CoolGaN™ Drive HB 600 V G5 for Motor Drive Applications

EVAL_2727B1M_GaN_MD User Guide

About this document

Scope and purpose

This document presents the EVAL_2727B1M_GAN_MD evaluation board, which is a three-phase motor drive board targeting 300 W applications with phase current up to 1 A (RMS). The board is designed with a MADK-M5 connector, compatible with the KIT_PSC3M5_CC2 PSOC™ Control C3 Motor Control Evaluation Kit, to enable quick device evaluation. For more information on CoolGaN™ Drive HB 600 V G5 IGI60L272B1M, please see the datasheet [1].

This document describes the demo hardware design with a summary of the test results, intended as a guide for design engineers demonstrating the performance of EVAL_2727B1M_GAN_MD demo board. This board is to be used during the design-in process for evaluating and measuring characteristic curves, and for checking datasheet specifications.

Target applications

• HVAC, Industrial Machines, Robotics, Home Appliances

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

Note: Boards do not necessarily meet safety, EMI, quality standards (for example UL, CE) requirements.

Safety precautions

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

Table 1 Safety precautions

	**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.*

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1 System and application description

1.1 Board overview

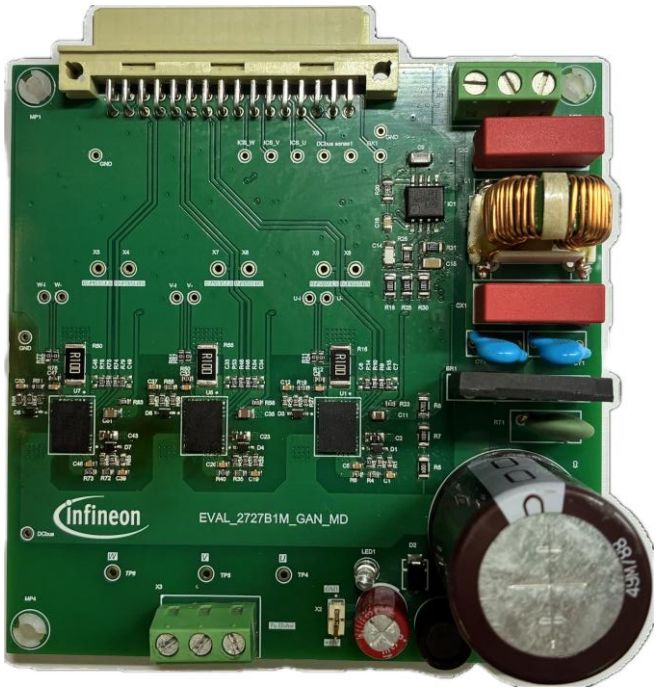


Figure 1 Evaluation board EVAL_2727B1M_GAN_MD

EVAL_2727B1M_GAN_MD is a 300 W three-phase motor drive evaluation board based on the CoolGaN™ Drive HB 600 V G5 IGI60L2727B1M, shown in **Figure 1**. Compared with discrete Si or IPM-based Si solutions, the higher switching speed and lower switching losses of CoolGaN™ Drive HB help improve system efficiency. This enables heatsink-free operation and supports a simple, compact, and flexible system design. The CoolGaN™ Drive HB 600 V G5 family offers $R_{DS(on)}$ variants from 110 mΩ to 500 mΩ, addressing different output power ranges.

The evaluation board is designed under following specification.

Table 2 EVAL_2727B1M_GAN_MD board parameter

Parameter	Specification
Board information	95.4mm × 95.8mm, 4 layers
Input voltage	90 ~264 Vac, 50..60 Hz
Output Range	1 A (RMS), 3-phase with natural cooling
Switching frequency	Typical 4 ~20kHz, up to 60kHz tested
Switching slew rate	Around 5 V/ns when hard switching

1.2 Block diagram

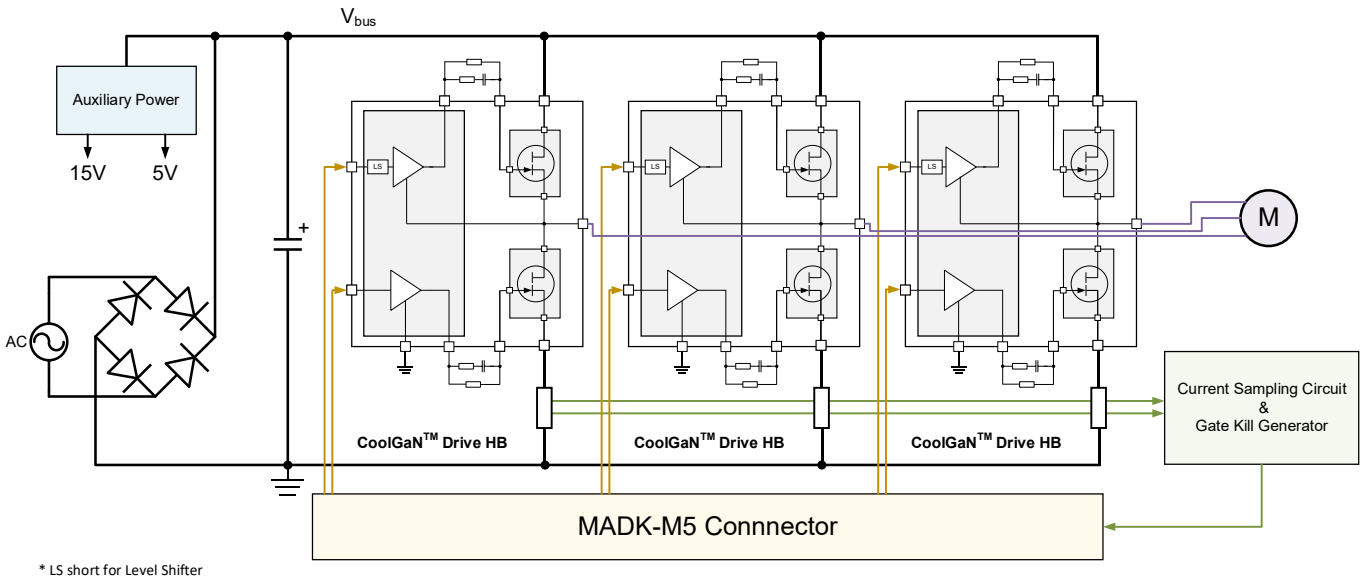


Figure 2 Simplified block diagram of EVAL_2727B1M_GAN_MD

Figure 2 shows the system block diagram. When cable is plugged in, AC power is rectified to DC link voltage with the input EMI filter and bridge diodes. With the auxiliary power circuit, 15 V and 5 V power rails are generated, where 15 V are used for CoolGaN™ Drive HB integrated gate driver power supply and 5 V is for current sensing circuit, gate kill generator circuit and MCU power supply. The board is designed with MADK-M5 connector, which is compatible with KIT_PSC3M5_CC2 kit [2]. MCU collects the current sensing and gate killing signals and provides the gate drive signals to the CoolGaN™ Drive HB, then the three phase integrated half bridges drive the motor as commands. Board description is shown in **Figure 3**.

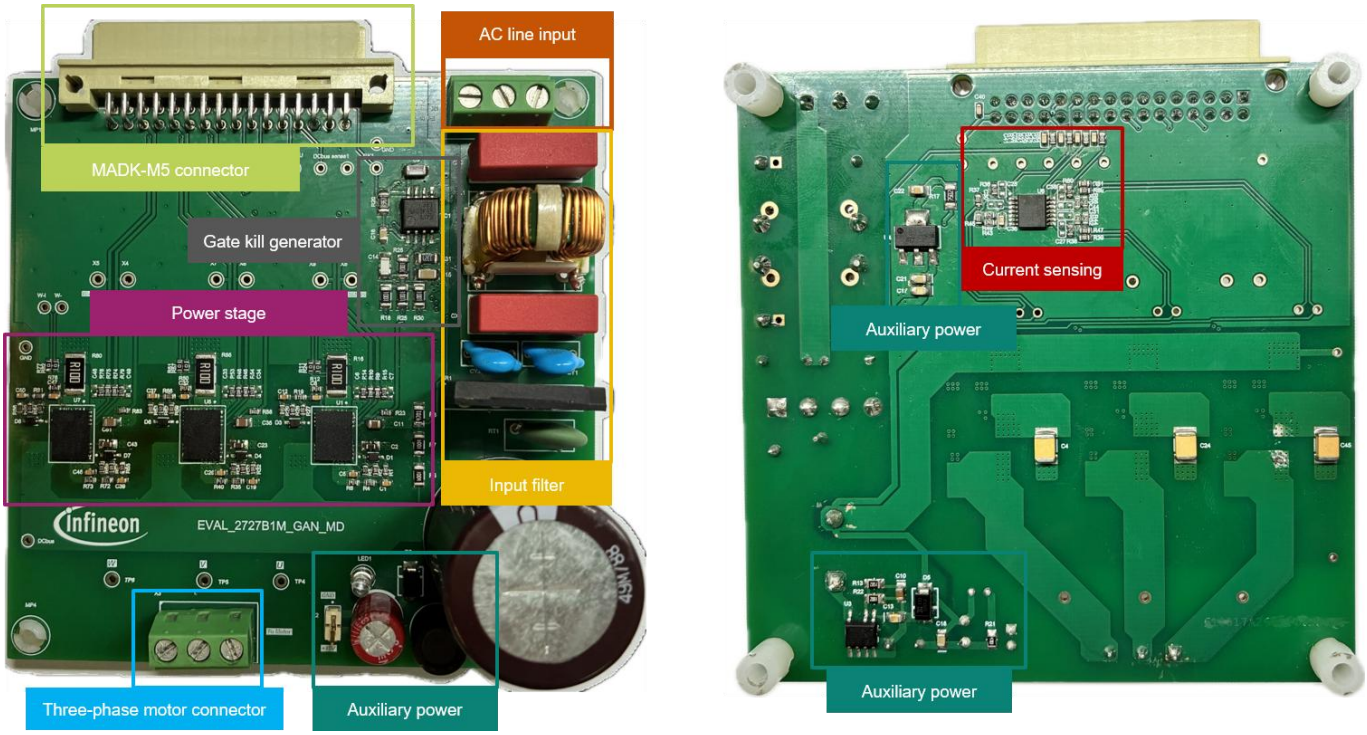


Figure 3 Board description of EVAL_2727B1M_GAN_MD

1.3 Hardware parameter configuration

1.3.1 Gate driver

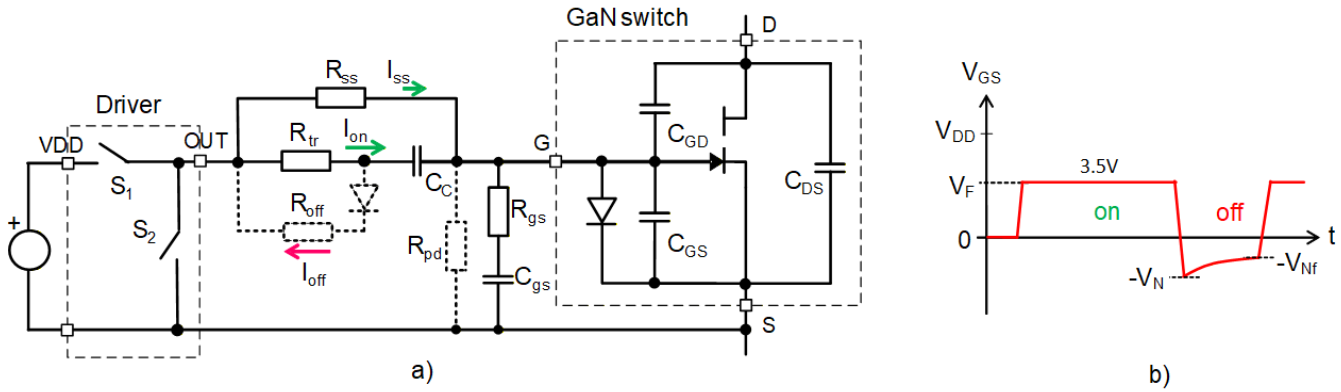


Figure 4 Equivalent circuit of GaN switch with RC gate drive in motor drive application (a) and gate-to-source voltage V_{GS} (b)

CoolGaN™ Drive HB combines gate driver and half-bridge gate injection transistor (GIT) GaN in one compact package, making it ideal in compact motor drive application. Due to ohmic contact pGaN gate structure, gate of GIT GaN behaves like a diode, requiring a continuous gate current during on-state. We suggest RC interface to properly drive GIT GaN device. **Figure 4** shows the equivalent gate driving circuit. For more information regarding how to drive GIT GaN, please refer to the white paper [3].

Motor drive application requires configurable switch node voltage dv/dt slew rate, typical < 5 V/ns to avoid damage to motor winding insulation. **Table 3** shares the gate configuration of EVAL_2727B1M_GAN_MD. To further slow down the slew rate, external C_{gs} and its damping R_{gs} are adding to the circuit. Additionally, it is highly recommended to add R_{pd} gate pull-down resistor, with the value normally from 50 kΩ to 100 kΩ, to not only protect the GaN gate from unexpected ESD damage but also avoid unknown gate status when the integrated gate driver is not powered normally. Users can modify the gate configuration accordingly, to balance the EMI and efficiency performance.

Table 3 Gate drive configuration of EVAL_2727B1M_GAN_MD

Component	Value	Component	Value
R_{ss}	3 kΩ	R_{on}	680 Ω
R_{off}	68 Ω	C_C	2.2 nF
R_{pd}	100 kΩ	External C_{gs}	680 pF
Damping R_{gs}	33 Ω		

1.3.2 Phase current and bus voltage sensing

EVAL_2727B1M_GAN_MD is designed with three-leg shunt configuration. For each phase, a 100 mΩ shunt resistor is in series with the low side transistor. With the differential amplifier circuit, the shunt current is modified with a 4x gain and a 2.5 V DC bias.

The DC bus voltage is sampled by a voltage divider with the downsizing factor of 4.7/2004.7 and then sent to the MCU after a RC filter.

1.3.3 Gate kill generator

To have a hardware level quick response to sudden overcurrent events, gate kill generator circuit is implemented in EVAL_2727B1M_GAN_MD as shown in **Figure 5**. When the shunt current reaches the protection limit I_{TRIP}, the comparator will pull down the GK signal, and then MCU will block the PWM signals quickly. The protection threshold has been set at 4.14 A in the design, and can be configured as following equation:

$$I_{\mathrm{TRIP}} = 5V \times \frac{R31}{R17 + R31} \times \frac{1}{R_{\mathrm{shunt}}} \quad (1)$$

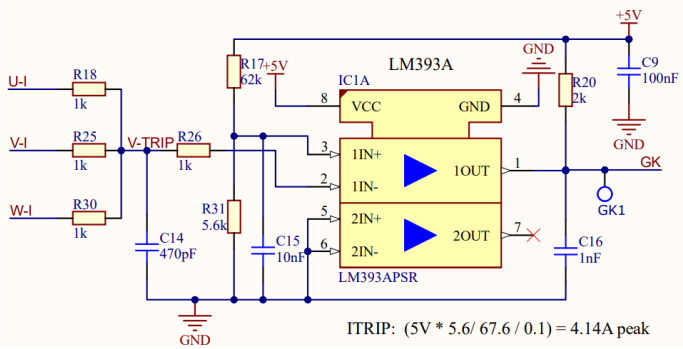
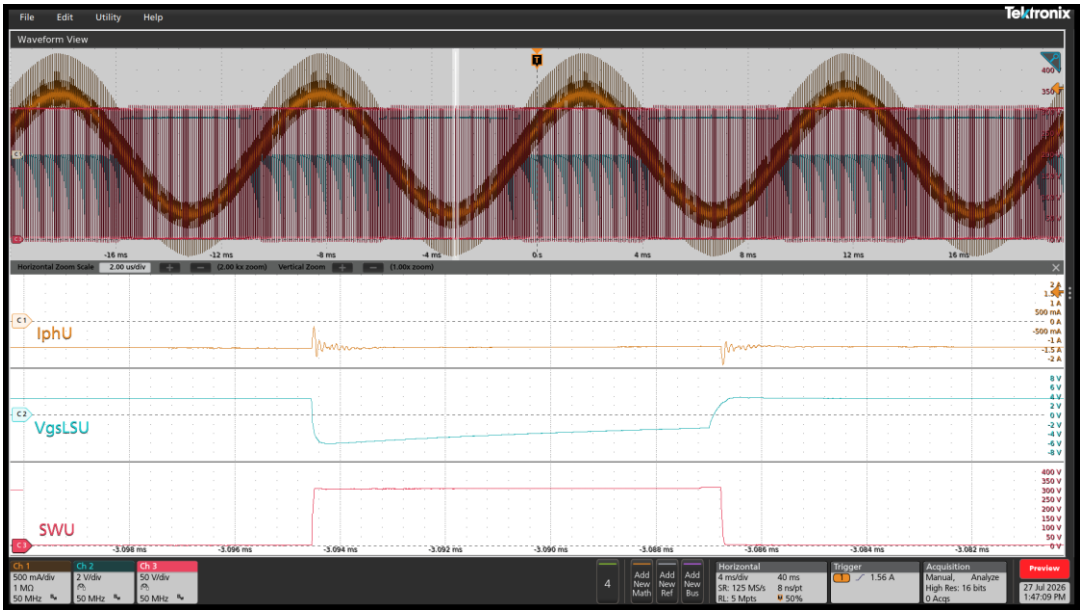


Figure 5 Gate kill generator circuit

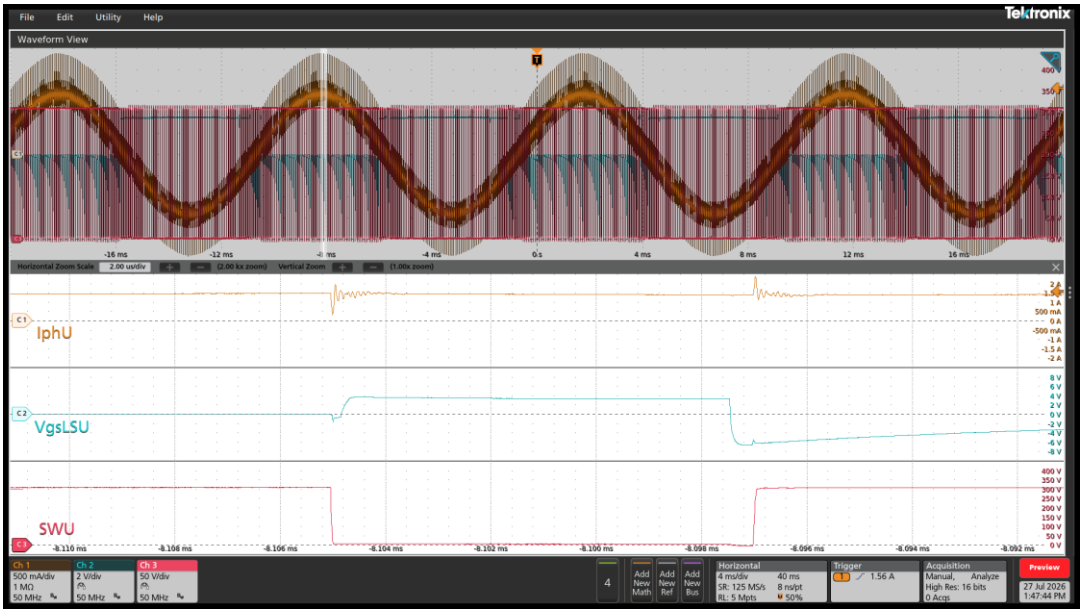
2 System performance

The test is based on the following conditions:

- Voltage mode open-loop test, SVPWM modulation;
- Three-phase Y-connection RL load, L = 12 mH, Rload = 100 Ω;
- Vdc = 310 V, Iph = 1 A (RMS), Fo = 100 Hz, Po = 300 W;
- Fsw = 15 kHz, Deadtime = 250 ns;
- VDD = 15 V.



(a) Switching waveform when LS working as active switch



(b) Switching waveform When LS working as passive switch

Figure 6 Phase U current (orange channel), phase U low-side switch Gate-Source signal (blue channel) and Phase U low-side switch Drain-Source signal (red channel)

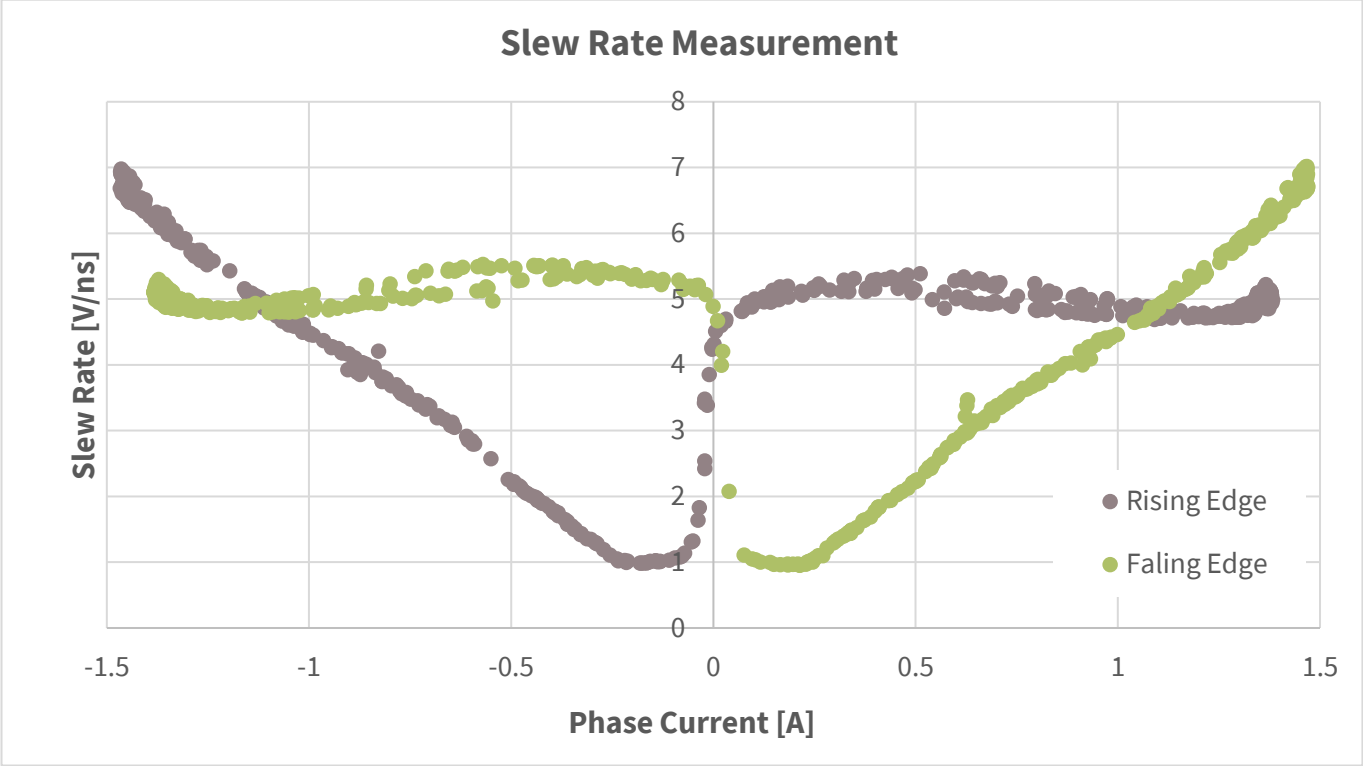


Figure 7 Butterfly chart of Vsw slew rate

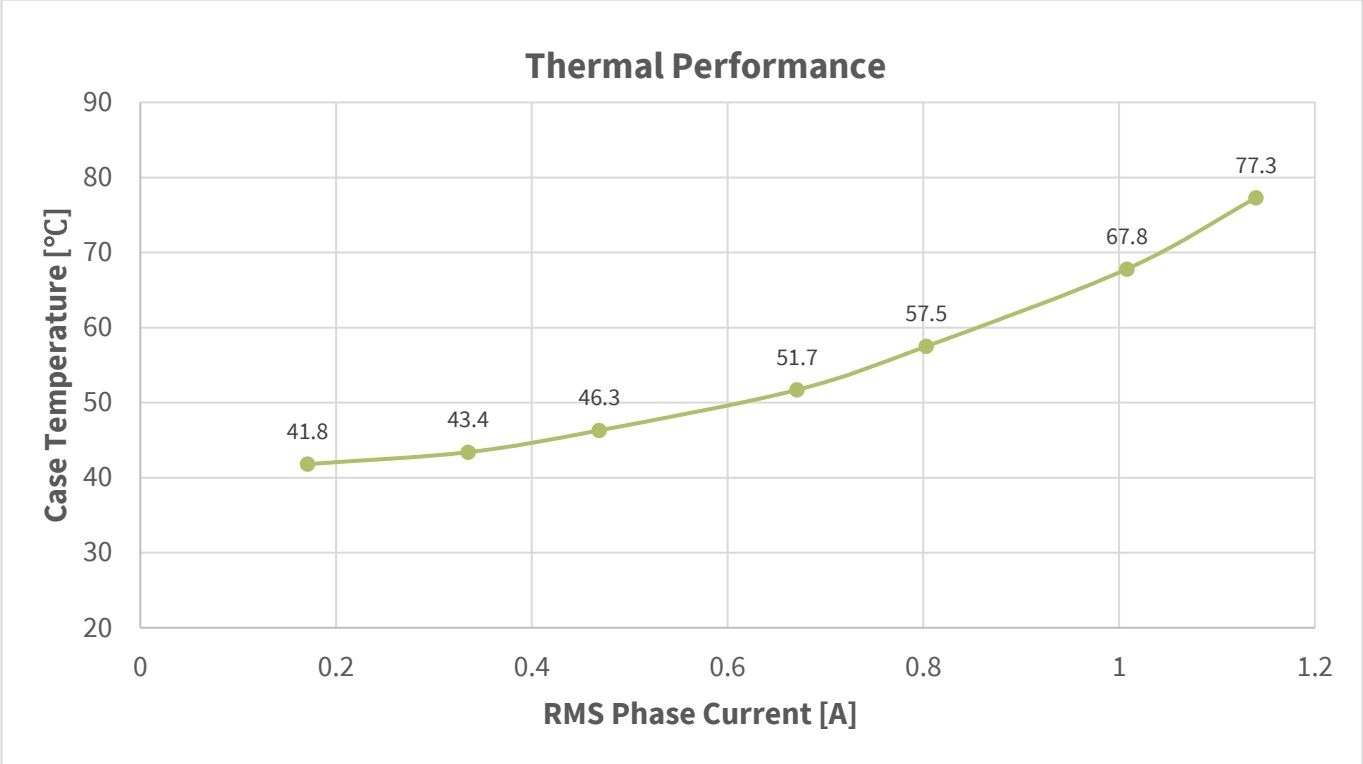


Figure 8 Phase V device case temperature with 25°C ambient temperature

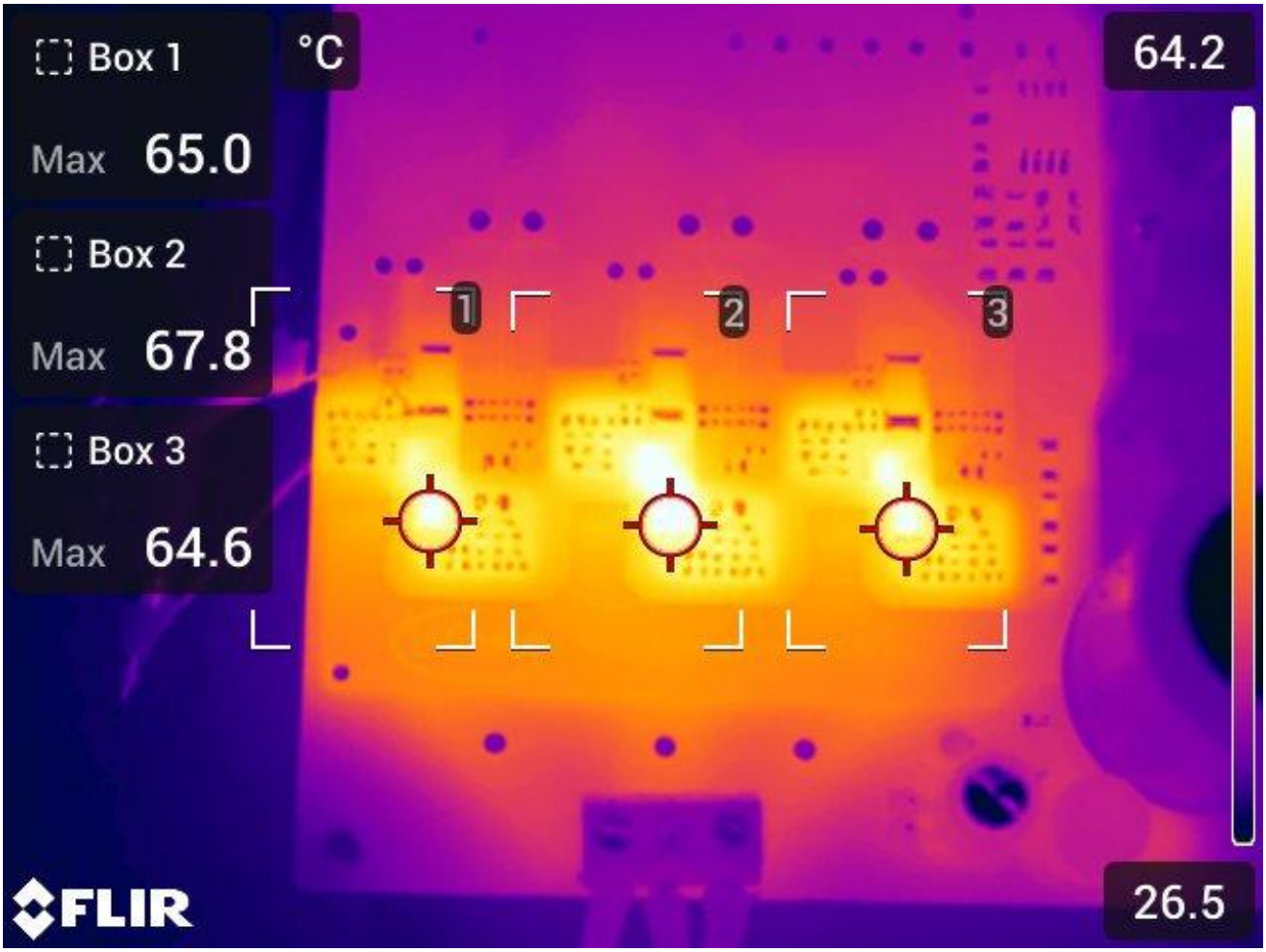


Figure 9 **Thermal Picture at Vbus = 310 V, Io = 1 A (RMS), Po = 300 W, Fsw = 15 kHz, Deadtime = 250 ns, with the maximum Tc = 67.8°C at 25°C ambient temperature.**

3 System design

3.1 Schematic

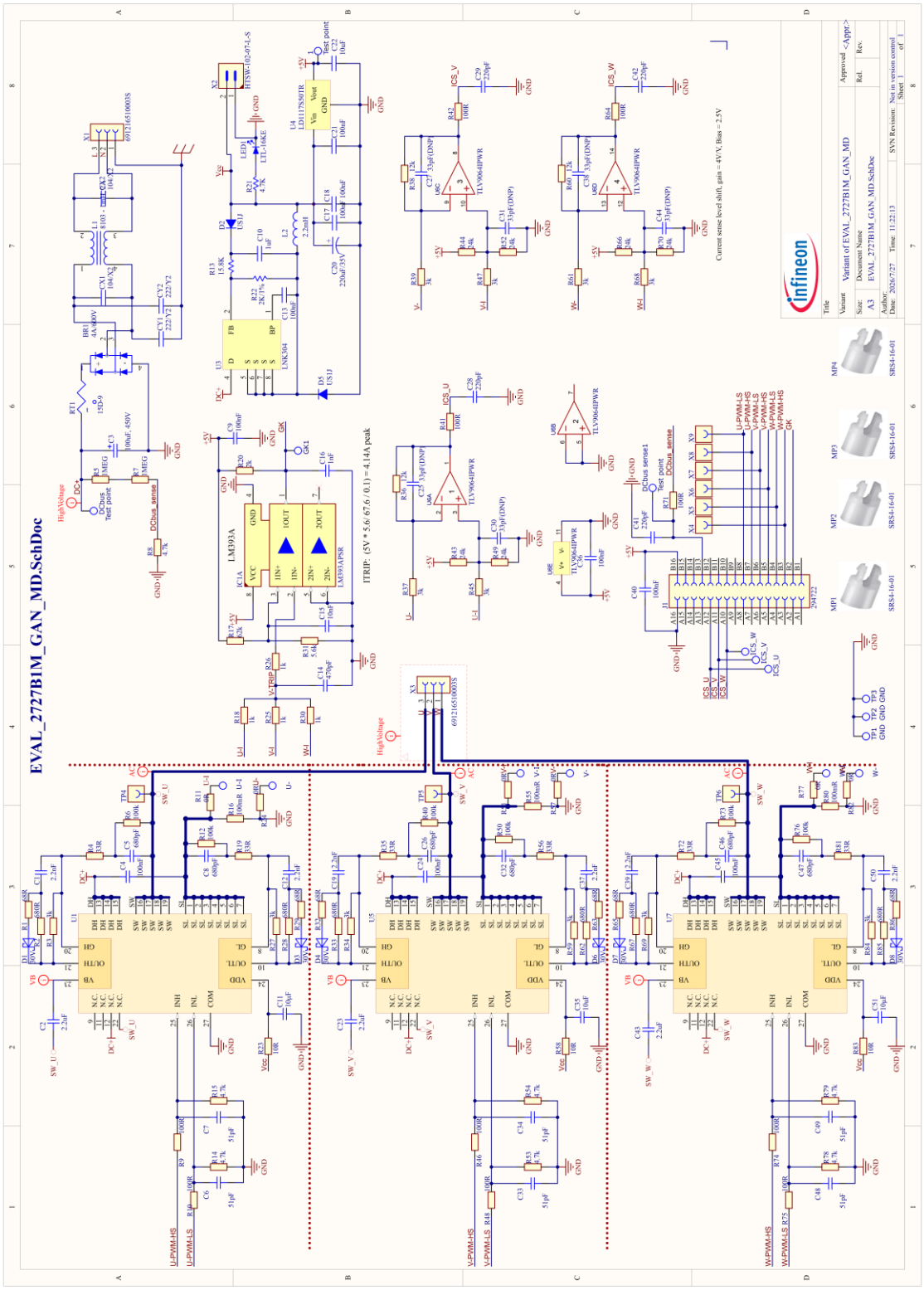
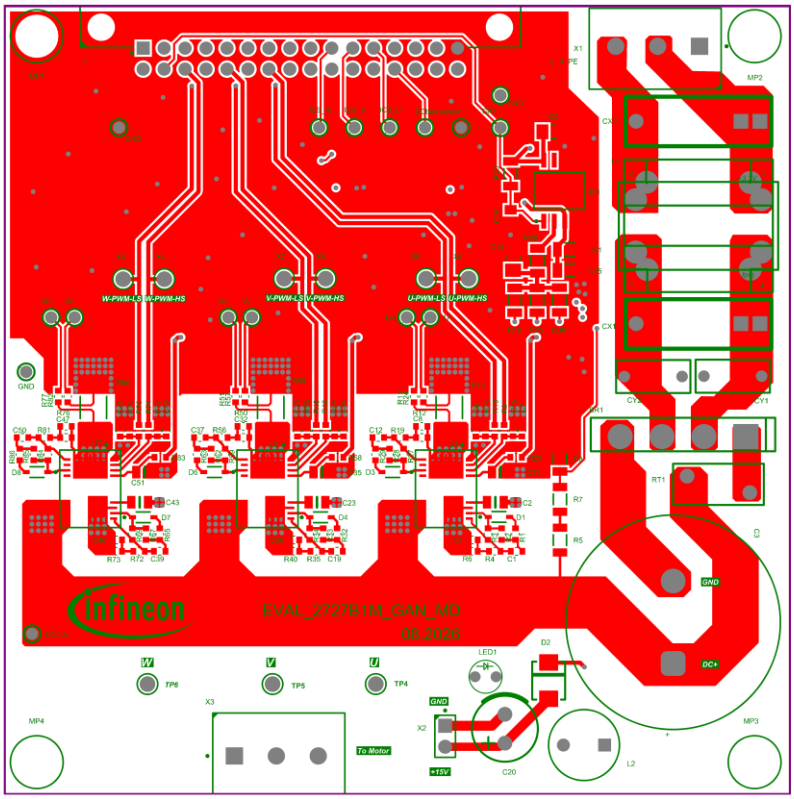
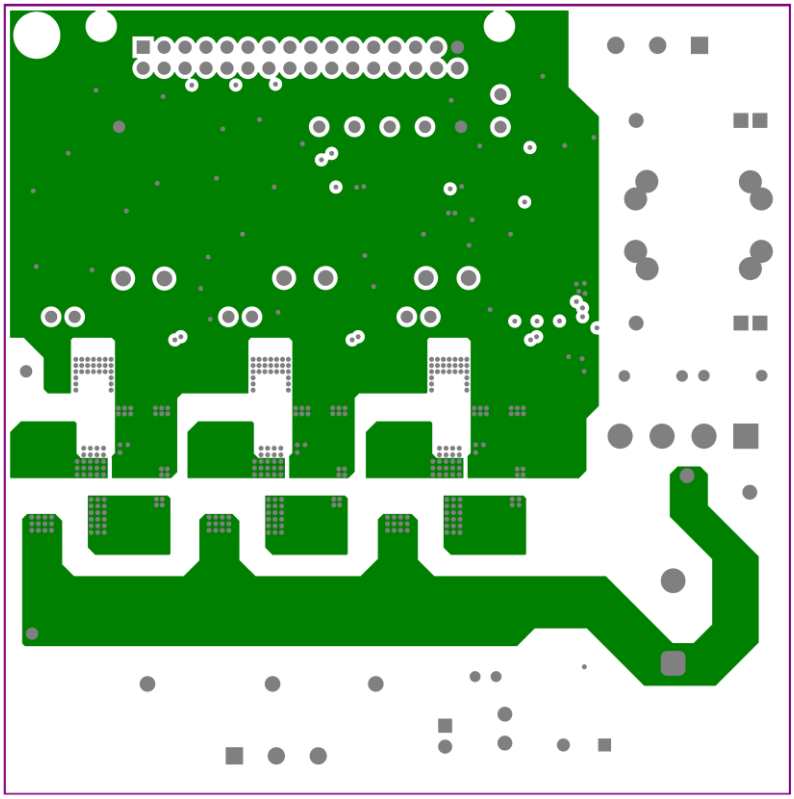


Figure 10 Schematic design

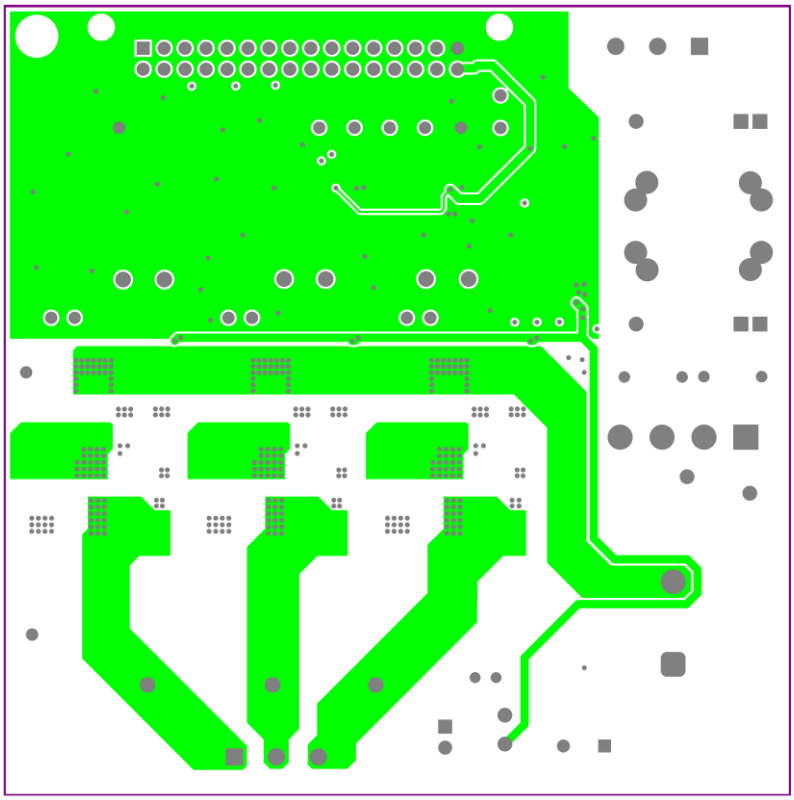
3.2 Layout



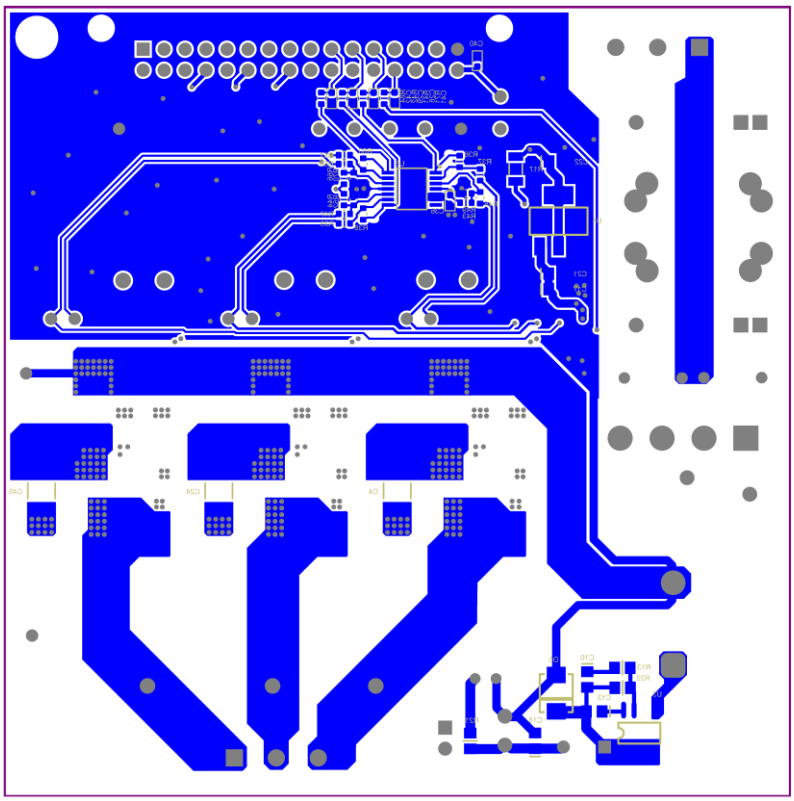
(a) Top layer



(b) Inner layer 1



(c) Inner layer 2



(d) Bottom layer

Figure 11 Layout details for each layer

3.3 Bill of material

Table 4 BOM of EVAL_2727B1M_GAN_MD

Comment	Description	Designator
GBU406	BRIDGE RECT 1PHASE 600V 4A GBU	BR1
2.2nF	CAP / CERA / 2.2nF / 50V / 5% / C0G / -55°C to 125°C / 0603 / SMD / -	C1, C12, C19, C37, C39, C50
2.2uF	CAP / CERA / 2.2uF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0805 / SMD / -	C2, C23, C43
100uF, 450V	WCAP-AIE8 Aluminum Electrolytic Capacitor, Snap-In, THT, D25xH25mm, 100uF, 450V	C3
100nF	CAP / CERA / 100nF / 630V / 10% / X7R (EIA) / -55°C to 125°C / 1812 / SMD / -	C4, C24, C45
680pF	CAP / CERA / 680pF / 100V / 5% / C0G / -55°C to 125°C / 0603 / SMD / -	C5, C8, C26, C32, C46, C47
51pF	CAP / CERA / 51pF / 50V / 5% / C0G / -55°C to 125°C / 0603 / SMD / -	C6, C7, C33, C34, C48, C49
100nF	CAP / CERA / 100nF / 50V / 5% / C0G (EIA) / NP0 / -55°C to 125°C / 1206 / SMD / -	C9
1uF	CAP / CERA / 1uF / 25V / 10% / X7R / -55°C to 125°C / 0805 / SMD / -	C10
10µF	CAP / CERA / 10uF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0805 / SMD / -	C11, C51
100nF	CAP / CERA / 100nF / 25V / 10% / X7R / -55°C to 125°C / 0805 / SMD / -	C13, C17, C18, C21
470pF	CAP / CERA / 470pF / 50V / 5% / C0G (EIA) / NP0 / -55°C to 125°C / 1206 / SMD / -	C14
10nF	CAP / CERA / 10nF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 1206 / SMD / -	C15
1nF	CAP / CERA / 1nF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0805 / SMD / -	C16
220uF/35V	CAP / ELCO / 220uF / 35V / 20% / Aluminum electrolytic / -55°C to 105°C / 3.50mm C X 0.60mm W 8.00mm Dia X 12.00mm H / THT / -	C20
10uF	CAP / CERA / 10uF / 25V / 10% / X7R / -55°C to 125°C / 0805 / SMD / -	C22
33pF(DNP)	CAP / CERA / 33pF / 50V / 5% / C0G / -55°C to 125°C / 0603 / SMD / -	C25, C27, C30, C31, C38, C44
220pF	CAP / CERA / 220pF / 50V / 5% / C0G / -55°C to 125°C / 0603 / SMD / -	C28, C29, C41, C42
10uF	CAP / CERA / 10uF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0805 / SMD / -	C35

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Comment	Description	Designator
100nF	CAP / CERA / 100nF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0603 / SMD / -	C36, C40
104/X2	CAP FILM 0.1UF 10% 275VAC RADIAL	CX1, CX2
222/Y2	CAP CER 2200PF 250VAC RADIAL	CY1, CY2
30V	Silicon Schottky Diode	D1, D3, D4, D6, D7, D8
US1J	Surface Mount Ultrafast Rectifier	D2, D5
LM393APSR	Dual Comparators, Low output saturation voltage, Output compatible with TTL, MOS, and CMOS	IC1
294722	DIN 41612 Female Connector	J1
8103 - 1mH, 2A	CMC 1MH 4.8A 2LN TH	L1
2.2mH	2.2mH,10%, D8.7xL12mm	L2
LTL-16KE	LED	LED1
SRS4-16-01	Self-retaining spacer	MP1, MP2, MP3, MP4
68R	RES / STD / 68R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R1, R29, R32, R63, R65, R86
680R	RES / STD / 680R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R2, R28, R33, R62, R67, R85
3k	RES / STD / 3k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R3, R27, R34, R37, R39, R45, R47, R59, R61, R68, R69, R84
33R	RES / STD / 33R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R4, R19, R35, R56, R72, R81
1MEG	RES / STD / 1MEG / 250mW / 5% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	R5, R7
100k	RES / STD / 100k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R6, R12, R40, R50, R73, R76
4.7k	RES / STD / 4.7k / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	R8
100R	RES / STD / 100R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R9, R10, R41, R42, R46, R48, R64, R71, R74, R75
0R	RES / STD / 0R / - / 0R / - / -55°C to 155°C / 0603 / SMD / -	R11, R24, R51, R57, R77, R82
15.8K	RES / STD / 15.8k /125mW / 1% / 100ppm/K / -55°C to 155°C / 0805 / SMD / -	R13
4.7k	RES / STD / 4.7k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R14, R15, R53, R54, R78, R79
100mR	RES / STD / 100mR / 1W / 1% / 100ppm/K / -55°C to 125°C / 2512 / SMD / -	R16, R55, R80

Comment	Description	Designator
62k	RES / STD / 62k / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	R17
1k	RES / STD / 1k / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	R18, R25, R26, R30
2k	RES / STD / 2k / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	R20
4.7K	RES / STD / 4.7k /125mW / 1% / 100ppm/K / -55°C to 155°C / 0805 / SMD / -	R21
2K	RES / STD / 2k / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805 / SMD / -	R22
10R	RES / STD / 10R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R23, R58, R83
5.6k	RES / STD / 5.6k / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	R31
12k	RES / STD /12k / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R36, R38, R60
24k	RES / STD /24k / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R43, R44, R49, R52, R66, R70
15D-9	THERMISTOR NTC ICL 10MM 15 OHM	RT1
20-2137	Black bead terminal assembly 1.02mm hole	TP4, TP5, TP6, X4, X5, X6, X7, X8, X9
IGI60L2727B1M	CoolGaN™ Drive HB 600 V G5, 6x8 mm TFLGA-27	U1, U5, U7
LNK304	Buck converter IC	U3
LD1117S50TR	Voltage Regulator	U4
TLV9064IPWR	TLV9064IPWR	U6
691216510003S	Horizontal Cable Entry With Rising Cage Clamp - WR-TBL, 3Pins	X1, X3
HTSW-102-07-L-S	Through hole .025 SQ Post Header, 2.54mm pitch, 2 pin, vertical, single row	X2

3.4 Connector description

Table 5 X1 AC line input connector

PIN	Label	Function
1	PE	Earth
2	N	Neutral
3	L	Line

Table 6 X2 VCC connector

PIN	Label	Function
1	GND	Auxiliary power reference ground
2	VCC	Auxiliary power input

Table 7 X3 Motor connector

PIN	Label	Function
1	W	Connected to motor phase W
2	V	Connected to motor phase V
3	U	Connected to motor phase U

Table 8 J1 KIT_PSC3M5_CC2 MADK M5 header 32pin interface connector

PIN	Label	Function
A1, A2, A3, A4, A5, A6, A7, A8, A9, A13, A14, A15, B1, B9, B10, B11, B12, B14, B15	NC	NC
A10	ICS_W	Current W sense
A11	ICS_V	Current V sense
A12	ICS_U	Current U sense
A16	GND	Ground
B2	GK	PWM kill feedback
B3	W-PWM-HS	PWM WH
B4	W-PWM-LS	PWM WL
B5	V-PWM-HS	PWM VH
B6	V-PWM-LS	PWM VL
B7	U-PWM-HS	PWM UH
B8	U-PWM-LS	PWM UL
B13	DCbus_sense	DC bus voltage sense
B16	+5V	+5V auxiliary power output for controller

References

[1] Infineon Technologies: CoolGaN™ Drive HB 600 V G5 IGI60L2727B1M GaN with integrated driver datasheet. Available online

[2] KIT_PSC3M5_CC2 PSOC™ Control C3M5 Motor Drive Control Card. Available online

[3] Gate drive configurations for GaN power transistors. Available online

Revision history

Document revision	Date	Description of changes
1.0	29/07/2026	Initial version

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Edition 2026-07-29
Published by

Infineon Technologies AG
81726 Munich, Germany

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Safety & Operating Instructions:
Customer shall check the Evaluation Board for any physical damage which may have occurred during transport. If customer detects any damages or defects in the Evaluation Board, customer shall not connect the Evaluation Board to a power source. Customer shall contact Infineon for further support. If customer observes unusual operating behavior during the evaluation process, customer shall immediately shut off the power supply to the Evaluation Board and consult Infineon for support.
Customer shall not touch the Evaluation Board during operation and keep a safe distance.
Customer shall not touch the Evaluation Board after disconnecting the power supply, several components may still store electrical voltage and can discharge through physical contact. Several parts, like heat sinks and transformers, may still be very hot. Allow the components to cool before touching or servicing.
The electrical installation must be completed in accordance with the appropriate safety requirements.