ADP5023CP-EVALZ/ADP5024CP-EVALZ/ ADP5034-1-EVALZ/ADP5037CP-EVALZ User Guide
UG-271

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Evaluation Board for the ADP5023/ADP5024/ADP5034/ADP5037 Micro Power Management Unit (PMU)

FEATURES

Full-featured evaluation board for the ADP5023/ADP5024/ ADP5034/ADP5037
Standalone capability
Simple device measurements, including line and load regulation, demonstrable with
A single voltage supply
A voltmeter
An ammeter
Load resistors
Easy access to external components
Cascading options to supply the low dropout (LDO) from either buck
Dedicated enable option for each channel
Mode option to change bucks from PFM to PWM operation

GENERAL DESCRIPTION

This user guide describes the hardware for the evaluation of the ADP5023/ADP5024/ADP5034/ADP5037 and includes detailed schematics and PCB layouts. The ADP5023/ADP5024/ ADP5034/ADP5037 are available in a 24-lead 4 mm × 4 mm LFCSP package. The ADP5023/ADP5024 are three-channel devices that share a common PCB evaluation board. The ADP5034/ADP5037 are four-channel devices and share a common evaluation board. The ADP5023/ADP5024/ADP5034 and ADP5037 all operate in the same manner. Note that this user guide covers all of these boards, but refers to the ADP5034 for simplicity.

The ADP5034 LFCSP evaluation board has two step-down regulators with two LDOs that enable evaluation of the ADP5034. The evaluation board is available in an adjustable voltage option.

Full details on the parts are provided in the appropriate product data sheet available from Analog Devices, Inc., which should be consulted in conjunction with this evaluation board user guide.

DIGITAL PICTURE OF THE ADP5034 EVALUATION BOARD

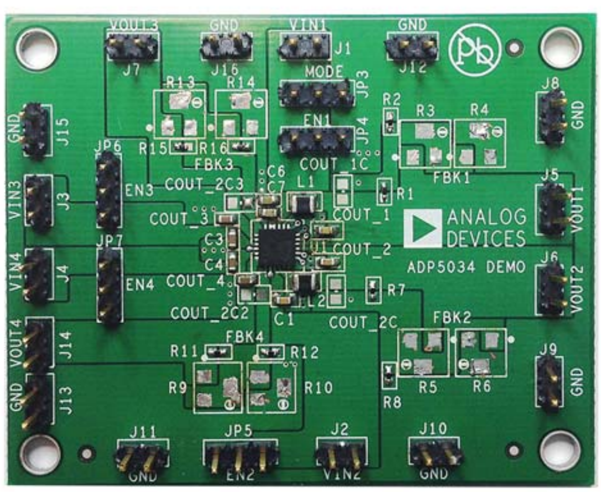

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Figure 1.

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7/12—Rev. 0 to Rev. A

Added ADP5023, ADP5024, and ADP5037 Throughout ... Universal
Replaced all Figures Throughout ... Universal
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8/11—Revision 0: Initial Version

USING THE EVALUATION BOARD

POWERING UP THE EVALUATION BOARD

The ADP5034 evaluation board is supplied fully assembled and tested. Before applying power to the evaluation board, follow the procedures in this section.

Enable

Each channel has its own enable pin, which must be pulled high to enable that channel (see Table 1).

Table 1. Channels of the Enable Pins

	Enable Pin	
Channel	**ADP5034/ADP5037**	**ADP5023/ADP5024**
1	JP4	JP4
2	JP5	JP5
3	JP6	JP6
4	JP7	N/A

Jumper J3 (MODE)

The Jumper JP3 as shown in Figure 1 is used to connect the MODE pin of the device to either ground or VIN1. To force Buck 1 and Buck 2 into forced PWM operation, shunt the center contact of Jumper JP3 (MODE) to the left pin header to pull the MODE pin high to J1 (VIN1). To allow Buck 1 and Buck 2 to operate in automatic PWM/PSM operation, shunt the center contact of JP3 (MODE) to the right pin header to pull the MODE pin low to J12 (GND1).

Input Power Source

If the input power source includes a current meter, use that meter to monitor the input current. Connect J1 (VIN1) to J2 (VIN2) with a short wire. Connect the positive terminal of the power source to J1 (VIN1) on the evaluation board and the negative terminal of the power source to J12 (GND).

If the power source does not include a current meter, connect a current meter in series with the input source voltage. Connect the positive lead (+) of the power source to the ammeter positive (+) connection, the negative lead (−) of the power source to J12 (GND) on the evaluation board, and the negative lead (−) of the ammeter to J1 (VIN1) on the board. Be aware that the current meters add resistance to the input source, and this voltage reduces with high output currents.

Output Load

Connect an electronic load or resistor to set the load current. If the load includes an ammeter, or if the current is not measured, connect the load directly to the evaluation board, with the positive (+) load connected to one of the channels. For example, connect Buck 1, J5 (VOUT1) and the negative (−) load connection to J8 (GND).

If an ammeter is used, connect it in series with the load. Connect the positive (+) ammeter terminal to the evaluation board for Buck 1, J5 (VOUT1), the negative (−) ammeter terminal to the positive (+) load terminal, and the negative (−) load terminal to the evaluation board at J8 (GND).

Input and Output Voltmeters

Measure the input and output voltages with voltmeters. Make sure that the voltmeters are connected to the appropriate evaluation board terminals and not to the load or power sources themselves.

If the voltmeters are not connected directly to the evaluation board, the measured voltages will be incorrect due to the voltage drop across the leads and/or connections between the evaluation board, the power source, and/or the load.

Connect the input voltage measuring voltmeter positive terminal (+) to the evaluation board at J1 (VIN1), and input voltage measuring voltmeter negative (−) terminal to the evaluation board at J12 (GND1).

Connect the output voltage measuring voltmeter positive (+) terminal to the evaluation board at J5 (VOUT1) for measuring the output voltage of Buck 1, and the output voltage measuring voltmeter negative (−) terminal to the evaluation board at J8 (PGND).

Turning On the Evaluation Board

When the power source and load are connected to the evaluation board, the board can be powered for operation. Ensure that:

The power source voltage for the Bucks (VIN1, VIN2) is >2.3 V to <5.5 V. The power source voltage for the LDOs (VIN3, VIN4) is from V_{OUT} LDO + 0.5 V or 1.7 V (whichever is greater) to 5.5 V.

The desired channel is enabled and monitors the output voltage.

If the load is not enabled, enable the load; check that it is drawing the proper current and that the output voltage maintains voltage regulation.

Setting the Output Voltage of the Bucks

The buck output voltage is set through external resistor dividers, shown in Figure 2 for Buck 1. The output voltage can optionally be factory programmed to default values as indicated in the data sheet. In this event, R1 and R2 are not needed, and FB1 can be left unconnected. In all cases, VOUT1 must be connected to the output capacitor. FB1 is 0.5 V.

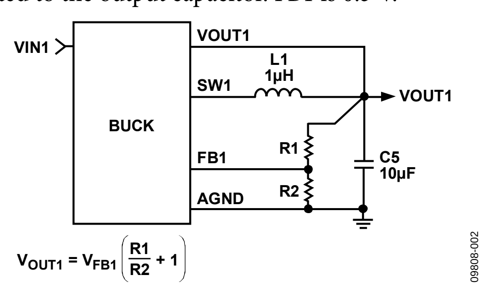

Figure 2. Buck 1 External Output Voltage Setting

Setting the Output Voltage of the LDOs

Each LDO output voltage is set through external resistor dividers as well as shown in Figure 3 for LDO1. The output voltage can optionally be factory programmed to default values as indicated in the data sheet. In this event, FB3 must be connected to the top of the capacitor on VOUT3 by placing a 0 Ω resistor on R_{TOP}, and leaving R_{BOT} unpopulated. Refer to Table 2 for the corresponding 0 Ω resistor placements on R_{TOP} per channel.

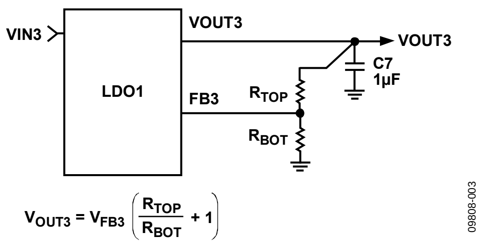

Figure 3. LDO1 External Output Voltage Setting

External Resistor Divider Setting for Bucks and LDOs

The ADP5023/ADP5024/ADP5034/ADP5037 demo boards are supplied with fixed resistors with values chosen for a target output voltage. Varying the resistor values of the resistor divider networks varies the output voltage accordingly.

Table 2. External Resistor Dividers (Fixed)

Resistor Divider	Buck 1	Buck 2	LDO1	LDO2
R_{TOP}	R1	R7	R15	R11
R_{BOT}	R2	R8	R16	R12

Aside from the fixed resistors shown in Table 2, the demo boards also have footprints for trimmer resistors as listed in Table 3. The trimmer resistors make for easier adjustments of the output voltage by turning the adjustment slots on top of the resistors as shown in Figure 4.

Turning the adjustment slot clockwise increases the resistance and vice versa; adjust accordingly to get the desired output voltage. The footprints are designed for 3214W-1-204E parts, which are 200 kΩ trimmer resistors. The trimmers are for quick evaluation purposes and are not recommended for final application; this is because of the possible mechanical issues and complex impedance. Once the desired output voltage is found, replace the trimmers with fixed value resistors.

Table 3. External Resistor Dividers (Trimmer Resistors)

Resistor Divider	Buck 1	Buck 2	LDO1	LDO2
R_{TOP}	R3	R5	R13	R9
R_{BOT}	R4	R6	R14	R10

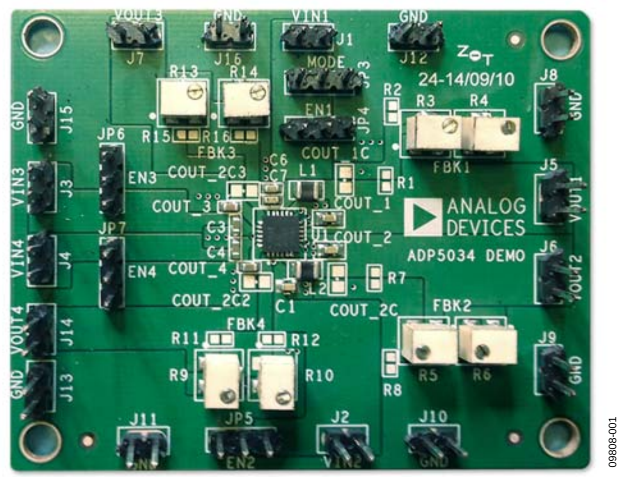

Figure 4. Demo Board with Trimmer Resistors

MEASURING EVALUATION BOARD PERFORMANCE

Measuring Output Voltage Ripple of the Buck Regulator

To observe the output voltage ripple of Buck 1, place an oscilloscope probe across the output capacitor (COUT_1) with the probe ground lead at the negative (−) capacitor terminal and the probe tip at the positive (+) capacitor terminal.

Set the oscilloscope to ac, 10 mV/division, and 2 µs/division time base, with BW set to 20 MHz to avoid noise to interfere with the measurements. It is recommended to shorten the ground loop of the oscilloscope probe to minimize coupling. A good way of measuring the output voltage ripple is to solder a wire to the negative (−) capacitor terminal and wrap it around the barrel of the probe, while the tip directly connects to the positive (+) capacitor terminal as shown in Figure 5.

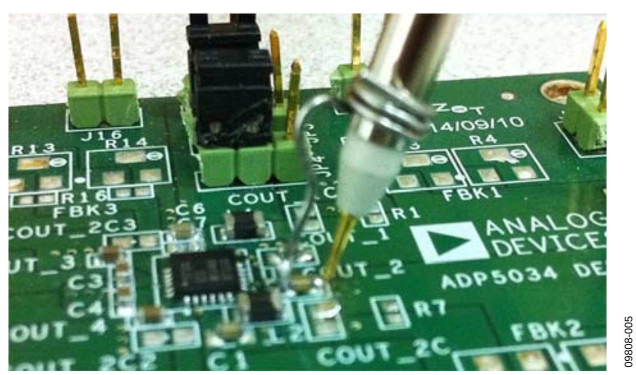

Figure 5. Measuring Output Voltage Ripple

Measuring the Switching Waveform of Buck

To observe the switching waveform with an oscilloscope, place the oscilloscope probe tip at the end of the inductor with the probe ground at GND. Set the oscilloscope to dc, 2 V/division, and 200 ns/division time base.

When the MODE pin is set to high, the buck regulators operate in forced PWM mode. When the MODE pin is set to low, the buck regulators operate in PWM mode when the load is above a predefined threshold. When the load current falls below a predefined threshold, the regulator operates in power save mode (PSM), improving the light load efficiency. Typical PWM and PSM switching waveforms are shown in Figure 6 and Figure 7.

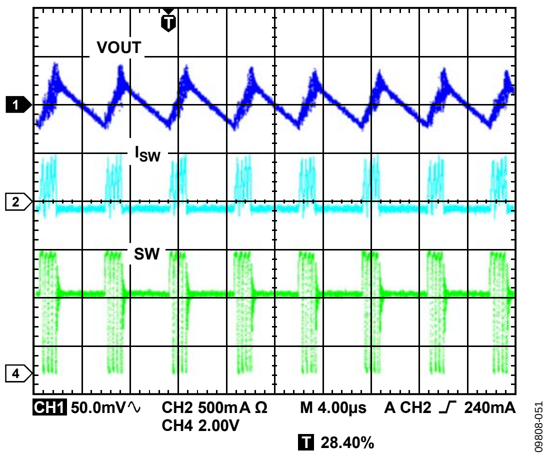

Figure 6. Typical Waveforms, $V_{OUT}1 = 3.3$ V, $I_{OUT}1 = 30$ mA, PSM Mode

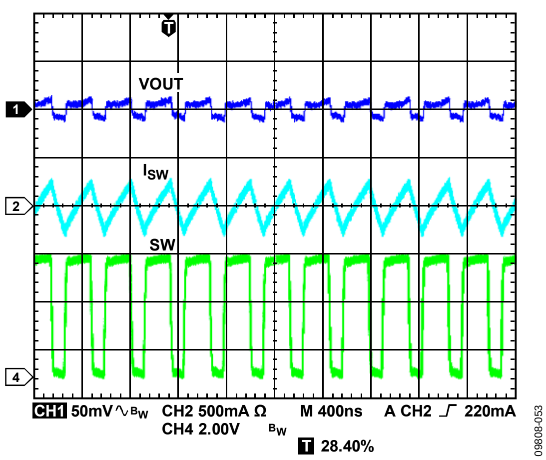

Figure 7. Typical Waveforms, $V_{OUT}1 = 3.3$ V, $I_{OUT}1 = 30$ mA, PWM Mode

Measuring Load Regulation of Buck

Test the load regulation by increasing the load at the output and looking at the change in output voltage. The input voltage must be held constant during this measurement. To minimize voltage drop, use short low resistance wires, especially for loads approaching maximum current.

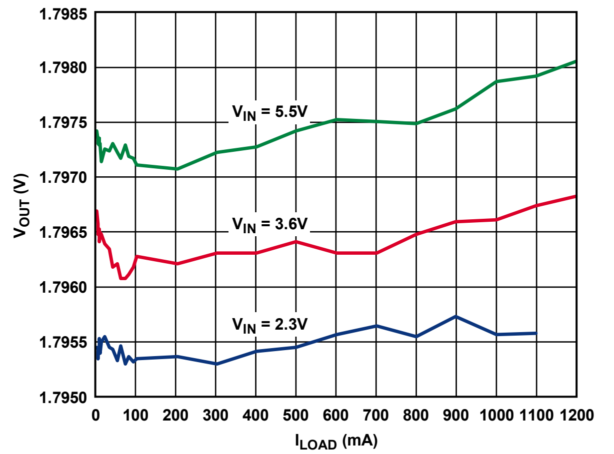

Figure 8. Buck Load Regulation

Measuring Line Regulation

Vary the input voltage and examine the change in the output voltage.

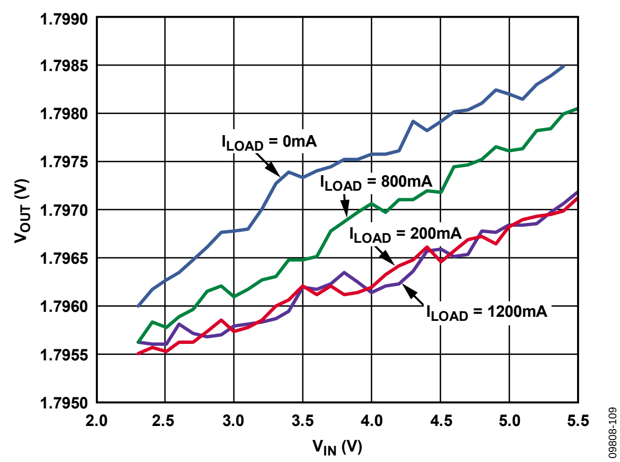

Figure 9. Buck Line Regulation

Measuring Efficiency of Buck

Measure the efficiency, η, by comparing the input power with the output power.

$$\eta = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times I_{IN}}$$

Measure the input and output voltages as close as possible to the input and output capacitors to reduce the effect of IR drops.

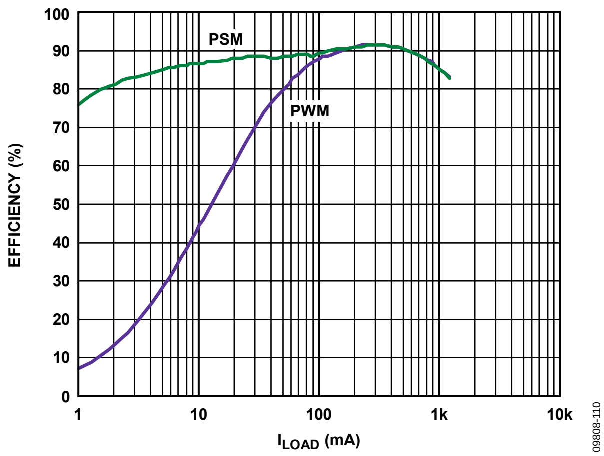

Figure 10. Buck Efficiency, V_{IN} = 3.6 V, V_{OUT} = 1.8 V

Measuring Inductor Current

Measure the inductor current by removing one end of the inductor from its pad and connecting a current loop in series. A current probe can be connected to this wire.

Measuring Line Regulation of LDOs

For line regulation measurements, the output of the regulator is monitored while its input is varied. For good line regulation, the output must change as little as possible with varying input levels. To ensure that the device is not in dropout mode during this measurement, V_{IN} must be varied between V_{OUT} nominal + 0.5 V (or 2.3 V, whichever is greater) and V_{IN} maximum. For example, a fixed 3.3 V output needs V_{IN} to be varied between 3.8 V and 5.5 V. This measurement can be repeated under different load conditions. Figure 11 shows the typical line regulation performance of the LDO with a fixed 3.3 V output.

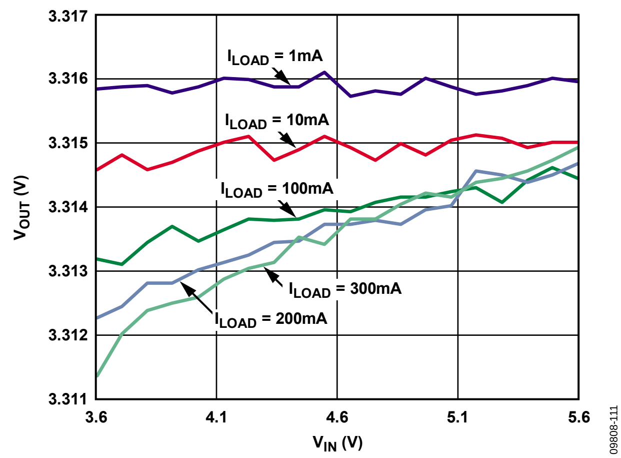

Figure 11. LDO Line Regulation

Measuring Load Regulation of LDO

For load regulation measurements, the regulator output is monitored while the load is varied. For good load regulation, the output must change as little as possible with varying loads. The input voltage must be held constant during this measurement. The load current can be varied from 0 mA to 300 mA. Figure 12 shows the typical load regulation performance of the LDO with a 3.3 V output for different input voltages.

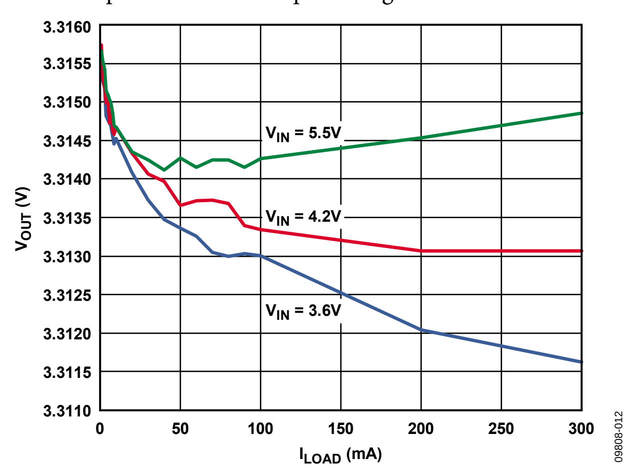

Figure 12. LDO Load Regulation

Measuring Dropout Voltage of LDO

Dropout voltage is defined as the input-to-output voltage differential when the input voltage is set to the nominal output voltage. One way to measure dropout voltage is to get the output voltage (V_{OUT} nominal) with V_{IN} initially set to V_{OUT} nominal + 0.5 V; output load can be set to 100 µA. Then, force the input voltage equal to V_{OUT} nominal, and measure the output voltage accordingly (V_{OUT} dropout). Dropout voltage is then calculated as V_{OUT} nominal – V_{OUT} dropout. This applies only for output voltages greater than 1.7 V. Dropout voltage increases with larger loads. For more accurate measurements, a second voltmeter can be used to monitor the input voltage across the input capacitor. The input supply voltage may need to be adjusted to account for IR drops, especially if large load currents are used.

Measuring Ground Current Consumption of LDO

Ground current measurements can determine how much current the internal circuits of the regulator consume while the circuits perform the regulation function. To be efficient, the regulator needs to consume as little current as possible. Typically, the regulator uses the maximum current when supplying its largest load level (300 mA). When the device is disabled, the ground current drops to less than 1 µA. Refer to Figure 14 for a detailed instruction on how to perform ground current measurements.

Cascading an LDO from the Buck Regulator

For certain applications such as analog circuit supplies, the LDOs are preferred over the bucks because of better noise performance. Where not all the buck outputs are being used, the input supply of the LDO can be taken from these outputs. An example demo board connection is shown in Figure 13 wherein VOUT1 is tied to VIN3, which is the supply of LDO1. In this configuration, the output voltage of the buck regulator should have enough headroom with the desired output voltage of the LDO to guarantee the LDO to operate within specifications.

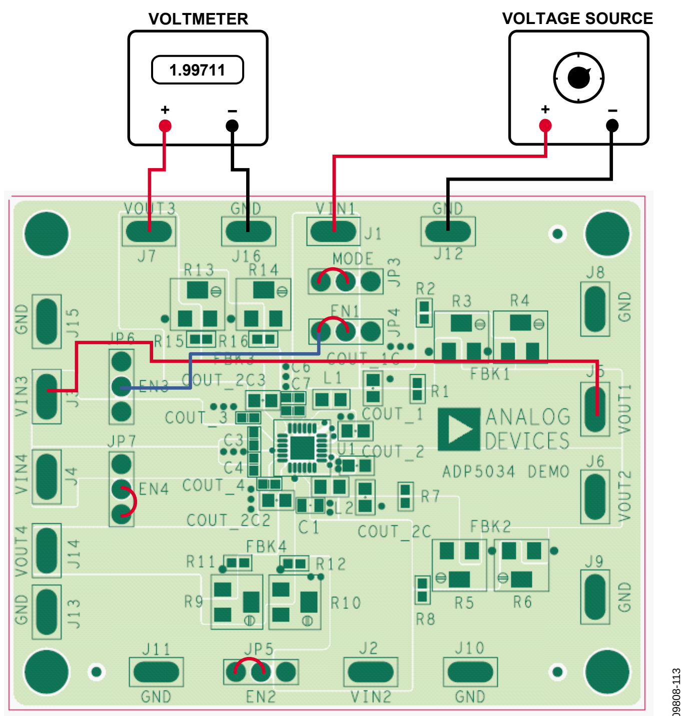

Figure 13. Cascading LDO from Buck

MEASURING OUTPUT VOLTAGE

Figure 14 shows how the evaluation board can be connected to a voltage source and a voltmeter for basic output voltage accuracy measurements.

Figure 14 shows a voltage source connected to VIN1 and a voltmeter connected to VOUT1, which is the output of Buck 1. EN1 is connected to VIN1 via a shunt, which enables Buck 1, and EN2, EN3, EN4 are connected to ground, disabling the other channels. When measuring the voltages on VOUT2, VOUT3, and VOUT4, make sure that the respective channels are enabled, and the voltmeters are connected to the respective outputs.

A resistor can be used as the load for the regulator. Ensure that the resistor has a power rating adequate to handle the power expected to be dissipated across it. An electronic load can also be used as an alternative. Ensure that the voltage source can supply enough current for the expected load levels.

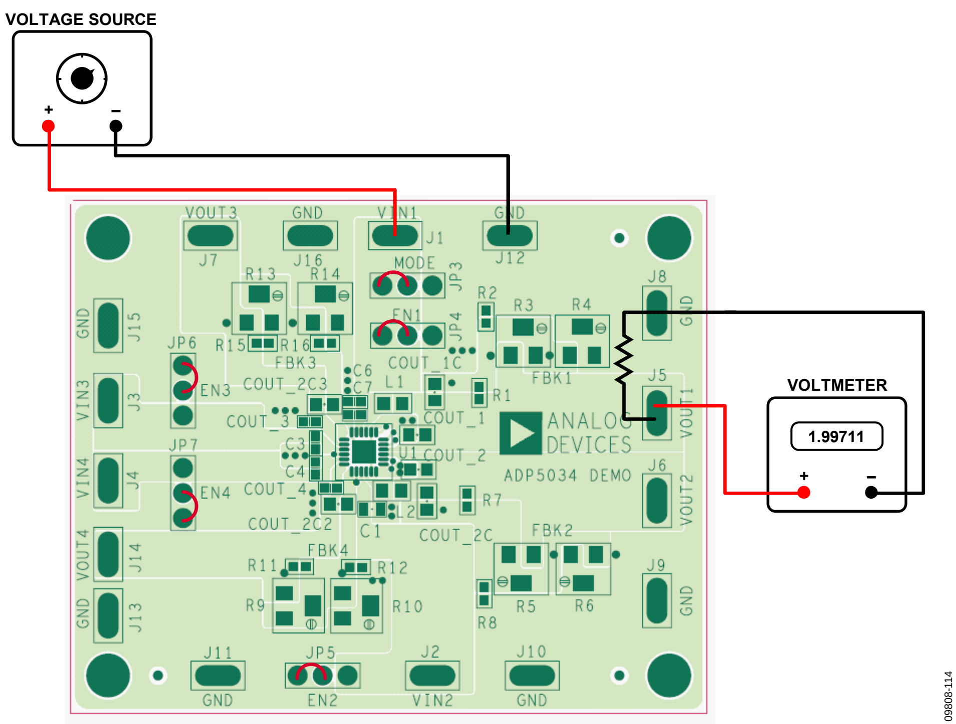

Figure 14. Ground Current Measurement

MEASURING GROUND CURRENT

Figure 15 shows the evaluation board connected to a voltage source and an ammeter for ground current measurements. A resistor can be used as the load for the regulator. Ensure that the resistor has a power rating that is adequate to handle the power expected to be dissipated across it. An electronic load can be used as an alternative. Ensure that the voltage source used can supply enough current for the expected load levels.

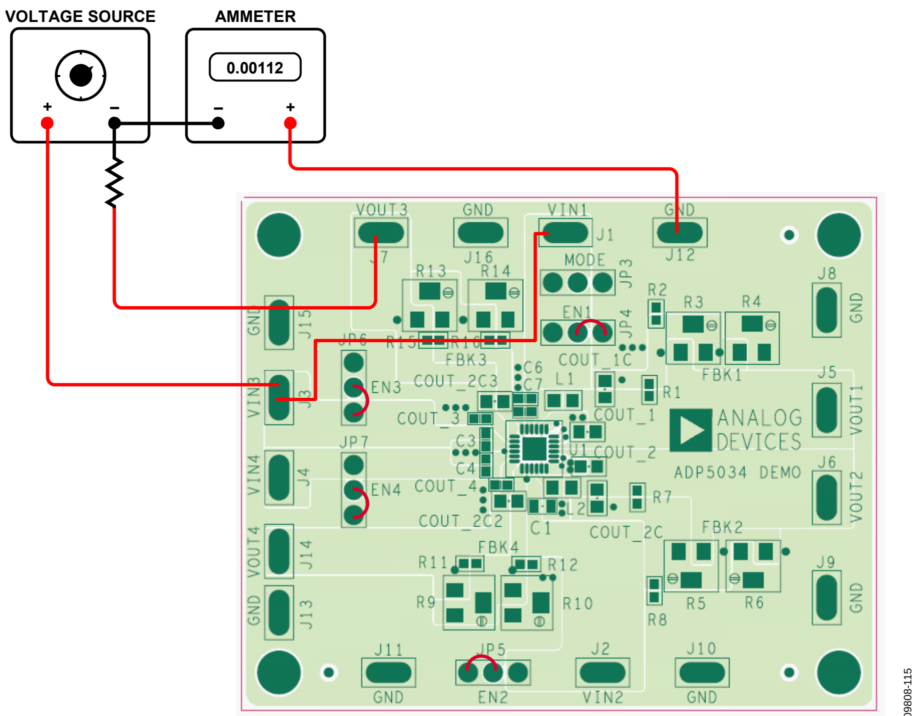

Figure 15. Ground Current Measurement

EVALUATION BOARD SCHEMATICS AND ARTWORK

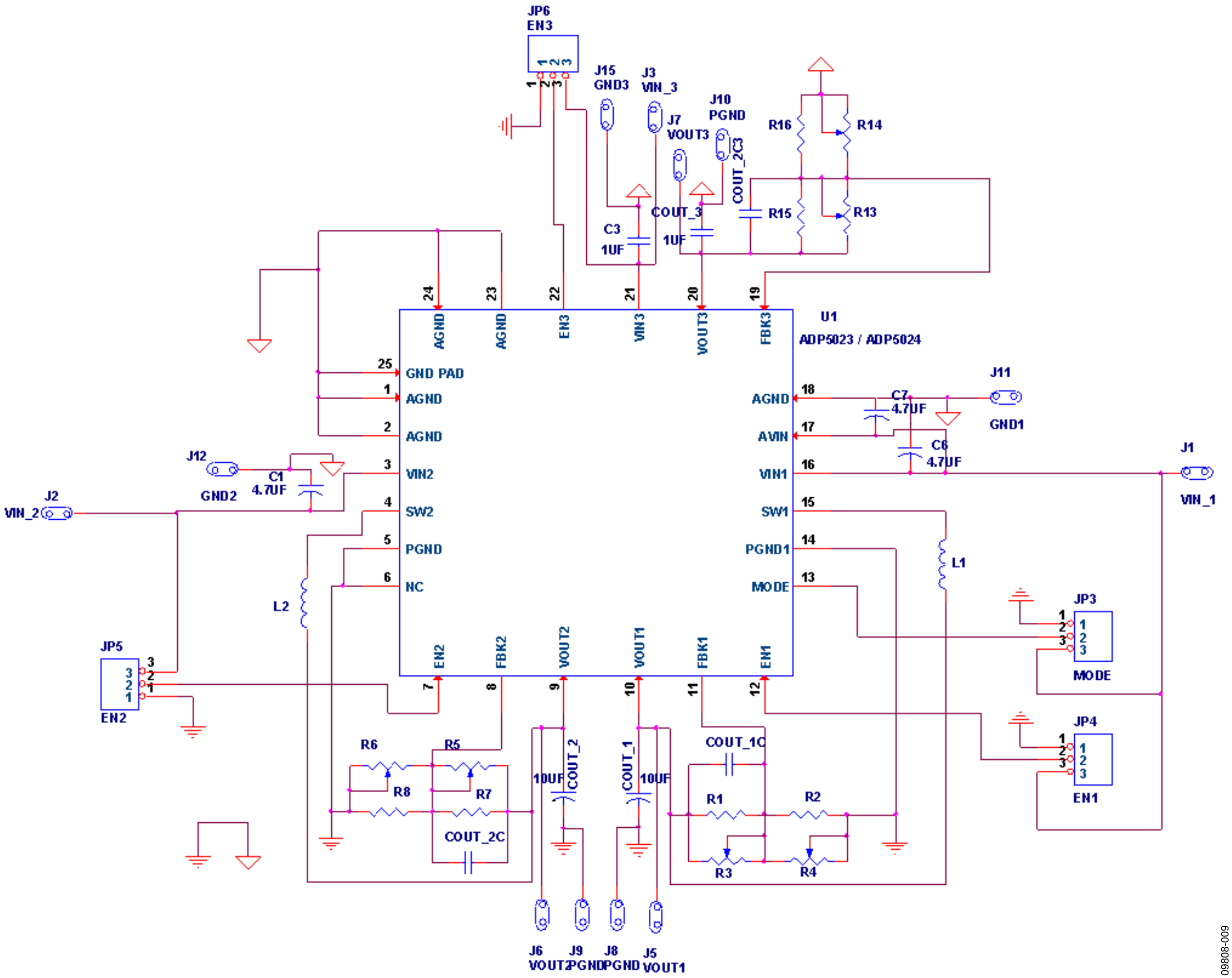

Figure 16. Evaluation Board Schematic of the ADP5023/ADP5024

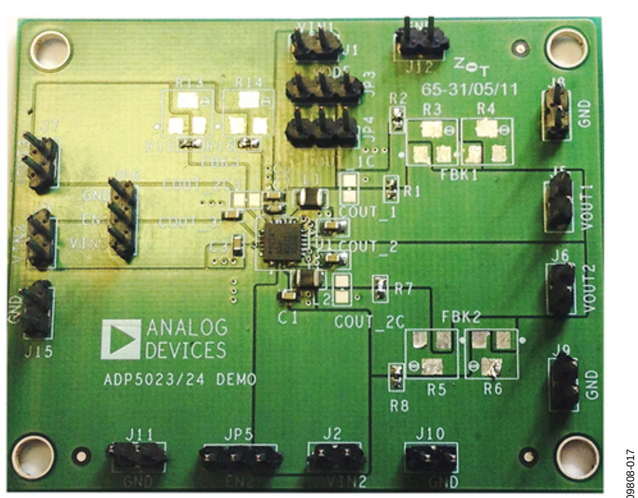

Figure 17. Evaluation Board Schematic of the ADP5023/ADP5024

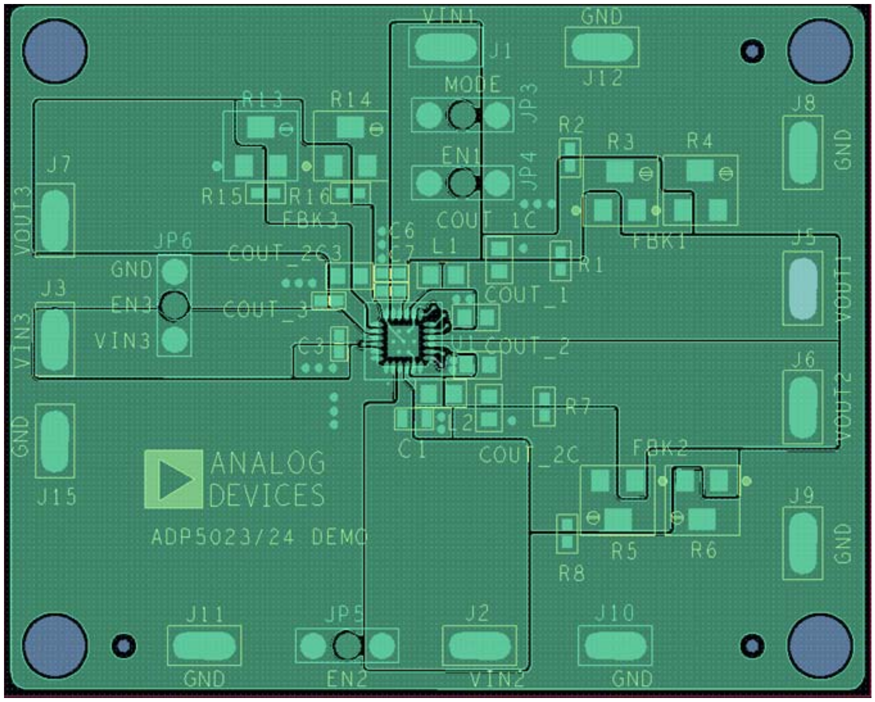

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Figure 18. Top Layer, Recommended Layout for ADP5023/ADP5024

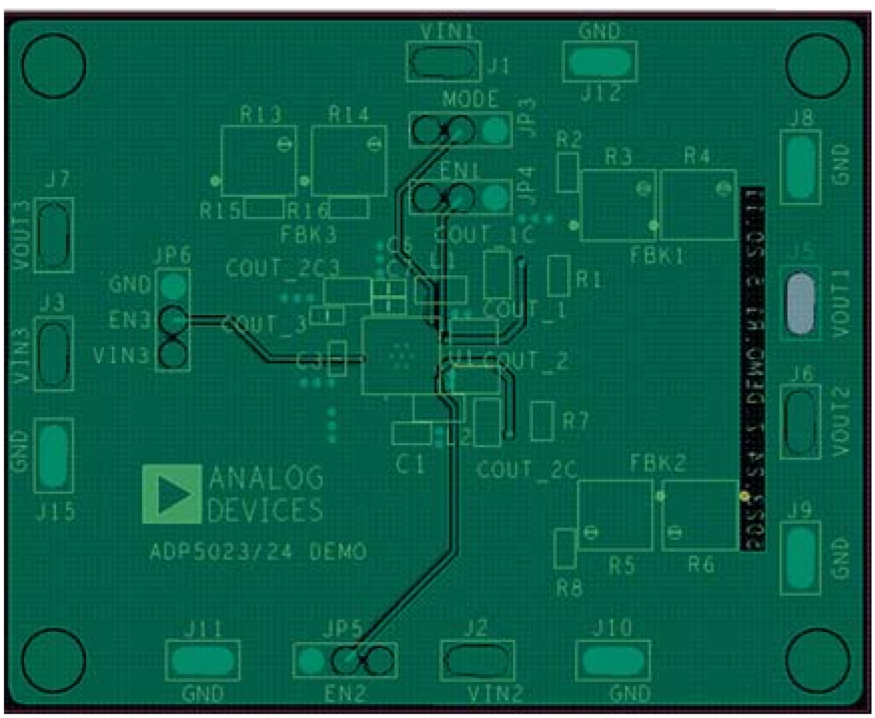

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Figure 19. Bottom Layer, Recommended Layout for ADP5023/ADP5024

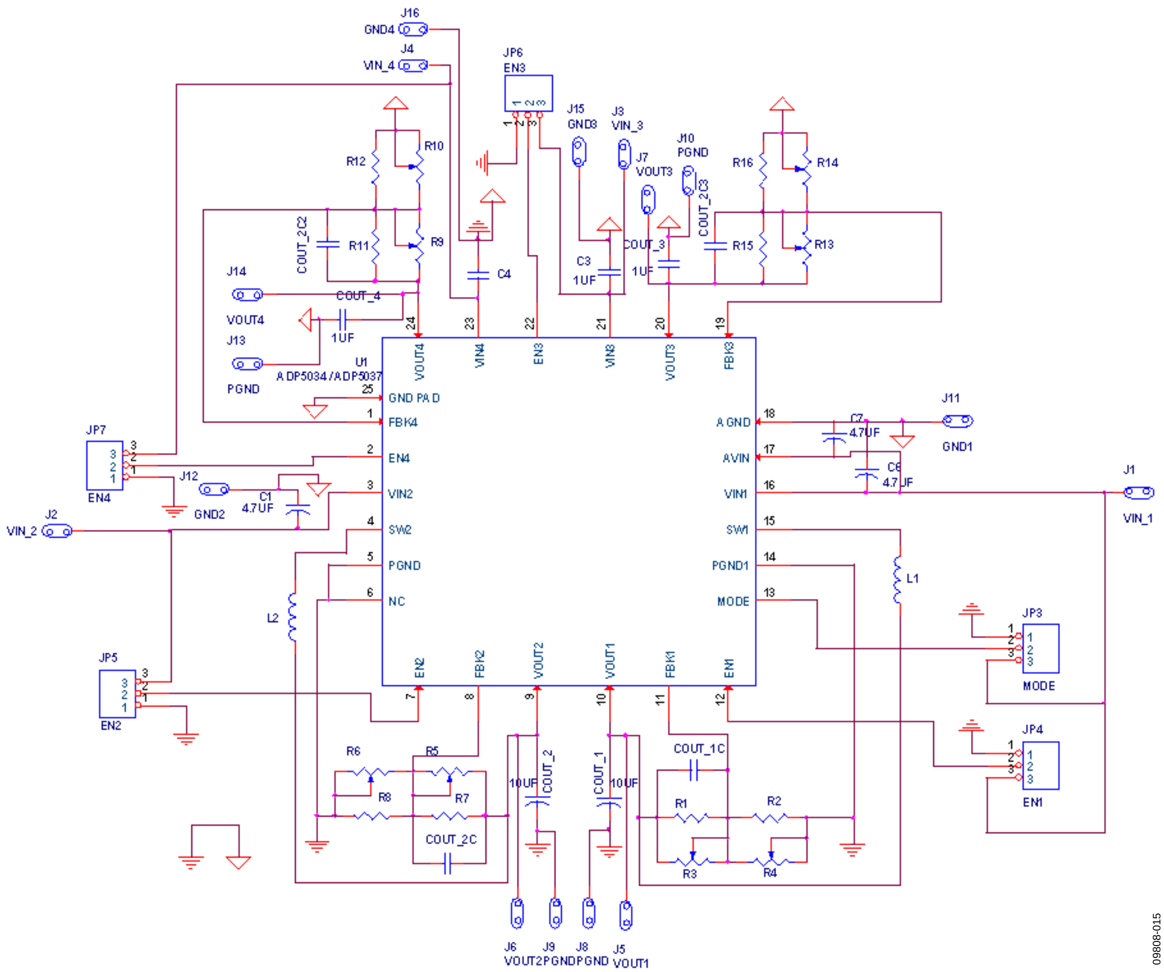

Figure 20. Evaluation Board Schematic of the ADP5034/ADP5037

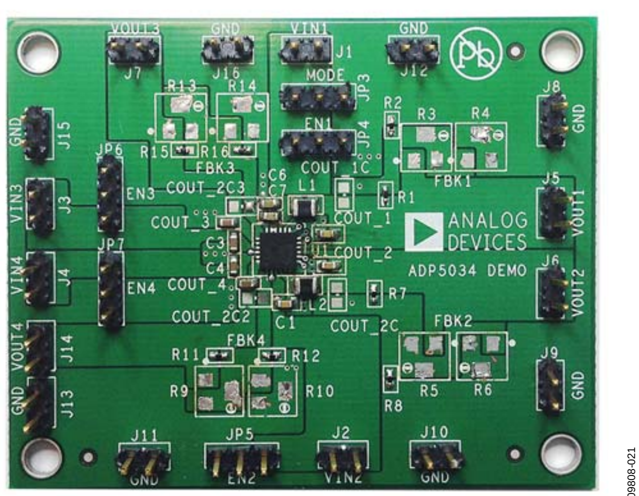

Figure 21. Evaluation Board Schematic of the ADP5034/ADP5037

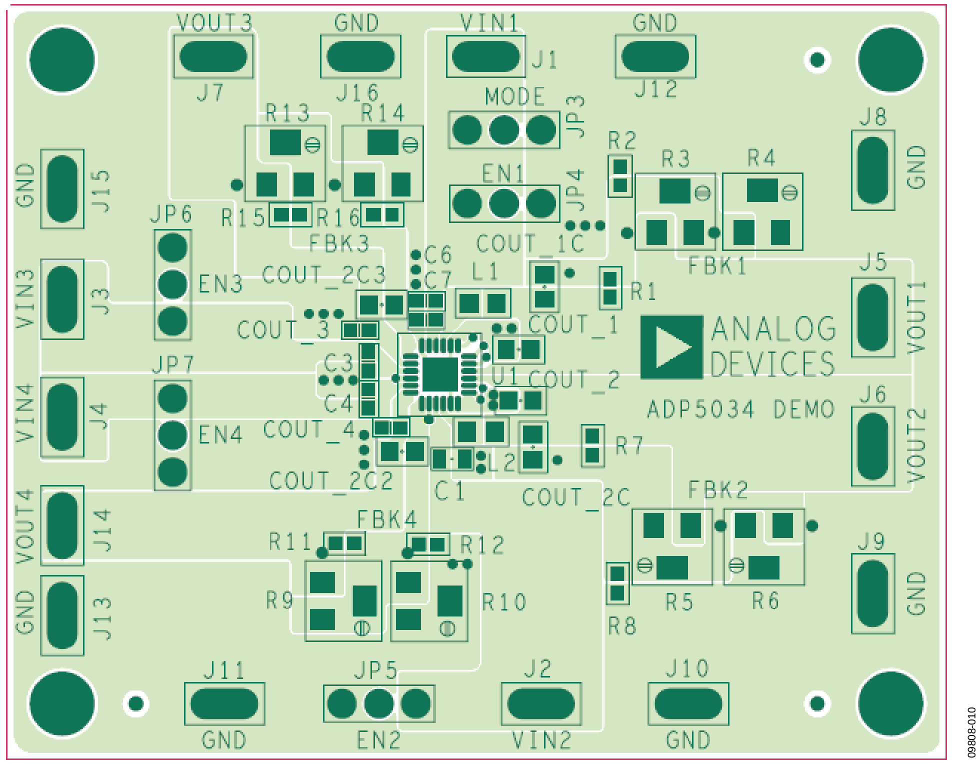

Figure 22. Top Layer, Recommended Layout for ADP5034/ADP5037

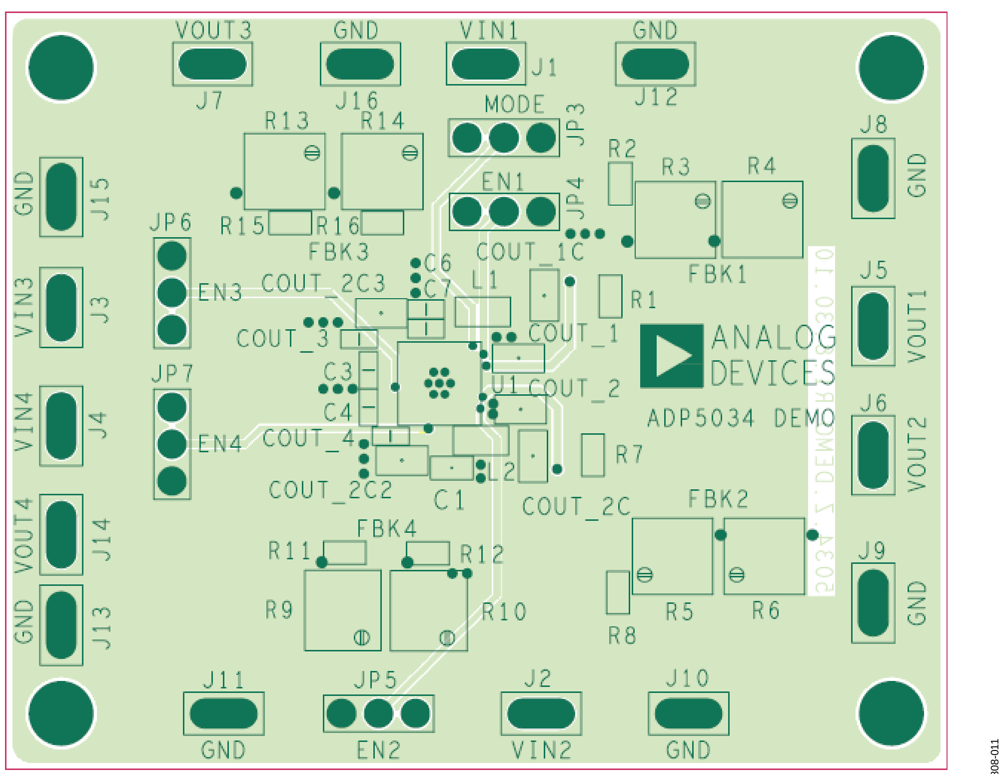

Figure 23. Bottom Layer, Recommended Layout for ADP5034/ADP5037

ORDERING INFORMATION

BILL OF MATERIALS

Table 4.

Qty.	Reference Designator	Description	Manufacturer	Part Number
1	U1	Micro PMU	Analog Devices	ADP5034 or ADP5037 or ADP5023 or ADP5024
2	C1, C6, C7	Capacitor, MLCC, 4.7 µF	Murata	GRM188R60J475ME19D
5	C4[1], C3, COUT_3, COUT_4[1]	Capacitor, MLCC, 1.0 µF	Murata	GRM188R60J105KA01B
2	COUT_2, COUT_1	Capacitor, MLCC, 10.0 µF	Murata	GRM188R60J106ME47D
2	L1, L2	Inductor, 1.0 µH	Murata	LQM2HPN1R0MJ0L
8	R3, R4, R5, R6, R9[1], R10[1], R13, R14	Trimmer resistors, 200 kΩ	Bournes, Inc.	3214W-1-204E
8	R8, R7, R1, R2, R15, R16, R11[1], R12[1]	Resistor, 0402, 49.9 K[2]	Vishay Draloric	CRCW040249K9FKED
4	COUT_1C, COUT_2C, COUT2C2[1], COUT_2C3	Not fitted	Not fitted	Not fitted

[1] With ADP5034/ADP5037 only.
[2] Subject to change depending on the output voltage chosen.

RELATED LINKS

Resource	Description
ADP5023	Dual 3 MHz, 800 mA Buck Regulator with One 300 mA LDO
ADP5024	Dual 3 MHz, 1200 mA Buck Regulators with One 300 mA LDO
ADP5034	Dual 3 MHz, 1200 mA Buck Regulator with Two 300 mA LDOs
ADP5037	Dual 3 MHz, 800 mA Buck Regulators with Two 300 mA LDOs

NOTES

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