RTKP51045DE0000BU

The RTKP51045DE0000BU evaluation board provides a simple platform to evaluate the 3.5×3.5mm 20-Ld QFN RRP51045 low-dropout linear regulator (LDO).

The RRP51045 is an ultra-low noise, high PSRR LDO regulator capable of sourcing up to 4A of load current with very low dropout. The output voltage can be programmed from 0.5V to 2.075V using voltage setting pins on the IC in 25mV steps. The evaluation board has convenient jumpers to exercise these pins. External feedback resistors can still be used for higher output voltage applications, allowing the output voltage to be programmed anywhere from 0.5V to 5.1V.

The LDO operates from an input voltage of 1.4V to 6.5V without VBIAS and 1.1V to 6.5V with VBIAS.

Features

- Output voltage set pins easily programmed with JP_VSET
- Switch between voltage set pins or external resistor divider using jumper JP_FB
- Convenient shutdown mode function using jumper JP_EN
- Power-good (PG) indication test point
- V_{BIAS} banana jack or turret for applications, where V_{IN} < 1.4V
- BNC_VIN and BNC_VOUT connections for PSRR and output noise testing

Specifications

This evaluation board is specified for the following operating conditions:

- Input voltage range: 1.4V to 6.5V without VBIAS and 1.1V to 6.5V with VBIAS
- V_{BIAS} voltage range: 3V to 6.5V ultra-low output noise: 7µVRMS

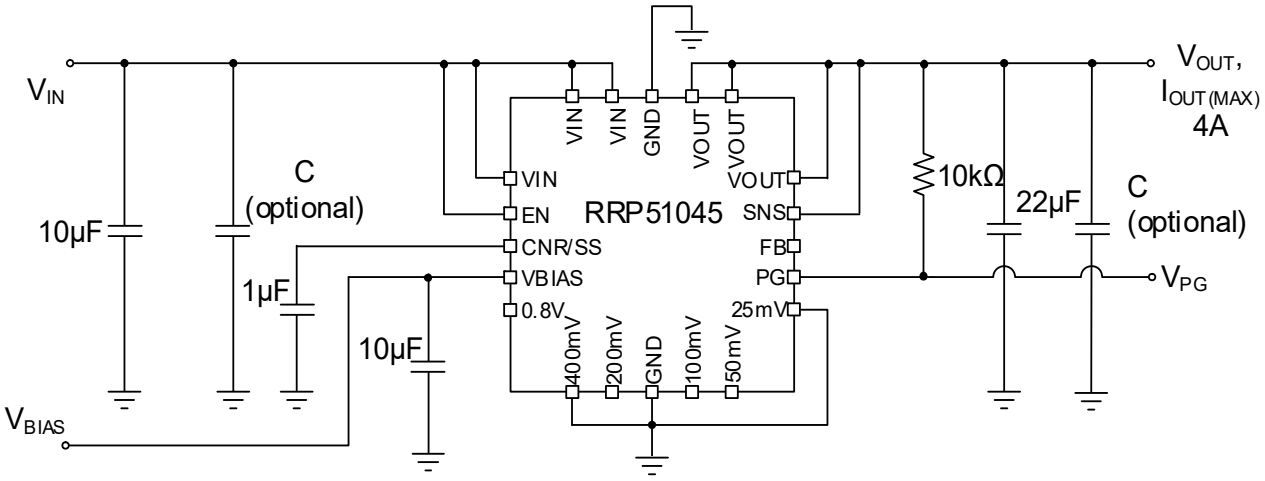

Figure 1. Typical Application Schematic

Contents

1. Functional Description

The RTKP51045DE0000BU evaluation board provides a simple platform for demonstrating the features of the RRP51045 low-noise, high-PSRR LDOs, helping design and system engineers evaluate critical performance parameters for their applications.

1.1 Setup and Configuration

1.1.1 Programming the Output Voltage

The output voltage can be programmed using the EVB PCB layout using convenient output voltage set pins (25mV, 50mV, 100mV, 200mV, 400mV, 800mV) or with traditional external feedback (FB) resistors. To switch between the two configurations, use the 3-pin JP_FB jumper.

The RRP51045 has an output voltage range of 0.5V to 2.075V using internal FB resistors and an output voltage range of 0.5V to 5.1V using traditional external FB resistors.

1.1.2 Internal Feedback Resistors and Output Voltage Set Pins

The evaluation board can use the internal FB resistors by shorting the device VOUT pins to SNS using the JP_FB jumper (short pins 1 and 2).

The output voltage set pins on the PCB are labeled 25mV, 50mV, 100mV, 200mV, 400mV, and 800mV. Grounding these pins adds the voltages assigned to each grounded pin to the reference voltage (V_{REF}), and the total equals the required output voltage, as expressed in Equation 1. The V_{REF} for the RRP51045 is 0.5V. The voltage set pins can be quickly grounded on the evaluation board using the J1 jumper.

(EQ. 1) $V_{OUT} = V_{REF} + \Sigma$ (Grounded Output Voltage Set Pins)

For example, to program the output voltage on the RRP51045 to 1.8V, ground the 100mV, 400mV, and 800mV pins using the J1 jumper. The sum of these three pins (1.3V) added to the 0.5V voltage reference gives 1.8V on the output of the LDO. The schematic in Figure 2 illustrates the proper connections.

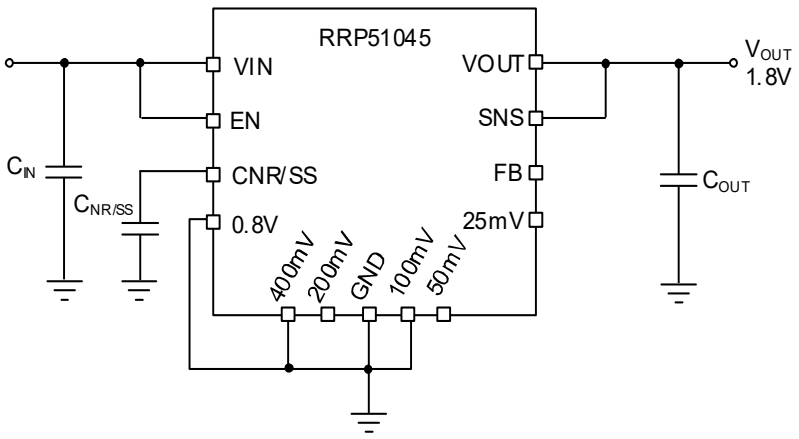

Figure 2. RRP51045 Simplified Schematic Using the Internal FB Resistors (V_{OUT} = 1.8V)

Table 1 provides a list of all the possible voltage set pin configurations and the corresponding output voltage for the RRP51045.

Table 1. Voltage Set Pin Configuration and Corresponding Output Voltages for RRP51045 (V_{REF} = 0.5V)

V_{OUT} (V)	25mV	50mV	100mV	200mV	400mV	800 mV	V_{OUT} (V)	25mV	50mV	100mV	200mV	400mV	800 mV
0.500	Open	Open	Open	Open	Open	Open	1.300	Open	Open	Open	Open	Open	GND
0.525	GND	Open	Open	Open	Open	Open	1.325	GND	Open	Open	Open	Open	GND
0.550	Open	GND	Open	Open	Open	Open	1.350	Open	GND	Open	Open	Open	GND
0.575	GND	GND	Open	Open	Open	Open	1.375	GND	GND	Open	Open	Open	GND
0.600	Open	Open	GND	Open	Open	Open	1.400	Open	Open	GND	Open	Open	GND
0.625	GND	Open	GND	Open	Open	Open	1.425	GND	Open	GND	Open	Open	GND
0.650	Open	GND	GND	Open	Open	Open	1.450	Open	GND	GND	Open	Open	GND
0.675	GND	GND	GND	Open	Open	Open	1.475	GND	GND	GND	Open	Open	GND
0.700	Open	Open	Open	GND	Open	Open	1.500	Open	Open	Open	GND	Open	GND
0.725	GND	Open	Open	GND	Open	Open	1.525	GND	Open	Open	GND	Open	GND
0.750	Open	GND	Open	GND	Open	Open	1.550	Open	GND	Open	GND	Open	GND
0.775	GND	GND	Open	GND	Open	Open	1.575	GND	GND	Open	GND	Open	GND
0.800	Open	Open	GND	GND	Open	Open	1.600	Open	Open	GND	GND	Open	GND
0.825	GND	Open	Open	GND	Open	Open	1.625	GND	Open	GND	GND	Open	GND
0.850	Open	GND	Open	GND	Open	Open	1.650	Open	GND	GND	GND	Open	GND
0.875	GND	GND	Open	GND	Open	Open	1.675	GND	GND	GND	GND	Open	GND
0.900	Open	Open	Open	Open	GND	Open	1.700	Open	Open	Open	Open	GND	GND
0.925	GND	Open	Open	Open	GND	Open	1.725	GND	Open	Open	Open	GND	GND
0.950	Open	GND	GND	Open	GND	Open	1.750	Open	GND	Open	Open	GND	GND
0.975	GND	GND	GND	Open	GND	Open	1.775	GND	GND	Open	Open	GND	GND
1.000	Open	Open	GND	GND	GND	Open	1.800	Open	Open	GND	Open	GND	GND
1.025	GND	Open	GND	GND	GND	Open	1.825	GND	Open	GND	Open	GND	GND
1.050	Open	GND	Open	GND	GND	Open	1.850	Open	GND	GND	Open	GND	GND
1.075	GND	GND	Open	GND	GND	Open	1.875	GND	GND	GND	Open	GND	GND
1.100	Open	Open	Open	Open	GND	Open	1.900	Open	Open	Open	GND	GND	GND
1.125	GND	Open	Open	Open	GND	Open	1.925	GND	Open	Open	GND	GND	GND
1.150	Open	GND	Open	Open	GND	Open	1.950	Open	GND	Open	GND	GND	GND
1.175	GND	GND	GND	Open	GND	Open	1.975	GND	GND	Open	GND	GND	GND
1.200	Open	Open	GND	GND	GND	Open	2.000	Open	Open	GND	GND	GND	GND
1.225	GND	Open	GND	GND	GND	Open	2.025	GND	Open	GND	GND	GND	GND
1.250	Open	GND	GND	GND	GND	Open	2.050	Open	GND	GND	GND	GND	GND
1.275	GND	GND	Open	GND	GND	Open	2.075	GND	GND	GND	GND	GND	GND

1.1.3 External Feedback Resistors

For applications with an output voltage exceeding 2.075V, use an external feedback resistor divider (R_{TOP} and R_{BOT}) as shown in Figure 3. This layout extends the output voltage range up to 5.1V.

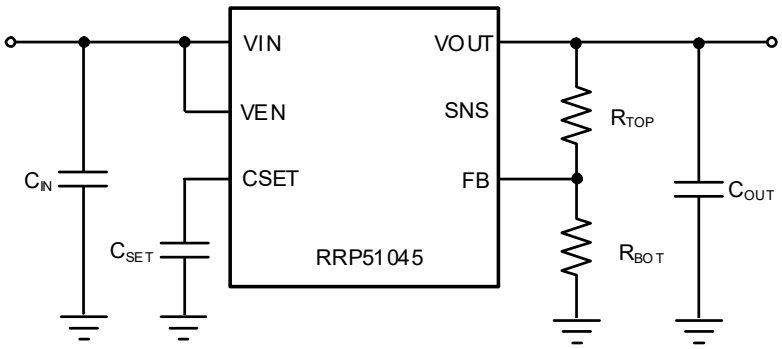

Figure 3. Simplified Schematic of LDO Using External FB resistors

The evaluation board can use external FB resistors by shorting the V_{OUT} to the top of R_{TOP} using the JP_FB jumper (short pins 2 and 3).

R_{BOT} can be easily calculated to program the output voltage by setting R_{TOP} to a required resistor value and solving Equation 2, where $V_{OUT(TARGET)}$ is the ideal output voltage. The V_{REF} for RRP51045 is 0.5V.

(EQ. 2) $$R_{BOT} = R_{TOP} \times \left(\frac{V_{REF}}{V_{OUT(TARGET)} - V_{REF}} \right)$$

Use Equation 3 to calculate the output voltage based on the R_{TOP} and R_{BOT} resistors.

(EQ. 3) $$V_{OUT} = V_{REF} \times \left(1 + \frac{R_{TOP}}{R_{BOT}} \right)$$

Table 2 provides a non-exhaustive list of recommended FB resistor values to obtain some common output voltages for RRP51045. The FB resistors are commercially available in 1% tolerances.

Table 2. Recommended FB Resistor Values for Common Output Voltages (V_{REF} = 0.5V)

$V_{OUT(TARGET)}$ (V)	R_{TOP} (kΩ)	R_{BOT} (kΩ)	$V_{OUT(CALCULATED)}$ (V)	Accuracy
0.5	0	DNP	0.500	0.00%
0.6	11.0	54.9	0.600	-0.03%
0.7	10.2	25.5	0.700	0.00%
0.75	10.0	20.0	0.750	0.00%
0.8	10.7	17.8	0.801	-0.07%
0.9	11.0	13.7	0.901	-0.16%
1	12.4	12.4	1.000	0.00%
1.05	11.0	10.0	1.050	0.00%
1.1	10.7	8.9	1.103	-0.29%
1.2	9.31	6.7	1.200	0.00%
1.5	12.4	6.19	1.502	-0.11%

Table 2. Recommended FB Resistor Values for Common Output Voltages (V_{REF} = 0.5V) (Cont.)

$V_{OUT(TARGET)}$ (V)	R_{TOP} (kΩ)	R_{BOT} (kΩ)	$V_{OUT(CALCULATED)}$ (V)	Accuracy
1.8	10.2	3.92	1.801	-0.06%
1.9	12.4	4.42	1.903	-0.14%
2.5	12.4	3.09	2.506	-0.26%
3	12.4	2.49	2.990	0.33%
3.3	10.7	1.91	3.301	-0.03%
3.6	12.4	2.00	3.600	0.00%
4.2	12.1	1.64	4.189	0.26%
4.5	14.7	1.84	4.495	0.12%
5	12.4	1.38	4.993	0.14%
5.1	20.5	2.23	5.093	-0.09%

1.1.4 VBIAS

If the input supply voltage (V_{IN}) is less than 1.4V but greater than 1.1V, use a VBIAS voltage of 3V to 6.5V. If the input voltage exceeds 1.4V, the VBIAS pin does not have to be connected and can be left floating or shorted to GND.

1.1.5 CNR/SS

Use a 1µF bypass capacitor between the CNR/SS pin and GND for optimal noise and ripple rejection performance. For LDO stability, a minimum capacitance of 100nF is required.

1.1.6 VEN

The ENABLE feature of the LDOs can be exercised using the JP_EN jumper. Short the VEN pin to VIN to automatically ENABLE the device when VIN is applied.

To DISABLE the LDO, connect the EN pin to GND.

To control the EN pin with a separate power supply, such as a function generator or logic signal from an MCU, remove the jumper from JP_EN and connect the separate supply to the TP_EN test point.

1.2 Recommended Equipment

- A VIN power supply to power up the LDO. The supply should be able to supply the load current the LDO needs to supply to its load.
- An EN power supply (such as a function generator, pulse generator, logic signal from an MCU, or a regular supply) to power EN. If not using an external EN power supply, tie EN to VIN for automatic enabling.
- A VBIAS power supply to power VBIAS for applications where V_{IN} < 1.4V.
- An electronic load or resistor load.
- Measurement equipment such as multimeters, oscilloscopes, and spectrum analyzers to evaluate the LDO.

1.3 Quick Start Guide

1.3.1 Internal FB Resistor Configuration Start Guide

1. If not using an external supply on EN, skip step 6 and use the JP_EN jumper to short EN to VIN for automatic enabling.
2. Use the JP_FB jumper to short the SNS pin to VOUT.
3. Use jumpers to ground the required IC voltage set pins to obtain the required output voltage.
4. Twist the positive input lead and ground return lead from the input power supply together, forming a twisted pair power supply wire, keeping them as short as possible to minimize input inductance. Then, turn the supply off.
5. Connect the positive input lead of the VIN power supply to the VIN banana jack and the ground return lead to the GND_IN banana jack.
6. (Optional) Connect the positive input lead of the VEN power supply to the TP_EN and the ground lead to any input side GND, such as TP_10. Turn the supply off.
7. (Optional) Connect the positive input lead of the VBIAS power supply to the VBIAS banana jack and the ground lead to the GND_VBIAS banana jack. Turn the supply off.
8. Connect the electronic or resistor load between VOUT and GND. The positive lead should be connected to the VOUT banana jack, and the ground return lead should be connected to the GND_OUT banana jack.
9. Power up all the necessary power supplies followed by the load (if using an electronic load).
10. Verify the output voltage with a voltmeter and/or oscilloscope.

1.3.2 External FB Resistor Configuration Start Guide

1. If not using an external supply on EN, skip step 6 and use the JP_EN jumper to short EN to VIN for automatic enabling.
2. Use the JP_FB jumper to short the top of R_TOP to the VOUT.
3. Populate the R_TOP and R_BOT resistor divider to obtain the required output voltage.
4. Twist the positive input lead and ground return lead from the input power supply together, keeping them as short as possible to minimize input inductance. Then, turn the supply off.
5. Connect the positive input lead of the VIN power supply to the VIN banana jack and the ground return lead to the GND_IN banana jack.
6. (Optional) Connect the positive input lead of the VEN power supply to the TP_EN and the ground lead to any input side GND, such as TP_10. Turn the supply off.
7. (Optional) Connect the positive input lead of the VBIAS power supply to the VBIAS banana jack and the ground lead to the GND_VBIAS banana jack. Turn the supply off.
8. Connect the electronic or resistor load between VOUT and GND. The positive lead should be connected to the VOUT banana jack, and the ground return lead should be connected to the GND_OUT banana jack.
9. Power up all the necessary power supplies followed by the load (if using an electronic load).
10. Verify the output voltage with a voltmeter and/or oscilloscope.

2. Board Design

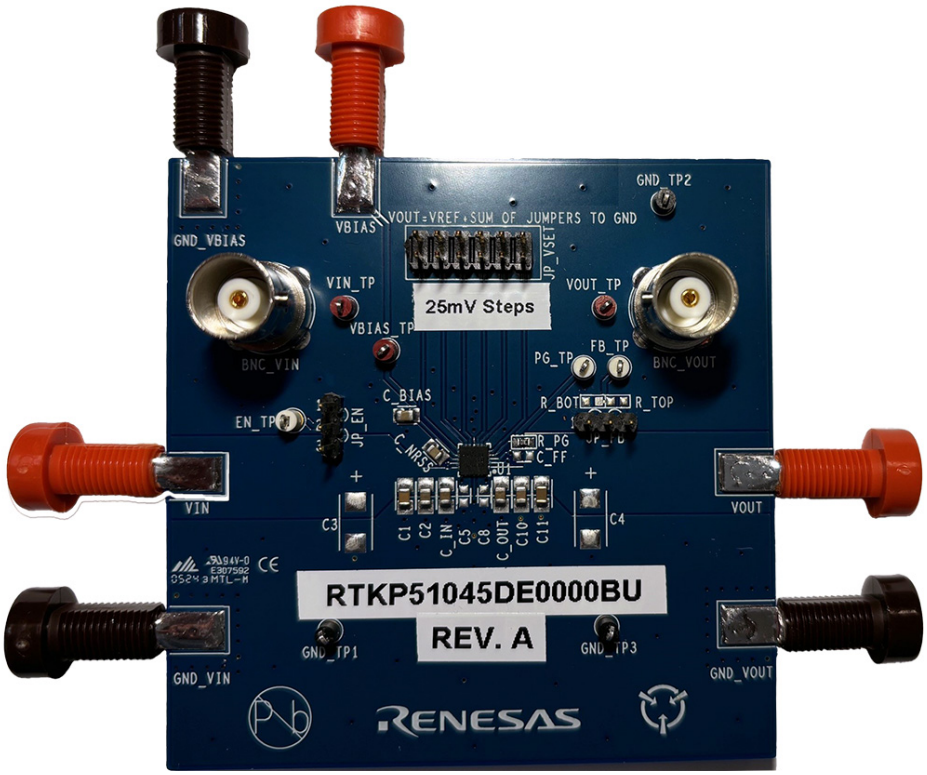

Figure 4. RTKP51045DE0000BU Evaluation Board (Top)

2.1 PCB Layout Guidelines

The following are recommendations for the PCB layout to achieve optimal LDO performance:

- Ensure the input and output capacitors have a good ground connection and place them as close to the IC as possible.
- The FB pin trace should be short, direct, and away from other noisy traces.
- Place them as close as possible to the IC if using external FB resistors.
- The package thermal EPAD is the largest heat conduction path for the package. Solder it to a copper pad on the PCB underneath the part. The PCB thermal pad should have as many plated vias as possible to increase the heat flow from the package thermal EPAD to the inner PCB areas and/or the bottom PCB area. Add thermal vias around the PCB package to help improve heat spread from the package to other board layers. Keep the vias small but not so small that their inside diameter prevents the solder from wicking through the holes during reflow. For efficient heat transfer, the vias must have low thermal resistance. Do not use thermal relief patterns to connect the vias. It is essential to have a complete connection of the plated through-hole to each plane. The top copper GND layer that the EPAD is connected to is the least thermally resistant path for heat flow. To this end, minimize the components and traces that cut this layer.

2.2 Schematic Diagrams

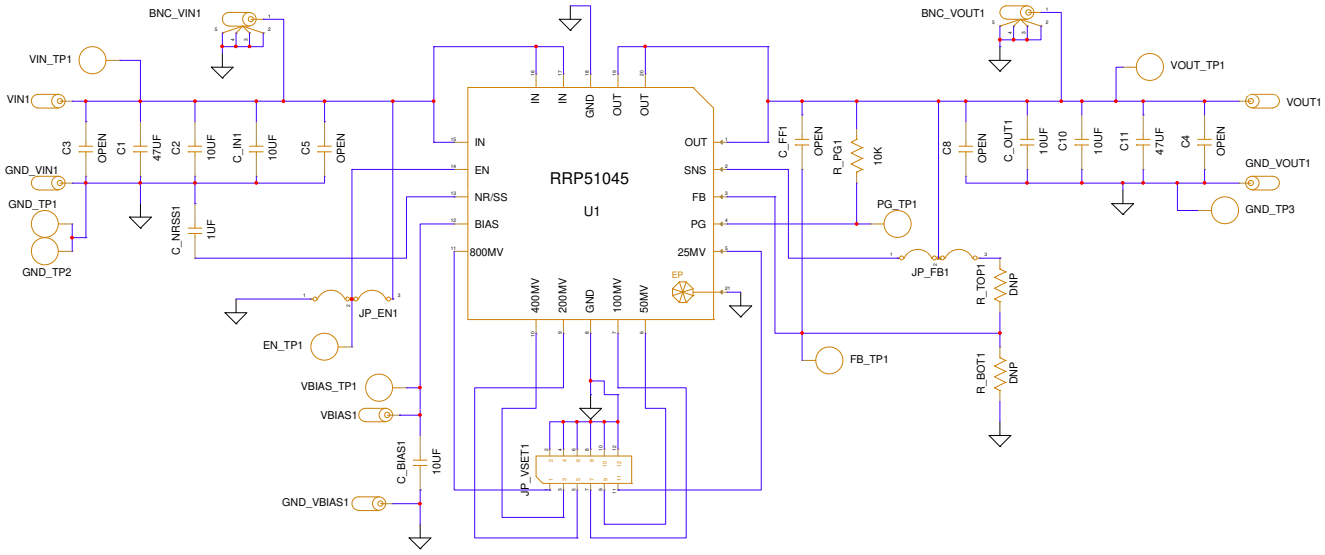

Figure 5. RTKP51045DE0000BU Schematic Diagram

2.3 Bill of Materials

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part Number
5	C_BIAS, C_IN, C_OUT C2, C10	CAP, SMD, 0805, 10µF, 16V, 10%, X7R, RoHS	Samsung	CL21B106KOQNNNE
2	C1, C11	CAP, SMD, 0805, 47µF, 10V, 20%, X5R, RoHS	Murata	GRM21BR61A476ME15
0	C_FF	CAP, SMD, 0603, DNP-PLACE HOLDER, RoHS	-	-
1	C_NRSS	CAP, SMD, 0805,1µF, 16V, 10%, X7R, RoHS	Kemet	C0805C105K4RACTU
0	C3, C4	CAP, SMD, 1206, DNP-PLACE HOLDER, RoHS	-	-
0	C5, C8	CAP, SMD, 0603, DNP-PLACE HOLDER, RoHS	-	-
3	VIN, VOUT, VBIAS	CONN-BANANA JACK, INSULATED, ORANGE, NYLON, RoHS	Johnson Components	108-0906-001
3	GND_VIN, GND_VOUT, GND_VBIAS	CONN-BANANA JACK, FE MALE, TH, W/SOLDER TABS, BROWN, RoHS	Cinch	108-0908-001
2	BNC_VIN, BNC_VOUT	CONN-BNC, RECEPTACLE, TH, 4 POST, 50Ω, GOLDCONTACT, RoHS	Amphenol	31-5329-52RFX
3	VIN_TP, VOUT_TP, VBIAS_TP	CONN-MINI TEST PT, VERTICAL, RED, RoHS	Keystone	5000
3	GND_TP1-GND_TP3	CONN-MINI TEST PT, VERTICAL, BLK, RoHS	Keystone	5001
3	EN_TP, FB_TP, PG_TP	CONN-MINI TEST POINT, VERTICAL, WHITE, RoHS	Keystone	5002
1	JP_VSET	CONN-HEADER, 2×6, BRKAWY-2×36, 2.54mm, RoHS	BERG/FCI	67996-272HLF

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part Number
2	JP_EN, JP_FB	CONN-HEADER,1×3, BREAKAWY 1×36, 2.54mm, RoHS	BERG/FCI	68000-236HLF
0	R_BOT, R_TOP	RESISTOR, SMD, 0603, 0.1%, MF, DNP-PLACE HOLDER	-	-
1	R_PG	RES, SMD, 0603,10K, 1/10W, 1%, TF, RoHS	Venkel	CR0603-10W-1002FT
1	U1	RRP51045 LDO, 20-QFN, Ultra Loise Noise High PSSR LDO	Renesas	RRP51045GNP#HC0

2.4 Board Layout

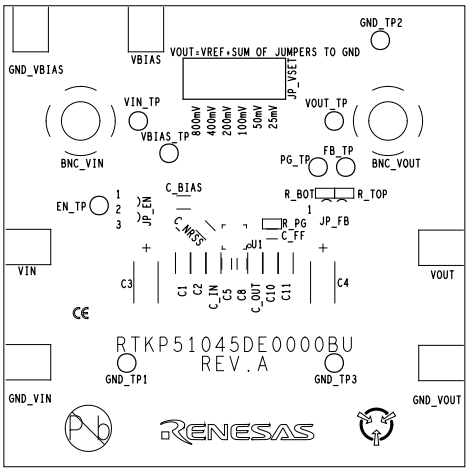

Figure 6. Assembly Layer

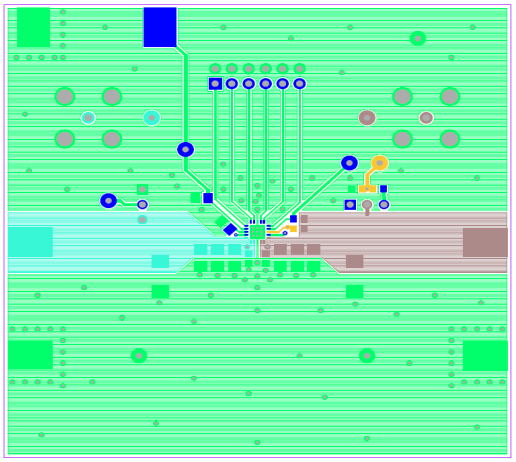

Figure 7. Top Layer

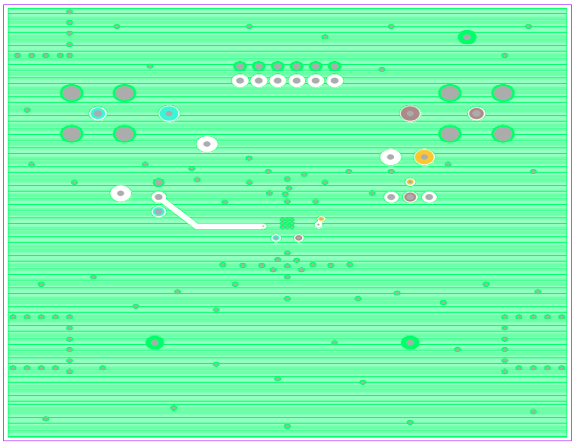

Figure 8. Second Layer

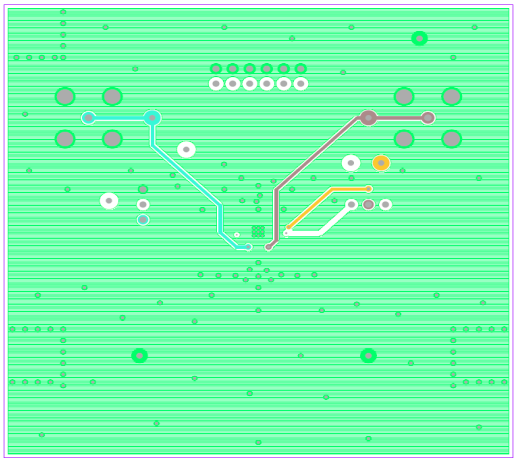

Figure 9. Third Layer

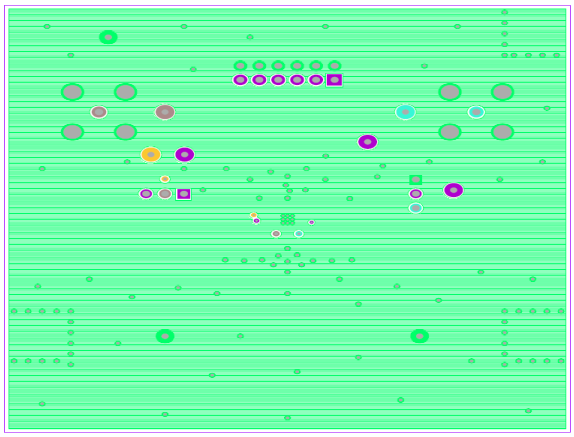

Figure 10. Bottom Layer

3. Typical Performance Graphs

Operating conditions unless otherwise noted: T_A = 25°C, V_{BIAS} = open, and PG pulled up to V_{OUT} with 10kΩ.

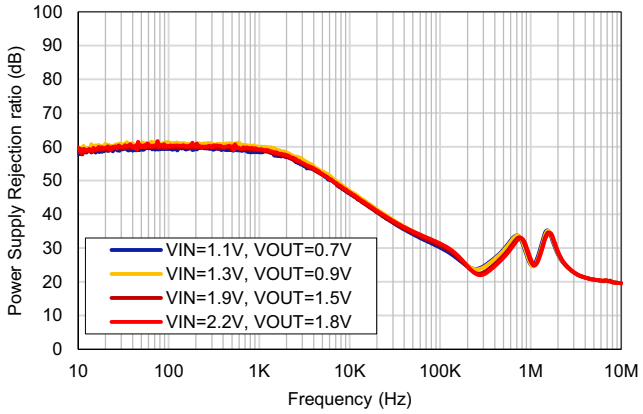

Figure 11. PSRR vs Frequency for Various V_{OUT}
(V_{IN} = V_{OUT} + 0.4V, V_{BIAS} = 5V, I_{OUT} = 4A, $C_{NR/SS}$ = 1µF)

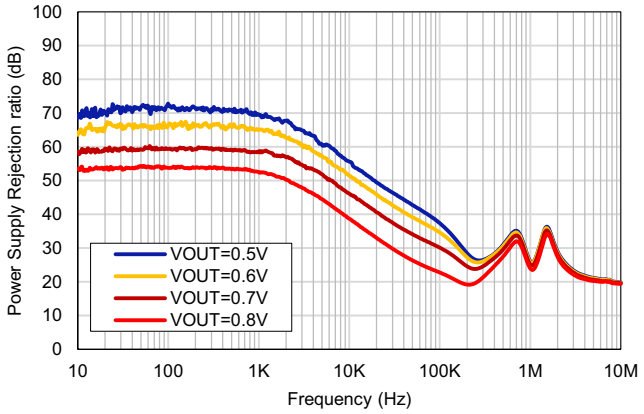

Figure 12. PSRR vs Frequency for Various V_{OUT}
(V_{IN} = 1.1V, V_{BIAS} = 5V, I_{OUT} = 4A, $C_{NR/SS}$ = 1µF)

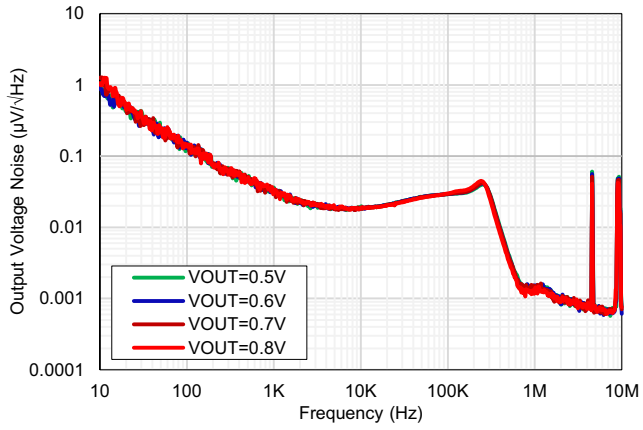

Figure 13. Output Voltage Noise for Various V_{OUT}
(V_{IN} = 1.4V, I_{OUT} = 4A, $C_{NR/SS}$ = 1µF)

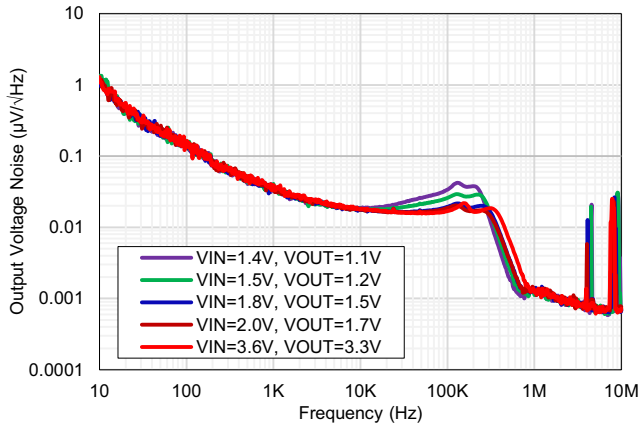

Figure 14. Output Voltage Noise for Various V_{OUT}
(V_{IN} = V_{OUT} + 0.3V, I_{OUT} = 4A, $C_{NR/SS}$ = 1µF)

4. Ordering Information

Part Number	Description
RTKP51045DE0000BU	RRP51045 Evaluation Board

5. Revision History

Revision	Date	Description
1.00	Sep 3, 2024	Initial release

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