

## LM4050QML Precision Micropower Shunt Voltage Reference

Check for Samples: [LM4050QML](#)

### FEATURES

- Low Dose Rate Qualified 100 krad(Si)
- SEFI Immune
- SET Immune with 60µF C<sub>LOAD</sub>
- C<sub>LOAD</sub> 0µF to 100µF
- Fixed Reverse Breakdown Voltage of 2.500V, 5.000V

### KEY SPECIFICATIONS

- **LM4050-2.5QML**
  - Output Voltage Tolerance IR = 100µA ±0.1% @ 25°C
  - Low Temperature Coefficient 15 ppm/°C
  - Low Output Noise 50 µVrms(typ)
  - Wide Operating Current Range 60 µA to 15 mA
- **LM4050-5.0QML**
  - Output Voltage Tolerance IR = 100µA ±0.1% @ 25°C
  - Low Temperature Coefficient 23 ppm/°C
  - Low Output Noise 100 µVrms(typ)
  - Wide Operating Current Range 74 µA to 15 mA

### APPLICATIONS

- Control Systems
- Data Acquisition Systems
- Instrumentation
- Process Control
- Energy Management

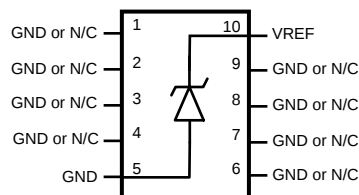
### DESCRIPTION

The LM4050QML precision voltage reference is available in a 10-Lead Ceramic CLGA package. The LM4050QML's design eliminates the need for an external stabilizing capacitor while ensuring stability with a capacitive load, thus making the LM4050QML easy to use. The LM4050-2.5QML has a 60 µA minimum and 15 mA maximum operating current. The LM4050-5.0QML has a 74 µA minimum and 15 mA maximum operating current.

The LM4050QML utilizes fuse and zener-zap reverse breakdown voltage trim during wafer sort to ensure that the prime parts have an accuracy of better than ±0.1% at 25°C. Bandgap reference temperature drift curvature correction and low dynamic impedance ensure stable reverse breakdown voltage accuracy over a wide range of operating temperatures and currents.

The LM4050QML operates over the temperature range of -55°C to +125°C.

### Connection Diagram



**Figure 1. 10-Lead Ceramic CFP, Top View**  
See NAC0010A Package



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**PIN DESCRIPTIONS**

| Pin Number | Pin Name | Function             |
|------------|----------|----------------------|
| 1          | GND/NC   | Ground or No Connect |
| 2          | GND/NC   | Ground or No Connect |
| 3          | GND/NC   | Ground or No Connect |
| 4          | GND/NC   | Ground or No Connect |
| 5          | GND      | Ground               |
| 6          | GND/NC   | Ground or No Connect |
| 7          | GND/NC   | Ground or No Connect |
| 8          | GND/NC   | Ground or No Connect |
| 9          | GND/NC   | Ground or No Connect |
| 10         | VREF     | Reference Voltage    |



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

**Absolute Maximum Ratings<sup>(1)</sup>**

|                                                               |              |                 |
|---------------------------------------------------------------|--------------|-----------------|
| Reverse Current                                               |              | 20 mA           |
| Forward Current                                               |              | 10 mA           |
| Power Dissipation ( $T_A = 25^\circ\text{C}$ ) <sup>(2)</sup> | CLGA Package | 467 mW          |
| Lead Temperature (Soldering, 10 seconds)                      | CLGA Package | 260°C           |
| Storage Temperature                                           |              | -65°C to +150°C |
| Package Weight (typical)                                      | CLGA Package | 241mg           |
| ESD Tolerance <sup>(3)</sup>                                  |              | Class 2 (2000V) |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
- (2) The maximum power dissipation must be derated at elevated temperatures and is dictated by  $T_{Jmax}$  (maximum junction temperature),  $\theta_{JA}$  (junction to ambient thermal resistance), and  $T_A$  (ambient temperature). The maximum allowable power dissipation at any temperature is  $PD_{max} = (T_{Jmax} - T_A)/\theta_{JA}$  or the number given in the Absolute Maximum Ratings, whichever is lower. For the LM4050QML,  $T_{Jmax} = 125^\circ\text{C}$ , and the typical thermal resistance ( $\theta_{JA}$ ), when board mounted, is  $214^\circ\text{C/W}$  for the 10-Lead Ceramic CLGA package.
- (3) The human body model is a 100 pF capacitor discharged through a 1.5 k $\Omega$  resistor into each pin.

**Operating Ratings<sup>(1)</sup>**

|                   |               |                                                      |
|-------------------|---------------|------------------------------------------------------|
| Temperature Range |               | $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ |
| Reverse Current   | LM4050-2.5QML | 60 $\mu\text{A}$ to 15 mA                            |
|                   | LM4050-5.0QML | 74 $\mu\text{A}$ to 15 mA                            |

- (1) The maximum power dissipation must be derated at elevated temperatures and is dictated by  $T_{Jmax}$  (maximum junction temperature),  $\theta_{JA}$  (junction to ambient thermal resistance), and  $T_A$  (ambient temperature). The maximum allowable power dissipation at any temperature is  $PD_{max} = (T_{Jmax} - T_A)/\theta_{JA}$  or the number given in the Absolute Maximum Ratings, whichever is lower. For the LM4050QML,  $T_{Jmax} = 125^\circ\text{C}$ , and the typical thermal resistance ( $\theta_{JA}$ ), when board mounted, is  $214^\circ\text{C/W}$  for the 10-Lead Ceramic CLGA package.

**Package Thermal Resistance**

| Package                          | $\theta_{JA}$<br>(Still Air) | $\theta_{JA}$<br>(500LF/Min Air flow) | $\theta_{JC}$           |
|----------------------------------|------------------------------|---------------------------------------|-------------------------|
| CLGA Package on 2 layer, 1oz PCB | $214^\circ\text{C/W}$        | $147^\circ\text{C/W}$                 | $20.87^\circ\text{C/W}$ |

## Quality Conformance Inspection

MIL-STD-883, Method 5005 - Group A

| Subgroup | Description         | Temp ( C) |
|----------|---------------------|-----------|
| 1        | Static tests at     | +25       |
| 2        | Static tests at     | +125      |
| 3        | Static tests at     | -55       |
| 4        | Dynamic tests at    | +25       |
| 5        | Dynamic tests at    | +125      |
| 6        | Dynamic tests at    | -55       |
| 7        | Functional tests at | +25       |
| 8A       | Functional tests at | +125      |
| 8B       | Functional tests at | -55       |
| 9        | Switching tests at  | +25       |
| 10       | Switching tests at  | +125      |
| 11       | Switching tests at  | -55       |
| 12       | Setting time at     | +25       |
| 13       | Setting time at     | +125      |
| 14       | Setting time at     | -55       |

## LM4050-2.5QML Electrical Characteristics SMD: 5962R0923561

The initial Reverse Breakdown Voltage tolerance is  $\pm 0.1\%$  @ 100 $\mu$ A.

| Symbol     | Parameter                           | Conditions        | Notes | Typical <sup>(1)</sup> | Min | Max        | Units   | Sub-groups |
|------------|-------------------------------------|-------------------|-------|------------------------|-----|------------|---------|------------|
| $V_R$      | Reverse Breakdown Voltage Tolerance | $I_R = 100 \mu A$ |       | 2.500                  |     |            | V       |            |
|            |                                     | $I_R = 60 \mu A$  |       |                        |     | $\pm 2.5$  | mV      | 1          |
|            |                                     | $I_R = 100 \mu A$ |       |                        |     | $\pm 2.5$  |         |            |
|            |                                     | $I_R = 1 mA$      |       |                        |     | $\pm 3.75$ |         |            |
|            |                                     | $I_R = 10 mA$     |       |                        |     | $\pm 10$   |         |            |
|            |                                     | $I_R = 15 mA$     |       |                        |     | $\pm 13$   |         |            |
|            |                                     | $I_R = 60 \mu A$  |       |                        |     | $\pm 5$    | mV      | 2          |
|            |                                     | $I_R = 100 \mu A$ |       |                        |     | $\pm 5$    |         |            |
|            |                                     | $I_R = 1 mA$      |       |                        |     | $\pm 6.25$ |         |            |
|            |                                     | $I_R = 10 mA$     |       |                        |     | $\pm 12.5$ |         |            |
|            |                                     | $I_R = 15 mA$     |       |                        |     | $\pm 14$   |         |            |
|            |                                     | $I_R = 60 \mu A$  |       |                        |     | $\pm 4.5$  | mV      | 3          |
|            |                                     | $I_R = 100 \mu A$ |       |                        |     | $\pm 4.5$  |         |            |
|            |                                     | $I_R = 1 mA$      |       |                        |     | $\pm 5.75$ |         |            |
|            |                                     | $I_R = 10 mA$     |       |                        |     | $\pm 13$   |         |            |
|            |                                     | $I_R = 15 mA$     |       |                        |     | $\pm 17.5$ |         |            |
| $I_{RMIN}$ | Minimum Operating Current           |                   |       | 40.5                   |     | 60         | $\mu A$ | 1          |
|            |                                     |                   |       |                        |     | 65         | $\mu A$ | 2, 3       |

(1) Typicals are at  $T_A = 25^\circ C$  and represent most likely parametric norm.

## LM4050-2.5QML Electrical Characteristics SMD: 5962R0923561 (continued)

The initial Reverse Breakdown Voltage tolerance is  $\pm 0.1\%$  @ 100 $\mu$ A.

| Symbol                | Parameter                                                                                                      | Conditions                                                      | Notes              | Typical <sup>(1)</sup> | Min | Max      | Units                 | Sub-groups |
|-----------------------|----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|--------------------|------------------------|-----|----------|-----------------------|------------|
| $\Delta V_R/\Delta T$ | Average Reverse Breakdown Voltage Temperature Coefficient @ $25^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ | $I_R = 60\mu\text{A}$                                           | See <sup>(2)</sup> | $\pm 3$                |     | $\pm 15$ | ppm/ $^\circ\text{C}$ | 2          |
|                       |                                                                                                                | $I_R = 100\mu\text{A}$                                          |                    | $\pm 3$                |     | $\pm 16$ |                       |            |
|                       |                                                                                                                | $I_R = 1\text{mA}$                                              |                    | $\pm 3$                |     | $\pm 18$ |                       |            |
|                       |                                                                                                                | $I_R = 10\text{mA}$                                             |                    | $\pm 4$                |     | $\pm 20$ |                       |            |
|                       |                                                                                                                | $I_R = 15\text{mA}$                                             |                    | $\pm 6$                |     | $\pm 22$ |                       |            |
|                       | Average Reverse Breakdown Voltage Temperature Coefficient @ $-55^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$ | $I_R = 60\mu\text{A}$                                           | See <sup>(2)</sup> | $\pm 3$                |     | $\pm 18$ | ppm/ $^\circ\text{C}$ | 3          |
|                       |                                                                                                                | $I_R = 100\mu\text{A}$                                          |                    | $\pm 3$                |     | $\pm 19$ |                       |            |
|                       |                                                                                                                | $I_R = 1\text{mA}$                                              |                    | $\pm 3.5$              |     | $\pm 22$ |                       |            |
|                       |                                                                                                                | $I_R = 10\text{mA}$                                             |                    | $\pm 10$               |     | $\pm 32$ |                       |            |
|                       |                                                                                                                | $I_R = 15\text{mA}$                                             |                    | $\pm 15$               |     | $\pm 45$ |                       |            |
| $Z_R$                 | Reverse Dynamic Impedance                                                                                      | $I_R = 1\text{mA}$ , $f = 120\text{Hz}$ ,<br>$I_{AC} = 0.1 I_R$ |                    | 0.3                    |     |          | $\Omega$              |            |
| $V_N$                 | Output Noise Voltage                                                                                           | $0.1\text{Hz} \leq f \leq 10\text{Hz}$                          |                    | 9                      |     |          | $\mu\text{Vpp}$       |            |
|                       |                                                                                                                | $10\text{Hz} \leq f \leq 10\text{KHz}$                          |                    | 50                     |     |          | $\mu\text{Vrms}$      |            |
| $C_{LOAD}$            | Load Capacitor                                                                                                 | Stable Over Temperature                                         | See <sup>(3)</sup> | 60                     | 0   | 100      | $\mu\text{F}$         |            |
| $V_{HYST}$            | Thermal Hysteresis                                                                                             | $\Delta T = -55^\circ\text{C}$ to $125^\circ\text{C}$           | See <sup>(4)</sup> | 1                      |     |          | ppm                   |            |

(2) Not tested post irradiation. Typical post irradiation values listed in the post radiation Tempco table.

(3) Capacitive load not required but improves SET stability. This parameter is ensured by design and/or characterization and is not tested in production.

(4) Thermal hysteresis is defined as the change in voltage measured at  $+25^\circ\text{C}$  after cycling to temperature  $-55^\circ\text{C}$  and the  $25^\circ\text{C}$  measurement after cycling to temperature  $+125^\circ\text{C}$ .

$$V_{HYST} = \frac{|V_{R1} - V_{R2}|}{V_R} \times 10^6 \text{ ppm}$$

Where:  $V_{HYST}$  = Thermal hysteresis expressed in ppm

$V_R$  = Nominal preset output voltage

$V_{R1} = V_R$  before temperature fluctuation

$V_{R2} = V_R$  after temperature fluctuation.

### Post Radiation @ $25^\circ\text{C}$ <sup>(1)</sup>

The initial Reverse Breakdown Voltage tolerance is  $\pm 0.1\%$  @ 100 $\mu$ A. Qualification is performed with a 1.5X overtest. See for [TOTAL IONIZING DOSE](#) details.

| Symbol | Parameter                           | Conditions             |     | 30 krad | 50 krad | 100 krad | Sub-groups |
|--------|-------------------------------------|------------------------|-----|---------|---------|----------|------------|
| $V_R$  | Reverse Breakdown Voltage Tolerance | $I_R = 60\mu\text{A}$  | Max | +0.42%  | +0.67%  | +1.75%   | 1          |
|        |                                     | $I_R = 100\mu\text{A}$ |     |         |         |          |            |
|        |                                     | $I_R = 1\text{mA}$     |     |         |         |          |            |
|        |                                     | $I_R = 10\text{mA}$    |     |         |         |          |            |
|        |                                     | $I_R = 15\text{mA}$    |     |         |         |          |            |

(1) Pre and post irradiation limits are identical to those listed under electrical characteristics except as listed in the post radiation table.

### Post Radiation Tempco<sup>(1)</sup>

| Symbol                | Parameter                                                                                                            | Conditions                                | TYPICALS |         |          |                       |
|-----------------------|----------------------------------------------------------------------------------------------------------------------|-------------------------------------------|----------|---------|----------|-----------------------|
|                       |                                                                                                                      |                                           | 30 krad  | 50 krad | 100 krad | Units                 |
| $\Delta V_R/\Delta T$ | Average Reverse Breakdown Voltage Temperature Coefficient Drift @ $25^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ | $60\mu\text{A} \leq I_R \leq 15\text{mA}$ | +41      | +83     | +144     | ppm/ $^\circ\text{C}$ |
|                       | Average Reverse Breakdown Voltage Temperature Coefficient Drift @ $-55^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$ | $60\mu\text{A} \leq I_R \leq 15\text{mA}$ | +46      | +87     | +166     | ppm/ $^\circ\text{C}$ |

(1) Not tested post irradiation. Typical post irradiation values listed in the post radiation Tempco table.

## Operational Life Test Delta Parameters

This table represents the drift seen from initial measurements post 1000hr Operational Life Burn-In. All units will remain within the electrical characteristics limits post 1000hr Operational Life Burn-In. Deltas required for QMLV product at Group B, Sub-Group 5.

| Symbol     | Parameter                           | Conditions       | Note | Min    | Max   | Units   | Temp |
|------------|-------------------------------------|------------------|------|--------|-------|---------|------|
| $V_R$      | Reverse Breakdown Voltage Tolerance | $I_R = 60\mu A$  |      | -0.873 | 0.873 | mV      | 1    |
|            |                                     | $I_R = 100\mu A$ |      | -0.873 | 0.873 |         |      |
|            |                                     | $I_R = 1mA$      |      | -0.998 | 0.998 |         |      |
|            |                                     | $I_R = 10mA$     |      | -3.93  | 3.93  |         |      |
|            |                                     | $I_R = 15mA$     |      | -5     | 5     |         |      |
| $I_{RMIN}$ | Minimum Operating Current           |                  |      | -0.623 | 0.623 | $\mu A$ | 1    |

## LM4050-5.0QML Electrical Characteristics SMD: 5962R0923562

The initial Reverse Breakdown Voltage tolerance is  $\pm 0.1\%$  @  $100\mu A$ .

| Symbol                | Parameter                                                                                             | Conditions                                       | Notes              | Typical <sup>(1)</sup> | Min | Max        | Units           | Sub-groups |
|-----------------------|-------------------------------------------------------------------------------------------------------|--------------------------------------------------|--------------------|------------------------|-----|------------|-----------------|------------|
| $V_R$                 | Reverse Breakdown Voltage                                                                             | $I_R = 100\mu A$                                 |                    | 5.000                  |     |            | V               |            |
|                       | Reverse Breakdown Voltage Tolerance                                                                   | $I_R = 74\mu A$                                  |                    |                        |     | $\pm 5.0$  | mV              | 1          |
|                       |                                                                                                       | $I_R = 100\mu A$                                 |                    |                        |     | $\pm 5.0$  |                 |            |
|                       |                                                                                                       | $I_R = 1mA$                                      |                    |                        |     | $\pm 8$    |                 |            |
|                       |                                                                                                       | $I_R = 10mA$                                     |                    |                        |     | $\pm 18$   |                 |            |
|                       |                                                                                                       | $I_R = 15mA$                                     |                    |                        |     | $\pm 20$   |                 |            |
|                       |                                                                                                       | $I_R = 74\mu A$                                  |                    |                        |     | $\pm 10$   | mV              | 2          |
|                       |                                                                                                       | $I_R = 100\mu A$                                 |                    |                        |     | $\pm 10$   |                 |            |
|                       |                                                                                                       | $I_R = 1mA$                                      |                    |                        |     | $\pm 12$   |                 |            |
|                       |                                                                                                       | $I_R = 10mA$                                     |                    |                        |     | $\pm 22.5$ |                 |            |
|                       |                                                                                                       | $I_R = 15mA$                                     |                    |                        |     | $\pm 28$   |                 |            |
|                       |                                                                                                       | $I_R = 74\mu A$                                  |                    |                        |     | $\pm 9$    | mV              | 3          |
|                       |                                                                                                       | $I_R = 100\mu A$                                 |                    |                        |     | $\pm 9$    |                 |            |
|                       |                                                                                                       | $I_R = 1mA$                                      |                    |                        |     | $\pm 11.5$ |                 |            |
|                       |                                                                                                       | $I_R = 10mA$                                     |                    |                        |     | $\pm 29$   |                 |            |
|                       |                                                                                                       | $I_R = 15mA$                                     |                    |                        |     | $\pm 37$   |                 |            |
| $I_{RMIN}$            | Minimum Operating Current                                                                             |                                                  |                    | 53                     |     | 70         | $\mu A$         | 1          |
|                       |                                                                                                       |                                                  |                    |                        |     | 74         | $\mu A$         | 2, 3       |
| $\Delta V_R/\Delta T$ | Average Reverse Breakdown Voltage Temperature Coefficient<br>@ $25^\circ C \leq T_A \leq 125^\circ C$ | $I_R = 74\mu A$                                  | See <sup>(2)</sup> | $\pm 9$                |     | $\pm 23$   | ppm/ $^\circ C$ | 2          |
|                       |                                                                                                       | $I_R = 100\mu A$                                 |                    | $\pm 9$                |     | $\pm 25$   |                 |            |
|                       |                                                                                                       | $I_R = 1mA$                                      |                    | $\pm 10$               |     | $\pm 28$   |                 |            |
|                       |                                                                                                       | $I_R = 10mA$                                     |                    | $\pm 11$               |     | $\pm 35$   |                 |            |
|                       |                                                                                                       | $I_R = 15mA$                                     |                    | $\pm 11$               |     | $\pm 40$   |                 |            |
|                       | Average Reverse Breakdown Voltage Temperature Coefficient<br>@ $-55^\circ C \leq T_A \leq 25^\circ C$ | $I_R = 74\mu A$                                  | See <sup>(2)</sup> | $\pm 10$               |     | $\pm 25$   |                 | 3          |
|                       |                                                                                                       | $I_R = 100\mu A$                                 |                    | $\pm 10$               |     | $\pm 29$   |                 |            |
|                       |                                                                                                       | $I_R = 1mA$                                      |                    | $\pm 10$               |     | $\pm 34$   |                 |            |
|                       |                                                                                                       | $I_R = 10mA$                                     |                    | $\pm 15$               |     | $\pm 45$   |                 |            |
|                       |                                                                                                       | $I_R = 15mA$                                     |                    | $\pm 20$               |     | $\pm 60$   |                 |            |
| $Z_R$                 | Reverse Dynamic Impedance                                                                             | $I_R = 1mA$ , $f = 120Hz$ ,<br>$I_{AC} = 0.1I_R$ |                    | 0.5                    |     |            | $\Omega$        |            |
| $V_N$                 | Output Noise Voltage                                                                                  | $10Hz \leq f \leq 10KHz$                         |                    | 100                    |     |            | $\mu V_{rms}$   |            |

(1) Typicals are at  $T_A = 25^\circ C$  and represent most likely parametric norm.

(2) Not tested post irradiation. Typical post irradiation values listed in the post radiation Tempco table.

## LM4050-5.0QML Electrical Characteristics SMD: 5962R0923562 (continued)

The initial Reverse Breakdown Voltage tolerance is  $\pm 0.1\%$  @ 100 $\mu$ A.

| Symbol            | Parameter          | Conditions                                                | Notes              | Typical <sup>(1)</sup> | Min | Max | Units   | Sub-groups |
|-------------------|--------------------|-----------------------------------------------------------|--------------------|------------------------|-----|-----|---------|------------|
| C <sub>LOAD</sub> | Load Capacitor     | Stable Over Temperature                                   | See <sup>(3)</sup> | 60                     | 0   | 100 | $\mu$ F |            |
| V <sub>HYST</sub> | Thermal Hysteresis | $\Delta T = -55^{\circ}\text{C}$ to $125^{\circ}\text{C}$ | See <sup>(4)</sup> | 20                     |     |     | ppm     |            |

(3) Capacitive load not required but improves SET stability. This parameter is ensured by design and/or characterization and is not tested in production.

(4) Thermal hysteresis is defined as the change in voltage measured at  $+25^{\circ}\text{C}$  after cycling to temperature  $-55^{\circ}\text{C}$  and the  $25^{\circ}\text{C}$  measurement after cycling to temperature  $+125^{\circ}\text{C}$ .

$$V_{\text{HYST}} = \frac{|V_{\text{R1}} - V_{\text{R2}}|}{V_{\text{R}}} \times 10^6 \text{ ppm}$$

Where:  $V_{\text{HYST}}$  = Thermal hysteresis expressed in ppm

$V_{\text{R}}$  = Nominal preset output voltage

$V_{\text{R1}}$  =  $V_{\text{R}}$  before temperature fluctuation

$V_{\text{R2}}$  =  $V_{\text{R}}$  after temperature fluctuation.

### Post Radiation @ $25^{\circ}\text{C}$ <sup>(1)</sup>

The initial Reverse Breakdown Voltage tolerance is  $\pm 0.1\%$  @ 100 $\mu$ A. Qualification is performed with a 1.5X overtest. See for [TOTAL IONIZING DOSE](#) details.

| Symbol         | Parameter                           | Conditions                      |     | 30 krad | 50 krad | 100 krad | Sub-groups |
|----------------|-------------------------------------|---------------------------------|-----|---------|---------|----------|------------|
| $V_{\text{R}}$ | Reverse Breakdown Voltage Tolerance | $I_{\text{R}} = 74\mu\text{A}$  | Max | +0.42%  | +0.67%  | +1.75%   | 1          |
|                |                                     | $I_{\text{R}} = 100\mu\text{A}$ |     |         |         |          |            |
|                |                                     | $I_{\text{R}} = 1\text{mA}$     |     |         |         |          |            |
|                |                                     | $I_{\text{R}} = 10\text{mA}$    |     |         |         |          |            |
|                |                                     | $I_{\text{R}} = 15\text{mA}$    |     |         |         |          |            |

(1) Pre and post irradiation limits are identical to those listed under electrical characteristics except as listed in the post radiation table.

### Post Radiation Tempco<sup>(1)</sup>

| Symbol                         | Parameter                                                                                                                         | Conditions                                         | TYPICALS |         |          |                         |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|----------|---------|----------|-------------------------|
|                                |                                                                                                                                   |                                                    | 30 krad  | 50 krad | 100 krad | Units                   |
| $\Delta V_{\text{R}}/\Delta T$ | Average Reverse Breakdown Voltage Temperature Coefficient Drift @ $25^{\circ}\text{C} \leq T_{\text{A}} \leq 125^{\circ}\text{C}$ | $74\mu\text{A} \leq I_{\text{R}} \leq 15\text{mA}$ | +87      | +166    | +387     | ppm/ $^{\circ}\text{C}$ |
|                                | Average Reverse Breakdown Voltage Temperature Coefficient Drift @ $-55^{\circ}\text{C} \leq T_{\text{A}} \leq 25^{\circ}\text{C}$ | $74\mu\text{A} \leq I_{\text{R}} \leq 15\text{mA}$ | +96      | +162    | +343     | ppm/ $^{\circ}\text{C}$ |

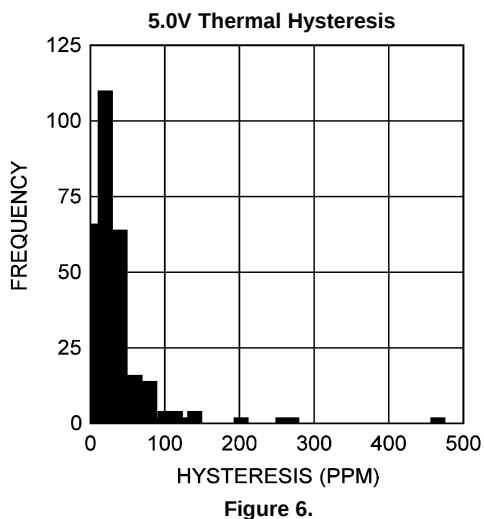
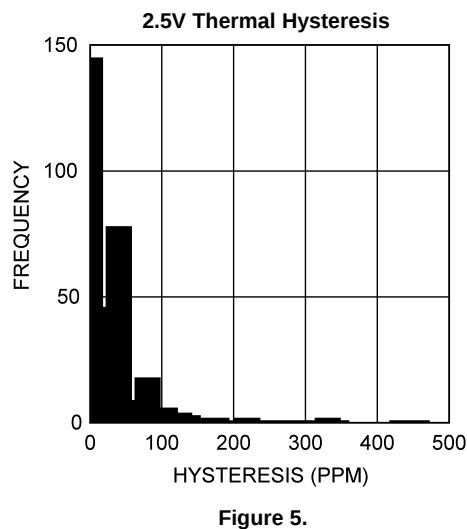
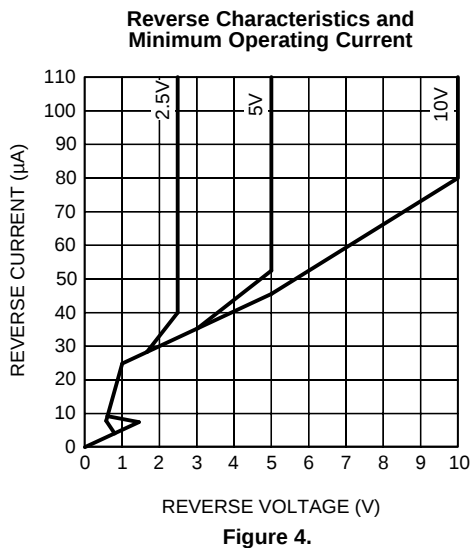
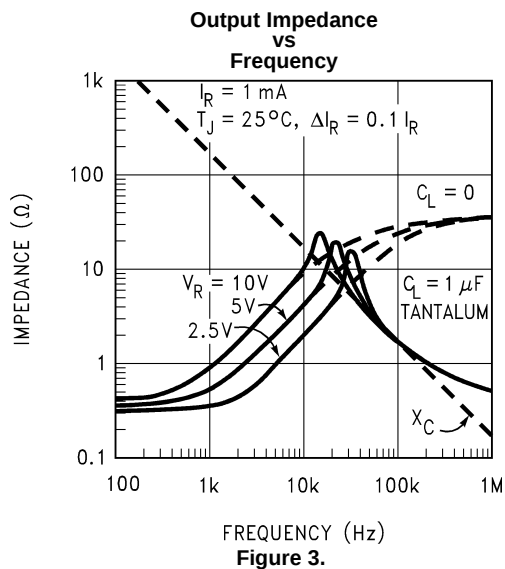
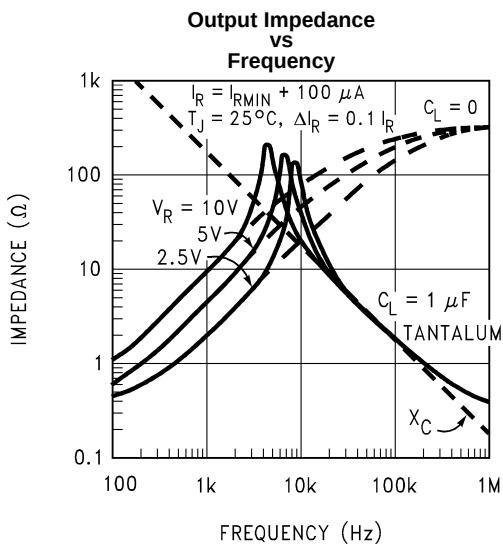
(1) Not tested post irradiation. Typical post irradiation values listed in the post radiation Tempco table.

### Operational Life Test Delta Parameters

This table represents the drift seen from initial measurements post 1000hr Operational Life Burn-In. All units will remain within the electrical characteristics limits post 1000hr Operational Life Burn-In. Deltas required for QMLV product at Group B, Sub-Group 5.

| Symbol            | Parameter                           | Conditions                      | Note | Min    | Max   | Units         | Temp |
|-------------------|-------------------------------------|---------------------------------|------|--------|-------|---------------|------|
| $V_{\text{R}}$    | Reverse Breakdown Voltage Tolerance | $I_{\text{R}} = 74\mu\text{A}$  |      | -0.8   | 0.8   | mV            | 1    |
|                   |                                     | $I_{\text{R}} = 100\mu\text{A}$ |      | -0.8   | 0.8   |               |      |
|                   |                                     | $I_{\text{R}} = 1\text{mA}$     |      | -0.84  | 0.84  |               |      |
|                   |                                     | $I_{\text{R}} = 10\text{mA}$    |      | -1.6   | 1.6   |               |      |
|                   |                                     | $I_{\text{R}} = 15\text{mA}$    |      | -2.6   | 2.6   |               |      |
| $I_{\text{RMIN}}$ | Minimum Operating Current           |                                 |      | -0.623 | 0.623 | $\mu\text{A}$ | 1    |

## Typical Performance Characteristics



## Typical Radiation Characteristics

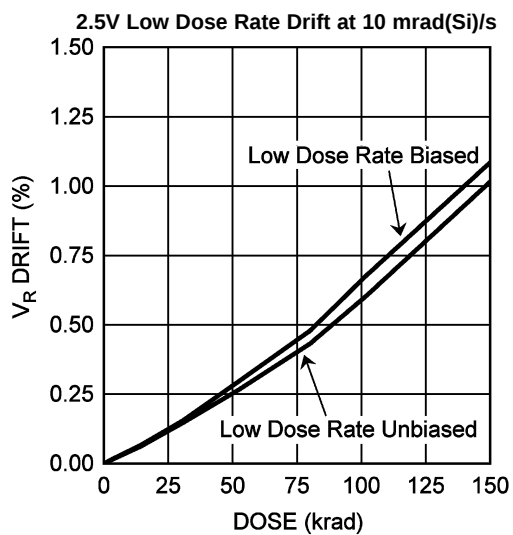


Figure 7.

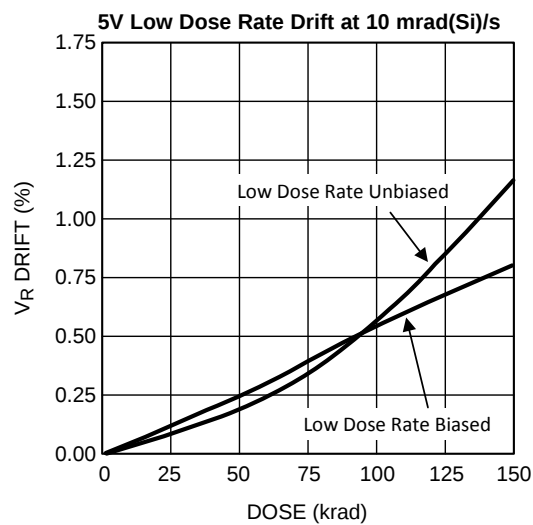


Figure 8.

## Start-Up Characteristics

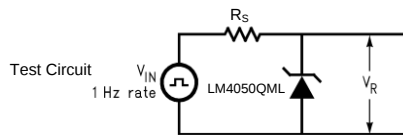


Figure 9.

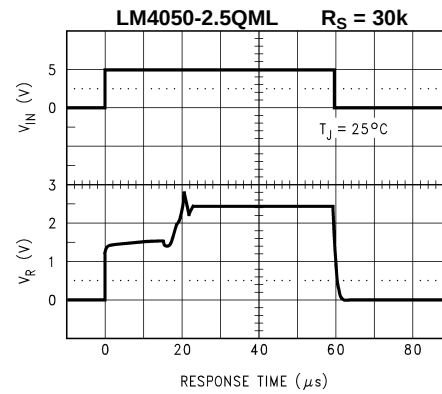


Figure 10.

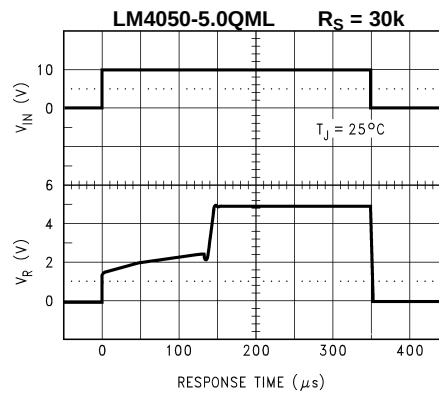
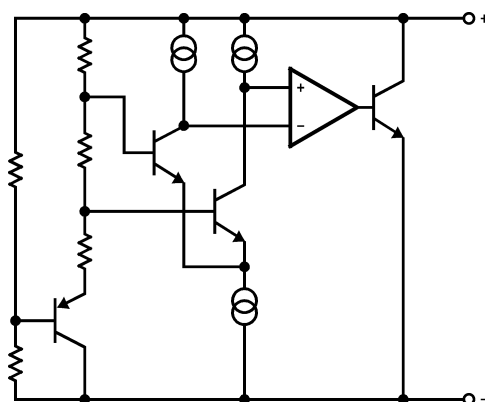


Figure 11.

### Functional Block Diagram



### APPLICATIONS INFORMATION

The LM4050QML is a precision micro-power curvature-corrected bandgap shunt voltage reference. The LM4050QML is available in the 10-Lead Ceramic CLGA package. The LM4050QML 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 LM4050QML remains stable. The LM4050-2.5QML has a 60  $\mu$ A minimum and 15 mA maximum operating current. The LM4050-5.0QML has a 74  $\mu$ A minimum and 15 mA maximum operating current.

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 -55°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 12), an external series resistor ( $R_S$ ) is connected between the supply voltage and the LM4050QML.  $R_S$  determines the current that flows through the load ( $I_L$ ) and the LM4050QML ( $I_Q$ ). Since load current and supply voltage may vary,  $R_S$  should be small enough to supply at least the maximum ensured  $I_{RMIN}$  (spec. table) to the LM4050QML even when the supply voltage is at its minimum and the load current is at its maximum value. When the supply voltage is at its maximum and  $I_L$  is at its minimum,  $R_S$  should be large enough so that the current flowing through the LM4050QML is less than 15 mA.

$R_S$  is determined by the supply voltage, ( $V_S$ ), the load and operating current, ( $I_L$  and  $I_Q$ ), and the LM4050QML's reverse breakdown voltage,  $V_R$ .

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

### Radiation Environments

Careful consideration should be given to environmental conditions when using a product in a radiation environment.

### TOTAL IONIZING DOSE

Radiation hardness assured (RHA) products are those part numbers with a total ionizing dose (TID) level specified in the Ordering Information table on the front page. Testing and qualification of these products is done on a wafer level according to MIL-STD-883, Test Method 1019. Wafer level TID data is available with lot shipments.

Testing and qualification is performed at the 30, 50 and 100 krad TID levels at a dose rate of 10 mrad/s, using a 1.5X overtest at each TID level. For the 30 krad level units are tested to 50 krad, for 50 krad units are tested to 80 krad and for 100 krad units are tested to 150 krad, with all parameters remaining inside the post irradiation test limits.

## SINGLE EVENT EFFECTS (SEE)

One time single event effects characterization was performed according to EIA/JEDEC Standard, EIA/JEDEC57. A test report is available upon request.

## SINGLE EVENT TRANSIENTS (SET)

With a 60  $\mu$ F capacitor on the output, no single event transients were seen at the highest linear energy transfer (LET) tested: 59 MeV-cm<sup>2</sup>/mg.

SET characterization with other capacitor values is in the SEE report, available upon request.

## SINGLE EVENT FUNCTIONAL INTERRUPT (SEFI)

No single event functional interrupts were detected to the highest linear energy transfer (LET) tested: 100 MeV-cm<sup>2</sup>/mg.

## Typical Applications

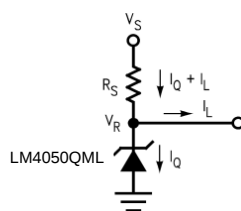


Figure 12. Shunt Regulator

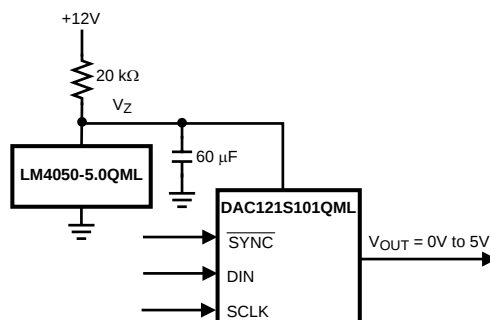
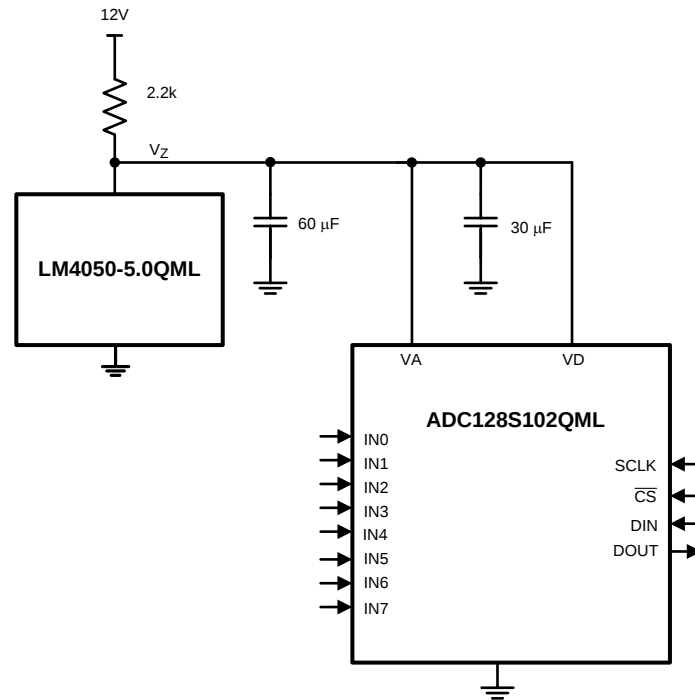


Figure 13. The LM4050QML as a power supply and reference



**Figure 14. The LM4050QML as a power supply and reference**

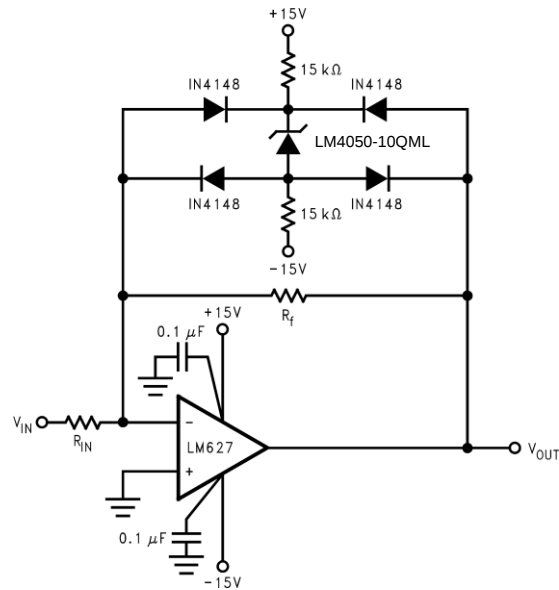
The LM4050QML is a good choice as a power regulator for the DAC121S101QML or ADC128S102QML. The minimum resistor value in the circuit of [Figure 13](#) or [Figure 14](#) should be chosen such that the maximum current through the LM4050QML does not exceed its 15 mA rating. The conditions for maximum current include the input voltage at its maximum, the LM4050QML voltage at its minimum, the resistor value at its minimum due to tolerance, and the DAC121S101QML or ADC128S102QML draws zero current. The maximum resistor value must allow the LM4050QML to draw more than its minimum current for regulation plus the maximum DAC121S101QML or ADC128S102QML current in full operation. The conditions for minimum current include the input voltage at its minimum, the LM4050QML voltage at its maximum, the resistor value at its maximum due to tolerance, and the DAC121S101QML or ADC128S102QML draws its maximum current. These conditions can be summarized as

$$R(\min) = (V_{IN}(\max) - V_Z(\min)) / (I_A(\min) + I_Z(\max)) \quad (2)$$

and

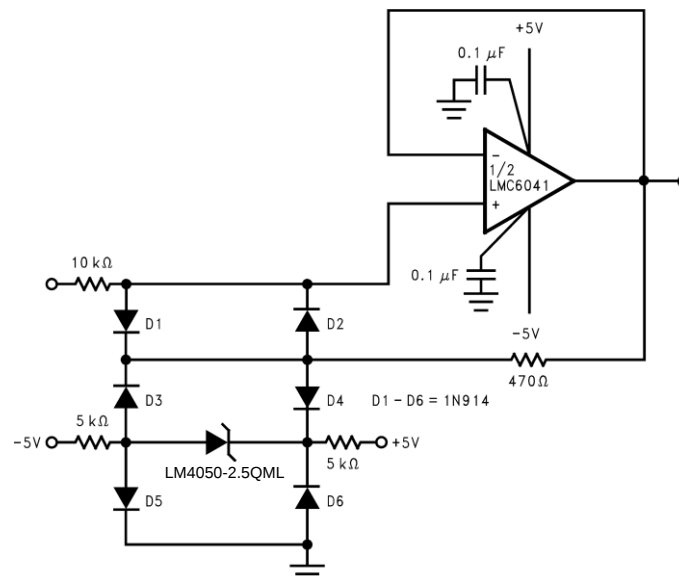
$$R(\max) = (V_{IN}(\min) - V_Z(\max)) / (I_A(\max) + I_Z(\min)) \quad (3)$$

where  $V_Z(\min)$  and  $V_Z(\max)$  are the nominal LM4050QML output voltages  $\pm$  the LM4050QML output tolerance over temperature,  $I_Z(\max)$  is the maximum allowable current through the LM4050QML,  $I_Z(\min)$  is the minimum current required by the LM4050QML for proper regulation,  $I_A(\max)$  is the maximum DAC121S101QML or ADC128S102QML supply current, and  $I_A(\min)$  is the minimum DAC121S101QML or ADC128S102QML supply current.



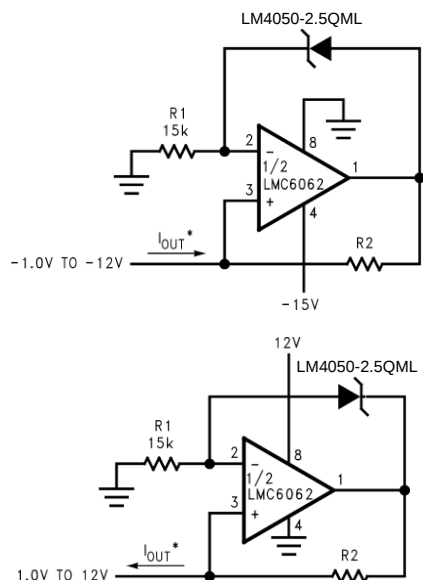
Nominal clamping voltage is  $\pm 11.5V$  (LM4050QML's reverse breakdown voltage + 2 diode  $V_F$ ). Bounded amplifier reduces saturation-induced delays and can prevent succeeding stage damage.

**Figure 15. Bounded amplifier**



The bounding voltage is  $\pm 4V$  with the LM4050-2.5QML (LM4050QML's reverse breakdown voltage + 3 diode  $V_F$ ).

**Figure 16. Protecting Op Amp input**

Figure 17. Precision 1  $\mu$ A to 1 mA Current Sources

$$*I_{OUT} = \frac{2.5V}{R_2}$$

(4)

### Engineering Samples (Parts with MPR suffix)

Engineering samples are available for order and are identified by the "MPR" in the orderable device name (see Package Options Addendum at the end of the datasheet). Engineering (MPR) samples meet the performance specifications of the datasheet at room temperature only and have not received the full space production flow or testing. Engineering samples may be QCI rejects that failed tests that would not impact the performance at room temperature, such as radiation or reliability testing.

### Revision History

| Date Released | Revision | Section                                                                                                                         | Changes                                                                                                                                                                                                                                                                                               |
|---------------|----------|---------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 08/20/2010    | A        | Initial Release                                                                                                                 | New Product Low Dose Qualified LM4050WG2.5RLQV Initial Release                                                                                                                                                                                                                                        |
| 01/20/2012    | B        | General Description, Features, Key Specifications, Ordering Table, Operating Ratings, Package Thermal Table, Electrical Section | General Description, Features, Key Specifications, Ordering Table, Operating Ratings, Package Thermal Table, Electrical Section — Added the 5.0 V option information for all sections. Added new NSIDS LM4050WG5.0RLQV and LM4050WG5.0-MPR Voltage option to data sheet. Revision A will be Archived. |
| 05/23/2012    | C        | Electrical Section                                                                                                              | Electrical Section — Updated Delta Vr/Delta T for typical limits for both the 2.5 and 5.0 versions. Revision B will be Archived.                                                                                                                                                                      |
| 04/01/2013    | F        | All                                                                                                                             | Changed layout of National Data Sheet to TI format.                                                                                                                                                                                                                                                   |
| 07/12/2013    | G        | Post Radiation @ 25°C; Added Engineering Samples                                                                                | Changed 5V and 2.5V Post Radiation limits so they are the same for both voltages. Added information about orderable engineering samples.                                                                                                                                                              |

## 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)                                          |
|---------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|--------------------------------------------------------------|
| <a href="#">5962R0923561VZA</a> | Active        | Production           | CFP (NAC)   10 | 54   JEDEC TRAY (5+1) | No          | Call TI                              | Level-1-NA-UNLIM                  | -55 to 125   | LM4050WG<br>2.5RLQV Q<br>5962R09235<br>61VZA ACO<br>61VZA >T |
| <a href="#">5962R0923562VZA</a> | Active        | Production           | CFP (NAC)   10 | 54   TUBE             | No          | Call TI                              | Level-1-NA-UNLIM                  | -55 to 125   | LM4050WG<br>5.0RLQV Q<br>5962R09235<br>62VZA ACO<br>62VZA >T |
| <a href="#">LM4050WG2.5-MPR</a> | Active        | Production           | CFP (NAC)   10 | 54   TUBE             | No          | Call TI                              | Level-1-NA-UNLIM                  | 25 to 25     | LM4050WG<br>2.5-MPR<br>ES ACO<br>ES >T                       |
| <a href="#">LM4050WG2.5RLQV</a> | Active        | Production           | CFP (NAC)   10 | 54   JEDEC TRAY (5+1) | No          | Call TI                              | Level-1-NA-UNLIM                  | -55 to 125   | LM4050WG<br>2.5RLQV Q<br>5962R09235<br>61VZA ACO<br>61VZA >T |
| <a href="#">LM4050WG5.0-MPR</a> | Active        | Production           | CFP (NAC)   10 | 54   TUBE             | No          | Call TI                              | Level-1-NA-UNLIM                  | 25 to 25     | LM4050WG-<br>5.0-MPR<br>ES ACO<br>ES >T                      |
| <a href="#">LM4050WG5.0RLQV</a> | Active        | Production           | CFP (NAC)   10 | 54   TUBE             | No          | Call TI                              | Level-1-NA-UNLIM                  | -55 to 125   | LM4050WG<br>5.0RLQV Q<br>5962R09235<br>62VZA ACO<br>62VZA >T |

<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.

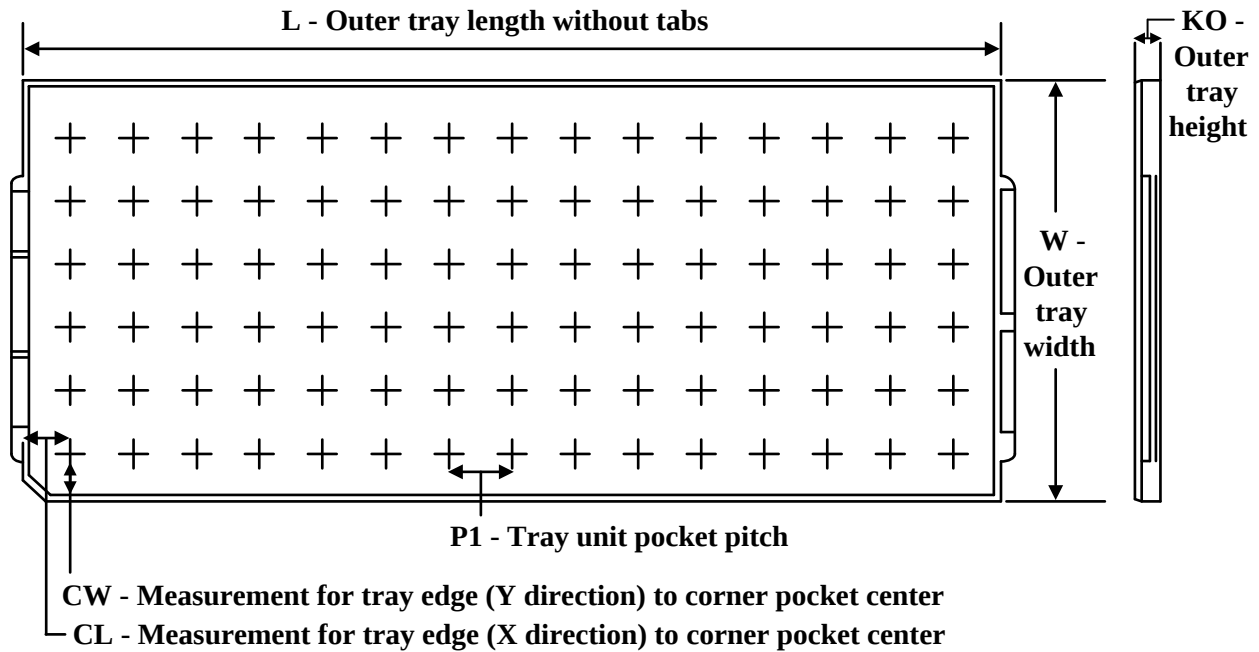
<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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.

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## TRAY



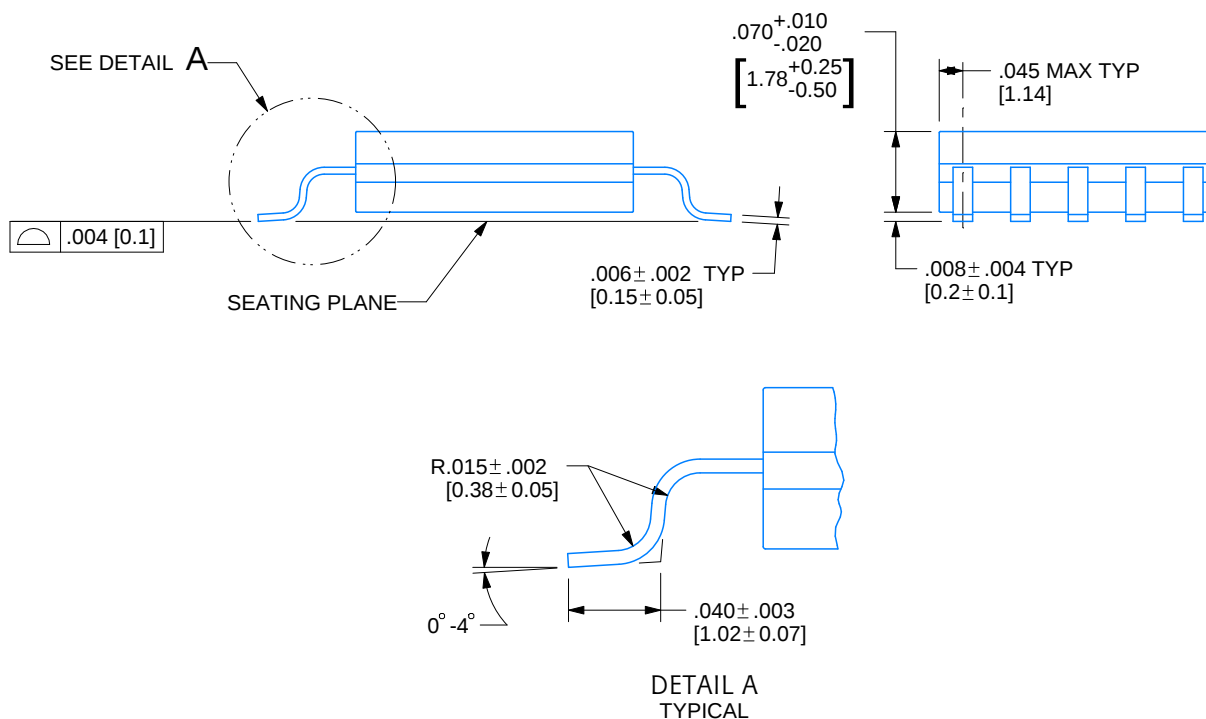
Chamfer on Tray corner indicates Pin 1 orientation of packed units.

\*All dimensions are nominal

| Device          | Package Name | Package Type | Pins | SPQ | Unit array matrix | Max temperature (°C) | L (mm) | W (mm) | K0 (µm) | P1 (mm) | CL (mm) | CW (mm) |
|-----------------|--------------|--------------|------|-----|-------------------|----------------------|--------|--------|---------|---------|---------|---------|
| 5962R0923561VZA | NAC          | CFP          | 10   | 54  | 6 X 9             | 100                  | 101.6  | 101.6  | 8001    | 2.78    | 16.08   | 16.08   |
| 5962R0923562VZA | NAC          | CFP          | 10   | 54  | 6 X 9             | 100                  | 101.6  | 101.6  | 8001    | 2.78    | 16.08   | 16.08   |
| LM4050WG2.5-MPR | NAC          | CFP          | 10   | 54  | 6 X 9             | 100                  | 101.6  | 101.6  | 8001    | 2.78    | 16.08   | 16.08   |
| LM4050WG2.5RLQV | NAC          | CFP          | 10   | 54  | 6 X 9             | 100                  | 101.6  | 101.6  | 8001    | 2.78    | 16.08   | 16.08   |
| LM4050WG5.0-MPR | NAC          | CFP          | 10   | 54  | 6 X 9             | 100                  | 101.6  | 101.6  | 8001    | 2.78    | 16.08   | 16.08   |
| LM4050WG5.0RLQV | NAC          | CFP          | 10   | 54  | 6 X 9             | 100                  | 101.6  | 101.6  | 8001    | 2.78    | 16.08   | 16.08   |



**CFP - 2.33mm max height**

[illegible]

NOTES:

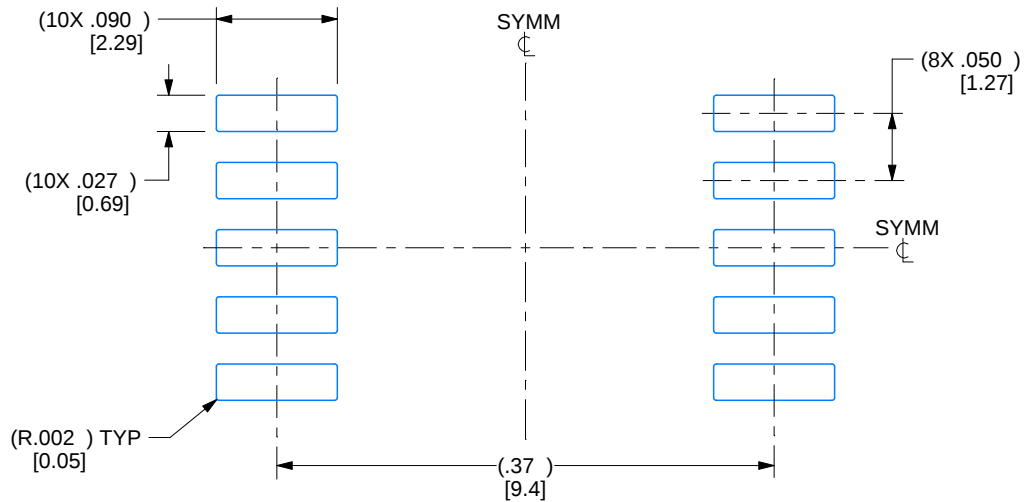
1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. For solder thickness and composition, see the ["Lead Finish Composition/Thickness"](#) link in the packaging section of the Texas Instruments website
3. Lead 1 identification shall be:
  - a) A notch or other mark within this area
  - b) A tab on lead 1, either side
4. No JEDEC registration as of December 2021

# EXAMPLE BOARD LAYOUT

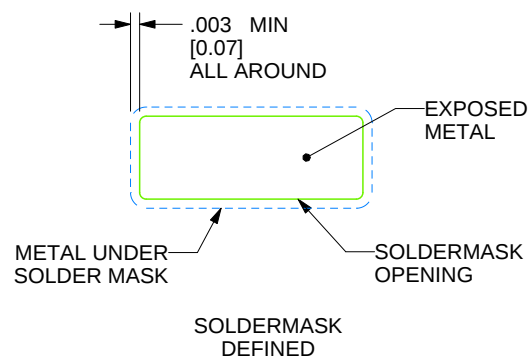
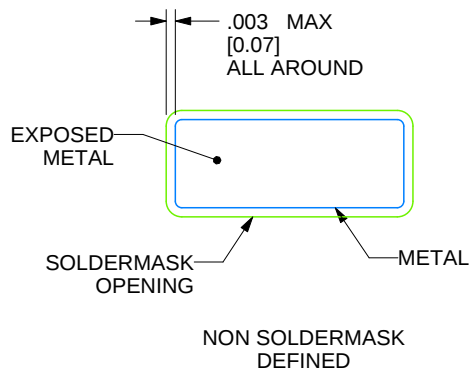
NAC0010A

CFP - 2.33mm max height

CERAMIC FLATPACK



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 7X



4215196/D 08/2022

REVISIONS

| REV | DESCRIPTION                                      | E.C.N.  | DATE       | BY/APP'D                |
|-----|--------------------------------------------------|---------|------------|-------------------------|
| A   | RELEASE TO DOCUMENT CONTROL                      | 2197877 | 12/30/2021 | DAVID CHIN / ANIS FAUZI |
| B   | NO CHANGE TO DRAWING; REVISION FOR YODA RELEASE; | 2198820 | 02/14/2022 | K. SINCERBOX            |
| C   | CHANGE PIN 1 ID LOCATION ON PIN                  | 2198845 | 02/18/2022 | D. CHIN / K. SINCERBOX  |
| D   | .2410± .0030 WAS .2700 +.0012/-.0002;            | 2200915 | 08/08/2022 | D. CHIN / K. SINCERBOX  |

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