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## Setting Up the Evaluation Boards for the ADP160/ADP161/ADP162/ADP163

### FEATURES

- Input voltage range:** 2.2 V to 5.5 V
- Output current range:** 0 mA to 150 mA
- Output voltage accuracy:**  $\pm 1\%$
- Operating temperature range:**  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$

### GENERAL DESCRIPTION

The [ADP160/ADP161/ADP162/ADP163](#) evaluation board is used to demonstrate the functionality of the ADP160/ADP161/ADP162/ADP163 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.

For more information about the ADP160/ADP161/ADP162/ADP163 linear regulator, see the ADP160/ADP161/ADP162/ADP163 data sheet.

### EVALUATION BOARDS

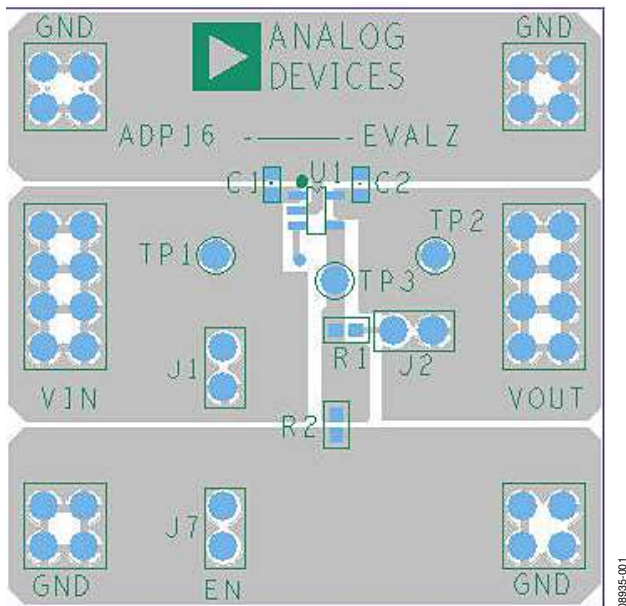


Figure 1. TSOT PCB Layout

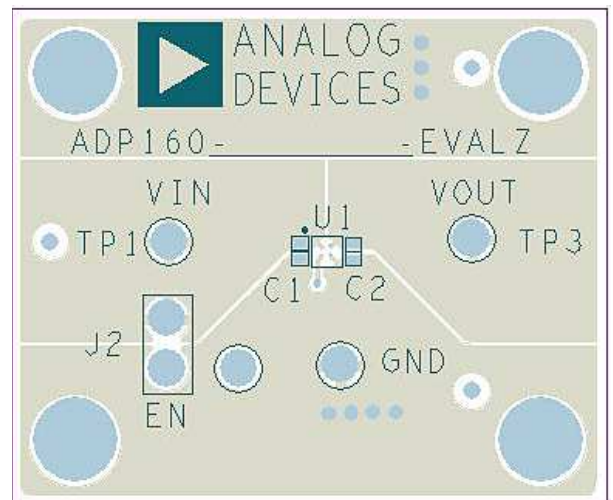


Figure 2. WLCSP PCB Layout

**TABLE OF CONTENTS**

Features .....	1	Line Regulation Measurements.....	5
General Description .....	1	Load Regulation Measurements.....	5
Evaluation Boards.....	1	Dropout Voltage Measurements.....	5
Revision History .....	2	Ground Current Measurements.....	6
Evaluation Board Hardware.....	3	Ground Current Consumption .....	7
Evaluation Board Configurations .....	3	Ordering Information.....	8
Output Voltage Measurements .....	4	Bill of Materials.....	8

**REVISION HISTORY**

**11/10—Rev. 0 to Rev. A**

Added ADP162 and ADP163 .....	Throughout
Changes to Evaluation Board Configurations Section.....	3

**7/10—Revision 0: Initial Version**

## EVALUATION BOARD HARDWARE

### EVALUATION BOARD CONFIGURATIONS

The ADP160/ADP161/ADP162/ADP163 evaluation board comes supplied with different components, depending on the version that is ordered. Components common to all versions are C1, C2, and J1. Resistors R1 and R2 and Jumper J2 are used for the adjustable output ADP161. Figure 3 and Figure 4 show the schematics of these evaluation board configurations. Table 1 describes the components.

The adjustable ADP161 has an output voltage range of 1.0 V to 4.0 V. The output voltage is set by the ratio of two external resistors, as shown in Figure 3. 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  $1.0 \text{ V}/R2$ , 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.

The output voltage can be calculated using the following equation:

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

The value of R1 should 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 ADP161 and ADP163, 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. Note, however, that high values of resistance introduce a small output voltage error. For example, assuming 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 in shutdown, the output is turned off and the divider current is zero.

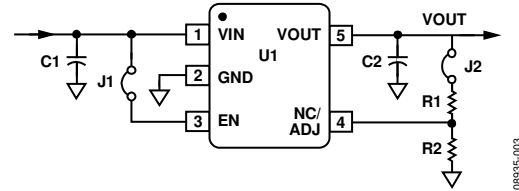


Figure 3. Evaluation Board Schematic, TSOT

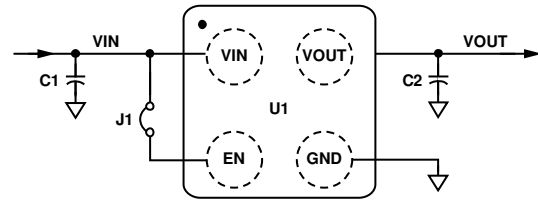


Figure 4. Evaluation Board Schematic, WLCSP

Table 1. Evaluation Board Hardware Components

Component	Description
U1 <sup>1</sup>	ADP160/ADP161/ADP162/ADP163 low dropout linear regulator
C1 <sup>2</sup>	Input bypass capacitor, 1 μF, 0603 size
C2 <sup>2</sup>	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 ADP161)
R1, R2	Resistor divider to set ADP161/ADP163 output voltage

<sup>1</sup> The evaluation board with the WLCSP package is the ADP16xCB-xxx-EVALZ. The evaluation board with the TSOT package is the ADP16xUJ-xxx-EVALZ.

<sup>2</sup> The ADP16x evaluation boards require only one input bypass capacitor and one output capacitor for stable operation.

## OUTPUT VOLTAGE MEASUREMENTS

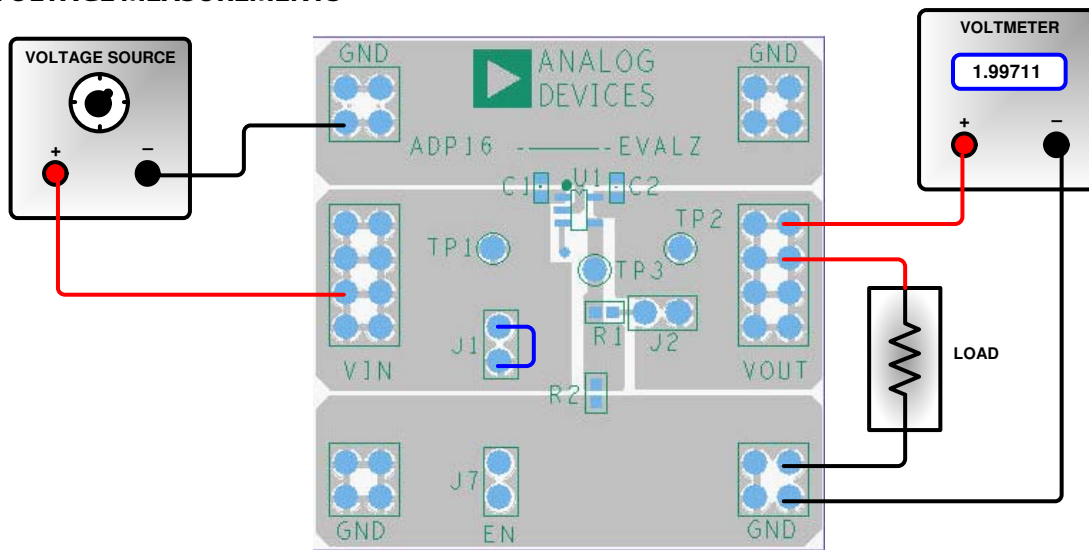


Figure 5. Output Voltage Measurement Setup, TSOT

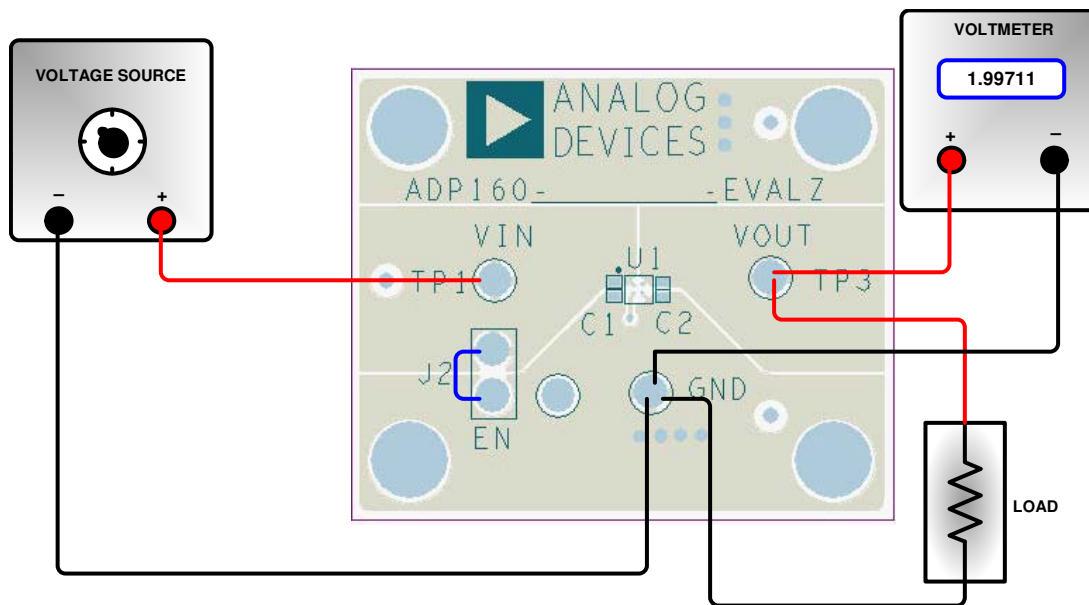


Figure 6. Output Voltage Measurement Setup, WLCSP

Figure 5 and Figure 6 show how the evaluation board can be connected to a voltage source and a voltmeter for basic output voltage accuracy 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 that is 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.

Follow these steps to connect 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 of the evaluation board.

3. Connect a load between the VOUT pad and one of the GND pads.
4. Connect the negative terminal (–) of the voltmeter to one of the GND pads.
5. Connect the positive terminal (+) of the voltmeter to the VOUT pad.

When these steps are completed, the voltage source can be turned on. If J1 is inserted (connecting EN to VIN for auto-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 this measurement,  $V_{IN}$  must be varied between  $V_{OUTNOM} + 0.4\text{ V}$  (or  $2.2\text{ V}$ , whichever is greater) and  $V_{INMAX}$ . For example, for an ADP160 with a fixed  $3.3\text{ V}$  output,  $V_{IN}$  needs to be varied between  $2.7\text{ V}$  and  $5.5\text{ V}$ . This measurement can be repeated under different load conditions. Figure 7 shows the typical line regulation performance of an ADP160 with a fixed  $3.3\text{ V}$  output.

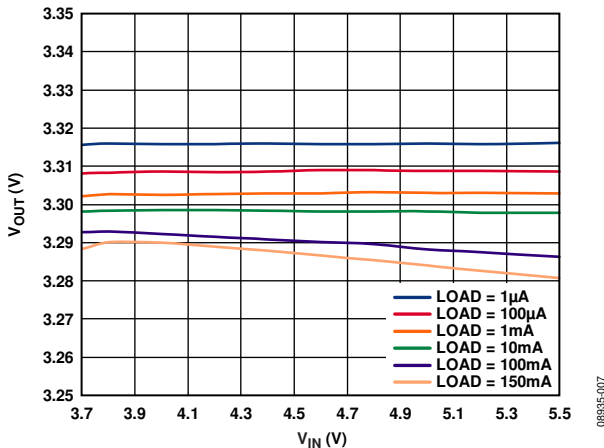


Figure 7. Output Voltage ( $V_{OUT}$ ) vs. Input Voltage ( $V_{IN}$ ) at  $V_{OUT} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$

**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 this measurement. The load current can be varied from  $0\text{ mA}$  to  $150\text{ mA}$ . Figure 8 shows the typical load regulation performance of an ADP160 with a fixed  $3.3\text{ V}$  output for an input voltage of  $3.7\text{ V}$ .

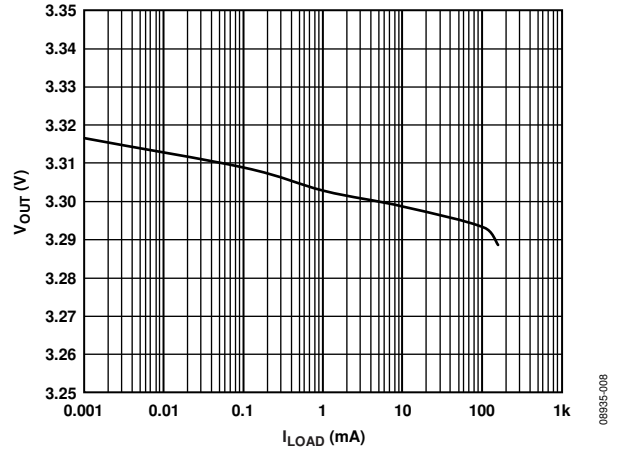


Figure 8. Output Voltage ( $V_{OUT}$ ) vs. Load Current ( $I_{OUT}$ ) at  $V_{IN} = 3.7\text{ V}$ ,  $V_{OUT} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$

**DROPOUT VOLTAGE MEASUREMENTS**

Dropout voltage can be measured using the configurations shown in Figure 5 and Figure 6. Dropout voltage is defined as the input-to-output voltage differential when the input voltage is set to the nominal output voltage. This applies only to output voltages above  $2.2\text{ V}$ . 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. Figure 9 shows the typical curve of dropout voltage measurements with different load currents.

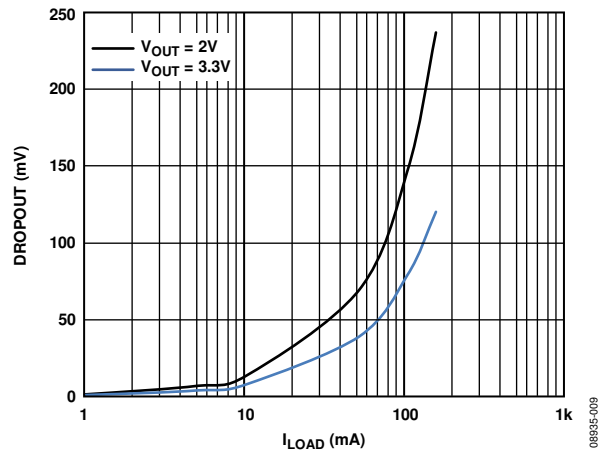


Figure 9. Dropout Voltage vs. Load Currents ( $I_{LOAD}$ ),  $V_{OUT} = 2.5\text{ V}$  and  $3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$

## GROUND CURRENT MEASUREMENTS

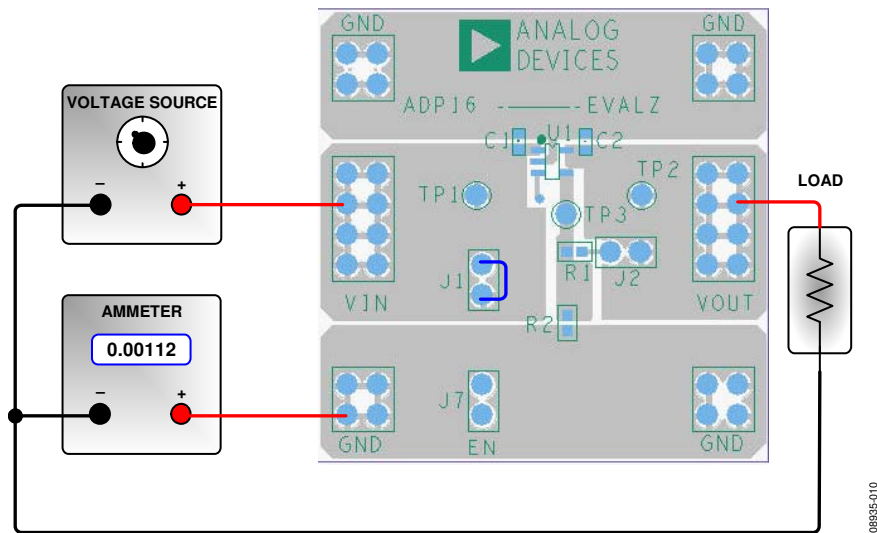


Figure 10. Ground Current Measurement Setup, TSOT

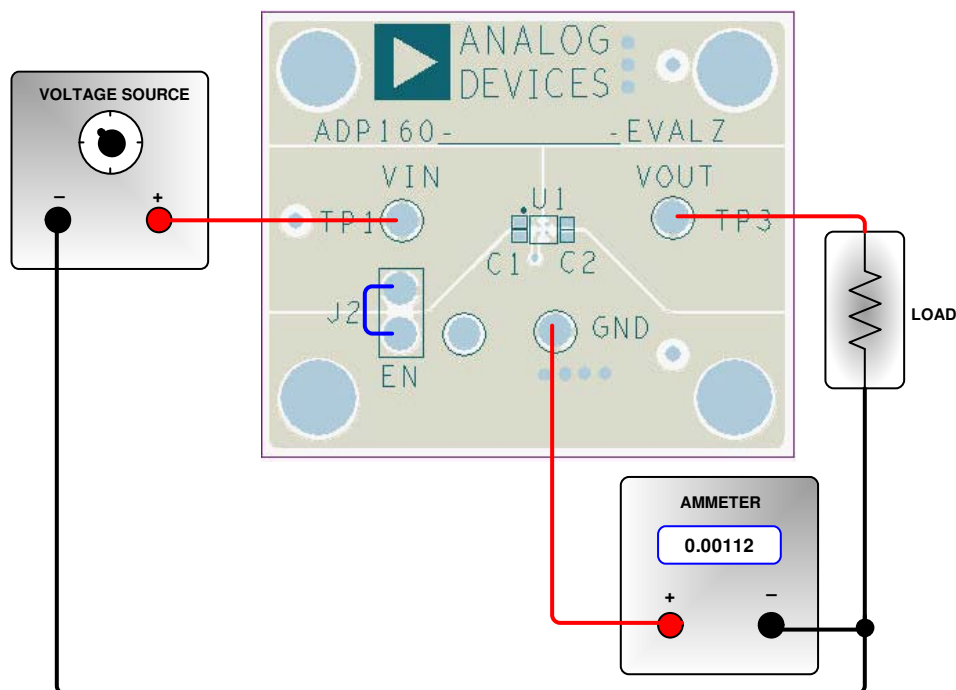


Figure 11. Ground Current Measurement Setup, WLCSP

Figure 10 and Figure 11 show how the evaluation board can be 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 can supply enough current for the expected load levels.

Follow these steps to connect 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 of 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 of 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 12 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 ( $EN = GND$ ), ground current drops to less than 50 nA.

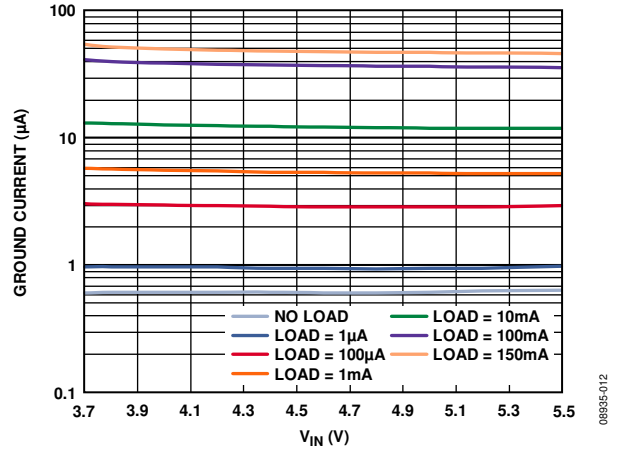


Figure 12. Ground Current vs. Input Voltage ( $V_{IN}$ ),  $V_{OUT} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$



## ORDERING INFORMATION

### BILL OF MATERIALS

Table 2.

Reference Designator	Description	Manufacturer	Part No.
C1, C2	Capacitor, MLCC, 1 $\mu$ F, 16 V, 0603, X5R	Murata (or equivalent)	GRM188R61C105KA93
J1, J2	Header, single, STR, 2 pins	Sullins Connector Solutions	PEC02SAAN
U1	IC, LDO regulator	Analog Devices, Inc.	<a href="#">ADP160/ADP161/ADP162/ADP163</a>
R1, R2	Resistor, 0402		



#### 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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