

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 μ A for the LM4040-2.5 to 100 μ 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

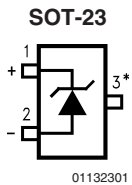
Key Specifications (LM4040-2.5)

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

Applications

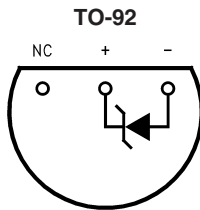
- Portable, Battery-Powered Equipment
- Data Acquisition Systems
- Instrumentation
- Process Control
- Energy Management
- Product Testing
- Automotive
- Precision Audio Components

Connection Diagrams

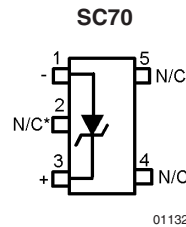


*This pin must be left floating or connected to pin 2.

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°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 μA to 15 mA
LM4040-2.5	60 μA to 15 mA
LM4040-3.0	62 μA to 15 mA
LM4040-4.1	68 μA to 15 mA
LM4040-5.0	74 μA to 15 mA
LM4040-8.2	91 μA to 15 mA
LM4040-10.0	100 μA 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)	$I_R = 100 \mu\text{A}$		± 2.0 ± 15	± 4.1 ± 17	mV (max) mV (max)
$I_{R\min}$	Minimum Operating Current		45	60 65	60 65	μA μA (max) μA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	$I_R = 10 \text{ mA}$	± 20			ppm/ $^\circ\text{C}$
		$I_R = 1 \text{ mA}$	± 15	± 100	± 100	ppm/ $^\circ\text{C}$ (max)
		$I_R = 100 \mu\text{A}$	± 15			ppm/ $^\circ\text{C}$
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note *NO TARGET FOR *)	$I_{R\min} \leq I_R \leq 1 \text{ mA}$	0.3	0.8 1.0	0.8 1.0	mV mV (max) mV (max)
		$1 \text{ mA} \leq I_R \leq 15 \text{ mA}$	2.5	6.0 8.0	6.0 8.0	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	Ω Ω (max)
e_N	Wideband Noise	$I_R = 100 \mu\text{A}$ $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	35			μV_{rms}

LM4040-2.0**Electrical Characteristics (Industrial Temperature Range)** (Continued)

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)
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = $25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100 \mu\text{A}$	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	$\Delta T = -40^\circ\text{C}$ to $+125^\circ\text{C}$	0.08			%

LM4040-2.0**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 C, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1.0\%$ and $\pm 2.0\%$, respectively.

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CIM3 LM4040CIZ LM4040CIM7 (Limit) (Note 5)	LM4040DIM3 LM4040DIZ LM4040DIM7 (Limit) (Note 5)	LM4040EIM7 LM4040EIZ (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)	$I_R = 100 \mu\text{A}$		± 10 ± 23	± 20 ± 40	± 41 ± 60	mV (max) mV (max)	
I_{RMIN}	Minimum Operating Current		45	60 65	65 70	65 70	μA μA (max) μA (max)	
		Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	$I_R = 10 \text{ mA}$	± 20				ppm/ $^\circ\text{C}$
			$I_R = 1 \text{ mA}$ $I_R = 100 \mu\text{A}$	± 15 ± 15	± 100	± 150	± 150	ppm/ $^\circ\text{C}$ (max) ppm/ $^\circ\text{C}$
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note *NO TARGET FOR *)	$I_{RMIN} \leq I_R \leq 1 \text{ mA}$	0.3	0.8 1.0	1.0 1.2	1.0 1.2	mV mV (max) mV (max)	
		$1 \text{ mA} \leq I_R \leq 15 \text{ mA}$	2.5	6.0 8.0	8.0 10.0	8.0 10.0	mV mV (max) mV (max)	
					0.9	1.1	1.1	Ω Ω (max)
e_N	Wideband Noise	$I_R = 100 \mu\text{A}$ $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	35				μV_{rms}	
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = $25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100 \mu\text{A}$	120				ppm	
V_{HYST}	Thermal Hysteresis (Note 8)	$\Delta T = -40^\circ\text{C}$ to $+125^\circ\text{C}$	0.08				%	

LM4040-3.0 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, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1.0\%$ and $\pm 2.0\%$, respectively.

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CIM3 LM4040DIZ LM4040CIM7 Limits (Note 5)	LM4040DIM3 LM4040DIZ LM4040DIM7 Limits (Note 5)	LM4040EIM7 LM4040EIZ Limits (Note 5)	Units (Limit)	
V_R	Reverse Breakdown Voltage	$I_R = 100 \mu\text{A}$	3.000				V	
	Reverse Breakdown Voltage Tolerance (Note 6)	$I_R = 100 \mu\text{A}$		± 15 ± 34	± 30 ± 59	± 60 ± 89	mV (max) mV (max)	
I_{RMIN}	Minimum Operating Current		45	60 65	65 70	65 70	μA μA (max) μA (max)	
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	$I_R = 10 \text{ mA}$	± 20				ppm/ $^\circ\text{C}$	
		$I_R = 1 \text{ mA}$	± 15	± 100	± 150	± 150	ppm/ $^\circ\text{C}$ (max)	
		$I_R = 100 \mu\text{A}$	± 15				ppm/ $^\circ\text{C}$	
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \leq I_R \leq 1 \text{ mA}$	0.4	0.8 1.1	1.1 1.3	1.1 1.3	mV mV (max) mV (max)	
			$1 \text{ mA} \leq I_R \leq 15 \text{ mA}$	2.7	6.0 9.0	8.0 11.0	8.0 11.0	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	$I_R = 1 \text{ mA}$, $f = 120 \text{ Hz}$ $I_{AC} = 0.1 I_R$	0.4	0.9	1.2	1.2	Ω Ω (max)	
e_N	Wideband Noise	$I_R = 100 \mu\text{A}$ $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	35				μV_{rms}	
ΔV_R	Reverse Breakdown Voltage Long Term Stability	$t = 1000 \text{ hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100 \mu\text{A}$	120				ppm	
V_{HYST}	Thermal Hysteresis (Note 8)	$\Delta T = -40^\circ\text{C}$ to $+125^\circ\text{C}$	0.08				%	

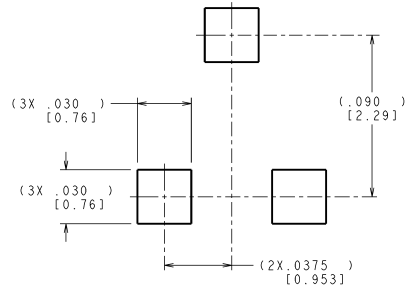
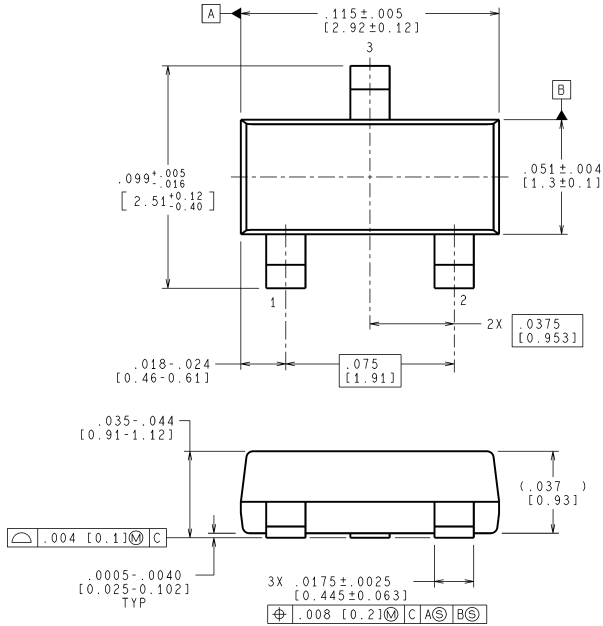
LM4040-3.0 Electrical Characteristics (Extended Temperature Range)

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, D and E designate initial Reverse Breakdown Voltage tolerances of $\pm 0.5\%$, $\pm 1.0\%$ and $\pm 2.0\%$, respectively.

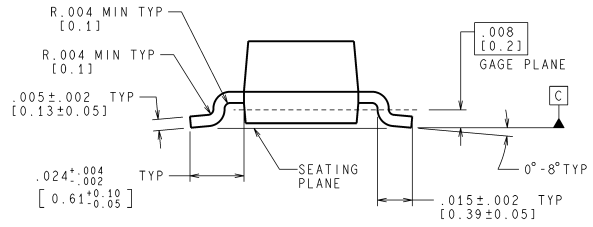
Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CEM3 Limits (Note 5)	LM4040DEM3 Limits (Note 5)	LM4040EEM3 Limits (Note 5)	Units (Limit)
V_R	Reverse Breakdown Voltage	$I_R = 100 \mu\text{A}$	3.000				V
	Reverse Breakdown Voltage Tolerance (Note 6)	$I_R = 100 \mu\text{A}$		± 15 ± 45	± 30 ± 75	± 60 ± 105	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		47	62 70	67 75	67 75	μA μA (max) μA (max)

Physical Dimensions inches (millimeters)

unless otherwise noted



RECOMMENDED LAND PATTERN



CONTROLLING DIMENSION IS INCH
 VALUES IN [] ARE MILLIMETERS

MF03A (Rev B)

Plastic Surface Mount Package (M3)
NS Package Number MF03A
(JEDEC Registration TO-236AB)