

RIC70847EVAL1 user guide

Single phase buck converter with R8 rad hard FETs

About this document

Scope and purpose

RIC70847 is a buck controller with integrated gate drivers and is intended for use in DC/DC power conversion applications such as point of load (PoL) rails. This evaluation board is designed to help the user evaluate RIC70847 with any logic level rad hard MOSFET in a SMD-0.5/e or SMD-0.2/e package. It comes prepopulated with **IRHLNMC87Y20** and **IRHLNKC87Y30**. This user manual includes overview, setup instructions, test results, schematic, printed circuit board layout drawings and bill of material.

Intended audience

The intended audience for this document is design engineers, technicians and developers of DC/DC power converters for PoL applications who are looking to evaluate and design RIC70847 for their application.

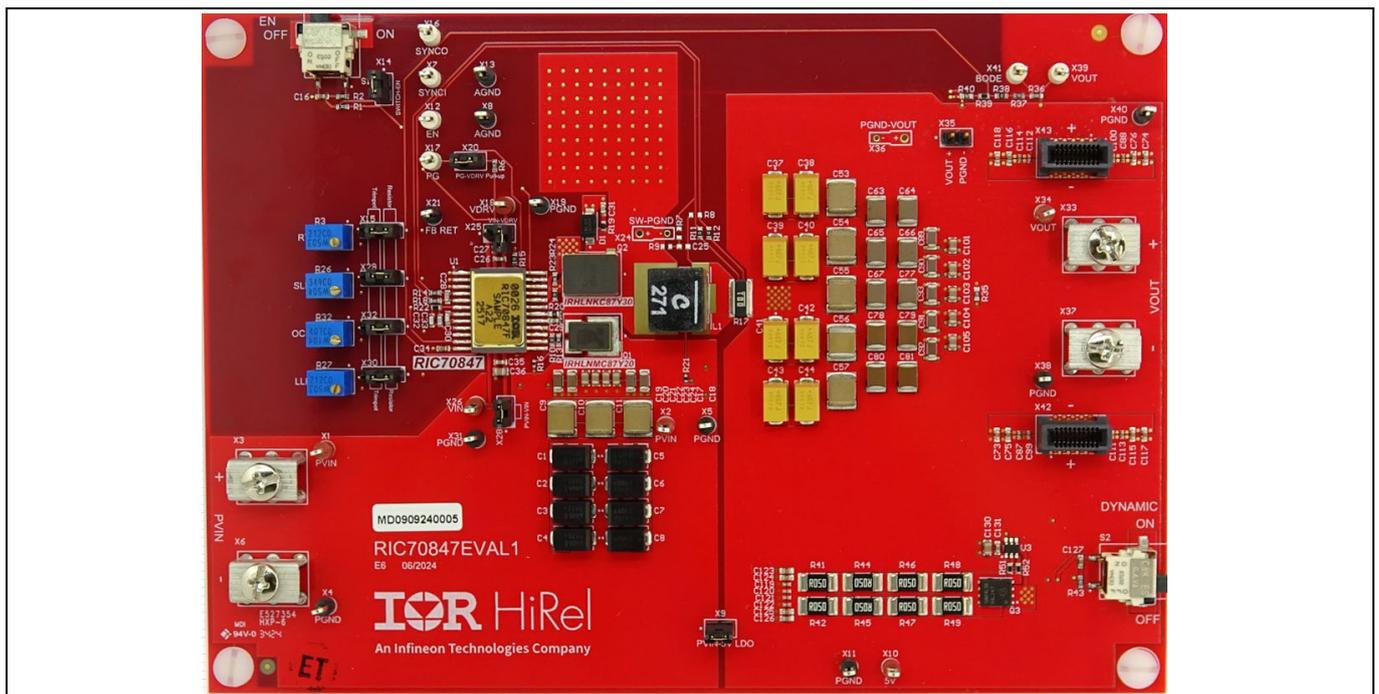


Figure 1 RIC70847EVAL1

Table 1 Safety precautions

| | |
|--|---|
| | <p>Warning: Operation under certain conditions may cause the board to become hot. Ensure that all safety precautions are followed before handling.</p> |
|--|---|

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Introduction

1 Introduction

RIC70847 is a buck controller with integrated 5 V half bridge gate driver, and is intended to work with logic level FET such as **rad hard R8 power FETs**. RIC70847EVAL1 demonstrates the performance of RIC70847 for PoL of space grade FPGA core rails like AMD® (former Xilinx®) XQRKU060 VCCINT rail, Microchip® RT PolarFire VDD rail and NanoXplore® NG-Ultra VDDCORE rail. This board is pre-populated with rad hard FETs IRHLNMC87Y20 and IRHLNKC87Y30 (rad hard R8 MOSFET in SMD-0.5e ceramic lid package with $R_{DS(on),max}=5.0\text{ m}\Omega$). The high side and low side FET can be replaced with any other logic level (5 V drive) FET in an SMD-0.2/e or SMD-0.5/e footprint.

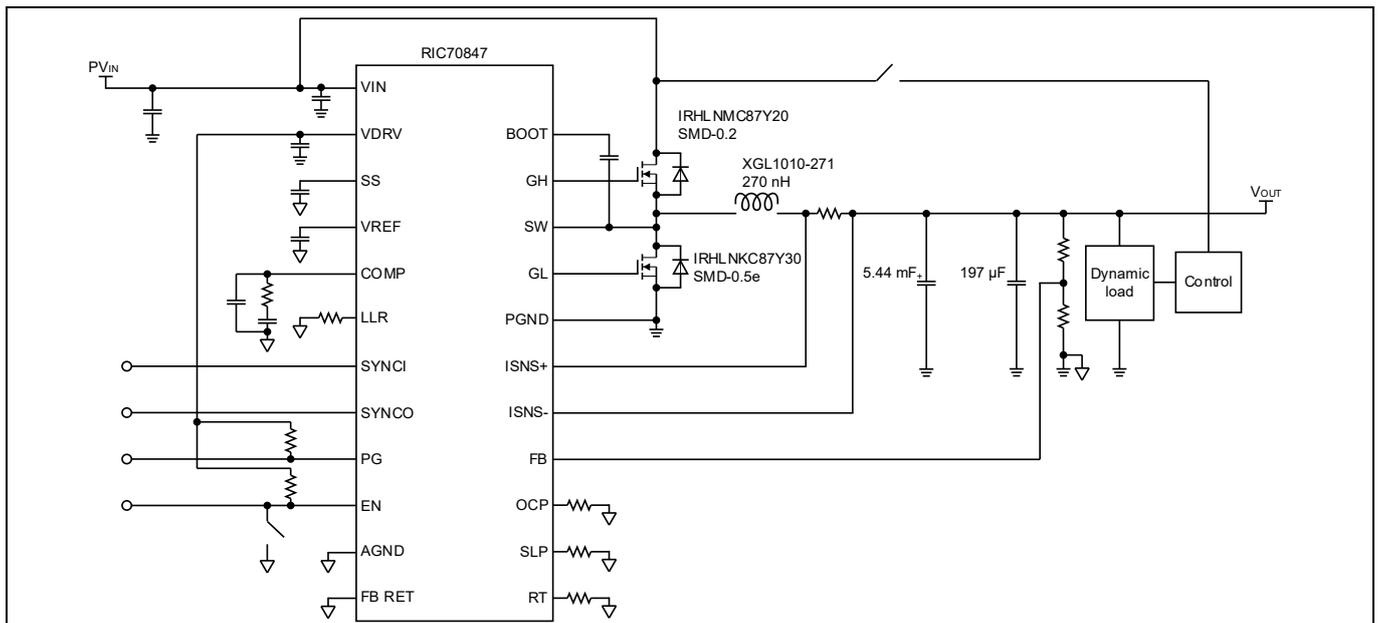


Figure 2 Simplified schematic of RIC70847EVAL1

1.1 Feature list

RIC70847EVAL1 is optimized for ease of use for both measurement in various configurations and modifications. Key features include:

- Easy connection to power source, load and measurement probes to allow for configuration to different states with improved measurement accuracy
- Optional potentiometers for easy adjustment of pin-strap resistor programmed parameters:
 - load line regulation (LLR)
 - Overcurrent limit (OCP)
 - Slope compensation (SLP)
 - Switching frequency (RT)
- Supports a wide range of inductor size and inductance with large footprint
- Supports a wide range of output capacitance values with numerous capacitor footprints in multiple package size
- Simplified ability for transient testing with an on-board dynamic load step circuit which features high slew rates typical of PoL applications
- “Near-flight-like configuration” with commercial off-the-shelf (COTS) equivalent of flight grade components used for key parameters (e.g. output inductor, output capacitor)

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1.2 Recommended operating conditions

For proper operation, the device should be used within the recommended operating conditions. All voltage parameters are referenced to PGND=AGND=FB RET unless otherwise stated. Additionally, refer to the RIC70847 datasheet for recommended and maximum operating limits for RIC70847.

Table 2 RIC70847EVAL1 recommended operating conditions

| Parameter | Symbol | Values | | | Unit |
|---------------------|-----------|--------|-------|------|------|
| | | Min. | Typ. | Max. | |
| Input voltage | V_{IN} | | 5, 12 | | V |
| Output voltage | V_{OUT} | | 1.0 | | V |
| Output current | I_{OUT} | | | 40 | A |
| Switching frequency | f_{SW} | | 480 | | kHz |

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Functional description

2 Functional description

2.1 Power input

RIC70847EVAL1 requires power input for the power stage (PVIN), RIC70847 bias (VIN) and the on-board dynamic load (if used).

2.1.1 Power stage (PV_{IN})

High current screw terminals X3 (PVIN) and X6 (PGND) are intended for input power connection for PVIN. Test points X1 (PVIN) and X4 (PGND) are adjacent to these screw terminals for measurement connections, such as the sense inputs for any power supply with 4-wire sensing. Additional test points X2 (PVIN) and X5 (PGND) are recommended for efficiency measurements.

2.1.2 RIC70847 bias (V_{IN})

The bias power for RIC70847 through the VIN pin can be supplied from the power stage (PVIN) or from a separate external supply. To power RIC70847 from PVIN, jumper X28 needs to be populated with a shunt connector. To power RIC70847 from a separate source, jumper X28 needs to be left open and power connection applied from X26 (VIN) to X31 (PGND).

When VIN=5V and RIC70847 is under certain bias configurations, the voltage drop of the internal LDO of RIC70847 may cause the VDRV pin voltage to be lower than desired. To overcome this, an external voltage may be applied to the VDRV pin to keep the voltage sufficiently high. If an external voltage is applied to the VDRV pin, it is recommended to apply the same voltage to the VIN pin as well. To connect the VIN pin to the VDRV pin on RIC70847EVAL1, the jumper X25 needs to be populated with a shunt connector.

Attention: The absolute maximum rating of the VDRV pin is lower than the VIN and PVIN pins. If a shunt connector is populated on jumper X26, ensure that the voltage on the VIN pin (and the PVIN pin if jumper X29 has a shunt connector) never exceeds the absolute maximum rating of the VDRV pin.

Table 3 Summary of various input power configuration options for RIC70847EVAL1

| Configuration | VDRV power | Recommended operating range | Jumper X28 state | Jumper X25 state |
|---------------|-------------------------|-------------------------------------|------------------|------------------|
| PVIN=VIN | Internal (RIC70847 LDO) | PVIN=VIN=5 V to 12 V | Short | Open |
| PVIN≠VIN | Internal (RIC70847 LDO) | PVIN =3 V to 12 V VIN =5V to 12V | Open | Open |
| PVIN=VIN | External (VIN=VDRV) | PVIN = VIN =5 V | Short | Short |
| PVIN≠VIN | External (VIN=VDRV) | PVIN =3 V to 12 V VIN =5 V | Open | Short |

2.1.3 On-board dynamic load

The on-board dynamic load requires a 5 V power supply to operate. This 5 V power can either be provided by a separate power supply connected from X10 (5 V) to X11 (PGND), or from PVIN through an LDO (G1) on RIC70847EVAL1. If the on-board dynamic load is used and it is desired to power the circuit from PVIN, a shunt

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connector needs to be populated on jumper X9. If the on-board dynamic load is not used, or is used with an external power supply, it is recommended to leave jumper X9 open.

Attention: For the most accurate efficiency measurements where transient testing with on-board dynamic load is not used, leave jumper X9 unpopulated (open) and use an external load

2.2 Output

High current screw terminals X33 (VOUT) and X37 (PGND) are intended for output power connection. Test points X34 (VOUT) and X38 (PGND) are adjacent to them and intended for DC measurements. For AC measurements of the output voltage, such as voltage ripple or peak overshoot/undershoot during transient testing, the 100 mil header X35 may be used. This header (X35) allows for direct connection with high bandwidth, low capacitance active differential probes. Additionally, test point X36, which are adjacent to X35, is intended to be used with a typical oscilloscope probe with probe tip ground spring to improve measurement accuracy.

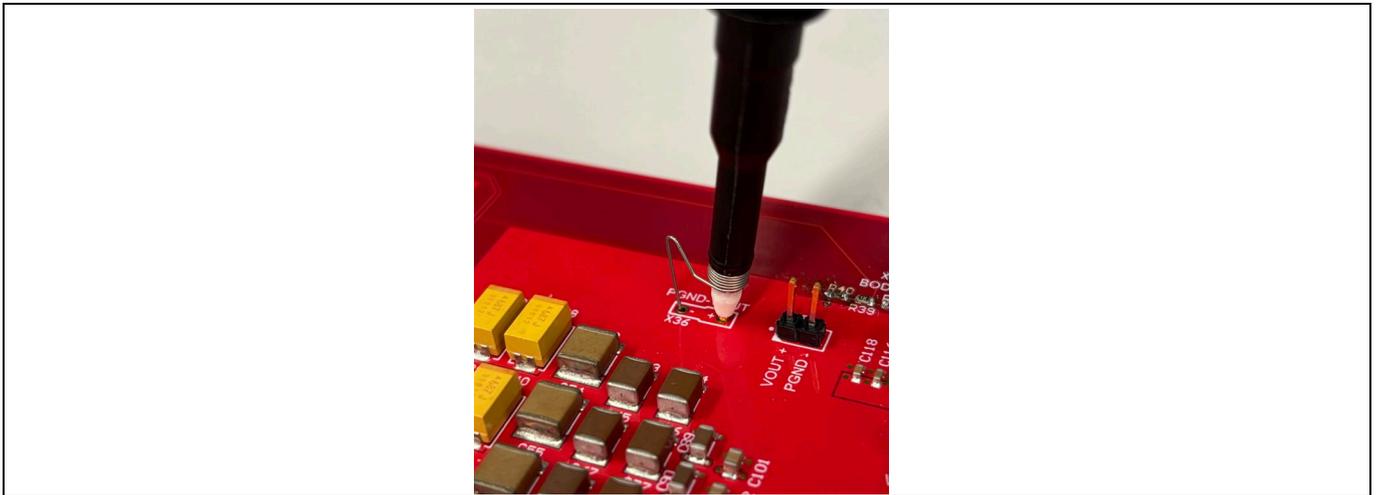


Figure 3 Example probe connection on test point X36

2.2.1 Dynamic load

RIC70847 is intended to power loads, like core rail power for FPGA and ASIC, which have dynamic current load step with high slew rates. These slew rates are typically higher than what external loads connected by cable can achieve. To simplify tests for high slew rate transients, RIC70847EVAL1 supports both on-board and external dynamic load circuits.

2.2.1.1 On-board dynamic load

The on-board dynamic load circuit is designed to pulse a 10 A load step at 1 kHz and 50% duty cycle with a turn on/off slew rate of 10 A/ μ s. This circuit can be used in conjunction with a DC load on the screw terminals X33 (VOUT) and X37 (PGND) to adjust the DC load. For example, a 20 A DC load with the on-board dynamic load enabled will allow for a load step between 20 A to 30 A. To use this circuit, a 5 V bias power supply needs to be provided, detailed in section 2.1.3. Once powered, to enable the dynamic load the switch S2 needs to be set into the “ON” position as indicated on the PCB silkscreen. The dynamic load can be turned off by setting switch S2 into the “OFF” position as indicated on the PCB silkscreen. It is recommended to keep S2 in the “OFF” position when not actively using the on-board dynamic load to prevent the circuit from interfering with other desired operation.

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2.2.1.2 External dynamic load

For enhanced dynamic load tests, RIC70847EVAL1 has connectors X42 and X43 at the output to connect with dynamic load modules such as Intel® Mini-Slammer.

2.3 Switch node, GH, GL measurement

For accurate, high bandwidth measurement of important power stage pulse width modulated (PWM) signals from RIC70847, UMCC connectors are provided on RIC70847EVAL1 for switch node (X23), GH (X22) and GL (X27) signals. All of these connectors are referenced to PGND and are on the bottom side of the PCB. These UMCC connectors are intended to connect to an oscilloscope with a cable such as TE Connectivity 2016682-4 and Amphenol RF 095-850-250-024. All UMCC connectors have a 953 Ω resistor in series with the test point. This 953 Ω resistor is in a 0402 package with 63 mW power rating to increase protection of the oscilloscope. To use these UMCC connectors with an oscilloscope, the oscilloscope must be set to 50 Ω termination with an external attenuation of 20 \times . This allows for the oscilloscope measurement bandwidth to cover the full range the oscilloscope is capable of over the entire operating range of RIC70847EVAL1.

2.4 Bode plot measurement

For bode plot measurements of control loop bandwidth and stability, RIC70847EVAL1 includes test points and a 10 Ω resistor R36 in series with the output voltage divider network for small signal injection. To run a bode plot measurement, the injected voltage can be applied across R36 through test points X39 and X41. The input can be measured from test point X41 (BODE) to X40 (PGND), and the output can be measured from test point X39 (VOUT) to X40 (PGND).

2.5 LLR, OCP, SLP, RT

For pins LLR, OCP, SLP and RT on RIC70847, the external resistor on each pin can either be set with a fixed resistor or with an adjustable potentiometer resistor. The desired operation can be selected by a shunt connector on the respective jumper, details of which are in [Table 4](#). Operating condition for all four pins can be dynamically adjusted while RIC70847 is operating, allowing for performance to be measured as the parameter value is varied.

Table 4 LLR, OCP, SLP, RT setting details

| Pin | Function | Resistor mode | Potentiometer mode |
|-----|---|-----------------------------------|-----------------------------------|
| RT | Sets standalone operation switching frequency | Shunt connector on pin 1-2 of X15 | Shunt connector on pin 2-3 of X15 |
| SLP | Sets slope compensation slope | Shunt connector on pin 1-2 of X29 | Shunt connector on pin 2-3 of X29 |
| OCP | Sets overcurrent protection limit | Shunt connector on pin 1-2 of X32 | Shunt connector on pin 2-3 of X32 |
| LLR | Sets load line regulation magnitude | Shunt connector on pin 1-2 of X30 | Shunt connector on pin 2-3 of X30 |

2.6 Current sense

RIC70847EVAL1 current sensing can be configured in two ways, either with a resistor in series with the inductor, or direct current resistance (DCR) current sensing. RIC70847EVAL1 comes pre-configured with a resistor in series with the inductor option.

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2.6.1 DCR current sensing

DCR current sensing is a technique to use the equivalent series resistance (ESR) of the inductor to measure the inductor current. This allows for higher efficiency since it eliminates the current sense resistor. To use DCR sensing, following changes need to be made to RIC70847EVAL1

- Replace R17 with high current 0 Ω jumper
- Remove R11 and R12 and leave unpopulated
- Populate R7 and R8 with 0 Ω jumpers
- Populate R9 and C25 with desired resistance and capacitance for DCR current sensing. Refer to section 5.6.1.3 in the [RIC70847 datasheet](#) for more information on how to select values

2.7 External clock operation

The RIC70847EVAL1 switching frequency can either be set by the resistance on the RT pin or an external clock on the SYNCI pin. An external clock can be applied to the RIC70847 SYNCI pin from X7 (SYNCI) to X8 (AGND) or X13 (AGND). Refer to section 5.5.2 in the [RIC70847 datasheet](#) for requirements of this external clock signal on SYNCI.

2.8 Enable

RIC70847EVAL1 has an optional 10 k Ω pull up resistor R1 from EN to VDRV that can be used for standalone enabling of operation with a switch S1. If S1 is in the “OFF” position as indicated on the PCB silkscreen, S1 connects EN to AGND and operation of RIC70847 is disabled. If S1 is in the “ON” position as indicated on the PCB silkscreen, S1 is open and EN is pulled up to VDRV through the pull up resistor R1. Switch S1 can be disconnected from the EN pin by removing the shunt connector on jumper X14, allowing external voltage to be applied to EN through X12.

2.9 Power good

RIC70847EVAL1 has an optional 10 k Ω pull up resistor R6 from PG to VDRV. When RIC70847 is operating normally, the PG pin in RIC70847 is open drain and the voltage on PG pin will be pulled up to VDRV. When an event occurs that activates PG, the PG pin in RIC70847 will be pulled to ground. VDRV and the 10 k Ω pull up resistor R6 can be disconnected from PG by removing the jumper populated on X20.

2.10 Pad for heatsink

The drain pads of both power FET Q1 and Q2 have thermal vias to exposed copper pads on the bottom of the board. These pads can be used with an external heatsink to improve the thermal dissipation of both power FETs. Note that these copper pads are electrically connected to the drain of each FET, so they are exposed to and are at different electrical potentials. If a heatsink is applied to these pads, it is recommended to use an electrically isolating thermal interface material.

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Recommended operation

3 Recommended operation

The following equipment is recommended to operate RIC70847EVAL1

- 5 V to 12 V power supply with current capability of at least 10 A at 5 V or 5 A at 12 V
- Electronic load capable of supporting voltage as low as 0.6 V and current of up to 40 A
- Multimeter with voltage and/or current range and accuracy sufficient for desired measurement
- Oscilloscope with a minimum 200 MHz bandwidth

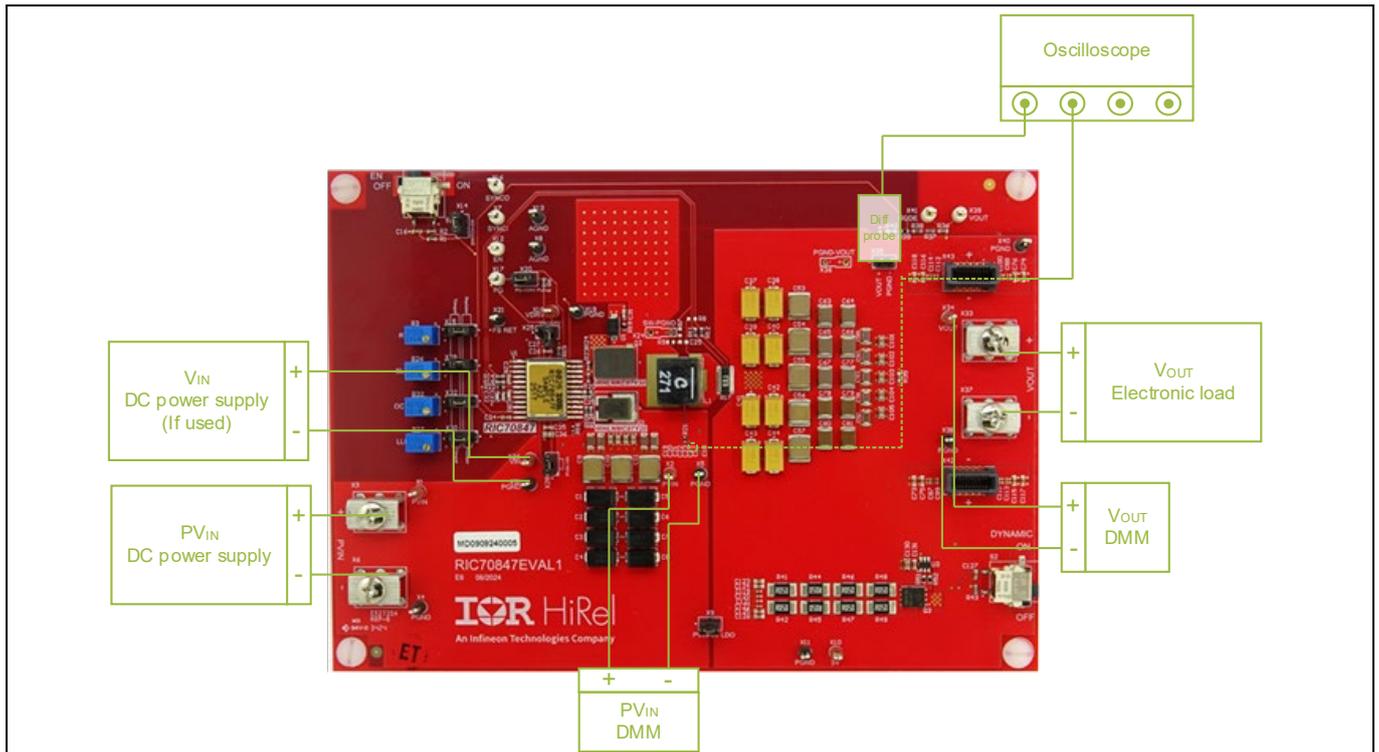


Figure 4 Recommended configuration of RIC70847EVAL1

3.1.1 Power up

The following procedure is recommended for powering up RIC70847EVAL1

1. Connect the PV_{IN} supply, V_{IN} supply (if separate from PV_{IN}), load and measurement probes. Set EN to “OFF” or hold low
2. Enable the PV_{IN}, V_{IN} supplies (if separate from PV_{IN}) and load (if desired)
3. Set EN switch S1 to “ON” or pull EN pin high

3.1.2 Power down

The following procedure is recommended for powering down RIC70847EVAL1

1. Set EN switch S1 to “OFF” or pull EN pin low
2. Disable the PV_{IN}, V_{IN} supplies (if separate from PV_{IN}) and load (if desired)
3. Remove the PV_{IN} supply, V_{IN} supply (if separate from PV_{IN}), load and measurement probes

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Test results

4 Test results

4.1 Design notes

RIC70847EVAL1 is designed to support up to 40 A load while meeting voltage regulation requirements in line with space grade FPGAs, such as AMD® XQRKU060 VCCINT rail, Microchip® RT PolarFire VDD rail and NanoXplore® NG-Ultra VDDCORE core rail. The target output voltage is 1.0 V \pm 3% (0.97 V to 1.03 V). The load is assumed to have a minimum DC value of 10 A with a maximum load step of 10 A at 10 A/ μ s. Load line regulation (LLR) is enabled to improve transient performance.

The output inductor is a 270 nH Coilcraft® XGL1010-271, which is the COTS version of flight grade Coilcraft CPS® AE series. The total output capacitance is 5,637 μ F and is split between tantalum and ceramic capacitors. Total capacitance from tantalum capacitors is 5.4 mF and is achieved by paralleling 8 units of 680 μ F Kyocera AVX® TPME687M006R0023, which is the COTS version of flight grade Kyocera AVX® TBM family. Total capacitance from ceramic capacitors is 197 μ F, which is achieved with a combination of capacitors ranging from 22 μ F to 33 nF. All capacitor case sizes, voltage ratings, dielectric materials and capacitances are limited to flight grade units available in Kyocera AVX® MIL-PRF-32535 X7R BME Multi-Layer Ceramic Capacitors (MLCC) family.

4.2 Steady state results

All tests have parameters $PV_{IN}=V_{IN}=5$ V and LLR, OCP, SLP and RT set in resistor mode unless otherwise stated. When in resistor mode, LLR is enabled and the switching frequency is set at 480 kHz. For tests where the LLR feature is disabled, the LLR pin is an open circuit (jumper on X30 is removed) and R36 is changed from 100 Ω to 1.02 k Ω .

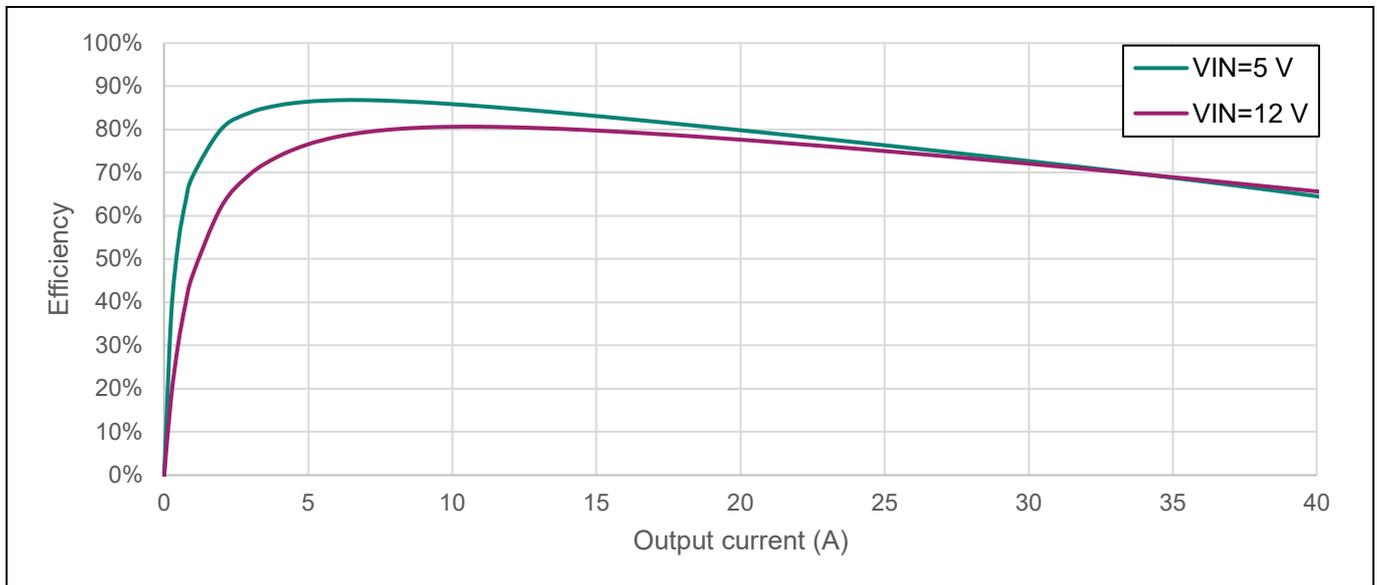


Figure 5 Efficiency over output current

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Test results

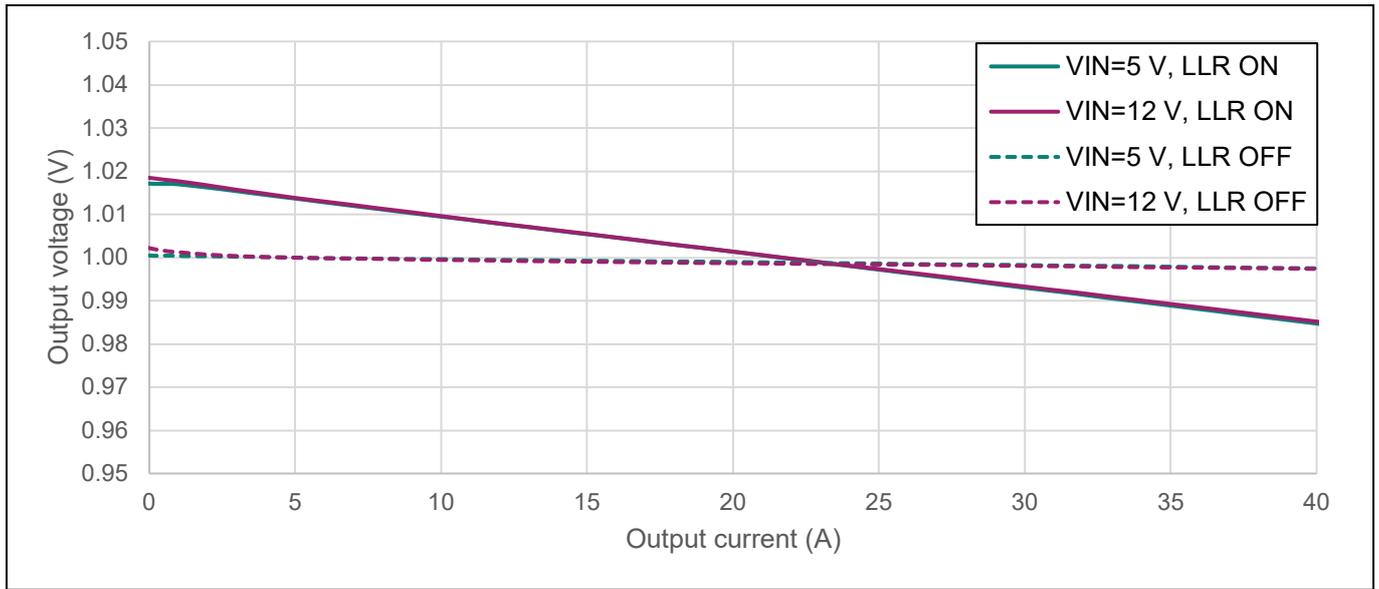


Figure 6 Output voltage over output current

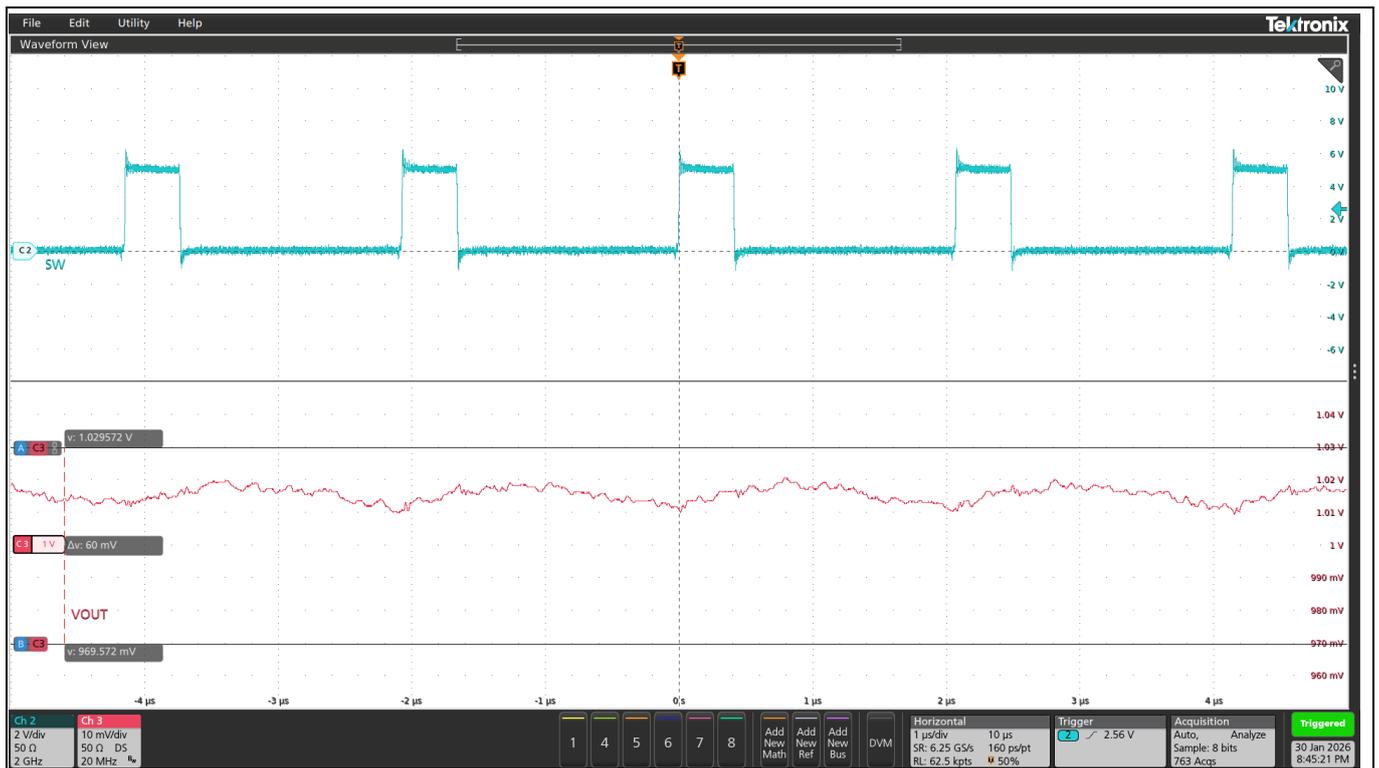


Figure 7 Steady state waveform at no load ($I_{OUT}=0$ A) with LLR enabled

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Test results

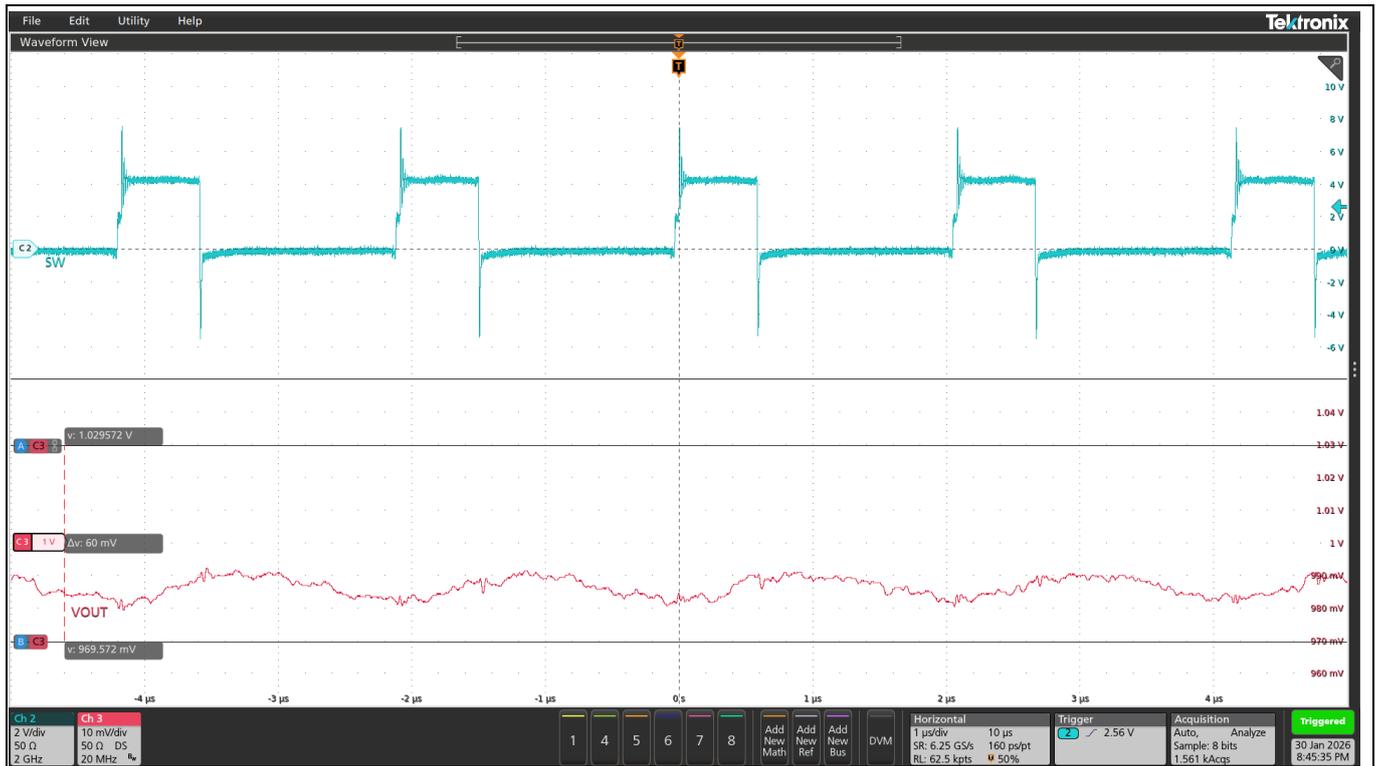


Figure 8 Steady state waveform at full load ($I_{OUT}=40\text{ A}$) with LLR enabled

4.3 Transient load step results

All tests have parameters $PV_{IN}=V_{IN}=5\text{ V}$ and LLR, OCP, SLP and RT set in resistor mode unless otherwise stated. When in resistor mode, LLR is enabled and the switching frequency is set at 480 kHz. For the transient load step, two Intel® 25 A Mini Slammers are used with the rise and fall slew rates set at 10 A/ μs .

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Test results

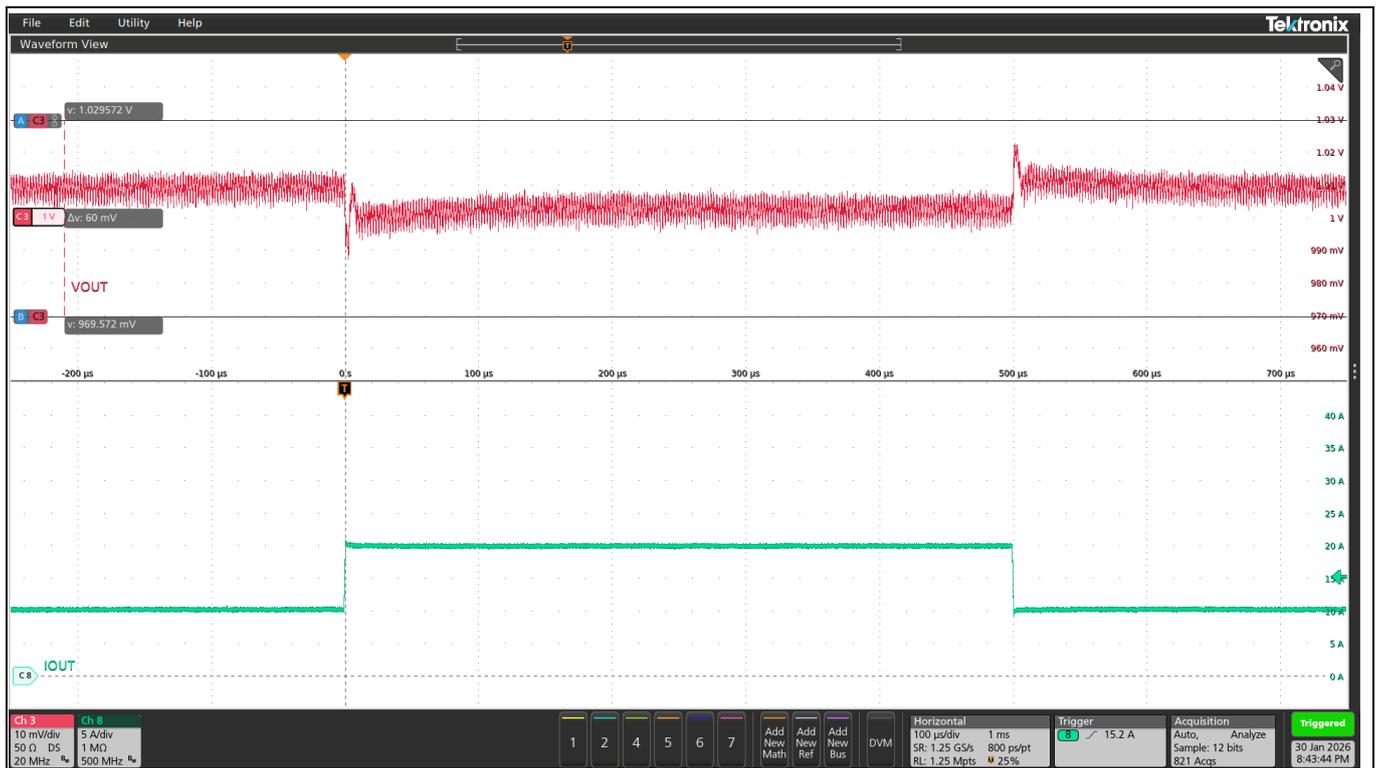


Figure 9 Transient load step and release with LLR enabled at minimum load (10 A to 20 A at 10 A/μs)

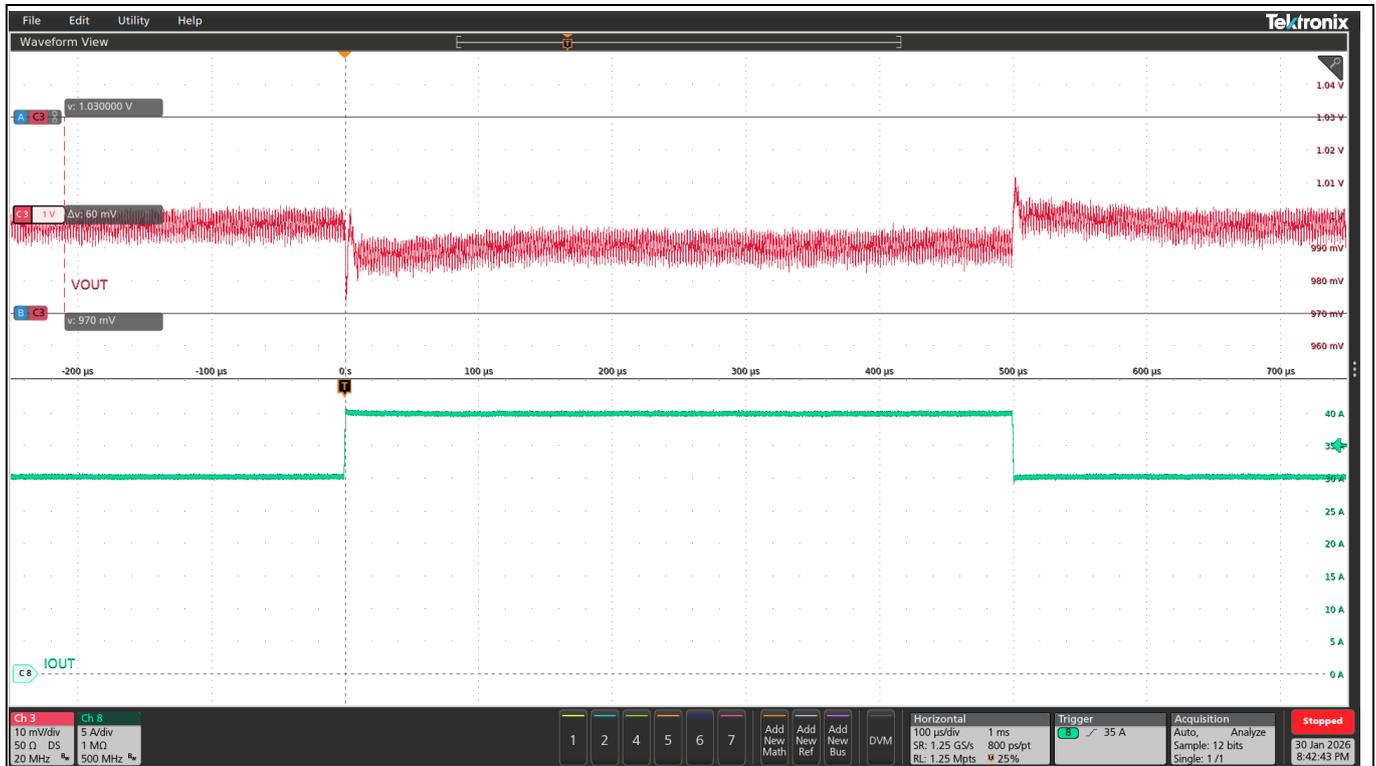


Figure 10 Transient load step and release with LLR enabled at maximum load (30 A to 40 A at 10 A/μs)

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Test results

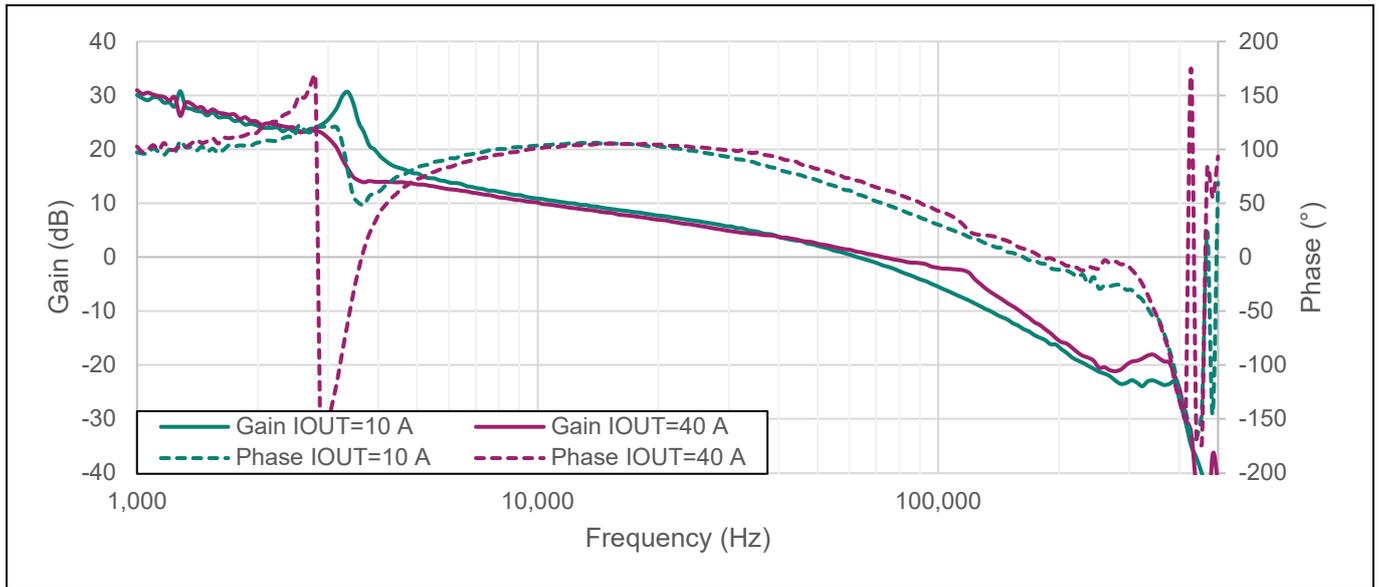


Figure 11 Bode plot

Table 5 Control bandwidth and stability parameters

| Output current | Bandwidth | Phase margin | Gain margin |
|----------------|-----------|--------------|-------------|
| 10 A | 63.0 kHz | 58.1 ° | -13.3 dB |
| 40 A | 72.7 kHz | 62.8 ° | -12.9 dB |

4.4 Startup and shutdown results

All tests have parameters $PV_{IN}=V_{IN}=5$ V and LLR, OCP, SLP and RT set in resistor mode unless otherwise stated. When in resistor mode, LLR is enabled and the switching frequency is set at 480 kHz. For startup and shutdown EN is pulled high and low with an external waveform generator (X14 jumper is removed). A power resistor is used for output load for all tests at full load ($I_{OUT}=40$ A).

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Test results

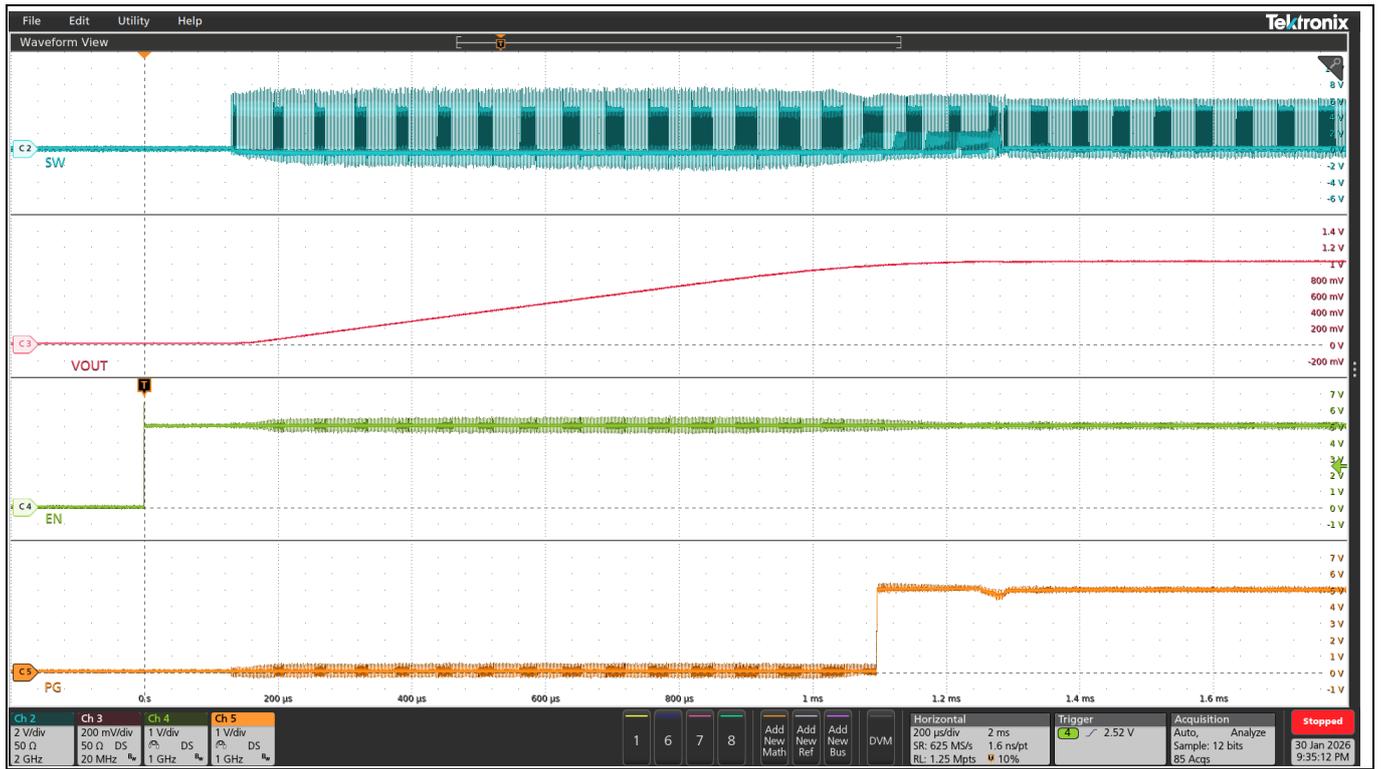


Figure 12 Startup into no load ($I_{OUT} = 0\text{ A}$)

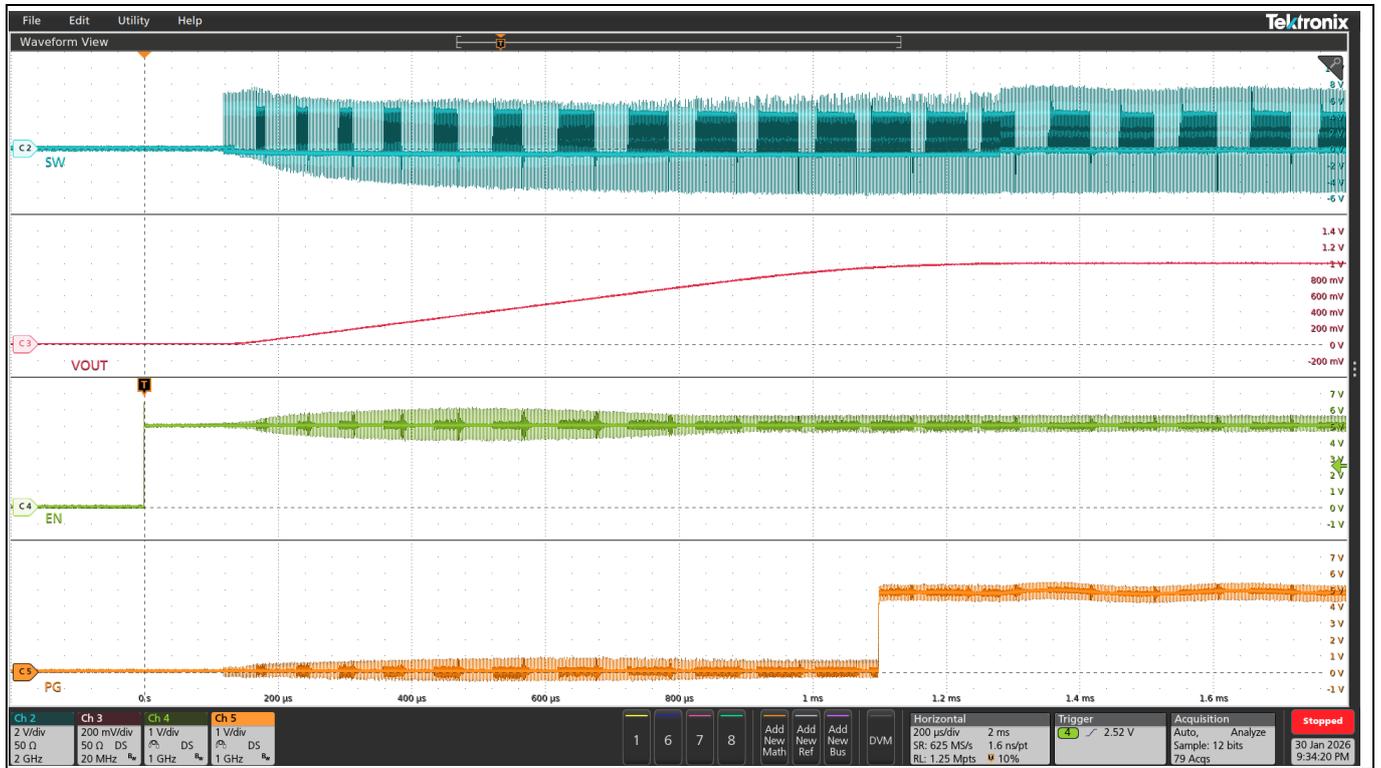


Figure 13 Startup into full load ($I_{OUT} = 40\text{ A}$)

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Test results

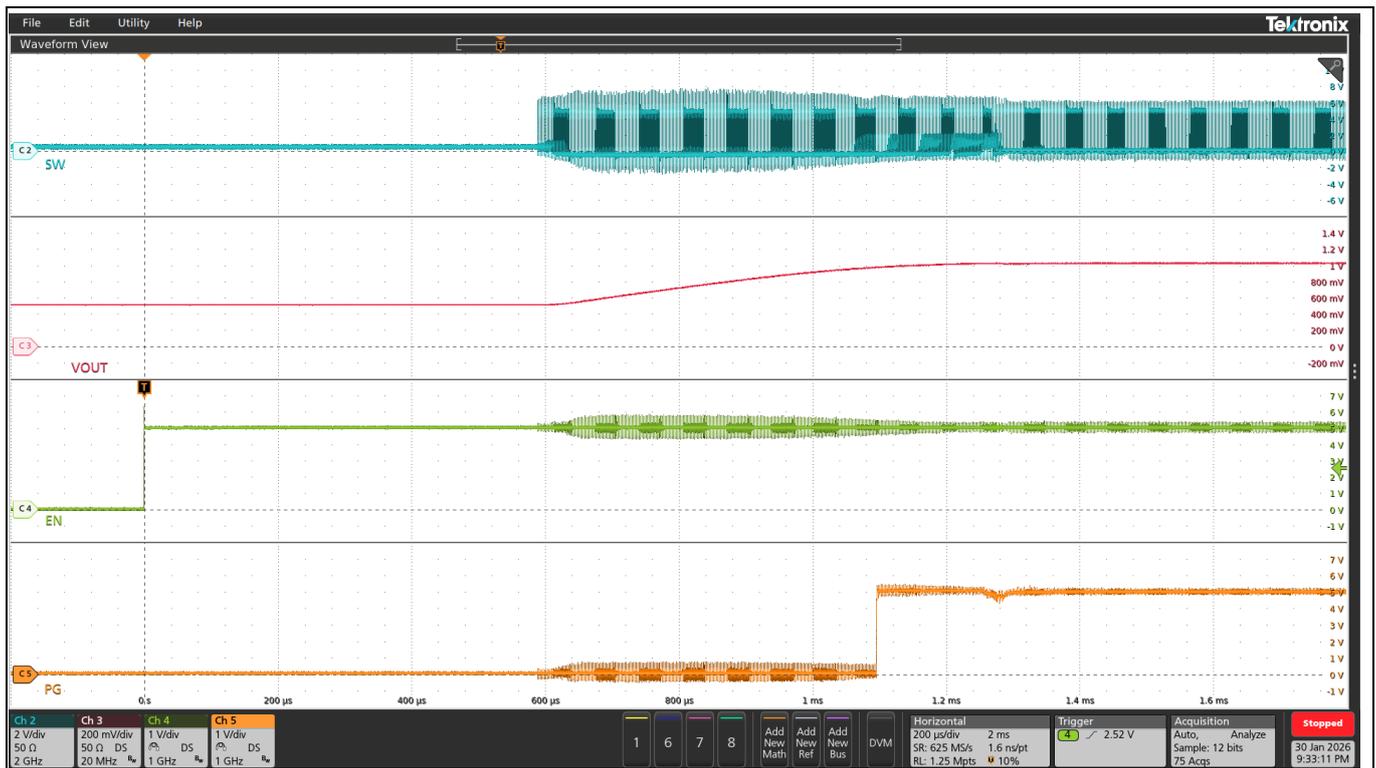


Figure 14 Startup into 0.5 V pre-bias at no load ($I_{OUT} = 0$ A)

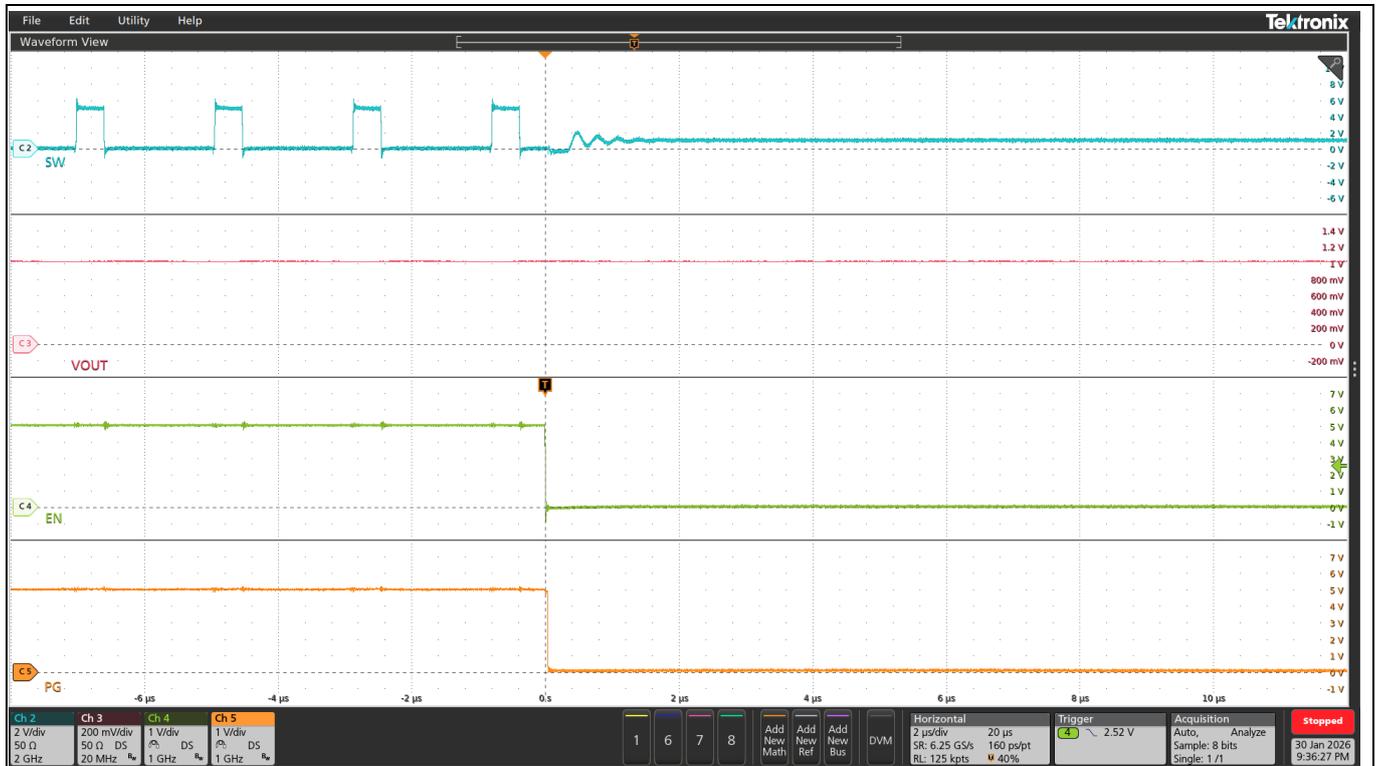


Figure 15 Shutdown with no load ($I_{OUT} = 0$ A)

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Test results

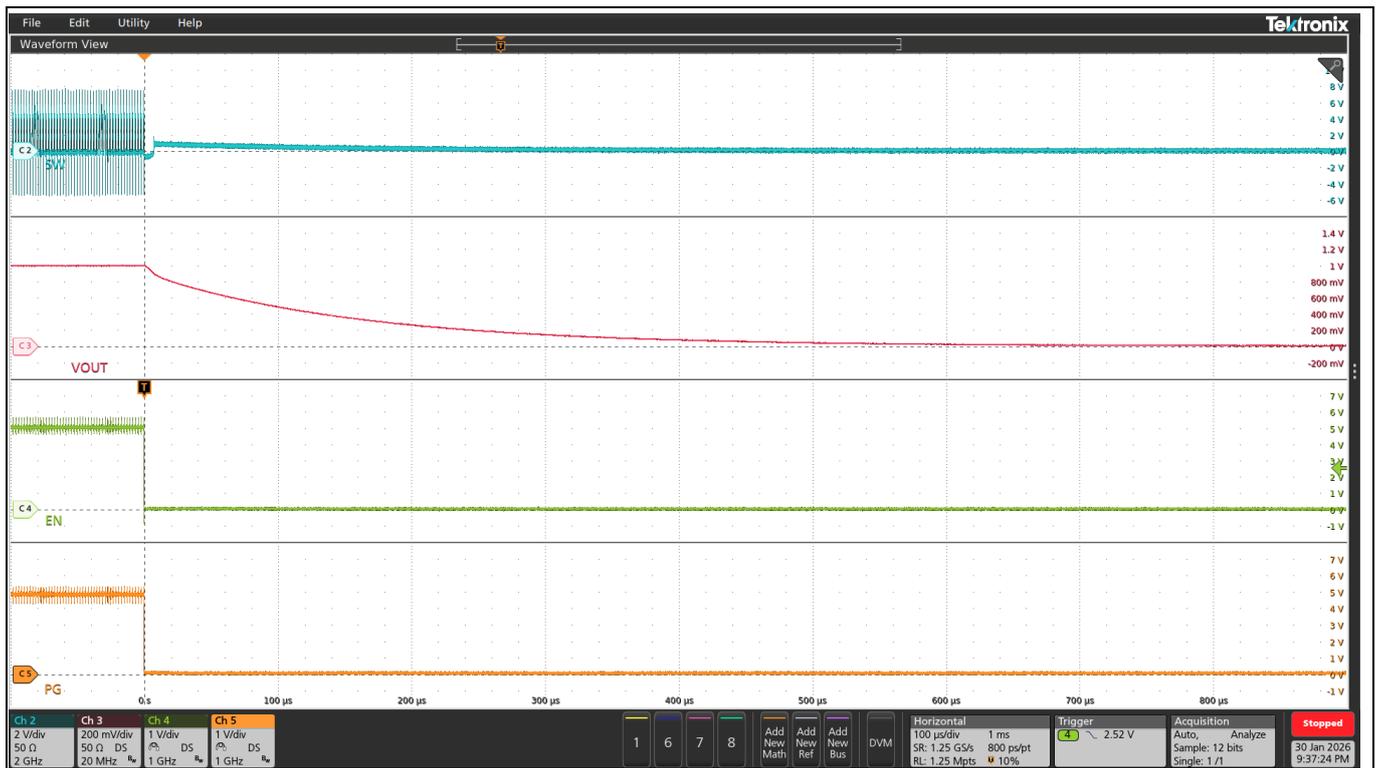


Figure 16 Shutdown with full load ($I_{OUT} = 40\text{ A}$)

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Schematic

5 Schematic

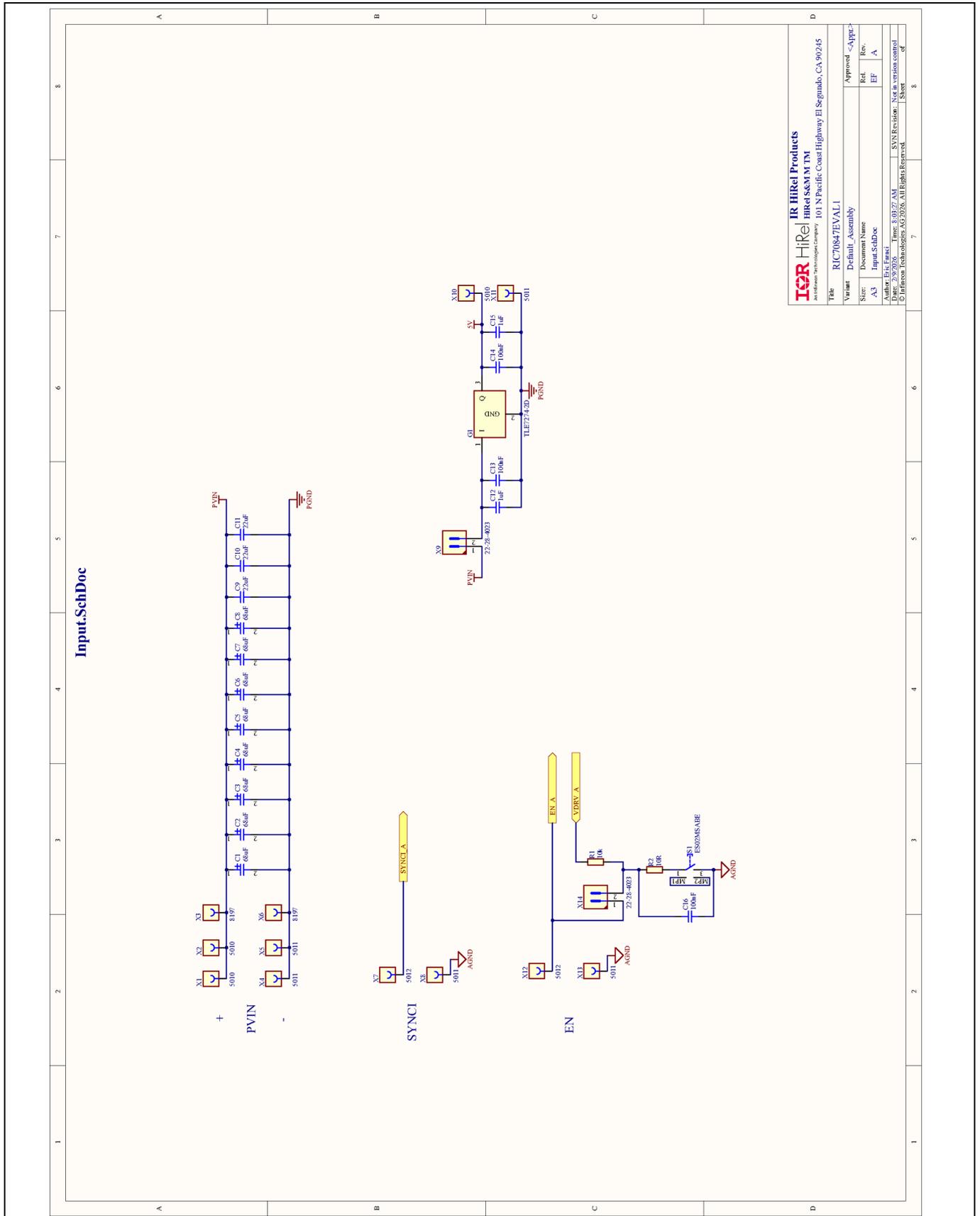
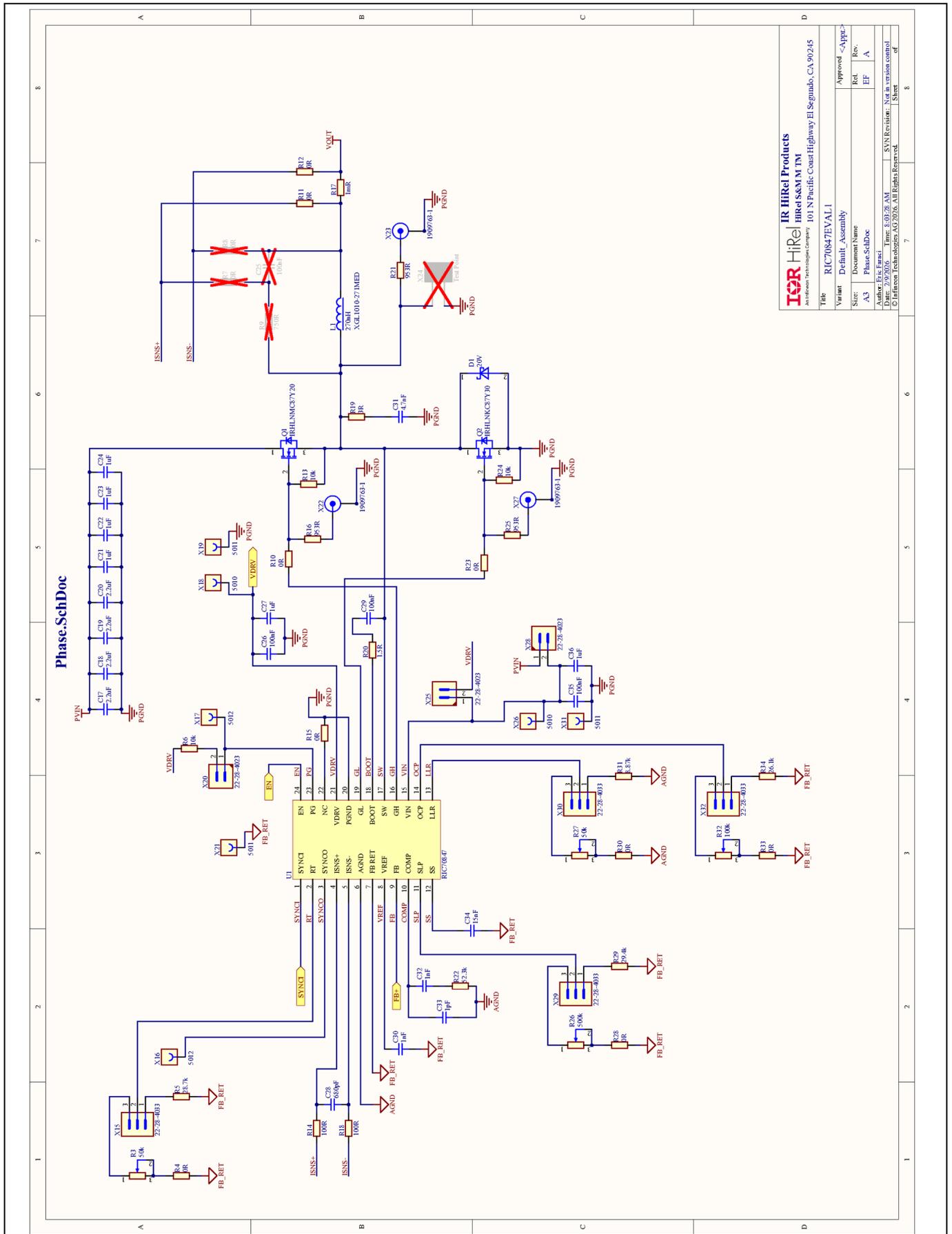


Figure 17 RIC70847EVAL1 schematic (1 of 3)

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Single phase buck converter with R8 rad hard FETs

Schematic



| | |
|--|------------------------|
| IOR HiRel Products An Infineon Technologies Company 101 N Pacific Coast Highway El Segundo, CA 90245 | |
| Title | RIC70847EVAL1 |
| Variant | Default_Assembly |
| Size | Document Name |
| A3 | Phase.SchDoc |
| Author | Eric.Franco |
| Date | 2/9/2016 |
| Time | 5:02:28 AM |
| © Infineon Technologies AG 2016. All Rights Reserved. | |
| Approved | <Appr> |
| Rel. | Rev. |
| EF | A |
| SVN Revision | Not in version control |
| Sheet | 1 of 8 |

Figure 18 RIC70847EVAL1 schematic (2 of 3)

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PCB layout

6 PCB layout

RIC70847EVAL1 is a 62 mil thick, 4 layer PCB with 2 oz copper on all layers.

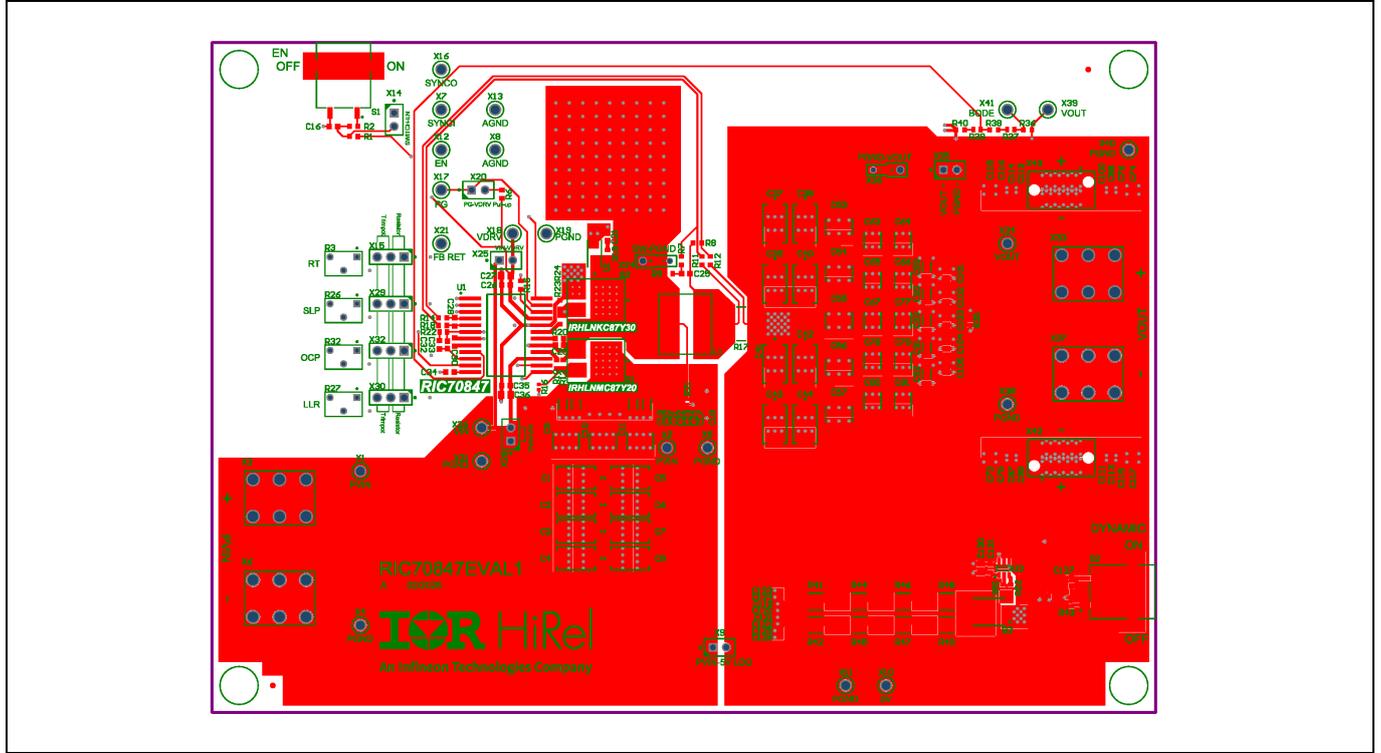


Figure 20 Top view of RIC70847EVAL1 top layer copper (red) and silkscreen (green)

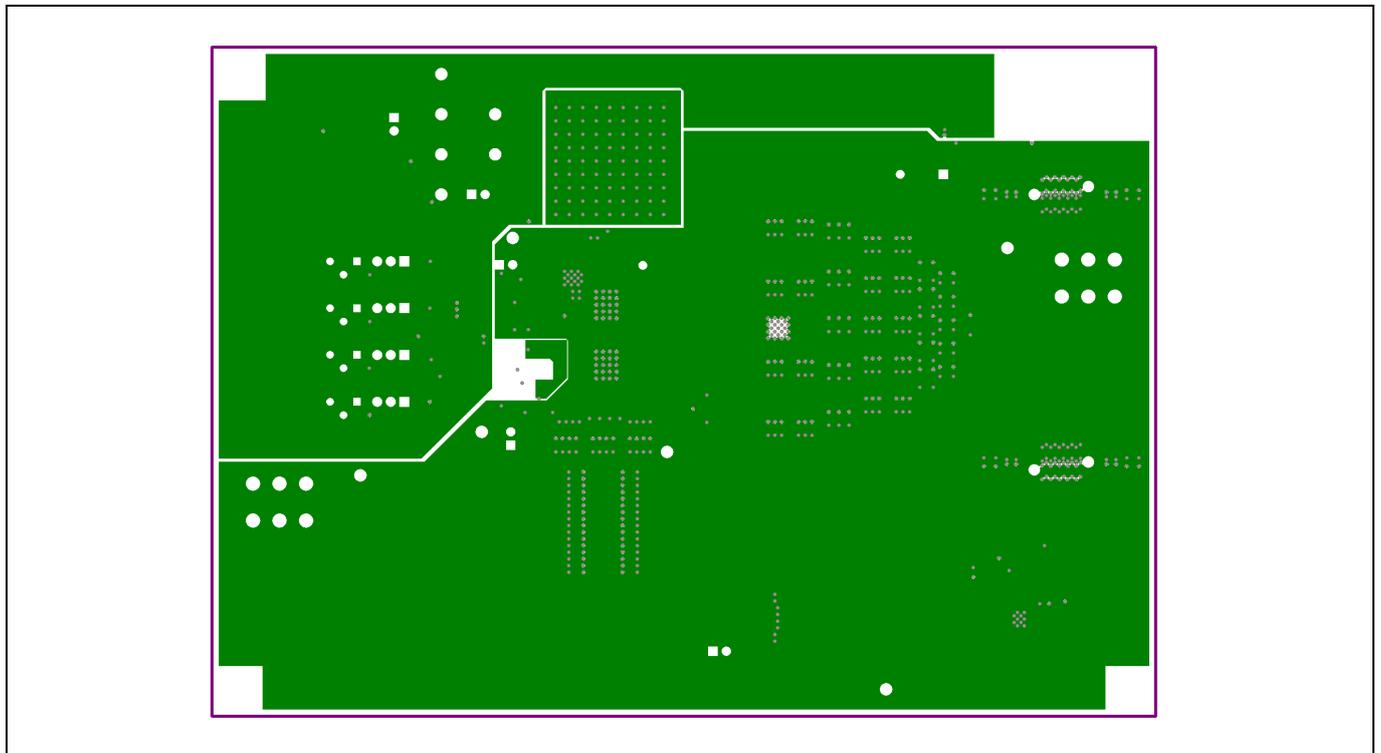


Figure 21 Mid-Layer 1 view of RIC70847EVAL1 copper (green)

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PCB layout

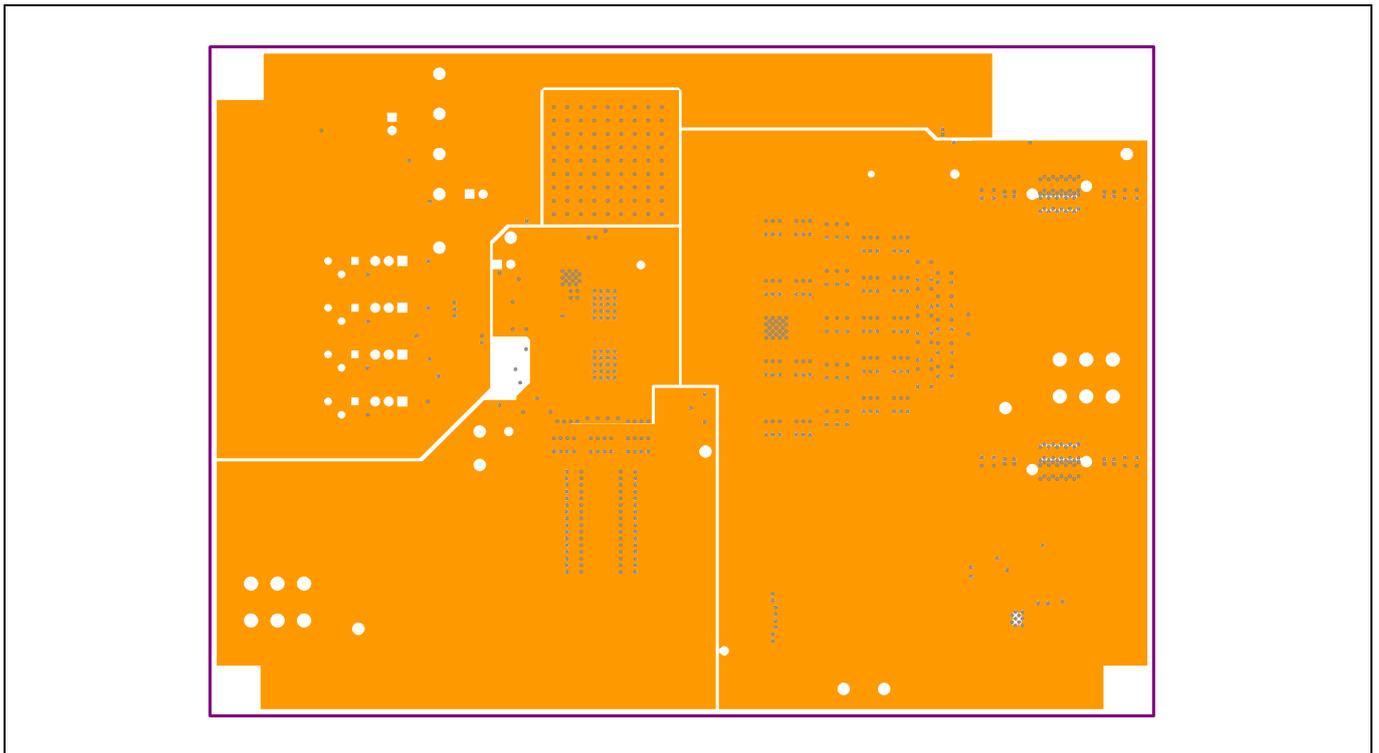


Figure 22 Mid-Layer 2 view of RIC70847EVAL1 copper (yellow)

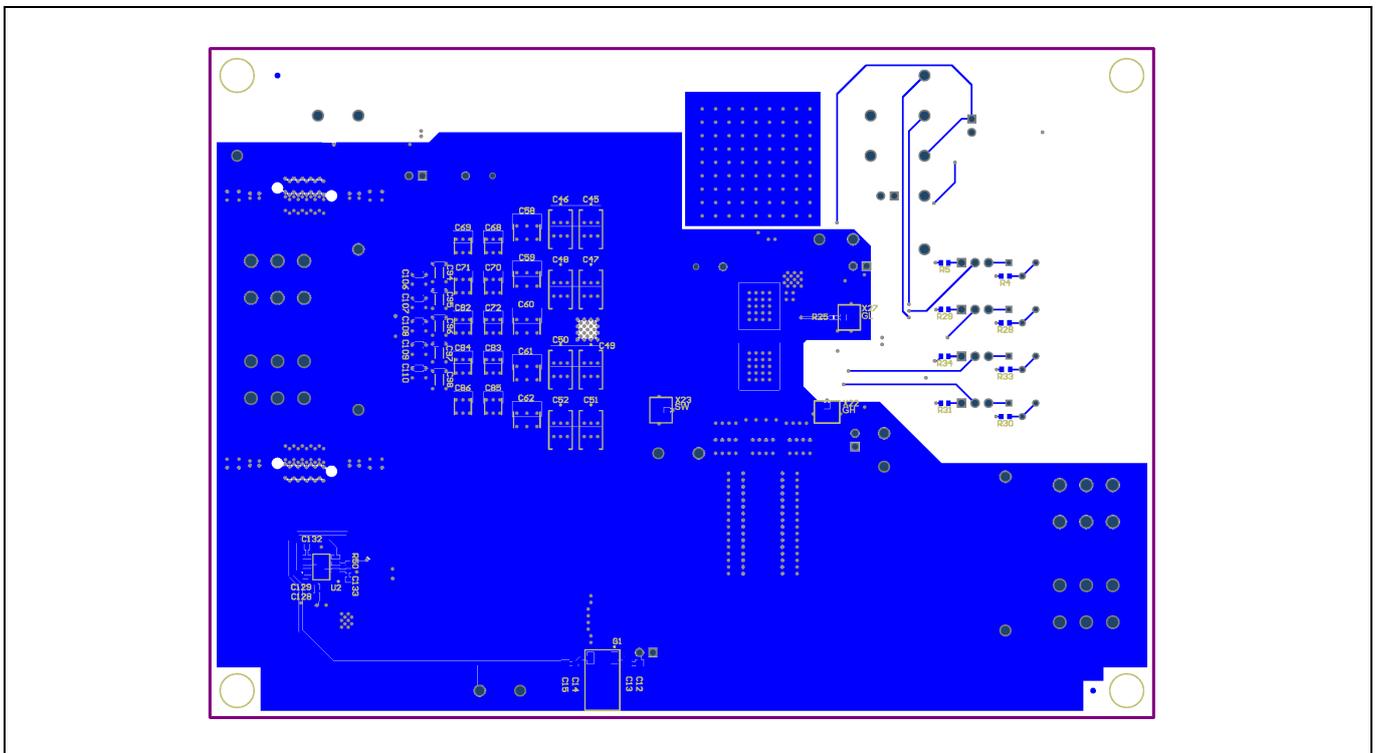


Figure 23 Flipped bottom view of RIC70847EVAL1 bottom layer copper (blue) and silkscreen (gold)

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Single phase buck converter with R8 rad hard FETs

Bill of materials

7 Bill of materials

Components used in RIC70847EVAL1 are listed below. Alternatives with identical parameters may be used.

Table 6 Bill of materials

| Designator | Description | Manufacturer | Part number |
|--|--|-----------------|----------------------|
| C1, C2, C3, C4, C5, C6, C7, C8 | CAP / ELCO / 68uF / 25V / 20% / Tantalumelectrolytic / -55°C to 105°C / 2917(7343) / SMD / - | Kyocera | TCJE686M025R0050E |
| C12, C15, C21, C22, C23, C24, C27, C36, C101, C102, C103, C104, C105, C128, C130 | CAP / CERA / 1uF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0805(2012) / SMD / - | Kemet | C0805C105K5RACTU |
| C13, C14, C16, C26, C29, C35, C127, C129, C131 | CAP / CERA / 100nF / 25V / 5% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / - | Kemet | C0603C104J3RAC |
| C132, C133 | CAP / CERA / 10nF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / - | AVX | 06035C103K4Z2A |
| C17, C18, C19, C20, C89, C90, C91, C92, C93 | CAP / CERA / 2.2uF / 35V / 20% / X7R (EIA) / -55°C to 125°C / 1206(3216) / SMD / - | TDK Corporation | CGA5L3X7R1V225M160AB |
| C28 | CAP / CERA / 680pF / 100V / 5% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / - | MuRata | GCM1885C2A681JA16 |
| C30, C32 | CAP / CERA / 1nF / 50V / 1% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / - | Kemet | C0603C102F5GAC |
| C31 | CAP / CERA / 4.7nF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / - | TDK Corporation | CEU3E2X7R1H472K080AE |
| C33 | CAP / CERA / 1pF / 50V / 250fF / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / - | TDK Corporation | CGA3E2C0G1H010C080AA |
| C34 | CAP / CERA / 15nF / 100V / 10% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / - | MuRata | GCM188R72A153KA37 |
| C37, C38, C39, C40, C41, C42, C43, C44 | CAP / ELCO / 680uF / 6.3V / 20% / Tantalumelectrolytic / -55°C to 125°C / 2917(7343) / SMD / - | AVX | TPME687M006R0023 |
| C63, C64, C65, C66, C67, C77, C78, C79, C80, C81 | CAP / CERA / 6.8uF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 1812(4532) / SMD / - | TDK Corporation | C4532X7R1H685K250KB |

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| Designator | Description | Manufacturer | Part number |
|--|--|-------------------------------|-------------------|
| C73, C74, C75, C76, C115, C116, C117, C118, C123, C124, C125, C126 | CAP / CERA / 180nF / 25V / 5% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / - | MuRata | GCM188R71E184JA55 |
| C87, C88, C99, C100, C111, C112, C113, C114, C119, C120, C121, C122 | CAP / CERA / 33nF / 25V / 5% / X7R (EIA) / -55°C to 125°C / 0402(1005) / SMD / - | MuRata | GCM155R71E333JA55 |
| C9, C10, C11, C53, C54, C55, C56, C57 | CAP / CERA / 22uF / 25V / 10% / X7R (EIA) / -55°C to 125°C / 2220(5750) / SMD / - | AVX | 22203C226KAZ2A |
| D1 | 3.0A Surface Mount Schottky Barrier Rectifier | Diodes Incorporated | B320A-13-F |
| G1 | 5-V Low Dropout Voltage Regulator | Infineon Technologies | TLE7274-2D |
| L1 | IND / STD / 270nH / 54A / 20% / - 40°C to 125°C / 470R / SMD / Inductor, SMD; 2-Leads, 10.00mm L x 11.3mm W x 10.00mm H body / SMD / - | Coilcraft | XGL1010-271MED |
| MP1, MP2, MP3, MP4 | 6-32, Binding Head Screw, Nylon 6/6 | Keystone Electronics Corp. | 9434 |
| MP5, MP6, MP7, MP8 | F-F Nylon Stand, 6-32 Thread Size | Keystone Electronics Corp. | 1903C |
| Q1 | Radiation Hardened Power MOSFET | IR HiRel | IRHLNMC87Y20 |
| Q2 | Radiation Hardened Power MOSFET | IR HiRel | IRHLNKC87Y30 |
| Q3 | N-Channel 40V 40A (Ta), 100A (Tc) 3W (Ta), 150W (Tc) Surface Mount PG-TDSON-8-6 | Infineon Technologies | BSC010N04LS6 |
| R1, R6, R13, R24 | RES / STD / 10k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Yageo | RC0603FR-0710KL |
| R14, R18, R35, R40 | RES / STD / 100R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Yageo | RC0603FR-07100RL |
| R16, R21, R25 | RES / STD / 953R / 63mW / 1% / 100ppm/K / -55°C to 155°C / 0402(1005) / SMD / - | Vishay | CRCW0402953RFB |
| R17 | RES / STD / 1mR / 3W / 1% / 75ppm/K / -55°C to 170°C / 2512(6432) / SMD / - | Cooper Bussmann | MSMA1225R0010FGM |

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| Designator | Description | Manufacturer | Part number |
|---|--|--------------|--------------------|
| R19 | RES / STD / 3R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW06033R00FK |
| R2, R36, R43 | RES / STD / 10R / 100mW / 1% / 200ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Yageo | RC0603FR-0710RL |
| R20 | RES / STD / 1.5R / 333mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW06031R50FKEAHP |
| R22 | RES / STD / 52.3k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW060352K3FKTA |
| R26 | RES / VAR / 500k / 250mW / 10% / 100ppm/K / -55°C to 125°C / Potentiometer, THT, 4.50mm L X 6.71mm W X 9.02mm H Body / THT / - | Bourns | 3266W-1-504LF |
| R29 | RES / STD / 29.4k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW060329K4FK |
| R3, R27 | RES / VAR / 50k / 250mW / - / 100ppm/K / -55°C to 125°C / Potentiometer, THT, 4.50mm L X 6.71mm W X 9.02mm H Body / THT / - | Bourns | 3266W-1-503LF |
| R31 | RES / STD / 8.87k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW06038K87FK |
| R32 | RES / VAR / 100k / 250mW / 10% / 100ppm/K / -55°C to 125°C / Potentiometer, THT, 4.50mm L X 6.71mm W X 9.02mm H Body / THT / - | Bourns | 3266W-1-104LF |
| R34 | RES / STD / 26.1k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW060326K1FKEA |
| R37 | RES / STD / 15k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW060315K0FK |
| R39 | RES / STD / 21.5k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW060321K5FK |
| R4, R10, R11, R12, R15, R23, R28, R30, R33, R38 | RES / STD / 0R / 100mW / 0R / 0ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Yageo | RC0603JR-070RL |

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| Designator | Description | Manufacturer | Part number |
|---|---|-------------------------------|-----------------|
| R41, R42, R44, R45, R46, R47, R48, R49 | RES / STD / 50mR / 1W / 1% / 100ppm/K / -55°C to 125°C / 2512(6332) / SMD / - | Panasonic | ERJL1WKF50MU |
| R5 | RES / STD / 28.7k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW060328K7FK |
| R50 | RES / STD / 71.5k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW060371K5FK |
| R51 | RES / STD / 360R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW0603360RFK |
| R52 | RES / STD / 430R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / - | Vishay | CRCW0603430RFK |
| S1, S2 | Sealed Tiny Slide Switches | C&K | ES02MSABE |
| U1 | Radiation Hardened PoL Buck Controller | IR HiRel | RIC70847F |
| U2 | General Purpose Timer | Analog Devices | ICM7555ESA+ |
| U3 | EiceDRIVER, Fast Single Channel 4A/8A Low-Side Gate Driver, UVLO - 4.2V | Infineon Technologies | 1EDN7511B |
| X1, X2, X10, X18, X26, X34 | PC Test Point-Multipurpose THT, Red | Keystone Electronics Corp. | 5010 |
| X15, X29, X30, X32 | 2.54mm Pitch KK Header, Breakaway, Vertical, 3 Circuits, 0.38µm Gold Selective Plating, Mating Pin Length 6.09mm | Molex | 22-28-4033 |
| X22, X23, X27 | U.FL (UMCC) Connector Jack, Male Pin | TE Connectivity | 1909763-1 |
| X3, X6, X33, X37 | Snap In PC Screw Terminal, Unassembled, Rated Current 30A | Keystone Electronics Corp. | 8197 |
| X4, X5, X8, X11, X13, X19, X21, X31, X38, X40 | PC Test Point-Multipurpose THT, Black | Keystone Electronics Corp. | 5011 |
| X42, X43 | SPD08 High Speed Card Edge Connector, 0.8MM Pitch SMD, 20Pins, 1.2A, 250V | 3M | SPD08-020-RB-TR |
| X44, X45, X46, X47, X48, X49, X50 | Jumper, 1x2-Positions, Pitch 2,54mm, Body 5,08x2,54mm, black, Au, without handle | Samtec | SNT-100-BK-G |
| X7, X12, X16, X17, X39, X41 | PC Test Point-Multipurpose THT, White | Keystone Electronics Corp. | 5012 |

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| Designator | Description | Manufacturer | Part number |
|--------------------------------|--|---------------------|--------------------|
| X9, X14, X20, X25, X28, X35 | 2.54mm Pitch KK header, Breakaway, Vertical, 2 Circuits, 0.38um Gold Selective Plating | Molex | 22-28-4023 |

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Single phase buck converter with R8 rad hard FETs

Bill of materials

Revision history

| Document revision | Date | Description of changes |
|-------------------|------------|------------------------|
| 1.0 | 2026-02-19 | Initial version |
| | | |
| | | |

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Edition 2026-02-19

Published by

Infineon Technologies AG

81726 Munich, Germany

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