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National Semiconductor

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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 µA for the LM4040-2.5 to 100 µA 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 ±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)

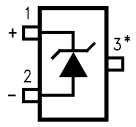
- Output voltage tolerance (A grade, 25˚C) ±0.1% (max)
- Low output noise (10 Hz to 10 kHz) 35 μV_{rms}(typ)
- Wide operating current range 60 µA to 15 mA
- Industrial temperature range –40˚C to +85˚C
- Extended temperature range –40˚C to +125˚C
- Low temperature coefficient 100 ppm/˚C (max)

Applications

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

Connection Diagrams

SOT-23

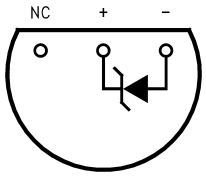


01132301

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

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

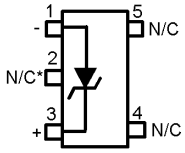
TO-92



01132303

Bottom View
See NS Package Number Z03A

SC70



01132330

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

Top View
See NS Package Number MAA05A

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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

Extended Temperature Range (–40 ˚C to +125˚C)

Reverse Breakdown Voltage Tolerance at 25 ˚C and Average Reverse Breakdown Voltage Temperature Coefficient	Package
	M3 (SOT-23) See NS Package Number MF03A
±0.5%, 100 ppm/˚C max (C grade)	LM4040CEM3-2.0, LM4040CEM3-2.5, LM4040CEM3-3.0, LM4040CEM3-5.0
±1.0%, 150 ppm/˚C max (D grade)	LM4040DEM3-2.0, LM4040DEM3-2.5, LM4040DEM3-3.0, LM4040DEM3-5.0
±2.0%, 150 ppm/˚C max (E grade)	LM4040EEM3-2.0, LM4040EEM3-2.5, LM4040EEM3-3.0

SOT-23 AND SC70 Package Marking Information

Only three fields of marking are possible on the SOT-23's and SC70's small surface. This table gives the meaning of the three fields.

Part Marking	Field Definition
RJA SOT-23 only R2A SOT-23 only RKA SOT-23 only R4A SOT-23 only R5A SOT-23 only R8A SOT-23 only R0A SOT-23 only	First Field: R = Reference Second Field: J = 2.048V Voltage Option 2 = 2.500V Voltage Option K = 3.000V Voltage Option 4 = 4.096V Voltage Option
RJB R2B RKB R4B R5B R8B SOT-23 only R0B SOT-23 only	5 = 5.000V Voltage Option 8= 8.192V Voltage Option 0 = 10.000V Voltage Option Third Field:
RJC R2C RKC R4C R5C R8C SOT-23 only R0C SOT-23 only	A–E = Initial Reverse Breakdown Voltage or Reference Voltage Tolerance A = ±0.1%, B = ±0.2%, C = +0.5%, D = ±1.0%, E = ±2.0%
RJD R2D RKD R4D R5D R8D SOT-23 only R0D SOT-23 only	
RJE R2E RKE	

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˚C) (Note 2)	
M3 Package	306 mW
Z Package	550 mW
M7 Package	241 mW
Storage Temperature	−65˚C to +150˚C
Lead Temperature	
M3 Package	
Vapor phase (60 seconds)	+215˚C
Infrared (15 seconds)	+220˚C
Z Package	
Soldering (10 seconds)	+260˚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	($T_{min} \le T_A \le T_{max}$)
Industrial Temperature Range	−40˚C ≤ T_A ≤ +85˚C
Extended Temperature Range	−40˚C ≤ T_A ≤ +125˚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˚C. The grades A and B designate initial Reverse Breakdown Voltage tolerances of ±0.1% and ±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 µA	2.048			V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 100 µA		±2.0 **±15**	±4.1 **±17**	mV (max) mV (max)
I_{RMIN}	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 mA I_R = 1 mA I_R = 100 µA	±20 ±15 ±15	 **±100**	 **±100**	ppm/˚C ppm/˚C (max) ppm/˚C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note *NO TARGET FOR *)	$I_{RMIN} \le I_R \le$ 1 mA	0.3	 0.8 **1.0**	 0.8 **1.0**	mV mV (max) mV (max)
		1 mA ≤ I_R ≤ 15 mA	2.5	 6.0 **8.0**	 6.0 **8.0**	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, I_{AC} = 0.1 I_R	0.3	 0.8	 0.8	Ω Ω (max)
e_N	Wideband Noise	I_R = 100 µA 10 Hz ≤ f ≤ 10 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 $T_A = T_J = 25^\circ C$. The grades A and B designate initial Reverse Breakdown Voltage tolerances of ±0.1% and ±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˚C ±0.1˚C I_R = 100 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = –40˚C to +125˚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 $T_A = T_J = 25^\circ C$. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of ±0.5%, ±1.0% and ±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 µA	2.048				V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 100 µA		±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)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA I_R = 1 mA I_R = 100 µA	±20 ±15 ±15	 **±100**	 **±150**	 **±150**	ppm/˚C ppm/˚C (max) ppm/˚C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note *NO TARGET FOR *)	$I_{RMIN} \le I_R \le$ 1 mA	0.3	 0.8 **1.0**	 1.0 **1.2**	 1.0 **1.2**	mV mV (max) mV (max)
		1 mA ≤ $I_R \le$ 15 mA	2.5	 6.0 **8.0**	 8.0 **10.0**	 8.0 **10.0**	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz I_{AC} = 0.1 I_R	0.3	 0.9	 1.1	 1.1	Ω Ω(max)
e_N	Wideband Noise	I_R = 100 µA 10 Hz ≤ f ≤ 10 kHz	35				μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25˚C ±0.1˚C I_R = 100 µA	120				ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = –40˚C to +125˚C	0.08				%

LM4040-2.0
Electrical Characteristics (Extended Temperature Range)

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}; all other limits $T_A = T_J = 25^\circ C$. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of ±0.5%, ±1.0% and ±2.0%, respectively.

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CEM3 (Limit) (Note 5)	LM4040DEM3 (Limit) (Note 5)	LM4040EEM3 (Limit) (Note 5)	Units (Limit)
V_R	Reverse Breakdown Voltage	I_R = 100 µA	2.048				V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 100 µA		±10 **±30**	±20 **±50**	±41 **±70**	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		45	 60 **68**	 65 **73**	 65 **73**	µA µA (max) µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA I_R = 1 mA I_R = 100 µA	±20 ±15 ±15	 **±100**	 **±150**	 **±150**	ppm/°C ppm/°C (max) ppm/°C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.3	 0.8 **1.0**	 1.0 **1.2**	 1.0 **1.2**	mV mV (max) mV (max)
		1 mA $\le I_R \le$ 15 mA	2.5	 6.0 **8.0**	 8.0 **10.0**	 8.0 **10.0**	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$	0.3	 0.9	 1.1	 1.1	Ω Ω (max)
e_N	Wideband Noise	I_R = 100 µA 10 Hz ≤ f ≤ 10 kHz	35				μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25°C ±0.1°C I_R = 100 µA	120				ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = –40°C to +125°C	0.08				%

LM4040-2.5
Electrical Characteristics (Industrial Temperature Range)

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

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040AIM3 LM4040AIZ (Limit) (Note 5)	LM4040BIM3 LM4040BIZ LM4040BIM7 Limits (Note 5)	Units (Limit)
V_R	Reverse Breakdown Voltage	I_R = 100 µA	2.500			V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 100 µA		±2.5 **±19**	±5.0 **±21**	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		45	 60 **65**	 60 **65**	µA µA (max) µA (max)

LM4040-2.5
Electrical Characteristics (Industrial Temperature Range) (Continued)

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

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040AIM3 LM4040AIZ (Limit) (Note 5)	LM4040BIM3 LM4040BIZ LM4040BIM7 Limits (Note 5)	Units (Limit)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA	±20			ppm/˚C
		I_R = 1 mA	±15	**±100**	**±100**	ppm/˚C (max)
		I_R = 100 µA	±15			ppm/˚C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.3			mV
				0.8	0.8	mV (max)
				1.0	**1.0**	mV (max)
		1 mA ≤ $I_R \le$ 15 mA	2.5			mV
				6.0	6.0	mV (max)
				8.0	**8.0**	mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$	0.3	0.8	0.8	Ω Ω (max)
e_N	Wideband Noise	I_R = 100 µA, 10 Hz ≤ f ≤ 10 kHz	35			μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs, T = 25˚C ±0.1˚C, I_R = 100 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = –40˚C to +125˚C	0.08			%

LM4040-2.5
Electrical Characteristics (Industrial Temperature Range)

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}; all other limits $T_A = T_J = 25^\circ C$. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of ±0.5%, ±1.0% and ±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 µA	2.500				V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 100 µA		±12	±25	±50	mV (max)
				±29	**±49**	**±74**	mV (max)
I_{RMIN}	Minimum Operating Current		45				µA
				60	65	65	µA (max)
				65	**70**	**70**	µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient(Note 6)	I_R = 10 mA	±20				ppm/˚C
		I_R = 1 mA	±15	**±100**	**±150**	**±150**	ppm/˚C (max)
		I_R = 100 µA	±15				ppm/˚C

LM4040-2.5
Electrical Characteristics (Industrial Temperature Range) (Continued)

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}; all other limits $T_A = T_J = 25^\circ C$. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of ±0.5%, ±1.0% and ±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)
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le 1$ mA	0.3				mV
				0.8	1.0	1.0	mV (max)
				1.0	**1.2**	**1.2**	mV (max)
		1 mA $\le I_R \le$ 15 mA	2.5				mV
				6.0	8.0	8.0	mV (max)
				8.0	**10.0**	**10.0**	mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz $I_{AC} = 0.1\ I_R$	0.3	0.9	1.1	1.1	Ω Ω(max)
e_N	Wideband Noise	I_R = 100 µA 10 Hz ≤ f ≤ 10 kHz	35				μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25˚C ±0.1˚C I_R = 100 µA	120				ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = −40˚C to +125˚C	0.08				%

LM4040-2.5
Electrical Characteristics (Extended Temperature Range)

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}; all other limits $T_A = T_J = 25^\circ C$. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of ±0.5%, ±1.0% and ±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 µA	2.500				V
	Reverse Breakdown Voltage Tolerance(Note 6)	I_R = 100 µA		±12	±25	±50	mV (max)
				±38	**±63**	**±88**	mV (max)
I_{RMIN}	Minimum Operating Current		45				µA
				60	65	65	µA (max)
				68	**73**	**73**	µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA	±20				ppm/˚C
		I_R = 1 mA	±15	**±100**	**±150**	**±150**	ppm/˚C (max)
		I_R = 100 µA	±15				ppm/˚C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le 1$ mA	0.3				mV
				0.8	1.0	1.0	mV (max)
				1.0	**1.2**	**1.2**	mV (max)
		1 mA $\le I_R \le$ 15 mA	2.5				mV
				6.0	8.0	8.0	mV (max)
				8.0	**10.0**	**10.0**	mV (max)

LM4040-2.5
Electrical Characteristics (Extended Temperature Range) (Continued)

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}; all other limits $T_A = T_J = 25^\circ C$. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of ±0.5%, ±1.0% and ±2.0%, respectively.

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CEM3 Limits (Note 5)	LM4040DEM3 Limits (Note 5)	LM4040EEM3 Limits (Note 5)	Units (Limit)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, I_{AC} = 0.1 I_R	0.3	0.9	1.1	1.1	Ω Ω (max)
e_N	Wideband Noise	I_R = 100 µA 10 Hz ≤ f ≤ 10 kHz	35				μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25˚C ±0.1˚C I_R = 100 µA	120				ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = –40˚C to +125˚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 $T_A = T_J = 25^\circ C$. The grades A and B designate initial Reverse Breakdown Voltage tolerances of ±0.1% and ±0.2%, respectively.

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040AIM3 LM4040AIZ (Limit) (Note 5)	LM4040BIM3 LM4040BIZ LM4040BIM7 Limits (Note 5)	Units (Limit)
V_R	Reverse Breakdown Voltage	I_R = 100 µA	3.000			V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 100 µA		±3.0 **±22**	±6.0 **±26**	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		47	 62 **67**	 62 **67**	µA µA (max) µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA I_R = 1 mA I_R = 100 µA	±20 ±15 ±15	**±100**	**±100**	ppm/˚C ppm/˚C (max) ppm/˚C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.6	 0.8 **1.1**	 0.8 **1.1**	mV mV (max) mV (max)
		1 mA ≤ I_R ≤ 15 mA	2.7	 6.0 **9.0**	 6.0 **9.0**	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, I_{AC} = 0.1 I_R	0.4	0.9	0.9	Ω Ω (max)
e_N	Wideband Noise	I_R = 100 µA 10 Hz ≤ f ≤ 10 kHz	35			μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25˚C ±0.1˚C I_R = 100 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = –40˚C to +125˚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 $T_A = T_J = 25^\circ C$. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of ±0.5%, ±1.0% and ±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 µA	3.000				V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 100 µA		±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 mA I_R = 1 mA I_R = 100 µA	±20 ±15 ±15	 **±100**	 **±150**	 **±150**	ppm/˚C ppm/˚C (max) ppm/˚C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.4	 0.8 **1.1**	 1.1 **1.3**	 1.1 **1.3**	mV mV (max) mV (max)
		1 mA $\le I_R \le$ 15 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 mA, f = 120 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 µA 10 Hz ≤ f ≤ 10 kHz	35				μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25˚C ±0.1˚C I_R = 100 µA	120				ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = −40˚C to +125˚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 $T_A = T_J = 25^\circ C$. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of ±0.5%, ±1.0% and ±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 µA	3.000				V
	Reverse Breakdown Voltage Tolerance(Note 6)	I_R = 100 µA		±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)

LM4040-3.0
Electrical Characteristics (Extended Temperature Range) (Continued)

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}; all other limits $T_A = T_J = 25^\circ C$. The grades C, D and E designate initial Reverse Breakdown Voltage tolerances of ±0.5%, ±1.0% and ±2.0%, respectively.

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CEM3 Limits (Note 5)	LM4040DEM3 Limits (Note 5)	LM4040EEM3 Limits (Note 5)	Units (Limit)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA	±20				ppm/˚C
		I_R = 1 mA	±15	**±100**	**±150**	**±150**	ppm/˚C (max)
		I_R = 100 µA	±15				ppm/˚C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.4				mV
				0.8	1.1	1.1	mV (max)
				1.1	**1.3**	**1.3**	mV (max)
		1 mA $\le I_R \le$ 15 mA	2.7				mV
				6.0	8.0	8.0	mV (max)
				9.0	**11.0**	**11.0**	mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$	0.4				Ω
				0.9	1.2	1.2	Ω (max)
e_N	Wideband Noise	I_R = 100 µA, 10 Hz ≤ f ≤ 10 kHz	35				μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs, T = 25˚C ±0.1˚C, I_R = 100 µA	120				ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = –40˚C to +125˚C	0.08				%

LM4040-4.1
Electrical Characteristics (Industrial Temperature Range)

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

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040AIM3 LM4040AIZ Limits (Note 5)	LM4040BIM3 LM4040BIZ LM4040BIM7 Limits (Note 5)	Units (Limit)
V_R	Reverse Breakdown Voltage	I_R = 100 µA	4.096			V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 100 µA		±4.1	±8.2	mV (max)
				±31	**±35**	mV (max)
I_{RMIN}	Minimum Operating Current		50			µA
				68	68	µA (max)
				73	**73**	µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient(Note 6)	I_R = 10 mA	±30			ppm/˚C
		I_R = 1 mA	±20	**±100**	**±100**	ppm/˚C (max)
		I_R = 100 µA	±20			ppm/˚C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.5			mV
				0.9	0.9	mV (max)
				1.2	**1.2**	mV (max)
		1 mA $\le I_R \le$ 15 mA	3.0			mV
				7.0	7.0	mV (max)
				10.0	**10.0**	mV (max)

LM4040-4.1
Electrical Characteristics (Industrial Temperature Range) (Continued)

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

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040AIM3 LM4040AIZ Limits (Note 5)	LM4040BIM3 LM4040BIZ LM4040BIM7 Limits (Note 5)	Units (Limit)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$	0.5	1.0	1.0	Ω Ω (max)
e_N	Wideband Noise	I_R = 100 µA 10 Hz ≤ f ≤ 10 kHz	80			μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25˚C ±0.1˚C I_R = 100 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	$\Delta T = -40^\circ C$ to $+125^\circ C$	0.08			%

LM4040-4.1
Electrical Characteristics (Industrial Temperature Range)

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

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CIM3 LM4040CIZ LM4040CIM7 Limits (Note 5)	LM4040DIM3 LM4040BIZ LM4040DIM7 Limits (Note 5)	Units (Limit)
V_R	Reverse Breakdown Voltage	I_R = 100 µA	4.096			V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 100 µA		±20	±41	mV (max)
				±47	**±81**	mV (max)
I_{RMIN}	Minimum Operating Current		50			µA
				68	73	µA (max)
				73	**78**	µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA	±30			ppm/°C
		I_R = 1 mA	±20	**±100**	**±150**	ppm/°C (max)
		I_R = 100 µA	±20			ppm/°C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.5			mV
				0.9	1.2	mV (max)
				1.2	**1.5**	mV (max)
		1 mA $\le I_R \le$ 15 mA	3.0			mV
				7.0	9.0	mV (max)
				10.0	**13.0**	mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$	0.5			Ω
				1.0	1.3	Ω (max)
e_N	Wideband Noise	I_R = 100 µA 10 Hz ≤ f ≤ 10 kHz	80			μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25°C ±0.1°C I_R = 100 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	$\Delta T = -40^\circ C$ to $+125^\circ C$	0.08			%

LM4040-5.0
Electrical Characteristics (Industrial Temperature Range)

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

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040AIM3 LM4040AIZ Limits (Note 5)	LM4040BIM3 LM4040BIZ LM4040BIM7 Limits (Note 5)	Units (Limit)
V_R	Reverse Breakdown Voltage	I_R = 100 µA	5.000			V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 100 µA		±5.0 **±38**	±10 **±43**	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		54	 74 **80**	 74 **80**	µA µA (max) µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA I_R = 1 mA I_R = 100 µA	±30 ±20 ±20	 **±100**	 **±100**	ppm/°C ppm/°C (max) ppm/°C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.5	 1.0 **1.4**	 1.0 **1.4**	mV mV (max) mV (max)
		1 mA $\le I_R \le$ 15 mA	3.5	 8.0 **12.0**	 8.0 **12.0**	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$	0.5	1.1	1.1	Ω Ω (max)
e_N	Wideband Noise	I_R = 100 µA 10 Hz ≤ f ≤ 10 kHz	80			μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25°C ±0.1°C I_R = 100 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = −40°C to +125°C	0.08			%

LM4040-5.0
Electrical Characteristics (Industrial Temperature Range)

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

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CIM3 LM4040CIZ LM4040CIM7 Limits (Note 5)	LM4040DIM3 LM4040BIZ LM4040DIM7 Limits (Note 5)	Units (Limit)
V_R	Reverse Breakdown Voltage	I_R = 100 µA	5.000			V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 100 µA		±25	±50	mV (max)
				±58	**±99**	mV (max)
I_{RMIN}	Minimum Operating Current		54			µA
				74	79	µA (max)
				80	**85**	µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA	±30			ppm/°C
		I_R = 1 mA	±20	**±100**	**±150**	ppm/°C (max)
		I_R = 100 µA	±20			ppm/°C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.5			mV
				1.0	1.3	mV (max)
				1.4	**1.8**	mV (max)
		1 mA $\le I_R \le$ 15 mA	3.5			mV
				8.0	10.0	mV (max)
				12.0	**15.0**	mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$	0.5	1.1	1.5	Ω / Ω (max)
e_N	Wideband Noise	I_R = 100 µA, 10 Hz ≤ f ≤ 10 kHz	80			μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs, T = 25°C ±0.1°C, I_R = 100 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = −40°C to +125°C	0.08			%

LM4040-5.0
Electrical Characteristics (Extended Temperature Range)

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

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CEM3 Limits (Note 5)	LM4040DEM3 Limits (Note 5)	Units (Limit)
V_R	Reverse Breakdown Voltage	I_R = 100 µA	5.000			V
	Reverse Breakdown Voltage Tolerance(Note 6)	I_R = 100 µA		±25	±50	mV (max)
				±75	**±125**	mV (max)
I_{RMIN}	Minimum Operating Current		54			µA
				74	79	µA (max)
				83	**88**	µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA	±30			ppm/˚C
		I_R = 1 mA	±20	**±100**	**±150**	ppm/˚C (max)
		I_R = 100 µA	±20			ppm/˚C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.5			mV
				1.0	1.0	mV (max)
				1.4	**1.8**	mV (max)
		1 mA ≤ $I_R \le$ 15 mA	3.5			mV
				8.0	8.0	mV (max)
				12.0	**15.0**	mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, I_{AC} = 0.1 I_R	0.5			Ω
				1.1	1.1	Ω (max)
e_N	Wideband Noise	I_R = 100 µA 10 Hz ≤ f ≤ 10 kHz	80			μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25˚C ±0.1˚C I_R = 100 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = −40˚C to +125˚C	0.08			%

LM4040-8.2
Electrical Characteristics (Industrial Temperature Range)

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}; all other limits $T_A = T_J = 25^\circ C$. The grades A and B designate initial Reverse Breakdown Voltage tolerances of ±0.1% and ±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 µA	8.192			V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 150 µA		±8.2 **±61**	±16 **±70**	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		67	 91 **95**	 91 **95**	µA µA (max) µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient(Note 6)	I_R = 10 mA I_R = 1 mA I_R = 150 µA	±40 ±20 ±20	 **±100**	 **±100**	ppm/˚C ppm/˚C (max) ppm/˚C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.6	 1.3 **2.5**	 1.3 **2.5**	mV mV (max) mV (max)
		1 mA $\le I_R \le$ 15 mA	7.0	 10.0 **18.0**	 10.0 **18.0**	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$	0.6	 1.5	 1.5	Ω Ω (max)
e_N	Wideband Noise	I_R = 150 µA 10 Hz ≤ f ≤ 10 kHz	130			μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25˚C ±0.1˚C I_R = 150 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = –40˚C to +125˚C	0.08			%

LM4040-8.2
Electrical Characteristics (Industrial Temperature Range)

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}; all other limits $T_A = T_J = 25^\circ C$. The grades C and D designate initial Reverse Breakdown Voltage tolerances of ±0.5% and ±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 µA	8.192			V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 150 µA		±41 **±94**	±82 **±162**	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		67	 91 **95**	 96 **100**	µA µA (max) µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA I_R = 1 mA I_R = 150 µA	±40 ±20 ±20	 **±100**	 **±150**	ppm/°C ppm/°C (max) ppm/°C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.6	 1.3 **2.5**	 1.7 **3.0**	mV mV (max) mV (max)
		1 mA ≤ $I_R \le$ 15 mA	7.0	 10.0 **18.0**	 15.0 **24.0**	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$	0.6	 1.5	 1.9	Ω Ω (max)
e_N	Wideband Noise	I_R = 150 µA 10 Hz ≤ f ≤ 10 kHz	130			μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25°C ±0.1°C I_R = 150 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = –40°C to +125°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 $T_A = T_J = 25^\circ C$. The grades A and B designate initial Reverse Breakdown Voltage tolerances of ±0.1% and ±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 µA	10.00			V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 150 µA		±10 **±75**	±20 **±85**	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		75	 100 **103**	 100 **103**	µA µA (max) µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA I_R = 1 mA I_R = 150 µA	±40 ±20 ±20	 **±100**	 **±100**	ppm/°C ppm/°C (max) ppm/°C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.8	 1.5 **3.5**	 1.5 **3.5**	mV mV (max) mV (max)
		1 mA $\le I_R \le$ 15 mA	8.0	 12.0 **23.0**	 12.0 **23.0**	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$	0.7	 1.7	 1.7	Ω Ω (max)
e_N	Wideband Noise	I_R = 150 µA 10 Hz ≤ f ≤ 10 kHz	180			μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25°C ±0.1°C I_R = 150 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = –40°C to +125°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 $T_A = T_J = 25^\circ C$. The grades C and D designate initial Reverse Breakdown Voltage tolerances of ±0.5% and ±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 µA	10.00			V
	Reverse Breakdown Voltage Tolerance (Note 6)	I_R = 150 µA		±50 **±115**	±100 **±198**	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		75	 100 **103**	 110 **113**	µA µA (max) µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient (Note 6)	I_R = 10 mA I_R = 1 mA I_R = 150 µA	±40 ±20 ±20	 **±100**	 **±150**	ppm/°C ppm/°C (max) ppm/°C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change (Note 7)	$I_{RMIN} \le I_R \le$ 1 mA	0.8	 1.5 **3.5**	 2.0 **4.0**	mV mV (max) mV (max)
		1 mA ≤ $I_R \le$ 15 mA	8.0	 12.0 **23.0**	 18.0 **29.0**	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$	0.7	 1.7	 2.3	Ω Ω (max)
e_N	Wideband Noise	I_R = 150 µA 10 Hz ≤ f ≤ 10 kHz	180			μV_{rms}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	t = 1000 hrs T = 25°C ±0.1°C I_R = 150 µA	120			ppm
V_{HYST}	Thermal Hysteresis (Note 8)	ΔT = −40°C to +125°C	0.08			%

Electrical Characteristics(Notes)

Note 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 guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Note 2: The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{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 LM4040, $T_{Jmax} = 125^{\circ}C$, and the typical thermal resistance (θ_{JA}), when board mounted, is 326˚C/W for the SOT-23 package, and 180˚C/W with 0.4" lead length and 170˚C/W with 0.125" lead length for the TO-92 package and 415˚C/W for the SC70 Package.

Note 3: The human body model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin. The machine model is a 200 pF capacitor discharged directly into each pin.

Note 4: Typicals are at $T_J = 25^{\circ}C$ and represent most likely parametric norm.

Note 5: Limits are 100% production tested at 25˚C. Limits over temperature are guaranteed through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate National's AOQL.

Note 6: The boldface (over-temperature) limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance $\pm[(\Delta V_R/\Delta T)(\max\Delta T)(V_R)]$. Where, $\Delta V_R/\Delta T$ is the V_R temperature coefficient, $\max\Delta T$ is the maximum difference in temperature from the reference point of 25˚C to T_{MIN} or T_{MAX}, and V_R is the reverse breakdown voltage. The total over-temperature tolerance for the different grades in the industrial temperature range where $\max\Delta T = 65^{\circ}C$ is shown below:

A-grade: ±0.75% = ±0.1% ±100 ppm/˚C x 65˚C

B-grade: ±0.85% = ±0.2% ±100 ppm/˚C x 65˚C

C-grade: ±1.15% = ±0.5% ±100 ppm/˚C x 65˚C

D-grade: ±1.98% = ±1.0% ±150 ppm/˚C x 65˚C

E-grade: ±2.98% = ±2.0% ±150 ppm/˚C x 65˚C

The total over-temperature tolerance for the different grades in the exteded temperature range where max $\Delta T = 100$ ˚C is shown below:

C-grade: ±1.5% = ±0.5% ±100 ppm/˚C x 100˚C

D-grade: ±2.5% = ±1.0% ±150 ppm/˚C x 100˚C

E-grade: ±3.5% = ±2.0% ±150 ppm/˚C x 100˚C

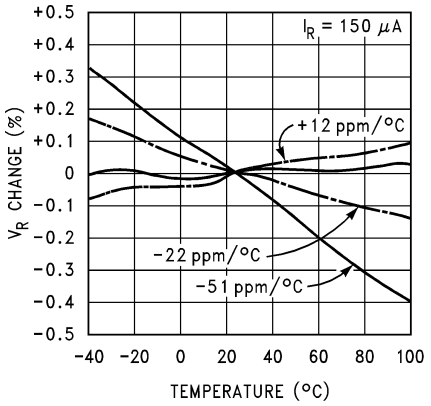
Therefore, as an example, the A-grade LM4040-2.5 has an over-temperature Reverse Breakdown Voltage tolerance of ±2.5V x 0.75% = ±19 mV.

Note 7: Load regulation is measured on pulse basis from no load to the specified load current. Output changes due to die temperature change must be taken into account separately.

Note 8: Thermal hysteresis is defined as the difference in voltage measured at +25˚C after cycling to temperature -40˚C and the 25˚C measurement after cycling to temperature +125˚C.

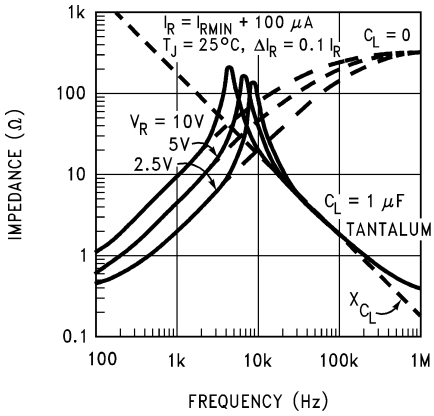
Typical Performance Characteristics

Temperature Drift for Different Average Temperature Coefficient



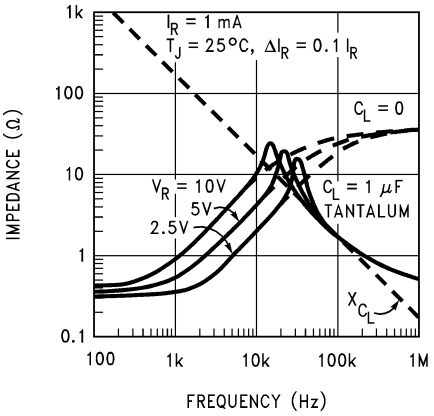
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Output Impedance vs Frequency



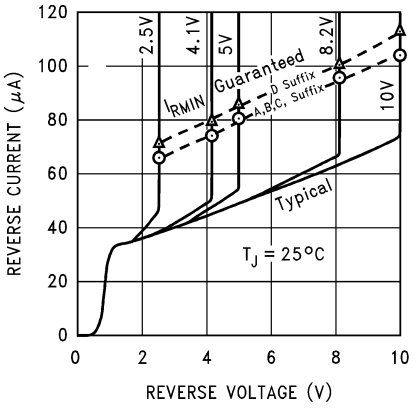
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Output Impedance vs Frequency



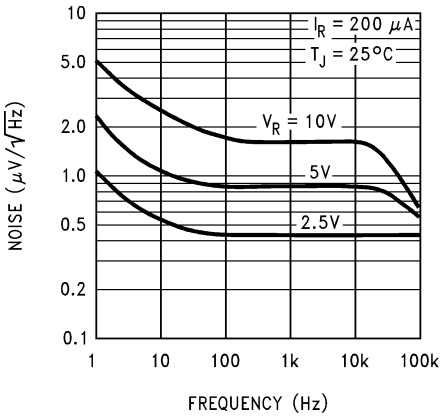
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Reverse Characteristics and Minimum Operating Current



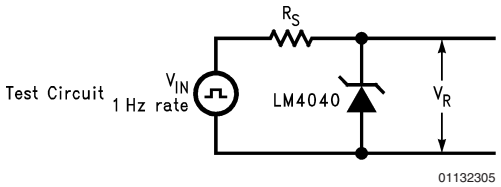
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Noise Voltage vs Frequency



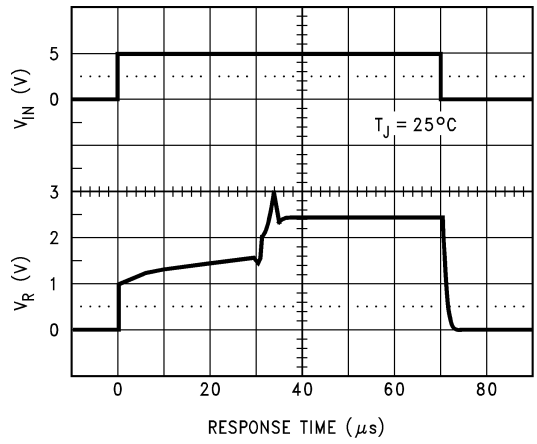
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Start-Up Characteristics



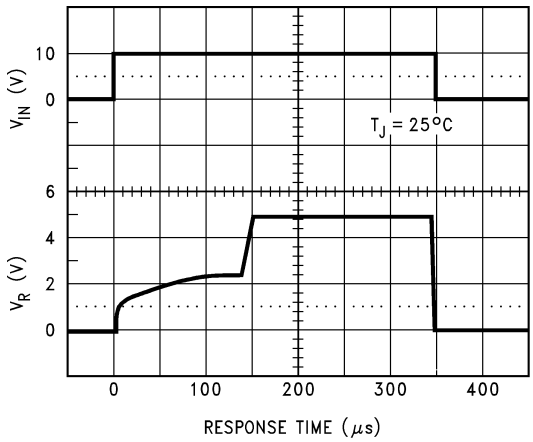
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LM4040-2.5 R_S = 30k



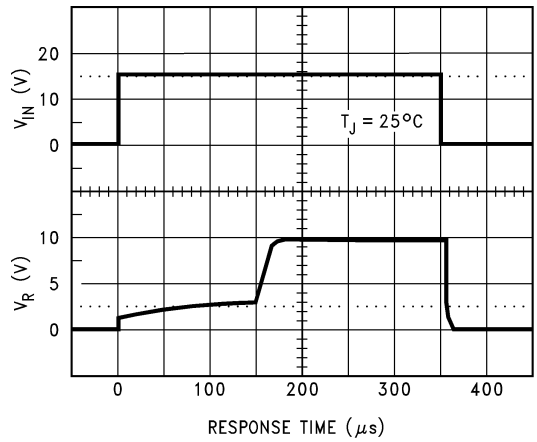
01132307

LM4040-5.0 R_S = 30k



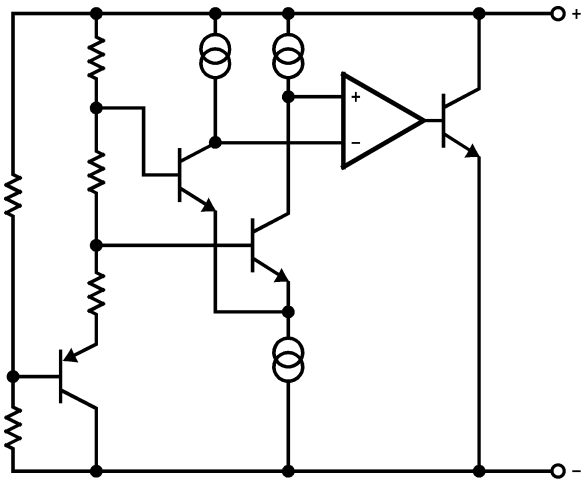
01132308

LM4040-10.0 R_S = 30k



01132309

Functional Block Diagram



01132314

Applications Information

The LM4040 is a precision micro-power curvature-corrected bandgap shunt voltage reference. For space critical applications, the LM4040 is available in the sub-miniature SOT-23 and SC70 surface-mount package. The LM4040 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 LM4040 remains stable. Reducing design effort is the availability of several fixed reverse breakdown voltages: 2.048V, 2.500V, 3.000V, 4.096V, 5.000V, 6.000, 8.192V, and 10.000V. The minimum operating current increases from 60 µA for the LM4040-2.048 and LM4040-2.5 to 100 µA for the LM4040-10.0. All versions have a maximum operating current of 15 mA.

LM4040s in the SOT-23 packages have a parasitic Schottky diode between pin 2 (–) and pin 3 (Die attach interface contact). Therefore, pin 3 of the SOT-23 package must be left floating or connected to pin 2.

LM4040s in the SC70 have a parasitic Schottky diode between pin 1 (–) and pin 2 (Die attach interface contact). Therefore, pin 2 must be left floating or connected to pin1.

The 4.096V version allows single +5V 12-bit ADCs or DACs to operate with an LSB equal to 1 mV. For 12-bit ADCs or DACs that operate on supplies of 10V or greater, the 8.192V version gives 2 mV per LSB.

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

In a conventional shunt regulator application (*Figure 1*) , an external series resistor (R_S) is connected between the supply voltage and the LM4040. R_S determines the current that flows through the load (I_L) and the LM4040 (I_Q). Since load current and supply voltage may vary, R_S should be small enough to supply at least the minimum acceptable I_Q to the LM4040 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 LM4040 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 LM4040's reverse breakdown voltage, V_R.

$$R_S = \frac{V_S - V_R}{I_L + I_Q}$$

Typical Applications

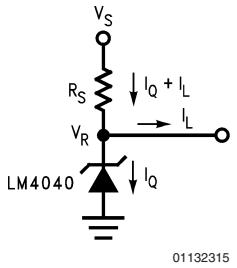
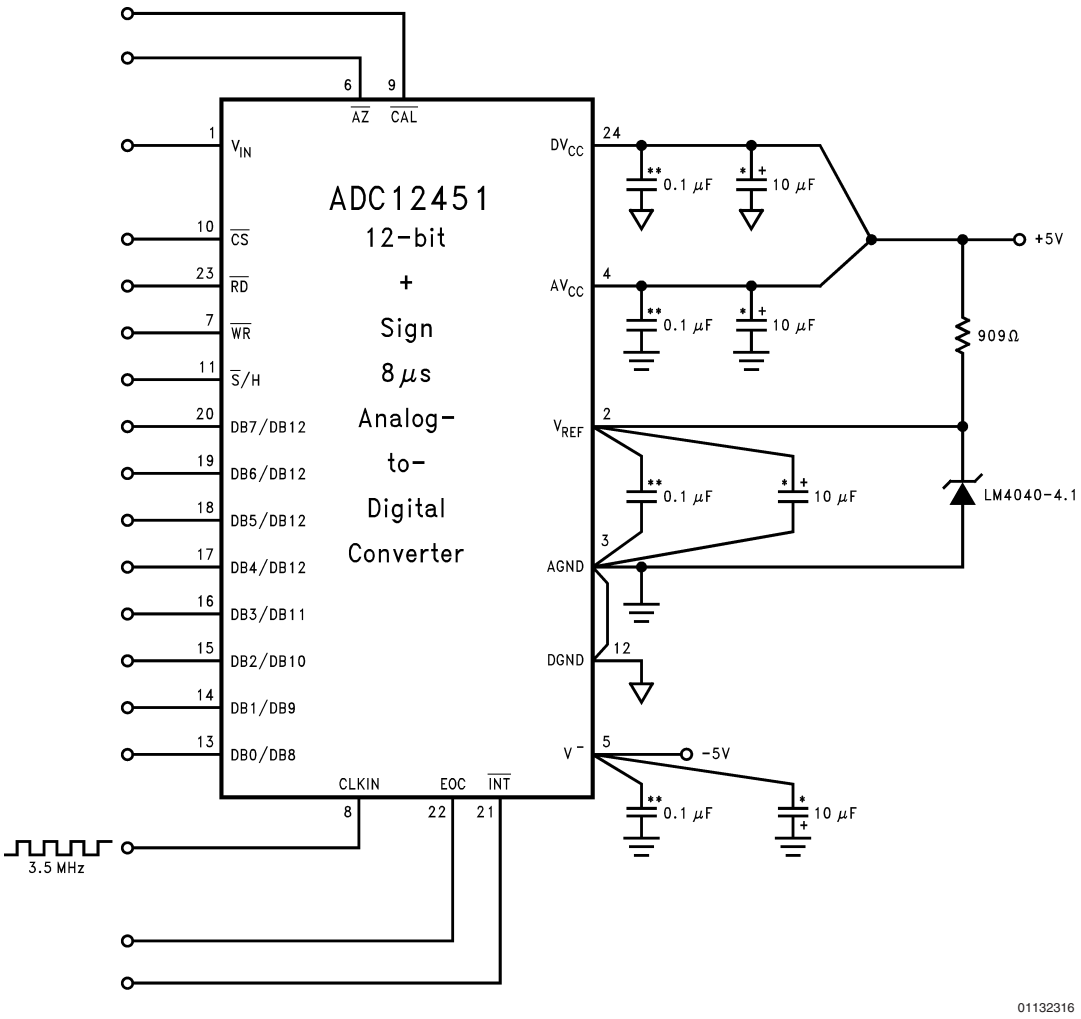


FIGURE 1. Shunt Regulator

Typical Applications (Continued)



**Ceramic monolithic

*Tantalum

FIGURE 2. LM4040-4.1's Nominal 4.096 breakdown voltage gives ADC12451 1 mV/LSB

Typical Applications (Continued)

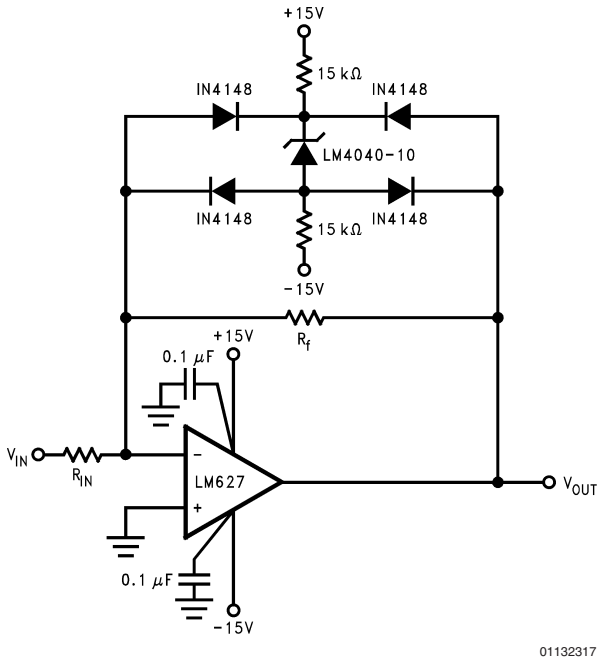


FIGURE 3. Bounded amplifier reduces saturation-induced delays and can prevent succeeding stage damage. Nominal clamping voltage is ±11.5V (LM4040's reverse breakdown voltage +2 diode V_F).

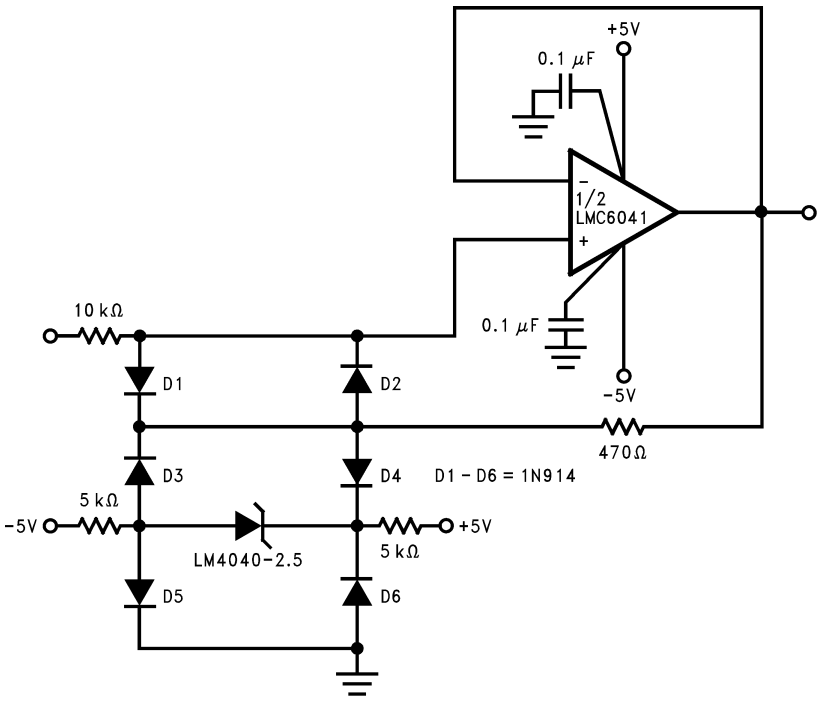


FIGURE 4. Protecting Op Amp input. The bounding voltage is ±4V with the LM4040-2.5 (LM4040's reverse breakdown voltage + 3 diode V_F).

Typical Applications (Continued)

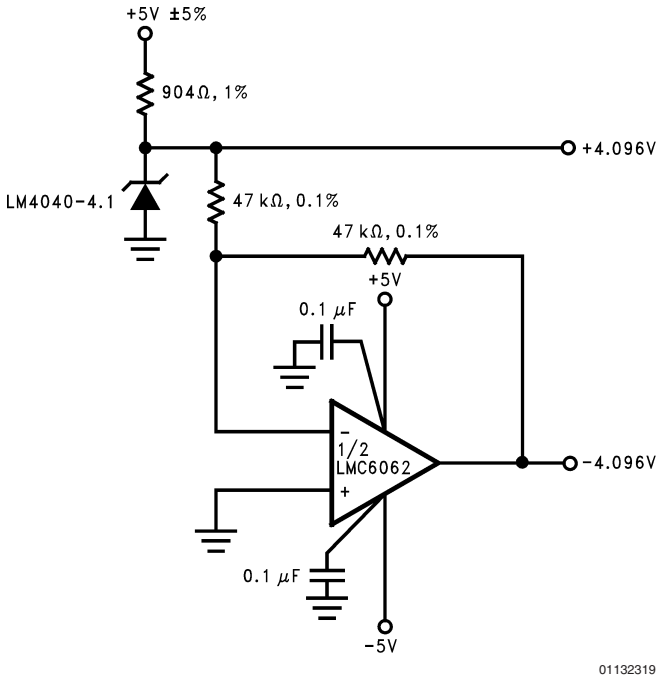
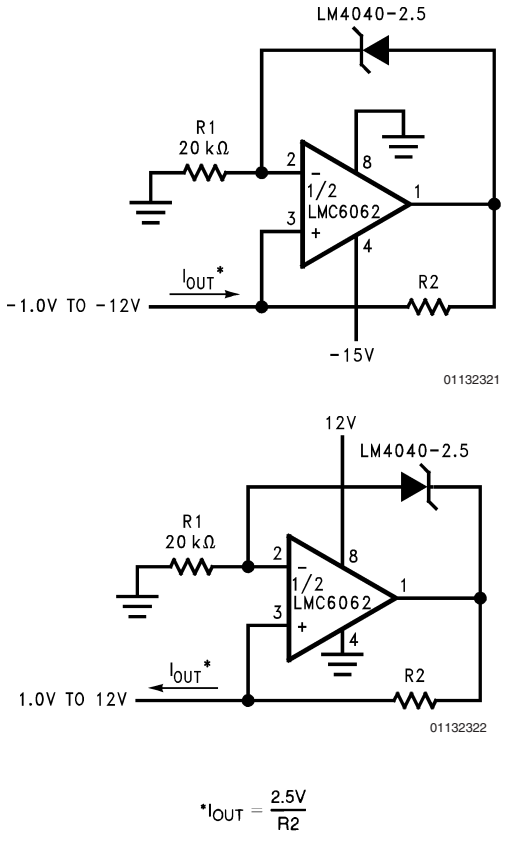


FIGURE 5. Precision ±4.096V Reference

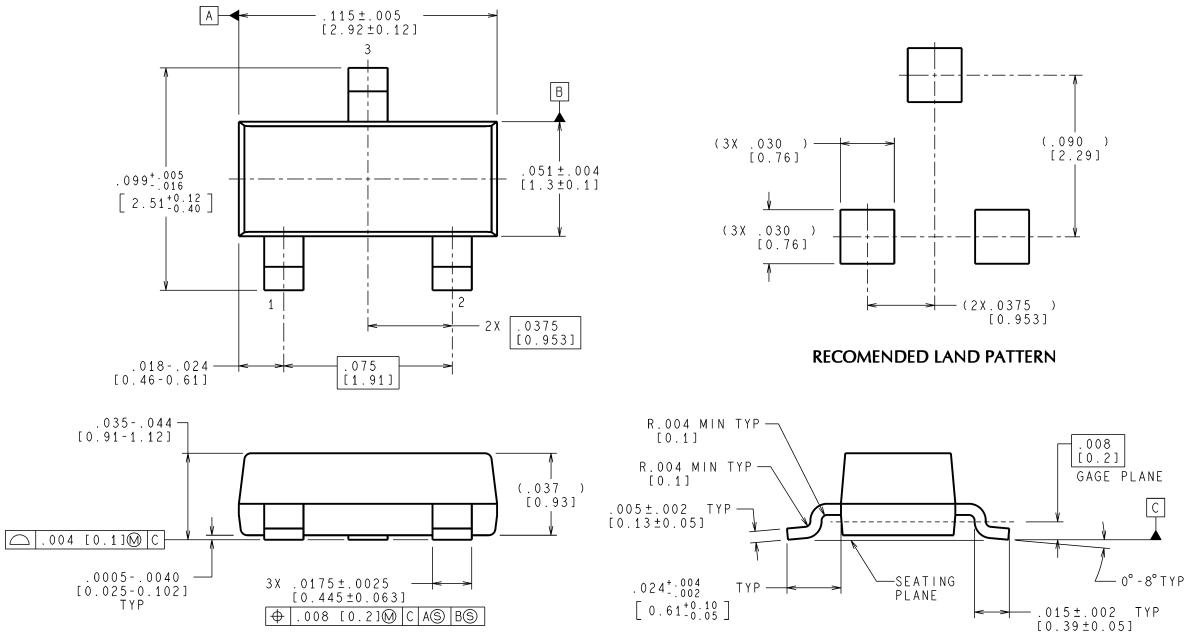


$$*I_{OUT} = \frac{2.5V}{R2}$$

FIGURE 6. Precision 1 µA to 1 mA Current Sources

Physical Dimensions inches (millimeters)

unless otherwise noted

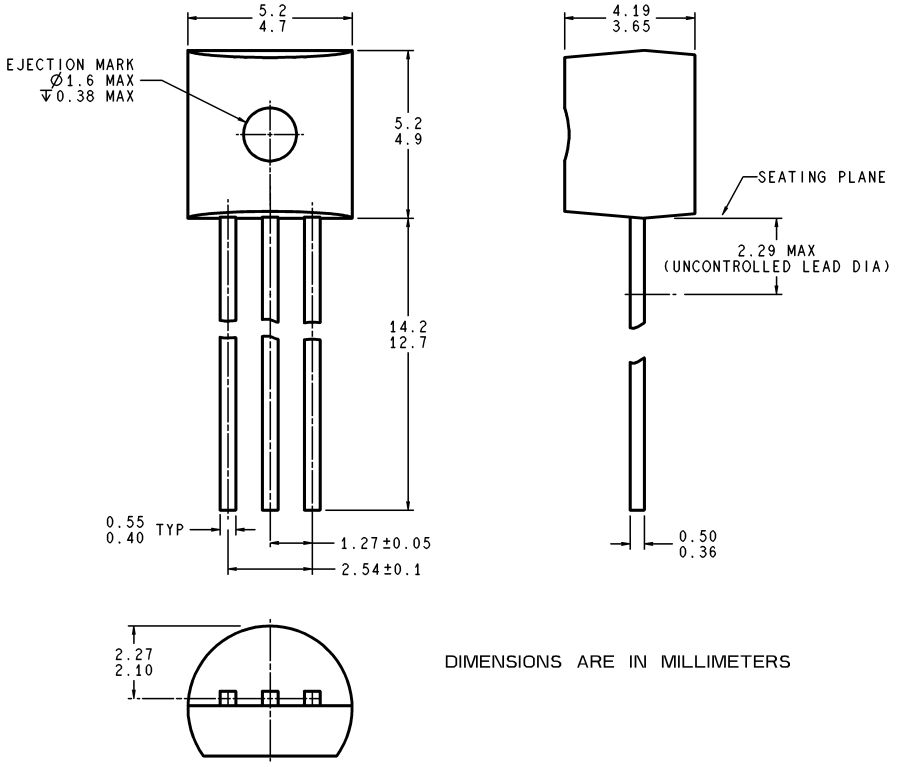


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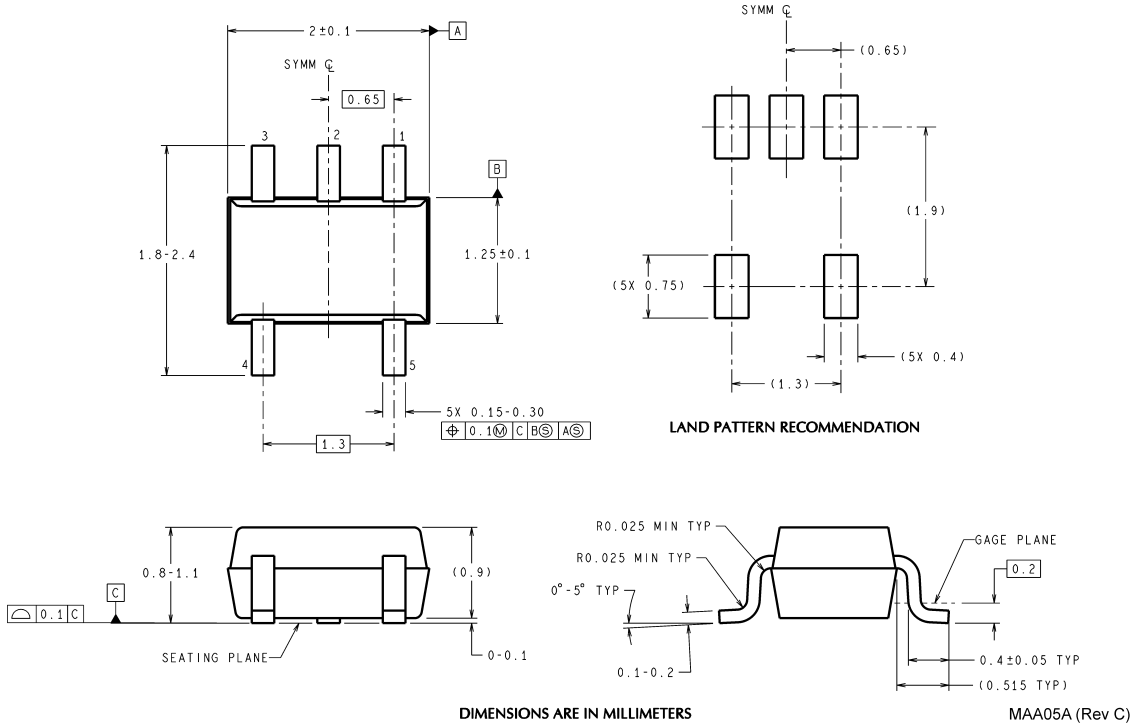
MF03A (Rev B)

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

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



Plastic Package (Z)
NS Package Number Z03A



Molded Package (SC70)
NS Package Number MAA05A

Notes

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