

# LM4051-N Precision Micropower Shunt Voltage Reference

## 1 Features

- No output capacitor required
- Tolerates capacitive loads
- Reverse breakdown voltage options of 1.225V and adjustable
- Key specifications:
  - Output voltage tolerance (A Grade, 25°C)  $\pm 0.1\%$  (maximum)
  - Output noise (10Hz to 10kHz) 20 $\mu$ Vrms
  - Operating current range: 60 $\mu$ A to 12mA
  - Industrial temp. range: -40°C to +85°C
  - Extended temp. range: -40°C to +125°C
  - Temperature coefficient: 50ppm/°C (maximum)

## 2 Applications

- [Battery-Powered Equipment](#)
- [Data-Acquisition Systems](#)
- [Instrumentation and Test Equipment](#)
- [Process Control](#)
- [Energy Management/Metering](#)
- [Automotive Electronics](#)
- [Precision Audio](#)
- [Base Stations](#)
- [Battery Chargers](#)
- [Medical Equipment](#)
- [Communication](#)

## 3 Description

Designed for space critical applications, the LM4051-N precision voltage reference is available in the sub-miniature (3mm x 1.30mm) SOT-23 surface mount package. The LM4051-N's advanced design eliminates the need for an external stabilizing capacitor while maintaining stability with any capacitive load, thus making the LM4051-N easy to use. Further reducing design effort is the availability of a fixed (1.225V) and adjustable reverse breakdown voltage. The minimum operating current is 60 $\mu$ A for the LM4051-1.2 and the LM4051-ADJ. Both versions have a maximum operating current of 12mA.

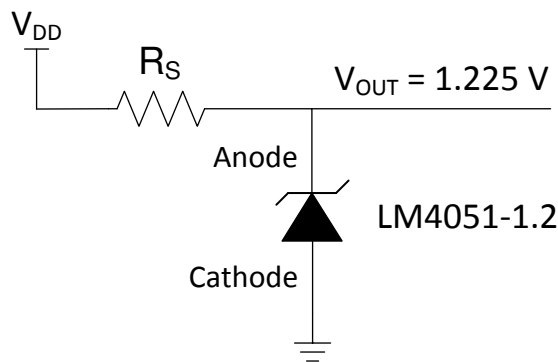
The LM4051-N comes in three grades (A, B, and C). The best grade devices (A) have an initial accuracy of 0.1%, while the B-grade have 0.2% and the C-grade 0.5%, all with a tempco of 50 ppm/°C designed for -40°C to 125°C.

The LM4051-N utilizes fuse and zener-zap trim of reference voltage during wafer sort to ensure that the prime parts have an accuracy of better than  $\pm 0.1\%$  (A grade) at 25°C.

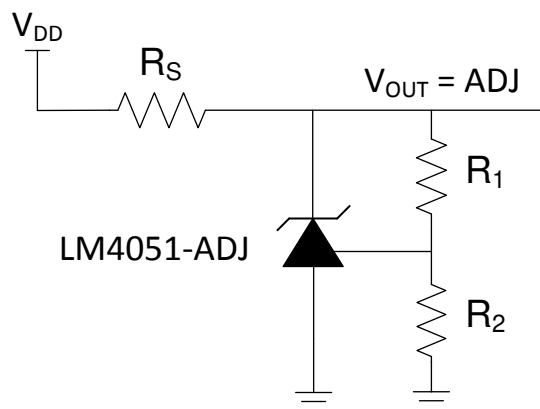
### Device Information

| PART NUMBER | PACKAGE <sup>(1)</sup> | BODY SIZE (NOM) <sup>(2)</sup> |
|-------------|------------------------|--------------------------------|
| LM4051-N    | SOT-23 (3)             | 3.00mm x 1.30mm                |

- (1) For all available packages, see the orderable addendum at the end of the data sheet.
- (2) The package size (length x width) is a nominal value and includes pins, where applicable.



**1.2 V<sub>REF</sub> Simplified Schematic**



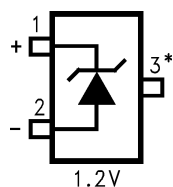
**Adjustable Reference Simplified Schematic**



## Table of Contents

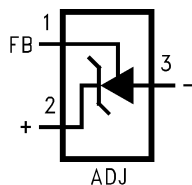
|                                                  |           |                                                                  |           |
|--------------------------------------------------|-----------|------------------------------------------------------------------|-----------|
| <b>1 Features</b> .....                          | <b>1</b>  | 7.3 Feature Description.....                                     | <b>12</b> |
| <b>2 Applications</b> .....                      | <b>1</b>  | 7.4 Device Functional Modes.....                                 | <b>12</b> |
| <b>3 Description</b> .....                       | <b>1</b>  | <b>8 Application and Implementation</b> .....                    | <b>13</b> |
| <b>4 Pin Configuration and Functions</b> .....   | <b>3</b>  | 8.1 Application Information.....                                 | <b>13</b> |
| Pin Functions.....                               | <b>3</b>  | 8.2 Typical Applications.....                                    | <b>14</b> |
| <b>5 Specifications</b> .....                    | <b>4</b>  | 8.3 System Examples.....                                         | <b>16</b> |
| 5.1 Absolute Maximum Ratings.....                | <b>4</b>  | 8.4 Power Supply Recommendations.....                            | <b>19</b> |
| 5.2 ESD Ratings.....                             | <b>4</b>  | 8.5 Layout.....                                                  | <b>19</b> |
| 5.3 Recommended Operating Conditions.....        | <b>4</b>  | <b>9 Device and Documentation Support</b> .....                  | <b>21</b> |
| 5.4 Thermal Information.....                     | <b>5</b>  | 9.1 Receiving Notification of Documentation Updates....          | <b>21</b> |
| 5.5 LM4051-1.2 Electrical Characteristics.....   | <b>5</b>  | 9.2 Support Resources.....                                       | <b>21</b> |
| 5.6 LM4051-ADJ Electrical Characteristics.....   | <b>6</b>  | 9.3 Trademarks.....                                              | <b>21</b> |
| 5.7 Typical Characteristics.....                 | <b>8</b>  | 9.4 Electrostatic Discharge Caution.....                         | <b>21</b> |
| <b>6 Parameter Measurement Information</b> ..... | <b>11</b> | 9.5 Glossary.....                                                | <b>21</b> |
| <b>7 Detailed Description</b> .....              | <b>12</b> | <b>10 Revision History</b> .....                                 | <b>21</b> |
| 7.1 Overview.....                                | <b>12</b> | <b>11 Mechanical, Packaging, and Orderable Information</b> ..... | <b>21</b> |
| 7.2 Functional Block Diagram.....                | <b>12</b> |                                                                  |           |

## 4 Pin Configuration and Functions



\* This pin must be left floating or connected to pin 2.<sup>(1)</sup>

**Figure 4-1. DBZ Package 1.2V, 3-Pin SOT-23 Top View**



**Figure 4-2. DBZ Package Adjustable, 3-Pin SOT-23 Top View**

## Pin Functions

| NAME    | PIN  |     | I/O | DESCRIPTION                                   |
|---------|------|-----|-----|-----------------------------------------------|
|         | 1.2V | ADJ |     |                                               |
| Anode   | 2    | 3   | O   | Common pin, normally connected to ground      |
| Cathode | 1    | 2   | I/O | Shunt Current/Voltage input                   |
| NC      | 3    | -   | -   | Must float or connect to anode <sup>(1)</sup> |
| FB      | -    | 1   | I   | Threshold relative to cathode                 |

- (1) In applications with high electromagnetic interference (for example, when placed near transformers or other electromagnetic sources) or significant high-frequency switching noise, TI recommends connecting this pin to the anode

## 5 Specifications

### 5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                                                                          | MIN                      | MAX | UNIT             |
|--------------------------------------------------------------------------|--------------------------|-----|------------------|
| Reverse current                                                          |                          | 20  | mA               |
| Forward current                                                          |                          | 10  | mA               |
| Maximum output voltage (LM4051-ADJ)                                      |                          | 15  | V                |
| Power dissipation ( $T_A = 25^\circ\text{C}$ ) <sup>(2)</sup> M3 package |                          | 280 | mW               |
| Lead temperature M3 packages                                             | Vapor phase (60 seconds) | 215 | $^\circ\text{C}$ |
|                                                                          | Infrared (15 seconds)    | 220 |                  |
| Storage temperature, $T_{\text{stg}}$                                    | -65                      | 150 | $^\circ\text{C}$ |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods can affect device reliability.
- (2) The maximum power dissipation must be derated at elevated temperatures and is dictated by  $T_{\text{Jmax}}$  (maximum junction temperature),  $\theta_{\text{JA}}$  (junction to ambient thermal resistance), and  $T_A$  (ambient temperature). The maximum allowable power dissipation at any temperature is  $P_{\text{Dmax}} = (T_{\text{Jmax}} - T_A) / \theta_{\text{JA}}$  or the number given in the [Section 5.1](#), whichever is lower. For the LM4051-N,  $T_{\text{Jmax}} = 125^\circ\text{C}$ , and the typical thermal resistance ( $\theta_{\text{JA}}$ ), when board mounted, is  $280^\circ\text{C/W}$  for the SOT-23 package.

### 5.2 ESD Ratings

|                                            | VALUE                                                                          | UNIT       |
|--------------------------------------------|--------------------------------------------------------------------------------|------------|
| $V_{\text{(ESD)}}$ Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1) (2)</sup>          | $\pm 2000$ |
|                                            | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(3)</sup> | $\pm 500$  |

- (1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
- (2) The human-body model is a 100pF capacitor discharged through a 1.5k $\Omega$  resistor into each pin. All pins are rated at 2kV for human-body model, but the feedback pin which is rated at 1kV.
- (3) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 250V CDM is possible with the necessary precautions.

### 5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

|                                                               | MIN                    | NOM  | MAX | UNIT             |
|---------------------------------------------------------------|------------------------|------|-----|------------------|
| Temperature ( $T_{\text{min}} \leq T_A \leq T_{\text{max}}$ ) | Industrial temperature |      | 85  | $^\circ\text{C}$ |
|                                                               | Extended temperature   |      | 125 |                  |
| Reverse current                                               | LM4051-1.2             |      | 12  | mA               |
|                                                               | LM4051-ADJ             |      | 12  |                  |
| Output voltage                                                | LM4051-ADJ             | 1.24 | 10  | V                |

## 5.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | LM4051-ADJ,<br>LM4051-1.2 V | UNIT |
|-------------------------------|----------------------------------------------|-----------------------------|------|
|                               |                                              | DBZ                         |      |
|                               |                                              | 3 PINS                      |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance       | 214.7                       | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case (top) thermal resistance    | 76.4                        | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 41.3                        | °C/W |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 2.0                         | °C/W |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 40.9                        | °C/W |

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 5.5 LM4051-1.2 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                 |                                                                          | TEST CONDITIONS                                               |                                                              | MIN                | TYP | MAX                  | UNIT          |
|---------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------------|--------------------|-----|----------------------|---------------|
| $V_R$                     | Reverse Breakdown Voltage                                                | $I_R = 100\mu A$                                              |                                                              | 1.225              |     |                      | V             |
|                           | Reverse Breakdown Voltage Tolerance <sup>(2)</sup>                       | $I_R = 100\mu A$                                              | LM4051AIM3 <sup>(1)</sup>                                    |                    |     | ±1.2                 | mV            |
|                           |                                                                          |                                                               | LM4051BIM3 LM4051BEM3 <sup>(1)</sup>                         |                    |     | ±2.4                 |               |
|                           |                                                                          |                                                               | LM4051CIM3 <sup>(1)</sup>                                    |                    |     | ±6                   |               |
|                           |                                                                          | Industrial Temp. Range<br>$T_A = T_J = T_{MIN}$ to $T_{MAX}$  | LM4051AIM3 <sup>(1)</sup>                                    |                    |     | ±5.2 <sup>(2)</sup>  |               |
|                           |                                                                          |                                                               | LM4051BIM3 <sup>(1)</sup>                                    |                    |     | ±6.4 <sup>(2)</sup>  |               |
|                           |                                                                          | Extended Temp. Range<br>$T_A = T_J = T_{MIN}$ to $T_{MAX}$    | LM4051CIM3 <sup>(1)</sup>                                    |                    |     | ±10.1 <sup>(2)</sup> |               |
| $I_{RMIN}$                | Minimum Operating Current                                                | $T_J = 25^\circ C$                                            |                                                              | 39                 |     |                      | $\mu A$       |
|                           |                                                                          | Industrial Temp. Range<br>$T_A = T_J = T_{MIN}$ to $T_{MAX}$  |                                                              | 65                 |     |                      |               |
|                           |                                                                          | Extended Temp. Range<br>$T_A = T_J = T_{MIN}$ to $T_{MAX}$    |                                                              | 70                 |     |                      |               |
| $\Delta V_R / \Delta T$   | Average Reverse Breakdown Voltage Temperature Coefficient <sup>(2)</sup> | $I_R = 10mA$                                                  |                                                              | ±20                |     |                      | ppm/°C        |
|                           |                                                                          | $I_R = 1mA$                                                   |                                                              | ±15                |     |                      |               |
|                           |                                                                          | $I_R = 100\mu A$<br>$\Delta T = -40^\circ C$ to $125^\circ C$ | $T_J = 25^\circ C$                                           | ±15                |     |                      |               |
|                           |                                                                          |                                                               | $T_A = T_J = T_{MIN}$ to $T_{MAX}$                           | ±50 <sup>(2)</sup> |     |                      |               |
| $\Delta V_R / \Delta I_R$ | Reverse Breakdown Voltage Change with Operating Current Change           | $I_{RMIN} \leq I_R \leq 1mA$                                  | $T_J = 25^\circ C$                                           | 0.3                |     |                      | mV            |
|                           |                                                                          |                                                               | Industrial Temp. Range<br>$T_A = T_J = T_{MIN}$ to $T_{MAX}$ | 1.1 <sup>(2)</sup> |     |                      |               |
|                           |                                                                          |                                                               | Extended Temp. Range<br>$T_A = T_J = T_{MIN}$ to $T_{MAX}$   | 1.5 <sup>(2)</sup> |     |                      |               |
|                           |                                                                          | $1mA \leq I_R \leq 12mA$                                      | $T_J = 25^\circ C$                                           | 1.8                |     |                      |               |
|                           |                                                                          |                                                               | Industrial Temp. Range<br>$T_A = T_J = T_{MIN}$ to $T_{MAX}$ | 6 <sup>(2)</sup>   |     |                      |               |
|                           |                                                                          |                                                               | Extended Temp. Range<br>$T_A = T_J = T_{MIN}$ to $T_{MAX}$   | 8 <sup>(2)</sup>   |     |                      |               |
| $Z_R$                     | Reverse Dynamic Impedance                                                | $I_R = 1mA$ , $f = 120Hz$                                     |                                                              | 0.5                |     |                      | $\Omega$      |
| $e_N$                     | Wide band Noise                                                          | $I_R = 100\mu A$<br>$10Hz \leq f \leq 10kHz$                  |                                                              | 20                 |     |                      | $\mu V_{rms}$ |

## 5.5 LM4051-1.2 Electrical Characteristics (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                                                                 | TEST CONDITIONS                                                                            | MIN | TYP  | MAX | UNIT |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----|------|-----|------|
| $\Delta V_R$ Reverse Breakdown Voltage Long Term Stability <sup>(3)</sup> | $t = 1000 \text{ hrs, } T = 25^\circ\text{C} \pm 0.1^\circ\text{C, } I_R = 100\mu\text{A}$ |     | 120  |     | ppm  |
| $V_{HYST}$ Thermal Hysteresis <sup>(4)</sup>                              | $\Delta T = -40^\circ\text{C to } 125^\circ\text{C}$                                       |     | 0.36 |     | mV/V |

- Limits are 100% production tested at  $25^\circ\text{C}$ . Limits over temperature are made sure through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate National's AOQL.
- This over temperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance  $\pm[(\Delta V_R/\Delta T)(\max\Delta T)(V_R)]$ . Where,  $\Delta V_R/\Delta T$  is the VR temperature coefficient,  $\max\Delta T$  is the maximum difference in temperature from the reference point of  $25^\circ\text{C}$  to  $T_{MAX}$  or  $T_{MIN}$ , and  $V_R$  is the reverse breakdown voltage. The total over temperature tolerance for the different grades in the industrial temperature range where  $\max\Delta T=65^\circ\text{C}$  is shown below:
  - A-grade:  $\pm 0.425\% = \pm 0.1\% \pm 50 \text{ ppm}/^\circ\text{C} \times 65^\circ\text{C}$
  - B-grade:  $\pm 0.525\% = \pm 0.2\% \pm 50 \text{ ppm}/^\circ\text{C} \times 65^\circ\text{C}$
  - C-grade:  $\pm 0.825\% = \pm 0.5\% \pm 50 \text{ ppm}/^\circ\text{C} \times 65^\circ\text{C}$

Therefore, as an example, the A-grade LM4051-1.2 has an over-temperature Reverse Breakdown Voltage tolerance of  $\pm 1.2\text{V} \times 0.425\% = \pm 5.2\text{mV}$ .

- Long-term stability is  $V_R$  at  $25^\circ\text{C}$  measured during 1000 hrs.
- Thermal hysteresis is defined as the difference in voltage measured at  $+25^\circ\text{C}$  after cycling to temperature  $-40^\circ\text{C}$  and the  $25^\circ\text{C}$  measurement after cycling to temperature  $+125^\circ\text{C}$ .

## 5.6 LM4051-ADJ Electrical Characteristics

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                                                                          | TEST CONDITIONS                                                                     | MIN                                                                 | TYP   | MAX                 | UNIT          |
|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------|-------|---------------------|---------------|
| Reference Voltage                                                                  | $I_R = 100\mu\text{A, } V_{OUT} = 5\text{V}$                                        |                                                                     | 1.212 |                     | V             |
| $V_{REF}$ Reference Voltage Tolerance <sup>(2) (4)</sup>                           | $I_R = 100\mu\text{A, } V_{OUT} = 5\text{V}$                                        | LM4051AIM3 <sup>(1)</sup>                                           |       | $\pm 1.2$           | mV            |
|                                                                                    |                                                                                     | LM4051BIM3 <sup>(1)</sup>                                           |       | $\pm 2.4$           |               |
|                                                                                    |                                                                                     | LM4051CIM3 <sup>(1)</sup>                                           |       | $\pm 6$             |               |
|                                                                                    | Industrial Temp. Range<br>$T_A = T_J = T_{MIN} \text{ to } T_{MAX}$                 | LM4051AIM3 <sup>(1)</sup>                                           |       | $\pm 5.2$           |               |
|                                                                                    |                                                                                     | LM4051BIM3 <sup>(1)</sup>                                           |       | $\pm 6.4$           |               |
|                                                                                    |                                                                                     | LM4051CIM3 <sup>(1)</sup>                                           |       | $\pm 10.1$          |               |
| $I_{RMIN}$ Minimum Operating Current                                               | LM4051AIM3 <sup>(1)</sup>                                                           |                                                                     |       | 36                  | $\mu\text{A}$ |
|                                                                                    |                                                                                     | LM4051BIM3 <sup>(1)</sup>                                           |       | 36                  |               |
|                                                                                    |                                                                                     | LM4051CIM3 <sup>(1)</sup>                                           |       | 36                  |               |
|                                                                                    | Industrial Temp. Range<br>$T_A = T_J = T_{MIN} \text{ to } T_{MAX}$                 | LM4051AIM3 <sup>(1)</sup>                                           |       | 60                  |               |
|                                                                                    |                                                                                     | LM4051BIM3 <sup>(1)</sup>                                           |       | 60                  |               |
|                                                                                    |                                                                                     | LM4051CIM3 <sup>(1)</sup>                                           |       | 65                  |               |
| $\Delta V_{REF}/\Delta I_R$ Reference Voltage Change with Operating Current Change | $I_{RMIN} \leq I_R \leq 1\text{mA}$<br>$V_{OUT} \geq 1.6\text{V}$ <sup>(3)</sup>    | $T_J = 25^\circ\text{C}$                                            |       | 0.3                 | mV            |
|                                                                                    |                                                                                     | Industrial Temp. Range<br>$T_A = T_J = T_{MIN} \text{ to } T_{MAX}$ |       | 1.1 <sup>(2)</sup>  |               |
|                                                                                    | $1\text{mA} \leq I_R \leq 12\text{mA}$<br>$V_{OUT} \geq 1.6\text{V}$ <sup>(3)</sup> | $T_J = 25^\circ\text{C}$                                            |       | 0.6                 |               |
|                                                                                    |                                                                                     | Industrial Temp. Range<br>$T_A = T_J = T_{MIN} \text{ to } T_{MAX}$ |       | 6 <sup>(2)</sup>    |               |
| $\Delta V_{REF}/\Delta V_O$ Reference Voltage Change with Output Voltage Change    | $I_R = 0.1\text{mA}$                                                                | $T_J = 25^\circ\text{C}$                                            |       | -1.69               | mV            |
|                                                                                    |                                                                                     | Industrial Temp. Range<br>$T_A = T_J = T_{MIN} \text{ to } T_{MAX}$ |       | -2.8 <sup>(2)</sup> |               |
| $I_{FB}$ Feedback Current                                                          |                                                                                     |                                                                     | 70    | 130                 | nA            |

## 5.6 LM4051-ADJ Electrical Characteristics (continued)

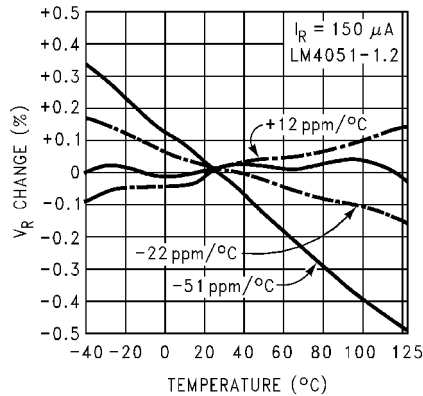
over operating free-air temperature range (unless otherwise noted)

| PARAMETER                                                                                    | TEST CONDITIONS                                                       | MIN                 | TYP                                                          | MAX            | UNIT             |
|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|---------------------|--------------------------------------------------------------|----------------|------------------|
| $\frac{\Delta V_{REF}}{\Delta T}$ Average Reference Voltage Temperature Coefficient (Note 8) | $V_{OUT} = 2.5V$<br>$\Delta T = -40^{\circ}C$ to $+125^{\circ}C$      | $I_R = 10mA$        | $T_J = 25^{\circ}C$                                          | 20             | ppm/ $^{\circ}C$ |
|                                                                                              |                                                                       |                     | Industrial Temp. Range<br>$T_A = T_J = T_{MIN}$ to $T_{MAX}$ | $\pm 50^{(2)}$ |                  |
|                                                                                              |                                                                       | $I_R = 1mA$         | $T_J = 25^{\circ}C$                                          | 15             |                  |
|                                                                                              |                                                                       |                     | Industrial Temp. Range<br>$T_A = T_J = T_{MIN}$ to $T_{MAX}$ | $\pm 50^{(2)}$ |                  |
|                                                                                              |                                                                       | $I_R = 100\mu A$    | $T_J = 25^{\circ}C$                                          | 15             |                  |
|                                                                                              |                                                                       |                     | Industrial Temp. Range<br>$T_A = T_J = T_{MIN}$ to $T_{MAX}$ | $\pm 50^{(2)}$ |                  |
| $Z_{OUT}$ Dynamic Output Impedance                                                           | $I_R = 1mA$ , $f = 120Hz$ , $I_{AC} = 0.1 I_R$                        | $V_{OUT} = V_{REF}$ |                                                              | 0.3            | $\Omega$         |
|                                                                                              |                                                                       | $V_{OUT} = 10V$     |                                                              | 2              |                  |
| $e_N$ Wide band Noise                                                                        | $I_R = 100\mu A$ , $V_{OUT} = V_{REF}$ , $10Hz \leq f \leq 10kHz$     |                     |                                                              | 20             | $\mu V_{rms}$    |
| $\Delta V_{REF}$ Reference Voltage Long Term Stability <sup>(5)</sup>                        | $t = 1000$ hrs, $I_R = 100\mu A$ , $T = 25^{\circ}C \pm 0.1^{\circ}C$ |                     |                                                              | 120            | ppm              |
| $V_{HYST}$ Thermal Hysteresis <sup>(6)</sup>                                                 | $\Delta T = -40^{\circ}C$ to $+125^{\circ}C$                          |                     |                                                              | 0.3            | mV/V             |

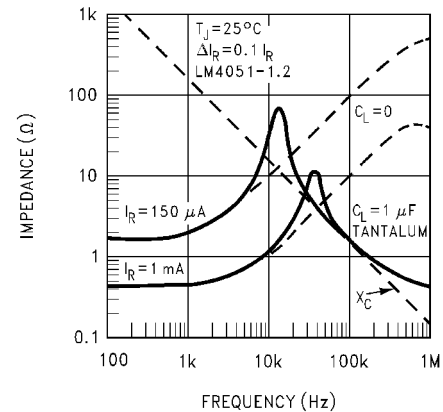
- (1) Limits are 100% production tested at  $25^{\circ}C$ . Limits over temperature are made sure through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate National's AOQL.
- (2) This over temperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance  $\pm [(\Delta V_R/\Delta T)(\max \Delta T)(V_R)]$ . Where,  $\Delta V_R/\Delta T$  is the  $V_R$  temperature coefficient,  $\max \Delta T$  is the maximum difference in temperature from the reference point of  $25^{\circ}C$  to  $T_{MAX}$  or  $T_{MIN}$ , and  $V_R$  is the reverse breakdown voltage. The total over temperature tolerance for the different grades in the industrial temperature range where  $\max \Delta T = 65^{\circ}C$  is shown below:
  - A-grade:  $\pm 0.425\% = \pm 0.1\% \pm 50ppm/^{\circ}C \times 65^{\circ}C$
  - B-grade:  $\pm 0.525\% = \pm 0.2\% \pm 50ppm/^{\circ}C \times 65^{\circ}C$
  - C-grade:  $\pm 0.825\% = \pm 0.5\% \pm 50ppm/^{\circ}C \times 65^{\circ}C$

Therefore, as an example, the A-grade LM4051-1.2 has an over temperature Reverse Breakdown Voltage tolerance of  $\pm 1.2V \times 0.425\% = \pm 5.2mV$ .
- (3) When  $V_{OUT} \leq 1.6V$ , the LM4051-ADJ in the SOT-23 package must operate at reduced  $I_R$ . This is caused by the series resistance of the die attach between the die (–) output and the package (–) output pin. See the Output Saturation curve in the [Section 5.7](#) section.
- (4) Reference voltage and temperature coefficient change with output voltage. See [Section 5.7](#) curves.
- (5) Long-term stability is  $V_R$  at  $25^{\circ}C$  measured during 1000 hrs.
- (6) Thermal hysteresis is defined as the difference in voltage measured at  $+25^{\circ}C$  after cycling to temperature  $-40^{\circ}C$  and the  $25^{\circ}C$  measurement after cycling to temperature  $+125^{\circ}C$ .

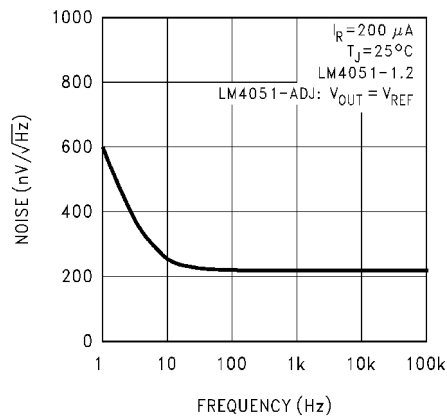
## 5.7 Typical Characteristics



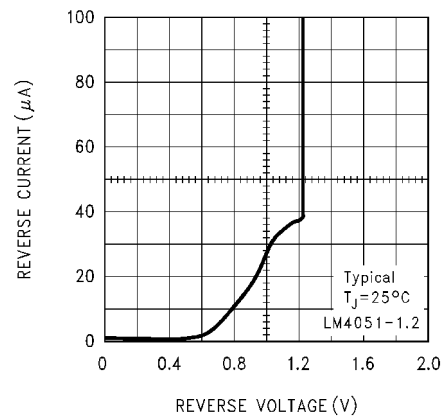
**Figure 5-1. Temperature Drift for Different Average Temperature Coefficient**



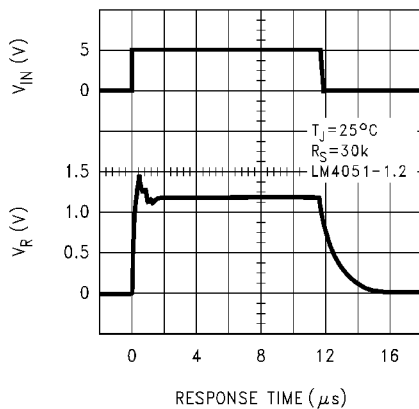
**Figure 5-2. Output Impedance vs Frequency**



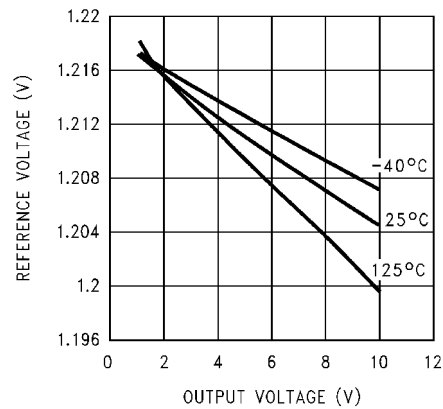
**Figure 5-3. Noise Voltage**



**Figure 5-4. Reverse Characteristics and Minimum Operating Current**



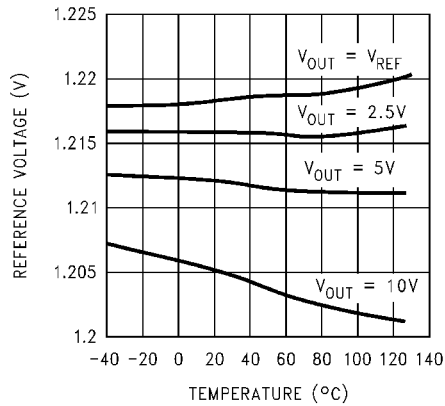
**Figure 5-5. Start-Up Characteristics**



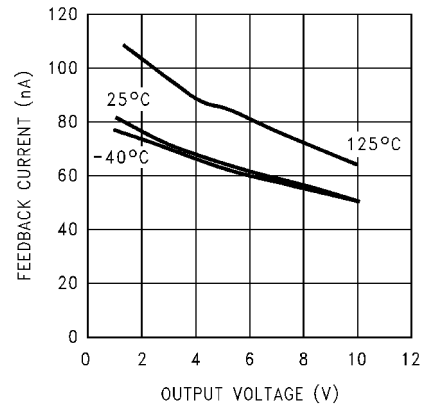
**Figure 5-6. Reference Voltage vs Output Voltage and Temperature**



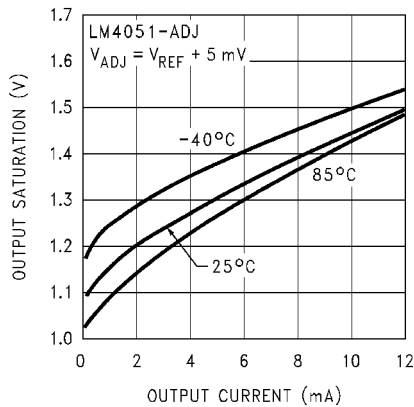
## 5.7 Typical Characteristics (continued)



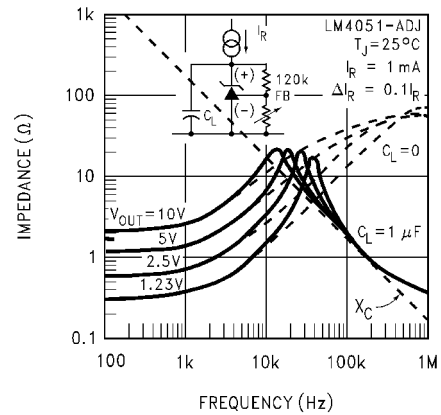
**Figure 5-7. Reference Voltage vs Temperature and Output Voltage**



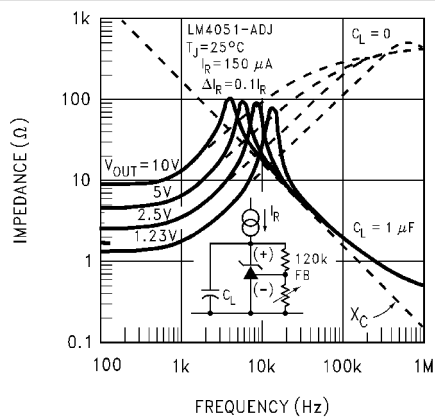
**Figure 5-8. Feedback Current vs Output Voltage and Temperature**



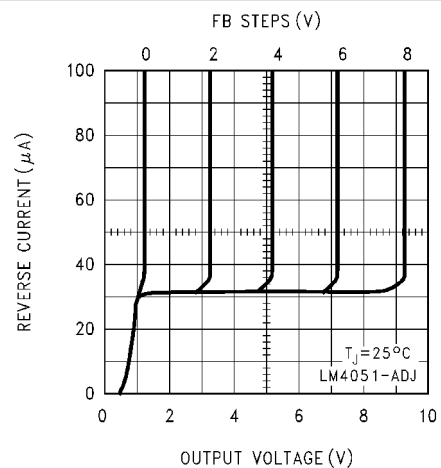
**Figure 5-9. Output Saturation (SOT-23 Only)**



**Figure 5-10. Output Impedance vs Frequency**



**Figure 5-11. Output Impedance vs Frequency**



**Figure 5-12. Reverse Characteristics**

## 5.7 Typical Characteristics (continued)

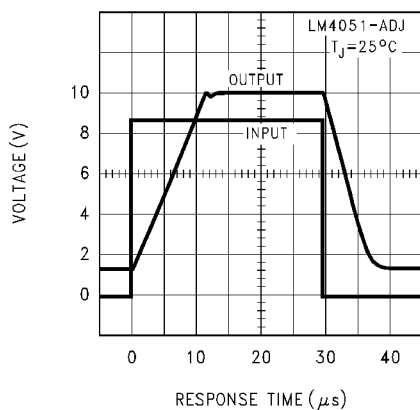


Figure 5-13. Large Signal Response

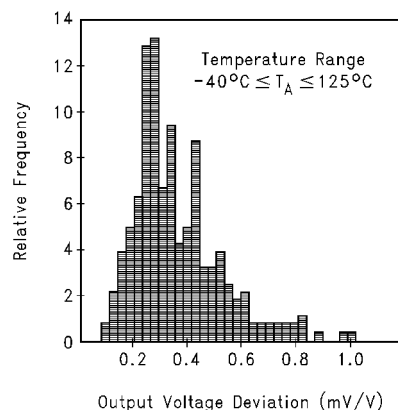
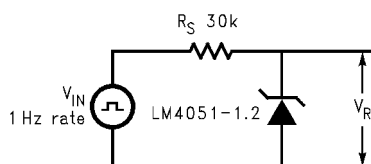
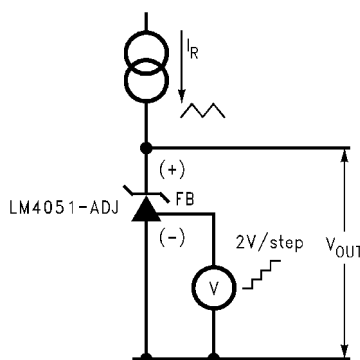


Figure 5-14. Thermal Hysteresis

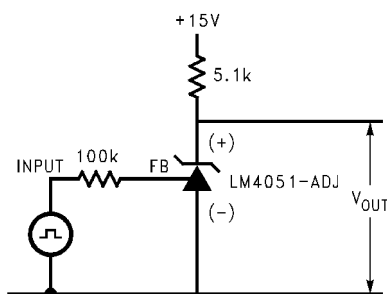
## 6 Parameter Measurement Information



**Figure 6-1. Test Circuit for Start-Up Characteristics**



**Figure 6-2. Test Circuit for Reverse Characteristics**



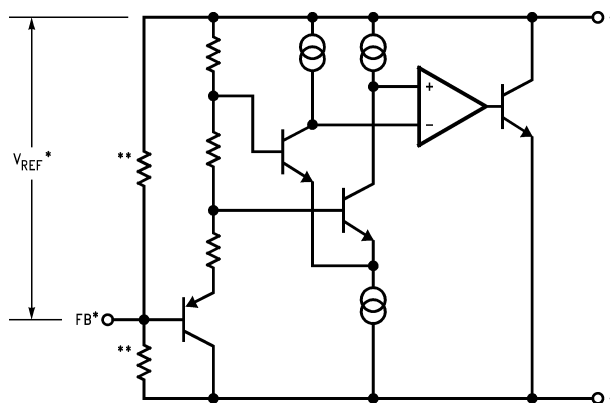
**Figure 6-3. Test Circuit for Large Signal Response**

## 7 Detailed Description

### 7.1 Overview

The LM4051-N is a precision voltage reference available in SOT-23 surface mount package. The LM4051-N is available in a 1.225V fixed-option as well as an adjustable voltage option. The LM4051-N comes in three different tolerance grades (A, B, and C). The best grade devices (A) have an initial accuracy of 0.1%, while the B-grade have 0.2% and the C-grade 0.5%, all with a temperature coefficient of 50ppm/°C maintained from -40°C to 125°C.

### 7.2 Functional Block Diagram



\*LM4051-ADJ only

\*\*LM4051-1.2 only

### 7.3 Feature Description

The LM4051-N device is effectively a precision Zener diode. The part requires a small quiescent current for regulation, and regulates the output voltage by shunting more or less current to ground, depending on input voltage and load. The only external component requirement is a resistor between the cathode and the input voltage to set the input current. An external capacitor can be used on the input or output, but is not required.

For the adjustable version, feedback is applied from the Cathode and Reference pins, the LM4051-N behaves as a Zener diode, regulating to a constant voltage dependent on current being supplied into the cathode. This is due to the internal amplifier and reference entering the proper operating regions. The same amount of current needed in the above feedback situation must be applied to this device in open loop, servo or error amplifying implementations to be in the proper linear region giving the LM4051-N enough gain.

### 7.4 Device Functional Modes

#### 7.4.1 LM4051-N-1.2 V

The LM4051-N-1.2V device is a fixed output voltage part, where the feedback is internal. Therefore, the part can only operate in a closed loop mode and the output voltage cannot be adjusted. The output voltage remains in regulation as long as  $I_R$  is between  $I_{RMIN}$ . Proper selection of the external resistor for input voltage range and load current range makes sure these conditions are met.

#### 7.4.2 LM4051-N - ADJ

The majority of applications involving LM4051-N uses closed loop operation to regulate a fixed voltage or current. The feedback enables this device to behave as an error amplifier, computing a portion of the output voltage and adjusting to maintain the desired regulation. This is done by relating the output voltage back to the reference pin in a manner to be equal to the internal reference voltage, which can be accomplished via resistive or direct feedback.

## 8 Application and Implementation

### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

### 8.1 Application Information

The LM4051-N is a precision micro-power curvature-corrected band gap shunt voltage reference. For space critical applications, the LM4051-N is available in the sub-miniature SOT-23 surface-mount package. The LM4051-N has been designed for stable operation without the need of an external capacitor connected between the "+" pin and the "-" pin. If, however, a bypass capacitor is used, the LM4051-N remains stable. Design effort is further reduced with the choice of either a fixed 1.2V or an adjustable reverse breakdown voltage. The minimum operating current is 60µA for the LM4051-1.2 and the LM4051-ADJ. Both versions have a maximum operating current of 12mA.

LM4051-N's using the SOT-23 package have pin 3 connected as the (–) output through the package's die attach interface. Therefore, the LM4051-1.2's pin 3 must be left floating or connected to pin 2 and the LM4051-ADJ's pin 3 is the (–) output.

The typical thermal hysteresis specification is defined as the change in +25 °C voltage measured after thermal cycling. The device is thermal cycled to temperature –40 °C and then measured at 25 °C. Next the device is thermal cycled to temperature +125 °C and again measured at 25 °C. The resulting  $V_{OUT}$  delta shift between the 25 °C measurements is thermal hysteresis. Thermal hysteresis is common in precision references and is induced by thermal-mechanical package stress. Changes in environmental storage temperature, operating temperature and board mounting temperature are all factors that can contribute to thermal hysteresis.

In a conventional shunt regulator application ([Figure 8-1](#)), an external series resistor ( $R_S$ ) is connected between the supply voltage and the LM4051-N.  $R_S$  determines the current that flows through the load ( $I_L$ ) and the LM4051-N ( $I_Q$ ). Since load current and supply voltage can vary,  $R_S$  needs to be small enough to supply at least the minimum acceptable  $I_Q$  to the LM4051-N even when the supply voltage is at the minimum and the load current is at the maximum value. When the supply voltage is at the maximum and  $I_L$  is at the minimum,  $R_S$  needs to be large enough so that the current flowing through the LM4051-N is less than 12mA.

$R_S$  is selected based on the supply voltage, ( $V_S$ ), the desired load and operating current, ( $I_L$  and  $I_Q$ ), and the LM4051-N's reverse breakdown voltage,  $V_R$ .

$$R_S = \frac{V_S - V_R}{I_L + I_Q} \quad (1)$$

The LM4051-ADJ's output voltage can be adjusted to any value in the range of 1.24V through 10V. The output voltage is a function of the internal reference voltage ( $V_{REF}$ ) and the ratio of the external feedback resistors as shown in [Figure 8-3](#). The output voltage is found using [Equation 2](#):

$$V_O = V_{REF} \left[ \left( R_2 / R_1 \right) + 1 \right] \quad (2)$$

where

- $V_O$  is the output voltage

$$R_S = \frac{V_S - V_R}{I_L + I_Q + I_F} \quad (3)$$

The actual value of the internal  $V_{REF}$  is a function of  $V_O$ . The *corrected*  $V_{REF}$  is determined by [Equation 4](#):

$$V_{REF} = V_O (\Delta V_{REF} / \Delta V_O) + V_Y \quad (4)$$

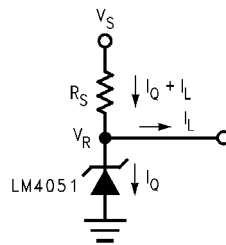
where

- $V_Y = 1.22V$

$\Delta V_{REF}/\Delta V_O$  is found in the [Section 5.6](#) and is typically  $-1.55mV/V$ . You can get a more accurate indication of the output voltage by replacing the value of  $V_{REF}$  in [Equation 2](#) with the value found using [Equation 4](#).

## 8.2 Typical Applications

### 8.2.1 Shunt Regulator



**Figure 8-1. Shunt Regulator**

#### 8.2.1.1 Design Requirements

$$V_{IN} > V_{OUT}$$

Select  $R_S$  such that:

$$I_{RMIN} < I_R < I_{RMAX} \text{ where } I_{RMAX} = 12mA$$

See [Section 5.5](#) for minimum operating current for each voltage option and grade.

#### 8.2.1.2 Detailed Design Procedure

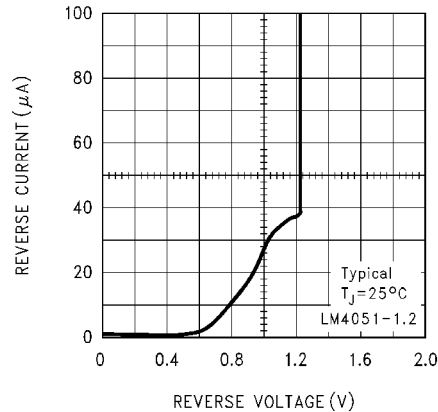
The resistor  $R_S$  must be selected such that current,  $I_R$ , remains in the operational region of the part for the entire  $V_{IN}$  range and load current range. The two extremes to consider are  $V_{IN}$  at the maximum, and the load at the minimum, where  $R_S$  must be large enough to main  $I_R < I_{RMAX}$ . For most designs,  $0.1mA \leq I_R \leq 1mA$  is a good starting point.

Use cross and cross to set  $R_S$  between  $R_{S\_MIN}$  and  $R_{S\_MAX}$ .

$$R_{S\_MIN} = \frac{V_{IN\_MAX} - V_{OUT}}{I_{LOAD\_MIN} + I_{R\_MAX}} \quad (5)$$

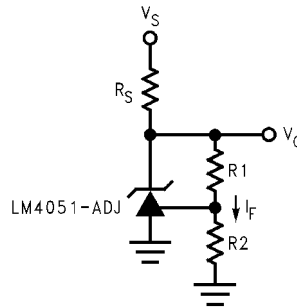
$$R_{S\_MAX} = \frac{V_{IN\_MIN} - V_{OUT}}{I_{LOAD\_MAX} + I_{R\_MIN}} \quad (6)$$

### 8.2.1.3 Application Curves



**Figure 8-2. Reverse Characteristics and Minimum Operating Current**

### 8.2.2 Adjustable Shunt Regulator



**Figure 8-3. Adjustable Shunt Regulator**

#### 8.2.2.1 Design Requirements

$$V_{IN} > V_{OUT}$$

Select  $R_S$  such that:

$$I_{RMIN} < I_R < I_{RMAX} \text{ where } I_{RMAX} = 12\text{mA}$$

See [Section 5.6](#) for minimum operating current for each voltage option and grade.

#### 8.2.2.2 Detailed Design Procedure

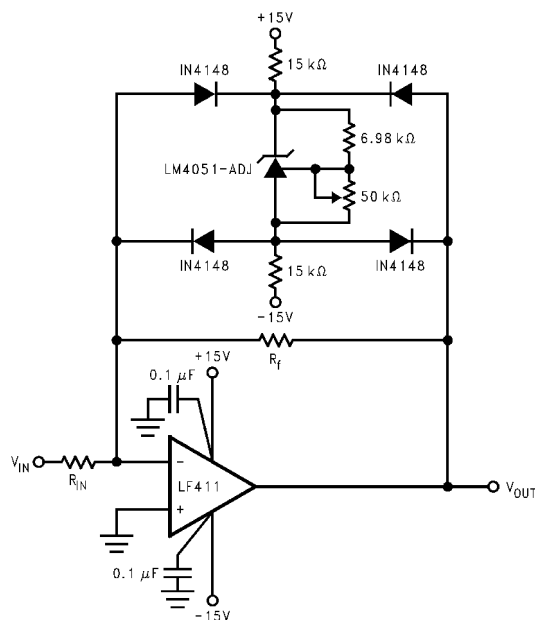
To program the cathode voltage to a regulated voltage a resistive bridge must be shunted between the cathode and anode pins with the mid point tied to the reference pin. This can be seen in [Figure 8-3](#), with R1 & R2 being the resistive bridge. The cathode/output voltage in the shunt regulator configuration can be approximated by the equation shown in [Equation 7](#). The cathode voltage can be more accurately determined by taking in to account the cathode current shown in equation [Equation 8](#).

$$V_O = V_{REF}[(R2/R1) + 1] \quad (7)$$

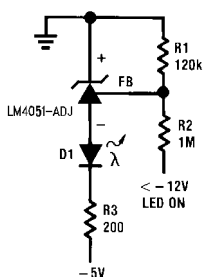
$$V_O = (1 + R2/R1) \times (V_{REF} - I_{REF} \times R1) \quad (8)$$

For this equation to be valid, LM4051-ADJ must be fully biased so there is enough open loop gain to mitigate any gain error. This can be done by meeting the  $I_{RMIN}$  denoted in [Section 5.6](#). When the output voltage,  $V_Z$ , is set below 2.5V on adjustable versions of LM4051-N, the device can experience increased reference voltage change with output voltage change ( $\Delta V_{REF}/\Delta V_O$ ) when compared to output voltages set equal to or above 2.5V

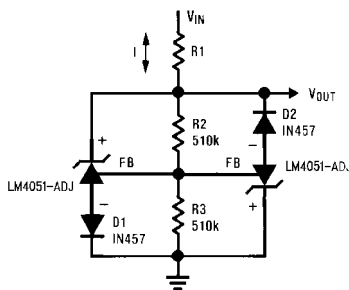
### 8.3 System Examples



**Figure 8-4. Bounded Amplifier Reduces Saturation-induced Delays and Can Prevent Succeeding Stage Damage. Nominal Clamping Voltage is  $\pm V_O$  (LM4051-N's Reverse Breakdown Voltage) +2 Diode  $V_F$  .**

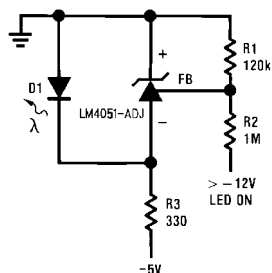


**Figure 8-5. Voltage Level Detector**

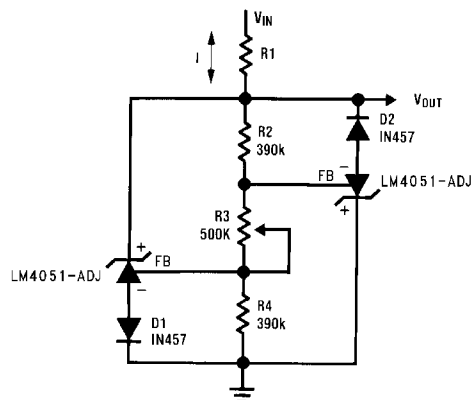


**Figure 8-6. Voltage Level Detector**

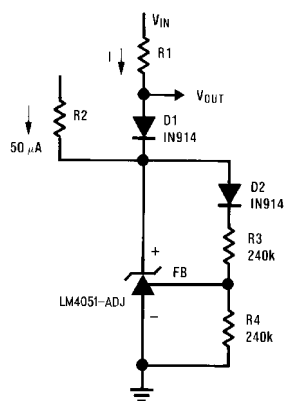




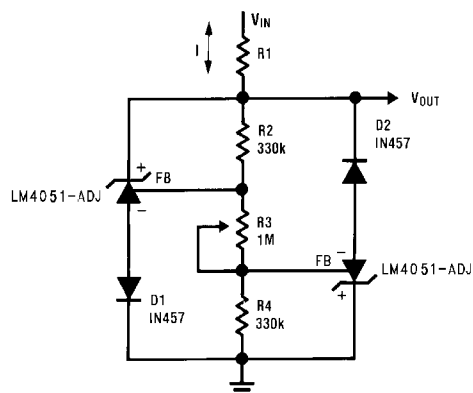
**Figure 8-7. Fast Positive Clamp  $2.4V + V_{D1}$**



**Figure 8-8. Bidirectional Clamp  $\pm 2.4V$**



**Figure 8-9. Bidirectional Adjustable Clamp  $\pm 18V$  to  $\pm 2.4V$**



**Figure 8-10. Bidirectional Adjustable Clamp  $\pm 2.4V$  to  $\pm 6V$**

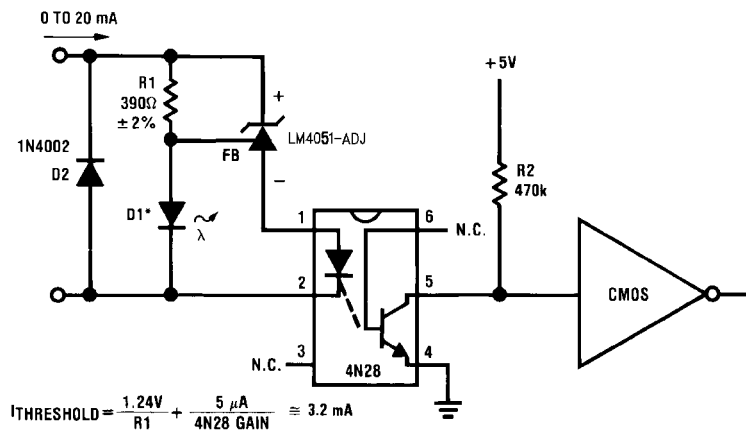
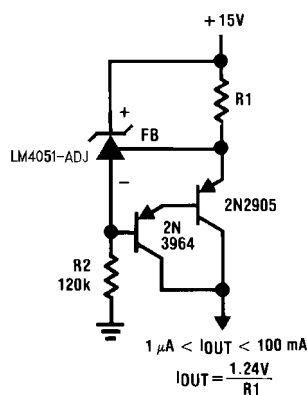


Figure 8-11. Simple Floating Current Detector



\*D1 can be any LED,  $V_F = 1.5V$  to  $2.2V$  at  $3mA$ . D1 may act as an indicator. D1 will be on if  $I_{THRESHOLD}$  falls below the threshold current, except with  $I = 0$ .

Figure 8-12. Current Source

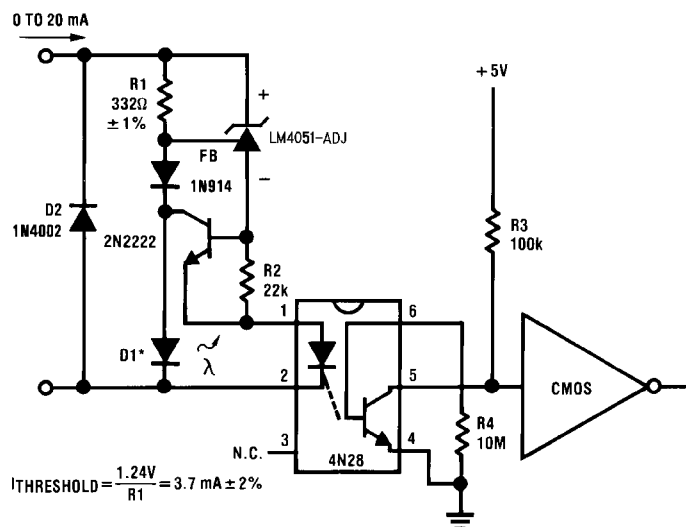
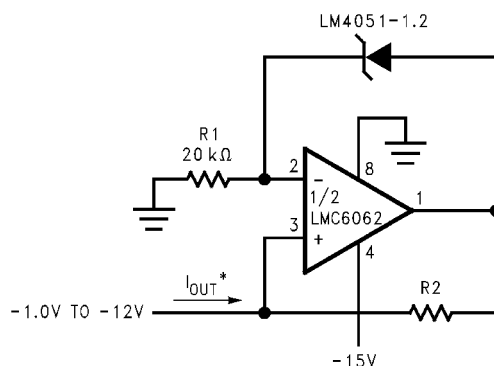
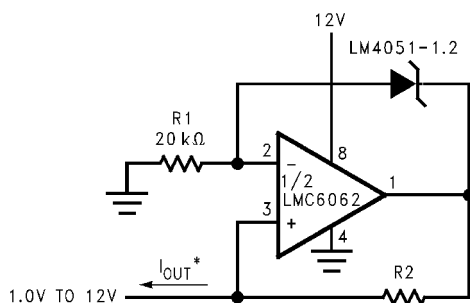


Figure 8-13. Precision Floating Current Detector



**Figure 8-14. Precision 1µA to 1mA Current Source**



**Figure 8-15. Precision 1µA to 1mA Current Source**

## 8.4 Power Supply Recommendations

While a bypass capacitor is not required on the input voltage line, TI recommends reducing noise on the input which can affect the output. A 0.1µF ceramic capacitor or larger is recommended.

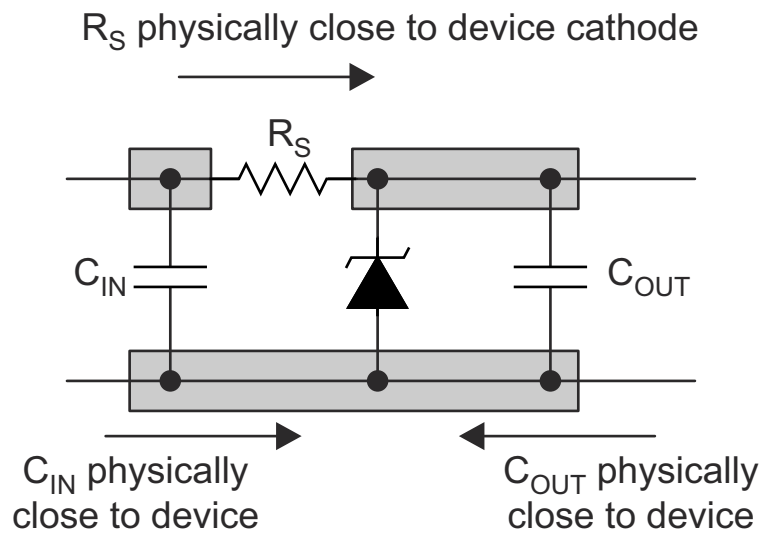
To not exceed the maximum cathode current, be sure that the supply current is limited. For applications shunting high currents, pay attention to the cathode and anode trace lengths, adjusting the width of the traces to have proper current density.

## 8.5 Layout

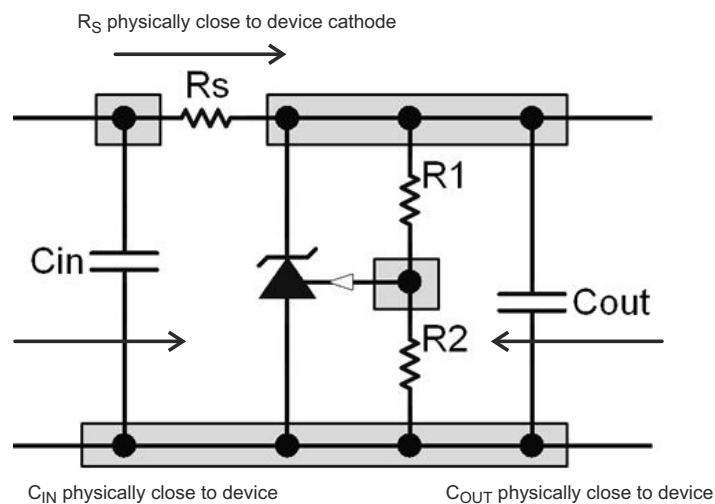
### 8.5.1 Layout Guidelines

Place bypass capacitors as close to the device as possible. Current-carrying traces need to have widths appropriate for the amount of current. Place  $R_S$  as close as possible to the cathode. Although not as critical, keep feedback resistor close to the device whenever possible.

### 8.5.2 Layout Example



**Figure 8-16. Layout Diagram**



**Figure 8-17. Feedback Resistors Layout Diagram**

## 9 Device and Documentation Support

### 9.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 9.2 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

### 9.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.  
All trademarks are the property of their respective owners.

### 9.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 9.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| <b>Changes from Revision D (September 2018) to Revision E (June 2024)</b>                                              | <b>Page</b>        |
|------------------------------------------------------------------------------------------------------------------------|--------------------|
| • Updated <i>Applications</i> links.....                                                                               | <a href="#">1</a>  |
| • Added information about device behavior in high EMI environments.....                                                | <a href="#">3</a>  |
| • Added information about device behavior in high EMI environments.....                                                | <a href="#">3</a>  |
| • Removed machine model (MM) ESD specification and added CDM ESD specification.....                                    | <a href="#">4</a>  |
| • Corrected Equation 7 and Equation 8, added information about device behavior with output voltage less than 2.5V..... | <a href="#">15</a> |
| • Added part number clarification for part numbers including "X".....                                                  | <a href="#">21</a> |

| <b>Changes from Revision C (March 2005) to Revision D (September 2018)</b>                                                                                                                                                                                                                                                                                                                                           | <b>Page</b>       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| • Added <i>Device Information</i> table, <i>Device Comparison</i> table, <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section..... | <a href="#">1</a> |

## 11 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of

this document. For browser-based versions of this data sheet, refer to the left-hand navigation. Part numbers containing an "X" contain the same electrical properties as those which do not contain an "X".

**Table 11-1. SOT-23 Package Marking Information**

| PART MARKING | FIELD DEFINITION              |                                                              |                                                                                                                                                      |
|--------------|-------------------------------|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| RHA<br>RIA   | First Field:<br>R = Reference | Second Field:<br>H = 1.225V Voltage Option<br>I = Adjustable | Third Field:<br>A-C = Initial Reserved Breakdown<br>Voltage or Reference Voltage<br>Tolerance<br>A = $\pm 0.1\%$ , B = $\pm 0.2\%$ , C = $\pm 0.5\%$ |
| RHB<br>RIB   |                               |                                                              |                                                                                                                                                      |
| RHC<br>RIC   |                               |                                                              |                                                                                                                                                      |

## PACKAGING INFORMATION

| Orderable part number                | Status<br>(1) | Material type<br>(2) | Package   Pins   | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|--------------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| LM4051AIM3-1.2/NO.A                  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RHA                 |
| <a href="#">LM4051AIM3-1.2/NOPB</a>  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RHA                 |
| LM4051AIM3-ADJ/NO.A                  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RIA                 |
| <a href="#">LM4051AIM3-ADJ/NOPB</a>  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RIA                 |
| LM4051AIM3X-1.2/NO.A                 | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RHA                 |
| <a href="#">LM4051AIM3X-1.2/NOPB</a> | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RHA                 |
| LM4051AIM3X-ADJ/NO.A                 | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RIA                 |
| <a href="#">LM4051AIM3X-ADJ/NOPB</a> | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RIA                 |
| LM4051BEM3-1.2/NO.A                  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RHB                 |
| <a href="#">LM4051BEM3-1.2/NOPB</a>  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RHB                 |
| LM4051BIM3-1.2/NO.A                  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RHB                 |
| <a href="#">LM4051BIM3-1.2/NOPB</a>  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RHB                 |
| LM4051BIM3-ADJ/NO.A                  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RIB                 |
| LM4051BIM3-ADJ/NO.B                  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RIB                 |
| <a href="#">LM4051BIM3-ADJ/NOPB</a>  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RIB                 |
| LM4051BIM3X-1.2/NO.A                 | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RHB                 |
| <a href="#">LM4051BIM3X-1.2/NOPB</a> | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RHB                 |
| LM4051BIM3X-ADJ/NO.A                 | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RIB                 |
| <a href="#">LM4051BIM3X-ADJ/NOPB</a> | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RIB                 |
| LM4051CIM3-1.2/NO.A                  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RHC                 |
| <a href="#">LM4051CIM3-1.2/NOPB</a>  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RHC                 |
| LM4051CIM3-ADJ/NO.A                  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RIC                 |
| <a href="#">LM4051CIM3-ADJ/NOPB</a>  | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RIC                 |
| LM4051CIM3X-1.2/NO.A                 | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RHC                 |
| <a href="#">LM4051CIM3X-1.2/NOPB</a> | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RHC                 |
| LM4051CIM3X-ADJ/NO.A                 | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | RIC                 |
| <a href="#">LM4051CIM3X-ADJ/NOPB</a> | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 85    | RIC                 |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

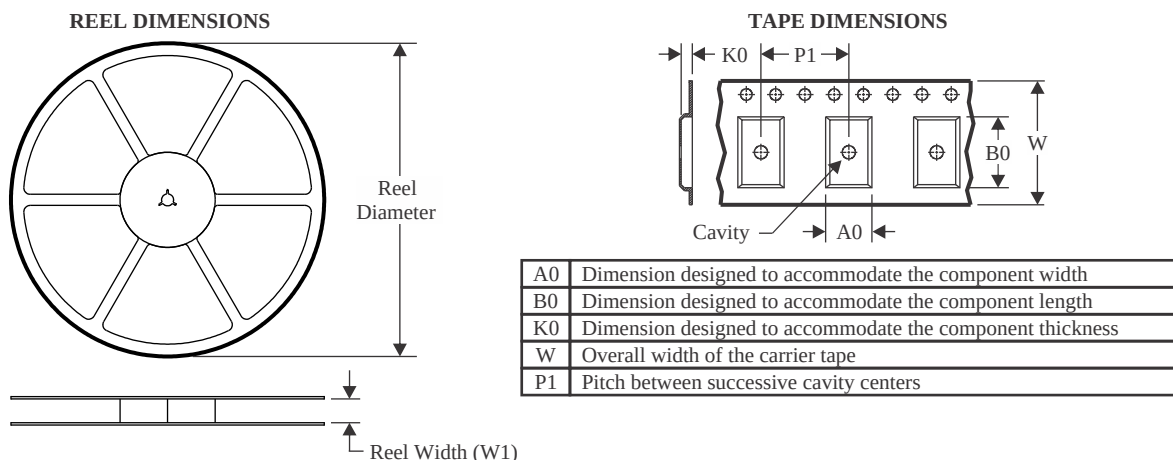
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

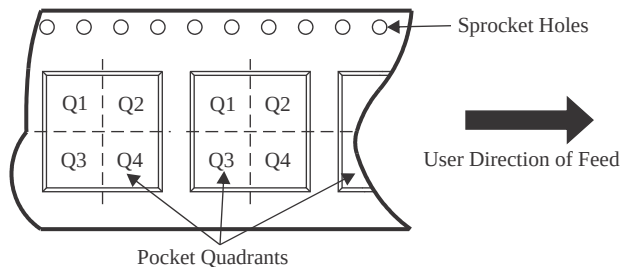
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.



## TAPE AND REEL INFORMATION



### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



\*All dimensions are nominal

| Device               | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM4051AIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051AIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051AIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051AIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051AIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051AIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051AIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051AIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051BEM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051BEM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051BIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051BIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051BIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051BIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051BIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |

| Device               | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM4051BIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051BIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051BIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051CIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051CIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051CIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051CIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051CIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051CIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |
| LM4051CIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| LM4051CIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 8.4                | 3.3     | 2.9     | 1.22    | 4.0     | 8.0    | Q3            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device               | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|----------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM4051AIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051AIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |
| LM4051AIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051AIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |
| LM4051AIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |
| LM4051AIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051AIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |
| LM4051AIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051BEM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |
| LM4051BEM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051BIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051BIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |
| LM4051BIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051BIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |
| LM4051BIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051BIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |
| LM4051BIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051BIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |

---

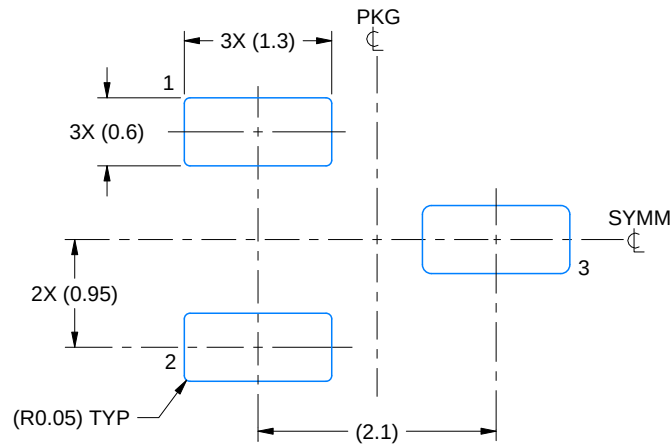
| Device               | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|----------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM4051CIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |
| LM4051CIM3-1.2/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051CIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051CIM3-ADJ/NOPB  | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |
| LM4051CIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051CIM3X-1.2/NOPB | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |
| LM4051CIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| LM4051CIM3X-ADJ/NOPB | SOT-23       | DBZ             | 3    | 3000 | 208.0       | 191.0      | 35.0        |



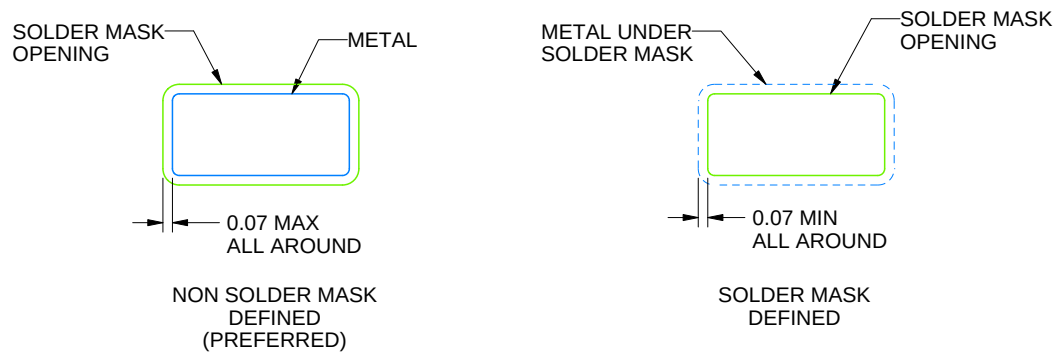
**DBZ0003A**

**SOT-23 - 1.12 mm max height**

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
SCALE:15X



## SOLDER MASK DETAILS

4214838/F 08/2024

NOTES: (continued)

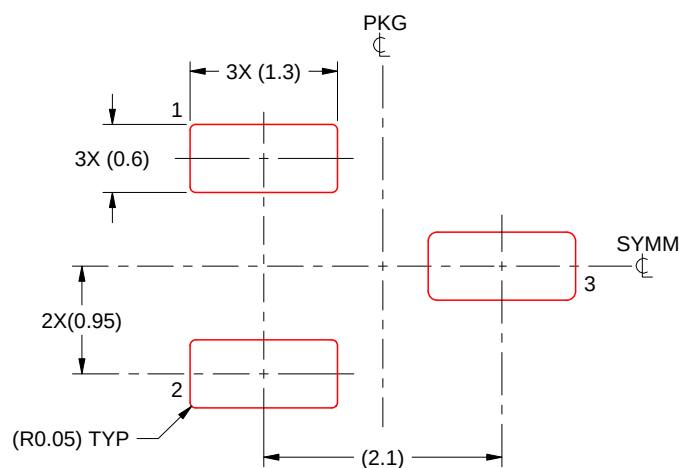
5. Publication IPC-7351 may have alternate designs.  
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE  
BASED ON 0.125 THICK STENCIL  
SCALE:15X

4214838/F 08/2024

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025