Solar optimizer with CoolGaN™ transistors in a buck configuration

About this document

Scope and purpose

This user guide helps you get started with the REF_OPTI_80V20A_GaN CoolGaN™ reference board for a solar optimizer. This document provides information on the hardware, mechanical structure, and test setup.

Intended audience

This user guide is intended for system application engineers who want to improve space utilization and seek inspiration for their next solar optimizer designs, with an input voltage up to 80 V and output current up to 20 A.



Figure 1 Reference board REF_OPTI_80V20A_GaN

About this product group

Target applications

The REF_OPTI_80V20A_GaN reference design is intended for low-voltage renewable-energy power stages where high power density, fast switching, and efficient DC-DC conversion are essential. Typical target applications include:

- Solar optimizers for residential and commercial photovoltaic systems
- Module-level power electronics (MLPE) such as DC power optimizers
- High-frequency DC-DC converters for distributed energy systems
- Smart energy storage interfaces requiring fast transient response
- Low-voltage conversion stages in renewable or hybrid power architectures

Product family

This reference design highlights Infineon's CoolGaN™ 100 V power transistor family, which provides superior switching performance for compact, high-efficiency power conversion. CoolGaN™ devices offer low specific on-resistance, low output charge, and robust high-frequency operation, making them well-suited for high-density DC-DC converters.

The design also integrates complementary Infineon components that together form a complete system solution:

- CoolGaN™ 100 V Transistors – optimized for high-speed switching and minimal switching losses
- EiceDRIVER™ 1EDN71x6U gate driver family – designed for GaN compatibility with differential input and active Miller clamp
- PSOC™ PSC3 microcontroller family – providing MPPT control, sensing, and system management
- OPTIREG™ LDO TLS205B0EJV33 – low-noise, low-quiescent-current power regulation for the controller and sensing circuits

This family of Infineon components enables small-form-factor, high-efficiency solar optimizer designs with simplified integration and broad application scalability.

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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 Introduction

REF_OPTI_80V20A_GaN is a compact reference design for solar optimizer applications. This board includes two CoolGaN™ Transistors 100 V IGC016K10S2 in a half-bridge configuration. Each transistor is driven by an EiceDRIVER™ 1EDN7116U gate driver. The input and output current is sensed by shunt resistors in a low-side configuration.

The board is equipped with a PSOC™ microcontroller that can handle Maximum Power Point Tracking (MPPT). It interfaces with another board or PC through UART and a debug interface.

The reference design was developed to demonstrate the high power densities achievable within a small size of only 40 mm × 60 mm × 17 mm. This is thanks to the reduction of the power inductor and bulk capacitance, and also by operating the inverter at a high switching frequency (≥400 kHz) without a significant power loss penalty. Moreover, CoolGaN™ Transistor 100 V IGC016K10S2 is a top-side cooling device on an exposed-die PQFN package that can efficiently extract the heat and provide more space for a top-bottom PCB implementation.

REF_OPTI_80V20A_GaN includes an aluminum heat sink.

The reference board is designed to be an all-in-one solar optimizer. It embeds a control system, comprising a PSOC™ microcontroller and sensing, and a power stage composed of two discrete Infineon CoolGaN™ Transistors. The half-bridge is driven by two independent gate drivers, which gives full independence regarding the preferred switching pattern and dead-time. The power stage is protected against overtemperature with a sensor mounted next to the CoolGaN™ Transistors.

The input and output voltages are acquired by a voltage divider, and the current is measured using low-side shunt resistors for both input and output currents. Overcurrent protection (OCP) and overvoltage protection (OVP) are detected by the microcontroller through internal variable limits set in the ADC acquisition of the shunt and voltage divider.

The block diagram shown in Figure 1 is a schematic of the fundamental circuits. The XMC™ Link [8] debug probe is used to program and control the reference design board.

Note: Environmental conditions were considered in the design of REF_OPTI_80V20A_GaN. The design was tested as described in this document but not qualified in terms of safety requirements, manufacturing, and operation over the entire operating temperature range or lifetime. The boards provided by Infineon must be used for functional testing only.

Note: Reference boards are not subject to the same procedures as regular products regarding returned material analysis (RMA), process change notification (PCN), and product discontinuation (PD). Reference boards must be handled by trained specialists only.

Introduction

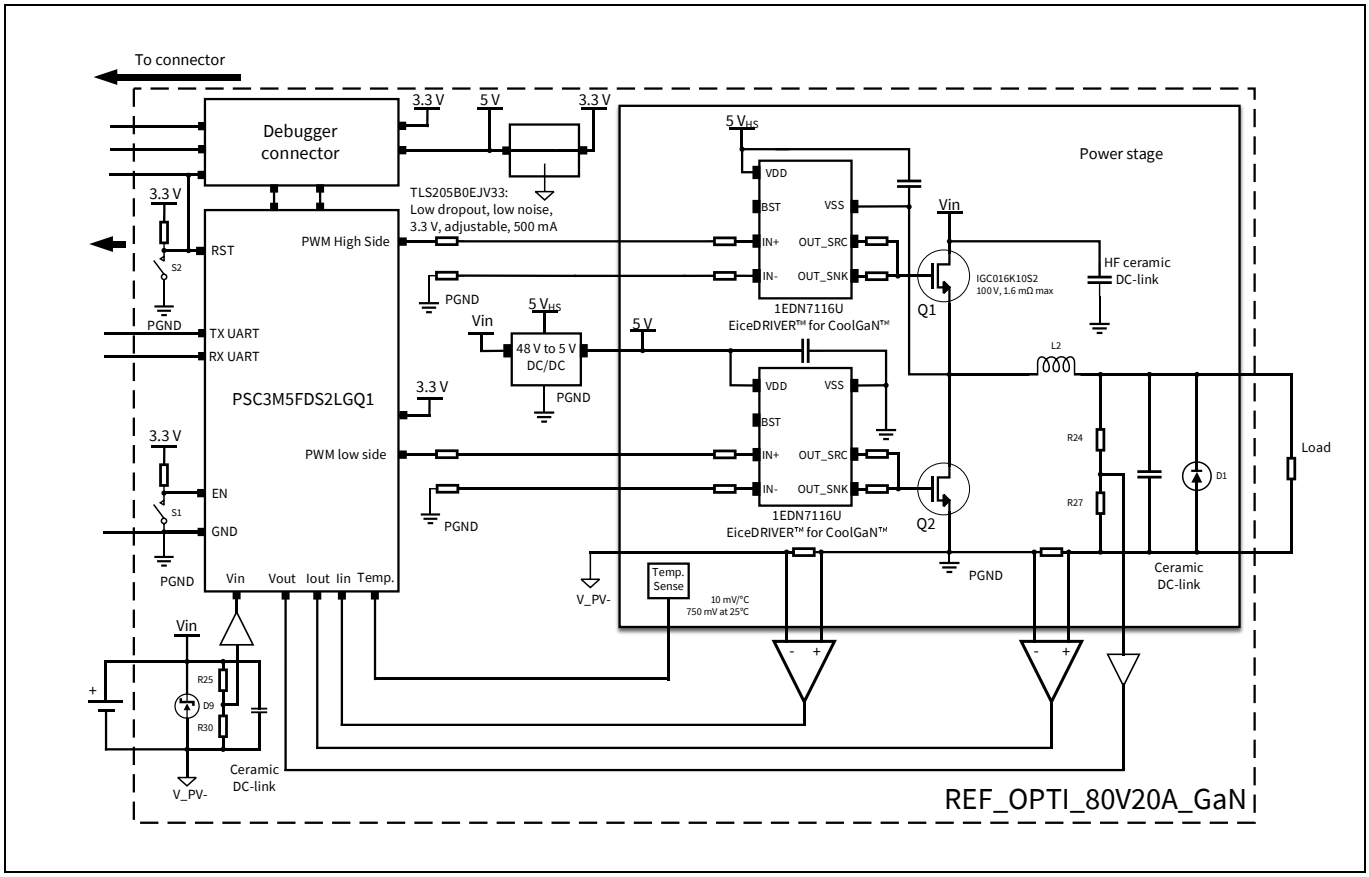


Figure 2 Block diagram of REF_OPTI_80V20A_GaN

2 Design features

REF_OPTI_80V20A_GaN is a reference design equipped with the latest generation of Infineon's CoolGaN™ Transistors in combination with a complementary EiceDRIVER™ gate driver and Infineon's PSOC™ microcontroller to execute the MPPT algorithm.

Main components:

- CoolGaN™ Transistor 100 V IGC016K10S2 [1], 1.6 mΩ (max.) in a 5 mm × 3 mm PQFN package
- EiceDRIVER™ 1EDN71x6U [2] gate driver for GaN transistors and MOSFETs
- PSOC™ PSC3M5FDS2LGQ1 [3] Industrial Arm® Cortex®-M33 MCU
- TLS205B0EJV33 [4] low noise 3.3 V LDO regulator with output current up to 500 mA

The reference design characteristics are:

- 15–80 V nominal input voltage
- High power density design in a 40 mm × 60 mm × 17 mm PCB with four layers of 70 µm (2 oz.) copper
- Ceramic capacitor DC link for lowest equivalent series resistance (ESR) and high-current ripple handling
- Optimized power loop inductance allowing for nanosecond switching transients and minimal overshoot
- Auxiliary power supply with 3.3 V and 5 V included
- Heatsink and mounting hardware included as a part of the kit

2.1 Highlighted products

2.1.1 CoolGaN™ Transistors 100 V

CoolGaN™ Transistors [1] offer fundamental advantages over silicon. In particular, the higher critical electrical field makes them very attractive as power semiconductor devices with outstanding specific on-state resistances and smaller capacitances compared to silicon MOSFETs. This makes GaN transistors a great solution for high-speed or high-frequency switching applications. GaN transistors can then be operated with reduced dead-times, which results in a higher efficiency and enables passive cooling. Operation at high switching frequencies allows the quantity of passive components to shrink, which improves system reliability and density.

2.1.2 EiceDRIVER™ 1EDN71x6U gate driver

EiceDRIVER™ 1EDN71x6U [2] is a single-channel gate driver IC optimized for compatibility with Infineon CoolGaN™ Transistors, and it is also compatible with other GaN transistors and silicon MOSFETs. This gate driver includes several key features that enable a high-performance system design with CoolGaN™ Transistors, including truly differential input (TDI), four driving strength options (from 0.5 A to 2 A depending on the part number), active Miller clamp, and bootstrap voltage clamp.

2.1.3 PSOC™ microcontroller

PSOC™ PSC3M5FDS2LGQ1 [3] is a high-performance, low-power 32-bit single-core Arm® Cortex® M33-based microcontroller with digital signal processor (DSP), floating-point unit (FPU), and state-of-the-art security features. The device has a high performance 12-bit SAR ADC with parallel idle sampling of up to 16 analog channels.

2.1.4 TLS205B0LDV low-dropout voltage regulator

TLS205B0EJV33 [4] is a monolithic integrated fixed linear voltage post regulator for load currents up to 500 mA. The IC regulates an adjustable output voltage of 1.22 V to 20 V with a precision of ±2.5%, supplied by an input voltage up to 20 V. TLS205B0EJV33 is specially designed for applications requiring very low standby currents. The device is available in a very small surface-mounted PG-DSO-8 package. The device is protected against overload and overtemperature conditions by the implemented output current limitation and overtemperature shutdown circuit.

2.2 Specifications

Table 2 REF_OPTI_80V20A_GaN reference board's specifications

Parameter	Value	Conditions/comments
Input		
Nominal input voltage	15–80V	–
Maximum input voltage	80 V	Maximum stable voltage before triggering the overvoltage protection (OVP)
Undervoltage lockout (UVLO)	10 V	Minimum voltage to turn off the DC-DC converter
Maximum input current	20 A	Maximum in steady state; more current achievable when firmware protection is disabled
Power max (electrical input)	500 W	48 V, Ta = 25°C, with heat spreader
Output		
Power max	500 W	48 V, Ta = 25°C with heat spreader
Current (max)	20 A	48 V, Ta = 25°C, natural convection, no heat spreader, and no forced air (in steady state)
Switching frequency		
Nominal switching frequency	400 kHz	
Current feedback		
Sensitivity	82 mV/A	±2%
Overcurrent detection (OCD)	20 A	Reconfigurable by user in the firmware
Offset	0 V	1.65 V can be added externally with separate PSU
DC link and output voltage feedback		
Sensitivity	37.7 mV/V	±1%
Onboard supply		
+5 V	±2%	Used for gate driving. Also supplies the 3.3 V regulator
+3.3 V	±3%	Used for the microcontroller and operational amplifiers current sensor
System environment		
Ambient temperature	From 0°C to 85°C	Noncondensing, maximum relative humidity of 95%
Temperature limit	Up to 110°C	The temperature is acquired by the sensor (U6)

Parameter	Value	Conditions/comments
PCB characteristics		
Material	High TG FR4 material (PCL370HR)	4 layers (1 PTH via), 70 µm copper each 1.6 mm total board thickness
Dimensions	40 mm × 60 mm × 17 mm	

2.3 Board description

Figure 3 and Figure 4 shows the top and bottom sides of the REF_OPTI_80V20A_GaN reference board, respectively.

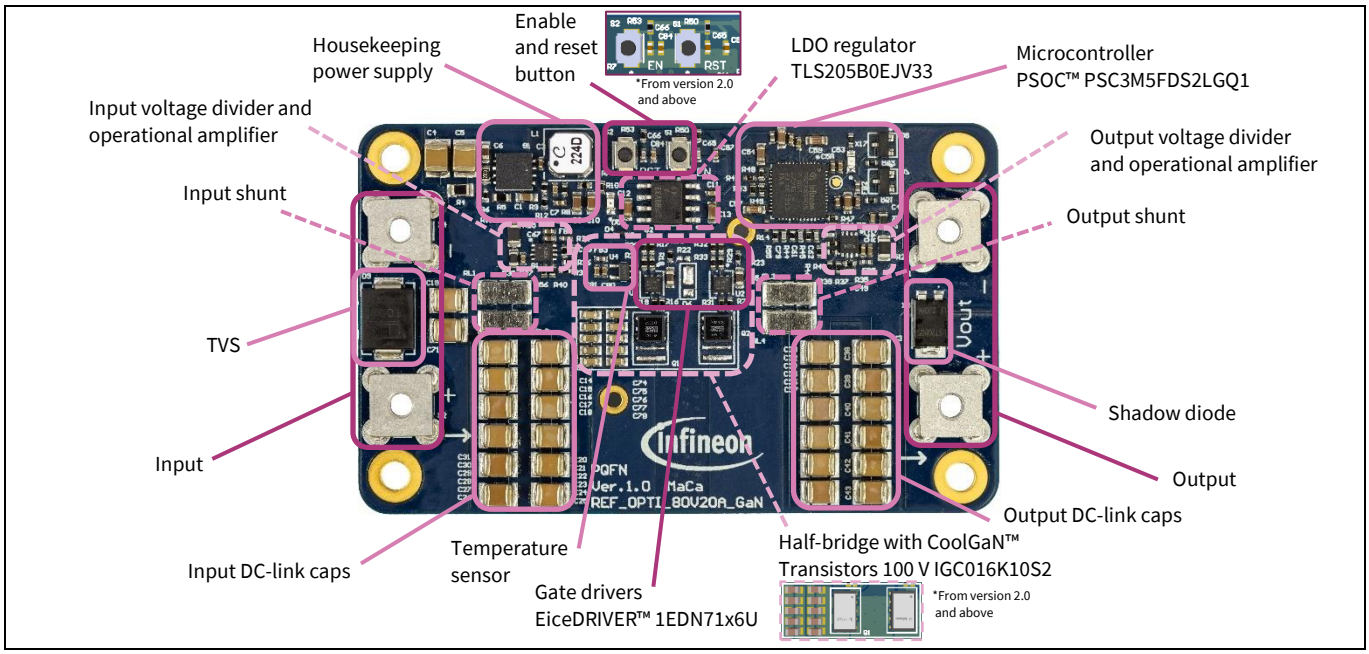


Figure 3 Top of REF_OPTI_80V20A_GaN board

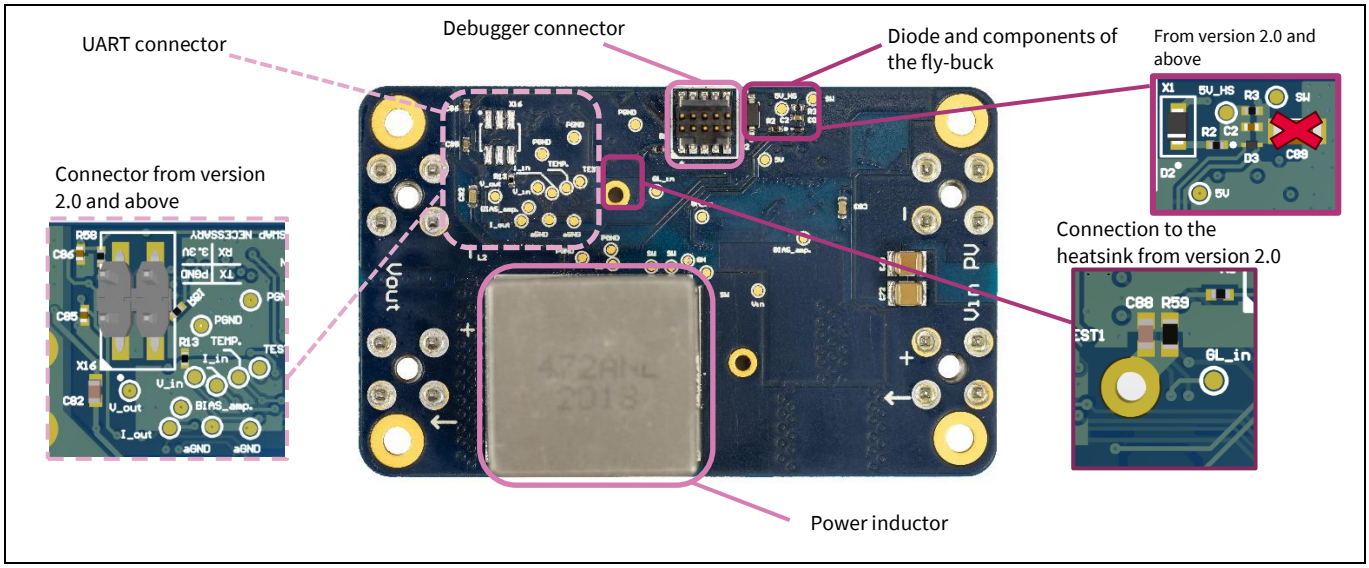


Figure 4 Bottom of REF_OPTI_80V20A_GaN board

Table 3 gives an overview of the pinout of the 4-pin male connector, which can be used to connect a UART transceiver, like the built-in XMC™ Link [8].

Table 3 X16 pinout

Pin no.	Description	Details
1	PGND	–
2	3.3 V	–
3	TX	Voltage input 0–3.3 V
4	RX	Voltage input 0–3.3 V

2.4 Heat spreader mounting

For evaluation, the REF_OPTI_80V20A_GaN board includes a metal heat spreader. The following contents are provided for mounting the heat spreader to the PCB:

- Two M1.6 × 6 mm screws
- Thermal interface material (TIM) pad 19 mm × 19 mm (T-Global TG-A1250, 500 µm thickness)
- One aluminum heat spreader/heatsink with integrated standoffs and alignment pins (R_{th}≈ 20°C/W)

The heat spreader guarantees heat extraction from the top of the device, as shown in Figure 5. The TIM needs to be compressed to 50% of the normal thickness (500 µm). Usually, the distance between the top of the device and the heatsink ranges from 200 µm to 300 µm. It is recommended to tighten the mounting screws carefully by hand with a screwdriver. A torque wrench is not required for safe assembly as long as overtightening is avoided.

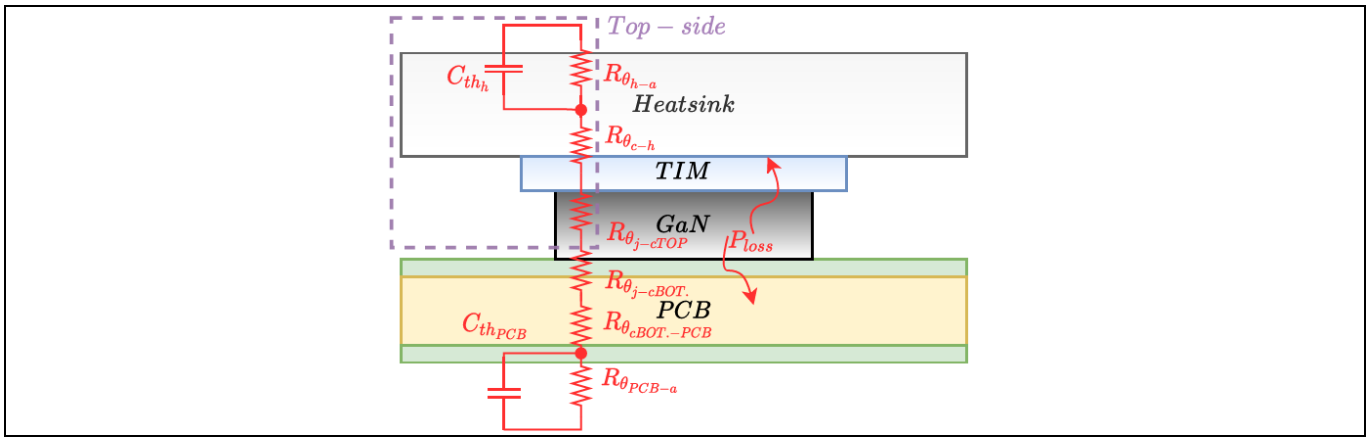


Figure 5 Cross-section showing the assembly of heat spreader with TIM applied to a single device for top-side cooling

The placement of the TIM is shown in Figure 6 (left). The protective plastic film on the TIM must be removed before use. The assembled reference board with the heat spreader is shown in Figure 6, on the right.

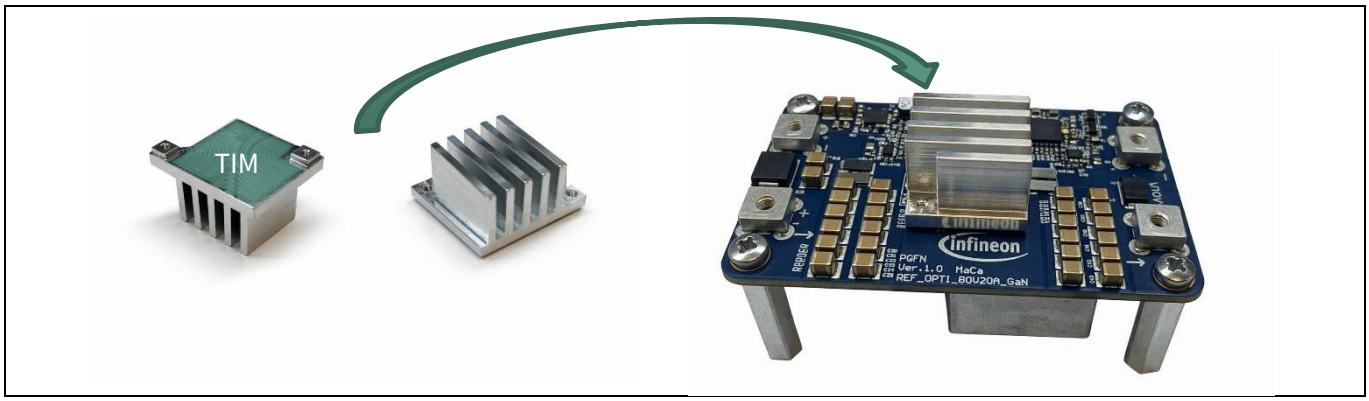


Figure 6 Placement of TIM across CoolGaN™ REF_OPTI_80V20A_GaN

2.5 Overview

A schematic overview of the motor drive is shown in Figure 7. The schematic can be divided into three core components:

- **Half-bridge:** This block has the CoolGaN™ half-bridge with current sensing, the DC-link/HF capacitors, and the current/voltage sensing
- **Power supply manager (Aux):** This block has all the housekeeping supplies. The 5 V supplies the gate driver for the low-side and the isolated flyback for the high-side, 3.3 V for the microcontroller and opamps
- **Microcontroller (Micro):** This block contains the PSOC™ microcontroller's pinout and connection to the different blocks like the inverter and the power supply manager block. In addition, the connection to the UART and the temperature sensor, that is located next to the CoolGaN™ half-bridge

In addition, connectors X1 and X16 are for the debugger and the UART interface connector respectively. The main connections to the solar panel are connectors X2 and X4. The output are connectors X3 and X5.

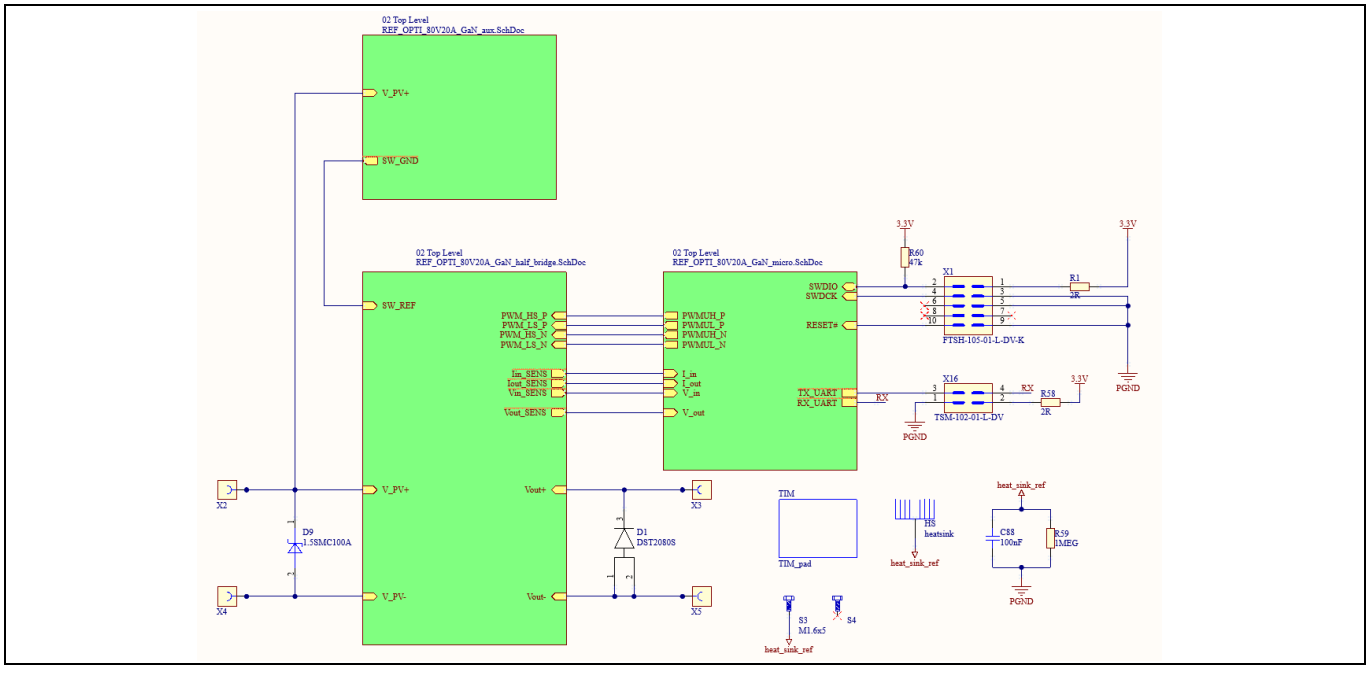


Figure 7 System-level overview of the motor drive schematic

2.6 Half bridge and bulk capacitors

The schematic of a single CoolGaN™ half-bridge is shown in Figure 8. The primary building block for the motor drive is an optimized half-bridge circuit, with two CoolGaN™ Transistors 100 V 1.6 mΩ (max.) in 5 mm × 3 mm PQFN lead-frame packages with exposed dies for dual-sided cooling. The design was optimized for low-power loop inductance by coplanar field compensation, as presented in [5], achieving an inductance of less than 500 pH. The gate loops were also designed to minimize common-source inductance while optimizing the gate driver circuits for fast switching without inserting a resistor for the turn-on of the two devices. Figure 9 reports the main bulk capacitance of the converter and as well the input sensing of the current and voltage.

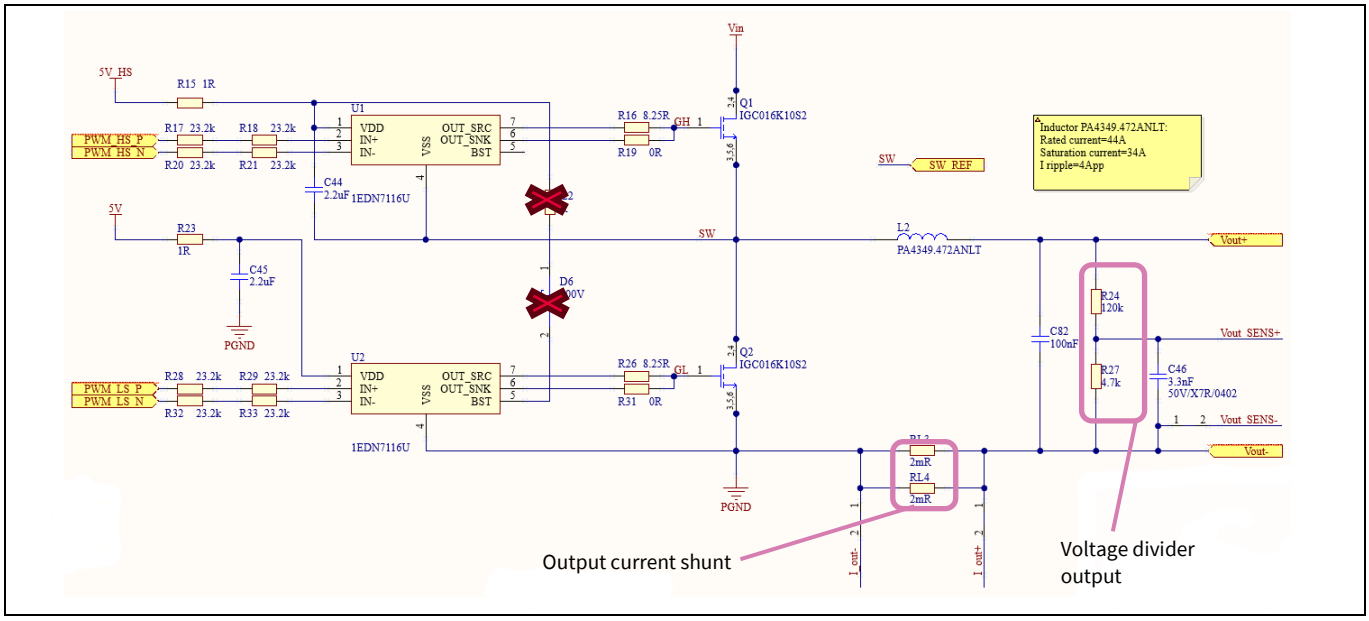


Figure 8 Schematic of power stage including gate driver, power inductor, and output voltage/current sensing

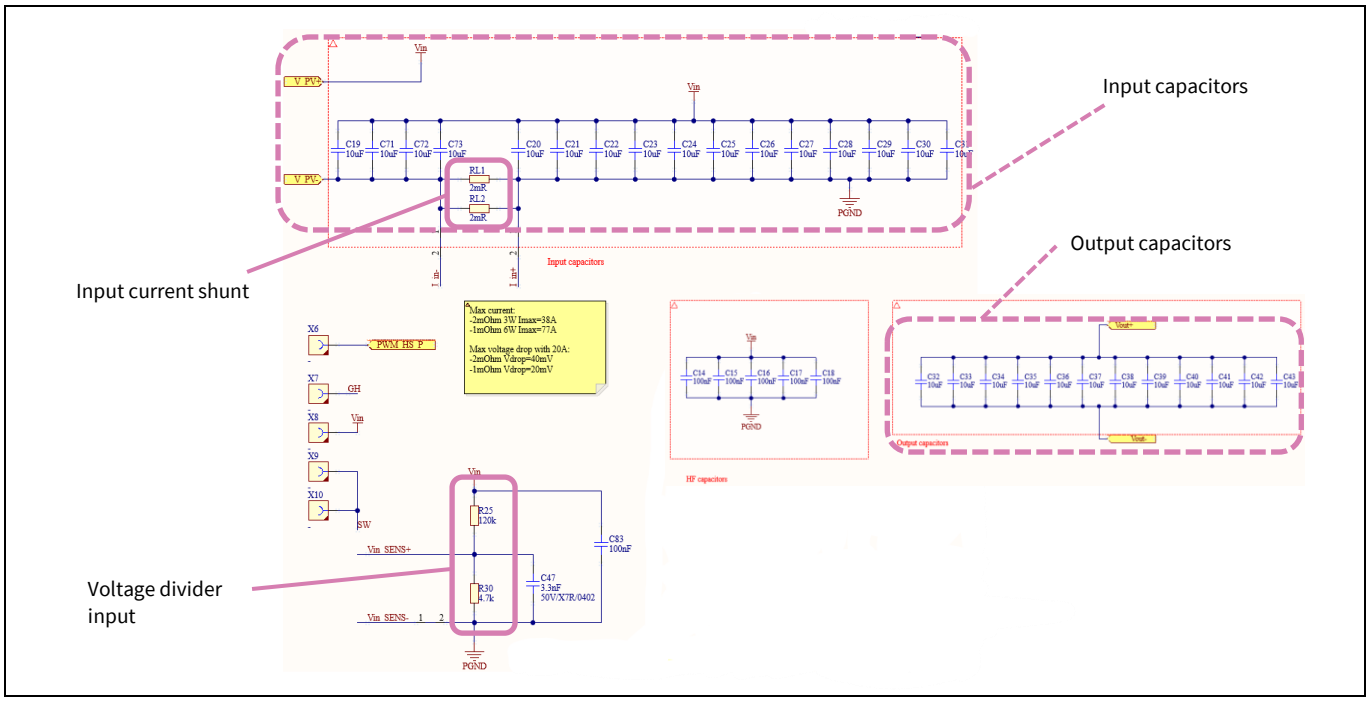


Figure 9 Schematic of input and output capacitance and input sensing

2.6.1 Gate driver

The EiceDRIVER™ 1EDN7116U gate driver incorporates several key features intended for GaN gate driving. One such feature is the truly differential input (TDI), which provides common-mode voltage rejection to the high-side during switching. TDI also provides ground-bounce immunity for the low-side, thereby guaranteeing stable operation even during fast switching transients.

1EDN7116U was selected in this design as it offers a 2 A peak source/sink current. In addition, this gate driver provides an active Miller clamp in the output stage, which amplifies the pull-down strength to 5 A after the turn-off transition, within 3 ns after the gate voltage has fallen below 0.4 V. After the driver latches in this state, it holds the gate voltage at V_{OFF} with a pull-down resistance of 0.3 Ω. In this way, the designer can adjust the GaN HEMT's turn-off speed without jeopardizing its immunity to induced turn-on.

2.6.2 Current and voltage sensing

Low-side shunt sensing (Figure 8 and Figure 9) is acquired using an operational amplifier in differential mode (Figure 10) with a gain of 82 on a 1 mΩ low-side shunt. The voltage sensing for the input and output is acquired through a voltage follower configuration that requires a voltage divider (Figure 8 and Figure 9). Current acquisition, as well as voltage sensing, is filtered at the amplifier feedback to create a pole at 2 kHz. An additional high-frequency filter is placed near the microcontroller, Figure 13.

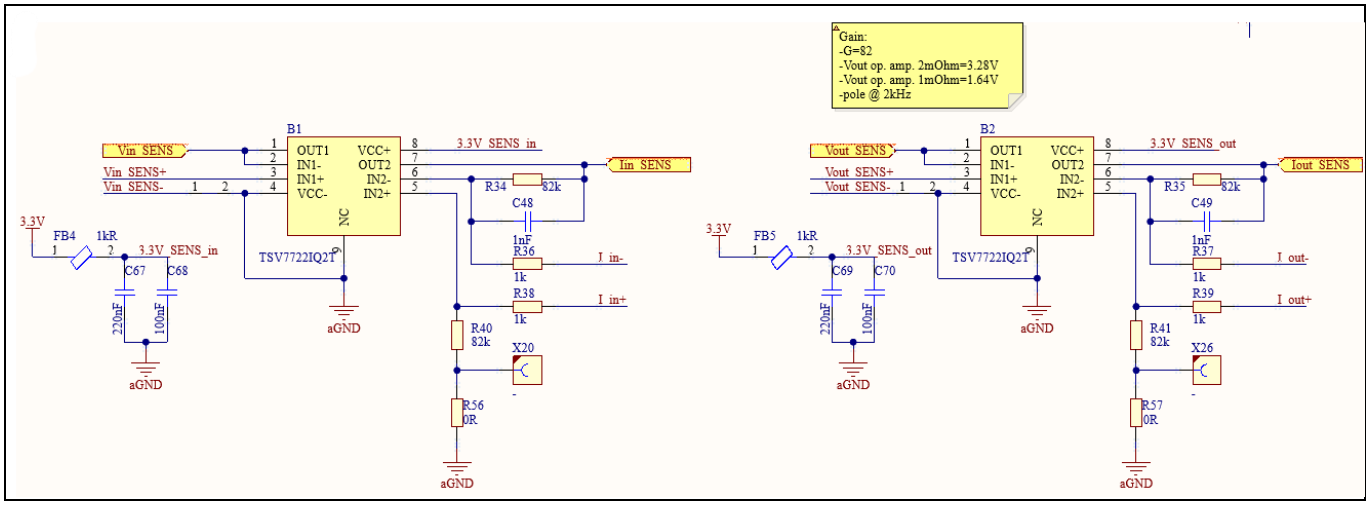


Figure 10 Schematic of the operational amplifier used for the voltage and current sensing

2.6.3 Half-bridge layout

The recommended layout for a CoolGaN™ Transistor half-bridge is shown in Figure 11. The two high-frequency loops for gate current and drain current are oriented perpendicular to each other to minimize common-source inductance. Moreover, an island for the return path is created on both sides of the half-bridge. The implementation of the power stage follows the rules listed in [5], already applied in similar reference designs [6] and [7].

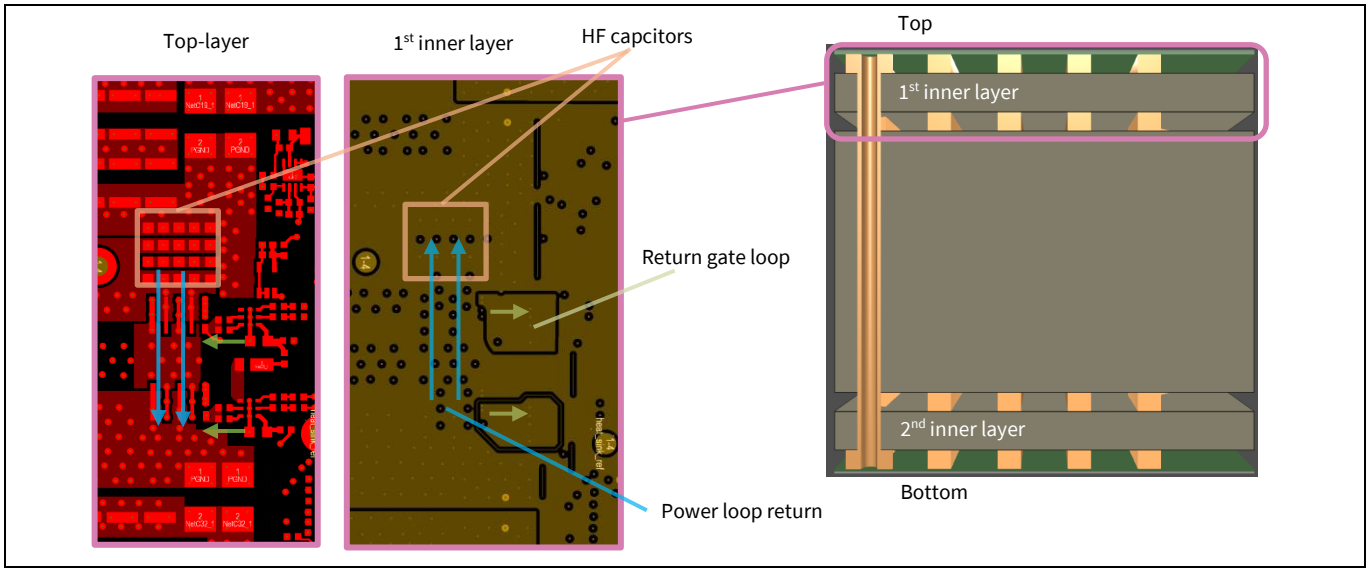


Figure 11 Half-bridge layout; arrows indicate flow of gate and drain switching currents and stack-up

2.7 Power supply manager

An onboard DC-DC converter generates the 5 V rail from the V_PV+ supply (see Figure 12). The 5 V rail directly determines the gate voltage applied to the CoolGaN™ Transistors by the 1EDN7116U gate drivers. In addition, the 3.3 V rail is derived from 5 V, with an LDO [4], to supply the operational amplifiers and the microcontroller. The DC-DC converter employs UVLO and will only start up when VIN exceeds 10 V. A green LED at the top-right corner indicates the status of the DC-DC converter. The upper limit is defined by the protection diode (D9) in Figure 7. To be able to approach 100% of the duty cycle, an isolated fly-buck is implemented, that will supply the high-side of the power stage in Figure 8.

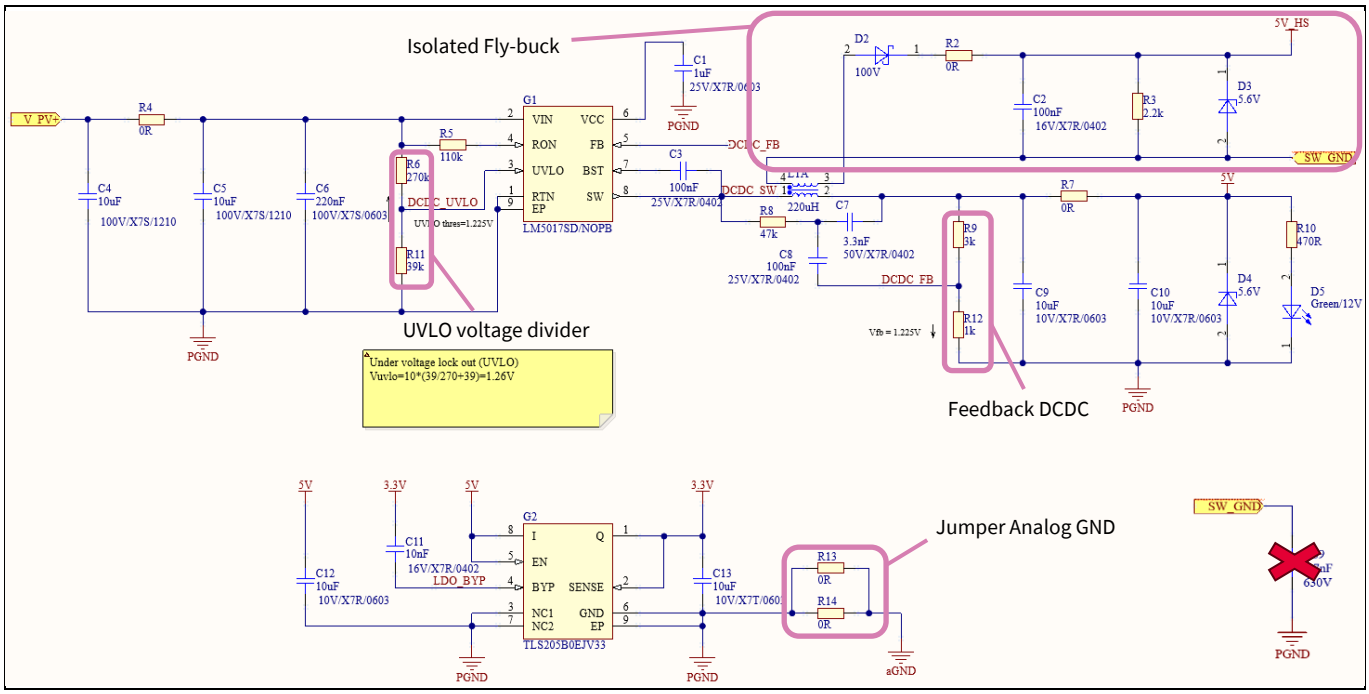


Figure 12 Schematic of the auxiliary power supply.

2.8 Microcontroller

The microcontroller schematic (Figure 13) represents the PSOC™ controller, plus all the discrete components necessary for decoupling and filtering the supply voltage. The PSOC™ microcontroller has a separate reference and ground for the analog part to separate the digital/power ground (PGND) with respect to the analog ground; the main separation of the ground is done by the jumper near the LDO in Figure 12.

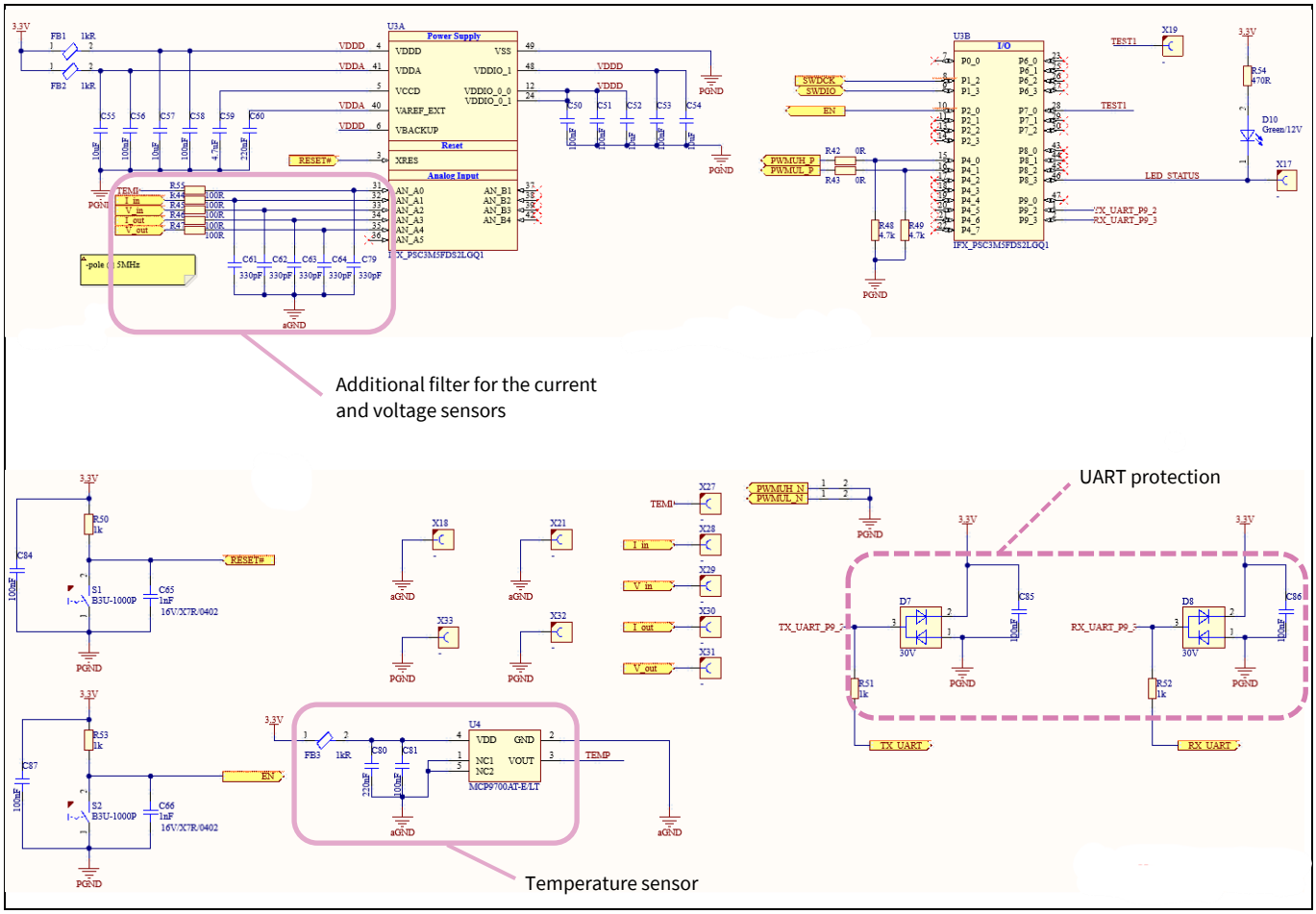


Figure 13 Schematic of the microcontroller and temperature sensor

2.8.1 Microcontroller layout

As shown in Figure 14, for the layout for the microcontroller, the current shunt and auxiliary power supply are consolidated in the top, 1st, and 2nd inner layers. The main routing is located in the 2nd inner layer, where a single point ground is placed to be able to connect to one point from the analog ground to the GND through a 0 Ω resistor, as reported in Figure 12. A solid copper plane for the power ground (PGND) is placed at the 1st inner layer that connects the microcontroller as well. No digital ground is placed due the different position of the half-bridge and the microcontroller; therefore the ground can be shared without any interference.

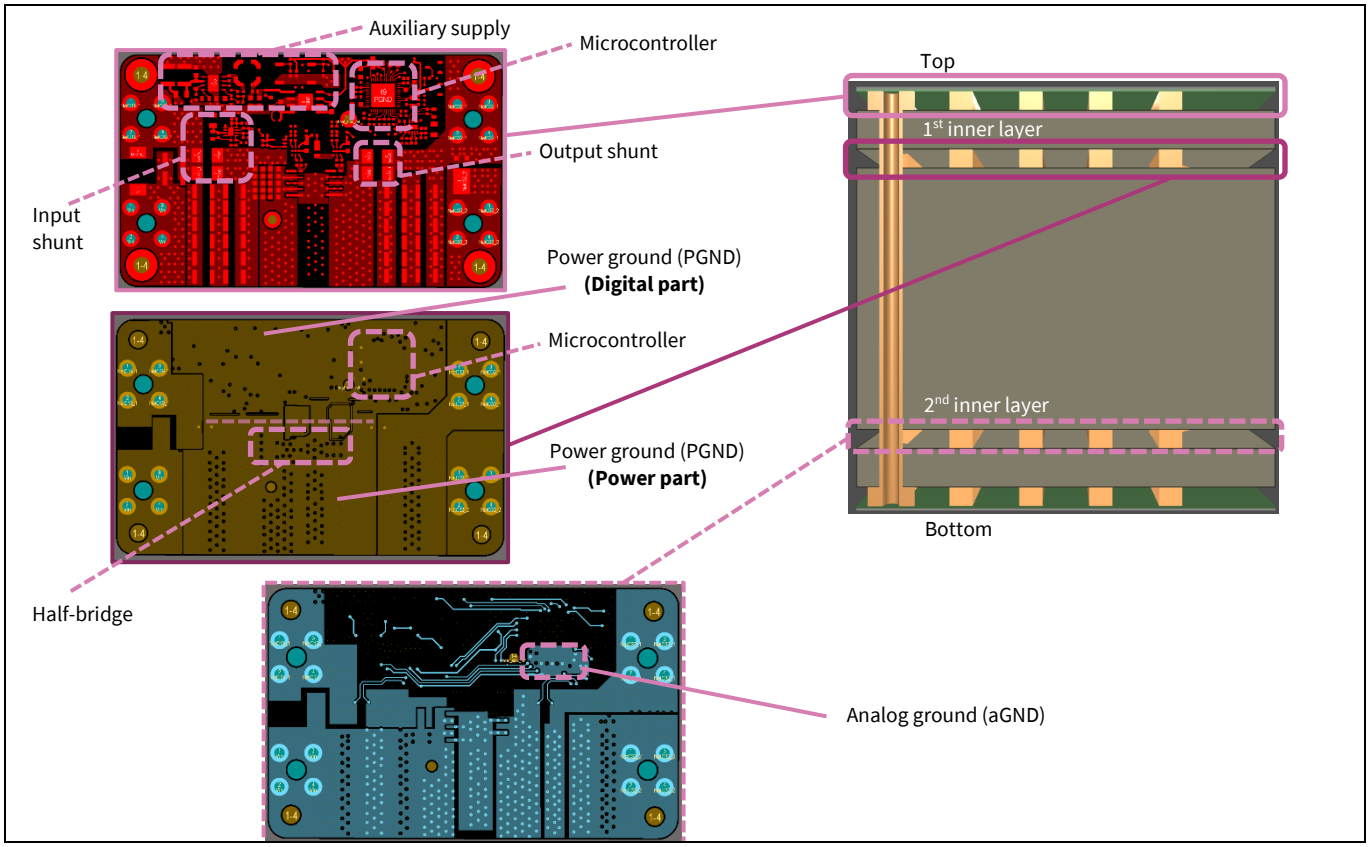


Figure 14 Layout of microcontroller

2.8.2 Temperature sensing

A temperature sensor, shown in Figure 3 and Figure 13, is connected directly to the same ground potential as the low-side switch Q2, with a scale factor of 10 mV/°C (or 20 mV/°C depending on the mounted parts, check BOM) and 750 mV offset at 25°C.

The temperature readout of the sensor is a measurement of the PCB near the CoolGaN™ Transistors, but it is not a direct readout of their junction temperatures. Therefore, it is recommended to choose a conservative threshold, e.g., 80°C or 1.3 V. This value will further depend on the heat spreader design, the selected TIM.

3 Probing points on board

REF_OPTI_80V20A_GaN has different probing points on the back of the board, as shown in Figure 15. An example of probing is reported in Figure 16, that is the best connection to minimize the interference and noise.

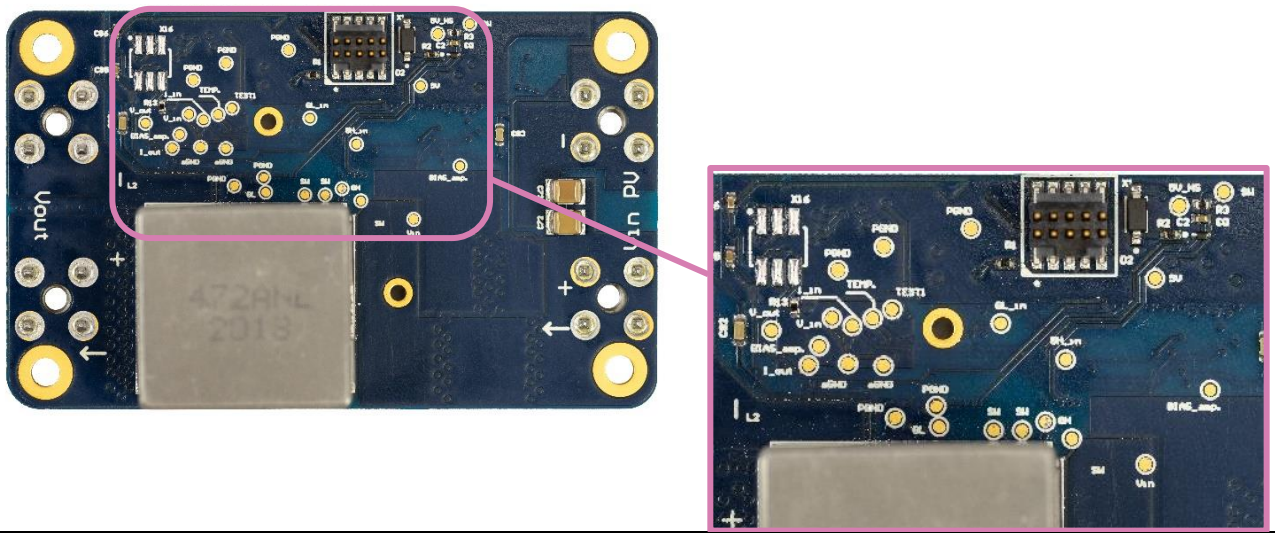


Figure 15 View of the probing points

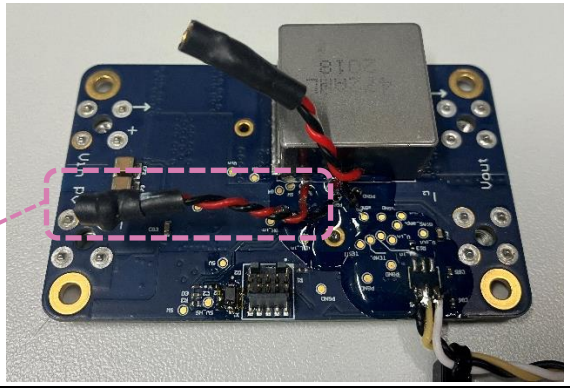


Figure 16 Probing points connections

4 Measurements

Here are some typical measurements that can be observed with the REF_OPTI_80V20A_GaN evaluation board for reference.

4.1 V_{DS} measurement

Figure 17 and Figure 18 show an example measurement of low-side V_{DS} using the test pads shown in Figure 16 with a buck configuration at V_{IN} = 72 V. dV/dt is measured at the max point of the slope of the waveform. Usually, the board is sealed with the 1EDN7116U gate drivers and an R_{on} of 8.25 Ω and an R_{off} of 0 Ω, as shown in Figure 8.

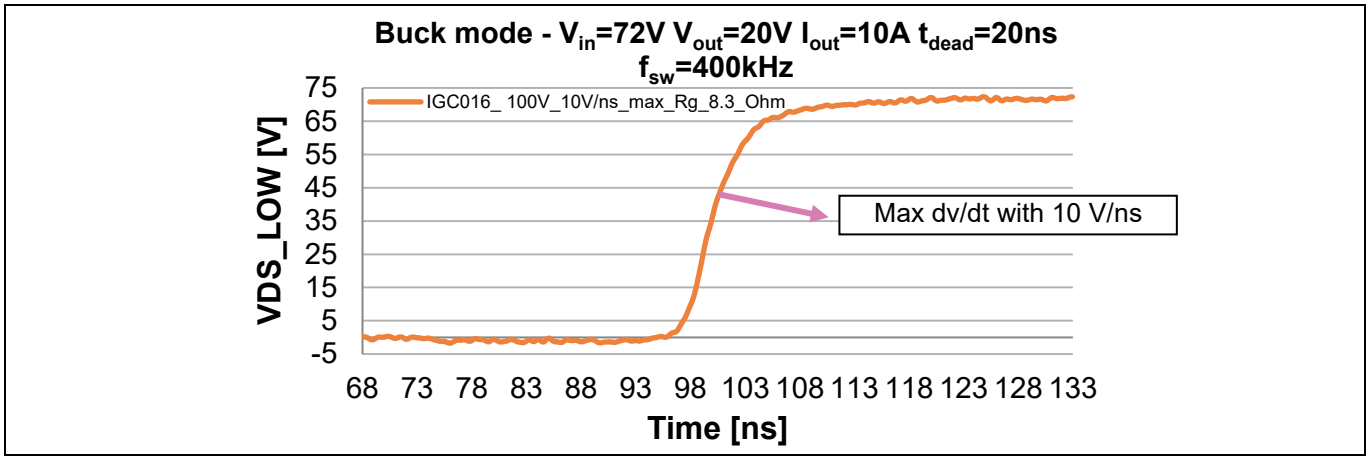


Figure 17 Turn-on of the high-side measured on the low-side

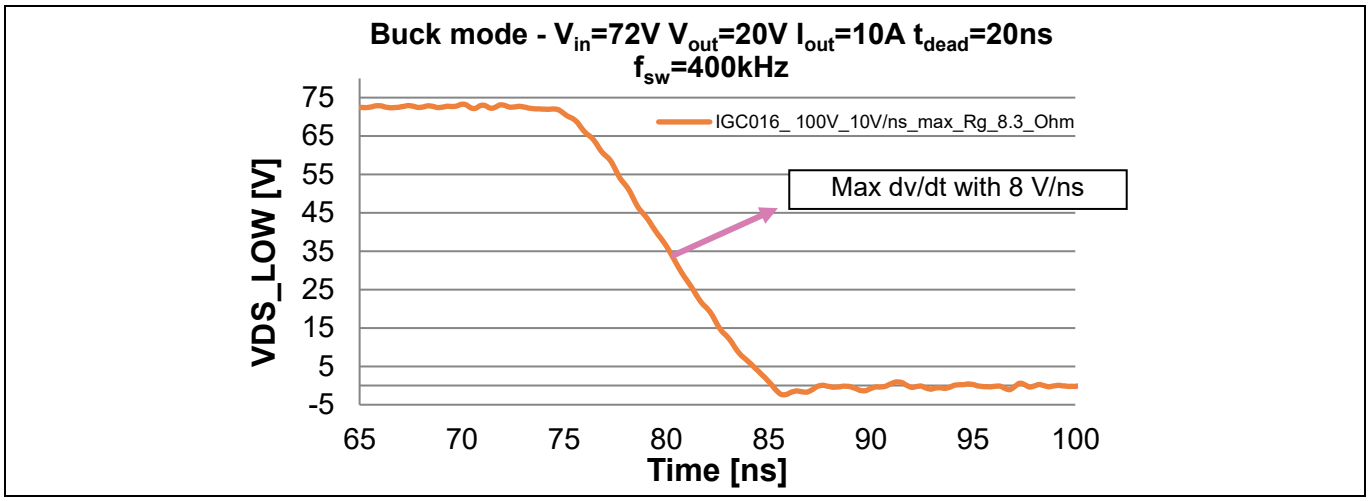


Figure 18 Turn-off of the high-side measured on the low-side

4.2 Buck mode configuration measurements

Figure 19 and **Figure 20** report the setup for measurements of a voltage-mode configuration test.

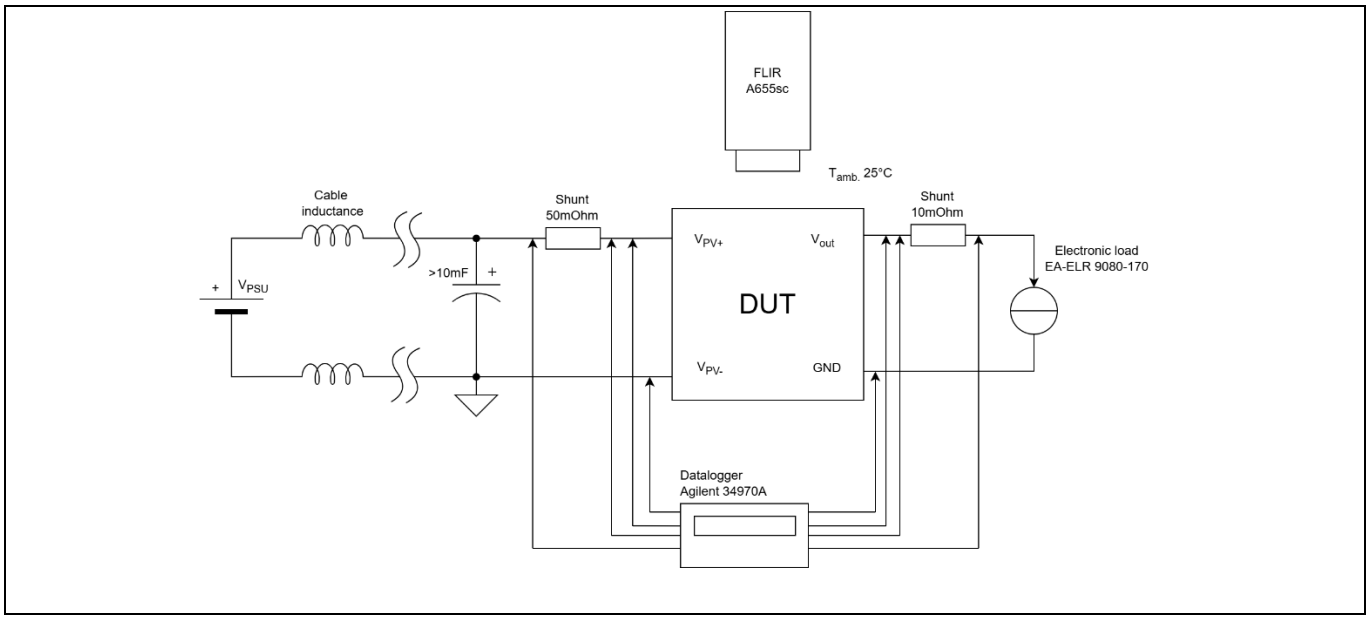


Figure 19 Buck-mode measurements set-up

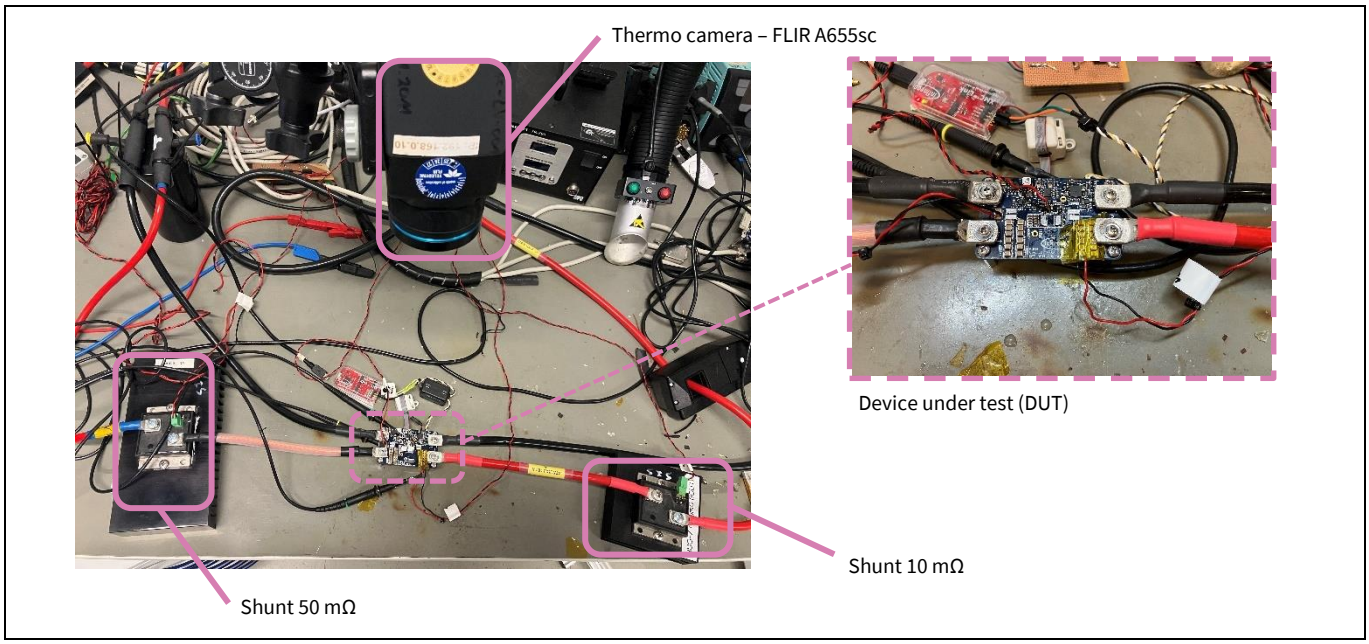


Figure 20 Overview of the measurements test bench set-up

Figure 21 reports the temperature acquired during the test of the board without a heatsink, where the hottest point is highlighted on the high-side of the half-bridge.

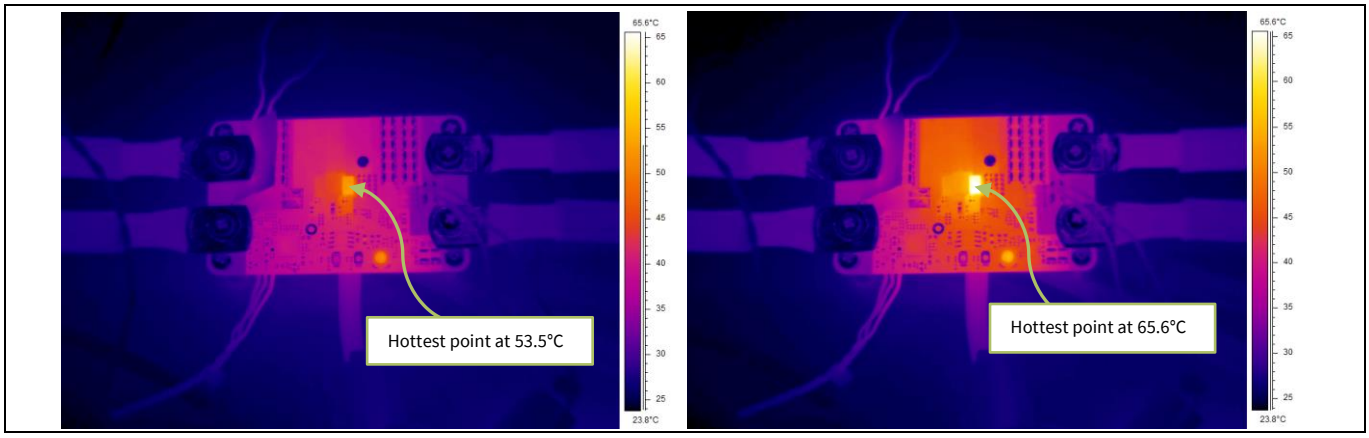


Figure 21 PCB temperature during the buck-mode test at f_{sw} = 400 kHz, Vin = 36 V and natural convection at 25°C; (left) phase current of 5 A_{out}; (right) output current of 10 A_{out}

4.2.1 Losses, temperature, and efficiency without heatsink

Losses are evaluated with the board in a step-down conversion voltage-regulation mode, with the output fixed at 20 V. Figure 22 reports the losses of the whole board using the setup shown in Figure 19 **and** Figure 20. The load current is evaluated up to 15 A, where the temperature rises to 140°C, approaching the maximum junction temperature of the transistor used. The acquisition reported in Figure 22 comes from the thermal picture of the hottest point shown in Figure 21.

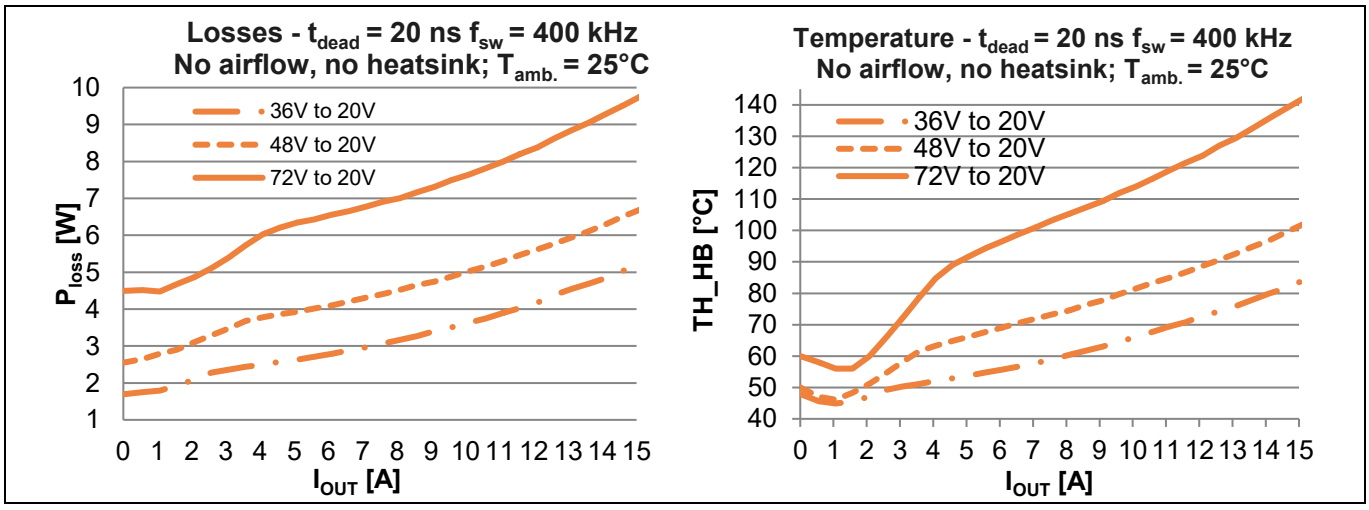


Figure 22 Losses and temperature of REF_OPTI_80V20A_GaN without heatsink

The efficiency in Figure 23 shows a reduction at the high voltage of 72 V, which is due to increased temperatures under these conditions. At full load, the optimizer's efficiency is always guaranteed to be greater than 96%, even with a step-down conversion to an output voltage as low as 20 V.

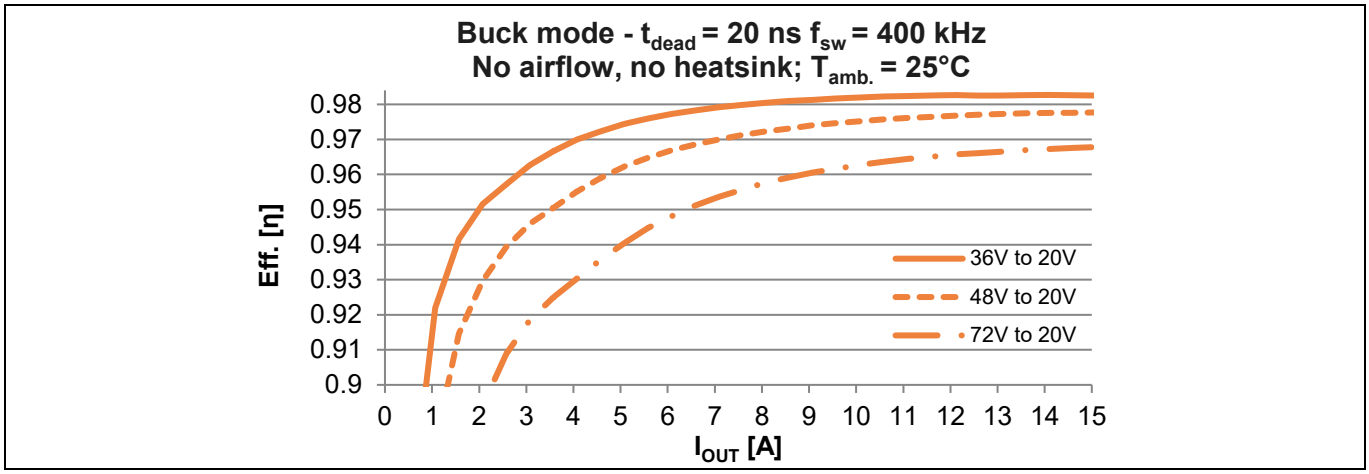


Figure 23 Efficiency of REF_OPTI_80V20A_GaN

4.2.2 Losses and efficiency with heatsink

The evaluation with the heatsink is done without any airflow to emulate a condition of static cooling, similar to an optimizer's final application. The temperature is measured at the top of the heatsink. Figure 24 shows the image from the thermal camera.

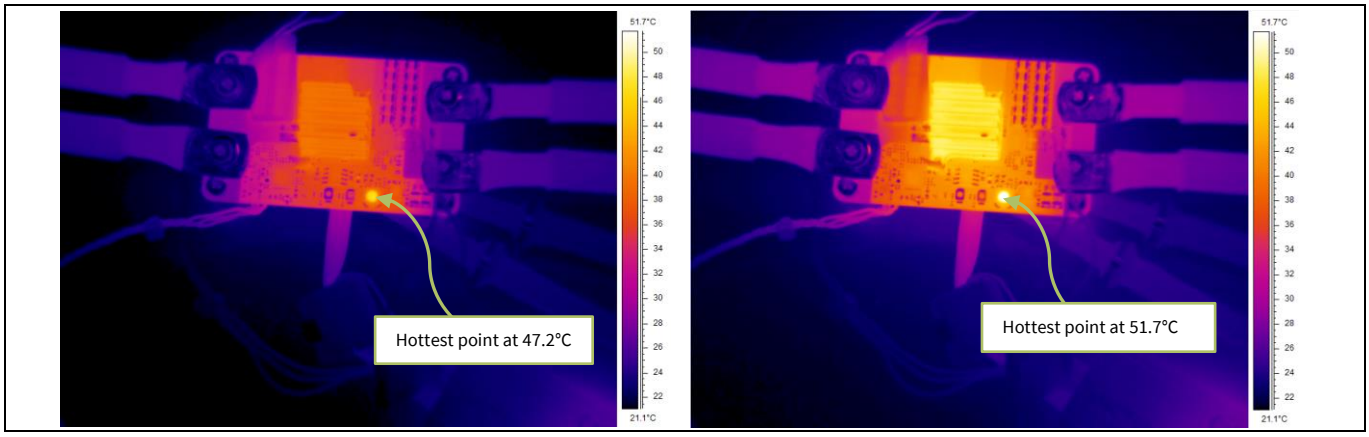


Figure 24 PCB temperatures during the buck-mode test at f_{sw} = 400 kHz, Vin = 36 V, with heatsink and natural convection at 25°C; (left) phase current of 5 A_{out}; (right) output current of 10 A_{out}

Figure 25 shows the losses of the board and the temperature on top of the heatsink. The efficiency in Figure 26 also reports an efficiency greater than 96% at its highest point. The efficiency for the 72 V input is interrupted due to the temperature shutdown set to 90°C on the temperature sensor, as shown in Figure 3 and Figure 13.

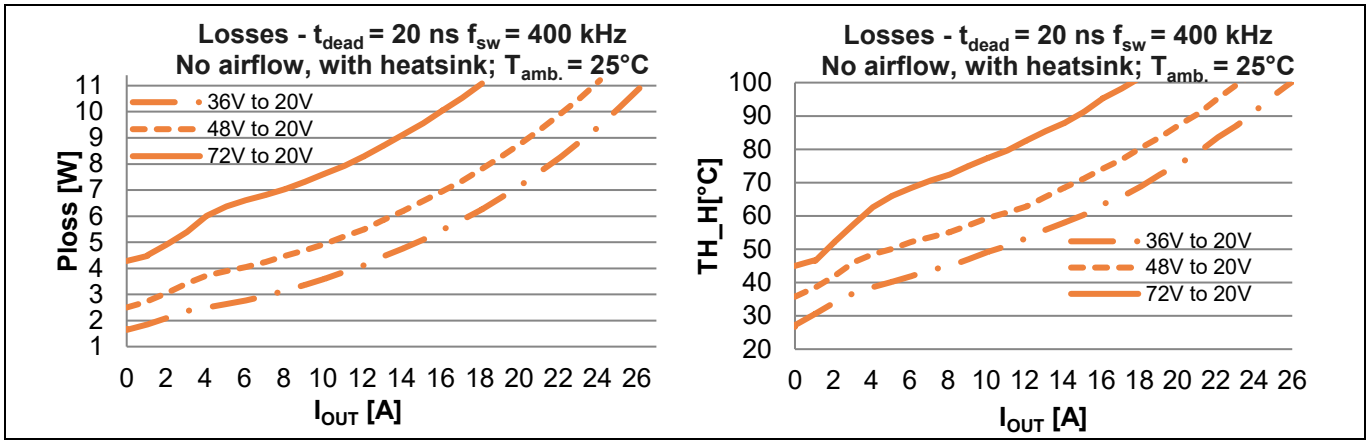


Figure 25 Losses and temperature of REF_OPTI_80V20A_GaN with heatsink

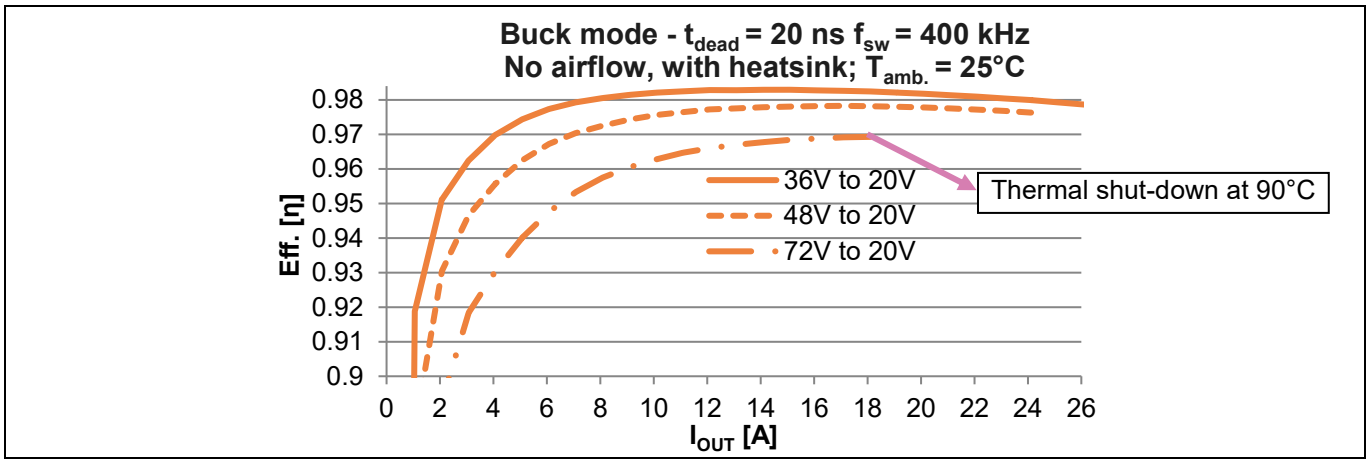


Figure 26 Efficiency of REF_OPTI_80V20A_GaN with heatsink

4.3 MPPT measurements

The optimizer is tested with the setup shown in Figure 27, where the IV-curve simulator was configured to follow a commercial PV panel [9]. The MPPT algorithm used is reported in Figure 28, which regulates the reference voltage of the loop shown in Figure 29.

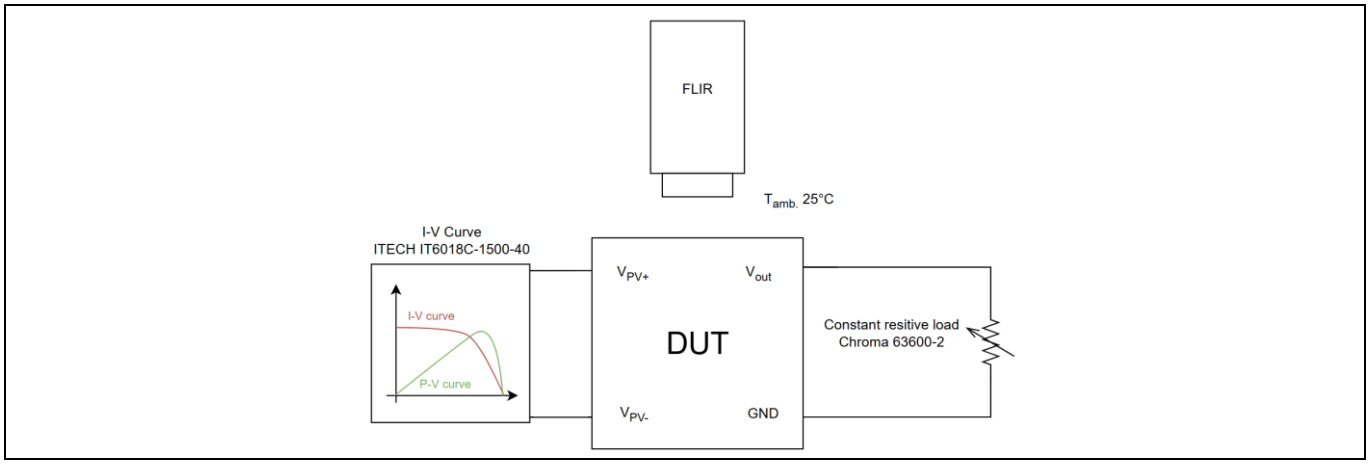


Figure 27 MPPT algorithm measurements setup

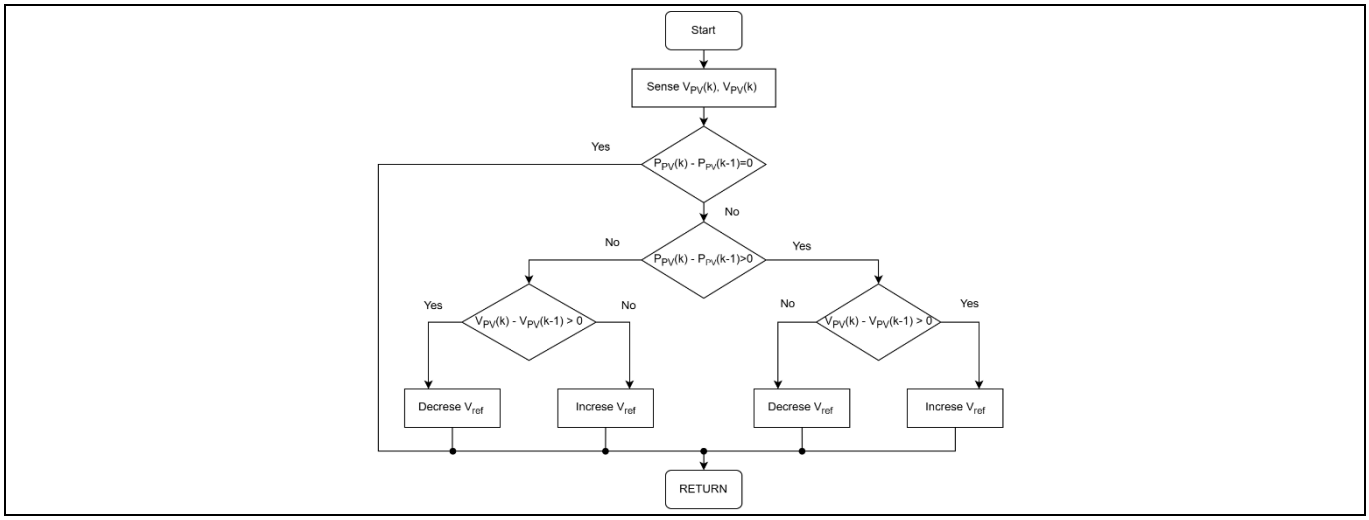


Figure 28 MPPT algorithm flowchart

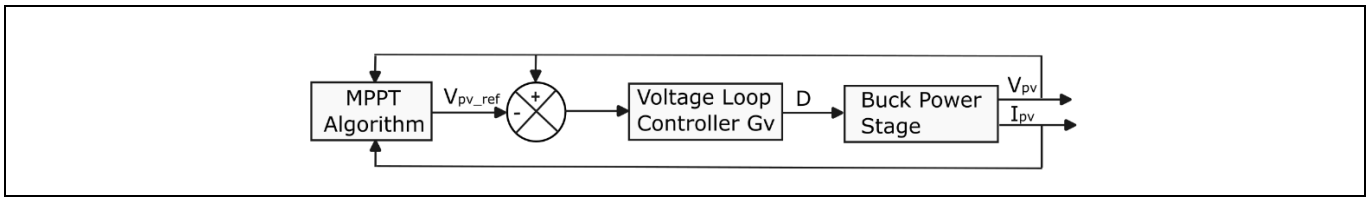


Figure 29 Control scheme for the MPPT algorithm

Figure 30 and Figure 31 show the measurements of the MPPT algorithm implemented for equivalent panel temperatures of 25°C and 50°C, respectively. Figure 32 shows the temperature of the board with and without a heatsink in an ambient temperature of 25°C.

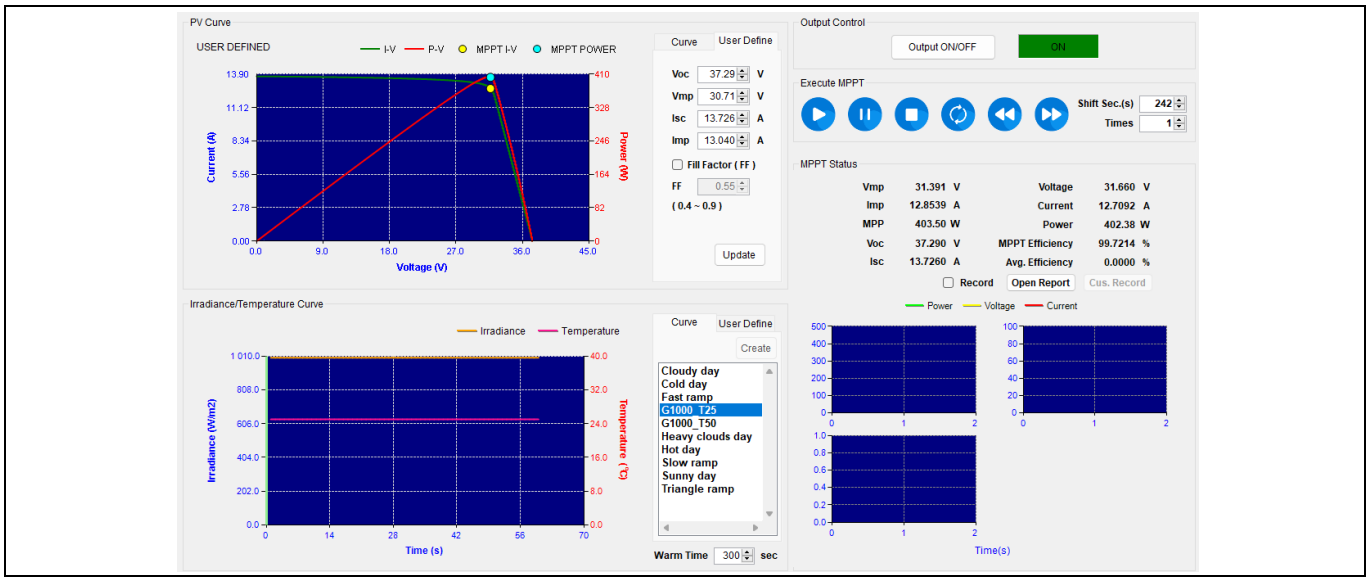


Figure 30 Max operating point of the panel [9] for a temperature of 25°C and constant irradiance

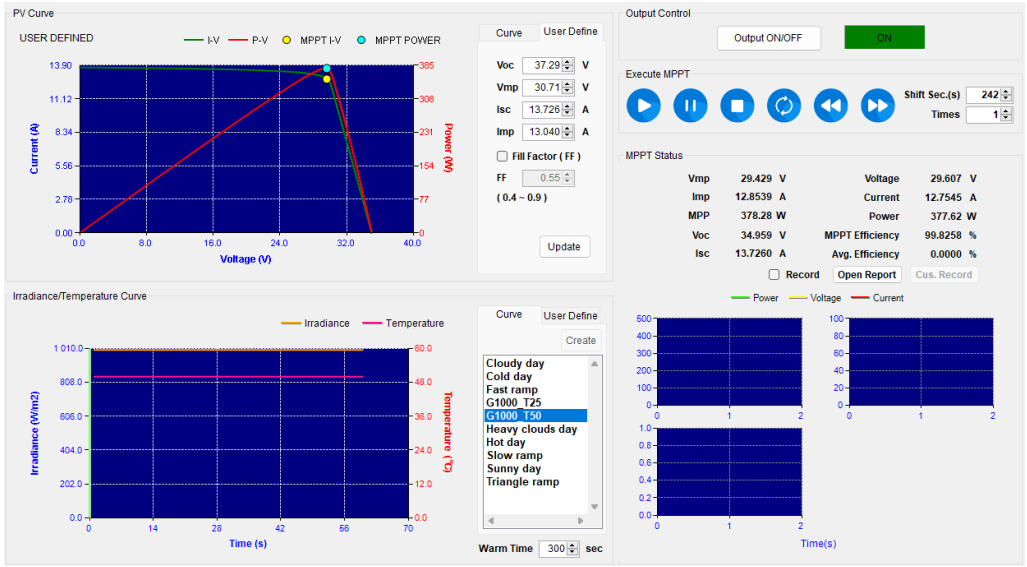


Figure 31 Max operating point of the panel [9] for a temperature of 50°C and constant irradiance

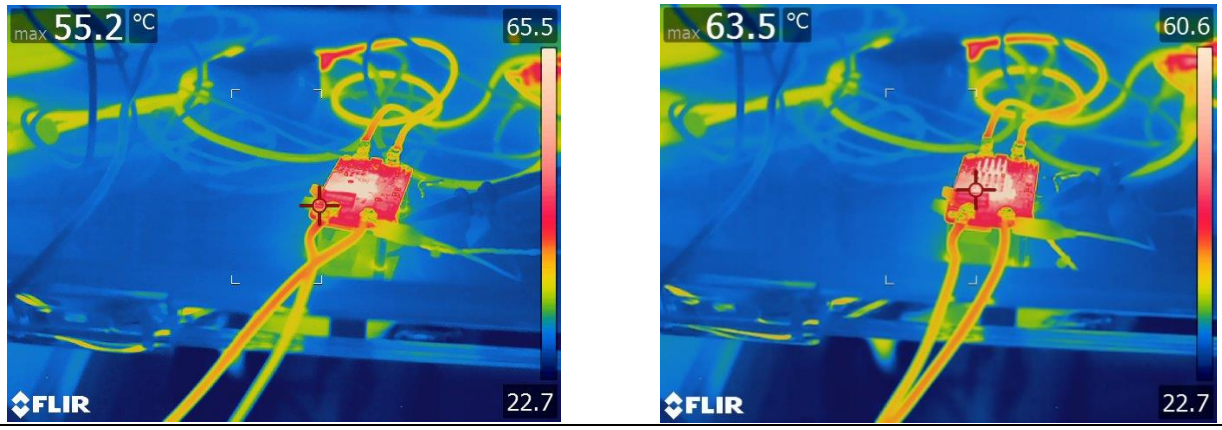


Figure 32 PCB temperature during the MPPT mode test at f_{sw} = 400 kHz at 25°C; (left) without heatsink; (right) with heatsink

5 Bill of materials

Table 4 Bill of materials for REF_OPTI_80V20A_GaN

No.	Qty.	Part description	Designator	Part No.	Manufacturer	Alternative parts
1	2	220 nF	B1, B2	TSV7722IQ2T	STM	
2	1	1 µF	C1	GRM188R71E105KA12	Murata	
3	1	100 nF	C2	GRM155R71C104KA88	Murata	16 V
4	2	100 nF	C3, C8	GRM155R71E104KE14	Murata	25 V
5	12	100 nF	C50, C51, C53, C56, C58, C68, C70, C81, C84, C85, C86, C87	GRM155R71C104JA88	Murata	16 V
6	30	10 µF	C4, C5, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39, C40, C41, C42, C43, C71, C72, C73	GRM32EC72A106KE05L	Murata	
7	1	220 nF	C6	MCASH168SC7224KTCA01	Taiyo yuden	
8	3	3.3 nF	C7, C46, C47	GRM155R71H332KA01	Murata	
9	3	10 µF	C9, C10, C12	GRM188Z71A106KA73D	Murata	
10	1	10 µF	C13	ZRB18AD71A106KE01L	Murata	
11	1	10 nF	C11	GRM155R71C103JA01	Murata	
12	13	100 nF	C14, C15, C16, C17, C18, C74, C75, C76, C77, C78, C82, C83, C88	GRM188R72A104KA35D	Murata	
13	2	2.2 µF	C44, C45	C0603C225M8RACTU	Kemet	
14	2	1 nF	C48, C49	GRM1555C1E102JA01	Murata	
15	2	1 nF	C65, C66	GRM155R71C102KA01	Murata	

Bill of materials

No.	Qty.	Part description	Designator	Part No.	Manufacturer	Alternative parts
16	4	10 µF	C52, C54, C55, C57	GRM188R61C106KAAL	Murata	
17	1	4.7 µF	C59	GRM188C71C475KE21D	Murata	
18	4	220 nF	C60, C67, C69, C80	GRM155R71C224KA12	Murata	
19	5	330 pF	C61, C62, C63, C64, C79	GRM1535C1H331GDD5	Murata	
20	1	Schottky diode	D1	DST2080S	Littelfuse	
21	1	Schottky barrier diode	D2	RB168VAM100	ROHM	
22	2	Zener diode, 200 mW, 5.6 V	D3, D4	DZ9F5V6S92	Diodes Inc.	
23	2	LED green	D5, D10	TLMG1100-GS08	Vishay	
24	1	Schottky barrier diode	D6	RB578VYM100FHTR	ROHM	
25	2	Silicon Schottky diode	D7, D8	BAT54-04	Infineon	
26	1	TVS	D9	1.5SMC100A	Littelfuse	
27	5	Ferrite	FB1, FB2, FB3, FB4, FB5	BLM15AX102SN1D	Murata	
28	1	DCDC	G1	LM5017SD	TI	
29	1	Low drop-out	G2	TLS205B0EJV33	Infineon	
30	1	Custom heatsink	HS			
31	1	220 µH	L1	LPD5030-224MRB	Coilcraft	
32	1	4.7 µH	L2	PA4349.472ANLT	Pulse E.	
33	2	GaN Transistors	Q1, Q2	IGC016K10S2	Infineon	
34	2	2 Ω	R1, R58	CRCW04022R00FK	Vishay	
35	7	0 Ω	R2, R7, R22, R42, R43, R56, R57	CRCW04020000Z0	Vishay	
36	1	2.2 kΩ	R3	CRCW04022K20FK	Vishay	
37	1	0 Ω	R4	CRCW08050000Z0EA	Vishay	
38	1	110 kΩ	R5	CRCW0603110KFK	Vishay	
39	1	270 kΩ	R6	CRCW0603270KFK	Vishay	
40	1	47 kΩ	R8	CRCW040247K0FK	Vishay	
41	1	3 kΩ	R9	CRCW04023K00FK	Vishay	
42	2	470 Ω	R10, R54	CRCW0402470RFK	Vishay	

Bill of materials

No.	Qty.	Part description	Designator	Part No.	Manufacturer	Alternative parts
43	1	39 kΩ	R11	CRCW040239K0FK	Vishay	
44	9	1 kΩ	R12, R36, R37, R38, R39, R50, R51, R52, R53	CRCW04021K00FK	Vishay	
45	2	0 Ω	R13, R14	RC0402JR-070RL	Yageo	
46	4	1 Ω	R15, R19, R23, R31	CRCW04021R00FK	Vishay	
47	2	15 Ω	R16, R26	CRCW040215R0FK	Vishay	
48	8	23.2 kΩ	R17, R18, R20, R21, R28, R29, R32, R33	CRCW040223K2FK	Vishay	
49	2	120 kΩ	R24, R25	CRCW0805120KFK	Vishay	
50	2	4.7 kΩ	R27, R30	CRCW06034K70FK	Vishay	
51	4	82 kΩ	R34, R35, R40, R41	CRCW040282K0FK	Vishay	
52	5	100 Ω	R44, R45, R46, R47, R55	CRCW0402100RFK	Vishay	
53	2	4.7 kΩ	R48, R49	RC0402FR-074K7L	Yageo	
54	1	1 MΩ	R59	RC0603FR-071ML	Yageo	
55	4	2 mΩ	RL1, RL2, RL3, RL4	TLR2HWDTE2L00F50	KOA	
56	2	Switch	S1, S2	B3U-1000P	Omron	
57	2	Screw M1.6 × 5 mm	S3, S4	179-5693	RS	
58	1	TIM	TIM			
59	2	Gate driver	U1, U2	1EDN7116U	Infineon	
60	1	Microcontroller	U3	PSC3M5FDS2LGQ1	Infineon	
61	1	Temp. sensor	U4	MCP9700AT-E/LT	Microchip	
62	1	Debug conn.	X1	FTSH-105-01-L-DV-K	Samtec	
63	4	Power conn.	X2, X3, X4, X5	74650073	WE	
64	27	Test pad	X6, X7, X8, X9, X10, X11, X12, X13, X14, X15, X17, X18, X19, X20, X21, X22, X23, X24,			

Bill of materials

No.	Qty.	Part description	Designator	Part No.	Manufacturer	Alternative parts
			X25, X26, X27, X28, X29, X30, X31, X32, X33			
65	1	UART conn.	X16	TSM-102-01-L-DV	Samtec	
66	1	4.7 nF, 630 V	C89	GCM31C7U2J472JX03	Murata	DNP
67	1	47 kΩ	R60	CRCW040247K0FK	Vishay	

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