



Setting Up the Evaluation Boards for the **ADP165/ADP166**

FEATURES

Input voltage range: 2.2 V to 5.5 V

Output current range: 0 mA to 150 mA

Output voltage accuracy: ±1%

Operating temperature range: -40°C to +125°C

GENERAL DESCRIPTION

The **ADP165/ADP166** evaluation boards are used to demonstrate the functionality of the **ADP165/ADP166** series of linear regulators.

Simple device measurements such as line and load regulation, dropout voltage, and ground current can be demonstrated with only a single voltage supply, a voltmeter, an ammeter, and load resistors.

Complete specifications for the **ADP165/ADP166** linear regulators are available in the **ADP165/ADP166** data sheet available from Analog Devices, Inc., and should be consulted in conjunction with this user guide when using the evaluation boards.

ADP165/ADP166 EVALUATION BOARDS

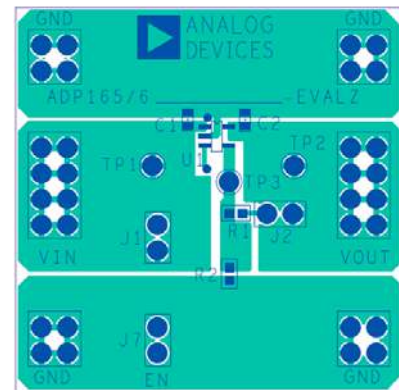


Figure 1. TSOT Printed Circuit Board (PCB) Layout

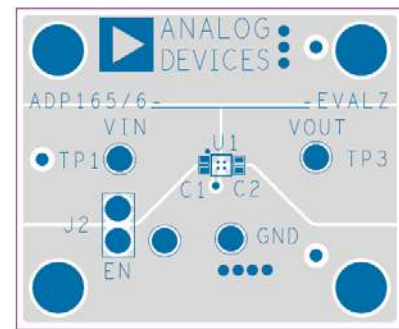


Figure 2. WLCSP PCB Layout

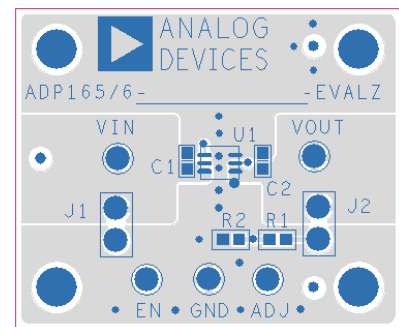


Figure 3. LFCSP PCB Layout

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REVISION HISTORY

2/15—Rev. 0 to Rev. A

Changes to General Description Section	1
Changes to Figure 8.....	4
Added ADP165Z-REDYKIT Contents Section and Table 3;	
Renumbered Sequentially.....	8
Added ADP166Z-REDYKIT Contents Section and Table 4	9

9/14—Revision 0: Initial Version

EVALUATION BOARD HARDWARE

EVALUATION BOARD CONFIGURATIONS

The [ADP165/ADP166](#) evaluation boards come supplied with different components, depending on the version ordered. Components common to all versions are C1, C2, and J1. Resistors R1 and R2 and Jumper J2 are used for the adjustable output [ADP165/ADP166](#), the 6-lead LFCSP and 5-lead TSOT options. Figure 4, Figure 5, and Figure 6 show the schematics of these evaluation board configurations. Table 1 describes the components.

The adjustable [ADP165/ADP166](#) has an output voltage range of 1.2 V to 4.2 V. The output voltage is set by the ratio of two external resistors, as shown in Figure 4 and Figure 6. The device serves the output to maintain the voltage at the ADJ pin at 1.0 V referenced to ground. The current in R1 is then equal to 1.0 V/R2, and the current in R1 is the current in R2 plus the ADJ pin bias current. The ADJ pin bias current, 10 nA at 25°C, flows through R1 into the ADJ pin.

Calculate the output voltage using the following equation:

$$V_{OUT} = 1.0 \text{ V}(1 + R1/R2) + (ADJ_{I-BIAS})(R1)$$

The value of R1 must be less than 200 kΩ to minimize errors in the output voltage caused by the ADJ pin bias current. For example, when R1 and R2 each equal 200 kΩ, the output voltage is 2.0 V. The output voltage error introduced by the ADJ pin bias current is 1 mV or 0.05%.

To minimize quiescent current in the [ADP165/ADP166](#), use high values of resistance for R1 and R2. Using a value of 1 MΩ for R2 keeps the total, no load quiescent current below 2 μA. However, high values of resistance introduce a small output voltage error. For example, assuming that R1 and R2 are 1 MΩ, the output voltage is 2 V. Taking into account the nominal ADJ pin bias current of 10 nA, the output voltage error is 0.25%.

Note that when the device is in shutdown, the output turns off, and the divider current is zero.

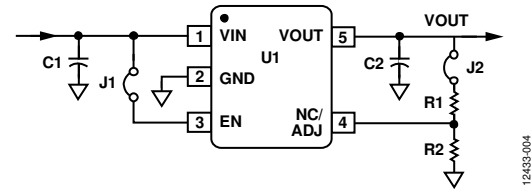


Figure 4. Evaluation Board Schematic, TSOT

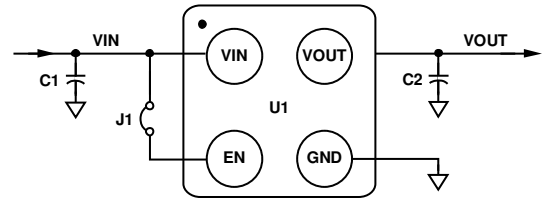


Figure 5. Evaluation Board Schematic, WLCSP

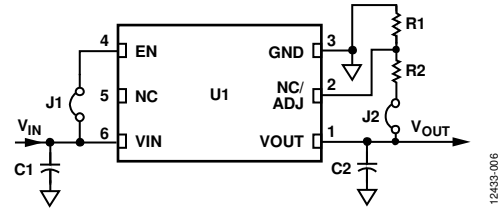


Figure 6. Evaluation Board Schematic, LFCSP

Table 1. Evaluation Board Hardware Components

Component	Description
U1	ADP165/ADP166 low dropout linear regulator
C1 ¹	Input bypass capacitor, 1 μF, 0603 size
C2 ¹	Output capacitor, 1 μF, 0603 size
J1	Jumper (connects EN to VIN for automatic startup)
J2	Jumper (connects VOUT to the resistor divider for the adjustable ADP165/ADP166)
R1, R2	Resistor divider to set ADP165/ADP166 output voltage

¹ The [ADP165/ADP166](#) evaluation boards require only one input bypass capacitor and one output capacitor for stable operation.

OUTPUT VOLTAGE MEASUREMENTS

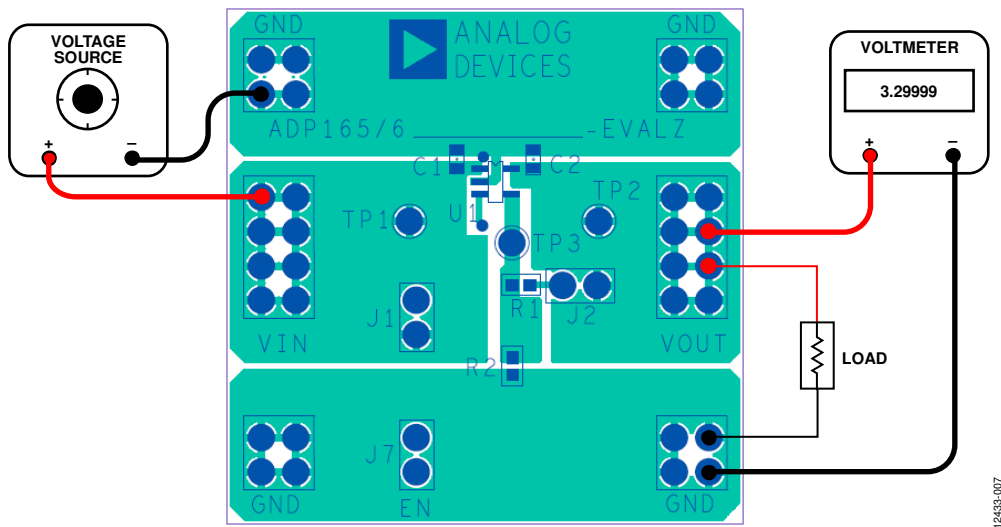


Figure 7. Output Voltage Measurement Setup, TSOT

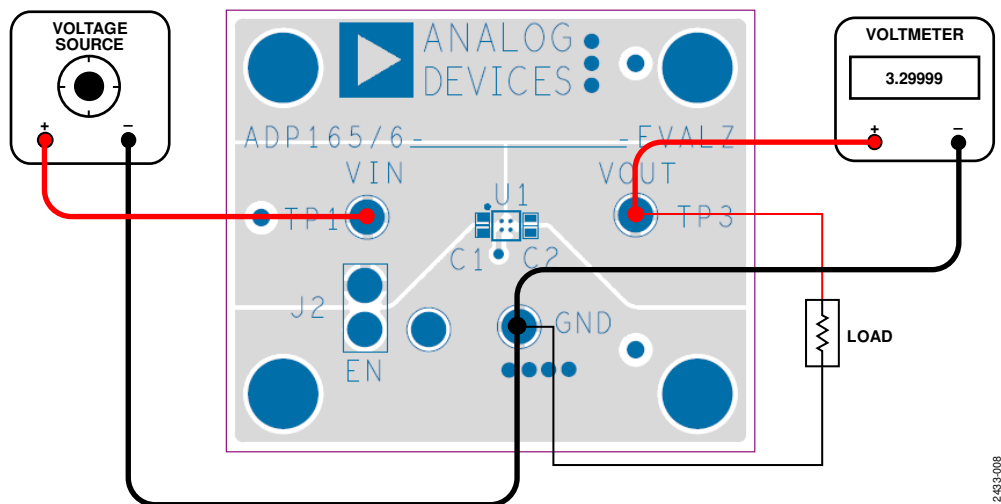


Figure 8. Output Voltage Measurement Setup, WLCSP

Figure 7 and Figure 8 show how the evaluation board can be connected to a voltage source and a voltmeter for basic output voltage accuracy measurements. Note that the LFCSP measurement setup is the same as the TSOT setup.

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 dissipate 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.

Follow these steps to connect the evaluation board to a voltage source and voltmeter:

1. Connect the negative terminal (–) of the voltage source to one of the GND pads on the evaluation board.
2. Connect the positive terminal (+) of the voltage source to the VIN pad on the evaluation board.
3. Connect a load between the VOUT pad and one of the GND pads on the evaluation board.
4. Connect the negative terminal (–) of the voltmeter to one of the GND pads on the evaluation board.
5. Connect the positive terminal (+) of the voltmeter to the VOUT pad on the evaluation board.

When these steps are completed, the voltage source can be turned on. If J1 is inserted (connecting EN to VIN for automatic startup), the regulator powers up.

If the load current is large, the user must connect the voltmeter as close as possible to the output capacitor to reduce the effects of IR drops.

LINE REGULATION MEASUREMENTS

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 line regulation measurement, V_{IN} must be varied between $V_{OUTNOM} + 0.4\text{ V}$ (or 2.2 V , whichever is greater) and V_{INMAX} . For example, for an ADP165 with a fixed 3.3 V output, V_{IN} must be varied between 2.7 V and 5.5 V . This measurement can be repeated under different load conditions. Figure 9 shows the typical line regulation performance of an ADP165 with a fixed 3.3 V output.

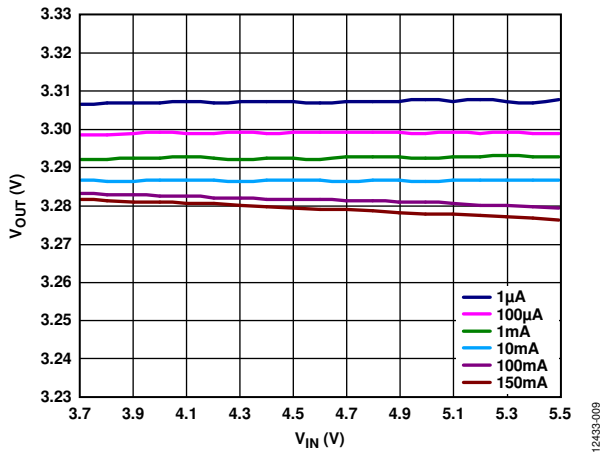


Figure 9. Output Voltage (V_{OUT}) vs. Input Voltage (V_{IN}) at $V_{OUT} = 3.3\text{ V}$, $T_A = 25^\circ\text{C}$

LOAD REGULATION MEASUREMENTS

For load regulation measurements, the output of the regulator is monitored while the load is varied. For good load regulation, the output must change as little as possible with varying load. The input voltage must be held constant during load regulation measurement. The load current can be varied from 0 mA to 150 mA . Figure 10 shows the typical load regulation performance of an ADP165 with a fixed 3.3 V output for an input voltage of 3.8 V .

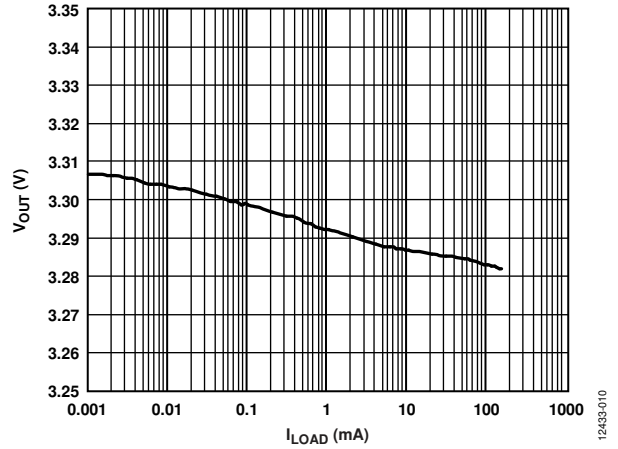


Figure 10. Output Voltage (V_{OUT}) vs. Load Current (I_{OUT}) at $V_{IN} = 3.8\text{ V}$, $V_{OUT} = 3.3\text{ V}$, $T_A = 25^\circ\text{C}$

DROPOUT VOLTAGE MEASUREMENTS

The dropout voltage can be measured using the configurations shown in Figure 7 and Figure 8. Dropout voltage is defined as the input to output voltage differential when the input voltage is set to the nominal output voltage. The ADP165/ADP166 only enter dropout mode for output voltages higher than 2.2 V ; for lower voltage outputs, the ADP165/ADP166 shut down. The dropout voltage increases with larger loads.

For accurate measurements, use a second voltmeter to monitor the input voltage across the input capacitor. The input supply voltage may need adjusting to account for IR drops, especially when using large load currents. Figure 11 shows the typical curve of dropout voltage measurements with different load currents.

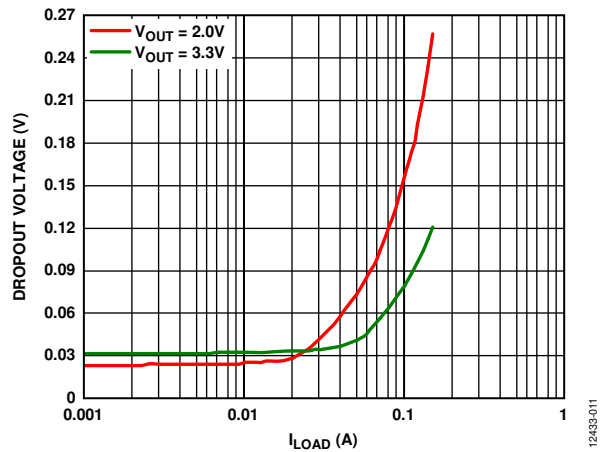


Figure 11. Dropout Voltage vs. Load Currents (I_{LOAD}), $V_{OUT} = 2.0\text{ V}$ and 3.3 V , $T_A = 25^\circ\text{C}$

GROUND CURRENT MEASUREMENTS

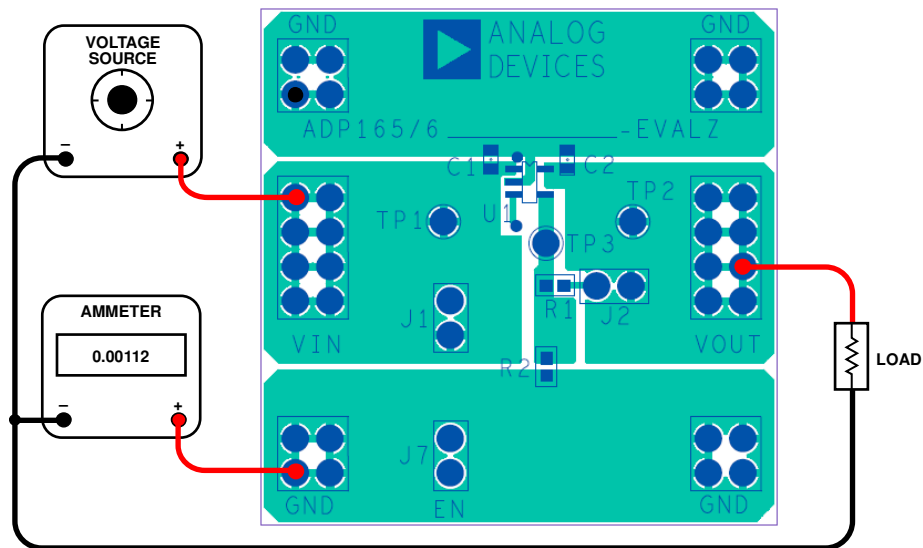


Figure 12. Ground Current Measurement Setup, TSOT

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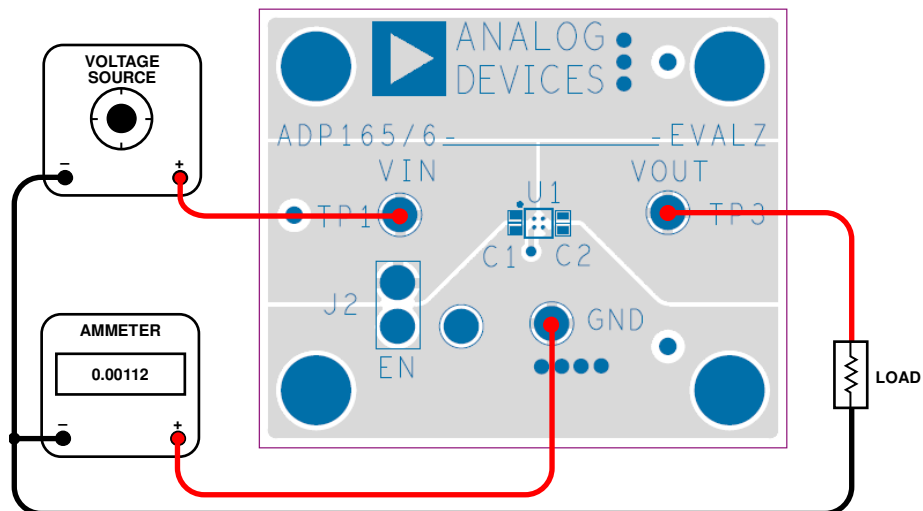


Figure 13. Ground Current Measurement Setup, WLCSP

12433-013

Figure 12 and Figure 13 show how the evaluation board can be connected to a voltage source and an ammeter for ground current measurements. Note that the LFCSP measurement setup is the same as the TSOT setup

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 can supply enough current for the expected load levels.

Follow these steps to connect the evaluation board to a voltage source and ammeter:

1. Connect the positive terminal (+) of the voltage source to the VIN pad on the evaluation board.
2. Connect the positive terminal (+) of the ammeter to one of the GND pads on the evaluation board.
3. Connect the negative terminal (-) of the ammeter to the negative terminal (-) of the voltage source.
4. Connect a load between the VOUT pad on the evaluation board and the negative terminal (-) of the voltage source.

When these connection steps are completed, the voltage source can be turned on. If J1 is inserted (connecting EN to VIN for automatic startup), the regulator powers up.

GROUND CURRENT CONSUMPTION

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 must consume as little current as possible. Typically, the regulator uses the maximum current when supplying its largest load level (150 mA). Figure 14 shows the typical ground current consumption for various load levels at $V_{OUT} = 3.3\text{ V}$ and $T_A = 25^\circ\text{C}$.

When the device is disabled ($EN = GND$), the ground current drops to less than 50 nA.

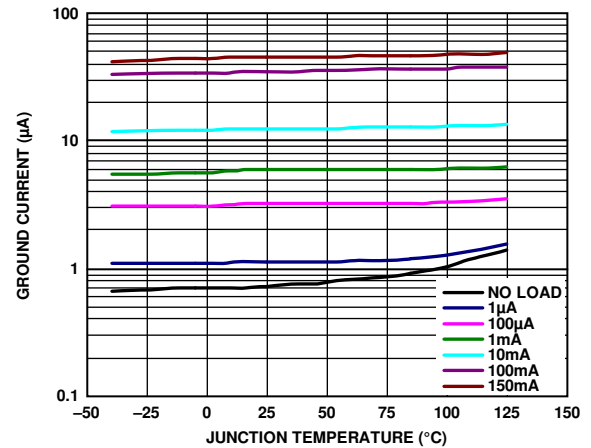


Figure 14. Ground Current vs. Input Voltage (V_{IN}),
 $V_{OUT} = 3.3\text{ V}$, $T_A = 25^\circ\text{C}$

12433-014

ORDERING INFORMATION**BILL OF MATERIALS**

Table 2.

Reference Designator	Description	Manufacturer	Part No.
C1, C2	Capacitor, MLCC, 1 μ F, 16 V, 0603, X5R	Murata (or equivalent)	GRM188R61C105KA93
J1, J2	Header, single, STR, two pins	Sullins Connector Solutions	PEC02SAAN
U1	IC, low dropout (LDO) regulator	Analog Devices, Inc.	ADP165/ADP166
R1, R2	Resistor, 0402, 1% tolerance	Any manufacturer	Depends on manufacturer

ADP165Z-REDYKIT CONTENTS

Table 3.

Quantity	Model	Output Voltage (V)	Maximum Current (mA)	Description
1	ADP165CB-EVALZ	1.8	150	Evaluation board
1	ADP165CP-EVALZ	2.3	150	Evaluation board
1	ADP165UJ-EVALZ	3.3	150	Evaluation board
1	ADP165ACPZN-R7	Adjustable	150	6-lead LFCSP
1	ADP165ACPZN-1.2-R7	1.2	150	6-lead LFCSP
1	ADP165ACPZN-1.8-R7	1.8	150	6-lead LFCSP
1	ADP165ACPZN-3.0-R7	3.0	150	6-lead LFCSP
1	ADP165ACPZN-3.3-R7	3.3	150	6-lead LFCSP
1	ADP165AUJZ-R7	Adjustable	150	5-lead TSOT
1	ADP165AUJZ-1.2-R7	1.2	150	5-lead TSOT
1	ADP165AUJZ-1.8-R7	1.8	150	5-lead TSOT
1	ADP165AUJZ-2.3-R7	2.3	150	5-lead TSOT
1	ADP165AUJZ-3.0-R7	3.0	150	5-lead TSOT

ADP166Z-REDYKIT CONTENTS

Table 4.

Quantity	Model	Output Voltage (V)	Maximum Current (mA)	Description
1	ADP166CB-EVALZ	1.8	150	Evaluation board
1	ADP166CP-EVALZ	2.3	150	Evaluation board
1	ADP166UJ-EVALZ	3.3	150	Evaluation board
1	ADP166ACPZN-R7	Adjustable	150	6-lead LFCSP
1	ADP166ACPZN-1.2-R7	1.2	150	6-lead LFCSP
1	ADP166ACPZN-1.8-R7	1.8	150	6-lead LFCSP
1	ADP166ACPZN-3.0-R7	3.0	150	6-lead LFCSP
1	ADP166ACPZN-3.3-R7	3.3	150	6-lead LFCSP
1	ADP166AUJZ-R7	Adjustable	150	5-lead TSOT
1	ADP166AUJZ-1.2-R7	1.2	150	5-lead TSOT
1	ADP166AUJZ-1.8-R7	1.8	150	5-lead TSOT
1	ADP166AUJZ-2.3-R7	2.3	150	5-lead TSOT
1	ADP166AUJZ-3.0-R7	3.0	150	5-lead TSOT

**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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