

## LM4040

# Precision Micropower Shunt Voltage Reference

### General Description

Ideal for space critical applications, the LM4040 precision voltage reference is available in the sub-miniature SC70 and SOT-23 surface-mount package. The LM4040's advanced design eliminates the need for an external stabilizing capacitor while ensuring stability with any capacitive load, thus making the LM4040 easy to use. Further reducing design effort is the availability of several fixed reverse breakdown voltages: 2.048V, 2.500V, 3.000V, 4.096V, 5.000V, 8.192V, and 10.000V. The minimum operating current increases from 60  $\mu$ A for the LM4040-2.5 to 100  $\mu$ A for the LM4040-10.0. All versions have a maximum operating current of 15 mA.

The LM4040 utilizes fuse and zener-zap reverse breakdown voltage trim during wafer sort to ensure that the prime parts have an accuracy of better than  $\pm 0.1\%$  (A grade) 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.

Also available is the LM4041 with two reverse breakdown voltage versions: adjustable and 1.2V. Please see the LM4041 data sheet.

### Features

- Small packages: SOT-23, TO-92 and SC70
- No output capacitor required

- Tolerates capacitive loads
- Fixed reverse breakdown voltages of 2.048V, 2.500V, 3.000V, 4.096V, 5.000V, 8.192V, and 10.000V

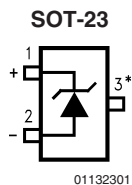
### Key Specifications (LM4040-2.5)

- Output voltage tolerance (A grade, 25°C)  $\pm 0.1\%$  (max)
- Low output noise (10 Hz to 10 kHz) 35  $\mu$ V<sub>rms</sub>(typ)
- Wide operating current range 60  $\mu$ A to 15 mA
- Industrial temperature range  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$
- Extended temperature range  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Low temperature coefficient 100 ppm/ $^{\circ}\text{C}$  (max)

### Applications

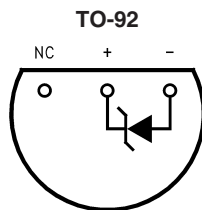
- Portable, Battery-Powered Equipment
- Data Acquisition Systems
- Instrumentation
- Process Control
- Energy Management
- Product Testing
- Automotive
- Precision Audio Components

### Connection Diagrams

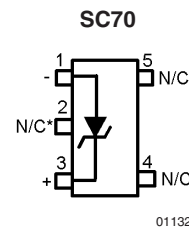


\*This pin must be left floating or connected to pin 2.

**Top View**  
See NS Package Number MF03A  
(JEDEC Registration TO-236AB)



**Bottom View**  
See NS Package Number Z03A



\*This pin must be left floating or connected to pin 1.

**Top View**  
See NS Package Number MAA05A

## Ordering Information Industrial Temperature Range (-40°C to +85°C)

Reverse Breakdown Voltage Tolerance at 25°C and Average Reverse Breakdown Voltage Temperature Coefficient	Package					NS Package Number
	M3 (SOT-23)		M7 (SC70)		Z (TO-92)	
	Supplied as 1000 Units Tape and Reel	Supplied as 3000 Units tape and Reel	Supplied as 1000 Units Tape and Reel	Supplied as 3000 Units Tape and Reel		
±0.1%, 100 ppm/°C max (A grade)	LM4040AIM3-2.0 LM4040AIM3-2.5 LM4040AIM3-3.0 LM4040AIM3-4.1 LM4040AIM3-5.0 LM4040AIM3-8.2 LM4040AIM3-10.0	LM4040AIM3X-2.0 LM4040AIM3X-2.5 LM4040AIM3X-3.0 LM4040AIM3X-4.1 LM4040AIM3X-5.0 LM4040AIM3X-8.2 LM4040AIM3X-10.0			LM4040AIZ-2.0 LM4040AIZ-2.5 LM4040AIZ-3.0 LM4040AIZ-4.1 LM4040AIZ-5.0 LM4040AIZ-8.2 LM4040AIZ-10.0	MF03A, Z03A
±0.2%, 100 ppm/°C max (B grade)	LM4040BIM3-2.0 LM4040BIM3-2.5 LM4040BIM3-3.0 LM4040BIM3-4.1 LM4040BIM3-5.0 LM4040BIM3-8.2 LM4040BIM3-10.0	LM4040BIM3X-2.0 LM4040BIM3X-2.5 LM4040BIM3X-3.0 LM4040BIM3X-4.1 LM4040BIM3X-5.0 LM4040BIM3X-8.2 LM4040BIM3X-10.0	LM4040BIM7-2.0 LM4040BIM7-2.5 LM4040BIM7-3.0 LM4040BIM7-4.1 LM4040BIM7-5.0	LM4040BIM7X-2.0 LM4040BIM7X-2.5 LM4040BIM7X-3.0 LM4040BIM7X-4.1 LM4040BIM7X-5.0	LM4040BIZ-2.0 LM4040BIZ-2.5 LM4040BIZ-3.0 LM4040BIZ-4.1 LM4040BIZ-5.0 LM4040BIZ-8.2 LM4040BIZ-10.0	MF03A, Z03A, MAA05A
±0.5%, 100 ppm/°C max (C grade)	LM4040CIM3-2.0 LM4040CIM3-2.5 LM4040CIM3-3.0 LM4040CIM3-4.1 LM4040CIM3-5.0 LM4040CIM3-8.2 LM4040CIM3-10.0	LM4040CIM3X-2.0 LM4040CIM3X-2.5 LM4040CIM3X-3.0 LM4040CIM3X-4.1 LM4040CIM3X-5.0 LM4040CIM3X-8.2 LM4040CIM3X-10.0	LM4040CIM7-2.0 LM4040CIM7-2.5 LM4040CIM7-3.0 LM4040CIM7-4.1 LM4040CIM7-5.0	LM4040CIM7X-2.0 LM4040CIM7X-2.5 LM4040CIM7X-3.0 LM4040CIM7X-4.1 LM4040CIM7X-5.0	LM4040CIZ-2.0 LM4040CIZ-2.5 LM4040CIZ-3.0 LM4040CIZ-4.1 LM4040CIZ-5.0 LM4040CIZ-8.2 LM4040CIZ-10.0	MF03A, Z03A, MAA05A
±1.0%, 150 ppm/°C max (D grade)	LM4040DIM3-2.0 LM4040DIM3-2.5 LM4040DIM3-3.0 LM4040DIM3-4.1 LM4040DIM3-5.0 LM4040DIM3-8.2 LM4040DIM3-10.0	LM4040DIM3X-2.0 LM4040DIM3X-2.5 LM4040DIM3X-3.0 LM4040DIM3X-4.1 LM4040DIM3X-5.0 LM4040DIM3X-8.2 LM4040DIM3X-10.0	LM4040DIM7-2.0 LM4040DIM7-2.5 LM4040DIM7-3.0 LM4040DIM7-4.1 LM4040DIM7-5.0	LM4040DIM7X-2.0 LM4040DIM7X-2.5 LM4040DIM7X-3.0 LM4040DIM7X-4.1 LM4040DIM7X-5.0	LM4040DIZ-2.0 LM4040DIZ-2.5 LM4040DIZ-3.0 LM4040DIZ-4.1 LM4040DIZ-5.0 LM4040DIZ-8.2 LM4040DIZ-10.0	MF03A, Z03A, MAA05A
±2.0%, 150 ppm/°C max (E grade)	LM4040EIM3-2.0 LM4040EIM3-2.5 LM4040EIM3-3.0	LM4040EIM3X-2.0 LM4040EIM3X-2.5 LM4040EIM3X-3.0	LM4040EIM7-2.0 LM4040EIM7-2.5 LM4040EIM7-3.0	LM4040EIM7X-2.0 LM4040EIM7X-2.5 LM4040EIM7X-3.0	LM4040EIZ-2.0 LM4040EIZ-2.5 LM4040EIZ-3.0	MF03A, Z03A, MAA05A

**Absolute Maximum Ratings** (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Reverse Current	20 mA
Forward Current	10 mA
Power Dissipation ( $T_A = 25^\circ\text{C}$ ) (Note 2)	
M3 Package	306 mW
Z Package	550 mW
M7 Package	241 mW
Storage Temperature	$-65^\circ\text{C}$ to $+150^\circ\text{C}$
Lead Temperature	
M3 Package	
Vapor phase (60 seconds)	$+215^\circ\text{C}$
Infrared (15 seconds)	$+220^\circ\text{C}$
Z Package	
Soldering (10 seconds)	$+260^\circ\text{C}$
ESD Susceptibility	
Human Body Model (Note 3)	2 kV

Machine Model (Note 3)

200V

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

**Operating Ratings**(Notes 1, 2)

Temperature Range	$(T_{\min} \leq T_A \leq T_{\max})$
Industrial Temperature Range	$-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$
Extended Temperature Range	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$

Reverse Current	
LM4040-2.0	60 $\mu\text{A}$ to 15 mA
LM4040-2.5	60 $\mu\text{A}$ to 15 mA
LM4040-3.0	62 $\mu\text{A}$ to 15 mA
LM4040-4.1	68 $\mu\text{A}$ to 15 mA
LM4040-5.0	74 $\mu\text{A}$ to 15 mA
LM4040-8.2	91 $\mu\text{A}$ to 15 mA
LM4040-10.0	100 $\mu\text{A}$ to 15 mA

## LM4040-2.0

### Electrical Characteristics (Industrial Temperature Range)

**Boldface limits apply for  $T_A = T_J = T_{\min}$  to  $T_{\max}$** ; all other limits  $T_A = T_J = 25^\circ\text{C}$ . The grades A and B designate initial Reverse Breakdown Voltage tolerances of  $\pm 0.1\%$  and  $\pm 0.2\%$ , respectively.

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040AIM3 LM4040AIZ (Limit) (Note 5)	LM4040BIM3 LM4040BIZ LM4040BIM7 (Limit) (Note 5)	Units (Limit)
$V_R$	Reverse Breakdown Voltage	$I_R = 100 \mu\text{A}$	2.048			V
	Reverse Breakdown Voltage Tolerance (Note 6)	$I_R = 100 \mu\text{A}$		$\pm 2.0$ <b><math>\pm 15</math></b>	$\pm 4.1$ <b><math>\pm 17</math></b>	mV (max) mV (max)
$I_{R\text{MIN}}$	Minimum Operating Current		45	60 <b>65</b>	60 <b>65</b>	$\mu\text{A}$ $\mu\text{A}$ (max) $\mu\text{A}$ (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	$I_R = 10 \text{ mA}$	$\pm 20$			ppm/ $^\circ\text{C}$
		$I_R = 1 \text{ mA}$	$\pm 15$	<b><math>\pm 100</math></b>	<b><math>\pm 100</math></b>	ppm/ $^\circ\text{C}$ (max)
		$I_R = 100 \mu\text{A}$	$\pm 15$			ppm/ $^\circ\text{C}$
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note *NO TARGET FOR *)	$I_{R\text{MIN}} \leq I_R \leq 1 \text{ mA}$	0.3	0.8 <b>1.0</b>	0.8 <b>1.0</b>	mV mV (max) mV (max)
		$1 \text{ mA} \leq I_R \leq 15 \text{ mA}$	2.5	6.0 <b>8.0</b>	6.0 <b>8.0</b>	mV mV (max) mV (max)
$Z_R$	Reverse Dynamic Impedance	$I_R = 1 \text{ mA}$ , $f = 120 \text{ Hz}$ , $I_{AC} = 0.1 I_R$	0.3	0.8	0.8	$\Omega$ $\Omega$ (max)
$e_N$	Wideband Noise	$I_R = 100 \mu\text{A}$ $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	35			$\mu\text{V}_{\text{rms}}$

## LM4040-10.0 Electrical Characteristics (Industrial Temperature Range)

**Boldface limits apply for  $T_A = T_J = T_{MIN}$  to  $T_{MAX}$** ; all other limits  $T_A = T_J = 25^\circ\text{C}$ . The grades A and B designate initial Reverse Breakdown Voltage tolerances of  $\pm 0.1\%$  and  $\pm 0.2\%$ , respectively.

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040AIM3 LM4040AIZ Limits (Note 5)	LM4040BIM3 LM4040BIZ Limits (Note 5)	Units (Limit)
$V_R$	Reverse Breakdown Voltage	$I_R = 150 \mu\text{A}$	10.00			V
	Reverse Breakdown Voltage Tolerance (Note 6)	$I_R = 150 \mu\text{A}$		$\pm 10$ <b><math>\pm 75</math></b>	$\pm 20$ <b><math>\pm 85</math></b>	mV (max) mV (max)
$I_{RMIN}$	Minimum Operating Current		75			$\mu\text{A}$
				100	100	$\mu\text{A}$ (max)
				<b>103</b>	<b>103</b>	$\mu\text{A}$ (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	$I_R = 10 \text{ mA}$	$\pm 40$			ppm/ $^\circ\text{C}$
		$I_R = 1 \text{ mA}$	$\pm 20$	<b><math>\pm 100</math></b>	<b><math>\pm 100</math></b>	ppm/ $^\circ\text{C}$ (max)
		$I_R = 150 \mu\text{A}$	$\pm 20$			ppm/ $^\circ\text{C}$
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \leq I_R \leq 1 \text{ mA}$	0.8			mV
				1.5	1.5	mV (max)
		$1 \text{ mA} \leq I_R \leq 15 \text{ mA}$		<b>3.5</b>	<b>3.5</b>	mV (max)
				8.0	12.0	12.0
			<b>23.0</b>	<b>23.0</b>	mV (max)	
$Z_R$	Reverse Dynamic Impedance	$I_R = 1 \text{ mA}, f = 120 \text{ Hz},$ $I_{AC} = 0.1 I_R$	0.7			$\Omega$
				1.7	1.7	$\Omega$ (max)
$e_N$	Wideband Noise	$I_R = 150 \mu\text{A}$ $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	180			$\mu\text{V}_{\text{rms}}$
$\Delta V_R$	Reverse Breakdown Voltage Long Term Stability	$t = 1000 \text{ hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 150 \mu\text{A}$	120			ppm
$V_{HYST}$	Thermal Hysteresis (Note 8)	$\Delta T = -40^\circ\text{C}$ to $+125^\circ\text{C}$	0.08			%

**LM4040-10.0****Electrical Characteristics (Industrial Temperature Range)**

**Boldface limits apply for  $T_A = T_J = T_{MIN}$  to  $T_{MAX}$** ; all other limits  $T_A = T_J = 25^\circ\text{C}$ . The grades C and D designate initial Reverse Breakdown Voltage tolerances of  $\pm 0.5\%$  and  $\pm 1.0\%$ , respectively.

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CIM3 LM4040CIZ Limits (Note 5)	LM4040DIM3 LM4040DIZ Limits (Note 5)	Units (Limit)
$V_R$	Reverse Breakdown Voltage	$I_R = 150 \mu\text{A}$	10.00			V
	Reverse Breakdown Voltage Tolerance (Note 6)	$I_R = 150 \mu\text{A}$		$\pm 50$ <b><math>\pm 115</math></b>	$\pm 100$ <b><math>\pm 198</math></b>	mV (max) mV (max)
$I_{RMIN}$	Minimum Operating Current		75			$\mu\text{A}$
				100	110	$\mu\text{A}$ (max)
				<b>103</b>	<b>113</b>	$\mu\text{A}$ (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	$I_R = 10 \text{ mA}$	$\pm 40$			ppm/ $^\circ\text{C}$
		$I_R = 1 \text{ mA}$	$\pm 20$	<b><math>\pm 100</math></b>	<b><math>\pm 150</math></b>	ppm/ $^\circ\text{C}$ (max)
		$I_R = 150 \mu\text{A}$	$\pm 20$			ppm/ $^\circ\text{C}$
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \leq I_R \leq 1 \text{ mA}$	0.8	1.5 <b>3.5</b>	2.0 <b>4.0</b>	mV mV (max) mV (max)
		$1 \text{ mA} \leq I_R \leq 15 \text{ mA}$	8.0	12.0 <b>23.0</b>	18.0 <b>29.0</b>	mV mV (max) mV (max)
$Z_R$	Reverse Dynamic Impedance	$I_R = 1 \text{ mA}$ , $f = 120 \text{ Hz}$ , $I_{AC} = 0.1 I_R$	0.7	1.7	2.3	$\Omega$ $\Omega$ (max)
$e_N$	Wideband Noise	$I_R = 150 \mu\text{A}$ $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	180			$\mu\text{V}_{rms}$
$\Delta V_R$	Reverse Breakdown Voltage Long Term Stability	$t = 1000 \text{ hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$	120			ppm
		$I_R = 150 \mu\text{A}$				
$V_{HYST}$	Thermal Hysteresis (Note 8)	$\Delta T = -40^\circ\text{C}$ to $+125^\circ\text{C}$	0.08			%

