RTKA96838DE0000BU

RRB96838 Buck-Boost Charger Evaluation Board

Description

The RTKA96838DE0000BU evaluation board evaluates the performance of the RRB96838. The default value numbers of maximum and minimum output voltages, autonomous charging mode, and the adapter current limit charging function can be programmed by the resistor from the PROG pin to GND. The values can also be set by SMBus.

The RRB96838 is a buck-boost battery charger supporting input voltages up to 23.4V and battery voltages up to 18.3V. The RRB96838 can operate in a direct battery charging mode without a battery FET, or it can operate in an NVDC charging mode with a battery FET. The advanced Renesas R3™ technology provides highly efficient light-load operation and fast transient response. The direct battery charging mode supports charging of 2- to 4-cell batteries for applications such as power tools, portable vacuums, drones, robots, and power banks.

As a Narrow-Voltage DC (NVDC) charger, the RRB96838 also regulates the system output to a narrow voltage range for stable system bus voltage. Under NVDC operation, system power is either provided from the adapter, battery, or a combination of both.

The RRB96838 accepts input power from a wide range of DC power sources, including USB-C PD adapters, and safely charges battery packs having up to four serially connected Li battery cells. Additionally, the RRB96838 supports reverse buck, boost, and buck-boost operation, in which power is transferred from an attached battery to the input port. The RRB96838 provides SMBus/I2C serial communication that allows programming of many critical parameters to deliver a customized solution.

Features

- Buck-boost NVDC charger for 2-, 3-, 4-cell Li-ion batteries
- Autonomous Charging Option (with BFET Configuration only)
- Pass-through mode in forward direction
- Allows trickle charging of depleted battery
- Adapter current and battery current monitor (AMON/BMON)
- ALERT# open-drain output
- Supports trickle charging of depleted battery
- Reverse buck, boost, and buck-boost operation from battery
- Battery Ship mode option
- SMBus and auto-increment I^2C compatible

Specifications

- V_{IN} = 3.9V to 23.4V (no dead zone)
- V_{OUT} = 2.4V to 18.304V
- MAX I_{charge} up to 6A
- f_{SW} = 1MHz (default)

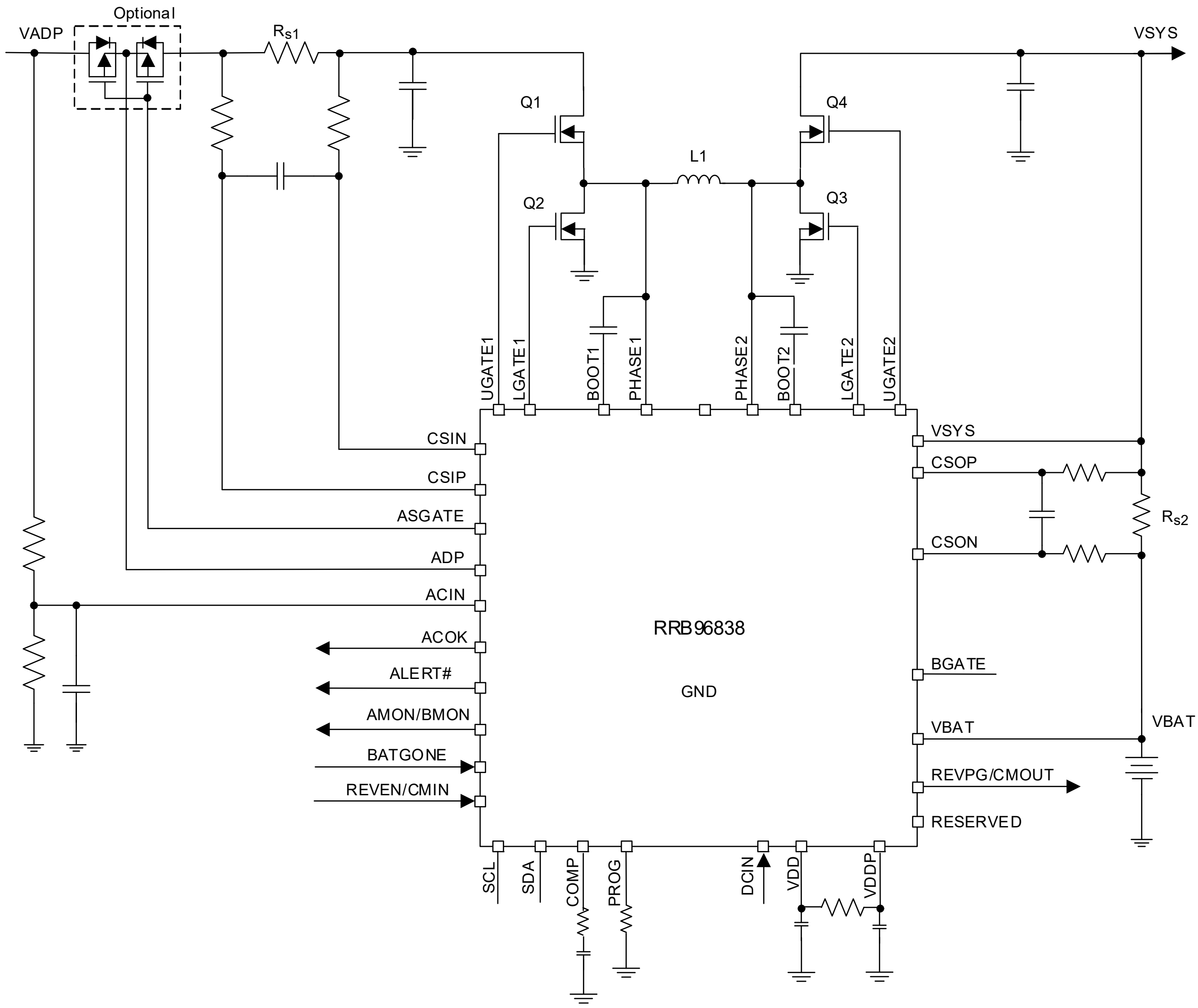


Figure 1. Circuit Topology for Battery-Charging Only Applications with No BFET

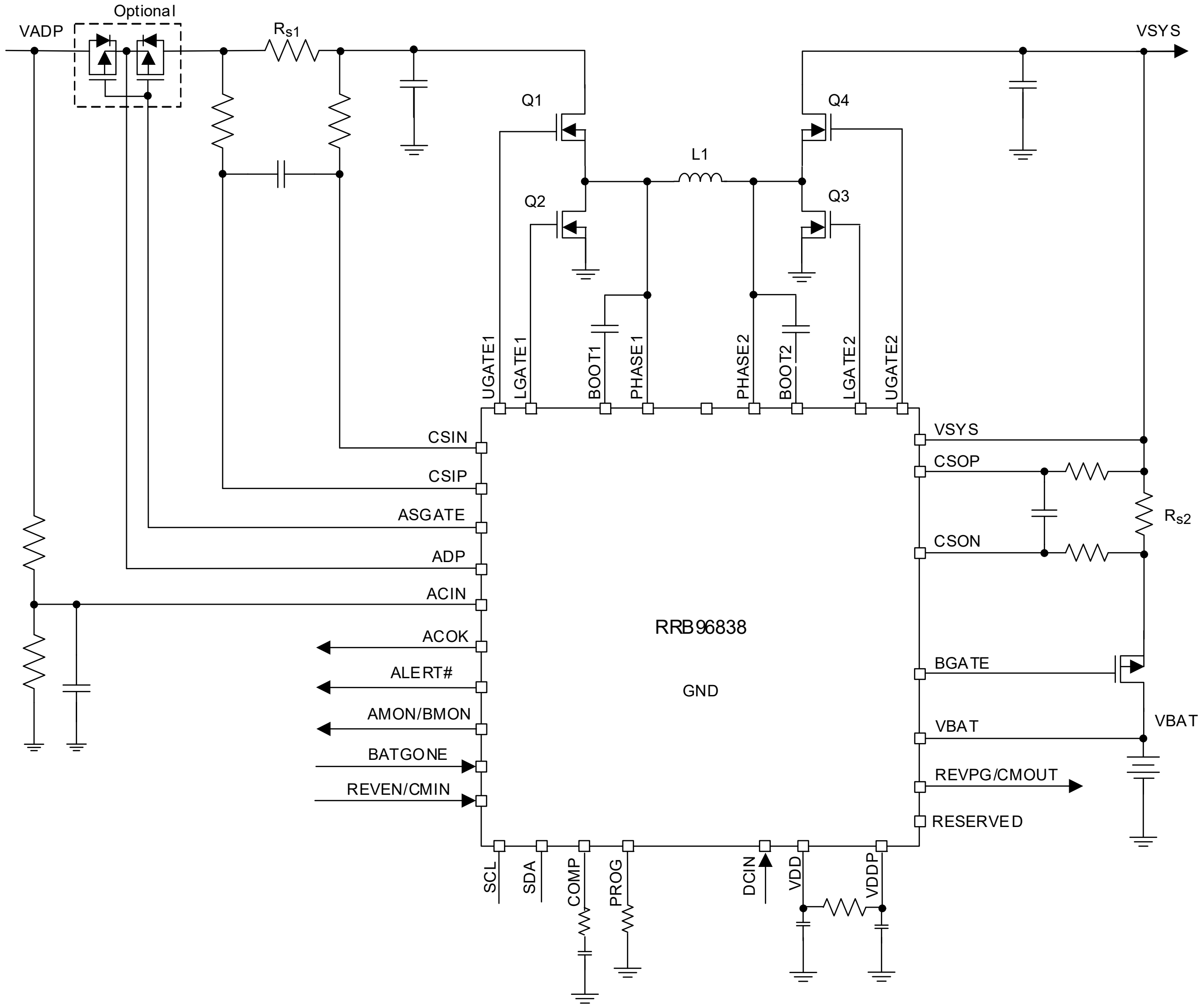


Figure 2. Circuit Topology for NVDC Charging with BFET

Contents

1. Functional Description

The RTKA96838DE0000BU provides all circuits required to evaluate the features of the RRB96838. A majority of the features of the RRB96838, such as the adjustable output voltage, Reverse (REV) mode, Trickle Charging mode for depleted battery, and the system power monitor at Buck, Boost, and Buck-Boost modes are available on this evaluation board.

1.1 Recommended Equipment

- 0V to 25V power supply with at least 6A source current capability
- Electronic load capable of sinking current up to 6A
- Battery emulator capable of sinking and sourcing current up to 6A
- Digital Multimeters (DMMs)
- 100MHz quad-trace oscilloscope

Note: Use a power supply that can source current but cannot sink current in parallel with an e-load Constant Current (CC) mode to emulate the battery. For example, to charge, set the charging current command lower than the CC mode e-load. If the e-load CC mode current is set to 3A, the charge current command is 2A, and the e-load draws 2A from the charger and draws another 1A from the power supply in parallel with it. To discharge, the power supply acts like the battery to discharge current. Also, use the e-load Constant Voltage (CV) mode to emulate the battery to take the charging current from the charger and set the e-load CV voltage below the MaxSystemVoltage register setting; however, this e-load CV mode cannot source current like a battery.

1.2 Quick Start Guide

The number of battery cell and adapter current limit default values can be configured with a standard 1% 0603 resistor (R_{23}) from the PROG pin to GND. The PROG Pin Programming Options table in the *RRB96838 Datasheet* shows the programming options. After the default number of cells in series is set, the default values for MaxSystemVoltage and MinSystemVoltage are set accordingly. These values can also be changed through the SMBus control registers in the Renesas GUI, shown in Figure 3.

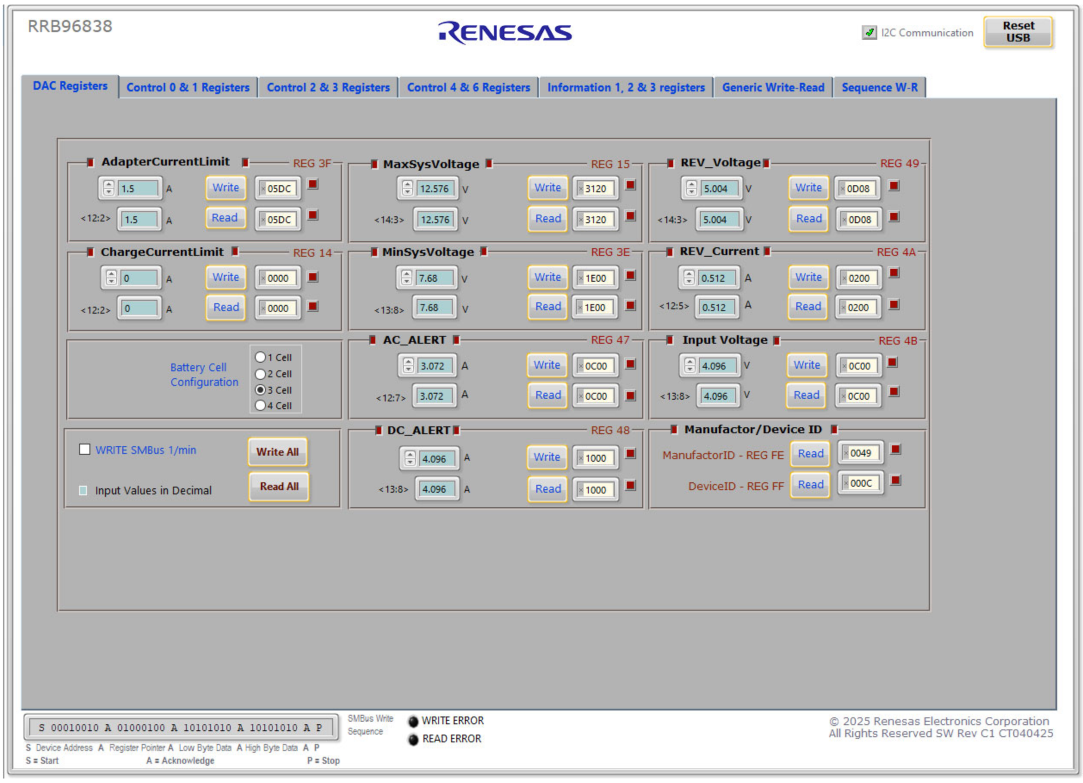


Figure 3. GUI Snapshot

Note: After turning ON any of the ADP Voltage or VBAT/VSYS voltage source A green check mark in the **I2C Communication** section of the GUI indicates the GUI is ready to communicate with the evaluation board. A red X in the **I2C Communicatio**n section indicates the GUI is not ready to communicate with the evaluation board. Click the **Reset** button until a green check mark shows in the **I2C Communication**. If a green check mark does not appear, verify the HID dongle connection.

The three LEDs indicate the ACOK, ALERT#, and REVPG/CMOUT status, respectively. For more details about the functions of these three pins, see the *RRB96838 Datasheet*. Complete the following steps to evaluate the RRB96838 key functions, including system voltage regulation, input current limit regulation, Charging mode, trickle Charging mode, and REV mode. Figure 4 shows the top view of the evaluation board and highlights the key testing points and connection terminals. For more information about the RRB96838, including other modes of operation, see the *RRB96838 Datasheet*. *Note*: The pull-up voltage rail, which powers the LED pull-up resistors, can be supplied in two ways and is controlled by jumper JP5. The first method involves connecting an external 3.3V source to test point TP53 and installing JP5 to link the 3.3V rail to the pull-up circuit. The second method uses the RRB96838's internal LDO regulator to provide 3.3V using its VDD pin. However, during the device's initial power-up, JP5 should remain disconnected to ensure proper startup of the RRB96838, and it should only be installed afterward.

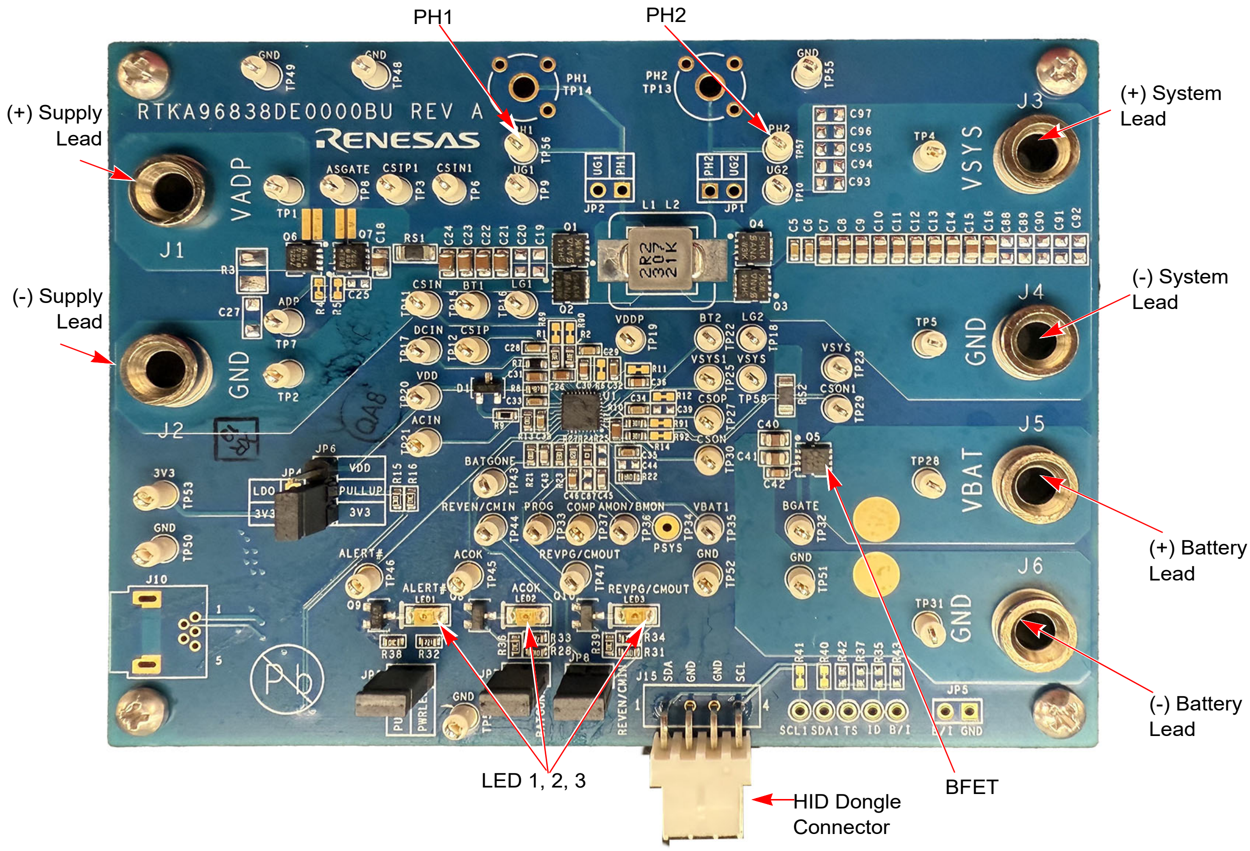


Figure 4. Evaluation Board Connection Guideline

Complete the following steps to evaluate the RRB96838 key functions for each of two different configurations below:

- Without BFET configuration – Input current limit regulation, Charging mode, Trickle Charging mode, and OTG mode.
- With BFET configuration – System voltage regulation, input current limit regulation, Charging mode, and Trickle Charging mode.

Note: The default configuration of Evaluation board includes a BFET(Q5). To change the evaluation board from the With BFET configuration to the Without BFET configuration, a hardware modification is required. To reconfigure it, remove MOSFET Q5 and solder a short between the Source and Drain pads of its footprint.

1.2.1 With BFET Configuration

1.2.1.1 System Voltage Regulation

1. Set the power supply to 5V. Disable the output and connect the (+) end to J1 and the (-) end to J2.
2. Ensure jumpers JP3, JP6, JP7, and JP8 are shorted.
3. Turn on the power supply and measure VSYS using the DMM across (+)TP4 and (-) TP5. VSYS should read 12.576V for 3 cell. The current meter on the supply should read <100mA. Slowly increase V_{IN} from 5V to 20V. Monitor PH1 and PH2 to observe seamless switching from Boost mode to Buck-Boost mode, and finally into Buck mode.

1.2.1.2 Input Current Limit Regulation

1. Keep V_{IN} as a constant value between 3.9V and 23.4V. Set the battery emulator voltage to 7.8V and connect the battery emulator output to battery leads J5 and J6. Turn on the battery emulator; there is no charge and discharge current for the battery, which is consistent with the BGATE signal of a high voltage level.
2. Add an electrical load on VSYS and GND terminals J3 and J4. Turn on the load and increase the electrical load slowly; the input current increases correspondingly and VSYS keeps stable at 12.576V. The output voltage (VSYS) starts dropping as the input current reaches the 1.5A input current limit. See the *RRB96838 Datasheet* for more information about the input current limit. If the VSYS voltage is 150mV lower than the battery voltage, the BGATE FET turns on at a low voltage level so that the battery supplies the current to the load.

1.2.1.3 Charging Mode

1. Set the power supply to a constant value between 3.9V and 23.4V, then complete steps 1 and 2 in System Voltage Regulation. Make sure the input current does not reach the limit.
2. Set the battery emulator voltage to 7.8V and connect the battery emulator output to battery leads J5 and J6.
3. Connect the HID dongle cable with proper wiring connections for the **I2C communication**.
4. Turn on the power supply. Turn on the battery emulator and open the RRB96838 GUI (shown in Figure 3).
   Note: A green check mark in the **I2C Communication** section of the GUI indicates the GUI is ready to communicate with the evaluation board. A red X in the **I2C Communicatio**n section indicates the GUI is not ready to communicate with the evaluation board. Click the **Reset** button until a green check mark shows in the **I2C Communication**. If a green check mark does not appear, verify the HID dongle connection.
5. Select **2 Cell** in the **Battery Cell Configuration** section. Click the **Write All** button. All controller register values are set to the corresponding default values. The system voltage is 8.4V, which is the value of **MaxSysVoltage** in the GUI. There is no charge and discharge current for the battery.
6. Change the **ChargeCurrentLimit** from 0A to 2A and click the **Write** button. The battery is now in a 2A current charge configuration. The charge current value can be monitored in the GUI by clicking the **Read** button in the **ChargeCurrentLimit** section. Monitor the BGATE signal status to confirm the battery is in Charging mode.

Note: Ensure the input current does not reach the input current limit value, especially for a small V_{IN} input.

1.2.2 Without BFET Configuration

1.2.2.1 Input Current Limit Regulation

1. Ensure jumpers are installed at JP3, JP6, JP7, and JP8.
2. Connect the HID dongle cable with proper wiring connections for the I2C communication.
3. Set the power supply to 20V. Disable the output and connect the (+) end to J1 and the (-) end to J2.
4. Turn on the power supply and open the RRB96838 GUI (shown in Figure 3).

   Note: A green check mark in the **I2C Communication** section of the GUI indicates the GUI is ready to communicate with the evaluation board. A red X in the **I2C Communication** section indicates the GUI is not ready to communicate with the evaluation board. Click the **Reset** button until a green check mark shows in the **I2C Communication**. If a green check mark does not appear, verify the HID dongle connection.

5. Click the **Read All** button and check the **AdapterCurrentLimit**, **ChargeCurrentLimit**, **MaxSysVoltage**, and **MinSysVoltage** values, which should be **AdapterCurrentLimit** = 1.5A, **ChargeCurrentLimit** = 0.00A, **MaxSysVoltage** = 12.576V, and **MinSysVoltage** = 7.68V. Set the **AdapterCurrentLimit** to 1A and **ChargeCurrentLimit** to 0.001A
6. Set the power supply to 12V and connect the battery emulator output to battery leads J5 and J6. Turn on the battery emulator. *Note*: Battery Leads read 12.576V across J5 and J6 before turning on the battery emulator.
7. Set the **ChargeCurrentLimit** to 2A. The current meter on the supply should read 1A. *Note*: Although the **ChargeCurrentLimit** is 2A, the current meter on the battery emulator cannot reach 2A and can be limited by the **AdapterCurrentLimit**, considering VIN and battery emulator voltage.

1.2.2.2 Charging Mode

1. Complete steps 1 to 6 in Input Current Limit Regulation.
2. Slowly increase VIN from 5V to 20V. Monitor PH1 and PH2 to observe seamless switching from Boost mode to Buck-Boost mode, and finally into Buck mode.
3. Set the **AdapterCurrentLimit** to 5A and click the **Write** button and check the read value through the **Read** button. The adapter current limit is now 5A.
4. Set the **ChargeCurrentLimit** to 2A and click the **Write** button and check the read value through the **Read** button. The current meter on the battery emulator should read 2A. The charge current value can be monitored in the GUI by clicking the **Read** button in the ChargeCurrentLimit section.
5. If the RS1 and RS2 values are different from the RS1 = 10mΩ and RS2 = 5mΩ option, scale the SMBus commands accordingly to obtain the correct current. Smaller current sense resistor values reduce the power loss and larger current sense resistor values give better accuracy.

1.2.2.3 Trickle Charging Mode

1. Complete all the steps in Charging Mode without any changes.
2. Decrease the battery emulator voltage and monitor the battery charging current. If the battery emulator voltage is less than 7.68V (lower than **MinSysVoltage**), the battery enters trickle Charging mode and the charge current decreases to 256mA. The trickle charge current value can be changed through the SMBus control registers. Refer to the *RRB96838 Datasheet* for more information.

1.2.2.4 REV Mode

1. Set the battery emulator voltage at a constant value between 5.8V and 18V. Connect battery leads J5 and J6 with the output disabled.
2. Connect an electric load on supply leads J1 and J2 with the output disabled.
3. Connect the HID dongle cable with proper wiring connections for the I2C communication.
4. Turn on the battery emulator and electrical load without adding any load.
5. Open the RRB96838 GUI. REV Voltage at register 0x49 is the voltage value for the load side, and REV Current at register 0x4A is the Reverse output current limit at the load side. Set these values as required within the output limit range. Refer to the *RRB96838 Datasheet* for the limit ranges.
6. Select the Control0 & 1 Registers tab. In the Control1 Register column, select 1: Enable in REV Function (Bit 11) to enable REV, then click Write. The load voltage is regulated as an REV Voltage value, set in step 4.
7. Increase the electrical load slowly and monitor the load voltage. If the load current is less than the REV Current limit value, the load voltage is regulated at the setting value.

Note: The test procedure for REV Mode with BFET Configuration is the same as REV Mode without BFET Configuration.

1.2.3 Trickle Charging Mode

1. Complete steps 1 through 6 in Charging Mode without any changes.
2. Decrease the battery emulator voltage and monitor the battery charging current. As long as the battery emulator voltage is less than 5.2V (lower than SystemMinVoltage), the battery enters trickle Charging mode and the charge current decreases to 256mA. The trickle charge current value can be changed through the SMBus control registers. See the *RRB96838 Datasheet* for more information.

Note: Ensure the input current does not reach the input current limit value, especially for small V_{IN} input.

2. Board Design

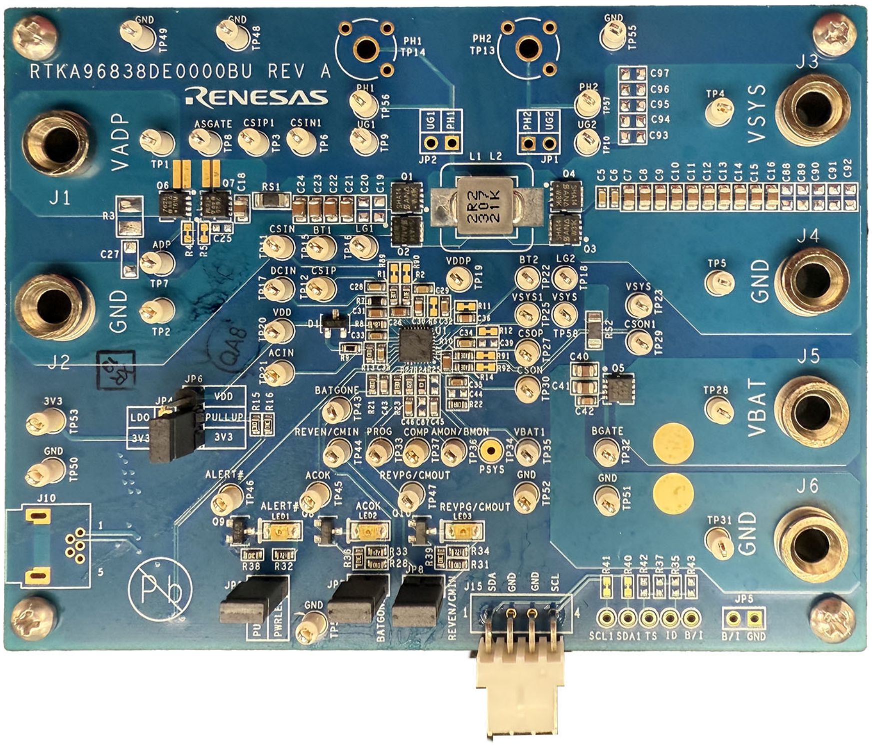


Figure 5. RTKA96838DE0000BU - Top

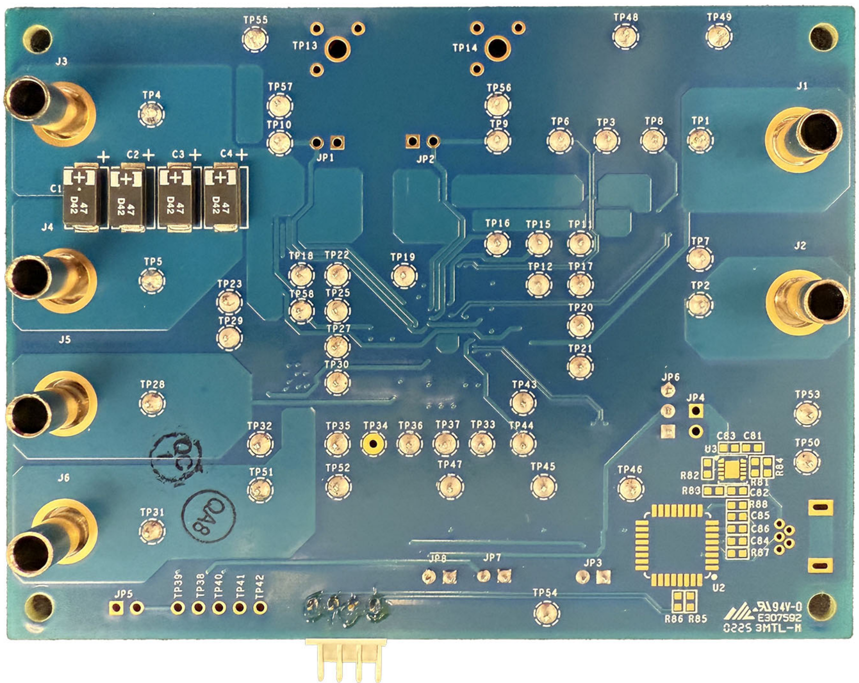
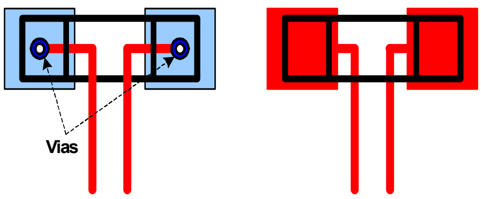


Figure 6. RTKA96838DE0000BU - Bottom

2.1 Layout Guidelines

<table>
<tr><th>Pin #</th><th>Pin Name</th><th>Layout Guidelines</th></tr>
<tr><td>Bottom Pad 33</td><td>GND</td><td>Connect the ground pad to the ground plane through a low impedance path. Use at least five vias to connect to the ground planes in the PCB to ensure sufficient thermal dissipation directly under the IC.</td></tr>
<tr><td>1</td><td>CSON</td><td rowspan="2">Run two dedicated traces with sufficient width in parallel (close to each other to minimize the loop area) from the two terminals of the battery current-sensing resistor to the IC. Place the differential mode and common-mode RC filter components in the general proximity of the controller.

Route the current-sensing traces through vias to connect the center of the pads, or route the traces into the pads from the inside of the current-sensing resistor. The following drawings show the two preferred ways of routing current-sensing traces.

</td></tr>
<tr><td>2</td><td>CSOP</td></tr>
<tr><td>3</td><td>VSYS</td><td>Signal pin provides feedback for the system bus voltage. Place the optional RC filter in the general proximity of the controller. Run a dedicated trace from the system bus to the pin and do not route near the switching traces. Do not share the same trace with the signal routing to the DCIN pin OR diodes and the CSOP trace.</td></tr>
<tr><td>4</td><td>BOOT2</td><td>Switching pin. Place the bootstrap capacitor in the general proximity of the controller. Use sufficiently wide traces. Do not allow any sensitive analog signal traces to cross over or get close to this pin.</td></tr>
</table>

<table>
<tr><th>Pin #</th><th>Pin Name</th><th>Layout Guidelines</th></tr>
<tr><td>5</td><td>UGATE2</td><td rowspan="2">Run the UGATE2 and PHASE2 traces in parallel with sufficient width. Do not allow any sensitive analog signal traces to cross over or get close to this pin. Renesas recommends routing the PHASE2 trace to the high-side MOSFET source pin instead of general copper.

Place the IC close to the gate terminals of the switching MOSFET and keep the gate drive signal traces short for a clean MOSFET drive. The IC can be placed on the opposite side of the switching MOSFETs.

Place the output capacitors as close as possible to the switching high-side MOSFET drain and the low-side MOSFET source. Use the shortest PCB trace connection. Place the capacitors on the same PCB layer as the MOSFETs instead of on different layers and using vias to make the connection.

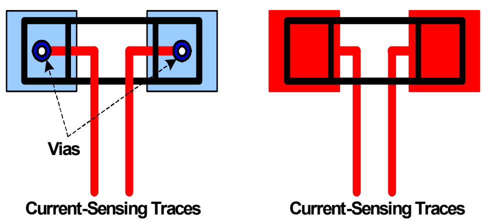
Place the inductor terminal as close as possible to the switching high-side MOSFET source and low-side MOSFET drain terminal. Minimize this phase node area to lower the electrical and magnetic field radiation, but make this phase node area large enough to carry the current. Place the inductor and the switching MOSFETs on the same PCB layer.</td></tr>
<tr><td>6</td><td>PHASE2</td></tr>
<tr><td>7</td><td>LGATE2</td><td>Switching pin. Run the LGATE2 trace parallel to the UGATE2 and PHASE2 traces on the same PCB layer. Use sufficient width. Do not allow any sensitive analog signal traces to cross over or get close to this pin.</td></tr>
<tr><td>8</td><td>VDDP</td><td>Place the decoupling capacitor in the general proximity of the controller. Run the trace connecting to the VDD pin with sufficient width.</td></tr>
<tr><td>9</td><td>LGATE1</td><td>Switching pin. Run the LGATE1 trace parallel to the UGATE1 and PHASE1 traces on the same PCB layer. Use sufficient width. Do not allow any sensitive analog signal traces to cross over or get close to this pin.</td></tr>
<tr><td>10</td><td>PHASE1</td><td rowspan="2">Run the PHASE1 and UGATE1 traces in parallel with sufficient width. Do not allow any sensitive analog signal traces to cross over or get close to these pins. Renesas recommends routing the PHASE1 trace to the high-side MOSFET source pin instead of general copper.

Place the IC close to the switching MOSFET's gate terminals and keep the gate drive signal traces short for a clean MOSFET drive. The IC can be placed on the opposite side of the switching MOSFETs.

Place the input capacitors as close as possible to the switching high-side MOSFET drain and the low-side MOSFET source terminal. Use the shortest PCB trace connection. Place the input capacitors on the same PCB layer as the MOSFETs instead of on different layers and using vias to make the connection.

Place the inductor terminal to the switching high-side MOSFET source and low-side MOSFET drain terminal as close as possible. Minimize the phase node area to lower the electrical and magnetic field radiation, but make this phase node area large enough to carry the current. Place the inductor and the switching MOSFETs on the same layer of the PCB.</td></tr>
<tr><td>11</td><td>UGATE1</td></tr>
<tr><td>12</td><td>BOOT1</td><td>Switching pin. Place the bootstrap capacitor in the general proximity of the controller. Use a sufficiently wide trace. Do not allow any sensitive analog signal traces to cross over or get close to this pin.</td></tr>
<tr><td>13</td><td>ASGATE</td><td>Run this trace with sufficient width parallel to the ADP pin trace.</td></tr>
<tr><td>14</td><td>CSIN</td><td rowspan="2">Run two dedicated traces with sufficient width parallel to (close to each other to minimize the loop area) the two terminals of the adapter current-sensing resistor to the IC. Place the differential mode and common-mode RC filter components in the general proximity of the controller.

Route the current-sensing traces through vias to connect the center of the pads or route the traces into the pads from the inside of the current-sensing resistor. The following drawings show the two preferred ways of routing current-sensing traces.


</td></tr>
<tr><td>15</td><td>CSIP</td></tr>
<tr><td>16</td><td>ADP</td><td>Run this trace with sufficient width parallel to the ASGATE pin trace.</td></tr>
<tr><td>17</td><td>DCIN</td><td>Place the OR diodes and the RC filter in the general proximity of the controller. Run the VADP trace and VSYS trace to the OR diodes with sufficient width.</td></tr>
<tr><td>18</td><td>VDD</td><td>Place the RC filter connecting with the VDDP pin in general proximity of the controller. Run the trace connecting to VDDP pin with sufficient width.</td></tr>
<tr><td>19</td><td>ACIN</td><td>Place the voltage divider resistors and the optional decoupling capacitor in the general proximity of the controller.</td></tr>
<tr><td>20</td><td>REVEN/CMIN</td><td>No special consideration.</td></tr>
</table>

Pin #	Pin Name	Layout Guidelines
21	SDA	Digital pins. No special consideration. Run the SDA and SCL traces in parallel.
22	SCL	
23	ALERTT#	Digital pin, open-drain output. No special consideration.
24	ACOK	
25	BATGONE	Digital pin. Place the 100kΩ resistor series in the BATGONE signal trace and the optional decoupling capacitor in the general proximity of the controller.
26	REVPG/CMOUT	Digital pin, open-drain output. No special consideration.
27	PROG	Signal pin. Place the PROG programming resistor in the general proximity of the controller.
28	COMP	Place the compensation components in the general proximity of the controller. Do not allow any switching signals to cross over or get close to this pin.
29	AMON/BMON	No special consideration. Place the optional RC filter in the general proximity of the controller.
30	RESERVED	Keep floating.
31	VBAT	Place the optional RC filter in the general proximity of the controller. Run a dedicated trace from the battery positive connection point to the IC.
32	BGATE	Use a sufficiently wide trace from the IC to the BGATE MOSFET gate. Place the capacitor from BGATE to ground close to the MOSFET.

2.2 RTKA96838DE0000BU Schematic

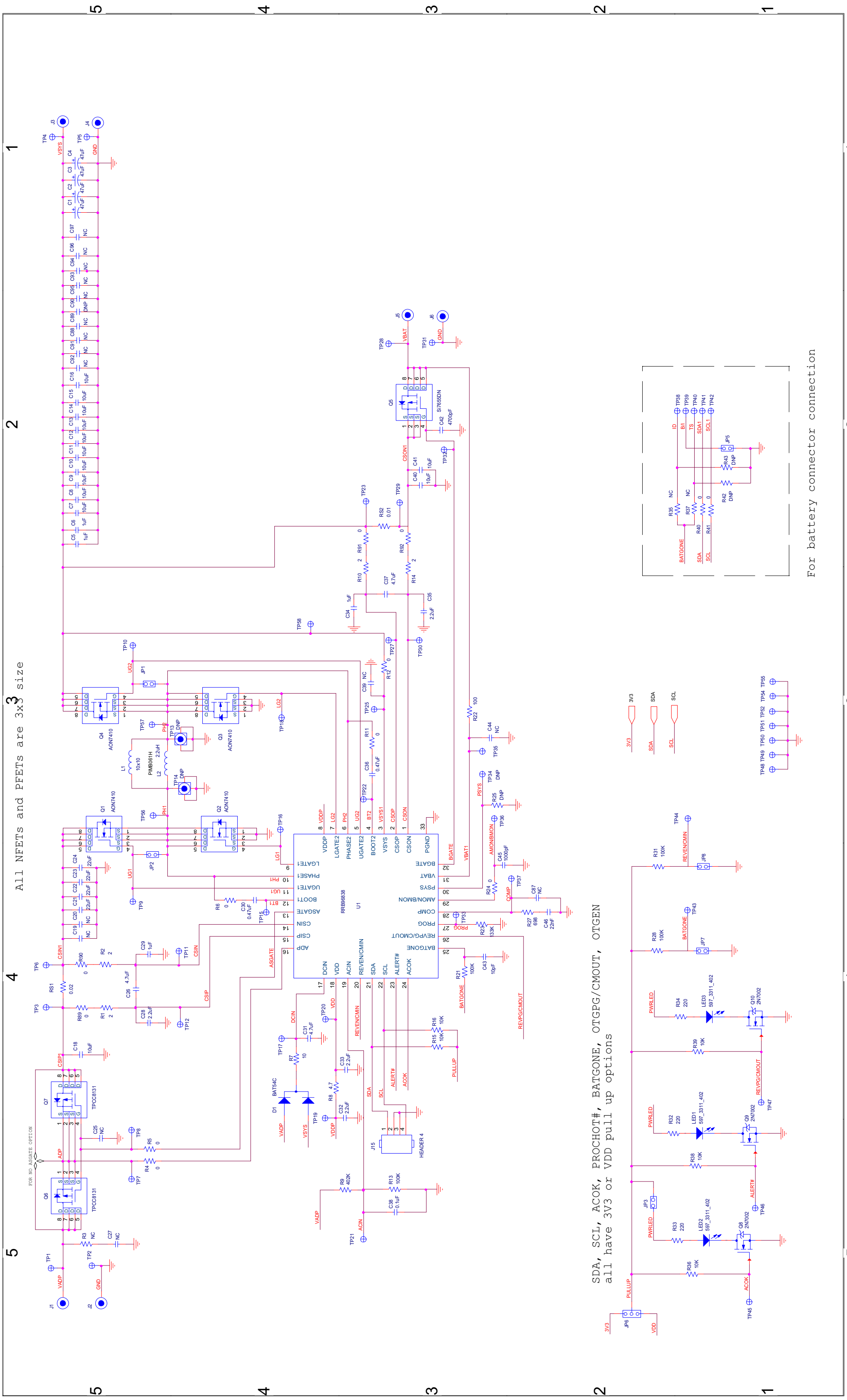


Figure 7. RTKA96838DE0000BU Board Schematic - PG1

2.3 Bill of Materials

Qty	Reference Designator	Description	Manufacturer	Manufacturer PN
4	C1, C2, C3, C4	CAP-POSCAP, SMD, 7.3×4.3×1.9, 47µF, 20V, 20%, 55mΩ, ROHS	Panasonic	20TQC47MYF
4	C21, C22, C23, C24	CAP, SMD, 0805, 22µF, 25V, 20%, X5R, ROHS	Murata	GRM21BR61E226M
3	C26, C31, C37	CAP, SMD, 0603, 4.7µF, 35V, 10%, X5R, ROHS	Murata	GRM188R6YA475KE15D
4	C28, C35, C32, C33	CAP, SMD, 0603, 2.2µF, 35V, 20%, X5R, ROHS	Murata	GRM188R6YA225MA12D
2	C30, C36	CAP, SMD, 0603, 0.47µF, 50V, 10%, X7R, ROHS	TDK	C1608X7R1H474K080AC
1	C38	CAP, SMD, 0603, 0.1µF, 50V, 10%, X7R, ROHS	Yageo	CC0603KPX7R9BB104
1	C42	CAP, SMD, 0603, 4700pF, 50V, 10%, X7R, ROHS	Murata	GRM188R71H472KA01D
1	C43	CAP, SMD, 0603, 10pF, 50V, 10%, NP0, ROHS	Kemet	C0603C100K5GACTU
1	C45	CAP, SMD, 0603, 1000pF, 50V, 5%, NPO, ROHS	Murata	GRM1885C1H102JA01J
1	C46	CAP-AEC-Q200, SMD, 0603, 0.022µF, 25V, 10%, X7R, ROHS	TDK	CGJ3E2X7R1E223K080AA
4	C5, C6, C29, C34	CAP-AEC-Q200, SMD, 0603, 1µF, 50V, 10%, X5R, ROHS	Murata	GRT188R61H105KE13D
13	C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C18, C40, C41	CAP, SMD, 0805, 10µF, 25V, 10%, X5R, ROHS	TDK	C2012X5R1E106K125AB
1	D1	DIODE-RECTIFIER, SMD, SOT23, 30V, 200mA, DUAL DIODE, ROHS	Diodes Inc.	BAT54C-7-F
4	Four corners	SCREW, 4-40×1/4in, PHILLIPS, PANHEAD, STAINLESS, ROHS	Keystone	9900
4	Four corners	STANDOFF, 4-40×5/8in, F/F, ROUND, ALUMINUM, 0.25 OD, ROHS	RAF Elec HW	1686-440-AL
6	J1, J2, J3, J4, J5, J6	CONN BANANA JACK SOLDER	Keystone	36-575-8-ND
1	J15	CONN HEADER R/A 4POS 2.54MM	Molex	22053041
3	JP3, JP7, JP8	CONN-HEADER, 1×2, RETENTIVE, 2.54mm, 0.230×0.120, ROHS	Adam Tech	PH1-02-UA
4	JP3, JP7, JP8, JP6-Pins 1-2	CONN-JUMPER, SHORTING, 2PIN, BLACK, GOLD, ROHS	Sullins	SPC02SYAN
1	JP6	CONN-HEADER, VERT, 1×3, 2.54mm, ROHS	Wurth	61300311121
1	L1	PWR CHOKE COIL, SMD, 6.95×6.6, 2.2µH, 10A, 20%, ROHS	Cyntec	CMLE063T-2R2MS
3	LED1, LED2, LED3	LED, GREEN, 560nm, 30mcd, 20mA, 2.1V, 1206	Dialight	597-3311-407NF-T
4	Q1, Q2, Q3, Q4	TRANSISTOR-MOS, N-CHANNEL, 8P, PWRPAK, 30V, 20A, ROHS	Vishay	SISHA14DN-T1-GE3
3	Q5, Q6, Q7	TRANSIST-MOS, P-CH, 30V, 35A, 8P, PWRPAK, ROHS	Vishay	SI7625DN-T1-GE3
3	Q8, Q9, Q10	TRANSISTOR, N-CHANNEL, 3LD, SOT-23, 60V, 115mA, ROHS	Diodes Inc.	2N7002-7-F
4	R1, R2, R10, R14	RES, SMD, 0603, 2Ω, 1/10W, 1%, TF, ROHS	Yageo	RC0603FR-072RL

Qty	Reference Designator	Description	Manufacturer	Manufacturer PN
4	R13, R21, R28, R31	RES, SMD, 0603, 100K, 1/10W, 1%, TF, ROHS	Yageo	RC0603FR--07100KL
5	R15, R16, R36, R38, R39	RES, SMD, 0603, 10K, 1/10W, 1%, TF, ROHS	Yageo	RC0603FR-0710KL
1	R22	RES, SMD, 0603, 100Ω, 1/10W, 1%, TF, ROHS	Yageo	RC0603FR-07100RL
1	R23	RES, SMD, 133K, 1%, 1/10W, 0603, ROHS	Yageo	RC0603FR-07133KL
1	R24	RES, SMD, 0603, 0Ω, 1/10W, TF, ROHS	Yageo	RC0603JR-070RL
1	R27	RES, SMD, 0603, 698Ω, 1/10W, 1%, TF, ROHS	Yageo	RC0603FR-07698RL
3	R32, R33, R34	RES, SMD, 0603, 220Ω, 1/10W, 1%, TF, ROHS	Yageo	RC0603FR-07220RL
1	R7	RES-AEC-Q200, SMD, 0603, 10R, 1/3W, 5%, PULSE_WITHSTANDING THICK FILM, ROHS	Panasonic	ERJ-PA3J100V
1	R8	RES, SMD, 4.7Ω, 1%, 1/10W, 0603, ROHS	Yageo	RC0603FR-074R7L
1	R9	RES-AEC-Q200, SMD, 0603, 402K, 1/16W, 1%, TF, ROHS	Panasonic	ERJ-3EKF4023V
1	RS1	RES-CURR.SENSE, SMD, 1206, 0.02Ω, 1W, 1%, 75ppm, ROHS	Vishay	WSLP1206R0200FEA
1	RS2	RES-CURR.SENSE, SMD, 1206, 0.01Ω, 1W, 1%, 75ppm, ROHS	Vishay	WSLP1206R0100FEA
1	U1	IC-BUCK BOOST NVDC BATTERY CHARGER, 32P, TQFN, ROHS	Renesas Electronics Corporation	RRB96838-BU7
50	-	CONN-MINI TEST POINT, VERTICAL, WHITE, ROHS	Keystone	5002
1	-	PWB-PCB, ISL9238CEVAL2Z, REVA, ROHS	MTL	RTKA96838DE0000BU REVA PCB

2.4 Board Layout

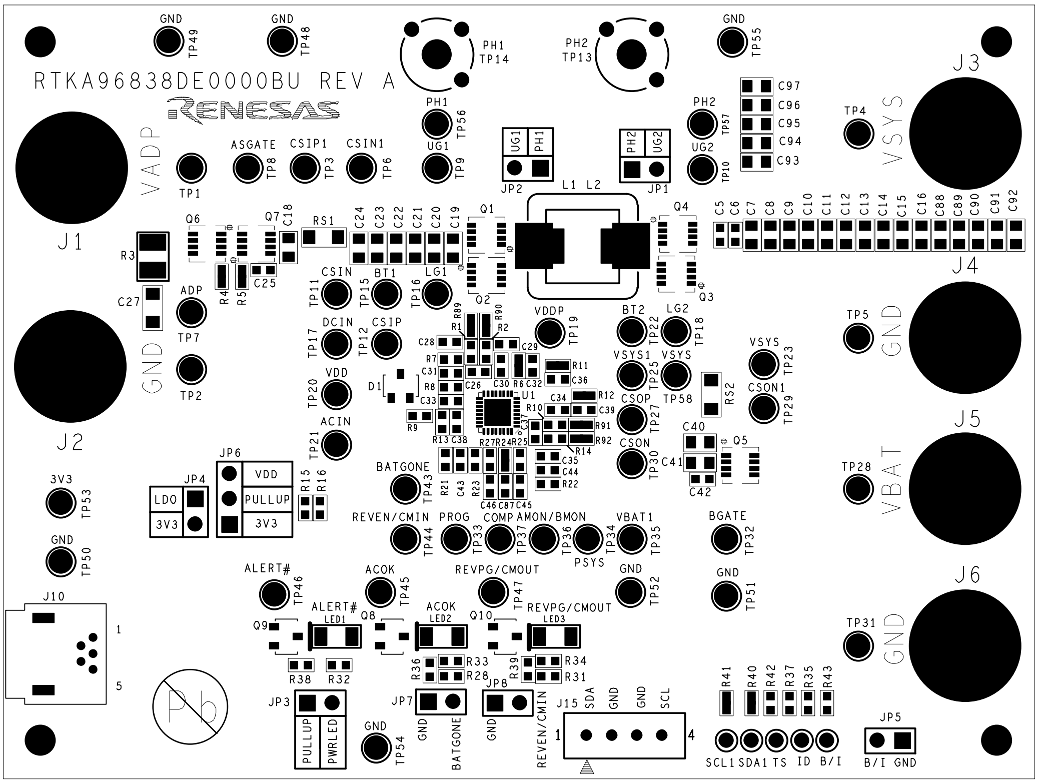


Figure 8. Top Silkscreen

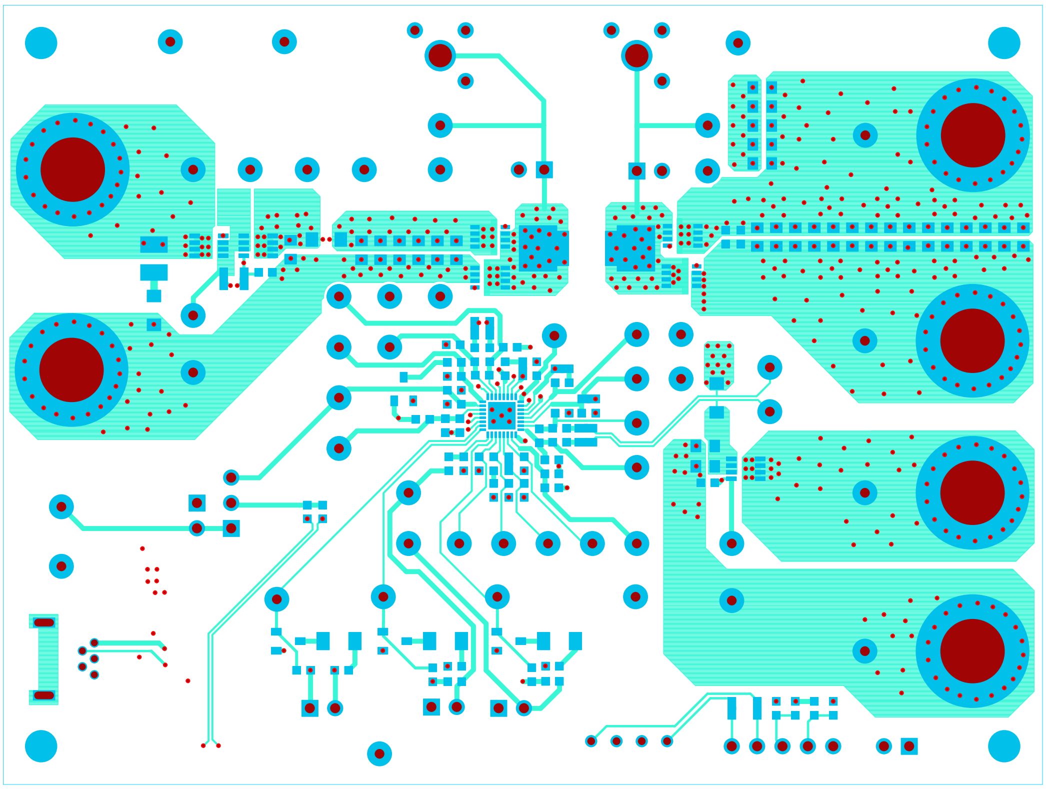


Figure 9. Top Layer

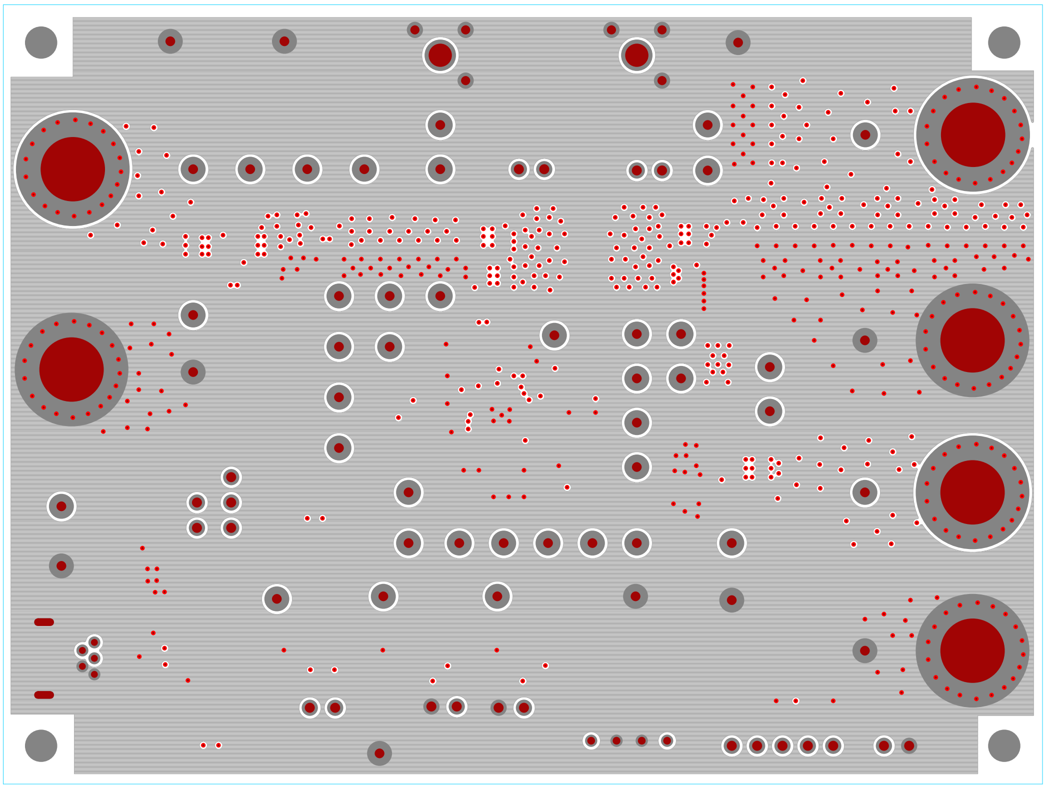


Figure 10. Layer 2

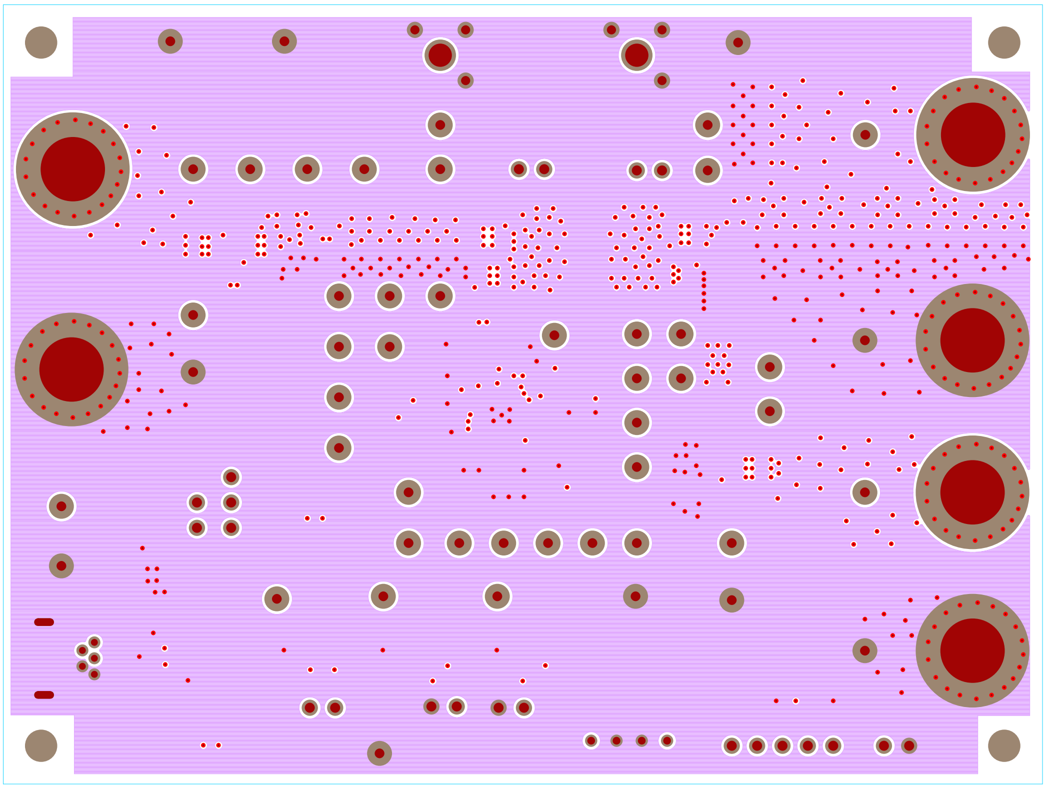


Figure 11. Layer 3

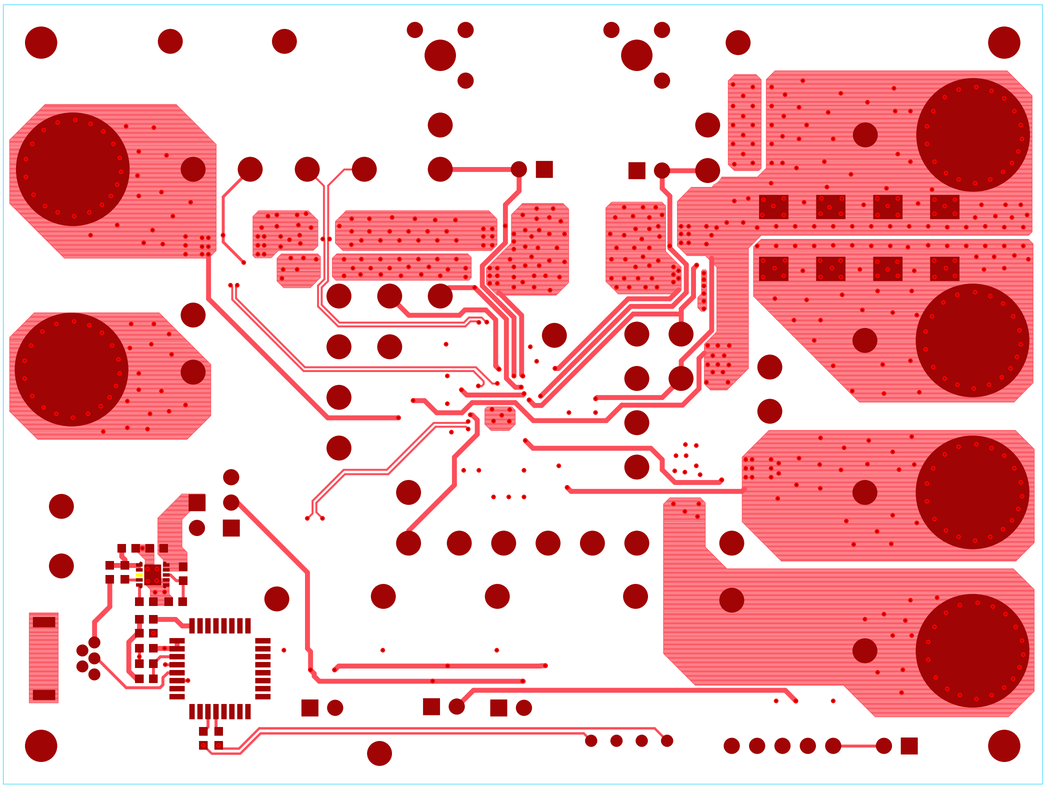


Figure 12. Bottom Layer

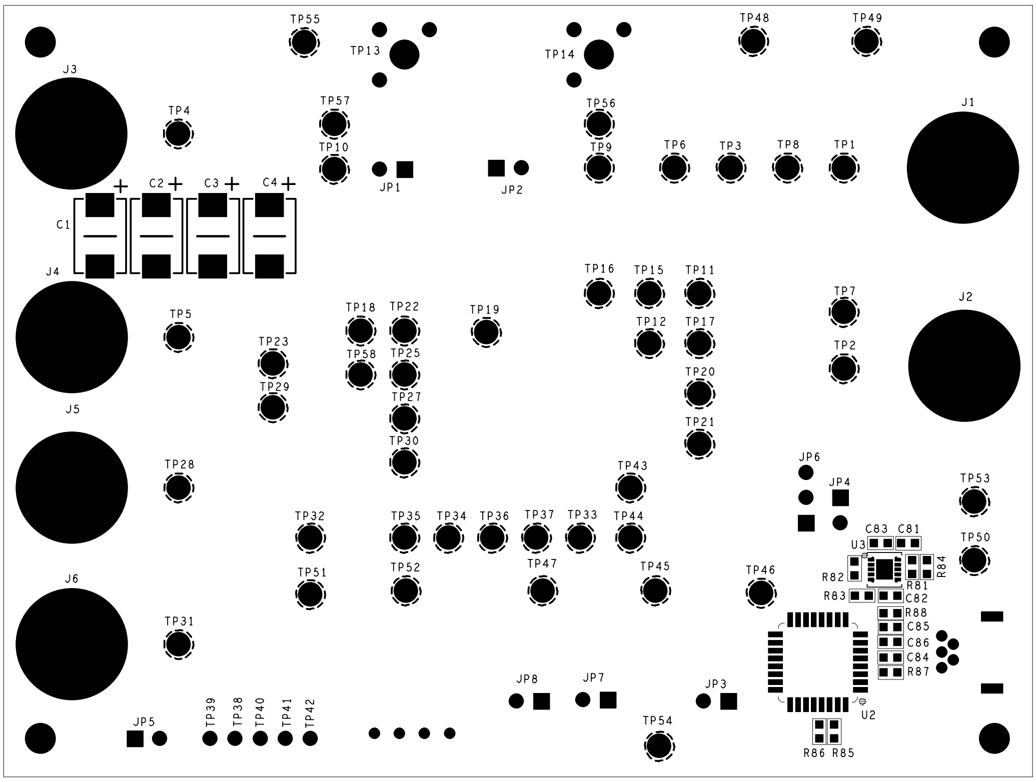


Figure 13. Bottom Silkscreen

3. Typical Performance Curves

3.1 Battery Charging Only (No BFET)

Figure 14. Boost Mode: Charge Current Loop to Adapter Current Loop, V_{ADP} = 5V, V_{BAT} = 12V, AdapterCurrentLimit = 3A, ChargeCurrent: 0.5A → 1.5A

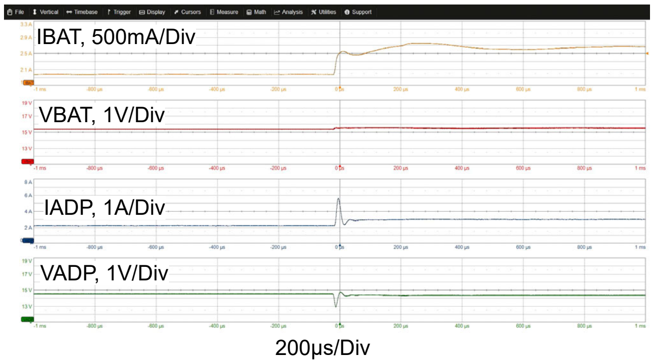


Figure 15. Buck_Boost Mode: Charge Current Loop to Adapter Current Loop, V_{ADP} = 15V, V_{BAT} = 15V, AdapterCurrentLimit = 3A, ChargeCurrent: 2A → 4A

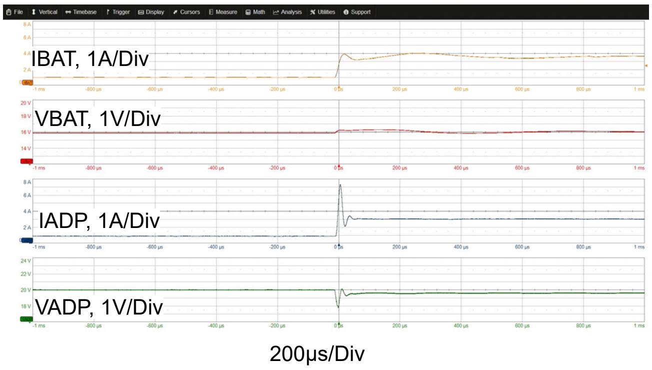


Figure 16. `Buck Mode: Charge Current Loop to Adapter Current Loop, V_{ADP} = 20V, V_{BAT} = 16V, AdapterCurrentLimit = 3A, ChargeCurrent: 1A → 6A

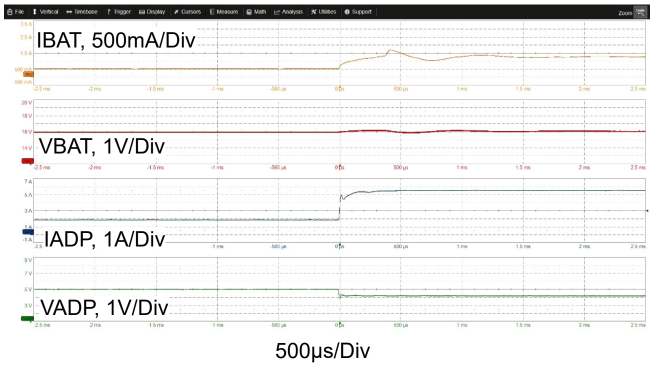


Figure 17. Boost Mode: Charge Current Loop to Input Voltage Loop, V_{ADP} = 5V, V_{BAT} = 16V, ChargeCurrent: 0.5A → 2A, InputVoltageLimit = 4.096V

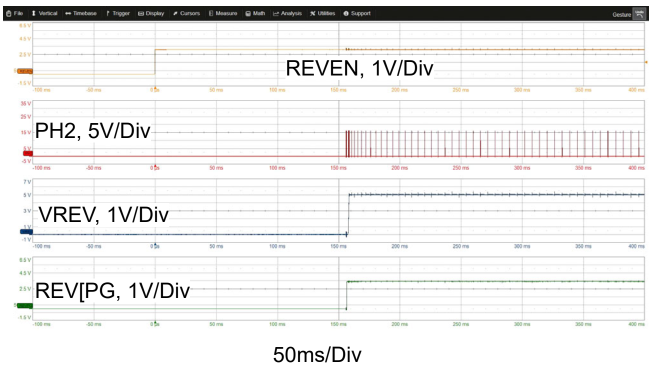


Figure 18. REV Mode Enable, REV_Debounce = 150ms, V_{BAT} = 16V, V_{REV} = 5V

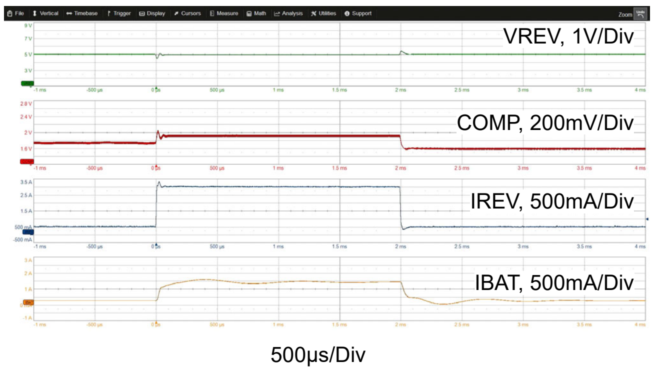
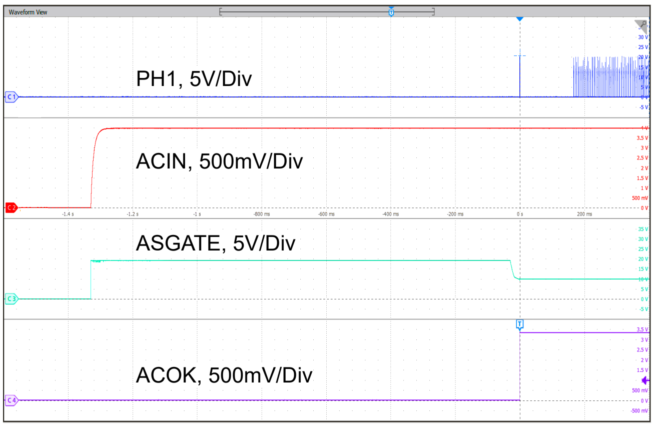


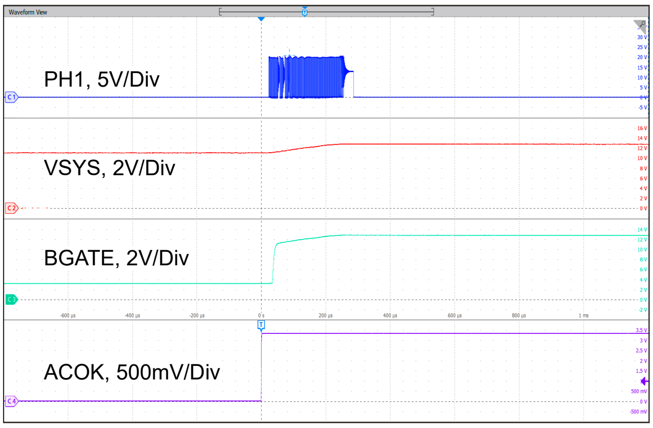
Figure 19. REV Mode Transients, V_{BAT} = 12V, V_{REV} = 5V, REV Load: 0.5A ↔ 3A

3.2 NVDC Charging (with BFET)



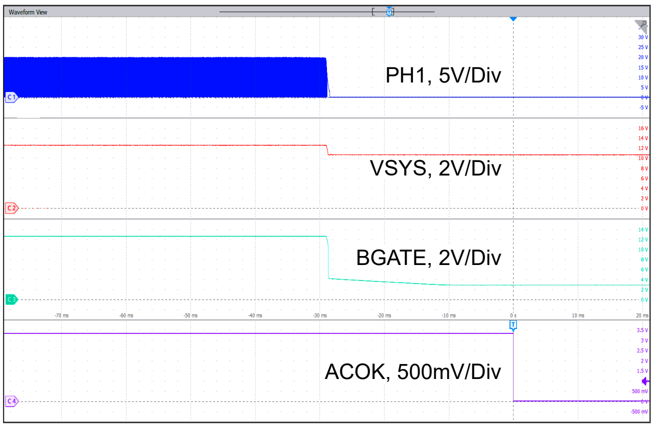
200ms/Div

Figure 20. Adapter Insertion, V_{ADP} = 20V, V_{BAT} = 11V, ChargeCurrent = 0A



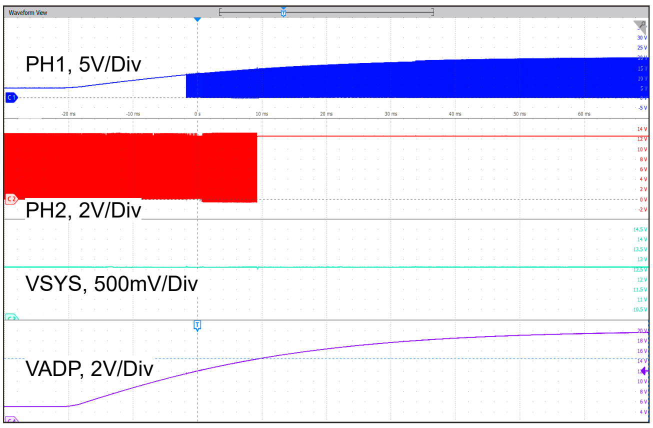
200µs/Div

Figure 21. Adapter Insertion, V_{ADP} = 20V, V_{BAT} = 11V, ChargeCurrent = 0A (Figure 20 Zoomed In)



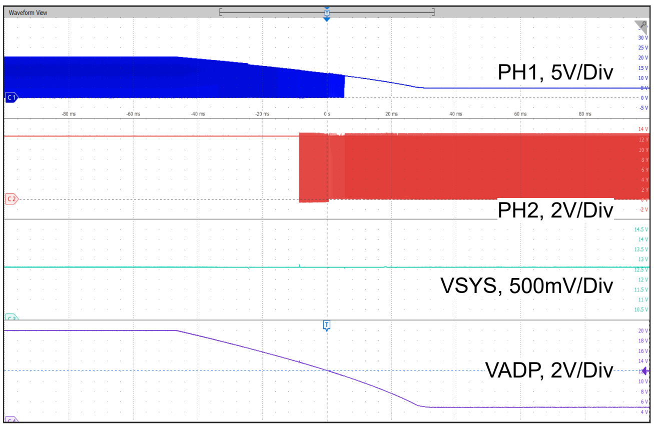
10ms/Div

Figure 22. Adapter Removal, V_{ADP} = 20V, V_{BAT} = 11V, ChargeCurrent = 0A



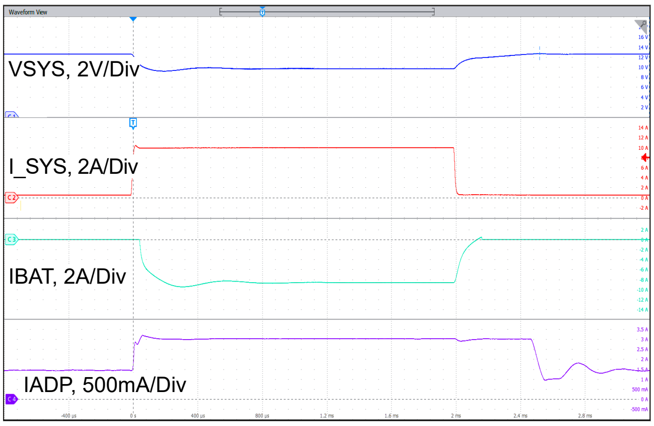
10ms/Div

Figure 23. Adapter Voltage Ramps Up, Boost -> Buck-Boost -> Buck Operation Mode Transition



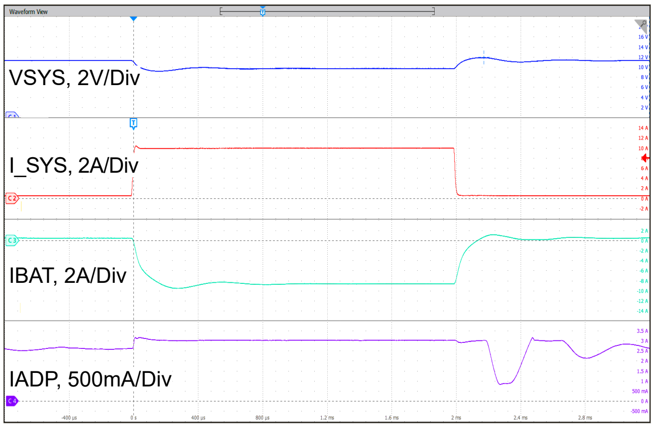
20ms/Div

Figure 24. Adapter Voltage Ramps Down, Buck -> Buck-Boost -> Boost Operation Mode Transition



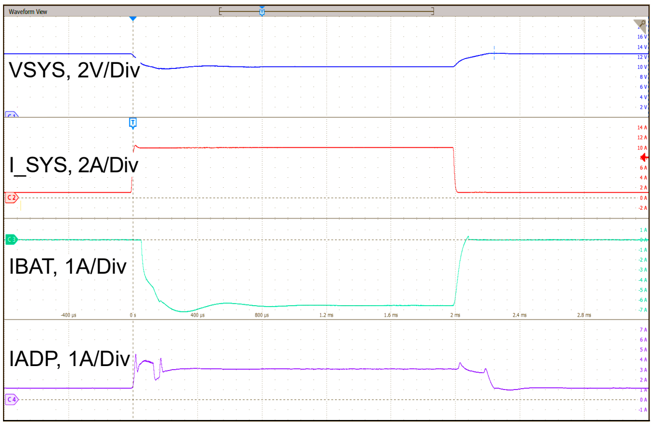
400µs/Div

Figure 25. Boost Mode, Output Voltage Loop to Adapter Current Loop Transition. V_{ADP} = 5V, MaxSystemVoltage = 12.576V, V_{BAT} = 11V, System Load 0.5A to 10A Step, AdapterCurrentLimit = 3A, ChargeCurrent = 0A



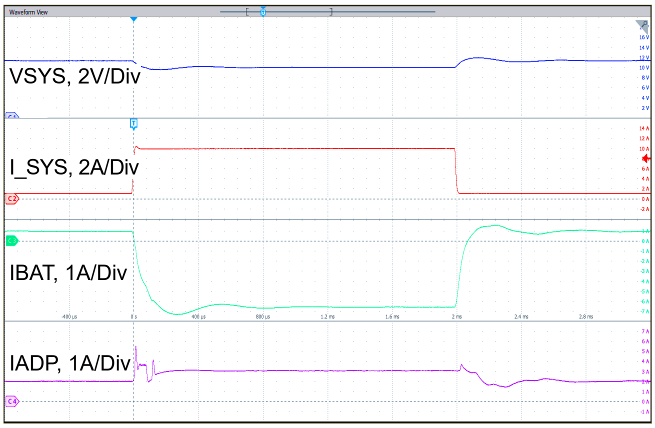
400µs/Div

Figure 26. Boost Mode, Charging Current Loop to Adapter Current Loop Transition. V_{ADP} = 5V, MaxSystemVoltage = 12.576V, V_{BAT} = 11V, System Load 0.5A to 10A Step, AdapterCurrentLimit = 3A, ChargeCurrent = 0.5A



400µs/Div

Figure 27. Buck-Boost Mode, Output Voltage Loop to Adapter Current Loop Transition. V_{ADP} = 12V, MaxSystemVoltage = 12.576V, V_{BAT} = 11V, System Load 1A to 10A Step, AdapterCurrentLimit = 3A, ChargeCurrent = 0A



400µs/Div

Figure 28. Buck-Boost Mode, Charging Current Loop to Adapter Current Loop Transition. V_{ADP} = 12V, MaxSystemVoltage = 12.576V, V_{BAT} = 11V, System Load 1A to 10A Step, AdapterCurrentLimit = 3A, ChargeCurrent = 1A

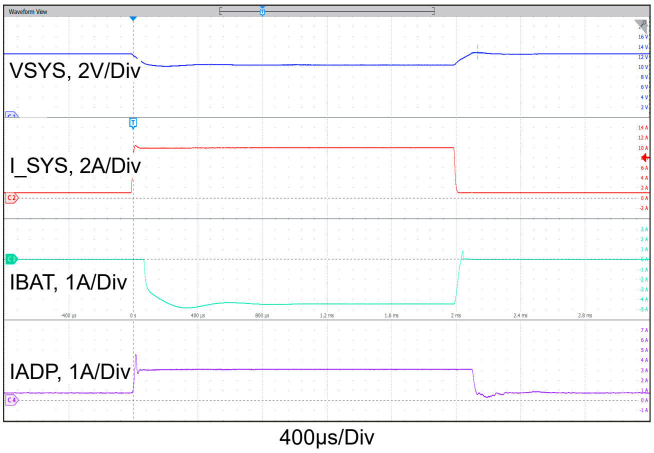


Figure 29. Buck Mode, Output Voltage Loop to Adapter Current Loop Transition. V_{ADP} = 20V, MaxSystemVoltage = 12.576V, V_{BAT} = 11V, System Load 1A to 10A Step, AdapterCurrentLimit = 3A, ChargeCurrent = 0A

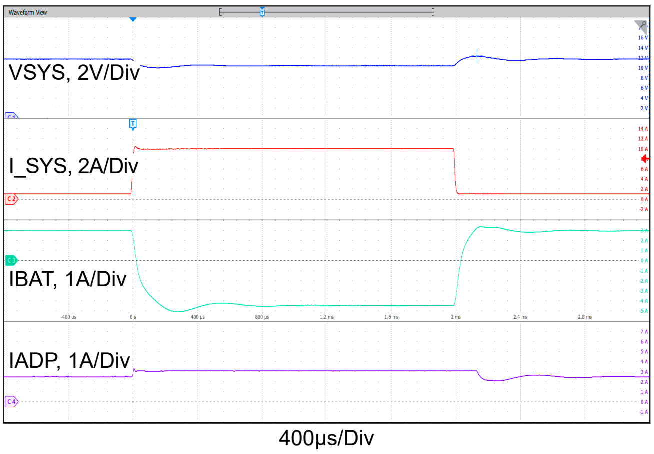


Figure 30. Buck Mode, Charging Current Loop to Adapter Current Loop Transition. V_{ADP} = 20V, MaxSystemVoltage = 12.576V, V_{BAT} = 11V, System Load 1A to 10A Step, AdapterCurrentLimit = 3A, ChargeCurrent = 3A

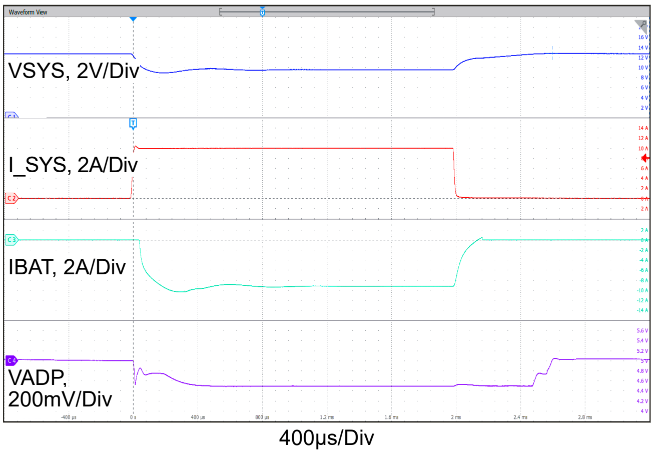


Figure 31. Boost Mode, Output Voltage Loop to Input Voltage Loop Transition. V_{ADP} = 5.004V, MaxSystemVoltage = 12.576V, V_{BAT} = 11V, VINDAC = 4.437V, System Load 0A to 10A Step, ChargeCurrent = 0A

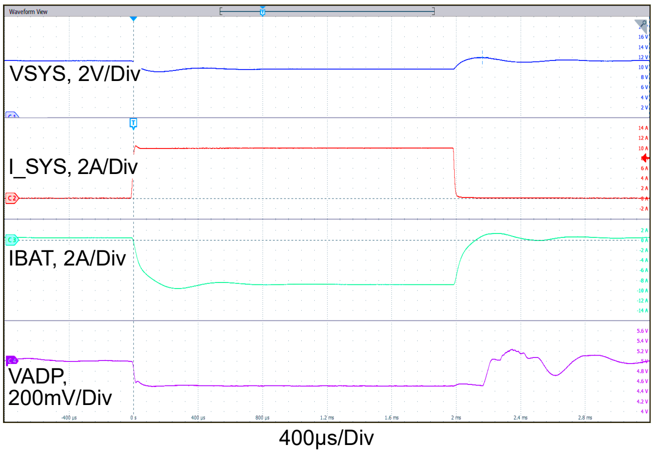
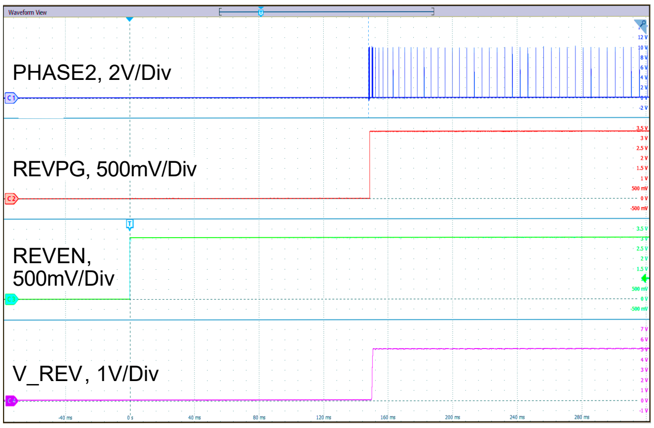
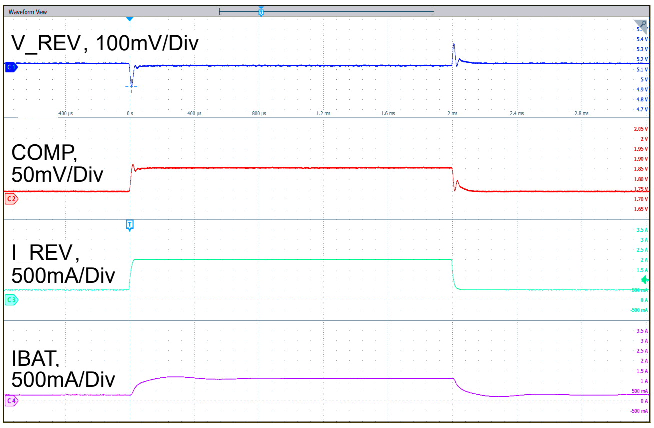


Figure 32. Boost Mode, Charging Current Loop to Input Voltage Loop Transition. V_{ADP} = 5.004V, MaxSystemVoltage = 12.576V, V_{BAT} = 11V, VINDAC = 4.437V, System Load 0A to 10A Step, ChargeCurrent = 0.5A



40ms/Div

Figure 33. REV Mode Enable, REV Enable 150ms Debounce Time



400µs/Div

Figure 34. REV Mode 0.5A to 2A Transient Load, REV Voltage = 5.12V

4. Ordering Information

Part Number	Description
RTKA96838DE0000BU	RRB96838 Buck-Boost Charger Evaluation Board

5. Revision History

Revision	Date	Description
1.00	May 27, 2025	Initial release.

IMPORTANT NOTICE AND DISCLAIMER

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