EVAL_10KW_B6_SIC400V user guide

Three-phase half-bridge topology with 400 V CoolSiC™ G2

About this document

Scope and purpose

This document describes the use and operation of the EVAL_10KW_B6_SIC400V Evaluation Kit. The evaluation kit is designed to evaluate and test the three-phase half-bridge (B6) topology.

The kit aims to provide engineers and researchers with a platform to experiment, validate, and optimize the B6 power conversion systems for different applications, such as solar, drives, and others with input DC bus voltage, ideally of 288–320 V DC depending on the desired margin.

Intended audience

This document is intended for design engineers, technicians, and developers of electronic systems.

CoolSiC™

Infineon's 400 V CoolSiC™ MOSFETs offer exceptional performance in switching behavior but also low conduction losses. These devices are designed to offer high efficiency and reliability, while maintaining low on-state resistance at low as well as high MOSFET junction temperatures. Its ability to turn off the device with zero gate bias makes the 400 V CoolSiC™ MOSFETs a true "normally-off" devices.

The CoolSiC™ family supports but is not limited to applications such as:

- Energy Storage Systems
- Industrial drives
- Motor control and drives
- Renewables
- UPS

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Safety precautions

Note: Please note the following warnings regarding the hazards associated with development systems.

Table 1 Safety precautions

	**Warning:** *The DC link potential of this board is up to 1000 VDC. When measuring voltage waveforms by oscilloscope, high voltage differential probes must be used. Failure to do so may result in personal injury or death.*
	**Warning***: The evaluation or reference board contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the drive system, wait five minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *The evaluation or reference board is connected to the grid input during testing. Hence, high-voltage differential probes must be used when measuring voltage waveforms by oscilloscope. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.*
	**Caution:** *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	**Caution:** *Only personnel familiar with the drive, power electronics and associated machinery should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.*
	**Caution:** *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*
	**Caution:** *A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.*
	**Caution:** *The evaluation or reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.*

Table of contents

1 Introduction

EVAL_10KW_B6_SIC400V Evaluation Kit uses a three-phase half-bridge, also known as a B6 topology, commonly used for driving motors. The EVAL_10KW_B6_SIC400V Evaluation Kit design can be used to drive the three-phase alternating current induction motor (ACIM) or permanent magnet synchronous motor (PMSM) with power levels up to 10 kW and the ability to fine-tune the power level using Infineon's CoolSiC™ G2 400 V packages.

The EVAL_10KW_B6_SIC400V Evaluation Kit design, as depicted in Figure 1, comprises three boards:

- Power board, which is implemented with an insulated metal substrate (IMS) PCB
- Capacitor board that keeps the circulating current within the inverter and prevents it from flowing back to the source
- Gate driver board

The capacitor board and the gate driver board are implemented on the FR4 PCB.

This design utilizes the following blocks:

- Power stage with CoolSiC™ G2 IMT40R011M2H 11.3 mΩ, max/400 V MOSFET
- Galvanically isolated single-channel gate driver (4 A/3.5 A) – EiceDRIVER™ 1EDI20H12AH
- Quasi-Resonant (QR) Flyback Controller – ICE5QSAG
- QR Flyback MOSFET with CoolSiC™ IMBG120R350M1H
- High-speed self-oscillating half-bridge driver IC with 50% duty cycle – EiceDRIVER™ IR2085S
- N-channel small signal 30 V MOSFET in TSOP-6 package – OptiMOS™ BSL302SN
- XMC™ XMC1000/4000 microcontroller drive card interface

In this evaluation kit design example, a single MOSFET is implemented in B6 configuration. All components typically used for trimming performance are located on FR4-based modules, such as gate resistors, while the power stage is implemented on the IMS PCB due to its good thermal properties. Additional heatsinks are used to cool the power PCB and allow for longer continuous running time.

The following sections describe the individual functional blocks and their interconnections. The aim is to enable the user to utilize these components in a working setup and adapt the circuits as per their own requirements.

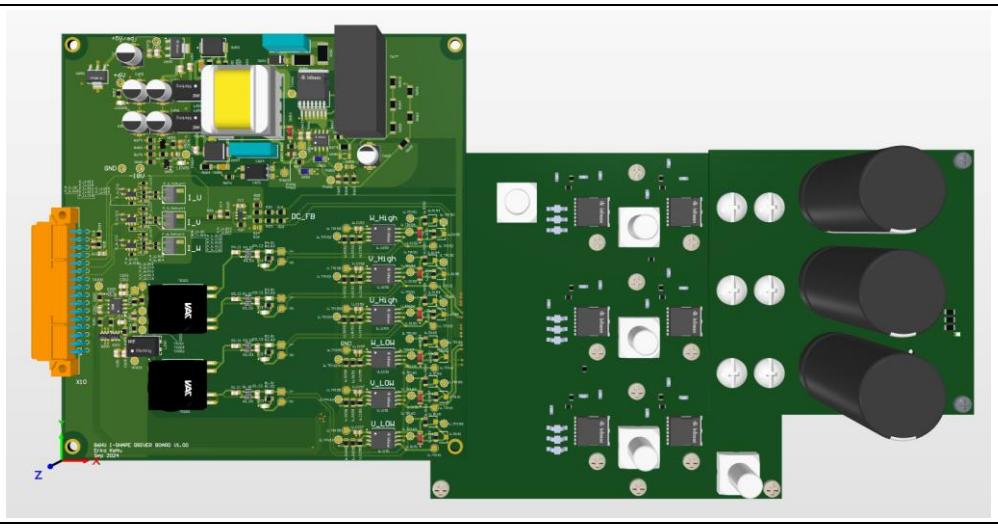


Figure 1 EVAL_10KW_B6_SIC400V assembly

2 Hardware description

EVAL_10KW_B6_SIC400V comprises the following hardware components:

- The **power board** is an IMS board mounted on top of an air-cooled aluminum heatsink
- The **gate driver board** provides the power management and interconnections to peripheral subsystems to functionally drive the half-bridges of the B6 power inverter
- The **capacitor board** facilitates the flow of reactive current within the inverter, preventing it from traveling back to the source
- **XMC™ XMC4400 Drive Card** (KIT_XMC4400_DC_V1) to provide the control signals

Figure 2 shows the building blocks from the top-level perspective.

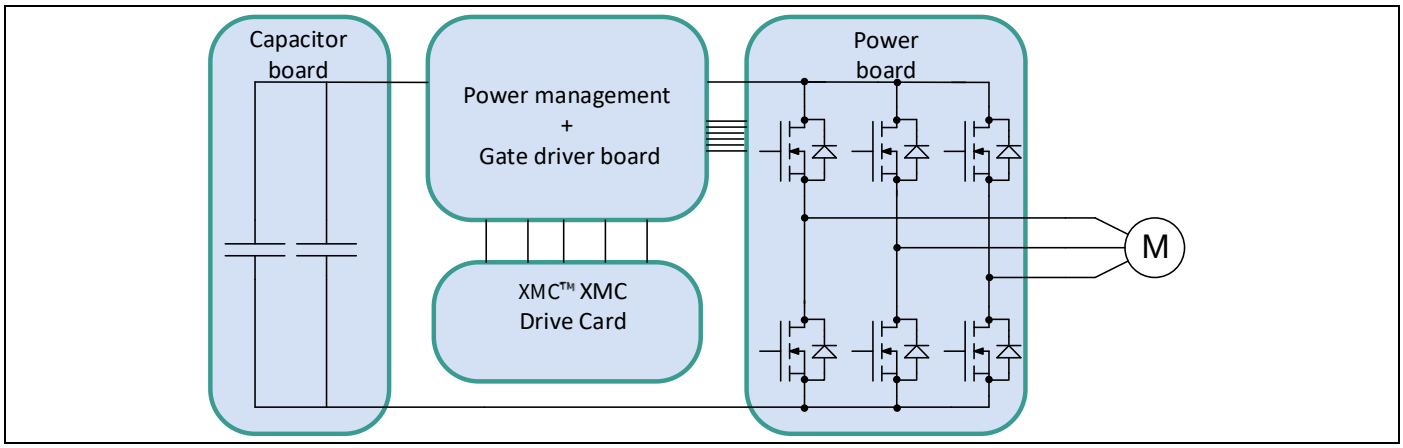


Figure 2 Top-level system overview

Power board

- B6 topology on two-layer IMS board

Gate driver board

- High-voltage (HV) side:
  - Interconnection to power board
  - Quasi-resonant flyback for isolation
- Signal side:
  - Gate drivers (input signals from control board, outputs to power board)
  - Sensor signal processing (buffers and filters for current and temperature sensing)
- Supply modules:
  - QR flyback – HV to 18 V
  - QR flyback – HV to 5 V
  - Linear regulator (3.3 V)

Capacitor board

- Capacitor bank (electrolytic capacitors and ceramic capacitors)

Control board

- XMC™ XMC4400 Drive Card

3 EVAL_10KW_B6_SIC400V Evaluation Kit

The following sections describe the EVAL_10KW_B6_SIC400V Evaluation Kit highlighting its specifications, schematics, and layout.

3.1 Power board

The power board comprises six IMT40R011M2H CoolSiC™ G2 MOSFETs (available in a TOLL package), which are mounted on two-layer IMS PCB. The layout has been optimized to mimic applications where the capacitor board can be placed on top of the IMS board. However, in that configuration, thermal cameras cannot be used to measure the temperature. The proposed solution was to design the IMS board in two layers, where the second layer is dedicated for a ground plane (return path). Additional bypass capacitors are also added to the power board for a better loop compensation.

Note: It is recommended to desolder the ceramic capacitors on the capacitor board to prevent oscillations between the two boards.

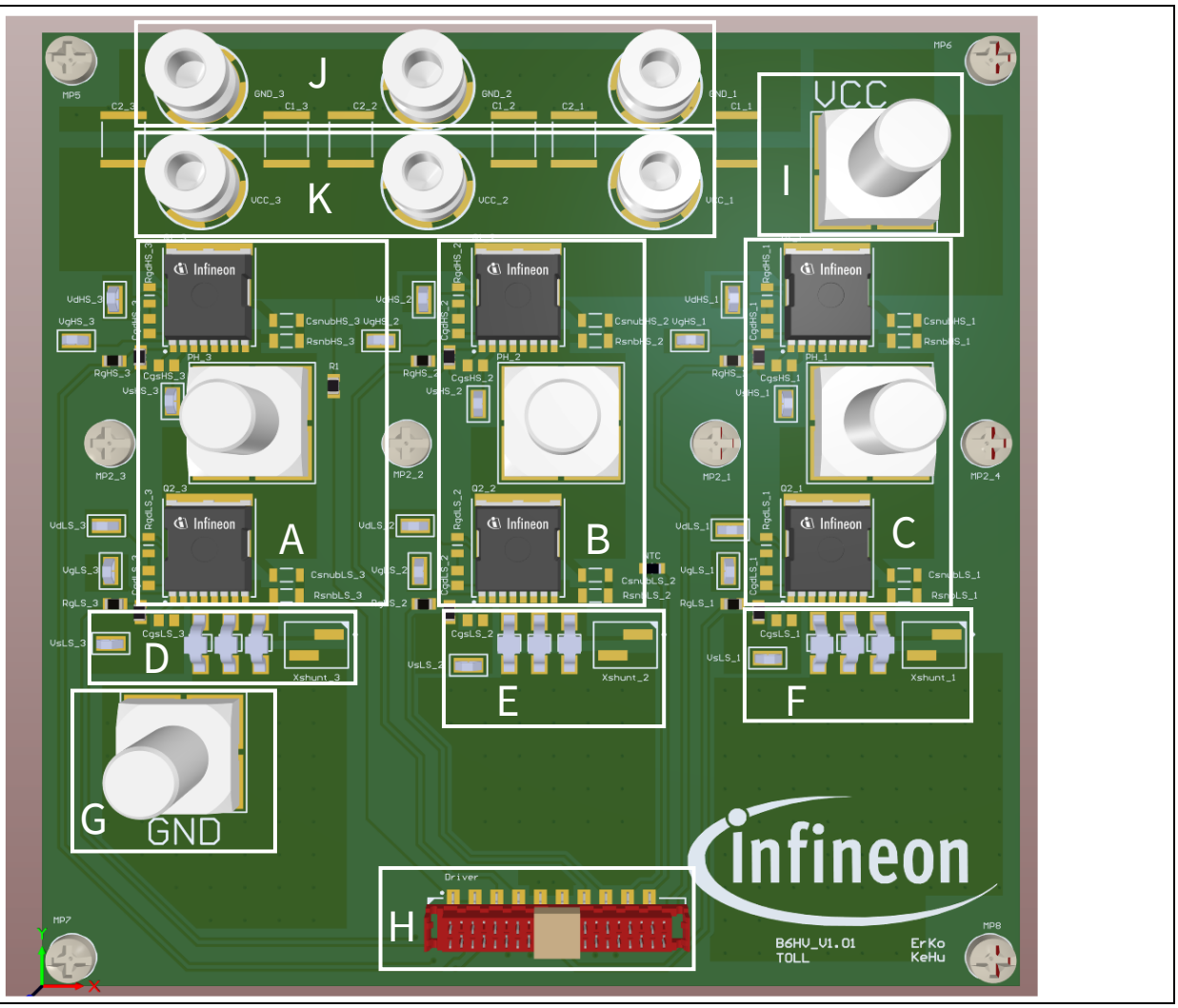


Figure 3 Power board in TOLL package

- **A:** MOSFETs and connector for Phase W
- **B:** MOSFETs and connector for Phase V
- **C:** MOSFETs and connector for Phase U
- **D:** Jumper and current feedback for Phase W
- **E:** Jumper and current feedback for Phase V
- **F:** Jumper and current feedback for Phase U
- **G:** Input DC bus power supply connector – ground
- **H:** Gate driver connector
- **I:** Input DC bus power supply connector – positive
- **J:** Capacitor board connector - ground
- **K:** Capacitor board connector - positive

3.1.1 Headers and connectors

Table 2 lists the headers and connectors of EVAL_10KW_B6_SIC400V.

Table 2 EVAL_400VSiC_ANPC headers and connectors

Name	Description	Comment
VCC	Power connector – Input voltage positive	Nominal: 288 V, Max: 320 V
GND	Power connector – Input voltage negative	–
VCC_1 VCC_2 VCC_3	Power connector – Capacitor board positive	3 x M5 x 6 mm lens head screw RS 908-7693
GND_1 GND_2 GND_3	Power connector – Capacitor board negative	3 x M5 x 6 mm lens head screw RS 908-7693
PH_3	Power connector - Phase W	Max: 40 Arms
PH_2	Power connector - Phase V	Max: 40 Arms
PH_1	Power connector - Phase U	Max: 40 Arms
Xshunt_3	Current sensor feedback connector Phase W	1x2 100 mil flat cable
Xshunt_2	Current sensor feedback connector Phase V	1x2 100 mil flat cable
Xshunt_1	Current sensor feedback connector Phase U	1x2 100 mil flat cable

3.1.2 Board specifications

The power boards use the Ventec VT-4B7 IMS type. Table 2 lists some of the main properties.

Table 3 IMS board details

Description	Dimension
Substrate thickness	1.5 mm
Dielectric thickness	105 µm
Copper thickness top and bottom each	35 µm
Overall board thickness	2 mm
Dielectric specific thermal conductivity λ [W/m*K]	7 W/(m*K)

3.1.3 Heatsink

To extend the power range of the inverter, attach the IMS board (43 mm x 240 mm) to the heatsink via 13 M3 screws.
To prepare the threaded holes in the heatsink, consider the dimensions in Figure 4.

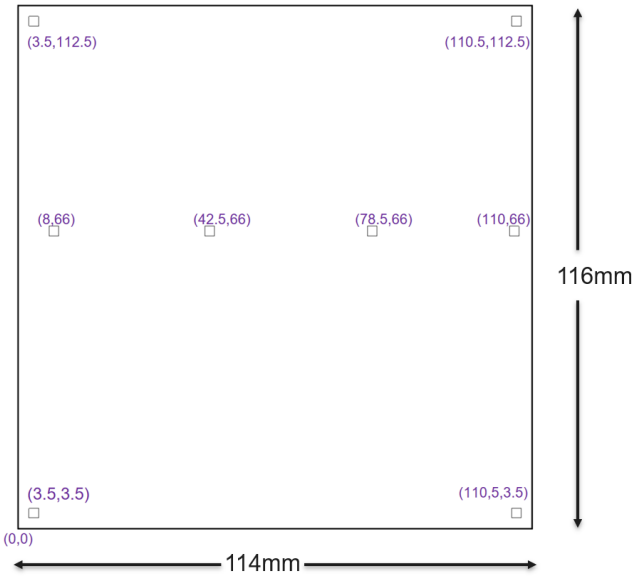


Figure 4 Heatsink screw positions

3.1.4 Current feedback

The current feedback can be taken from all three phases by desoldering the jumpers and soldering the shunt resistors. The connectors next to resistors (Xshunt_1, Xshunt2, and Xshunt_3) are standard 100 mil surface mount headers and can be used to take the feedback to the gate driver board.

Pin1 (dotted) is the positive signal whereas Pin2 is ground. Figure 5 shows the current feedback block on the PCB.

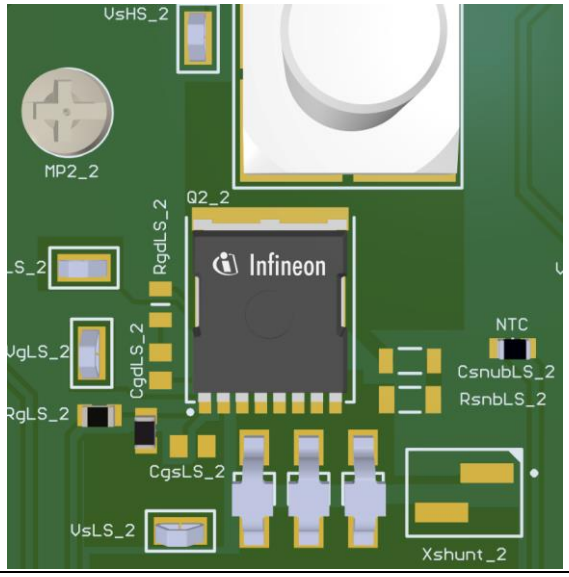


Figure 5 Current feedback

3.2 Gate driver board

The gate driver board shown in Figure 6 is composed of several blocks:

- The QR flyback converter converts the high voltage to isolated 18 V and 5 V for logic level operations and gate driver supplies
- 6x1EDI20H12AH 1200 V single-channel gate driver IC with galvanic isolation
- Forward Converter stage for isolated voltage creation for gate drivers. This block creates four galvanically isolated 18 V; three of them are used for high-side MOSFETs and one of them is common for all low-side MOSFETs
- Current and voltage feedback amplification stage for phase current and supply voltage measurements
- Connection interface to XMC™ XMC4400 Driver Card

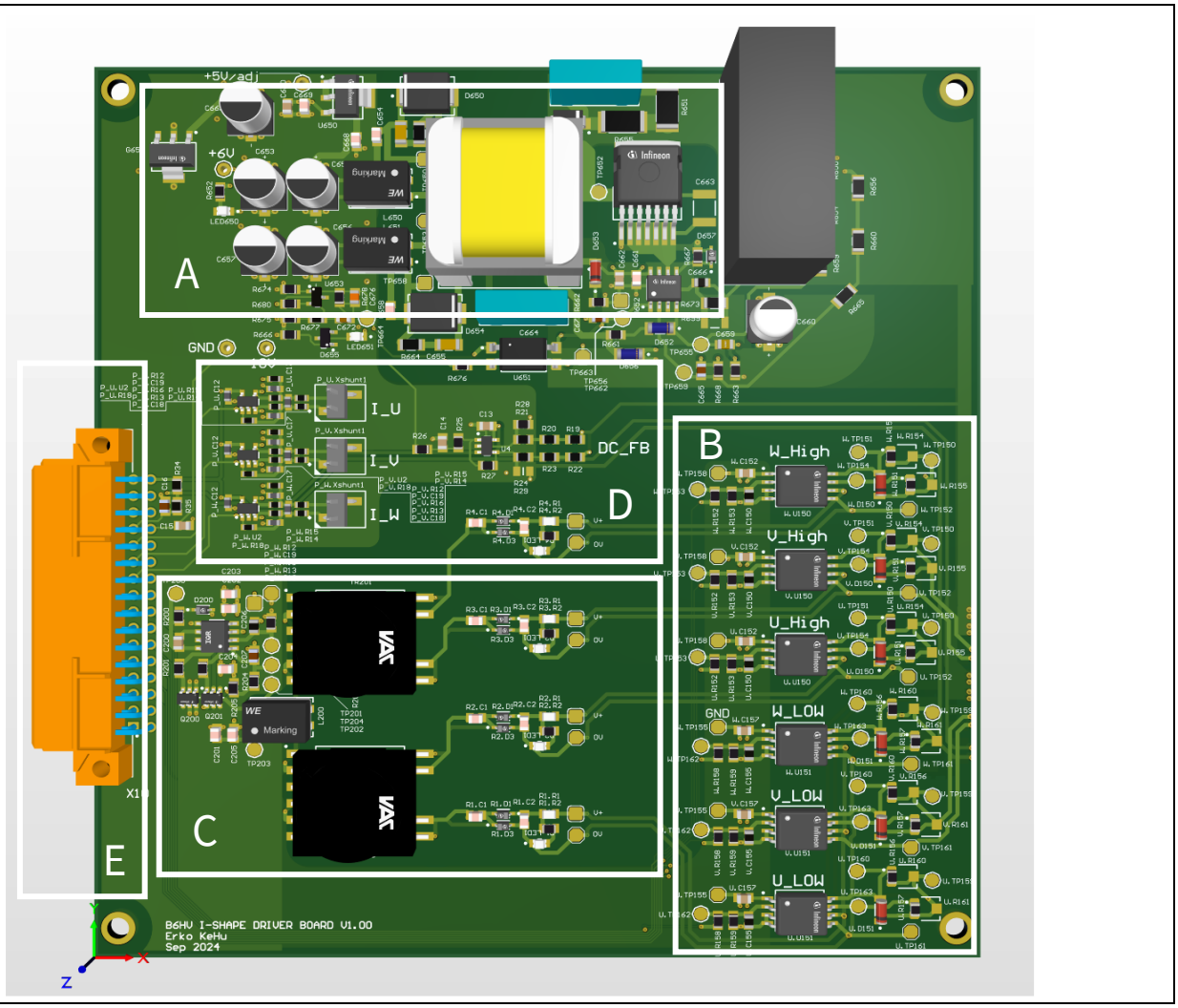


Figure 6 Gate driver board

- **A:** QR flyback converter
- **B:** Gate drivers
- **C:** Forward converter for isolated gate driver voltage creation
- **D:** Current and voltage feedback amplification stage
- **E:** XMC™ XMC4400 Drive Card interface

3.2.1 Current feedback

Three-phase current feedback is taken from the power board connectors (Xshunt_1, Xshunt_2, and Xshunt_3) through 1x2 flat cable and carried to the gate driver board. Pin1 (dotted) is positive feedback and Pin2 is ground for the current feedback.

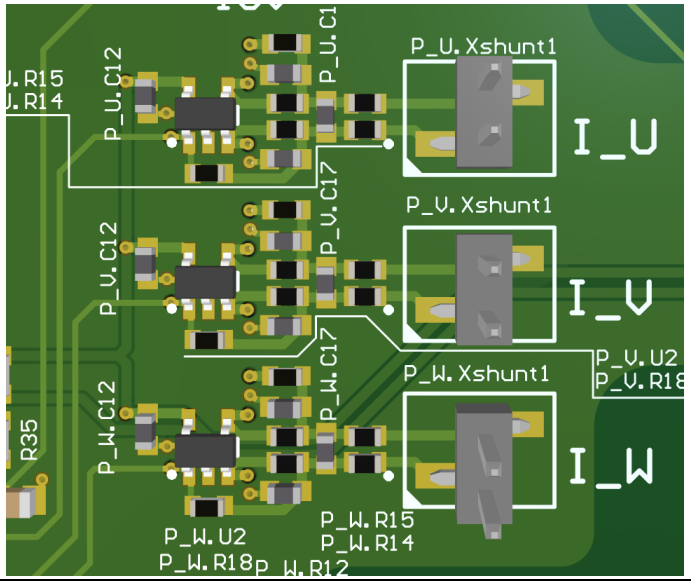


Figure 7 Current feedback

3.3 Capacitor board

The capacitor board keeps the circulating current within the inverter and prevents it from flowing back to the source. The bypass capacitors control the overshoot during switching transitions. The board is mechanically fastened the to the power board with six standard M5 x 6 mm screws. These RS 908-7693 screws are recommended to connect the power board and the capacitor board.

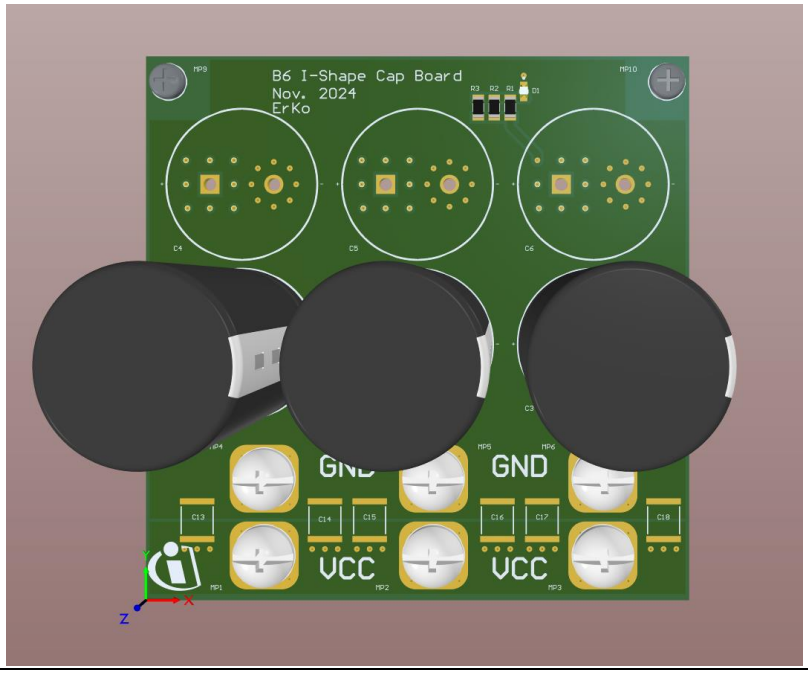


Figure 8 Capacitor board

3.4 XMC™ XMC4400 Drive Card

XMC™ XMC4400 Drive Card (KIT_XMC4400_DC_V1) control card is intended to interface the power board. The X4 connector in the power board is connected to X302 (MAB32B2) on XMC™ XMC4400 Drive Card.

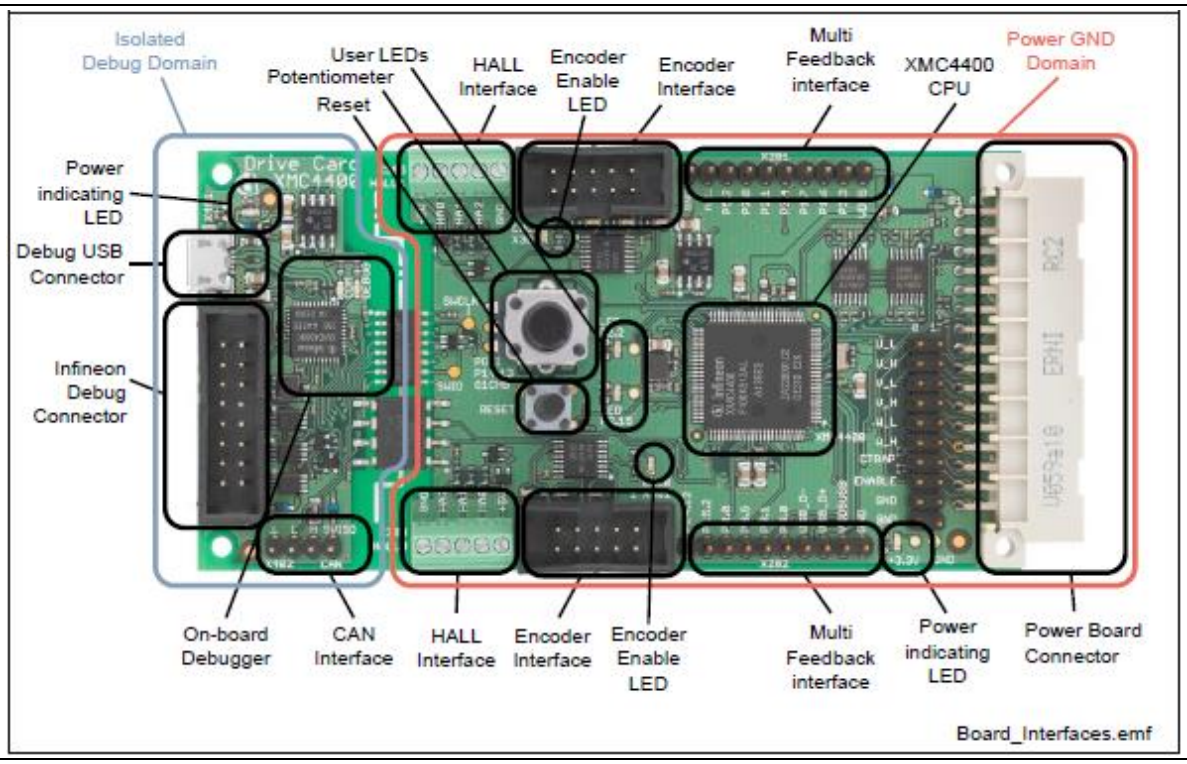


Figure 9 XMC™ XMC4400 Drive Card demonstration board

4 Schematics

4.1 Power board

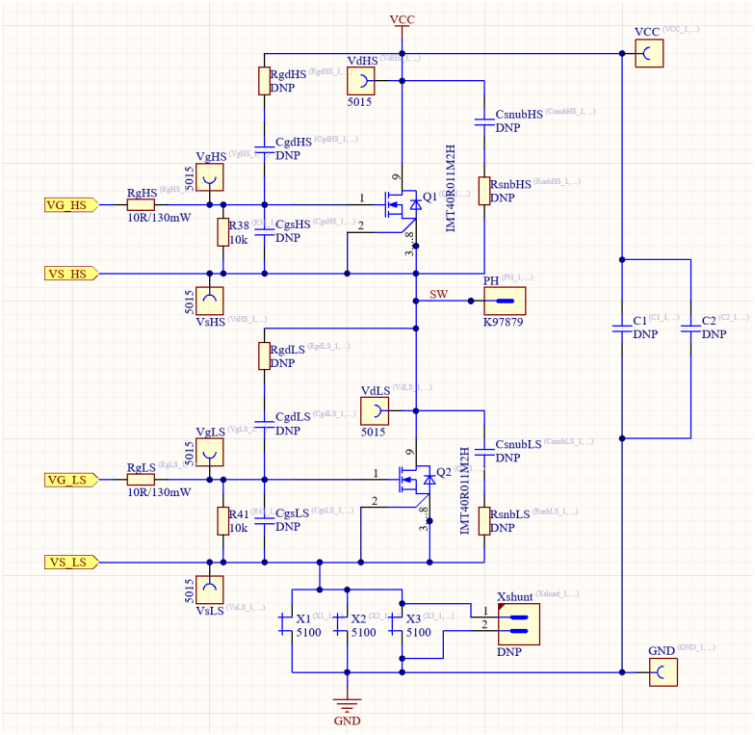


Figure 10 Power board schematic – one phase

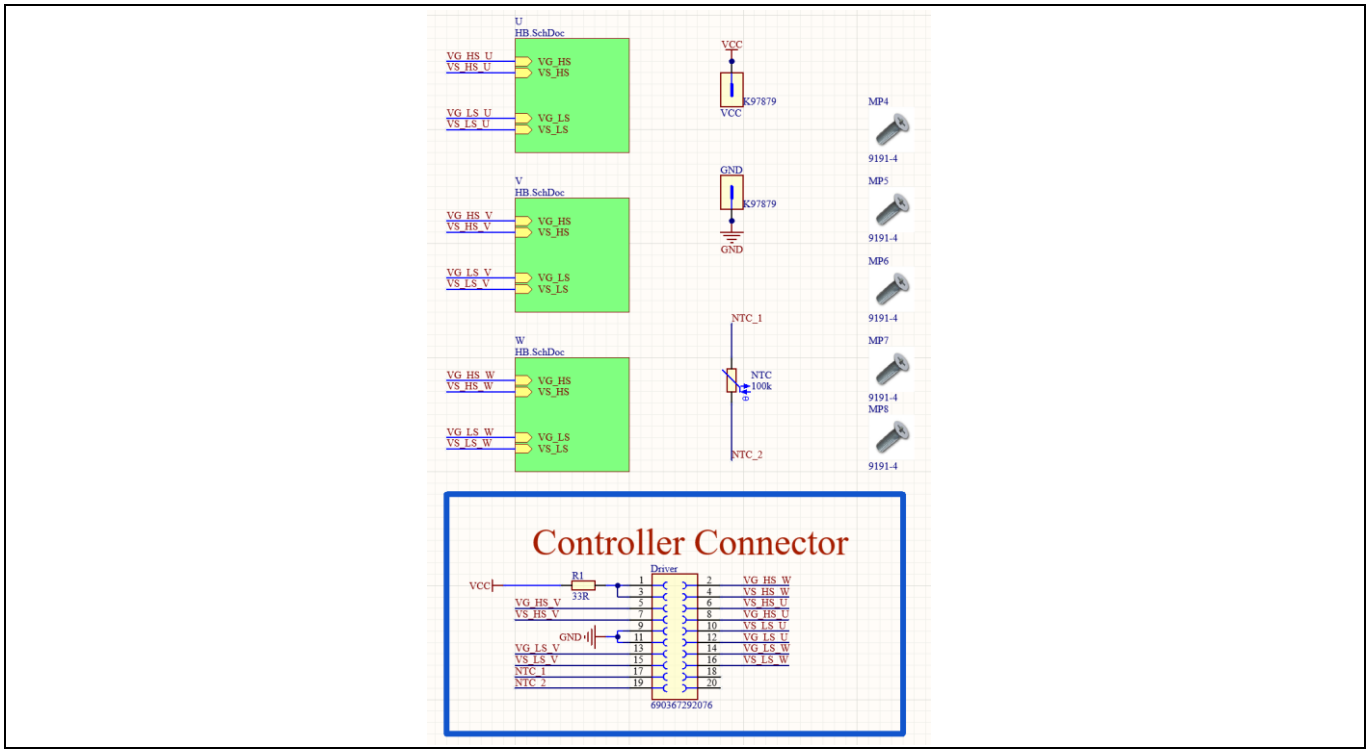


Figure 11 Power board schematic

4.2 Gate driver board

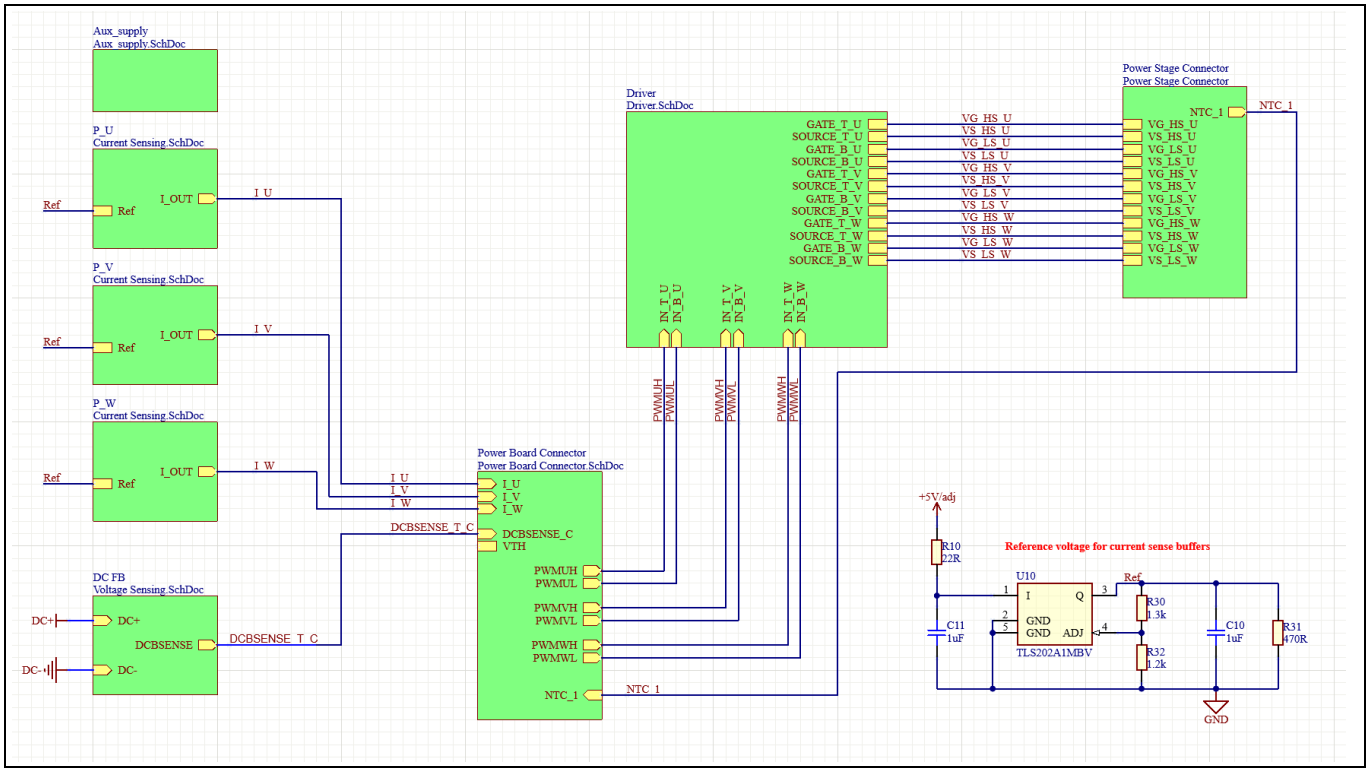


Figure 12 Gate driver board – overview

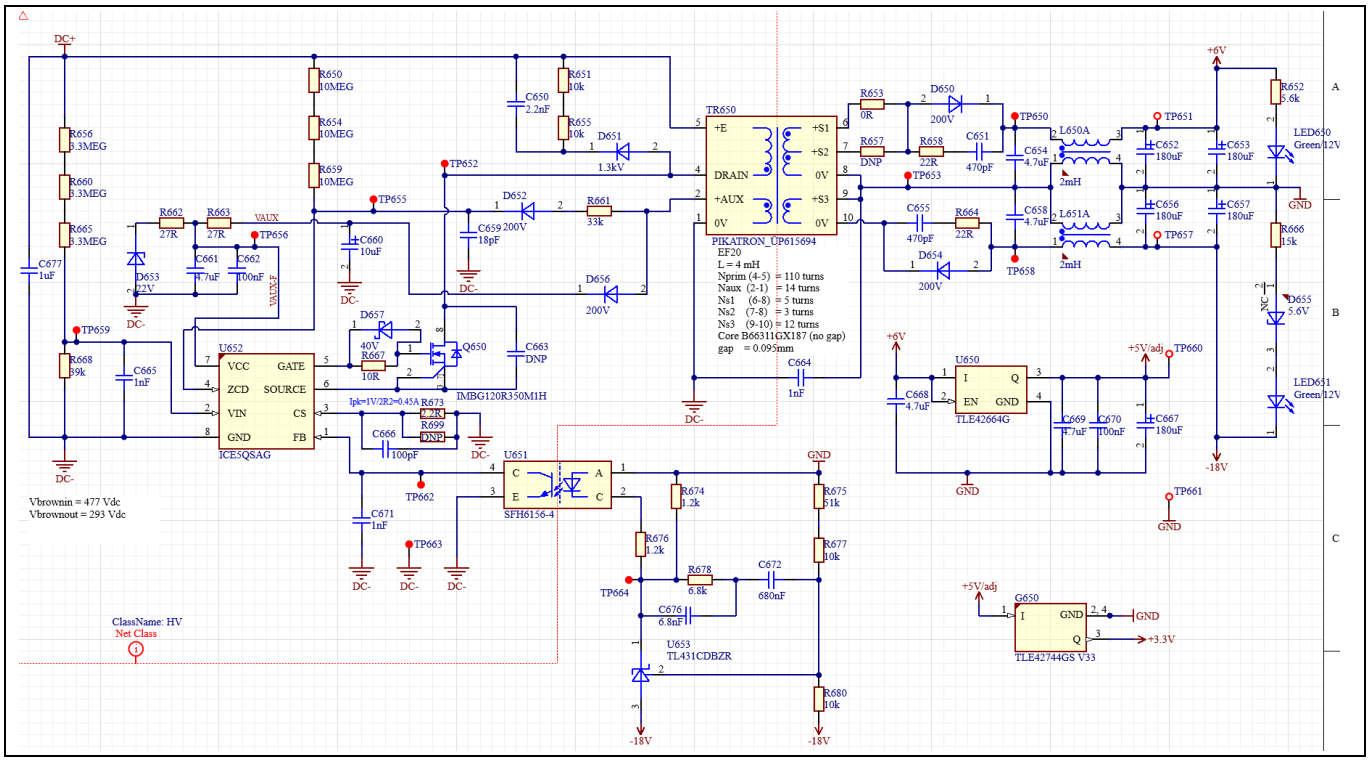


Figure 13 Gate driver board – auxiliary supply

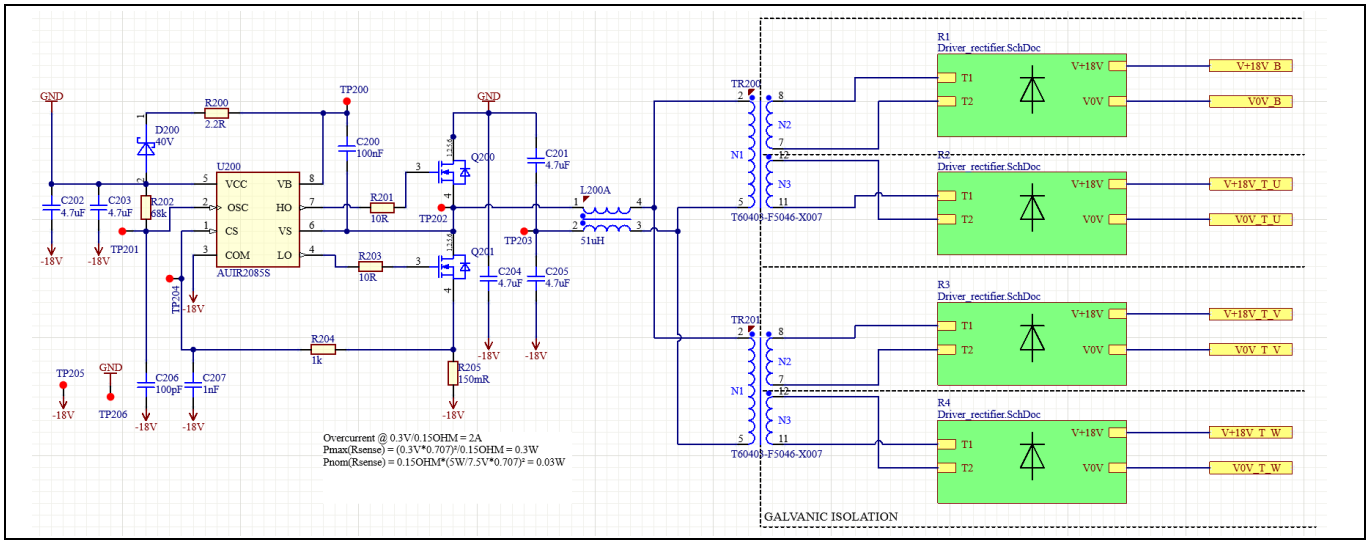


Figure 14 Gate driver board – isolated power supply

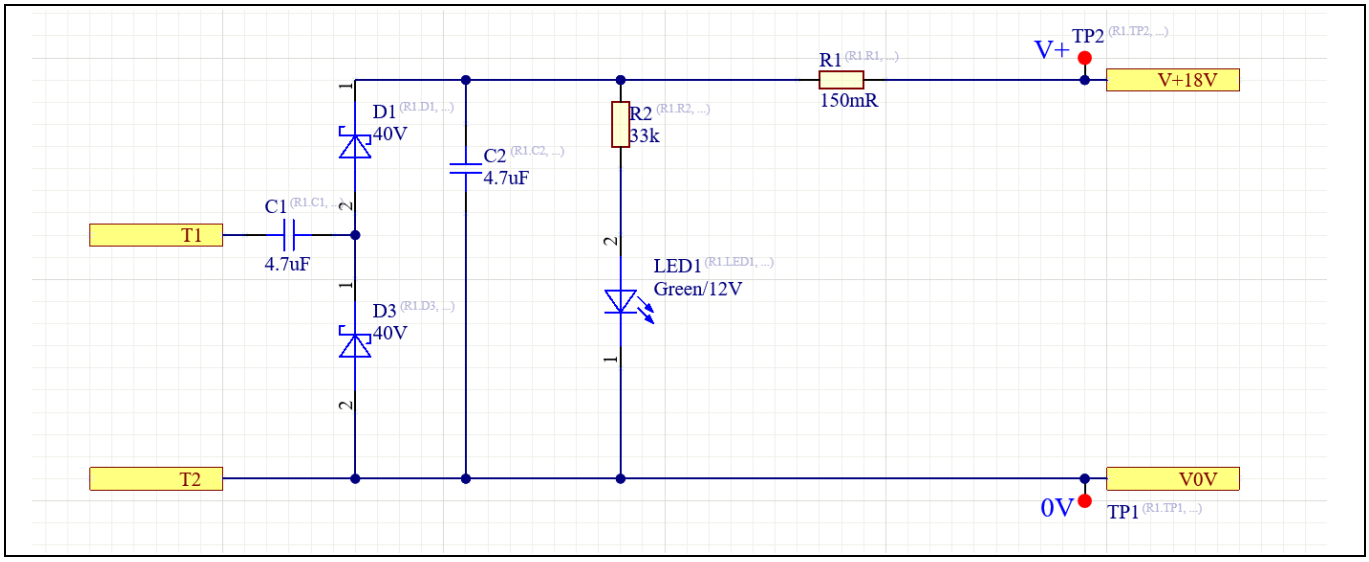


Figure 15 Gate driver board – isolated power supply rectifier

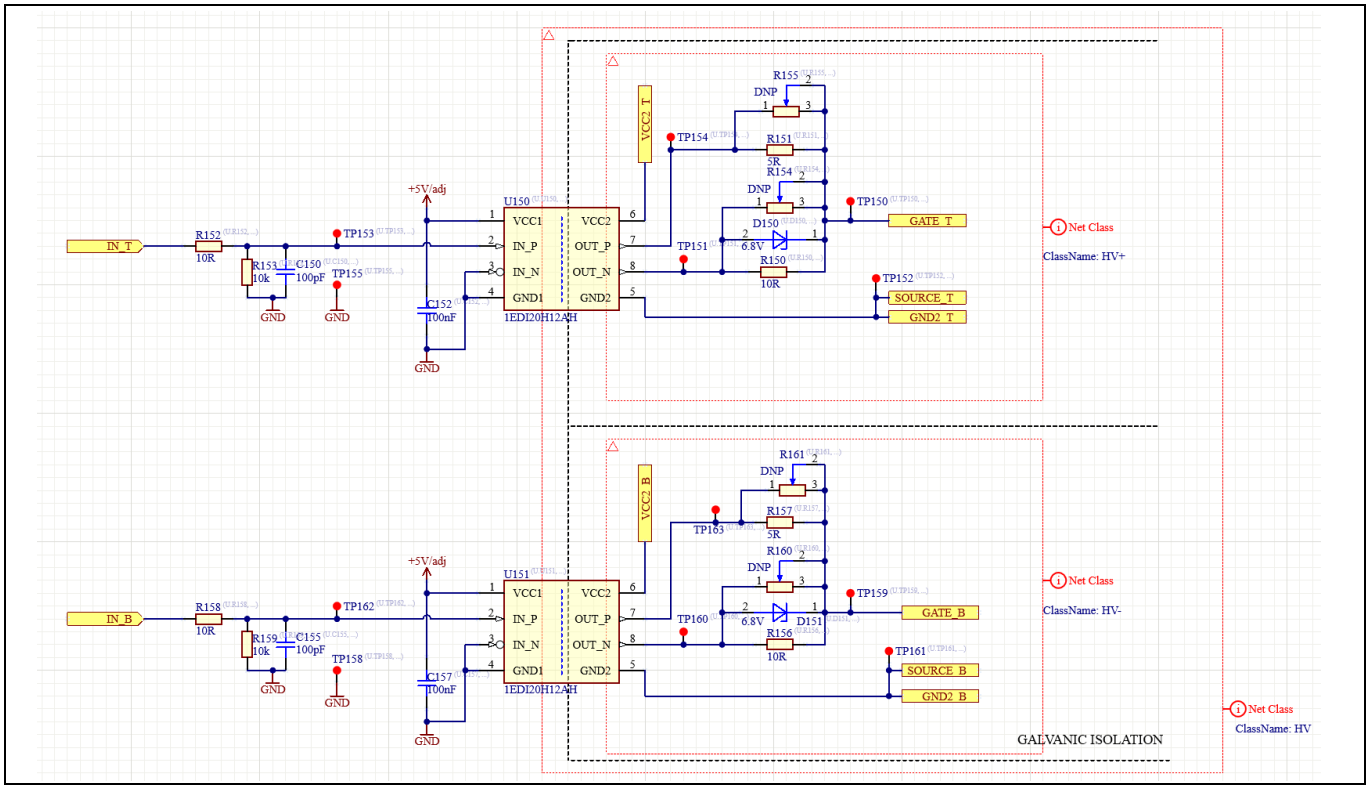


Figure 16 Gate driver board – gate driver single leg

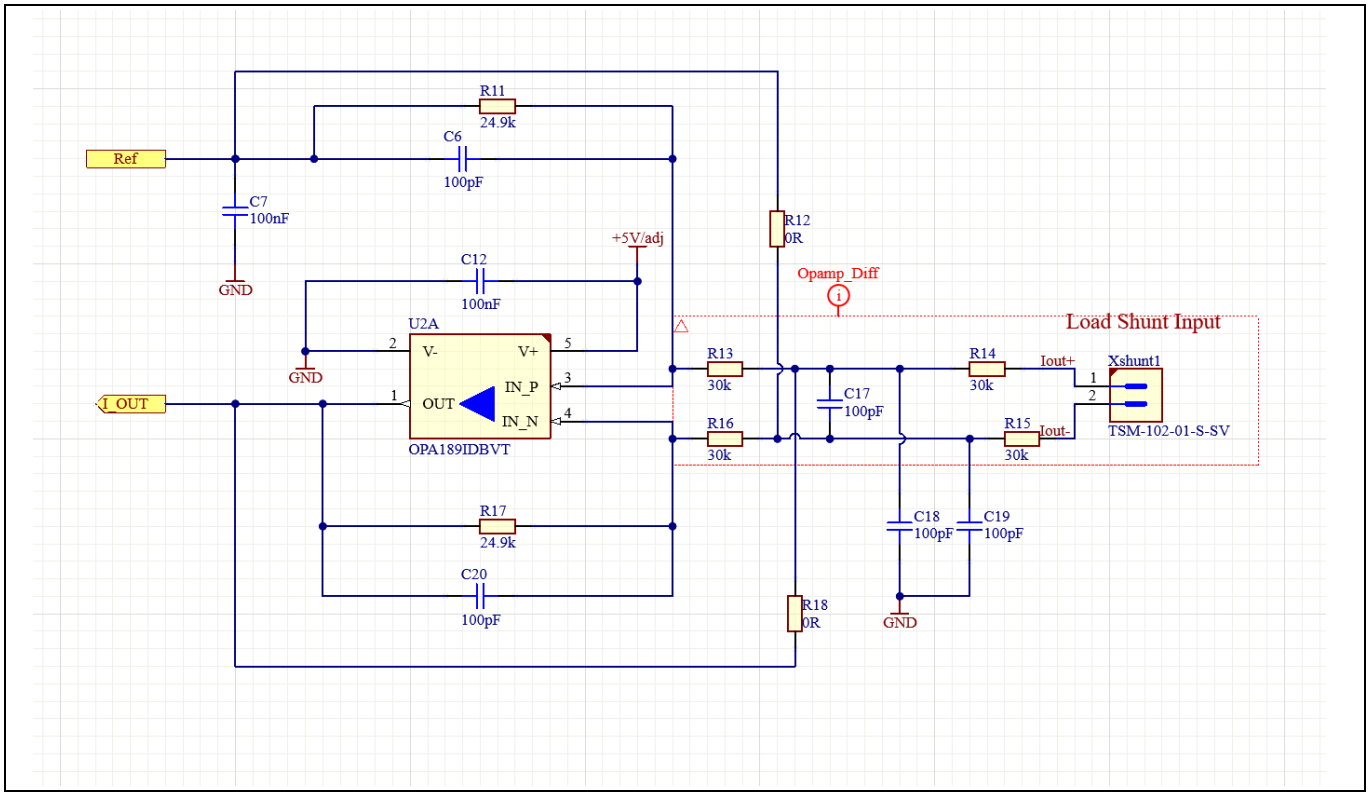


Figure 17 Gate driver board – current sensing

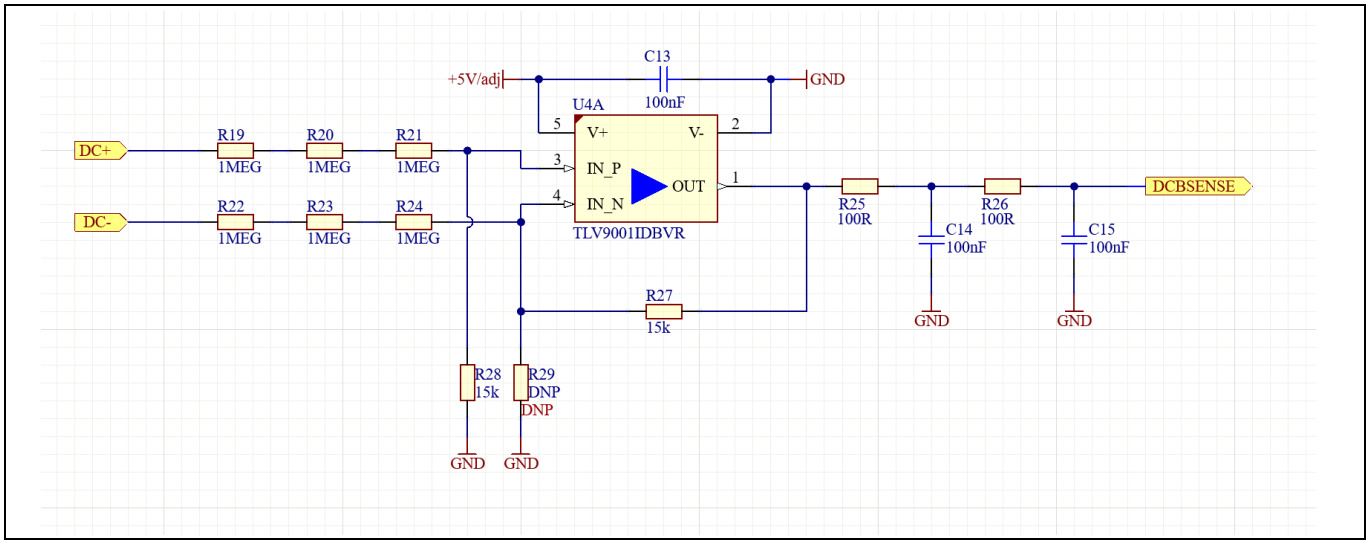


Figure 18 Gate driver board – voltage sensing

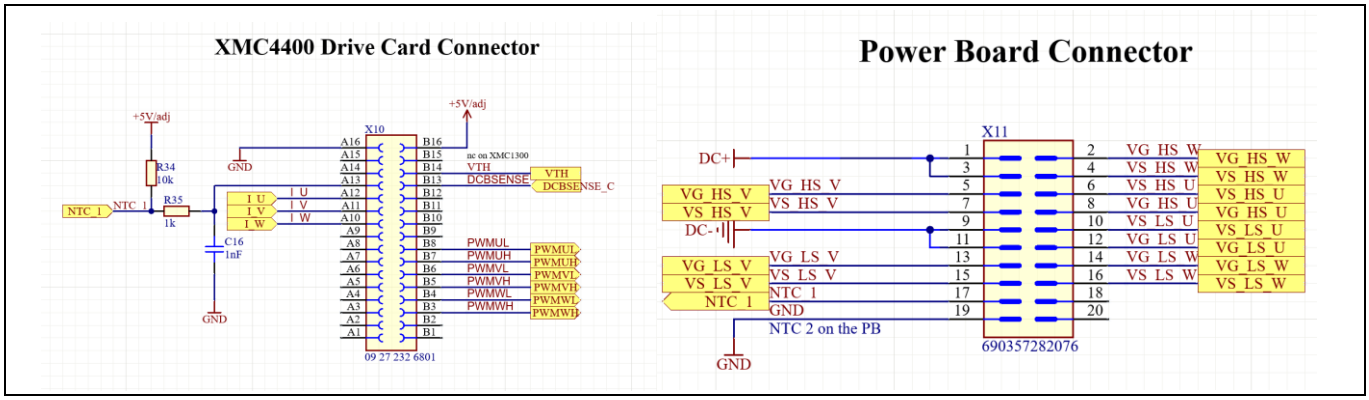


Figure 19 Gate driver board – connectors

4.3 Capacitor board

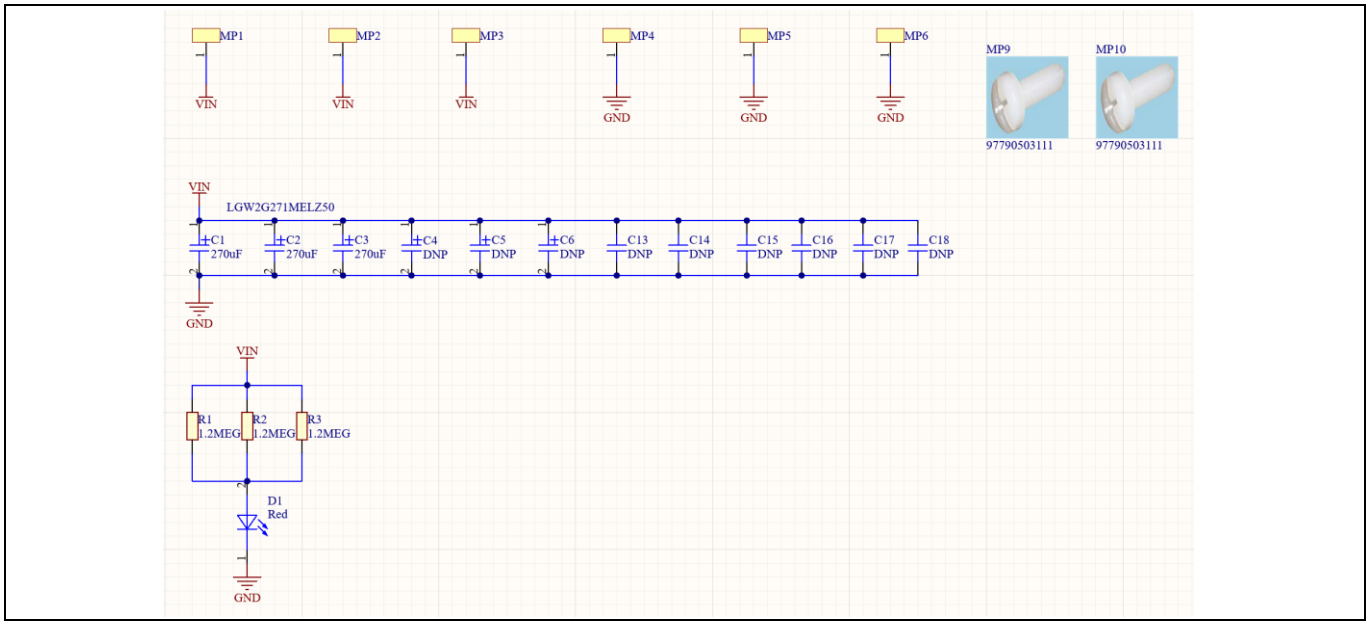


Figure 20 Capacitor board

5 PCB layout

5.1 Power board

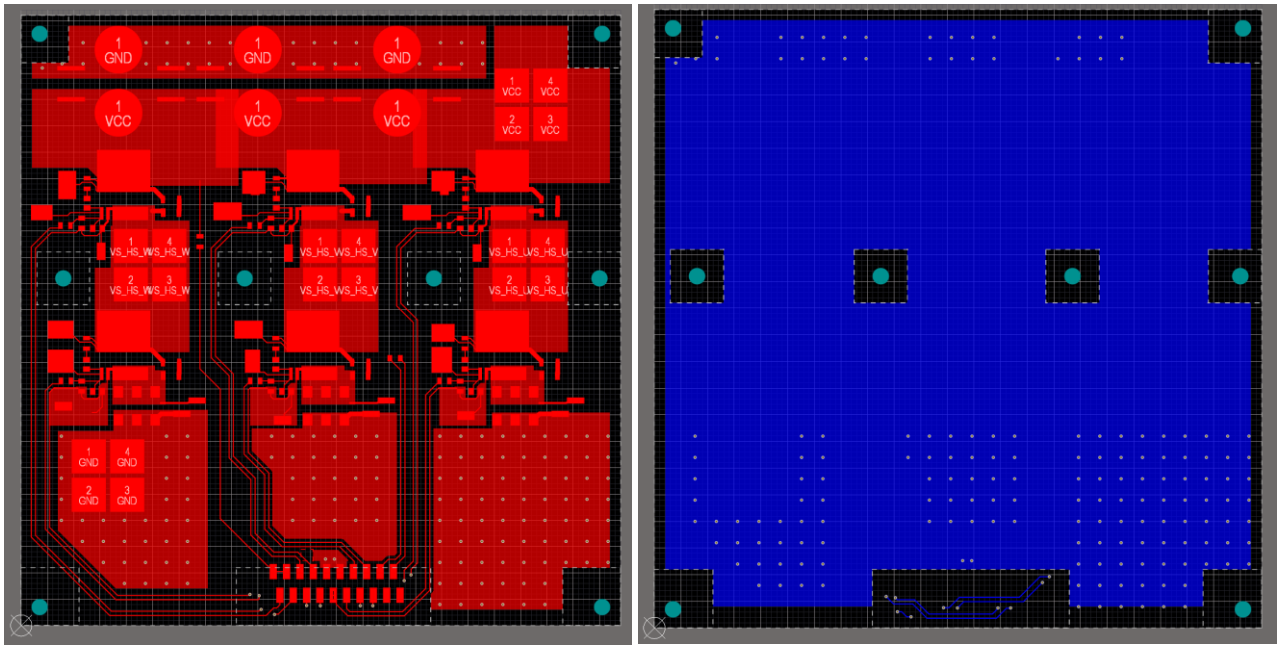
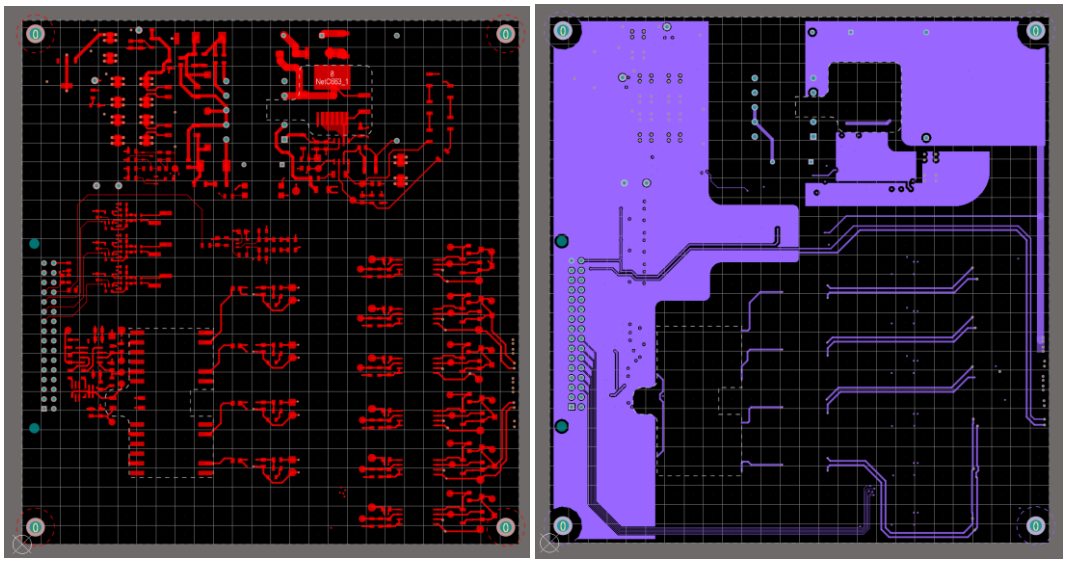


Figure 21 (a) Layer 1 (Top); (b) Layer 2 (Bottom)

Stack up		Layer stack			
Layer	Board layer stack	Name	Material	Thickness	Constant
1		Top Paste	–	–	–
2		Top Overlay	–	–	–
3		Top Solder	Solder Resist	0.025 mm	3.5
4		Layer 1	Copper	0.035 mm	–
5		Dielectric 1	S1000H	0.105 mm	4.6
6		Layer 2	Copper	0.107 mm	–
7		Dielectric 2	VT-4B7	0.035 mm	–
8		Alu Core	Aluminum	1.5 mm	–

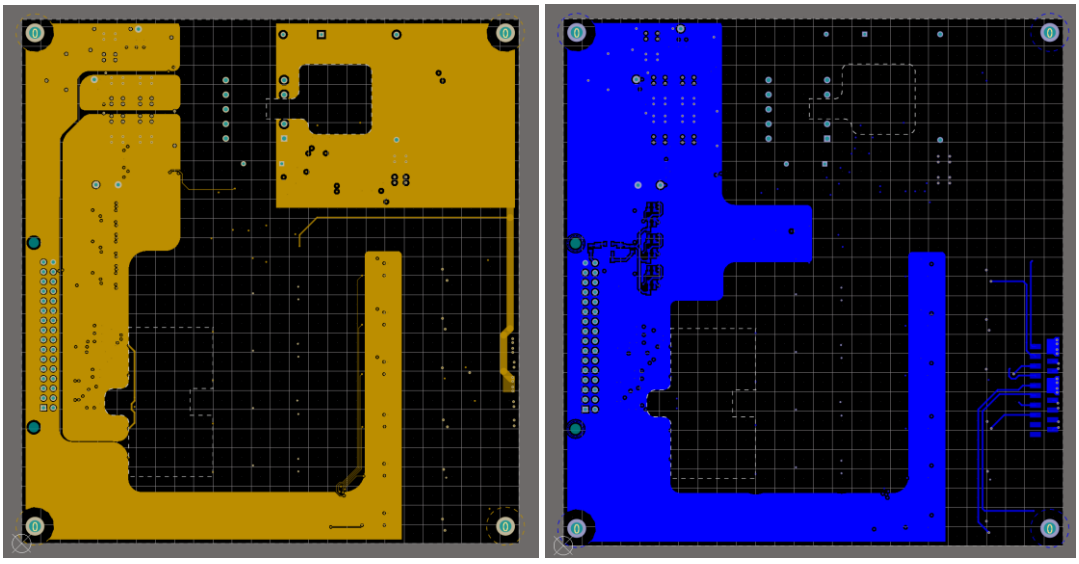
Figure 22 Power board stack up

5.2 Gate driver board



(a) (b)

Figure 23 (a) Layer 1 (Top); (b) Layer 2



(a) (b)

Figure 24 (a) Layer 3; (b) Layer 4 (Bottom)

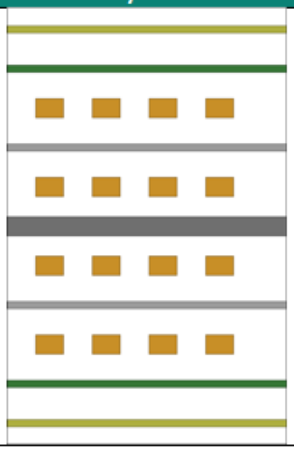
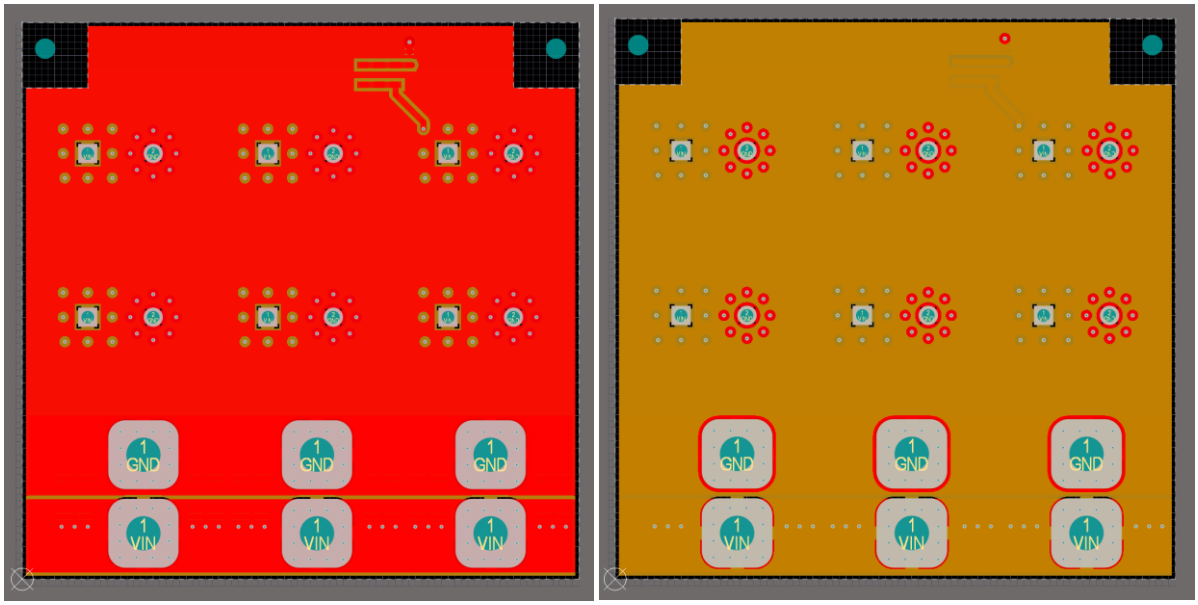
Stack up		Layers stack			
Layer	Board layer stack	Name	Material	Thickness	Constant
1		Top Paste	–	–	–
2		Top Overlay	–	–	–
3		Top Solder	Solder Resist	0.020 mm	3.5
4		Layer 1	Copper	0.035 mm	–
5		Dielectric 1	FR-4	0.140 mm	4.2
6		Layer 2	Copper	0.035 mm	–
7		Core	FR-4	1.200 mm	4.2
8		Layer 3	Copper	0.035 mm	–
9		Dielectric 2	FR-4	0.140 mm	4.2
10		Layer 4	Copper	0.035 mm	–
11		Bottom Solder	Solder Resist	0.020 mm	3.5
12		Bottom Overlay	–	–	–
13		Bottom Paste	–	–	–

Figure 25 Gate driver board stack up

5.3 Capacitor board



(a) (b)

Figure 26 (a) Layer 1 (Top); (b) Layer 2

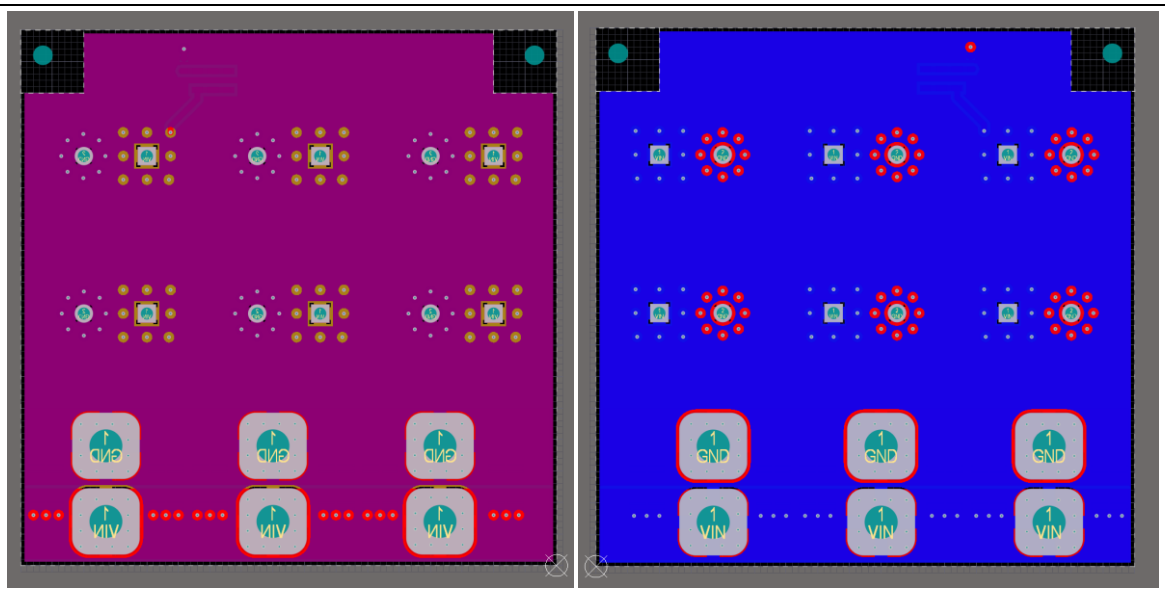


Figure 27 (a) Layer 3; (b) Layer 4 (Bottom)

Stack up		Layer stack			
Layer	Board layer stack	Name	Material	Thickness	Constant
1		Top Paste	–	–	–
2		Top Overlay	–	–	–
3		Top Solder	Solder Resist	0.020 mm	3.5
4		Layer 1	Copper	0.035 mm	-
5		Dielectric 1	FR-4	0.140 mm	4.2
6		Layer 2	Copper	0.035 mm	–
7		Core	FR-4	1.200 mm	4.2
8		Layer 3	Copper	0.035 mm	–
9		Dielectric 2	FR-4	0.140 mm	4.2
10		Layer 4	Copper	0.035 mm	–
11		Bottom Solder	Solder Resist	0.020 mm	3.5
12		Bottom Overlay	–	–	–
13		Bottom Paste	–	–	–

Figure 28 Capacitor board stack up

6 Bill of materials

6.1 Power board

Table 1 Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
Driver	Connector, 2.54 mm pitch, 20 Pins, Female, SMT	1	690367292076	Würth Elektronik	690367292076
GND, PH_1, PH_2, PH_3, VCC	PowerOne Element SMD Bolt M8	5	K97879	Würth Elektronik	K97879
GND_1, GND_2, GND_3, VCC_1, VCC_2, VCC_3	BCS Powerelement Buchse M5, SMD	6	225858	ERNI	225858
MP2_1, MP2_2, MP2_3, MP2_4, MP5, MP6, MP7, MP8	Pan Head Screw, M3X0.5	8	9191-4	Keystone Electronics Corp.	9191-4
NTC	RES / NTC / 100k / 210mW / 1% / - / -40Â°C to 150Â°C / 0805(2012) / SMD / -	1	100k	Vishay	NTCS0805E3104FMT
Q1_1, Q1_2, Q1_3, Q2_1, Q2_2, Q2_3	400V CoolSiC G2 MOSFET, Ideal for High Frequency Switching and Synchronous Rectification	6	IMT40R011M2H	Infineon Technologies	IMT40R011M2H
R1, RgdHS_1, RgdHS_2, RgdHS_3, RgdLS_1, RgdLS_2, RgdLS_3	RES / STD / 33R / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805 / SMD / -	7	33R, DNP	Vishay	CRCW080533R0FK
R38_1, R38_2, R38_3, R41_1, R41_2, R41_3	RES / STD / 10k / 500mW / 5% / 200ppm/K / -55°C to 155°C / 0805(2012) / SMD / -	6	10k	Panasonic	ERJP06J103V
RgHS_1, RgHS_2, RgHS_3, RgLS_1, RgLS_2, RgLS_3	RES / STD / 10R/130mW / 130mW / 1% / 200ppm/K / -55°C to 155°C / 0805(2012) / SMD / -	6	10R/130mW	Yageo	RC0805FR-0710RL

Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
RsnbHS_1, RsnbHS_2, RsnbHS_3, RsnbLS_1, RsnbLS_2, RsnbLS_3	RES / STD / 33R / 250mW / 5% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	6	DNP	Yageo	AC1206JR-0733RL
VdHS_1, VdHS_2, VdHS_3, VdLS_1, VdLS_2, VdLS_3, VgHS_1, VgHS_2, VgHS_3, VgLS_1, VgLS_2, VgLS_3, VsHS_1, VsHS_2, VsHS_3, VsLS_1, VsLS_2, VsLS_3	Test Point, Miniature, Surface Mount, Finish-Silver Plate	18	5015	Keystone Electronics Corp.	5015
X1_1, X1_2, X1_3, X2_1, X2_2, X2_3, X3_1, X3_2, X3_3	Jumper-0.64mm Thick Copper	9	5100	Keystone Electronics Corp.	5100
Xshunt_1, Xshunt_2, Xshunt_3	SMT .025 SQ Post Header, 2.54mm pitch, 2 pin, vertical, single row	3	DNP	Samtec	TSM-102-01-S-SV

6.2 Gate driver board

Table 2 Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
C10, C11	CAP / CERA / 1uF / 25V / 10% / X7R (EIA) / -55°C to 125°C / 0805(2012) / SMD / -	2	1uF	AVX	08053C105K4Z2A
C13, C14, C15, C200, C662, C670, U.C152, U.C157, V.C152, V.C157, W.C152, W.C157	CAP / CERA / 100nF / 50V / 5% / X7R (EIA) / -55Â°C to 125Â°C / 0805(2012) / SMD / -	12	100nF	Kemet	C0805C104J5RACAUTO
C16, C207, C665, C671	CAP / CERA / 1nF / 50V / 10% / X7R (EIA) / -55Â°C to 125Â°C / 0805(2012) / SMD / -	4	1nF	Kyocera	08055C102KAT2A
C201, C202, C203, C204, C205, C654, C658, C661, C668, C669, R1.C1, R1.C2, R2.C1, R2.C2, R3.C1, R3.C2, R4.C1, R4.C2	CAP / CERA / 4.7uF / 50V / 10% / X5R (EIA) / -55Â°C to 85Â°C / 0805(2012) / SMD / -	18	4.7uF	Samsung	CL21A475KBQNNNE
C206, C666, U.C150, U.C155, V.C150, V.C155, W.C150, W.C155	CAP / CERA / 100pF / 50V / 5% / C0G (EIA) / NP0 / -55Â°C to 125Â°C / 0805(2012) / SMD / -	8	100pF	Würth Elektronik	885012007057
C650	CAP / FILM / 2.2nF / 1.5kV / 20% / MKP (Metallized Polypropylene) / - / 10.00mm C X 0.60mm W 13.00mm L X 4.00mm T X 9.00mm H / THT / -	1	2.2nF	TDK Corporation	B32021A3222M289
C651, C655	CAP / CERA / 470pF / 200V / 5% / C0G (EIA)	2	470pF	Kemet	C1206C471J2GAC7800

Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
	/ NP0 / -55°C to 125°C / 1206(3216) / SMD / -				
C652, C653, C656, C657, C667	CAP / ELCO / 180uF / 16V / 20% / Aluminium electrolytic / -55°C to 105°C / 6.60mm L X 6.60mm W X 6.00mm H / SMD / -	5	180uF	Panasonic	16SVPF180M
C659	CAP / CERA / 18pF / 50V / 10% / C0G (EIA) / NP0 / -55°C to 125°C / 0805(2012) / SMD / -	1	18pF	Kemet	C0805C180K5GAC7800
C660	CAP / ELCO / 10uF / 50V / 20% / Aluminiumelectrolytic / -55°C to 105°C / 6.60mm L X 6.60mm W X 6.30mm H / SMD / -	1	10uF	NIC Components Corp.	NACZ100M50V6.3X6.3TR15F
C664	CAP / FILM / 1nF / 1.5kV / 10% / MKP (Metallized Polypropylene) / - / 10.00mm C X 0.60mm W 13.00mm L X 4.00mm T X 9.00mm H / THT / -	1	1nF	TDK Corporation	B32021A3102K000
C672	CAP / CERA / 680nF / 50V / 10% / X7R (EIA) / -55Â°C to 125Â°C / 0805(2012) / SMD / -	1	680nF	Kemet	C0805X684K5RECAUTO
C676	CAP / CERA / 6.8nF / 50V / 5% / C0G (EIA) / NP0 / -55Â°C to 150Â°C / 0805(2012) / SMD / -	1	6.8nF	TDK Corporation	CGA4C2NP01H682J060AA
C677	CAP / FILM / 1uF / 750V / 10% / MKP (Metallized Polypropylene) / -40°C to 105°C / 27.50mm C X 0.80mm W 31.50mm L X 12.50mm T X 21.50mm H / THT / -	1	1uF	TDK Corporation	B32674D1105K000

Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
D200, D657, R1.D1, R1.D3, R2.D1, R2.D3, R3.D1, R3.D3, R4.D1, R4.D3	Medium Power AF Schottky Diode	10	40V	Infineon Technologies	BAT165
D650, D654	Surface Mount Ultrafast Power Rectifier	2	200V	ON Semiconductor	MURS320T3G
D651	Highly reliable 1.0 Amp silicon Ultra Fast Recovery rectifier	1	1.3kV	Central Semiconductor Corp	CMR1U-13M TR13
D652, D656	Surface Mount Glass Passivated Ultrafast Rectifier	2	200V	Vishay	EGL34D-E3/98
D653	Voltage Regulator Diode	1	22V	Nexperia	BZV55-C22,115
D655	Zener Voltage Regulator, 5.6V/5mA	1	5.6V	ON Semiconductor	BZX84C5V6LT1 G
G650	Monolithic integrated low dropout voltage regulator, device is designed for the harsh environment of automotive applications, Very Low Current Consumption, Output Current Limitation, Reverse Polarity Protection	1	TLE42744GS V33	Infineon Technologies	TLE42744GS V33
L200	IND / STD / 51uH / 1A / 30% / -40Â°C to 125Â°C / 160mR / SMD / Inductor, SMD; 4-Leads, 9.20 mm W X 6.00 mm L X 5.30 mm H body / SMD / -	1	51uH	Würth Elektronik	744227
L650, L651	IND / STD / 2mH / 600mA / 50% / -40Â°C to 125Â°C / 420mR / SMD / Inductor, SMD; 4-Leads, 9.20 mm W X 6.00 mm L X 5.30 mm H body / SMD / -	2	2mH	Würth Elektronik	744221

Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
LED650, LED651, R1.LED1, R2.LED1, R3.LED1, R4.LED1	CHIPLED, Green Colour, 570nm	6	Green/12V	OSRAM Opto Semiconductors	LG R971-KN-1
P_U.C6, P_U.C17, P_U.C18, P_U.C19, P_U.C20, P_V.C6, P_V.C17, P_V.C18, P_V.C19, P_V.C20, P_W.C6, P_W.C17, P_W.C18, P_W.C19, P_W.C20	CAP / CERA / 100pF / 50V / 1% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / -	15	100pF	Kemet	C0603C101F5GAC
P_U.C7, P_U.C12, P_V.C7, P_V.C12, P_W.C7, P_W.C12	CAP / CERA / 100nF / 25V / 5% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	6	100nF	Kemet	C0603C104J3RAC
P_U.R11, P_U.R17, P_V.R11, P_V.R17, P_W.R11, P_W.R17	RES / STD / 24.9k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	6	24.9k	Vishay	CRCW060324K9FK
P_U.R12, P_U.R18, P_V.R12, P_V.R18, P_W.R12, P_W.R18	Thick Film Resistors - SMD 0 Ohms 100mW 0603 1% AEC-Q200	6	0R	Yageo	AC0603FR-070RL
P_U.R13, P_U.R14, P_U.R15, P_U.R16, P_V.R13, P_V.R14, P_V.R15,	RES / STD / 30k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	12	30k	Vishay	CRCW060330K0FK

Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
P_V.R16, P_W.R13, P_W.R14, P_W.R15, P_W.R16					
P_U.U2, P_V.U2, P_W.U2	Precision, Lowest-Noise 36-V, Zero-Drift, 14-MHz MUX-Friendly, Rail-to-Rail Output, Operational Amplifier	3	OPA189IDBVT	Texas Instruments	OPA189IDBVT
P_U.Xshunt1, P_V.Xshunt1, P_W.Xshunt1	SMT .025 SQ Post Header, 2.54mm pitch, 2 pin, vertical, single row	3	TSM-102-01-S-SV	Samtec	TSM-102-01-S-SV
Q200, Q201	HEXFET Power MOSFET	2	IRFTS8342	Infineon Technologies	IRFTS8342
Q650	Insulated-Gate Field-Effect Transistor (IGFET), N-Channel, Enhancement, Body Diode, Pin 1 Gate, 2 Sense, 3 Source, 4 Source, 5 Source, 6 Source, 7 Source, 8 Drain, 8 Pins	1	IMBG120R350M1H	Infineon Technologies	IMBG120R350M1H
R1.R1, R2.R1, R3.R1, R4.R1	RES / - / 150mR / 500mW / 1% / 50ppm/K / - / 0805(2012) / SMD / -	4	150mR	Susumu	KRL1220E-M-R150-F-T5
R1.R2, R2.R2, R3.R2, R4.R2, R661	RES / STD / 33k / 125mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	5	33k	Vishay	CRCW080533K0FK
R10	RES / STD / 22R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	1	22R	Vishay	CRCW060322R0FK
R19, R20, R21, R22, R23, R24	RES / - / 1MEG / 125mW / 1% / 100ppm/K / - / 0805 / SMD / -	6	1MEG	Multicomp	MCMR08X1004FTL

Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
R25, R26	RES / STD / 100R / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805 / SMD / -	2	100R	Vishay	CRCW0805100R FK
R27, R28	RES / STD / 15k / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805 / SMD / -	2	15k	Vishay	CRCW080515K0 FK
R30	RES / STD / 1.3k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	1	1.3k	Vishay	CRCW06031K30 FK
R31	RES / STD / 470R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	1	470R	Vishay	CRCW0603470R FK
R32	RES / STD / 1.2k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	1	1.2k	Yageo	RC0603FR-071K2L
R34	RES / STD / 10k / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805(2012) / SMD / -	1	10k	Yageo	RC0805FR-0710KL
R35	RES / STD / 1k / 125mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	1	1k	Yageo	AC0805FR-071KL
R200	RES / STD / 2.2R / 125mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	1	2.2R	Vishay	CRCW08052R20 FK
R201, R203, R667, U.R152, U.R158, V.R152, V.R158, W.R152, W.R158	RES / STD / 10R / 125mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	9	10R	Vishay	CRCW080510R0 FK

Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
R202	RES / STD / 68k / 125mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	1	68k	Vishay	CRCW080568K0FK
R204	RES / STD / 1k / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805(2012) / SMD / -	1	1k	Vishay	CRCW08051K00FK
R205	RES / STD / 150mR / 125mW / 1% / 250ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	1	150mR	Panasonic	ERJ-6RSFR15V
R650, R654, R659	RES / STD / 10MEG / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206(3216) / SMD / -	3	10MEG	Vishay	CRCW120610M0FK
R651, R655	RES / STD / 10k / 1W / 1% / 100ppm/K / -55Â°C to 155Â°C / 2512(6332) / SMD / -	2	10k	Vishay	CRCW251210K0FK
R652	RES / STD / 5.6k / 125mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	1	5.6k	Vishay	CRCW08055K60FK
R653	RES / STD / 0R / 125mW / - / - / -55Â°C to 155Â°C / 0805(2012) / SMD / -	1	0R	Vishay	CRCW08050000Z
R656, R660, R665	RES / STD / 3.3MEG / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206(3216) / SMD / -	3	3.3MEG	Vishay	CRCW12063M30FKEA
R658, R664	RES / STD / 22R / 250mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 1206(3216) / SMD / -	2	22R	Vishay	CRCW120622R0FK
R662, R663	RES / STD / 27R / 125mW / 1% /	2	27R	Vishay	CRCW080527R0FK

Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
	100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -				
R666	RES / STD / 15k / 125mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	1	15k	Vishay	CRCW080515K0FK
R668	RES / STD / 39k / 125mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	1	39k	Vishay	CRCW080539K0FK
R673	RES / STD / 2.2R / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206(3216) / SMD / -	1	2.2R	Vishay	CRCW12062R20FK
R674, R676	RES / STD / 1.2k / 125mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	2	1.2k	Vishay	CRCW08051K20FK
R675	RES / STD / 51k / 125mW / 1% / 100ppm/K / -55¡ãC to 155¡ãC / 0805(2012) / SMD / -	1	51k	Vishay	CRCW080551K0FK
R677	RES / STD / 10k / 125mW / 1% / 100ppm/K / -55¡ãC to 155¡ãC / 0805(2012) / SMD / -	1	10k	Yageo	RC0805FR-0710KL
R678	RES / STD / 6.8k / 125mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	1	6.8k	Vishay	CRCW08056K80FK
R680, U.R153, U.R159, V.R153, V.R159, W.R153, W.R159	RES / STD / 10k / 125mW / 1% / 100ppm/K / -55Â°C to 155Â°C / 0805(2012) / SMD / -	7	10k	Vishay	CRCW080510K0FK

Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
TR200, TR201	Pulse transformers GateDrive Transf SMD 1: 1: 1 85uVs 850V	2	T60403-F5046-X007	Vacuumschmelze	T60403-F5046-X007
TR650	Flyback Transformer	1		Pikatron	ÜP615694
U4	Low-Power, RRIO, 1-MHz Operational Amplifier for Cost-Sensitive Systems	1	TLV9001IDBVR	Texas Instruments	TLV9001IDBVR
U10	Adjustable Linear Voltage Post Regulator, Adjustable Output Voltage from 1.2 V to 5.25 V	1	TLS202A1MBV	Infineon Technologies	TLS202A1MBV
U200	High Speed, 100V, Self-Oscillating 50% Duty Cycle, Half-Bridge Driver	1	AUIR2085S[1]	Infineon Technologies	AUIR2085S
U650	Monolithic integrated low dropout fixed voltage regulator for load currents up to 100 mA, Temp Range(-40°C to 150°C)	1	TLE42664G	Infineon Technologies	TLE42664G
U651	Optocoupler, Phototransistor Output, High Reliability	1	SFH6156-4	Vishay	SFH6156-4
U652	Quasi-Resonant PWM Controller	1	ICE5QSAG[2]	Infineon Technologies	ICE5QSAG
U653	Precision Programmable Reference	1	TL431CDBZR	Texas Instruments	TL431CDBZR
U.D150, U.D151, V.D150, V.D151, W.D150, W.D151	Voltage Regulator Diode/6.8V	6	6.8V	Nexperia	BZV55-C6V8,115
U.R150, U.R156, V.R150,	RES / STD / 10R / 125mW / 1% / 100ppm/K / -55°C to	6	10R	Vishay	CRCW080510R0FK

[1]AUIR2085S is not recommended for new designs; instead, use IR2085S.

[2]ICE5QSAG is not recommended for new designs; instead, use ICE5QSBG.

Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
V.R156, W.R150, W.R156	155°C / 0805(2012) / SMD / -				
U.R151, U.R157, V.R151, V.R157, W.R151, W.R157	RES / STD / 5R / 500mW / 1% / 100ppm/K / - / 0805(2012) / SMD / -	6	5R	Vishay	CRCW08055R00FKEAHP
U.U150, U.U151, V.U150, V.U151, W.U150, W.U151	Single Channel IGBT Gate Driver IC, Output Current Configuration (±2.0 A for High Speed IGBTs)	6	1EDI20H12AH[1]	Infineon Technologies	1EDI20H12AH
X10	DIN Signal Type 2Q Female Solder Angled 32 Pole, Connector, THT, 2.54 Pitch, 32 Pin	1	09 27 232 6801	Harting	09 27 232 6801
X11	WR MM Male SMT Connector, 20 Position, 2.54 Pitch, 1.5A, 250V	1	690357282076	Würth Elektronik	690357282076

[1]1EDI20H12AH is not recommended for new designs; instead, use 1EDI20I12MF.

6.3 Capacitor board

Table 3 Bill of materials

Designator	Description	Qty	Value	Manufacturer	Manufacturer order number
C1, C2, C3	CAP / ELCO / 270uF / 400V / 20% / Aluminiumelectrolytic / -25°C to 105°C / 10.00mm Pitch X 23.50mm Dia X 52.00mm H body / THT / -	3	3	Nichicon	LGW2G271MELZ50
D1	CHIP LED	1	1	OSRAM Opto Semiconductors	LS R976-NR-1
MP1, MP2, MP3, MP4, MP5, MP6	M5 Screw Footprint	6	6	RS	RS 908-7693
MP9, MP10	Pan Head Screw, M3X5 mm	2	2	Würth Elektronik	97790503111
R1, R2, R3	RES / STD / 1.2MEG / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206(3216) / SMD / -	3	3	Vishay	CRCW12061M20FK

7 System performance

7.1 Power board turn-on and turn-off waveforms

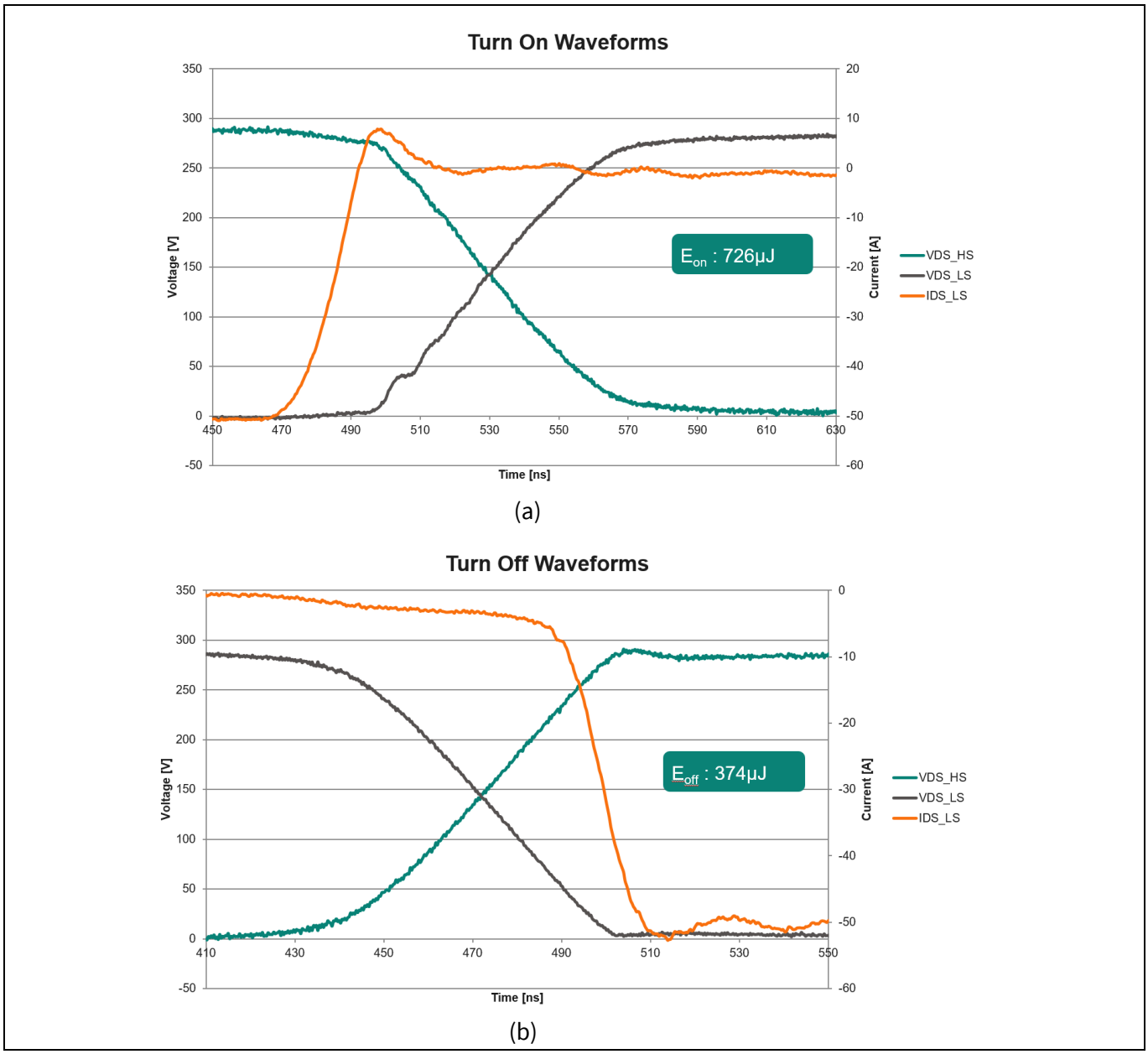


Figure 29 (a) Turn-on; (b) turn-off waveforms

Both turn-on and turn-off waveforms show clear transition with dv/dt lower than 5 V/ns. For this test, an 18 V gate driver voltage together with a 15 Ω turn-on gate resistor (gate driver board: 5 Ω + power board: 10 Ω), and 20 Ω turn-off gate resistor (gate driver board: 10 Ω + power board: 10 Ω) was used for a 300 V input voltage at a 50 A test current.

7.2 Thermal tests

Four different thermal tests were conducted and the thermal tests conditions and results with a heatsink of a thermal resistance value of 1.5 K/W are depicted in Table 4.

Table 4 Thermal test results

Test no.	VDC (V)	Iphs (A)	Vphs (V)	RG(on) (Ω)	RG(oFF) (Ω)	fsw (kHz)	Dead-time (ns)	Modulator	S (VA)	P (W)	Ploss (W)	Tj, max (°C)	Efficiency (%)
#1	300	31.5	101	15	20	10	150	SinPWM	9435	7548	59.58	119	99.22
#2	300	26.2	101	15	20	10	150	SinPWM	7863	6290.4	42.579	92	99.33
#3	300	20.9	101	15	20	10	150	SinPWM	6270	5016	29.46	71	99.42
#4	300	15.7	101	15	20	10	150	SinPWM	4710	3768	18.834	55	99.50

References

[1] Infineon Technologies AG: *KIT_XMC4400_DC_V1 webpage*; Available online

[2] Infineon Technologies AG: *IMT40R011M2H webpage*; Available online

Revision history

Document revision	Date	Description of changes
V 1.0	2025-02-26	Initial release

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