

# PRECISION MICROPOWER SHUNT VOLTAGE REFERENCE

Check for Samples: [LM4040-EP](#)

## FEATURES

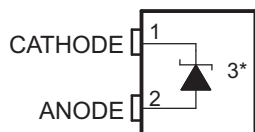
- Fixed Output Voltage of 2.5 V
- Tight Output Tolerances and Low Temperature Coefficient
  - Max 0.65%, 100 ppm/°C
- Low Output Noise: 35  $\mu\text{V}_{\text{RMS}}$  Typ
- Wide Operating Current Range: 45  $\mu\text{A}$  Typ to 15 mA
- Stable With All Capacitive Loads; No Output Capacitor Required

## SUPPORTS DEFENSE, AEROSPACE, AND MEDICAL APPLICATIONS

- Controlled Baseline
- One Assembly/Test Site
- One Fabrication Site
- Available in Military (–55°C/125°C) Temperature Range<sup>(1)</sup>
- Extended Product Life Cycle
- Extended Product-Change Notification
- Product Traceability

## APPLICATIONS

- Data-Acquisition Systems
- Power Supplies and Power-Supply Monitors
- Instrumentation and Test Equipment
- Process Controls
- Precision Audio
- Automotive Electronics
- Energy Management
- Battery-Powered Equipment

DBZ (SOT-23) PACKAGE  
(TOP VIEW)


\* Pin 3 is attached to substrate and must be connected to ANODE or left open.

(1) Custom temperature ranges available

## DESCRIPTION/ORDERING INFORMATION

The LM4040 series of shunt voltage references are versatile, easy-to-use references that cater to a vast array of applications. The 2-pin fixed-output device requires no external capacitors for operation and is stable with all capacitive loads. Additionally, the reference offers low dynamic impedance, low noise, and low temperature coefficient to ensure a stable output voltage over a wide range of operating currents and temperatures. The LM4040 uses fuse and Zener-zap reverse breakdown voltage trim during wafer sort to offer an output voltage tolerance of 0.65%.

Packaged in a space-saving SOT-23-3 package and requiring a minimum current of 45  $\mu\text{A}$  (typ), the LM4040 also is ideal for portable applications. The LM4040C25 is characterized for operation over an ambient temperature range of –55°C to 125°C.

### ORDERING INFORMATION<sup>(1)</sup>

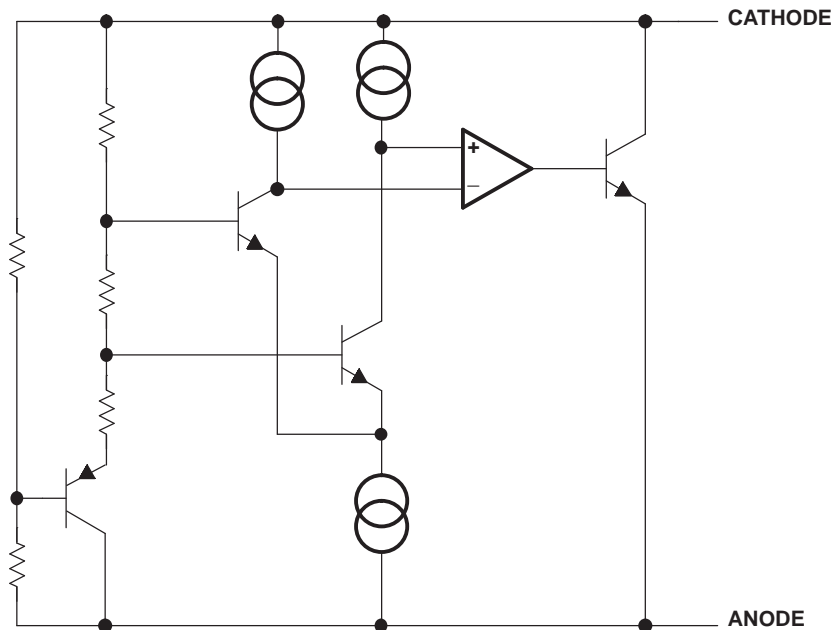
$T_A$	DEVICE GRADE	$V_{KA}$	PACKAGE		ORDERABLE PART NUMBER	TOP-SIDE MARKING <sup>(2)</sup>
–55°C to 125°C	0.65% initial accuracy and 100 ppm/°C temperature coefficient	2.5 V	SOT-23-3 (DBZ)	Reel of 250	LM4040C25MDBZTEP	SAGU

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](#).  
 (2) The actual top-side marking has one additional character that designates the wafer fab/assembly site.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

**FUNCTIONAL BLOCK DIAGRAM**



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

over free-air temperature range (unless otherwise noted)

	MIN	MAX	UNIT
$I_Z$ Continuous cathode current	-10	25	mA
$T_J$ Operating virtual junction temperature		150	°C
$T_{stg}$ Storage temperature range	-65	150	°C

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

**THERMAL INFORMATION**

THERMAL METRIC <sup>(1)</sup>		LM4040	UNITS
		DBZ	
		3 PINS	
$\theta_{JA}$	Junction-to-ambient thermal resistance <sup>(2)</sup>	320.8	°C/W
$\theta_{JC}$	Junction-to-case thermal resistance	98.2	
$\theta_{JB}$	Junction-to-board thermal resistance <sup>(3)</sup>	53.3	
$\Psi_{JT}$	Junction-to-top characterization parameter <sup>(4)</sup>	3.3	
$\Psi_{JB}$	Junction-to-board characterization parameter <sup>(5)</sup>	51.8	

- (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).  
(2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.  
(3) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.  
(4) The junction-to-top characterization parameter,  $\Psi_{JT}$ , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining  $\theta_{JA}$ , using a procedure described in JESD51-2a (sections 6 and 7).  
(5) The junction-to-board characterization parameter,  $\Psi_{JB}$ , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining  $\theta_{JA}$ , using a procedure described in JESD51-2a (sections 6 and 7).

## Recommended Operating Conditions

		MIN	MAX	UNIT
$I_Z$	Cathode current	See <sup>(1)</sup>	15	mA
$T_A$	Free-air temperature	–55	125	°C

(1) See parametric tables

## Electrical Characteristics

at extended temperature range, full-range  $T_A = -55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
$V_Z$	Reverse breakdown voltage	$I_Z = 100\ \mu\text{A}$	25°C	2.5		V
$\Delta V_Z$	Reverse breakdown voltage tolerance	$I_Z = 100\ \mu\text{A}$	25°C	–16	16	mV
		Full range	–42		42	
$I_{Z,\text{min}}$	Minimum cathode current		25°C	45	75	$\mu\text{A}$
		Full range			82	
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage	$I_Z = 10\ \text{mA}$	25°C	$\pm 20$		ppm/°C
		$I_Z = 1\ \text{mA}$	25°C	$\pm 15$		
			Full range		$\pm 100$	
		$I_Z = 100\ \mu\text{A}$	25°C	$\pm 15$		
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1\ \text{mA}$	25°C	0.3	0.8	mV
			Full range		1.1	
		$1\ \text{mA} < I_Z < 15\ \text{mA}$	25°C	2.5	6	
			Full range		9	
$Z_Z$	Reverse dynamic impedance	$I_Z = 1\ \text{mA}$ , $f = 120\ \text{Hz}$ , $I_{AC} = 0.1\ I_Z$	25°C	0.3		$\Omega$
$e_N$	Wideband noise	$I_Z = 100\ \mu\text{A}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$	25°C	35		$\mu\text{V}_{\text{RMS}}$
	Long-term stability of reverse breakdown voltage	$t = 1000\ \text{h}$ , $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ , $I_Z = 100\ \mu\text{A}$		120		ppm
$V_{\text{HYS}}$	Thermal hysteresis <sup>(1)</sup>	$\Delta T_A = -55^{\circ}\text{C}$ to $125^{\circ}\text{C}$		0.08		%

(1) Thermal hysteresis is defined as  $V_{Z,25^{\circ}\text{C}}$  (after cycling to  $-55^{\circ}\text{C}$ ) –  $V_{Z,25^{\circ}\text{C}}$  (after cycling to  $125^{\circ}\text{C}$ ).

## TYPICAL CHARACTERISTICS

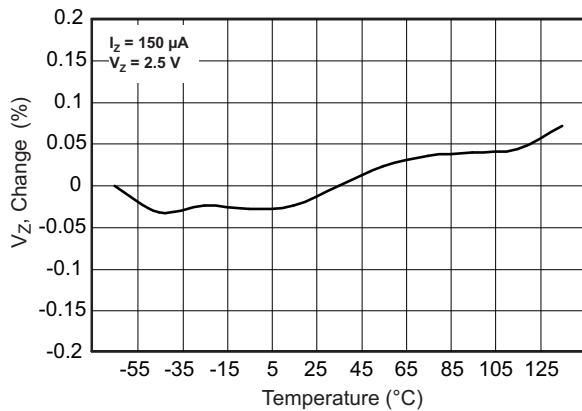
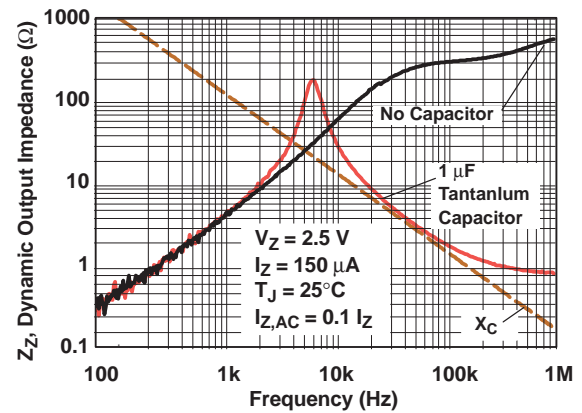
Figure 1. Change in  $V_Z$  vs Change in Temperature

Figure 2. Output Impedance vs Frequency

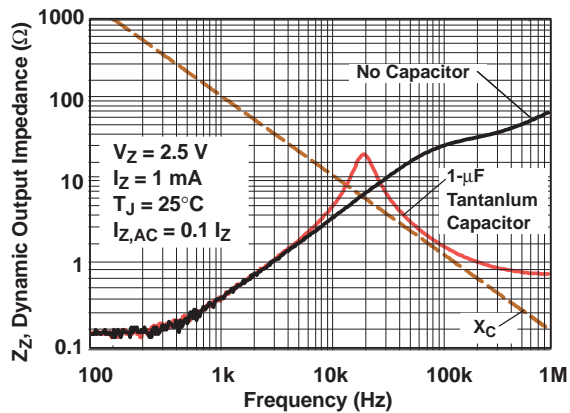


Figure 3. Output Impedance vs Frequency

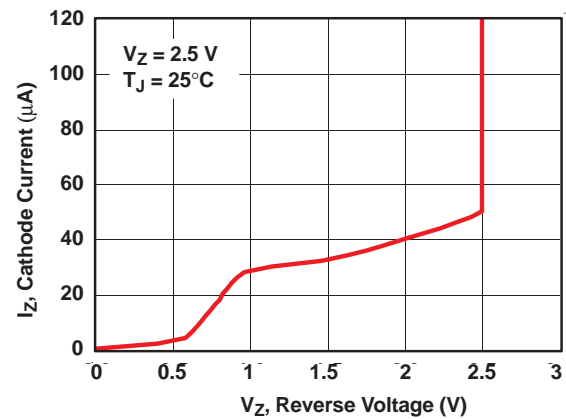


Figure 4. Cathode Current vs Reverse Voltage

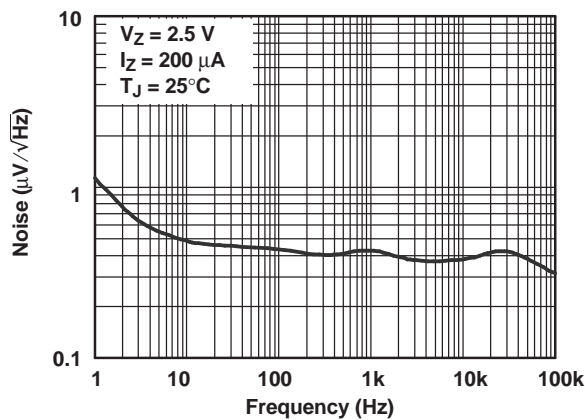


Figure 5. Noise Voltage vs Frequency

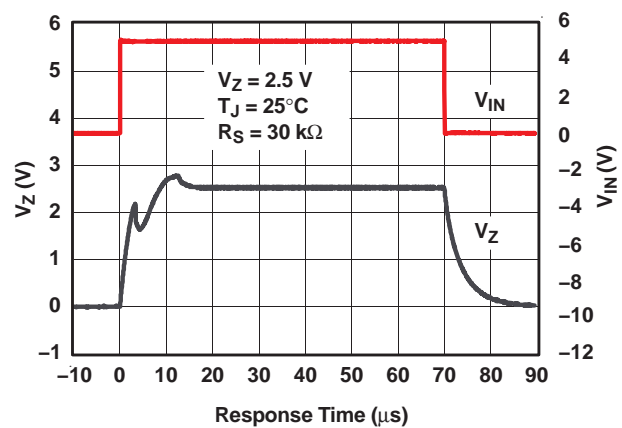


Figure 6. Start-Up Characteristics

## APPLICATION INFORMATION

### Start-Up Characteristics

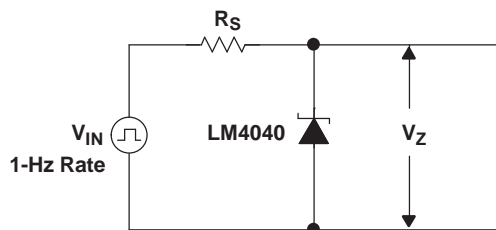


Figure 7. Test Circuit

### Output Capacitor

The LM4040 does not require an output capacitor across cathode and anode for stability. However, if an output bypass capacitor is desired, the LM4040 is designed to be stable with all capacitive loads.

### SOT-23 Connections

There is a parasitic Schottky diode connected between pins 2 and 3 of the SOT-23 packaged device. Thus, pin 3 of the SOT-23 package must be left floating or connected to pin 2.

### Cathode and Load Currents

In a typical shunt-regulator configuration (see [Figure 8](#)), an external resistor,  $R_S$ , is connected between the supply and the cathode of the LM4040.  $R_S$  must be set properly, as it sets the total current available to supply the load ( $I_L$ ) and bias the LM4040 ( $I_Z$ ). In all cases,  $I_Z$  must stay within a specified range for proper operation of the reference. Taking into consideration one extreme in the variation of the load and supply voltage (maximum  $I_L$  and minimum  $V_S$ ),  $R_S$  must be small enough to supply the minimum  $I_Z$  required for operation of the regulator, as given by data-sheet parameters. At the other extreme, maximum  $V_S$  and minimum  $I_L$ ,  $R_S$  must be large enough to limit  $I_Z$  to less than its maximum-rated value of 15 mA.

$R_S$  is calculated according to [Equation 1](#):

$$R_S = \frac{(V_S - V_Z)}{(I_L + I_Z)} \quad (1)$$

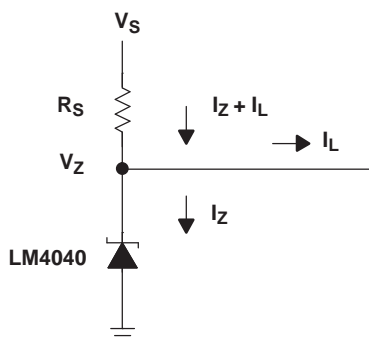


Figure 8. Shunt Regulator

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/ Ball Finish	MSL Peak Temp <sup>(3)</sup>	Samples (Requires Login)
LM4040C25MDBZTEP	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
V62/11615-01XB	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBsolete:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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**OTHER QUALIFIED VERSIONS OF LM4040C25-EP :**

- Catalog: [LM4040C25](#)

NOTE: Qualified Version Definitions:

- 
- Catalog - TI's standard catalog product

**TAPE AND REEL INFORMATION**
**REEL DIMENSIONS**

**TAPE DIMENSIONS**


A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

**TAPE AND REEL INFORMATION**

\*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
LM4040C25MDBZTEP	SOT-23	DBZ	3	250	179.0	8.4	3.15	2.95	1.22	4.0	8.0	Q3



## TAPE AND REEL BOX DIMENSIONS

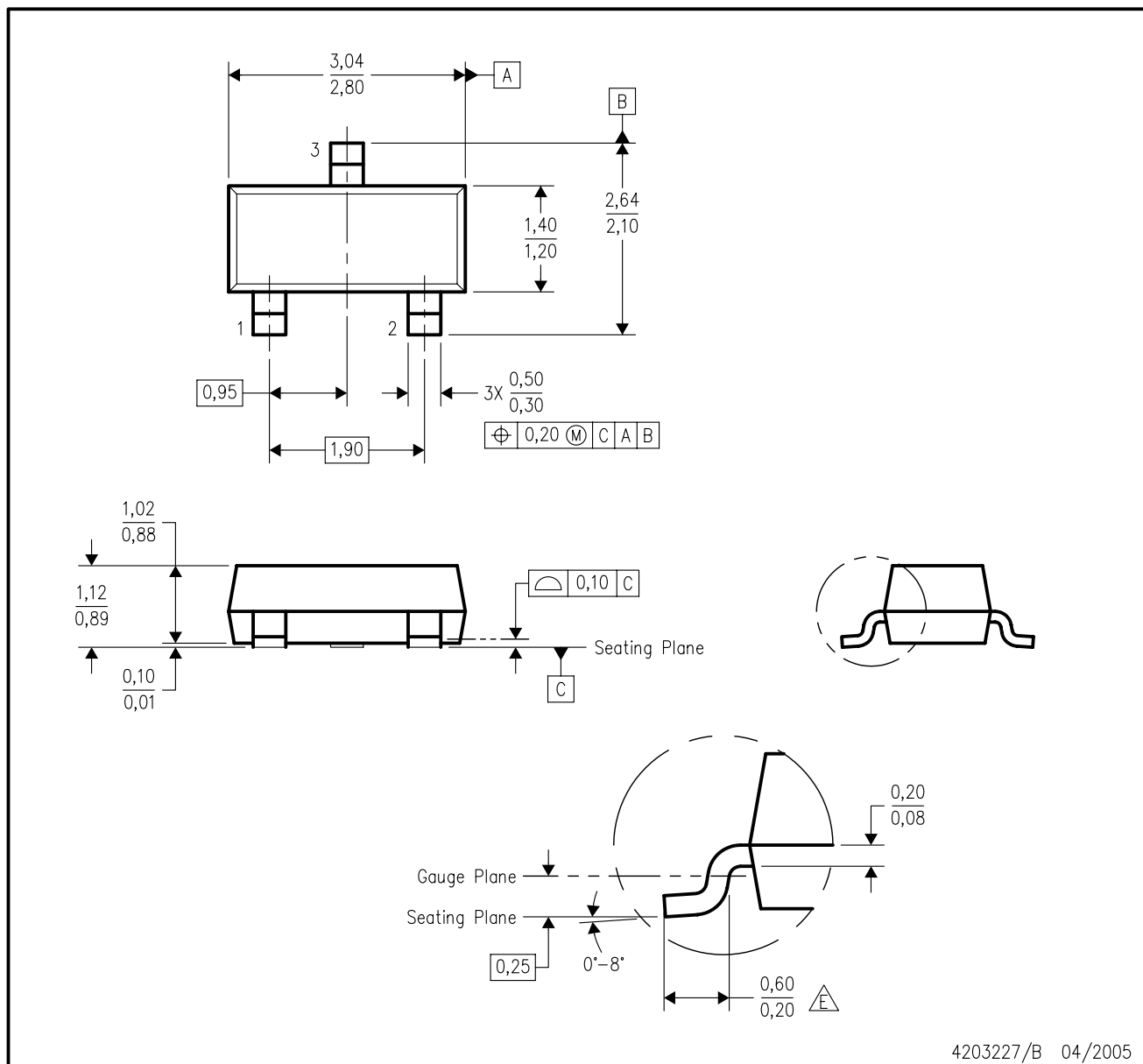


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM4040C25MDBZTEP	SOT-23	DBZ	3	250	203.0	203.0	35.0

DBZ (R-PDSO-G3)

PLASTIC SMALL-OUTLINE



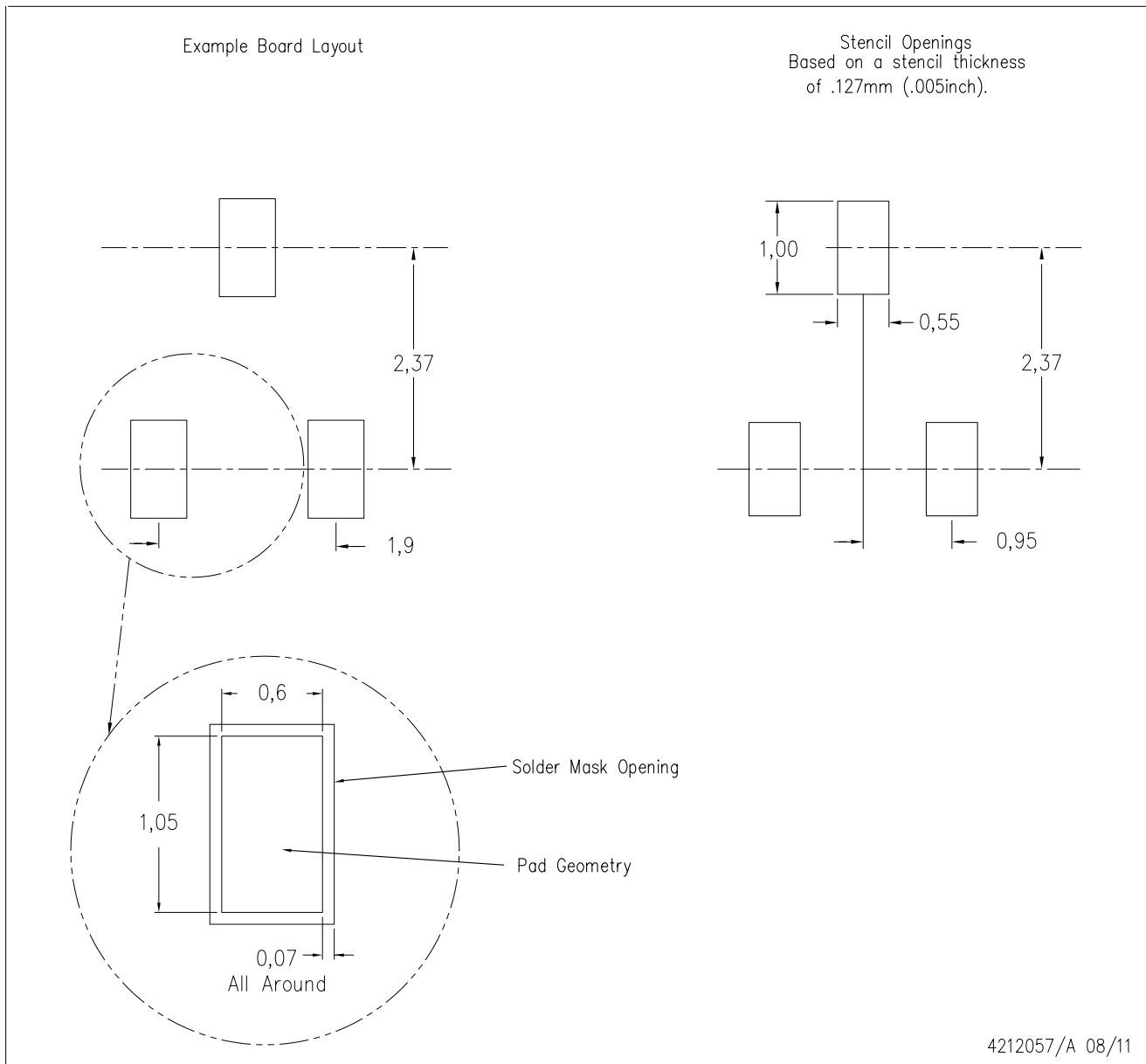
4203227/B 04/2005

NOTES:

- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
- B. This drawing is subject to change without notice.
- C. Lead dimensions are inclusive of plating.
- D. Body dimensions are exclusive of mold flash and protrusion. Mold flash and protrusion not to exceed 0.25 per side.
- E. Falls within JEDEC TO-236 variation AB, except minimum foot length.

DBZ (R-PDSO-G3)

PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

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