

## Evaluation Board for the **ADP2387** 20 V, 6 A Synchronous, Step-Down, DC-to-DC Regulator

### FEATURES

- Input voltage: 4.5 V to 20 V**
- ±1% output voltage accuracy**
- Integrated MOSFET: 44 mΩ typical/11 mΩ typical**
- Continuous output current: 6 A**
- Programmable current-limit threshold**
- Programmable switching frequency: 200 kHz to 1.4 MHz**
- Precision enable and power good**
- External compensation**
- Internal soft start with external adjustable option**
- Startup into a precharged output**

### GENERAL DESCRIPTION

The **ADP2387-EVALZ** evaluation board is a complete 6 A, 20 V, step-down regulator solution that allows users to evaluate the performance of the **ADP2387** with a near ideal printed circuit board (PCB) layout.

The programmable current-limit function allows the inductor to be optimized by output current. The peak current-limit threshold is preset to 9 A to ensure the 6 A output current capability.

The switching frequency can be programmed between 200 kHz and 1.4 MHz, which provides the possibility for a stackable multiphase power solution.

The output of the **ADP2387-EVALZ** evaluation board is preset to 3.3 V, and the switching frequency is set to 600 kHz. Different output voltage settings can be achieved by changing the appropriate passive components. The ambient temperature operating range is  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ .

Full details on the **ADP2387** regulator are provided in the **ADP2387** data sheet, available from Analog Devices, Inc., which should be consulted in conjunction with this user guide when working with this evaluation board.

### EVALUATION BOARD PHOTOGRAPH

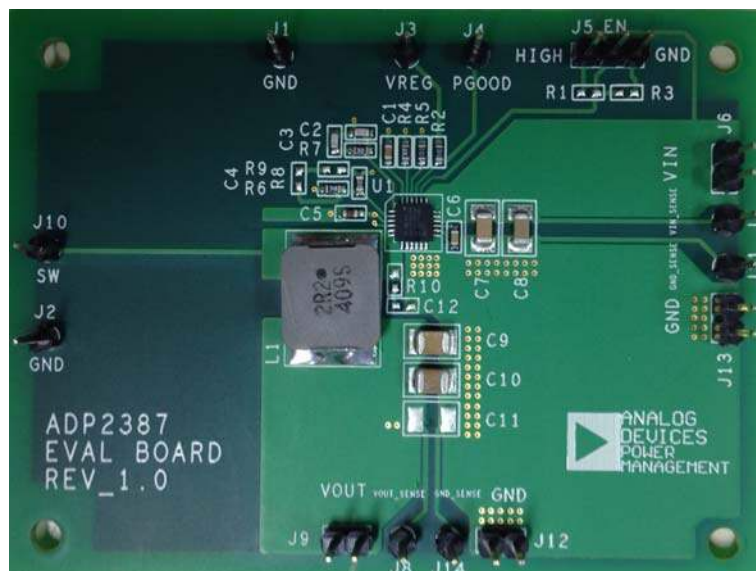


Figure 1.

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**REVISION HISTORY**

**1/16—Revision A: Initial Version**

## USING THE EVALUATION BOARD

### POWERING UP

The ADP2387-EVALZ evaluation board is supplied fully assembled and tested. Before applying power to the evaluation board, follow the procedures in this section.

#### **Jumper J5 (Enable)**

Use one of the following methods to enable or to disable the regulator:

- To enable the regulator, short the middle pin of J5, EN, to high.
- To disable the regulator, short the middle pin of J5, EN, to GND.

#### **Input Power Source**

If the input power source includes a current meter, use that meter to monitor the input current. Connect the positive terminal of the power source to J6 (VIN) of the evaluation board, and the negative terminal of the power source to J13 (GND) of the evaluation board.

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 positive (+) ammeter terminal, the negative lead (-) of the power source to J13 (GND), and the negative lead (-) of the ammeter to J6 (VIN).

#### **Output Load**

Before connecting the load, ensure that the board is turned off. Connect an electronic load or resistor to set the load current.

Connect the positive terminal of the load to J9 (VOUT) of the evaluation board and connect the negative terminal of the load to J12 (GND).

#### **Input and Output Voltmeter**

Measure the input and output voltages using voltmeters. Make sure that the voltmeters are connected to the appropriate terminals of the evaluation board and not to the load or power source. If the voltmeters are not connected directly to the evaluation board, the measured voltages are incorrect due to the voltage drop across the leads and/or connections between the evaluation board, the power source, and/or the load.

To measure the input voltage, connect the positive terminal of the voltmeter to J7 (VIN\_SENSE) and the negative terminal to J11 (GND\_SENSE). Likewise, to measure the output voltage, connect the positive terminal of the voltmeter to J8 (VOUT\_SENSE) and the negative terminal to J14 (GND\_SENSE).

#### **Turning On the Evaluation Board**

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

Perform the following steps to turn on the board:

1. Ensure that the power source voltage is >4.5 V and <20 V.
2. Ensure that EN is high, and monitor the output voltage.
3. Turn on the load, check that it is drawing the proper load current, and verify that the output voltage maintains its regulation.

## MEASURING EVALUATION BOARD PERFORMANCE

### **Measuring the Switching Waveform**

To observe the switching waveform with an oscilloscope, place the oscilloscope probe tip at Test Point J10 (SW) with the probe ground at J2 (GND). Set the scope to dc with the appropriate voltage and time divisions. The switching waveform limits alternate approximately between 0 V and the input voltage.

### **Measuring Load Regulation**

Test the load regulation by observing the change in the output voltage with increasing output load current. To minimize the voltage drop, use short low resistance wires.

### **Measuring Line Regulation**

Vary the input voltage and examine the change in the output voltage with a fixed output current.

### **Line Transient Response**

Generate a step input voltage change and observe the behavior of the output voltage using an oscilloscope.

### **Load Transient Response**

Generate a load current transient at the output and observe the output voltage response using an oscilloscope. Attach the current probe to the wire between the output and the load to capture the current transient waveform.

### **Measuring Efficiency**

The efficiency ( $\eta$ ) is measured 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 voltage drop.

### **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 onto this wire.

**Measuring Output Voltage Ripple**

To observe the output voltage ripple, place the oscilloscope probe across the output capacitor with the probe ground lead connected to the negative (-) capacitor terminal and the probe tip placed at the positive (+) capacitor terminal. Set the oscilloscope to ac, 10 mV/division, 2 μs/division time base, and 20 MHz bandwidth.

A standard oscilloscope probe has a long wire ground clip. For high frequency measurements, this ground clip picks up high frequency noise and injects it into the measured output ripple. Figure 2 shows an easy way to measure the output ripple properly. Remove the oscilloscope probe sheath and wrap an unshielded wire around the oscilloscope probe. By keeping the ground length of the oscilloscope probe as short as possible, the true ripple can be measured.

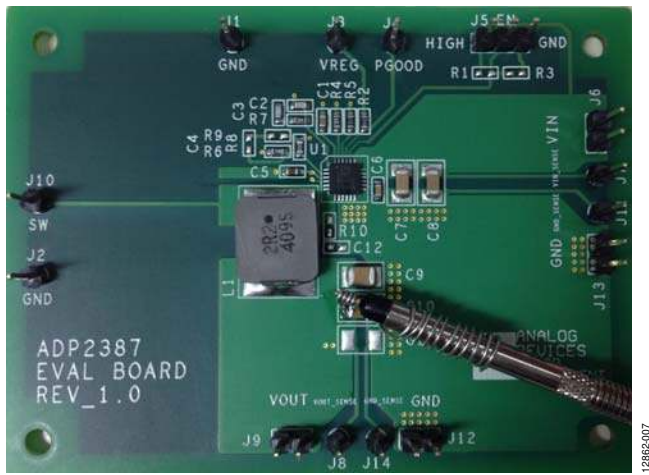


Figure 2. Measuring Output Voltage Ripple

**MODIFYING THE BOARD**

To modify the ADP2387 evaluation board configuration, unsolder and/or replace or remove the appropriate passive components or jumpers on the board.

**Changing the Output Voltages**

The output voltage set points of the ADP2387 can be changed by replacing the R8 and R6 resistors with the resistor values shown in Table 1.

Table 1. Resistive Divider for Various Output Voltages

VOUT (V)	R8, ±1% (kΩ)	R6, ±1% (kΩ)
1.0	10	15
1.2	10	10
1.5	15	10
1.8	20	10
2.5	47.5	15
3.3	10	2.21
5.0	22	3

To limit output voltage accuracy degradation due to the FB pin bias current (0.1 μA maximum) to less than 0.5% (maximum), ensure that the bottom divider string resistor, R6, is less than 30 kΩ.

The value of the top resistor (R8) is calculated using the following equation:

$$R8 = R6 \times \left( \frac{V_{OUT} - 0.6 \text{ V}}{0.6 \text{ V}} \right)$$

When the output voltage is changed, the values of the inductor (L1), the output capacitors (C9, C10, and C11), and the compensation components (R7, C2, and C3) must be recalculated and changed to ensure stable operation (see the ADP2387 data sheet for details on external component selection).

**Changing the Switching Frequency**

The switching frequency (f<sub>sw</sub>) set point can be changed by replacing the R5 resistor with a different value, as shown in the following equation:

$$f_{sw} \text{ [kHz]} = 69,120 / (R5 \text{ [k}\Omega\text{]} + 15)$$

A 215 kΩ resistor sets the frequency to 300 kHz, and a 100 kΩ resistor sets the frequency to 600 kHz.

When the switching frequency is changed, the values of the inductor (L1), the output capacitors (C9, C10, and C11), and the compensation networks (R7, C2, and C3) must be recalculated and changed for stable operation (see the ADP2387 data sheet for details on external component selection).

**Changing the Soft Start Time**

The soft start time of the ADP2387 on the evaluation board is programmed to 4 ms.

To change the soft start time (t<sub>ss</sub>), replace the C1 capacitor value using the following equation:

$$C1 \text{ [nF]} = 5.17 \times t_{ss} \text{ [ms]}$$

**Changing the Peak Current-Limit Threshold**

The peak current-limit threshold of ADP2387 can be changed by replacing the R4 resistor with a different value, as shown in the following equation:

$$I_{OCP} \text{ [A]} = 405 / (R4 \text{ [k}\Omega\text{]} + 0.5)$$

A 44.2 kΩ resistor sets the current-limit threshold to 9.2 A, a 66.5 kΩ resistor sets the current-limit threshold to 6.1 A, and a 133 kΩ resistor sets the current-limit threshold to 2.9 A.

By programming the peak current-limit threshold at different levels, the value and size of the inductor (L1) can be optimized based on actual applications.

# EVALUATION BOARD SCHEMATIC AND ARTWORK

## SCHEMATIC

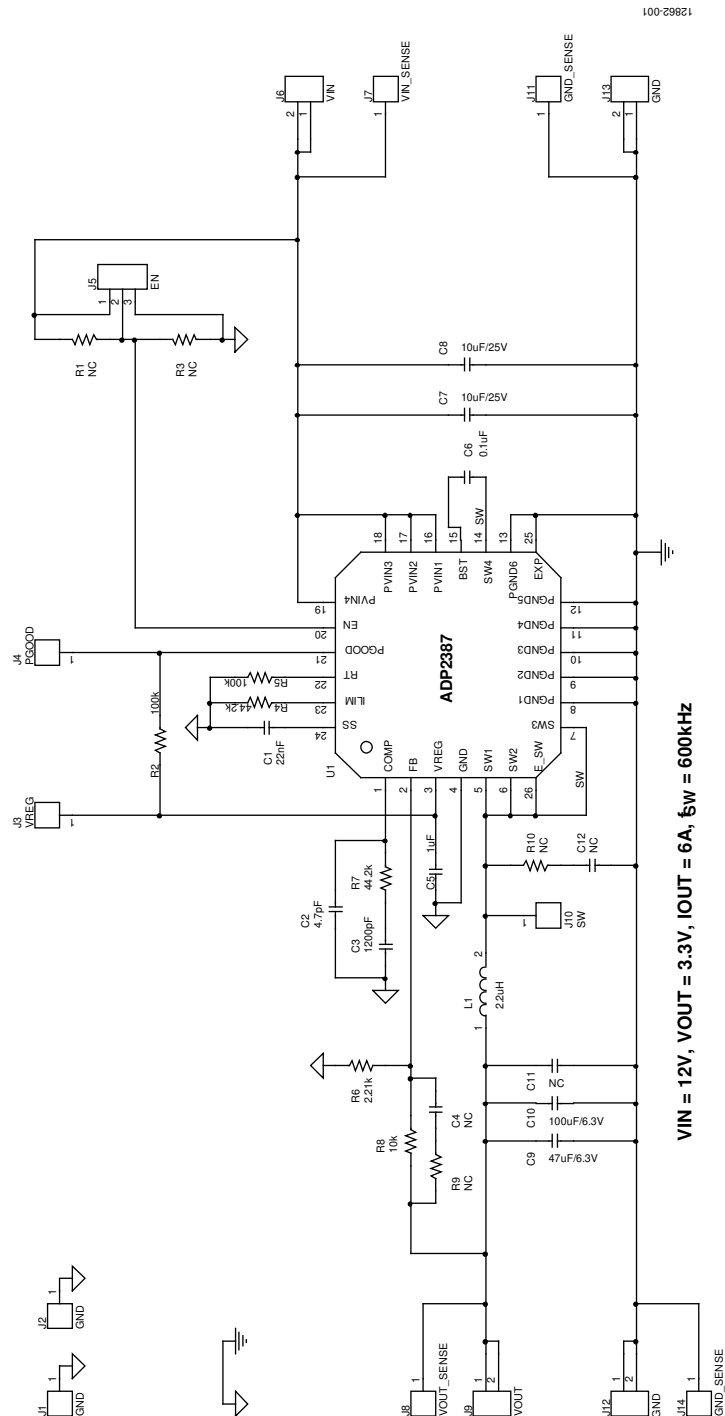


Figure 3. Evaluation Board Schematic for the [ADP2387](#)

PCB LAYOUT

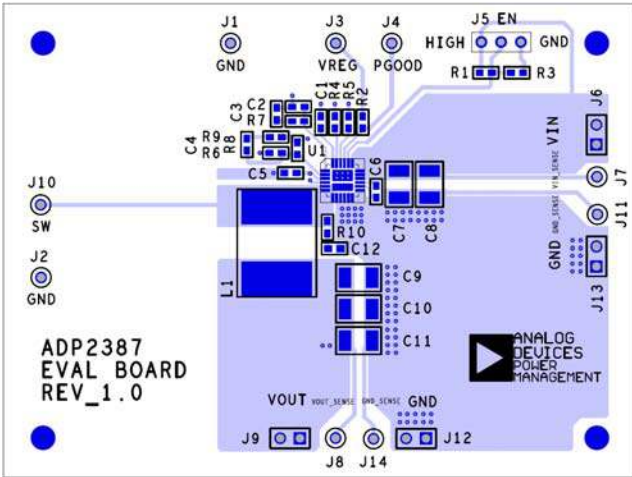


Figure 4. Layer 1, Component Side

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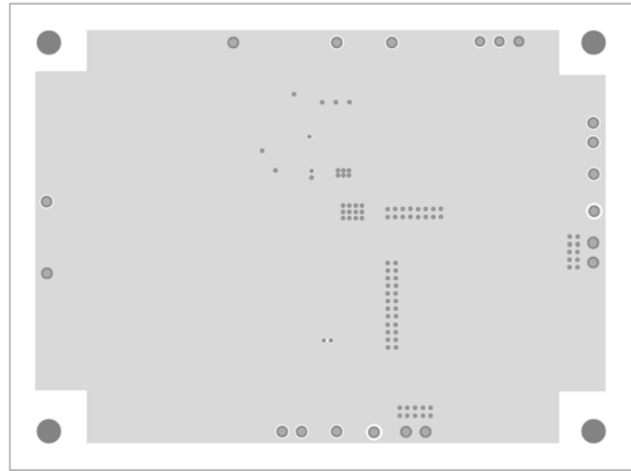


Figure 6. Layer 2, Ground Plane

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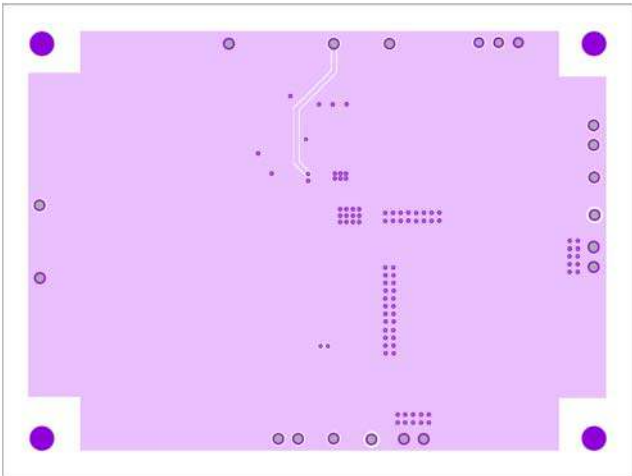


Figure 5. Layer 3, Power Plane

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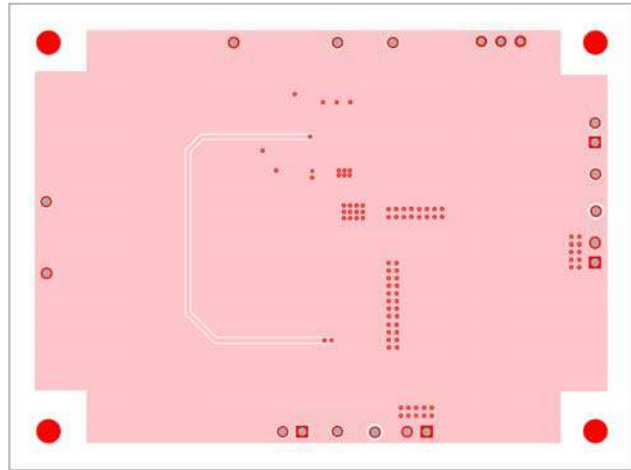


Figure 7. Layer 4, Bottom Side

12862-005

## ORDERING INFORMATION

### BILL OF MATERIALS

Table 2.

Qty	Reference Designator	Description	Part Number/Vendor
1	C1	22 nF, 16 V, capacitor, 0603	GRM188R71C223KA01D/Murata
1	C2	4.7 pF, 50 V, capacitor, 0603	GRM1885C1H4R7CZ01D/Murata
1	C3	1200 pF, 50 V, capacitor, 0603	GRM188R71H122KA01D/Murata
2	C4, C12	Optional, capacitor, 0603	Optional/Murata
1	C5	1 $\mu$ F, 16 V, capacitor, 0603	GRM188R61C105KA93D/Murata
1	C6	0.1 $\mu$ F, 16 V, capacitor, 0603	GRM188R71C104KA01D/Murata
2	C7, C8	10 $\mu$ F, 25 V, capacitor, 1206	GRM31CR61E106MA12L/Murata
1	C9	47 $\mu$ F, 6.3 V, capacitor, 1210	GRM32ER70J476KE19L/Murata
1	C10	100 $\mu$ F, 6.3 V, capacitor, 1210	GRM32ER60J107ME20L/Murata
1	C11	Optional, capacitor, 1210	Optional/Murata
1	L1	Inductor, FDVE1040, L = 2.2 $\mu$ H, I <sub>RAT</sub> = 11.4 A, DCR = 6.1 m $\Omega$	FDVE1040-2R2M/Toko
4	R1, R3, R9, R10	Optional, resistor, 0603	Optional/Vishay Dale
2	R2, R5	100 k $\Omega$ , 1%, resistor, 0603	CRCW0603100KFKEA/Vishay Dale
1	R6	2.21 k $\Omega$ , 1%, resistor, 0603	CRCW06032K21FKEA/Vishay Dale
2	R4, R7	44.2 k $\Omega$ , 1%, resistor, 0603	CRCW060344K2FKEA/Vishay Dale
1	R8	10 k $\Omega$ , 1%, resistor, 0603	CRCW060310K0FKEA/Vishay Dale
1	U1	20 V, 6 A, synchronous, step-down regulator, 24-lead, LFCSP_WQ, with exposed paddles	<a href="#">ADP2387</a> /Analog Devices, Inc.
9	J1, J2, J3, J4, J7, J8, J10, J11, J14	Test point, 2.54 mm pitch SIL vertical PC tail pin header, 6.1 mm mating pin height, tin, SIP1	M20-9990245/Harwin
4	J6, J9, J12, J13	Connector, 2.54 mm pitch SIL vertical PC tail pin header, 6.1 mm mating pin height, tin, 2-way, SIP2	M20-9990245/Harwin
1	J5	Jumper, 0.1-inch header, 3-way, SIP3	M20-9990346/Harwin

## NOTES

**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.

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