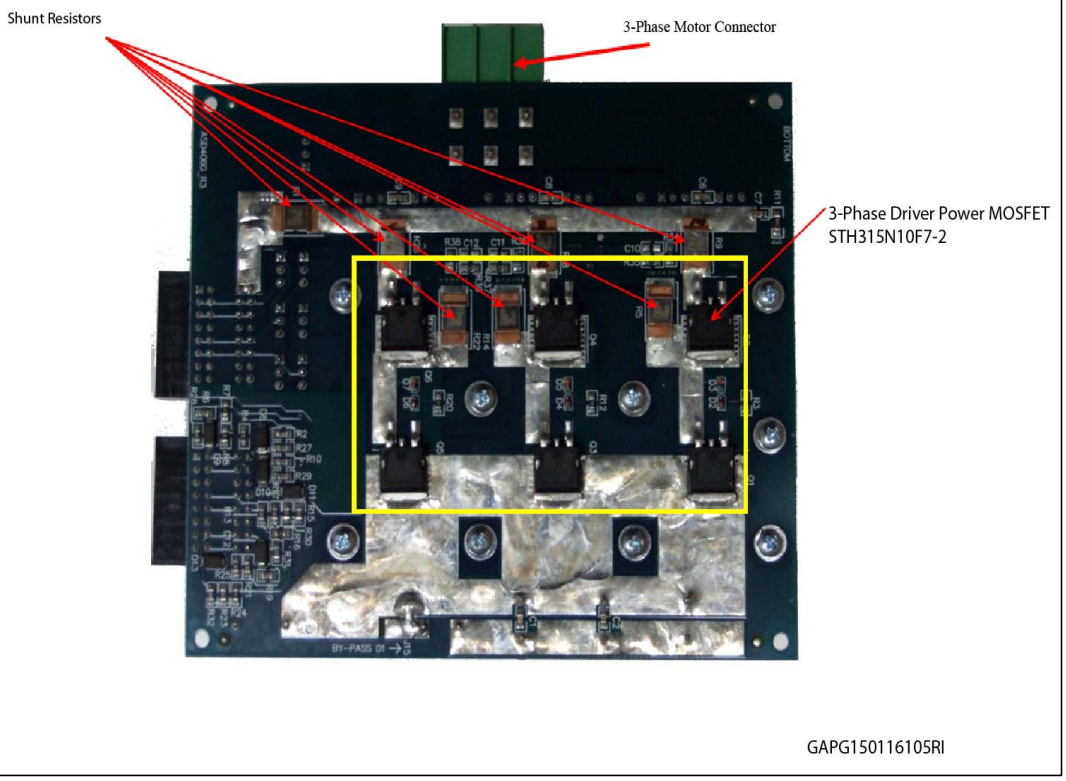


Figure 9. Output Power Board - Components and connectors (Top view)



2.3 L9907 gate driver board

2.3.1 L9907 gate driver board - Jumper description

Table 1. Jumpers descriptions

Name	Description	Type
J1	Vcc source jumper: – 1-2 = from microcontroller board – 2-3 = from on board regulator	3 way jumper
J2	VBAT source for boost – 1-2 from connector J5 – 2-3 from DC/DC regulator 12 V	2 way jumper
J3	VB source: 1-2 from DC/DC regulator 12 V 2-3 same of VBOOST 2-4 VBAT scaled by 0.6	3 way jumper
J5	Vbat	Screw
J13	BST_DIS jumper – 1-2= pin 58 grounded – 3-2= pin 58 connected to the micro, A30 on X1	Configurable two positions jumper
J14	EN1 Signal source jumper – 2-1= Vcc – 2-3= micro – 3-4= GND	Configurable three positions jumper
J15	BST_C jumper – ON= pin connected – OFF= pin disconnected	ON/OFF jumper
J16	BST_L jumper – ON= pin connected – OFF= pin disconnected	ON/OFF jumper
J17	Ground line – ON= C10 & C2 connected to GND through R12	ON/OFF jumper
J20	BGND jumper – ON= pin connected – OFF= pin disconnected	ON/OFF jumper
J34	EN2 Signal source jumper – 2-1= Vcc – 2-3= micro – 3-4= GND	Configurable two positions jumper
J50	GCR Signal source jumper – 2-1= R1=1K – 3-2= R10=6K	Configurable two positions jumper
J65	HALL SENSOR connector	Multipin with polarization

Table 1. Jumpers descriptions (continued)

Name	Description	Type
J66	ENCODER connector	Multipin with polarization
Jxx	xx= 9,10,18,19,21,22,23,24,25,26,27,28,29,30,31,32	Solder jumpers

2.3.2 L9907 gate driver board - Connectors

Table 2. L9907 Gate driver board - APG Connector descriptions

JP1/JP2	INVERTER connector	Multipin with polarization
J5	Ignition and Vcc	Screw
X1	Microcontroller connector	Multipin

Figure 10. L9907 Gate driver board - SPC56 Discovery + Connector

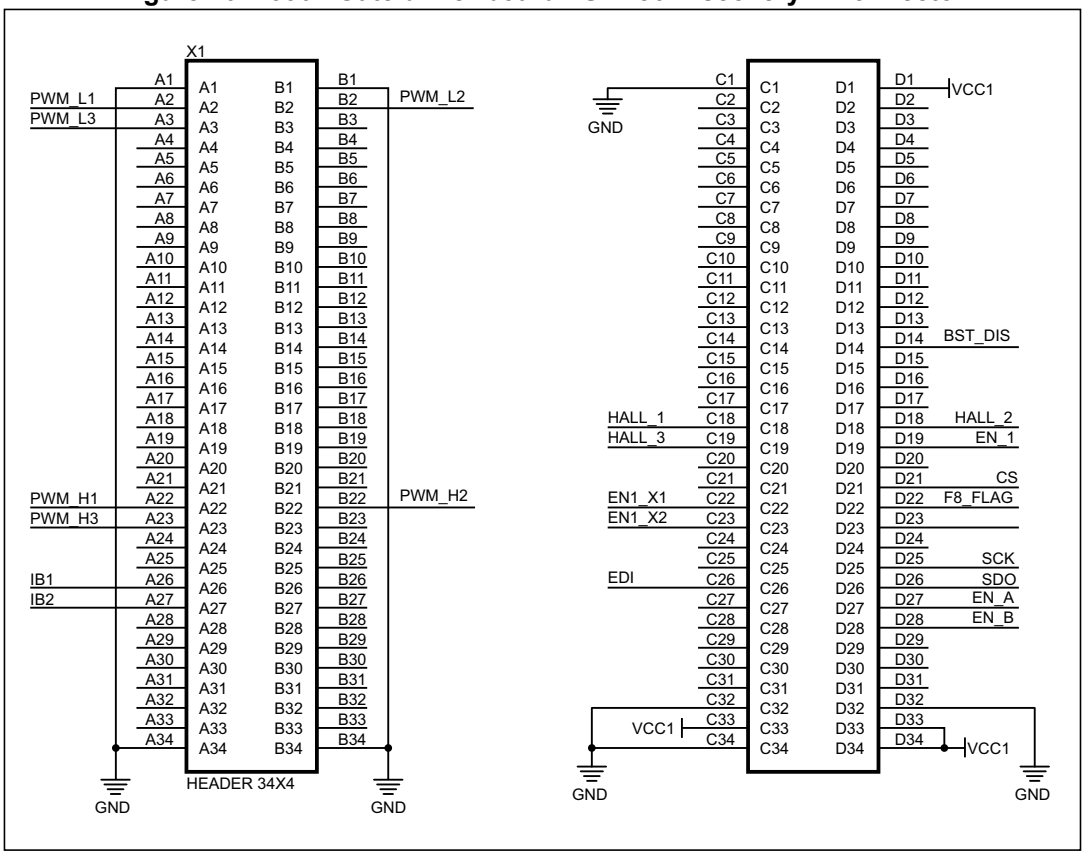


Figure 11. Gate driver board connector: control signals

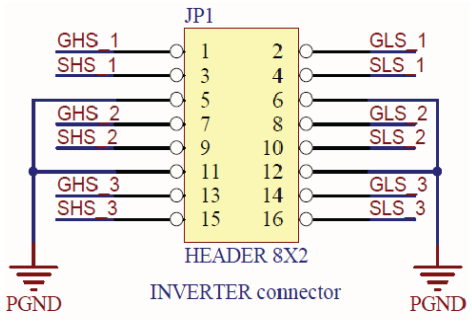
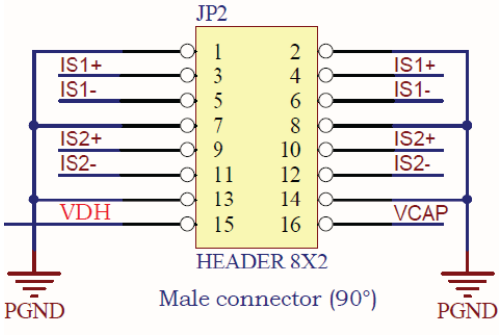


Figure 12. Gate driver board connector: phase signals



2.4 L9907 gate driver board - Test point description

I: Input,

O: Output

Table 3. L9907 gate driver board – Test point description

TP Name	Pin Name	Description	I/O Type
TP1	VCAP	Decoupling capacitor for power supply of low-side drivers	I
TP2	Vcc	5 V	I
TP3	BST_L	Boost regulator inductance connection	O
TP4	BST_C	Boost regulator capacitance connection	I
TP5	VB	Protected Battery supply	I
TP6	VDH	High-side Drain Voltage sense	I
TP7	BGND	Boost Ground	GND
TP8	Vdd	3.3V Power Supply Output	O
TP9	CBS_1	Bootstrap capacitor for high-side MOSFET, phase 1	I
TP10	SHS_1	Source connection for high-side MOSFET, phase 1	I
TP11	GHS_1	Gate connection for high-side MOSFET, phase 1	O
TP12	GLS_1	Gate connection for low-side MOSFET, phase 1	O
TP13	SLS_1	Source connection for low-side MOSFET, phase 1	I
TP14	CBS_2	Bootstrap capacitor for high-side MOSFET, phase 2	I
TP15	SHS_2	Source connection for high-side MOSFET, phase 2	I
TP16	GHS_2	Gate connection for high-side MOSFET, phase 2	O
TP17	GLS_2	Gate connection for low-side MOSFET, phase 2	O

Table 3. L9907 gate driver board – Test point description (continued)

TP Name	Pin Name	Description	I/O Type
TP18	SLS_2	Source connection for low-side MOSFET, phase 2	I
TP19	EN2	Enable Input 2 (ANDed with EN1 to enable any gate drive output).	I
TP20	PWM_H1	PWM command input for high-side phase 1	I
TP21	PWM_L1	PWM command input for low-side phase 1	I
TP22	PWM_H2	PWM command input for high-side phase 2	I
TP23	PWM_L2	PWM command input for low-side phase 2	I
TP24	PWM_H3	PWM command input for high-side phase 3	I
TP25	PWM_L3	PWM command input for low-side phase 3	I
TP26	EN1	Enable Input 1 (ANDed with EN2 to enable any gate drive output).	EN1 Test point
TP27	CBS_3	Bootstrap capacitor for high-side MOSFET, phase 3	Test point
TP28	SHS_3	Source connection for high-side MOSFET, phase 3	I
TP29	GHS_3	Gate connection for high-side MOSFET, phase 3	O
TP30	GLS_3	Gate connection for low-side MOSFET, phase 3	O
TP31	SLS_3	Source connection for low-side MOSFET, phase 3	I
TP32	FS_FLAG	Fault Status Flag Output	O
TP33	SI	SPI Serial Data Input	I
TP34	CS	SPI Chip Select Input	I
TP35	SCK	SPI Serial Clock Input	I
TP36	SO	SPI Serial Data Output	O
TP37	VCbst	Cbst voltage	
TP38	PGND	PGND Test point	
TP39	IB1	Output for Current Sense Amplifier 1 (Test Mode digital Output #1)	O
TP40	IB2	Output for Current Sense Amplifier 2 (Test Mode digital Output #2)	O
TP41	IS2-	Negative Input for Current Sense Amplifier 2	I
TP42	IS2+	Positive Input for Current Sense Amplifier 2	I
TP43	IS1-	Negative Input for Current Sense Amplifier 1	I
TP44	IS1+	Positive Input for Current Sense Amplifier 1	I
TP45	HALL_1	Hall Sensor 1	O
TP46	HALL_2	Hall Sensor 2	O
TP47	HALL_3	Hall Sensor 3	O
TP48	INDEX	Encoder INDEX	O

Table 3. L9907 gate driver board – Test point description (continued)

TP Name	Pin Name	Description	I/O Type
TP50	Channel A	Encoder Channel A	O
TP51	Channel B	Encoder Channel B	O
TP54	GND	Ground	GND
TP55	GND	Ground	GND
TP56	GND	Ground	GND
TP57	GND	Ground	GND

2.5 Inverter board

2.5.1 Inverter board - Jumper description

Table 4. Inverter board – Jumper description

Name	Description	Type
J15	D1 conf	Solderable contact (bottom side)
J1, J2, J3, J4, J5, J6, J8, J9, J11, J12, J13, J14	Is+/- selector	Configurable two positions jumper
J16	BENF Sensing	Pins

2.5.2 Inverter board - Connectors

Table 5. Inverter board – Connectors description

Name	Description	Type
J7	Power connector	Screw
J10	Motor phase connector	Screw
JP1	Mother Board male connector for control signals	Multipin with polarization
JP3	Mother Board female connector for control signals	Multipin with polarization
JP2	Mother Board male connector for phase current	Multipin with polarization
JP4	Mother Board female connector for phase current	Multipin with polarization

Figure 13. Inverter board connector - control signals- Male

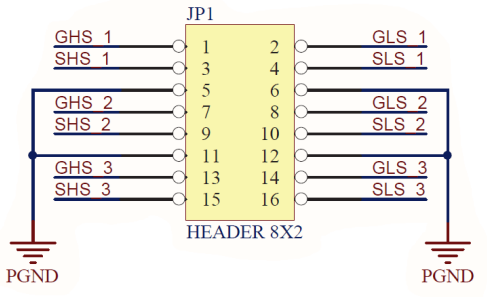


Figure 14. Inverter board connector - control signals- Female

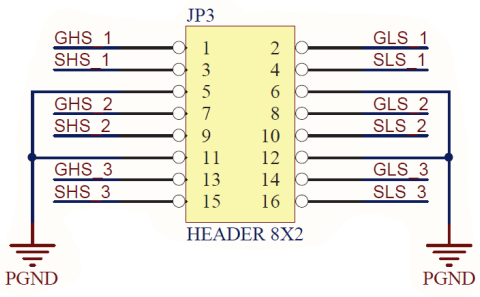


Figure 15. Inverter board connector - phase signals- Male

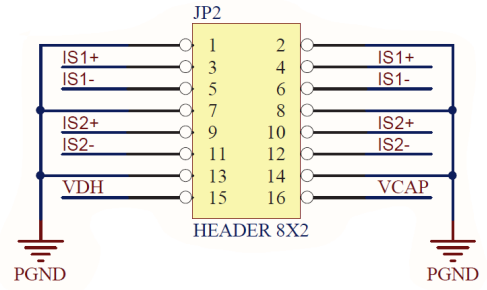
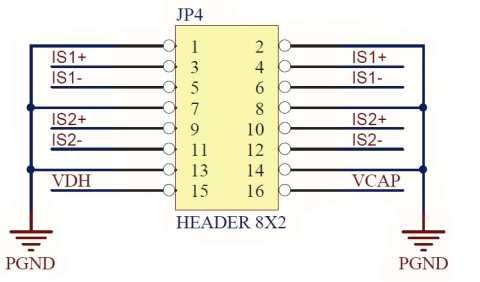


Figure 16. Inverter board connector - phase signals- Female



2.6 Inverter board - Test point description

Table 6. Inverter board – Test point description

TP Name	Pin Name	Description	I/O Type
TP1	--	Vbat	I
TP2	--	GND	I
TP3	--	Phase A	I
TP4	--	Phase B	I
TP5	--	Phase C	I

3 Functional description

3.1 Jumper setting using SPC5 Discovery+ board (SPI communication)

Table 7. Jumpers setting to set SPI communication from X1 and X2 connector

Name	Description	Configuration
J1	Vcc source jumper	2-3
J2	VBAT source for boost	2-3
J3	VB source	1-2
J13	BST_DIS jumper	1-2
J14	EN1 Signal source jumper	2-3(1)
J15	BST_C Line	ON
J16	BST_L Line	ON
J17	Ground Line	ON
J20	BGND Line	ON
J34	EN2 Signal source jumper	2-3(2)
J50	GCR Signal source jumper	3-2 or 2-1(3)

1. J14 = 3-4 = GND and/or J34 = 3-4= GND device disabled; J14 = 1-2 = Vcc and J34 = 1-2 = Vcc device enabled.
2. J14 = 3-4 = GND and/or J34 = 3-4= GND device disabled; J14 = 1-2 = Vcc and J34 = 1-2 = Vcc device enabled.
3. Depending on selected current for Gate Driver (ref. Datasheet Table 10 Igxx_1/ Igxx_2)

3.2 Current sense amplifier setting

The jumpers in the inverter board in combination with the two CSA (Current Sensing Amplifier) allow the user to configure the board to implement any combination of current sensing; the possible combinations are summarized in the following *Table 8*:

Table 8. Current Sensing configuration: Jumper setup

IS1 Source Selector		IS2 Source Selector		R1 DC link Selector		R5/R9 PhaseU or Brench U Selector		R14/R18 PhaseV or BrenchV Selector		R22/R26 Phase W or Brench W Selector		Is1+ Output	Is1- Output	Is2+ Output	Is2- Output
IS1 +	IS1-	IS2 +	IS2-	DC		U		V		W					
J1	J2	J3	J4	J5	J6	J8	J9	J11	J12	J13	J14				
1-2	1-2	1-2	1-2	off	off	1-2	1-2	1-2	1-2	off	off	PhaseU+	PhaseU-	PhaseV+	PhaseV-
1-2	1-2	2-3	2-3	off	off	1-2	1-2	off	off	1-2	1-2	PhaseU+	PhaseU-	PhaseW+	PhaseW-

Table 8. Current Sensing configuration: Jumper setup (continued)

IS1 Source Selector		IS2 Source Selector		R1 DC link Selector		R5/R9 PhaseU or Brench U Selector		R14/R18 PhaseV or BrenchV Selector		R22/R26 Phase W or Brench W Selector		Is1+ Output	Is1- Output	Is2+ Output	Is2- Output
IS1 +	IS1-	IS2 +	IS2-	DC		U		V		W					
1-2	1-2	off	off	1-2	1-2	1-2	1-2	off	off	off	off	PhaseU+	PhaseU-	Tot	Tot
2-3	2-3	2-3	2-3	off	off	off	off	1-2	1-2	1-2	1-2	PhaseV+	PhaseV-	PhaseW+	PhaseW-
2-3	2-3	off	off	1-2	1-2	off	off	1-2	1-2	off	off	PhaseV+	PhaseV-	Tot	Tot
off	off	1-2	1-2	2-3	2-3	off	off	1-2	1-2	off	off	Tot	Tot	PhaseV+	PhaseV-
off	off	2-3	2-3	2-3	2-3	off	off	off	off	1-2	1-2	Tot	Tot	PhaseW+	PhaseW-
1-2	1-2	1-2	1-2	off	off	2-3	2-3	2-3	2-3	off	off	BranchU +	BranchU -	BranchV+	BranchV-
1-2	1-2	2-3	2-3	off	off	2-3	2-3	off	off	2-3	2-3	BranchU +	BranchU -	BranchW+	BranchW-
1-2	1-2	off	off	1-2	1-2	2-3	2-3	off	off	off	off	BranchU +	BranchU -	Tot	Tot
2-3	2-3	2-3	2-3	off	off	off	off	2-3	2-3	2-3	2-3	BranchV+	BranchV-	BranchW+	BranchW-
2-3	2-3	off	off	1-2	1-2	off	off	2-3	2-3	off	off	BranchV+	BranchV-	Tot	Tot
off	off	1-2	1-2	2-3	2-3	off	off	2-3	2-3	off	off	Tot	Tot	BranchV+	BranchV-
off	off	2-3	2-3	2-3	2-3	off	off	off	off	2-3	2-3	Tot	Tot	BranchW+	BranchW-
1-2	1-2	1-2	1-2	off	off	1-2	1-2	2-3	2-3	off	off	PhaseU+	PhaseU-	BranchV-	BranchV+
1-2	1-2	2-3	2-3	off	off	1-2	1-2	off	off	2-3	2-3	PhaseU+	PhaseU-	BranchW-	BranchW+
1-2	1-2	1-2	1-2	off	off	2-3	2-3	1-2	1-2	off	off	PhaseV+	PhaseV-	BranchU-	BranchU+
2-3	2-3	2-3	2-3	off	off	off	off	1-2	1-2	2-3	2-3	PhaseV+	PhaseV-	BranchW-	BranchW+
1-2	1-2	2-3	2-3	off	off	2-3	2-3	off	off	1-2	1-2	PhaseW+	PhaseW-	BranchU-	BranchU+
2-3	2-3	2-3	2-3	off	off	off	off	2-3	2-3	1-2	1-2	PhaseW+	PhaseW-	BranchV-	BranchV+

4 Getting started with EVAL-L9907-H

This document describes how to configure the EVAL-L9907-H using the dedicated GUI.

4.1 Evaluation board setup

4.1.1 HW configuration

- Vbat =12 V
- Vcc = 5 V
- Microcontroller board: SPC560P-DISP

LOAD:

BLDC motor: MAXON EC 167176

- nominal voltage: 12V
- max speed: 10300 rpm
- nominal speed: 9050 rpm
- nominal torque: 107 mNm
- nominal current: 10.4A
- stall torque: 985 mNm

Table 9. Maxon EC167176 – Motor Winding

Motor winding	Wire color	Board Connector	Test Point	Motor phase
1	red	J10	TP5	W
2	black	J10	TP4	V
3	white	J10	TP3	U

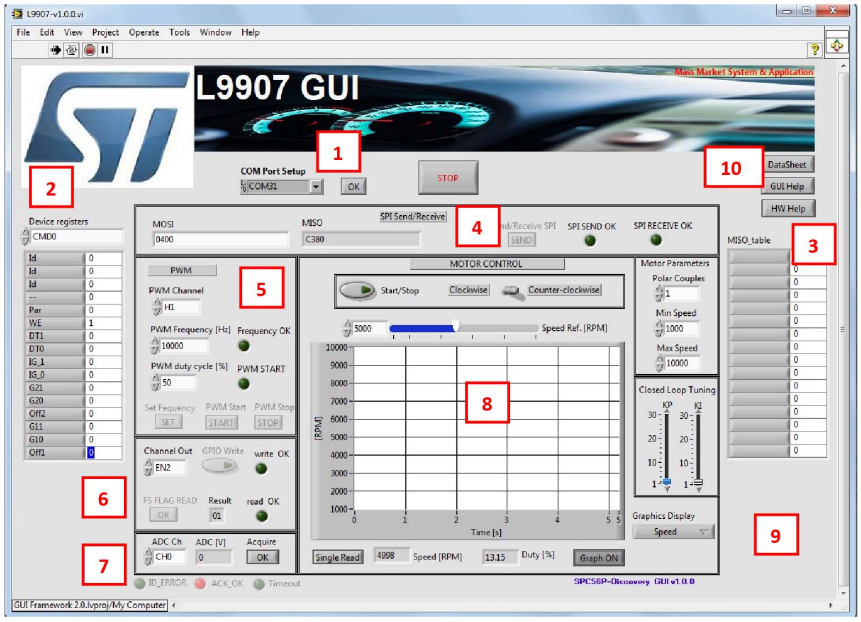
Table 10. Maxon EC167176 – hall sensor wires and connection

Hall sensor	Wire color	Board Connector	Test point	Microcontroller connector
1	red/grey	J65/1	TP45	C18
2	black/grey	J65/2	TP46	D18
3	white/grey	J65/3	TP47	C19
V Hall	green	J65/4	---	
GND	blue	J65/5	---	

5 Graphical User Interface description

The STSW-L9907 GUI includes the fields highlighted in *Figure 17*.

Figure 17. STSW-L9907-H Graphical User Interface (GUI) for EVAL-L9907-H



1. **Com Port Setup**: this menu allows to set the COM port.
2. **SDI**: this menu allows to select and to configure each device register. It is possible to program all the bits of each register.
3. **SDO**: the value of each register is copied in the field of this menu. This portion of the GUI allows to monitor the device status.
4. **SPI Send/Receive**: in this portion of the GUI it is possible:
   a) To end an SPI commands or configuration as programmed in the SDI menu (see #2) by pressing the "***SEND***" button.
   b) To send a single SPI command manually written in the MOSI field (HEX format). In the same time it is available to read the register value in the MISO filed.
   c) **SPI functionality**: the LEDs, SPI SEND OK and SPI RECEIVE OK provide a visual feedback about the SPI communication status (if the LEDs are on it means that communication is working properly).
5. **PWM signals**: the Frequency and the Duty cycle of the each PWM signals are programmed in this frame. The "START" button enables the PWM signal generators (PWM signals: L1, L2, L3, H1, H2 and H3), whereas "***STOP***" button stops the PWM signals. Before sending a PWM configuration, the selected Frequency must be confirmed by pushing the "***SET***" button.
6. **ENABLE SETUP – BST_DIS SETUP & FS_FLAG STATUS:** this frame is used to configure the EN1, EN2 and BST_DIS pins of the L9907 and to read the FS_FLAG status.
7. **ADC READ**: this section displays the value of the Ib1 and Ib2 pins (ADC inputs).
8. **MOTOR CONTROL**: this menu is used to start a BLDC Motor Control based on Closed

Loop and by using 6-Steps Algorithm technique, to setup some parameters and to view some useful waveforms:

a) **Motor Parameters**: through this menu is possible to setup some parameters of the BLDC Motor, such as “Polar Couples”, minimum and maximum rotation speed.

b) **Closed Loop Tuning**: through this menu it is possible to setup the PI parameters for Closed Loop and Kp and Ki values.

c) **Graphics Display**: with this button it is possible to select a graph between Speed, Error, Duty, ADC IB1 and ADC IB2.

d) **Speed Ref**.: by using this cursor it is possible to set the target BLDC motor speed.

e) **Single Read**: this button allows to read the instantaneous speed value.

f) **Duty%**: it shows the value of the current Duty Cycle.

g) **Graph ON/OFF**: the button allows to turn ON and OFF the Graph window.

9. **Sampling Time Graph**: this field allows to setup the sampling time for the graph.
10. **HELP**: through this menu it is possible to download the SW help, the L9907 Datasheet and info about the HW.

6 Startup procedure

The start-up procedure to configure the board EVAL-L9907-H with the GUI is described here below:

a) Start up at Vcc= 5 V

The Power Up default value for Vcc over voltage threshold is “10”; it is the value related for a Vcc=3.3V application. If the Vcc=5V the procedure must be modified as described here below:

1. Configure the COM port
2. Press “OK” button”
3. In field #7, force one of the EN pins to 0
4. Send the command 0x2401 (0b 0010010000000001) – CMD1 register in order to reset the fault.
5. Press “SEND” in the field #4.
6. LED “SPI SEND OK” is turned on if the communication is established and the command is sent and interpreted properly. If the device answer has been received properly, the LED “SPI RECEIVE OK will be turned on.
7. The field #3 will be updated with the device registers value as well as in the field #4 the SDI and SDO expressed in hex
8. Send the SPI frame 0xC800 (0b 1100100000000000) - DIAG & 0xE000 (0b1110000000000000) – DIAG2 in order to reset the diagnostic
9. Set High the EN pin previously set to zero (step 3).
10. Check the FS_FLAG status (field #6): the value should be 01

b) How to start the PWM independently

1. Set the desired channel (L1, L2, L3, H1, H2 and H3) – Field #5
2. Set the frequency value in the field #5.
3. Press “SET”
4. Set Duty Cycle value.
5. Press “START”
6. to enable the PWM signals
7. In the field #5, press “STOP PWM” to stop the PWM signals.
8. Press the button “STOP” on the top side of the GUI to stop the execution of Labview code and close the window.

c) How to start the MOTOR CONTROL

1. STOP all the PWM signals by pressing “STOP PWM” for all 6 channels (L1, L2, L3, H1, H2 and H3), see Field #5. This action will stop all PWM signals from L9907.
2. Follow the procedure described at point A or B depending on the Vcc supply value.
3. Set up the BLDC motor parameters (polar couples, min and max speed)
4. Set Kp and Ki values for example by using a for a 60W BLDC motor set Kp= 10 and Ki=5)[(b)]
5. Press “Start/Stop Motor” button and the motor will start to run. If the Motor shaft does not turn it means that a fault is present. Stop the Motor Control and reset the fault

following the procedure at section A, point 3 to 5. Restart the motor control[c].

6. Set the rotation direction: Clockwise or Counter Clockwise
7. Press “Start/Stop Motor” to stop the Motor shaft.
8. Press the button “STOP” on the top side of the GUI to stop the execution of Labview code and close the window.

b. The Kp and Ki constants depend on the BLDC motor characteristics and must be tuned to achieve the best control

c. Due to the Start-up procedure developed in the Firmware, depending on the BLDC motor and the BLDC rotor position, a cross conduction between high-side and low-side Power MOSFET could happen; under this working condition a fault is detected.

7 Functional test

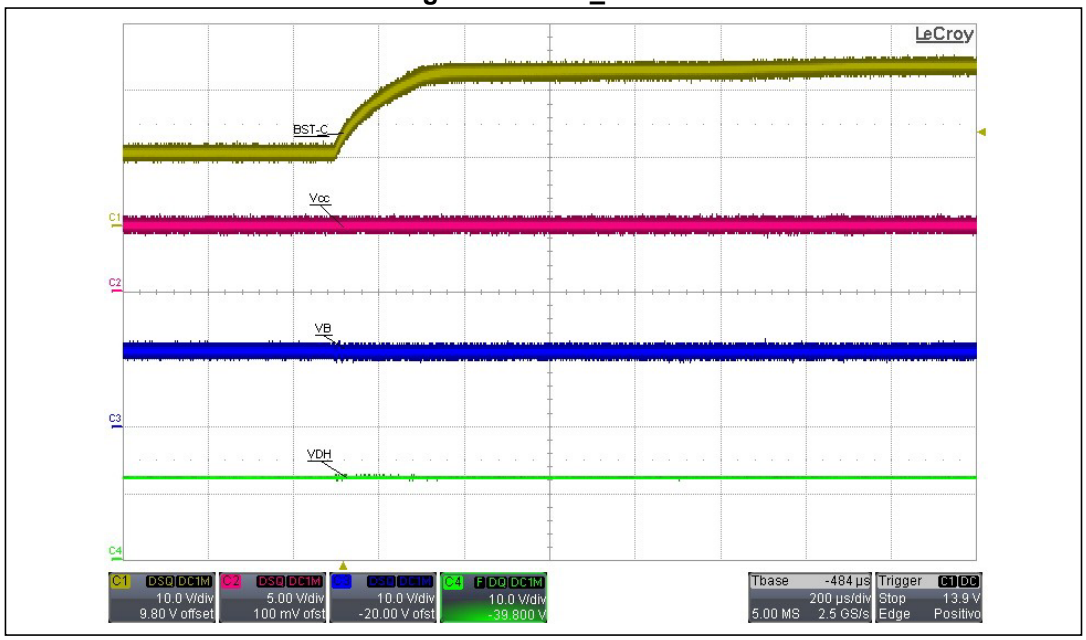
7.1 BLDC Motor OFF – Vbst_c Start

The BOOST behavior is tested by measuring the output voltage on pin 60 (BST_C—test point 4).

The voltage level should be approximately Vbatt+10V.

It is recommended to check the logic level of pin 37 (test point 32) (FS_FLAG, low if any fault is latched) and read out the status of DIAG and DIAG2 register to determine the kind of faults reported

Figure 18. Vbst_c Start



7.2 BLDC motor running

Next scope snapshots display the waveforms of a 6-Steps Algorithm technique.

Test condition:

- Vbat= 12 V
- Vcc=5 V
- Load: MAXON EC 167176
- Control Algorithm: Six Step at 20 kHz

Figure 19. BLDC motor running PWM_H1/GHS_1

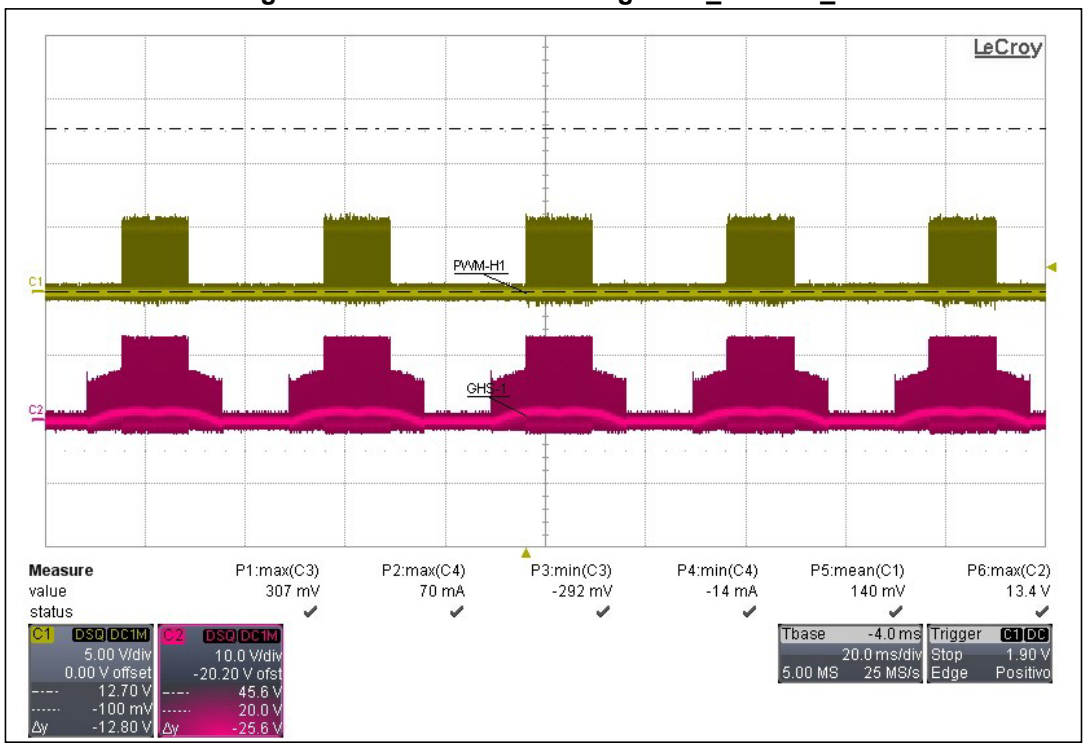
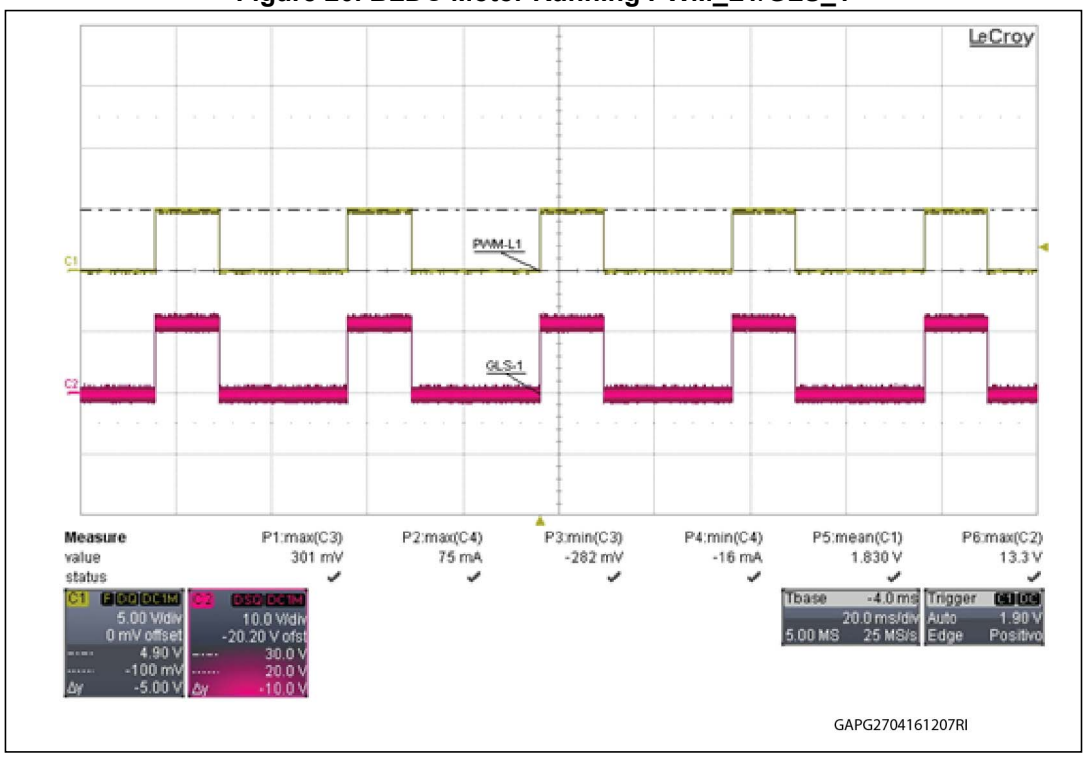


Figure 20. BLDC Motor Running PWM_L1/GLS_1



7.3 Current sensing amplifier output

The power board allows the user to choose any combination of current sensing using the two current sense amplifiers of the L9907.

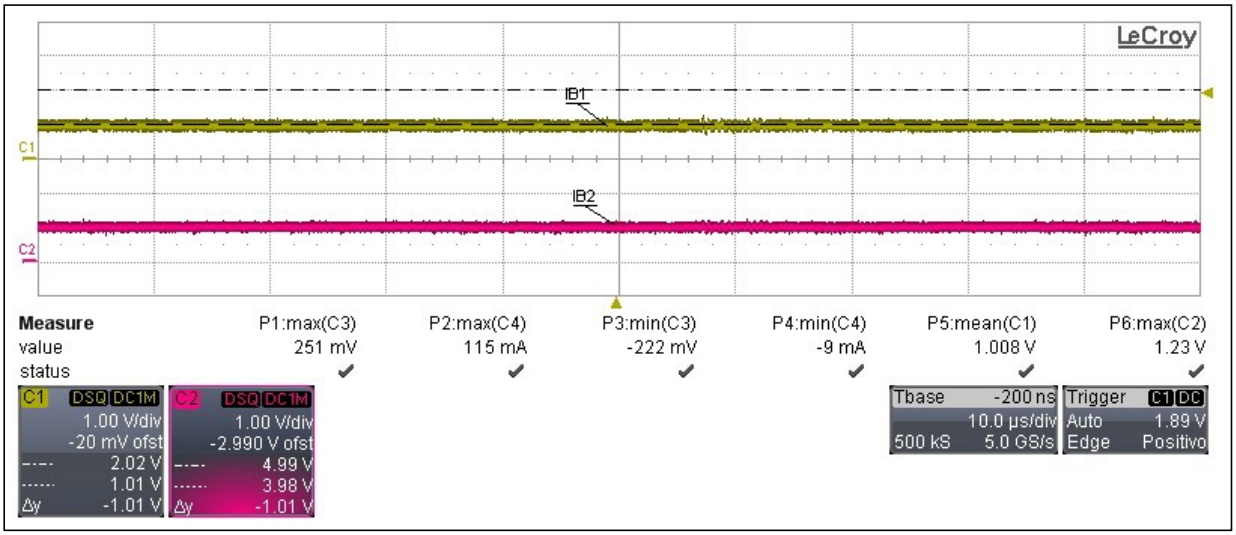
Table 8 shows the allowed combinations.

7.3.1 BLDC Motor OFF - Vbat=12 V – Vcc=5 V

Test condition:

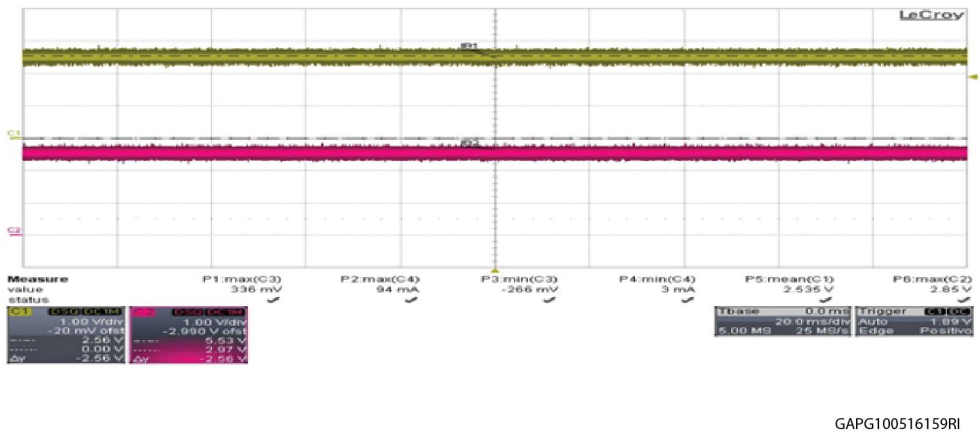
- CMD0 register setup:
  - B0 & B3 = 0 CSA1 & CSA2 ground
  - Gain1/2=10 (B2,B1) =(0,0)
  - Load: MAXON EC 167176

Figure 21. CSA Output. Motor: OFF. B0 and B3=0; CSA1 and CSA2=GND; Gain1/2=10 (B2,B1)=(0,0)



- CMD0 register setup:
  - B0 & B3 = 0 CSA1 & CSA2 Phase
  - Gain1/2=10 (B2,B1) =(0,0)
  - Load: MAXON EC 167176

Figure 22. CSA Output. Motor: OFF. B0 and B3=0; CSA1 and CSA2=Phase; Gain1/2=10 (B2,B1)=(0,0)

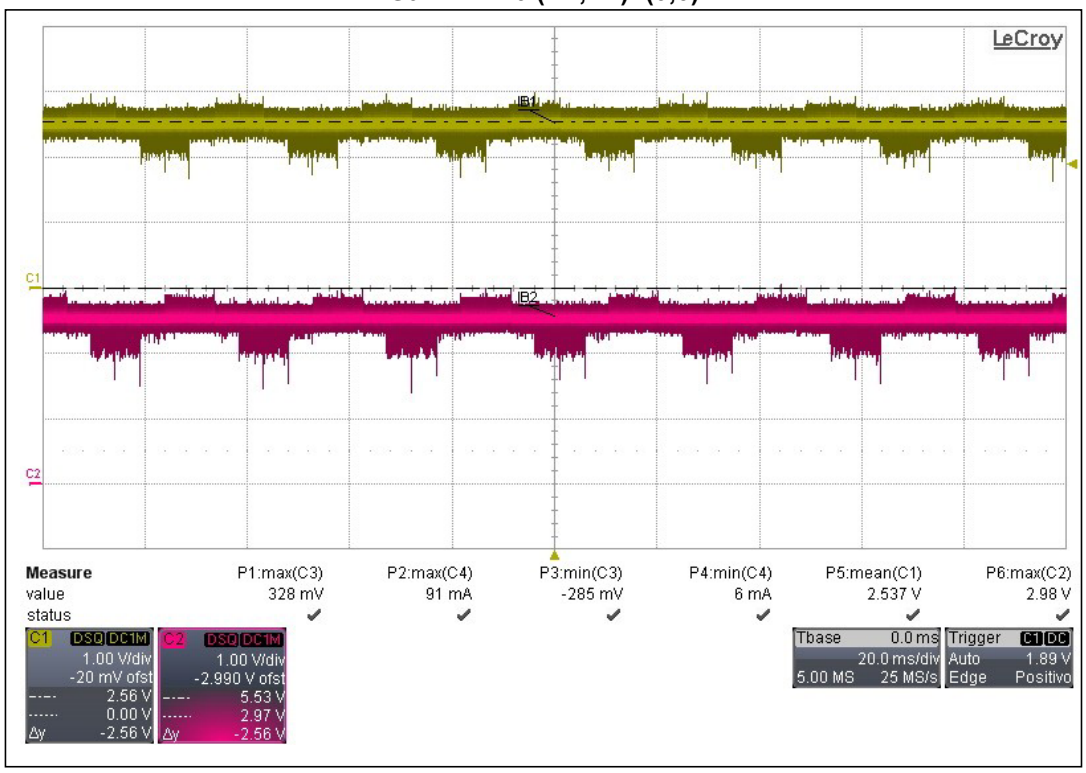


7.3.2 BLDC motor running - Vbat=12 V – Vcc=5 V

Test condition:

- CMD0 register setup:
  - B0 & B3 = 0 CSA1 & CSA2 ground
  - Gain1/2=10 (B2,B1) =(0,0)
  - Load: MAXON EC 167176

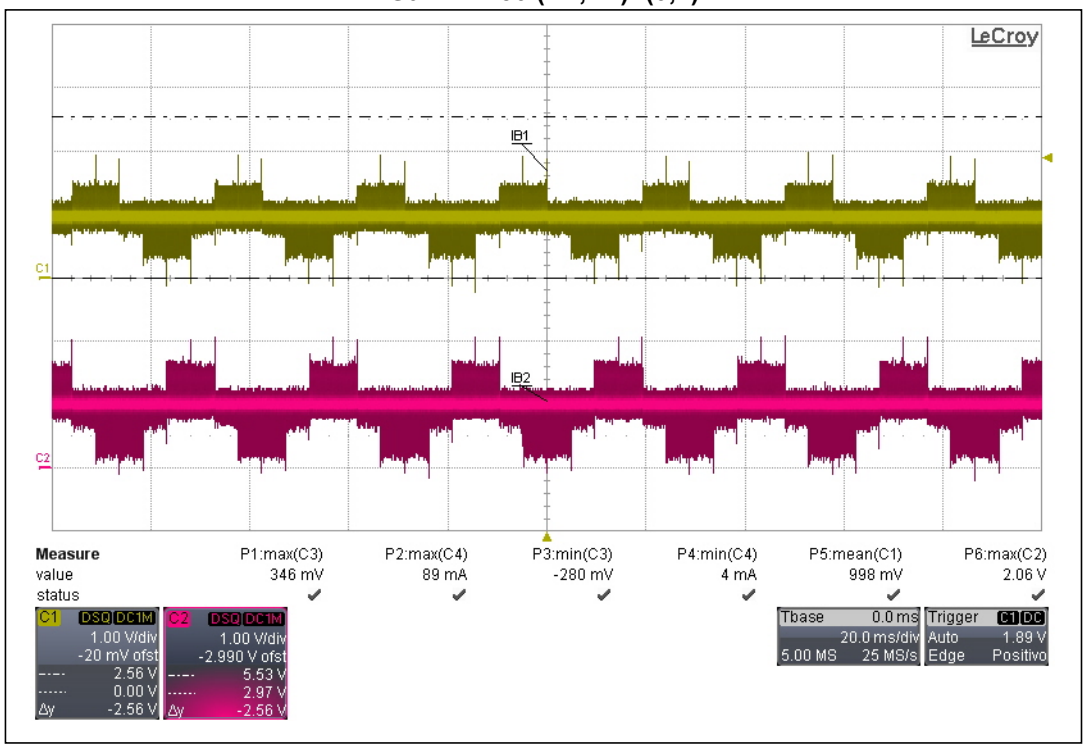
Figure 23. CSA Output. Motor: ON (Vbatt=12V): B0 and B3=0; CSA1 and CSA2=GND; Gain1/2=10 (B2,B1)=(0,0)



Test condition:

- CMD0 register setup:
  - B0 & B3 = 0 CSA1 & CSA2 ground
  - Gain1/2=30 (B2,B1) =(0,1)
  - Load: MAXON EC 167176

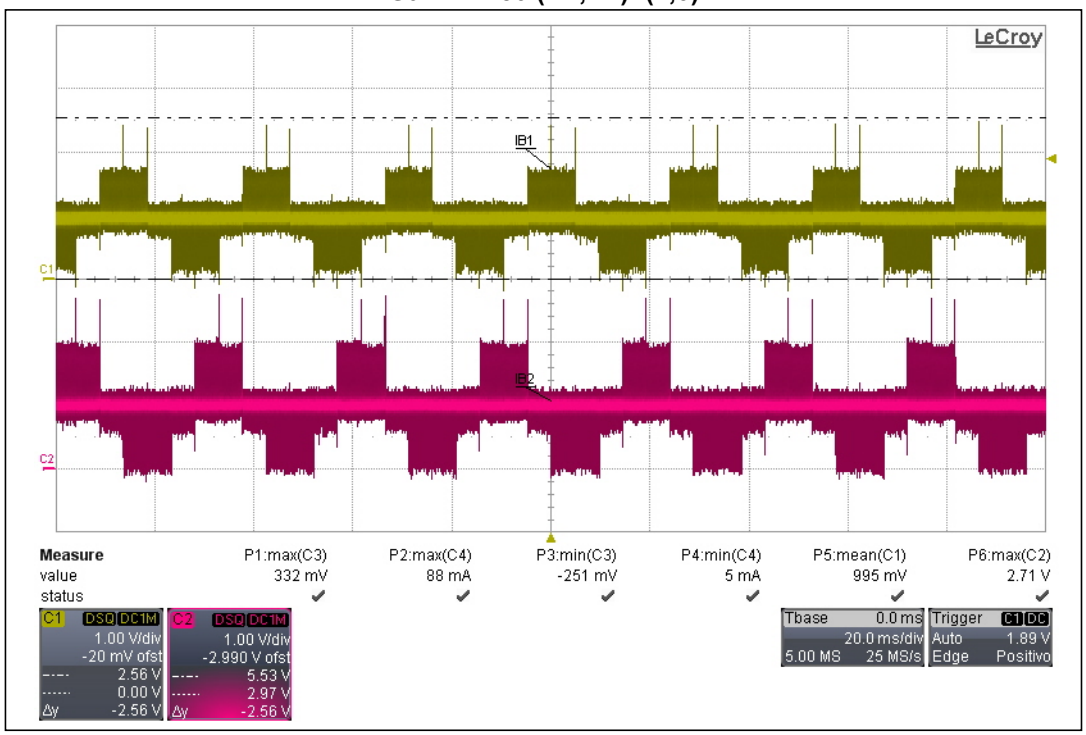
Figure 24. CSA Output. Motor: ON (Vbatt=12V): B0 and B3=0; CSA1 and CSA2=GND; Gain1/2=30 (B2,B1)=(0,1)



Test condition:

- CMD0 register setup:
  - B0 & B3 = 0 CSA1 & CSA2 ground
  - Gain1/2=50 (B2,B1) =(1,0)
  - Load: MAXON EC 167176

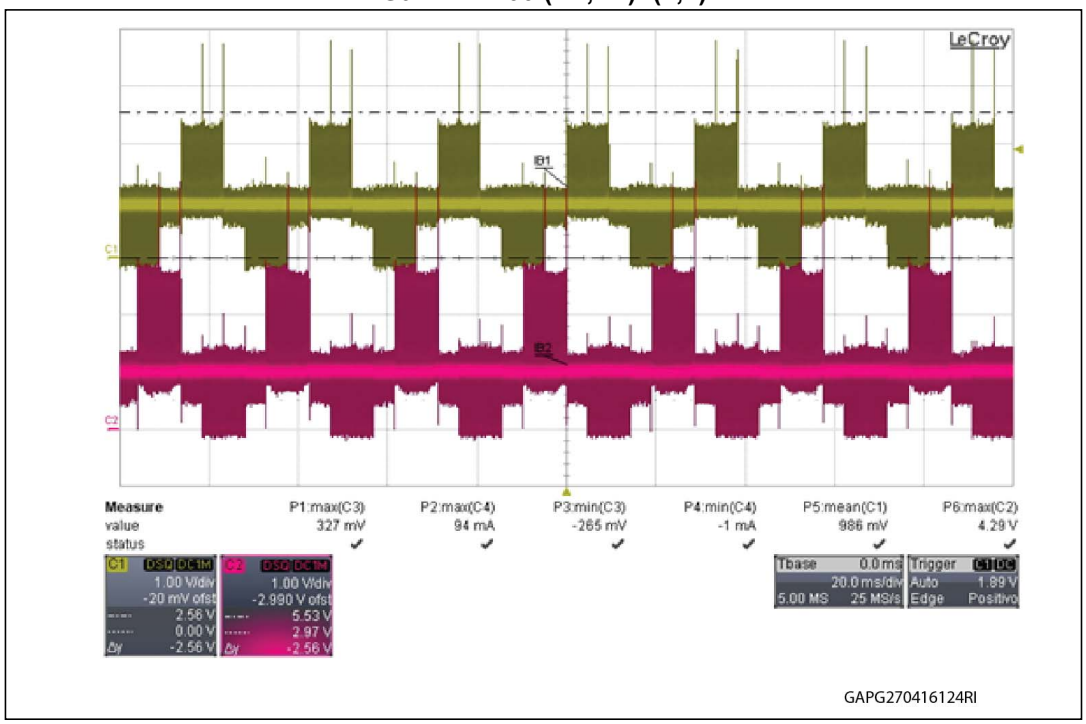
Figure 25. CSA Output. Motor: ON (Vbatt=12V): B0 and B3=0; CSA1 and CSA2=GND; Gain1/2=50 (B2,B1)=(1,0)



Test condition:

- CMD0 register setup:
  - B0 & B3 = 0 CSA1 & CSA2 ground
  - Gain1/2=100 (B2,B1) =(1,1)
  - Load: MAXON EC 167176

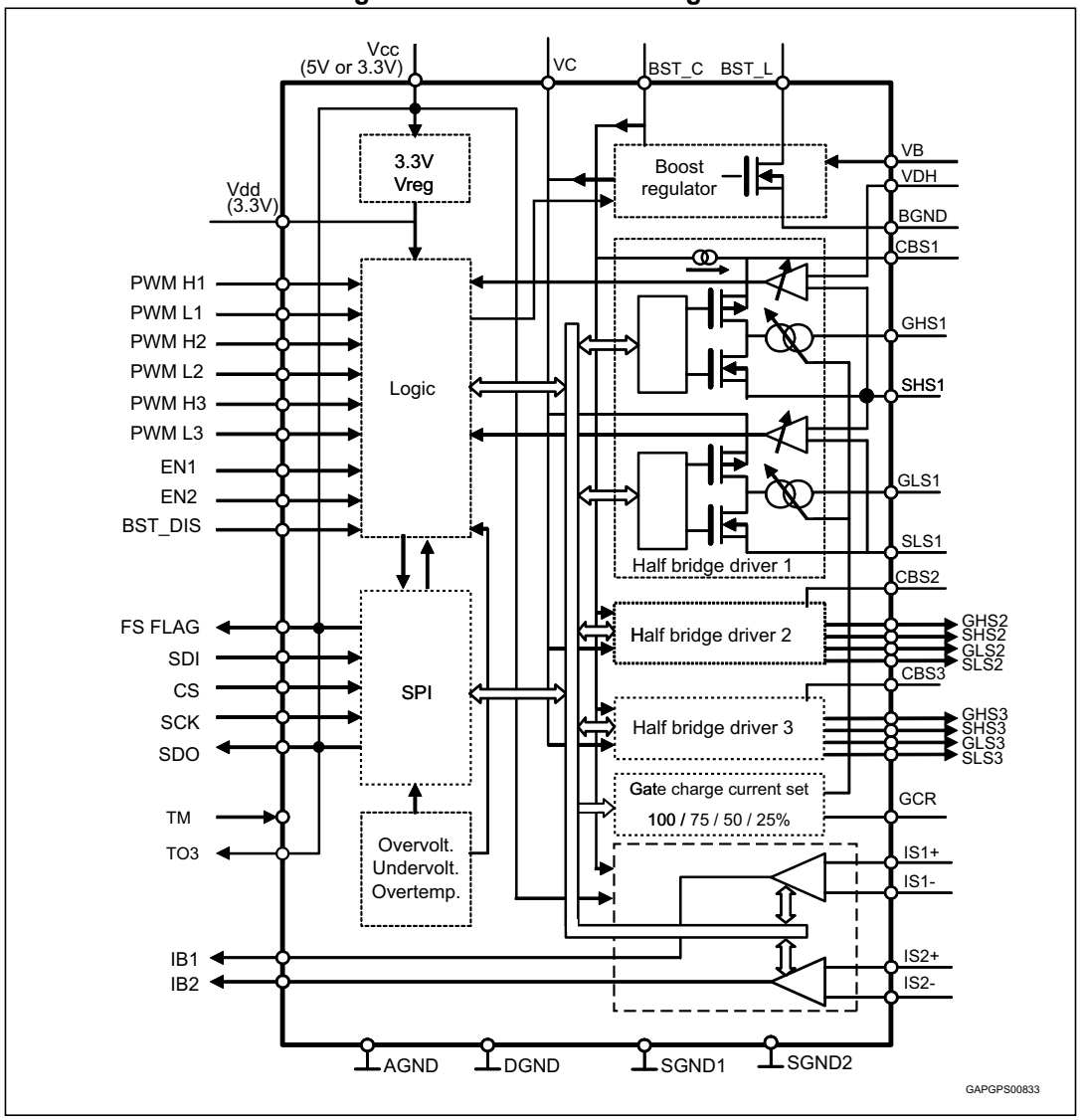
Figure 26. CSA Output. Motor: ON (Vbatt=12V): B0 and B3=0; CSA1 and CSA2=GND; Gain1/2=100 (B2,B1)=(1,1)



Appendix A Appendix

A.1 L9907 – Block diagram

Figure 27. L9907 – Block diagram



A.2 L9907 – Pin connection diagram and pin function

Figure 28. L9907 – Pin connection diagram

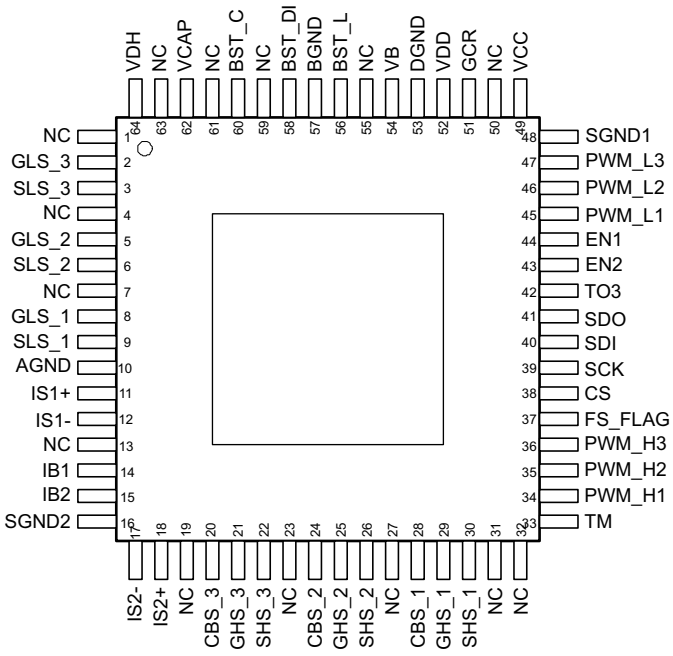


Table 11. L9907 – Pin function

Pin Number	Pin Name	Description	I/O Type
1	NC	NC	-
2	GLS_3	Gate connection for low-side MOSFET, phase 3	O
3	SLS_3	Source connection for low-side MOSFET, phase 3	I
4	NC	NC	-
5	GLS_2	Gate connection for low-side MOSFET, phase 2	O
6	SLS_2	Source connection for low-side MOSFET, phase 2	I
7	NC	NC	-
8	GLS_1	Gate connection for low-side MOSFET, phase 1	O
9	SLS_1	Source connection for low-side MOSFET, phase 1	I
10	AGND	Analog Ground	GND
11	IS1+	Positive Input for Current Sense Amplifier 1	I
12	IS1-	Negative Input for Current Sense Amplifier 1	I
13	NC	NC	-
14	IB1	Output for Current Sense Amplifier 1 (Test Mode digital Output #1)	O
15	IB2	Output for Current Sense Amplifier 2 (Test Mode digital Output #2)	O

Table 11. L9907 – Pin function (continued)

Pin Number	Pin Name	Description	I/O Type
16	SGND2	Substrate (and ESD_GND) connection 2	GND
17	IS2-	Negative Input for Current Sense Amplifier 2	I
18	IS2+	Positive Input for Current Sense Amplifier 2	I
19	NC	NC	-
20	CBS_3	Bootstrap capacitor for high-side MOSFET, phase 3	I
21	GHS_3	Gate connection for high-side MOSFET, phase 3	O
22	SHS_3	Source connection for high-side MOSFET, phase 3	I
23	NC	NC	-
24	CBS_2	Bootstrap capacitor for high-side MOSFET, phase 2	I
25	GHS_2	Gate connection for high-side MOSFET, phase 2	O
26	SHS_2	Source connection for high-side MOSFET, phase 2	I
27	NC	NC	-
28	CBS_1	Bootstrap capacitor for high-side MOSFET, phase 1	I
29	GHS_1	Gate connection for high-side MOSFET, phase 1	O
30	SHS_1	Source connection for high-side MOSFET, phase 1	I
31	NC	NC	-
32	NC	NC	-
33	TM	Test Mode enable input	I
34	PWM_H1	PWM command input for high-side phase 1	I
35	PWM_H2	PWM command input for high-side phase 2	I
36	PWM_H3	PWM command input for high-side phase 3	I
37	FS_FLAG	Fault Status Flag Output	O
38	CS	SPI Chip Select Input	I
39	SCK	SPI Serial Clock Input	I
40	SDI	SPI Serial Data Input	I
41	SDO	SPI Serial Data Output	O
42	TO3	Test Output	O
43	EN2	Enable Input 2 (ANDed with EN1 to enable any gate drive output).	I
44	EN1	Enable Input 1 (ANDed with EN2 to enable any gate drive output).	I
45	PWM_L1	PWM command input for low-side phase 1	I
46	PWM_L2	PWM command input for low-side phase 2	I
47	PWM_L3	PWM command input for low-side phase 3	I
48	SGND1	Substrate (and ESD_GND) connection 1	GND

Table 11. L9907 – Pin function (continued)

Pin Number	Pin Name	Description	I/O Type
49	Vcc	5V / 3.3V Power Supply Input	I
50	NC	NC	-
51	GCR	Connection to Resistor for current selection of Gate driver	O
52	Vdd	3.3V Power Supply Output (for IC internal purpose only)	O
53	DGND	Digital Ground	GND
54	VB	Protected Battery monitor	I
55	NC	NC	-
56	BST_L	Boost regulator inductance connection	O
57	BGND	Boost Ground	GND
58	BST_DIS	Boost Disable	I
59	NC	NC	-
60	BST_C	Boost regulator capacitance connection	I
61	NC	NC	-
62	VCAP	Decoupling Capacitor for Power Supply of low-side Drivers	I
63	NC	NC	-
64	VDH	high-side Drain Voltage sense	I

A.3 Motor data – Maxon 167176

Figure 29. MAXON EC 167176 - Motor data

Motor Data		167176
Values at nominal voltage		
1 Nominal voltage	V	12
2 No load speed	rpm	10300
3 No load current	mA	886
4 Nominal speed	rpm	9050
5 Nominal torque (max. continuous torque)	mNm	107
6 Nominal current (max. continuous current)	A	10.4
7 Stall torque	mNm	985
8 Starting current	A	89.2
9 Max. efficiency	%	81
Characteristics		
10 Terminal resistance phase to phase	Ω	0.134
11 Terminal inductance phase to phase	mH	0.0266
12 Torque constant	mNm/A	11.0
13 Speed constant	rpm/V	865
14 Speed/torque gradient	rpm/mNm	10.5
15 Mechanical time constant	ms	9.39
16 Rotor inertia	gcm²	85.0

GAPG2804171143RI

A.4 Motor and Sensors connection (Maxon 167176)

Figure 30. Motor connection

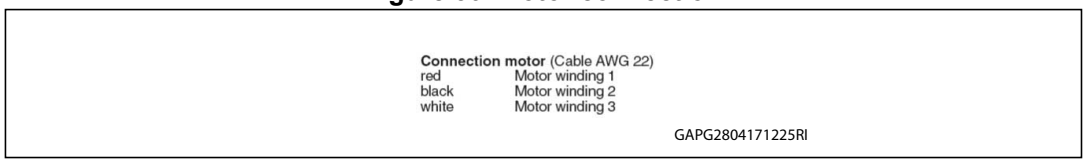
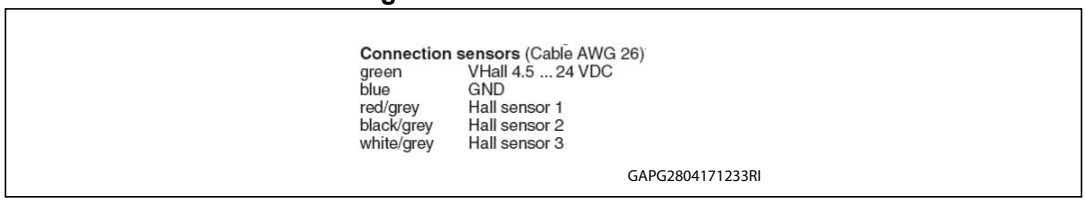


Figure 31. Sensor connection



A.5 Gate driver board

A.5.1 L9907 gate driver board - PCB Layout

Figure 32. Gate driver board - PCB Layout – Top view

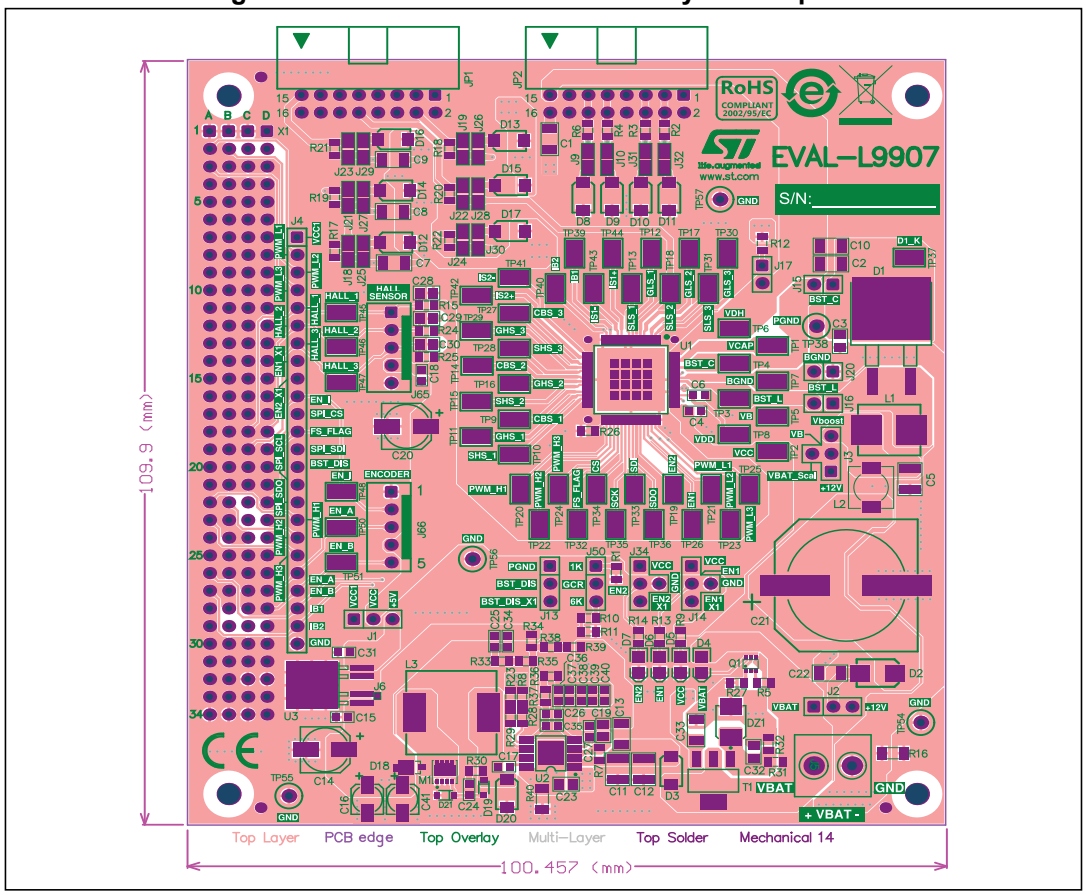
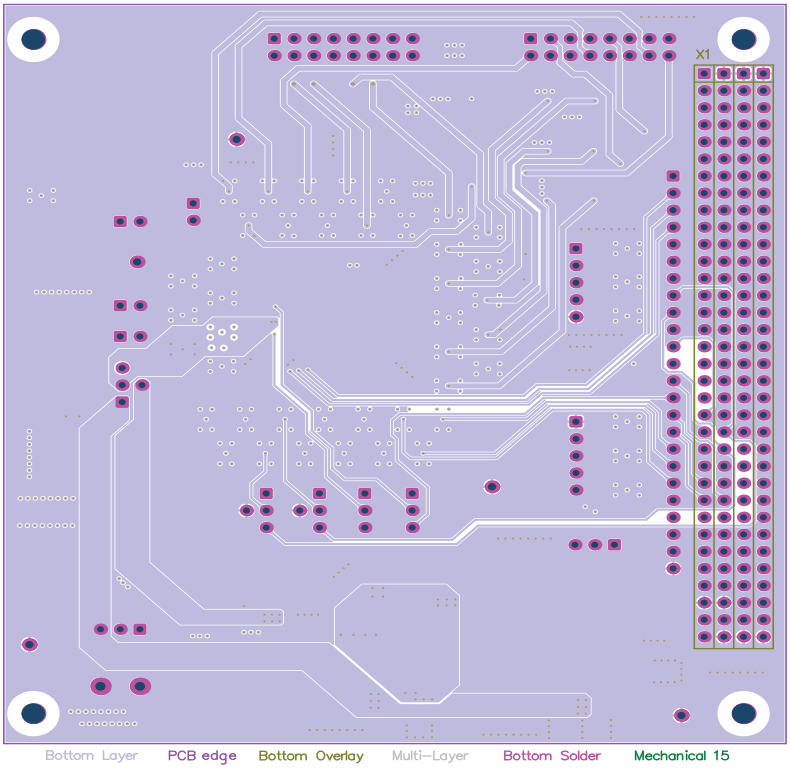


Figure 33. Gate driver board - PCB Layout – Bottom view



A.6 Inverter board: PCB Layout

Figure 34. Inverter board - PCB Layout – Top view

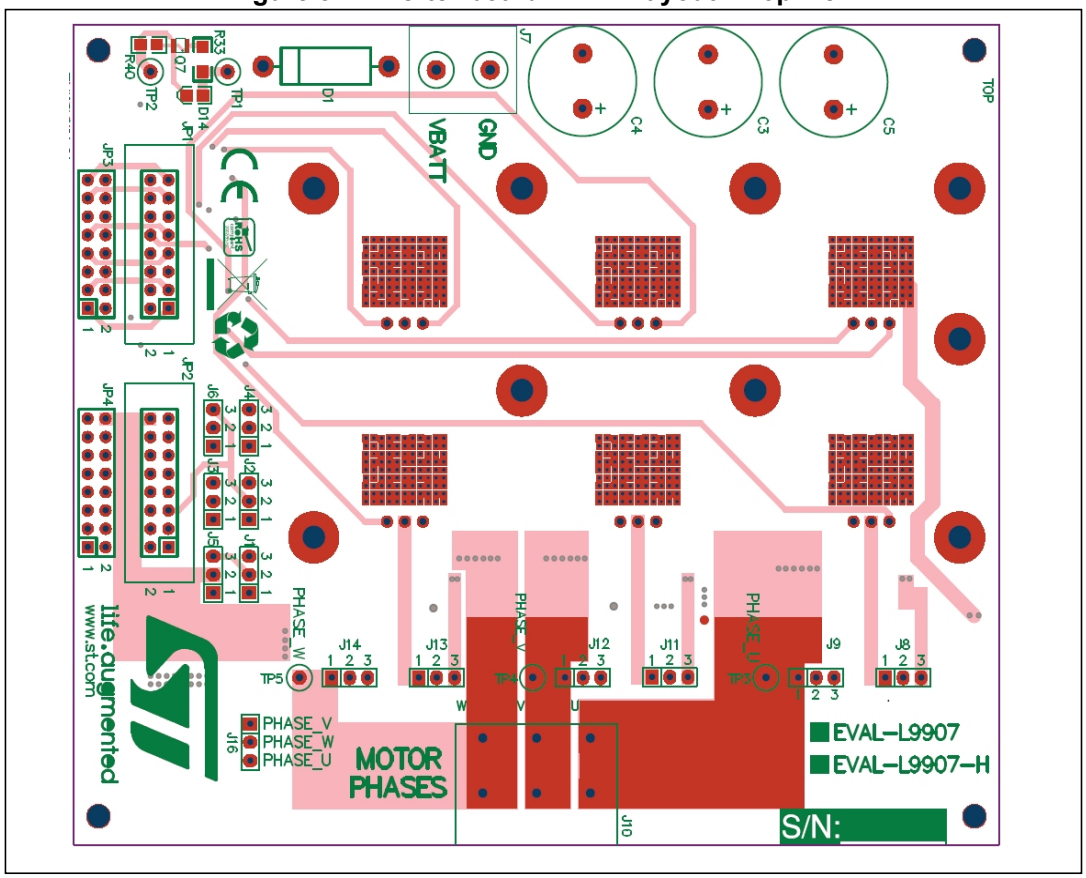
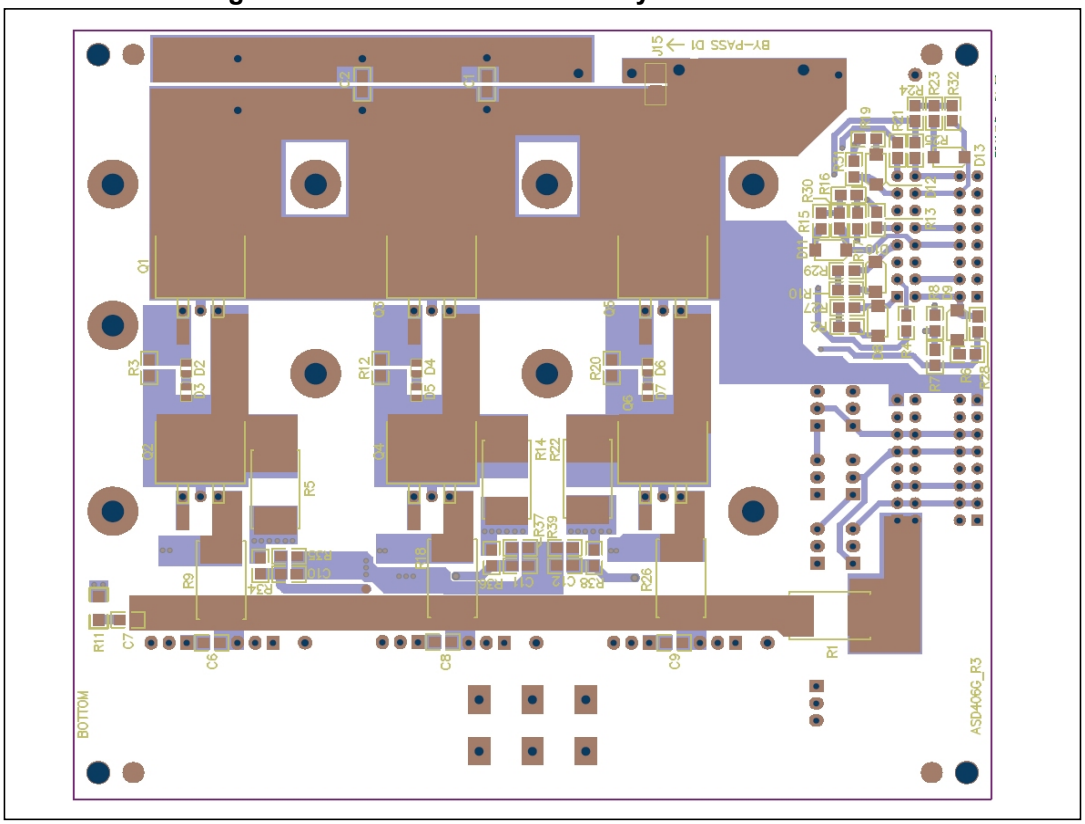


Figure 35. Inverter board - PCB Layout – Bottom view



Revision history

Table 12. Document revision history

Date	Revision	Changes
09-Jun-2016	1	Initial release.
11-Apr-2019	2	Updated: – Minor text changes; – *Section 2: EVAL-L9907-H: Board description*; – *Section 3: Functional description*; – *Section 6: Startup procedure*; – *A.5: Gate driver board*.