



5.5 kW Totem Pole PFC Evaluation Board TotemPolePFC_5.5kW-TSB-001

<High Voltage Safety Precautions>

◇ Read all safety precautions before use.

Please note that this document covers only the **5.5 kW Totem Pole PFC** evaluation board (**TotemPolePFC_5.5kW-TSB-001**) and its functions. For additional information, please refer to the datasheet.

To ensure safe operation, please carefully read all precautions before handling the evaluation board



Depending on the configuration of the board and voltages used,

potentially lethal voltages may be generated.

Therefore, please make sure to read and observe all safety precautions described in the red box below.

Before Use

- [1] Verify that the parts/components are not damaged or missing (i.e. due to drops).
- [2] Check that there are no conductive foreign objects on board.
- [3] Be careful when performing soldering on the module and/or evaluation board to ensure that solder splash does not occur.
- [4] Ensure there is no condensation or water droplets on the circuit board.

During Use

- [5] Be careful not to allow conductive objects to come into contact with the board.
- [6] **Brief accidental contact or even bringing your hand close to the board may result in discharge and lead to severe injury or death.**

Therefore, DO NOT touch the board with your bare hands or bring them too close to the board.

In addition, as mentioned above, please exercise extreme caution when using conductive tools such as tweezers and screwdrivers.

- [7] If used under conditions beyond its rated voltage, it may cause defects such as short-circuit or, depending on the circumstances, explosion or other permanent damages.
- [8] Be sure to wear insulated gloves when handling is required during operation.

After Use

- [9] The ROHM Evaluation Board contains circuits which store high voltage. Since it stores the charges even after the connected power circuits are cut, please discharge the electricity after using it, and please ensure the board is fully discharged before handling.
- [10] Protect against electric shocks by wearing insulated gloves when handling.

This evaluation board is intended for use only in research and development facilities and should be handled **only by qualified personnel familiar with all safety and operating procedures.**

We recommend carrying out operations in a safe environment that includes the use of high voltage signage at all entrances, safety interlocks, and protective glasses.

TotemPolePFC_5.5kW-TSB-001

5.5 kW Totem Pole PFC Evaluation Board

This document is the user's guide for the 5.5 kW Totem Pole PFC Evaluation Board "TotemPolePFC_5.5kW-TSB-001".

This evaluation board is a reference design for a high-efficiency, high-power-density PFC (Power Factor Correction) converter, designed for AI server power supplies in data centers, telecommunication rectifiers, and industrial AC-DC power supplies. This document describes the specifications and evaluation results of the evaluation board.



Figure 1. Evaluation Board Appearance

Description

The TotemPolePFC_5.5kW-TSB-001 is a 5.5 kW Totem Pole PFC (Power Factor Correction) evaluation board that adopts GaN HEMTs (under development) for the high-frequency leg and SJ-MOSFETs (under development) for the low-frequency leg. This board operates with AC inputs from major global 200 V-class commercial power supplies and outputs a stabilized 400 V DC, intended for feeding downstream DC/DC converters. The output current supports up to 13.75 A (at 5.5 kW).

This board achieves ZVS (Zero Voltage Switching) of the switching devices across the entire load range, and reduces switching losses by adopting an interleaved configuration that performs phase shedding (single-phase shutdown) at light loads. These features enable highly efficient operation, achieving a peak efficiency of 99.0 %. Furthermore, the power factor and iTHD comply with the OCP (Open Compute Project) standard, satisfying the power quality criteria required for data centers and similar applications.

The GaN HEMTs and SJ-MOSFETs are configured on daughter boards, making them easy to replace and allowing for device replacement evaluation. Note that the components that generate the most heats on this evaluation board are the high-frequency inductors. When considering power expansion beyond the rating, redesigning is necessary. Additionally, the control MCU for this evaluation board is the Texas Instruments control card "TMDSCNCD280049C", and the software provided by TI is used for driving it.

Features

- Topology: Totem Pole PFC (2-phase interleaved)
- AC Input Voltage: 210 Vrms ~ 240 Vrms
- Output Voltage: 400 V
- Recommended Output Power: 5 kW
- Maximum Output Power: 5.5 kW
- Peak Efficiency: 99.0 %
- Switching Frequency: Approx. 100 kHz ~ 1 MHz
- Fast Leg: BM3G402MUV-LA ($R_{DS(on)typ.} = 21 \text{ m}\Omega$, 650V, 2 MHz) Under development
 - * The specifications are subject to change without notice.
- Slow Leg: SJ-MOSFET ($R_{DS(on)max.} = 22 \text{ m}\Omega$, 600 V) Under development
 - * The specifications are subject to change without notice.
- Protection Functions: Under Voltage Lockout (UVLO), Input Over Current Protection (OCP), Output Over Voltage Protection (OVP)
- Board Size: 340 mm × 70 mm × 35 mm
- Power Density: 119 W/in³

Applications

- Data Center / AI Server Power Supplies
- Telecommunication Rectifiers
- Industrial AC-DC Power Supplies

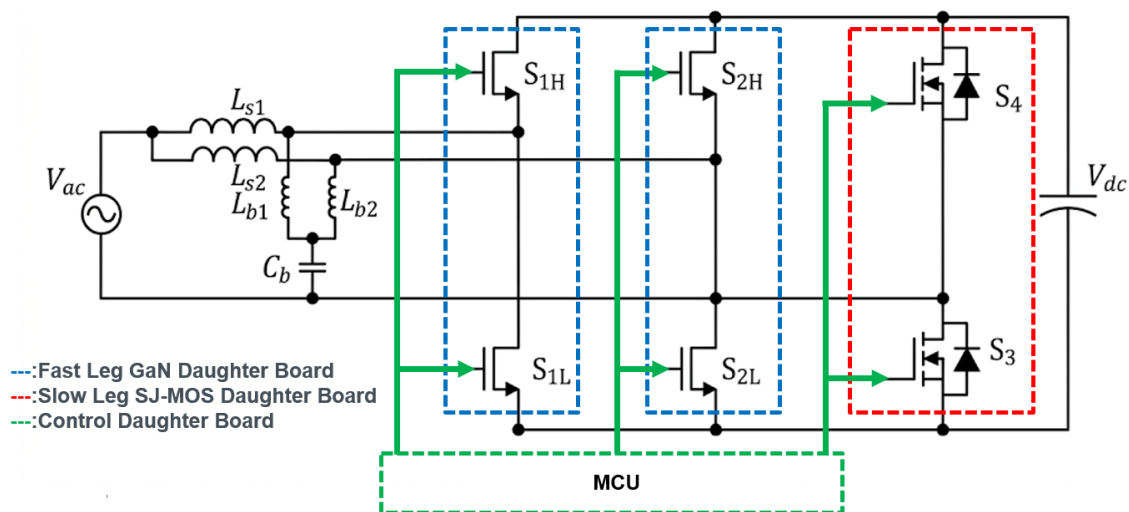


Figure 2. Simplified Schematic

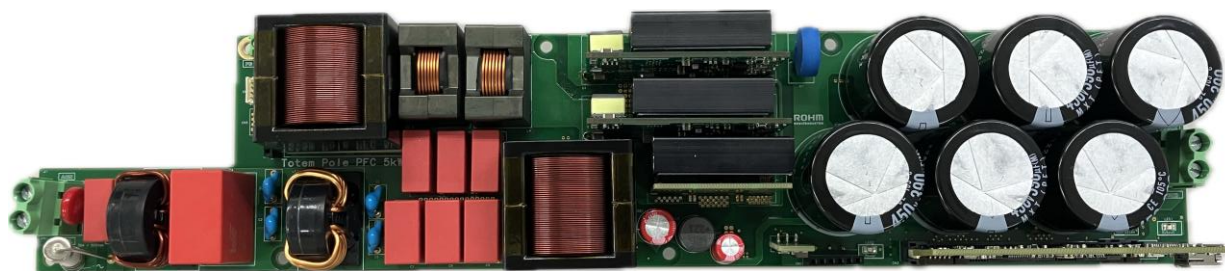


Figure 3. Main Board Top View



Figure 4. Main Board Bottom View



Figure 5. Fast Leg GaN Daughter Board Top View



Figure 6. Fast Leg GaN Daughter Board Bottom View



Figure 7. 3-pin DC/DC Daughter Board Top View

1 Specifications

Table 1. Board Specifications

Parameter	Specification
AC Input Voltage	210 Vrms ~ 240 Vrms
DC Output Voltage	400 V
Efficiency	99.0 % peak
Power Factor	0.998 peak
iTHD (Input Power = 5 kW)	4.84 %
Recommended Output Power	5 kW
Maximum Output Power	5.5 kW
Maximum Output Current	13.75 A
Input Over Current Protection	44 A
Output Over Voltage Protection	450 V
Ripple Voltage *1	20.5 V ripple
Under Voltage Lock Out	75 Vrms
Operating Temperature Range	Room Temperature (20 ~ 25 °C)

*1: Excluding spike noise.

2 Measurement Environment

The Totem Pole PFC topology adopted in this evaluation board (TotemPolePFC_5.5kW-TSB-001) achieves high system efficiency; however, special care is required when setting up the measurement environment. This section describes measurement challenges and an example of a measurement setup for safe and accurate evaluation.

2.1 Common Mode Current Issues

Unlike conventional PFC circuits that use diode bridges, the Totem Pole PFC enters a floating state where the circuit's reference potential (PGND) fluctuates with the AC polarity reversal on the input side. Due to this PGND potential fluctuation, a common-mode current is generated in the measurement environment.

In the simplified schematic of this evaluation board (Figure 2), one side of the AC input is directly connected to the midpoint of the slow leg. In a typical AC power supply environment, one side of the AC input (Neutral) is roughly at the same potential as the earth ground. However, because the switching state changes at every zero-cross of the AC input (50 Hz or 60 Hz), the PGND potential becomes a square wave that rapidly oscillates between 0 V and the output voltage (-400 V) relative to the earth ground.

If you connect the GND lead of an earth-grounded oscilloscope or a non-isolated electronic load to PGND in this state, a short circuit will occur between PGND and earth through the measuring instrument. When the PGND potential switches, a large common-mode current flows in through the device's ground wire, which is the direct cause of MCU malfunctions and damage to measuring equipment.

2.2 Recommended Environment and Countermeasures

To protect the MCU and measurement equipment from the common-mode current mentioned in the previous section, and to safely proceed with testing, the evaluation was performed using the measurement setup shown in Figure 8. The various devices used for evaluation are listed in Table 2.

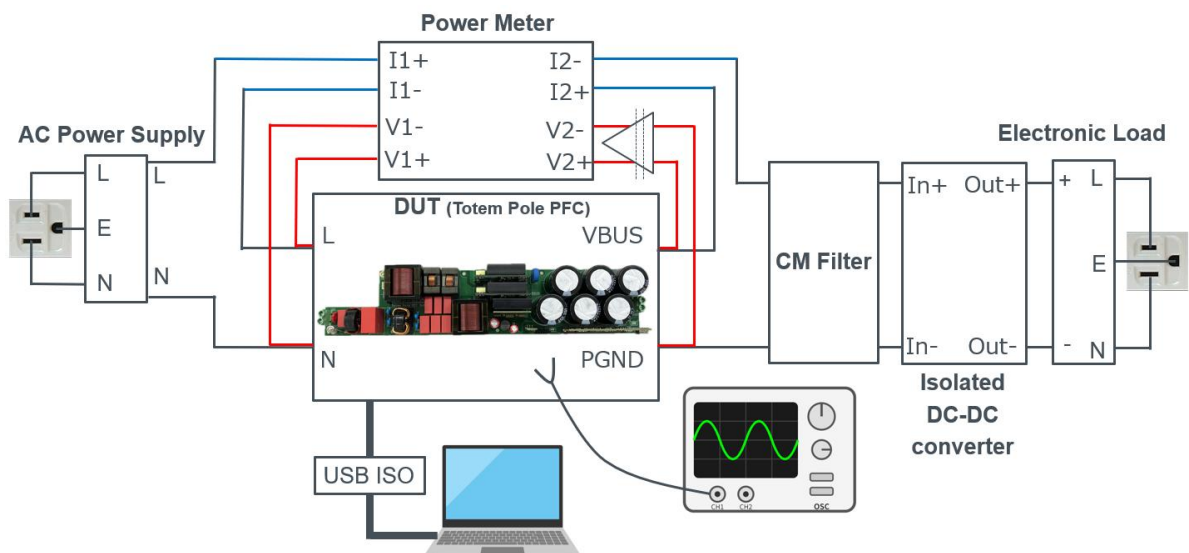


Figure 8. Recommended Connection Configuration Example of Measurement Equipment

Table 2. Measurement Equipment

Equipment	Manufacturer	Model Number
AC Power Supply	NF	DP060S
Power Meter	YOKOGAWA	WT1800
Oscilloscope	YOKOGAWA	DLM4038
High-Voltage Differential Probe	YOKOGAWA	PBDH0150
Current Probe	YOKOGAWA	PBC050
Electronic Load	KIKUSUI	PLZ1004WH

There are mainly three points to note regarding the measurement:

■ Output Side Isolation Measures

Please connect a common-mode filter and an isolated DC/DC converter to the output side (between the DUT and the electronic load). This physically blocks the path of the common-mode current and prevents noise to the electronic load or the ground of the measurement equipment. This is recommended to accurately measure high efficiencies exceeding 99 %.

■ Communication Interface Isolation (Using a USB Isolator)

Connecting the control PC's GND to the board's PGND poses a risk of short circuits, communication errors, and potential damage to the PC. To prevent these issues, it is recommended to isolate the communication line using a USB isolator.

■ Precautions for Waveform Observation Using an Oscilloscope

When observing waveforms, it is recommended to avoid connecting the oscilloscope GND or the passive probe's GND clip directly to the evaluation board's PGND or similar points, and instead use a high-voltage differential probe (isolated probe).

3 Efficiency Evaluation Results

The efficiency measurement results at an ambient temperature (T_a) of 25 °C are shown. This evaluation board achieved a peak efficiency of 99.0 %. Moreover, an efficiency of 98.8 % was obtained at the recommended output power of 5 kW. The efficiency measurement results are shown in Figure 9.

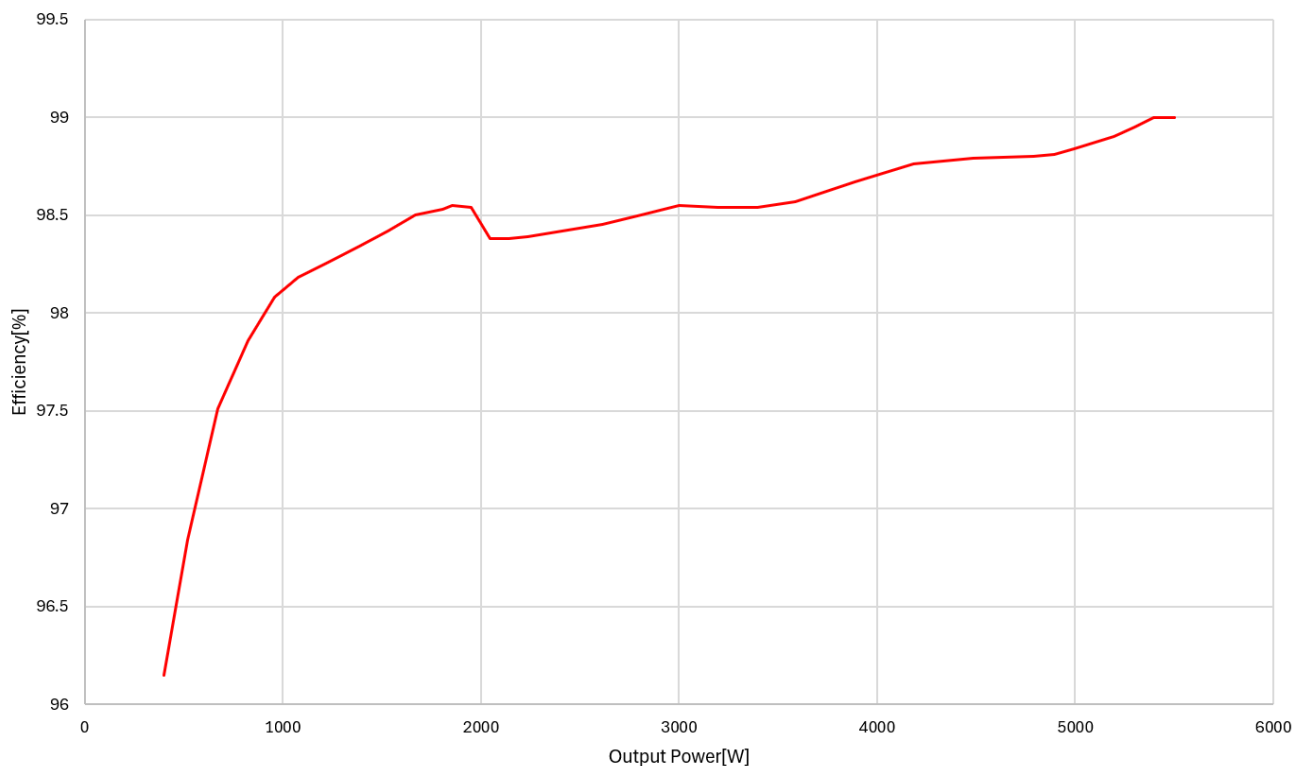


Figure 9. Efficiency Measurement Results

4 Power Factor Evaluation Results

The power factor measurement results at an ambient temperature (T_a) of 25 °C are shown. This evaluation board complies with the OCP standard and achieved a peak power factor of 0.998. Similarly, a power factor of 0.998 was obtained at the recommended output power of 5 kW. The power factor evaluation results are shown in Figure 10.

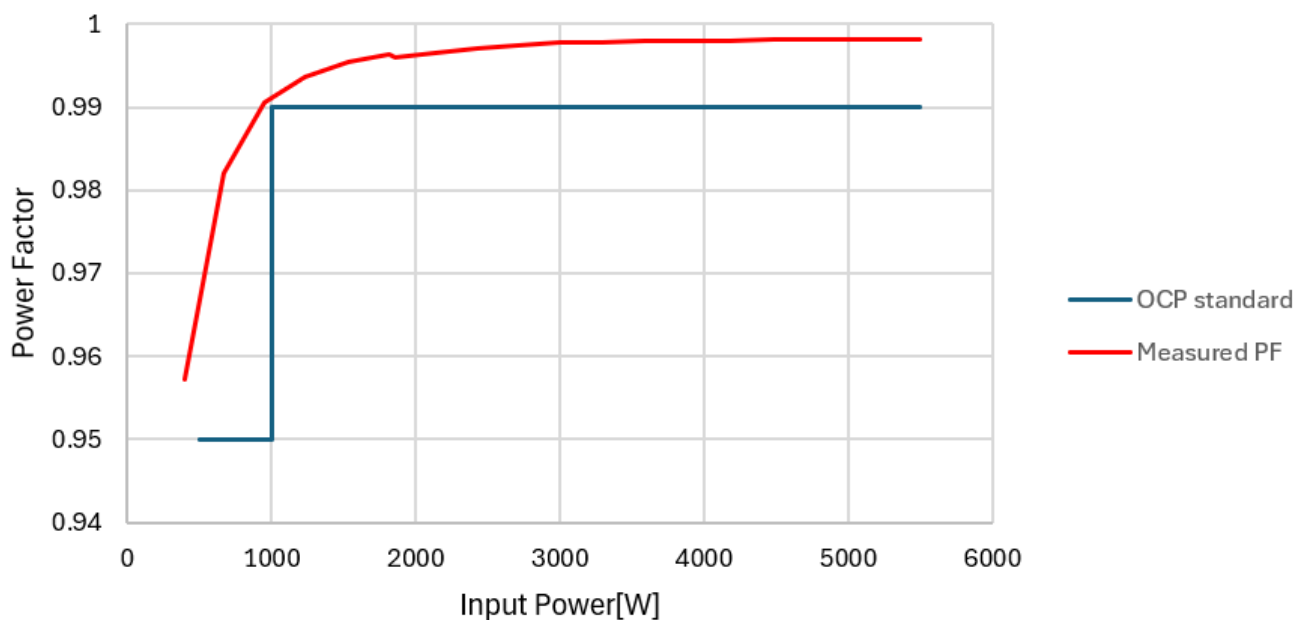


Figure 10. Power Factor Measurement Results

5 Input Current Total Harmonic Distortion (iTHD) Evaluation Results

The iTHD measurement results at an ambient temperature (T_a) of 25 °C are shown. This evaluation board complies with the OCP standard. An iTHD of 4.84 % was obtained at the recommended output power of 5 kW. The iTHD measurement results are shown in Figure 11.

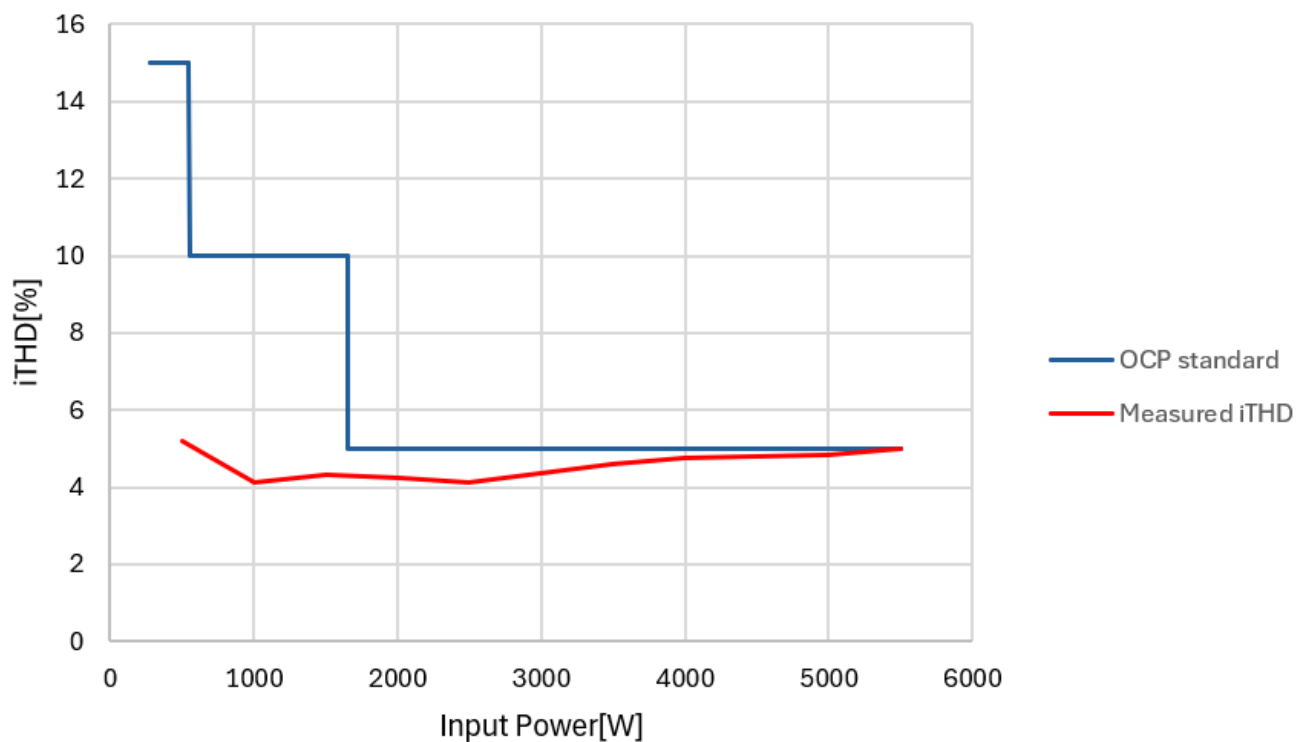


Figure 11. iTHD Measurement Results

6 Operation Waveforms

Figure 12 to Figure 18 show the operation waveforms at various instantaneous input voltages with an output power of 4 kW.

The measurement targets for each channel are as follows:

- CH1: Phase1 Low-side GaN HEMT V_{DS}
- CH2: Phase2 Low-side GaN HEMT V_{DS}
- CH3: Phase1 Low-frequency inductor current I_{LS1}
- CH4: Phase1 High-frequency inductor current I_{Lb1}
- CH5: Phase1 GaN HEMTs switching current I_{sw1}

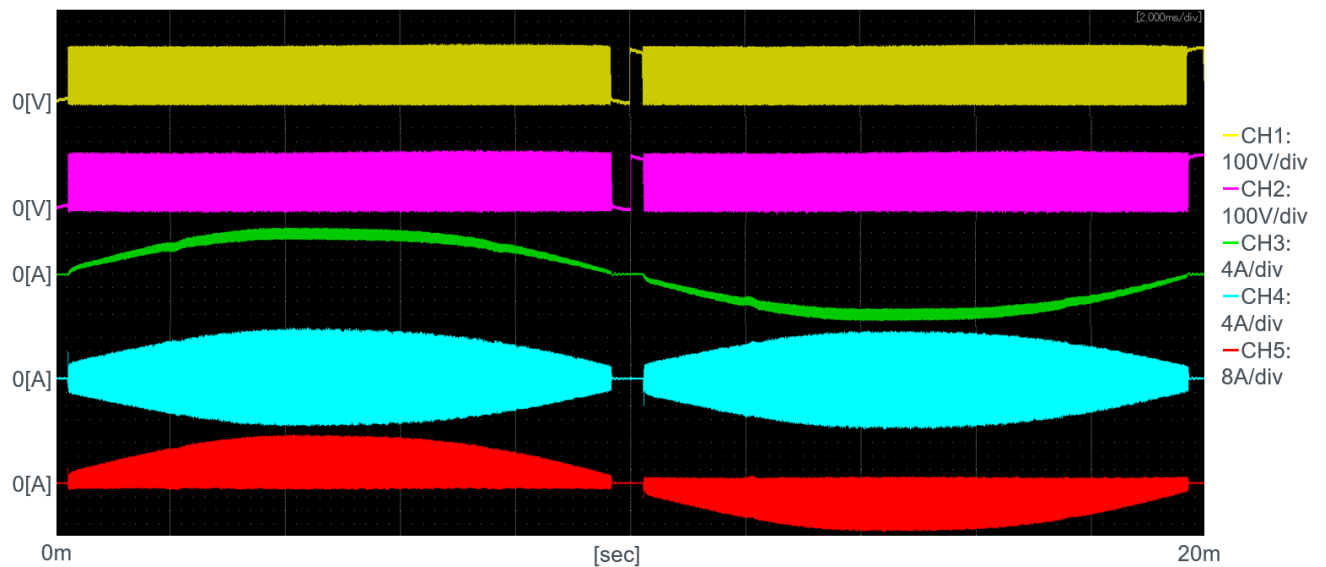


Figure 12. PFC Operation Waveform (Overall)

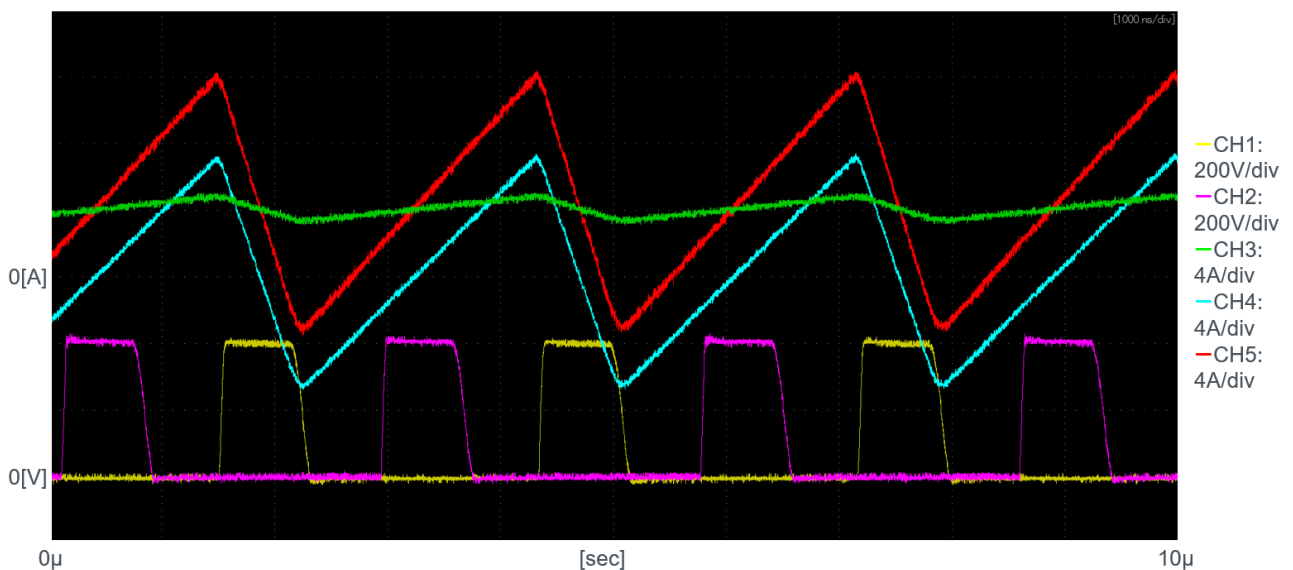


Figure 13. PFC Operation Waveform ($V_{in}=100\text{ V}$)

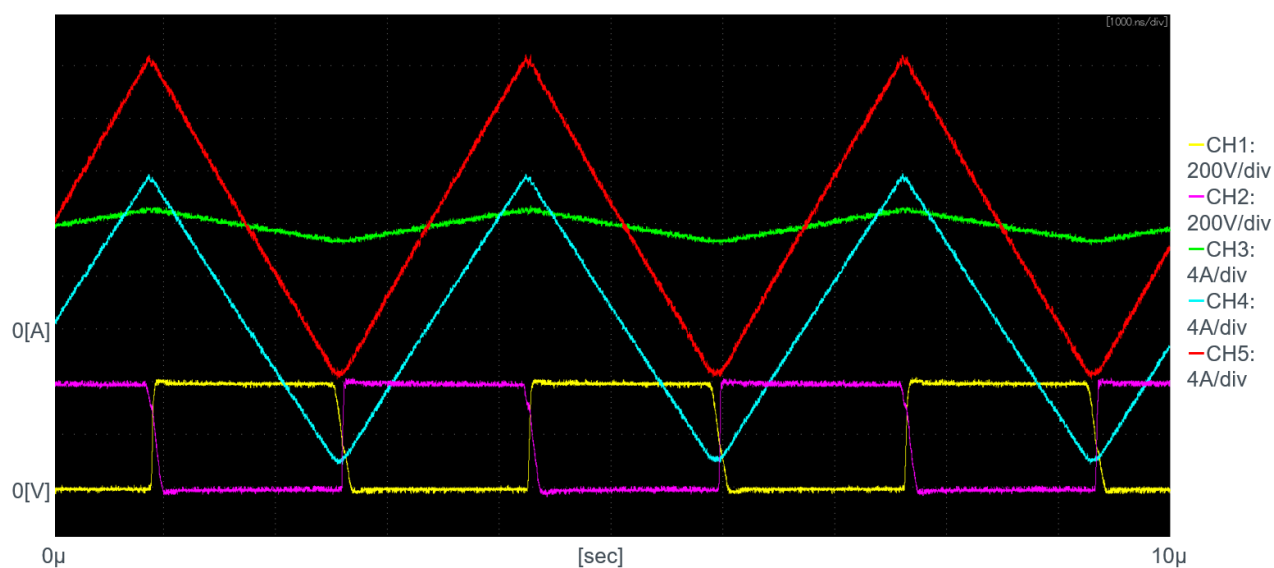


Figure 14. PFC Operation Waveform (Vin=200 V)

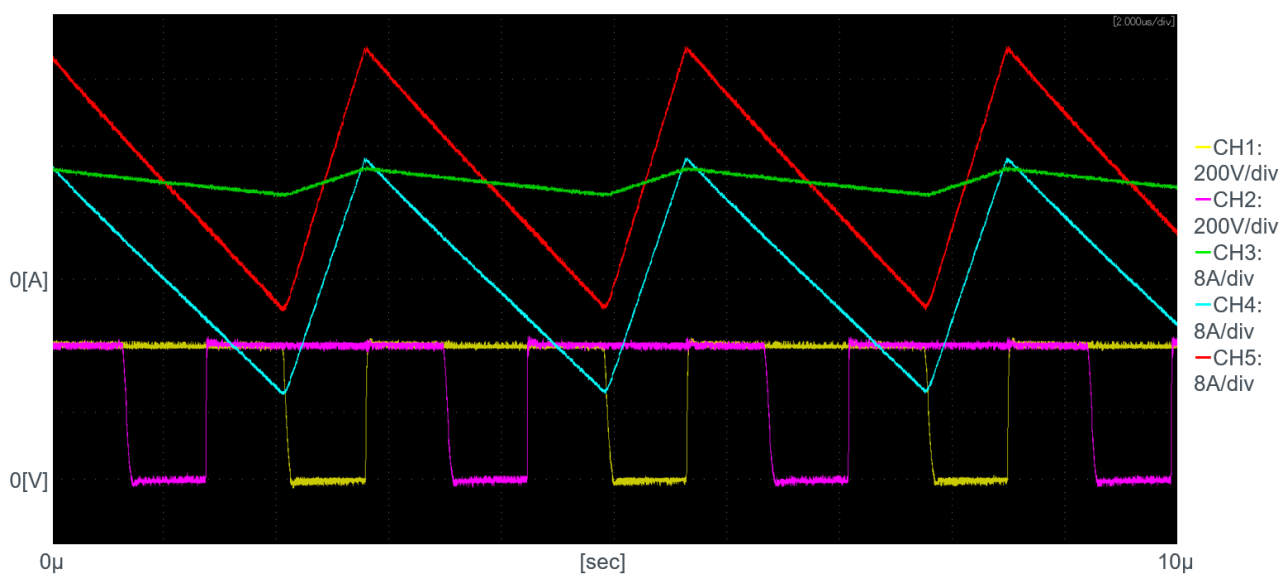
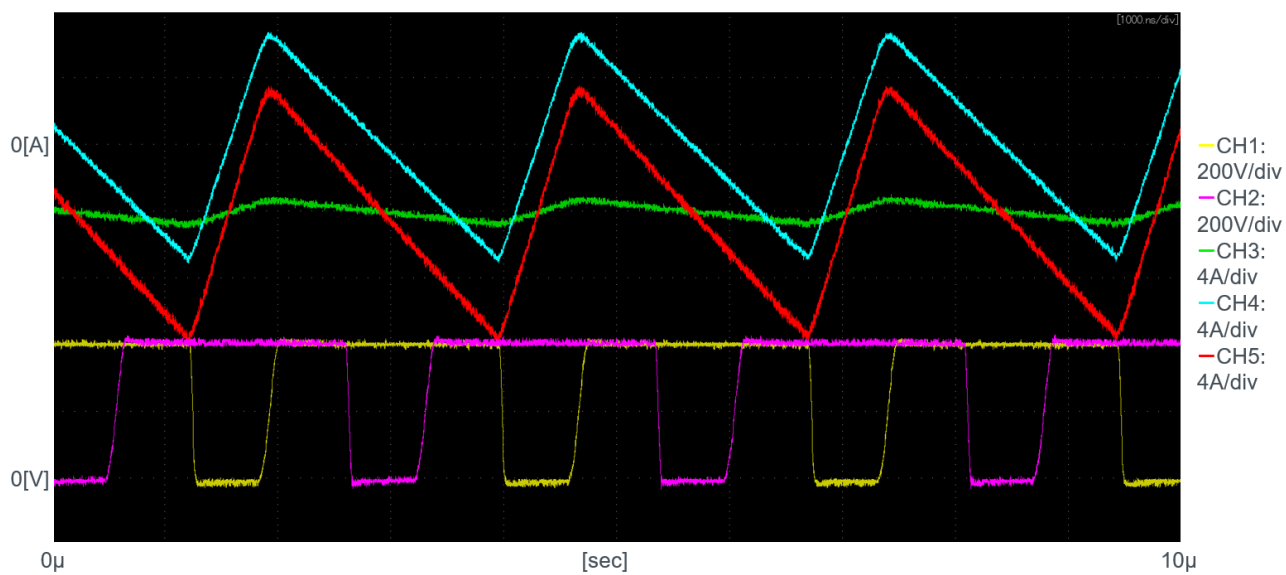
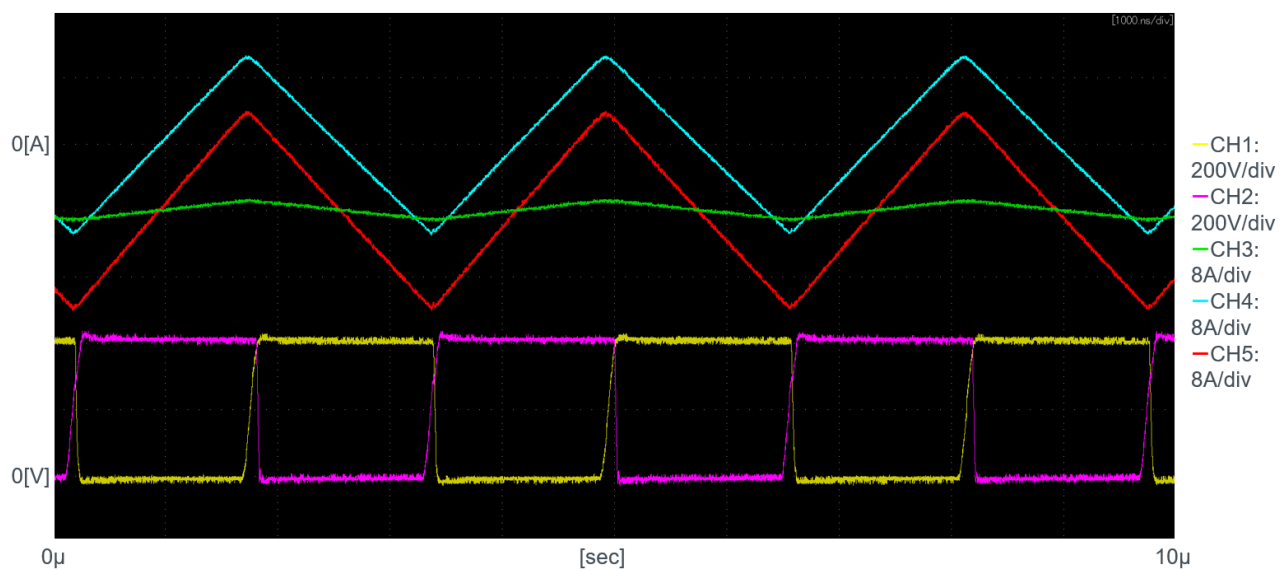
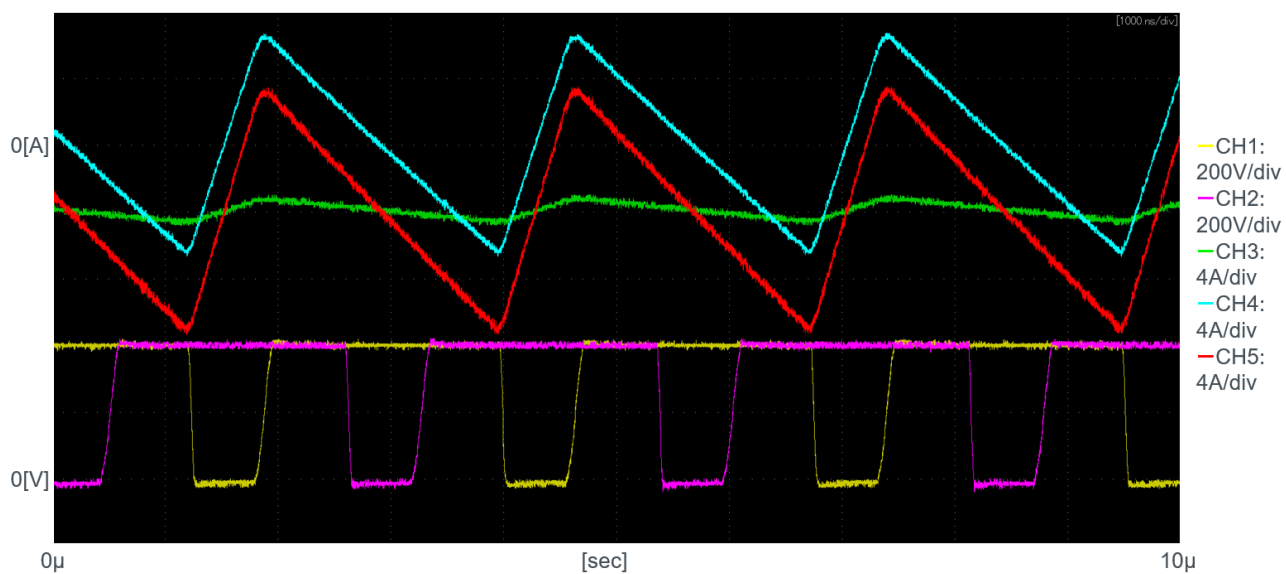


Figure 15. PFC Operation Waveform (Vin=300 V)

Figure 16. PFC Operation Waveform ($V_{in} = -100\text{ V}$)Figure 17. PFC Operation Waveform ($V_{in} = -200\text{ V}$)

Figure 18. PFC Operation Waveform ($V_{in} = -300\text{ V}$)

7 Thermal Characteristics (Temperature Evaluation Results)

The thermal characteristic evaluation results when operated at the recommended output power (5 kW) for 10 minutes are shown ($T_a=25\text{ }^{\circ}\text{C}$). The board surface temperature distribution captured by a thermography camera is shown in Figure 19, and the detailed temperatures for each measurement point (MP) are shown in Table 3. Note that this measurement was conducted under forced air cooling using an external fan, with heatsinks attached to the Fast Leg GaN Daughter Board and the Slow Leg SJ-MOSFET Daughter Board. The highest temperature on this evaluation board occurs at the high-frequency inductor. If you are considering using it at higher power levels, the inductor must be redesigned, as the current rating and thermal design margin may become insufficient.

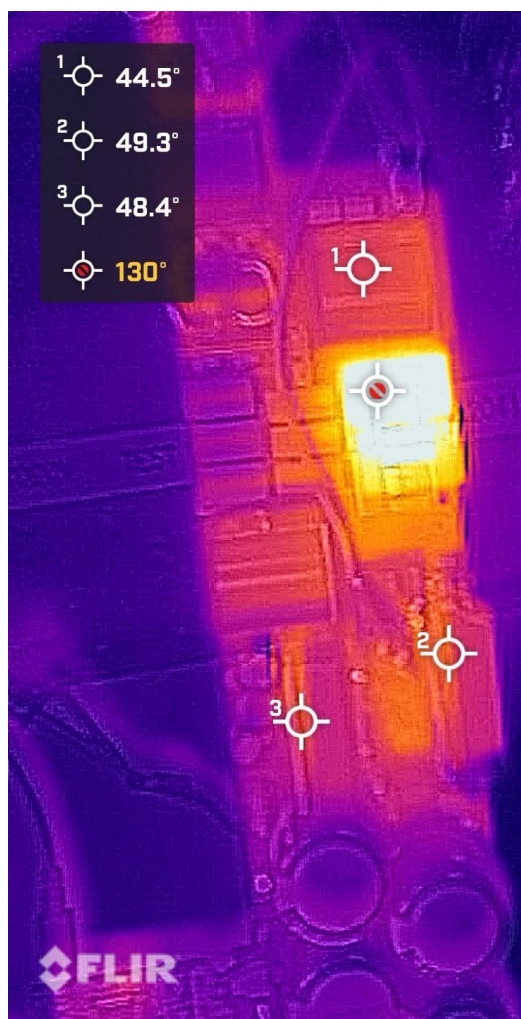


Figure 19. Surface Temperature Distribution (at the recommended output power)

Table 3. Temperatures at Each Measurement Point

Point	Description	Temp. ($^{\circ}\text{C}$)
MP1	Low-frequency Inductor	44.5 $^{\circ}\text{C}$
MP2	GaN HEMT	49.3 $^{\circ}\text{C}$
MP3	SJ-MOSFET	48.4 $^{\circ}\text{C}$
MP-MAX	High-frequency Inductor	130 $^{\circ}\text{C}$

8 Introduction of Major ROHM Devices Mounted

This evaluation board (TotemPolePFC_5.5kW-TSB-001) is equipped with many ROHM devices that contribute to higher system efficiency, space savings, and reduced design effort. This section introduces the features of the key power ICs supporting the main circuit of the evaluation board.

8.1 AC/DC Converter for Auxiliary Power Supply Circuit: [BM2P129TF](#)

This IC is adopted for the auxiliary power supply to drive the control circuits of this evaluation board.

- **Significant Reduction in Peripheral Components:** When using an equivalent product from a competitor that features a variable output voltage, many peripheral components (resistors, capacitors, and diodes) are required for voltage setting and phase compensation. In contrast, since this IC is a "fixed output voltage type", these external components can be eliminated. As shown in Figure 20, by adopting this fixed-output voltage type IC, the peripheral components surrounded by the dashed box in the left figure can be omitted, allowing for the construction of a very simple power supply circuit.
- **Contribution to High Power Density:** By reducing the number of components, the mounting area of the auxiliary power supply circuit can be minimized, contributing to the miniaturization of the entire evaluation board and the realization of high-power density.

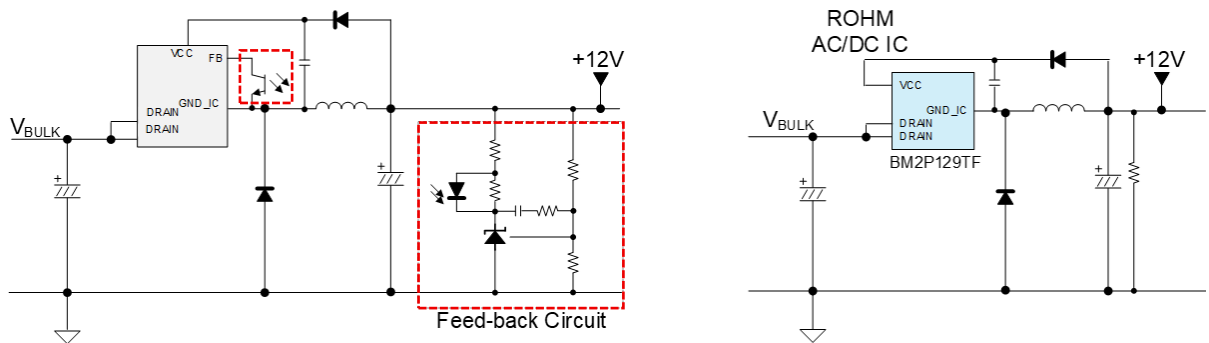


Figure 20. Schematic Comparison (Competitor's variable output voltage type vs. BM2P129TF)

8.2 Isolated Switch Driver IC for Inrush Current Limit Circuit: [BM79330FV-LB](#)

In the inrush current limit circuit of this evaluation board, this IC is adopted as an isolated switch driver to drive the SJ-MOSFET for current path switching. At startup, it safely charges the output capacitors via a thermistor to protect the circuit from large currents. After the output capacitors are fully charged and just before starting the switching operation, it switches the current path from the thermistor to the SJ-MOSFET for steady-state operation. This IC handles this control.

- **Component Reduction by Eliminating Driving Power Supply:** An independent power supply circuit to drive the secondary-side (power-side) MOSFET is not required. This reduces peripheral components, contributing to space savings and cost reduction.
- **Reliable Isolation between Digital and Power Sides:** It provides reliable isolation between the controller (Digital side), such as the MCU, and the PFC circuit handling high voltage (Power side), ensuring system safety and high reliability.
- **Optimized Specs for the Application:** Switching the path in the inrush current limit circuit occurs only once at startup, so high-speed switching performance is not required. This IC avoids unnecessary over-specification for such applications that require "reliable isolation and driving without high-speed switching," making it the optimal and latest choice.

- **Securing Gate Voltage through Series Connection Utilizing Floating Outputs:** As shown in Figure 21, this IC features "floating voltage outputs (4ch)" where each channel independently generates a driving voltage. On this board, by connecting these 4-channel outputs in series, the gate voltage necessary to reliably drive the SJ-MOSFET is secured without adding a dedicated external power supply or boost circuit.

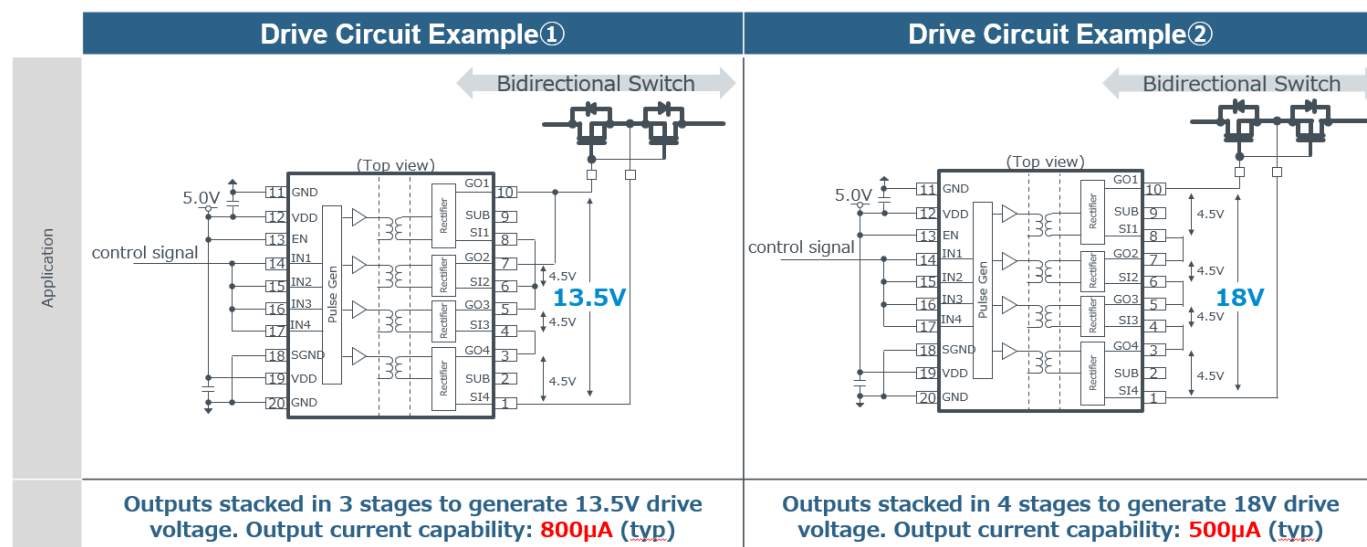


Figure 21. Circuit Examples of BM79330FV-LB

8.3 Step-Down DC/DC Converter: [BD9E105FP4-Z](#)

This IC is adopted on the 3-pin DC/DC daughter board shown in the schematic of Figure 34.

- **Size Compatibility:** This IC adopts a small SOT23 package size (2.8 mm × 2.9 mm). Compared to a typical SOP-J8 (JEDEC standard: equivalent to SOIC8) package (4.9 mm × 6.0 mm), the component area can be reduced by approximately 72 %, contributing significantly to the miniaturization of the power supply section. In addition, the 3-pin DC/DC daughter board equipped with this IC is designed with the exact same package size (10 mm × 16 mm) as industry-standard Linear Voltage Regulators (LDOs). This allows for easy replacement evaluation without changing the existing board layout.

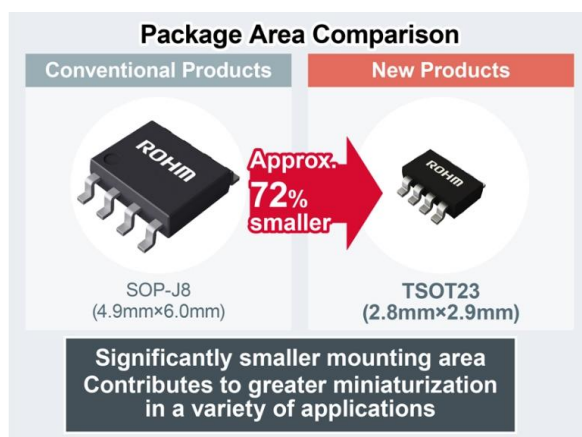


Figure 22. Package Area Comparison (SOP-J8 vs. SOT23)

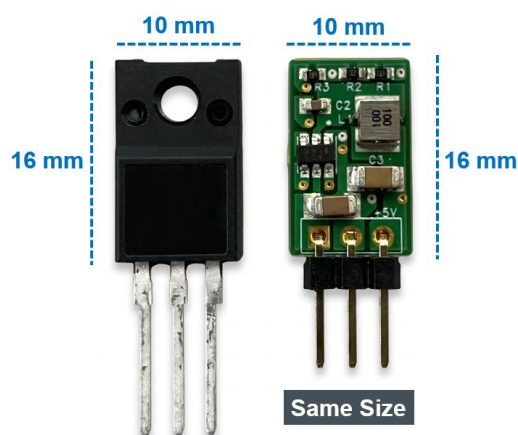


Figure 23. Package Area Comparison (LDO vs. DCDC)

9 High-frequency Inductor Specifications

This evaluation board uses high-current inductors manufactured by Würth Elektronik. The main electrical characteristics and constants of the inductor are shown in Table 4.

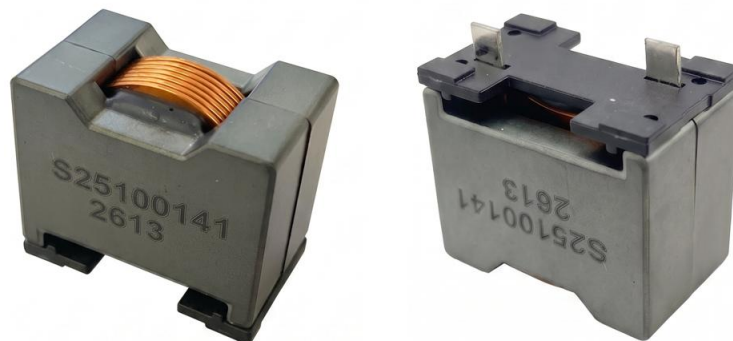


Figure 24. High-frequency Inductor Appearance

Table 4. Constants of High-frequency Inductor

Parameter	Specification
Inductance	15 μ H
Rated Current ($\Delta T=40K$)	27 A
Saturation Current ($I_{\Delta L}/I_L < 30\%$)	26 A
D.C. Resistance	2.3 m Ω

The high-frequency inductor mounted on this evaluation board has the following AC Resistance (ACR) characteristics in the operating frequency band (100 kHz ~ 1 MHz). Please refer to Figure 25 for the ACR characteristics versus frequency.

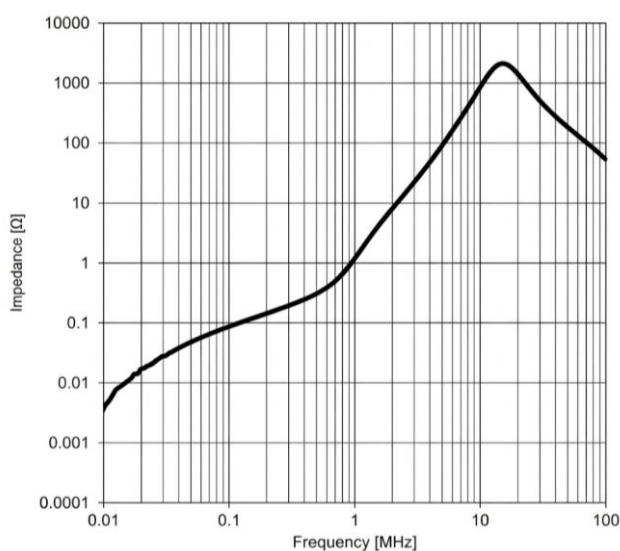


Figure 25. ACR Characteristics of High-frequency Inductor

10 Low-frequency Inductor Specifications

This evaluation board uses high-current inductors manufactured by Würth Elektronik. The main electrical characteristics and constants of the inductor are shown in Table 5.

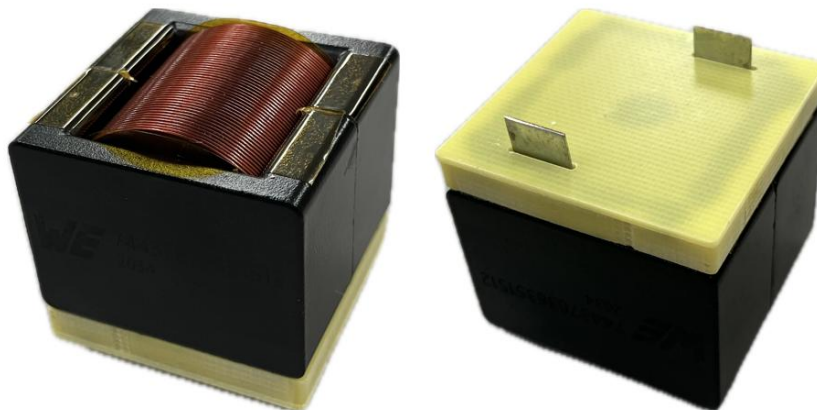


Figure 26. Low-frequency Inductor Appearance

Table 5. Constants of Low-frequency Inductor

Parameter	Specification
Inductance	150 μ H
Rated Current ($\Delta T=50$ K)	14 A
Saturation Current ($I_{\Delta L}/I_L < 30\%$)	32 A
D.C. Resistance	19.5 m Ω

11 Loss Calculation Results

Figure 27 shows a comparison between the calculated efficiency and measured efficiency of this evaluation board (TotemPolePFC_5.5kW-TSB-001). They match with high accuracy, with an error of within 0.5 % across the entire load range. This calculation model can be used to estimate loss trends in any load range.

Figure 28 also shows the breakdown of power losses by device at each load point based on theoretical calculations.

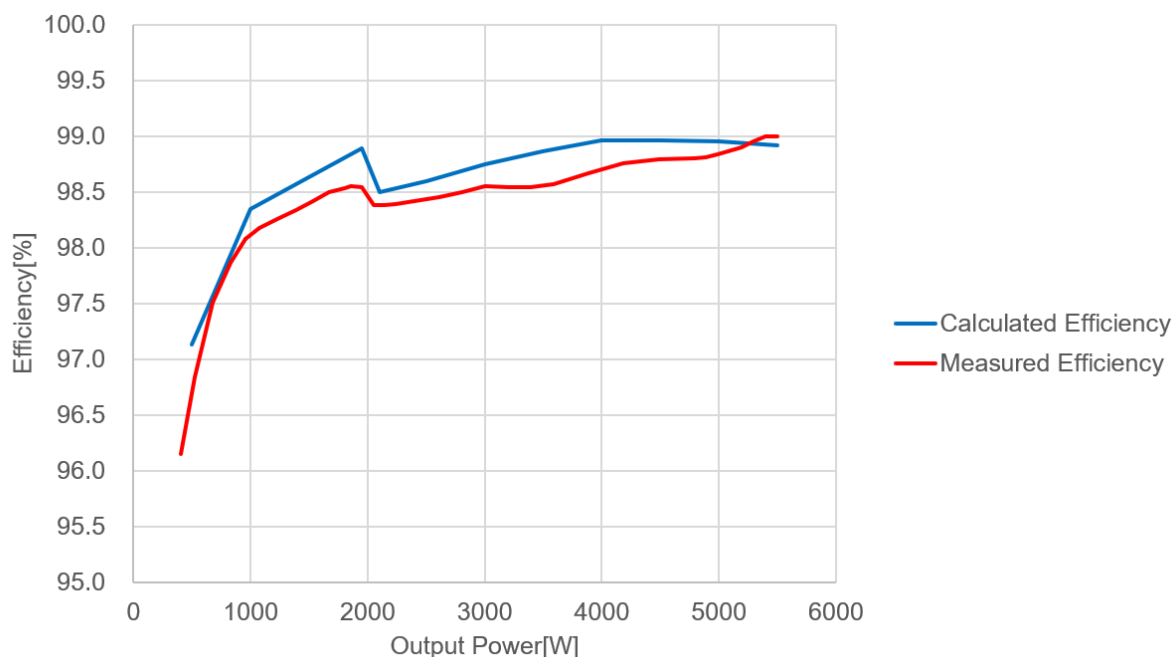


Figure 27. Comparison between Measured and Calculated Efficiency

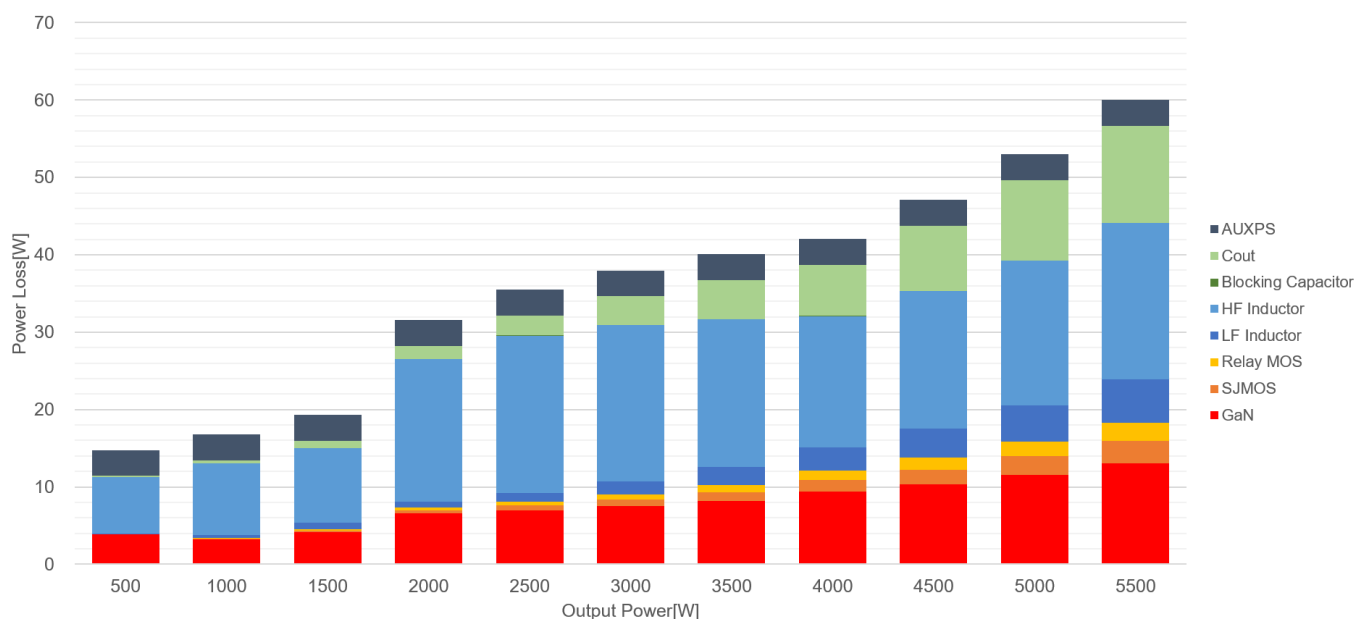


Figure 28. Loss Calculation Breakdown

Since this evaluation board has an AC input, the input voltage constantly fluctuates with time. Furthermore, to maintain ZVS (Zero Voltage Switching), the switching frequency is also continuously controlled to vary. Therefore, the loss calculation in this section is performed by setting a specific operating point (1 point at $V_{in} = 230\text{ V}$) as a representative condition. All parameters, such as the current values of each device used in the calculation, are also based on this specific condition. The formulas used to calculate the losses of each element are as follows:

■ Fast Leg GaN HEMT Loss (P_{GaN})

The total loss of the GaN HEMT is mainly the sum of conduction loss, switching loss, and gate drive loss. Since this evaluation board operates with ZVS, the turn-on loss is calculated as zero.

- Conduction Loss:

$$P_{cond_GaN} = I_{rms_GaN}^2 \times R_{DS(on)_GaN}$$

(※ I_{rms_GaN} : RMS current flowing through the GaN HEMT under calculation conditions)

- Switching Loss:

$$P_{sw_GaN} = \frac{1}{2} \times V_{SD} \times I_{off} \times t_{off} \times f_{sw}$$

- IC Drive Loss:

$$P_{drive_GaN} = V_{DD} \times I_{DD}$$

- Dead-time Loss during ZVS:

$$P_{deadtime} = V_{SD} \times I_{ZVS} \times T_{rv} \times f_{sw} \times 2$$

(※ I_{ZVS} : Negative current flowing for ZVS, T_{rv} : Dead time for ZVS)

■ Slow Leg SJ-MOSFET Loss ($P_{SJ\text{MOS}}$)

Because switching occurs at the commercial power frequency (50 Hz / 60 Hz), switching losses are negligibly small, and conduction loss is dominant.

- Conduction Loss:

$$P_{cond_SJ\text{MOS}} = I_{rms_SJ\text{MOS}}^2 \times R_{DS(on)_SJ\text{MOS}}$$

(※ $I_{rms_SJ\text{MOS}}$: RMS current of the SJ-MOSFET under calculation conditions)

■ High-frequency Inductor Loss (P_{L_HF})

Commercial frequency AC current does not flow through the high-frequency inductor; only the high-frequency ripple current of the switching frequency flows. Therefore, copper loss is calculated using only the AC component by applying the AC Resistance (ACR) at the operating frequency.

- Copper Loss:

$$P_{cu_HF} = I_{HF_rms}^2 \times ACR$$

(※ ACR: AC resistance considering frequency characteristics at the operating frequency)

- Iron Loss (Core Loss):

$$P_{core_HF} = K \times f_{sw}^\alpha \times \Delta B^\beta \times V_e$$

(※ K, α, β : Constants specific to the core material, ΔB : Operating magnetic flux density amplitude,
 V_e : Effective core volume)

■ Low-frequency Inductor Loss (P_{L_LF})

Since mainly current at the commercial power frequency flows, copper loss using DC Resistance (DCR) is dominant.

- Copper Loss:

$$P_{cu_LF} = I_{LF_rms}^2 \times DCR$$

(※ I_{LF_rms} : I_{IN_rms} during 1-phase operation, $0.5 \times I_{IN_rms}$ during 2-phase operation)

- Iron Loss (Core Loss):

$$P_{core_HF} = K \times f_{sw}^\alpha \times \Delta B^\beta \times V_e$$

■ Output Capacitor Loss (P_{Cout})

The output capacitors of the PFC circuit primarily experience low-frequency ripple current with twice the commercial power frequency (f_{ac}) and high-frequency ripple current of the switching frequency. In aluminum electrolytic capacitors, the loss due to the low-frequency ripple current is dominant, so in this calculation, the loss is calculated based on the component twice the input frequency (100 Hz or 120 Hz). This evaluation board uses six 390 μ F aluminum electrolytic capacitors mounted in parallel to disperse and reduce the loss by lowering the total Equivalent Series Resistance (ESR).

- Output Electrolytic Capacitor Loss:

$$P_{Cout} = I_{Cout_rms}^2 \times ESR_{total}$$

(※ $ESR_{total} = \frac{\tan \delta}{2\pi \times (2f_{ac}) \times C_{total}}$, $I_{Cout_rms} = \frac{I_{out}}{\sqrt{2}}$)

■ Auxiliary Power Supply (12 V System) Loss (P_{AUXPS})

This evaluation board generates 12 V for driving the control circuits from high voltage using the auxiliary power supply circuit (AC/DC converter) mounted on the main board and supplies it to the entire system (MCU, gate driver ICs, various logic ICs, etc.) as an internal 12 V source. The power consumed by this 12 V system circuit is calculated using the following formula and added to the total system loss.

- Auxiliary Power Supply Loss:

$$P_{AUXPS} = 12 [V] \times I_{12V_total}$$

(※ I_{12V_total} : Total current consumed by the entire 12 V system circuit)

12 Bill of Materials

Table 6. Main Board BOM

Part Reference	Description	Part Number	Manufacture	Qty.
C1	CAP Film 0.33μF ±10% 630V Class X2 SMT	890334025034CS	Würth Elektronik	1
C2,C3,C5,C6	CAP CER 1000pF ±20% 400Vac Class X1Y2 SMT	DE2E3SA102MN3AY02F	Murata	4
C4	CAP Film 2.2μF ±10% 630V Class X2 SMT	890334026034	Würth Elektronik	1
C7,C8,C9	CAP Film 0.68μF ±10% 310V Class X2 SMT	890334025045	Würth Elektronik	3
C10,C11,C12	CAP Film 0.47μF ±10% 275V Class X2 SMT	890324025039	Würth Elektronik	3
C13,C22,C25,C30	CAP CER 1000pF ±20% 100Vdc X7R 1608 SMD	MSASH168SB7102MTNA01	Taiyo Yuden	4
C14,C26,C29,C31,C33,C49,C50,C63,C67,C68,C76,C77	CAP CER 1μF ±10% 25Vdc X7R 1608 SMD	MSAST168SB7105KTNA01	Taiyo Yuden	12
C15,C21,C24,C47,C57,C58,C59,C60,C64,C74,C75	CAP CER 0.1μF ±20% 100Vdc X7R 1608 SMD	MSASH168SB7104MTNA01	Taiyo Yuden	11
C16,C17,C18,C19	CAP CER 0.22μF ±10% 630Vdc X7R 5750 SMD	885342214142	Würth Elektronik	4
C20,C23	CAP CER 10μF ±20% 35Vdc X7R 3216 SMD	MSASG31LAB7106MTNB25	Taiyo Yuden	2
C27,C28,C32,C65,C66	CAP CER 22μF ±10% 25Vdc X7R 3225 SMD	MSAST32MSB7226KPNB25	Taiyo Yuden	5
C34,C35,C36,C37,C38,C39	CAP Electrolytic 390μF ±20% 450V Φ30x30mm SMT	450MXT390MEFCN30X30	Rubycon	6
C40,C41	CAP CER 0.068μF ±10% 630Vdc X7R 3225 SMD	885342209005	Würth Elektronik	2
C42,C43,C73	CAP CER 2200pF ±20% 100Vdc X7R 1608 SMD	MSASH168SB7222MTNA01	Taiyo Yuden	3
C44,C45,C69	CAP CER 220pF ±10% 100Vdc X7R 1608 SMD	MLASH168SSD221KTNA01	Taiyo Yuden	3
C46,C51,C52,C53,C54	CAP CER 47nF ±20% 100Vdc X7R 1608 SMD	MSASH168SB7473MTNA01	Taiyo Yuden	5
C48	CAP CER 2.2μF ±10% 50Vdc X7R 2012 SMD	MSASU21GBB7225KTNA01	Taiyo Yuden	1
C55,C56	CAP CER 4700pF ±20% 100Vdc X7R 1608 SMD	MSASH168SB7472MTNA01	Taiyo Yuden	2
C61	CAP Electrolytic 4.7μF ±20% 450V Φ10×16mm SMT	860241475018	Würth Elektronik	1
C62	CAP Electrolytic 220μF ±20% 25V Φ8×13mm SMT	860080474010	Würth Elektronik	1
C70,C71,C72	CAP CER T.B.DF - -Vdc - - SMD	NON-1608	Taiyo Yuden	3
CN1,CN2	CONNECTOR 2pin 300V AC Inlet C14	691218410002	Würth Elektronik	2
CN3	CONNECTOR 120pin 304V AC Inlet C14	HTEC8-160-01-L-DV-A-BL	Samtec	1
CN4,CN5	CONNECTOR 4pin 50V 1.5mm pitch SMT	64800411622	Würth Elektronik	2
CN6,CN7	CONNECTOR 6pin 250V AC Inlet C14	61300611821	Würth Elektronik	2
CN8	CONNECTOR 2pin -V 3.5mm pitch SMT	691214110002S	Würth Elektronik	1
D1,D2,D3,D4	DIODE FAST RECOVERY 600V 10A VF:1.25V TO-252AA(D-P)	RFNL10BGE6S	ROHM	4
D5	DIODE FAST RECOVERY 700V 0.8A VF:1.5V PMDTM SMD	RFN1LAM7S	ROHM	1
D6	DIODE FAST RECOVERY 600V 0.8A VF:1.45V PMDTM SMD	RFN1LAM6S	ROHM	1
D7	DIODE RECTIFIER 600V 0.2A VF:1.1V TUMD25M SMD	RRE02VSM6S	ROHM	1
F1	FUSE 500V 30A SMT	0505030.MXEP	Littelfuse	1
IC1	IC CURRENT SEN HE/DIFF 65A SMD	ACS724KMA	Allegro	1
IC2	IC Isolated Driver SMD	BM79330FV-LB	ROHM	1
IC3,IC4	IC 1ch Gate Driver Providing Galvanic Isolation SMD	BM61M22BFJ-C	ROHM	2
IC5,IC12	IC Low Noise OPAMP 5.5V SSOP5 SMD	LMR1802G	ROHM	2
IC6	IC Voltage References - SOT-23-3	TLV431AIDBZR	TI	1
IC7,IC8	IC Digital Isolator SMD	18012115411L	Würth Elektronik	2
IC9	IC DC/DC converter SMD	BM2P129TF	ROHM	1
IC10,IC11	IC LDO 3.3V 200mA SSOP5 SMD	BU33SD2MG-M	ROHM	2
J1	Dual counter-rotating fan 12V 1.8A 0.9m ³ /min	9CRV0412P5J201	SANYO DENKI	2
L1,L2	COIL 150μH±15% 19.5mΩ 23A PQ3635 x 33.2mm SMT	74437636351512	Würth Elektronik	2
L3,L4	COIL 15μH±10% 0.0023Ω 27A φ-mm x 22.23mm SMT	S25100141	Würth Elektronik	2
L5	COIL 220μH±20% 0.51Ω 1A φ11mm x 11.5mm SMT	7447471221	Würth Elektronik	1
LED1	LED RED 20mA VF 2.2V SMD	SML-H12U8TT86	ROHM	1
LED2	LED Green 20mA VF 2.2V SMD	SML-H12M8TT86	ROHM	1
LED3	LED Blue 5mA VF 2.9V SMD	SMLMN2BCTT86	ROHM	1
LF1	LINE FILTER 1mH 2.4mΩ 20A SMT	7448042001	Würth Elektronik	1
LF2	LINE FILTER 1.5mH 3.2mΩ 18A SMT	7448041801	Würth Elektronik	1
Q1,Q2,Q3,Q4	TRANSISTOR MOSFET Nch 600V Id:T.B.DA 0.05Ω SMD	RJ2X050DA	ROHM	4
R1,R2,R3,R4,R5,R6	RES 100kΩ J(±5%) 3216 0.25W 500V SMD	KTR18EZPJ104	ROHM	6
R7	RES PTC 56Ω SMT	B59451C1130B070	TDK	1
R8,R11,R15	RES 1kΩ J(±5%) 1608 0.1W 50V SMD	MCR03EZPJ102	ROHM	3
R9	RES 1Ω J(±5%) 3216 0.5W 200V SMD	ESR18EZPJ1R0	ROHM	1
R10	RES 470kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX4703	ROHM	1
R12,R14,R16	RES 10Ω J(±5%) 3216 0.5W 200V SMD	ESR18EZPJ100	ROHM	3
R13,R17,R43	RES 1kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX1001	ROHM	3
R18,R19,R20,R22,R23,R24,R30,R31,R32	RES 100kΩ F(±1%) 3216 0.25W 200V SMD	MCR18EZPF1003	ROHM	9
R21,R25,R33	RES 1.8kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX1801	ROHM	3
R26,R27,R28	RES 1MΩ F(±1%) 3216 0.25W 200V SMD	MCR18EZPF1004	ROHM	3
R29	RES 18kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX1802	ROHM	1
R34,R65	RES 100Ω J(±5%) 1608 0.1W 50V SMD	MCR03EZPJ101	ROHM	2
R35	RES 4.3kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX4301	ROHM	1
R36	RES 5.1kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX5101	ROHM	1
R37	RES 10Ω FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX10R0	ROHM	1
R38	RES T.B.D 1608 SMD	NON-MCR03	ROHM	1
R39,R50,R51,R52,R53,R66	RES 0Ω J(±5%) 1608 0.1W 50V SMD	MCR03EZPJ000	ROHM	6
R40	RES 4.7kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX4701	ROHM	1
R41	RES 3.6kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX3601	ROHM	1
R42	RES 5.6kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX5601	ROHM	1
R44,R45,R46,R47	RES 15kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX1502	ROHM	4
R48,R49	RES 10kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX1002	ROHM	2
R54,R61,R62,R63,R64	RES 100kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX1003	ROHM	5
R55,R56	RES 470kΩ F(±1%) 3216 0.25W 500V SMD	KTR18EZPF4703	ROHM	2
R57	RES 2.2kΩ F(±1%) 3216 0.25W 200V SMD	MCR18EZPF2201	ROHM	1
R58	RES 100Ω FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX1000	ROHM	1
R59,R60	RES 47kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX4702	ROHM	2
U1,U2	Daughter Board (GaN for PFC)	GaN_D-Card_TL_Rev2510	ROHM	2
U3	Daughter Board (LF MOSFET for PFC)	LFMOS_Rev2510_A	ROHM	1
U5	Daughter Board (DCDC for PFC)	DCDC3PIN_VO5_Rev2510_A	ROHM	1
ZN1	VARISTOR 420V 2500A 10mm SMT	V320LA10P	Littelfuse	1

Table 7. Fast Leg GaN Daughter Board BOM

Part Reference	Description	Part Number	Manufacture	Qty.
C1,C2	CAP CER 0.1μF ±10% 50Vdc X7R 1608 SMD	MAASU168SB7104KTNA01	Taiyo Yuden	2
C3,C4,C33,C34	CAP CER 100pF ±10% 100Vdc X7R 1608 SMD	MSASH168SSD101KTNA01	Taiyo Yuden	4
C5,C6,C7,C8,C37,C38	CAP CER 1μF ±10% 50Vdc X7R 1608 SMD	MSASU168AB7105KTNA01	Taiyo Yuden	6
C10	CAP CER 10μF ±20% 35Vdc X7R 3216 SMD	MSASG31LAB7106MTNB25	Taiyo Yuden	1
C11,C12	CAP CER 10μF ±10% 25Vdc X7R 3216 SMD	MSAST31LAB7106KTNA01	Taiyo Yuden	2
C13,C16,C43,C44	CAP CER 100pF ±10% 100Vdc X7R 1608 SMD	MSASH168SSD101KTNA01	Taiyo Yuden	4
C14,C17	CAP CER 1000pF ±20% 100Vdc X7R 1608 SMD	MSASH168SB7102MTNA01	Taiyo Yuden	2
C15,C19	CAP CER 0.22μF ±10% 50Vdc X7R 1608 SMD	MSASU168SB7224KTNB25	Taiyo Yuden	2
C22	CAP CER 33nF ±5% 1000Vdc C0G 3225 SMD	C3225C0G3A333J	TDK	1
C24	CAP CER 0.1μF ±10% 1000Vdc X7R 4532 SMD	GRM43DR7LW104KW01L	Murata	1
C36	CAP CER 0.1μF ±10% 50Vdc X7R 1608 SMD	MAASU168SB7104KTNA01	Taiyo Yuden	1
C41	CAP CER 10μF ±20% 25Vdc X7R 3216 SMD	MSAST31LAB7106MTNA01	Taiyo Yuden	1
C42	CAP CER 0.1μF ±20% 100Vdc X7R 1608 SMD	MSASH168SB7104MTNA01	Taiyo Yuden	1
D1	DIODE SCHOTTKY BARRIER 150V 0.5A VF:0.95V SOD-323HE SMD	RB568VAM150	ROHM	1
HS1	HEAT SINK 11.5-5.9°C/W 33x37.5mm T:10mm SMT	SK40037.5AL	Fischer elektronik	1
IC1	IC DC/DC Converter 8V to 40V- HTSOP-38 SMD	BD7F100EFJ-LB2	ROHM	1
IC2,IC3	IC Gate Driver Isolation 4ch SSOP SMD	ISO7741FDBQR	TI	2
IC4,IC5	IC GaN HEMT Power Stage 650V 21mΩ 2MHz SMD	BM3G402MUV-LA	ROHM	2
IC6	IC AND gate SMD	BD7LS08ZG-C	ROHM	1
IC7	IC LDO 3.3V 200mA SSOP5 SMD	BU33SD2MG-M	ROHM	1
R1,R2	RES 51Ω FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX51R0	ROHM	2
R4,R8,R27,R28	RES 0Ω J(±5%) 1608 0.1W 50V SMD	MCR03EZPJ000	ROHM	4
R5,R6	RES 51Ω FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX51R0	ROHM	2
R7	RES 100kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX1003	ROHM	1
R10,R15	RES 2.2kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX2201	ROHM	2
R11,R13,R21,R23	RES 20Ω FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX20R0	ROHM	4
R12,R22	RES 300Ω FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX3000	ROHM	2
R14	RES 100kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX1003	ROHM	1
R26	RES 10kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX1002	ROHM	1
R29,R32	RES 2.7kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX2701	ROHM	2
R30	RES 3.9kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX3901	ROHM	1
R31	RES 15kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX1502	ROHM	1
R34	RES 4.7kΩ F(±1%) 3216 0.25W 200V SMD	MCR18E2PF4701	ROHM	1
R35,R36	RES 10Ω FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX10R0	ROHM	2
R37,R38	RES 430kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX4303	ROHM	2
TR1	TRANSFORMER Bobbin:EP7-8pin Core:EP7 SMD	750310022	Würth Elektronik	1

Table 8. Slow Leg SJ-MOS Daughter Board BOM

Part Reference	Description	Part Number	Manufacture	Qty.
C1,C2	CAP CER T.B.DF - -Vdc - - SMD	NON-1608	-	0
HS1	HEAT SINK 11.5-5.9°C/W 33x37.5mm T:10mm SMT	SK40037.5AL	Fischer elektronik	1
Q1,Q2,Q3,Q4	-	NON-TOLL	-	0
Q5,Q6,Q7,Q8	SJ-MOSFET 600V RDS(on)max.=22mΩ in TOLL Package (Under Development)	(Under Development)	ROHM	4

Table 9. 3-pin DC/DC Daughter Board BOM

Part Reference	Description	Part Number	Manufacture	Qty.
C1	CAP CER 10μF ±20% 35Vdc X7R 3216 SMD	MSASG31LAB7106MTNB25	Taiyo Yuden	1
C2	CAP CER 0.1μF ±20% 100Vdc X7R 1608 SMD	MSASH168SB7104MTNA01	Taiyo Yuden	1
C3	CAP CER 22μF ±20% 16Vdc X7R 3216 SMD	MSASE31LBB7226MTNA01	Taiyo Yuden	1
IC1	IC DCDC Converter SMD	BD9E105FP4-Z	ROHM	1
L1	COIL 10μH±20% 280mΩ 1.2A φ-mm x 2mm SMD	74438336100	Würth Elektronik	1
R1	RES 47kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX4702	ROHM	1
R2	RES 3.3kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX3301	ROHM	1
R3	RES 6.8kΩ FX(±1%) 1608 0.1W 50V SMD	MCR03EZPFX6801	ROHM	1
CN1	CONNECTOR 3pin 250V AC Inlet C14	61300311021	Würth Elektronik	1

13 Schematics



Figure 29. Main Board Schematic No.1





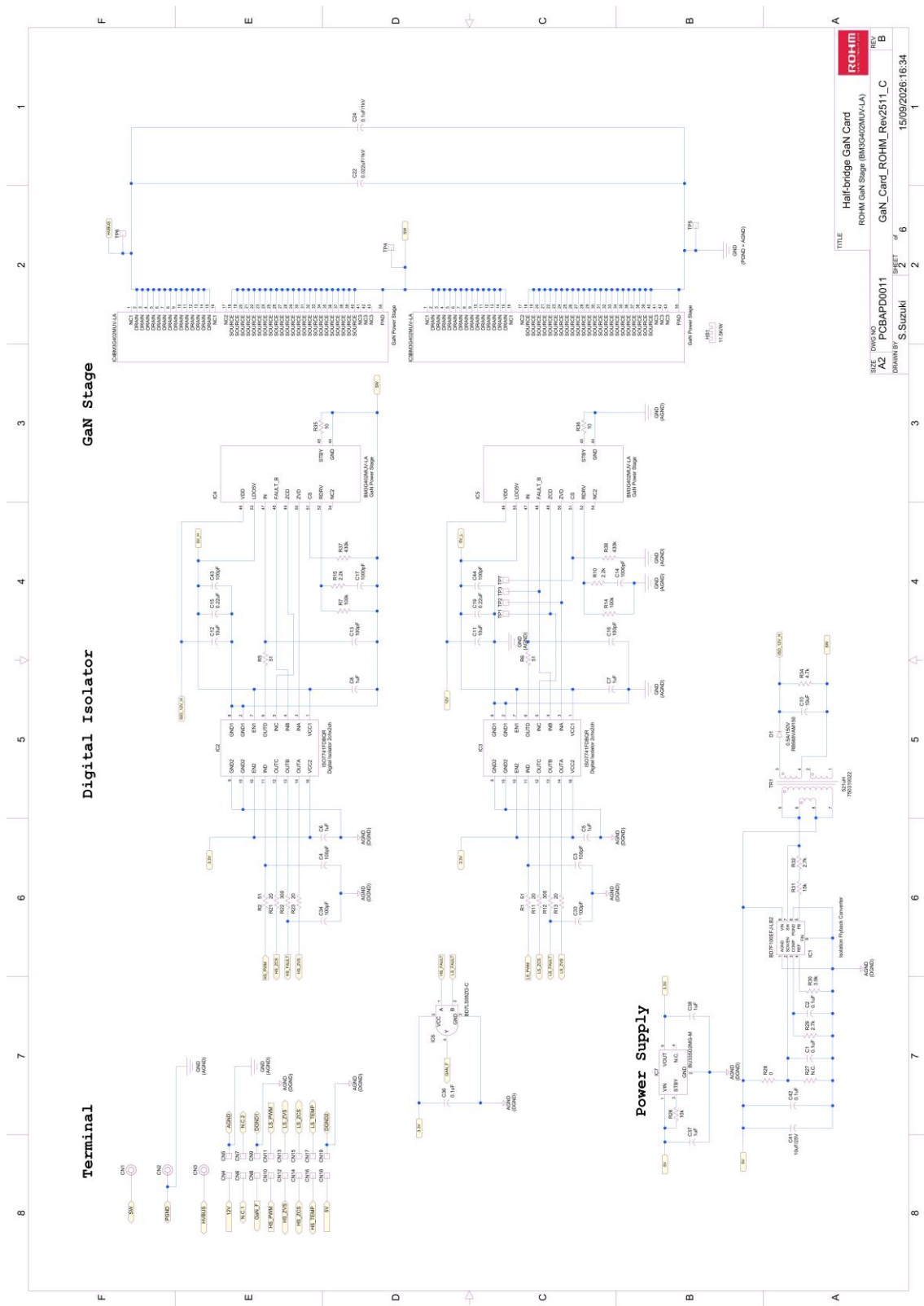
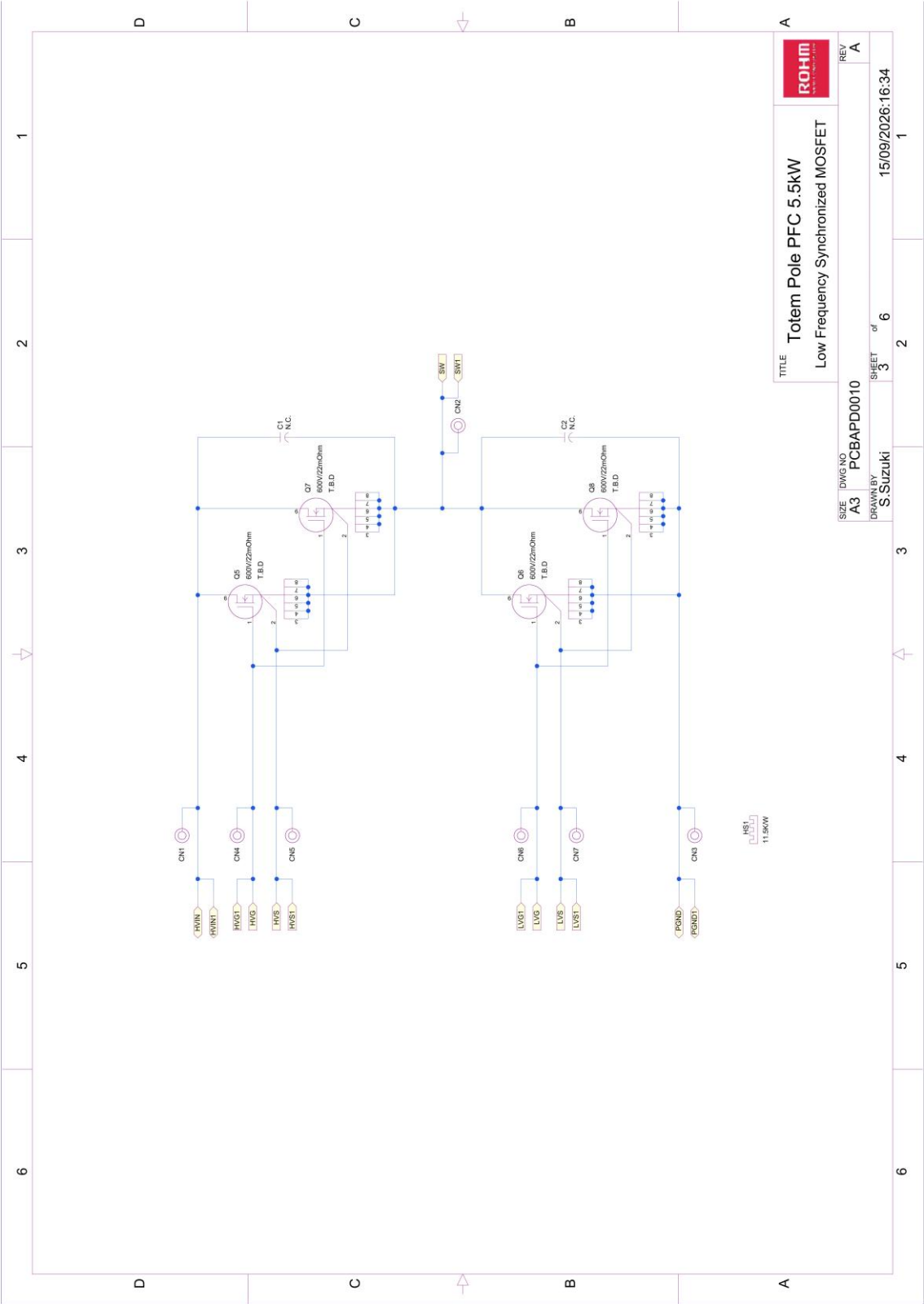


Figure 32. Fast Leg GaN Daughter Board Schematic



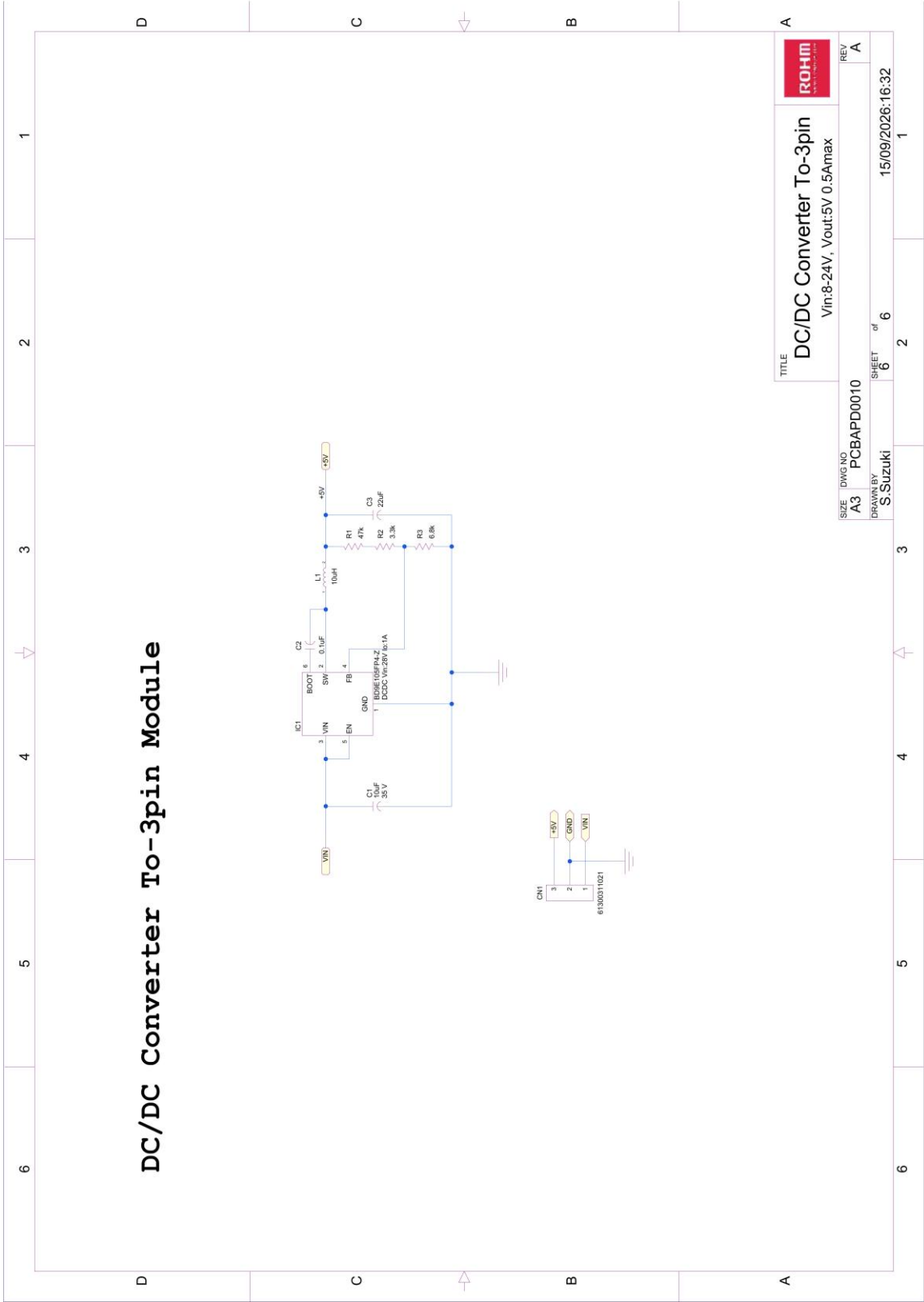
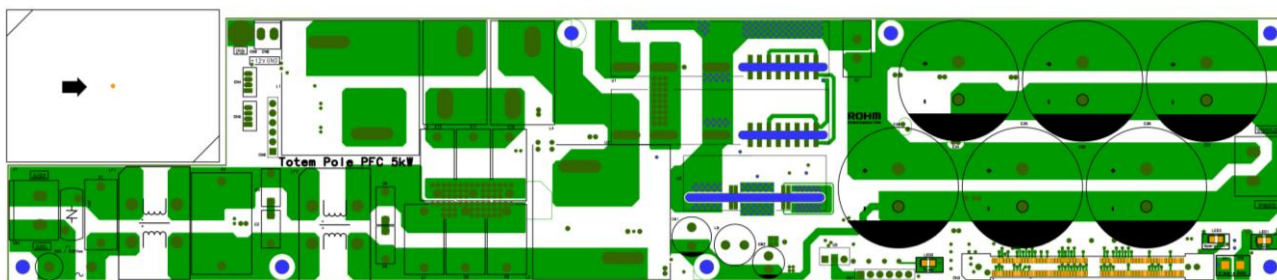
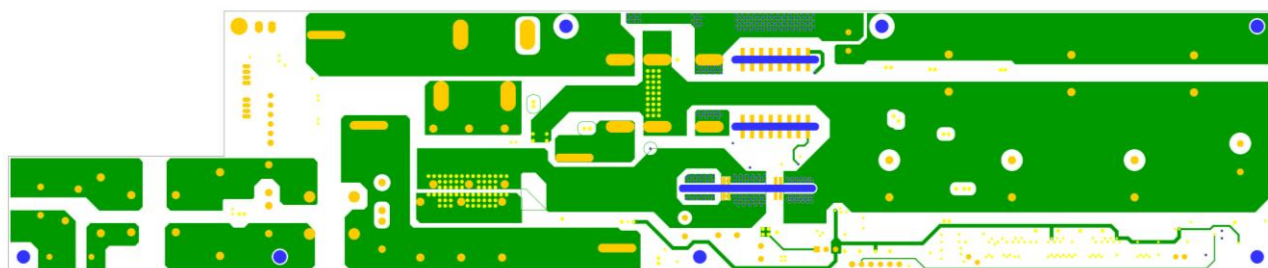


Figure 34. 3-pin DC/DC Daughter Board Schematic

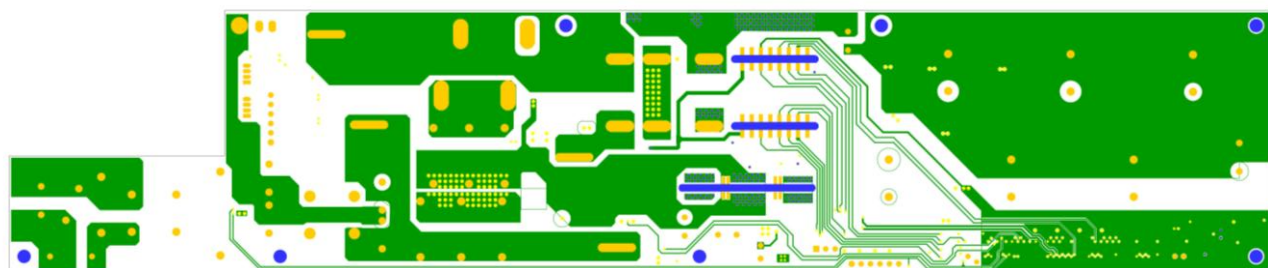
14 Layout Diagrams



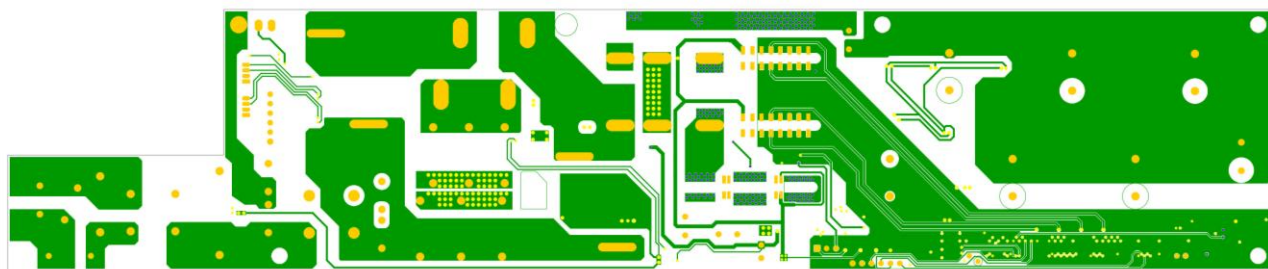
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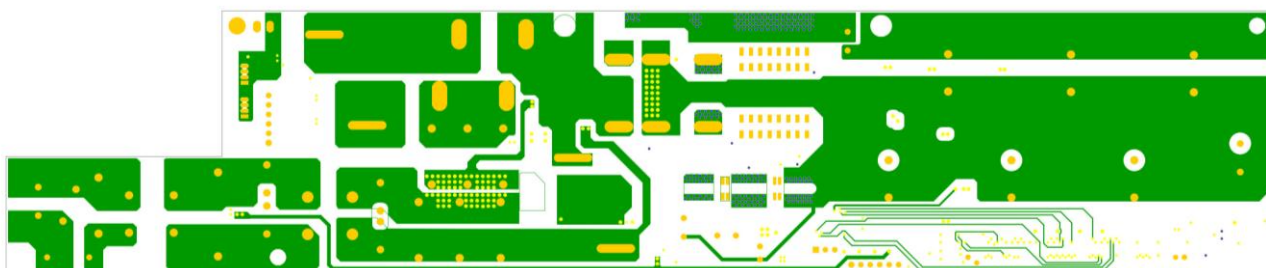
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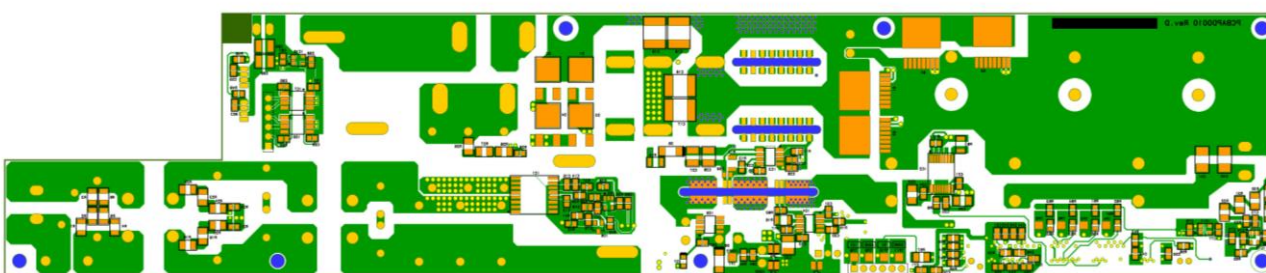
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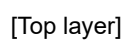
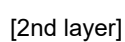
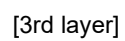


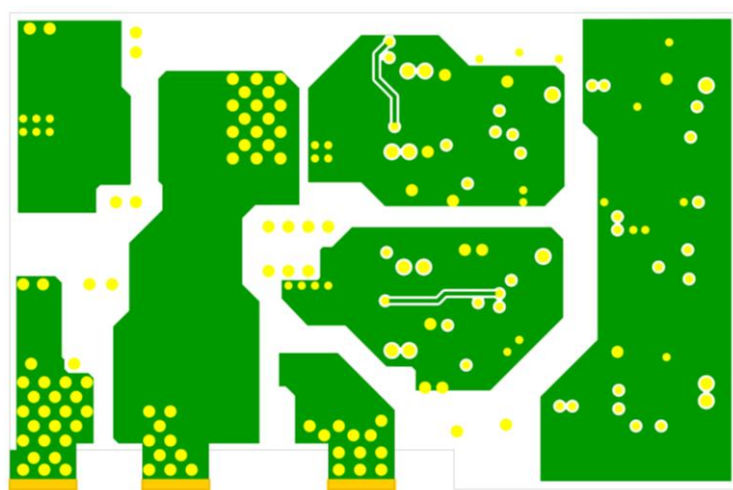
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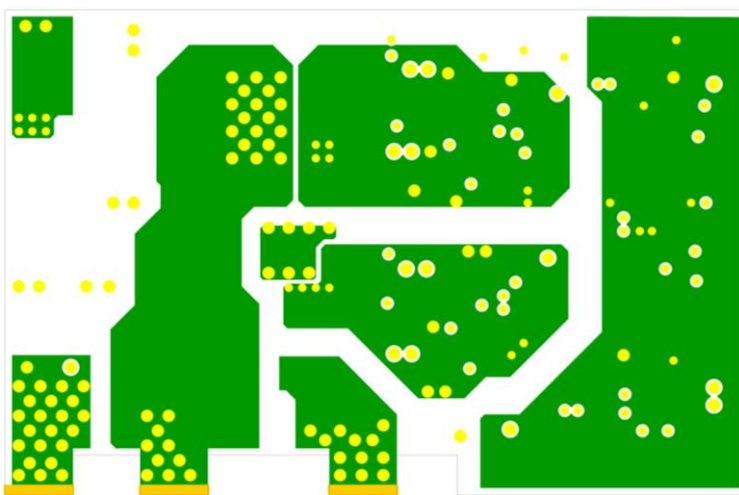
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Figure 35. Main Board Layout

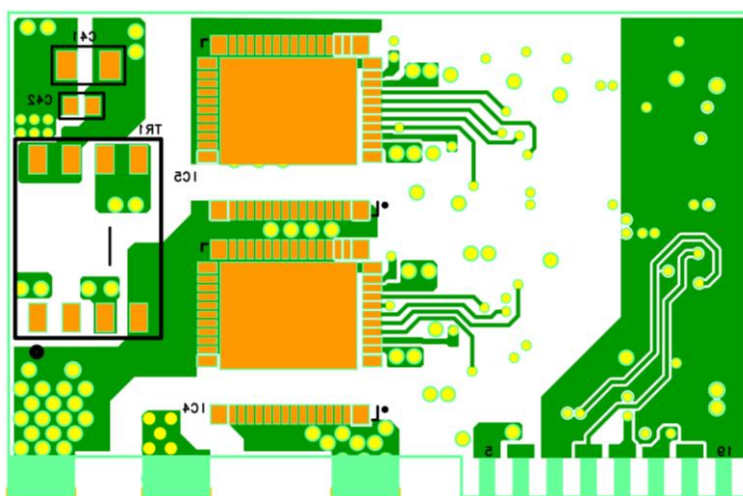




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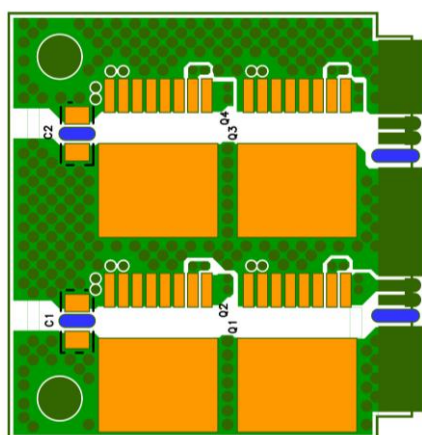


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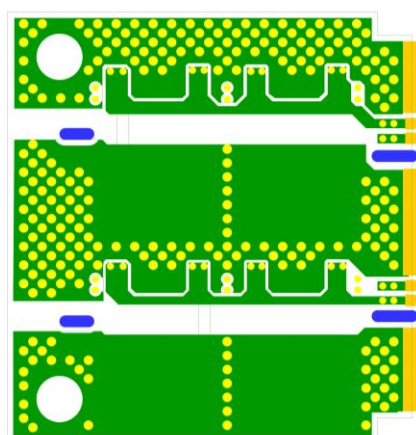


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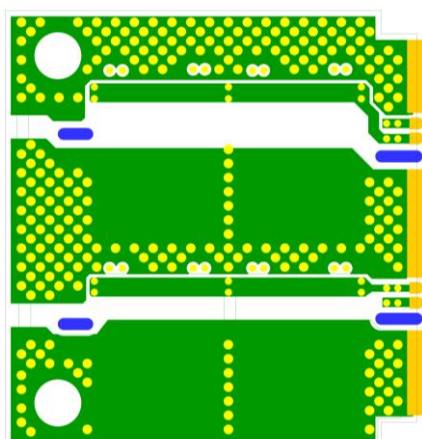
Figure 36. Fast Leg GaN Daughter Board Layout



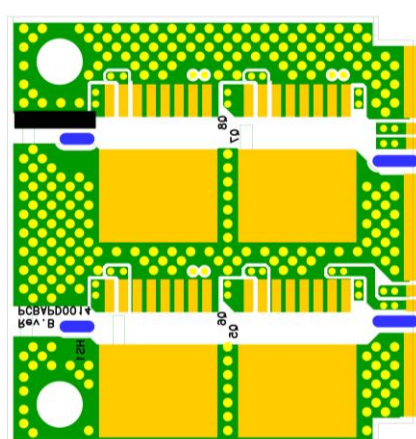
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[2nd layer]



[Bottom layer]

Figure 37. Slow Leg SJ-MOS Daughter Board Layout

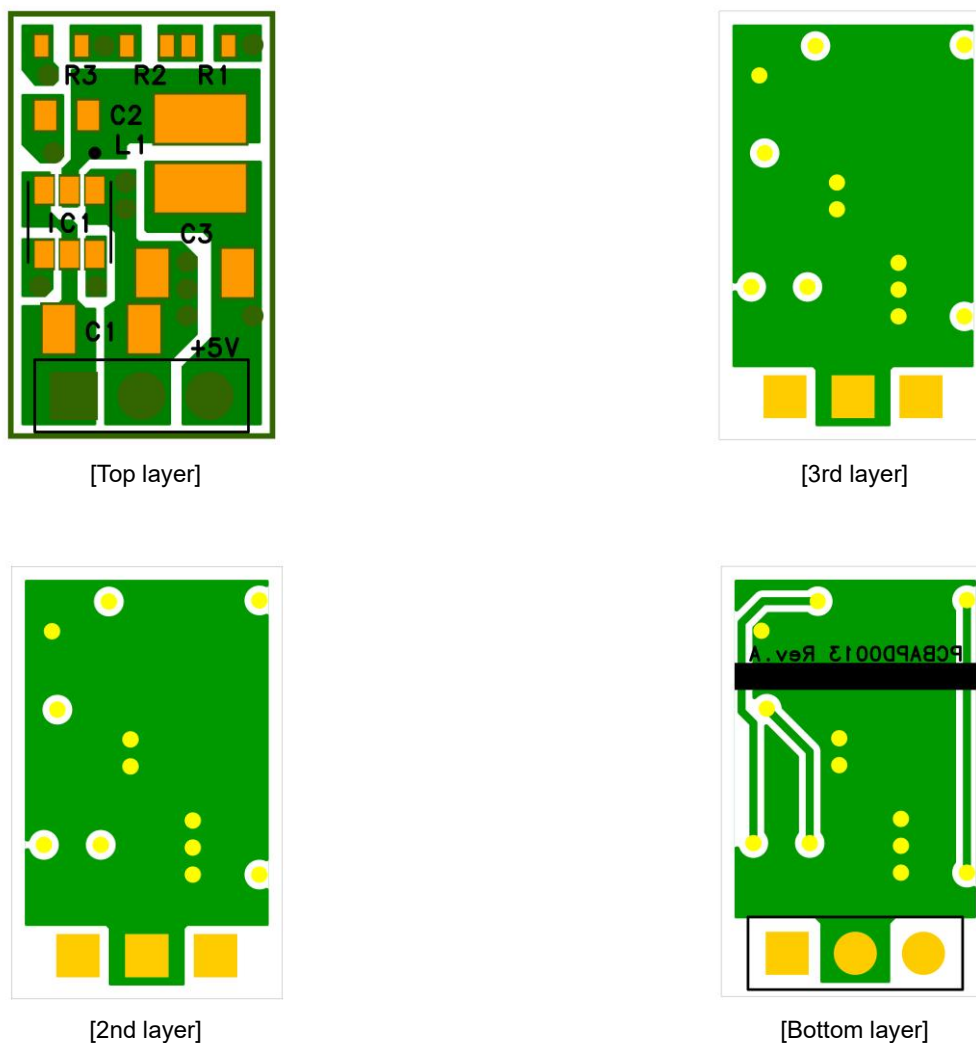


Figure 38. 3-pin DC/DC Daughter Board Layout

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