

## Evaluating the **ADP5135** Micropower Management Unit

### FEATURES

- Full featured evaluation board for the **ADP5135****
- 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**
- Dedicated precision enable on each channel for easier power sequencing**
- Factory programmable soft start options**
- Factory programmable UVLO options**
- Dedicated power-good pins for monitoring**
- Mode option to change bucks from PFM to PWM operation**

### GENERAL DESCRIPTION

This user guide describes the hardware for the evaluation of the **ADP5135** micropower management unit (micro PMU), and includes detailed schematics and printed circuit board (PCB) layouts. The **ADP5135** is available in a 24-lead, 4 mm × 4 mm LFCSP.

The **ADP5135CP-EVALZ** LFCSP evaluation board has three step-down regulators that enable evaluation of the **ADP5135**. The evaluation board is available with an adjustable voltage option.

Full details specifications for the **ADP5135** are available in the **ADP5135** data sheet, which should be consulted in conjunction with this user guide when using this evaluation board.

### **ADP5135CP-EVALZ** EVALUATION BOARD PHOTOGRAPH



Figure 1.

## TABLE OF CONTENTS

|                                                       |   |                                                             |    |
|-------------------------------------------------------|---|-------------------------------------------------------------|----|
| Features .....                                        | 1 | Measuring Performance .....                                 | 6  |
| General Description .....                             | 1 | Measuring Output Voltage Ripple of the Buck Regulator ..... | 6  |
| ADP5135CP-EVALZ Evaluation Board Photograph .....     | 1 | Measuring the Switching Waveform of the Buck Regulator..... | 6  |
| Revision History .....                                | 2 | Measuring the Load Regulation of the Buck Regulator .....   | 6  |
| Setting Up the Hardware .....                         | 3 | Measuring Line Regulation of Buck .....                     | 7  |
| Enable.....                                           | 3 | Measuring Buck Efficiency .....                             | 7  |
| Jumper P17 (MODE) .....                               | 3 | Measuring Inductor Current .....                            | 7  |
| Input Power Source .....                              | 3 | Connecting Regulators in Sequence .....                     | 8  |
| Output Load .....                                     | 4 | Measuring Output Voltage .....                              | 9  |
| Input and Output Voltmeters.....                      | 4 | Measuring Ground Current .....                              | 10 |
| Powering Up the Evaluation Board.....                 | 5 | Evaluation Board Schematics and Artwork.....                | 11 |
| Setting the Output Voltage of the Bucks .....         | 5 | Ordering Information.....                                   | 14 |
| External Resistor Divider Setting for the Bucks ..... | 5 | Bill of Materials.....                                      | 14 |
| Power-Good Pins for Output Voltage Monitoring .....   | 5 | Related Links.....                                          | 14 |

## REVISION HISTORY

12/14—Revision 0: Initial Version

## SETTING UP THE HARDWARE

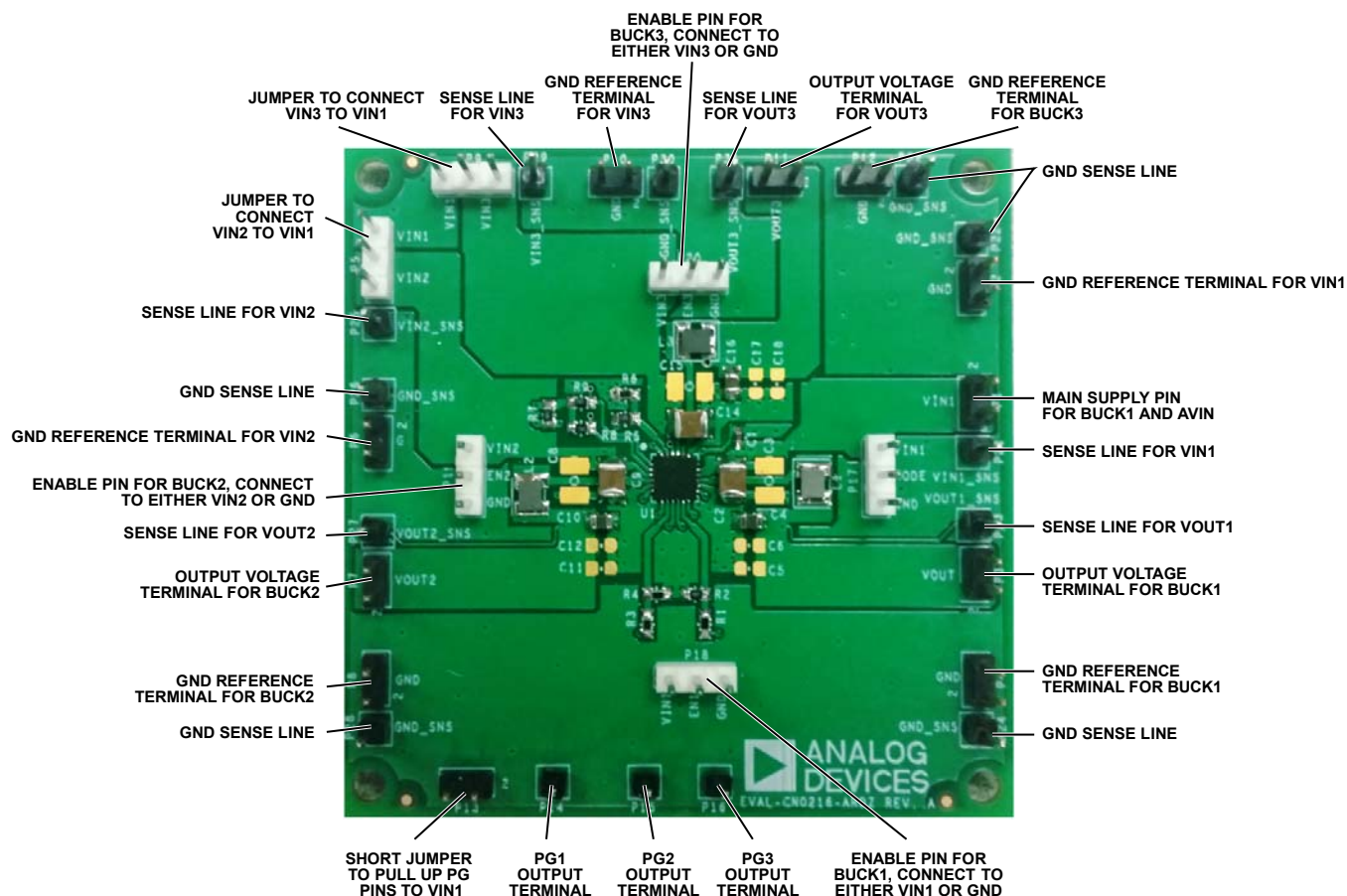


Figure 2. Evaluation Board Overview

The [ADP5135CP-EVALZ](#) 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

| Channel | Enable Pin |
|---------|------------|
| 1       | P18        |
| 2       | P19        |
| 3       | P20        |

### JUMPER P17 (MODE)

Jumper P17 connects the MODE pin of the device to either ground or VIN1. To force BUCK1, BUCK2, and BUCK3 into forced PWM operation, shunt the center contact of Jumper P17 (MODE) to the top pin header to pull the MODE pin high to VIN1. To allow BUCK1, BUCK2, and BUCK3 to operate in automatic PWM/PSM operation, shunt the center contact of P17 (MODE) to the bottom pin header to pull the MODE pin low to GND.

### INPUT POWER SOURCE

If the input power source includes a current meter, use that meter to monitor the input current. The board allows easy connection of all power supply pins to the main power source at terminal P1 (VIN1).

To connect the power supply pins to the main power source, shunt the center contact of Jumper P5 (VIN2) to the top pin header to connect VIN2 to VIN1. Then, shunt Jumper P9 to the left pin header to connect VIN3 to VIN1.

Connect the positive terminal of the power source to P1 (VIN1) on the evaluation board, and connect the negative terminal of the power source to P2 (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, connect the negative lead (–) of the power source to P2 (GND) on the evaluation board, and connect the negative lead (–) of the ammeter to P1 (VIN1) on the evaluation board. Note 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 BUCK1, P3 (VOUT1), and the negative (–) load connection to P4 (GND)

If an ammeter is used, connect it in series with the load. Connect the positive (+) ammeter terminal to the evaluation board for BUCK1, P3 (VOUT1), connect the negative (–) ammeter terminal to the positive (+) load terminal, and connect the negative (–) load terminal to the evaluation board at P4 (GND).

## INPUT AND OUTPUT VOLTMETERS

Measure the input and output voltages with voltmeters. Ensure 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 P21 (VIN1\_SNS), and connect input voltage measuring voltmeter negative (–) terminal to the evaluation board at P22 (GND\_SNS).

Connect the output voltage measuring voltmeter positive (+) terminal to the evaluation board at P23 (VOUT1\_SNS) for measuring the output voltage of BUCK1, and connect the output voltage measuring voltmeter negative (–) terminal to the evaluation board at P24 (GND\_SNS).

## POWERING UP THE EVALUATION BOARD

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

Before powering up the board, ensure that

- The power source voltage for the bucks (VIN1, VIN2, and VIN3) ranges from 3.0 V 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 3 for BUCK1. Optionally, the output voltage can be factory programmed to default values as indicated in the [ADP5135](#) data sheet. In this case, 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.

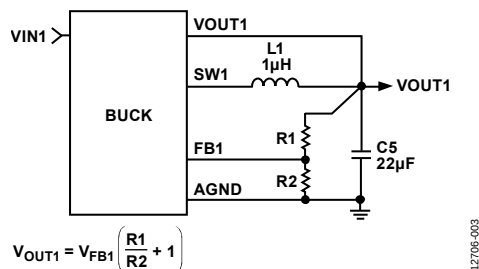


Figure 3. BUCK1 External Output Voltage Setting

## EXTERNAL RESISTOR DIVIDER SETTING FOR THE BUCKS

The [ADP5135CP-EVALZ](#) evaluation board is 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 shows the resistor divider assignments on the evaluation board.

Table 2. External Resistor Dividers (Fixed)

| Resistor Divider | BUCK1 | BUCK2 | BUCK3 |
|------------------|-------|-------|-------|
| R <sub>TOP</sub> | R1    | R3    | R5    |
| R <sub>BOT</sub> | R2    | R4    | R6    |

## POWER-GOOD PINS FOR OUTPUT VOLTAGE MONITORING

Each buck has a dedicated power-good output to monitor the output voltages of the three regulators. In the [ADP5135](#) LFCSP, the BUCK1 power-good output is available at Pin 6 (PG1); the BUCK2 power-good output is available at Pin 2 (PG2); and the BUCK3 power-good output is available at Pin 1 (PG3). Each PGx pin is set to logic low when the monitored VOUTx falls below 85% of the nominal VOUTx level. The power-good function also allows sequencing and enabling of external regulators tied to the PGx pins.

As shown in Figure 4, the [ADP5135CP-EVALZ](#) board has pull-up resistors tied between the open-drain PGx pins and a supply rail. To connect the pull-up resistors to VIN1, shunt Pin 1 to Pin 2 of Jumper P13.

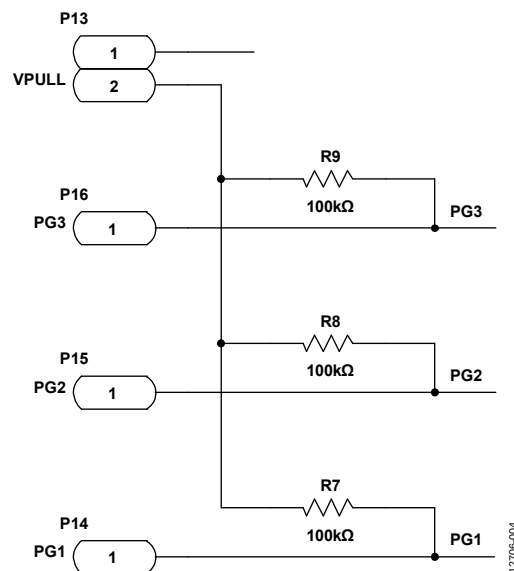


Figure 4. Power-Good Pin Circuit

## MEASURING PERFORMANCE

### MEASURING OUTPUT VOLTAGE RIPPLE OF THE BUCK REGULATOR

To observe the output voltage ripple of BUCK1, place an oscilloscope probe across the output capacitor (C4) 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  $\mu$ s/division time base, with bandwidth set to 20 MHz to avoid noise that can interfere with the measurements. It is recommended to shorten the ground loop of the oscilloscope probe to minimize coupling.

A good way to measure 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.

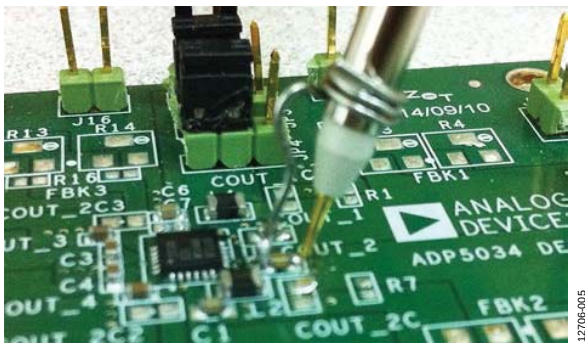


Figure 5. Measuring Output Voltage Ripple

### MEASURING THE SWITCHING WAVEFORM OF THE BUCK REGULATOR

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 PSM and PWM switching waveforms are shown in Figure 6 and Figure 7, respectively.

### MEASURING THE LOAD REGULATION OF THE BUCK REGULATOR

Test the load regulation by increasing the load at the output and observing 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.

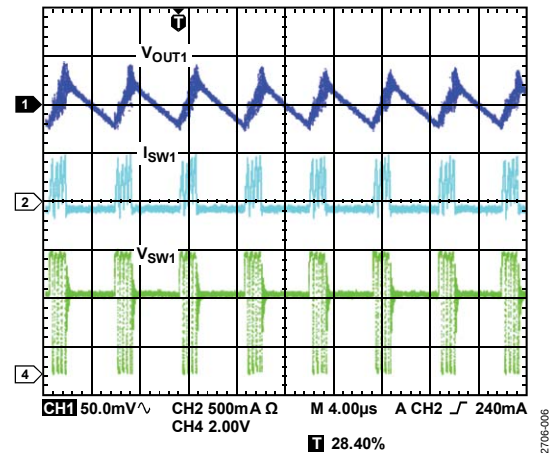


Figure 6. Typical Waveforms,  $V_{OUT1} = 3.3$  V,  $I_{OUT1} = 30$  mA, PSM Mode

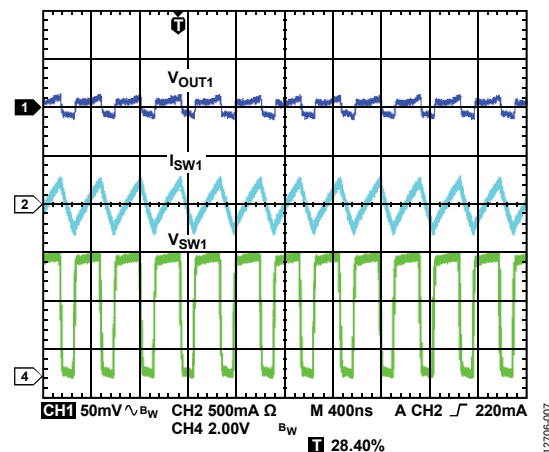


Figure 7. Typical Waveforms,  $V_{OUT1} = 3.3$  V,  $I_{OUT1} = 30$  mA, PWM Mode

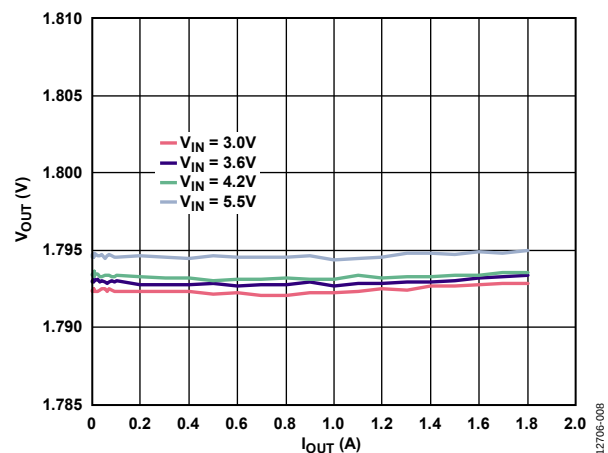


Figure 8. Buck Load Regulation

## MEASURING LINE REGULATION OF BUCK

To measure the line regulation, vary the input voltage and observe the change in the output voltage.

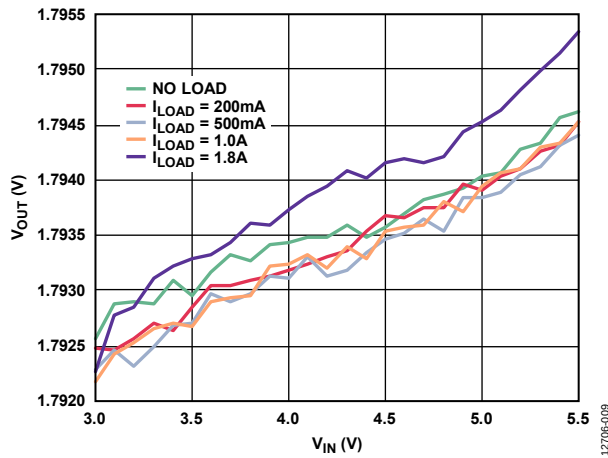


Figure 9. Buck Line Regulation

## MEASURING BUCK EFFICIENCY

Measure the efficiency,  $\eta$ , 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.

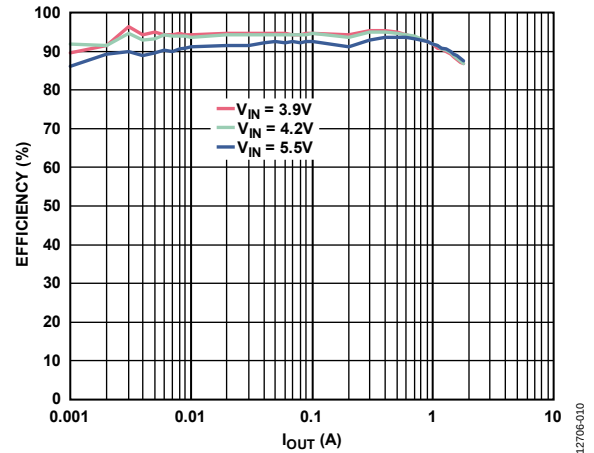


Figure 10. Buck1 PSM Efficiency, Across  $V_{IN}$ ,  $V_{OUT1} = 3.3\text{V}$

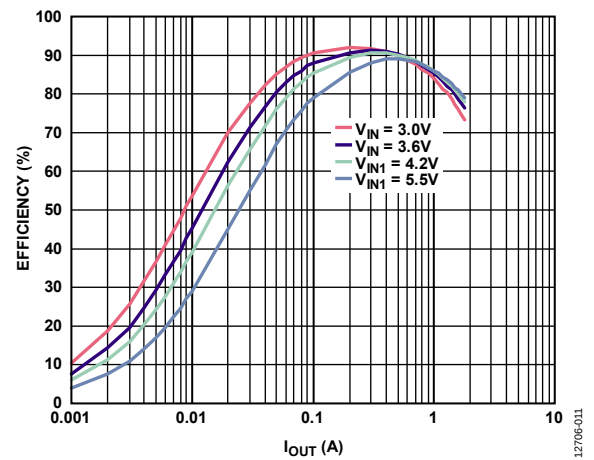


Figure 11. Buck2 FPWM Efficiency, Across  $V_{IN}$ ,  $V_{OUT2} = 1.8\text{V}$

## 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.

## CONNECTING REGULATORS IN SEQUENCE

Figure 12 shows the jumper connections when regulators are powered up in sequence. The EN1 pin of BUCK1 is tied to VIN1 through Jumper P18, which allows automatic startup for BUCK1, whereas the ENx pins of the other regulators are tied in sequence.

Connecting a resistor divider to VOUT1 allows activation of BUCK2 when BUCK1 reaches its target level. In this setup, the regulator startups are controlled so that BUCK1 turns on first, followed by BUCK2, then BUCK3. By changing the connections of the resistor dividers, a different start-up sequence can be achieved.

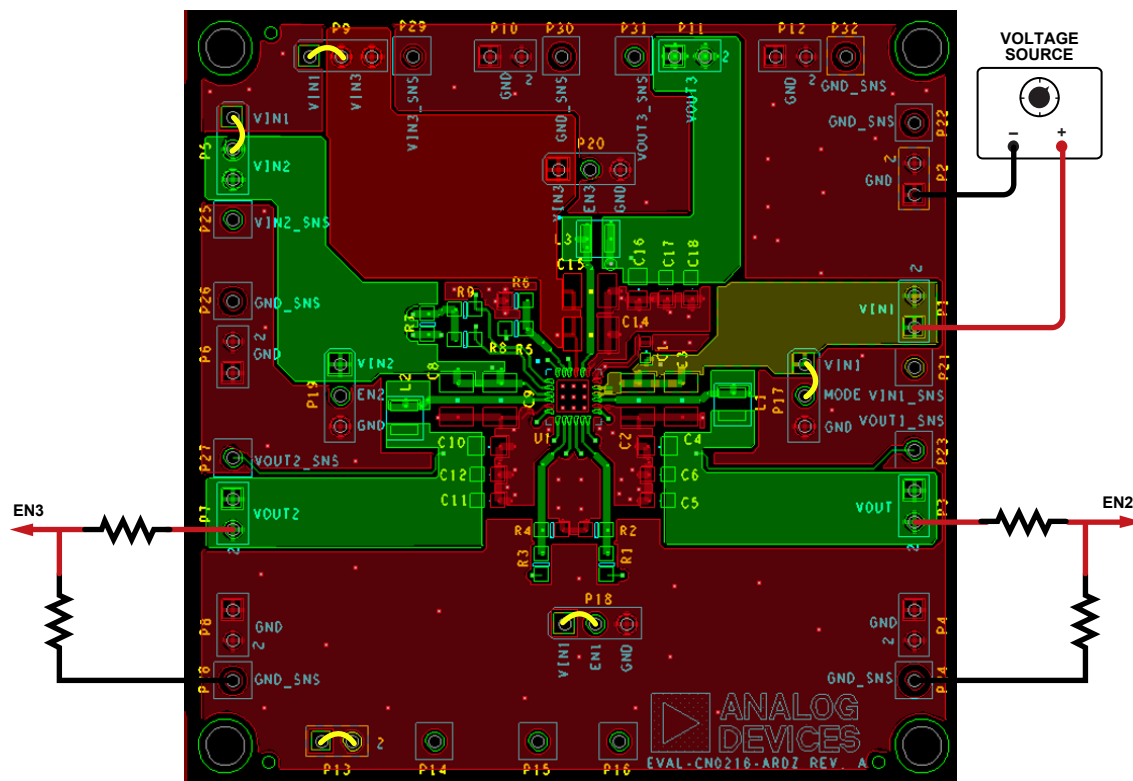


Figure 12. Regulators Connected in Sequence

12706-012

## MEASURING OUTPUT VOLTAGE

Figure 13 shows how the evaluation board can be connected to a voltage source and a voltmeter for basic output voltage accuracy measurements.

Figure 13 shows a voltage source connected to VIN1 and a voltmeter connected to VOUT1, which is the output of BUCK1. EN1 is connected to VIN1 via a shunt, which enables BUCK1, and EN2 and EN3 are connected to ground, disabling the other channels. When measuring the voltages on VOUT2 and VOUT3,

ensure that the respective channels are enabled and that 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.

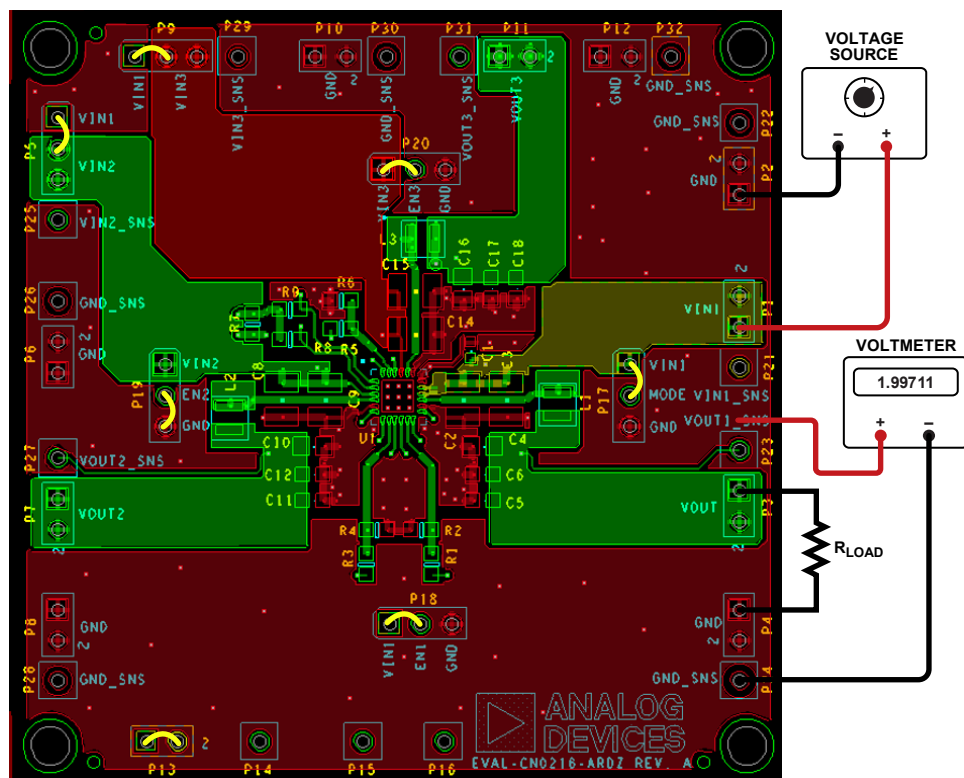
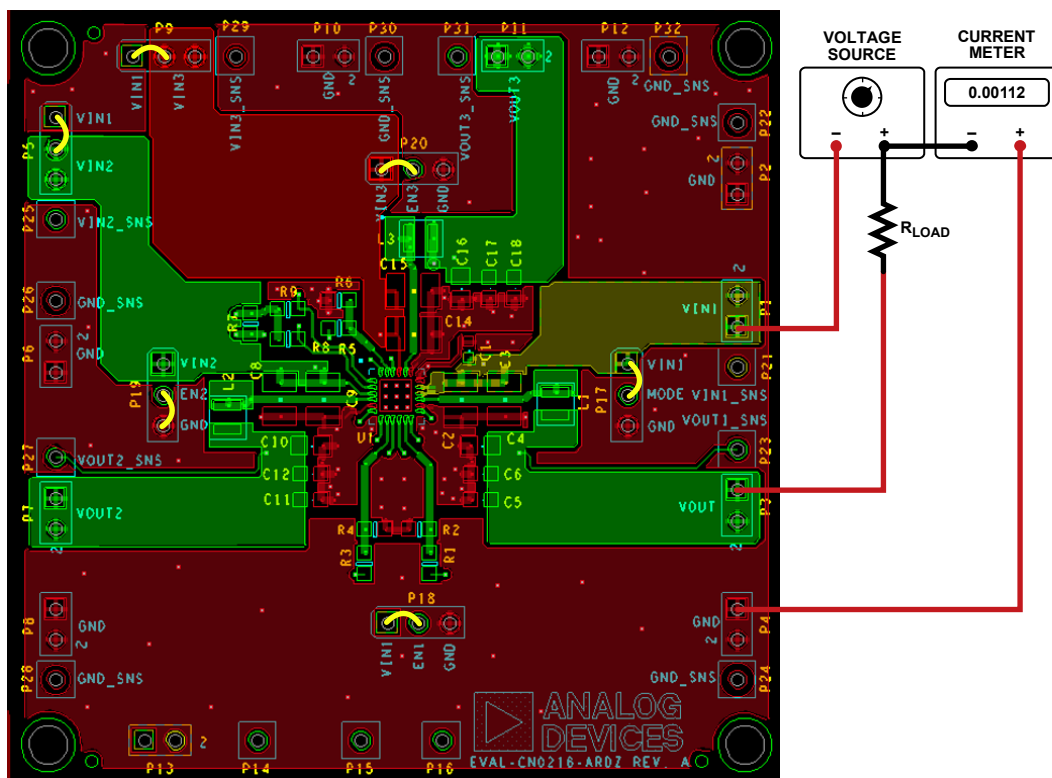


Figure 13. Output Voltage Measurement

## MEASURING GROUND CURRENT

Figure 14 shows the evaluation board connected to a voltage source and a current meter 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.



## EVALUATION BOARD SCHEMATICS AND ARTWORK

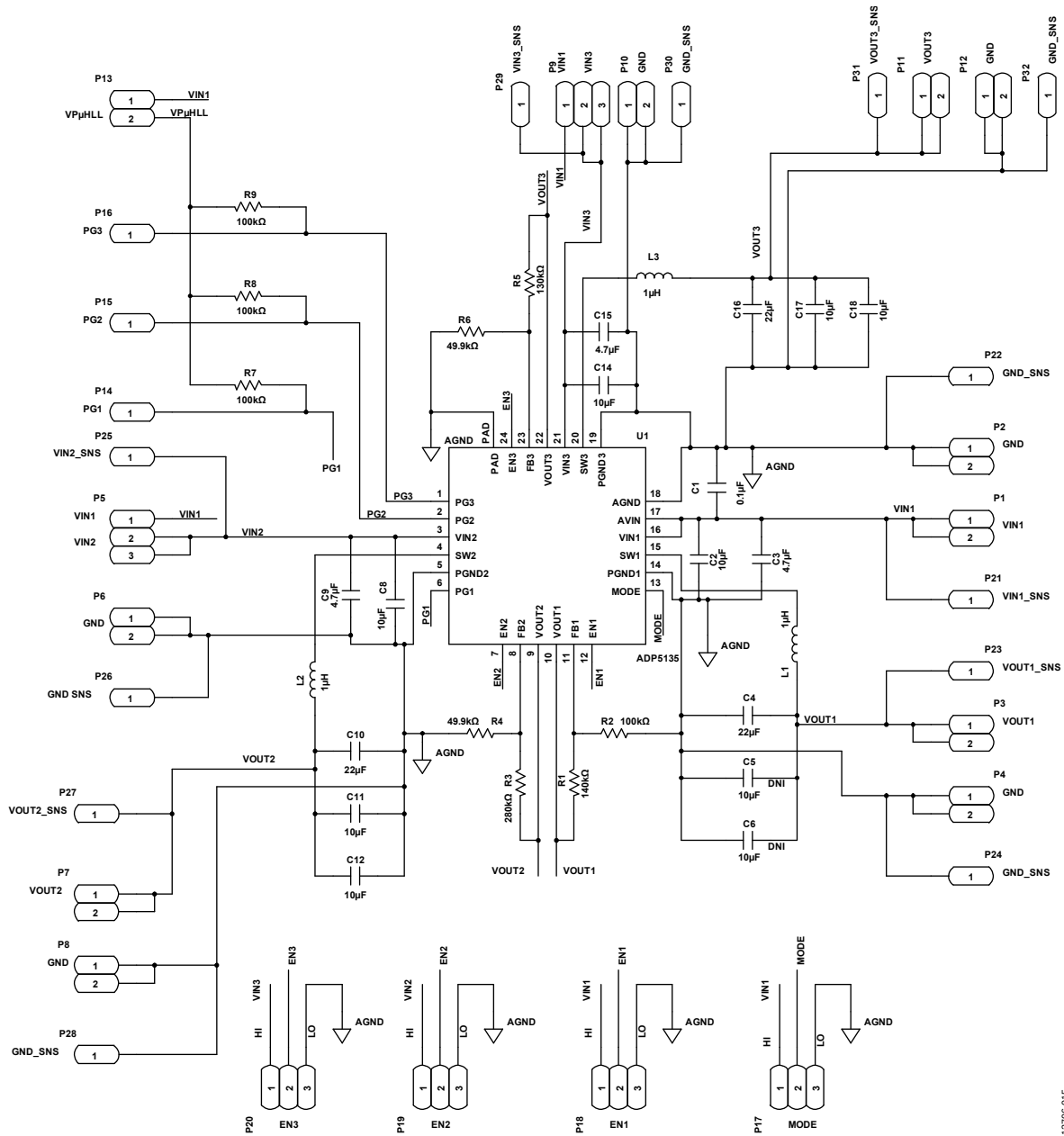


Figure 15. ADP5135CP-EVALZ Evaluation Board Schematic

12705-015

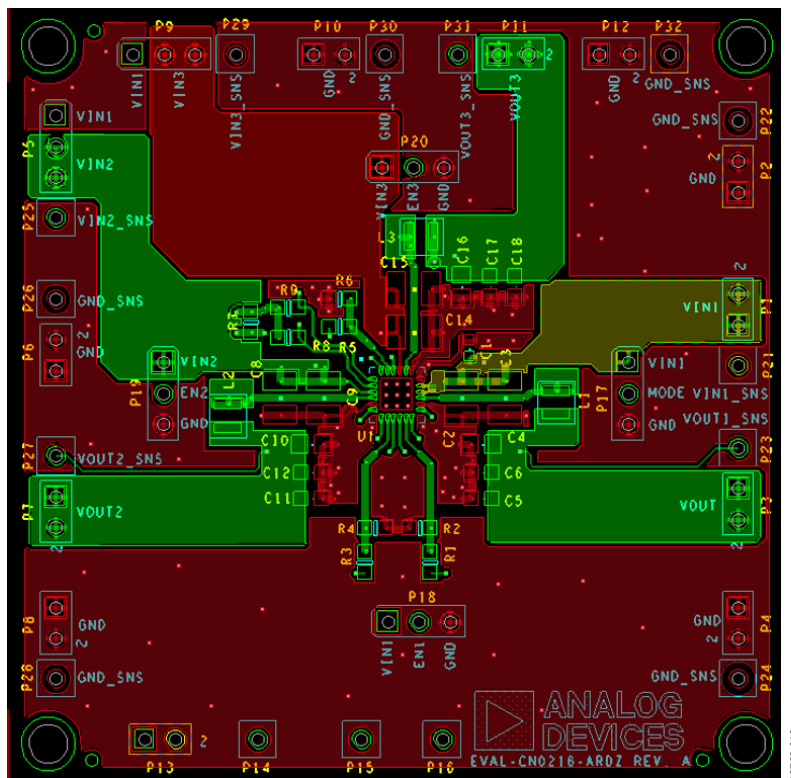


Figure 16. Top Layer, ADP5135CP-EVALZ Layout

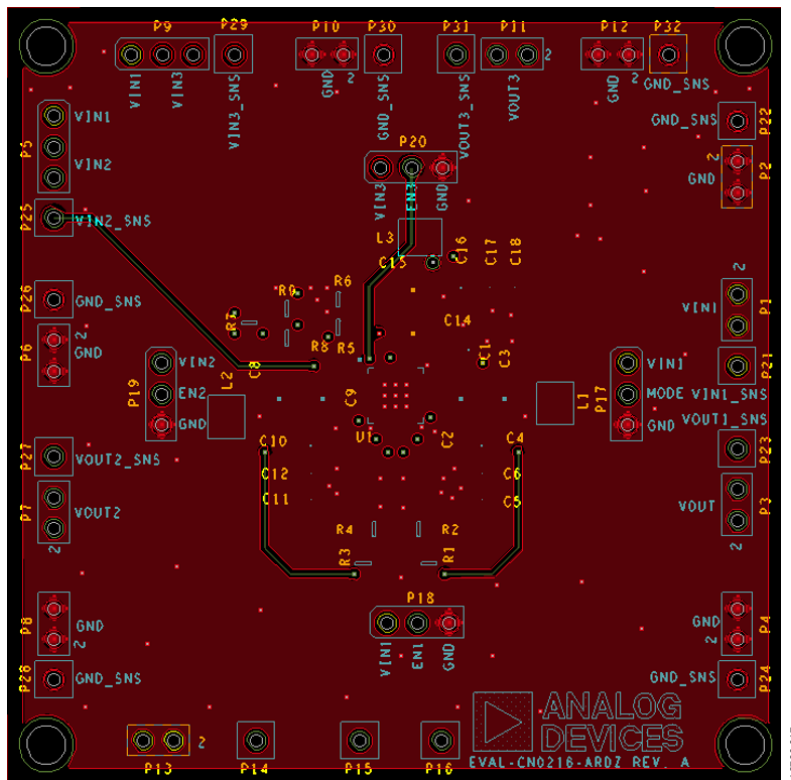


Figure 17. Layer 2 (GND Plane), ADP5135CP-EVALZ Layout

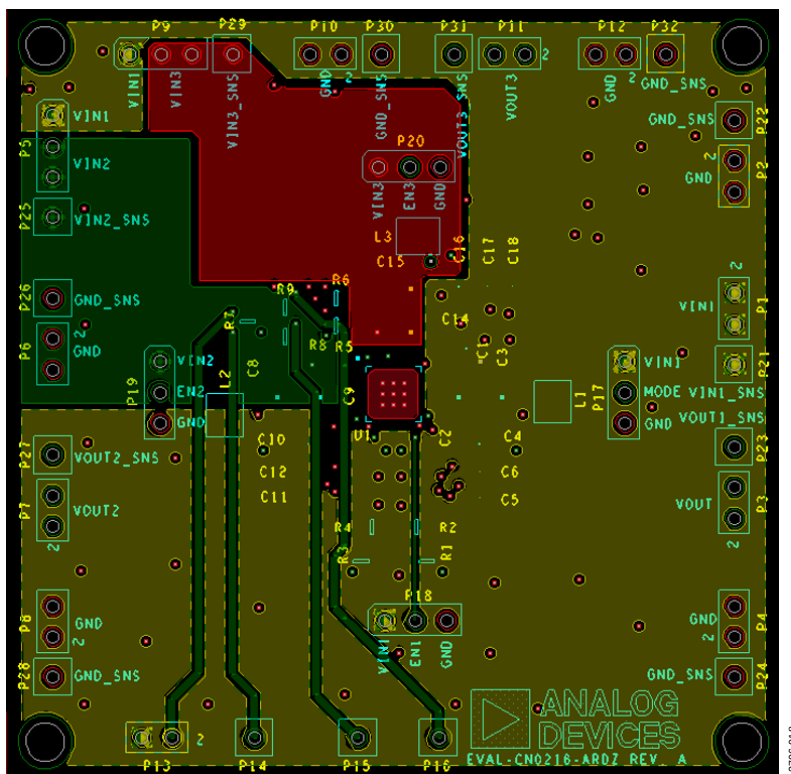


Figure 18. Layer 3 (PWR Plane), ADP5135CP-EVALZ Layout

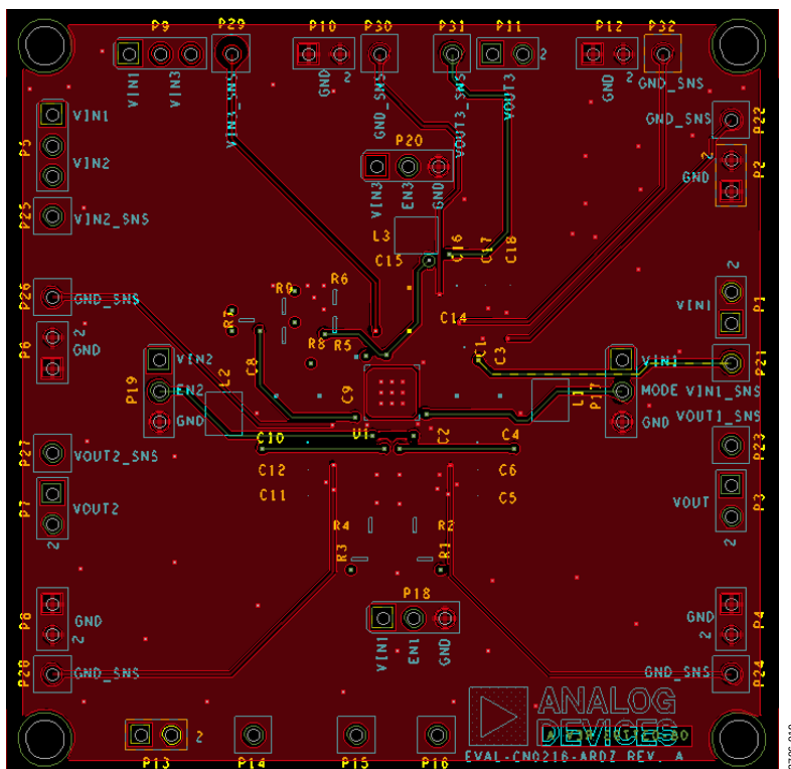


Figure 19. Bottom Layer, ADP5135CP-EVALZ Layout

## ORDERING INFORMATION

## BILL OF MATERIALS

Table 3.

| Qty. | Reference Designator       | Description                     | Manufacturer         | Part Number             |
|------|----------------------------|---------------------------------|----------------------|-------------------------|
| 1    | U1                         | Micro PMU                       | Analog Devices, Inc. | <a href="#">ADP5135</a> |
| 1    | C1                         | Capacitor, MLCC, 0.1 $\mu$ F    | Murata               | GRM155R71C104KA88D      |
| 3    | C2, C8, C14                | Capacitor, MLCC, 10.0 $\mu$ F   | Murata               | GRM32DR61E106KA12L      |
| 3    | C4, C10, C16               | Capacitor, MLCC, 22.0 $\mu$ F   | Taiyo Yuden          | LMK212BJ226MG-T         |
| 2    | L1, L2                     | Inductor, 1.0 $\mu$ H           | Wurth Elektronik     | 74438323010             |
| 1    | R1                         | Resistor, 0603, 140 k $\Omega$  | Panasonic            | ERJ-3EKF1403V           |
| 4    | R2, R7, R8, R9             | Resistor, 0603, 100 k $\Omega$  | Panasonic            | ERJ-3EKF1003V           |
| 1    | R3                         | Resistor, 0603, 280 k $\Omega$  | Panasonic            | ERJ-3EKF2803V           |
| 2    | R4, R6                     | Resistor, 0603, 49.9 k $\Omega$ | Panasonic            | ERJ-3EKF4992V           |
| 1    | R5                         | Resistor, 0603, 49.9 k $\Omega$ | Multicomp            | MC0603SAF1303T5E        |
| 3    | C3, C9, C15                | Capacitor, MLCC, 4.7 $\mu$ F    | Not fitted           | Not fitted              |
| 6    | C5, C6, C11, C12, C17, C18 | Capacitor, MLCC, 10.0 $\mu$ F   | Not fitted           | Not fitted              |

## RELATED LINKS

| Resource                | Description                                                                                          |
|-------------------------|------------------------------------------------------------------------------------------------------|
| <a href="#">ADP5023</a> | Dual 3 MHz, 800 mA buck regulator with one 300 mA LDO                                                |
| <a href="#">ADP5024</a> | Dual 3 MHz, 1200 mA buck regulators with one 300 mA LDO                                              |
| <a href="#">ADP5034</a> | Dual 3 MHz, 1200 mA buck regulator with two 300 mA LDOs                                              |
| <a href="#">ADP5037</a> | Dual 3 MHz, 800 mA buck regulators with two 300 mA LDOs                                              |
| <a href="#">ADP5033</a> | Dual 3 MHz, 800 mA buck regulators with two 300 mA LDOs with two EN pins                             |
| <a href="#">ADP5133</a> | Dual 3 MHz, 800 mA buck regulators with two EN pins                                                  |
| <a href="#">ADP5134</a> | Dual 3 MHz, 1200 mA buck regulators with two 300 mA LDOs with precision enable and power-good output |
| <a href="#">AN-1311</a> | Application Note, <i>Complex Power Supply Sequencing Made Easy</i>                                   |

**ESD Caution**

**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

**Legal Terms and Conditions**

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS (\$100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.