

EVAL-2ED1324S12PM1 User Guide

1200 V SOI gate driver 2ED1324S12P evaluation board

About this document

Scope and purpose

This user guide provides an overview of the evaluation board EVAL-2ED1324S12PM1 including its main features, key components, pin assignments, and mechanical dimensions. This guide also describes how to run a brushless direct current (BLDC) motor.

EVAL-2ED1324S12PM1 is a power evaluation board that includes an M1 connector, one EasyPIM™ 1B 1200 V, 25 A three-phase input rectifier power integrated module (PIM) with TRENCHSTOP™ IGBT7, and three half-bridge silicon-on-insulator (SOI) gate drivers for motor drive applications. In combination with either EVAL-M1-101T or other control board with compatible M1 connectors, the EVAL-2ED1324S12PM1 features and demonstrates Infineon's IGBT module and SOI gate driver technology for motor drives.

EVAL-2ED1324S12PM1 was developed to support users during their first steps in designing applications with Infineon's EasyPIM™ 1B IGBT 7 power integrated module and the half-bridge gate driver.

Intended audience

This document is intended for all technical specialists who have a knowledge of motor control and electronic converters capable of handling several kilowatts of power. The board must be used only under laboratory conditions.

Evaluation board

EVAL-2ED1324S12PM1 is designed to evaluate the 1200 V SOI half-bridge gate driver 2ED1324S12P along with the EasyPIM™ 1B IGBT 7 power integrated module FP25R12W1T7_B11.

This board will be used during design-in process for evaluation and measurement of characteristics, and proof of data sheet specifications.

Note: PCB and auxiliary circuits are NOT optimized for final customer design.

Ordering information

Base part number	Package	Standard pack		Orderable part number
		Form	Quantity	
EVAL-2ED1324S12PM1	MADK EVAL	Boxed	1	EVAL2ED1324S12PM1TOBO1
2ED1324S12P	PG-DSO-24	Tape and Reel	1000	2ED1324S12PXUMA1
EVAL-M1-101T	MADK EVAL	Container	1	EVALM1101TTOBO2
FP25R12W1T7_B11	AG-EASY1B	Tray	24	FP25R12W1T7B11BPSA1
ICE5QSAG	PG-DSO-8	Tape and Reel	2500	ICE5QSAGXUMA1
IMBF170R1K0M1	PG-TO263-7	Tape and Reel	1000	IMBF170R1K0M1XTMA1
IFX25001TFV33	PG-TO252-3	Tape and Reel	2500	IFX25001TFV33ATMA2

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Important notice

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Safety precautions

Safety precautions

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

Table 1 Safety precautions

	<p>Warning: The DC link potential of this board is up to 800 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.</p>
	<p>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.</p>
	<p>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.</p>
	<p>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.</p>
	<p>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.</p>
	<p>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.</p>
	<p>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.</p>
	<p>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.</p>
	<p>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.</p>

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The board at a glance

1 The board at a glance

The evaluation board EVAL-2ED1324S12PM1 provides an AC (or DC) input and a three-phase output for power motors. It contains the gate driver IC 2ED1324S12P, the EasyPIM™ 1B IGBT 7 power integrated module FP25R12W1T7_B11, a heat sink, a relay and a power resistor for inrush current limiter, bus capacitors, a single shunt for current sensing, a voltage divider for DC-link voltage measurement, and other peripheral circuits.

1.1 Scope of delivery

The EVAL-2ED1324S12PM1 evaluation board is delivered along with a daughter board (EVAL-2ED1324S12PM1D) for the gate drivers, and an iMOTION™ 2.0 M1 interface connector.

The package also contains a quasi-resonant, pulse-width modulation (PWM) controller; a CoolSiC™ MOSFET-based auxiliary power supply to provide 15 V and 3.3 V; inrush current limiter; a single shunt for current sensing and overcurrent protection; and a voltage divider for DC-link voltage measurement. The board can be operated directly with the required three-phase AC input or DC power supply without any additional components.

1.2 Block diagram

Figure 1 shows a typical application diagram of EVAL-2ED1324S12PM1 for driving a BLDC motor. The system adopts a single-shunt configuration, which is prevalent for current BLDC motor drive applications.

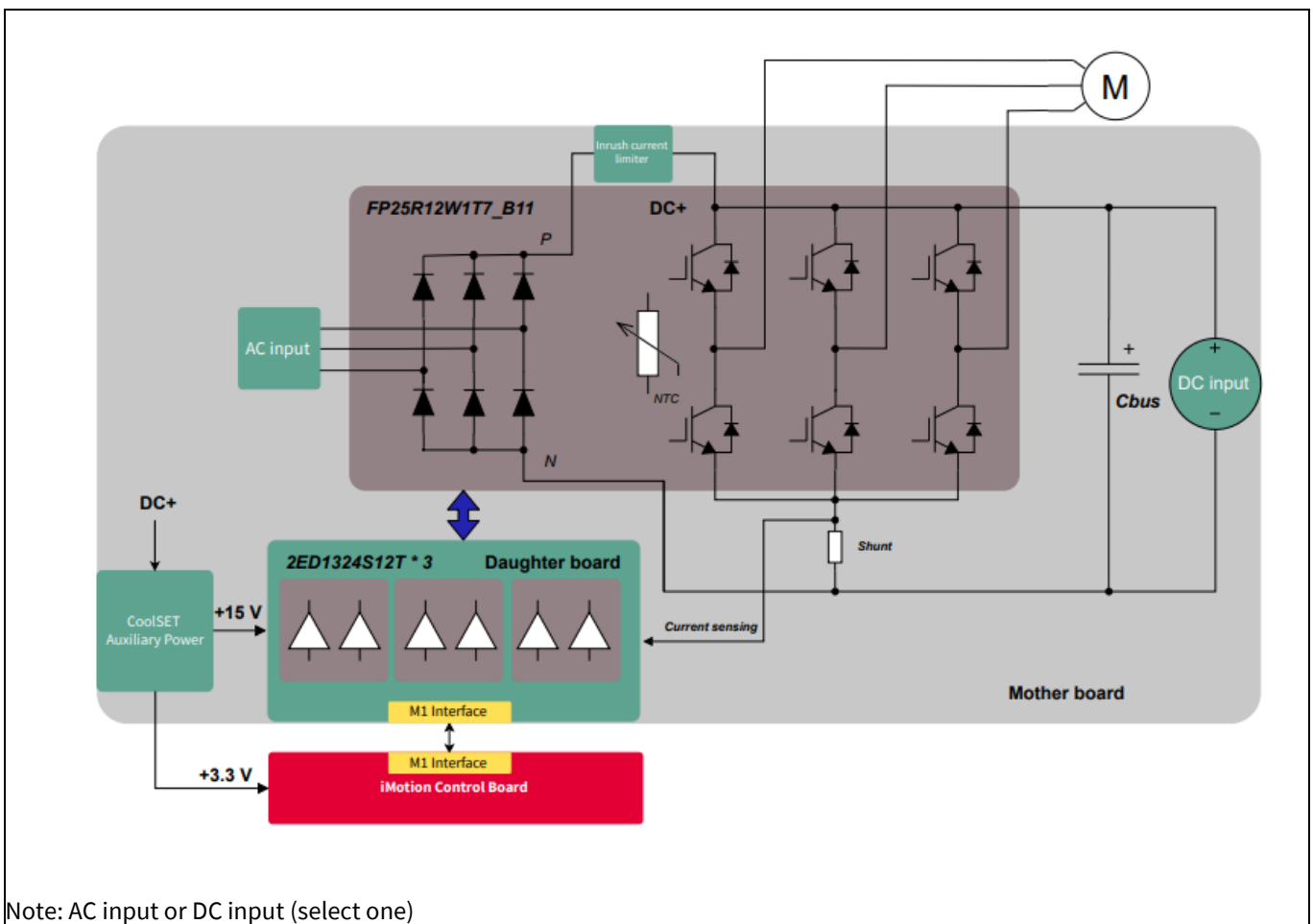


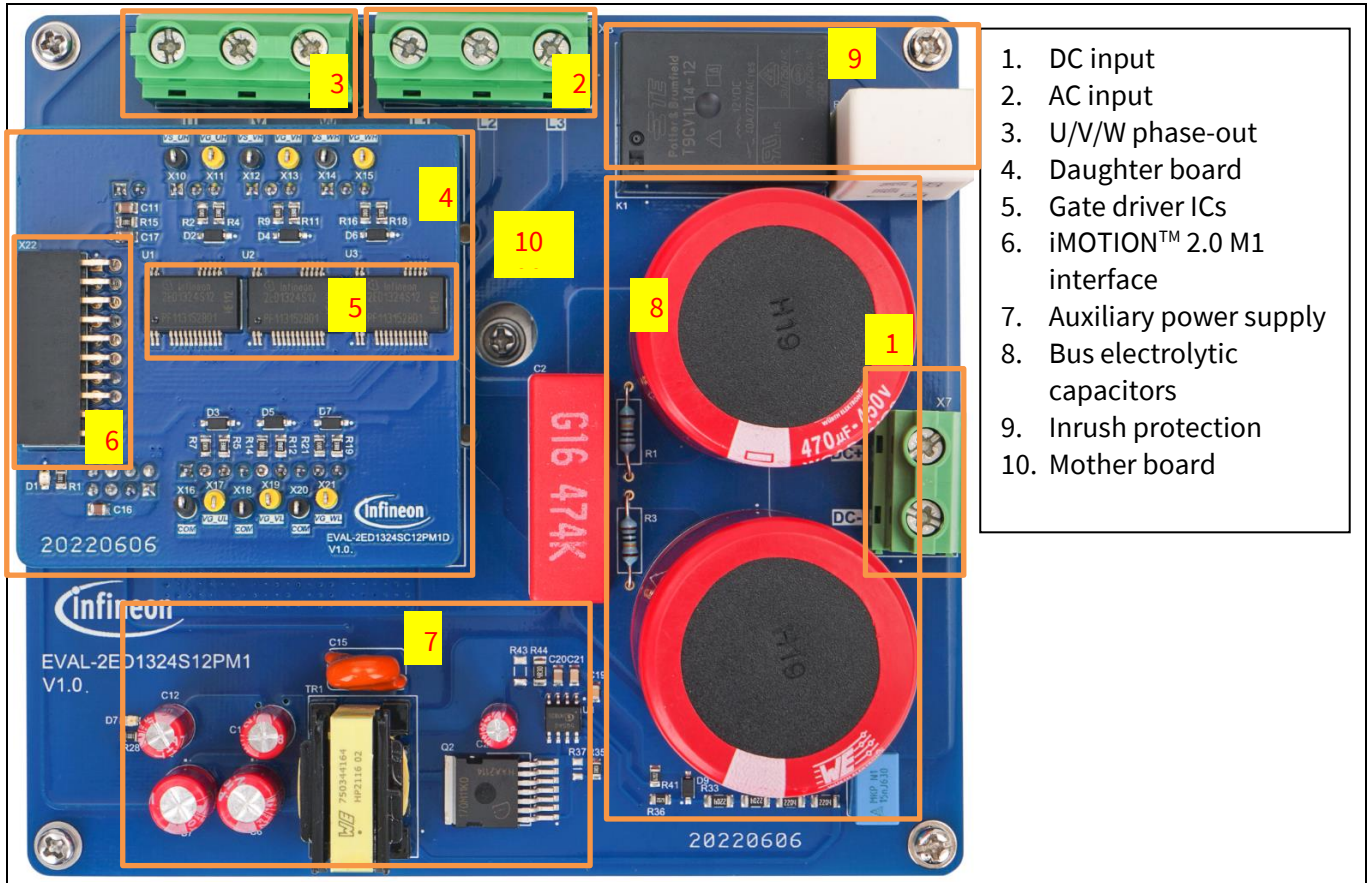
Figure 1 Typical application block diagram of EVAL-2ED1324S12PM1

The functional blocks of EVAL-2ED1324S12PM1 are presented in Figure 2 and Figure 3.

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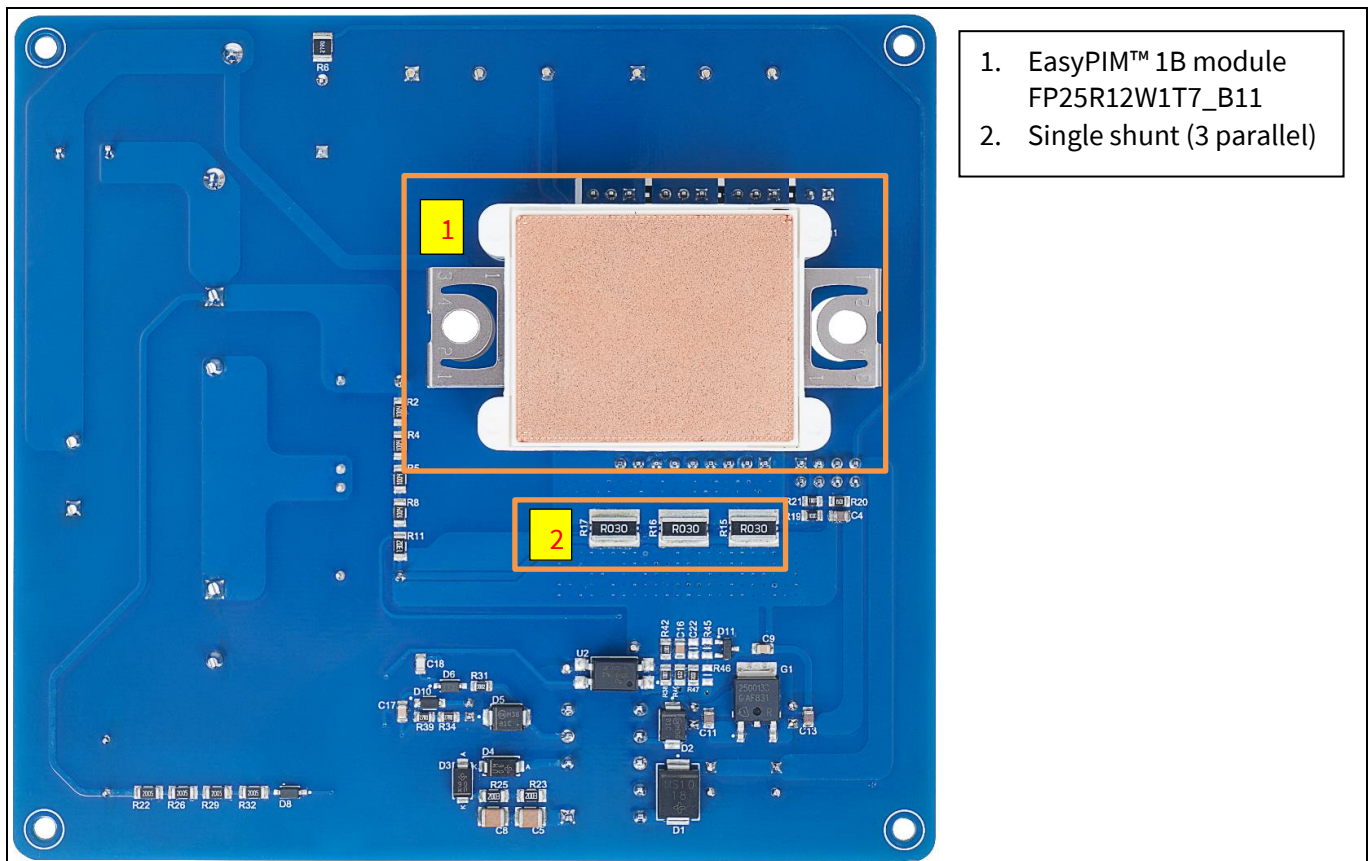
1200 V SOI gate driver 2ED1324S12P evaluation board

The board at a glance



1. DC input
2. AC input
3. U/V/W phase-out
4. Daughter board
5. Gate driver ICs
6. iMOTION™ 2.0 M1 interface
7. Auxiliary power supply
8. Bus electrolytic capacitors
9. Inrush protection
10. Mother board

Figure 2 Functional blocks of EVAL-2ED1324S12PM1 (top view)



1. EasyPIM™ 1B module FP25R12W1T7_B11
2. Single shunt (3 parallel)

Figure 3 Functional blocks of EVAL-2ED1324S12PM1 (bottom view)

The board at a glance

1.3 Main features

The main features of EVAL-2ED1324S12PM1 include:

- Nominal AC input voltage of 380 V
- Inrush current limiter
- Design for maximum 3 kW motor power output
- Single shunt for current sensing
- Sensing of DC-link voltage
- Internal negative temperature coefficient (NTC) thermistor for over-temperature protection
- +15 V and +3.3 V auxiliary power supplies on the board
- M1 interface compatible with the iMOTION™ control board

1.4 Board parameters and technical data

The key specifications of EVAL-2ED1324S12PM1 are listed in Table 2.

Table 2 Specifications of EVAL-2ED1324S12PM1

Parameter	Symbol	Conditions	Value			Unit
			Min.	Nom.	Max.	
Input						
Input voltage	V_{IN}	AC voltage	120	380	500	V
Input current	I_{IN}	Input current	–	–	5.8	A
Output						
Output current	I_{OUT}	RMS phase-out current	–	–	6.7	A
Output power	P_{OUT}	Additional heat dissipation is needed (e.g. forced air cooling)	–	–	3	kW
Overcurrent protection	I_{OCP}	Peak phase-out current	–	–	24.9	A
Thermal protection						
NTC over-temperature threshold	VTH	Configuration in MCEWizard	1.09	2.75	–	V
			100	25	–	°C
Switching frequency						
Inverter carrier frequency	F_{SW}		–	8	–	kHz
Auxiliary power supply						
Gate driver power supply	V_{CC}		–	15	–	V
Controller power supply			–	3.3	–	V
System environment						
Ambient temperature		With adequate cooling method	–	25	–	°C
PCB characteristics						
Dimensions	L	Length	–	130	–	mm
	W	Width	–	120	–	mm
	H	Height	–	111	–	mm

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1200 V SOI gate driver 2ED1324S12P evaluation board



The board at a glance

Parameter	Symbol	Conditions	Value			Unit
			Min.	Nom.	Max.	
Input						
Layer			-	2	-	
PCB thickness			-	1.6	-	mm
Copper thickness			-	2	-	oz.
Weight		Weight of the entire PCB assembly	-	1060	-	g
Material		FR-4, RoHS-compliant				

2 System and functional description

2.1 Getting started with EVAL-2ED1324S12PM1

To run the motor system, a combination of the iMOTION™ power board EVAL-2ED1324S12PM1 and a matching iMOTION™ control board (e.g. EVAL-M1-101T) are required. This chapter explains how to set up the system and get started with the iMOTION™ development platform.

The power board EVAL-2ED1324S12PM1 can run a BLDC motor by connecting to the iMOTION™ 2.0 control board EVAL-M1-101T through an M1 interface. The system connection is shown in Figure 4, and the test results are listed in Section 4.1.

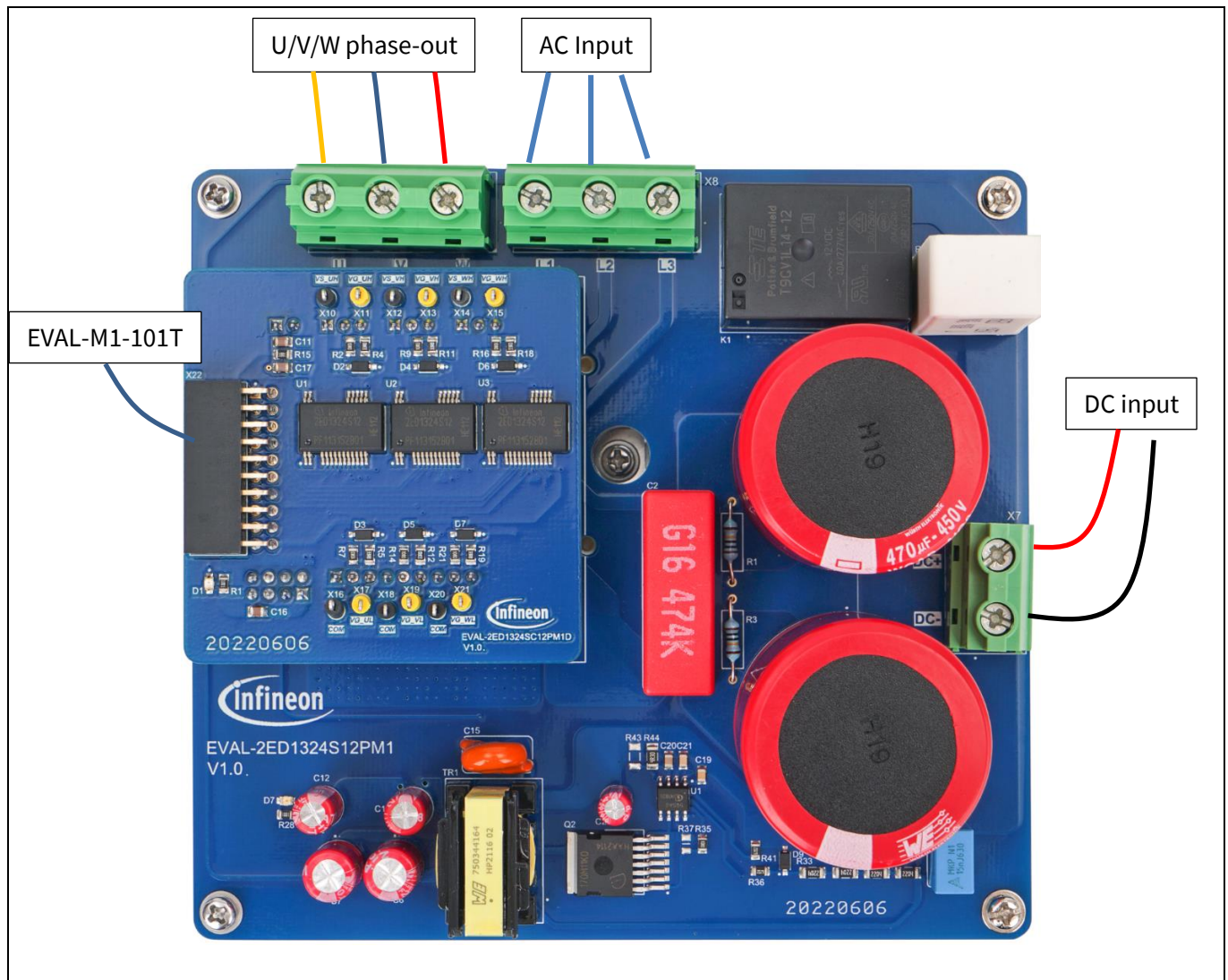


Figure 4 The system connection for running a BLDC motor

2.1.1 The iMOTION™ control board

You can order the Infineon control board EVAL-M1-101T from <https://www.infineon.com/cms/en/product/evaluation-boards/eval-m1-101t> and download the latest IMC101T-T038 MCE software package from www.infineon.com/imotion-software.

After obtaining EVAL-M1-101T and the latest software, connect your PC to the control board via a USB cable to program and tune it.

System and functional description

1. Connect EVAL-M1-101T's M1 20-pin interface connector J2 to the daughter board X22.
2. In the MCEWizard, enter the system and operating parameters of the target motor and the hardware parameters of the evaluation board. This data is used for calculating the digital parameter set of the controller, representing the complete motor drive system.
3. Go to the Verify & Save page and click **Calculate Parameters**. Then, save the drive parameter set into your project directory by clicking **Export to MCEDesigner file (.txt)** (see Figure 6). This saved drive system parameter file will be used later by the MCEDesigner. Refer to Section 2.1.4 or the MCEWizard user guide for more information.
4. Connect motor phase outputs (X9 on the mother board) to the motor.
5. Connect AC input to the power input connector (X8 on the mother board), then power on the system.
6. Start the MCEDesigner tool.
7. Click **File > Open** to open the MCEDesigner default configuration file (.irc) for the IMC101T-T038 controller (IMC101T_Vxxx.irc). The IMC101T_Vxxx.irc file is included in the IMC101T-T038 MCE software package.
8. The MCEDesigner should automatically connect to the EVAL-M1-101T control board using the default COM port (indicated by a green circle next to the "COMx Up" status in the bottom frame of the MCEDesigner GUI). If the connection cannot be established, change the COM port as follows:
 - a) Open the System Page window.
 - b) Click **Preferences > Connection > Connect using**.
 - c) Choose one of the other available COM ports from the drop-down list.
9. Program the system parameters into the internal SRAM of the iMOTION™ IC using the following steps:
 - a. Click **Tools > Programmer** and select **Program Parameters**.
 - b. Browse and select the System Drive Parameters file created in step 3. See Section 2.1.4 for more information.
10. Start the motor by clicking the green traffic light button in the control bar. To stop the motor, click the red traffic light button in the control bar.

2.1.2 iMOTION™ development tools and software

The EVAL-2ED1324S12PM1 evaluation board can run a BLDC motor when connected to an external control board EVAL-M1-101T. Users must configure the iMOTION™ development tool and software according to the system and BLDC motor parameters.

The MCEDesigner and MCEWizard are based on MCEDesigner v2.3.1 and MCEWizard v2.3.1, and can be downloaded together with supported files from <http://www.infineon.com/imotion-software>.

2.1.3 MCEWizard setup overview

Use the MCEWizard to configure the parameters for the evaluation board or motor. Figure 5 shows the Welcome page of the MCEWizard. Here, users can select the control board or power board from a drop-down list. Infineon releases new control and power boards regularly. Therefore, it is possible that some of the latest power boards have not been pre-configured in the MCEWizard tool and cannot be selected from the drop-down menu. In that case, users can select another power board (as similar as possible) and follow the setup steps in the MCEWizard by entering parameters specific to the power board chosen. Please refer to the application note of the corresponding power board for additional information.

After selecting the modular application design kit (MADK) control board and the power board, click **Next** in the right-hand bottom corner of the Welcome page to start the MCEWizard system setup process.



Figure 5 Welcome page of the MCEWizard

The iMOTION™ system enables users to easily test different combinations of control and power boards with their motors. Users should be familiar with system-level parameters related to the motor used. There are a limited number of parameters specific to the control board or power board hardware. Table 3 lists the hardware parameters specific to the EVAL-2ED1324S12PM1 power board for MCEWizard setup. Similar tables are available for each control board in its application note. A combination of data in this table and the corresponding table of the control board provides sufficient information to set up the motor drive system quickly.

Table 3 MCEWizard setup overview table

Parameter	Value
Control board selecting	EVAL-M1-101T for example
Motor 1 shunt configuration	Single shunt
Controller supply voltage	+3.3 V
Max DC bus voltage	780 V
DC bus sensing high resistor	4000 kΩ
DC bus sensing low resistor	13 kΩ
NTC temperature shutdown value	Refer to the control board's application note [6]
Gate sense low-side devices	High is true
Gate sense high-side devices	High is true
Motor 1 current input scaling	Calculated in the corresponding section of the control board's application note [6]

After all the MCEWizard questions are answered, the Verify & Save page opens (see Figure 6.)

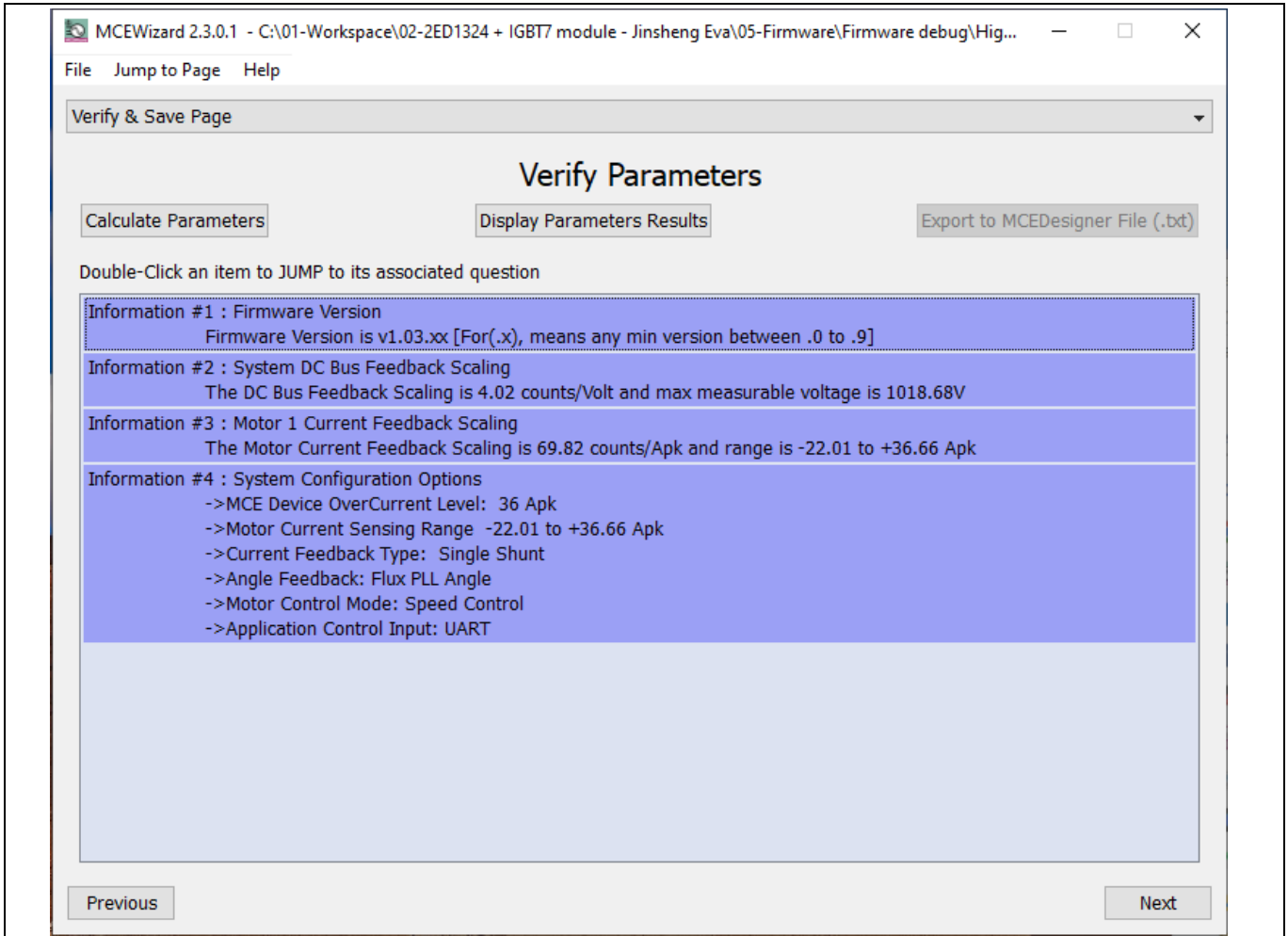


Figure 6 Verify & Save page of the MCEWizard

Click **Calculate Parameters** and then **Export to MCEDesigner File (.txt)** to save the parameter file. This file will be used by the MCEDesigner in the next steps.

System and functional description

2.1.4 MCEDesigner setup overview

The MCEDesigner is a user interface to access or debug the control board. Open the MCEDesigner and then open the IMC101T_xx.irc file. The main display page for EVAL-M1-101T opens, as shown in Figure 7.

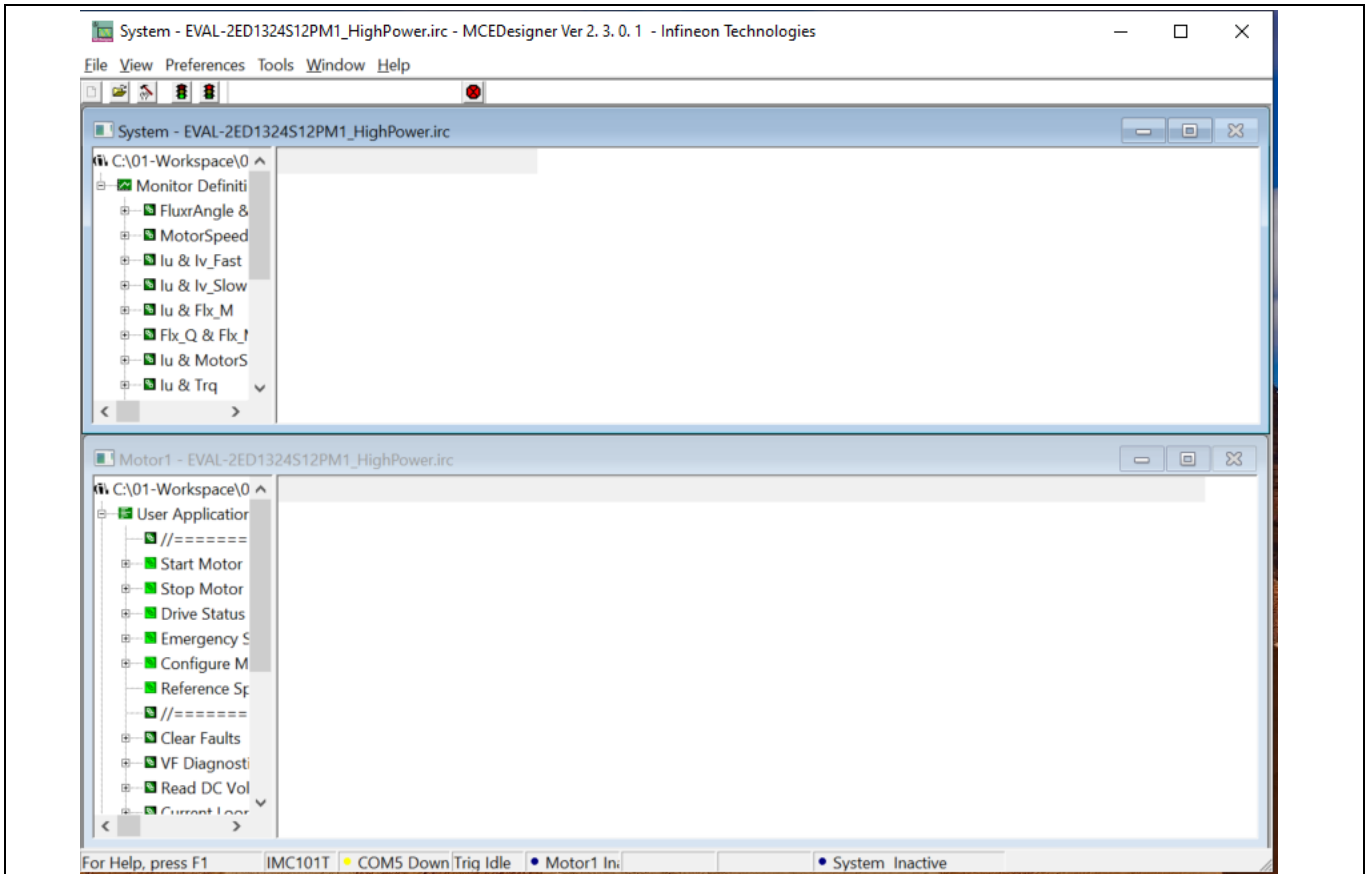


Figure 7 MCEDesigner’s main display for EVAL-M1-101T

After the drive system parameter file has been programmed into the IMC101 controller, and the motor drive system powered, the MCEDesigner can be used to start/stop the motor, display motor current traces, change the motor speed, modify drive parameters, and perform many other functions. Please refer to the MCEDesigner documentation [8] for more details.

2.2 Description of functional blocks

The motor inverter in EVAL-2ED1324S12PM1 hardware design is implemented by three 1200 V SOI half-bridge gate drivers 2ED1324S12P and one EasyPIM™ 1B 1200 V, 25 A three-phase input rectifier power- integrated module (PIM) with TRENCHSTOP™ IGBT7 FP25R12W1T7_B11. The auxiliary power supply is based on the quasi-resonant controller ICE5QSAG and CoolSiC™ MOSFET IMBF170R1K0M1.

2.2.1 Overview of 2ED1324S12P

Figure 8 shows the functional block diagram of 2ED1324S12P. For more information such as static and dynamic electrical characteristics of the gate driver, please refer to the datasheet of 2ED1324S12P.

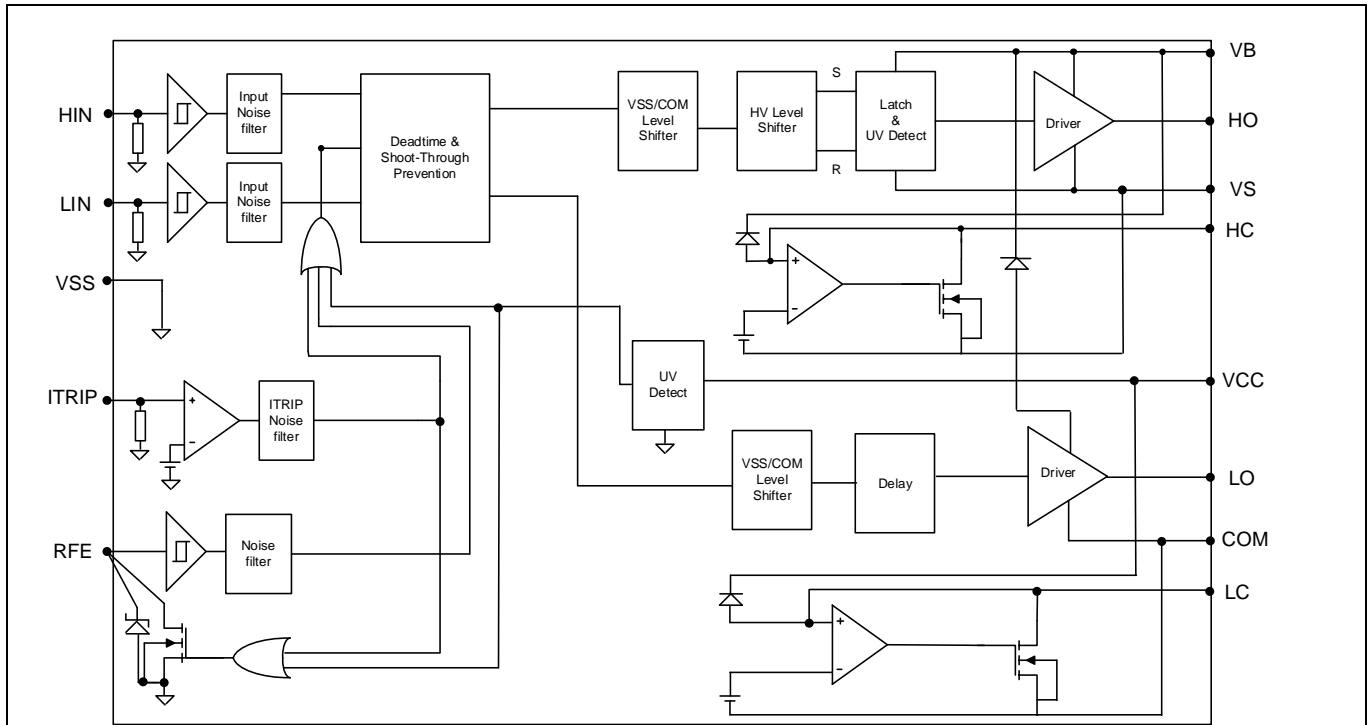


Figure 8 Functional block diagram of 2ED1324S12P

The main features of 2ED1324S12P include:

- Unique Infineon thin-film silicon-on-insulator (SOI) technology
 - Floating channel designed for bootstrap operation
- Maximum bootstrap voltage (VB node) of + 1225 V
- Operating voltages (VS node) up to + 1200 V
- Negative VS transient voltage immunity of 100 V
 - With repetitive 700 ns pulses
- 2.3 A / 2.3 A peak output source / sink current capability
- Integrated ultra-fast overcurrent protection (OCP)
 - $\pm 5\%$ high accuracy reference threshold
 - Less than 1 μ s overcurrent sense to output shutdown
- Integrated active Miller clamp (AMC) with 2 A sink current capability
- Integrated short-circuit clamp (SCC) function
- Integrated ultra-fast, low-resistance bootstrap diode
- Integrated dead-time and shoot-through prevention logic
- Enable, fault, and programmable fault clear input
- Logic operational up to -8 V on VS pin
- Independent per channel undervoltage lockout (UVLO)
- 25 V VCC supply voltage (maximum)
- Separate logic (VSS) and output ground (COM)
- Greater than 5 mm clearance / creepage
- 2 kV HBM ESD capability

Table 4 Absolute maximum ratings of 2ED1324S12P

Symbol	Definition	Min.	Max.	Units
V_B	High-side floating well supply voltage ^{Note 1}	-0.5	1225	V
V_S	High-side floating well supply return voltage ^{Note 1}	$V_B - 25$	$V_B + 25$	
V_{BS}	High-side floating supply voltage (V_B vs. V_S) (internally clamped)	-1	25	
$V_{HO/HC}$	Floating gate drive output voltage	-0.5	$V_B + 0.5$	
V_{CCGND}	Low-side supply voltage (V_{CC} vs. V_{SS}) (internally clamped)	-1	25	
V_{CC}	Low-side supply voltage (V_{CC} vs. V_{COM}) (internally clamped)	-1	25	
$V_{LO/LC}$	Low-side output voltage	-0.5	$V_{CC} + 5$	
V_{IN}	Logic input voltage (HIN, LIN, RFE, ITRIP)	$V_{SS} - 5$	$V_{CC} + 0.5$	
V_{LCLAMP}	Pin LC voltage	-0.5	$V_{CC} + 0.5$	
V_{HCLAMP}	Pin HC voltage	$V_S - 0.5$	$V_B + 0.5$	
t_{CLP}	Maximum short-circuit clamping time ($I_{CLAMP/OUT}=500mA$)	—	10	
dV_S/dt	Allowable V_S offset supply transient relative to COM	—	50	V/ns
P_D	Package power dissipation @ $T_A \leq +25^\circ C$ ^{Note 2}	—	1.5	W
R_{thJA}	Thermal resistance, junction to ambient ^{Note 3}	—	81	$^\circ C/W$
Ψ_{Jtop}	Characterization parameter, junction to package top ^{Note 3}		5	
T_J	Junction temperature	-40	150	$^\circ C$
T_S	Storage temperature	-55	150	
T_L	Lead temperature (soldering, 10 seconds)	—	300	

Note 1: There is an additional power dissipation in the internal bootstrap diode between pins VCC and VB for activated bootstrap diode in case $V_{CC} > V_B$.

Note 2: Consistent power dissipation of all outputs. All parameters inside operating range

Note 3: Obtained in a simulation on a JEDEC-standard and $T_a = 50^\circ C$, $P_D = 1W$, PCB: JEDEC 2s2p (JESD 51-5)

System and functional description

2.2.2 Overview of FP25R12W1T7_B11

The FP25R12W1T7_B11 is an EasyPIM™ 1B 1200 V, 25 A three-phase input rectifier PIM (power integrated-module) IGBT module with TRENCHSTOP™ IGBT7, emitter-controlled 7 diode, NTC and PressFIT contact technology.

Figure 9 shows the circuit diagram of FP25R12W1T7_B11. For more information about the module, please refer to the datasheet of FP25R12W1T7_B11.

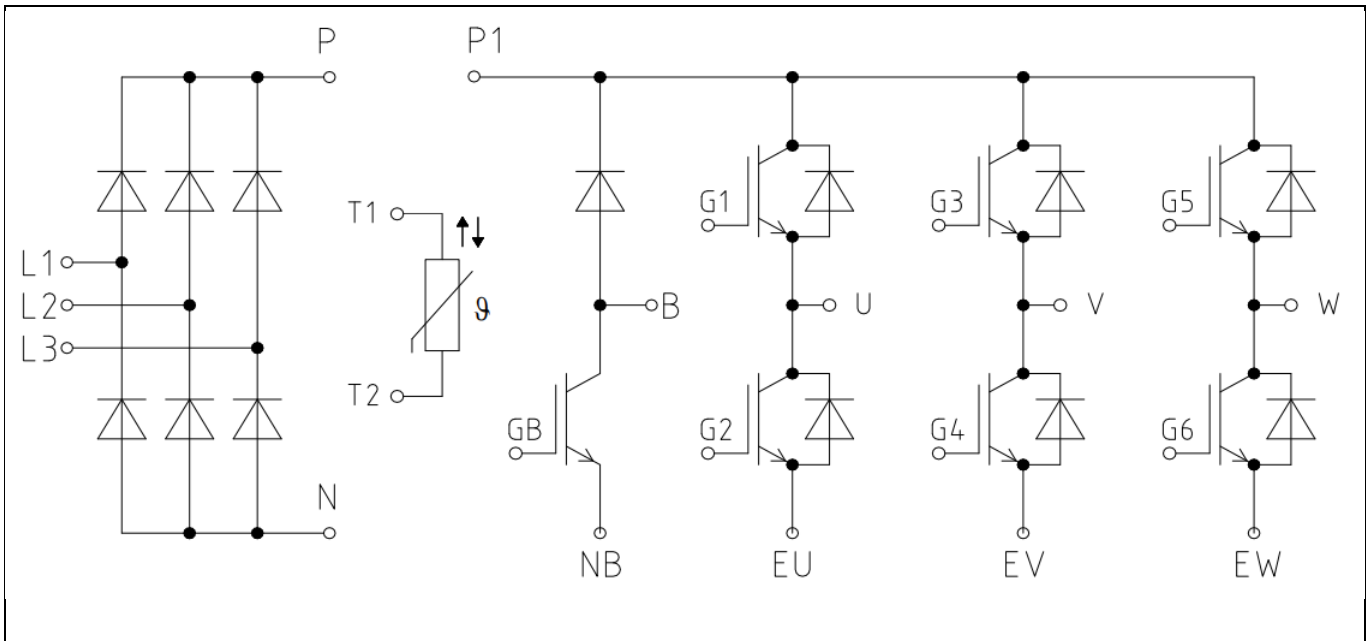


Figure 9 **Circuit diagram**

The main features of FP25R12W1T7_B11 include:

- **Electrical features**
 - $V_{CES} = 1200 \text{ V}$
 - $I_{C\text{nom}} = 25 \text{ A} / I_{CRM} = 50 \text{ A}$
 - TRENCHSTOP™ IGBT7
 - Overload operation up to 175°C
 - Low V_{CESat}
- **Mechanical features**
 - High power density
 - PressFIT contact technology
 - 2.5 kV AC 1 min insulation
 - Al_2O_3 substrate with low thermal resistance
 - Compact design

2.2.3 Overview of ICE5QSAG

The quasi-resonant fly-back PWM controller, which is the fifth and latest generation, offers high performance and a comprehensive protection package to increase system robustness.

Figure 10 shows the functional block diagram of ICE5QSAG. For more information regarding the PWM controller, please refer to the datasheet of ICE5QSAG.

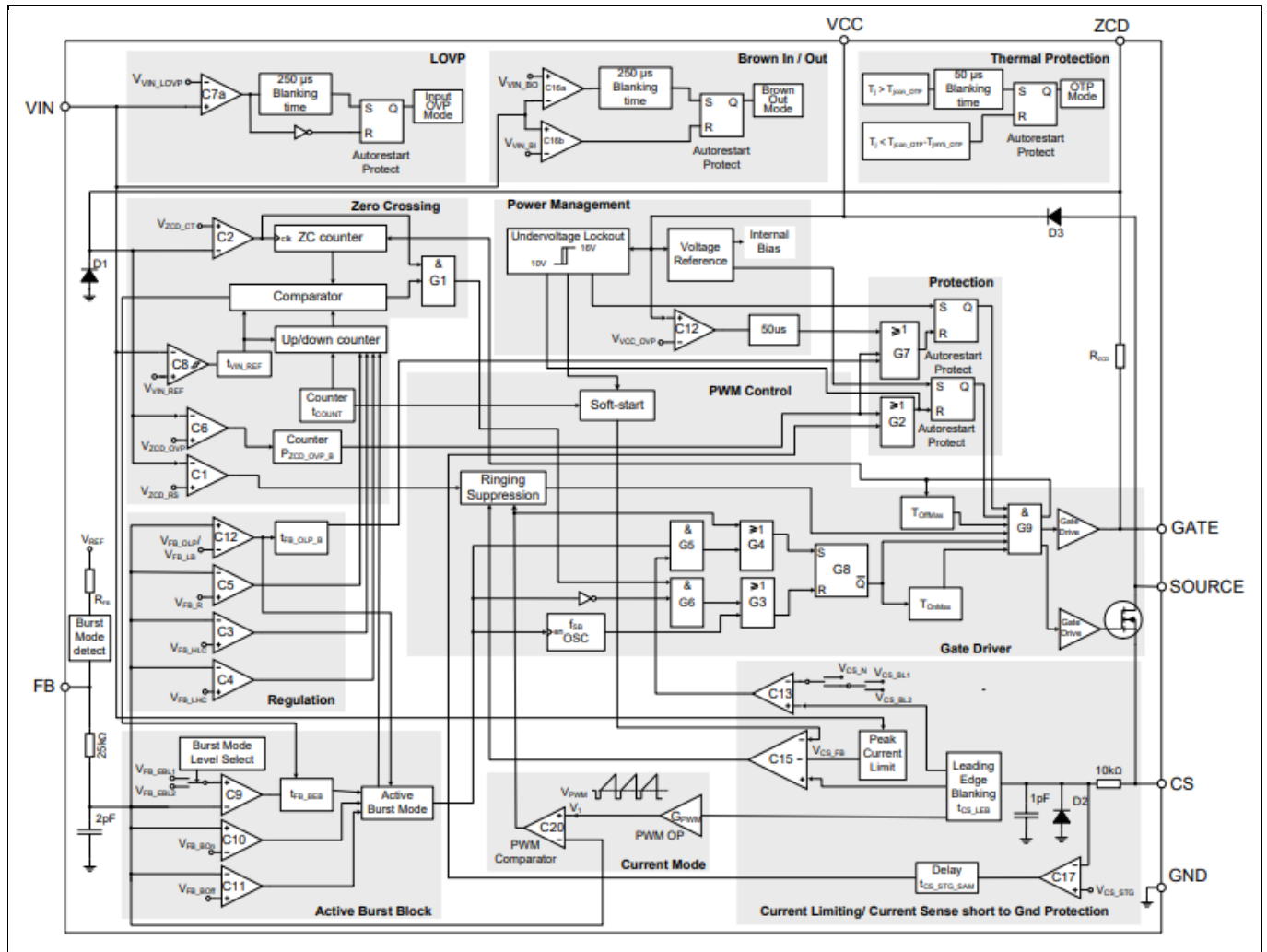


Figure 10 **Circuit diagram**

The main features of ICE5QSAG include:

- Novel quasi-resonant operation and proprietary implementation for low EMI
- Enhanced active burst mode with selectable entry and exit standby power
- Active burst mode to reach the lowest standby power
- Fast startup thanks to through cascade configuration
- Digital frequency reduction for better overall system efficiency
- Robust line protection with input overvoltage protection and brownout protection
- Comprehensive protection
- Lead-free plating, halogen-free mold compound, RoHS compliant

2.2.4 Overview of IMBF170R1K0M1

IMBF170R1K0M1 is a CoolSiC™ 1700 V, 1000 mΩ SiC MOSFET in a TO-263-7 high-creepage package; optimized for fly-back topologies. It can be used in auxiliary power supplies connected to DC-link voltages from 600 V up to 1000 V in numerous power applications. For more information regarding the power device, please refer to the datasheet of IMBF170R1K0M1.

The main features of IMBF170R1K0M1 include:

- Use of silicon carbide as revolutionary semiconductor material
- Optimized for fly-back topologies
- 12 V/0 V gate-source voltage compatible with most fly-back controllers
- Very low switching losses
- Benchmark gate threshold voltage, $V_{GS(th)} = 4.5 \text{ V}$
- Fully controllable dV/dt for EMI optimization

3 System design

This chapter covers the hardware design of EVAL-2ED1324S12PM1 in detail. Users can modify the circuit or re-select the component values based on actual applications in the field.

3.1.1 DC-link voltage measurement and inrush current limiter

Bus capacitors should be large enough to stabilize the bus voltage. The resistors R1 and R3 are used to balance the voltage on the electrolytic capacitors in series, and the inrush current limiter (K1, R7) as shown in Figure 11.

Note: The resistor R11 is soldered on the mother board of EVAL-2ED1324S12PM1. Therefore, the 13.3 kΩ pull-down resistor located on the EVAL-M1-101T control board must be removed.

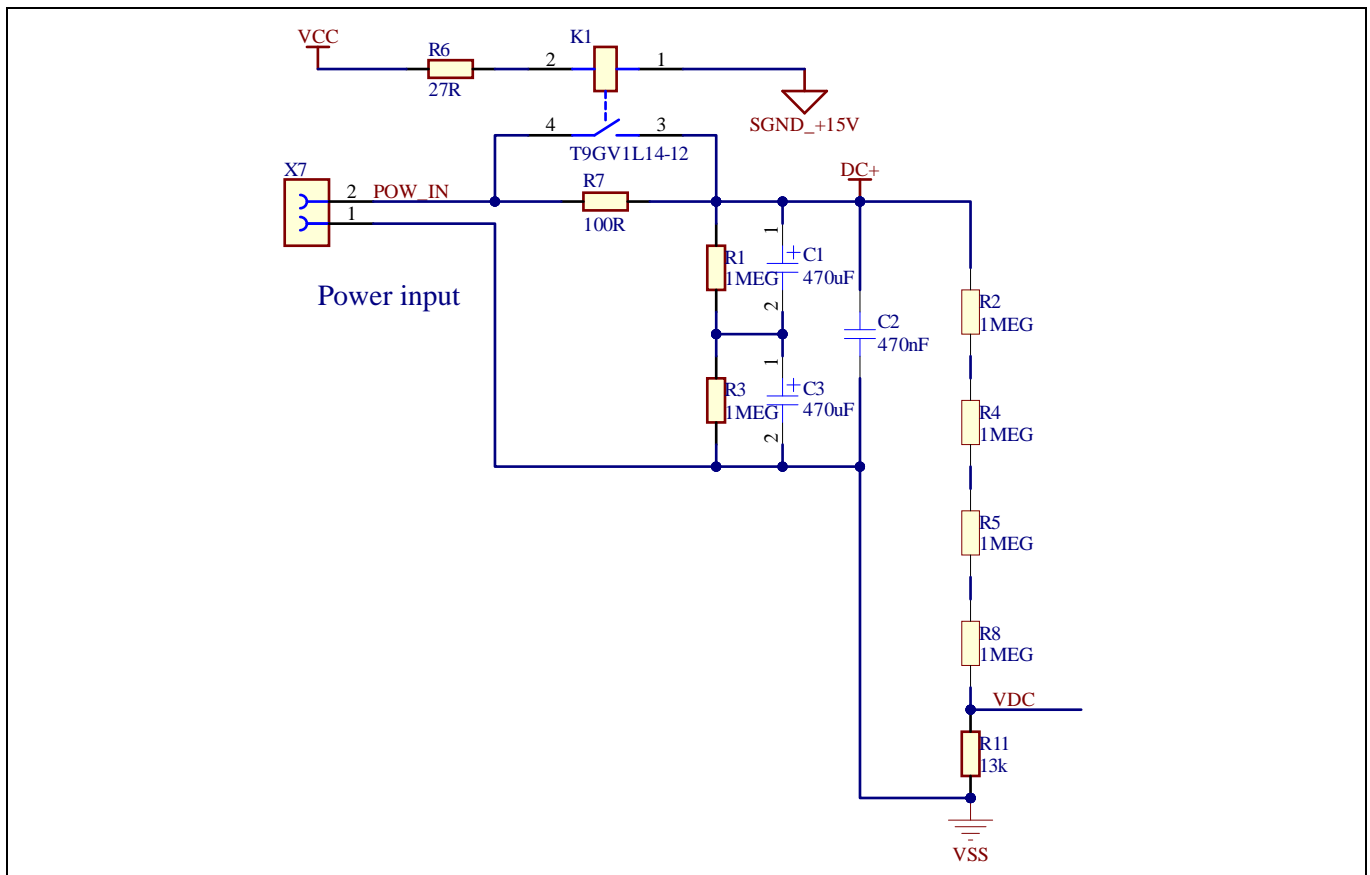


Figure 11 Bus capacitor configuration and DC bus sensing

EVAL-2ED1324S12PM1 User Guide

1200 V SOI gate driver 2ED1324S12P evaluation board

System design

3.1.3 Drive circuit with 2ED1324S12P

A dedicated daughter board for the three half-bridge gate drivers 2ED1324S12P are mounted on top of the mother board to drive the IGBT module. The configuration of 2ED1324S12P is shown in Figure 13.

The capacitor C3 (C9, C14) is used as bootstrap capacitor to provide the necessary floating supply voltage VBS. Thanks to the bootstrap diode integration in 2ED1324S12P, an external bootstrap diode is not needed.

2ED1324S12P (high-voltage integrated circuit) HVIC is equipped with ITRIP input pin. This functionality can be used to detect overcurrent events in the DC bus. When the HVIC detects an overcurrent event through the ITRIP pin for one of the three phases, the output is shut down and the RFE is pulled to VSS to report the fault condition. The outputs of the other two phases are also shut down because of the daisy chain connection with the RFE pins. The RFE can also be used as the enable input pin and fault-clear time programmable pin.

The fault-clear time setup is based on the datasheet of 2ED1324S12P. The main feature of 2ED1324S12P designed with Infineon's C5SOI technology is its tolerance in terms of negative transient voltage in inductive load applications. 2ED1324S12P can tolerate repetitive negative transient voltage of up to 100 V (pulse width up to 700 nanoseconds).

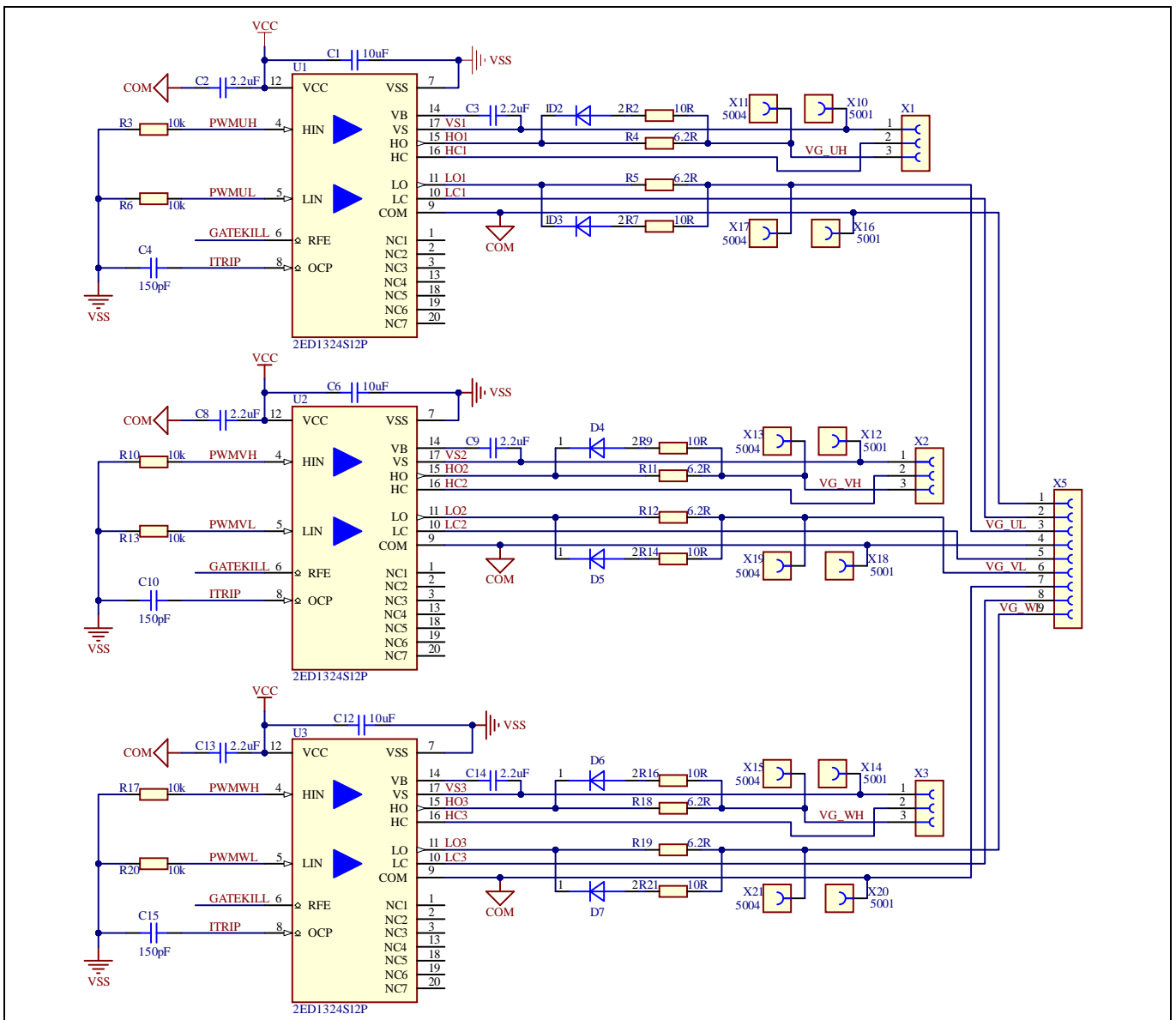


Figure 13 Drive circuit design with 2ED1324S12P

System design

3.1.4 Overcurrent protection

The overcurrent circuit is shown in Figure 12. To save power loss of the shunt resistor, the R_{shunt} value is set as 10 mΩ by using three 30 mΩ / 3 W surface-mounted devices (SMD) resistors (R15/R16/R17) and low equivalent series inductance (ESL) in parallel. In the design, the target current for overcurrent protection (I_{ocp}) is 25 A. The overcurrent threshold of the ITRIP pin is 0.44 V. An additional 0.19 V DC-bias voltage is needed at the ITRIP pin to meet the target current of 25 A. This is achieved by using resistor dividers R19 and R20 with 3.3 V supply.

The I_{ocp} is calculated using:

$$I_{ocp} = \frac{(V_{ITRIP+} - \frac{R19}{R19 + R20} * 3.3V) * (R19 + R20)}{R20 * Rshunt}$$

$$= 24.93 A$$

Here, V_{ITRIP+} is the positive-going threshold for ITRIP and its typical value is 0.44 V, $R19 = 100 \Omega$, and $R20 = 1 k\Omega$.

Note: If EVAL-M1-101T is used as the controller board, the offset circuit needs to be removed from it, as this circuit is already provided on the main board.

3.1.5 NTC thermistor configuration

FP25R12W1T7_B11 includes a NTC thermistor. Its temperature curve is shown in Figure 14. The resistance of the NTC thermistor is 5 kΩ at 25°C and 493 Ω at 100°C.

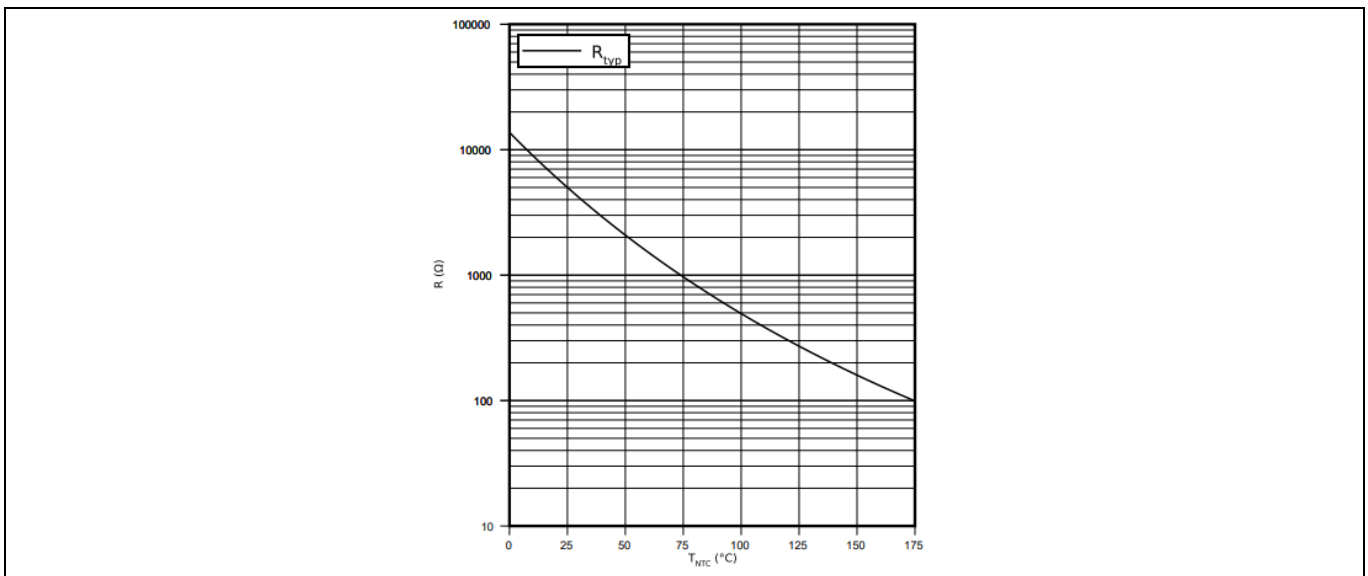


Figure 14 Typical temperature characteristics of the NTC thermistor

A 1 kΩ pull-up resistor is provided on the daughter board. As shown in the NTC thermistor configuration in Figure 15, the sensing voltage V_{TH} equals 2.75 V at 25°C and 1.09 V at 100°C. In the MCEWizard, the over-temperature voltage threshold of the NTC thermistor is set to 1.09 V to protect the power module.

Note: If EVAL-M1-101T is used as the control board, the 4.87 kΩ pull-up resistor for NTC needs to be removed to avoid conflict with the pull-up resistor on the daughter board.

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1200 V SOI gate driver 2ED1324S12P evaluation board

System design

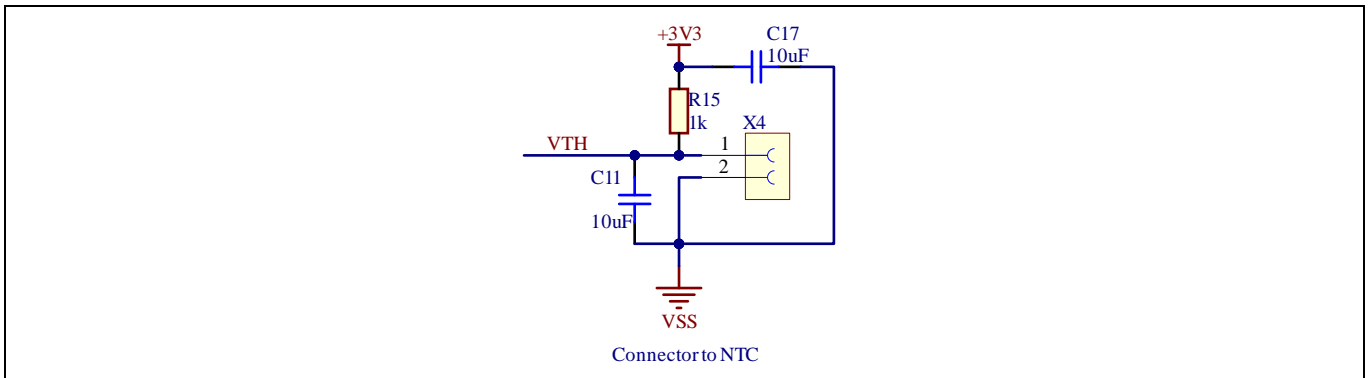


Figure 15 NTC thermistor configuration

3.1.6 Auxiliary power supply

The auxiliary power supply circuit adopts the quasi-resonant, fly-back controller ICE5QSAG and the CoolSiC™ 1700 V SiC MOSFET IMBF170R1K0M1 in a TO-263-7 package. There are two secondary windings. One generates 15 V DC and the other generates 7 V DC. The 15 V DC is connected to the gate drivers. 3.3 V power supply is derived from the 7 V DC using the linear regulator IFX25001ME V33. This 3.3 V power supply is used in the overcurrent bias circuit. Both 15 V and 3.3 V are also present at the 20-pin interface connector X22 on the daughter board. The primary ground, and secondary +15 V and +3.3 V reference grounds are in a star ground connection on the main board as shown in the schematic in Figure 18.

3.2 Schematics

The schematics of EVAL-2ED1324S12PM1 are shown in Figure 16, Figure 17, and Figure 18.

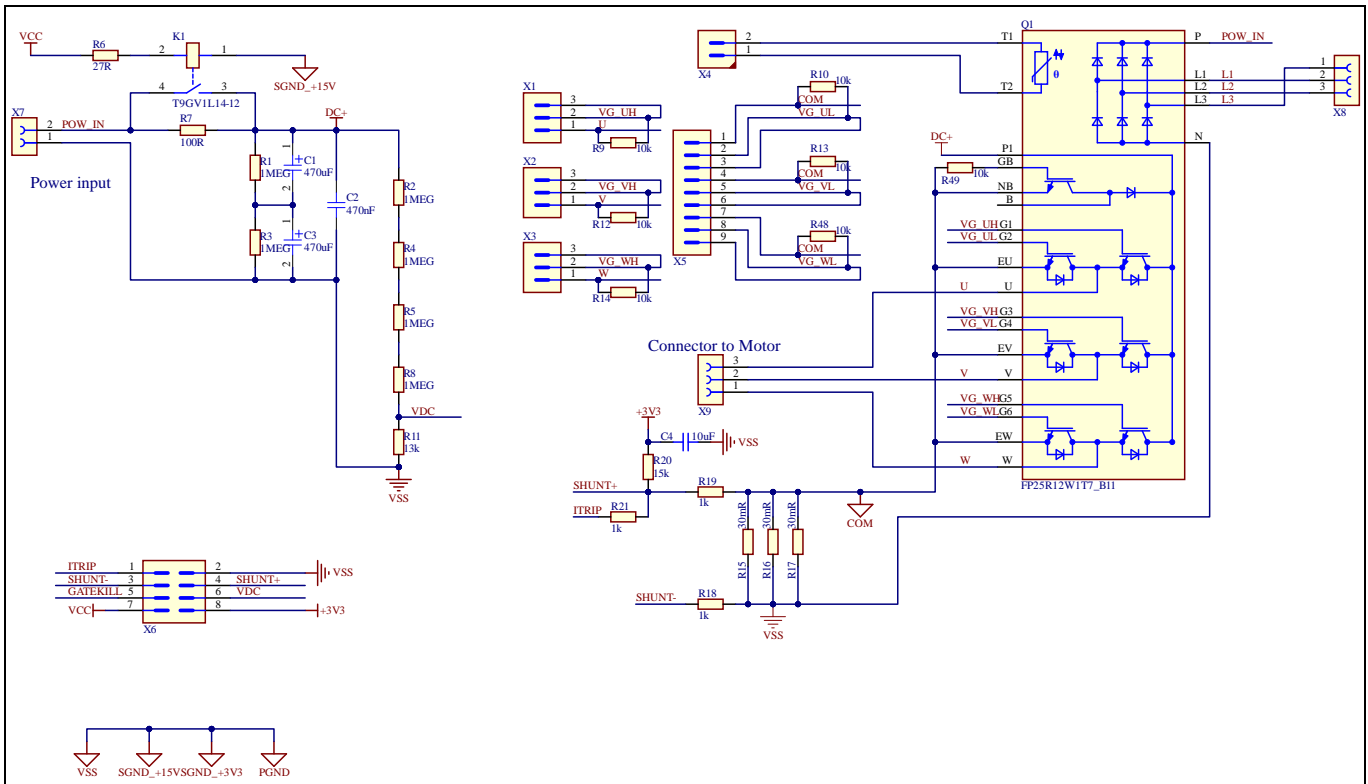


Figure 16 Circuitry of the power inverter board (mother board)

System design

3.3 Layout

3.3.1 Layout details

Detailed layouts of the power inverter board and daughter board are shown in Figure 19 to Figure 22.

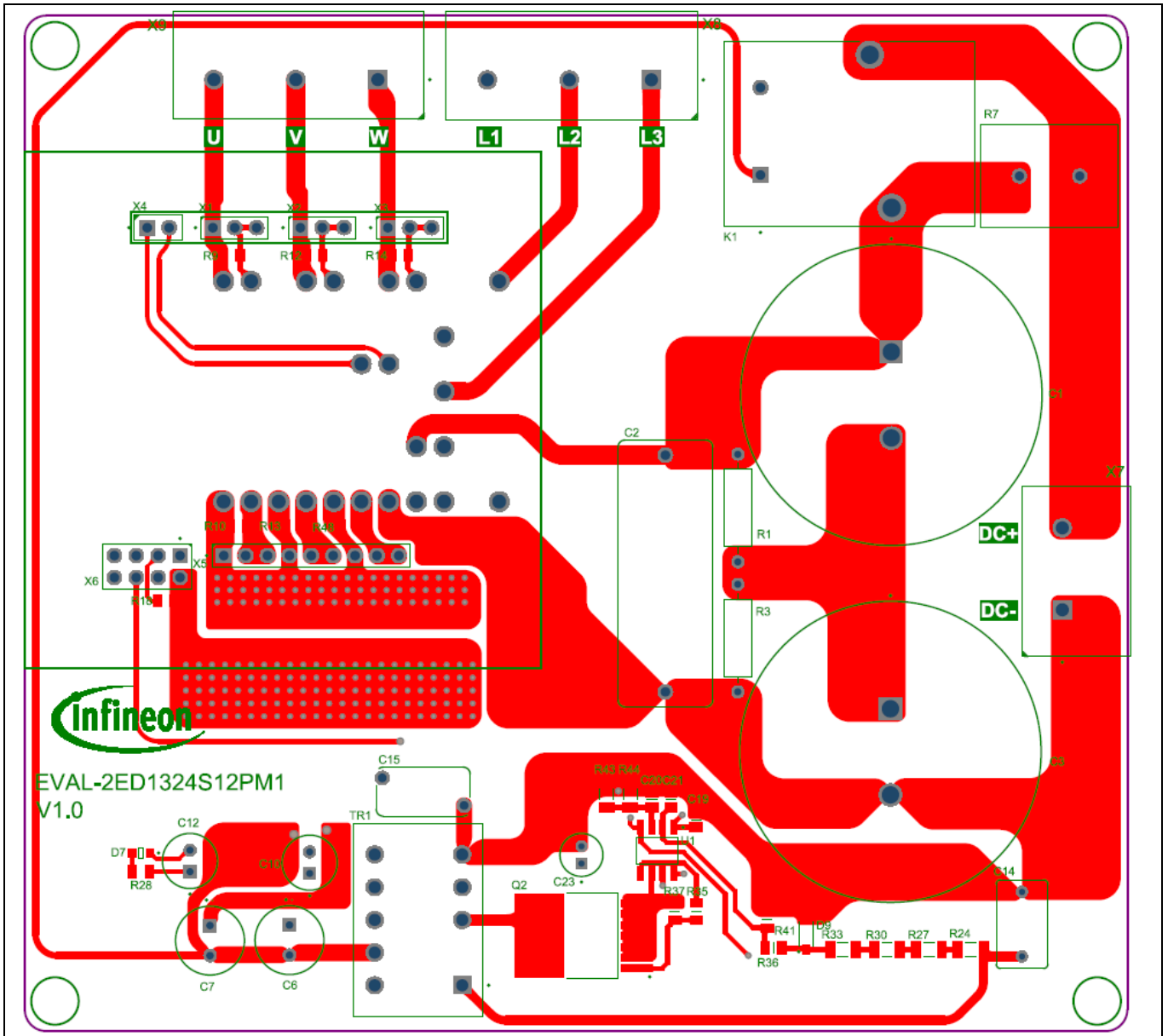


Figure 19 Power inverter board layout (top view)

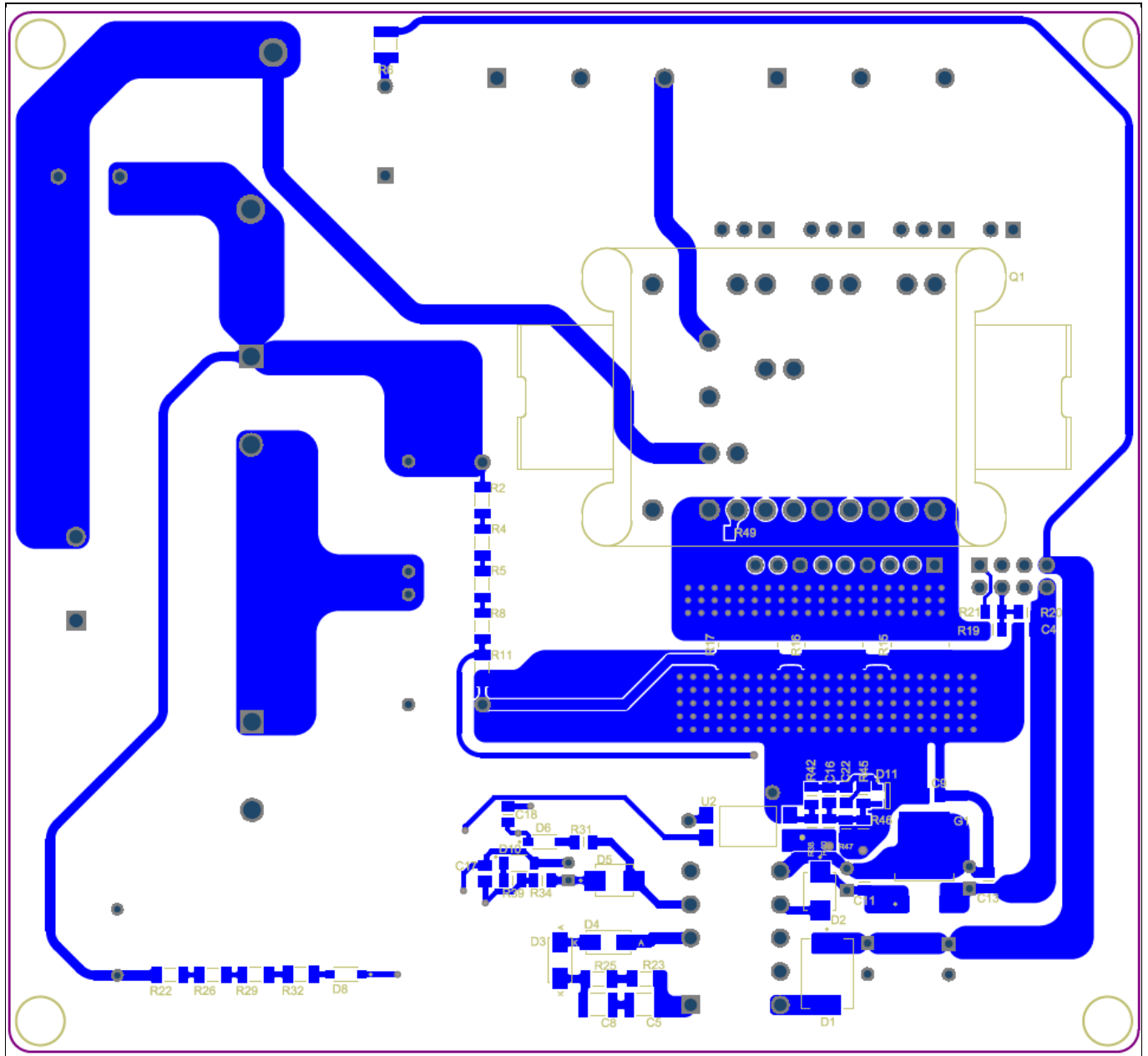


Figure 20 Power inverter board layout (bottom view)

System design

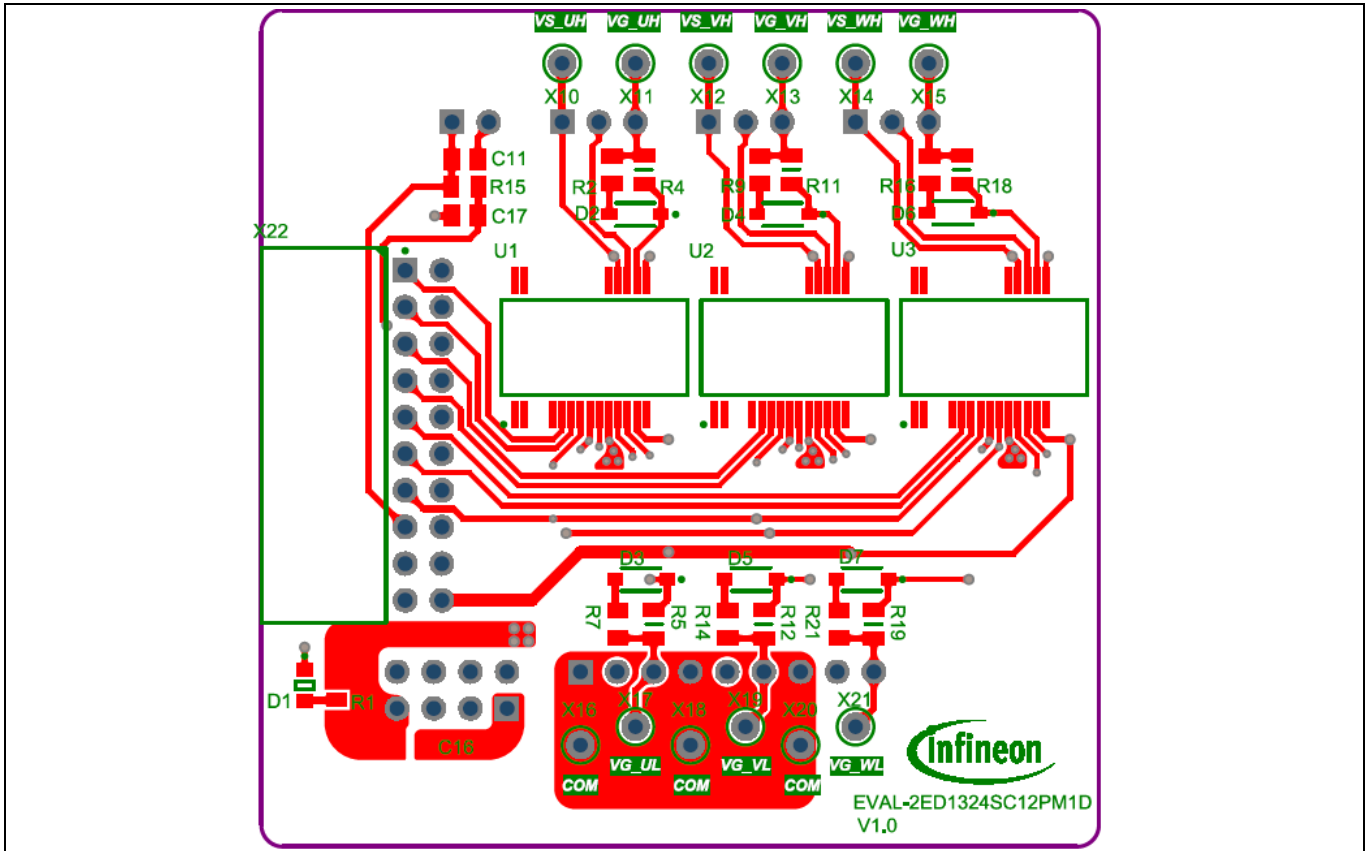


Figure 21 Drive circuitry layout of the daughter board (top view)

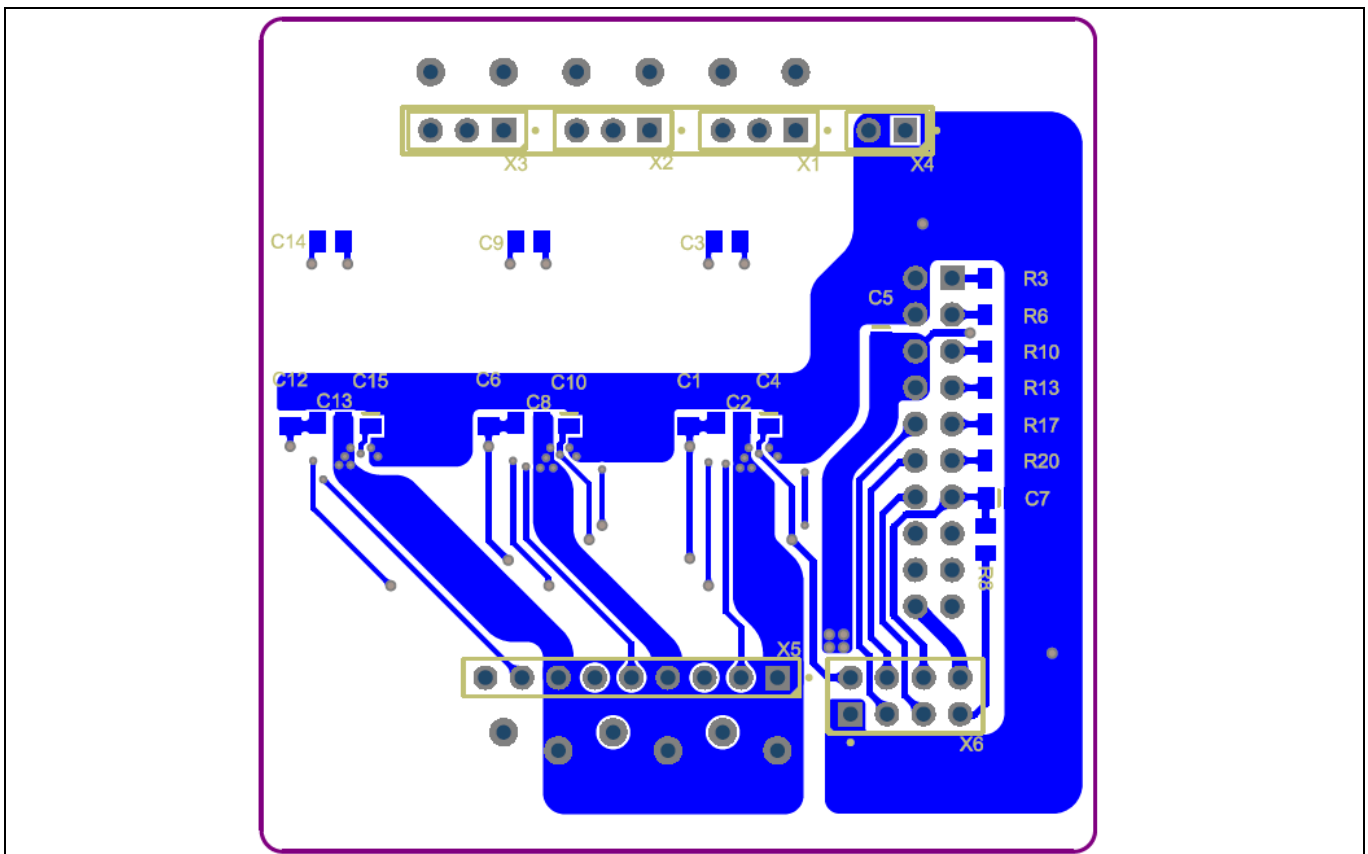


Figure 22 Drive circuitry layout of the daughter board (bottom view)

3.3.2 Layout guidelines

Some basic layout guidelines are as follows:

- The V_{CC} and V_{BS} bypass capacitors should be close to the IC
- The drive loop should be as small as possible
- The loop of VSS and COM should be made as small as possible by connecting the VSS and COM directly at the shunt-resistor terminals
- The two current-sensing traces should be started from the shunt terminals and placed close to each other

System design

3.4 Bill of material

The complete bill of material (BOM) is available in the Downloads section of Infineon’s homepage. A login is required to download this material.

Table 5 lists the important components used in EVAL-2ED1324S12PM1.

Table 5 BOM of the most important/critical parts

No.	Ref designator	Description	Manufacturer	Manufacturer P/N
1	U1/U2/U3 (daughter board)	1200 V half-bridge gate-driver with overcurrent protection	Infineon Technologies	2ED1324S12P
2	Q1 (mother board)	EasyPIM™ 1B power integrated module with TRENCHSTOP™ IGBT7	Infineon Technologies	FP25R12W1T7_B11
3	U1 (mother board)	Quasi-resonant controller	Infineon Technologies	ICE5QSAG
4	Q2 (mother board)	1700 V/1 Ω SiC MOSFET in TO263-7 package	Infineon Technologies	IMBF170R1K0M1
5	G1 (mother board)	5 V/400 mA linear voltage regulator	Infineon Technologies	IFX25001TF V33
6	R15, R16, R17 (mother board)	30 mΩ / 3 W SMD shunt resistor	Viking	CS25FTG:R030W
7	C1, C3 (mother board)	470 μF 450 V aluminum electrolytic capacitor	Würth	861011486024
8	C2 (mother board)	0.47 μF film capacitor - 1000V (1 kV) polyester, metallized radial	Würth	890493427007CS

3.5 Connector details

Table 6 Connectors

PIN	Label	Function
	X1, X2, X3, X4, X5, X6	Daughter and mother board connections
DC+, DC-	X7 (DC+/DC-, mother board)	DC power supply input
L1, L2, L3	X8 (L1/L2/L3, mother board)	Three-phase AC input
U, V, W	X9 (U/V/W, mother board)	Three phase-outs (U/V/W) to the motor
	X22 (daughter board)	iMOTION™ MADK-M1 20-pin interface connector

4 System performance

4.1 System setup for running a BLDC motor

EVAL-2ED1324S12PM1 is tested while running a BLDC motor in the setup shown in Figure 23.

Test conditions:

- Input: $V_{IN} = 380 \text{ VAC}$
- Phase-out current: $I_{PHASE} = 10.8 \text{ A}_{rms}$
- Room temperature
- BLDC motor: GK6081-6AC31-FE, $I_{PHASE} = 10.8 \text{ A}$, test at speed = 1500 r/min and 7.1 Nm
- Heat sink with natural ventilation for the six-pack module

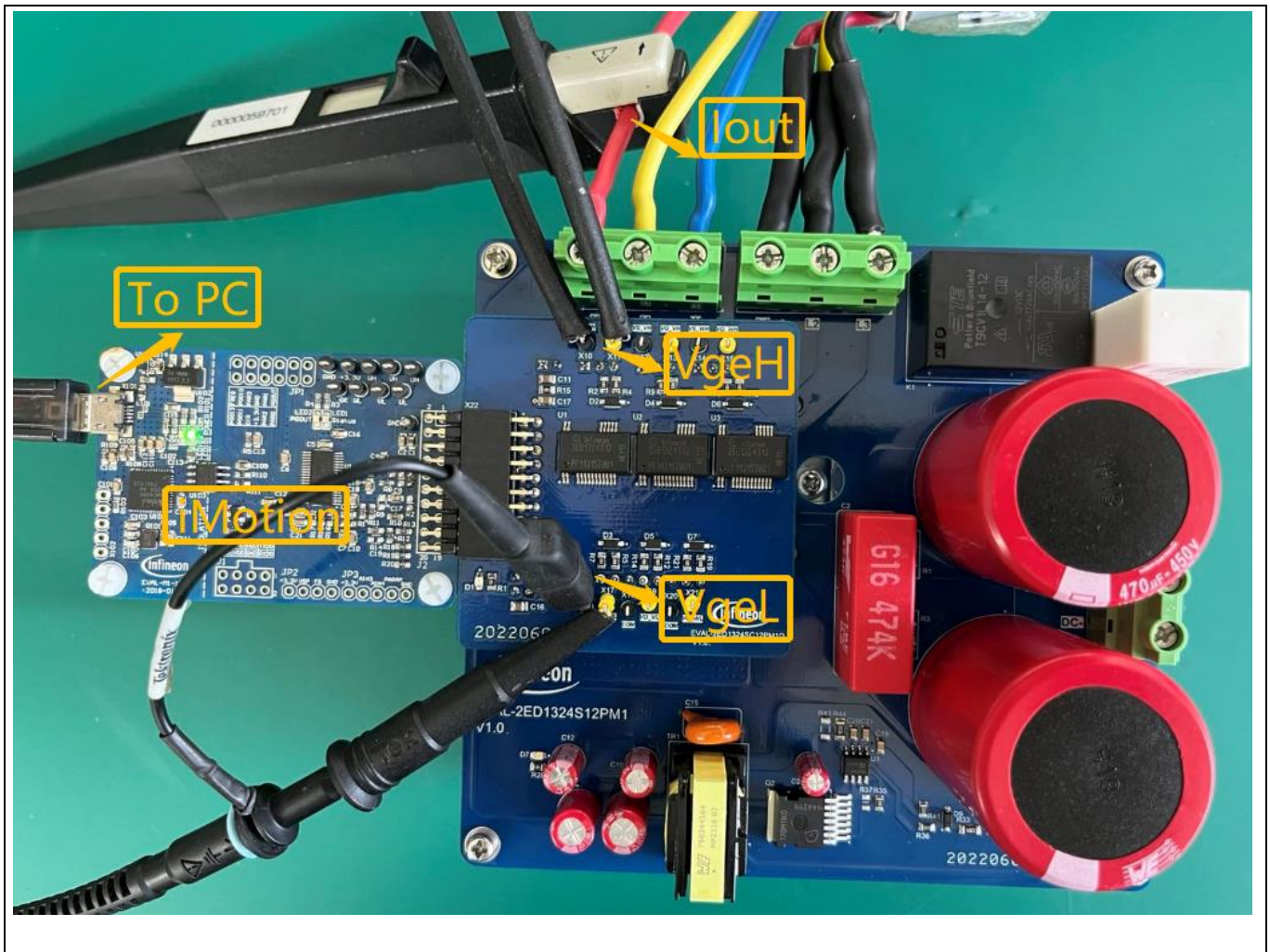


Figure 23 System setup for running a BLDC motor

System performance

4.2 The output phase current

Figure 24 shows the waveform when running a BLDC motor.

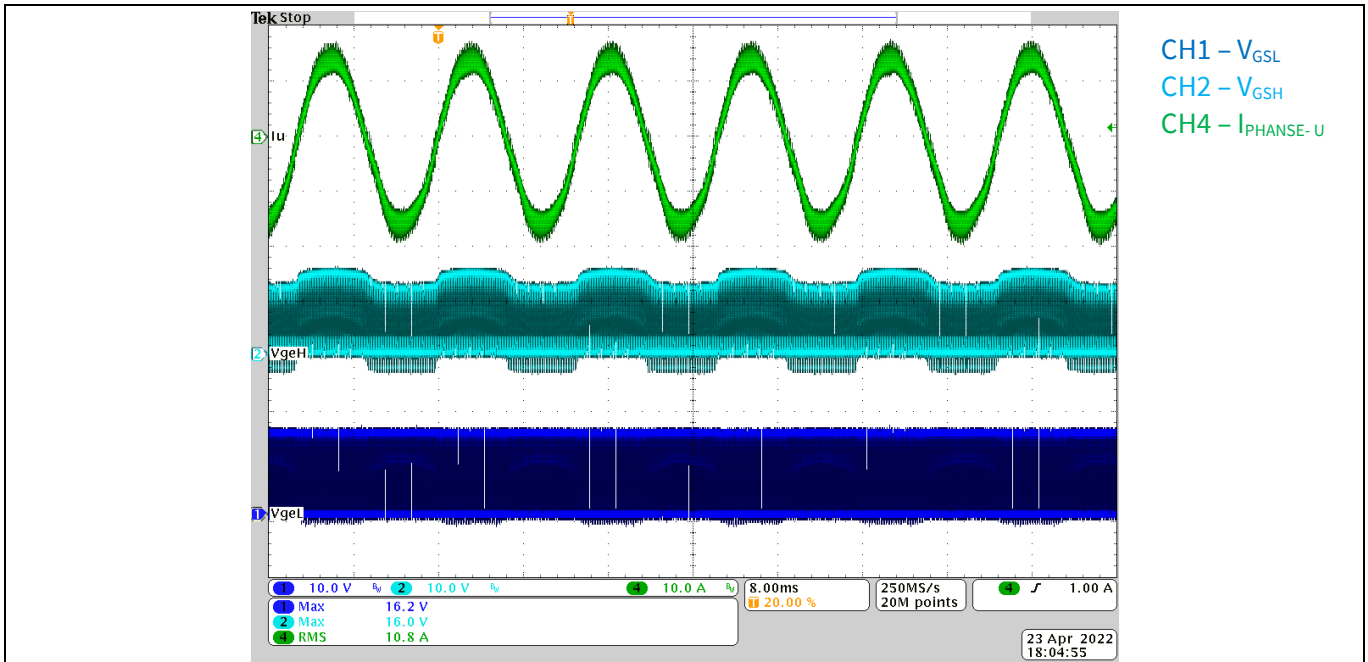


Figure 24 Phase U output current 10.8 A waveform at $V_{IN} = 380 \text{ VAC}$, $P_{IN} = 2 \text{ kW}$, $F_{SW} = 8 \text{ kHz}$

4.3 Test result for overcurrent protection

Figure 25 shows the overcurrent detection function of EVAL-2ED1324S12PM1 by ITRIP input of 2ED1324S12P. Overcurrent detection shuts down the outputs of the gate driver if the ITRIP pin input is over 440 mV and lasts longer than 500 nanoseconds. In that case, the overcurrent protection starts when the peak current is around 24.93 A.

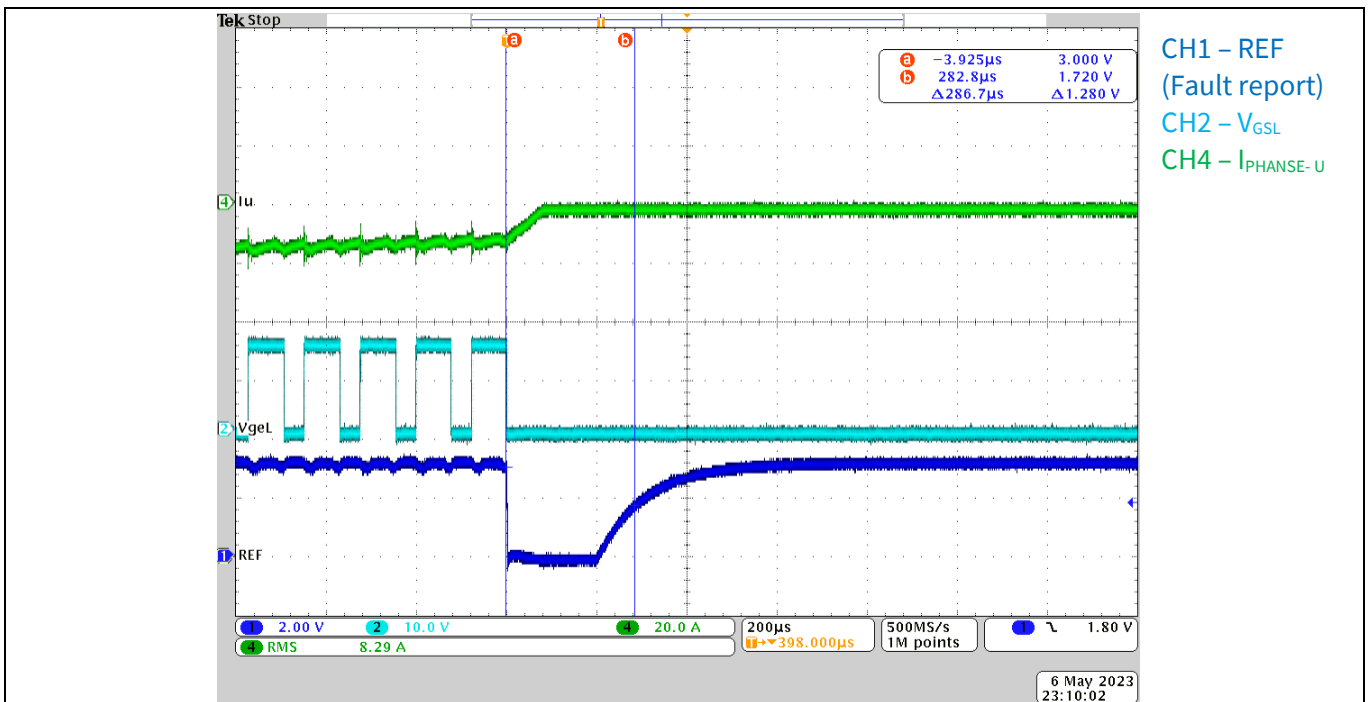


Figure 25 Overcurrent protection

System performance

4.4 Test result for short-circuit protection

Figure 26 shows the short-circuit protection of EVAL-2ED1324S12PM1. The total short-circuit protection delay time (including external RC filter, 1 kΩ / 150 pF) is about 650 nanoseconds when the input voltage V_{IN} is 600 V and the maximum current is about 87 A.



Figure 26 Short-circuit protection at $V_{IN} = 600$ V

4.5 Inverter’s efficiency vs input power

Figure 27 shows the inverter’s efficiency vs different input powers at $V_{IN} = 380$ VAC, $I_{PHASE} = 6.7$ A, $F_{SW} = 8$ kHz, and $T_a = 25^\circ\text{C}$.

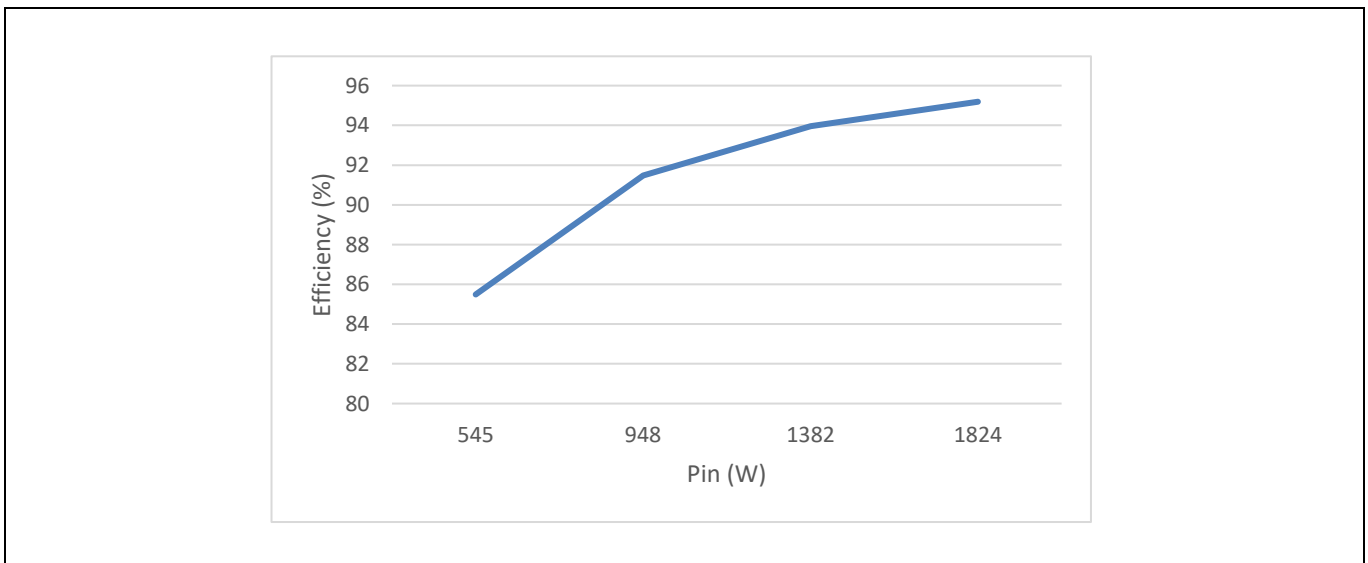


Figure 27 Inverter’s efficiency vs input power at $V_{IN} = 380$ VAC, $I_{PHASE} = 6.7$ A, $F_{SW} = 8$ kHz, $T_a = 25^\circ\text{C}$

System performance

4.6 Inverter's efficiency vs carrier frequency

Figure 28 shows the inverter efficiency vs different carrier frequencies at $V_{IN} = 380 \text{ VAC}$, $I_{PHASE} = 6.7 \text{ A}$, $P_{IN} = 2 \text{ kW}$, and $T_a = 25^\circ\text{C}$.

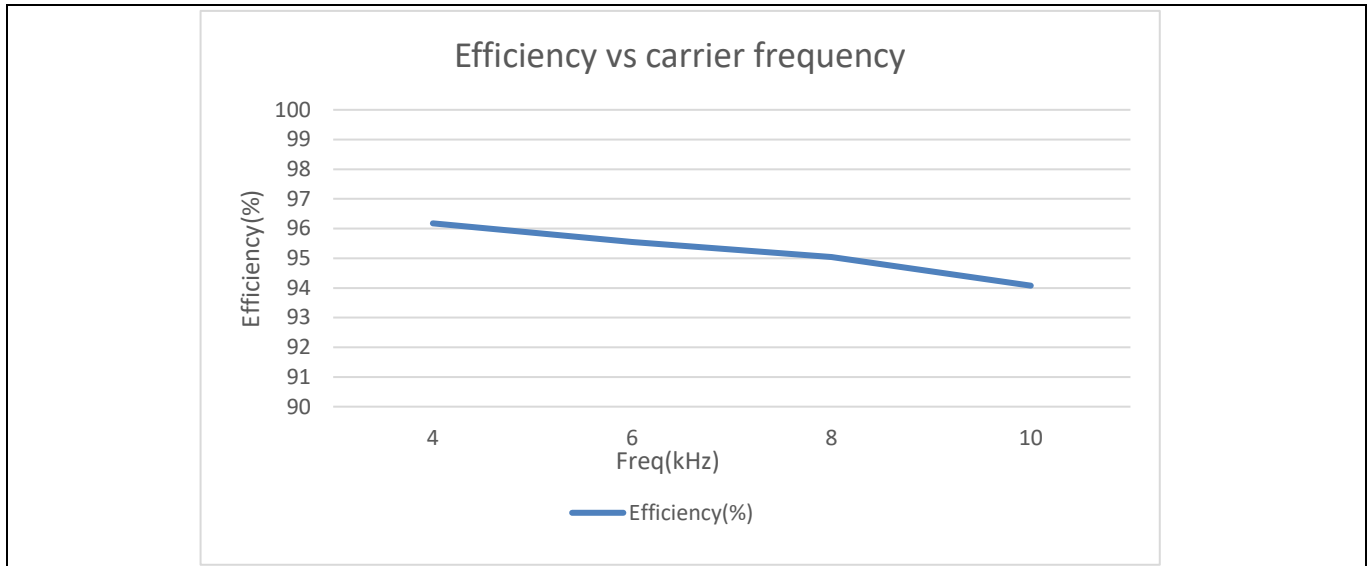


Figure 28 Inverter efficiency vs carrier frequency at $V_{IN} = 380 \text{ VAC}$, $I_{PHASE} = 6.7 \text{ A}$, $P_{IN} = 2 \text{ kW}$, $T_a = 25^\circ\text{C}$

5 References and appendices

5.1 Abbreviations and definitions

Table 7 Abbreviations

Abbreviation	Meaning
IC	Integrated circuit
IGBT	Insulated gate bipolar transistor
DC	Direct current
AC	Alternating current
BLDC	Brushless direct current
PIM	Power integrated module
PWM	Pulse width modulation
NTC	Negative temperature coefficient
EVAL	Evaluation board
PCB	Printed circuit board
SOI	Silicon on insulator

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Revision history

Revision history

Document version	Date of release	Description of changes
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